Density dependence of the symmetry energy

Nuclear Equation of State

\[ E/A(\rho, \delta) = E/A(\rho, 0) + \delta^2 \cdot S(\rho) \]

Current status of the density dependence of symmetry energy

\( \rho / \rho_0 < 1 \): improved constraints at NSCL, TAM, GANIL, INFN-Catania

\( \rho / \rho_0 \approx 1-2 \): establish constraints at NSCL, RIKEN, FRIB

\( \rho / \rho_0 > 2 \): verify and establish constraints at GSI

Require international collaborations

\[ S = S_0 + \frac{L}{3} \left( \frac{\rho_B - \rho_0}{\rho_0} \right) + \frac{K_{\text{sym}}}{18} \left( \frac{\rho_B - \rho_0}{\rho_0} \right)^2 + \ldots \]

\[ L = 3 \rho_0 \frac{\partial S}{\partial \rho_B} \bigg|_{\rho_B = \rho_0} = \frac{3}{\rho_0} P_0 \]

Current constraints at subnormal density from heavy ion collisions, nuclear masses and nuclear collective motion in subnormal density.