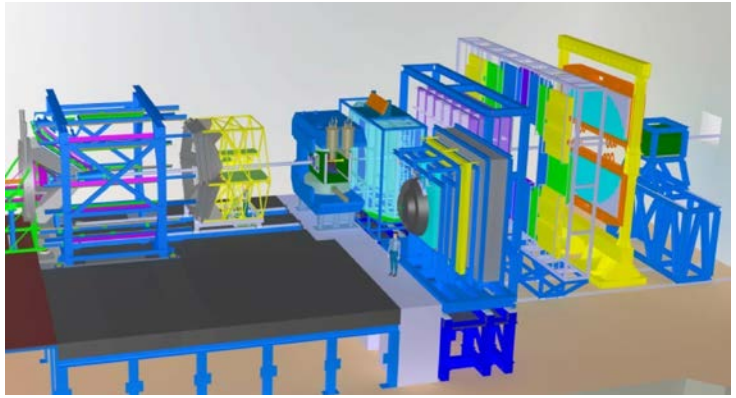


Status of the
Compressed Baryonic Matter Experiment at FAIR

Hans Rudolf Schmidt
University of Tübingen & GSI Darmstadt

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

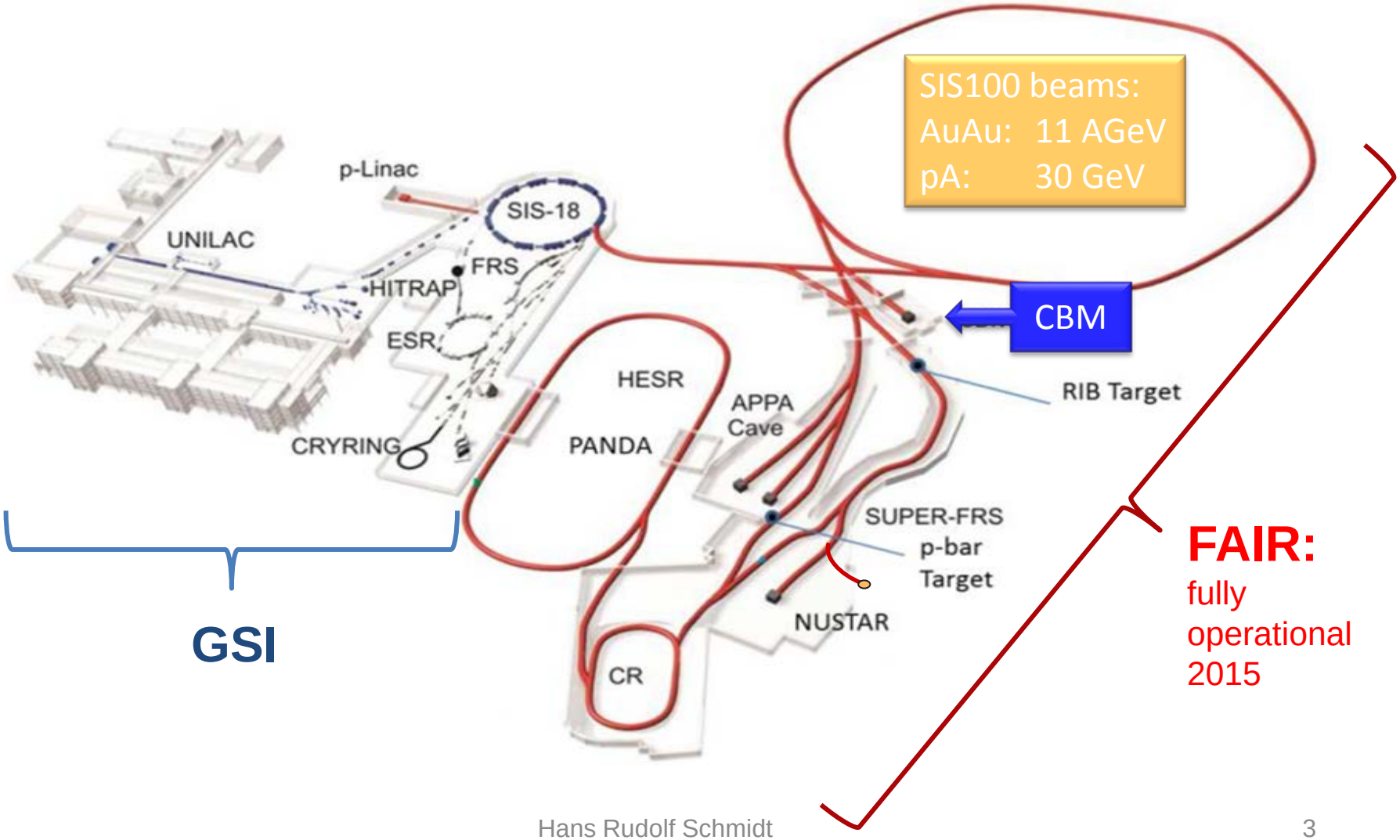
Outline

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

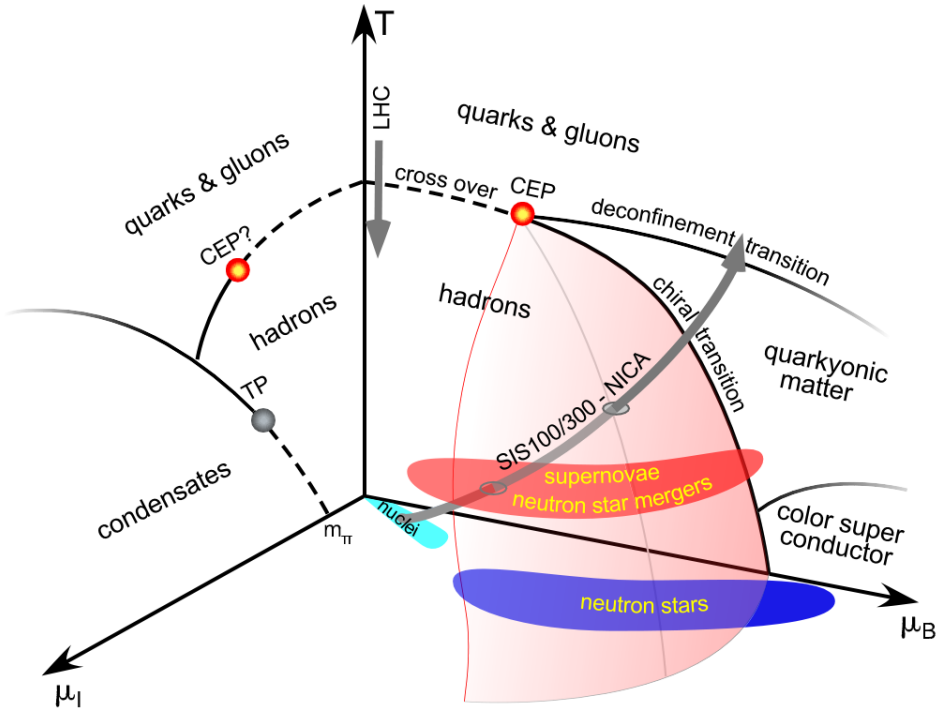
    } unique feature of CBM
- Status of CBM
  - CBM-FAIR Phase 0 program

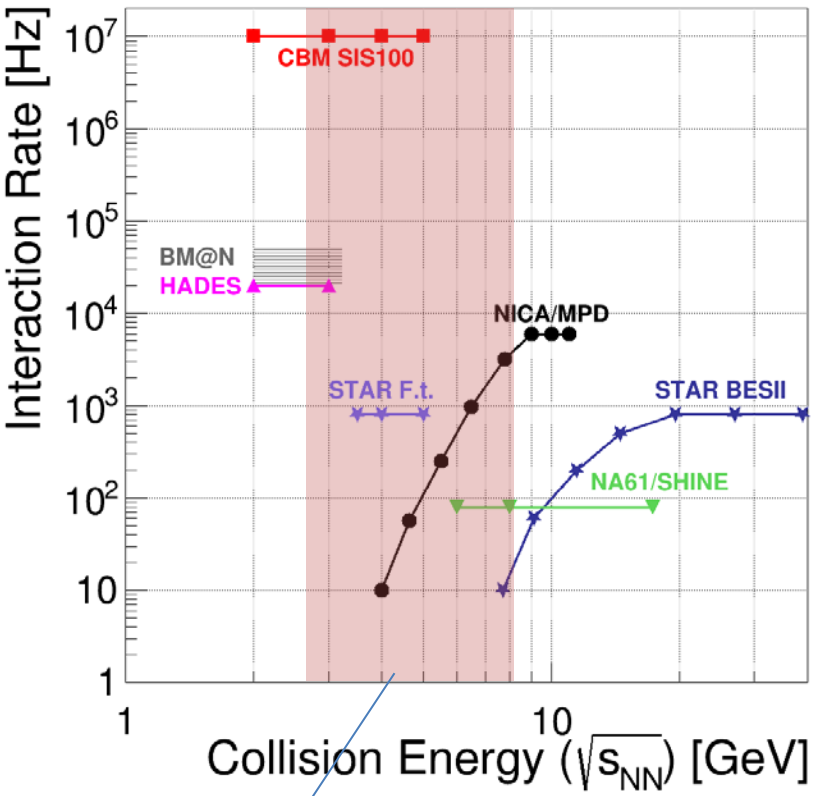
  - (*) Not covered (because of time constraints)
    - bulk observables
      - fluctuations, correlations, ….
    - Hadrons in Dense Matter
      - low mass vector mesons
      - charm & open charm
    - Dileptons

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

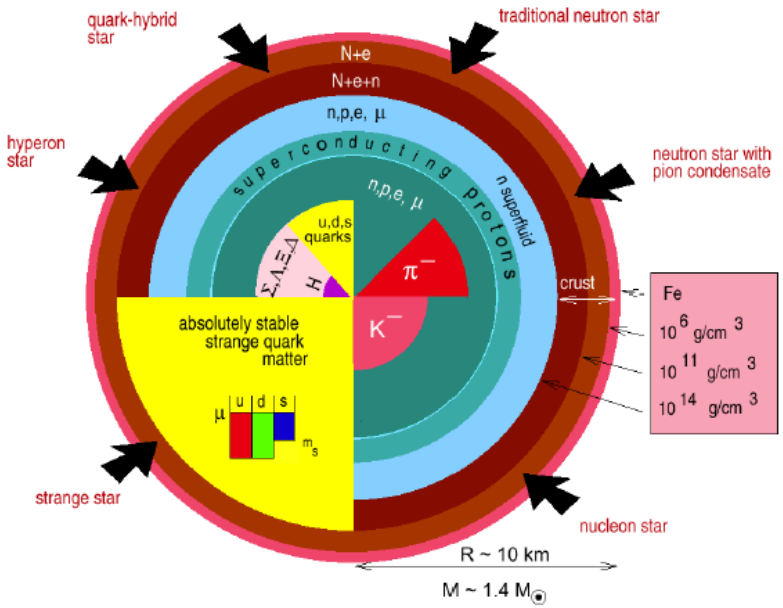
CBM Physics

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

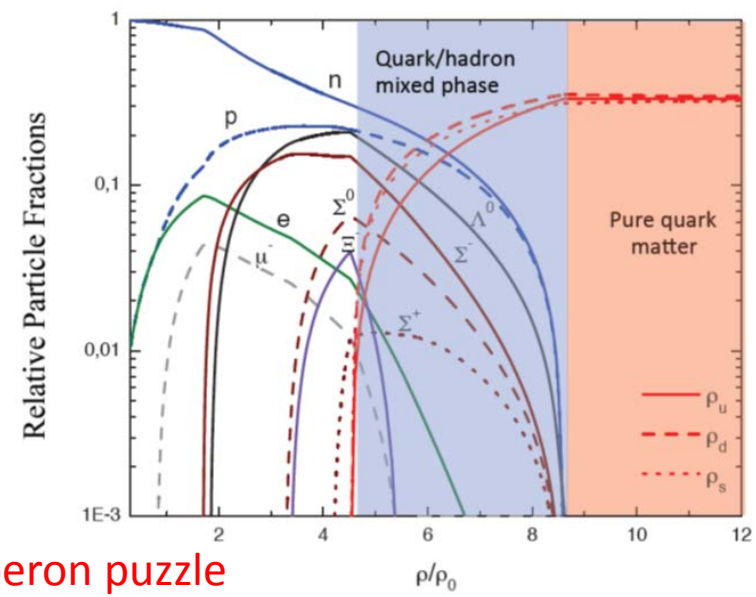
Example:

Each arrow indicates a different model for the neutron star

Each model represents a different EoS



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

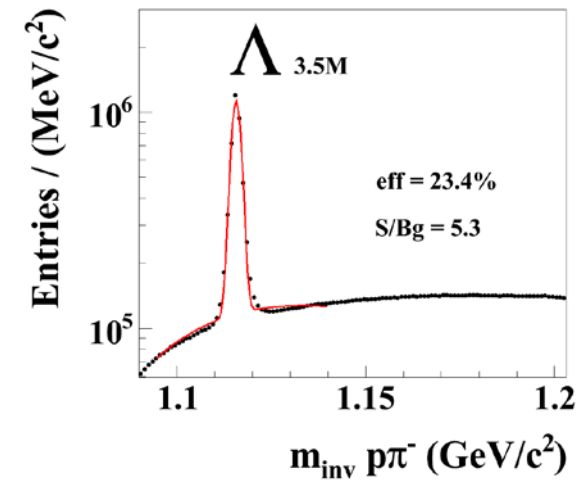


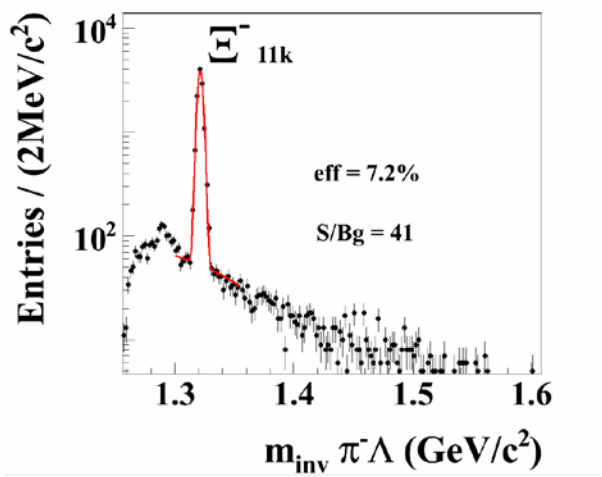
recent observation of a $\frac{M}{M_\odot} \approx 2$ Neutron Star → hyperon puzzle

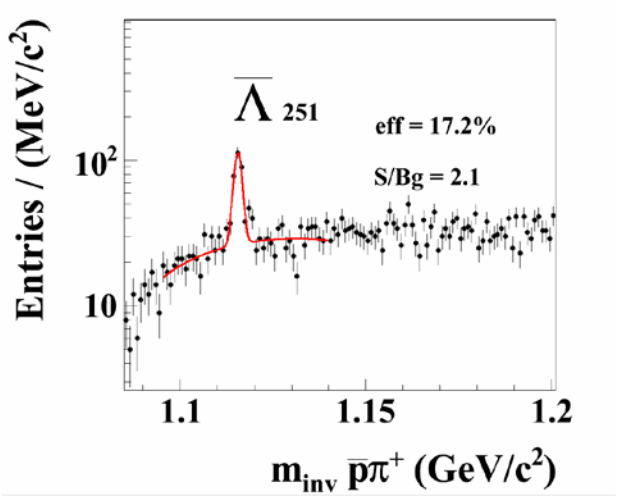
- not stable against gravitational collaps with soft EOS, i.e., a $2M_\odot$ NS should not exist!
- stable Neutron Star with quark-hadron mixed phase incl. hyperons possible (?)
  - EoS of hybrid matter (soft, hard ?)

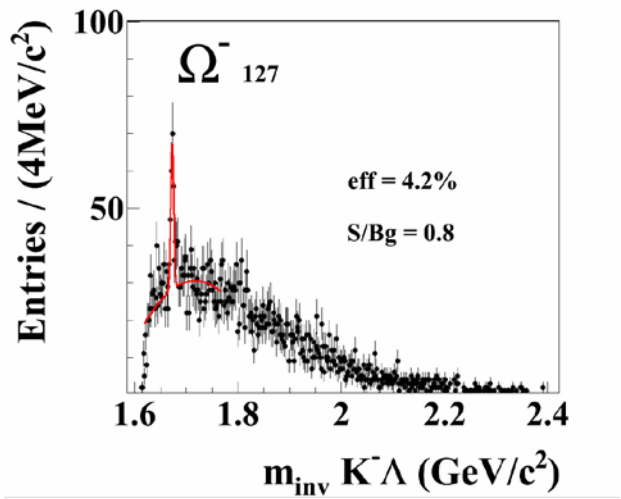
CBM as a „Hyperon Factory“

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



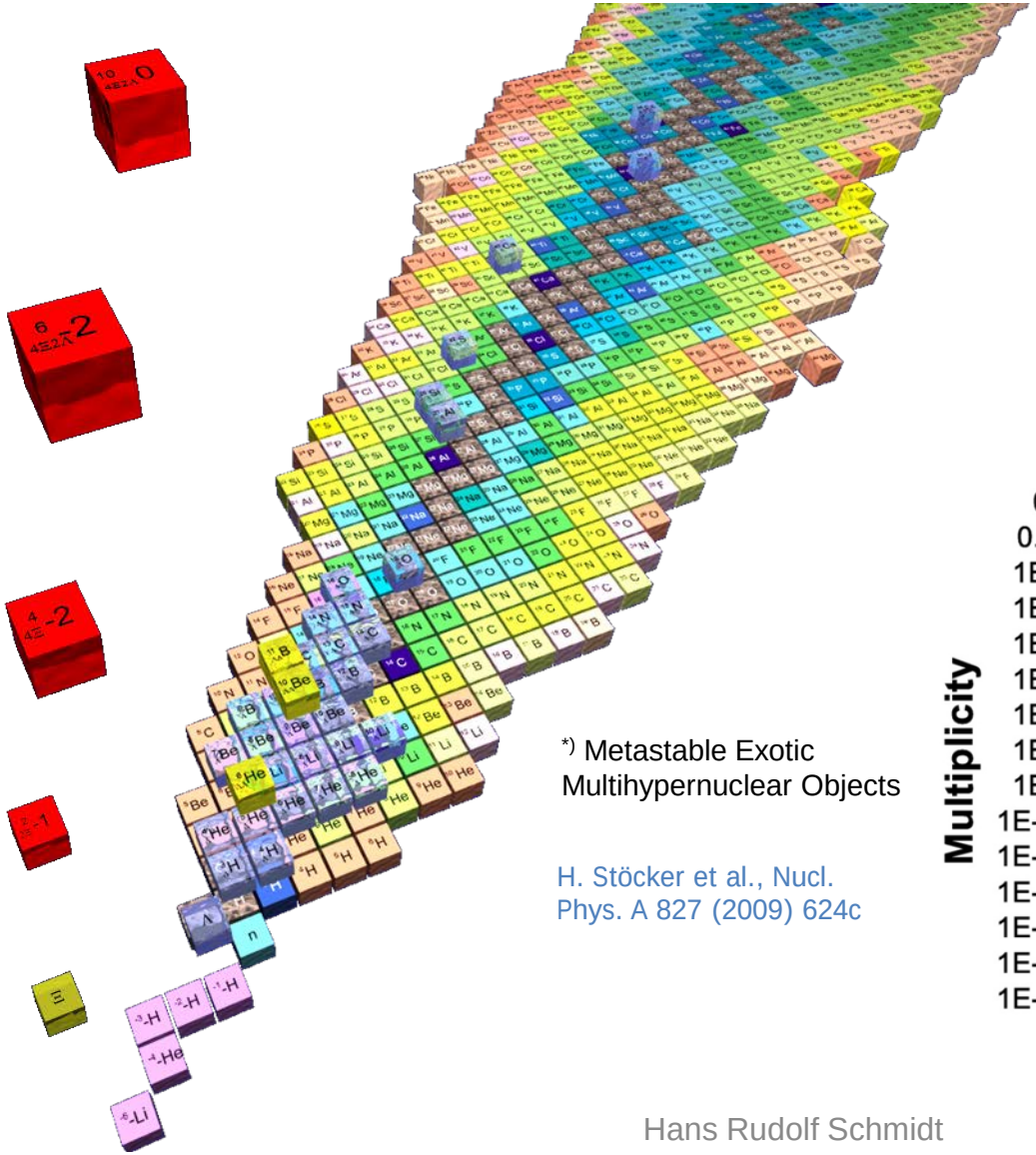






- sub-threshold production cross section of Ξ^-, Ω^- probes dense, baryonic matter….
- little data in the CBM energy range
- In addition: kaons and baryon resonances (K*,Λ*,Σ*,Ξ*)

Multi-Strangeness

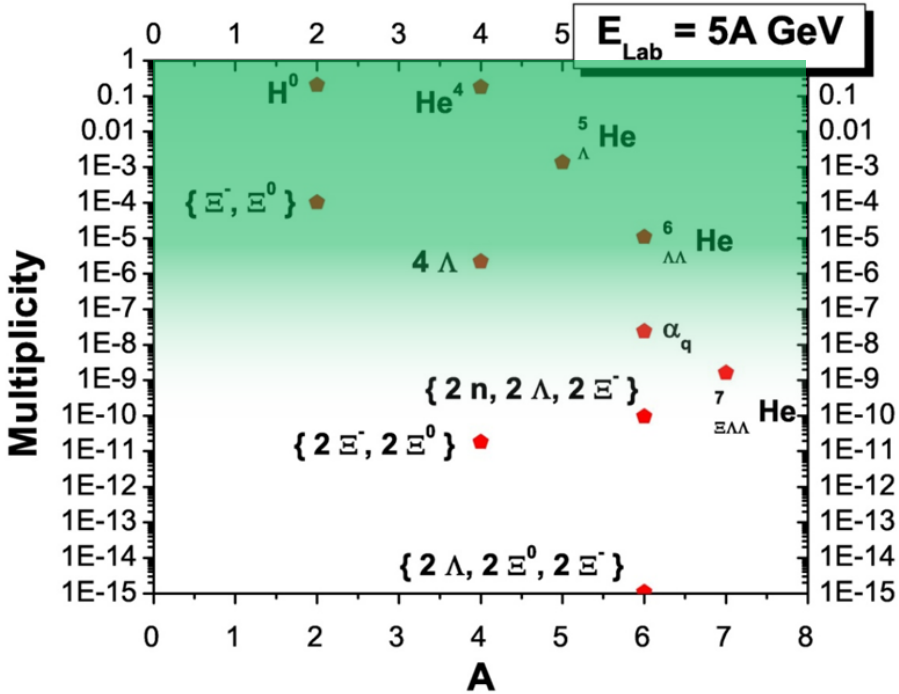


*) Metastable Exotic Multihypernuclear Objects

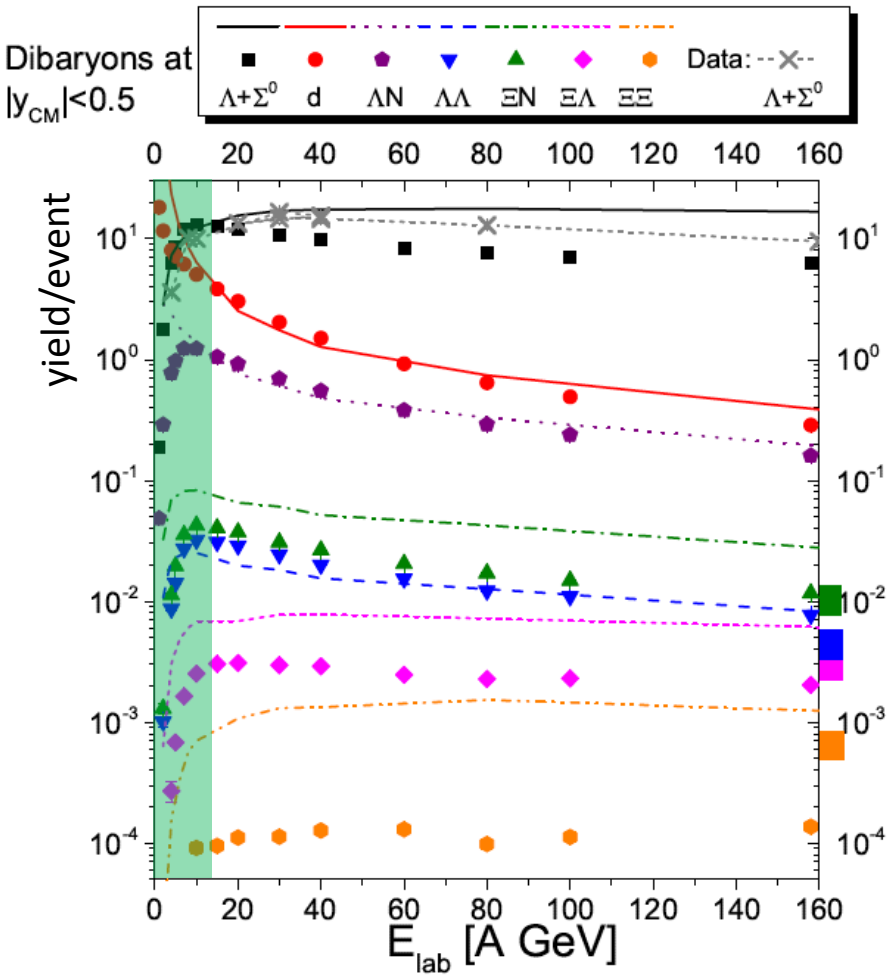
H. Stöcker et al., Nucl. Phys. A 827 (2009) 624c

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?



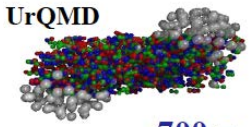
lines: UrQMD + thermal hydrodynamics
symbols: DCM + coalescence

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

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^-

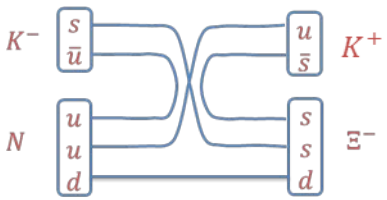
copious production of hyperons (due to high rate) and favorable phase space make CBM@FAIR a:

- di-baryon factory ☺

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

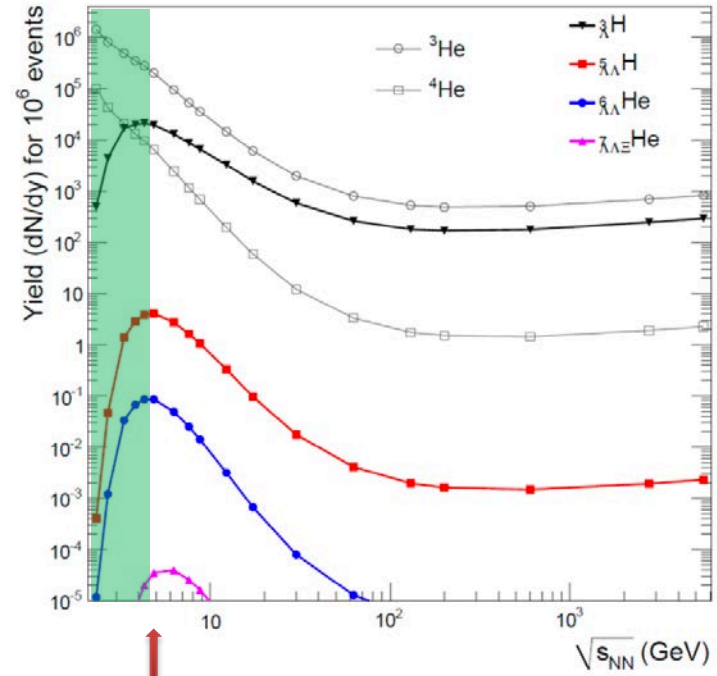
Search for Double Hypernuclei

conventional production mechanism*):



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

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



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

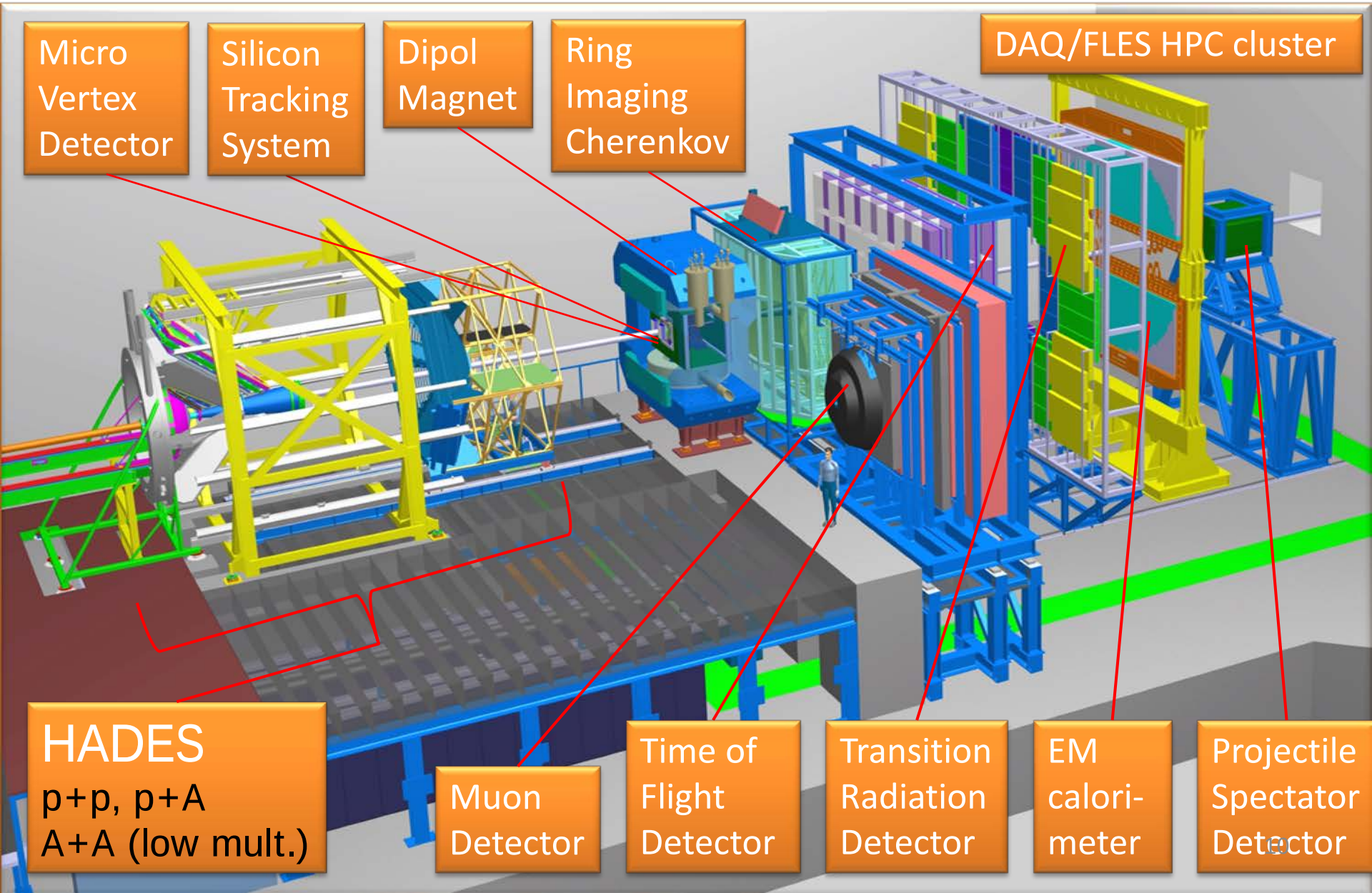
<u>heavy collisions:</u>
production via coalescence of Λ with light fragments

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

yield: $\underbrace{10^{-6}\ {}_{\Lambda\Lambda}^{5}H}_{120/\text{week}}, \underbrace{3 \cdot 10^{-8}\ {}_{\Lambda\Lambda}^{6}He}_{3.6/\text{week}}$ /central collision

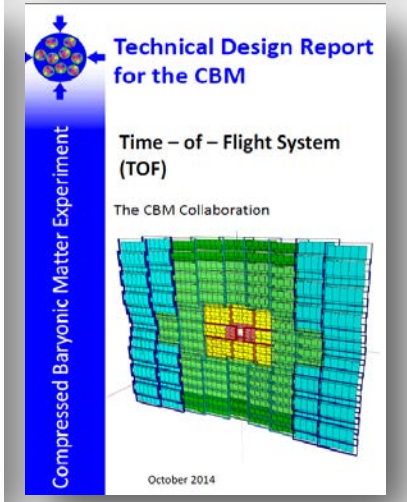
*) Takahashi et al, PRL 87 (2001)

The CBM Detector System



Technical Design Reports

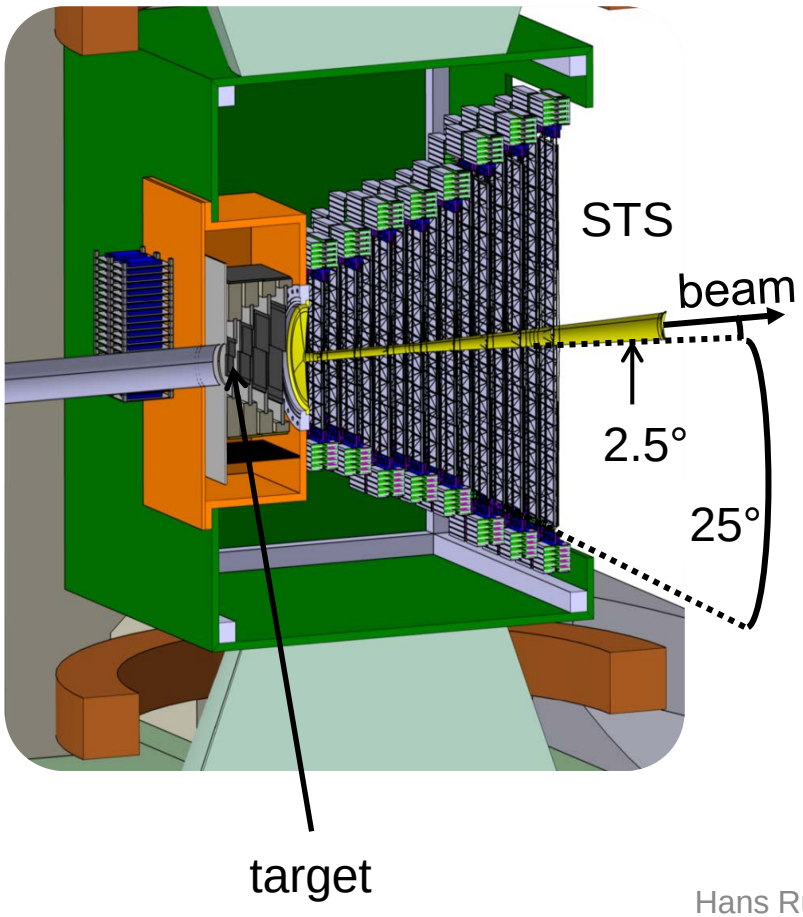
#	Project	TDR Status
1	Magnet	approved
2	STS	approved
3	RICH	approved
4	TOF	approved
5	MuCh	approved
6	HADES ECAL	approved
7	PSD	approved
8	MVD	submission 2017
9	DAQ/FLES	submission 2017
10	TRD	submission 2017
11	ECAL	submission 2017



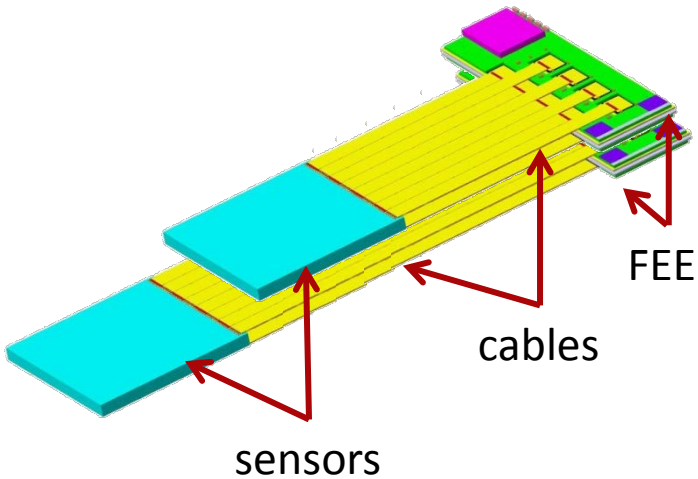
⇒ CBM start version is ready to be build

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….



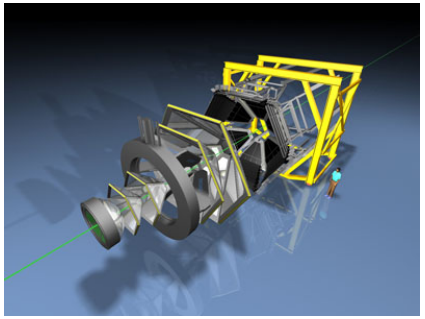
- readout electronics outside of active area
  - ultra-thin (long!) readout cables
- ultra light support structure
  - carbon fiber (-> ALICE)
- 300 µm μstrip sensor with double sided stereo readout



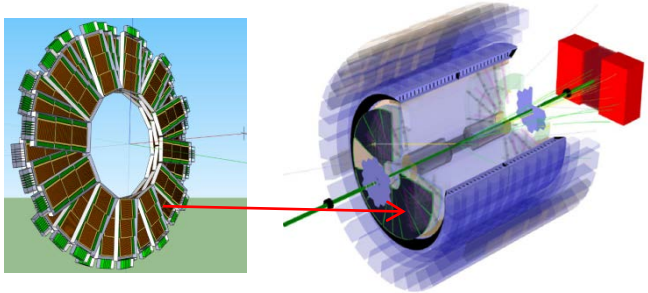
CBM-FAIR Phase 0 (>2018)

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

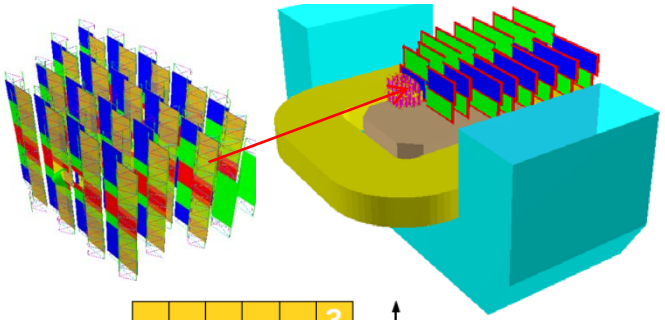
- Multi-strange baryons
- φ production study via K^+K^- and e^+e^-
- Dileptons around and beyond vector meson mass region



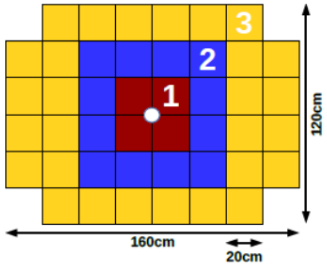
10% of the CBM TOF modules including read-out chain at STAR/RHIC (BES II 2019/2020)



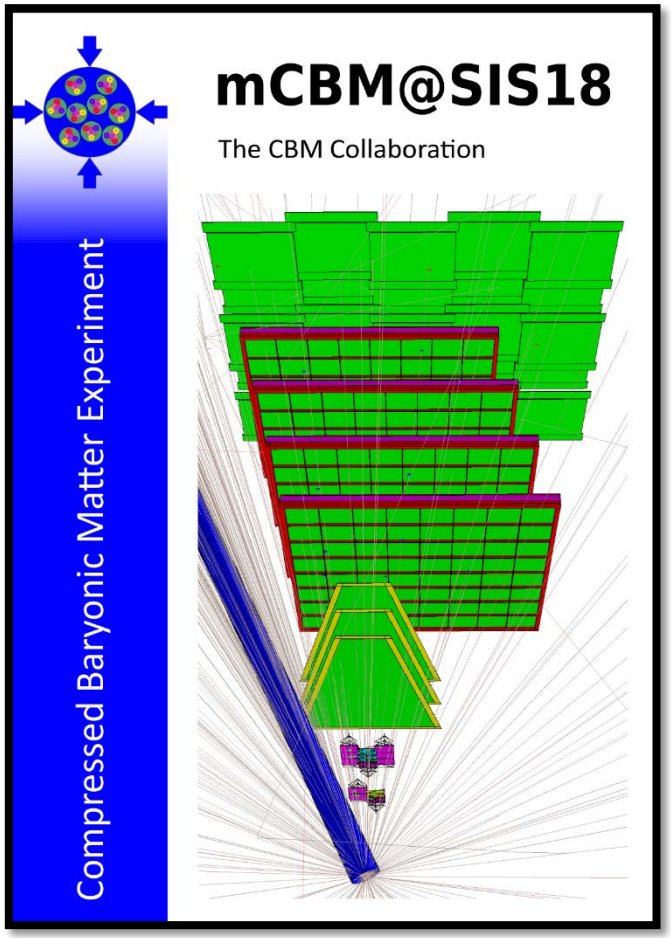
Silicon Tracking Stations in the BM@N experiment at the Nuclotron in JINR/Dubna (Au-beams up to 4.5 A GeV in 2018/19)



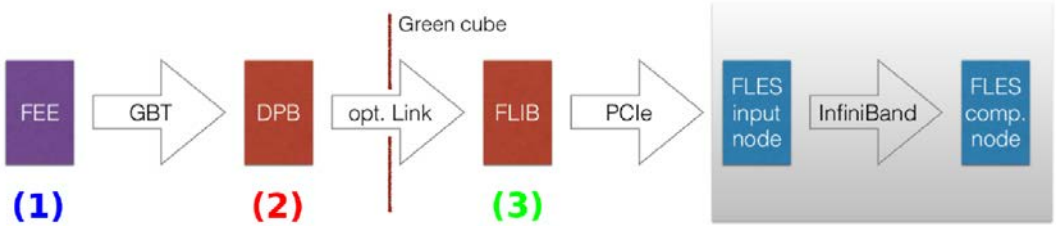
CBM Project Spectator Detector at the BM@N experiment



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