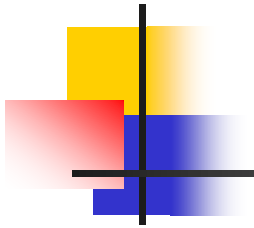


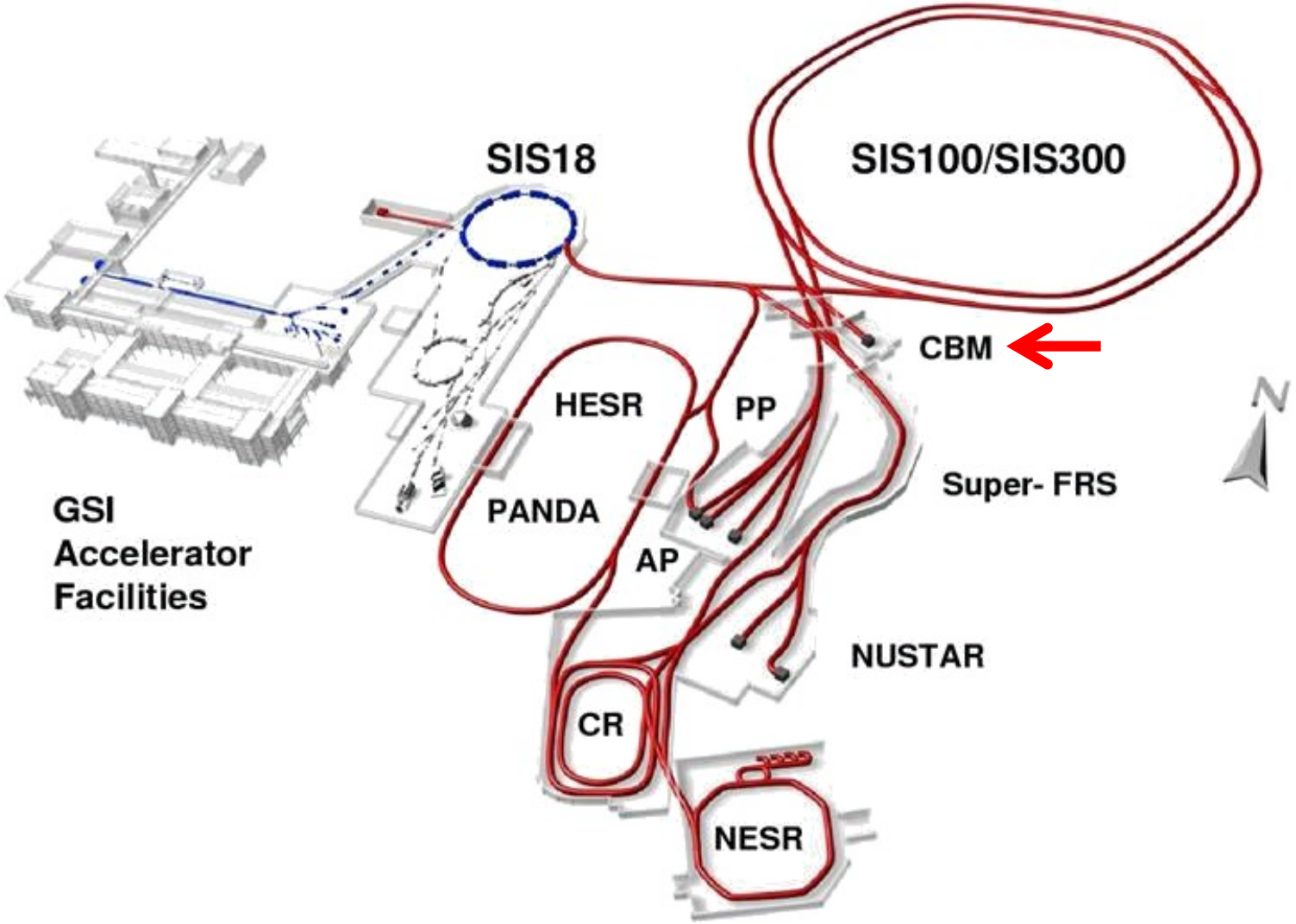
GEM R&D for CBM@FAIR

U.Frankenfeld GSI Darmstadt

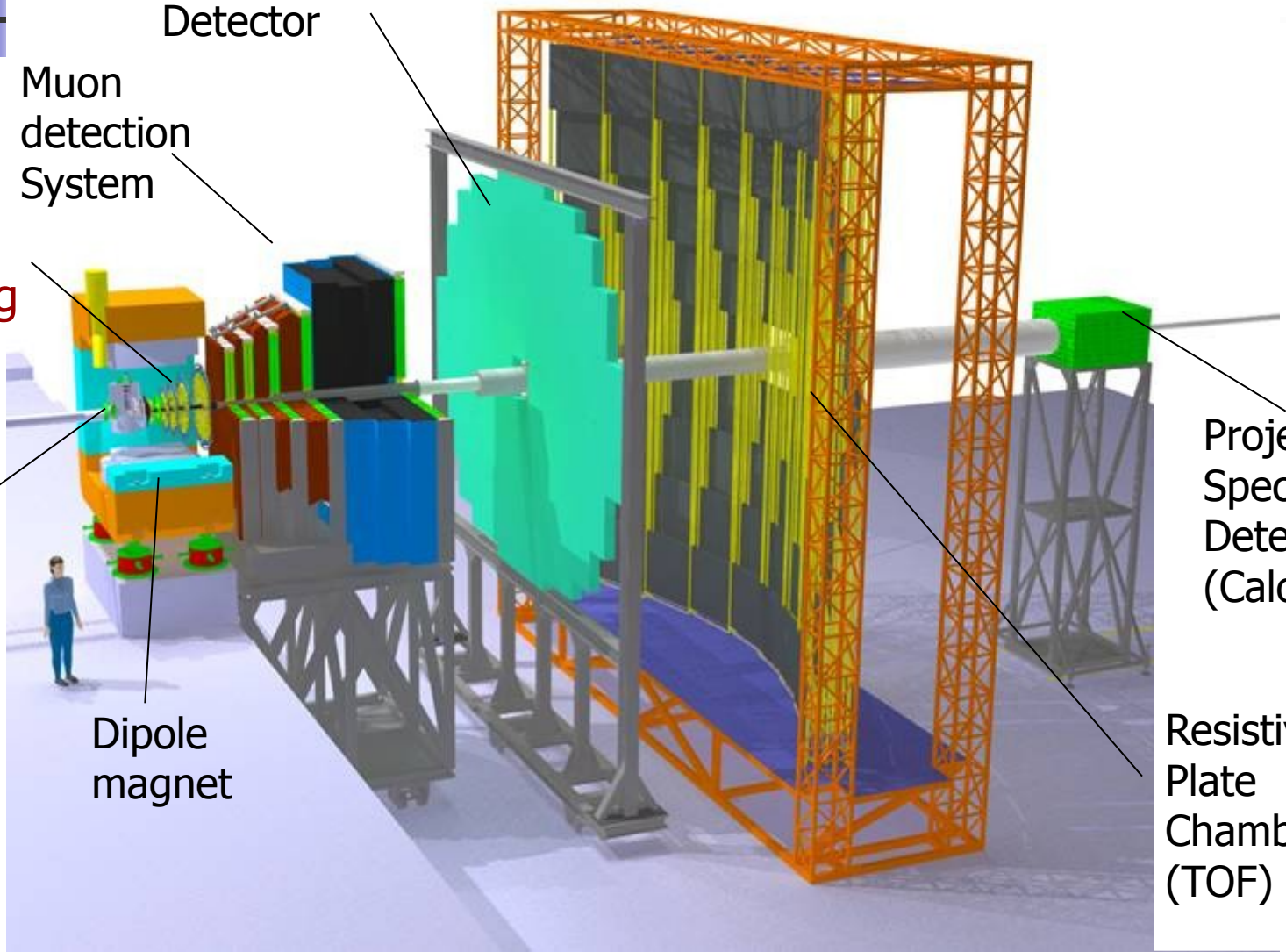
Outline

- The CBM Experiment @ FAIR
  - Muon Sub-detector
  - GEM-based Layout
  - Experimental Conditions
- GEM R&D and Tests
  - Beam Test at SPS
  - Laboratory Tests

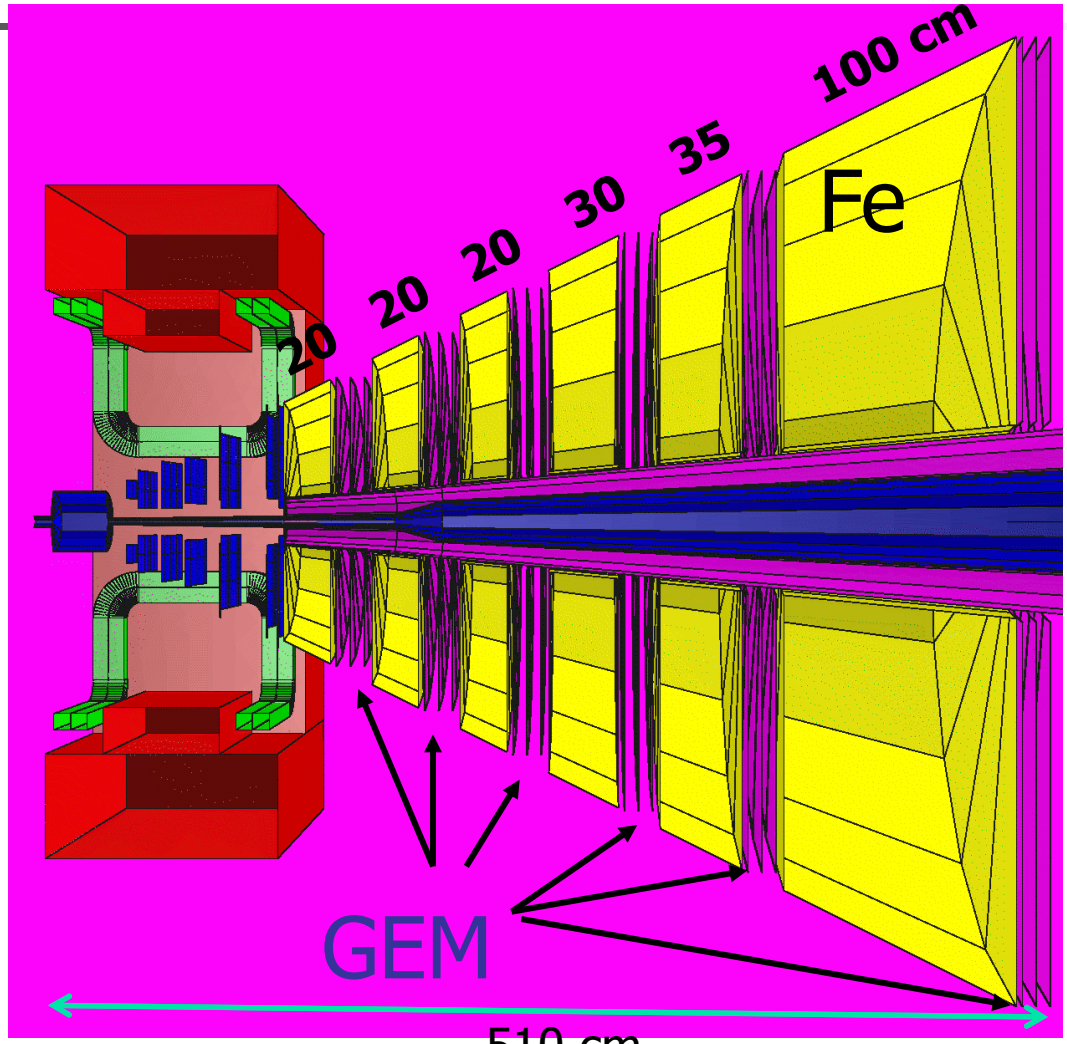
New FAIR Accelerator Center



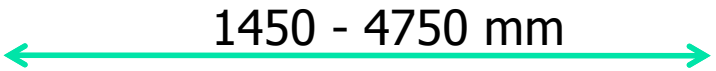
The CBM Experiment

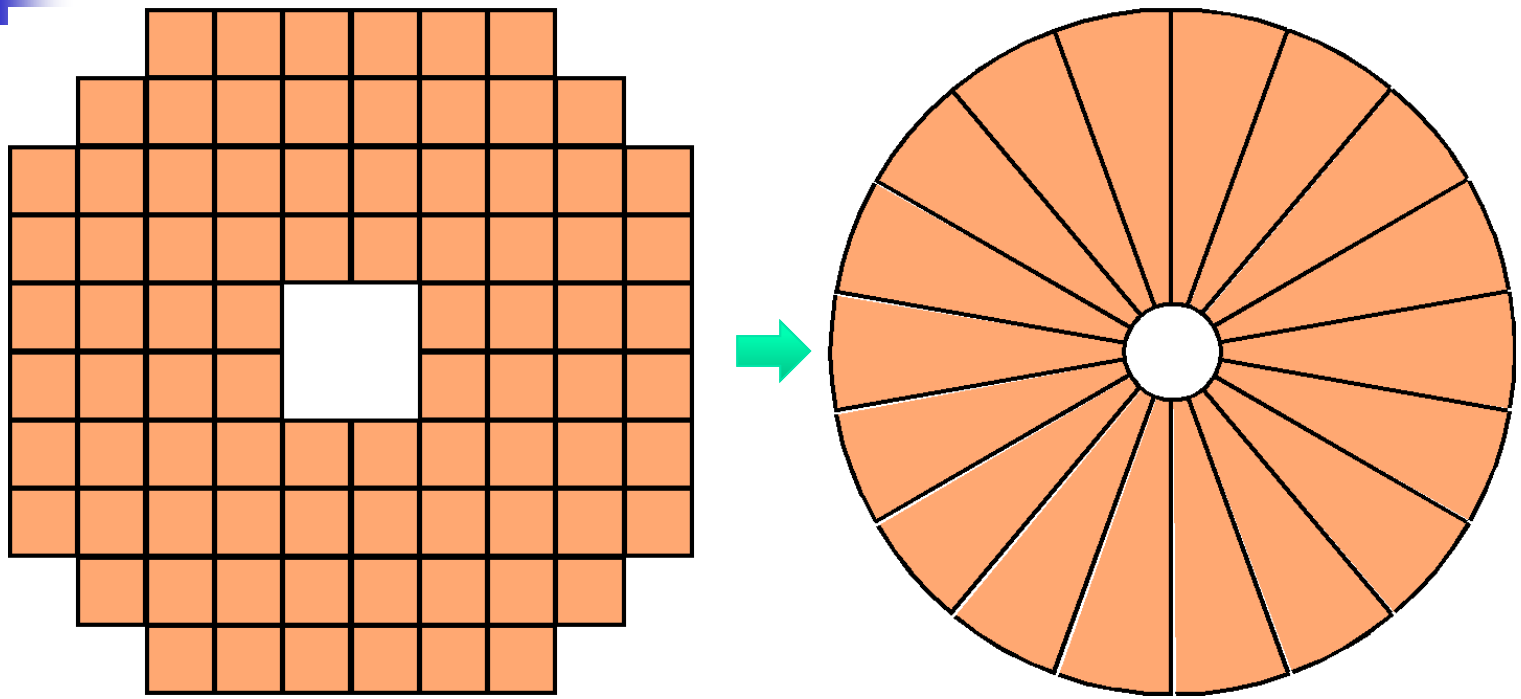


Muon Detection System: MUCH



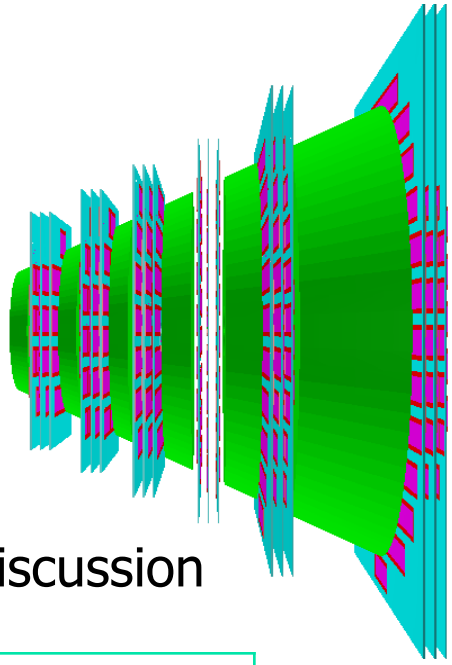
New Tracking Station Layout





- old layout
  - based on 30 x 30 cm^2 double mask GEMs
- new layout
  - based on large area single mask GEMs
- CBM baseline option

Much GEM Area

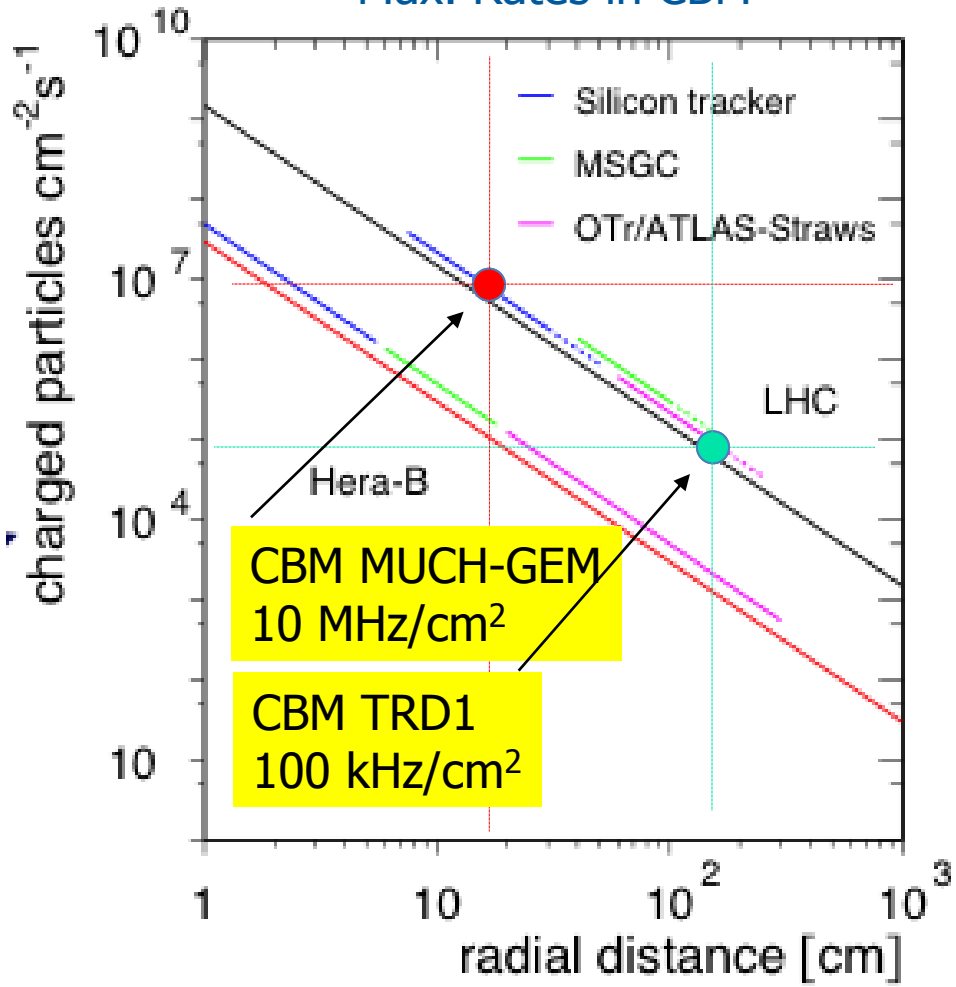


- standard layout:
  - 6 (5) stations each 3 layers of triple GEMs
  - stations using MicroMegas or Straws under discussion

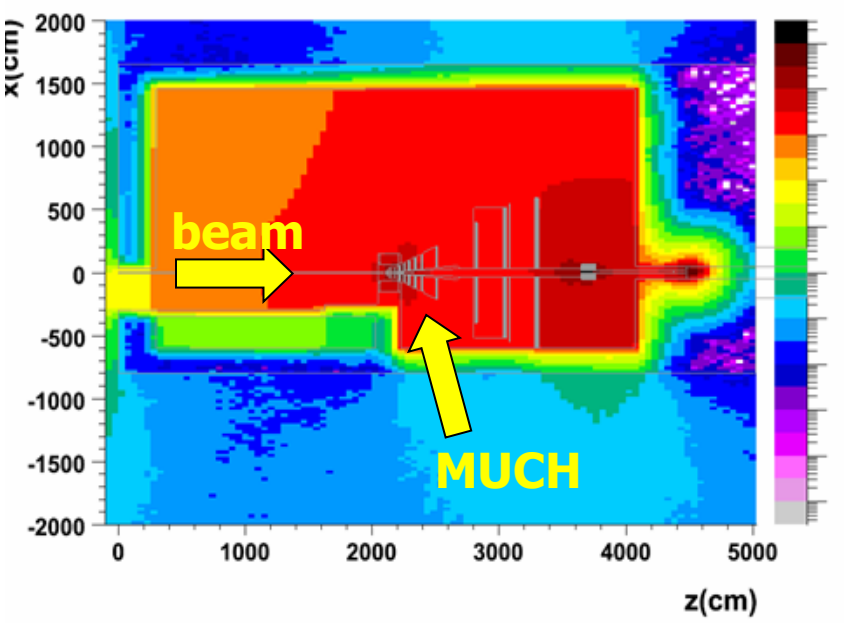
station	distance to target [cm]	Diameter [cm]	GEM area [m^2] (3 triple GEMs)
1	155	145	4.6
2	205	190	8.1
3	255	240	12.5
4	315	300	19.1
5	380	355	28.1
6	510	475	50.3
all			73/123

Particle Rates Dose @ LHC DESY FAIR

Max. Rates in CBM

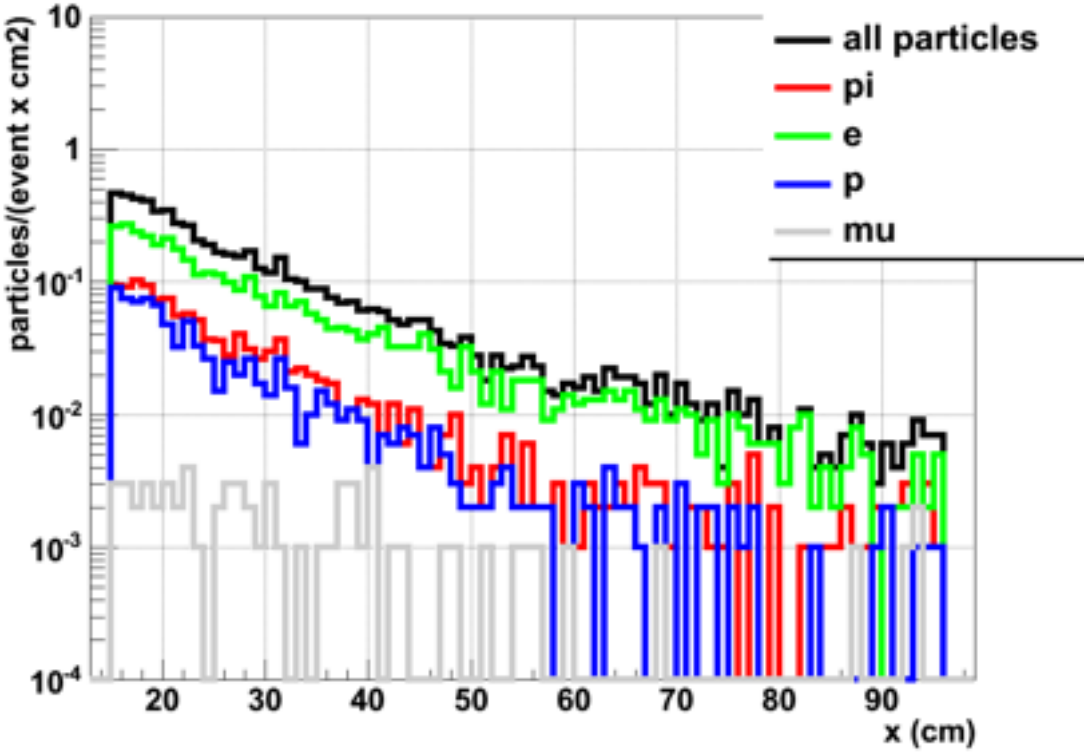


Neutron fluence in CBM cave
(FLUKA –simulation)



Typical operation scenario:
6 years ⇒ 10^{13} - 10^{15} n_{eq}/cm^2
⇒ radiation hardness regime of LHC experiments

Particle Composition in MUCH



- Radial density profile of secondary particles at the first detector plane (after 20 cm Fe) of the CBM Muon Detector for central Au+Au collisions at 25 AGeV.
- The maximum particle density is 0.5 particles/cm^2/event (event rate 10^7)

Discharge Probabilities for Slow Hadrons

Performance of GEM detectors in high intensity particle beams

S. Bachmann[a], A. Bressan[a], B. Ketzer[a], M. Deutel[a], L. Ropelewski[a], F. Sauli[a,*], A. Bondar[b], A. Buzulutskov[b], L. Shekhtman[b], A. Sokolov[b], A. Tatarinov[b], A. Vasil'ev[b], S. Kappler[c], E. Schulte[d]

[a] *CERN, EP Division, 1211 Geneva 23, Switzerland*
[b] *Budker institute of Nuclear Physics, Novosibirsk, Russia*
[c] *University of Karlsruhe, Germany*
[d] *University of Helsinki, Finland*

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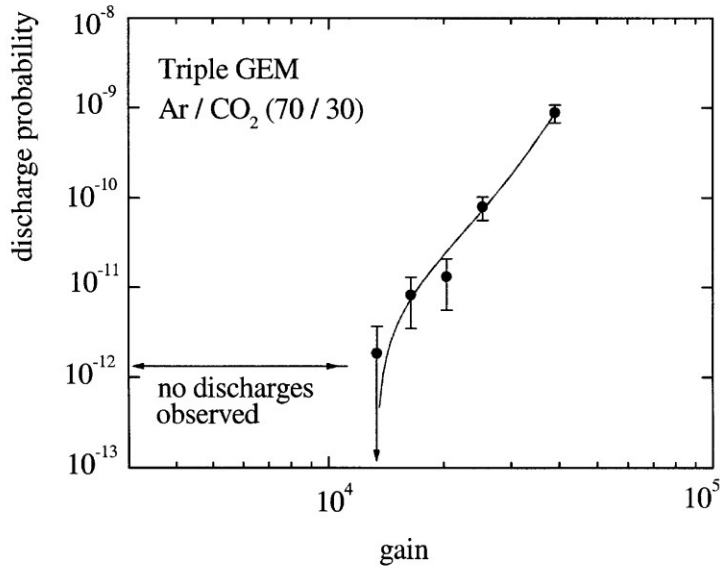


Fig. 22. Discharge probability per incident particle for the Triple GEM measured at the PSI πM1 beam.

- beam rate: 10^7-10^8 π/s (215/325) MeV
- (8 kHz/mm^2)
- spark rate independent of particle flux
- significantly increased spark rate for admixture of 63 MeV protons (6 x MIP)

R&D Tasks

- measure discharge probability for CBM conditions
  - SPS conditions (max rate)
  - slow, heavily ionizing particles after first absorbers
- tracking efficiency for muons with and w/o hadronic environment
- efficiency (with VFAT digital chip)
- cluster size & resolution (with VFAT digital chip)

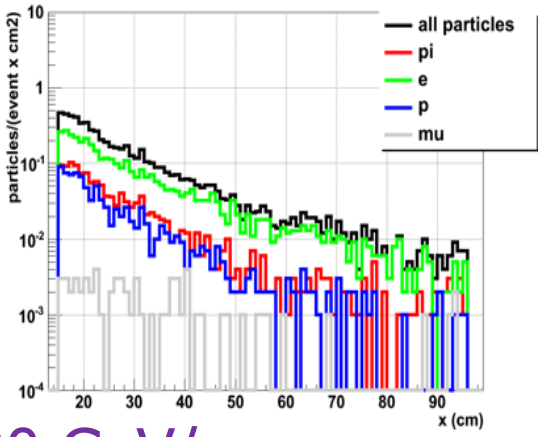
beam tests
Scheduled
10-16 Oct
(CBM Fair)
@ CERN SPS

- further studies include
  - gain homogeneity
  - longterm stability, ageing
  - rate capability
  - more discharge studies using an α-source

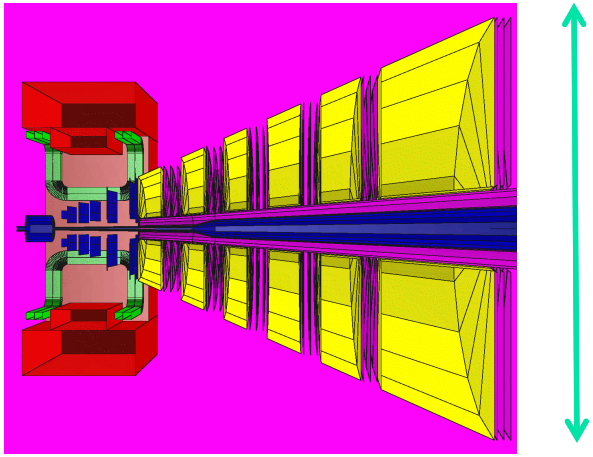
lab tests
@ GSI

Why SPS beam?

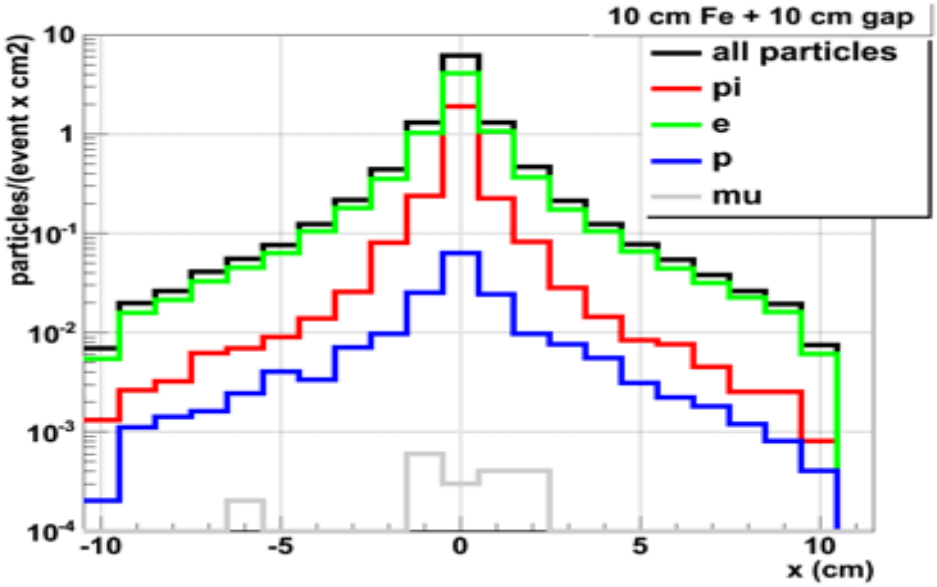
CBM:

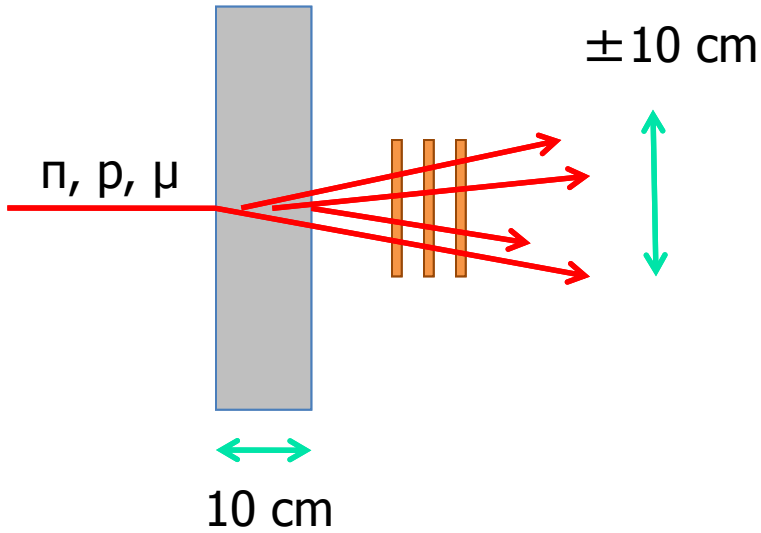


±100 cm



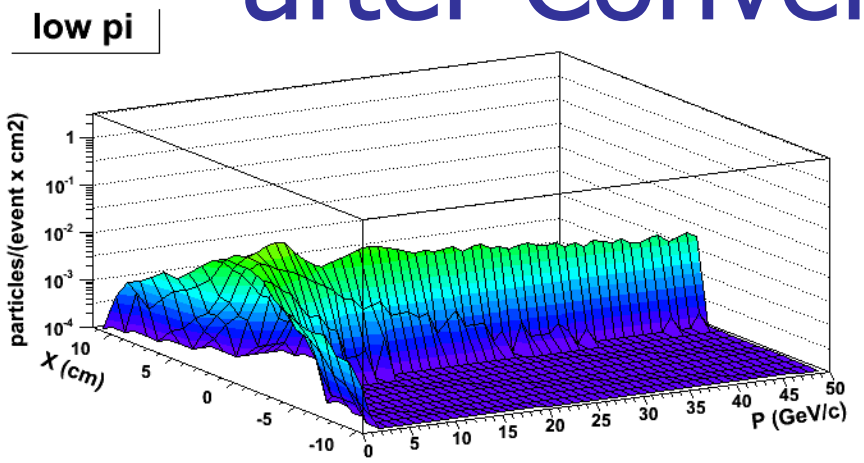
SPS @ 200 GeV/c:

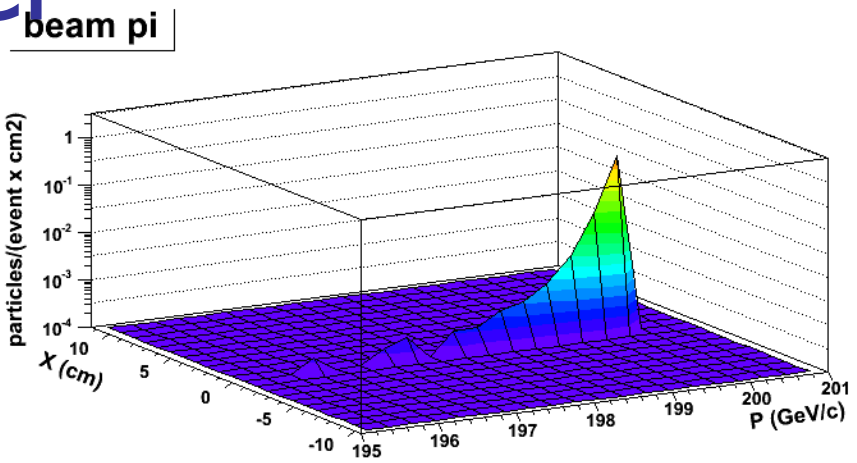




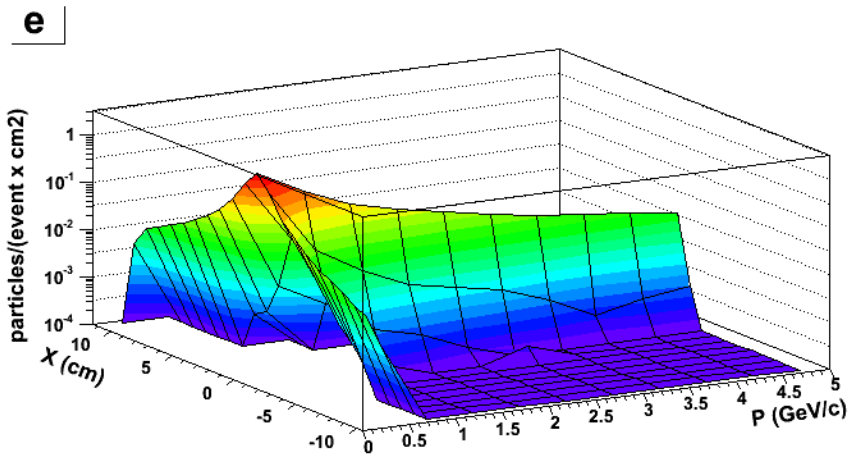
Mini-MUCH (scale 1:10)

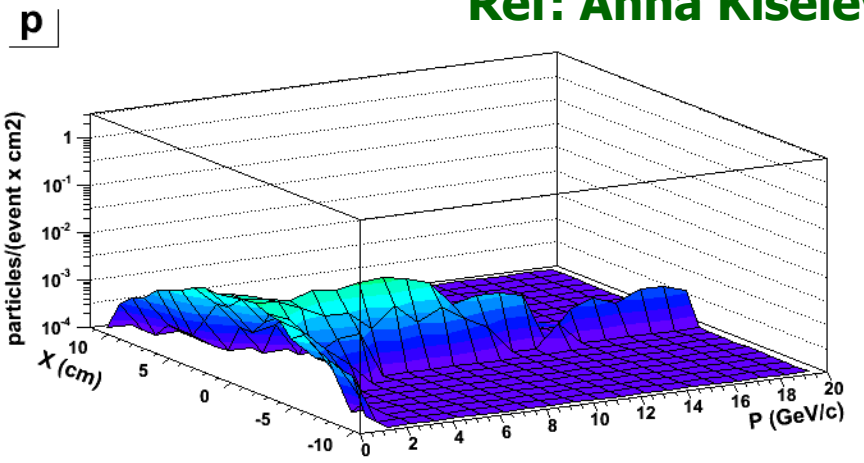
Energy Profiles Test Beam after Converter





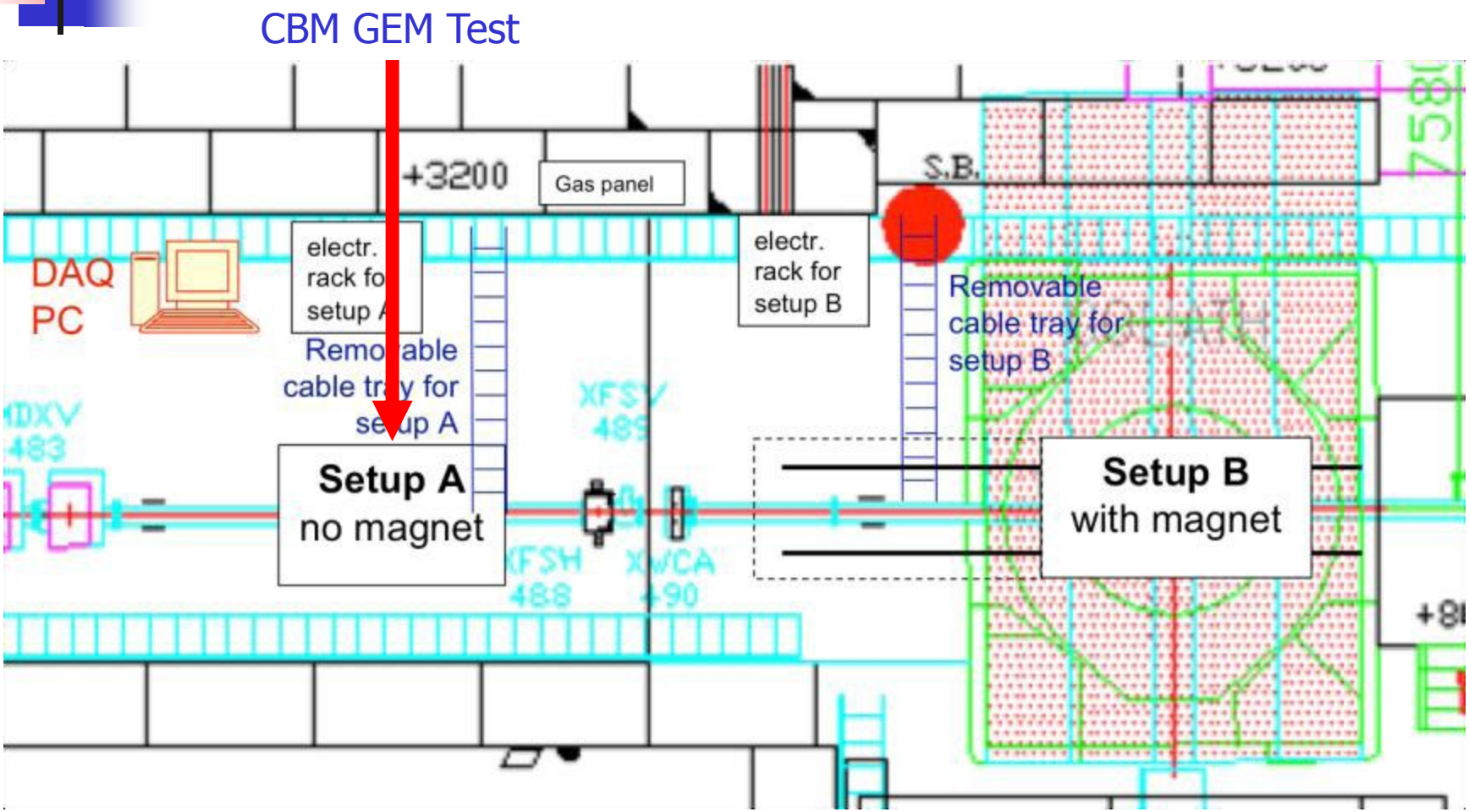
Ref: Anna Kiseleva



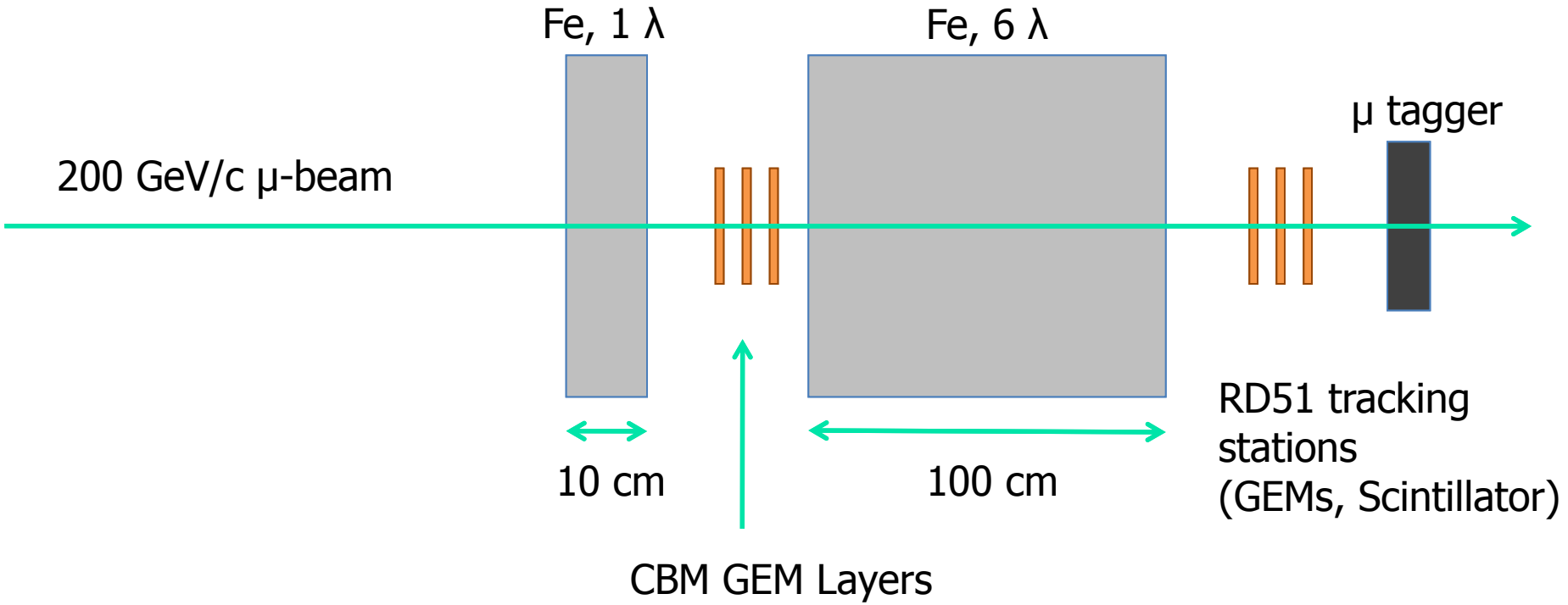


- Showers contains slow protons and pions, which are potentially harmful for GEMs

H4/RD51 Test Area

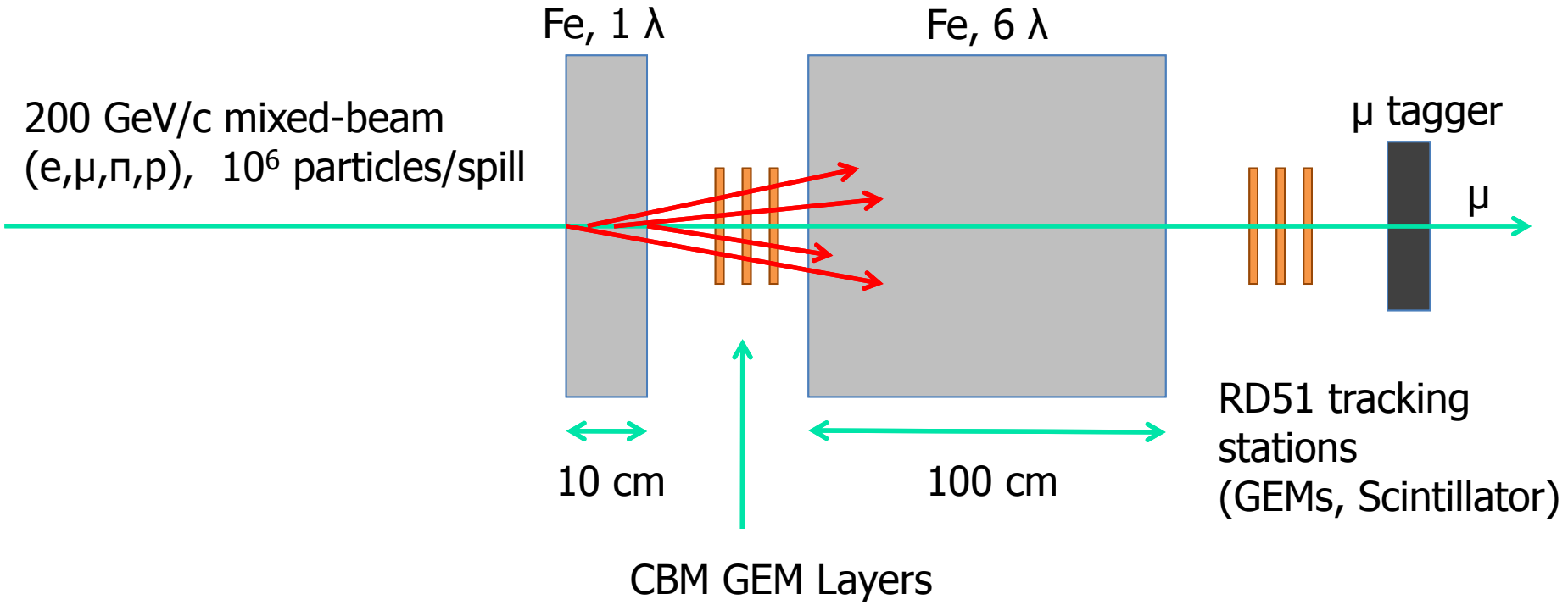


Proposed Setup for Beam Test@H4 beamline (CERN-SPS) Reference



- measurement of tracking efficiency with "clean" μ-beam, at least one CBM GEM layer (3 triple GEMs)

Proposed Setup for Beam Test@H4 beamline (CERN-SPS) Measurement



- measurement of spark probability
- measurement of μ tracking efficiency with mixed beam, hadrons shower up in converter (maybe 5-10% chance coincidence of beam μ with hadronic shower)

Beam Test Preparation

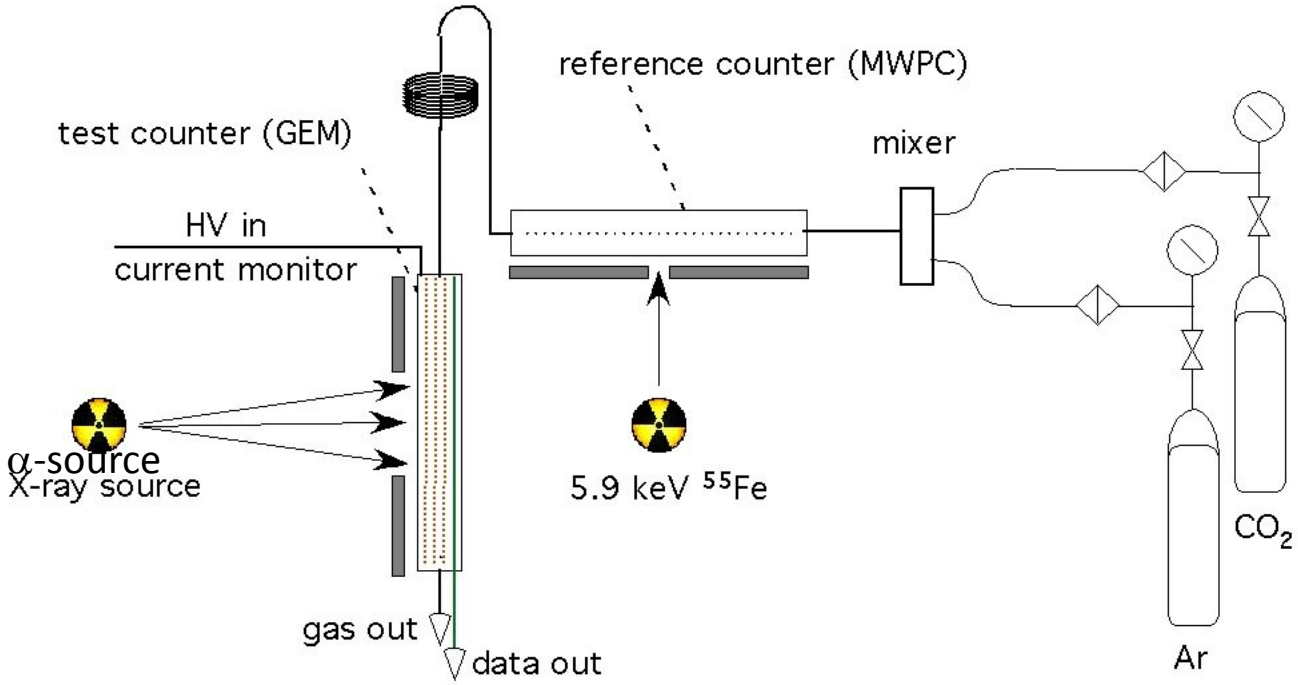
- Area Layout:
  - floor space for iron converter/absorber
  - beam intensity/ radiation check -> additional area shielding?
  - table/mounts for GEMs
  - geometry survey?
- Desired infrastructure from RD51/H4:
  - Gas distribution
  - DAQ (for VFAT/Turbo board)
  - HV

Rate and Int. Charge: Comparison

	Rate [kHz/cm^2]	**Gas Gain**	**No. of Total Electrons**	**Charge (10 y) [C/cm^2]**
CMS forward tracker (LHC)	~1	~8000	Ar/CO2 (70:30) = Nt (3mm gap) = 31.2 Ar/CO2/CF4 (45:15:40) = Nt (3mm gap) = 31.9	0.01
CMS forward tracker (sLHC)	10-50	~5000	same as above	0.5
CBM typical	1-100	1000	30	<0.15
CBM max (first station)	10000	1000	30	15

- integrated charge/cm^2 at FAIR-CBM significantly higher than sLHC - $\Rightarrow$ ageing behavior investigation under intense hadron radiation

GSI DetLab Test Setup



- irradiation of (selected) areas of Single Mask-GEM with x-rays (10x kHz/cm2) for several month
- recording of gain (pulseheight, current), gas quality, environmental parameters (T, p, ….)

Summary

- Positive Reports on RD51/CMS large area single mask GEMs at CBM Much workshop 01/2011 at GSI -> now baseline option for CBM
- GEMs as tracker behind absorbers -> intense hadron (shower-like) environment with slow component
- test setup in with 200 GeV beam in H4 with converter/absorber to simulate typical hadron environment
  - Support from RD51 very MUCH appreciated
- lab setup for stability/ageing measurement (>10 C/10 years integrated charge/cm^2)

Team SPS beamtest

- GSI:
  - Saikat Biwas, PostDoc
  - Chilo Garabatos, senior staff (presently at CERN)
  - Uli Frankenfeld, senior staff
  - Jörg Hehner, Engineer
  - + CBM personnel
- PI Tübingen :
  - Rudi Schmidt, senior staff
  - Jens Wiechula, staff
  - Benedikt Plasa, student
- India:
  - NN
- In collaboration with CERN:
  - Archana Sharma, CMS forward tracker upgrade spokesperson
  - Stefano Colafranceschi, PhD student
- ….