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Recent results from NA61/SHINE at the CERN SPS

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Abstract. This contribution is devoted to looking at the NA61/SHINE experiment [1] through the prism of the needs of neutrino oscillation experiments. The new preliminary results on hadron production measurements from p+C (thin target - 0.04 λ_I) interactions at 31 GeV/c from 2009 data are presented. These results are crucial for the precise determination of background contamination in the neutrino flux of the Tokai to Kamioka (T2K) experiment at J-PARC [2].

1 Introduction

These days, while we are entering the high precision neutrino measurement era, the accelerator long baseline oscillation neutrino experiments need to lower their systematic uncertainties. The analysis techniques used in these experiments are based on the comparison of the interaction rates at far detectors with predictions with and without oscillations. The extrapolation of measurements in near detectors is done by the so-called far-to-near ratio, which strongly depends on the knowledge of the primary hadron production in the target. It is of high importance to precisely measure charged pions, kaons, neutral kaons, and lambda hyperons because these particles contribute directly or via decays to the neutrino production. (see Fig. 1).

2 NA61/SHINE detector

The NA61/SHINE detector [4] is an upgrade of the NA49 experimental setup [5] at the CERN SPS. The former NA49 detectors, four large Time Projection Chambers (TPCs); one small TPC for the low polar angle particles (GAP TPC); two time-of-flight detectors (TOFs), are completed by the new forward TOF, specially designed for the T2K needs, and the Particle Spectator Detector (PSD), which is important for the centrality determination in nucleus-nucleus collisions.

3 Data analysis techniques

The main part of data for T2K was collected in two periods: in the year 2007 and 2009. In 2009 the data were collected with higher luminosity and larger statistic. In both cases the proton beam

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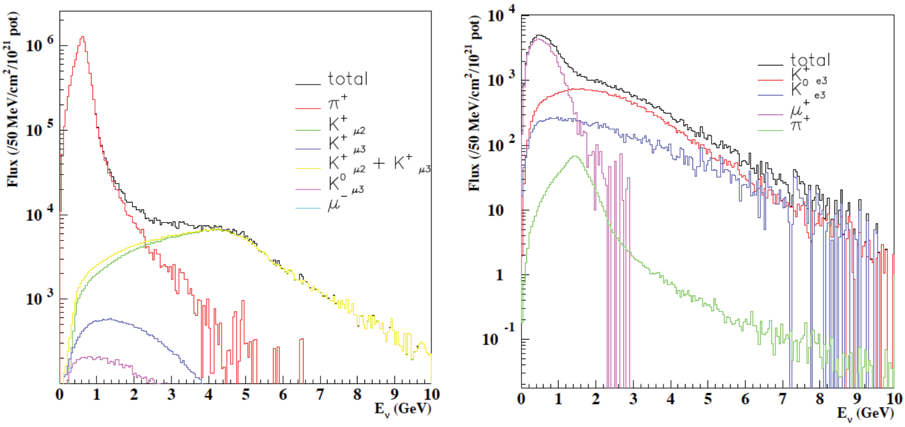

Figure 1. The ν_μ (left) and ν_e (right) energy spectrum at T2K far detector (JNUBEAM simulations) [3].

interacted with a thin 2 cm carbon target (0.04 λ_I) and a 90 cm T2K replica target (1.9 λ_I). This contribution is devoted to thin carbon target data results. A few different approaches of particle yields extraction were developed:

- The h^- method [6]. For the negatively charged tracks it is possible to obtain information about π^- production even without detailed particle identification. In this energy range mainly pions are produced (see Fig. 2, right). Therefore the analysis can be based on the Monte Carlo corrections. The biggest advantage of this method is the possibility to obtain results in a wide phase space region parts of which are not accessible for other methods.
- The dE/dx analysis [6]. This method was used in the low momentum region (<1-3 GeV/c) where Bethe-Bloch curves do not cross (see Fig. 2).

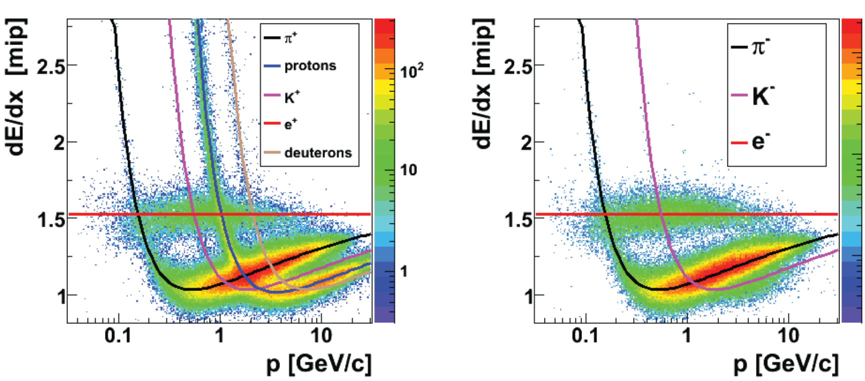

Figure 2. The specific energy loss in the TPCs for positively (left) and negatively (right) charged particles as a function of momentum. Curves show parameterizations of the mean dE/dx calculated for different particle species.

- The combined dE/dx and time-of-flight analysis [6, 7]. This information is available for particle momenta larger than about 0.8 GeV/c and emission angles smaller than about 300 mrad.
- The analysis of neutral strange hadrons. This was performed via invariant mass distribution studies [8].

For the normalization of spectra and the calculation of the production cross section the procedures described in [6, 8] were used.

4 Results

Spectra of π^+ and π^- were obtained from 2007 and 2009 data. Spectra of π^+ are presented in Fig. 3. For the 2007 data three analysis methods were applied (see section 3). The consistency between different approaches was checked in the overlapping regions. The 2009 results were obtained using only the combined dE/dx and time-of-flight method. The distributions of proton and charged kaon multiplicities were also obtained with the 2009 data as a function of momentum in different intervals of polar angle. The differential cross section for charged pions, kaons, and protons are used in the T2K beam simulation program to reweight hadron yields obtained from models. The comparison to GEANT4 models clearly shows that none of them can satisfactorily describe the data. The knowledge of neutral kaon production is also required for the accurate calculation of the ν_e and $\bar{\nu}_e$ fluxes from $K^0_L \rightarrow \pi$ e ν_e decays (see Fig. 1). The preliminary 2009 results on differential cross sections of K^0_S were obtained. The 2009 analysis of Λ production is in progress (the results on 2007 data were published in [8]).

Acknowledgements

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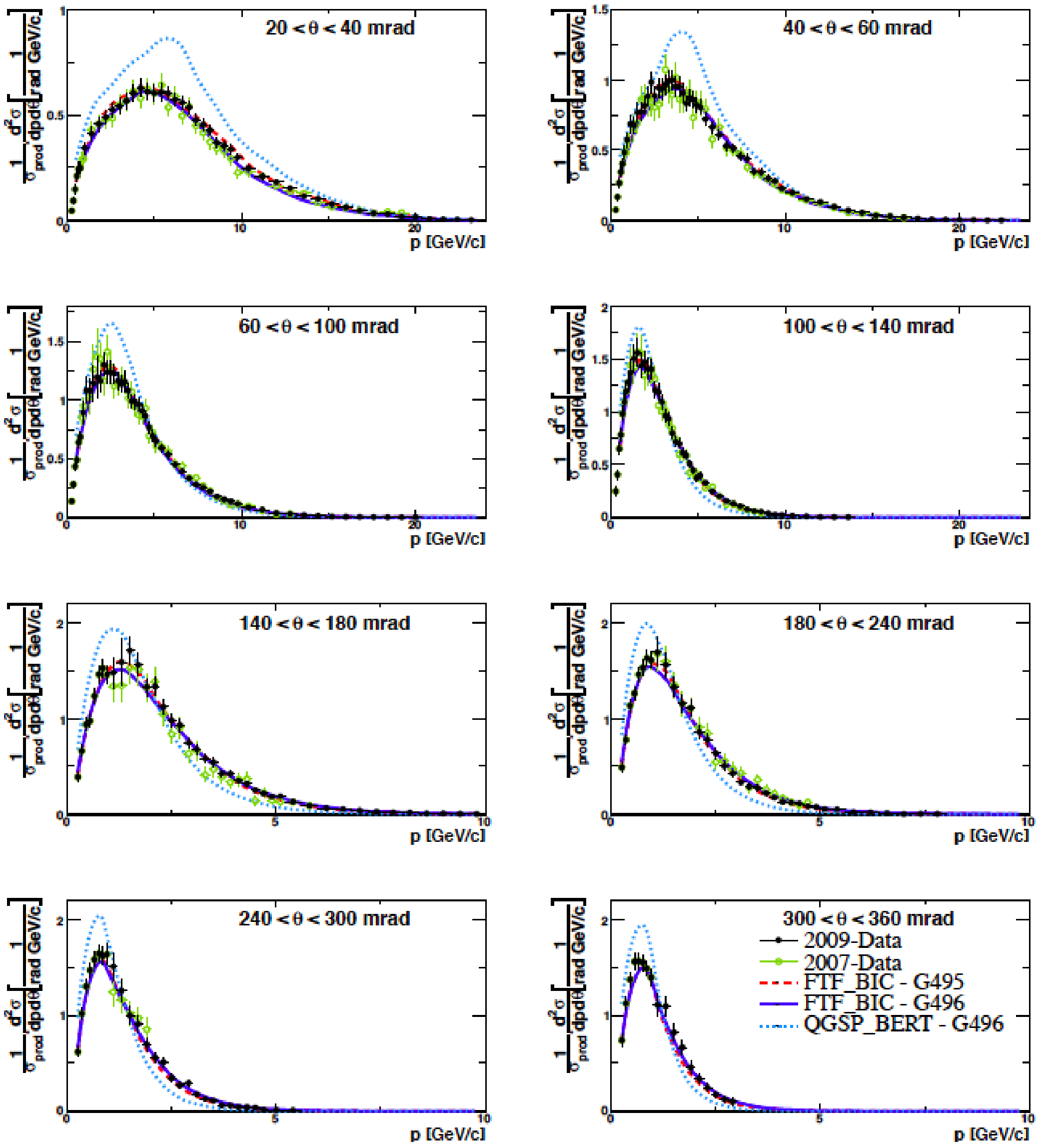

Figure 3. The production cross section of π^+ in p-C interactions at 31 GeV/c in different intervals of polar angle θ versus the laboratory momentum p. Error bars indicate statistical uncertainty. Data points are compared to various model predictions [9, 10].