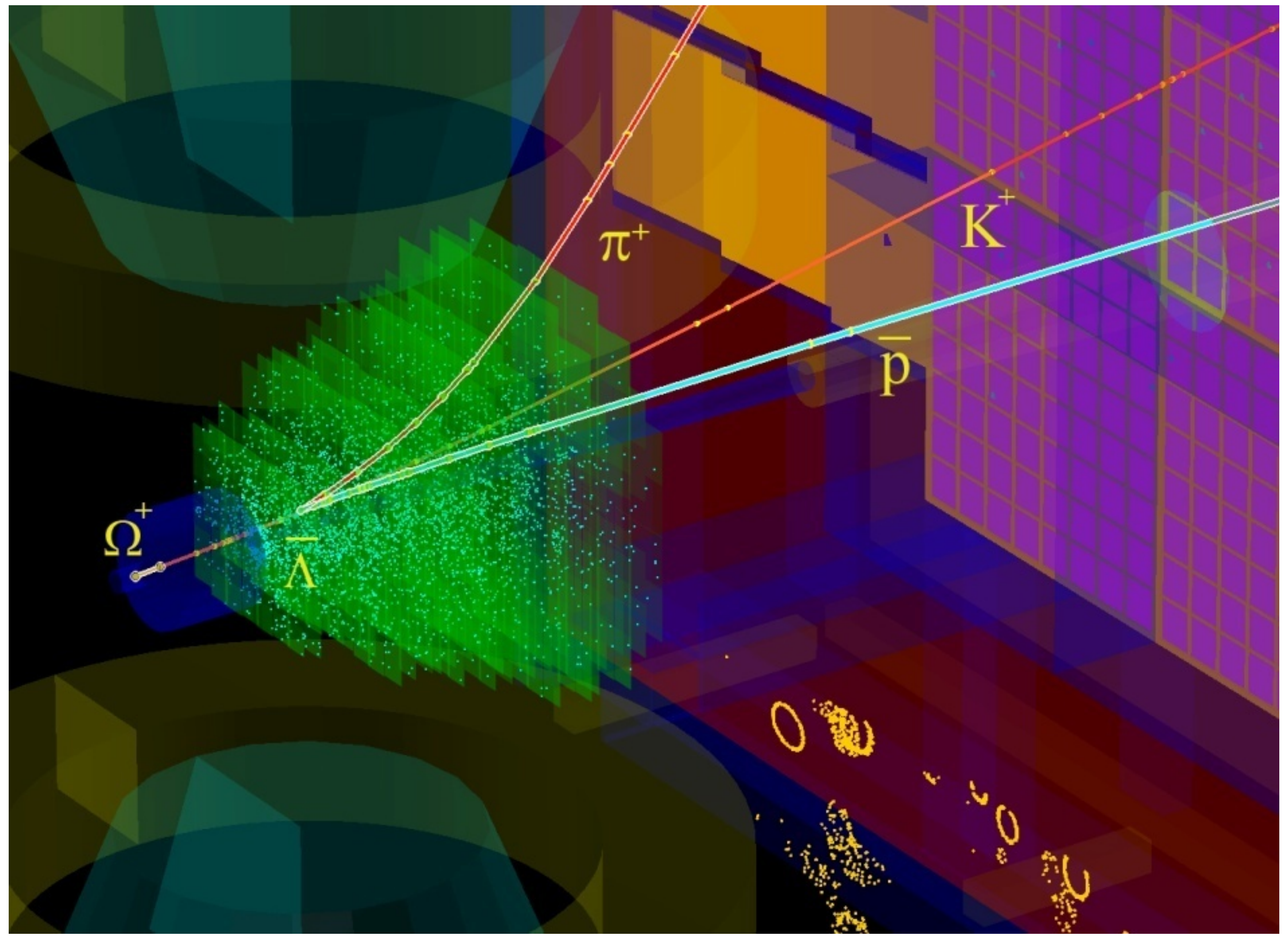
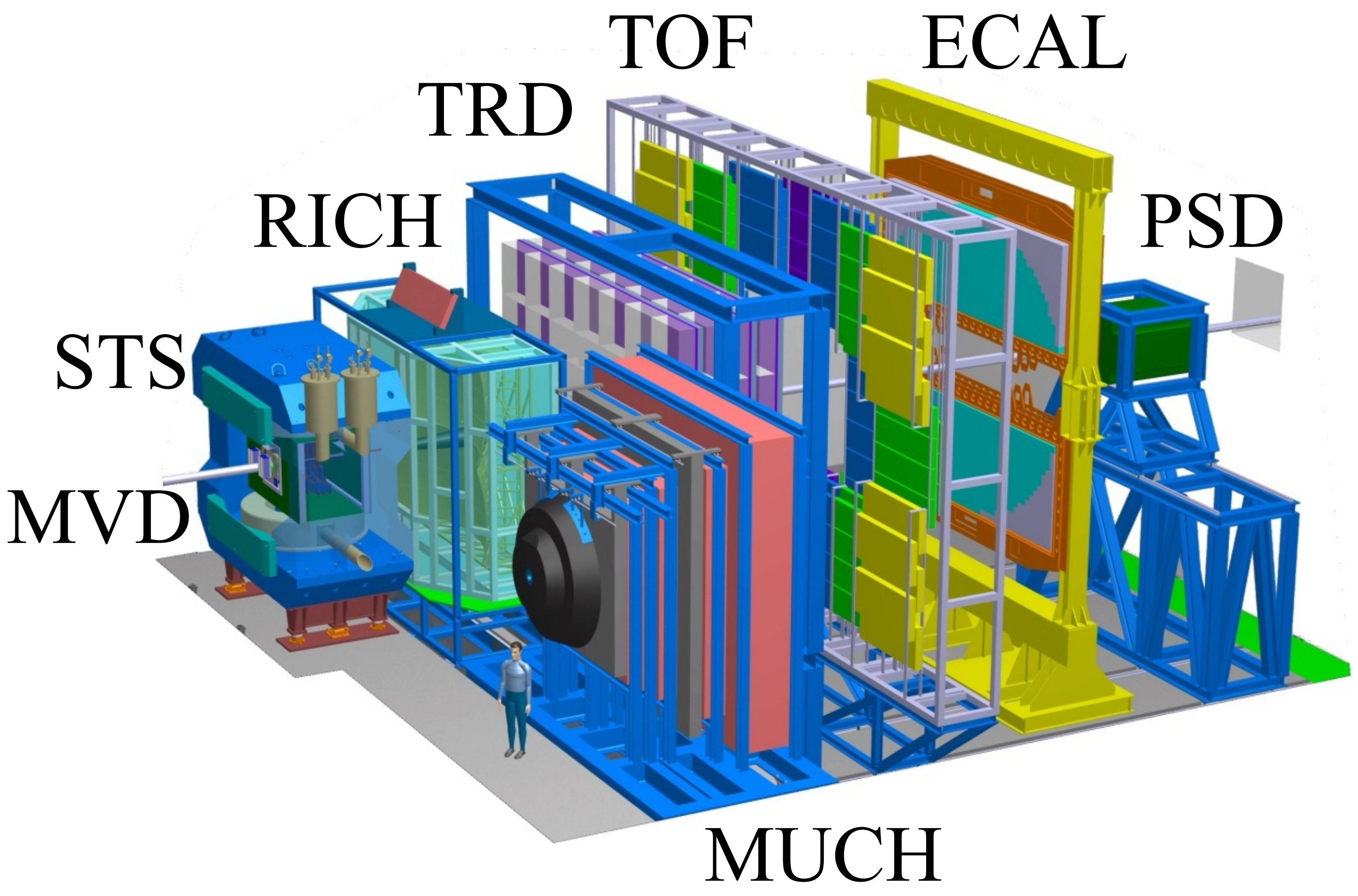
Perspectives on strangeness physics with CBM experiment at FAIR

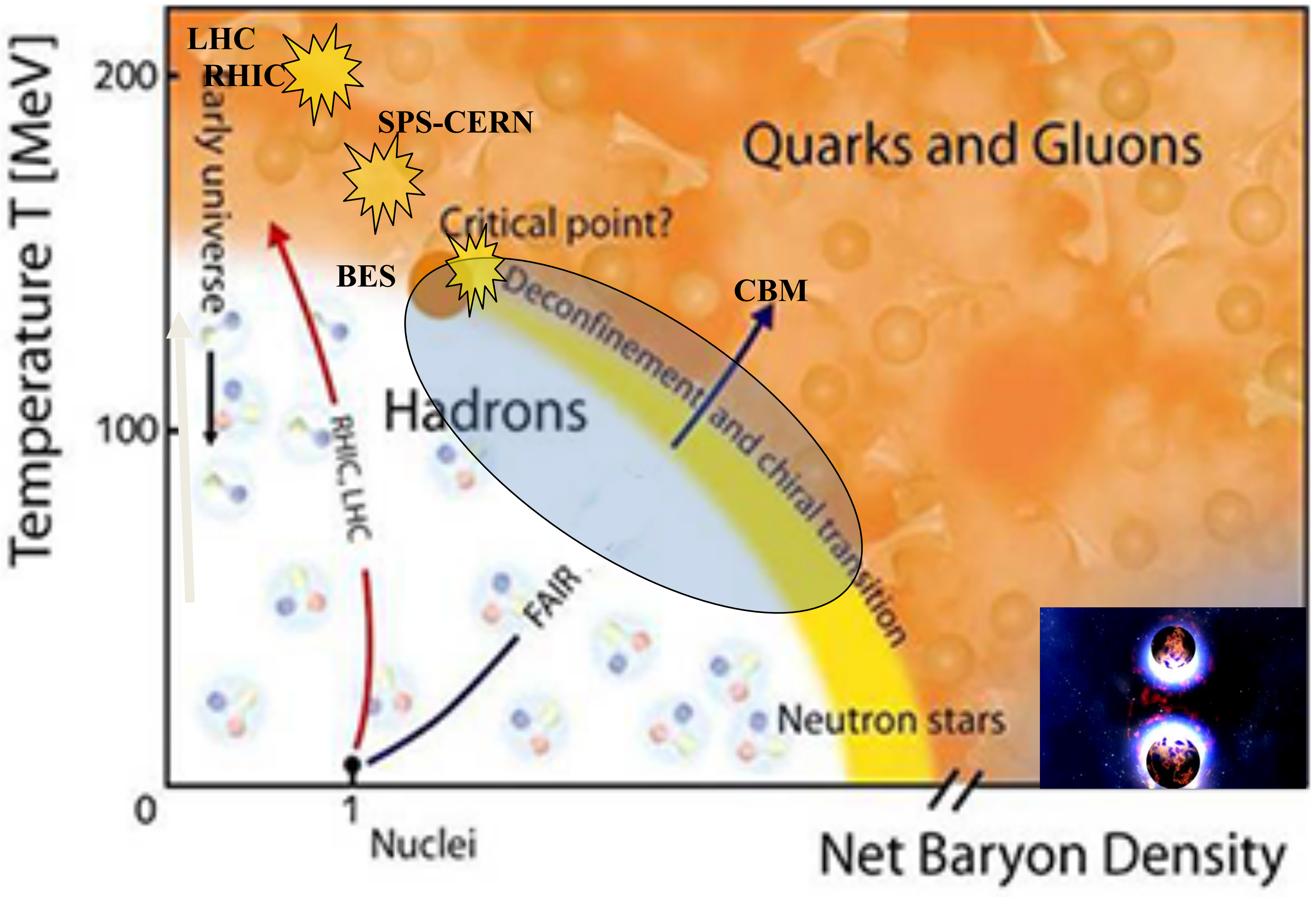
I.Vassiliev for the CBM Collaboration





- **Physics case**
- **Multi strange hyperons reconstruction**
- **Hyper nuclei reconstructions**
- **Summary**

Physics case: Exploring the QCD phase diagram



The equation-of-state at high ρ_B
collective flow of hadrons,
particle production at threshold energies:
multi-strange hyperons, hypernuclei

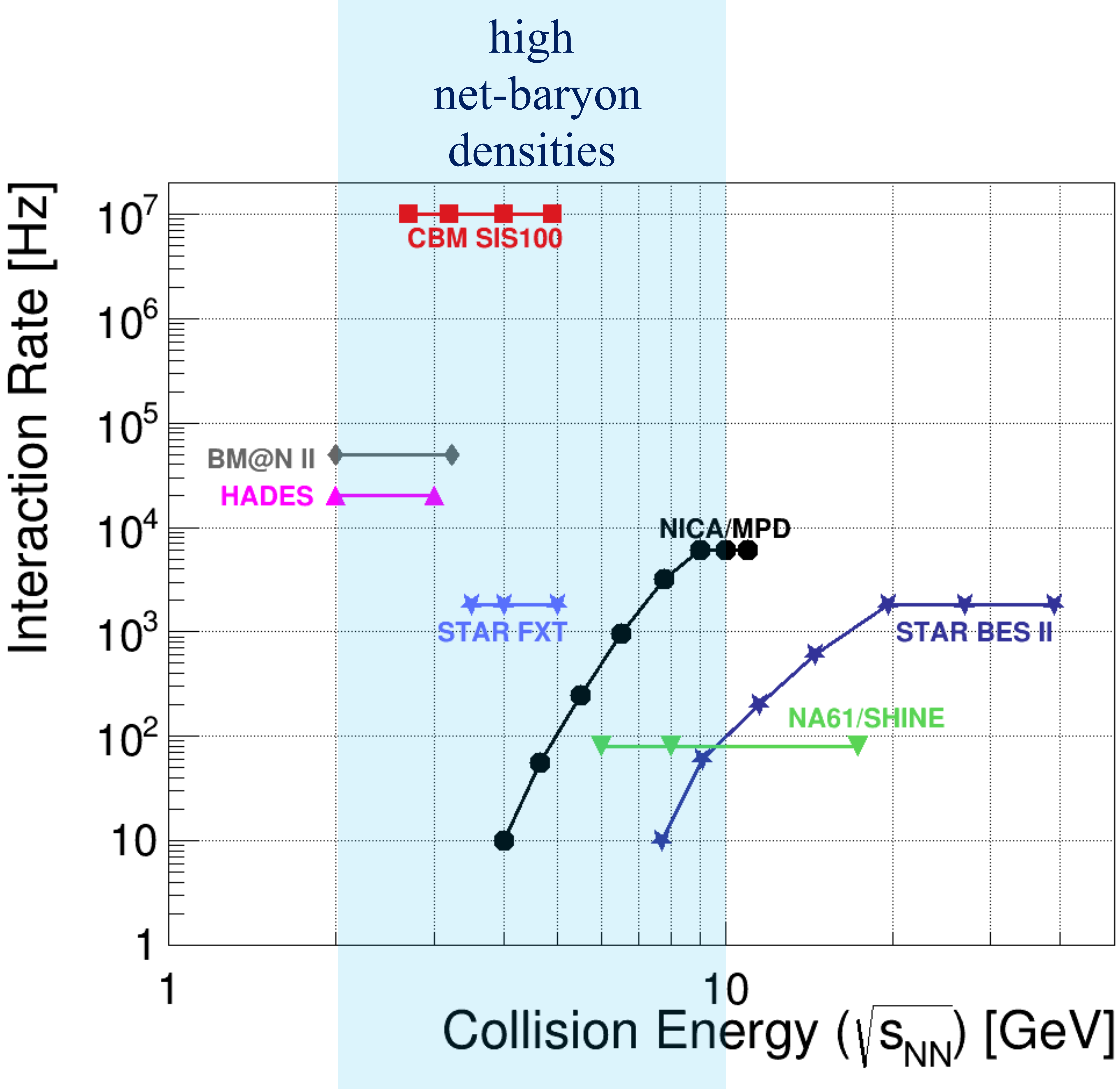
Deconfinement phase transition at high ρ_B
excitation function and flow of
strangeness (**K, Λ, Σ, Ξ, Ω**)

Onset of chiral symmetry restoration at high μ_B
in-medium modifications of hadrons (ρ)
excitation function of **multi-strange (anti)hyperons**

QCD critical endpoint
excitation function of event-by-event fluctuations
(π, K, p, Λ, Ξ, Ω…)

Projects to explore the QCD phase diagram at large μ_B:
RHIC (STAR) beam energy-scan, HADES, NA61@SPS,
MPD@NICA: bulk observables
CBM: bulk and **rare observables, high statistic!**

Experiments exploring dense QCD matter

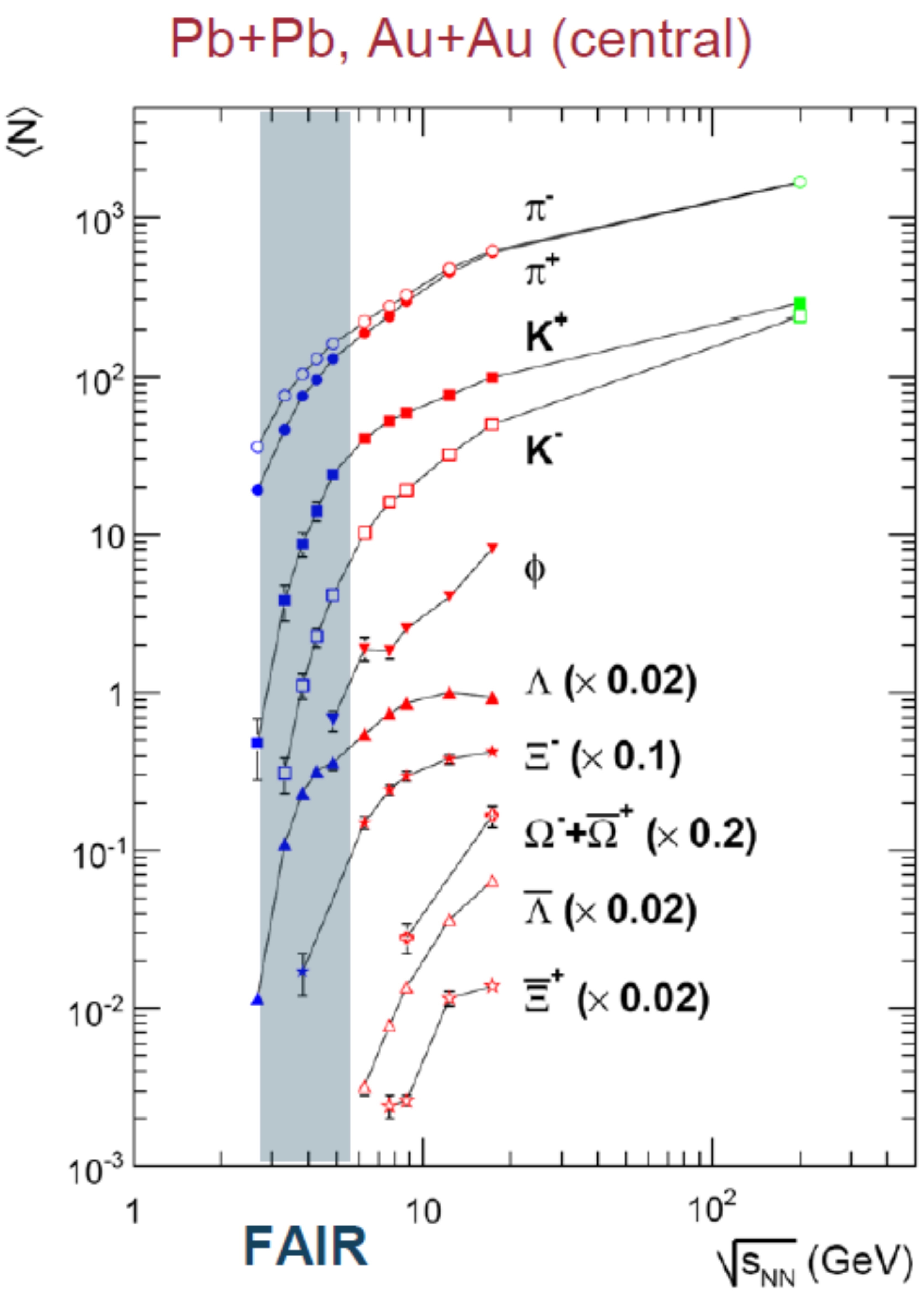


CBM:

unprecedented rate capability

- determination of (displaced) vertices with high resolution (≈ 50 μm)
- identification of leptons and hadrons
- fast and radiation hard detectors
- self-triggered readout electronics
- high speed data acquisition and
- online event selection
- powerful computing farm and 4D tracking
- software triggers

Strangeness world data



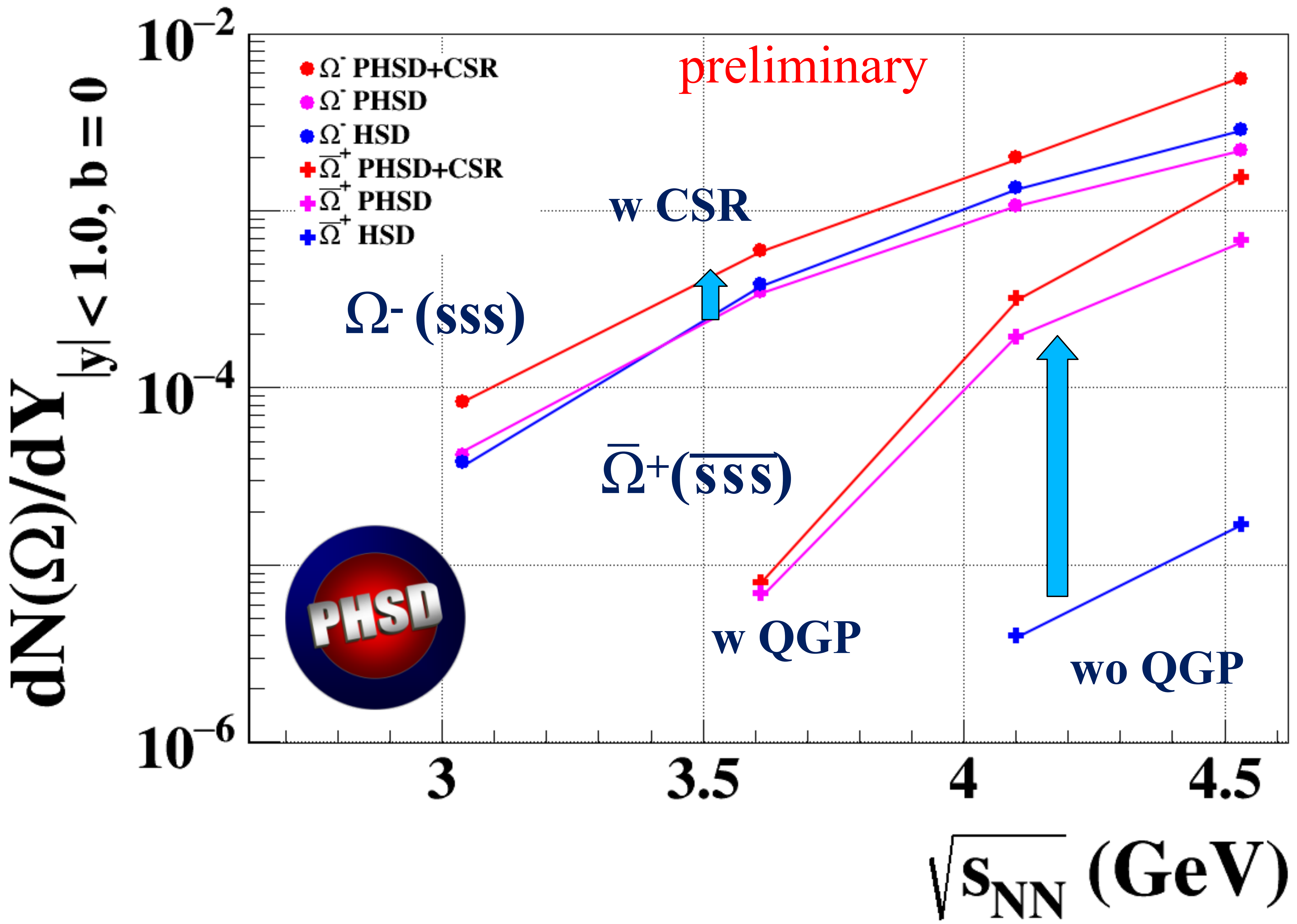
No data available at FAIR energy

In the AGS (SIS100) energy range, only about 300 Ξ^- hyperons have been measured in Au+Au collisions at 6A GeV

High-precision measurements of excitation functions of multi-strange hyperons in A+A collision with different mass numbers A at SIS100 energies have a discovery potential to find a signal for the onset of deconfinement in QCD matter at high net-baryon densities.

QGP and Chiral symmetry restoration

"Chiral symmetry restoration versus deconfinement in heavy-ion collisions at high baryon density"
W. Cassing, A. Palmese, P. Moreau, and E. L. Bratkovskaya Phys.Rev. C93 (2016), 014902, arXiv:1510.04120 [nucl-th]

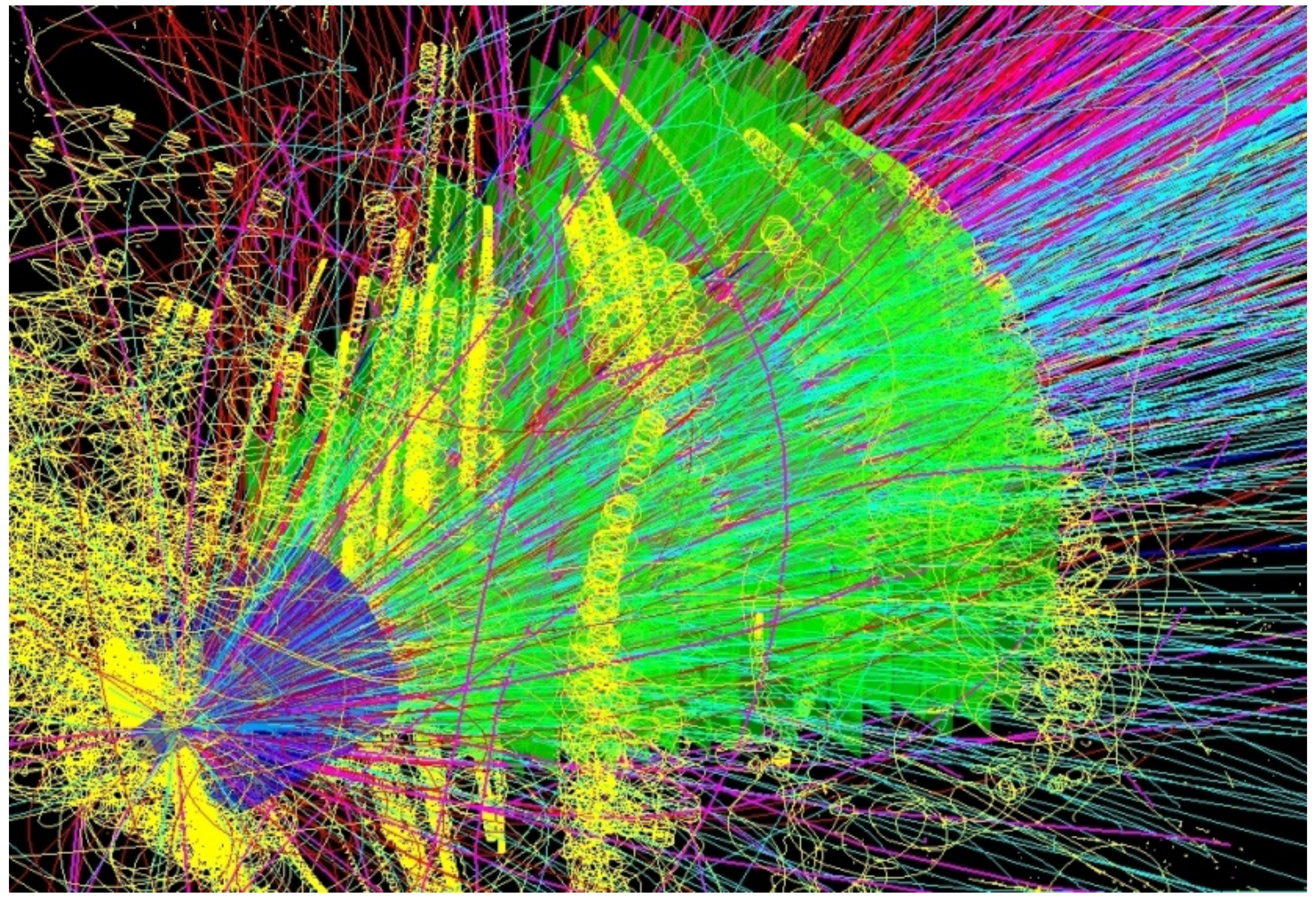


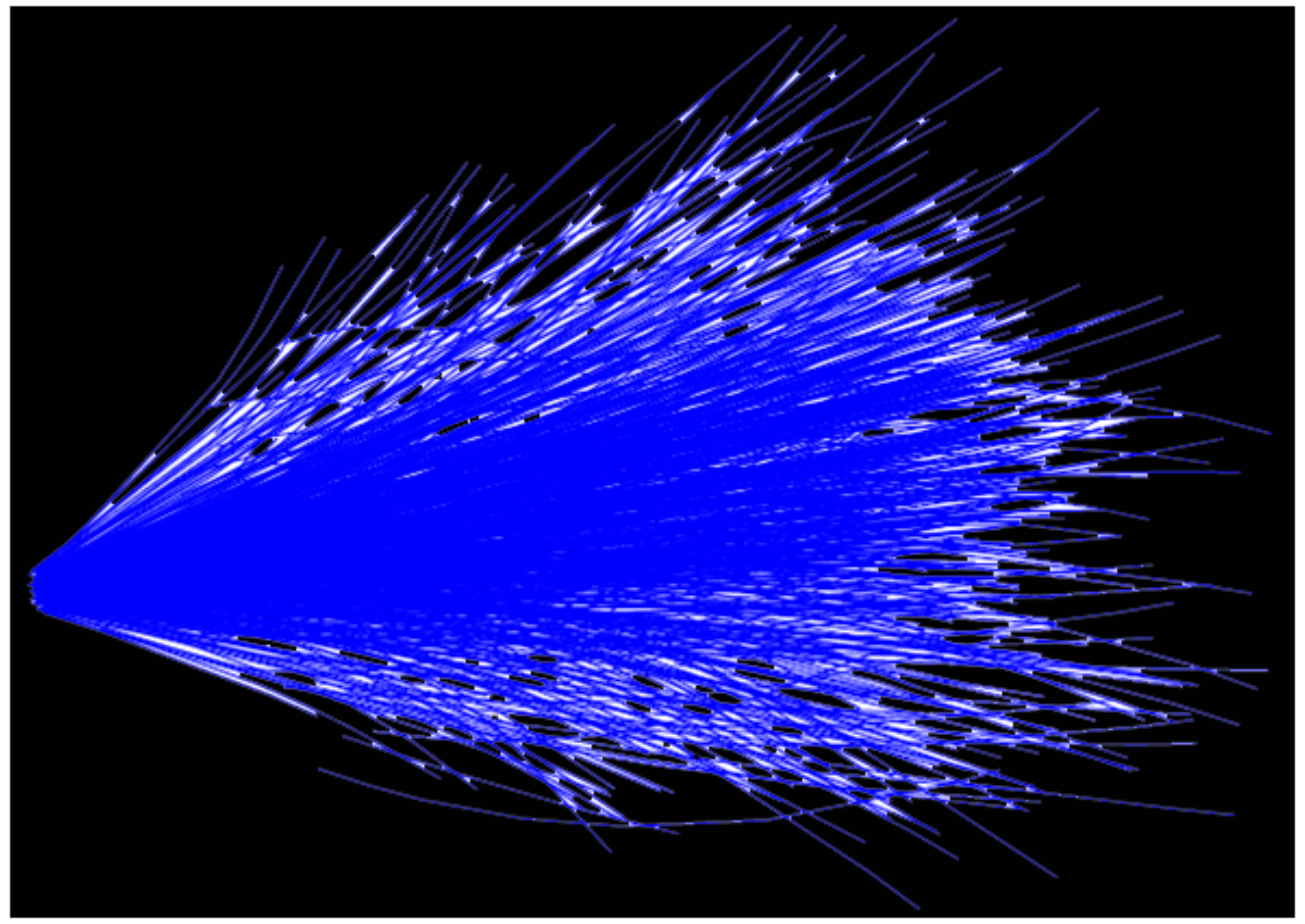
Chiral symmetry restoration (CSR) change the flavor decomposition – more s-sbar pairs produced.

Droplets of QGP allow to interact s-sbar quarks and create more multi-strange (anti)baryons.

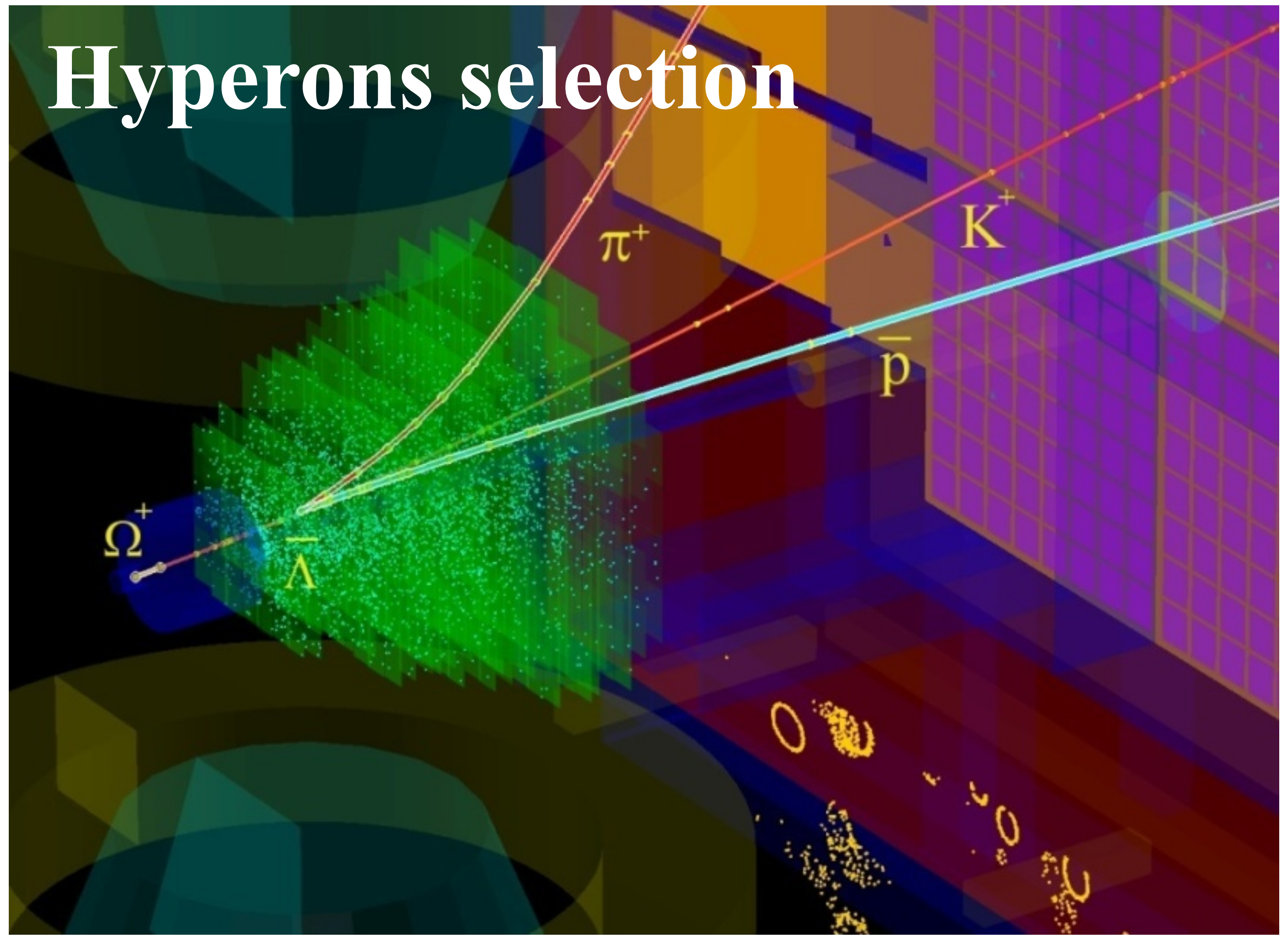
- Presence of QGP significantly increase yield of Ω^+ at FAIR energy
- CSR effect increase yield of Ω^- and Ω^+ at FAIR energy

Performance of the CBM track finder





AuAu 10 AGeV/c
165 π
170 p
26 K
15 Λ
20 K_S^0
0.3 Ξ^-



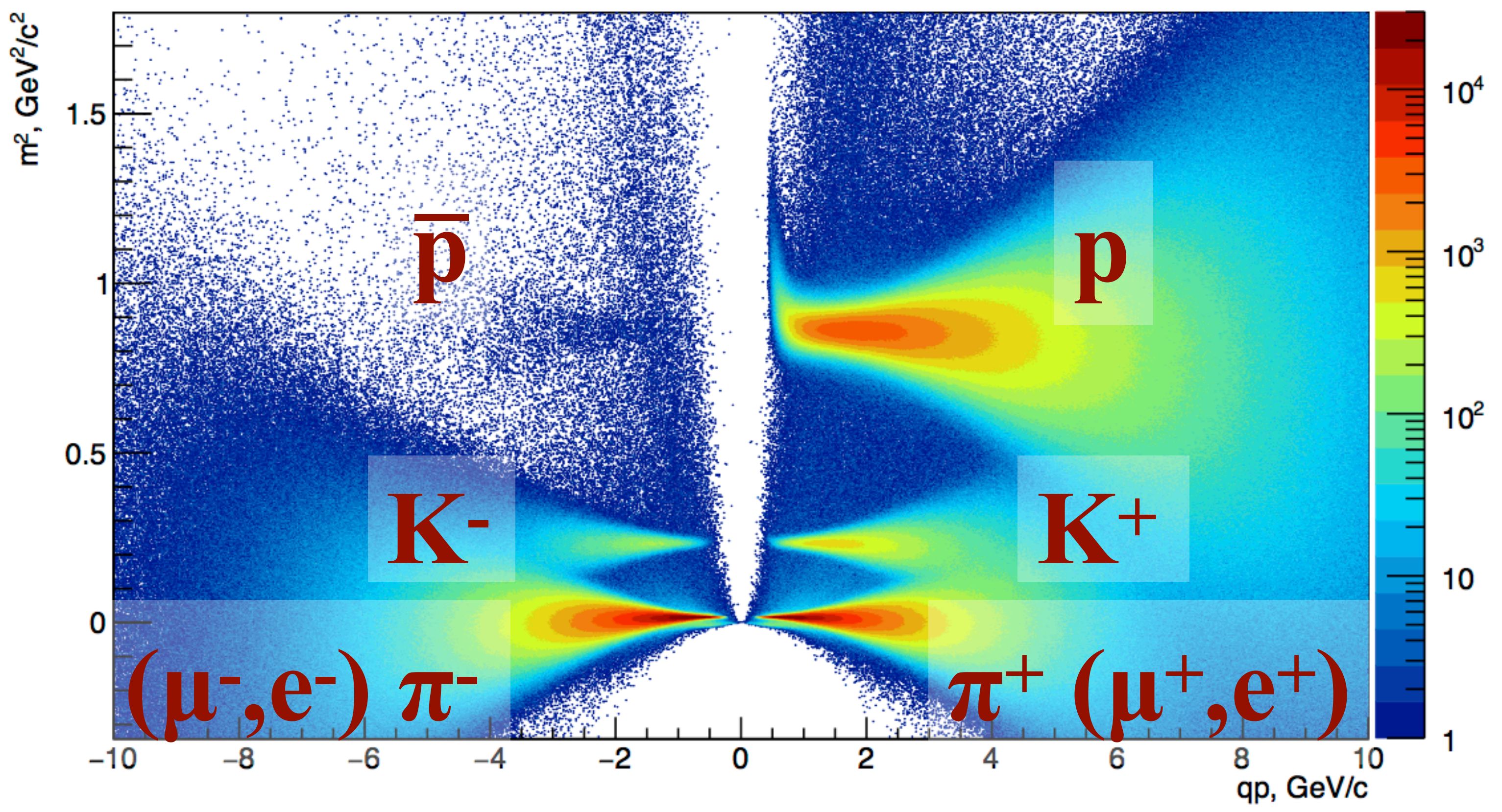
- For studies several theoretical models like UrQMD and PHSD are used.
- Track finder is based on the Cellular Automaton method.
- High efficiency for track reconstruction of more then 92%, including fast (more then 90%) and slow (more then 65%) secondary tracks.
- Time-based track finder is developed,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

(V. Akishina CBM poster)

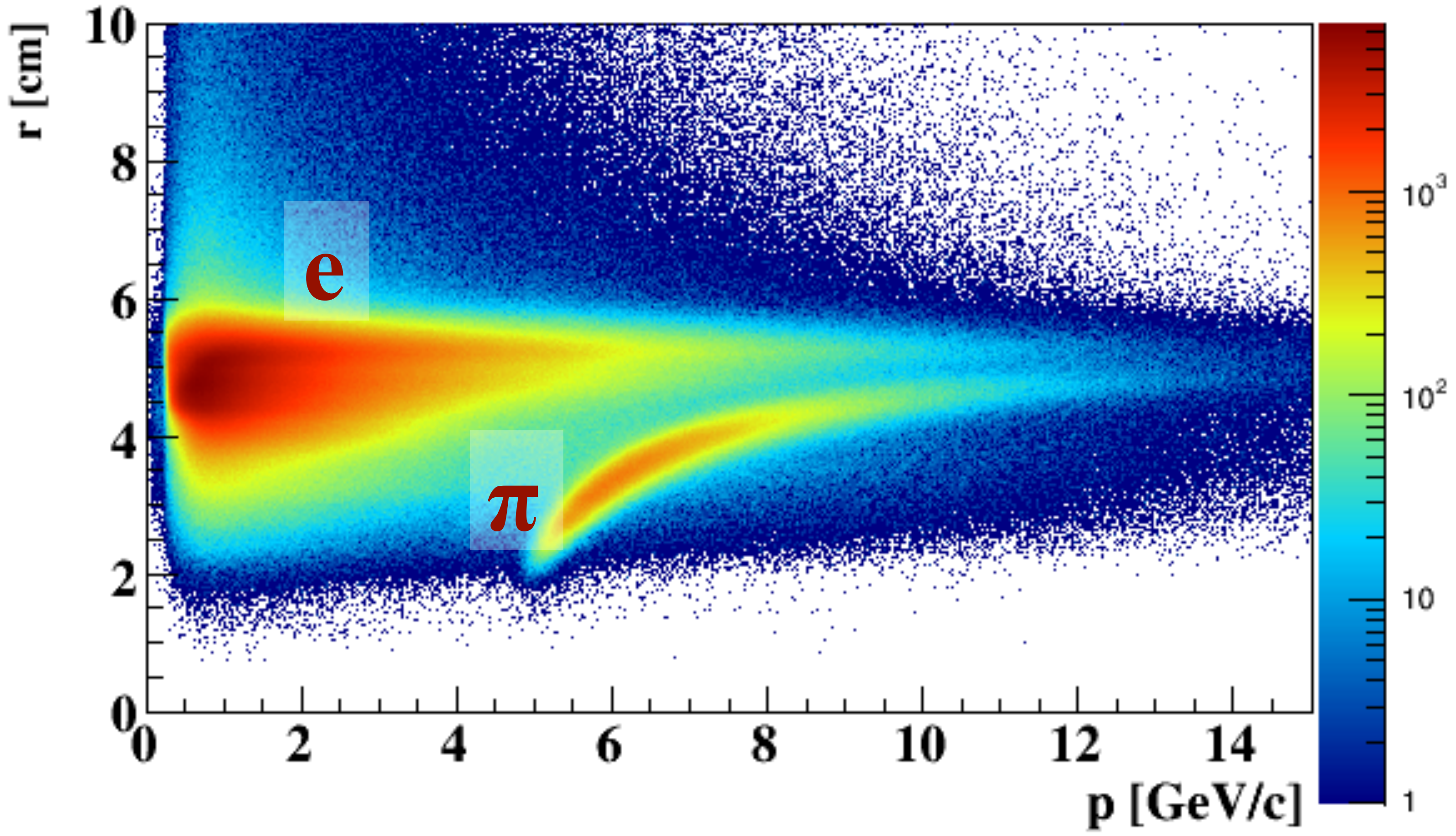
minimum bias : 6ms/core track finder, 1 ms/core particle finder

Particle identification with PID detectors

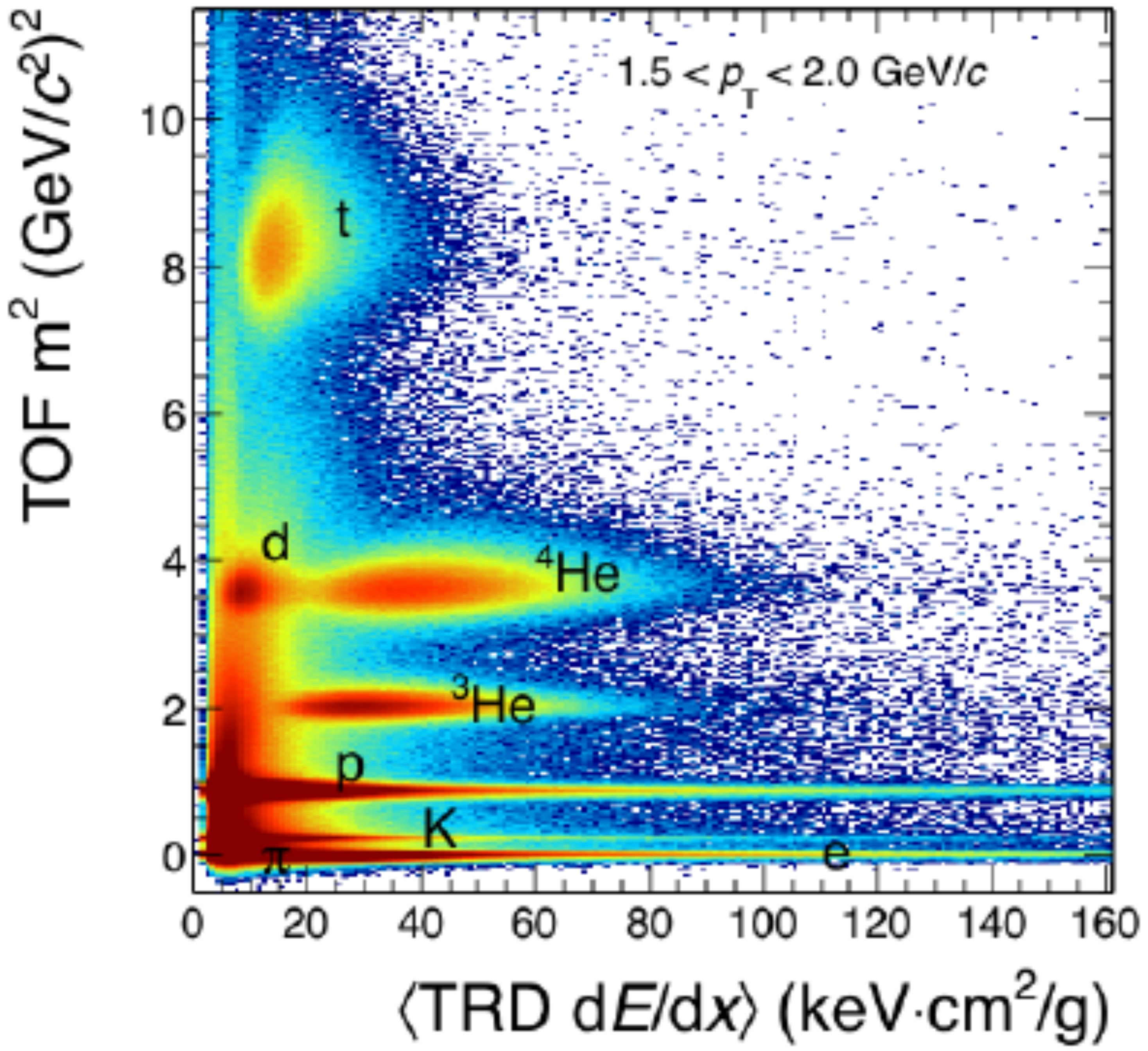
ToF: hadron identification



RICH: electron identification



TRD: d-He separation



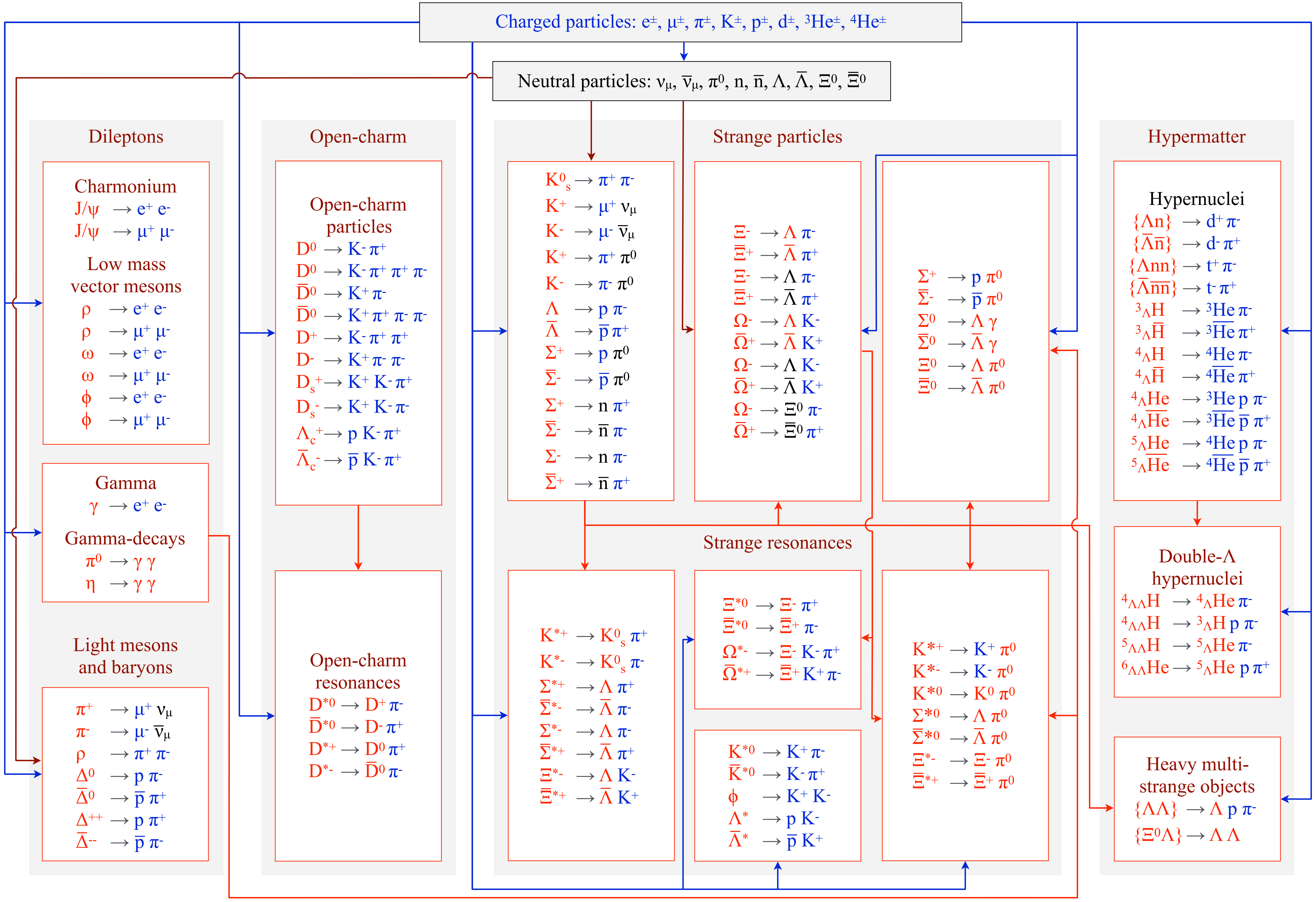
PID detectors:

- ToF (Time of Filght) — hadron identification;
- RICH (Ring Imaging CHerenkov detector) — electron identification;
- TRD (Transition Radiation detector) — electron and heavy fragments identification.

PID detectors of CBM will allow a clear identification of charged tracks.

(I. Deppner, C. Blume, J. Bendarouach CBM posters)

KF Particle Finder for the CBM Experiment

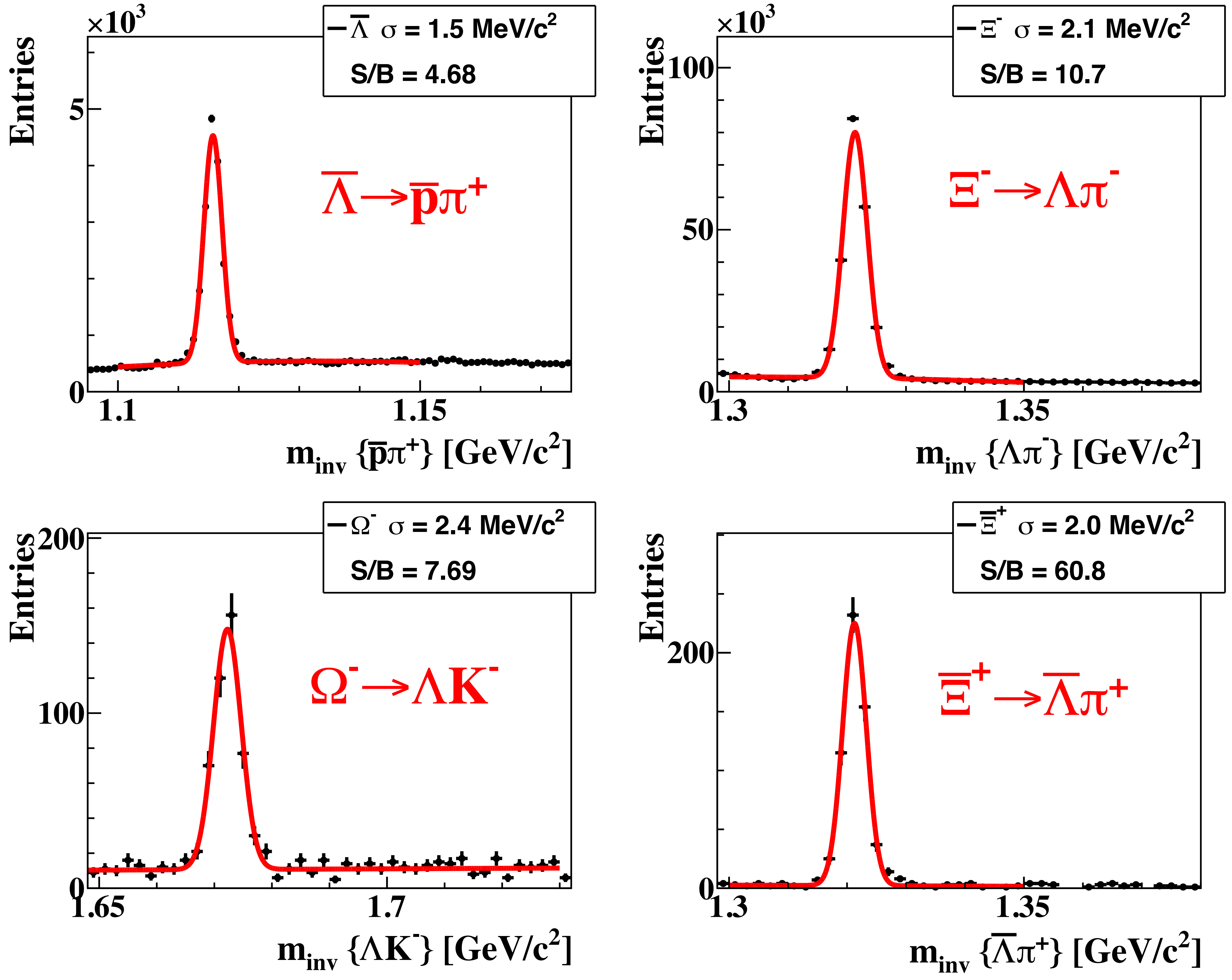


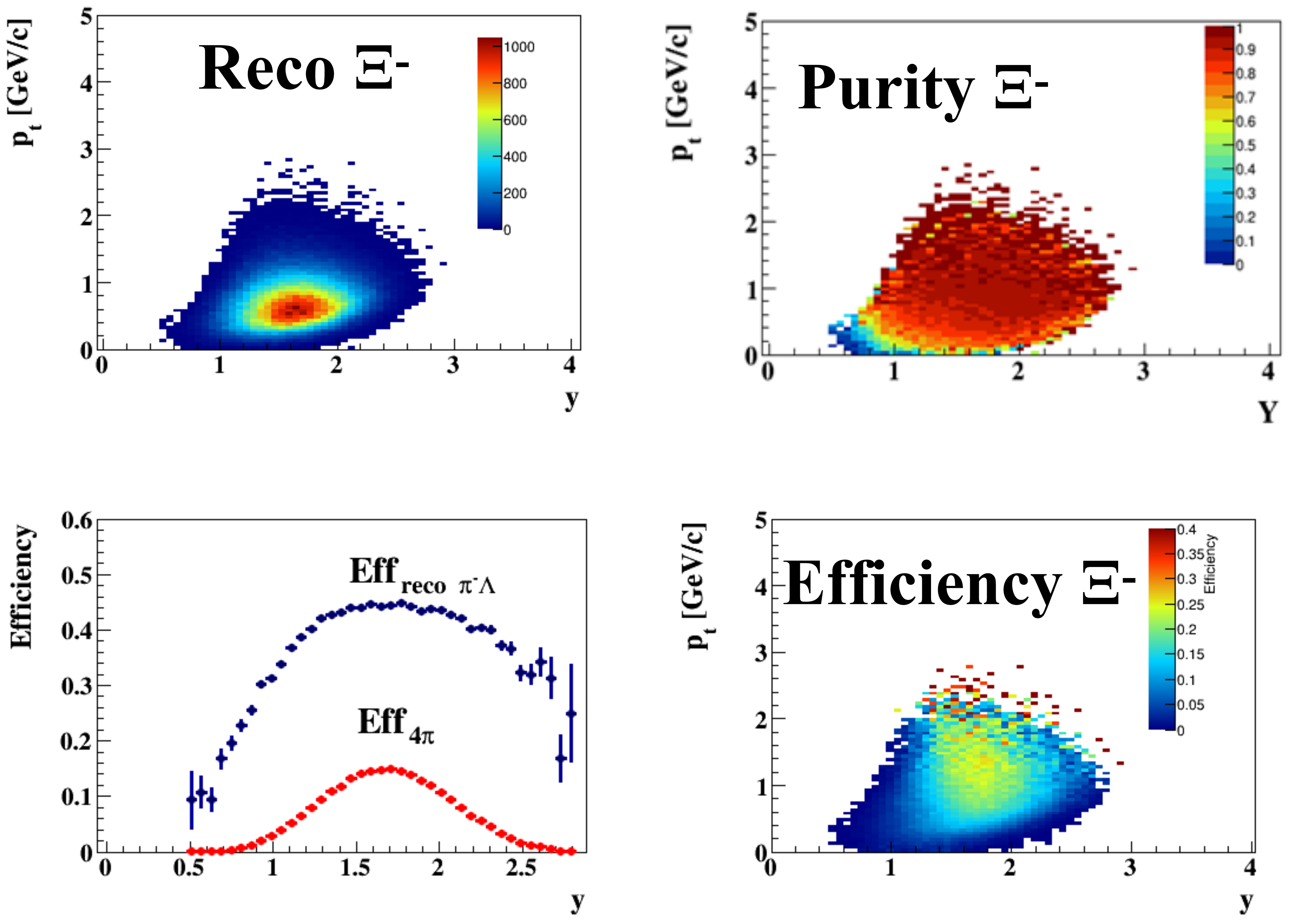
- More then 100 decays.
- All decays are reconstructed in one go.
- Based on the Kalman filter method — mathematically correct parameters and their errors.
- Available in and approbated within STAR, ALICE, PANDA.

(M. Zyzak CBM poster)

Strange particle reconstruction performance

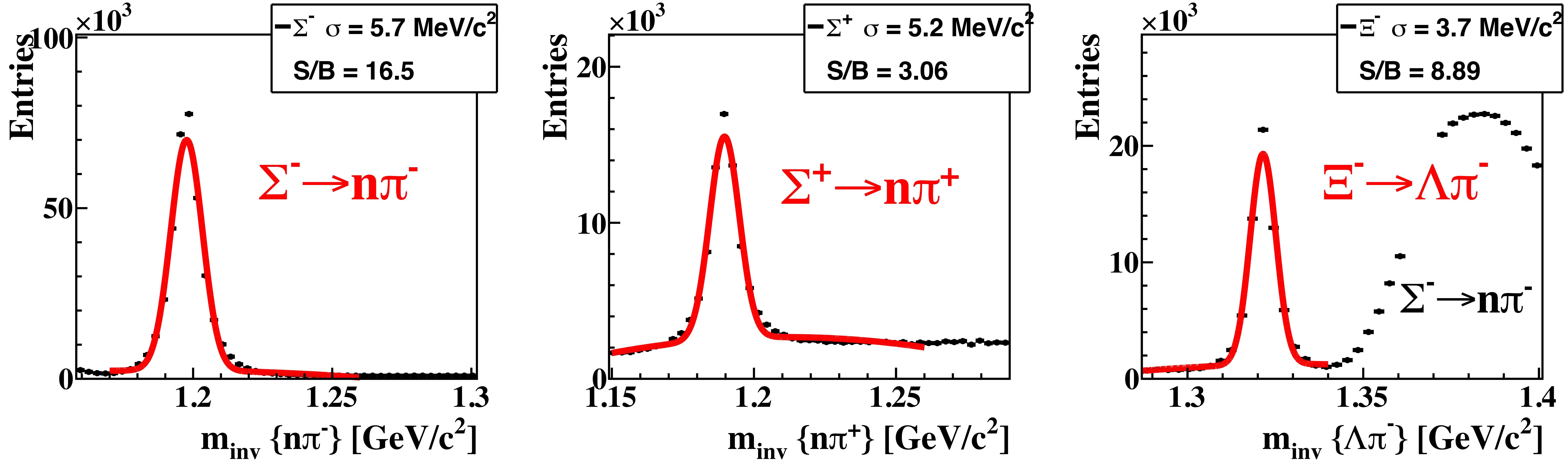
5M central AuAu collisions 10AGeV/c

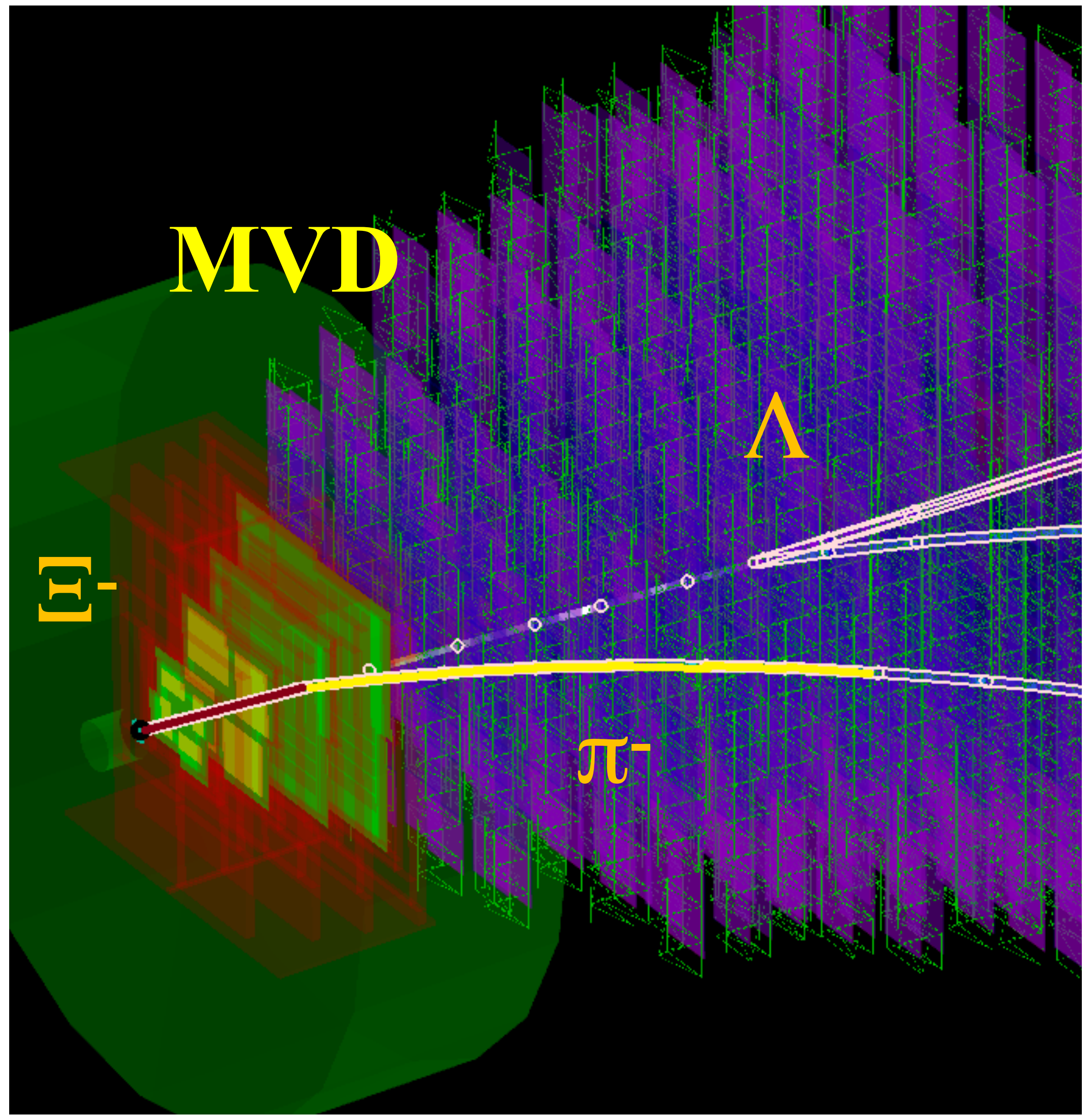




- CBM will allow clean reconstruction of rare strange probes with high efficiency and high statistics.
- Tools for the multi-differential physics analysis are prepared.

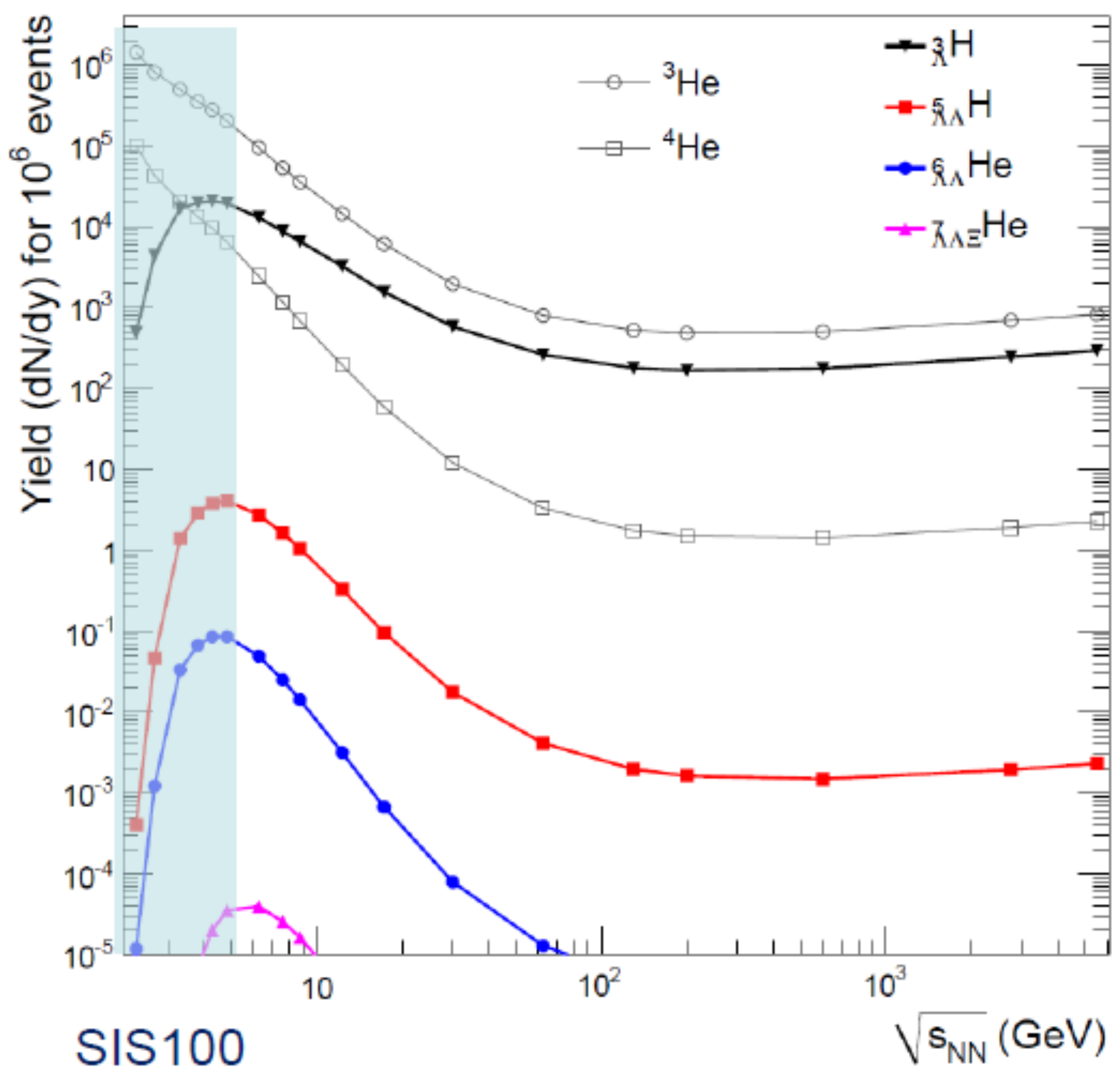
5M central AuAu collisions 10AGeV/c





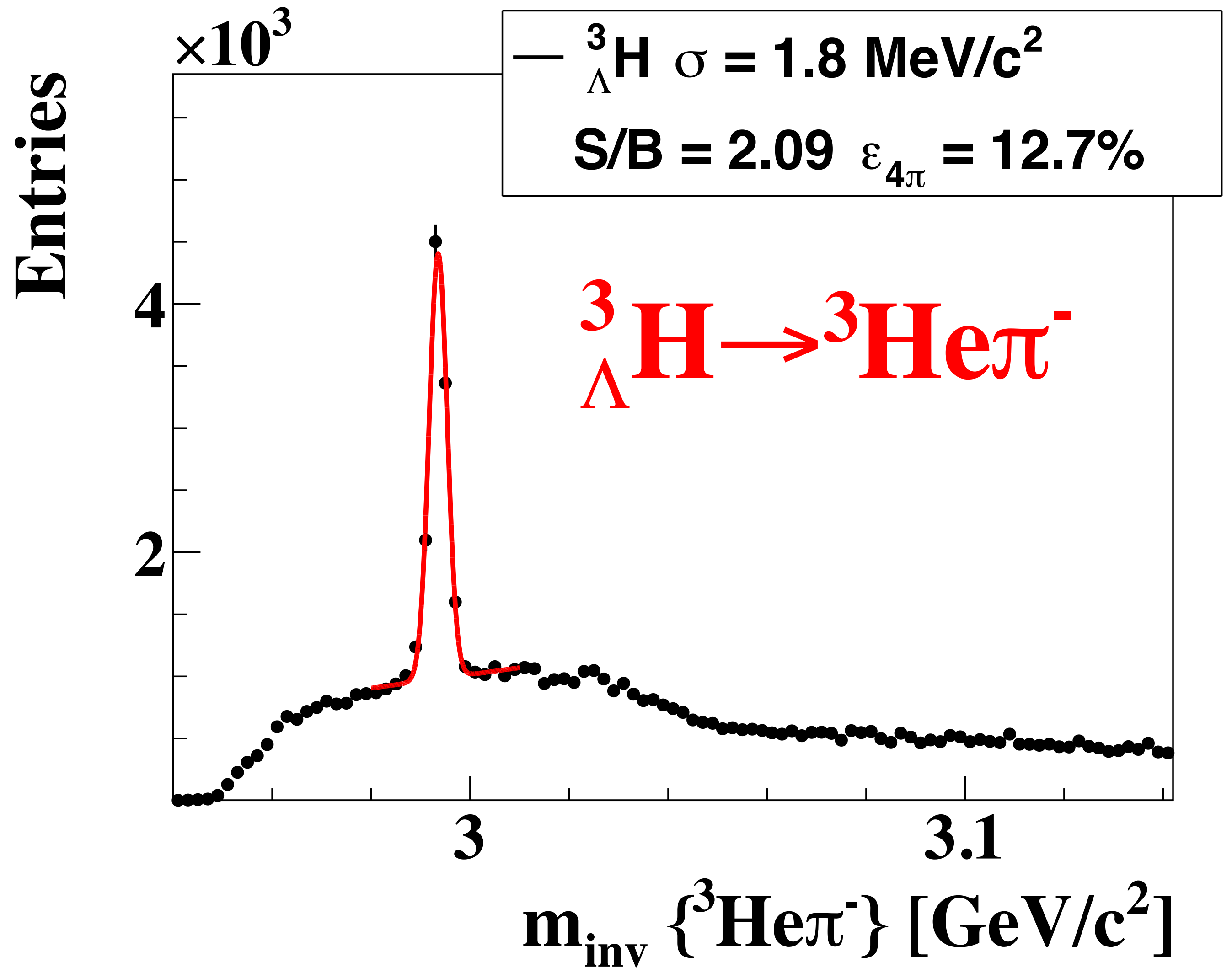
- Σ^+ and Σ^- physics:
  - completes the picture of strangeness production: abundant particles, carry out large fraction of strange quarks;
  - reconstruction of resonances, like Λ(1405);
  - reconstruction of hypothetic particles, like H-dybarion.
- Having high acceptance for Σ hyperons CBM is capable to reconstruct them by the Missing Mass Method.
- The method provides also independent way for reconstruction of Ξ and Ω hyperons, that will allow systematics study.

Hypernuclei production in A+A collisions

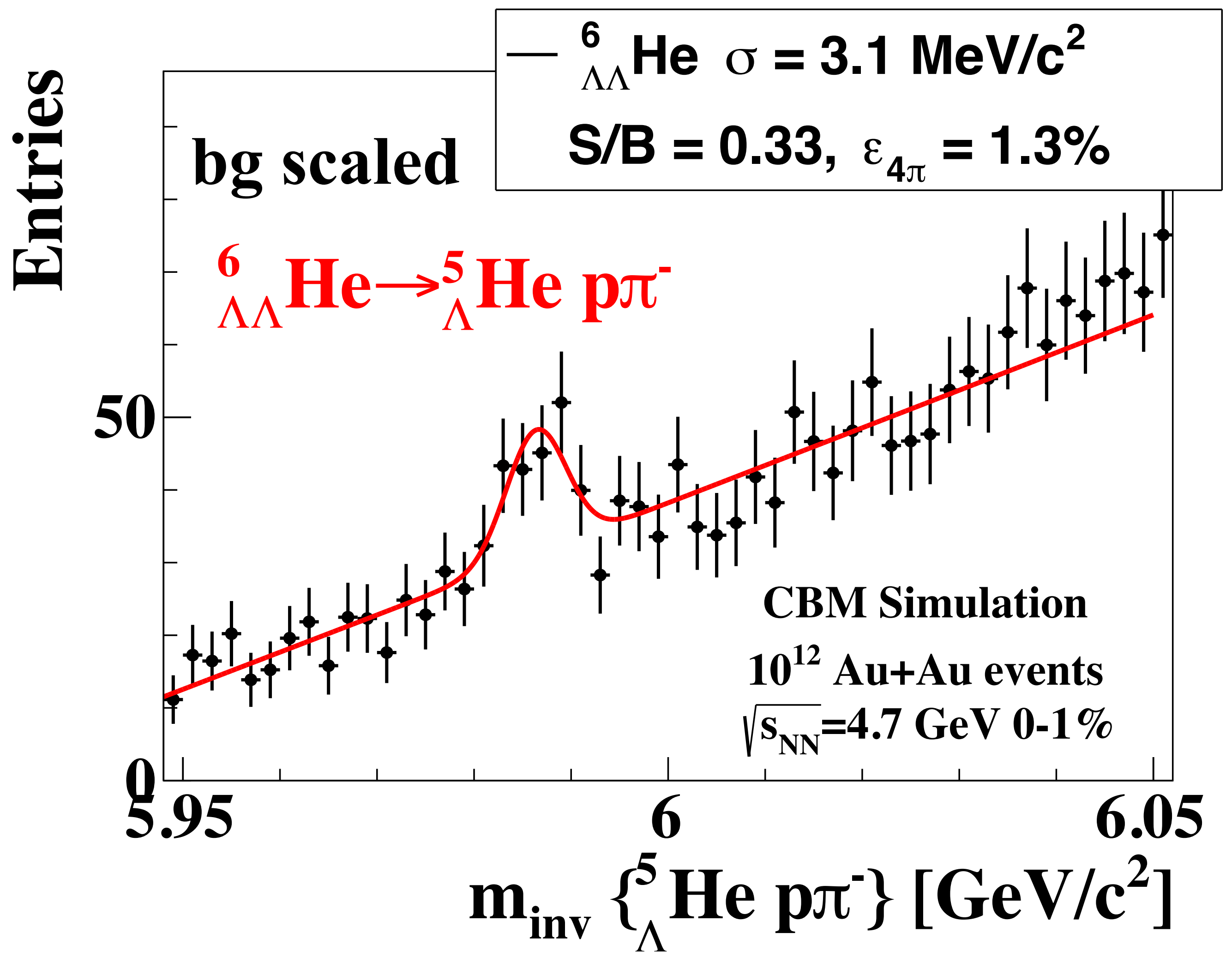


A. Andronic et al., Phys. Lett. B697 (2011) 203

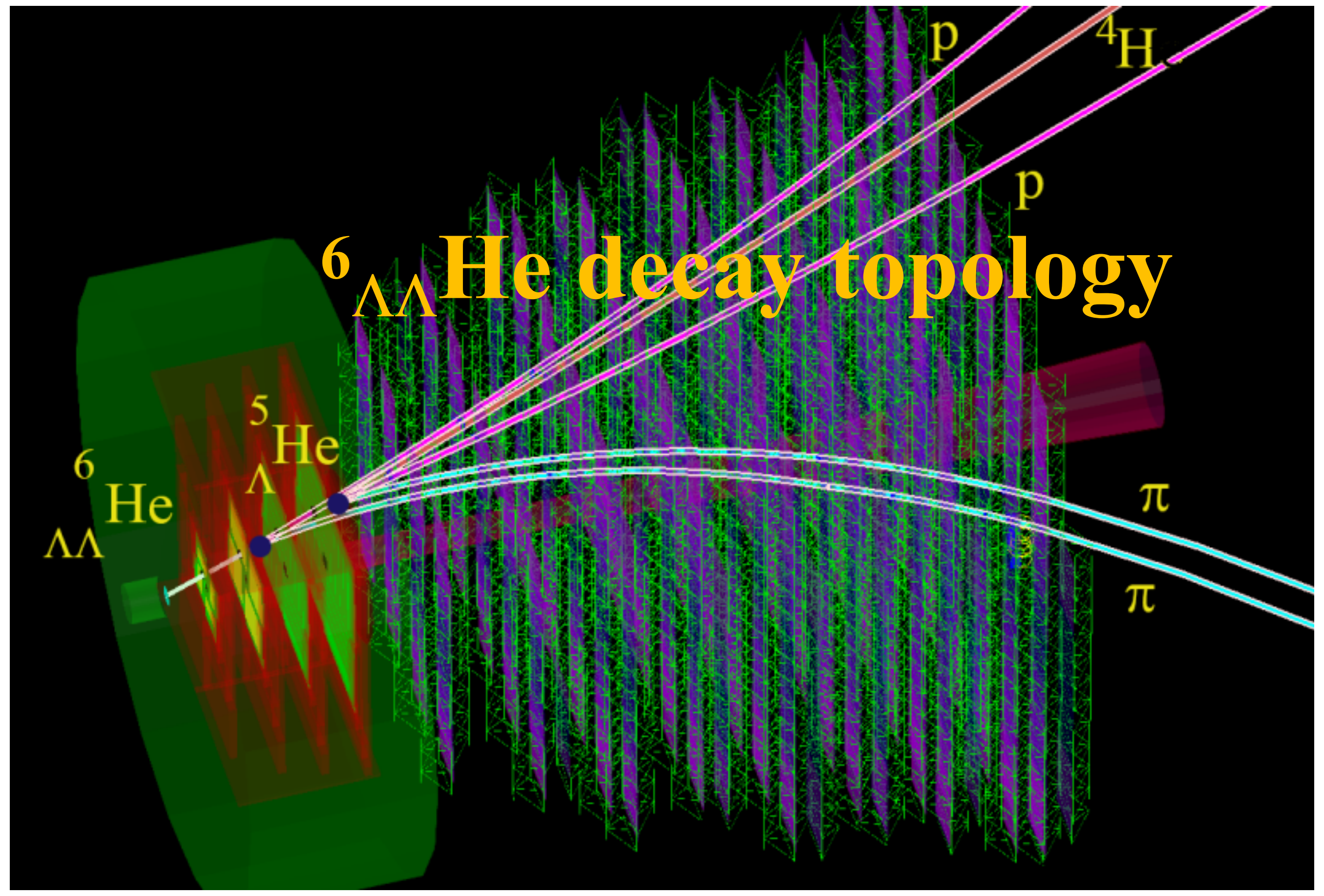
5M mbias events Au+Au at 10AGeV/c
5 sec at 1MHz IR (1.8 k/sec)



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



- According to the current theoretical predictions CBM will be able to perform comprehensive study of hypernuclei, including:
  - precise measurements of lifetime;
  - excitation functions;
  - flow.
- It has a huge potential to register and investigate double Λ hypernuclei.



Summary

- CBM detector is an excellent device to measure not only bulk observables, but strangeness, hypernuclei and other rare probes with high statistic.
- The CBM experiment will provide multidifferential high precision measurements of strange hadrons including multi-strange (anti)-hyperons.
- High precision measurements of excitation functions of multi-strange hyperons in A+A collision with different mass numbers A at SIS100 energies have a discovery potential to find a signal for the onset of deconfinement in QCD matter at high net-baryon densities
- 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.

CBM Collaboration: 64 Institutes, ~600 members