IMPACT PARAMETERS RESOLUTION STUDIES

Measurements of the Transverse Impact Parameter Distributions to Test Track Resolution of the Inner Detector of the ATLAS Experiment at LHC with 2016 – 2018 Data

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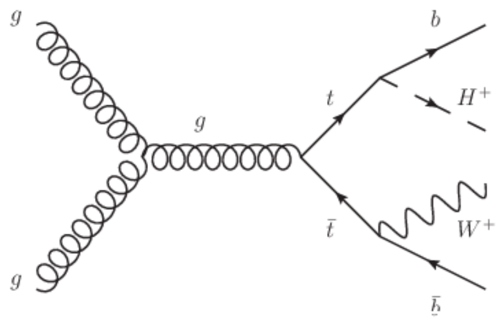
b tagging – Why is it Important?

b-tagging

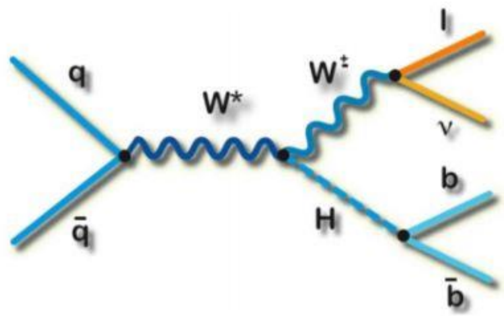
Identification of jets originating from the hadronization of b quark

Essential tool for physics processes that include b-jets in the final state

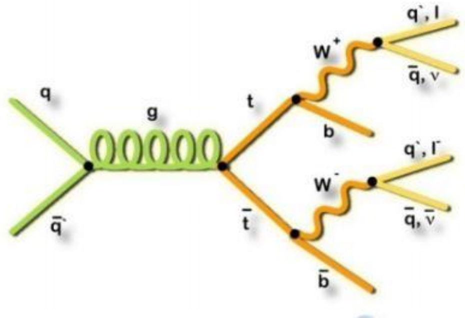
New physics search $H^+ \to tb$



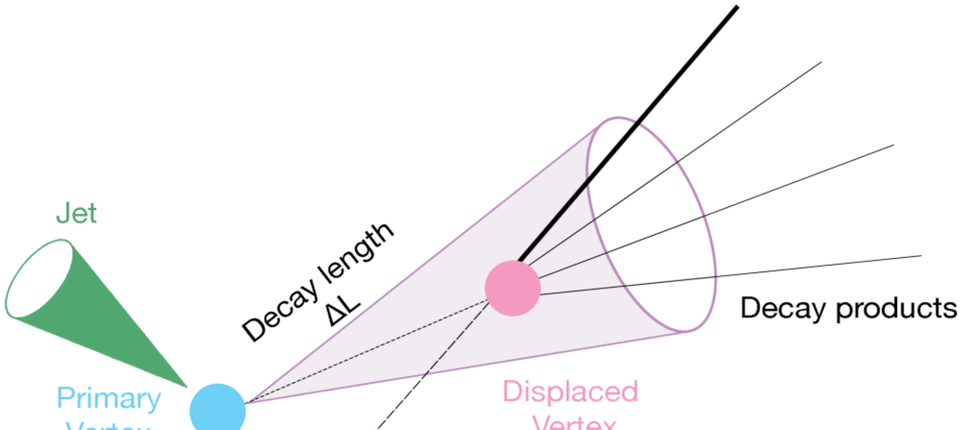
Higgs search $H \to b\bar{b}$

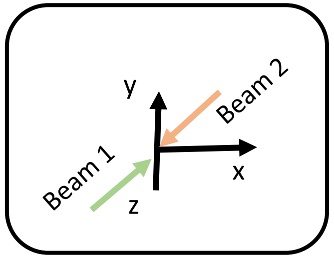


Top Physics $t \to Wb$



b hadrons Properties





Identification of *b-jets* relies on the distinctive properties of *b hadrons*

RELATIVELY LARGE LIFETIME ($\tau \approx 1.5$ ps)

- *b-hadrons* travel several mm from the interaction point before decaying

➡ displaced secondary vertices inside the jet cone

HIGH MASS (> 5 GeV)

- Large multiplicity of decay products with larger momentum with respect to the jet axis

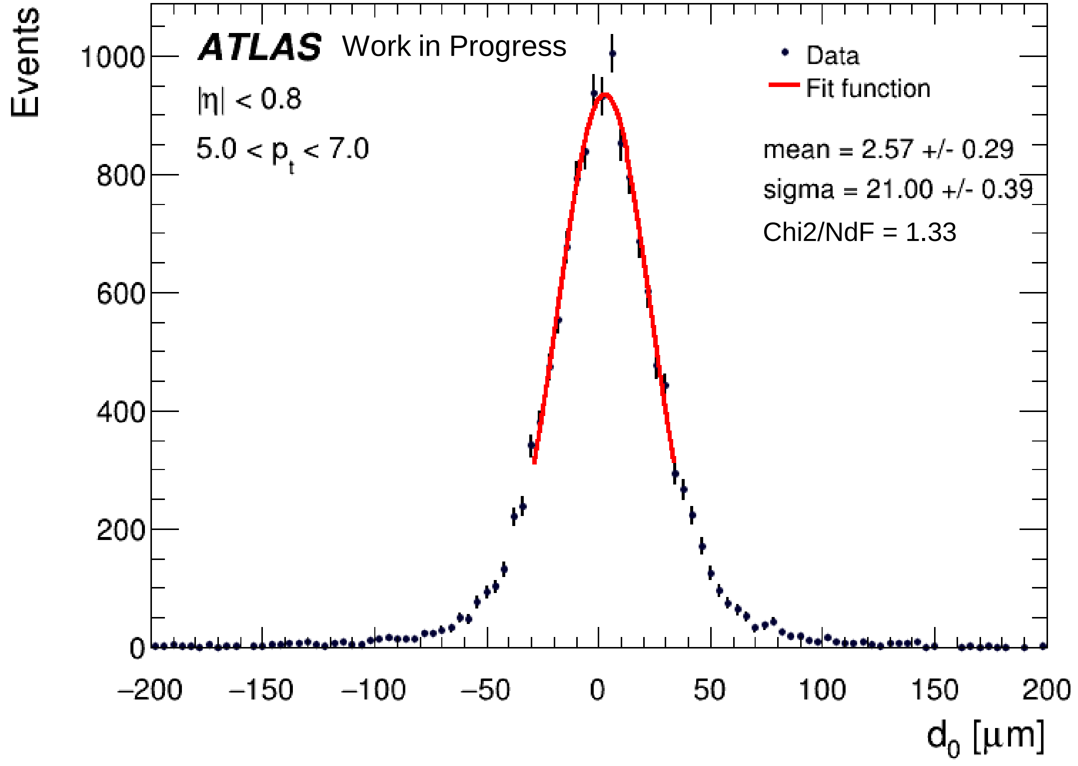
- Precise measurements of the impact parameters and **correct modeling in simulation** are crucial

A **Transverse Impact Parameter d_0**: defined as the shortest distance between a track and the beam line in the transverse plane

Impact Parameters Resolution

The resolution of the impact parameters is retrieved from an iterative Gaussian fit performed on the **core of the IP distribution**

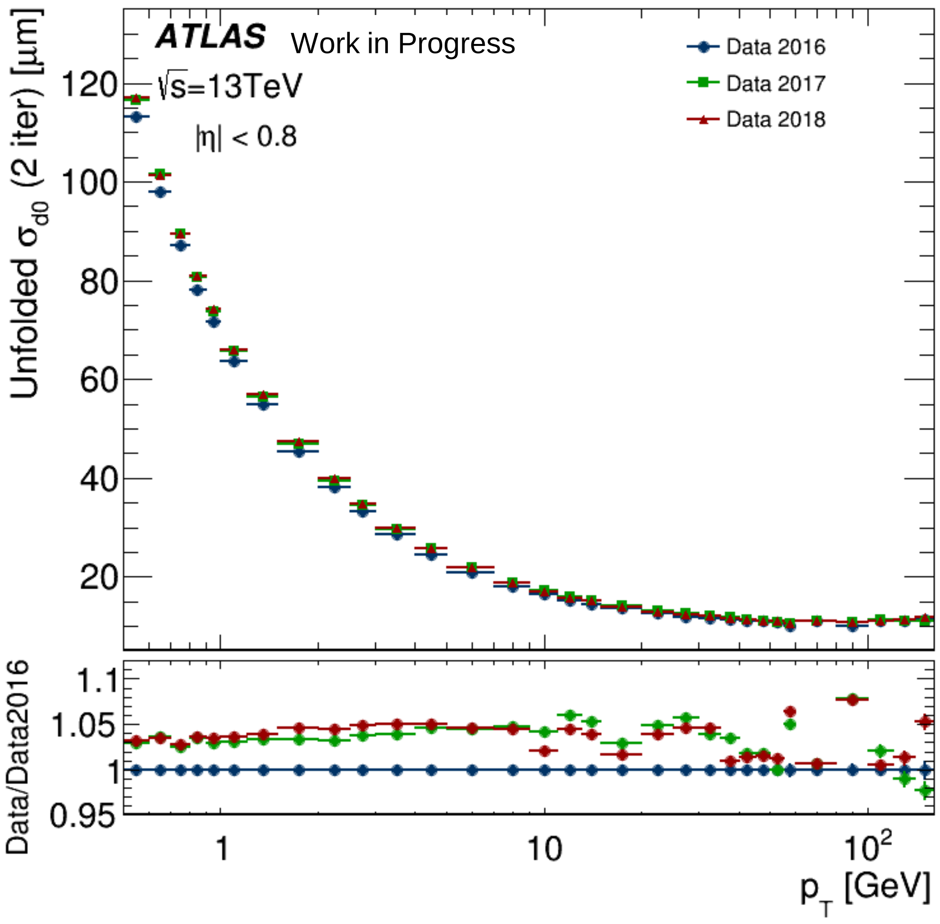
- Automatic range adjustment to exclude tails given by:
  - Contamination from poorer quality tracks (missing IBL hit)
  - Reconstruction issues
  - Secondary particles due to hadronic interactions with the detector material
  - Long-lived heavy flavor hadrons



Impact Parameter Resolution Studies

2

d_0 Resolution vs. p_T



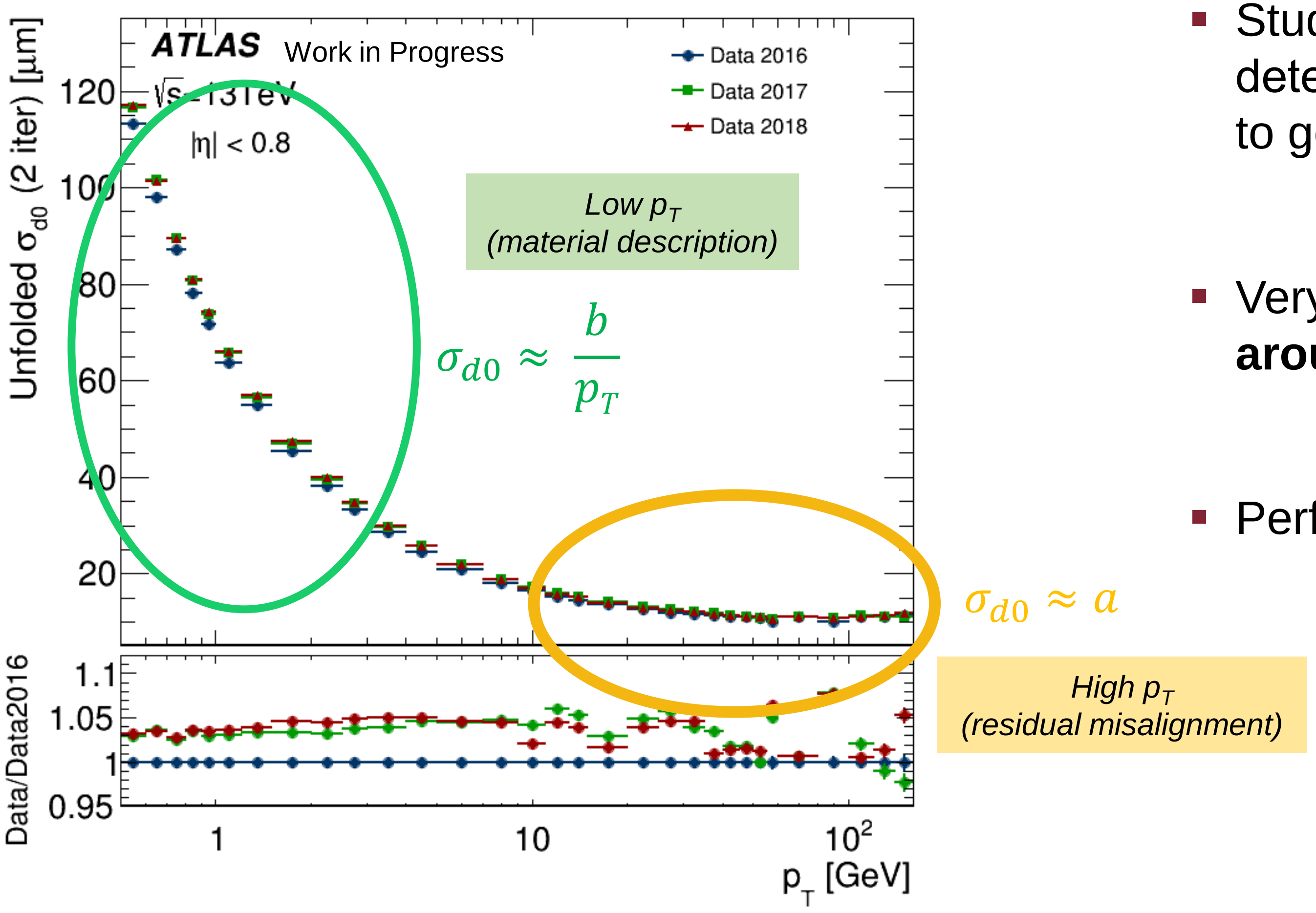
- Study of the resolution in the central part of the detector ➡ $|\eta| < 0.8$ (stable resolution region, to get rid of the pseudorapidity dependence)
- Very stable ➡ best resolution in 2016 **around 5% worse** in 2017 and 2018
- Perfectly follows the formula of the resolution:

$$\sigma_{d0} = \sigma_{intrinsic} \oplus \sigma_{MS} = a \oplus \frac{b}{p_T}$$

Intrinsic resolution of the detector and misalignment

Multiple scattering occurring when a particle traverses detector material

d_0 Resolution vs. p_T



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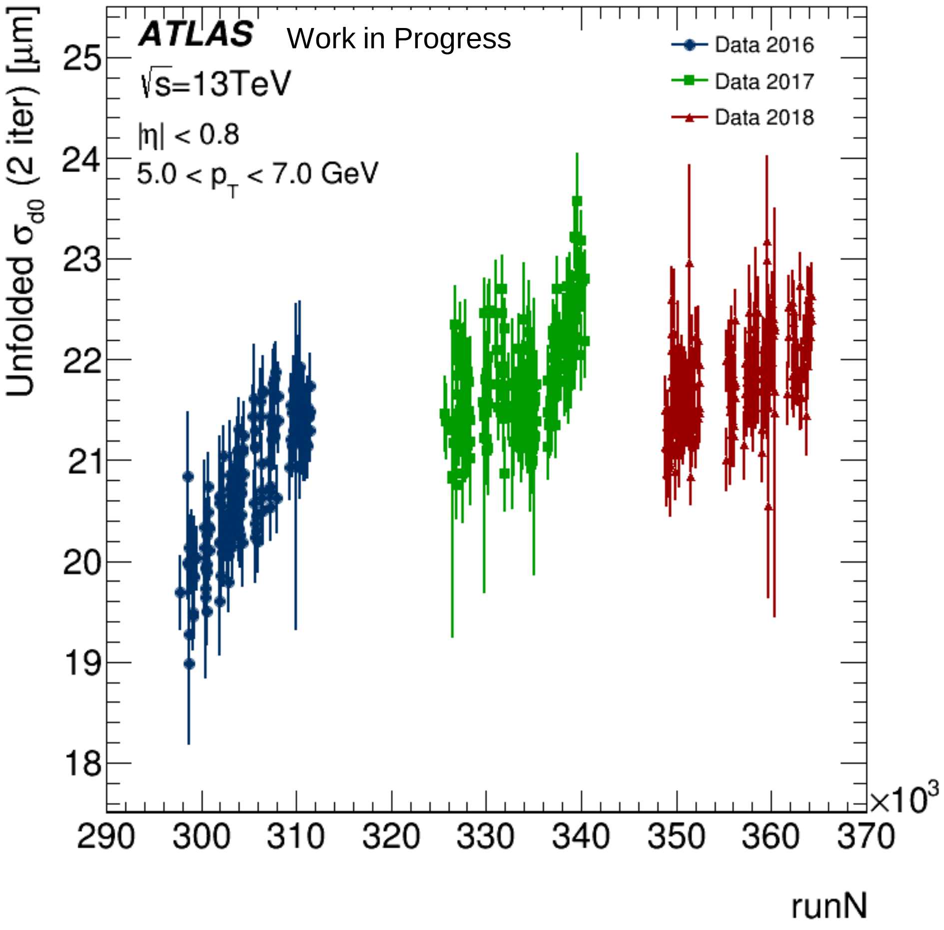
d_0 Resolution vs. Run Number



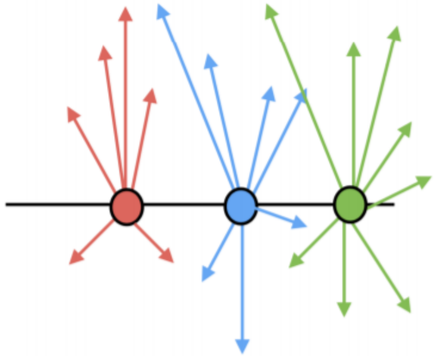
5% degradation in 2017 and 2018

RADIATION DAMAGE or CHANGES IN RUNNING CONDITIONS?

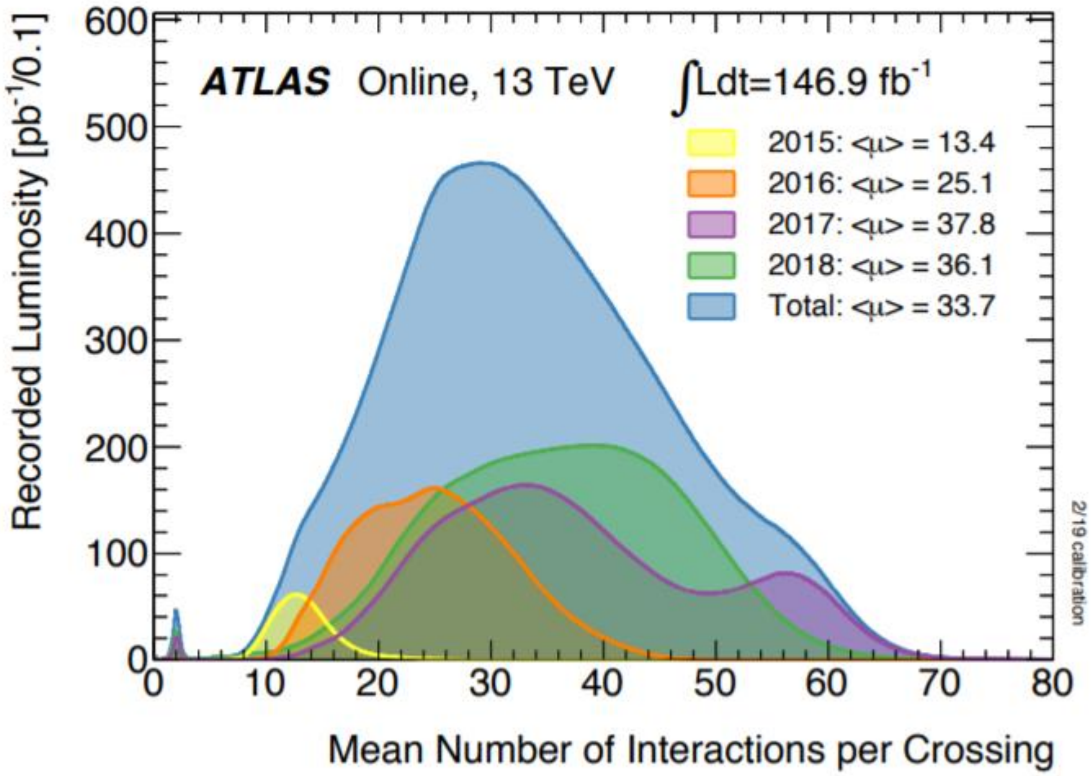
Charged Particle Production in pp Collisions – Pileups $\langle\mu\rangle$

- Multiple pp interactions per bunch crossing (**pileup**), but usually only one hard scattering – event of interest (**primary vertex**)
- Higher luminosity ➡ Generally higher pile-up
- In 2018, ~ 37 => O(10^2) charged particles leaving O(10^4) hits in the detector trackers

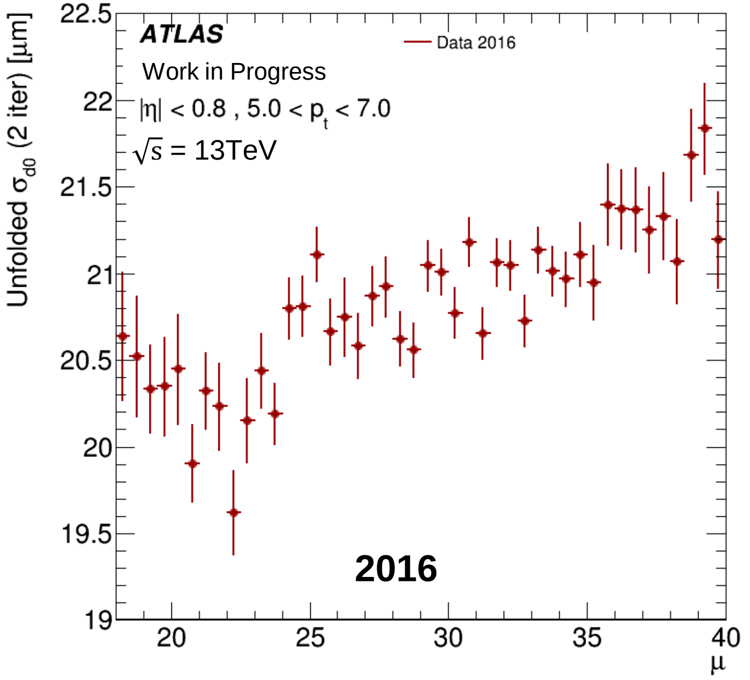
$$\langle\mu\rangle = \frac{L \cdot \sigma_{\text{inel}}}{N_{\text{bunch}} \cdot f_{\text{LHC}}}$$

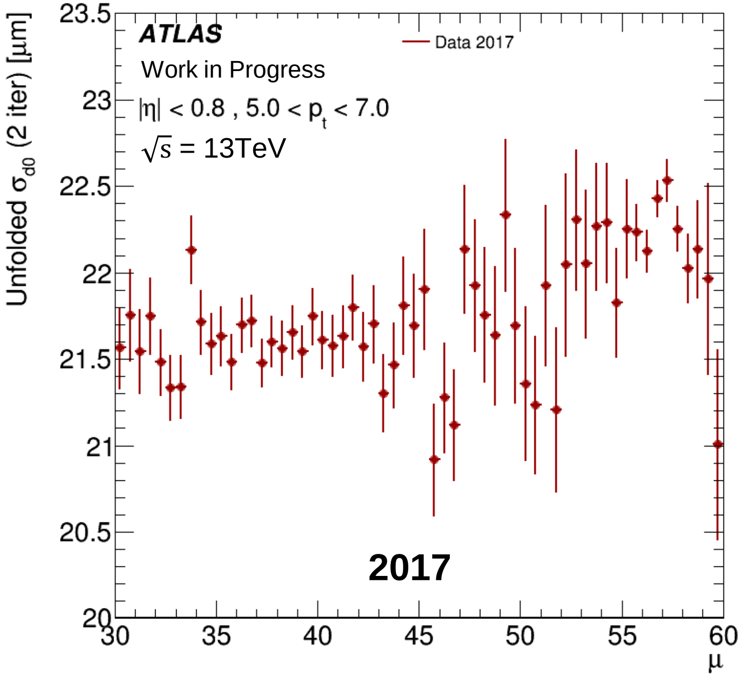


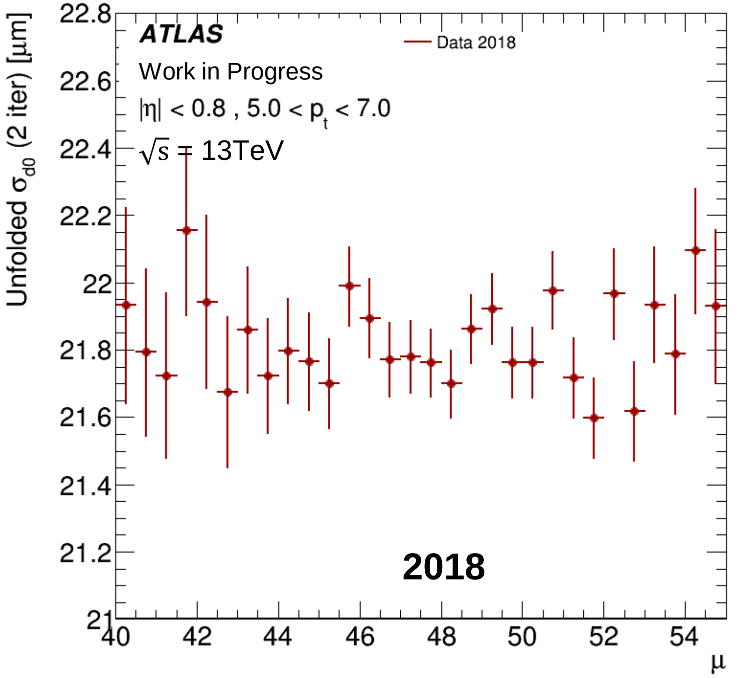
1 pp interaction ⟶ **~37 pp interaction**



d_0 Resolution vs $\langle\mu\rangle$







It has the best resolution but it appears unstable

Changing running conditions during the LHC luminosity ramp-up

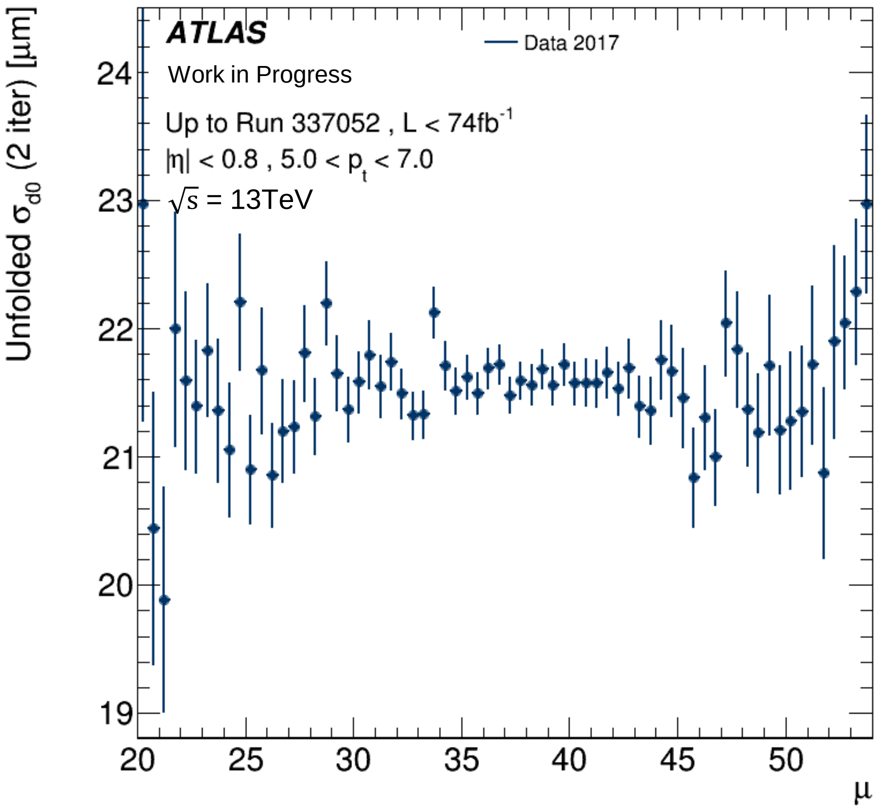
Degradation of 0.8 μm starting from $\langle\mu\rangle \approx 52$

Change in the LHC filling scheme: 8b4e scheme introduced in September

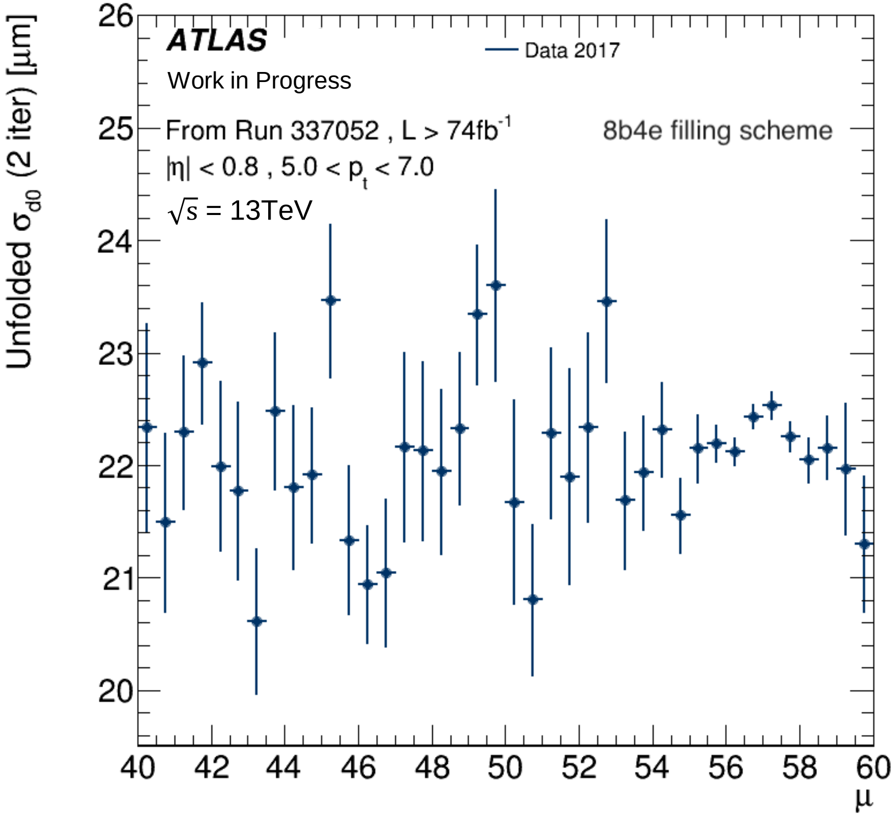
Computing a linear fit, it has the most stable behavior

But visible degradation in the plot of σ_{d0} vs RunN

d_0 Resolution vs $\langle\mu\rangle$ – 2017



2017 until September



2017 from September

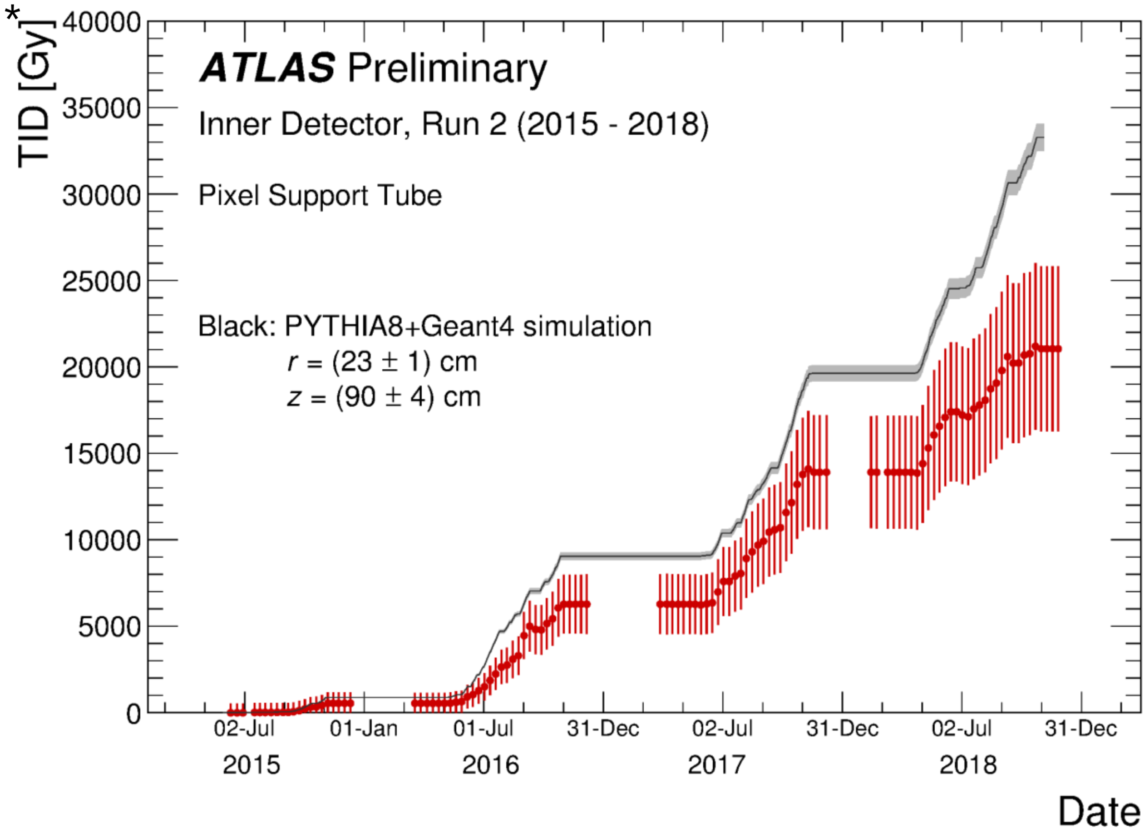
2017 sample should be always divided into two parts to remove the dependence on running conditions

d_0 Resolution vs $\langle\mu\rangle$ − Radiation Damage

The resolution shows a very small dependence on $\langle\mu\rangle$ during 2017 and 2018

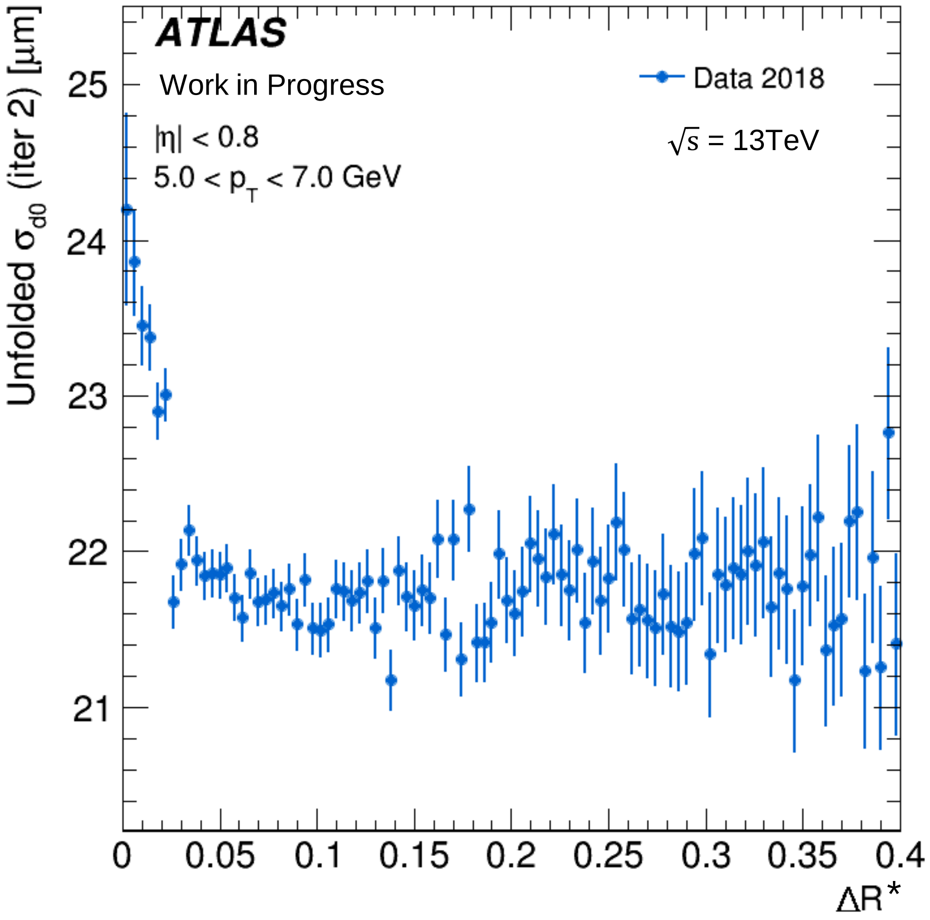
The degradation is the result of the convolution of changes in the running conditions and radiation effects

SURFACE EFFECTS



** Total Ionizing Dose*

The d_0 Resolution Dependence on Track Density



** ΔR is defined as the distance between a track and the jet axis*

Stable for ΔR > 0.02

For ΔR < 0.02 the resolution gets worse by approximately 10%

Too many tracks in proximity of the jet axis

Energy deposits become too close to be individually resolved

Degradation in the track reconstruction

Conclusions

Conclusions and Summary

- Degradation of the impact parameters resolution over the Run 2 data taking period ➡ Mainly due to radiation damage (2017 and 2018) , changes in the running conditions (2016) and condition changes applied to compensate the effects of radiation on silicon material (small effect)

- 0.8 μm degradation of the resolution for the 2017 data sample (8b4e filling scheme introduced in September) ➡ 2017 sample should be treated separately to remove the dependence on running conditions and study the effect of radiation on the resolution. In this way, we expect an improvement on the uncertainties and a better agreement between data and simulated samples

Thank You!

Chiara Magliocca