

# Final technical report: Characterization of the initial state and medium properties of heavy-ion collisions at ALICE

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## Introduction

This report summarizes the key achievements from DOE award, which started February 1st 2015, and ended January 31st 2018. The award funded experimental research into relativistic heavy-ion collisions at two facilities: The ALICE detector at the Large Hadron Collider (LHC) at CERN, and the STAR detector at Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. Relativistic heavy-ion collisions aim to create the Quark Gluon Plasma (QGP) is a unique state where the building blocks of nuclear matter, quarks and gluons, melt and move freely over the volume of the nucleus. It is believed that the universe temporarily existed in such a state shortly after the big bang, where the temperatures needed for this transition are roughly 100,000 times bigger than the temperature at the center of the Sun. Experimental data collected over the past decade at RHIC have provided evidence that the QGP has been created in the laboratory.

Since 2010, the LHC has successfully collided Pb-Pb ions at the highest ever energies, producing thousands of particles in a single collision, and adding evidence for the formation of the QGP in such high energy heavy-ion collisions. The large numbers of particles produced in the collisions appear to flow out of the volume of the collision with an angular dependence, called azimuthal flow. Azimuthal flow is sensitive to the initial configuration of matter within the colliding nuclei, and key QGP properties, and the award helped facilitate many ground breaking new measurements.

## Key Publications

The publications associated with this award, where either the P.I. or graduate students funded by the award were authors with a leading role can be found below. All of the publications were in high profile journals and the majority garnered popular science articles.

1. Anisotropic flow in Xe-Xe collisions at 5.44 TeV, S. Acharya et al. (ALICE collaboration), *Phys. Lett.* B784 (2018) 82-95. Popular science article in CERN Courier <https://cerncourier.com/anisotropic-flow-in-xe-xe-collisions/>
2. Anisotropic flow of charged particles in Pb-Pb collisions at 5.02 TeV, J. Adam et al. (ALICE collaboration), *Phys. Rev. Lett.* 116 (2016) 132302. Popular science article in CERN Courier: <http://cerncourier.com/cws/article/cern/64340>

3. Pseudorapidity dependence of the anisotropic flow of charged particles in PbPb collisions at, J. Adam et al. (ALICE collaboration), Phys. Lett. B 762 (2016) 376-388. Popular science article in CERN Courier: <http://cerncourier.com/cws/article/cern/66557>
4. Correlated event-by-event fluctuations of flow harmonics in Pb-Pb collisions at 2.76 TeV, J. Adam et al. (ALICE collaboration), Phys. Rev. Lett. 117 (2016) 182301. Popular science article in CERN Courier: <http://cerncourier.com/cws/article/cern/66557>
5. Energy Dependence of the Third Harmonic of Azimuthal Correlations in Au+Au Collisions at RHIC (STAR collaboration), Phys. Rev. Lett. 116 (2016) 112302

### **Graduate students supported by the award**

Three graduate students were supported by the award. Liao Song graduated Spring 2016 with a thesis titled “The Ridge And Di-Hadron Correlations From The Beam Energy Scan Program At RHIC”. Fabian Ng graduated Spring 2018 with a thesis titled “Anisotropic Flow Measurements In Ultra-Central Pb-Pb Collisions For Run 10 And Run 11 By ALICE”. Finally, Muqing Jin is due to graduate Spring 2019.

### **High profile presentations**

The award was critical in facilitating high profile presentations to the field of relativistic heavy-ion physics. The P.I. presented the invited talk “Overview of ALICE results at Quark Matter 2017”, a keynote talk at the most prestigious conference in our field. Both the P.I. and Liao Song presented parallel talks at Quark Matter 2015. The P.I. and graduate students have been invited to give numerous other talks during the time of the award.

### **Other award achievements**

The award facilitated essential trips to each of the experiments. These trips involved taking experimental shifts, and attending experimental meetings. The award also helped facilitated experimental service, including upgrades to critical experimental software.