Reconstruction of Low Mass Vector Mesons using machine learning techniques for CBM Experiment at FAIR SIS100

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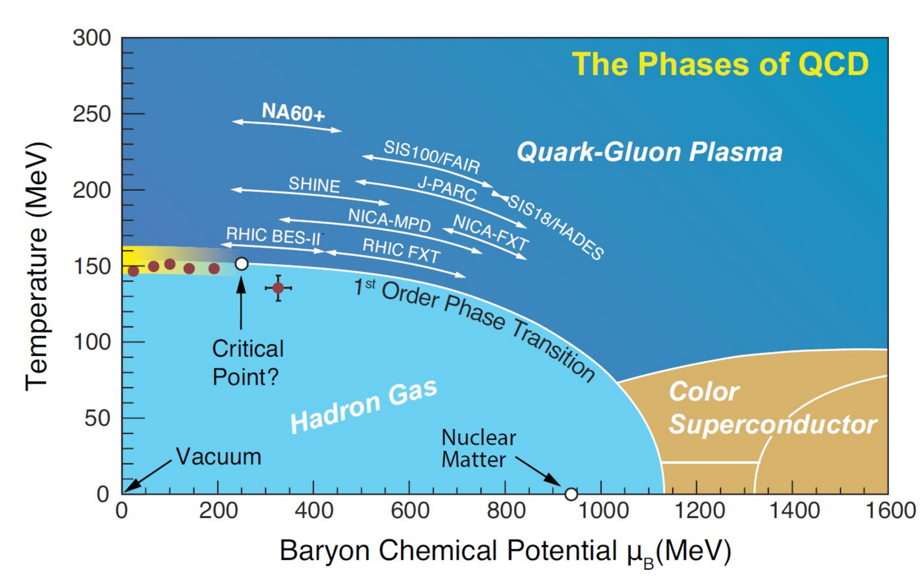
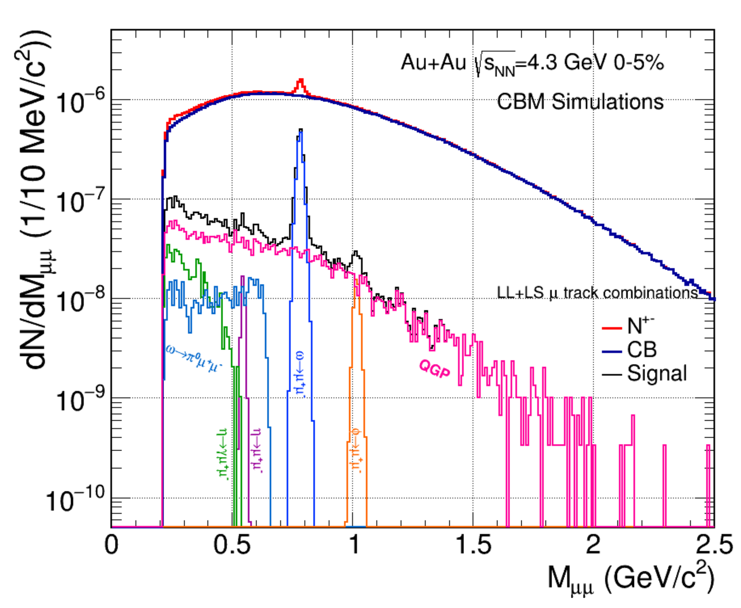
Introduction

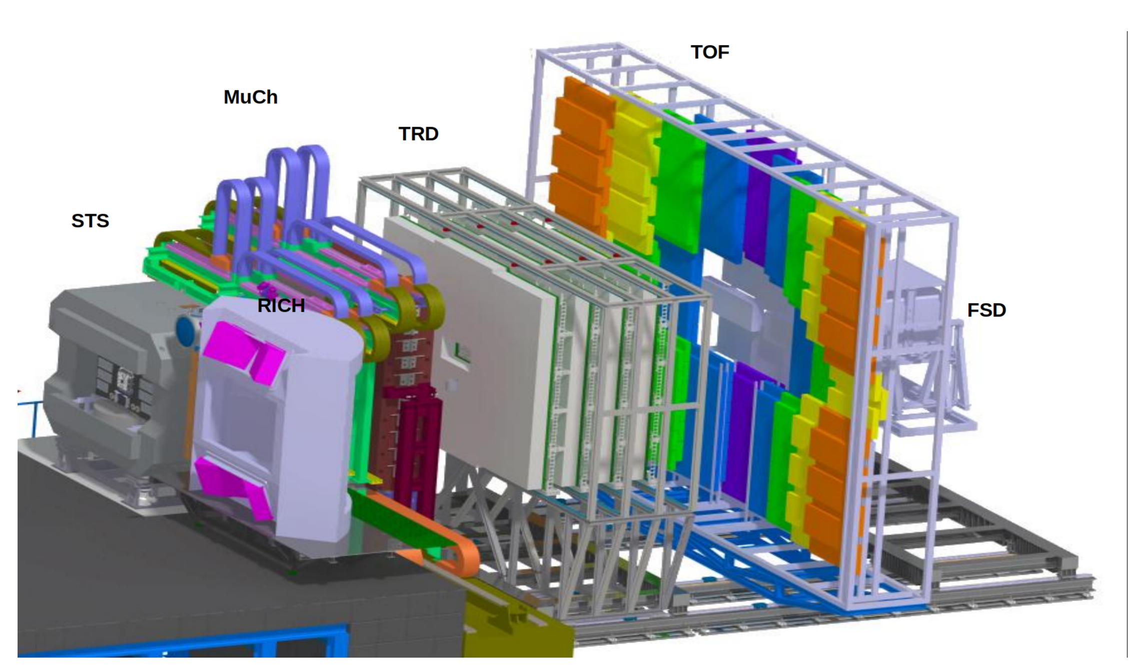
- The Compressed Baryonic Matter Experiment is planned within the accelerator facility known as Facility for Anti Proton Ion Research (FAIR) in Darmstadt, Germany.
- The goal of the CBM experiment is to investigate the phase diagram of strongly interacting matter under conditions characterized by high net baryon densities and moderate temperatures.
- The rare probes carries the information about the in-medium modification of light vector mesons, hypernuclei, charm production and their propagation inside the nuclear matter.
- The particle multiplicity of the particle like ω, η, ϕ, ρ is quite low.





- The precision and rare probes need high statistics with decent efficiency. The signal efficiency obtained through traditional uni-variate cut method is low.
- Therefore the need for multivariate analysis for the dimuon detection is required.

CBM Experimental Setup



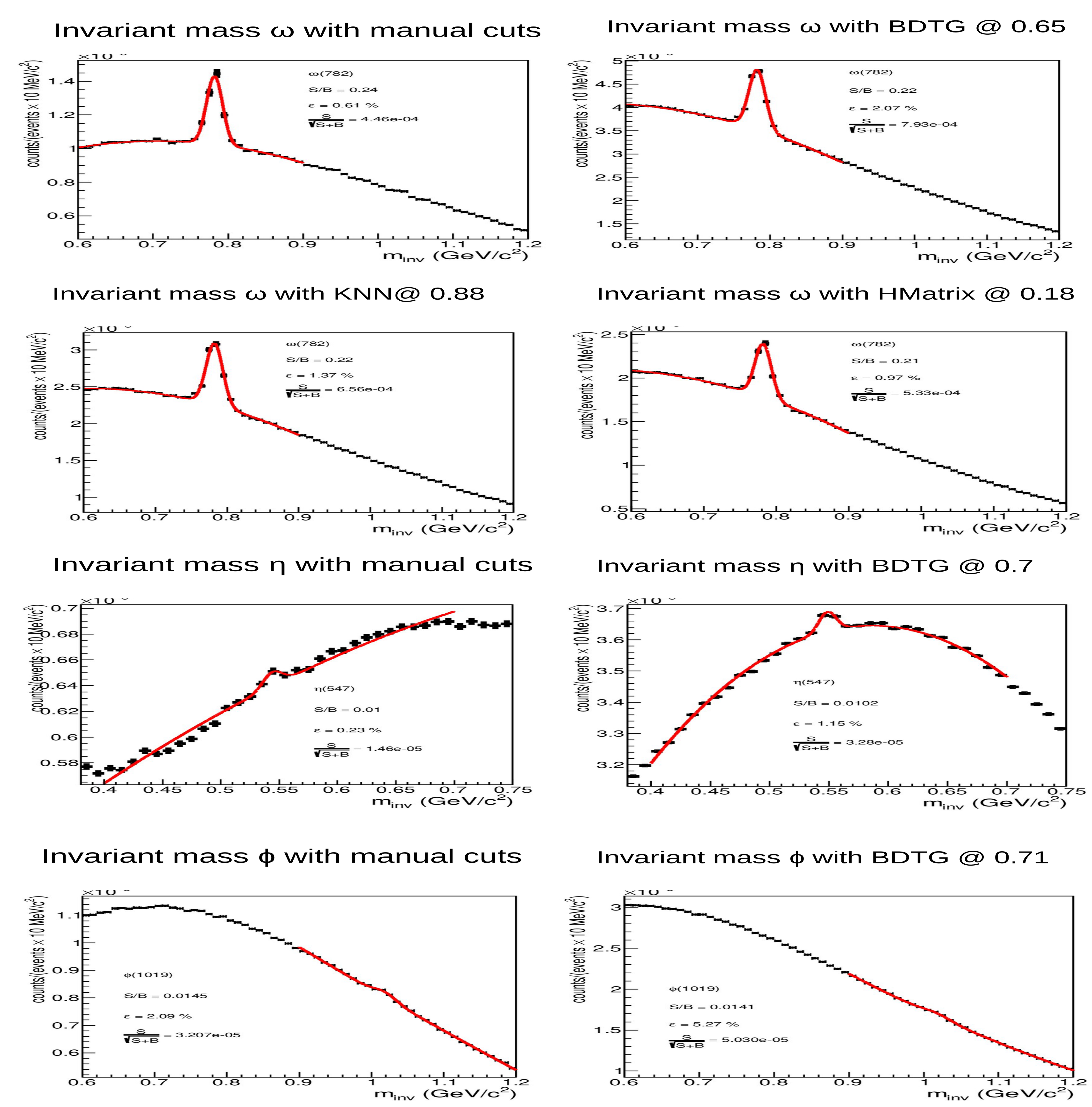
1. **STS:** Silicon Tracking System Momentum and Tracking
2. **MuCh or RICH:** Muon Chamber and Ring Imaging Cherenkov Detector dilepton detector(MuCh for muons and RICH for electrons)
3. **TRD:** Transition Radiation Detector particle tracking and for the identification of e^+e^-
4. **ToF:** Time of Flight Detector for hadrons identification

Improvement in physics observables using TMVA class

Manual Cuts: Number of STS Hits 7, Number of MuCh Hits 11, Number of TRD Hit 1, Number of TOF Hits 1, χ^2 Vertex 2.5, χ^2 STS 2.0, χ^2 MuCh 3.0 and TOF mass cut 2σ.

Soft Cuts: Number of STS Hits 5, Number of MuCh Hits 8, Number of TRD Hit 1, Number of TOF Hits 1, χ^2 Vertex 20.0, χ^2 STS 20.0, χ^2 MuCh 20.0 and TOF mass cut 2σ.

Results



Particle	Method	S/B	Efficiency	Normalised Significance
$\omega \rightarrow \mu^+\mu^-$	Manual	0.24	0.61	1.00
$\omega \rightarrow \mu^+\mu^-$	BDTG @ 0.65	0.22	2.07	1.77
$\omega \rightarrow \mu^+\mu^-$	KNN @ 0.88	0.22	1.37	1.47
$\omega \rightarrow \mu^+\mu^-$	HMatrix @ 0.18	0.21	0.97	1.19
$\eta \rightarrow \mu^+\mu^-$	Manual	0.01	0.23	1.00
$\eta \rightarrow \mu^+\mu^-$	BDTG @ 0.7	0.01	1.15	2.24
$\phi \rightarrow \mu^+\mu^-$	Manual	0.01	2.09	1.00
$\phi \rightarrow \mu^+\mu^-$	BDTG @ 0.71	0.01	5.07	1.57

Table 1: Results for Invariant Mass using Manual and Machine Learning Technique

Conclusion || Discussion

- There is an increase in the efficiency of particle reconstruction using TMVA method.
- Further investigation of complete dimuon cocktail production and for high mass region for J/ψ production is under progress.
- These ML algorithms can also be used at the digitization and reconstruction level as well for improving the detector efficiency.

References

1. The CBM Collaboration,Technical Design Report for the CBM Muon Chambers,GSI-201502580.
2. TMVA - Toolkit for Multivariate Data Analysis, arXiv:physics/0703039

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