Übungen zu Physik an Hadron-Collider SS 2011
Prof. Karl Jakobs, Dr. Iacopo Vivarelli
Übungsblatt Nr. 4

Die Lösungen müssen bis 11 Uhr am Donnerstag den 2.6.2011 in die Briefkästen im Erdgeschoss des Gustav-Mie-Hauses eingeworfen werden!

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1. **Minimum bias interactions**

   Download the three ntuples name MinBias_900GeV(2TeV,7TeV).root from

   `http://wwwhep.physik.uni-freiburg.de/~ivivarel/col_phys/`

   They contain the final state particles of simulated (with Pythia 8) non diffractive proton proton collisions at three different center of mass energies. Each ntuple has a structure which should be obvious: for each events, 5 vectors are defined, containing the transverse momentum, the pseudorapidity, the ϕ angle, the charge and the PDG id of each particle produced in the event. The PDG id is a unique identifier for the particle identification ($\pi^{\pm}, \pi^0, K^{\pm}$ and so on). To decode the PDG id, the following link can be useful:

   `http://pdg.lbl.gov/2002/montecarlorpp.pdf`

   Each ntuple contain 10^5 events. The cross sections (according to Pythia) are 35 (40, 50) mb for $\sqrt{s} = 900$ $(2000, 7000)$ GeV

   For each of the three center of mass energies:

   - To what integrated luminosity correspond the 10^5 events? **[1 point]**
   - Investigate the particle spectrum. What is the average composition of particles with $p_T > 100$ MeV? **[2 point]**
   - Where do all those photons come from mainly? Is the fraction of $\pi^{\pm}$ with respect to π^0 roughly in agreement with arguments from isospin symmetry? **[2 point]**
   - Plot the following distribution of charged particles with $p_T > 100$ MeV and $|\eta| < 2.5$ (be careful with the normalization):

   $$\frac{1}{N_{ev}}\frac{dN_{ch}}{d\eta} \quad \frac{1}{N_{ev}}\frac{1}{2\pi p_T}\frac{d^2N_{ch}}{dp_T d\eta} \quad \frac{1}{N_{ev}}\frac{dN_{ev}}{dn_{ch}} \tag{1}$$

   where N_{ev} is the number of event, N_{ch} is the number of charged particles, n_{ch} is the number of charged particles per event. **[2 points per distribution]**

   [Bonus questions:] Address also the following points:

   - What is the average charged particle multiplicity (with $p_T > 100$ MeV) at $\eta = 0$ in each center of mass energy point? Make a plot. **[2 bonus points]**
   - Compare the results with those shown in
     `http://arxiv.org/pdf/1012.5104v2`
     shortly discussing possible sources of differences in the results. **[2 bonus points]**