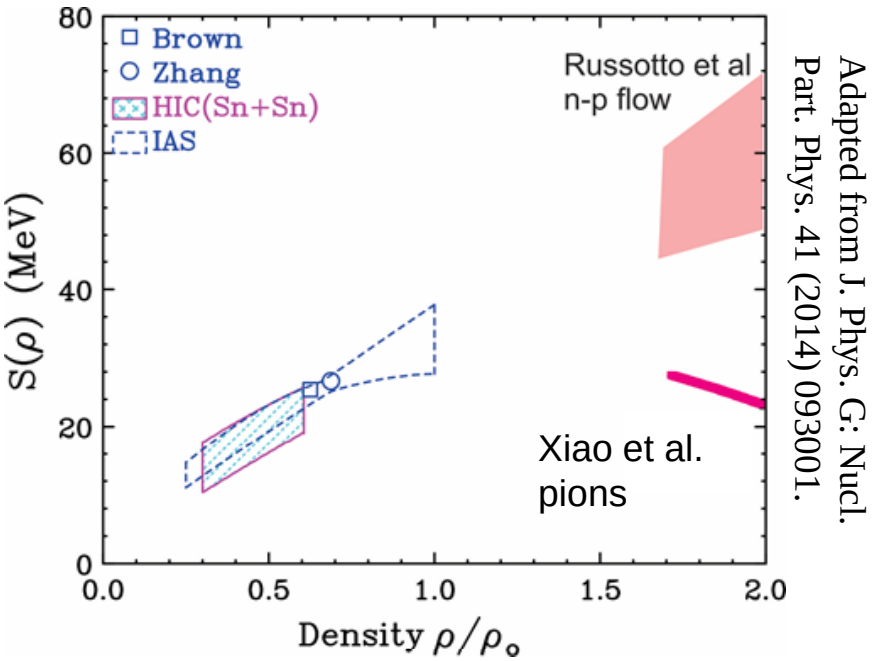
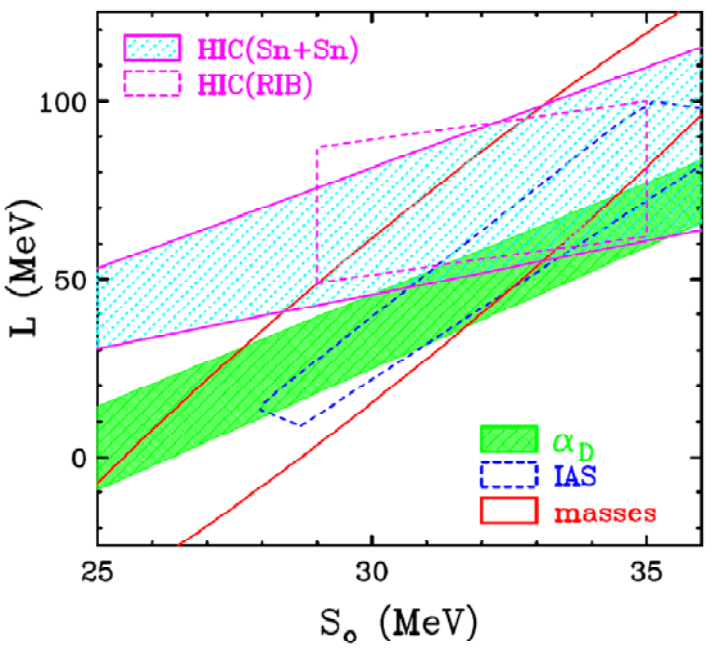
Present status of laboratory measurements

Where sensitive densities are assessed



Adapted from J. Phys. G: Nucl. Part. Phys. 41 (2014) 093001.

For $\rho<\rho_0$ $S(\rho) = S_o + \frac{L}{3}\frac{\rho_B - \rho_0}{\rho_0} + \ldots$



Adapted from J. Phys. G: Nucl. Part. Phys. 41 (2014) 093001.

- Have initial constraints at sub saturation densities – relevant to n-star crust
  - Contours reflect assessment of theoretical and experimental uncertainties.
  - Each observable probes S(ρ) or $\partial S/\partial\rho$ at a characteristic density.
    - Masses (0.6-0.7ρ_0), skins ($\partial S/\partial\rho|_{\rho_0}$), isospin diffusion (~0.4 ρ_0), etc.
    - Important to understand the sensitivity.
- Initial constraints at $\rho<\rho_0$ indicate the importance of 3-neutron forces.
- No consistency at $\rho\approx 2\rho_0$ - density relevant to m-R relationship of n-stars.
- Information on n – p effective mass splitting: relevant to n-star cooling

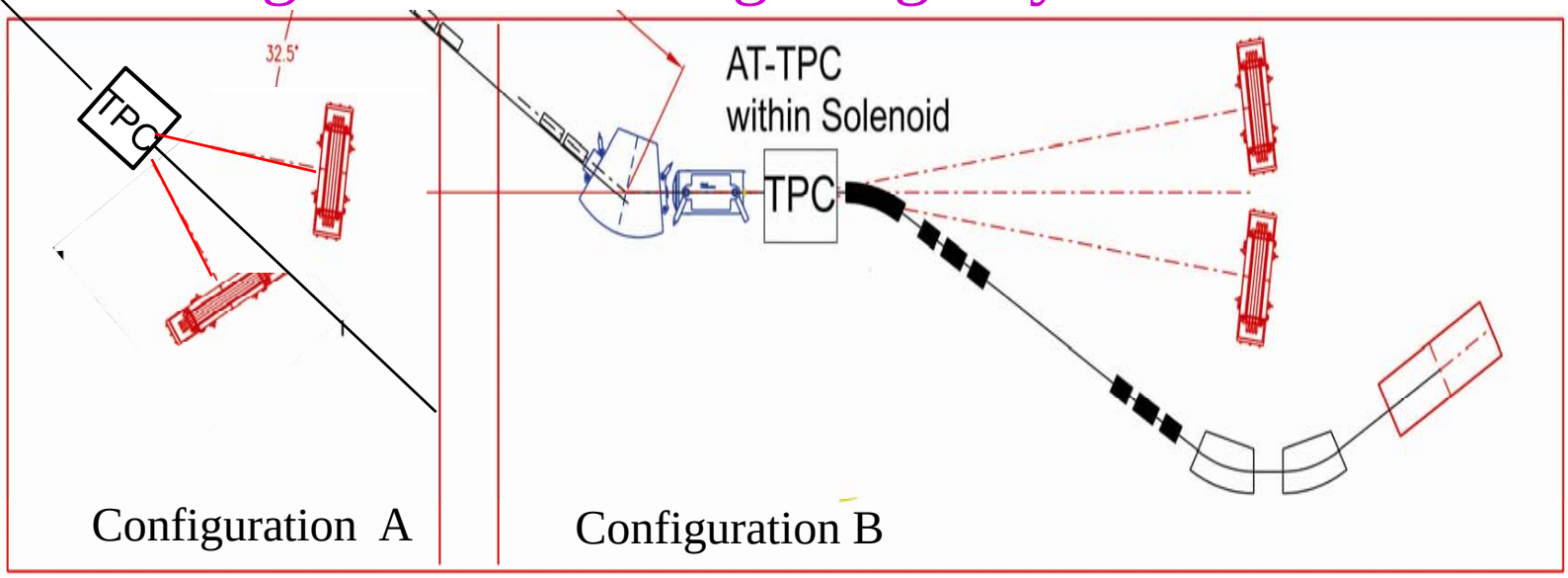
Opportunities and objectives of EoS studies I

- At $\rho \leq \rho_0$:
  - Complete PREXII and CREX measurements (needs Jlab time).
  - Obtain more precise isospin diffusion , neutron flow and GMR data.
    - More accurate theoretical modeling of Isospin diffusion, neutron flow data and ot GMR excitation energies is needed.
  - Better understanding of theoretical uncertainties.
  - Better understanding of clusterization at low densities.
    - Relevant to observables in HIC and also to possible benchmark studies relevant to the neutrino-sphere EoS.
  - Better understanding of the connection to neutron star phenomena e.g. inner crust thicknesses, magnetar oscillations, etc.
- For momentum dependence: n, p effective masses m_n^*, m_p^*
  - More relevant data of the ratios of mirror nuclei spectra. (NSCL beam time and experiment equipment)
    - More accurate theoretical models and a better understanding of the theoretical uncertainties. e.g. Possible competing influence of short range correlations.

Opportunities and objectives of EoS studies II

- At ρ/ρ_0: ≈1.5-2
  - Probe symmetry energy at supra-saturation densities by comparing the energy spectra and flows of isospin mirrors, e.g. π^- to π^+, n to p, t to ^{3}He.
    - TPC's available: SπRIT (RIKEN), also AT-TPC (NSCL) can be used.
    - At we need to position a TPC at NCLS/FRIB where one can access the most neutron-rich beams over a wide range of energies, corresponding to a large range of density.
    - Additional theoretical modeling needed to assess theoretical uncertainties.

Two Configurations for High Rigidity Vaults at FRIB



- Configuration A
  - Allows standalone operation and more flexible arrangements and higher angular coverage.
  - pion production and flow
  - n-p, t, ^{3}He, fragment (IMF) spectra and flows
  - Fragmentation studies, very low density (neutrino-sphere EOS)
- Configuration B
  - Allow some of the studies of configuration but with reduced efficiency.
  - Allows GMR studies in active target mode
  - Allows (d,^{2}He) excitations of Gamow-Teller and Spin Dipole resonances
  - five week typical switchover times between major configurations