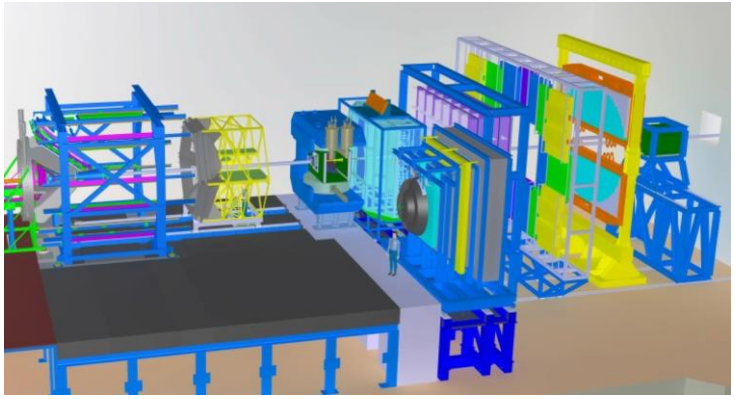


Status of the
Compressed Baryonic Matter Experiment at FAIR

Hans Rudolf Schmidt
University of Tübingen & GSI Darmstadt

EPS Conference on High Energy Physics
Venice, Italy 5-12 July 2017

Outline

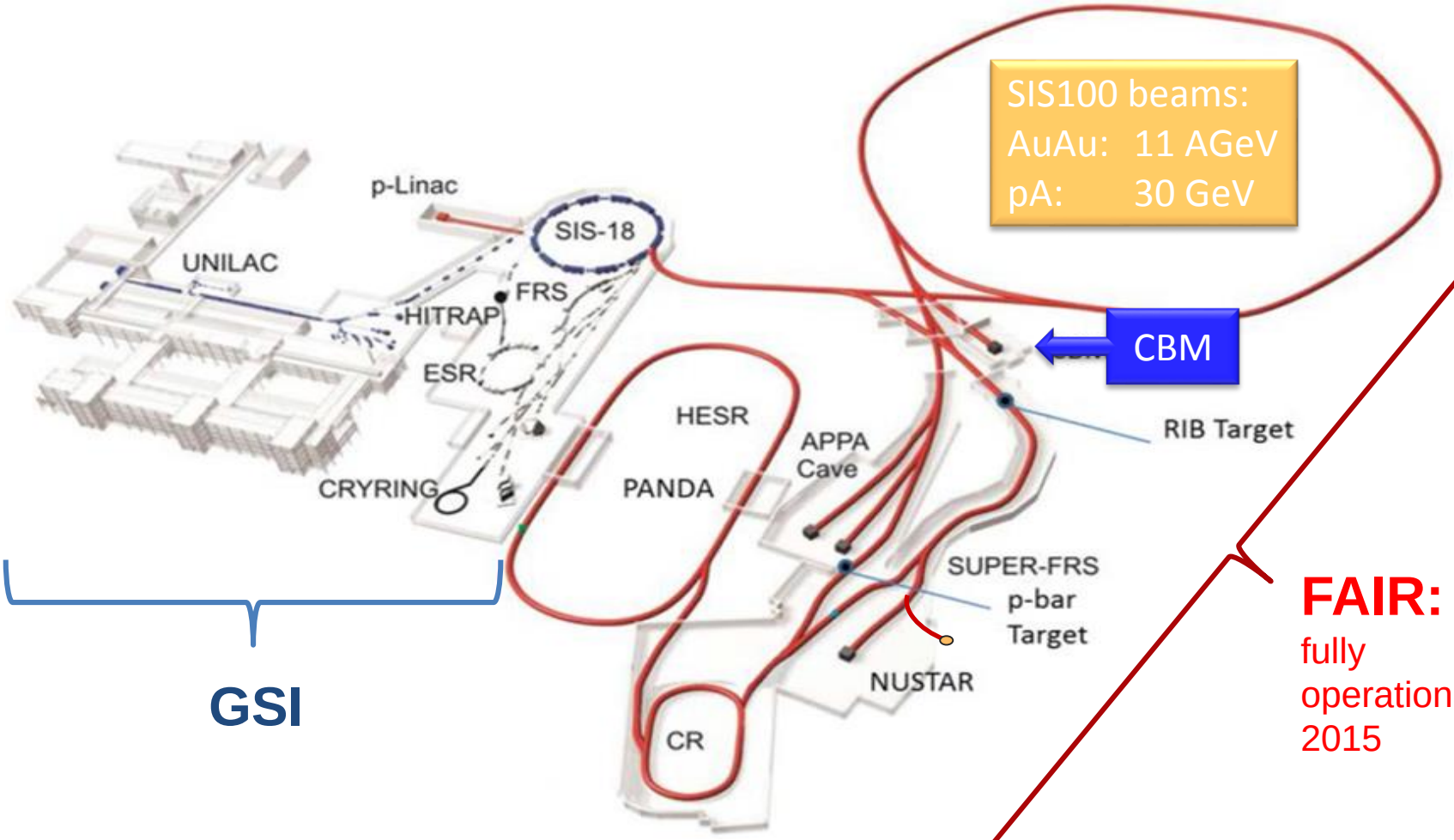
- Physics: Exploration of Dense Matter with new, rare probes
  - Focus(*) on strange matter
    - (sub)threshold production of multi-strange hyperons
    - (double)-hyper-nuclei

  } unique feature of CBM

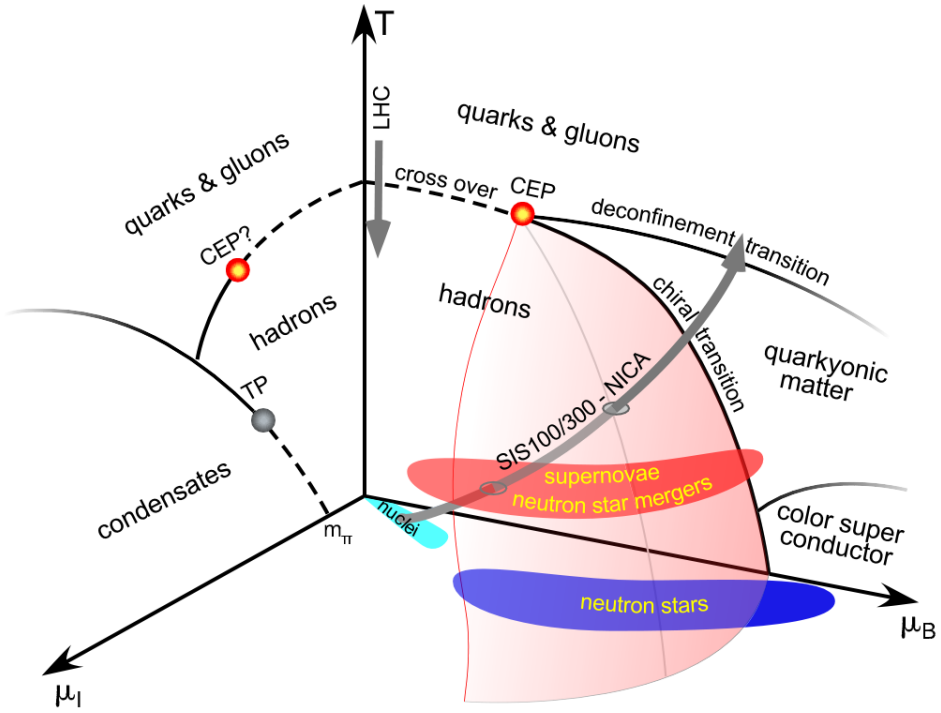
- Status of CBM
  - CBM-FAIR Phase 0 program

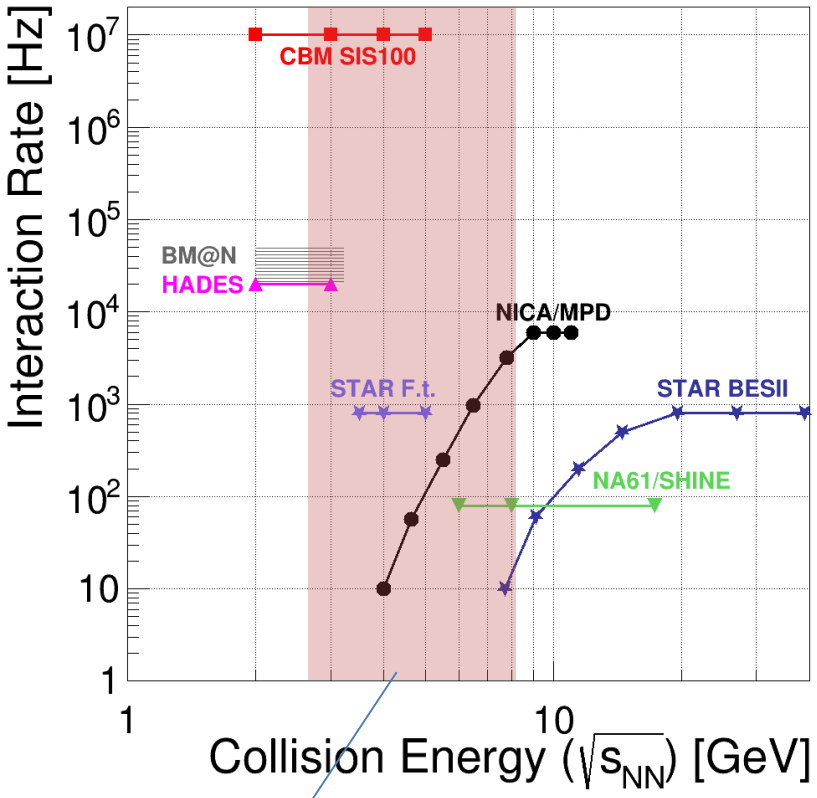
  - (*) Not covered (because of time constraints)
    - bulk observables
      - fluctuations, correlations, ….
    - Hadrons in Dense Matter
      - low mass vector mesons
      - charm & open charm
    - Dileptons

FAIR Accelerator Complex



Probing the QCD 3D-Phasedigramm





- equation of state (EOS) at neutrons star densities
- search for the limits of hadronic existence at moderate temperature and high density
- QCD critical end point

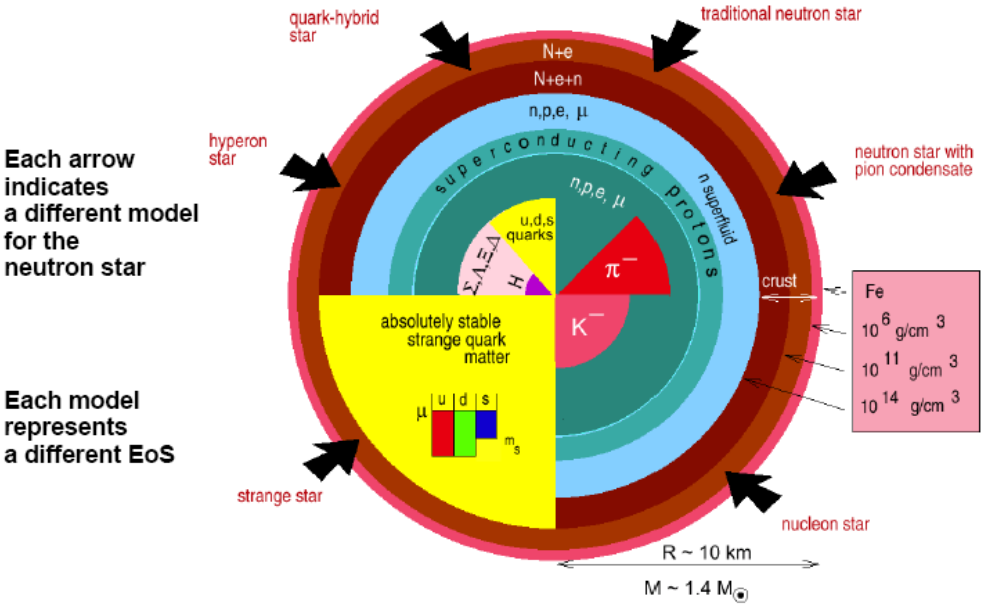
highest net-baryon densities

note: at CBM energies $1min$ CBM $\sim 1\ y$ STAR@RHIC

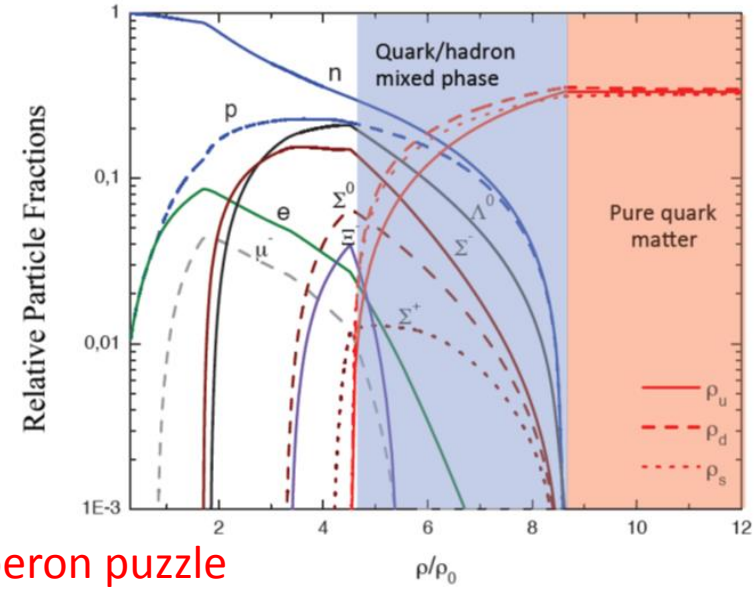
CBM Physics

QCD matter at finite baryon densities is not understood, neither experimentally not theoretically!

Example:



M. Orsaria, H. Rodrigues, F. Weber, G.A. Contrera
Phys. Rev. D 87, 023001 (2013)

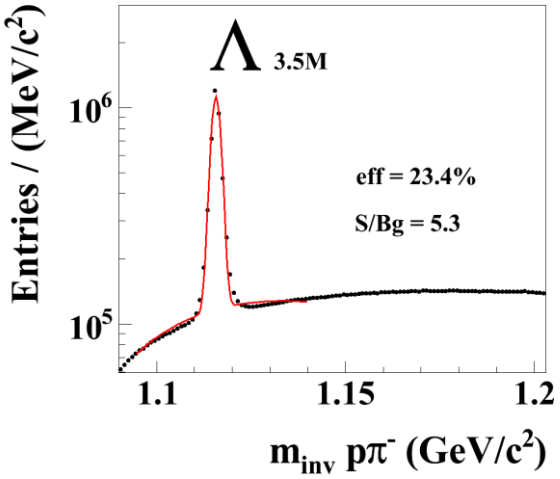


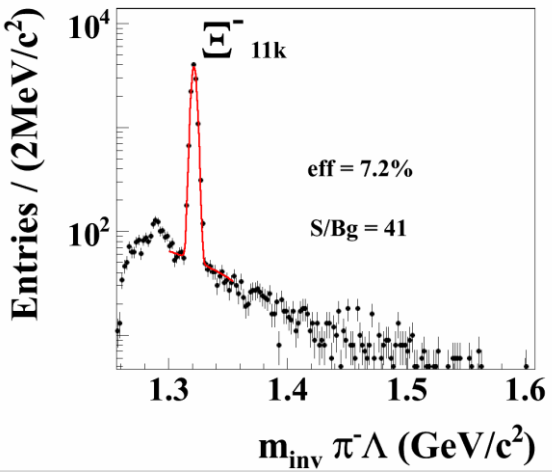
recent observation of a $\frac{M}{M_\odot} \approx 2$ Neutron Star → hyperon puzzle

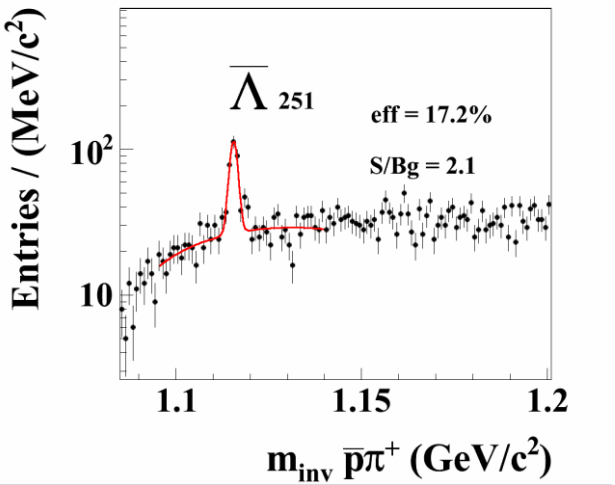
- not stable against gravitational collaps with soft EOS, i.e., a $2M_\odot$ NS should not exist!
- stable Neutron Star with quark-hadron mixed phase incl. hyperons possible (?)
  - EoS of hybrid matter (soft, hard ?)

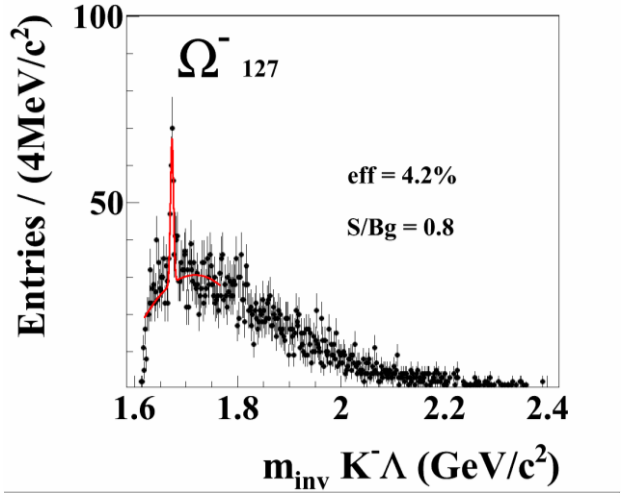
CBM as a „Hyperon Factory“

Simulations: Au+Au at 8 A GeV, 10^6 central collisions
promise and challenge of CBM: data taking of a few seconds at 10^7 Hz



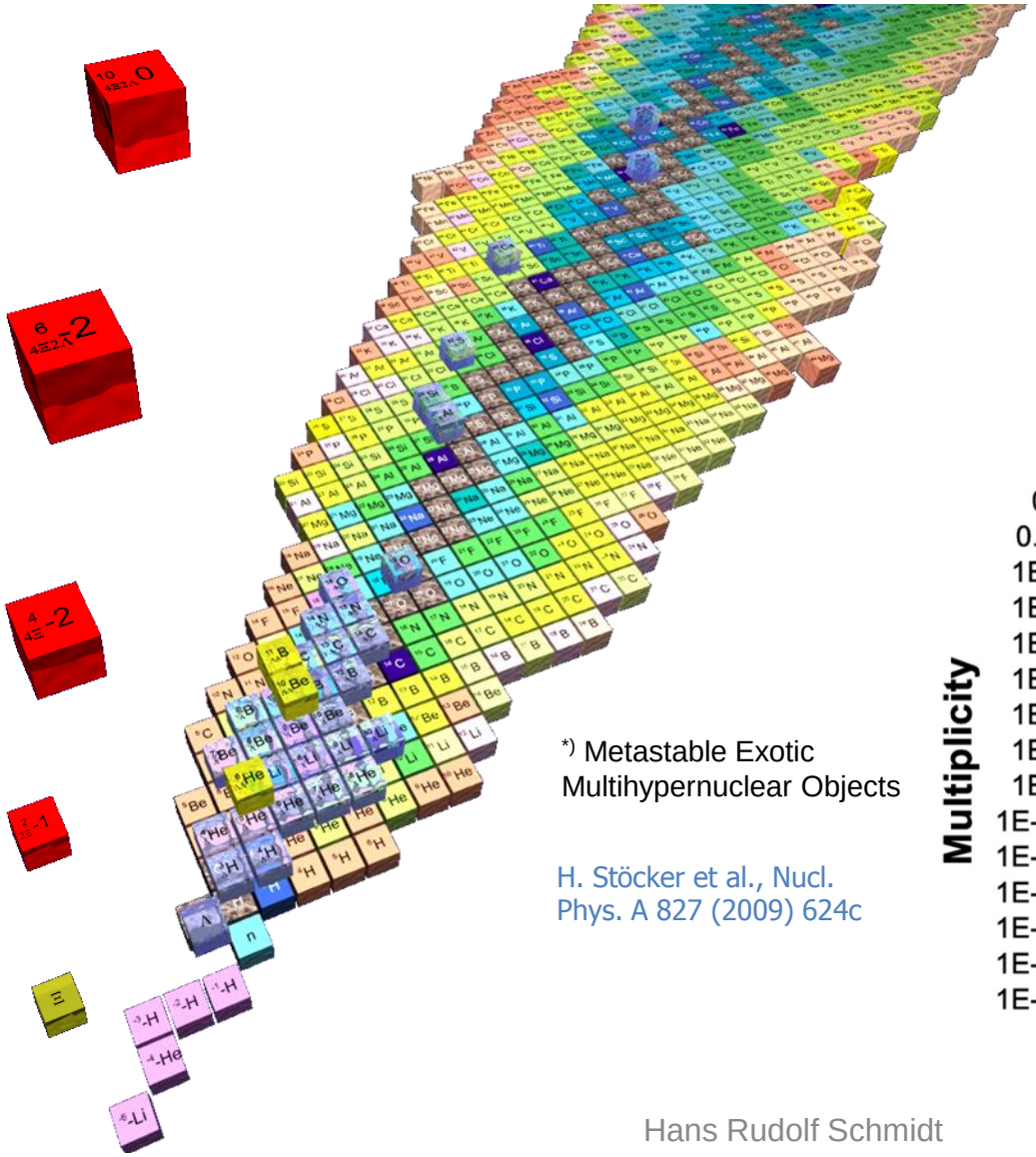






- sub-threshold production cross section of Ξ^-, Ω^- probes dense, baryonic matter….
- little data in the CBM energy range
- In addition: kaons and baryon resonances (K*,Λ*,Σ*,Ξ*)

Multi-Strangeness

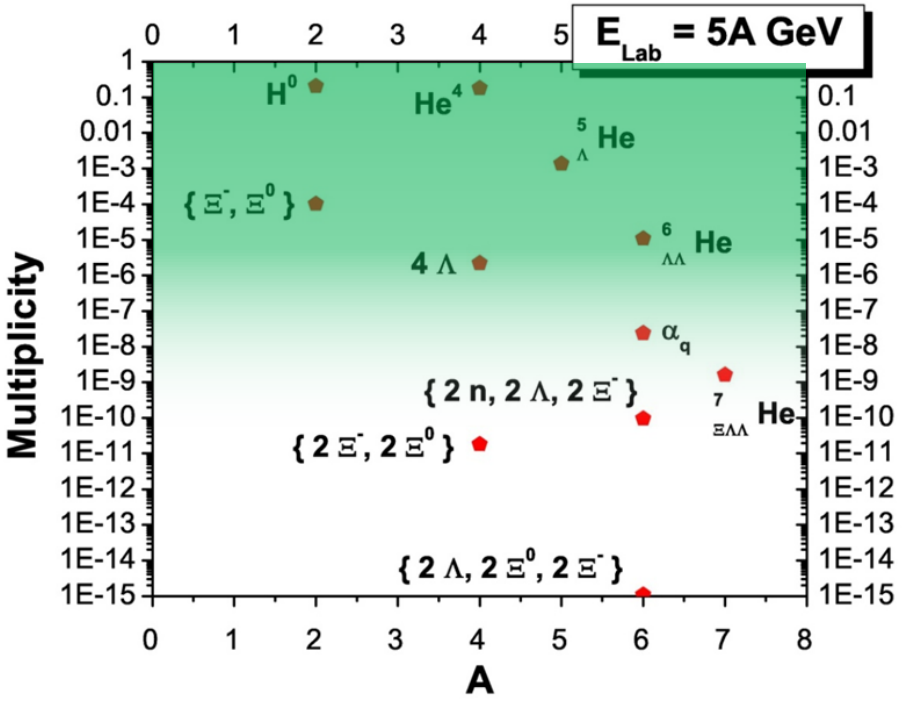


*) Metastable Exotic Multihypernuclear Objects

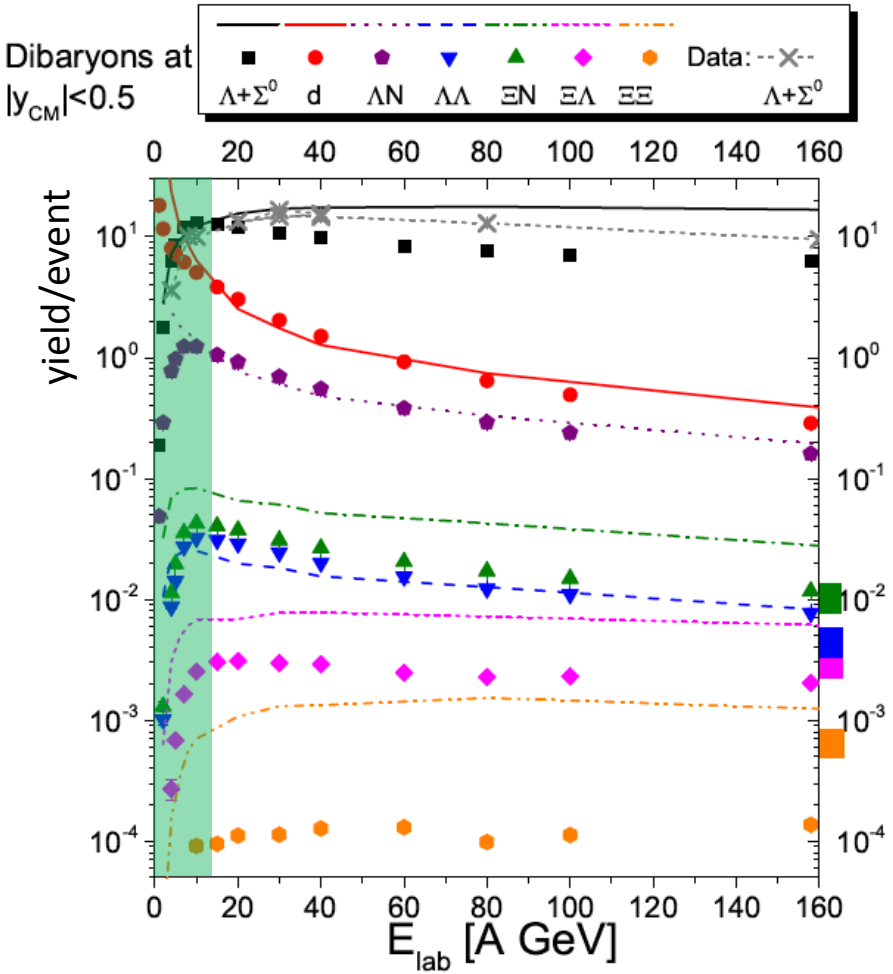
H. Stöcker et al., Nucl. Phys. A 827 (2009) 624c

search for

- hyperon correlations
  - ✓ $\Lambda\Lambda, \Lambda\Sigma, \ldots$
- double hyper-nuclei
  - ✓ ${}^{5}_{\Lambda\Lambda}H, {}^{6}_{\Lambda\Lambda}He$
- MEMOS*)
  - ✓ $(\Xi^0\Xi^-)_b, (\Xi^0\Lambda)_b, \ldots$



Di-Baryons and Hyperons Correlations at FAIR/CBM?

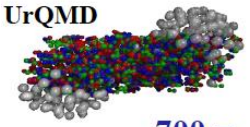


lines: UrQMD + thermal hydrodynamics
symbols: DCM + coalescence

PHSD

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

UrQMD



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

copious production of hyperons (due to high rate) and favorable phase space make CBM@FAIR a:

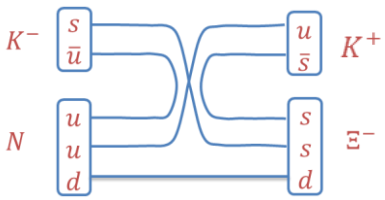
- di-baryon factory ☺

…but will at least provide good stat. correlation data (→ hyperon couplings) important to under neutron star EoS

J. Steinheimer, K. Gudima, A. Botvina, I. Mishustin, M. Bleicher, H. Stöcker, Phys. Lett B714 (2012) 85

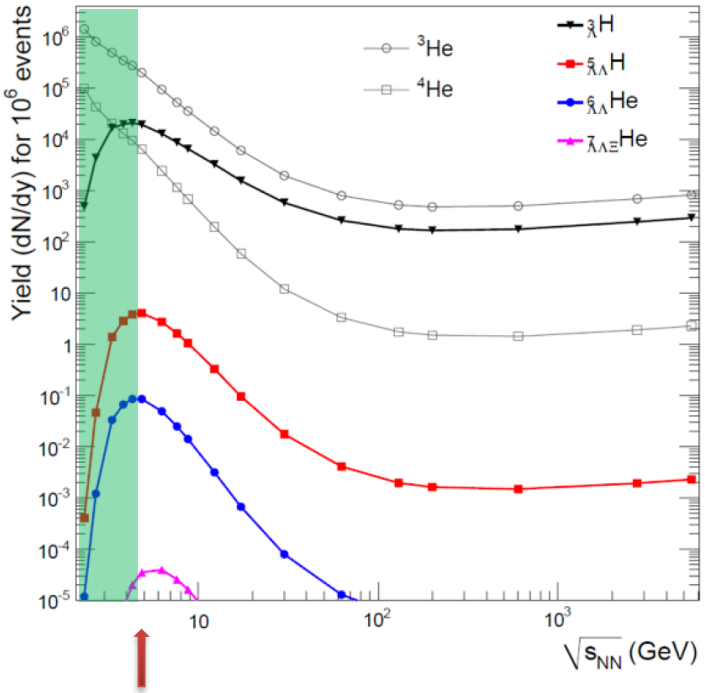
Search for Double Hypernuclei

conventional production mechanism*):



$$+ \quad \Xi^- + {}^{12}C \rightarrow {}^{\ 6}_{\Lambda\Lambda}He + {}^{4}He + t$$

A. Andronic, P. Braun-Munzinger, J. Stachel, H. Stöcker , PL B697 (2011) 204



coalecense probability has maximum at $\sqrt{s_{NN}} = 4 - 5\ GeV$

<u>heavy collisions:</u>
production via coalescence of Λ with light fragments

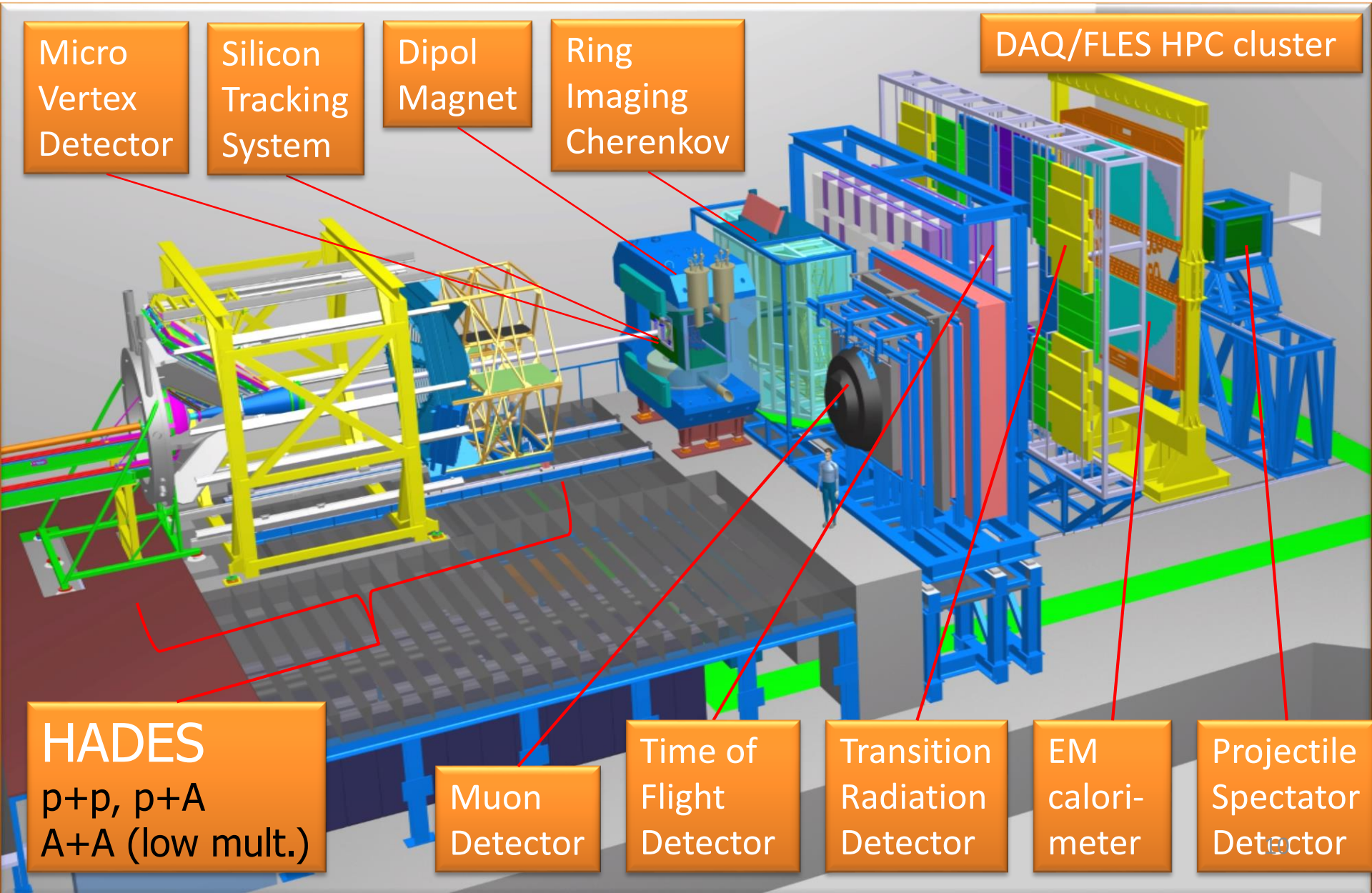
40 AGeV: 50 $\Lambda's$/central Au+Au collision
10 AGeV: 15 $\Lambda's$/central Au+Au collision

yield: $10^{-6}\ {}^{\ 5}_{\Lambda\Lambda}H, 3 \cdot 10^{-8}\ {}^{\ 6}_{\Lambda\Lambda}He$ /central collision

120/week 3.6/week

*) Takahashi et al, PRL 87 (2001)

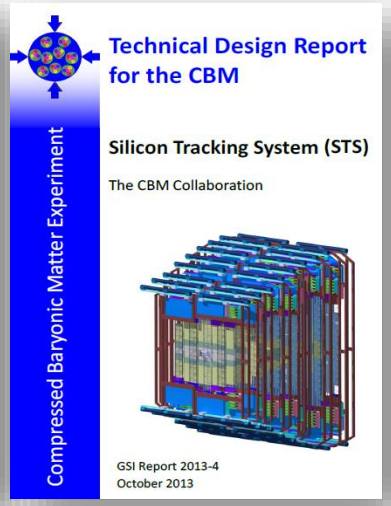
The CBM Detector System

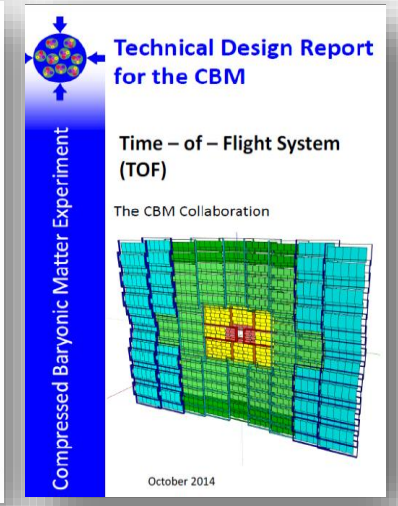


Technical Design Reports

#	Project	TDR Status
1	Magnet	approved
2	STS	approved
3	RICH	approved
4	TOF	approved
5	MuCh	approved
6	HADES ECAL	approved
7	PSD	approved
8	MVD	submission 2017
9	DAQ/FLES	submission 2017
10	TRD	submission 2017
11	ECAL	submission 2017

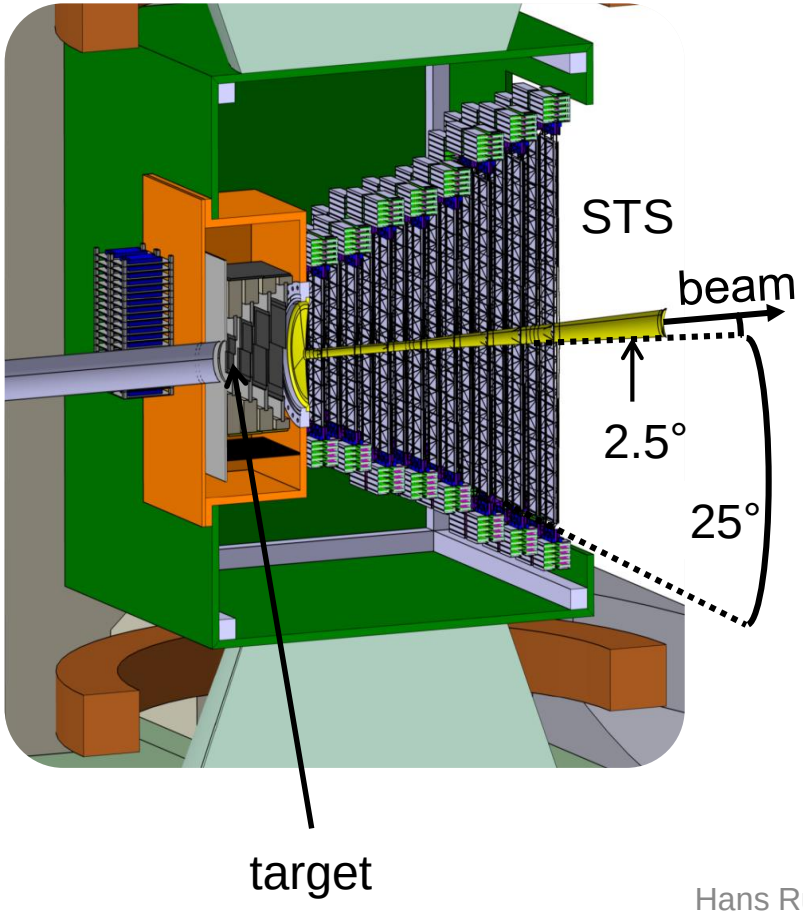
⇒ CBM start version is ready to be build



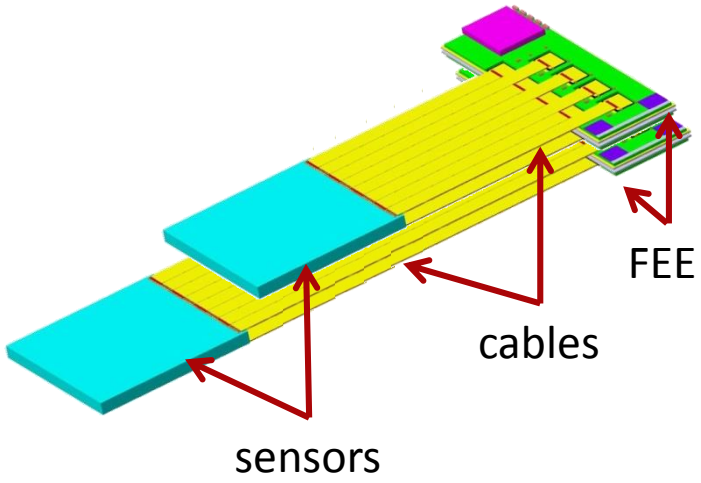


The Central Detection System: a Silicon Tracker

At SIS-energies (and design spatial resolution < 25 µm) the momentum resolution is dominated by multiple scattering, i.e., for good momentum resolution the active area has to be practically massless….



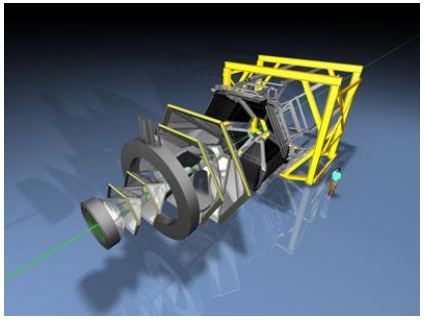
- readout electronics outside of active area
  - ultra-thin (long!) readout cables
- ultra light support structure
  - carbon fiber (-> ALICE)
- 300 µm μstrip sensor with double sided stereo readout



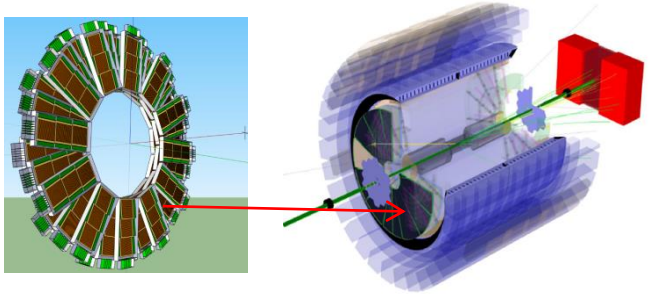
CBM-FAIR Phase 0 (>2018)

Hades physics programm@SIS18 (p+p, p+A, Ag+Ag 1.65 AGeV)

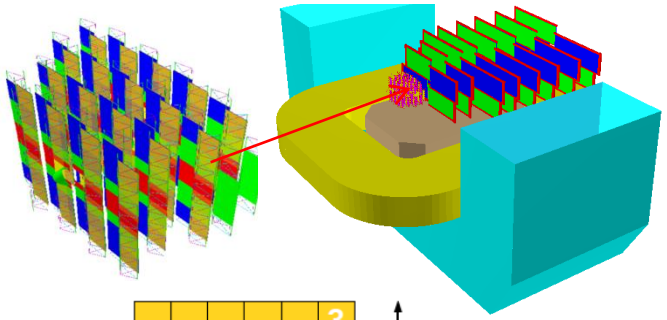
- Multi-strange baryons
- φ production study via K^+K^- and e^+e^-
- Dileptons around and beyond vector meson mass region



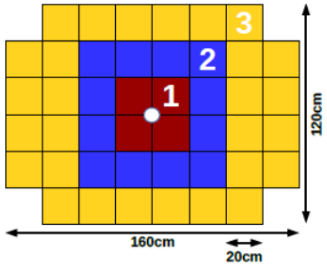
10% of the CBM TOF modules including read-out chain at STAR/RHIC (BES II 2019/2020)



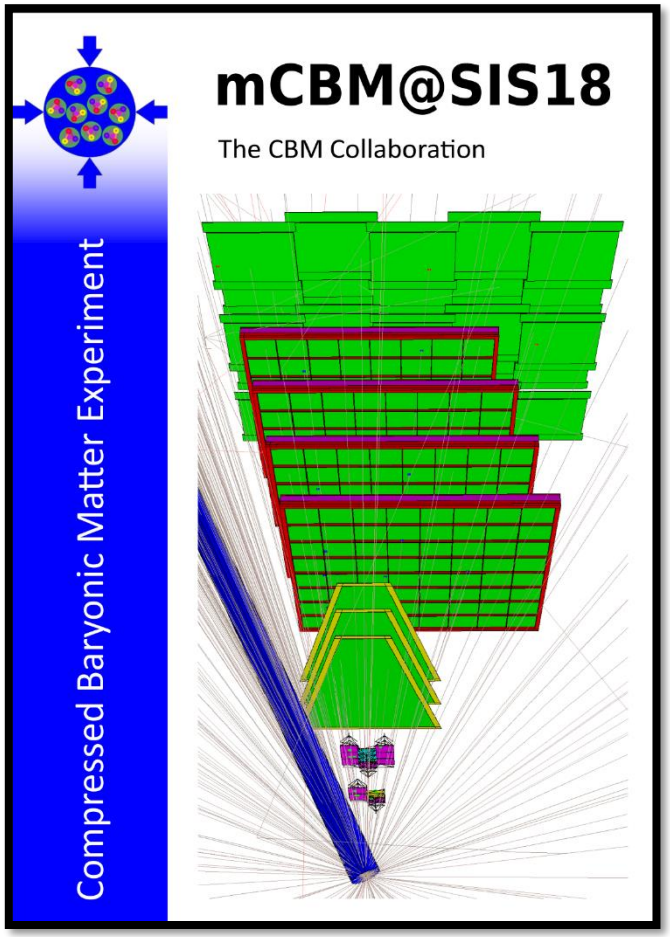
Silicon Tracking Stations in the BM@N experiment at the Nuclotron in JINR/Dubna (Au-beams up to 4.5 A GeV in 2018/19)



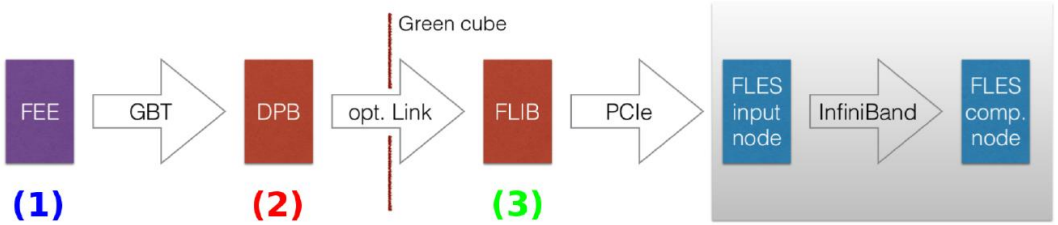
CBM Project Spectator Detector at the BM@N experiment



mCBM@SIS18 (>2018)



Demonstrator for full
CBM data taking and analysis chain



Test facility

- for high interaction rate operation (10MHz)
- free streaming readout
- online data compression

All CBM subsystems participating!

Summary

- CBM will measure rare probes at unprecedented interaction rates
- CBM (FAIR Phase-0) program starts 2018
- CBM (day-1 @ SIS100) starts 2025