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

Tomasz Jan Palczewski[a],
Nicolas Abgrall[b]***, Sebastien Murphy***[b]***, Magdalena Zofia Posiadala***[c]***,Claudia Strabel***[d]
for NA61/SHINE Collaboration
[a]Soltan Institute for Nuclear Studies, Warsaw, Poland
[b]University of Geneva, Geneva, Switzerland
[c]University of Warsaw, Warsaw, Poland
[d]ETH Zurich, Zurich, Switzerland

Abstract

This poster presents preliminary results from a fixed target experiment NA61/SHINE at the CERN SPS [1]. One of the main physics goals of the NA61 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 [5] 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 large angular acceptance, full coverage of T2K phase space region, and good particle identification. In this poster preliminary dn/dp distributions of negatively charged pion in p+C (thin target) interactions at 31 GeV/c from the 2007 pilot run data are presented. Three different types of analyses of the negatively charged pion production are compared. The agreement of the obtained results is observed. New high statistics data have been already registered in the 2009 run of NA61. We collected 6M triggers with a thin target and 3M with the T2K replica target configurations. Analyses of these data start now.

1. Motivation

INFORMATION on hadron production in p+C interactions in the region of several tens of GeV is necessary for neutrino beam and cosmic ray event simulations. It is the region in which the extrapolations performed using low energy and high energy models do not agree. Therefore, T2K experiment needs more precise information about pions and kaons production in p+C interactions. For precise predictions of the T2K neutrino beam parameters the measurements of NA61/SHINE experiment are performed on the thin carbon target as well as on the replica of the target installed at JPARC, Tokai. We have tested three different methods of extraction of yields for pion production using a sample of tracks registered in the 2007 test run.

2. The NA61/SHINE detector

THE NA61/SHINE detector is an upgrade of the NA49 experimental setup at CERN [3]. The layout of the NA61/SHINE setup is shown on Fig. 1.

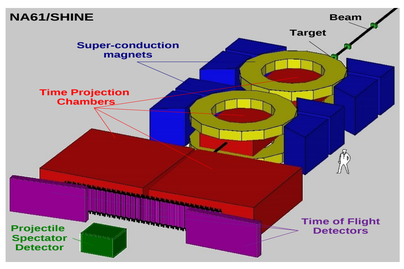

Figure 1: *The layout of the NA61/SHINE setup*

In the first stage the NA61/SHINE measured interactions of 31 GeV/c proton momentum beam (i.e. initial T2K beam momentum) 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.

3. Carbon targets used in 2007 and 2009 runs

TWO carbon, isotropic graphite targets were used during 2007 run (see Fig. 2):

- a 2cm long target (about 4% of nuclear interaction length, λ_I) with density $\rho = 1.84\frac{g}{cm^3}$, so called **thin target**,
- a 90 cm long cylinder of 2.6 cm diameter (about 1.9 λ_I), so called **T2K replica target**.

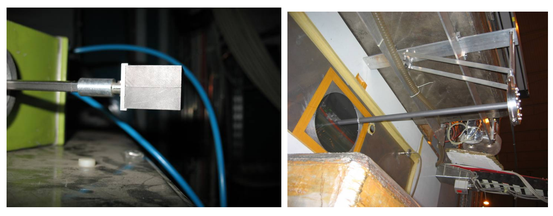

Figure 2: *Thin (left) and T2K replica (right) targets used during the 2007 and 2009 runs.*

4. Particle identification strategy

PARTICLE identification startegy was based on:

Energy loss measurements.
In NA61/SHINE experiment particle identification is possible due to ionization measurements in active volume of the TPCs (see Fig. 3), which are filled with mixtures of $Ar + CO_2$ (90:10) for VTPCs and (95:5) for MTPCs.

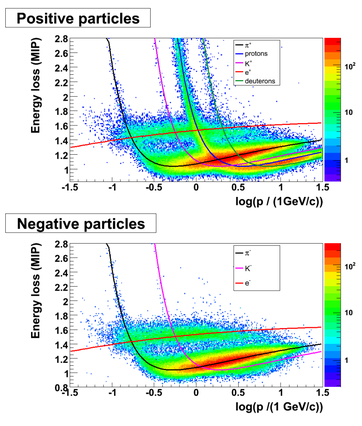

Figure 3: $\frac{dE}{dx}$ *as a function of momentum for p+C at 31 GeV/c beam momentum for positively (top) and negatively (bottom) charged particles, together with the Bethe-Bloch curves for positrons (electrons), pions, kaons, (anti)protons and deuterons. All data collected on thin target from 2007 run were used.*

This analysis was divided into subregions:

- below 1 GeV/c momentum - dedicated dE/dx analysis to identify pions
- in [1,4] GeV/c momentum range - Bethe Bloch curves cross each other making particle separation not reliable, additional information from Time of Flight is required.
- above 4 GeV/c momentum - dE/dx analysis in relativistic rise region.

Combined energy loss and Time of Flight measurements.
Identification of pions was performed using combined dE/dx and Time of Flight information for region of [1,10] GeV/c momentum. Factorisation of different corrections was assumed and some of them were calculated semi-analytically.

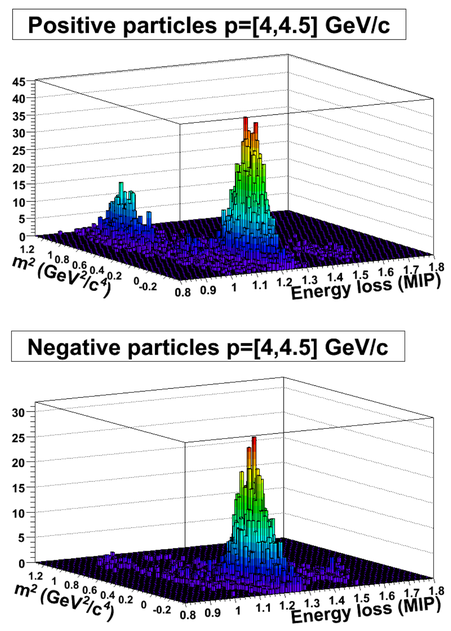

Figure 4: *Measured mass squared as a function of dE/dx for positively (top) and negatively (bottom) charged particles for interval of particle momenta: 4-4.5 GeV/c.*

Analysis of negatively charged particles further referred to as h^-, is based on the theoretical and experimental premises that the produced negative hadrons at incident energy consist mainly of negative π mesons (see Fig. 4) with few percent admixture of negative kaons, electrons from Dalitz decays of neutral mesons, and a negligible fraction of antiprotons. Venus [7] -GHEISHA [6] and Geant [4] Monte Carlo simulation chain is used to calculate corrections for geometrical acceptance, reconstruction efficiency. In addition, this procedure also takes into account the admixture of pions from decays and secondary interactions close to the vertex because such effects are present in the simulations.
Finally, the correction factor is used to determine corrected spectra of negatively charged pions from the primary interaction.

5. Preliminary results

THE first preliminary results for positively and negatively charged pions are presented.

- π^+ and π^- below 1GeV/c momentum results from dE/dx analysis. On Fig. 5 dn/dp distributions for different Θ slices are shown.

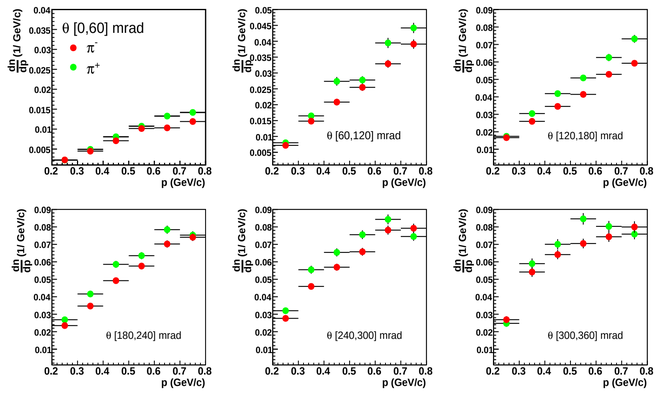

Figure 5: *dn/dp distributions for different Θ slices for positive (green) and negative (red) pions, obtained from dE/dx analysis, are presented.*

- Comparison of π^- results obtained from dE/dx and h^- analyses (see Fig. 6)

Figure 6: *dn/dp distributions for different Θ slices for negative pions obtained using dE/dx analysis (red) and h^- (black) are presented.*

- Comparison of π^- results obtained from h^- and dE/dx+ToF analyses (see Fig. 7).

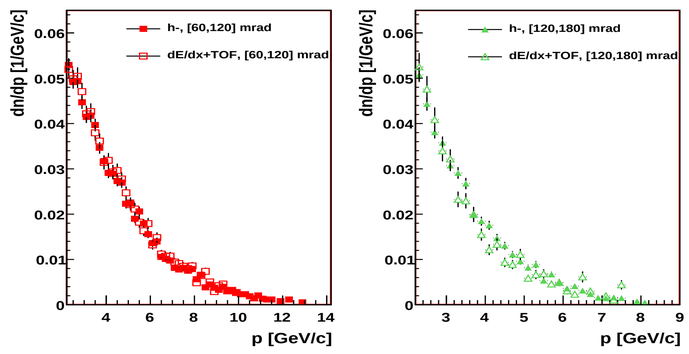

Figure 7: *dn/dp distribution in 60-120 mrad polar angle interval (left) and 120-180 mrad polar angle interval (right) of negatively charged pions from the primary interaction. Results from two different methods are shown.*

- Finally, distributions of dn/dp for π^-, from h^- analysis, in all selected momentum range are shown on Fig. 8

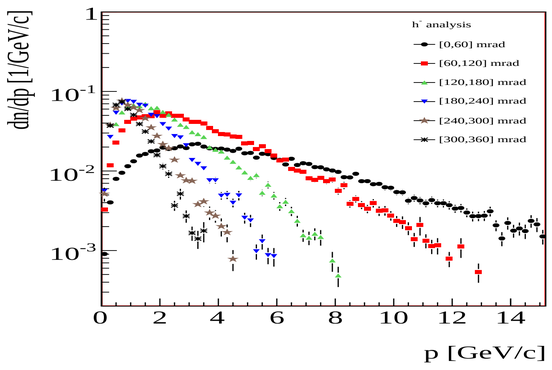

Figure 8: *Distributions of dn/dp in a polar angle slices for negatively charged pions produced from proton interactions on a thin carbon target. Results from h^- analysis.*

The results presented here are preliminary. The work to minimalize systematic biases is in progress. The dependence on the details of the MC generators is also under study.

References

[1] N.Antoniou *et al.* [NA49-future Collaboration], CERN-SPSC-2006-034, (2006).

[2] N.Antoniou *et al.* [NA61/Shine Collaboration], CERN-SPSC-2007-019, (2007).

[3] S. Afanasiev *et al.* [NA49 Collaboration], Nucl. Instrum.257 Meth. A430 (1999).

[4] R.Brun, M.Hansroul, and J.C.Lassalle. GEANT Users Guide, DD/EE/82 edition, (1982).

[5] Y. Hayato *et al.* [T2K Collaboration], T2K at J-PARC, Nucl. Phys. Proc. Suppl. 143: 269-276, (2005).

[6] H.J. Klein and J. Zoll. PATCHY Reference Manual, Program Library L400. CERN, (1988).

[7] K. Werner, Phys. Rep. 232, 87 (1993).