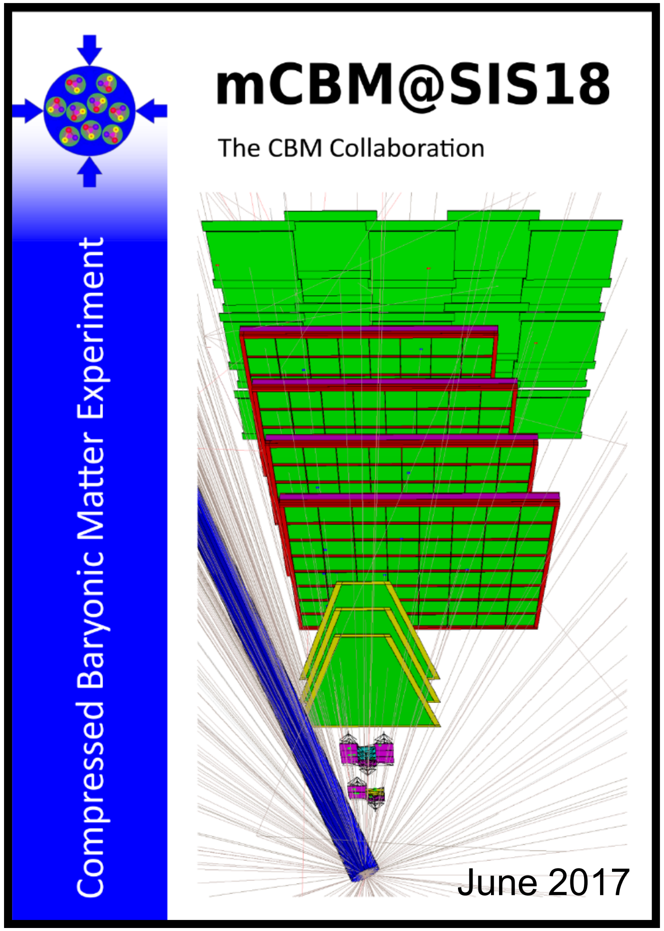
The mini-CBM project during FAIR Phase-0

mCBM : a CBM full system test-setup
for high-rate nucleus-nucleus collisions at GSI / FAIR



Outline

Motivation
- Detector prototype performance
- DAQ development
- Physics reconstruction performance

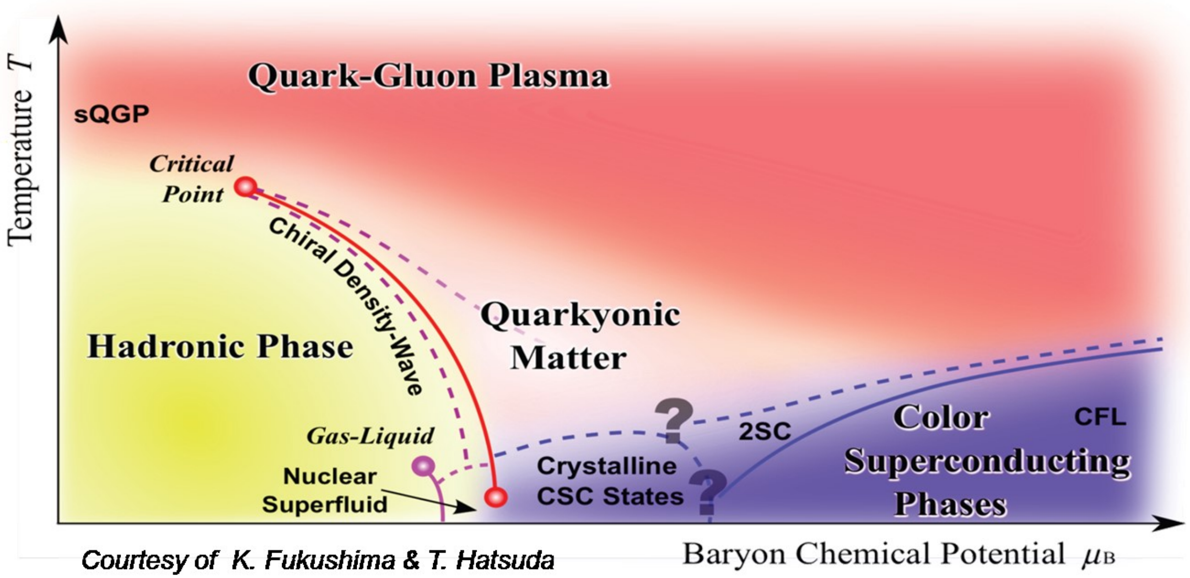
Setup
- Cave
- Detectors

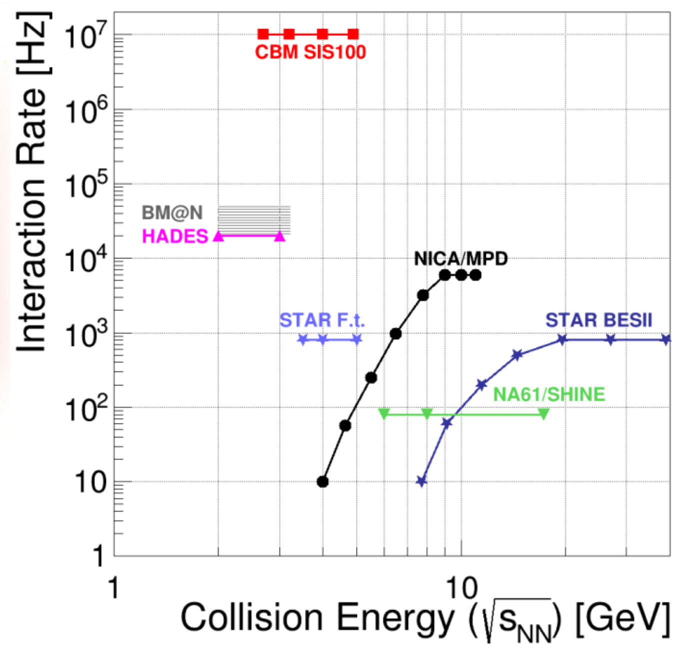
Status
- Site preparation
- Timeline

Physics potential

Full version of proposal:
https://cbm-wiki.gsi.de/foswiki/pub/Public/Documents/mcbm-proposal2GPAC-fullVersion.pdf

CBM – Goals





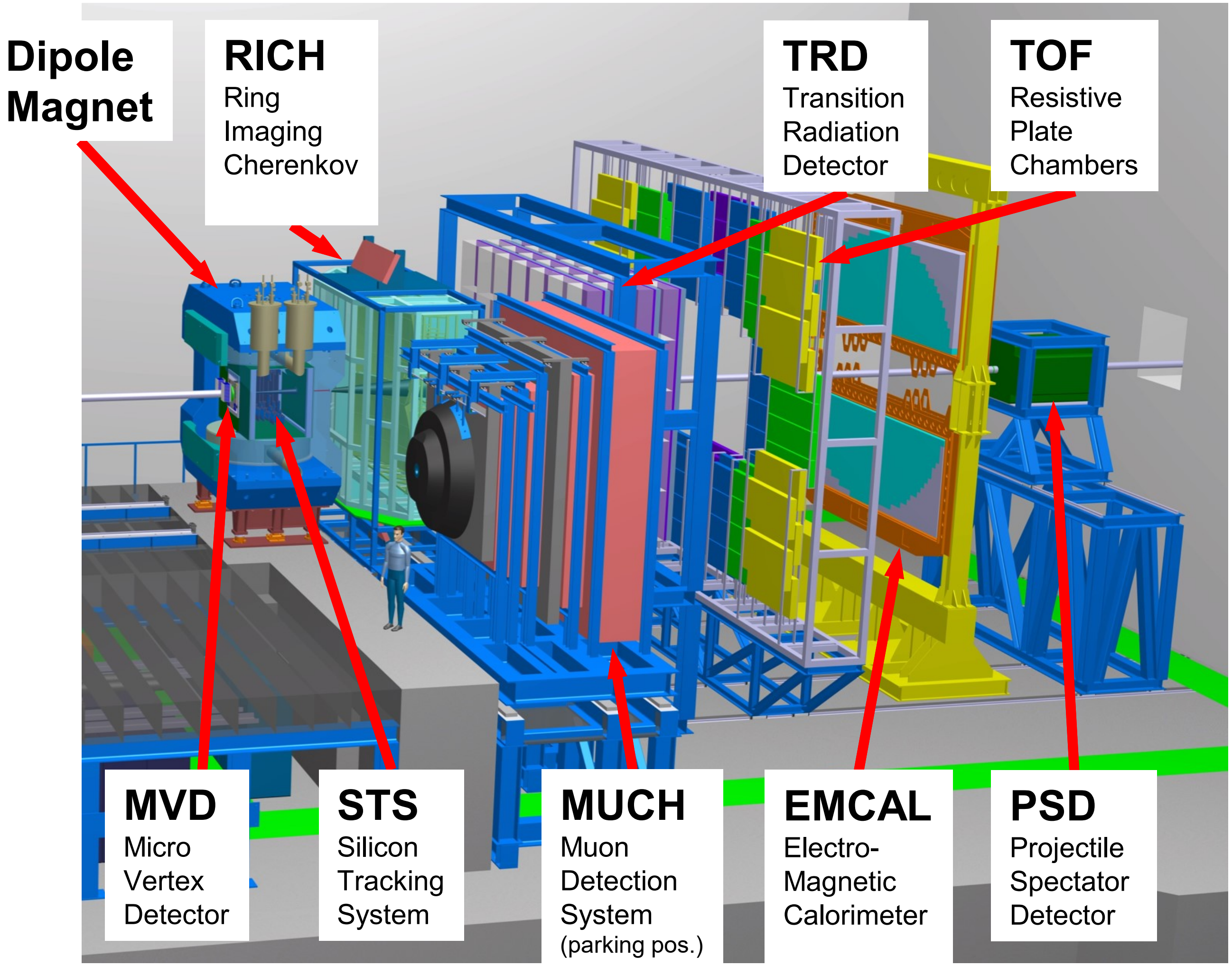
CBM goal:

systematically explore baryon-rich dense matter with rare probes.

CBM strategy:

radiation hard detectors,
free streaming data recording,
software based event selection.

CBM Experimental Setup



- Tracking acceptance: $2^o < \theta_{lab} < 25^o$
- Free streaming DAQ

  R_{int} = 10 MHz (Au+Au)

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

CBM experimental challenges

Perform measurements at unprecedented reaction rates

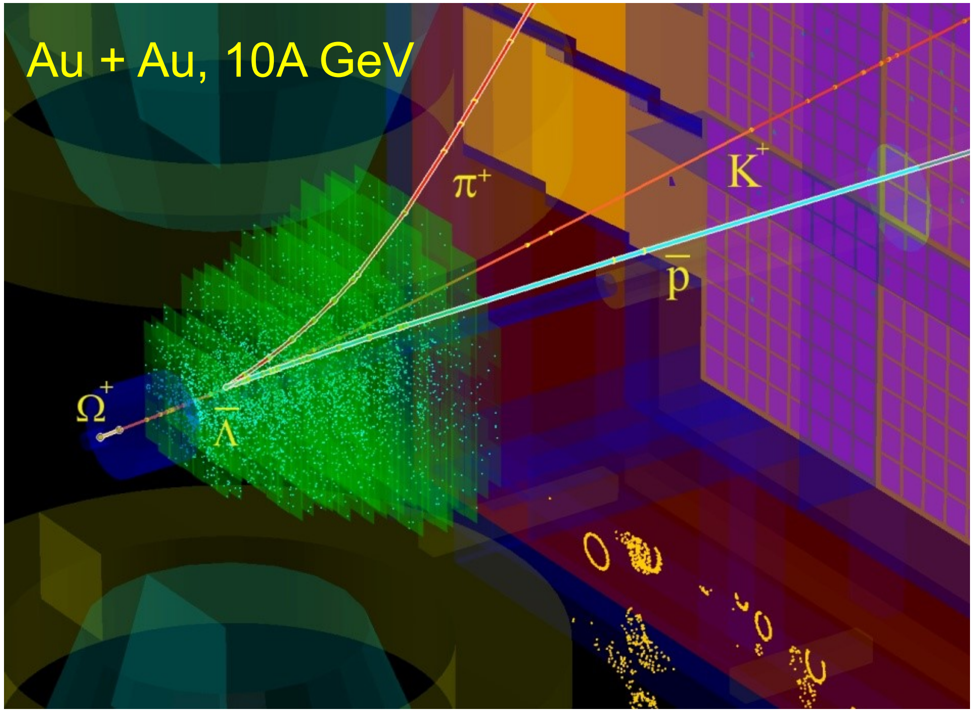
10^5 - 10^7 Au+Au reactions/sec

→ fast and radiation hard detectors

→ free-streaming read-out electronics

→ high speed data acquisition and
  high performance computer farm for online event selection

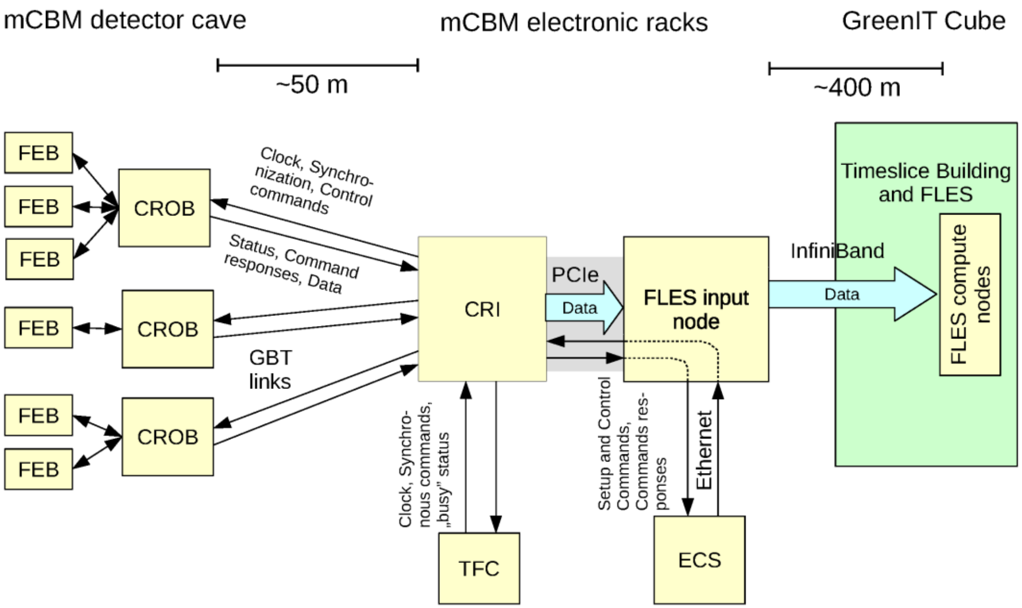
→ 4-D event reconstruction



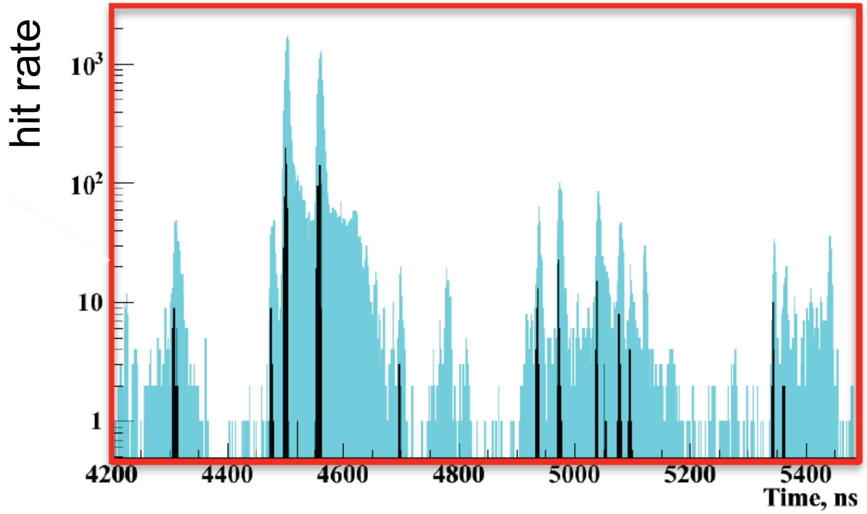
Identification
of leptons and hadrons

Determination of
(displaced) vertices ($\sigma \approx 50$ μm)

CBM readout and online systems



Au + Au, 10^7 collisions per second



Novel readout scheme

- no hardware trigger of events,
- free streaming (triggerless) data,
- all detector hits with time stamps

Full online 4-D track and event reconstruction
Requirement: online calibration

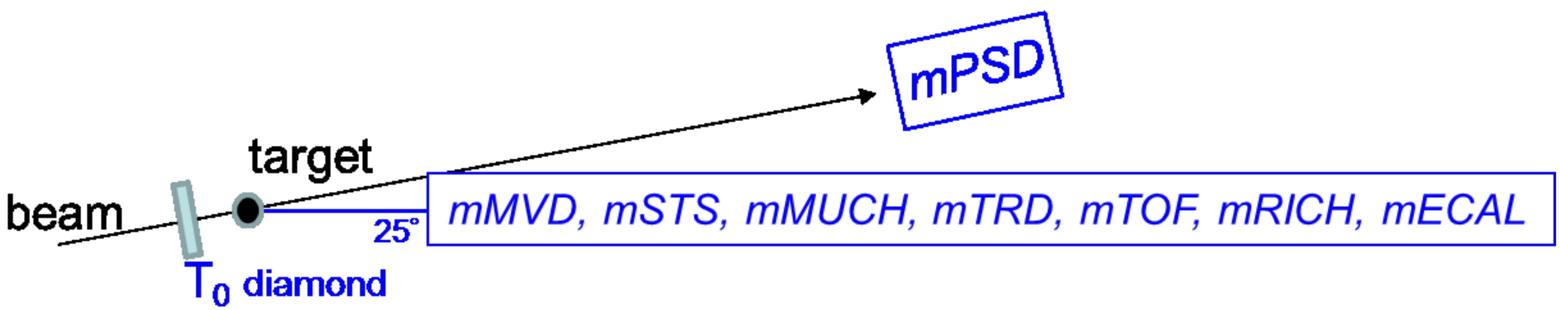
mCBM@SIS18 - Goals

Topics to be addressed

- free streaming data transport to mFLES compute farm
- detector tests of final detector prototypes
- online reconstruction and event selection
- offline data analysis
- controls

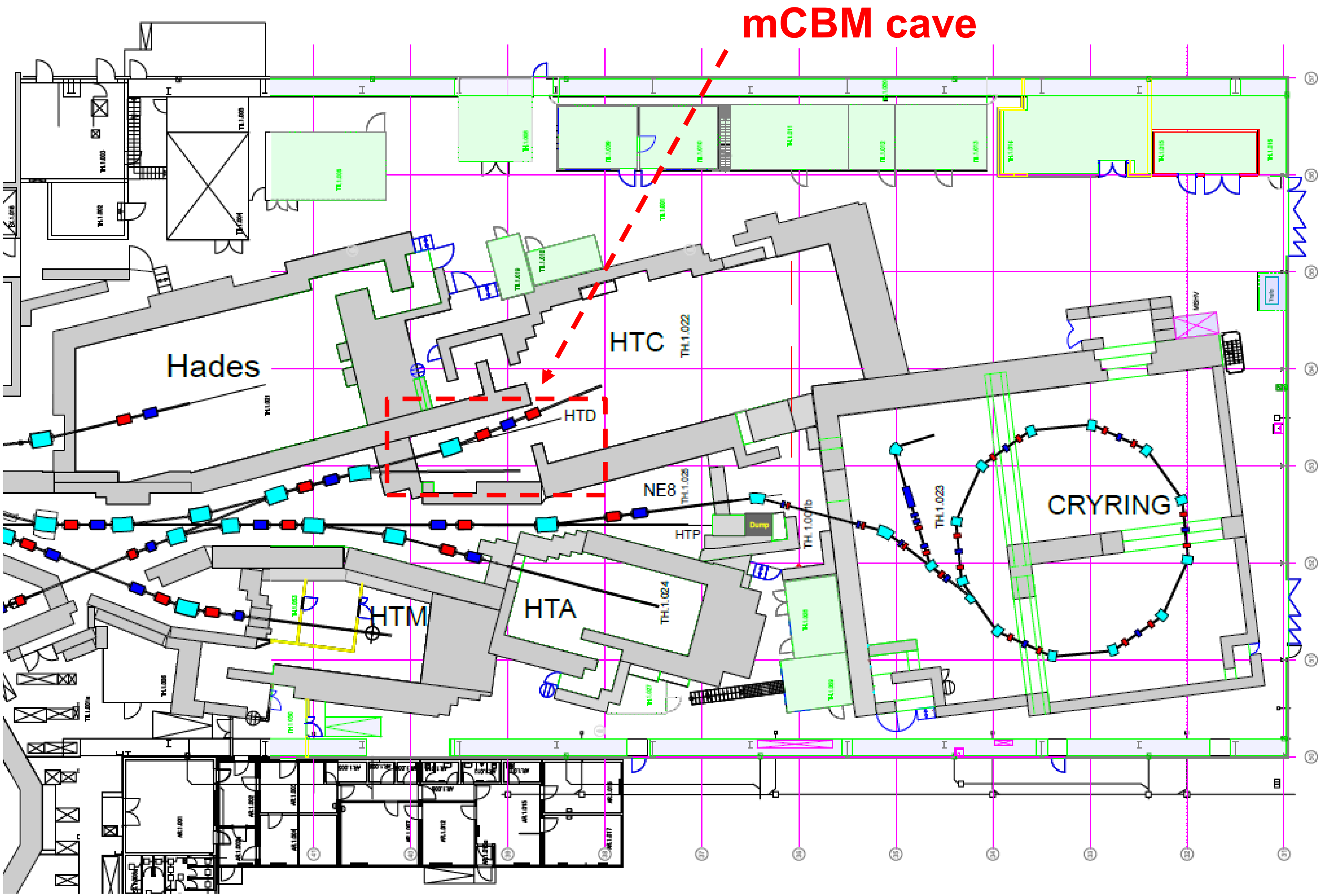
Needs:

permanent test-setup at host lab

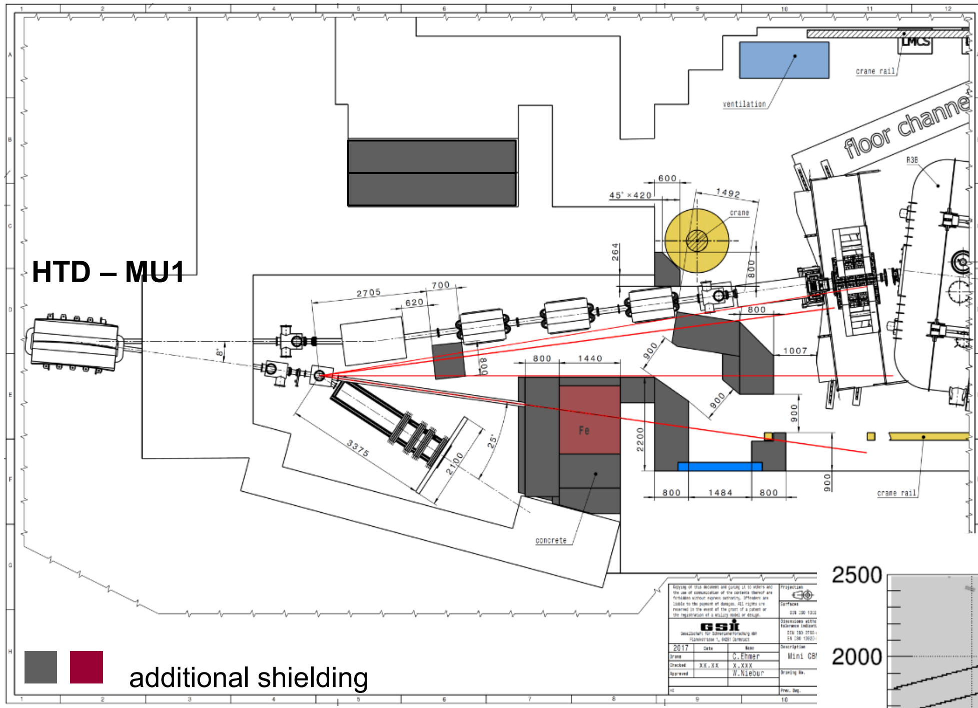


- detector prototypes at $\theta_{lab} \approx 25°$
- straight tracks, no B-field
- high resolution TOF (t_0 – TOF stop wall)
- event characterization with PSD prototype

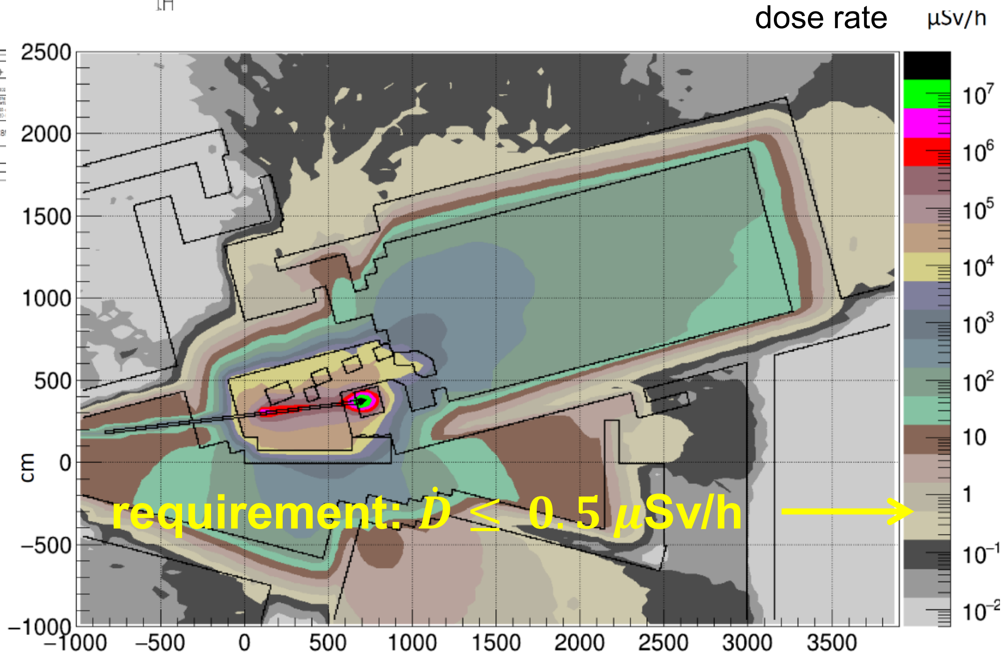
Experimental hall at SIS18



mCBM Cave (HTD)

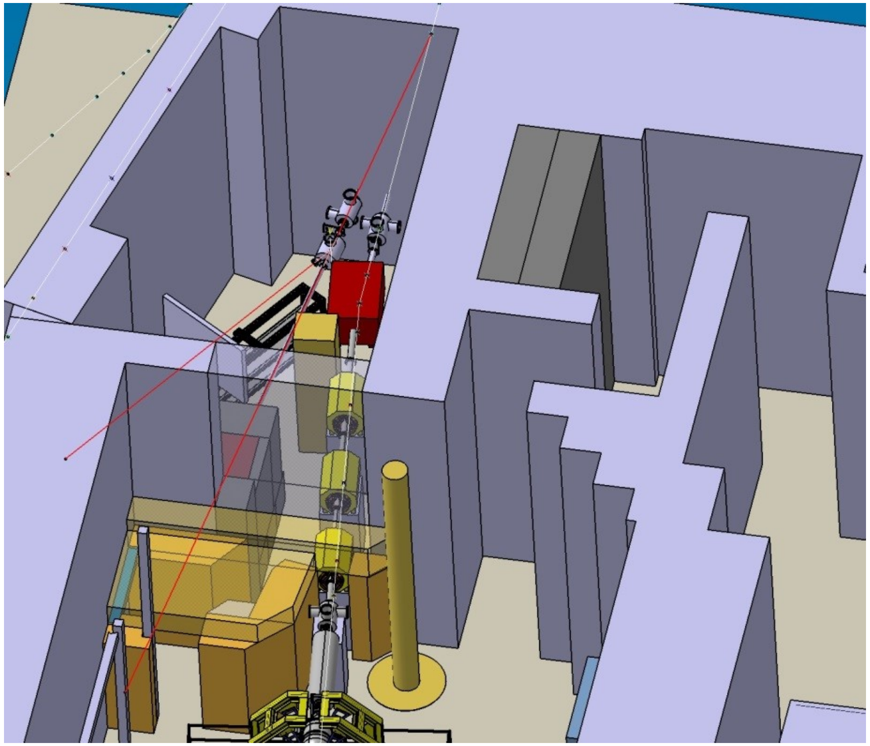


- Modified switching magnet (HTD – MU1)
- New beam dump
- Additional shielding



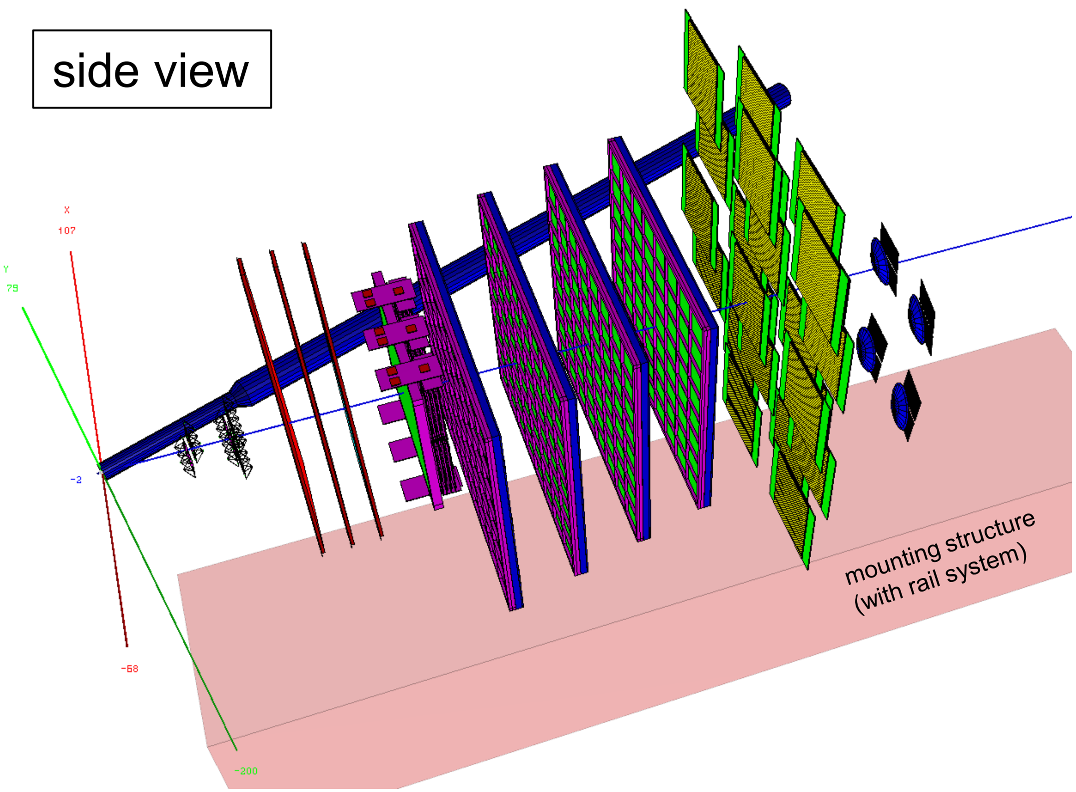
FLUKA calculations:
10^8 Au ions s^{-1}, 1.24 AGeV,
2.5 mm Au target (P_{int} = 10%)
vertical section: **beam level**

Status of the cave reconstruction

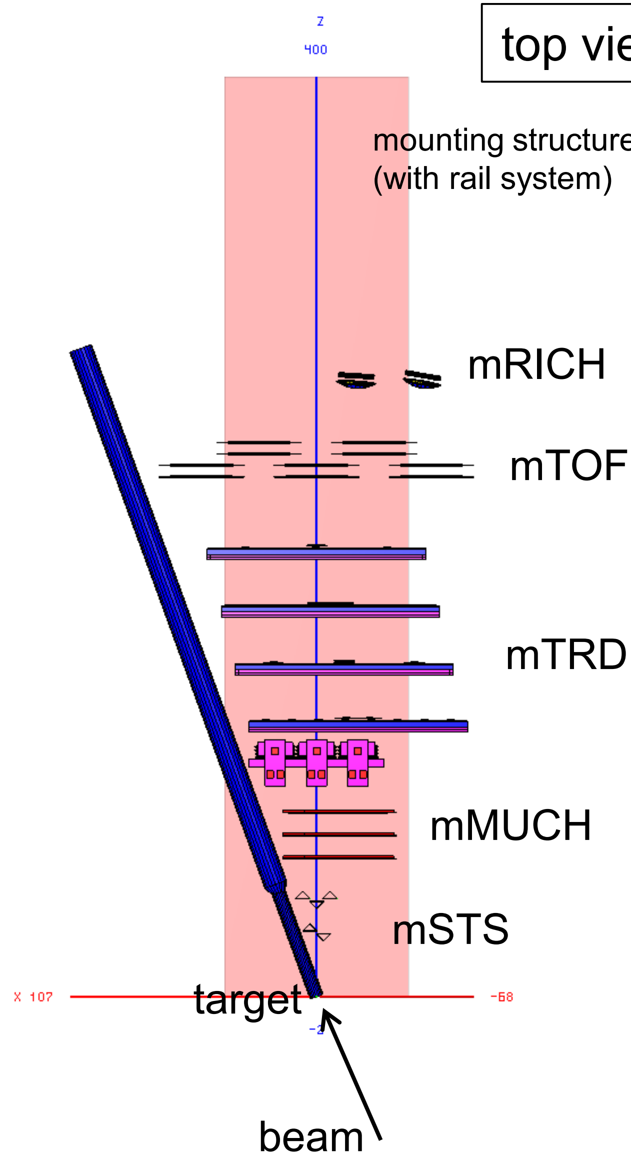


Design of the mCBM setup

side view



top view



Wuhan CM: mCBM contributions

mCBM: Detector Systems - 201 (16:00-17:30)

- Conveners: Sturm, Christian; Emschermann, David

Monday, Sept. 25

time	[id] title	presenter
16:00	[73] Status of mSTS	Dr. HEUSER, Johann
16:10	[74] Status of mMUCH	DUBEY, Anand Kumar
16:20	[75] Status of mTRD	BLUME, Christoph
16:30	[76] Status of mTOF	DEPPNER, Ingo
16:40	[77] Status of mRICH	HÖHNE, Claudia PAULY, Christian
16:50	[78] Status of mPSD	GUBER, Fedor
17:00	[79] Discussion	STURM, Christian

DAQ and DCS: mCBM - 301 (11:00-12:30) **Tuesday,Sept. 26**

- Conveners: Emschermann, David

Software: mCBM - 301 (14:00-15:30)

- Conveners: Friese, Volker

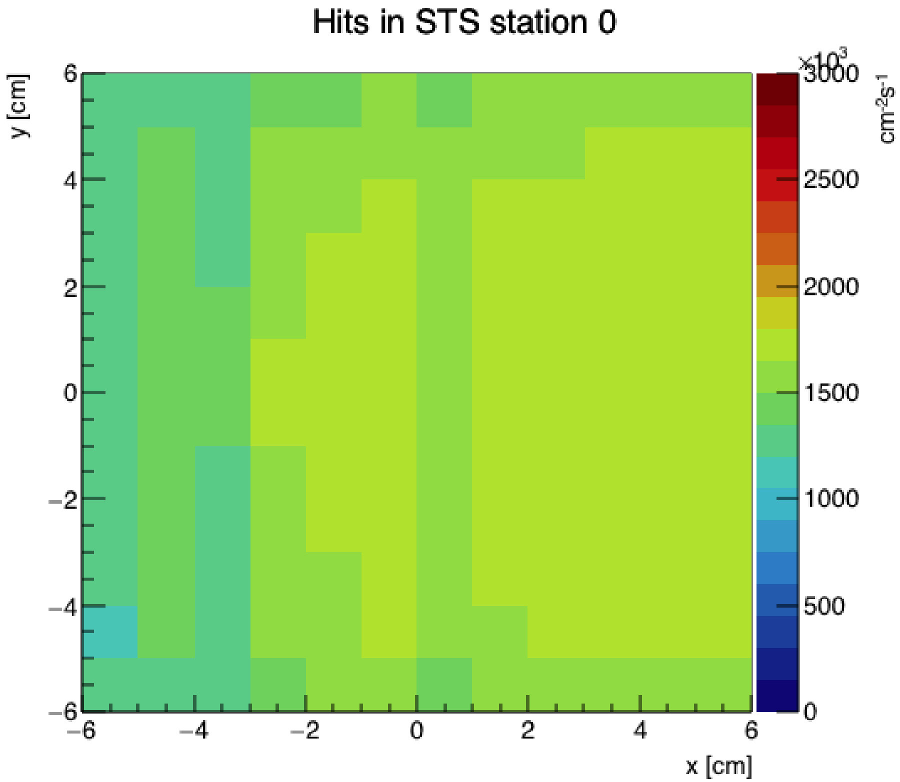
Tuesday, Sept. 26

time	[id] title	presenter
14:00	[62] FLESnet for mCBM	DE CUVELAND, Jan
14:15	[38] Unpackers	LOIZEAU, Pierre-Alain
14:30	[39] Towards mCBM: simple event builder and FairMQ	PROKUDIN, Mikhail
14:45	[40] Local reconstruction	FRIESE, Volker
15:00	[41] Track finding (L1)	AKISHINA, Valentina
15:15	[42] Track finding	ABLYAZIMOV, Timur

Plenary: mCBM Coordination - 409 (11:00-11:45) **Wednesday, Sept. 27**

- Conveners: Sturm, Christian

Hit rates

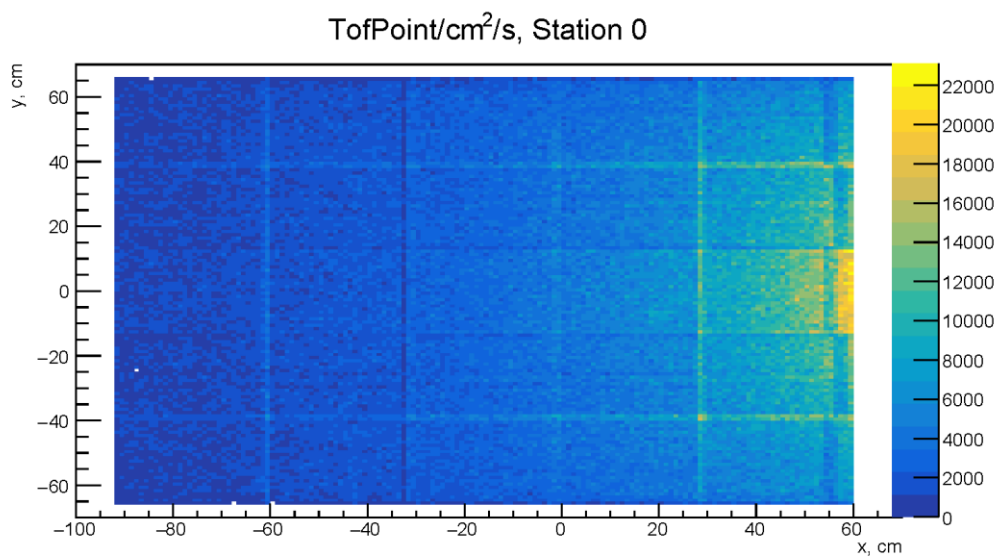


mSTS, 1st station

max. (design) rate: 1.5 MHz/cm^2

mTOF

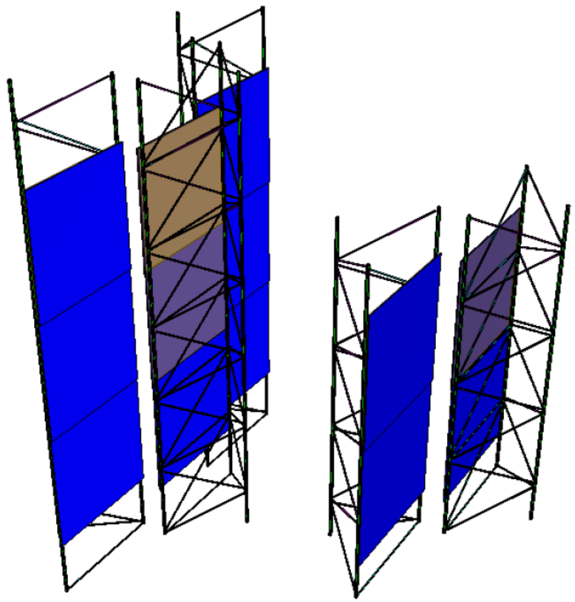
max. (design) rate: 20 kHz/cm^2

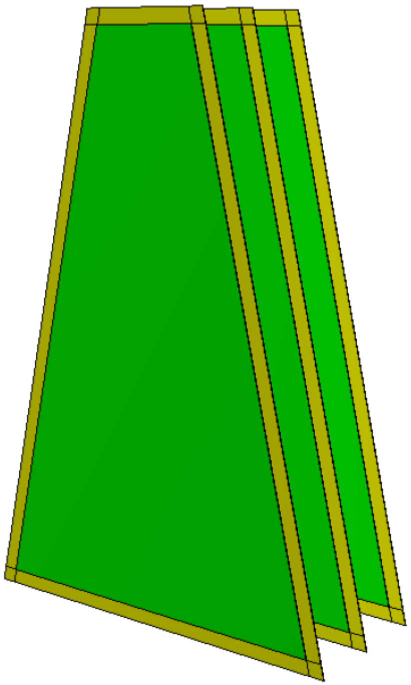


Input:
UrQMD, Au+Au 1.24 AGeV, mbias,
incl. δ-electrons

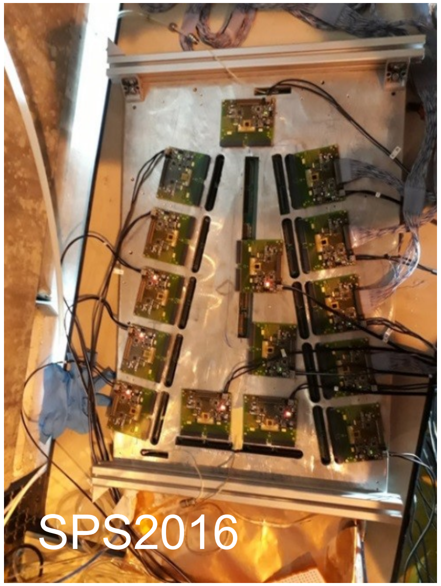
mCBM – subsystems: STS, MUCH

mSTS





mMUCH



mSTS: 2x stations

Contribution by GSI

- 1st: 2x2 modules
- 2nd: 3x3 modules
  = 5 half-ladders
  = 13x 6x6 cm² sensors

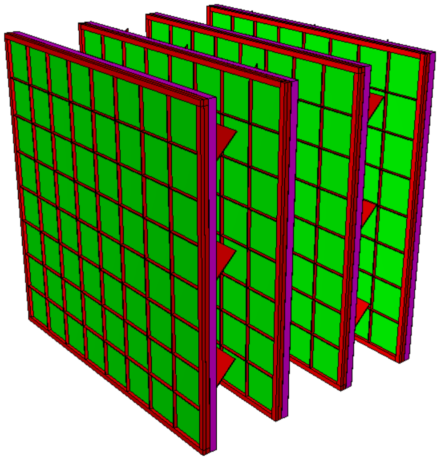
mMUCH: 3x layers

Contribution by India

- 3x M2 GEM modules
- 18x FEBs per module (STS-XYTER)
- used during CERN beamtest 2016

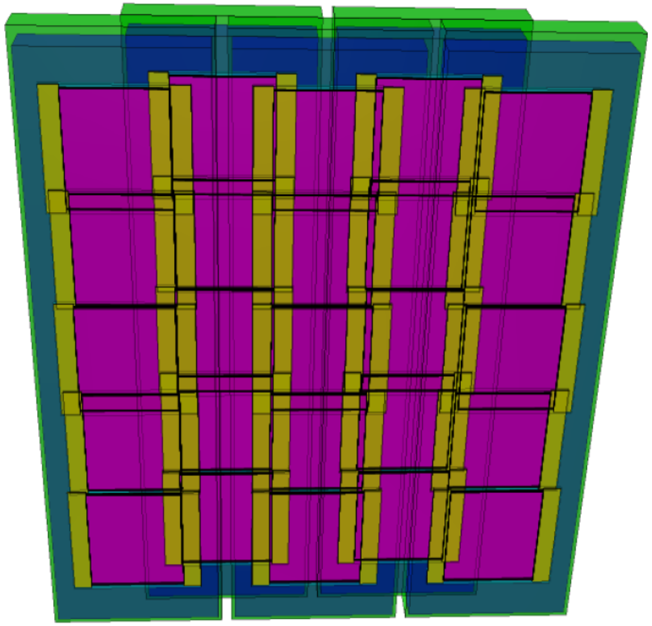
mCBM – subsystems: TRD & TOF

mTRD



SPS 2016

mTOF



mTOF

Contribution by China and Heidelberg

- 5x STAR modules
- 5x MRPC counter / module
- read-out scheme is identical to the STAR setup

mTRD: 4 layers

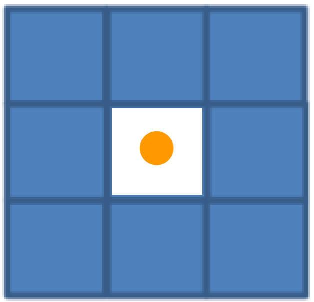
Contribution by Frankfurt/Münster and Bucharest

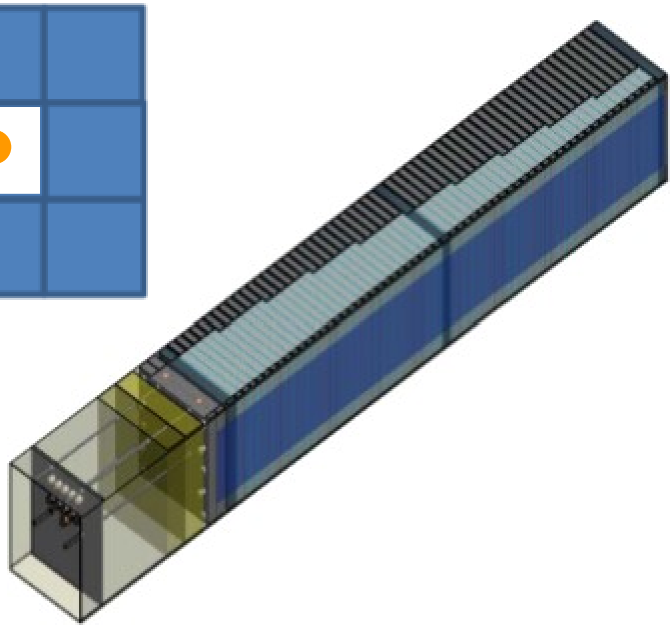
- TRD modules incl. read-out

  from DESY/CERN tests 2017

mCBM – subsystems: PSD & RICH

mPSD



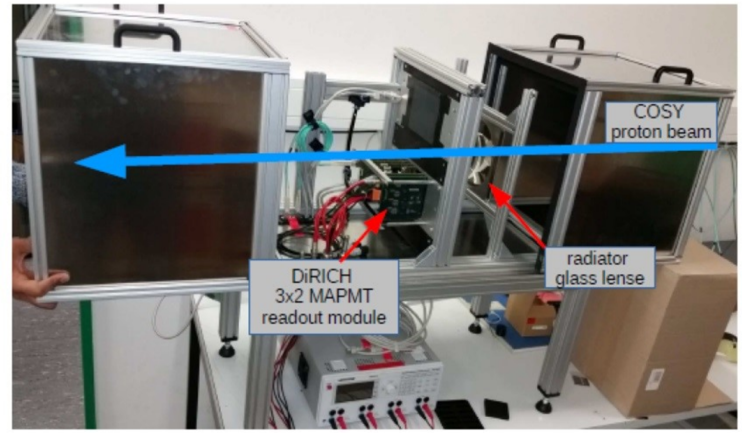


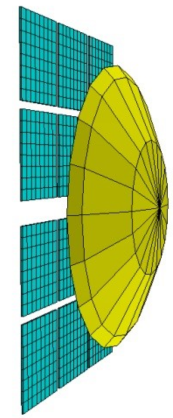
3x3 – 1 configuration

Contribution by Russia

- tests at CERN in 2017/18
- delivery to mCBM
  after beamtest at CERN

mRICH



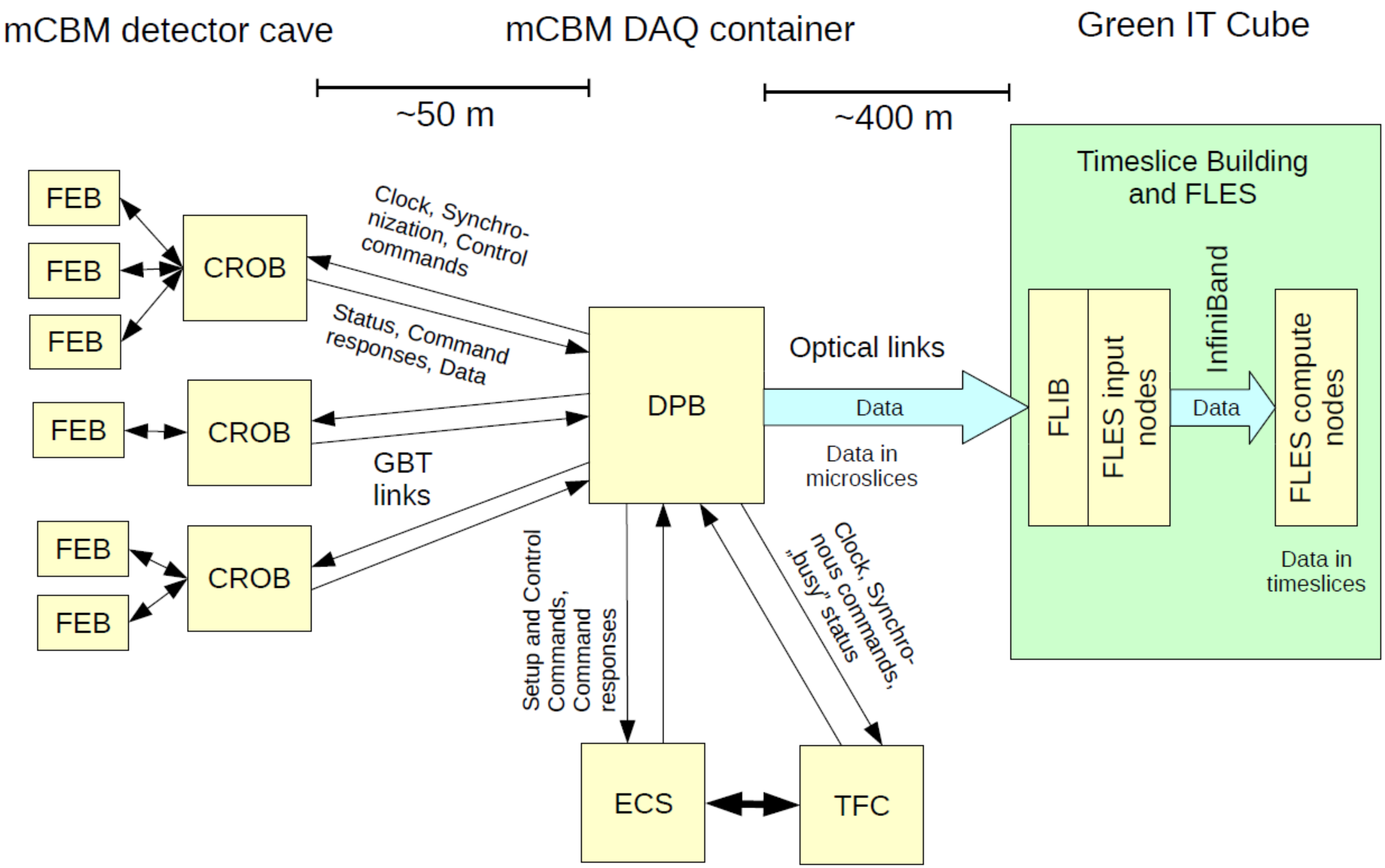


4x RICH solid-state modules

Contribution by Gießen
and Wuppertal

- radiator: glas or quartz
- installation in 2019
- 2x 2x3 MAPMT modules
  (for each solid-state module)

mCBM read-out and data transport
Start version (2018)



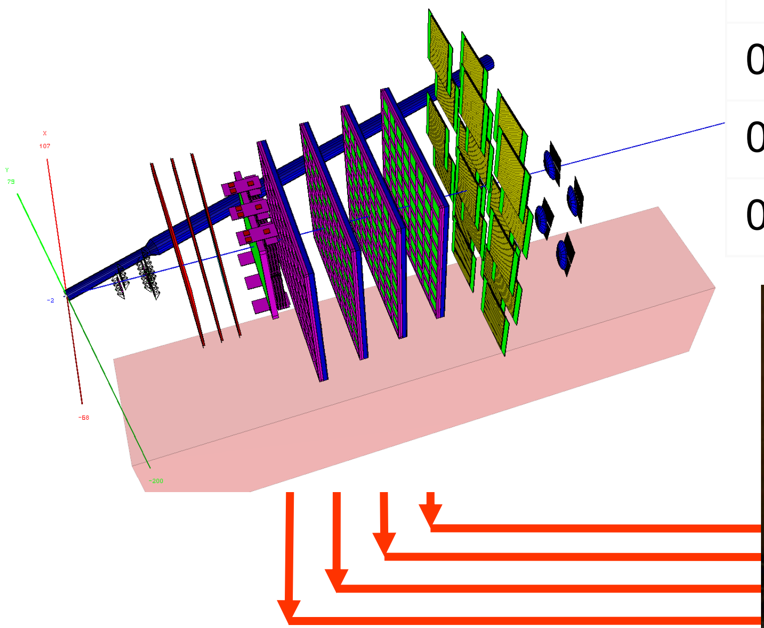
Contribution by:

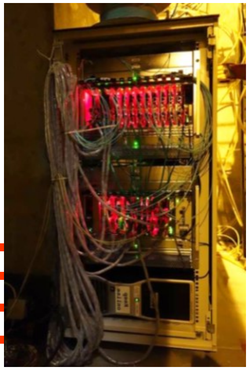
detector groups GSI, WUT, KIT Frankfurt

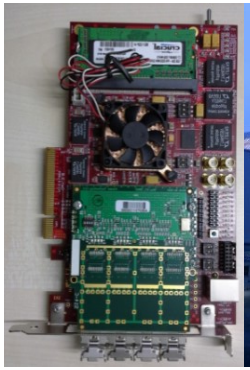
Schedule of mCBM construction

Schedule

10/2017	cave & beam line: reconstruction started, procurement started
11/2017	mDAQ test stand @ Heidelberg operational
12/2017	beam dump mounted
03/2018	cave reconstruction completed
04/2018	mFLES cluster @ Green IT Cube installed
05/2018	beam line installed and commissioned
05/2018	installation of detector stations
06/2018	start commissioning w/o beam
08/2018	start commissioning with beam







Beam time 2018 - 2019

G-PAC: Requested beamtime was fully granted

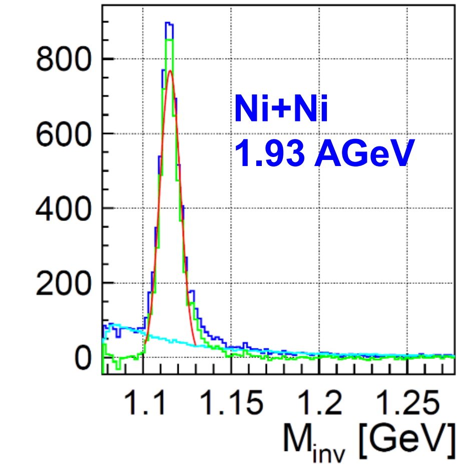
	year	objective	projectile	intensity	extraction	shift type	number of shifts
(1)	2018	developing and commissioning	ions, 1 - 2 AGeV	10^5 - 10^6 s^{-1}	slow, 10 s	para-sitic	30
(2)	2018	high-rate detector tests	ions, 1 - 2 AGeV	10^6 - 10^7 s^{-1}	slow, 10 s	para-sitic	21
(3)	2019	approaching full performance	ions, 1 - 2 AGeV	10^6 - 10^8 s^{-1}	slow, 10 s	para-sitic	30
(4)	2019	running at full performance	Au 1.24 AGeV, Ni 1.93 AGeV	10^7 - 10^8 s^{-1}	slow, 10 s	main	6

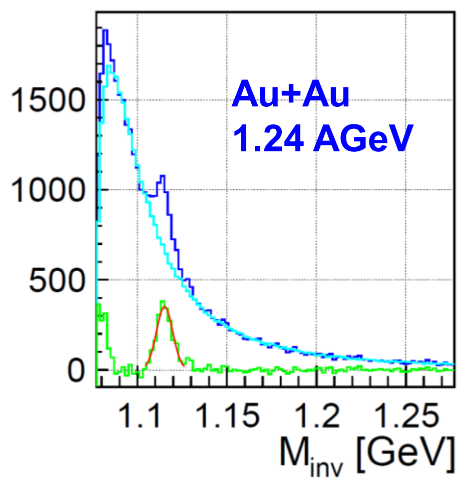
Table 9: Application for SIS18 beam time in the years 2018 and 2019 for mCBM.

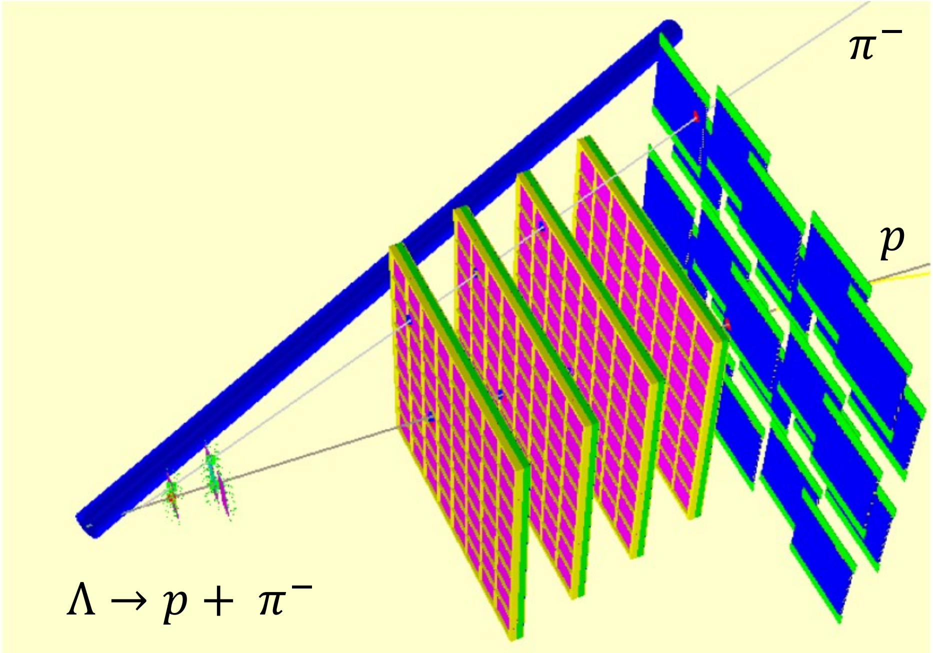
mCBM performance benchmark

(Sub)threshold Λ – baryon reconstruction.

Event based MC simulation of 10^8 events
(measurement time: 10 s)



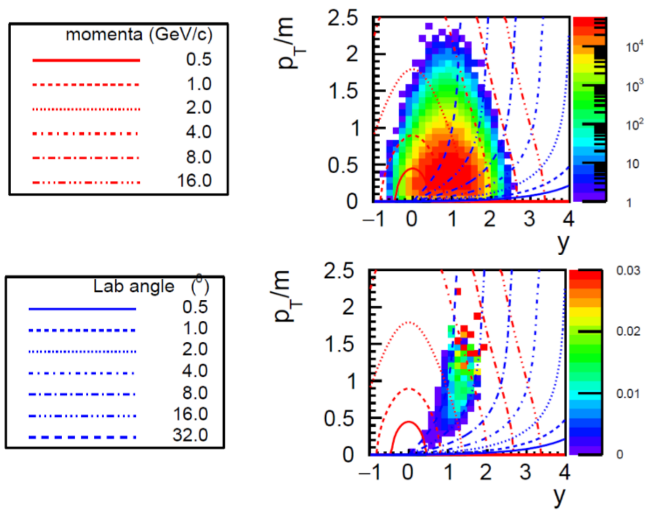




Acceptance

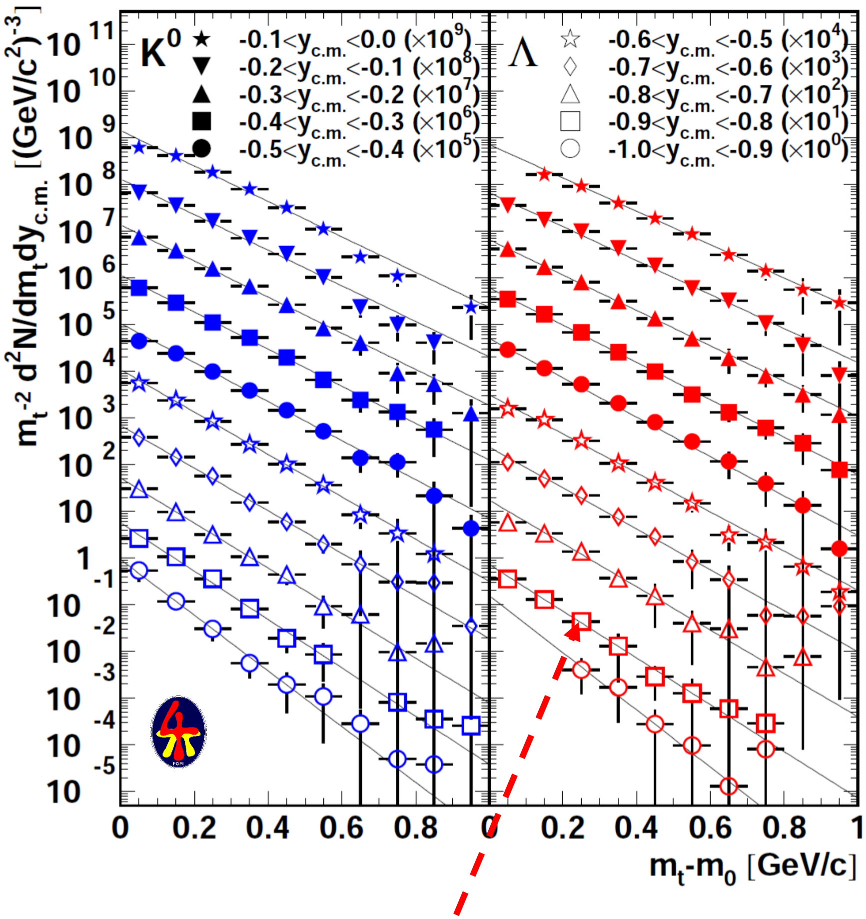
&

Efficiency



Reference data for Λ – production

M. Merschmeyer et al. (FOPI), PRC 76, 024906 (2007)



midrapidity

Reaction:

^{58}Ni + ^{58}Ni at 1.93 AGeV

Centrality:

350 mb (most central)

$\frac{\sigma_{cen}}{\sigma_{geo}} \leq 0.13$

Data taking period:

17.1.2003 – 3.2.2003

Statistics:

~ 60.000 reconstructed Λ

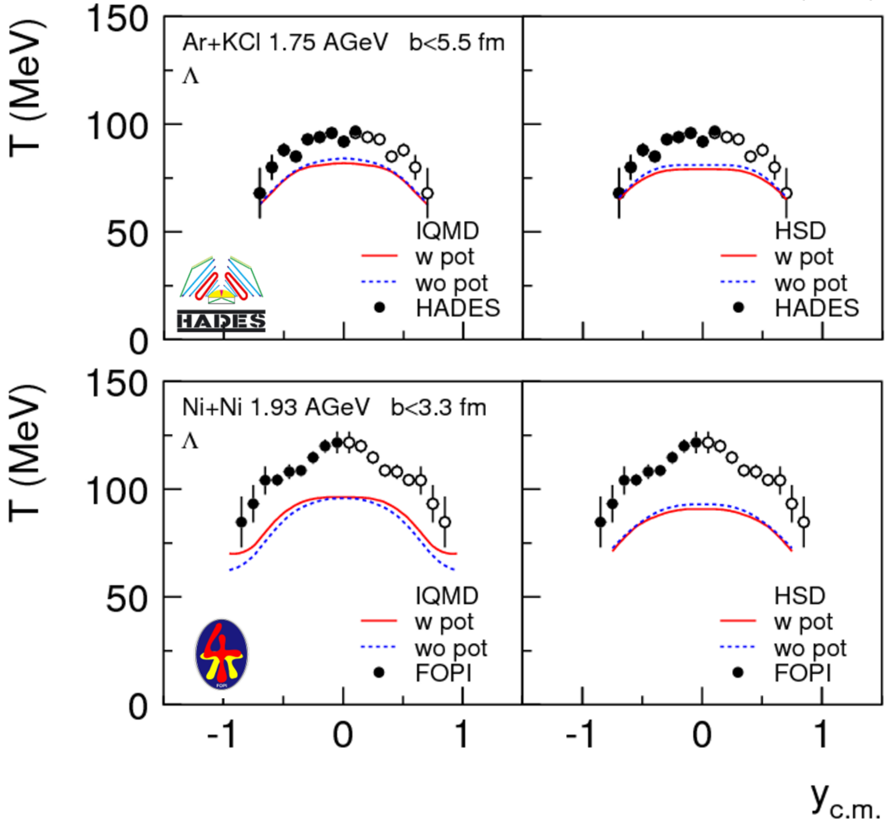
Derived quantities:

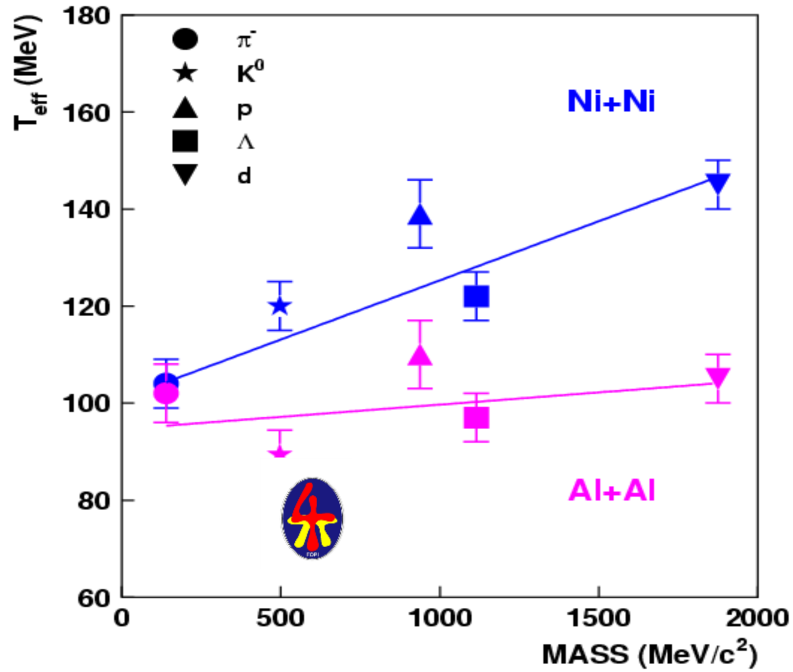
slope parameter

integrated yield

Physics of the benchmark observable

C. Hartnack et al. PR 510 (2012)





Λ - slope parameter:

- smaller than proton
- not explained by transport models
- reason unclear:
  - rescattering cross section
  - repulsive potential

Announcement for beam time request 2020 - 2021

year	objective	projectile	intensity	extraction	shift type	number of shifts
2020	preparation of 1^{st} benchmark run	ions 1 - 2 AGeV, preferably: Au 1.24 AGeV, Ni 1.93 AGeV	10^7 - 10^8 s^{-1}	slow, 10 s	para-sitic	15
2020	1^{st} benchmark run, Λ reconstruction	Au 1.24 AGeV, Ni 1.93 AGeV	10^7 - 10^8 s^{-1}	slow, 10 s	main	15
2021	preparation of 2^{nd} benchmark run	ions 1 - 2 AGeV, preferably: Au 1.24 AGeV, Ni 1.93 AGeV	10^7 - 10^8 s^{-1}	slow, 10 s	para-sitic	15
2021	2^{nd} benchmark run, Λ excitation function	Au, Ni 0.8-1.93 AGeV	10^8 s^{-1}	slow, 10 s	main	15

Table 10: Preview for 2020 and 2021 of planned requirements on SIS18 beam time for mCBM.

CBM – Collaboration: 54 institutions, 460 members

China:
CCNU Wuhan
Tsinghua Univ.
USTC Hefei
CTGU Yichang

Czech Republic:
CAS, Rez
Techn. Univ. Prague

France:
IPHC Strasbourg

Hungary:
KFKI Budapest
Eötvös Univ.

Germany:
Darmstadt TU
FAIR
Frankfurt Univ. IKF
Frankfurt Univ. FIAS
Frankfurt Univ. ICS
GSI Darmstadt
Giessen Univ.
Heidelberg Univ. P.I.
Heidelberg Univ. ZITI
HZ Dresden-Rossendorf
KIT Karlsruhe
Münster Univ.
Tübingen Univ.
Wuppertal Univ.
ZIB Berlin

India:
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
IIT Kharagpur
IIT Indore
Gauhati Univ.

Korea:
Pusan Nat. Univ.

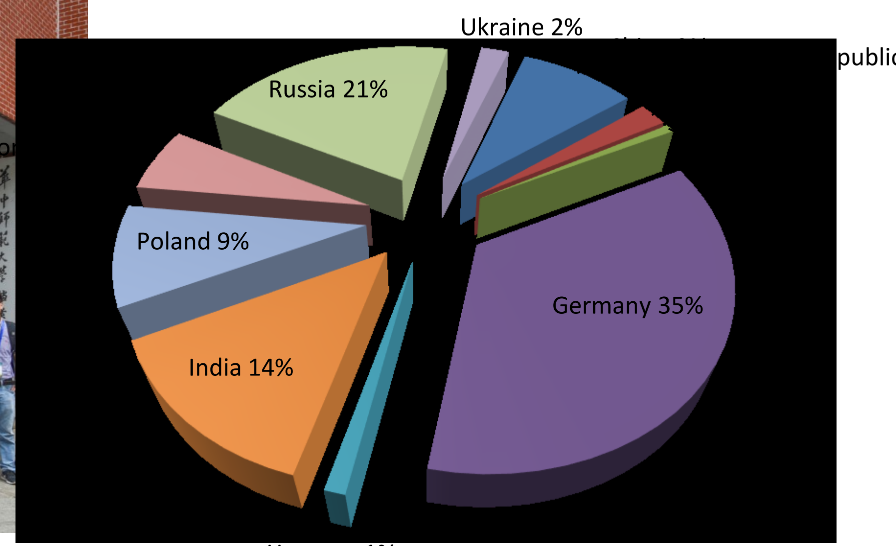
Poland:
AGH Krakow
Jag. Univ. Krakow
Warsaw Univ.
Warsaw TU

Romania:
NIPNE Bucharest
Univ. Bucharest

Russia:
IHEP Protvino
INR Troitzk
ITEP Moscow
Kurchatov Inst., Moscow
VBLHEP, JINR Dubna
LIT, JINR Dubna
MEPHI Moscow
PNPI Gatchina
SINP MSU, Moscow

Ukraine:
T. Shevchenko Univ. Kiev
Kiev Inst. Nucl. Research

CBM Scientists

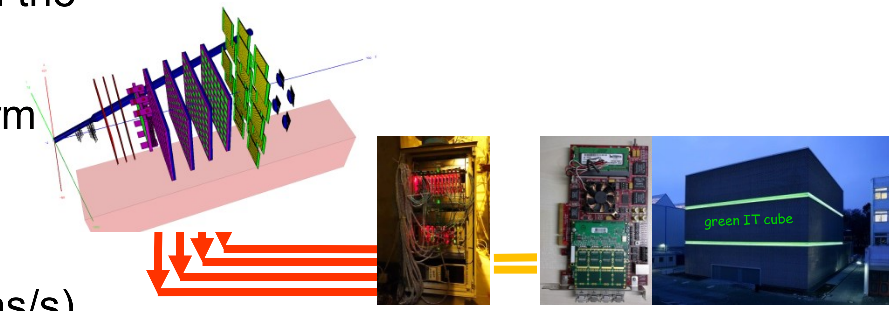


Summary: mCBM in FAIR Phase-0

The **mCBM test-setup** ("mini-CBM") **will focus** on the

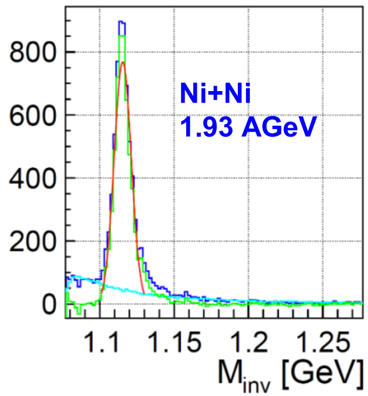
- test of final detector prototypes
- free streaming data transport to a computer farm
- online reconstruction and event selection
- offline data analysis

under full load conditions (Au + Au, 10^7 interactions/s)



mCBM performance benchmark

Λ – baryon reconstruction



Major construction milestones:

12/2017 beam dump mounted

03/2018 cave reconstruction completed

04/2018 mFLES cluster in Green IT Cube operational

06/2018 start commissioning w/o beam

08/2018 start commissioning with beam