

**Final Technical Report on
DE-SC0007995:
“2012 Advanced Accelerator Concepts Workshop”**

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INTRODUCTION. Particle accelerator development advances US interests in medicine, industry, energy, environment, national security and discovery science [AAF09, ARD10]. The 15th Advanced Accelerator Concepts (AAC 2012) Workshop, hosted by the PI in Austin, TX, in June 2012 drew an unprecedented gathering of nearly 300 scientists including 70 students from around the world, demonstrating the growing vitality of advanced accelerator science [Zga12]. This is a final technical report on the organization and outcome of AAC 2012.

SUMMARY OF MAJOR RESULTS (2012). AAC 2012 was devoted to cross-disciplinary discussion of advanced accelerator concepts, including new methods of particle acceleration and high energy photon generation, techniques for production of ultra-high accelerating gradients, diagnostics and control of particle and photon beams and various associated energy, particle beam and RF sources. The workshop was organized in several stages:

1) *Organizing Committee.* The AAC Core Committee, consisting of 8 current and previous AAC Chairs and a DOE rep, selected the AAC 2012 Organizing Committee (OC) at its Nov. 9, 2010 meeting during the APS-DPP 2010 meeting in Chicago. The OC for AAC 2012 included wide representation from U.S. Universities and National Laboratories, and one representative each from Europe and Asia:

Ilan Ben-Zvi*	BNL	Wim Leemans*	LBNL
Allen Caldwell	MPI Physik, Munich	LK Len*	DOE
John Cary	Tech-X Corp.	Howard Milchberg*	U. Maryland
Mike Downer, * Chair	U. Texas	Zheng-Ming Sheng	Jiao Tung U.
Wei Gai*	ANL	Vladimir Shiltsev	FNAL
Dan Gordon	NRL	Gennady Shvets*	U. Texas
Manuel Hegelich	LANL	Dave Sutter*	U. Maryland
Mark Hogan	SLAC	Sami Tantawi	SLAC
Chan Joshi*	UCLA	Vitaly Yakimenko	BNL

* AAC Core Committee members

2) *Working Groups.* Working Groups (WGs) form the basic structure of the AAC Workshop. Each WG has a Leader and Co-Leader who manage WG sessions during the Workshop. The OC selected WG Leaders and Co-Leaders for AAC 2012 at its March 30, 2011 meeting during the Particle Accelerator Conference (PAC 2011) in New York City. WG Leaders (and Co-Leaders) together with the OC comprised the **AAC 2012 Workshop Program Committee**. The Program Committee guides the scientific program of the workshop, including selection of Plenary Talks and the agendas of individual WGs. The WG leaders selected talks from submitted abstracts for oral presentations in their WGs, and solicited some invited oral presentations in their WGs that contribute to the mission of the WG. WG leaders orally summarized the deliberations of their WG on the last day of the workshop, and submitted a written summary to the Workshop Proceedings.

Themes and leaders for each of the eight WGs for AAC 2012 are summarized below.

WG 1: Laser-Plasma Wakefield Acceleration

WG 1 addressed acceleration of electrons and other charged particles using laser-driven plasma wakefields, as well as related diagnostics and simulations. GeV beams and control over injection and beam stability have now been observed, and further work in these areas is required for

applications. Two applications motivate work and discussion in this area: (i) High energy physics colliders at the TeV scale, and methods for achieving required emittance and luminosity, and for injecting particles and staging. (ii) Novel and compact radiation sources, and methods for uniquely or advantageously driving them by laser-plasma wakefield accelerators.

Leader: Carl Schroeder, LBNL (CBSchroeder@lbl.gov)

Co-leader: Mike Helle, NRL (mikehelle@gmail.com)

WG 2: Computations for Accelerator Physics

WG 2 reviewed and assessed state-of-the-art computational tools for realistic and rapid simulations of plasma and laser wakefield accelerator stages, high gradient structures, and high brightness sources. It will discuss near- and long-term computational needs, recent advances in algorithmic development, model validation and verification, and trade-offs among computation tools such as PIC, quasi-static PIC, and fluid codes.

Leader: David Bruhwiler, Tech-X Corp. (bruhwile@txcorp.com)

Co-leader: Brian Albright, LANL (balbright@lanl.gov)

WG 3: Laser and High-Gradient Structure-Based Acceleration

WG 3 assessed current challenges involved in developing an advanced accelerator based on electromagnetic (EM) structures, and survey state-of-the-art methods to address those challenges. A critical challenge for EM structures is gradient limitation imposed by breakdown, pulsed heating, dark current, quench, thermal breakdown and other factors, depending on structure type, pulse width, duty cycle and regime of operation. WG 3 will assess the understanding of gradient-limiting phenomena over the range of frequencies in room temperature, superconducting, THz and optical EM, and dielectric-based structures. It will survey the state of the art in RF source and component development and new ideas in material development, surface coating and processing for accelerator applications. WG 3 will also address challenges beyond gradient limitation, including simulation challenges, high order mode characteristics and damping, emittance requirements, power source requirements, wall-plug to beam power efficiency, limitations to luminosity or brightness, and fabrication tolerances.

Leader: Mike Fazio, SLAC (mfazio@slac.stanford.edu)

Co-leader: Scott Anderson, LLNL (Anderson131@llnl.gov)

WG 4: Beam-Driven Acceleration

The OC for AAC 2012 renamed WG4 from “e-Beam Driven Plasma Accelerators” to the current title in recognition of the growing importance of proton-driven plasma accelerators, and to widen its scope to include dielectric, as well as plasma, beam-driven accelerators. Themes included community use of the FACET facility, fundamental physics of beam-plasma interaction, synergy between beam- and laser-driven plasma acceleration, and future applications of beam-driven accelerators including light sources and colliders.

Leader: Patric Muggli, USC/MPI (muggli@usc.edu)

Co-leader: Joel England, SLAC (england@slac.stanford.edu)

WG 5: Beam and radiation generation, monitoring and control

WG 5 addressed 3 major themes: (i) beam sources for modern and future accelerators, including photo-injectors and thermionic cathode sources, and associated challenges such as high intensity, small emittance, short bunch lengths, and strict synchronization requirements; (ii) beam control and manipulation methods to tailor beams to meet stringent requirements of future accelerators, including emittance exchange, microbunch generation, ellipsoidal beam generation, and flat beam transforms; (iii) advanced beam diagnostics, includes longitudinal diagnostics for ultrashort bunches, non-intercepting diagnostics, THz to X-ray generation and detection, electro-optical techniques, and slice emittance techniques.

Leader: Pietro Musumeci, UCLA (musumeci@physics.ucla.edu)

Co-leader: Jeroen van Tilborg, LBNL (JvanTilborg@lbl.gov)

WG 6: Laser-Plasma Acceleration of Ions

The OC for AAC 2012 separated this WG from its previous home in the “Advanced Concepts” WG in recognition of rapid recent developments in laser-plasma ion acceleration. This WG reviewed various acceleration mechanisms, target media and configurations, and laser parameters used in recent experiments and simulations. Paths for achieving monoenergetic proton and ion beams at and above 200 MeV, as needed for application in medicine and radiography, were explored.

Leader: Sergei Tochitsky, UCLA (sergei12@ucla.edu)

Co-Leader: Manuel Hegelich, LANL (hegelich@lanl.gov)

WG 7: Muon Colliders and Advanced Concepts

The subject matter of this WG has evolved over the years. The muon collider has become a viable concept for achieving 3-5 TeV center-of-mass energy. WG 7 will address major challenges facing the muon collider community, such as high-gradient acceleration and emittance reduction via cooling. Laser-based methods for muon production and beam cooling were explored. Among other advanced concepts, production of positrons using Compton scattering and other advanced techniques, and new acceleration techniques such as PASER and IFEL that lie outside the purview of the other WGs, were explored.

Leader: Sergey Nagaitsev, FNAL (nsergei@fnal.gov)

Co-leader: Scott Berg, BNL (jsberg@bnl.gov)

WG 8: Laser Technology for Laser-Plasma Accelerators

This newly created WG harkened back to AAC 1996, which featured a very successful WG entitled “Laser Sources for Particle Acceleration” at a time when multi-terawatt chirped-pulse-amplified solid-state laser systems were beginning to heavily influence advanced accelerator research. Today multi-petawatt laser systems are sparking another renaissance in laser-plasma electron and ion acceleration and associated x-ray source development. This WG brought together researchers from academia and national laboratories and representatives of commercial vendors of high average- and peak-power laser systems to explore needs for the next generation of laser-plasma acceleration research.

Leader: Erhard Gaul, U. Texas-Austin and National Energetics, Inc. (gaul@physics.utexas.edu)

Co-Leader: Csaba Toth, LBNL (ctoth@lbl.gov)

3) *Workshop Venue & Schedule.* AAC 2012 was held at the AT&T Executive Education and Conference Center on the University of Texas at Austin campus. Plenary sessions were held in the amphitheater (capacity >250). Working group sessions were held in seminar rooms with varying capacities. Housing arrangements were contracted with the AT&T Executive Education and Conference Center hotel. The schedule for AAC 2012 is shown below.

	Sunday June 10	Monday June 11	Tuesday June 12	Wednesday June 13	Thursday June 14	Friday June 15
Morning I 8:30-10:15		Plenary	Plenary	Plenary	Plenary	Plenary
Morning II 10:30-12:00		Plenary	Plenary	Working Groups	Working Groups	Working Groups
Afternoon I 1:00-2:45		Plenary	Working Groups	Working Groups	Working Groups	Working Group Summary
Afternoon II 3:00-4:45		Student Tutorials; Plenary	Working Groups	Social Event	Working Group Poster Session & Reception	Working Group Summary
Evening	Welcome Reception	Evening Reception	Student Poster Session & Reception		Workshop Banquet	

Detailed content of plenary and working group presentations is given on the AAC 2012 workshop web site.

4) *Websites:* Two website related to AAC2012 were initiated, and remain active:

(i) *AAC 2012 workshop web site.* An AAC 2012 workshop web site

(<http://w3fusion.ph.utexas.edu/ifs/aac2012/index.html>),

launched in early 2012, contains extensive workshop-related information that was updated regularly before, during and after the workshop. It will remain posted indefinitely as a resource to the advanced accelerator community, future workshop organizers, and the general public. Posted information includes workshop chairs and organizing committees, complete technical presentation schedules, abstracts and selected presentations, a list of student scholarship awardees, links to the workshop Proceedings published by the American Institute of Physics, photographs of workshop activities, and housing and travel information.

(ii) *AAC 2012 workshop proceedings.* An on-line Proceedings of the AAC 2012 workshop was published by the American Institute of Physics, and is available at

<http://proceedings.aip.org/resource/2/apcpcs/1507/1?isAuthorized=no>

or via a link from the AAC 2012 web site. The on-line Proceedings has AIP Conference Proceedings Volume number 1507, ISBN 978-0-7354-1125-8, is registered with the Library of Congress, includes color graphics, and is available in perpetuity to all interested users at no

charge, without the need for username/password [Zga12]. There was no print book Proceedings because of insufficient demand.

PhD DEGREES AWARDED under this project:

None

2012 PUBLICATIONS (acknowledges DOE support)

- [Zga12] R. Zgadzaj, E. W. Gaul and M. C. DOWNER, eds., *Advanced Accelerator Concepts XV, AIP Conf. Proc.* **1507**, 1-958 (2012). Proceedings of the 15th Advanced Accelerator Concepts Workshop, Austin, TX, 10-15 June 2012.

References Cited in Report:

- [AAF10] “Accelerators for America’s Future,” W. Henning and C. V. Shank, eds., DOE report (2010) --- www.acceleratorsamerica.org/report/
- [ARD12] “Office of High Energy Physics Accelerator R&D Task Force Report,” commissioned by Jim Siegrist, Associate Director HEP, Office of Science (2012) --- www.acceleratorsamerica.org/report/