Strangeness Prospects with the CBM Experiment

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GSI Darmstadt
on behalf of the CBM Collaboration

JOINT INSTITUTE FOR NUCLEAR RESEARCH
Strangeness in Quark Matter
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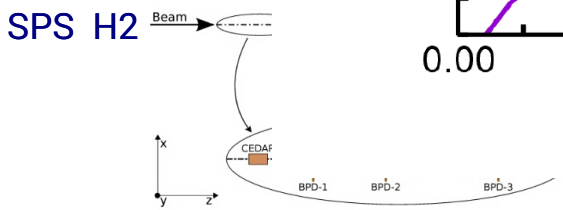
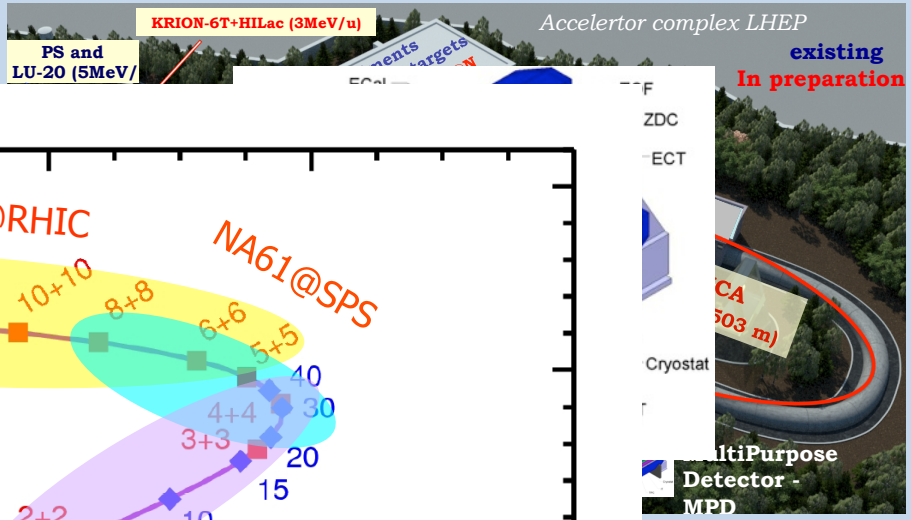
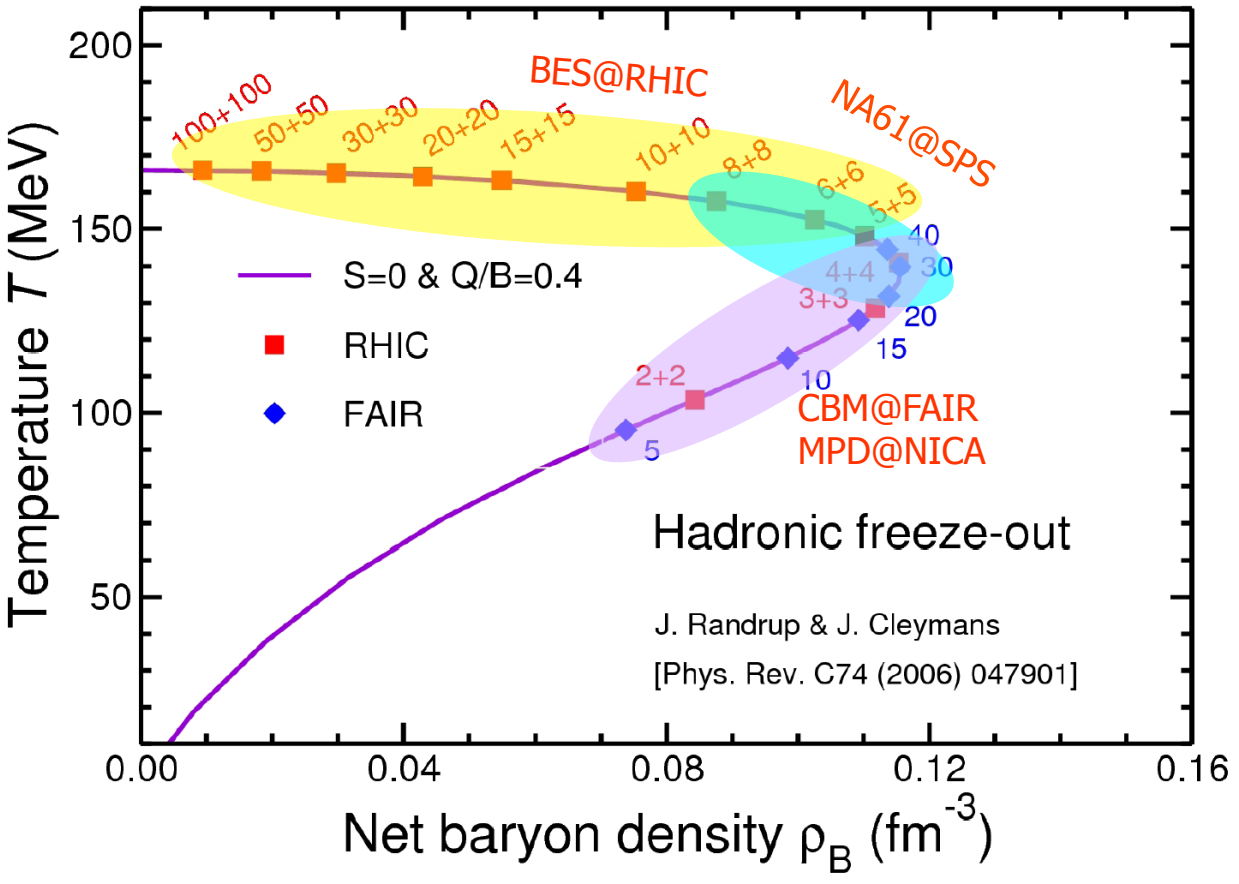
SQM DUBNA 2015

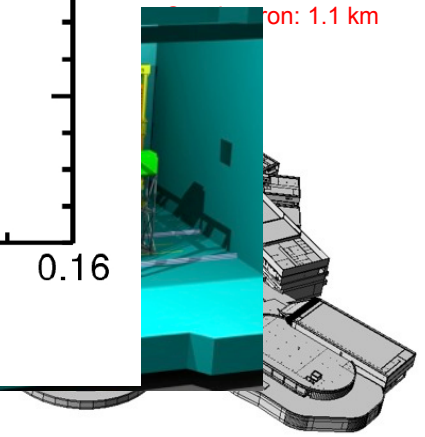
Exploring Dense Matter: Landscape

NA61/SH

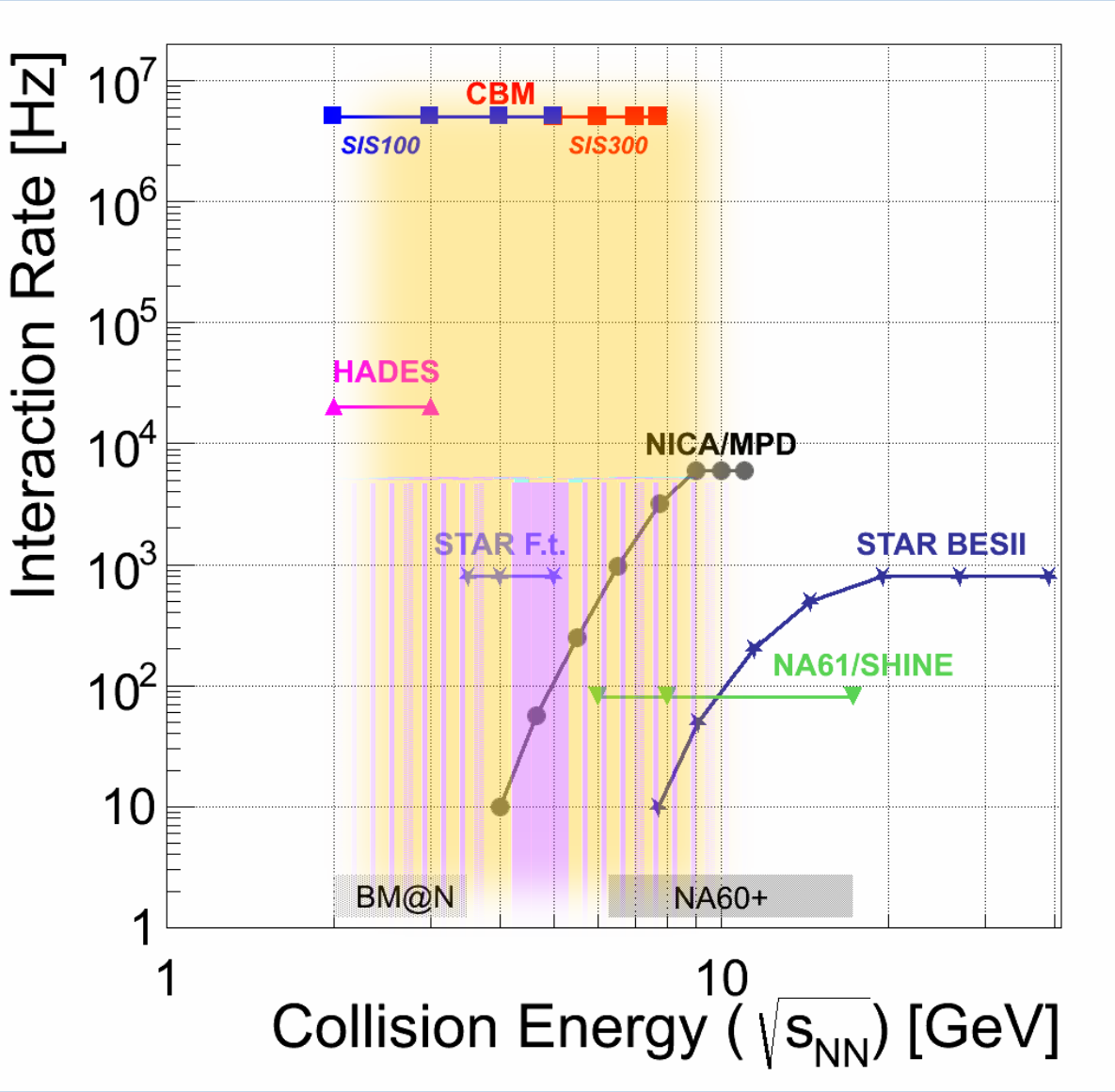




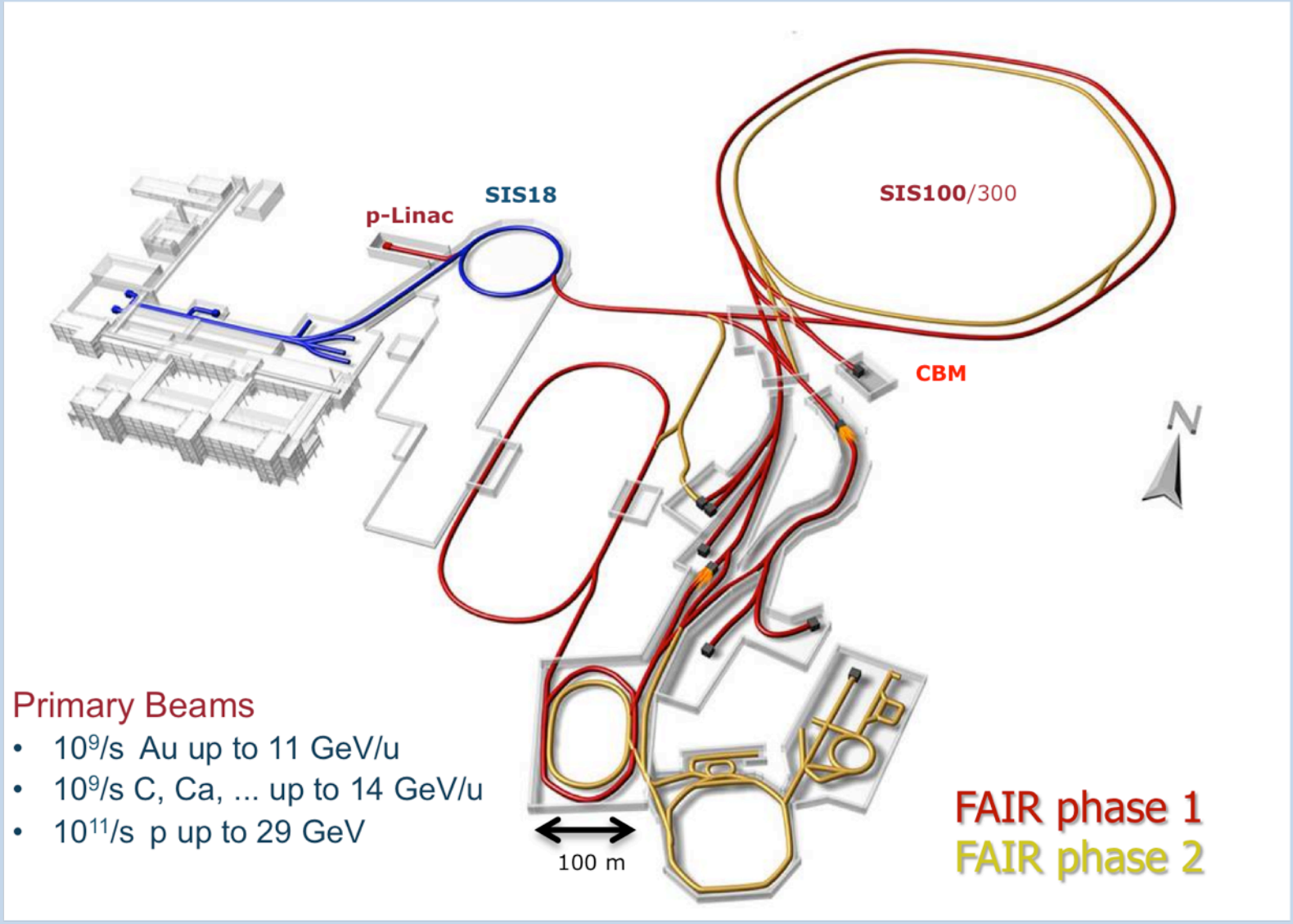




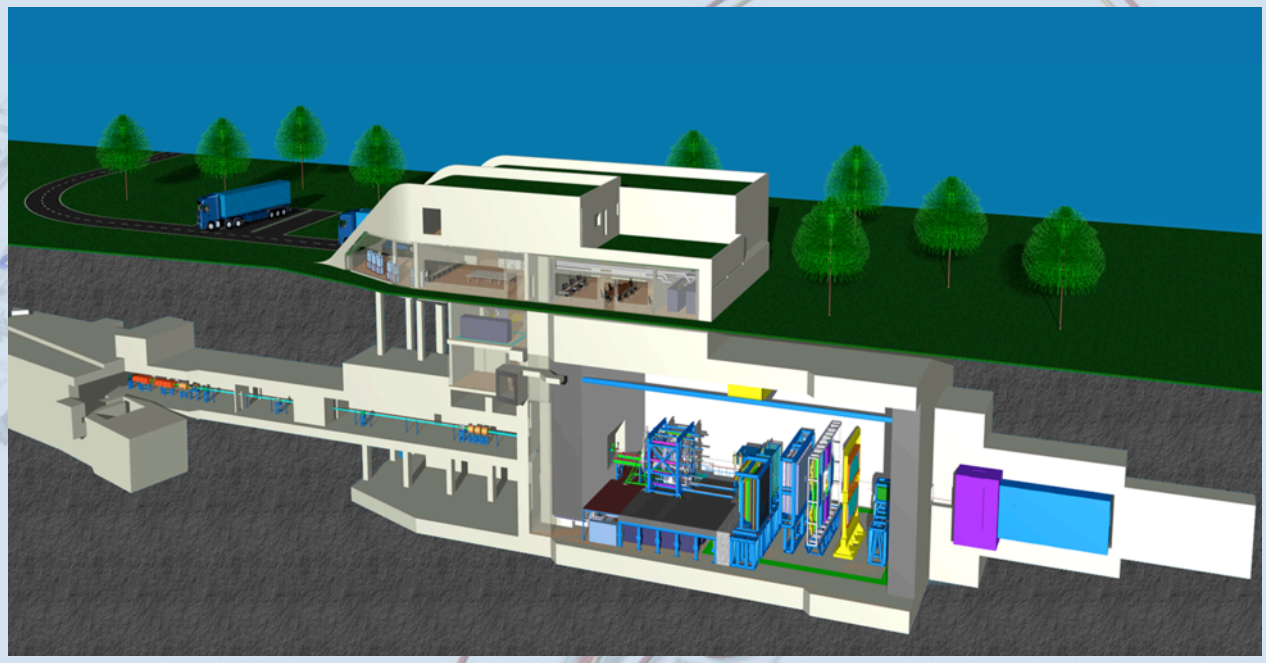
The CBM Punchline: High Rates



FAIR Accelerator Complex

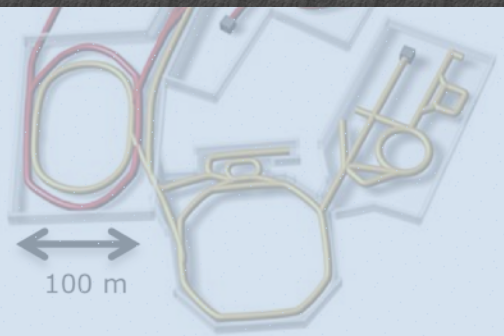


FAIR Accelerator Complex and CBM



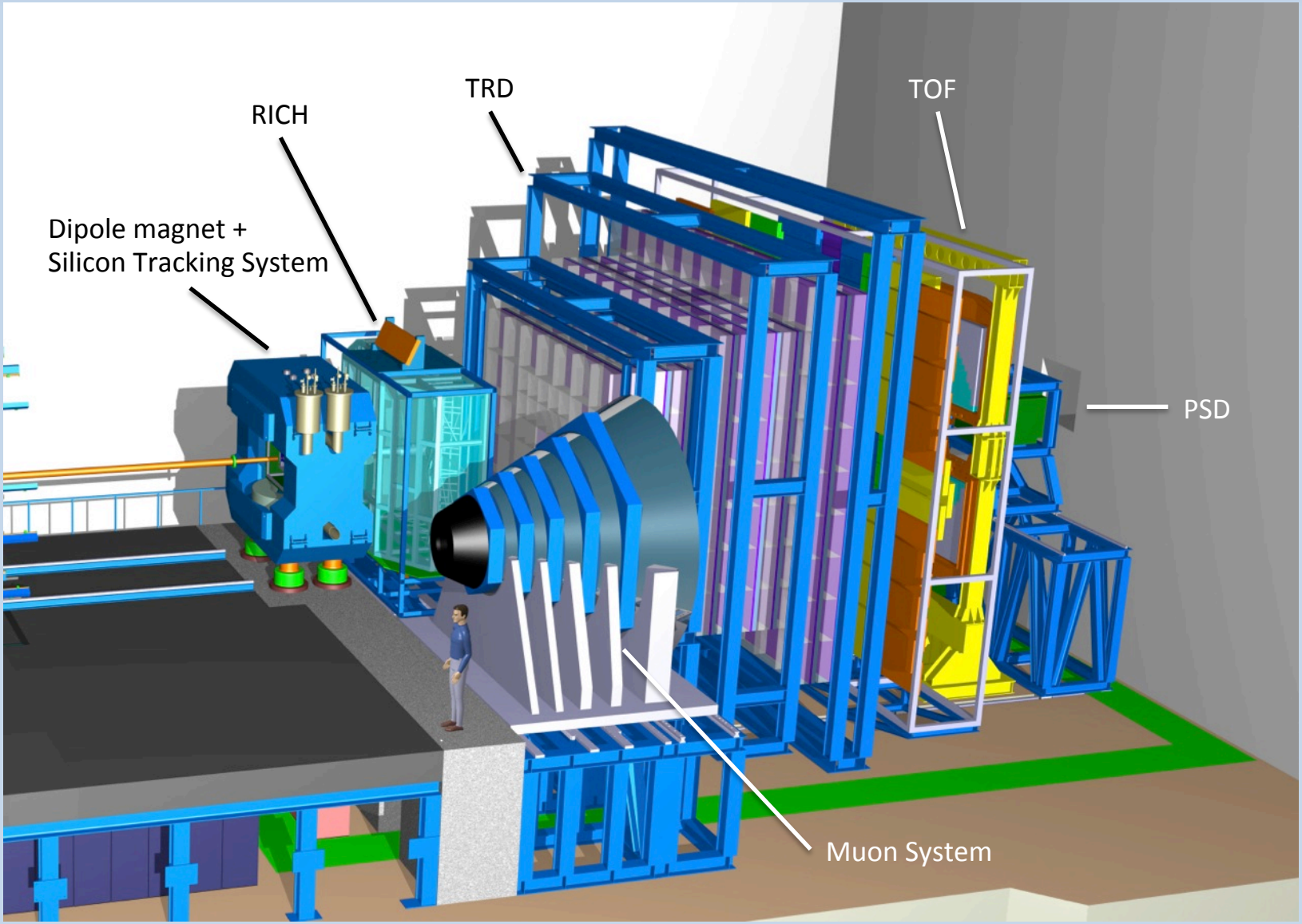
Primary Beams

- 10^9/s Au up to 11 GeV/u
- 10^9/s C, Ca, ... up to 14 GeV/u
- 10^{11}/s p up to 29 GeV

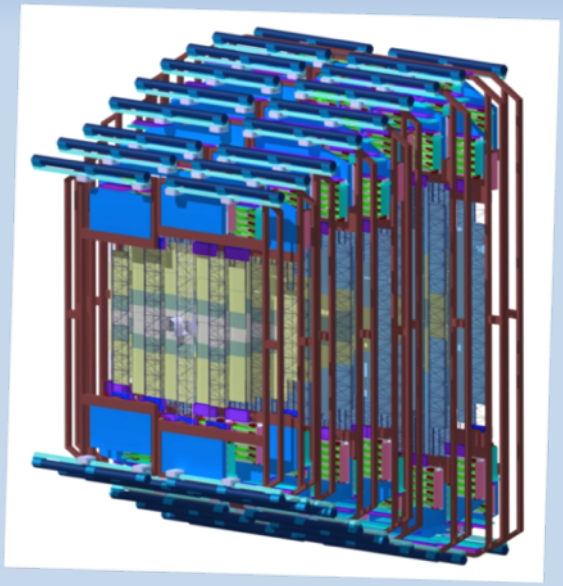


FAIR phase 1
FAIR phase 2

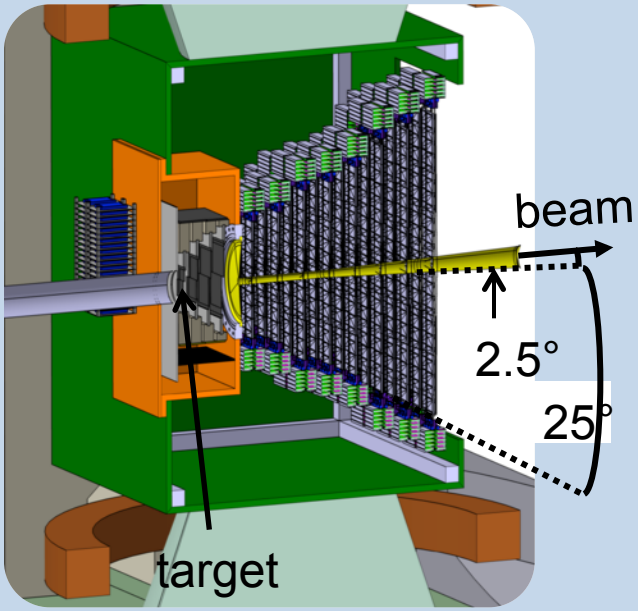
CBM: Experiment Systems

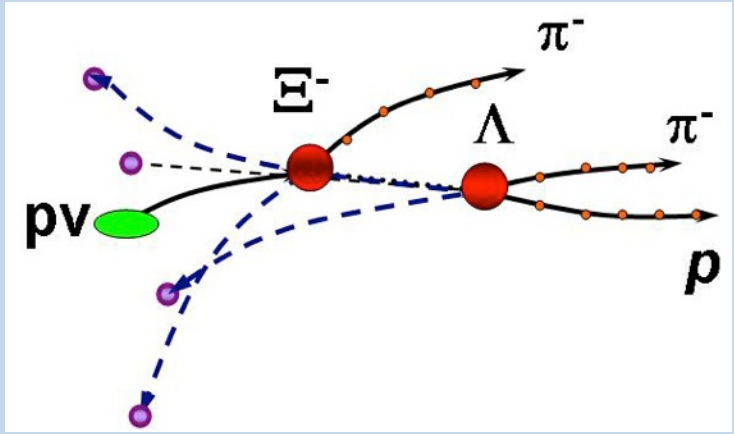


The Workhorse: Silicon Tracking System



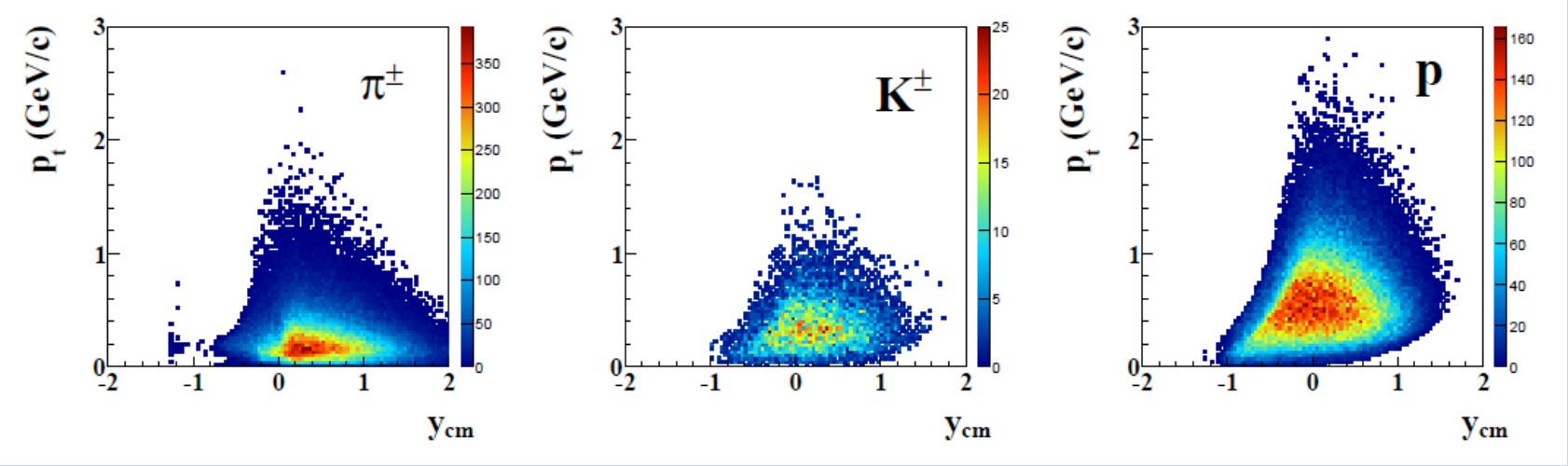
- *8 tracking stations in dipole magnet: between 0.3 m and 1 m from target*
- *Aperture: 2.5° < Θ < 25° (38°)*
- *Double-sided micro-strip sensors arranged in modules on low-mass, carbon-fiber supported ladders.*
- *1,220 sensors (4 m^2), 1.8 M channels*
- *Readout electronics at periphery*
- *Thermal enclosure, sensors at -5 °C*
- *CO_2 cooling (42 kW power dissipation)*



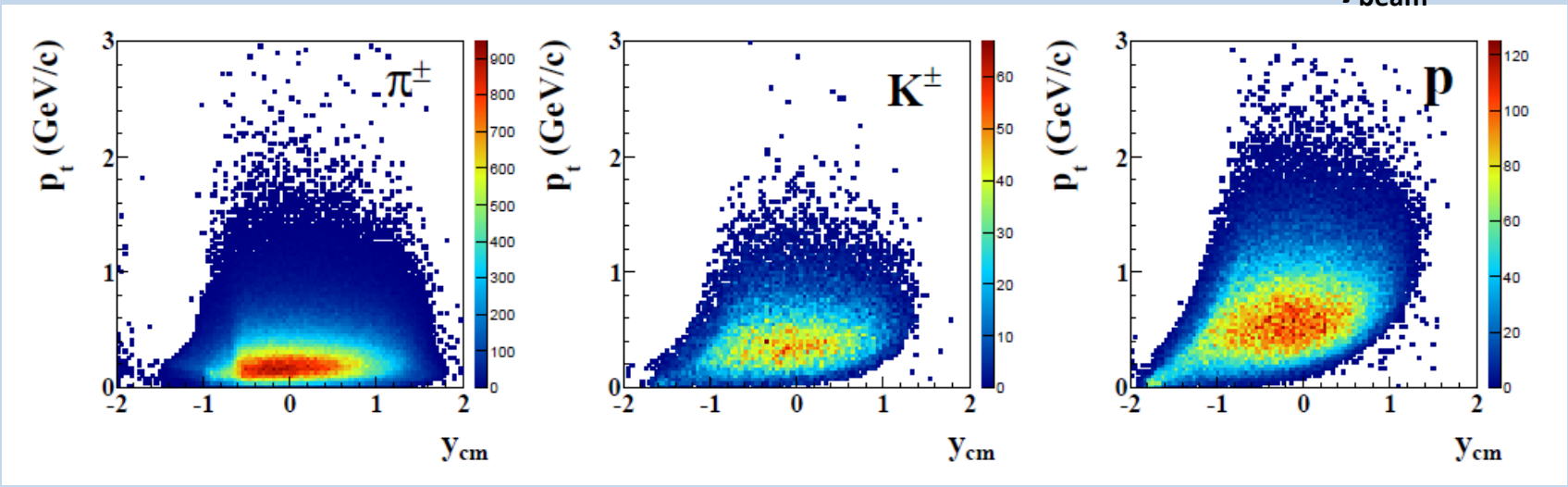


STS Acceptance...

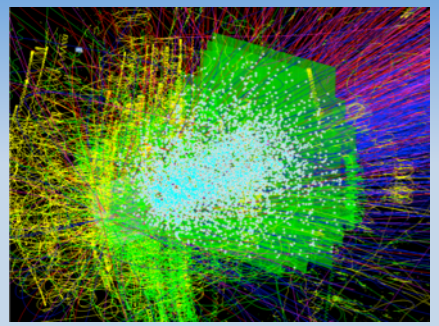
Au+Au 6 AGeV $y_{beam} = 1.28$



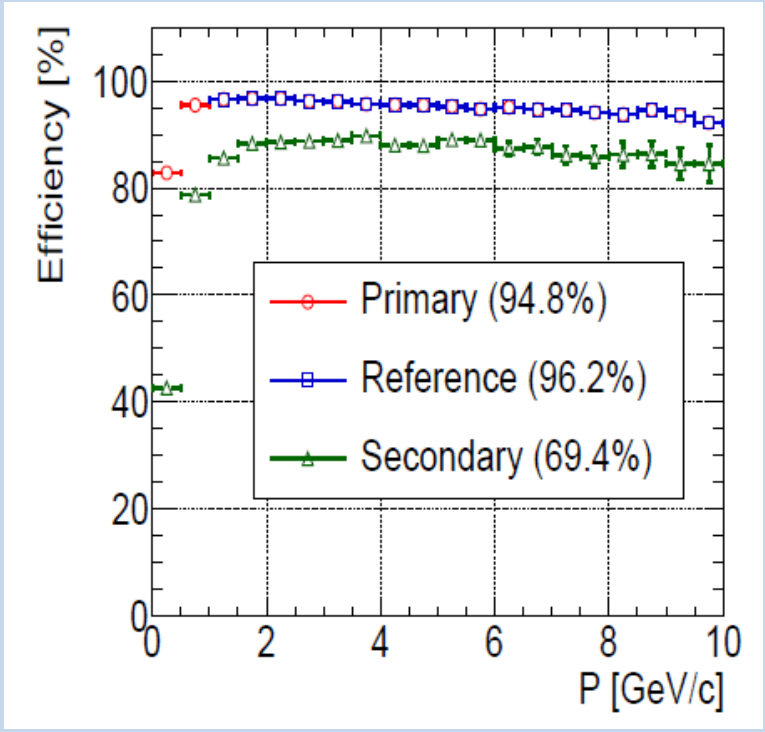
Au+Au 25A GeV $y_{beam} = 1.98$



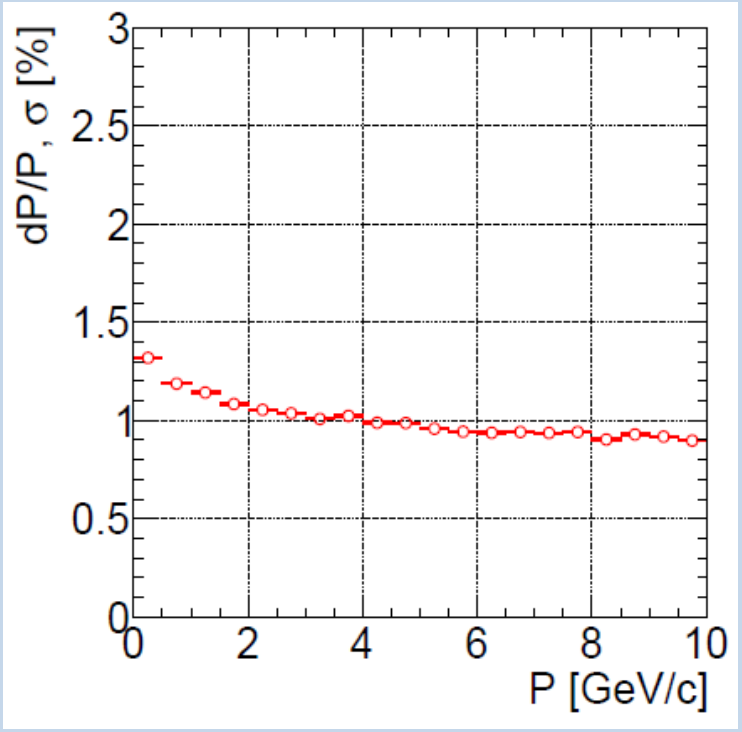
... and Performance



Track finding efficiency central Au+Au 25A GeV

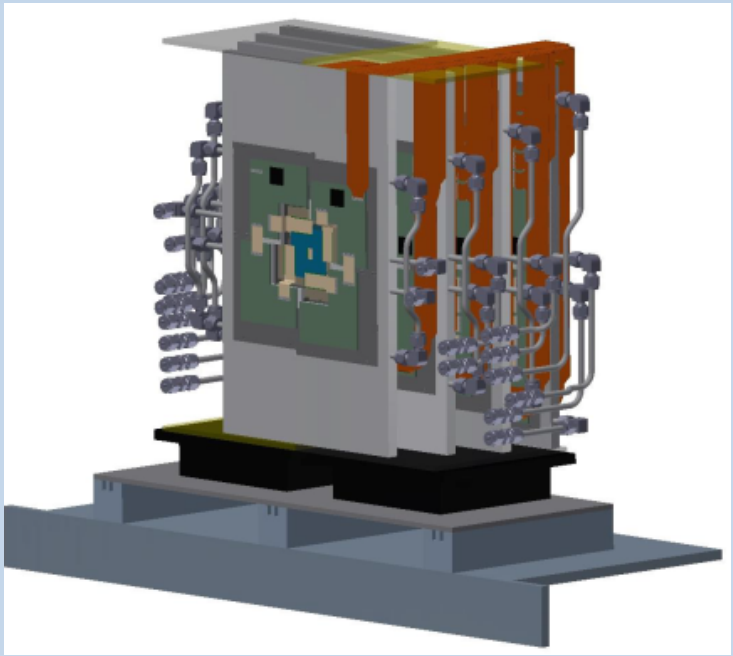


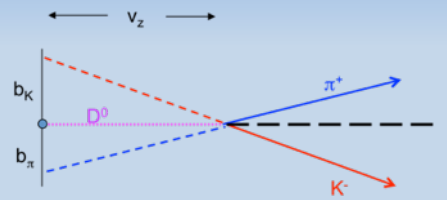
Momentum resolution



Track reconstruction with Cellular Automaton and Kalman Filter

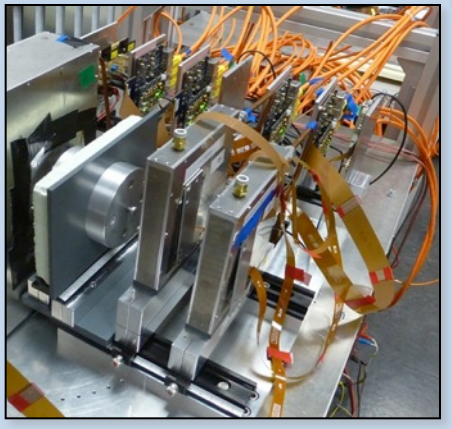
Precision Vertexing: Micro-Vertex Detector



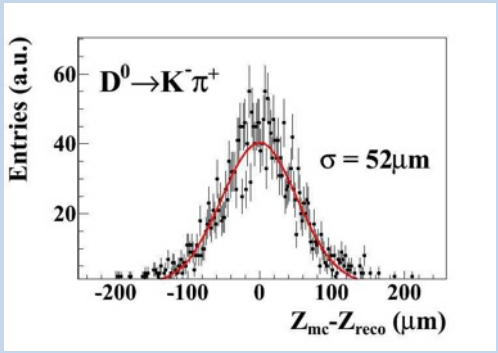


- *4 layers of Monolithic Active Pixel Sensors*
- *located at z = 5 cm - 20 cm*
- *pixel size 20 x 20 μm²*
- *resolution 4 μm*
- *low-mass: < 0.5 % X_0 per layer*
- *operated in vacuum*
- *rad. hardness 10^{13} n_{eq}/cm^2 / 3 MRad*
- *vertex resolution ≈ 50 μm along beam axis*

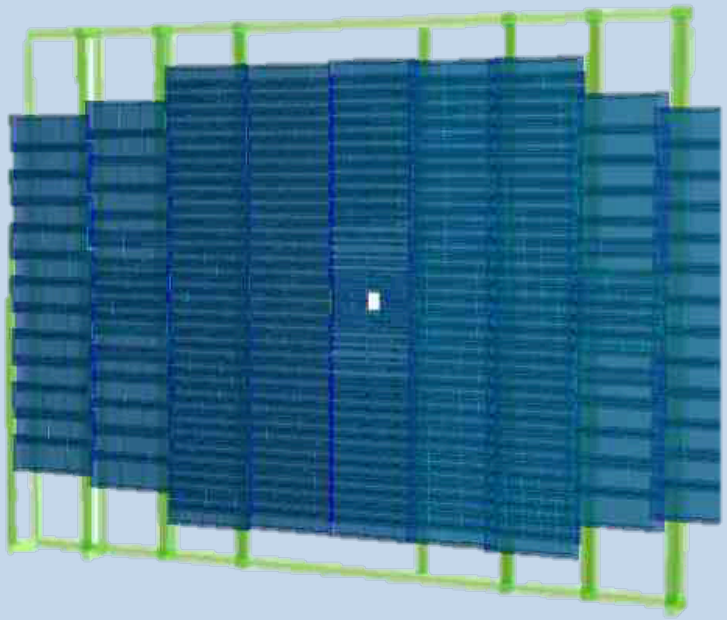
MIMOSA-26

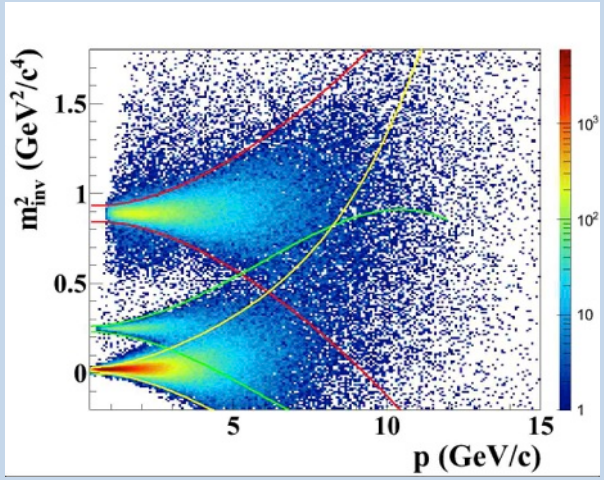


Prototype station



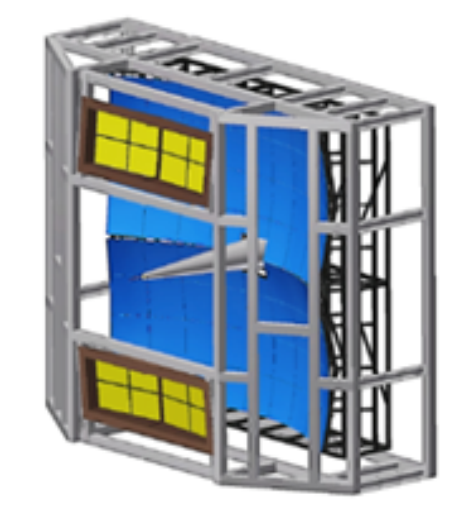
Hadron ID: Time-of-Flight Detector



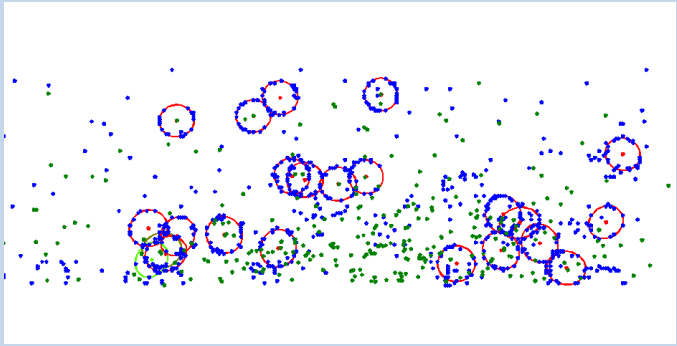


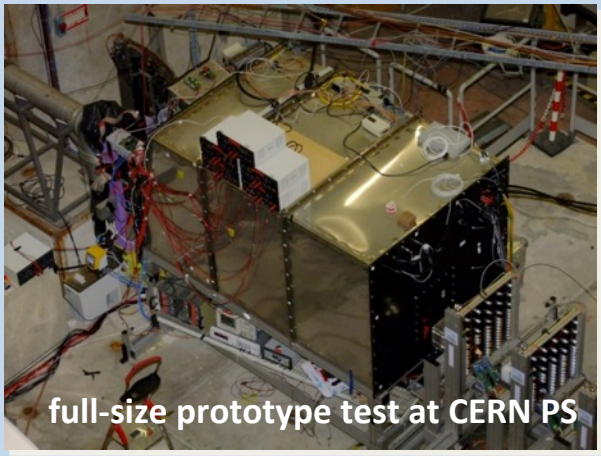
- *array of Resistive Plate Chambers (120 m^2)*
- *resolution ≈ 60 ps*
- *high rate capability (- 25 kHz/cm^2)*
- *located at z = 6 m (10 m) from the target*

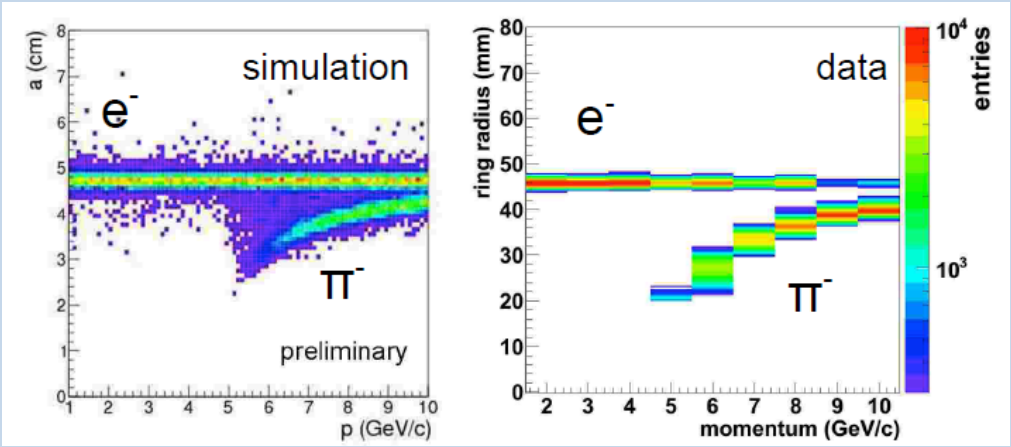
Electrons Only: Ring-Imaging Cherenkov Detector



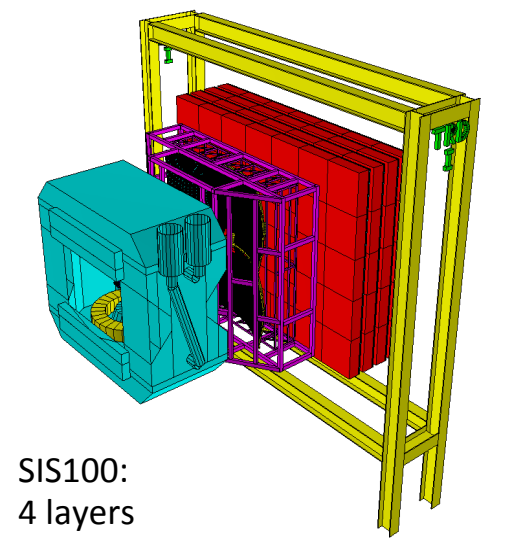
- *CO_2 radiator*
- *Double-focusing mirror optics*
- *Highly granular photon detection by*



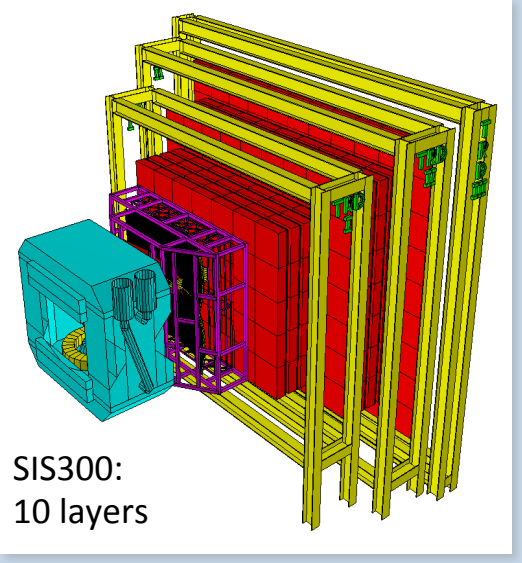




Electrons and More: Transition Radiation Detector

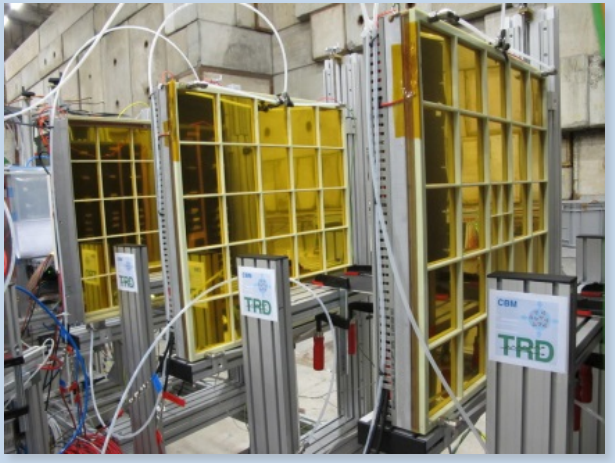


SIS100:
4 layers

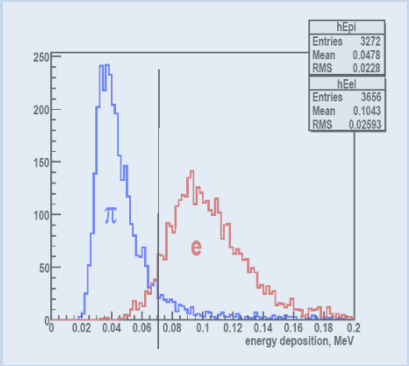


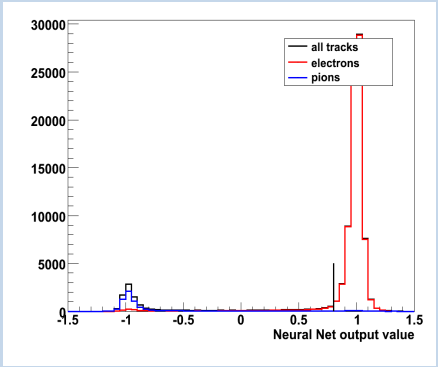
SIS300:
10 layers

- *4 (10) layers of radiators with MWPC chambers*
- *different radiator materials and chamber types und investigation*
- *for e/hadron separation*
- *for intermediate tracking to TOF / after MUCH*

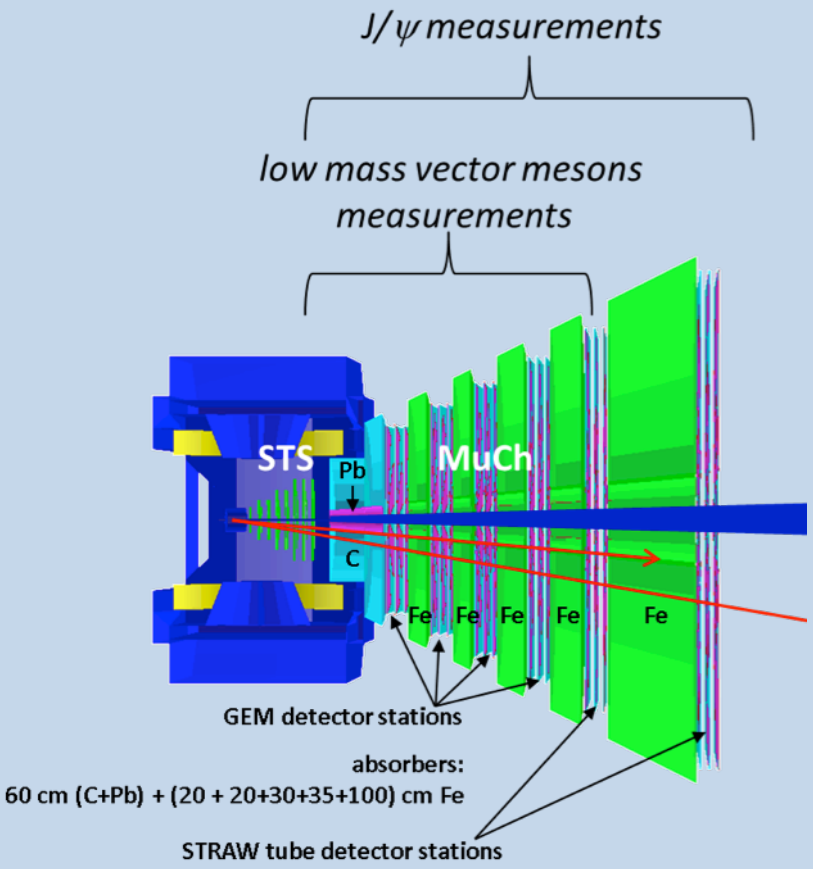


Test beam at CERN-PS

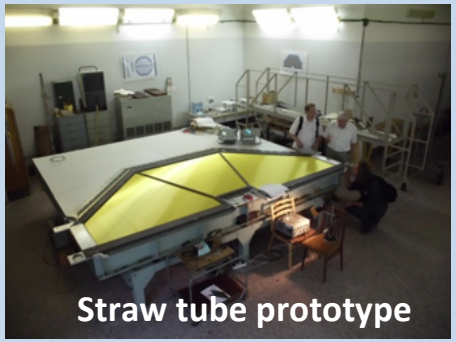


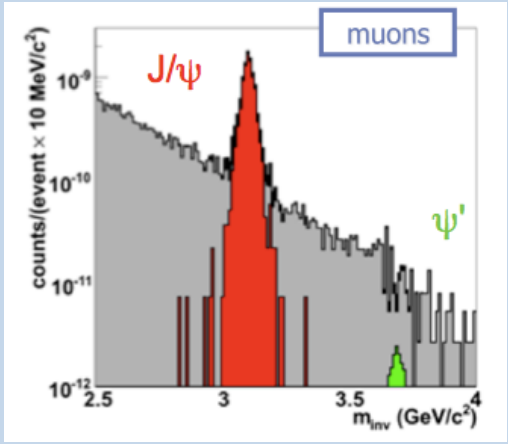


No Hadrons Allowed: Muon Detector



- *active absorber system with tracking detectors (GEM/straw) sandwiched between absorber slices*
- *allows track following through the system*

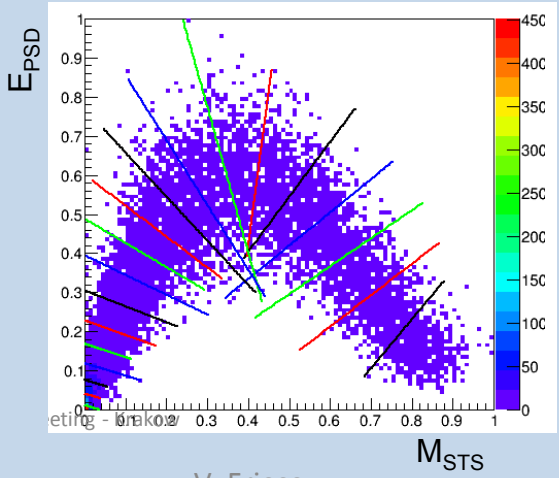


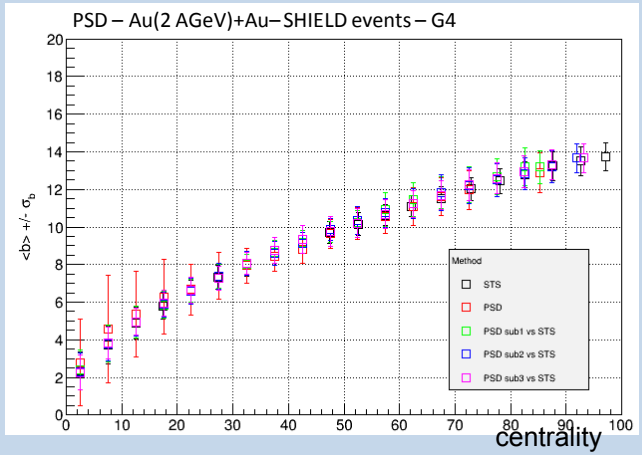


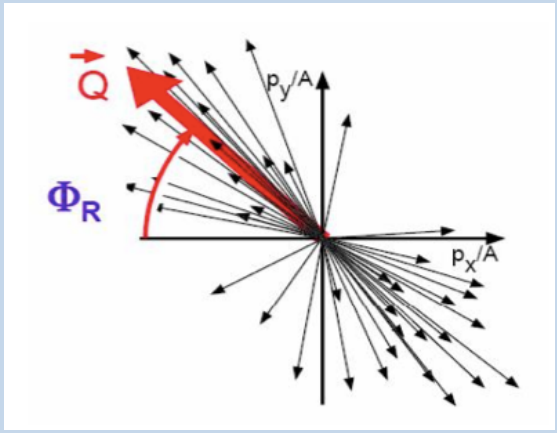
Centrality and event plane: Projectile Spectator Detector

Detector module

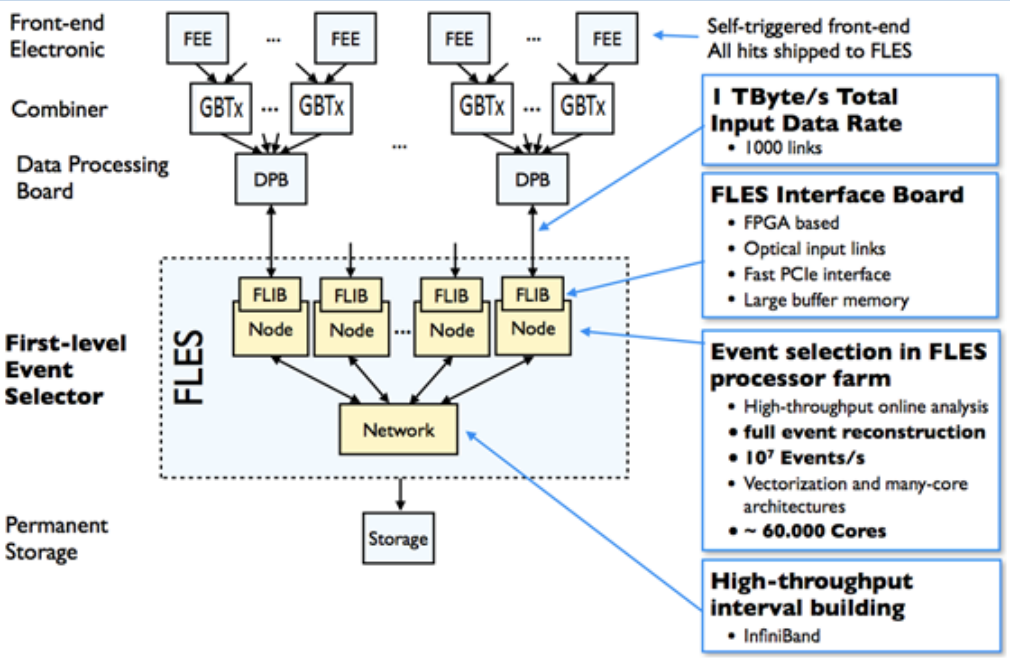
- *full compensating calorimeter*
- *44 modules with 20 x 20 cm^2 each*
- *60 lead/scintillator layers per module*
- *read out by MAPDs through wavelength shifting fibers*







DAQ and First-Level Event Selector



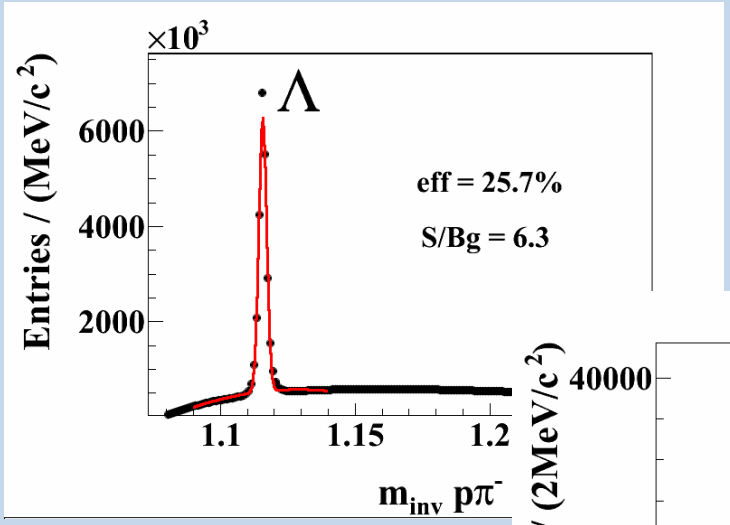
- *no hardware trigger: free-streaming FEE and DAQ with time-stamped messages*
- *data rate up to 1 TB/s*
- *high-throughput event building and –selection in software on an online computer farm (FLES)*
- *data reduction by several 100 before storage*

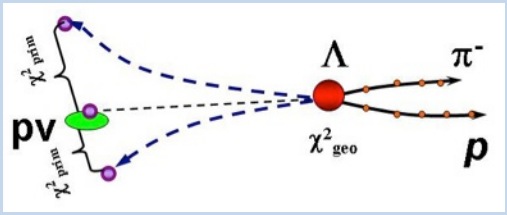
FLES prototype: Loewe CSC Frankfurt

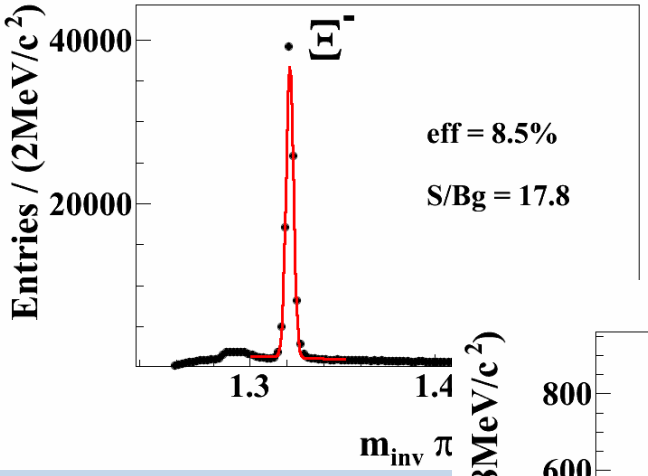
SIS-100 and SIS-300

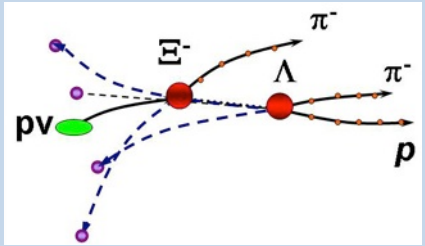
- SIS-100 and CBM are part of the FAIR Modularised Start Version (MSV)
- SIS-300 is not; not yet funded; timeline unsure
- we concentrate now on CBM@SIS-100
  - Au: 2A – 11A GeV
  - Ni: 2A – 15A GeV
  - p: up to 30 GeV
- staying open for SIS-300 as later upgrade

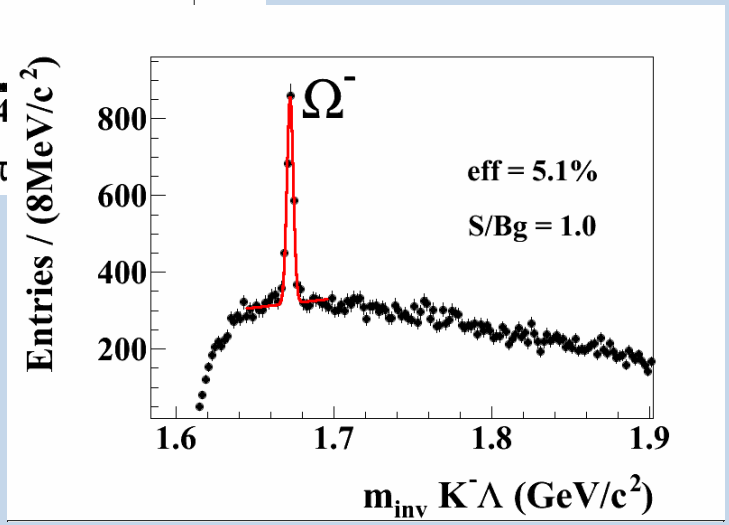
Performance for Hyperons





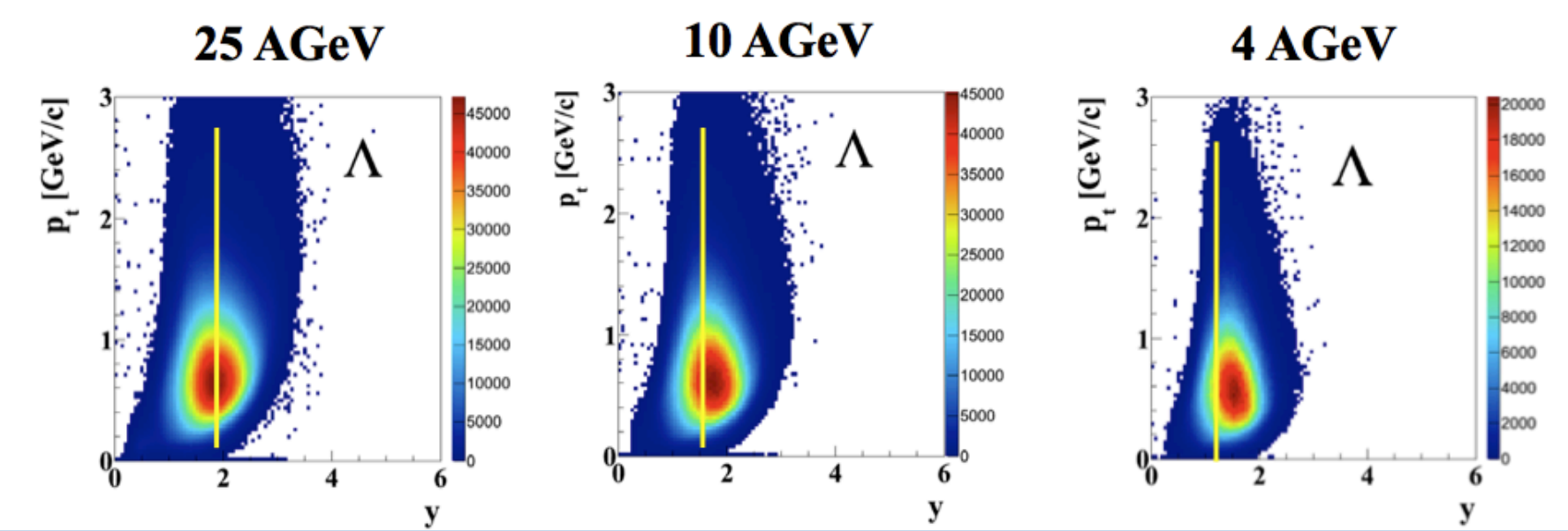






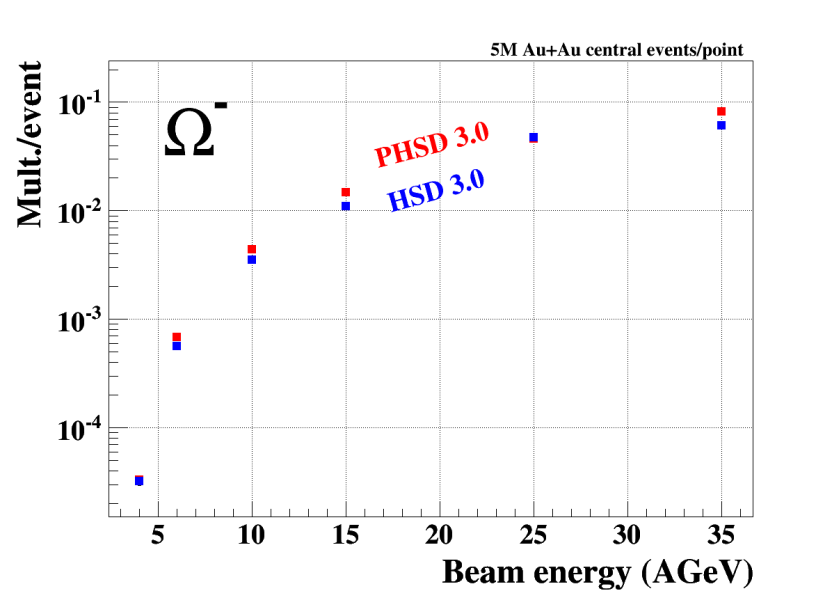
Input: UrQMD, central Au+Au, 10A GeV

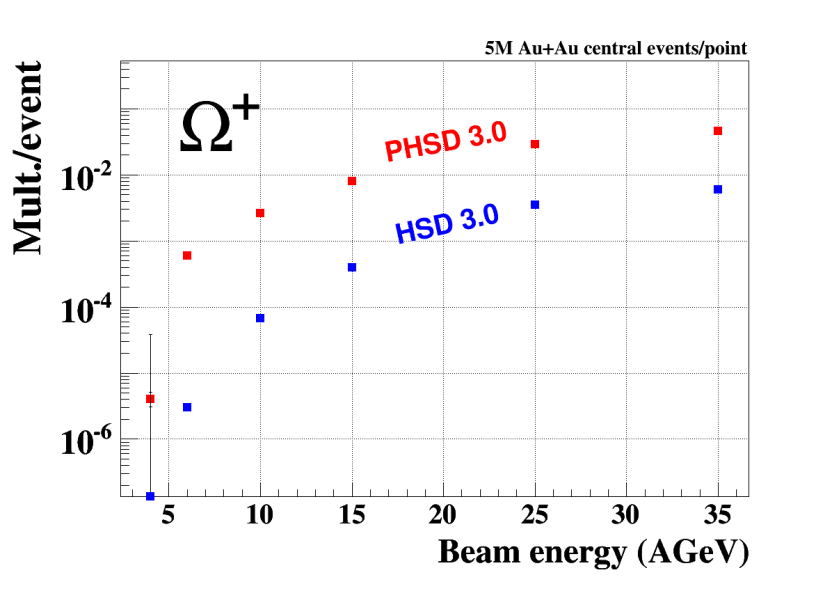
Hyperons: Phase-Space Coverage



Ant-Hyperons: Even More Interesting?

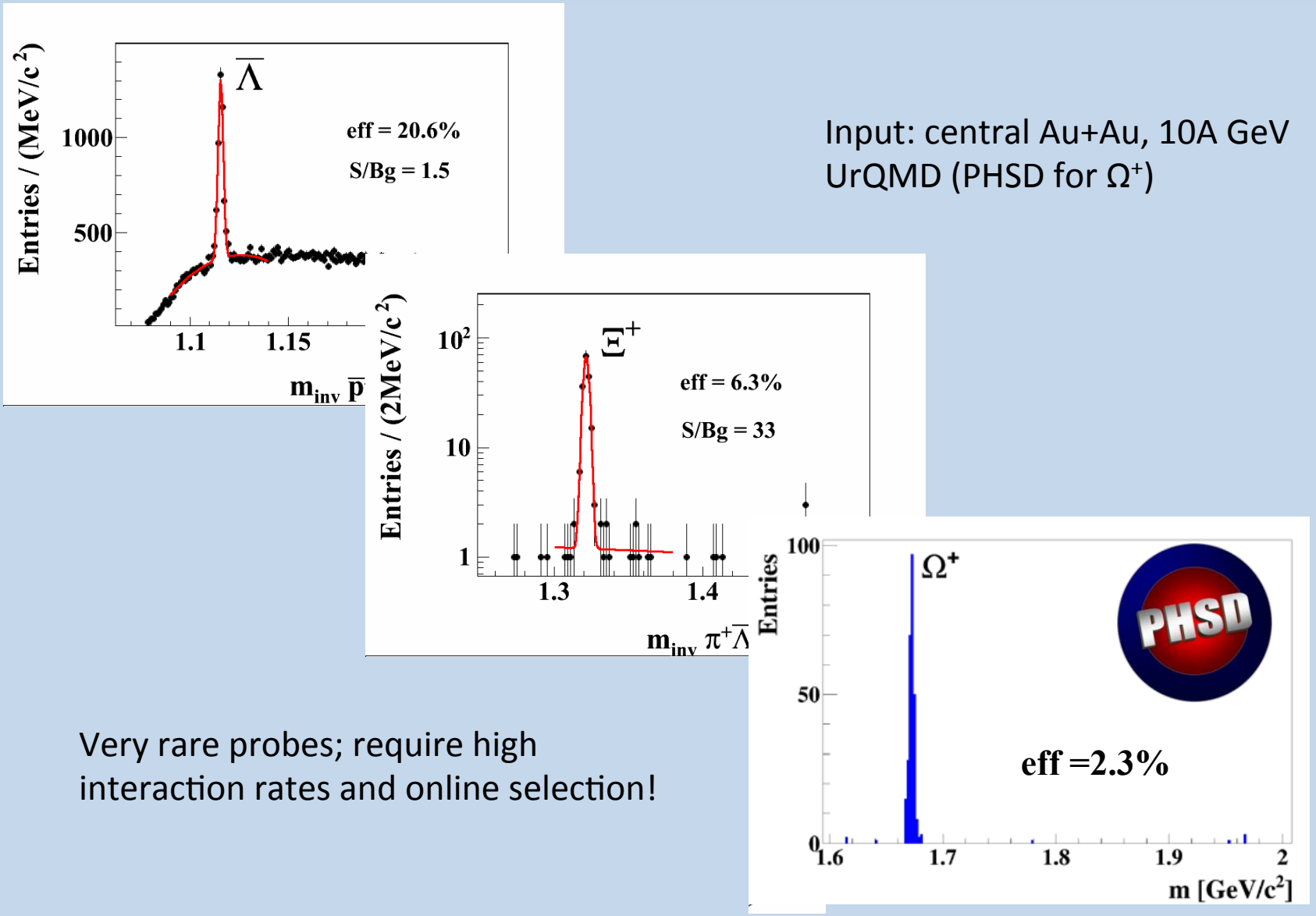
PHSD central Au+Au, preliminary





PHSD prediction:
QGP formation manifests much more visibly in multi-strange anti-hyperons

Performance: Anti-Hyperons



Input: central Au+Au, 10A GeV
UrQMD (PHSD for Ω^+)

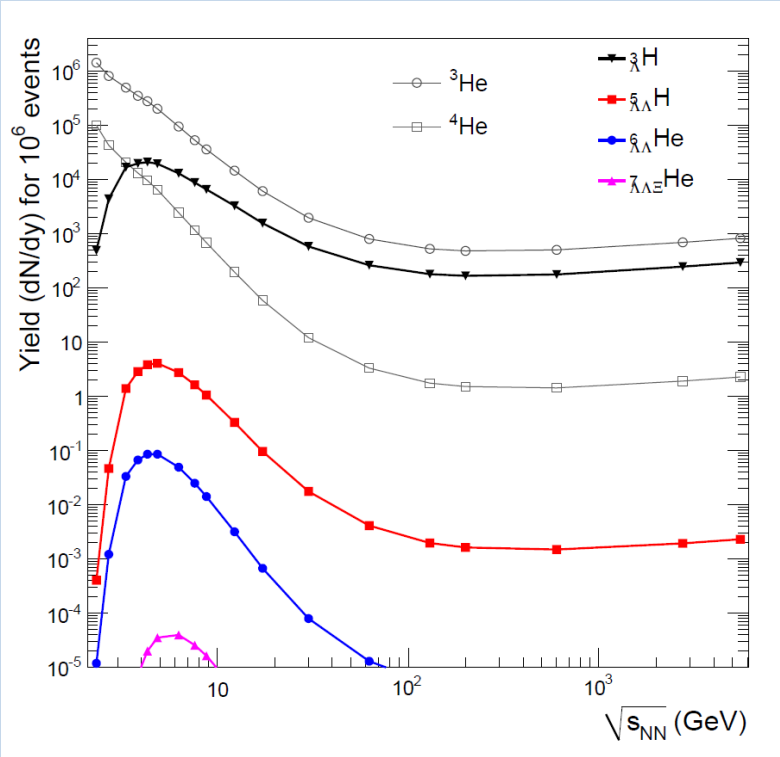
Very rare probes; require high interaction rates and online selection!

Hyperons: Expected Statistics

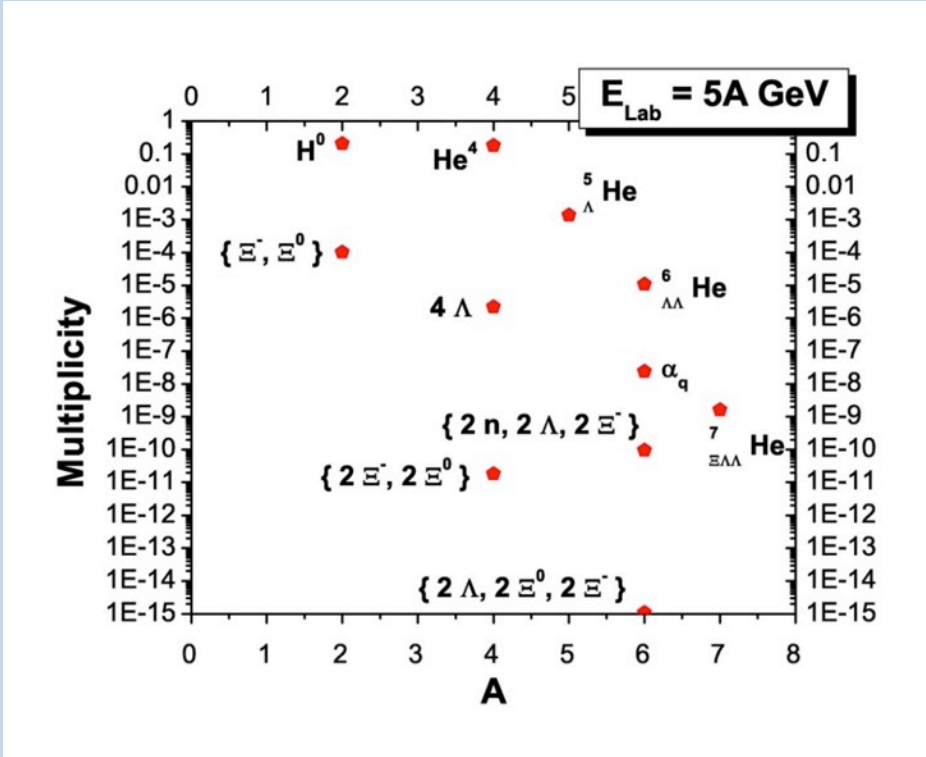
Au+Au 10 AGeV	Λ	Ξ^-	Ω^-	Ω^+
decay channel	$p\,\pi^-$	$\pi^-p\,\pi^-$	$K^-\,p\,\pi^-$	$K^+\bar{p}\,\pi^+$
$\mathbf{M_{UrQMD\ 3.3}}$	17.4	0.22	5.5E-3	6.7E-5
BR(%)	63.9	~100	67.8	67.8
total eff. (%)	**25.7**	**8.5**	**5.4**	**2.3**
$\mathbf{S/B_{2\sigma}}$	**.3**	**17.8**	**1.0**	**~10**
Reco yield/sec. ~ 1MHz	**4.5M**	**20k**	**280**	**1.5**

Hyper-Nuclei and Strange Di-Baryons

Model predictions: FAIR energy range is best suited for the production of hyper-nuclei

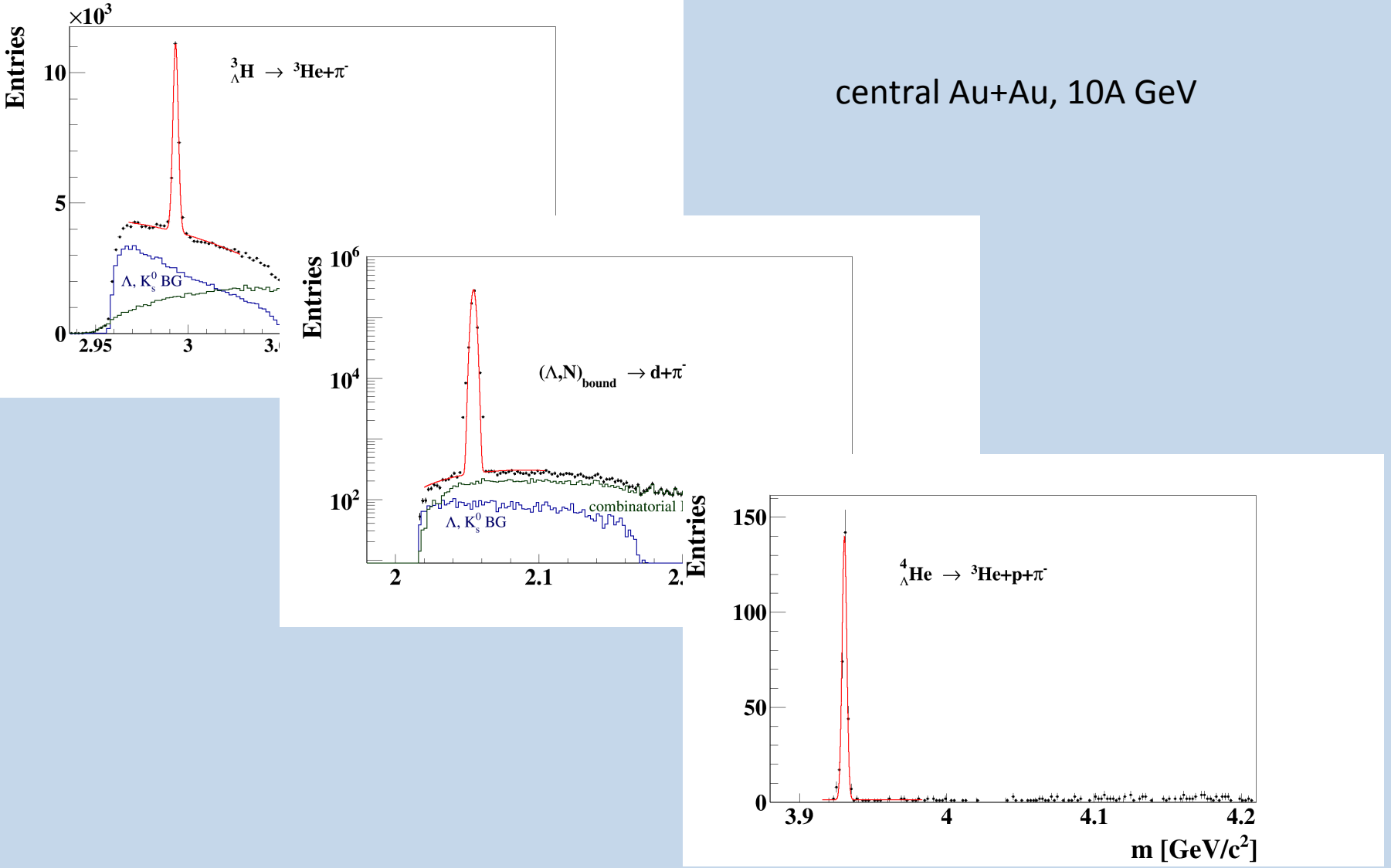


A. Andronic et al., Phys. Lett. B697 (2011) 203



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

Sensitivity to Hypermatter

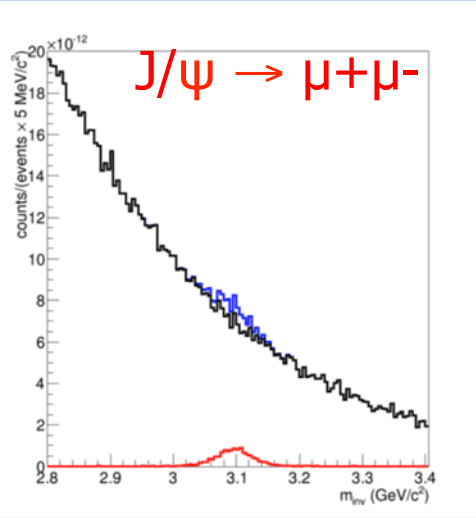


central Au+Au, 10A GeV

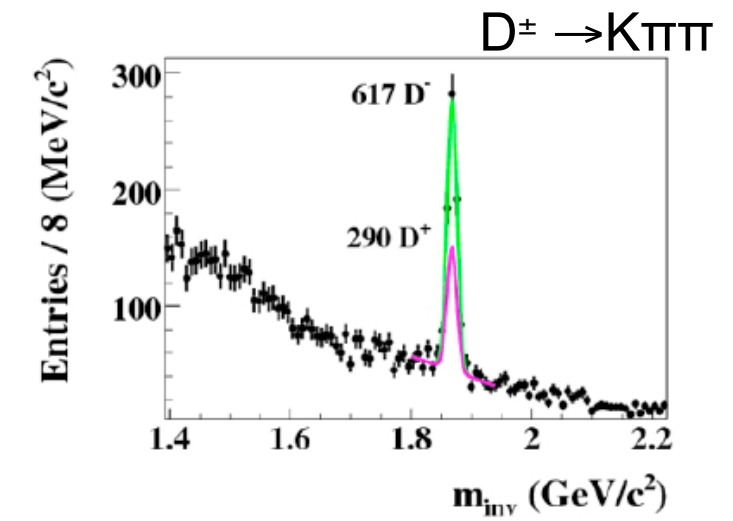
Charm? At SIS-100?

- The CBM charm programme is tailored for SIS-300 energies
- At SIS-100:
  - charmonium at top energy: Au+Au, 11A GeV (sub-threshold, extremely challenging)
  - Z/A = 0.5 (e.g., Ni+Ni) @ 15A GeV (slightly above threshold)
  - open and hidden charm in p+A up to 30 GeV (c-cbar cross section, cold matter effects)

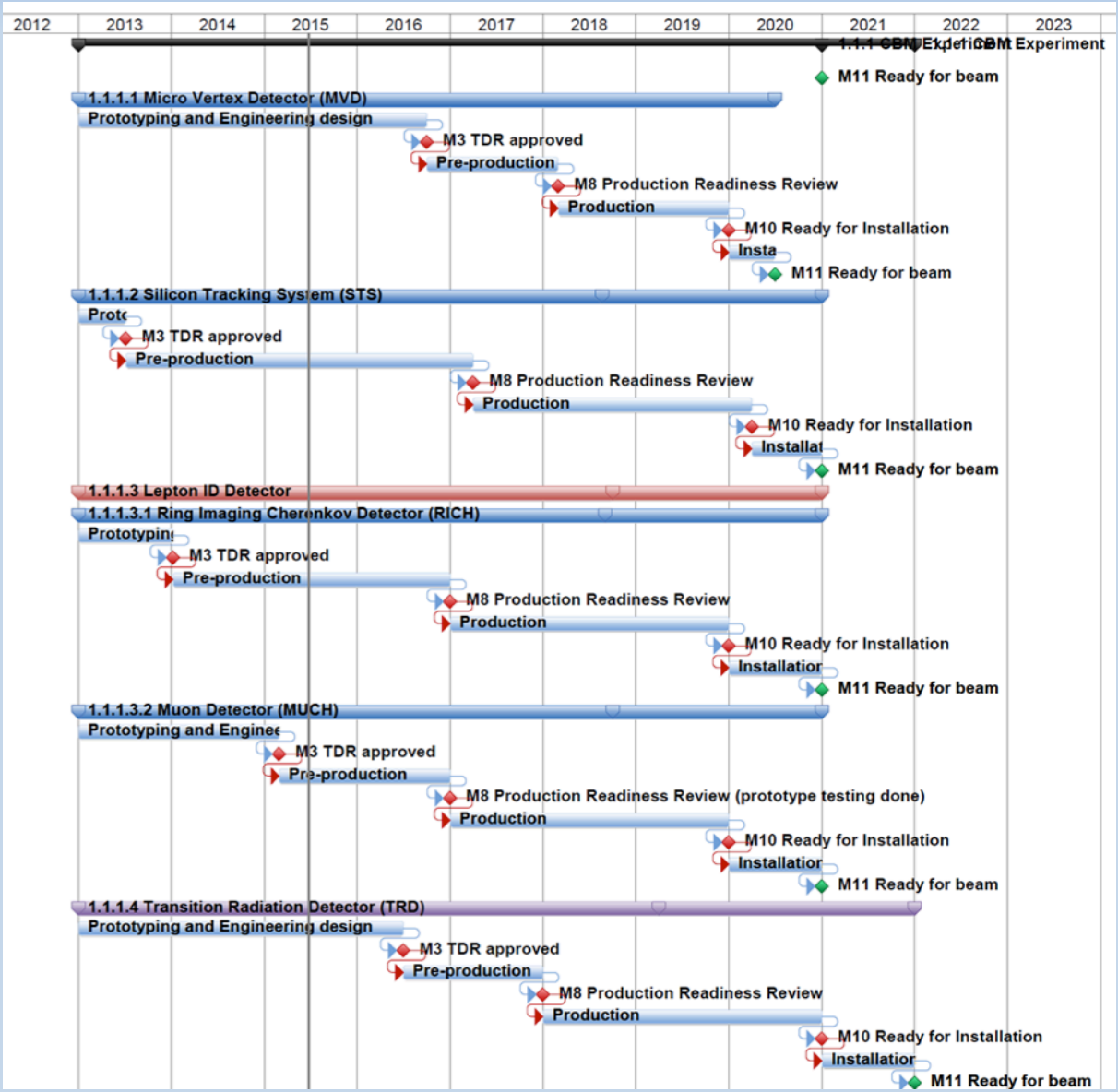
central Au + Au, 10A GeV



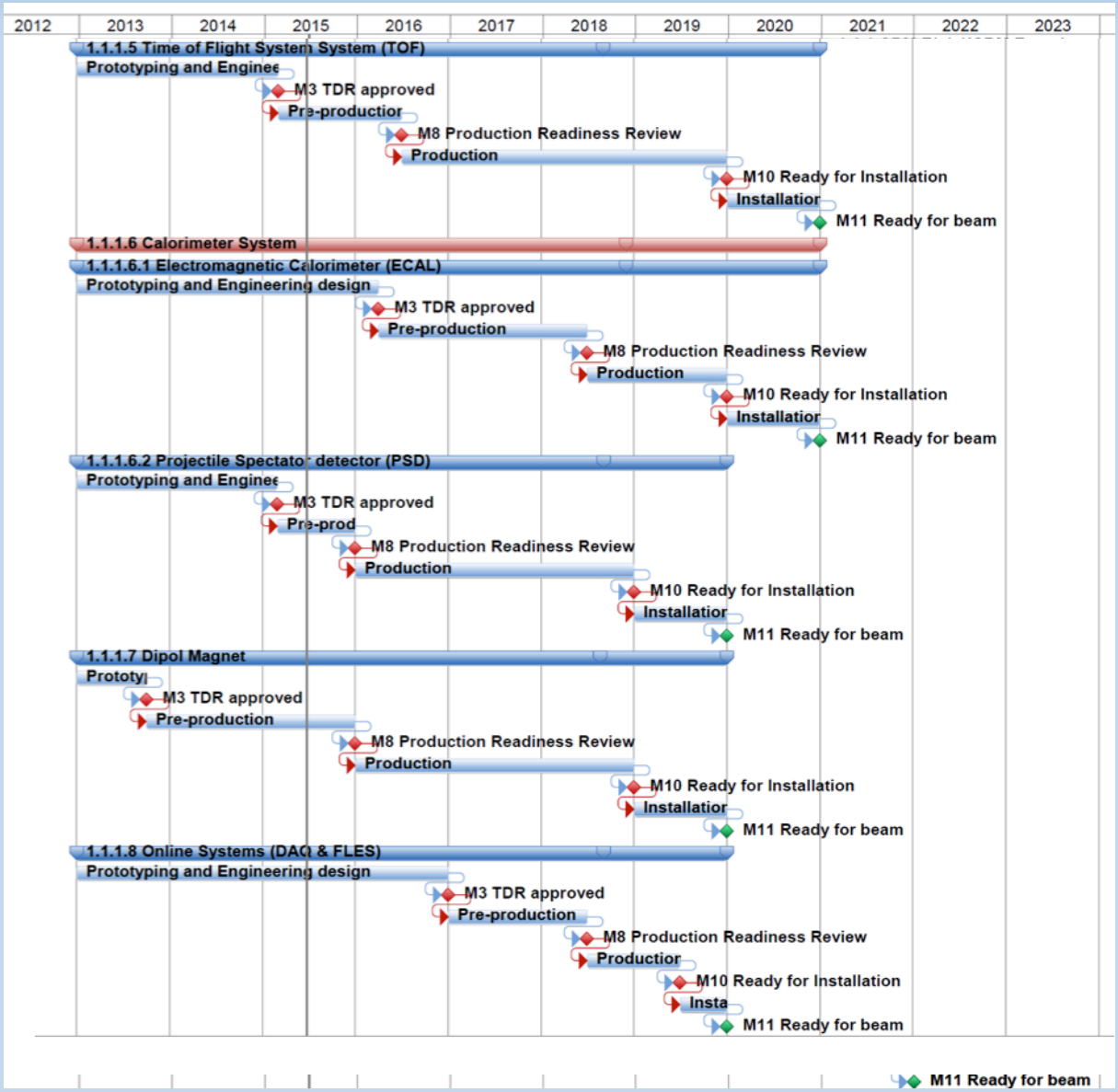
p + C, 30 GeV



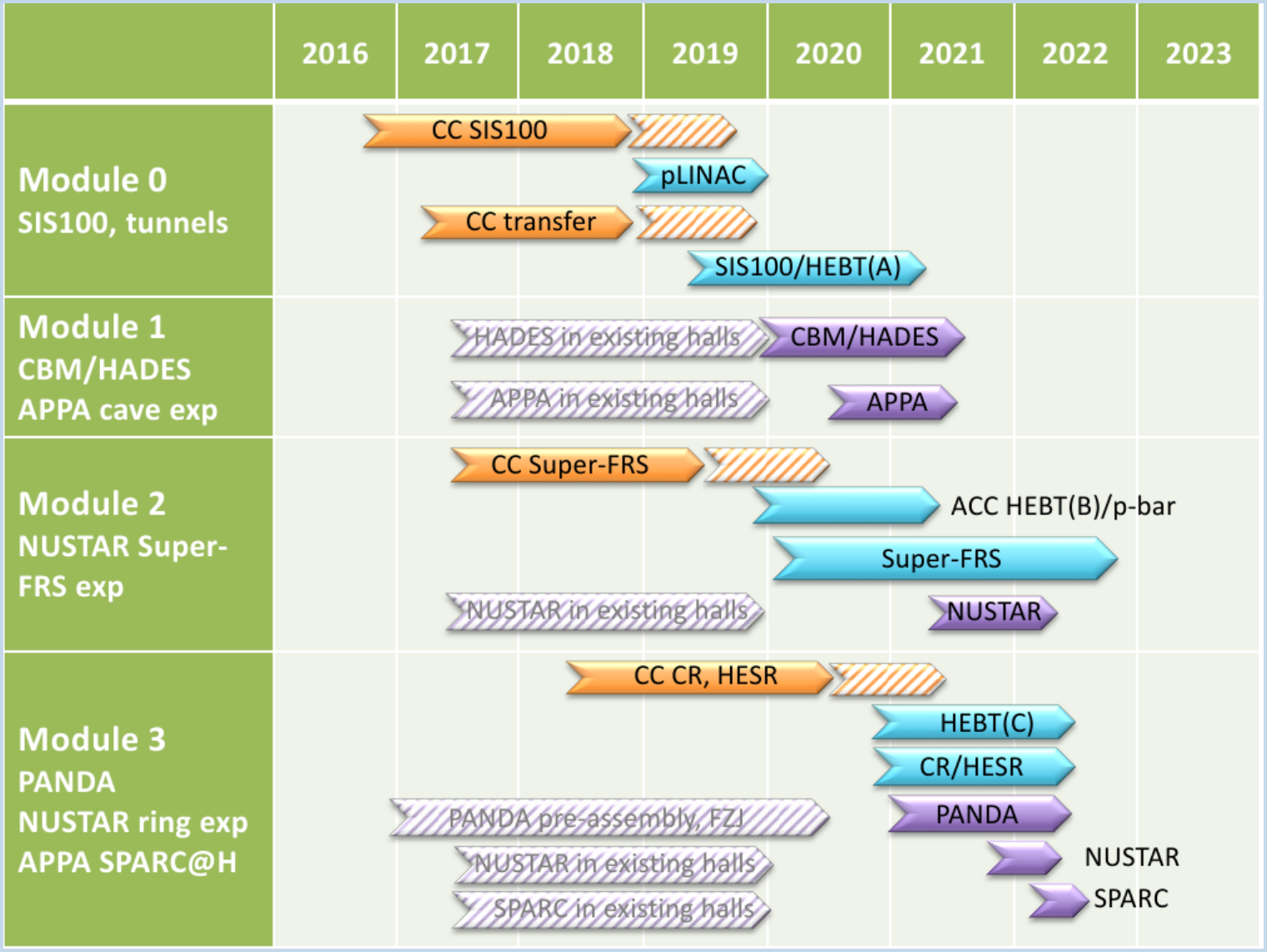
CBM Timeline (1)



CBM Timeline (2)

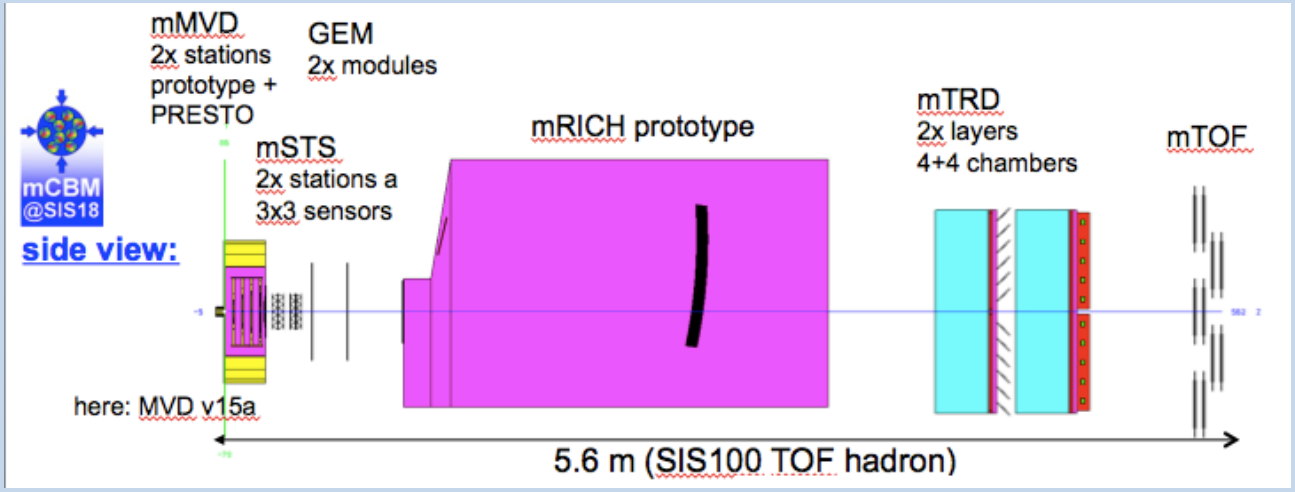


FAIR Timeline



Strategy Towards First Beam From SIS-100

- In view of FAIR delay:
  - install and commission CBM detector elements at other facilities
    - TOF->STAR; STS->BM@N; MVD, PSD->NA61
  - build mCBM at SIS-18 beamline to test interplay of systems and the full data chain



- objective: gain operational experience to minimize start-up time at SIS-100

Summary

- CBM is moving on:
  - most TDRs approved
  - entering pre-production phase
  - completion of systems end of 2019
- First measurements at SIS-100: sytematic, high-precision, multi-differential measurements of multi-strange (anti-)hyperons, hyper-nuclei, search for exotica, di-lepton spectra in the energy range 2A – 11A GeV
  - from 2021 on