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August 31, 2015

Dr. George Fai
Program Manager for Theory
Division of Nuclear Physics
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Dear George:

Attached please find the final report of the Topical Collaboration in Nuclear Theory "Jet and Electromagnetic Tomography (JET) of Extreme Phases of Matter in Heavy-Ion Collisions" (**Contract No. DE-SC0004104**). My final report on the OSU task is followed by the final report of the entire collaboration.

Best regards,

Ulrich W. Heinz
Distinguished Professor of Physics
Fellow APS, AAAS

Final Report (06/01/2010 – 05/31/2015)

Funding Agency: DOE, Office of Nuclear Physics (Nuclear Theory)
Project title: **Jet and electromagnetic tomography (JET) of extreme phases of matter in heavy-ion collisions** (Ohio State University task)
DOE grant number: DE-SC0004104
Grant Period: 06/01/2010 - 05/31/2015
Principal Investigator: Ulrich Heinz
Additional Personnel: (working on project during part or all of the reporting period but not all fully supported by the grant)
postdocs: Dr. Will Horowitz, Dr. Abhijit Majumder (Visiting Assist. Prof.), Dr. Mauricio Martinez, Dr. Guang-You Qin, Dr. Huichao Song
graduate students: Dennis Bazow, Jia Liu, Christopher Plumberg, Zhi Qiu, Chun Shen, Daniel White
undergraduate students: Brian Baker, Andy Goldschmidt, J. Scott Moreland, Jordan Singer, Amy Weisman, Kevin Welsh
Recipient Organisation: Ohio State University Research Foundation, 1960 Kenny Road, Columbus, OH 43210-1063
Recipient Account Number: OSURF project number 600 236 21

1. Executive Summary

The Ohio State University (OSU) group contributed to the deliverables of the JET Collaboration three major products: **1.** The code package `iEBE-VISHNU` for modeling the dynamical evolution of the soft medium created in relativistic heavy-ion collisions, from its creation all the way to final freeze-out using a hybrid approach that interfaces a free-streaming partonic pre-equilbrium stage with a (2+1)-dimensional viscous relativistic fluid dynamical stage for the quark-gluon plasma (QGP) phase and the microscopic hadron cascade `UrQMD` for the hadronic rescattering and freeze-out stage. Except for `UrQMD`, all dynamical evolution components and interfaces were developed at OSU and tested and implemented in collaboration with the Duke University group. **2.** An electromagnetic radiation module for the calculation of thermal photon emission from the QGP and hadron resonance gas stages of a heavy-ion collision, with emission rates that have been corrected for viscous effects in the expanding medium consistent with the bulk evolution. The electromagnetic radiation module was developed under OSU leadership in collaboration with the McGill group and has been integrated in the `iEBE-VISHNU` code package. **3.** An interface between the Monte Carlo jet shower evolution and hadronization codes developed by the Wayne State University (WSU), McGill and Texas A&M groups and the `iEBE-VISHNU` bulk evolution code, for performing jet quenching and jet shape modification studies in a realistically modeled evolving medium that was tuned to measured soft hadron data. Building on work performed at OSU for the theoretical framework used to describe the interaction of jets with the medium, initial work on the jet shower Monte Carlo was started at OSU and moved to WSU when OSU Visiting Assistant Professor Abhijit Majumder accepted a tenure track faculty position at WSU in September 2011. The jet-hydro interface was developed at OSU and WSU and tested and implemented in collaboration with the McGill, Texas A&M, and LBNL groups.

2. OSU contributions to the JET Collaboration:

This is a report on the contributions to the JET Collaboration made by the Ohio State University group. Through the JET Collaboration the OSU group received funding for between 10 and 11 graduate student months per year throughout the 5-year funding period. These funds were used to provide partial support to postdocs and graduate students in the group during periods when their work was particularly focussed on JET-related tasks. The OSU PI's research program is supported by DOE through a regular research grant, DE-SC004286 (U. Heinz and Yu. Kovchegov, co-PIs), that supports on average 1 postdoc and two GRAs working with the PI on topics that were, during the JET funding period, in general quite well aligned with the particular tasks to which the PI had committed when joining the JET Collaboration. During the second half of the JET funding cycle, the PI served as co-spokesperson of the JET Collaboration.

The (2+1)-dimensional viscous relativistic fluid dynamics code `VISH2+1`, which forms the core of the `iEBE-VISHNU` package and is used to describe the dynamical evolution of the quark-gluon plasma (QGP) stage in heavy-ion collisions, was developed at OSU by Huichao Song before the start of the JET Collaboration and later (in Years 1–3 of the JET Collaboration) repeatedly improved for increased stability when evolving strongly fluctuating initial profiles (which tend to produce large viscous stresses) and for enhanced user friendliness by Zhi Qiu and Chun Shen. The improved version presently in use in `iEBE-VISHNU` has been named `VISHnew`. The `iEBE-VISHNU` code package was made available to collaboration members in Year 2 of the collaboration and to the general public in Year 4. Even before others were permitted to use the code, hydrodynamic space-time profiles and freeze-out surfaces for Au+Au collisions at RHIC energies with smooth ensemble-averaged initial density profiles computed with the code were posted on the TECHQM web site for the rest of the JET Collaboration (as well as for the heavy-ion community at large) as test-media for yet quenching and electromagnetic radiation studies (Year 1).

Chun Shen, in collaboration with Pasi Huovinen (Frankfurt), implemented a state-of-the-art equation of state (EoS) into the code in Year 1. The first interface `H2O` between `VISH2+1` and the hadron cascade `UrQMD` that describes the late hadronic rescattering and freeze-out stage of the collision, after the QGP has converted to a hadron resonance gas ("hadronization"), was written by Huichao Song in Year 1, but later (in Years 2 and 3) replaced by a much faster and more efficient interface named `iSS`, developed and integrated into `iEBE-VISHNU` by Zhi Qiu and Chun Shen. In Year 2 of the collaboration, the `iEBE-VISHNU` code was used by the OSU and Duke groups for the first quantitative extraction of the QGP specific shear viscosity $(\eta/s)_{\rm QGP}$ (Phys. Rev. Lett. 106, 192301 (2011)). This work has become an iconic reference in the field.

The free-streaming partonic pre-equilibrium evolution module and its Landau-matching interface to `VISH2+1` were developed and integrated into `iEBE-VISHNU` by Jia Liu in Years 4 and 5, building on initial work during Years 1 and 2 by Daniel White.

The electromagnetic radiation module, with newly calculated (Years 2 and 3) thermal emission rates that are corrected for modifications caused by the viscous stresses in

the expanding thermal medium, was developed and integrated with the iEBE-VISHNU package by Chun Shen, in collaboration with Jean-Francois Paquet at McGill University, during Years 3–5. This work was reported in a series of publications listed in Sec. 3.A below and in Chun Shen's Ph.D. thesis (which was awarded an Honorable Mention in the 2015 RHIC Thesis Award competition).

A detailed documentation of the iEBE-VISHNU software package, with comprehensive numerical tests, was prepared by the OSU and Duke groups and submitted to Computer Physics Communications in Year 5 of the project; it has been accepted for publication.

Mostly through the efforts of Abhijit Majumder and Will Horowitz who worked at OSU during Year 1 and part of Year 2 of the JET Collaboration funding period, the OSU group has also made significant contributions to the understanding of jet quenching and jet shape modification in hydrodynamically evolving QGP media. In Year 1 of the Collaboration, OSU work focussed on the contributions from the Higher Twist and DGLV approaches to the so-called "QGP brick" model comparison analysis which was published in Phys. Rev. C86, 064904 (2012). Using the hydrodynamic evolution profiles obtained from VISH2+1, the effect of parton energy loss on leading hadron production (Phys. Rev. Lett. 109, 202301 (2012)) was studied in the Higher Twist approach. OSU work on the hydrodynamic medium and on parton energy loss in the Higher Twist approach contributed decisively to the "JET mid-term report" in which experimental data on high-p_T leading hadron production at RHIC and LHC were used for the first quantitative extraction of the jet transport parameter $\hat{q}$ (Phys. Rev. C90, 014909 (2014)). Work on developing a Monte Carlo code based on the Higher Twist approach for jet shower evolution in an expanding thermal medium was started at OSU in Year 1 and moved to WSU after Dr. Majumder moved there during Year 2 of the JET Collaboration.

In 2013 OSU hosted the JET Summer School and Collaboration Meeting, supported with $30K from the JET Collaboration budget. The fourth JET Summer School was held June 12-14, 2013. Over a period of 3 days, 7 lecturers from the US and Europe (4 theorists and three 3 experimentalists) delivered 19 hours of lectures on electromagnetic signatures, jet medium modification and jet quenching, initial fluctuations and hydrodynamic evolution, and the "ridge" in pp, pA, and AA collisions at RHIC and LHC. The summer school was attended by 43 students and young postdocs from around the world. The JET Summer School was preceded by a 2-day collaboration meeting on June 10-11, 2013. Convenors from the working groups and delegates from the inidividual member institutions gave progress reports, the iEBE-VISHNU interactive software package for event-by-event hydrodynamic + cascade evolution "on demand" was presented to the Collaboration and demonstrated in a tutorial, and the status of the jet quenching software package and jet-hydro interface was reported with a demonstration. In the morning of the second day we heard 5 talks by experimentalists on the latest progress on jet reconstruction with the PHENIX and STAR detectors at RHIC and the ALICE, ATLAS and CMS detectors at the LHC. In the afternoon, short presentations from each group of their plans for the coming year were followed by specific work assignments and a discussion of how to best integrate the various efforts in preparation of the end game of the Collaboration during Year 5.

3. Research output and impact

This section lists all publications authored and talks given by Collaboration members during the JET funding period, 06/01/2010-05/31/2015, in which support by the JET Collaboration was acknowledged.

PI/Investigator	published	preprints/submitted	conference reports	talks
U. Heinz	34	4	13	55
A. Majumder	9	1	0	16
H. Song	8	0	4	12
M. Martinez	5	0	3	12
W. Horowitz	2	0	2	9
G.-Y. Qin	1	0	0	4
students	34	5	17	89
Total	46	7	19	197

A. Publications:

1. W. A. Horowitz and B. A. Cole,
   Systematic theoretical uncertainties in jet quenching due to gluon kinematics,
   Phys. Rev. C 81 (2010) 024909 (13 pages).
2. G.-Y. Qin and A. Majumder,
   A pQCD-based description of heavy and light flavor jet quenching,
   Phys. Rev. Lett. 105 (2010) 262301 (4 pages).
3. M. Asakawa, A. Majumder, and B. Müller,
   Electric Charge Separation in Strong Transient Magnetic Fields,
   Phys. Rev. C 81 (2010) 064912 (18 pages).
4. A. Majumder and M. van Leeuwen,
   The theory and phenomenology of perturbative QCD based jet quenching,
   Prog. Part. Nucl. Phys. 66 (2011) 41-92.
5. A. Majumder and B. Müller,
   Hadron mass spectrum from Lattice QCD,
   Phys. Rev. Lett. 105 (2010) 252002 (4 pages).

6. T. Renk, H. Holopainen, U. Heinz, and C. Shen,
A systematic comparison of jet quenching in different fluid-dynamical models,
Phys. Rev. C 83 (2010) 014910 (16 pages).
7. C. Shen, U. Heinz, P. Huovinen, and H. Song,
Systematic parameter study of hadron spectra and elliptic flow from viscous hydrodynamic simulations of Au+Au collisions at $\sqrt{s_{NN}} = 200\,GeV$,
Phys. Rev. C 82 (2010) 054904 (13 pages).
8. H. Song, S. A. Bass, U. Heinz, T. Hirano and C. Shen,
200 A GeV Au+Au collisions serve a nearly perfect quark-gluon liquid,
Phys. Rev. Lett. 106 (2011) 192301 (4 pages).
9. W. A. Horowitz,
Qualitative and quantitative energy loss?,
in *Hard Probes 2010*, Nucl. Phys. A855 (2011) 225-229 [refereed].
10. H. Song, S. A. Bass, and U. Heinz,
Viscous QCD matter in a hybrid hydrodynamic+Boltzmann approach,
Phys. Rev. C 83 (2011) 024912 (16 pages).
11. H. Song, S. A. Bass, U. Heinz, T. Hirano, and C. Shen,
Hadron spectra and elliptic flow for $200\,A\,GeV$ *Au+Au collisions from viscous hydrodynamics coupled to a Boltzmann cascade*,
Phys. Rev. C 83 (2011) 054910 (12 pages).
12. C. Shen and U. Heinz,
Hydrodynamic flow in heavy-ion collisions with large hadronic viscosity,
Phys. Rev. C 83 (2011) 044909 (10 pages).
13. H. Song, S. A. Bass and U. Heinz,
Elliptic flow in 200 A GeV Au+Au collisions and 2.76 A TeV Pb+Pb collisions: insights from viscous hydrodynamics + hadron cascade hybrid model,
Phys. Rev. C 83 (2011) 054912 (6 pages).
14. W. A. Horowitz,
Qualitative and quantitative jet physics in Pb + Pb at LHC,
Proceedings of Science PoS KRUGER **2010** (2011) 060 (5 pages) [refereed].
15. Z. Qiu and U. Heinz,
Event-by-event shape and flow fluctuations of relativistic heavy-ion collision fireballs,
Phys. Rev. C 84 (2011) 024911 (21 pages).
16. C. Shen, U. Heinz, P. Huovinen and H. Song,
Radial and elliptic flow in Pb+Pb collisions at the Large Hadron Collider from viscous hydrodynamics,
Phys. Rev. C 84 (2011) 044903 (13 pages).
17. T. Renk, J. Auvinen, K. J. Eskola, U. Heinz, H. Holopainen, R. Paatelainen and C. Shen,
Systematics of parton-medium interaction from RHIC to LHC,
in *Quark Matter 2011*, J. Phys. G 38 (2011) 124089 (4 pages) [refereed].
18. C. Shen, S. A. Bass, T. Hirano, P. Huovinen, Z. Qiu, H.-C. Song and U. Heinz,
The QGP shear viscosity – elusive goal or just around the corner?,
in *Quark Matter 2011*, J. Phys. G 38 (2011) 124045 (5 pages) [refereed].

19. U. Heinz and J. S. Moreland,
Energy dependent growth of the nucleon and hydrodynamic initial conditions,
Phys. Rev. C 84 (2011) 054905 (6 pages).
20. Z. Qiu, C. Shen and U. Heinz,
Hydrodynamic elliptic and triangular flow in Pb-Pb collisions at sqrt(s)=2.76ATeV,
Phys. Lett. B 707 (2012) 151-155.
21. A. Majumder and C. Shen,
Suppression of the high p_T charged hadron R_{AA} at the LHC,
Phys. Rev. Lett. 109 (2012) 202301 (5 pages).
22. Z. Qiu and U. Heinz,
Event-by-event hydrodynamics for heavy-ion collisions,
in *PANIC11*, AIP Conf. Proc. 441 (2012) 774-776 [refereed].
23. U. Heinz, C. Shen and H. Song,
The viscosity of quark-gluon plasma at RHIC and the LHC,
in *PANIC11*, AIP Conf. Proc. 1441 (2012) 766-770 [refereed].
24. H. Song,
VISHNU hybrid model for viscous QCD matter at RHIC and LHC energies,
in *Proceedings of CPOD 2011*, Central European Journal of Physics 10 (2012) 1242-1244 [refereed].
25. A. Majumder,
Hard collinear gluon radiation and multiple scattering in a medium,
Phys. Rev. D **85** (2012) 014023 (30 pages).
26. Chun Shen and U. Heinz,
Collision energy dependence of viscous hydrodynamic flow in relativistic heavy-ion collisions,
Phys. Rev. C 85 (2012) 054902 (12 pages) [Erratum *ibid.* 86 (2012) 049903 (1 page)].
27. Z. Qiu and U. Heinz,
Hydrodynamic event-plane correlations in Pb+Pb collisions at $\sqrt{s} = 2.76\,A\ TeV$,
Phys. Lett. B 717 (2012) 261-265.
28. N. Armesto, W. A. Horowitz, A. Majumder *et al.*,
Comparison of jet quenching formalisms for a quark-gluon plasma 'brick',
Phys. Rev. C 86 (2012) 064904 (2012) (27 pages).
29. Z. Qiu, C. Shen and U. Heinz,
Resonance decay contributions to higher-order anisotropic flow coefficients,
Phys. Rev. C 86 (2012) 064906 (12 pages).
30. H. Song,
Hydrodynamic modeling and the QGP shear viscosity,
Eur. Phys. J. A 48 (2012) 163 (10 pages).
31. A. Majumder,
Calculating the jet quenching parameter $\hat{q}$ in Lattice Gauge Theory,
Phys. Rev. C 87 (2013) 034905 (12 pages)
32. C. Shen and U. Heinz,
Viscous flow in heavy-ion collisions from RHIC to LHC,
in *Quark Matter 2012*, Nucl. Phys. A904-905 (2013) 361c-364c [refereed].

33. J. S. Moreland, Z. Qiu and U. Heinz,
Imprinting quantum fluctuations on hydrodynamic initial conditions,
in *Quark Matter 2012*, Nucl. Phys. A904-905 (2013) 815c-818c [refereed].
34. H. Song,
QGP viscosity at RHIC and the LHC - a 2012 status report,
in *Quark Matter 2012*, Nucl. Phys. A904-905 (2013) 114c-121c [refereed].
35. U. Heinz and R. Snellings,
Collective flow and viscosity in relativistic heavy-ion collisions,
Ann. Rev. Nucl. Part. Phys. 63 (2013) 123-151.
36. U. Heinz, Z. Qiu and C. Shen,
Fluctuating flow angles and anisotropic flow measurements,
Phys. Rev. C 87 (2013) 034913 (9 pages).
37. U. Heinz,
Towards the Little Bang Standard Model,
in *Discovery Physics at the LHC (Kruger2012)*, J. Phys. Conf. Ser. 455 (2013) 012044 (10 pages) [refereed].
38. C. J. Plumberg, C. Shen and U. Heinz,
HBT interferometry relative to the triangular flow plane in heavy-ion collisions,
Phys. Rev. C 88 (2013) 044914 (11 pages).
39. H. Song, S. Bass and U. Heinz,
Spectra and elliptic flow for identified hadrons in 2.76 A TeV Pb+Pb collisions,
Phys. Rev. C 89 (2014) 034919 (9 pages).
40. C. Shen, U. Heinz, J.-F. Paquet and C. Gale,
Thermal photons as a quark-gluon plasma thermometer reexamined,
Phys. Rev. C 89 (2014) 044910 (9 pages).
41. K. M. Burke, A. Buzzatti, N. Chang, C. Gale, M. Gyulassy, U. Heinz, S. Jeon, A. Majumder, B. Müller, G.-Y. Qin, B. Schenke, C. Shen, X.-N. Wang, J. Xu, C. Young, and H. Zhang (The JET Collaboration),
Extracting jet transport coefficient from jet quenching at RHIC and LHC,
Phys. Rev. C 90 (2014) 014909 (14 pages).
42. D. Bazow, U. Heinz and M. Strickland,
Second-order (2+1)-dimensional anisotropic hydrodynamics,
Phys. Rev. C 90 (2014) 054910 (26 pages).
43. C. Shen, U. Heinz, J.-F. Paquet, I. Kozlov and C. Gale,
Anisotropic flow of thermal photons as a quark-gluon plasma viscometer,
Phys. Rev. C 91 (2015) 024908 (Editor's choice, 10 pages).
44. T. Altinoluk, N. Armesto, G. Beuf, M. Martinez and C. A. Salgado,
Next-to-eikonal corrections in the CGC: gluon production and spin asymmetries in pA collisions,
JHEP 1407 (2014) 068 (34 pages).
45. G. S. Denicol, U. Heinz, M. Martinez, J. Noronha and M. Strickland,
New exact solution of the relativistic Boltzmann equation and its hydrodynamic limit,
Phys. Rev. Lett. 113 (2014) 202301 (Editor's choice, 5 pages).

46. G. S. Denicol, U. Heinz, M. Martinez, J. Noronha and M. Strickland,
Studying the validity of relativistic hydrodynamics with a new exact solution of the Boltzmann equation,
Phys. Rev. D 90 (2014) 125026 (Editor's choice, 20 pages).
47. C. Shen, Z. Qiu, H. Song, J. Bernhard, S. Bass and U. Heinz,
The iEBE-VISHNU code package for relativistic heavy-ion collisions,
Comp. Phys. Comm., in press [arXiv:1409.8164 [nucl-th] (47 pages).
48. C. Shen, J. F. Paquet, U. Heinz and C. Gale,
Photon emission from a momentum anisotropic quark-gluon plasma,
Phys. Rev. C 91 (2015) 014908 (15 pages).
49. U. Heinz,
Quark gluon soup – the perfectly liquid phase of QCD,
Int. J. Mod. Phys. A 30 (2015) 1530011 (20 pages).
50. C. Shen, Z. Qiu and U. Heinz,
Shape and flow fluctuations in ultra-central Pb+Pb collisions at the CERN Large Hadron Collider,
Phys. Rev. C 92 (2015) 014901 (10 pages).
51. Y. Hatta, M. Martinez and B. W. Xiao,
Analytic solutions of the relativistic Boltzmann equation,
Phys. Rev. D 91 (2015) 085024 (9 pages).
52. M. Martinez,
Coherence effects between the initial and final state radiation in a dense QCD medium,
in *IS2013*, Nucl. Phys. A926 (2014) 242-249 [refereed].
53. M. Martinez,
Decoherence between the initial and final state radiation in a dense QCD medium,
in *Quark Matter 2014*, Nucl. Phys. A931 (2014) 320-325 [refereed].
54. C. Shen, J. F. Paquet, J. Liu, G. Denicol, U. Heinz and C. Gale,
Event-by-event direct photon anisotropic flow in relativistic heavy-ion collisions,
in *Quark Matter 2014*, Nucl. Phys. A931 (2014) 675-680 [refereed].
55. U. Heinz, D. Bazow and M. Strickland,
Viscous hydrodynamics for strongly anisotropic expansion,
in *Quark Matter 2014*, Nucl. Phys. A931 (2014) 920-925 [refereed].
56. C. Shen, U. Heinz, J. F. Paquet and C. Gale,
Thermal photon anisotropic flow serves as a quark-gluon plasma viscometer,
in *Hard Probes 2013*, Nucl. Phys. A932 (2014) 184-187 [refereed].
57. U. Heinz, J. Liu and C. Shen,
Electromagnetic fingerprints of the Little Bang,
in *Hard Probes 2013*, Nucl. Phys. A932 (2014) 310-317 [refereed].
58. A. Goldschmidt, Z. Qiu, C. Shen and U. Heinz,
Collision geometry and flow in U+U collisions,
in *WPCF 2014*, arXiv:1502.00603 [nucl-th] (9 pages) [refereed].
59. U. Heinz,
Quark-gluon soup – the perfectly liquid phase of QCD,

in: *50 Years of Quarks*, H. Fritzsch and M. Gell-Mann (eds.) (World Scientific, Singapore, 2015), pp. 413-434.

60. T. Altinoluk, N. Armesto, G. Beuf, M. Martinez and C. A. Salgado,
Next-to-eikonal corrections in the CGC,
PoS DIS 2014 (2014) 089 (7 pages) [refereed].
61. S. Jeon and U. Heinz,
Introduction to hydrodynamics,
invited book chapter, to appear in *Quark-Gluon Plasma 5*, X.-N. Wang (ed.), World Scientific, Singapore, 2015 arXiv:1503.03931 [hep-ph] (59 pages).
62. C. Plumberg and U. Heinz,
Interferometric signatures of the temperature dependence of the specific shear viscosity in heavy-ion collisions,
Phys. Rev. C 91 (2015) 054905 (9 pages).
63. D. Bazow, U. Heinz and M. Martinez,
Nonconformal viscous anisotropic hydrodynamics,
Phys. Rev. C 91 (2015) 064903 (11 pages).
64. J. Liu, C. Shen and U. Heinz,
Pre-equilibrium evolution effects on heavy-ion collision observables,
Phys. Rev. C 91 (2015) 064906 (19 pages).
65. C. Shen and U. Heinz,
The road to precision: Extraction of the specific shear viscosity of the quark-gluon plasma,
Nuclear Physics News 25:2 (2015) 6-11.

These publications include 1 paper with more than 250 citations, 6 papers with between 100 and 250 citations, and 8 papers with between 50 and 100 citations on INSPIRE.

B. Unpublished reports:

1. A. Majumder,
Monte-Carlo for hard jets in e+A collisions,
in: *Gluons and the quark sea at high energies: Distributions, polarization, tomography*,
D. Boer *et al.* (eds.), Brookhaven National Laboratory report BNL-96164-2011, p.370-375 [arXiv:1108.1713 [nucl-th]].
2. Z. Qiu,
Event-by-event Hydrodynamic Simulations for Relativistic Heavy-ion Collisions,
Ph. D. thesis, The Ohio State University, Aug. 2013, arXiv:1308.2182 [nucl-th] (159 pages).
3. C. Shen,
The standard model for relativistic heavy-ion collisions and electromagnetic tomography,
Ph. D. thesis, The Ohio State University, Aug. 2014 (382 pages).
4. F. Antinori, U. Heinz *et al.*,
Thoughts on opportunities from high-energy nuclear collisions,
arXiv:1409.2981 [hep-ph] (10 pages).

5. U. Heinz, P. Sorensen *et al.*,
   Exploring the properties of the phases of QCD matter - research opportunities and priorities for the next decade,
   summary of the "Phases of QCD Matter" Town Meeting at Temple University, Philadelphia, 13-15 Sep. 2014, prepared for the 2015 NSAC Long Range Plan Writing Committee, arXiv:1501.06477 [nucl-th] (53 pages).
6. Y. Akiba, W. A. Zajc, U. Heinz *et al.*,
   The Hot QCD White Paper: Exploring the Phases of QCD at RHIC and the LHC,
   prepared for the 2015 NSAC Long Range Plan Writing Committee, arXiv:1502.02730 [nucl-ex] (110 pages).
7. A. Weisman, Z. Qiu, C. Shen, and U. Heinz,
   Event-plane correlations in Cu+Au collisions at RHIC,
   in preparation

C. Unpublished talks and posters presented by Collaboration members

1. U. Heinz,
   Hydrodynamics at RHIC (ideal and viscous): Where it works, where and how it breaks down, and why,
   invited lecture at the *Berkeley School on Collective Dynamics in High-Energy Collisions*, LBNL, June 7-11, 2010.
2. J. S. Moreland,
   Viscosity from elliptic flow – study of fKLN and Glauber initializations,
   seminar, J. W.-Goethe Universität, Frankfurt, Germany, 6/7/2010.
3. A. Majumder,
   Alternate mechanisms of charge separation in heavy-ion collisions,
   invited talk, Workshop on *Local Strong Parity Violation*, 2010 RHIC & AGS Annual Users' Meeting, BNL, 6/7/2010.
4. W. A. Horowitz,
   Theory update on energy loss,
   invited talk, 2010 RHIC & AGS Users' Meeting, BNL, 6/8/2010.
5. Guang-You Qin,
   Gamma-jet correlations,
   invited talk, 2010 RHIC & AGS Annual Users' Meeting, BNL, June 7-11, 2010.
6. H. Song,
   Results from viscous hydrodynamics coupled to UrQMD,
   invited talk, INT Workshop on *Quantifying the Properties of Hot QCD Matter*, Institute for Nuclear Theory, University of Washington, 6/14/2010.
7. A. Majumder,
   The factorized approach to jet modification,
   invited talk, Symposium on *Jet and Electromagnetic Tomography of Dense Matter*, LBNL, 6/18/2010.
8. H. Song,
   Viscous hydrodynamics + UrQMD – medium for JET,
   report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.

9. W. A. Horowitz,
Theory comparisons,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.
10. Guang-You Qin,
Fluctuating initial conditions from Glauber and CGC models,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.
11. A. Majumder,
The Higher Twist approach,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.
12. A. Majumder,
Heavy-flavor suppression in Higher Twist,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.
13. H. Song,
Parton shower simulation in the Higher Twist formalism,
report, 1st JET Collaboration Meeting, LBNL, 6/20/2010.
14. W. A. Horowitz,
RHIC challenges and LHC Outlook,
invited talk, INT Workshop on *Quantifying the Properties of Hot QCD Matter*,
Institute for Nuclear Theory, University of Washington, 6/21/2010.
15. A. Majumder,
The Higher twist approach to jet modification,
invited talk, INT Workshop on *Quantifying the properties of Hot QCD Matter*,
Institute for Nuclear Theory, University of Washington, 6/21/2010.
16. Guang-You Qin,
Perturbative description of jet-medium interaction,
invited talk, INT Workshop on *Quantifying the properties of Hot QCD Matter*,
Institute for Nuclear Theory, University of Washington, 6/24/2010.
17. J. S. Moreland,
Statistical fluctuations and correlations in hadronic equilibrium systems,
seminar, J. W.-Goethe Universität, Frankfurt, Germany, 7/12/2010.
18. W. A. Horowitz,
Energy loss mechanisms and jet physics,
invited talk, PHENIX Collaboration Meeting, Iowa State University, 7/12/2010.
19. W. A. Horowitz,
Heavy ion physics at RHIC and LHC,
seminar, University of Tennessee, Knoxville, TN, 7/16/2010.
20. Guang-You Qin,
Interactions between jets and the hot, dense medium,
hadronic physics seminar, McGill University, 7/27/2010.
21. W. A. Horowitz,
Heavy ion physics and Electron Ion Colliders,
Electron-Ion Collider Collaboration Meeting, Catholic University of America, 7/29/2010.
22. A. Majumder,
A factorized approach to hard jet modification in dense matter,

invited talk at the International Workshop on *High Energy Strong Interactions (HESI 2010)*, Yukawa Institute, Kyoto University, Kyoto, Japan, 8/2/2010.

23. U. Heinz,
The QCD brick problem,
invited talk, International Workshop on *Jets in Proton-Proton and Heavy-Ion Collisions*, Prague, Aug. 12-14, 2010.
24. U. Heinz,
Status of viscous hydrodynamics and the extraction of $(\eta/s)_{\rm QGP}$ *from experimental data*,
opening talk, CERN Theory Institute on *The first heavy ion collisions at the LHC (HIC10)*, CERN, 8/16/2010.
25. W. A. Horowitz,
RHIC in the age of the LHC,
seminar, BNL, 8/24/2010.
26. A. Majumder,
A factorized approach to hard jet modification in dense matter,
talk at the CERN Theory Institute on *The first heavy ion collisions at the LHC (HIC10)*, CERN, 9/2/2010.
27. Zhi Qiu,
Scaling in viscous hydrodynamics,
talk at the 2010 Midwest Theory Get-Together, Argonne National Laboratory, 9/10/2010.
28. W. A. Horowitz,
Phenomenology of the Quark-Gluon Plasma,
Colloquium, University of Tennessee, Knoxville, TN, 9/13/2010.
29. W. A. Horowitz,
The EIC, heavy quarks, and QGP phenomenology,
invited talk, INT Workshop on *Gluons and the quark sea at high energies: distributions, polarization, tomography*, Institute for Nuclear Theory, University of Washington, 10/4/2010.
30. A. Majumder,
Using hard jets to study soft matter at the EIC,
invited talk, INT Workshop on *Gluons and the quark sea at high energies: distributions, polarization, tomography*, Institute for Nuclear Theory, University of Washington, 10/12/2010.
31. U. Heinz,
Quark Soup – The Perfect Liquid?,
invite overview talk in the KITPC Program on *AdS/CFT and Novel Approaches to Hadron and Heavy Ion Physics*, KITPC, Beijing, 10/14/2010.
32. U. Heinz,
Viscous hydrodynamics and the extraction of $(\eta/s)_{\rm QGP}$ *from heavy-ion collision data*,
invited talk, *3rd Asian Heavy-Ion Triangle Conference (ATHIC2010)*, Institute of Particle Physics, Huazhong Normal University, Wuhan, China, 10/19/2010.

33. U. Heinz,
The Quark-Gluon Plasma at RHIC & LHC – from discovery to quantitative characterization,
Colloquium, Institute for High Energy Physics, Chinese Academy of Sciences, Beijing, 10/20/2010.
34. U. Heinz,
The Quark-Gluon Plasma at RHIC & LHC – from discovery to quantitative characterization,
Colloquium, Tsinghua University, Beijing, 10/21/2010.
35. Zhi Qiu,
Scaling in viscous hydrodynamics, and robust viscous hydro,
talk at the *2010 Midwest Critical Mass* conference, University of Toledo, Toledo, OH, 10/23/2010.
36. U. Heinz,
From the sparking vacuum to the perfect QGP liquid – aspects of strongly coupled quantum field systems,
invited talk, Symposium *From Strong Fields to Colorful Matter*, Asheville, NC, 10/26/2010.
37. A. Majumder,
The study of soft color fields with hard jets in DIS and heavy-ion collisions,
contributed talk, Symposium *From Strong Fields to Colorful Matter*, Asheville, NC, 10/26/2010.
38. J. S. Moreland,
Fluctuating initial conditions in viscous hydrodynamics,
poster, CEU Conference at the 2010 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM, Nov. 2-6, 2010.
39. A. Majumder,
Jet modification in dense matter via leading hadrons,
invited opening talk for the Mini-Symposium on *Lessons from Leading Particle Jet Energy Loss* at the 2010 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM, Nov. 2-6, 2010.
40. A. Majumder,
Jet quenching in DIS and heavy-ion collisions: moving towards a more quantitative approach,
Physics Department Seminar, Brookhaven National Lab, 11/18/2010.
41. A. Majumder,
Probing QCD matter at the sub-femtometer scale,
Colloquium, University of Colorado, 12/13/2010.
42. A. Majumder,
Setting up jet quenching as a probe of QCD media at HERA, RHIC and LHC,
High Energy Physics Seminar, University of Virginia, 1/26/2011.
43. Chun Shen,
Viscous hydrodynamic radial and elliptic flow from RHIC to LHC,
Nuclear Physics Seminar, Ohio State University, 1/27/2011.

44. U. Heinz,
Event-by-event shape and flow fluctuations in RHIC fireballs,
invited talk, RIKEN/RBRC Workshop on *Initial-State Fluctuations and Final-State Particle Correlations*, BNL, 2/04/2011.
45. Zhi Qiu,
Event-by-event shape and flow fluctuations in RHIC fireballs,
Nuclear Physics Seminar, Ohio State University, 2/10/2011.
46. U. Heinz,
Elliptic flow from RHIC to LHC,
Workshop on *Heavy Ions at the LHC: a first assessment*, CERN, 3/4/2012.
47. A. Majumder,
Jet modification: a bottom up approach to the structure of QCD matter,
Physics Department Colloquium, Wayne State University, Detroit, MI, 3/8/2011.
48. Chun Shen,
Viscous hydrodynamic radial and elliptic flow from RHIC to LHC,
Nuclear Physics Seminar, BNL, 3/18/2011.
49. Chun Shen,
Viscous hydrodynamic radial and elliptic flow from RHIC to LHC,
APS April Meeting, Mini-symposium on *Early-Time and Long-Range Correlations in Relativistic Heavy Ion Collisions*, Anaheim, CA, 4/30/2011.
50. Chun Shen,
Viscous hydrodynamic elliptic flow from RHIC to LHC,
poster, Ohio State University Graduate Research Poster Competition, 5/16/2011.
51. Zhi Qiu,
Event-by-event hydrodynamic calculations for heavy-ion collisions,
poster (1st Prize, Clifford Heer Award, $1500), Ohio State University Graduate Research Poster Competition, 5/16/2011.
52. Chun Shen,
Viscous Hydrodynamic Elliptic Flow from RHIC to LHC,
poster at *Quark Matter 2011*, Annecy, France, May 23-28, 2011.
53. Huichao Song,
Viscous QCD matter at RHIC and LHC energies: Results from viscous hydrodynamics + hadron cascade,
poster (presented by U. Heinz), *Quark Matter 2011*, Annecy, France, May 23-28, 2011.
54. Chun Shen,
Viscous hydrodynamic radial and elliptic flow from RHIC to LHC,
Nuclear Physics Seminar, McGill University, 6/2/2011.
55. A. Majumder,
Twist expansion of QCD processes and jet propagation in dense matter,
3 lectures presented at the *2011 JET Summer School*, Duke University, June 15-17, 2011.
56. U. Heinz,
Bulk evolution and JET interface,
2nd JET Collaboration Meeting, Duke University, June 17-19, 2011.

57. A. Majumder,
Developments in the theory of parton energy loss,
2nd JET Collaboration Meeting, Duke University, June 17-19, 2011.

58. U. Heinz,
VISHNU a dynamical evolution model for heavy-ion collisions,
invited talk, 2011 RHIC&AGS Annual Users' Meeting, BNL, June 20-24, 2011.

59. U. Heinz,
Thoughts on a RHIC research program for the next decade,
contribution to the panel discussion *The Future of RHIC* at the 2011 RHIC&AGS Annual Users' Meeting, BNL, June 20-24, 2011.

60. Zhi Qiu,
Event-by-event hydrodynamic calculations for heavy-ion collisions,
poster, *National Nuclear Physics Summer School 2011*, University of North Carolina, Chapel Hill, NC, 6/24/2011.

61. U. Heinz,
The quark-gluon plasma shear viscosity from RHIC to LHC,
International Workshop on *Non-equilibrium Dynamics*, Heraklion, Crete, Aug. 31 Sep. 3, 2011.

62. U. Heinz,
The quark-gluon plasma shear viscosity from RHIC to LHC,
seminar, University of Crete, Heraklion, Crete, 9/4/2011.

63. Zhi Qiu,
Event-by-event hydrodynamic calculations for heavy-ion collisions,
Mid-Western Theory Get-Together, Argonne National Laboratory, 9/21/2011.

64. D. White,
Early flow from matching pre-equilibrium dynamics to viscous hydrodynamics,
Mid-Western Theory Get-Together, Argonne National Laboratory, 9/21/2011.

65. Chun Shen,
Viscous elliptic and triangular flows at the LHC,
Mid-Western Theory Get-Together, Argonne National Laboratory, 9/22/2011.

66. U. Heinz,
The shear viscosity of quark-gluon plasma at RHIC & LHC,
invited keynote talk, *DNP11 Mini-Symposium: From RHIC to LHC – Lessons Learned about the QGP*, Michigan State University, East Lansing, 26-29 Sep. 2011.

67. Zhi Qiu,
Event-by-event viscous hydrodynamics for RHIC and LHC,
contributed talk, *DNP11 Mini-Symposium: From RHIC to LHC – Lessons Learned about the QGP*, Michigan State University, East Lansing, 26-29 Sep. 2011.

68. Daniel White,
Early flow from matching pre-equilibrium dynamics to viscous hydrodynamics,
contributed talk , *DNP11 Mini-Symposium: From RHIC to LHC – Lessons Learned about the QGP*, Michigan State University, East Lansing, 26-29 Sep. 2011.

69. Chun Shen,
(2+1)-d vs. (3+1)-d viscous hydrodynamics from RHIC to LHC,
JET Collaboration Bulk WG Meeting, 10/31/2011.

70. Zhi Qiu,
Shooting the elephant: First blood,
JET Collaboration Bulk WG Meeting, 10/31/2011.

71. Huichao Song,
Hydrodynamics in heavy ion collisions,
invited lecture, *International School for High-Energy Nuclear Collisions*, Wuhan, China, Oct. 31 - Nov. 6, 2011.

72. Huichao Song,
QGP viscosity at RHIC and LHC energies,
7th International Workshop on Critical Point and Onset of Deconfinement, Wuhan, China, Nov. 7-11, 2011.

73. Huichao Song,
Quark gluon plasma – its fluid nature and viscosity,
Nuclear Physics Seminar, University of Science and Technology of China, Hefei, 11/22/2011.

74. Huichao Song,
Quark gluon plasma – its fluid nature and viscosity,
Nuclear Physics Seminar, Peking University, Beijing, 11/24/2011.

75. Huichao Song,
Quark gluon plasma – its fluid nature and viscosity,
Nuclear Physics Seminar, Institute for High Energy Physics (IHEP), Chinese Acadamy of Sciences, Beijing, 11/25/2011.

76. Huichao Song,
Quark gluon plasma – its fluid nature and viscosity,
Nuclear Physics Seminar, Jiao Tong University, Shanghai, 11/30/2011.

77. U. Heinz,
Initial shape and final flow fluctuations in event-by-event hydrodynamics for RHIC and LHC,
invited talk, International Workshop *Exploring QCD Frontiers: From RHIC and LHC to EIC*, Stellenbosch, South Africa, Jan. 30 - Feb. 3, 2012.

78. Chun Shen,
Hydrodynamic flows from RHIC to LHC,
contributed talk, *2012 Edward F. Hayes Graduate Research Forum*, Ohio State University, 2/24/2012.

79. Zhi Qiu,
The shear viscosity of quark-gluon plasma extracted from heavy-ion collisions,
contributed talk, *2012 Edward F. Hayes Graduate Research Forum*, Ohio State University, 2/24/2012.

80. Chun Shen,
Hydrodynamic flow from RHIC to LHC,
Nuclear Seminar, McGill University, 3/1/2012.

81. U. Heinz,
Flow and fluctuations of the Little Bang at RHIC and LHC,
Nuclear and Particle Physics Colloquium, MIT, 3/5/2012.
82. U. Heinz,
Phenomenological limits on QGP shear viscosity and what they imply for QGP thermalization,
Workshop Program on *Gauge Field Dynamics In and Out of Equilibrium (INT-12-1)*, Institute for Nuclear Theory, 3/19/2012.
83. U. Heinz,
How perfect is 'perfect'? The Quark-Gluon Plasma at RHIC & LHC,
invited plenary talk, *11th International Conference on Nucleus-Nucleus Collisions (NN2012)*, San Antonio, TX, May 27 - June 1, 2012.
84. Huichao Song,
QGP viscosity at RHIC and LHC,
invited talk, *Eleventh Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2012)*, St. Petersburg, FL, May 29-June 3, 2012.
85. U. Heinz,
Quark-gluon plasma – the perfect liquid,
invited talk, Symposium on *Contemporary Subatomic Physics*, McGill University, June 12-14, 2012.
86. U. Heinz,
"Perfect fluidity" in relativistic heavy-ion collisions,
invited talk, EMMI Workshop on *Relaxation, Turbulence and Non-Equilibrium Dynamics of Matter Fields (RETUNE 2012)*, Heidelberg, Germany, June 21-24, 2012.
87. U. Heinz,
Little Bang und Quark-Gluon-Plasma – Ein Fest der Superlative,
Physikalisches Kolloquium, J. W. Goethe-Universität, Frankfurt, Germany, June 27, 2012.
88. Zhi Qiu,
Reducing initial condition ambiguities using multiple measured anisotropic flows,
invited talk, workshop on *Initial State Fluctuations and Final State Correlations in Heavy-Ion Collisions*, ECT*, Trento, July 1-6, 2012.
89. U. Heinz,
Initial state fluctuations and final state flows in heavy-ion collisions,
invited talk, workshop on *Initial State Fluctuations and Final State Correlations in Heavy-Ion Collisions*, ECT*, Trento, July 1-6, 2012.
90. Chun Shen,
Hydrodynamic flow from RHIC to LHC,
student talk, National Nuclear Physics Summer School, Santa Fe, NM, 7/11/2012.
91. Zhi Qiu,
Flow from hydrodynamical simulations for relativistic heavy-ion physics,
student talk, National Nuclear Physics Summer School, Santa Fe, NM, 7/11/2012.
92. J. S. Moreland,
Imprinting quantum fluctuations on hydrodynamic initial conditions,

poster presentation, DOE Stewardship Science Graduate Fellowship Conference, Washington, DC, July 26-27, 2012.

93. Zhi Qiu,
QGP shear viscosity from combined analysis of elliptic and triangular flow,
poster presentation, *Quark Matter 2012*, Washington DC, Aug. 13-18, 2012.
94. Chun Shen,
Thermal photon emission with PCE equation of state,
poster presentation, *Quark Matter 2012*, Washington DC, Aug. 13-18, 2012.
95. U. Heinz,
Theory flow overview: Describing the evolving medium in heavy-ion collisions,
invited talk, QM12 Satellite Workshop *Jet Modification in the RHIC and LHC Era*, Wayne State University, August 20-23, 2012.
96. U. Heinz,
Quark-gluon-plasma: the perfect liquid phase of QCD,
invited overview talk, International Workshop on *Quantum Chromodynamics: History and Prospects*, Oberwölz, Austria, Sep. 3-8, 2012.
97. Zhi Qiu,
Flows from event-by-event hydrodynamical simulations for relativistic heavy-ion collisions,
contributed talk, 25th Annual Midwest Theory Get-Together, Argonne National Laboratory, 9/7/2012.
98. Jia Liu,
Matching pre-equilibrium dynamics to viscous hydrodynamics,
contributed talk, 25th Annual Midwest Theory Get-Together, Argonne National Laboratory, 9/8/2012.
99. Chun Shen,
Thermal photon emission with partial chemical equilibrium equation of state,
contributed talk, 25th Annual Midwest Theory Get-Together, Argonne National Laboratory, 9/8/2012.
100. Huichao Song,
QGP viscosity at RHIC and LHC,
Nuclear Physics Seminiar, Wayne State University, 9/14/2012
101. Zhi Qiu,
Pure hydrodynamical simulations for relativistic heavy-ion collisions,
Nuclear Seminar, Indiana University, Bloomington, IN, 9/26/2012.
102. Chun Shen,
Collision energy dependence of hydrodynamic flow in relativistic heavy-ion collisions,
Nuclear Seminar (via EVO), HENPIC Forum, 9/27/2012.
103. Chun Shen,
Collision energy dependence of hydrodynamic flow in relativistic heavy-ion collisions,
Nuclear Seminar, University of Illinois at Chicago, 10/29/2012.

104. Zhi Qiu,
Proposed hydro-jet interface,
JET Collaboration talk (via EVO), Nov. 27 & 28, 2012.

105. Chun Shen,
Viscous hydrodynamic flow and thermal photon emission in heavy-ion collisions from RHIC to LHC,
Nuclear Seminar, McGill University, 11/29/2012.

106. U. Heinz,
Towards the Little Bang Standard Model,
invited talk, International Workshop on *Discovery Physics at the LHC (Kruger2012)*, Krueger Park, South Africa, Dec. 3-7, 2012.

107. Chun Shen,
The shining of the quark-gluon plasma,
Graduate Research Poster Competition, Physics Department, The Ohio State University, Feb. 25-28, 2013.

108. Chun Shen,
Photon emission from a nearly equilibrated medium in relativistic heavy-ion collisions,
EVO talk, JET Bulk Working Group, March 6, 2013.

109. Ulrich Heinz,
Flow angle fluctuations and anisotropic flow measures,
EVO talk, JET Bulk Working Group, March 20, 2013.

110. Andy Goldschmidt,
Study on the eccentricity distribution of the initial condition for uranium-uranium collisions,
poster presentation, *2013 Denman Research Forum*, Ohio State University, March 28, 2013. This poster won a **3rd Prize** at the Forum.

111. Andy Goldschmidt,
Study on the eccentricity distribution of the initial condition for uranium-uranium collisions,
poster presentation, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

112. Christopher Plumberg,
HBT inteferometry with respect to the 3rd-order event plane,
contributed talk, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

113. Ulrich Heinz,
Flow angle fluctuations and anisotropic flow measures,
contributed talk, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

114. Zhi Qiu,
Hydrodynamic event-plane correlations in Pb+Pb collisions at the LHC,
contributed talk, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

115. Ulrich Heinz,
Fluctuations, flow and viscosity in the Little Bang,
invited talk, RBRC Workshop *Jet quenching at RHIC vs. LHC in Light of Recent dAu vs. pPb Controls*, Brookhaven National Laboratory, April 15-17, 2013.
116. Zhi Qiu,
Automated event-by-event hybrid simulation for relativistic heavy-ion collisions,
report, *2013 JET Collaboration Meeting*, Ohio State University, June 10, 2013.
117. Ulrich Heinz,
Nuclear Theory for High Energy Collisions,
presentation to the DOE Nuclear Physics Program Review Committee, Washington, D.C., June 18, 2013.
118. Chun Shen,
Event-by-event viscous photon emission in relativistic heavy-ion collisions,
Nuclear Physics Seminar, McGill University, June 19, 2013.
119. Ulrich Heinz,
Hydrodynamics for Relativistic Heavy-Ion Collisions,
invited lecture series (three 90-minute lectures) at the *11th Korean Nuclear Physics School*, Jeju Island, South Korea, June 24-28, 2013.
120. Zhi Qiu,
Knee structure in the elliptic flow from hydrodynamic simulations for U+U collisions,
invited talk, Workshop on *U+U and Cu+Au shape studies at RHIC*, *2013 RHIC & AGS Users Meeting*, Brookhaven National Laboratory, June 26, 2013.
121. Ulrich Heinz,
Towards the Little Bang Standard Model,
invited talk,*2013 Heavy Ion Meeting*, Jeju National University, Korea, June 28, 2013.
122. Ulrich Heinz,
Hydrodynamics for Relativistic Heavy-Ion Collisions,
invited lecture series (three 90-minute lectures) at the *Peking Summer School for Phenomena & Theories in Heavy Ion Physics*, Peking University, Beijing, July 1-5, 2013.
123. Ulrich Heinz,
Towards the Little Bang Standard Model,
Nuclear Physics Seminar, Tsinghua University, Beijing, July 5, 2013.
124. Chun Shen,
Improved sampling procedure in iEBE+VISHNU,
invited talk, *Workshop on Sampling Particles on the Cooper-Frye Transition Surface (Sampling 2013)*, Frankfurt, Germany, July 18, 2013.
125. Ulrich Heinz,
Uncertainties in the underlying e-by-e viscous fluid simulation,
invited talk, *Jet Workfest*, Wayne State University, Aug. 24-25, 2013.
126. Ulrich Heinz,
U+U Collisions from Hydrodynamics,
invited talk, *STAR Collaboration Meeting*, UCLA, Aug. 30, 2013.

127. Dennis Bazow,
Ellipsoidal anisotropic hydrodynamics,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 6, 2013.

128. Chun Shen,
Thermal photons as a quark-gluon plasma thermometer?,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 6, 2013.

129. Christopher Plumberg,
HBT inteferometry with respect to the 3rd-order event plane,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

130. Andy Goldschmidt,
Knee structure in elliptic flow from hydrodynamic U+U collisions,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

131. Amy Weisman,
Initial conditions for asymmetric Cu+Au collisions,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

132. Jia Liu,
Importance of pre-equilibrium dynamics in heavy-ion collisions,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

133. Andy Goldschmidt,
Knee structure in elliptic flow from hydrodynamic simulations for U+U collisions,
poster presentation, 7th Annual Fall Undergraduate Research Week, Ohio State University, Sep. 20, 2013.

134. Ulrich Heinz,
The Little Bang fluctuation spectrum,
invited opening talk, *9th International Workshop on Relativistic Aspects of Nuclear Physics (RANP 2013)*, Rio de Janeiro, Sep. 23-27, 2013.

135. Chun Shen,
Photon emission from a nearly equilibrated medium in relativistic heavy-ion collisions,
EVO talk, JET Bulk Working Group, Oct. 15, 2013.

136. Andy Goldschmidt,
Knee structure in elliptic flow from hydrodynamic simulations for U+U collisions,
poster presentation, CEU award, *2013 Fall Meeting of the Division of Nuclear Physics of the APS*, Newport News, Oct. 24, 2013.

137. Ulrich Heinz,
Electromagnetic fingerprints of the Little Bang,
invited plenary talk, *Hard Probes 2013*, Stellenbosch, South Africa, Nov. 3-8, 2013.

138. Chun Shen,
Anisotropic flow of thermal photons as a quark-gluon plasma viscometer,
selected parallel talk, *Hard Probes 2013*, Stellenbosch, South Africa, Nov. 3-8, 2013.

139. Christopher Plumberg,
HBT inteferometry with respect to the 3rd-order event plane,
invited talk, *IX Workshop on Particle Correlations and Femtoscopy (WPCF 2013)*, Catania, Sicily, November 8, 2013.

140. Ulrich Heinz,
The Little Bang Standard Model,
invited talk, *New Frontiers in QCD 2013 (NFQCD 2013)*, Kyoto, Dec. 2-6, 2013.

141. Ulrich Heinz,
The Little Bang Standard Model,
seminar, Kavli Institute for the Physics and Mathematics of the Universe, University of Tokyo, Dec. 13, 2013.

142. Mauricio Martinez,
Coherence phenomena between the initial and final state radiation in a dense QCD medium,
Nuclear Physics Seminar, Kent State University, Dec. 17, 2013.

143. Dennis Bazow,
Second-order anisotropic hydrodynamics,
Nuclear Physics Seminar, Kent State University, Dec. 19, 2013.

144. Chun Shen,
Viscous hydrodynamics in heavy-ion collisions from RHIC to LHC,
Nuclear Physics Seminar (via Skype), Lawrence Berkeley National Laboratory, Jan. 8, 2014.

145. Chun Shen,
Photon emission from viscous hydrodynamics in relativistic heavy-ion collisions,
invited talk, *EMMI Rapid Reaction Task Force on the Direct Photon Flow Puzzle*, GSI, Darmstadt, Germany, Feb. 24, 2014.

146. D. Bazow,
Viscous hydrodynamics for systems undergoing strongly anisotropic expansion,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

147. J. Liu,
Free-streaming limit of pre-equilibrium evolution in heavy-ion collisions,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

148. M. Martinez,
Next-to-eikonal corrections to the shock wave in QCD,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

149. C. Plumberg,
3rd order HBT interferometry and event-by-event fluctuations,

contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

150. C. Shen,
Thermal photons as a quark-gluon plasma thermometer revisited,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.
151. M. Martinez,
Next-to-eikonal corrections to the shock wave in QCD,
Nuclear Physics Seminar, Wayne State University, Detroit, Michigan, March 14, 2014.
152. A. Goldschmidt,
Knee structure in the elliptic flow in ultracentral U+U collisions,
poster, *2014 Natural and Mathematical Sciences Undergraduate Research Forum*, The Ohio State University, March 7, 2014, and *2014 Denman Undergraduate Research Forum*, The Ohio State University, March 26, 2014.
153. A. Weisman,
Hydrodynamic flow anisotropies in Cu+Au collisions at the Relativistic Heavy-Ion Collider,
poster, *2014 Natural and Mathematical Sciences Undergraduate Research Forum*, The Ohio State University, March 5, 2014, and *2014 Denman Undergraduate Research Forum*, The Ohio State University, March 26, 2014.
154. M. Martinez,
Next-to-eikonal corrections to the shock wave in QCD,
Physics Seminar, Baruch College, New York (NY), March 31, 2014.
155. U. Heinz,
Viscous fluid dynamics for anisotropically expanding fireballs,
invited talk, RBRC Workshop *The Approach to Equilibrium in Strongly Interacting Matter*, Brookhaven National Laboratory, April 2-4, 2014.
156. U. Heinz,
A Standard Model for the Little Bang – how far are we from the goal?,
invited talk, International Workshop on *Hydrodynamics of Strongly Coupled Fluids*, ECT*, Trento, May 12-16, 2014.
157. A. Goldschmidt,
Knee structure in the elliptic flow in ultracentral U+U collisions,
poster, *Quark Matter 2014*, Darmstadt, Germany, May 20, 2014.
158. U. Heinz,
Thoughts on opportunities from high-energy nuclear collisions,
invited talk, *Think Tank on the Future of Relativistic Heavy-Ion Physics*, Mont Sainte Odile, France, May 24-26, 2014.
159. M. Martinez,
Using conformal symmetries to solve exactly the relativistic Boltzmann equation,
Seminar, Physics Department, Universidade de Santiago de Compostela, Santiago de Compostela, Spain, May 30, 2014.
160. U. Heinz,
Viscous relativistic hydrodynamics for heavy-ion collisions,

ten 90-minute lectures at the *2014 Huada School on QCD*, IOPP, Wuhan, China, June 10-14, 2014.

161. U. Heinz,
The Little Bang Standard Model,
invited talk, International Symposium on *The Frontier of Hadron Physics – Celebrating Al Mueller's 75th Birthday*, Center for Nuclear Matter Science, Wuhan, China, June 14-15, 2014.
162. C. Shen,
The iEBE program package,
invited talk, *2014 JET Collaboration Meeting*, UC Davis, June 17-18, 2014.
163. M. Martinez,
Color decoherence in the dense-dilute regime,
GHRAFITE Seminar, Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil, June 18, 2014.
164. U. Heinz,
Hydrodynamics,
three 1-hour lectures at the *2014 JET Summer School*, UC Davis, June 19-21, 2014.
165. C. Plumberg,
HBT interferometry with respect to the triangular flow-plane,
student talk, *2014 JET Summer School*, UC Davis, June 21, 2014.
166. C. Shen,
Thermal photon emission in relativistic heavy-ion collisions,
student talk, *2014 JET Summer School*, UC Davis, June 21, 2014.
167. C. Plumberg,
How to measure a distribution of HBT radii,
contributed talk, MADAI Workhop *Toward quantitative conclusions for heavy-ion collisions*, NCSL, Michigan State University, July 8, 2014.
168. C. Shen,
The iEBE program package,
invited talk, MADAI Workhop *Toward quantitative conclusions for heavy-ion collisions*, NCSL, Michigan State University, July 8, 2014.
169. M. Martinez,
Decoherence between the initial and final state radiation in a dense QCD medium,
contributed talk, *3rd Workshop on Jet Modification in the RHIC and LHC Era*, Wayne State University, Detroit, Michigan, August 19, 2014.
170. C. Shen,
Photon tomography of relativistic heavy-ion collisions,
invited talk, RBRC Workshop on *Thermal Photons and Dileptons in Heavy-Ion Collisions*, Brookhaven National Laboratory, Aug. 20-22, 2014.
171. A. Goldschmidt,
Orientation resolution in U+U collisions,
invited talk, *International Workshop on Particle Correlations and Femtoscopy (WPCF 2014)*, Károly Róbert College, Gyöngyös, Hungary, August 26, 2014.

172. U. Heinz,
The Little Bang Standard Model,
Colloquium, Argonne National Laboratory, Sep. 5, 2014.

173. C. Plumberg,
How to measure a distribution of HBT radii (and why you might want to),
contributed talk, *27th Annual Midwest Theory Get Together*, Argonne National Laboratory, Sep. 5, 2014.

174. J. Liu,
Towards phenomenological limits on the thermalization time in relativistic heavy-ion collisions,
contributed talk, *27th Annual Midwest Theory Get Together*, Argonne National Laboratory, Sep. 5, 2014.

175. M. Martinez,
A new exact solution to the relativistic Boltzmann equation and its hydrodynamical limit, contributed talk, *27th Annual Midwest Theory Get Together*, Argonne National Laboratory, Sep. 6, 2014.

176. B. Baker,
Imprinting sub-nucleonic fluctuations on d+Au initial conditions,
poster, *NMS Fall Undergraduate Research Forum 2014*, The Ohio State University, Sep. 18, 2014.

177. A. Weisman,
Hydrodynamic flow anisotropies in Cu+Au collisions at the Relativistic Heavy-Ion Collider,
poster, *NMS Fall Undergraduate Research Forum 2014*, The Ohio State University, Sep. 18, 2014.

178. K. Welsh,
Analyzing initial conditions for p+Au collisions,
poster, *NMS Fall Undergraduate Research Forum 2014*, The Ohio State University, Sep. 18, 2014.

179. U. Heinz,
Why I still don't know what we have learnt from BES I,
invited presentation, International Workshop on *Beam Energy Scan II at RHIC*, Lawrence Berkeley National Laboratory, Sep. 27-29, 2014.

180. U. Heinz,
Report from the Joint QCD Town Meeting, Philadelphia, Sep. 13-15, 2014,
invited presentation, Long Range Plan session at the 2014 Joint Fall Meeting of the APS DNP and JPS, Waikoloa, Hawaii, Oct. 7-11, 2014.

181. U. Heinz,
A standard model for the Little Bang – how far are we from the goal?,
invited overview talk, Workshop on *The Future of Hydrodynamic Modeling of Relativistic Heavy Ion Collisions* at the 2014 Joint Fall Meeting of the APS DNP and JPS, Waikoloa, Hawaii, Oct. 7-11, 2014.

182. U. Heinz,
The physics of heavy-ion collisions – recent insights and open questions,

invited talk, 3rd International Workshop on *Discovery Physics at the LHC (Kruger 2014)*, Kruger Gate, South Africa, Dec. 1-6, 2014.

183. M. Martinez,
Studying the validity of viscous hydrodynamics with a new exact solution of the Boltzmann equation,
Nuclear Physics Seminar, The Ohio State University, Dec. 4, 2014.

184. M. Martinez,
A new exact solution to the Boltzmann equation and its hydrodynamical limit,
Nuclear Theory Seminar, Brookhaven National Laboratory, Jan. 16, 2015.

185. M. Martinez,
A new exact solution to the Boltzmann equation and its hydrodynamical limit,
Nuclear Theory Seminar, Columbia University, New York (NY), Jan. 19, 2015.

186. U. Heinz,
Bulk dynamics and soft observables in relativistic heavy ion collisions,
eight 1-hour lectures at the School *Frontiers in Nuclear and Hadronic Physics*, Galileo Galilei Institute for Theoretical Physics, Florence, Italy, Feb. 23-27, 2015.

187. B. Baker,
Imprinting sub-nucleonic fluctuations on d+Au and p+Pb collisions,
poster, *2015 Denman Forum for Undergraduate Research*, The Ohio State University, March 25, 2015.

188. J. Singer,
Simulating initial conditions in collisions of light and heavy nuclei,
poster, *2015 Denman Forum for Undergraduate Research*, The Ohio State University, March 25, 2015.

189. K. Welsh,
Modeling initial conditions in light-ion collisions,
poster, *2015 Denman Forum for Undergraduate Research*, The Ohio State University, March 25, 2015.

190. U. Heinz,
The physics of the Little Bang,
invited overview talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

191. U. Heinz,
Constraining the quark-gluon plasma viscosity with thermal photons,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

192. K. Welsh,
Initial conditions for relativistic light-ion collisions,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

193. A. Goldschmidt,
Collision geometry and flow in U+U collisions,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

194. C. Plumberg,
Event-by-event fluctuations of HBT radii and the QGP shear viscosity,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

195. D. Bazow,
Nonconformal viscous anisotropic hydrodynamics,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 28, 2015.

196. J. Liu,
Pre-equilibrium evolution effects on heavy-ion collision observables,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 28, 2015.

197. M. Martinez,
Investigating the domain of validity of the recently found new solution to the relativistic Boltzmann equation,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 28, 2015.

4. Graduate and undergraduate students in the group:

Graduate student table:

Student	Date Entered Grad. School	Joined Group	Degree Program	Degree Awarded or Expected	Advisor
Dennis Bazow	Sep. 2012	Sep. 2012	Ph.D.	Aug. 2017	Heinz
Christopher Plumberg	Sep. 2009	Sep. 2012	Ph.D.	Aug. 2016	"
Jia Liu	Sep. 2011	Sep. 2011	Ph.D.	Dec. 2015	"
Chun Shen	Sep. 2009	Sep. 2009	Ph.D.	Aug. 2014	"
Zhi Qiu	Sep. 2009	Sep. 2009	Ph.D.	Aug. 2013	"
Daniel White	Sep. 2008	April 2009	Ph.D.	(left group in 2012)	"

Zhi Qiu left in August 2013 with a Ph.D. to work for Google. **Chun Shen** left in September 2014 with a Ph.D. for a postdoctoral position at McGill University. At any given time during the JET funding period, one of the graduate students listed in this

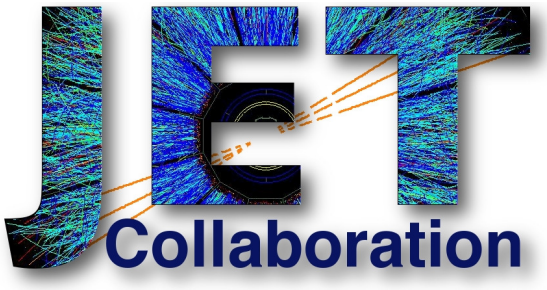
table was (at least partially) supported from the JET Collaboration grant, on a rotating basis.

In addition, the PI supervised the following undergraduates during the JET funding period, on projects at least peripherally related with the goals of the JET Collaboration: **Scott Moreland** (now a Ph.D. student at Duke University), **Andy Goldschmidt**, **Amy Weisman** (now a Ph.D. student in Medical Physics at the University of Wisconsin), **Brian Baker**, **Jordan Singer**, and **Kevin Welsh**.

Final Report (2010-2015)

for the Topical Collaboration on

Quantitative Jet and Electromagnetic Tomography (JET) of Extreme Phases of Matter in Heavy-ion Collisions



(in alphabetical order of institutions)
Miklos Gyulassy (Columbia University)
Paul Romatschke (University of Colorado, Boulder)
Steffen Bass and Berndt Müller (Duke University)
Michael Strickland (Kent State University)
Xin-Nian Wang (Lawrence Berkeley National Laboratory)
Ramona Vogt (Lawrence Livermore National Laboratory)
Ivan Vitev (Los Alamos National Laboratory)
Charles Gale and Sangyong Jeon (McGill University)
Ulrich Heinz (Ohio State University)
Denes Molnar (Purdue University)
Rainer Fries and Che-Ming Ko (Texas A&M University)
Abhijit Majumder (Wayne State University)

Co-Spokespersons:
Ulrich Heinz (2013-15), Berndt Müller (2010-13) and Xin-Nian Wang (2010-15)

Principal Investigator:
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August 31, 2015
Prepared for
U.S. Department of Energy
Office of Science

Executive Summary

Jet and electromagnetic tomography of QCD matter is based on the principle that the interaction between hard partons and the medium is calculable within perturbative QCD (pQCD) and can be used to probe properties of the strongly coupled quark-gluon plasma (sQGP) in heavy-ion collisions at the relativistic heavy-ion collider (RHIC) and the large hadron collider (LHC). The Topical Collaboration on the Quantitative Jet and Electromagnetic Tomography (JET) of Extreme Phases of Matter in Heavy-ion Collisions (JET Collaboration) funded by DOE during 2010-2015 aims to combine pQCD calculations of parton energy loss, model implementations and realistic 3+1D models of the bulk matter evolution to develop tools that can be used for phenomenological analyses of the experimental data.

During the 5-year funding period (2010-2015), the JET Collaboration carried out a comprehensive research program with coordinated efforts involving all PI members and external associated members according to the plan and milestones outlined in the approved JET proposal. We identified important issues in the study of parton energy loss and made significant progress toward NLO calculations; advanced event-by-event hydrodynamic simulations of bulk matter evolution; developed Monte Carlo tools that combine different parton energy loss approaches, hydrodynamic models and parton recombination model for jet hadronization; and carried out the first comprehensive phenomenological study to extract the jet transport parameter. Specifically, our major achievements during the last 5 years are:

- **Parton energy loss**: We completed a comparative study of modified fragmentation functions from four different approaches to parton energy loss and identified the main source of discrepancy as the collinear approximation in the treatment of gluon radiation. Within the soft-collinear effective theory (SCET), we derived the medium-induced splitting kernels beyond the soft-gluon approximation. We carried out the first complete NLO pQCD calculation of the transverse momentum weighted cross section of semi-inclusive deeply inelastic scattering (SIDIS) and verified the factorization at twist-four. We also calculated the radiative energy loss induced by longitudinal diffusion for both light and heavy quarks. These improvements can be incorporated into the final jet transport MC simulation package.

- **Event-by-event hydrodynamics**: We have developed and refined the 2+1D VISHNU and 3+1 D MUSIC viscous hydrodynamics simulation suites with the UrQMD hadronic after-burner for modeling the event-by-event dynamical evolution of the bulk medium in relativistic heavy-ion collisions. We also developed and tested alternative numerical algorithms for solving hydrodynamic equations and studied anisotropic hydrodynamics for early time non-equilibrium evolution. We developed the code package iEBE-VISHNU and an interface with the Monte Carlo jet shower evolution and hadronization codes for performing jet quenching and jet shape modification studies.

- **Parton recombination model for jet hadronization**: We have developed a hybrid model of parton recombination and remnant string fragmentation including recombination with thermal partons for MC simulations of hadronization of jet showers in heavy-ion collisions. Such a code is an integral part of the MC package for jet transport and hadronization in heavy-ion collisions. A description of heavy flavor hadronization based on recombination and consistent with in-medium scattering rates of heavy

quarks has also been developed and applied for the study of open and hidden heavy flavor hadrons in heavy-ion collisions.

- **Monte Carlo model of jet propagation and evolution**: We made significant progress in developing components of a full Monte Carlo simulation program for jet quenching in an event-by-event hydrodynamic medium including CUJET, High-twist (HT), Linear Boltzmann Transport (LBT), and MARTINI models that couple to the iEBE-VISHNU hydrodynamic code package for bulk evolution. These models plus iEBE-VISHNU are being combined with the parton recombination module for jet hadronization in heavy-ion collisions to produce the final complete Monte Carlo simulation package.

- **Electromagnetic probes of QGP**: An electromagnetic radiation module was developed for the calculation of thermal photon emission from the QGP and hadron resonance gas stages of heavy-ion collisions, with emission rates corrected for viscous effects in the expanding medium consistent with the bulk evolution. This electromagnetic radiation module has been integrated with the iEBE-VISHNU code package and used to calculate photon and dilepton spectra and elliptic flow.

- **Phenomenology and extraction of the jet transport parameter**: As an intermediate step to a full Monte Carlo package for jet quenching, we have assembled an integration of programs that incorporated five different approaches to parton energy loss and suppression of single hadron spectra. With this package, we carried out a first comprehensive study of single hadron suppression in heavy-ion collisions at both RHIC and LHC. We extracted values of the jet transport parameter at RHIC and LHC with significantly smaller theoretical uncertainties than previous studies. Other phenomenological studies of jet quenching, modification of constructed jets, heavy quark transport, collective bulk expansion and novel models of jet-medium interaction such as the sQGMP model were also carried out within each parton energy loss module and hydrodynamic models, respectively.

During the 5-year funding period, the JET Collaboration provided a unique environment conducive for collaborative work among participating scientists and for close interaction between theorists and experimentalists through regular video group meetings, symposia and topical workshops. We closely worked with experimentalists on topics related to both current data analyses and R&D for future experiments and organized 9 workshops and symposia focusing on topics of current interest to the community. We organized 5 annual JET summer schools together with JET Collaboration meetings at member institutions that attracted a large number of graduate students and postdoctoral fellows. We have successfully created 2 JET-bridged faculty positions and funded another junior university faculty position all of whom become active members of the JET Collaboration and young leaders in the field.

Combining different expertise with coordinated efforts, research activities organized by the JET Collaboration and achievements made through both individual PI's and collaborative work within and outside the JET Collaboration have had a great impact on hard probes physics and overall heavy-ion physics worldwide, as evidenced in the large number of publications, conference talks by JET members and citations to the JET collective work.

1 Introduction

Jets and electromagnetic probes have been a successful tool to establish the formation of a strongly coupled quark-gluon plasma in high-energy heavy-ion collisions at RHIC and LHC. However, more quantitative study of the properties of the dense matter through these jet and EM probes requires the understanding and reduction of theoretical uncertainties in the description of phenomena such as parton recombination, heavy quark energy loss, path length dependence of the jet quenching and collective medium excitation induced by a propagating jet. The Topical Collaboration on Quantitative Jet and Electromagnetic Tomography (JET) of Extreme Phases of Matter in Heavy-ion Collisions, referred to as the JET Collaboration, was funded by the US Department of Energy during 2010-2015 to address the outstanding challenges in the study of hard probes in high-energy heavy-ion collisions. The goal of the JET Collaboration is to address theoretical and phenomenological challenges for quantitative study of the properties of the dense matter through hard and electromagnetic probes. Specifically, the JET Collaboration was proposed to

(a) Extend the theoretical framework for jet-medium interaction beyond soft and collinear approximations and thereby reduce uncertainties intrinsic to the current theoretical studies;

(b) Develop new and powerful Monte Carlo algorithms for jet propagation and evolution inside a dynamic medium;

(c) Implement in the jet-medium interaction a realistic space-time evolution of the bulk medium as described by a combination of viscous hydrodynamics with parton and hadron cascades;

(d) Carry out systematic phenomenological studies of experimental data on single hadron (including heavy flavors) and photon spectra, multi-hadron and γ-hadron correlation and jet shape.

According to the proposal submitted to and approved by DOE, the JET Collaboration planned to carry out 5-year collaborative research activities with well defined milestones. The final goals of the JET Collaboration during the proposed 5-year funding period are:

- Extend the calculation of medium induced gluon bremsstrahlung beyond collinear and soft approximation and explore matching schemes connecting collinear and hard gluon radiation, thereby reducing a major theoretical uncertainty in jet tomographic studies.

- Consider hadronization via quark recombination and possible effects of rescattering between hadrons from jet fragmentation and the bulk medium, including the heavy flavor mesons.

- Develop and utilize viscous hydrodynamics and parton and hadron cascade models for a complete description of all stages of the expanding medium; explore applying jet tomography to constrain initial conditions for accurate extraction of shear viscosity within viscous hydrodynamics; study collective excitations induced by jet-medium interaction.

- Develop a general framework and numerical implementations of different approaches to jet modification in a medium, incorporating elastic and radiative energy loss, flavor

conversion, quark mass dependence (heavy quarks) and exact four-momentum conservation. Develop Monte Carlo simulation codes in the form of Open Source Codes and Algorithmic Routines (OSCAR) and make them available to the entire heavy-ion community

- Calculate direct γ production within NLO pQCD, including effects of parton energy loss, induced gluon bremsstrahlung and gluon conversion. thermal emission from QGP and hadronic phases.

- Calculate jet and high-p_T hadron spectra, multi-hadron and γ-hadron correlations, and jet shape within NLO pQCD and their medium modification in high-energy heavy-ion collisions. Carry out systematic and quantitative phenomenological studies of experimental data on jet and electromagnetic tomography to extract properties of the sQGP, such as jet transport parameter, shear viscosity, initial temperature and screening mass of the medium.

In addition, the JET Collaboration proposed to organize annual summer schools with pedological lectures that emphasize on basic knowledge and skills in pQCD, multiple scattering in medium, thermal field theory at finite temperature, jet and electromagnetic tomography, experimental heavy-ion physics. The JET Collaboration planned to engage participating students and postdoctoral fellows through coordinated activities and provide joint mentoring of students and postdoctoral fellows. The JET Collaboration also planned to provide a platform for close interaction and collaboration between theorists and experimentalists working on the same problems and provide community-wide service. The JET Collaboration proposed to advance the nuclear theory workforce in the US by leveraging the limited incremental funding from DOE to support graduate students and postdoctoral fellows, and support one or two bridged junior faculty positions at universities that presently have strong experimental programs at RHIC and LHC, but no theorists working in this area.

Over all, we have fully completed the planned research activities according to the timelines outlined in the proposal and achieved all of the scientific goals and beyond. The final product of a comprehensive MC package is being assembled and will soon be publicly available for phenomenological studies. In this report, we describe the research activities and accomplishments by the JET Collaboration during the 5-year funding period, June 1, 2010 - May 31, 2015.

2 Manpower and activities supported by the JET Collaboration

The JET Collaboration provided partial funding for two bridged positions, Paul Romatschke at University of Colorado at Boulder and Michael Strickland at Kent State University. It also provided research funding for Abhijit Majumder after he transitioned from a postdoctoral position at the Ohio State University to a junior position at the Wayne State University. JET provided partial support for the following postdoctoral fellows and students during June 1, 2010 - May 31, 2015 (for detailed information on students see reports from university groups):

- Postdoctoral fellows: R. Abir (WSU), A. Buzzatti (LBNL), S. Cao (LBNL), M. Hahrgang (Duke), Z. Kang (LANL), R. D. Neufeld (LANL), A. Majumder (OSU), M. Martinez

(OSU), G. Ovanesyan (LANL), R. Ryblewski (Kent), H. Xing (LANL), J. J. Zhang (LBNL), G. Y. Qin (OSU, Duke, WSU).

- Graduate students (year of Ph. D. awarded or expected):
  Columbia: A. Buzzatti (2013), J. Xu (2015);
  UC Boulder: T. Gorda (2016), M. Habich (2017), R. E. Young (2018);
  Duke: C. Coleman-Smith (2014), D. Yang (2014) , S. Cao (2014), J. Bernhard (2015), J. S. Moreland (2016), Y. Xu (2018), X. Yao (2018), W. Ke (2019);
  KSU: M. Nopoush (201x);
  OSU: Dennis Bazow (2017), J. Liu (2015) , C. Shen (2014) , C. Plumberg (2016), Z. Qiu (2013), D. White (left group in 2012);
  Purdue: D. Sun (2015), D. Hemphill (2015), M. Damodaran (2016), Z. Wolf (2014);
  TAMU: K. Han (2015), F. Li (2015), Y. Sun (2017), Z. Yang (2017), S. Rose (2016), S. Somanathan (2016), G. Chen (2013);
  WSU: G. Kaur (M.S. 2013), K. Burke (M.S. 2014) , M. Kordell (2016);

The JET Collaboration organized 5 annual JET summers schools and provided local support for student participants, as well as travel and local support for lecturers. The JET Collaboration also provided travel support to all members and some associated collaboration members during Summer Schools and collaboration meetings, and travel support for exchange visits by members and students within the JET Collaboration. The JET Collaboration also organized two symposia on JET physics and 7 workshops. The JET working groups used EVO video conference service for regular meetings; the cost of the service has been provided by JET since 2013 when the service started to charge a fee.

Grants for Duke, OSU, Purdue and TAMU were sent directly from DOE. Support for the bridged position at UC Boulder was sent via a subcontract from LBNL for the first two years (with some forward funding) and converted into a direct grant from DOE for the remainder of the JET funding. Support for the bridged position at KSU and funding for Columbia University and WSU were provided via subcontracts from LBNL. Funding to LBNL supported 50% two postdoctoral positions over two years each, some of the JET Summer Schools, JET Collaboration meetings, workshops, symposia and visits between collaboration members and external associated members.

3 Research Activities and Accomplishments

To accomplish the planned goals in the JET proposal and coordinate research activities within the JET Collaboration, we formed 4 Working Groups in 2010-2012:

1. Parton energy loss Working Group: Convener - Abhijit Majumder, Members: N. Armesto, C. Coleman-Smith, M. Djordjevic, R. J. Fries, C. Gale, M. Gyulassy, U. Heinz, W. Horowitz, P. M. Jacobs, S. Jeon, D. Molnar, B. Mueller, J. Owens, G-Y. Qin, R. Rodriguez, C. A. Salgado, B. Schenke, H. Song, C. Shen, X.-N. Wang.

2. Monte-Carlo Working Group: Convener - Björn Schenke, Members: Huichao Song, Xin-Nian Wang, Christopher Coleman-Smith, Steffen Bass, Berndt Mueller, Korinna Zapp, Urs Wiedemann, Abhijit Majumder, Sangyong Jeon, Charles Gale, Carlos Salgado, Nestor Armesto.

3. Bulk Evolution Working Group: Convener - Denes Molnar, members: Steffen Bass, Berndt Mueller, Guangyou Qin, Hanna Petersen, Ivan Vitev, Xin-Nian Wang; Huichao Song, Long-Gang Pang, Deke Sun, Cristina Moody, Ulrich Heinz, Abhijit Majumder, Chun Shen, Zhi Qiu, Daniel White, Che-Ming Ko, Rainer Fries.

4. Parton Recombination Working Group: Convener - Rainer Fries, Members: Guangyao Chen, Kyongchol Han, Ulrich Heinz, Zi-Wei Lin, Che-Ming Ko, Berndt Mueller, Björn Schenke, Xin-Nian Wang

As we made progress in planned research activities, we merged the parton energy loss and Monte Carlo Working Groups in 2013. So from 2013 to 2015 there were three working groups within the JET Collaboration:

1. Monte Carlo Working Group: Convener - Abhijit Majumder, Members: N. Armesto, C. Coleman-Smith, M. Djordjevic, R. J. Fries, C. Gale, M. Gyulassy, U. Heinz, W. Horowitz, P. M. Jacobs, S. Jeon, D. Molnar, B. Mueller, J. Owens, G-Y. Qin, R. Rodriguez, C. A. Salgado, B. Schenke, H. Song, C. Shen, X.-N. Wang, Björn Schenke, Christopher Coleman-Smith, Steffen Bass,Korinna Zapp, Urs Wiedemann, Sangyong Jeon, Charles Gale, Carlos Salgado.

2. Bulk Evolution Working Group: Convener - Michael Strickland, Members: Steffen Bass, Berndt Mueller, Guangyou Qin, Hanna Petersen, Ivan Vitev, Xin-Nian Wang; Huichao Song, Long-Gang Pang, Deke Sun, Cristina Moody, Ulrich Heinz, Abhijit Majumder, Chun Shen, Zhi Qiu, Christopher Plumberg, Che-Ming Ko, Rainer Fries, Paul Romatschke (Convener during 2013-2014).

3. Parton Recombination Working Group: Convener - Rainer Fries, Members: Guangyao Chen, Kyongchol Han, Ulrich Heinz, Zi-Wei Lin, Che-Ming Ko, Berndt Mueller, Björn Schenke, Xin-Nian Wang

Members of each Working Group carried out coordinated research in their respective area and met regularly through internet teleconferences. Associated members of the JET Collaboration and occasionally outside physicists were also invited to the video meetings. Annual collaboration meetings and some ad hoc working group meetings were organized to discuss progress, research results and coordinate community-wide efforts. Results of the research were published in papers that were coauthored by members of the collaboration and external associated members that were involved in the project. In total, members of the JET Collaboration have published 409 papers (34 to be published, including refereed conference proceedings) and gave 551 conference/workshop presentations (these numbers include published 57 papers, 13 submitted papers and 109 talks by members of McGill group who contributed very actively but did not receive direct funding from DOE through JET).

The following are highlights of the accomplishments of the JET Collaboration in the past 5 years.

3.1 Parton Energy Loss and Jet Quenching

Eight institutions (Columbia University, Duke University, LANL, LBNL, LLNL, McGill University, OSU, TAMU and WSU) were involved in the study of parton propagation, parton

energy loss, jet tomographic and related study of heavy-ion collisions.

Comparative study of parton energy loss: We have worked together with the TECHQM group members to continue the work on a comparative study of different parton energy loss models in a simple brick problem. Such a comparative study was necessary to understand the basic differences between different models and their effect in the final tomographic study and it required the collaboration among different groups both within and outside the JET Collaboration. We reviewed the currently available formalisms for radiative energy loss of a high-momentum parton in a dense strongly interacting medium. The underlying theoretical framework of the four commonly used formalisms was discussed and the differences and commonalities between the formalisms were highlighted. A quantitative comparison of the single gluon emission spectra as well as the energy loss distributions were given for a model system consisting of a uniform medium (the Brick) with a fixed length ($L = 2$ fm and $L = 5$ fm). Sizable quantitative differences were found. The largest differences can be attributed to specific kinematic approximations made in the calculation of the radiation spectrum.

QCD factorization for single inclusive deeply inelastic scattering (SIDIS) at twist-4 in NLO: Within the framework of the high-twist approach, we calculated the next-to-leading order (NLO) perturbative QCD corrections to the transverse momentum broadening in semi-inclusive hadron production in deeply inelastic $e + A$ collisions, as well as lepton pair production in $p + A$ collisions. With explicit calculations of both real and virtual contributions, we verified for the first time the factorization theorem at twist-4 in NLO for the transverse momentum weighted differential cross section and demonstrated the universality of the associated twist-4 quark-gluon correlation function. Our results provide a first identification of the QCD evolution equation for the twist-4 quark-gluon correlation function, which can be solved to determine the scale dependence of the jet transport parameter in the study of jet quenching.

Medium-induced splitting kernels from soft collinear effective theory (SCET): We derived the splitting kernels for partons produced in large Q^2 scattering processes that subsequently traverse a region of strongly-interacting matter, using the recently-developed soft collinear effective theory SCET. We included all corrections beyond the small-x approximation, consistent with the power counting of SCET. We demonstrated how medium recoil, geometry and expansion scenarios, and phase space cuts can be implemented numerically for phenomenological applications. For the simplified case of infinite transverse momentum kinematics and a uniform medium, we derived closed-form analytic results that can be used to validate the numerical simulations. Fig. 1 shows the parton splitting intensity $x(dN/dx)$ for the q to $q + g$ process. The solid black line in Fig. 1 is the result with exact kinematics and recoil of the particles in the medium.

Angular distributions of higher order splitting functions: We studied the angular distributions of the final-state partons of higher order, 1 to 3, collinear splitting functions in vacuum and in dense QCD matter. We concentrated our investigation on the illustrative example of the q to qgg splitting. In dense QCD matter we used SCET to derived the medium-induced q to ggq splitting, to first order in opacity, beyond the soft gluon approximation. We found that in all cases the amount of radiation that leaks out of angular

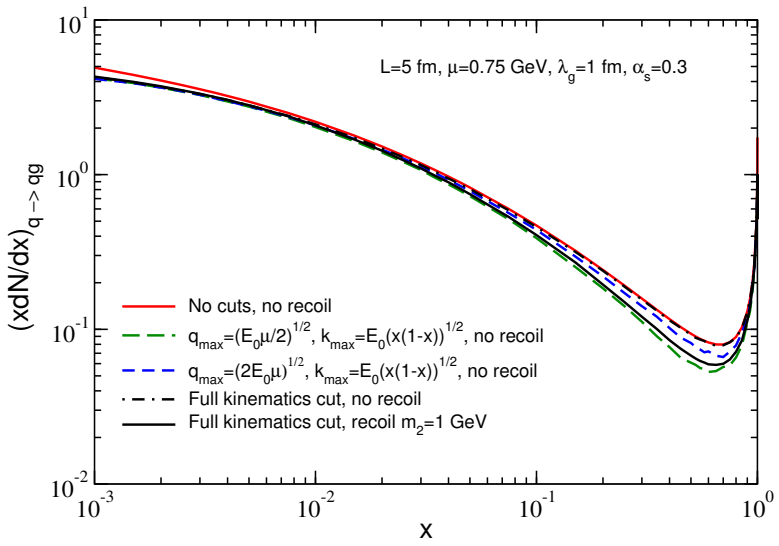

Figure 1: Parton splitting intensity for the q to $q+g$ process in the medium, including finite x corrections, nuclear recoil, finite kinematic cuts. The energy of the quark jet was chosen to be 100 GeV.

ordered cones corresponds to no angular ordering. In fact, standard parton cascade based on binary branchings reproduces very well the distribution of the final-state partons. Our results indicate that the proper angular distributions inside the parton shower are different from the angular ordering ansatz. Still the traditional approach to include angular ordering into collinear splitting functions is claimed to resum infrared large Sudakov logarithms and is phenomenologically successful. One thing to verify is whether or not the amount of collinear radiation that leaks outside of the angular ordered cones leads to a significant correction for parton shower phenomenology. This has to be checked for intra-jet observables, such as jet shapes, of well-isolated jets. The same conclusion holds for the medium induced parton shower. Our detailed analysis found no evidence of angular ordering or angular anti-ordering. An important feature is that the broad angular distribution, noticeably broader than in the vacuum case, found in the lowest order, 1 to 2, branchings persists to higher order.

One example is shown in Fig. 2. We choose the following numerical values: $z_1 = 0.01$, $z_2 = 2/3$ for the light-cone momentum fractions of 2 out of the 3 final-state partons. For the angles of the 2 hard partons we chose 10 and 20 degrees. θ_{01} is the running angle between the soft gluon and the initial parton is on the horizontal axis. For the in-medium calculation we choose a Debye screening length $\mu = 0.75$ GeV, a size of the medium $L = 5$ fm and a gluon scattering length $\lambda_g = 1$ fm. We see that the medium-induces splitting (black curve) and the medium cascade (green curve) do not show angular ordering or angular anti-ordering. The same is true for the vacuum splitting (red curve). The most characteristic feature is the broad angular distribution that is also found in the lowest order in-medium splitting kernels.

Energy loss of heavy quarks: We have made a first attempt to calculate radiative loss induced by longitudinal diffusion within the HT formalism for both light and heavy quarks. We found that, for heavy quarks, both $\hat{q}$ and $\hat{e}$ can stimulate radiation. Also, stimulated emission for heavy quarks is found to be more sensitive to a larger x part of the in-medium

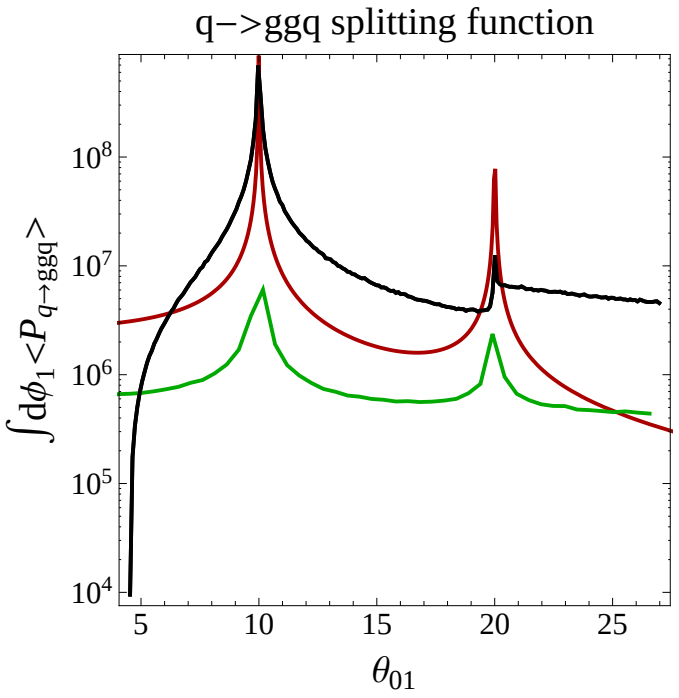

Figure 2: The q to ggq splitting function for 10 and 20 degree opening angles for 2 of the final-state partons relative the original direction. The black line is the result in the medium. The red line is the result in the vacuum and the green line is an unnormalized binary cascade.

transport coefficients $\hat{q}$ and $\hat{e}$. We can further calculate induced transverse diffusion and longitudinal drag induced by multiple scattering .

Within the framework of the Langevin equation, we also studied the evolution and energy loss of heavy quarks in a quark gluon plasma due to quasi-elastic multiple scatterings. The effect of QGP geometry and flow profiles was investigated in details and we found they play important role in heavy quark energy loss and the development of elliptic flow, thus affect the spectra and elliptic flow of final state D-mesons and non-photonic electrons. The relative contributions of charm and bottom quarks are found to affect the quenching and elliptic flow patterns of heavy flavor decay electrons. We have further studied heavy quark evolution at LHC energies with the inclusion of elastic collisions as well as medium-induced gluon radiation. Radiative energy loss was found to be very important to heavy quark energy loss, especially at high transverse momentum regime reached by the LHC. Combining with a (2+1)-dimensional viscous hydrodynamic model, we have provided a good description of the measured D meson suppression, and made a prediction for B meson suppression and elliptic flow.

Radiative energy loss in an evolving bulk medium: We studied two aspects of the coupling between radiative energy loss and bulk medium evolution. First, continuing past work that combined first-order Gyulassy-Levai-Vitev (GLV) energy loss with realistic expanding bulk medium evolution from the parton transport MPC, we investigated the distribution of harmonic flow coefficients for fluctuating initial conditions in Au+Au at RHIC. For a Monte-Carlo Glauber initial condition ensemble, fluctuations of normalized flow coefficients

$v_n/\langle v_n \rangle$ for $n = 2, 3$ and 4 were *both* for the bulk medium (transport) and pions from the jets (energy loss) largely *independent* of transverse momentum, and followed the distributions of the corresponding normalized initial spatial anisotropy moments. We found best agreement if spatial coefficients were weighted with radius squared in the transverse plane. In addition, the orientation of 2nd and 3rd harmonic planes was also highly correlated with the plane of the corresponding spatial anisotropy coefficient. These features are quite remarkable because initial density fluctuations are by no means small, individual events exhibit spikes that often exceed 3 times the average density at the very center of the collision zone. We also extended the calculation to charm quarks in the DGLV framework and found very similar results. Our findings also agree qualitatively with the behavior of bulk medium flow coefficients seen in ideal and viscous hydrodynamics, so they see that those observations carry over to transport and (D)GLV energy loss as well.

We used our new MPC/Grid radiative transport code to cross-check some of the earlier thermalization results by BAMPS and the $gg \to ggg$ cross section (the infamous factor of 6). We first calculated rates in thermal equilibrium, with Debye-screened LO pQCD matrix elements. For $gg \leftrightarrow ggg$ we compared the Bertsch-Gunion form in BAMPS to the full leading order result. The $2 \to 3$ rates we find are much lower than those in the BAMPS paper, unless they are multiplied by a factor 5-6. This does seem to support the argument by Chen *et al* that a factor 1/3! has been missed by the BAMPS authors.

3.2 Monte Carlo simulation

The Jet propagation and Monte Carlo working group was charged with the development of a comprehensive jet in medium Monte-Carlo event generator, which will include an event by event hydrodynamic simulation coupled with a shower Monte-Carlo routine and jet hadronization. Individual groups have made progress in developing and improving different jet quenching modules with different implementation of parton energy loss and jet-medium interaction models. These different modules will be coupled to a choice of hydrodynamic evolution of the bulk medium and a parton recombination module for hadronization. The last stage of coupling to parton recombination module recently developed is being carried out and the final product will become available soon.

HT-M Monte-Carlo module: We have developed an in-medium shower Monte-Carlo event generator based on the higher-twist formalism of jet modification. By undoing one of the light-cone integrals which sets the corresponding light-cone momentum to be equal in the amplitude and the complex conjugate, an uncertainty in the smaller light-cone momentum component was introduced. This allows for the generalization of the standard analytic formalism to a Wigner transform like formalism, where the non-conjugate large light-cone momentum and position are retained for each parton. Jets were generated event-by-event by simulating this Wigner transform kernel.

This model has been applied to study jets in d+Au collisions. The basic Monte Carlo picture of the initial state, which so far has included sampling the Woods-Saxon distribution is extended to the MC sampling of shell model distributions. These are combined with simulations of the deuteron using the Hulthen potential. The nucleon-nucleon collisions are simulated with PYTHIA, and the final hard outgoing partons are modified using the in-

medium HT Monte-Carlo. This work will offer the most detailed look at the hard sector in d-Au ever carried out.

Using this in-medium MC event generator, we have also calculated the mean rate of jet mass depletion as a jet propagates through dense matter. Along with energy loss, jet mass depletion allows another means to compare with jets produced in p-p collisions. It has been demonstrated that escaping partons with reduced energies tend to have a much smaller mass than a corresponding parton produced in a hard interaction in p-p collisions.

MARTINI Monte Carlo module: For the study of hard parton propagation at finite temperature, MARTINI (Modular Algorithm for Relativistic Treatment of IoN Interactions) event generator was developed, which is a Monte-Carlo simulation based on PYTHIA 8.1 and the AMY (Arnold, Moore, and Yaffe) energy loss formalism. Our work focuses on how finite-temperature effects modify jet observables and the hadronic spectrum in heavy-ion collisions. Bulk dynamics of QGP is implemented using 3+1-dimensional viscous hydrodynamics simulation with event-by-event initial conditions, within MUSIC developed at McGill. Coupling MUSIC with the UrQMD hadronic afterburner and MARTINI is also implemented. The modification of heavy quark properties in QGP, and the modeling of their propagation is also studied. We also investigated finite size effect on the radiative energy loss. This model has been used to explain the di-jet asymmetry.

Linear Boltzmann Transport (LBT) module : We have developed a Linear Boltzmann Transport (LBT) model for jet propagation, within which the propagation of jet shower partons and medium excitation are simulated according to a linearized Boltzmann equation with elastic and inelastic parton collisions. The elastic scattering amplitude in pQCD is used with Debye screened propagators. The induced radiation during each elastic scattering is carried out according to the high-twist approach with a Poisson-like multiple emissions. In this approach, both shower and recoiled medium partons are followed after each scattering and go through further scatterings in the medium. To account for the back-reaction in the Boltzmann transport, initial thermal partons that participate in each scattering , or negative partons, are transported according to the Boltzmann equation. Their energies and momenta will be subtracted from all final observables. These negative partons are considered as part of the recoiled partons that are responsible for jet-induced medium excitations. Thermal recoil and "negative" partons are collectively referred to as jet-induced medium partons and will have significant effect on distributions and structures of reconstructed jets. The parton recombination module developed by JET is also incorporated into LBT and is ready for simulations of final hadron spectra from jets propagating and hadronizing in medium.

CUJET Monte Carlo module: During the early stage of JET funding period, we constructed a new open source CUJET1.0=DGLV+HTL+Bjorken 1+1D Monte Carlo code to evaluate the jet opacity series in Bjorken 1+1 evolving plasma including dynamical magnetic scattering enhancement effects. We showed that this generalization of the static DGLV opacity series kernel explained quantitatively the heavy quark non-photonic electron data. CUJET1.0 code was further generalized to include multi-scale running QCD jet medium coupling effects in the DGLV scattering kernel and used to show that the surprising similarity of nuclear modification of jets discovered at LHC to that observed at RHIC and which could be quantitatively explained with CUJET1.0 as due to perturbative QCD running couplings

at high Q and high T.

Based on CUJET1.0, we constructed a much more powerful CUJET2.0 numerical code that coupled for the first time our pQCD based CUJET1.0 model of high p_T jet-medium dynamics to the bulk matter via 2+1D viscous hydrodynamic temperature profiles. The current CUJET3.0 code was further developed to include two novel competing nonperturbative and nonconformal effects near the QCD cross-over transition temperature $T_c \sim 160$ MeV: (1) the suppression of quark and gluon chromo charge degrees of freedom near $T_c \sim 160$ MeV, aka the semi-QGP model and (2) emergent chromo magnetic monopoles near T_c, aka the magnetic scenario. This model of jet-medium interaction generalizes the pQCD quasiparticle picture assumed in earlier models to be transformed into an emergent semi-Quark-Gluon-Monopole-Plasma (sQGMP) near T_c that smoothly interpolates and reduces to the perturbative QCD/HTL picture at high $Q \gg T_c$ or $T \gg T_c$ scales. We showed that the enhanced jet-monopole component coupling greatly enhanced the effective $\hat{q}(E,T)$ jet transport coefficient near T_c and solves quantitatively the v_2 puzzle while preserving the agreement with the world data on azimuthal averaged R_{AA}. We demonstrated furthermore that the generalized DGLV theory of jet energy loss coupled to the emergent sQGMP medium provides a first quantitative, robust, and consistent link between hard jet quenching phenomenon and soft bulk peffect fluidity.

Semi-analytic jet quenching package: The study of jet modification in relativistic heavy-ion collisions has entered the quantitative era, aiming for a precise determination of jet transport coefficients via detailed comparison between sophisticated phenomenological calculations and available various experimental measurements. As an intermediate step, we have constructed an integrated computing package for studying jet energy loss in high energy nuclear collisions. Several jet quenching model calculations, which are currently available, have been incorporated in this package including the Higher-Twist-Majumder (HT-M), the Higher-Twist-Berkeley-Wuhan (HT-BW), and the AMY formalism. These are combined with realistic hydrodynamic models for simulating the space-time evolution of a quark gluon plasma created at RHIC and the LHC heavy-ion experiments. Utilizing this package, one may perform calculations for various jet quenching observables, such as the modification of single inclusive hadron production, the correlations between back-to-back hadron pairs, and the energy loss and elliptic flow of heavy flavors, with the flexibility to utilize different jet quenching models and hydrodynamics models, for a large class of centralities for both Au+Au collisions at RHIC and Pb+Pb collisions at the LHC. The package will serve as the first powerful theoretical tool for performing systematic phenomenological study of jet quenching and allow users to compare their own calculations to experimental measurements of various observables. This package was made available to the JET community. It allows the user to pick from a variety of centralities, collision energies and system sizes to run a hydro simulation. Following this, the user, may pick either the AMY or the HT energy loss kernel to calculate the modification of hard jets in this medium. The current version of the code includes single and double inclusive calculations. The user also has the ability to incorporate his or her own fluid dynamical simulation and/or jet quenching model to calculate these observables. First study of jet quenching data and extraction $\hat{q}$ was completed and published. Shown in Fig. 3 is one example of the comparison of HT-M model calculations with experimental data on single hadron suppression at LHC energies.

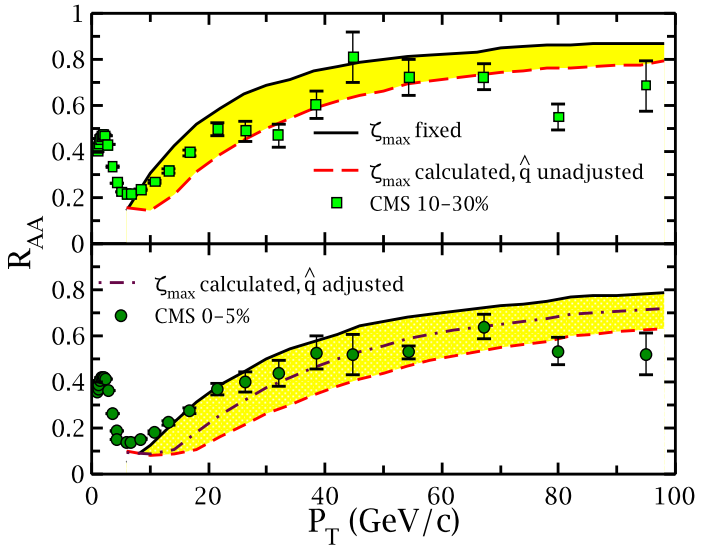

Figure 3: A calculation of the R_{AA} with the HT-M model in the 0-5% most central and 20-30% central Pb+Pb collisions at the LHC compared with CMS data.

3.3 Bulk Evolution

The Bulk Evolution Working Group mainly provides quantitative modeling of the bulk medium evolution to enable accurate calculation of hard probe observables. Major theory frameworks pursued are: Viscous Hydrodynamics, Anisotropic Viscous Hydrodynamics and Covariant Transport for Final Hadronic Evolution. The Bulk Evolution Working Group (Bulk WG) consists of twelve PIs and twenty ancillary personnel from nine U.S. and international institutions.

iEBE-VISHNU hydrodynamic code package: We developed a Python-based interactive program package that allows users to do their own event-by-event hydrodynamic simulations for heavy-ion collisions, with or without UrQMD cascade afterburner. At the moment the package includes modules for computing the fluctuating initial density profile, for (2+1)-dimensional hydrodynamic evolution with the code VISH2+1 (a module for (3+1)-dimensional evolution with MUSIC is currently under construction), for the computation of spectra and anisotropic flow coefficients from the Cooper-Frye spectra (including all resonance decays if desired), for Monte-Carlo sampling the Cooper-Frye spectra to obtain input for the UrQMD cascade (spectra sampler), and a Python-based analysis module that uses an SQLite data base, in which the results from all event-by-event runs are stored, to compute any soft hadron observable desired. A version that includes a module for computing electromagnetic radiation has also been developed, as is a module for computing HBT correlations. The hydro code was successfully tested against a semi-analytic solution of azimuthally symmetric and longitudinally boost-invariant (1+1)-dimensional viscous expansion, found by Gubser in the Navier-Stokes limit and recently generalized by Marrochio et al. for the second-order Israel-Stewart approach. The spectra sampler was tested against the exact Cooper-Frye spectra, and the sampling routine was optimized for speed and accuracy.

A recent improvement includes multiplicity fluctuations in the initialization module so that experimental multiplicity distributions in pp collisions are correctly described. The package is open to the public at https://u.osu.edu/vishnu.

MUSIC hydrodynamic simulation: We have developed a 3+1 dimensional viscous hydrodynamics simulation of relativistic heavy-ion collisions, named MUSIC (MUScl for Ion Collisions). It has been used to describe bulk dynamics of systems created at both RHIC and the LHC, including event-by-event fluctuations and finite shear viscosity. We have also shown that inclusion of the sub-nucleonic fluctuations to be crucial in understanding the details of the anisotropic flow in heavy ion collisions at RHIC and the LHC.

SuperSONIC: We have studied alternative approaches towards a realistic viscous hydrodynamics algorithm. We found that the main stumbling block to performing realistic event-by-event heavy-ion medium simulations through 'traditional' hydrodynamics algorithms such as VH2+1 could be removed by performing local smearing of low energy-density regions. This opened up the possibility of performing fully dynamic 2+1d viscous hydrodynamics simulations of heavy-ion and even light-on-heavy ion collisions on an event-by-event basis.

Coupled with first-principles simulations of dynamical equilibration from AdS/CFT and coupled to a late-stage hadronic cascade simulation, this approach has led to the creation of a 'super-hybrid' algorithm of hydrodynamic medium simulations in relativistic ion collisions, dubbed 'superSONIC'. The superSONIC package has been used to simulate $^3\mathrm{He} + Au$ collisions and was an important ingredient in motivating the experimental $^3\mathrm{He} + Au$ program at RHIC. Furthermore, superSONIC (and its predecessor SONIC) have been used to perform super-hybrid simulations of nuclear collisions of C + C, Al + Al, Cu + Cu, Au + Au, and Pb + Pb from $\sqrt{s} = 62.4$ - 2760 GeV, storing the simulated space-time medium information in publicaly available format for use in JET modification simulations of these collision systems. Moreover, superSONIC has been used to simulate collisions of p+Au d+Au, ^{3}He+Au and p+Pb for various collision energies ranging from $\sqrt{s} = 7$ GeV to $\sqrt{s} = 5.02$ TeV, making predictions for experimental flow signatures, the limits of hydrodynamic applicability in small systems as well as identifying possible experimental signatures of pre-equilibrium QCD dynamics (see Fig. 4).

Anisotropic hydrodynamics: The non-equilibrium evolution of the QGP is complicated because the quark gluon plasma (QGP) is not isotropic in the local rest frame (LRF) at early times and near the edges of the system. To account for these large early-time deviations from local momentum isotropy non-perturbatively, a framework called anisotropic hydrodynamics (aHydro) was developed. Anisotropic hydrodynamics extends traditional viscous hydrodynamical treatments to cases in which the local transverse-longitudinal momentum-space anisotropy of the plasma can be large. The dynamical equations of aHydro were derived from kinetic theory using the zeroth and first moments of the Boltzmann equation in the relaxation time approximation.

At next-to-leading order, one can include deviations from the spheroidal leader-order form. The resulting framework provides non-perturbative dynamical equations for the momentum-space anisotropy (ξ), the transverse temperature (Λ), the LRF velocity ($\mathbf{u}$), and the longitudinal boost-angle associated with the LRF (ϑ). These equations are coupled to an evolution equation for the dissipative corrections generated by $\delta\tilde{f}$. As a way to test to

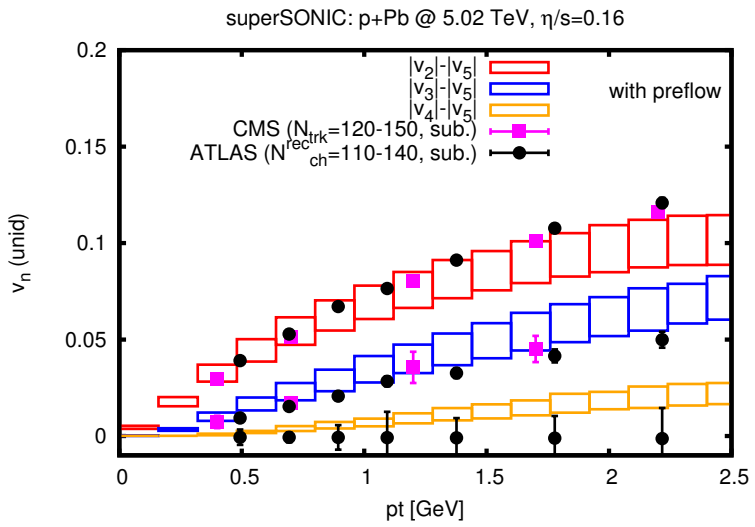

Figure 4: Flow anisotropy coefficients v_n from superSONIC simulations of p+Pb collisions at $\sqrt{s} = 5020$ GeV compared to experimental data from the CMS and ATLAS experiments.

the efficacy of this approach, one can check how well the equations above reproduce exact numerical solution of the Boltzmann equation in the case of transversely homogeneous boost invariant (0+1)d system (see Fig. 5).

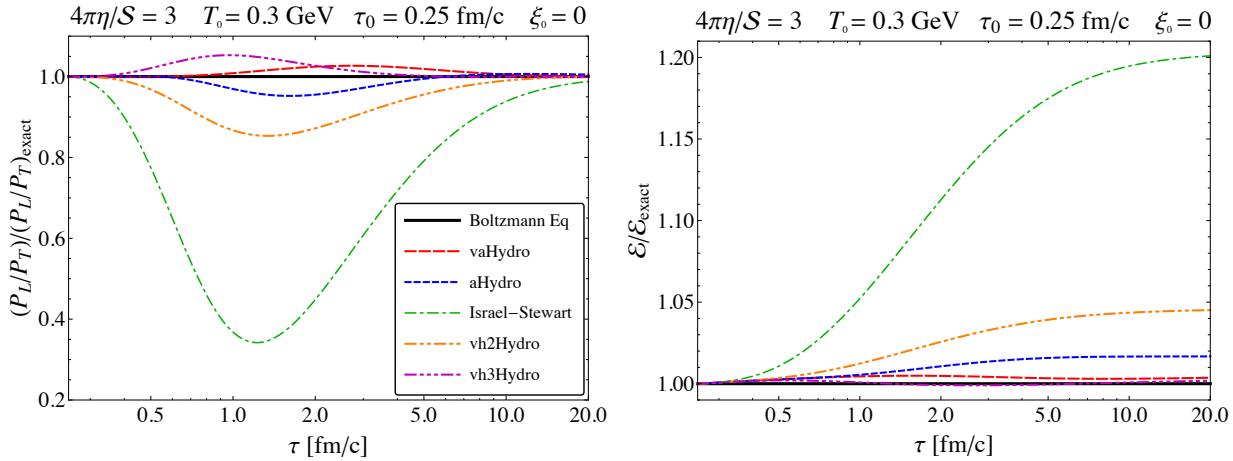

Figure 5: (Color online) Relative error of various dissipative hydrodynamics approaches compared to the exact solution of the (0+1)d Boltzmann equation in relaxation time approximation. The left panel shows the relative error in the pressure ratio and the right panel shows the relative error in the energy density. The legend applies to both panels.

The Little Bang fluctuation spectrum: The influence of event-by-event fluctuations in the initial density profile of the fireballs created heavy-ion collisions on the finally observed flow patterns, and the extraction of QGP transport coefficients from flow data, was a focus of attention of the Bulk WG of the JET Collaboration. We found that the flow angles associated with the anisotropic flow coefficients depend on transverse momentum and particle

species, and that their fluctuations have a significant and measurable influence on experimentally used anisotropic flow measures. We predicted specific features of the so-called breaking of flow-factorization in two-particle correlations due to these flow angle fluctuations, in conjunction with simultaneous fluctuations of the magnitudes of the anisotropic flow coefficients. Our predictions were successfully verified by the CMS Collaboration in Pb+Pb collisions at the LHC.

Event plane correlations in high-energy heavy-ion collisions: Event plane correlations as a function of pseudo-rapidity gap and event-by-event v_n fluctuations in heavy-ion collisions at the LHC are investigated within both the AMPT model and a 3+1D ideal hydrodynamic model. The initial conditions for both models are given by the HIJING model that incorporates a Monte Carlo Glauber model for multiple nucleon interactions and two component model for particle production. Particle production from soft coherent interaction of overlapping nucleons and incoherent semi-hard parton scatterings leads to fluctuations of local energy density in the transverse as well as longitudinal direction. Event plane correlations as a function of rapidity gap are calculated. They are shown to become decorrelated at large rapidity gap due to longitudinal fluctuations in initial energy density and their sensitivity to transport properties of the medium are studied.

Conversion of viscous fluid to particles: We studied question of how to properly convert the output of viscous hydrodynamics simulations to hadronic particles. The main challenge in generating particle spectra from viscous hydrodynamics calculations is to determine $\chi_j(p/T)$ in the general form of viscous corrections $\delta f_j \sim \chi_j(p/T) p^\mu p^\nu \pi_{\mu\nu}/[2(e+p)T^2] f_{eq,j}$ for *all* particle species j. It is customary to assume quadratic momentum dependence, with a universal coefficient for all hardon species (democratic Grad ansatz). This ignores microscopic hadron gas dynamics, and so introduces uncontrolled errors into comparison of hydrodynamic and hydrodynamics+transport calculations to data and the extraction of medium parameters. We have been addressing this problem in a self-consistent approach based on linearized transport theory, which provides viscous corrections that depend on microscopic interactions in the hadron gas. We calculated the momentum dependence of viscous corrections for different hadron gases, and implemented feeddown from resonance decays so that they can better address observables.

Initial conditions from classical gluon fields: We also worked on the question of how to precisely fix the initial conditions necessary for the bulk evolution from classical gluon fields. Previously, we have developed a framework together with J. Kapusta and Y. Li to solve the classical Yang-Mills equations for colliding nuclei analytically for small times. We used this approach to calculate the event-averaged energy momentum tensor of the initial gluon field in nuclear collisions. The two most interesting results of this study are (a) analytic expressions for the time evolution of transverse and longitudinal pressure; (b) analytic expressions for the space-time structure of the transverse flow field. It turns out that Gauss Law mandates the existence of a rapidity-odd flow field that can lead to directed flow in finite impact parameter collisions and to interesting asymmetries in asymmetric collisions systems like Cu+Au and p+Pb. Our results are valid only at the earliest times, up to $\sim 1/Q_s$. However they could be useful, either directly as initial conditions for hydrodynamics with large dissipative stress, or as input for a simulations of thermalizing color fields. While the current analytic results are

event-averaged, it is straight forward to construct an event-generator based on this method.

Mean-field effects in baryon-rich matter: Within the framework of a multiphase transport (AMPT) model that includes both initial partonic and final hadronic interactions, we have shown that including mean-field potentials in the baryon-rich hadronic matter leads to a splitting of the elliptic flows of particles and their antiparticles, thus providing a partial explanation for the larger p than $\bar{p}$, K^+ than K^-, and π^- than π^+ elliptic flows observed in the beam energy scan (BES) program at the Relativistic Heavy-Ion Collider (RHIC). Using a partonic transport model based on the Nambu-Jona-Lasinio (NJL) model, we have further found a similar effect on the quark and antiquark elliptic flows from the vector mean field in the baryon-rich quark matter. Results from including both the partonic and the hadronic mean-field potentials in the AMPT model further indicate that an appreciable vector mean field in the partonic matter is needed to describe the observed elliptic flow differences between particles and their antiparticles. To further understand the properties of baryon-rich quark-gluon plasma, we have used both the quantum linear response theory and the semi-classical Vlasov equation to study the growth rate of its unstable modes due to the spinodal instability.

3.4 Electromagnetic Probes of QGP

Photons and dileptons rarely interact with the medium in which they are produced, owing to the smallness of the fine structure constant. Hence, they constitute clean probes of QGP properties and the details of its evolution in heavy ion collisions. With the realistic hydrodynamics background provided by VISH2+1 MUSIC, we have been investigating the effect of initial states as well as the effect of non-zero viscosities in photon and dilepton productions.

Photon and dilepton emission: One of the major goals of our efforts has been understanding the direct photon puzzle. RHIC and the LHC data have shown that the direct photons flow as strongly as the hadrons. This is puzzling in the sense that one would expect that photons would be produced mainly in the early times when anisotropy of the system is not so pronounced. Therefore getting both the spectrum of the direct photons and the elliptic flow of the photons is a very stringent test of our understanding of the photon production.

We have completed and published the derivation of viscous corrections to the thermal photon emission rates from all 2-to-2 scattering processes in both the QGP and the chemically non-equilibrated late hadronic phase. The new rates, together with our viscous hydrodynamic evolution code, have enabled the first theoretical prediction of higher-order anisotropic flow coefficients for thermal photons, and shed new light on the physical interpretation of the experimentally measured large inverse slope parameters for thermal photons at RHIC and LHC. We find that state-of-the-art calculations of thermal photon emission under-predict the soft photon yield in the transverse momentum distribution, the thermal photon elliptic and triangular flow, and they over-predict the slope of the centrality dependence of the total thermal photon yield. All these observations point to missing brightness of our thermal medium during its late hadronic stage and/or the phase transition region. With our latest efforts, we are very close to resolving this puzzle.

Dileptons have an important additional feature – the invariant mass – which can be tuned to the energy and/or the time scale of interest. Anticipating more detailed data soon to be

released by the LHC experiments, we have made predictions showing the importance of the viscosities as well as the initial state flow and also the effect of the color suppression near T_c.

Jet-triggered photons: We have previously reported on our project to devise ways to identify photons from interactions of jets with quark gluon plasma. Those photons are an important but elusive probe of jet-medium interactions. It is difficult to extract them from either the single inclusive direct photon spectrum or the elliptic photon flow. We have suggested to use jets as triggers and to look for photons emitted from Compton back scattering of the away-side jet off QGP. Over the past year we have worked out corrections to this process due to energy loss of the trigger jets. With the currently available data the residual signal from Compton back-scattering is small, but improvements in jet reconstruction techniques in heavy ion collisions could increase the signal to background ration in the future.

3.5 Parton Recombination

A dedicated Parton Recombination (PR) working group, convened by R. J. Fries, has existed since the beginning of the JET collaboration. Its charge was to work out a general formalism for quark recombination of jet showers in vacuum and in a medium, and to implement it in an event-by-event Monte Carlo code. The working group has met regularly online. Over the past year the meetings were usually shared between the QR and the shower Monte Carlo working group. A first version of the JET hadronization MC code via parton recombination is now implemented in JET shower MC codes.

Jet fragmentation via shower parton recombination: We have studied hadron production in jets by applying quark recombination to jet shower partons on an event-by even basis. We augment perturbative vacuum jet showers, for example those obtained from PYTHIA, by additional non-perturbative effects like gluons splitting into quark-antiquark pairs. We then apply an instantaneous recombination model in phase space, using Wigner functions for mesons and baryons, to calculate the recombination probability for pairs or triplets of quarks and antiquarks. The hadron Wigner functions are based on harmonic oscillator potentials, with quarks modeled as Gaussian wave packets which leads to overlap integrals which are positive definite and amenable to Monte Carlo techniques. We throw dice to determine recombined hadrons from those probabilities. Subsequently we connect leftover partons with strings which are treated according to the Lund fragmentation model (as incorporated in PYTHIA). We have computed hadron spectra in $e^+ + e^-$ collisions at $\sqrt{s} = 200$ GeV. Including contributions from resonance decays, we have found that the resulting longitudinal and transverse (with respect to the jet axis) momentum spectra for pions, kaons, and protons reproduce reasonably those from the string fragmentation as implemented in PYTHIA.

Jet fragmentation in the presence of a hot medium: We have extended our jet shower hadronization model to include hadron production from quenched jets in the quark-gluon plasma produced in heavy ion collisions. In this case shower partons have to be propagated to the $T = T_c$ hyper-surface. The thermal quark distribution on the critical surface is sampled and recombination probabilities of all possible quark/antiquarks pairs and triplets are considered as long as they contain at least one shower parton. An enhanced production

of intermediate-momentum hadrons is obtained as a result of the recombination of shower partons from quenched jets with thermal partons in the quark-gluon plasma.

3.6 Jet Quenching Phenomenology

During the funding period, we carried out a wide range of phenomenological studies of jet quenching in heavy-ion collisions using models and Monte Carlo codes developed within each group individually and collaboratively within JET. The following are some highlights.

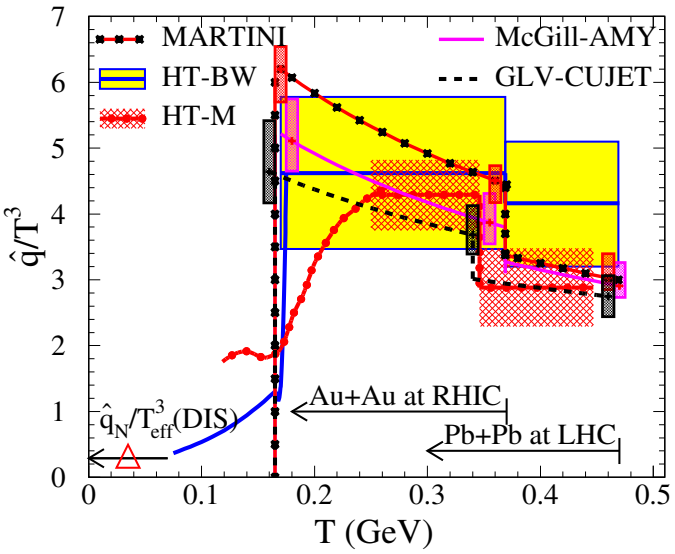

Figure 6: Scaled jet transport parameter $\hat{q}/T^3$ in different jet quenching models for an initial quark jet with energy $E = 10$ GeV at the center of the most central A+A collisions at an initial time $\tau_0 = 0.6$ fm/c . Errors from the fits are indicated by filled boxes at three separate temperatures at RHIC and LHC, respectively. The triangle indicates the value of $\hat{q}_N/T^3_{\rm eff}$ in cold nuclei from DIS experiments.

Extraction of jet transport parameter at RHIC and LHC: With a package that combined different parton energy loss models as implemented in pQCD parton model and realistic 2+1D or 3+1D hydrodynamic model for bulk evolution, we carried out a first comprehensive study of suppression of single hadron spectra. Within five different approaches to parton propagation and energy loss in dense matter, a phenomenological study of experimental data on suppression of large p_T single inclusive hadrons in heavy-ion collisions at both RHIC and LHC was carried out, see Fig. 6. The evolution of bulk medium used in the study for parton propagation was given by 2+1D or 3+1D hydrodynamic models which are also constrained by experimental data on bulk hadron spectra. Values for the jet transport parameter $\hat{q}$ at the center of the most central heavy-ion collisions are extracted or calculated within each model, with parameters for the medium properties that are constrained by experimental data on the hadron suppression factor R_{AA}. For a quark with initial energy of 10 GeV we find that $\hat{q} \approx 1.2 \pm 0.3$ GeV^2/fm at an initial time $\tau_0 = 0.6$ fm/c in Au+Au collisions at $\sqrt{s} = 200$ GeV/n and $\hat{q} \approx 1.9 \pm 0.7$ GeV^2/fm in Pb+Pb collisions at $\sqrt{s} = 2.76$

TeV/n. Compared to earlier studies, these represent significant convergence on values of the extracted jet transport parameter, reflecting recent advances in theory and the availability of new experiment data from the LHC.

γ-triggered jet suppression: We have studied the medium modification of γ-tagged jets in high-energy heavy-ion collisions within a Linearized Boltzmann Transport model for jet propagation that includes both elastic parton scattering and induced gluon emission. Inclusion of recoiled medium partons in the reconstruction of partonic jets is found to significantly reduce the net jet energy loss. Experimental data on γ-jet asymmetry and survival rate in Pb + Pb collisions at LHC can be reproduced. Medium modifications of reconstructed jet fragmentation function, transverse profile and energy flow outside the jet-cone are found to be sizable especially for γ-tagged jets with small values of $x = p_T^{jet}/p_T^{\gamma}$. γ-jet events with different values of $x = p_T^J/p_T^{\gamma}$ can be used as jet quenching tomography tools. It is found that larger x jets are mainly produced from the surface of the medium, while smaller x jets are from those jets which have traversed longer distance of medium. Combined with the momentum spectrum of the γ-tagged jets, this leads to stronger suppression and centrality dependence for larger x jets, and weaker suppression (or enhancement) for smaller x jets.

Two puzzling features in the experimental study of jet quenching in central Pb+Pb collisions at the LHC are explained within a linearized Boltzmann transport model for jet propagation. A γ-tagged jet is found to lose about 15% of its initial energy while its azimuthal angle remains almost unchanged due to rapid cooling of the medium. The reconstructed jet fragmentation function is found to have some modest enhancement at both small and large fractional momenta as compared to that in the vacuum because of the increased contribution of leading particles to the reconstructed jet energy and induced gluon radiation and recoiled partons. A γ-tagged jet fragmentation function is proposed that is more sensitive to jet-medium interaction and the jet transport parameter in the medium (see Fig. 7).

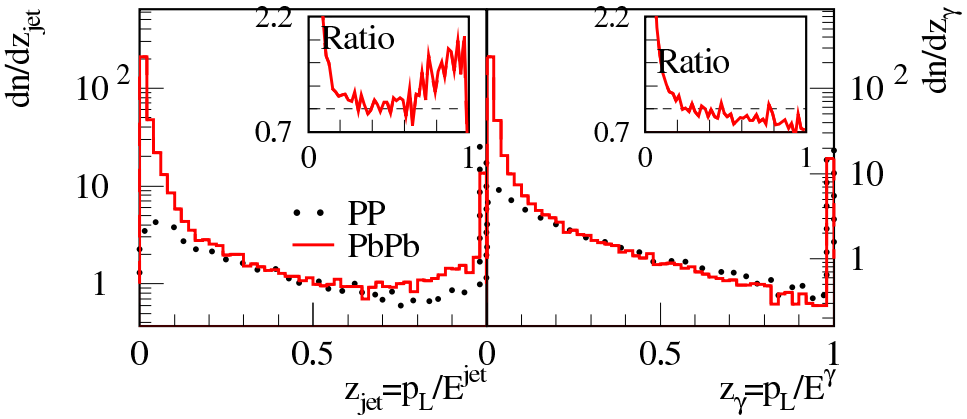

Figure 7: The reconstructed (left) and γ-tagged jet fragmentation functions (right) within a jet cone $R = 0.3$ of γ-tagged jets in central (0%–10%) Pb+Pb collisions at $\sqrt{s} = 2.76$ TeV.

Jet mass evolution in a dense medium: Using the in-medium MC event generator, which was developed within JET based on the higher-twist formalism of jet modification, including a space-time dependent information along with momentum information for all the

partons in the shower, we have calculated the mean rate of jet mass depletion as a jet propagates through dense matter. Along with energy loss, jet mass depletion allows another means to compare with jets produced in p-p collisions. It has been demonstrated that escaping partons with reduced energies tend to have a much smaller mass than a corresponding parton produced in a hard interaction in p-p collisions.

Single hadron suppression at LHC within the HT-M model: We have improved the standard calculation of single inclusive calculation in the HT formalism. Two different extreme calculations of the mean length traversed by surviving jets has been carried out. This length controls the virtuality of the jet on exit from the medium. Using this range of exit virtualities, one calculates the the multiple emission evolved medium modified fragmentation function in a 2+1 D viscous hydro.

Z_0-tagged jets: Electroweak bosons produced in conjunction with jets in high energy collider experiments is one of the principle final-state channels that can be used to test the accuracy of perturbative Quantum Chromodynamics calculations and to assess the potential to uncover new physics through comparison between data and theory. In proton-proton reactions at LHC (see Fig. 8) we elucidated up to $\mathcal{O}(G_F\alpha_s^2)$ the constraints that jet tagging via the Z_0/γ^* decay dileptons provide on the momentum distribution of jets. In nucleus-nucleus reactions (see Fig. 9) we demonstrated that tagged jets can probe important aspects of the dynamics of quark and gluon propagation in hot and dense nuclear matter and characterized the properties of the medium-induced parton showers in ways not possible with more inclusive measurements. We gave specific predictions for the anticipated suppression of the Z_0/γ^*+jet production cross section in the quark-gluon plasma that is expected to be created in central lead-lead collisions at the LHC relative to the naive superposition of independent nucleon-nucleon scatterings.

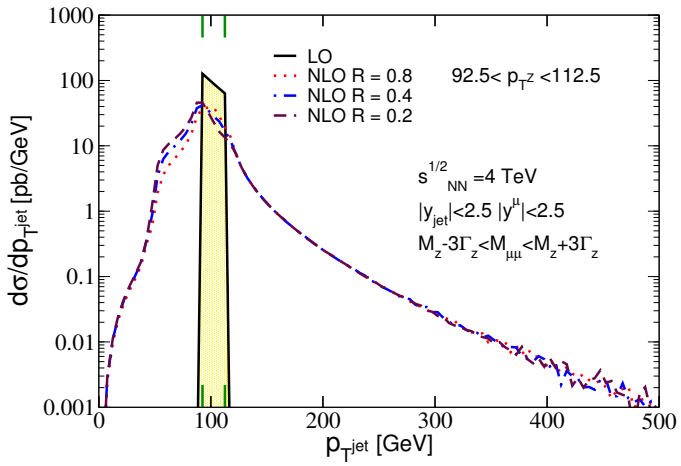

Figure 8: The distribution of jets associated with a Z_0 tag (via its dilepton decay channel) at lowest and next-to-leading orders for $\sqrt{s} = 4$ TeV in p+p collisions at the LHC. At LO the pT of the jet is well-determined. At NLO, large uncertainty $\pm$ 25% arises from radiative processes.

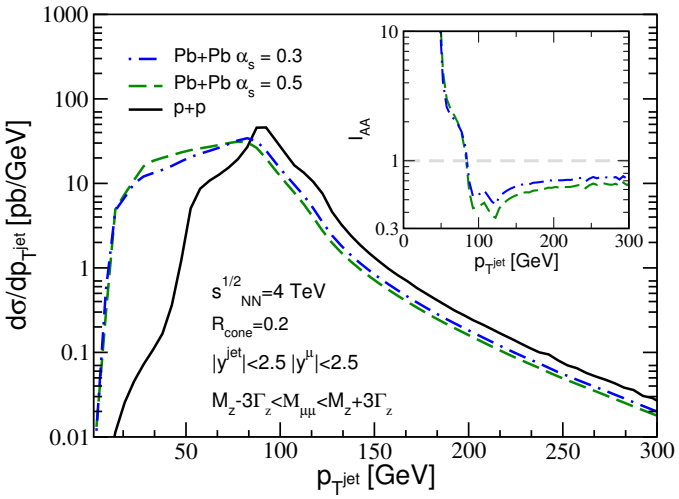

Figure 9: The modification of jets associated with a Z_0 tag in central Pb+Pb collisions at the LHC. We find suppression for momenta larger than the momentum of the Z_0 and string enhancement for lower momenta. The insert shows the final-state QGP induced modification that depends on the jet cone radius.

Photon-tagged light and heavy meson production at RHIC and LHC: We also studied the photon-triggered light and heavy meson production in both p+p and A+A collisions. We found that a parton energy loss approach that successfully describes inclusive hadron attenuation in nucleus-nucleus reactions at RHIC can simultaneously describe well the experimentally determined photon-triggered light hadron fragmentation functions. Using the same framework, we generalized our formalism to study photon-triggered heavy meson production. We found that the nuclear modification of photon-tagged heavy meson fragmentation functions in A+A collision is very different from that of the photon-tagged light hadron case. While photon-triggered light hadron fragmentation functions in A+A collisions are suppressed relative to p+p, photon-triggered heavy meson fragmentation functions can be either enhanced or suppressed, depending on the specific kinematic region. The anticipated smaller energy loss for b-quarks manifests itself as a flatter photon-triggered B-meson fragmentation function compared to that for the D-meson case. We made detailed predictions for both RHIC and LHC energies. The LHC example is shown in Fig. 10. We concluded that a comprehensive comparative study of both photon-tagged light and heavy meson production can provide new insights in the details of the jet quenching mechanism.

$b-\bar{b}$ **jets and photon-tagged** b**-jets**: We have now had the opportunity to extend the results for inclusive b-jets to photon-tagged b-jets. Jets tagged by photons or electroweak boson (W, Z) are particularly well suited to studying heavy-ion collisions since the tagging particle escapes the region of strongly-interacting matter unscathed. For example, the CMS collaboration measurements in lead-lead (Pb+Pb) collisions show absence of significant modification of high transverse momentum photon production relative to the binary collision-scaled proton-proton (p+p) result within the current statistical and systematic uncertainties. Thus, in the collinear factorization approach gammas can provide, on average, constraints on the energy of the away-side parton shower. Furthermore, jets tagged by photons or elec-

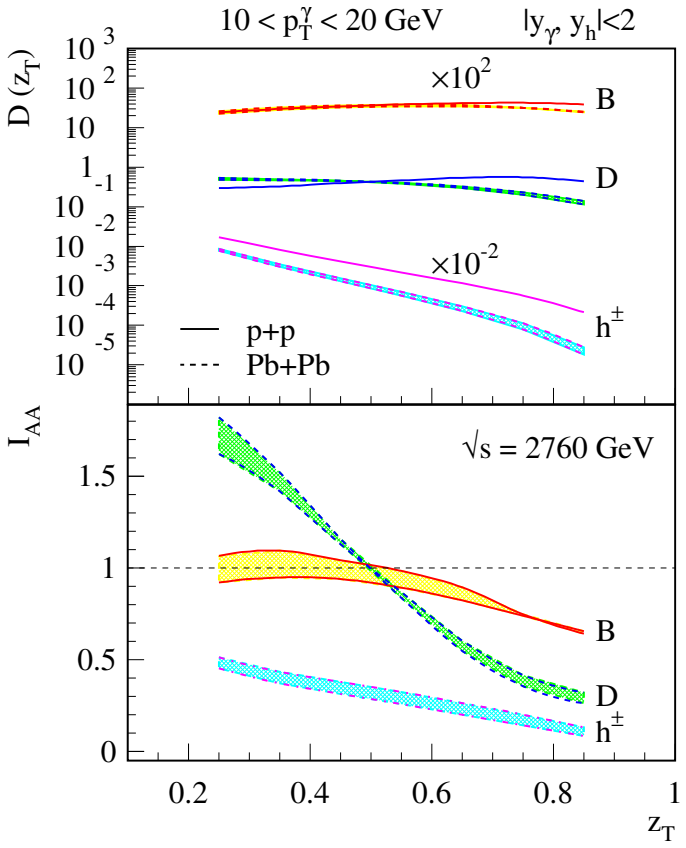

Figure 10: Top panel: predictions for the photon-triggered fragmentation functions, where the solid lines are for proton-proton collisions at center of mass energy 2.76 TeV. Bottom panel: predictions for the nuclear modification factor, where the solid lines are for B-mesons, the dashed lines are for D-mesons, and the dash-dotted lines are for charged hadrons.

troweak bosons are largely unaffected by the fluctuations of the soft hadronic background that may complicate the interpretation of di-jet modification in heavy-ion collisions. We also extended the calculation to B-meson tagged b-jets.

We predicted the 2-D nuclear modification R_{AA} and the related momentum imbalance shift of isolated-photon-tagged and B-meson-tagged b-jets in Pb+Pb collisions at $\sqrt{s} = 5.1$ TeV at the LHC, see Figure 10 for example. We validated the Pythia 8 simulations of tagged b-jet cross sections in nucleon-nucleon collisions through comparison of photon-tagged b-jet results at $\sqrt{s} = 1.96$ TeV from the Tevatron. We also found that particle tagging can significantly increase the fraction of recoiling b-jets that originate from prompt b-quark relative to the inclusive b-jet case. While in the latter case this fraction can be as low as 20%, B-meson tagging in particular can increase the contribution of prompt b-quarks to 70-80%. In Pb+Pb collisions in the LHC we further considered the medium-induced parton shower in the soft gluon energy loss limit and any additional dissipation of its energy in the QGP due to collisional interactions. We found significant nuclear suppression when the trigger particle momentum is similar to the b-jet momentum p_T^B p_T^j . A modest 5-10% increase in the transverse momentum imbalance for $\gamma + b$-jet production in Pb+Pb collisions is predicted from our calculations, depending on the specific kinematic cuts, which is slightly smaller

than that observed for gamma+light jet production. For B-tagged b-jets we found an even larger suppression of the double differential cross section since both the jet and the tagging b-quark lose energy. On the other hand, the asymmetry variable z_{jB} in $B + b$-jet production shows a slight increase from p+p to A+A collisions, a behavior quite different from the one observed in dijet asymmetry distributions. By using the flexibility of b-jet tagging, comparison of upcoming experimental measurements to theoretical calculations, such as the ones presented here, can provide us with unique new insights into heavy flavor dynamics in the strongly-interacting plasma. In the future, we expect that the theoretical uncertainty of b-jet production in nuclear matter can be further reduced by going beyond the current radiative energy loss approximations and by including higher order computations for multiple scattering with full account of heavy quark mass effects.

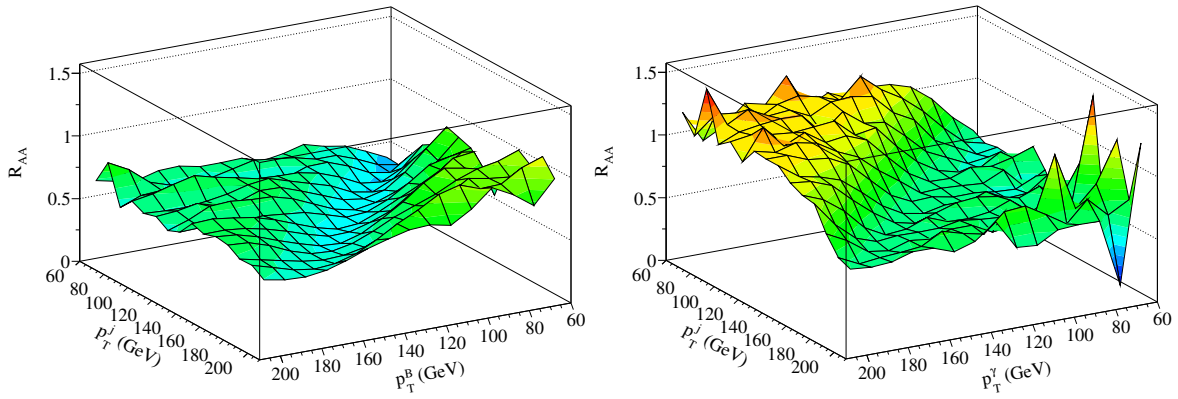

Figure 11: Left: The nuclear modification factor R_{AA} for γ+b-jet production in Pb+Pb collisions at LHC at $\sqrt{s} = 5.1$ TeV is plotted as a function of the b-jet transverse momentum p_T^j and the photon p_T^γ. Right: R_{AA} for B-meson-tagged b-jet production as functions of b-jet p_T^j and B-meson p_T^B.

Di-jet asymmetry in Pb+Pb collisions at the LHC: We developed a model for jet quenching and in-medium energy transport with the goal of understanding the physics mechanisms for the modified di-jet asymmetry A_J in Pb+Pb collisions at the LHC observed by ATLAS and CMS. The model treats radiative energy loss in the perturbative higher-twist formalism and collisional energy loss as a deterministic process involving longitudinal energy degradation and transverse momentum diffusion. The radiated gluons are allowed to interact with the medium via elastic collisions resulting in energy degradation and transverse momentum diffusion. Gluons that fall below a certain energy threshold are considered as thermalized. The model contains three parameters: the transverse momentum diffusion coefficient $\hat{q}$, the longitudinal energy loss parameter dE/dx, and the thermalization threshold $E_{\rm cut}$. The medium geometry is treated schematically using a Glauber model profile of the hot medium.

We found that the model can nicely explain the shift of the A_J-distribution from a shape sharply peaked at $A_J = 0$ to one that shows a broad shoulder at $A_J \approx 0.6$ as observed by CMS. We could not reproduce the peak at $A_J = 0.6$ seen in the most central ATLAS data (but neither could anyone else's model!). The required energy loss parameters are in quite good agreement with those needed to explain the RHIC jet quenching data (mainly R_{AA}),

with linear entropy density (multiplicity) extrapolation to Pb+Pb collisions at the LHC.

CUJET3.0 and jet transport coefficient: Using the most recent version of jet quenching model CUJET3.0 that incorporated a novel model of semi-Quark-Gluon-Monopole Plasma (sQGMP) with non-conformal and non-perturbative dynamical effects near T_c, we have carried out a systematic study of single hadron spectra suppression and azimuthal anisotropy simultaneously. The results of the study lead to to several highly nontrivial findings: a consistent and robust description of both bulk perfect fluidity and high p_T jet quenching phenomena; a strong increase of $\hat{q}/T^3$ (see Fig. 12) accompanied by a strong decrease of η/s toward T_c; that provides a simultaneous description consistent with *all* current high $p_T > 10$ GeV R_{AA} and v_2 data at RHIC and the LHC for both light and heavy flavor jets. Future tests on small $p+p$ and $p+A$ systems will be important to test and constrain the dynamical details of sQGMP state of matter produced in high energy $B+A$ nuclear collisions at RHIC and LHC. The CUJET3.0 link between high p_T jet quenching and low p_T perfect fluidity is particularly exciting because it shows that demanding robustness and consistency between these two classes of observables at RHIC and LHC may eventually provide the strongest experimental evidence for the existence of the cross over deconfinement transition from hadronic degrees of freedom toward partially deconfined but still strongly coupled and screened sQGMP chromodynamic degrees of freedom as T crosses T_c, as predicted by lattice QCD.

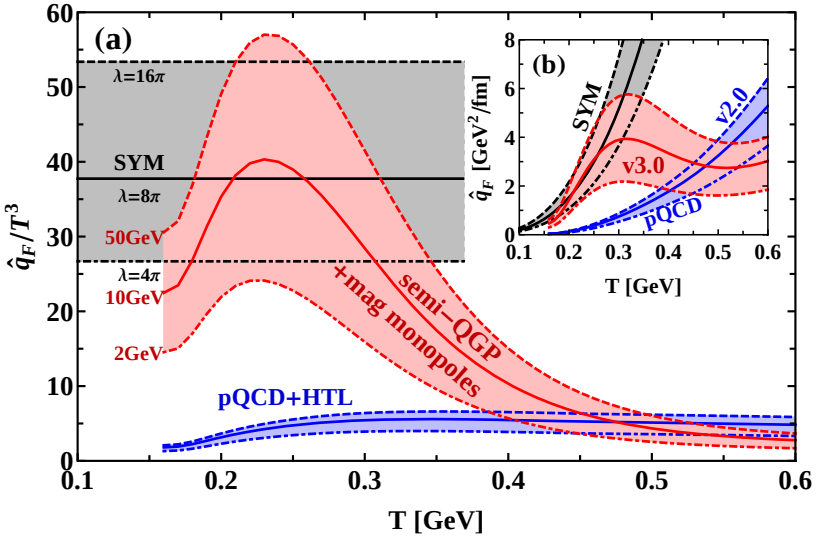

Figure 12: Temperature dependence of (a) the dimensionless jet transport coefficient $\hat{q}/T^3$ and (b) $\hat{q}$ for a quark jet with energy $E = 2, 10, 50$ GeV, from CUJET3.0 (red) assuming an sQGMP medium compared to CUJET2.0 (blue) pQCD+ HTL medium, and to a $\mathcal{N} = 4$ Super Yang-Mills (SYM) 5D Black Hole.

Predictions for p+Pb at 5 TeV We coordinated a community-wide effort to compile predictions by JET Collaboration members and external associated members for the p+Pb run at the LHC in the winter of 2013. Predictions include charged hadrons; identified particles such as π^0, $K^{\pm}$, and $p/\overline{p}$; photons; jets; J/ψ; and gauge bosons. The observables

included individual distributions, ratios such as $R_{p\mathrm{Pb}}$, and correlation functions. The paper in which these predictions were compiled was submitted and published in International Journal of Modern Physics E before the p+Pb run began.

4 Collaboration Events

The JET Collaboration organized annual JET Summer Schools and JET Collaboration meetings during each year of the funding period. We also organized two symposia, several topical workshops and topic group meetings. The following is the list of collaboration events in chronological order. Details of these schools and meetings can be found at the JET website: http://jet.lbl.gov.

- **JET Summer School 2010**
  Date: June 14-17, 2010
  Place: Lawrence Berkeley National Laboratory, Berkeley, California
  Local Organizer: X.-N. Wang
  Number of students: 63
  Description: The first JET Summer School was held with 6 series of lectures in both theory and experiment. Since this is the first JET Summer School, the lectures focused on pedagogical lectures in pQCD and over view of experimental status. Each day was supplemented with few short student seminars on their current research. We had total 63 registered participants in the JET Summer School, 41 of the participants received full local support from the JET Collaboration. The overall rating for the Summer School Program by the participating students are very positive. According to the exit survey, students rated the overall Summer School program 4.16 (out of 5) and many thought the Summer School learned something new about JET physics (4.39 out of 5) and increased their interest in JET physics (4.26 out of 5).

- **JET Inaugural Symposium 2010**
  Date: June 18, 2010 Place: Lawrence Berkeley National Laboratory, Berkeley, California
  Organizers: P. Jacobs, V. Koch, B. Müller, X.-N. Wang (Chair) and Y. Feng
  Number of Participants: 71
  Description: We also held a one-day inaugural Symposium on Jet and Electromagnetic Tomography of Dense Matter on June 18, 2010, immediately following the JET Summer School, with 15 invited speakers and 71 registered participants. The symposium provided an overview of the past achievements and future challenges in the JET physics. Discussions focused on strategies and collaborative effects that are needed to use JET for future quantitative studies of the properties of the sQGP in heavy-ion collisions at RHIC and LHC.

- **Collaboration Meeting 2010**
  Date: June 14-17, 2010
  Place: Lawrence Berkeley National Laboratory, Berkeley, California
  Local Organizer: X.-N. Wang
  Description: All PI members of the JET Collaboration attended the JET Symposium

and the JET Collaboration meeting. During the collaboration meeting we have discussed the physics problems that we plan to study within the framework of the JET Collaboration. We decided to form 4 working groups each focusing one set of problems as outlined in the JET Proposal. These working groups and the respective conveners played a crucial role in coordinating research activities across the JET Collaboration. We agreed to form the Collaboration Council. One representative PI from each institution. We have agreed to add two more associated members to the JET Collaboration: William Horowitz and Ralf Rapp. Both have agreed to become JET associate members after having been approved by the JET Collaboration Council. In the meantime, Björn Schenke has left McGill university and started a postdoctoral position at BNL. The Collaboration also voted to make him an associated member of the JET Collaboration.

- **JET Summer School 2011**
  Date: June 15-17, 2011
  Place: Duke University, Durham, NC
  Organizers: S. Bass and B. Müller
  Number of students: 23
  Description: The JET Summer School 2011 at Duke University had 7 series of lectures in both theory and experiment. The lectures focused on jet physics within pQCD and experimental techniques of jet studies. The school was supplemented with two short sessions with student seminars on their current research.

- **JET Collaboration Meeting 2011**
  Date: June 18-19, 2011
  Place: Duke University
  Local Organizers: S. Bass and B. Müller
  Description: Following the JET Summer School, DOE carried out a mini-review of the JET Collaboration which was followed by the second JET Collaboration meeting during June 18-19, 2011. During the collaboration meeting we reviewed the progress and discussed the physics problems and adjustment to the program and organization of the JET Collaboration. We agreed to form a NLO working group.

- **Jets @ RHIC Mini-workshop 2012**
  Date: March 3-4, 2012
  Place: Duke University, Durham, NC.
  Organizers: S. Bass and B. Müller
  Number of participants: 18
  Description: The Jets@RHIC Mini-workshop was organized at the Duke University to investigate the future opportunities of jet physics at RHIC. The workshop is motivated by discussion with experimentalists about future potential and opportunities at RHIC. We discussed various aspects of jet physics that are unique in the RHIC energy regime and specific theoretical calculations that can be made within the JET Collaboration to illustrate the physics opportunities at RHIC.

- **JET Collaboration Meeting 2012**
  Date: June 14-15, 2012
  Place: McGill University, Montreal, Canada
  Local Organizer: C. Gale and S. Jeon

Description: The third annual JET Collaboration meeting was held at McGill University prior to the 2012 JET Summer School. Conveners of the working groups gave progress reports and several young people gave talks on their latest work. With the progress made in each working group, we felt it was time to integrate all different studies into a single MC simulation package. This requires the merging of all different efforts. We spent most of the time discussing how to integrate the different efforts over the next 2 years. We identified Abhijit Majumder to be the convener of this coordinated effort and decided on the strategy for the end-game and the funding scheme.

- **JET Summer School 2012**
  Date: June 16-18, 2012
  Place: McGill University, Montreal, Canada
  Organizers: C. Gale and S. Jeon
  Number of students: 30
  Description: The third JET Summer School was held at McGill University during June 16-18, 2012. There were 19 hours of lectures given by 7 lecturers in 3 days, on topics ranging from jet physics in QCD, hydrodynamics and heavy quarks to experimental study of jet physics. The summer school was attended by 30 students from around the world.

  Workshop on Jet Modification in the RHIC and LHC era 2012
  Date: August 20-23, 2012
  Place: Wayne State University, Detroit, MI
  Organizers: T. Cormier, A. Majumder (Chair), C. Pruneau, J. Putschke, S. Gavin and S. Voloshin
  Number of Participants: 40
  Description: The JET Collaboration co-organized the Quark Matter 2012 Satellite Workshop on Modification in the RHIC and LHC era during August 20-23, 2012 at Wayne State University. The goal of this 3.5-day satellite meeting was to review the most important new experimental measurements and theoretical breakthroughs presented at Quark Matter 2012, and to critically address the question whether a consistent picture of jet quenching has emerged.

- **JET Collaboration Meeting 2013**
  Date: June 10-11, 2013
  Place: The Ohio State University, Columbus, OH
  Local Organizer: U. Heinz
  Description: The JET Collaboration meeting was held before the JET Summer School 2013. Conveners from working groups and delegates from individual member institutions gave progress reports, the iEBE interactive software package for event-by-event hydrodynamic + cascade evolution on demand was presented to the Collaboration and demonstrated in a tutorial, and the status of the jet quenching software package and jet-hydro interface was reported with a demonstration. In the morning of the second day we heard 5 talks by experimentalists on the latest progress on jet reconstruction with the PHENIX and STAR detectors at RHIC and the ALICE, ATLAS and CMS detectors at the LHC. In the afternoon, short presentations from each group of their plans for the coming year were followed by specific work assignments and a discussion of how to best integrate the various efforts in preparation of the end game of the

Collaboration during Year 5.

- **JET Summer School 2013**
  Date: June 12-14, 2013
  Place: The Ohio State University, Columbus, OH
  Organizer: U. Heinz
  Number of students: 43
  Description: The fourth JET Summer School was held at The Ohio State University. Over a period of 3 days, 7 lecturers from the US and Europe (4 theorists and three 3 experimentalists) delivered 19 hours of lectures on electromagnetic signatures, jet medium modification and jet quenching, initial fluctuations and hydrodynamic evolution, and the ridge in pp, pA, and AA collisions at RHIC and LHC. The summer school was attended by 43 students and young postdocs from around the world.

- **The 2nd Workshop on Jet Modification at RHIC and LHC era 2013:**
  Date: August 22 -23, 2013
  Place: Wayne State University, Detroit, MI
  Organizers: A. Majumder, J. Putschke and C. Pruneau
  Number of Participants: 25
  The JET Collaboration sponsored the Second Workshop on Jet Modification at RHIC and LHC era at WSU during Aug. 20-22, 2013. The goal of this meeting was to review the most important new experimental measurements and theoretical breakthroughs that have occurred in the past year and to throughly explore the limits of perturbative QCD based approaches to the description of hard processes in heavy-ion collisions. Over the period of three days, topics covered will include new experimental observables that may discern between different perturbative approaches, the inevitable transformation of analytic schemes to Monte-Carlo event generators, and the progress made towards Next to Leading Order calculations of energy loss. We also had a work-fest meeting focusing on future perspective of jet physics at RHIC.

- **JET Collaboration Meeting on NLO Calculation and MC Simulations 2013**
  Date: August 22-23, 2013
  Place: Wayne State University, Detroit, MI
  Local Organizer: A. Majumder
  Description: An additional JET Collaboration meeting was held at WSU during Aug. 22-23, 2013 where we developed the main idea behind the first comprehensive study of jet quenching using the integrated package of jet quenching programs and extracting values of $\hat{q}$. We also had a working group meeting on NLO parton energy loss.

- **JET at RHIC Strategy Meeting 2013**
  Date: August 24-25, 2013
  Place: Wayne State University, Detroit, MI
  Organizer: A. Majumder
  Number of Participants: 20
  Description: The JET Collaboration organized a strategy meeting on jet-modification at RHIC at Wayne State University. The goal of the meeting was to chart out a road map of what needs to be done theoretically and experimentally to carry out an un-

ambiguous extraction of jet transport coefficients $\hat{q}$, $\hat{e}$, their temperature dependences and any other transport coefficients that may be discerned by jet modification.

- **Workshop on NLO Energy Loss 2014**
  Date: March 3-14, 2014
  Place: Lawrence Berkeley National Laboratory, Berkeley, CA
  Organizers: X.-N. Wang and B. Xiao
  Number of participants: 14
  Description: The JET Collaboration held a small working group meeting on NLO jet energy loss at Lawrence Berkeley National Laboratory from March 3 to 14., 2014. This was a small informal meeting with active experts in this subfield to discuss recent progresses and near term challenges on calculation of parton energy loss and momentum broadening at the next-to-leading order (NLO). Only 1-2 talks were scheduled each day and the rest was devoted to informal and in-depth discussions.

- **JET Collaboration Meeting 2014**
  Date: June 17-18, 2014
  Place: UC Davis, Davis, CA
  Local Organizer: R. Vogt
  Description: The JET Collaboration Meeting was held at UC Davis during the summer of 2014. Working Group conveners and some individual PI gave reports on the progress of JET projects. We discussed in particular the final version of the report on the extraction of $\hat{q}$ from RHIC and LHC experimental data with the semi-analytical JET package and possible plans to continue the JET Collaboration after the funding period.

- **JET Summer School 2014**
  Date: June 19-21, 2014
  Place:UC Davis, Davis, CA
  Organizers: D. Cebra, M. Calderon, X.-N. Wang and R. Vogt (Chair)
  Number of students: 26
  Description: The fifth JETSummer School was held at UC Davis. There were 26 registered students at the summer school from 14 institutions, both domestic and international. Most of the lecturers gave 3 hour-long lectures each but two of the experimental talks, on bulk properties, were one hour each. The interactions between students and lecturers was very good. There were also four student seminars on the last afternoon.

- **The 3rd Workshop on Jet Modification at RHIC and LHC era 2013:**
  Date: August 18 - 20, 2014
  Place: Wayne State University, Detroit, MI
  Organizers: A. Majumder, J. Putschke, C. Pruneau and Rosi Reed
  Number of Participants: 30
  The JET Collaboration sponsored the Third Workshop on Jet Modification at RHIC and LHC era at WSU during Aug. 19 -20, 2014. This 3 day international workshop was held to review the most important new experimental measurements and theoretical breakthroughs in the study of quark-gluon plasma using the modification of jets. The workshop was slow paced with a mixture of longer invited talks and shorter contributed

talks, allowing sufficient time for discussion, as well as time to follow up on more technical aspects of the data analysis and theoretical calculations.

- **JET Closing Symposium 2015**
  Date: June 26-27, 2015
  Place: McGill University, Montreal, Canada
  Organizers: C. Gale, U. Heinz, S. Jeon, C. Shen, G. Denicol, A. Majumder and X.-N. Wang
  Number of Participants: 30 Descriptions: This second symposium on Jet and Electromagnetic Tomography of Dense Matter, hosted by McGill University (one of the member institutions of the JET Collaboration) just before the start of the Hard Probes 2015 Conference, reviewed the accomplishments of the JET Collaboration at this transition point, assessed the progress made so far, and outline future challenges for the field and how collaborative activities would continue to maintain a strong research program, but without dedicated DOE funding.

- **EVO Video Conferences**
  Each of the Working Groups within the JET Collaboration meet regularly online to discuss progress and technical details of the project. Slides and notes of these meetings can be found at the JET web site: http:
  jet.lbl.gov.

5 List of Publications and Conference Talks (2010-2015)

5.1 Published papers

1. N. Armesto, *et al.*
   Comparison of Jet Quenching Formalisms for a Quark-Gluon Plasma 'Brick',
   Phys. Rev. C **86**, 064904 (2012).

2. J. L. Albacete *et al*,
   Predictions for p+Pb collisions at $\sqrt{s_{NN}} = 5$ TeV,
   Int. J. Mod. Phys. E **22** (2013) 1330007.

3. K. M. Burke, A. Buzzatti, N. Chang, C. Gale, M. Gyulassy, U. Heinz, S. Jeon, A. Majumder, B. Müller, G.-Y. Qin, B. Schenke, C. Shen, X.-N. Wang, J. Xu, C. Young, and H. Zhang (The JET Collaboration),
   Extracting jet transport coefficient from jet quenching at RHIC and LHC,
   Phys. Rev. C 90 (2014) 014909.

4. B. Wu and P. Romatschke,
   Shock wave collisions in AdS5: approximate numerical solutions,
   Int. J. Mod. Phys. C **22** (2011) 1317.

5. P. Romatschke,
   Relativistic (Lattice) Boltzmann Equation with Non-Ideal Equation of State,
   Phys. Rev. D **85** (2012) 065012.

6. P. Romatschke and R. E. Young,
   Implications of hydrodynamic fluctuations on the minimum shear viscosity of the dilute Fermi gas at unitarity,
   Phys. Rev. A **87** (2013) 053606.

7. P. Romatschke and J. D. Hogg,
   Pre-Equilibrium Radial Flow from Central Shock-Wave Collisions in AdS5,
   JHEP **1304** (2013) 048.

8. W. van der Schee, P. Romatschke and S. Pratt,
   A fully dynamical simulation of central nuclear collisions,
   Phys. Rev. Lett. **111** (2013) 222302.

9. A. M. Adare, M. P. McCumber, J. L. Nagle and P. Romatschke,
   Tests of the Quark-Gluon Plasma Coupling Strength at Early Times with Heavy Quarks,
   Phys.Rev. **C90** (2014) 2, 024911.

10. J. L. Nagle, A. Adare, S. Beckman, T. Koblesky, J. O. Koop, D. McGlinchey, P. Romatschke and J. Carlson *et al.*,
    Exploiting Intrinsic Triangular Geometry in Relativistic He3+Au Collisions to Disentangle Medium Properties,
    Phys. Rev. Lett. **113** (2014) 11, 112301.

11. M. Habich and P. Romatschke,
Onset of cavitation in the quark-gluon plasma,
JHEP **1412** (2014) 054.

12. P. Kovtun, G. D. Moore and P. Romatschke,
Towards an effective action for relativistic dissipative hydrodynamics,
JHEP **1407** (2014) 123.

13. T. Gorda and P. Romatschke,
Precision studies of v_n fluctuations,
Phys. Rev. C **90** (2014) 5, 054908.

14. P. Arnold, P. Romatschke and W. van der Schee,
Absence of a local rest frame in far from equilibrium quantum matter,
JHEP **1410** (2014) 110.

15. M. Habich, J. L. Nagle and P. Romatschke,
Particle spectra and HBT radii for simulated central nuclear collisions of C + C, Al + Al, Cu + Cu, Au + Au, and Pb + Pb from $\sqrt{s} = 62.4$ - 2760 GeV,
Eur. Phys. J. C **75** (2015) 1, 15.

16. H. Bantilan and P. Romatschke,
Simulation of Black Hole Collisions in Asymptotically Antide Sitter Spacetimes, Phys. Rev. Lett. **114** (2015) 8, 081601.

17. T. Gorda and P. Romatschke,
Equation of state in two-, three-, and four-color QCD at nonzero temperature and density,
Phys. Rev. D **92** (2015) 1, 014019.

18. P. Romatschke,
Light-Heavy Ion Collisions: A window into pre-equilibrium QCD dynamics?
Eur. Phys. J. C **75** (2015) 7, 305.

19. A. Buzzatti and M. Gyulassy,
Dynamical magnetic enhancement of light and heavy quark jet quenching at RHIC,
Nucl. Phys. A **855**, 307 (2011) [arXiv:1012.0614 [hep-ph]].

20. M. Gyulassy, A. Buzzatti, A. Ficnar, J. Noronha and G. Torrieri,
Jet tomography versus holography at RHIC and LHC,
EPJ Web Conf. **13**, 01001 (2011).

21. A. Buzzatti and M. Gyulassy,
Jet Flavor Tomography of Quark Gluon Plasmas at RHIC and LHC,
Phys. Rev. Lett. **108**, 022301 (2012) [arXiv:1106.3061 [hep-ph]].

22. A. Buzzatti and M. Gyulassy,
An overview of the CUJET model: Jet Flavor Tomography applied at RHIC and LHC,
Nucl. Phys. A **910-911**, 490 (2013) [arXiv:1207.6020 [hep-ph]].

23. A. Buzzatti and M. Gyulassy,
A running coupling explanation of the surprising transparency of the QGP at LHC,
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Effect of initial-state nucleon-nucleon correlations on collective flow in ultra-central heavy-ion collisions,
arXiv:1406.7792 [nucl-th].

31. I. Kozlov, M. Luzum, G. Denicol, S. Jeon and C. Gale,
Transverse momentum structure of pair correlations as a signature of collective behavior in small collision systems,
arXiv:1405.3976 [nucl-th].

32. G. Vujanovic, J. F. Paquet, G. S. Denicol, M. Luzum, B. Schenke, S. Jeon and C. Gale,
Probing the early-time dynamics of relativistic heavy-ion collisions with electromagnetic radiation,
arXiv:1404.3714 [hep-ph].

33. C. Young, S. Jeon, C. Gale and B. Schenke,
Monte-Carlo simulation of jets in heavy-ion collisions,
arXiv:1109.5992 [hep-ph].

34. S. Jeon and T. Epelbaum,
Perturbative Vacuum Wavefunctional for Gauge Theories in the Milne Space
arXiv:1506.00672 [hep-ph].

5.3 Conference Talks

1. Miklos Gyulassy,
   Jet Studies in the next decade,
   JET Symposium, Berkeley, June 18, 2010

2. A. Buzzatti,
   Can dynamical expanding inhomogeneous QCD medium explain heavy jet quenching?
   JET Summer School, Berkeley, June 14-17, 2010

3. Miklos Gyulassy,
   Jet Tomography at RHIC vs LHC,
   INT-10-2A Workshop, Seattle, June 28, 2010.

4. Miklos Gyulassy,
   Holographic vs. Tomography of Hot sQGP at RHIC ad LHC,
   Hot and Cold Baryonic Matter 2010, Budapest, Aug. 16, 2010.

5. Miklos Gyulassy,
   Heavy quark energy loss,
   Hard Probes 2010, Eilat, Israel, Oct. 10-15, 2010.

6. Z. Buzzatti,
   High order Monet Carlo DGLV heavy quarkl energy loss with dynamic interaction in expanding diffuse A+A system,
   Int. workshop on Heavy Quark Production in Heavy-ion Collisions, Purdue University, Jan. 4-6, 2011.

7. A. Buzzatti,
   Heavy Quark Jet Puzzle,
   APS Spring Meeting 4/30/11, Annaheim CA.

8. M. Gyulassy,
   R_{AA} and high p_T azimuthal anisotropy,
   RBRC workshop on Jet Quenching at RHIC vs LHC in Light of Recent dAu vs pPb Controls, 4/17/2013, BNL, New York.

9. M. Gyulassy,
   Does E and A make a difference?
   Frontier of nuclear physics 2013, Guadaloupe.

10. M. Gyulassy,
    Heavy flavor probes of QGP,
    RHIC and LHC jet quenching, EMMI2013, 11/2-/2-13, LBNL, California.

11. J. Xu,
    Azimuthal jet flavor topography via CUJET with running coupling in 2+1D viscous QGP fluids,
    Hard Probes 2013, 11/4/2013, Cape Town, South Africa.

12. M. Gyulassy,
Jet flavor and azimuthal tomography in 2+1D perfect fluid QGP at RHIC and LHC,
Yukawa Institute Theoretical Physics Workshop, 12/5/2013, Kyoto, Japan.

13. J. Xu,
Azimuthal jet flavor topography via CUJET with running coupling in 2+1D viscous QGP fluids,
New Frontier in QCD 2013, YITP, Kyoto, Japan.

14. M. Gyulassy,
Will perfect fluidity of the sQGP survive in light of the BES & D+Au & p+Au data?
contributed talk at QM2014, Darmstadt, May 19-24, 2014.

15. J. Xu,
Azimuthal Jet Flavor Tomography with CUJET2.0 of Nuclear Collisions at RHIC and LHC,
student talk at Huada School on QCD 2014, Central China Normal University, Wuhan, China, June 6, 2014.

16. M. Gyulassy,
The Open Jet v2 Problem @ RHIC and LHC,
JET Collaboration Meeting, Davis, CA, June 16, 2014.

17. J. Xu,
Azimuthal Jet Flavor Tomography with CUJET2.0 of Nuclear Collisions at RHIC and LHC,
Student talk at JET Summer School 2014, University of California, Davis, CA, June 21, 2014.

18. M. Gyulassy,
In Celebration of 7 Decades of Rings of Fire (A+A) by Nagamiya-sensei,
2nd Int. Symp. on Science at J-PARC, July 17, 2014.

19. M. Gyulassy,
Initial-State Bremsstrahlung versus Final-State Hydrodynamic Sources of Azimuthal Harmonics at RHIC and LHC,
APS/JPS Joint Meeting, Waikoloa Village, HI, Oct 11, 2014

20. J. Xu,
Azimuthal Jet Flavor Tomography at RHIC and LHC via CUJET,
Joint APS/JPS Meeting, Waikoloa Village, HI, Oct 11, 2014.

21. J. Xu,
pQCD energy loss and flavor dependence in CUJET v2.0 & v3.0,
SGW2014 - The Second Sapore Gravis Workshop on Heavy Flavor and Quarkonium Production in High-Energy Heavy-Ion Collisions, Padova, Italy, Dec 12, 2014.

22. J. Xu,
Open heavy flavor at high p_T in A+A collisions (within CUJET),
Heavy Flavor Workshop, LBNL, Berkeley, CA, Jan 8, 2015.

23. M. Gyulassy,
The Strongly Coupled Quark-Gluon-Monopole Plasma (sQGMP) as viewed through jet v2 at RHIC and LHC,
The 31st Winter Workshop on Nuclear Dynamics, 25-31 January 2015, Keystone Lodge and Spa, Keystone Resort, Colorado, USA

24. M. Gyulassy,
Perspective on Large versus Small and the pA+DA+BES challenge since 2012,
RBRC Workshop Collectivity in Small Colliding Systems with High Multiplicity, BNL, March 5, 2015.

25. J. Xu,
Anisotropic Jet Quenching in semi-Quark-Gluon Plasmas with Magnetic Monopoles,
APS April Meeting 2015, Baltimore, MD, April 11, 2015.

26. J. Xu,
Anisotropic jet quenching in semi-quark-gluon plasmas with magnetic monopoles,
6th Workshop of the APS Topical Group on Hadronic Physics, Baltimore, MD, April 10, 2015.

27. M. Gyulassy,
Jet Tomography of Quark Gluon Plasmas in High Energy Nuclear Collisions,
2015 Bonner Prize session, APS April Meeting, Baltimore, MA, April 13, 2015.

28. J. Xu,
Anisotropic Jet Quenching in semi-Quark-Gluon Monopole Plasmas,
ALICE Jet Workshop 2015, Yale University, New Haven, CT, May 14, 2015.

29. Paul Romatschke,
A non-AdS/CFT bound on η/s,
talk at Xth Quark Confinement, Munich October, 2012

30. Paul Romatschke,
The Good, the Bad and the Perfect Fluid,
Talk at Garcia Collin Meeting, Mexico City, Septem- ber 2013

31. Paul Romatschke,
Modelling Heavy-Ion LHC Experiments as black hole collisions in AdS5,
Talk at New Frontiers in Dynamical Gravity, Cambridge, UK, 24-28 March 2014

32. Paul Romatschke,
Strong coupling far-from-equilibrium thermalization for 'nuclei' ,
Talk at the Approach to Equilibrium in Strongly Interacting Matter, BNL 2 -4 April 2014

33. Paul Romatschke,
Exploiting intrinsic triangular geometry in relativistic He3+Au collisions to disentangle medium properties,
Talk at Quark Matter 2014, Darmstadt, 19-24 May 2014

34. Paul Romatschke,
Colorado Group Activities,
Talk at Jet Collaboration Meeting, UC Davies, 17 - 18 June 2014

35. Paul Romatschke,
Phenomenology from AdS/CFT pre-equilibrium flow in pA and AA,
Talk at Initial Stages in Heavy-Ion Collisions, Napa Valley, 3 - 7 Dec 2014

36. Paul Romatschke,
Simulation of Black Hole Collisions in Asymptotically AdS Spacetimes,
Talk at Numerical Holography, CERN, 8 - 18 Dec 2014

37. Paul Romatschke,
Simulation of Black Hole Collisions in AdS spacetimes,
Talk at Holographic Methods for Strongly Coupled Systems, Florence, 9-30 April 2015

38. Paul Romatschke,
Extracting the shear viscosity of a high temperature hadron gas,
Talk at the 31st Winter Workshop Nuclear Dynamics, Keystone, 25 - 31 Jan 2015

39. G.Y. Qin,
Gamma-jet correlations,
invited talk at RHIC/AGS Annual Users' Meeting, June 7-11, 2010, Brookhaven National Laboratory, NY, USA.

40. G.Y. Qin,
Fluctuating initial conditions from Glauber and CGC,
talk at 2010 JET collaboration meeting, June 19-20, 2010, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.

41. Chris Coleman-Smith,
Implementing the LPM effect in a Parton Cascade,
talk at 2010 JET collaboration meeting, June 19-20, 2010, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.

42. G.Y. Qin,
Perturbative description of jet-medium interaction,
invited talk at 2010 INT workshop on "Quantifying properties of Hot QCD Matter", June 21-25, 2010, University of Washington, Seattle, WA, USA.

43. G.Y. Qin,
Interactions between jets and the hot, dense medium,
talk for hadronic physics seminar in Physics Department at McGill University, July 27, 2010, Montreal, Canada.

44. B. Müller,
Exploration of Hot QCD Matter: The Next Decade
CERN Theory Institute: The first heavy ion collisions at the LHC (HIC10), CERN, Geneva (Switzerland).

45. S.A. Bass,
The Quest for the Quark-Gluon-Plasma - from Discovery to Quantitative Exploration,
Keynote talk at the HIM conference, Daegu, South Korea.

46. B. Müller,
Parton Energy Loss in Strongly Coupled AdS/CFT,
Hard Probes 2010, Eilat (Israel).

47. G.Y. Qin,
High transverse momentum jets,
plenary talk at the 3rd Asian Triangle Heavy-Ion Conference, October 18-20, 2010, Huazhong Normal University, Wuhan, China.

48. G.Y. Qin,
QGP with hot spots,
talk at STAR Regional Meeting, Shandong University, October 22-24, Jinan, China.

49. S.A. Bass,
What do we know about the viscosity of QCD matter?
Invited plenary talk at the 6^{th} *International Conference on Physics and Astrophysics of the Quark Gluon Plasma* (ICPAQGP-2010), December 6-10 2010, Goa, India.

50. Chris Coleman-Smith,
Implementing the LPM effect in a Parton Cascade,
6^{th} *International Conference on Physics and Astrophysics of the Quark Gluon Plasma* (ICPAQGP-2010), December 6-10 2010, Goa, India.

51. G.Y. Qin,
From geometry fluctuations to harmonic flows,
invited talk at the RIKEN BNL Research Center Workshop on Initial State Fluctuations and Final-State Particle Correlations, Brookhaven National Laboratory, Upton, NY, USA, February 2-4, 2011.

52. G. Qin,
Jet shower evolution in medium and dijet asymmetry at the LHC
Quark Matter 2011, May 23-28, 2011, Annecy, France.

53. G. Qin, *Jet evolution in matter*
Lectures at the 2nd JET School & Collaboration Meeting, June 15–19, 2011, Durham, NC USA.

54. S. Cao,
Thermalization of charm quarks in infinite and finite QGP matter,
Annual JET Collaboration Meeting, June 19–20, 2011, Duke University, Durham, NC.

55. B. Müller,
Compelling open and quantitatively addressable questions requiring a next generation of RHIC,
BNL Users Meeting, June 21, 2011, Brookhaven National Laboratory, Upton, NY.

56. G. Qin,
Exploring quark-gluon plasma in relativistic heavy-ion collisions,
Invited talk, Workshop in Preparation for the Institute for Advance Studies, Huazhong USTC, Wuhan, China.

57. G. Qin,
The nuclear modification of di-jet asymmetry at the LHC,
Invited talk at Symposium on Jet Physics at RHIC and LHC, Hangzhou, China.

58. G.Qin,
The nuclear modification of dijet asymmetry at the LHC,
Selected talk at 19th Particles & Nuclei International Conference (PANIC 2011), July 24–29, 2011, MIT, Boston, USA.

59. C. Coleman-Smith,
Jet Modification in a Brick of QGP Matter,
talk at 19th Particles & Nuclei International Conference (PANIC 2011), July 24–29, 2011, MIT, Boston, USA.

60. B. Müller,
Jets in the QGP: What do we want to know? What should be measured?
PHENIX Decadal Planning Workshop, September 9, 2011, BNL, Upton, NY.

61. S.A. Bass,
High Energy-Density QCD Matter,
Invited talk at the XLI International Symposium on Multiparticle Dynamics (ISMD 2011), September 26–30, 2011, Miyajima Island, Hiroshima, Japan.

62. B. Mueller,
Future challenges of heavy ion physics,
Workshop on Future Directions of High Energy QCD, October 20-22, 2011, RIKEN Nishina Research Center, Wako-shi, Japan.

63. D.-L.Yang,
Jet Quenching and Holographic Thermalization,
INT Program 11-3: Frontiers in QCD, September 19 – November 18, 2011, Institute of Nuclear Theory, Seattle, WA.

64. S.A. Bass,
What do we know about the viscosity of QCD matter?,
Invited talk at the 7th International Workshop on the Critical Point and Onset of Deconfinement (CPOD 2011), November 7-11, 2011, CCNU, Wuhan, China.

65. C. Coleman-Smith,
Dijets at RHIC with VNI/BMS,
RHIC Jets Workshop, 2 March 2012, Duke, NC, USA

66. G.-Y. Qin,
Jet modification at RHIC ,

Talk at the Workshop on JET@RHIC, Duke University, Durham, NC, USA, March 3-4, 2012.

67. S. Cao,
Thermalization of Charm Quarks in Infinite and Finite QGP Matter,
11th International Conference on Nucleus-Nucleus Collisions, San Antonio, USA.

68. B. Müller,
No Pain, No Gain: Hard Probes of the QGP Coming of Age (Opening Lecture),
International Conference on Hard Probes 2012, Cagliari, Italy.

69. C. Coleman-Smith,
What can we learn from the Dijets? A systematic study at RHIC and the LHC with VNI/BMS,
Hard Probes 2012, 27-01 May/June 2012, Caligari, Sardina, Italy

70. S.A. Bass,
What do we know about the viscosity of QCD matter?,
Invited talk at the Symposium on Contemporary Subatomic Physics, June 12-14, 2012, Montreal, Canada.

71. D.-L. Yang,
Jet Quenching and Holographic Thermalization ,
Parallel talk at the 11th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2012), St. Petersburg, FL, USA, May 29 - June 3, 2012.

72. G.-Y. Qin,
Jet modification in dense nuclear matter
Invited talk at the 11th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2012), St. Petersburg, FL, USA, May 29 - June 3, 2012.

73. B. Müller,
Jets as QCD Matter Probes (Summary Lecture)
Workshop on Jet Modification in the RHIC and LHC Era, Wayne State University, Detroit, MI.

74. S. Cao,
Heavy Quark Evolution and Flow in Hot and Dense Medium
Quark Matter 2012, 12-18 August 2012, Washington D.C, USA

75. C. Coleman-Smith,
Systematic Monte-Carlo studies of dijets at the LHC and RHIC
Quark Matter 2012, 12-18 August 2012, Washington D.C, USA

76. D.-L. Yang,
Jet Quenching and Holographic Thermalization (Poster)
Quark Matter 2012, 12-18 August 2012, Washington D.C, USA

77. B. Müller,
Exploring the sQGP with Relativistic Heavy Ions at LHC and RHIC
XXXV Reunião de Trabalho sobre Fisica Nuclear, Maresias, SP, Brasil.

78. S.A. Bass,
A Decade of Quark-Gluon-Plasma Physics: what have we learned and what does the future hold?
Invited lecture at the Kobayashi-Maskawa Institute for the Origin of Particles and the Universe (KMI), Nagoya, Japan.

79. S.A. Bass,
What do we know about the viscosity of QCD matter?
Invited talk at the Nagoya Mini-Workshop 2012 on the Phenomenology and Experiments at RHIC and LHC, September 25-26 2012, Nagoya, Japan.

80. B. Müller,
The Exploration of Hot QCD Matter: Insights and Open Questions
Symposium on Hot Topics in Hot Matter, Weizmann Institute, Rehovot, Israel.

81. S. Cao,
Heavy Quark Energy Loss in Hot and Dense Nuclear Matter
Hot Quarks 2012, 14-20 October, Copamarina, Puerto Rico, USA

82. C. Coleman-Smith,
Systematic Studies of Dijet Modification At RHIC and the LHC with VNI/BMS
Hot Quarks 2012, 14-20 October, Copamarina, Puerto Rico, USA

83. S.A. Bass *Hot and Dense QCD Matter – Unraveling the Mysteries of the Strongly Interacting Quark Gluon Plasma*
Relativistic Heavy-Ion Town Hall Meeting at the Division of Nuclear Physics fall meeting, October 24-28 2012, Newport Beach, CA, USA

84. G.-Y. Qin,
Parton transport in matter
Invited talk at the 8th International Workshop on High pT Physics at LHC (HPT2012), 21-24 October 2012, Central China Normal University, Wuhan, China.

85. D.-L. Yang,
Jet Quenching of Light Probes in Non-Equilibrium Strongly Coupled Plasmas
Talk at Non-Equilibrium and String Theory Workshop, University of Michigan, Ann Arbor, MI, USA, October 19-21, 2012.

86. G.-Y. Qin,
Correlations between jets and neutral bosons
Invited talk at the 4th Asian Triangle Heavy-Ion Conference (ATHIC 2012), Pusan, South Korea, on November 14-17, 2012.

87. S.A. Bass,
Heavy-Quark Dynamics in the QGP

Invited talk at the 5th International Workshop on Heavy Quark Production in Heavy-Ion Collisions, 14-17 November 2012, Utrecht, Netherlands.

88. B. Müller,
Quark-Gluon Plasma: From RHIC to LHC
Strong Coupling Gauge Theories in the LHC Perspective (SCGT 12), Kobayashi-Maskawa Institute, Nagoya, Japan.

89. S.A. Bass,
Computational Modeling of Relativistic Heavy-Ion Collisions
Lecture at the SERC 2013 School at the Variable Energy Cyclotron Centre, Kolkata, India.

90. S.A. Bass,
What do we know about the viscosity of QCD matter
Lecture at the SERC 2013 School at the Variable Energy Cyclotron Centre, Kolkata, India.

91. S.A. Bass,
Phenomenology of Jet Energy-Loss
Lecture at the SERC 2013 School at the Variable Energy Cyclotron Centre, Kolkata, India.

92. S.A. Bass,
A Decade of QGP Physics: What have we learned and what does the future hold?
Lecture at the SERC 2013 School at the Variable Energy Cyclotron Centre, Kolkata, India.

93. S.A. Bass,
Heavy Quark Dynamics in the QGP
Invited talk at the International Workshop on Frontiers in Nuclear Physics, Guadaloupe, France.

94. B. Müller,
Investigation of hot QCD matter with relativistic heavy ions
Nobel Symposium on LHC Results, Uppsala, Sweden,

95. S. Cao,
Heavy Quark Energy Loss and Hadronization in a QGP Medium
invited talk at 2013 RHIC & AGS Annual Users' Meeting, Brookhaven National Lab, USA.

96. S.A. Bass,
A brief History of Hybrid Hydro+Micro Transport Models
Invited talk at the Workshop on Particle Sampling on the Cooper-Frye transition surface, Schmitten, Germany.

97. B. Müller,
The exploration of hot and cold nuclear matter
Nuclear Physics Summer School, Central China Normal University, Wuhan, China.

98. B. Müller,
High energy nuclear collisions: The future
Future Trends in High Energy Nuclear Collisions, Beijing, China.

99. C.E. Coleman-Smith,
The Parton Cascade Model and Jet Quenching in Heavy Ion Physics
2nd Workshop on Jet Modification in the RHIC and LHC Era, Wayne State University Detroit.

100. C.E. Coleman-Smith,
What can we learn from modified jets in Heavy Ion collisions?
9th International Workshop on High-pT physics at the LHC, Grenoble, France.

101. S. Cao,
Heavy Flavor Dynamics and Angular De-correlation in a QGP Medium
invited talk at the Workshop on Heavy Flavor Correlations in Nuclear Collisions, Bergen, Norway.

102. J. Scott Moreland,
Heavy Quark Propagation in a Linearized Boltzmann Description
2013 DNP fall meeting of the APS, Newport News, VA, USA.

103. S. Cao,
Dynamical Evolution, Hadronization and Angular De-correlation of Heavy Flavor in Hot and Dense QCD Matter at RHIC and LHC
Hard Probes 2013, Cape Town, South Africa.

104. B. Müller,
The physics of QCD matter: Challenges and opportunities
YITP Workshop on New Frontiers in QCD, Yukawa Institute, Kyoto University, Kyoto, Japan.

105. S.A. Bass,
Heavy Quark Dynamics in the QGP
YITP Workshop on New Frontiers in QCD, Yukawa Institute, Kyoto University, Kyoto, Japan.

106. M. Nahrgang,
Theory: Heavy quark production
invited overview talk, STAR Collaboration meeting, FIAS, Frankfurt, Germany.

107. S. Cao,
Heavy-flavor Evolution in QGP and Hadron Gas: Suppression, Flow and Angular De-correlation
Quark Matter 2014, Darmstadt, Germany.

108. M. Nahrgang,
Correlations and higher-order flow: new heavy-quark observables in relation to the bulk dynamics
Quark Matter 2014, Darmstadt, Germany.

109. S. Cao,
Heavy Flavor Dynamics in QGP and Hadron Gas
INT Workshop on Heavy Flavor and Electromagnetic Probes in Heavy Ion Collisions, Seattle, USA.

110. S.A. Bass,
Heavy Quark Dynamics in the QGP
Workshop on Heavy Quark Physics in Heavy-Ion collisions: experiments, phenomenology and theory, March 16th - March 20th, ECT*, Trento, Italy.

111. S.A. Bass,
Heavy Quark Dynamics in a Hot and Dense QCD Medium
2015 JET Symposium, June 26th - 27th, Montreal, Canada.

112. M. Strickland,
Testing dissipative hydrodynamics using exact solutions of the Boltzmann equation,
sQGP and extreme QCD workshop, Kavli Institute for Theoretical Physics, Beijing, China, June 2015.

113. M. Strickland,
Non-perturbative reorganization of viscous hydrodynamics,
Fourth Joint Meeting of the Nuclear Physics Divisions of the American Physical Society and The Physical Society of Japan, Kona, Hawaii, October 2014.

114. M. Strickland,
Anisotropic Hydrodynamics (Three Lectures),
Cracow School of Theoretical Physics, Zakopane, Poland, June 2014.

115. M. Strickland,
Second-Order Anisotropic Hydrodynamics,
New Frontiers in QCD 2013, Yukawa Institute for Theoretical Physics, Kyoto, Japan, November 2013.

116. M. Strickland,
Anisotropic Hydrodynamics,
International Conference on the Initial Stages in High-Energy Nuclear Collisions, Illa da Toxa, Spain, September 2013.

117. M. Strickland,
Anisotropic Hydrodynamics (Three Lectures),
JET Summer School, Ohio State University, June 2013.

118. I. Vitev,
The GLV approach and next-to-leading order calculations, JET collaboration meeting, June 2010, LBNL, Berkeley, CA

119. I. Vitev,
Lecture 1: Introduction, color algebra, cross sections and decay rates,
JET summer school, June 2010, LBNL, Berkeley, CA

120. I. Vitev,
Lecture 2: Collisional Interactions of Partons and Particles in Nuclear Matter,
JET summer school, June 2010, LBNL, Berkeley, CA

121. I. Vitev,
Lecture 3: Medium-induced bremsstrahlung, LPM effects, applications to jet quenching,
JET summer school, June 2010, LBNL, Berkeley, CA

122. I. Vitev,
Lecture 4: Inclusive & tagged jets, jet shapes and cross sections in nuclear collisions,
JET summer school, June 2010, LBNL, Berkeley, CA

123. R. B. Neufeld,
Tagged jets and jet reconstruction as a probe of QGP induced partonic energy loss,
JET Workshop in Prague, The Emauzy Abbey, Prague, Czech Republic, August 12-14, 2010.

124. R. B. Neufeld,
Tagged jets and reconstructed jets as a probe of hot and dense QCD matter,
Hard Probes, Eilat, Israel, October, 10-15, 2010.

125. R. B. Neufeld,
Theoretical advances in understanding jet and open heavy flavor production,
Fall meeting of the APS Division of Nuclear Physics, Santa Fe, New Mexico, November, 2-6, 2010

126. R. B. Neufeld,
NLO calculations of the dijet asymmetry for sPHENIX,
Mini SPHENIX workshop, Duke University, Duke, NC

127. G. Ovanesyan,
Effective Theory for jets in medium,
Meeting of division of particles and fields of the American Physical Society, Providence, August 2011.

128. I. Vitev,
The Energy Frontier, Heavy Ions at the LHC,
Invited overview talk atthe QCD workshop, APS Division of Nuclear Physics Meeting, October 2011, East Lansing, MI.

129. I. Vitev,
Next-to-leading order analysis of inclusive jet, tagged jet and di-jet production in Pb+Pb collisions at the LHC,
Invited talk at the international conference Quark Matter 2011, May 2011, Annacy, France.

130. G. Ovanesyan,
Angular distributions of partons inside the parton shower: from vacuum to dense QCD matter,
Winter Workshop on Nuclear Dynamics 2013, Squaw Valley, CA, February, 2013.

131. G. Ovanesyan,
Medium-induced splitting kernels from SCETG,
Quark Matter 2012, Washington D.C., August 2012

132. G. Ovanesyan,
Electroweak radiative corrections and unitarity of Standard Model,
SCET Workshop 2012, Madrid, Spain, March 2012

133. H. Xing,
Cold nuclear matter effects in p+A collisions,
Invited talk, PHENIX collaboration, Los Alamos National Laboratory, NM, October 2012.

134. I. Vitev,
The Z-tagged jet event asymmetry at LHC,
Winter workshop on nuclear dynamics, Puerto Rico, April 2012

135. I. Vitev,
Jet probes of QCD matter,
Quark Matter 2012 , Washington, DC, August 2013

136. I. Vitev,
Electroweak boson-tagged jet event asymmetries at the Large Hadron Collider,
Quark Matter 2012 , Washington, DC, August 2013

137. I. Vitev,
Hadron, photon and jet production at the LHC,
High pT at the LHC workshop, CCNU, Wuhan, China, October 2102

138. I. Vitev,
Jet Quenching,
QCD Structure I, CCNU, Wuhan, China, October 2102

139. H. Xing,
Transverse momentum broadening at next-to-leading order,
?Invited talk, JET collaboration meeting on NLO & MC, Wayne State University, MI, USA, August 22 - 23, 2013 (T2), Los Alamos National Laboratory, NM, October 2012.

140. I. Vitev,
Heavy ion physics with the sPHENIX upgrades,
sPHENIX workshop, Santa Fe, NM, February 2014

141. I. Vitev,
Selected topics in Jet Quenching,
International workshop on high p_T physics at the LHC, Grenoble, France, September 2013

142. Z. B. Kang,
Forward physics from a theoretical perspective,
Invited theory overview, STAR Meeting on eSTAR Letter of Intent, Forward-Upgrades

and Results from U+U Collisions, University of California Los Angeles, Los Angeles, CA, August 28-30, 2013.

143. Z. B. Kang,
Parton multiple scattering and small-x physics,
Invited talk, Berkeley Summer Program 2013, QCD Landscape of the Nucleon and Atomic Nuclei, Lawrence Berkeley National Laboratory, Berkeley, CA, August 12-16, 2013.

144. Z. B. Kang,
Unique opportunities in p+A collisions at RHIC and LHC,
Invited talk for Phases of QCD Matter, APS Division of Nuclear Physics 2014 Long-range plan: Joint Town Meetings on QCD, Temple University, Philadelphia, PA, September 13-15, 2014.

145. Z. B. Kang,
Energy loss and heavy flavor jet production,
The 3rd Workshop on Jet Modification in the RHIC and LHC Era, Wayne State University, Detroit, MI, August 18-20, 2014.

146. H. Xing,
Transverse momentum broadening in nuclear medium,
The 31st Winter Workshop on Nuclear Dynamics, Keystone Resort, CO, USA, January 25-31, 2015.

147. H. Xing,
NLO computations of pt-broadening and proof of twist-4 factorization,
Invited talk, Physics Opportunities at an ElecTron-Ion Collider, Yale University, CT, USA, September 22-26, 2014.

148. H. Xing,
Probing QCD dynamics of multiple parton interaction,
Invited talk, POSTDOC SUMMER SEMINAR SERIES, Los Alamos National Laboratory, NM, USA, August 13, 2014.

149. H. Xing,
Multiple scattering in cold nuclear matter,
Invited talk, Jet Collaboration Meeting 2014, UC Davis, CA, USA, June 17-18, 2014.

150. I. Vitev,
Inclusive and tagged b-jet production as a probe of heavy flavor dynamics in the QGP,
Invited talk CIPANP, Aspen, CO, May 2015

151. I. Vitev,
Jet quenching phenomenology from Soft Collinear Effective Theory with Glauber Gluons,
Winter Workshop on Nuclear Dynamics, Keystone, CO, January 2015

152. I. Vitev,
Theoretical interpretation of pA results,
ICPAQGP 2015, Kolkata, India February 2015.

153. I. Vitev,
Jet quenching phenomenology from Soft Collinear Effective Theory with Glauber Gluons,
PIETOC V Conference, Yale U, New Haven, CT September 2014

154. I. Vitev,
Jet quenching phenomenology from Soft Collinear Effective Theory with Glauber Gluons,
Joint APS-JPS Meeting, Waikoloa, HI October 2014

155. Z. Kang,
Jet quenching phenomenology form soft collinear effective theory with Glauber gluons,
JET symposium, McGill University, Montreal, Canada June 2015.

156. H. Xing,
Photon-tagged and B-meson-tagged b-jet production at the LHC,
Hard probes 2015 McGill University, Montreal, Canada June 2015.

157. U. Heinz,
Hydrodynamics at RHIC (ideal and viscous): Where it works, where and how it breaks down, and why,
invited lecture at the *Berkeley School on Collective Dynamics in High-Energy Collisions*, LBNL, June 7-11, 2010.

158. A. Majumder,
Alternate mechanisms of charge separation in heavy-ion collisions,
invited talk, Workshop on *Local Strong Parity Violation*, 2010 RHIC & AGS Annual Users' Meeting, BNL, 6/7/2010.

159. W. A. Horowitz,
Theory update on energy loss,
invited talk, 2010 RHIC & AGS Users' Meeting, BNL, 6/8/2010.

160. Guang-You Qin,
Gamma-jet correlations,
invited talk, 2010 RHIC & AGS Annual Users' Meeting, BNL, June 7-11, 2010.

161. H. Song,
Results from viscous hydrodynamics coupled to UrQMD,
invited talk, INT Workshop on *Quantifying the Properties of Hot QCD Matter*, Institute for Nuclear Theory, University of Washington, 6/14/2010.

162. A. Majumder,
The factorized approach to jet modification,
invited talk, Symposium on *Jet and Electromagnetic Tomography of Dense Matter*, LBNL, 6/18/2010.

163. H. Song,
Viscous hydrodynamics + UrQMD – medium for JET,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.

164. W. A. Horowitz,
Theory comparisons,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.

165. Guang-You Qin,
Fluctuating initial conditions from Glauber and CGC models,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.

166. A. Majumder,
The Higher Twist approach,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.

167. A. Majumder,
Heavy-flavor suppression in Higher Twist,
report, 1st JET Collaboration Meeting, LBNL, 6/19/2010.

168. H. Song,
Parton shower simulation in the Higher Twist formalism,
report, 1st JET Collaboration Meeting, LBNL, 6/20/2010.

169. W. A. Horowitz,
RHIC challenges and LHC Outlook,
invited talk, INT Workshop on Quantifying the Properties of Hot QCD Matter, Institute for Nuclear Theory, University of Washington, 6/21/2010.

170. A. Majumder,
The Higher twist approach to jet modification,
invited talk, INT Workshop on *Quantifying the properties of Hot QCD Matter*, Institute for Nuclear Theory, University of Washington, 6/21/2010.

171. Guang-You Qin,
Perturbative description of jet-medium interaction,
invited talk, INT Workshop on Quantifying the properties of Hot QCD Matter, Institute for Nuclear Theory, University of Washington, 6/24/2010.

172. W. A. Horowitz,
Energy loss mechanisms and jet physics,
invited talk, PHENIX Collaboration Meeting, Iowa State University, 7/12/2010.

173. W. A. Horowitz,
Heavy ion physics and Electron Ion Colliders,
Electron-Ion Collider Collaboration Meeting, Catholic University of America, 7/29/2010.

174. A. Majumder,
A factorized approach to hard jet modification in dense matter,
invited talk at the International Workshop on *High Energy Strong Interactions (HESI 2010)*, Yukawa Institute, Kyoto University, Kyoto, Japan, 8/2/2010.

175. U. Heinz,
The QCD brick problem,
invited talk, International Workshop on *Jets in Proton-Proton and Heavy-Ion Collisions*, Prague, Aug. 12-14, 2010.

176. U. Heinz,
Status of viscous hydrodynamics and the extraction of $(\eta/s)_{\rm QGP}$ *from experimental data*,
opening talk, CERN Theory Institute on *The first heavy ion collisions at the LHC (HIC10)*, CERN, 8/16/2010.

177. A. Majumder,
A factorized approach to hard jet modification in dense matter,
talk at the CERN Theory Institute on *The first heavy ion collisions at the LHC (HIC10)*, CERN, 9/2/2010.

178. Zhi Qiu,
Scaling in viscous hydrodynamics,
talk at the 2010 Midwest Theory Get-Together, Argonne National Laboratory, 9/10/2010.

179. W. A. Horowitz,
The EIC, heavy quarks, and QGP phenomenology,
invited talk, INT Workshop on *Gluons and the quark sea at high energies: distributions, polarization, tomography*, Institute for Nuclear Theory, University of Washington, 10/4/2010.

180. A. Majumder,
Using hard jets to study soft matter at the EIC,
invited talk, INT Workshop on *Gluons and the quark sea at high energies: distributions, polarization, tomography*, Institute for Nuclear Theory, University of Washington, 10/12/2010.

181. U. Heinz,
Quark Soup – The Perfect Liquid? invite overview talk in the KITPC Program on *AdS/CFT and Novel Approaches to Hadron and Heavy Ion Physics*, KITPC, Beijing, 10/14/2010.

182. U. Heinz,
Viscous hydrodynamics and the extraction of $(\eta/s)_{\rm QGP}$ *from heavy-ion collision data*,
invited talk, *3rd Asian Heavy-Ion Triangle Conference (ATHIC2010)*, Institute of Particle Physics, Huazhong Normal University, Wuhan, China, 10/19/2010.

183. Zhi Qiu,
Scaling in viscous hydrodynamics, and robust viscous hydro,
talk at the *2010 Midwest Critical Mass* conference, University of Toledo, Toledo, OH, 10/23/2010.

184. U. Heinz,
From the sparking vacuum to the perfect QGP liquid – aspects of strongly coupled quantum field systems,
invited talk, Symposium *From Strong Fields to Colorful Matter*, Asheville, NC, 10/26/2010.

185. A. Majumder,
The study of soft color fields with hard jets in DIS and heavy-ion collisions,
contributed talk, Symposium *From Strong Fields to Colorful Matter*, Asheville, NC, 10/26/2010.

186. J. S. Moreland,
Fluctuating initial conditions in viscous hydrodynamics,
poster, CEU Conference at the 2010 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM, Nov. 2-6, 2010.

187. A. Majumder,
Jet modification in dense matter via leading hadrons,
invited opening talk for the Mini-Symposium on *Lessons from Leading Particle Jet Energy Loss* at the 2010 Fall Meeting of the APS Division of Nuclear Physics, Santa Fe, NM, Nov. 2-6, 2010.

188. U. Heinz,
Event-by-event shape and flow fluctuations in RHIC fireballs,
invited talk, RIKEN/RBRC Workshop on *Initial-State Fluctuations and Final-State Particle Correlations*, BNL, 2/04/2011.

189. U. Heinz,
Elliptic flow from RHIC to LHC,
Workshop on *Heavy Ions at the LHC: a first assessment*, CERN, 3/4/2012.

190. Chun Shen,
Viscous hydrodynamic radial and elliptic flow from RHIC to LHC,
APS April Meeting, Mini-symposium on *Early-Time and Long-Range Correlations in Relativistic Heavy Ion Collisions*, Anaheim, CA, 4/30/2011.

191. Huichao Song,
Viscous QCD matter at RHIC and LHC energies: Results from viscous hydrodynamics + hadron cascade,
poster (presented by U. Heinz), *Quark Matter 2011*, Annecy, France, May 23-28, 2011.

192. A. Majumder,
Twist expansion of QCD processes and jet propagation in dense matter,
3 lectures presented at the *2011 JET Summer School*, Duke University, June 15-17, 2011.

193. U. Heinz,
Bulk evolution and JET interface,
2nd JET Collaboration Meeting, Duke University, June 17-19, 2011.

194. A. Majumder,
Developments in the theory of parton energy loss,
2nd JET Collaboration Meeting, Duke University, June 17-19, 2011.

195. U. Heinz,
VISHNU a dynamical evolution model for heavy-ion collisions,
invited talk, 2011 RHIC&AGS Annual Users' Meeting, BNL, June 20-24, 2011.

196. U. Heinz,
Thoughts on a RHIC research program for the next decade,
contribution to the panel discussion *The Future of RHIC* at the 2011 RHIC&AGS Annual Users' Meeting, BNL, June 20-24, 2011.

197. U. Heinz,
The quark-gluon plasma shear viscosity from RHIC to LHC,
International Workshop on *Non-equilibrium Dynamics*, Heraklion, Crete, Aug. 31 Sep. 3, 2011.

198. Zhi Qiu,
Event-by-event hydrodynamic calculations for heavy-ion collisions,
Mid-Western Theory Get-Together, Argonne National Laboratory, 9/21/2011.

199. D. White,
Early flow from matching pre-equilibrium dynamics to viscous hydrodynamics,
Mid-Western Theory Get-Together, Argonne National Laboratory, 9/21/2011.

200. Chun Shen,
Viscous elliptic and triangular flows at the LHC,
Mid-Western Theory Get-Together, Argonne National Laboratory, 9/22/2011.

201. U. Heinz,
The shear viscosity of quark-gluon plasma at RHIC & LHC,
invited keynote talk, *DNP11 Mini-Symposium: From RHIC to LHC – Lessons Learned about the QGP*, Michigan State University, East Lansing, 26-29 Sep. 2011.

202. Zhi Qiu,
Event-by-event viscous hydrodynamics for RHIC and LHC,
contributed talk, *DNP11 Mini-Symposium: From RHIC to LHC – Lessons Learned about the QGP*, Michigan State University, East Lansing, 26-29 Sep. 2011.

203. Daniel White,
Early flow from matching pre-equilibrium dynamics to viscous hydrodynamics,
contributed talk , *DNP11 Mini-Symposium: From RHIC to LHC – Lessons Learned about the QGP*, Michigan State University, East Lansing, 26-29 Sep. 2011.

204. Huichao Song,
Hydrodynamics in heavy ion collisions,
invited lecture, *International School for High-Energy Nuclear Collisions*, Wuhan, China, Oct. 31 - Nov. 6, 2011.

205. Huichao Song,
QGP viscosity at RHIC and LHC energies,
7th International Workshop on Critical Point and Onset of Deconfinement, Wuhan, China, Nov. 7-11, 2011.

206. U. Heinz,
Initial shape and final flow fluctuations in event-by-event hydrodynamics for RHIC and LHC,
invited talk, International Workshop *Exploring QCD Frontiers: From RHIC and LHC to EIC*, Stellenbosch, South Africa, Jan. 30 - Feb. 3, 2012.

207. Chun Shen,
Hydrodynamic flows from RHIC to LHC,
contributed talk, *2012 Edward F. Hayes Graduate Research Forum*, Ohio State University, 2/24/2012.

208. Zhi Qiu,
The shear viscosity of quark-gluon plasma extracted from heavy-ion collisions,
contributed talk, *2012 Edward F. Hayes Graduate Research Forum*, Ohio State University, 2/24/2012.

209. U. Heinz,
Phenomenological limits on QGP shear viscosity and what they imply for QGP thermalization,
Workshop Program on *Gauge Field Dynamics In and Out of Equilibrium (INT-12-1)*, Institute for Nuclear Theory, 3/19/2012.

210. U. Heinz,
How perfect is 'perfect'? The Quark-Gluon Plasma at RHIC & LHC,
invited plenary talk, *11th International Conference on Nucleus-Nucleus Collisions (NN2012)*, San Antonio, TX, May 27 - June 1, 2012.

211. Huichao Song,
QGP viscosity at RHIC and LHC,
invited talk, *Eleventh Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2012)*, St. Petersburg, FL, May 29-June 3, 2012.

212. U. Heinz,
Quark-gluon plasma – the perfect liquid,
invited talk, Symposium on *Contemporary Subatomic Physics*, McGill University, June 12-14, 2012.

213. U. Heinz,
Perfect fluidity in relativistic heavy-ion collisions,
invited talk, EMMI Workshop on *Relaxation, Turbulence and Non-Equilibrium Dynamics of Matter Fields (RETUNE 2012)*, Heidelberg, Germany, June 21-24, 2012.

214. Zhi Qiu,
Reducing initial condition ambiguities using multiple measured anisotropic flows,

invited talk, workshop on *Initial State Fluctuations and Final State Correlations in Heavy-Ion Collisions*, ECT*, Trento, July 1-6, 2012.

215. U. Heinz,
Initial state fluctuations and final state flows in heavy-ion collisions,
invited talk, workshop on *Initial State Fluctuations and Final State Correlations in Heavy-Ion Collisions*, ECT*, Trento, July 1-6, 2012.

216. J. S. Moreland,
Imprinting quantum fluctuations on hydrodynamic initial conditions,
poster presentation, DOE Stewardship Science Graduate Fellowship Conference, Washington, DC, July 26-27, 2012.

217. U. Heinz,
Theory flow overview: Describing the evolving medium in heavy-ion collisions,
invited talk, QM12 Satellite Workshop *Jet Modification in the RHIC and LHC Era*, Wayne State University, August 20-23, 2012.

218. U. Heinz,
Quark-gluon-plasma: the perfect liquid phase of QCD,
invited overview talk, International Workshop on *Quantum Chromodynamics: History and Prospects*, Oberwölz, Austria, Sep. 3-8, 2012.

219. Zhi Qiu,
Flows from event-by-event hydrodynamical simulations for relativistic heavy-ion collisions,
contributed talk, 25th Annual Midwest Theory Get-Together, Argonne National Laboratory, 9/7/2012.

220. Jia Liu,
Matching pre-equilibrium dynamics to viscous hydrodynamics,
contributed talk, 25th Annual Midwest Theory Get-Together, Argonne National Laboratory, 9/8/2012.

221. Chun Shen,
Thermal photon emission with partial chemical equilibrium equation of state,
contributed talk, 25th Annual Midwest Theory Get-Together, Argonne National Laboratory, 9/8/2012.

222. U. Heinz,
Towards the Little Bang Standard Model,
invited talk, International Workshop on *Discovery Physics at the LHC (Kruger2012)*, Krueger Park, South Africa, Dec. 3-7, 2012.

223. Christopher Plumberg,
HBT inteferometry with respect to the 3rd-order event plane,
contributed talk, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

224. Ulrich Heinz,
Flow angle fluctuations and anisotropic flow measures,
contributed talk, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

225. Zhi Qiu,
Hydrodynamic event-plane correlations in Pb+Pb collisions at the LHC,
contributed talk, *Ohio Section of the APS Spring Meeting*, Ohio University, Athens, OH, March 30, 2013.

226. Ulrich Heinz,
Fluctuations, flow and viscosity in the Little Bang,
invited talk, RBRC Workshop *Jet quenching at RHIC vs. LHC in Light of Recent dAu vs. pPb Controls*, Brookhaven National Laboratory, April 15-17, 2013.

227. Ulrich Heinz,
Hydrodynamics for Relativistic Heavy-Ion Collisions,
invited lecture series (three 90-minute lectures) at the *11th Korean Nuclear Physics School*, Jeju Island, South Korea, June 24-28, 2013.

228. Zhi Qiu,
Knee structure in the elliptic flow from hydrodynamic simulations for U+U collisions,
invited talk, Workshop on *U+U and Cu+Au shape studies at RHIC*, *2013 RHIC & AGS Users Meeting*, Brookhaven National Laboratory, June 26, 2013.

229. Ulrich Heinz,
Towards the Little Bang Standard Model,
invited talk,*2013 Heavy Ion Meeting*, Jeju National University, Korea, June 28, 2013.

230. Ulrich Heinz,
Hydrodynamics for Relativistic Heavy-Ion Collisions,
invited lecture series (three 90-minute lectures) at the *Peking Summer School for Phenomena & Theories in Heavy Ion Physics*, Peking University, Beijing, July 1-5, 2013.

231. Chun Shen,
Improved sampling procedure in iEBE+VISHNU,
invited talk, *Workshop on Sampling Particles on the Cooper-Frye Transition Surface (Sampling 2013)*, Frankfurt, Germany, July 18, 2013.

232. Ulrich Heinz,
Uncertainties in the underlying e-by-e viscous fluid simulation,
invited talk, *Jet Workfest*, Wayne State University, Aug. 24-25, 2013.

233. Ulrich Heinz,
U+U Collisions from Hydrodynamics,
invited talk, *STAR Collaboration Meeting*, UCLA, Aug. 30, 2013.

234. Dennis Bazow,
Ellipsoidal anisotropic hydrodynamics,

contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 6, 2013.

235. Chun Shen,
Thermal photons as a quark-gluon plasma thermometer?
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 6, 2013.

236. Christopher Plumberg,
HBT inteferometry with respect to the 3rd-order event plane,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

237. Andy Goldschmidt,
Knee structure in elliptic flow from hydrodynamic U+U collisions,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

238. Amy Weisman,
Initial conditions for asymmetric Cu+Au collisions,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

239. Jia Liu,
Importance of pre-equilibrium dynamics in heavy-ion collisions,
contributed talk, *Midwestern Theory Get-Together 2013*, Argonne National Laboratory, September 7, 2013.

240. Ulrich Heinz,
The Little Bang fluctuation spectrum,
invited opening talk, *9th International Workshop on Relativistic Aspects of Nuclear Physics (RANP 2013)*, Rio de Janeiro, Sep. 23-27, 2013.

241. Ulrich Heinz,
Electromagnetic fingerprints of the Little Bang,
invited plenary talk, *Hard Probes 2013*, Stellenbosch, South Africa, Nov. 3-8, 2013.

242. Chun Shen,
Anisotropic flow of thermal photons as a quark-gluon plasma viscometer,
selected parallel talk, *Hard Probes 2013*, Stellenbosch, South Africa, Nov. 3-8, 2013.

243. Christopher Plumberg,
HBT inteferometry with respect to the 3rd-order event plane,
invited talk, *IX Workshop on Particle Correlations and Femtoscopy (WPCF 2013)*, Catania, Sicily, November 8, 2013.

244. Ulrich Heinz,
The Little Bang Standard Model,
invited talk, *New Frontiers in QCD 2013 (NFQCD 2013)*, Kyoto, Dec. 2-6, 2013.

245. Chun Shen,
Photon emission from viscous hydrodynamics in relativistic heavy-ion collisions,
invited talk, *EMMI Rapid Reaction Task Force on the Direct Photon Flow Puzzle*, GSI, Darmstadt, Germany, Feb. 24, 2014.

246. D. Bazow,
Viscous hydrodynamics for systems undergoing strongly anisotropic expansion,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

247. J. Liu,
Free-streaming limit of pre-equilibrium evolution in heavy-ion collisions,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

248. M. Martinez,
Next-to-eikonal corrections to the shock wave in QCD,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

249. C. Plumberg,
3rd order HBT interferometry and event-by-event fluctuations,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

250. C. Shen,
Thermal photons as a quark-gluon plasma thermometer revisited,
contributed talk, *Midwest Critical Mass 2014*, University of Toledo, Ohio, March 8, 2014.

251. U. Heinz,
Viscous fluid dynamics for anisotropically expanding fireballs,
invited talk, RBRC Workshop *The Approach to Equilibrium in Strongly Interacting Matter*, Brookhaven National Laboratory, April 2-4, 2014.

252. U. Heinz,
A Standard Model for the Little Bang – how far are we from the goal?,
invited talk, International Workshop on *Hydrodynamics of Strongly Coupled Fluids*, ECT*, Trento, May 12-16, 2014.

253. U. Heinz,
Thoughts on opportunities from high-energy nuclear collisions,
invited talk, *Think Tank on the Future of Relativistic Heavy-Ion Physics*, Mont Sainte Odile, France, May 24-26, 2014.

254. U. Heinz,
Viscous relativistic hydrodynamics for heavy-ion collisions,
ten 90-minute lectures at the *2014 Huada School on QCD*, IOPP, Wuhan, China, June 10-14, 2014.

255. U. Heinz,
The Little Bang Standard Model,
invited talk, International Symposium on *The Frontier of Hadron Physics – Celebrating Al Mueller's 75th Birthday*, Center for Nuclear Matter Science, Wuhan, China, June 14-15, 2014.

256. C. Shen,
The iEBE program package,
invited talk, *2014 JET Collaboration Meeting*, UC Davis, June 17-18, 2014.

257. U. Heinz,
Hydrodynamics,
three 1-hour lectures at the *2014 JET Summer School*, UC Davis, June 19-21, 2014.

258. C. Plumberg,
HBT interferometry with respect to the triangular flow-plane,
student talk, *2014 JET Summer School*, UC Davis, June 21, 2014.

259. C. Shen,
Thermal photon emission in relativistic heavy-ion collisions,
student talk, *2014 JET Summer School*, UC Davis, June 21, 2014.

260. C. Plumberg,
How to measure a distribution of HBT radii,
contributed talk, MADAI Workhop *Toward quantitative conclusions for heavy-ion collisions*, NCSL, Michigan State University, July 8, 2014.

261. C. Shen,
The iEBE program package,
invited talk, MADAI Workhop *Toward quantitative conclusions for heavy-ion collisions*, NCSL, Michigan State University, July 8, 2014.

262. M. Martinez,
Decoherence between the initial and final state radiation in a dense QCD medium,
contributed talk, *3rd Workshop on Jet Modification in the RHIC and LHC Era*, Wayne State University, Detroit, Michigan, August 19, 2014.

263. C. Shen,
Photon tomography of relativistic heavy-ion collisions,
invited talk, RBRC Workshop on *Thermal Photons and Dileptons in Heavy-Ion Collisions*, Brookhaven National Laboratory, Aug. 20-22, 2014.

264. A. Goldschmidt,
Orientation resolution in U+U collisions,
invited talk, *International Workshop on Particle Correlations and Femtoscopy (WPCF 2014)*, Károly Róbert College, Gyöngyös, Hungary, August 26, 2014.

265. C. Plumberg,
How to measure a distribution of HBT radii (and why you might want to),

contributed talk, *27th Annual Midwest Theory Get Together*, Argonne National Laboratory, Sep. 5, 2014.

266. J. Liu,
Towards phenomenological limits on the thermalization time in relativistic heavy-ion collisions,
contributed talk, *27th Annual Midwest Theory Get Together*, Argonne National Laboratory, Sep. 5, 2014.

267. M. Martinez,
A new exact solution to the relativistic Boltzmann equation and its hydrodynamical limit,
contributed talk, *27th Annual Midwest Theory Get Together*, Argonne National Laboratory, Sep. 6, 2014.

268. U. Heinz,
Why I still don't know what we have learnt from BES I,
invited presentation, International Workshop on *Beam Energy Scan II at RHIC*, Lawrence Berkeley National Laboratory, Sep. 27-29, 2014.

269. U. Heinz,
Report from the Joint QCD Town Meeting, Philadelphia, Sep. 13-15, 2014,
invited presentation, Long Range Plan session at the 2014 Joint Fall Meeting of the APS DNP and JPS, Waikoloa, Hawaii, Oct. 7-11, 2014.

270. U. Heinz,
A standard model for the Little Bang – how far are we from the goal?
invited overview talk, Workshop on *The Future of Hydrodynamic Modeling of Relativistic Heavy Ion Collisions* at the 2014 Joint Fall Meeting of the APS DNP and JPS, Waikoloa, Hawaii, Oct. 7-11, 2014.

271. U. Heinz,
The physics of heavy-ion collisions – recent insights and open questions,
invited talk, 3rd International Workshop on *Discovery Physics at the LHC (Kruger 2014)*, Kruger Gate, South Africa, Dec. 1-6, 2014.

272. U. Heinz,
Bulk dynamics and soft observables in relativistic heavy ion collisions,
eight 1-hour lectures at the School *Frontiers in Nuclear and Hadronic Physics*, Galileo Galilei Institute for Theoretical Physics, Florence, Italy, Feb. 23-27, 2015.

273. U. Heinz,
The physics of the Little Bang,
invited overview talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

274. U. Heinz,
Constraining the quark-gluon plasma viscosity with thermal photons,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

275. K. Welsh,
Initial conditions for relativistic light-ion collisions,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

276. A. Goldschmidt,
Collision geometry and flow in U+U collisions,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

277. C. Plumberg,
Event-by-event fluctuations of HBT radii and the QGP shear viscosity,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 27, 2015.

278. D. Bazow,
Nonconformal viscous anisotropic hydrodynamics,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 28, 2015.

279. J. Liu,
Pre-equilibrium evolution effects on heavy-ion collision observables,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 28, 2015.

280. M. Martinez,
Investigating the domain of validity of the recently found new solution to the relativistic Boltzmann equation,
contributed talk, *Ohio-Region Section of the APS (OSAPS) Spring Meeting 2015*, Kent State University, Kent, Ohio, March 28, 2015.

281. A. Majumder,
The temperature dependence of jet transport coefficients,
International Conference on the Physics and Astrophysics of the Quark Gluon Plasma (ICPAQGP 2015), Invited plenary talk, Saha Institute, Kolkata India, Feb. 1-6, 2015.

282. A. Majumder,
The temperature dependence of jet transport coefficients,
Division of Nuclear Physics of the APS, annual fall meeting 2014, Invited talk, Kona, HI, Oct. 6-10, 2014.

283. A. Majumder,
Calculating Jet Transport Coefficients in Lattice QCD,
APS Division of Nuclear Physics, Long range plan joint town meetings on QCD,brief contribution, Temple University, Philadelphia PA, Sept. 13-15, 2014.

284. A. Majumder,
Topical Collaborations and Graduate Education,
APS Division of Nuclear Physics, Long range plan meeting on education and innovation, Invited talk, Michigan State University, Lansing, MI, Aug 6-8, 2014.

285. A. Majumder,
Progress in the Monte-Carlo simulation of jets and jet quenching,
JET collaboration meeting, University of California Davis, CA, June 17-18, 2014.

286. A. Majumder,
Jet Modification as a function of energy lost and jet mass depletion,
Quark Matter 2014: The Twenty-fourth International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions, parallel talk, Darmstadt, Germany, May 19-24, 2014.

287. A. Majumder,
What remains to be done at Leading Order,
invited talk, Workshop on energy loss at NLO, Lawrence Berkeley National Laboratory, Berkeley, CA, Mar 3-14, 2014.

288. A. Majumder,
Full jet modification and transport coefficients of the Quark Gluon Plasma,
Parallel talk, Workshop on High Energy Physics and Phenomenology, 2013, Puri, India, Dec 12-21, 2013.

289. A. Majumder,
Hard Probes from RHIC to LHC and onwards to the EIC ,
Plenary talk, Workshop on High Energy Physics and Phenomenology, 2013, Puri, India, Dec 12-21, 2013.

290. A. Majumder,
Color Propagation in Nuclei JLAB12, EIC, RHIC, LHC ,
Invited talk, QCD Frontier workshop, JLAB Oct. 21-22, 2013.

291. A. Majumder,
Jet Modification in heavy-ion collisions: Theory Overview,
Invited talk, ISMD 2013, Illinois Institute of Technology, Chicago, Sept 16-20, 2013.

292. A. Majumder,
The HT-MC event generator ,
JET NLO-MC group meeting, Wayne State University, Aug 22-23, 2013.

293. A. Majumder,
The JET(HT)MC event generator and coordination ,
4th annual JET collaboration meeting, Columbus, OH, June 10-11, 2013.

294. A. Majumder,
JET Progress at Wayne State University,
4th annual JET collaboration meeting, Columbus, OH, June 10-11, 2013.

295. A. Majumder,
Jet modification in A-A, p-A and D-A at RHIC and LHC,
Invited talk, RIKEN BNL workshop on Jet Quenching at RHIC and LHC, BNL, April 15-17, 2013.

296. A. Majumder,
Calculating the jet quenching parameter $\hat{q}$ in lattice gauge theory ,
Parallel talk at Hard Porbes 2012, Cagliari, Sardinia, Italy, May 27 - June 1, 2012

297. A. Majumder,
First principles modification of full jets at the LHC: the brick road to Geneva from Monte-Carlo,
Invited talk at Heating nuclei, boiling black holes and burning rubber: a symposium on contemporary subatomic physics, McGill University, Montreal, QC Canada, Jun 11-14, 2012.

298. A. Majumder,
Developments in the theory of parton energy loss (Year 2),
3rd annual JET collaboration meeting, McGill University, Montreal, QC Canada, Jun 14-15, 2012

299. A. Majumder,
Calculating the jet quenching parameter $\hat{q}$ in lattice gauge theory ,
Parallel talk at Quark Matter 2012, Washington, D.C. Aug 11-18, 2012.

300. A. Majumder,
Jet Tomography at Lower Energies and the temperature dependence of Jet transport coefficients ,
Invited talk, annual DNP meeting of the APS, New Port Beach, CA, Oct 24-27, 2012.

301. A. Majumder,
Correlations between jets and neutral bosons ,
Invited talk at the 4th Asian Triangle Heavy-Ion Conference (ATHIC 2012), Pusan, South Korea, on November 14-17, 2012.

302. A. Majumder,
Parton transport in matter ,
Invited talk at the 8th International Workshop on High pT Physics at LHC (HPT2012), 21-24 October 2012, Central China Normal University, Wuhan, China.

303. A. Majumder,
Jet modification in dense nuclear matter ,
Invited talk at the 11th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2012), St. Petersburg, FL, USA, May 29 - June 3, 2012.

304. A. Majumder,
Jet modification at RHIC ,
Talk at the Workshop on JET@RHIC, Duke University, Durham, NC, USA, March 3-4, 2012.

305. G.-Y. Qin,
Calculating NLO medium-modified fragmentation function,
JET Collaboration Meeting on NLO & MC, Detroit, MI, USA, August 22-24.

306. G.-Y. Qin,
Jet Medium Interaction,
2nd workshop on jet modification in the LHC & RHIC era, Detroit, MI, USA, August 20-22.

307. G.-Y. Qin,
Progress report on JET midterm Package,
JET Collaboration Meeting, Columbus, OH, June 10, 2013.

308. G.-Y. Qin,
Jet modification at RHIC,
Mini Workshop on JET@RHIC, Duke University, Durham, NC, USA, March 3-4, 2012.

309. R. Abir,
Drag induced radiative loss and the excess suppression of heavy-flavors,
Hard Probes 2015, McGill University, June 29, 2015 - July 3, 2015.

310. R. Abir,
Heavy quark energy loss,
Workshop on energy loss at NLO, Lawrence Berkeley National Laboratory, Berkeley, California, March 3-14, 2014.

311. M. Kordell,
A structure based study of initial state fluctuations in D-Au collision,
the APS April Meeting 2013, Denver, CO.

312. R. Vogt,
Quarkonium as a Tool: What Kind of Tool Would It Be?; Open Heavy Flavor Production at RHIC,
Quarkonium 2010: Three Days of Quarkonium Production in pp and pA collisions, Ecole Polytechnique, Palaiseau, France, 7/10.

313. R. Vogt,
J/ψ Production and Absorption in pA and d+Au Collisions,
talk at the $4^{\rm th}$ International Conference on Hard and Electromagnetic Probes of High Energy Nuclear Collisions, Eilat, Israel, 10/10.

314. R. Vogt,
Fraction of J/ψ production from B decays at RHIC and LHC,
APS Division of Nuclear Physics Fall Workshop, Santa Fe, NM, 11/10.

315. R. Vogt,
J/ψ production and absorption in pA and d+Au collisions,
International Workshop on Heavy Quark Production in Heavy-Ion Collisions, Purdue University, West Lafayette, IN, 1/11.

316. R. Vogt,
Estimating Uncertainties on Quarkonium production in the Color Evaporation Model,
Invited talk at Quarkonium Production: Probing QCD at the LHC, Institute of High Energy Physics, Vienna, Austria, 4/11.

317. R. Vogt,
Estimating the Uncertainty on J/ψ Production,
Invited talk at Quarkonium Production in Elementary and Heavy Ion Collisions, Brookhaven National Laboratory, Upton, NY, USA, 6/11.

318. R. Vogt,
Heavy Quark Discussion,
JET Collaboration meeting, Duke University, Durham, NC, USA, 6/11.

319. R. Vogt,
Uncertainty Quantification of Quarkonium and Heavy Flavor Production,
Invited talk at EMMI Workshop on Deconfined Matter, Acitrezza, Italy, 9/11.

320. Randy Nelson,
Determining the uncertainty on the charm cross section and the effect on the J/ψ cross section,
APS April Meeting, Atlanta, GA, USA, 3-4/12. Talk presented by UC

321. R. Vogt,
Charmonium Production,
Invited talk at 4^{th} Berkeley School of Collective Dynamics in High-Energy Collisions, LBNL, Berkeley, CA, USA, 5/12.

322. R. Vogt,
Improving the J/ψ Production Baseline at RHIC and the LHC,
5^{th} International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions, Cagliari, Sardinia, Italy, 5-6/12.

323. R. Vogt,
Heavy Flavor and Quarkonium Production at RHIC and the LHC,
Invited talk: Confinement X, 10^{th} Quark Confinement and the Hadron Spectrum, Munich, Germany, 10/12.

324. R. Vogt,
Heavy Flavor and Quarkonium Production at RHIC and the LHC,
Invited talk: Hot Topics in Hot Matter, 70^{th} Birthday Symposium for Itzhak Tserruya, Weizmann Institute, Rehovot, Israel, 10/12.

325. R. Vogt,
Predictions for $\sqrt{s_{NN}} = 5$ TeV p+Pb Collisions,
Invited talk: 8^{th} International Workshop on High p_T Physics at the LHC, Central China Normal University, Wuhan, China, 10/12.

326. R. Vogt,
Heavy Quarks and Quarkonia in pA Collisions,
Invited talk: Physics at A Fixed Target Experiment using the LHC beam, Trento, Italy, 2/13.

327. R. Vogt,
J/ψ Production in Cold Nuclear Matter,
Talk: GHP 2013, Denver, CO, USA, 4/13.

328. R. Vogt,
Predictions for p+Pb Collisions at the LHC,
Invited talk: Workshop on proton-nucleus collisions at the LHC, Trento, Italy, 5/13.

329. R. Vogt,
Open and Hidden Heavy Flavor Production in pp, pA and AA Collisions,
Invited plenary talk: Strangeness in Quark Matter, University of Birmingham, Birmingham, UK, 7/13.

330. R. Vogt,
Predictions for p+Pb Collisions at $\sqrt{s_{NN}} = 5$ TeV: Expectations vs. Data,
Talk: $6^{\rm th}$ International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions, Stellenbosch, South Africa 11/13.

331. R. Vogt,
J/ψ's Are Jazzy,
Talk: 45 Years of Nuclear Theory at Stony Brook: A Tribute to Gerald E. Brown State University of New York at Stony Brook, Stony Brook, NY, USA, 11/13.

332. R. Vogt,
Predictions for p+Pb collisions at $\sqrt{s_{NN}} = 5$ TeV: Expectations vs. data,
Talk: Quark Matter 2014, $24^{\rm th}$ International Conference on Ultrarelativistic Nucleus-Nucleus Collisions.

333. R. Vogt,
Update on p+Pb Collisions: Expectations vs. Data,
Talk: JET Collaboration Meeting and Summer School, UC Davis, Davis, CA, 6/14.

334. R. Vogt,
Quarkoniun and jet production in studies of nucleon/nuclear parton densities,
Invited talk: Future directions in forward heavy-ion physics & *The LHC Forward Physics and Diffraction WG meeting*, University of Kansas, Lawrence, KS, 9/14.

335. R. Vogt,
Quarkonium in cold nuclear matter and nuclear parton densities,
Talk: $10^{\rm th}$ International Workshop on Heavy Quarkonium, CERN, Geneva, Switzerland, 11/14.

336. R. Vogt,
Cold Nuclear Matter Effects on Open and Hidden Heavy Flavor Production in p+Pb Collisions,
Invited talk: Heavy Quark Physics in Heavy-Ion Collisions: Experiments, phenomenology and theory, Trento, Italy, 3/15.

337. R. Vogt,
Nuclear Modification of Quarkonium Production in p+Pb Collisions at the LHC,
Talk: GHP 15, Baltimore, MD, 4/15.

338. X.-N. Wang,
Jet transport parameters from jet quenching at RHIC and LHC,
The 31st Winter Workshop on Nuclear Dynamics, 25-31 January 2015, Keystone Lodge and Spa, Keystone Resort, Colorado, USA

339. X.-N. Wang,
Probing properties of QGP with jets at RHIC and LHC: a theoretical perspective,
Town meeting on phases of QCD Matter, Temple University, Sept. 13-15, 2014.

340. X.-N. Wang,
Qualitative extraction of $\hat{q}$ from combined jet quenching at RHCI and LHC,
contributed talk at QM2014, Darmstadt, May 19-24, 2014

341. X.-N. Wang,
Properties of the hottest matter at a future high-energy collider,
Center for future high-energy physics Symposium, IHEP, Beijing Feb. 24-25, 2014.

342. X.-N. Wang,
Jet transport coefficients in heavy-ion collisions, Symposium on New Frontiers in QCD 2013,
December 2 - 6, 2013, Yukawa Institute for Theoretical Physics, Kyoto, Japan

343. X.-N. Wang,
Theory: what hard probes tell us about quark-gluon plasma,
plenary talk at HP2013, Cape Town, Nov. 3-7, 2013

344. X.-N. Wang,
Charting the phase diagram of strong-interaction matter,
opening workshop of the DAAD network on "From extreme matter to financial markets", Bielefeld, October 8-10, 2013

345. X.-N. Wang,
Towards the extraction of $\hat{q}$ and $\hat{e}$ from factorized high-twist approach,
RHIC physics strategy meeting, Wayne State University, Detroit, August 24-25, 2013

346. X.-N. Wang,
High-twist approach to jet quenching,
2nd workshop on "jet modification in RHIC and LHC era", Wayne State University, Detroit, August 20-22, 2013

347. X.-N. Wang,
Jet tomography of high-energy nuclear collisions,
workshop on "Future trends in High-energy nuclear collisions", Beijing, August 19-22, 2013

348. X.-N. Wang,
Hard and Soft Probes of Dense Matter,
Hadron and Nuclear Physics Conference 2013, Zhang Jia Jie, China, July 18-22, 2013

349. X.-N. Wang,
QCD and Heavy-ion Collisions: a Theoretical Overview,
Summer School on Phenomenology and theory in heavy-ion physics, Peking University, Beijing, China, July 1-5, 2013

350. X.-N. Wang,
Ultrarelativistic heavy-ion collisions: a theoretical overview,
Plenary talk at International Nuclear Physics Conference 2013, Firence, Italy, 2-7 July 2013.

351. X.-N. Wang,
Strong interacting matter at high temperature and high density,
"Shuang Qing Forum" National Natural Science Foundation of China, Beijing, Nov. 3-4, 2012

352. X.-N. Wang,
Jet Modification in Medium,
Post QM2012 Workshop on "Jet Modification in the RHIC and LHC Era", Wayne State University, Detroit, August 20-23, 2012.

353. X.-N. Wang,
Jet Induced Excitation in Anisotropic Medium,
STAR Regional Meeting, Weihai, China, July 22-15, 2012

354. X.-N. Wang,
Jet-induced hadron correlation,
Symposium on contemporary subatomic physics, Joe-fest, McGill, June 12-14, 2012

355. X.-N. Wang,
Parton energy loss in cold nuclei and implications on jet quenching in AA collisions,
Hard Probes, Cagliari, Italy, May 27- June 1, 2012

356. X.-N. Wang,
Hot spots and dihadron correlations,
INT workshop on "Ridge Correlations, May 7-11, 2012

357. X.-N. Wang,
Jet Quenching and Dihadron Correlations,
Berkeley School of Collectivity, Berkeley, May 14-18, 2012

358. X.-N. Wang,
Properties of dense matter in high-energy heavy-ion collisions,
YIPQS Symposium: Perspective in Theoretical Physics - From quark-hadron science to unification of theoretical physics, Feb. 6-8, 2012 Yukawa Institute for Theoretical Physics, Kyoto, Japan

359. X.-N. Wang,
Jet propagation in medium,
Hirschegg 2012: Facets of strong interaction physics- International Workshop XL on Gross Properties of Nuclei and Nuclear Excitations, Hirschegg, Kleinwalsertal, Austria, January 15 - 21, 2012

360. X.-N. Wang,
Parton propagation in nuclear medium,
plenary talk at the 3rd Workshop on Hadron Physics in China and Opportunities in the US, Weihai, August 9-11, 2011

361. X.-N. Wang,
Jet and Electromagnetic Tomography of High-energy Heavy-ion Collisions,
RHIC and AGS Annual Users Meeting, June 20-24, 2011.

362. X.-N. Wang,
Introduction to pQCD and jets,
3 lectures given at the 2011 JET Summer School, Duke University, June 15-19, 2011

363. X.-N. Wang,
Summary,
RIKEN BNL Research Center Workshop on "Initial State Fluctuations and Final-State Particle Correlations", February 2-4, 2011

364. X.-N. Wang,
Hot spots, Ridges, Jets and Dihadron Correlation,
From Strong Fields to Colorful Matter: A symposium in honor of B. Mueller's 60th Birthday, October 24-27, 2010, Asheville, NC.

365. X.-N. Wang,
Mach cones induced by ?-triggered jets in high-energy heavy-ion collisions,
Hard Probes 2010, Eilat, Israel, Oct. 10-15, 2010

366. X.-N. Wang,
Jet Quenching and Medium Excitation in Heavy-ion Collisions,
CERN TH Institute, First Heavy-ion Collisions at LHC, CERN, August 23-27, 2010

367. X.-N. Wang,
Jet and Electromagnetic Tomography of Dense Matter in High-energy Heavy-ion Collisions,
Symposium on High-energy Strong Interaction 2010, Yukawa Institute for Theoretical Physics, Kyoto, August 9-13, 2010

368. X.-N. Wang,
Jet and Electromagnetic Tomography of Dense Matter in High-energy Heavy-ion Collisions,
invited talk at CAP Congress 2010, University of Toronto, June 7-11, 2010

369. S. Cao,
Theoretical Progress on Open Heavy Flavors in Heavy-Ion Collisions,
at Hard Probes 2015, Montreal, Canada, 07/02/15

370. S. Cao,
Heavy Flavor Production in Heavy-Ion Collisions,
at 2015 RHIC & AGS Annual Users' Meeting, Brookhaven National Lab, USA, 06/10/15

371. S. Cao,
Suppression, Flow and Two-Particle Correlations of Open Heavy Flavor in Relativistic Nuclear Collisions,
at CIPANP 2015, Vail, USA, 05/22/15

372. S. Cao,
Transport of Open Heavy Flavor in Relativistic Heavy-Ion Collisions,
at Workshop on Heavy Flavor Production in High-Energy Collisions, Berkeley, USA, 01/08/15

373. S. Cao,
Heavy Flavor Dynamics in QGP and Hadron Gas,
talk at INT Workshop on Heavy Flavor and Electromagnetic Probes in Heavy Ion Collisions, Seattle, USA, 09/30/14

374. Denes Molnar & Deke Sun,
Realistic medium averaging in GLV energy loss, Hard Probes, May 27 - Jun 1, 2012, Cagliari, Italy

375. Denes Molnar & Deke Sun,
GLV energy loss in realistic expanding medium,
8th International Workshop on High pT Physics at the LHC, Oct 21-24, 2012 Central China Normal University, Wuhan, China

376. Denes Molnar & Deke Sun,
Hard and soft responses from parton transport,
Workshop on Jet Quenching at RHIC vs LHC in Light of Recent dAu vs pPb controls, Apr 15-17, Brookhaven National Laboratory, Upton, NY

377. Denes Molnar & Deke Sun,
Event-by-event correlation between medium and jet flow,
Strange Quark Matter, Jul 21-27, 2013, Birmingham, UK

378. Denes Molnar & Deke Sun,
Interplay between bulk medium evolution and (D)GLV energy loss,
Hard Probes, Nov 4-8, 2013, Stellenbosch, South Africa

379. Denes Molnar,
Jet energy loss and fluid dynamics,
Workshop on Jet Modification in the RHIC and LHC Era, Aug 18-20, 2014, Wayne State University, Detroit, Michigan

380. Deke Sun & Denes Molnar,
Interplay between bulk medium evolution and covariant (D)GLV energy loss,
31st Winter Workshop on Nuclear Dynamics (WWND2015), Jan 26-31, 2015, Keystone, Colorado

381. Denes Molnar,
Jet quenching and fluid dynamics,
12th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2015), May 19-24, Vail, Colorado

382. C. M. Ko,
Strings, Jets and Quark Coalescence in Transport Models,
International Workshop on Critical Examination of RHIC Paradigms, Austin, Texas, April 14-17, 2010.

383. C. M. Ko,
Overview of Relativistic Heavy Ion Collisions,
International Workshop on Exotics in Heavy Ion Collisions, Kyoto, Japan, May 17-29, 2010.

384. C. M. Ko,
Exotic Hadrons from Heavy Ion Collisions,
International Mini-Symposium on Exotics in Heavy Ion Collisions, Kyoto, Japan, May 19, 2010.

385. C. M. Ko,
Charmonium Production and Elliptic Flow in Relativistic Heavy Ion Collisions,
International Workshop on Hot and Cold Baryonic Matter, Budapest, Hungary, August 15-20, 2010.

386. C. M. Ko,
Identified Hadrons of Intermediate and High Transverse Momenta in Relativistic Heavy Ion Collisions,
International Workshop on Interplay between Soft and Hard Interaction in Particle Production at Ultra-Relativistic Energies, Catania, Italy, September 8-10, 2010.

387. C. M. Ko,
Particle Production in Heavy Ion Collisions,
Colloquium, Institute for Theoretical Physics, University of Frankfurt, Frankfurt, Germany, October 21, 2010.

388. T. Song,
J/ψ Production and Elliptic Flow in Relativistic Heavy-Ion Collisions,
Seminar, McGill University, Montreal, Quebec, Canada, November 25, 2011.

389. T. Song,
J/ψ Production and Elliptic Flow in Relativistic Heavy-Ion Collisions,
International Workshop on Heavy Quark Production in Heavy-Ion Collisions, West Lafayette, Indiana, January 4-7, 2011.

390. J. Xu,
The Effect of Triangular Flow on Di-hadron Azimuthal Correlations,
RIKEN BNL Workshop on Initial State Fluctuations and Final-State Particle Correlations, Upton, New York, February 2-4, 2011.

391. C. M. Ko,
Triangular Flow in Relativistic Heavy Ion Collisions,
International Workshop on In-Medium Effects in Hadronic and Partonic Systems, Obergurgl, Austria, February 21-25, 2011.

392. C. M. Ko,
Hadronziation by Quark Coalescence,
Jet and Electromagnetic Tomography Summer School, Duke University, Durham, North Carolina, June 15-17, 2011.

393. C. M. Ko,
Triangular flow in Relativistic Heavy Ion Collisions,
Workshop on QCD Phase Transitions and Relativistic Heavy Ion Collisions, Hangzhou, China, July 18-20, 2011.

394. C. M. Ko,
Quarkonia Production in HIC,
International Symposium on Non-equilibrium Dynamics, Heraklion, Crete, Greece, August 31 - September 3, 2011.

395. C. M. Ko, Anisotropic Flows and Dihadron Correlations in Heavy Ion Collisions,
International Workshop on Particle Correlations and Femtoscopy, Tokyo, Japan, September 20-24, 2011.

396. C. M. Ko, Quarkonia Production in Heavy Ion Collisions,
International Conference on Primordial QCD Matter in LHC Era, Cairo, Egypt, December 4-8, 2011.

397. C. M. Ko,
Exotic Hadrons Production in HIC,
Workshop on Hyperon-Hyperon Interactions and Searches for Exotic Di-Hyperons in Nuclear Collisions, Brookhaven National Laboratory, Upton, New York, February 29 -March 2, 2012.

398. C. M. Ko,
Resonances In AMPT,
Workshop on Hadronic Resonance Production in Heavy Ion and Elementary Collisions, Austin, Texas, March 5-7, 2012.

399. C. M. Ko,
Anisotropic Flows in HIC,
Symposium on Cosmo, Cancer, Criticality and Chromoplasmology, Seattle, Washington, May 6, 2012.

400. C. M. Ko,
Dihadron Correlations in AMPT,
Workshop on the Ridge Correlation in High-Energy Collisions at RHIC and LHC, Seattle, Washington, May 7-11, 2012.

401. C. M. Ko,
Why Particles and Antiparticles Flow Differently?,
Symposium on Contemporary Subatomic Physics, Montreal, Canada, June 12-14, 2012.

402. C. M. Ko,
Effects of Hadronic Mean-Field Potentials on Elliptic Flows in HIC,
Second International Symposium on Non-Equilibrium Dynamics, Heraklion, Greece, June 25-30, 2012.

403. C. M. Ko,
Anisotropic Flows and Dihadron Correlations in AMPT,
Workshop on Initial State Fluctuations and Final State Correlations in Heavy-Ion Collisions, Trento, Italy, July 2-6, 2012.

404. C. M. Ko,
Quarkonia Production in Relativistic Heavy Ion Collisions,
Conference on Heavy Ion Collisions in the LHC Era, Qui Nhon, Vietnam, July 15-21, 2012.

405. C. M. Ko,
Mean-Field Effects on Elliptic Flow in Relativistic Heavy Ion Collisions,
Bertsch Symposium on Nuclear Physics, Seattle, Washington, September 6-9, 2012.

406. C. M. Ko,
On Physics and Status of AMPT,
International Workshop on Particle Production in Proton-Proton Interactions and Beyond, Bad Liebenzell, Germany, April 19 - May 3, 2013.

407. C. M. Ko,
Elliptic Flow Difference between Particles and Antiparticles and The EOS of Baryon-Rich Matter,
XXXI Max Born Symposium and HIC for FAIR Workshop on Critical Behavior in Hot Dense QCD, Wroclawski, Poland, June 14 16, 2013.

408. C. M. Ko,
Hadronization via Coalescence in the AMPT Approach,
International Workshop on Transport Theory in Heavy Ion Collisions, Frankfurt, Germany, July 15 - 17, 2013.

409. C. M. Ko,
Elliptic Flow as a Probe of the QCD Phase Diagram at Finite Chemical Potential,
10th International Workshop on QCD Phase Transition and Relativistic Heavy Ion Physics, Chengdu, Sichuan, China, August 8 - 10, 2013.

410. C. M. Ko,
Fluctuations and Correlations in AMPT,
2nd Workshop on Initial Fluctuations and Final Correlations, Chengdu, China, August 11 - 14, 2013.

411. C. M. Ko,
Elliptic Flow of Baryon-Rich Matter,
The 9th International Workshop on Relativistic Aspects of Nuclear Physics, Rio de Janeiro, Brazil, September 23 - 27, 2013.

412. C. M. Ko,
Mean-Field Effects in Hot Dense Matter,
Tribute to Gerald E. Brown Conference, Stony Brook, New York, November 24 - 26, 2013.

413. C. M. Ko,
Elliptic flow as a probe of the properties of baryon-rich QGP,
International Workshop on New Frontiers in QCD, Kyoto, Japan, December 2 - 6, 2013.

414. C. M. Ko,
Particle Production in Heavy Ion Collisions,
International Workshop on Simulations of Low and Intermediate Energy Heavy Ion Collisions, Shanghai, China, January 8-12, 2014.

415. C. M. Ko,
Jet Fragmentation via Shower Parton Recombination,
Third International Symposium on Non-Equilibrium Dynamics, Hersonissos, Crete, Greece, June 9-14, 2014.

416. C. M. Ko,
Baryon-Rich Matter in Heavy-Ion Collisions,
Workshop on High Temperature and High Density Nuclear Matter Study, Weihai, Shandong, China, August 19-22, 2014.

417. R. J. Fries,
Quark Recombination in Heavy Ion Collisions,
JET Collaboration Meeting, Berkeley CA, June 19, 2010.

418. R. J. Fries,
Jet Chemistry and Contributions to EM Probes,
INT Workshop Quantifying Properties of Hot QCD Matter,
Institute for Nuclear Theory, University of Washington, Seattle WA, July 14, 2010.

419. R. J. Fries,
Event-by-Event Jet Quenching and Fourier Moments,
4th International Conference on Hard and Electromagnetic Probes of High Energy Nuclear Collisions (Hard Probes 2010), Eilat, Israel, October 14, 2010.

420. R. J. Fries,
Quark Recombination and Quark Scaling Still Puzzling?,
Workshop From Strong Fields to Colorful Matter,
Asheville NC, October 26, 2010.

421. R. J. Fries,
Event-by-Event Jet Quenching and Fourier Moments,
APS Division of Nuclear Physics Meeting (DNP 2010), Santa Fe NM, October 21, 2010.

G. Chen*,
Behavior of Early Time Gluon Fields in High Energy Nuclear Collisions,
APS Division of Nuclear Physics Meeting (DNP 2010), Santa Fe NM, November 6, 2010.

422. R. J. Fries,
Quark Recombination and Heavy Quarks,
Invited Talk, 6th Workshop on High-PT Physics at the LHC, Utrecht NL, April 6, 2011

423. R. J. Fries,
Quark Recombination and Heavy Quarks,
Nuclear Physics Seminar, University of Minnesota, Minneapolis MN, April 20, 2011

424. R. J. Fries,
Quark Recombination and Heavy Quark Diffusion,
Quark Matter 2011, Annecy, France, May 23, 2011

425. R. J. Fries,
Jet-Triggers for Photons,
Workshop on Jet Measurements at RHIC, Duke University, Durham NC, March 3, 2012.

426. R. J. Fries,
Quark Recombination,
Workshop Cosmos, Cancer, Criticality and Chromoplasmology, Seattle WA, May 6, 2012.

427. R. J. Fries,
Jet-Triggered Back-Scattering Photons for QGP Tomography,
5th Hard Probes 2012, Cagliari (Italy), May 31, 2012.

428. R. J. Fries,
Flowing Gluon Fields,
Symposium on Contemporary Subatomic Physics (SCSP 2012), McGill University, Montreal QC, June 13, 2012.

429. R. J. Fries,
Jet-Triggered Back-Scattering Photons for QGP Tomography,
Quark Matter 2012, Washington DC, August 15, 2012.

430. R. J. Fries,
Toward a Comprehensive Description of Heavy Flavor Dynamics,
KMI Workshop QGP 2012, Kobayashi-Maskawa Institute, Nagoya (Japan), September 26, 2012.

431. R. J. Fries,
Open Heavy Flavor Probes in Strongly Interacting Nuclear Matter,
Invited Talk, 8th Workshop on High-PT Physics at LHC, Wuhan (China), October 24, 2012.

432. R. J. Fries,
Recombination for JET Shower MC: Status and Discussion,
JET NLO and Monte Carlo Meeting, Detroit, August 22-23, 2013.

433. R. J. Fries,
Uncertainties In Jet Event Generators due to Hadronization Scheme, Other Issues with Energy Loss on E-by-E hydro, and the Extraction of Transport Coefficients, RHIC Strategy Meeting, Detroit MI, August 24-25, 2013.

434. R. J. Fries,
Flowing Gluon Fields: Collective Phenomena in Classical QCD,
15th Conference on Elastic and Diffractive Scattering (EDS Blois 2013), Saariselka (Finland), September 9-13, 2013.

435. R. J. Fries, Flowing Gluon Fields: Collective Phenomena in Classical QCD, 9th Workshop on High PT @ LHC, Grenoble (France), September 25-28, 2013.

436. R. J. Fries,
Initial Flow of Gluon Fields in Heavy Ion Collisions,
Hard Probes 2013, Cape Town (South Africa), November 4-8, 2013.

437. R. J. Fries,
Flow and Energy Momentum Tensor From Classical Gluon Fields,
New Frontiers in QCD (NFQCD 2013), Kyoto (Japan), December 2-6, 2013.

438. R. J. Fries,
Energy Density, Pressure and Flow At Early Times,
XXX. Winter Workshop on Nuclear Dynamics, Galveston TX, April 6-12 2014.

439. R. J. Fries,
Hadronization for Jet Shower Monte Carlos,
Workshop on Jet Modifications in the RHIC and LHC Era", Wayne State University, Detroit MI, August 18-20 2014.

440. R. J. Fries,
In Medium Hadronization: Hadrons and Jets,
Workshop on Jet Modifications in the RHIC and LHC Era", Wayne State University, Detroit MI, August 18-20 2014.

441. R. J. Fries,
The (3+1)-D Structure of Nuclear Collisions,
II. International Conference on the Initial Stages in High-Energy Nuclear Collisions (IS 2014), Napa CA, December 3-7 2014.

442. R. J. Fries,
Quark Recombination,
ICPAQGP 2015, VECC Kolkata, India, February 2, 2015.

Conference talks by the McGill Group

443. C. Gale,
QCD under extreme conditions: Hot, shiny fluids and sticky business,
Invited plenary talk, Annual Congress of the Canadian Association of Physicists, University of Alberta, June 15 2015.

444. C. Gale,
Extreme QCD: characterizing the quark-gluon plasma,
Talk at Town Hall Meeting of the Canadian Institute of Nuclear Physics, University of Alberta, June 13 - 14, 2015.

445. C. Gale,
Electromagnetic radiation and hydrodynamics,
Invited opening plenary talk, RIKEN-BNL Research Center Workshop on Thermal Photons and Dileptons, Brookhaven National Laboratory, August 20 - 22, 2014.

446. C. Gale,
Heavy-ion collisions: Theory update,
Invited plenary talk, 37th International Conference on High-Energy Physics (ICHEP 2014), Valencia, Spain, July 2 - 9, 2014.

447. C. Gale,
Photons and dileptons in relativistic heavy-ion collisions: Light from the hydro,
Invited talk at International Workshop on the Hydrodynamics of Strongly Coupled Fluids, European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT*), Trento, Italy, May 12 - 16, 2014.

448. C. Gale,
The photon flow puzzle : A theoretical overview,
Invited talk at EMMI Rapid Reaction Task Force on "Photon flow puzzle", GSI, Darmstadt, Germany, February 24 - 28, 2014:

449. C. Gale,
Electromagnetic radiation from high-energy heavy-ion collisions: from microscopic aspects to bulk dynamics,
Invited talk at EMMI Rapid Reaction Task Force on "Emissivity of matter under extreme conditions, dileptons and chiral symmetry: established connections and missing links", GSI, Darmstadt, Germany, October 5 - 15, 2013.

450. C. Gale,
Photons and dileptons from relativistic nuclear collisions,
Invited talk, International Workshop on Nuclear Dynamics and Thermodynamics, Texas A&M University, August 19 - 22, 2013.

451. C. Gale,
Relativistic nuclear collisions: Hot fluids and sticky business,
Invited talk, Annual Congress of the Canadian Association of Physicists, Université de Montréal, May 27 - 31, 2013.

452. C. Gale,
High pT photons from the quark-gluon plasma,
Invited talk, Workshop on Electromagnetic Probes of Strongly Interacting Matter: Status and Future of Low-Mass Lepton-Pair Spectroscopy, European Centre for Theoretical Studies in Nuclear Physics and Related Areas, Trento, Italy, May 20 - 24, 2013:.

453. C. Gale,
Finite-Temperature field theory: Theory and Applications,
Invited lecturer, Summer School on QCD, Central China Normal University, Wuhan, China.

454. C. Gale,
Electromagnetic radiation in relativistic heavy-ion collisions: Progress and puzzles,
Invited talk, International Workshop on Hot Topics in Hot Matter, Weizmann Institute, Rehovot, Israel, October 17-18, 2012.

455. C. Gale,
Electromagnetic radiation in relativistic heavy-ion collisions: Progress and puzzles,
Invited talk, International Workshop on Nuclear Physics, Institute for Nuclear Theory, Seattle, WA, September 7-9, 2012.

456. C. Gale,
Rapporteur Summary Talk on Heavy Flavors and Electro-Weak Probes,
Invited plenary summary talk, The XXXIII International Conference on Ultrarelativistic Nucleus-Nucleus Collisions ¡D0¿ Quark Matter 2012, Washington, DC, August 13-18, 2012.

457. C. Gale,
Initial state fluctuations, shear viscosity, and electromagnetic observables,
Invited talk, International Workshop on Initial State Fluctuations and Final State Correlations in Heavy-Ion Collisions, European Centre for Theoretical Studies in Nuclear Physics and Related Areas, Trento, Italy, July 2-6, 2012.

458. C. Gale,
Electromagnetic radiation in relativistic heavy-ion collisions: Progress and puzzles,
Invited plenary talk, 5th International Conference on Hard and Electromagnetic Probes of High Energy Nuclear Collisions (Hard Probes 2012), Cagliari, Italy, May 27-June 1, 2012.

459. C. Gale,
Viscous photons in relativistic heavy ion collisions,
Invited talk, Workshop on thermal photons and dileptons, Brookhaven National Laboratory, December 5 -7, 2011.

460. C. Gale,
August *Real photons from hot and dense ideal and viscous media*,
Invited talk, International workshop on Non-equilibrium dynamics, Heraklion, Greece, August 31st - September 3rd.

461. C. Gale,
Photons at RHIC and the LHC: the role of viscosity and of event-by-event fluctuations,
Selected talk, Quark Matter 2011, Annecy, France, May 22 - 28, 2011

462. C. Gale,
Dileptons and direct photons in heavy ion collisions,
Invited talk, STAR Collaboration Analysis Meeting, UCLA, June 17, 2010

463. C. Gale,
High pT photons from the quark-gluon plasma,
Invited talk, International Workshop on Electromagnetic Probes of Strongly Interacting Matter: Status and Future of Low-Mass Lepton-Pair Spectroscopy, ETC*, Trento, Italy, Sept. 13 17, 2010.

464. C. Gale,
QCD Basics,
Invited lecture, 4th International Conference on Hard and Electromagnetic Probes of High Energy Nuclear Collisions (Hard Probes 2010), Eilat, Israel, October 10 -15, 2010.

465. C. Gale,
High pT photons from heavy ion collisions,
Invited talk, From Strong Fields to Colorful Matter an International Symposium on Modern Nuclear Physics, Asheville, NC, October 24 - 27, 2010.

466. C. Gale,
High pT photons from relativistic nuclear collisions,
Invited talk, EMMI Workshop on Strongly Coupled Systems, GSI Helmholtzzentrum Schwerionenforschung, Darmstadt, Germany, November 15 -17, 2010.

467. S. Jeon,
em Dissipation in Quanturm Field Theory,
Invited lecture, CNT LECTURES ON HOT/DENSE MATTER-2015, 24th February - 28th February, 2015, VECC, Kolkata, India

468. S. Jeon,
em News and highlights in the Quark Gluon Plasma characterization,
Plenary talk, 11th Conference on Quark Confinement and the Hadron Spectrum, St. Petersburg, Russia, September 2014.

469. S. Jeon,
em Lectures on Hydrodynamics,
Invited Lectures, the Central China Normal University, Wuhan, China, June 2014.

470. S. Jeon,
em Recent developements in Relativistic Heavy Ion Physics,
Invited Seminar in Rare Isotope Science Project, Institute for Basic Science, Daejeon, Korea, June 2014.

471. S. Jeon,
em Theoretical Overview of Initial State and Flow Physics,
Plenary talk, 6th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions, Capetown, South Africa, November 2013.

472. S. Jeon,
em Jets in MARTINI,
Second Workshop on Jet Modification, Wayne State University, Detroit, USA, August 2013.

473. S. Jeon,
em Introduction to Hard Probes in Heavy Ion Collisions & Hydrodynamics in Heavy Ion Collisions,
Invited Lectures, National Nuclear Physics Summer School, Stonybrook University, Stonybrook, USA, July 2013.

474. S. Jeon,
em Introduction to Hard Probes in Heavy Ion Collisions,
Invited Lectures, Summer School for Phenomena & Theories in Heavy Ion Collisions, Peking University, Beijing, China, July 2013.

475. S. Jeon,
em Introduction to Hard Probes in Heavy Ion Collisions,
Invited Lectures, 11th Nuclear Physics Summer School, Jeju Island, Korea, June 2013.

476. S. Jeon,
Jet asymmetry at LHC,
, Symposium on jet physics at RHIC and LHC, Hangzhou, China, Jul. 21, 2011.

477. S. Jeon,
em Initial state fluctuations in hydrodynamic simulations,
Plenary talk, Asian Triangle Heavy Ion Conference 2012, Pusan, Korea, November 2012.

478. S. Jeon,
em sQGP – A theorist's point of view,
Invited talk, APS DNP meeting, Newport Beach, CA, USA, October 2012.

479. S. Jeon,
MUSIC with the UrQMD Afterburner,
Contributed talk, Quark Matter 2012, Washington D.C., USA, August 2012.

480. S. Jeon,
The First 30 Yocto Seconds of Little Big Bang,
Invited Seminar, Nagoya University, Nagoya, Japan, July 2012.

481. S. Jeon,
Higher Harmonics in Heavy Ion Collisions,
Conference on Heavy Ion Collisions in the LHC Era, Quy Nhon, Vietnam, Jul. 16 – Jul. 20, 2012

482. S. Jeon,
Elliptic and Triangular Flows in 3+1D Viscous Hydrodynamics with Fluctuating Initial Conditions,
Quark Matter 2011, Annecy, France, May.27, 2011.

483. S. Jeon,
Anisotropic flow from viscous hydrodynamics,
The 9th workshop on QCD phase transitions and relativistic heavy ion collisions, Hangzhou, China, Jul. 19, 2011.

484. S. Jeon,
MARTINI and MUSIC,
Brookhaven National Laboratory, Upton, NY. Nov. 16, 2010.

485. S. Jeon,
MARTINI and MUSIC,
The 3rd Asian Triangle Heavy-Ion Conference, Wuhan, China, Oct. 18-20, 2010.

486. B. Schenke,
Event-by-event Hydrodynamic Description of Anisotropic Flow and Correlations,
at RHIC and LHC RIKEN workshop on Initial State Fluctuations and Final-State Particle Correlations, Brookhaven National Laboratory, Upton, NY, 02/02/2011.

487. B. Schenke,
Monte-Carlo Simulation of Heavy-Ion Collisions,
Hard Probes 2010 Eilat, Israel,10/11/2010

488. B. Schenke,
Monte-Carlo Simulations for Heavy-Ion Collisions,
Nuclear Theory and RIKEN Seminar Brookhaven National Laboratory, Upton, NY, 08/27/2010.

489. B. Schenke,
MARTINI: Monte-Carlo for Heavy-Ion Collisions,
Workshop on Jets in p+p and Heavy-Ion Collisions Prague, Czech Republic,08/13/2010.

490. B. Schenke,
Monte-Carlo Simulations for the Hard Probes in Heavy-Ion Collisions,
International Nuclear Physics Conference 2010 University of British Columbia, Vancouver, BC, Canada,07/08/2010.

491. B. Schenke,
Jet evolution in a weakly coupled QGP,
JET Collaboration Symposium Lawrence Berkeley National Laboratory, Berkeley, CA, 06/18/2010.

492. B. Schenke,
Monte-Carlo simulation of high-energy nucleus-nucleus collisions,
2010 Canadian Association of Physicists (CAP) Congress University of Toronto, Toronto, Canada, 06/09/2010.

493. B. Schenke,
Hadron-hadron correlations. A theory overview,
RHIC/AGS users' meeting Brookhaven National Laboratory, Upton, NY, 06/08/2010.

494. C. Young,
Heavy quark diffusion and quarkonium transport,
Heavy Quark Production in Heavy-Ion Collisions, Purdue University, 5 January 2011.

495. C. Young,
Quarkonium production in sQGP,
Quarkonium Production in Elementary and Heavy-Ion Collisions, Brookhaven National Laboratory, 10 June 2011.

496. C. Young,
Hard-scale probes of heavy-ion collisions,
University of Minnesota, 15 February 2012.

497. G. Denicol,
Extracting the bulk viscosity of the quark-gluon plasma, New Frontiers in QCD (NFQCD) 2013, Kyoto, Japan, 2013.

498. G. Denicol,
Extracting the bulk viscosity of the quark-gluon plasma,
URHIC group seminar, Jyväskylä University, Finland, 21.2.2014.

499. G. Denicol,
Derivation of fluid dynamics from kinetic theory,
International Conference on the Initial Stages in High-Energy Nuclear Collisions 2013 (IS2013), Illa de A Toxa, Galicia, Spain, Sep. 2013.

500. G. Denicol,
Extracting the bulk viscosity of the quark-gluon plasma,
Relativistic Aspects of Nuclear Physics 2013 (RANP2013), Rio de Janeiro, RJ, Brazil, Sep. 2013.

501. G. Denicol,
Hydrodynamics in heavy ion collisions and its derivation from kinetic theory,
Topical Group on Hadronic Physics (GHP) Workshop 2013, Denver, Colorado, USA, Apr. 2013.

502. M. Luzum,
p_T structure of two-particle correlations: flow, non-flow and fluctuations,
JET Collaboration Bulk working group remote seminar, February 2013.

503. M. Luzum,
Hot Quark Soup: VIscosity, Flow, and Flow Fluctuations in Relativistic Heavy-Ion Collisions,
CNRS job interview, Paris VI, 28 March 2013.

504. M. Luzum,
Mapping the hydrodynamic response to initial conditions in heavy-ion collisions,
LBNL, Heavy-Ion Tea Seminar, 7 May 2013.

505. M. Luzum,
p_T structure of two-particle correlations: flow, non-flow and fluctuations,
LBNL, informal seminar with STAR group, 9 May 2013.

506. M. Luzum,
p_T structure of two-particle correlations: flow, non-flow and fluctuations,
2nd International Workshop on Initial State Fluctuations and Final State Correlations Chengdu, China, 11 August 2013.

507. M. Luzum,
Constraining properties of the initial state from flow data,
Invited plenary, IS2013, Spain, 12 September 2013.

508. M. Luzum,
Hot Quark Soup: Viscosity, Flow and Flow Fluctuations in Relativistic Heavy-Ion Collisions,
Invited colloquium, University of Houston, 29 October 2013.

509. M. Luzum,
Hot Quark Soup: Viscosity, Flow and Flow Fluctuations in Relativistic Heavy-Ion Collisions,
Invited seminar, Rice University, 30 October 2013.

510. C. Shen,
MUSIC with diffusion – theory and modeling for the bean energy scan, BNL RBRC workshop, Feb. 26-27, 2015

511. C. Shen,
MUSIC with diffusion – recent theory developments for beam energy scan, Seminar in nuclear physics, the Ohio State University, Mar. 6, 2015.