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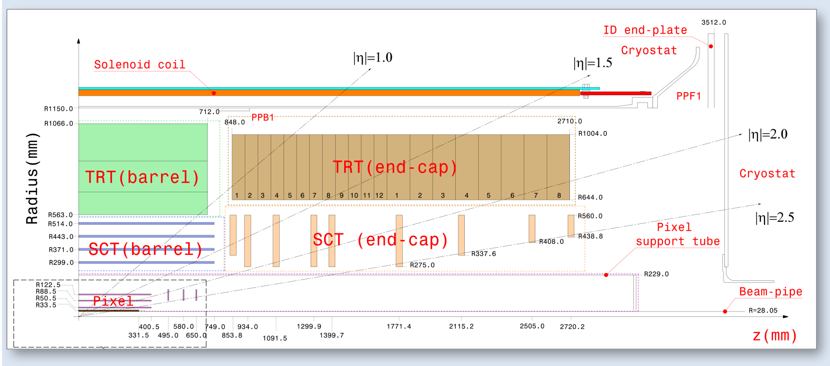
Large Radius Tracking at the ATLAS Experiment

Many exotics and SUSY models include particles which are long-lived, resulting in decays which are displaced from the proton-proton interaction point (IP). The standard track reconstruction algorithm used by the ATLAS collaboration is optimized for tracks from “primary” particles, which point back to the IP. Thus, tight restrictions on the transverse and longitudinal impact parameters, as well as on several other tracking variables, are applied to improve the track reconstruction performance and to reduce the fake rate. This track reconstruction is very efficient for primary particles, but not for the non-prompt particles mentioned above. In order to reconstruct tracks with large impact parameters from displaced decays, a tracking algorithm has been optimized to re-run with loosened requirements over the hits left-over after standard track reconstruction has finished. Enabling this “retracking” has significantly increased the efficiency of reconstructing tracks from displaced decays, which has benefited the search for beyond the Standard Model particles. This poster shows the results of studies which have been done to improve the retracking.

Tracking in the ATLAS inner detector

ATLAS inner detector

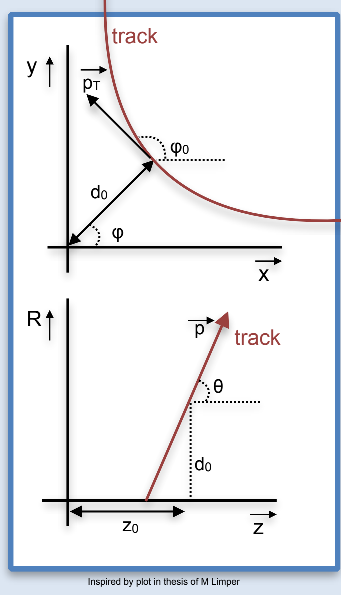


Tracking

Standard tracking
inside out
- Tracks formed with ‘seeds’ of 3 space points in the silicon detectors
- Seeds which meet criteria have track candidates formed using combinatorial Kalman filter
- Tracks must pass through ambiguity solver
- Tracks then extended into TRT

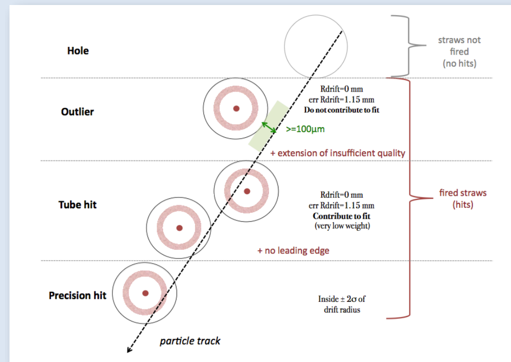
outside in
- Tracks are seeded in the TRT and extended back in towards the silicon detectors

Large radius tracking
Very similar to standard *inside out* tracking, using leftover hits from standard passes, except
- Looser requirements on track seeds and candidates
- Track candidate formation sequential rather than combinatorial



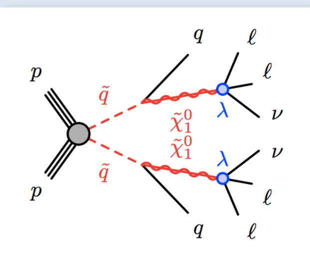
	Standard Tracks	Large radius tracks
d_0 [mm]	10	300
z_0 [mm]	250	1500
|η|	2.7	5
Minimum silicon hits	7	7
Max. shared silicon modules	1	2
Seed extension	Combinatorial	Sequential

TRT extension

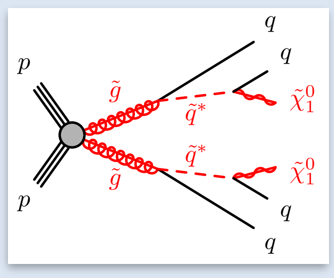


- *Failed TRT extension* - track cannot be extended into TRT, may be outside η acceptance
- *Rejected TRT extension* - TRT extension does not meet minimum hit or precision hit fraction, or causes track fit to become worse - all hits become marked as outliers
- *Successful TRT extension* - TRT extension meets minimum hit and precision hit fraction requirements, improves track fit

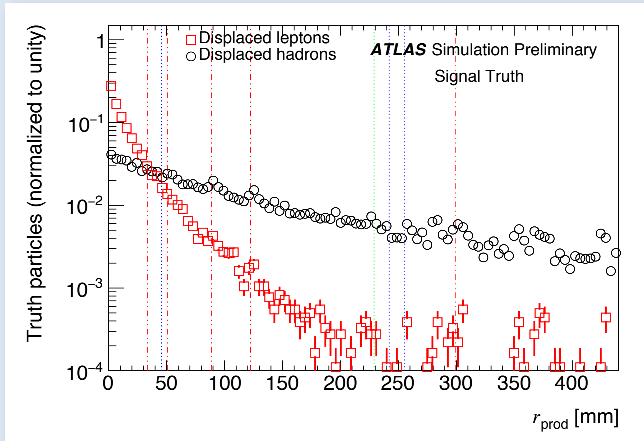
Signal test models

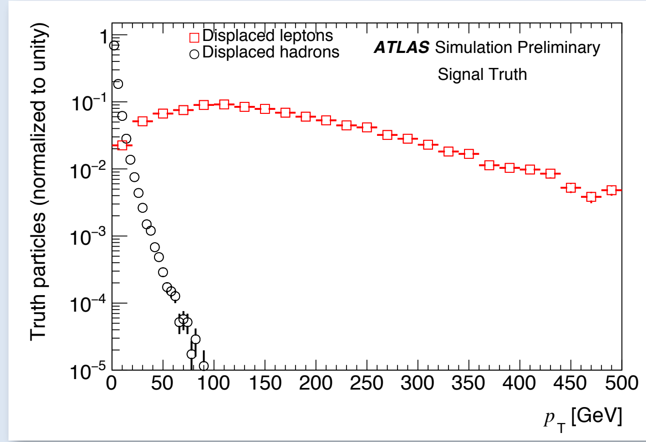


Displaced leptons
RPV $\tilde{q}$(700 GeV), $\tilde{\chi}_1^0$(500 GeV; τc = 30 mm)

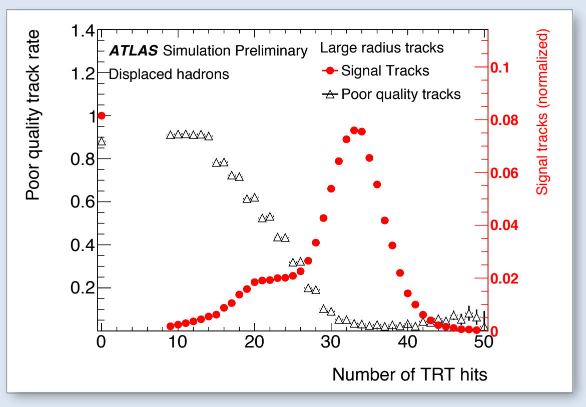


Displaced hadrons
R-hadron, $\tilde{g}$(1400 GeV; τc = 300 mm), $\tilde{\chi}_1^0$(1300 GeV)

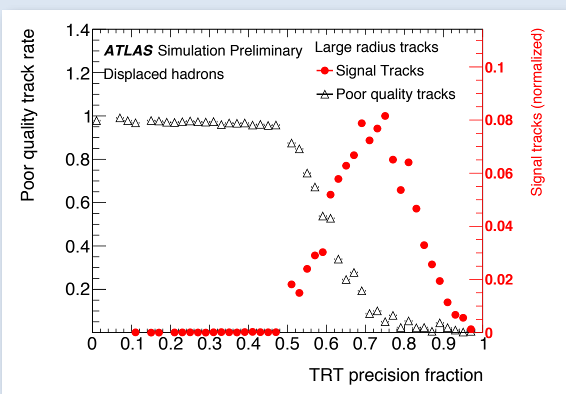


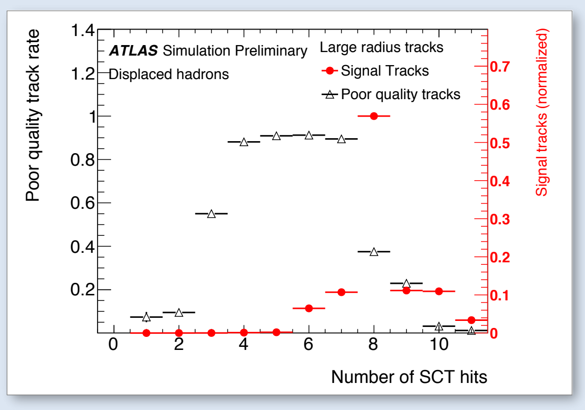


Improving track quality



- Large radius tracking naturally has very high rate of poor quality tracks
- Many will be eliminated by analyses during vertex forming, but issue still causes high CPU usage
- TRT and SCT hits and TRT precision hit fraction can be exploited to reduce the poor quality track rate
- Summary plots show that tracks with low nTRT hits or nSCT hits are primarily poor quality
- Among tracks with TRT hits, those with low precision hit fraction have negligible contribution to signal efficiency
- Stricter cuts on these parameters could lower the rate of poor quality tracks without sacrificing efficiency



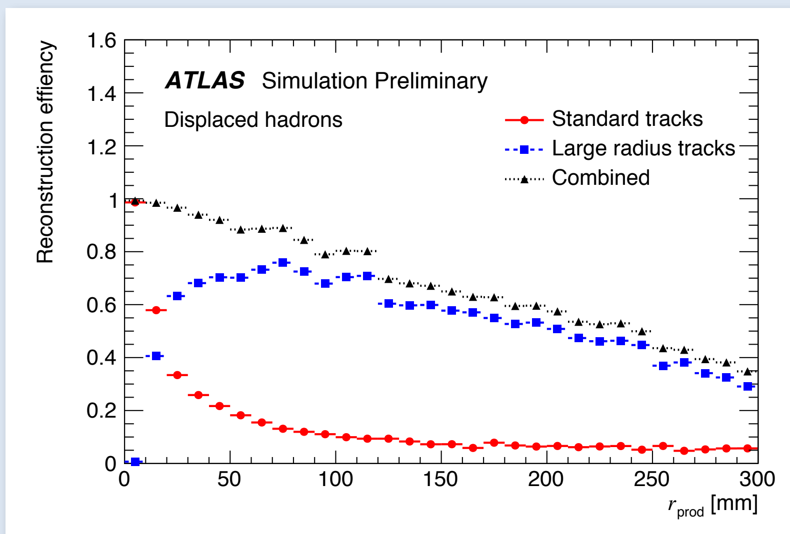


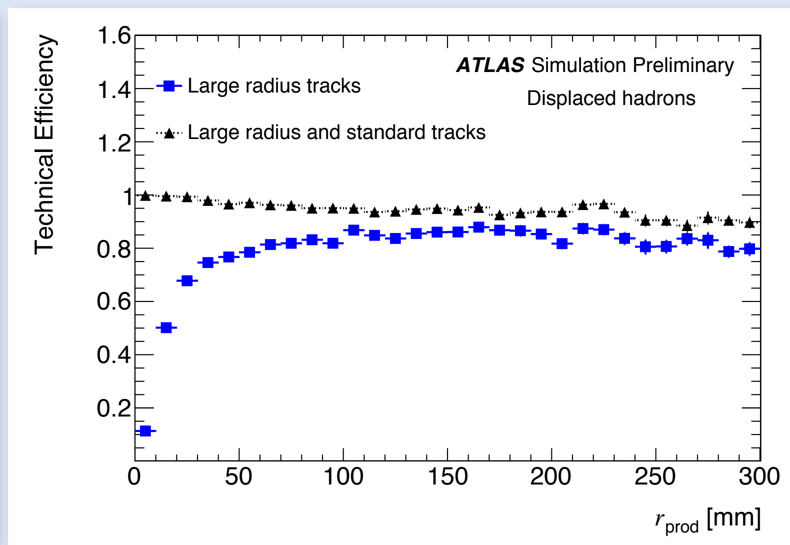
Track reconstruction efficiency

- Large radius tracking greatly improves efficiency for reconstructing particles from displaced decays
- Algorithm performance tested using technical efficiency
- Technical efficiency only considers truth particles which leave enough energy deposits in the detector to be reconstructed - extra restriction for truth listed in table
- With the addition the large radius tracking, track reconstruction has 90% or higher technical efficiency across the acceptance for track production radius
- Similar results hold for the displaced leptons sample

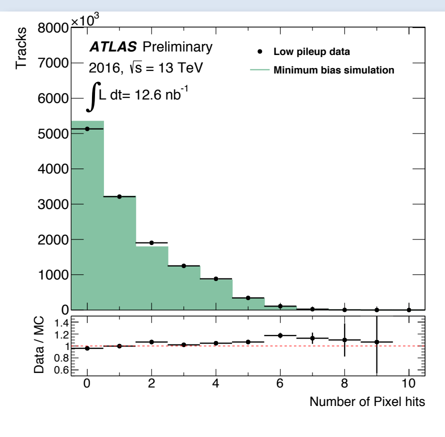
Technical efficiency

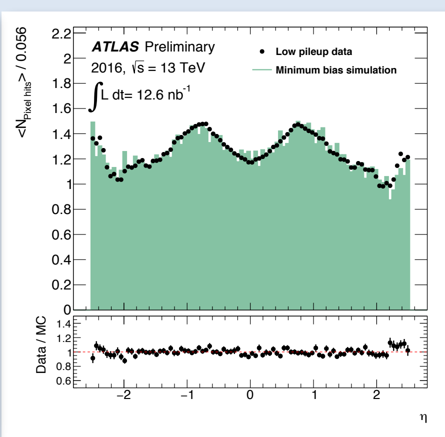
Max. r_{prod}	300 mm
Min. silicon hits	7
Max. |η|	5
Min. p_T	1 GeV

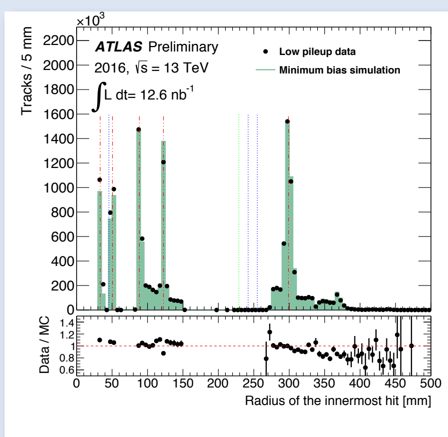




Comparison of tracking on minbias data and MC simulation



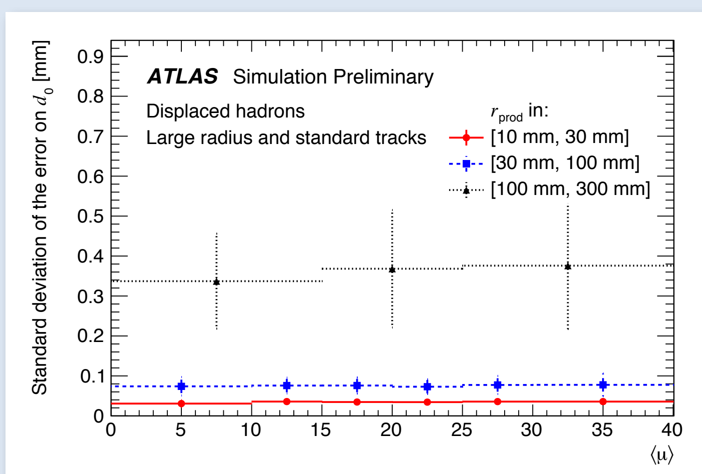


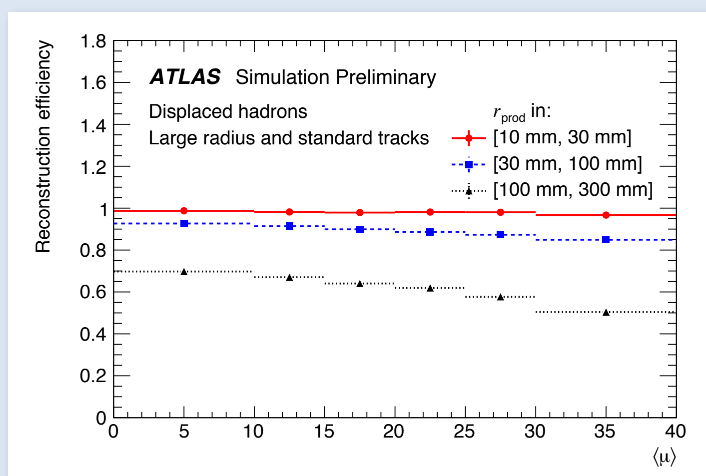


- Data was selected with a minimum bias trigger in very low pileup conditions (μ ~0.5)
- Displaced particles are mainly from hadronic interactions with detector material
- MC tracks are weighted to match pT, η, and kinematic distributions in data
- Some disagreement exists between data and MC simulation in the reconstruction of the innermost track hits, related to some non-uniformities in the physical detector which aren’t modeled properly in simulation

Robustness against pileup

- The level of pileup in the collisions produced by the LHC is expected to increase throughout Run 2 and in the future
- While this increases the likelihood of interesting physics, higher occupancy environments introduce challenges
- In the range of μ < 40, the standard deviation on the error for d_0 shows little dependence on the level of pileup.
- Track reconstruction efficiency decreases somewhat with increased occupancy, especially for the more displaced tracks. This will be one of the next issues addressed by the group in the effort to further improve the large radius tracking.





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