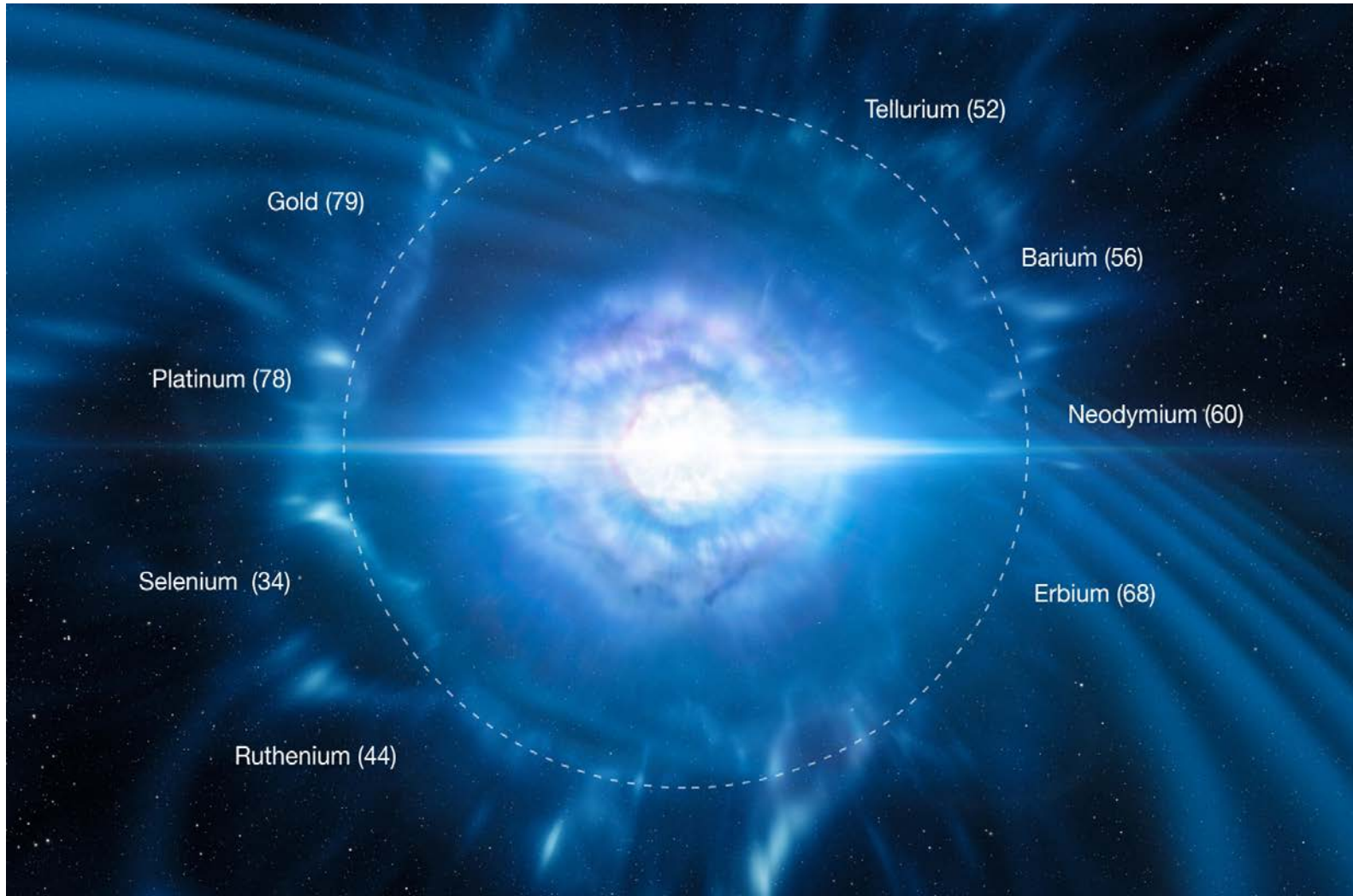


CNN Headline (Oct 17, 2017):

Neutron star collision creates light, gravitational waves and gold

Astronomy.com: LIGO Detects a Neutron Star Merger



Two Nuclear Physics Questions

1. How to make Au?

- Nucleosynthesis

2. What happens to the neutron stars during and after merger?

- **Nature of neutron matter**

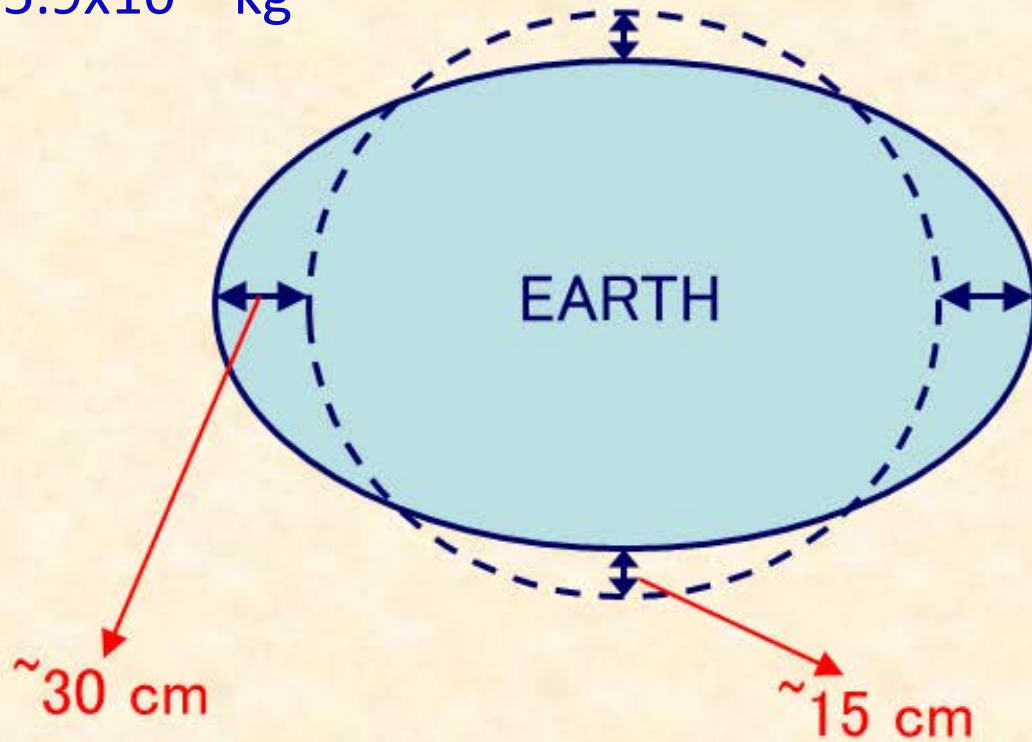


<https://people.nsl.msu.edu/~tsang/>

Tidal deformation of the Earth

Diameter: 8000 km
Weight: 5.9×10^{24} kg

Diameter: 3500 km
Weight: 7.3×10^{22} kg
Distance: 384,400 km



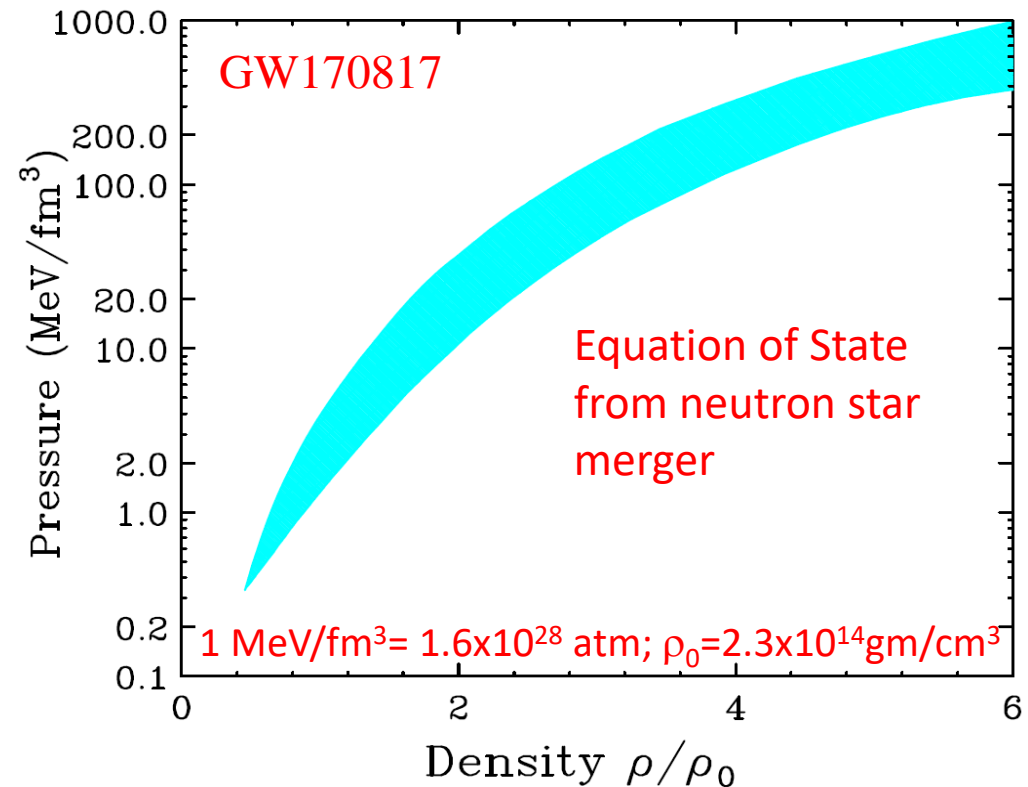
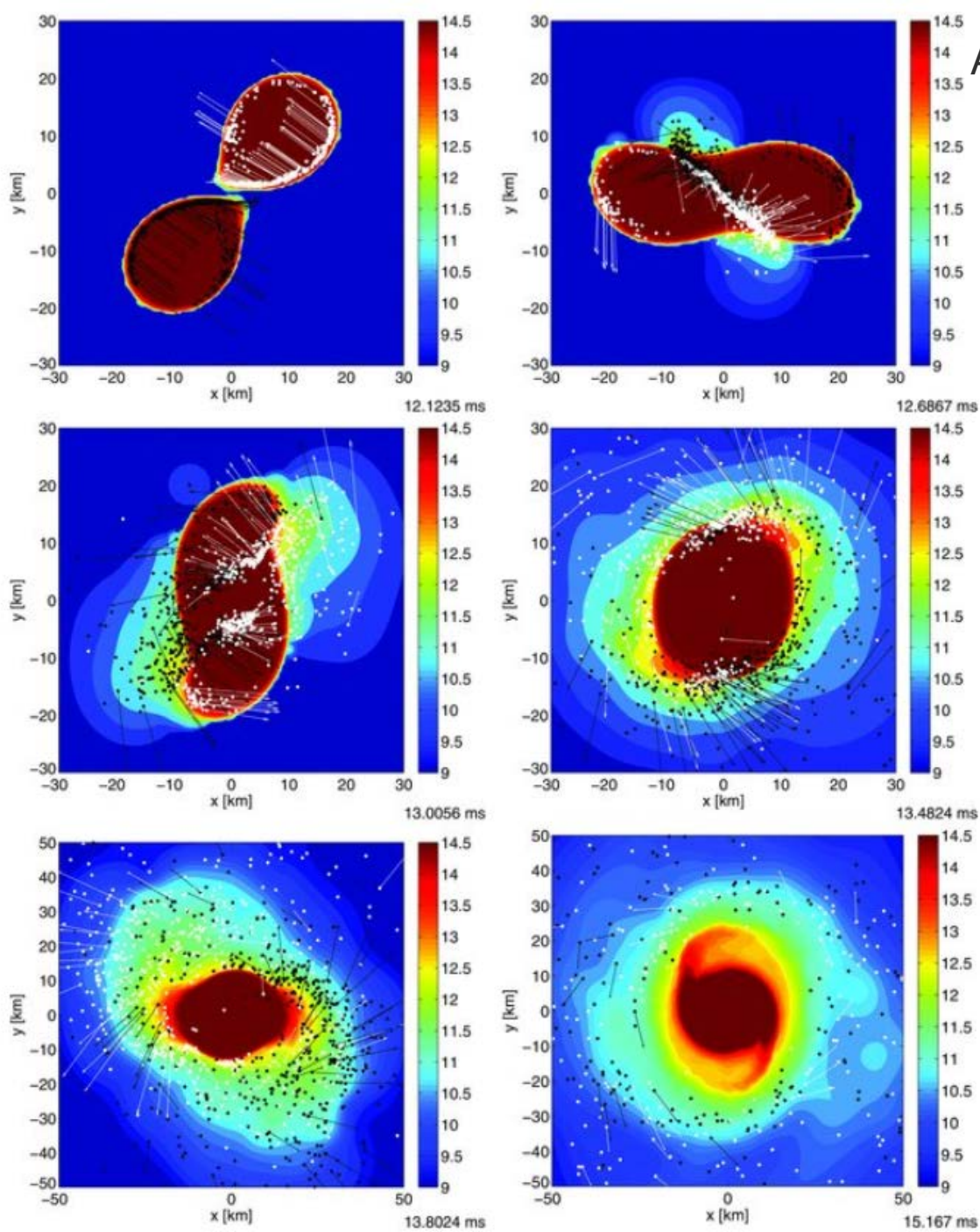
Neutron star



Diameter: 22 km
Weight: 4×10^{30} kg
Measurable Tidal deformation occurs ~ 200 km during merger

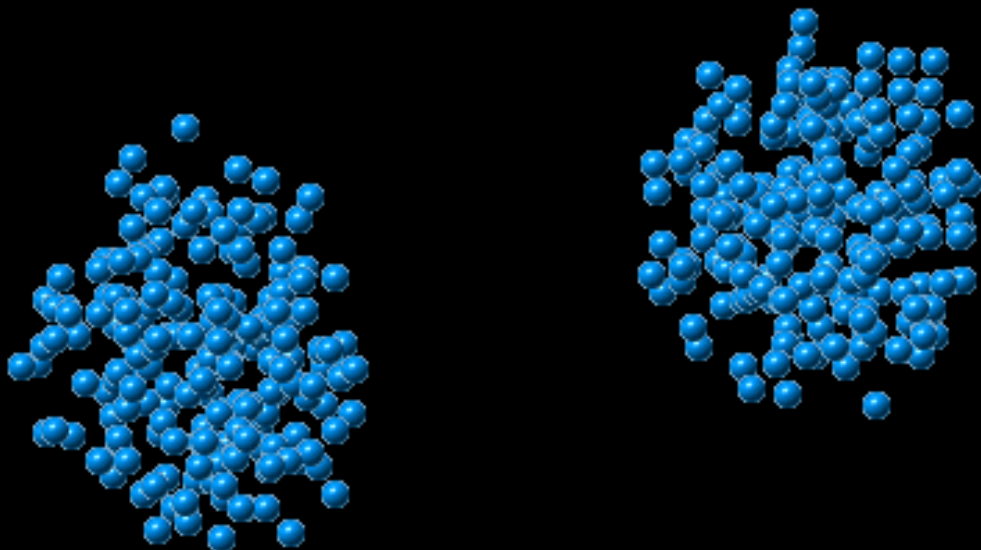
A. Bauswein, S. Goriely, and H.-T. Janka: APJ, 773, 21 (2013)

Tidal deformation of the Neutron Star yield information on properties of neutron star e.g. how big, how massive and how much can the matter be compressed?



In nuclear collisions, dense matter similar to neutron star matter can be created and studied.

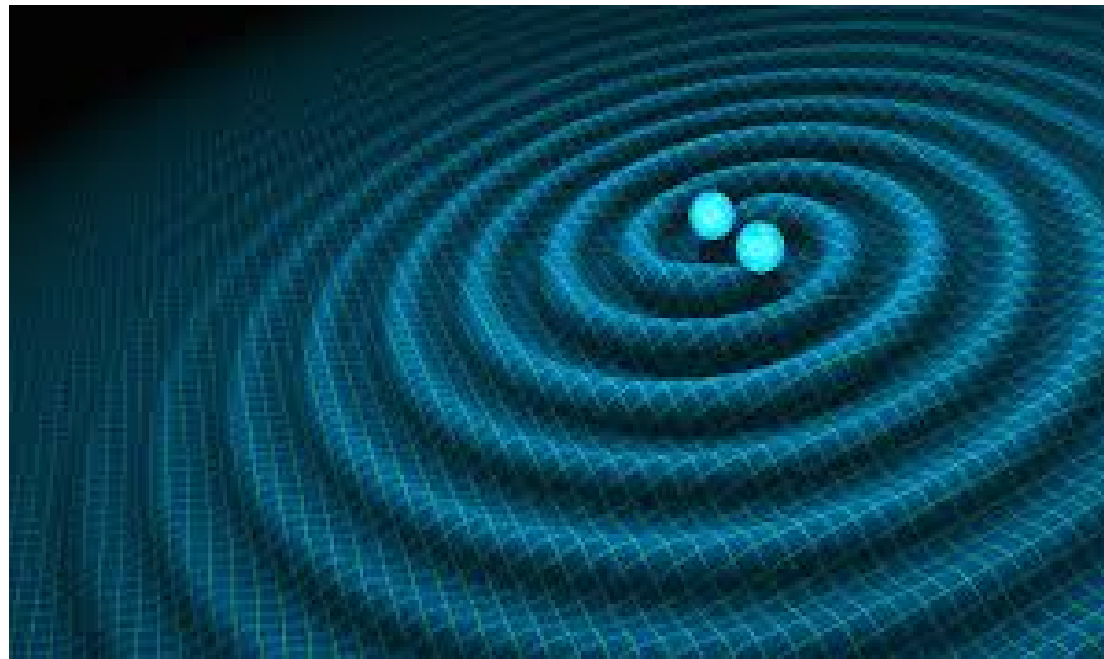
Nucleon
Baryon
Meson



Au+Au collisions
400 MeV/u
b=5 fm



N-Star Merger
(More to come)



Time Scale

N-Star merger: millions of year

N-collisions: <zeta seconds 10^{-21} sec



Front End Electronics



2011-2013

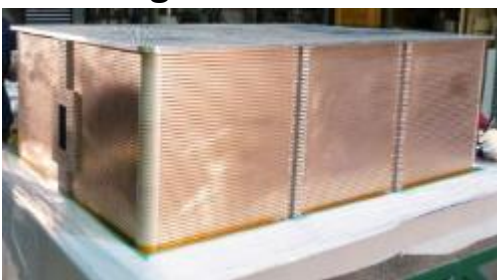
A Time Projection Chamber (SpiRIT TPC) built to study Sn+Sn collisions in RIKEN, Japan.

-- Joint US(DOE)-Japan (MEXT) project
-- later joined by Korea, China, Poland, Germany

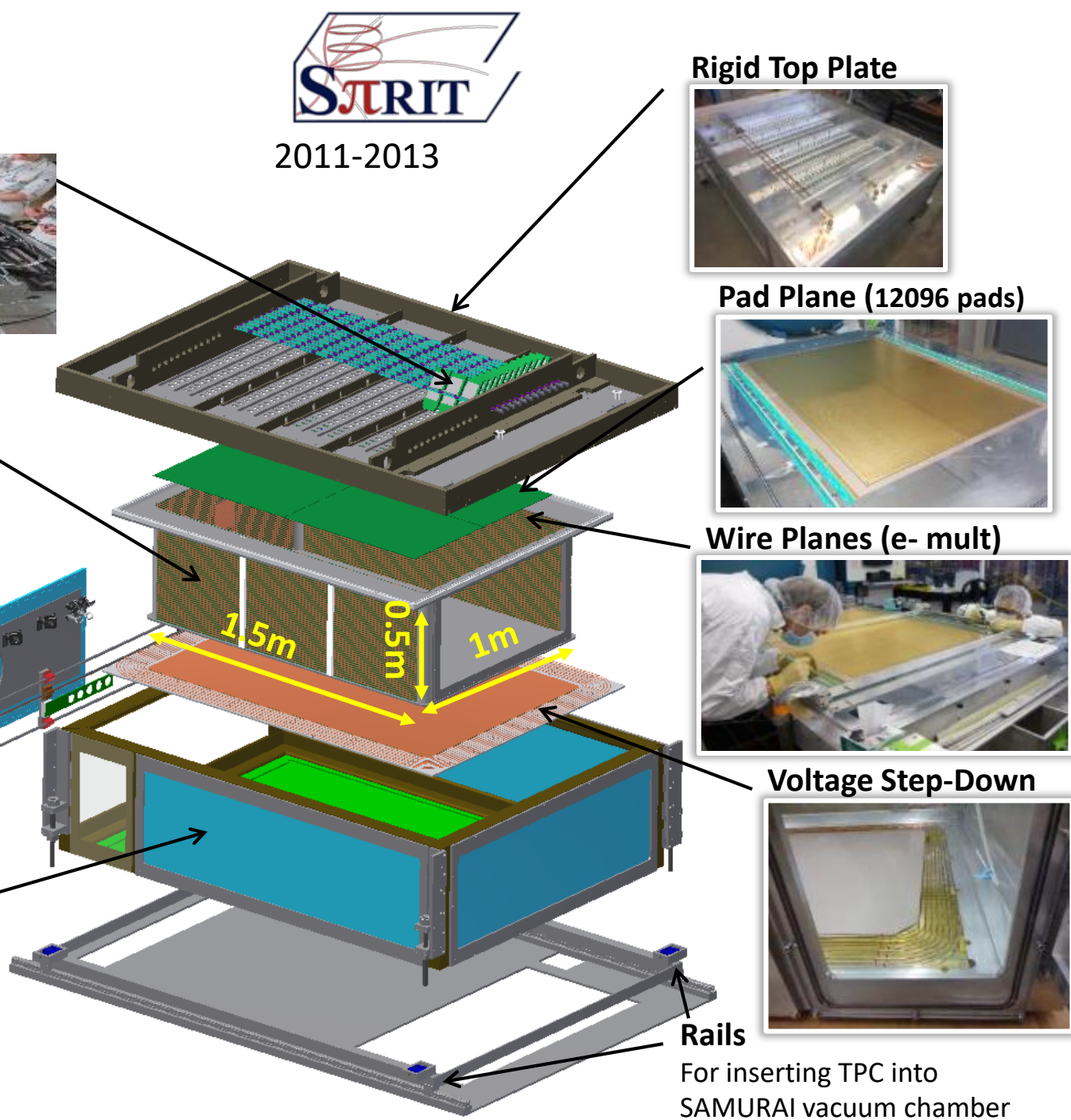
<https://groups.nsl.msu.edu/hira/cosmic/SpiritTPC.html>



Field Cage



Thin-Walled Enclosure



Rigid Top Plate



Pad Plane (12096 pads)



Wire Planes (e- mult)



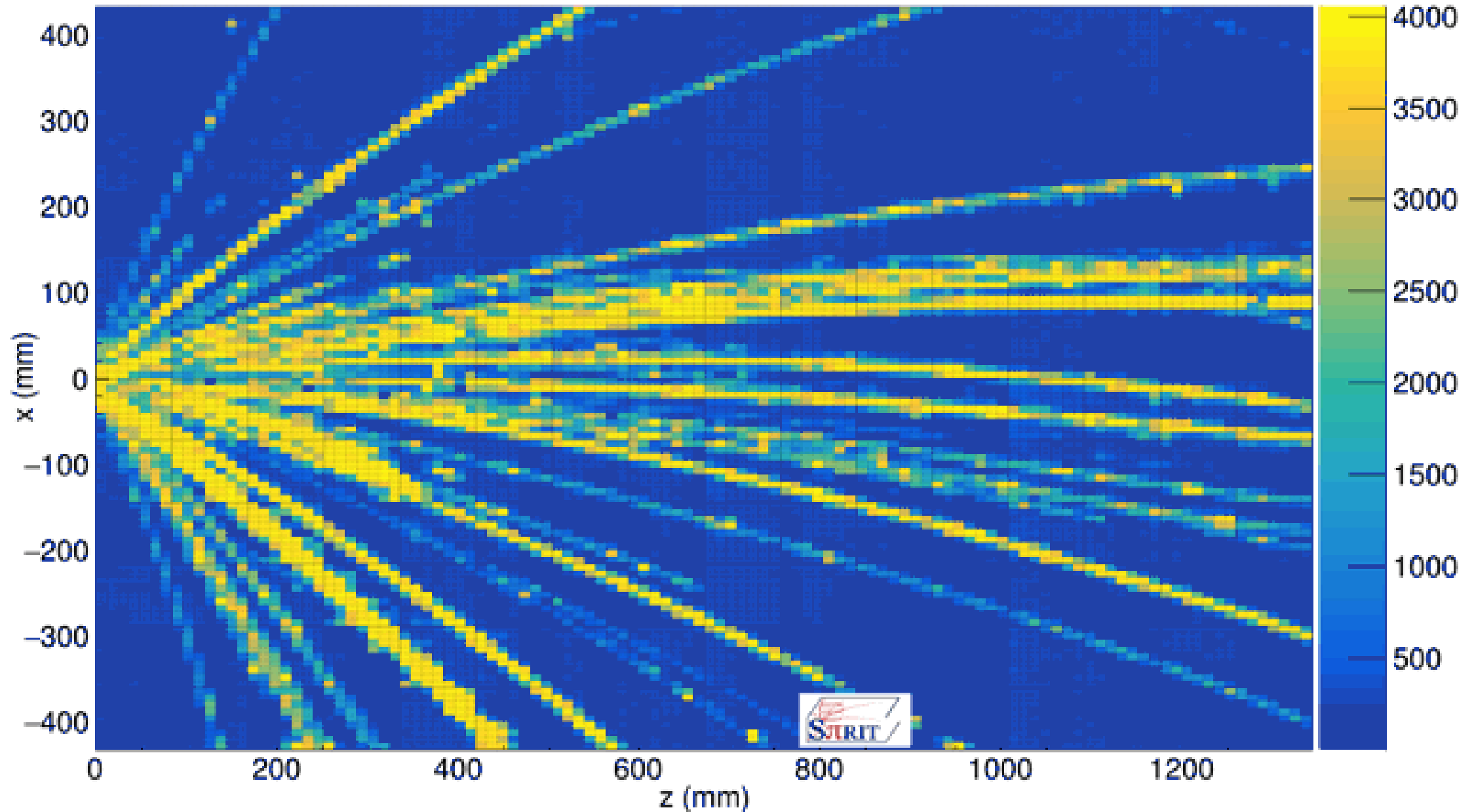
Voltage Step-Down



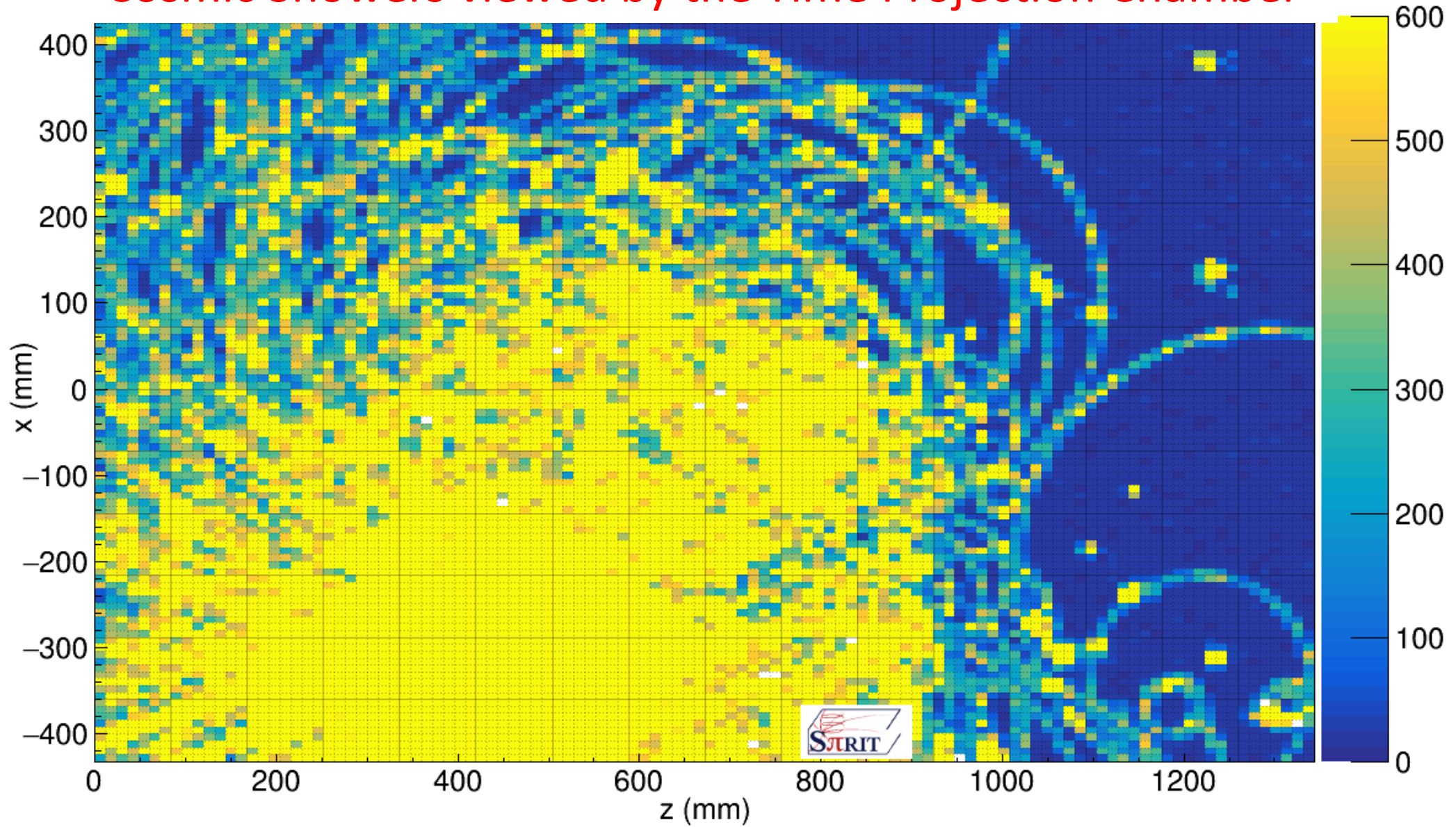
Rails

For inserting TPC into SAMURAI vacuum chamber

The time projection chamber allows 3D viewing of nuclear collisions

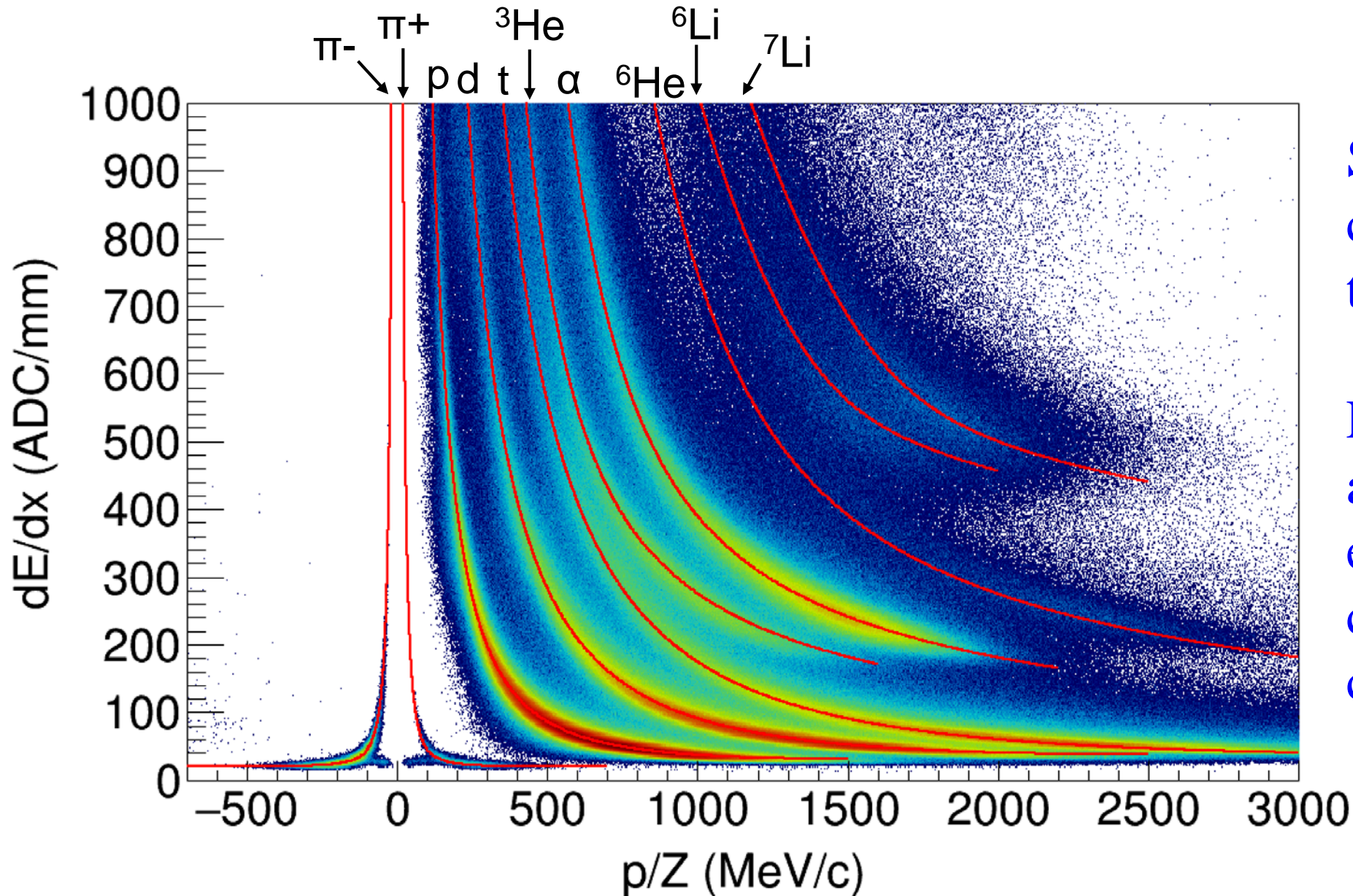


Cosmic Showers viewed by the Time Projection Chamber



<https://groups.nslc.msu.edu/hira/cosmic/>

Particles from nuclear collisions detected by the TPC



Simulate nuclear collisions with theoretical models

Extract information about the nuclear equation of state by comparing calculations to data

Research Project

Read about neutron stars properties and LIGO news about neutron star merger and neutron star-black hole merger

Relate observable from LIGO detection of the merger events to nuclear physics variables with models

Simulate heavy ion collisions and compare to data

Experimental Opportunities

Data analysis of TPC experiments and other NSCL experiments

Detector development and participation in upcoming experiment at NSCL in March and September 2020