Feasibility study of muon detection in the CBM experiment at FAIR

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Physics Motivation

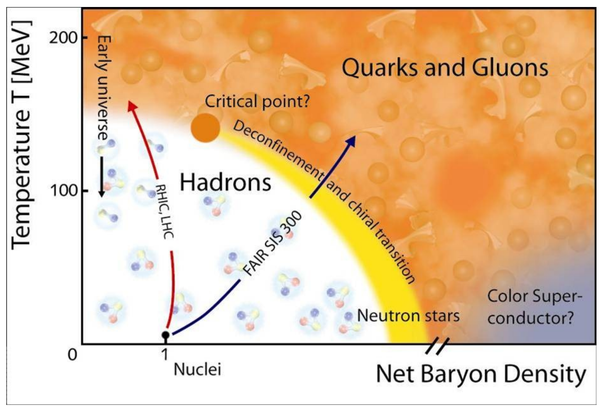


Fig.1 : A schematic conjectured phase diagram of strongly interacting matter.

The Compressed Baryonic Matter (CBM) Experiment at the Future Facility for Anti Proton and Ion Research (FAIR) is aiming at the investigation of strongly interacting matter at very high baryon densities. The research program of CBM comprises :

- The exploration of equation of state of dense hadronic matter
- The search for the deconfinement first order phase transition which is expected to occur at high net baryon densities.
- The study of in-medium modifications of hadrons

Observables & Challenge

Goal of CBM experiment: comprehensive and systematic (energy, system size) studies of all relevant diagnostic probes including:

- hadrons, event-by-event fluctuations, correlations, collective flow
- multistrange hyperons
- low-mass vector mesons
- open charm (D^0, $D^{\pm}$, Λ_c)
- charmonium (J/ψ, ψ')

rare probes!

W. Cassing, E. Bratkovskaya, A. Sibirtsev, Nucl. Phys. A 691 (2001) 745

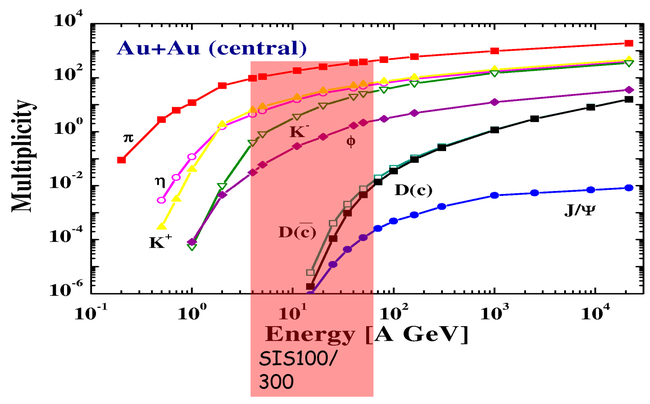
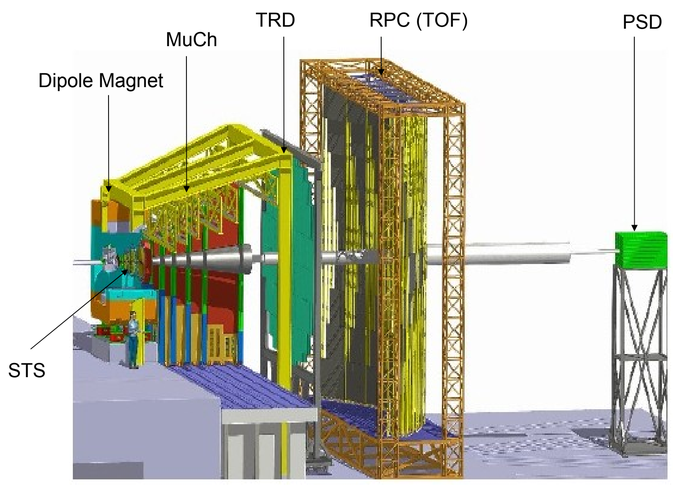


Fig.2: Multiplicity in central Au-Au collisions

CBM setup with muon detector (MuCh)



STS : track , vertex and momentum reconstruction

MuCh : muon identification

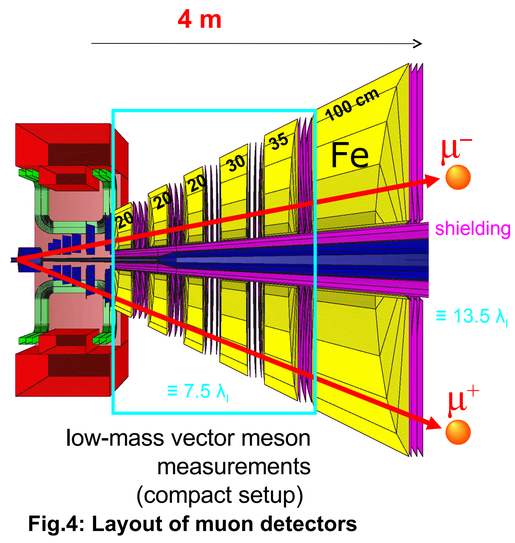
TRD : global tracking

RPC-TOF : time of flight measurement

PSD : centrality determination

Fig.3: CBM experimental setup with muon detection system

Muon Detection System



low-mass vector meson measurements (compact setup)

Fig.4: Layout of muon detectors

Detectors sandwiched in between two absorbers

Chambers:high resolution gas detectors (major Indian participation)

Challenges:
- ✓ high rate capability (up to 1MHz/cm2)
- ✓ high granularity (up to 1 hit/cm2 in central Au-Au coliisions)
- ✓ position resolution < 300μm

GEM for the first few stations and staw tubes for the latter stations

Scenarios

Start version p-A @ SIS 100 | **Intermediate version A-A @ SIS 100** | **Full version A-A @ SIS 300**

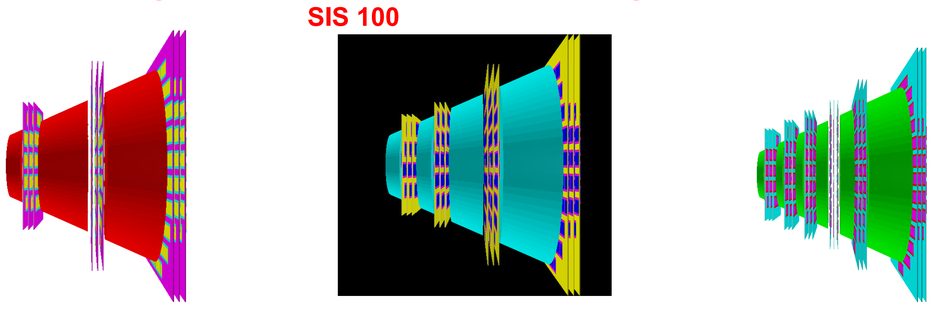


Fig 5 : Schematic view of the three geometries: Reduced (left) , Intermediate (middle) and full (right)

	Reduced	Intermediate	Full
# of stations	3	4	6
# of layers	3 x 3 = 9	3 x 4 = 12	3 x 6 = 18
Total Absorber thickness	225 cm (30+95+100)	225 cm (30+30+65+100)	225 cm (20+20+20+30+35+100
Distance between layers	10 cm	10 cm	10 cm

Feasibility Studies

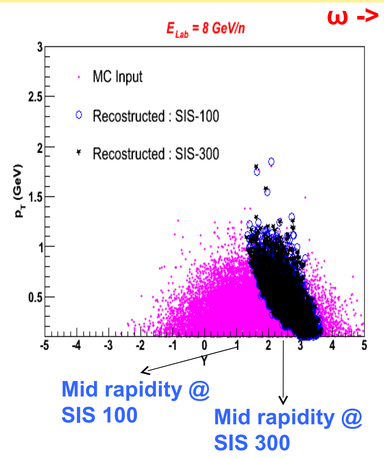


Fig 6 : Acceptance plot for ω at 8 A GeV energy

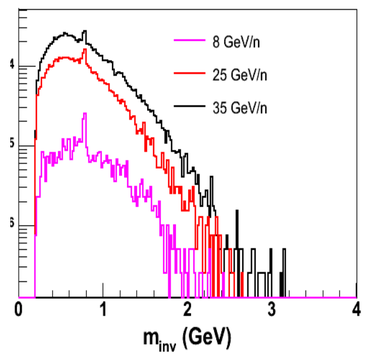


Fig 7 :Invariant Mass spectra of ω for 8 A , 25 A and 35 A GeV energies

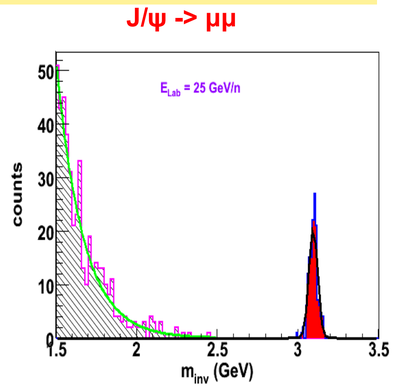


Fig 8 :Invariant Mass spectra of J/Ψ at 25 A GeV energy

- ❖ **Simulation studies include full event reconstruction**
- ❖ **Combinatorial background is calculated using mixed event analysis**
- ❖ **Mass peak (ω) visible only for full geometry**
- ❖ **Clean J/Ψ signal !**

Reconstruction Efficiency & S/B

System	Setup	Efficiency (%)	S/B
A+ A (8 GeV) J/Ψ -> μμ	Reduced (9 layers)	5.1	3.1
A+A (8 GeV) ω -> μμ	Reduced (6 layers)	0.94	0.05
A+A (25 GeV) J/Ψ -> μμ	Full (18 layers)	13	7
A+A (25 GeV) ω -> μμ	Full (15 layers)	1.58	0.49

Segmentation : Minm. Pad size: 4 mm. * 4mm. Maxm. Pad size: 3.2 cm. * 3.2 cm

Table 2 : Reconstruction Efficiency and Signal-to-background ratio for ω and J/Ψ in central collisions at 8 A & 25 A GEV energies for different geometries

Summary and Conclusions

- **Designs are mostly defined by requirements of Low Mass Vector Meson (LMVM) measurements.**
- **Charmonium measurements (with additional 1 m Iron absorber) are less sensitive to the configuration details.**
- **Simulations of both lowest (minimum boost) & highest energy (maximum multiplicity) are performed.**
- **Even at the lowest energy there seems to be no inexpensive version capable for measurements of LMVM.**
- **Mid-rapidity is not covered for ω at lowest energy.**
- **Segmentation with minimum pad dimension 4mm*4mm is a suitable choice.**