Analysis and preparation for the two SRC experiments at BM@N

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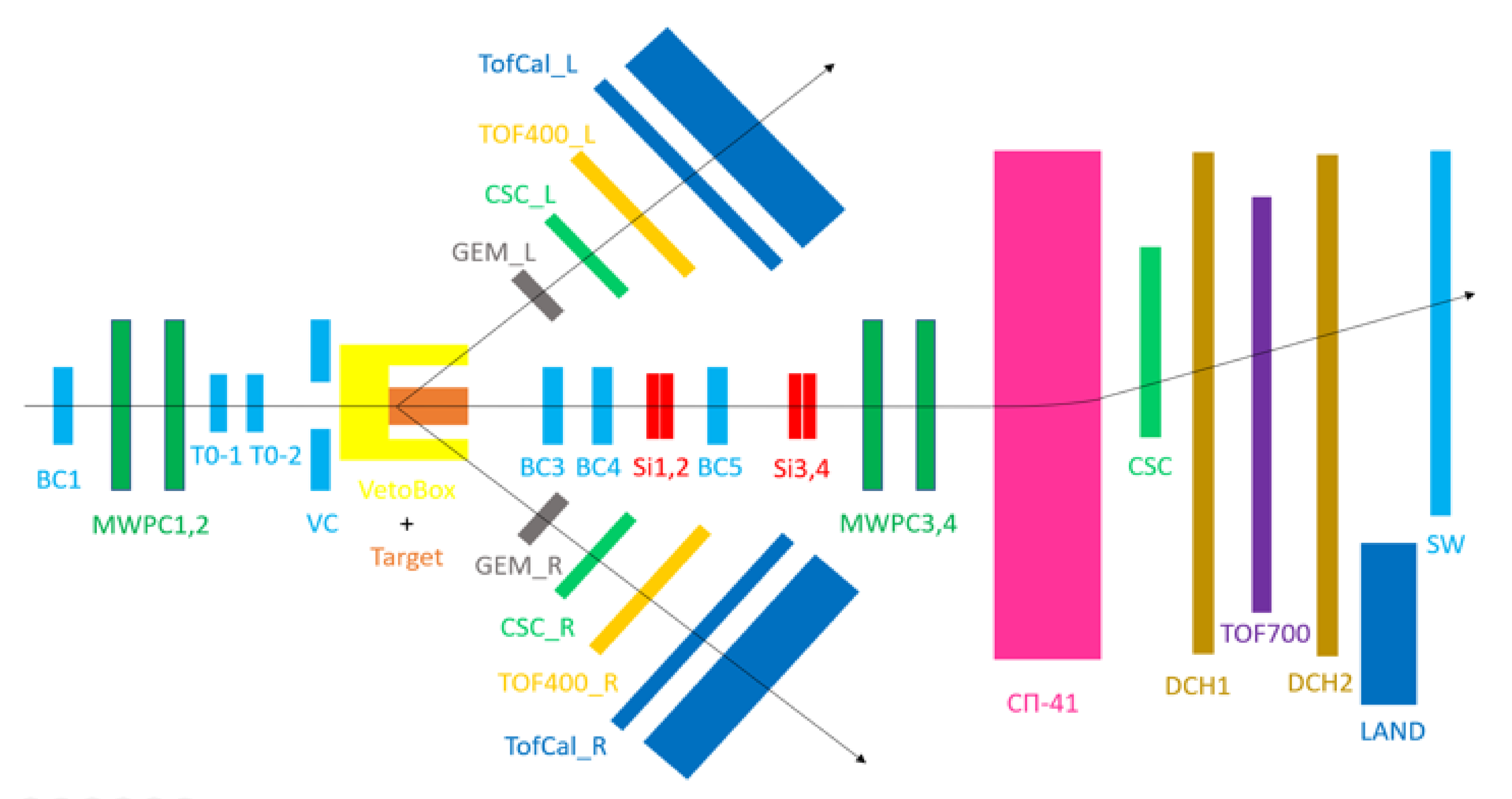
Introduction

The first SRC experiment at the BM@N facility (2018) demonstrated that when the ^{11}B nucleus is registered after the interaction, ^{12}C(p,2p) hard quasi-elastic scattering reaction occurs on an effectively "transparent" carbon nucleus with a largely suppressed rescattering (ISI/FSI). Additionally, this experiment successfully registered 25 events of hard quasi-elastic knockout of SRC pair [1,2] in reactions ^{12}C(p,2p)^{10}B and ^{12}C(p,2p)^{10}Be. The width of the SRC center-of-mass motion was directly measured for the first time and the observed SRC properties agreed with the results of SRC experiments conducted with electron beams. The second SRC experiment at BM@N took place in 2022 with the goals of on increasing the statistics, determining absolute cross-sections, quenching and attenuation at high momentum transfer within the context of quasi-elastic knockout of a single proton.

Improved setup for SRC-2022

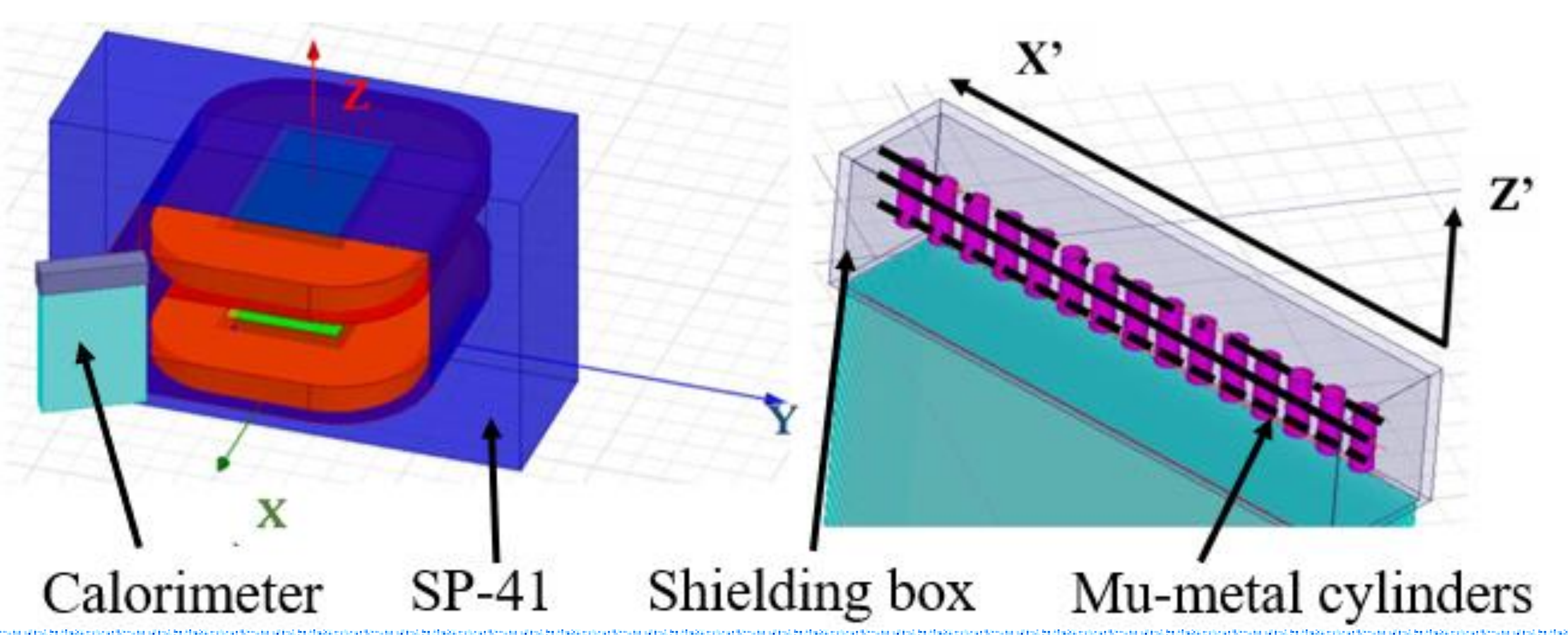
1. We created a new two-arm calorimeter with a fast time-of-flight layer;
2. created and upgraded the scintillator beam counters;
3. implemented a laser calibration system;
4. implemented the veto-box detector;
5. added a second coordinate station to the arms;
6. added the scintillator wall.

SRC-2022 experimental setup scheme



Magnetic shielding simulation for the 2022 experiment

3D model of SP-41 magnet and calorimeter with shielding box



The PMTs at the new two-arm calorimeter required magnetic field shielding, as they are sensitive to the magnetic field values above 1 Gauss. This study helped to design an effective passive magnetic shielding for a set of PMTs.

A detailed 3D magnetic field simulation for the SP-41 dipole magnet was done using Ansoft Maxwell 15.0. The maximum magnetic field in the PMTs region is 25 Gauss [3]. A steel box covering the array of PMTs was developed and tested in the simulation. The magnetic field magnitude doesn't exceed 5 Gauss inside the box. With the box and individual mu-metal shielding for each PMT the magnetic field amplitude drops to 0.03 Gauss.

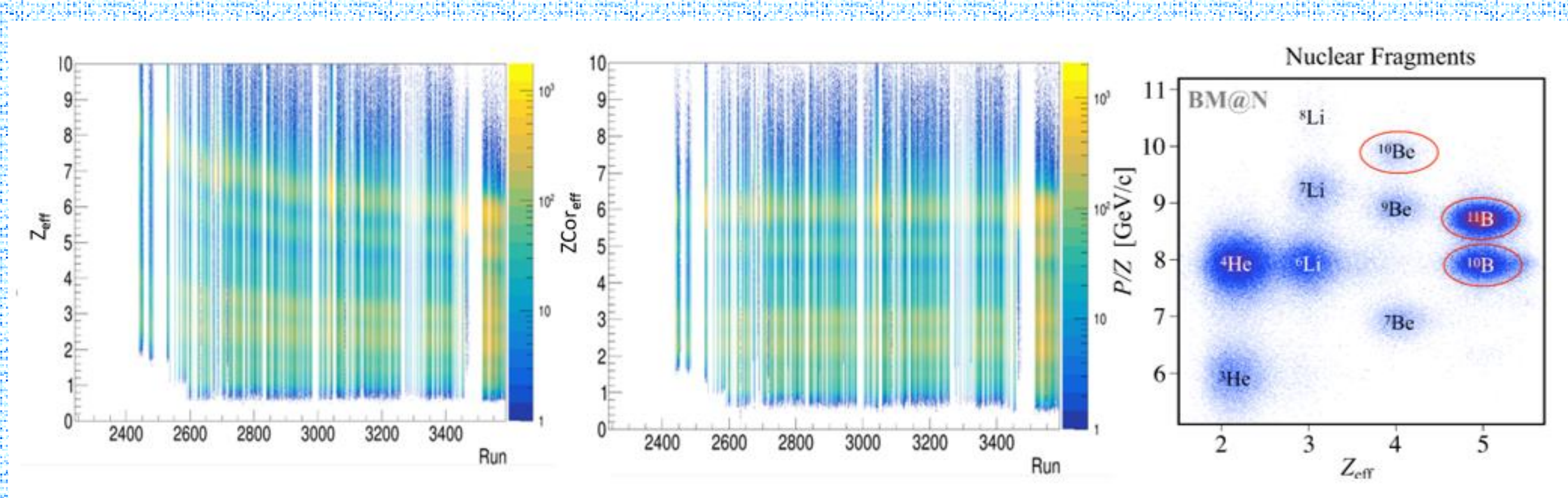
References:

[1] Patsyuk M., et al., DOI: 10.1038/S41567-021-01193-4

[2] Patsyuk M., et al., DOI: 10.1134/S1063779621040481

[3] T. Atovullaev, et al., DOI: 10.1134/S1547477122040082

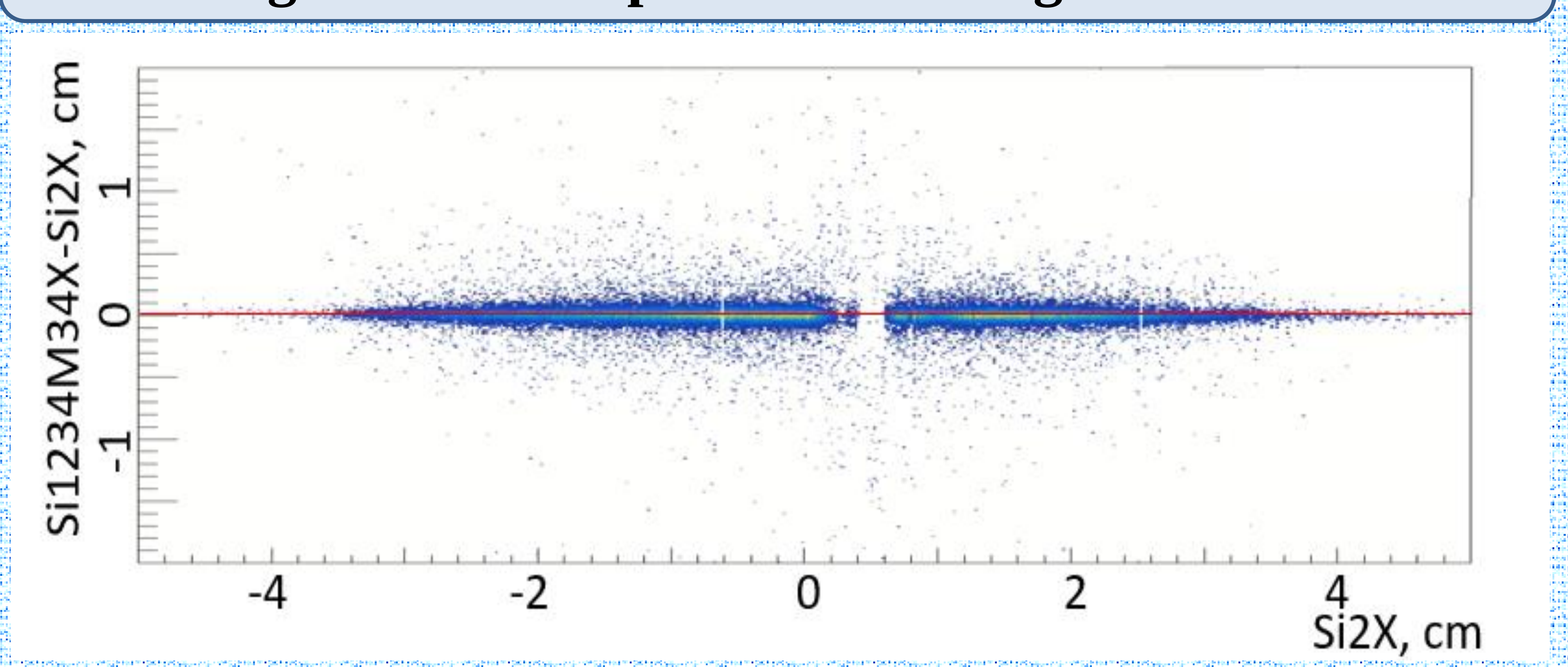
Charge amplitude correction and fragment identification for 2018 data



Effective charge before and after correction — PID

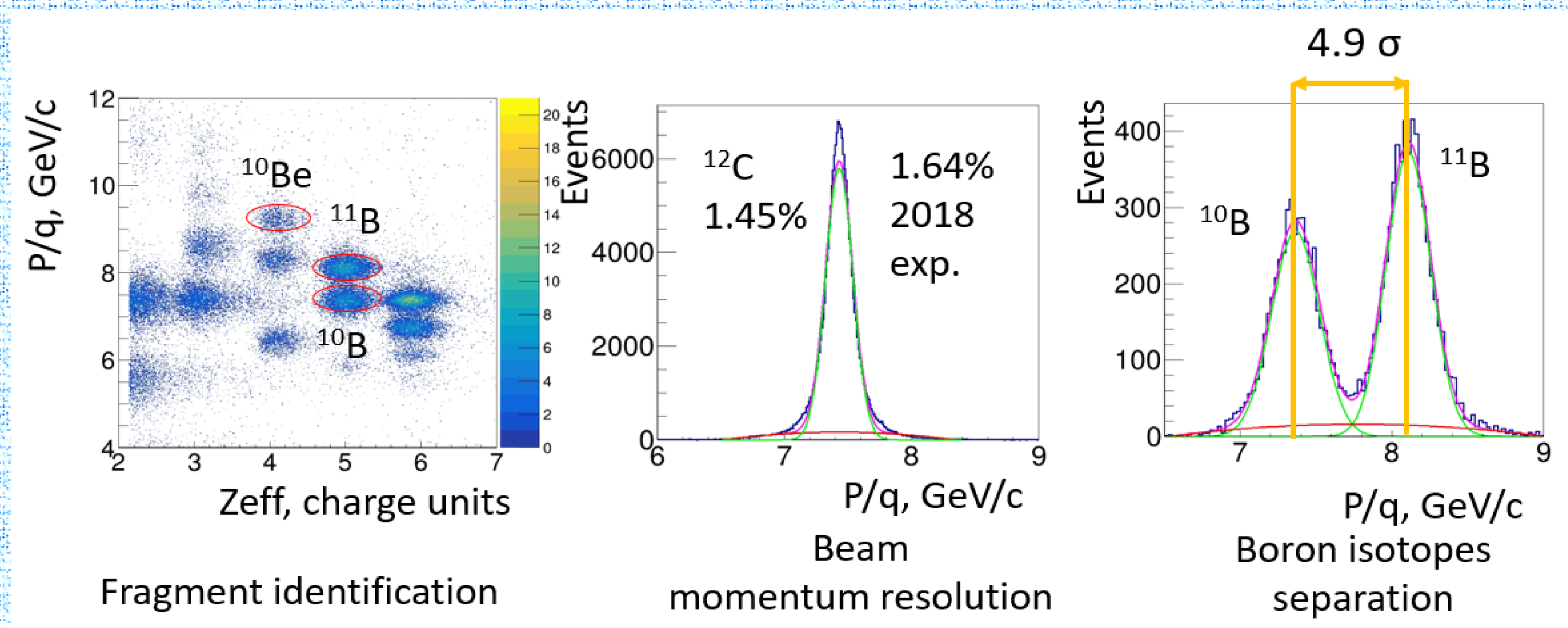
The BC and T0 amplitudes were corrected by charge in the 2018 data. The incoming ion was identified by charge, and the final-state fragments were identified using charge and the reconstructed momentum.

Si alignment and Upstream tracking for 2022 data



For the 2022 data the Upstream tracks between the target and the magnet were reconstructed from the Si and MWPC hits after the geometrical alignment of the Si detectors. The tracking efficiency for ^{12}C is 82%.

Momentum reconstruction and fragment identification for 2022 data

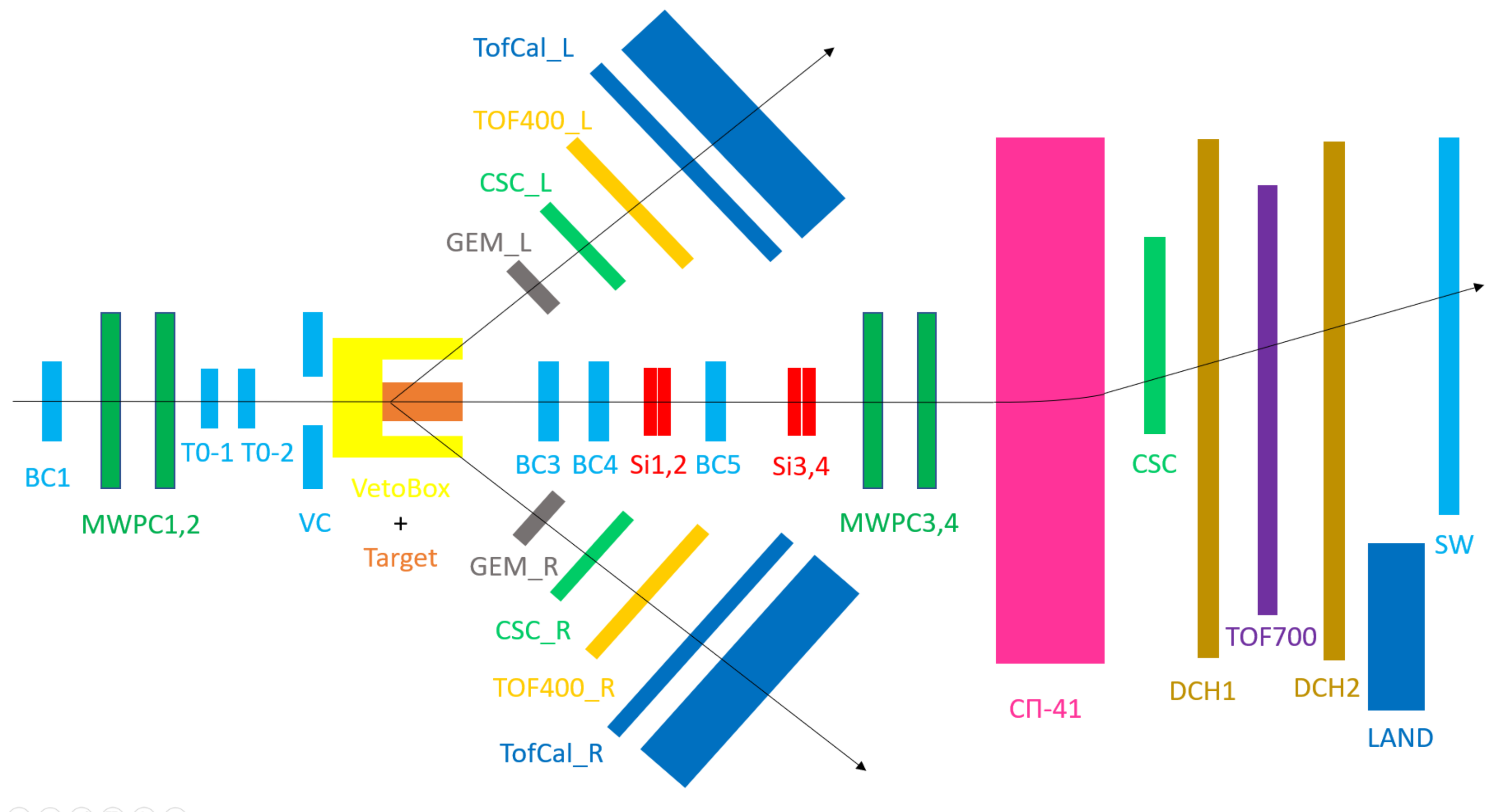


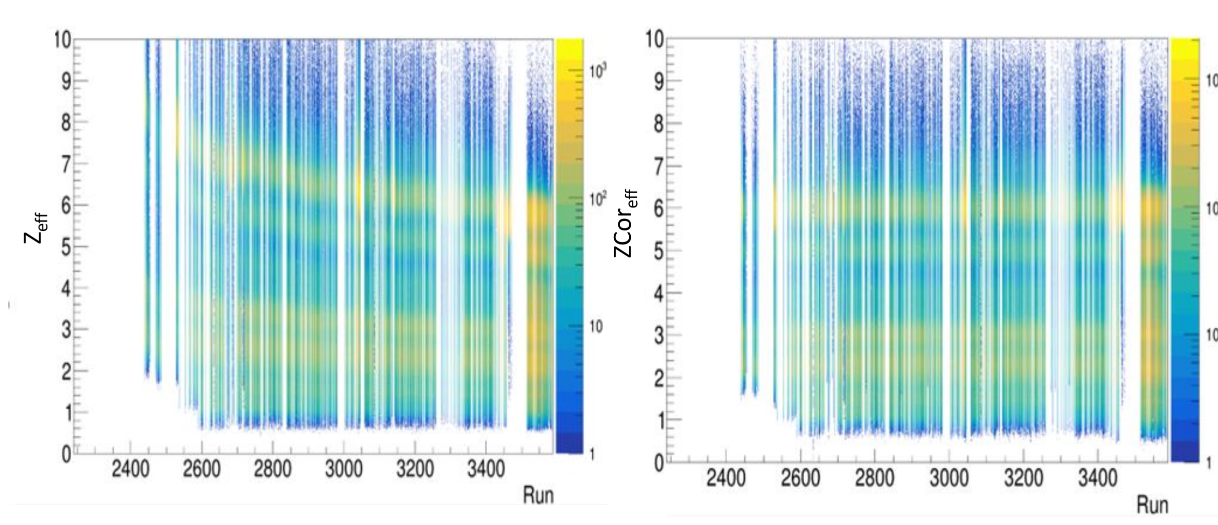
The identification of the final-state isotopes: Li, Be, B, and C was done using the MDF (MultiDimentional Fit) method based on the tracks before and after the magnet (Upstream and DCH) and the reconstructed charge.

Conclusion

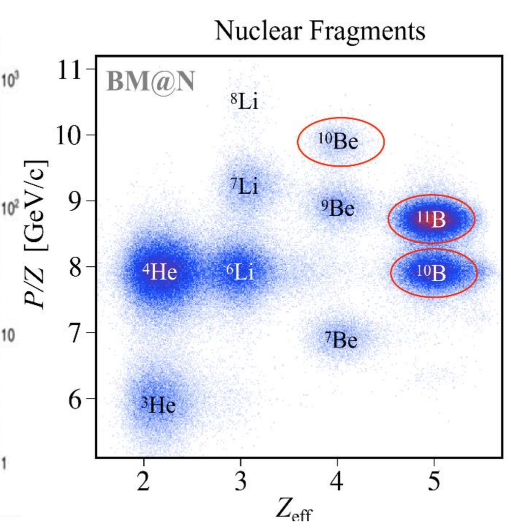
The analysis of the 2018 data and preparation, data taking, and data analysis of the 2022 data has been done with the major contribution of the author. The presented work will be the basis for a PhD thesis.

SRC-2022 experimental setup scheme



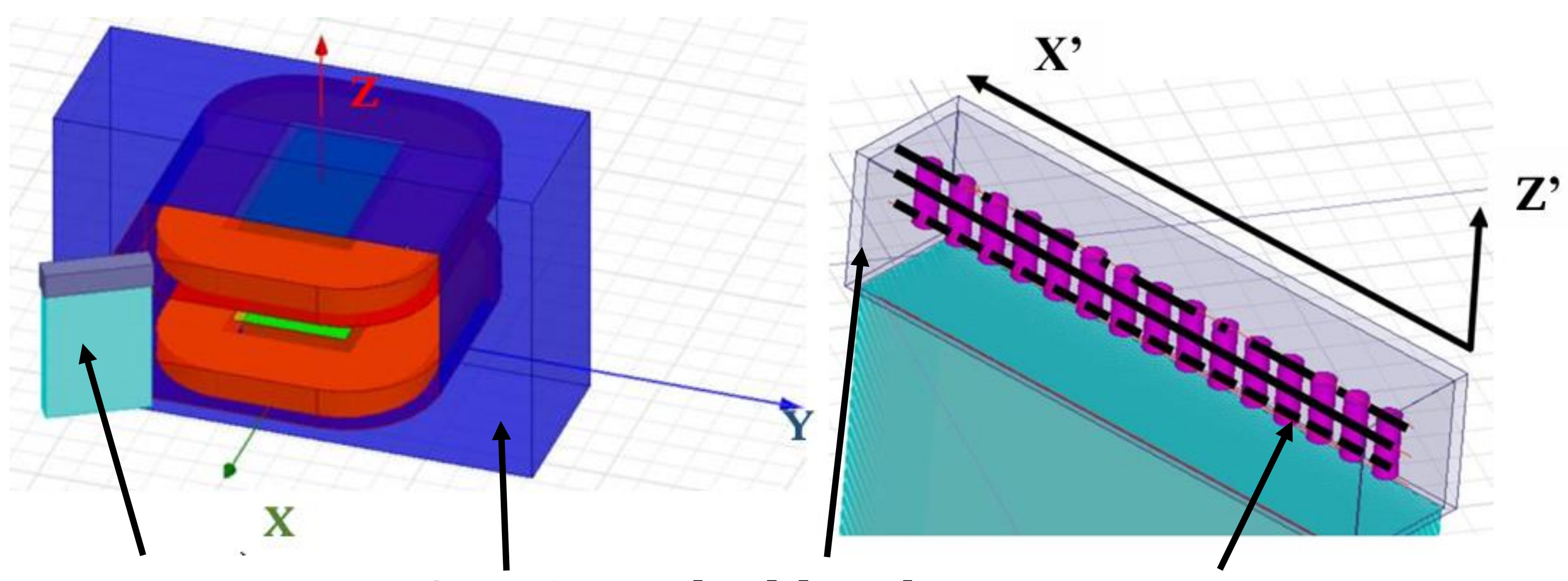


Effective charge before and after correction



PID

3D model of SP-41 magnet and calorimeter with shielding box



Calorimeter SP-41 Shielding box Mu-metal cylinders