JOINT INSTITUTE FOR NUCLEAR RESEARCH
Veksler and Baldin Laboratory of High Energy Physics

FINAL REPORT ON THE SUMMER STUDENT PROGRAM

Monte Carlo simulations of the GEM detectors for the SRC/BM@N experiment

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Abstract. The report presents the results that have been obtained during the summer student program. The work of Gas Electron Multipliers (GEMs) was analyzed on the experimental data of run seven. In that run, the GEMs were the basic detectors for the following tracking reconstruction. The work consisted of two steps. In the first one, we revealed the main parameters according to these we evaluated the quality of GEM stations work. Then we adopted the simulation procedure in order to make the GEM parameters in Monte Carlo data almost the same as for the experimental data.

Contents

Introduction

The **S**hort **R**ange **C**orrelation (SRC) experiment is a part of the BM@N program [1]. It studies the scattering of 48 GeV/c ^{12}C beam with a liquid hydrogen target. The facility consists of several types of detectors (Fig.1), such as **M**ulti-**W**ire **P**roportional **C**hamber (MWPC), several trigger systems (BC1-4, VC, X1-2, Y1-2), **Si**licon detectors, GEMs, **D**rift **Ch**ambers (DCh), and **T**ime-**of**-**F**light detectors (TOF). The triggers and detectors in the right and left arms are needed to select the $(p, 2p)$ reaction [2, 3]. We worked with the tracking system reconstruction that based on the GEM detectors that are located in analysing magnet SP-41 [4].

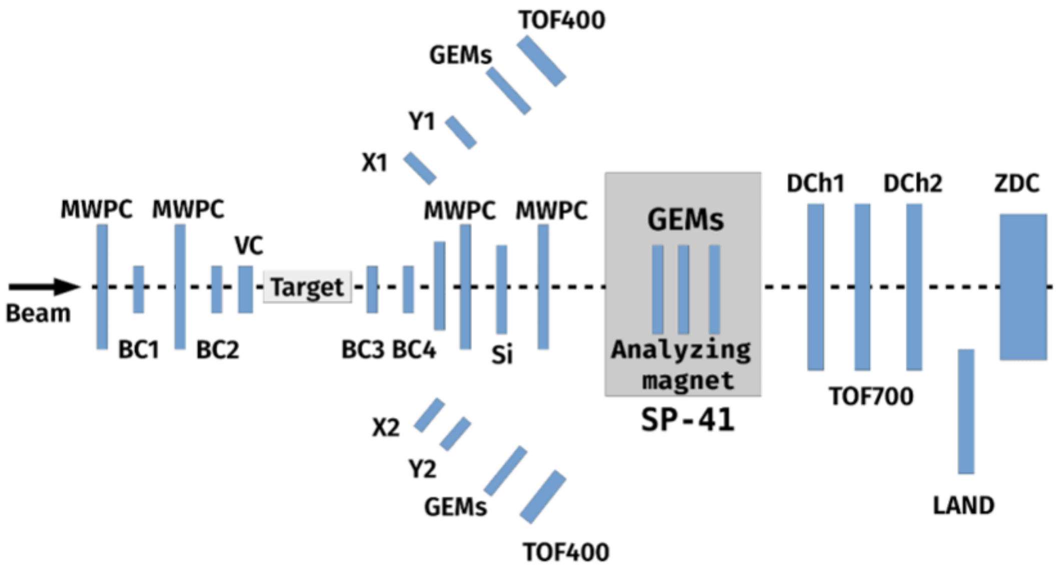

Figure 1: The scheme of the SRC facility

The procedure of reconstruction consists of several steps. Firstly, the tracks in the GEM detectors (gem-tracks) are built based on various combinations of hits in that stations. It requires the presence of 3 hits at least in six stations. In the same way, tracks are found in the DCh+TOF detectors (DCH-tracks) and the MWPC+Sil detectors (upstream tracks). Then these tracks are combined in one global track.

Now, one can distinguish different fragments in the charge-momentum space in the experimental data. To study the physical parameters of these spots, we have to find the inefficiency of the work of each station in the experiment, also we have to define the inefficiency of reconstruction and take into account many other features, such as misalignment, Lorentz shift e.t.c.

Analysis of the experimental data

First of all, we evaluated the efficiency of each GEM station by equation 1

$$Eff = \frac{N_1}{N_{allHits}}, \tag{1}$$

where N_1 is a number of hits in one GEM station for 5 or 6 hits per track in the event and $N_{allHits}$ is the number of missed hits in the stations for 4 hits in track and a general number of hits in stations in the other cases.

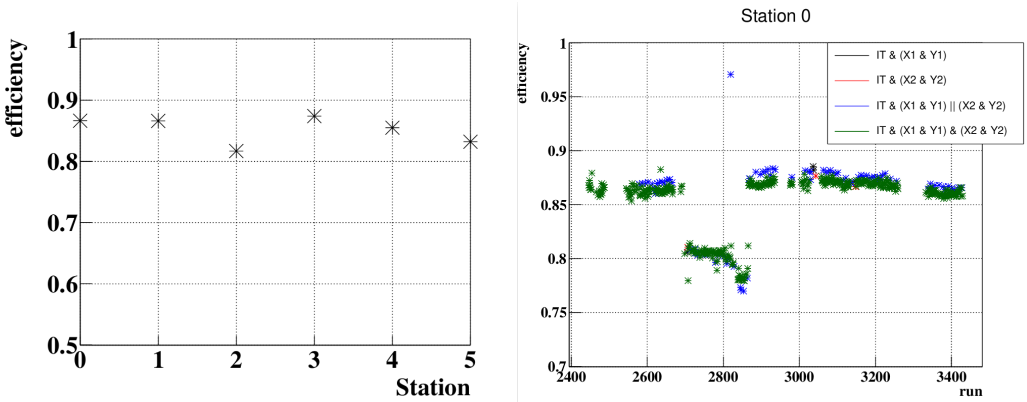

Figure 2: The experimental efficiency for the 3425 run and the efficiency for the runs during the SRC experiment

In Fig.2 we can see the low efficiency in station 6. To reveal the reason for the decrease we considered the hit distribution in each station. Fig. 3 shows the hits distribution in 4, 5, 6 and 7 stations. There are empty zones in that stations. It could be explained by non-working electronics. The effects should be taken into account in the simulation procedure, so we create the map of unworked strips in the experiment and that will be used in the following research.

After that, we studied the difference between the coordinates of hits obtained in the stations and the tracks that corresponded to that hits. These values, which are called residuals, are presented in Fig 4. Fig 4 shows that in some modules the residuals have some misalignment. Coefficients for misalignment corrections were found and used in the following reconstruction procedure.

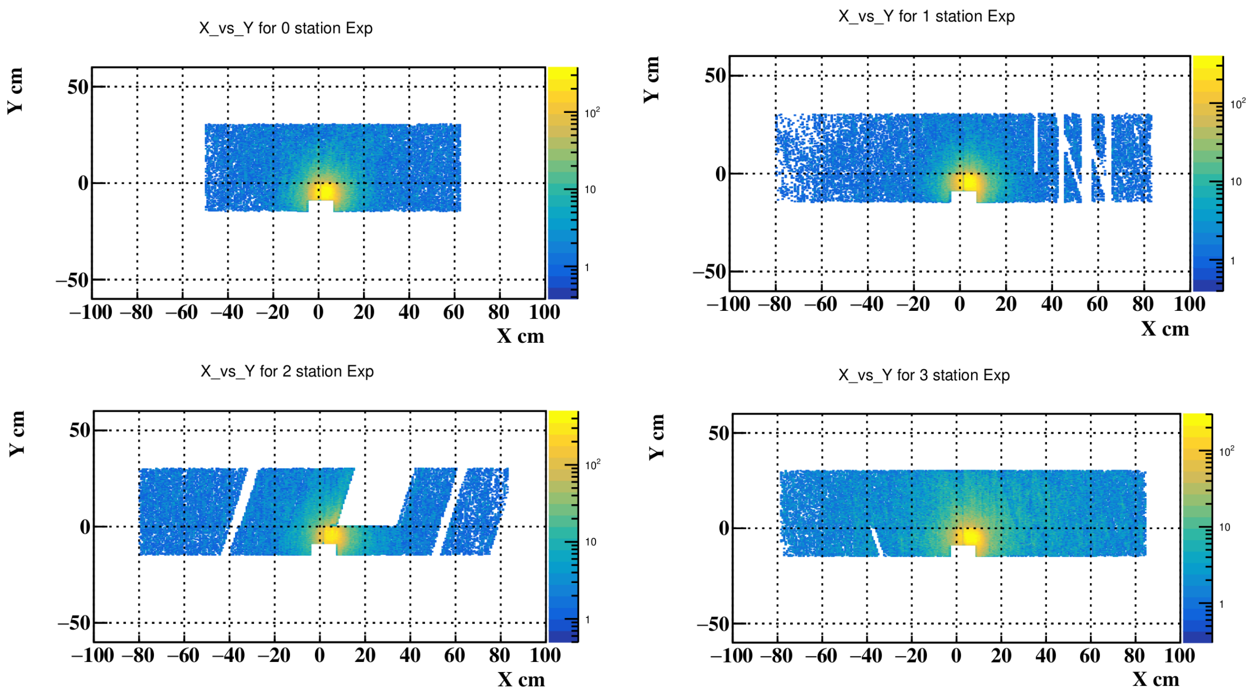

Figure 3: The hits distribution in GEM stations

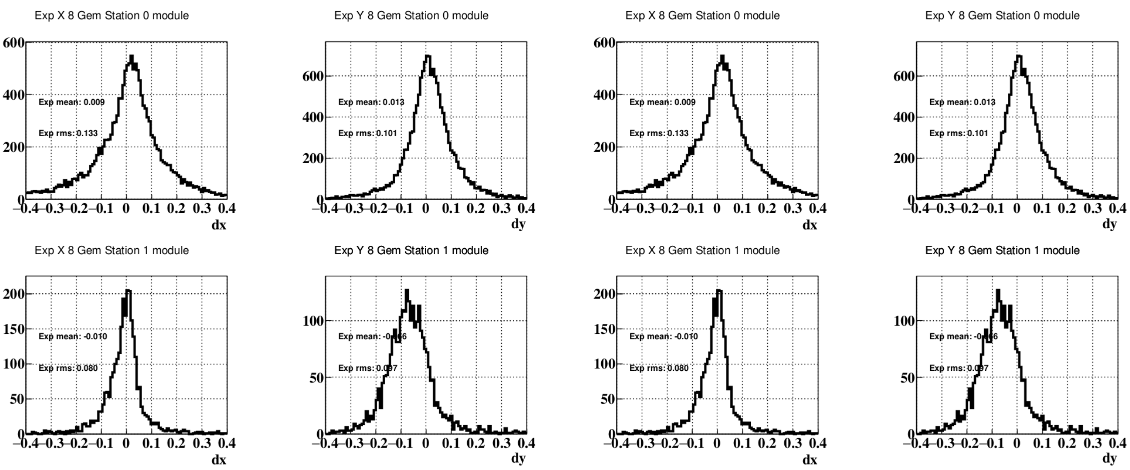

Figure 4: The residals in 8 (two left columns) and 9 (two right columns) GEM stations before calibration

Modification of the simulation procedure

As was mentioned above, the experimental data has to be compared with Monte Carlo data. The simulation procedure has to repeat experimental data as much as possible. Firstly, we simulated not worked strips in the MC data. It decreased the efficiency of the GEM stations work in simulation. The hits distribution after the corrections is presented in Fig. 5

The missed hits caused the efficiency to decrease. However, it wasn't equal

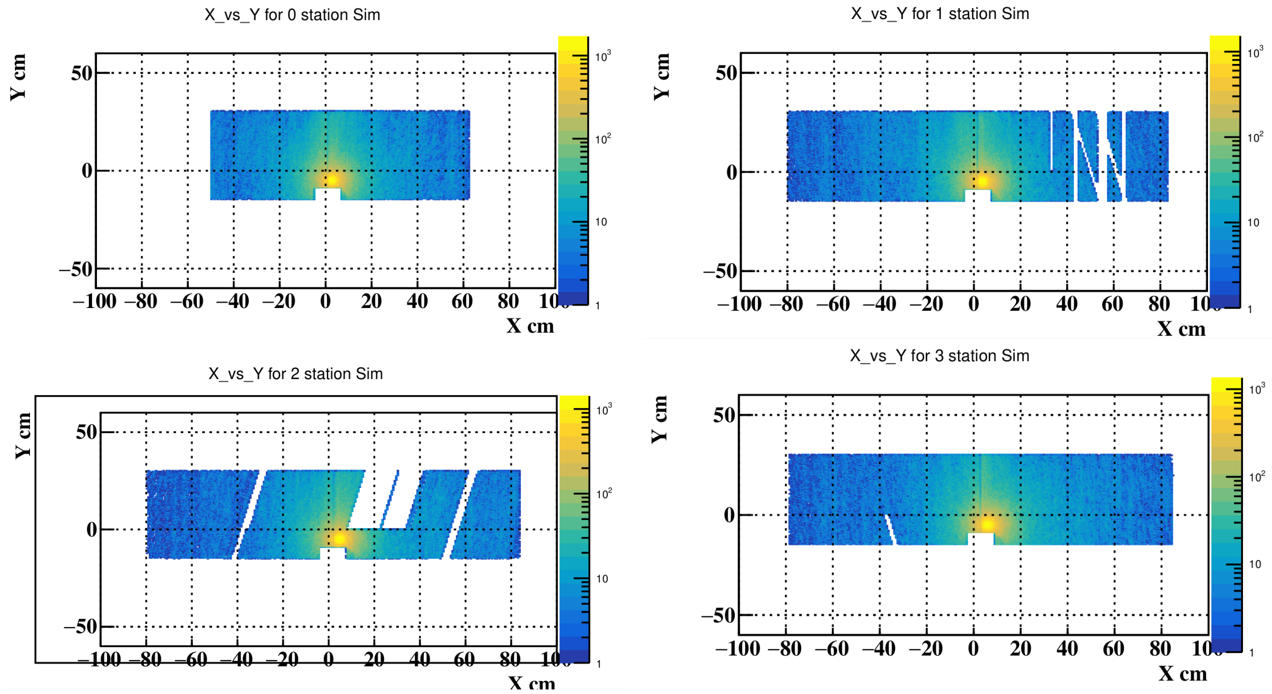

Figure 5: The hits distribution in simulatiom

to the experimental efficiency anyway. To fix that we added in the simulation procedure, so-called, real effects included Lorentz shift linked with the existence of a magnetic field in the space where the GEM stations were and misalignment. These effects should be used in the reconstruction procedure. We found the coefficients that take into account these effects Fig. 6.

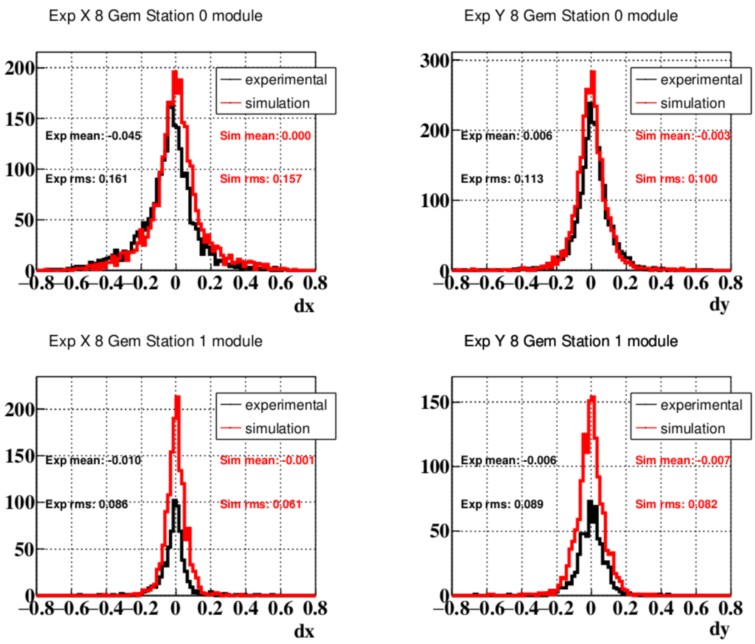

Figure 6: Residuals for the experiment and simulation data. Station 8

Additionally, we studied cluster width in GEM stations. Cluster width is the number of strips associated with the point in the detector. A charged particle generates an electron avalanche, as it is passing through the detector. The avalanche radius increases under the influence of the strong electric field in GEM detectors. We found that the cluster widths in MC data are greater than in the experiment. So we calibrated signal thresholds and variance of the avalanche. The results of such calibration are presented in Fig. 7

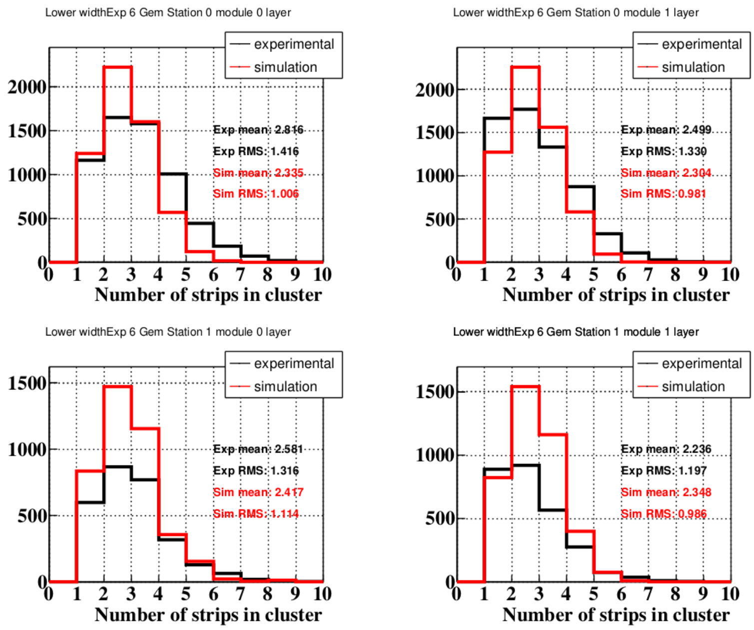

Figure 7: The cluster width in the experiment an simulation

Fine-tuning of the efficiency was performed by modification of tracking reconstruction. We defined artificially the probability that some hits in the stations weren't worked. Final results of such calibration for efficiency is performed in Fig. 8

The further analysis revealed the existence of empty events in the experimental data, i.e. the events where the number of tracks is equal to zero. For the correct analysis, we restricted the analyzable events. We required that the number of tracks was greater than zero and the global track has the vertex inside the target for experimental data. Also, we set the limits on the work of X1-2 and Y1-2 triggers in the data simulated.

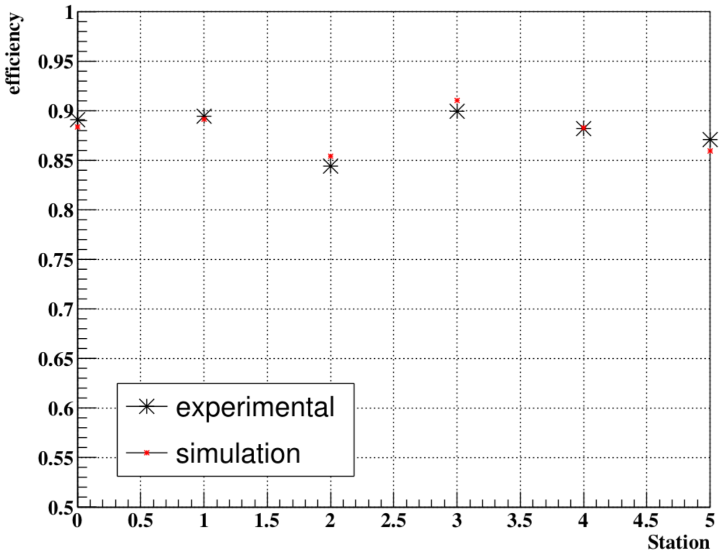

Figure 8: The efficiency after corrections obtained

Summary

During the Summer Student School, we had obtained the important results. Firstly, we studied the GEM station efficiency of the experimental data during the SRC experiment and revealed some problems for the few runs. Secondly, we calibrated GEM stations in the experimental data. Then, we created the map of not worked strips and used that in the simulation procedure. It can be useful in the others experiments such as BMN. We also modified the work of simulation that Monte Carlo parameters in GEM stations were as much as possible be closer to the experiment. All these results are the basis for the current physical analysis.

References

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