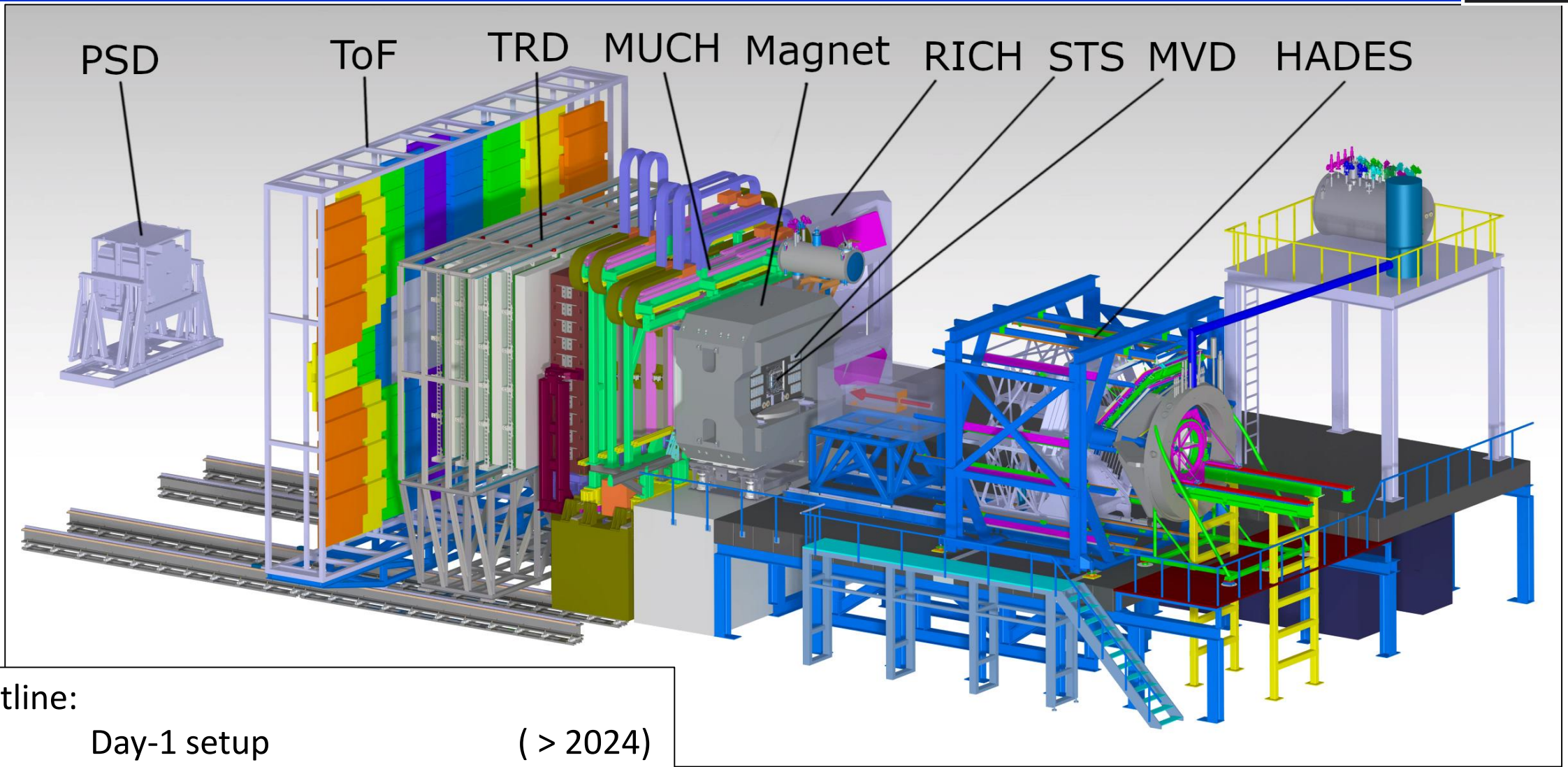


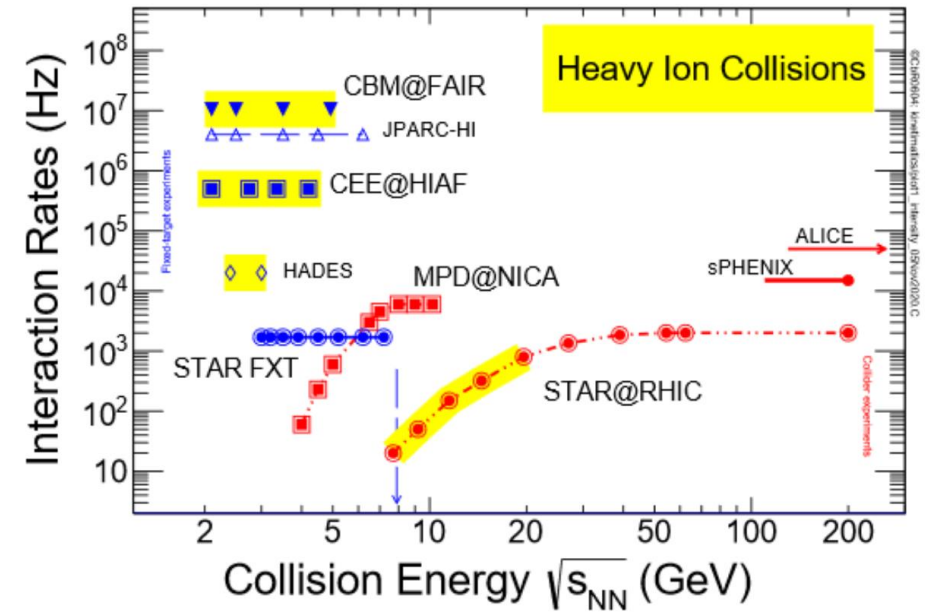
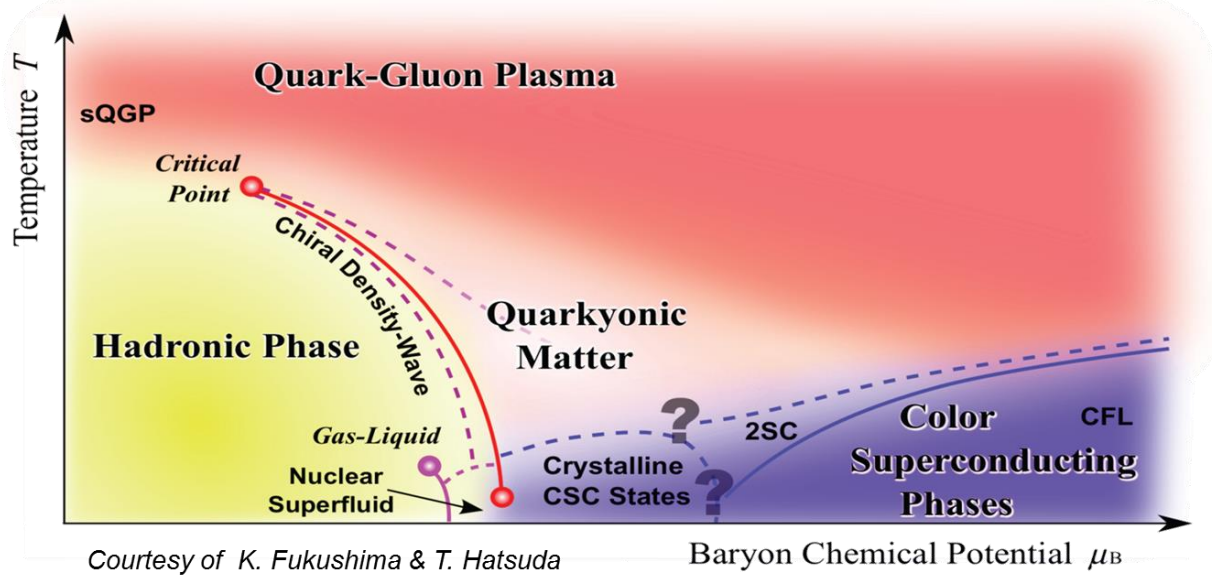
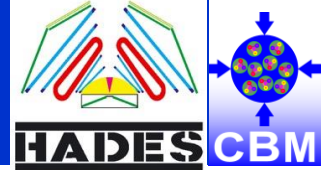
CBM experiments



Outline:

Day-1 setup (> 2024)
FAIR phase 0 program (2018 – 2024)

CBM – Goals



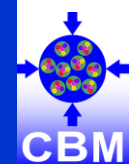
Mission:

Systematically explore QCD matter at large baryon densities with high accuracy and rare probes.

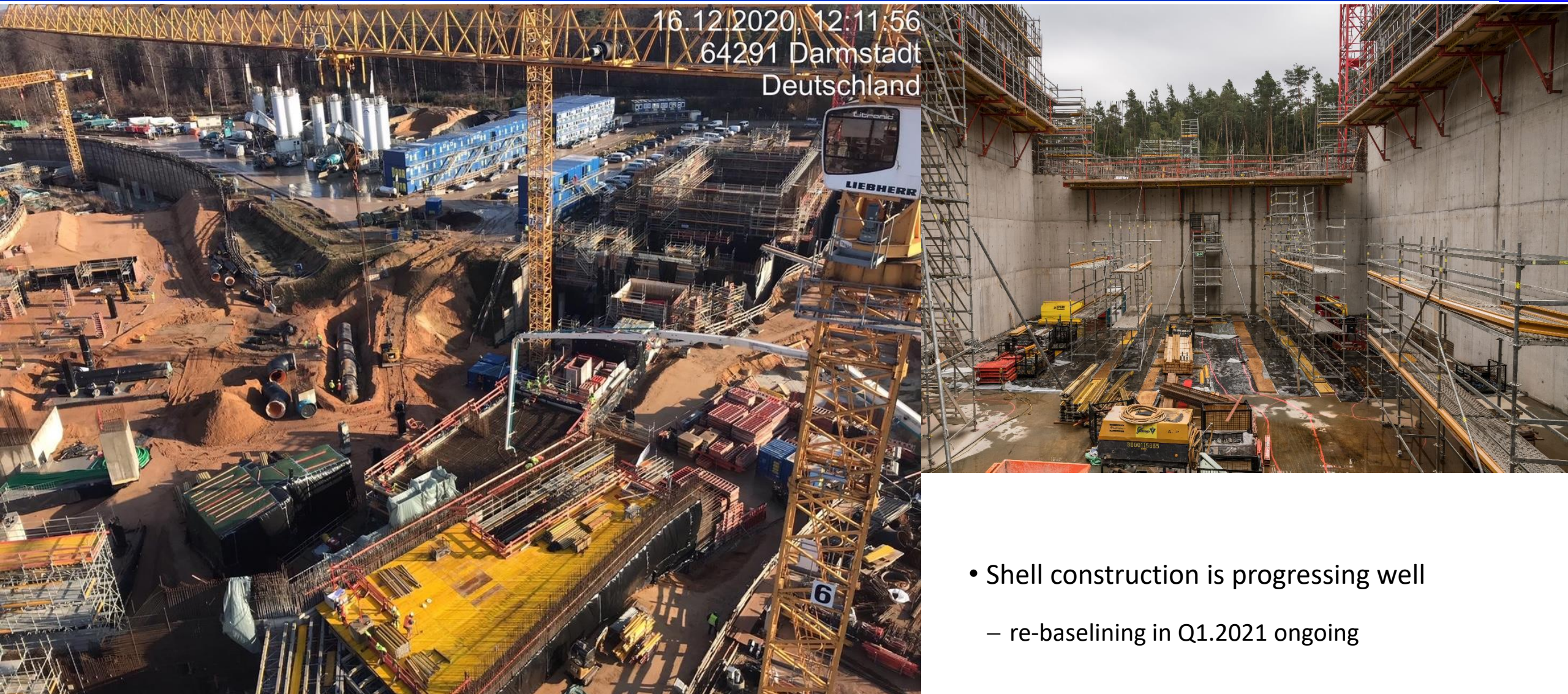
Fundamental questions:

- Equation of State of QCD matter at neutron star core densities
- Phase structure of QCD matter
- Chiral symmetry restoration at large densities
- Bound states with strangeness
- Charm in dense baryonic matter

CBM Building

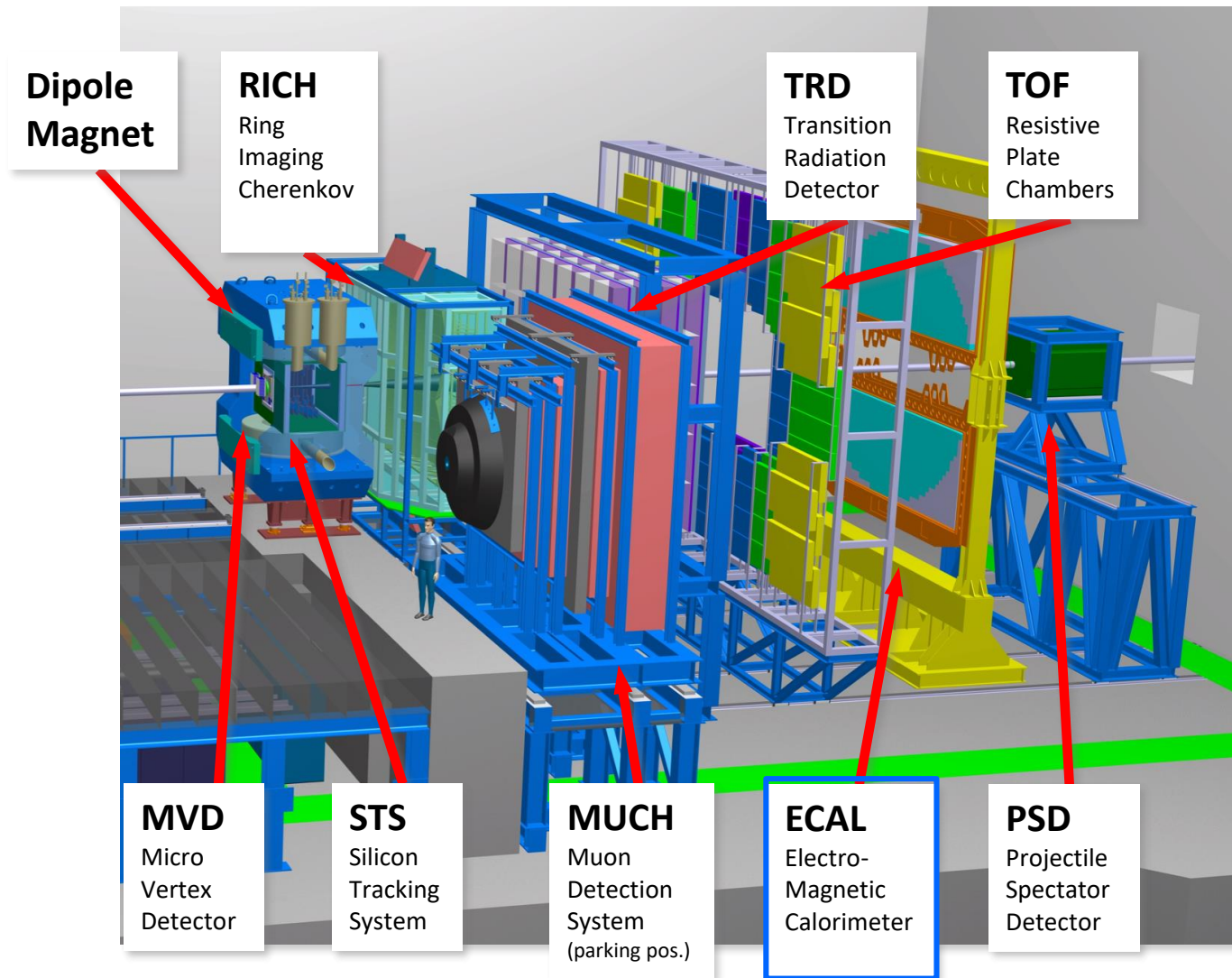
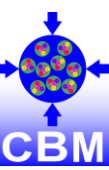


16.12.2020, 12:11:56
64291 Darmstadt
Deutschland



- Shell construction is progressing well
 - re-baselining in Q1.2021 ongoing

CBM experimental setup (day-1)



- Tracking acceptance:
 $2^\circ < \theta_{\text{lab}} < 25^\circ$
- Free streaming DAQ
- $R_{\text{int}} = 10 \text{ MHz (Au+Au)}$

$R_{\text{int}} \approx 0.5 \text{ MHz}$

full bandwidth:

Det. – Entry nodes

reduced bandwidth

Entry nodes – Comp. farm

with

$R_{\text{int}} \text{ (MVD)} = 0.1 \text{ MHz}$

- Software based event selection

Day-1 funding:
~ 90% secured

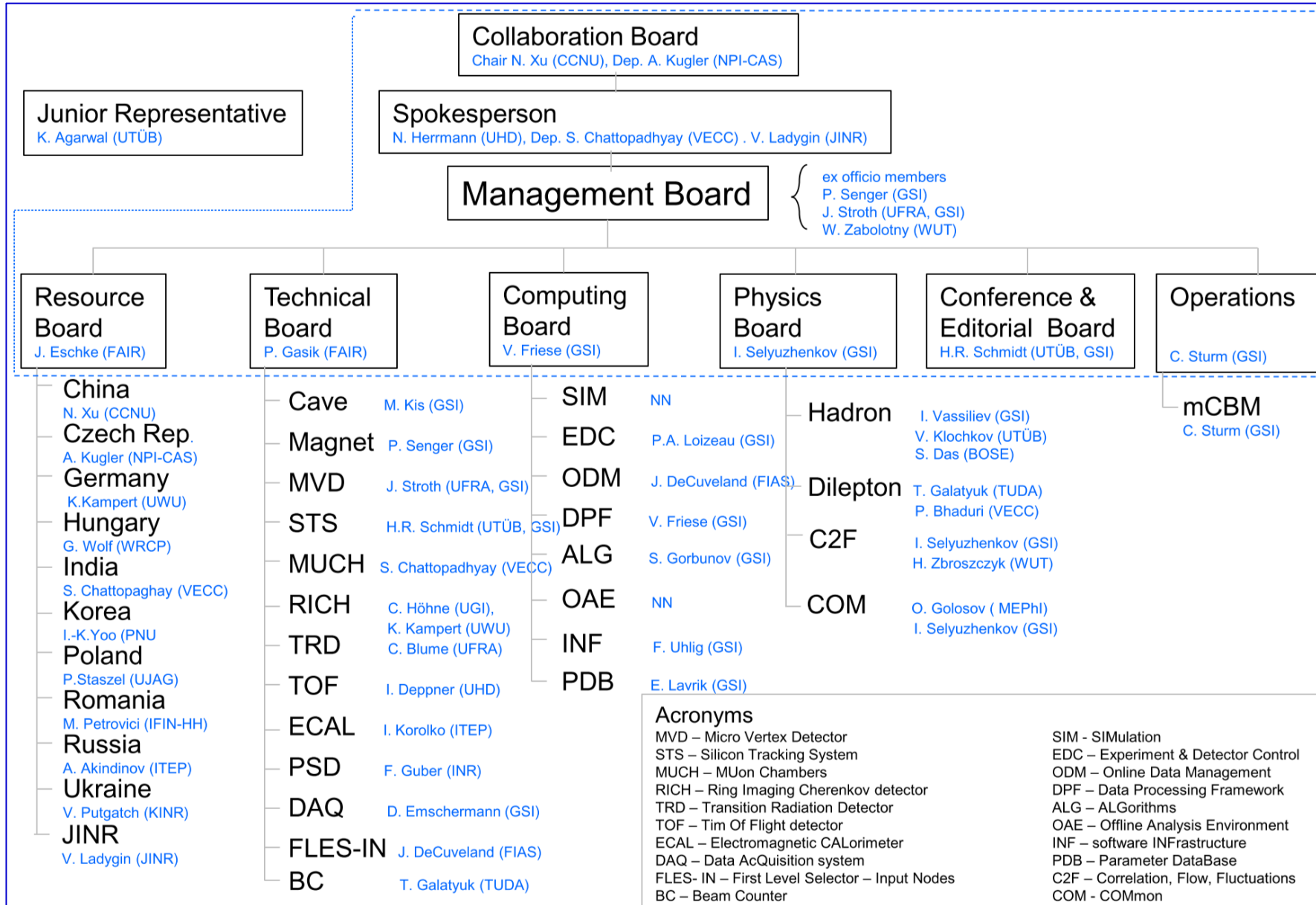
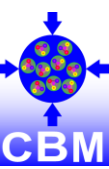
Day-1 setup = MSV setup – Compute Performance - ECAL

C.B.M. status – Score Card



	Component/ Sub-System	TDR	Cost [k€ 2005]	Funding	Construction	Construction completed	Test/ Commissioning
Day-1	Micro Vertex Detector (MVD)		914			04/2025	
	Silicon Tracking System (STS)		9504			08/2024	
	Ring Image Cherenkov Detector (RICH)		3697			01/2024	
	Muon Detector (MUCH)		6138			03/2024	
	Transition Radiation Detector (TRD)		2615			11/2024	
	Time of Flight System (TOF)		5785			11/2024	
	Projectile Spectator Detector (PSD)		944			11/2023	
	Dipol Magnet		3758			10/2022	
	Online Systems (DAQ and FLES)		1825			12/2023	
	Beam monitoring system		120			02/2025	
	Infrastructure		2192			12/2023	
		92% <i>value weighted</i>	37492	93% <i>secured</i>	18,7% <i>value weighted</i>		
Phase-0 (SIS18) & Day-1 (SIS100)	HADES upgrade		2594			03/2023	
Change since report 2020-II		unchanged		6%	2,5%		
Reporting Data Date: 12.01.2021							

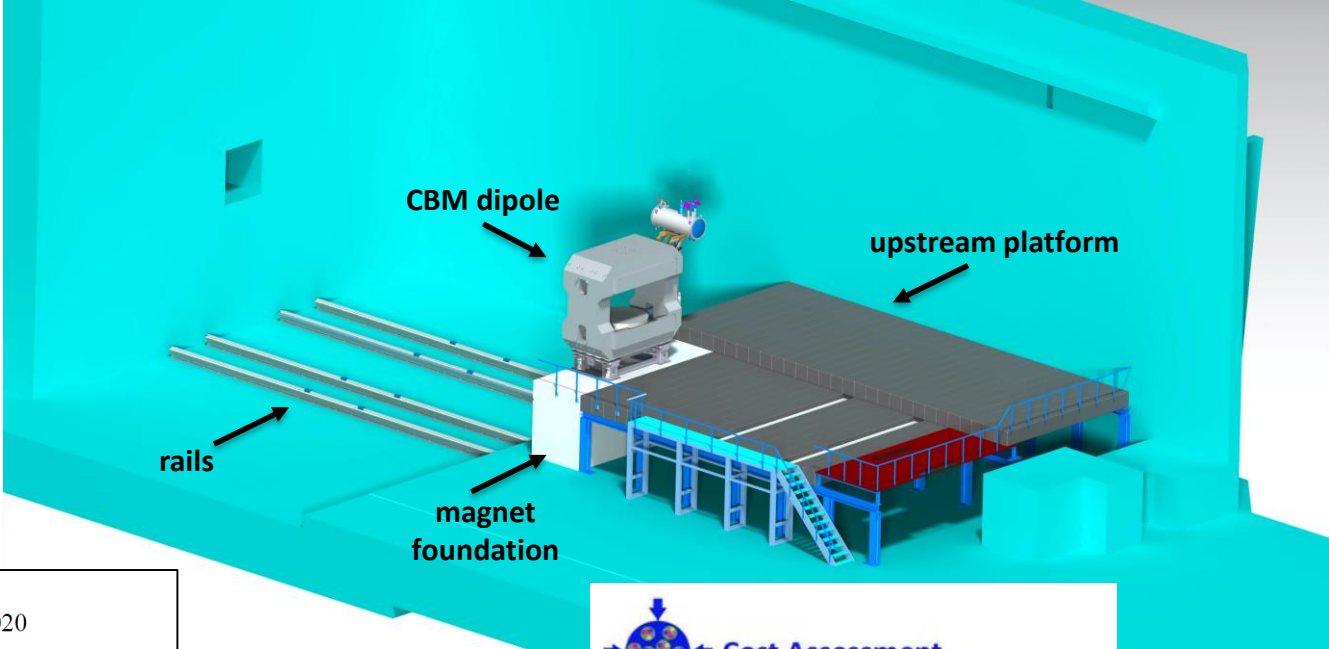
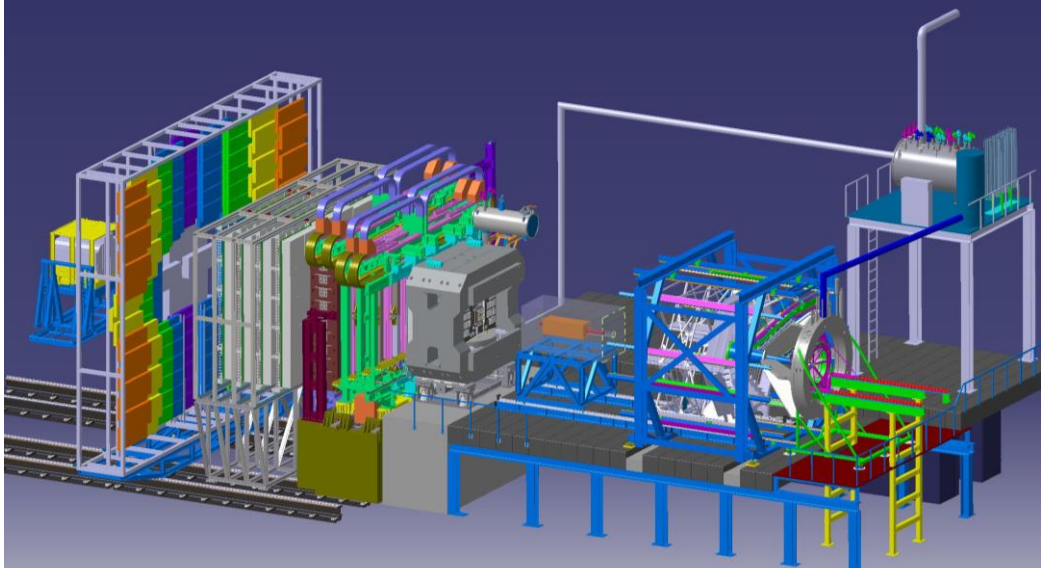
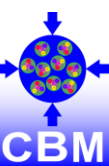
CBM collaboration structure



Full + Associated Member Institutions

- 66 institutes
- 490 members

Cave infrastructure



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



Cost Assessment

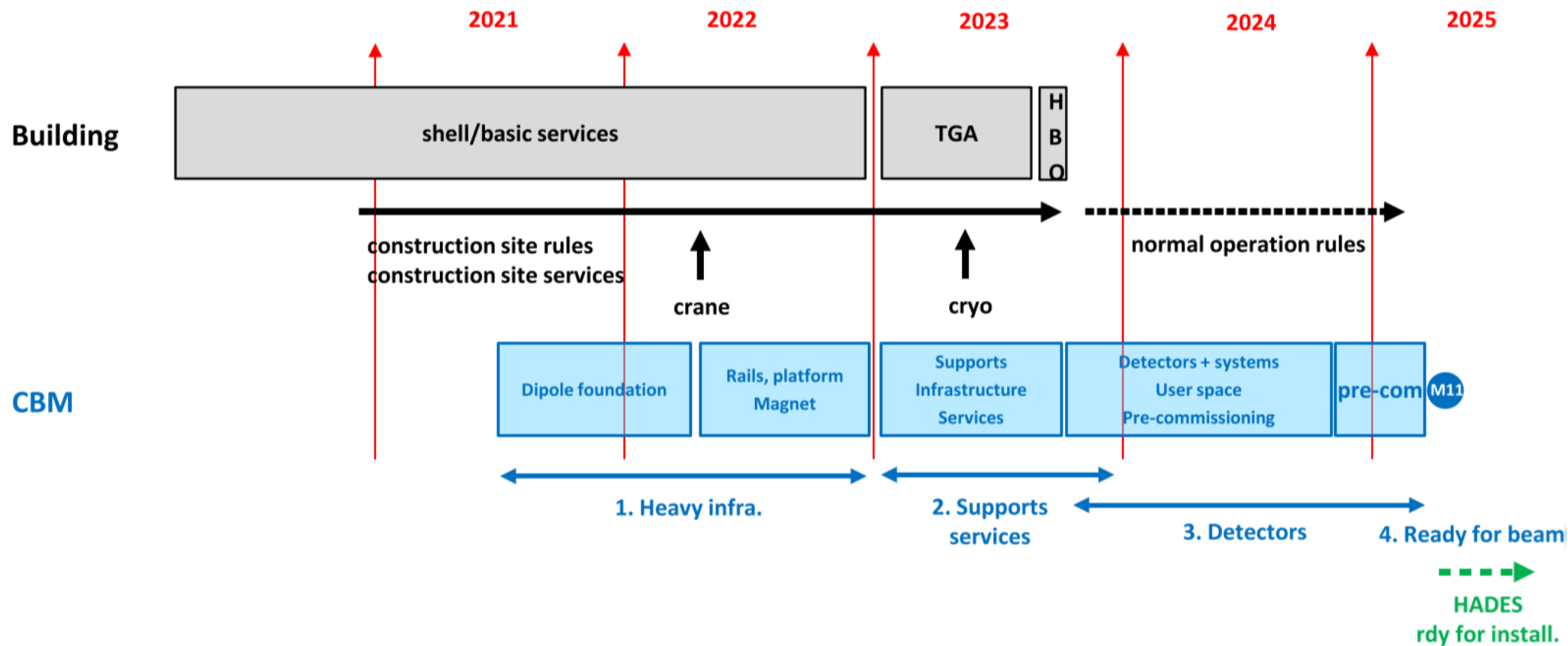
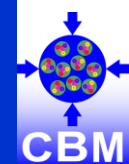
Common Infrastructure
of the CBM Experiment at FAIR



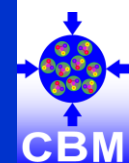
Compressed Baryonic Matter Experiment

October 2019

CBM installation – towards baseline 2021

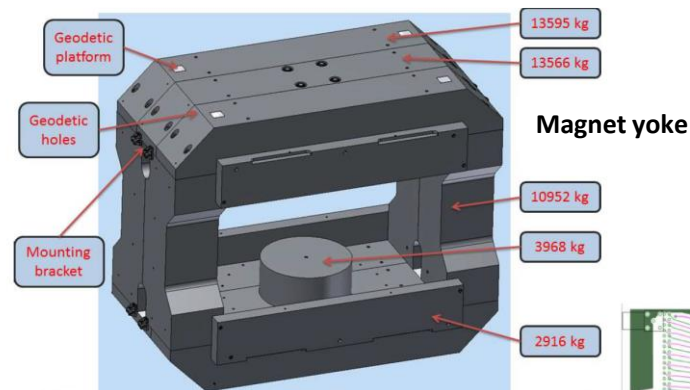


Highlights from the detector projects



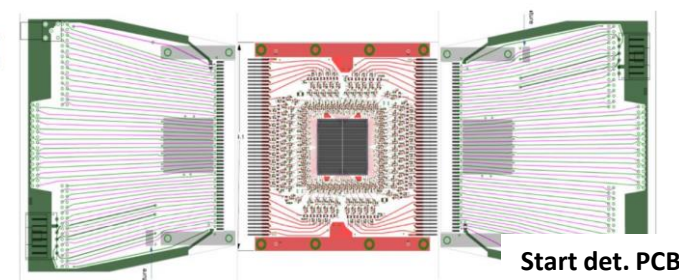
Magnet (GSI, BINP Novosibirsk, JINR Dubna)

- Progress in design of coils, branch box, transfer line, cryostat.
- Successful Yoke and Power Supply Production Readiness Review in February 2021
- Hall at BINP prepared for Factory Acceptance Tests



Beam monitor and start detectors (TU Darmstadt)

- Endorsed as an independent project
- Start detector Concept for Day-1 based on pcCVD high purity diamond sensors
- A concept of the beam abort system being worked out



MVD (U Frankfurt, GSI, IKF Frankfurt, IPHC Strasbourg, Pusan Nat'l Univ.)

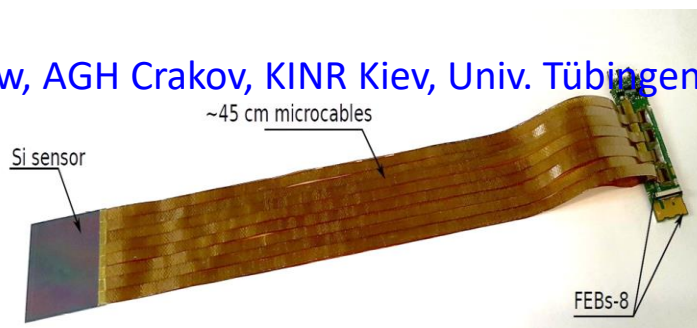
- MIMOSIS-1: first full size sensor prototype available! First tests successful, systematic studies ongoing
- TDR ready for collaboration review in December 2020
- MIMOSIS-2 submission in H2.2021



MIMOSIS-1 (evaluation PCB)

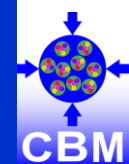
STS (GSI Darmstadt, JINR Dubna, KIT Karlsruhe, JU Crakow, AGH Crakow, KINR Kiev, Univ. Tübingen, Warsaw UT)

- All sensors delivered, QA done
- Successful Module and Ladder assembly EDR in Dec. 2020
- New ASICs available (STS-XYter2.2)
- Preproduction in Q2/Q3.2021
- PRR prior to mass production in 10.2021



Assembled STS module

Highlights from the detector projects



MUCH (Aligarh Muslim Univ., Bose Inst. Kolkata, Panjab Univ., Univ. of Jammu., Univ. of Kashmir, Univ. of Calcutta, B.H. Univ. Varanasi, VECC Kolkata, IOP Bhubaneswar, NISER Bhubaneswar, IIT Kharagpur, IIT Indore, Gauhati Univ., PNPI Gatchina)

- Mechanics CDR accepted, EDR in 09.2021
- 2nd station GEM chamber - assembly in progress for mCBM '21, GEM CDR in 03.2021
- RPC station - assembly in progress for mCBM '21

RICH (Univ. Giessen, Univ. Wuppertal, PNPI Gatchina, GSI Darmstadt)

- Mechanics CDR accepted, EDR in 09.2021
- Camera design EDR completed; pre-production (demonstrator incl. cooling) launch in 2021
- Mirrors EDR/PRR in Q1.2021 followed by start of mirror production

TRD (NIPNE Bucharest, Univ. Frankfurt, Univ. Heidelberg, Univ. Münster, IRI Frankfurt)

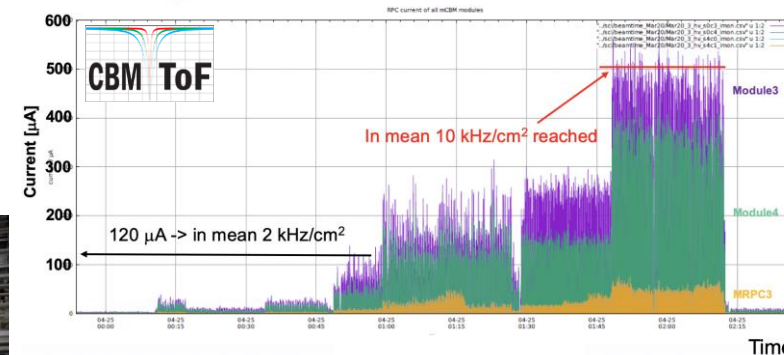
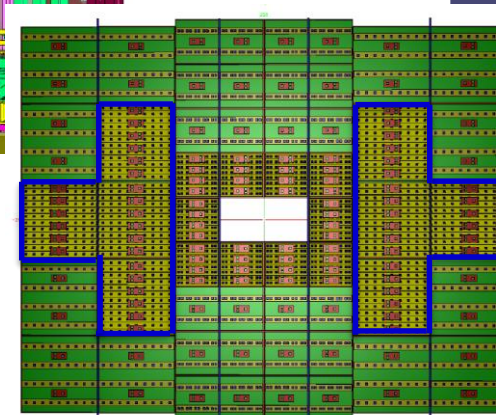
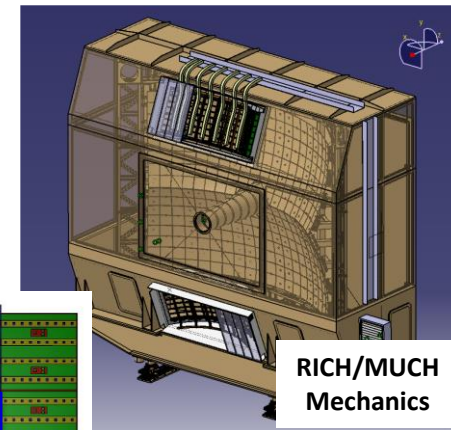
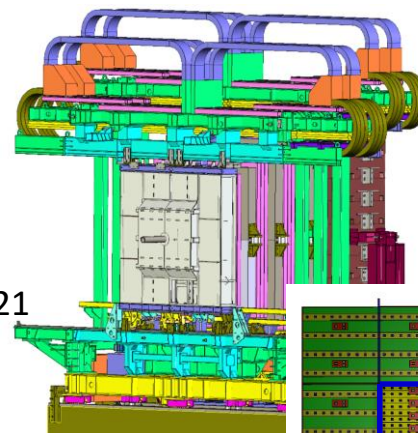
- Outer modules PRR completed, first of series production (5 modules) in H1.2021
- Inner modules TDR Addendum ready for submission in 04.2021
- SPADIC 2.3 ASIC test submission in Dec. 2020

TOF (THU Beijing, NIPNE Bucharest, GSI Darmstadt, TU Darmstadt, USTC Hefei, Univ. Heidelberg, ITEP Moscow, HZDR Rossendorf, CCNU Wuhan)

- New ASIC PADI XI successfully tested – PRR in 03.2021
- Unprecedented time resolution of 35 ps reached (prelim.)
- Particle fluxes > 10 kHz/cm² reached
- Ageing studies ongoing in Bucharest (ISRAM facility);

PSD (INR Moscow, TU Darmstadt, CTU Prague, NPI Rez)

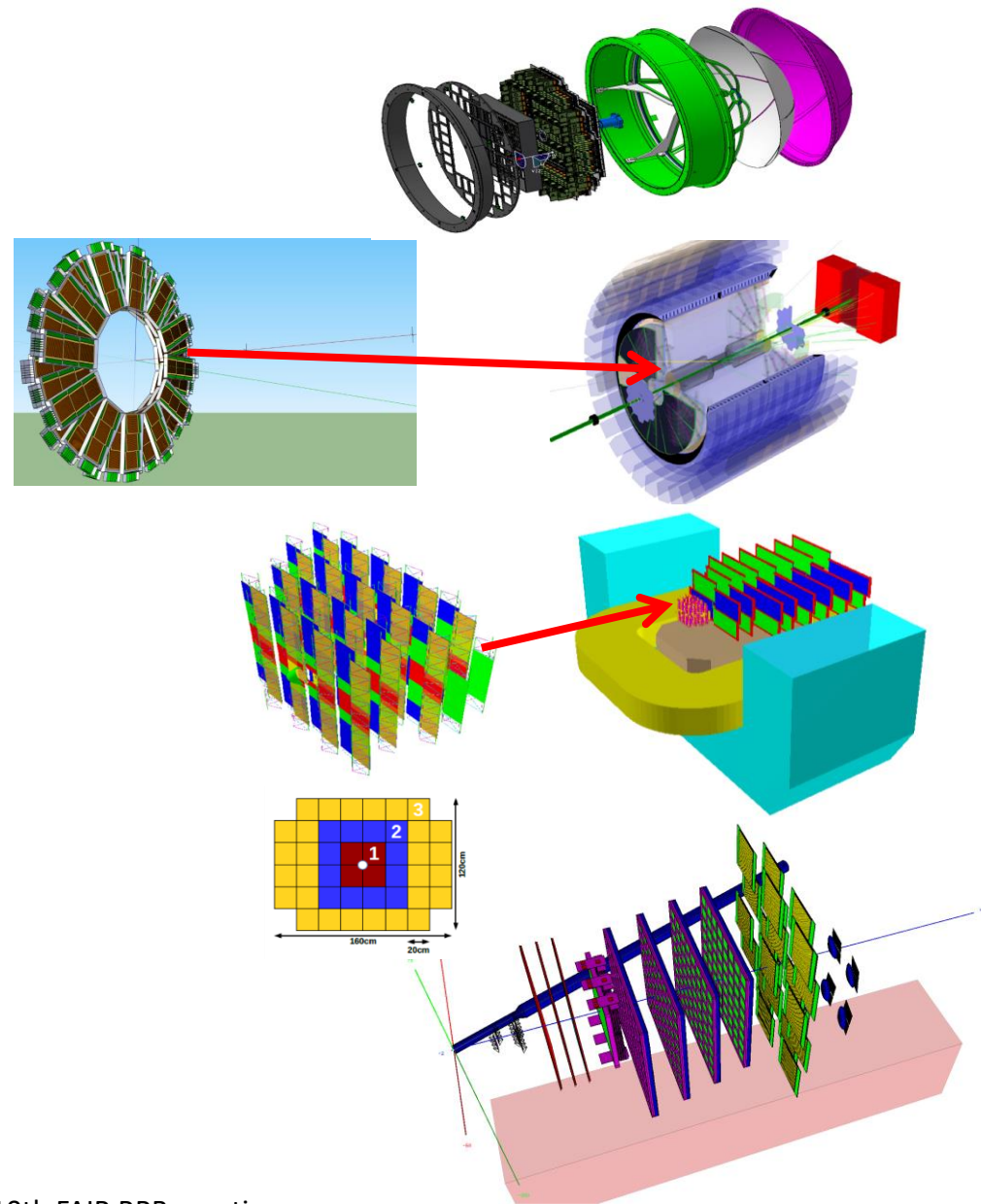
- All modules produced, Upper support structure arrived at FAIR in 09.2020



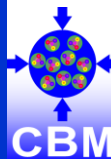
PSD support SAT

CBM – FAIR Phase 0 projects (2018 – 2024)

1. Install, commission and use 430 out of 1100 CBM RICH multi-anode photo-multipliers (MAPMT) including FEE in HADES RICH photon detector
2. Install, commission and use 10% of the CBM TOF modules including read-out chain at STAR/RHIC (BES II 2019/2020)
3. Upgrade BM@N experiment with 4 Silicon stations of CBM/STS design in the BM@N experiment at the Nuclotron JINR/Dubna (Au-beams in late 2022)
4. Install, commission and use the Project Spectator Detector at the BM@N experiment
5. mini CBM (mCBM@SIS18) demonstrator for full CBM data taking and analysis chain



HADES Proposals for last G-PAC



Pion induced reactions on CH₂ and C, Ag targets

The HADES Collaboration



Spokespersons: J. Stroth (jstroth@mpi.de), P. Thyti (thyti@fzj.cas.cz)
GSI contact: J. Pietraszkó (jpietraszk@mpi.de)
Infrastructure: SIS18 pion production target and HADES cave
Beam: Nitrogen at 2A GeV, maximum intensity, slow extraction

Abstract
We will study baryon excitation and decay in the third resonance region. Emphasis is on the electromagnetic structure of baryons and the role of intermediate ρ mesons in dense matter in the dense process. The measurement of e^+e^- production off the carbon in the transition to the electromagnetic transition form factors of baryons. Hadronic final states will be included in Partial Wave Analysis to extract various hadronic resonances, among which are ρ and ω , with unprecedented precision. Pion-nuclear data allow to investigate nuclear effects in cold nuclear matter. The whole data set constitutes an important input to calculations of the viscosity of dense and hot hadronic matter.

Below is an executive summary of the proposed study with π^- beam using the HADES spectrometer

This is a new experiment proposal.
We request 80 shifts.

Not granted due to limited available beam time

p+p reactions at 4.5 GeV on CH₂

The HADES and HADES-PANDA Collaborations



Spokespersons: J. Stroth (jstroth@mpi.de), P. Thyti (thyti@fzj.cas.cz)
GSI contact: J. Pietraszkó (jpietraszk@mpi.de)
Infrastructure: SIS18, CH₂ (LiH₂) target, HADES cave
Beam: p at 4.5 GeV, beam intensity 2×10^7 protons/s, slow extraction

Abstract
We propose to investigate p-p reactions with an improved experimental set-up which enables measurements of charged particles emitted into the very forward hemisphere. This is achieved by additional tracking stations composed of straw modules built for the PANDA Forward Tracker. This will enable us to equip with a magnetic field, rather, particle identification is provided by an efficient time-of-flight measurement with a new RPC detector placed about 6 m downstream of the target. Two main physics topics are addressed: (i) identification of meson production; (ii) inclusive measurement of strange particle production and detection of strange particles; (iii) study of heavy ion data sets (i) A-p exclusive reconstruction of strangeness production; (ii) strange production, and production of strange particles and detection production as reference for p-A and heavy ion data sets (i) A-p scattering parameters and phase shifts; (ii) understanding charge-conjugation in hadron-hadron collisions and phase shifts; (iii) understanding charge-conjugation in nuclei; (iv) search for a dark photon in the detection channel. This results will also provide an important reference for the future program at FAIR.

Below is an executive summary of the proposed study with proton beam using the HADES spectrometer combined with the new forward detection system.

This is a new experiment proposal.
We request 88 shifts.

100% granted
run scheduled for 2022

p+Ag reactions at 4.5 GeV

The HADES Collaboration



Spokespersons: J. Stroth (jstroth@mpi.de), P. Thyti (thyti@fzj.cas.cz)
GSI contact: J. Pietraszkó (jpietraszk@mpi.de)
Infrastructure: SIS18, HADES cave and part of the NeuLAND detector to measure the recoil neutron
Beam: p at 3.5-4.5 GeV, beam intensity 4×10^7 protons/s, slow extraction

Abstract
We propose to investigate p-Ag reactions with an improved experimental set-up which enables measurements of charged particles emitted into the very forward hemisphere. Main physics topics are addressed: (i) detection production in the low and intermediate mass region; (ii) α disintegration in ^7Li nuclear matter; (iii) strangeness production and propagation in ^7Li nuclear matter (compression and expansion for thermal and transport properties); (iv) A-p scattering parameters and phase shifts; (v) understanding charge-conjugation in nuclei; (vi) search for a dark photon in the detection channel. This results will also provide an important reference for the future program at FAIR.

Below is an executive summary of the proposed study with proton beam using the HADES spectrometer combined with the new forward detection system.

This is a new experiment proposal.
We request 88 shifts.

Not granted due to limited available beam time

Studies of QCD matter with Au+Au collisions at 800-600-400-200A MeV

The HADES Collaboration



Spokespersons: J. Stroth (jstroth@mpi.de), P. Thyti (thyti@fzj.cas.cz)
GSI contact: J. Pietraszkó (jpietraszk@mpi.de)
Infrastructure: SIS18 and HADES cave
Beam: slow extraction Au at 800-600-400-200A MeV, beam intensity 1.2×10^7 ions/s (flat top) C at 800-600.4 MeV, beam intensity 3×10^7 ions/s (flat top)

Abstract
We will study baryonic matter in the region of highest net-baryon densities close to the nuclear liquid-gas phase transition. The heavy Au-Au collisions (30 shifts for 800.4 MeV and 30 shifts for 600.4 MeV) are optimized for abundant low-mass dilepton and strangeness production; the lighter Au-C collisions (30 shifts for 400.4 MeV and 30 shifts for 200.4 MeV) will allow to collect most abundant particles (π , p , d , ^3He , ^4He) in large quantities, e.g., suitable for event-by-event analysis of particle correlations and fluctuations as well as to extract properties of the system at low temperatures. We aim at a high statistics beam energy scan to study the QCD phase diagram. Collisions of C beams on C target (6 shifts for 800.4 MeV and 6 shifts for 600.4 MeV) will serve as reference measurements.


Below is an executive summary of the proposed study with Au beam using the HADES spectrometer.

This is a new experiment proposal.
We request 90 shifts.

40% granted
run scheduled for 2022

Beam Energy Scan for proton and neutron induced reactions on protons.

The HADES Collaboration



Spokespersons: J. Stroth (jstroth@mpi.de), P. Thyti (thyti@fzj.cas.cz)
GSI contact: J. Pietraszkó (jpietraszk@mpi.de)
Infrastructure: SIS18, HADES cave and part of the NeuLAND detector to measure the recoil neutron
Beam: d with kinetic energy of $T_d = 1.0, 1.13, 1.25, 1.75, 1.75, 1.75$ A GeV, beam intensity 2×10^7 deuterons/s, slow extraction

Abstract
We propose to investigate p-p and quasi-free n-p reactions with deuterium beam on a LiF target with an improved experimental set-up which enables measurements of charged particles emitted into the very forward hemisphere. Quasi-free p-p and n-p reactions will be disentangled by tagging the proton spectator from detection break-up in the forward detector which covers almost complete $(-\pi, \pi)$ phase space for the spectator emission. The main goals of proposal are: (i) measurement of NN reference spectra for interpretation of medium effects in heavy-ion collisions at 1-2 AGeV; (ii) characteristics of dilepton production from baryonic sources; (iii) studies of isospin dependence of kaon (K^+ , K^0) production close to the threshold and (iv) deuterium $M_d = 2360$ MeV ($I = 0$, $J^P = 1^+$) production in quasi-free p-p interactions. The results will also provide an important reference for the future heavy-ion program at FAIR.

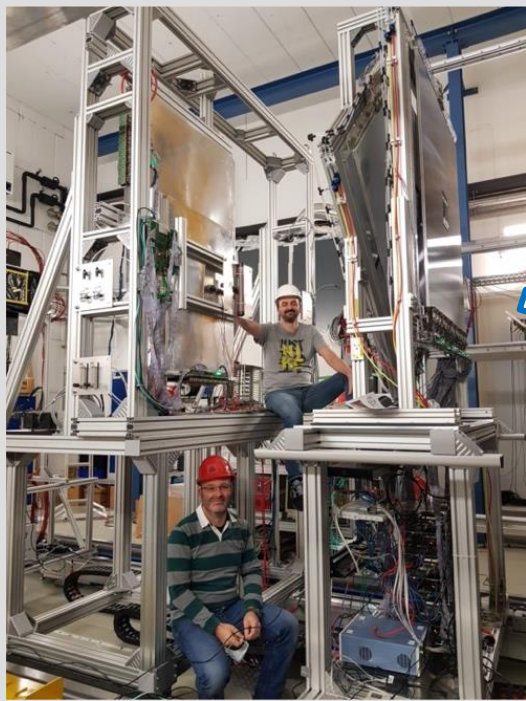
Below is an executive summary of the proposed study with proton beam using the HADES spectrometer combined with the new forward detection system.

This is a new experiment proposal.
We request 104 shifts.

Not granted due to limited available beam time

The upgraded HADES detector (five new detector systems)

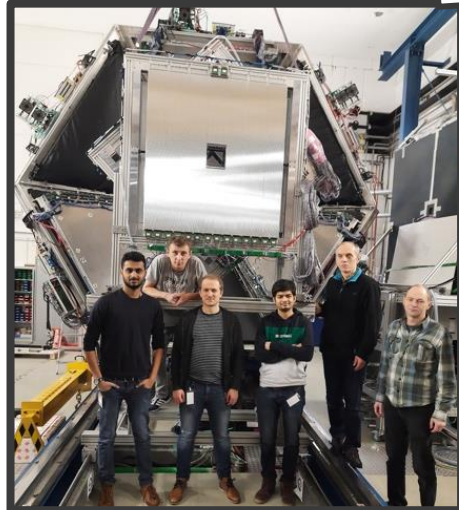
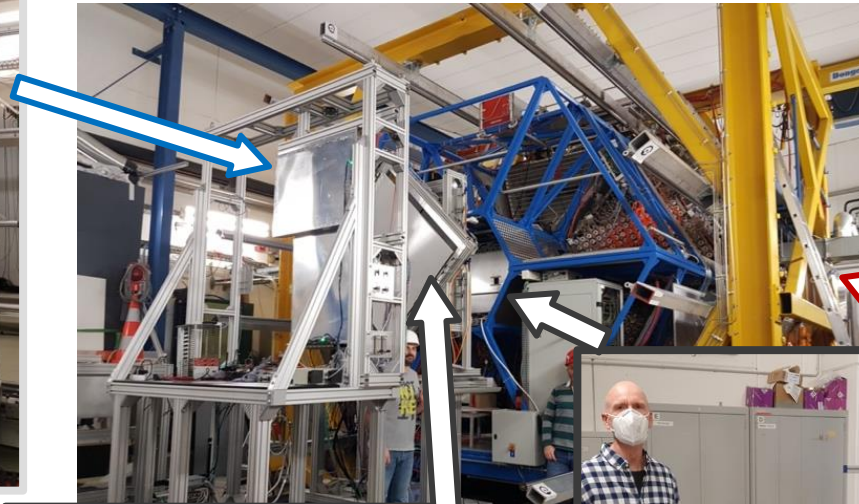
- Improved physics performance through instrumentation of the very forward hemisphere using FAIR technology.
- In particular important for the Hyperon Program.



Forward RPC

LIP Coimbra

- Based on R&D for neuLAND
- TRB3 read-out



STS2

Jagiellonian Univ.

- PANDA straw technology
- PANDA PASTTRECK FEE chip



STS1

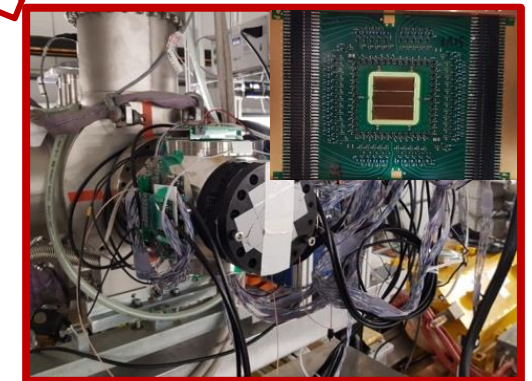
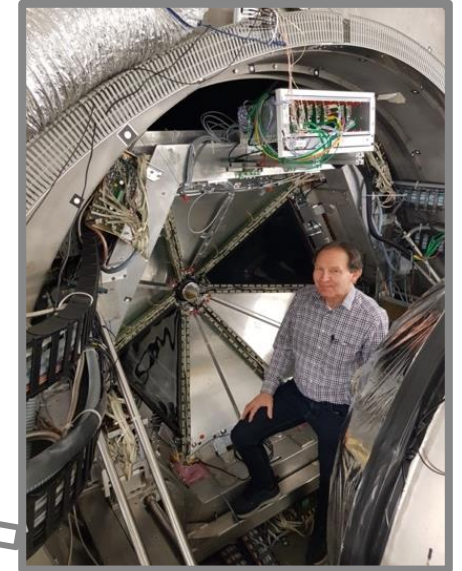
TransFAIR, Jülich

- PANDA straw technology
- PANDA PASTTRECK FEE chip

iTOF

TransFAIR, Jülich

- APD read-out
- Enhances trigger purity

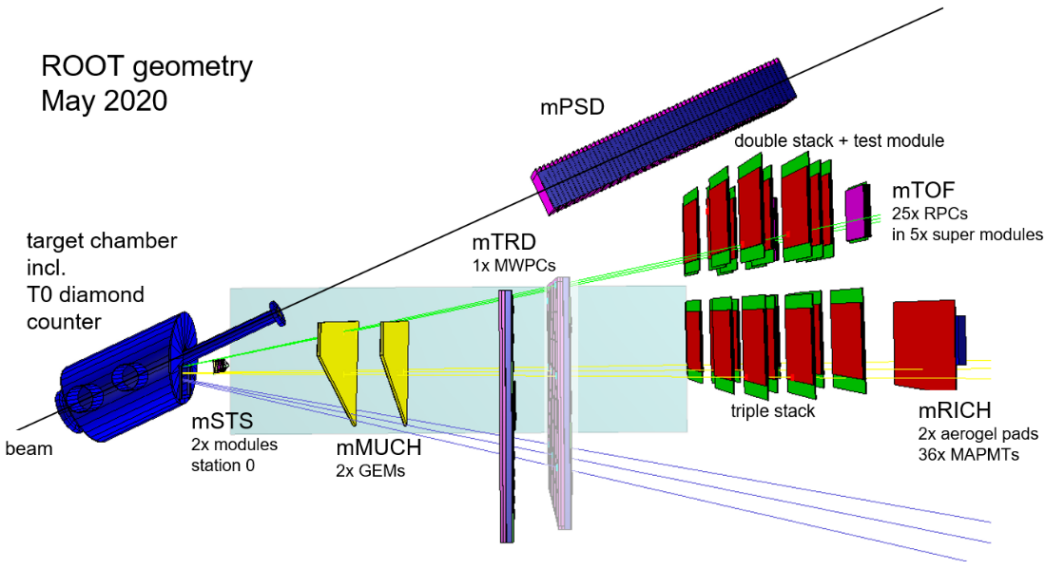


TO

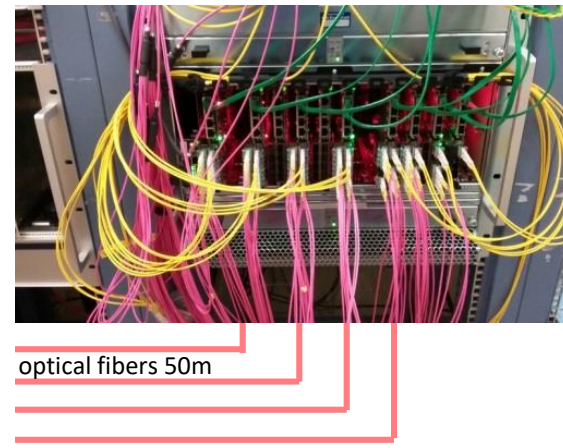
GSI, TU Darmstadt

- LGAD technology
- In-beam detector

The mCBM experiment at SIS18 -



DAQ container



optical fibers
300 m



triggerless-streaming FEE
assigning time stamps to hits

1 m Copper

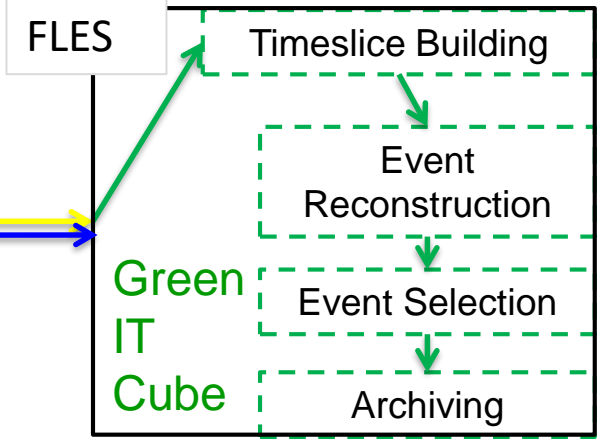
GBTx

50 m optical

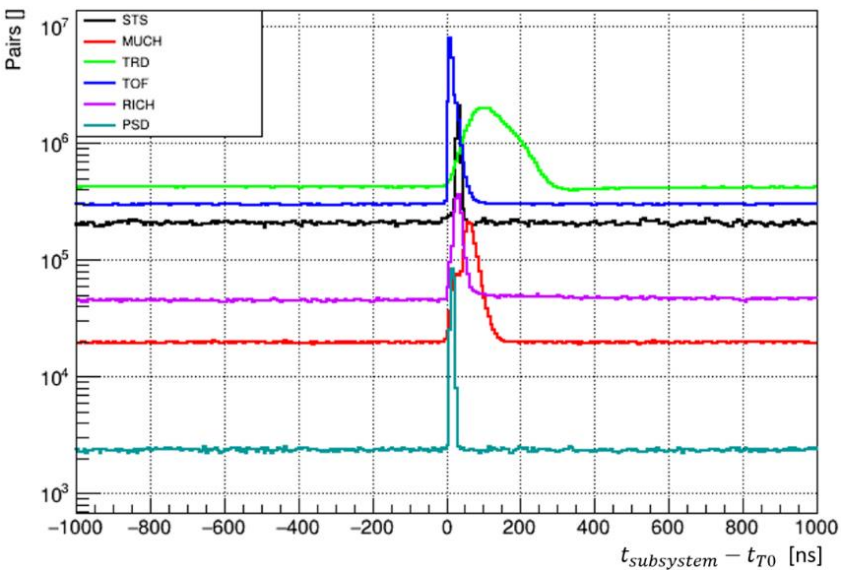
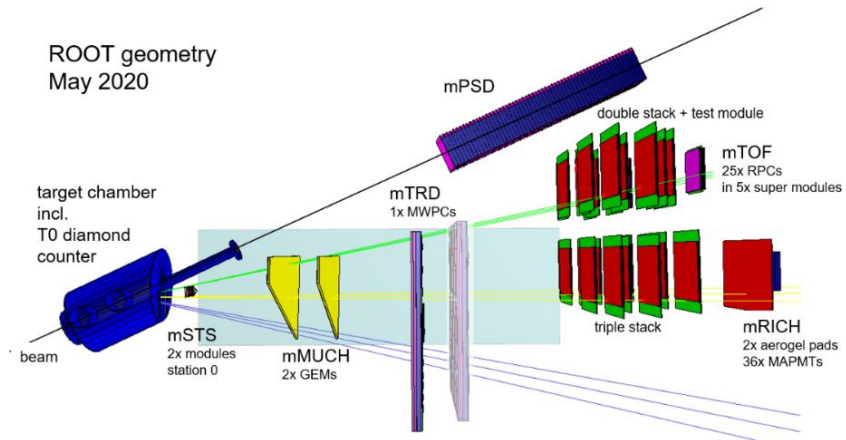
DPB: FPGA, μ Slice building, (FLES interface)

300 m optical

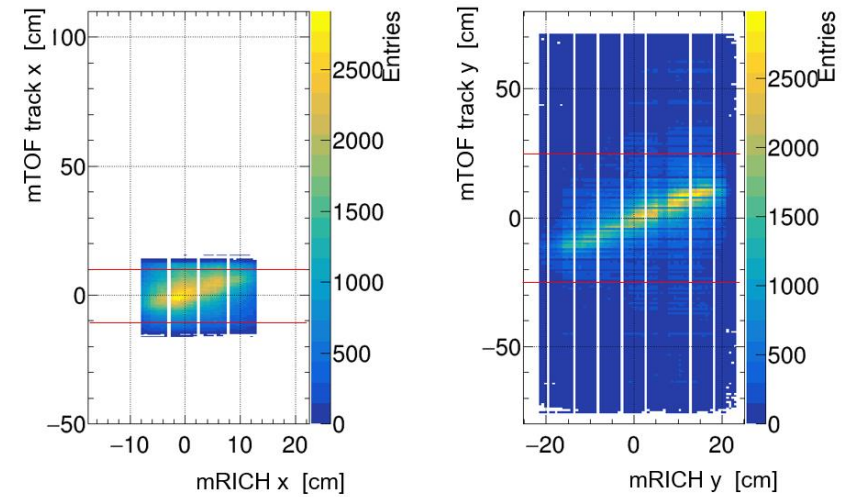
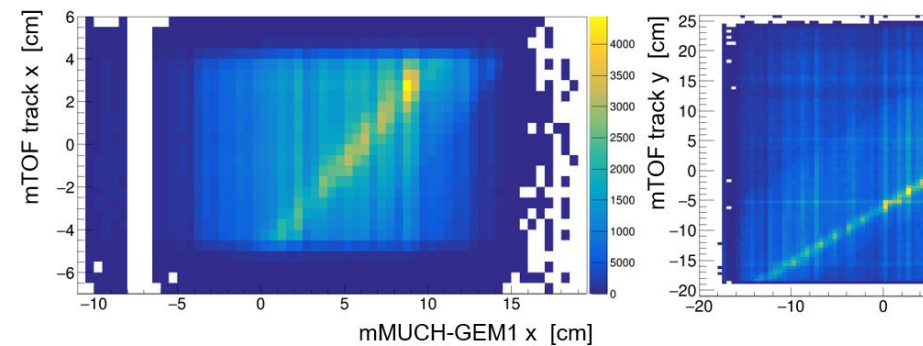
TFC



mCBM commissioning with beam, first results



subsystem time offset corrected,
no time calibration

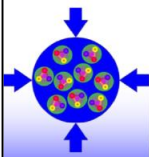


data:
run 831, May 4th, 2020
²⁰⁸Pb + Au, 1.060 AGeV
"low" collision rate \approx 20kHz

Observed time and spatial correlations between detector subsystems:
first steps towards verification of the triggerless-streaming DAQ system of CBM,
to be verified up to the CBM design limit of 10 MHz collision rate.

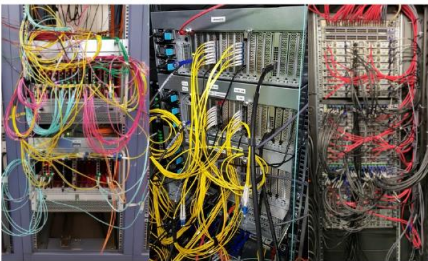
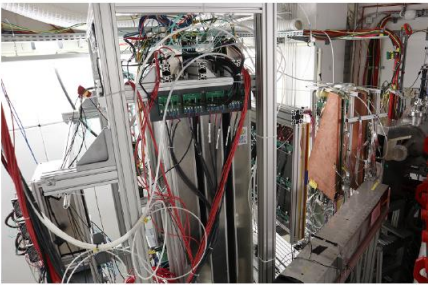
preliminary - May 2020 data

mCBM - data campaign 2021



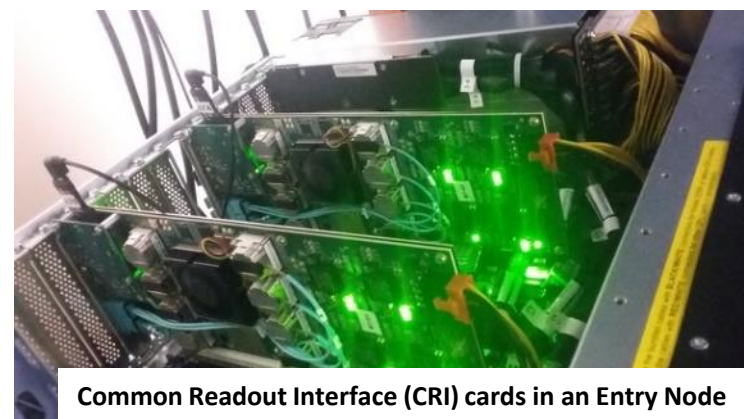
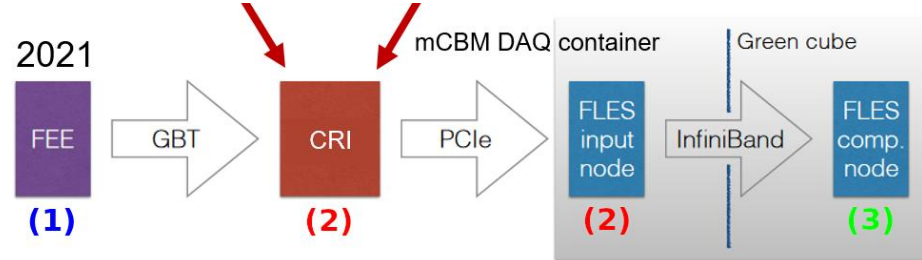
mCBM@SIS18

The CBM Collaboration



June 2020

Compressed Baryonic Matter Experiment



Common Readout Interface (CRI) cards in an Entry Node

DAQ (GSI Darmstadt, KIT Karlsruhe, Warsaw UT, + detector groups)
FLES (FIAS Frankfurt, Univ. Frankfurt)

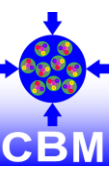
- Migration to the final configuration of the CBM data transport chain
- Completion of detector stations / subsystems
- Upgrade of cave infrastructure (cooling, vacuum, alignment)
- Further development of CBM online/offline software packages incl. controls / run control

Beam time schedule 2021

- (1) Commissioning of upgraded data transport and detector subsystems & high-rate detector tests
 ^{208}Pb beam, shifts (sec. user) within March 2021
- (2) Commissioning of benchmark runs (Λ production) incl. online reconstruction & selection
 ^{78}Kr beam, (prim. user) May 2021 and ^{16}O beam, June 2021

beam time application for 2021/22 fully granted

CBM eTOF @ STAR



Run20 (Dec2019 – Sep2020) successfully completed

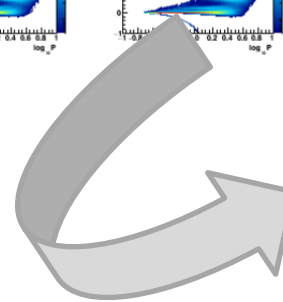
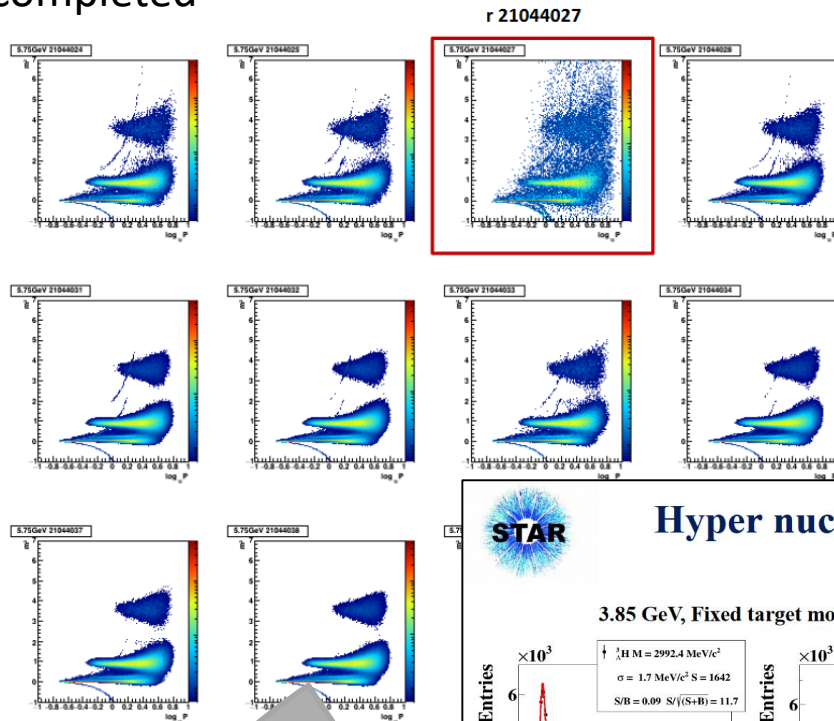
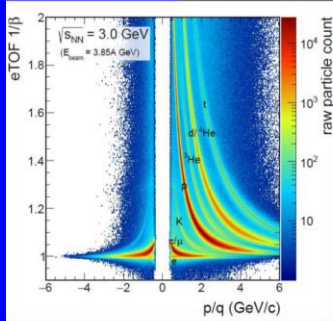


CBM
Compressed
Baryonic
Matter
experiment
at FAIR



**PROGRESS
REPORT**

2019



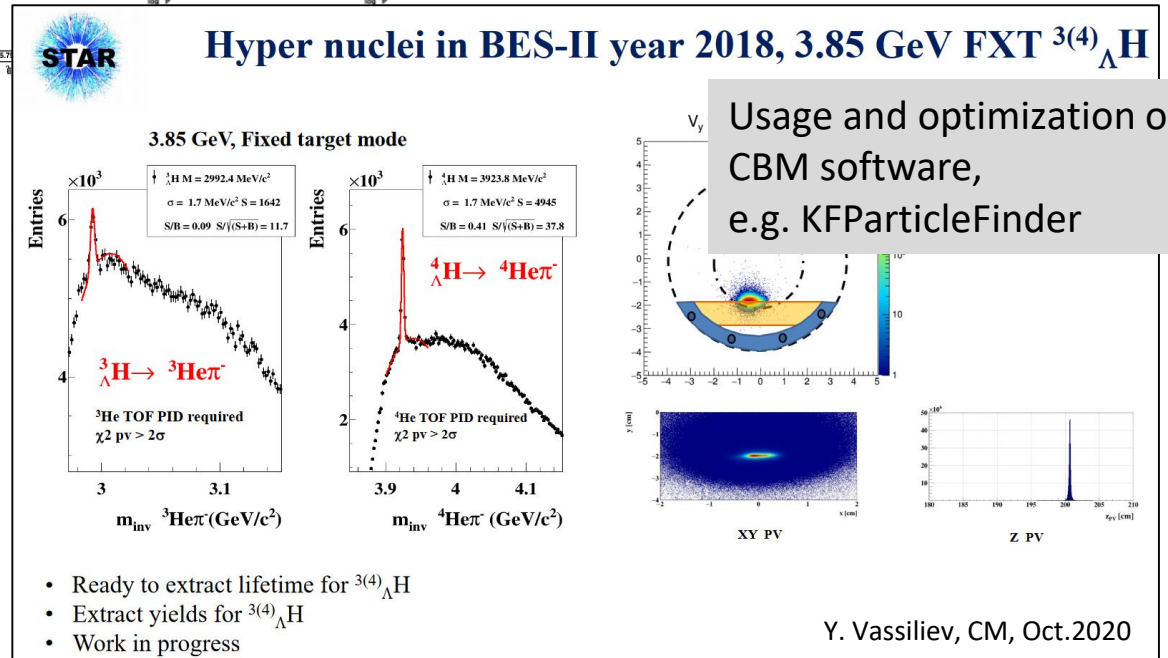
**Large potential for
physics results**

Progress Report

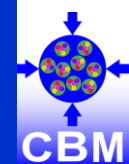
<https://repository.gsi.de/record/228172>

Run-by-Run online QA
of eTOF **Run20** data

Important step towards
CBM control concept



CBM collaboration meeting

A large grid of video conference windows showing participants. The grid is approximately 10 columns wide and 10 rows high. The bottom right portion of the grid is replaced by a dark grey area containing text labels for several participants.

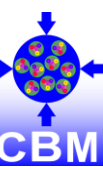
Dominik Smith Ulrich Frankenfeld atoia Qiunan

Marten Becker Philipp Weidenkaff Christoph Blume Esteban Rubio

Jürgen

36th CBM Collaboration Meeting
19-23 October 2020

Summary / Conclusion



CBM scientific program at SIS100 is unique

- explore QCD matter at neutron star core densities

- employ high statistics capability

 - to achieve high-precision of multi-differential observables

 - to enable rare processes as sensitive probes

CBM day-1 setup allows start of program with significant discovery potential

- excitation function of hyperons production

- excitation function of di-lepton production

- study of light hypernuclei

CBM Phase 0 activities targeted towards usage and understanding

of major components & production of physics results with CBM devices

- CBM – RICH sensors & readout

- in HADES at SIS18

- CBM – TOF and HPC software

- in STAR at RHIC/BNL

- CBM – PSD and CBM - STS

- in BM@N at Nuclotron/JINR

- Integration of all subsystems & FLES

- in mCBM at SIS18

CBM collaboration is open for contributions from additional groups.

CBM needs the sustained support of all funding agencies for HW and SW projects.