LHCf operations in RUN III and prospects

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1. INTRODUCTION

The LHC-forward (LHCf) aim is to measure neutral particle production in the pseudorapidity region |η|>8.4 to provide experimental data needed to test and tune **hadronic interaction** models widely used to predict the interaction of cosmic rays with the Earth's atmosphere. The experiment consists in two **sampling and imaging** calorimeters made of tungsten and Gd_2SiO_5 **(GSO) scintillator layers**, interleaved with tracking detectors, made by **GSO fibres** for Arm1 and **silicon microstrips** for Arm2. This year the LHCf experiment performed operations during the RUN III, in p-p collisions at $\sqrt{s}$=13.6 TeV. The targets of these operations were enhancing **light meson statistics** (π^0, η and K_s^0) with respect to RUN II data and adding the information from **ATLAS, ZDC and Roman pots** that are very important for **LHCf-ATLAS joint measurements**.

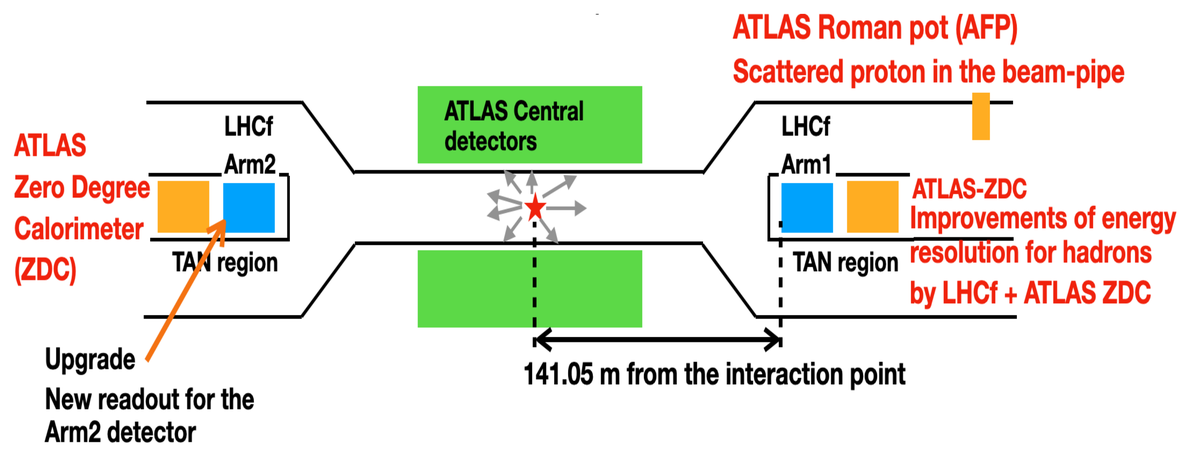
2. DATA TAKING SETUP

Several hardware upgrades in LHCf:

- **New silicon electronics for Arm2,** overall DAQ rate increased from 0.5 to 1.5 kHz.
- **New front counter in Arm1**, to tag photons hitting ZDC but not LHCf.
- **New trigger schemes and prescale,** to enhance acquisition of π^0, η and K_s^0 mesons.

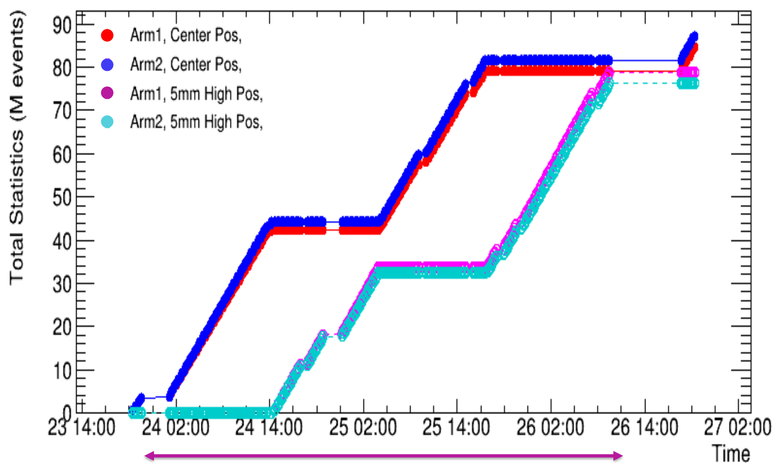
Joint data taking with several ATLAS detectors:

- **ATLAS central detectors,** to study the contribution of diffractive processes in the forward particle production, to estimate the forward-central correlation and to indirectly measure p-π cross section via one-pion exchange.
- **Roman pot (AFP and ALFA),** to measure scattered protons for the single diffractive events analysis.
- **ATLAS Zero Degree Calorimeter (ZDC),** to improve the hadronic energy resolution of LHCf and obtain a better measurement of neutrons and inelasticity. Energy resolution improvement is also required for the one-pion exchange measurement.



3. ACQUIRED DATA

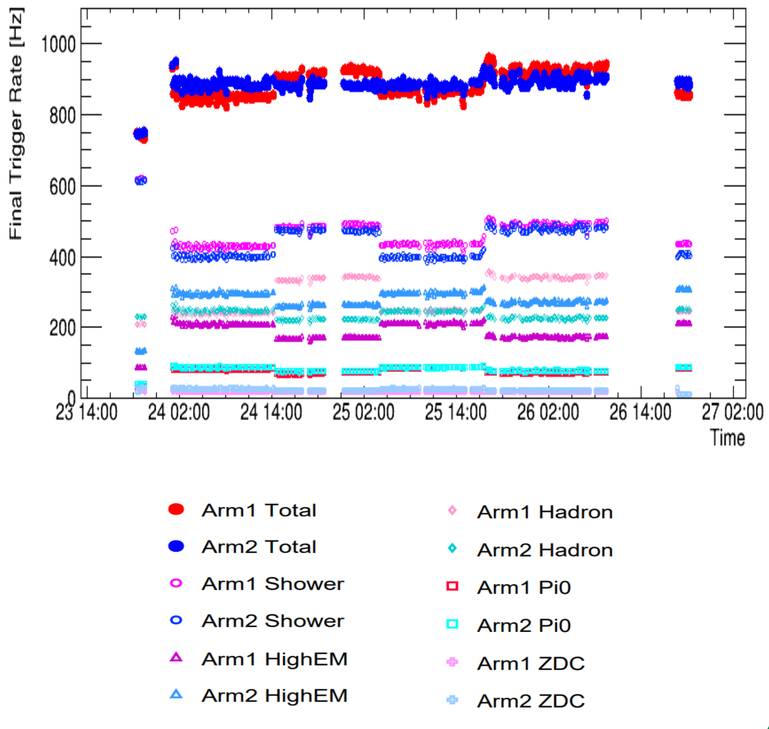
LHCf acquired statistics



More than 55 hours fill!!

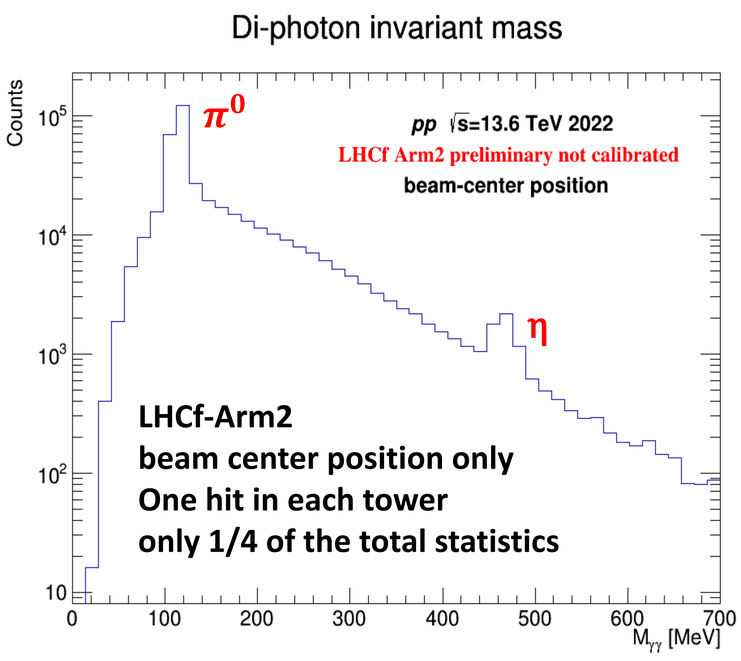
- Operation during 24-26 September 2022, fills 8178 for more than 55 hours, **the longest ever for LHC**, and 8179 for a few hours.
- Data acquired in **two different positions** to completely cover the regions with |η|>8.4.
- **About 150 M events were recorded for each detector.** About eight times the statistics with respect to RUN II.
- The several **trigger schemes** and the **prescale** allowed for an enhancement of different event categories.
- The **correlation of energy deposit** between LHCf and ZDC detectors was confirmed using the data.

LHCf trigger rates



4. FIRST RESULTS

- The first observed result is the **di-photon invariant mass**, where the π^0 and η peaks are clearly visible. This results refer to a limited portion of the statistics.
- In the full dataset, the statistics of π^0 and η are **about 6-7 times higher** than in the RUN II data.
- **A consistent shift** of the two peaks from the reference value is present.
- A **precise calibration** will be performed using the data acquired during the **SPS beam-test** of this year, October.
- **This operation was also successfully performed!**



5. PROSPECTS

- The data analysis will be performed with a **precise calibration** using SPS beam test data acquired in October.
- The **high statistics** data obtained in Run III will improve π^0 and η measurement, which **will be published from Run II data soon.**
- **Joint analysis** of LHCf and ATLAS was already started.
- The collaboration will also start the hardware work for the **expected p-O run**, planned for 2024, which will give us an important opportunity to understand the **mechanisms underlying atmospheric showers.**