Performance of Particle Identification of the Atlas Transition Radiation Tracker

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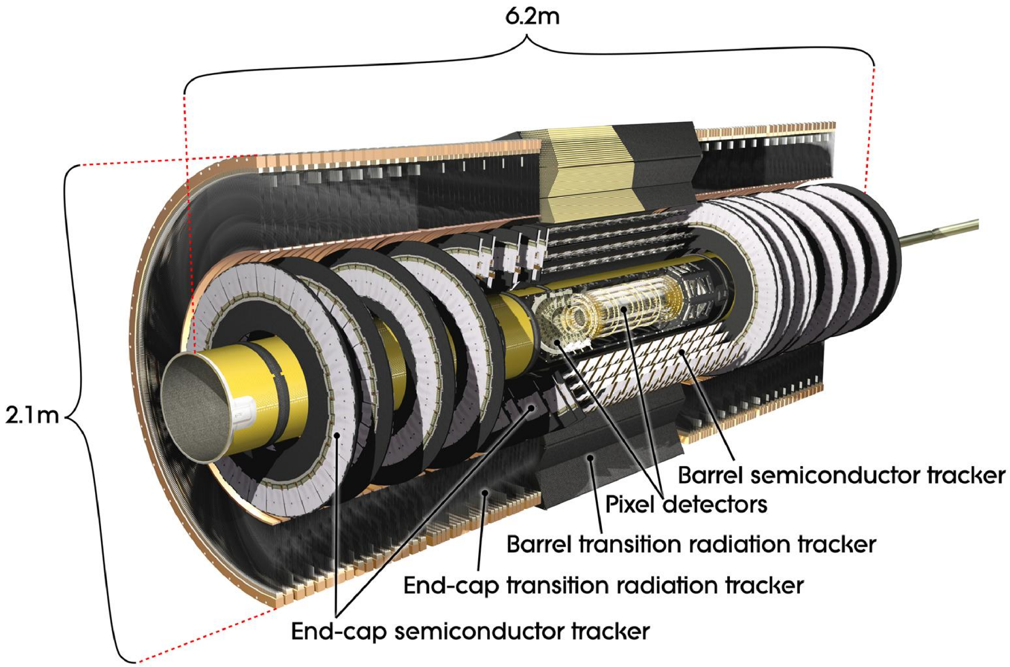
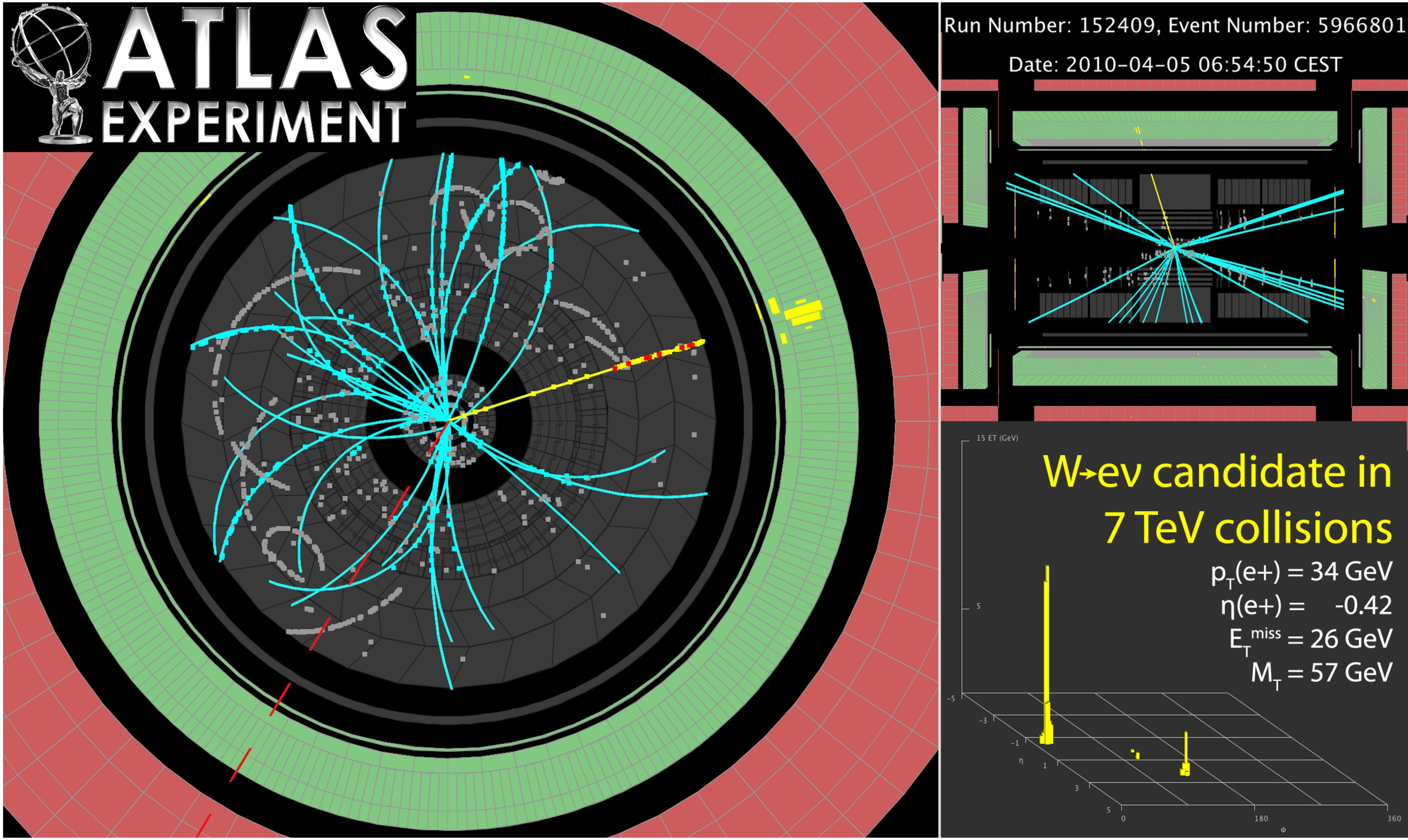
for the Atlas Collaboration

TRDs for the 3rd Millennium
15 Sept 2011

The ATLAS Transition Radiation Tracker

- Operates as both a straw tracker and a TRD
- Active Gas of 70% Xenon used for efficient absorption of TR photons
- Electronics employ a two-level threshold
  - Low Threshold for Tracking of ~300 eV
  - High Threshold of about 6-7 keV for detection of large energy deposits from TR photons





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Selection

- Electrons from 2 sources
  - Tag and probe using photon conversions in min-bias
    - Abundant in early data – provides lots of statistics quickly for electrons up to ~20 GeV
  - Tag and probe using Z boson decays
    - Ability to probe higher momenta
- Pions from min-bias tracks
  - Veto electrons from conversions
  - Veto low momentum protons and kaons using dE/dx measurement in the Pixel detector

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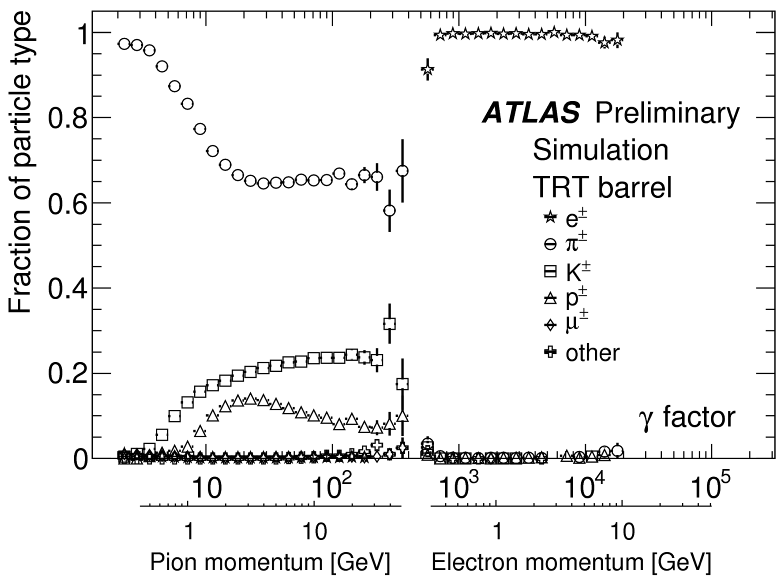
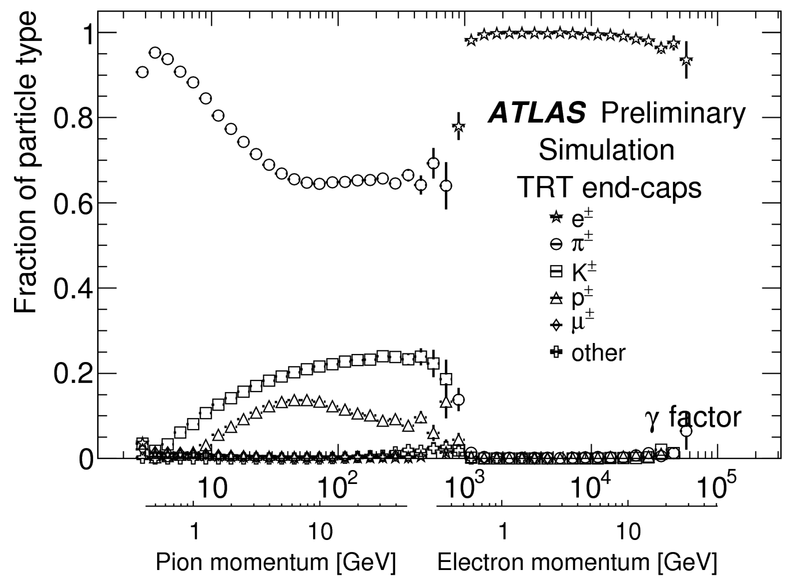
A Word On Purity of Samples

- First estimated from Monte Carlo
- Purity of Conversion Electron Selection is >99%
  - Contamination worst at high η and highest momenta probed
- Purity of Pion Sample is ~85% in total
  - Primarily from Protons and Kaons, p>2 GeV – not a problem since all hadrons behave similarly at this momenta
  - Contamination from electrons <0.5%





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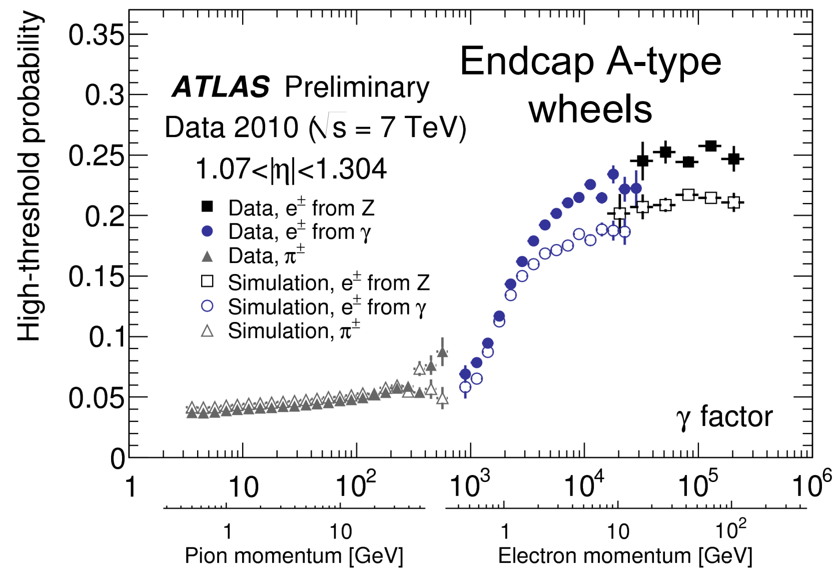
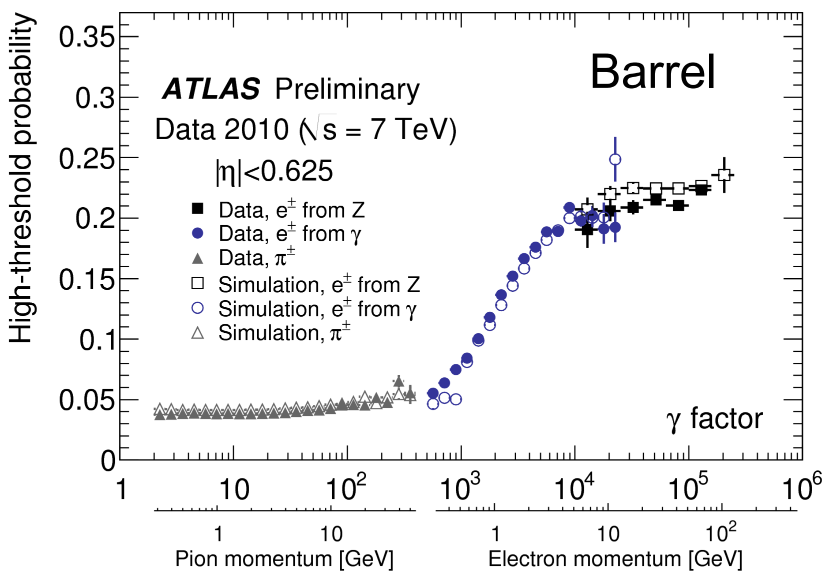
Cross Checks on Purity

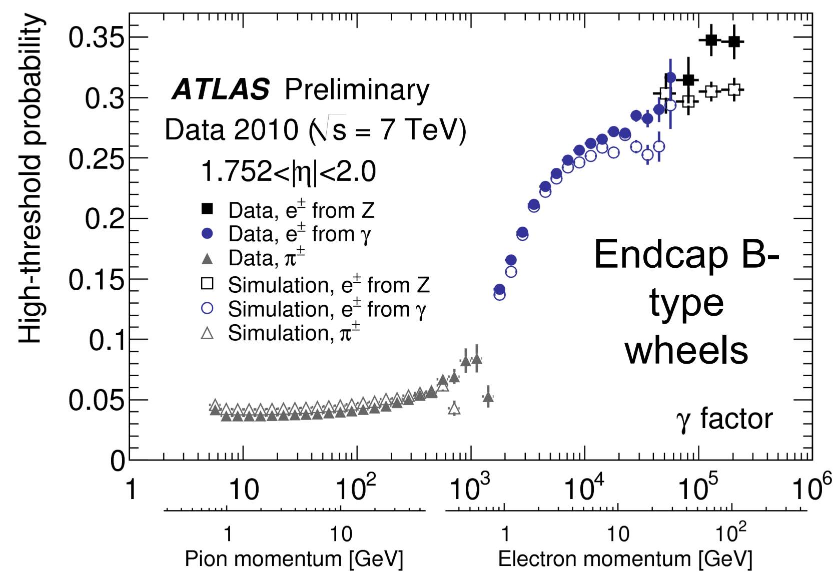
- Pion sample also taken from K short decays
  - Purer sample (>98% pion), results in good agreement confirm no significant dependence on hadron type for p > 1-2 GeV
- All samples also tested with a data driven method
  - Results in good agreement with Monte Carlo predictions
- For Z-sample only data driven method is used – shows purity of >99%

Turn On Curves

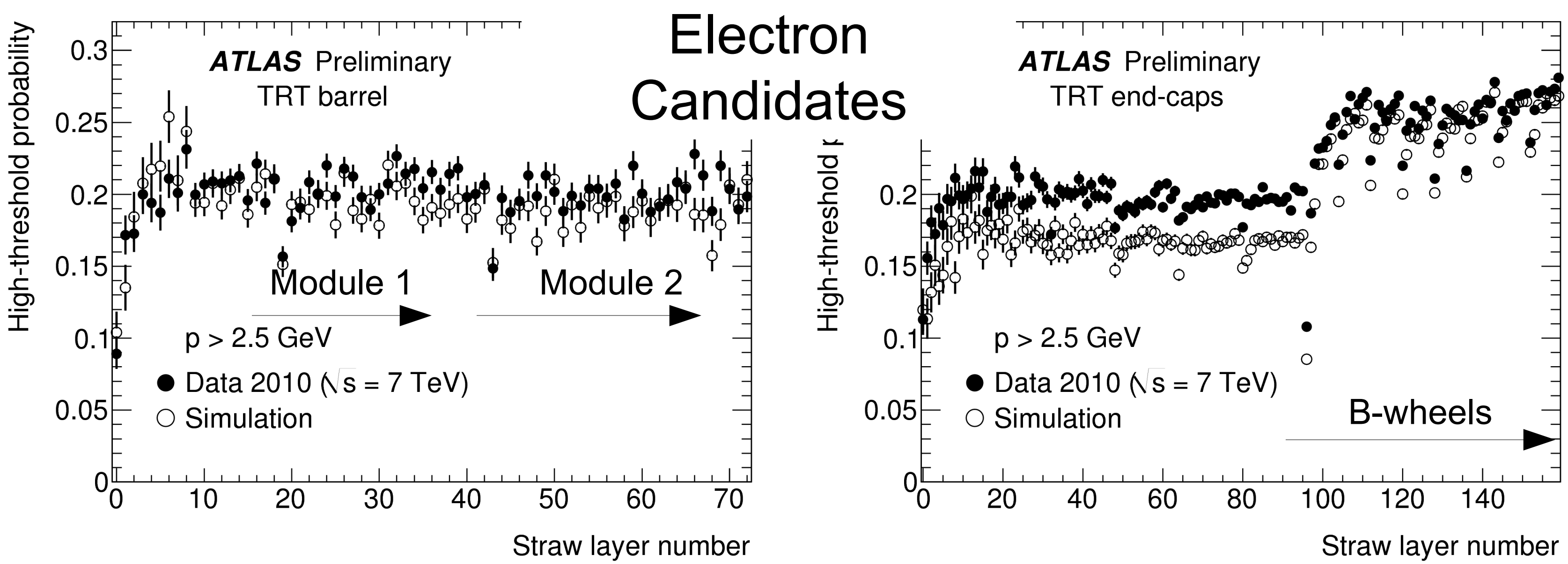
- Turn on behavior of TR is clearly visible as a function of Lorentz gamma
- Data is out performing MC expectations in the endcaps
- Only prototype barrel modules were available in the ATLAS Combined Test Beam, decreased ability to tune end-cap simulation as accurately before collision data



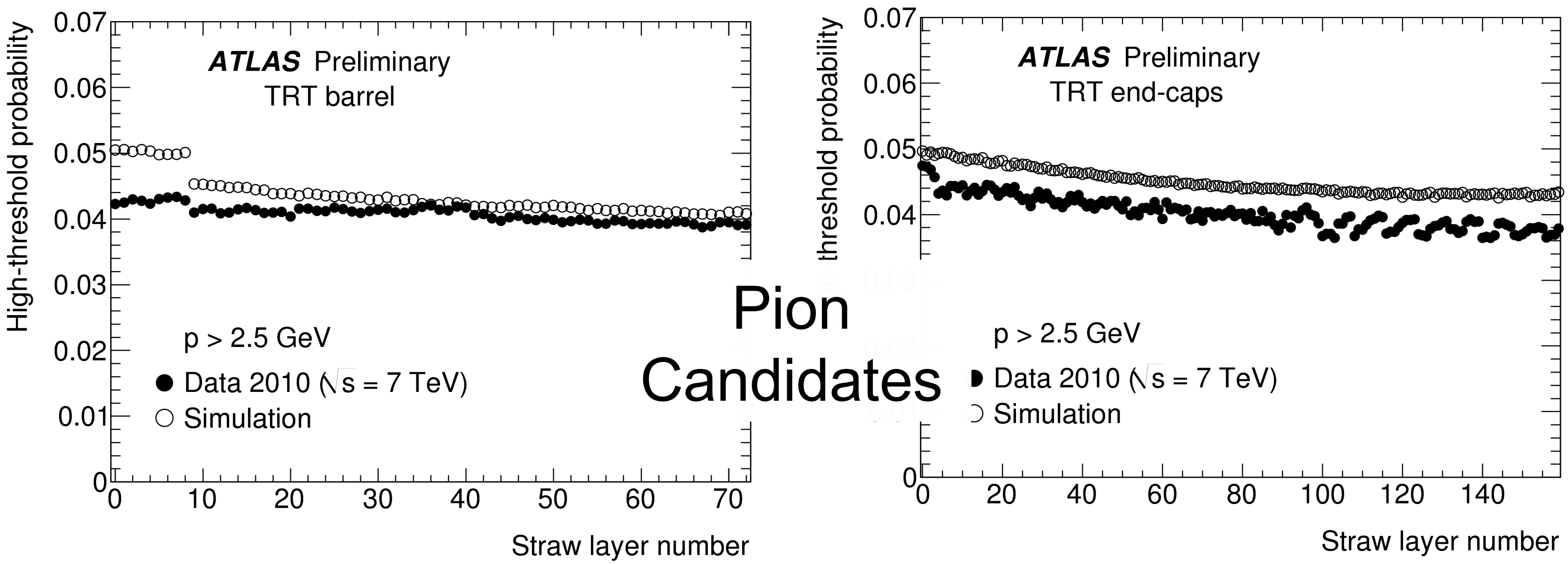




- TR also shows interesting dependence on the detector structure
  - “Build-up effect” between detector modules (in barrel) and wheels (in end-cap) reflect passive material between detecting elements



- In contrast, hadron candidates do not see this “build up” effect (no TR photons) – only differences in track lengths in straw leading to higher ionization on average
- Can be used to refine particle ID

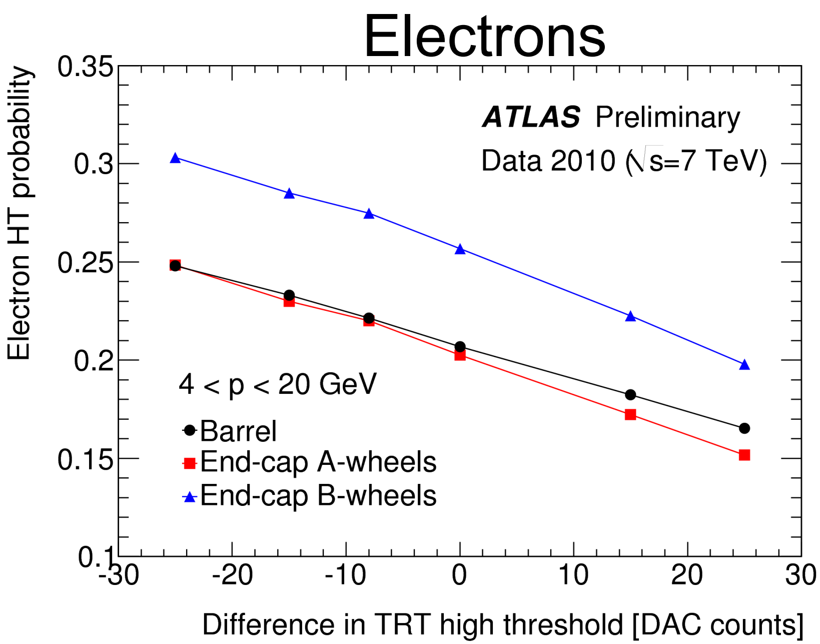


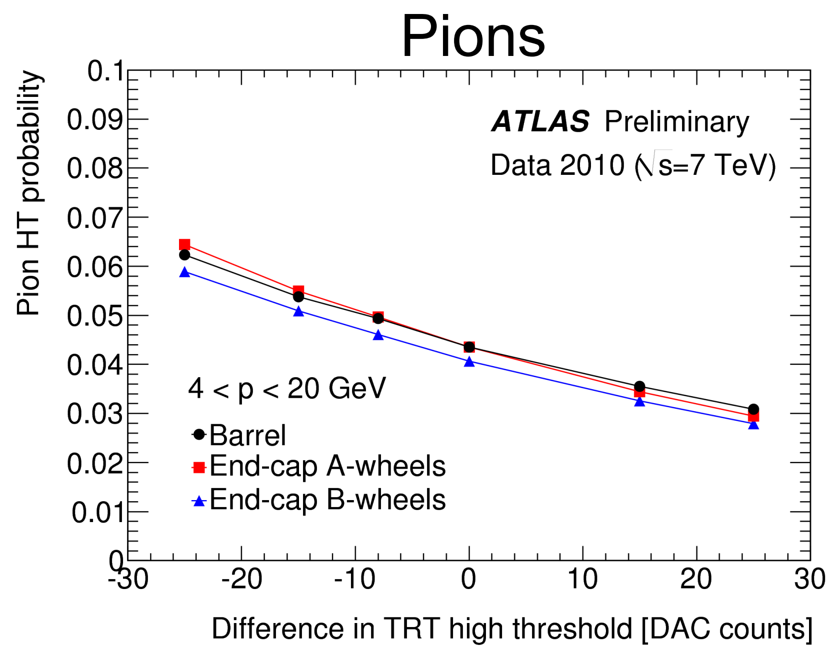
Pion Candidates

Validation of Hardware Settings

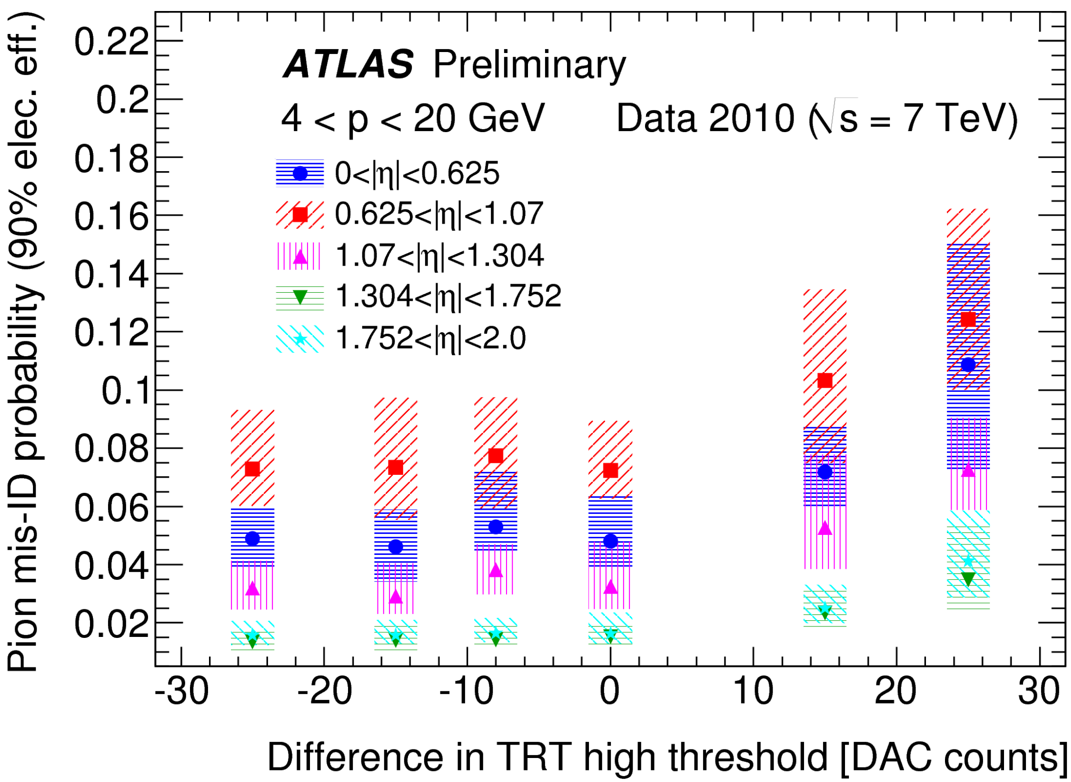
- Thresholds are adjustable through on-detector electronics, measured in Digital to Analogue Converter setting (DAC Counts)
- The initial high-threshold setting used was the value that gave maximum separation power in the combined test-beam
- The variation across the detector taken was into account by use of electronic noise scans
- Special run was taken Summer 2010 where thresholds were changed during the run on the fly
- A total of 20 nb^{-1} were taken at nominal, ±15, ± 25, and -8 DAC Counts

- Dependence on hardware threshold not well modeled in the simulation, so validation must be performed using real data

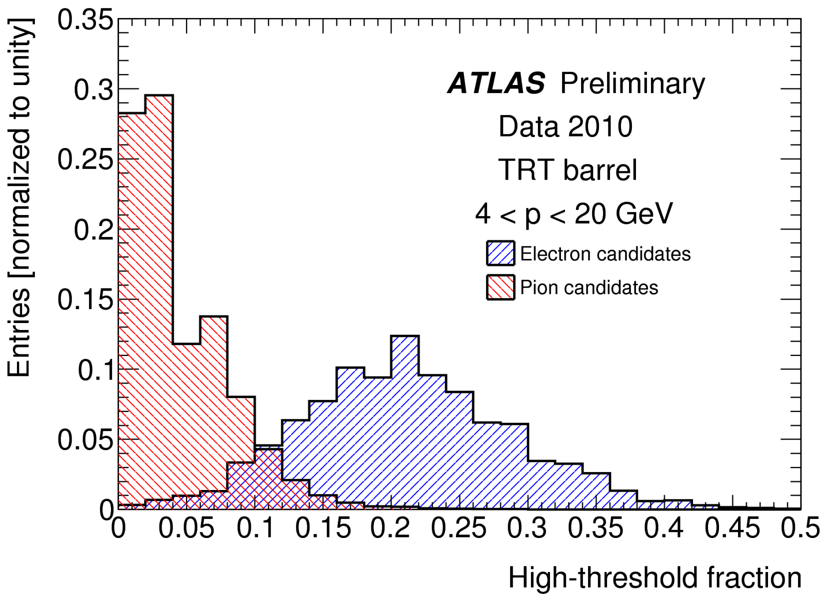


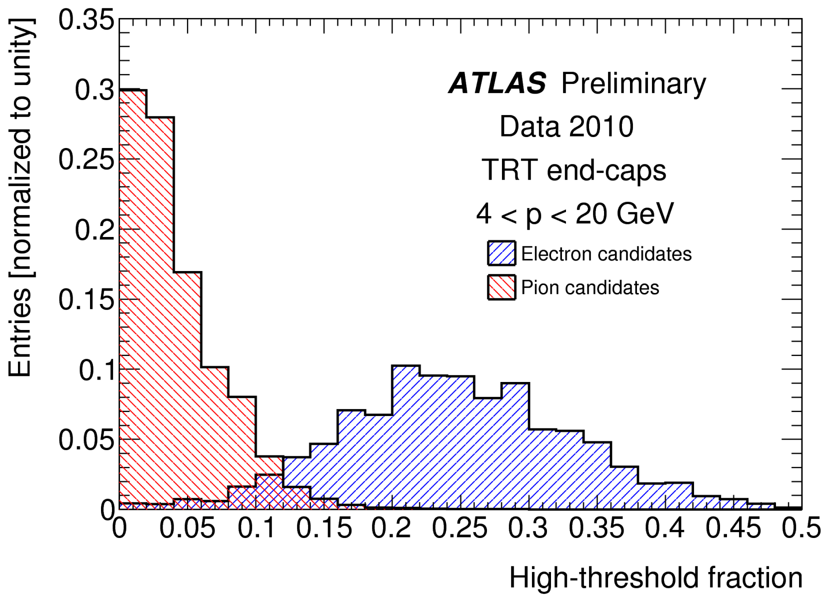


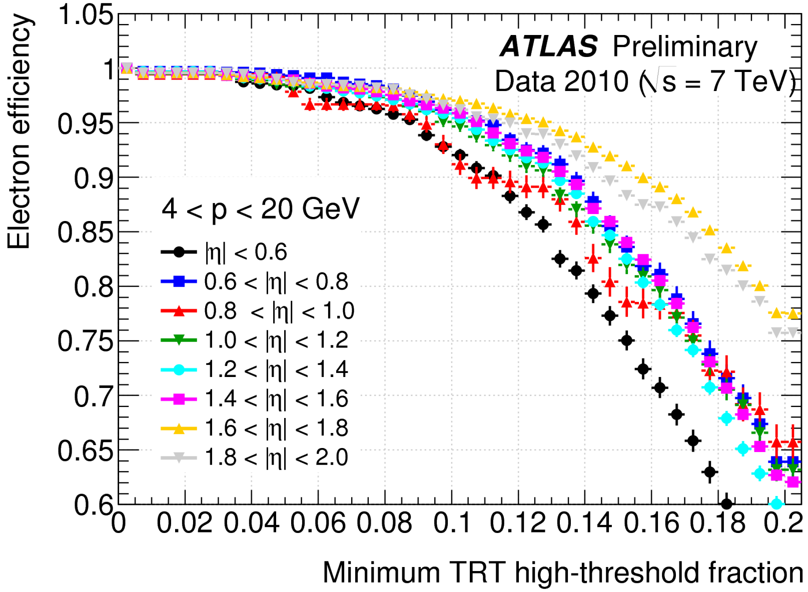
- The results of the test show that PID performance is stable for 2010 settings and lower, but degrades for higher settings
- The decision was made to lower slightly for 2011 in order to ensure stable data conditions
- The data was also used to refine chip-level high-threshold equalizations across the detector

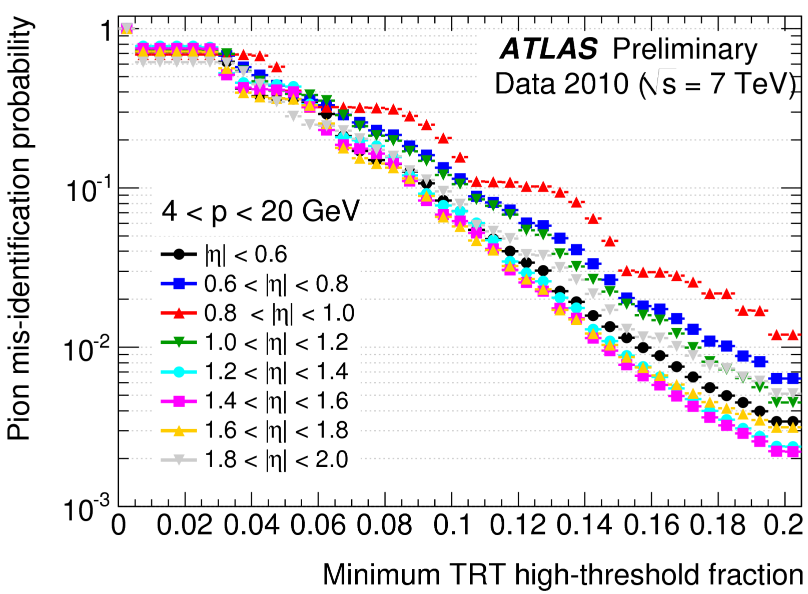


- Satisfied that hardware settings are optimal – proceed to detailed studies of the TR performance
- Concentrating on electrons that are above the TR threshold, good separation is seen in the fraction of HT hits



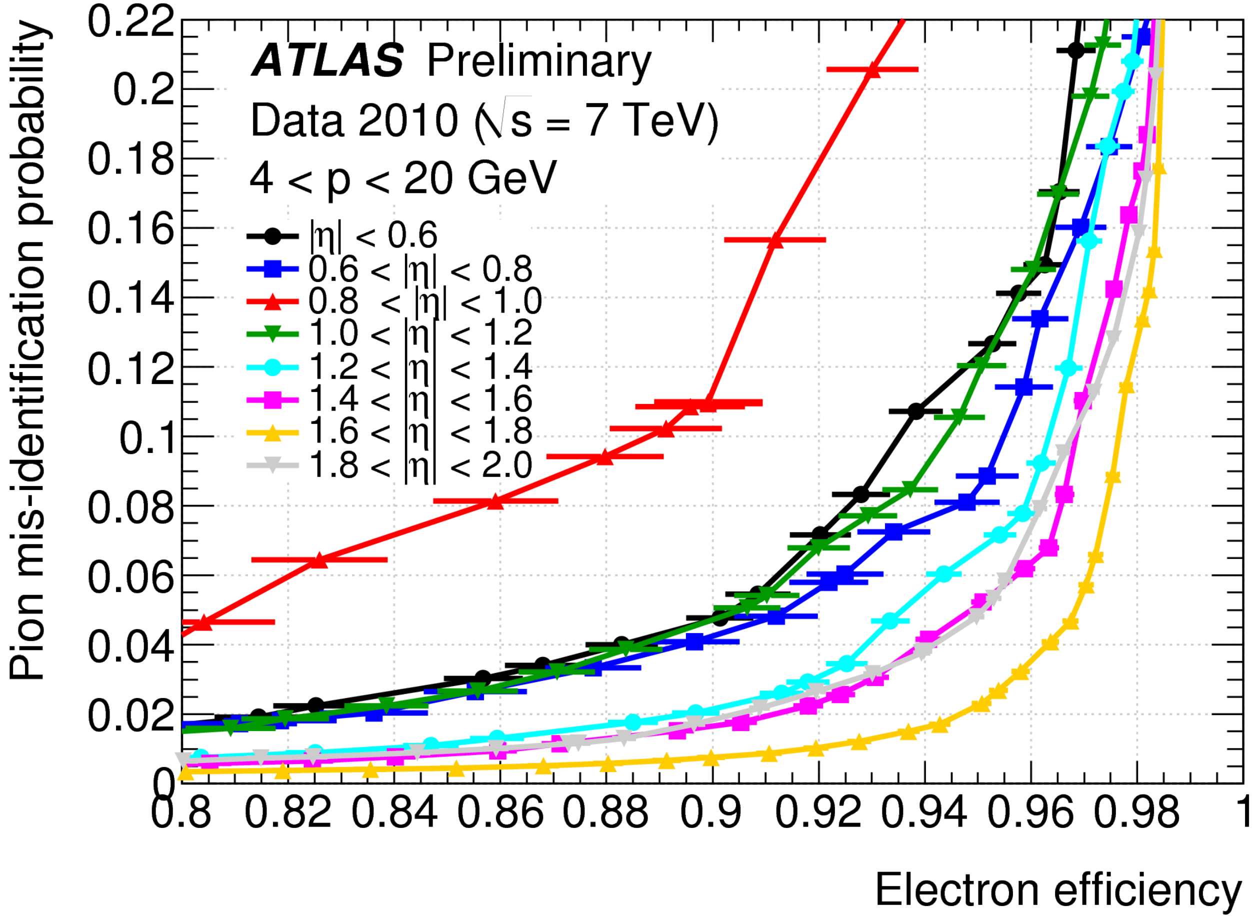




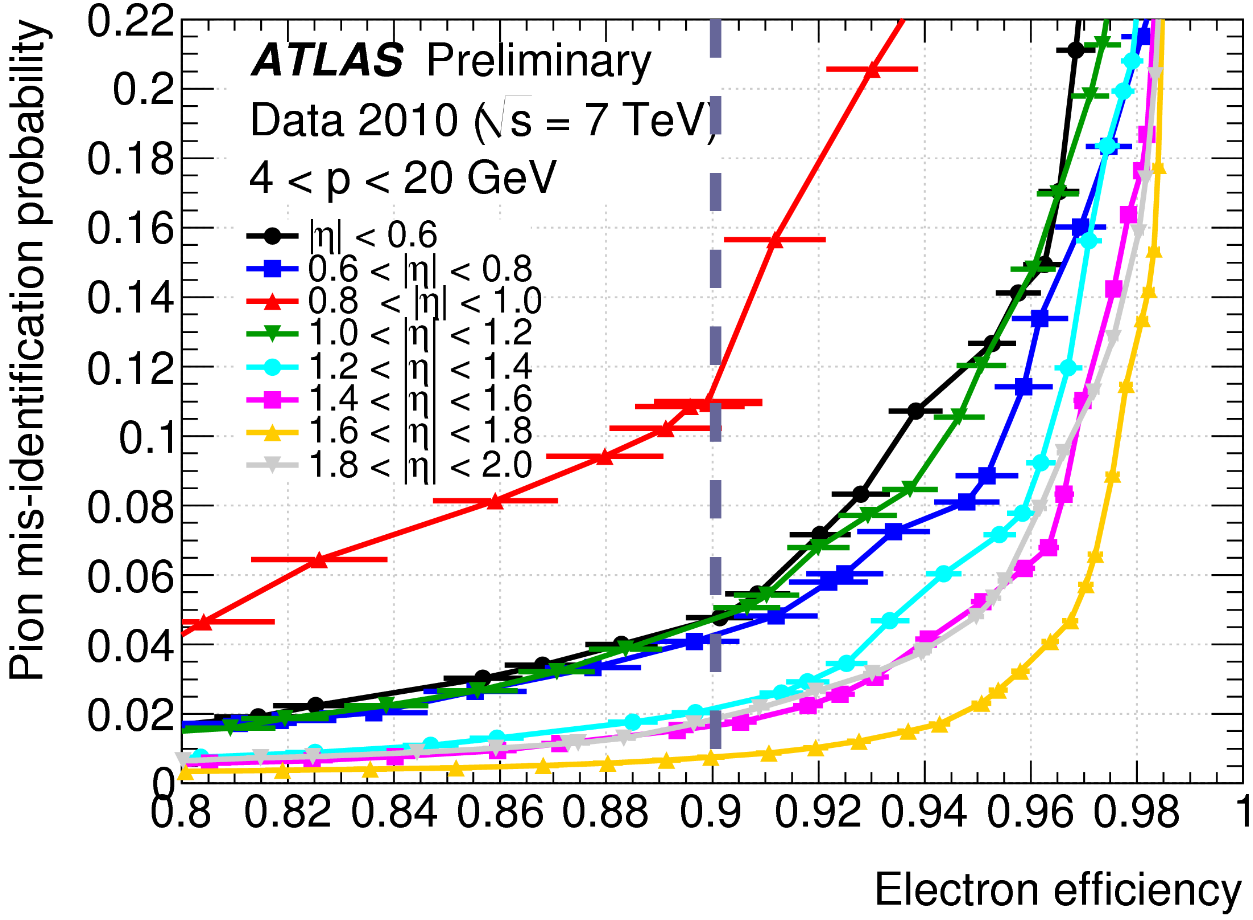


- Vary a cut on high-theshold fraction and see what the efficiency is for electron and pion candidates to pass this cut (Electron efficiency and Pion Mis-ID proability)
- Use finer η binning than previous plots, since high threshold response is greatly dependent on η
- Errors here are statistical only – no systematics for contamination taken into account
- As expected end-caps out perform barrel

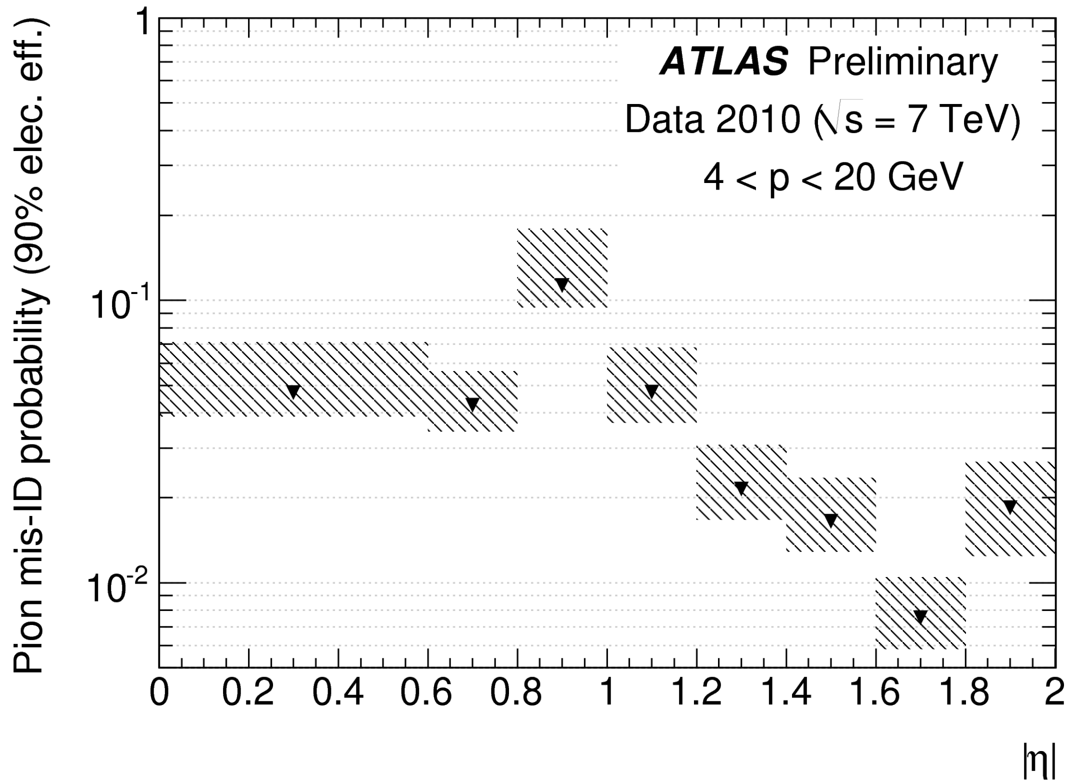
And combining the two:



Using the 90% electron efficiency as benchmark point

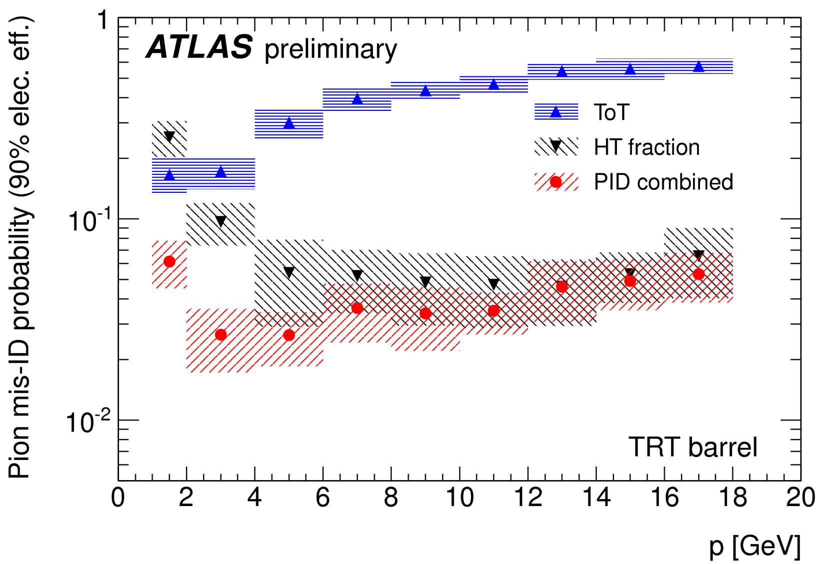


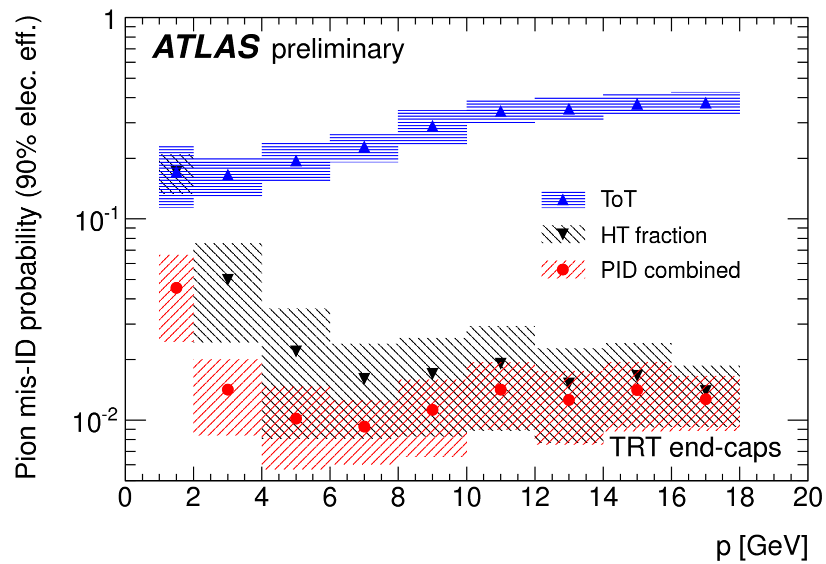
- Using 90% electron efficiency as a benchmark point, determine pion mid-ID probability
- Pion rejection factors >10 seen everywhere except transition region between barrel and endcap
- Greatest rejection of > 100 in the most efficient regions of the the endcap B-type wheels



Preview of Coming Attractions:

- Full PID power of the TRT exploits the combination of HT information with the additional separation power of Time over Threshold
  - Full talk by Jean-Francois Marchand on Friday on the use of ToT





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Summary and Conclusions

- Particle ID with the ATLAS TRT is performing very well
  - Even exceeding MC expectations in several ranges of η
- Pion rejection factors of 10-100 obtained for high-threshold cuts giving 90% electron efficiencies
- Detailed studies with Z->ee data coming from 2011 ~100x statistics from 2010