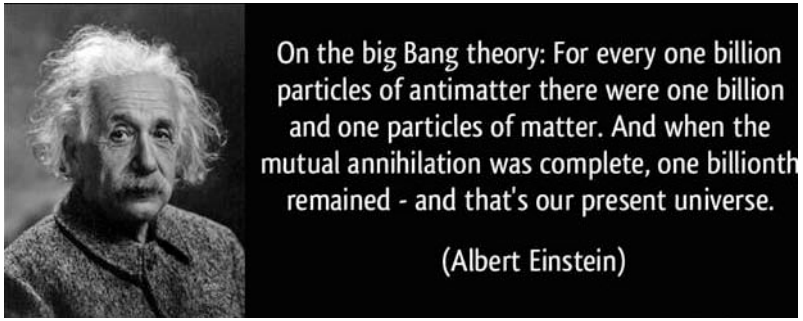
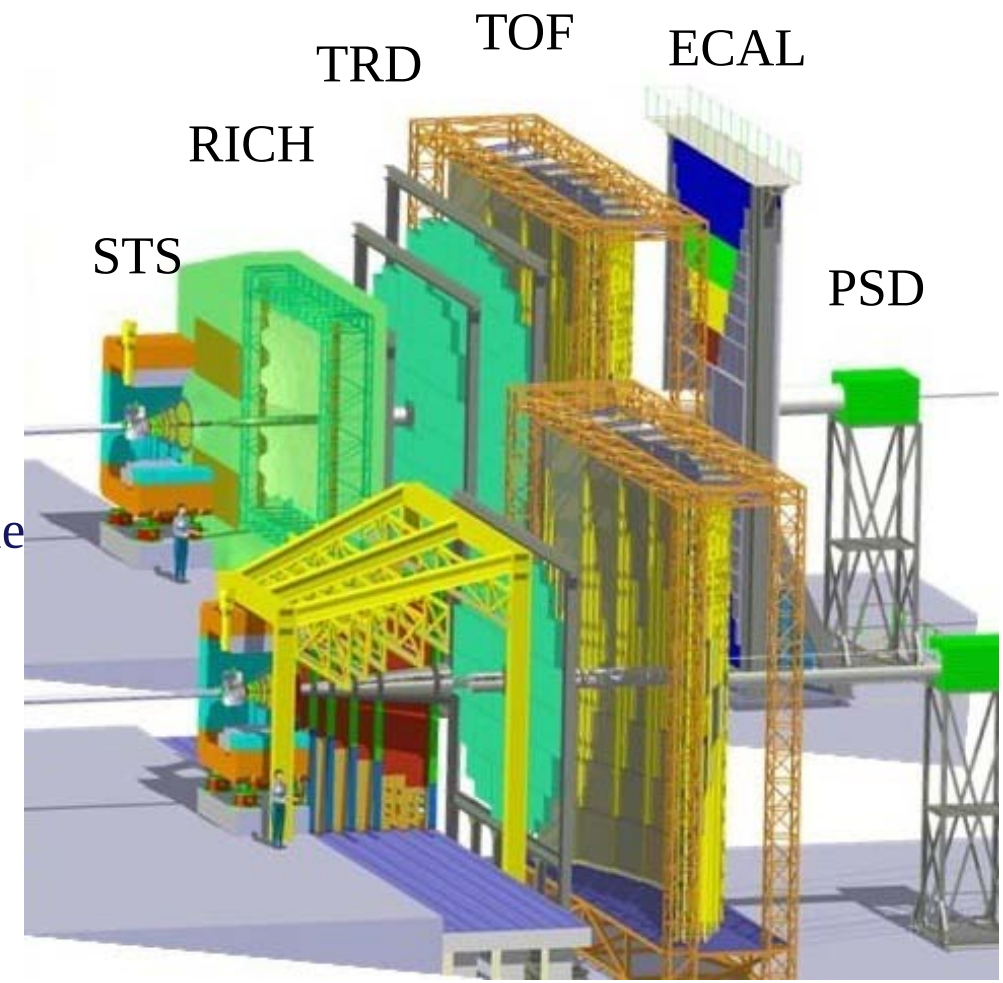
Hypermatter in CBM



Hyperons in Nuclear Matter
GSI, 22 July 2015
Vassiliev Iouri, M. Zyzak and I. Kisel

- Motivation
- CBM detector (event rerconstruction)
- Multi-strange hyperons reconstruction
- Hypernuclei & Di-baryons
- Neutral particle reconstruction technique
- Conclusions

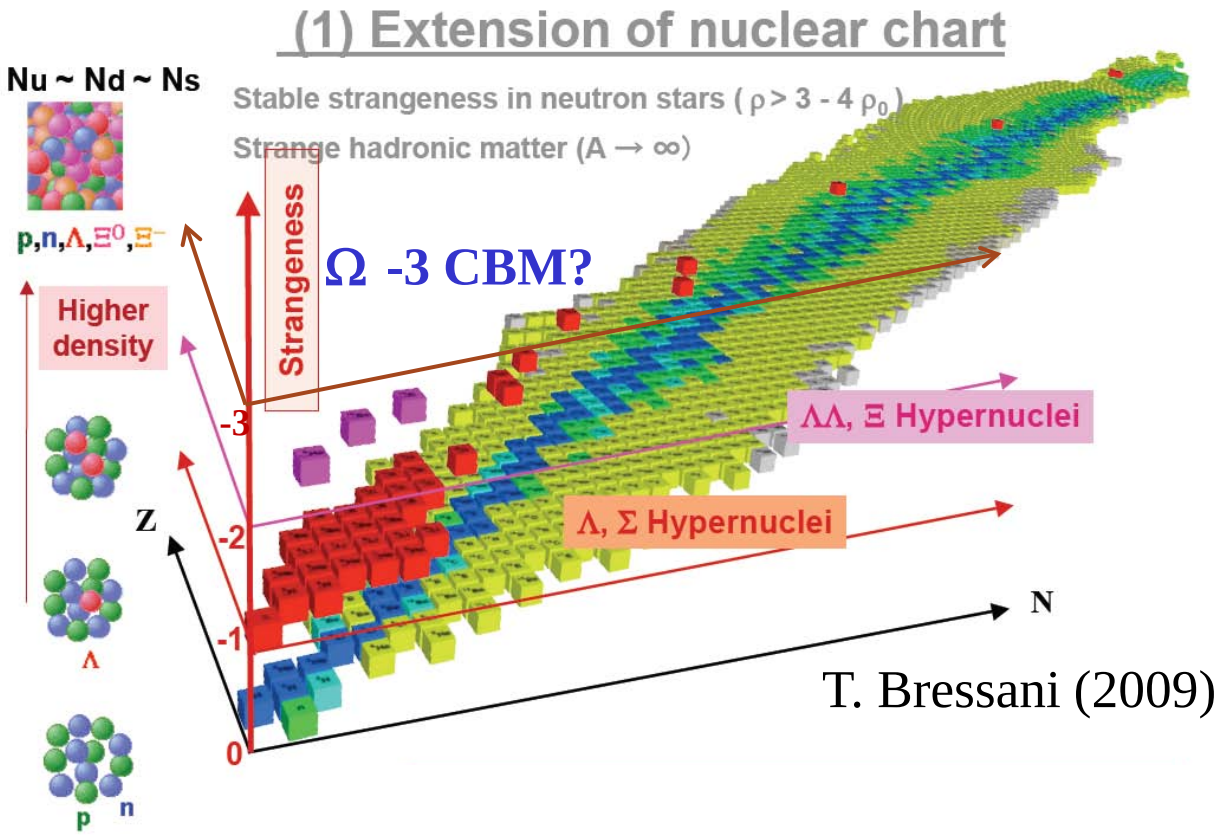


Motivation:

How far can we extend the chart of nuclei towards the third (strange) dimension by producing single and double hypernuclei?

Does strange matter exist in the form of heavy multi-strange objects?

CBM
Au+Au



- **new physics items:**
- search for *H particle*
- neutron star composition
- are there S=-2 deeply bound K(bar) states?
- **challenges:**
- (abundant) production of ΛΛ-hypernuclei is very **difficult (CBM!)**
- identification of produced hypersystems is **problematic (CBM!)**

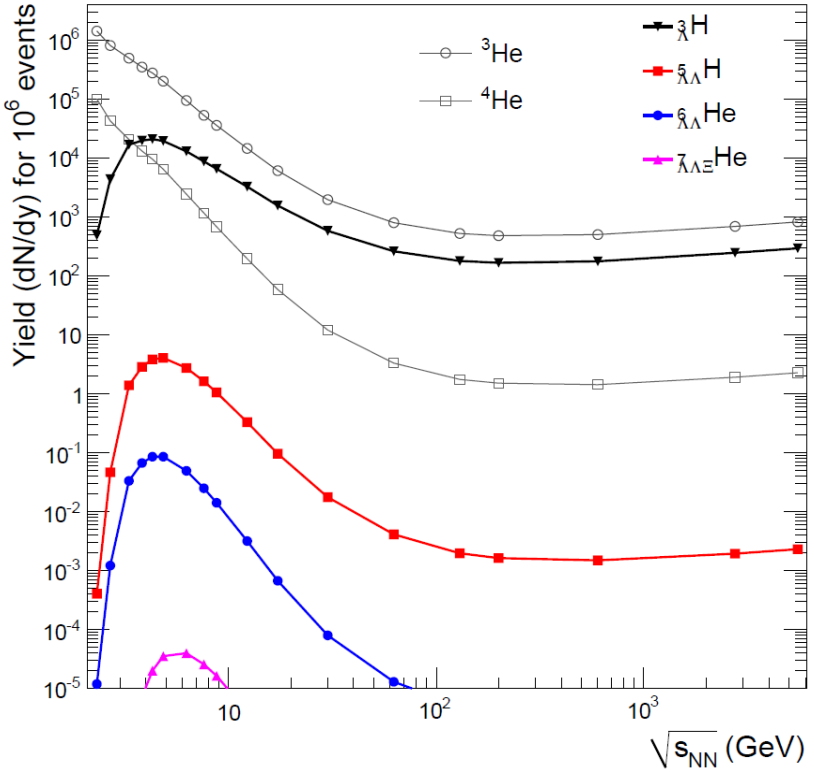
Motivation: CBM physics program III (P.Senger)

No data at FAIR energies

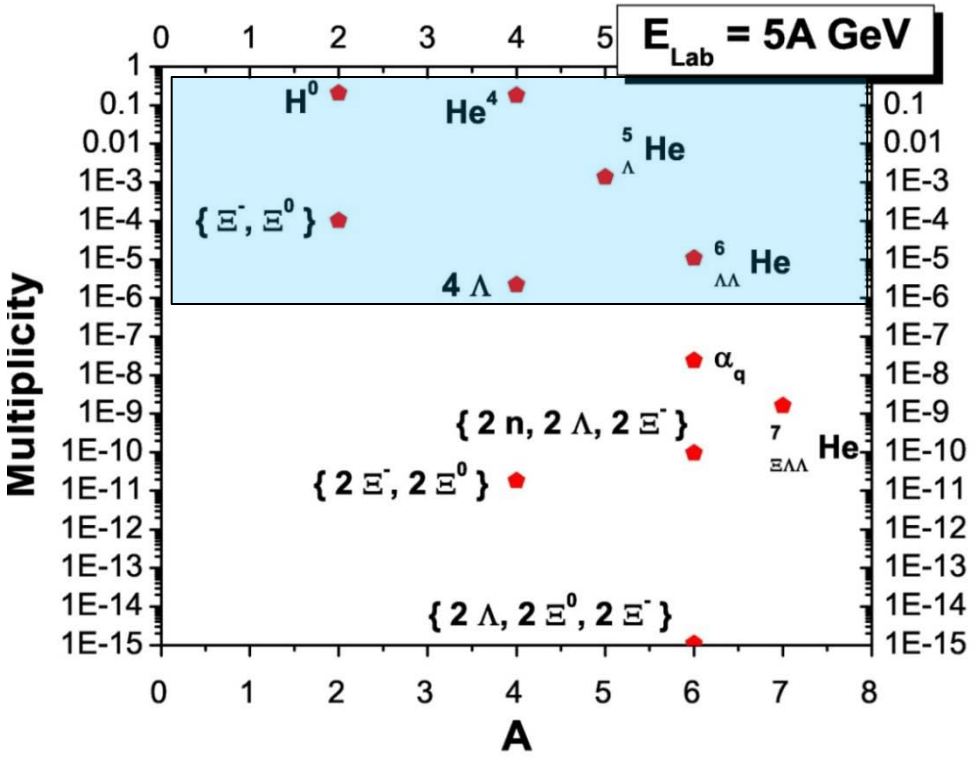
Strange matter

Hypernuclei, strange dibaryons and massive strange objects

Production of hypernuclei via coalescence of hyperons and light nuclei



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



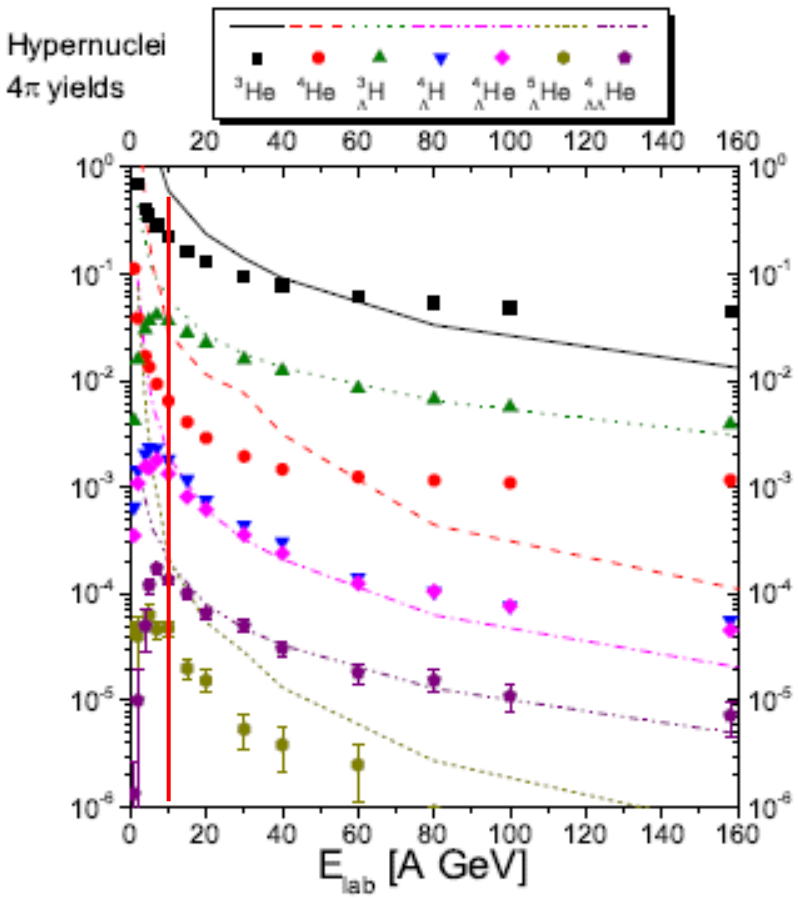
H. Stöcker et al., Nucl. Phys. A 827 (2009) 624c

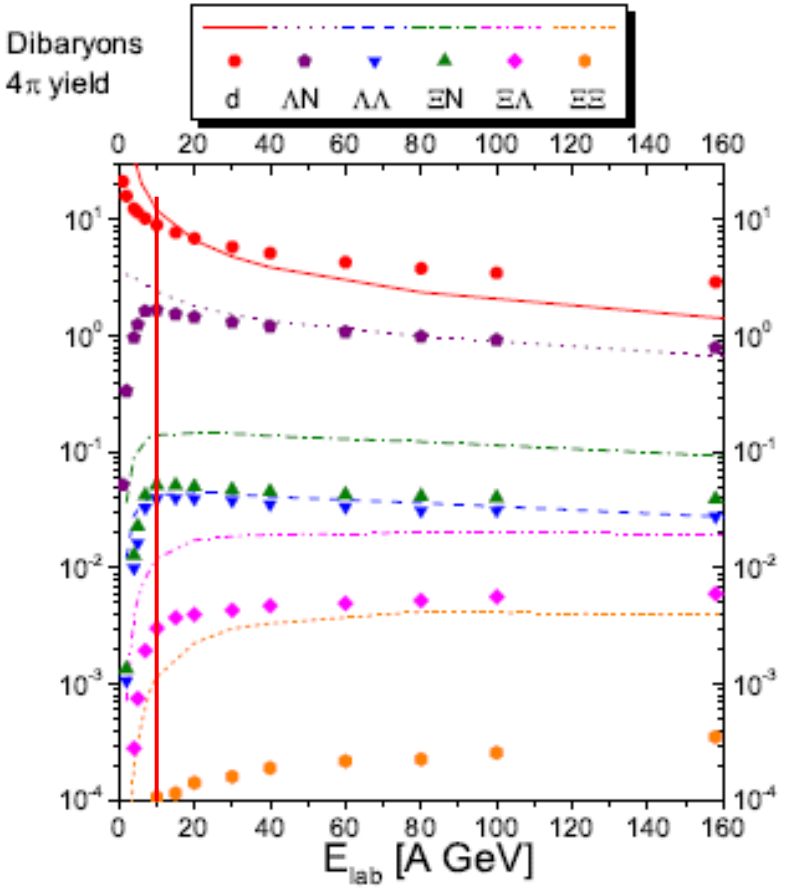
Motivation:

Hypernuclei, dibaryon and antinuclei production in high energy heavy ion collisions: Thermal production vs. Coalescence

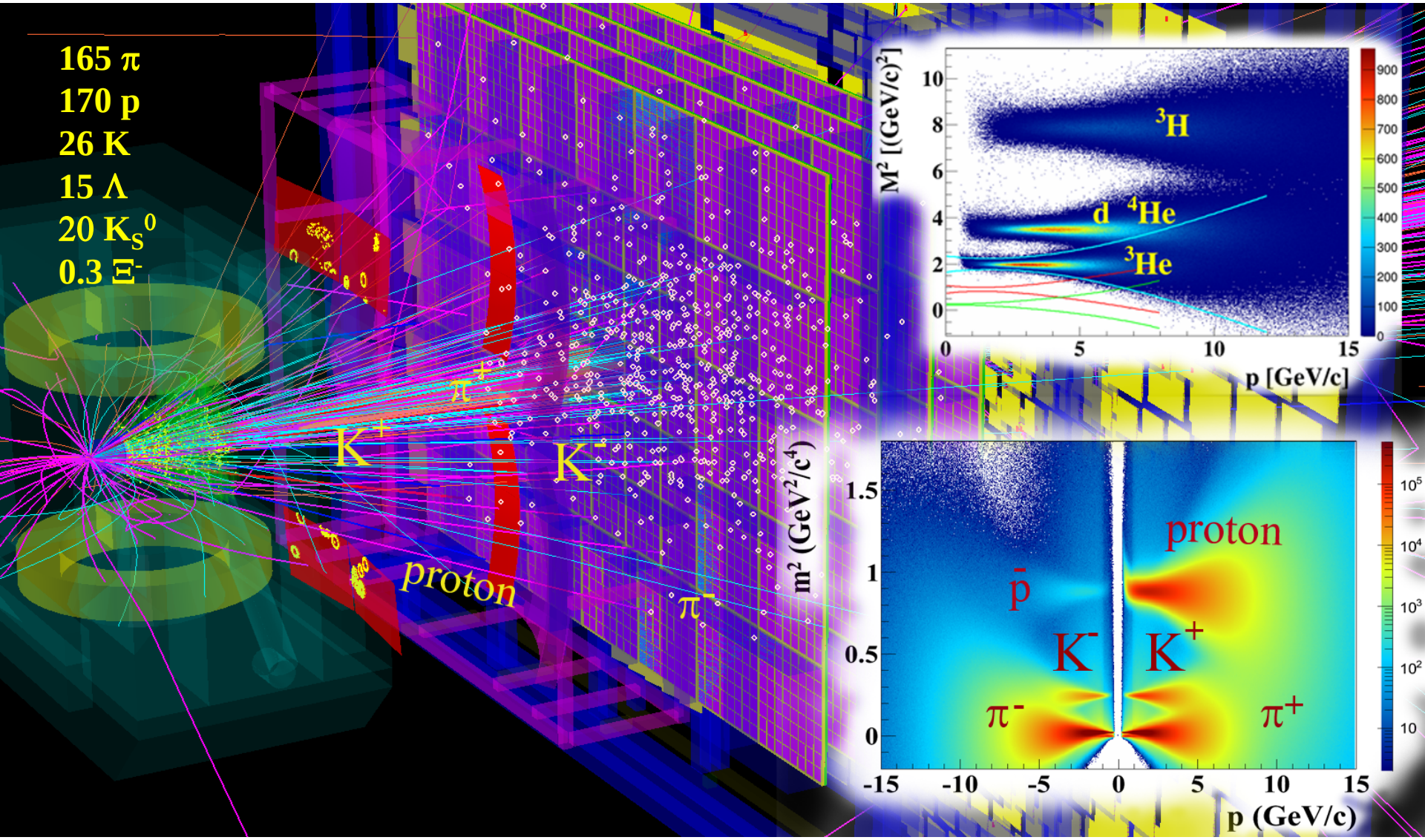
J. Steinheimer, K. Gudima, A. Botvina, I. Mishustin, M. Bleicher, H. Stöcker
Phys. Lett. B**714**, 85, (2012)

Lines: UrQMD + thermal hydrodynamics, symbols: DCM + coalescence



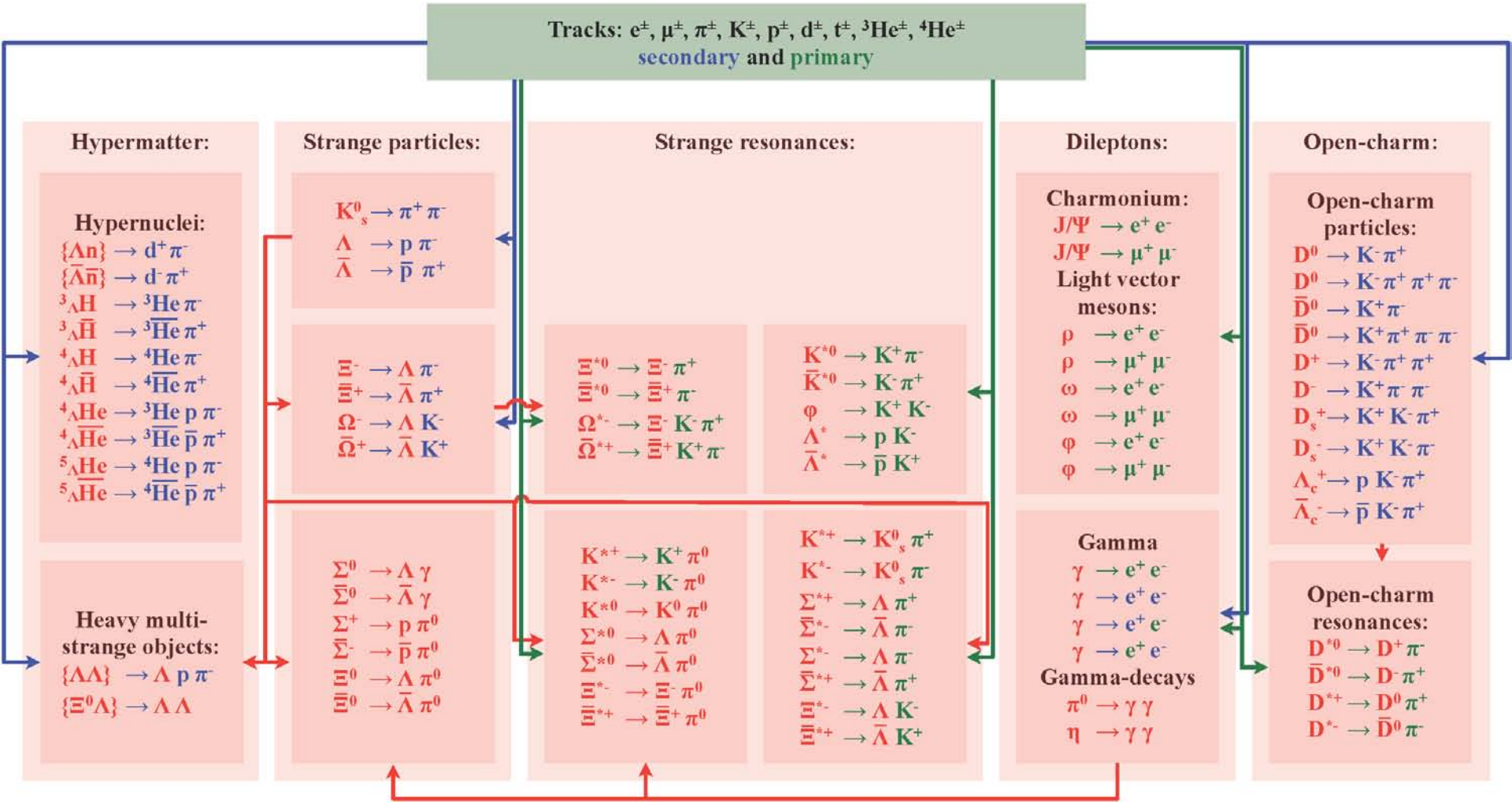


KF Particle Finder with ToF track ID: Au+Au @ 10AGeV SIS100

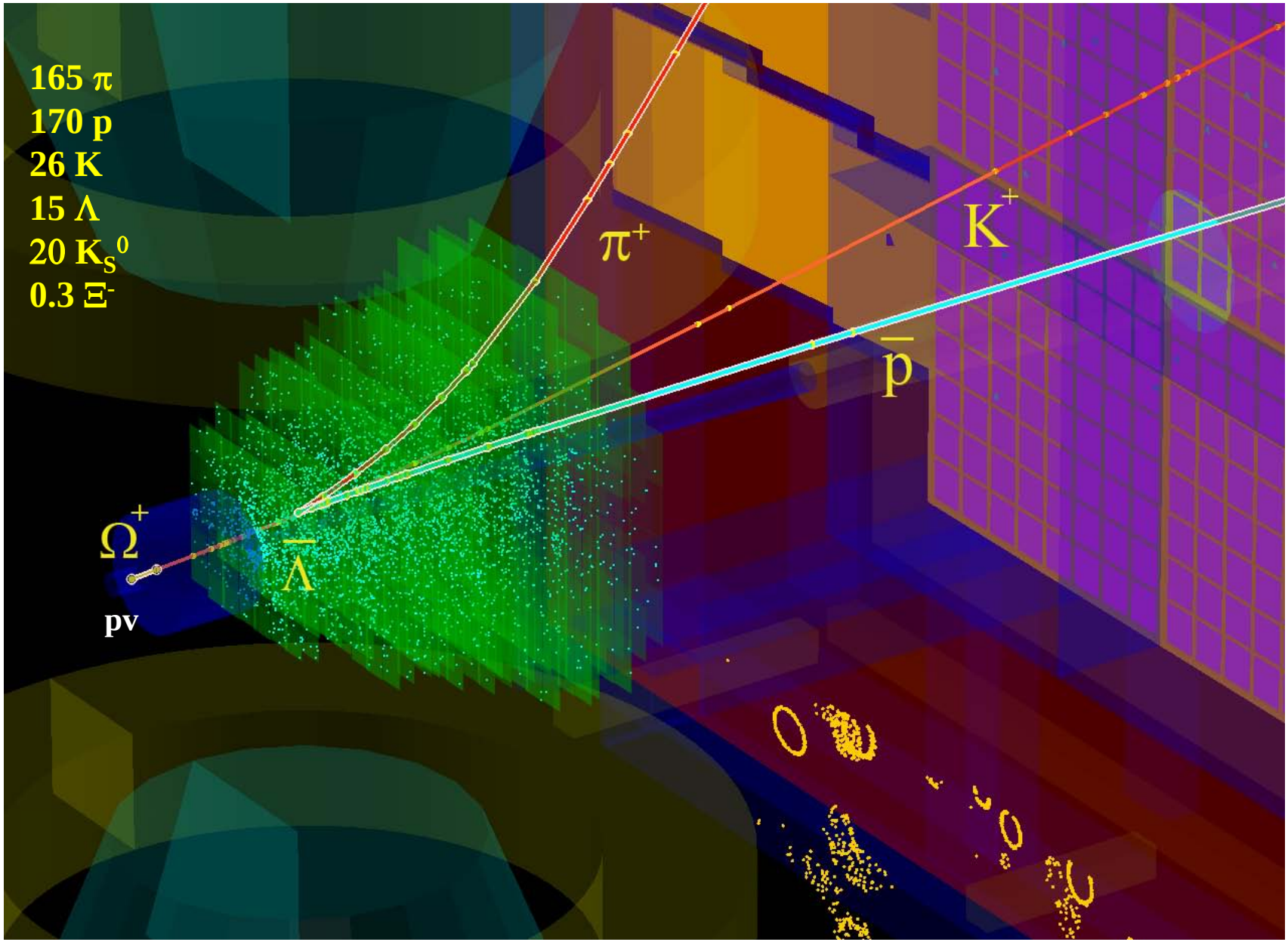


central: 40 (TF) + 8 (PF) ms/core
mbias : 5 (TF) + 1 (PF) ms/core, up to 80 cores/CPU

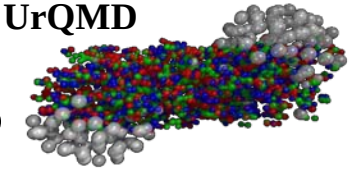
KF Particle Finder for the CBM Experiment (development)

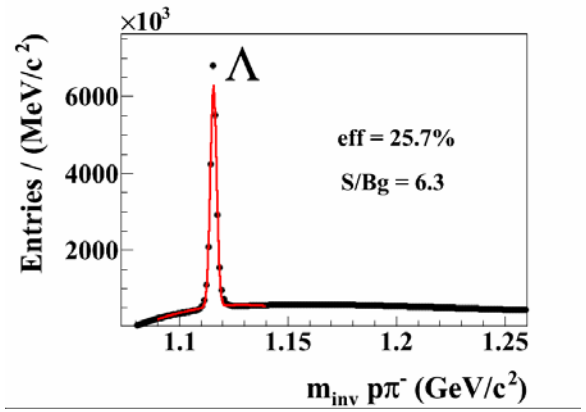


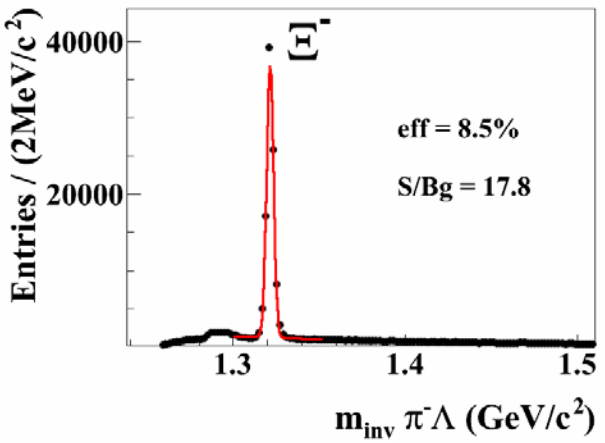
KF Particle Finder with ToF track ID: Au+Au @ 10AGeV SIS100

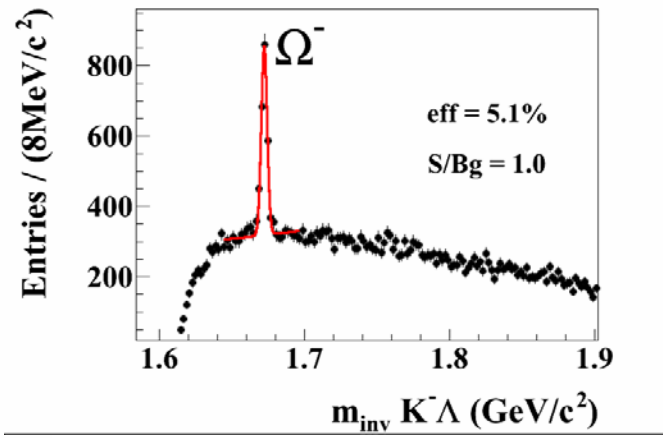


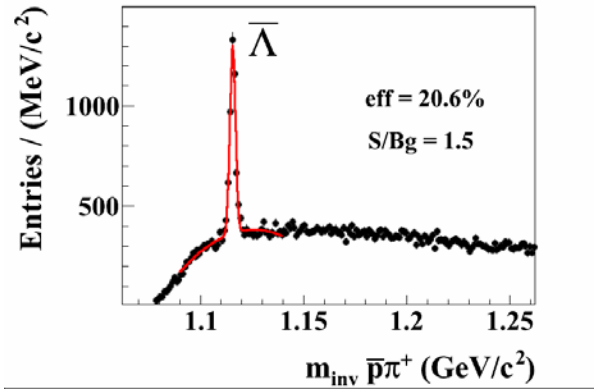
Au+Au 10 AGeV 5M central events

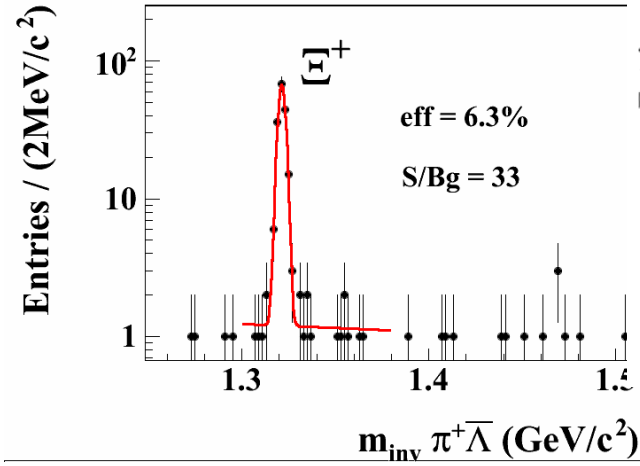


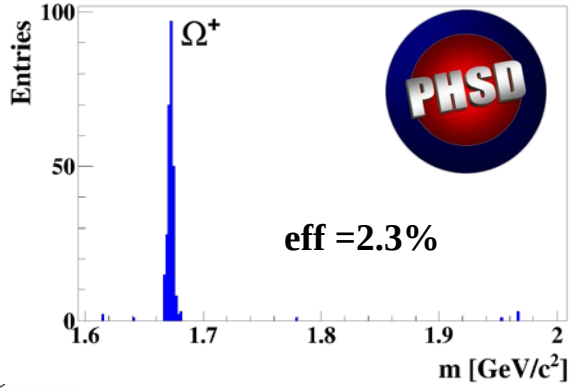




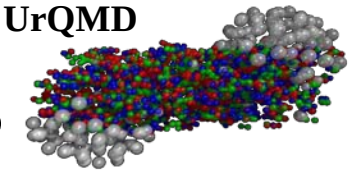




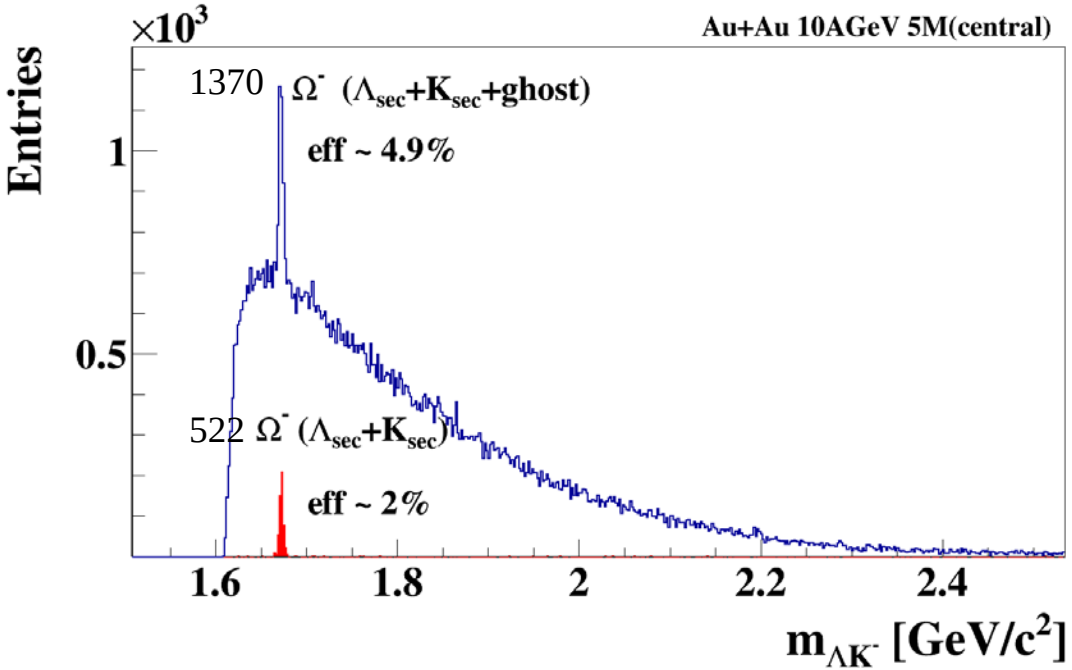


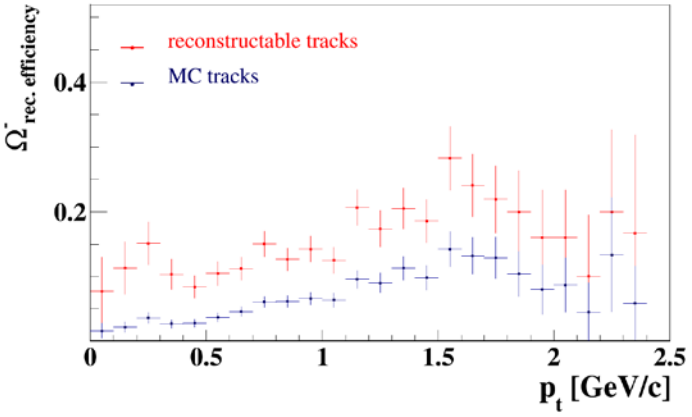


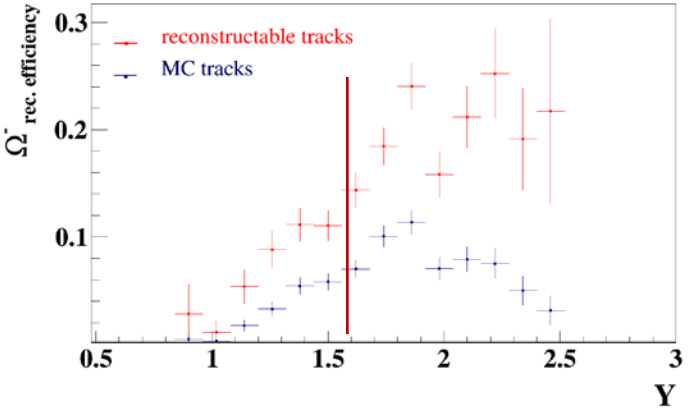
Au+Au 10 AGeV 5M central events

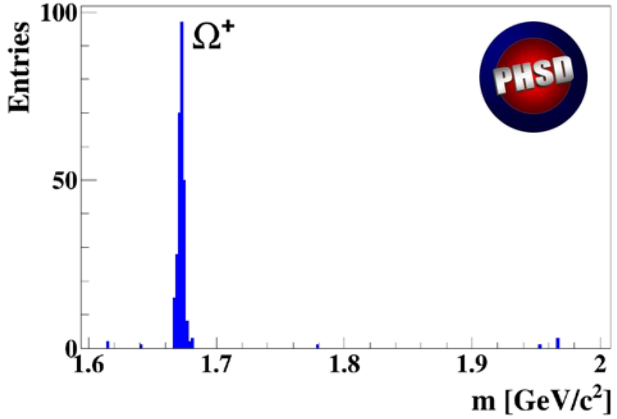


Extended KFParticle Finder







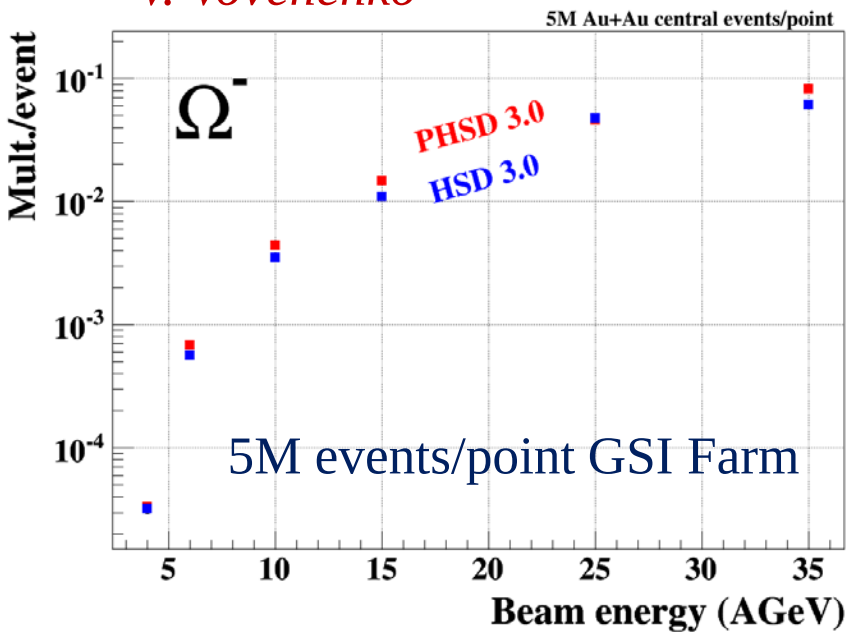


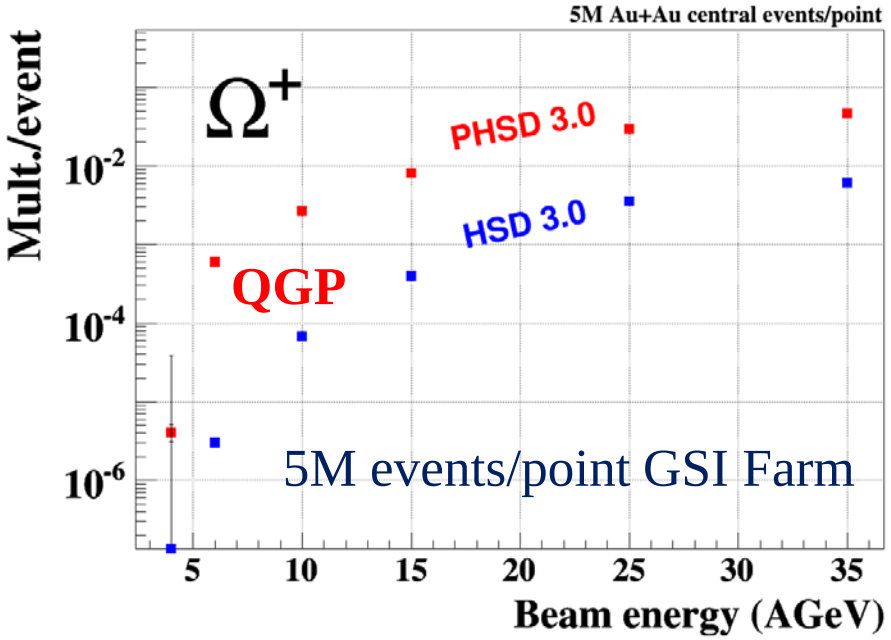
QGP signatures at FAIR energies: Multi-strange antibaryons

E.Bratkovskaya

fias.uni-frankfurt.de/~brat/PHSD/index1.html

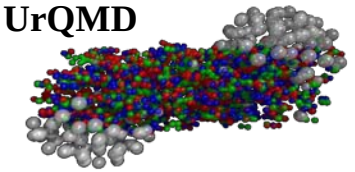
V. Vovchenko

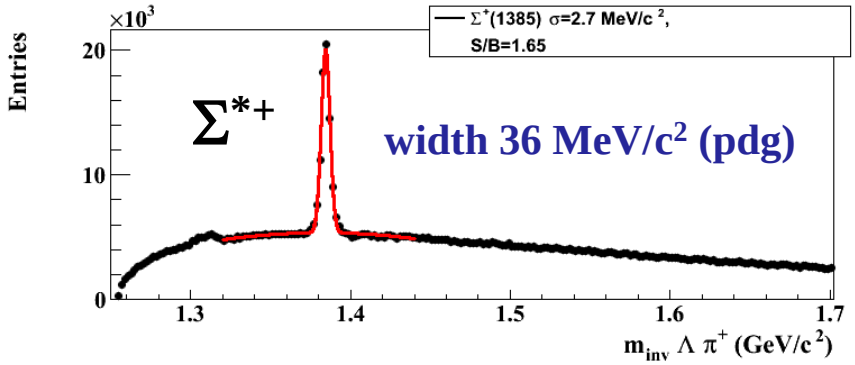


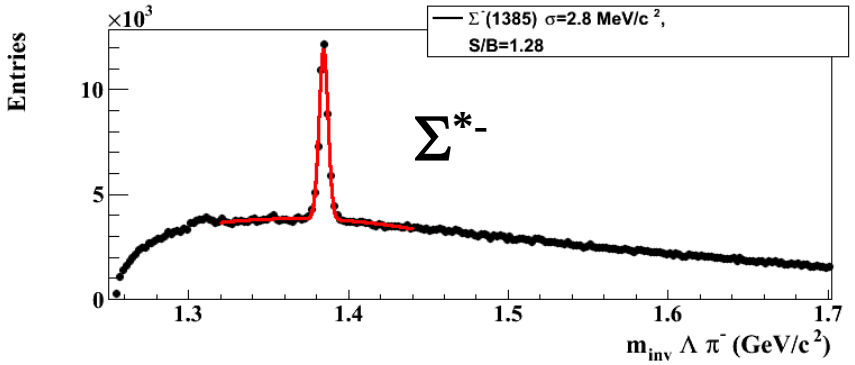


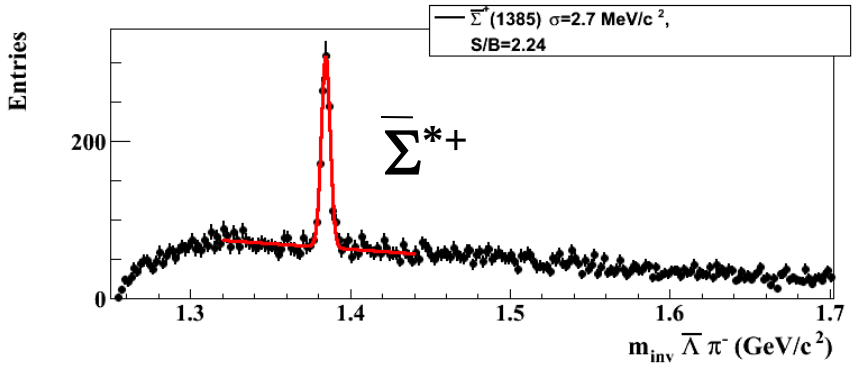
Most of the Ω+ produced by QGP @ FAIR energy!?

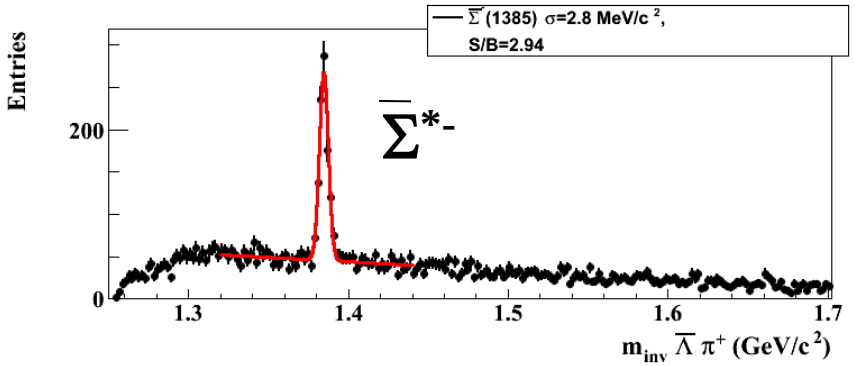
p+C 25 GeV 50M central events

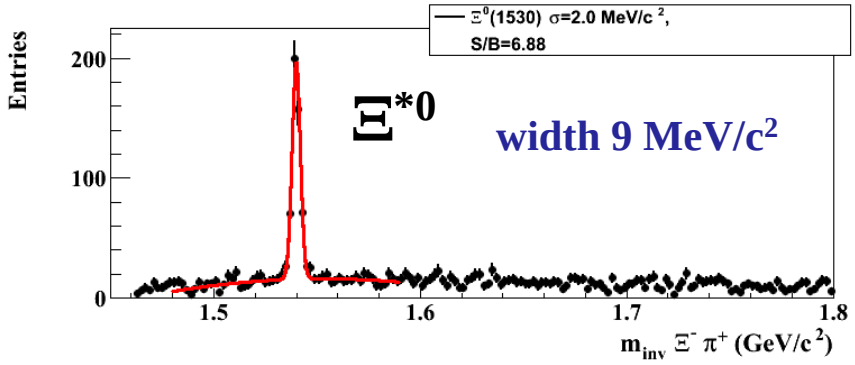


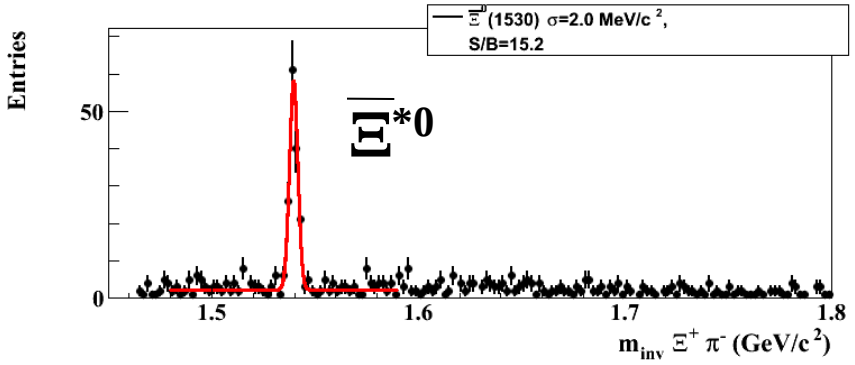




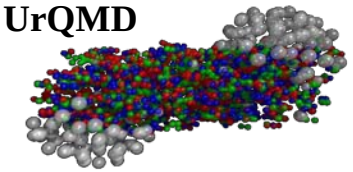


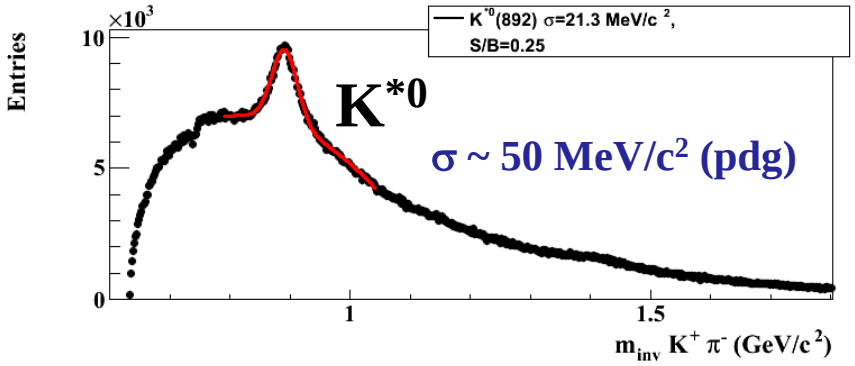


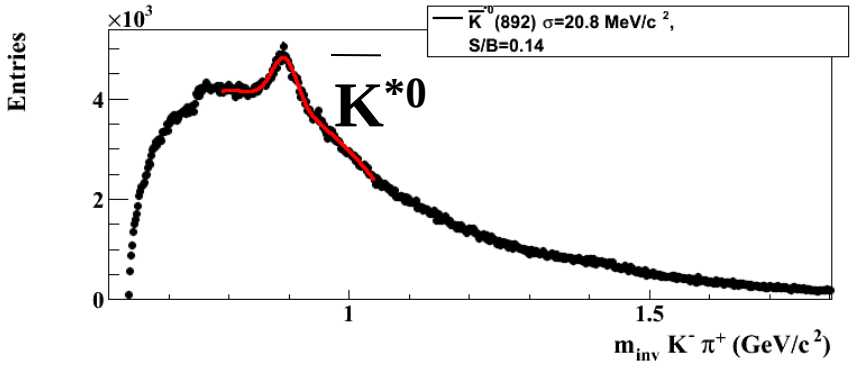


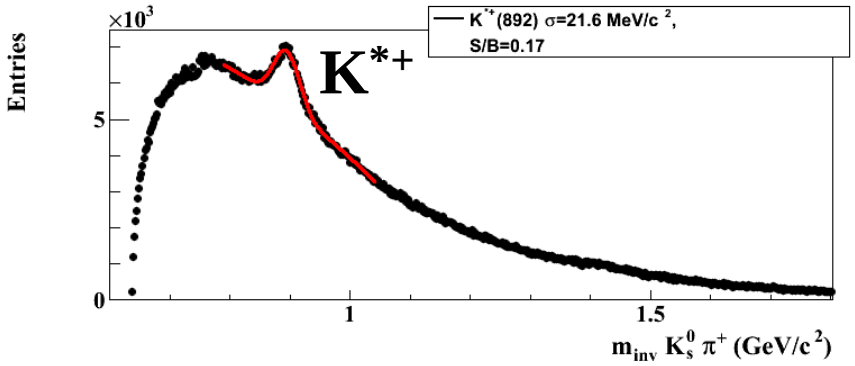


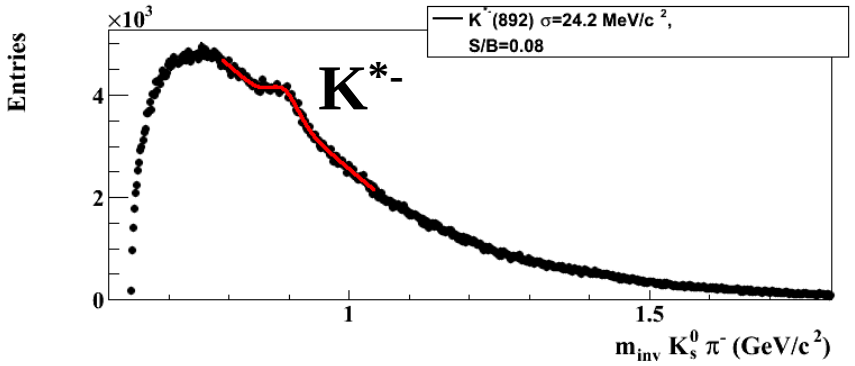
p+C 25 GeV 50M central events

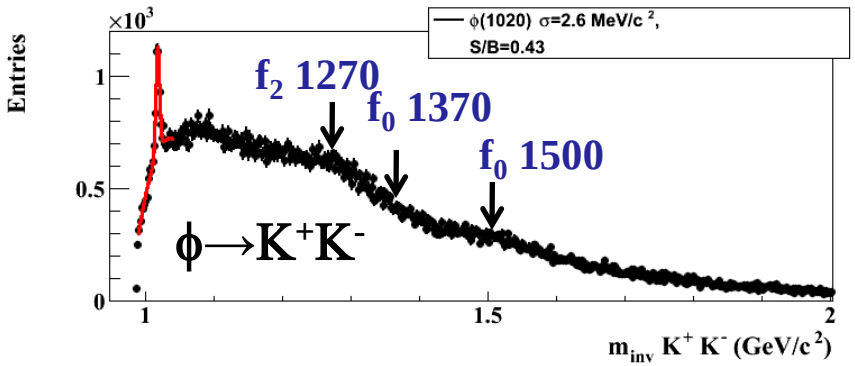


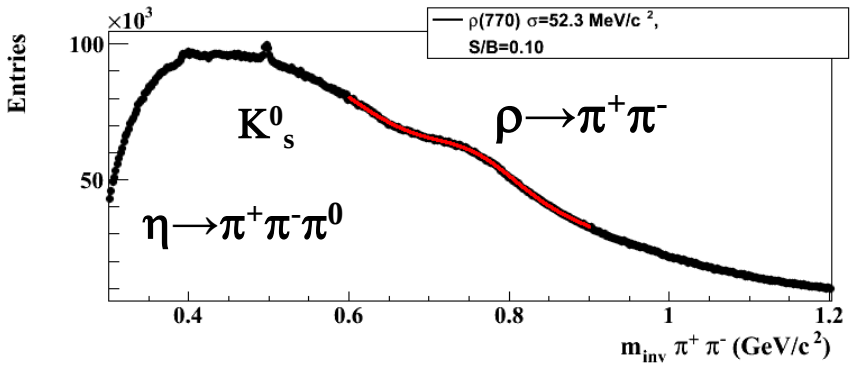




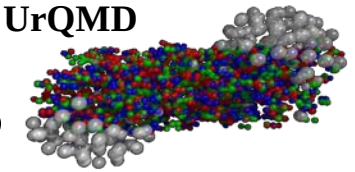




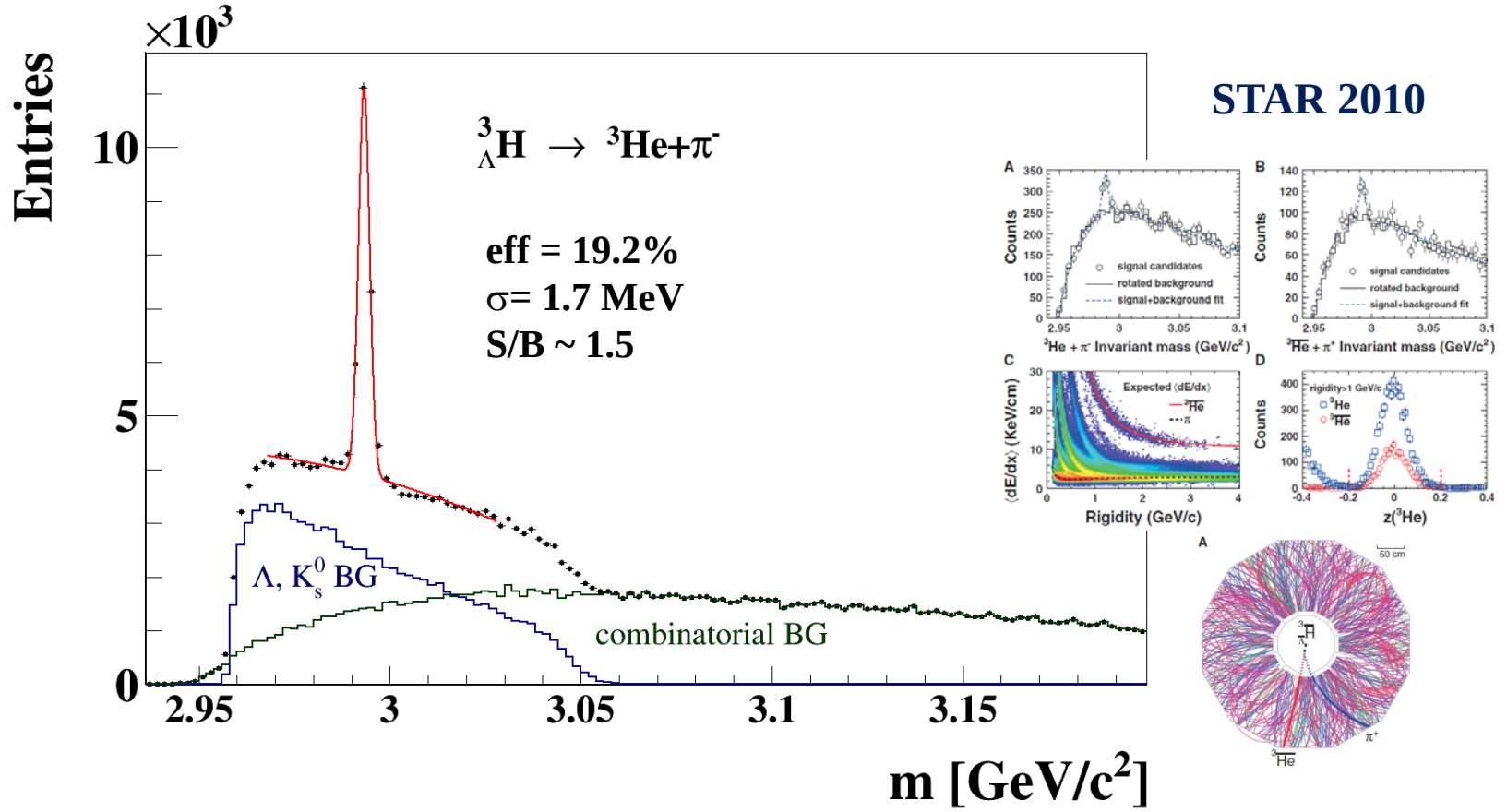




Au+Au 10 AGeV 5M central events

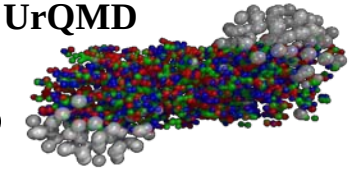


Extended KFParticle Finder $^{3}_{\Lambda}H$

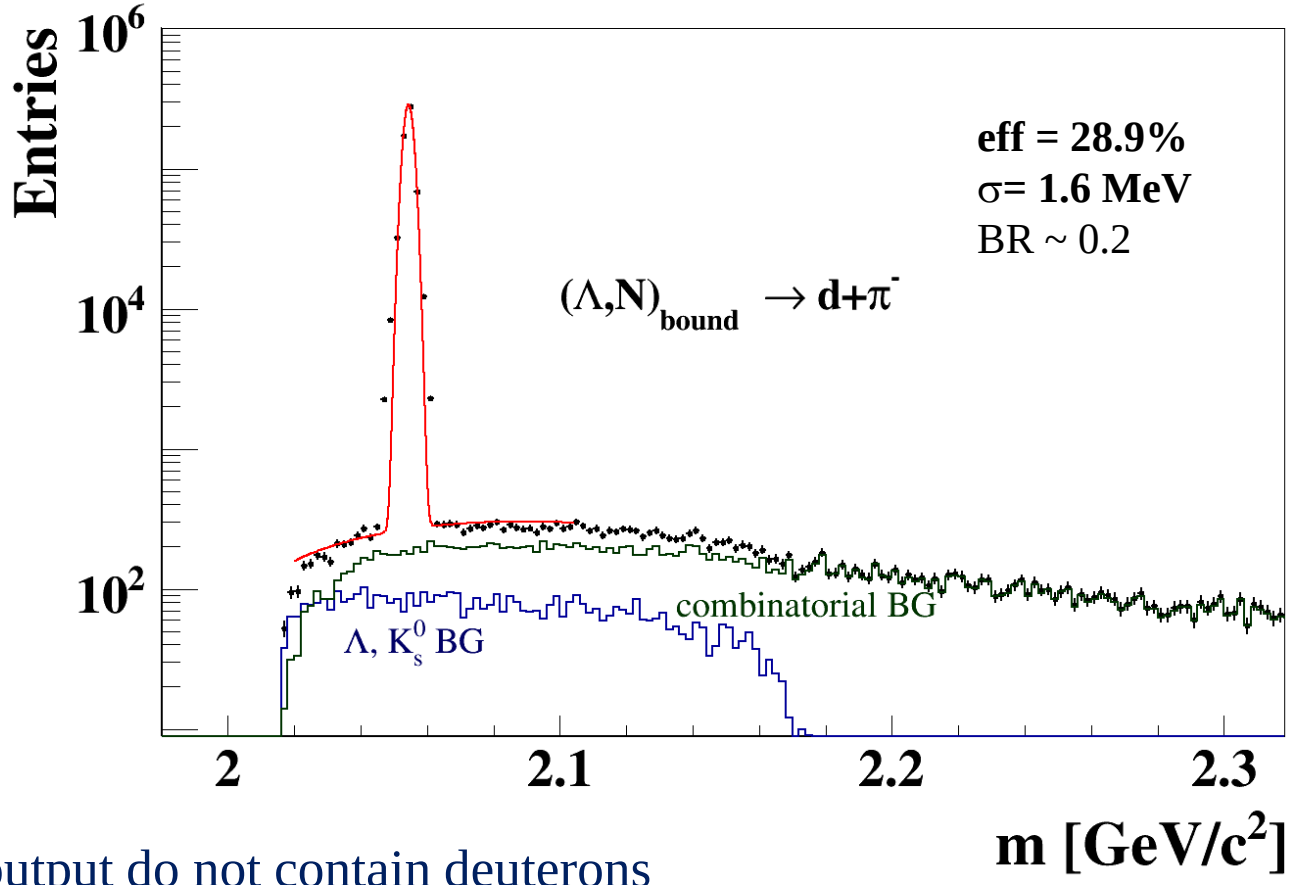


BR from H. Kamada et al., Phys. Rev., Ser. C 57, 1595 (1998)

Au+Au 10 AGeV 5M central events

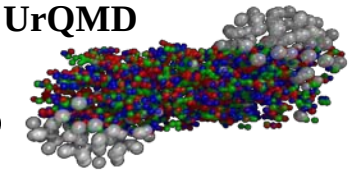


Extended KFParticle Finder $(\Lambda,N)_{bound}$

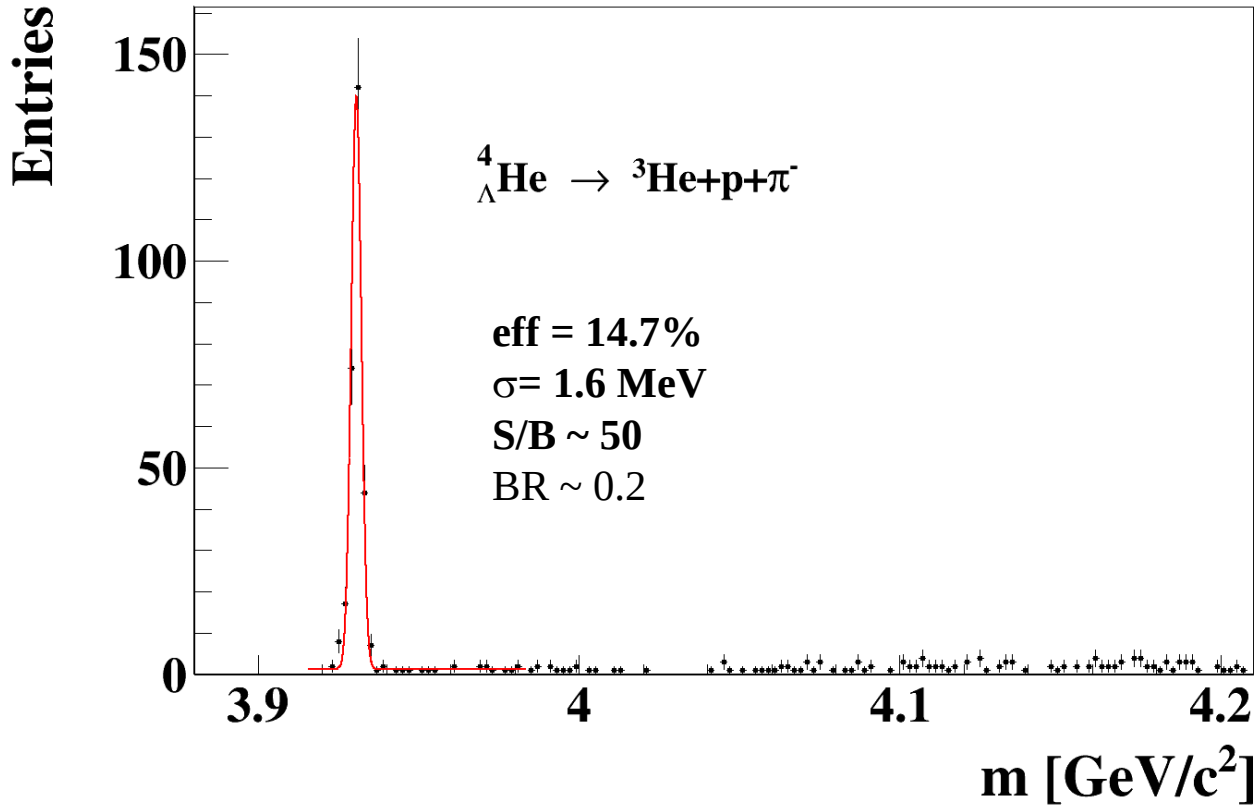


UrQMD output do not contain deuterons
~ 5.6 d/event expected (no secondary d's)!

Au+Au 10 AGeV 5M central events

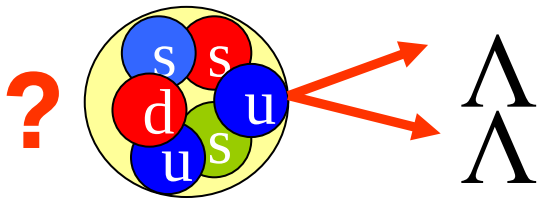


Extended KFParticle Finder $^{4}_{\Lambda}$He

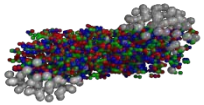


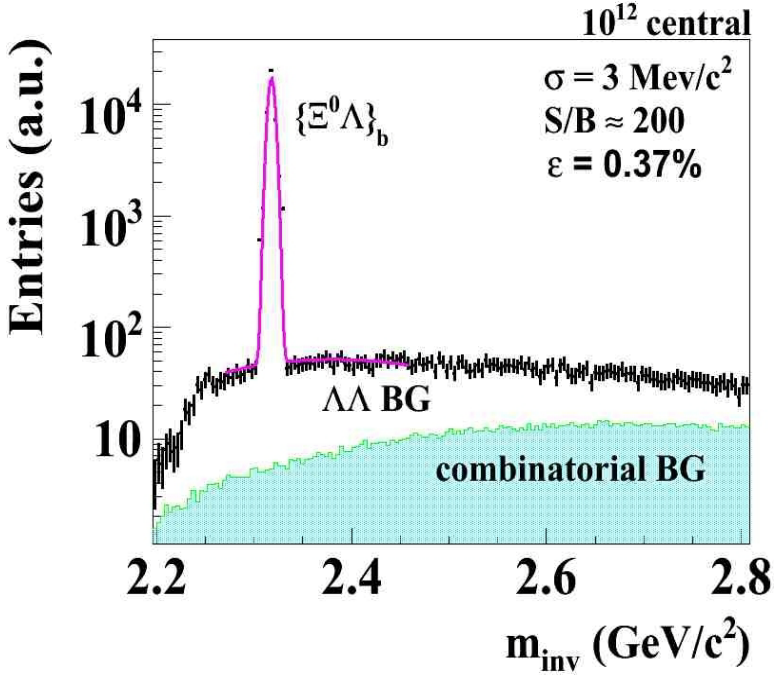
3 prong detached vertex is good signature of $^{4}_{\Lambda}$He decay

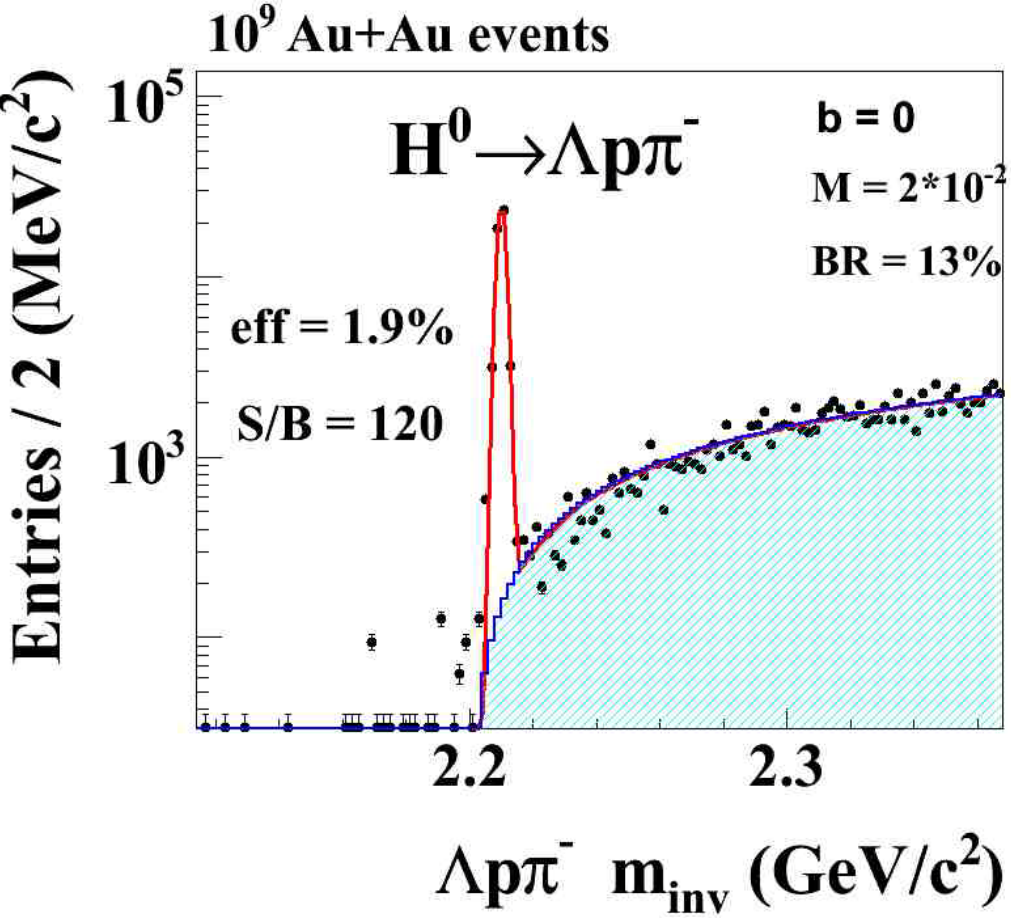
Strange and Hyper matter in the Lab



Does strange matter exist in the form of heavy multi-strange objects?



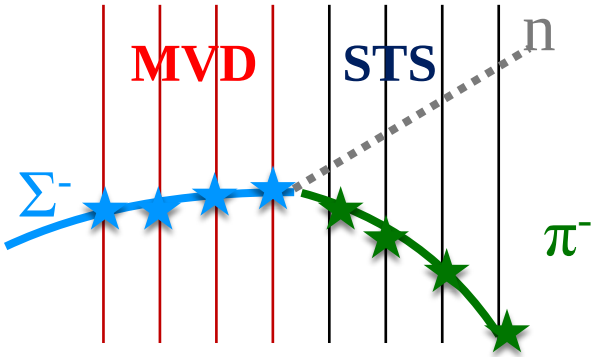


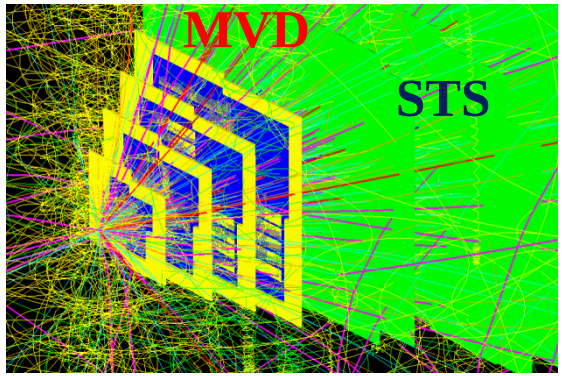


New horizons: $\Sigma^{\pm}$ reconstruction

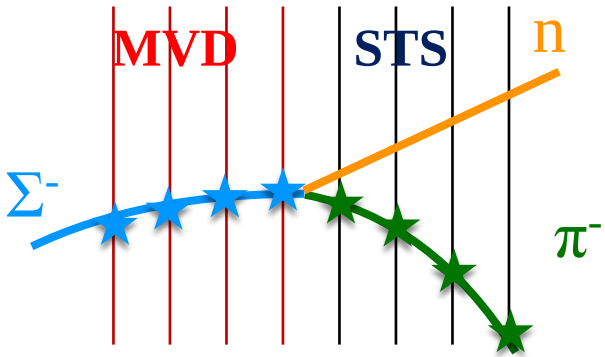
- Σ^+ and Σ^- have only channels with at least one neutral daughter.
- A lifetime is sufficient to be registered by the tracking system: $c\tau$ = 2.4 cm for Σ^+ and $c\tau$ = 4.4 cm for Σ^-.
- Can not to be identified by the PID detectors.
- Identification is possible by the decay topology:

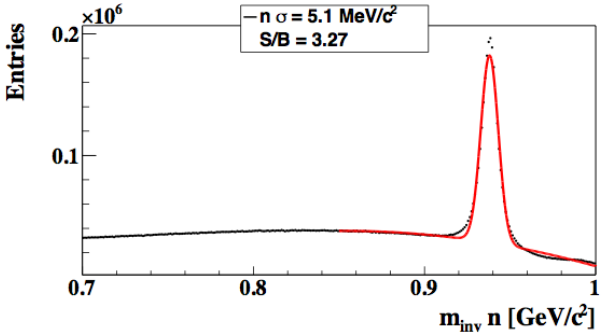
1. Find tracks of Σ and its daughter in STS and MVD



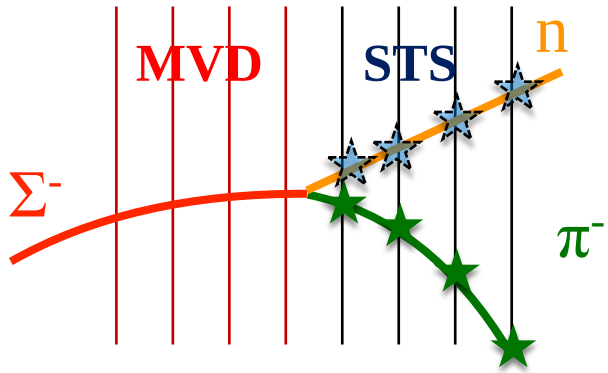


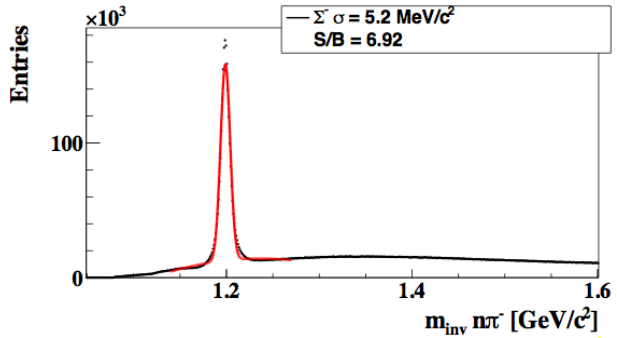
2. Reconstruct a neutral daughter from the mother and the charged daughter





3. Reconstruct Σ mass spectrum from the charged and obtained neutral daughters



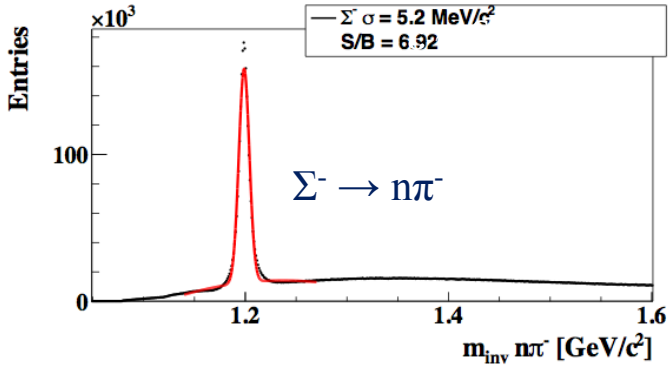


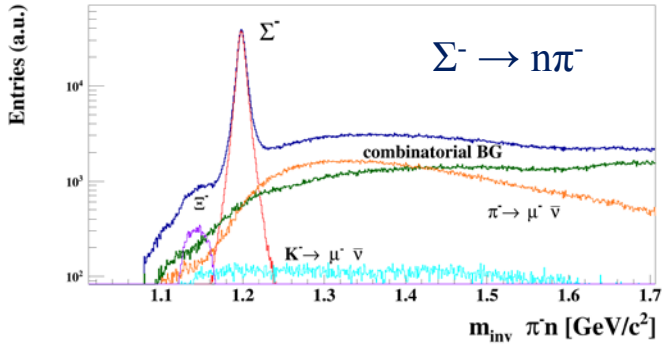
Σ^+ and Σ^- reconstruction with STS and MVD

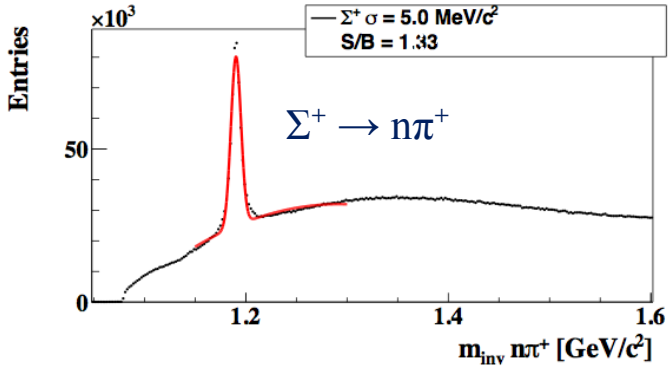
Other decays, that can be reconstructed by the proposed method:

$\Xi^- \rightarrow \Lambda\pi^-$
$\bar{\Xi}^+ \rightarrow \bar{\Lambda}\bar{\pi}^+$
$\Omega^- \rightarrow \Lambda K^-$
$\bar{\Omega}^+ \rightarrow \bar{\Lambda}\bar{K}^+$
$\Omega^- \rightarrow \Xi^0\pi^-$

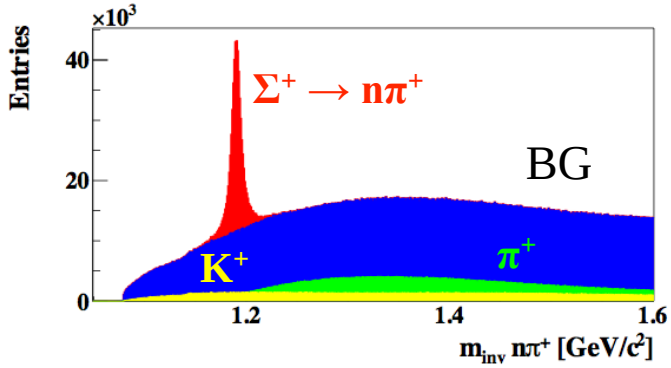
$\bar{\Omega}^+ \rightarrow \bar{\Xi}^0\pi^+$

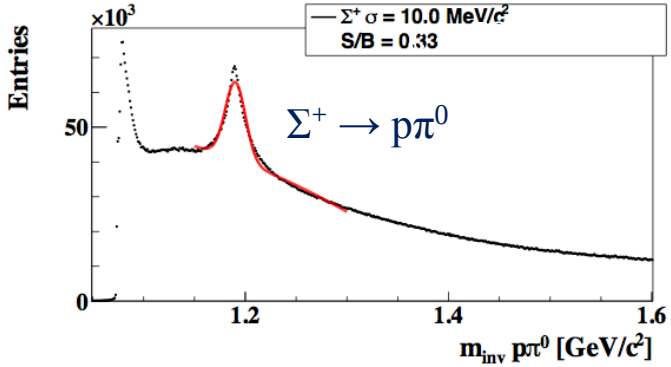


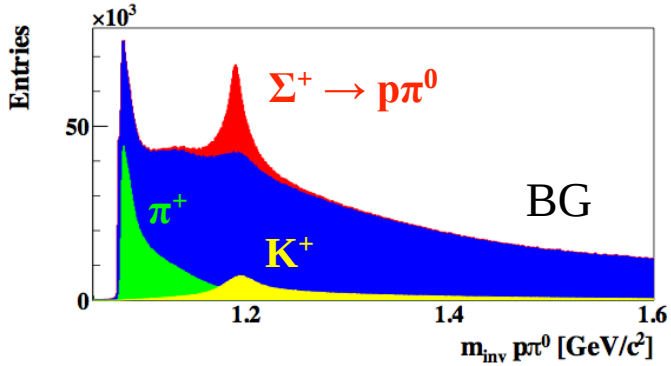




STS + MVD





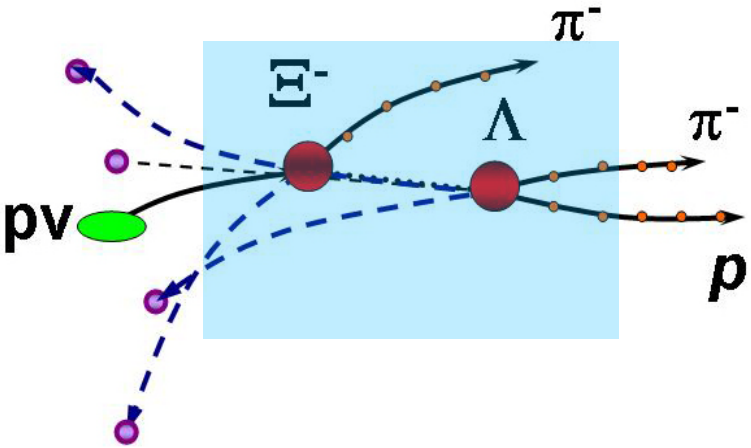


Summary:

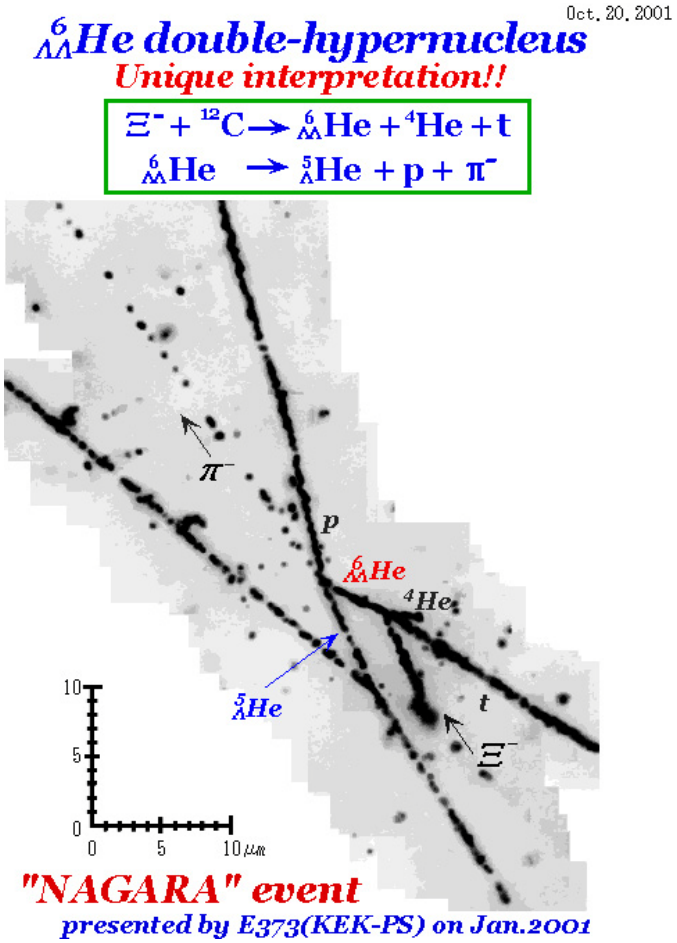
• CBM detector is an excellent device for measuring strange and multi-strange hyperons with huge discovery potential of hypernuclei and hypothetic heavy multi-strange objects like the di-baryons.

• The discovery and investigation of new hypernuclei and of hypermatter will shed light on the hyperon-nucleon and hyperon-hyperon interactions which are essential ingredients for the nuclear equation-of-state at high densities and low temperatures.

Motivation:



KFParticle Finder + ToF PID

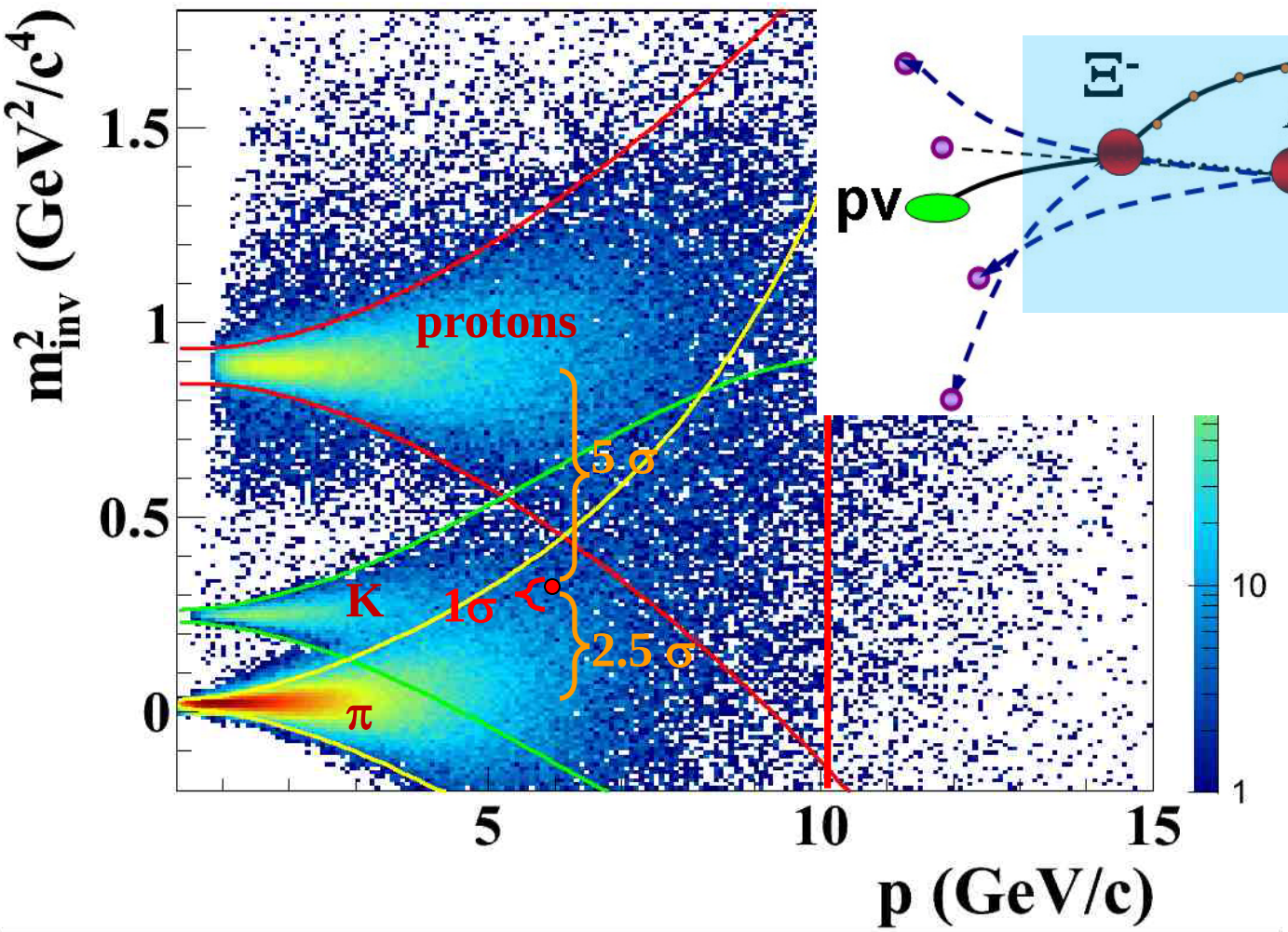


- Complicated topology is good for CBM !

KF Particle Finder with ToF track ID

$m^2 = m^2_{pdg} \pm N\sigma$ (N = 1… 3)

$D_{sel\ ID} < \forall D_{i\ ID}$

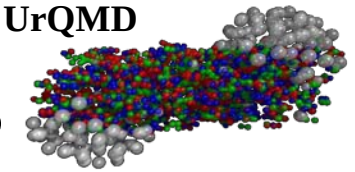


central: 82 (TF) + 16 (PF) ms/core

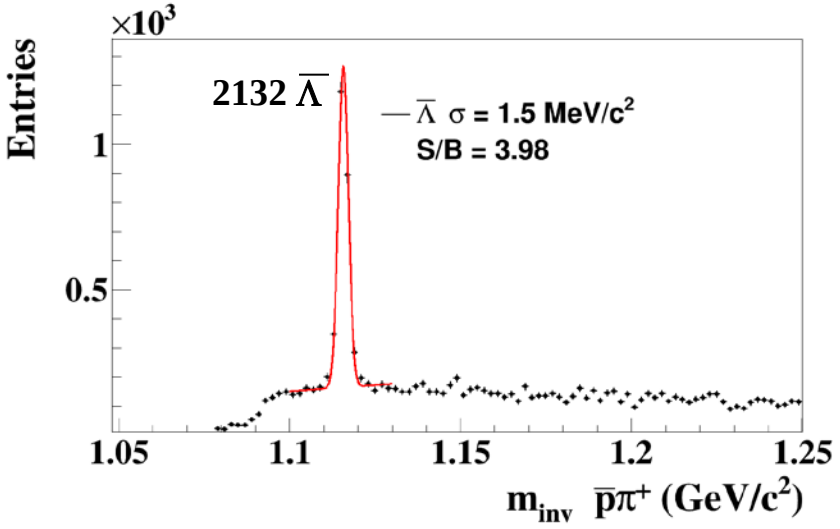
mbias : 10 (TF) + 2 (PF) ms/core

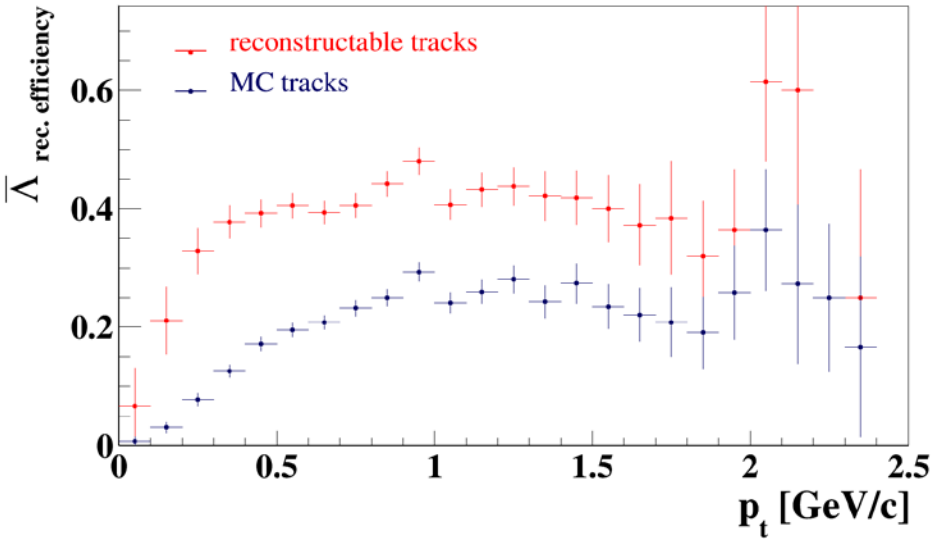
up to 80 cores/CPU

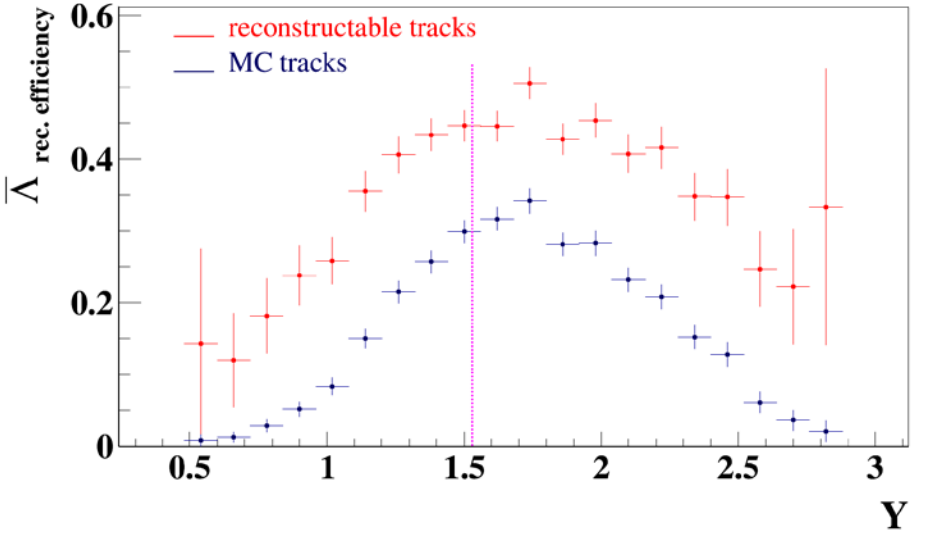
Au+Au 10 AGeV 5M central events



Extended KFParticle Finder:

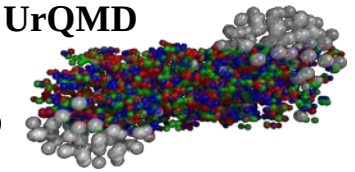






MC tracks:
one hit of particle or daughters

Au+Au 10 AGeV 5M central events



Extended KFParticle Finder