

Study of Quark Gluon Plasma and Machine Learning in High Energy Nuclear Physics

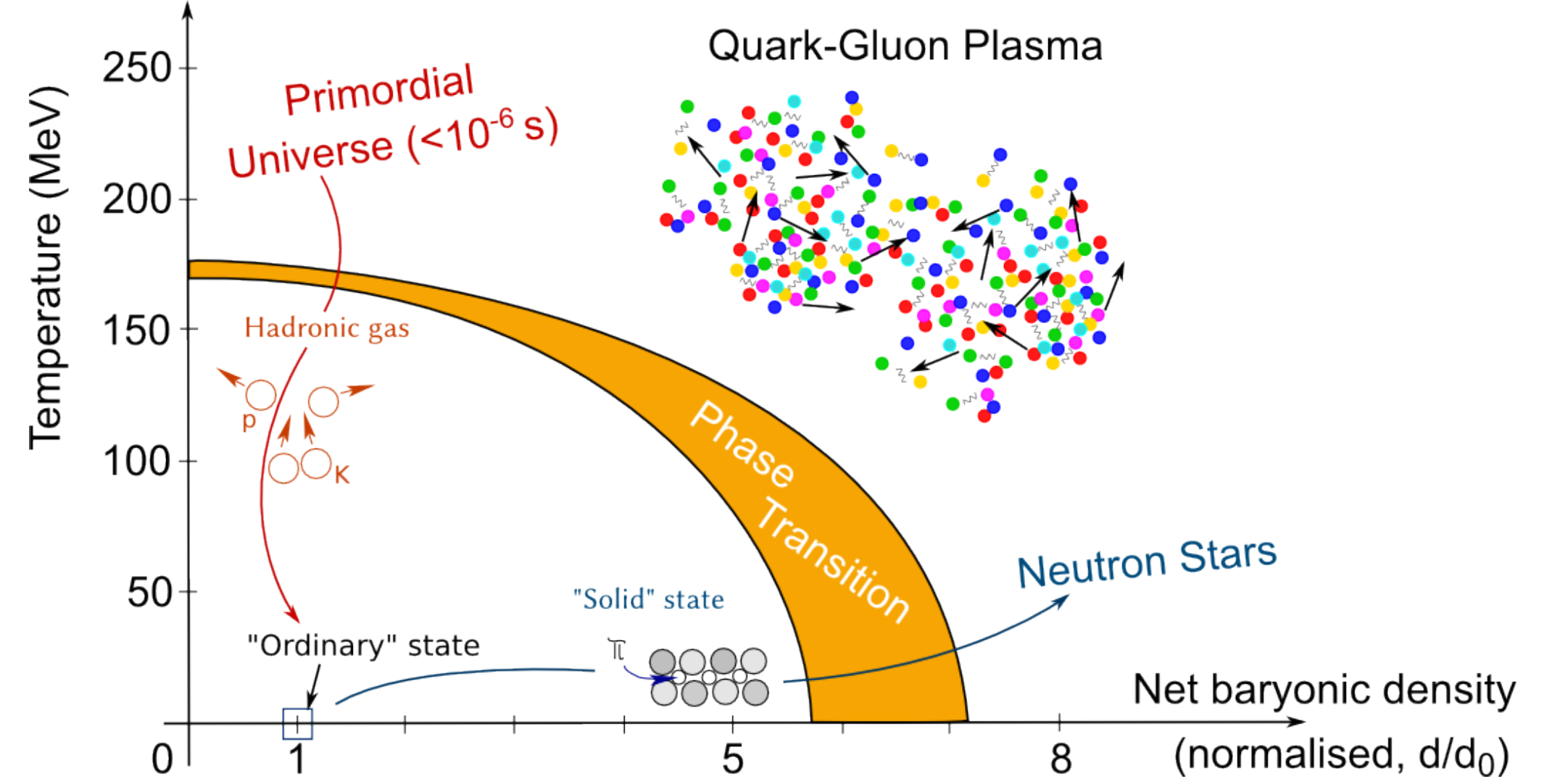
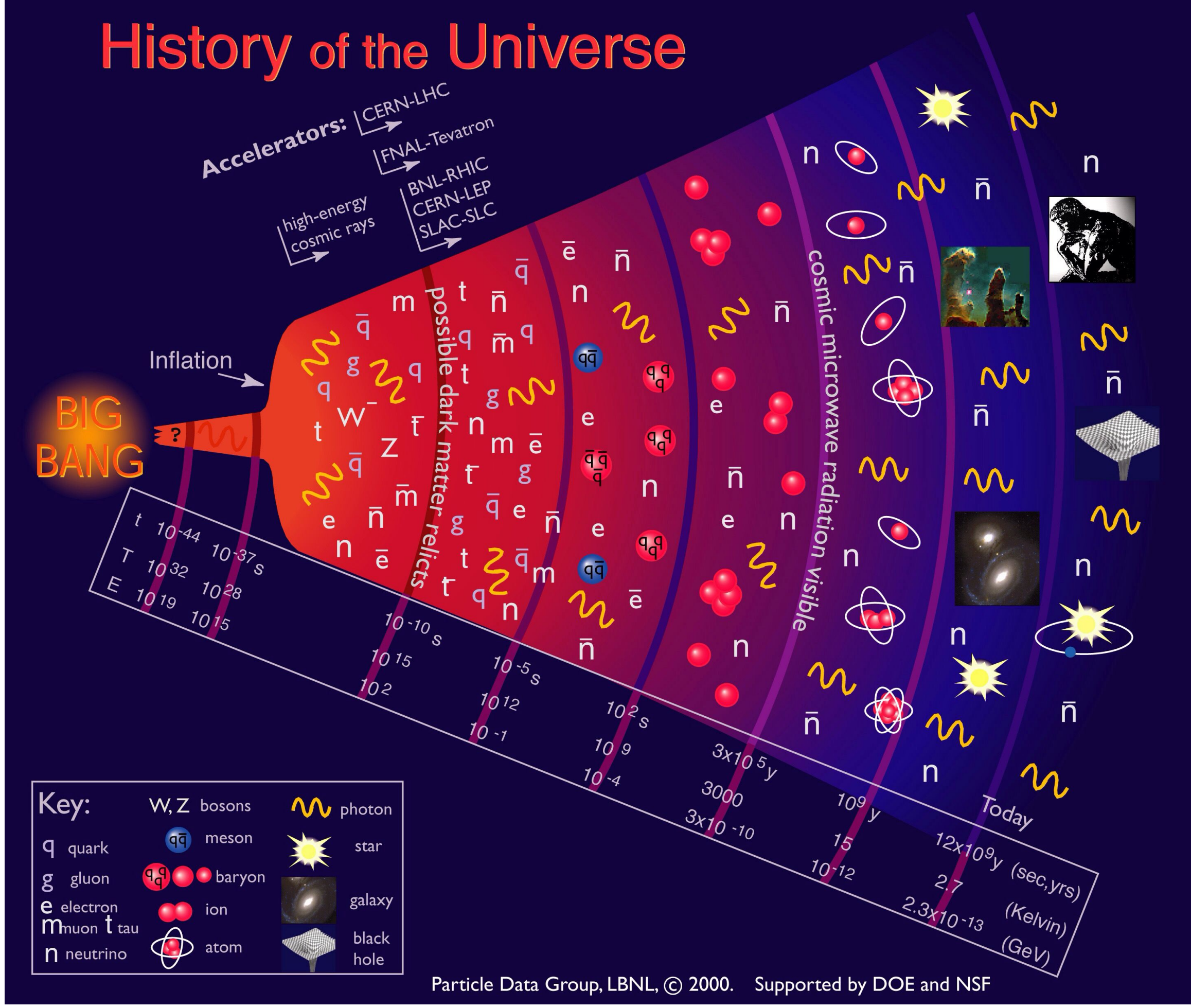
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2023 Aug 25*



Brookhaven
National Laboratory

What is Quark Gluon Plasma (QGP)?

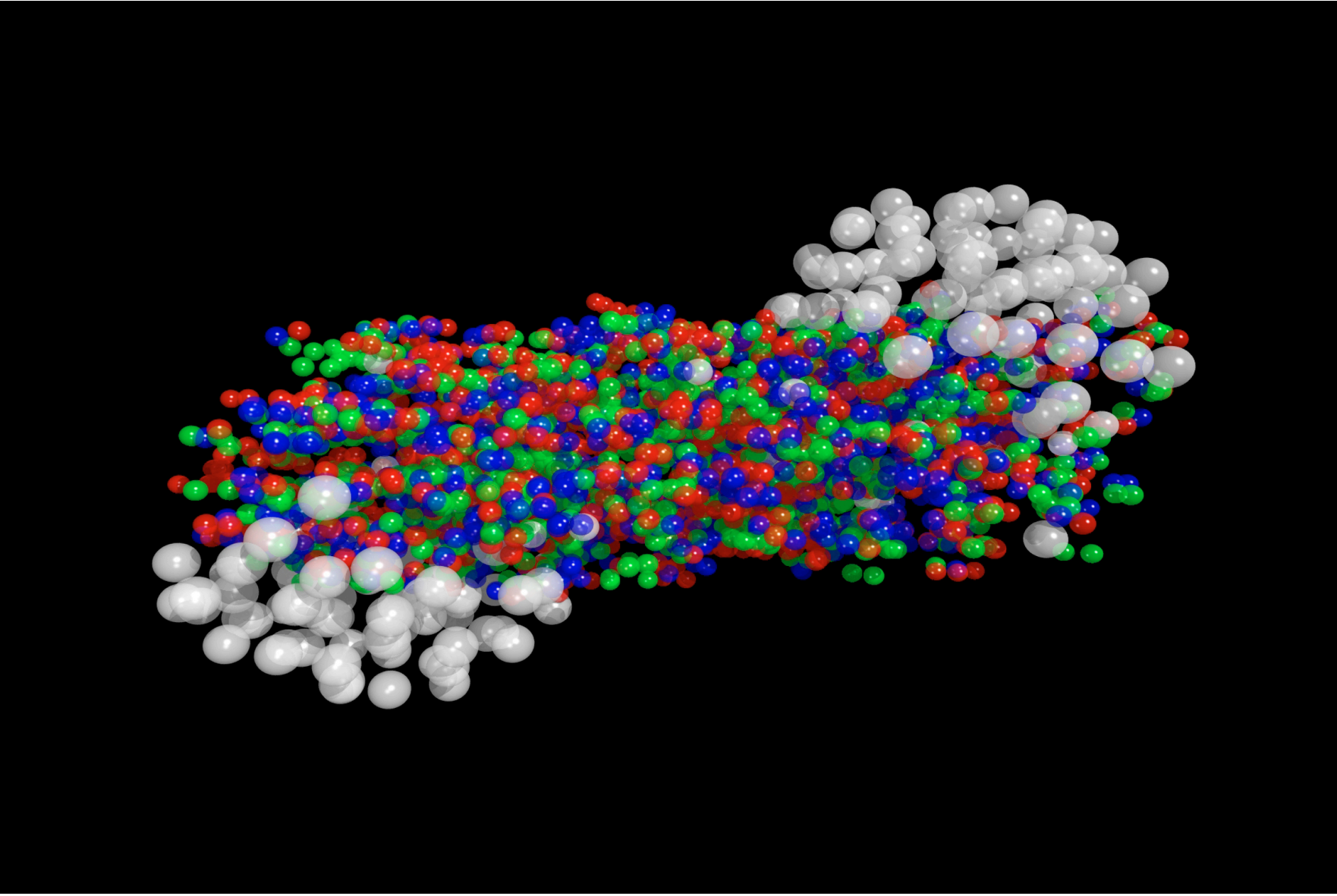
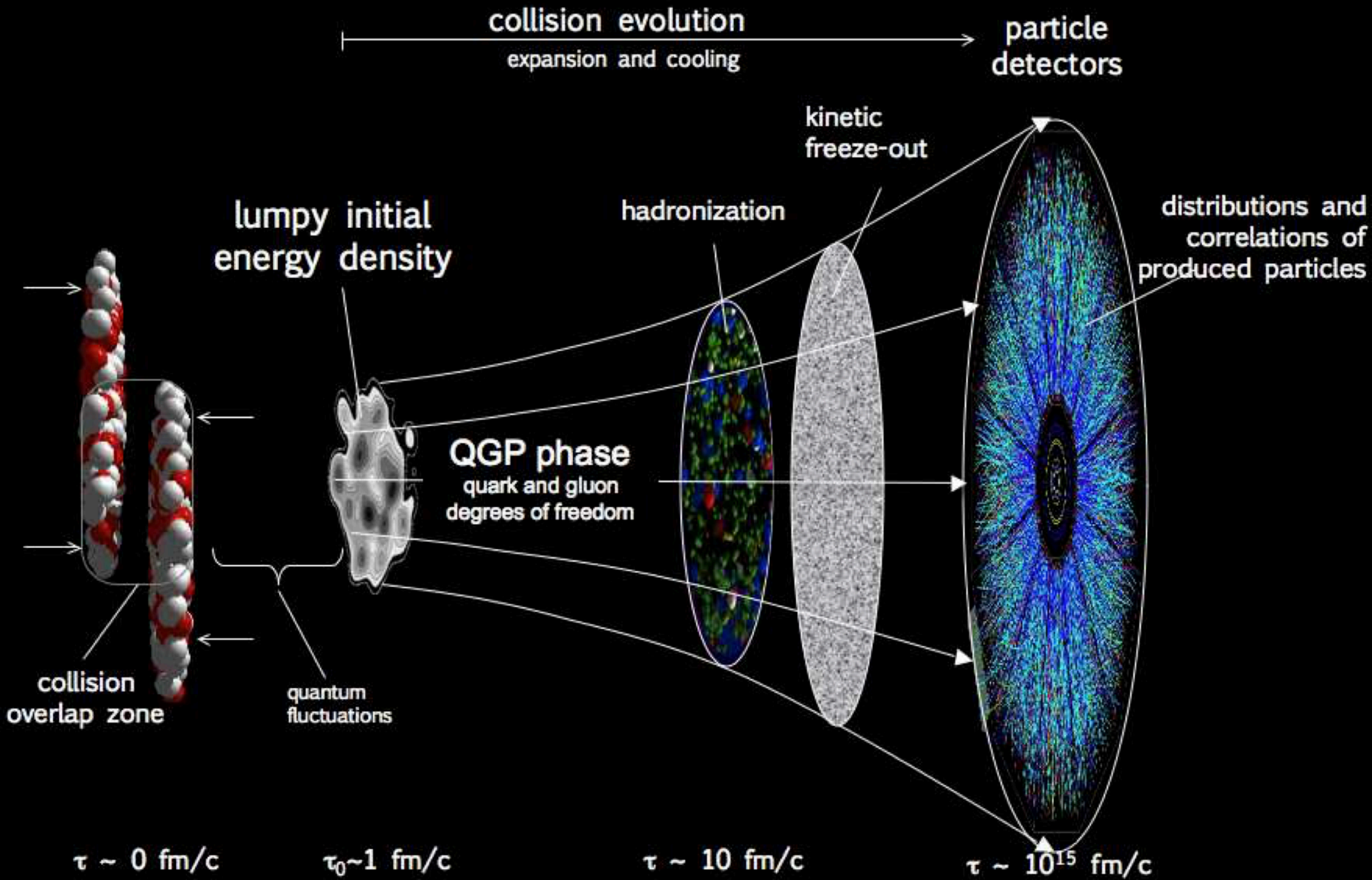


- **Quark Gluon Plasma (QGP):** extremely hot and dense phase of matter in which quarks and gluons are no more confined into hadrons
- ➔ properties known as an almost perfect fluid
- ➔ lowest specific shear viscosity (η/s) of any known substance

Understanding Strongly Interacting QCD and Early Universe!

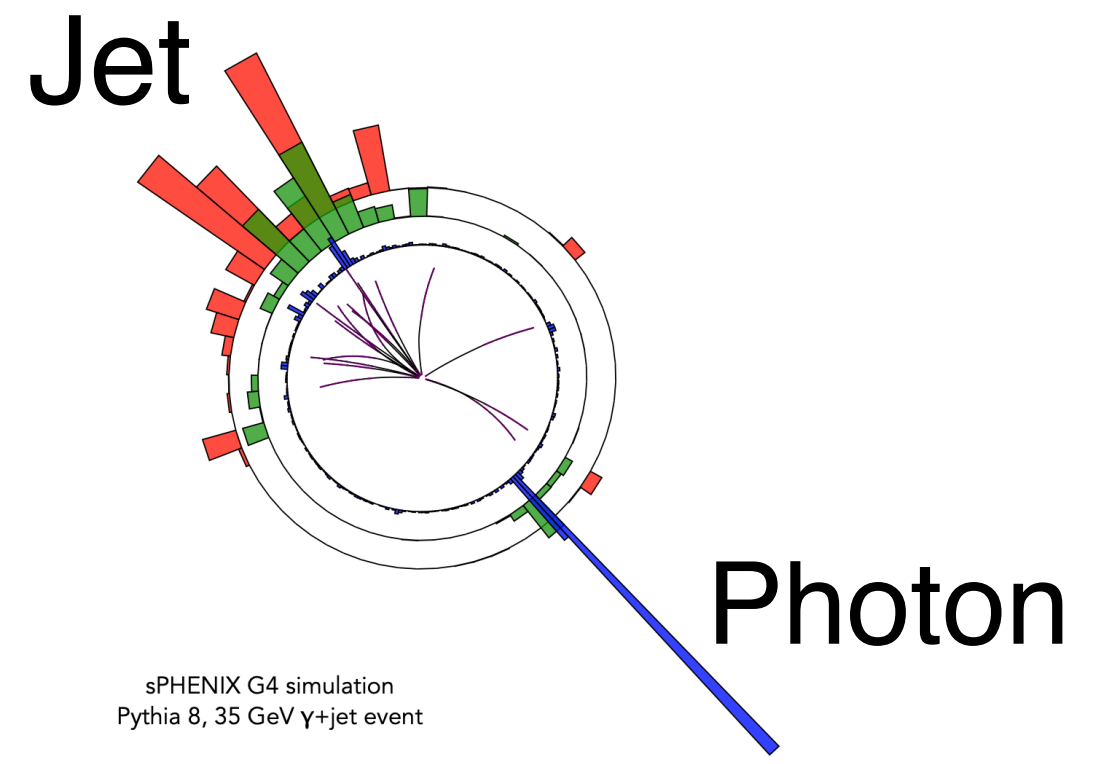
How to study QGP? Use Heavy Ion Collisions

Nuclear collisions and the QGP expansion



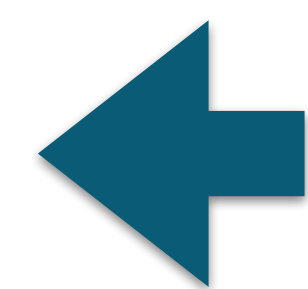
Jet: Probe for QGP

- **Jets:** particle stream produced from hard-scattered parton showers
- ➔ Jet loses energy by strongly interacting with QGP in heavy ion collisions
- ➔ Jets in proton-proton (pp) collisions are used as reference

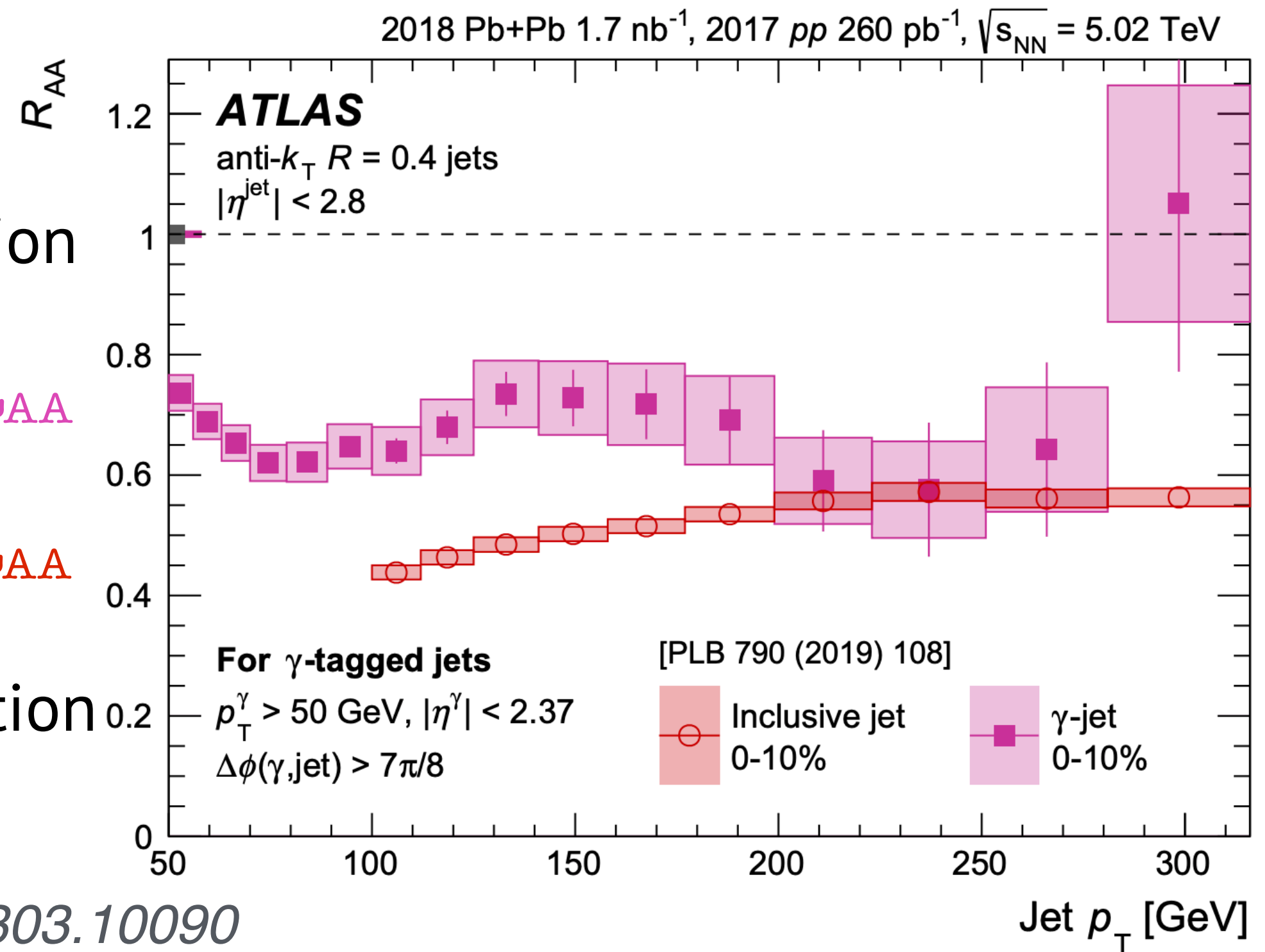


$$R_{AA} = \frac{\text{AA}}{\text{NN-scaled pp}}$$

Gluons lose more energy than quarks when interacting with QGP



quark-to-QGP interaction
 Photon-tagged jet R_{AA}
 Inclusive jet R_{AA}
 gluon-to-QGP interaction

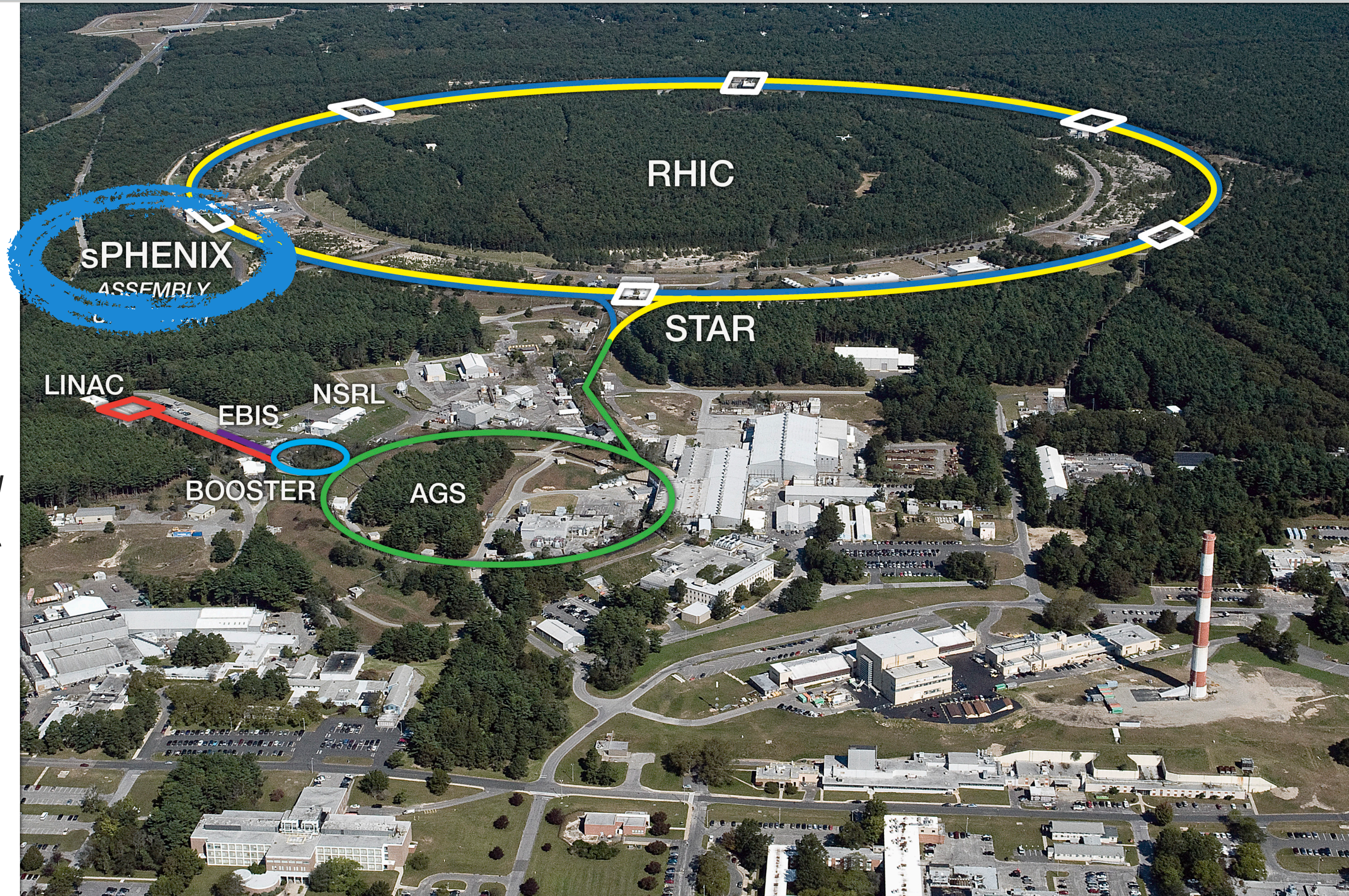


arXiv 2303.10090

sPHENIX Experiment

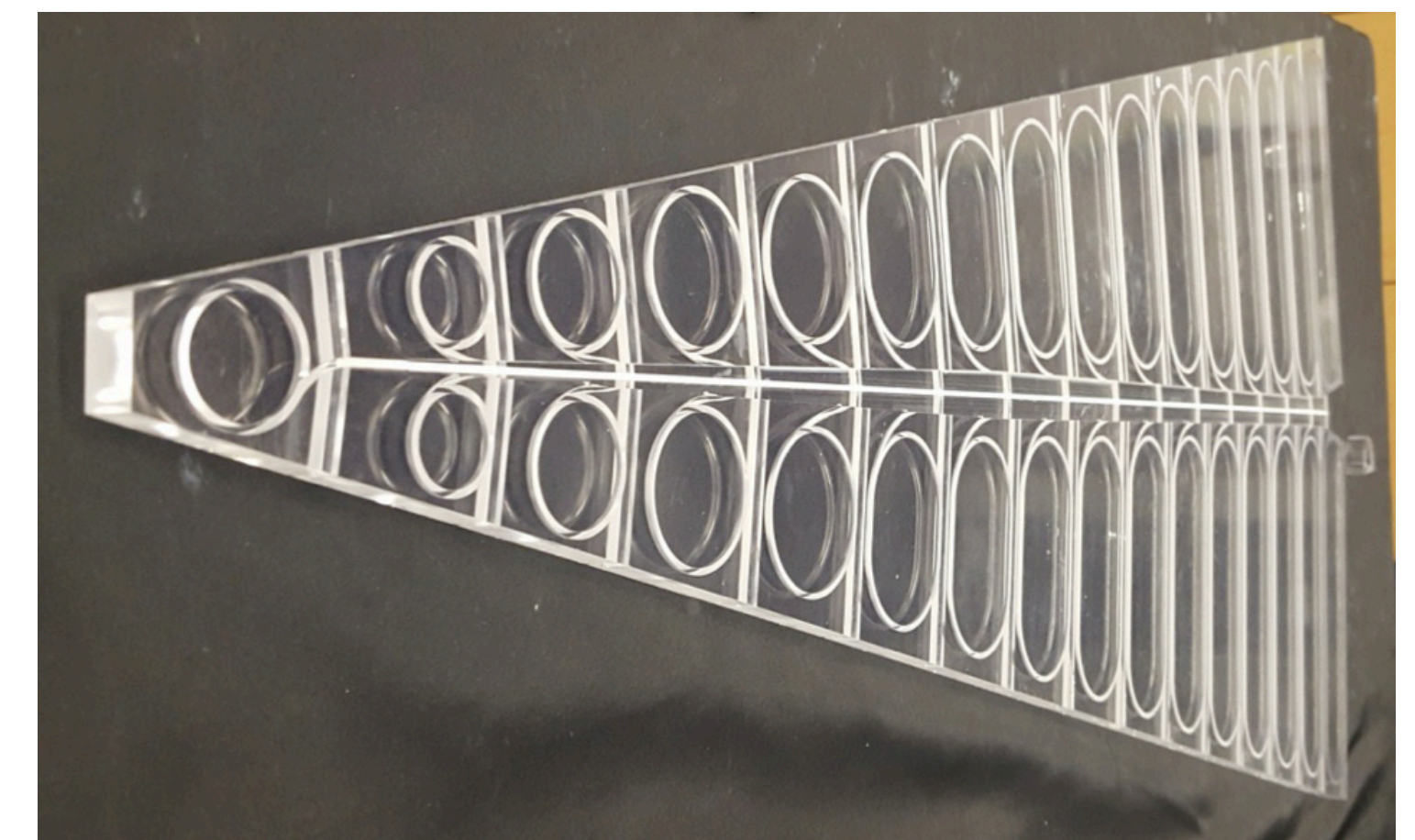
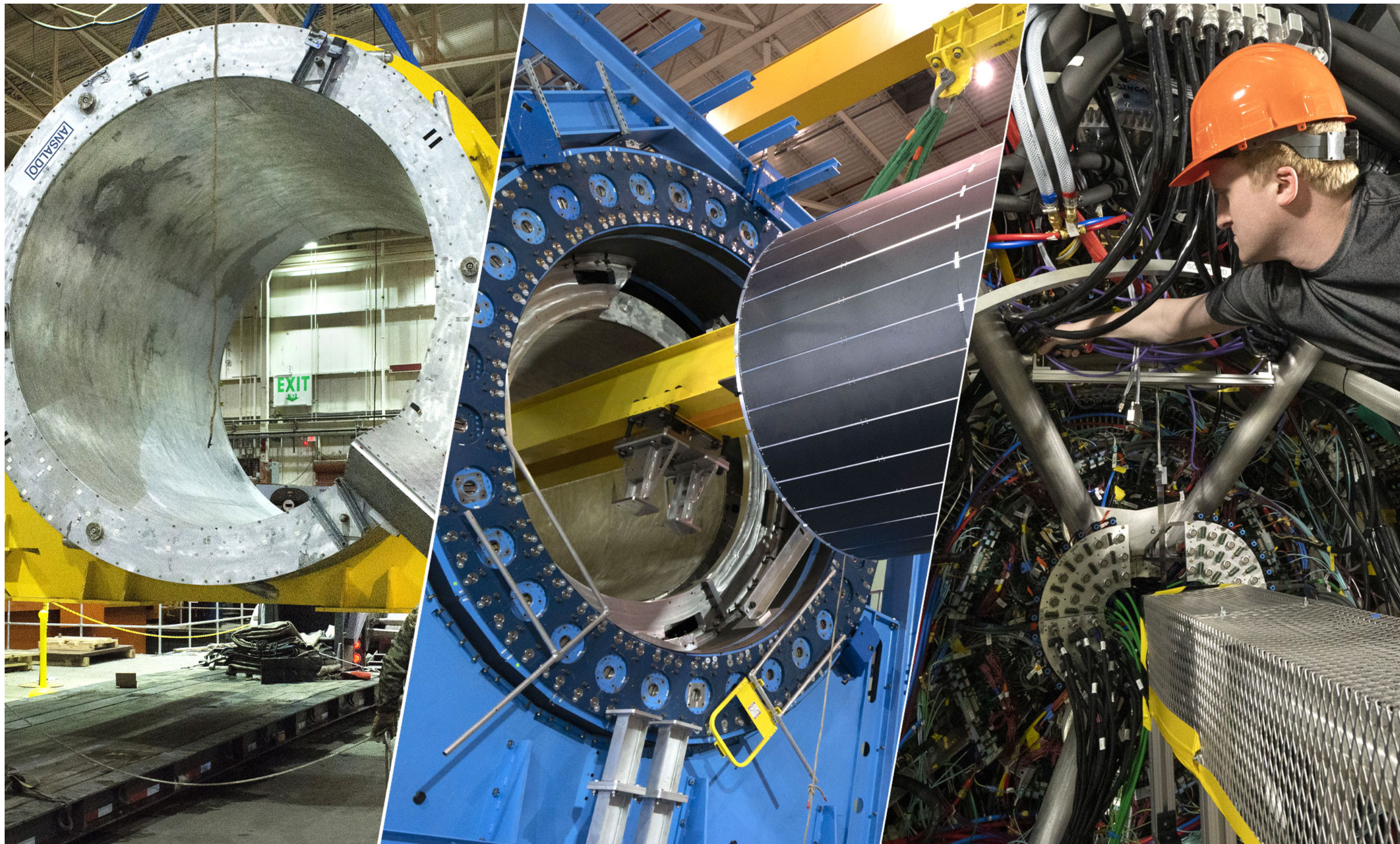


- *Run Started in April, 2023*
- *Detector Commissioning on-going*
- *Designed for versatile Jet Physics*



sPHENIX Detector Construction and Run Preparation

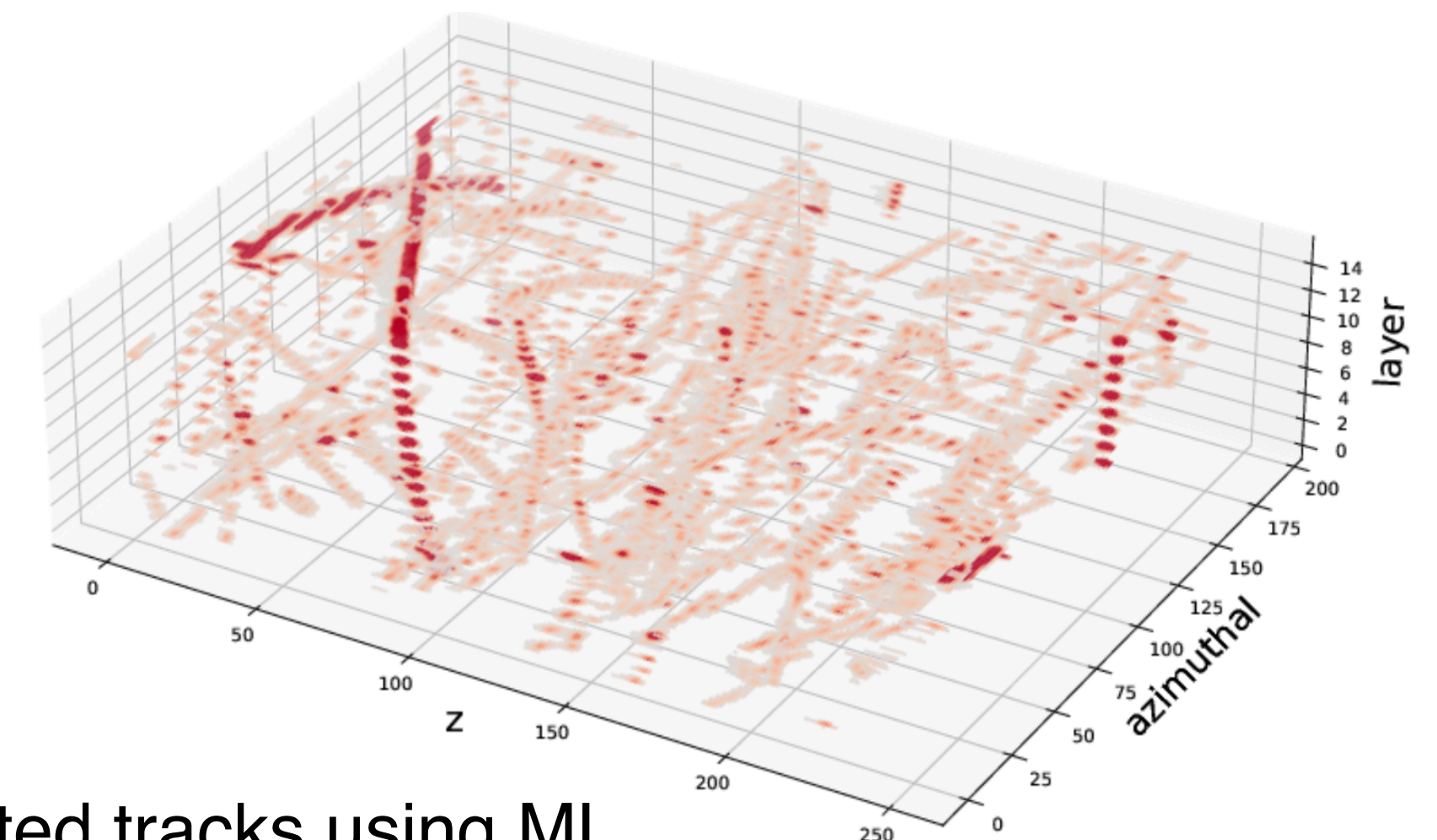
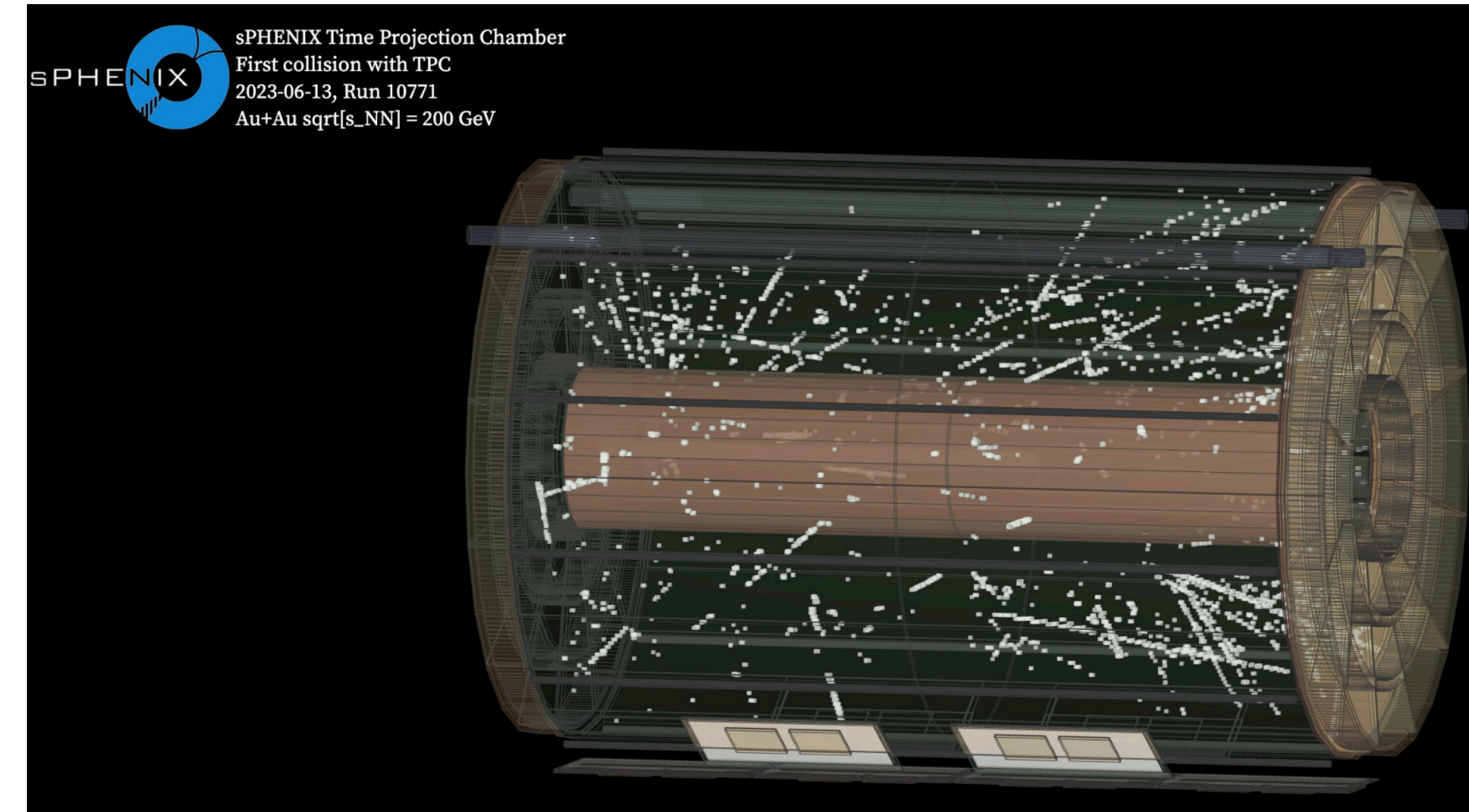
- Involved in detector construction and preparations
 - ➔ Assembled Hadronic Calorimeter
 - ➔ Developed online DAQ/trigger system
 - ➔ Conducted performance tests on Event Plane Detector



Machine Learning in High Energy Nuclear Physics

- Real-time AI Data Reduction
 - ➔ Integration of AI methods in the sPHENIX experiment
 - online triggering for Time Projection Chamber (TPC)
 - ➔ to extend the insights to the EIC
- ML/AI algorithms for jet and photon reconstruction in heavy ion collisions
- Collaborating with Computational Science Initiative (CSI)

***Cutting-edge developments
in the Nuclear Physics field!***



Reconstructed tracks using ML