Estimation of the signal of ϕ(1020) detected at the BM@N experiment

Abstract

This work is devoted to the search for ϕ(1020) after collisions in the Baryonic Matter at Nuclotron (BM@N) experiment, running at the NICA accelerator complex. Reconstruction efficiency of the ϕ(1020) was derived by employing a phase space analysis of a Monte Carlo data set. This result was then combined with a similar procedure applied to experimental data in order to estimate the number of detected ϕ(1020) in the collision.

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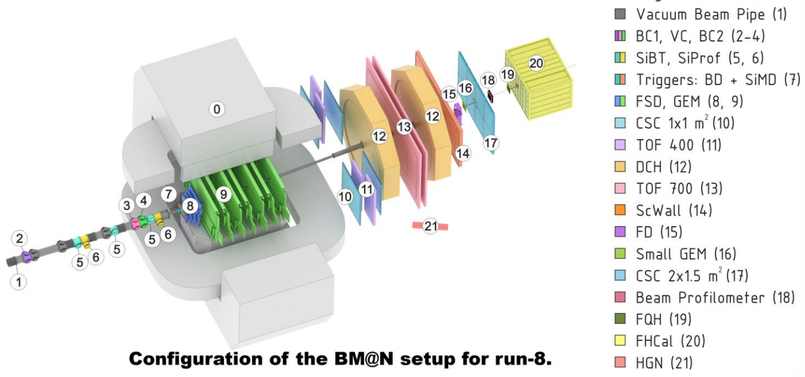
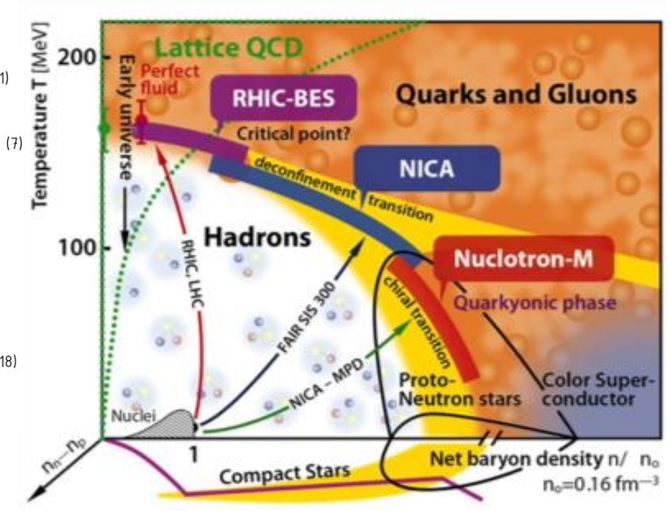
1. Background

BM@N experiment



Configuration of the BM@N setup for run-8.

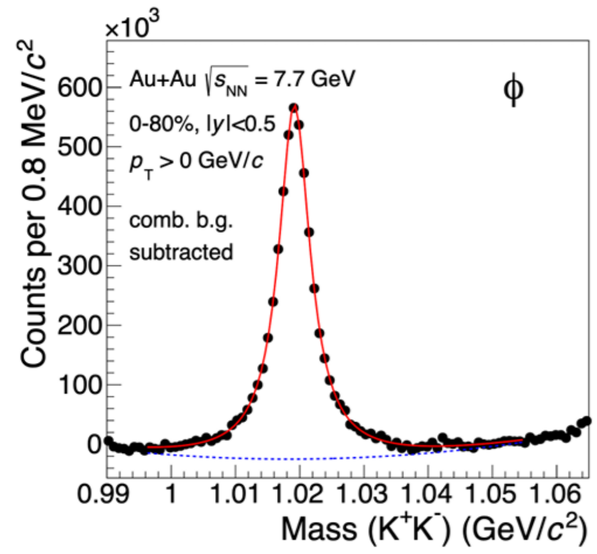
Beam energy of 3.8 AGeV, a CsI target and Xe beam (https://bmn.jinr.int/).



QCD diagram.

Why is φ(1020) interesting to study?

φ(1020) is expected to have a small cross-section for interactions with other non-strange particles, and its life time is relatively long (~41 fm/c), it may keep information of the early stage of the system's evolution [1].



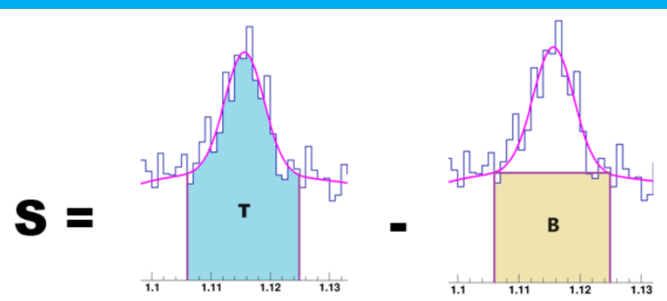
One of the results of search for φ(1020) by STAR Beam Energy Scan Program [2].

2. Analysis procedure

The resulting invariant mass distributions are approximated by means of a complex function consisting of a sum of a Gaussian function (used to describe the signal) and the product of an exponential function and a power function (employed to describe the background). The function in question is presented below:

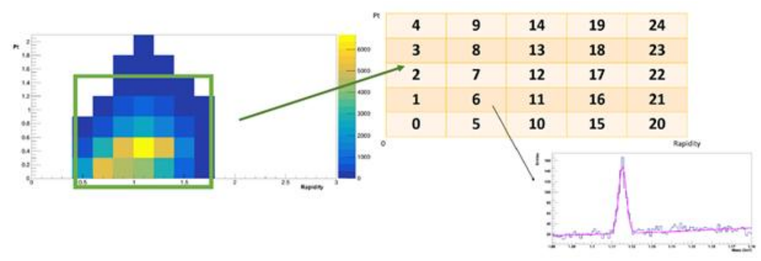
$$BG = A \cdot \sqrt{x - 0.985} \cdot e^{-B(x-0.985)},$$

where A and B are two free parameters that have to be selected according to the background present.



An overview of signal extraction from the mass spectrum.

The value T is the sum of the signal and background in the mass region corresponding to the tabulated value of the mass of the reconstructed particle and is calculated as the sum of the histogram values in the range under consideration. The value of B is an estimate of the background events, which is defined as the integral of the function obtained after the approximation process. The signal is calculated as the difference between T and B.



A schematic overview of phase space analysis.

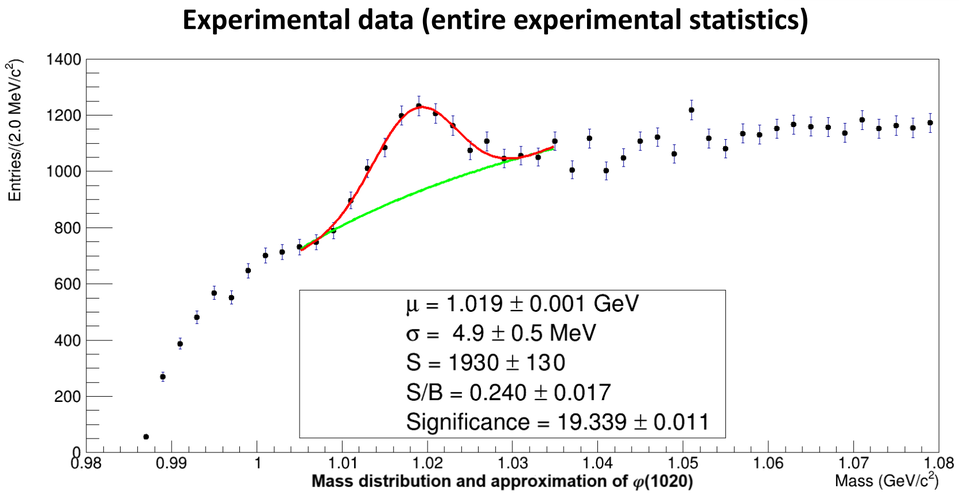
$$N_{exp} = S_{exp} \cdot \frac{N_{rec}}{N_{gen}}$$

$$(Efficiency = \frac{N_{rec}}{N_{gen}} \cdot 100\%),$$

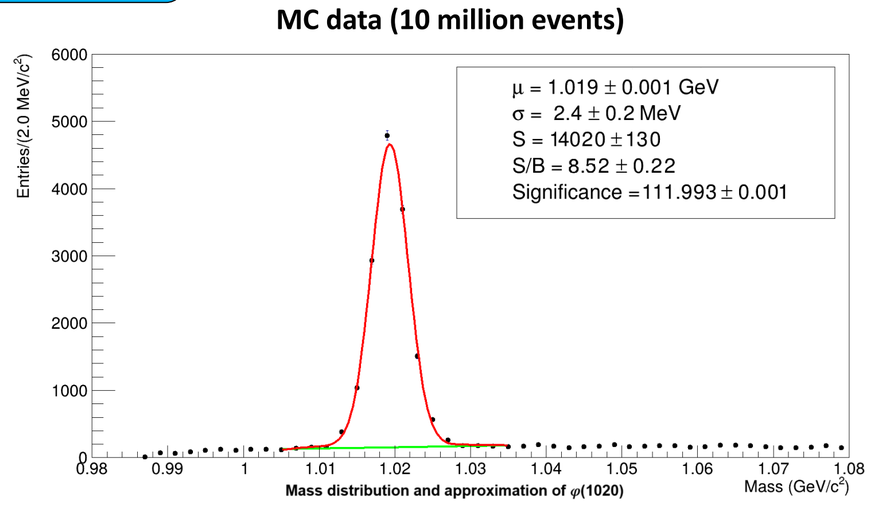
where N_{rec} represents the number of reconstructed strange particles and N_{gen} represents the number of simulated strange particles and S_{exp} is the number of reconstructed strange particles in the case of experimental data.

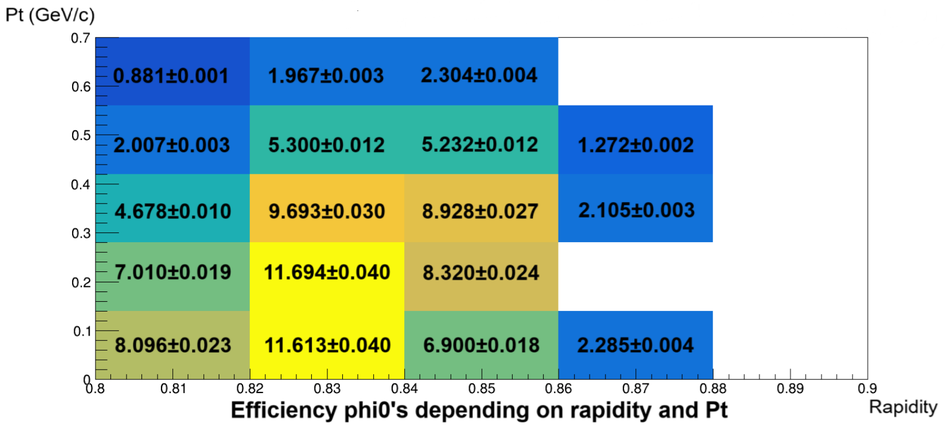
3.Results

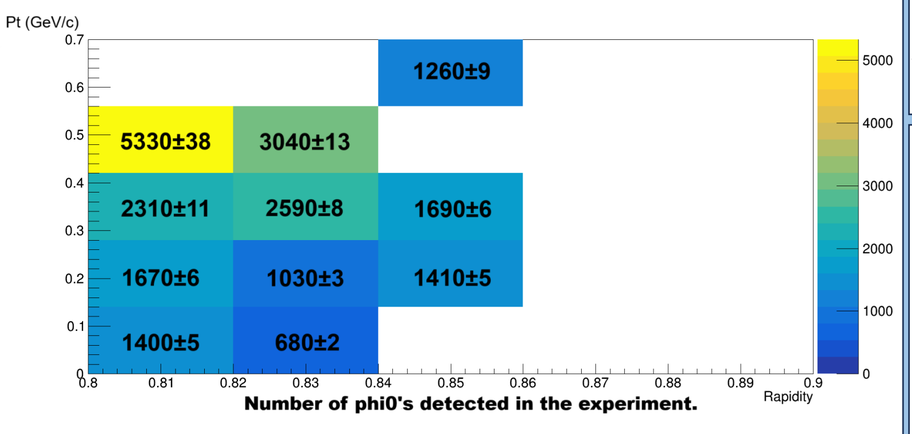
Experimental data (entire experimental statistics)



MC data (10 million events)







4.Conclusions

- ϕ(1020) was successfully reconstructed in both MC and experimental cases.
- Reconstruction efficiency varies from 1 to 12% and the number of detected ϕ(1020)'s from 700 to 5000: both strongly depend on the region of phase space considered.
- A rapidity interval of 0.82-0.84 and a transverse momentum of 0.0-0.28 GeV/c seem to be the best option for reconstructing ϕ(1020).
- The largest number of estimated detected particles seems to be located within the intervals 0.8-0.82 for rapidity and 0.42-0.56 GeV/c for the transverse momentum.
- Work to be done to reach a better agreement between the experimental and MC data.

References

[1]J. Phys. G: Nucl. Part. Phys. 32, S373-S380 (2006) DOI: 10.1088/0954-3899/32/12/S46.
[2]https://indico.jinr.ru/event/5217/contributions/30336/attachments/22099/38986/zhu_MPD2025_v0.pdf.