

Studies by LHCf and ATLAS (+ZDC)

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Introduction

■ Motivation

- Several studies of joint analyses btw. LHCf + ATLAS are on-going now. These can be good inputs to RHICf + STAR joint analyses because these can be done in RHICf + STAR also.

■ Contents

- Physics cases of LHCf + ATLAS joint analyses.
 - Central and forward correlation
 - forward and forward correlation (w/ ZDC, w/ RPs)
- Performance of LHCf + ATLAS ZDC.
 - Joint test beam at CERN-SPS
 - Very preliminary result from pp , $\sqrt{s}=13.6$ TeV operation in 2022

Joint operation data set

■ LHCf + ATLAS

- Op 2015: pp $\sqrt{s} = 13$ TeV
 - Only 6 M events of common events
 - No ZDC and RPs jointed the operation
- Op 2022: pp $\sqrt{s} = 13.6$ TeV
 - Huge statistics of 300 M common events (all LHCf trigger events)
 - RPs (AFP and ALFA) and ZDC-HAD jointed the operation

■ RHICf + STAR

- Op 2017: pp $\sqrt{s} = 0.5$ TeV
 - RHICf was installed in the front of ZDC
 - RPs jointed in the last fill

Physics cases for joint operation

- with Central Detector

- Measurement of diffractive collisions
- Properties of Multi-parton interaction

- with Roman Pots

- Single diffractive measurement
- Measurement of $N(1440)$ and $\Delta(1232)$

- with ZDC

- Improvement of energy resolution for neutrons to $\sim 20\%$
- Measurement of Λ ($\Lambda \rightarrow n + \pi^0$)
- One-Pion-Exchange process

Simple diffractive study with ATLAS

Identification of diffractive events by ATLAS

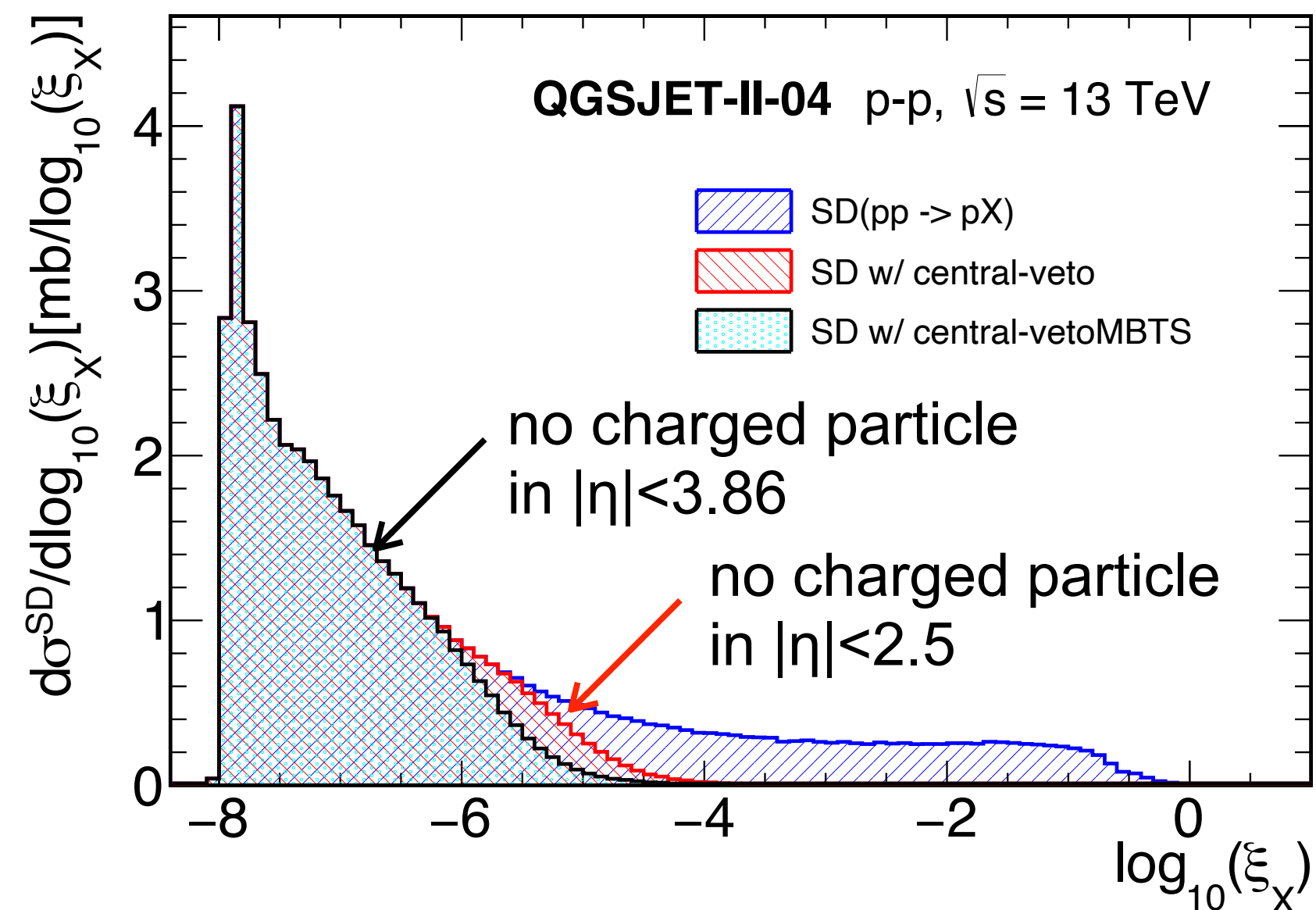
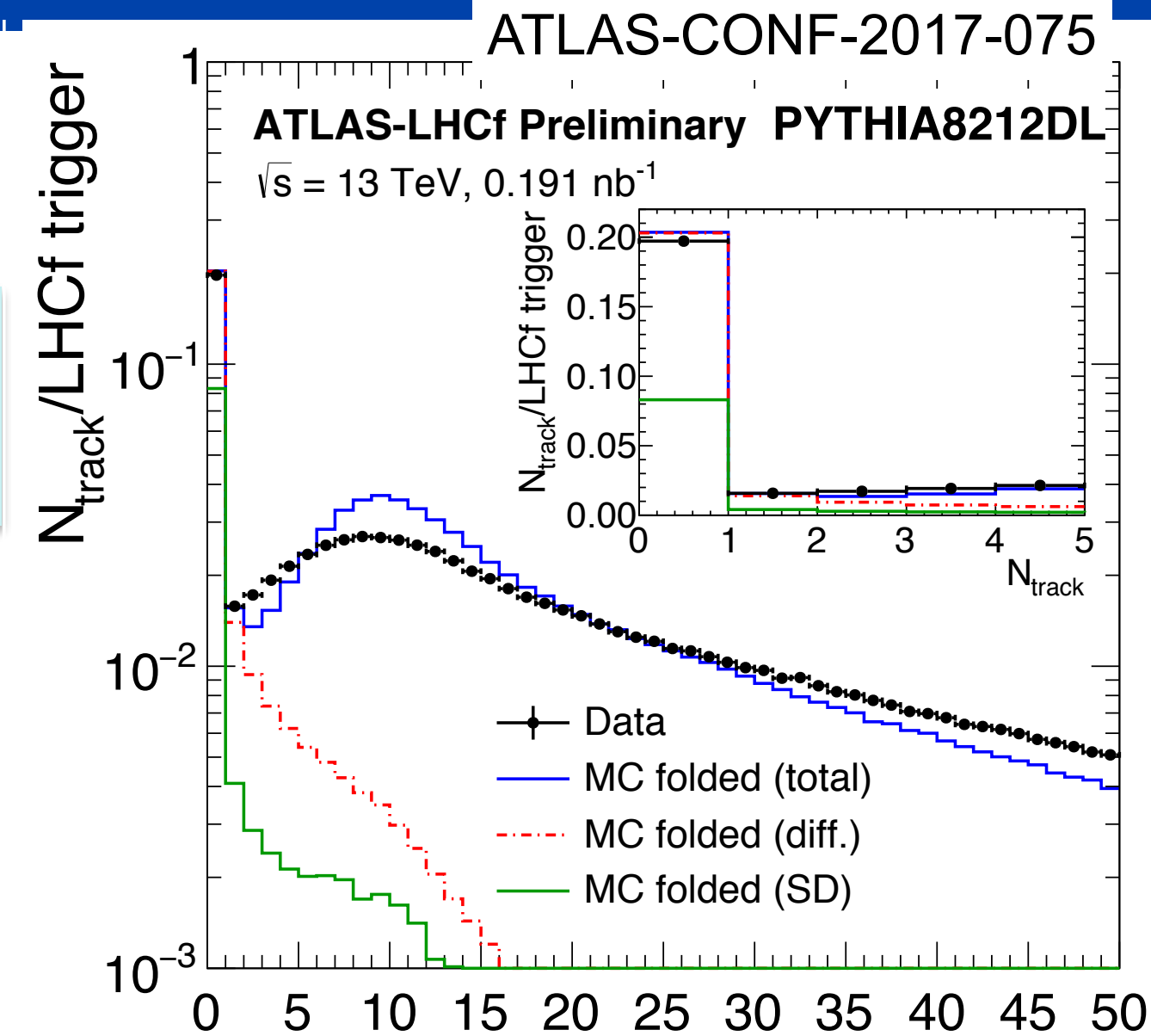
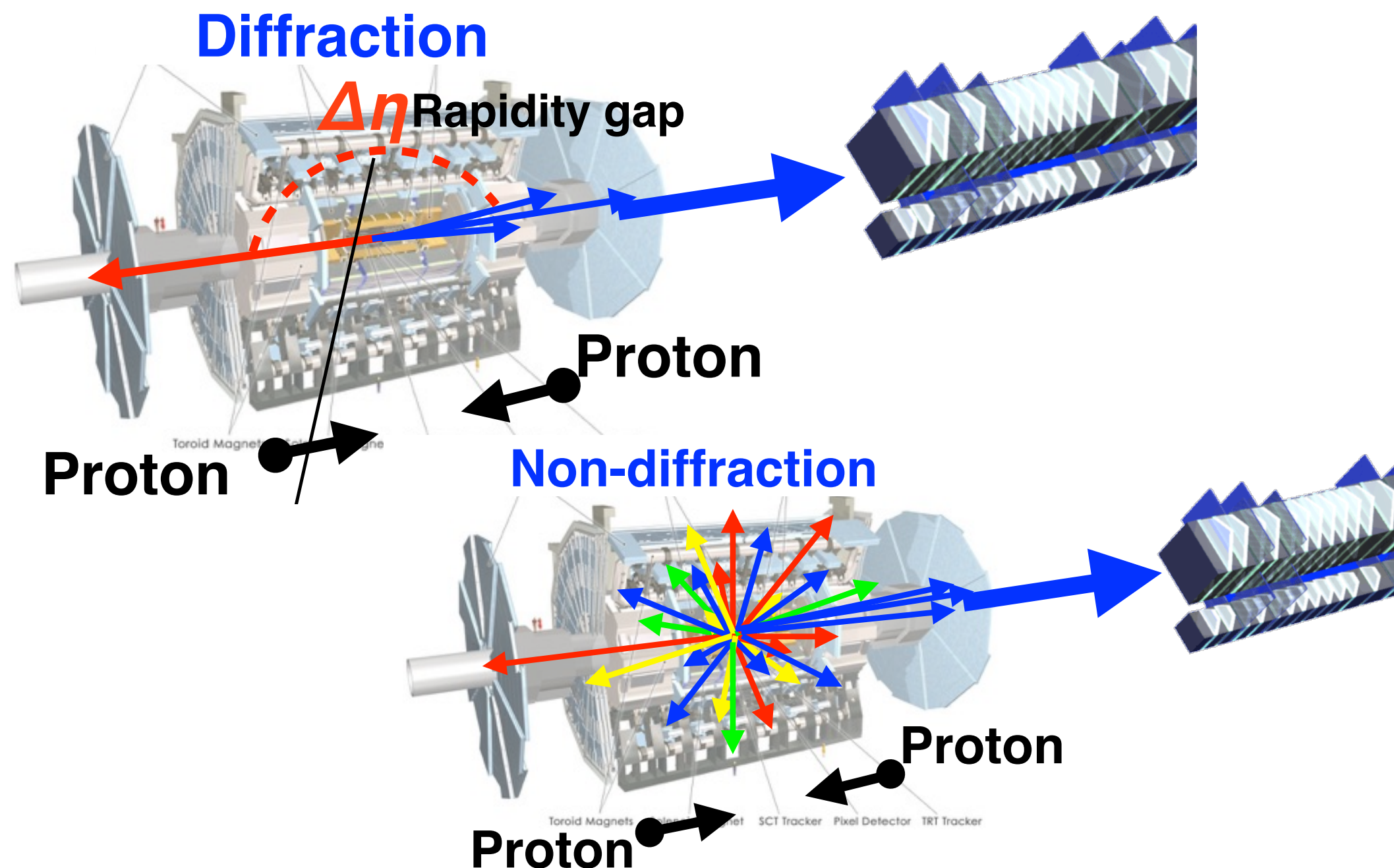
Method

- Event selection by $N_{\text{tracks}}=0 \iff$ Large rapidity gap $\Delta\eta > 5$

N_{tracks} : the number of tracks detected

by ATLAS inner trackers ($|\eta| < 2.5$, $p_T > 100$ MeV)

- Selecting pure samples of proton dissociations.
- Sensitive to only low-mass dissociations $M_X \lesssim 50$ GeV

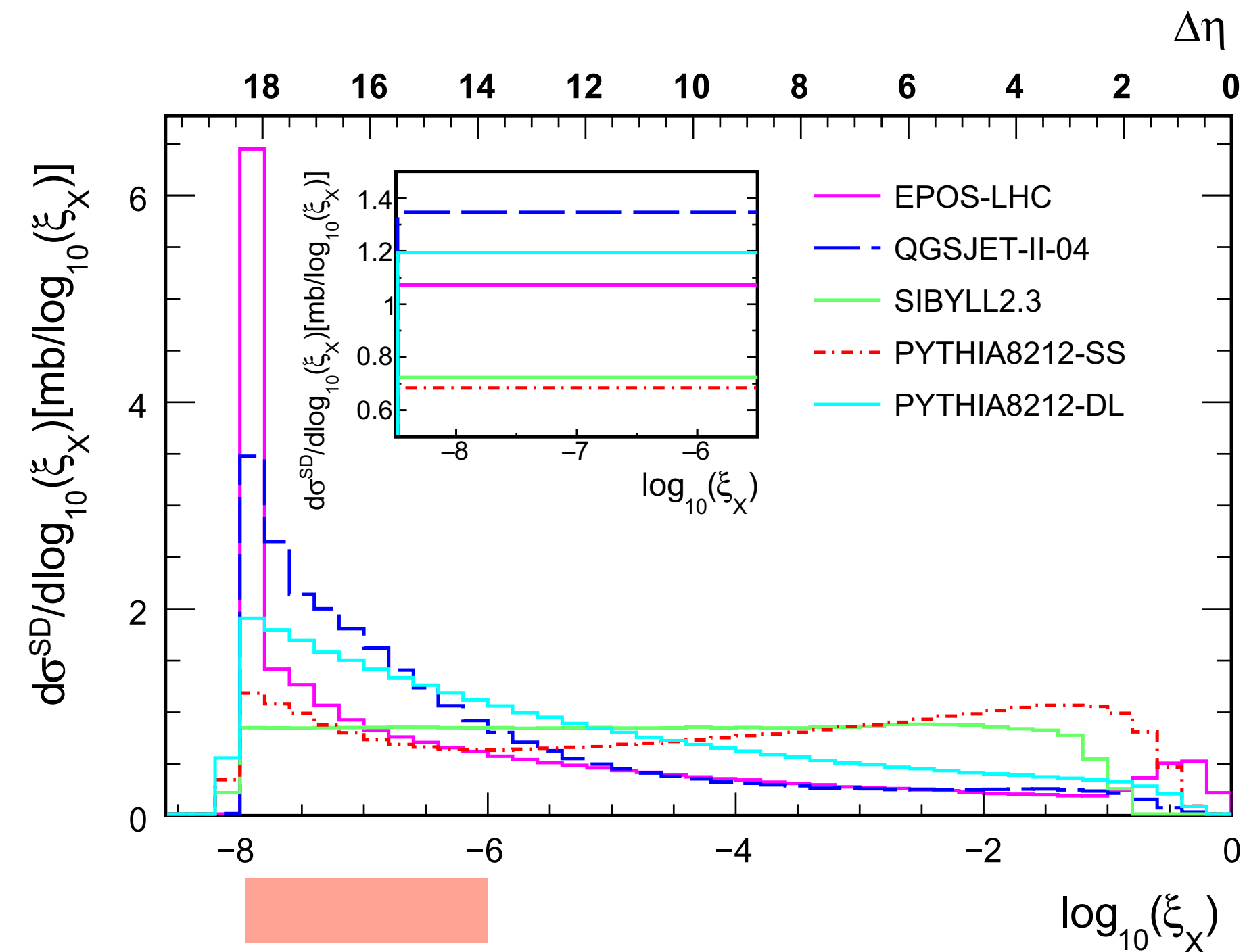
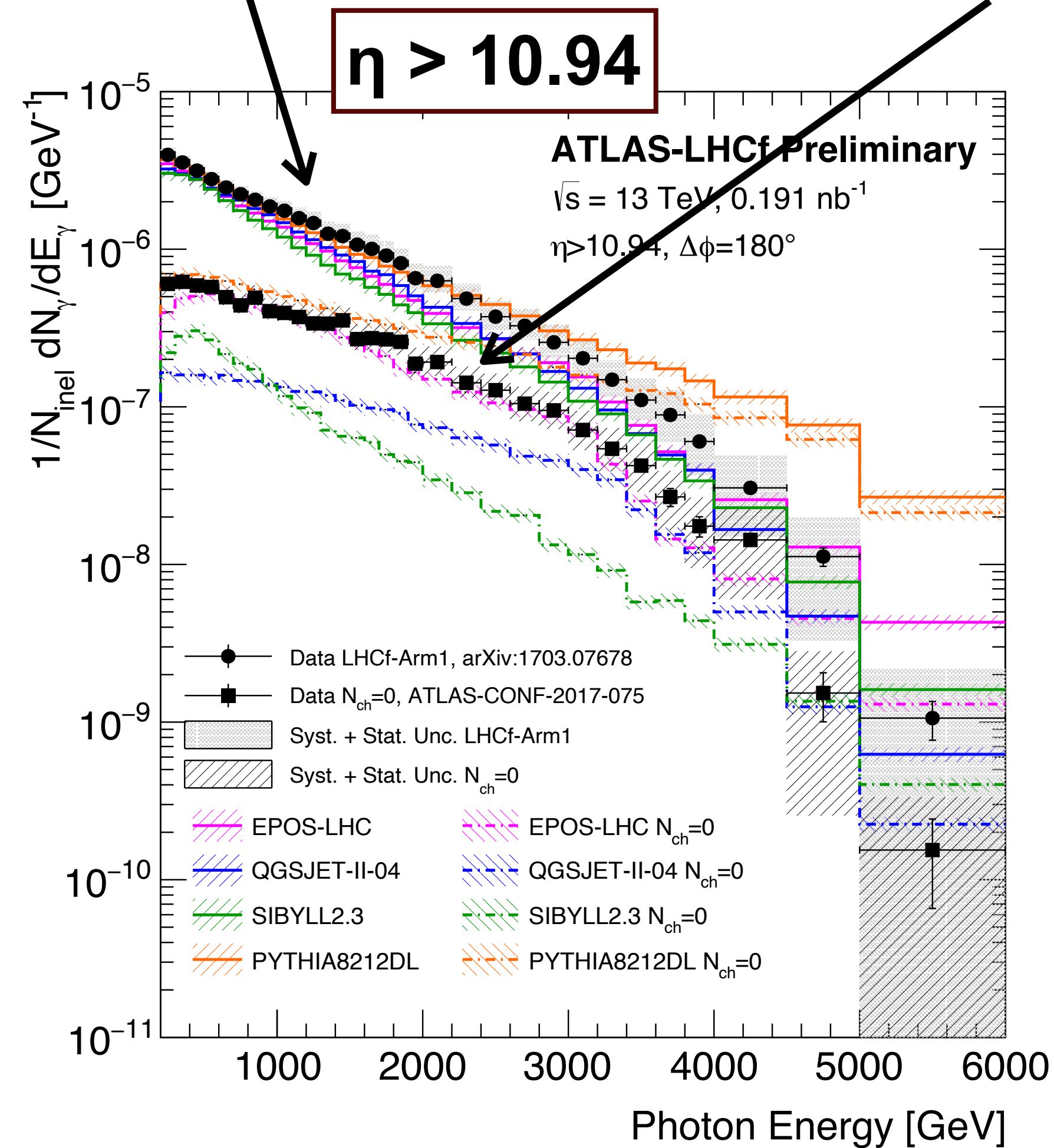


Preliminary result

Preliminary result of the measurement for forward photons is published
in a conference-note; ATLAS-CONF-2017-075

Inclusive photon spectra

Photon spectra w/ $N_{\text{ch}} = 0$ selection



Joint operation with RPs

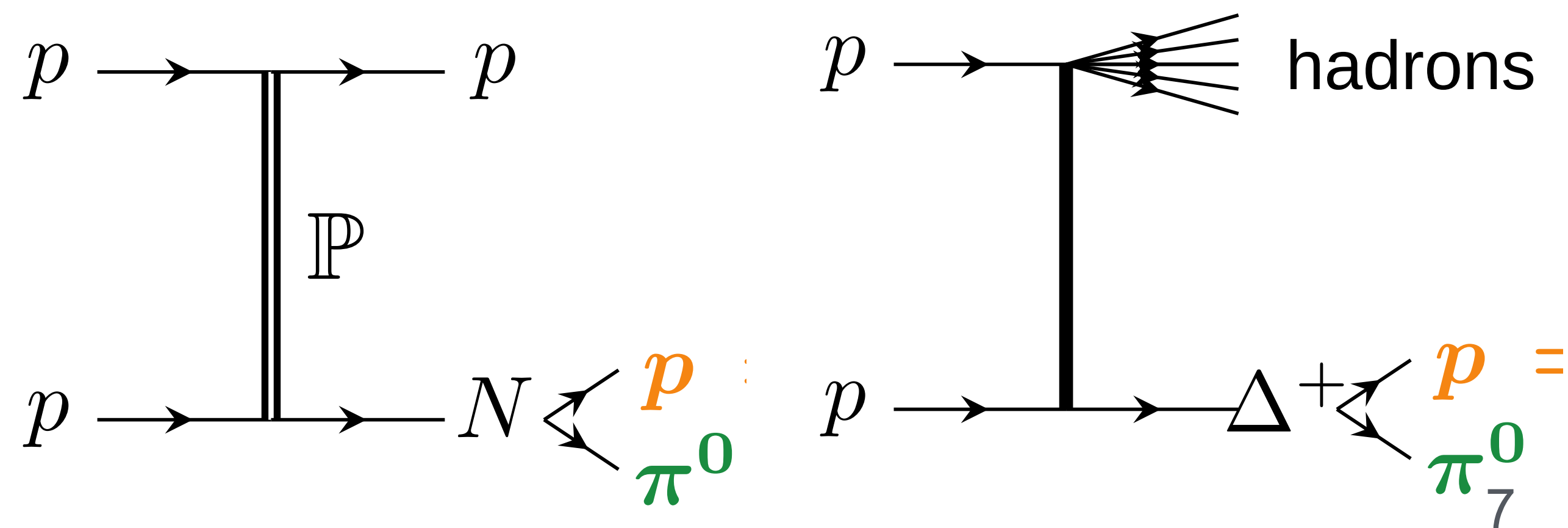
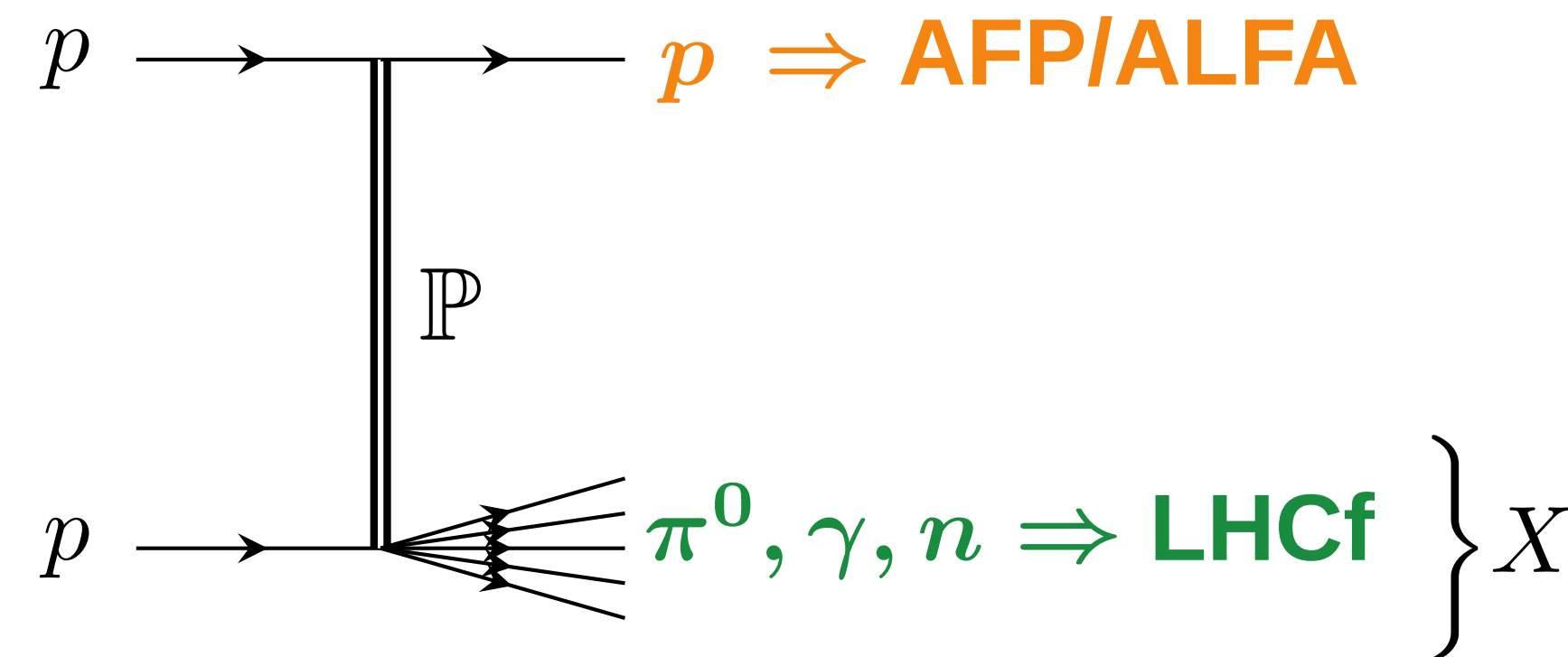
■ Physics cases

□ Single diffractive measurement

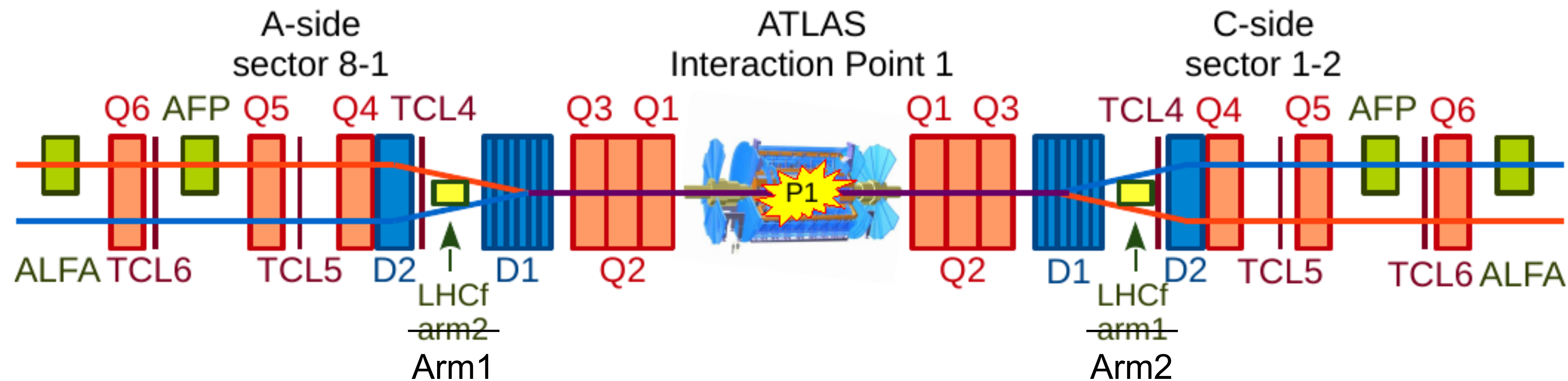
- Measuring the scattered proton, the diffractive mass can be estimated event-by-event.
- Can address the hadron production from a specific mass decay.
cross-section = (diffractive mass spectrum) x (hadron production)

□ Resonance measurement : $N(1440)$ and $\Delta(1232)$

- N : probe the very low mass diffractive process.



ATLAS AFP and ALFA

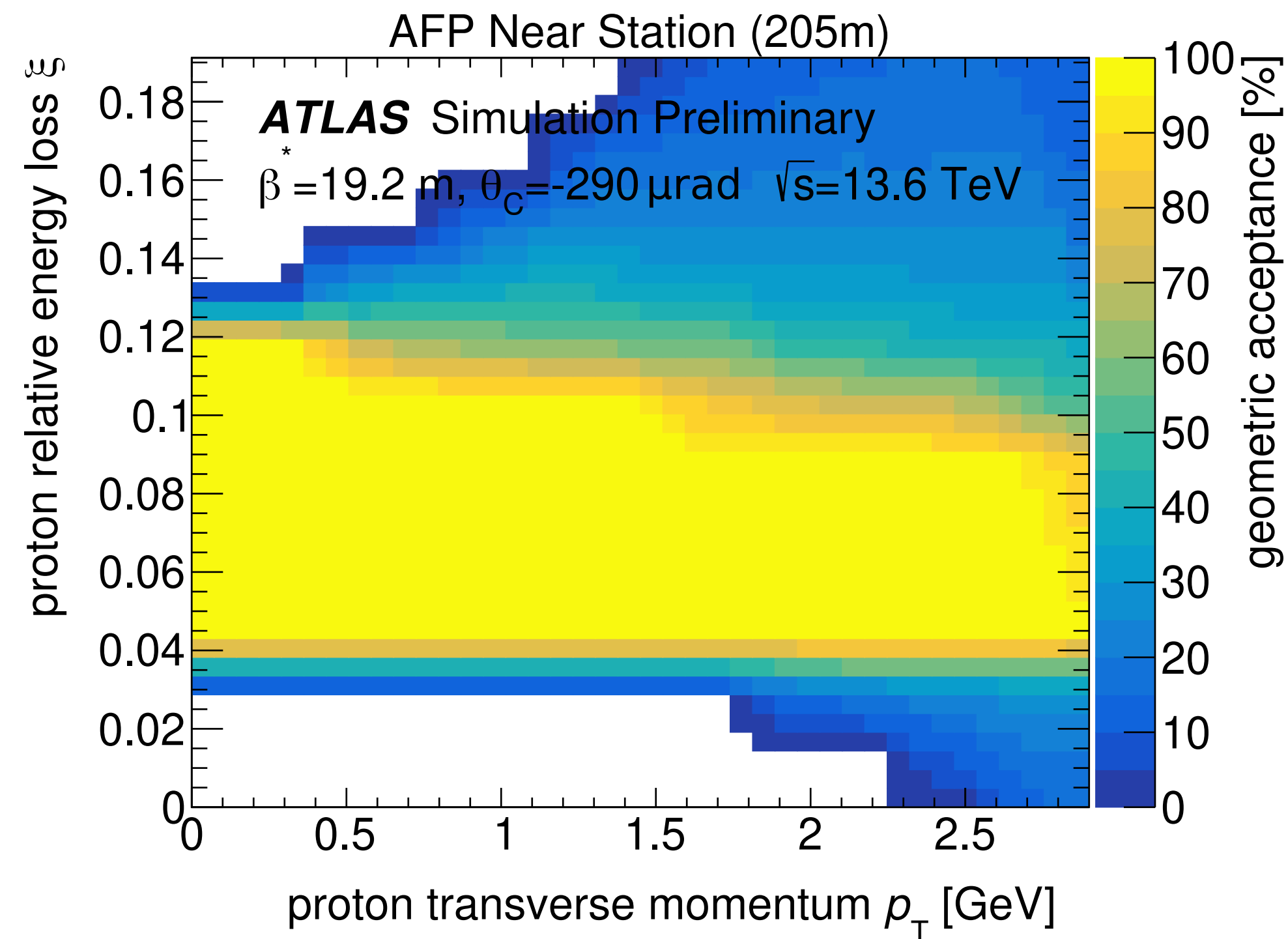


- ALFA : optimized for high- β^* operation
 - AFP : designed for operation in nominal pp runs
 - Both the detectors were operated during the 2022 operation
- Feasibility study of LHCf + ATLAS RPs was done by an ATLAS PhD. student.

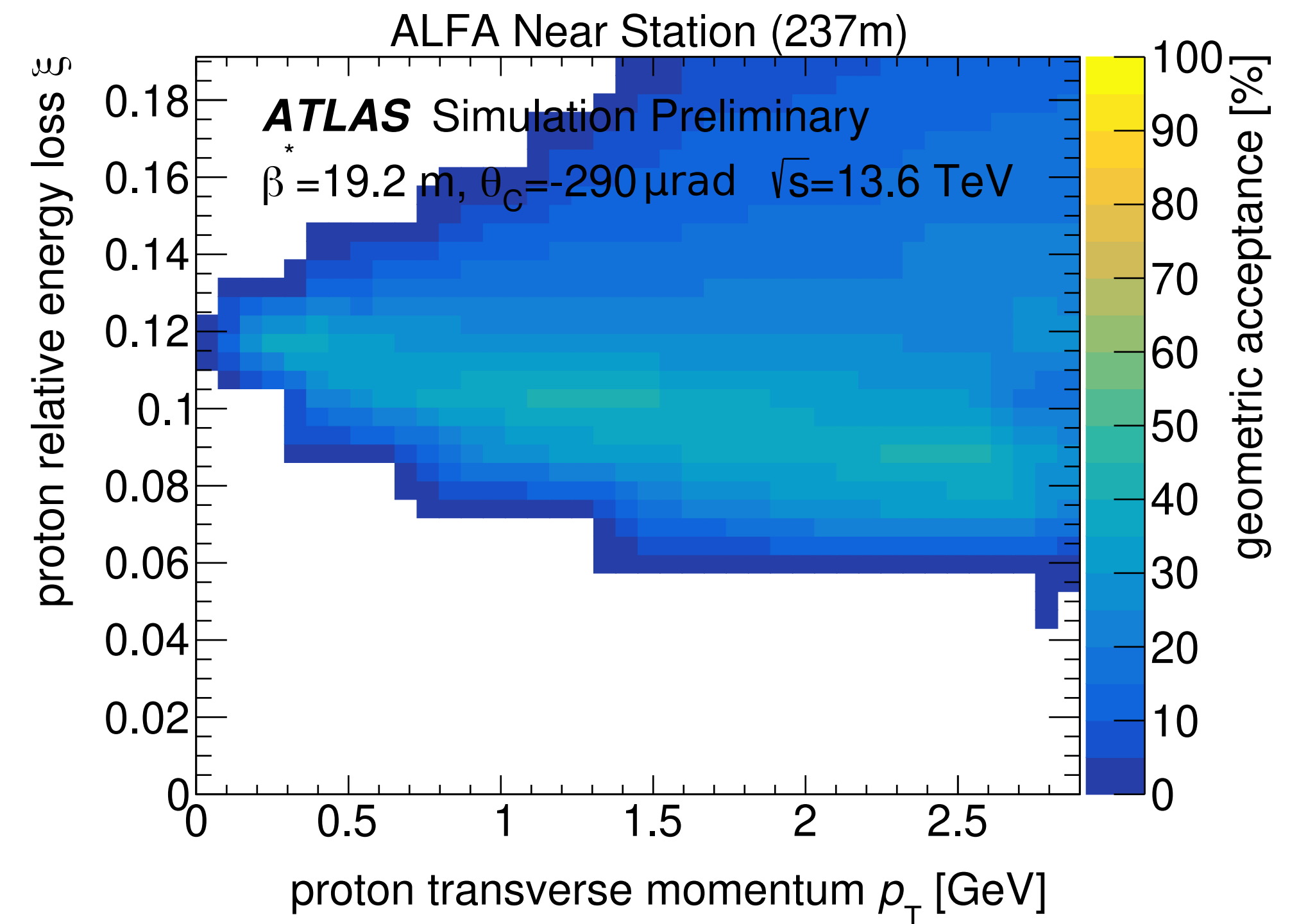
Acceptance of RPs

- Study the acceptance for protons using the MC simulation

AFP near station: 5.2 mm \rightarrow 6.5 mm



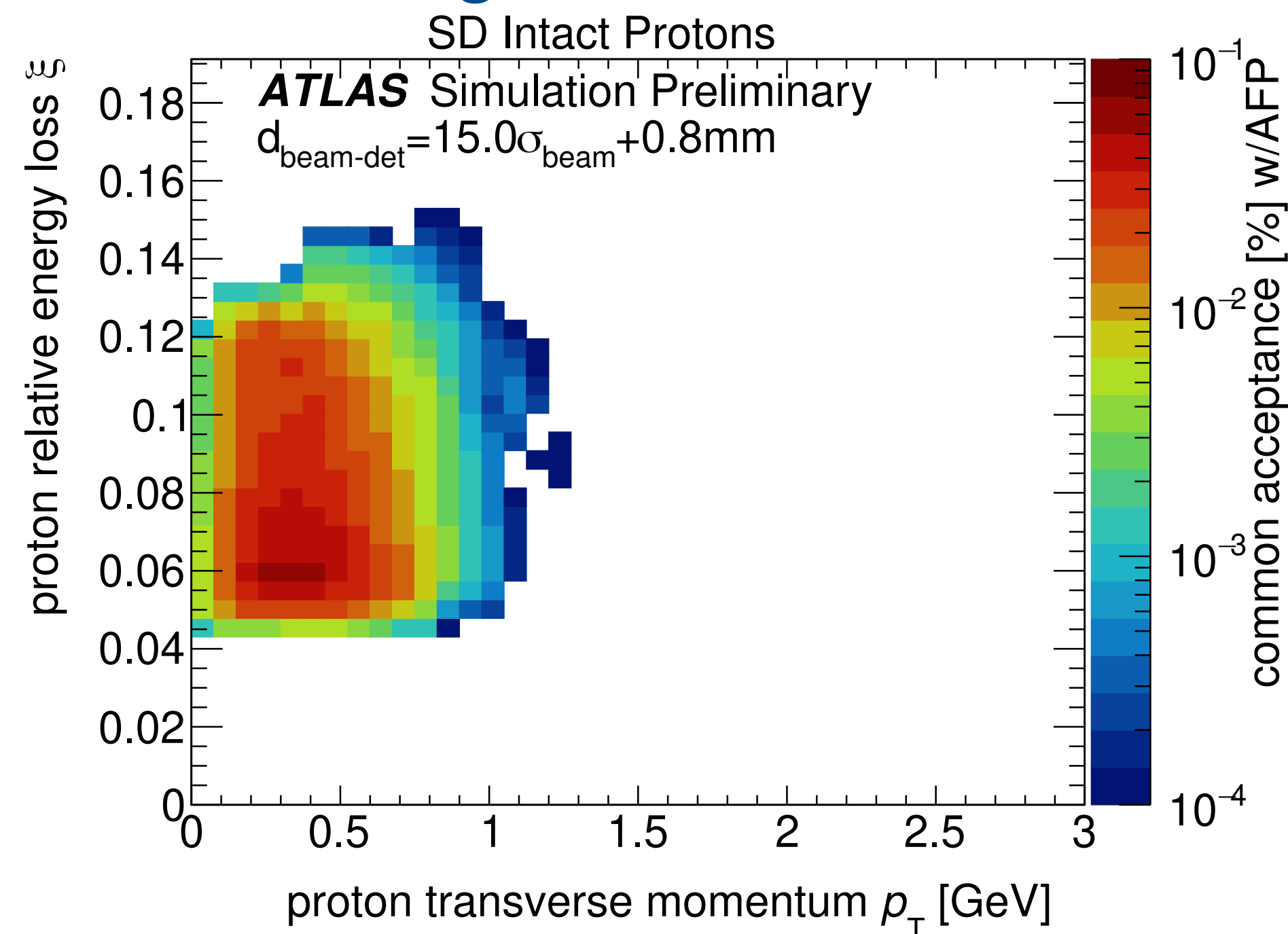
ALFA near station: 3.9 mm \rightarrow 6.1 mm



Acceptance for single-diffractive process

LHCf+AFP

Single diffraction



scattered proton in AFP

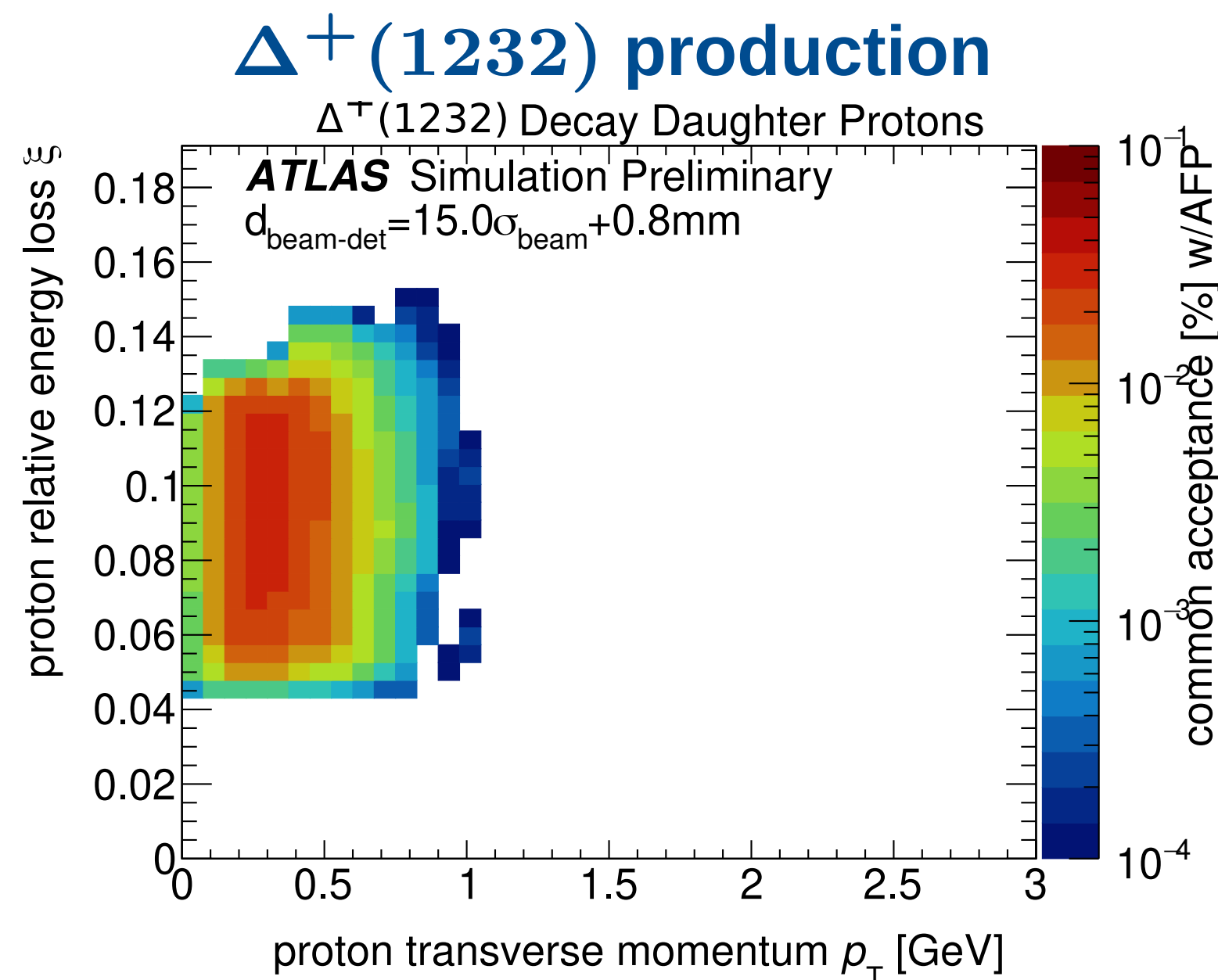
+

Any particle with > 200 GeV in LHCf

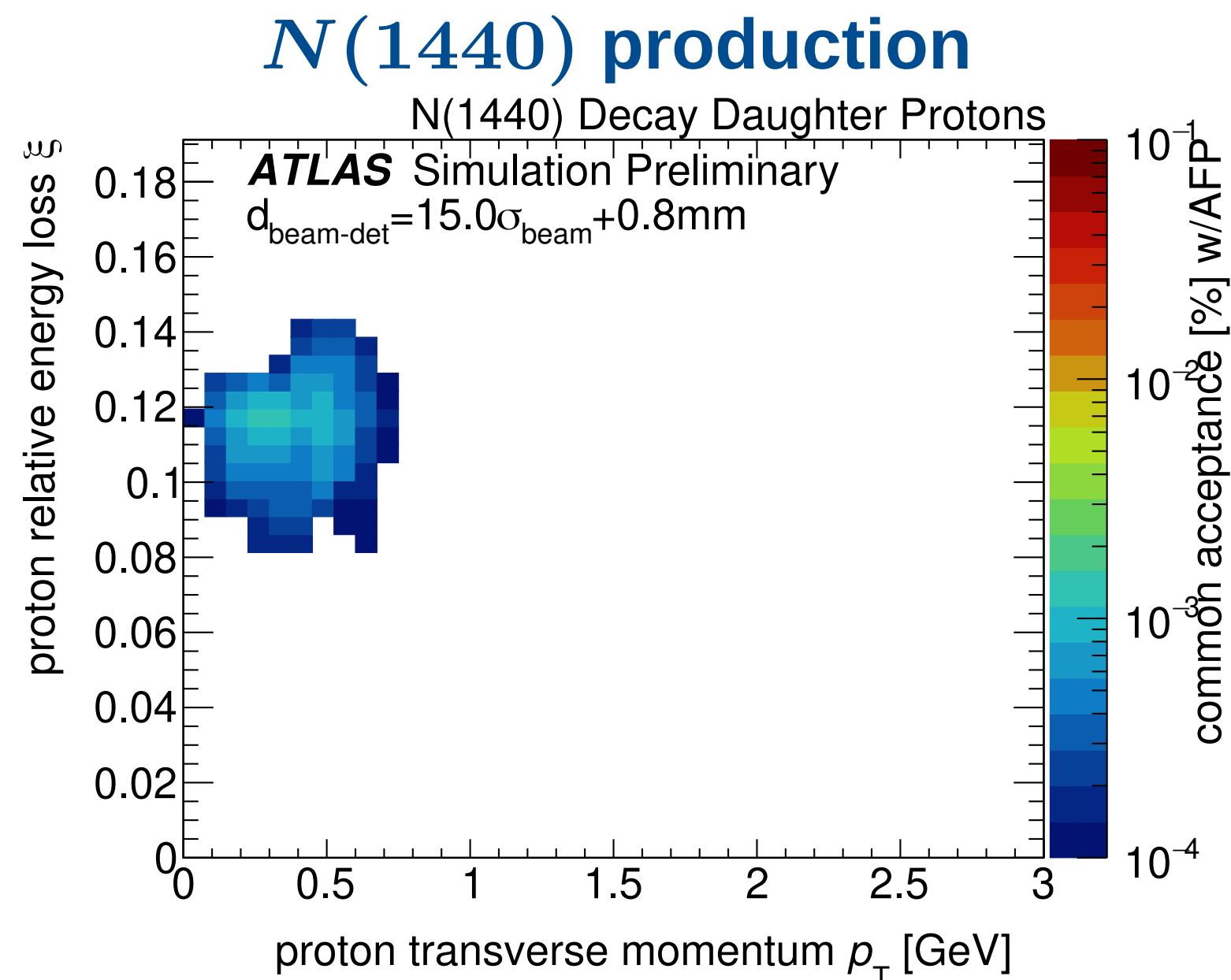
Large statistics events can be expected

event rate [Hz]	# events (2 d)
46.5 ± 1.3	8.0 ± 0.3 million

Acceptance for N and Δ resonances



event rate [mHz]	# events (2 d)
17.7 ± 0.6	3050 ± 100



event rate [mHz]	# events (2 d)
13.6 ± 1.3	2350 ± 220

scattered proton in AFP
 +
 pi0 in LHCf

These event numbers are
 estimated assuming
 100% DAQ efficiency

→ Statistics may be limited
 In addition, the combinatorial
 background may be a problem
 for this analysis.

Physics case with ZDC

- Improvement of energy resolution for neutrons to 20%
 - \leftrightarrow LHCf/RHICf alone : $\sim 40\%$, ($\sim 30\%$ with event selection)
 - General improvement of neutron diff. cross-section measurements
- Measurement of Λ
 - Λ can be a good probe of strange baryon production
 - Detection : $\Lambda \rightarrow n + \pi^0$
- One-Pion-Exchange measurement to study the p - π interaction

