EPJ Web of Conferences **37**, 09028 (2012)
DOI: 10.1051/epjconf/20123709028

Measurements of hadron production from p+C interactions at 31 GeV/c with NA61/SHINE detector at the CERN SPS

Tomasz Jan Palczewski[a] on behalf of the NA61/SHINE Collaboration

National Centre for Nuclear Research, Warsaw, Poland

Abstract. Preliminary results on K^0_S production in p+C interactions at 31 GeV/c using data registered during the 2007 run are shown. In addition, an overview of charged pion and koan results is presented. These results are needed for the high precision determination of background contamination in the neutrino beam of the Tokai to Kamioka (T2K) experiment at J-PARC. Performance of the NA61/SHINE detector is discussed. Inclusive production cross sections for π^-, π^+, K^+, and K^0_S as a function of laboratory momentum and polar angle with statistical and systematic errors are shown. The K^+ / π^+, K^0_S/K^+, and K^0/π^- ratios are also presented.

1 Introduction

Accelerator long baseline oscillation neutrino experiments are challenged to lower their systematic uncertainties to be able to obtain high precision nutrino oscillation parameter measurements. 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. Extrapolation of measurements in near detectors is done by so-called far-to-near ratio, which strongly depends on the knowledge of the primary hadron production in the target. It is of importance to measure charged pions and kaons, neutral kaons, and lambda hyperons because these particles contribute directly or via decays to the neutrino production (see Fig. 1). Knowledge of neutral kaon production is required for the accurate calculation of the ν_e and $\bar{\nu}_e$ fluxes from $K^0_L \to \pi$ e ν_e decays.

2 The NA61/SHINE detector and analysis method

The NA61/SHINE detector is an upgrade of the NA49 experimental setup at CERN SPS [1]. Four large Time Projection Chambers (TPCs), one small TPC for the low polar angle particles (GAP TPC), and two time-of-flight detectors (TOFs) are former NA49 detectors which are used in NA61/SHINE experiment. The TPCs and new forward TOF, specially designed for the T2K needs, are the main components of the NA61/SHINE experiment. The Particle Spectator Detector (PSD), which is important for the centrality determination in nucleus-nucleus collisions, complete the setup. The layout of the NA61/SHINE setup is shown in Fig. 2.

A few different approaches of the particle yields extraction were applied.

- For the negatively charged tracks it is possible to obtain information about π^- production even without detailed particle identification because from theory and other experiments we know that in this energy range mainly pions are produced. This analysis is based on the Monte Carlo corrections. The biggest advantage of this method is the possibility to obtain results in the wide phase space region which parts are not feasible for other methods.

[a] e-mail: tomasz.palczewski@fuw.edu.pl

– The dE/dx analysis. This method was used in the low momentum region (<1-3 GeV/c) where Bethe-Bloch curves do not cross. This approach was used to obtain π^+, π^-, and proton yields.
– The combined dE/dx and time-of-flight analysis. This information is available for particle momenta larger than about 0.8 GeV/c and emission angles smaller than about 300 mrad. This approach was used to obtain π^+, π^-, K^+ results.
– The analysis of neutral strange hadrons was performed via invariant mass distribution studies. Preliminary results of K_S^0 were obtained.

All results were corrected for the detector effects (geometrical acceptance, reconstruction efficiency) and contamination of electrons and other particles, secondary interactions and weak decays. In K_S^0 case correction for BR is also applied. Full systematic error studies were performed.

3 Results and conclusions

The π^+ and π^- combined final results normalized to mean multiplicity in production processes are presented in Fig. 3 ([3]). The final K^+ results and K^+ / π^+ ratios are shown in Fig. 4 ([4]). The preliminary K_S^0 results are shown in Fig. 5.The inclusive cross section for K_S^0 production corrected to the whole phase space region is equal to 28.58 ± 1.85 (stat) ± 1.72 (sys) mb. The K_S^0 / K^+ ratios are shown in Fig. 6. In the production point number of K_S^0 is equal to number of K_L^0. Therefore, using K_S^0 results one can evaluate information about K^0. The K^0 / π^- ratios are shown in Fig. 7. The ratio of K^0's to π^-'s provides information on strangeness suppression factor λ since it is a ratio of $d\bar{s}$ to $d\bar{u}$ quark system. The charged pion and Kaon production cross-sections are the most important for the tuning of the T2K neutrino beam predictions. These results were used by T2K Collaboration to minimize systematic error of the θ_{13} measurement [5]. All results were compared to Monte Carlo models (VENUS, UrQMD, Fluka) and recently used by the authors of Fluka and UrQMD to tune their predictions.

References

1. N. Antoniou *et al.* [NA61/SHINE Collaboration], CERN SPSC-2007-019, (2007).
2. K. Abe *et al.* [T2K Collaboration], Nucl.Instrum.Meth. **A659**, 106-135 (2011).
3. N. Abgrall *et al.* [NA61/SHINE Collaboration], Phys. Rev. C **84**, 034604 (2011).
4. N. Abgrall *et al.* [NA61/SHINE Collaboration], Phys. Rev. C **85**, 035210 (2012).
5. K. Abe *et al.* [T2K Collaboration], Phys. Rev. Lett. **107** 041801 (2011).

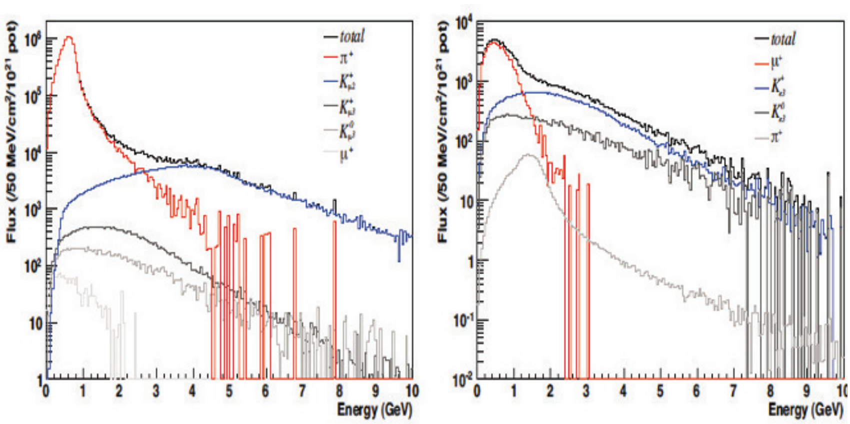

Fig. 1. ν_μ(left) and ν_e (right) energy spectrum at T2K far detector. JNUBEAM simulations.

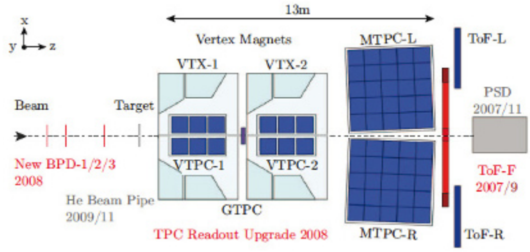

Fig. 2. The layout of the NA61/SHINE setup.

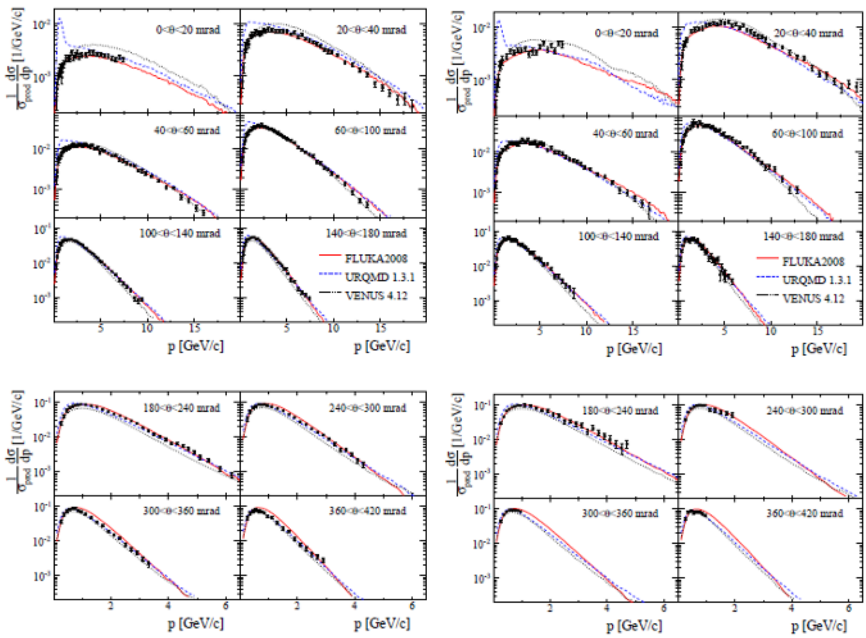

Fig. 3. The π^- (left ten panels) and π^+ (right ten panels) mean multiplicity in production processes from p+C at 31 GeV/c. Only statistical error are shown. Monte Carlo model predictions are superimposed.

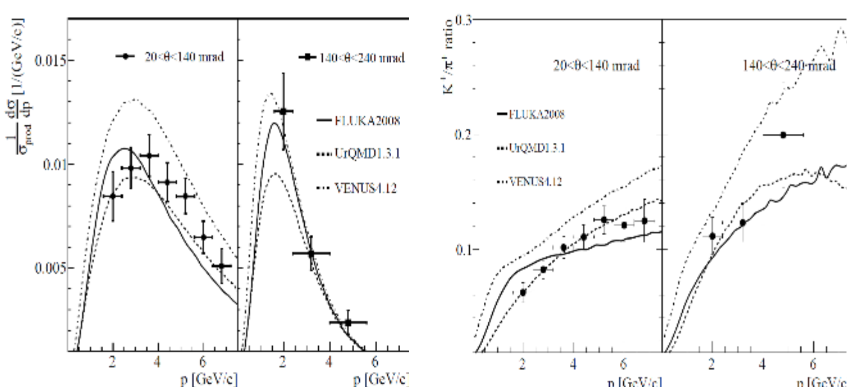

Fig. 4. Mean K^+ multiplicity in all production p+C interactions (left). K^+ / π^+ ratios (right). The vertical error bars on the data points show the total (stat. and syst.) uncertainty. Monte Carlo model predictions are superimposed.

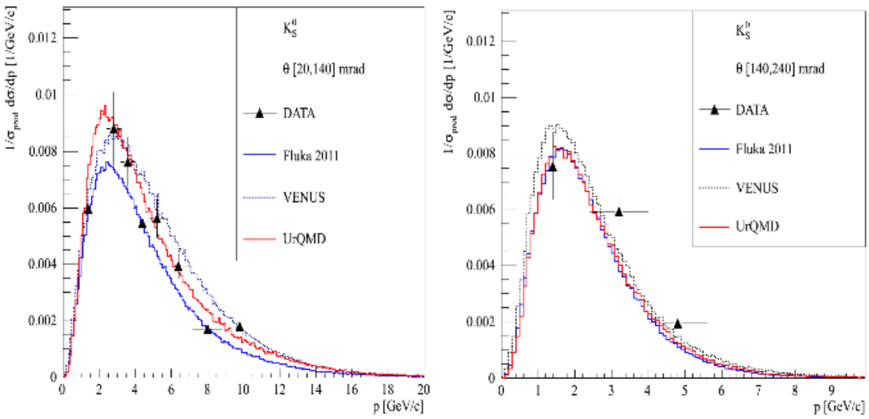

Fig. 5. The K_S^0 mean multiplicities in production processes in two polar angle intervals. Only statistical errors are shown. Monte Carlo model predictions are superimposed.

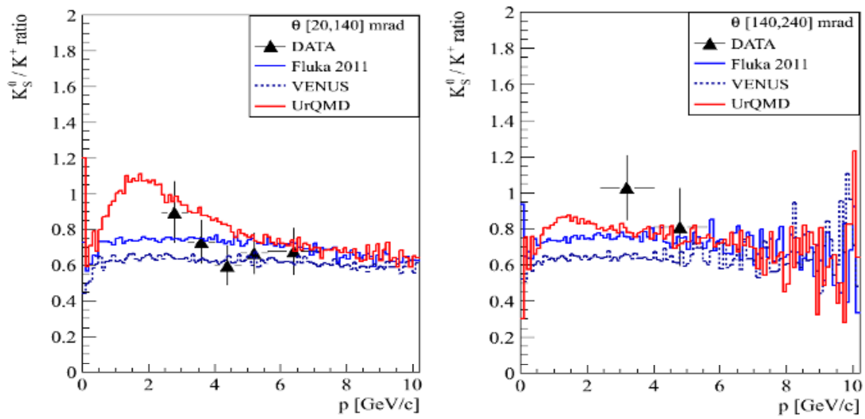

Fig. 6. The K_S^0 / K^+ ratios in two polar angle intervals. The vertical error bars on the data points show the total (stat. and syst.) uncertainty. Monte Carlo model predictions are superimposed.

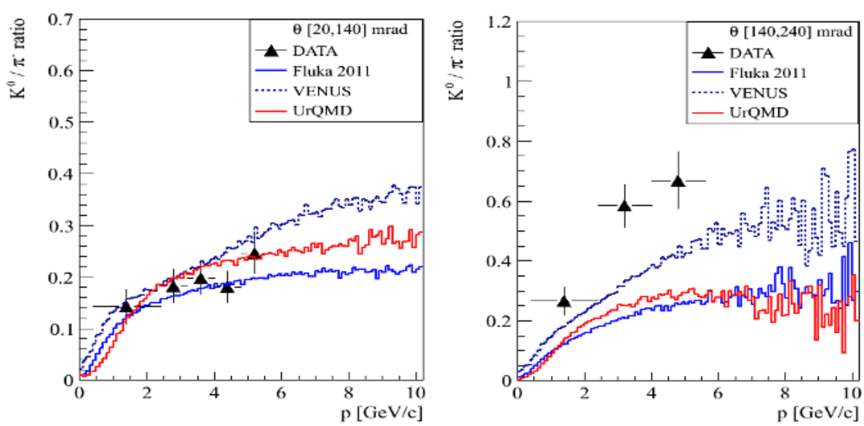

Fig. 7. The K^0 / π^- ratios in two polar angle intervals. The vertical error bars on the data points show the total (stat. and syst.) uncertainty. Monte Carlo model predictions are superimposed.