Measurement of the forward η meson production cross section in p-p collisions at $\sqrt{s}$=13 TeV with the LHCf Arm2 detector

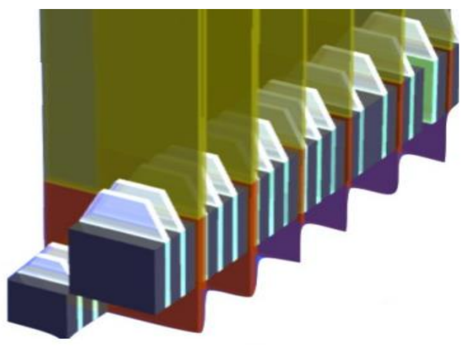
Giuseppe Piparo [1,2,3] on behalf of LHCf collaboration

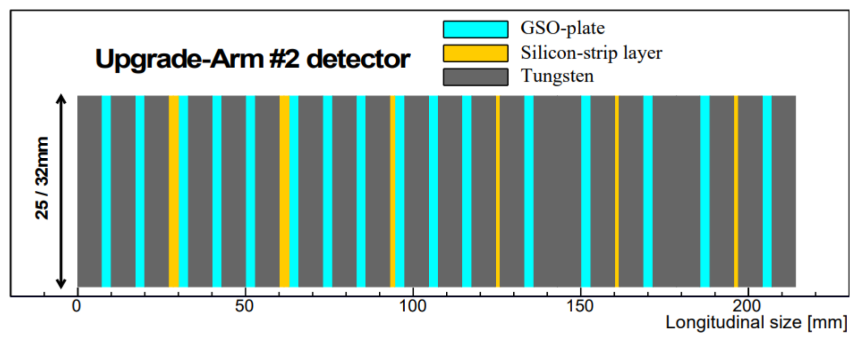
[1] INFN Section of Catania, Catania, Italy
[2] University of Catania, Catania, Italy
[3] CSFNSM, Catania, Italy

LHC-forward [1] (LHCf) is a **unique experiment** designed to measure neutral particle production in the pesudorapidity region $|\eta| > 8.4$. The aim of LHCf is to provide experimental data needful to tune and calibrate **hadronic interaction models** widely used by ground-based cosmic ray experiments. One of the characterizing parameters of the models is the **strange quark contribution**, that induces a large discrepancy on the expected **η production cross section**. A precise measure of this quantity allows to discriminate which of the analyzed models is more suitable to describe the interaction between primary cosmic rays and the earth's atmosphere.

ARM2 DETECTOR

- Located at about 140 m from LHC interaction point 1 (IP1).
- two calorimetric towers with **16 GSO scintillator layers [2], 22 tungsten plates and 4 XY silicon microstrip imaging layers [3]**, with a total length of about 44 X_0 and 1.6 λ_I.
- The **energy resolution** is better than 3% for photons and 30÷40% for neutrons, while the **position resolution** for electromagnetic showers is about 40 μm.





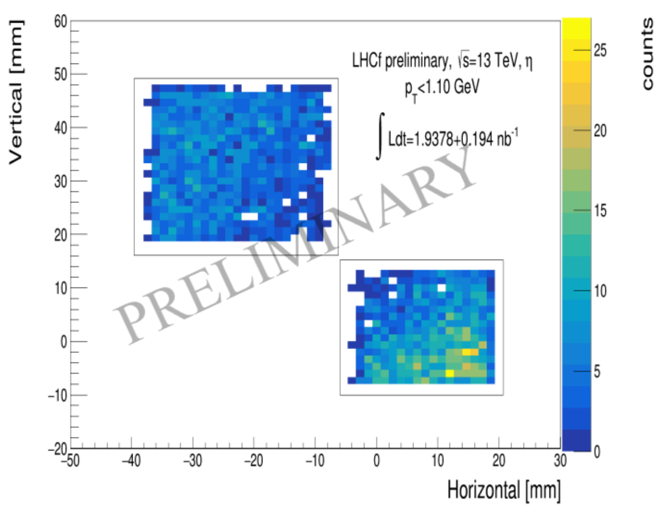
EVENT RECONSTRUCTION AND SELECTION

- The η meson identification is carried out by reconstructing position and energy of the two photons originated in the decay $\eta \rightarrow \gamma\gamma$ (B.R. 39.41%) and by selecting with several criteria.
- The **invariant mass distribution** is fitted with a model consisting of an asymmetric Gaussian for the signal and a 3^{rd} order Chebyshev polynomial function for the background.
- The η mesons are selected in a window of 3σ from the peak, **about 1500 candidates were found.** Background was subtracted by using a sideband method.
- An **artificial shift of +2.65%** on single photon energies was applied to bring the η invariant mass peak into agreement with η rest mass.

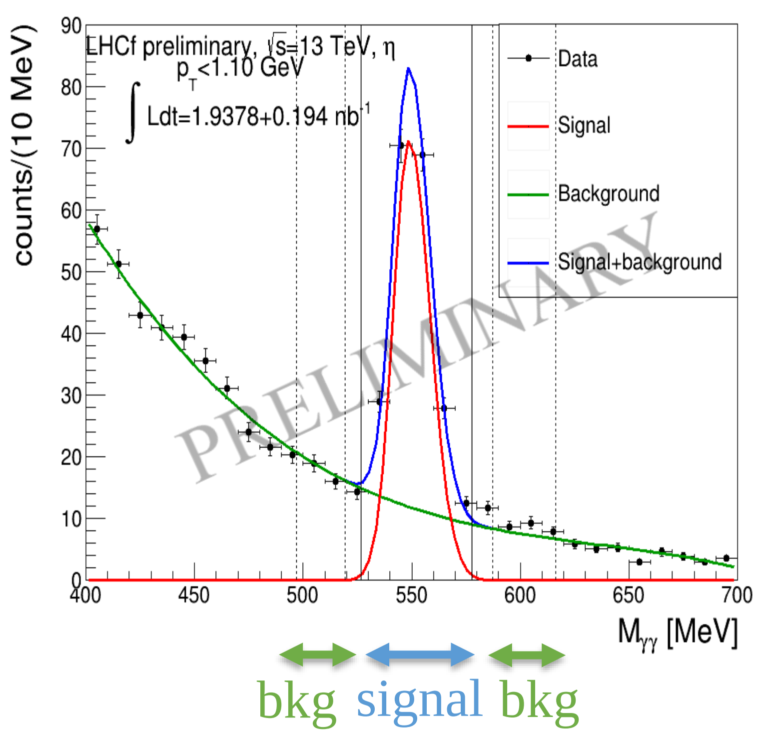
Criteria for η event selection

Event type	Type-I
Energy threshold	E_{photon}>200 GeV
Incident position	Within 2 mm from the edge of calorimeter
Number of hits	Single hit in each tower
Particle identification	Photonlike in each tower($L_{90} < L_{thr}(E)$)

Selected events hitmap



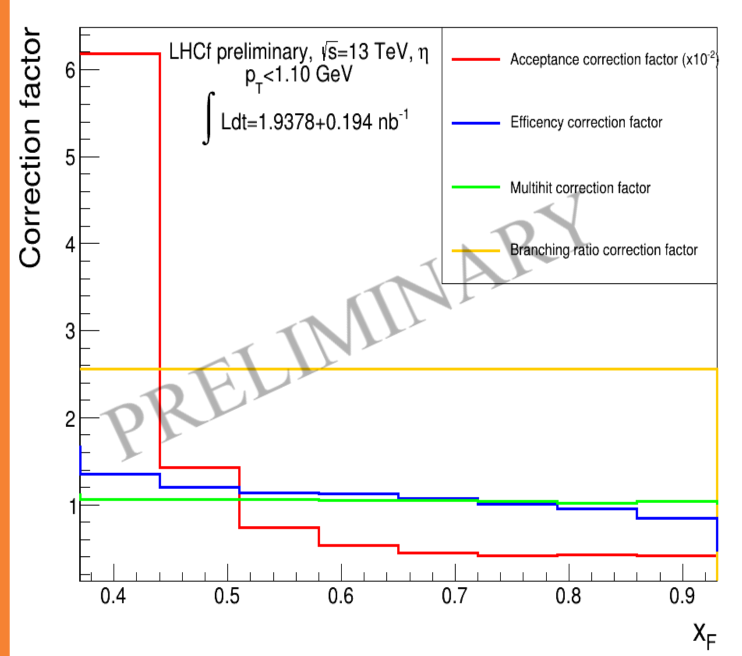
Invariant mass distribution



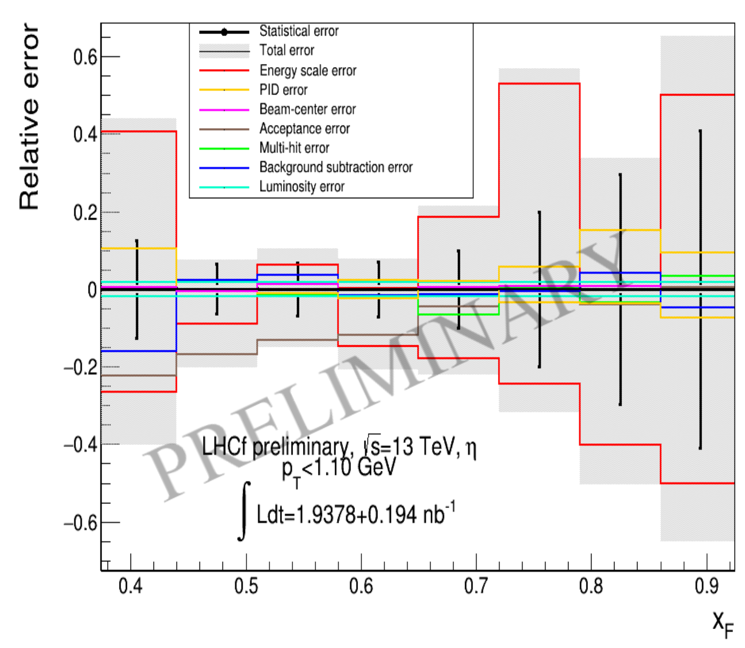
EXPERIMENTAL CORRECTIONS AND UNCERTAINTIES

- The **Feynman-x** distribution ($x_F = 2p_z/\sqrt{s}$) of η mesons was corrected for several experimental effects:
  a) η selection inefficency.
  b) Geometrical acceptance.
  c) Loss of events due to multihit cut.
  d) Branching ratio inefficency.
- QGSJET model informations were used to calculate a) and c), while for b) the mean of the correction values obtained by QGSJET and EPOS were considered.
- The **systematic uncertainties** were estimated by using both the **data sample** (for energy scale, PID and beam-center stability errors) and the results of the **QGSJET and EPOS model simulations** (for acceptance, multihit and background subtraction errors).

Distributions of correction factors



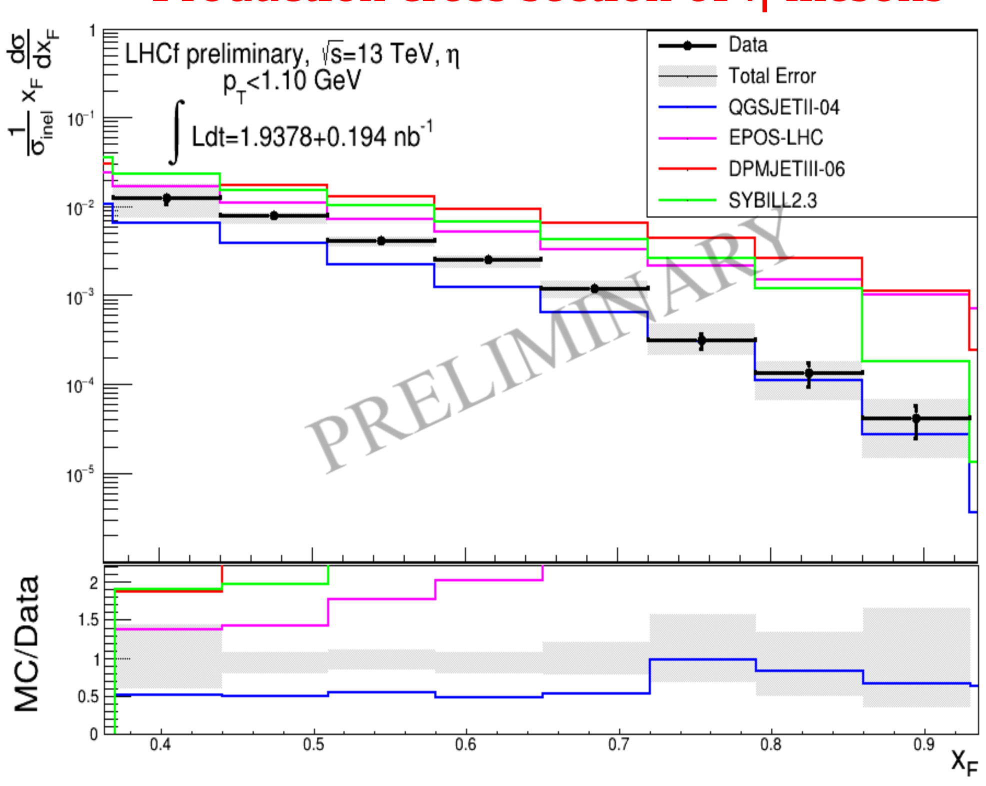
Contributions to uncertainty



RESULTS AND COMPARISON WITH MODELS

- The η **experimental x_F spectrum** was compared with several hadronic interaction models.
- **None of the models** is able to reproduce the experimental distribution in the whole x_F range.
- Among the models the one that seems to better reproduce the data is **QGSJETII-04.**
- Thanks to the **detector read-out upgrade**, the new data taking during LHC Run III, scheduled for September 2022, will allow **to increase the statistics** of the η mesons and **to improve the precision** of the measurement [4]. For more details see poster by K. Ohashi [5] (poster location A26).

Production cross section of η mesons



REFERENCES

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[4] LHCf collaboration (2019), "LHCf–Technical Proposal for the LHC Run 3".

[5] K. Ohashi (2022/05), "Prospects of the LHCf operation in 2022 ", Poster, LHCP 2022, Taipei (TW), Online.

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