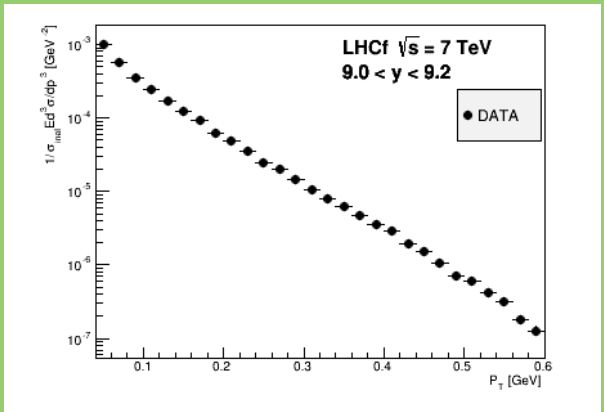
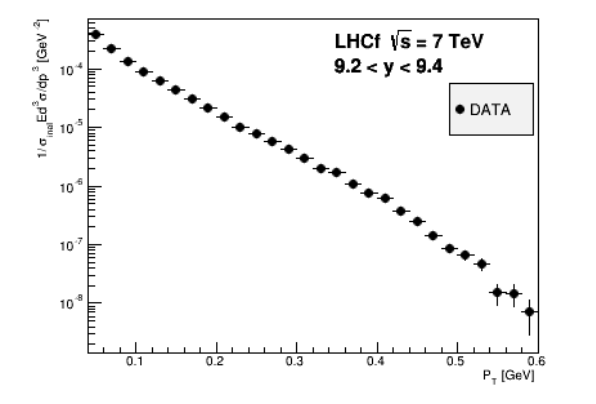
The single photon P_T spectra were obtained using the same single photon selection procedure. The inclusive photon production is given by:

$$\frac{1}{\sigma_{inel}} E \frac{d^3\sigma}{dp^3} = \frac{1}{N_{inel}} \frac{d^2N(P_T, y)}{2\pi \cdot P_T \cdot dP_T \cdot dy} \qquad (1)$$

Six rapidity y bins were chosen to better study the details of the photon P_T spectra: 8.9 to 9.0, 9.0 to 9.2, 9.2 to 9.4, 9.4 to 9.6, 9.6 to 10.0 and 10.0 to 11.0.





Due to lack of time, a full and consistent calculation of the systematic uncertainties wan not carried out.

Conclusions

In this dissertation the single photon P_T spectra were extracted from the data collected by the LHCf experiment in p-p collisions at $\sqrt{s}$ = 7 TeV. The procedures to select and reconstruct single photon events were described.

As said before, estimate of the systematic uncertainties which affect this analysis was not computed. For this reason, it has been impossible to perform a meaningful comparison between experimental data and Monte Carlo predictions. Thus, future development of this analysis will focus on the detailed evaluation of the systematic uncertainties. In addition, to extract inclusive spectra able to be compared with the theoretical predictions, the raw spectra should also be corrected for the geometric acceptance factor of the LHCf detector.

Acknowledgements

I would like to thank Prof. A. Tricomi for her help throughout the development of this dissertation. Furthermore, a warm thanksgiving goes to Dr. G. Mitsuka and A. Tiberio and E. Berti, and in general to the whole LHCf collaboration team, for their precious help.

UNIVERSITÀ DEGLI STUDI DI CATANIA
DIPARTIMENTO DI FISICA E ASTRONOMIA
CORSO DI LAUREA MAGISTRALE IN FISICA

STEFANO CALÍ

MEASUREMENT OF SINGLE PHOTON P_T SPECTRA IN P-P COLLISIONS AT $\sqrt{s}$ = 7 TeV WITH THE LHCf EXPERIMENT

TESI DI LAUREA

Relatore:
Chiar.ma Prof.ssa A. Tricomi

ANNO ACCADEMICO 2014/2015

Introduction

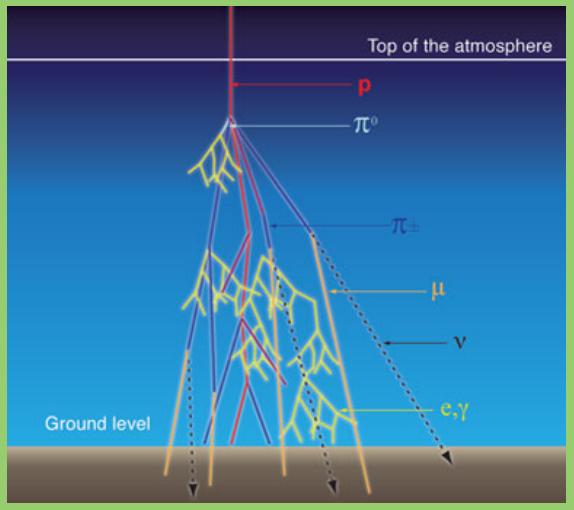
In the last decades, High Energy Cosmic Rays (HECR) and Ultra High Energy Cosmic Rays (UHECR) physics has made notable steps forward, allowing us to increase our knowledge about such high energy events. However, still a large part of the interpretation of data analysis results of these experiments is based on Monte Carlo simulations of the hadronic interaction between the primary cosmic rays and the Earth's atmosphere.

The LHCf experiment allows to measure the spectra of neutral particles (mainly photons, pions and neutrons) in the very forward region $|\eta| > 8.3$. The LHCf experiment already took data in the energy range from $\sqrt{s} = 900$ GeV to $\sqrt{s} = 13$ TeV and, in the next future, will take data up to $\sqrt{s} = 14$ TeV, i.e. up to $\simeq 10^{17}$ eV in the laboratory frame. These spectra will be used to tune the hadronic interaction Monte Carlo codes, improving their theoretical predictions.

In this dissertation single photon P_T spectra have been extracted in order to compare them with the predictions of the most used Monte Carlo codes in UHECR physics.

Cosmic Rays

The detection of HECR and UHECR can be performed only indirectly, measuring the showers of secondary particles produced in the interaction with atmosphere.



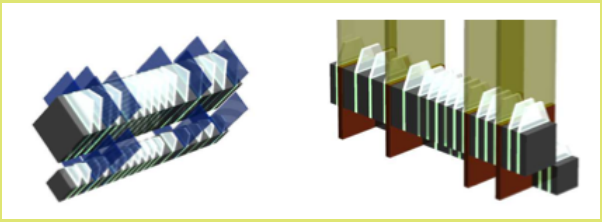
Fundamental cosmic rays information like energy, chemical composition and arrival direction can be extracted from the shower properties.

In particular X_{MAX}, the atmospheric depth at which the maximum number of charged particles is reached, is a fundamental parameter. In fact, it is the only tool we have which allows to distinguish the cosmic rays chemical composition.

Before the LHC era, the only available data on the production of neutral particles in the very forward region were the one collected by the UA7 collaboration at 10^{14} eV in the laboratory frame. Thus, the hadronic interaction Monte Carlo codes had to extrapolate hadronic cross sections up to 6-7 magnitude orders to compare their predictions with the highest energy cosmic rays observed ($10^{20} - 10^{21}$ eV). This introduces systematic uncertainties in the Monte Carlo simulations which make very difficult to compare experimental data with Monte Carlo predictions.

LHCf Detector

The LHCf detector is composed by two independent detectors, called Arm1 and Arm2, that have been installed in the instrumentation slots of the Target Neutral Absorbers (TANs) at $\pm$ 140 m from ATLAS interaction point. Each LHCf detector has two sampling and imaging calorimeters composed of 44 radiation lengths (X_0) of tungsten and 16 sampling layers of 3mm thick plastic scintillator. Four X-Y layers of position sensitive detectors are interleaved with the layers of tungsten and scintillator to complete the detectors. The transverse sizes of the calorimeters are 20×20 mm^2 and 40×40 mm^2 for Arm1, and 25×25 mm^2 and 32×32 mm^2 in Arm2.



Data Analysis

In this dissertation, only Arm2 data were analyzed.

Firstly, to check the correct use of the LHCf data analysis software, it was decided to reproduce the already obtained single photon energy spectra.

Single photon selection is carried out applying the following requirements:

- Reconstructed energy > 100 GeV.
- Events with only one photon entering in a calorimeters are selected.
- Events that hit calorimeters within 2 mm from the edges are removed from the analysis.
- Photons are distinguished from hadrons using the $L_{90\%}$ parameter.

The obtained spectra are very similar to those previously published by the LHCf collaboration both in the spectral shape and in the MC/Data ratio.