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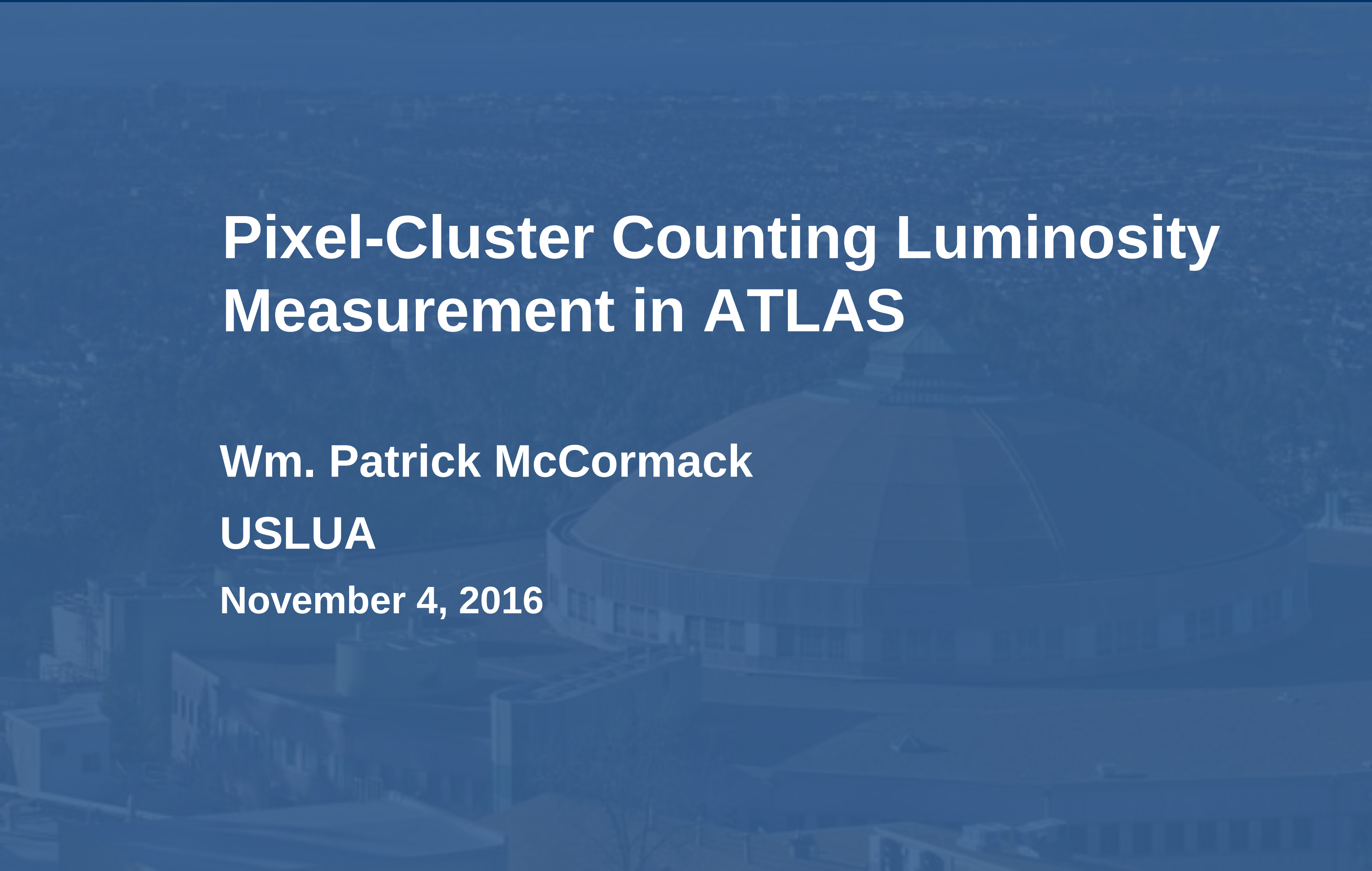

# Pixel-Cluster Counting Luminosity Measurement in ATLAS

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# Motivation

- Understanding luminosity vital to physics operations
- Several detectors monitor luminosity over long periods between calibrations

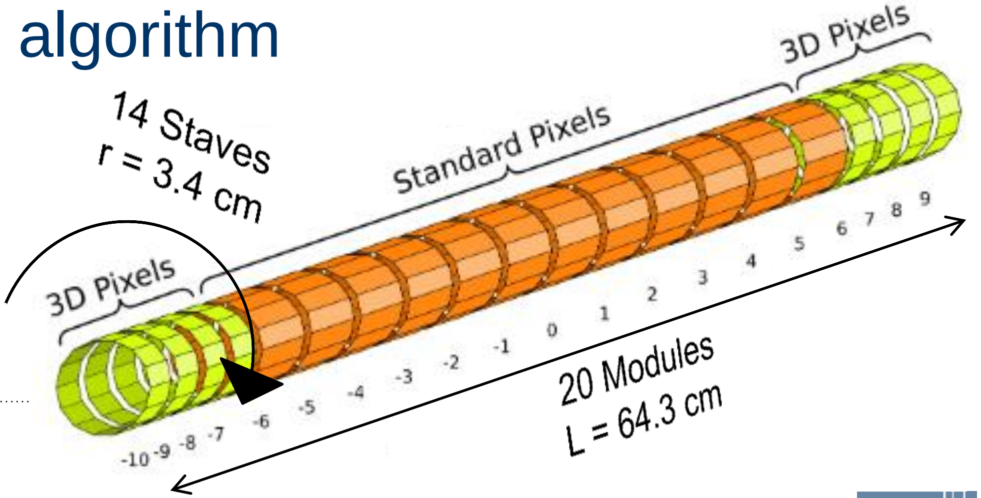
  -Track counting vital to transfer low luminosity to high luminosity calibration

- New algorithm: Pixel Cluster Counting (PCC) in IBL

  -Provide independent check of tracking values

  -PCC is CMS baseline algorithm

Layout of the Insertable b-Layer (IBL)

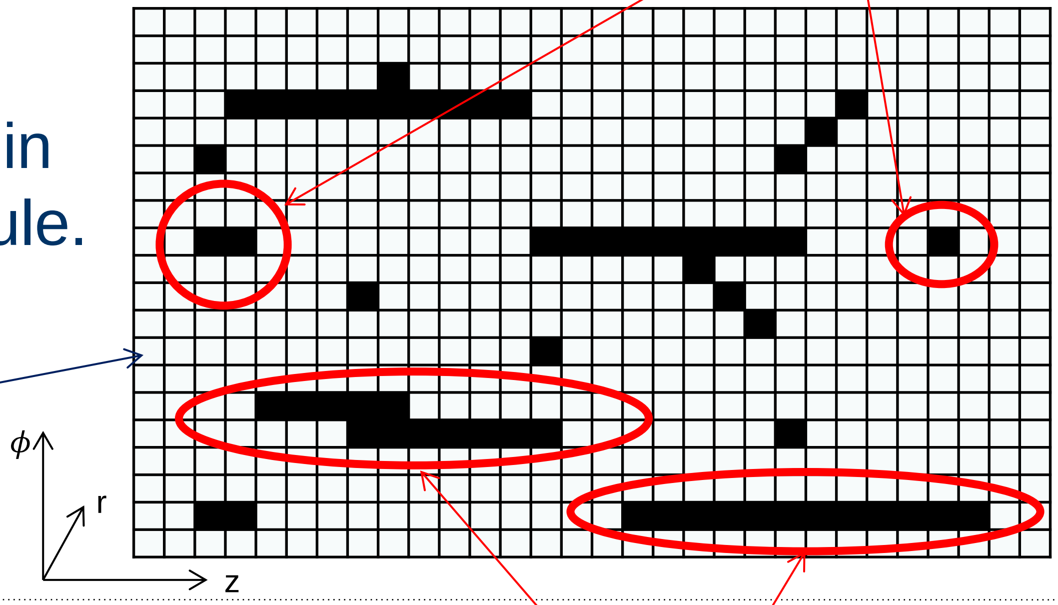


# Pixel clusters

- Groups of adjacent activated pixels in the ATLAS silicon pixel detector
- Not all clusters are created equal
- We should only count clusters from collision debris

Illustration of pixel clusters in a high $\eta$ module.

IBL Pixels are 250x50$\mu\text{m}^2$



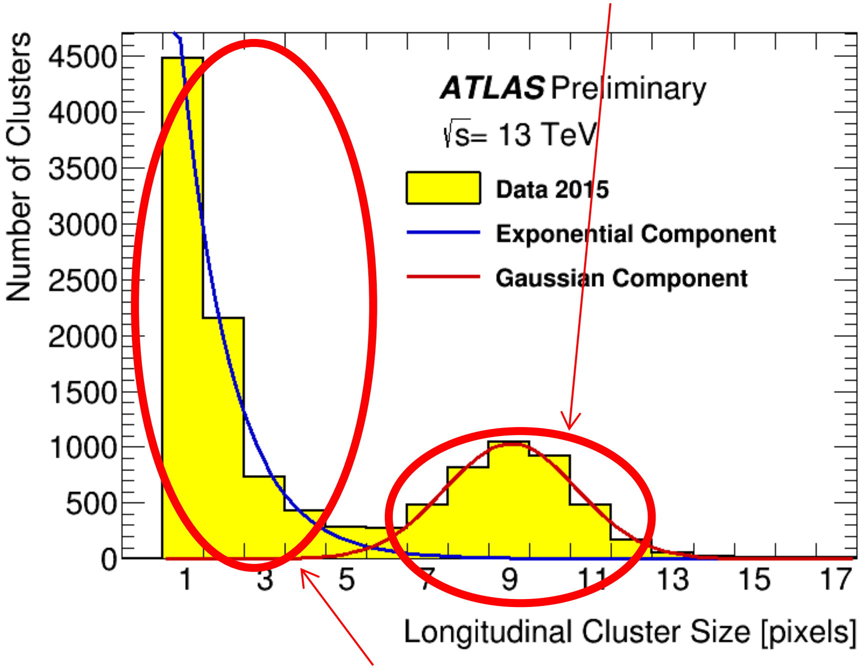
Short cluster examples

Long cluster examples

# Cluster length distribution

- Module's clusters modelled as a two-component function: Gaussian-shaped signal region of long clusters and an exponentially falling background
- Background results from afterglow, spiraling particles, broken clusters, hot pixels, etc.
- We will focus on the IBL's 3D modules; higher $\eta$ gives better background-signal separation

Signal region cluster length depends on $\eta$



Background region

https://cds.cern.ch/record/2201126

# Further control

- Taking the Gaussian signal-region area as our scaling variable, we solve the problem of counting the correct clusters
- Must control factors that influence signal-region area

-Module performance

-Beamspot position

-Beamspot size

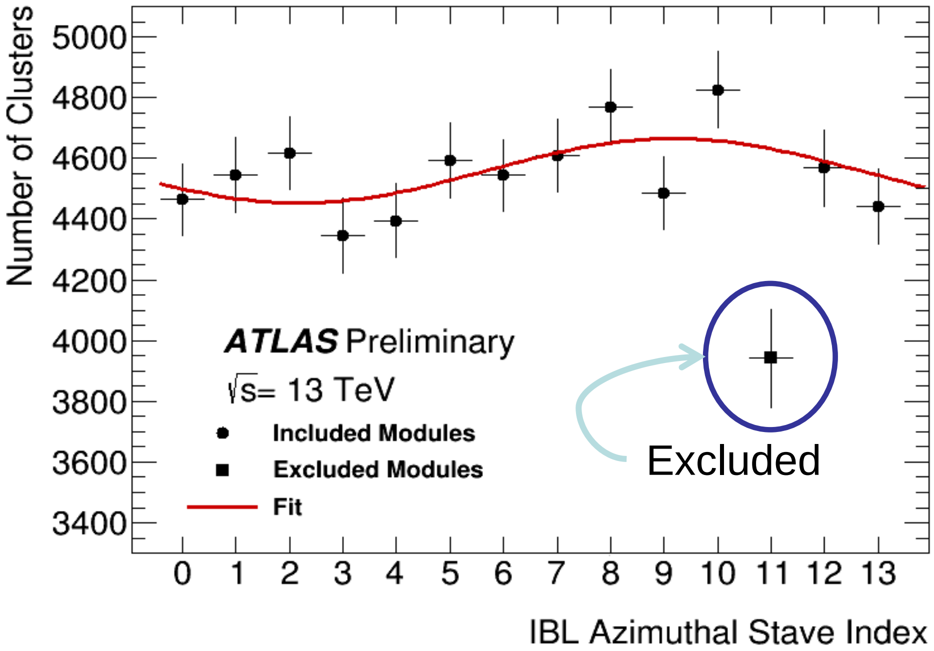
Missing pixels or hot pixels

3D modules’ acceptance depends on beamspot

Longer beampot increases signal-region area

# Example moderating variable: Module performance

- Not all modules perform with perfect efficiency
- Find the average signal region around an $\eta$-ring and exclude outliers



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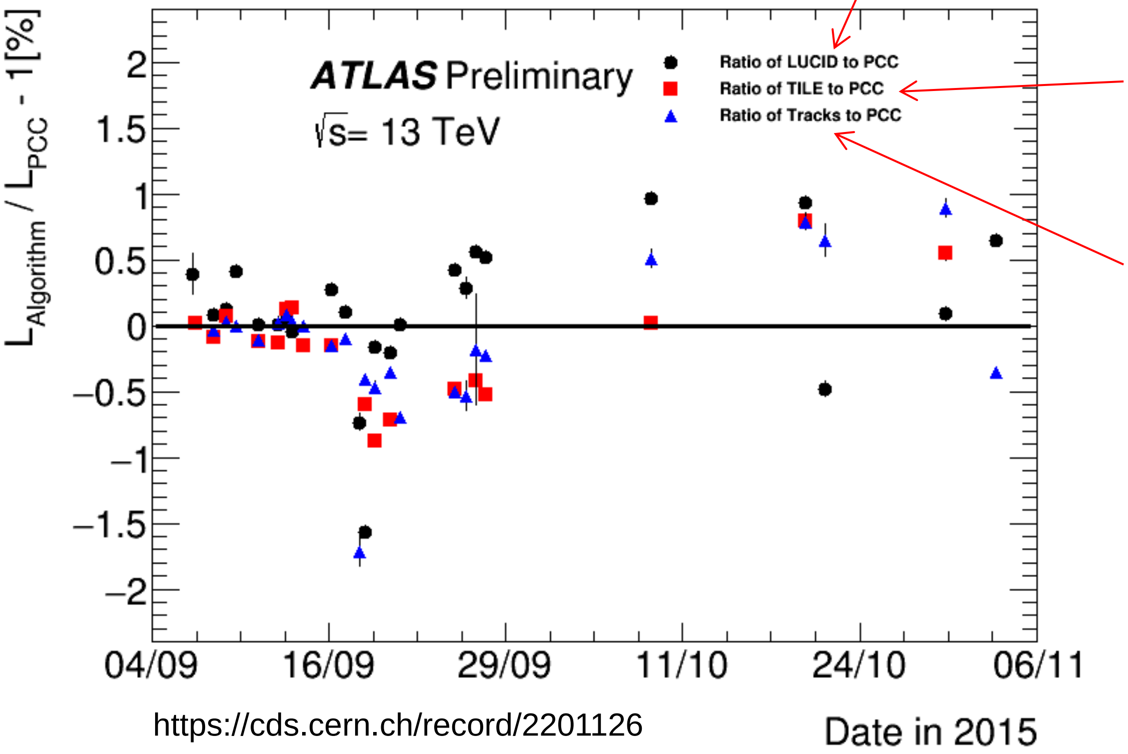
# Results



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Luminosity specific C4F10 front-end Cherenkov detector

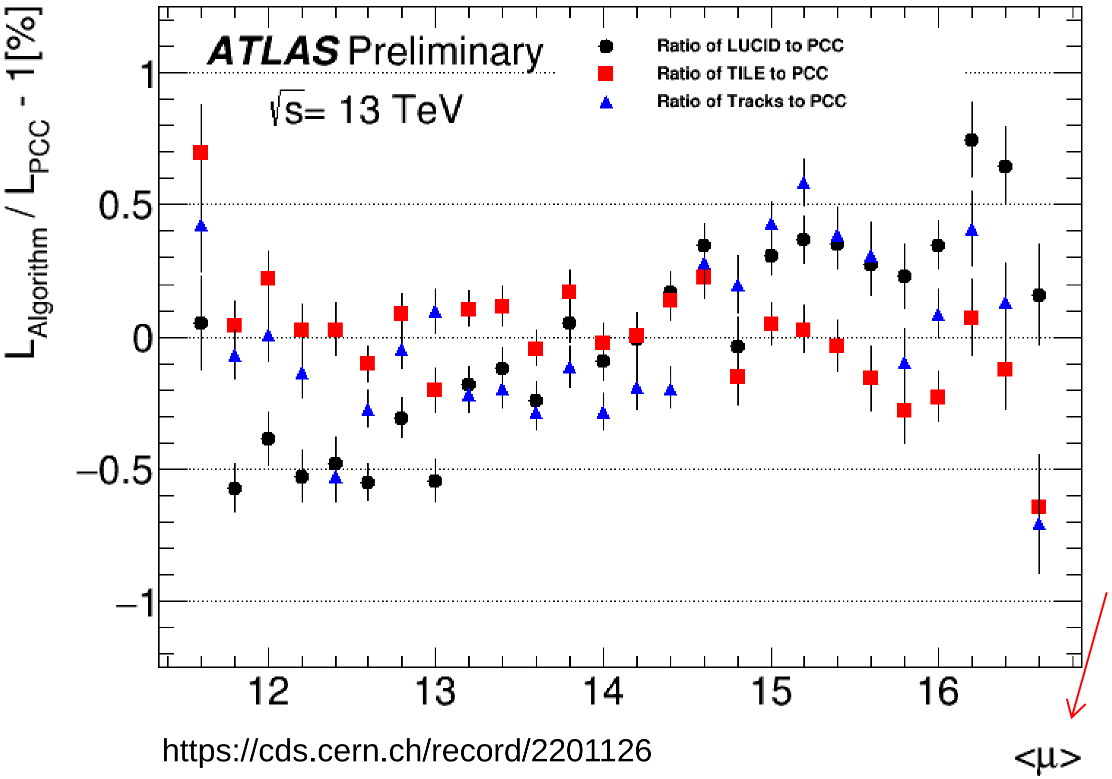
Based on calorimeter activity

Based on track counting

→Luminosity algorithms must be stable with respect to time

→PCC is stable with respect to other algorithms to ±1%

# Results



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Number of interactions per bunch crossing

→Luminosity algorithms must be stable with respect to pileup

→PCC is stable with respect to other algorithms to ±1%

# Conclusions

- PCC-derived luminosities are stable with respect to other ATLAS luminosity measurements to within $\pm 1\%$ or better
- Method will be competitive with other relative-luminosity monitoring strategies

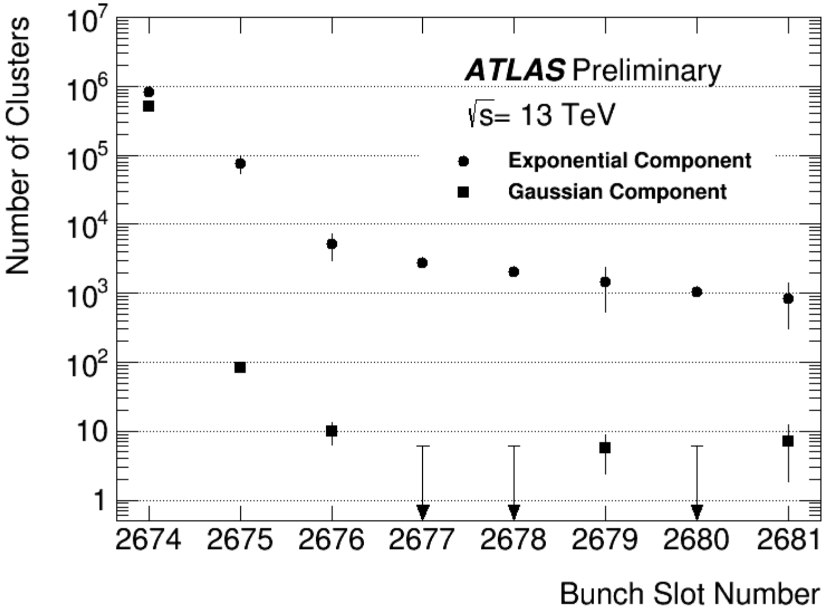
# Future Work

- Analyze 2016 data
- Implement algorithm at official level

# Backup

# Afterglow

- Collision debris activate detector material, producing delayed background of short clusters that decays much more slowly than luminosity-induced cluster count
- Effect moderated by considering signal-region clusters



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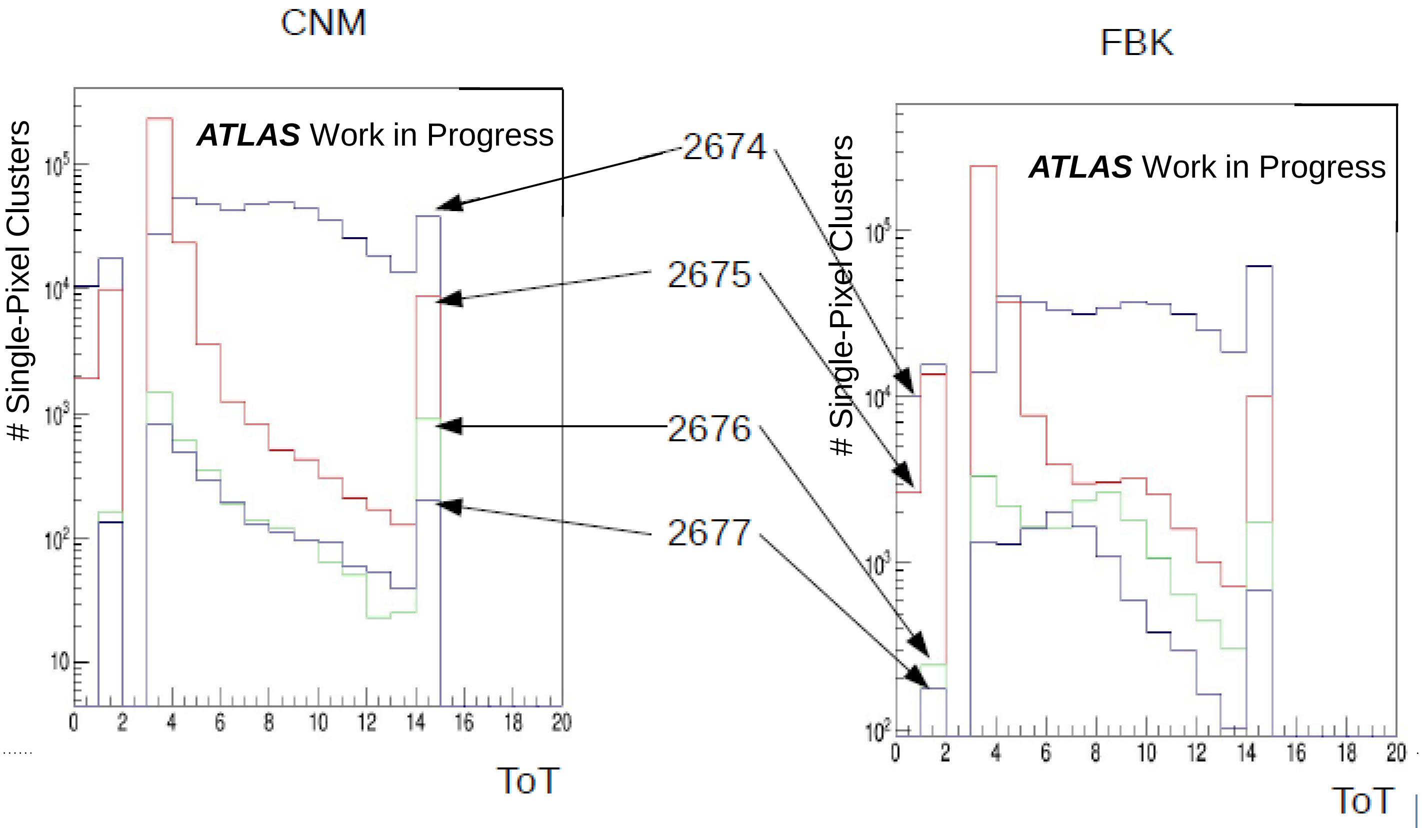
# Single pixel hits

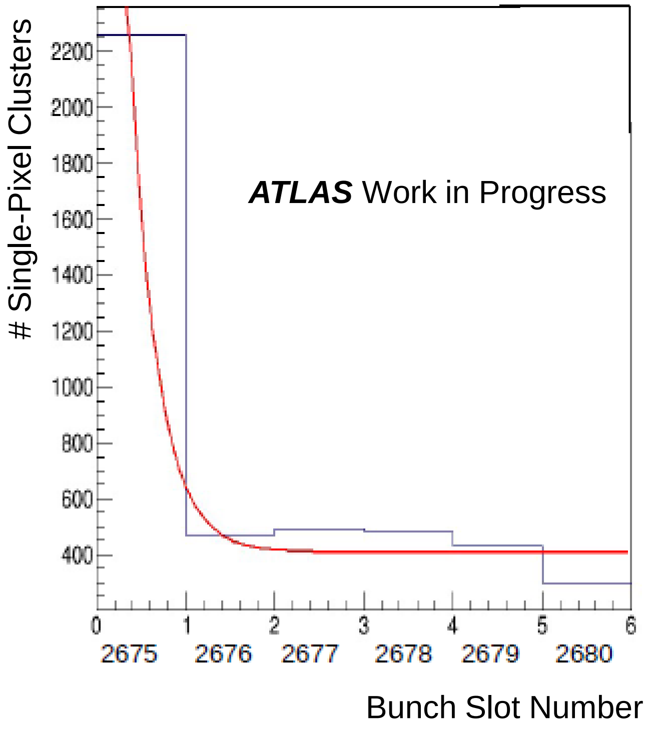
- What materials give us afterglow: examine single pixel hits as a function of time (after a collision)
- Different manufacturers give different characteristic decays!

Different ToT distributions for single pixel clusters in empty BCIDs.

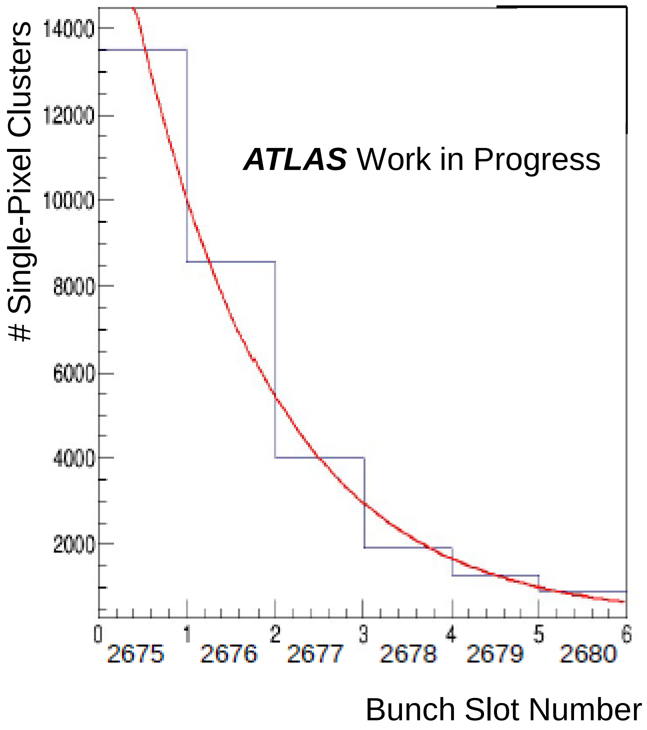


# Are different materials activated?

CNM



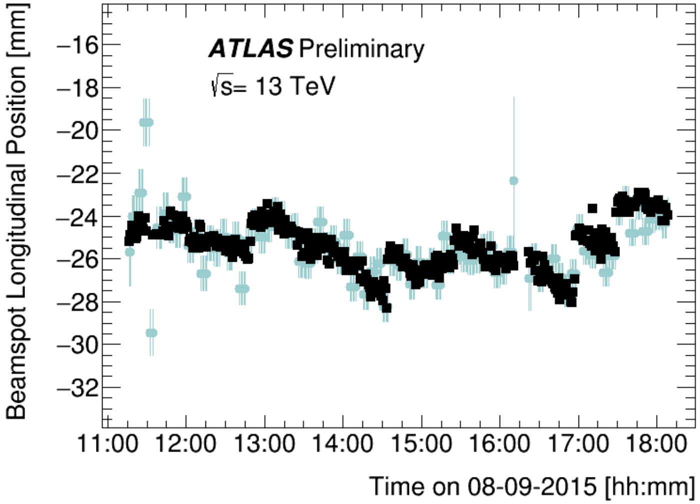
FBK

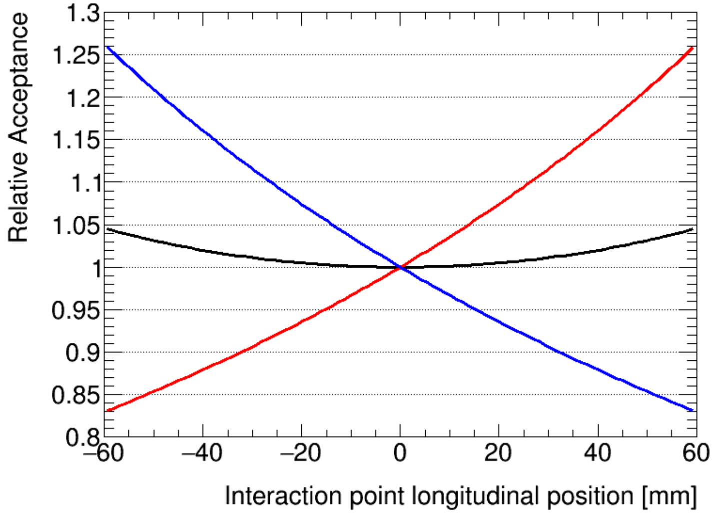


Chips from the two manufacturers have different ToT distributions for single pixel clusters in empty BCIDs

# Moderating variable: Beamspot position

- Drift in the beamspot gives forward-backward asymmetry in signal region of cluster-length distribution
- This can be used to compute longitudinal position of the beamspot
- Change in acceptance must be accounted for





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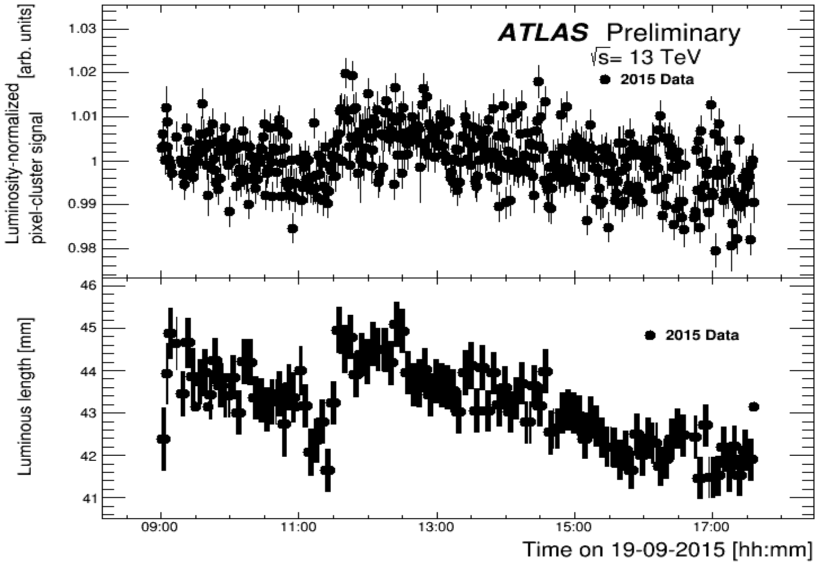
# Moderating variable: Beamspot size

- Longer beamspot produces more signal-region clusters
- The total correction is of the form:

$$Gaussian\ signal\ area \rightarrow \frac{Area}{1 + c_1 * (position)^2 + c_2 * (length)}$$



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