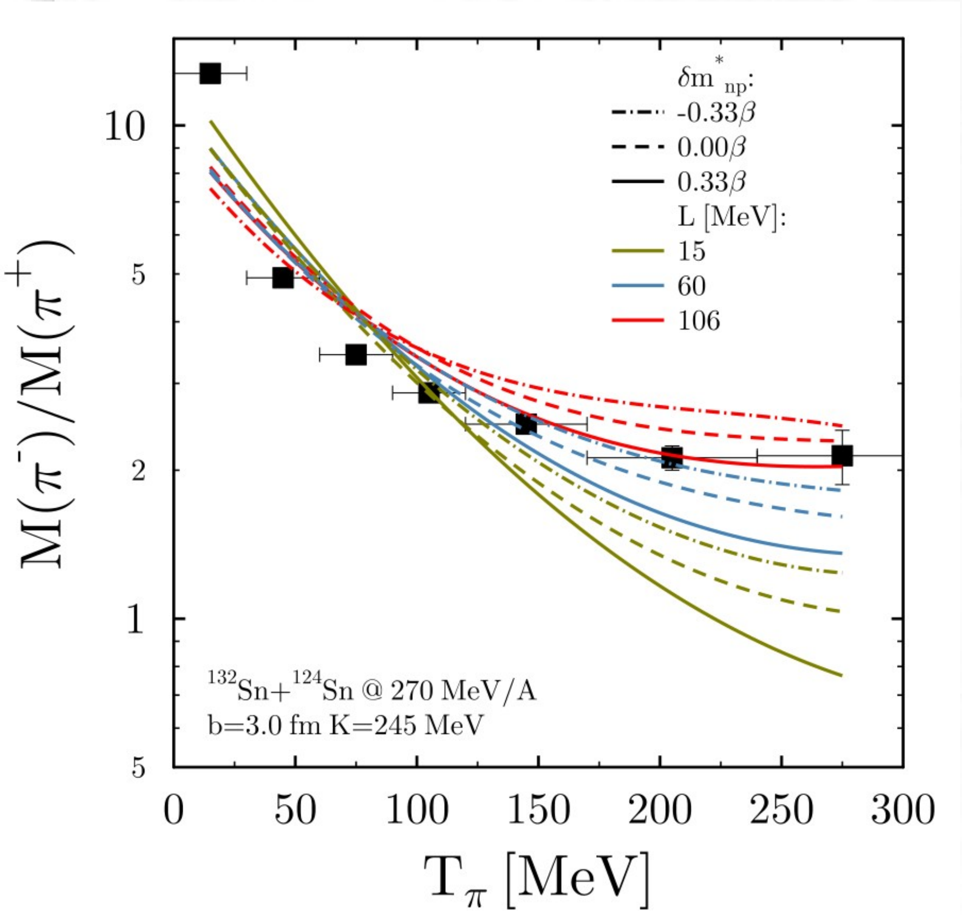
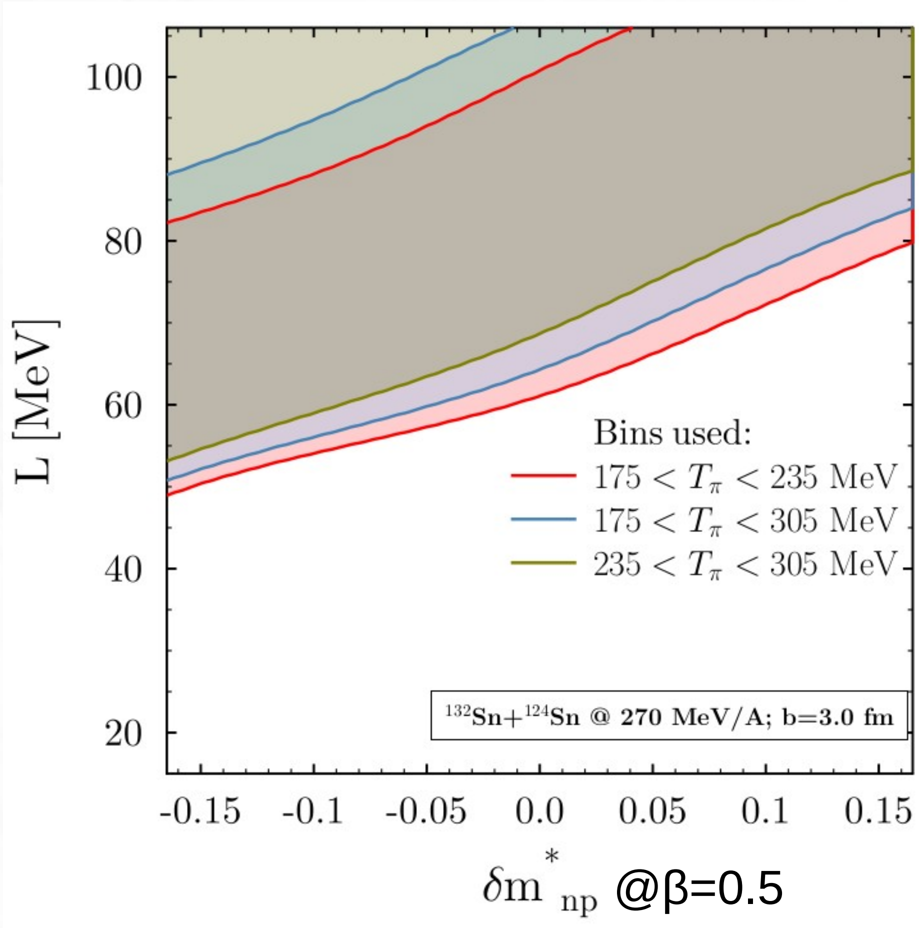
Constraint for Asy-EoS (& npEMD)

using pion data alone

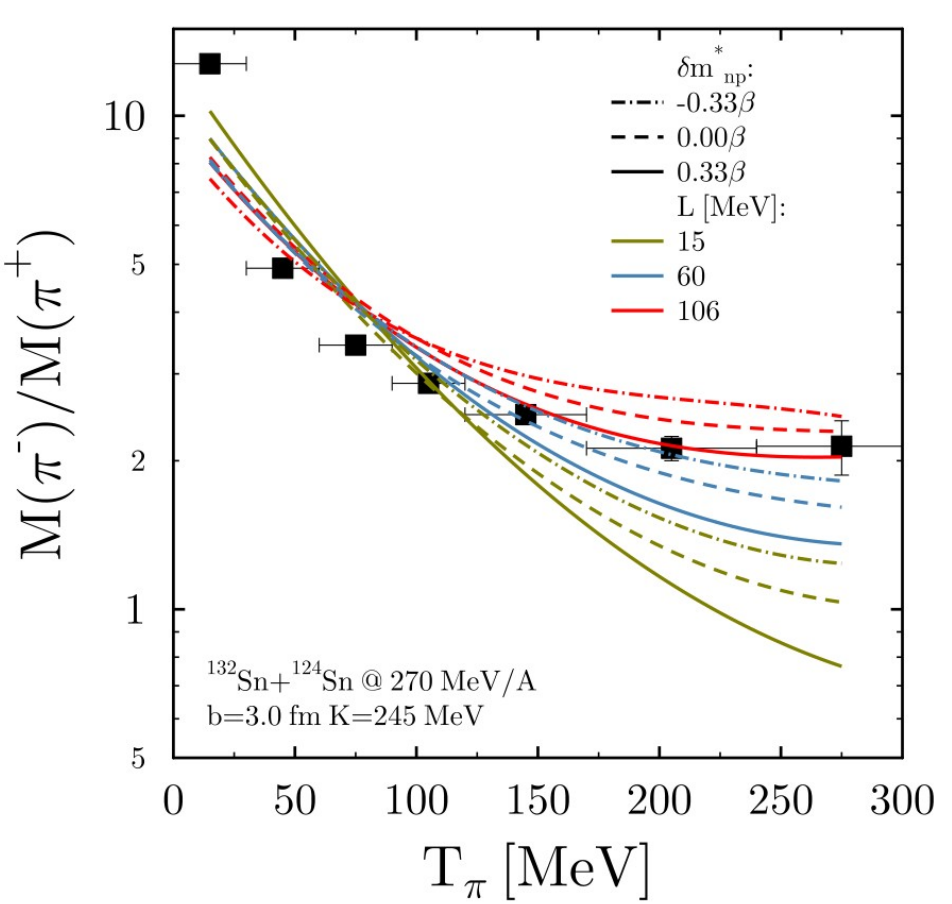




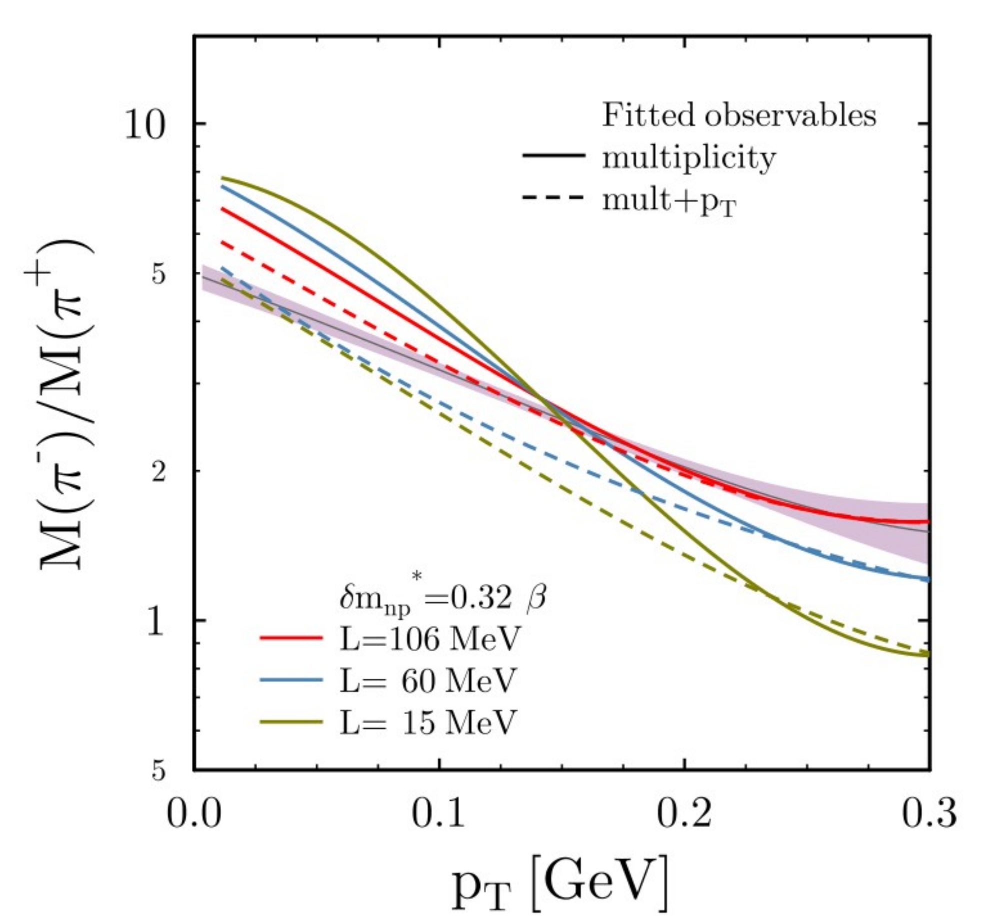
- Compressibility modulus K_0=245 MeV
- Isoscalar effective mass: m*=0.70 (empirical nucleon optical potential)
- Empirical nucleon-nucleon medium modified cross-sections (UrQMD)

Constraint for Asy-EoS (& npEMD)

SPIRIT ^{132}Sn+^{124}Sn 270 MeV/A; b=3.0 fm



FOPI AuAu 400 MeV/A; $0.25 < b_0 < 0.45$

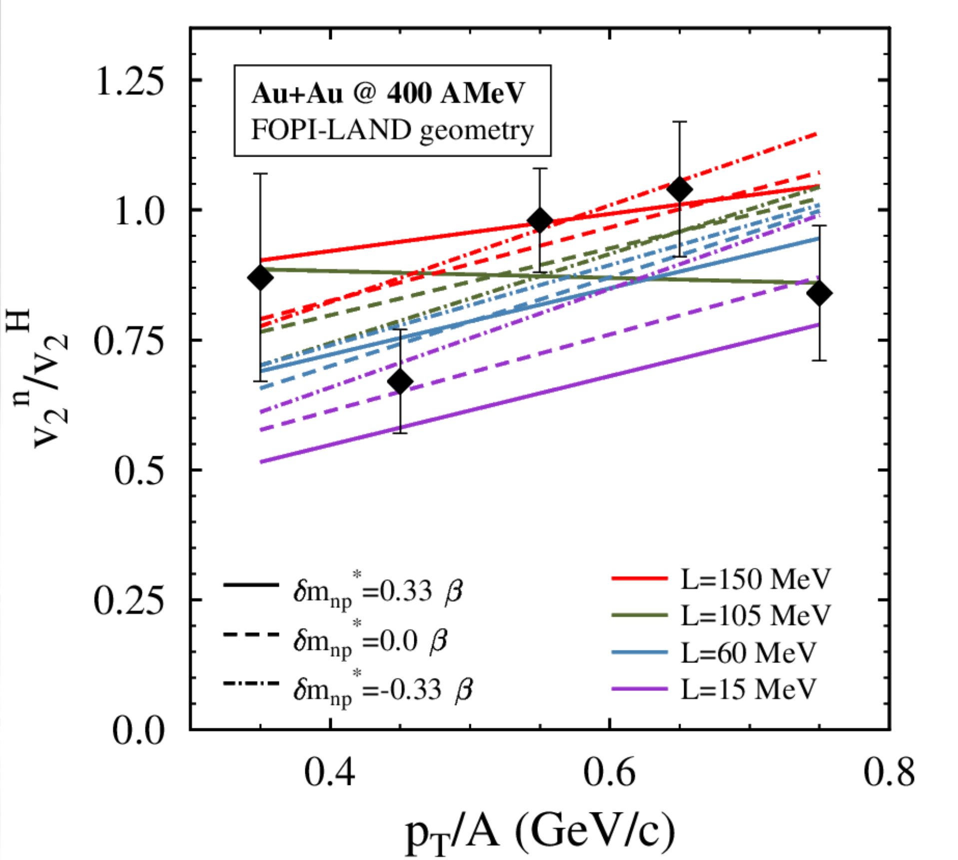


- Spectra sensitive to residual model dependence of Δ(1232) potential
- Use experimental data for $<T_\pi>$ or $<p_T>$ to determine “safe” region

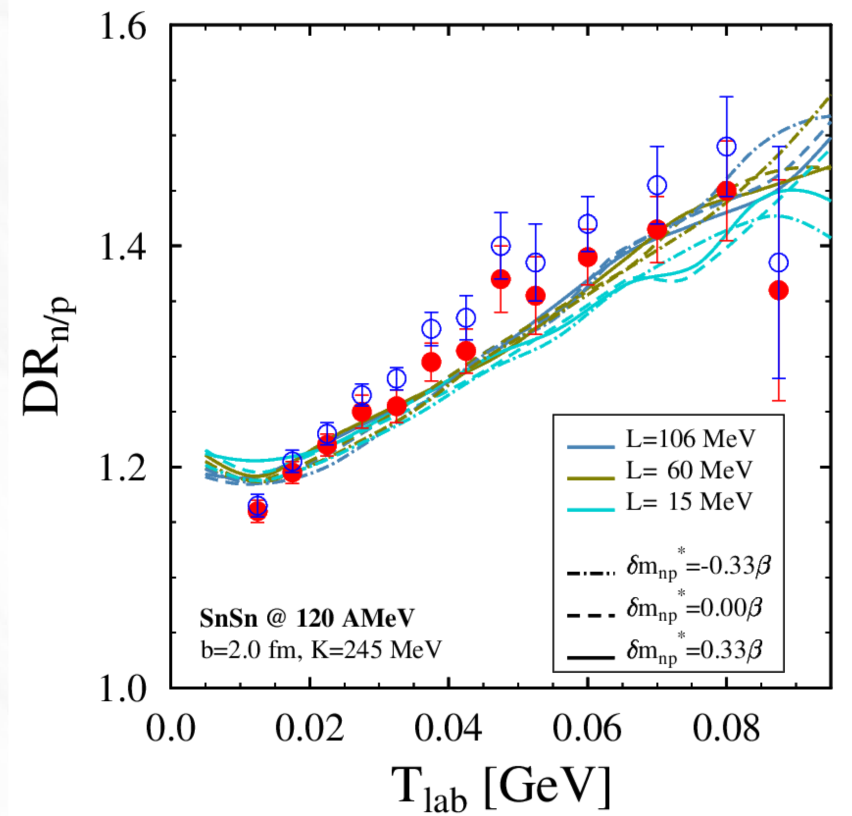
Determining npEMD from other sources

I) using the same model: elliptic flow ratios (FOPI-LAND, ASYEOS)
np multiplicity ratios

Neutron-to-hydrogen EFR



Double Ratio of Multiplicities (CI)



See also: DC, EPJA 54, 40 (2018)

D. Coupland et al., PRC 94, 011601 (2016)
P. Morfouace et al., PLB 799, 135045 (2019)

Determining npEMD from other sources

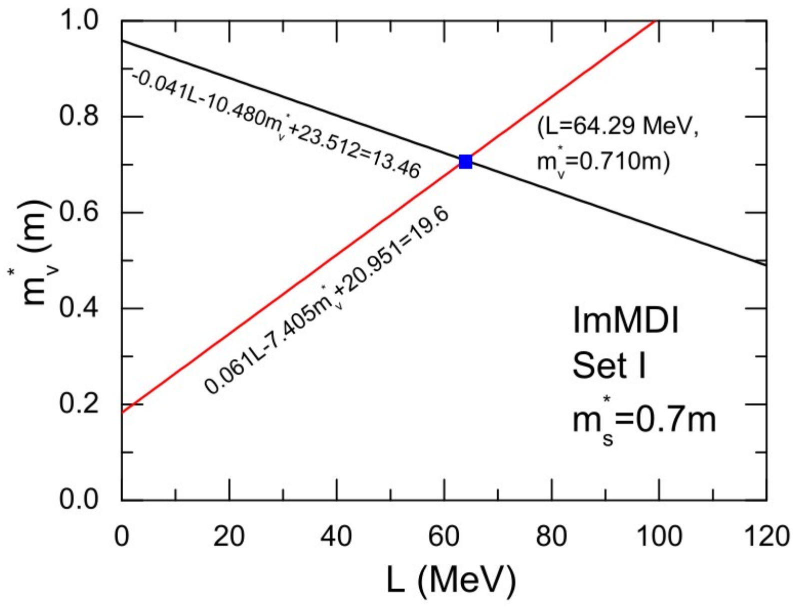
II) using the same energy density functional:

correlation between L,m* and npEMD

To determine m* use:
- Hama empirical potential (0.70)
- excitation energy of ISGQR (0.84)

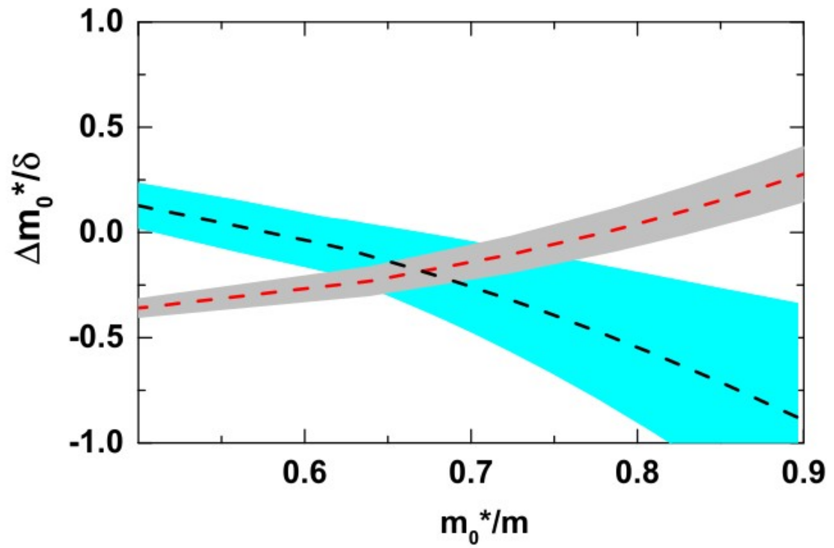
-energy density functional quadratic in p^2
-compatible with Skyrme EDFs
-constructed by imposing Gibbs-Duhem relations (thermodynamic consistency)

two constraints: centroid energy of IVGDR and α_D



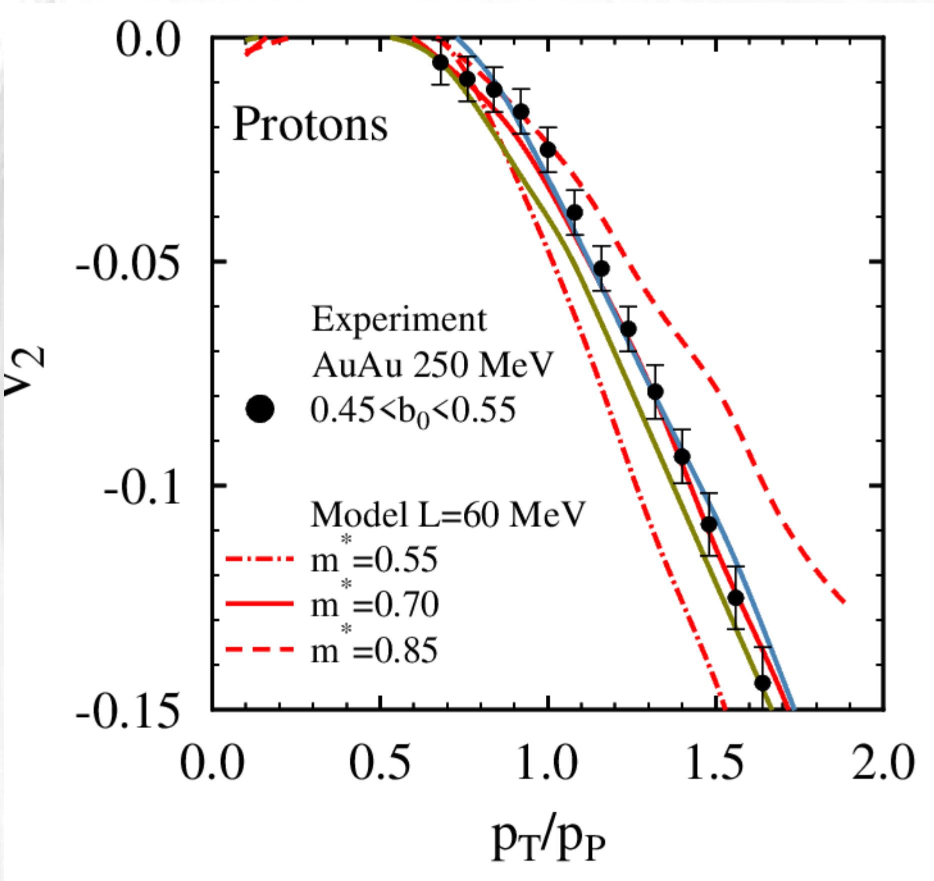
results for npEMD and m* correlated

H.Y. Kong et al., PRC 95, 034324 (2017)



T. Malik et al., PRC 98, 064316 (2018)

Extracting m* from HIC



C. Xu et al. , NPA 865, 1 (2011)

$$
\begin{aligned}
E_{\mathrm{sym},2}(\rho) &= \frac{1}{3}t(k_F) + \frac{1}{6}\frac{\partial U_0}{\partial k}\bigg|_{k_F} k_F + \frac{1}{2}U_{\mathrm{sym},1}(\rho, k_F) \\
&= \frac{\hbar^2}{6m}\left(\frac{3\pi^2}{2}\right)^{2/3}\rho^{2/3} \\
&\quad + \frac{(C_{\tau,\tau}+C_{\tau,\tau'})}{3\rho_0}\frac{\pi\Lambda^2}{h^3}\left[4p_F - \left(2p_F + \frac{\Lambda^2}{p_F}\right)\ln\left(\frac{4p_F^2+\Lambda^2}{\Lambda^2}\right)\right] \\
&\quad + \frac{(A_l - A_u)}{4}\frac{\rho}{\rho_0} - x\frac{B}{\sigma+1}\frac{\rho^\sigma}{\rho_0^\sigma} \\
&\quad + \frac{(C_{\tau,\tau}-C_{\tau,\tau'})}{3\rho_0}\frac{\pi\Lambda^2}{h^3}2p_F\ln\left(\frac{4p_F^2+\Lambda^2}{\Lambda^2}\right),
\end{aligned}
$$

Use stopping and different impact energies
to lift degeneracy with K_0 and medium cross-sections