Yennello Research Group

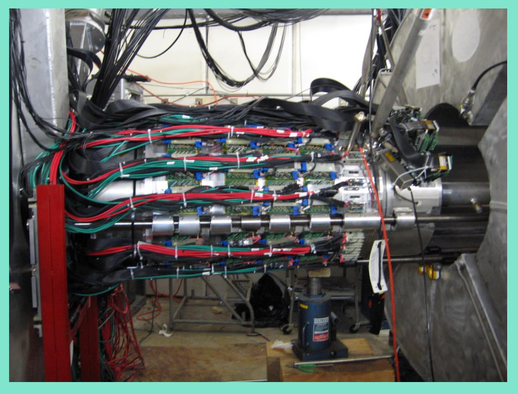
CYCLOTRON INSTITUTE
Texas A&M University

The properties of isospin asymmetric nuclear matter (that is matter with an excess of neutrons or protons) at densities higher or lower than normal nuclear matter can be studied using heavy ion reactions. These reactions are important for studying the structure, chemical composition and evolution of neutron stars and the dynamics of supernovae explosions. Predictions have been made that the decay of excited nuclear matter would be dependent on N/Z, due to the difference in the chemical potential of the neutrons and protons. These predictions indicated that a neutron-rich system would undergo a “distillation” that results in a low density (or gas) phase that receives much of the neutron richness and a high density (or liquid) phase that would become more isospin symmetric.

The Yennello Research Group is involved in carrying out studies on isospin dependencies on the dynamical formation of excited systems, the process of isospin equilibration and the subsequent disintegration of these systems in heavy-ion reactions. The group is based at the Texas A&M University Cyclotron Institute and utilizes the K500 superconducting cyclotron, to accelerate our projectiles up to 40 percent the speed of light and collide it with a stationary target nuclei. These collisions create excited systems that decay by emitting fragments that are then collected using various detector arrays. These fragments can then provide information about the reactions that took place. We also collaborate with other groups in the U.S. and around the world. Some of our interesting results and equipment that we use are described below.

NIMROD-ISiS

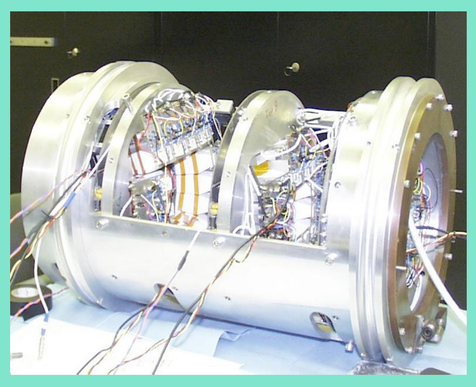
Neutron and Ion Multidetector for Reaction Oriented Dynamic - Indian Silicon Sphere



NIMROD-ISiS is a 4pi (spherical) detector consisting of 228 detector modules covering from ~3-167 degrees. Each detector module consists of 1 or 2 silicon wafers and a CsI crystal. The combination of Si-Si and Si-CsI detectors yields elemental resolution for high Z’s as well as isotopic resolution for elements of Z = 1 - ~17. NIMROD-ISiS is coupled with the TAMU Neutron Ball. The Neutron Ball is composed of 6 tanks of Gd doped pseudocumine enveloping the NIMROD-ISiS array. This gives near 4π detection of neutrons for event neutron multiplicity estimation. The ability to collect quasi-complete events with isotopic resolution and neutron multiplicity makes the NIMROD-ISiS array useful for cutting edge nuclear experiments.

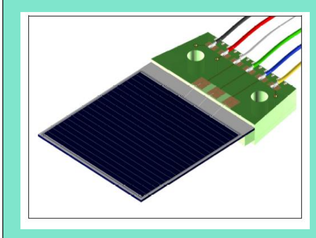
FAUST

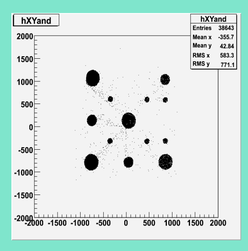
Forward Array Using Silicon Technology

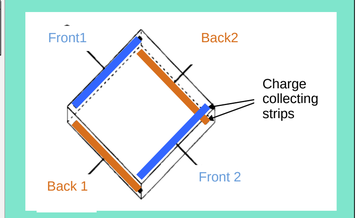


FAUST has 68 ΔE-E (Si-CsI) detector telescopes used for studying peripheral reactions. FAUST is mobile and can be used in any of the lines in the Cyclotron Institute. Its main use has been for peripheral heavy ion collisions.
FAUST has been adapted to accept a Dual-Axis Dual Lateral Position Sensitive Silicon Detector to increase its position sensitivity 1000 fold. This detector is currently in development in the SJY group.

Dual-Axis Dual-Lateral Position Sensitive Silicon Detector







Energy given by:

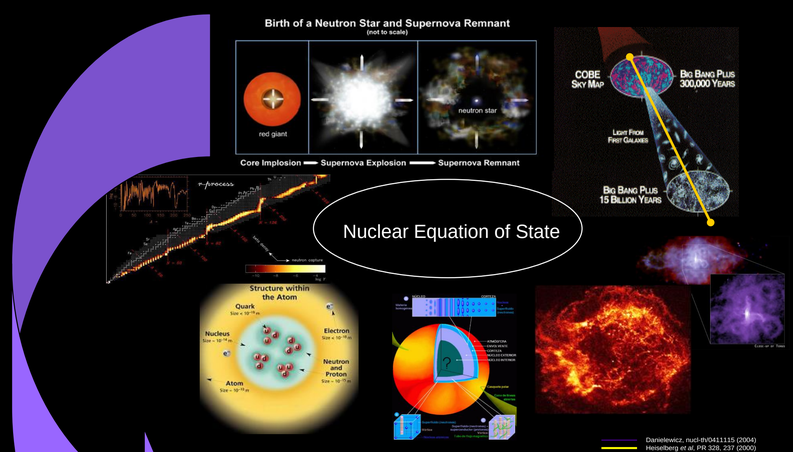
$$E_{Front} = Q_{F1} + Q_{F2}$$
$$E_{Back} = Q_{B1} + Q_{B2}$$
$$E_{Tot} = E_{Front} = E_{Back}$$

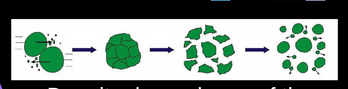
Position

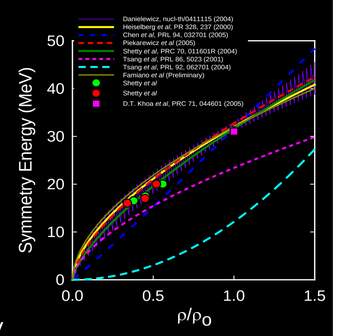
$$X \propto (Q_{B1} - Q_{B2})/(Q_{B1} + Q_{B2})$$
$$Y \propto (Q_{F1} - Q_{F2})/(Q_{F1} + Q_{F2})$$

This detector is a double sided p-on-n silicon structure with highly uniform resistive junction and ohmic layers with equipotential channels. The readout between two anodes is orthogonal with respect to the readout between the two cathodes. The position sensitivity is on the order of 200 um. Under fully reversed biased conditions, the lateral effect dominates over surface recombination for current distributions. On a given side, the lateral effect allows for linear position reconstruction without the necessity of software correction.

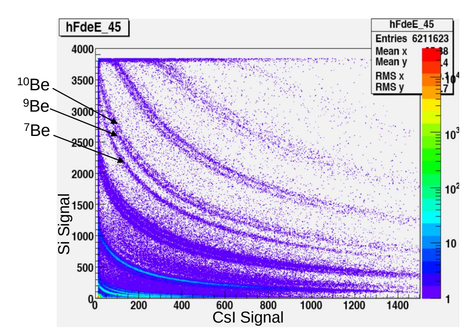
From Atomic Nuclei to Neutron Stars

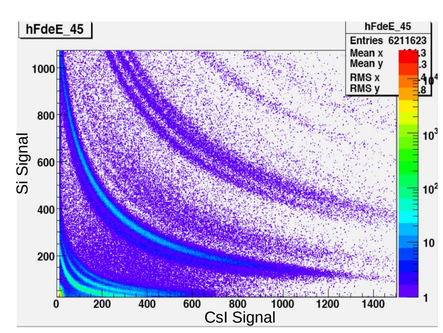


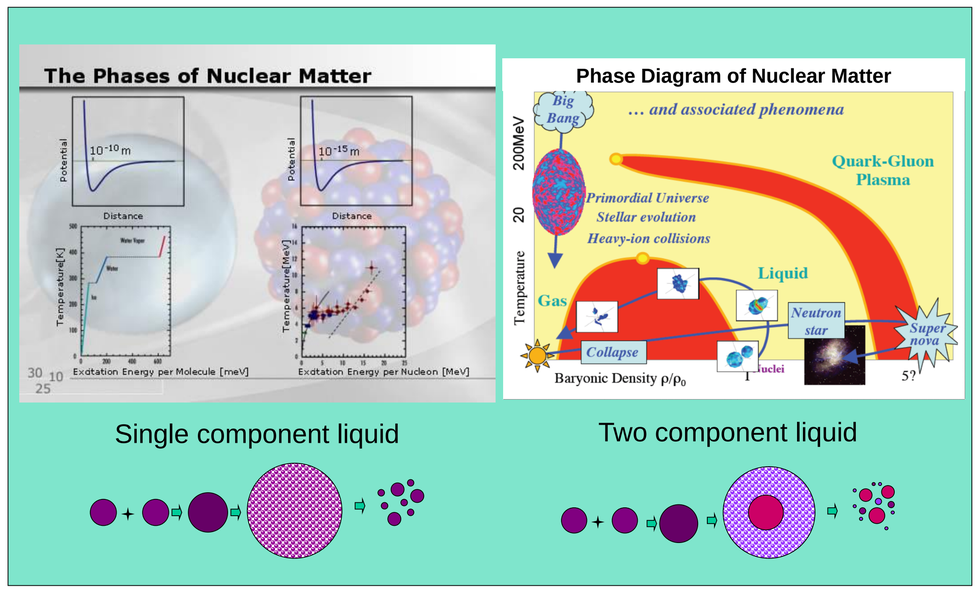




Density dependence of the symmetry energy in nuclear equation of state is largely unconstrained.
Data favors a “ stiff ” form of the density dependence of the symmetry energy
A constraint of $E_{sym}(r) = C(\rho/\rho_0)^{\gamma}$ with C = 31 – 33 MeV and γ = 0.6 – 1.05 is obtained by comparing with various other studies



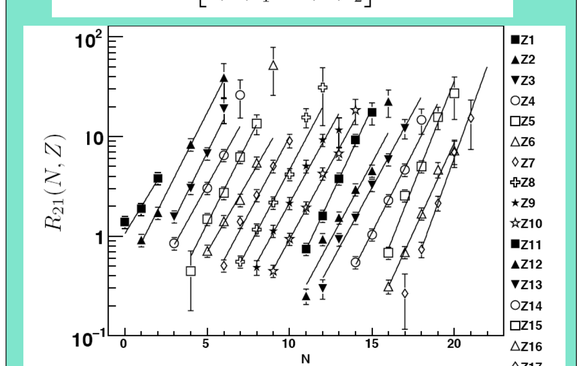


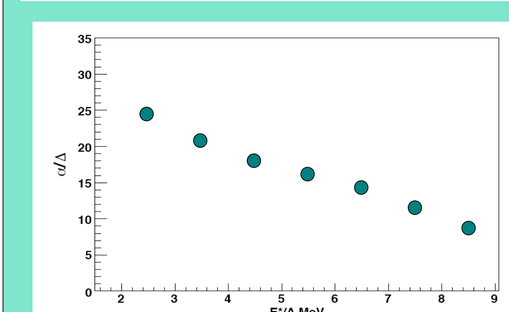


Using Isoscaling to extract information about the symmetry energy.

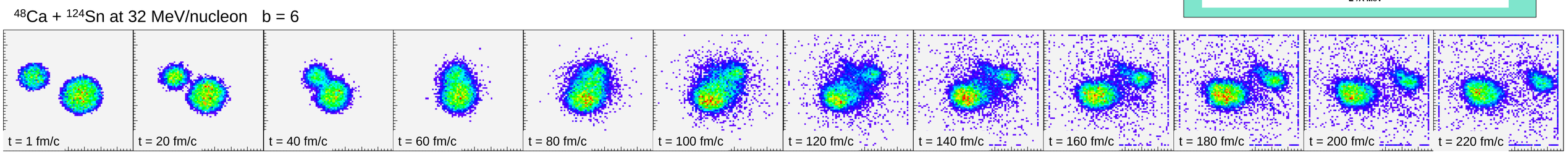
$$R_{21}(N,Z) = Y_2(N,Z)/Y_1(N,Z) = C\exp(N\alpha + Z\beta)$$

$$\alpha = \frac{4C_{sym}}{T}\left[\left(\frac{Z}{A}\right)_1^2 - \left(\frac{Z}{A}\right)_2^2\right] = \frac{4C_{sym}}{T}\Delta$$





$^{48}Ca + ^{124}Sn$ at 32 MeV/nucleon b = 6



For more information about the facility visit: http://cyclotron.tamu.edu
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