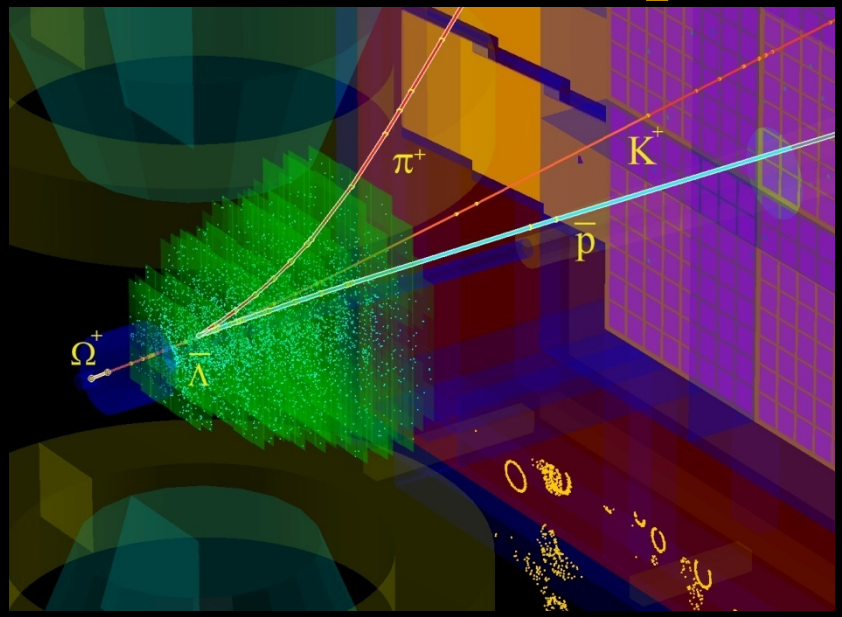
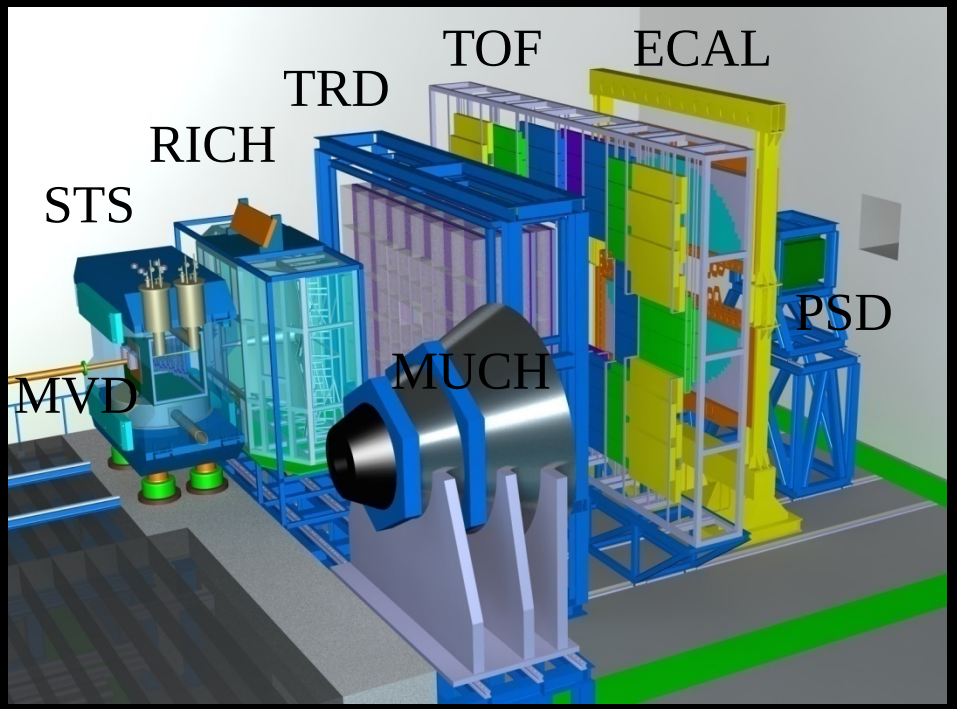
Perspectives on strangeness physics with the CBM experiment at FAIR

I.Vassiliev, I.Kisel and M. Zyzak
for the CBM Collaboration

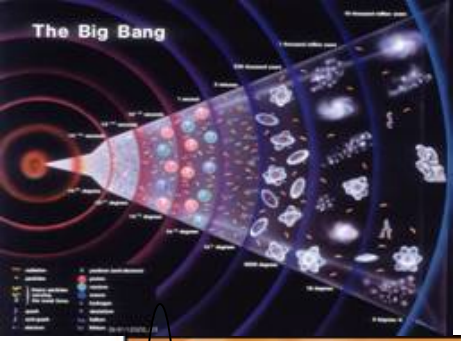


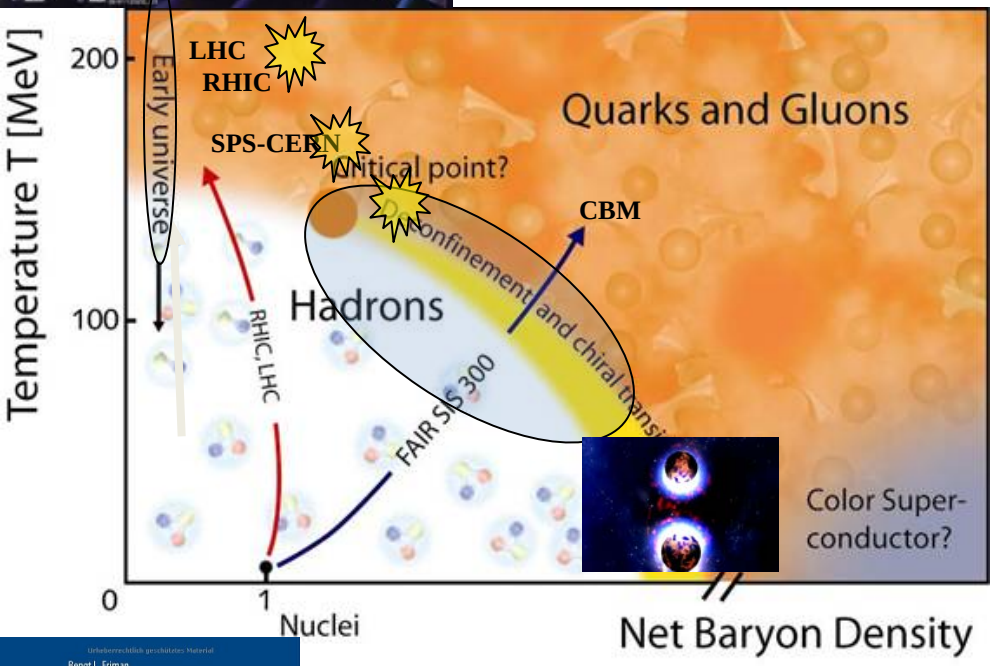


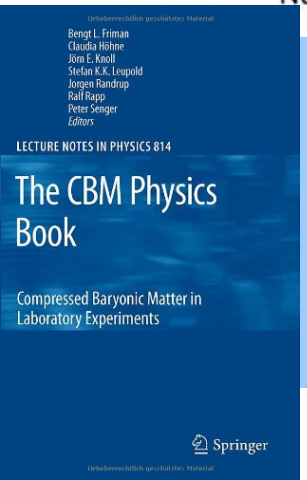
- Physics case
- Developed methods & tasks
- High rate scenario
- Conclusions

February 2018 Bochum

Physics case: Exploring the QCD phase diagram







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

The equation-of-state at high ρ_B
- collective flow of hadrons
- particle production at threshold energies:

open charm, multi-strange hyperons, HN

Deconfinement phase transition at high ρ_B
- excitation function and flow of

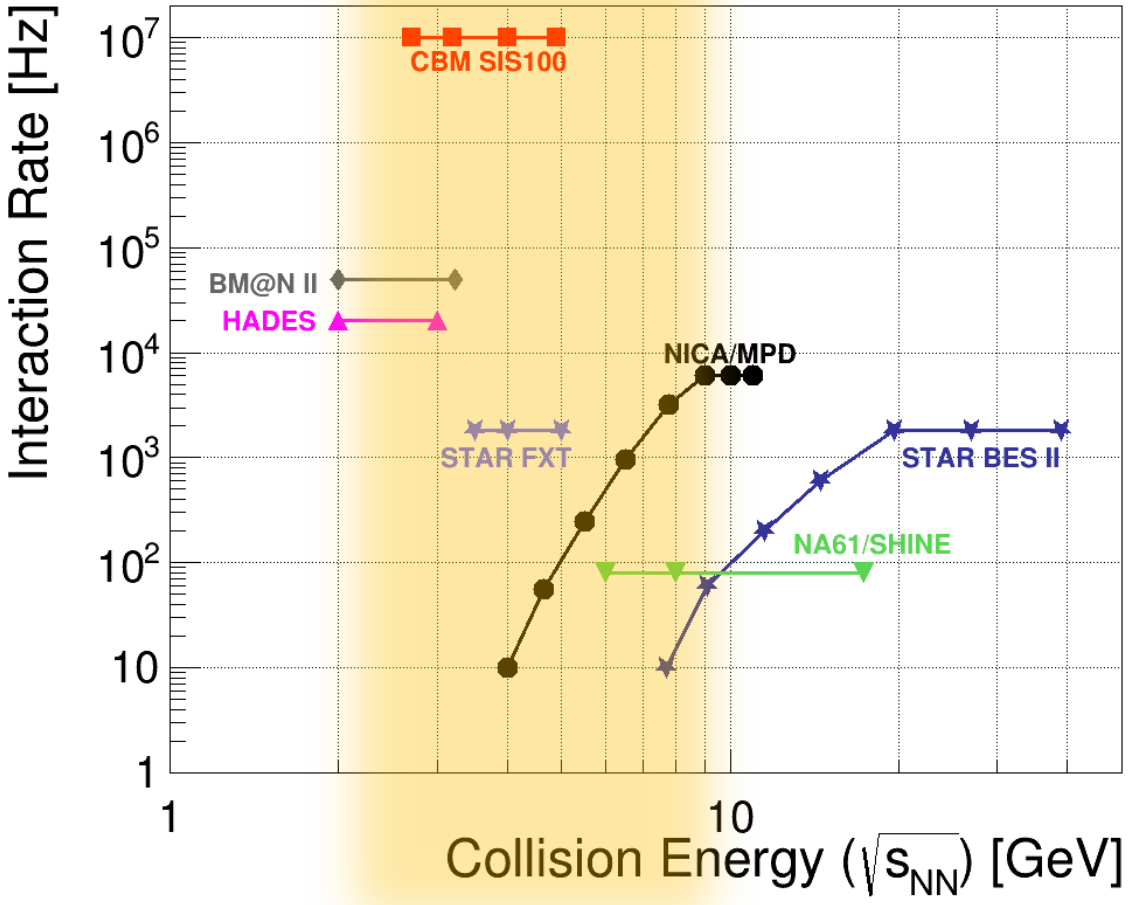
strangeness (K, Λ, Σ, Ξ, Ω)

QCD critical endpoint
- excitation function of event-by-event fluctuations (**K/π**, ... **Ξ/ π, Ω/ π**)

Onset of chiral symmetry restoration at high ρ_B
- in-medium modifications of hadrons (ρ,ω,ϕ)
- excitation function of **multi-strange (anti)hyperons (PHSD 4.0)**

Experiments exploring dense QCD matter

high
net-baryon
densities

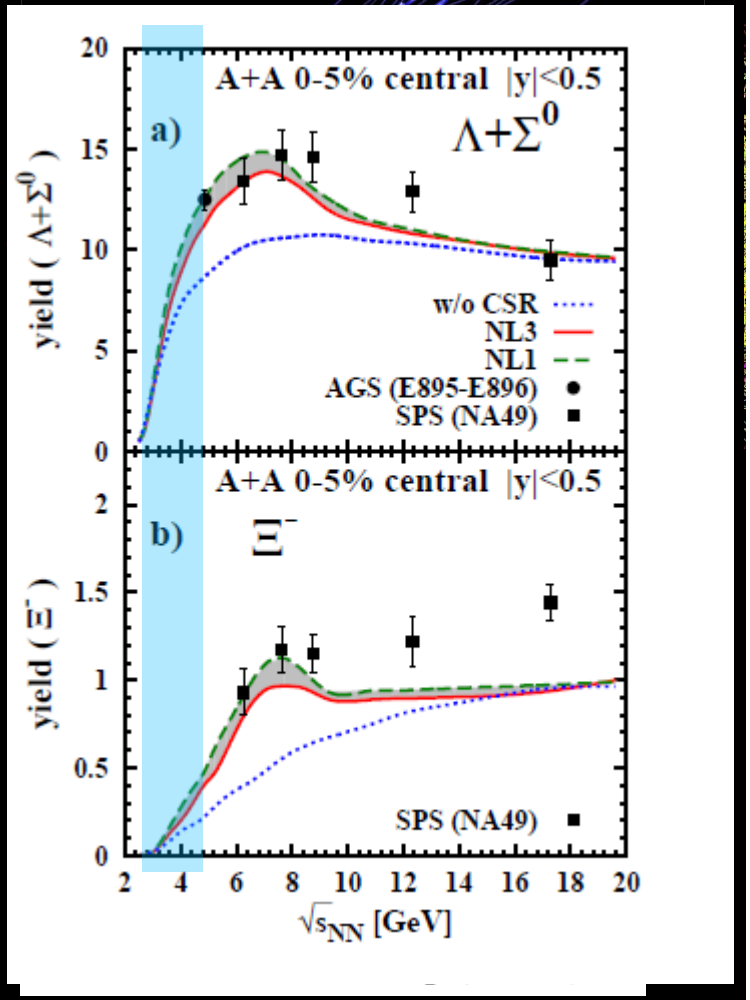


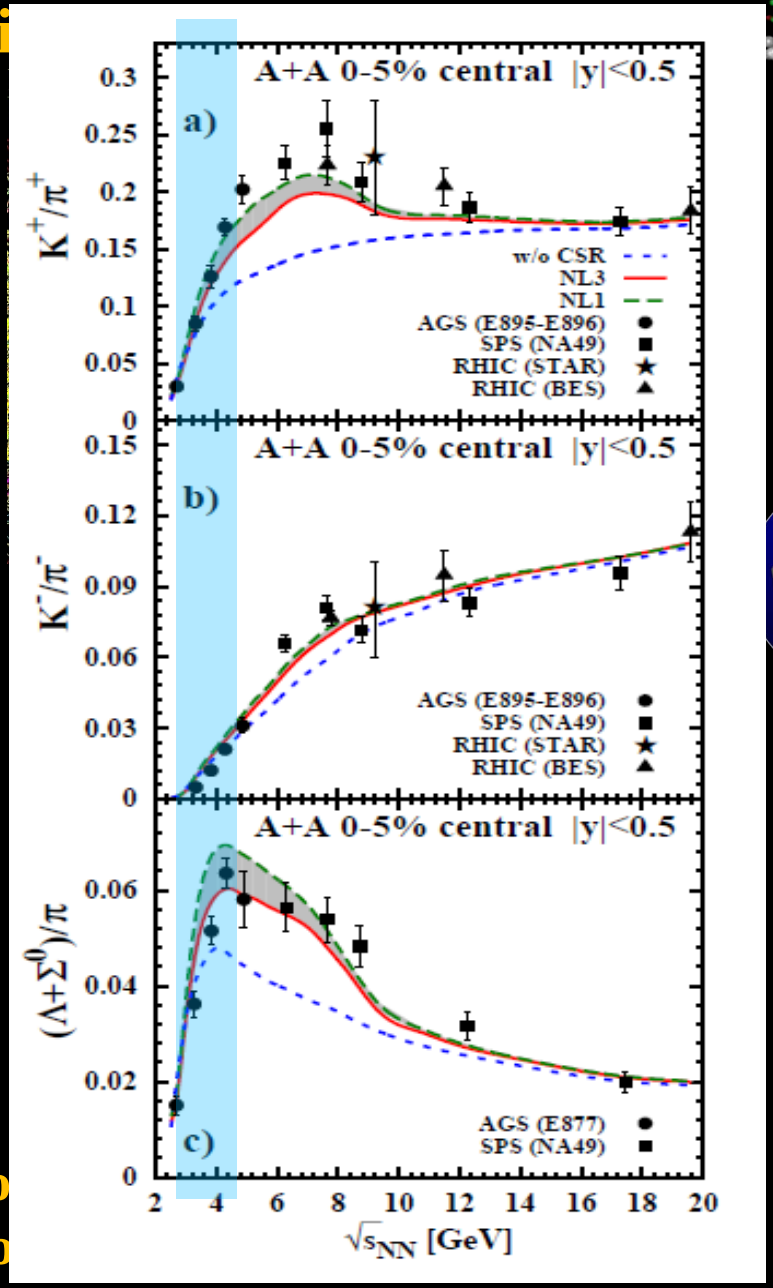
CBM:
world record
rate capability

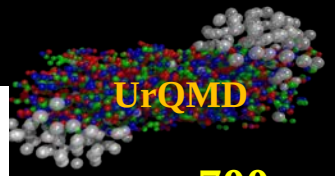
- determination of (displaced) vertices with high resolution (≈ 50 μm)
- identification of leptons and hadrons
- fast and radiation hard detectors
- self-triggered readout electronics
- high speed data acquisition and online event selection
- powerful computing farm and 4D tracking
- software triggers

SIS-300: central Au + Au (UrQMD or PHSD) events

Simulation and reconstructi







~700 π
160 p
53 K
32 Λ
27 K_S^0
0.44 Ξ-
0.018 Ω-

PHSD

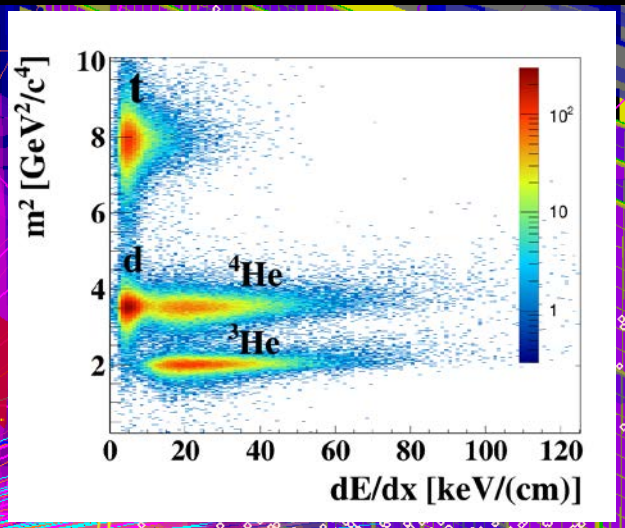
~700 π
174 p
42 K
30 Λ
24 K_S^0
2.4 Ξ-
0.005 Ω-

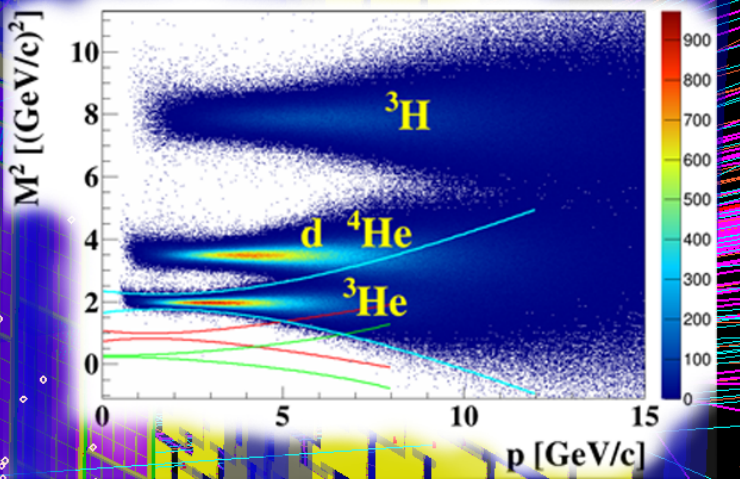
central: 82 (TF) + 16 (PF) ms/co
mbias : 10 (TF) + 2 (PF) ms/co
up to 80 cores/CPU

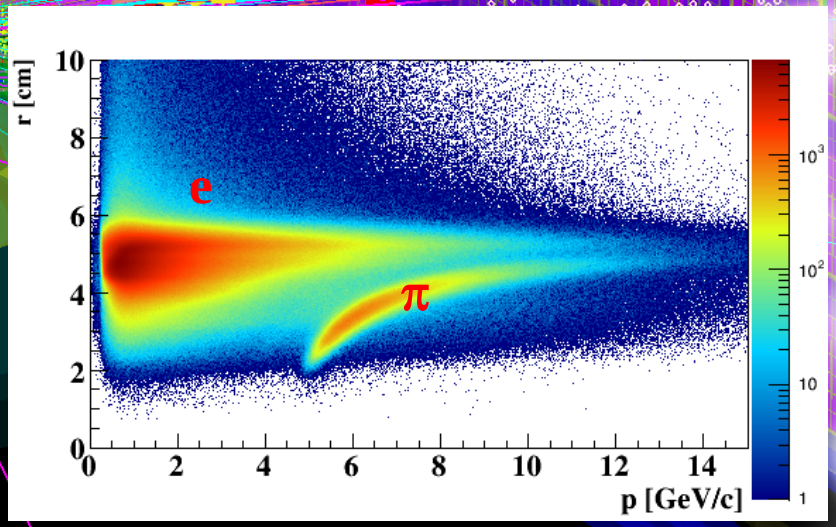
dp/p = 1.2%

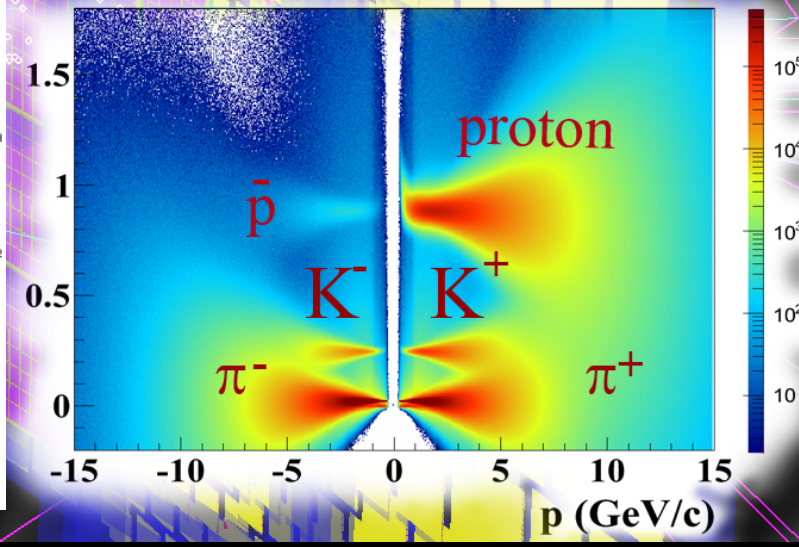
Particle identification with PID detectors

Ni+Ni 15 AGeV
123 π
53 p
6 K^+
1.6 K^-
4 Λ
7.5 K_S^0
0.4 Ξ$^-$



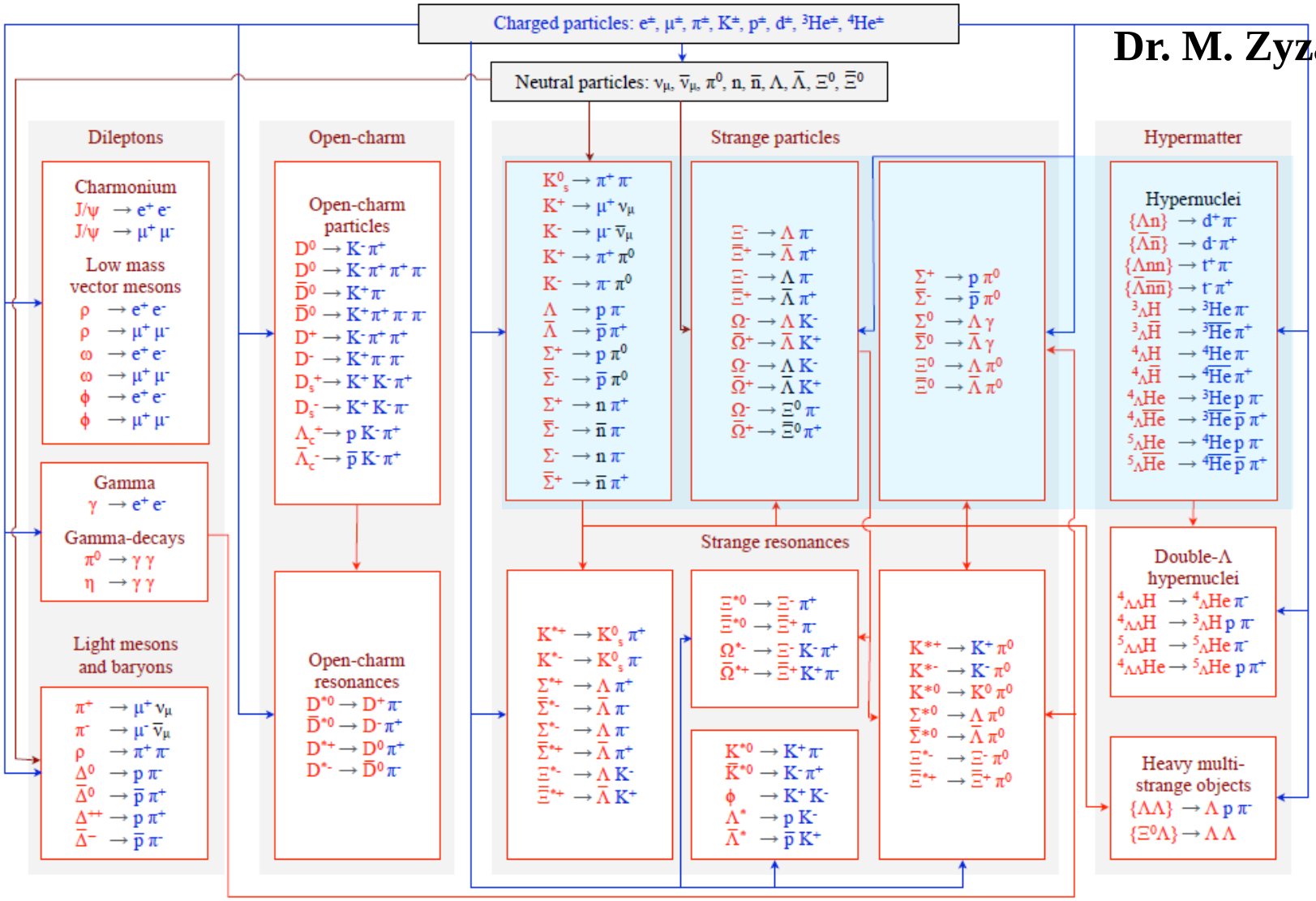






Central event: 40 (TF) + 7 (PF) ms/core with MVD!
(~ 2 faster w/o MVD)

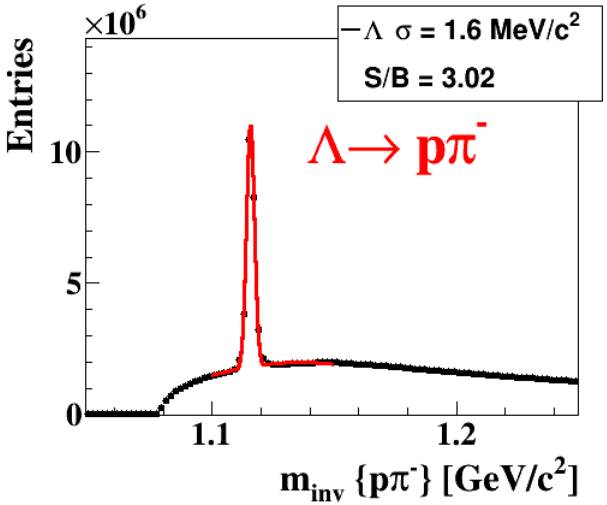
KF Particle Finder for the CBM Experiment

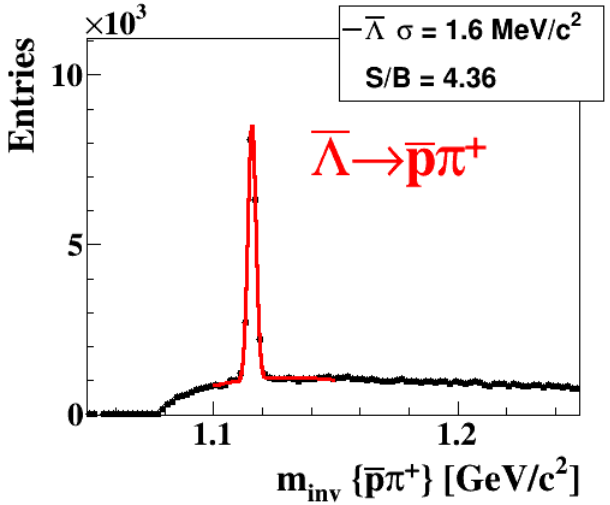


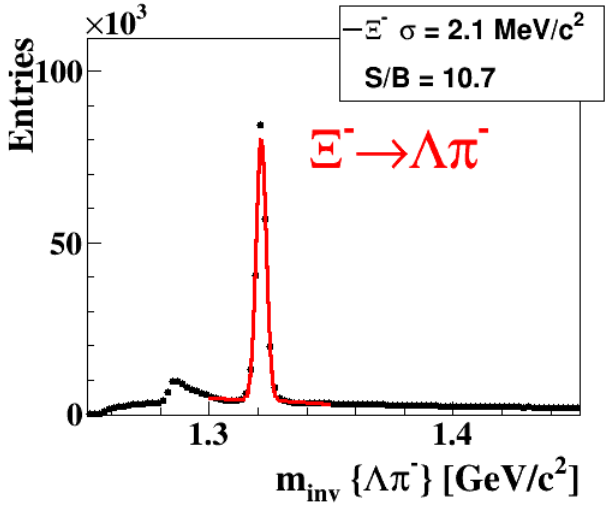
Dr. M. Zyzak

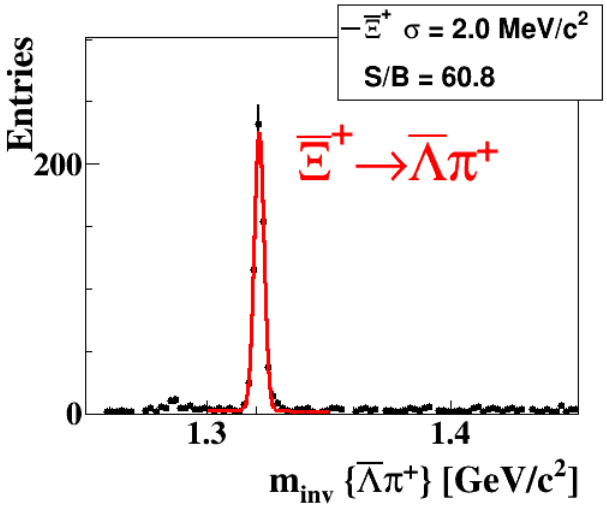
+ STAR, ALICE, PANDA, HADES, NA61

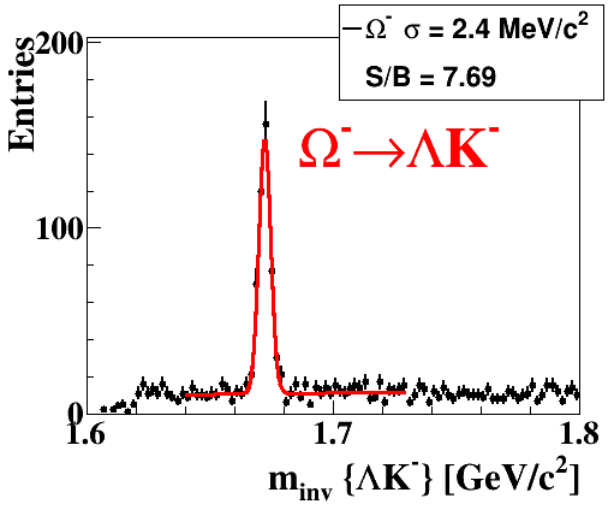
5M central AuAu collisions, 10AGeV

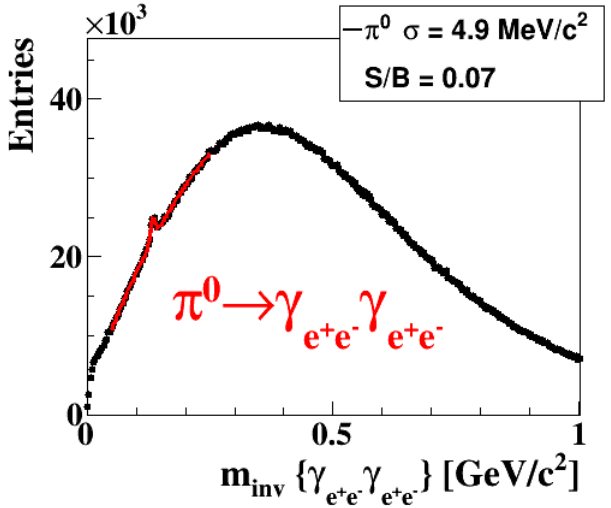




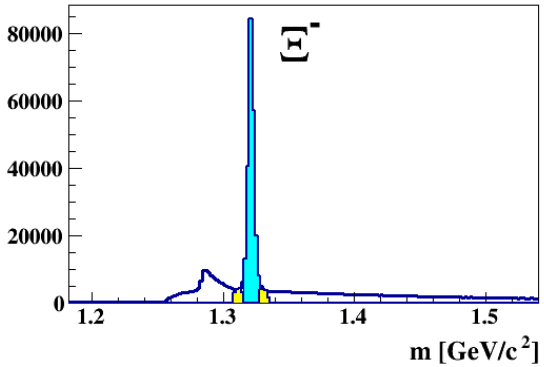


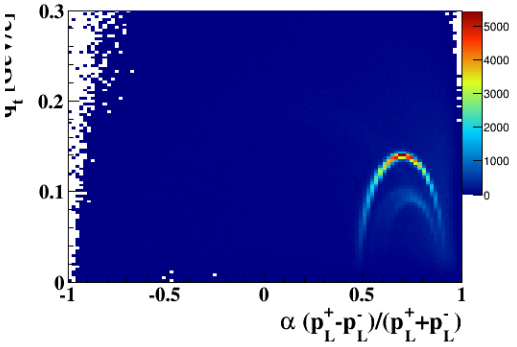


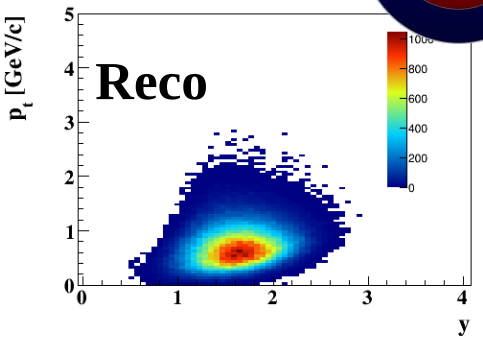


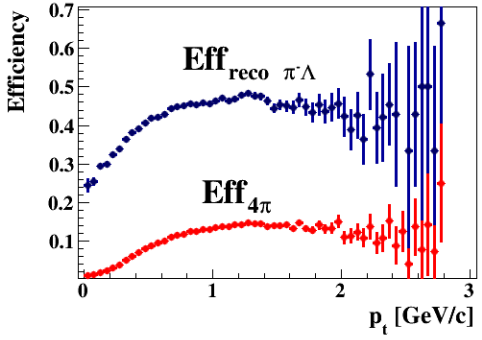


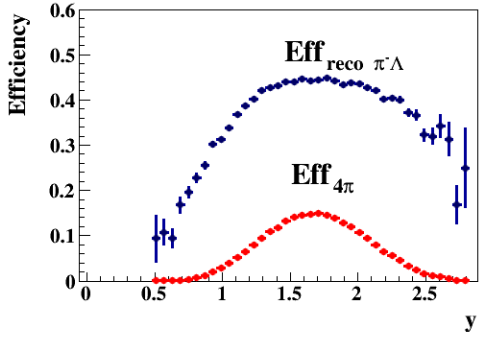
5M central Au Au collisions, 10AGeV (Ξ^-)

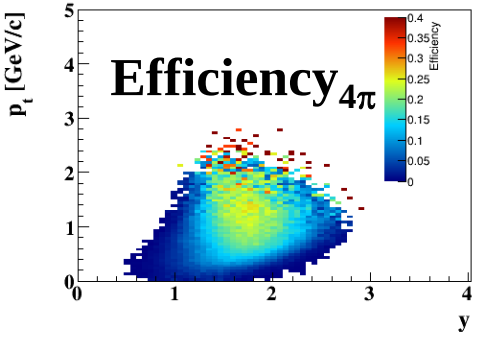


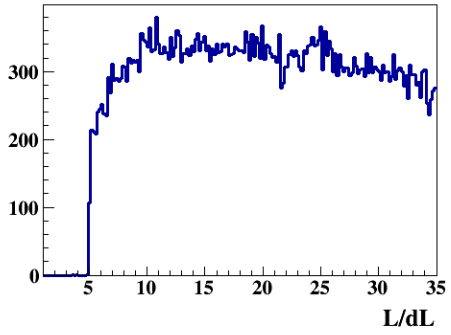


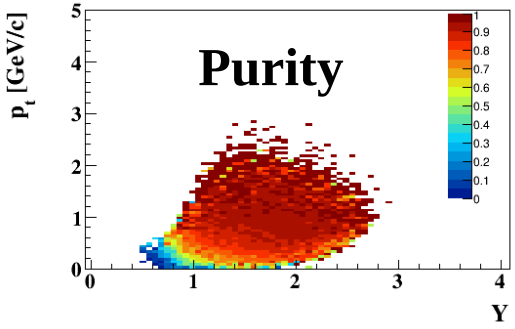


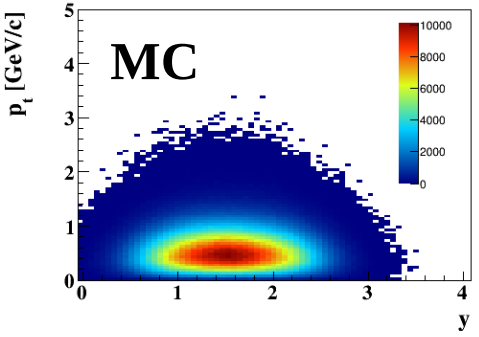




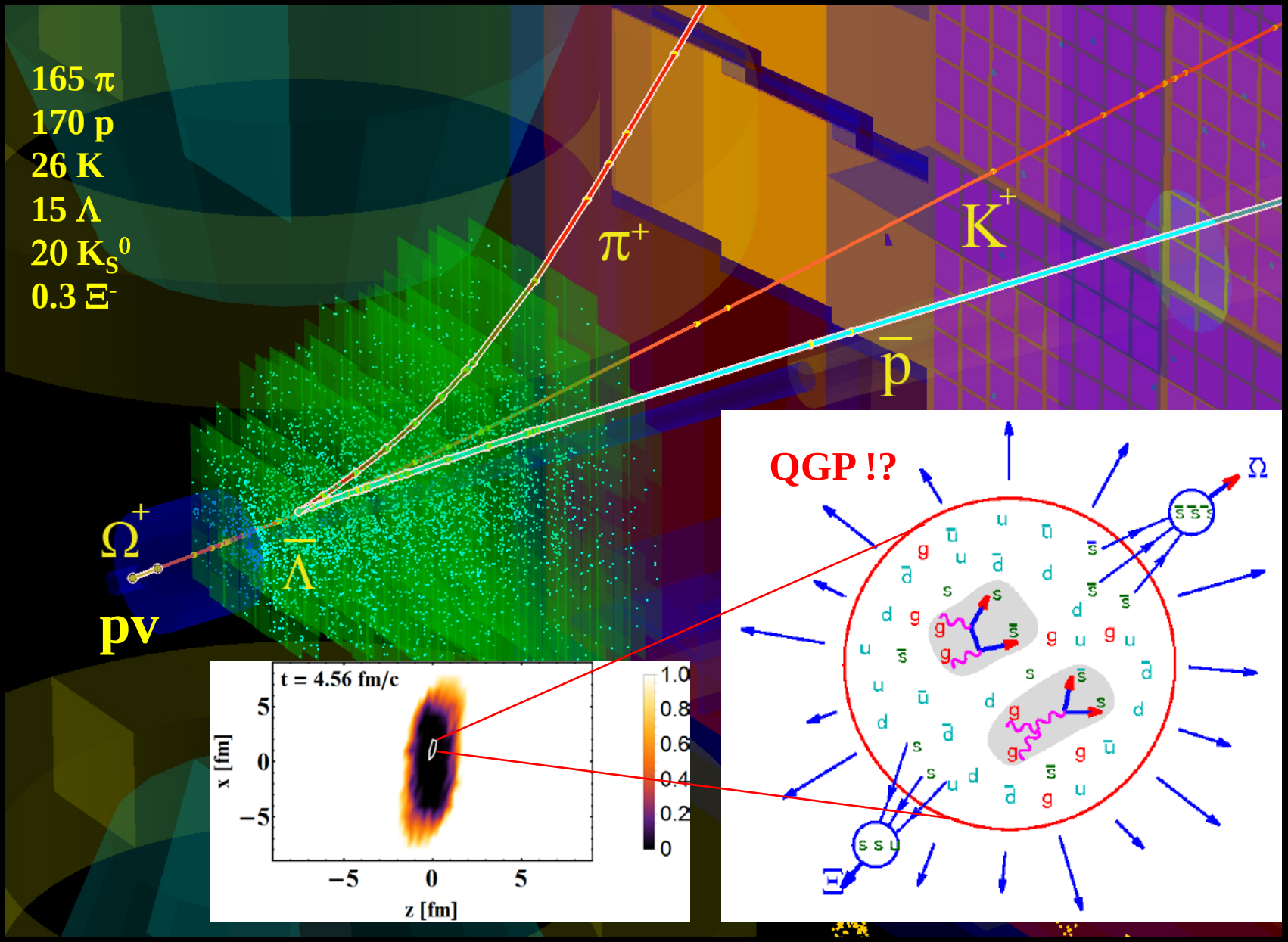




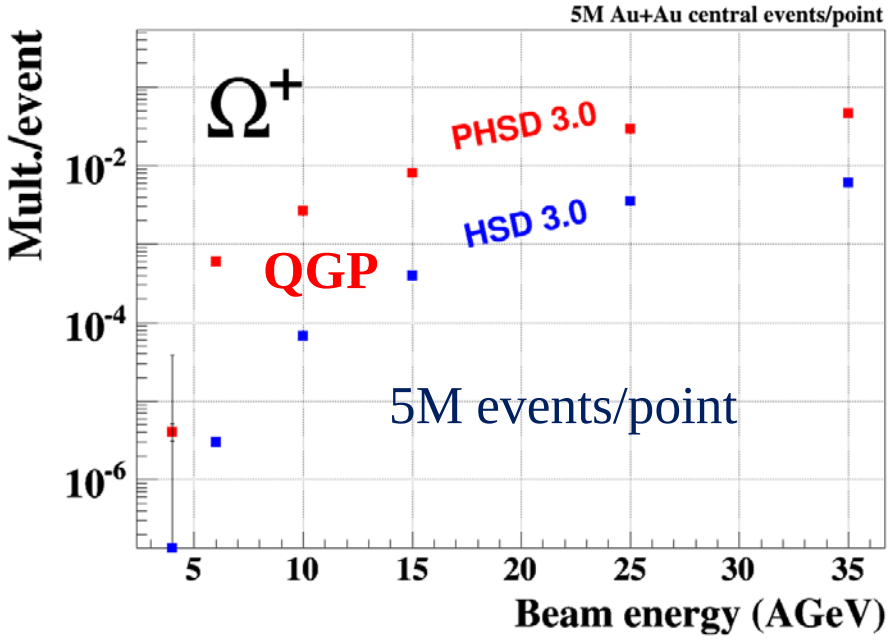




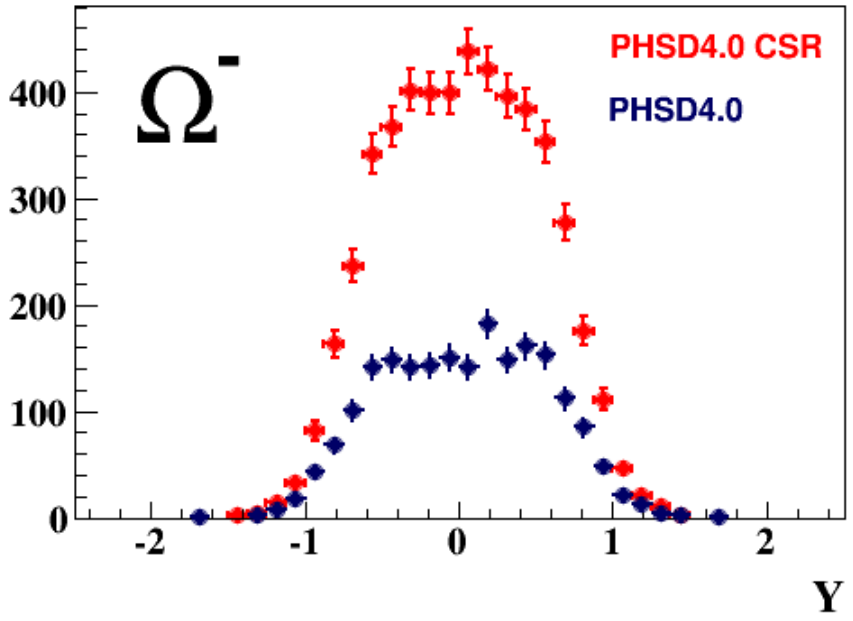
KF Particle Finder with ToF track ID: Au+Au @ 10AGeV



QGP and CSR signatures at FAIR energies: Multi-strange baryons and antibaryons

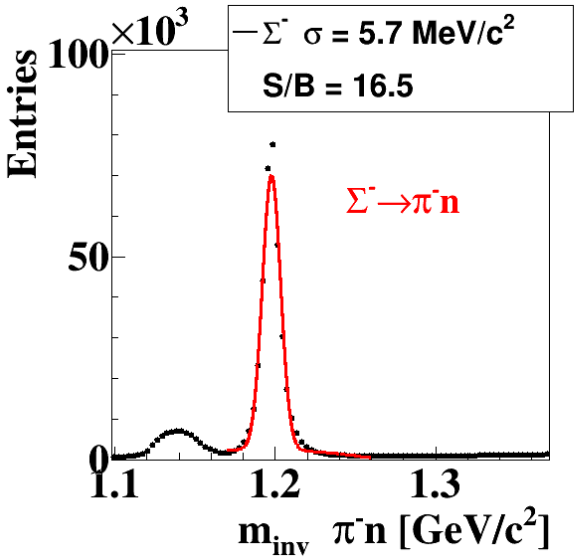


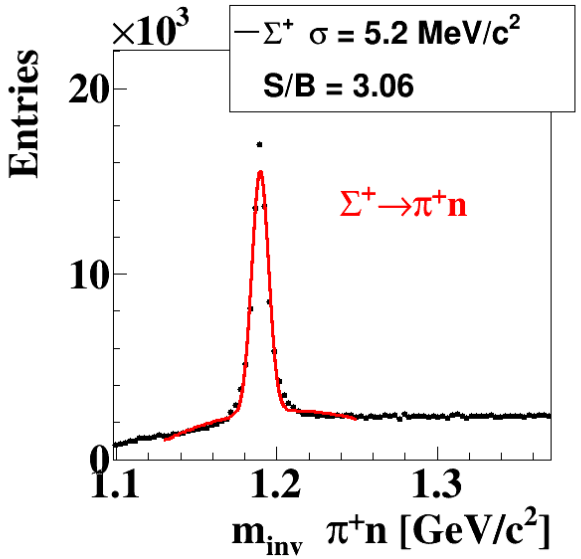
PHSD 4.0 Au + Au @ 10 AGeV

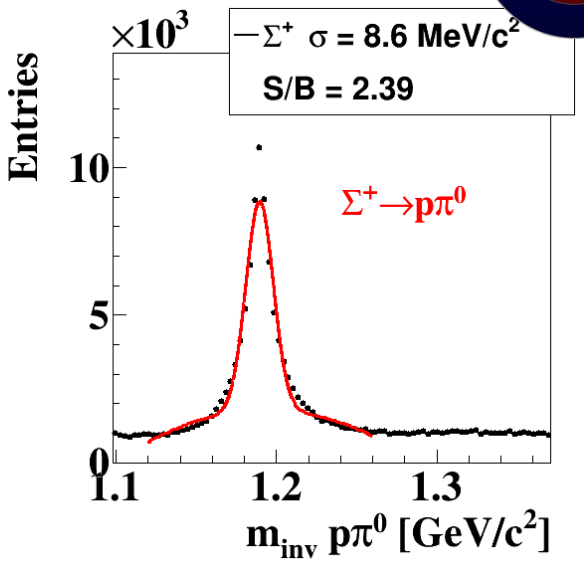


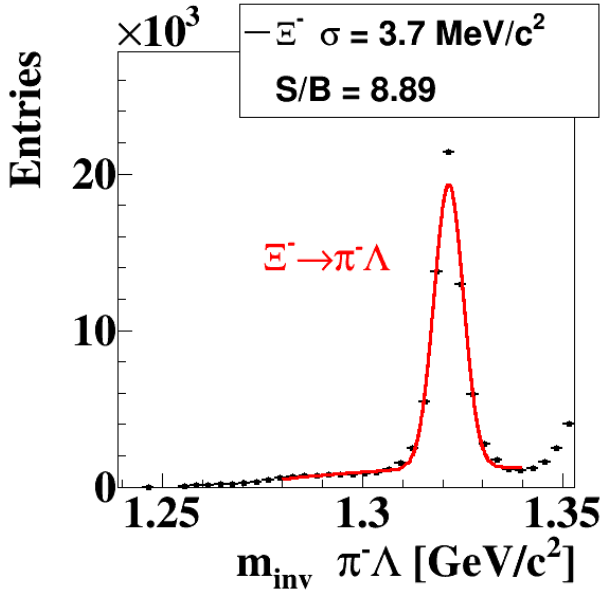
- Most of the Ω+ produced by QGP @ FAIR energy
- CSR increase yield of MS Baryons & Antibaryons

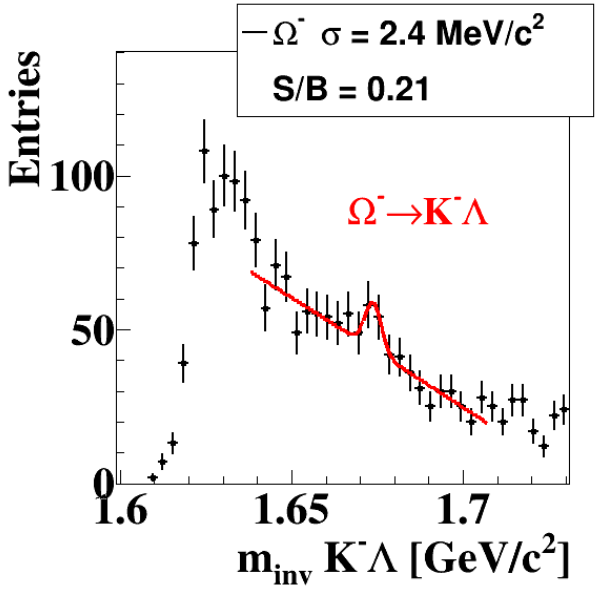
PHSD 4.0 (CSR) 5M central Au +Au collisions , M^3 (P. Kisel)

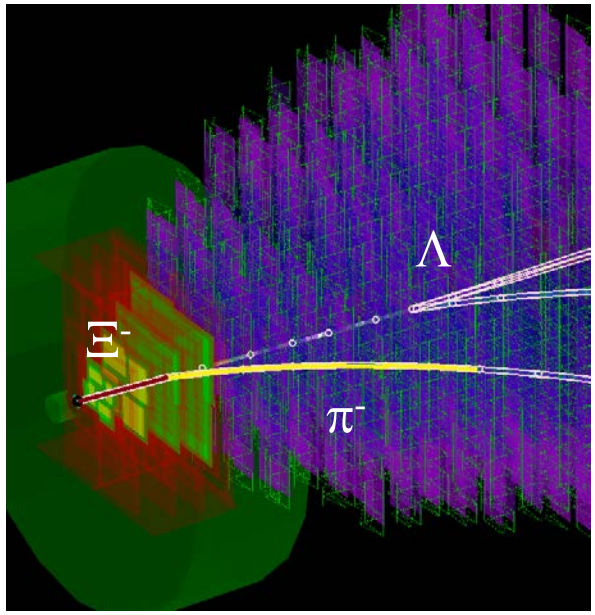




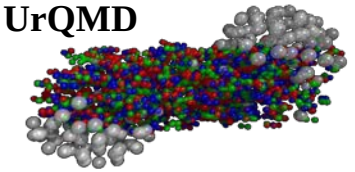




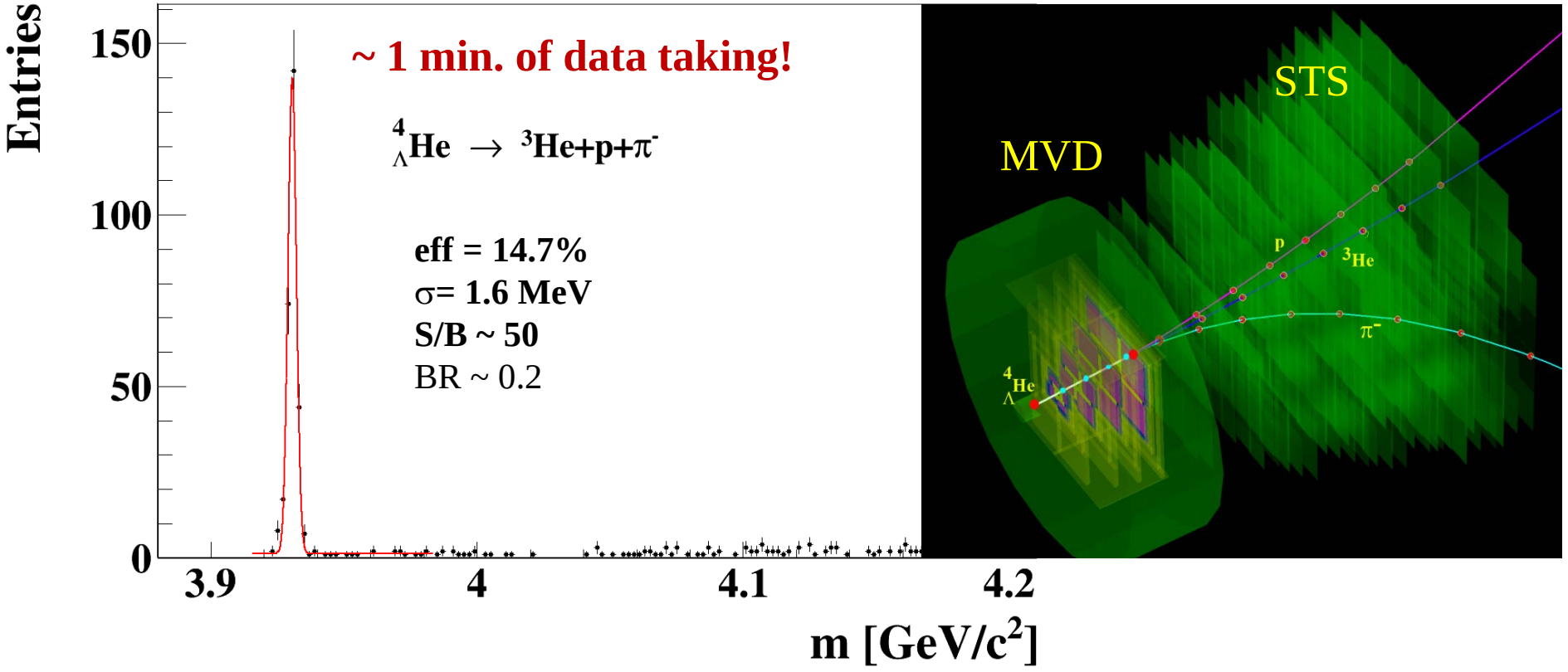




Au+Au 10 AGeV 5M central events



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

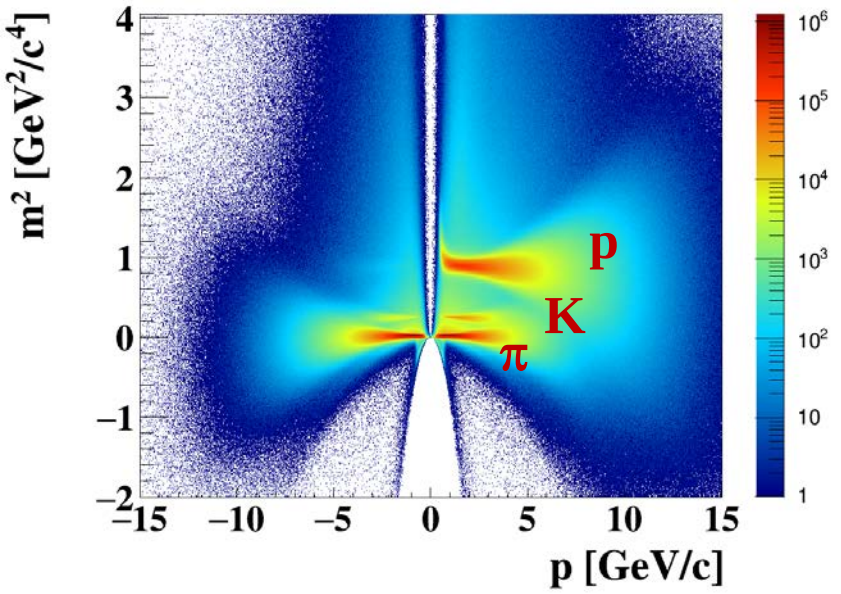


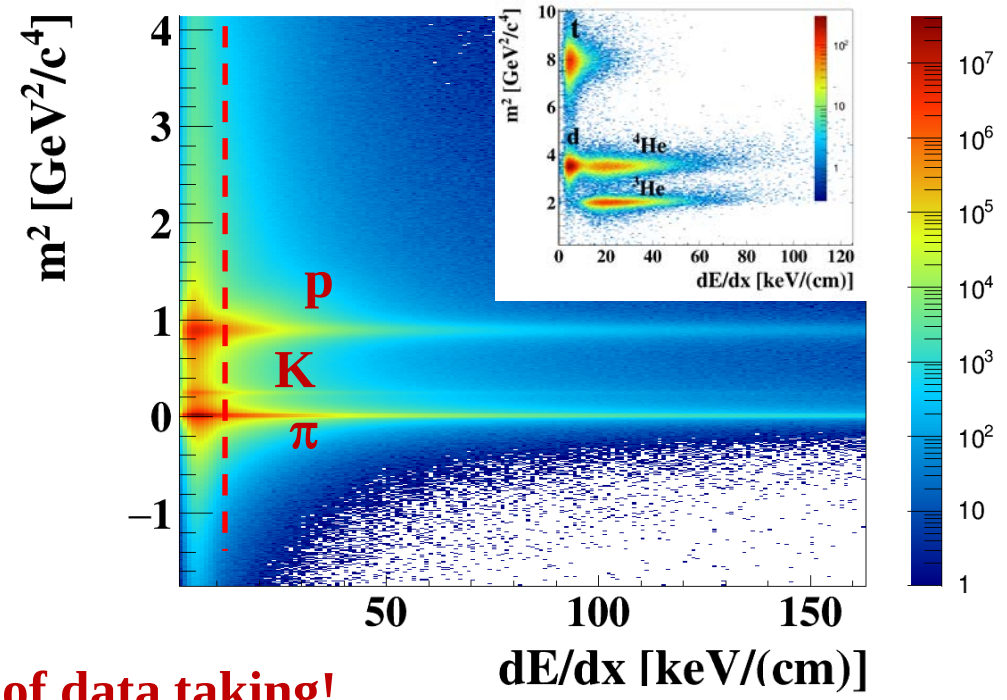
3 prong detached vertex is good signature of $^{4}_{\Lambda}$He decay

M from J. Steinheimer et al., Phys. Lett. B**714**, 85, (2012)

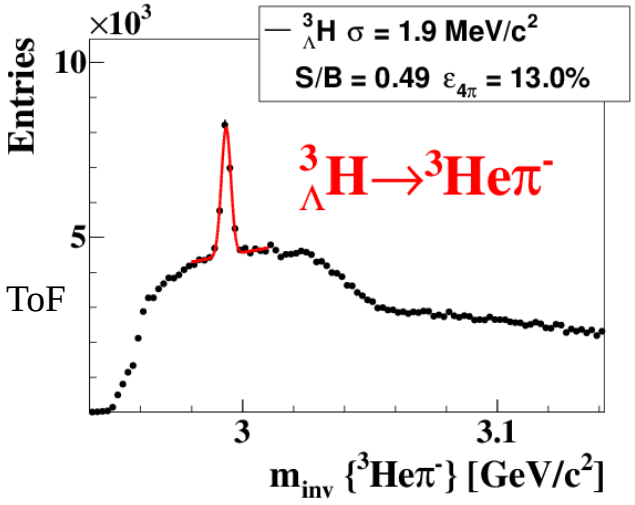
5M mbias AuAu collisions, 10AGeV

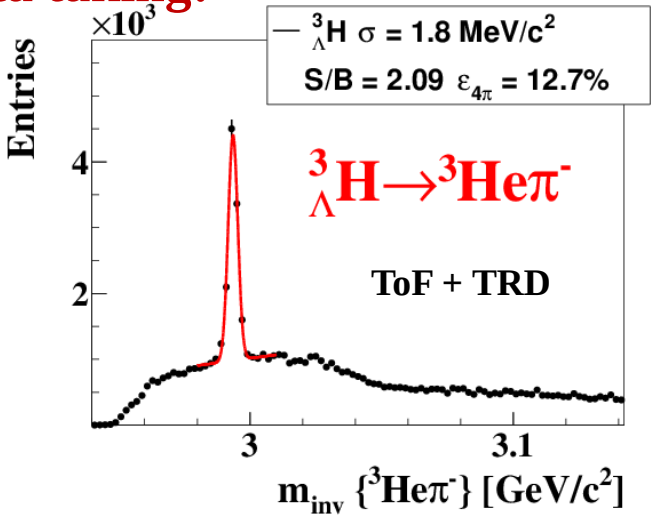
KFParticle Finder $^{3}_{\Lambda}H$





5 seconds of data taking!

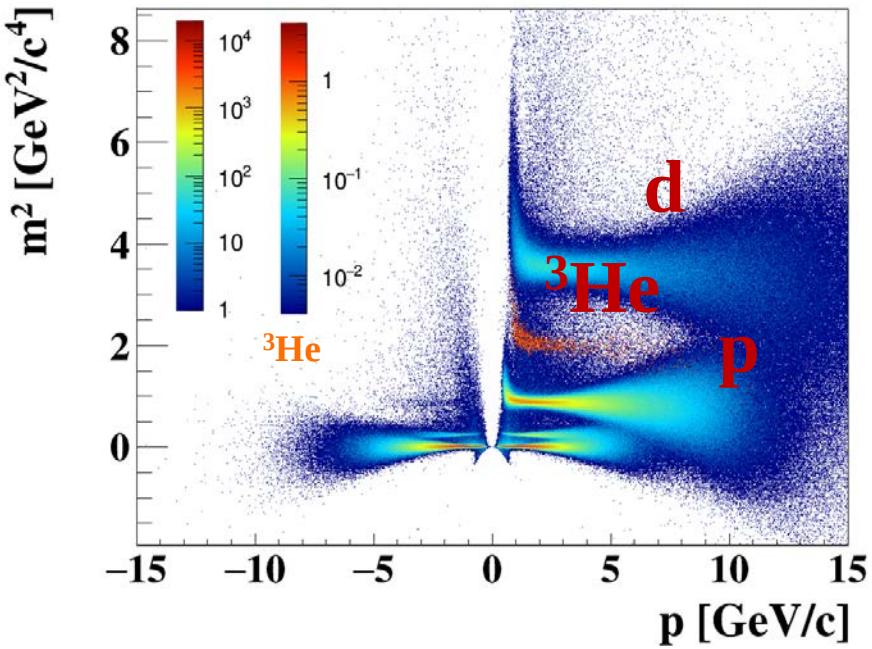


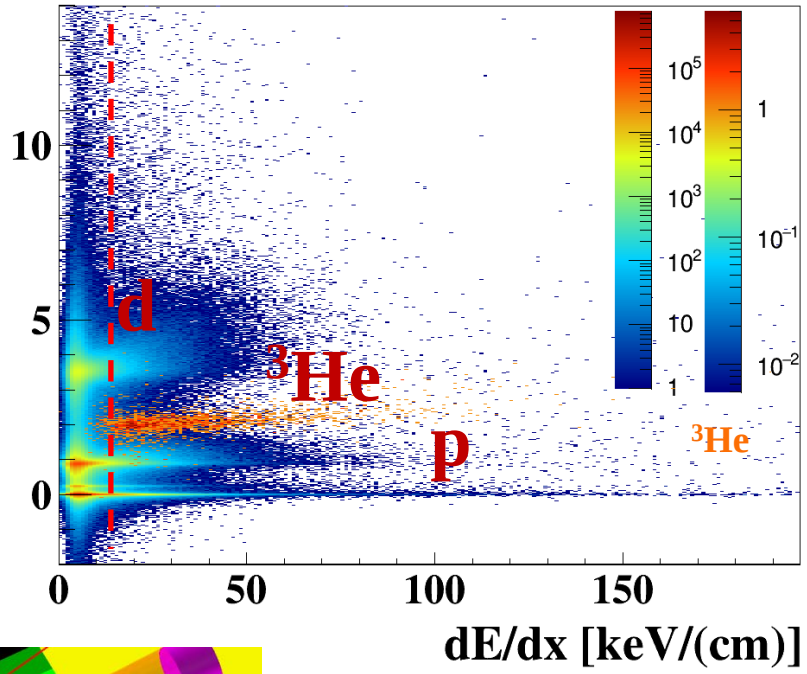


DCM with CBM detector 5M mbias C + C collisions

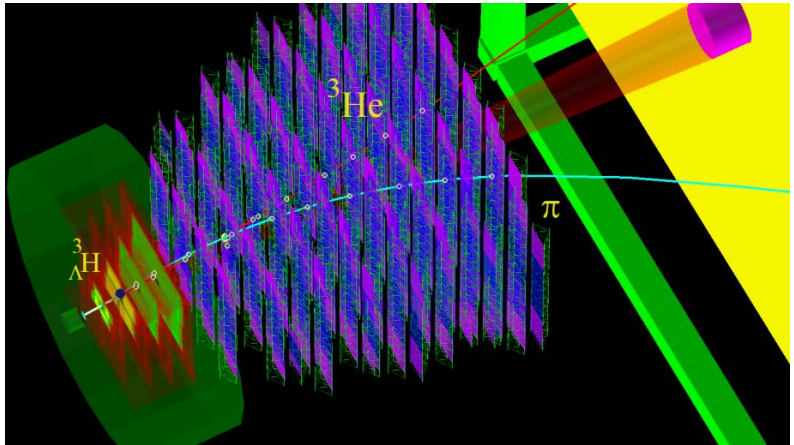
A.S.Botvina, K.K.Gudima, J.Pochodzalla.
Production of hypernuclei in peripheral relativistic ion collisions.
Phys. Rev. C , v. 88, p. 054605, 2013.

10 AGeV

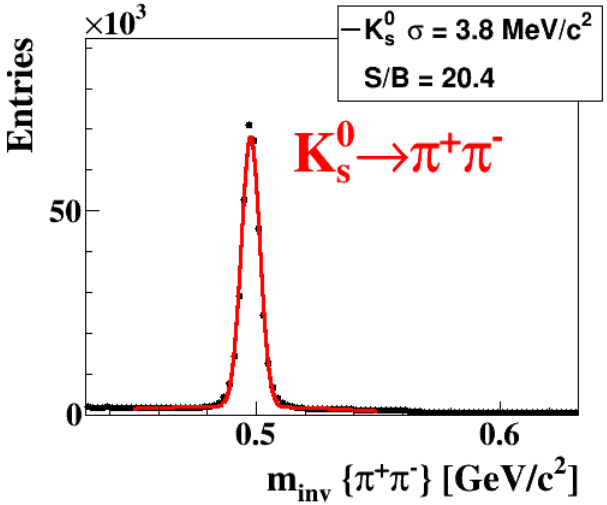


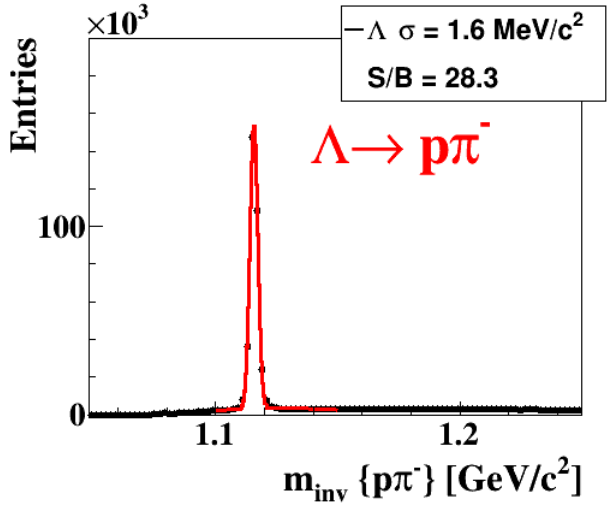


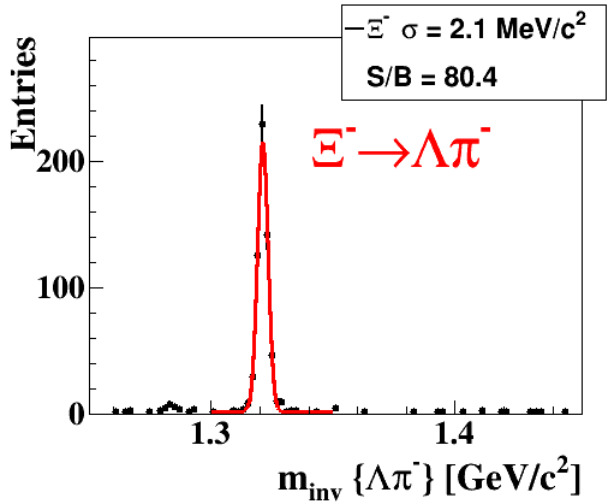
$^{3}_{\Lambda}H \rightarrow {}^{3}He + \pi^{-}$

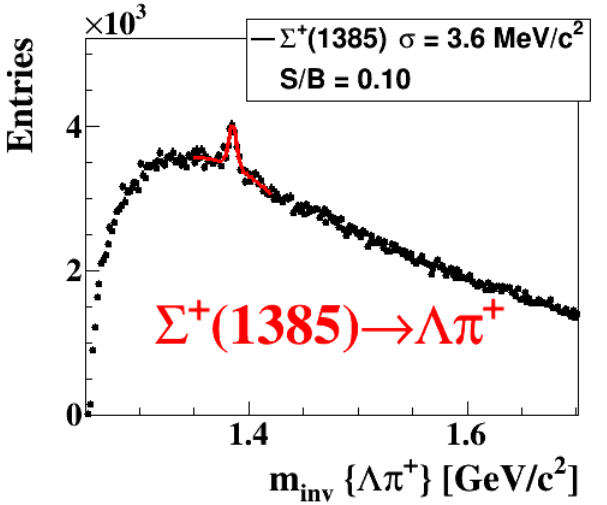


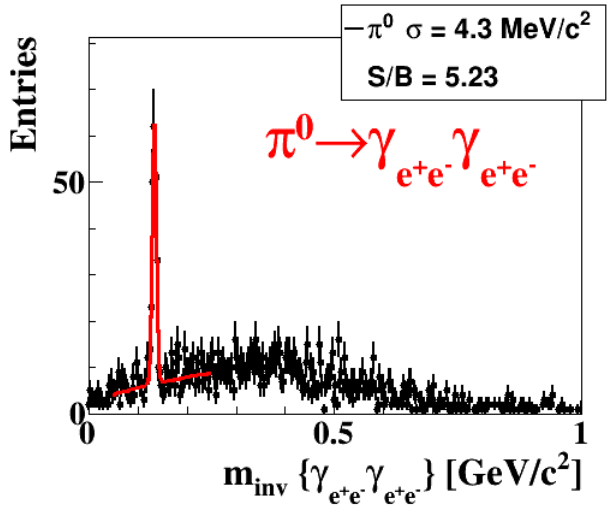
DCM with CBM detector 5M mbias C + C collisions
About 10 sec of data taking assuming 5*10^5 IR

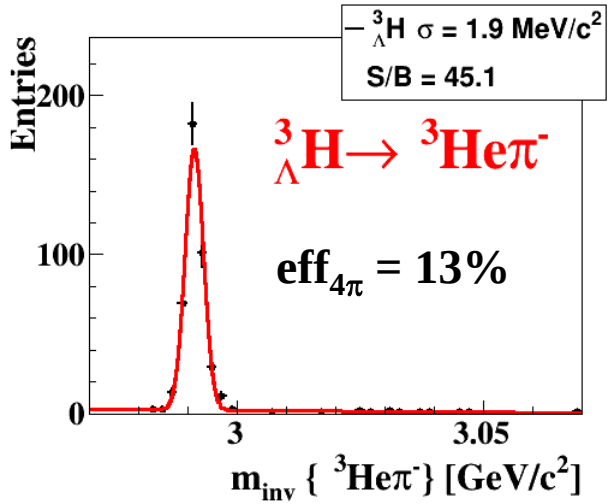




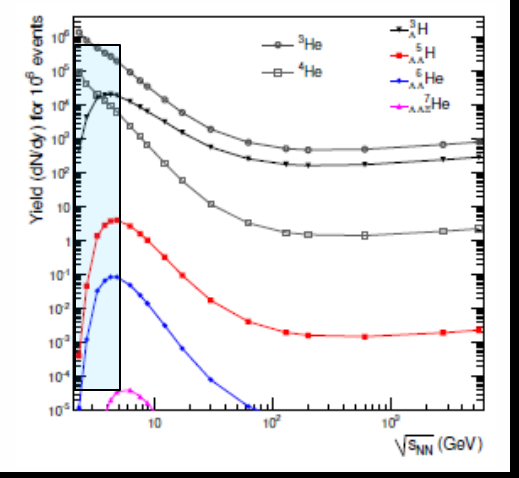






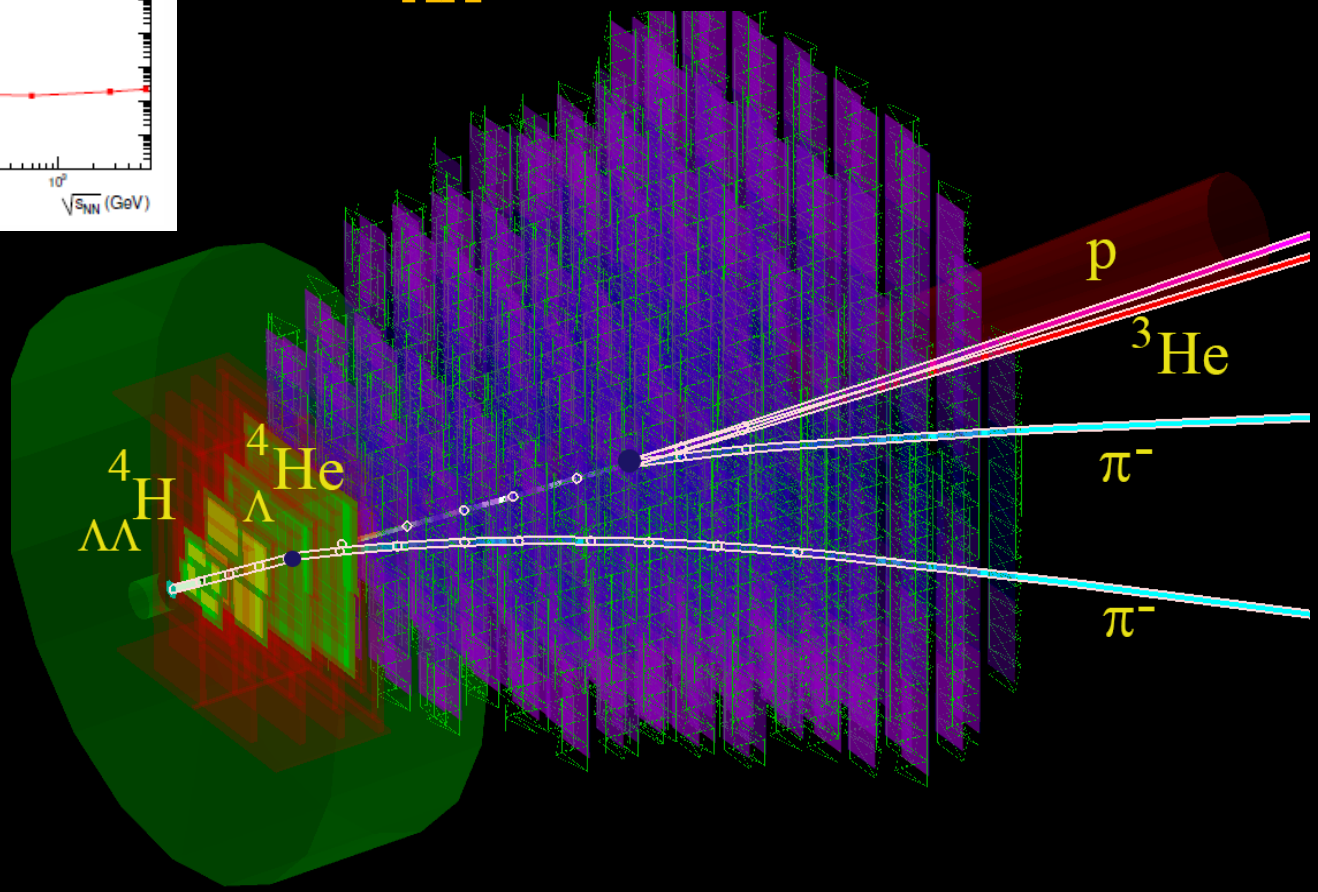


Λ N, ΛNN, $^4_\Lambda$H and $^4_\Lambda$He

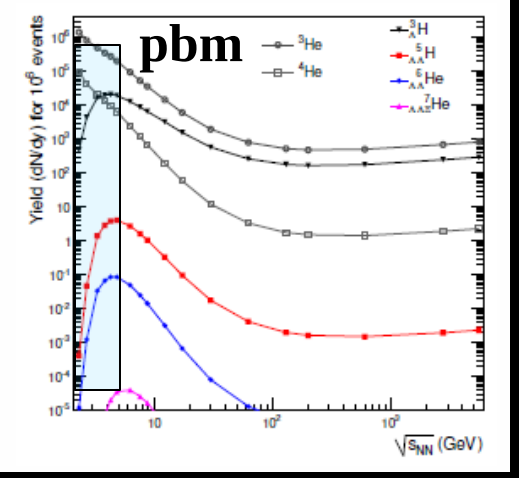


A. Andronic, et al., Phys. Lett. B697 (2011) 203

$^4_{\Lambda\Lambda}$H decay topology



$^4_{\Lambda\Lambda}$H decay reconstructed with CBM detector



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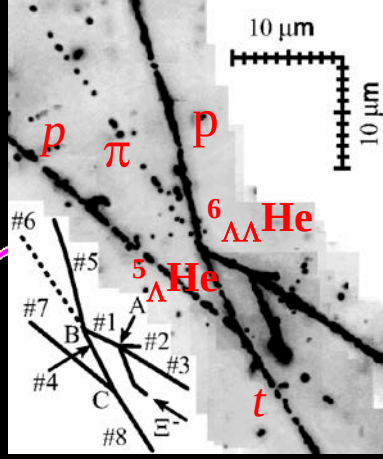
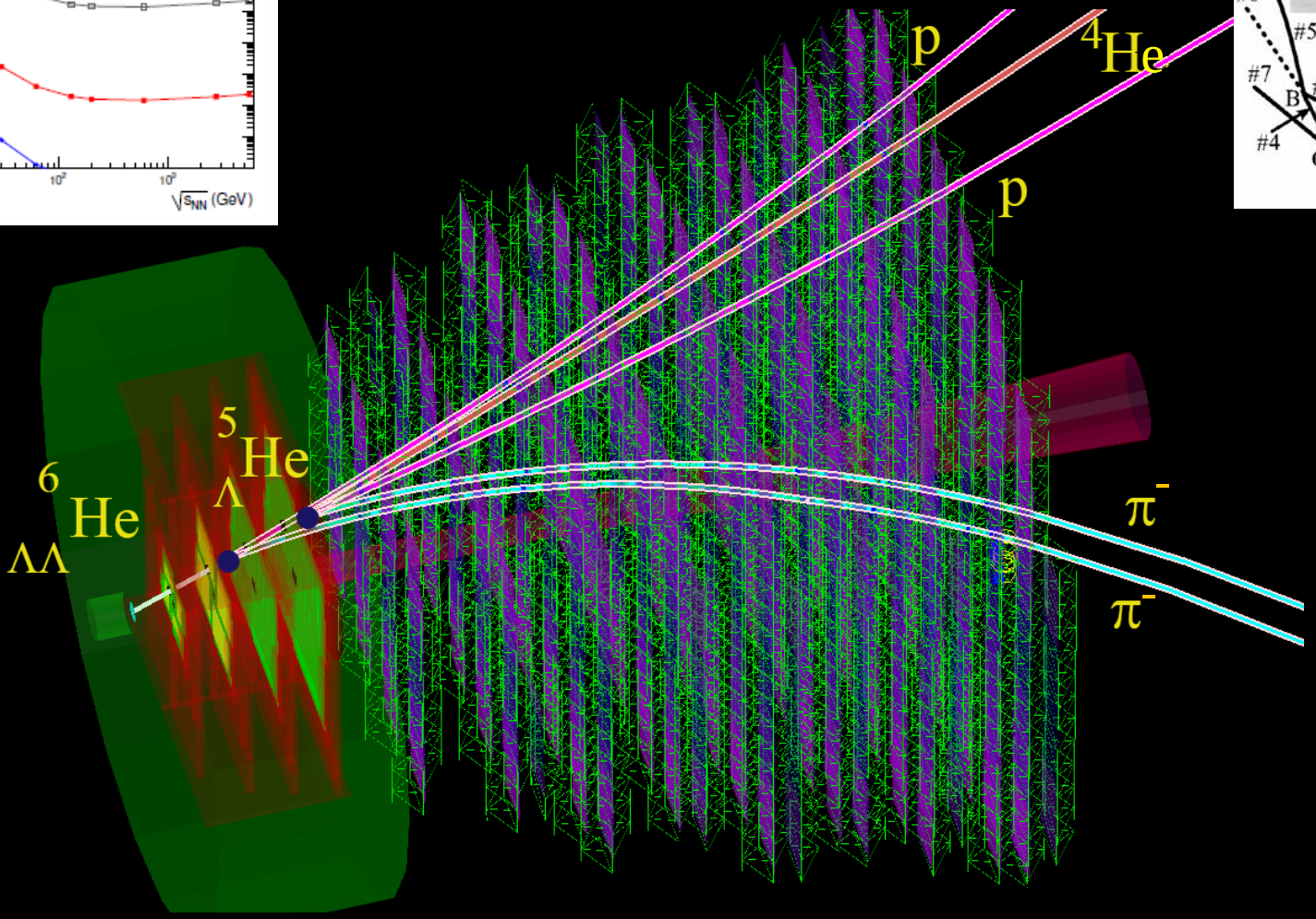
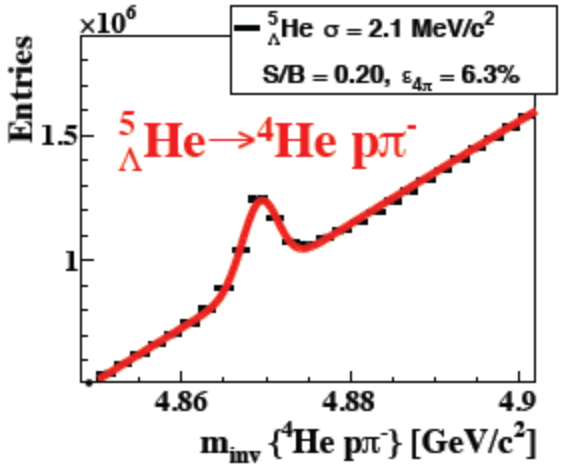
$^{6}_{\Lambda\Lambda}$He decay topology

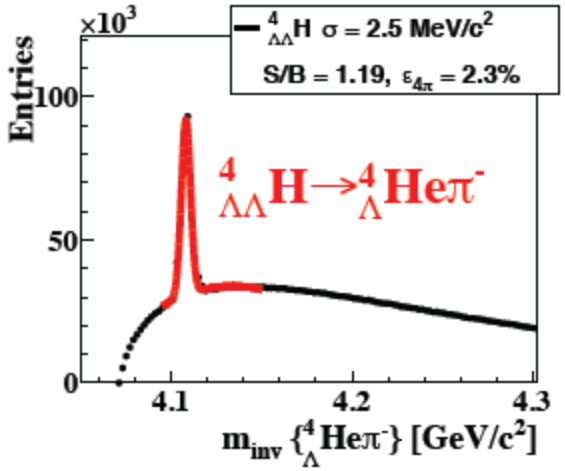


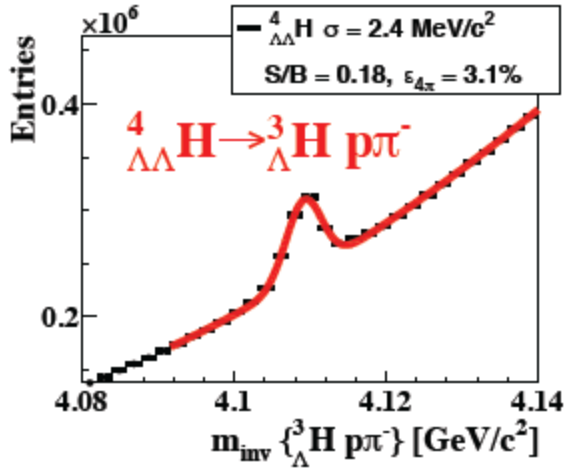


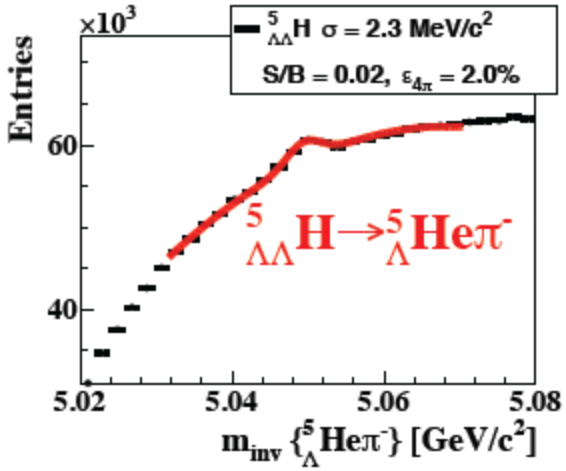
$^{6}_{\Lambda\Lambda}$He decay reconstructed with CBM detector

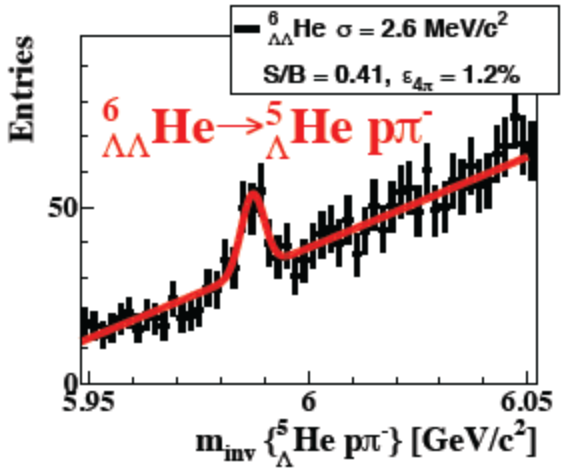
Double-Λ hypernuclei











- Background can be further reduced with additional dE/dx PID.
- For $^{5}_{\Lambda}$He and $^{5}_{\Lambda\Lambda}$H background will be reduced selecting only primary hypernuclei.

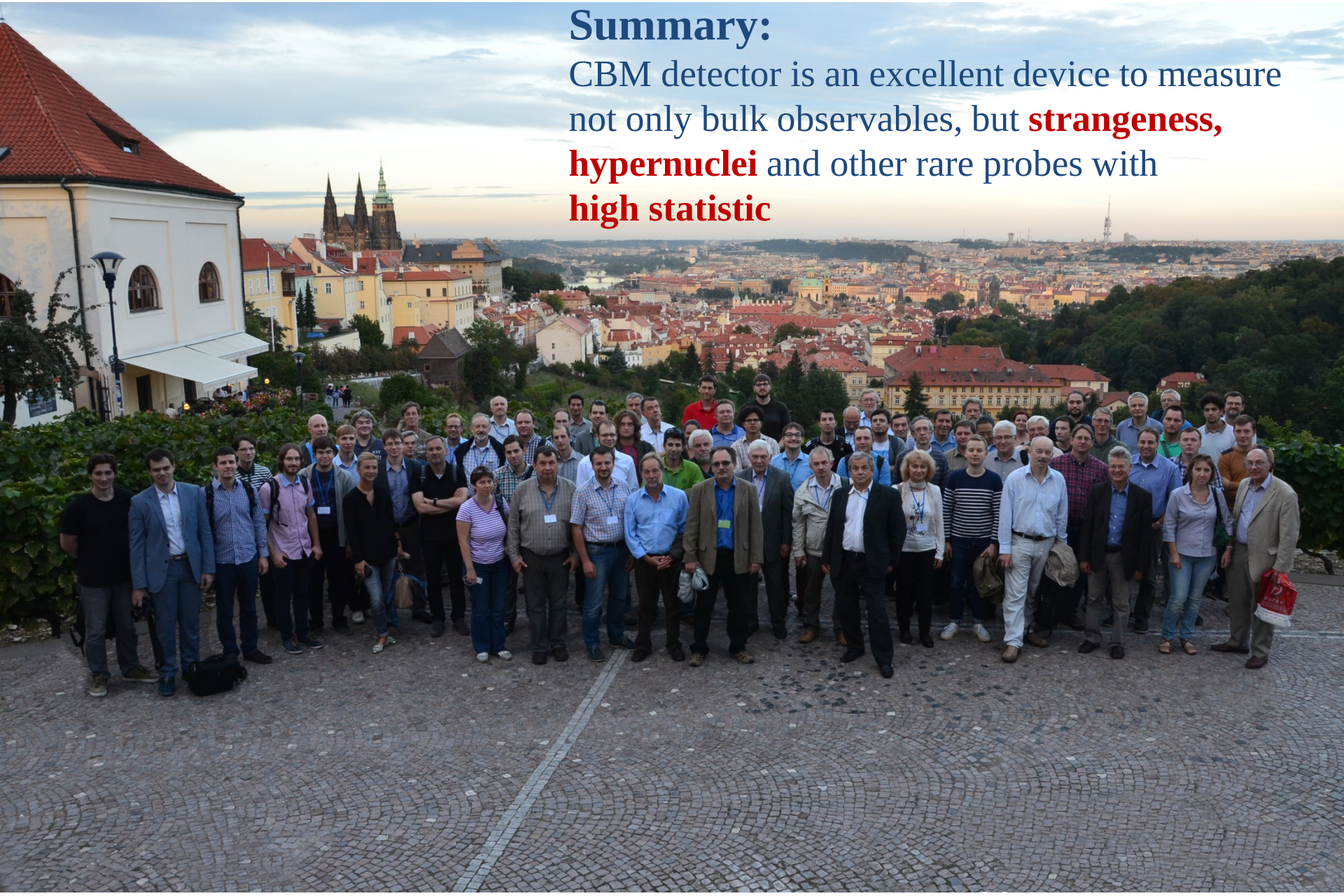
AuAu, 10 AGeV, 10^{12} central events, TOF PID

High statistic measurements at 10^{7} interaction rates will allow to measure double-Λ hypernuclei

Expected particle yields Au+Au @ 10 AGeV

Particle (mass MeV/c^2)	Multi-plicity 10 AGeV	decay mode	BR	ε (%)	yield (s^{-1}) 10AGeV	yield in 10 weeks 10 AGeV	IR MHz
$\bar{\Lambda}$ (1115)	0.034	$\bar{p}\pi^+$	0.64	11	81.3	$2.2\cdot10^8$	**10**
Ξ^- (1321)	0.222	$\Lambda\pi^-$	1	6	$1.3\cdot10^4$	$7.8\cdot10^{10}$	**10**
Ξ^+ (1321)	$5.4\cdot10^{-4}$	$\bar{\Lambda}\pi^+$	1	3.3	17.8	$1.1\cdot10^8$	**10**
Ω^- (1672)	$5.6\cdot10^{-3}$	ΛK^-	0.68	5	164	$9.6\cdot10^8$	**10**
Ω^+ (1672)	$7\cdot10^{-5}$	$\bar{\Lambda}K^+$	0.68	3	0.86	$5.2\cdot10^6$	**10**
${}^3_{\Lambda}H$ (2993)	$3.8\cdot10^{-2}$	${}^3He\pi^-$	0.25	19.2	$1.8\cdot10^3$	$1.1\cdot10^{10}$	**10**
${}^4_{\Lambda}He$ (3930)	$1.9\cdot10^{-3}$	${}^3He p\pi^-$	0.32	14.7	87	$5.2\cdot10^8$	**10**
${}^5_{\Lambda\Lambda}He$(5047)	$5.0\cdot10^{-6}$	${}^3He2p2\pi$	0.01	1	$5\cdot10^{-3}$	$3\cdot10^4$	**10**
${}^6_{\Lambda\Lambda}He$(5986)	$1.0\cdot10^{-7}$	${}^4He2p2\pi$	0.01	1	$1\cdot10^{-4}$	600	**10**

60 Institutes, 600 members



Summary:

CBM detector is an excellent device to measure not only bulk observables, but **strangeness, hypernuclei** and other rare probes with **high statistic**