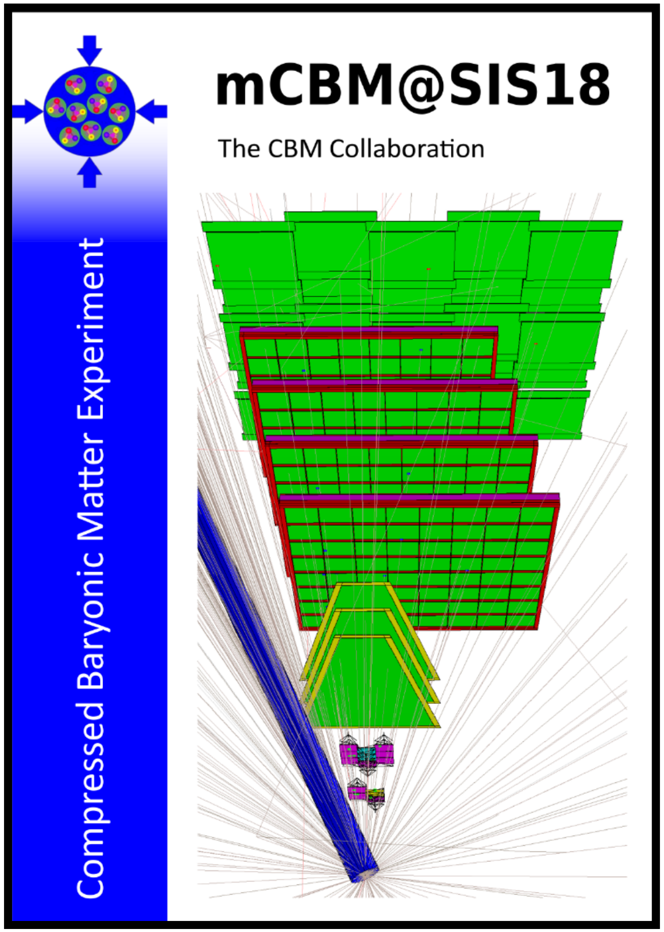
Proposal S471: mCBM@SIS18

A CBM full system test-setup
for high-rate nucleus-nucleus collisions at GSI / FAIR

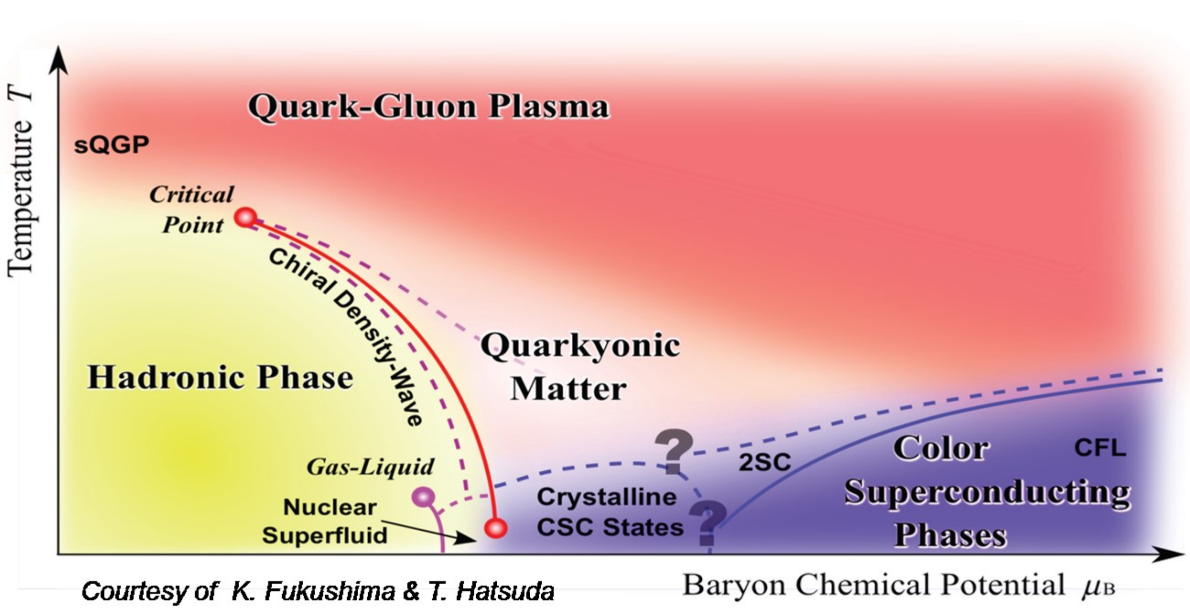


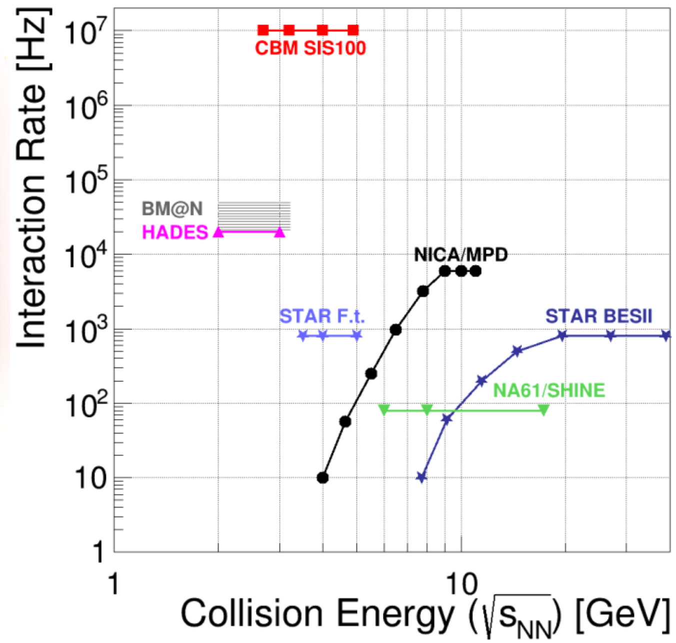
Outline

- Motivation
- Setup
  - Detectors
  - Cave
- Goals
  - Detector prototype performance
  - DAQ development
  - Physics reconstruction performance
- Beamtime request

download of the full version:
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 – 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.

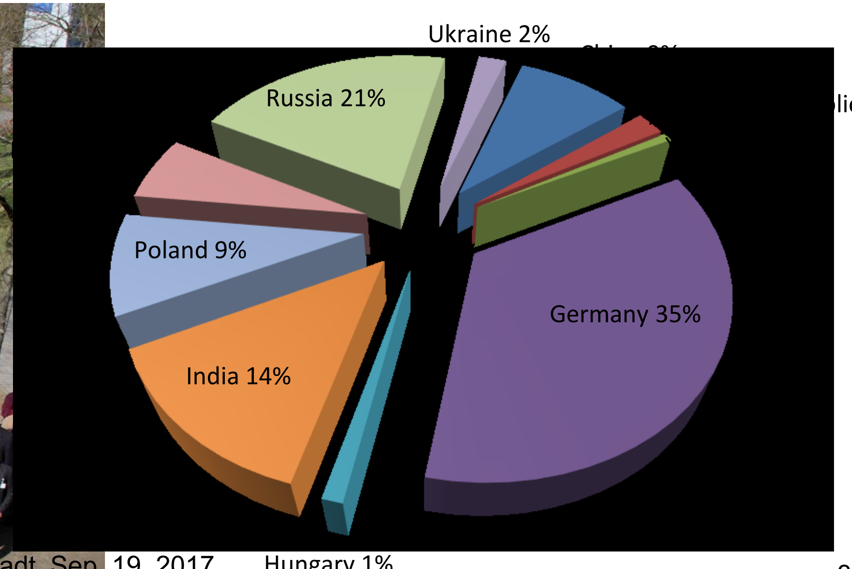
Poland:
AGH Krakow
Jag. Univ. Krakow
Warsaw Univ.
Warsaw TU

Romania:
NIPNE Bucharest
Univ. Bucharest

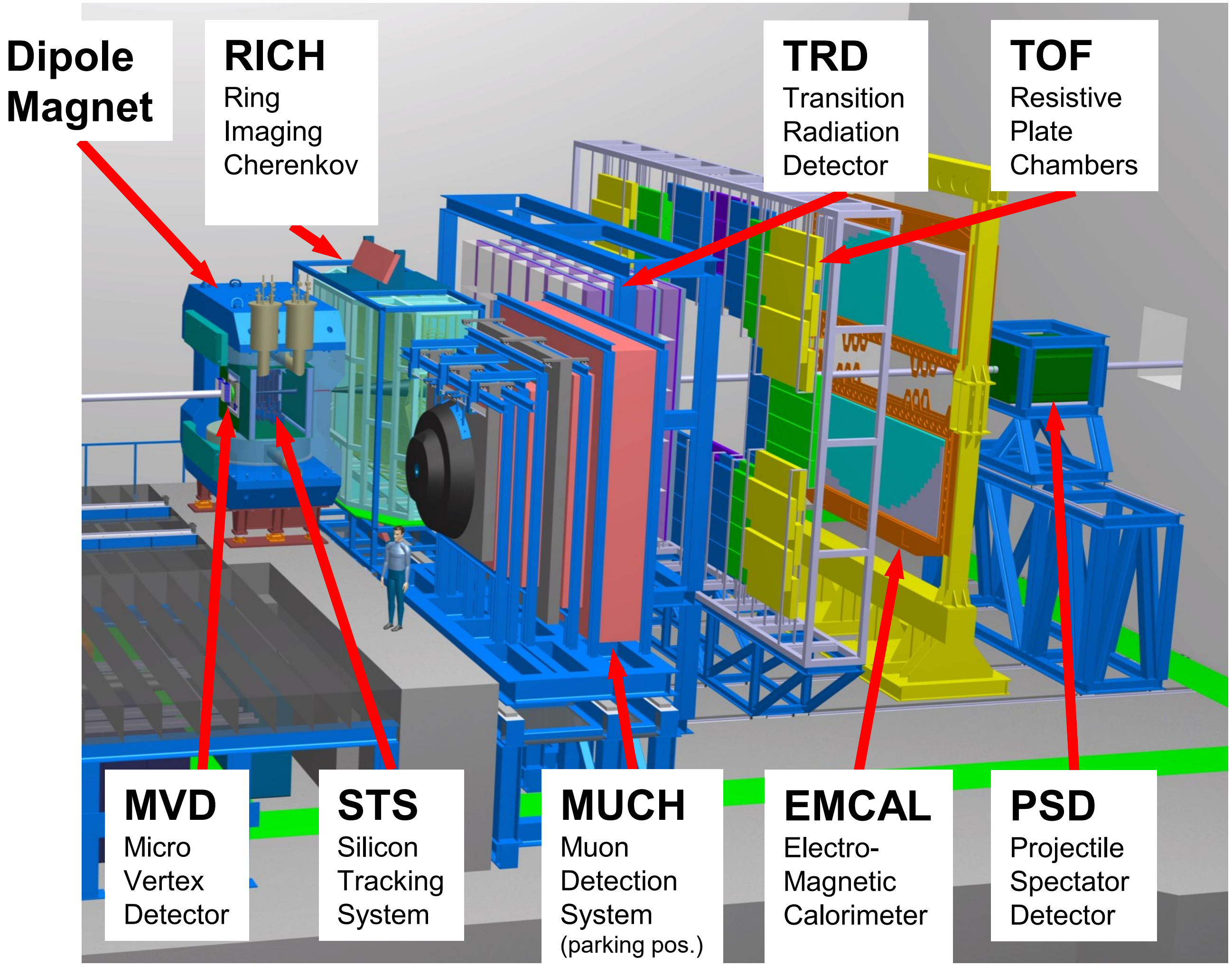
Russia:
IHEP Protvino
INR Troitzk
ITEP Moscow
Kurchatov Inst., Moscow
VBLHEP, JINR Dubna
LIT, JINR Dubna
MEPHI Moscow
PNPI Gatchina
SINP MSU, Moscow

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

CBM Scientists



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

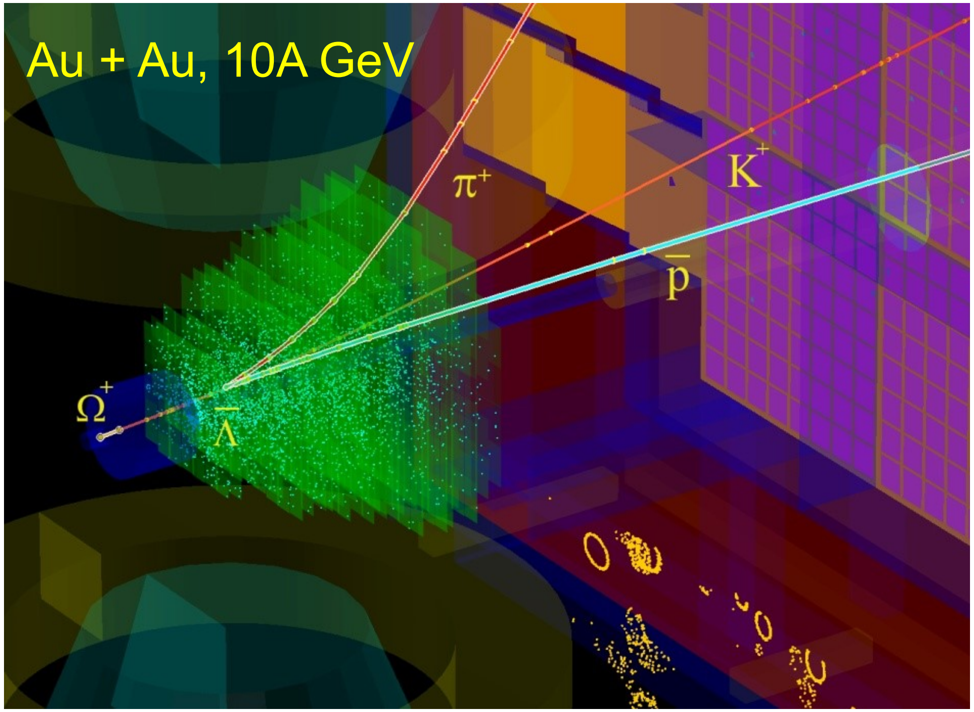
10^5 - 10^7 Au+Au reactions/sec

→ fast and radiation hard detectors

→ free-streaming read-out electronics

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

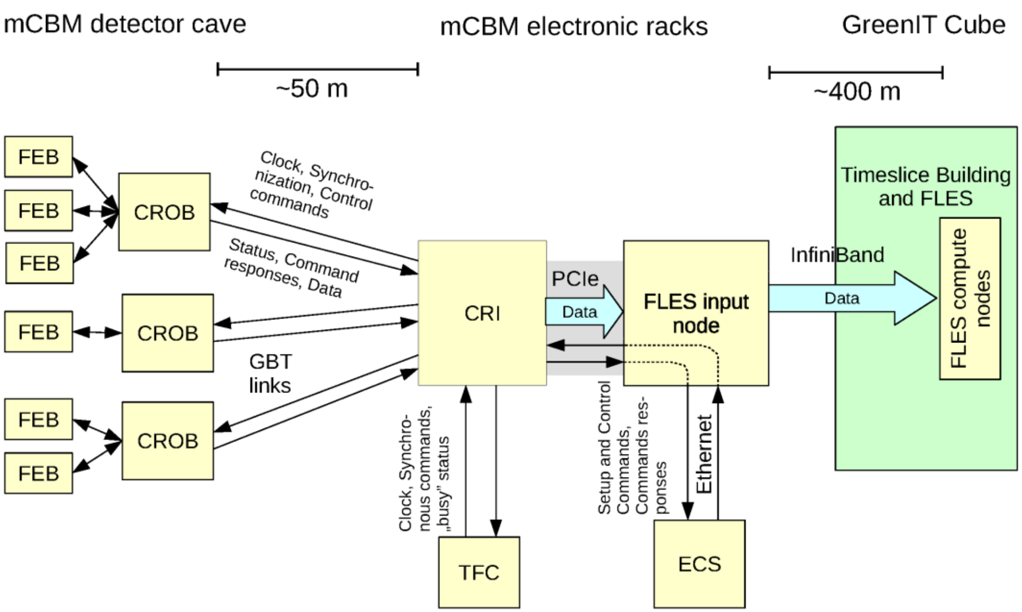
→ 4-D event reconstruction



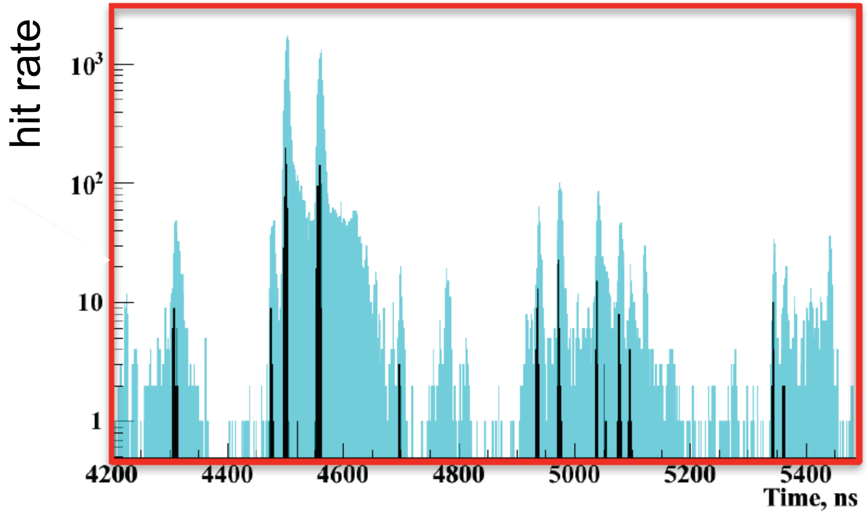
Identification
of leptons and hadrons

Determination of
(displaced) vertices ($\sigma \approx 50\ \mu m$)

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

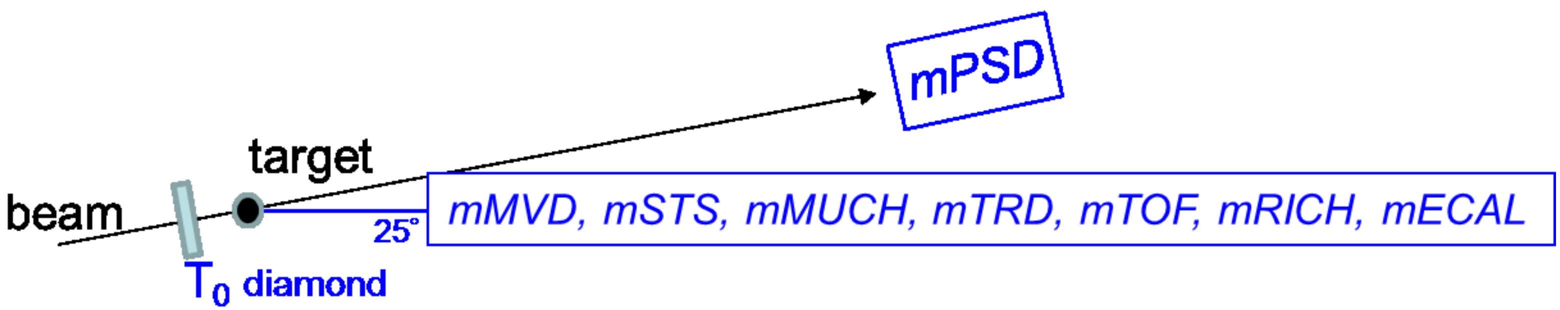
mCBM@SIS18 - Goals

Topics to be addressed

- free streaming data transport to the mFLES
- online reconstruction
- offline data analysis
- controls
- detector tests of final detector prototypes

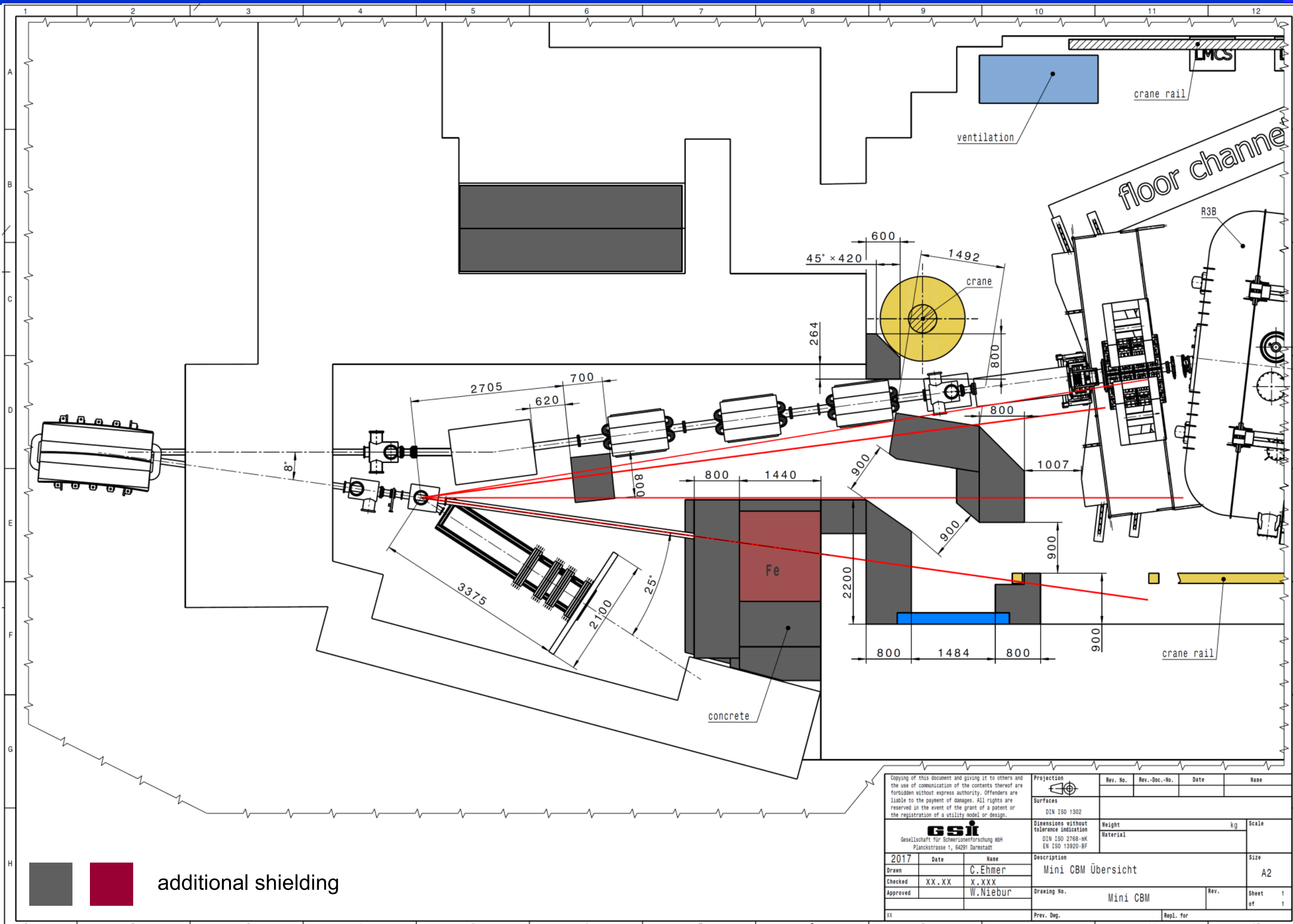
Needs:

permanent test-setup at the host lab



- ➢ straight tracks, no B-field
- ➢ high resolution TOF (t_0 – TOF stop wall)
- ➢ event characterization with PSD prototype

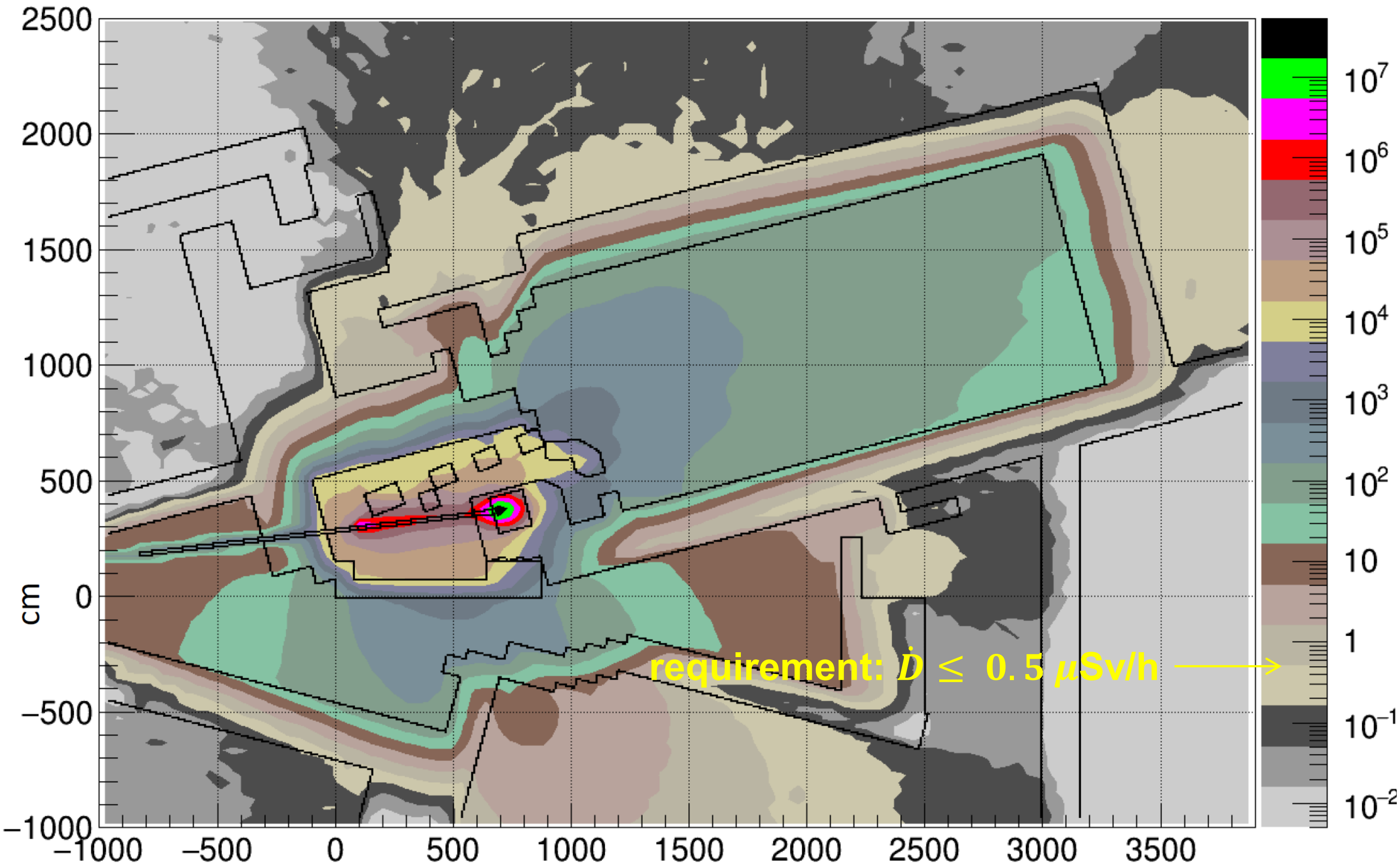
Design of the mCBM Cave - HTD



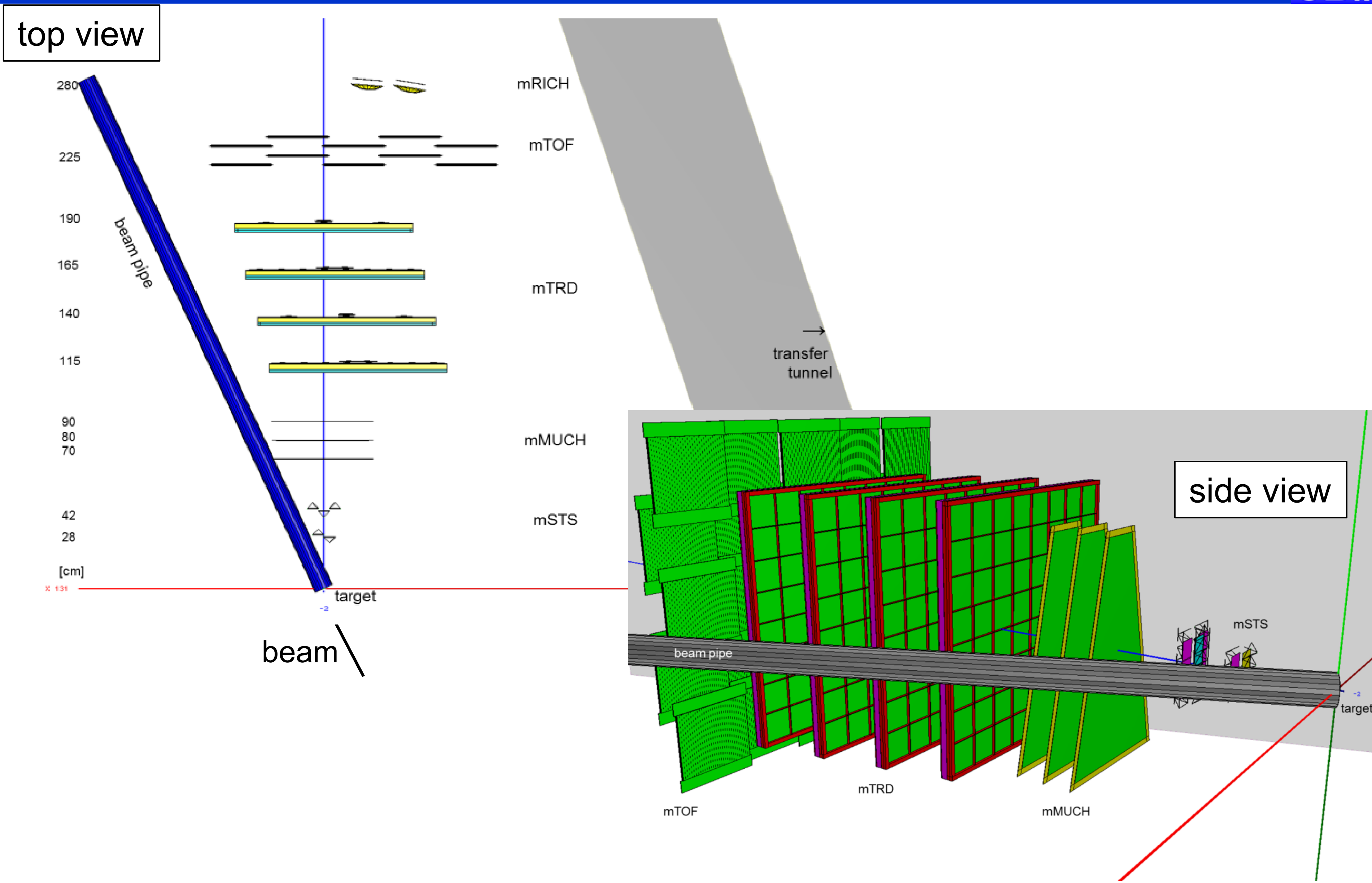
additional shielding

Monte Carlo shielding calculations (FLUKA)

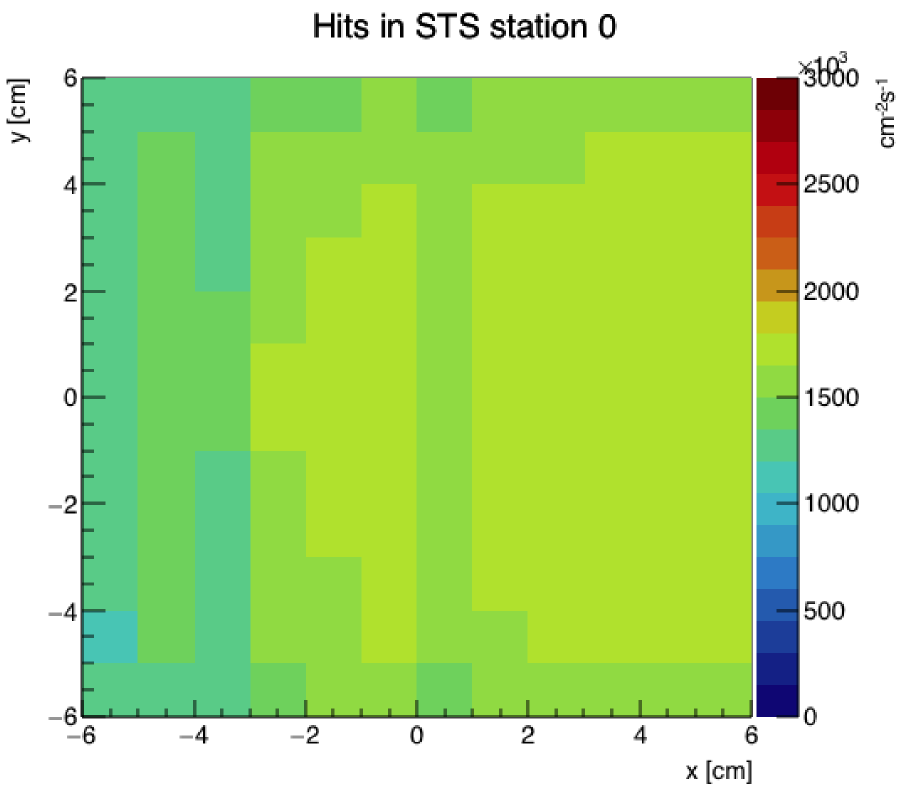
10^8 Au ions s^{-1}, 1.24 AGeV, on 2.5 mm Au target (P_{int} = 10%)
vertical section: **beam level**



Design of mCBM test-setup



Hit rates

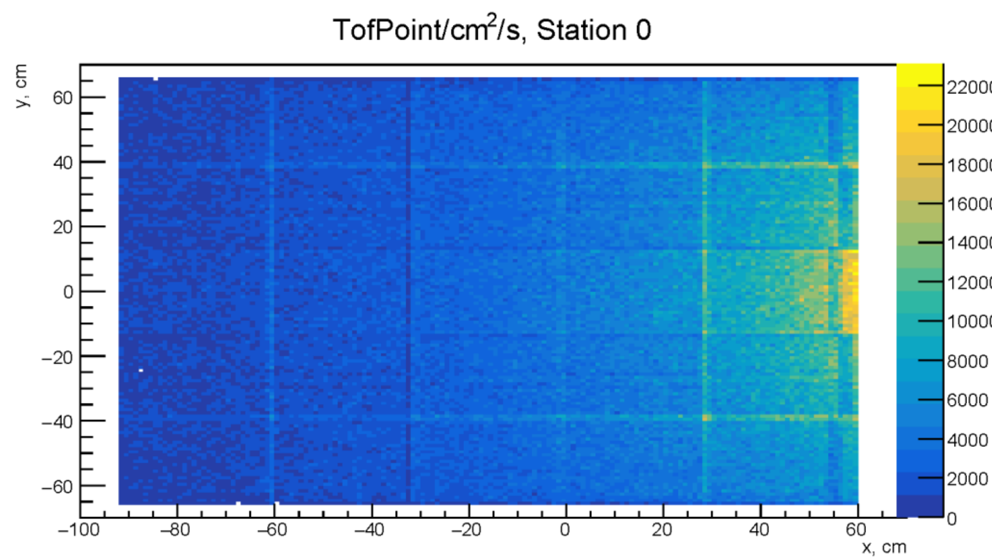


mSTS, 1st station

max. (design) rate: 1.5 MHz/cm²

mTOF

max. (design) rate: 20 kHz/cm²

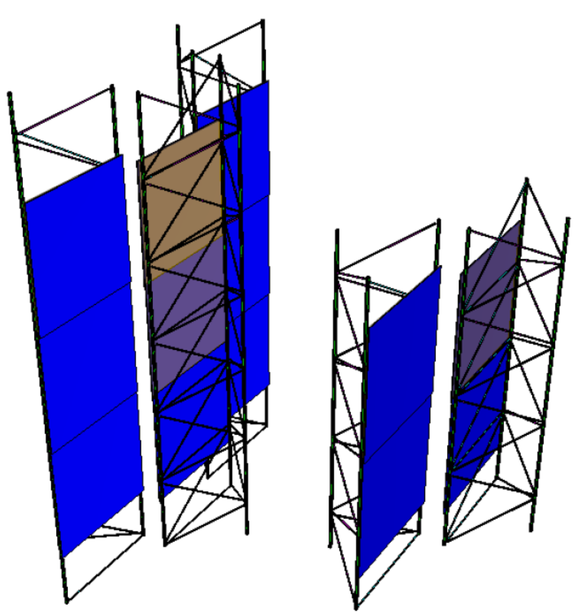


Input:

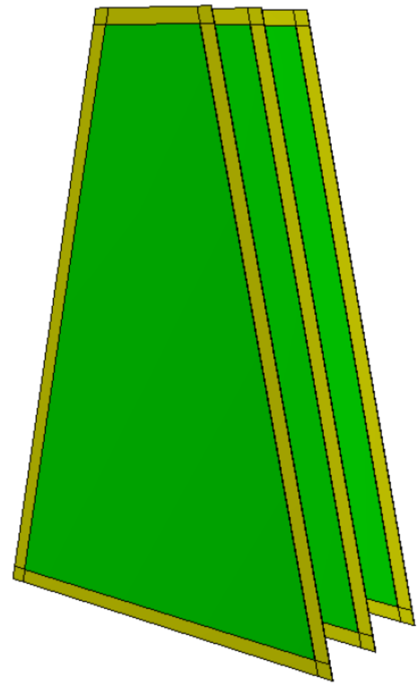
UrQMD, Au+Au 1.24 AGeV, mbias, incl. δ-electrons

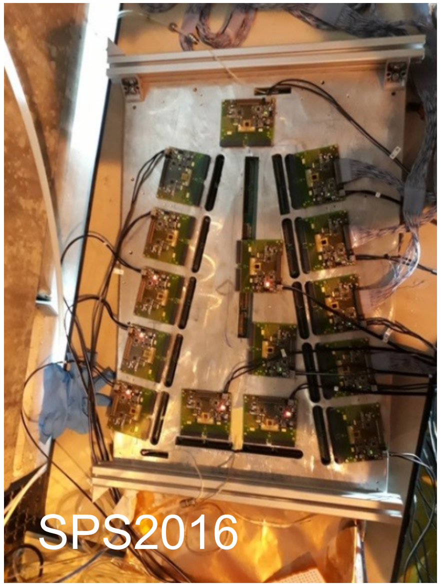
mCBM – subsystems: STS, MUCH

mSTS



mMUCH





mSTS: 2x stations

Contribution by GSI

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

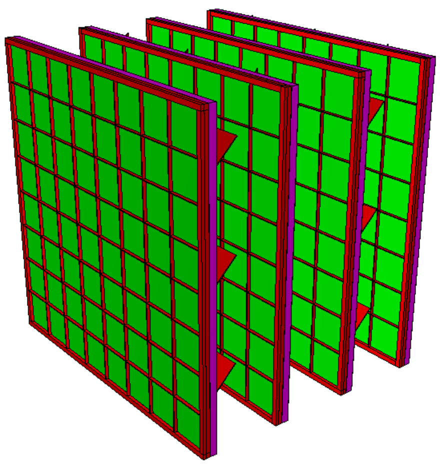
mMUCH: 3x layers

Contribution by India

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

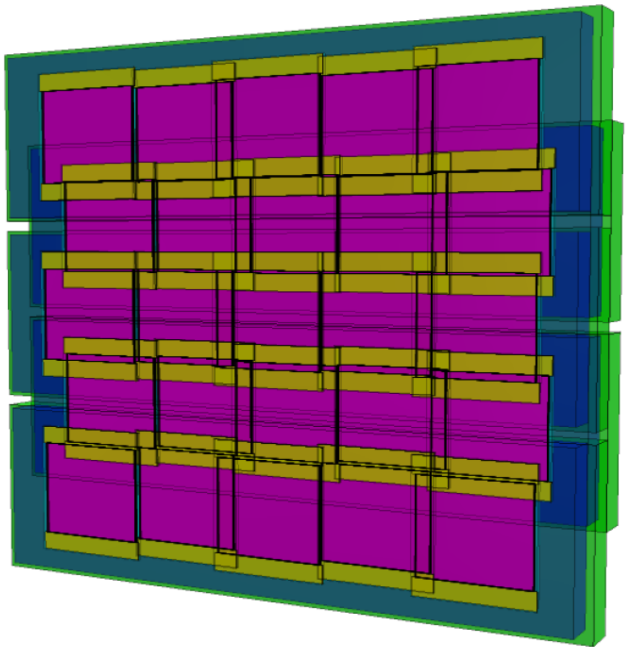
mCBM – subsystems: TRD & TOF

mTRD



SPS 2016

mTOF



mTRD: 4 layers

Contribution by Frankfurt/Münster and Bucharest

- TRD modules incl. read-out

  from DESY/CERN tests 2017

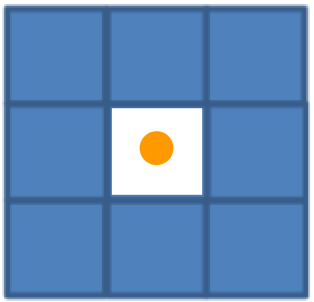
mTOF

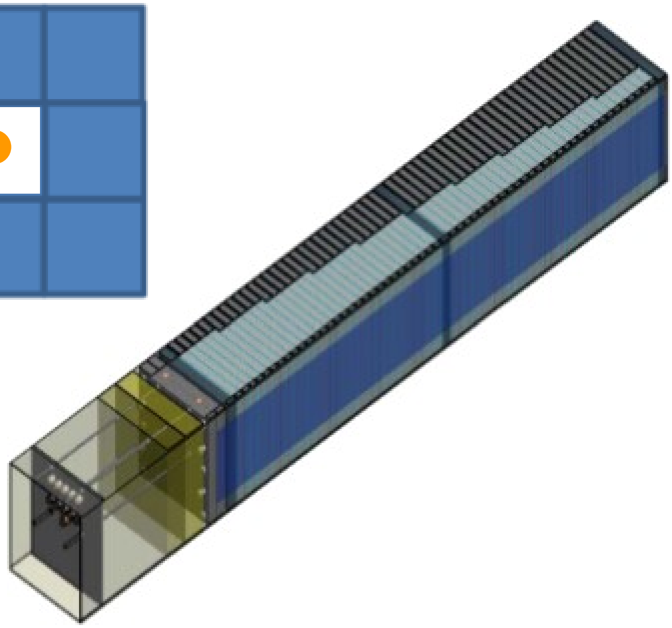
Contribution by China and Heidelberg

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

mCBM – subsystems: PSD & RICH

mPSD

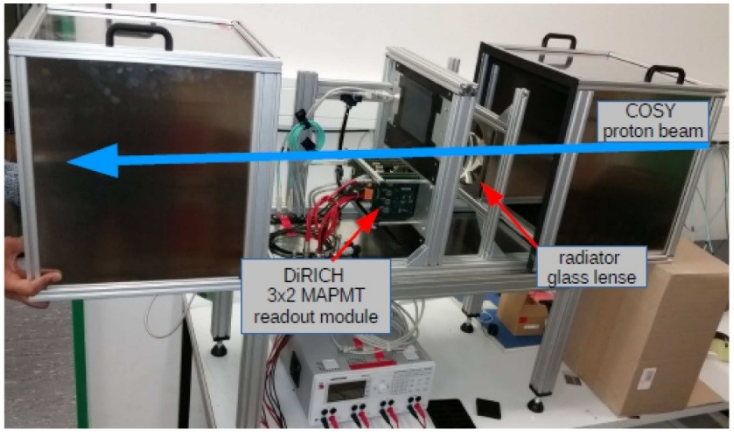


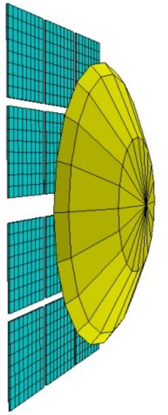


3x3 – 1 configuration
Contribution by Russia

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

mRICH

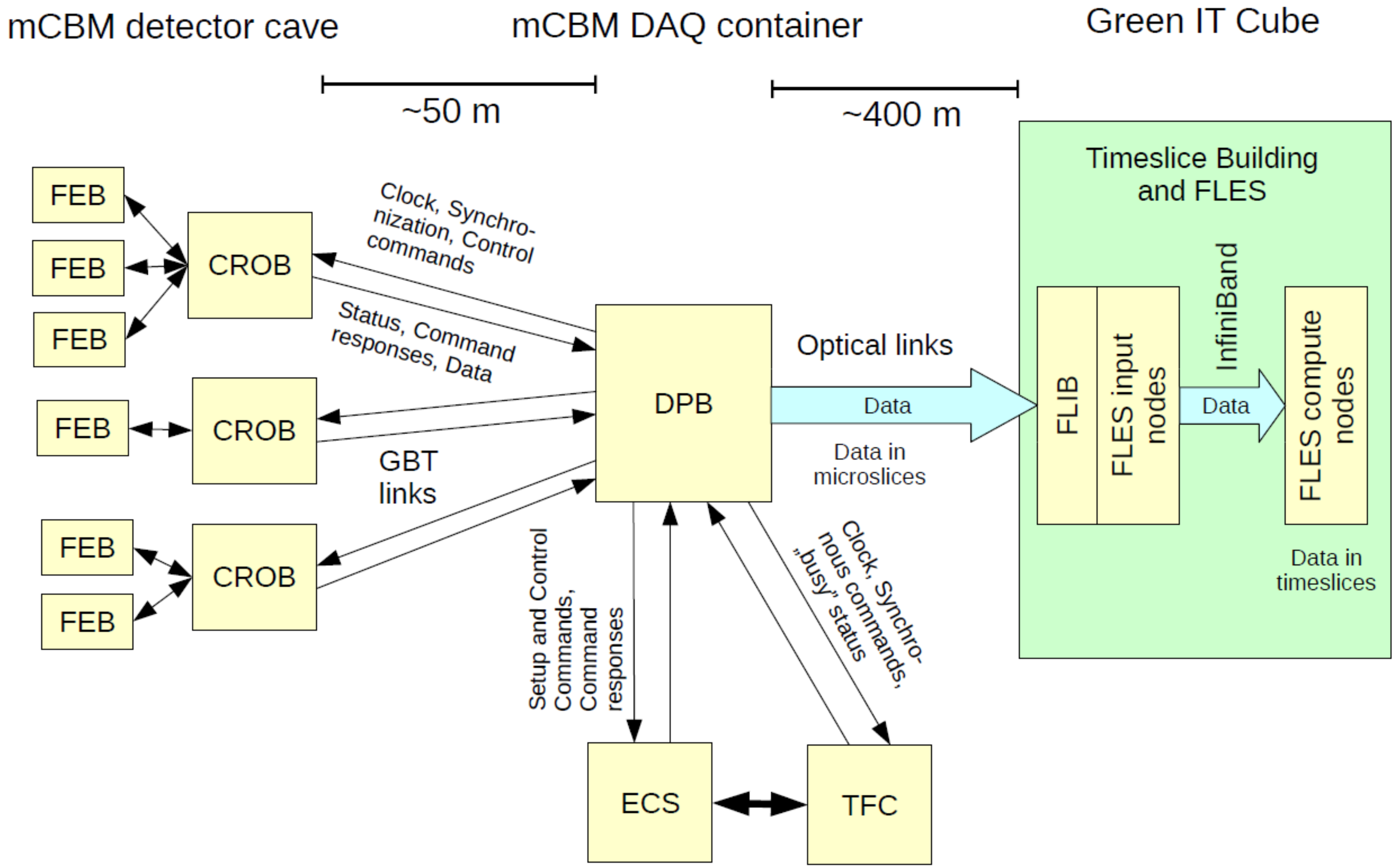




4x RICH solid-state modules
Contribution by Gießen
and Wuppertal

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

mCBM read-out and data transport
Start version



Contribution by:

detector groups

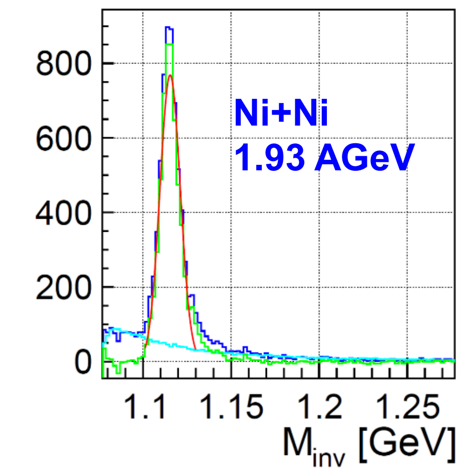
GSI, WUT, KIT

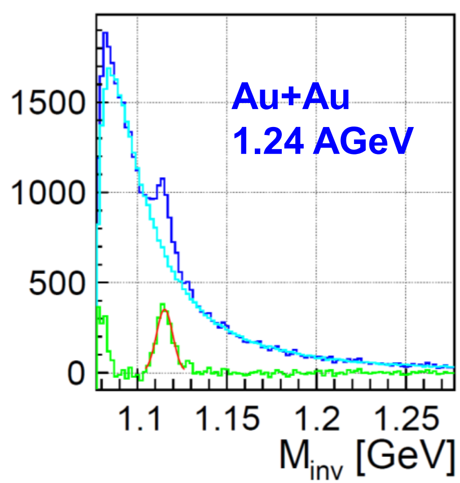
Frankfurt

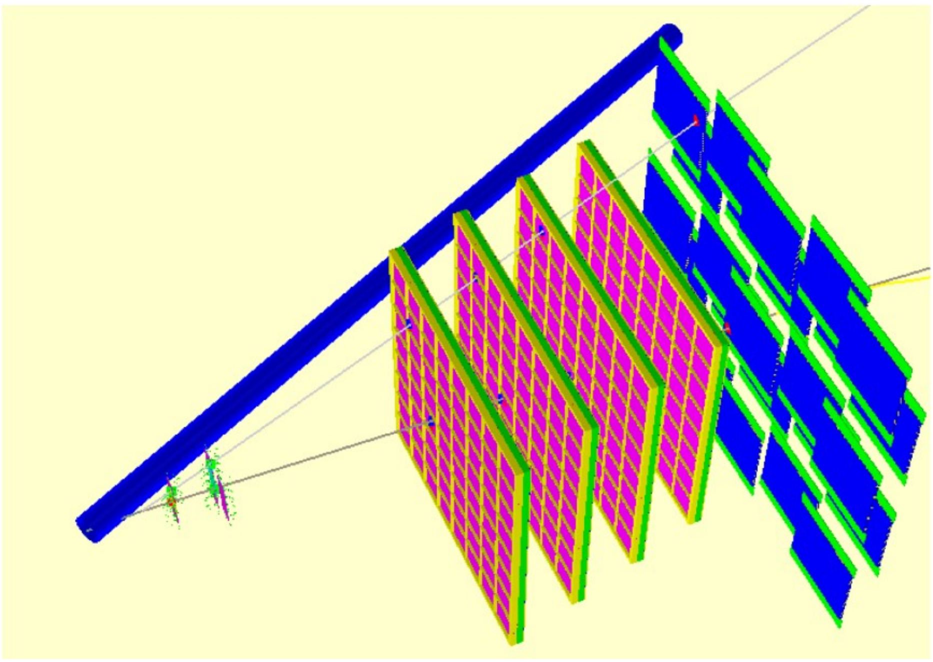
mCBM performance benchmark

(Sub)threshold Λ – baryon reconstruction.

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



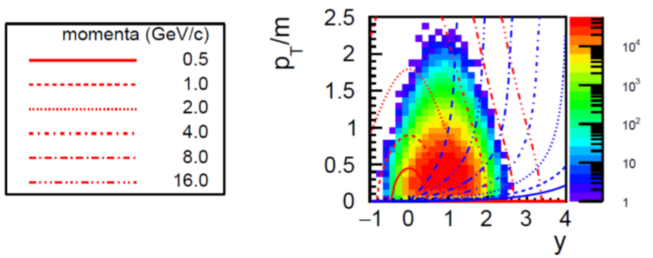


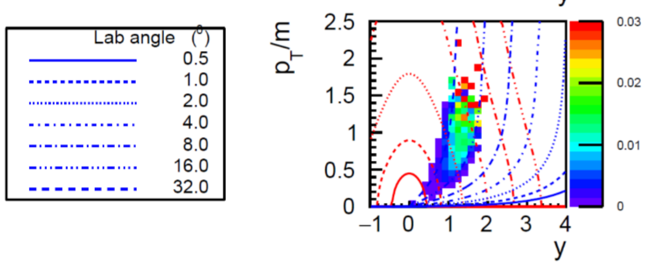


Acceptance

&

Efficiency





Beam time request 2018 - 2019

	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

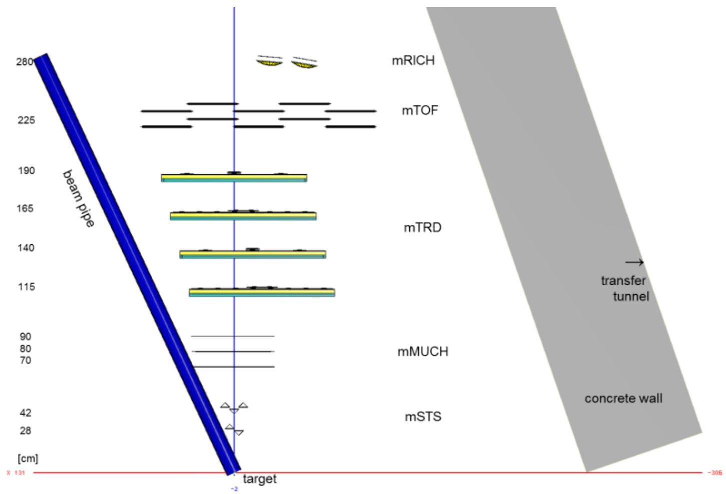
Table 9: Application for SIS18 beam time in the years 2018 and 2019 for mCBM.

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.

Summary mCBM@SIS18



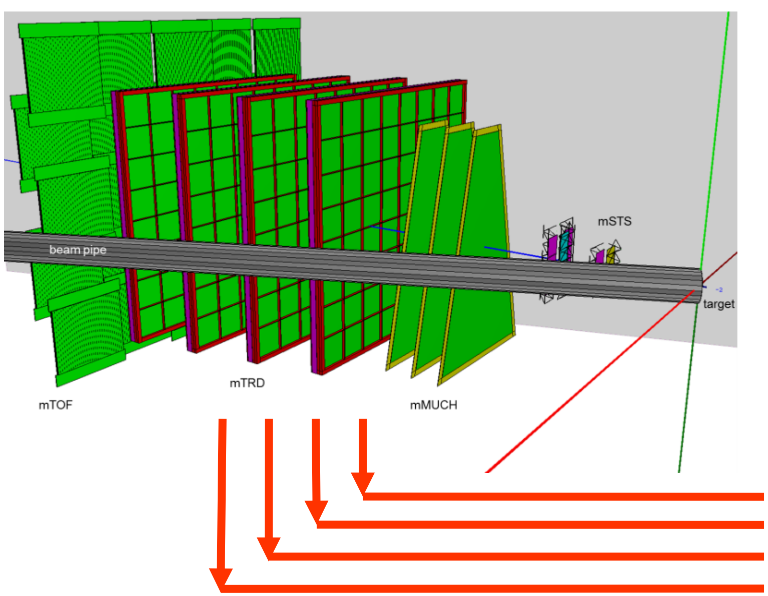
The mCBM test-setup ("mini-CBM") will focus on the

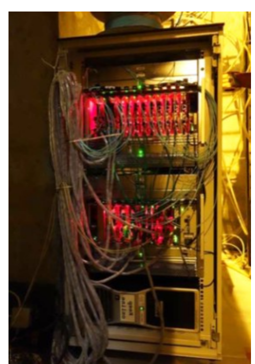
- test of final detector prototypes
- free streaming data transport to a computer farm
- online reconstruction and event selection
- offline data analysis

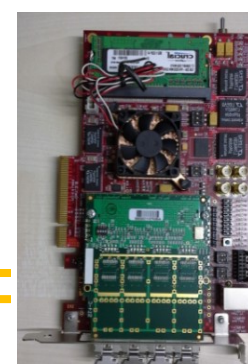
under full load conditions (Au + Au, 10^7 interactions/s)

Milestones:

10/2017 vacuum chamber for switching magnet ordered
10/2017 cave and beam line preparation started
03/2018 mFLES cluster in Green IT Cube operational
05/2018 ready for installation of detector subsystems
06/2018 start commissioning w/o beam
09/2018 start commissioning with beam



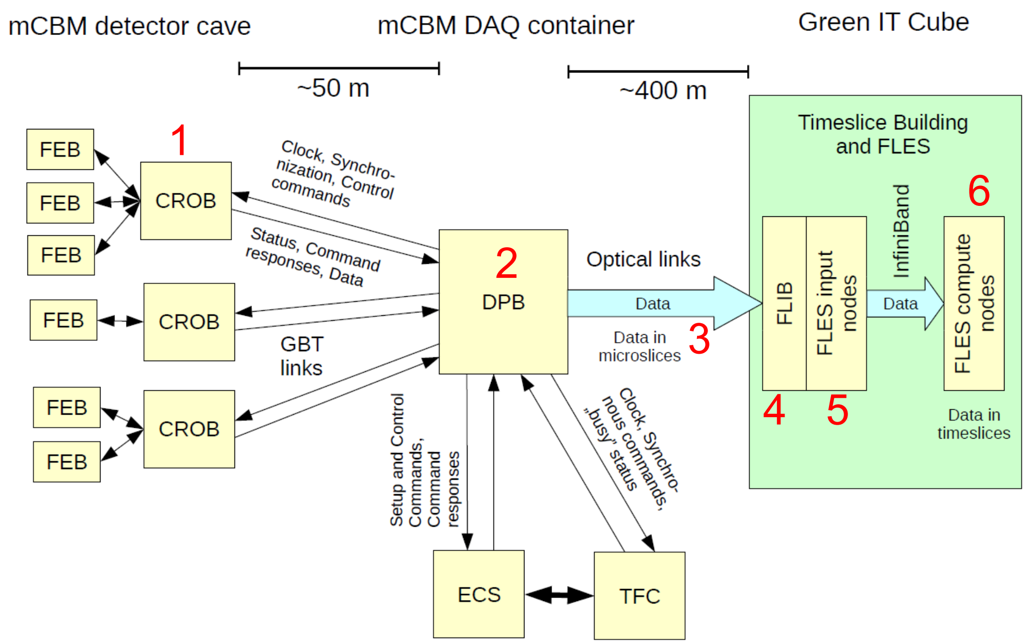




additional material

mDAQ and mFLES 2018 (start version)

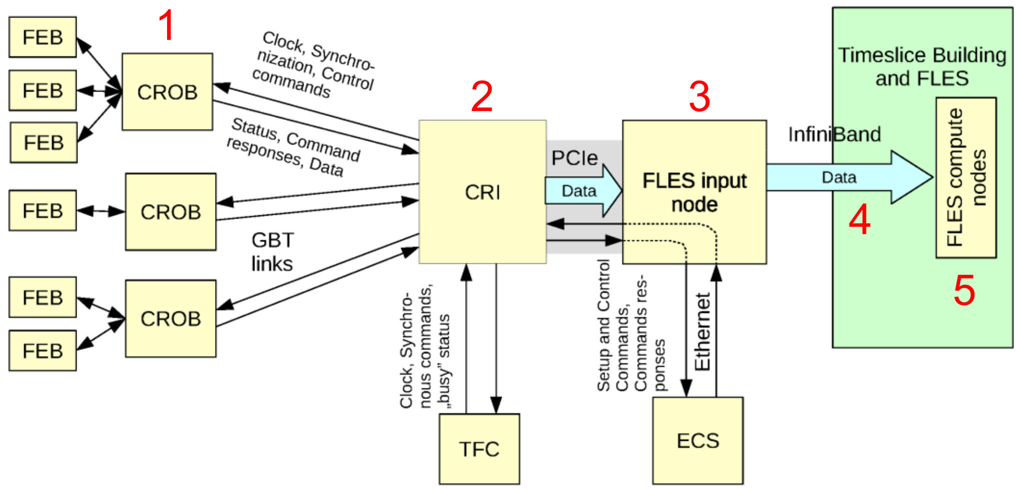
present design



		Device	Function	Location
1	70x	GBTx	data concentrator	Cave, on detector
2	12x	AFCK	1st layer FPGA board	DAQ container
3	96x	Optical fibers	Data transport	DAQ → Green IT Cube
4	4x	FLIB	2nd layer FPGA board	Green IT Cube
5	2x	mFLES input node	Input stage	Green IT Cube
6	42x	mFLES compute nodes	Processing stage	Green IT Cube

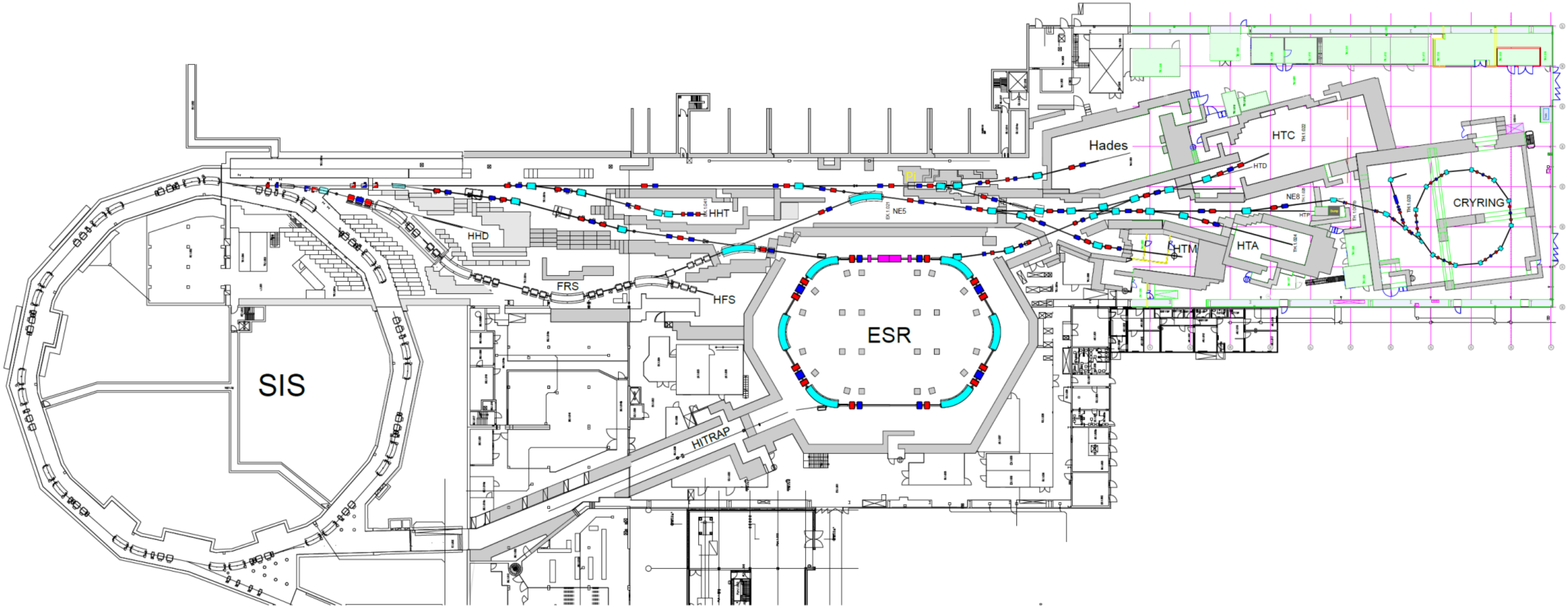
mDAQ and mFLES 2019 (SIS100 version)

present design

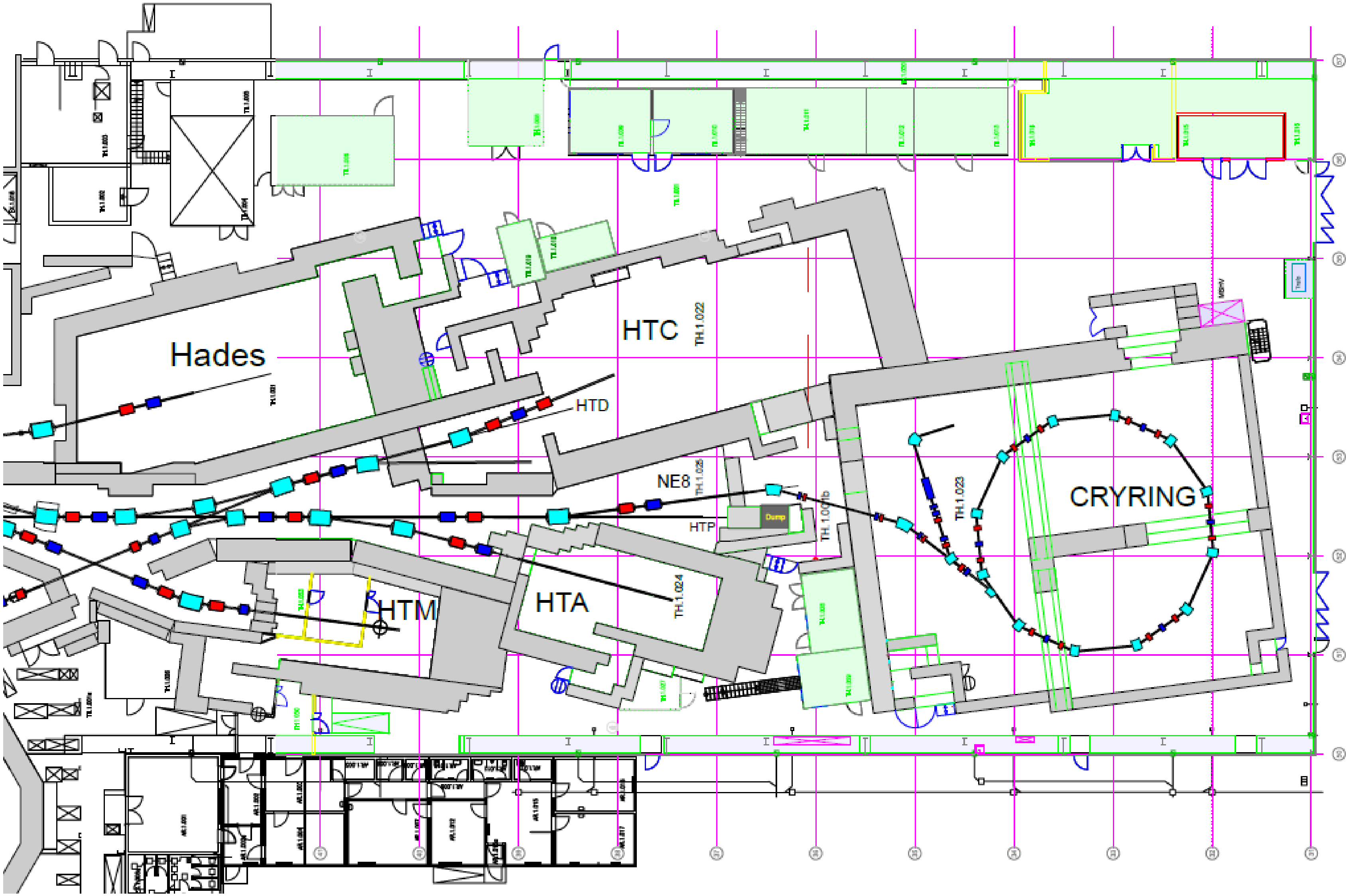


		Device	Function	Location
1	70x	GBTx	data concentrator	Cave, on detector
2	6x	CRI	FPGA board (1x layer only)	DAQ container
3	2x	mFLES input node	Input stage	DAQ container
4	96x	Optical fibers	Data transport	DAQ → Green IT Cube
5	42x	mFLES compute nodes	Processing stage	Green IT Cube

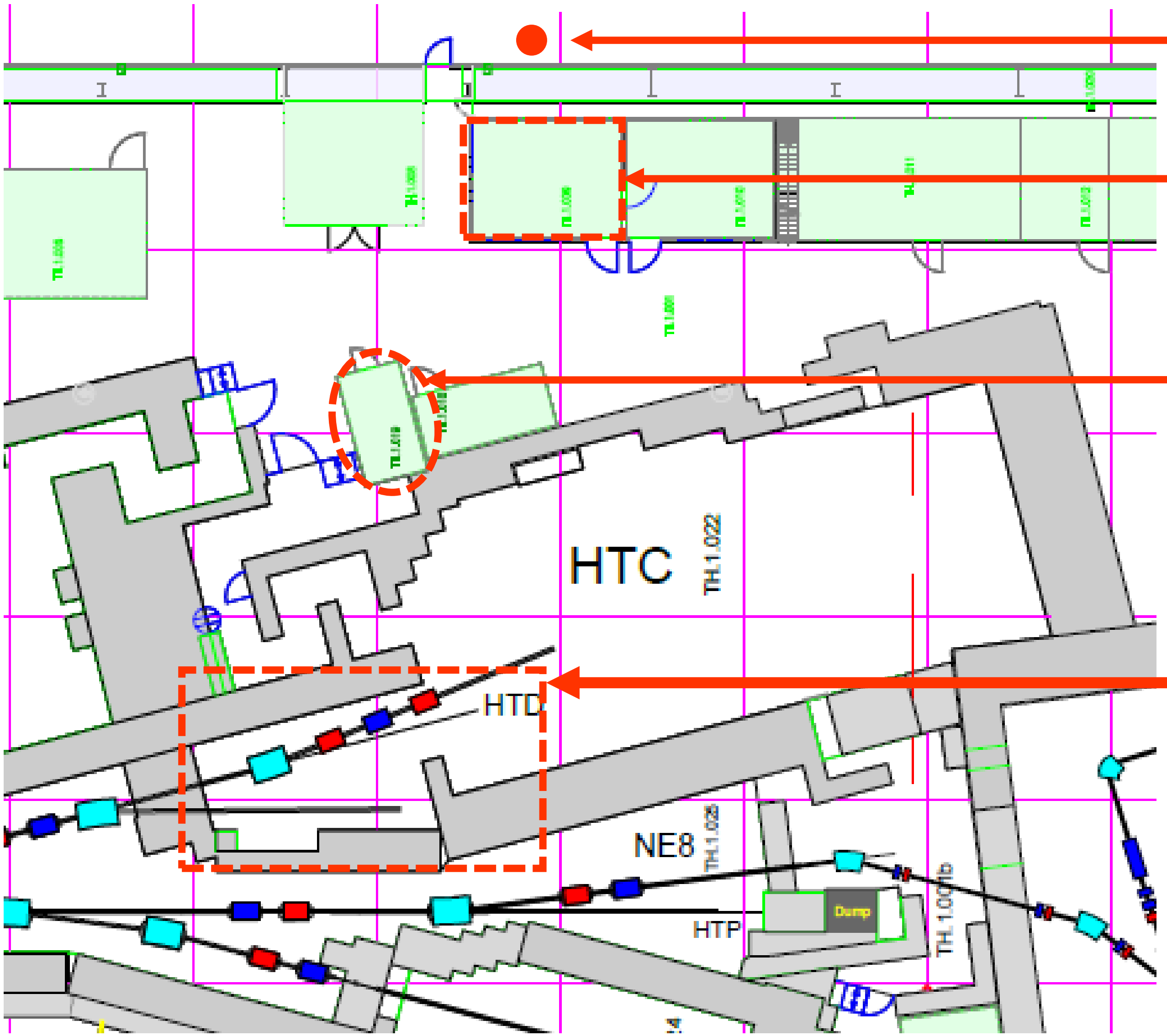
Present SIS18 facility



Experimental hall at SIS18



mCBM – support infrastructure



gas area

counting house

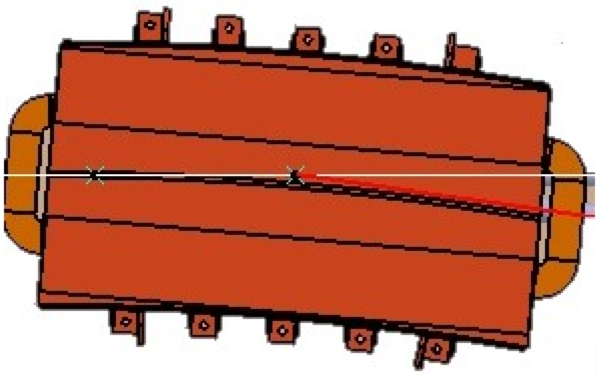
DAQ container

mCBM cave

Green IT Cube

Enhancing the rigidity of the existing switching magnet

Switching magnet HTD-MU1

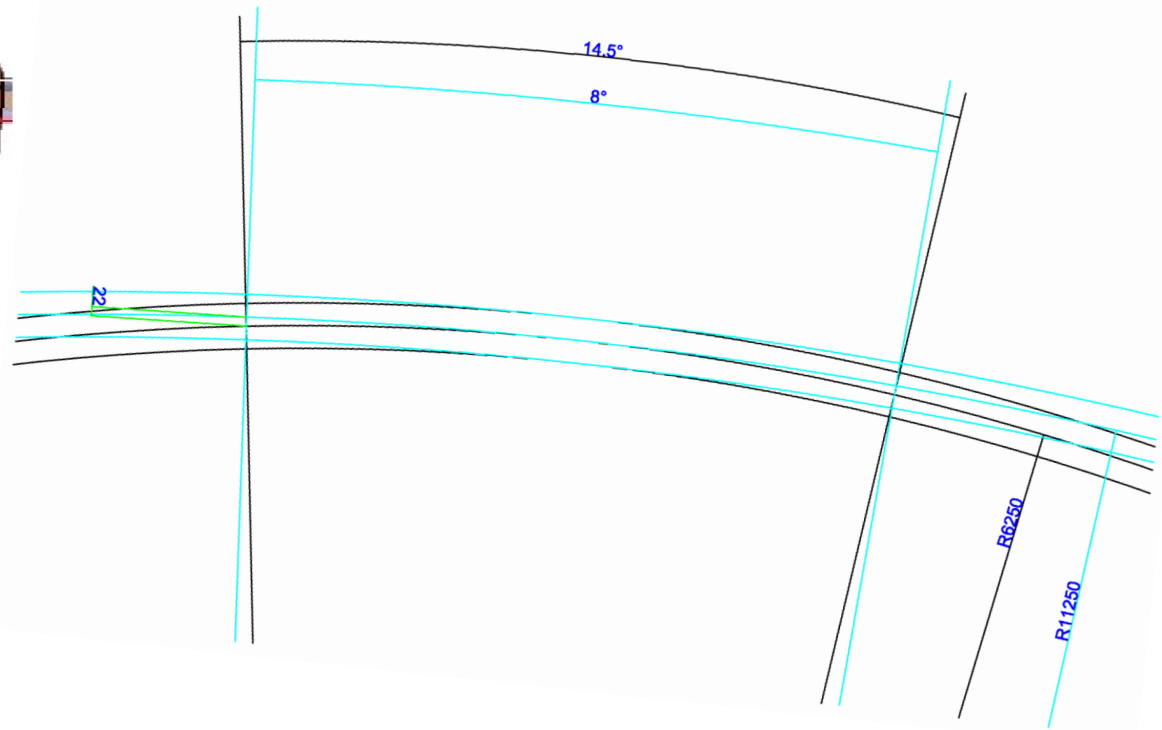


	T_{lab} [GeV] or [AGeV]	
Rigidity (beamline)	10 Tm	18.66 Tm
p	2.21	4.74
Ca	0.83	2.02
Ni	0.79	1,93
Ag (46⁺)	0.65	1.65
Au (69⁺)	0.45	1.24

Present beamline to HTD:

$\rho = 6.25\text{m} \rightarrow 14.5^o$

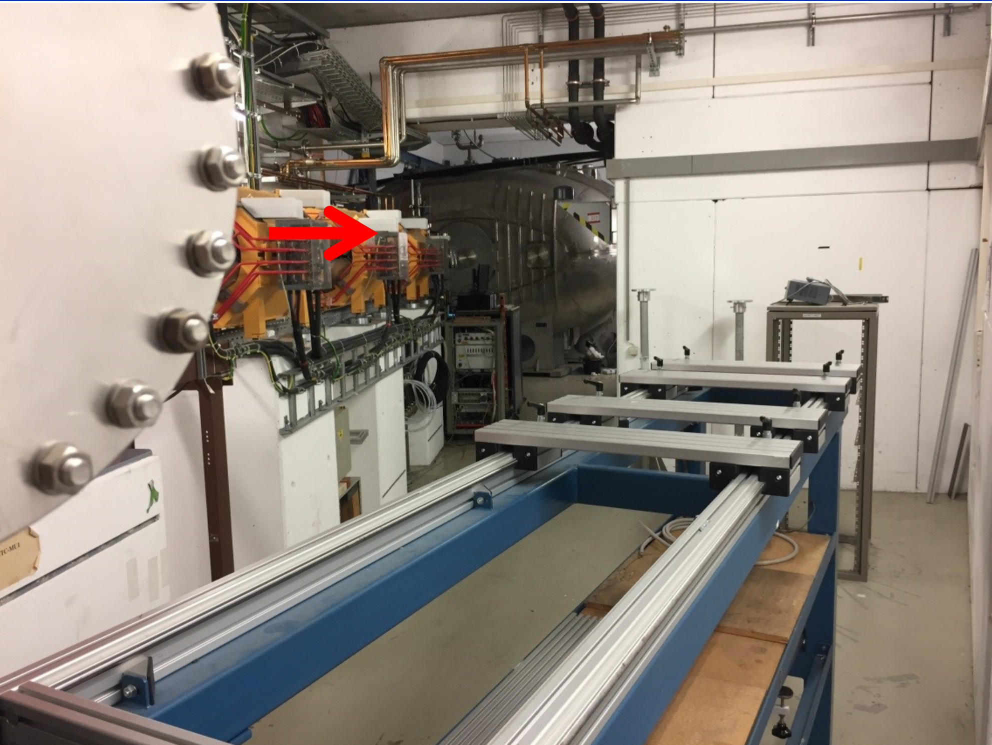
$B = 1.6$ T , $B\rho = 10$ Tm



$\rho = 11.25\text{m} \rightarrow 8.0^o$

$B = 1.66\text{T}$, $B\rho = 18.66$ Tm

mCBM Cave - HTD at present



mCBM in preparation ...