# Forward Physics at ATLAS for Astroparticle Physics

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# **Cosmic Rays and Astroparticle Physics**





- Cosmic rays are relativistic nuclei (~90% proton)
- Creates secondary particle showers
  - Extensive Air Showers (EAS)
  - ✤ Mostly pions, kaons, etc.
  - EAS are dominated by soft-QCD interactions DESY.

- Makes indirect measurements by cherenkov lights
- Gamma-initiated vs nuclei-initiated showers

   π<sup>0</sup> distribution relates the two
- Model predictions have large uncertainties

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primary  $\gamma$ e<sup>+</sup> e<sup>-</sup> e<sup>+</sup> e<sup>+</sup> e<sup>+</sup> e<sup>-</sup> e<sup>+</sup> e<sup>-</sup> e<sup>-</sup>

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# **Accelerator and Forward Physics**





- Proton-proton collisions at LHC energy mimics EAS
- Soft-QCD events ~25-30% of total inelastic cross-section at LHC



# **Accelerator and Forward Physics**



proton





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**ZDC** (ATLAS Zero Degree Calorimeter ): Detection of forward neutrons and photons

**AFP**(ATLAS Forward Proton Detector): Detection of forward protons

# **Single Diffractive Processes**



# **Common acceptance for LHCf and AFP**



- First time such set of detectors were to be used together
- Common acceptance between LHCf and AFP detectors
   Expected event rate = 66.2 Hz
  - ✤ Total number of exp. events (for 2 days) = ~12 million
- Study generated enough incentive to convince all sides
- ✤ Joint run successfully performed in September, 2022
  - Single run lasted for 2 days 12 hours
    - ✤ Longest LHC run so far
    - Biggest forward data set taken at once
  - More than 300 millions events are recorded (total)

# Proton-oxygen run in 2024



- There is a planned proton-oxygen run in 2024
- Promises a better approximation for the EAS
- Model prediction distributions have dicrepancy in the very forward region
  - ✤ Up to 50%
  - Generator tuning is required
- Common acceptance study for LHCf, ZDC and AFP is still continuing

#### Conclusion

- Cosmic ray models strongly depend on good understanding of soft-QCD interactions
- ✤ Accelerator experiments such as LHC provides useful information for such interactions
- Forward region detectors are the key to understanding of such events
- A successful collaboration between ATLAS, AFP and LHCf has been achieved for the proton-proton run
   Single diffraction analysis of the collected data is currently undergoing
- Next is the proton-oxygen run in 2024
  - The study for the common acceptance is continuing



#### Thank you for your attention!