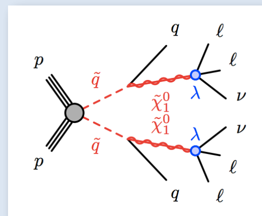
LHCC Poster Session - CERN, 28 February 2018

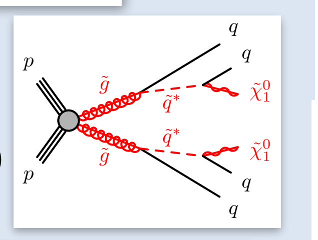
Reconstruction of large radius tracks with the ATLAS detector

Signal test models



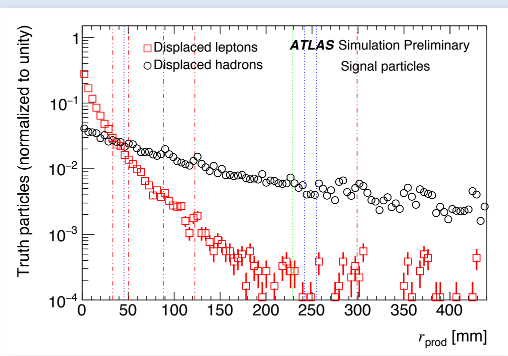
Displaced leptons

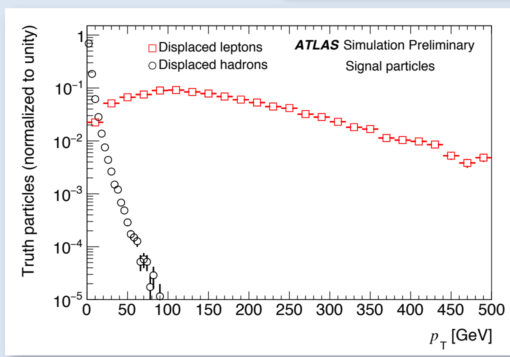
RPV - $\tilde{q}(700\text{ GeV})$, $\tilde{\chi}^0_1(500\text{ GeV}; \tau c = 30\text{ mm})$



Displaced hadrons

R-hadron - $\tilde{g}(1400\text{ GeV}; \tau c = 300\text{ mm})$, $\tilde{\chi}^0_1(1300\text{ GeV})$

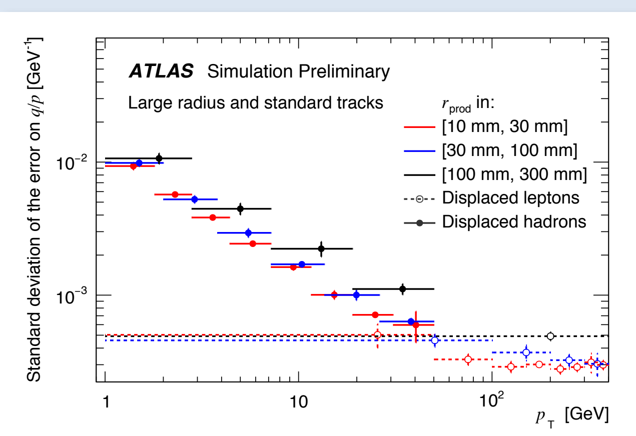


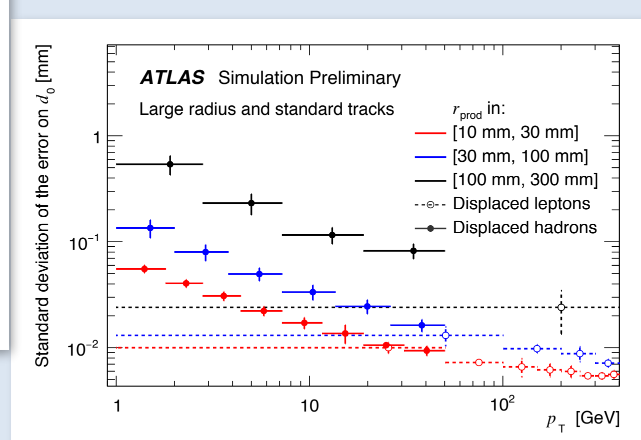


Motivation

A variety of compelling BSM physics models incorporate long-lived particles, which tend to decay at positions that are displaced from the proton-proton interaction point (IP). The standard track reconstruction algorithm used in ATLAS analyses is optimized primarily for prompt particles, with tracks which point back to the IP. To this end, tight requirements are placed on the reconstructed tracking parameters, such as the transverse and longitudinal impact parameters, to reduce the number of fake tracks and the CPU usage while keeping a high track reconstruction efficiency for "primary" particles. In order to reconstruct most non-prompt particles – whose tracks often have larger impact parameters – the tracking algorithm has been re-optimized to run with looser tracking requirements over the hits remaining after the standard track reconstruction has finished. This "retracking" has significantly increased the ability to reconstruct tracks (and thus vertices) from displaced decays, and allowed for long-lived particle searches in ATLAS.

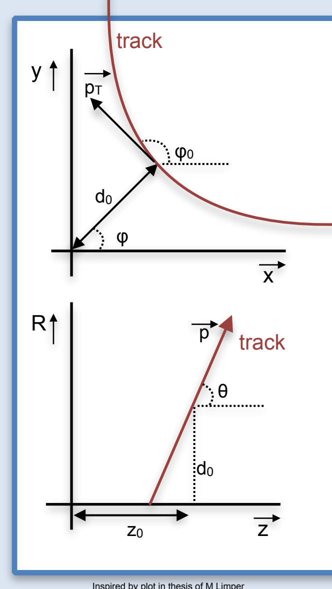
Track resolution



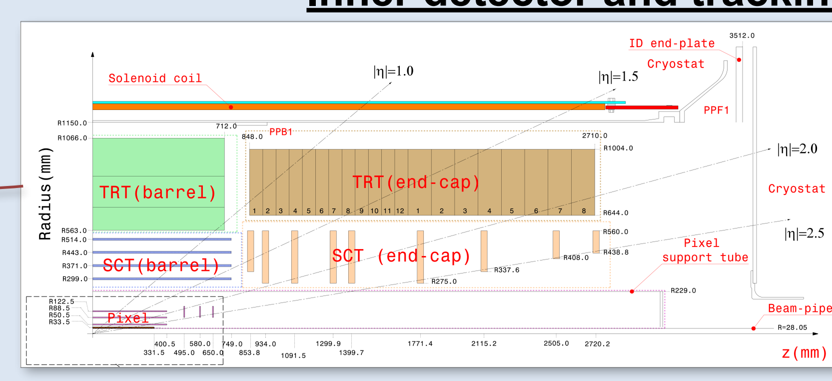


- Resolutions shown for two test signal samples (described above) to take advantage of the complementarity of their p_T distributions
- Resolution of q/p and d_0 residuals distributions vs p_T for all reconstructed tracks
- Degradation of resolution with displacement as one loses precision measurements on the tracks

Inner detector and tracking



Inspired by plot in thesis of M Limper



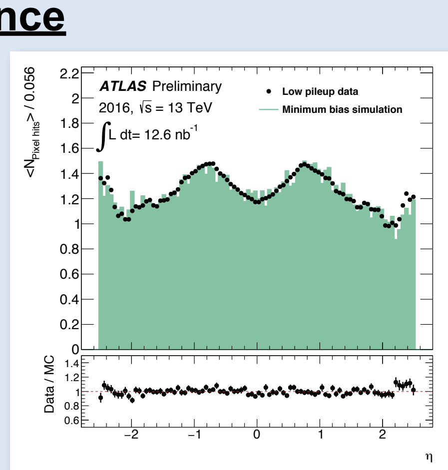
	Standard Tracks	Large radius tracks
d_0 [mm]	10	300
z_0 [mm]	250	1500
η	2.7	5
Minimum silicon hits	7	7
Max. shared silicon hits	1	2
Seed extension	Combinatorial	Sequential

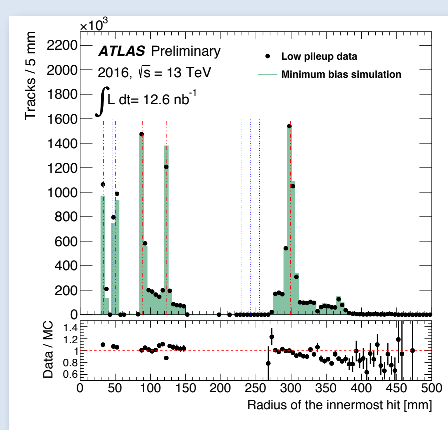
ATLAS tracking steps

- Standard tracking passes
  - Seeds primarily in pixel and SCT sub-detectors
  - Combinatorial Kalman filter - creates in parallel all possible track candidates from a given seed
  - Strict track parameter requirements
  - Second, TRT seeded tracking pass
- Large radius tracking pass
  - Uses hits left over from the standard tracking pass
  - As with standard tracking, seeds in silicon sub-detectors
  - Combinatorics too high for Combinatorial Kalman filter
  - Relaxed track parameter requirements, allowing greater freedom to reconstruct highly displaced tracks

MC vs data performance

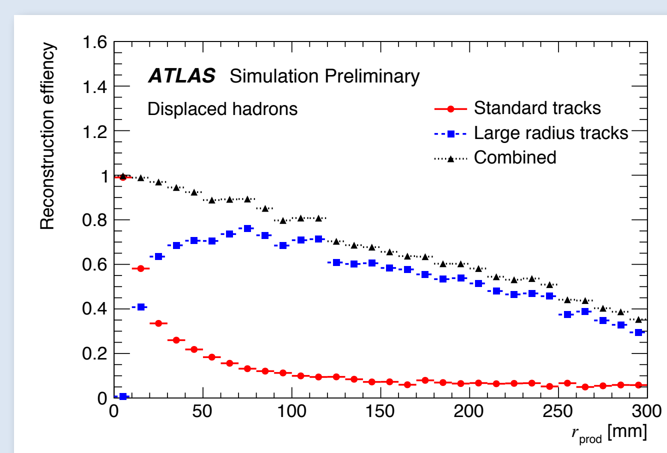
- Validation of large radius tracking done on minbias MC simulation and data collected with minbias trigger
- Very reasonable agreement is seen in nHits distributions, as well as track parameter distributions
- Some discrepancies in distributions are due to mis-modeling of the detector in simulation and from aging effects in the physical detector





Track reconstruction efficiency

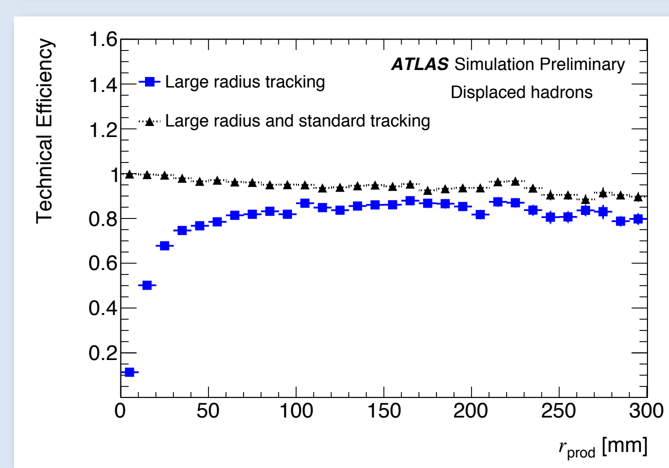
- Efficiency to reconstruct signal particles
- Large radius tracking dramatically increases efficiency for r_{prod} > ~20 mm



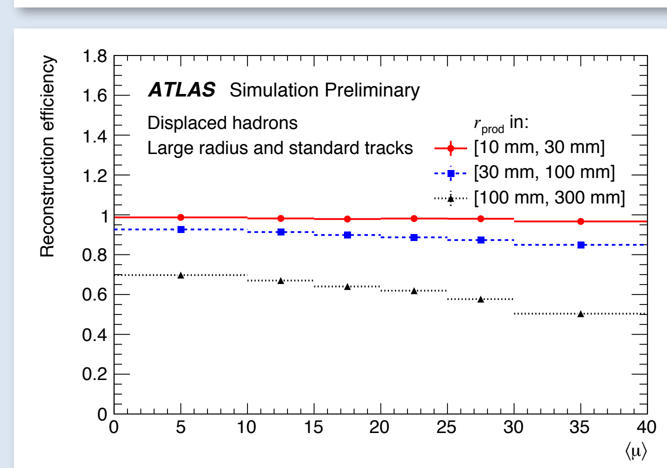
Technical efficiency

Max. r_{prod}	300 mm
Min. silicon hits	7
Max. η	2.5
Min. p_T	1 GeV

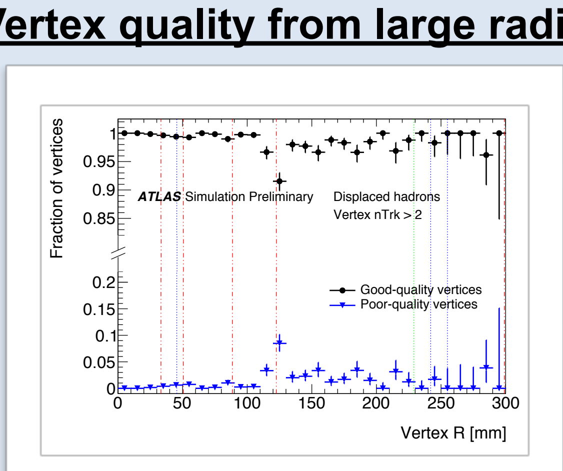
- Technical efficiency takes into account only particles which are "reconstructable"
- Very efficient at reconstructing truth with ≥ 7 energy deposits in silicon, for r_{prod} < 300 mm

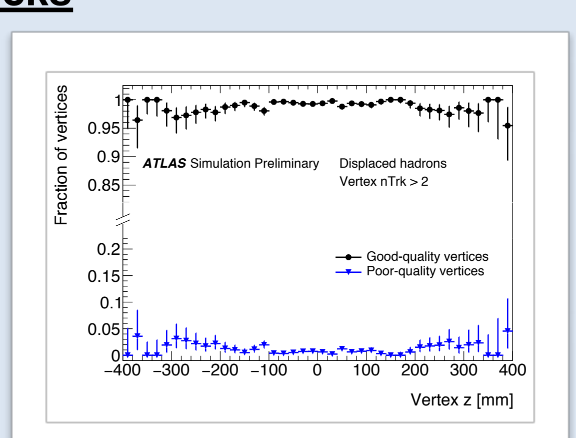


- Some degradation is seen in reconstruction efficiency vs pile-up
- Particularly true for more displaced tracks
- Some studies already undertaken to mitigate these effects



Vertex quality from large radius tracks





- Secondary vertices created from all reconstructed tracks with d_0 > 2 mm
- Vertices considered are required to be within fiducial volume R < 300 mm and |z| < 400 mm
- Vertices are also required to have ≥ 3 tracks, as hadronic decays tend to be dominated by large nTrk vertices

- Good-quality vertices required to be < 5 mm from a simulated (truth) vertex and have ≥ 2 tracks matched to truth particles
- All other vertices considered to be of poor-quality
- Fraction of poor-quality secondary vertices very low across R and z
- Dashed and dotted lines in R represent inner detector material

Margaret Lutz, for the ATLAS Collaboration

ATLAS EXPERIMENT