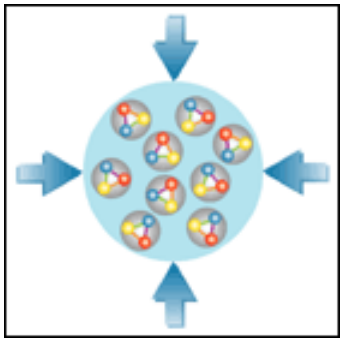
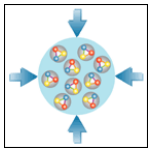
The CBM experiment at FAIR



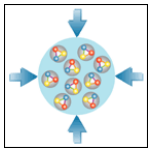
Walter F.J. Müller
CBM Technical Coordinator
FAIR, Darmstadt

Journées FAIR-France
17-18 May 2017



The CBM Detector Setup

Rare Probes → High Rates



- Key observables are rare probes
  - either low cross section (e.g. Ω^+,d, or J/Ψ)
  - or low branching ratio (e.g. ρ,ω,φ → e^+e^-)
- High interaction rate
  - design point: 10^7 Au+Au int/sec @ 11 A GeV
    → high count rate detectors
    → significant radiation level for FEE
- Selective triggers
  - key triggers are 'tracking triggers' (decay topology)
    → *no hardware trigger, 'data push' architecture*
    → *event selection in software*
    → high DAQ bandwidth
    → high computing requirements

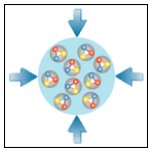
Required FAIR Infrastructure: SIS100+Cave

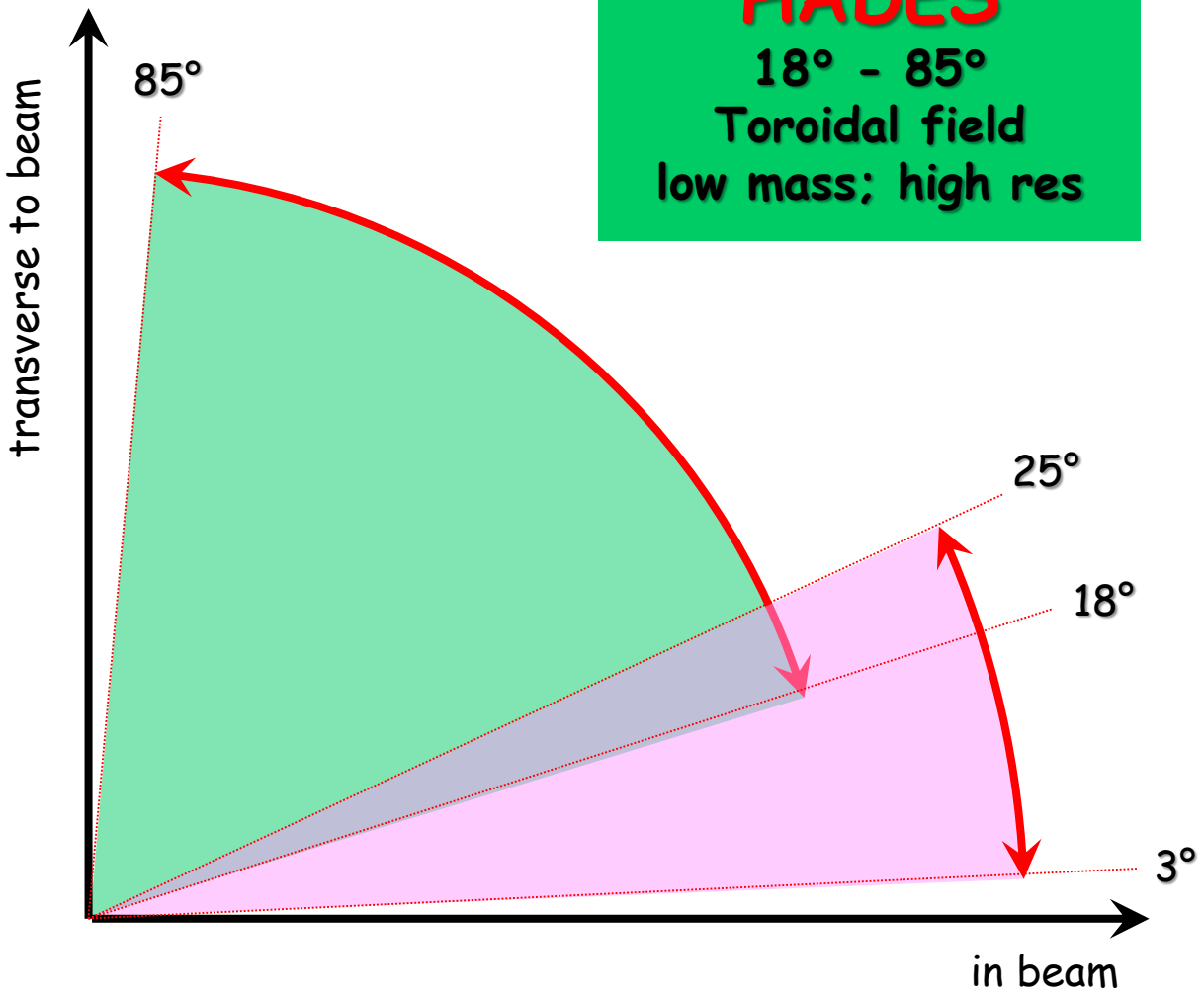
- 10^9/s C, Ca, ... up to 14 GeV/u
- 10^{11}/s p up to 29 GeV

FAIR phase 1

FAIR phase 2

HADES & CBM: Complementary Setups

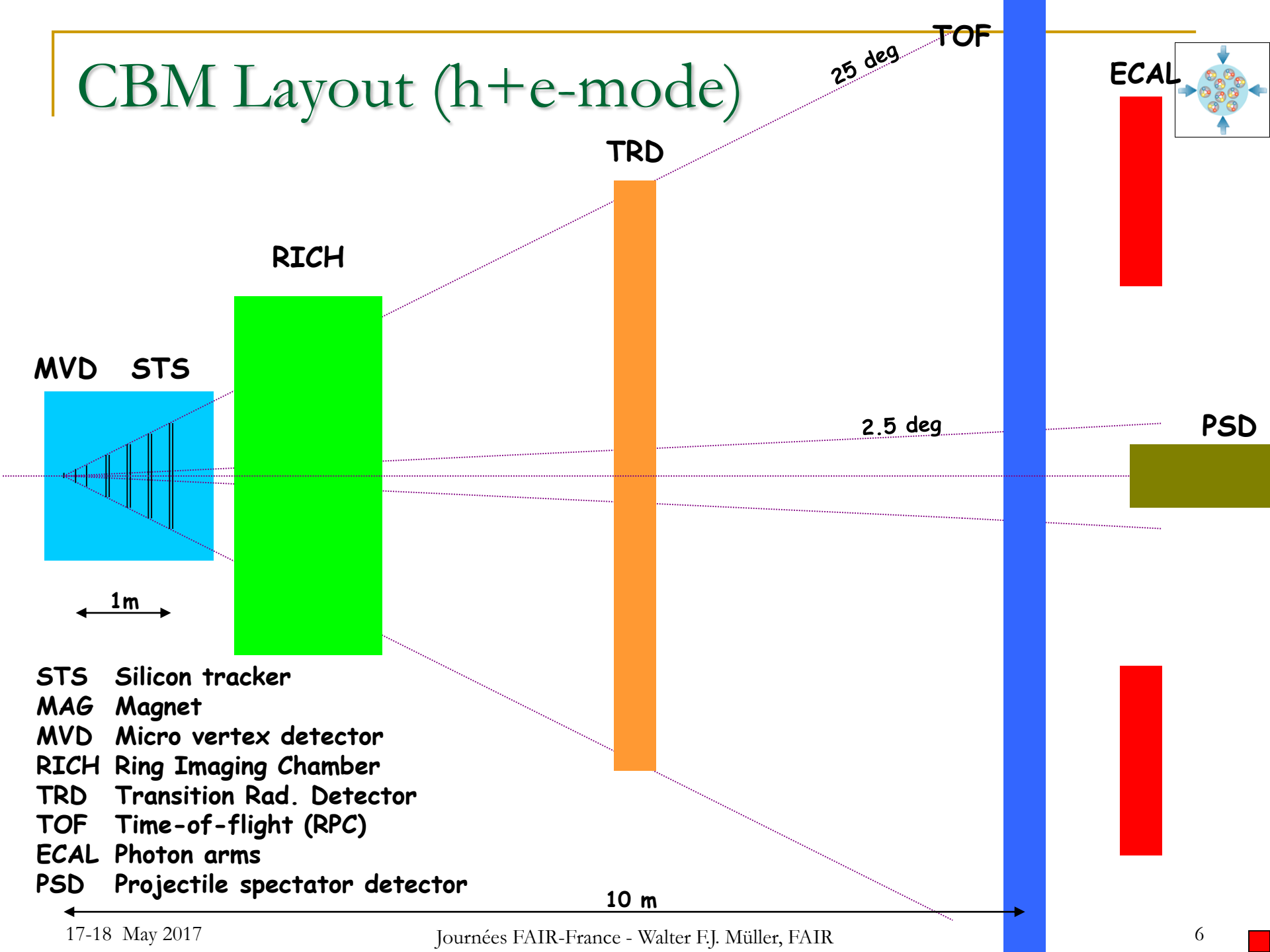




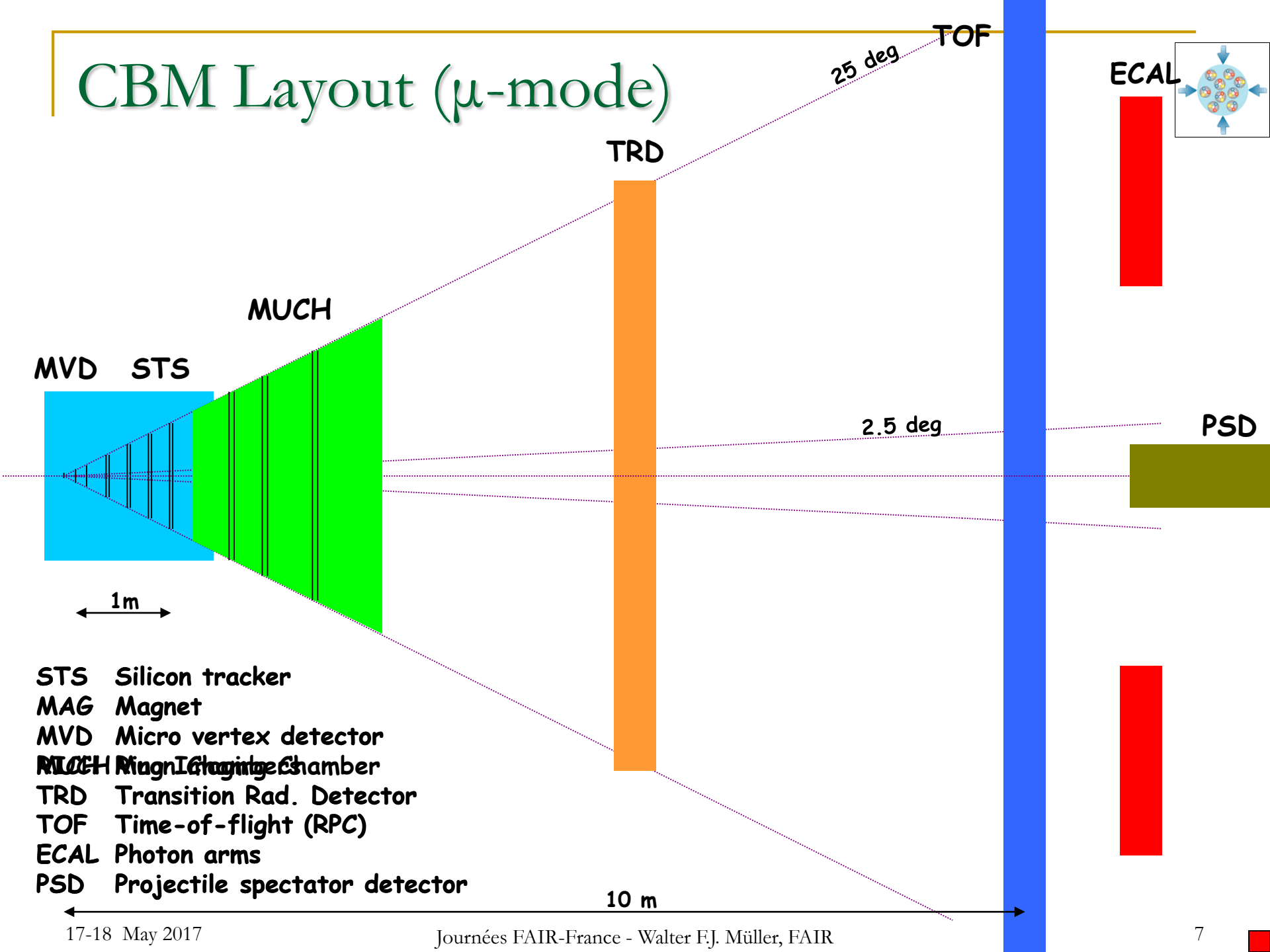
HADES
18° - 85°
Toroidal field
low mass; high res

CBM
3° - 25°
Dipole field
high rate

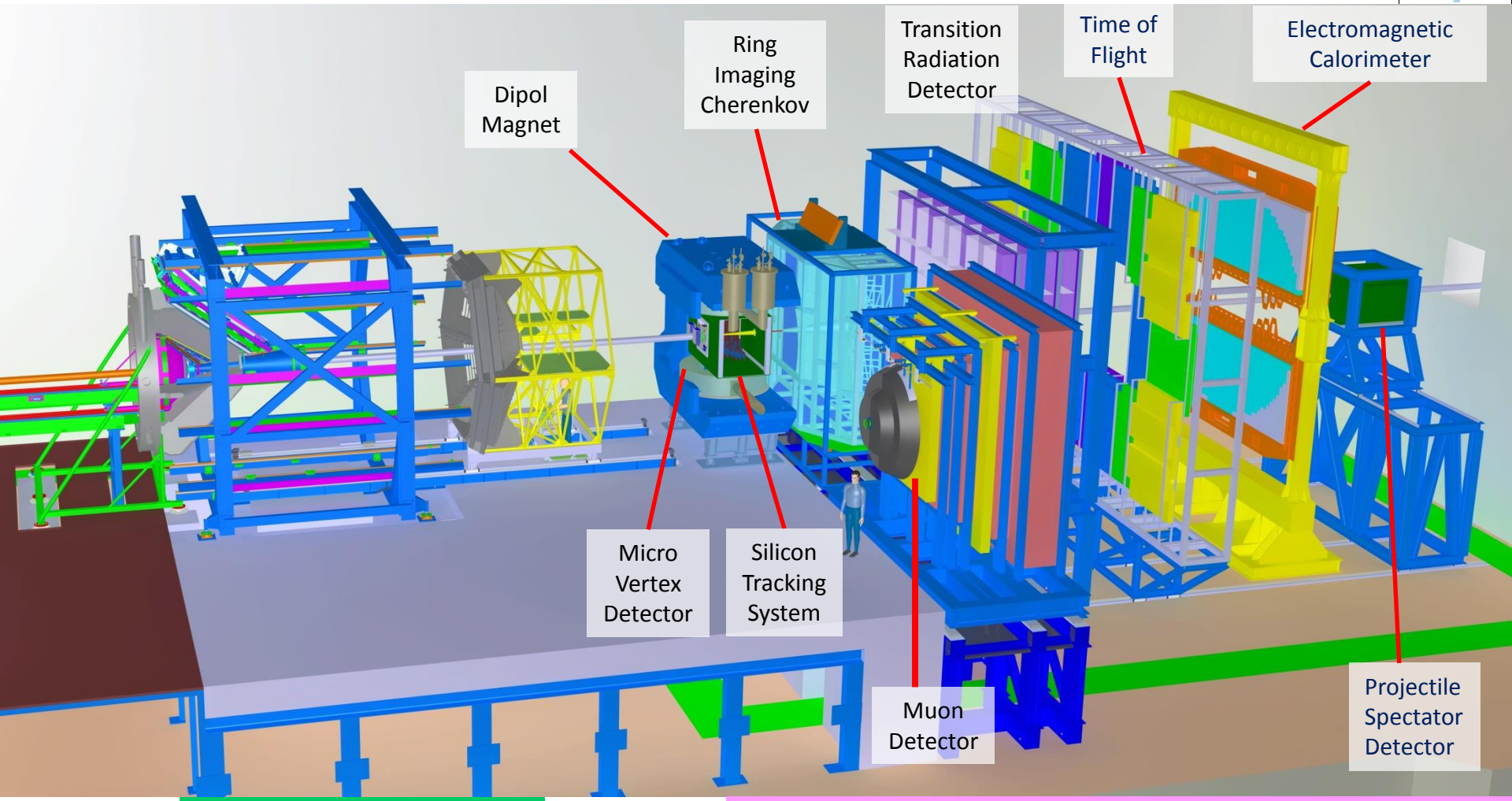
CBM Layout (h+e-mode)



CBM Layout (μ-mode)



Full HADES+CBM Setup in CBM Cave



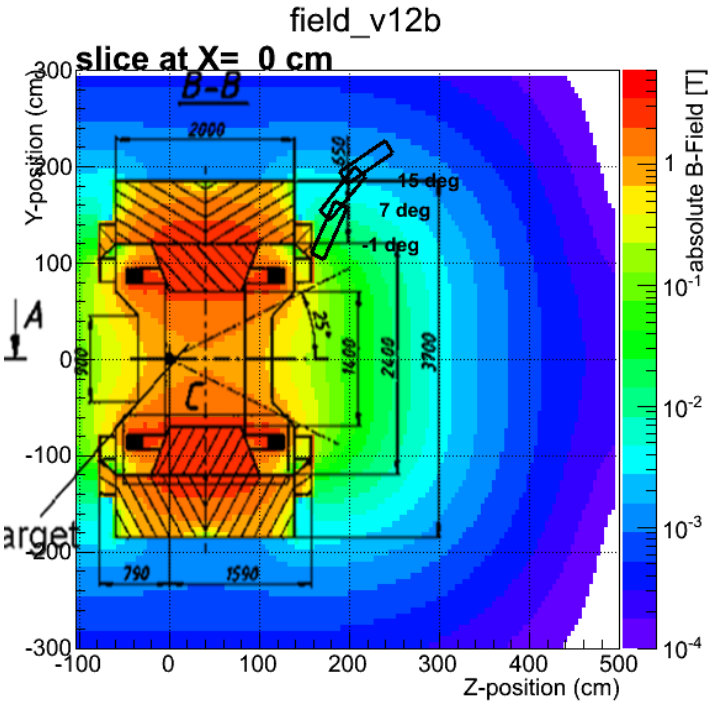
HADES

p+p, p+A
A+A (low mult.)

CBM

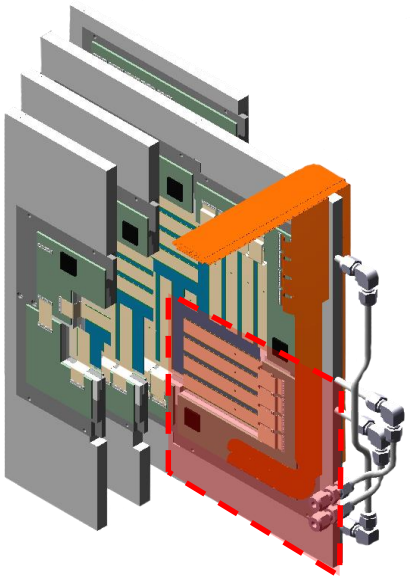
p+A, A+A

Superconducting Dipole Magnet



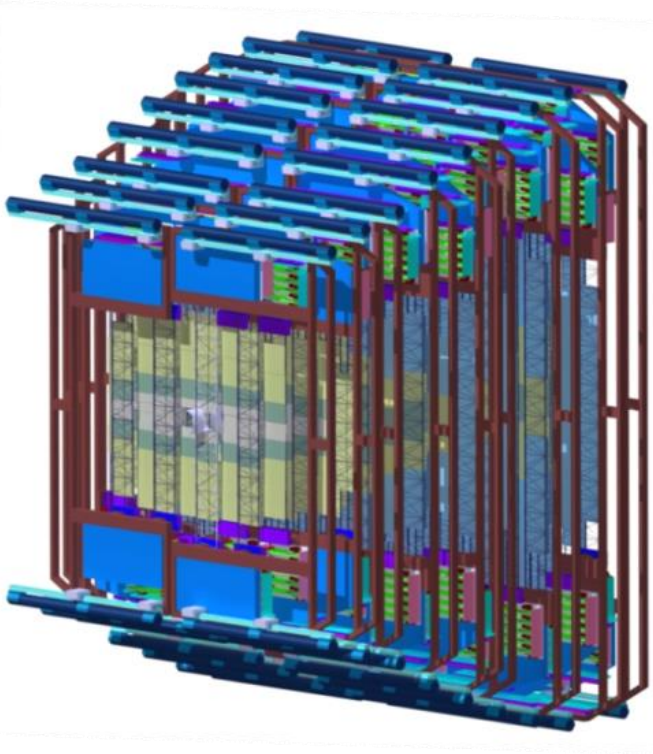
- Large-acceptance superconducting dipole magnet.
- The pole gap is 144 cm, the bending power 1 Tm.
- Participating institutes:
  JINR Dubna, BINP Novosibirsk, GSI Darmstadt

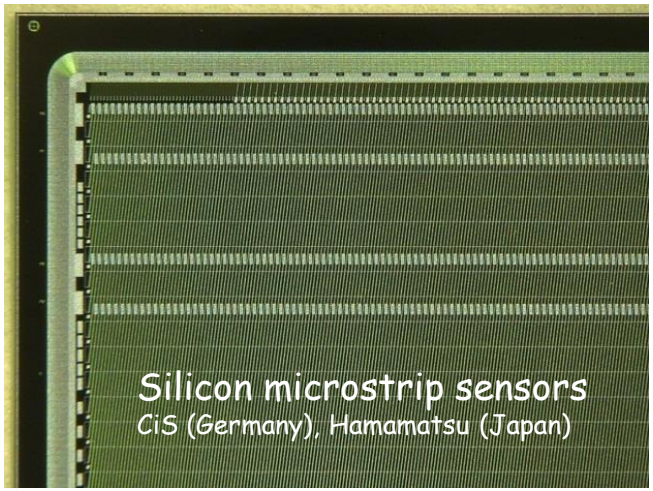
Micro Vertex Detector

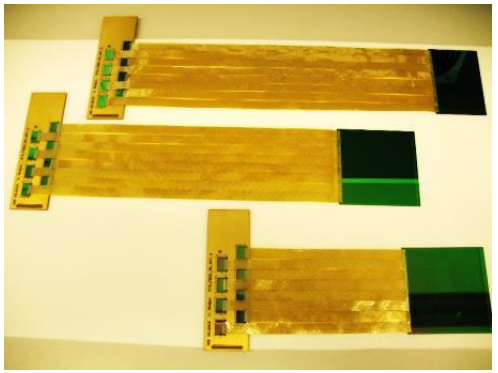


- Key objectives
  - Background suppression for di-electron measurements
  - Determination of secondary vertices of open charm decays
  - Improved tracking for hyperon-ID
- Participating institutes: Univ. Frankfurt, IPHC Strasbourg
  → see presentation by Marc Winter

Silicon Tracking System

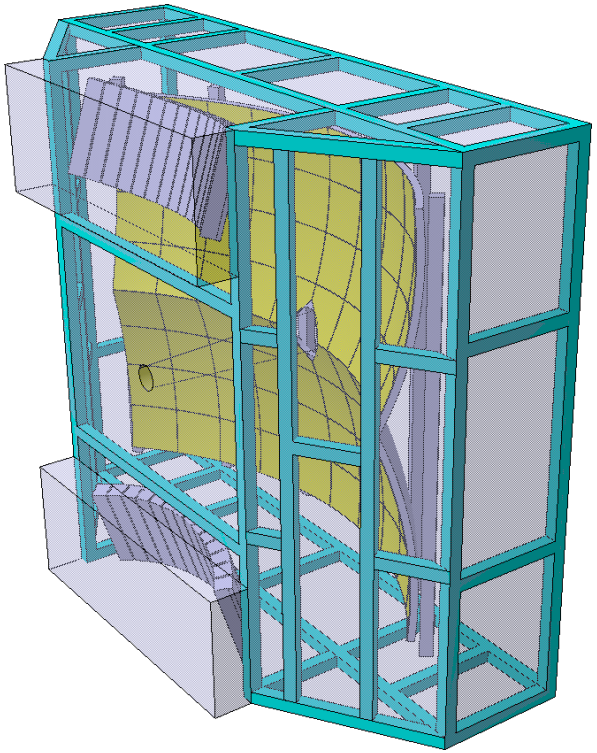


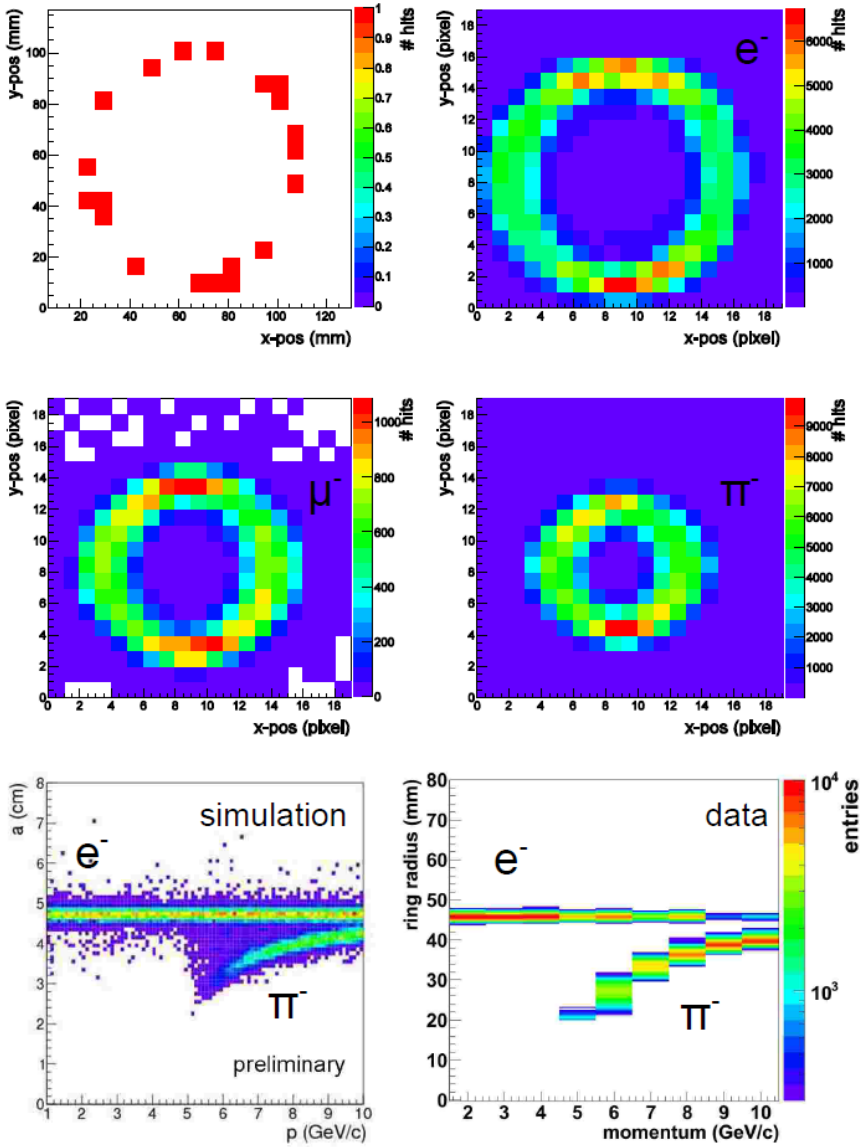




- The STS consists of about 1000 double-sided silicon micro-strip sensors arranged in 8 detector arrays located inside the dipole magnet. The detector provides track reconstruction and momentum determination for up to 1000 particles per event. The detector is operated at about -10°C, heat dissipation of the front-end electronics 40 kW, bi-phase CO2 cooling system
- Participating institutes: GSI, Darmstadt, JINR Dubna, KIT, INR Kiev, AGH and UJ Krakow, Univ. Tübingen, Warsaw UT

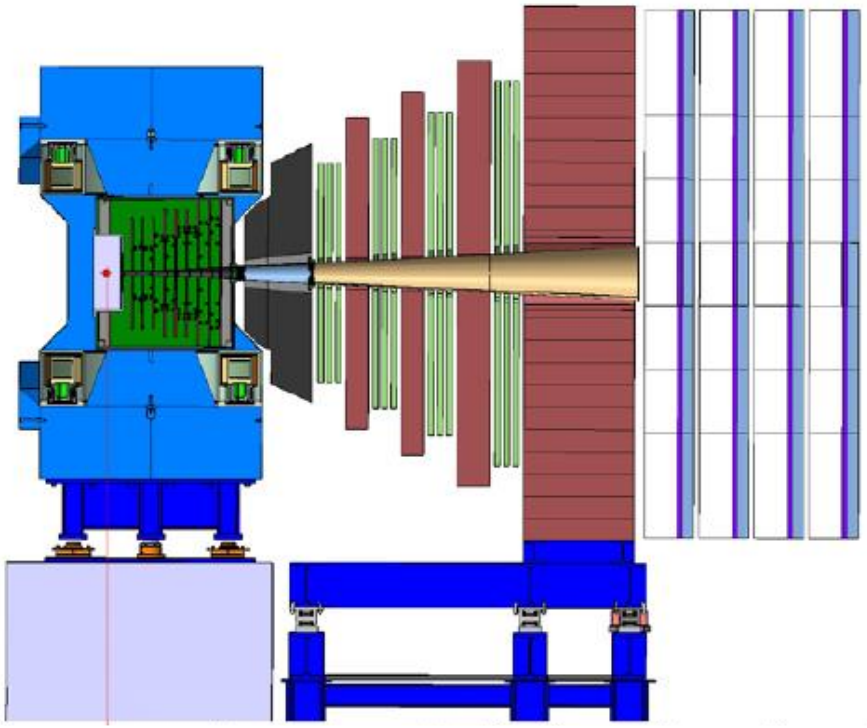
Ring-imaging Cherenkov (RICH) Detector





- The RICH is used for the identification of electrons with momenta below 8 GeV/c (pion suppression factor of > 500).
- Participating institutes: Gießen, Univ., Wuppertal, PNPI Gatchina

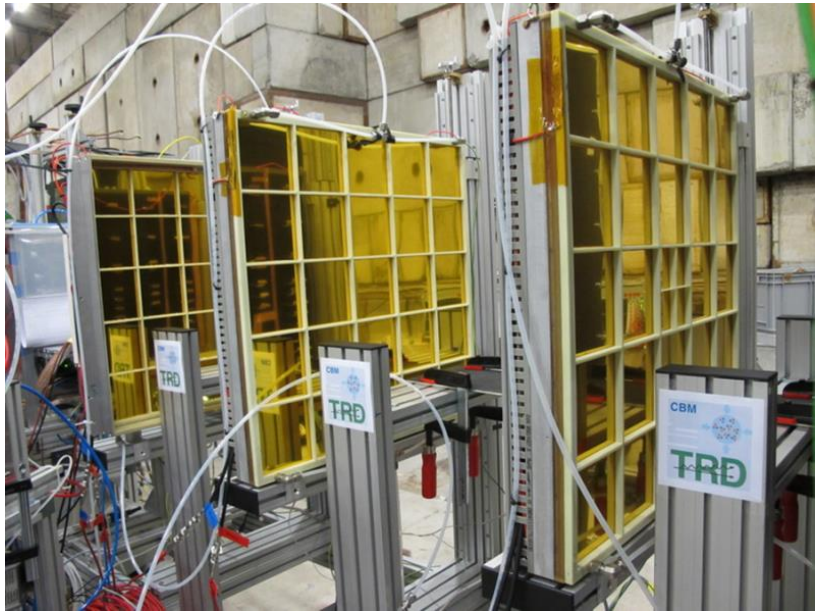
Muon Chamber (MuCh) System

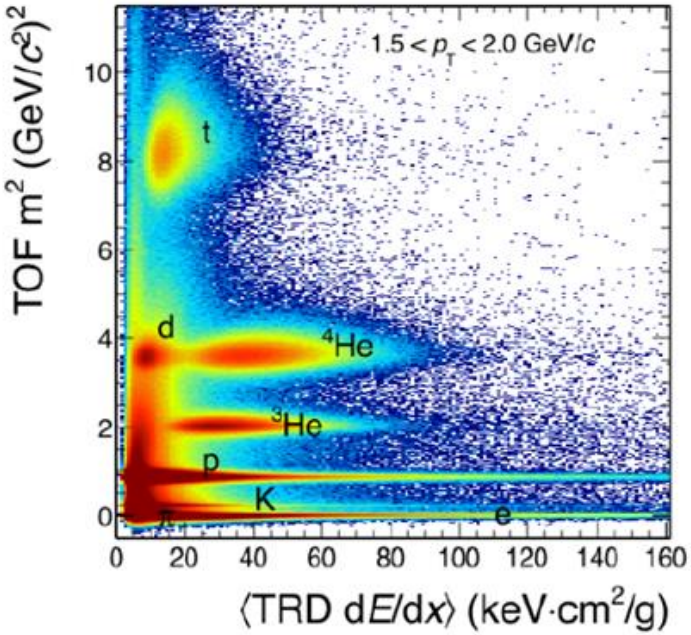


Full size GEM detectors tested with free-streaming read-out electronics at the CERN-SPS Nov.-Dec. 2016

- The MUCH consists of a combination of 15 detector stations sandwiched between one carbon and 4 iron absorber layers for hadron suppression. The MUCH provides the identification of muons with momenta above 1.5 GeV/c.
  - Tracking station 1+2: Two Gas-Electron-Multiplier (GEM) detector triplets
  - Tracking station 3+4: two low-resistivity trigger RPC triplets
  - Tracking station 5: four Transition Radiator Detectors (used only as trackers)
- Participating institutes: VECC Kolkata + 12 Indian Inst., PNPI Gatchina

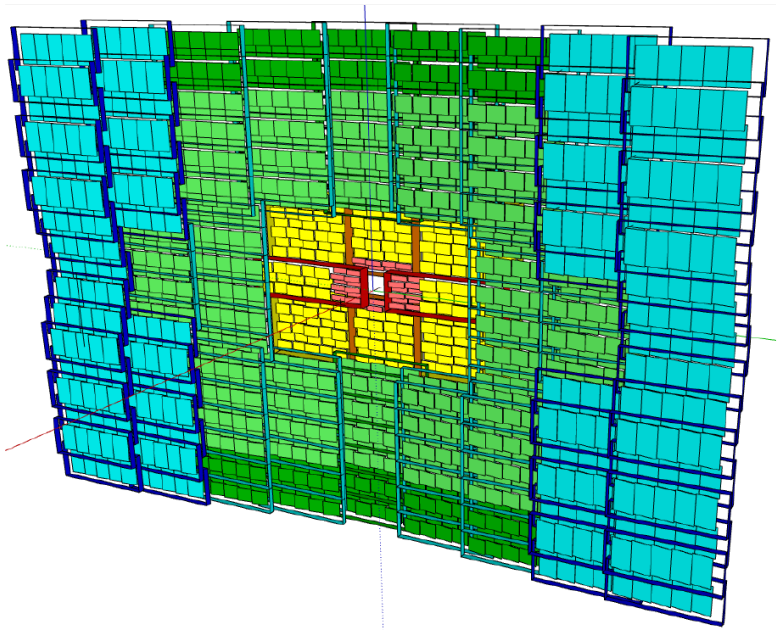
Transition Radiation Detector (TRD)





- The TRD consists of 4 detectors layers. It provides additional identification power for of electrons with momenta above 1.5 GeV/c, and an energy-loss measurement
- Participating institutes: NIPNE Bucharest, JINR Dubna, Univ. Frankfurt, Univ. Heidelberg, Univ. Münster

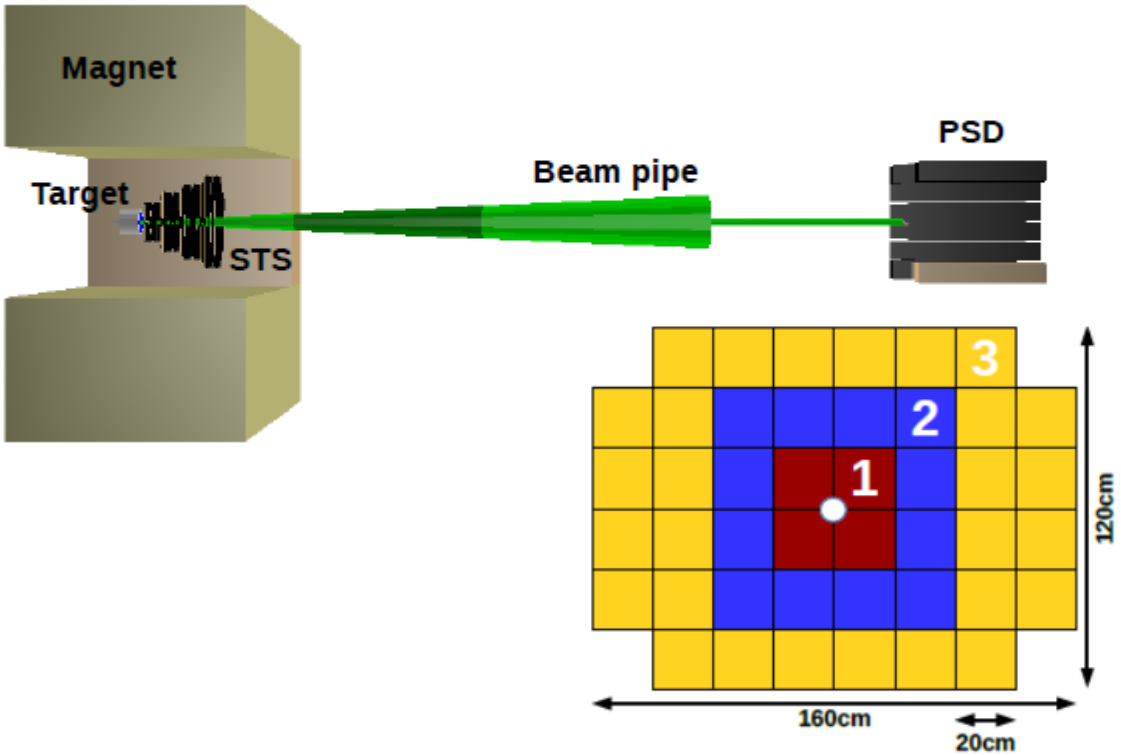
High Rate MRPC TOF Wall



ToF MRPC detectors tested with free-streaming read-out electronics at the CERN-SPS Nov.-Dec. 2016

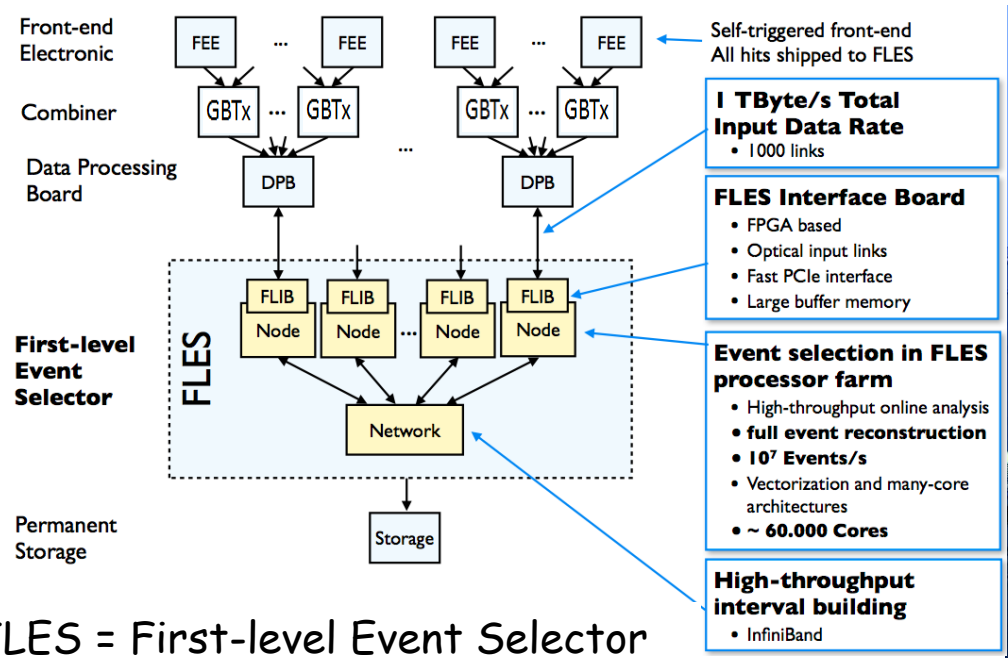
- Multigap Resistive Plate Chambers (MRCP) provide the time-of-flight measurement for hadron identification. Challenge: Time resolution of 60 ps at rates of 25 kHz/cm2, inner part low-resistivity glass electrodes, area 100 m2
- Participating institutes: THU Beijing, NIPNE Bucharest, GSI Darmstadt, TU Darmstadt, IfI Frankfurt, USTC Hefei, Univ. Heidelberg, ITEP Moscow, HZDR Rossendorf, CCNU Wuhan

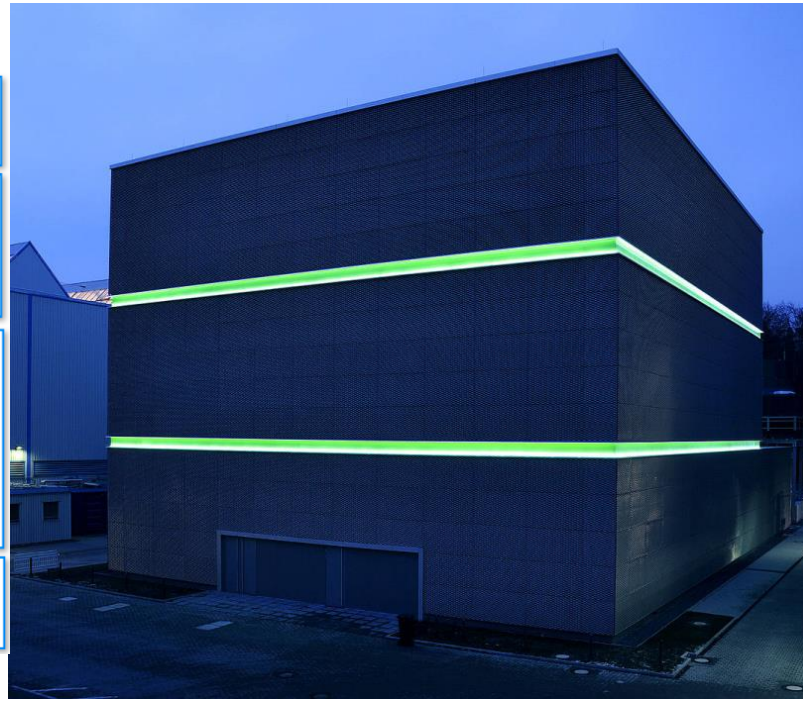
Projectile Spectator Detector (PSD)



- The PSD is a lead-scintillator calorimeter and is used for the determination of the collision centrality and the orientation of the reaction plane.
- Participating institutes: INR Moscow, Prague, Rez, TU Darmstadt

Online Systems

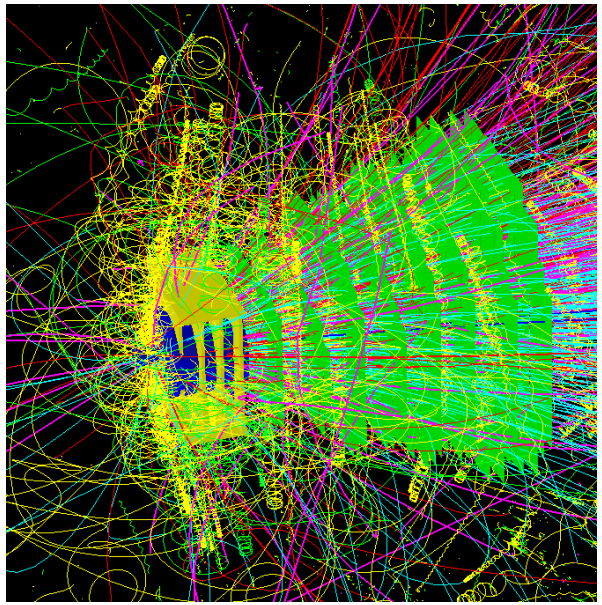




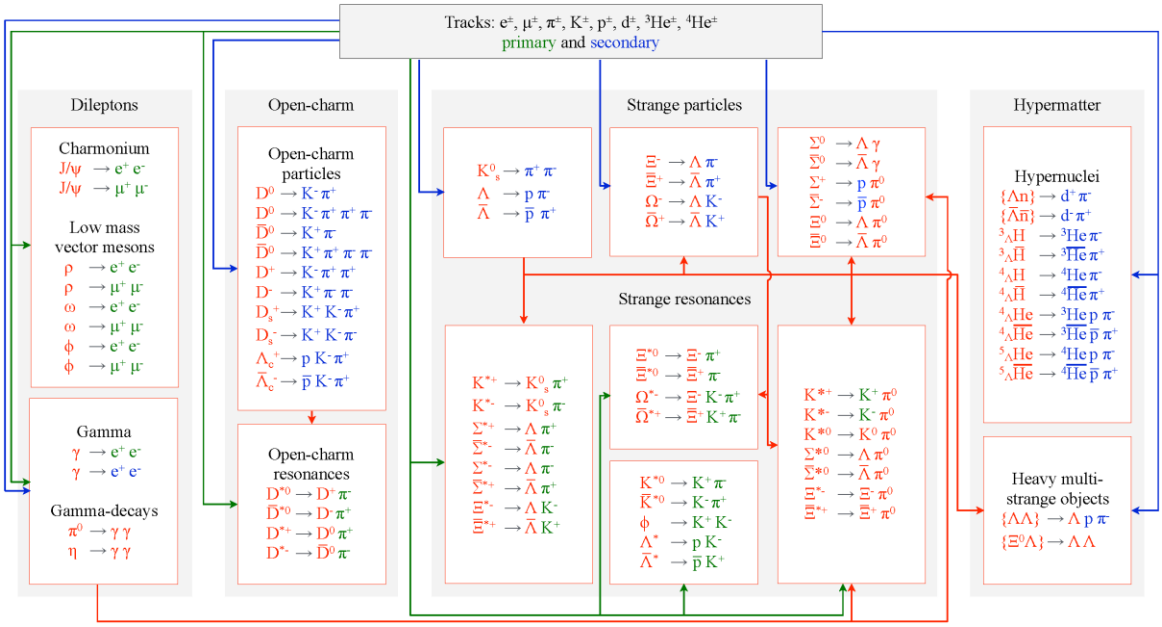
FLES = First-level Event Selector

- CBM features a novel data readout and acquisition system:
  no hardware trigger on events, detector hits with time stamps, full online 4-D track and event reconstruction
- Participating institutes: Univ. Frankfurt, FIAS, GSI Darmstadt, KIT Karlsruhe, Warsaw UT

.... and lots of Software



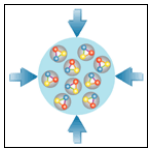
Au+Au 8 A GeV central collision
UrQMD + GEANT3



Online particle identification in CBM: The KF Particle Finder

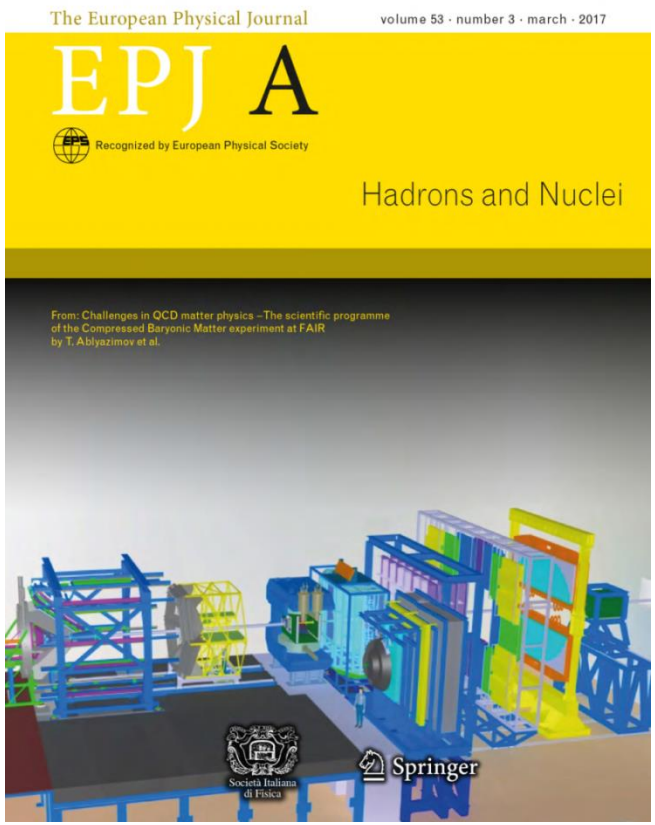
- ... and a large software project:
  - common tools and frameworks; controls & configuration; read out & time slice building; monitoring & QA & event displays; data bases; simulation; reconstruction & calibration;
- Participating institutes: many

Possible Technical Contributions



- MVD
  - MAPS sensor development done in Strasbourg
    → see presentation by Marc Winter
  - sensors for MVD are the most natural French in-kind
- STS
  - contribution to module/ladder assembly
    existing expertise, e.g. from ALICE ITS Strip
- Software
  - many work packages / tasks still looking for a care taker
- New Ideas
  - CBM is in construction phase, but certainly open for ideas to make the setup more powerful. Example: forward dE/dx

For Further Reading ...



"Challenges in QCD Matter Physics – the scientific programme of the Compressed Baryonic Matter Experiment at FAIR"

Ablyazimov, T. et al. Eur. Phys. J. A (2017) 53
doi:10.1140/epja/i2017-12248-y

135 contributions, 220 pages

ISBN 978-3-9815227-4-7.

https://repository.gsi.de/record/201318

The CBM Collaboration: 55 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.
Rajasthan Univ.
Univ. of Jammu
Univ. of Kashmir
Univ. of Calcutta
B.H. Univ. Varanasi
VECC Kolkata
IOP Bhubaneswar
IIT Kharagpur
IIT Indore
Gauhati Univ.

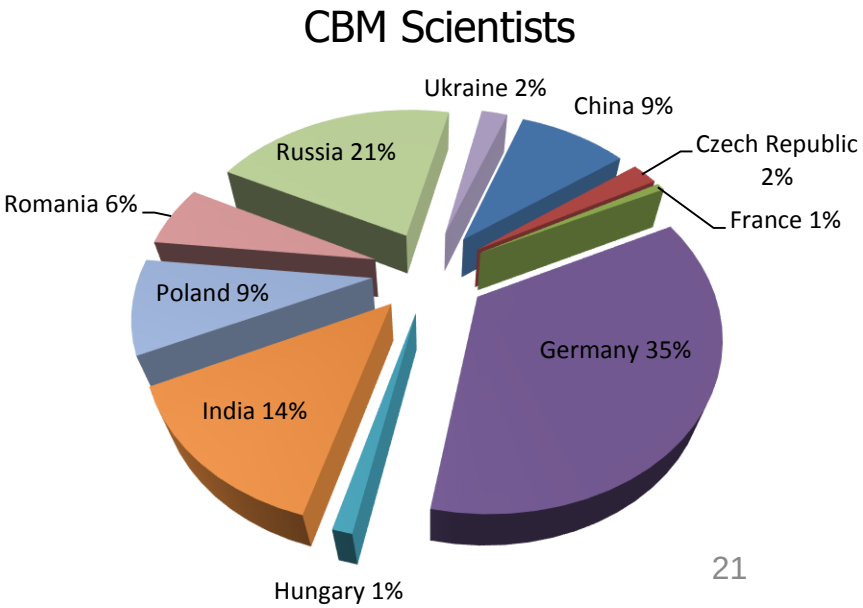
Korea:
Pusan Nat. Univ.

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

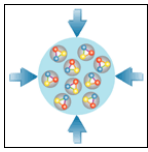
Romania:
NIPNE Bucharest
Univ. Bucharest

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

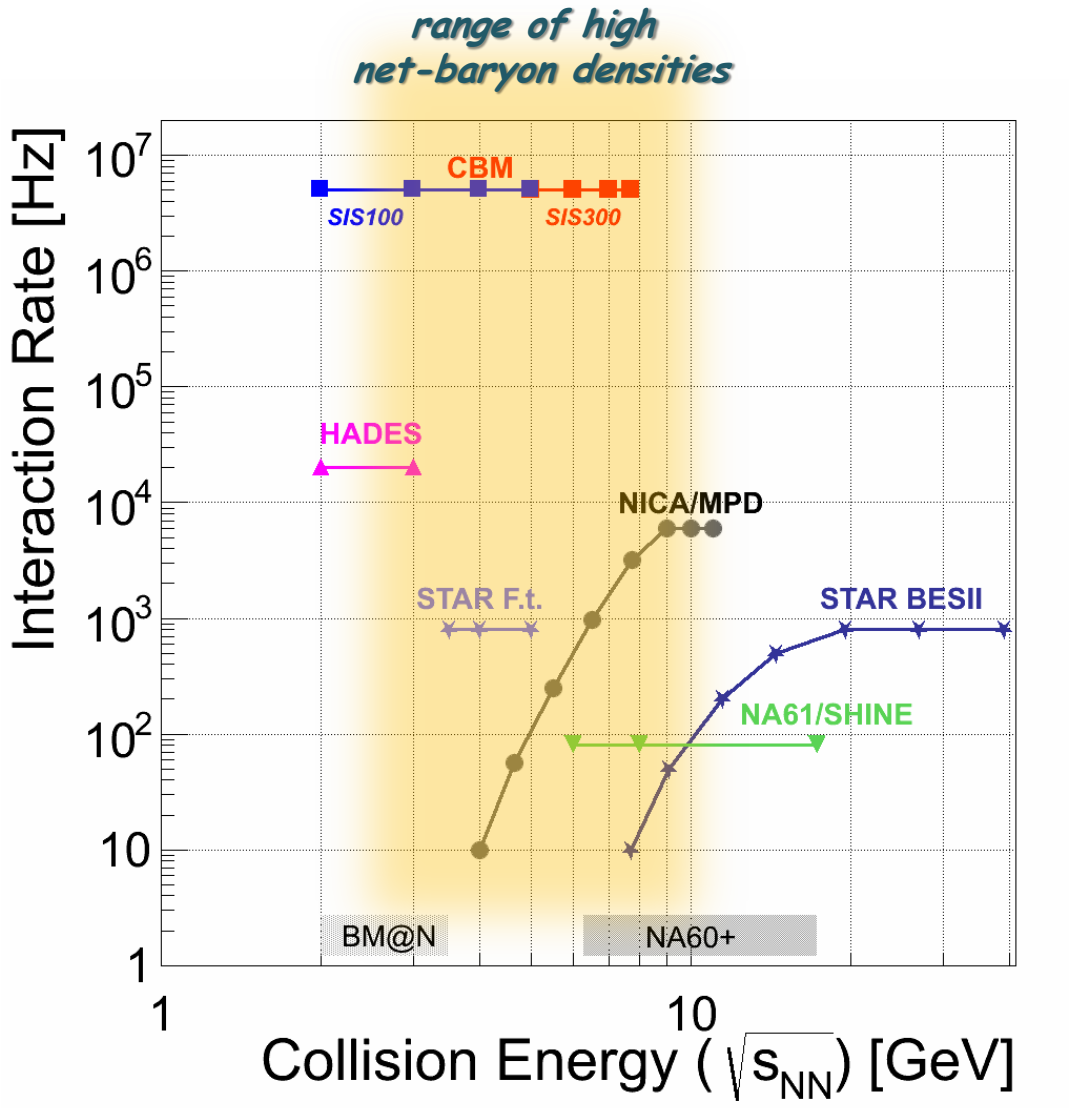


The End



Thanks for your attention

The Interaction Rate Landscape



Shown are run average rates

They determine sensitivity

Detectors + FEE must be designed for peak rate !

FAIR T0 Centre as CBM FLES Location