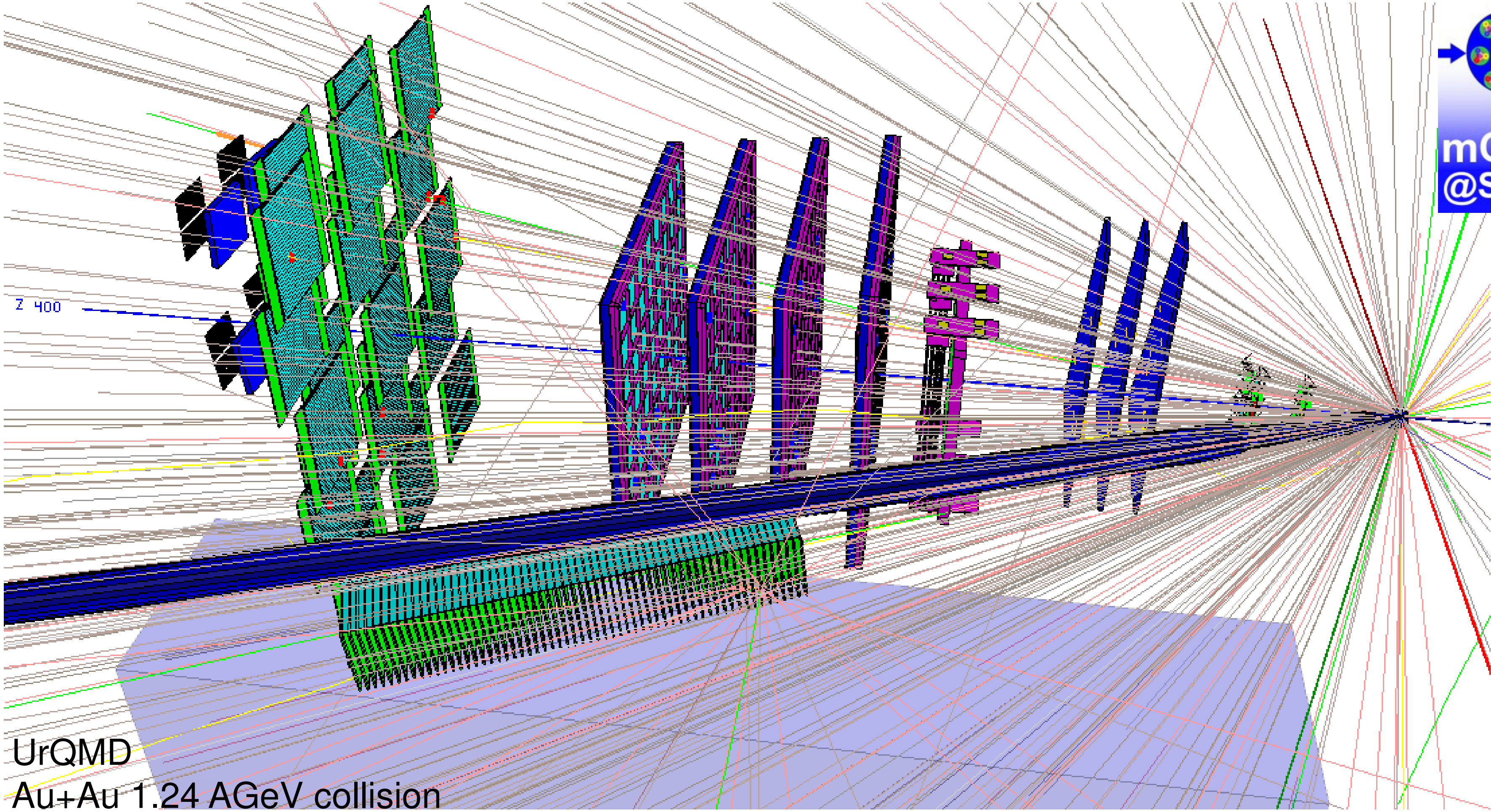


mCBM
@SIS18

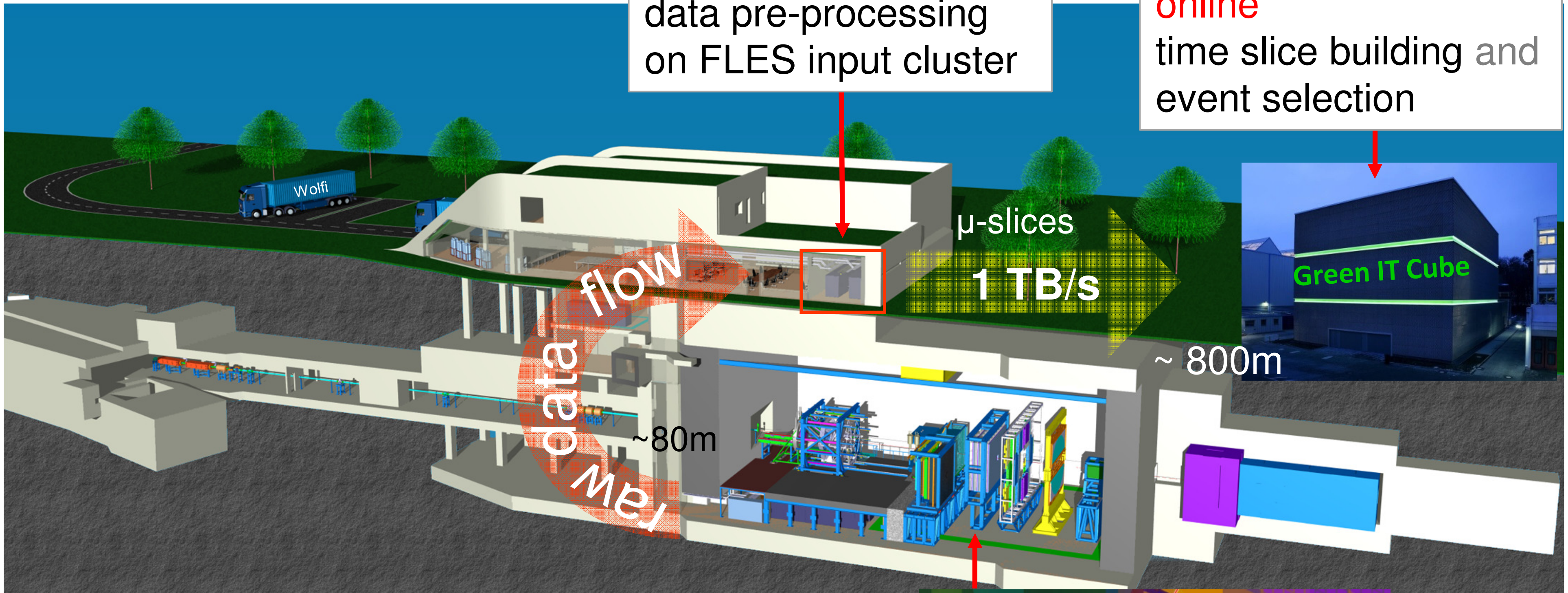
Status of mCBM@SIS18

C.Sturm for the CBM Collaboration

The high-performance free-streaming DAQ system of CBM

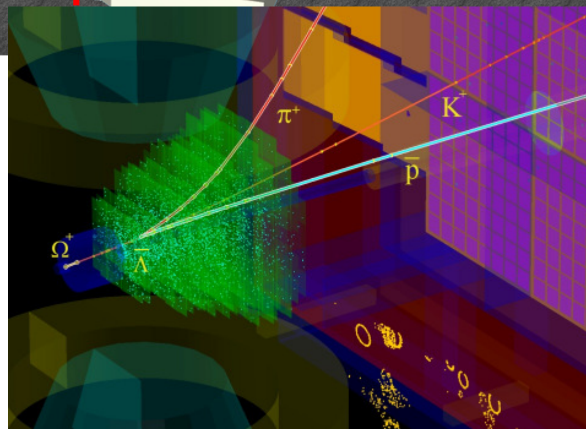
DAQ room:
data pre-processing
on FLES input cluster

Green IT Cube:
online
time slice building and
event selection

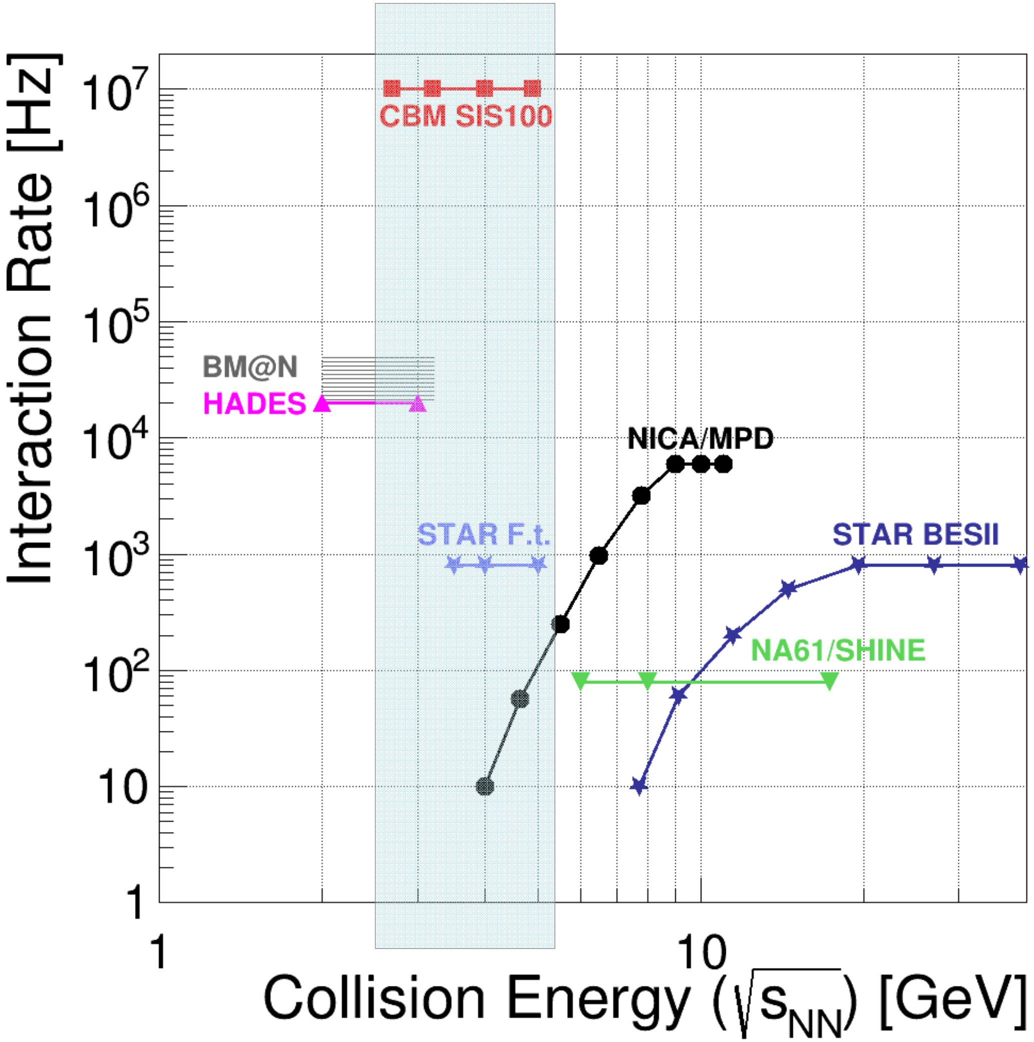


Main features:

- radiation tolerant detectors and front-end electronics
- free-streaming DAQ system
  - all detector hits with time stamps,
  - software based event selection



Experiments exploring dense QCD matter: Rate capabilities



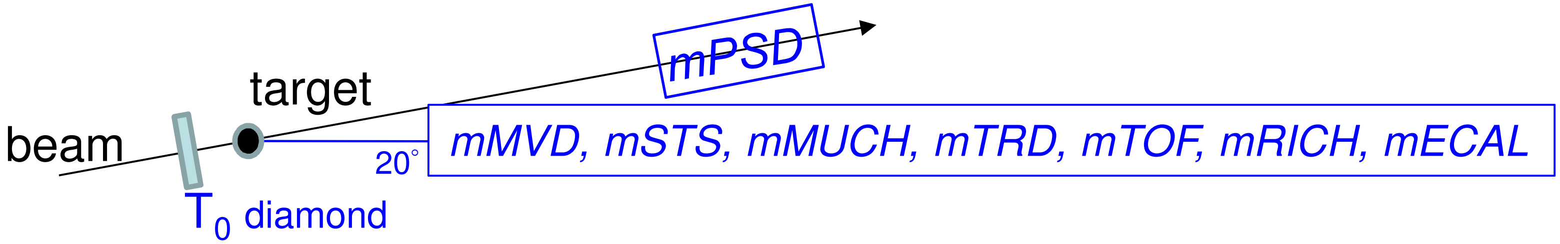
FAIR SIS100 energies (Au ions)	
E_{kin}^{lab} [A·GeV]	$\sqrt{s_{NN}}$ [GeV]
2	2.7
4	3.3
8	4.3
11	4.9
14 (Ca) 29 (p)	5.5 7.6

<u>CBM's unique feature:</u>
ultimate rate capability for high statistics measurement of rare probes

A CBM full-system test-setup at GSI/FAIR: *mCBM@SIS18*

<u>concept:</u>

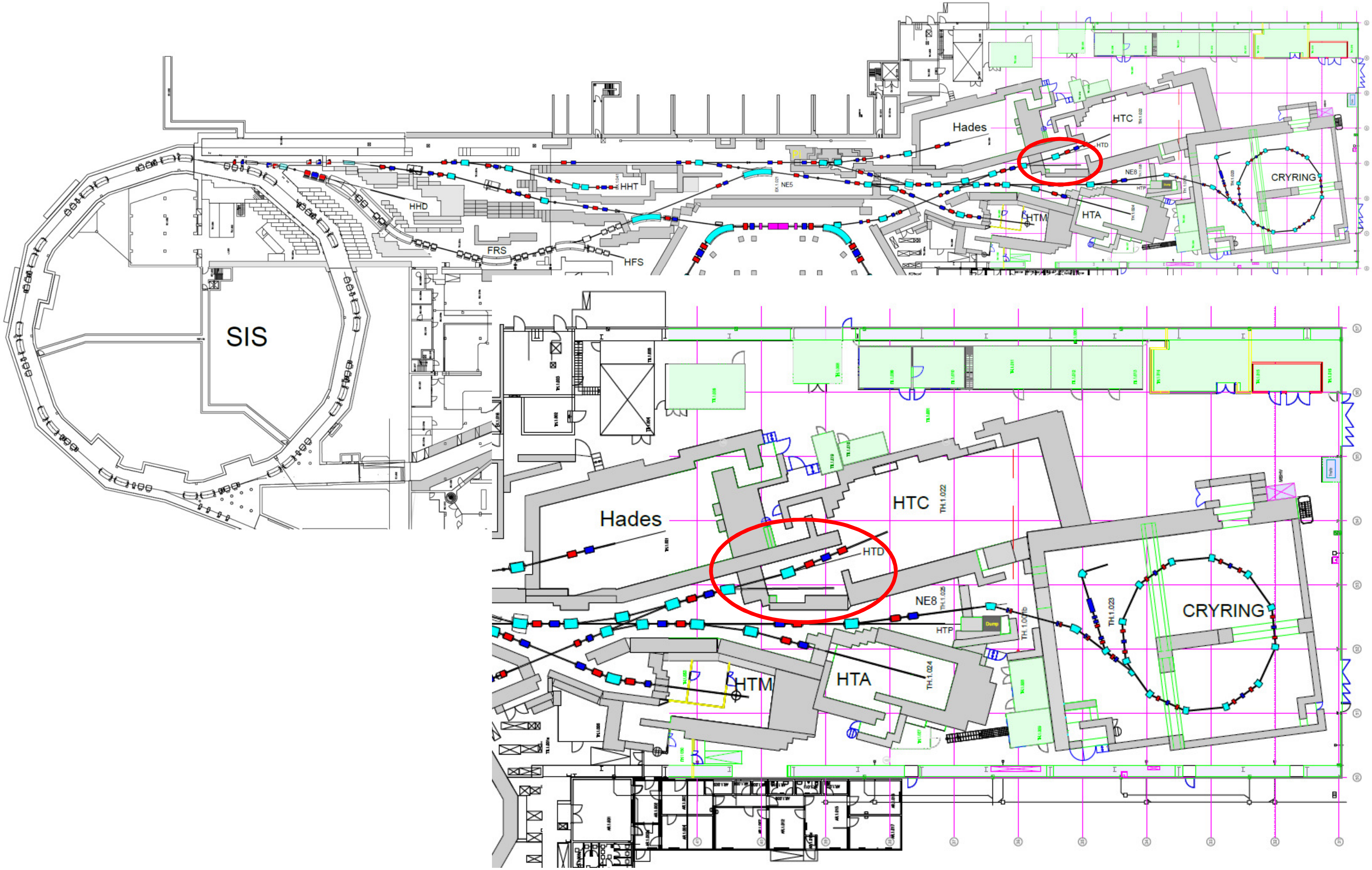
- **detector prototypes** at $\theta_{lab} \approx 20°$
- no B-field → straight tracks
- high resolution TOF (T_0 – TOF stop wall)
- CBM collision rates



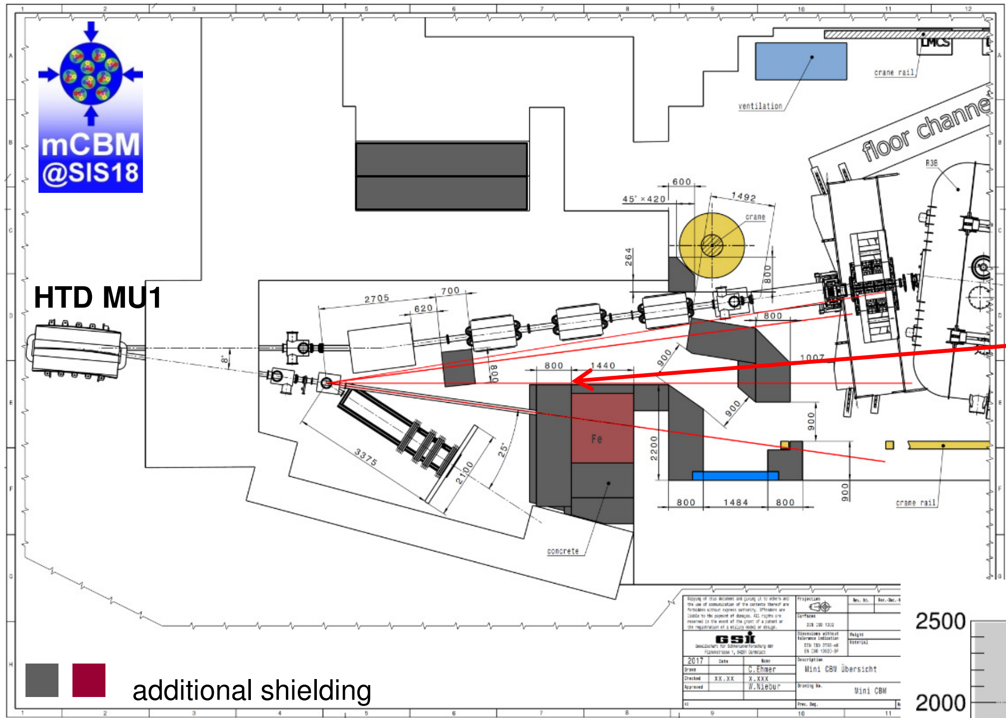
Topics to be addressed

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

mCBM @ SIS18 facility

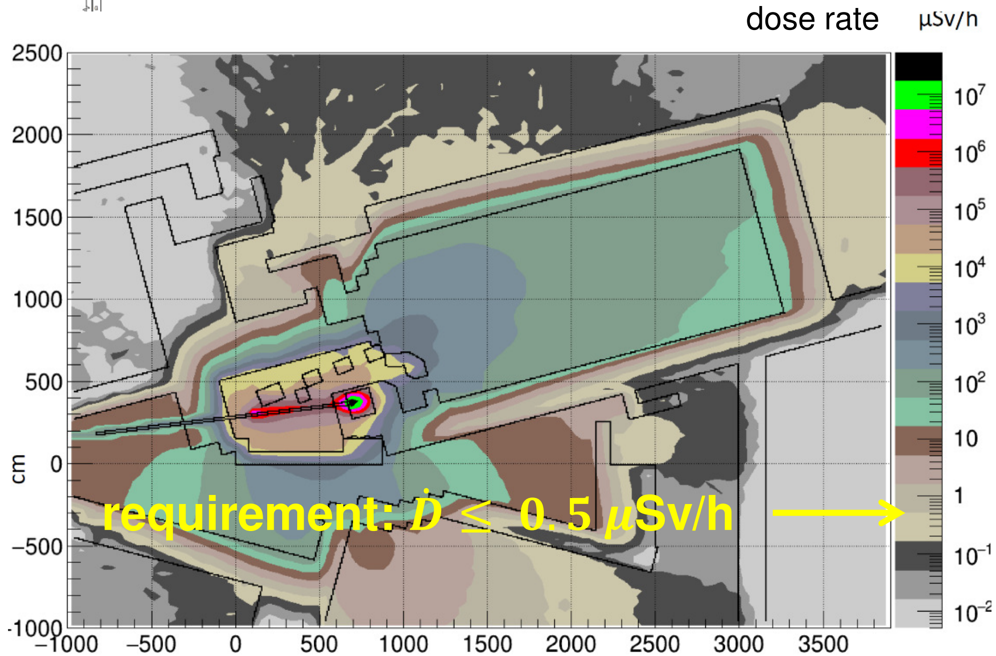


mCBM Cave (HTD @ SIS18 facility)

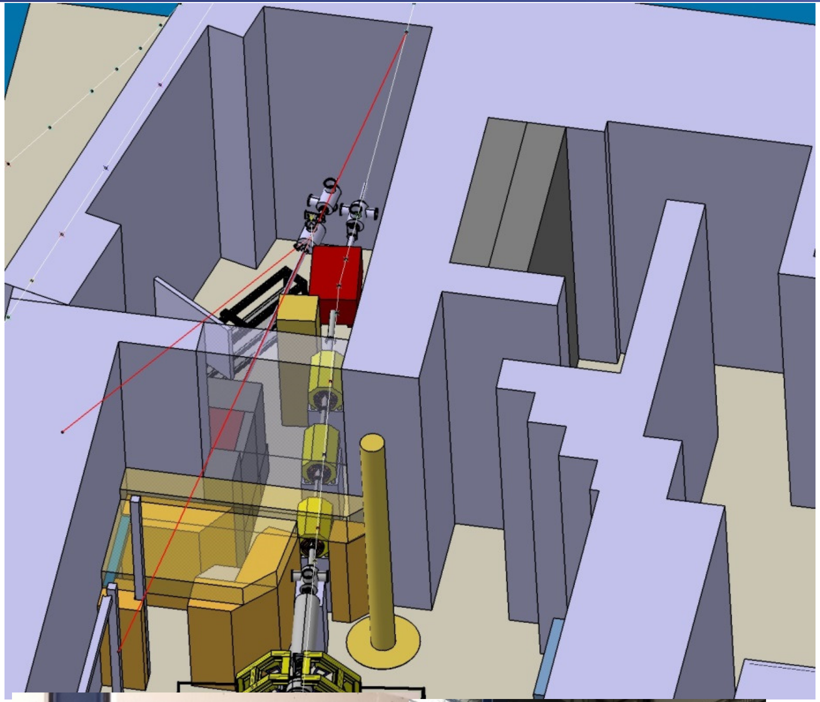


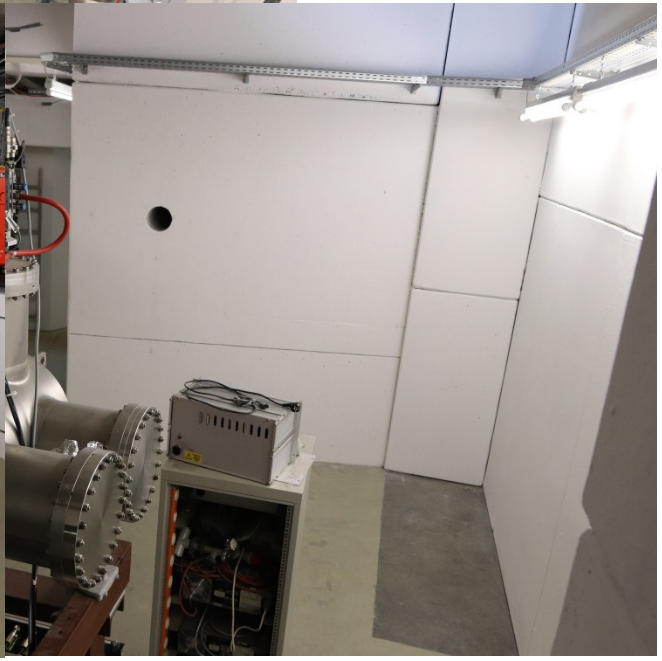
- modified switching magnet (HTD MU1)
- new beam dump
- additional shielding

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



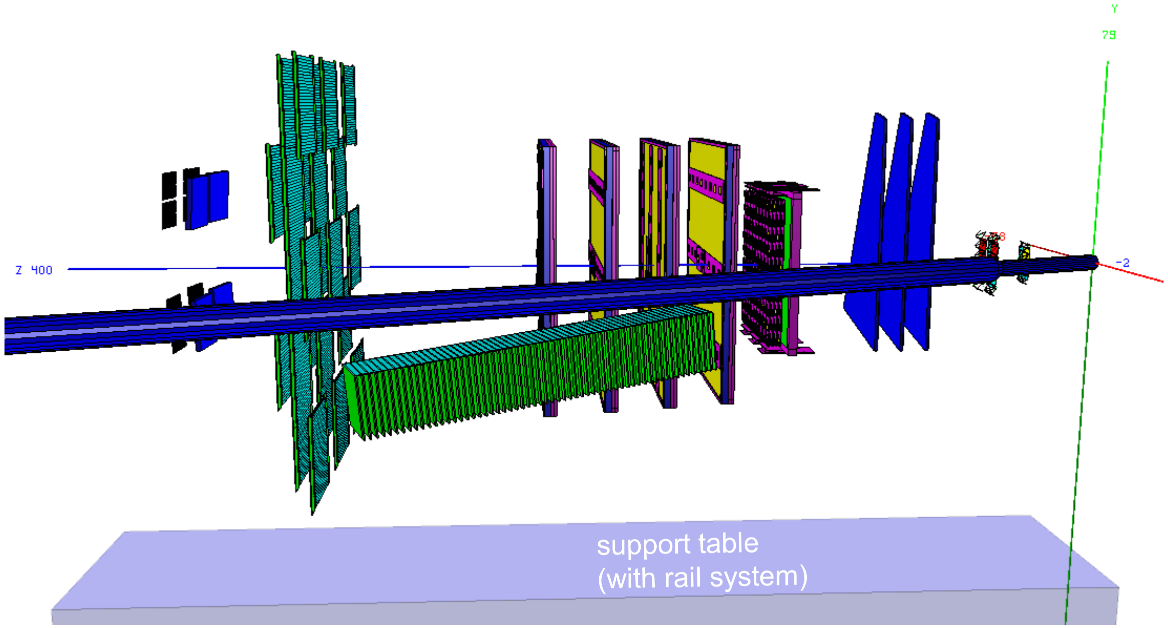
Status of the cave reconstruction



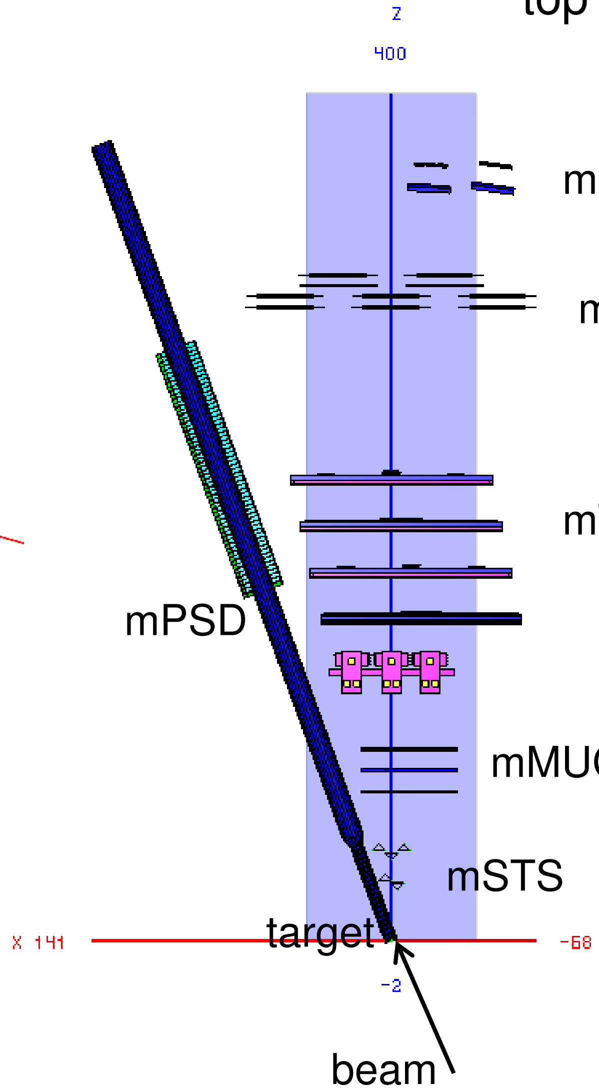


Design of the mCBM test-setup

side view



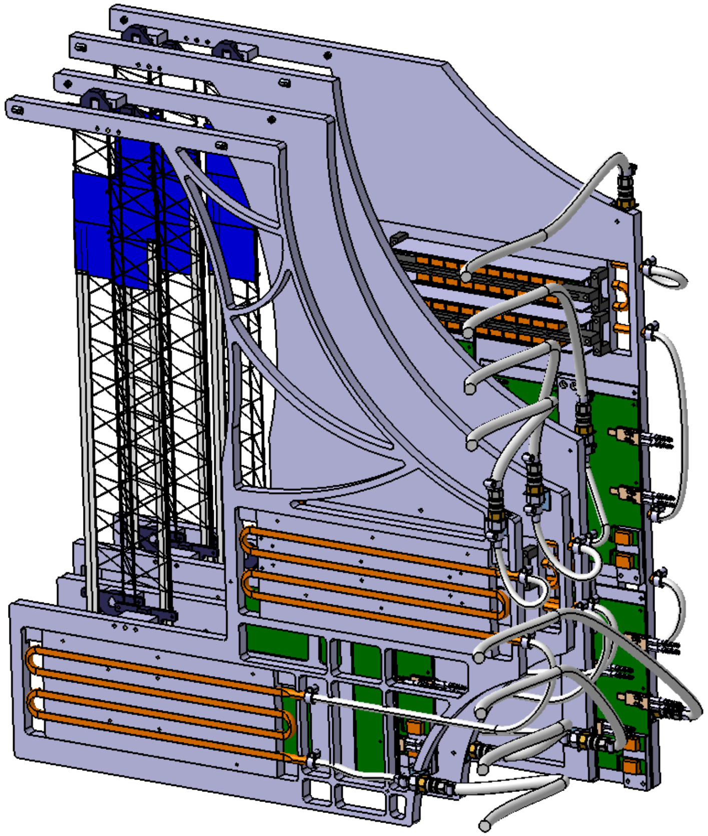
top view

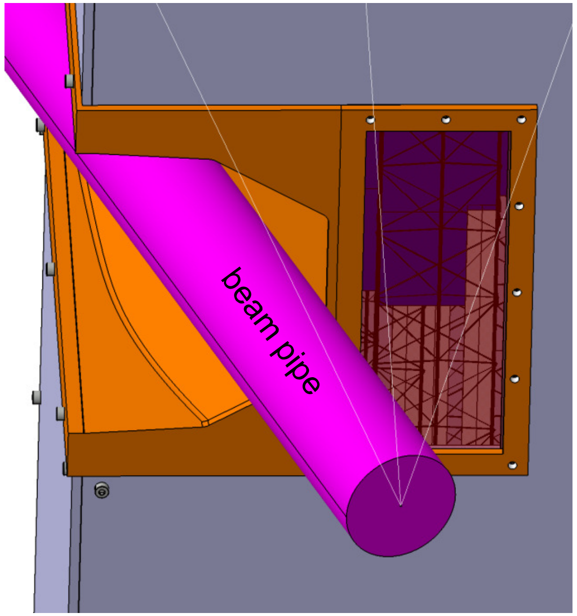


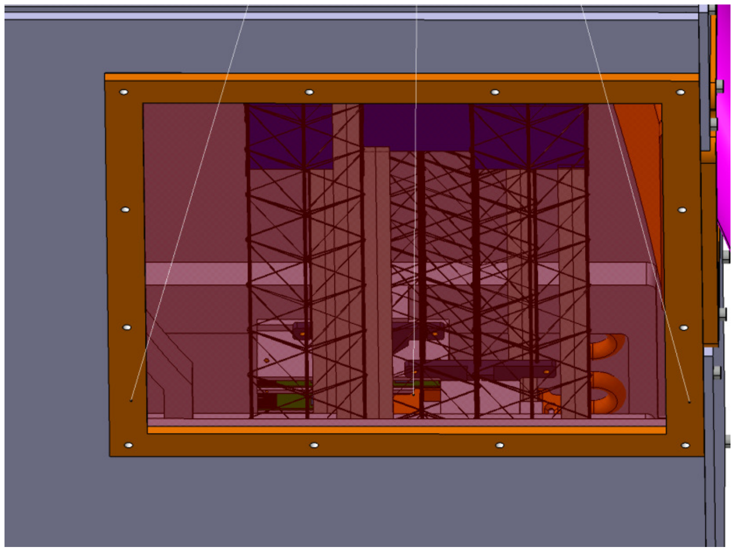
Example: mSTS integration

4 C-frames (“Units”)

- holding the ladders with modules
- holding the read-out and powering electronics (FEB, C-ROB, POB) on cooling plates

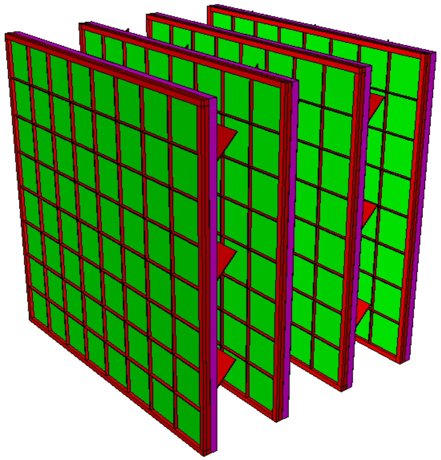


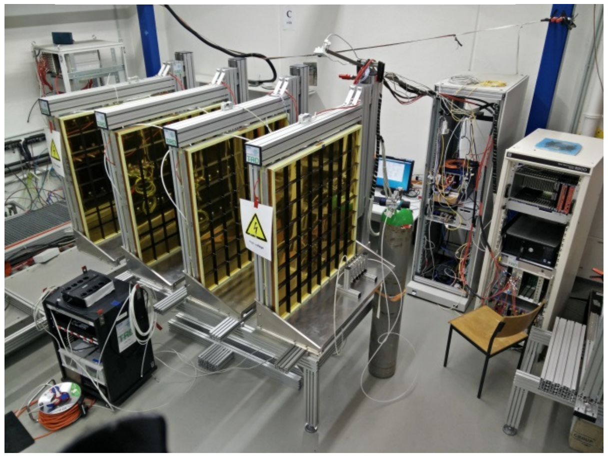




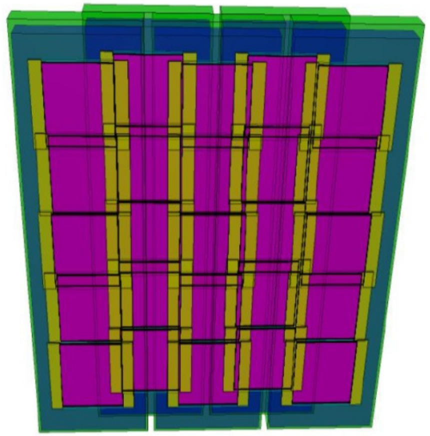
The mTRD and mTOF subsystems

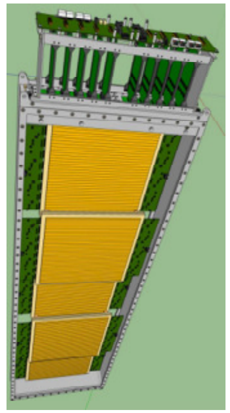
mTRD setup
4 layers
TRD modules
from DESY/CERN tests 2017

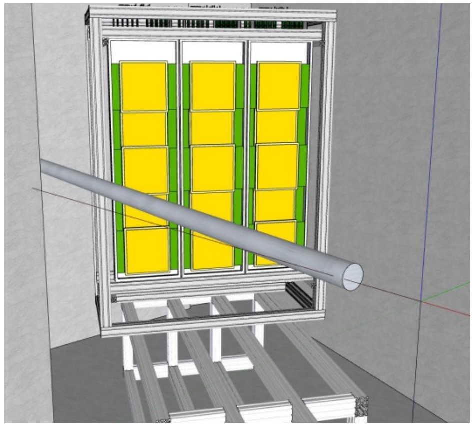




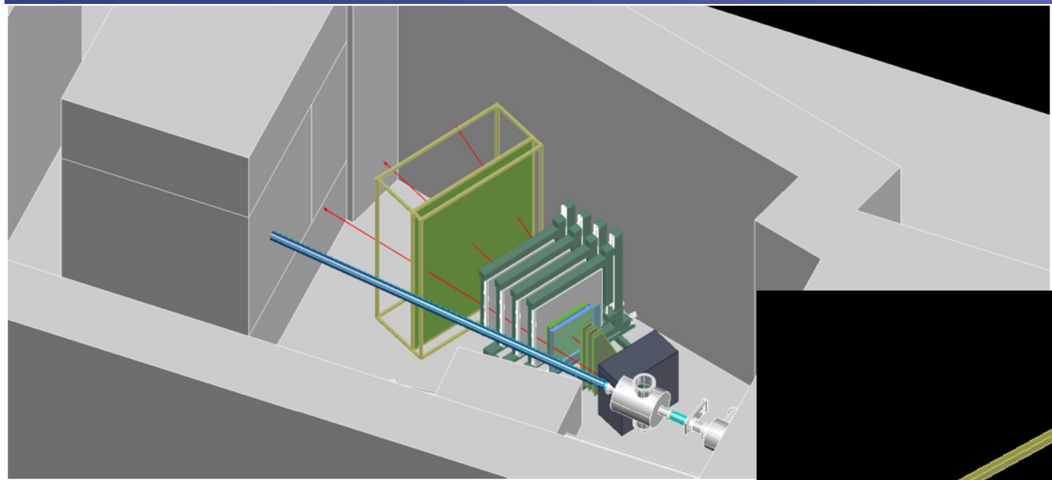
mTOF setup
25 MRPC(3a) counters
(= 5x STAR modules)
150 x 120 cm^2 active area
1600 readout channels

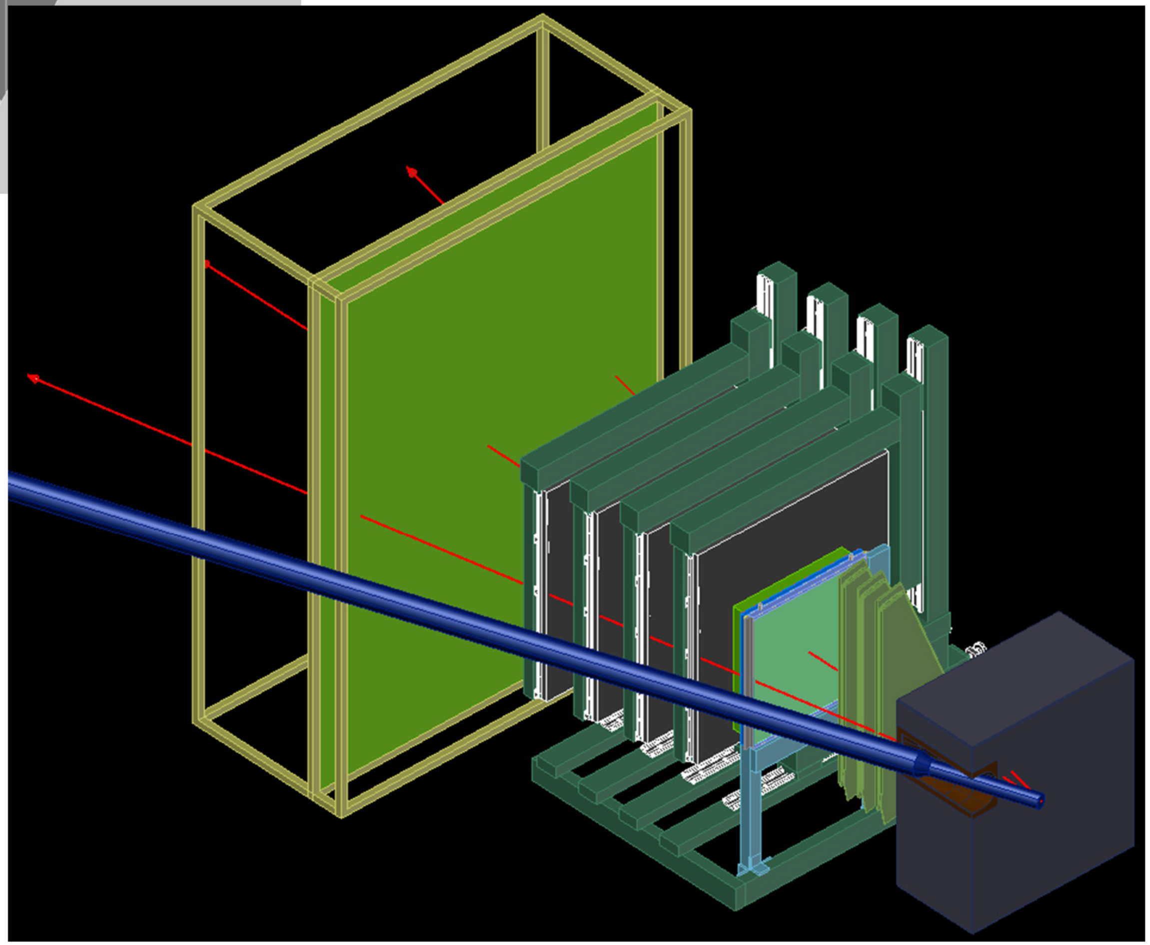






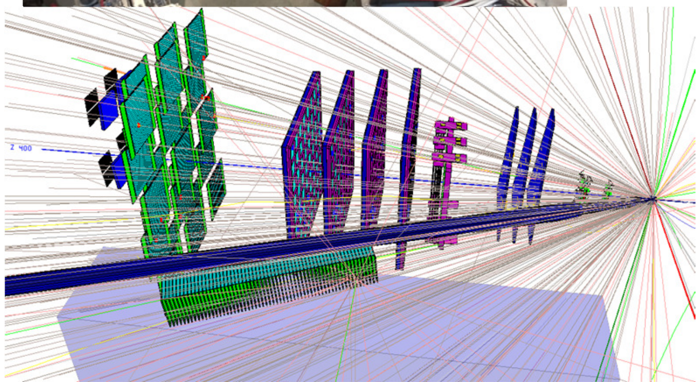
Engineering design (CAD)





mCBM
@SIS18

Schedule of mCBM@SIS18 construction

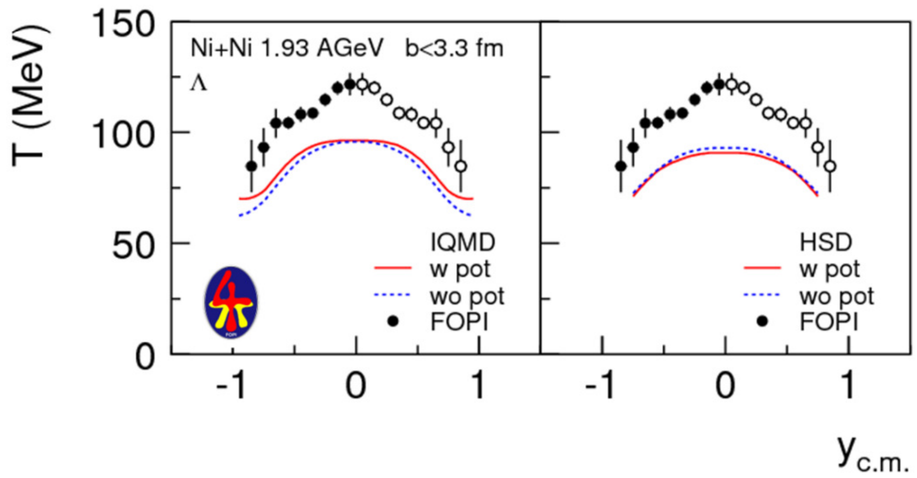


Schedule

10/2017	cave & beam line: reconstruction started, procurement started
12/2017	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

mCBM data taking

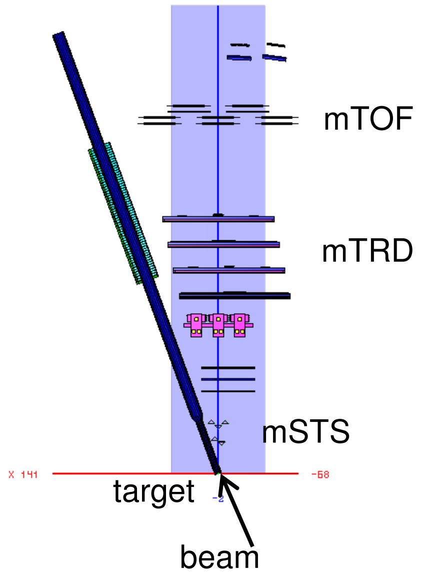
2018	development & commissioning data transport, data analysis, detector tests	requested beam time was fully granted by the G-PAC
2019	approaching full performance subsystems completed, high-rate data transport / processing → online reconstruction	
2020	1^{st} benchmark run Λ reconstruction production runs benchmark coll. systems: Ni+Ni 1.93AGeV & Au+Au 1.24AGeV	proposal to be submitted in 2019
2021	2^{nd} benchmark run Λ reconstruction in Ni+Ni and Au+Au collisions at various projectile energies → Λ production excitation function	

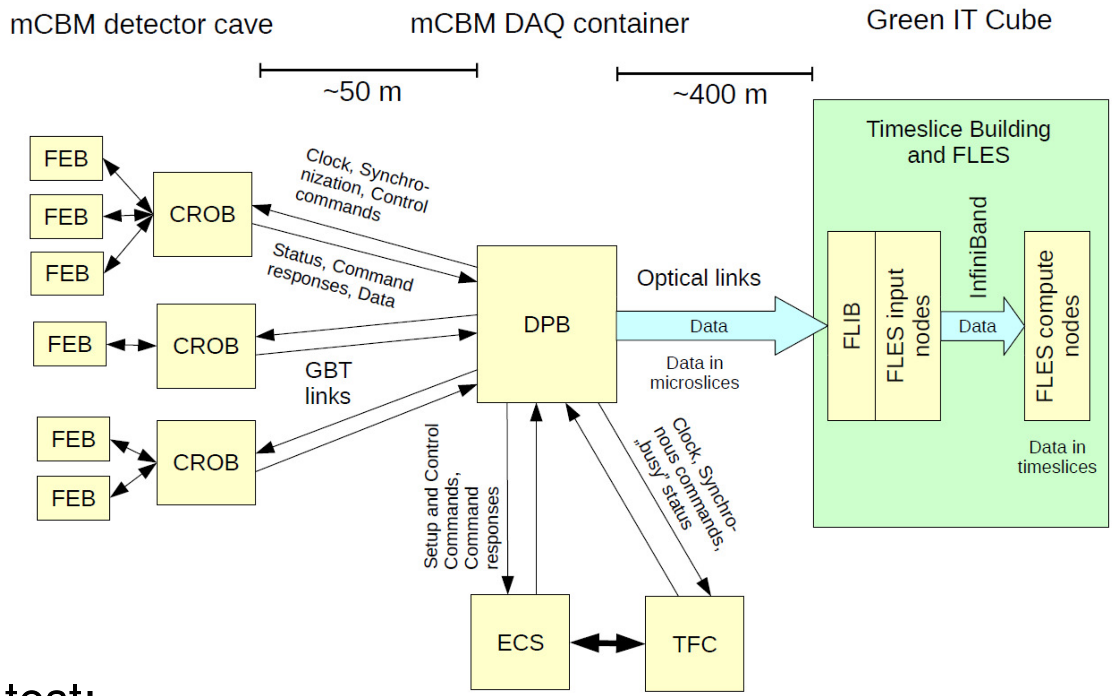


<u>Λ - slope parameter:</u>

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

start version for 2018





<u>Start the CBM full system test:</u>

- operate mTRD, mTOF (+ T_0 counter) and mSTS (1x station)
- data transport to mFLES @ Green IT Cube incl. event building
- parasitic beam: ions, T_{lab}> 1 AGeV & slow extraction (10s), 10^5 - 10^6 s^{-1} (→ ^{107}Ag/^{109}Ag 1.65AGeV is fine !)
- basic data analysis → correlated hits between detector stations

Support by beam diagnostics team required.
No show-stopper visible.

Backup

mCBM

Granted mCBM beam time 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.

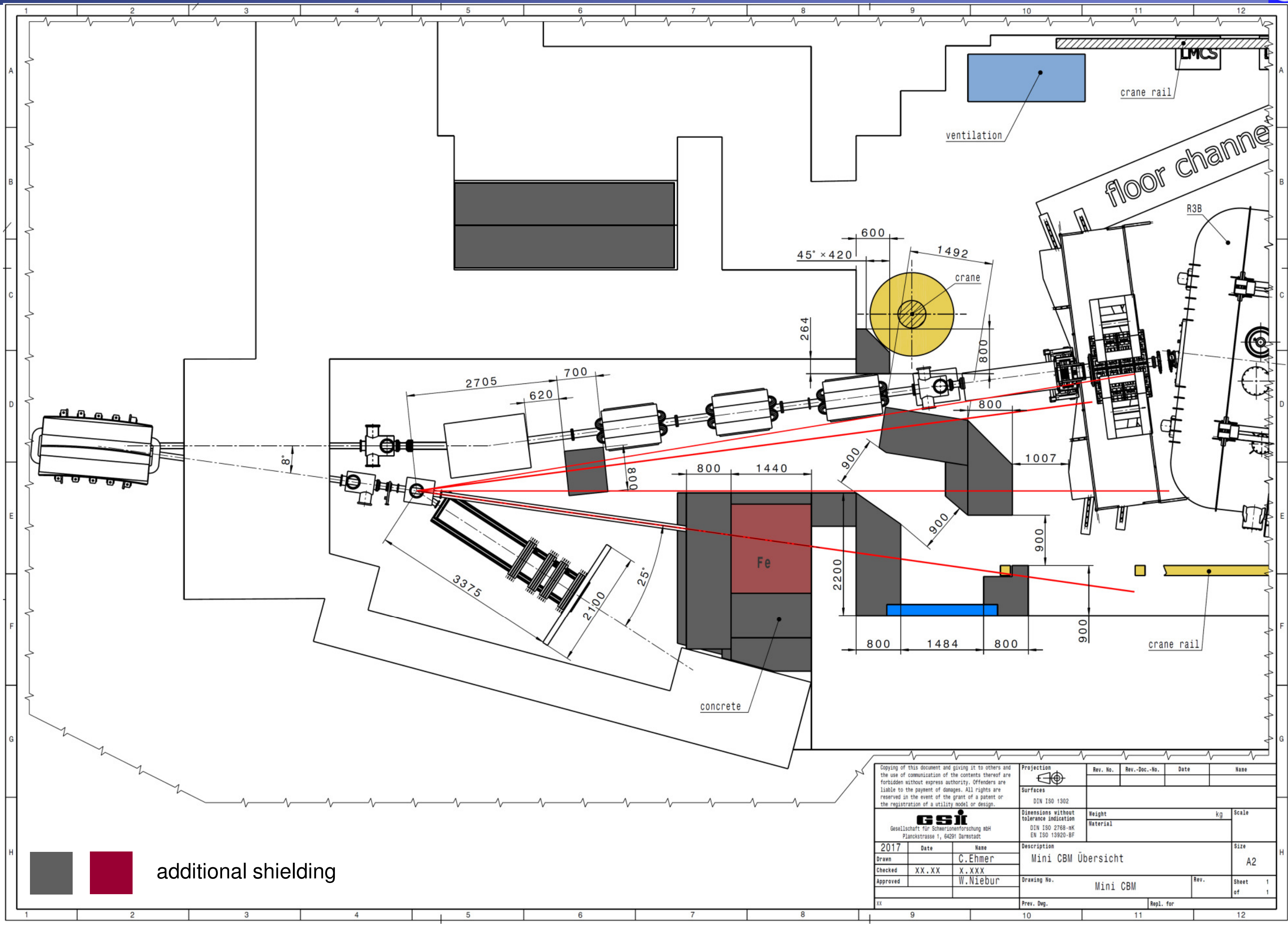
"For this task, we apply (1) for 30 shifts of parasitic beam time, distributed over four development weeks. At the end of that year's block of SIS18 beam we apply (2) for 21 shifts (one full week) of parasitic beam time to perform high-rate detector tests." mCBM@SIS18 proposal, submitted on June 19, 2017

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.

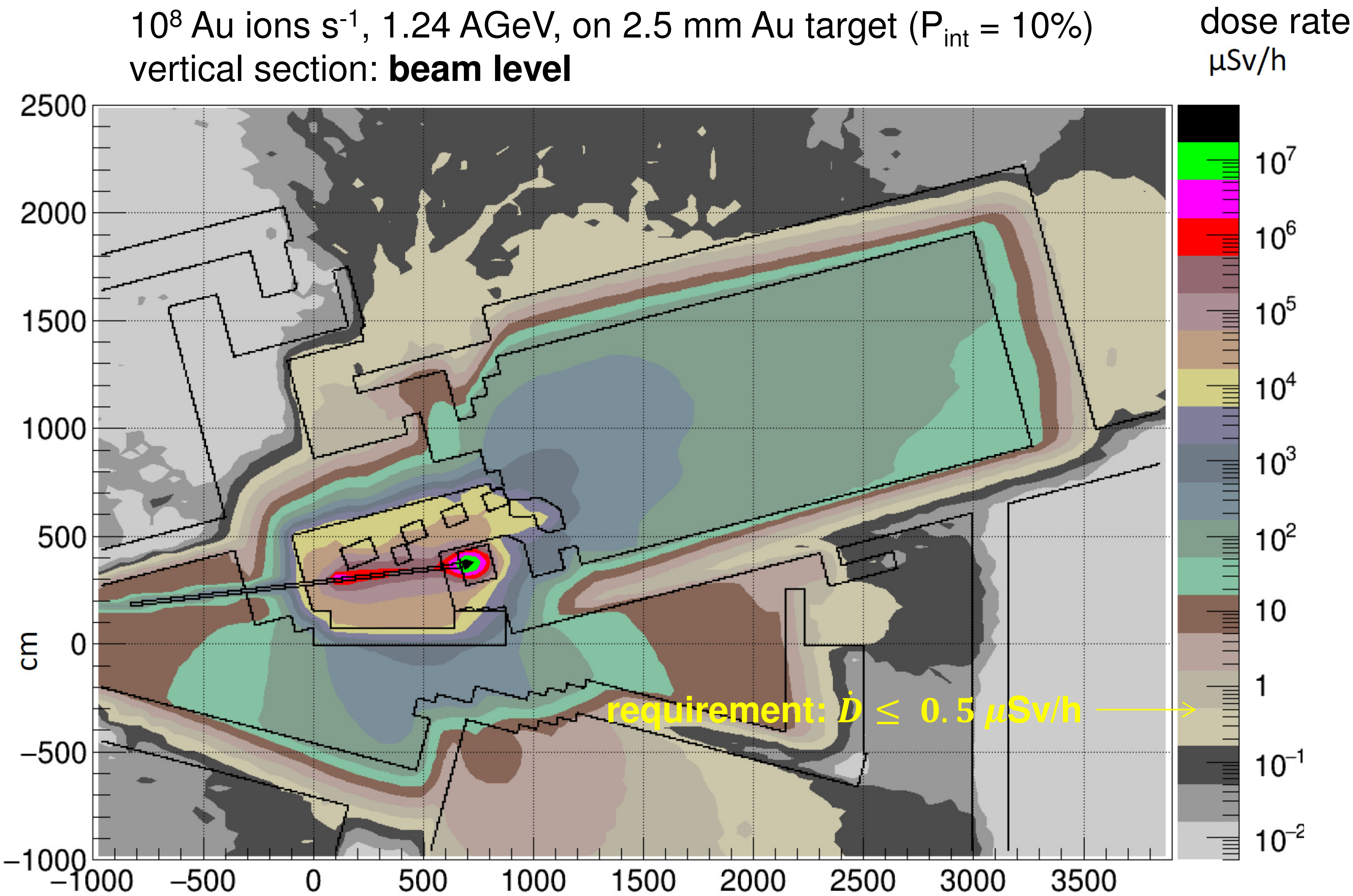
Design of the mCBM Cave - HTD



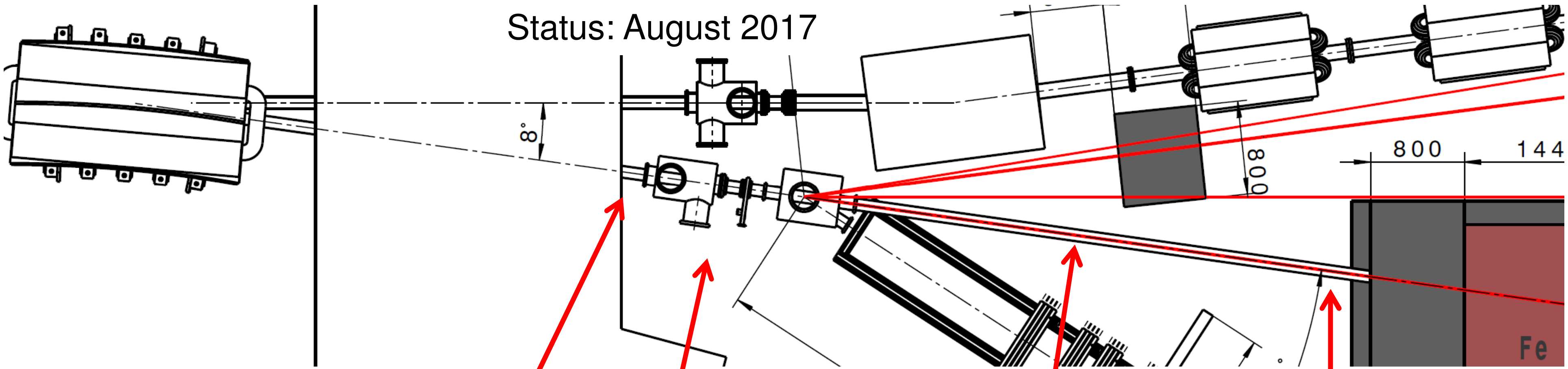
additional shielding

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**



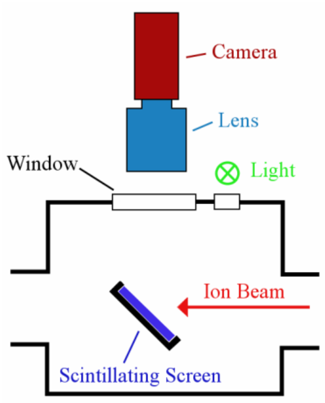
mCBM beam line



Present concept:

beam diagnostic chamber
scintillation screen
vacuum: accelerator

beam pipe
carbon, d=100mm
vacuum: experiment



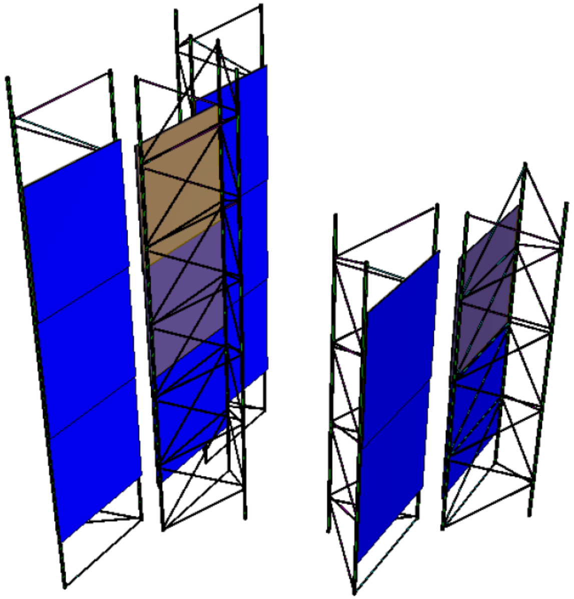
target chamber
- T_0 diamond counter
- target ladder
- small permanent magnet (?)
  (to bend-out low-E δe)

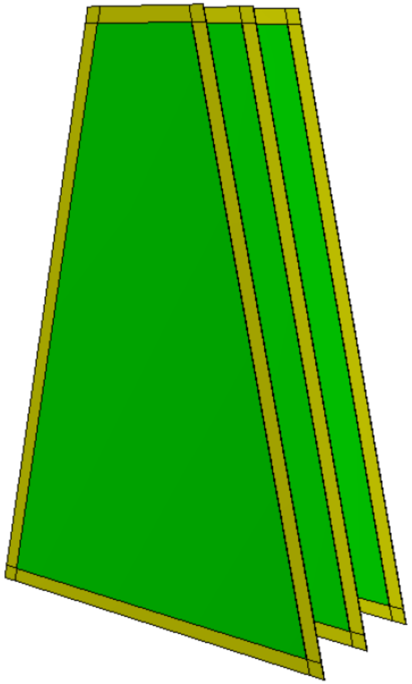
vacuum: experiment

scintillation screen
in front of the beam dump
atmospheric pressure

mCBM – subsystems: STS, MUCH

mSTS





mMUCH

mSTS: 2x stations

Contribution by GSI

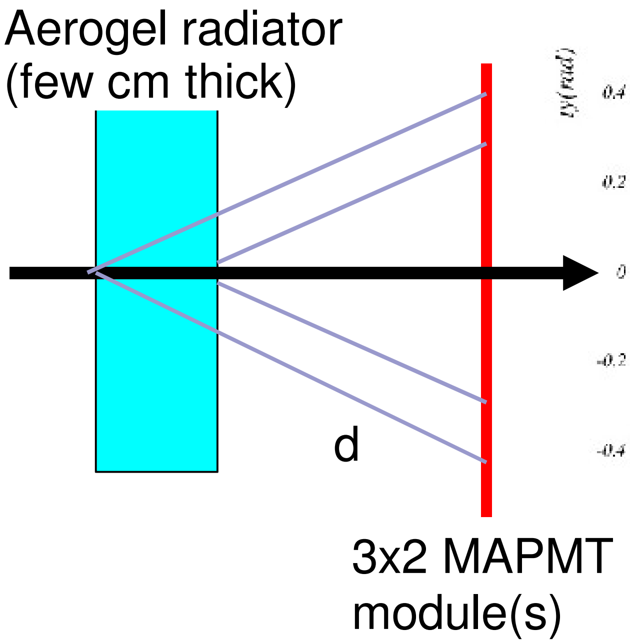
- 1st: 2x2 modules
- 2nd: 3x3 modules
  = 5 half-ladders
  = 13x 6x6 cm^2 sensors

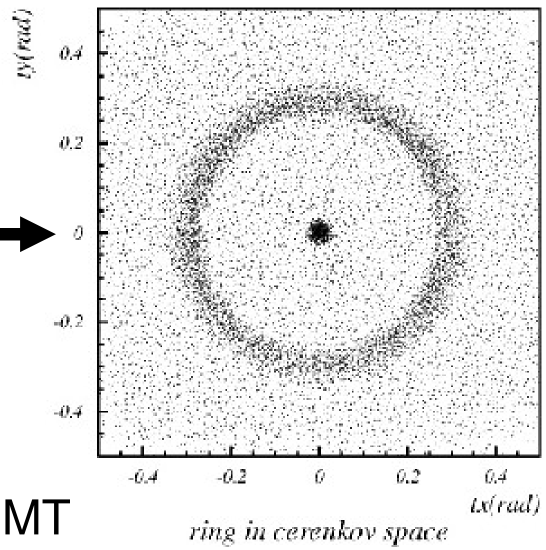
mMUCH: 3x layers

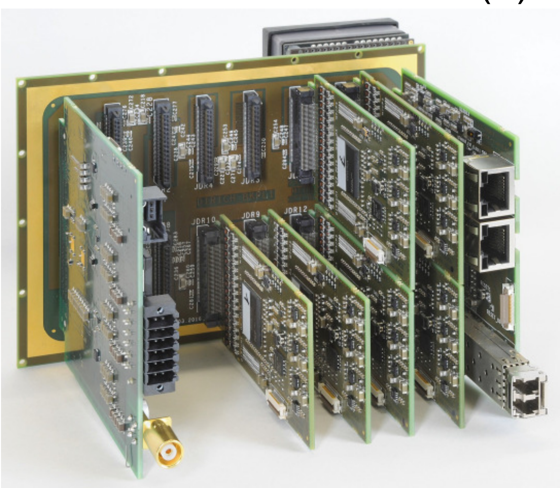
Contribution by India

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

mRICH







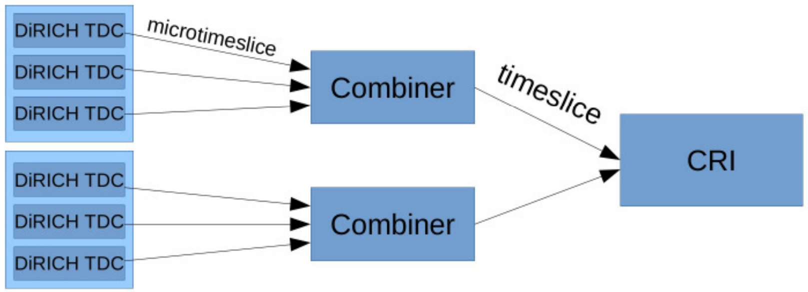
<u>New proposal by the RICH group:</u>
Aerogel proximity focusing RICH to be installed for phase II / 2019,
≈ 0.5m^2 acceptance,
need 50 – 70 cm space behind mTOF

open issues:

- read-out
  DiRICH & TRBnet to be included into the mCBM DAQ
  → synergy with mPSD

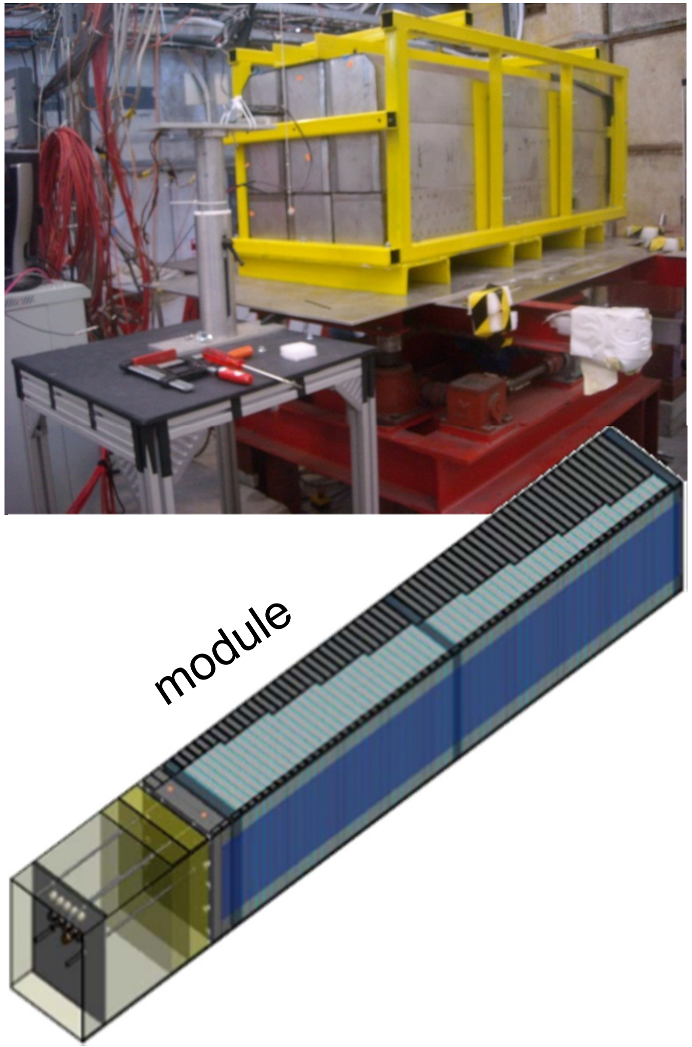
- detector integration
- integration into mCBM

→ All TRBnet Subsystems generate timeslice in common time interval

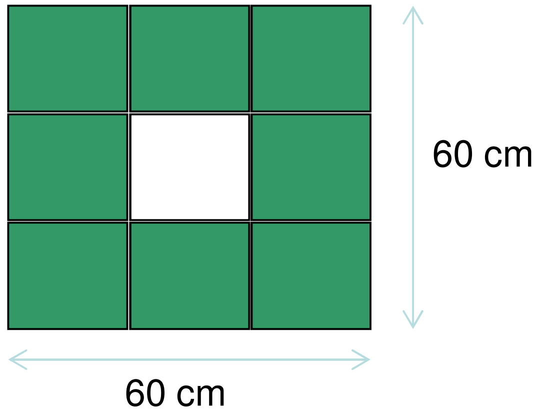


mPSD

PSD supermodule – array from 3x3 modules.
total size 600 x 600 x1650 mm^3, total weight ≈ 5t.



proposed for mCBM:



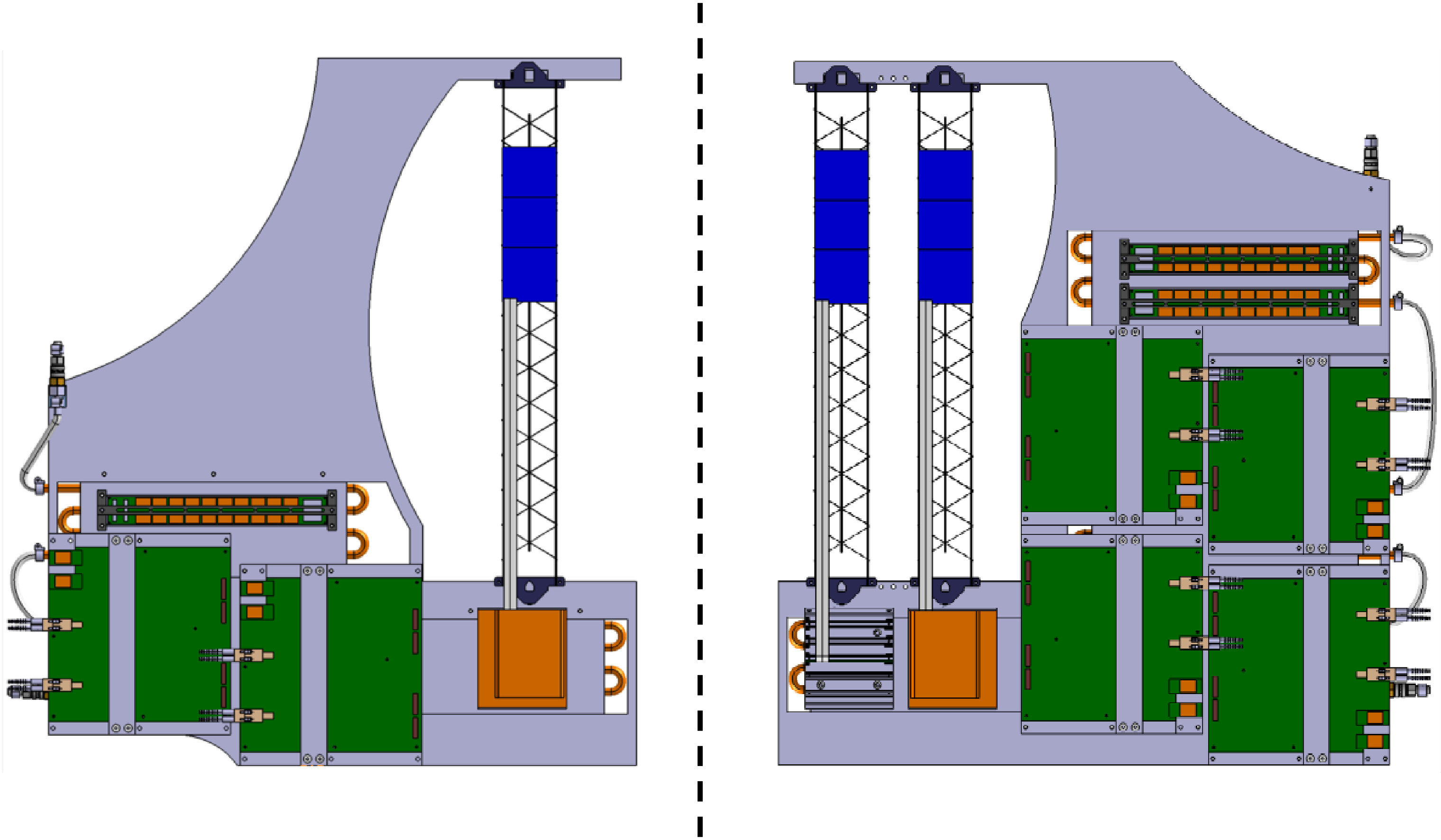
open issues:

- mounting structure
- read-out system
  PaDiWa & TRBnet ?
  → synergy with mRICH

→ proposal:
installation for phase II / 2019

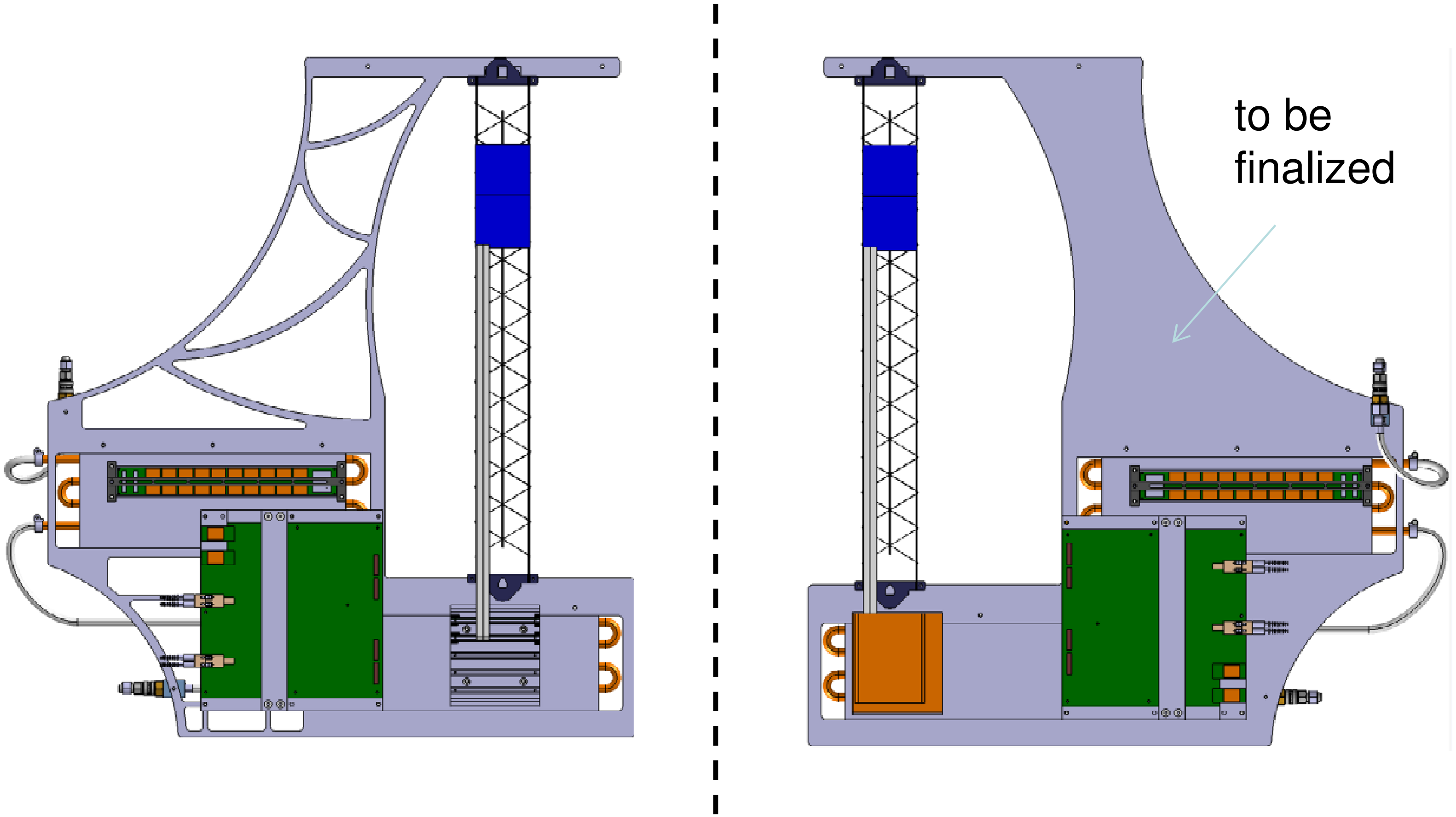
Example: mSTS integration

Units 02 and 03 (“station 1”)

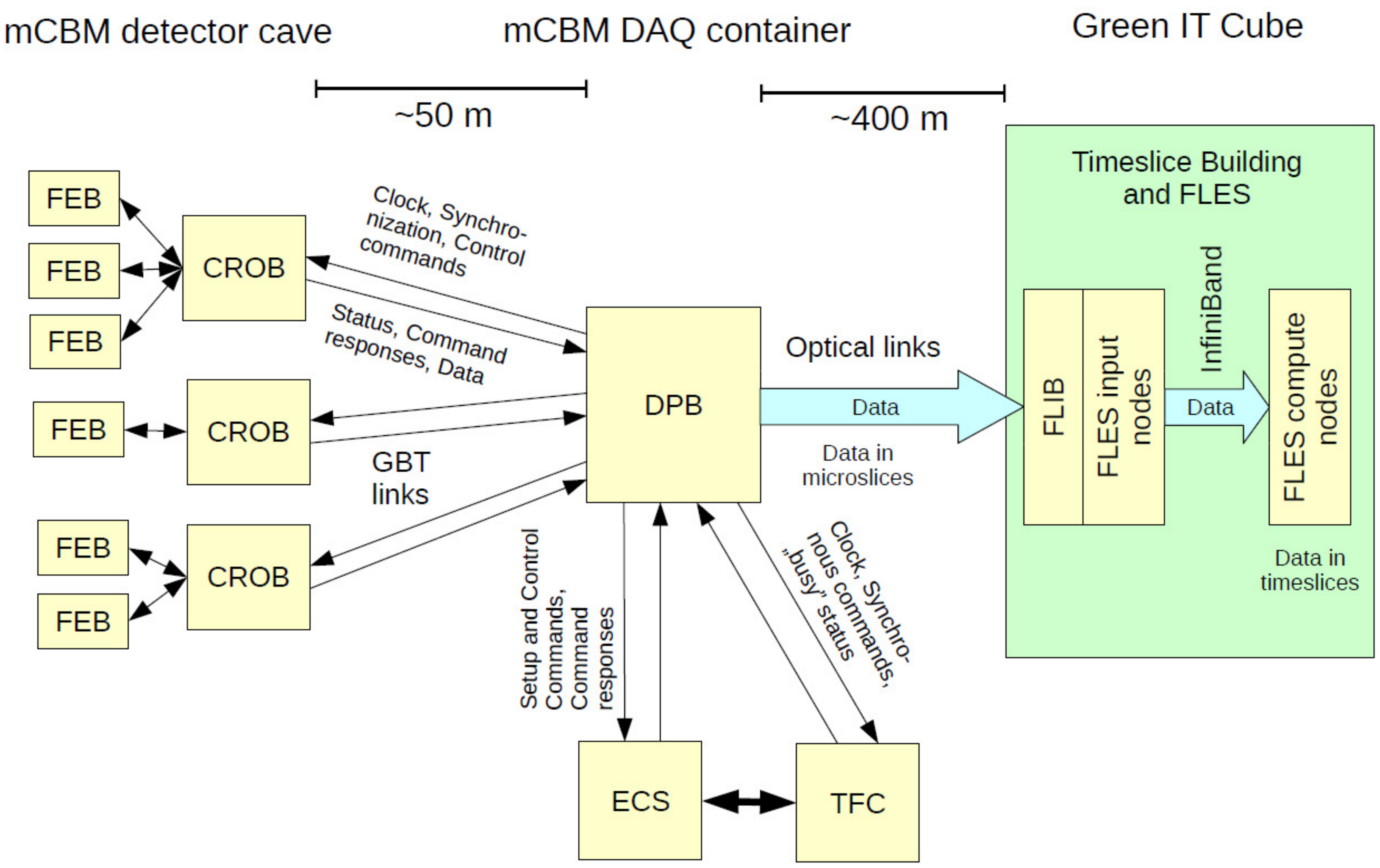


Example: mSTS integration

Units 00 and 01 (“station 0”)

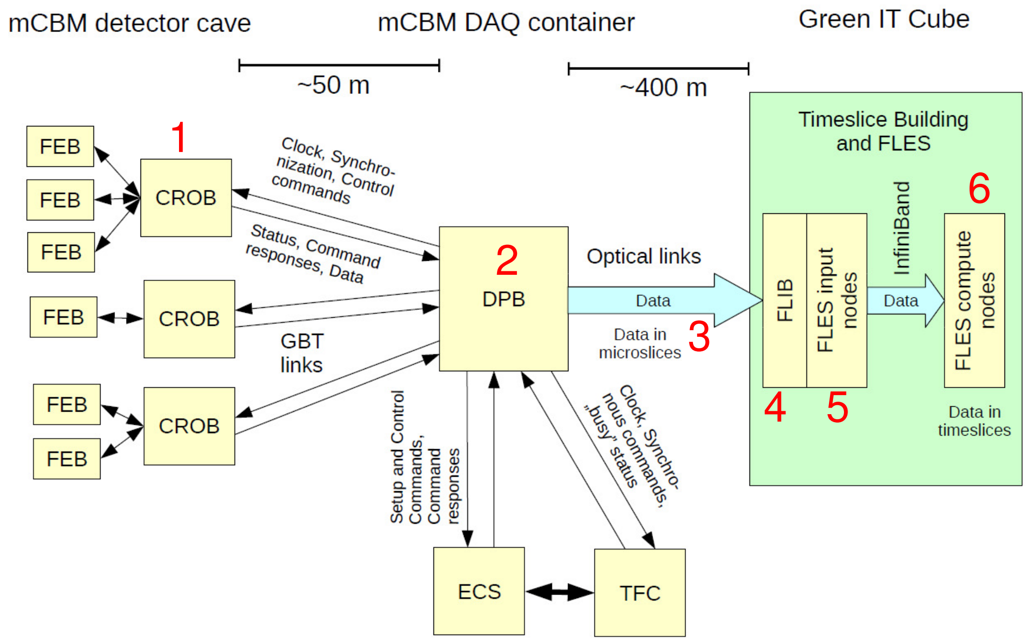


mCBM read-out and data transport
Start version



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

Example: read-out chain for mSTS

STS modules
8 STS-XYTER v2.0 on FEB-8

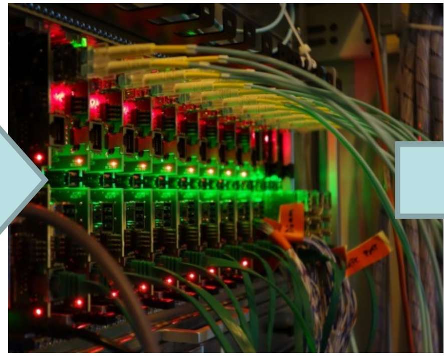
Common GBTx Readout Board

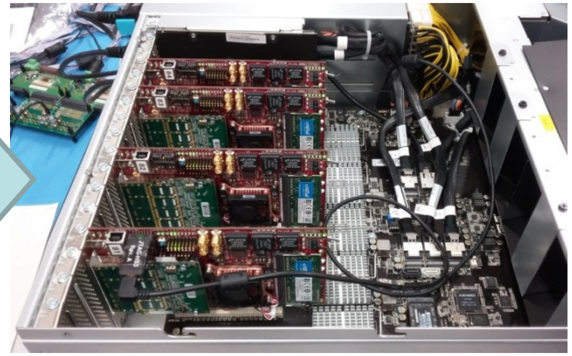
fully featured prototype currently being tested and commissioned

will enough CROB be available in time for mCBM?

µTCA crate with AFCKs

FLES IN with FLIBs





copper link

optical link

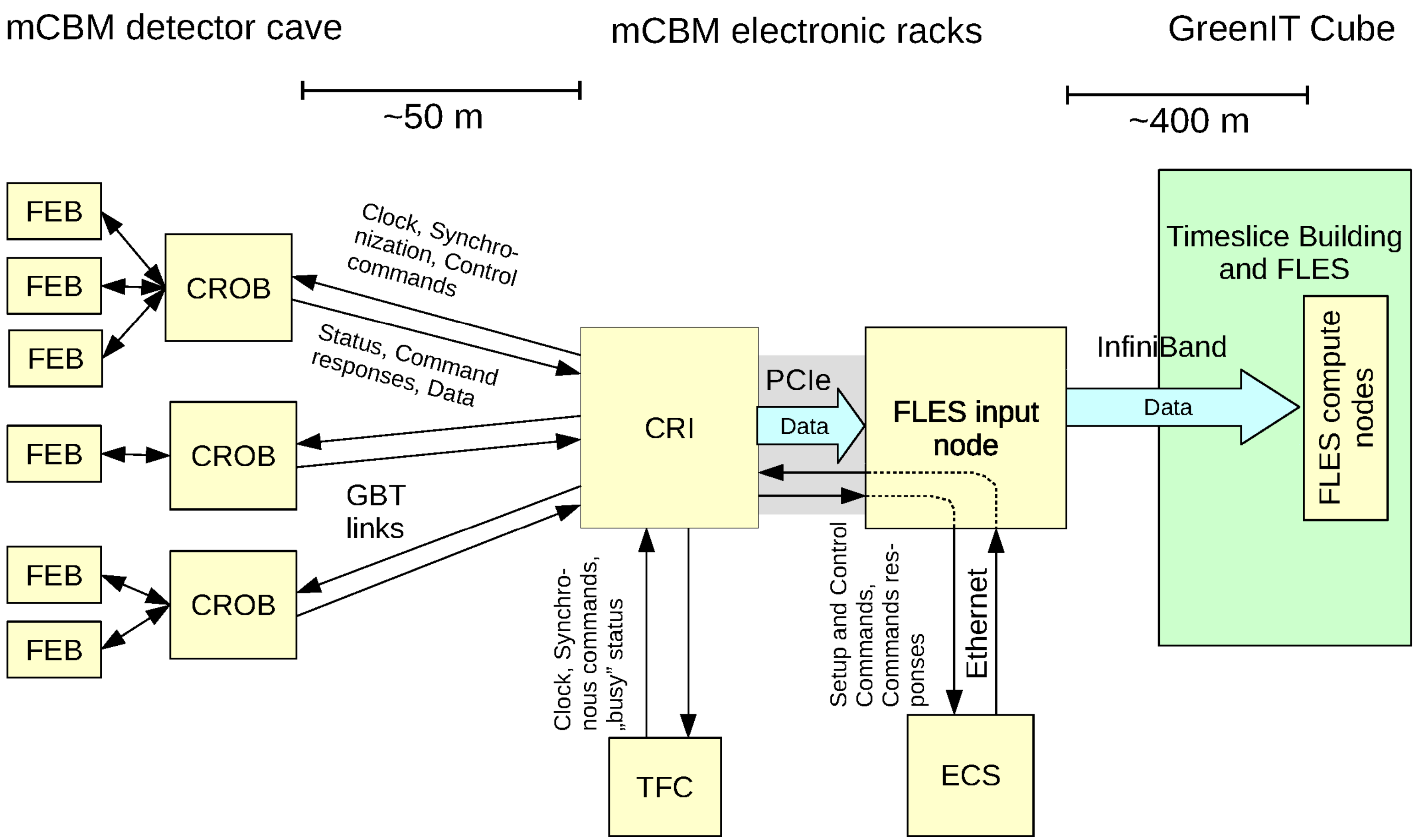
optical link

on detector

DAQ container

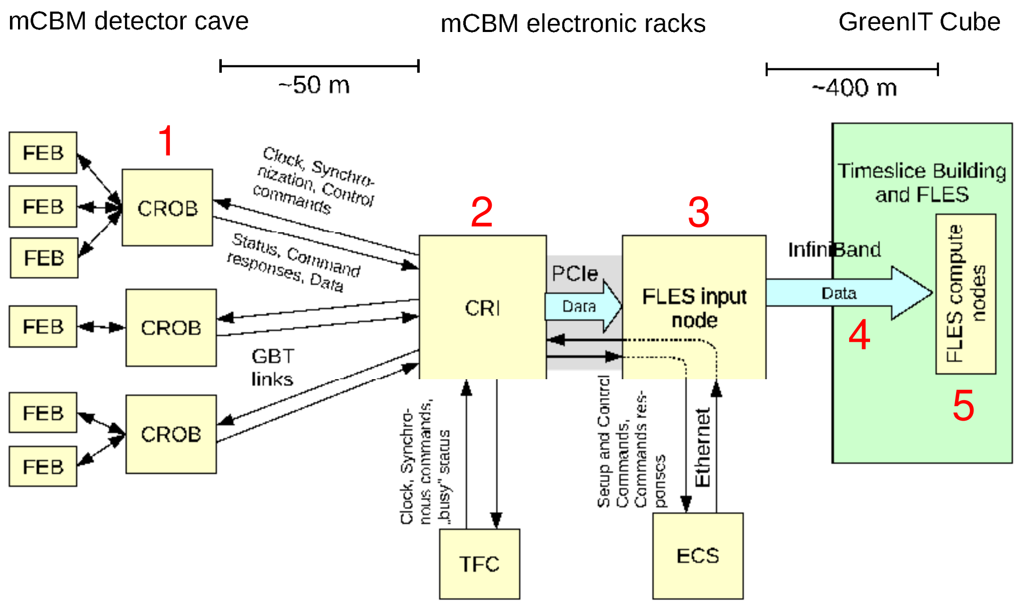
Green Cube

mCBM read-out, data transport and processing
Final version



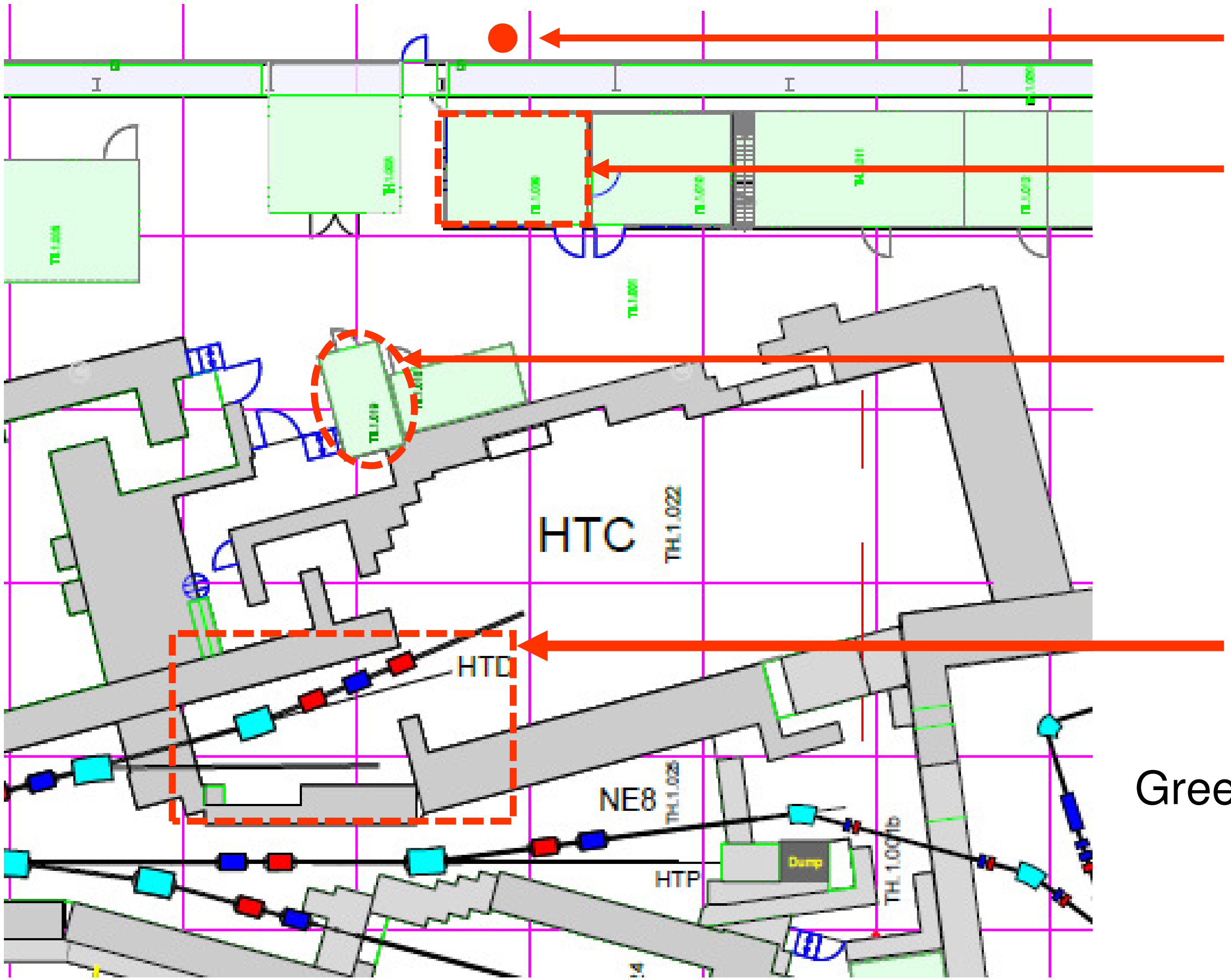
mDAQ and mFLES 2019 (SIS100 version)

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

mCBM – support infrastructure



gas area

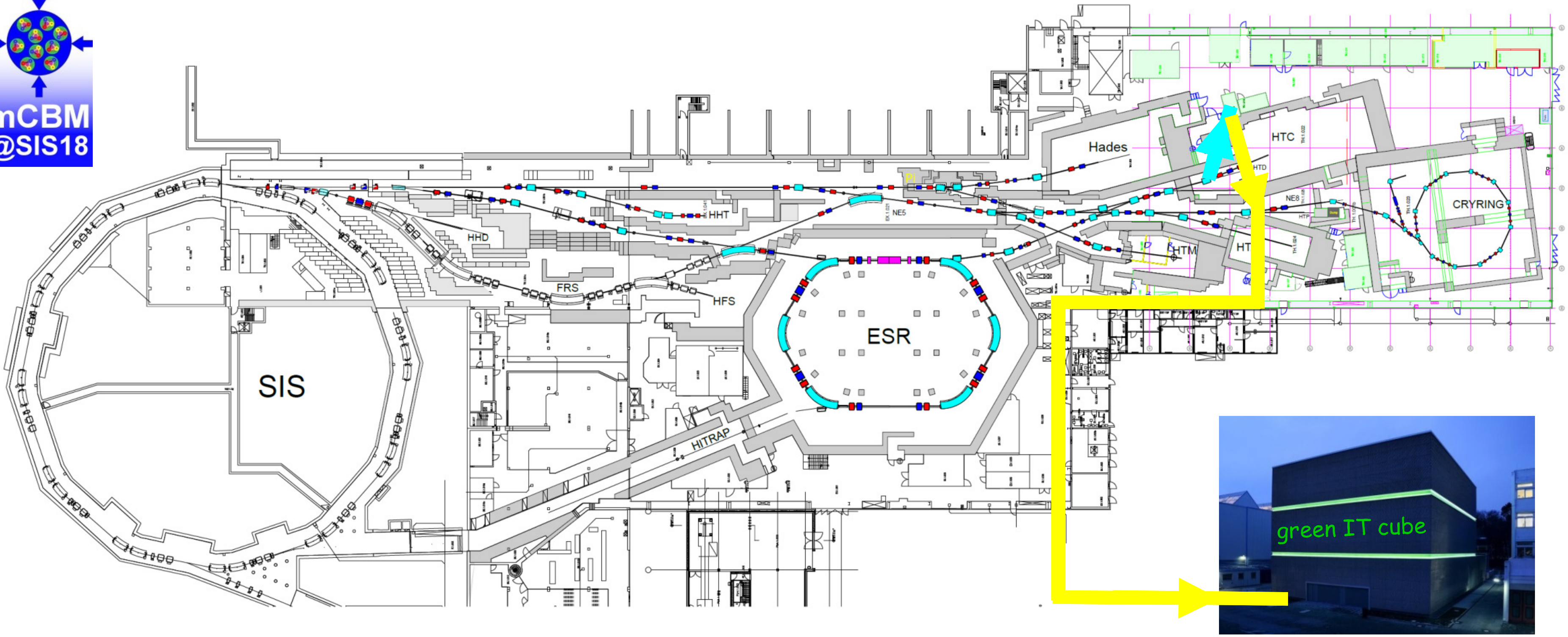
counting house

DAQ container

mCBM cave

Green Cube

mCBM optical link to the Green IT Cube

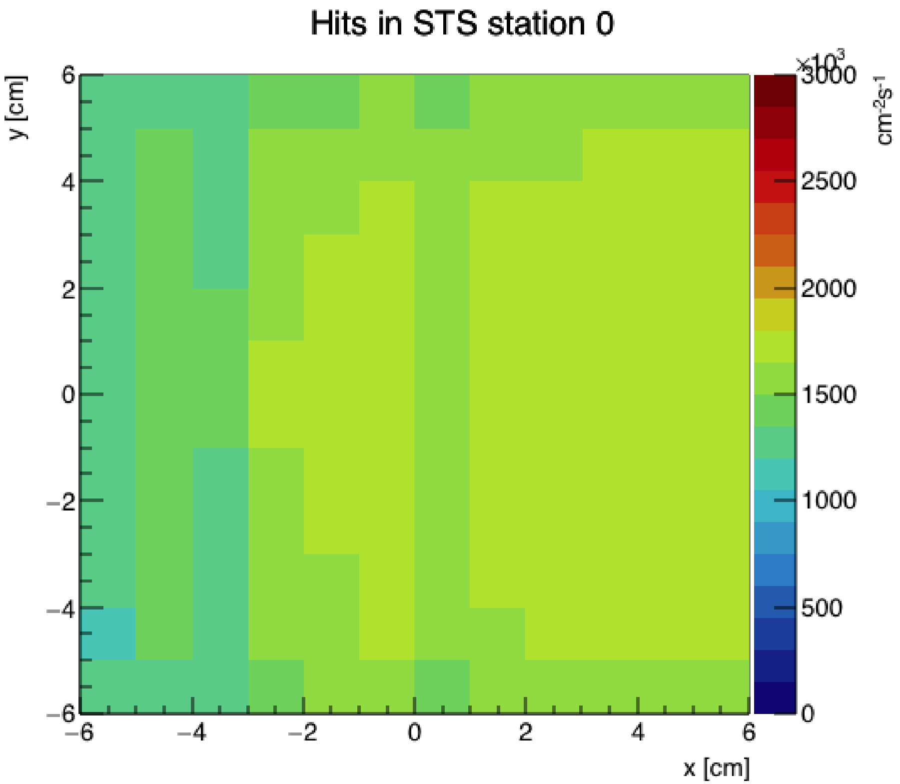


multi-mode fiber cave – DAQ container, about **50m** distance

single-mode fiber DAQ container - GC, about **300m** distance

to be installed in April 2018

Hit rates at mCBM (simulation)

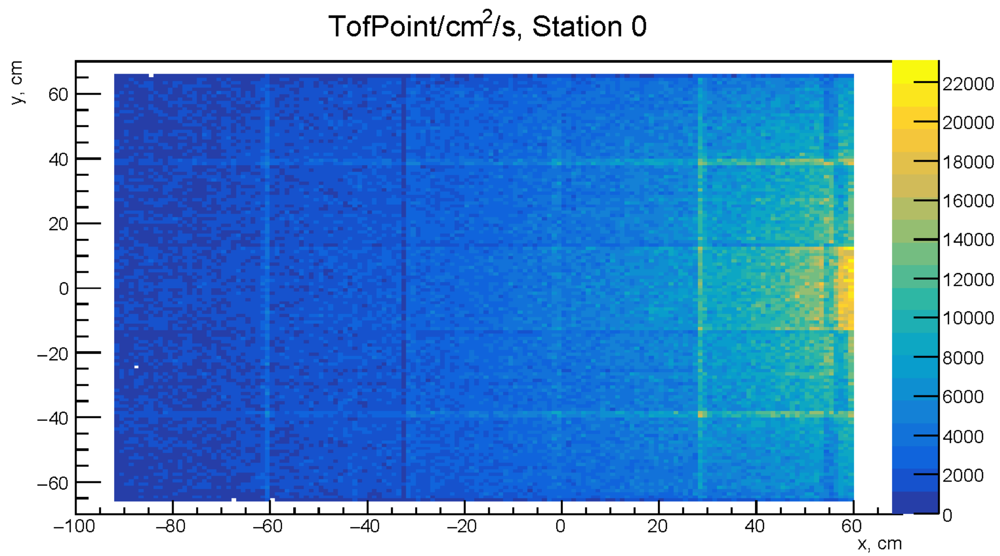


mSTS, 1st station

max. (design) rate: 1.5 MHz/cm²

mTOF

max. (design) rate: 20 kHz/cm²

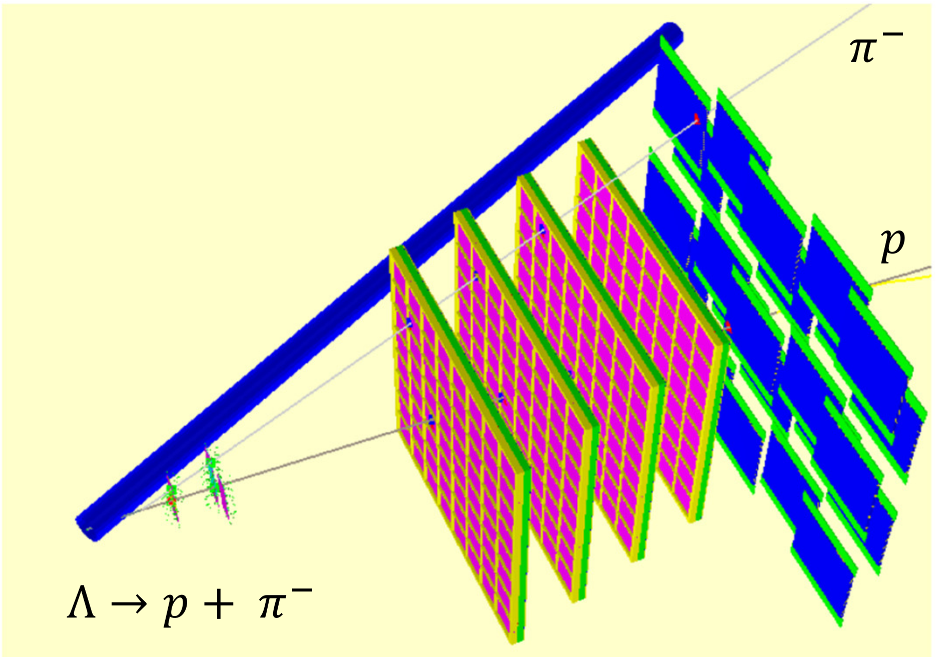


Input:
UrQMD, Au+Au 1.24 AGeV, mbias, incl. δ-electrons

mCBM benchmark observable: Λ reconstruction

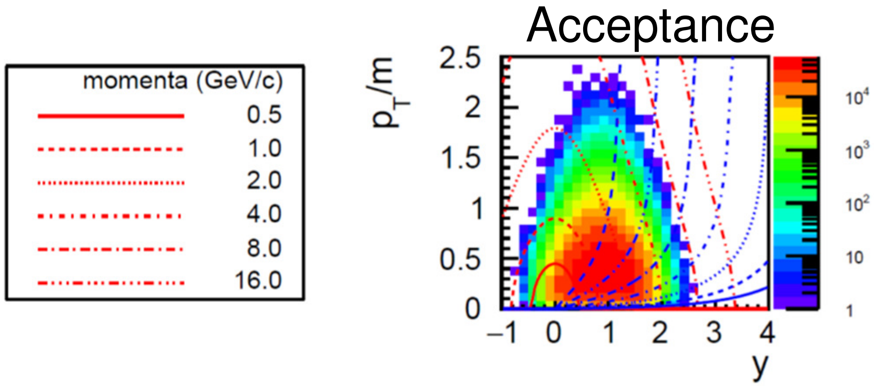
$\Lambda \rightarrow p\pi^-$

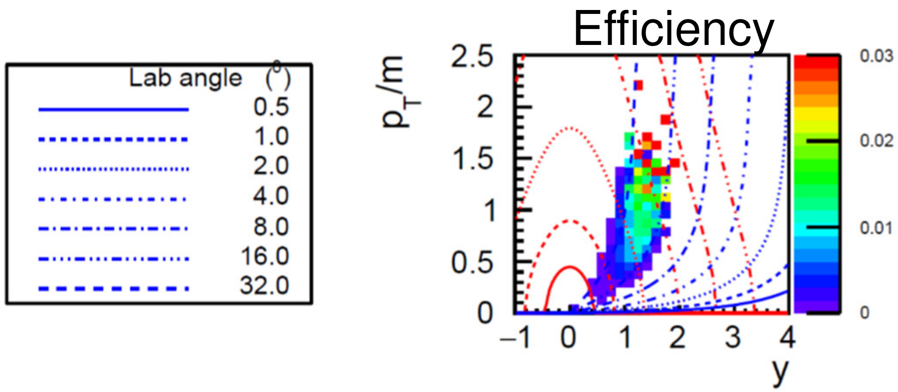
<u>Feasibility study using *mSTS* & *mTOF (3x stations)*:</u>
- straight track candidates *mTOF* → *mSTS* (hit station-0, hit station-1) assuming primary vertex on (0,0,0)
- proton and pion candidate by selection on transverse distance to primary vertex
- momenta from time-of-flight assuming proton and pion mass → p, M_{inv}

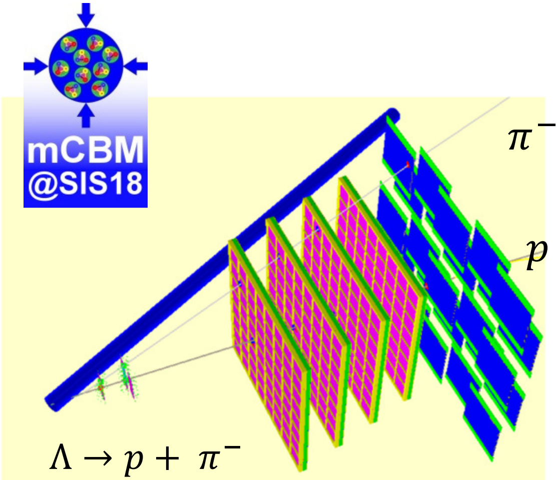


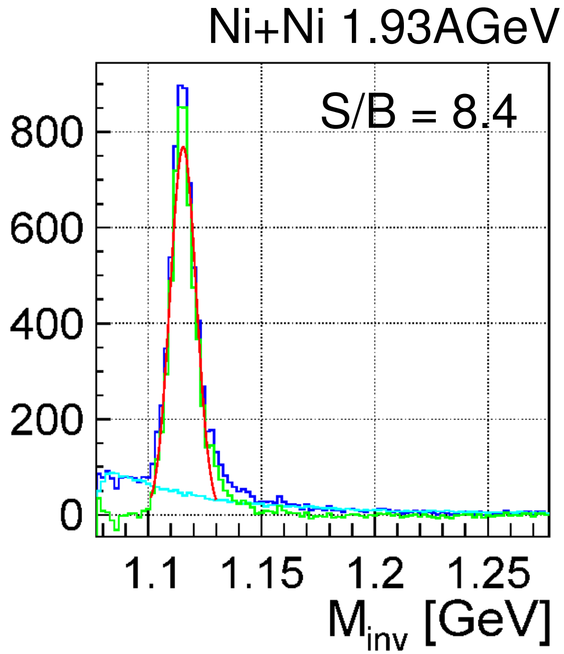
mCBM benchmark observable: Λ reconstruction

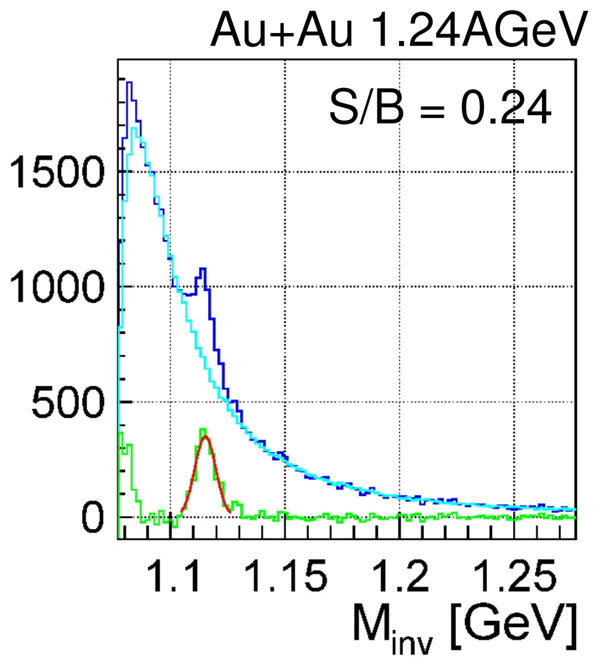
Simulation input: 10^8 UrQMD events, min. bias







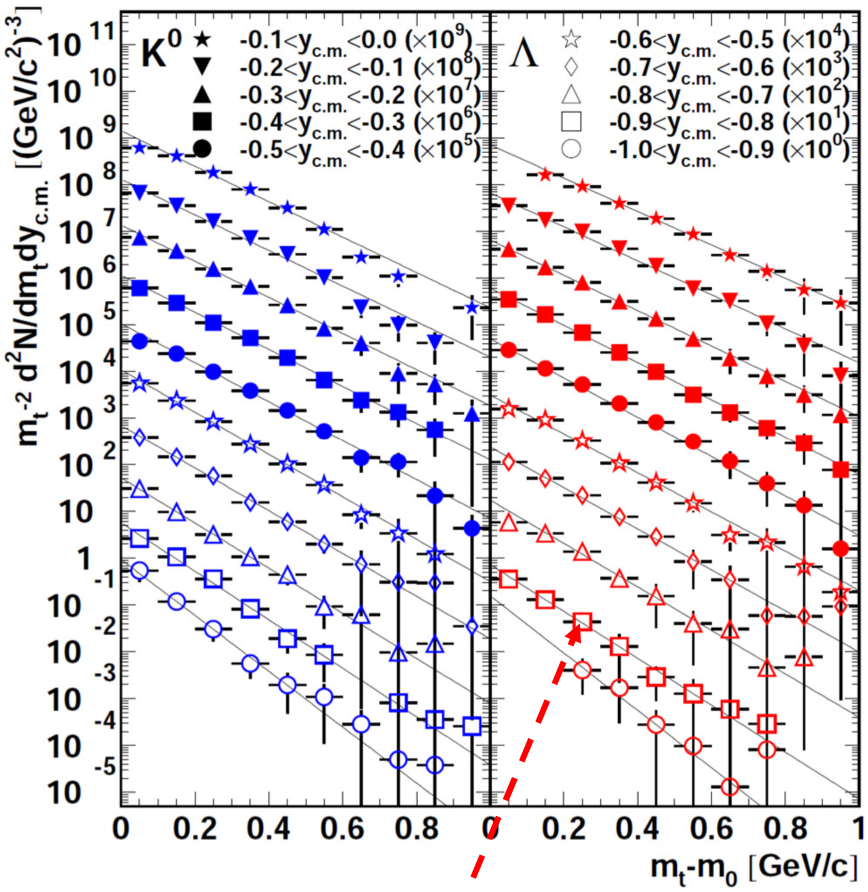




Λ production at SIS18 energies – mCBM reference data

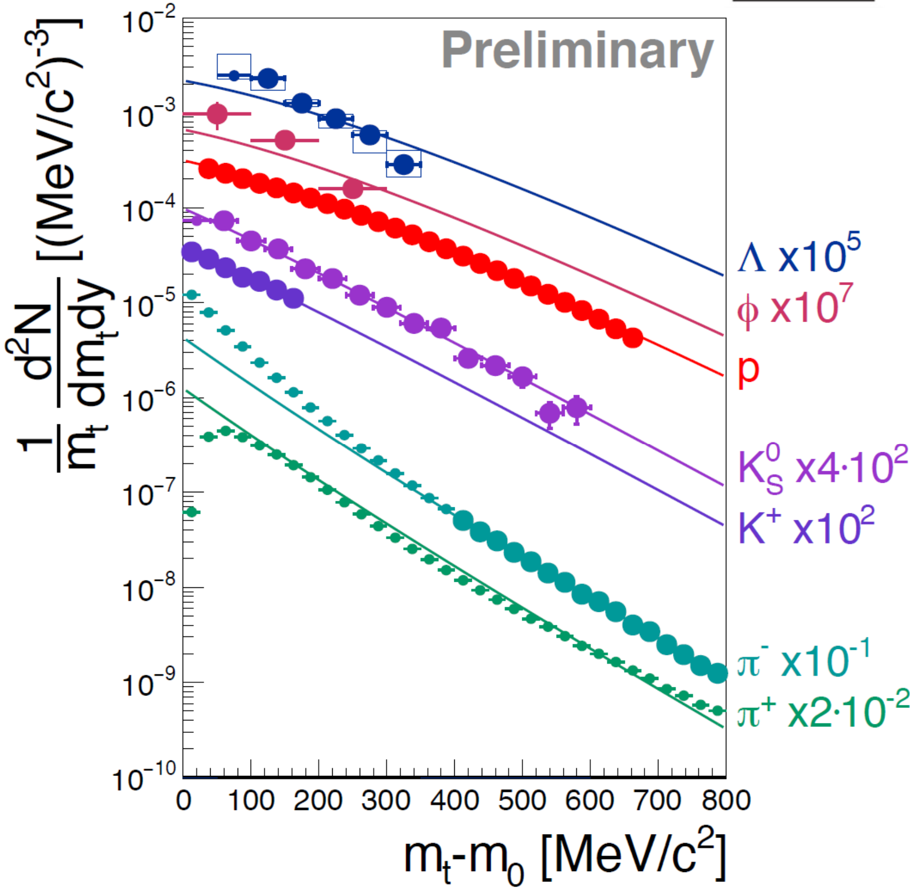
Ni + Ni 1.93 AGeV

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



midrapidity

Au + Au 1.23 AGeV



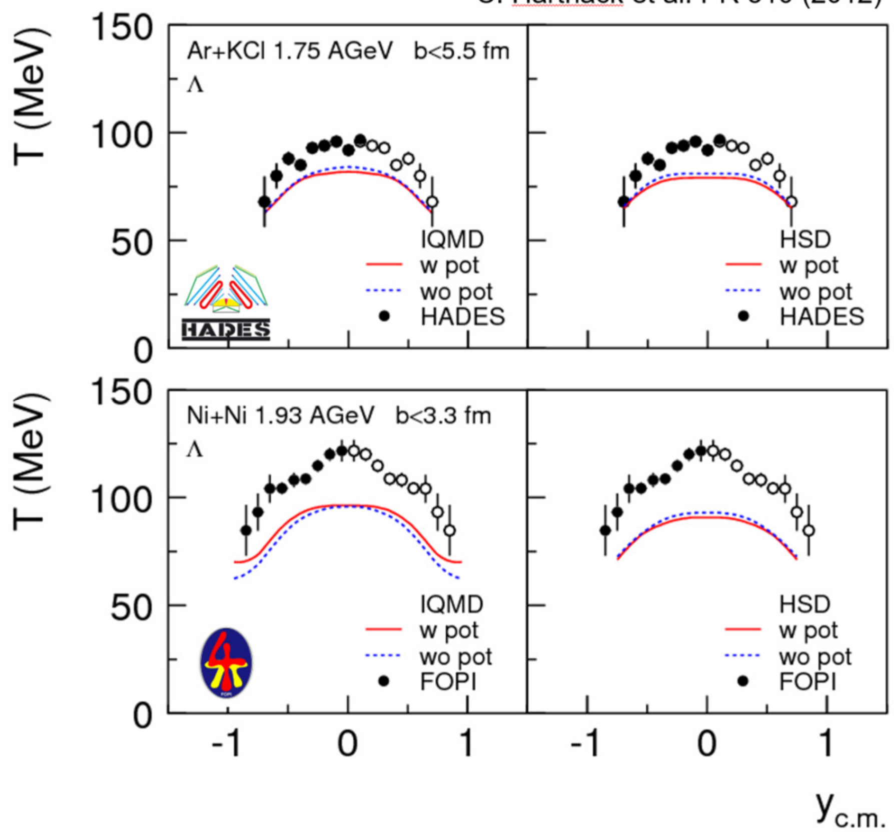
H. Schuldes et al. (HADES)
EPJ Web of Conferences 171, 01001 (2018), SQM2017

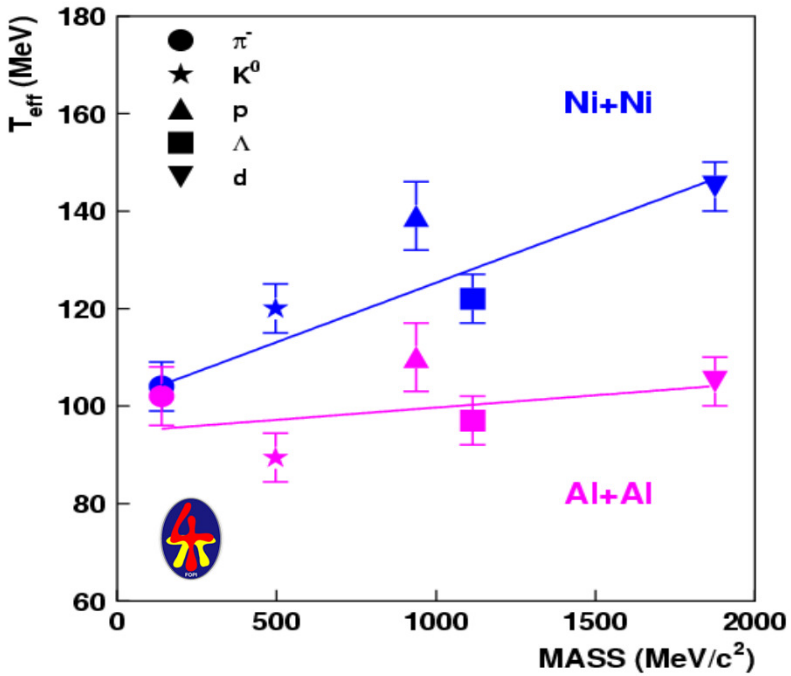
Physics of the benchmark observable

Data:
HADES : Eur. Phys. J. A (2011) 47
FOPI : PRC 76, 024906 (2007)

IQMD transport calculation:
C.Hartnack et al., PR 510 (2012)

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 ?

Backup

CBM intro

Experimental challenges

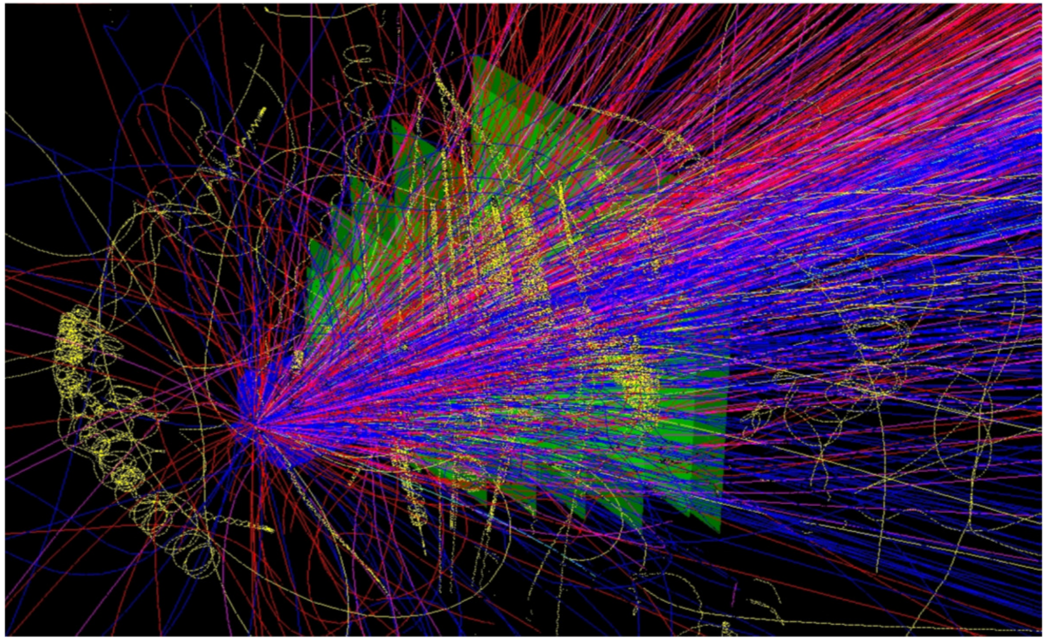
Perform measurements at unprecedented reaction rates

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

→ fast and radiation tolerant detectors

→ free-streaming read-out electronics

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



Central Au+Au at 25 A GeV / UrQMD+GEANT4
160 p, 450 $\pi^+ + \pi^-$, 44 K^+, 13 K^-

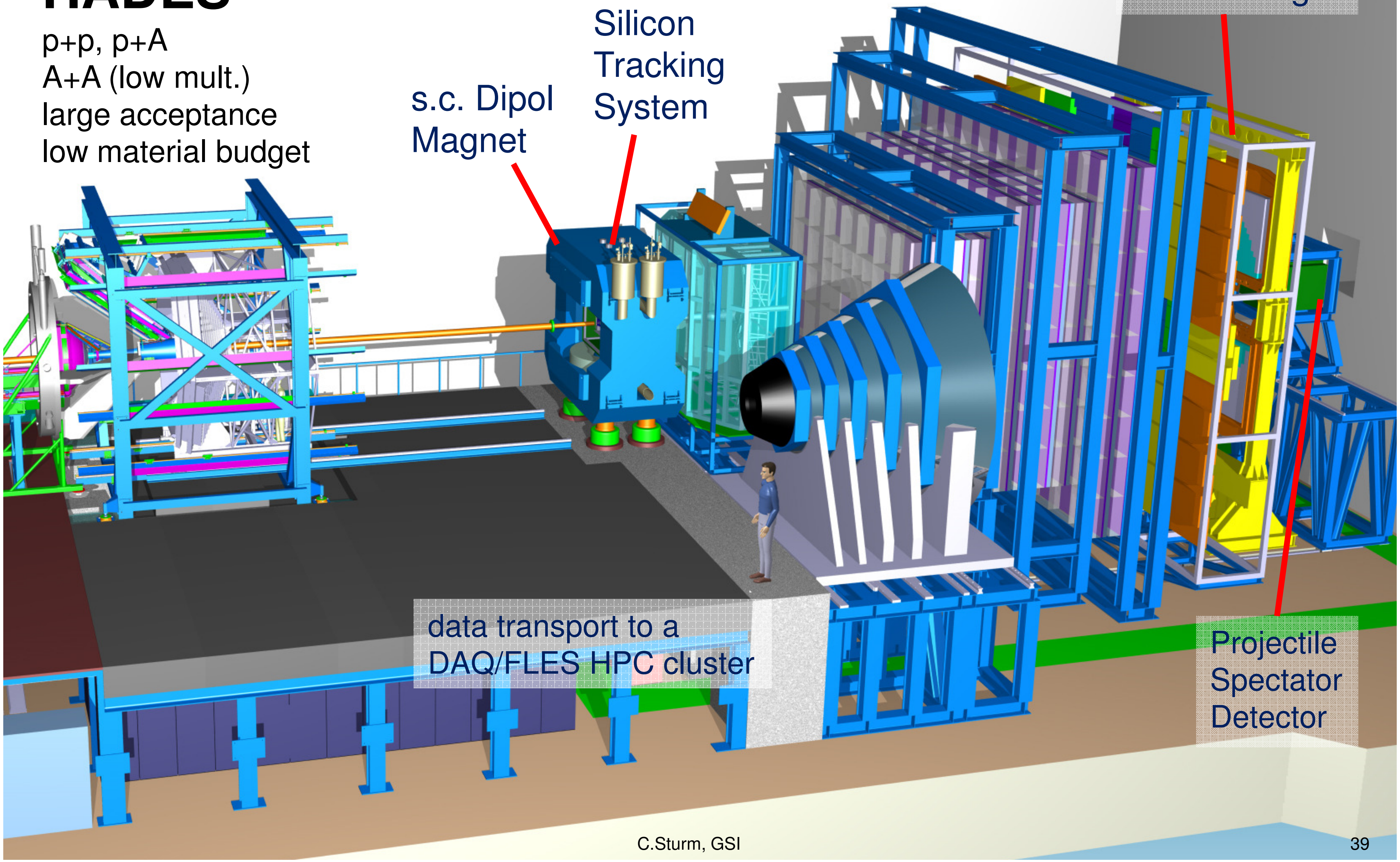
Identification
of leptons and hadrons

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

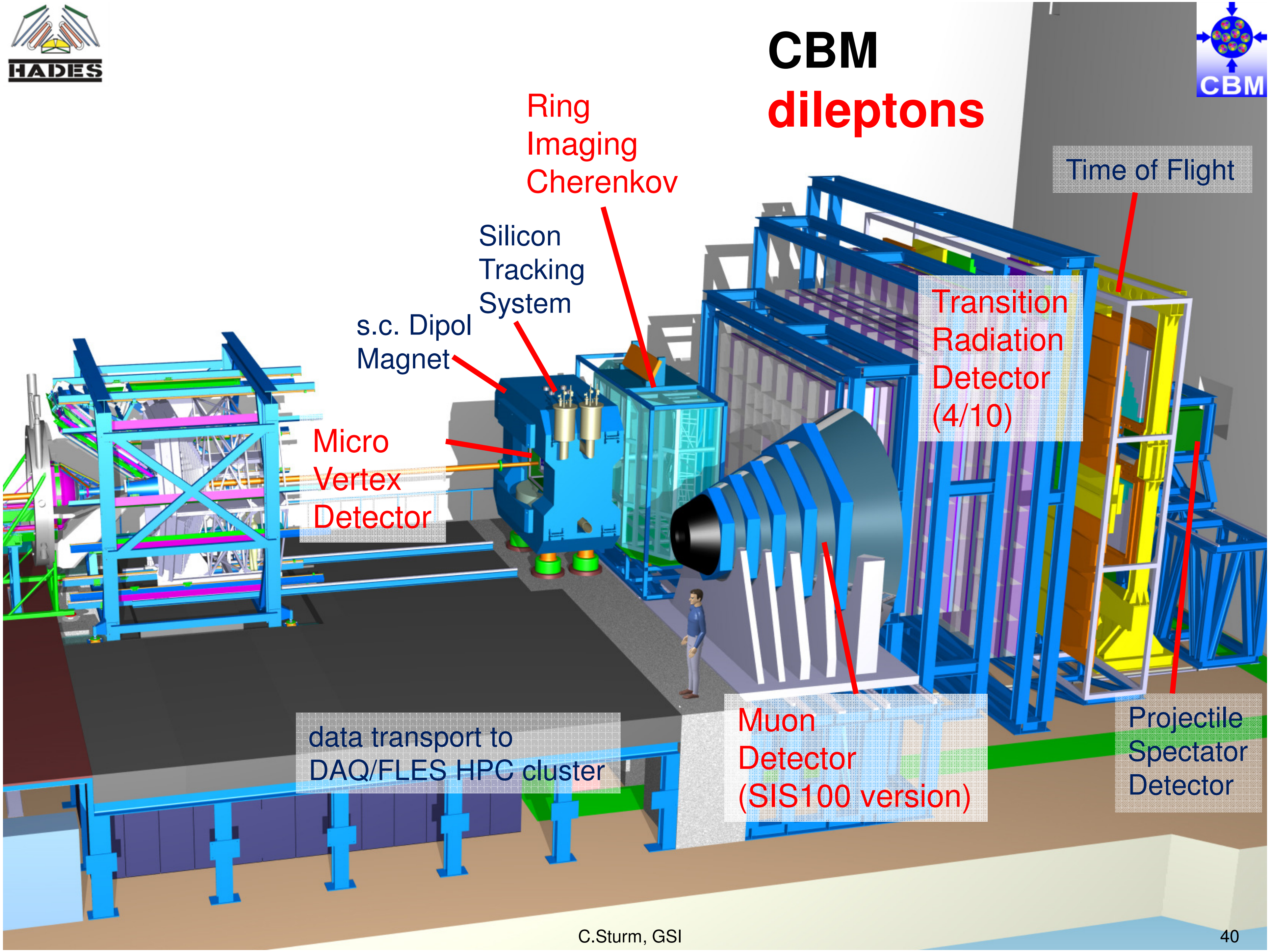
momentum resolution
$\delta p / p \cong 1\%$

CBM
hadrons

HADES
p+p, p+A
A+A (low mult.)
large acceptance
low material budget



CBM
dileptons



CBM Collaboration: 55 institutions, 470 members

China:
CCNU Wuhan
Tsinghua Univ.
USTC Hefei
CTGU Yichang
Chongqing Univ.

Czech Republic:
CAS, Rez
Techn. Univ. Prague

France:
IPHC Strasbourg

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

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NIPNE Bucharest
Univ. Bucharest

Hungary:
KFKI Budapest
Eötvös Univ.

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

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