EMMI Workshop "5th Workshop on Anti-Matter, Hyper-Matter and Exotica Production"

Day-5 wrap up

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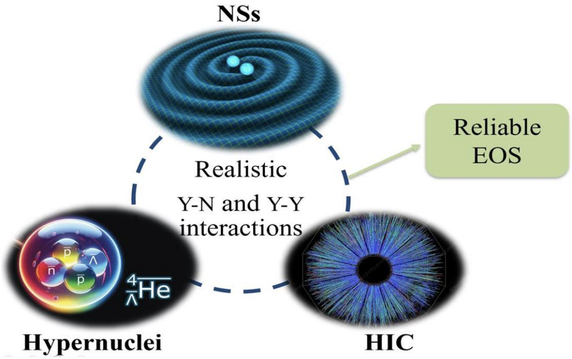
Neutron stars: Dense matter factory

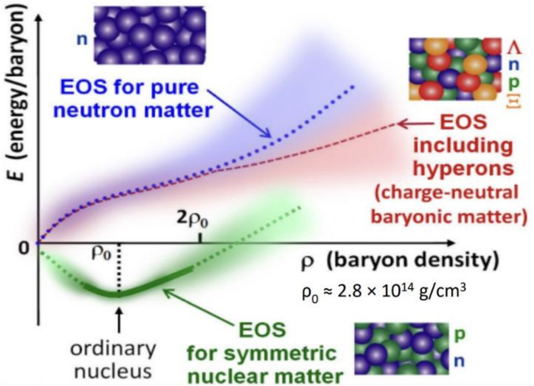
Mahboubeh Shahrbaf Motlaghz



Hyperon	Mass (MeV/c^2)
Λ	1115.57 ± 0.06
Σ^+	1189.37 ± 0.06
Σ^0	1192.55 ± 0.10
Σ^-	1197.50 ± 0.05
Ξ^0	1314.80 ± 0.8
Ξ^-	1321.34 ± 0.14
Ω^-	1672.43 ± 0.14

The Most Robust Observational Inputs

- Maximum mass of pulsars
- NICER mass-radius measurements
- Gravitational waves detected by LIGO-VIRGO-KAGRA
  - mass-radius
  - Tidal Deformability
- Cooling and thermal evolution



➢ **The most important check with hyperons**

H.Tamura, JPS Conf. Proc. , 011003 (2014)

Including hyperon ⟶ Softening the EOS ⟶ $M_{max} < 2M_\odot$

EOS of hypernuclei matter

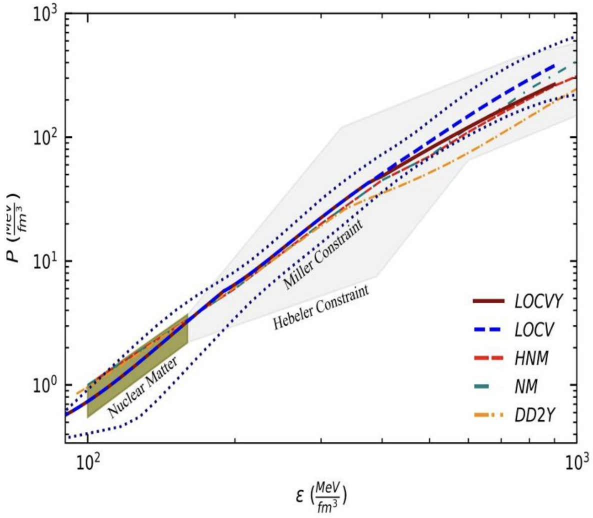
Mahboubeh Shahrbaf Motlaghz

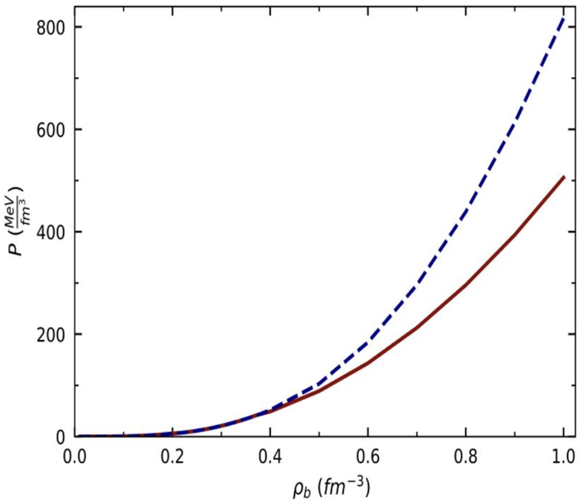
→ Observed softening of EOS as expected

- Additional repulsive effects in the EOS (e.g., ΛΛ interaction, three-body forces or any kind of many-body repulsions)

✓ Consistent with chiral EFT + astrophysical constraints

- softening after Λ onset



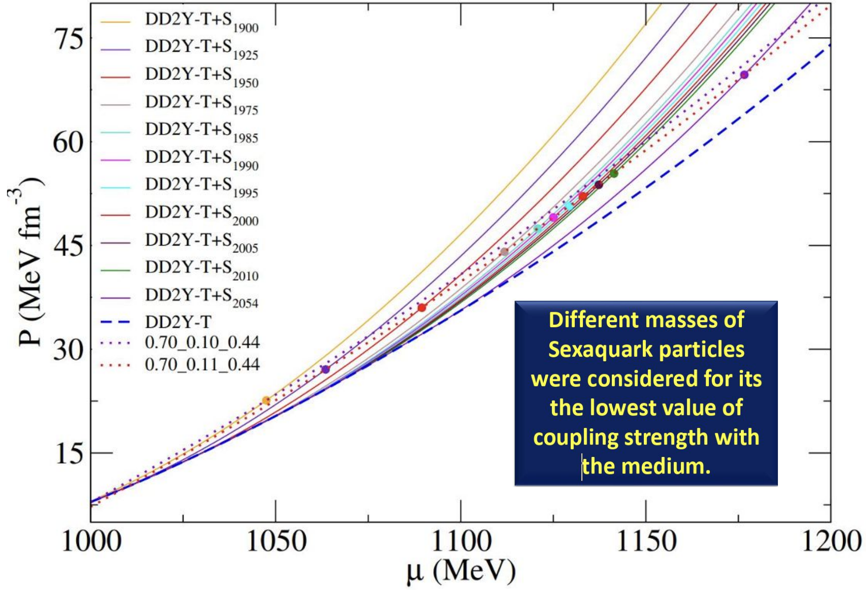


The slow increase in the Λ fraction moderates the overall softening once hyperons appear.

- The net repulsive ΛΛ interaction becomes significant at high densities.
- Central correlation functions provide additional medium-induced repulsion.
- The effect of tensor correlations is suppressed in the ΛΛ interaction due to zero isospin.

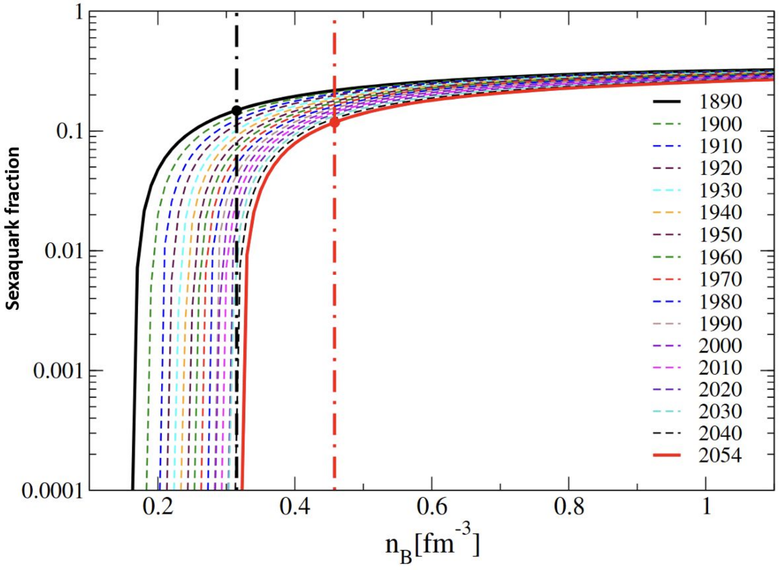
Sexaquarks as probe of NS-EOS

Davood Rafiei Karkevandi



Different masses of Sexaquark particles were considered for its the lowest value of coupling strength with the medium.

The maximum Sexaquark fraction allowed in our models varies from about 12% for the highest S-particle mass to 15% for the lightest one.



Sexaquarks as probe of NS-EOS

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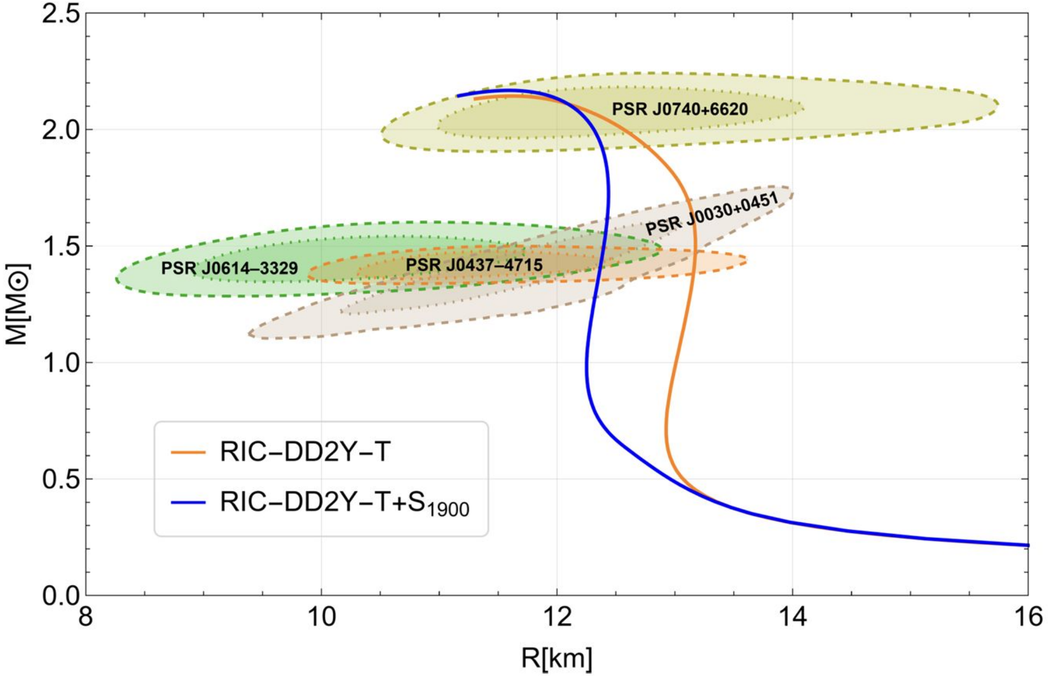


M. Shahrbaf, P. Thakur, D.R.K, ***arXiv:2510.08115***

→ Including sexaquarks bring model calculations closer to Neutron Star Interior Composition Explorer (NICER) results

Orange curve : without Sexaquark

Blue curve : with Sexaqurak, $m_s = 1900\ MeV\ and\ x_s = 0.03$

Modelling the Nuclei production - Pythia 8.3

Marika Rassa

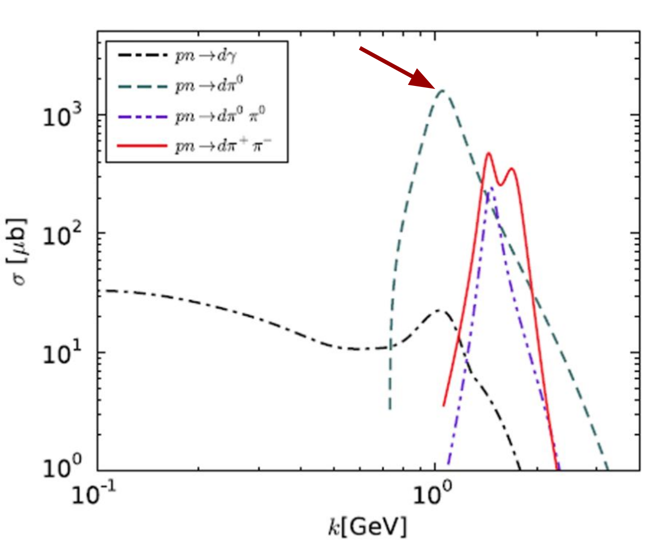
→ Pion-deutron femtoscopy measurement shows the contribution from Δ(1232) resonance
→ Nuclear Fusion reactions to treat the nuclei production
→ Approach based on Dal-Raklev empirical modelling

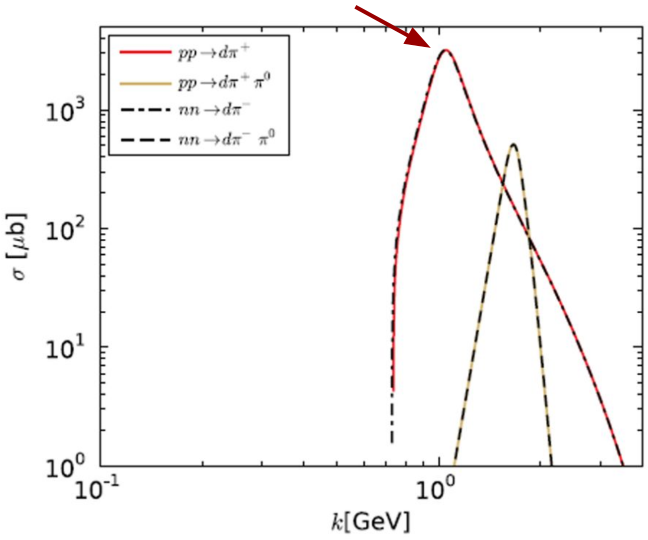
- Model independent evidence
  - About 80% of the (anti)deuterons are produced in nuclear fusion reactions following the decay of short lived resonances
  - About the 60% of them derive from the Δ(1232)

Different reactions are considered:

pn → γd	pn → π^0d	pp → π^+d	nn → π^-d
pn → $\pi^-\pi^+$d	pn → $\pi^0\pi^0$d	pp → $\pi^+\pi^0$d	nn → $\pi^-\pi^0$d

→ similar treatment for anti-nuclei

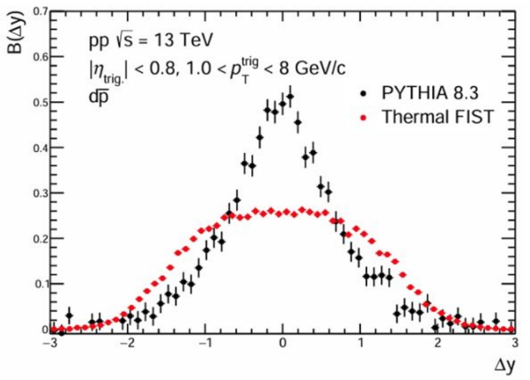


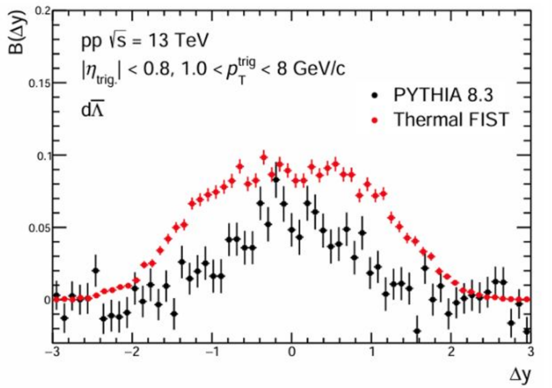


Deuteron balance function

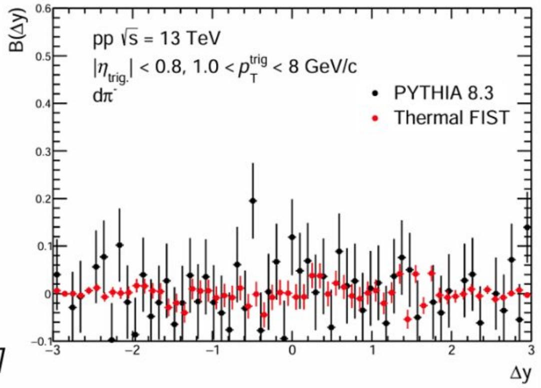
Marika Rassa

- Is it possible to estimate the balance function for all the cases
- Different shape for the one predicted by PYTHIA and THERMAL FIST due to the instrinsic differences of the models





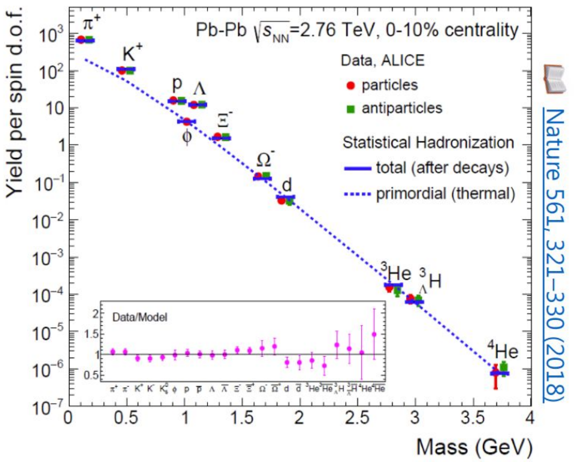
- More observations can be made comparing these balance functions with the one triggered by protons
- But still, no experimental data available for these observables

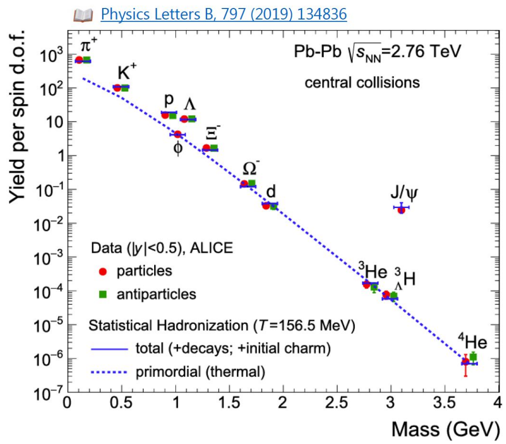


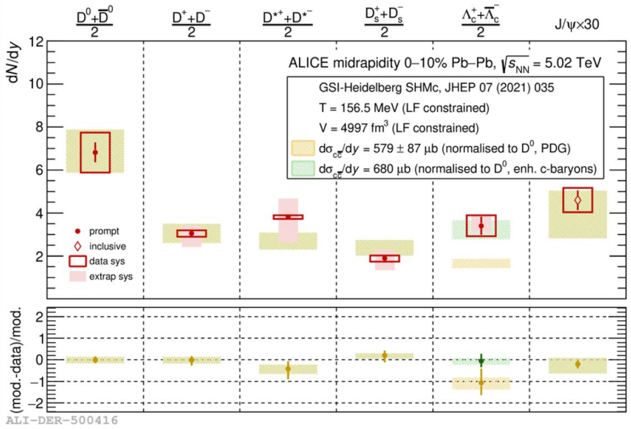
S. Tripathy, P. Christiansen, *arXiv:2509.03195 [hep-ph]*

Charm quark and SHM

Luigi Dello Stritto







Thermal density of hadron species i

$$n_i(T_H) \propto m_i^2 T_H\, K_2\left(\frac{m_i}{T_H}\right)$$

→ Can heavy quarks be considered in thermal and chemical equilibrium with the medium?

- J/ψ enhanced compared to other M = 3 GeV hadrons.
- Number of c-quarks in Pb-Pb collisions at LHC energy is about 30 times larger than expected for pure thermal production.
  - $g_c \sim 30$

For open heavy flavor hadrons strong contribution from **resonance decays**.

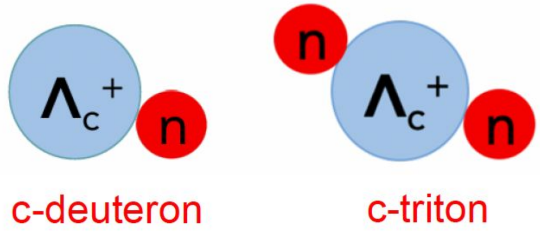
- include all known charm hadron states as of PDG.
- **Additional feed-down** from excited baryon states not yet measured but predicted by lQCD.

Deutron - coming from charm decay in HI

Luigi Dello Stritto

The lightest possible bound states of a charm baryon and a nucleon without Coulomb repulsion.

constraints for in-medium and "molecular" coalescence



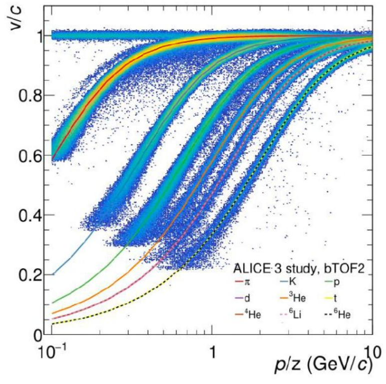
c-deuteron and c-tritium

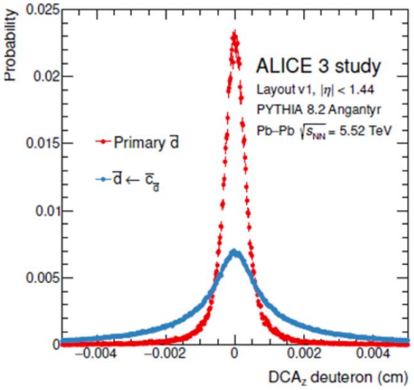
- Excellent performance of ALICE 3 for the identification of light nuclei with TOF.
- Main background source: combinatorial of primary deuterons with pions and kaons.
  - ➢ Excellent DCA resolution to reject primary deuterons.

The most promising decay channels:

$$c_d \rightarrow d + K^- + \pi^+$$

$$c_t \rightarrow t + K^- + \pi^+$$





- Assuming the production rates of the SHM, in 1 month of Pb-Pb collisions (5.6 nb^{-1}):
  - ➢ ~ 50 significance for c_d
  - ➢ ~ 3 significance for c_t

ALICE 3 sensitive to c_d and c_t !!!

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Thank you