

Comparison of Geant4 hadron generators with data: a critical appraisal

I. Boyko (for the HARP-CDP group)

Joint Institute for Nuclear Research, Dubna, Russian Federation

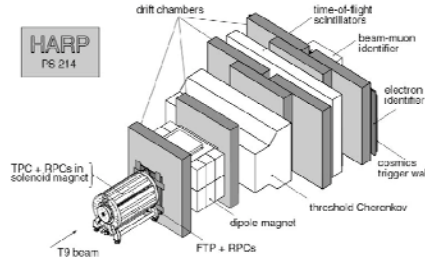
Introduction

Precise spectra of secondary hadrons from the interaction of protons and pions with nuclei are, inter alia, of importance for the improvement and physics validation of models of hadron generation in Monte Carlo simulation tool kits such as Geant4.

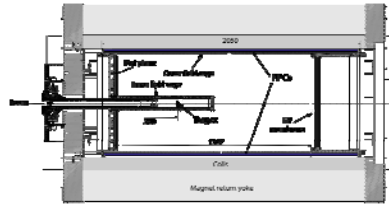
The HARP experiment at the CERN PS took data in 2001 and 2002 with proton and pion beams with momentum between 1.5 and 15 GeV/c. It was the first 4π detector dedicated to the measurement of secondary hadron spectra. The detector comprised a forward spectrometer and a large-angle spectrometer. This poster is exclusively concerned with data from the HARP large-angle spectrometer.

The latter consists of a cylindrical TPC that measures p_T and the polar angle θ of tracks, and their specific ionization dE/dx . Timing RPCs that surround the TPC measure time of flight with a view to complementing and corroborating particle identification.

Detector characteristics & performance



Large-angle spectrometer
TPC and RPCs inside 0.7 T solenoidal magnet



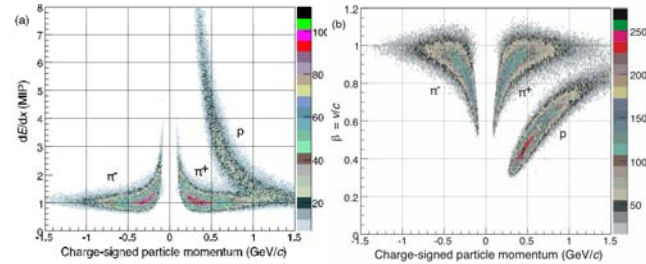
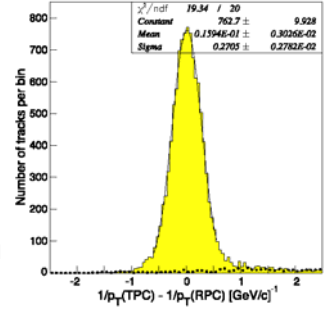
TPC

- $\sigma(1/p_T) \approx 0.20$ (GeV/c)⁻¹
- $\sigma(\theta) \approx 9$ mrad
- $\sigma(dE/dx)/(dE/dx) \approx 0.16$

RPCs

- Efficiency $\approx 98\%$
- $\sigma(\text{TOF}) \approx 175$ ps

Good particle identification by combining dE/dx from TPC and TOF from RPCs

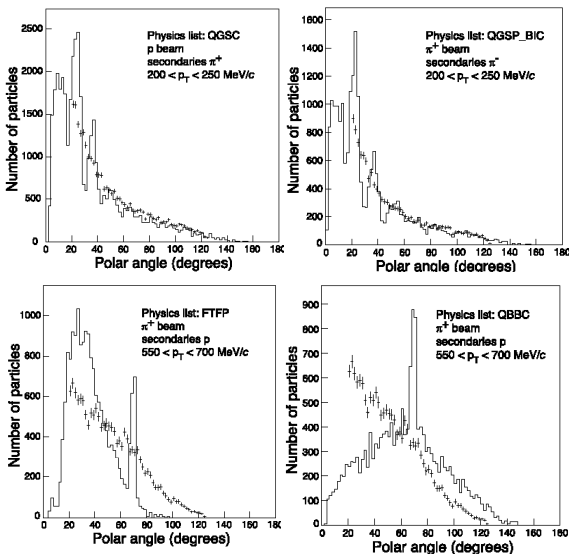


Geant4 physics lists

We have compared data of 8.9 GeV/c protons and pions interacting in a 5% λ_{abs} Be target with the most commonly used physics lists of Geant4 (version 9.1). None of them satisfactorily reproduces our data.

The most striking features of the generated spectra are:

- a diffraction-like pattern
- an unphysical elastic scattering peak at 70°
(this problem has been fixed for some of the models in recent releases)



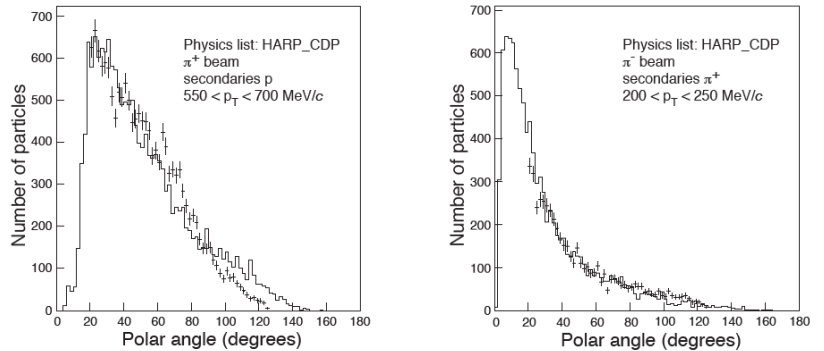
Polar-angle distributions of examples of hadron production from 8.9 GeV/c protons and pions as generated by various Geant4 physics lists; the crosses denote our measurements.

HARP_CDP physics list

To reproduce our measurements we have created a new physics list. It is based on the QBBC physics list, modified as follows

- $E_{\text{kinetic}} > 6$ GeV/c:
Quark-Gluon String Model replaced by the FRITIOF String Fragmentation Model;
- $E_{\text{kinetic}} < 6$ GeV/c:
Bertini Cascade is used to describe pion interactions;
Binary Cascade is used to describe proton interactions;
elastic and quasi-elastic scattering is disabled.

This new physics list proved to give satisfactory results both for pion and proton interactions at 8.9 GeV/c beam momentum.



Polar-angle distributions of examples of hadron production from 8.9 GeV/c pions as generated in Geant4 with the new HARP_CDP physics list; the crosses denote our measurements.

References

- [1] V. Ammosov et al., NIM A588 (2008) 294 and NIM A578 (2007) 119
- [2] A. Bolshakova et al., Comparison of Geant4 hadron generation with data from the interactions with beryllium nuclei of +8.9 GeV/c protons and pions, and of -8.0 GeV/c pions, Preprint CERN-PH-EP/2008-007, accepted for publication in EPJ C.