Status of the 
Compressed Baryonic Matter Experiment at FAIR

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Outline

• Physics: Exploration of Dense Matter with new, rare probes
  – Focus\(^(*)\) on strange matter
    • (sub)threshold production of multi-strange hyperons
    • (double)-hyper-nuclei
  \[\text{unique feature of CBM}\]

• Status of CBM
  – CBM-FAIR Phase 0 program

  \[\text{\(^(*)\) 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

GSI

CBM

SIS100 beams:
AuAu: 11 AGeV
pA: 30 GeV

FAIR:
fully operational
2015
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

**Note:** at CBM energies
1 min CBM ~ 1 y

STAR@RHIC

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QCD matter at finite baryon densities is not understood, neither experimentally nor theoretically!

Example:

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

- not stable against gravitational collapse 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 $\Xi^-$, $\Omega^-$ probes dense, baryonic matter...
- little data in the CBM energy range
- In addition: kaons and baryon resonances ($K^*,\Lambda^*,\Sigma^*,\Xi^*$)

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Multi-Strangeness

search for
- hyperon correlations
  - $\Lambda\Lambda$, $\Lambda\Sigma$, ...
- double hyper-nuclei
  - $\Lambda\Lambda H$, $\Lambda\Lambda He$
- MEMOS*)
  - $(\Xi^0\Xi^-)_b$, $(\Xi^0\Lambda)_b$, ...

*) Metastable Exotic Multihypernuclear Objects


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Di-Baryons and Hyperons Correlations at FAIR/CBM?


- 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 understand neutron star EoS
Search for Double Hypernuclei

conventional production mechanism\textsuperscript{)\textdagger):}

\[
\begin{align*}
K^- & \quad \bar{s} \quad \bar{u} \\
N & \quad \bar{u} \quad \bar{d} \\
K^+ & \quad s \quad d \quad \Xi^- \\
& \quad \Xi^- + {}^{12}\text{C} \to \Lambda\Lambda^6He + {}^4He + t
\end{align*}
\]

heavy collisions: production via coalescence of $\Lambda$ with light fragments

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

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

120/week \hspace{1cm} 3.6/week

\textsuperscript{)\textdagger\textsuperscript{)} Takahashi et al, PRL 87 (2001)
The CBM Detector System

Micro Vertex Detector
Silicon Tracking System
Dipol Magnet
Ring Imaging Cherenkov

DAQ/FLES HPC cluster

HADES
p+p, p+A
A+A (low mult.)

Muon Detector
Time of Flight Detector
Transition Radiation Detector
EM calorimeter

Projectile Spectator Detector
## Technical Design Reports

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⇒ CBM start version is ready to be build
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
Hades physics programm@SIS18 (p+p, p+A, Ag+Ag 1.65 AGeV)
- Multi-strange baryons
- \( \phi \) 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