Prospects of the LHCf operation in 2022

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Abstract

LHC forward (LHCf) experiment measures forward neutral particles to improve hadronic interaction models adopted in cosmic-ray air shower simulations. This summer, we plan to have a data taking in proton-proton collisions. We expect ten times larger statistics than the previous operation in 2015 which allows us to measure pi0 and eta mesons more precisely. Moreover, we plan to have a joint operation with the ATLAS Zero degree calorimeter in this operation. Improvements in energy resolution for hadrons are expected by the joint operation and allow us to select the one-pion exchange process. In this talk, we present the prospects for the next LHCf operation.

Motivation & LHCf detectors

Particle productions in the forward direction are important for predictions of the development of cosmic-ray air showers. The LHCf experiment aims to validate predictions of forward particle productions by hadronic interaction models.

LHCf detectors are two detectors, Arm1 and Arm2. (Figure 1) Each detector consists of two sampling calorimeters with position-sensitive layers. Arm1 consists of tungsten, GSO scintillator, and GSO bar hod-scope. Arm2 consists of tungsten, GSO scintillator, and silicon microstrip detector. The read-out of the silicon strip detector of the Arm2 detector was upgraded after the last operation in 2015.
Energy resolution: < 5% for photons and ~40% for hadrons / Position resolution : < 300 μm

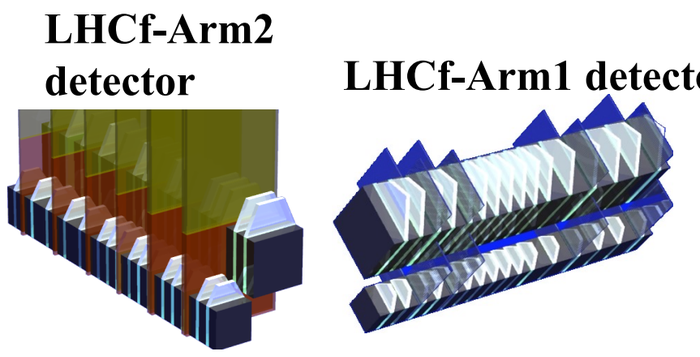

Figure 1 : LHCf-Arm1 (right) and Arm2 (left) detectors.

Operation in 2022

Overview & Schedule

Common data taking with ATLAS central detectors, ZDC, and Roman pots.
Hadronic energy resolution will be improved from 40% to 20% by detecting the shower particles leaked from the LHCf using ATLAS-ZDC. (Figures 2&3)
~2-day data-taking in 1-week low luminosity programs after TS 1 in Sep. 2022.

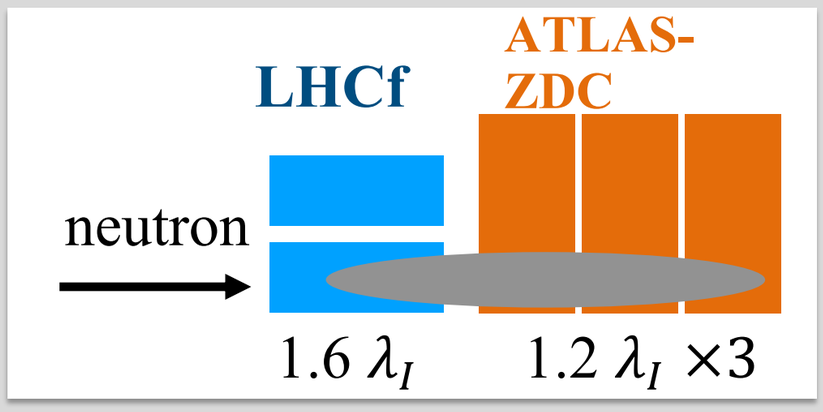

Figure 2 : Schematic view of LHCf and ATLAS-ZDC detectors and a particle shower produced by a incident neutron

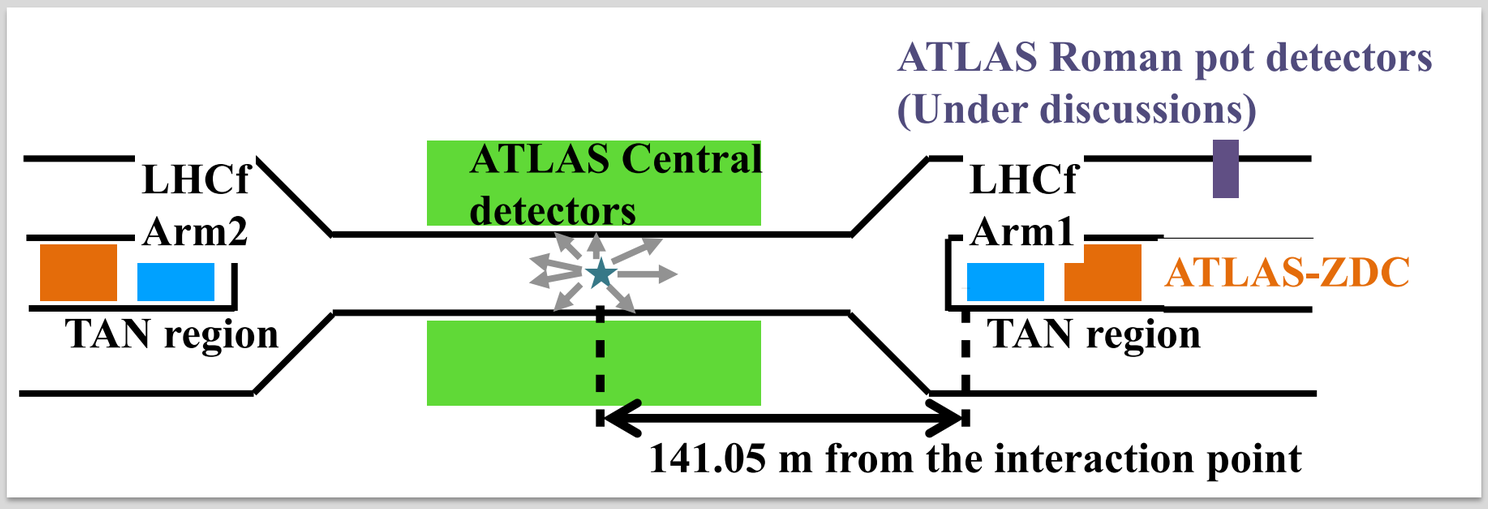

Figure 3 : Schematic view of ATLAS and LHCf detectors in the operation in 2022.

Trigger and DAQ

Prescale will be installed in the Trigger to enhance trigger modes for π^0 and η mesons.
ATLAS Level 0 ID is received by LHCf DAQ and LHCf final trigger send to issue ATLAS Level 1 trigger.
Offline event matching will be performed.

Expected performance

Neutral pions, kaons, and eta mesons

Ten times larger statistics of π^0 and η mesons are expected thanks to upgrades in the Arm2 read-out and prescale in the trigger.
5,000 η candidates are expected.
A few hundred candidates of $K_S^0 \rightarrow 2\pi^0 \rightarrow 4\gamma$ are expected.

One-pion exchange process

By tagging high energy neutrons and selecting events with many tracks in ATLAS inner tracker, we can select the one-pion exchange process [2]. (Figure 4)
Thus, we can measure virtual π^+ and proton collisions using ATLAS central detectors.

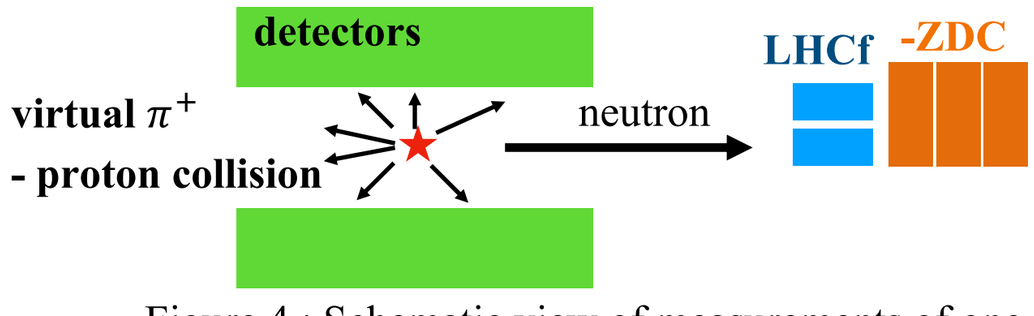

Figure 4 : Schematic view of measurements of one-pion exchange process.

References

[1] LHCf collaboration, “LHCf – Technical Proposal for the LHC Run 3 “ https://cds.cern.ch/record/2679323
[2] Ken Ohashi et al, PoS(ICRC2021) 190
https://pos.sissa.it/395/190/