Perspectives on (multi-strange) hypernuclei physics with the CBM experiment at FAIR

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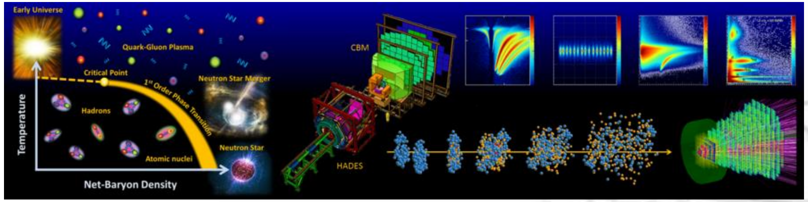
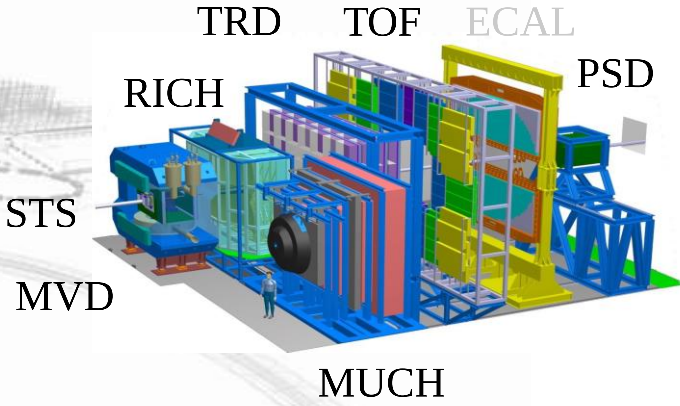




- Motivation
- Physics case
- CBM advantages
- Performance of the CBM track finder & PID detectors
- Single-Λ & Double-Λ hypernuclei

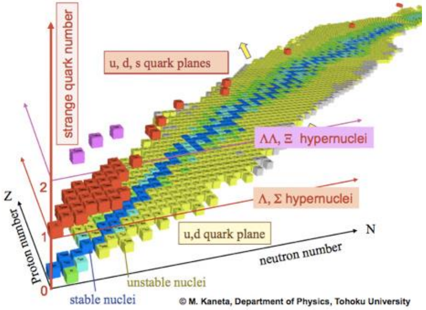
Motivation

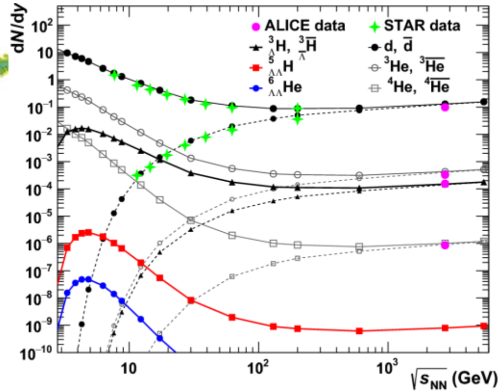
CBM physics case: hypernuclei

- Single and **double** hypernuclei.
- Precise measurements of hypernuclei lifetime (YN & **YY** interaction).
- Measurement of branching ratios of hypernuclei.
- Direct access to the hyperon-nucleon YN interaction through measurements of B_Λ in a hypernucleus.
- "Hyperon puzzle" in the astrophysics: understanding of YN interaction is crucial for neutron star physics.
- Search for strange matter in the form of heavy multi-strange objects.

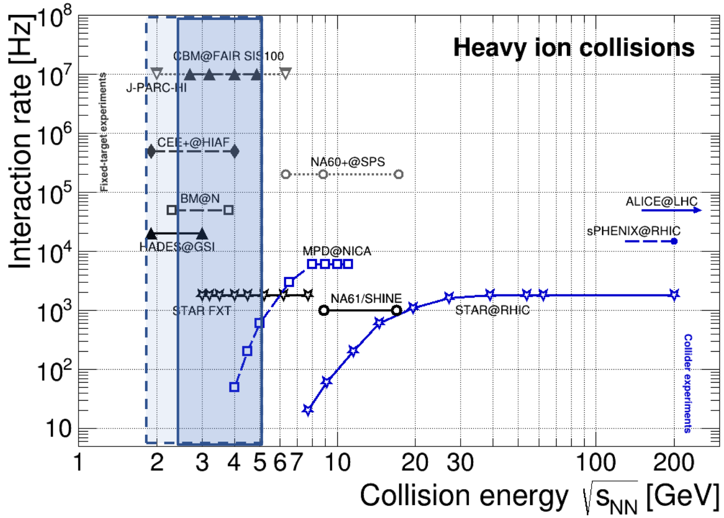
Advantages of the CBM:

- According to theoretical predictions energy region of CBM is preferable for production of hypernuclei. **(STAR BES-II data!)**
- **Complex topology of decays** can be easily identified in CBM with a low background.
- The detector system is well suited for identification of produced hypersystems.
- **High interaction rates**, optimal collision energies and clean identification will allow to search for ΛΛ-hypernuclei.

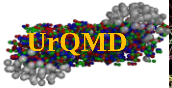


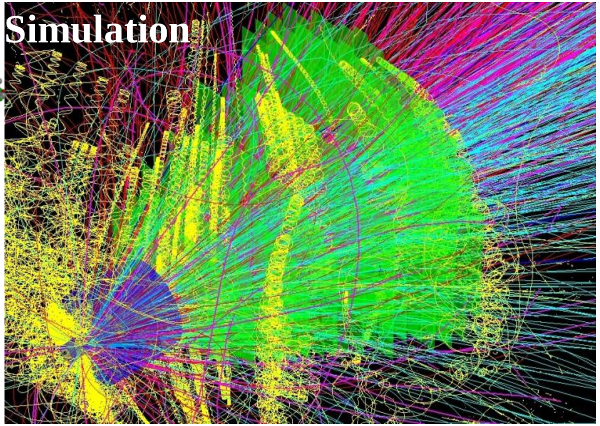


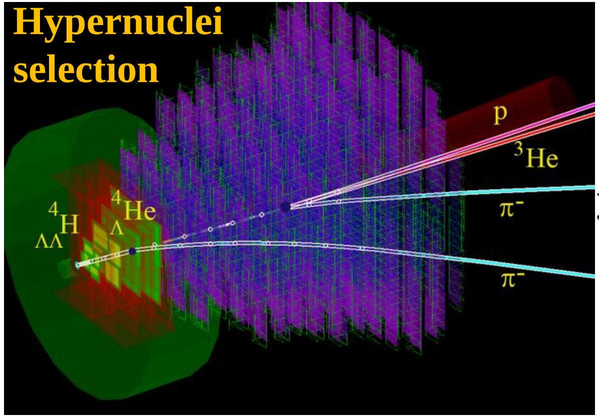
B. Dönigus, Eur. Phys. J. A (2020) 56:280
A. Andronic et al, PLB 697 (2011)203



Performance of the CBM track finder & PID detectors

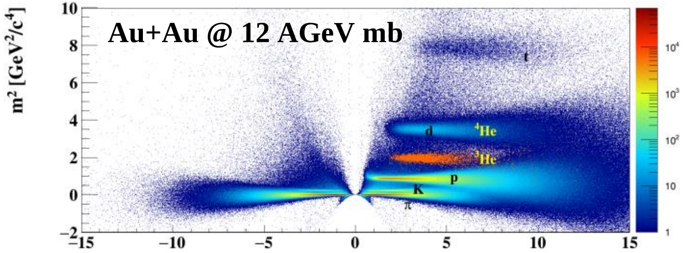


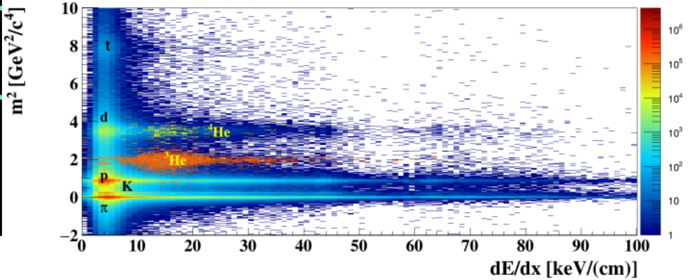




- For studies several theoretical models like UrQMD and PHSD are used.
- Track finder is based on the Cellular Automaton method.
- High efficiency for track reconstruction of more then **92%**, including fast (more then **90%)** and slow (more then **65%**) secondary tracks.
- Time-based track finder is developed, efficiency is stable with respect to the interaction rate.
- Low level of split and wrongly reconstructed (ghost) tracks.

minimum bias : 8ms/core track finder, 1 ms/core particle finder



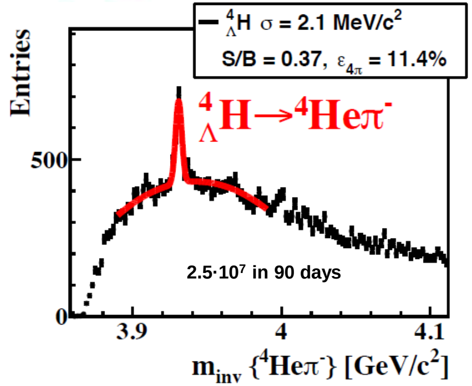


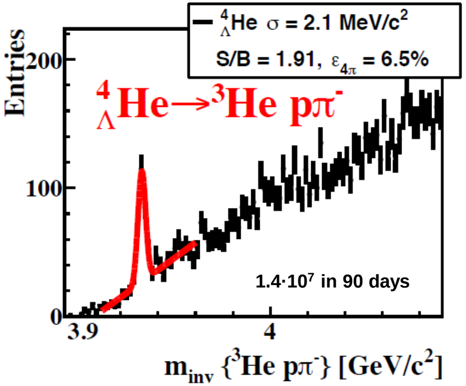
PID detectors:

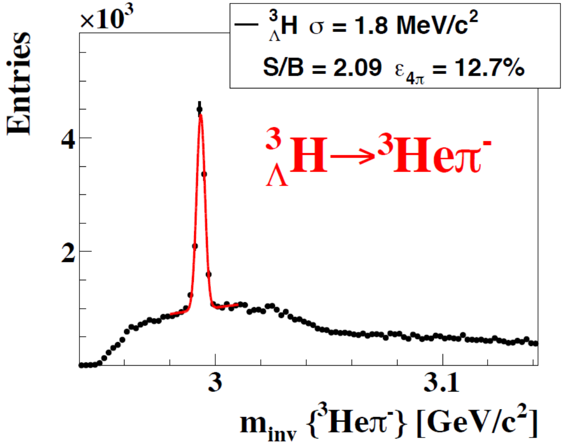
- ToF (Time of Filght) - hadron identification;
- TRD (Transition Radiation detector) - electron and heavy fragments identification

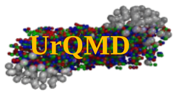
Single-Λ hypernuclei

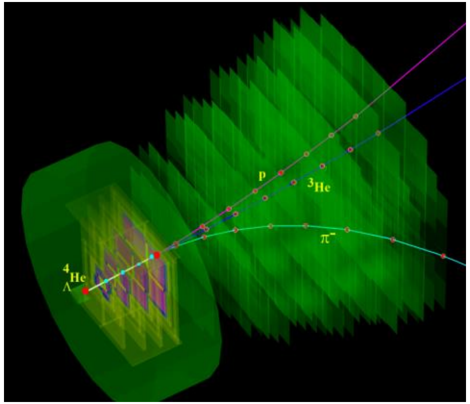
5M mbias events Au+Au at 10AGeV/c
50 sec (!) at 0.1MHz IR (1.8 k/sec)

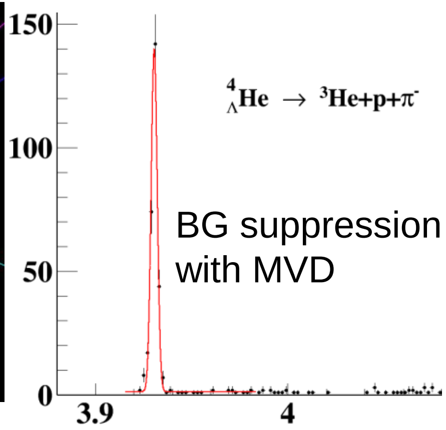












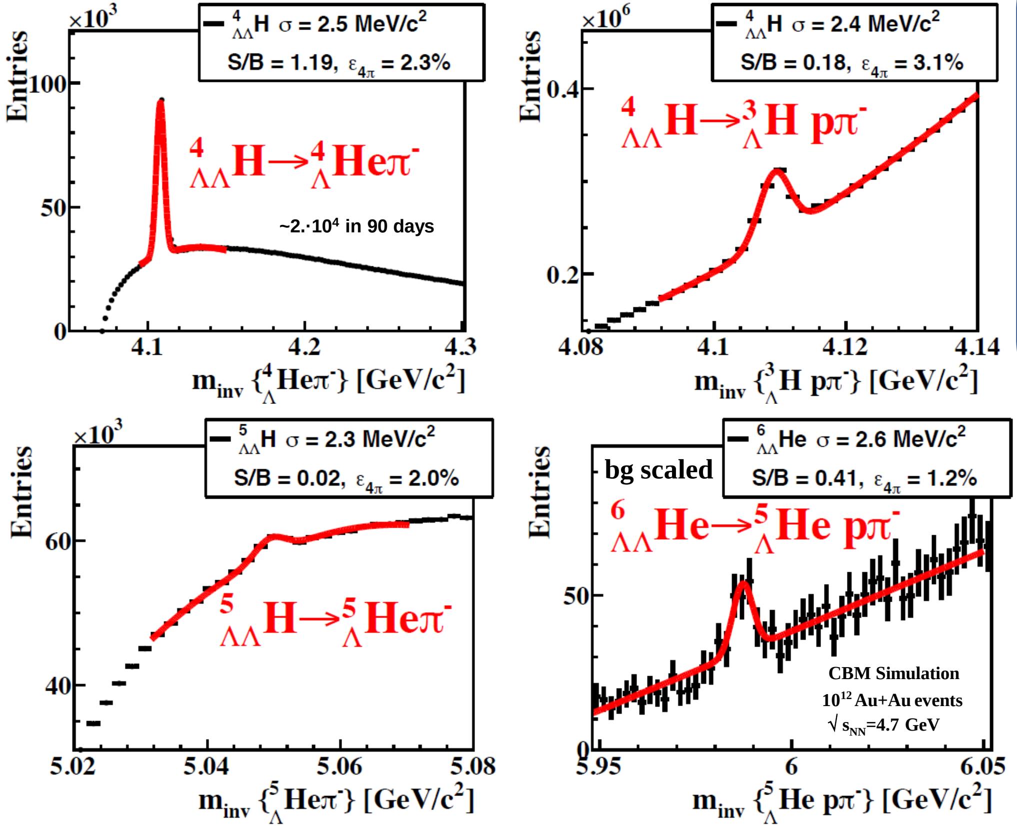
- AuAu, 10 AGeV, 5M central UrQMD events + thermal isotropic signal, TOF PID.
- Background can be further reduced with additional dE/dx PID.
- For $^4_\Lambda$He background can be reduced selecting only primary hypernuclei.

CBM is sensitive to light hypernuclei containing a single-Λ within current predictions of their multiplicities and STAR BES-II measurements.

Multiplicities:

- A.Andronic, et. al, “Production of light nuclei, hypernuclei and their antiparticles in relativistic nuclear collisions,” Phys. Lett. B, 697 (2011) 203
- J. Steinheimer et al., “Hypernuclei, dibaryon and antinuclei production in high energy heavy ion collisions: Thermal production versus Coalescence,” Phys. Lett. B 714 (2012) 85

Double-Λ hypernuclei



AuAu, 10 AGeV, scaled to 10^{12} central UrQMD events equivalent, thermal isotropic signal, TOF PID. For $^{6}_{\Lambda\Lambda}$He upper limit of one entry per 5M events was assumed.

Conclusions

- The CBM experiment will provide multidifferential high precision measurements of single- and double-Λ hypernuclei.
- The discovery of double-Λ hypernuclei and the determination of their lifetimes will provide information on the hyperon-nucleon and hyperon-hyperon interactions, which are essential ingredients for the understanding of the nuclear matter EoS at high densities, and, hence, of the structure of neutron stars.

Expected collection rate: ~ 60 $^{6}_{\Lambda\Lambda}$He in 1 week at **10MHz IR**