Available online at www.sciencedirect.com

ScienceDirect

Nuclear and Particle Physics Proceedings 279–281 (2016) 118–124

www.elsevier.com/locate/nppp

Recent Results From NA61/SHINE

M. Unger[a,b], for the NA61/SHINE Collaboration[c]

[a] *Karlsruhe Institute of Technology, Karlsruhe, Germany*
[b] *on leave of absence at New York University, New York, USA*
[c] `http://shine.web.cern.ch/content/author-list`

Abstract

We present preliminary measurements of the production spectra of identified charged pions and ρ^0 production in π^-+C interactions at 158 and 350 GeV/c with the NA61/SHINE detector. The results are compared to predictions of hadronic interaction models used for the interpretation of extensive air showers.

Keywords: air showers, cosmic rays, fixed target, NA61/SHINE, hadronic interactions

1. Introduction

Ultrahigh energy cosmic rays are measured by detecting the secondary particles produced in extensive air showers. The interpretation of data from cosmic-ray experiments such as the Pierre Auger Observatory [1], KASCADE-Grande [2], IceTop [3] or the Telescope Array [4] therefore relies on the understanding of hadronic interactions in air shower cascades. The majority of hadronic particles observed at ground is produced at equivalent beam energies below a TeV [5, 6]. Unfortunately, there exist no comprehensive and precise particle production measurements for the most numerous projectile in air showers, the π-meson. Therefore, new data with pion beams at 158 and 350 GeV/c on a thin carbon target were collected by the NA61/SHINE experiment at the CERN SPS.

Spectra of unidentified hadrons have been previously derived from this data set and the spectra revealed discrepancies between the data and predictions from generators for hadronic interactions [7, 8, 9].

In this contribution we will present new preliminary measurements of the production spectra of identified charged pions and ρ^0 production in π^-+C interactions at 158 and 350 GeV/c [10]. This data is of particular importance to study the origin of shortcomings of hadronic interactions models in describing the muon production in air showers (see e.g. [11, 12, 13]).

Other reactions measured by NA61/SHINE of relevance for air shower physics include protons on carbon at 31 GeV/c [14, 15, 16, 17] and proton-proton interactions at 20, 31, 40 80 and 158 GeV/c [18, 19, 20].

2. The NA61/SHINE Experiment

NA61/SHINE facility [21] is a multi-purpose fixed target experiment to study hadron production in hadron-nucleus and nucleus-nucleus collisions at the CERN Super Proton Synchrotron (SPS). Among its physics goals are precise hadron production measurements for improving calculations of the neutrino beam flux in the T2K neutrino oscillation experiment [22] as well as for more reliable simulations of hadronic interactions in air showers. Moreover, p+p, p+Pb and nucleus+nucleus collisions are measured to study the properties of the onset of de-confinement and search for the critical point of strongly interacting matter (see e.g. Ref. [23]).

The NA61/SHINE Collaboration uses large time-projection-chambers (TPCs) inherited from the NA49 experiment [24] to measure the charge and momentum of particles. The momentum resolution, $\sigma(1/p) = \sigma(p)/p^2$, is about 10^{-4} (GeV/c)$^{-1}$ at full magnetic field and the tracking efficiency is better than 95%. A set of scintillation and Cherenkov counters as well as beam position detectors upstream of the spectrometer provide

http://dx.doi.org/10.1016/j.nuclphysbps.2016.10.017

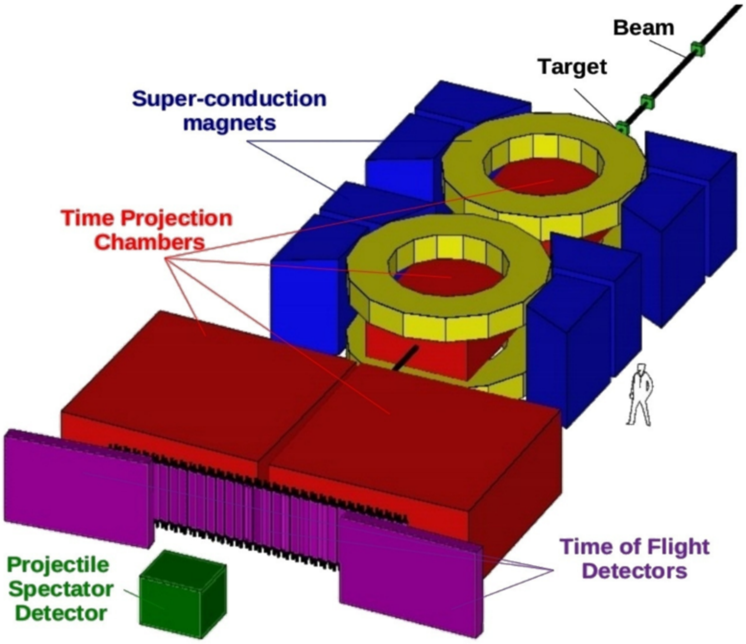

Figure 1: Schematic layout of the NA61/SHINE experiment.

timing reference, identification and position measurements of the incoming beam particles. Particle identification is achieved by measuring the energy loss along the tracks in the TPCs and by determining their velocity from the time of flight provided by large scintillator walls placed downstream of the TPCs. The centrality of nucleus-nucleus collisions can be estimated using the measurement of the energy of projectile spectators with a calorimeter [25] located behind the time of flight detectors. For nucleon-nucleus collisions, the centrality is determined by counting low momentum particles from the target (so called 'gray protons') with a small TPC around the target [26]. The detector setup is illustrated in Fig. 1.

Data taking with the NA61/SHINE experiment started in 2007. After a first run with proton on carbon at 31 GeV/c, the data acquisition system was upgraded during 2008 to increase the event recording rate by a factor of ≈10 [27]. In the last years, a wealth of data has been recorded by the experiment at beam momenta ranging from 13 to 350 GeV/c with various beam particles and targets. In this paper we present results obtained from a special run with negative pions as beam particles and carbon as the target. Since pions are the most numerous particles in an air shower, this data set is the most relevant for tuning hadronic interaction models used for interpretation of air showers at ultra-high energies.

3. Production of Charged Pions in π^--C Interactions

For each track detected in the TPCs of NA61, the particle type can be estimated by using the truncated mean of the energy that is deposited per unit track length (dE/dx) along the particle trajectory. An example of a dE/dx-distribution in a specific bin in momentum p and transverse momentum p_T is shown in Fig. 2. As can be seen, the distribution can be well described by the sum of the energy loss distributions of electrons, protons, pions and kaons (see Ref. [28] for details) and given the fitted fraction of each particle type, the corresponding number, Δn, of produced tracks within each p/p_T-bin can be reconstructed.

This number is then corrected for the detector acceptance, selection efficiency, feed-down from weak decays and re-interactions in the target. The latter two corrections are currently estimated using model predictions (Epos1.99, QGSJetII-04, DPMJet3.06) and they are typically well below 5%, but can reach up to 20% at low particle momenta. Overall, the systematic uncertainty of the corrected number of tracks, $\Delta n'$, is estimated to be ≤7%.

The average multiplicity of particles produced within a p/p_T-bin is then obtained by dividing $\Delta n'$ by the total number of recorded events in which an interaction occurred, N_prod. N_prod is estimated by extrapolating the number of recorded interaction triggers to full phase