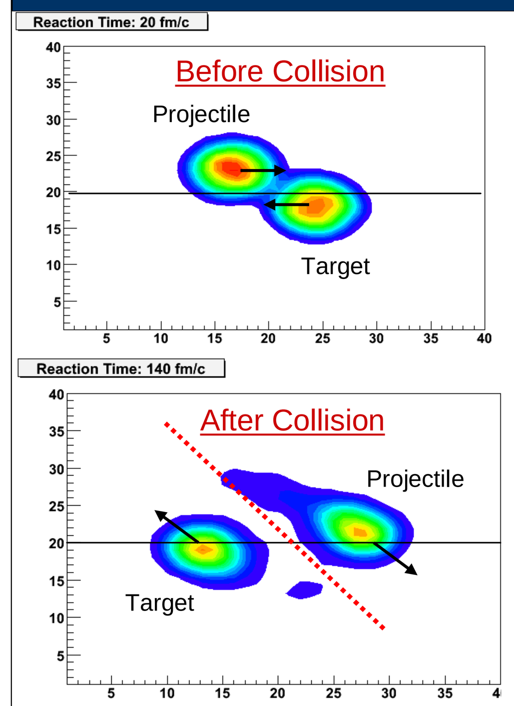
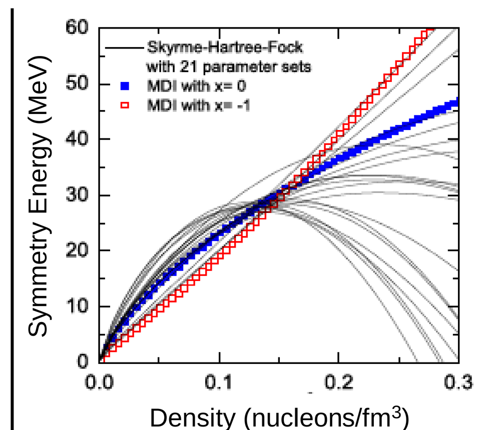
Graduate Student Projects in Nuclear Chemistry

Zach Kohley
Advisor: Sherry Yennello
Research Topic: Symmetry Energy and Collective Flow



The goal of my research is to try to learn about how the symmetry energy changes as a function of density. The collective flow of fragments has been suggested to be sensitive to the density dependence of the symmetry energy. Therefore, it may be possible to extract out information on the density dependence of the symmetry energy by comparing experimental data to theoretical simulations, which use different symmetry energy parameterizations.



The symmetry energy can be thought of as the energy needed to convert all of the protons in symmetric nuclear matter to neutrons.

Through studying the symmetry energy, one is trying to understand the N/Z dependence of the nucleon-nucleon interaction.

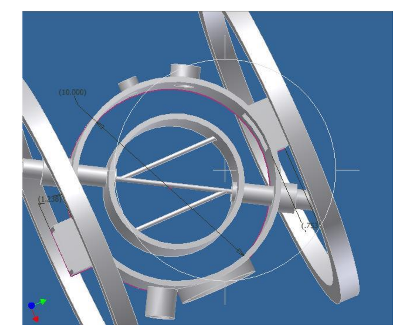
The transverse flow can be thought of as the slope of the dotted red line, which represents the *flow* of nuclear matter.

$$\frac{E}{A}(\rho,I)=\frac{E}{A}(\rho)+\frac{E_{sym}}{A}(\rho)I^2 \qquad with \quad I=\frac{\rho_N-\rho_Z}{\rho_{Total}}$$

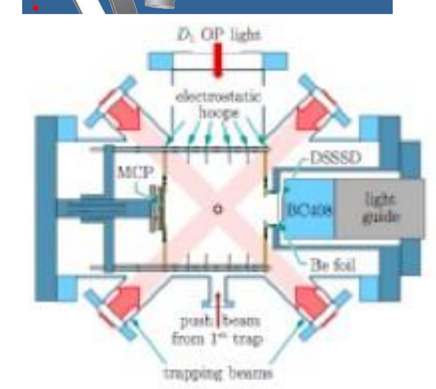
$$E_{sym}(\rho)\approx E(\rho,1)-E(\rho,0) \qquad \rho = density$$

Spencer Behling
Advisor: Dan Melconian
Research Topic: Standard model constraints and the search for new physics

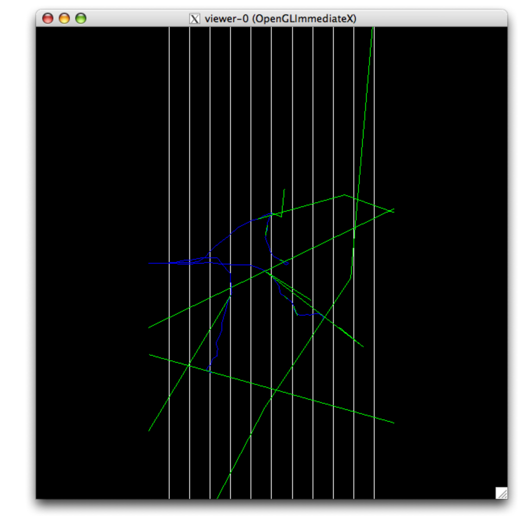
The goal of our research is to test the predictions of the Standard Model and to look for new physics. We do this by measuring the spin polarized angular distribution of the β^+ decay of ^{37}K.



We are currently designing and building a new experimental setup that will allow us to measure correlation parameters to 0.1%. Making our experiment significant in the world wide effort to put limits on the standard model.



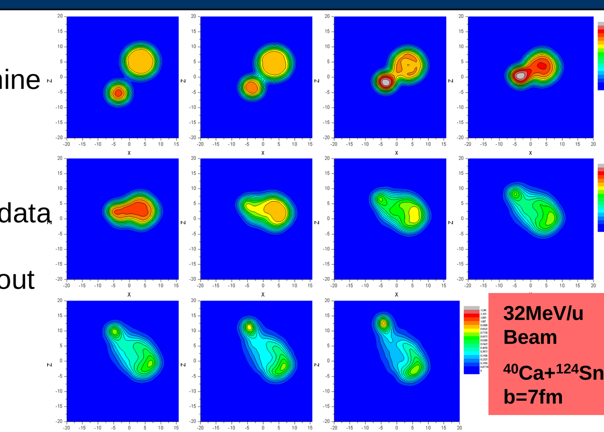
^{37}K atoms are made by the accelerator at TRIUMF then confined and polarized with lasers in a Magneto-Optical trap.

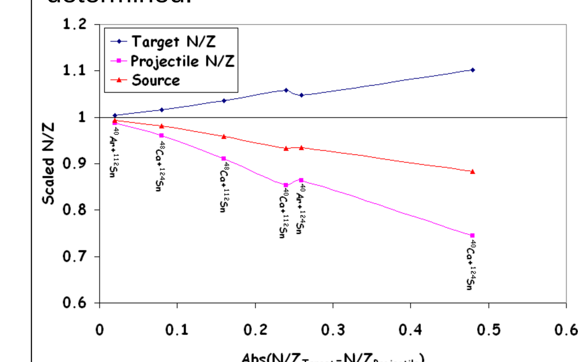


Our understanding of the experiment is enhanced by Monte Carlo simulations of the experimental setup. Shown is the tracks of positrons (blue) interacting in a stack of silicon detectors. Green lines are gammas from annihilation reactions.

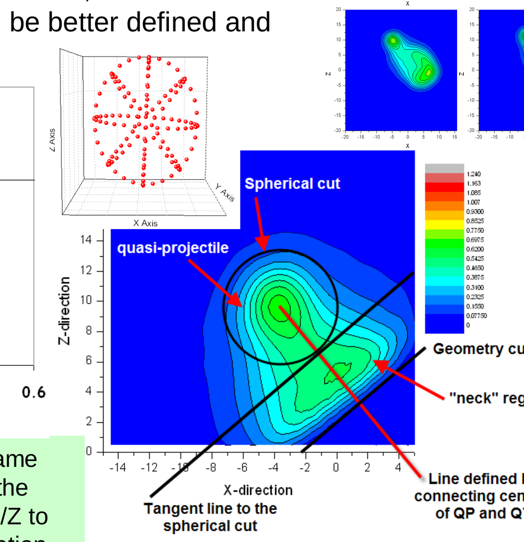
Larry May
Advisor: Sherry Yennello
Research Topic: N/Z Equilibration in Quasi-Projectiles

Understanding the transfer of nucleons from the target to the projectile in quasi-projectile (QP) formation can help us determine important aspects of the equation of state of nuclear matter. Various methods can be applied to experimental data in order determine the magnitude of transfer of protons and neutrons between the target and projectile. By comparing experimental data to calculations, in this case the iBUU (isospin-dependent Boltzmann-Uehling-Uhlenbeck) transport code, information about the nuclear equation of state (EOS) can be better defined and determined.





A fully N/Z equilibrated system will have the same N/Z of the composite system. By determining the distance along the path from initial projectile N/Z to final QP N/Z, a measure of how much equilibration has occurred can be determined.



For this analysis, new techniques were developed for identification of a QP in simulated data from theoretical codes. The new method consisted of systematic geometry cuts in three dimensions that were derived from density gradients. Other significant regions were also identified and examined.

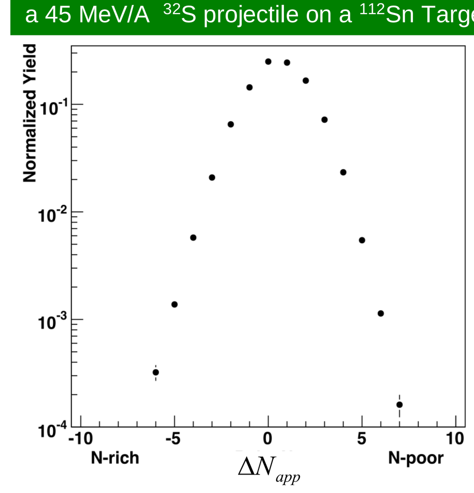
Brian Stein
Advisor: Sherry Yennello
Research Topic: Nucleon Transport as a Measure of the Nuclear EOS

Boltzmann transport models have suggested nucleon transport in peripheral and mid-peripheral nuclear reactions to be sensitive to the density dependence of the nuclear equation of state (EOS). By comparing the experimental quasi-projectile distributions detected in such reactions with the original projectile nucleus impinged on the target, some measure of the nucleon transport during interaction is possible. Since these reactions result in excitation and possibly fragmentation of the quasi-projectile, high efficiency arrays such as FAUST are required for such studies.

$$\Delta N_{app}=A_{beam}-\sum_{i}^{CP_{mult}}A_{frag,\,i}\,,$$

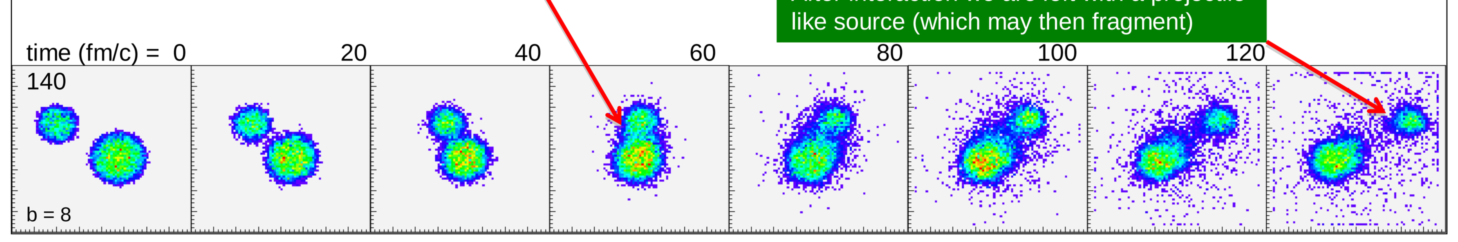
$$\text{for events where } Z_{beam}=\sum_{i}^{CP_{mult}}Z_{frag,\,i}$$

Quasi-projectile distribution for the reaction of a 45 MeV/A ^{32}S projectile on a ^{112}Sn Target

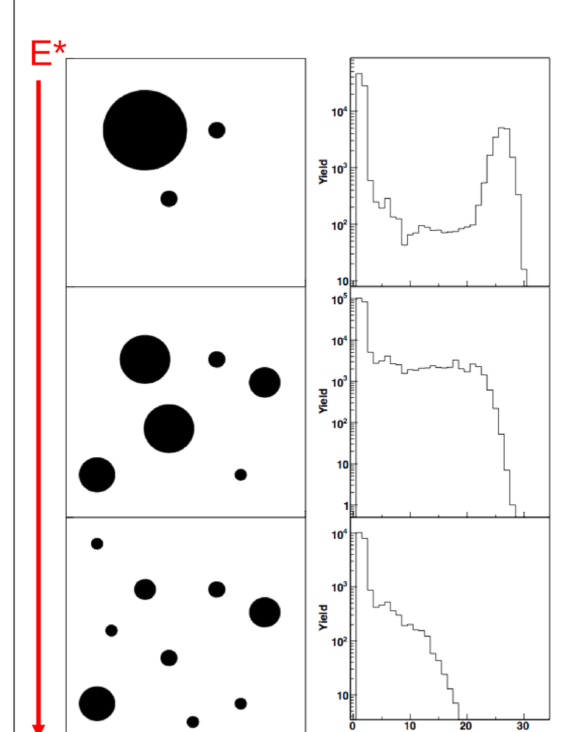


During interaction, nucleon transfer is possible between the target and projectile.

After interaction we are left with a projectile like source (which may then fragment)

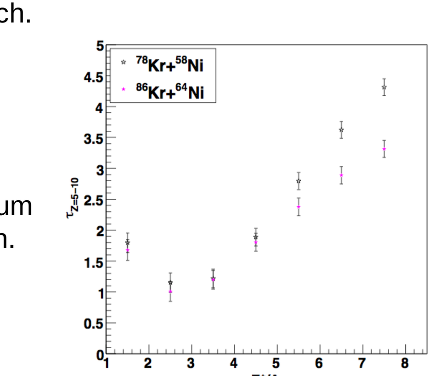


Sara Wuenschel
Advisor: Sherry Yennello
Research Topic: Effect of the Nuclear Neutron-to-Proton ratio on the nuclear Liquid-to-Gas phase transition



For many years, the evolution of fragmentation in nuclei has been studied for a phase transition. At low energy (liquid), the nucleus disposes of energy by evaporating a few light particles from the surface. At moderate energies (phase transition), many possible fragmentation configurations are available and the nucleus breaks into similarly sized fragments. This is referred to as multi-fragmentation. At high energies (gas), the nucleus is vaporized into small fragments and free neutrons and protons. For many years, the onset of multi-fragmentation in excited nuclei has been associated with a liquid-to-gas type phase transition. Many years of research have yielded general information about nuclear phase transitions. Understanding, the effect of the two-component nature of the nucleus on this phase transition is the goal of my research.

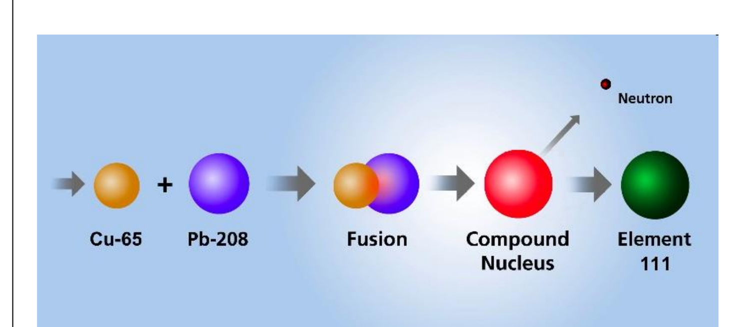
The slope of the fragment distribution has been shown to follow $Yield \propto l^{-\tau}$ where l is the cluster size (A,Z). The value of τ reaches a minimum in the multi-fragmentation region. This observable is useful for comparing fragmenting sources with different neutron-to-proton ratios.



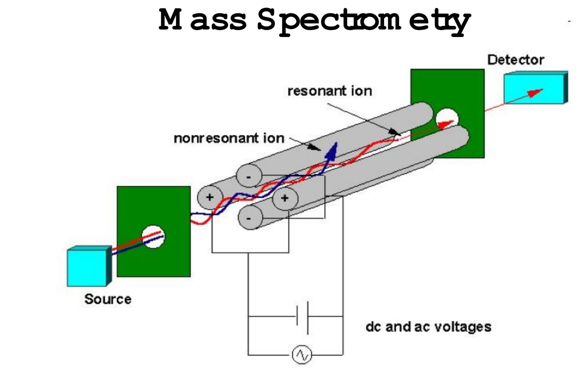
Marisa Alfonso
Advisor: Charles M. Folden III
Research Topic: Chemistry of the Heaviest Elements Using Mass Spectrometry

Formation of the Heaviest Elements

My research focuses on the transactinides, the elements with atomic numbers of 104 and higher. These heavy elements have very low half-lifes and are created by fusing two lighter ones together as shown below. Only relatively small numbers of atoms can be produced, so ultra-sensitive atom-at-a-time techniques are used to study their production mechanisms, decay properties, and chemical properties.



Mass Spectrometry

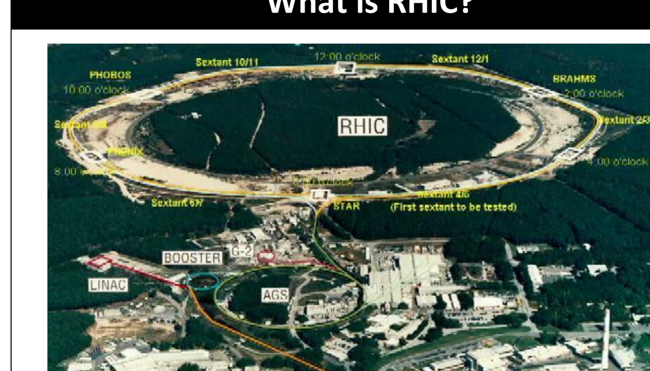


Previous transactinide experiments have tried to react these elements to form molecules. The decay of the transactinide has been used to infer the products of the chemical reaction. The goal of my research is to to form transactinide molecules, and to measure their masses with a quadrupole mass spectrometry. Information gained from this type of experiment would help understand the speciation of transactinides in the gas phase.

Chemistry Dept.

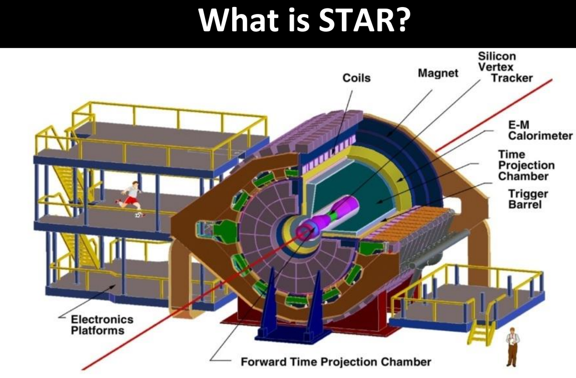
Martin J.M. Codrington
Advisor: Saskia Mioduszewski
Research Topic: γ+Jet Measurements in √S = 200 GeV Au+Au Collisions with STAR

What is RHIC?



The Relativistic Heavy Ion Collider (RHIC) was created to study what the universe may have looked like in the first few moments the big-bang. Two beams of gold ions are accelerated to 99.995% the speed of light in opposite directions in the two 2.4 mile underground tunnels. Understanding the nature of the matter created in these collisions may shed some light on the formation of the universe itself!

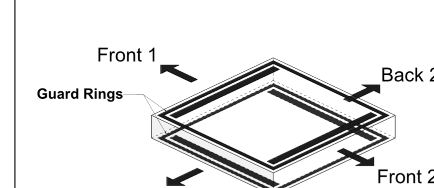
What is STAR?



The Solenoidal Tracker At RHIC (STAR) is like a large digital camera- taking a snap-shot of each collision. The detector has full 4π coverage. Its two largest detectors are the Time Projection Chamber (TPC), which records the momentum of charged particles & the Barrel Electro Magnetic Calorimeter (BEMC), which measures the energy of electromagnetic particles. The STAR collaboration is comprised of 609 scientists (Including 10 here at Texas A&M) from 55 institutions, in 12 countries.

A short abstract on γ+Jet analysis is located here: http://is.gd/lCrF
More on STAR: www.star.bnl.gov

Sarah Soisson
Advisor: Sherry Yennello
Research Topic: Dual-Axis Dual-Lateral Position Sensitive Detectors

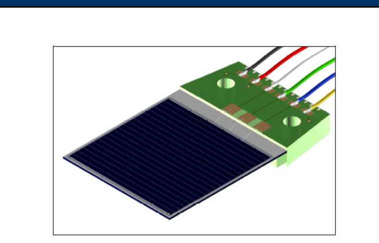


Energy is given by:

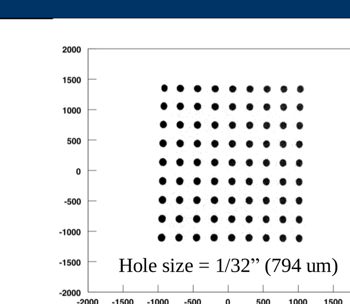
$$E_{Front}=Q_{F1}+Q_{F2}$$
$$E_{Back}=Q_{B1}+Q_{B2}$$
$$E_{Tot}=E_{Front}=E_{Back}$$

Position is given by:

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



A dual-axis dual-lateral position sensitive detector for charged particle detection, developed at TAMU for the FAUST array, is a double-sided p-on-n silicon structure with a highly uniform resistive junction and ohmic layers with equi-potential channels.



Position Sensitivity:
Front – 80 um
Back – 150 um
Non-linearity:
0.002% (rms)
Energy Resolution:
80.2 keV
For 6.778 MeV peak

Moving towards a higher angular resolution detector can give us a greater understanding of collision events. It will extend our imaging techniques to provide information about the space-time properties at freeze-out and about the excitation energy of primary fragments. These features are of particular interest as we move to more exotic nuclei, describe the interplay of nuclear structure and nuclear reactions and will pave way for experiments that will probe unanswered questions in stellar evolution.

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