Cosmic ray propagation
• protons and most of the nuclei in CR are referred to as primaries
• when primary species propagate through the galaxy they can scatter on the interstellar gas and create so-called secondary cosmic rays
• secondary production mode is very important for certain nuclei like lithium, beryllium, and boron
• a large fraction of antinuclei in CR is believed to be of secondary origin

Experimental setup of NA61/SHINE at CERN SPS

Preliminary NA61/SHINE results on boron production and next step of data analysis

Calculation of fragmentation elemental cross-sections

Comparison of simulation with actual data

Simulation framework
• GEANT 4 with geometry of NA61/SHINE detector
• QSSP-INCLUX: physics list used (Quark Gluon String Model with Precompound nucleus + Liege Intraneutal Cascade)
• two targets implemented: C or PE + target removed mode
• two modes of simulation:
  – particle gun mode: no target, propagation of selected isotopes through detector (defined target, start in target position); simulation with simple assumptions to check basic effects
  – beam fragmentation mode: C or PE target, mix of isotopes is produced as result of fragmentation, simulation of fragments’ propagation through detector

Modeling of the fragmentation elemental cross-sections

In order to reveal the best possible cut for off-target fragment production reduction, the actual data was compared to simulation in beam fragmentation mode.

Due to poor statistics of target out data, it was necessary to develop a method for off-target fragment production reduction. Two different approaches were developed:
• based on simulations: in the simulation it is precisely known how many and where the different fragments were produced. Therefore, it is possible to calculate efficiency of the before-GTPC cut in the simulation. Then it is assumed that the before-GTPC cut in the simulation has the same efficiency as the GTPC cut in the data and in the in-target fragment production is estimated.
• based on the target out data: it is proposed to scale the available statistics in order to reduce the off-target fragment production. It is expected that quantitatively, the fragment production downstream of the GTPC should be the same both in target and target out data; thus, it becomes possible to introduce a scaling factor and express the in-target fragment production.

Performance of both methods is verified by the test calculation of the fragmentation elemental cross-sections and its further comparison with available data in this energy range [A. Kopylov et al. J. Phys. G, vol. 26, pp. 1171–1186]