Abstract: The LHC-forward (LHCf) experiment is intended to provide useful information for the calibration of hadronic interaction models used by ground-based cosmic rays experiments. This is achieved detecting neutral particles having pseudorapidity $\eta > 8.4$ produced by LHC p-ion collisions at different center of mass energies $\sqrt{s}$. In this way it is possible to study different parameters related to the interaction of a cosmic ray with the atmosphere: forward production spectra, inelasticity, nuclear modification factor and validity of scaling laws. While the analysis of data acquired during p-p collisions at $\sqrt{s} = 13$ TeV is still ongoing and a special run for p-Pb collisions at $\sqrt{s_{NN}} = 8.1$ TeV is scheduled for this year, in this poster we present the results obtained by LHCf in Run I.

From Cosmic Rays to LHC

Measurements of flux and composition of cosmic rays up to the GZK cutoff can be performed only at ground through the detection of extensive air showers (EASs). The properties of the primary particle are reconstructed making use of simulations, but among hadronic interaction models very different predictions are found, strongly contributing to the final uncertainty. The main purpose of the LHCf experiment is to provide high energy experimental calibration measurements for the tuning of these models.

What to measure at LHC

- Inelastic cross section
- Forward production spectra
  - photon, $\pi^0$
  - inelasticity $k = 1 - p_{\text{miss}}/p_{\text{proton}}$
- Nuclear modification factor
- p-Pb collisions
  - $\sqrt{s_{NN}} = 5.02$ TeV
- Validity of scaling laws
- p-p collisions at different $\sqrt{s}$

In this section we discuss the main analysis results obtained by the LHCf experiment in Run I.

Single photon energy spectra [4] for p-p collisions at $\sqrt{s} = 7$ TeV. Data lay in the middle of the very different model predictions.

Types of $\pi^0$ detectable by LHCf:
- Type I if there is a photon in both towers (left)
- Type II if both photons hit one tower (right)

Nuclear modification factor of $\pi^0$ production in the proton side [6].

Considering the large error bars, all models are in good agreement with data, indicating a strong suppression in the $\pi^0$ production rate in p-Pb collisions respect to p-p collisions.

Neutron energy spectra [5] relative to p-p collisions at $\sqrt{s} = 7$ TeV.

At large $\eta$, a high production rate in the most energetic region is present, only qualitatively predicted by QGSJET II-03, implying small inelasticity.

Data on p-Pb collisions at $\sqrt{s_{NN}} = 8.1$ TeV. No model perfectly reproduces data, but differences are not so strong. The models in best agreement are QGSJET II-04 and EPOS-LHC.

Conclusions

Using data acquired during LHC Run I, LHCf has already published several results relative to photon, $\pi^0$ and neutron production spectra. No model perfectly reproduces experimental data, but deviation is not so strong, especially for LHC tuned models. Scaling laws, like Feynman scaling, holds at the 20% level in the worst case and production is strongly suppressed in the case of p-Pb collisions. The plan for the future is to extend the $\sqrt{s}$ and $p_T$ coverage making use of two special runs foreseen for the next months: LHC p-Pb collisions at $\sqrt{s_{NN}} = 8.1$ TeV, RHIC p-p collisions at $\sqrt{s} = 510$ GeV.

References

[1] The LHCf Collaboration et al., JINST 3.08 (2008), S08006