Charged Particle Detector to Identify Higher Energy Fragments from Heavy Ion Collisions

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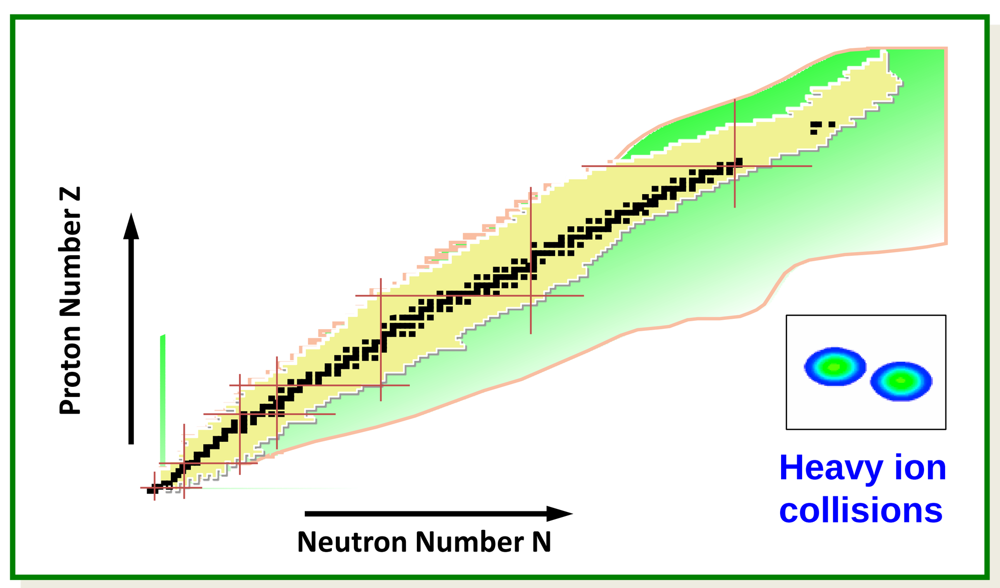
PHYSICS MOTIVATION

Why doesn't a neutron star collapse under its own weight? ***(one teaspoon = 5.5 E12 kg)***

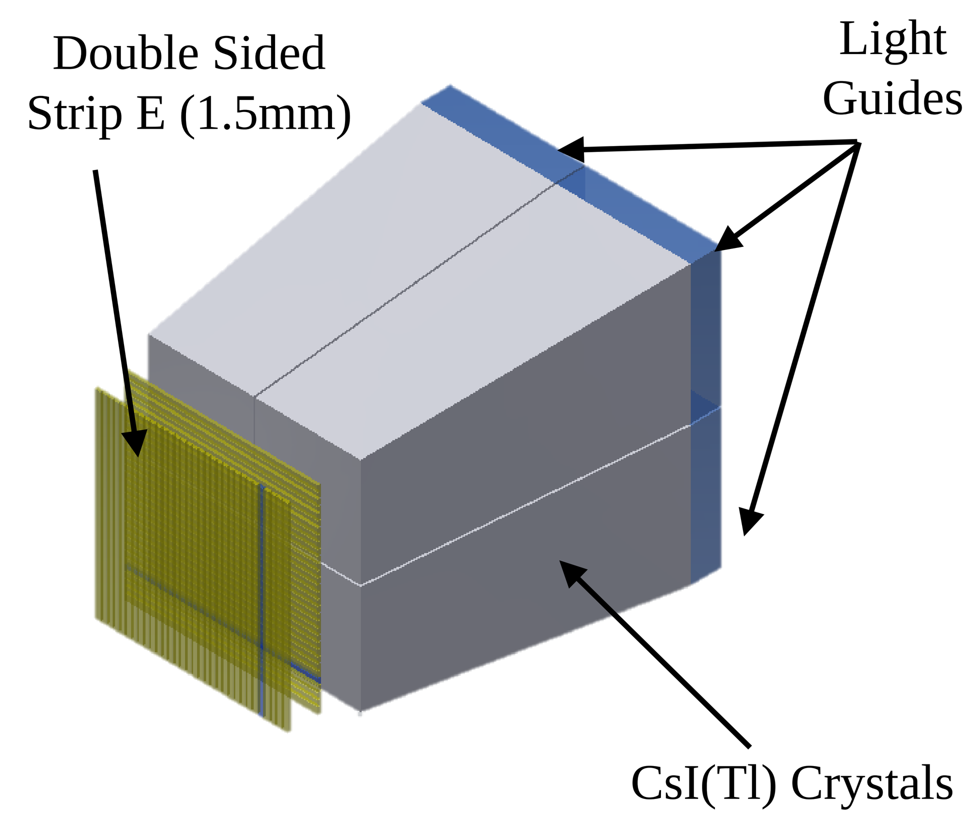
Pressure from the ***nuclear symmetry energy*** from the imbalance of neutrons to protons counters the gravitational force. Symmetry energy is the variation of the ***nuclear binding energy of protons (Z) and neutrons (N)***. This is the same physics that governs the ***properties of nuclei***.

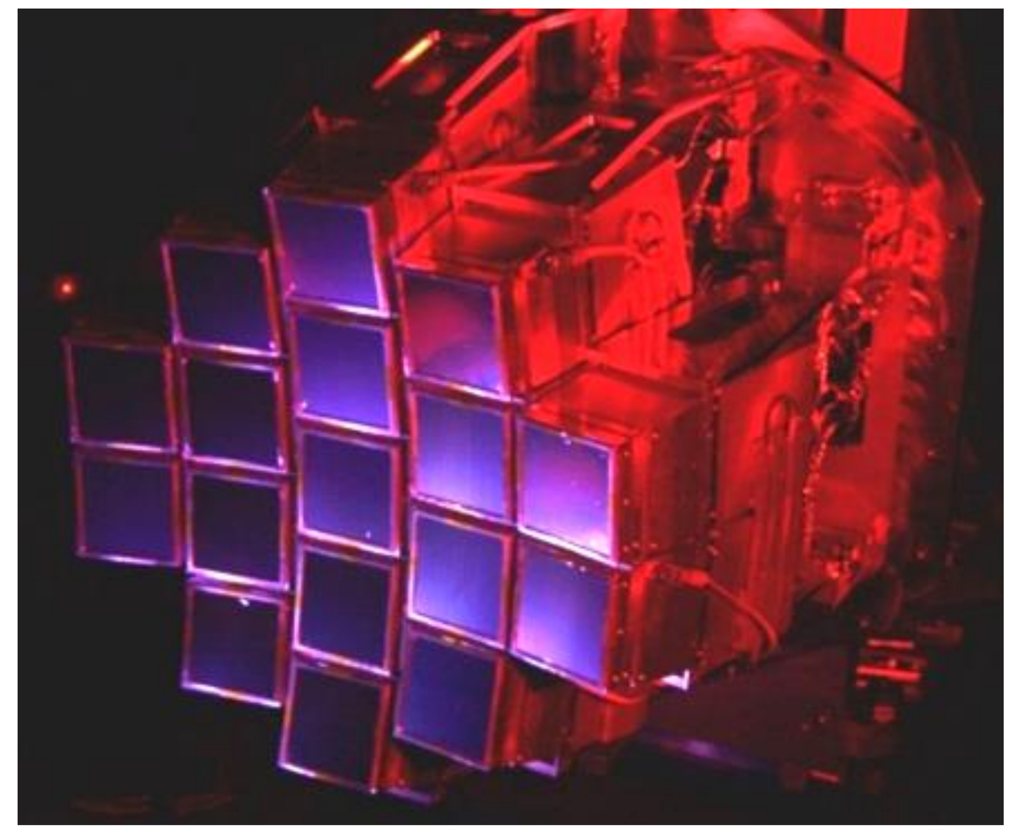


Crab Pulsar

At FRIB, scientists use HiRA to measure isotopes emitted in Sn+Sn collisions in order to understand the ***symmetry energy*** and its constraints.

THE HIGH RESOLUTION ARRAY (HiRA)





HiRA SPECIFICATIONS

- 32 strip, double-sided "E" layer
- ***4 CsI(Tl) crystals 10 cm long*** for particles that go through the "E"

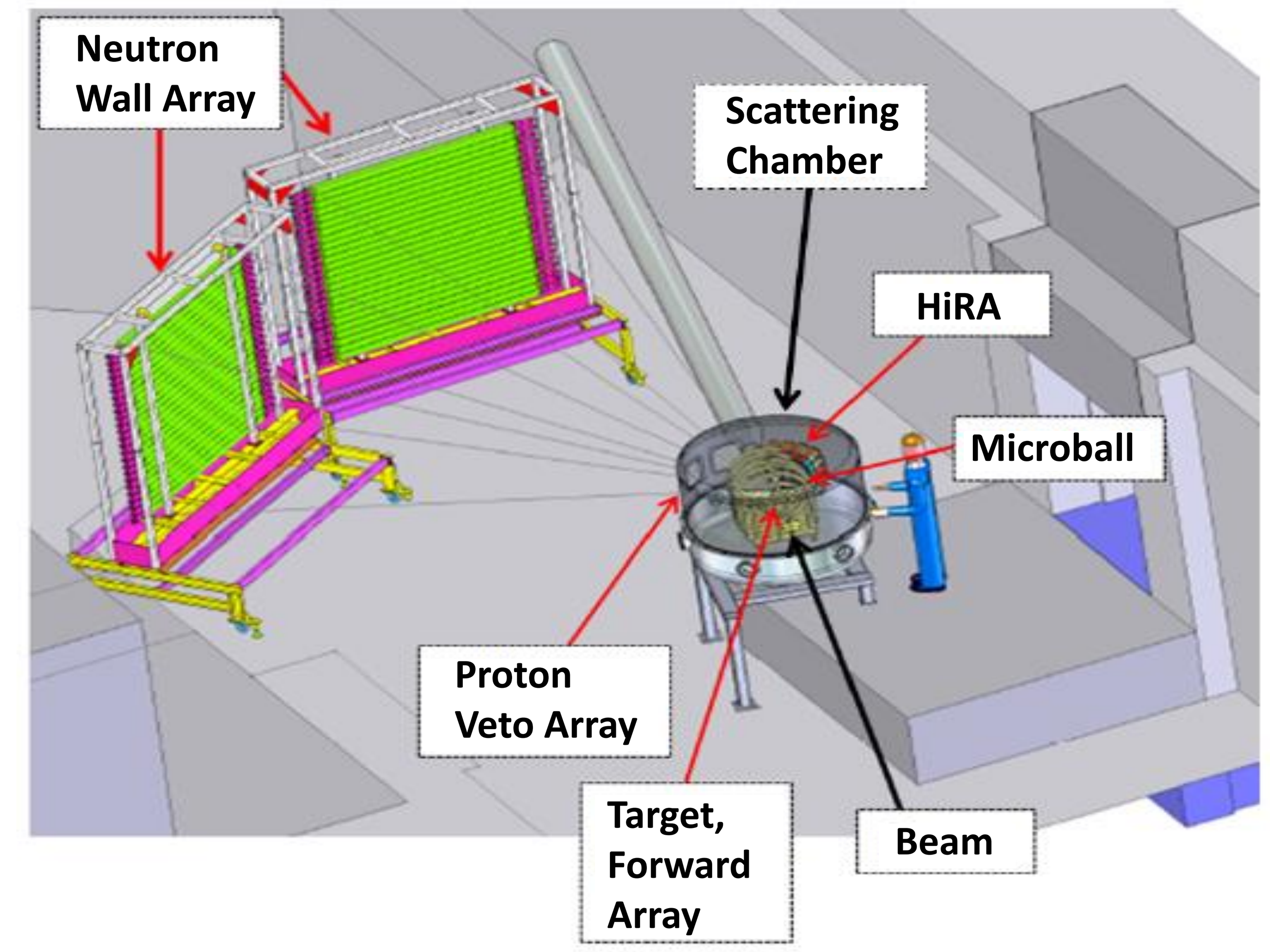
ARRANGEMENT

The 12 HiRA telescopes ***can be arranged in any shape or design***. Each experiment typically calls for different arrangements in order to maximize efficiency.

PRINCIPLES OF OPERATION

Particle identification: Isotopes are identified using the ΔE-E technique. By comparing the energy loss in the "E" to energy deposited in the CsI, particles in the detector can be uniquely identified.
Position sensitivity: The perpendicular strips on the front and back of the thick "E" detector define a pixel that characterizes the particle's trajectory. Each "E" detector contains 1024 pixels.

Experimental Setup Drawing for E15190/E14030



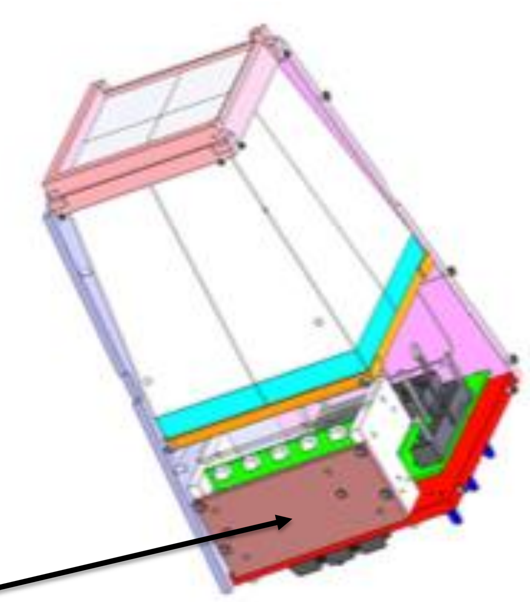
PLANNED EXPERIMENTS

E14030/E15190: The goal of these two experiments is to ***constrain the nuclear mean field potential***. The HiRA10 array along with the Large Area Neutron Array (LANA) will be used to measure proton and neutron spectra. From these we will be able to construct neutron/proton spectral ratios which are sensitive to variables of the nuclear mean field potential.

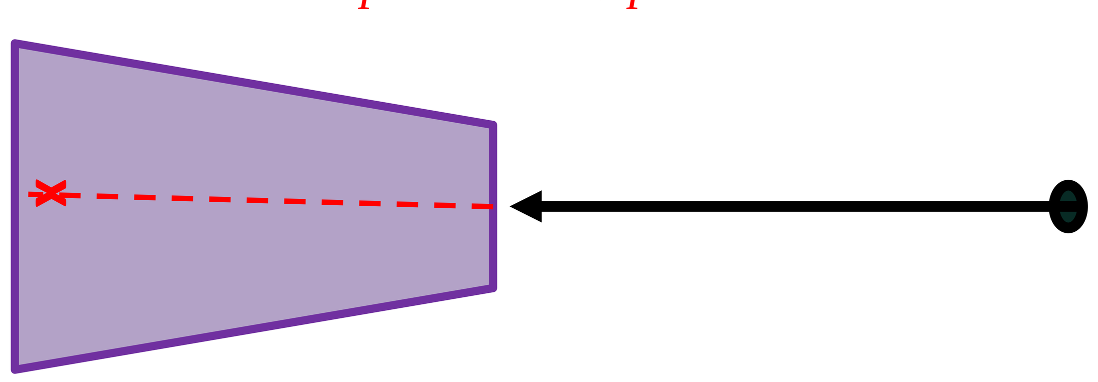
HiRA Telescopes

CESIUM IODIDE (CsI) CRYSTALS

CsI crystals are useful for ***measuring the energies of particles*** that come from nuclear reactions. The crystals produce light when electrons are ionized as particles travel through. The light produced is measured to obtain the energy of the particle. The light hits Si photo-diodes, which have a current $\propto$ to the collected light and to the energy deposited.



10 cm CsI can stop a 190 MeV proton



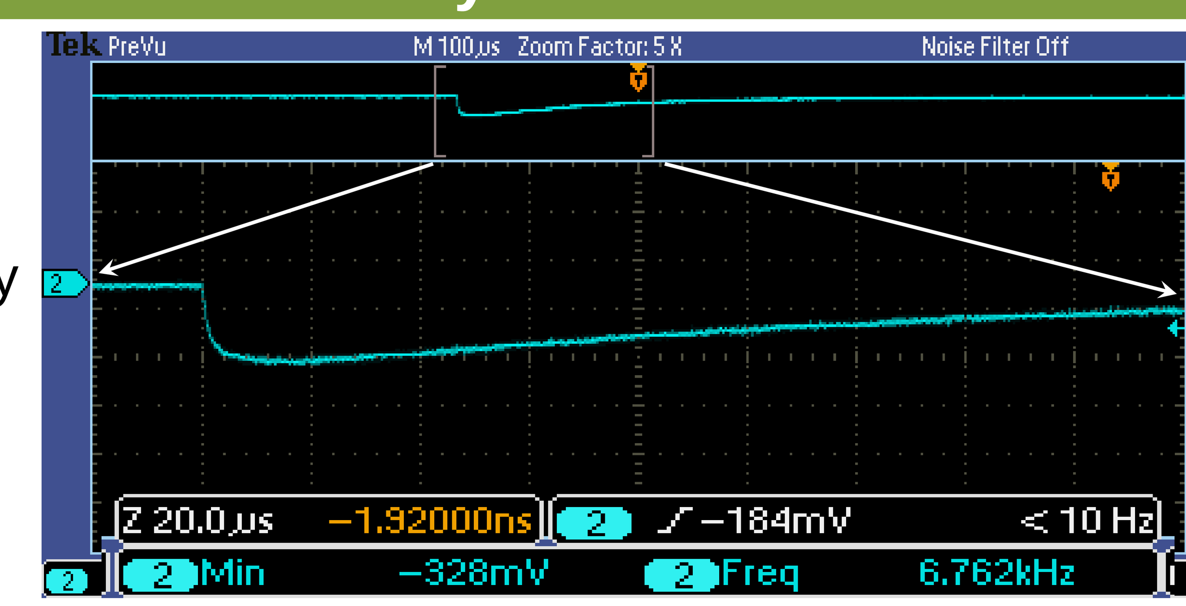
PRE-AMP BOX AND COOLING PLATE

5 pre-amps are used within the telescope in order to ***amplify the signal from the crystal***. The cooling plate helps keep the temperature moderate.

Testing CsI with Cosmic Rays

COSMIC RAYS

Cosmic rays are high-energy radiation that originate from cosmic events throughout the universe. They are mostly composed of ***high energy protons and atomic nuclei***. We can use these ***free accelerated particles*** in order to test HiRA. The accelerated particles from FRIB will be much higher energy than cosmic rays.



Seeing a cosmic ray on the oscilloscope means the crystal works!

TESTING WITH COSMIC RAYS

We test for cosmic rays in order to see if the HiRA CsI crystals work properly. ***Some energy is deposited from a cosmic ray*** within the CsI crystals and the resulting electrical signal from the pre-amp can be observed with an oscilloscope.

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