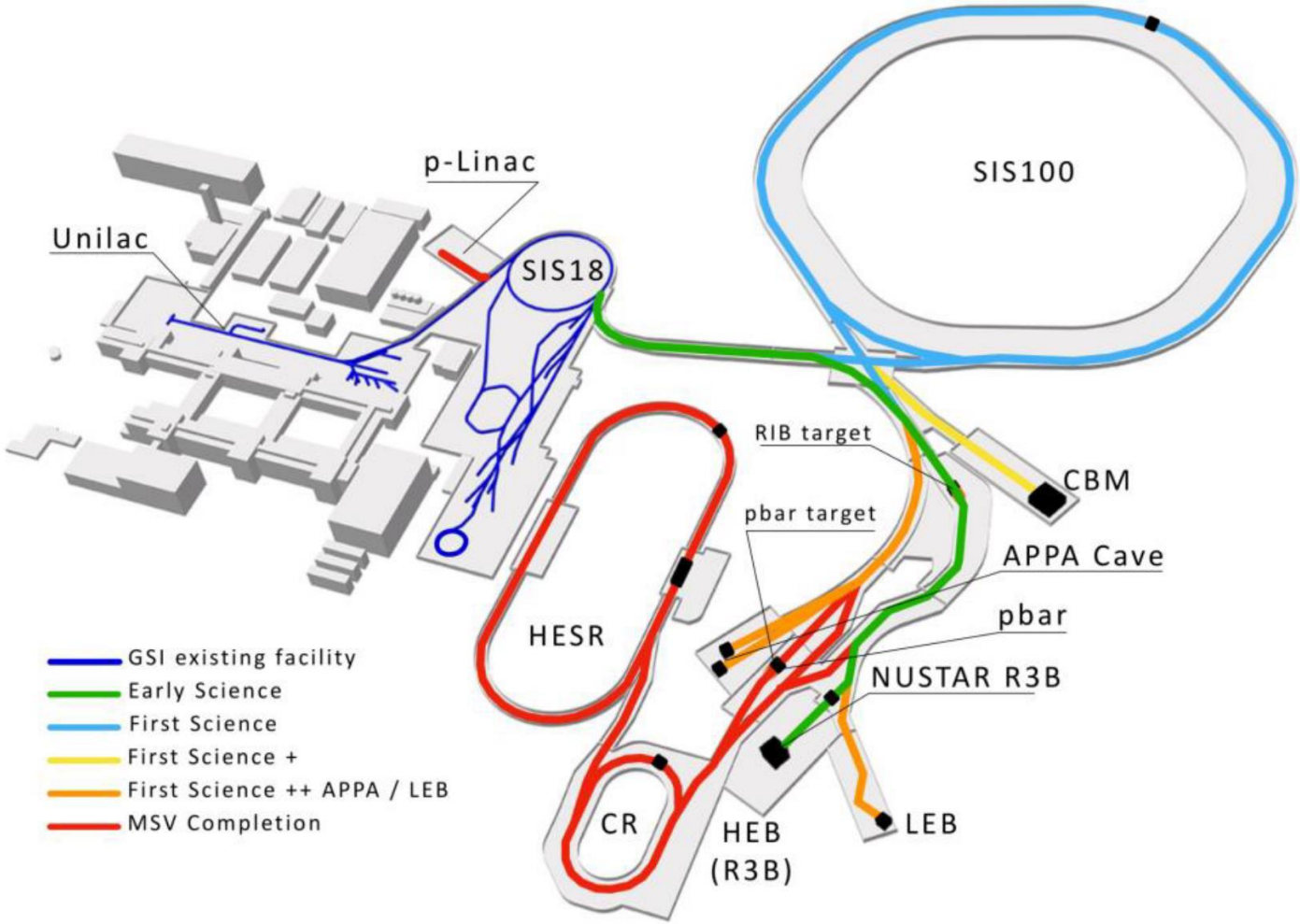
# Status of experiments (CBM & HADES)

N. Herrmann, Heidelberg University

# Recent developments of FAIR and CBM




Substantial cost increase surfaced in 2021,
Russian attack on Ukraine

Science evaluation in 2022
(chairs: R. Heuer, R. Tribble)

Recommendation:
downscope FAIR project with cost cap

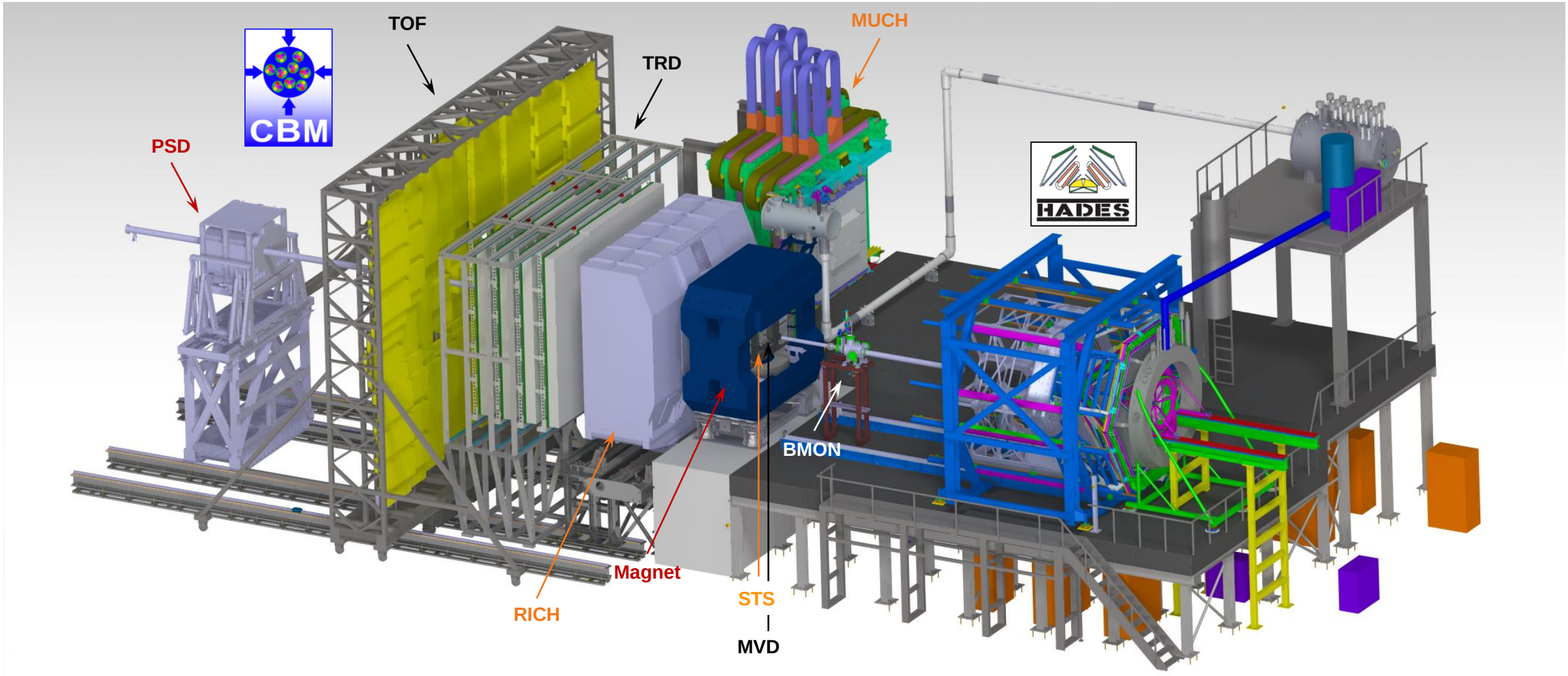
Suggested scenario:
FS+: SIS100 & SFRS/R3B & CBM

Additional funds provided by BMBF
Planned scenario: FS

Start of FS operation: 2028/29

https://www.gsi.de/fileadmin/oeffentlichkeitsarbeit/fair/FAIR-report_221025.pdf

# C.B.M. experiments



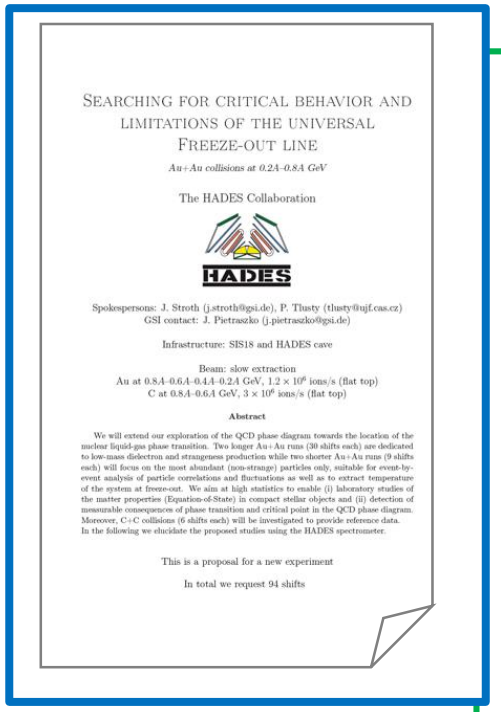

CBM Day-1 configuration (2028) : rate capability 100 kHz Au+Au reactions with streaming (triggerless) readout of MVD, STS, RICH, MUCH, TRD, TOF and FSD

# HADES

HADES: continue physics program at SIS18

Future measurements with SIS100 beams not part of FS+, will be done once SIS18 program is finished

**Au+Au BES < 1 *A* GeV**



SEARCHING FOR CRITICAL BEHAVIOR AND LIMITATIONS OF THE UNIVERSAL FREEZE-OUT LINE

*Au+Au collisions at 0.2A–0.8A GeV*

The HADES Collaboration

HADES

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)

Infrastructure: SIS18 and HADES cave

Beam: slow extraction
Au at 0.8A–0.6A–0.4A–0.2A GeV, $1.2 \times 10^6$ ions/s (flat top)
C at 0.8A–0.6A GeV, $3 \times 10^6$ ions/s (flat top)

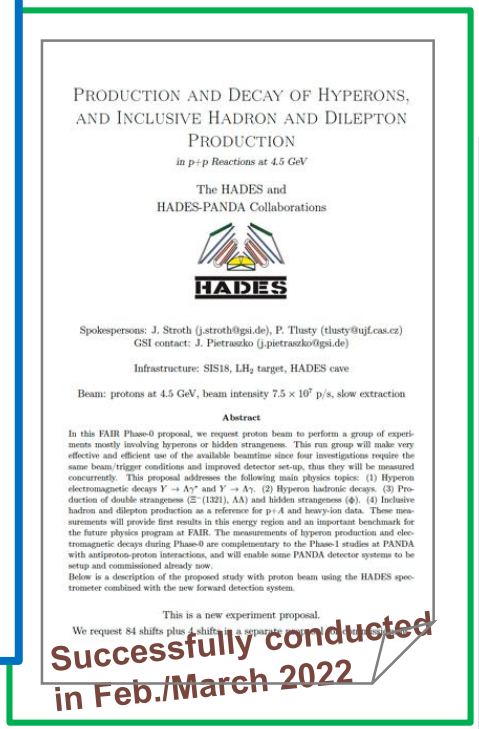
**Abstract**

We will extend our exploration of the QCD phase diagram towards the location of the nuclear liquid-gas phase transition. Two longer Au+Au runs (30 shifts each) are dedicated to low-mass dielectron and strangeness production while two shorter Au+Au runs (9 shifts each) will focus on the most abundant (non-strange) particles only, suitable for event-by-event analysis of particle correlations and fluctuations as well as to extract temperature of the system at freeze-out. We aim at high statistics to enable (i) laboratory studies of the matter properties (Equation-of-State) in compact stellar objects and (ii) detection of measurable consequences of phase transition and critical point in the QCD phase diagram. Moreover, C+C collisions (6 shifts each) will be investigated to provide reference data. In the following we elucidate the proposed studies using the HADES spectrometer.

This is a proposal for a new experiment

In total we request 94 shifts

**EM transition form factors of hyperons**



PRODUCTION AND DECAY OF HYPERONS, AND INCLUSIVE HADRON AND DILEPTON PRODUCTION

*in p+p Reactions at 4.5 GeV*

The HADES and
HADES-PANDA Collaborations

HADES

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)

Infrastructure: SIS18, $LH_2$ target, HADES cave

Beam: protons at 4.5 GeV, beam intensity $7.5 \times 10^7$ p/s, slow extraction

**Abstract**

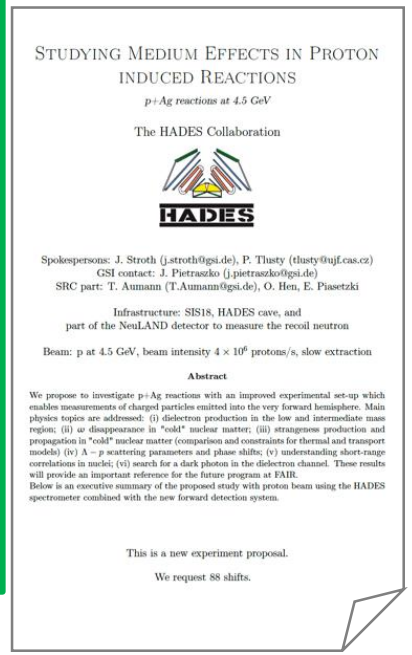
In this FAIR Phase-0 proposal, we request proton beam to perform a group of experiments mostly involving hyperons or hidden strangeness. This run group will make very effective and efficient use of the available beamtime since four investigations require the same beam/trigger conditions and improved detector set-up, thus they will be measured concurrently. This proposal addresses the following main physics topics: (1) Hyperon electromagnetic decays $Y^* \to \Lambda\gamma^*$ and $Y^* \to \Lambda\gamma$. (2) Hyperon hadronic decays. (3) Production of double strangeness ($\Xi^-(1321)$, $\Lambda\Lambda$) and hidden strangeness ($\phi\phi$). (4) Inclusive hadron and dilepton production as a reference for p+*A* and heavy-ion data. These measurements will provide first results in this energy region and an important benchmark for the future physics program at FAIR. The measurements of hyperon production and electromagnetic decays during Phase-0 are complementary to the Phase-1 studies at PANDA with antiproton-proton interactions, and will enable some PANDA detector systems to be setup and commissioned already now.
Below is a description 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 84 shifts plus 4 shifts in a separate run [illegible]

**Successfully conducted in Feb./March 2022**

**Cold matter effects including line shapes and SRC**



STUDYING MEDIUM EFFECTS IN PROTON INDUCED REACTIONS

*p+Ag reactions at 4.5 GeV*

The HADES Collaboration

HADES

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)
SRC part: T. Aumann (T.Aumann@gsi.de), O. Hen, E. Piasetzki

Infrastructure: SIS18, HADES cave, and
part of the NeuLAND detector to measure the recoil neutron

Beam: p at 4.5 GeV, beam intensity $4 \times 10^6$ protons/s, slow extraction

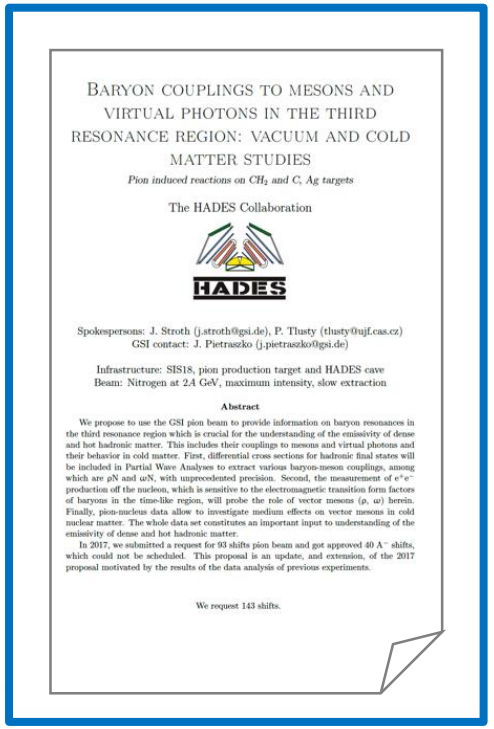
**Abstract**

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) dielectron production in the low and intermediate mass region; (ii) $\omega$ disappearance in "cold" nuclear matter; (iii) strangeness production and propagation in "cold" nuclear matter (comparison and constraints for thermal and transport models) (iv) $\Lambda - p$ scattering parameters and phase shifts; (v) understanding short-range correlations in nuclei; (vi) search for a dark photon in the dielectron channel. These results will 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.

**Baryon resonances, meson baryon coupling in the 3rd resonance region**



BARYON COUPLINGS TO MESONS AND VIRTUAL PHOTONS IN THE THIRD RESONANCE REGION: VACUUM AND COLD MATTER STUDIES

*Pion induced reactions on $CH_2$ and C, Ag targets*

The HADES Collaboration

HADES

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)

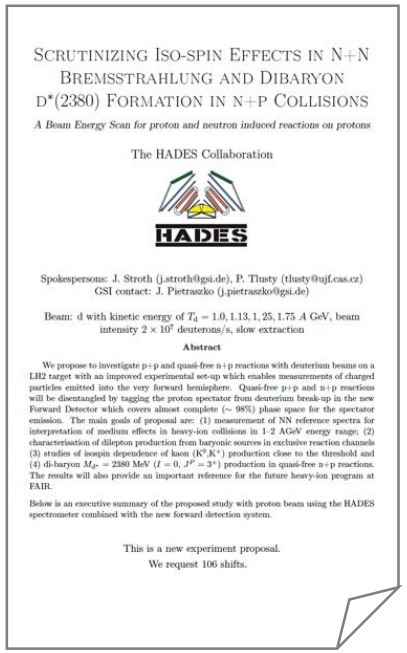
Infrastructure: SIS18, pion production target and HADES cave
Beam: Nitrogen at 2*A* GeV, maximum intensity, slow extraction

**Abstract**

We propose to use the GSI pion beam to provide information on baryon resonances in the third resonance region which is crucial for the understanding of the emissivity of dense and hot hadronic matter. This includes their couplings to mesons and virtual photons and their behavior in cold matter. First, differential cross sections for hadronic final states will be included in Partial Wave Analyses to extract various baryon-meson couplings, among which are $\rho$N and $\omega$N, with unprecedented precision. Second, the measurement of $e^+e^-$ production off the nucleon, which is sensitive to the electromagnetic transition form factors of baryons in the time-like region, will probe the role of vector mesons ($\rho$, $\omega$) herein. Finally, pion-nucleus data allow to investigate medium effects on vector mesons in cold nuclear matter. The whole data set constitutes an important input to understanding of the emissivity of dense and hot hadronic matter.
In 2017, we submitted a request for 93 shifts pion beam and got approved 40 $A^-$ shifts, which could not be scheduled. This proposal is an update, and extension, of the 2017 proposal motivated by the results of the data analysis of previous experiments.

We request 143 shifts.

**Iso-spin effects in dilepton production**



SCRUTINIZING ISO-SPIN EFFECTS IN N+N BREMSSTRAHLUNG AND DIBARYON $D^*(2380)$ FORMATION IN N+P COLLISIONS

*A Beam Energy Scan for proton and neutron induced reactions on protons*

The HADES Collaboration

HADES

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)

Beam: d with kinetic energy of $T_d = 1.0, 1.13, 1, 25, 1.75$ *A* GeV, beam intensity $2 \times 10^7$ deuterons/s, slow extraction

**Abstract**

We propose to investigate p+p and quasi-free n+p reactions with deuterium beams on a LH2 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 deuterium break-up in the new Forward Detector which covers almost complete (~ 98%) phase space for the spectator emission. The main goals of proposal are: (1) measurement of NN reference spectra for interpretation of medium effects in heavy-ion collisions in 1-2 AGeV energy range; (2) characterisation of dilepton production from baryonic sources in exclusive reaction channels (3) studies of isospin dependence of kaon ($K^0$,$K^+$) production close to the threshold and (4) di-baryon $M_{d^*} = 2380$ MeV ($I = 0$, $J^P = 3^+$) production in quasi-free n+p reactions. 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 106 shifts.

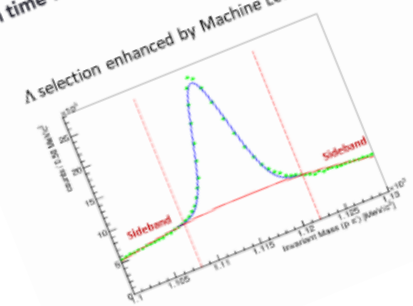
15 Billion events Ag+Ag taken already in 2019.

# Recent HADES achievements

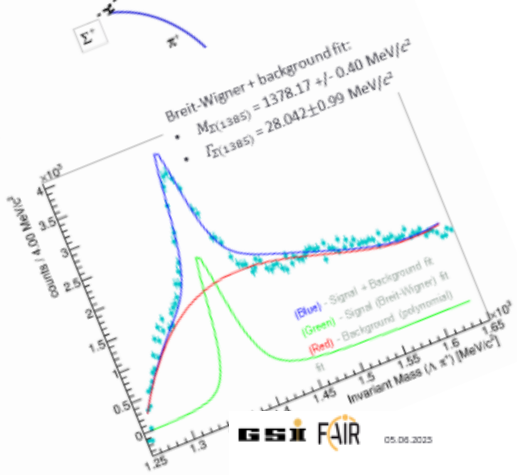
## Σ(1385) reconstruction p+p 4.5 GeV

**Study Dalitz decays of Λ(1520)/Σ(1385)→ Λe⁺e⁻ allow for first measurement of hyperon form factors in time-like region**

Λ selection enhanced by Machine Learning



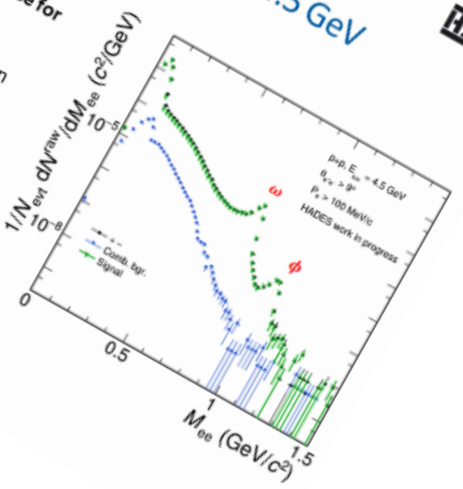




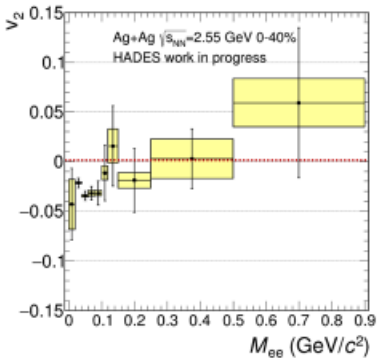

## $e^+e^-$ inclusive invariant mass spectrum p+p 4.5 GeV

**Study dilepton production mechanisms (baryon Dalitz-decay, vector meson decay, ...), reference for medium effects (p/A+A at SIS100 energies)**

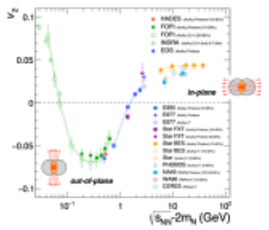
- Signal-to-background ratio in the vector-meson region better than 150
- Mesons peaks are clearly seen, ω and φ
- Number of pairs allows multidifferential studies:
- $M_{e+e-}$ < 150 MeV/c²: $N_{e+e-}$ = 2.1×10⁶
- $N_\omega$=1.1×10⁴, $N_\varphi$=350
- $M_{e+e-}$ > 1020 MeV/c²: $N_{e+e-}$ = 112



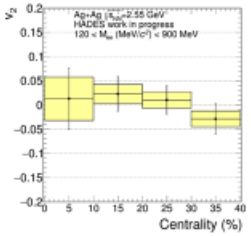

## Elliptic flow of inclusive $e^+e^-$ Ag+Ag 1.58A GeV




$M_{e+e-}$ < 150 MeV/c² dominated by $\pi^0$-Dalitz decay → negative $v_2$ consistent with charged pions

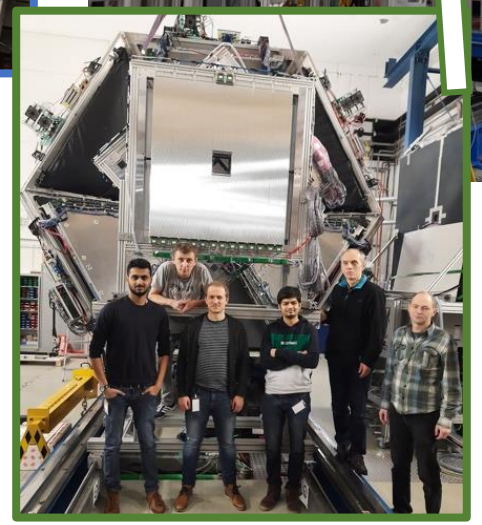


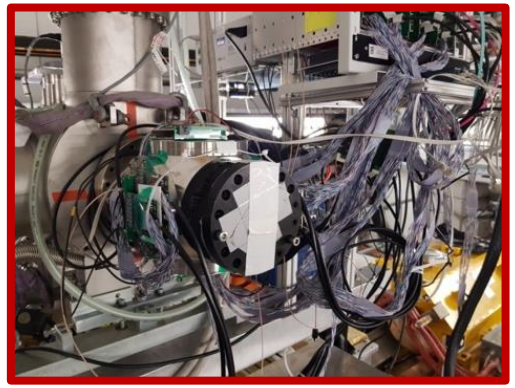

$v_2$ consistently around zero for $M_{e+e-}$ > 150 MeV/c², seen in centrality, rapidity and $p_T$



# 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 PASTTREC FEE chip

***STS1***

*TransFAIR, Jülich*

- PANDA straw technology
- PANDA PASTTREC FEE chip

***iTOF***

*TransFAIR, Jülich*

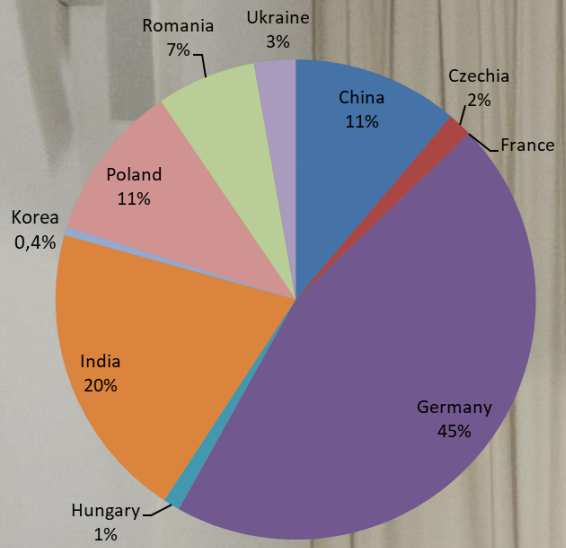
- APD read-out
- Enhances trigger purity

***T0***

*GSI, TU Darmstadt*

- LGAD technology
- In-beam detector

# CBM collaboration




47 (+10) institutes

310 full members

**41st CBM collaboration meeting, Mar. 2023, TUD, Darmstadt**

# CBM experimental hall

# CBM installation in experimental hall

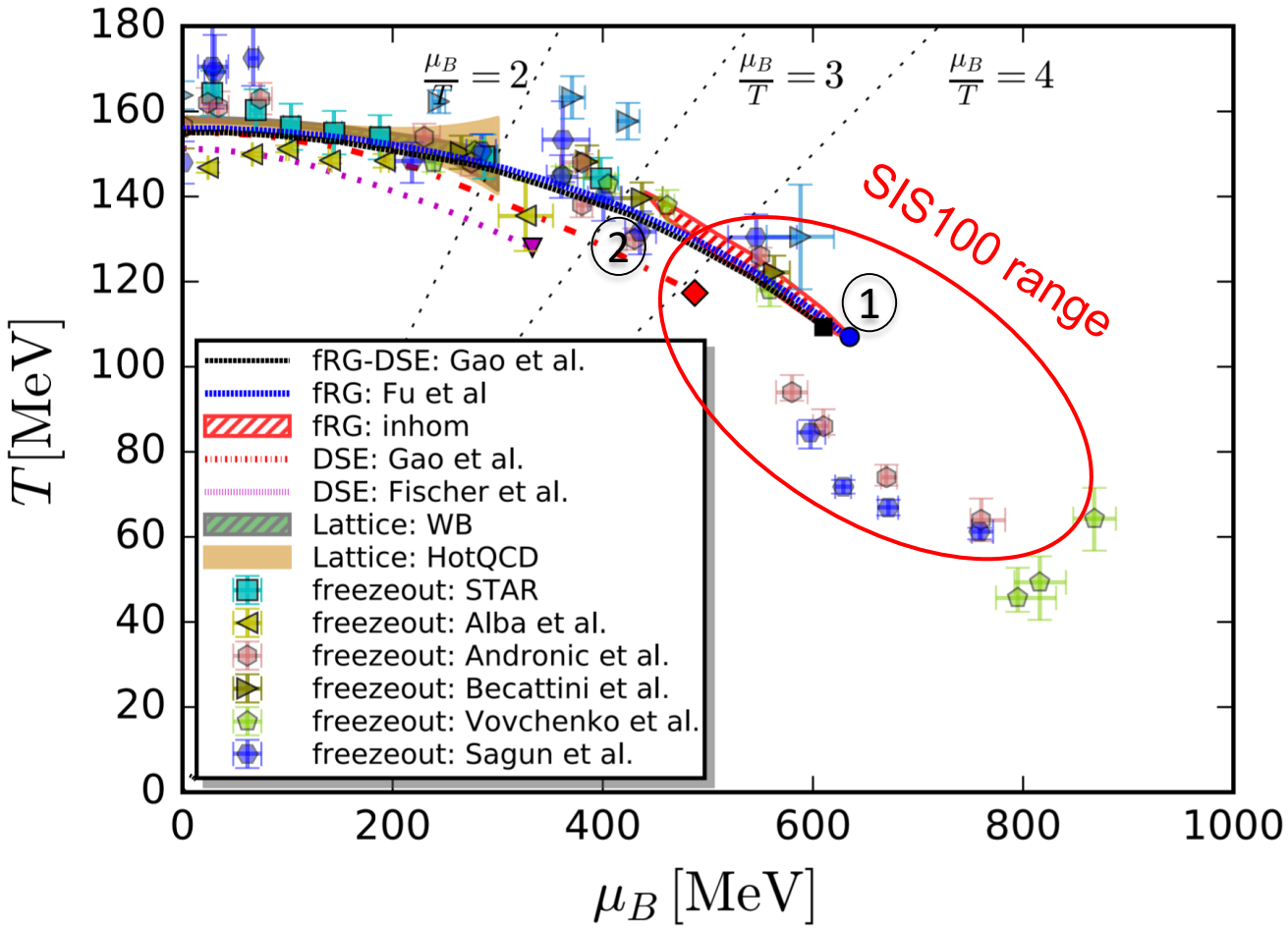
Upstream platform

Czech contribution to CBM

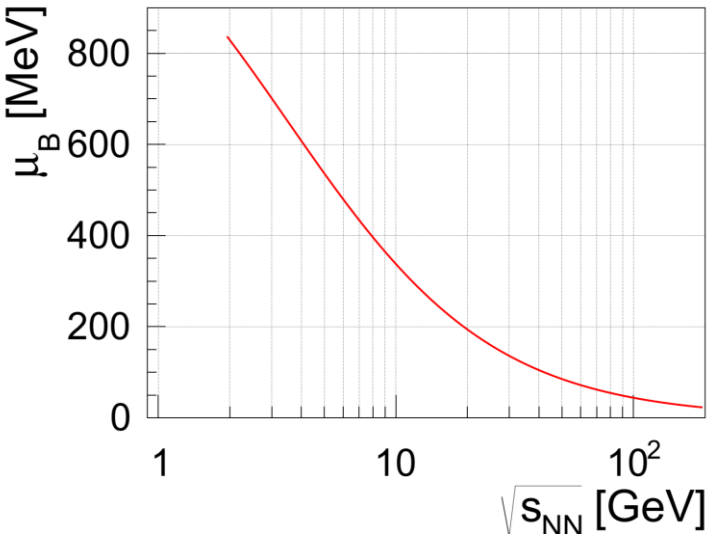
# Phase structure of QCD

Location of chiral cross over

W. Fu, J. Pawlowski, F. Rennecke, *Phys.Rev.D* 101 (2020) 5, 054032, arXiv:1909.02991




A. Andronic et al., Nucl.Phys.A772:167 (2006)



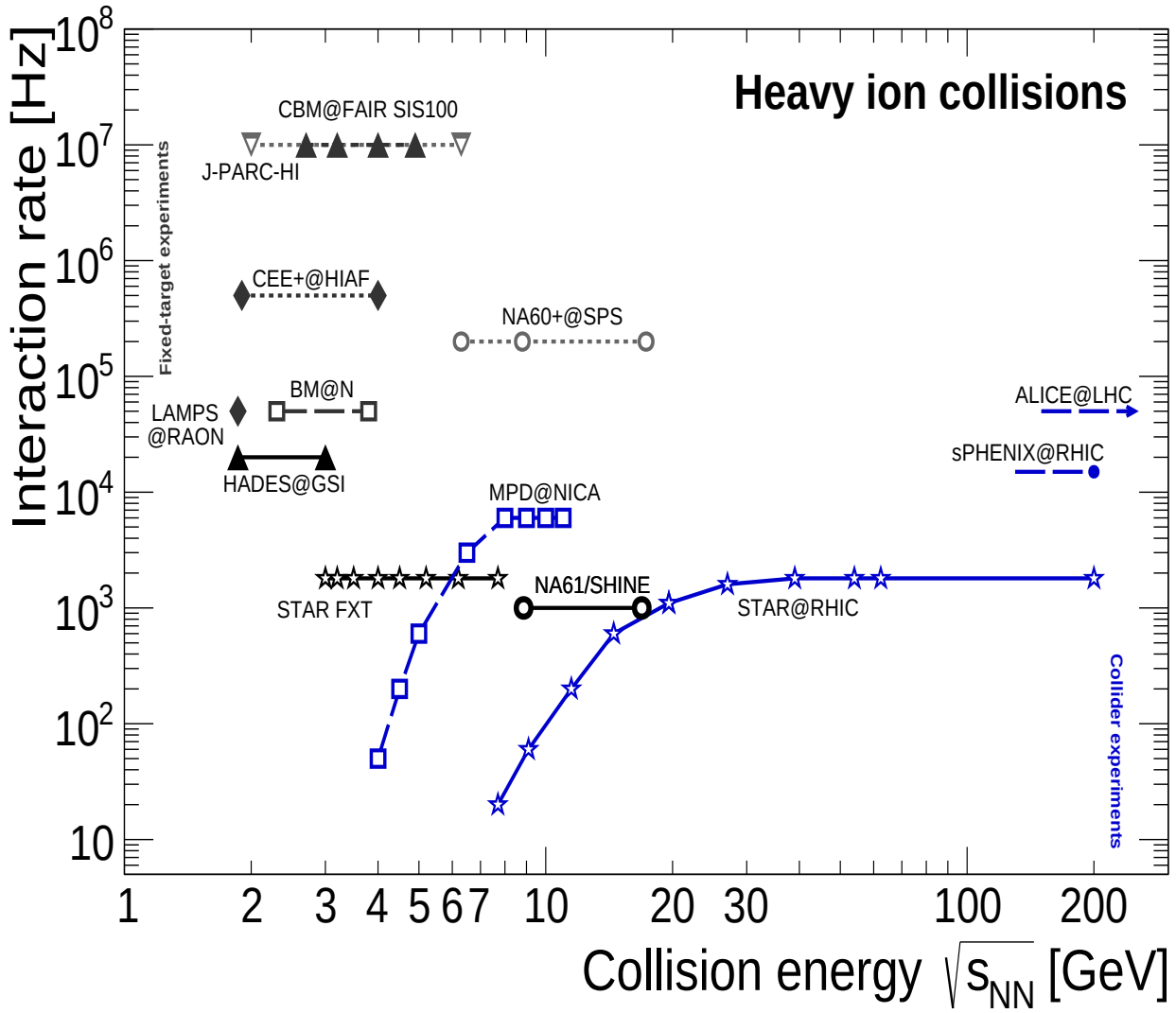

| | $\mu_B$ (MeV) | $\sqrt{s_{NN}}$ (GeV) | $T_{lab}$ (A GeV) |
|---|---|---|---|
| 1 | 622 | 3.8 | 6.0 |
| | 500 | 5.2 | 15.0 |
| 2 | 400 | 7.8 | 31.5 |

Challenges:

Phase transition not at freeze-out line, need probes with memory,
reaction dynamics needs to be controlled.

# CBM – Technological Goal

T. Galatyuk, https://github.com/tgalatyuk/interaction_rate_facilities, 2022




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

**Disclaimer:**
not all measurements benefit from the highest possible rates.

# CBM observables

Criticality

Emissivity

Vorticity

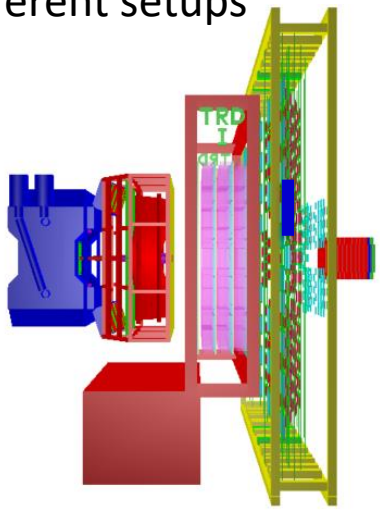
Hypernuclei

Charm in cold matter

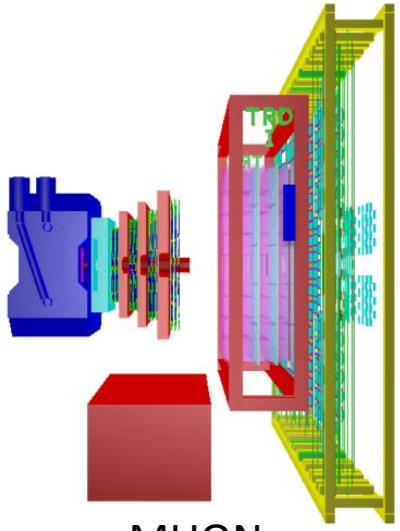
Equation-of-State

# CBM setups

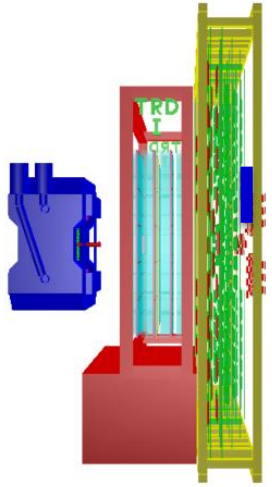
Sideview of different setups



ELEHAD



MUON

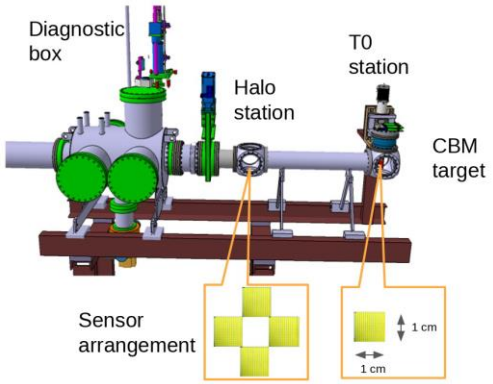


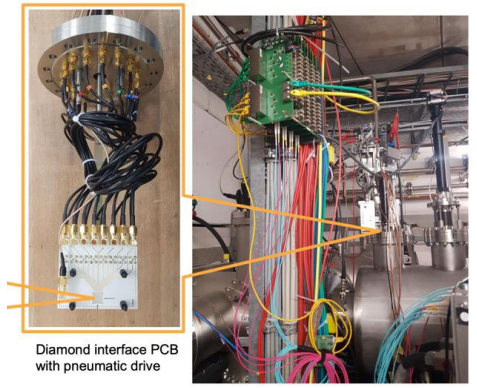
HADR

| Setup | Included subsystems | Average day-1 interaction rate | Average MSV - interaction rate | Average event size in Au+Au collisions |
|---|---|---|---|---|
| ELEHAD | MVD,STS,RICH,TRD,TOF,FSD | 0.1 MHz | 0.1 MHz | 75 kB |
| MUON | STS,MUCH,TRD,TOF,FSD | 1 MHz | 5 MHz | 30 kB |
| HADR | STS,TRD,TOF,FSD | 0.5 MHz | 5 MHz | 50 kB |

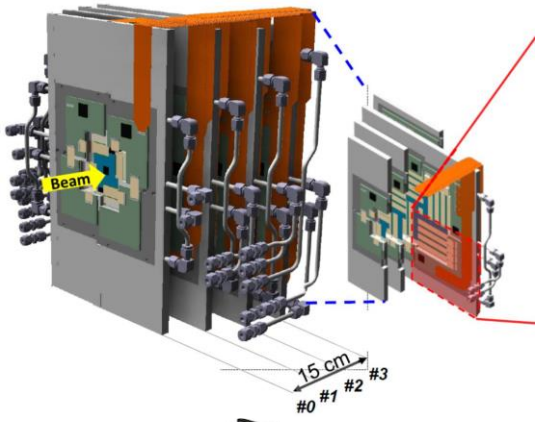
# Status of CBM detector systems

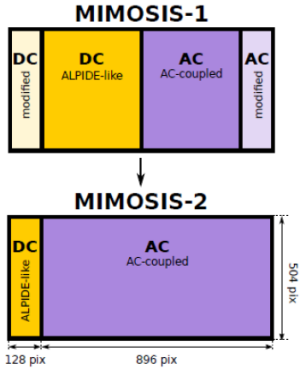
**Beam Monitor (BMON)**
- T0 high purity pcCVD diamond demonstrator successfully tested in mCBM 2022 runs
- novel sensor technologies (LGAD, SiC) under investigation

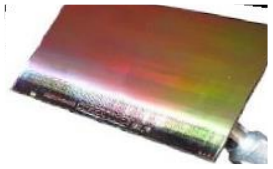


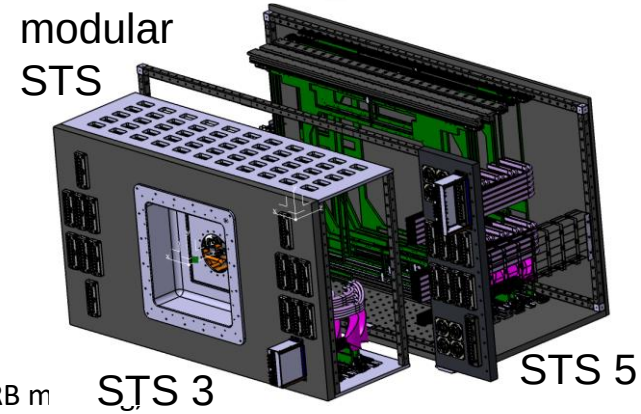

**Micro Vertex Detector (MVD)**
- Intensive test campaigns of full-size MAPS prototype MIMOSIS-1 → MIMOSIS-2 expected for mid of 2023
- Preproduction quadrant in preparation

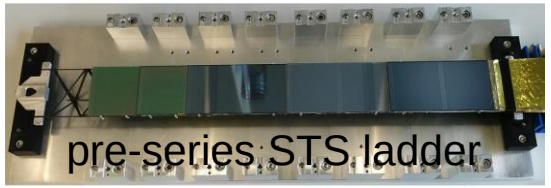


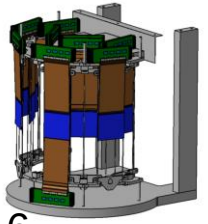



**Silicon Tracking System (STS)**
- Revised modular design with 3+5 stations
- Ladder preproduction will be deployed in J-PARC E16
- Re-design of FEB8-2 and FEB8-5



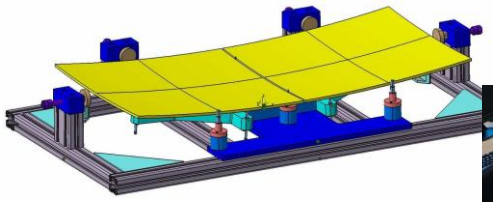

STS ladder pre-series production deployed in J-PARC E16

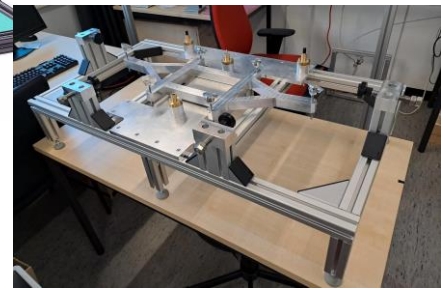


# Status of CBM detector systems

**Ring Imaging CHerenkov detector (RICH)**

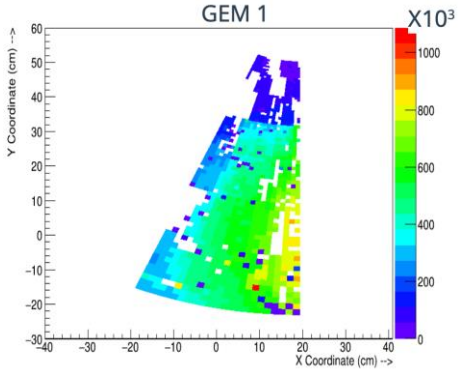
- Towards mechanics engineering design and production readiness
- Photocamera - series production of readout electronics
- Successful runs at HADES and mCBM





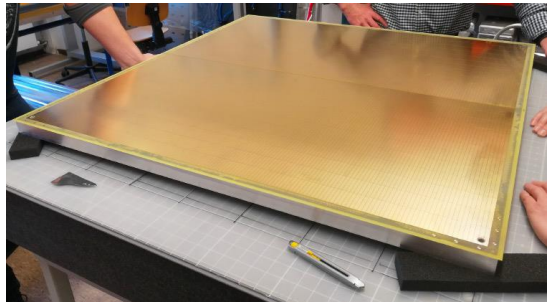
**MUon CHamber system (MUCH)**

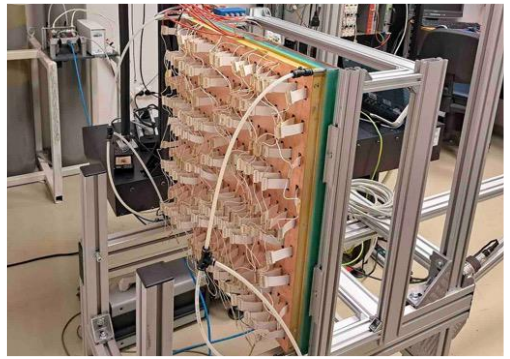
- Intensive test campaigns of full-size GEM and RPC prototypes at GIF++ and mCBM, readout stability significantly improved, data analysis ongoing.




**Transition Radiation Detector (TRD)**

- Preproduction of 4 standard modules
- Construction of full-size TRD-2D prototype (inner part)
- New SPADIC 2.4 design, test submission planned for April 2023
- TRD as intermediate tracker, successful runs at mCBM

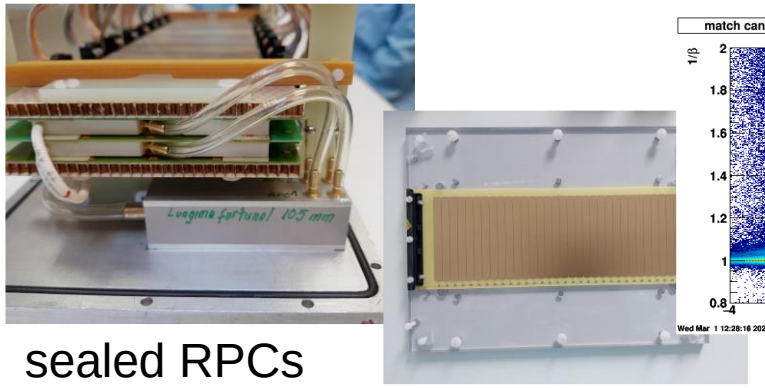




# Status of CBM detector systems

**Time of Flight system (TOF)**

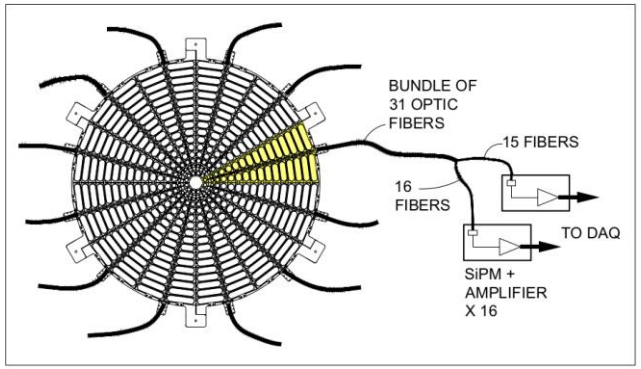
- Successful data taking at STAR and mCBM, data analysis ongoing
- Sealed RPCs to enhance rate capability
- Engineering design of main frame
- RPC preproduction

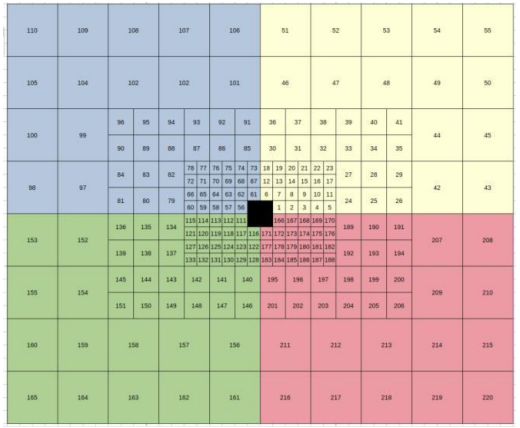



sealed RPCs

**Forward Spectator Detector (FSD)**

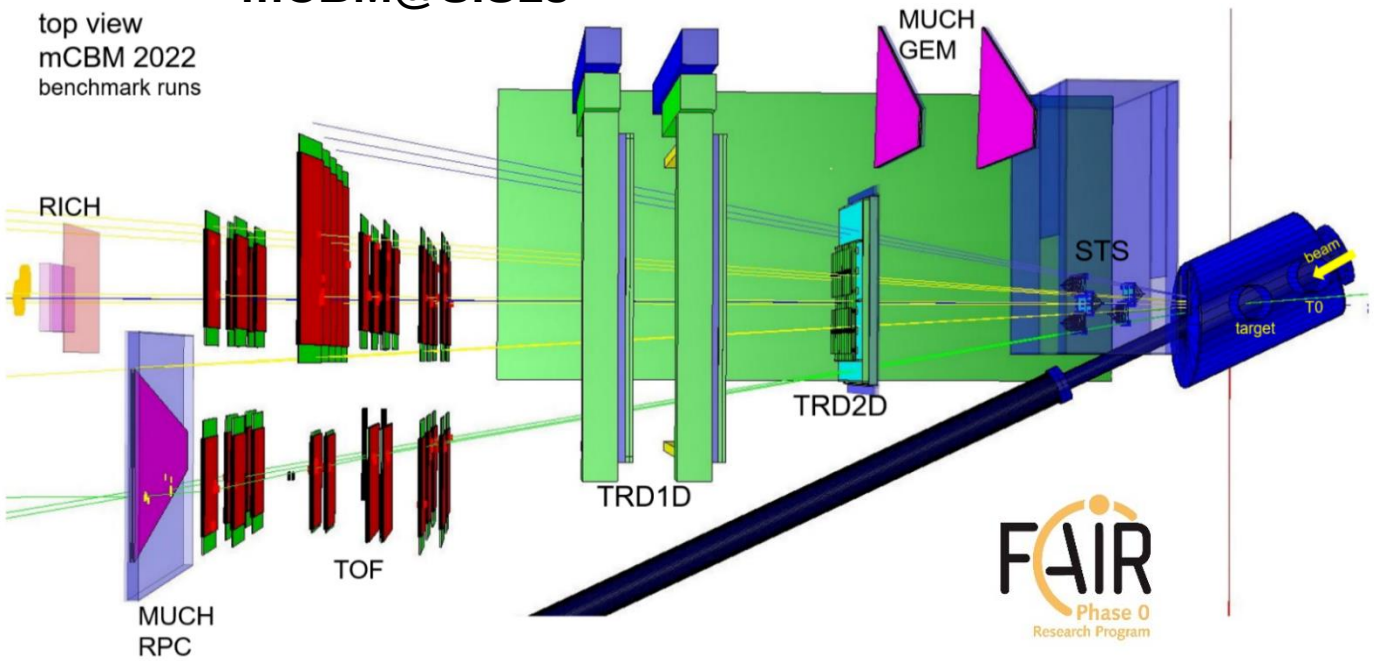
- New design, likely based on ZnS scintillators and LYSO crystals for central part
- Read-out via SiPM
- Readout electronics based on existing solutions



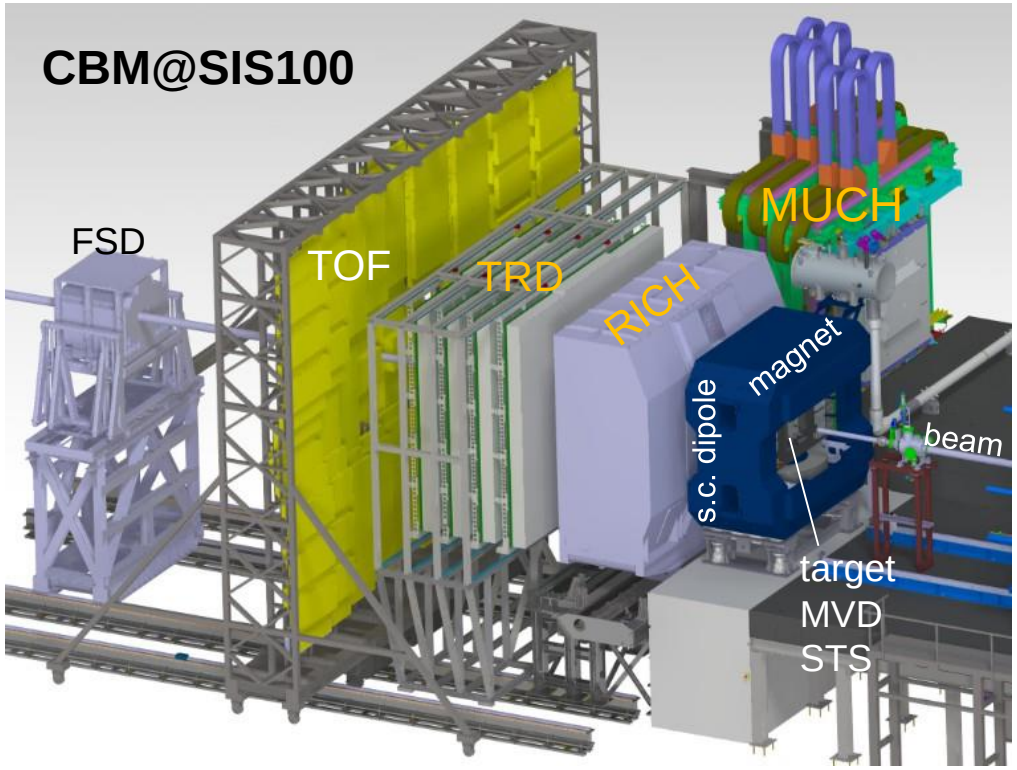



# With mCBM towards CBM

**mCBM@SIS18**




**CBM@SIS100**

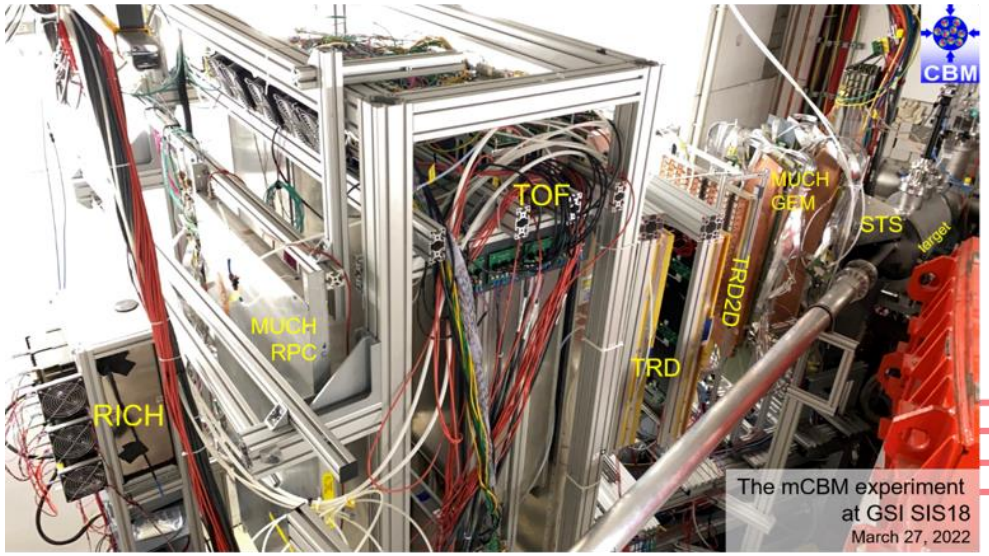



CBM full-system test setup at SIS18/GSI comprising pre-series productions of all CBM detector systems:

| | |
|---|---|
| T0 | 16+16ch pcCVD diamond, 1x1cm$^2$, 80 µm, part of BMON |
| STS | 11 modules, 6x6cm$^2$ and 6x12cm$^2$ double-sided silicon-strip sensors, 5 ladders on 2 stations |
| MUCH | 2 GEMs M2 modules (MUCH 1+2), 1 RPC (MUCH 3+4) |
| TRD | 2 MWPCs with rect. pad (TRD1D, outer region), 1 MWPC with triang. pads (TRD2D, inner part) |
| TOF | 8 MRPCs modules in 2 stacks |
| RICH | 2 aerogel radiators (2 20x20cm$^2$), 36 MAPMTs |

FSD and MVD test systems in preparation

# The free-streaming CBM DAQ and data processing




optical fibers 50m

DAQ container

CRI (PCIe) @ FLES entry nodes

optical fibers 300 m


FLES processing nodes

FAIR Phase 0 Research Program

triggerless-streaming FEE **assigning time stamps to hits**

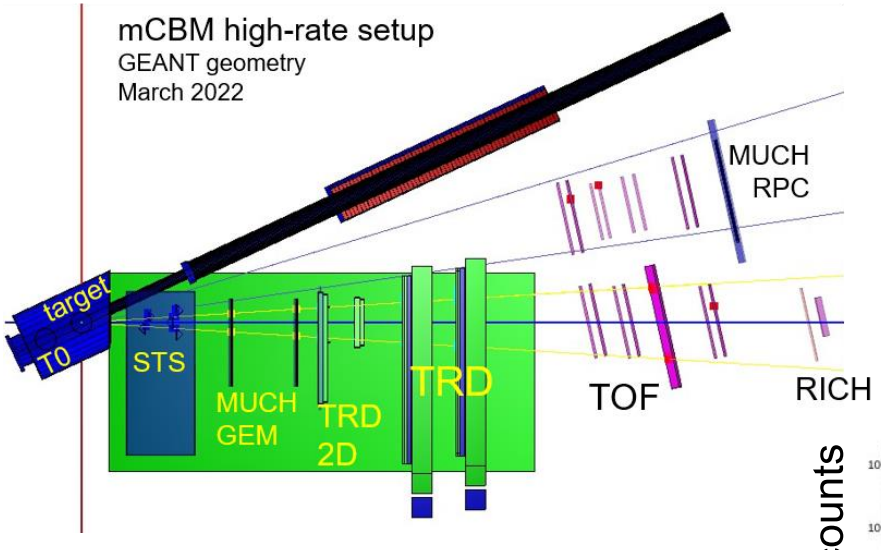
1 m Copper → GBTx → 50 m optical → CRI FPGA **µSlice building** FLES entry nodes

TFC (CRI based)

300 m optical InfiniBand → Green IT Cube

Timeslice Building
- Event Reconstruction
- Event Selection
- Archiving

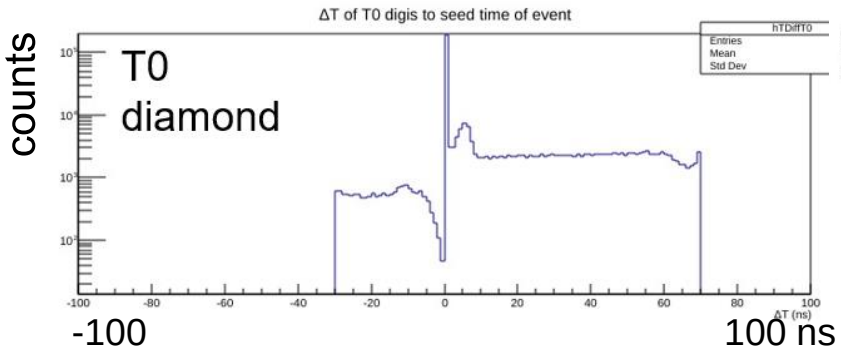
# 1st test version of an (FAIR MQ based) online selection

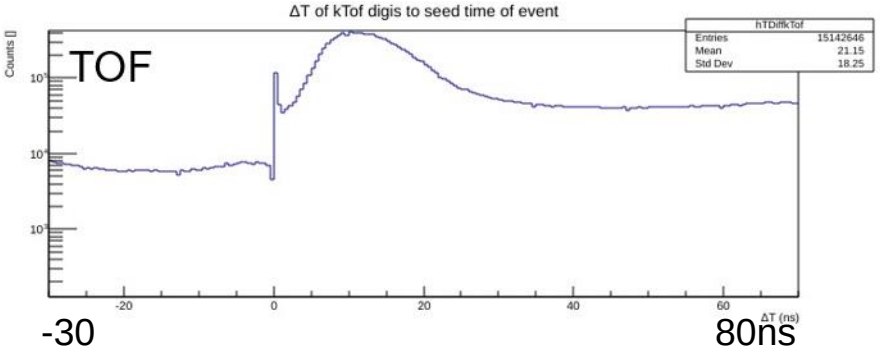


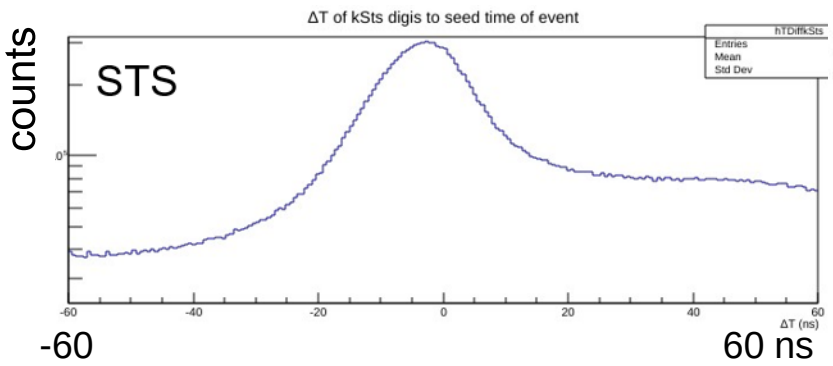

run 2188, March 31, 03:15 CET,
$10^7$ U ions per spill, approx. 100 kHz averaged collision rate

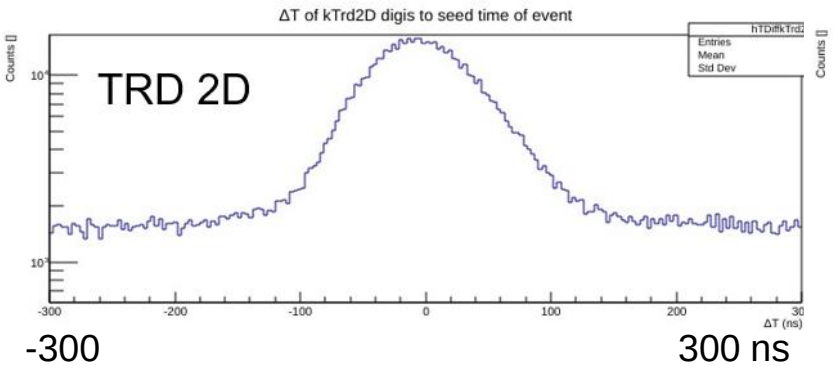
Applied
filter condition: 1 T0 hit, 2 STS hits, 5 TOF hits ("Λ trigger")

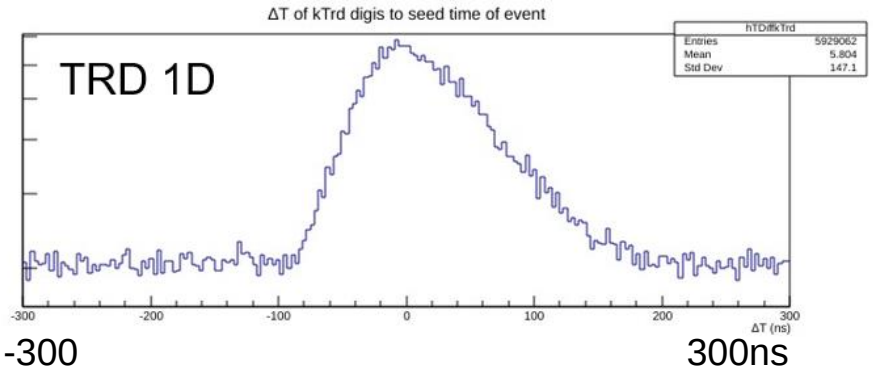
coincidence with T0



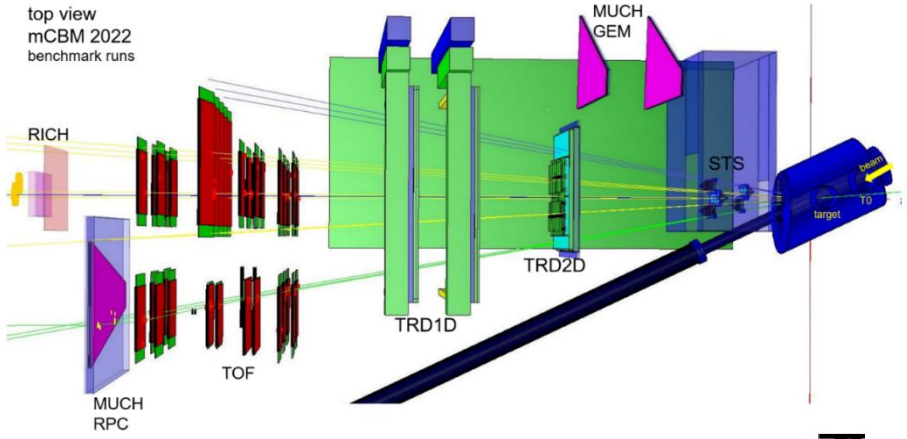



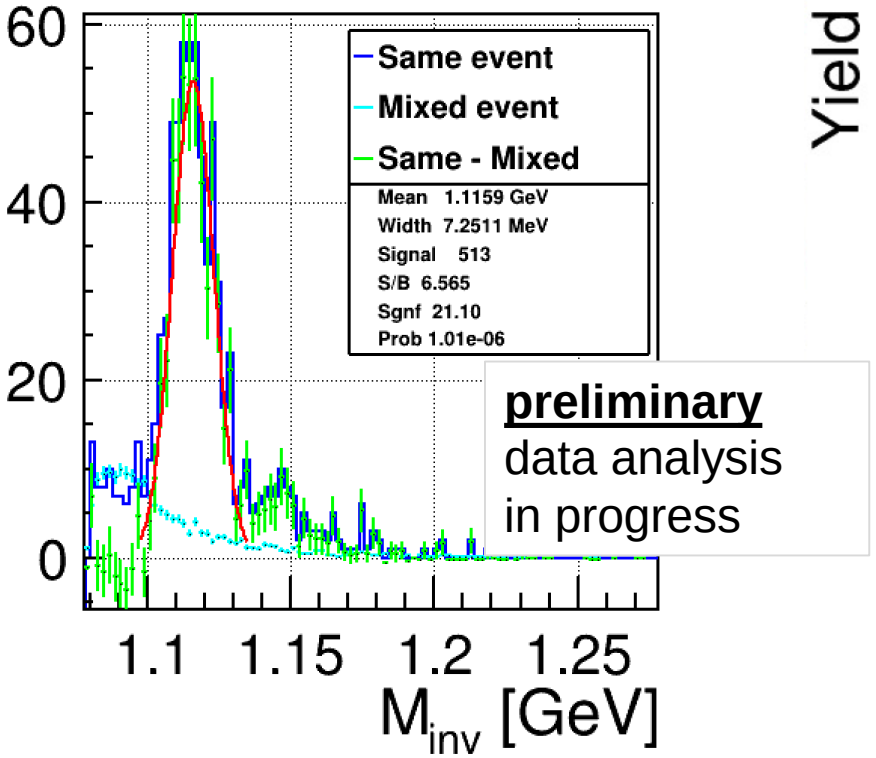




Δt (ns)

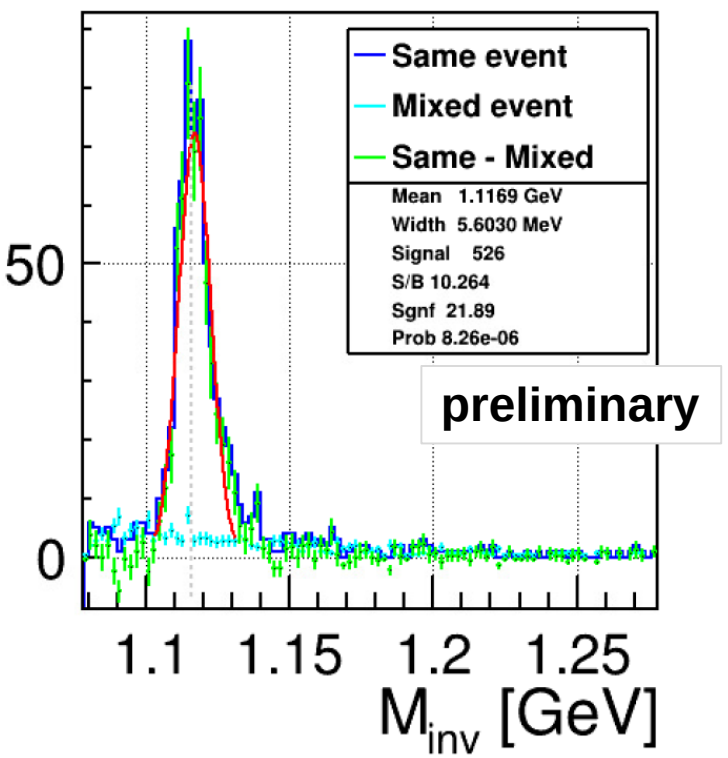
# mCBM: Λ reconstruction in Ni+Ni collisions at 1.93 AGeV




**Data**, run 2391, total run duration **1:57h**
4x to 5x10$^7$ ions per spill, 10s spill
400 - 500 kHz average collision rate

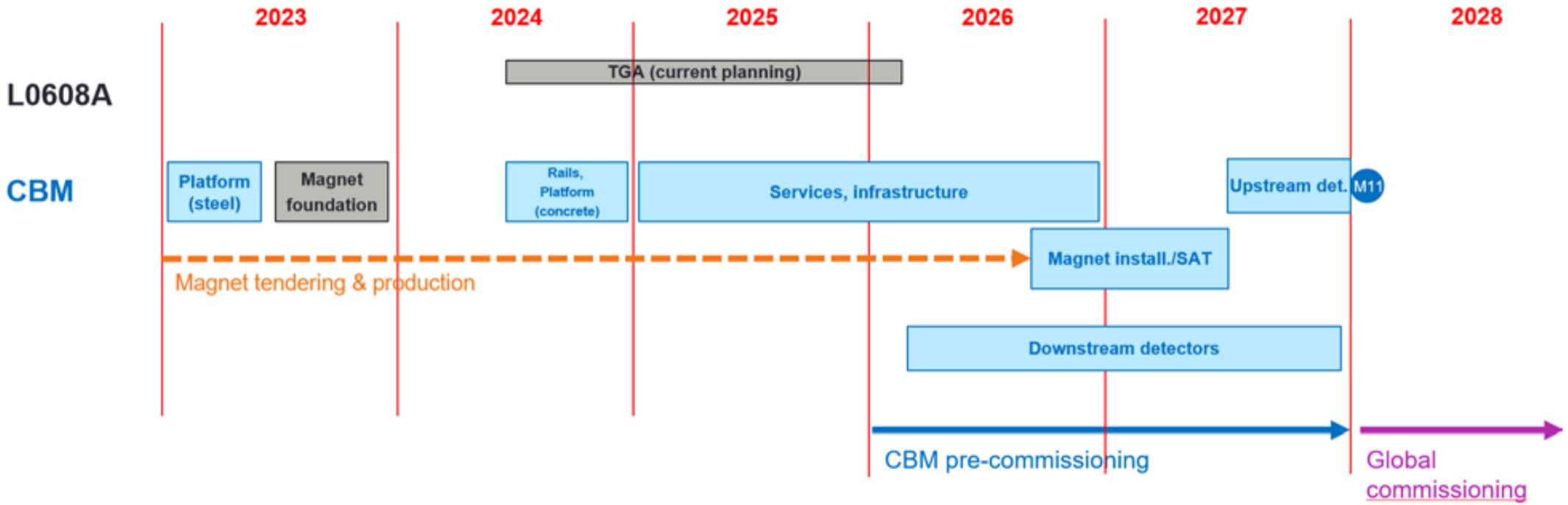



**MC** , identical reconstruction chain
100 M generated events
10$^5$ events / s
63.7 M triggered events




rare signal reconstructed,
- milestone reached !

# Timeline


2023
2024
2025
2026
2027
2028
L0608A
TGA (current planning)
CBM
Platform (steel)
Magnet foundation
Rails, Platform (concrete)
Services, infrastructure
Upstream det.
M11
Magnet install./SAT
Magnet tendering & production
Downstream detectors
CBM pre-commissioning
Global commissioning

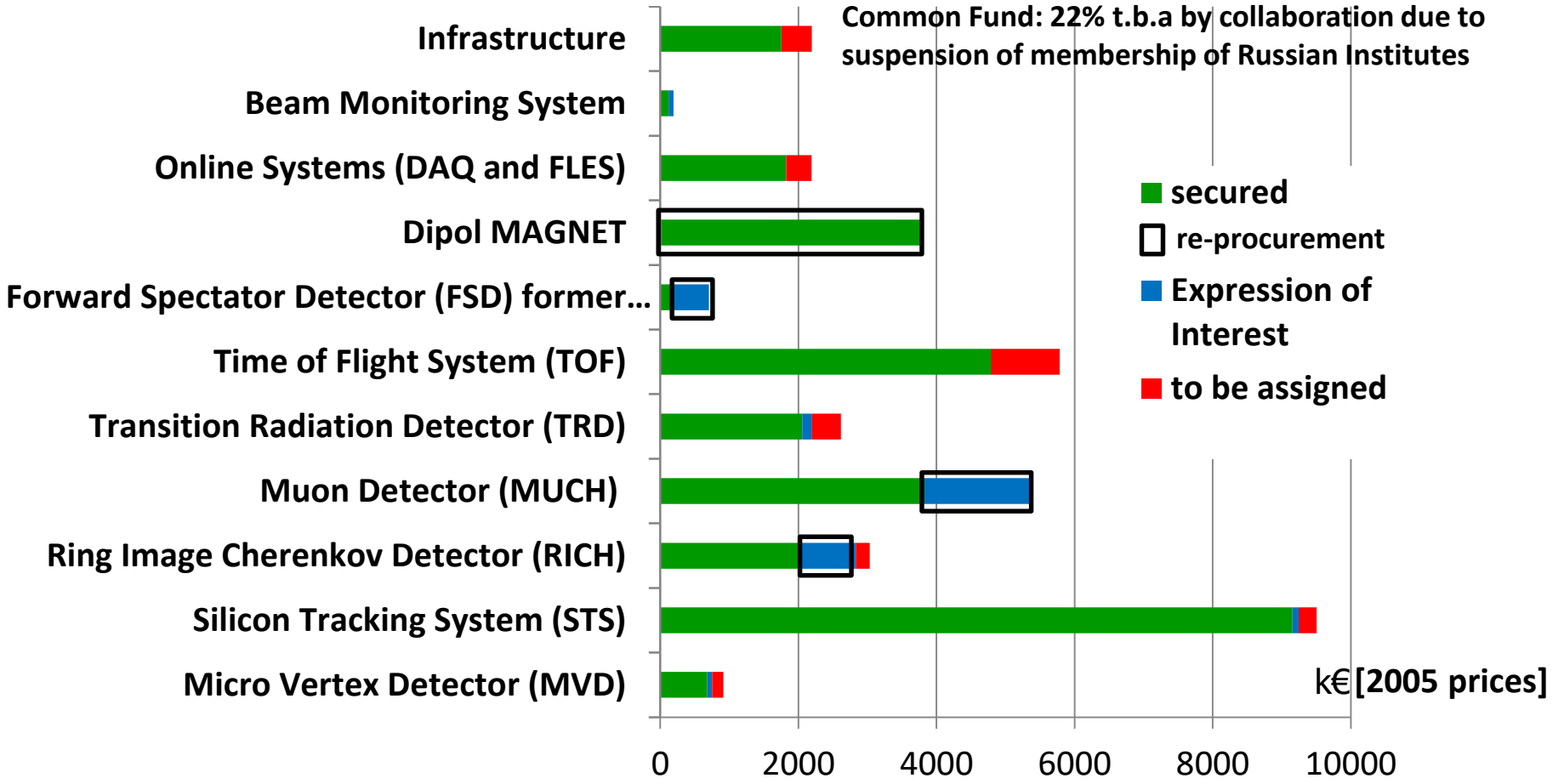
# Revised CBM day-1 funding (Jun. 2023)

**Estimated re-procurement costs [2023 EUROS]**

- Magnet: 6,14 M€
- Forward Detector (former PSD): 0,72 M€
- RICH mechanics, gassystem: 1,28 M€
- MUCH absorbers, mechanics: 2,56 M€

**total cost: 35,97 M€ (2005 EURO)**
**secured: 30,17 M€**
**EoI: 3,32 M€**
**t.b.a. 2,48 M€**

**83,9 % secured funding**



# Consequences of FS / FS+

- Council decision:

**(6) The additional non-German commitments will in principle be used to secure First Science. Exceptions from this principle with regard to a possibility to go beyond First Science require a Council decision, in particular the CBM magnets, expected for Summer 2023.**

- FAIR management plan:

Table 1: Components/services to be procured for the completion of the CBM science programme, their estimated costs (current price level) and their latest date for procurement/expense to keep the timeline.

| | | | | |
|---|---|---|---|---|
| 1 | EXP | CBM SC Dipole magnet | 4-5 Mio. € | July 2023 |
| 2 | EXP | CBM Silicon Tracker System | 0,9 Mio. € | Q3 2024 |
| 3 | EXP | CBM PSD | 0,5 Mio. € | Q4 2024 |
| 4 | EXP | CBM RICH | 1,0 Mio. € | Q2 2025 |
| 5 | EXP | CBM MUCH | 2,0 Mio. € | Q3 2025 |
| 6 | ACC | CBM beamline magnets | 4,2 Mio. € | Q4 2024 |
| 7 | ACC | CBM beamline vacuum comp. | 2,3 Mio. € | Q4 2024 |
| 8 | S&B | TGA CBM cave | 14,3 Mio. € | Q2 2024 |
| 9 | S&B | TGA CBM cave risks | 7 Mio. € | 2024/2025 |
| | | **Sum** | **ca. 37 Mio. €** | |

The collaboration is actively seeking alternative funding sources for detector components (items 2-5), thus, possibly mitigating the financial needs. In case of several years of delay, a significant increase of costs of at least 20% would be expected.

**CBM is part of FAIR2028.**
**Thanks to all involved committees (ECE, JSC, AFC) and FAIR management!**

- Note: Project core invest is necessary but not sufficient to keep the CBM collaboration active.
  BMBF – funds through German „Verbundforschung“ are indispensable and needed for funding of personnel (PhD students and postdocs)

# Residual needs beyond project CI

## Lead institutions

Univ. Frankfurt
GSI, Univ. Tübingen
Univ. Münster, Frankfurt
Univ. Giessen, Wuppertal
Univ. Heidelberg
TU Darmstadt
Univ. Frankfurt, FIAS
GSI
VECC Kolkata
Rez, Prague -> FSD

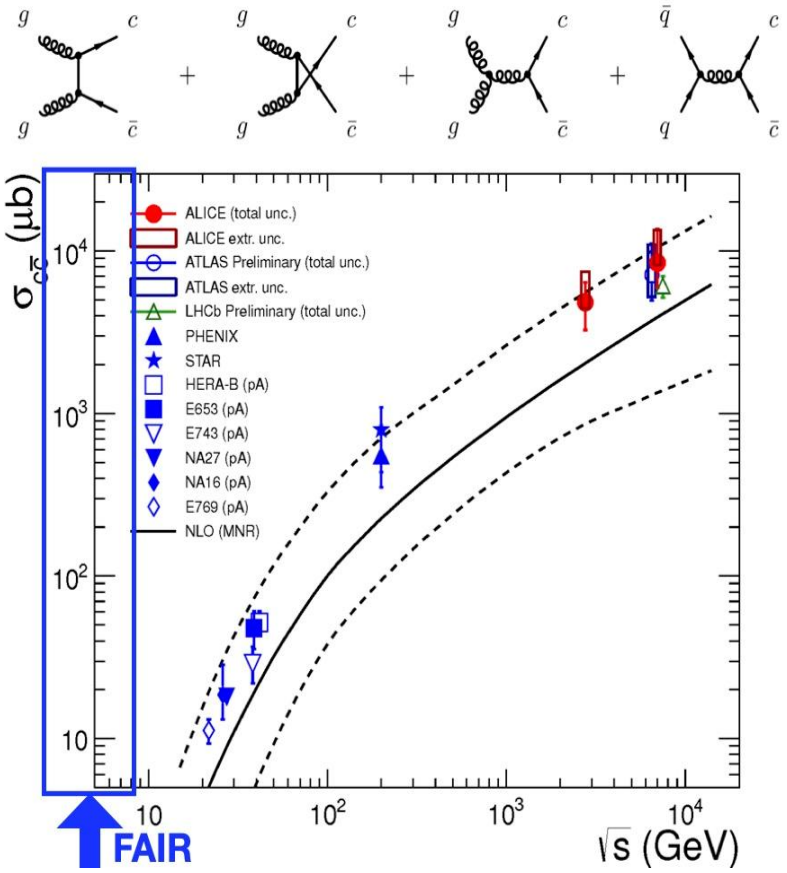
GSI

| CBM day 1 setup detector / system | Costs | Common fund | Germany: GSI and FAIR project funds | Germany: University funding (VF) | FAIR ( re-procurment) *IKC for STS with JINR (will be terminated) | India | Poland | Romania | China | Czech Republic | Hungary | France | Korea | Ukraine | to be assigned |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MVD** | 1,49 | | | 0,60 | | | | | | | | 0,51 | 0,12 | | 0,27 |
| **STS** | 15,54 | | 7,57 | 0,99 | * 3,46 | | 2,94 | | | | | | | 0,15 | 0,42 |
| **TRD** | 4,28 | | | 1,28 | | | | 2,02 | | | 0,23 + 0,06 | | | | 0,68 |
| **RICH** | 4,96 | | **2,03** | 1,32 | 1,28 + | | | | | | | | | | 0,33 |
| **TOF** | 9,46 | | 1,21 | 0,72 | 0,00 | | | 1,22 | 4,67 | | | | | | 1,63 |
| **Beam Monitoring System** | 0,39 | | | 0,12 | | | | | | 0,08 | | | | | 0,20 |
| **Online Systems** (DAQ+FLES) day-1 setup | 2,98 | | **1,44** | 1,22 | | | 0,33 | | | | | | | | |
| **Magnet** | 6,14 | | | | + 6,14 | | | | | | | | | | |
| **MuCh** | 8,82 | | | | 2,57 + | 6,26 | | | | | | | | | |
| **Forward Detector (former PSD)** | 1,15 | | | | 0,72 + | | | | | 0,27 + 0,16 | | | | | |
| **Infrastructure** | 3,58 | **2,87** | | | | | | | | | | | | | 0,72 |
| **ECAL** (not part of day 1 setup) | | | | | | | | | | | | | | | |
| **Sum in 2023 M€** | **58,81** | **2,87** | **12,25** | **6,25** | **4,57 + 9,60** | **6,26** | **3,27** | **3,24** | **4,67** | **0,35 + 0,16** | **0,23 + 0,06** | **0,51** | **0,12** | **0,15** | **4,25** |
| Sum in 2005 M€ | 35,97 | 1,75 | 7,49 | 3,82 | 2,79 + 5,87 | 3,83 | 2,00 | 1,98 | 2,86 | 0,21 + 0,10 | 0,14 + 0,04 | 0,31 | 0,07 | 0,09 | 2,60 |
| escalation factor (1./1.635) | | | | | | | | | | | | | | | |
| This calculation uses an escalation factor of 1.635 between 2005 prices and 2023 prices | | | | | amounts in green are considered as secured / | | | | | | 83,9 % secured | | | | |
| 1,635 | | | | | amounts in blue - Expression of Interest (EoI) | | | | | | | | | | |
| | | | | | amounts in red - to be assigned | | | | | | | | | | |
| **CBM phase 1 setup** | | | | | | | | | | | | | | | |
| **CBM day 1 setup** | 58,81 | 2,87 | 12,25 | 6,25 | 4,57 + 9,60 | 6,26 | 3,27 | 3,24 | 4,67 | 0,35 + 0,16 | 0,23 + 0,06 | 0,51 | 0,12 | 0,15 | 4,25 |
| **full bandwidth (DAQ/FLES)** | 0,59 | | | | | | | | | | | | | | 0,59 |
| **plus ECAL** | 4,59 | | | | 4,59 | | | | | | | | | | |
| **Sum in 2023 M€** | **63,99** | **2,87** | **12,25** | **6,25** | **9,15 9,60** | **6,26** | **3,27** | **3,24** | **4,67** | **0,35 + 0,16** | **0,23 + 0,06** | **0,51** | **0,12** | **0,15** | **4,84** |
| Sum in 2005 M€ | 39,14 | 1,75 | 7,49 | 3,82 | 5,60 + 5,87 | 3,83 | 2,00 | 1,98 | 2,86 | 0,21 + 0,10 | 0,14 + 0,04 | 0,31 | 0,07 | 0,09 | 2,96 |
| | | | | | | | | | | | 77,1 % secured | | | | |

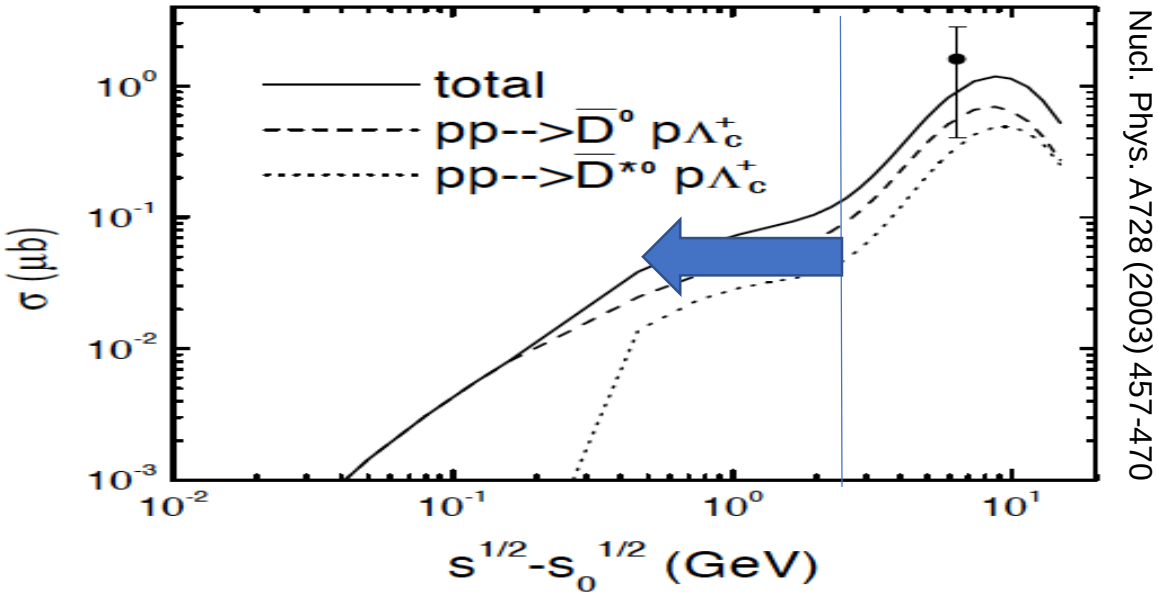
# Extension of the CBM Physics Program

Physics potential of 29 GeV proton beams is being explored together with PANDA groups (J. Messchendorp, J. Ritman, P. Salabura)

Example for Day-1 CBM hadron setup: charm production, charm-N interaction




- Validity of pQCD at SIS100 energies?
- SU(4) estimates for (exclusive) charm hyperon production: 100 nb@SIS100
- Perspectives to study for the first time near-threshold charm production

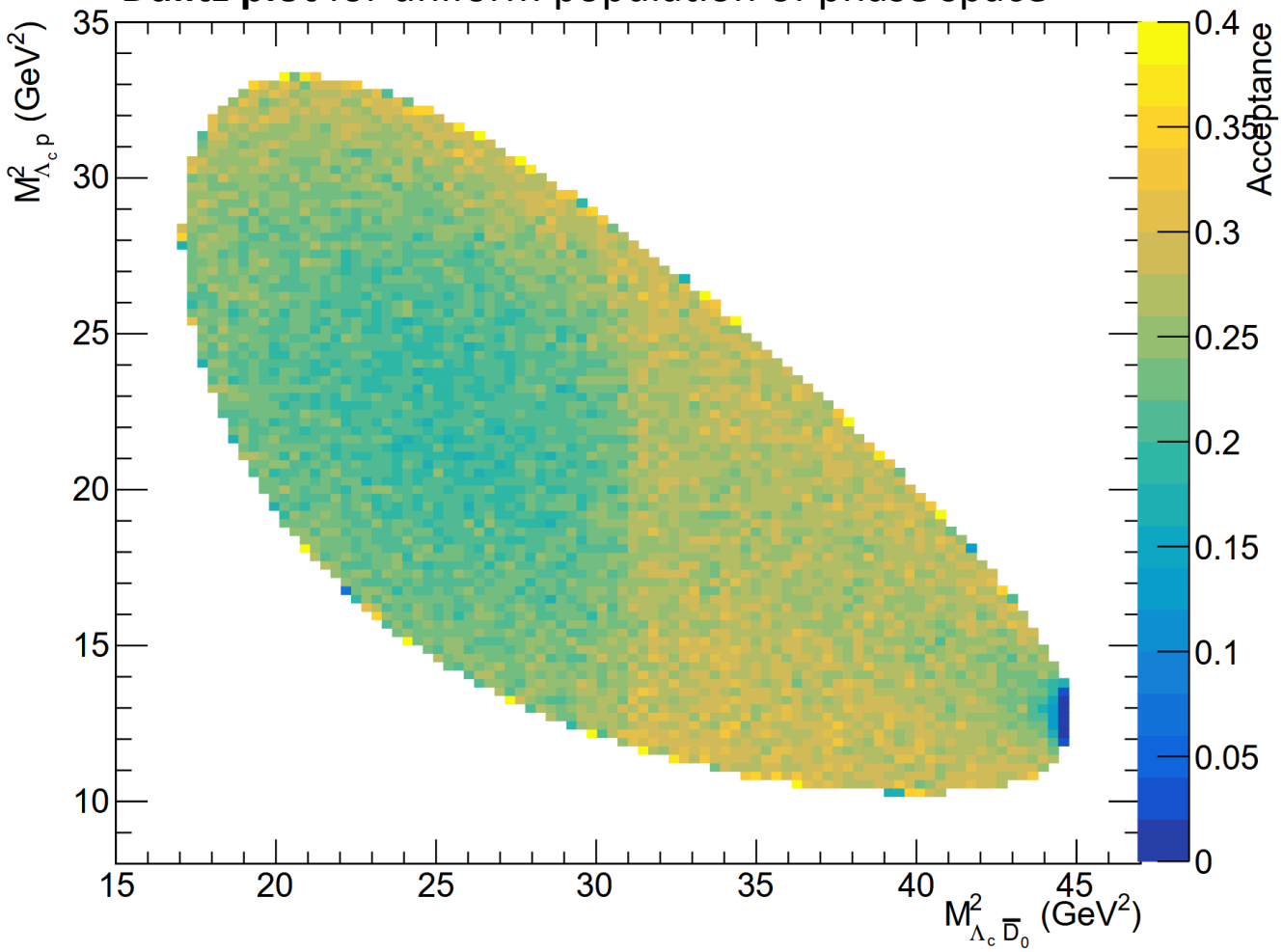



Can intrinsic charm of nucleon enhance production cross section?
(Analogy of ss bar content in nucleon and ϕ production)

# CBM projection for studying exclusive reactions

$$pp \rightarrow p\Lambda_c(\rightarrow pK^-\pi^+)\,\bar{D}_0(\rightarrow K^+\pi-)$$

**Dalitz plot** for uniform population of phase space




**Rate estimate:**

Cross section: 100 nb

Beam intensity: $10^{12}$ 1/s

Target: LH2

Target thickness: 5 cm

Duty cycle: 50%

$\Rightarrow$ Detected reaction rate (including BRs): 1 Hz = 8.6 $10^4$ / d

Detailed studies of pD and p$\Lambda_c$ interactions become possible (femtoscopy).

# Conclusion

- Hades will continue successful program with SIS18 beams (HI, p, $\pi$)

- CBM pushes to be part of the official FAIR2028 program by FAIR Council decision

  - uniqueness of physics program is confirmed by Heuer/Tribble, ECE and JSC
  - CBM planning is assuming a positive decision of FAIR council and goes for first SIS100 beams in 2028
  - missing the `urgency requirement´ will be hindering the application for necessary funds for completion
  - personnel funding (PhD students, postdocs) is essential for the university groups to continue
  - CBM groups should be funded to secure alternatives in SIS100 usage in 2027/2028

- CBM is working on the possibility of including the beam line to CBM-Cave into FAIR 2018

  - CBM is in contact with PANDA groups to define a competitive hadron physics program with proton beams.
  - APPA (ESA) measurement options are being investigated.