# Analysis of $\Lambda$ and $K^0_S$ production in Xe+CsI collisions at the BM@N experiment

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## Abstract

The aim of this work is investigation of the production of strange particles during the second order phase transition from the baryonic matter to the so-called Quark-Gluon-Plasma (QGP). The following two particles were studied: $\Lambda$ and $K^0_S$. Algorithms were developed to enable the reconstruction of these two particles and their functionality was tested by comparing the resulting mass distributions in both cases to the expected values. Furthermore, an in-depth analysis was performed related to reconstruction efficiency of $\Lambda$ and $K^0_S$ when employing experimental data. Finally, some preliminary research has occurred with regards to tuning Monte Carlo generated data to the one experienced in the latest run.

## Background

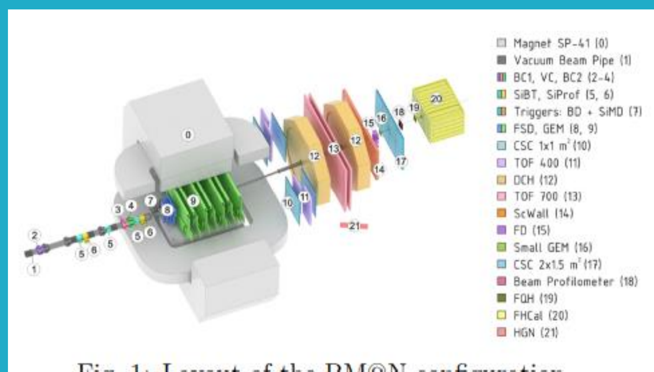

Fig. 1: Layout of the BM@N configuration.

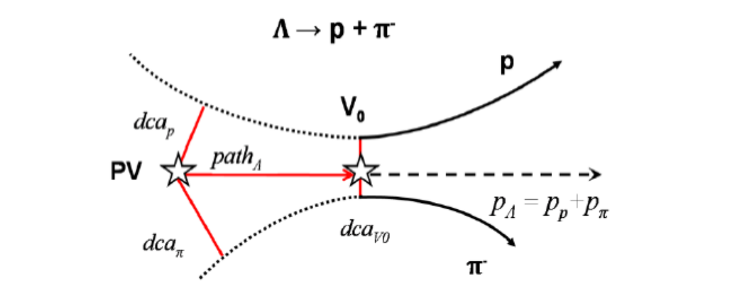


Fig. 2: A graphical overview of $\Lambda$ decay and geometrical restrictions used in the reconstruction algorithm.

$\Lambda$ and $K^0_S$ are unstable particles. Their main decay channels are the following:

$$\Lambda \to p + \pi^-, \quad (1)$$

$$\Lambda \to n + \pi^0, \quad (2)$$

$$K^0_S \to \pi^+ + \pi^-, \quad (3)$$

$$K^0_S \to \pi^0 + \pi^0. \quad (4)$$

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:

$$BG = A \cdot \sqrt{x - 1.075} \cdot e^{-B(x-1.075)}, \quad (5)$$

where A and B are two free parameters that have to be selected according to the background present. The results of this process are shown in Fig.4 and Fig. 5.

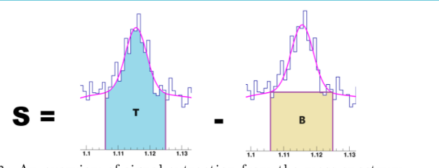


Fig. 3: An overview of signal extraction from the mass spectrum.

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 5 obtained after the approximation process. The signal is calculated as the difference between T and B.

## Results

**Monte Carlo generator**
**E = 3.9 AGeV**
**600000 events**

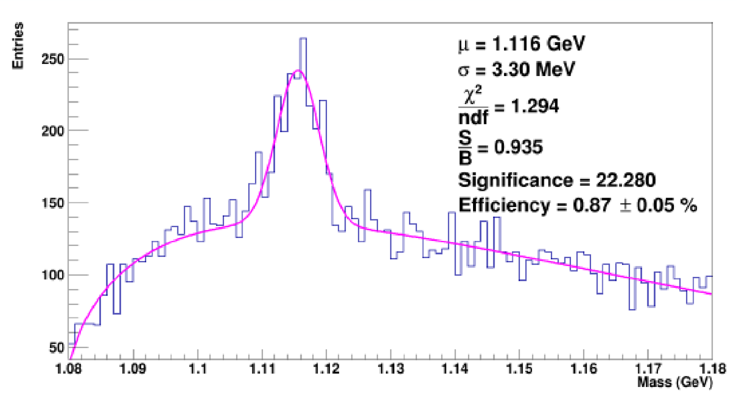


Fig. 4: Mass distribution and approximation for $\Lambda$.

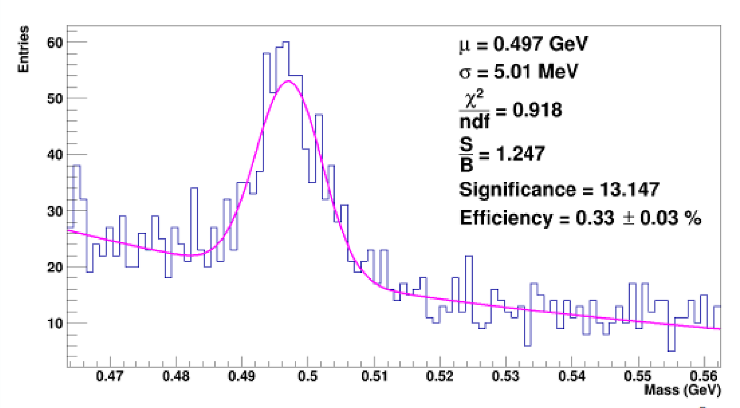


Fig. 5: Mass distribution and approximation for $K^0_S$.

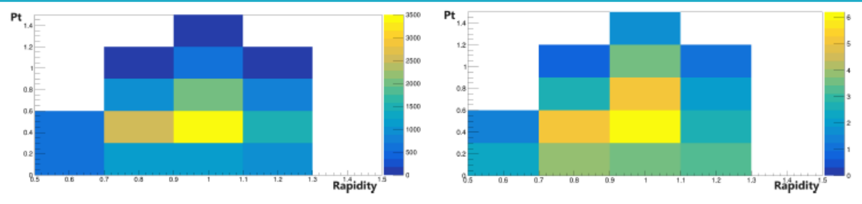


Fig. 6: Distribution of the number of $\Lambda$ in phase space based on data obtained after the reconstruction process, imposition of geometric constraints and signal extraction (left) and the efficiency of reconstruction of $\Lambda$ in phase space (right).

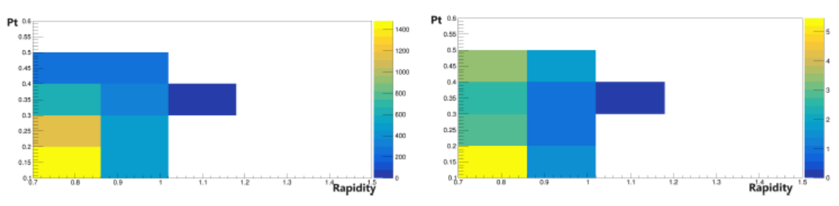


Fig. 7 : Distribution of the number of $K^0_S$ in phase space based on data obtained after the reconstruction process, imposition of geometric constraints and signal extraction (left) and the efficiency of reconstruction of $K^0_S$ in phase space (right).

**Experimental data**
**E = 3.8 AGeV**
**1000000 events**

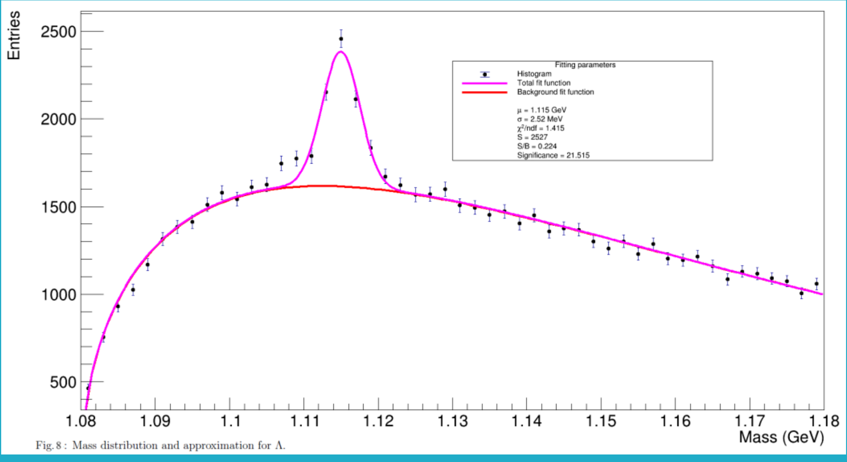


Fig. 8: Mass distribution and approximation for $\Lambda$.

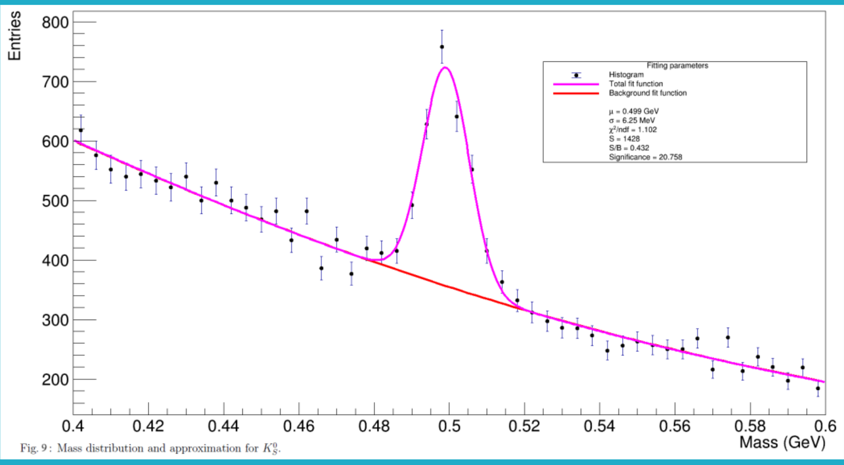


Fig. 9: Mass distribution and approximation for $K^0_S$.

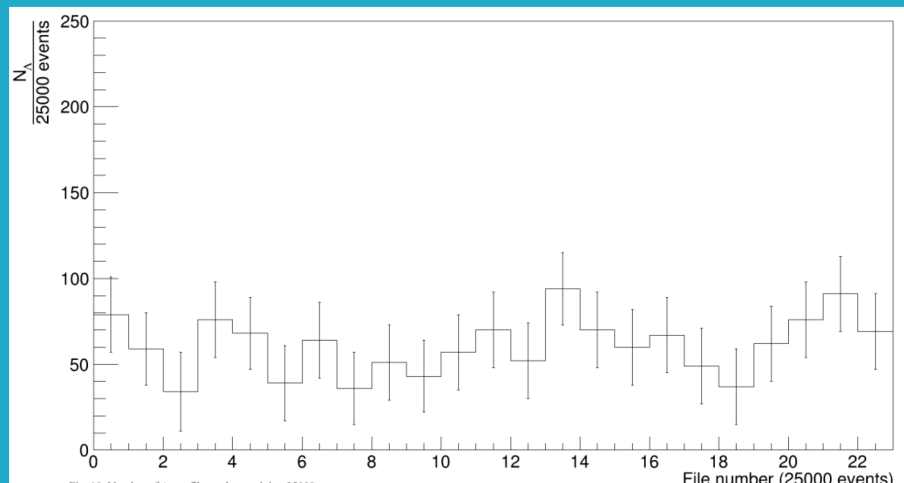


Fig. 10: Number of $\Lambda$ per file, each containing 25000 events.

## Conclusions

The results of an analysis of the efficiency of reconstructing $\Lambda$ and $K^0_S$ using the proposed algorithm were shown. Both particles were successfully reconstructed, which is clearly shown in the distributions of invariant masses in Fig.3 and Fig.4. The reconstruction efficiency of both $\Lambda$ and $K^0_S$ strongly depends on the region of phase space in which the particle is being reconstructed, and varies from 1 to 6%. A rapidity interval of 0.9-1.1 and a transverse momentum of 0.3-0.6 seem to be the best option for reconstructing $\Lambda$ , and intervals of 0.7-0.86 and 0.1-0.2 for reconstructing $K^0_S$. A similar analysis was performed by employing experimental data.

## Future work

- Comparison between model and experimental data by considering basic distributions (momentum, number of hits in a track, number of tracks, residuals in GEM and FSD).
- Apply adjustments to the modeling process to align the distributions being considered.
- Compare the distributions of proton-pion pairs depending on the imposed geometric constraints for model and experimental data. In case of differences, apply corrections to the modeling.
- Calculate the reconstruction efficiency of $\Lambda$ in phase space after agreement is reached between the model and experimental data.
- Estimate the yield and cross section for the production of $\Lambda$.
- Repeat all the previous points for $K^0_S$.