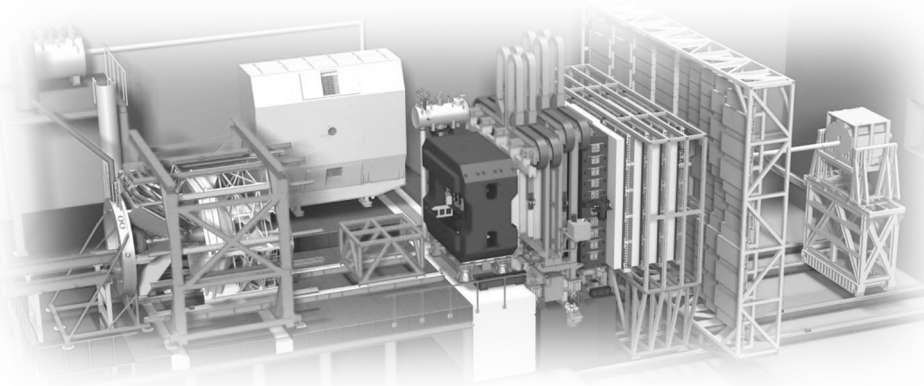
Welcome

Tetyana Galatyuk, GSI / TU Darmstadt

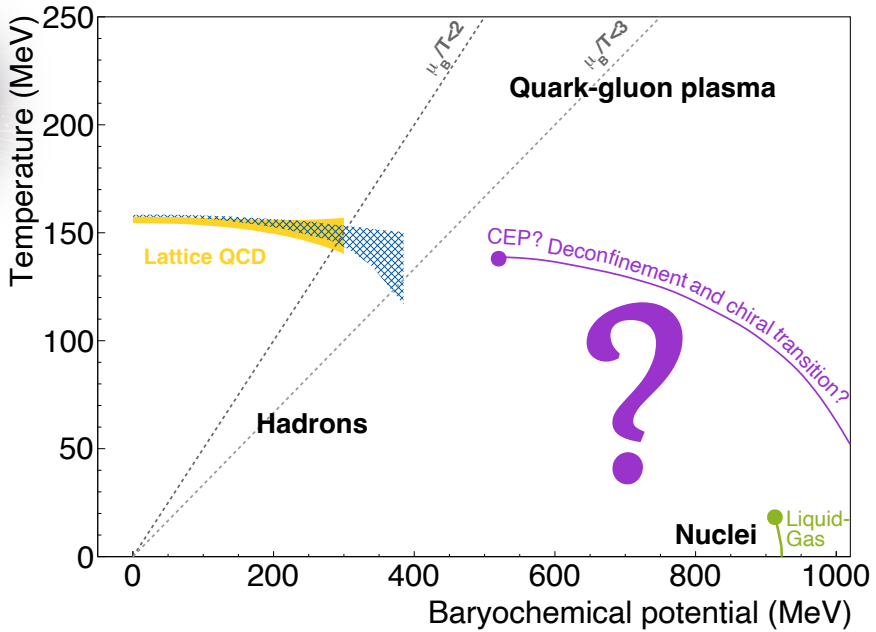
46th CBM Collaboration Meeting
October 19-24, 2025



CBM objective

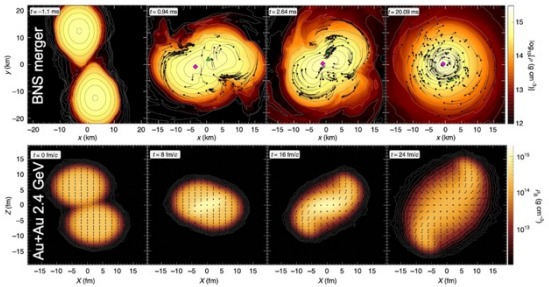
"Explore the phase properties and microscopic structure of strong-interaction matter at high(est) net-baryon densities"

Early Universe
LHC



- Limits of hadronic existence?
- 1st order transition?
- QCD critical point?
- Equation-of-state of dense matter?

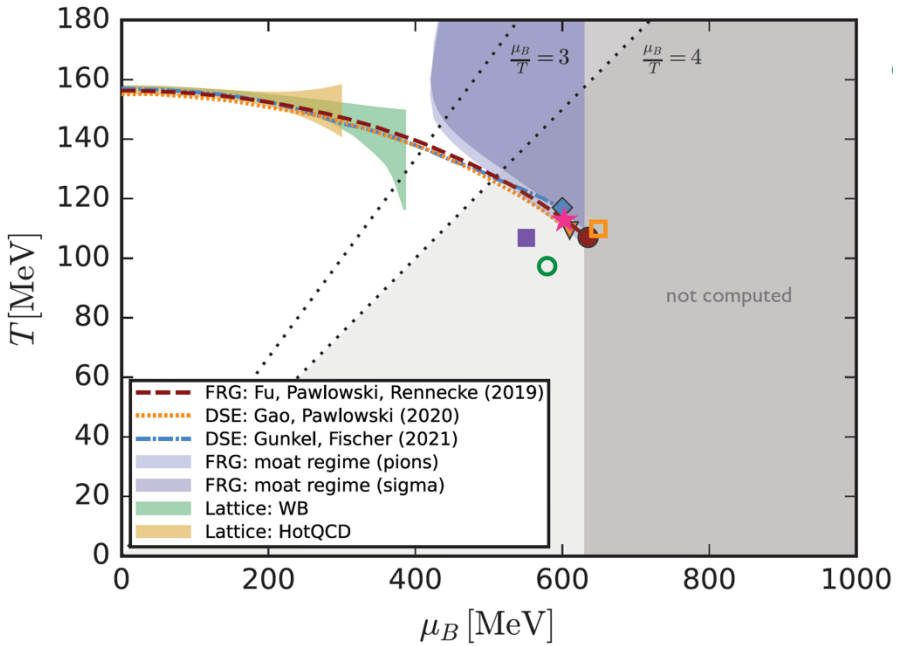
No first principle calculations
Driven by experiments
Relevance for astrophysics



HADES, Nature Phys. 15 (2019) 1040

CBM mission

Fabian Rennecke, Quark Matter 2025



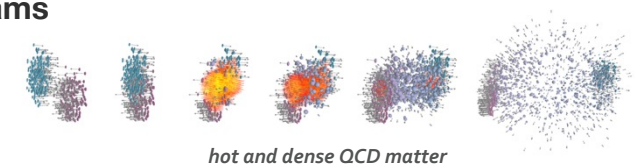
CEP location well constrained by now. And it's in FAIR range!

$\sqrt{s_{NN}} = 3.6 - 4.1$ GeV

Search for landmarks of the QCD matter phase diagram:

- isolate unambiguous signals of new phases of QCD matter, order of phase transitions, conjectured QCD critical point
- establish high net-baryon density EoS
- probe microscopic matter properties

→ **heavy-ion beams**

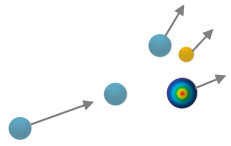


hot and dense QCD matter

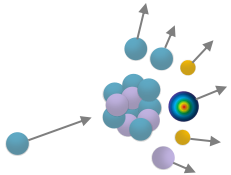
Study various aspects of meson/baryon physics:

- (*u, d, s, c*) hadron production mechanism, spectroscopy (|*s*|=*2,3,* |*c*|=*1*), interactions, hadron structure
- electromagnetic transition form-factors

→ **p, d beams**

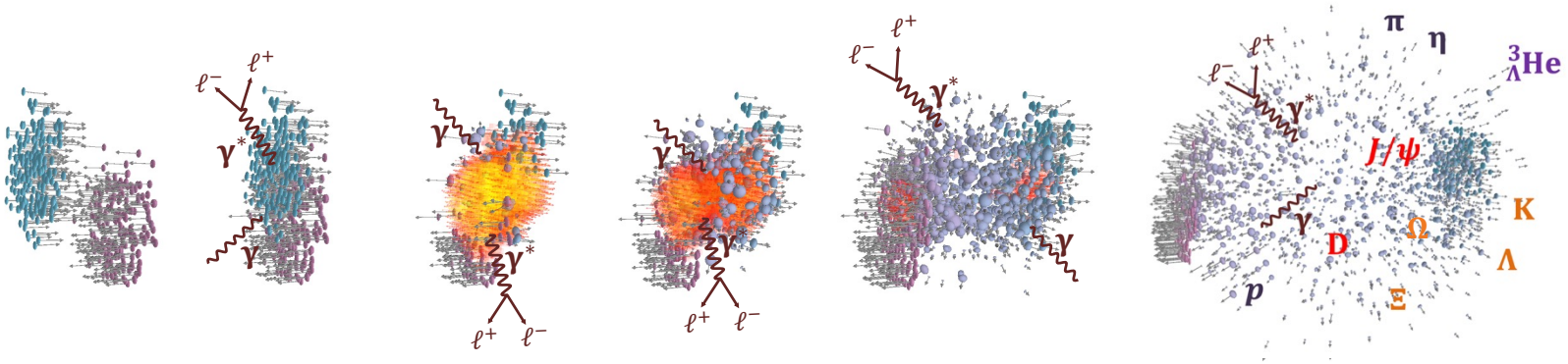


elementary process



cold QCD matter

CBM strategy

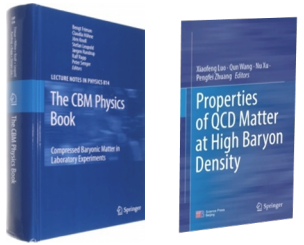


Measure with utmost precision (abundant / rare):

- light flavour hadrons, incl. (multi-)strangeness
  ↦ chemical freeze-out T, μ_B
  flow, vorticity ↦ equation-of-state

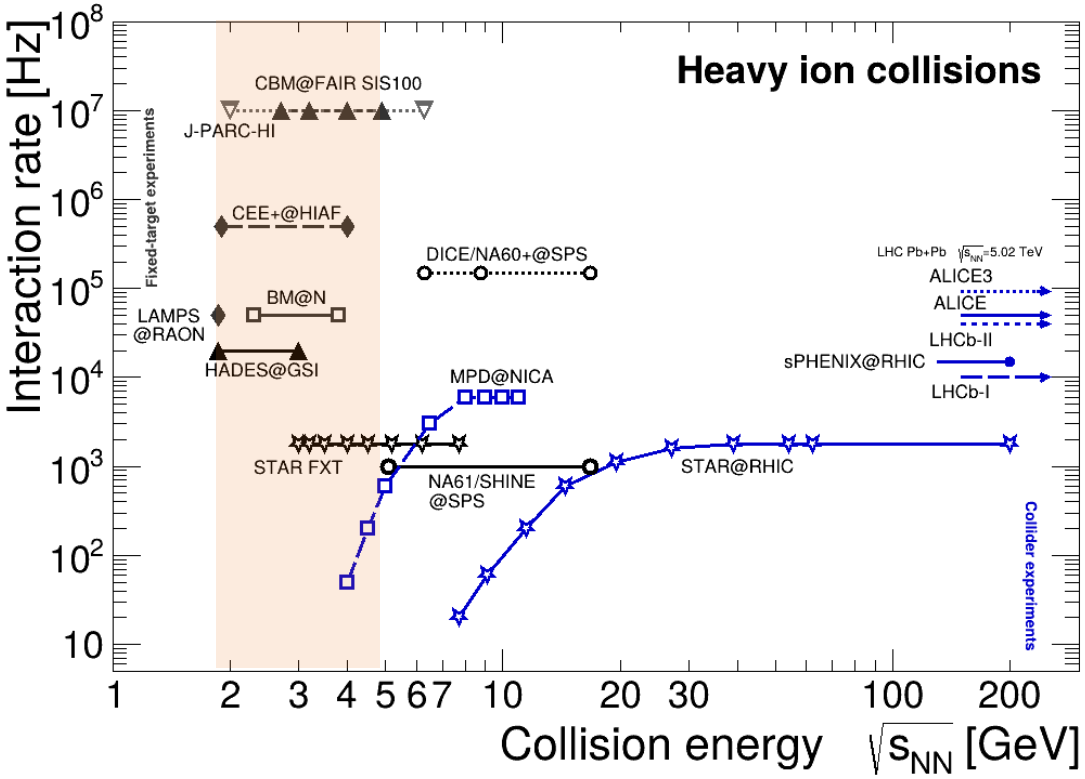
- event-by-event fluctuations (criticality)
- dileptons (emissivity)
- charm (transport properties)
- hypernuclei (interaction, production mechanism ↦ EoS)

Worldwide experimental and theoretical efforts



Friman *et al.*, Lect. Notes Phys. 814 (2011) 1
Chen, Dong, Fukushima, Galatyuk, *et al.*, doi:10.1007/978-981-19-4441-3_4 (2022)

High μ_B facilities



Program needs ever more precise data and sensitivity for rarest signals

- **CBM** will play a unique role in the exploration of the QCD phase diagram in the region of high μ_B with rare and electromagnetic probes: high rate capability
- **HADES**: established thermal radiation at high μ_B, limited to 20kHz and $\sqrt{s_{NN}}$=2.4 GeV
- **STAR FXT@RHIC**: BES program completed; limited capabilities for rare probes
- CEE+@HIAF construction: multipurpose detector based on TPC, anticipated rate capability 500 kHz
- J-PARC-HI proposal
- BM@N: limited capabilities for rare probes

- $\mu_B \cong 0$: ALICE / ALICE 3: exploit the forefront detector technologies and high luminosity potential of the LHC for ions

TG, NPA 982 (2019), update 2025 https://github.com/tgalatyuk/interaction_rate_facilities
CBM, EPJA 53 3 (2017) 60

Visibility in the community

Quark Matter 2025, XXXI International Conference on Ultra-relativistic Nucleus-Nucleus Collisions, 6-12 Apr. 2025

1004 participants

Chair D. Rischke, co-chairs: **T. Galatyuk**, H. Appelshäuser

- 1 plenary HADES (**H. Zbroszczyk**, WUT, Warsaw)
- 3 parallel HADES + 1 parallel CBM (**P. Chaloupka**, CTU, Prag)
- 8 posters HADES + 17 posters CBM
- Student Lecture (**P. Gasik**, FAIR)
- LoC and IAC members

- High μ_B science prominently discussed
- Physics of High net-baryon Densities (PHD2025), satellite meeting, 13-15 Apr, 2025

2024 Priority defined in

NuPECC Long Range Plane – Strategic planning until 2034

Recommendations for Nuclear Physics Infrastructures

The NuPECC Long Range Plan 2024 resulted in the following main recommendations for infrastructures of importance for nuclear physics:

- The first phase of the international **FAIR** facility is expected to be operational by 2028, facilitating experiments with SIS100 using the High-Energy Branch of the Super-FRS, the CBM cave and the current GSI facilities. Completing the full facility including the **APPA, CBM, NUSTAR** and **PANDA** programmes will provide European science with world-class opportunities for decades and is highly recommended.

Recommendations for Fundamental Nuclear Physics

Future flagship facilities and experiments

- To investigate nuclear matter at high baryonic density, the timely completion of **SIS-100** at **FAIR** and the completion of the **CBM** experiment are of utmost importance. Efforts should continue to support R&D activities related to advanced **CBM** silicon vertexing and tracking devices.

particular **HADES** and **R3B** at **SIS-18/SIS-100**, should receive full support.

https://www.nupecc.org/lrp2024/Documents/nupecc_lrp2024.pdf

Input to European Strategy for Particle Physics 2026

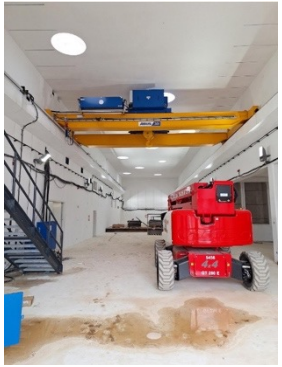
The full exploration of the phase diagram towards high μ_B (CBM at SIS100, NA60+/DiCE at SPS) will be a central recommendation

“Physics Briefing Book: Input for the 2026 update of the European Strategy for Particle Physics” Jorge de Blas et al., DOI:10.17181/CERN.35CH.2O2P (Oct 17, 2025)”

FAIR Project Progress

SIS100 installation

CBM building is accessible by road

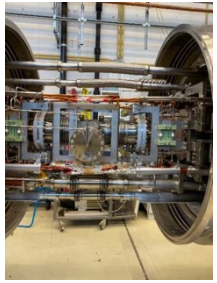


30-ton crane installed and commissioned

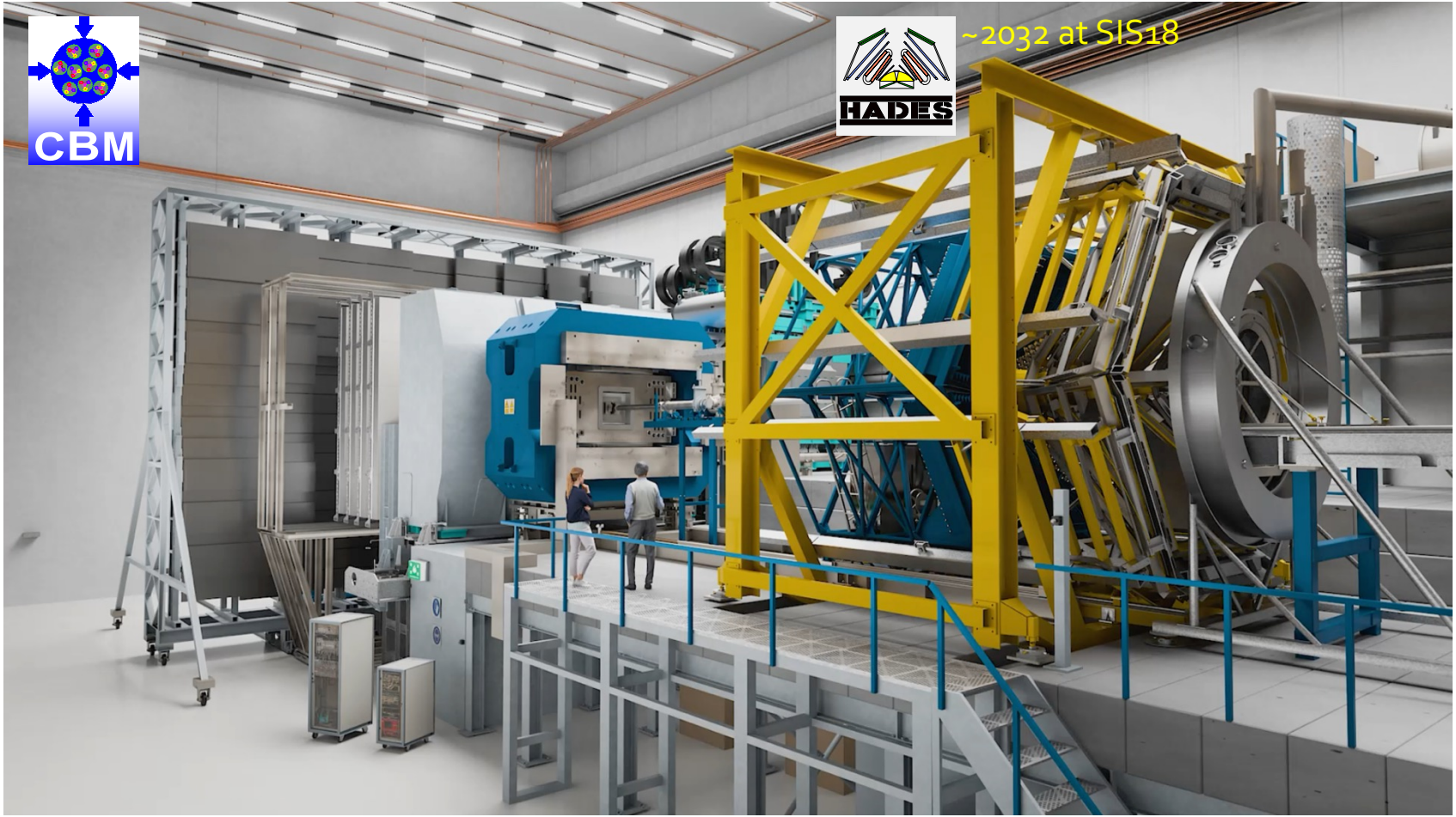
Installation of the main dipole- and quadrupole power converters in SIS100 tunnel started

Start of commissioning of Cryo plant and Cooling water system

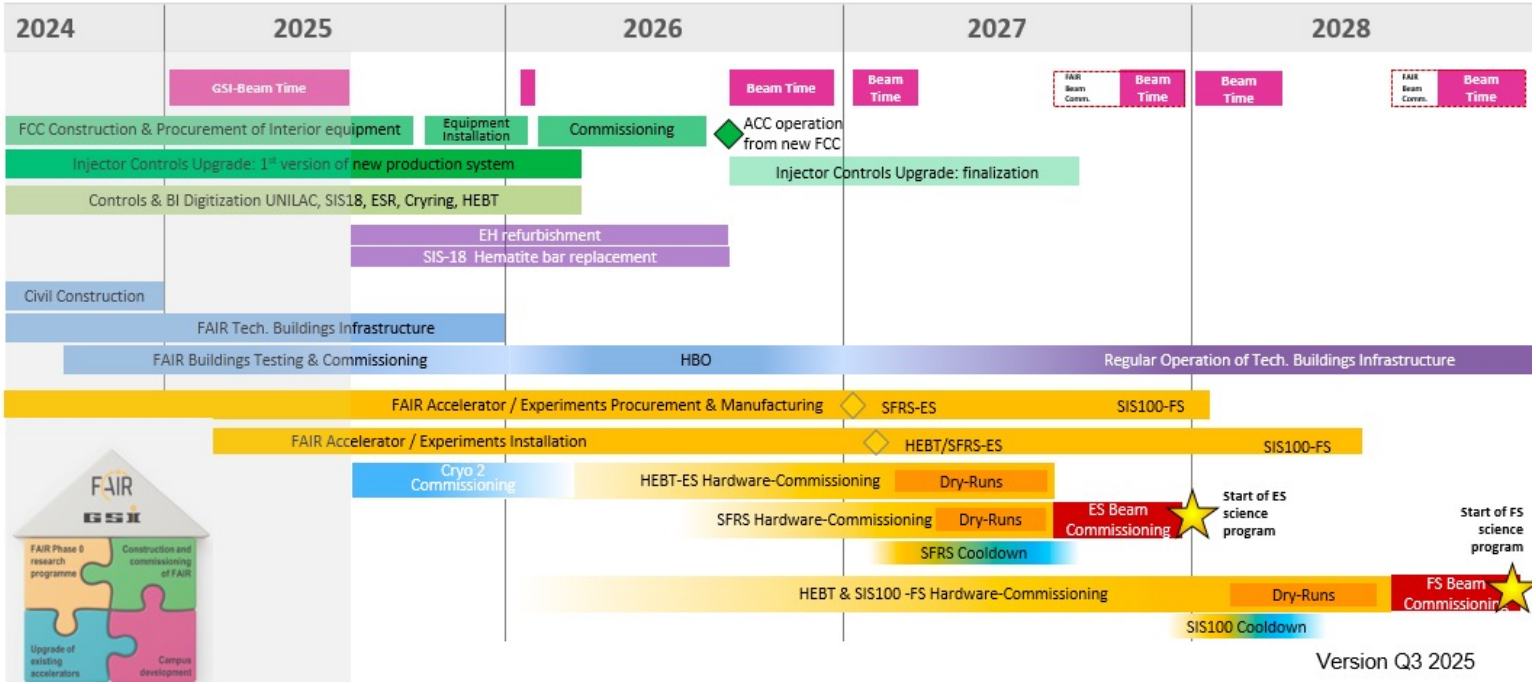
Process line welding successfully developed



Start of installation of the SIS100 laser cooling system

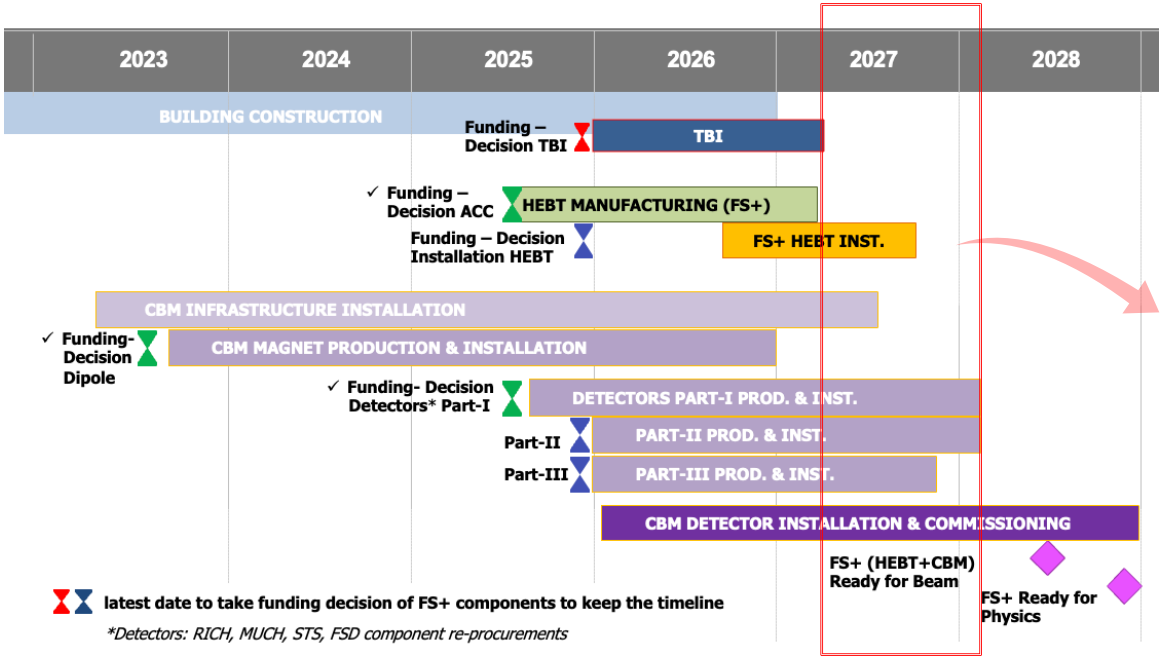

CBM
HADES
~2032 at SIS18

FAIR and GSI integrated schedule



- Beam time beyond 2028: Increase for science to 200 days annually
- New evaluation procedure for experiments at GSI and FAIR (in the discussion with the GSI/FAIR JSC)

Key milestones for timely CBM realization



Critical path

- TBI + EXP components re-procurement, Positive decision of the FAIR Council on the FS+ in Dec'25 is crucial
- FS+ window for detector installation is shrinking – no more contingency

⧗ **Magnet** re-procurement *accomplished.*

⧗ **High Energy Beam Transfer** to CBM cave. FAIR Council Jul'25: *"… the procurement of the HEBT beam line to CBM for the value of 1,75 M€@today have been approved"*

⧗ Access to the building is available since March '25, crane is installed and commissioned.

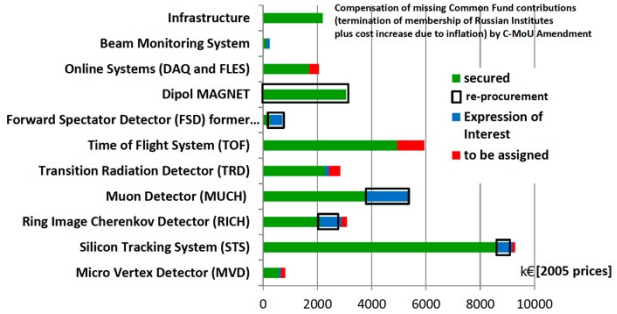
⧗ **Technical Building Infrastructure** (**TBI**) of CBM building. *FAIR Council Dec'24 approved the contracting of TBI engineering!*

⧗ **CBM components:** FAIR Council Jul'25: *"Procurement of CBM detector components for the value of 700 k€@today have been approved by Council."*

CBM funding and MoUs

Composition Funding of CBM experiment:

- **In-kind** contributions/contracts from shareholders
- FAIR **project funds** (from terminated Collaboration Contracts)
- **Other funding** from shareholder and non-shareholder countries



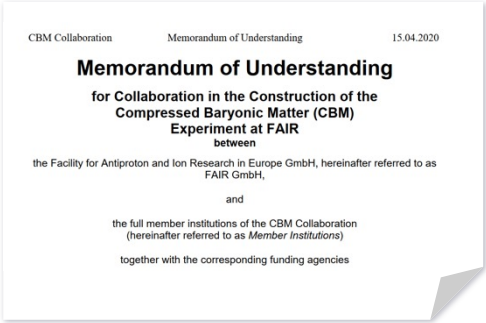
total cost: M€ 35,27 (2005 Euro)
secured: M€ 29,72
EoI: M€ 3,67
t.b.a.: M€ 1,87

84,3% secured funding

Estimated re-procurement costs (2025 EURO)

- **Magnet:** 5,26M€
- **STS (assembly station 1-4):** 0,78 M€
- **Forward Spectator Detector (ex-PSD):** 0,76 M€
- **RICH mechanics, gas system:** 1,35 M€
- **MUCH absorbers, mechanics:** 2,70 M€

0.7 M€@today have been approved by Council Jul'25


CBM Collaboration Memorandum of Understanding 15.04.2020

Memorandum of Understanding

for Collaboration in the Construction of the Compressed Baryonic Matter (CBM) Experiment at FAIR

between

the Facility for Antiproton and Ion Research in Europe GmbH, hereinafter referred to as FAIR GmbH,

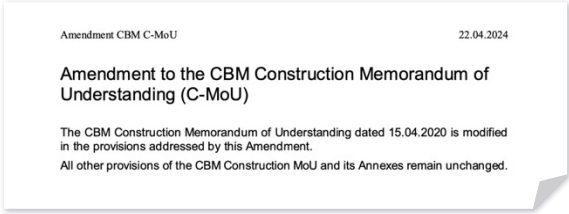
and

the full member institutions of the CBM Collaboration (hereinafter referred to as *Member Institutions*)

together with the corresponding funding agencies

Status CBM MoUs:

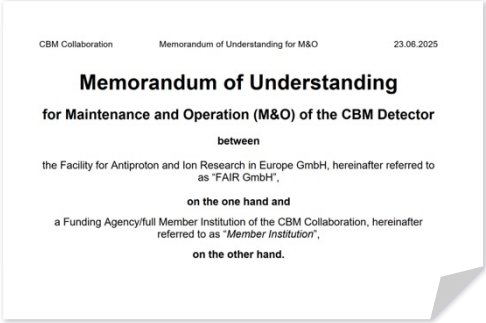
1. CBM Construction MoU (C-MoU) signed in 2020
2. Amendment to C-MoU agreed (signing starting)
3. Maintenance & Operation MoU draft will be discussed with funding agencies in RRB


Amendment CBM C-MoU 22.04.2024

Amendment to the CBM Construction Memorandum of Understanding (C-MoU)

The CBM Construction Memorandum of Understanding dated 15.04.2020 is modified in the provisions addressed by this Amendment.

All other provisions of the CBM Construction MoU and its Annexes remain unchanged.


CBM Collaboration Memorandum of Understanding for M&O 23.06.2025

Memorandum of Understanding

for Maintenance and Operation (M&O) of the CBM Detector

between

the Facility for Antiproton and Ion Research in Europe GmbH, hereinafter referred to as "FAIR GmbH",

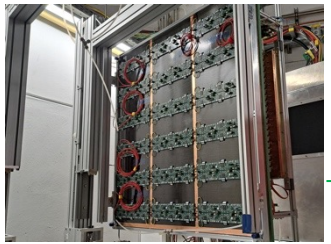
on the one hand and

a Funding Agency/full Member Institution of the CBM Collaboration, hereinafter referred to as "*Member Institution*",

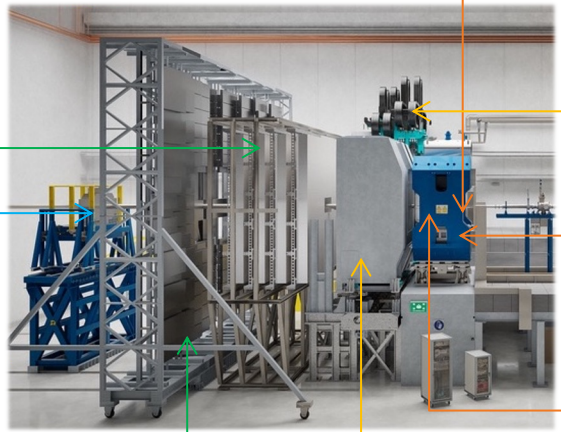
on the other hand.

CBM systems mass production

Transition Radiation Detector

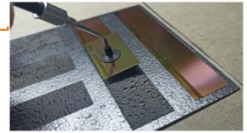


pre-production modules of 1D and 2D options ready

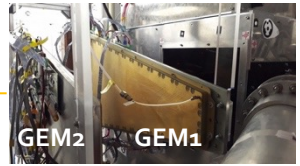


Micro Vertex Detector

sensor/module integration



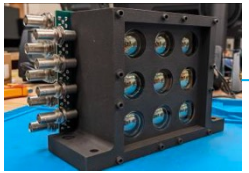
GEM1&2 modules for mCBM'25 series production of GEM station1



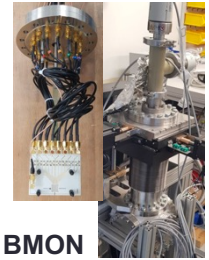
Superconducting dipole magnet

Magnet support factory acceptance test

Forward Spectator Detector



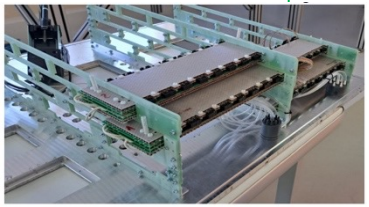
3x3 FSD test module



BMON

T0 manipulator X/Y/Z
Vacuum test – done

Time of flight detector

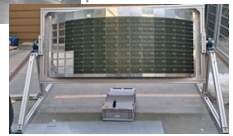


20% counters assembled, module pre-production ongoing successful operation of mToF in 2025

Ring Imaging Cherenkov detector

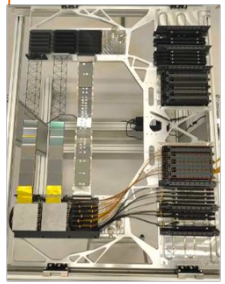
photo camera 1

photo camera 2

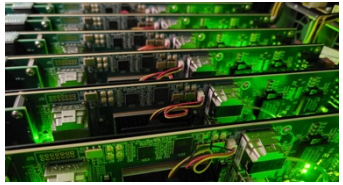


preparations for final batch of 1500 DIRICH FEBs

Silicon Tracking System



STS half-unit assembly and Integration

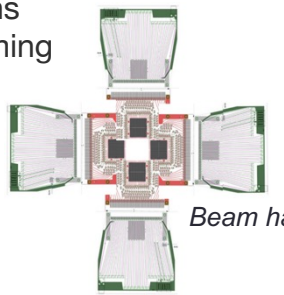


DAQ / FLES *TFC2 (Timing and Fast Control system) demonstrator setup*

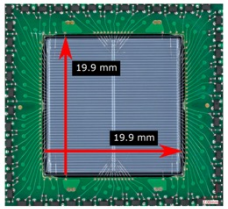
Knowledge transfer

LGAD-based ion imaging system

LGAD sensor tests with heavy ions (C/Ag) demonstrated excellent timing performance (σ < 40 ps).

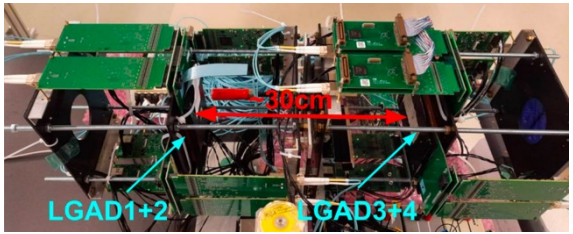


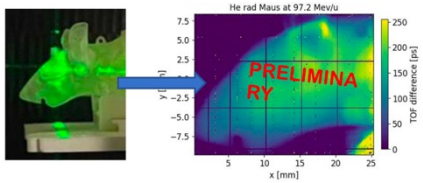
Beam halo



LGAD sensor

First experimental TOF-Helium radiography of a mouse phantom
MedAustron test beam in April 2024



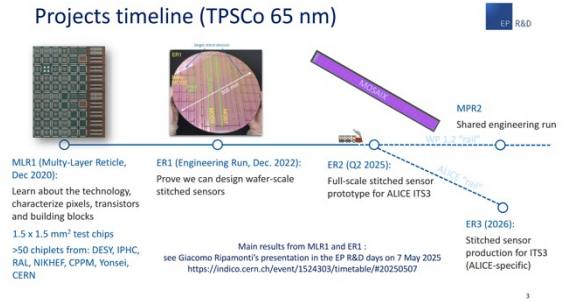


First TOF-based pRad

Ulrich-Pur et al., Phys.Med.Biol. 69 (2024) 7, 075031

Silicon detector upgrade
ECFA DRD3 Octopus: 3

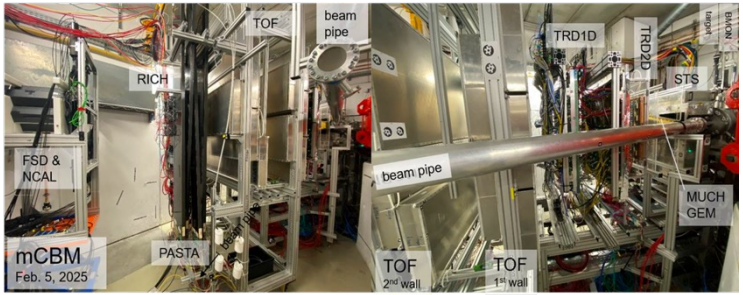
M. Deveaux

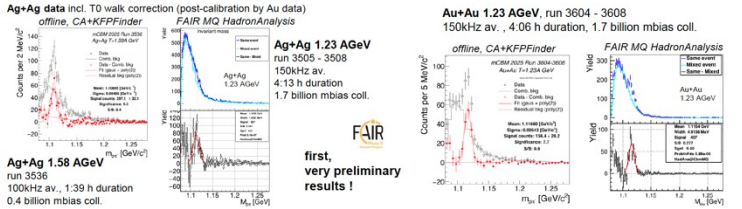


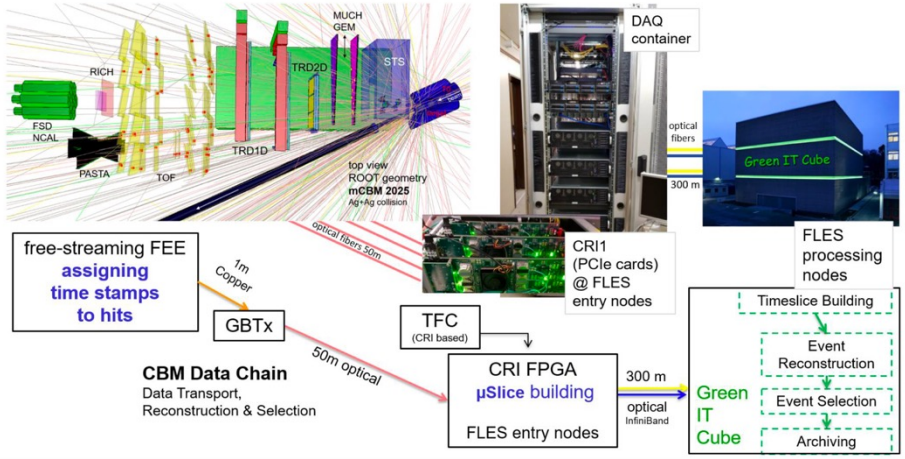
Prototype of CBM online data processing with mini-CBM

Full system test with SIS18 beam

- Detector pre-series modules
- Free-streaming readout implemented and commissioned
- Connection scheme and hardware close to the final CBM DAQ
- Gained experience in operations, calibration and alignment
  → speed up of commissioning of CBM







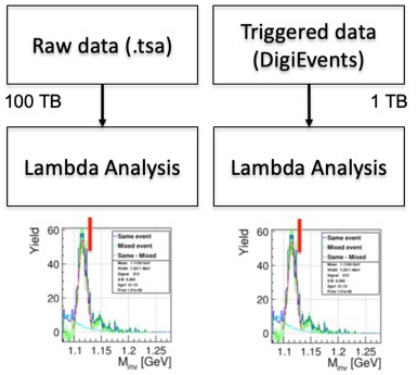
Goal: establish significant data reduction at high purity and selectivity (bench mark Λ production) to enable high interaction rates with CBM

- Feb'25 benchmark run Ag+Ag at 1.58 and 1.23 AGeV
- May'25 high-rate detector tests, Bi beam → detector PRRs

CBM Systems Commissioning 2026/27

- **Importance to maintain the SIS18 test cite (mCBM) for CBM**
  - tests of the final prototypes and production modules
  - online data processing (full-chain tests of detectors, DAQ, and online systems)
- **Run Coordinator and RUC-deputy,** with TC and CC plan and prepare runs

To be prepared in "live" replay of the raw data at real speed



G-24-00279UR

Beamtime application for

CBM Systems Commissioning 2026/27

The CBM Collaboration

Submitted to the GSI / FAIR Management
December 2nd, 2024

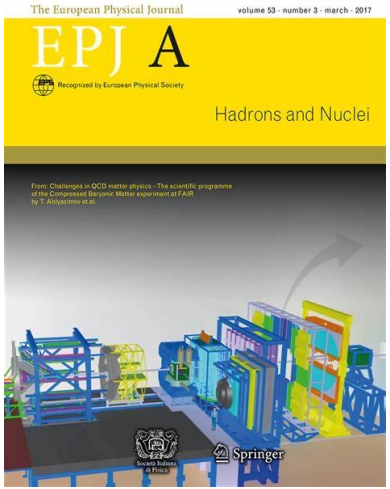
Executive summary

The Compressed Baryonic Matter (CBM) experiment at the SIS100 of GSI/FAIR is under construction. Pre-series and series productions of CBM detector modules has started, the experiment infrastructure is in preparation as well as the development and optimization of the complex online/offline data chain. While first SIS100 beams are expected in 2028, the installation of the CBM detector systems within the CBM cave will start in 2027. To significantly shorten the commissioning phase of the CBM experiment at SIS100, this beamtime application "CBM Systems Commissioning 2026/27" has been submitted by the CBM Collaboration on December 2nd, 2024, to the GSI/FAIR Management into the category "pure detector tests".

	Year	Objective	Projectile	Intensity per spill	Extraction	User type	Shifts	Target station
(S1)	2026	Pre-commissioning of the full-system	ions up to Ag at 1.5 - 2 AGeV, preferably: C, Ni, Ag	10^7 at max. rigidity	slow, 10 s	secondary	2	HTD @ SIS18
(S2)	2026	Full-system commissioning incl. CRI2 integration and rate scans	ions up to Ag at 1.5 - 2 AGeV, preferably: C, Ni, Ag	10^7 - 10^9 at max. rigidity	slow, 10 s	main	10	HTD @ SIS18
(S3)	2026	Stand-alone detector commissioning	all ions, preferably at max. rigidity	10^7 - 10^9	slow, 10 s	parasitic	30	all @ SIS18
(S4)	2026	Radiation tolerance tests of components	all ions	10^7 - 10^9	slow, 4 - 10 s	parasitic	180	all @ SIS18 or SIS18 septum

granted:
20 shifts (10 shifts/year)

CBM Collaboration papers



CBM, EPJA 53 (2017) 3, 60

Our second CBM Collaboration paper and the first one dealing with real data is on the arXiv

Performance of the prototype Silicon Tracking System of the CBM experiment tested with heavy-ion beams at SIS18

CBM Collaboration • A. Agarwal (Calcutta, VECC) Show All(339)

May 26, 2025

e-Print: 2505.20517 [physics.ins-det]

Experiments: GSI-FAIR-CBM

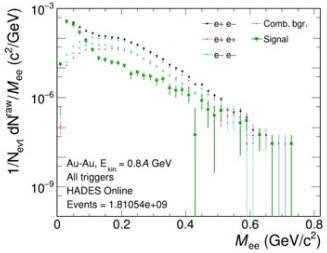
View in: ADS Abstract Service

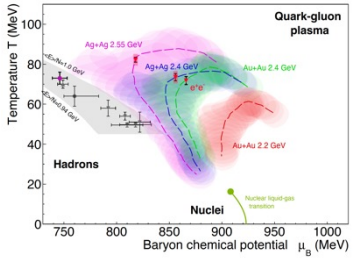
CBM, arXiv:2505.20517 [physics.ins-det]

Successful Phase-0: HADES, STAR, E16

HADES RICH photodetector upgrade employing CBM technology

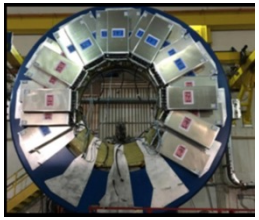
Fast on-line dilpton spectra from 2025 Au+Au, 800 AMeV

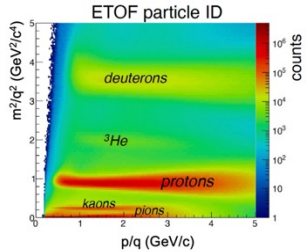




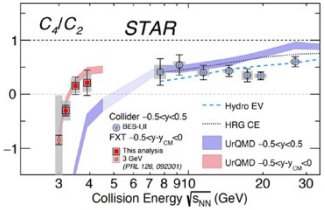
HADES

N. Schild, S. Kim, QM25



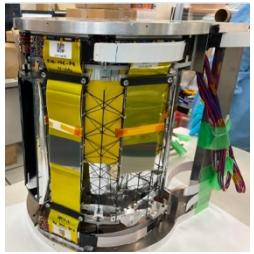


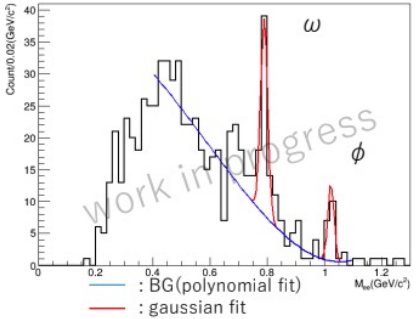
eTOF provided by CBM-FAIR, crucial for BES-II, especially for the FXT program



STAR

Zachary Sweger, QM25





Result of E16 pilot run (p+A collision) ~20h data taking

Yuhei Morino, QM25

*10 pre-series STS modules were built, assembled and tested at GSI and are installed as innermost tracking detector of the **E16** experiment at J-PARC*

- Demonstrate performance of major components
- Physics results with CBM devices and software packages

Synergies between CBM and PANDA: the “MuST have a PASTA” initiative

- Discussion initiated between PANDA and CBM SPs and TCs
- “MuST” working group has been established to evaluate the use of LHCb straw tube detectors, as a viable alternative for Stations 3 and 4 of the CBM MuCh detector.
- Memorandum of Understanding between CBM and PANDA indicate **synergy in technical aspects** and a broader opportunity for scientific collaboration **opening new avenues for hadron physics using the CBM detector.**

Memorandum of Understanding
between
the PANDA and the CBM
collaborations

Purpose of the MoU:

The interest of this group serves two purposes.

Structure of the MoU:

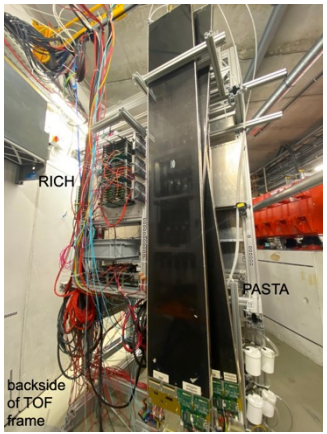
This MoU has been approved by the CBM and PANDA Collaboration Boards and is signed by spokespersons of both collaborations:

Dates of signatures: 30.09.2025

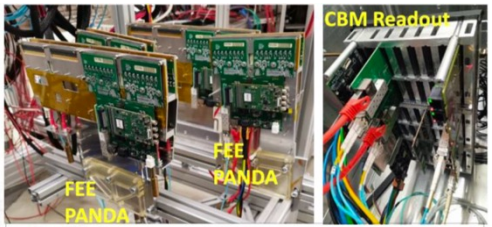
Kai-Thomas Brinkmann
Spokesperson of the PANDA collaboration

Tetyana Galatyuk
Spokesperson of the CBM collaboration

LHCb OT at GSI/FAIR



Integration and test in the mCBM



FEE Panda in CBM DAQ

Strengthening the long-standing collaborations

- Theme Meeting on FAIR-Science, **Panjab University Chandigarh, India,** Apr'25. A two days outreach program on CBM, NuSTAR and BioPhysics. CBM-Day April 25th to assess the contributions from institutions in India and to discuss groups future plans.

- CBM-Day in **Shenzhen** and **Wuhan**, Nov'24 → Detector Control System (DCS) workshop 16 Apr. '25. To coordinate the activities in the DCS project Peter Zumbruch (GSI) and Min Li (Lanzhou) were endorsed as project coordinators.

- STS project teams met for a three day retreat in the Taunus, Frankfurt, 26-28 May '25. Further focus was on the next steps in STS construction to enable CBM being ready for beam in 2028.

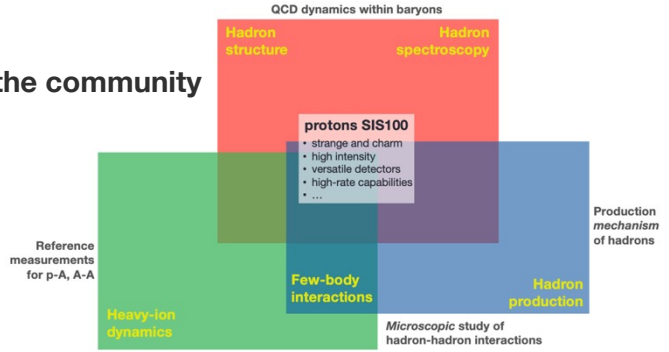
- Our computing strategy has been setup some years back. Reconsider our CPB management structure in order to optimize it to the most pressing tasks and available human recourses. Make the most of new developments that have been successfully employed in running experiments.

- Dec 2025, visit **IFIN-HH, Bucharest**

Hadron Physics at GSI and FAIR

- Initiative (2022) from FAIR-motivated group from within CBM, HADES, PANDA
  → strengthen CBM science in hadron physics by involving exclusive channels
- High potential for hadron physics with **proton & deuteron beam from SIS100**
- **Substantial extension of QCD program at FAIR** and its impact on increased attractivity/visibility for international community
- **Importance of physics with GSI pion beams + HADES strongly emphasized by the community**

- Series of workshops took place already:
  - Kraków, Poland, Jun 21, 2023: https://indico.gsi.de/event/17693/
  - Wuppertal, Germany, Feb 6–9, 2024: https://indico.gsi.de/event/18475/
  - Darmstadt, Germany, Nov 11–14, 2024: https://indico.gsi.de/event/20301/
  - Catania, Italy, Jun 23-27, 2025: https://indico.gsi.de/event/21757/



White Paper with GSI/FAIR JSC
Editors: J. Messchendorp and F. Nerling
Over 50 contributors, 200+ pages!


Physics Opportunities at FAIR with Proton and Pion Beams

Abstract

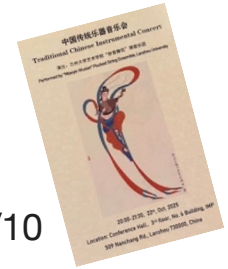
This white paper outlines a coordinated, decade-spanning programme of hadron and QCD studies anchored at the GSI/FAIR accelerator complex. By exploiting intense proton and pion beams coupled with high-rate capable detectors and an international theory effort, the initiative addresses five challenges: (i) elucidating confinement and dynamical mass generation, (ii) mapping the complete baryon–meson spectrum—including exotic states, (iii) quantifying baryon–baryon and meson–baryon interactions, (iv) constraining neutron-star structure through terrestrial data. A phased roadmap with SIS100 accelerator start-up, and envisaged detector upgrades—will yield precision cross-sections, transition form factors, in-medium spectral functions and validated lattice/EFT inputs. Synergies with JLab 12 GeV, J-PARC, the EIC and RHIC/LHC are foreseen. The programme is expected to bring about decisive advances in non-perturbative QCD, astrophysics topics, such as questions related to the equation of state of neutron stars, and high-rate detector and data-science technology.

Contents

1 Introduction: Key Questions in Strong Interaction Physics

46th CBM Collaboration Meeting Program

- Maximise **exchange**, honor **progress**, identify **critical items**
  → plenary session only + work group sessions
- Highlight talks on Friday Morning



- As part of the social event – Tour for ECE experiment,
  Chinese Traditional Music Concert on Wed 22/10, Tour on Thu 23/10

- Collaboration Meetings preceded by the PIFI Day & CBM Student's Colloquium: Junior's day on Sun 19/10

Summary: The future is bright!

Realization of FS+ is on promising track
- FAIR Council gradually approves funding of mission critical items

Timely completion of SIS100: unique physics program with CBM
- High μ_B region is driven by experiment
- Large discovery potential

Focus our forces on the timely realisation of CBM
- Ultimate goal: CBM ready for beam in 2028

Steadily push and develop physics cases to maximally utilize CBM's new and unique capabilities

谢谢

IMP

CENTRAL CHINA NORMAL UNIVERSITY

中國科學院
CHINESE ACADEMY OF SCIENCES