Virtual Photon Measurements at FAIR

Thermal Photons and Dileptons in HI Collisions
BNL, USA
August 20-22 , 2014

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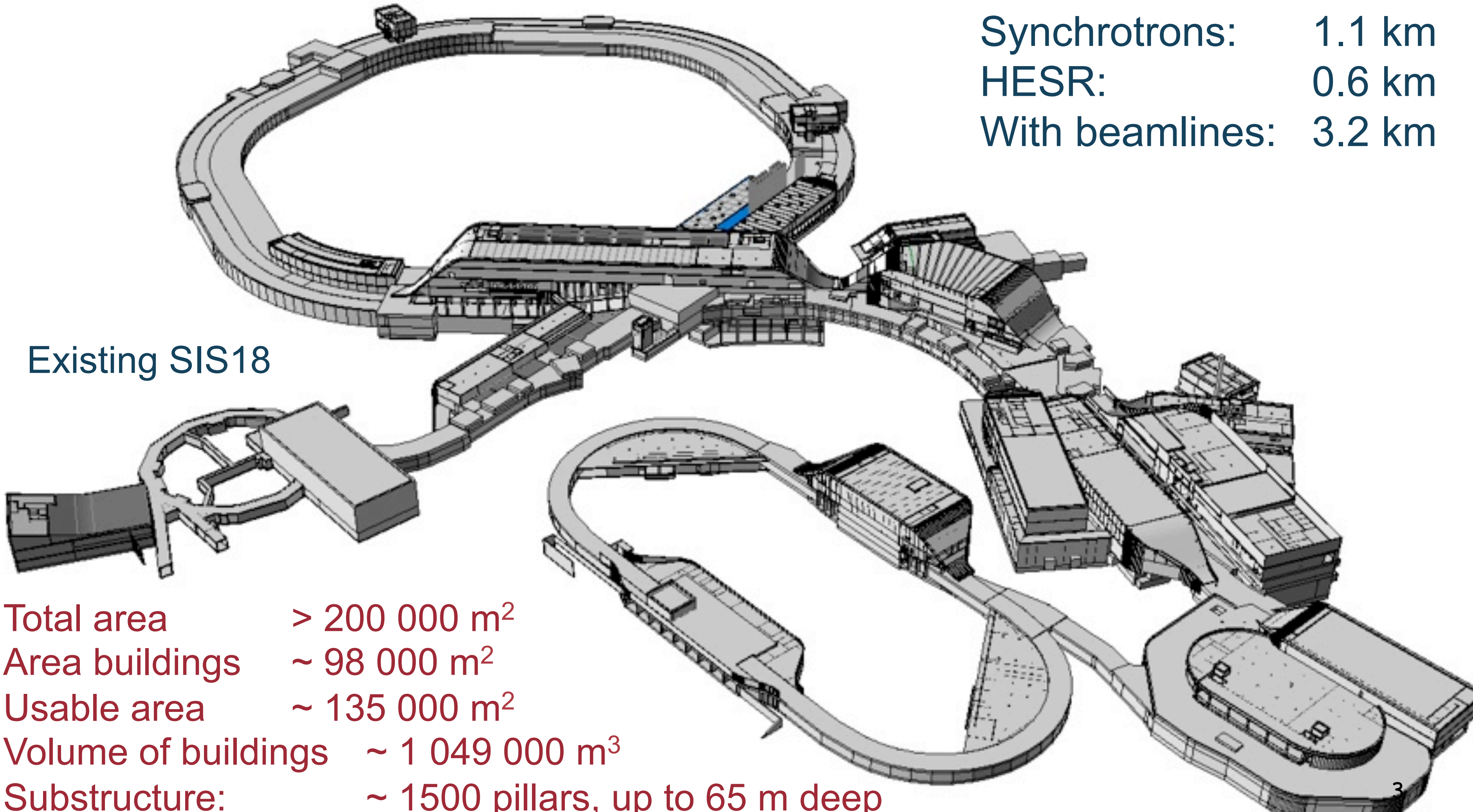
for the C.B.M. Collaborations


these days at FAIR

GSI news 22.05.2014: Safety inspection of the FAIR construction plans – final construction permit for FAIR

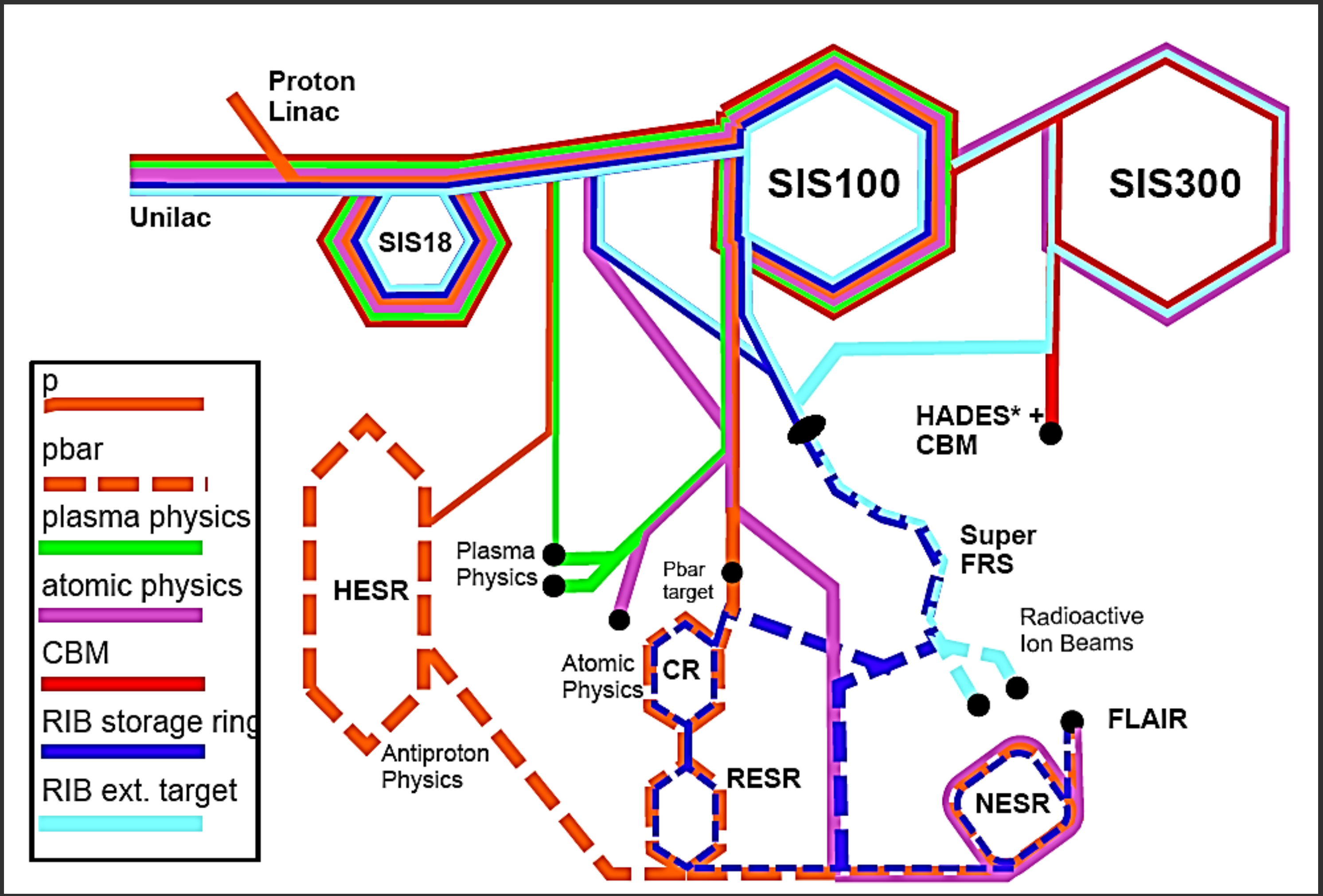
Synchrotrons: 1.1 km
HESR: 0.6 km
With beamlines: 3.2 km



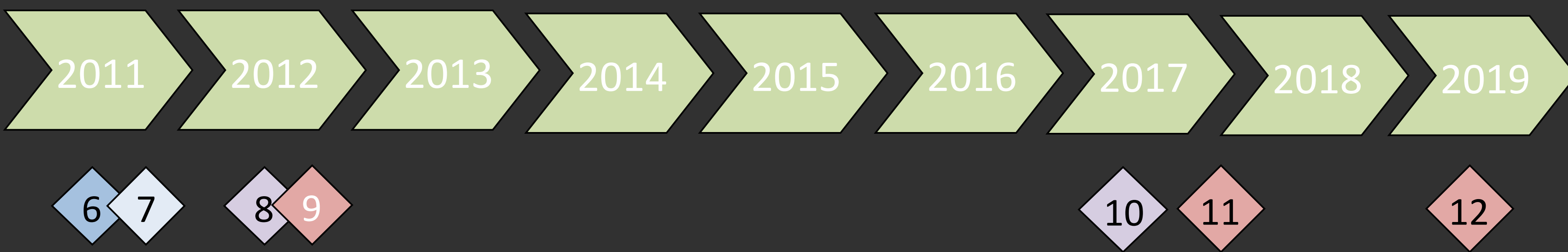
Total area > 200 000 m^2
Area buildings ~ 98 000 m^2
Usable area ~ 135 000 m^2
Volume of buildings ~ 1 049 000 m^3
Substructure: ~ 1500 pillars, up to 65 m deep

The Original FAIR Concept

Parallel operation using two rings to serve a broad community.

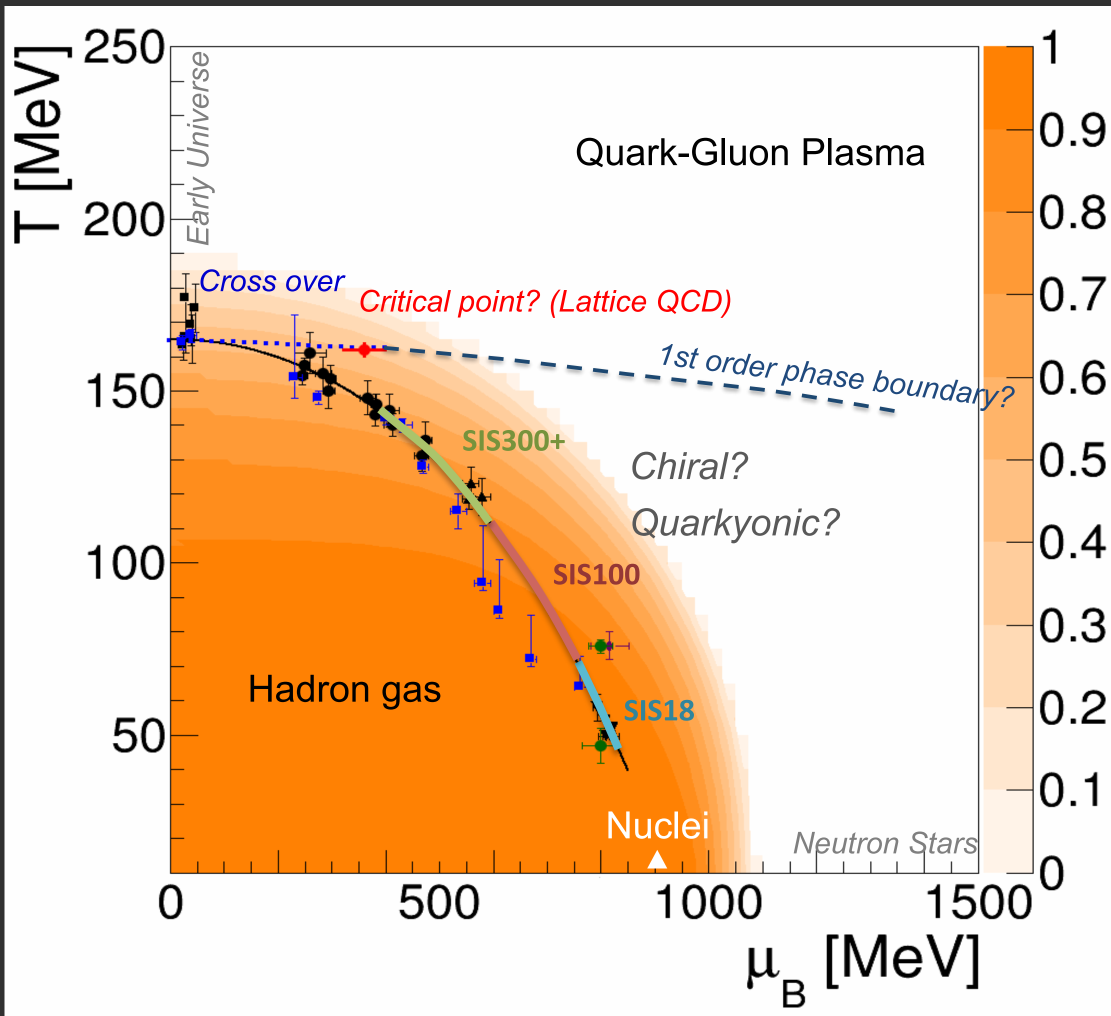


FAIR time line (as of 07/2014)



- 6 Submission of construction application
- 7 Start Site preparation
- 8 First civil construction contracts
- 9 Building of accelerator & detector components
- 10 Civil construction partly finished
- 11 Start installing & commissioning accelerator and detector components
- 12 Start commissioning with beam

C.B.M. Physics Case



- Search for new phases of strongly interacting matter in the region of high net-baryon density

$$\rho_{crit.} \approx \left(4R_?^3\right)^{-1}$$

- Emphasis on
  - ✘ Multi-strange baryons
  - ✘ Dileptons
  - ✘ Charm

… systematics!

Why Dileptons

- Not measured at AGS and lower SPS energies.

- Observables:
  - ✘ Spectral shape
    -> electromagnetic properties of hadrons in the time-like region, partonic radiation
  - ✘ Abundance -> trajectory in the phase diagram
  - ✘ Phase space distribution -> emission time

… but complicated:

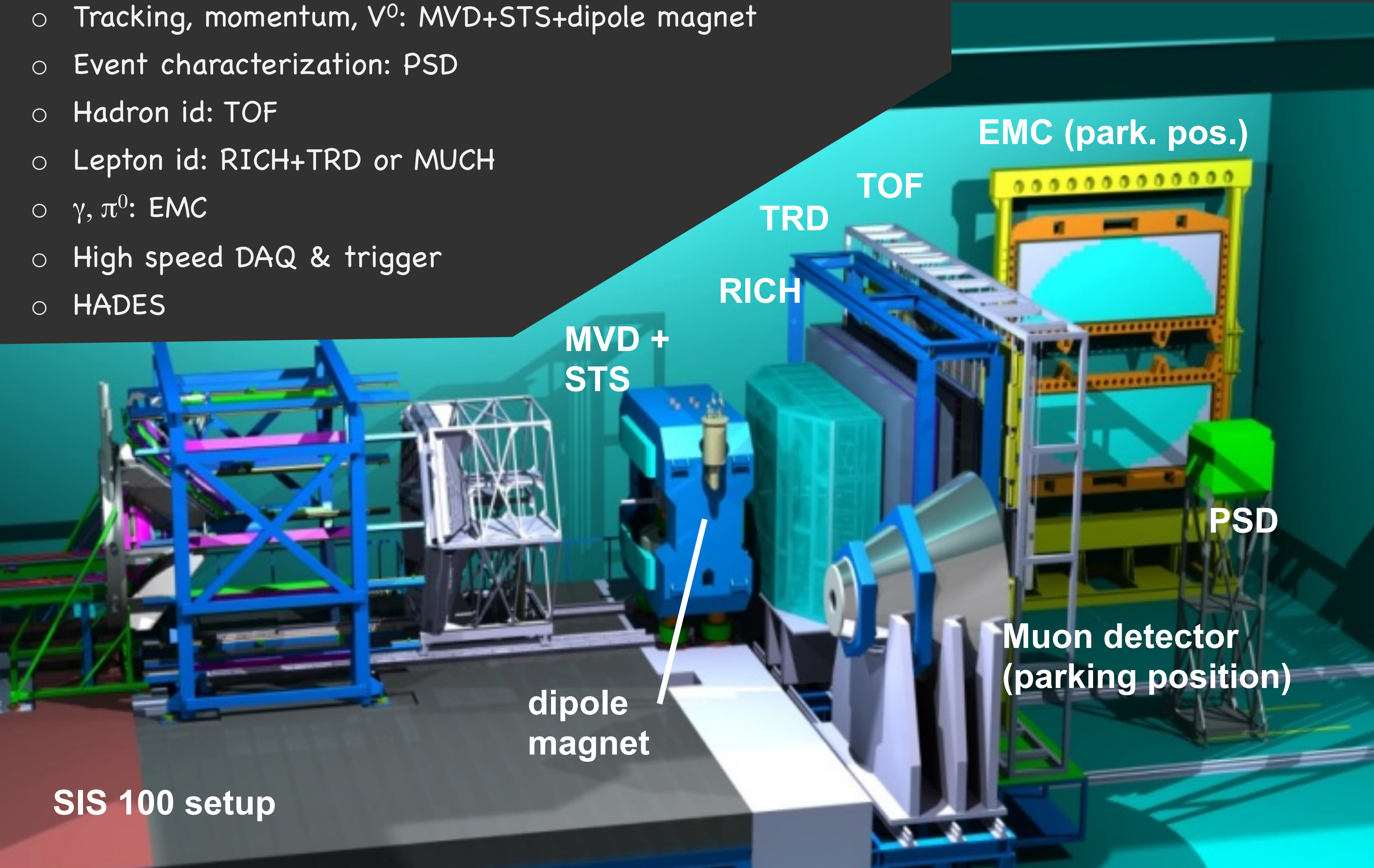
Rare probe

Separation of emission from the fireball (HG, QGP, pre-thermal)

Requires systematic measurements also of elementary processes.

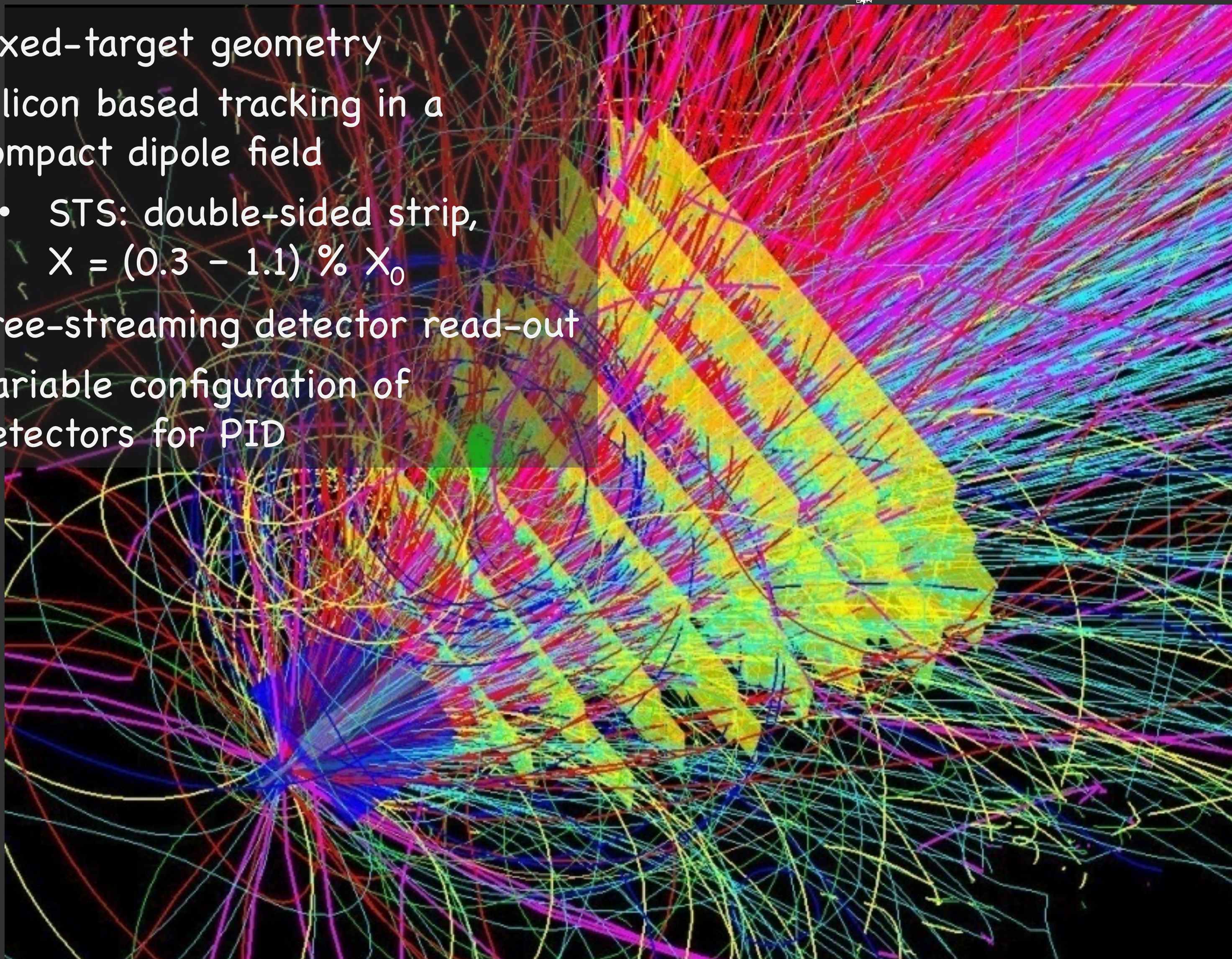
The C.B.M. Experiments

- Tracking, momentum, V^0: MVD+STS+dipole magnet
- Event characterization: PSD
- Hadron id: TOF
- Lepton id: RICH+TRD or MUCH
- γ, π^0: EMC
- High speed DAQ & trigger
- HADES



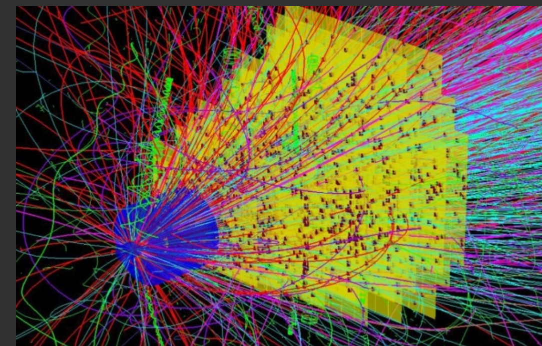
CBM Strategy

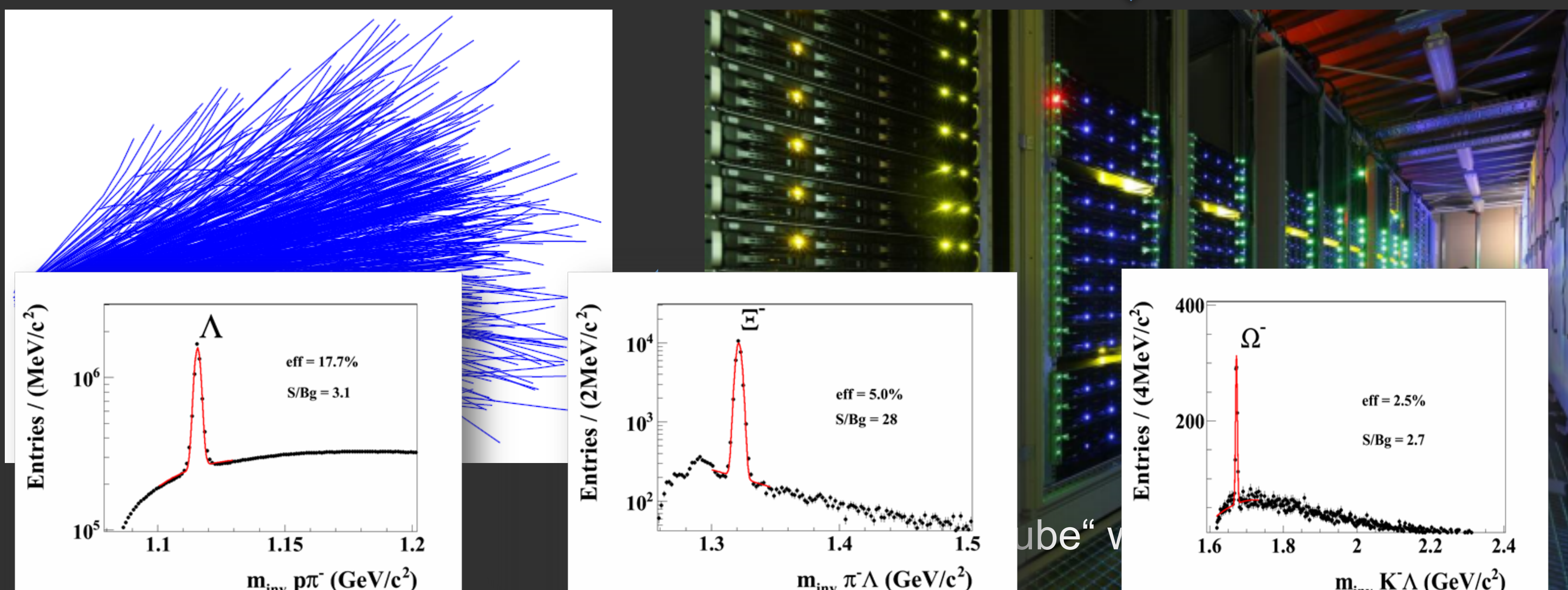
- Fixed-target geometry
- Silicon based tracking in a compact dipole field
  - STS: double-sided strip, $X = (0.3 - 1.1)\ \%\ X_0$
- Free-streaming detector read-out
- Variable configuration of detectors for PID



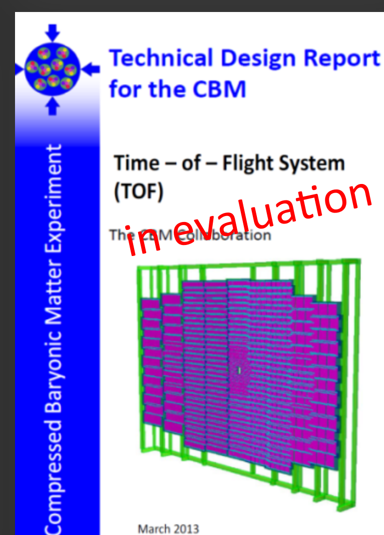
CBM Strategy

- First Level Event Selection (FLES)
- Vectorized, parallelized, portable and scalable reconstruction code
- Real-time reconstruction of weak decays.



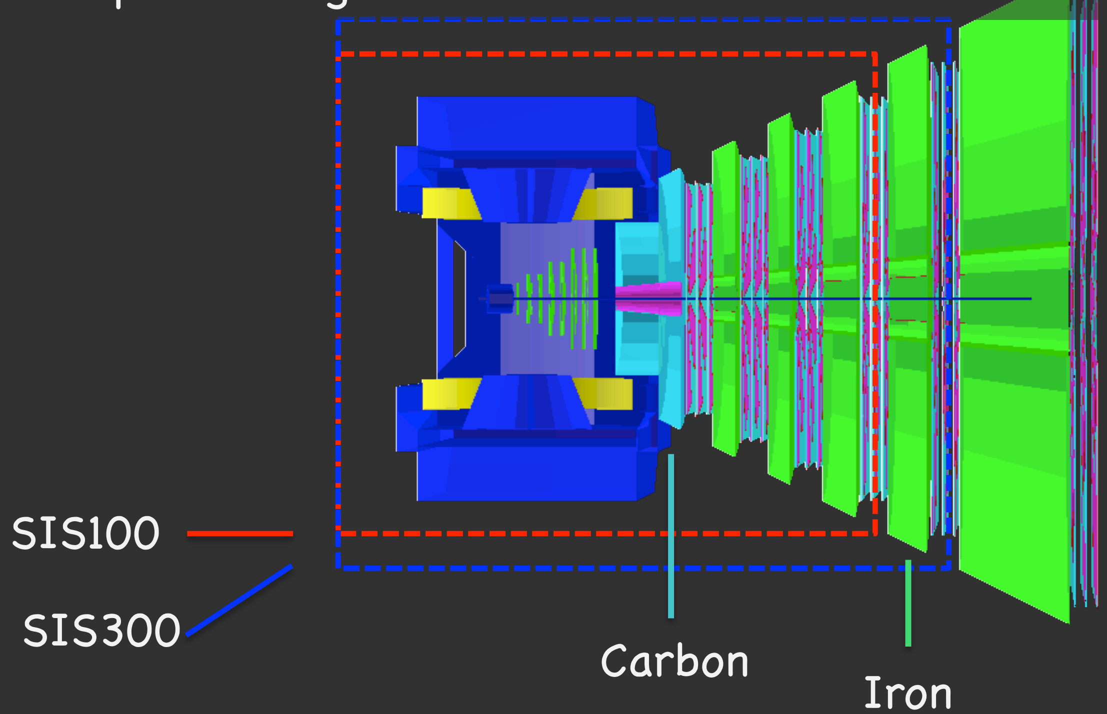


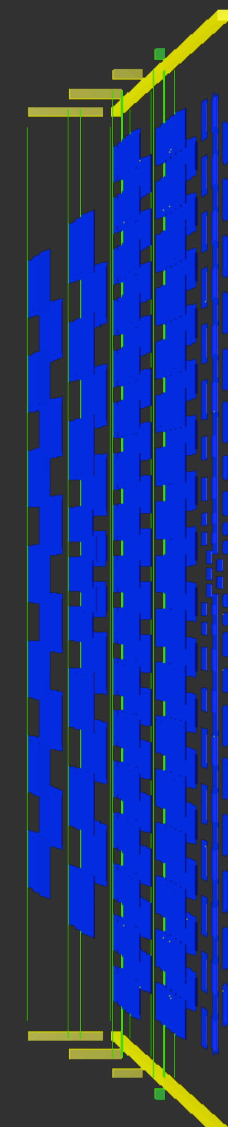
R&D close to finished



The MUCH detector system

- Different absorber configurations
    - for SIS100 and SIS300
    - for continuum and Charmonium
- Instrumented absorber (GEMs and Straws)
- Compact configuration to minimize BG from weak decays

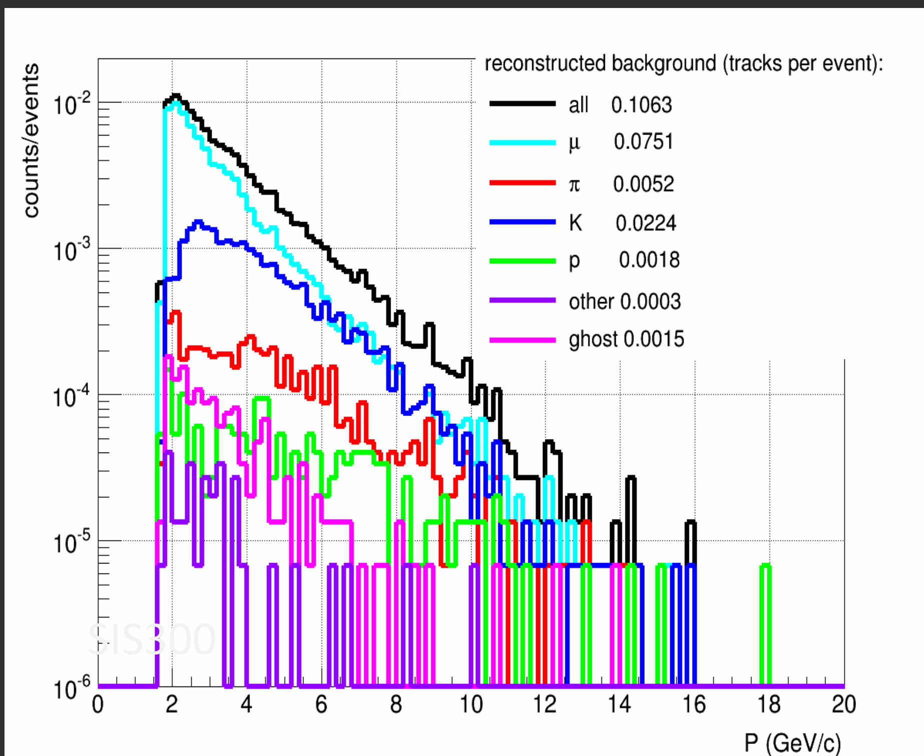




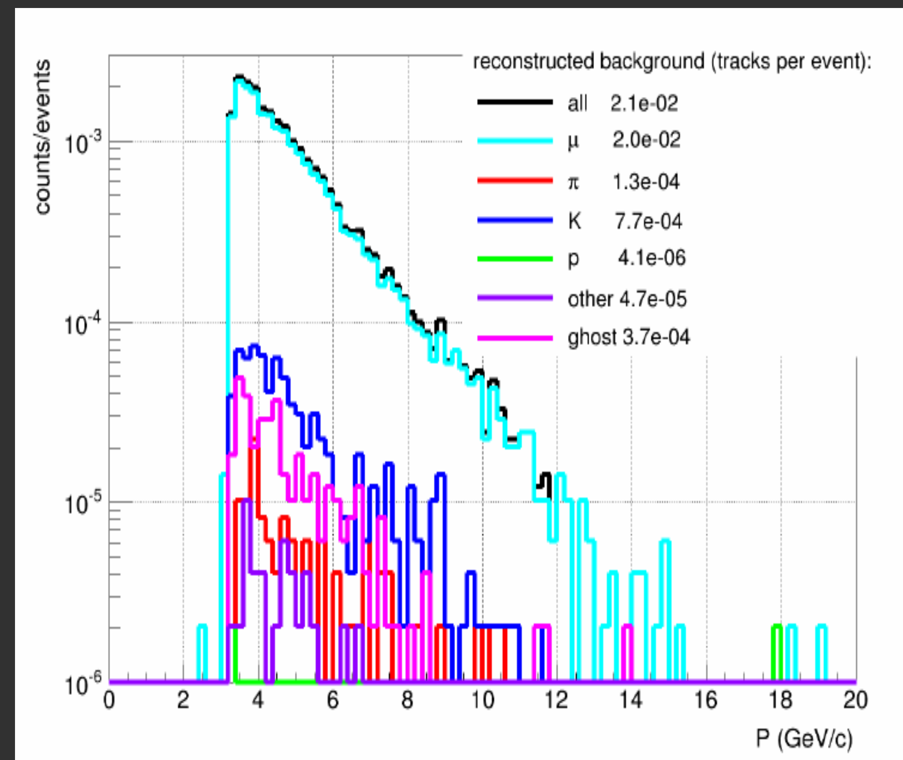
Background systematics Dimuons

Au+Au 25 AGeV, central collisions

Low-mass setup



Charmonium setup (+70 cm iron)

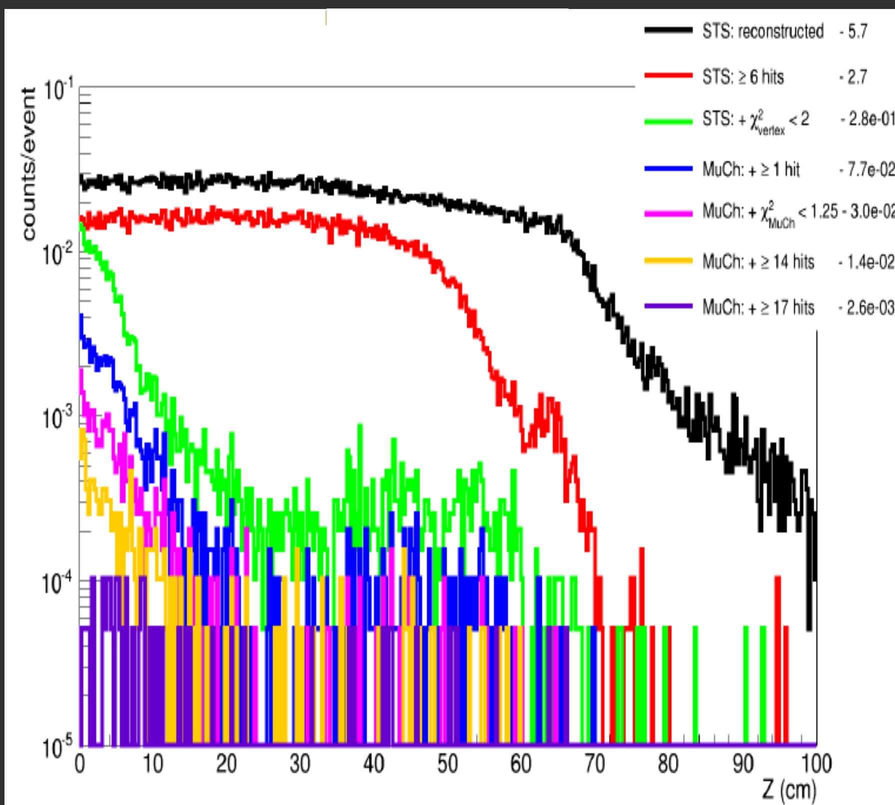


Dominant source: weak decays of π and K, some punch through for low-mass.

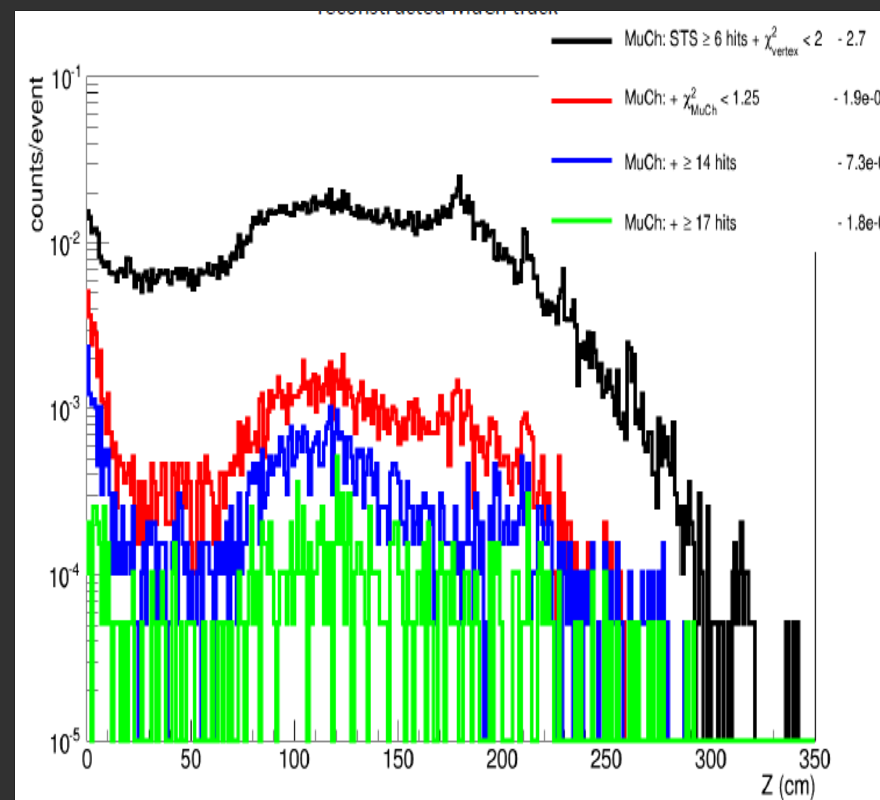
Background systematics Dimuons

Au+Au 25 AGeV, central collisions

Tracking in STS

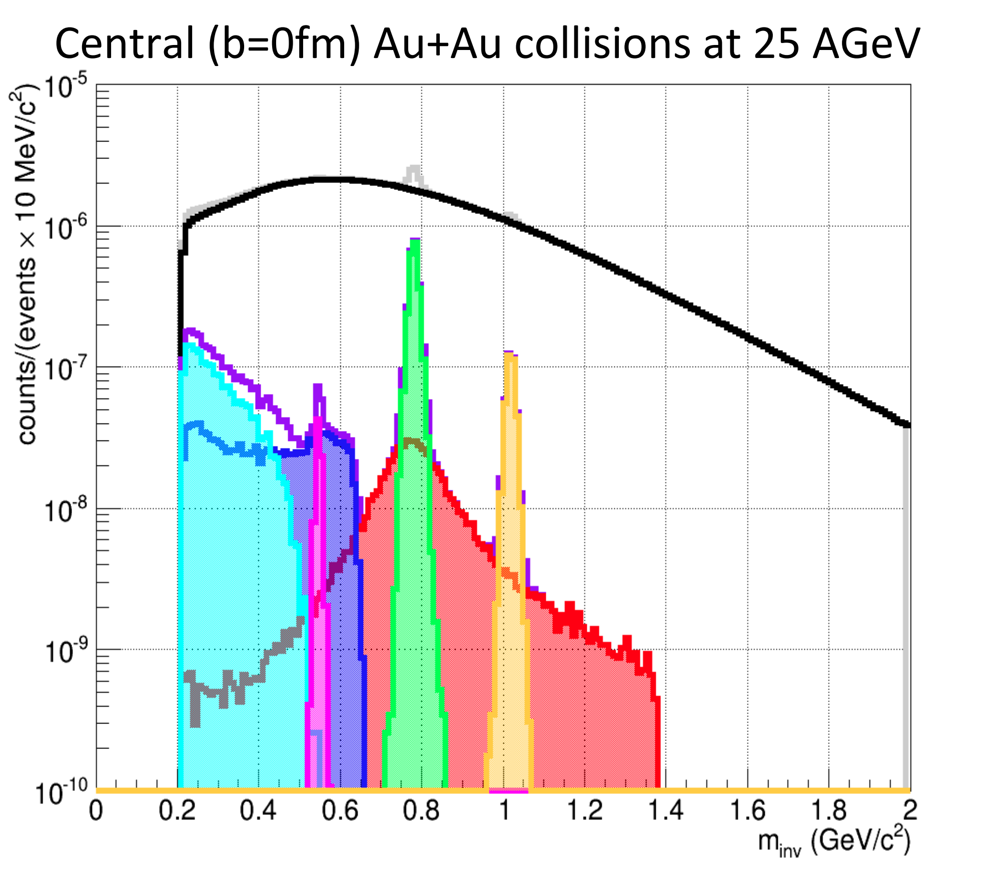


Tracking in MUCH

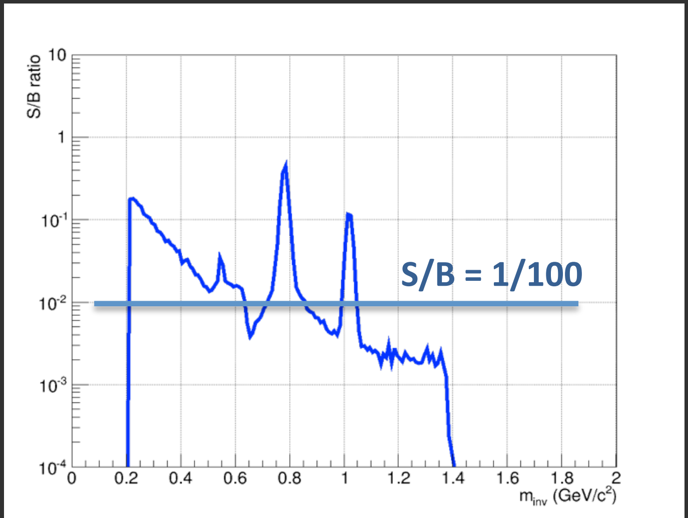


Background tracks of order 1 out of 10 events

Dimuon low-mass performance

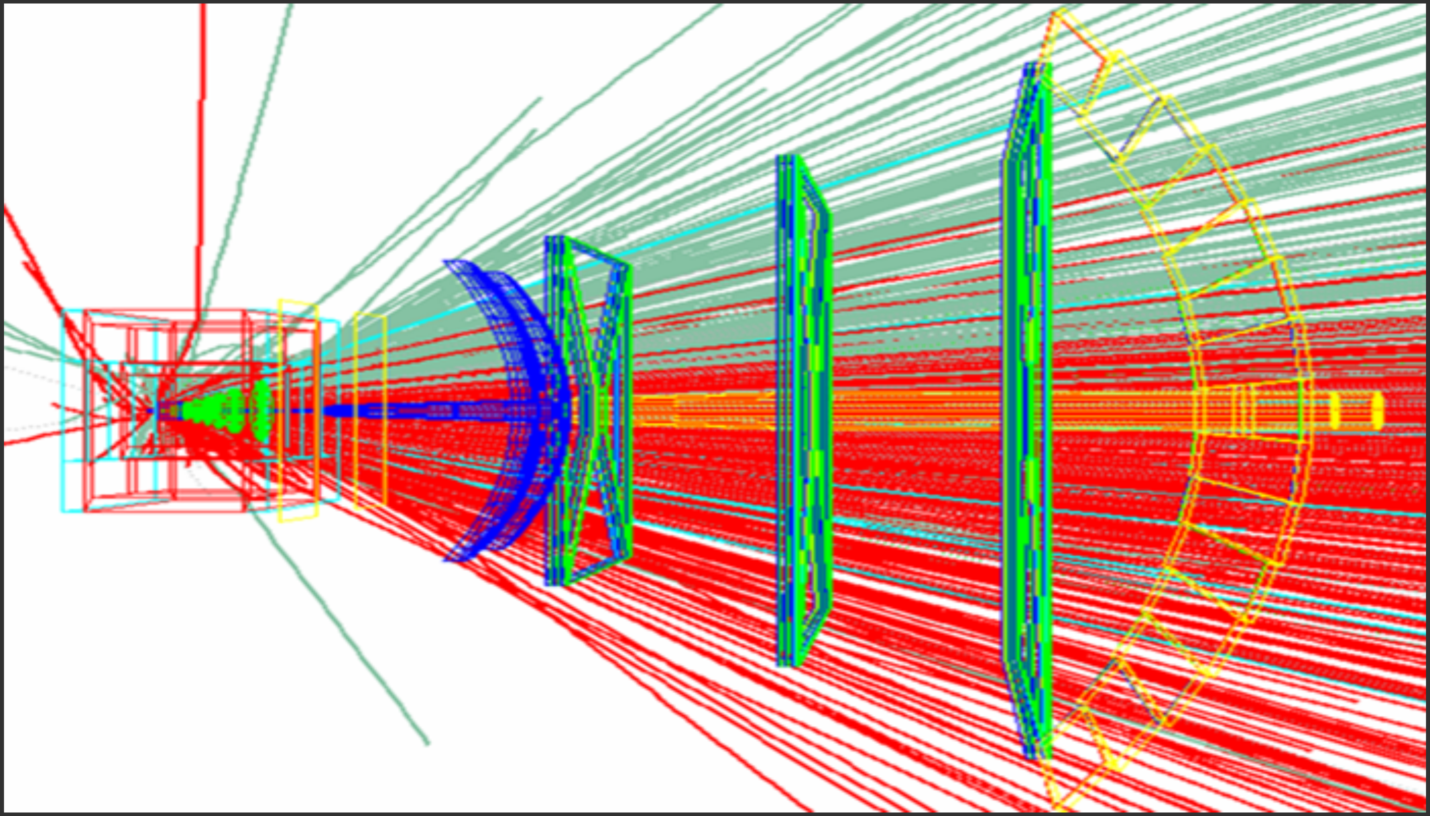


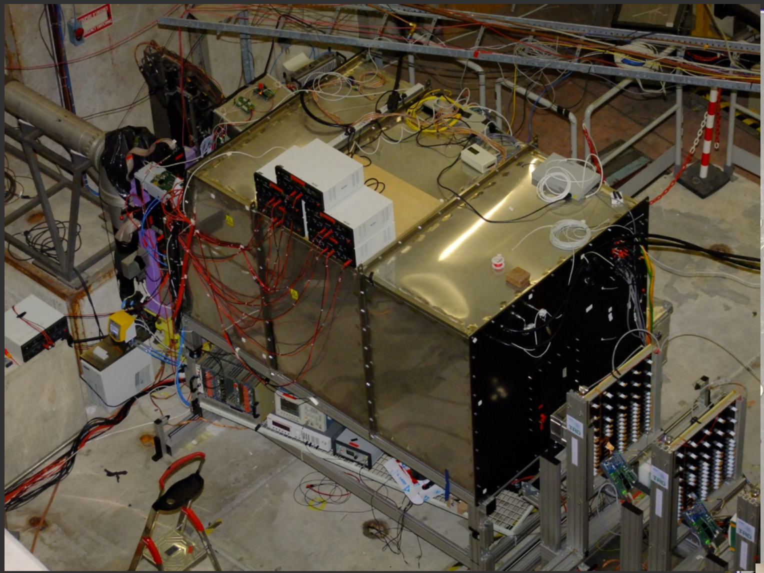
- Mass resolution:
  - 12 MeV (ω)
  - 29 MeV (J/ψ)
- Dominant background weak decays of π and K
- Only cocktail simulated

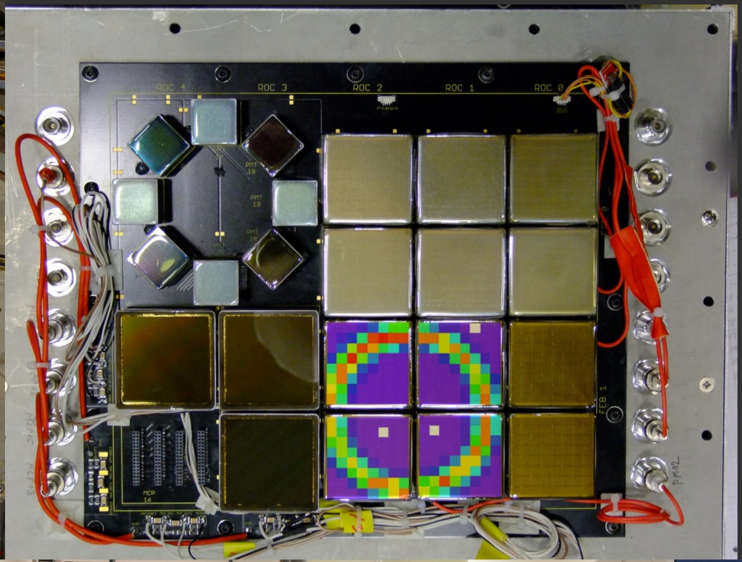


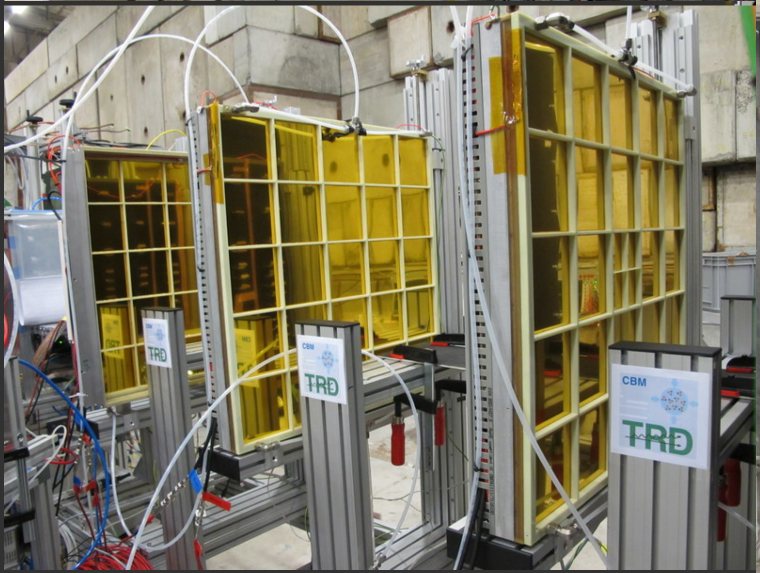
Dielectrons with CBM

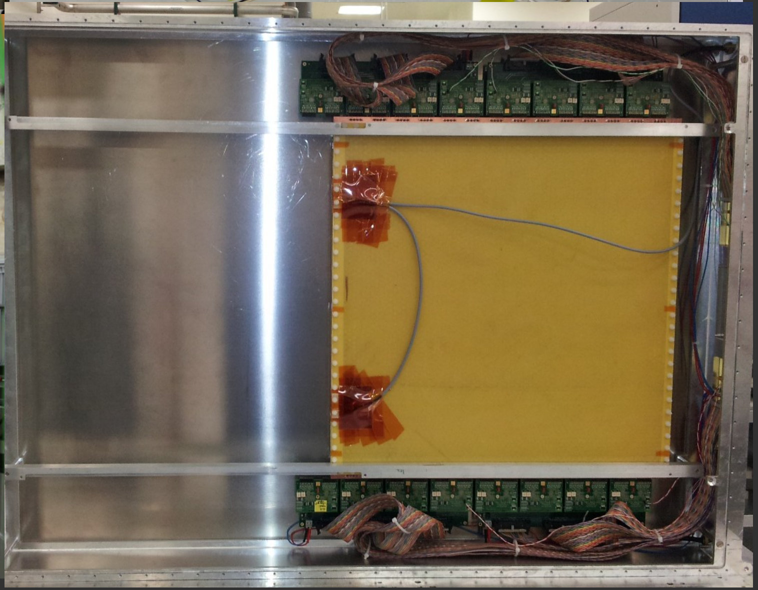
Electron id with TOF, RHICH and TRD






ROC 4
ROC 3
ROC 2
ROC 1
ROC 0

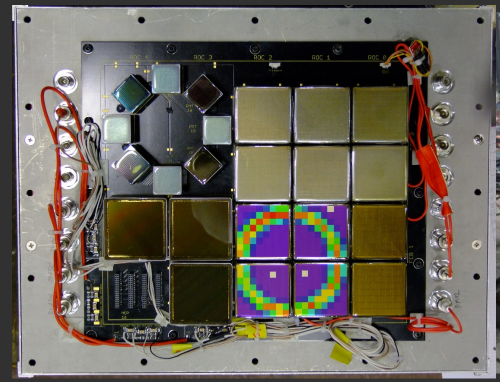

CBM
TRD
TRD
TRD

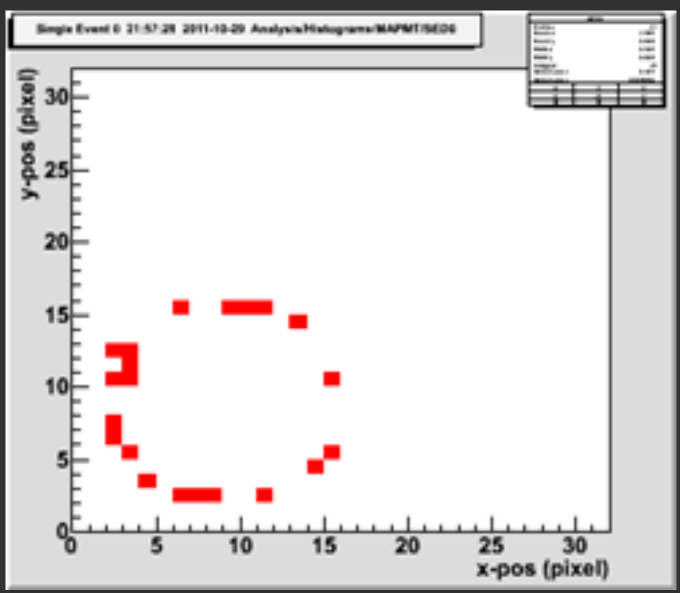


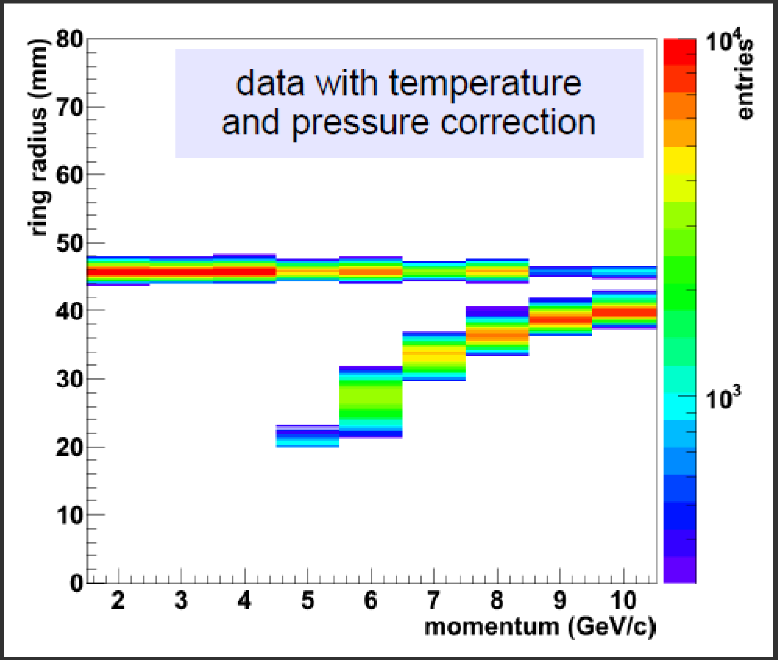
RICH Beam Test

Full-size prototype tested @ CERN

- Mixed beam (π,e), 2-10 GeV
- CO_2 radiator
- Response to single electron
  - ✘ ≥ 20 hits/ ring
  - ✘ noise/channel ~10Hz



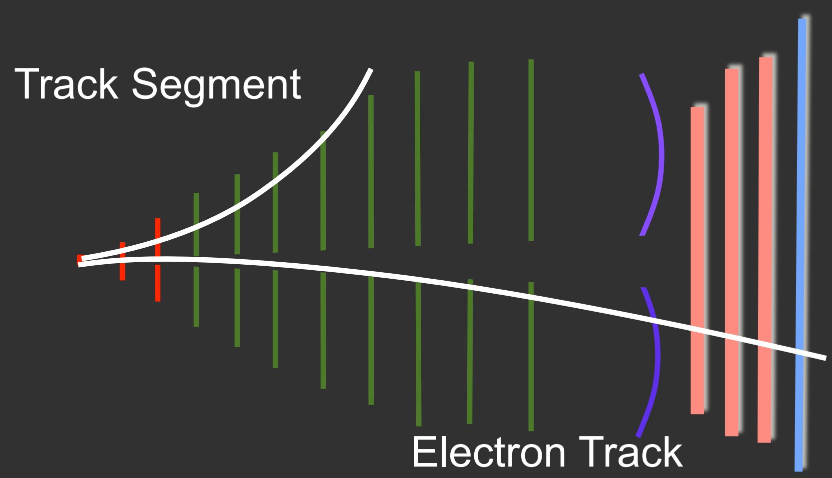


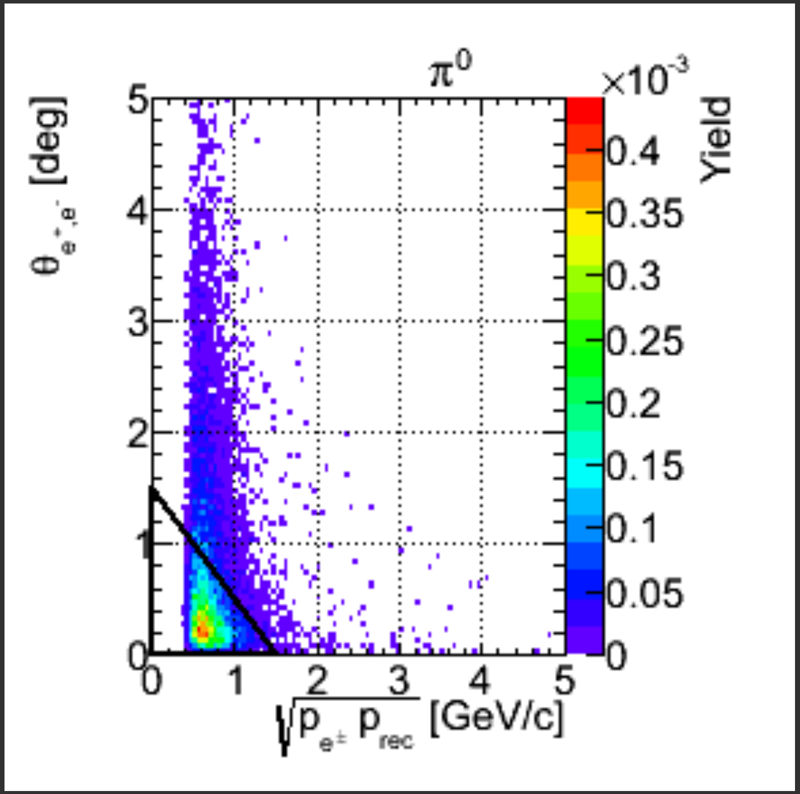


Dielectron Background Rejection

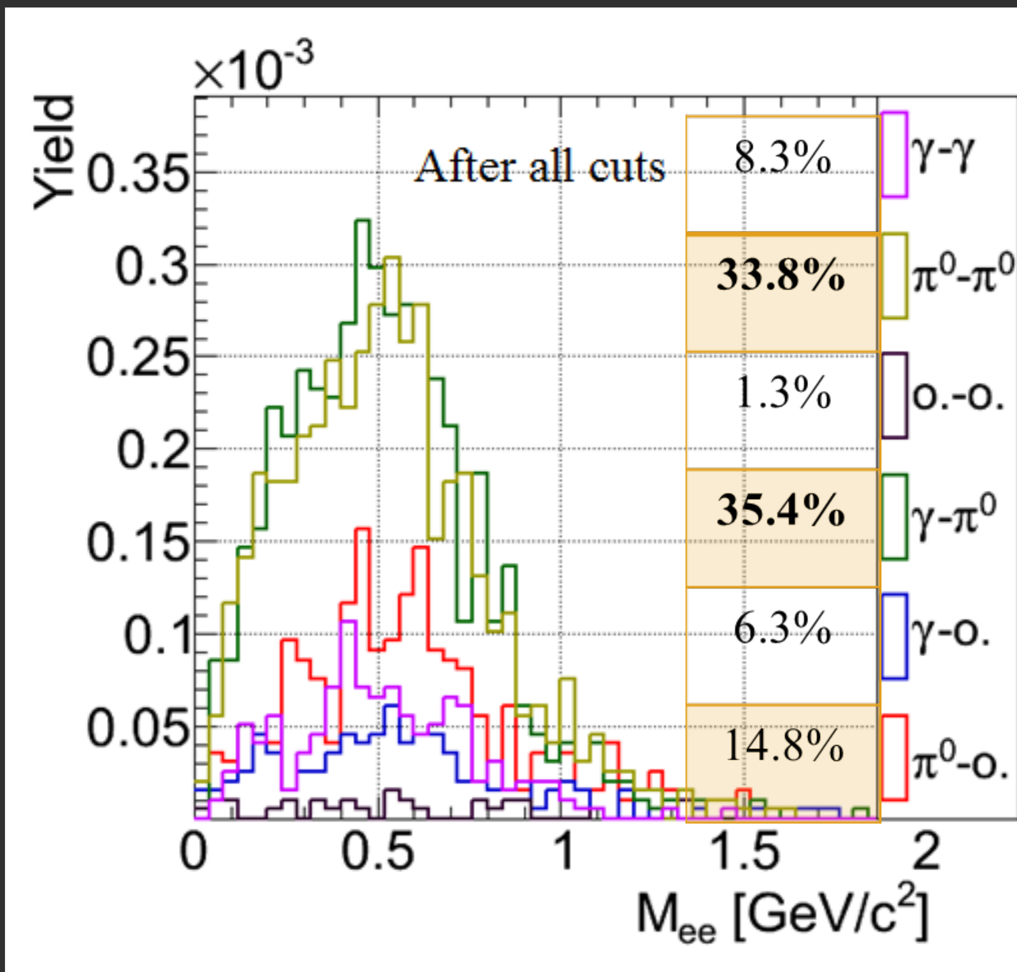
CBM compromise:

- No field-free region behind target
- Identification of track topology (conversion/π^0 pairs) using excellent tracking capability





Dielectron Background Rejection



e^+,e^- tracks contributing per event:

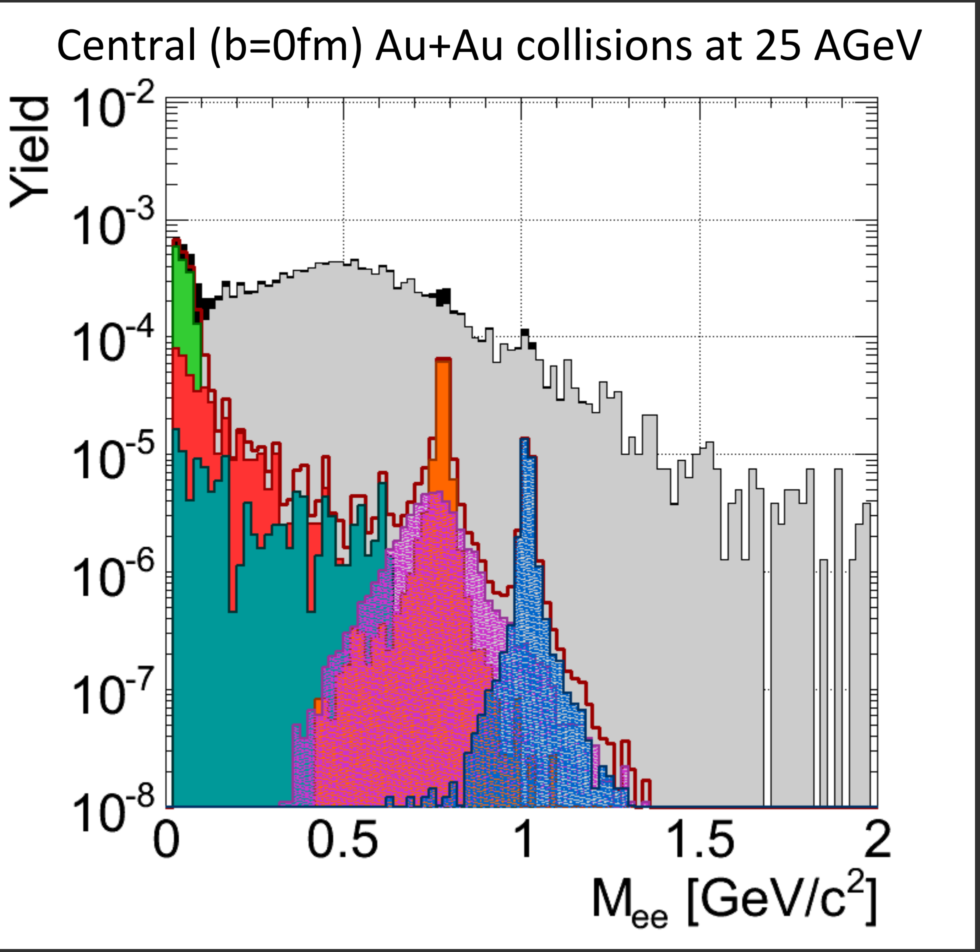
0.14 from p^0-Dalitz decay (60%)

0.07 from g-conversion (29%)

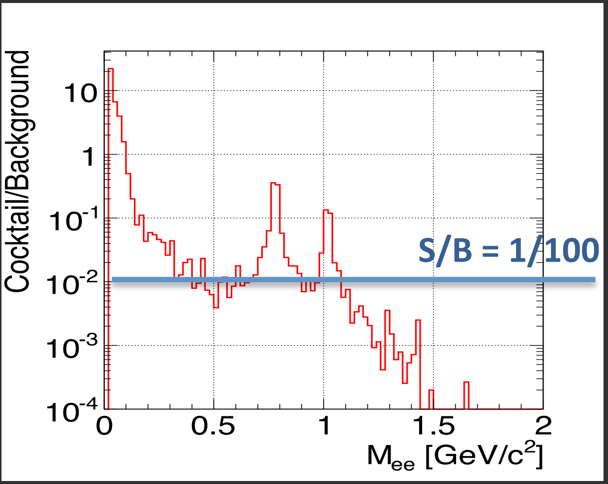
0.007 misidentified $p^{\pm}$ (3.3%)

0.016 secondary $e^{\pm}$ (7%)

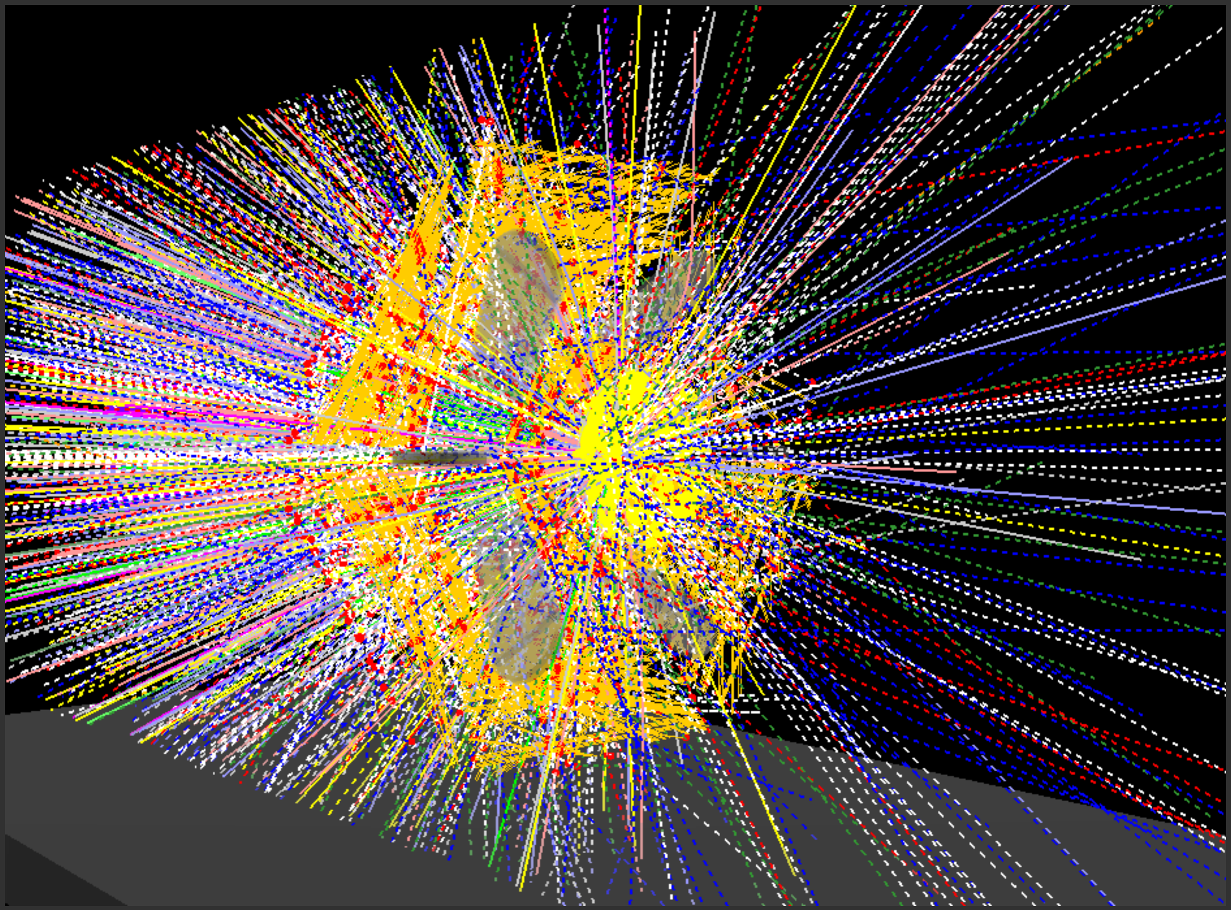
Dielectron low-mass Performance



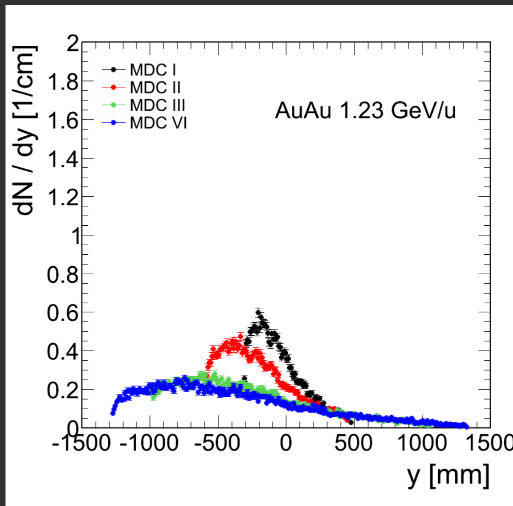
- Mass resolution:
  - 12 MeV (ω) and
  - 29 MeV (J/ψ)
- Only cocktail simulated
- Dominant background from π^0-Dalitz

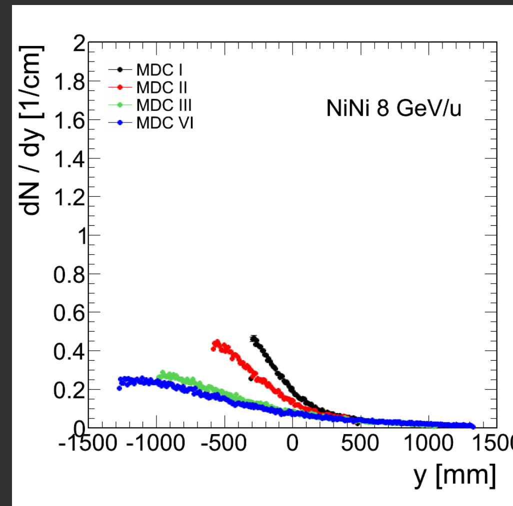


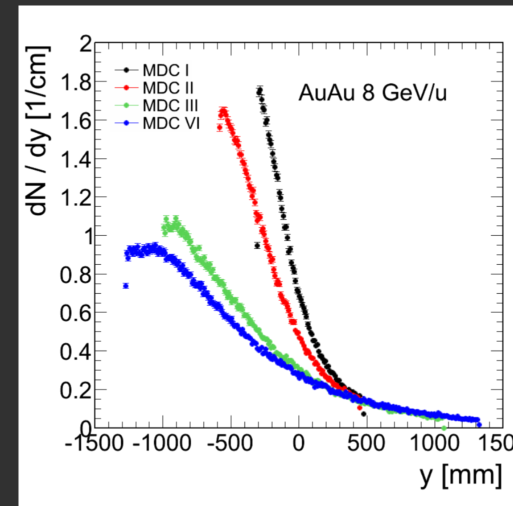
HADES at SIS100

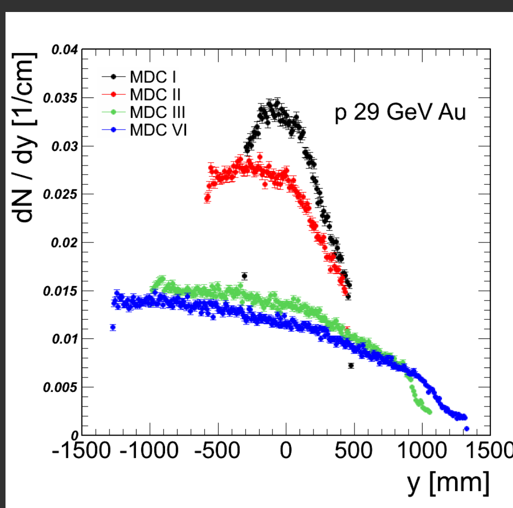


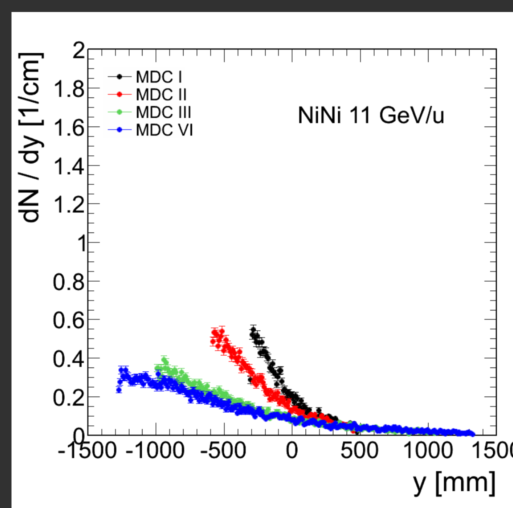
HADES Drift Chamber Occupancies

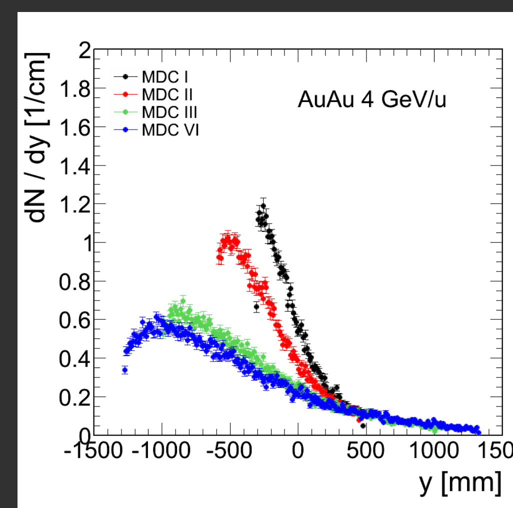












HADES Rapidity Coverage

thermal ρ (BW) -> e^+e^-

E_{beam} = 1 GeV/u

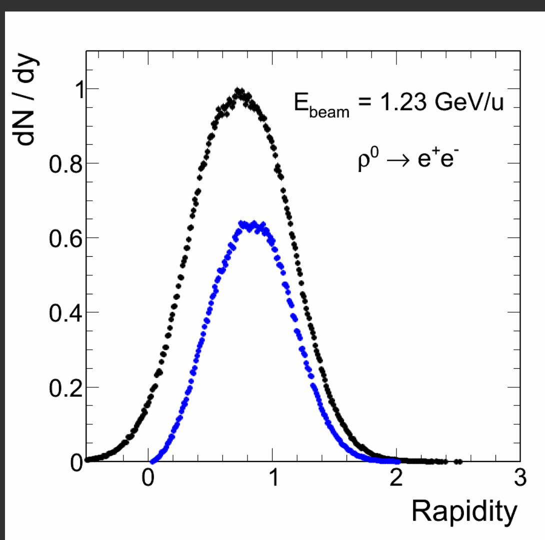
- Acc ≈ 35%
- mid-rapidity coverage, shift to forward

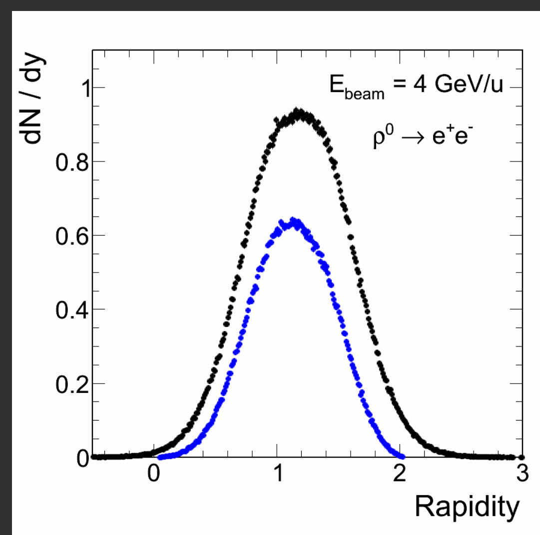
E_{beam} = 4 GeV/u

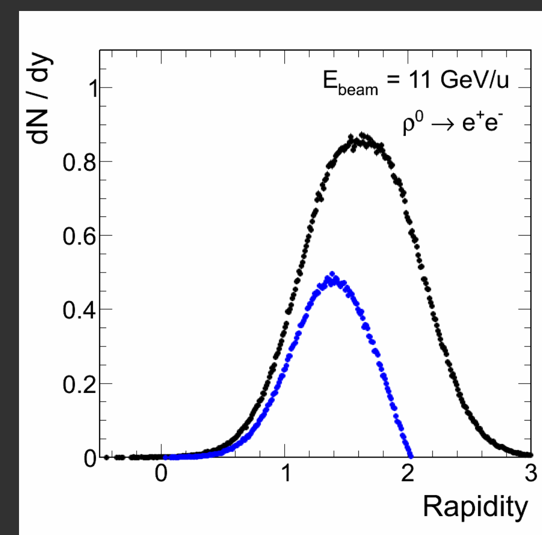
- Acc ≈ 33%
- mid-rapidity coverage, shift to backward

E_{beam} = 11 GeV/u

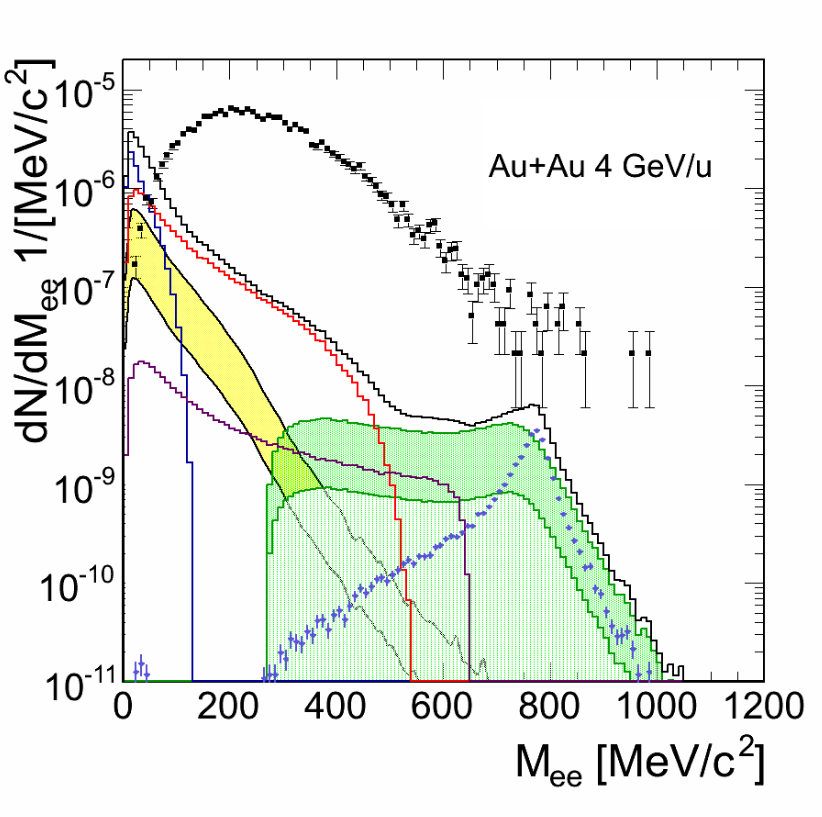
- Acc ≈ 20%
- mid-rapidity coverage lost



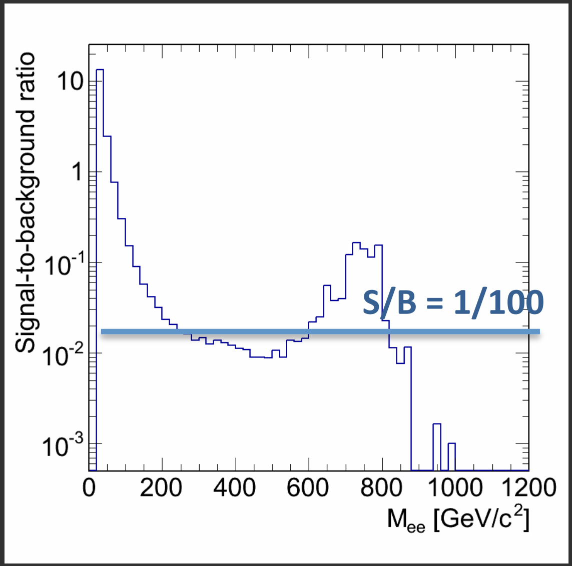




HADES Dielectron Performance



- Mass resolution:
  - 16 MeV (ω) and
- Cocktail includes baryonic sources
- Dominant background from π^0-Dalitz



The C.B.M. Strategy at FAIR

- Complementary detector systems for optimal performance in experiments addressing:
  - Elementary reactions
  - Cold matter
  - HI reactions
- HADES:
  - low-mass tracking (X/X_0 = 0.2 % + 0.3 % air)
  - polar acceptance 18 to 85 degree
  - Interaction rates 10 – 50 kHz (depending on occupancy)
- CBM
  - Fast, high-precision tracking (X/X_0 = 3-8 %)
  - polar acceptance 2.5 to 25 degree
  - Interaction rates < MHz (FLES performance important)
- Time-line:
  - HADES runs at SIS18 after SIS18 shut-down (2017-2018)
  - Start version of CBM at SIS100
  - HADES moves to SIS100

Summary

- FAIR will enable a comprehensive program to address the phase diagram at high μ_B
- FAIR is a dedicated facility for heavy-ion and strong interaction physics (like RHIC)
- The Compressed Matter (C.B.M.) Program will utilize versatile detector set-ups to optimally address a large variety of observables
- Two different spectrometers (HADES, CBM) and both muons (MUCH) and electrons will be used to make the most of dilepton physics
- We are prepared for discoveries