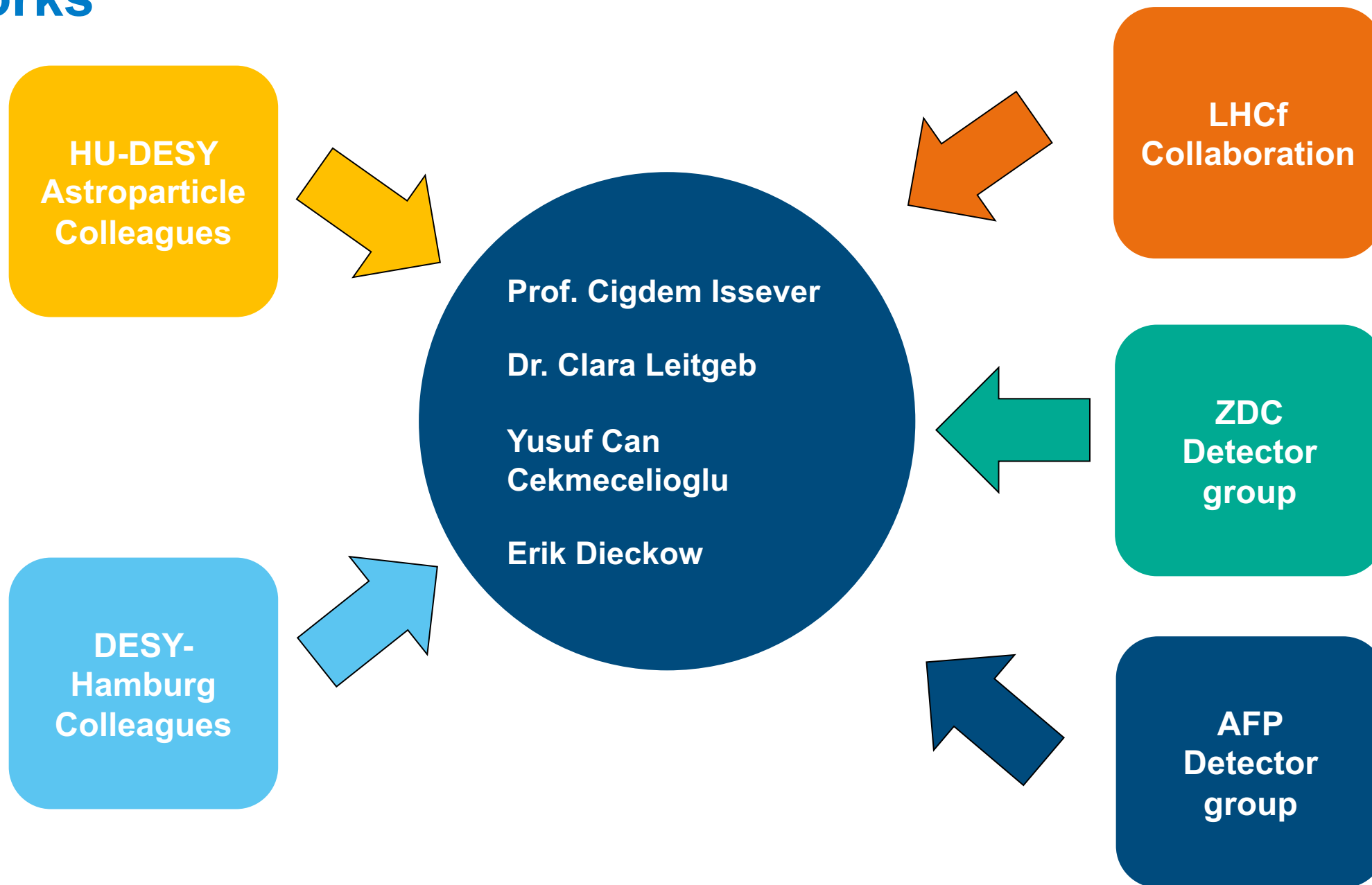


Forward Physics at ATLAS for Astroparticle Physics

Yusuf Can Cekmecelioglu
on behalf of the DESY ATLAS Forward Group

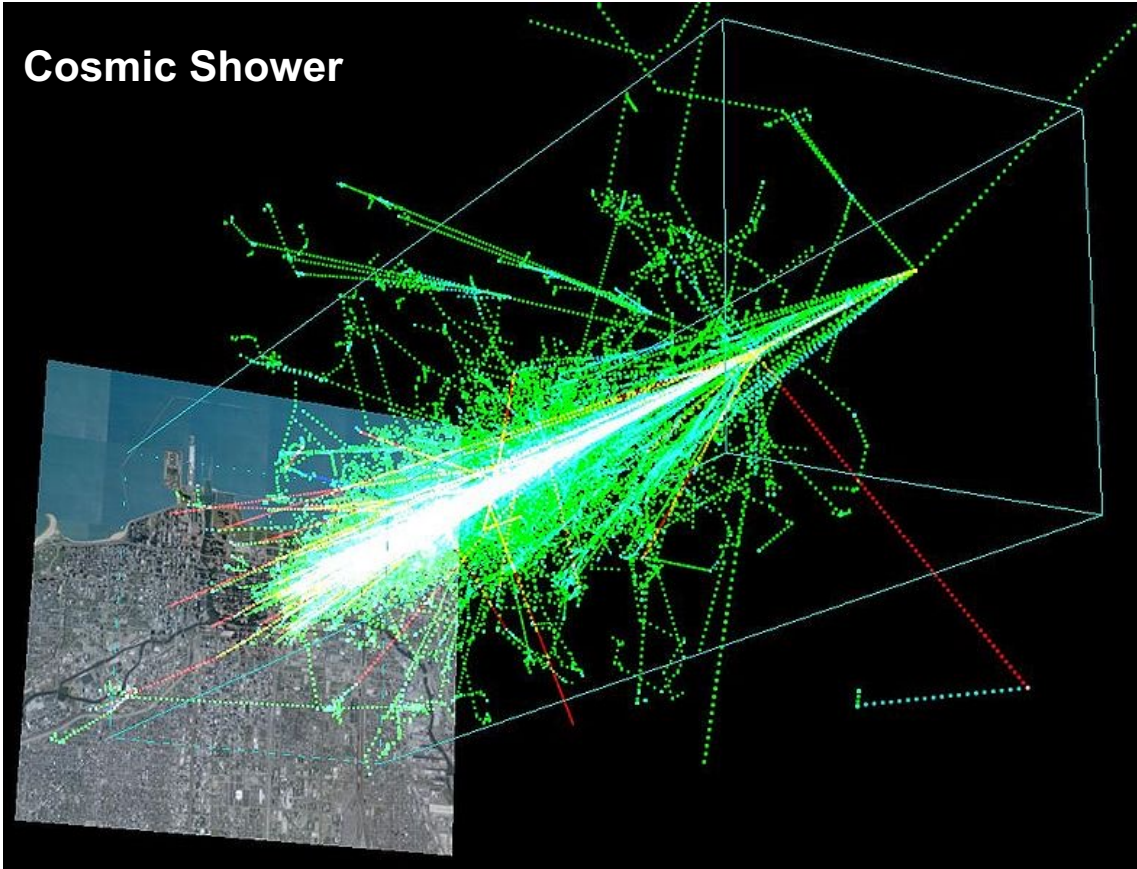
DESY Zeuthen Physics Retreat, 12.06.2023

Networks



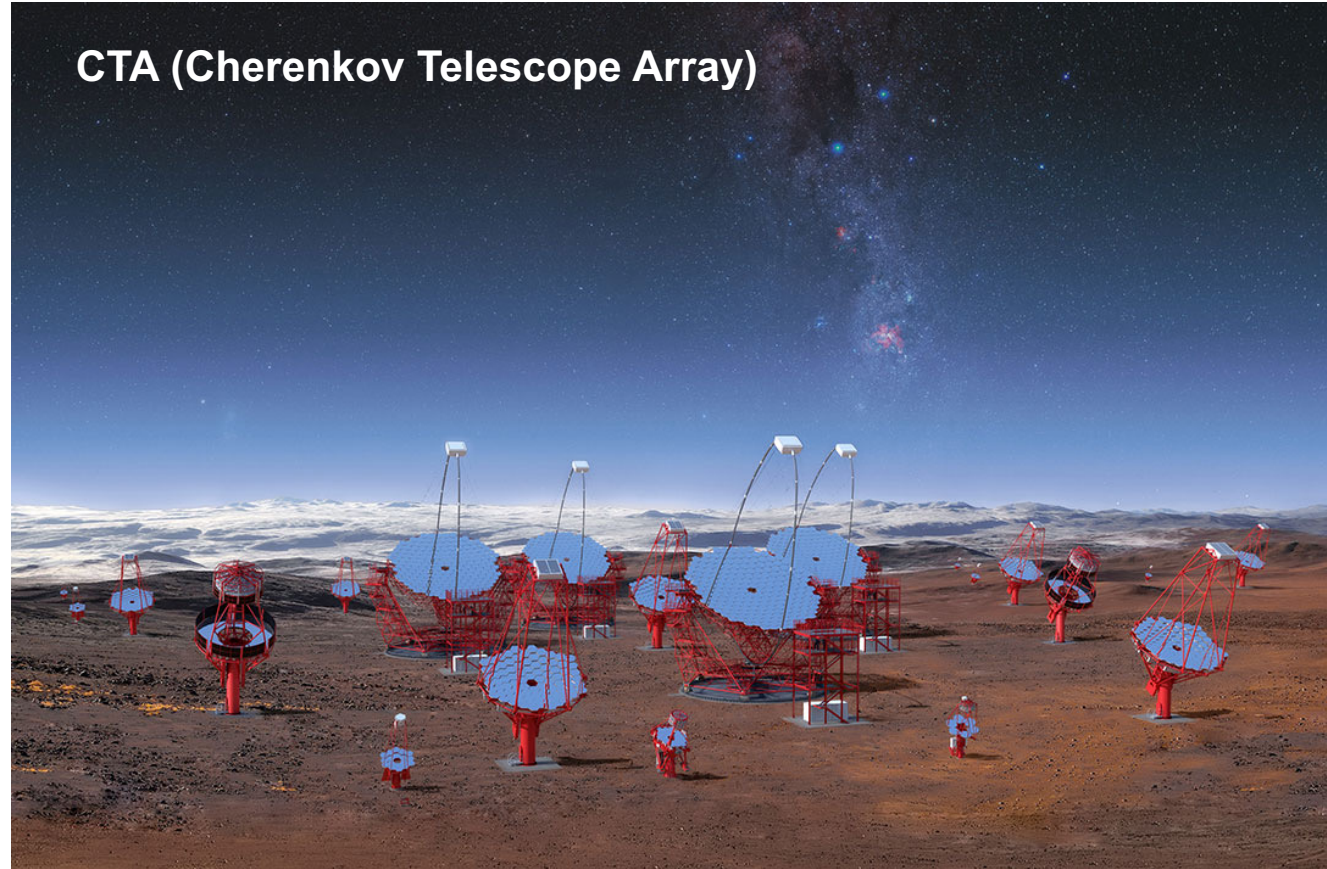
Cosmic Rays and Astroparticle Physics

Cosmic Shower



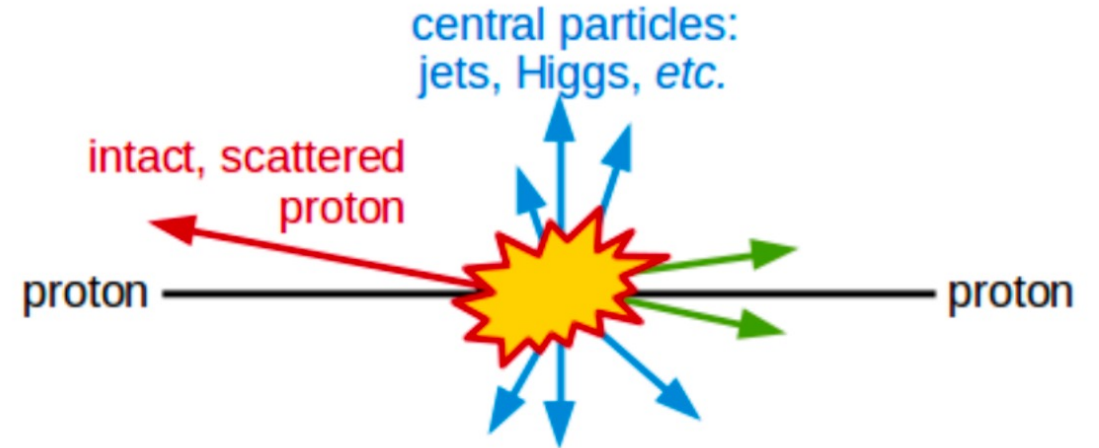
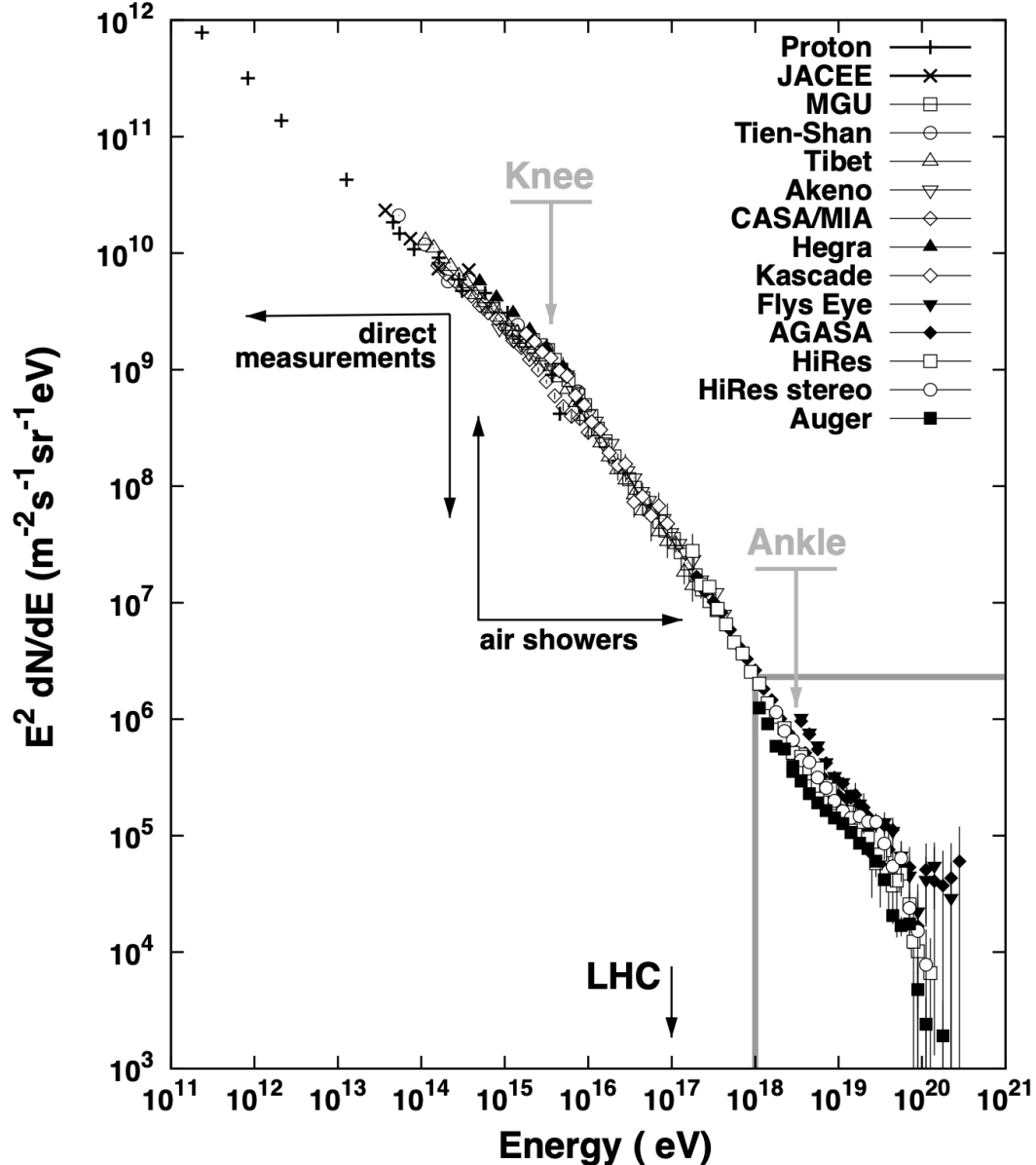
- ❖ Cosmic rays are relativistic nuclei (~90% proton)
- ❖ Creates secondary particle showers
 - ❖ Extensive Air Showers (EAS)
 - ❖ Mostly pions, kaons
 - ❖ EAS are dominated by soft-QCD interactions

CTA (Cherenkov Telescope Array)



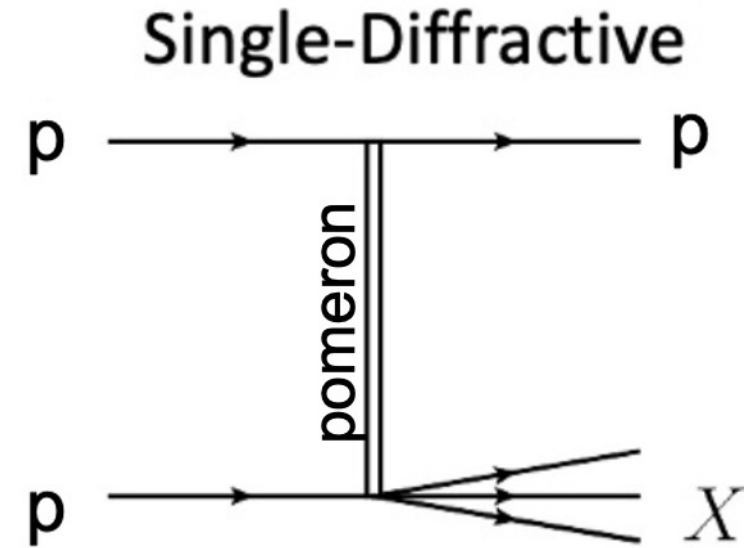
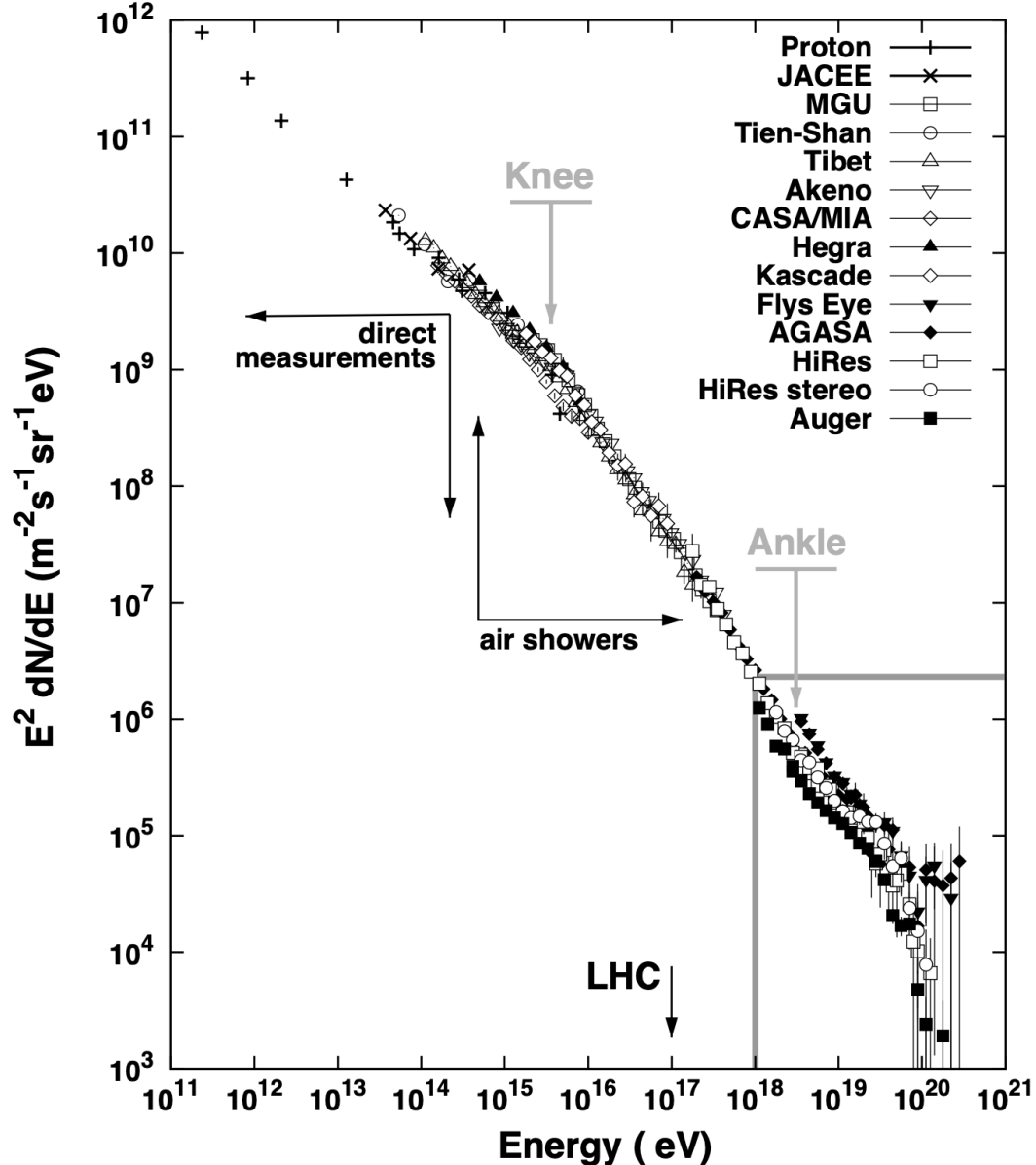
- ❖ Makes indirect measurements by cherenkov lights
- ❖ Gamma-initiated vs nuclei-initiated showers
 - ❖ π^0 distribution relates the two
- ❖ Muon Puzzle
 - ❖ Models need tuning

Accelerator and Forward Physics



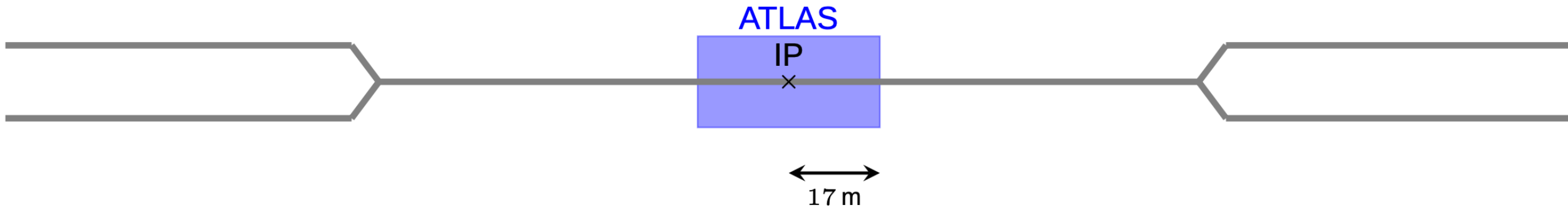
- ❖ Proton-proton collisions at LHC energy mimics EAS
- ❖ Soft-QCD events ~10% of total cross-section of LHC
- ❖ Single diffraction processes
 - ❖ One proton scatters intact
 - ❖ Other proton dissociates into forward particles

Accelerator and Forward Physics

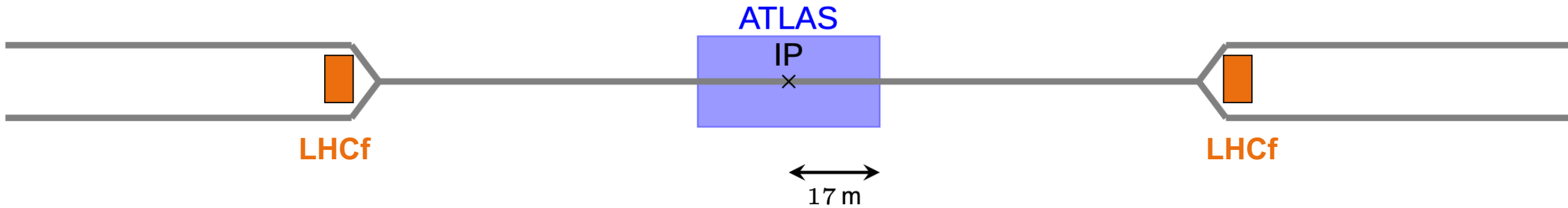


- ❖ Proton-proton collisions at LHC energy mimics EAS
- ❖ Soft-QCD events ~10% of total cross-section of LHC
- ❖ Single diffraction processes
 - ❖ One proton scatters intact
 - ❖ Other proton dissociates into forward particles

Forward Detectors at ATLAS

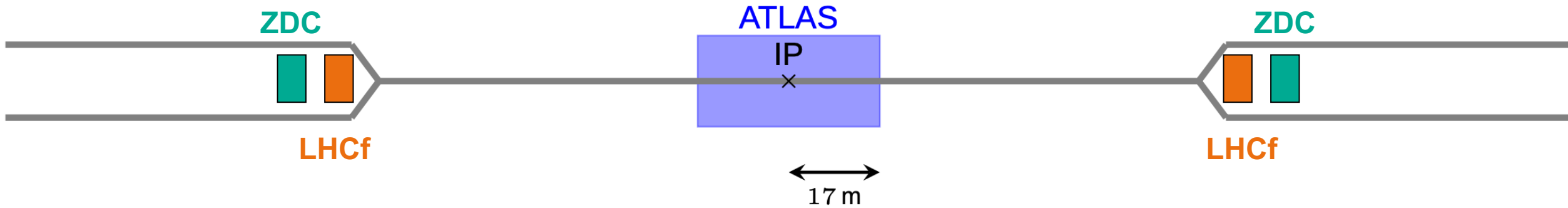


Forward Detectors at ATLAS



LHCf: Energy spectra of forward neutral particles

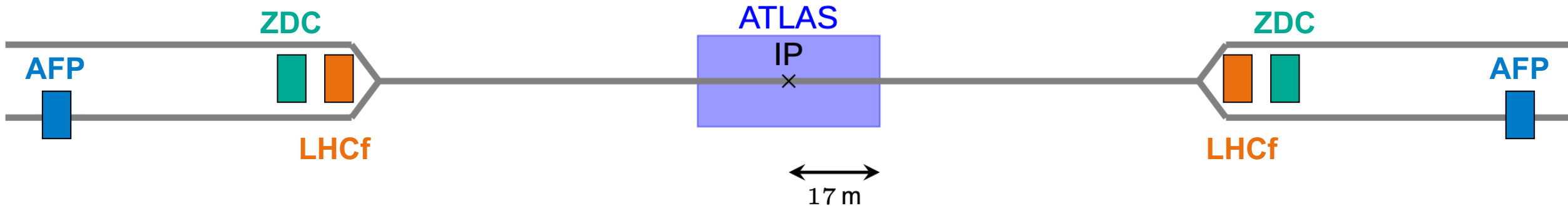
Forward Detectors at ATLAS



LHCf: Energy spectra of forward neutral particles

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

Forward Detectors at ATLAS

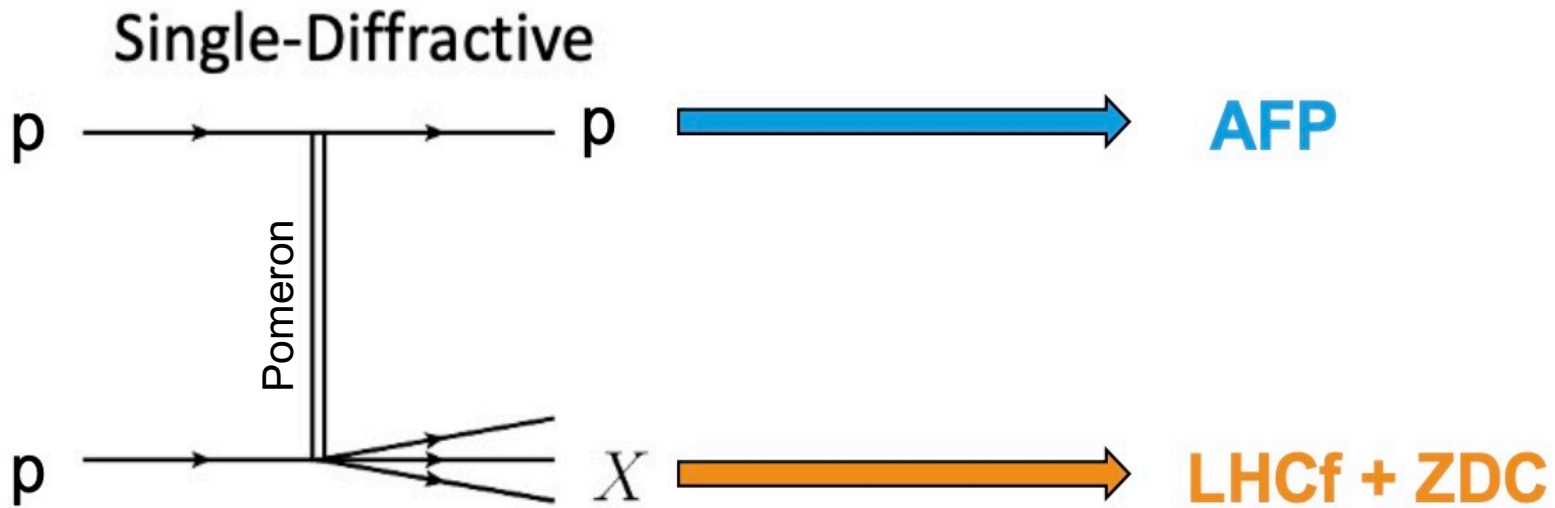


LHCf: Energy spectra of forward neutral particles

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

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

Forward Detectors at ATLAS

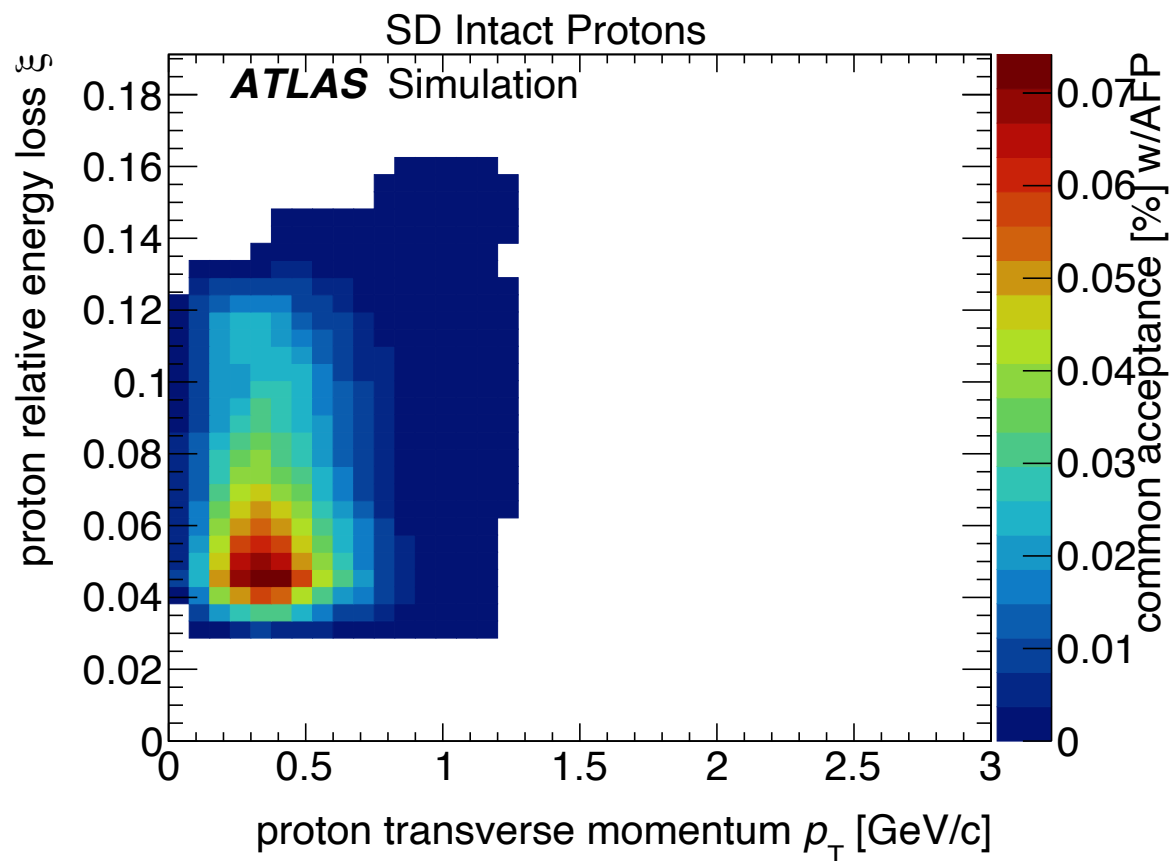


LHCf: Energy spectra of forward neutral particles

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

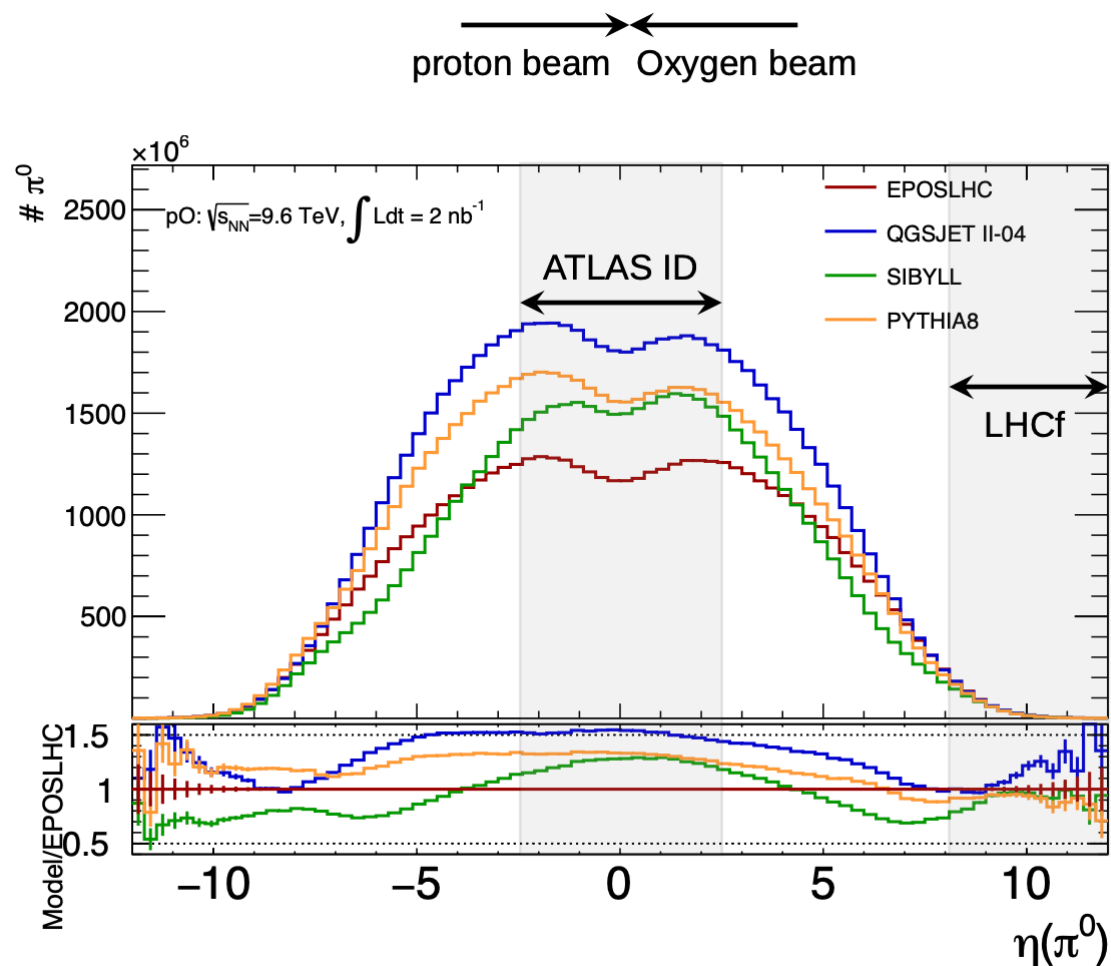
AFP(ATLAS Forward Proton Detector): Detection of forward protons

Common acceptance for LHCf and AFP



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

Proton-oxygen run in 2024



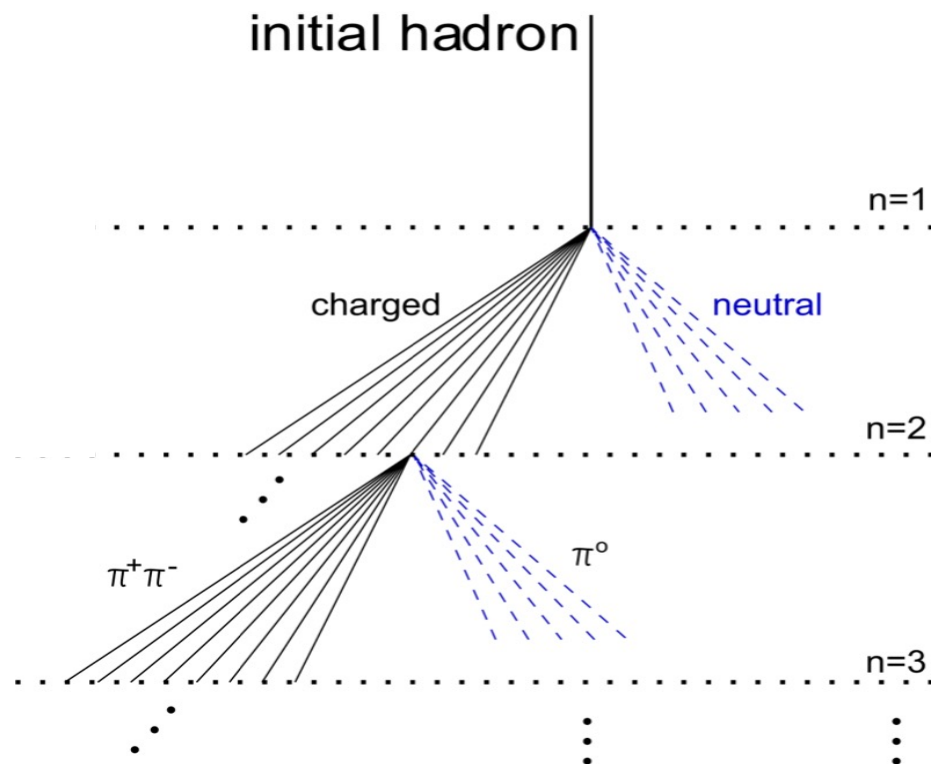
- ❖ There is a planned proton-oxygen run in 2024
- ❖ Promises a better approximation for the EAS
- ❖ Model prediction distributions have discrepancy in the very forward region
 - ❖ Up to 50%
 - ❖ Generator tuning is required
- ❖ Common acceptance study for LHCf, ZDC and AFP is still continuing

Conclusion

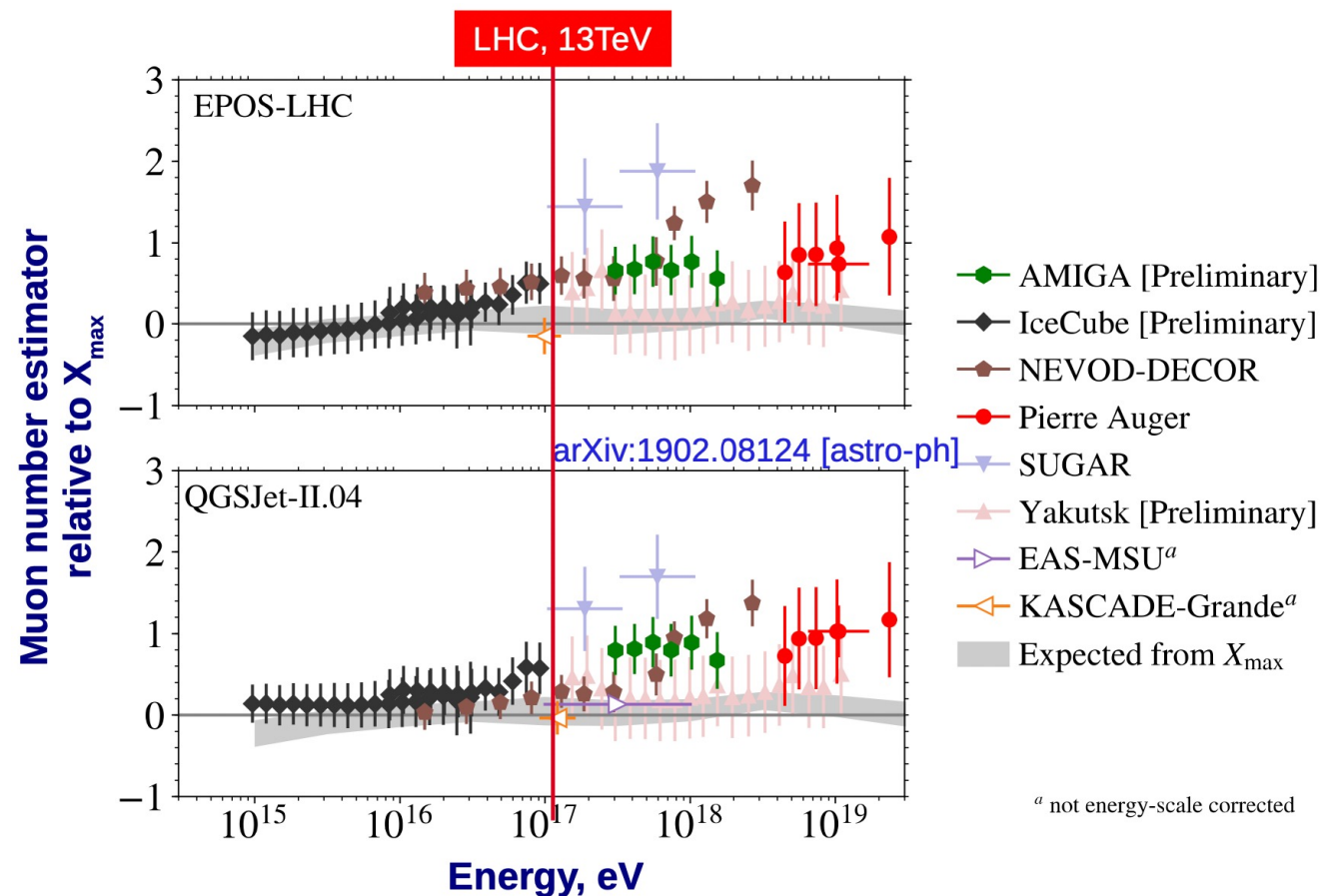
- ❖ Cosmic ray models strongly depend on good understanding of soft-QCD interactions
- ❖ Accelerator experiments such as LHC provides useful information for such interactions
- ❖ Forward region detectors are the key to understanding of such events
- ❖ A successful collaboration between ATLAS, AFP and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

Thank you for your attention!

Cosmic Rays and Astro-Physics



- ❖ Cosmic rays are relativistic nuclei
- ❖ Creates secondary particle showers
 - ❖ Extensive Air Showers (EAS)
 - ❖ Mostly pions, kaons
 - ❖ Dominated by soft-QCD interactions



- ❖ Collects final state particles from showers
- ❖ Mostly muons due to relative long life-time
- ❖ Number of muon_{observed} > muon_{expected}
 - ❖ Rises faster with energy
 - ❖ 8 σ significance
 - ❖ Muon Puzzle