Preliminary results of NA61/SHINE at the CERN SPS on pion production in p+C interactions at 31 GeV/c for T2K

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Abstract
Preliminary results from the fixed target experiment NA61/SHINE at the CERN SPS [1] are presented. One of the main physics goals of the NA61/SHINE experiment is to provide new experimental information on hadron production in p+C interactions in the region of several tens of GeV [2]. These data are necessary for the T2K [3] neutrino experiment at J-PARC to improve the accuracy of neutrino flux simulations and consequently calculate the initially produced neutrino flux. The NA61 detector has a full coverage of the T2K phase space region. In this work preliminary dn/dp distributions of negatively charged pions produced in p+C (thin target) interactions at 31 GeV/c from the 2007 pilot run are presented. The dn/dp distributions for π^+ mesons are also shown for momentum interval 0.2-1.0 GeV/c. Three different types of analyses of negatively charged pion production are compared. Agreement is observed between the results.

1 Motivation

A measurement of the production of pions and kaons in p+C interactions at 31 GeV/c is crucial for the proper prediction of the neutrino fluxes at the near and far positions, which are different, and hence vital to study the neutrino oscillation signals in T2K. Information on hadron production in p+C interactions in the region of several tens of GeV is also necessary for cosmic ray event simulations. It is the region in which the extrapolations performed using low energy and high energy models do not agree. For predictions of the T2K neutrino beam parameters the measurements of the NA61/SHINE experiment are performed on a thin carbon target as well as on a replica of the target installed at JPARC, Tokai. We have tested three different methods of extraction of pion yield using a sample of tracks registered in the 2007 pilot run.

2 The NA61/SHINE detector

The NA61/SHINE detector (The layout of the setup is shown on Fig. 1) is an upgrade of the NA49 experimental setup at CERN [4]. In the first stage NA61/SHINE measured interactions of 31 GeV/c protons with carbon target. For the 2007 pilot run a new forward Time of Flight detector (TOF-F) was constructed in order to extend the acceptance of the NA61/SHINE setup for pion and kaon identification as required for T2K measurements. Two carbon graphite targets were used: a 2cm long target (about 4% of nuclear interaction length, λ_I) with density ρ = 1.84 g/cm^3 (so called thin target) and a 90 cm long cylinder of 2.6 cm diameter, about 1.9 λ_I (so called T2K replica target).

2.1 Particle identification strategy

Particle identification was based on three different approaches -
First, identification via ionisation energy loss measurements in the active volumes of the NA61/SHINE TPCs which are filled with mixtures of Ar and CO_2 (90:10) for VTPCs and (95:5) for MTPCs. Scatter plots of the energy loss, i.e. the truncated mean dE/dx value of the track (in MIP units), versus the

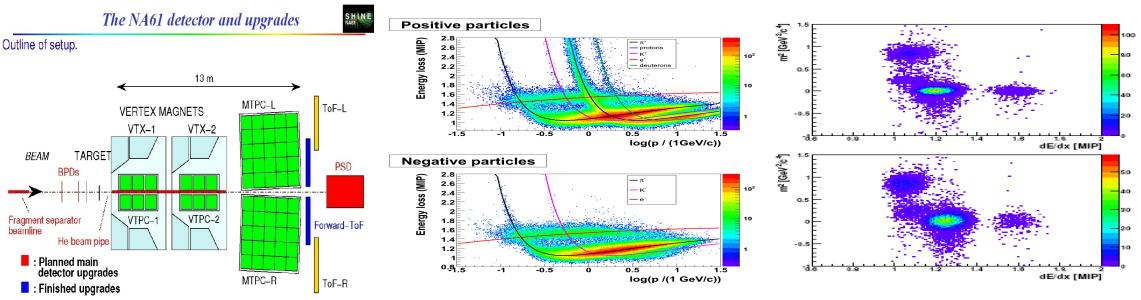

Fig. 1: Left panel - The layout of the NA61/SHINE setup; Middle panel - dE/dx as a function of momentum for p+C at 31 GeV/c beam momentum for positively (top) and negatively (bottom) charged particles, together with the Bethe-Bloch curves. Right panel - Examples of combined ToF and dE/dx PID performance for positively charged particles in the momentum range 2-3 GeV/c (top), 3-4 GeV/c (bottom).

particle momentum in the laboratory frame are shown in Fig. 1 (middle) for positively and negatively charged particles produced in p+C interactions at 31 GeV/c.

The second approach was based on combined measurements of energy loss and time of flight. In [1,4] GeV/c momentum range Bethe-Bloch ionisation curves cross each other making dE/dx analysis not reliable and additional information from Time of Flight is required. Examples of combined ToF and dE/dx PID performance for positively charged particles are shown in Fig. 1 (right). Identification of pions was performed using combined dE/dx and TOF information in the region of [1,10] GeV/c momentum. Factorisation of different corrections was assumed and some of them were calculated semi-analytically. In the last approach, analysis of negatively charged particles (further referred to as h-) is based on the theoretical and experimental premises that the produced negative particles at SPS energies consist mainly of negative pions with a few percent admixture of negative kaons, electrons, and a negligible fraction of antiprotons. Electron contamination is large only in the low momentum range. Venus [5], GHEISHA [6], and Geant [7] Monte Carlo simulation chain is used to calculate corrections for geometrical acceptance and reconstruction efficiency. In addition, this procedure provides estimates of the admixture of pions from decays and secondary interactions close to the vertex.

3 Preliminary results

First preliminary results for positively and negatively charged pions in p+C interactions at 31 GeV/c were obtained. We present momentum spectra in polar angle slices for π^+ and π^- below 1GeV/c momentum from the dE/dx analysis in Fig. 2(left). In Fig. 2 (right) a comparison of π^- results obtained from dE/dx and h- analyses is shown. Finally, distributions for π^-, from h- analysis, are presented in Fig. 3 (left) and π^- results obtained from h- and dE/dx+ToF analyses are compared in Fig. 3 (right).

4 Summary and Outlook

Preliminary pion spectra in p+C interactions at 31 GeV/c are presented. The spectra were obtained from three different analysis methods applied to the NA61 pilot data collected in 2007. Work to minimize the systematic biases is in progress. The dependence on the details of the MC generators is also under study. New high statistics data have already been registered in the 2009 run of NA61. We collected 6M triggers with a thin target and 3M with the T2K replica target configurations.

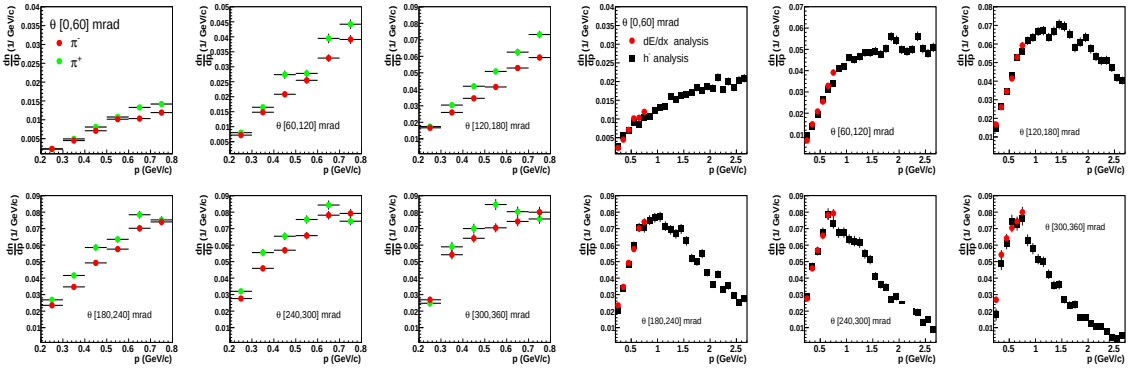

Fig. 2: Left six panels - dn/dp distributions for different θ slices for positive (green) and negative (red) pions, obtained from dE/dx analysis. Right six panels - dn/dp distributions for different θ slices for negative pions obtained using dE/dx (red) and h- (black) analyses.

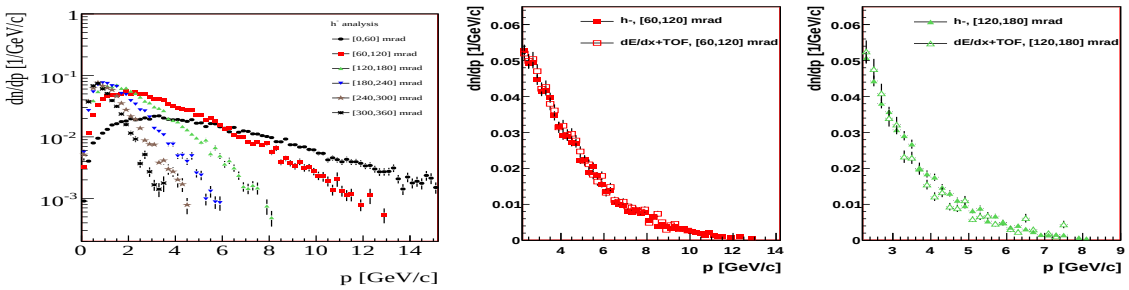

Fig. 3: Left panel - Distributions of dn/dp in a polar angle slices from h- analysis for negatively charged pions produced from proton interactions on a thin carbon target. Middle panel - Distributions of dn/dp of negatively charged pions from the primary interaction in the 120-180 mrad polar angle inteval from h- (full symbols) and dE/dx+ToF (open symbols) analyses. Right panel - Distributions of dn/dp of negatively charged pions from the primary interaction in the 120-180 mrad polar angle inteval from h- (full symbols) and dE/dx+ToF (open symbols) analyses.

Acknowledgments

This work was supported by the Polish Ministry of Science and Higher Education (grant NN202 3956 33), Swiss OFES FORCE (grants: 206621-117734, 206620-119959, and 206620-125334), ETH Zurich (Research grant TH-01 07-3), Russian Foundation for Basic Research (grant 09-02-00664), and EU-CARD/NEU2012.

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