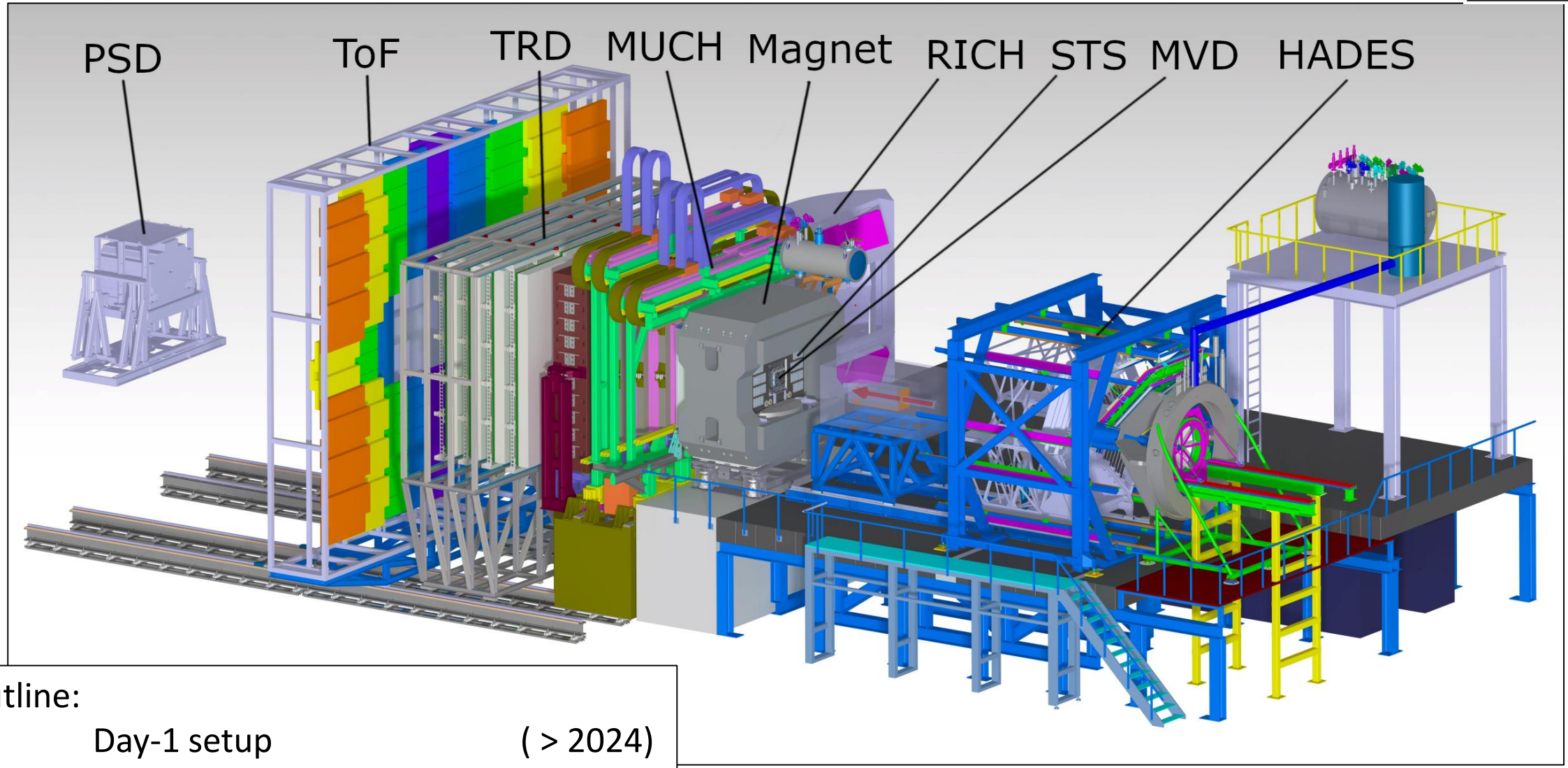
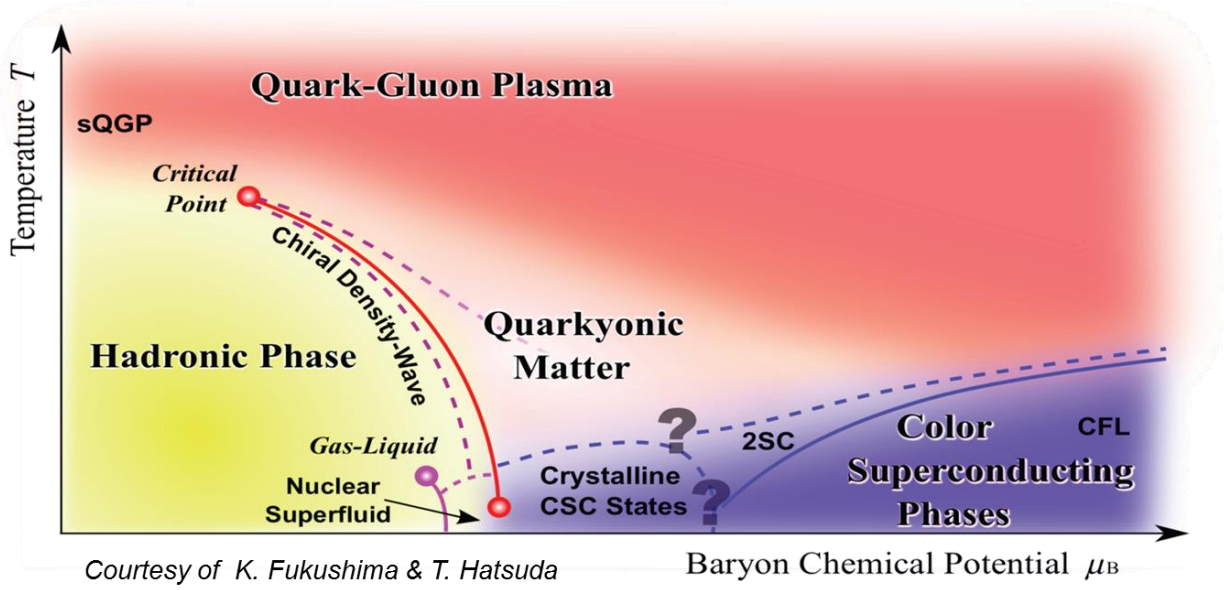
CBM experiments



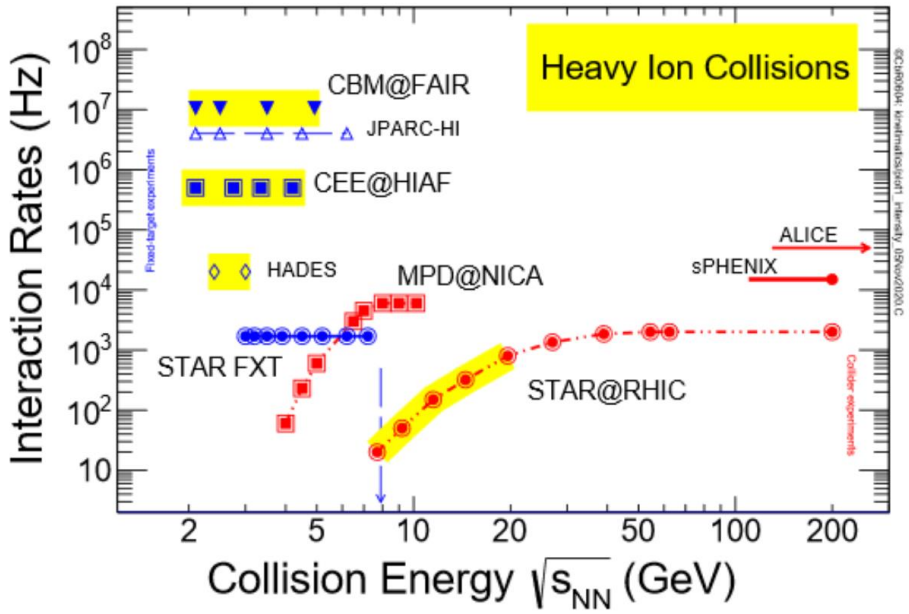
Outline:

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

CBM – Goals



Courtesy of K. Fukushima & T. Hatsuda



Mission:

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

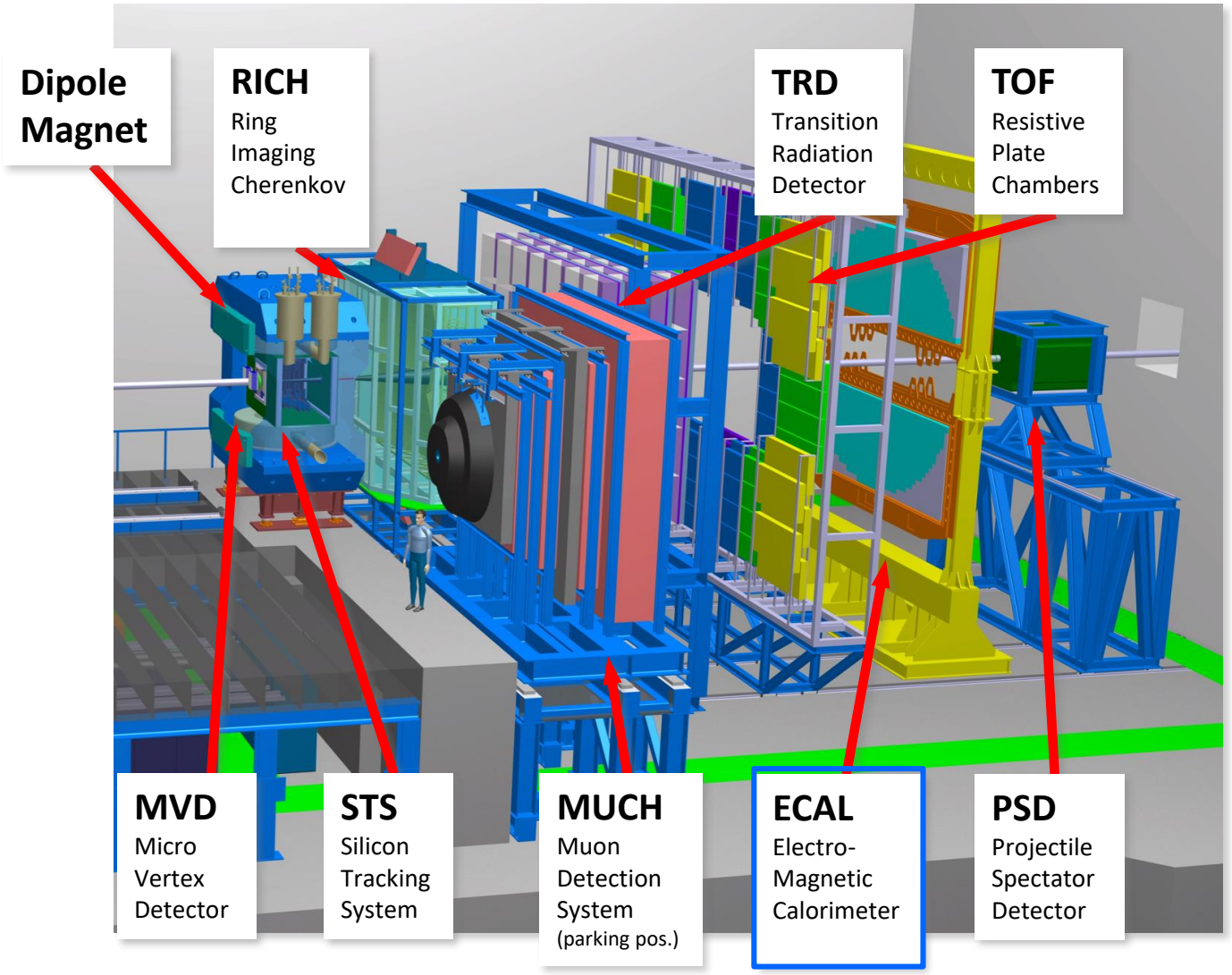
Fundamental questions:

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

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

CBM experimental setup (day-1)



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

  $R_{int} \approx 0.5$ MHz
  full bandwith:
  Det. – Entry nodes
  reduced bandwidth
  Entry nodes – Comp. farm

  with
  R_{int} (MVD)=0.1 MHz
- Software based event selection

Day-1 funding:
~ 90% secured

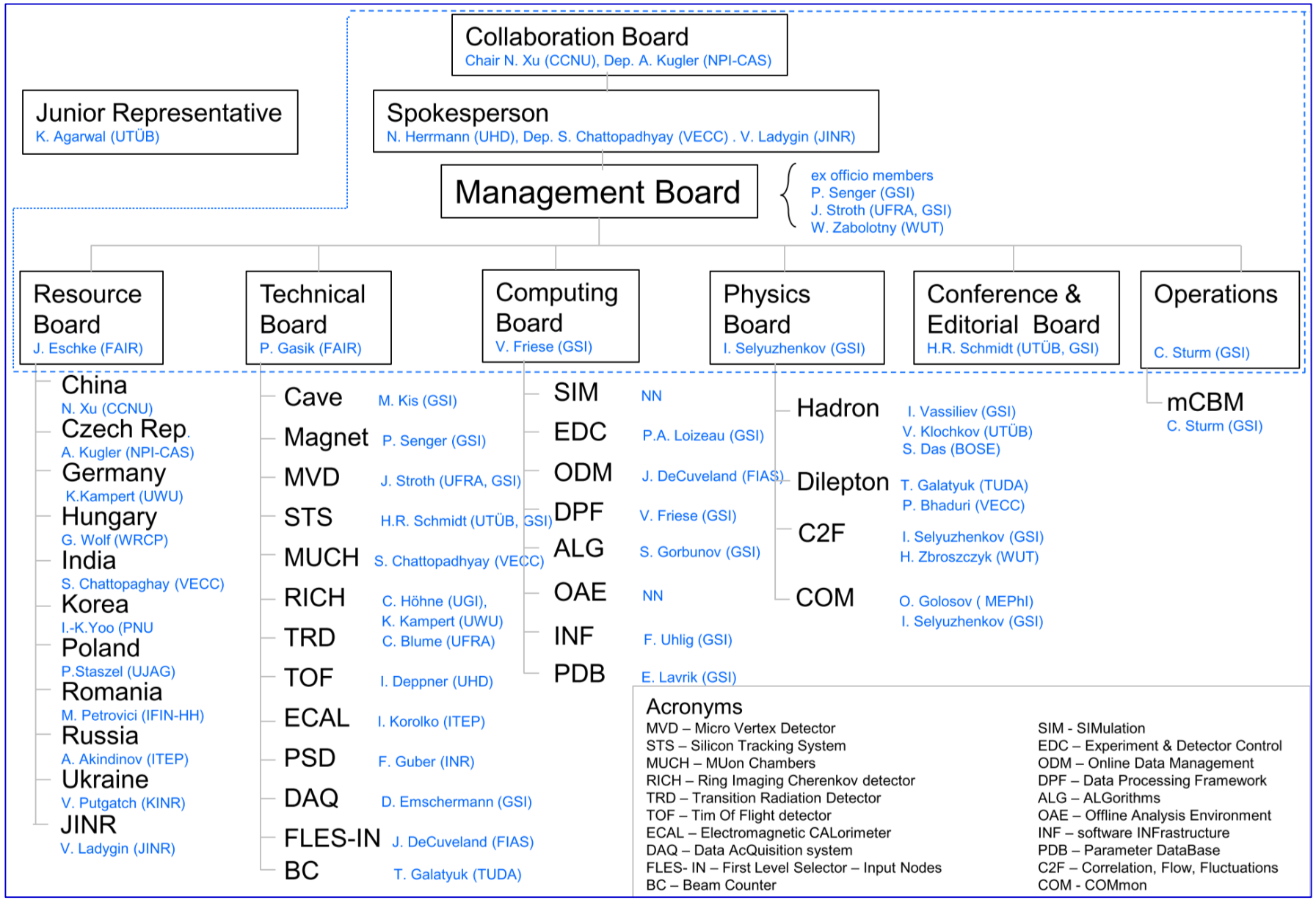
Day-1 setup = MSV setup – Compute Performance - ECAL

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% *value weighted*	37492	93% *secured*	18,7% *value weighted*		
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

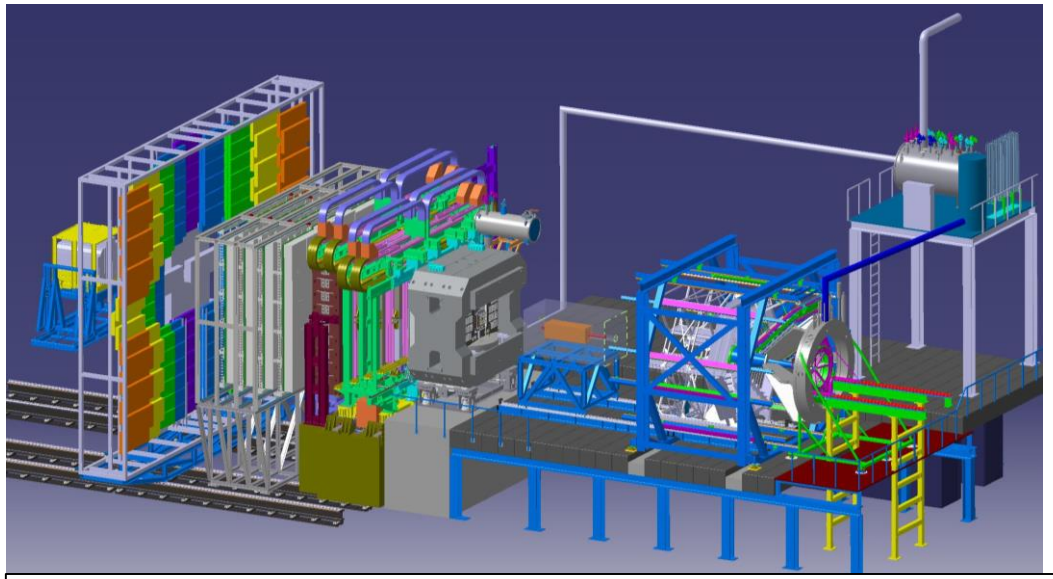
CBM collaboration structure

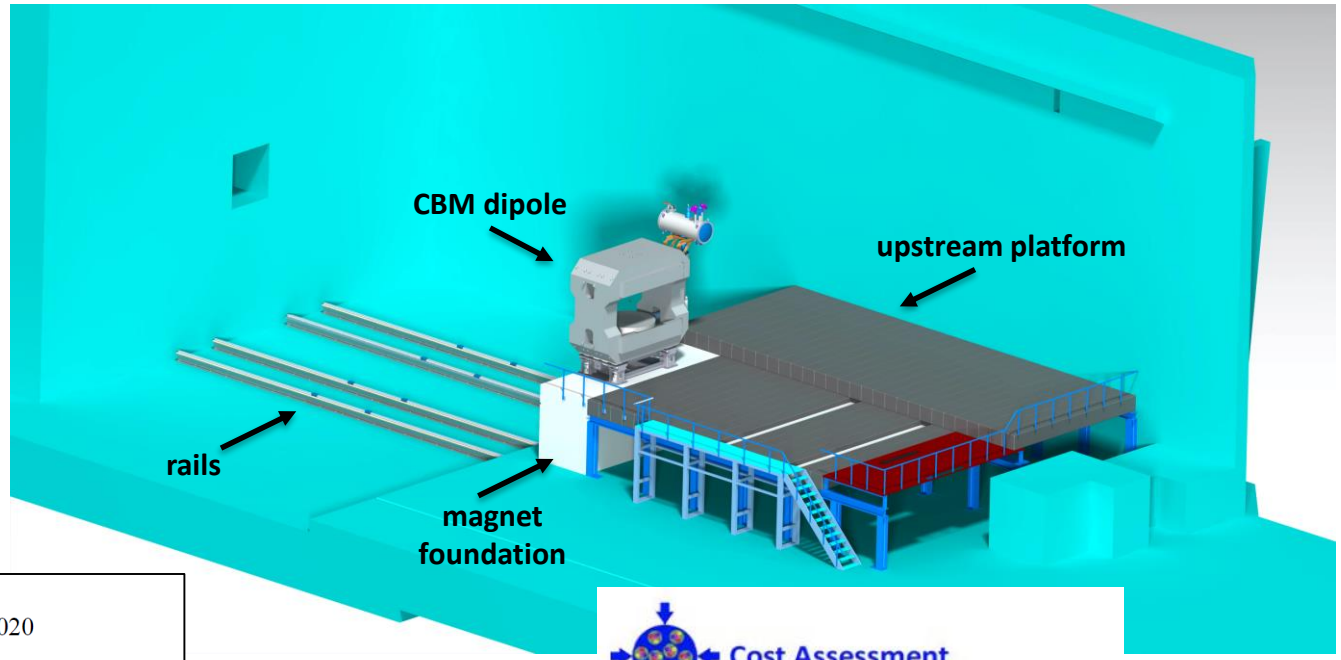


Full + Associated Member Institutions

- 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

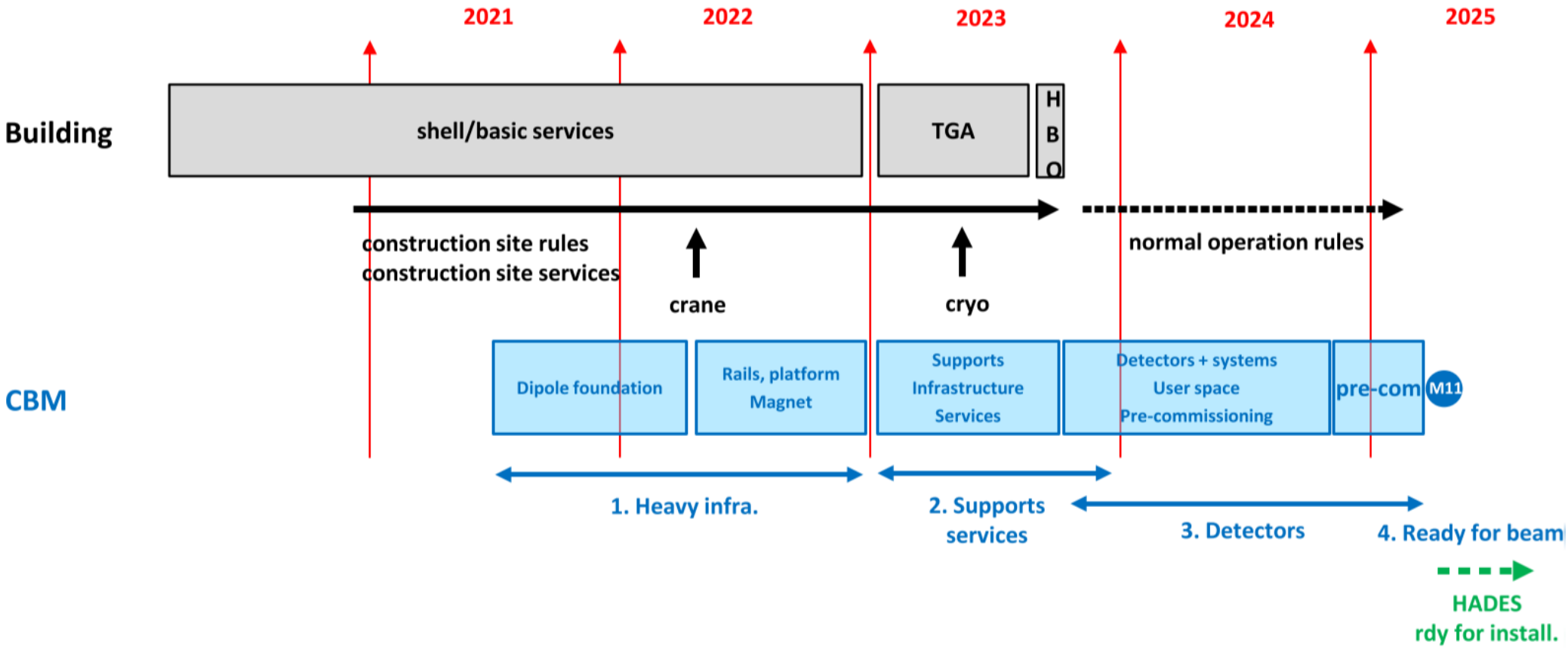
the Facility for Antiproton and Ion Research in Europe GmbH, hereinafter referred to as FAIR GmbH,

and

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

together with the corresponding funding agencies

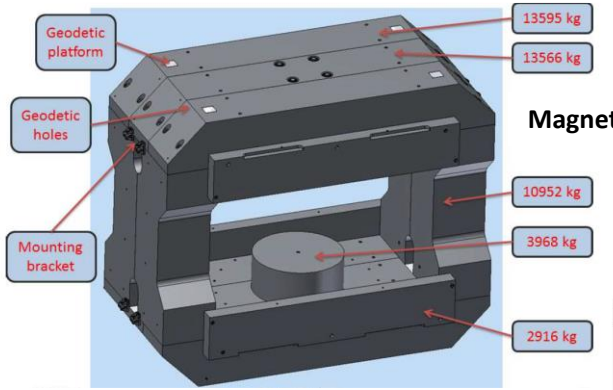
CBM installation – towards baseline 2021



Highlights from the detector projects

Magnet (GSI, BINP Novosibirsk, JINR Dubna)

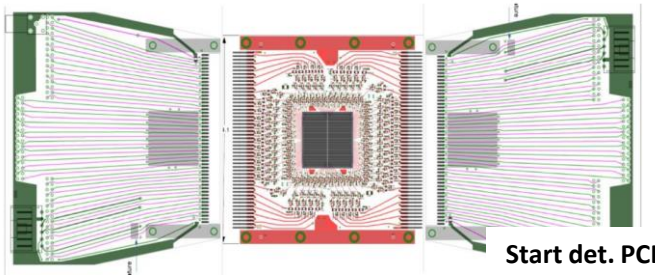
- Progress in design of coils, branch box, transfer line, cryostat.
- Successful Yoke and Power Supply Production Readiness Review in February 2021
- Hall at BINP prepared for Factory Acceptance Tests



Magnet yoke

Beam monitor and start detectors (TU Darmstadt)

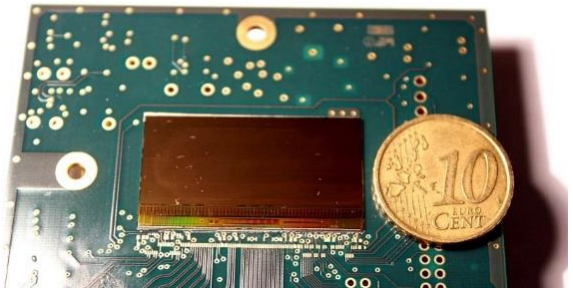
- Endorsed as an independent project
- Start detector Concept for Day-1 based on pcCVD high purity diamond sensors
- A concept of the beam abort system being worked out



Start det. PCB

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 Crakov, KINR Kiev, Univ. Tübingen, Warsaw UT)

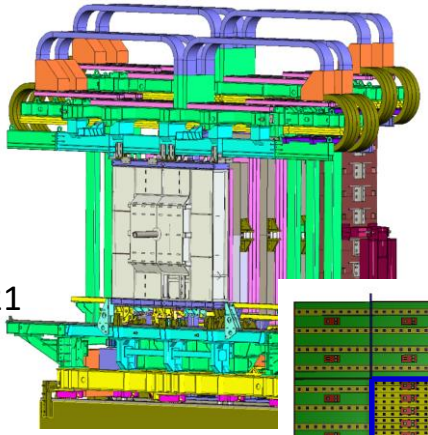
- All sensors delivered, QA done
- Successful Module and Ladder assembly EDR in Dec. 2020
- New ASICS available (STS-XYter2.2)
- Preproduction in Q2/Q3.2021
- PRR prior to mass production in 10.2021

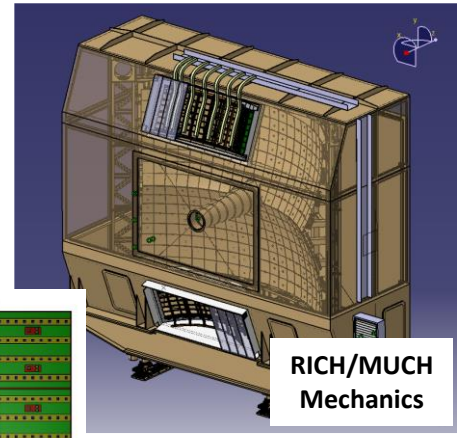
Assembled STS module

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

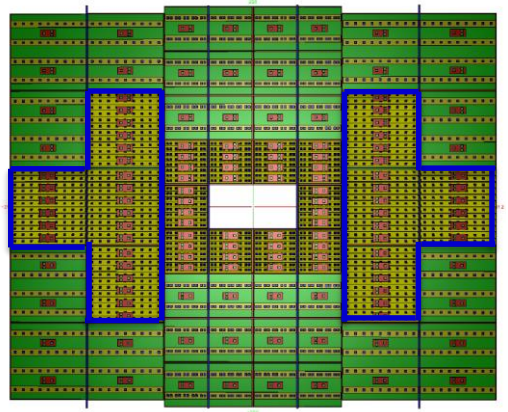




RICH/MUCH Mechanics

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



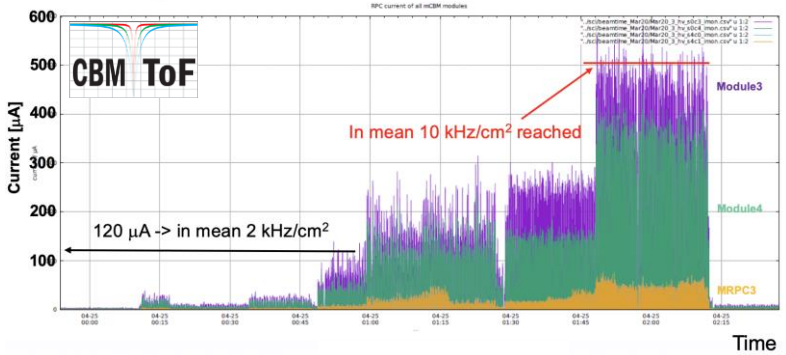
TRD wall layout
Module type "5"

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/cm^2 reached
- Ageing studies ongoing in Bucharest (ISRAM facility);



TOF high-rate test

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)

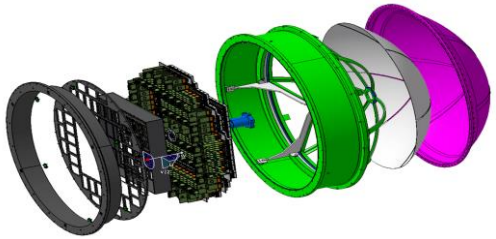
1. Install, commission and use 430 out of 1100
   CBM RICH multi-anode photo-multipliers (MAPMT)
   including FEE in HADES RICH photon detector

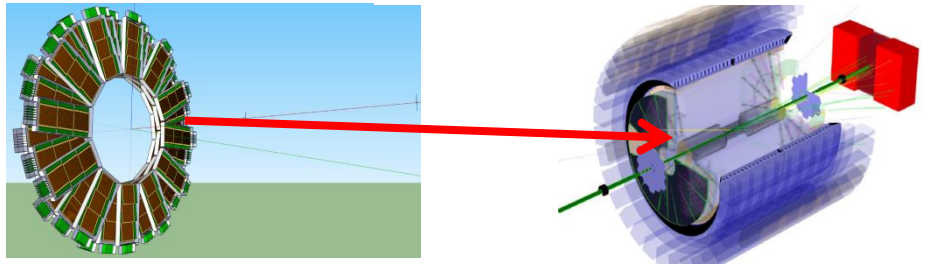
2. Install, commission and use
   10% of the CBM TOF modules
   including read-out chain
   at STAR/RHIC (BES II 2019/2020)

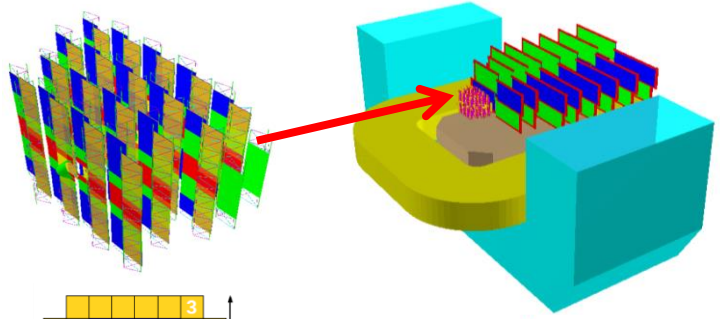
3. Upgrade BM@N experiment
   with 4 Silicon stations of CBM/STS design in the
   BM@N experiment at the Nuclotron JINR/Dubna
   (Au-beams in late 2022)

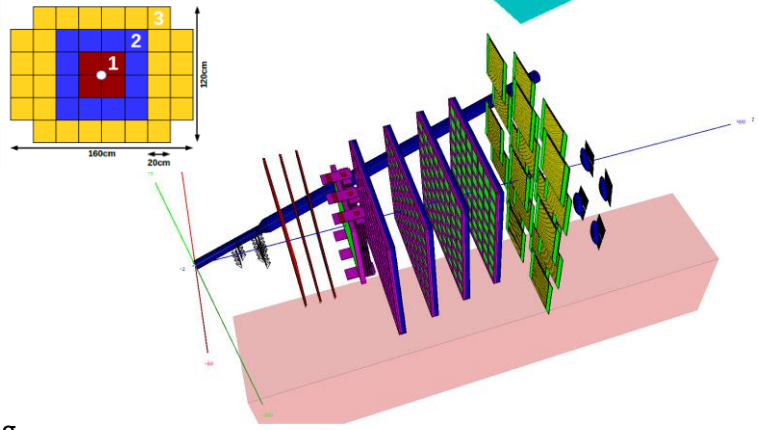
4. Install, commission and use the Project
   Spectator Detector at the BM@N experiment

5. mini CBM (mCBM@SIS18) demonstrator for
   full CBM data taking and analysis chain







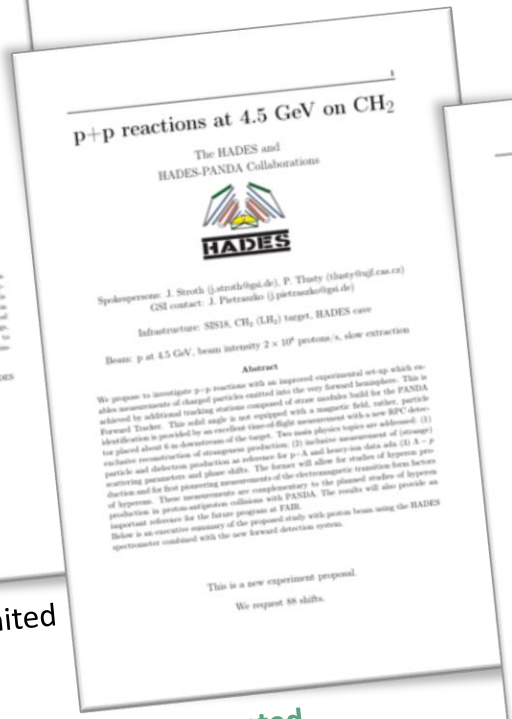


HADES Proposals for last G-PAC


Pion induced reactions on CH_2 and C, Ag targets

The HADES Collaboration

Not granted due to limited available beam time


p+p reactions at 4.5 GeV on CH_2

The HADES and HADES-PANDA Collaborations

100 % granted run scheduled for 2022


p+Ag reactions at 4.5 GeV

The HADES Collaboration

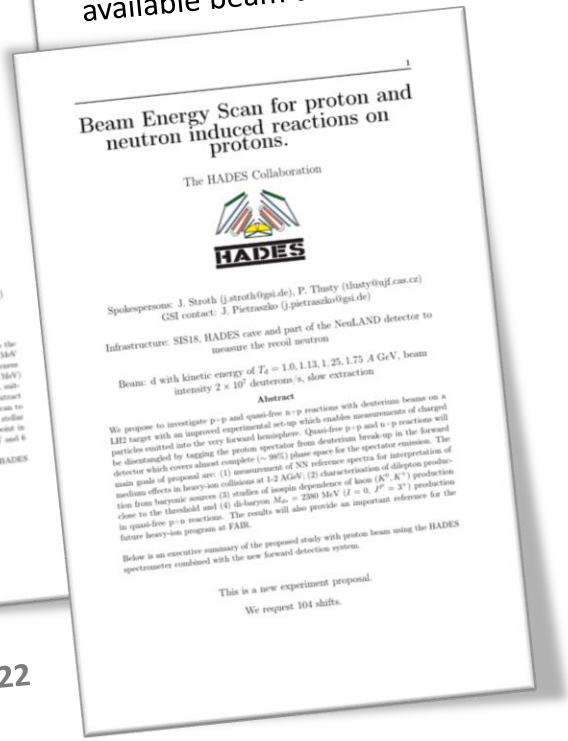
Not granted due to limited available beam time


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

The HADES Collaboration

40% granted run scheduled for 2022

Not granted due to limited available beam time


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

The HADES Collaboration

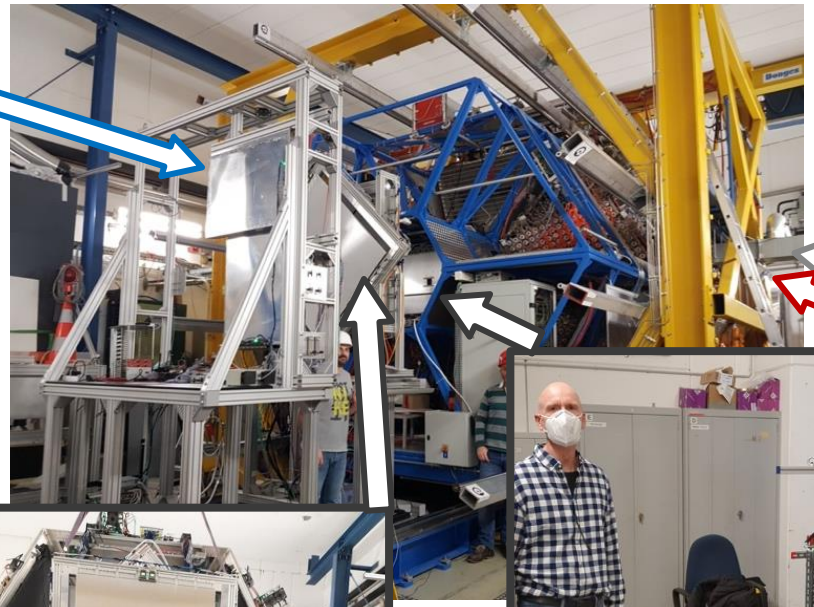
The upgraded HADES detector (five new detector systems)

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

Forward RPC

LIP Coimbra

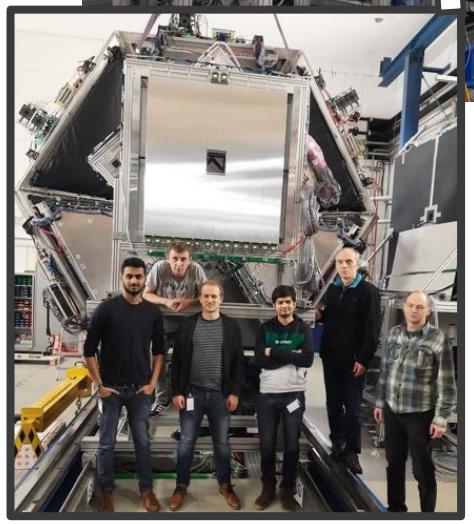
- Based on R&D for neuLAND
- TRB3 read-out



iTOF

TransFAIR, Jülich

- APD read-out
- Enhances trigger purity



STS2

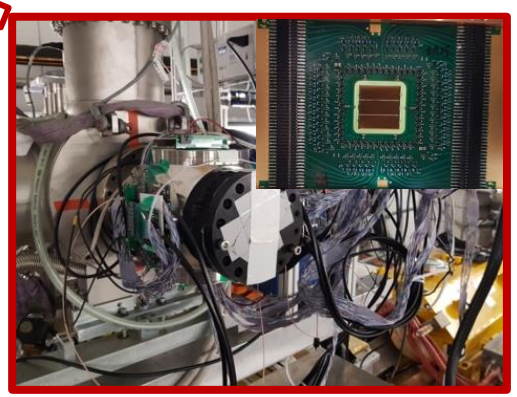
Jagiellonian Univ.

- PANDA straw technology
- PANDA PASTTRECK FEE chip

STS1

TransFAIR, Jülich

- PANDA straw technology
- PANDA PASTTRECK FEE chip

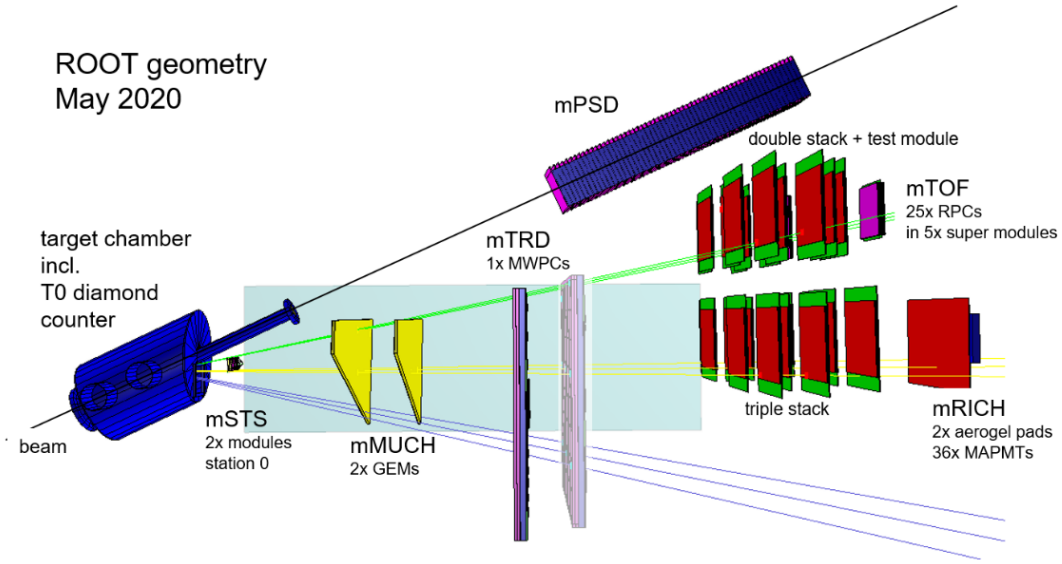


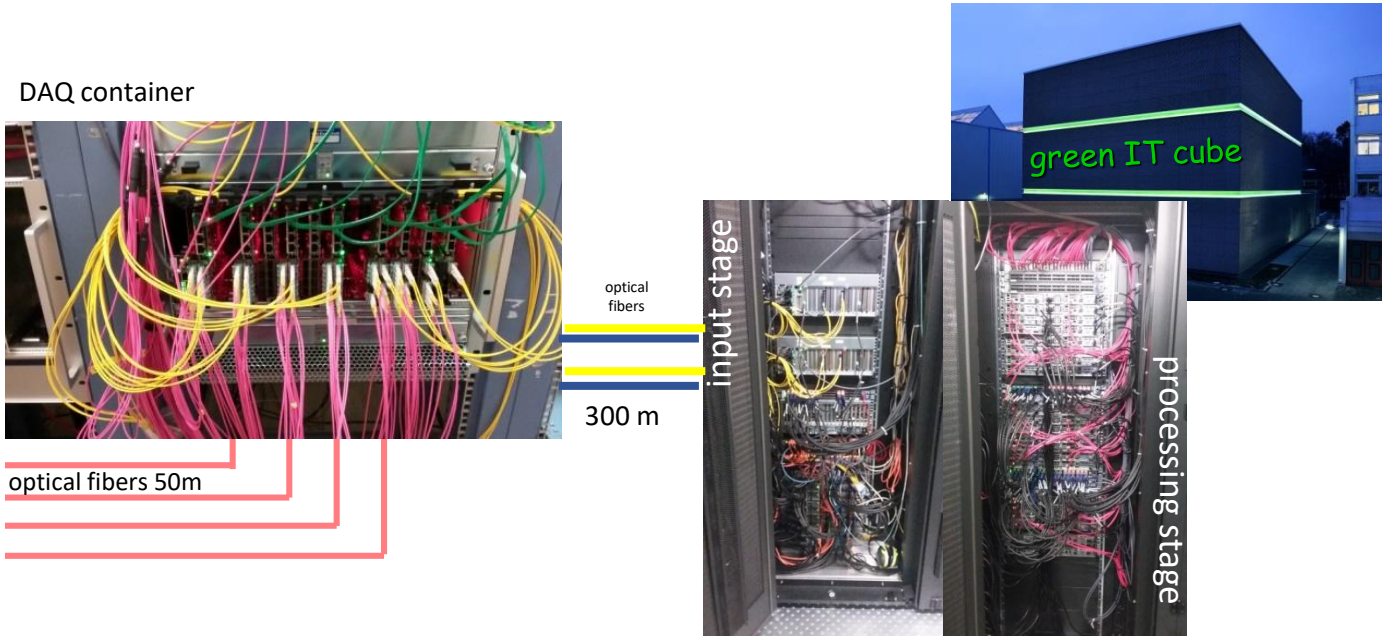
T0

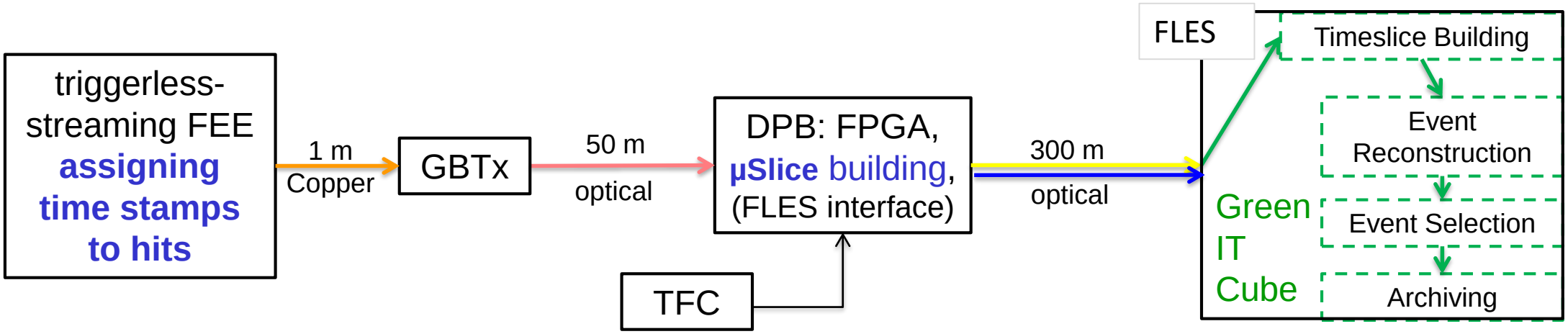
GSI, TU Darmstadt

- LGAD technology
- In-beam detector

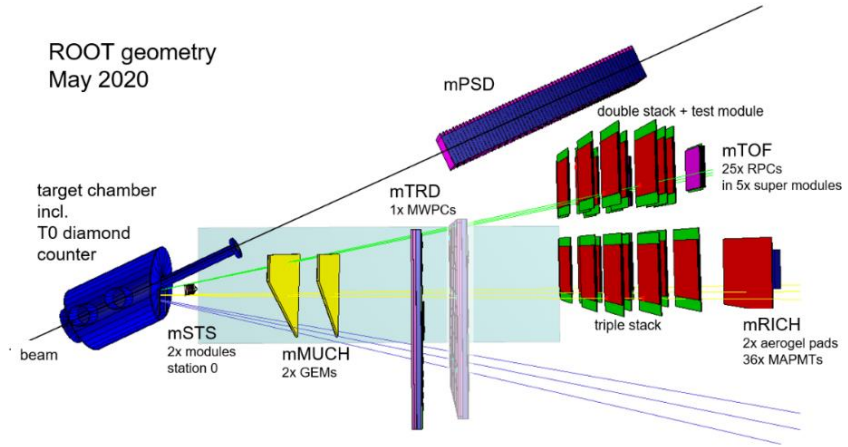
The mCBM experiment at SIS18 -

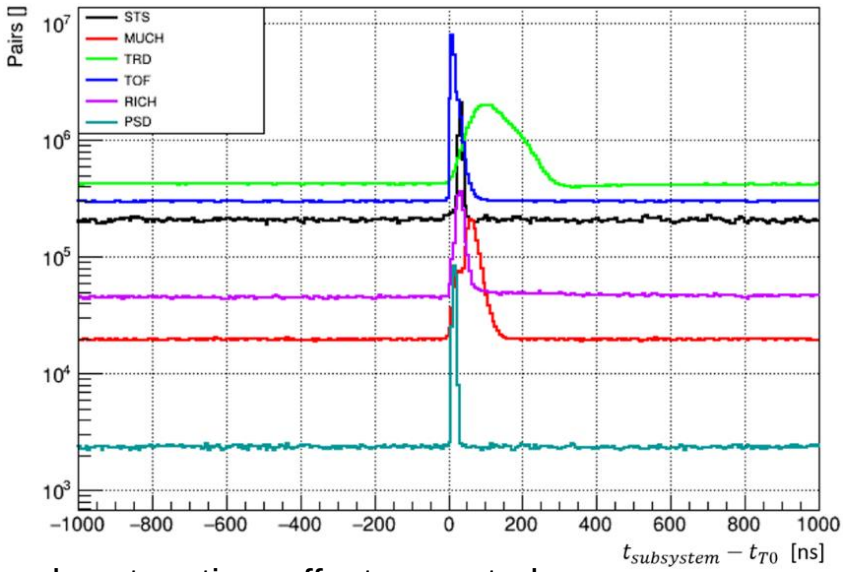




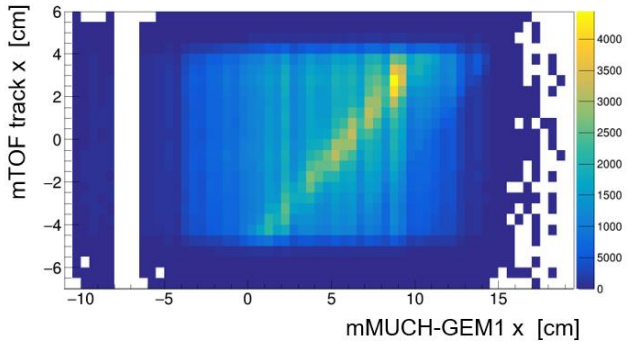


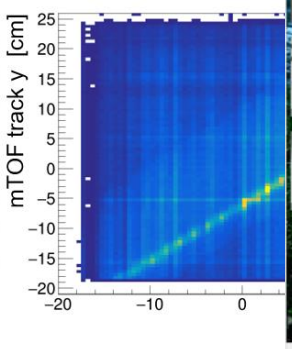
mCBM commissioning with beam, first results

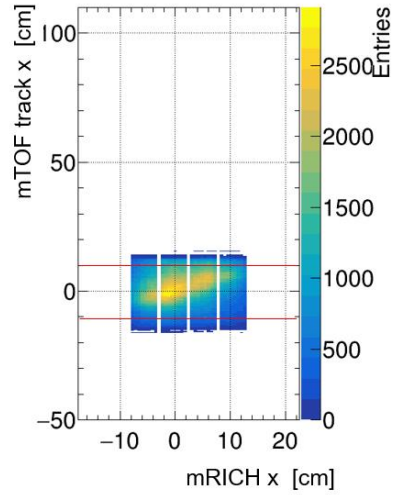


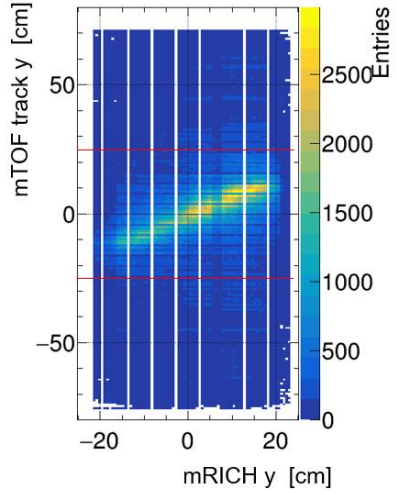


subsystem time offset corrected,
no time calibration







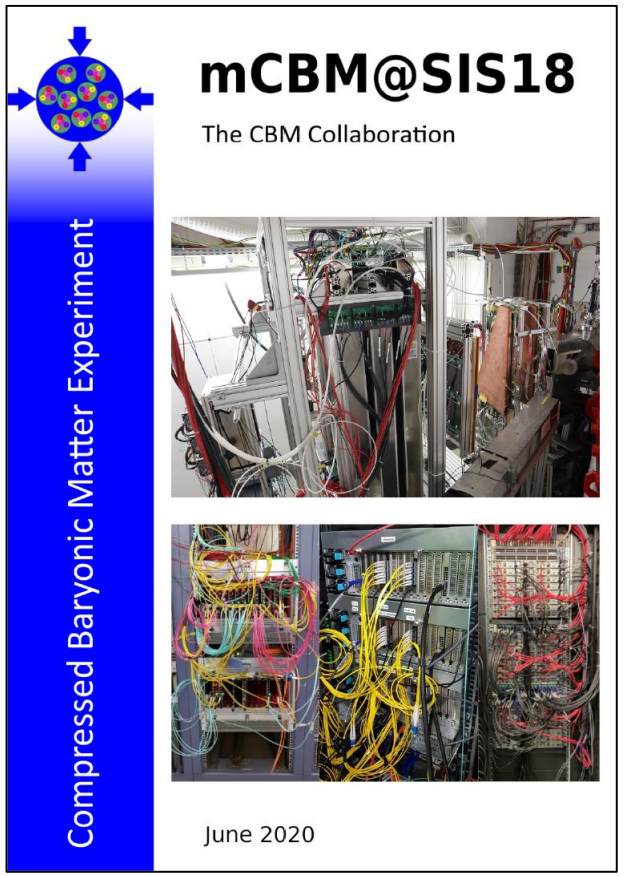


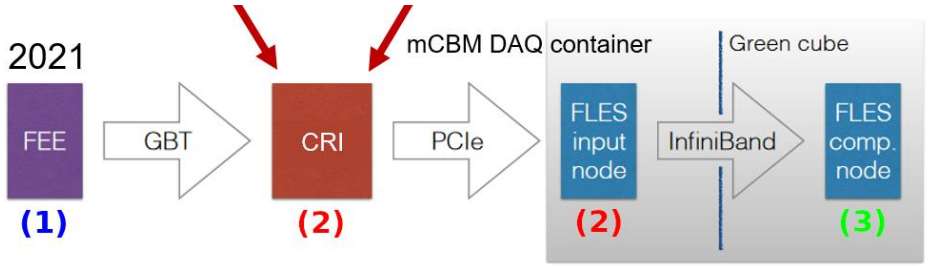
<u>data:</u>
run 831, May 4th, 2020
^{208}Pb + Au, 1.060 AGeV
"low" collision rate ≈ 20kHz

preliminary - May 2020 data

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.

mCBM - data campaign 2021





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 application for 2021/22 fully granted

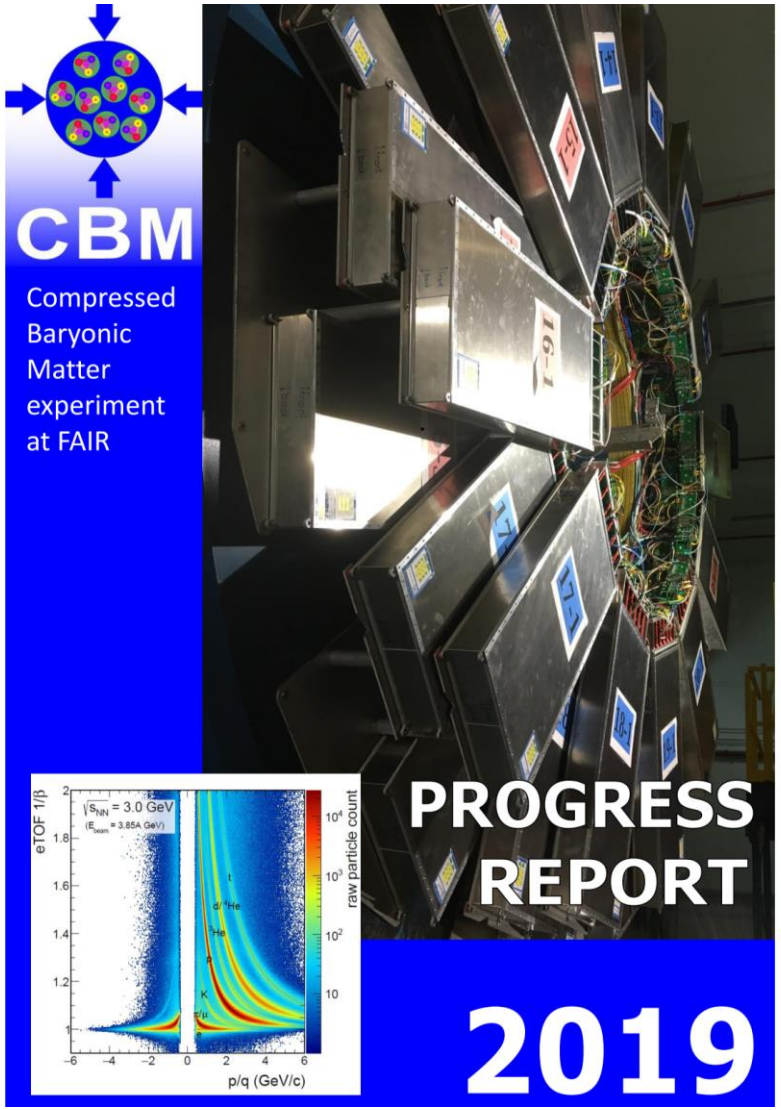
Beam time schedule 2021

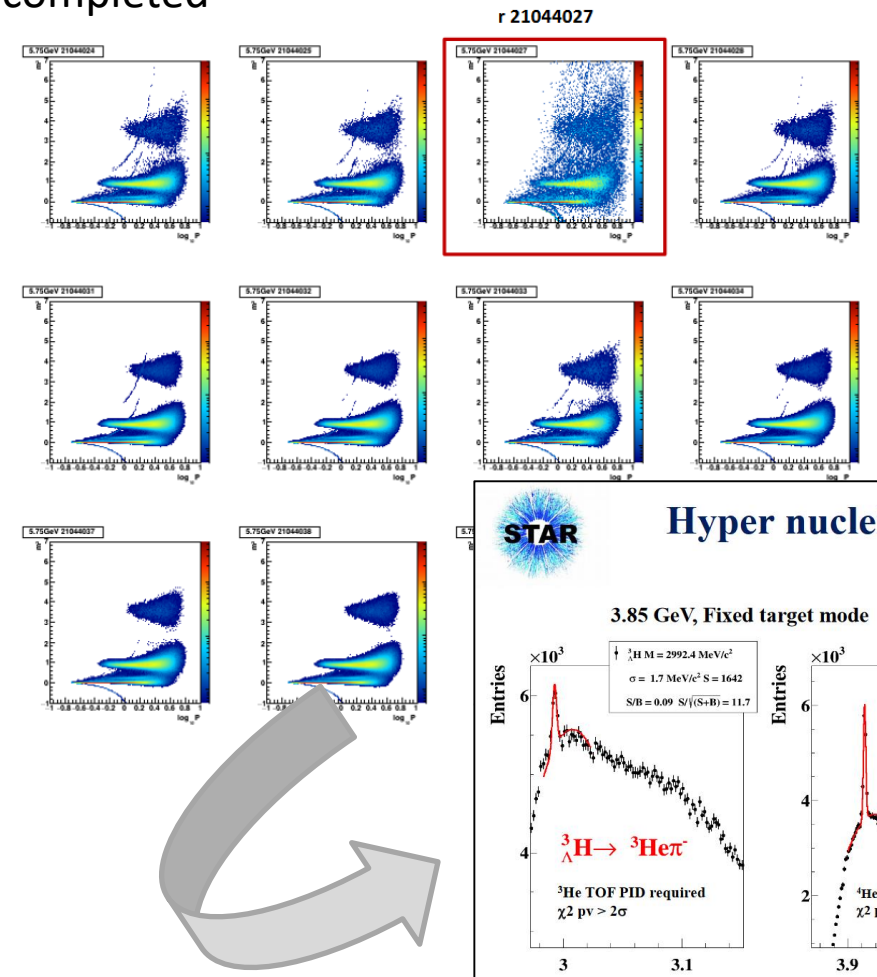
(1) Commissioning of upgraded data transport and detector subsystems & high-rate detector tests
^{208}Pb beam, shifts (sec. user) within March 2021

(2) Commissioning of benchmark runs (Λ production) incl. online reconstruction & selection
^{78}Kr beam, (prim. user) May 2021 and ^{16}O beam, June 2021

CBM eTOF @ STAR

Run20 (Dec2019 – Sep2020) successfully completed





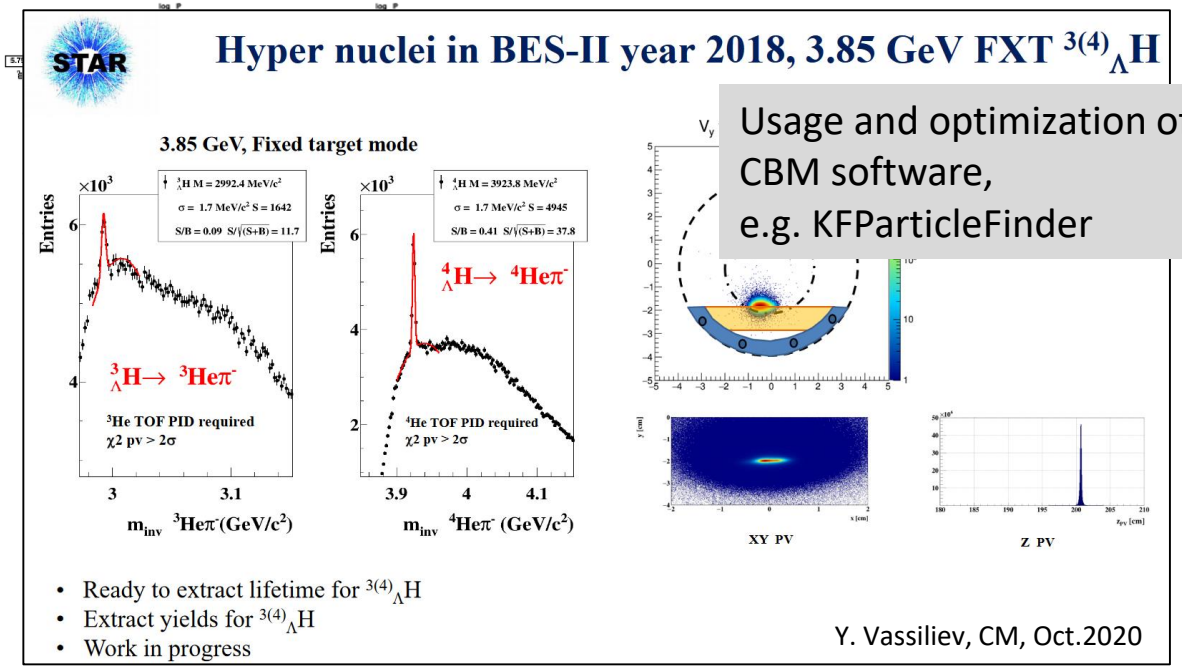
Large potential for physics results

Progress Report

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

Run-by-Run online QA of eTOF Run20 data

Important step towards CBM control concept



Usage and optimization of CBM software, e.g. KFParticleFinder

CBM collaboration meeting

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.