UNIVERSITY OF BIRMINGHAM

Single diffraction cross-section measurement with ATLAS in p-p collisions at $\sqrt{s}$ = 8 & 13 TeV

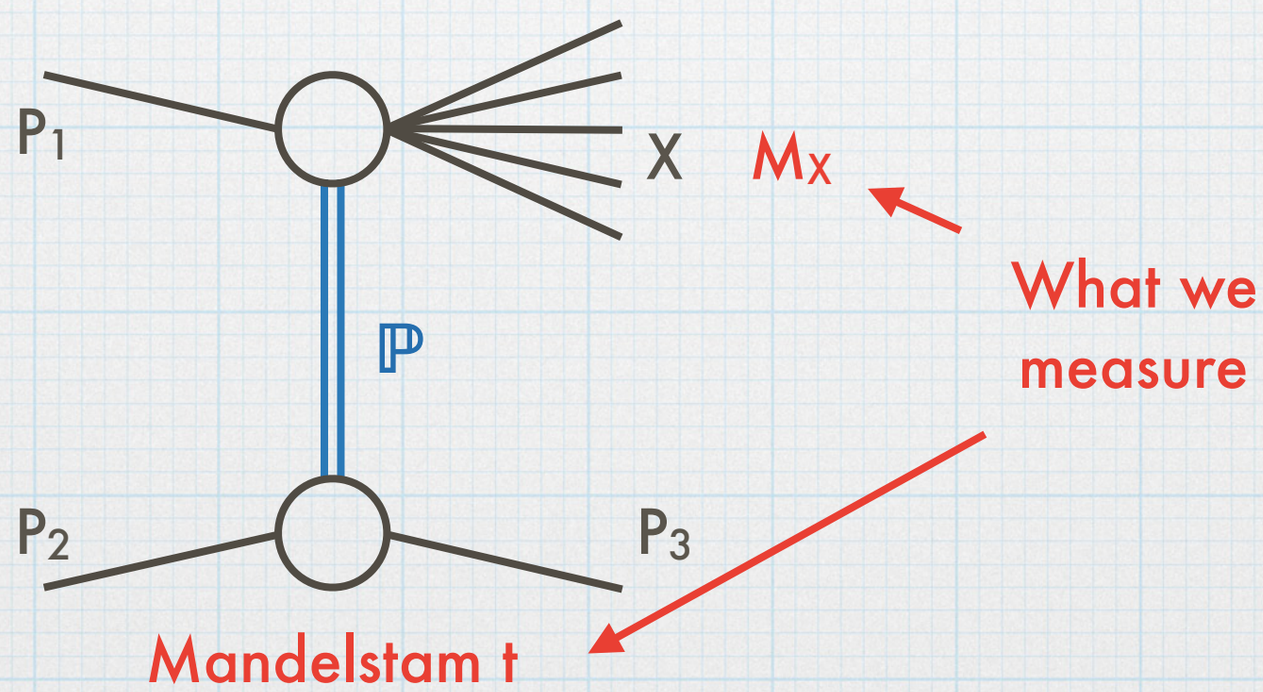
James Kendrick

J Kendrick - University of Birmingham

J.Kendrick@CERN.ch

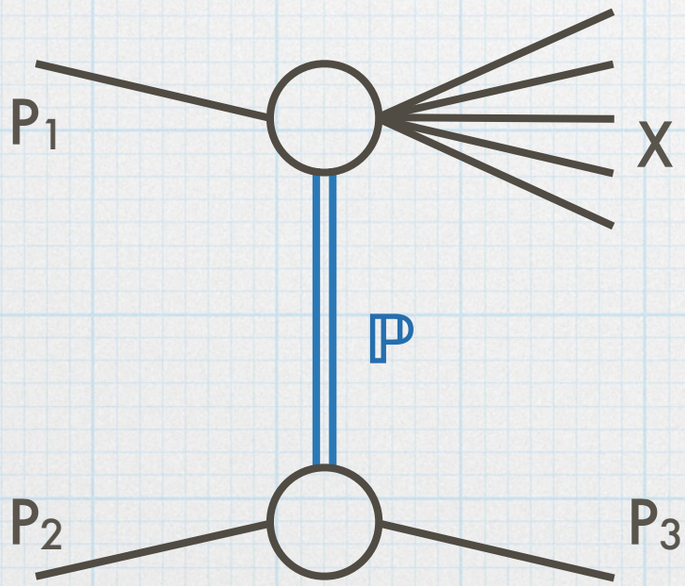
Single diffraction

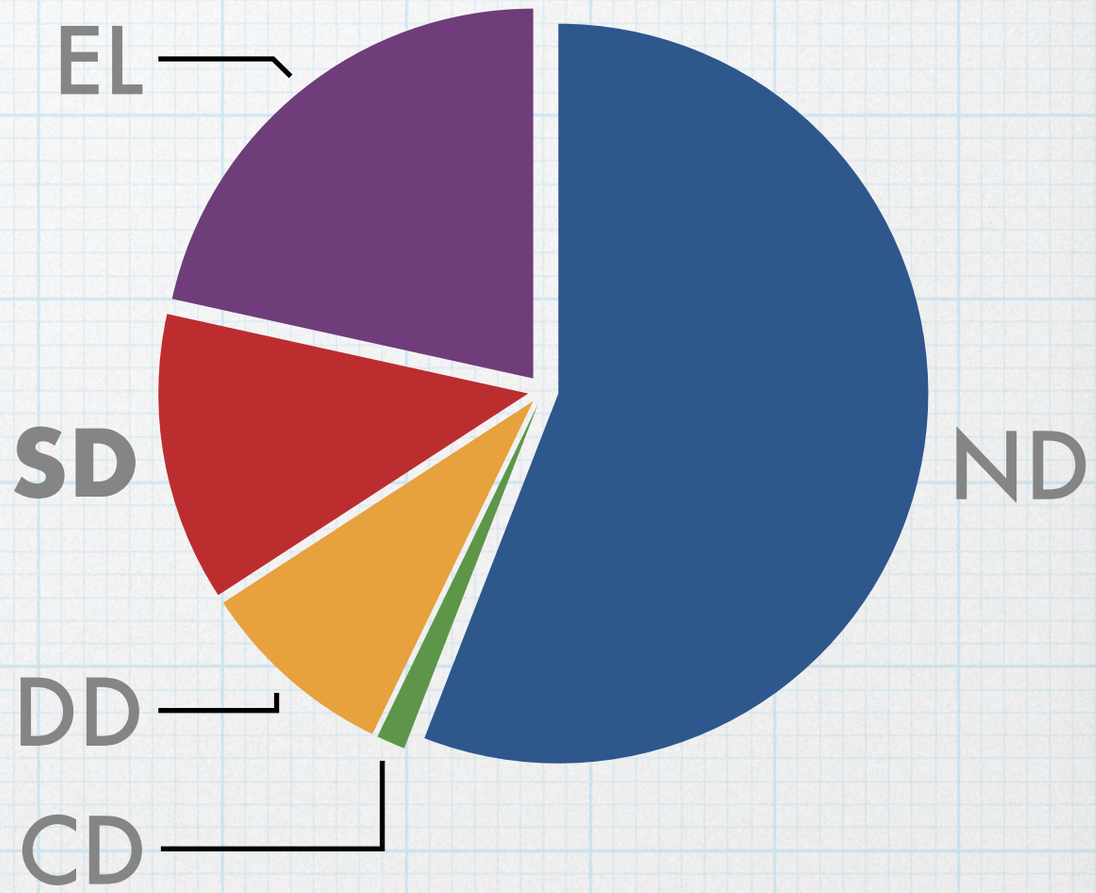
- Small 4-momentum transfer with no quantum numbers exchanged between the protons
- 1 proton remains intact, 1 dissociates into a diffractive X system
- Characteristics of an SD event:
  - 1 intact proton at very large rapidity
  - Large gap in rapidity space between proton and edge of diffractive system



Single diffraction

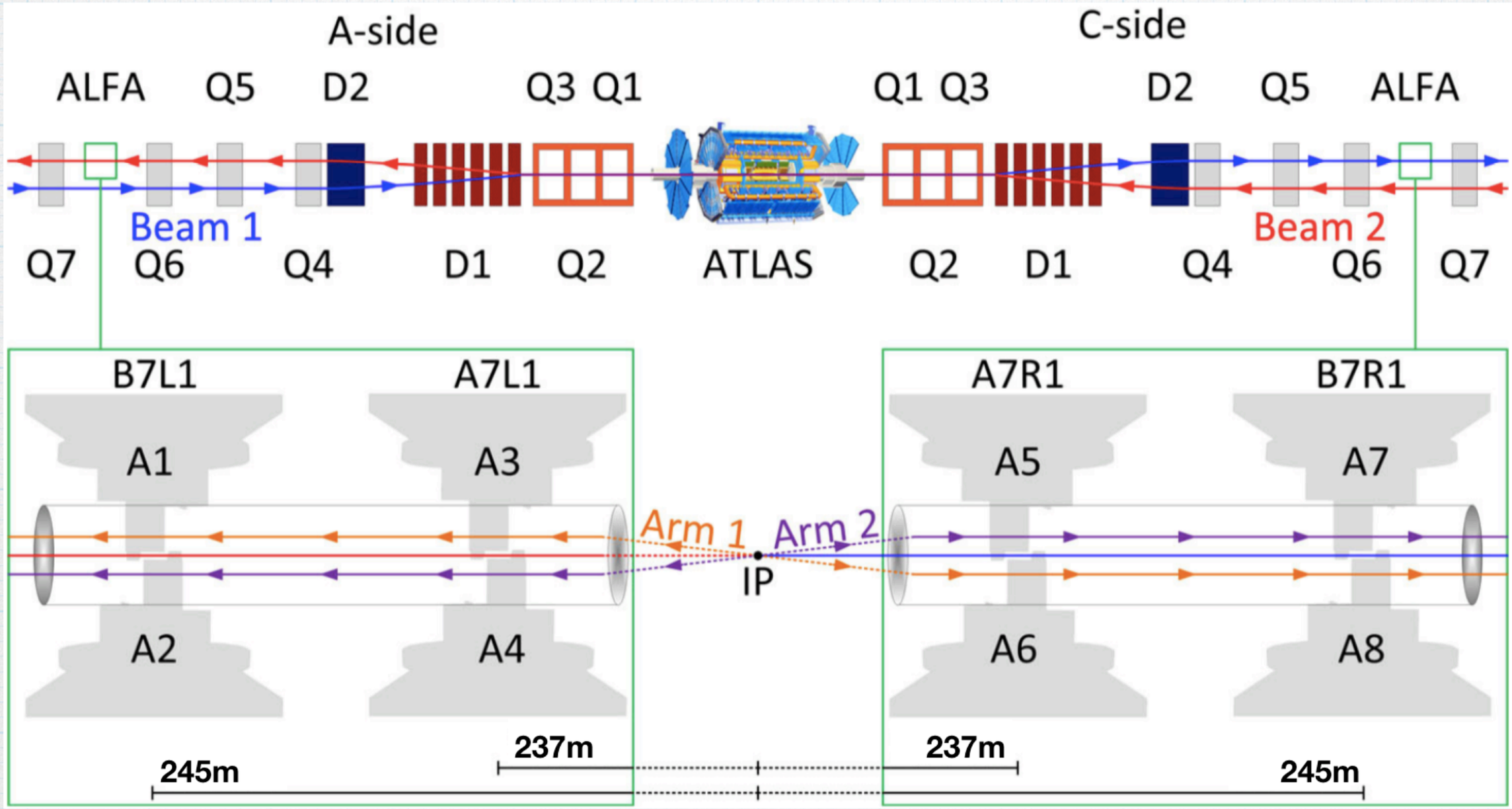
- SD accounts for ~10% of total p-p cross-section
- Poorly understood
- Intact protons can be tagged & measured
- No published LHC measurements using proton tagging





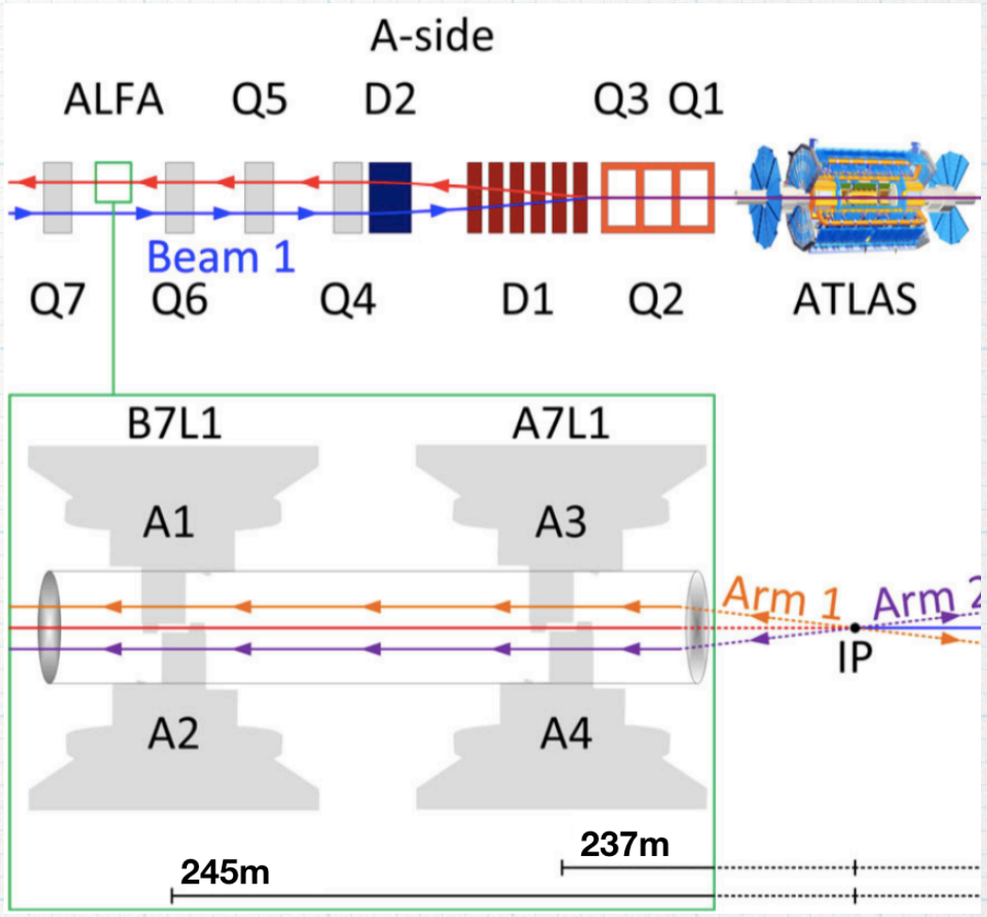
*Plot constructed using default σ from Pythia8 for √s = 13 TeV

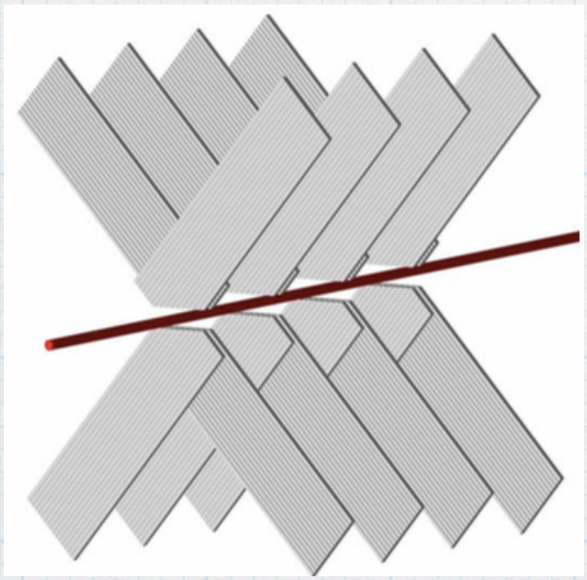
ALFA spectrometer

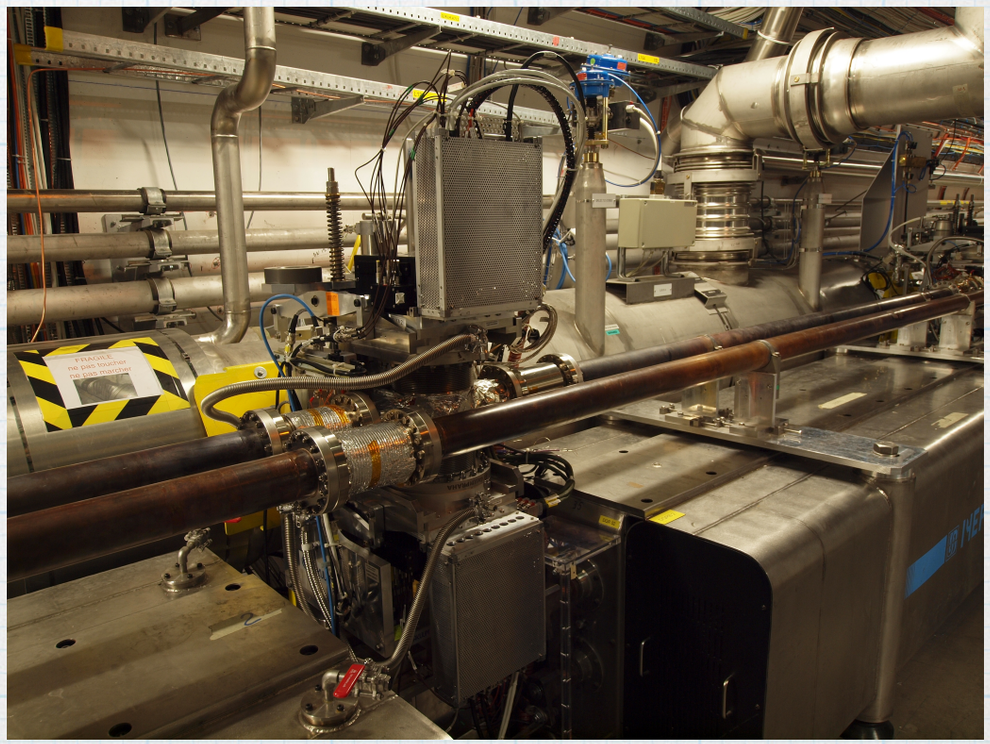


ALFA spectrometer

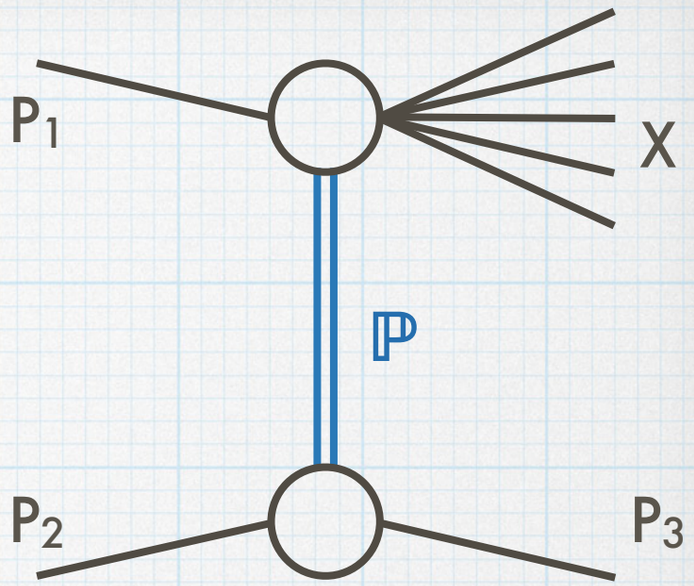
- Requires low pile-up, high β* LHC runs
- Above & below outgoing beams
- ±237m & ±245m away from IP
- Inserted following stable beams
- Used to identify the outgoing diffractive proton, ~10μrad away from ‘normal’
- Can reconstruct proton kinematics with the effect of magnets taken into account







SD differential variables



- Fractional energy loss of proton, ξ, measure as:
  - ξ_{ALFA} - Reconstruct proton kinematics from ALFA tracks
  - ξ_{EPz} - Measure invariant mass of X system with ATLAS inner detector and calorimeter

$$\xi = 1 - \frac{E_3}{E_2}$$

$$\xi_{Epz} = \frac{M_X^2}{s} \approx \frac{\Sigma_i (E^i \pm p_z^i)}{\sqrt{s}}$$

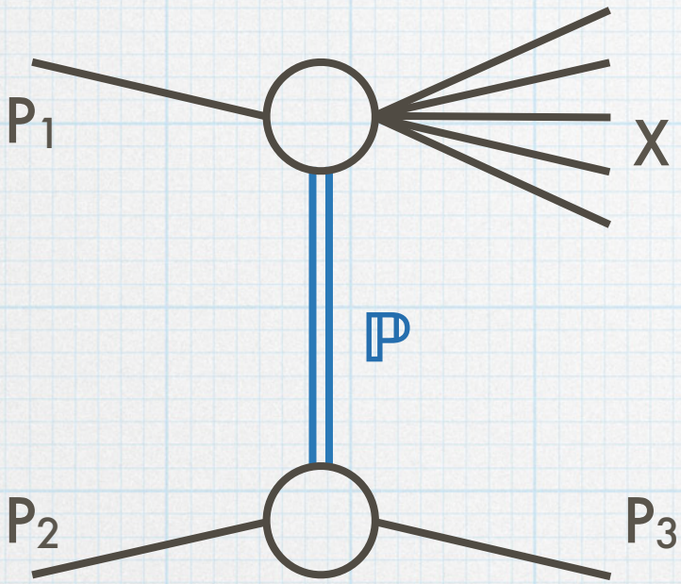
- Gap in rapidity space, Δη:
  - Measured with respect to ID / calorimeter edge on side of ALFA proton

- t channel exchange, measure by:
  - Reconstruct proton's P_T from ALFA tracks

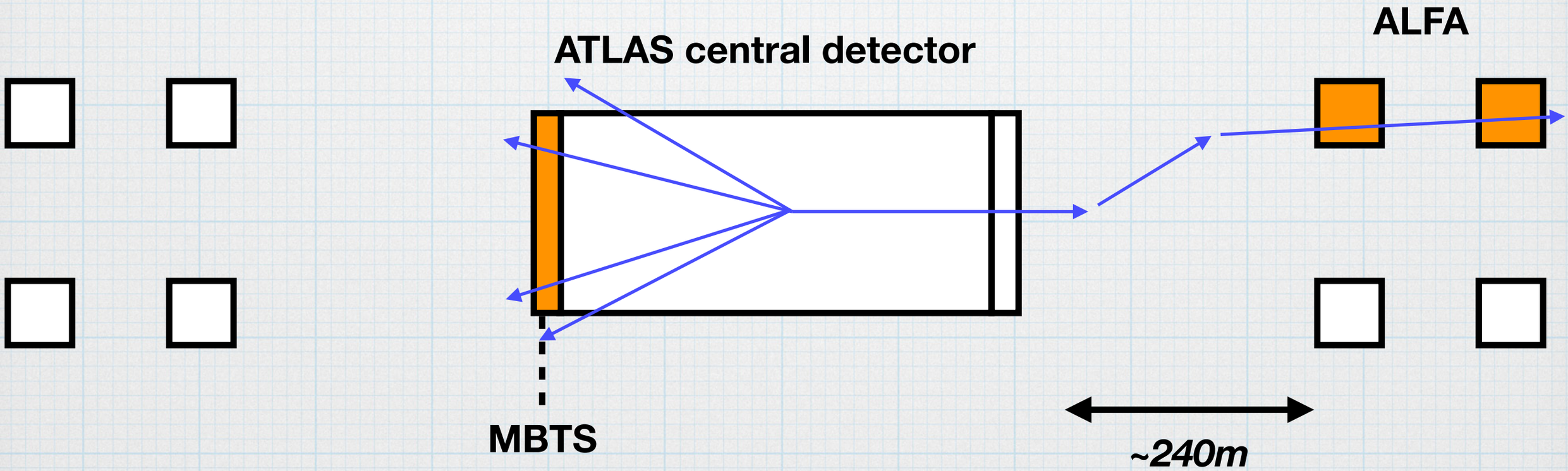
$$t = (p_3 - p_2)^2$$

$$t \approx -P_T^2$$

Event selection

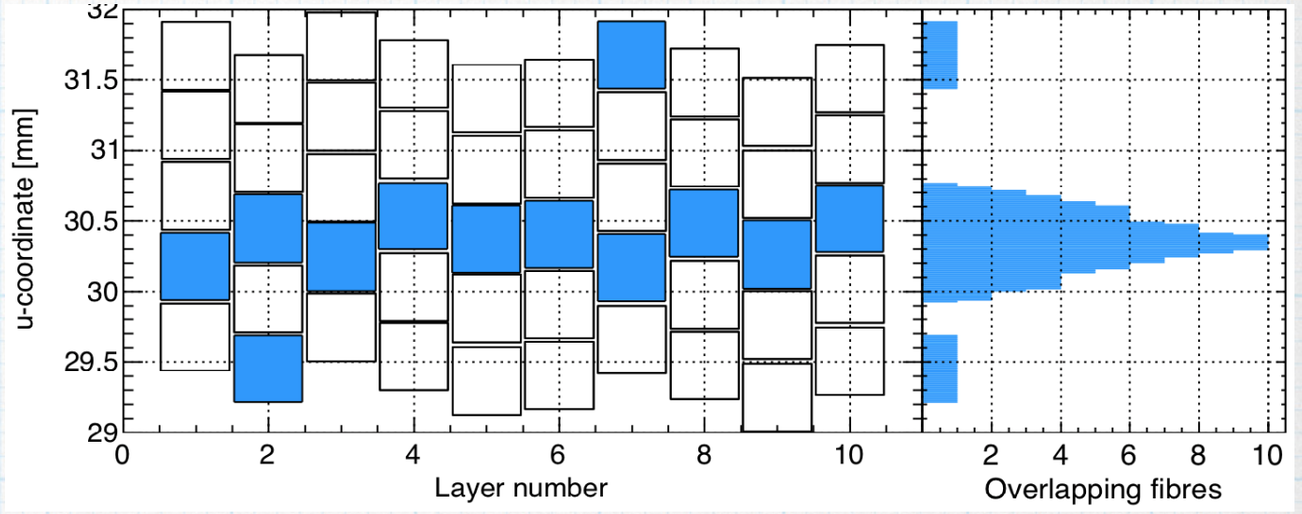


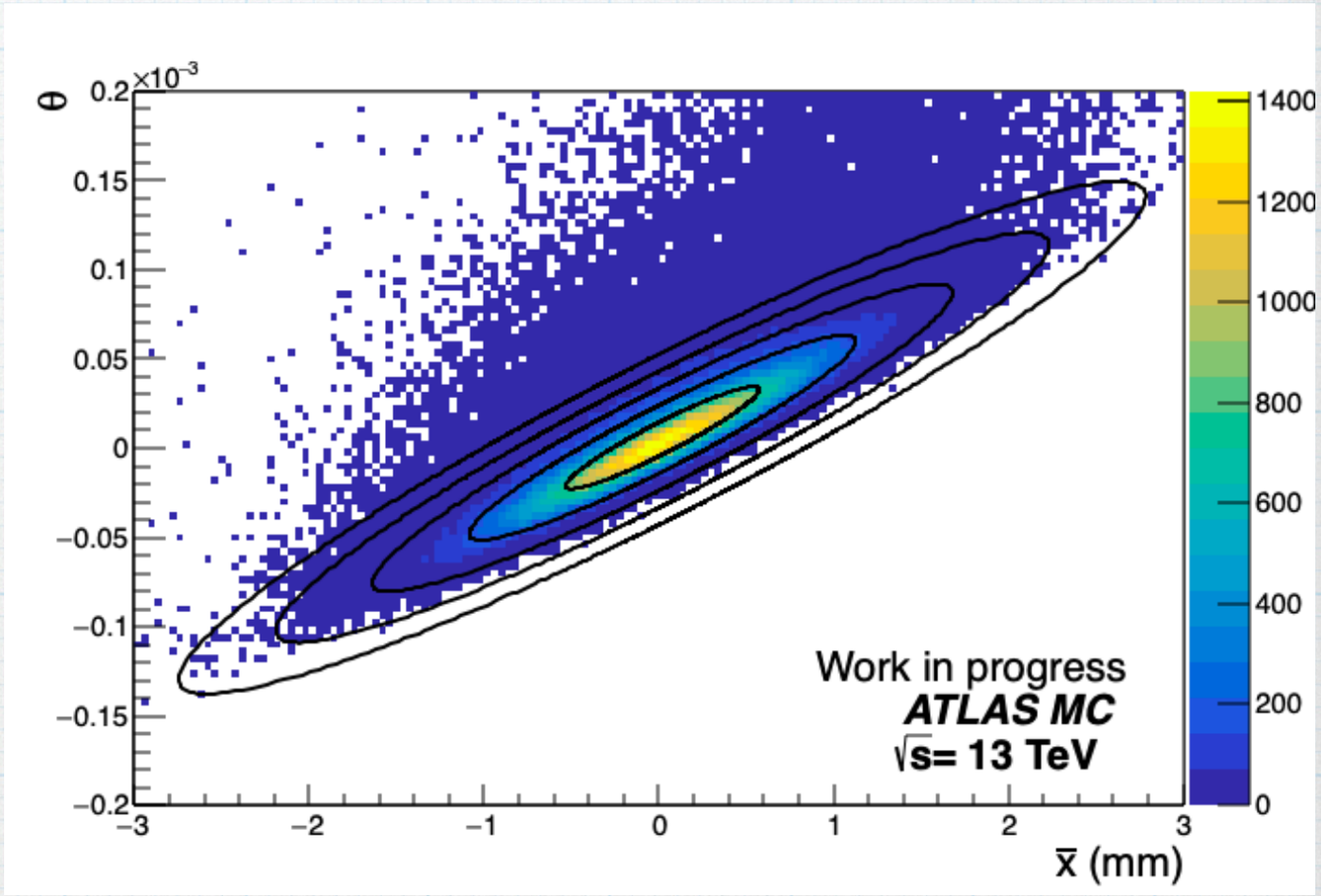
- Trigger:
  - ALFA signal from both near & far pots
  - MBTS signal on opposing side
- Offline:
  - Reconstructed primary vertex
  - MBTS signal
  - ALFA selection
  - $\log \xi_{CALO} < -0.2$ (13 TeV only)



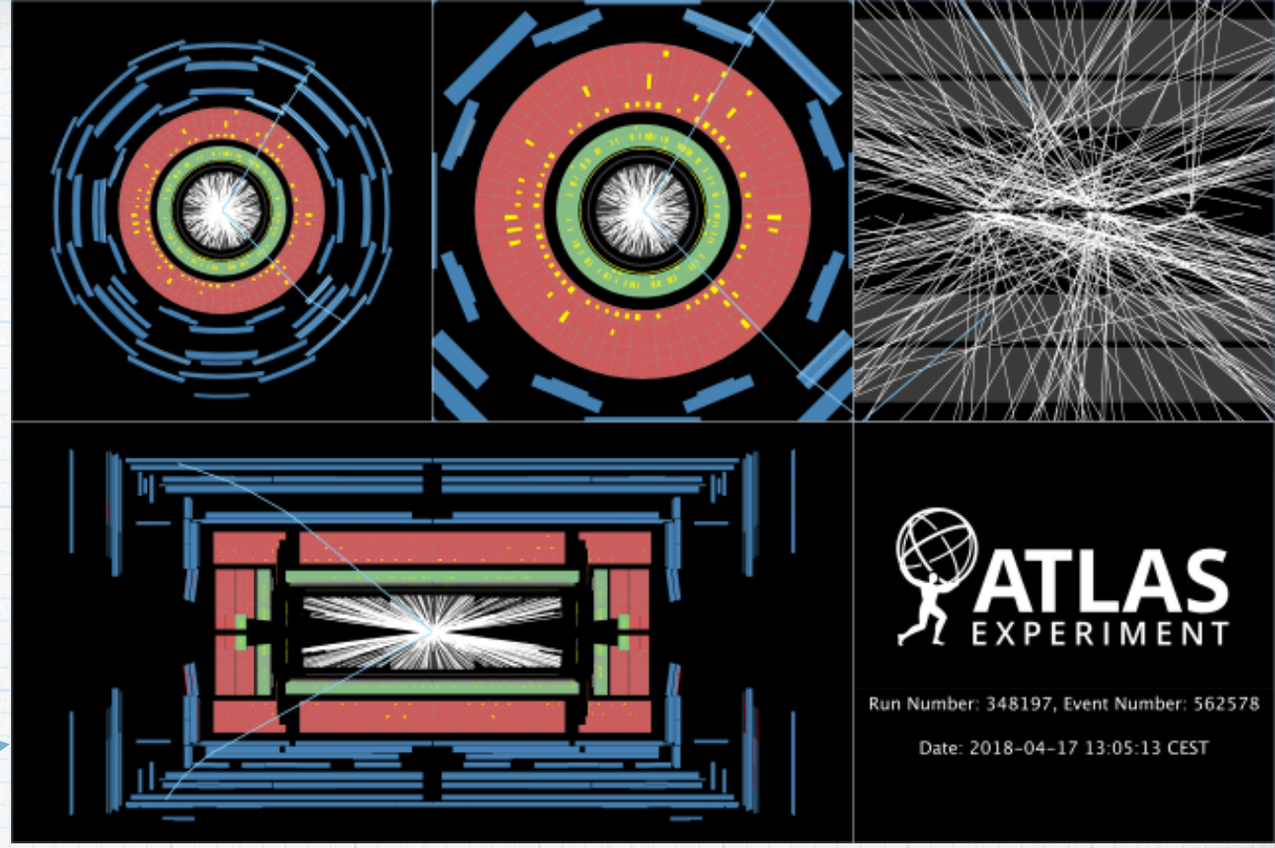
ALFA selection

- Reconstruction requires at least 6 fibres hit in each plane
- Apply additional selection based on:
  - $\bar{x}$ the average x coordinate between the two stations
  - θ the local angle in the x plane between the two station
- Plot shows the elliptical distribution expected





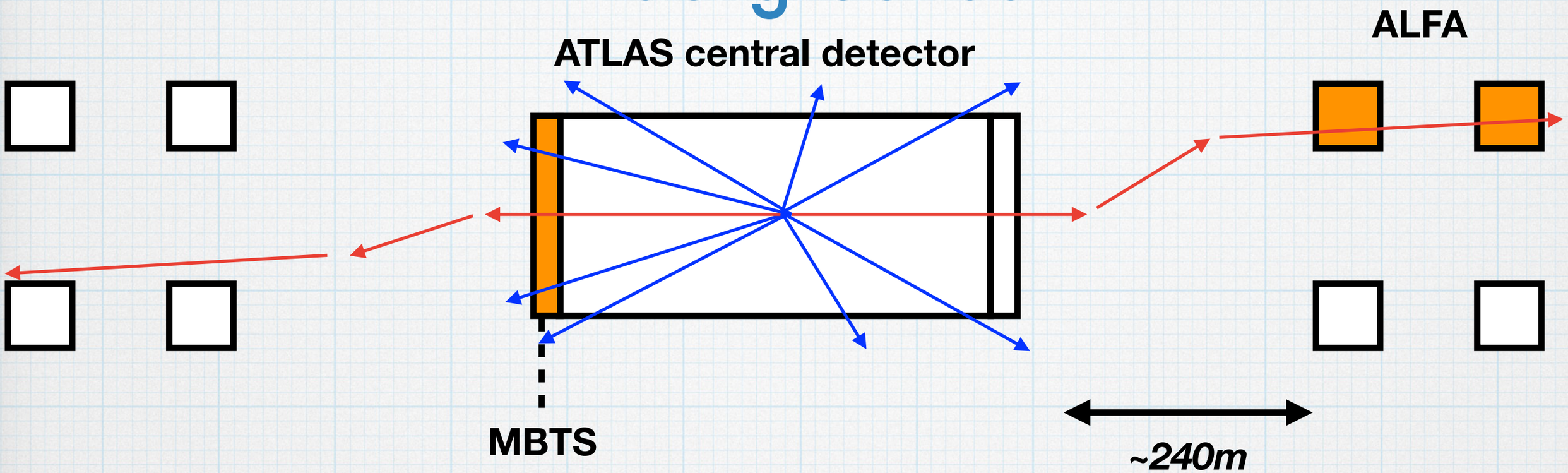
LHC conditions



- Typically for run-2:
  - High pile-up: ~50 collisions per bunch crossing
  - Low β*: 30 to 50 cm
  - Ideal for high-luminosity production

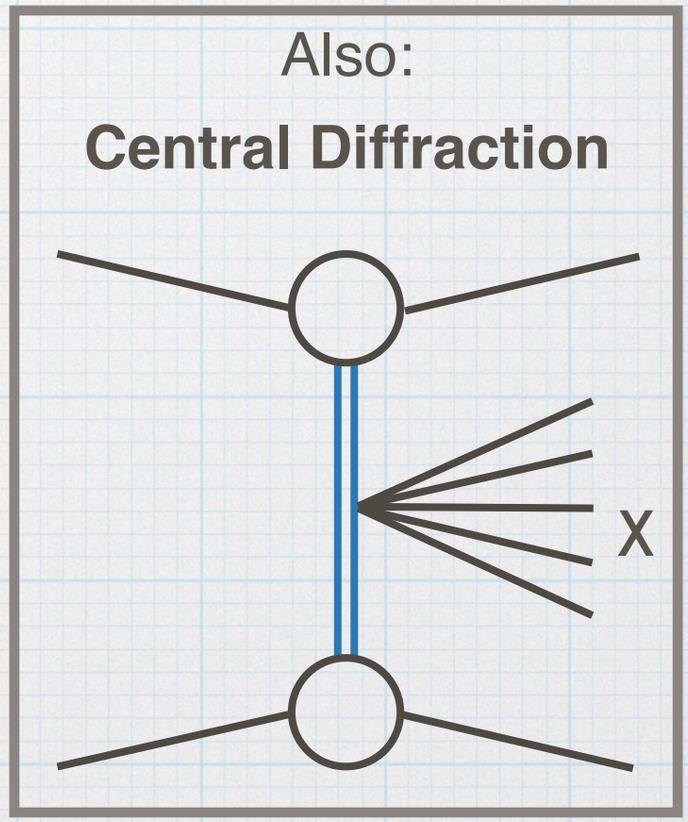
- For this data:
  - Low pile-up: ~0.1 collisions per bunch crossing
  - High β*: 90m
  - Ideal for ALFA tagging

Backgrounds



- 2 p-p interactions can result in same signal as SD
- **Elastic / beam induce background** & **non-diffractive** interactions, for example

- This is estimated by using a partially data driven technique
- Applying a non-diffractive selection to data and recording the rate in ALFA
- ALFA requirement for MC selection is then relaxed according to pile-up rate

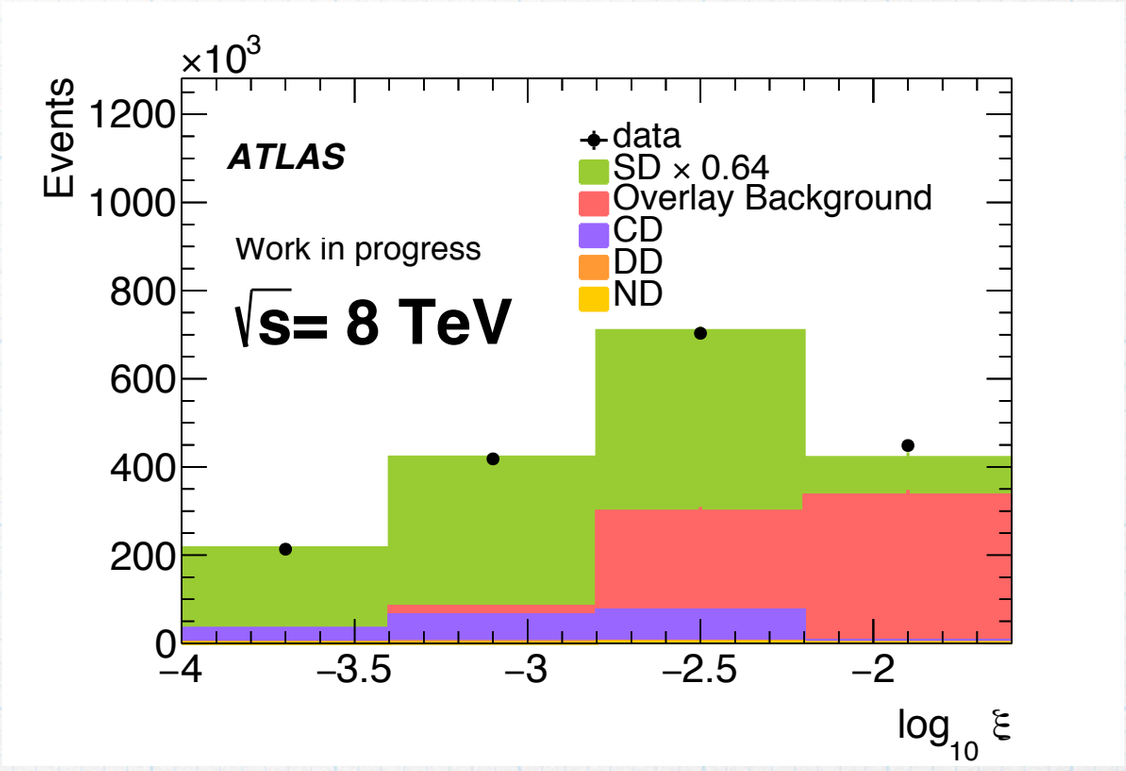


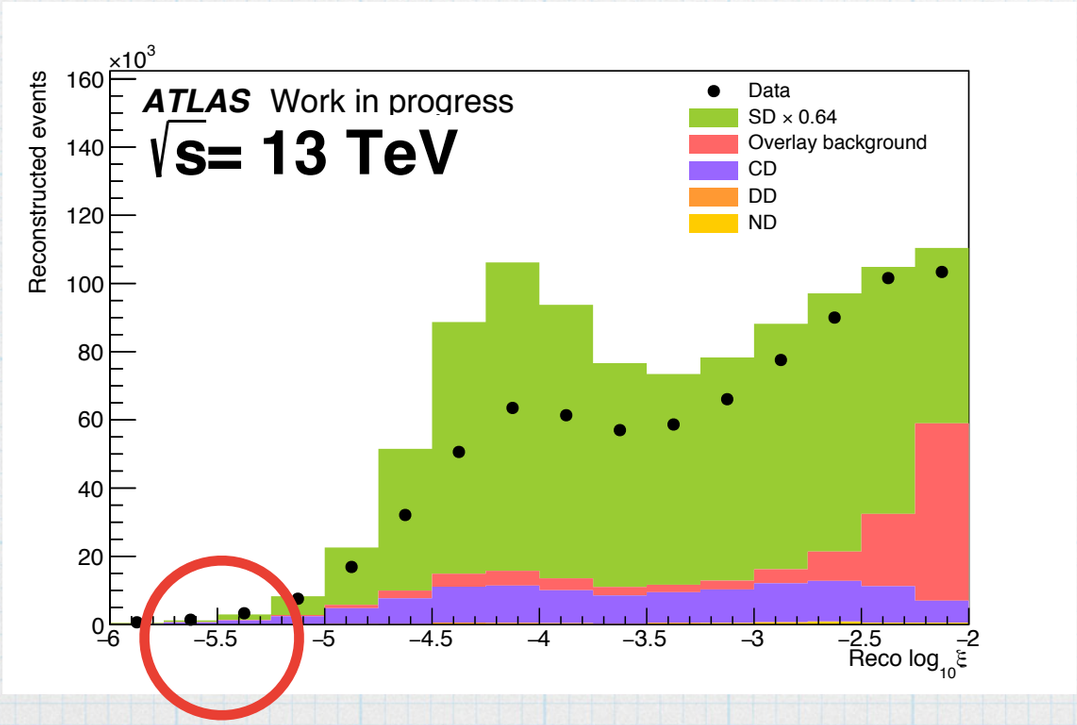
Reconstructed ξ

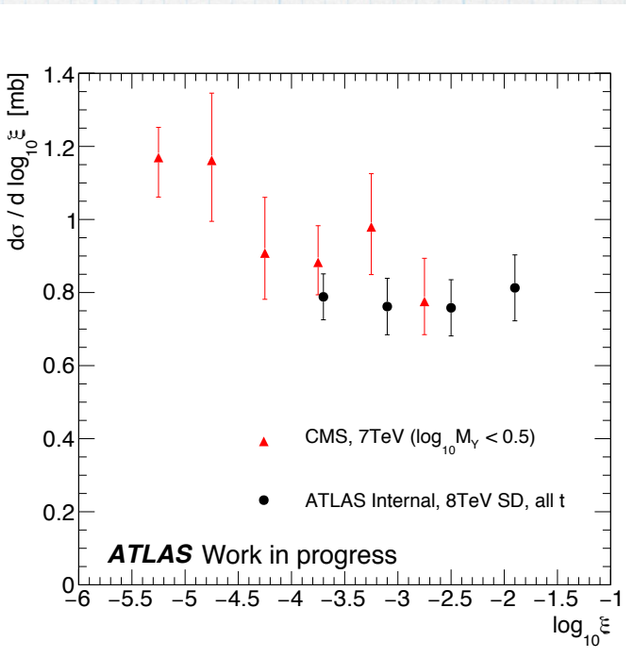
$$\xi = 1 - \frac{E_3}{E_2}$$

$$\xi_{Epz} = \frac{M_X^2}{s} \approx \frac{\Sigma_i (E^i \pm p_z^i)}{\sqrt{s}}$$

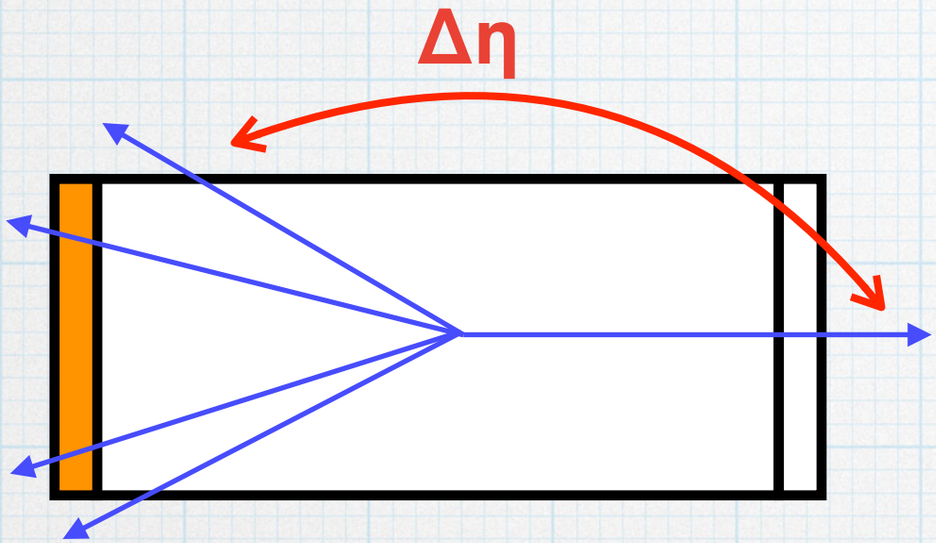
- SD σ is normalised to approximate result from equivalent 8 TeV analysis
- 13 TeV MC selection is not final and lacking some corrections

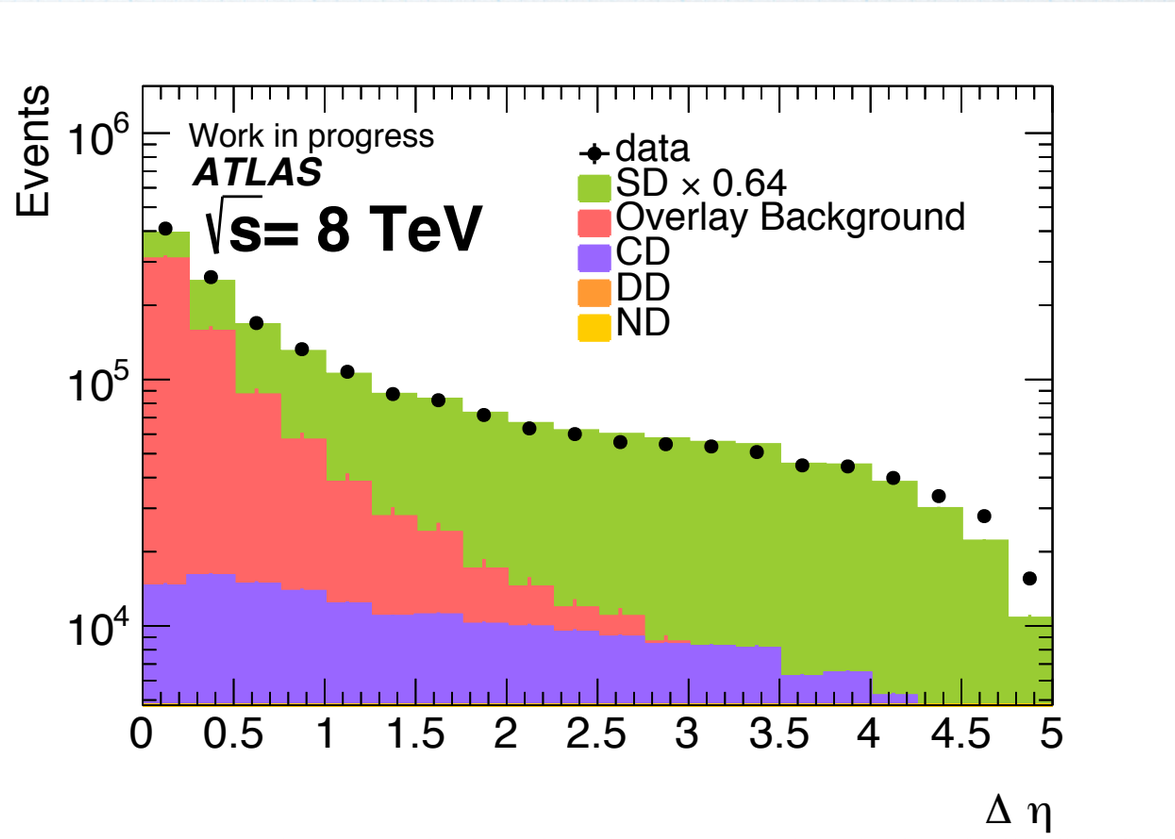


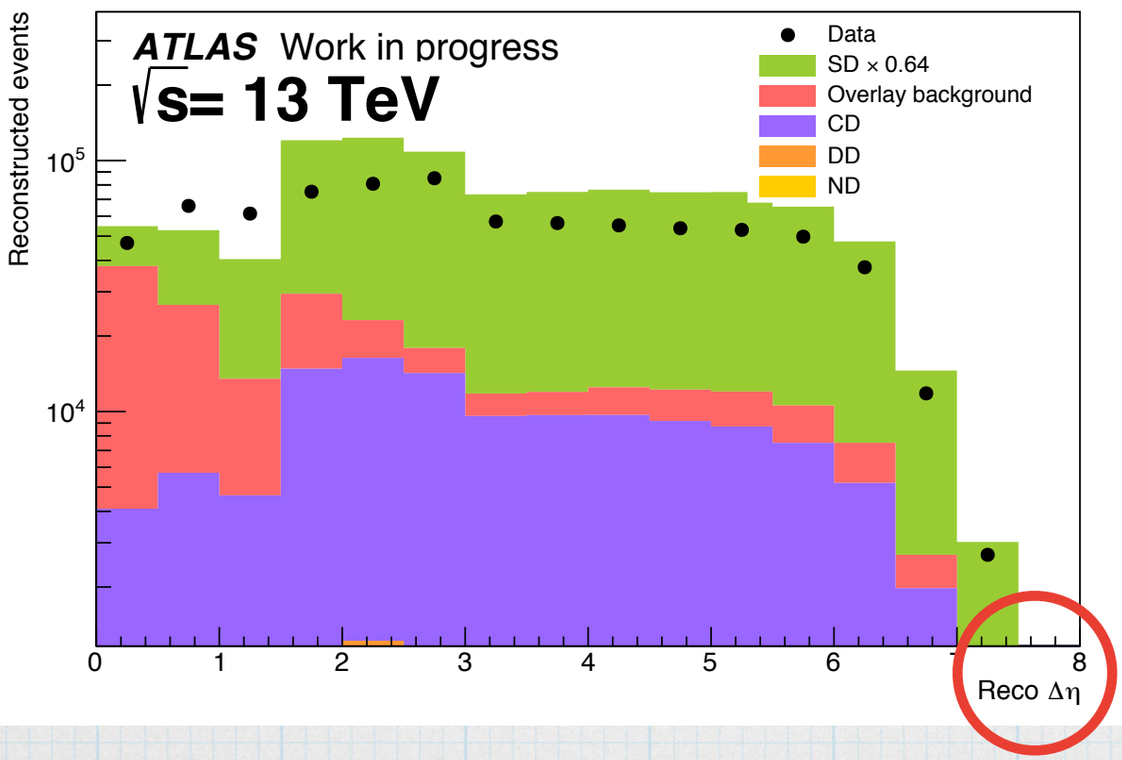


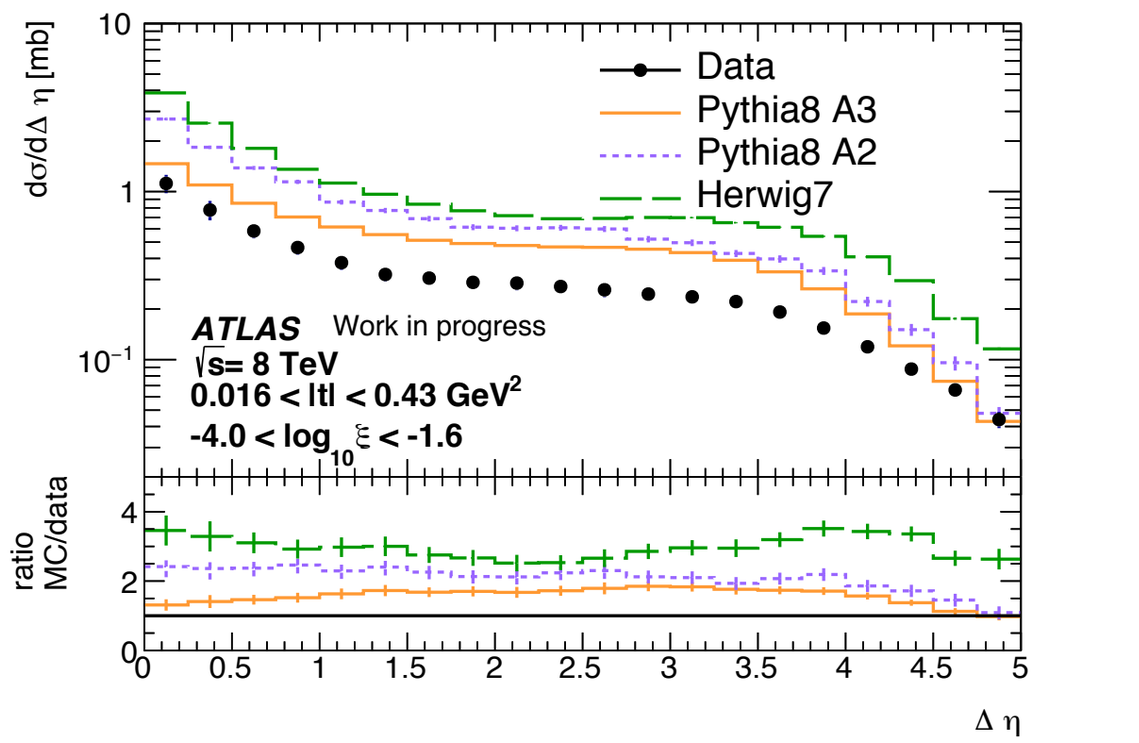


Reconstructed Δη

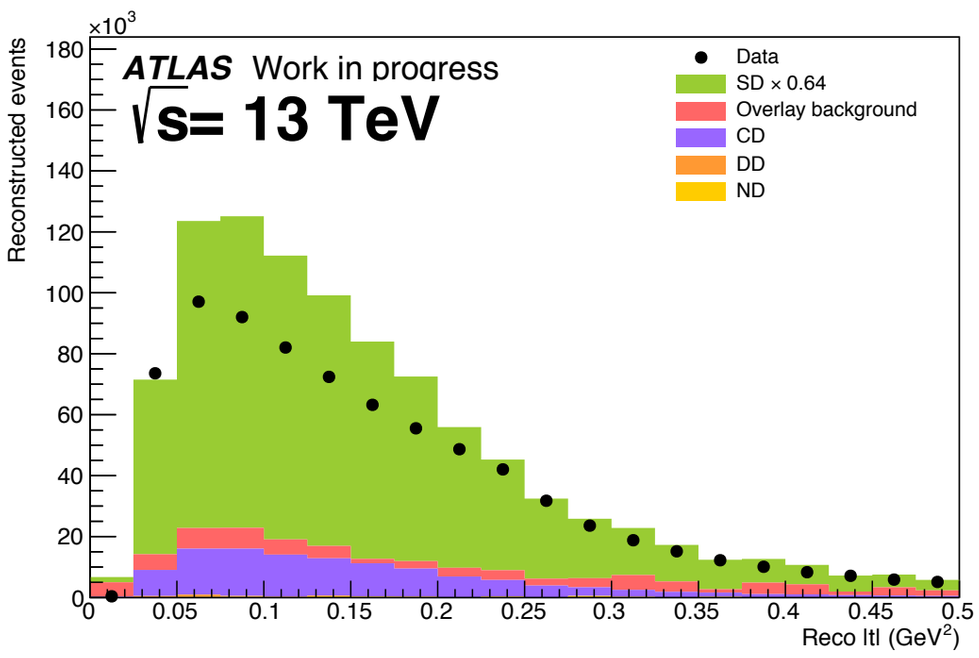


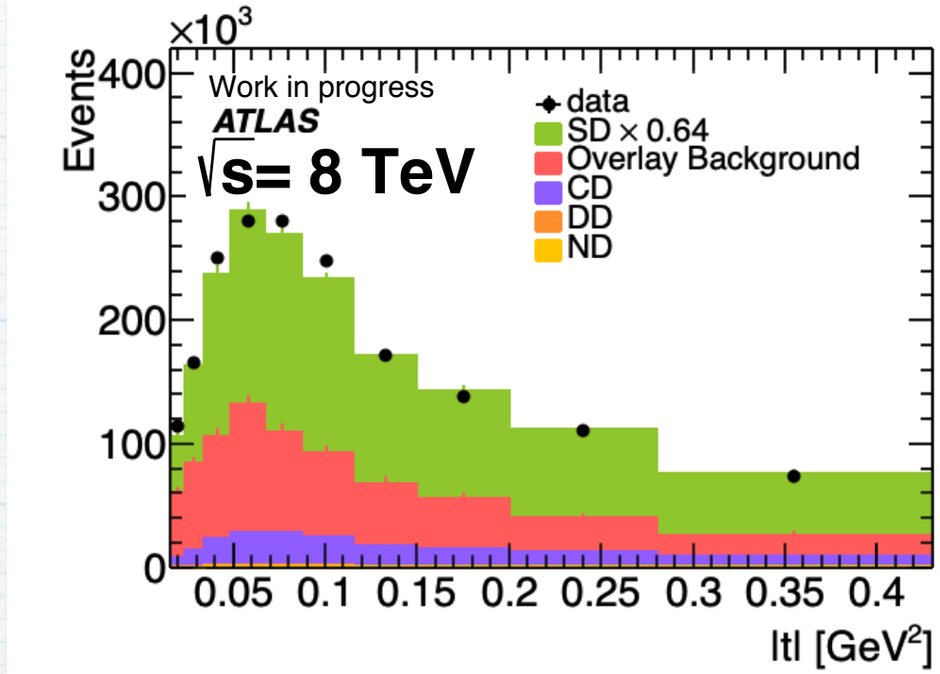


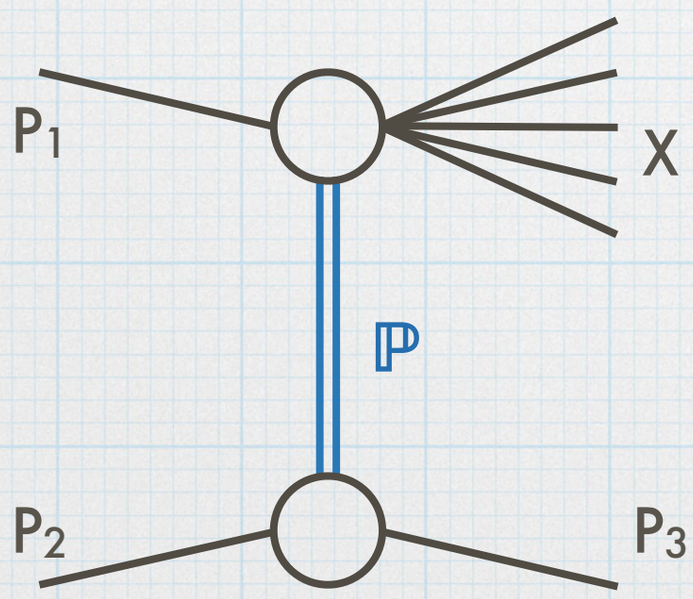




Reconstructed |t|







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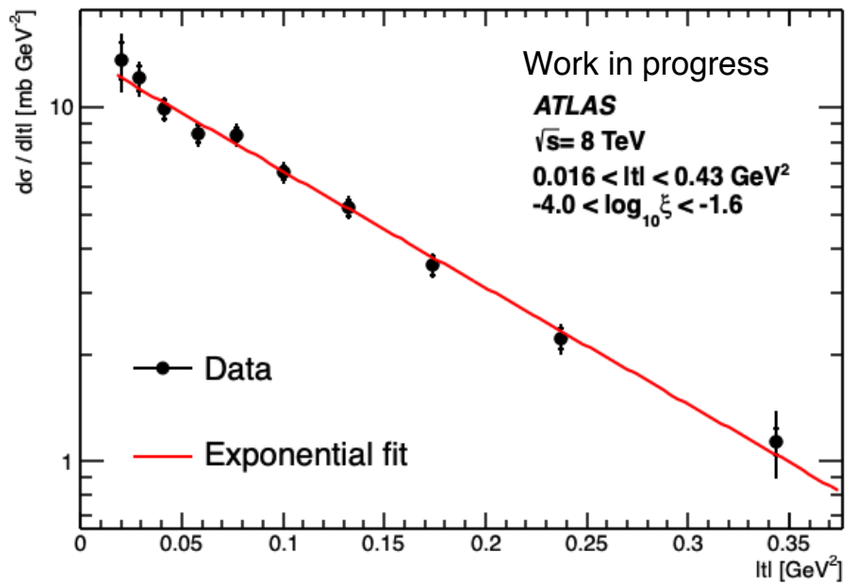

Conclusions & outlook

- 8 TeV analysis:
  - SD σ to be ~$^2/_3$ of expected value
  - α(0) = 1.07 ± 0.09 c.f. with 1.14 & 1.00 for PYTHIA8 A3 & A2
  - B = 7.60 ± 0.23 (stat) ± 0.22 (syst) GeV^{-2}

- 13 TeV analysis:
  - New MC samples produced
  - Calorimeter data provides better ξ resolution & larger fiducial range