

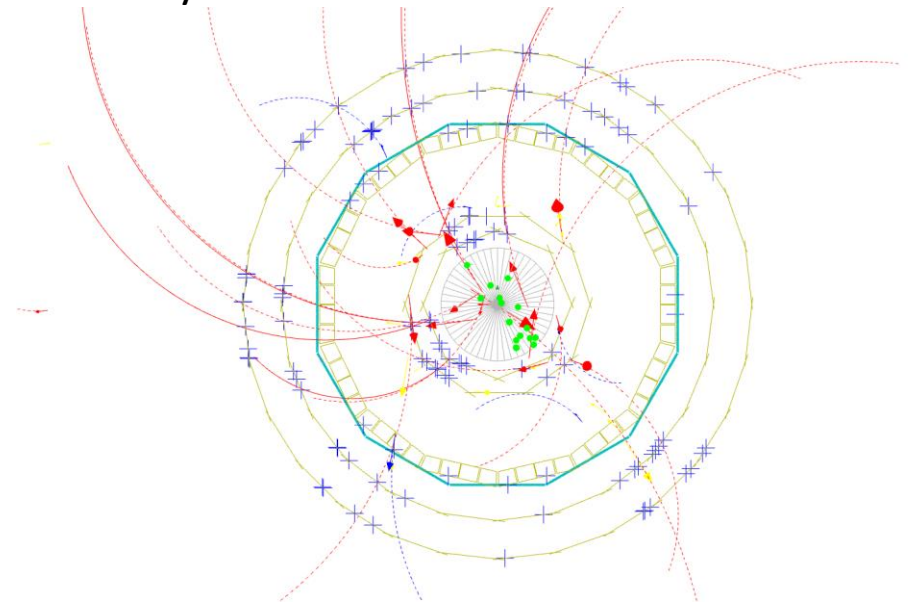
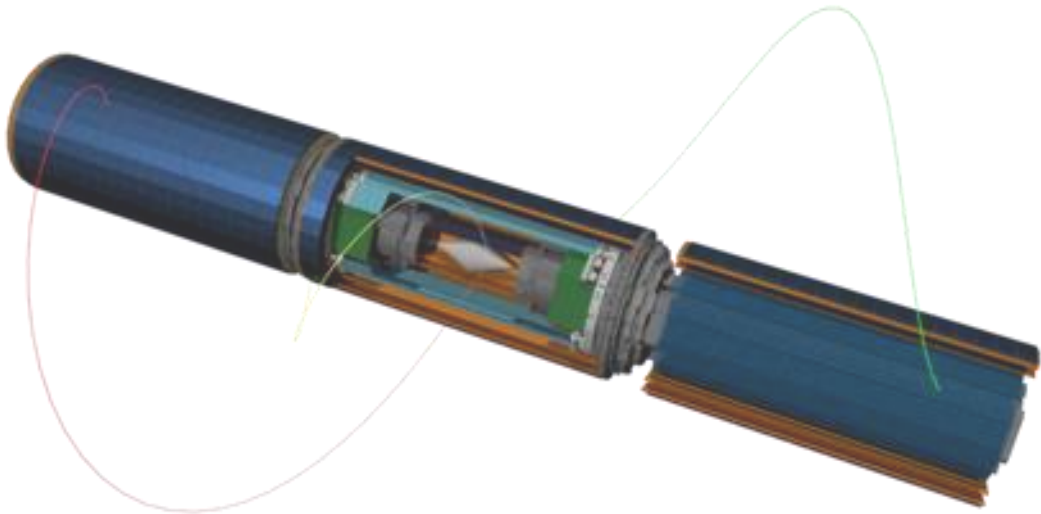


Simulation studies on the Mu3e tile detector

Clustering & Time alignment

Erik Steinkamp & Maximilian Köper for the Mu3e collaboration

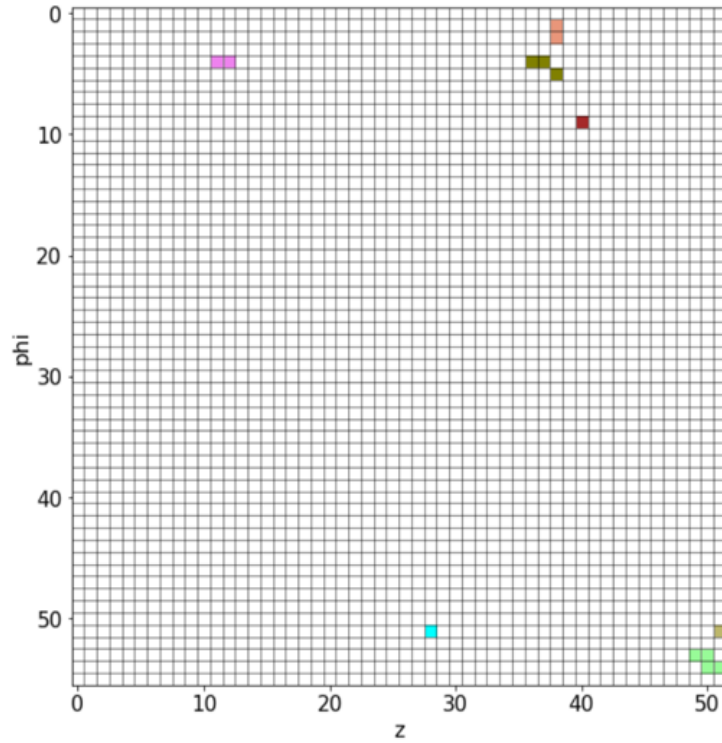
Kichhoff-Institute for Physics, Heidelberg University



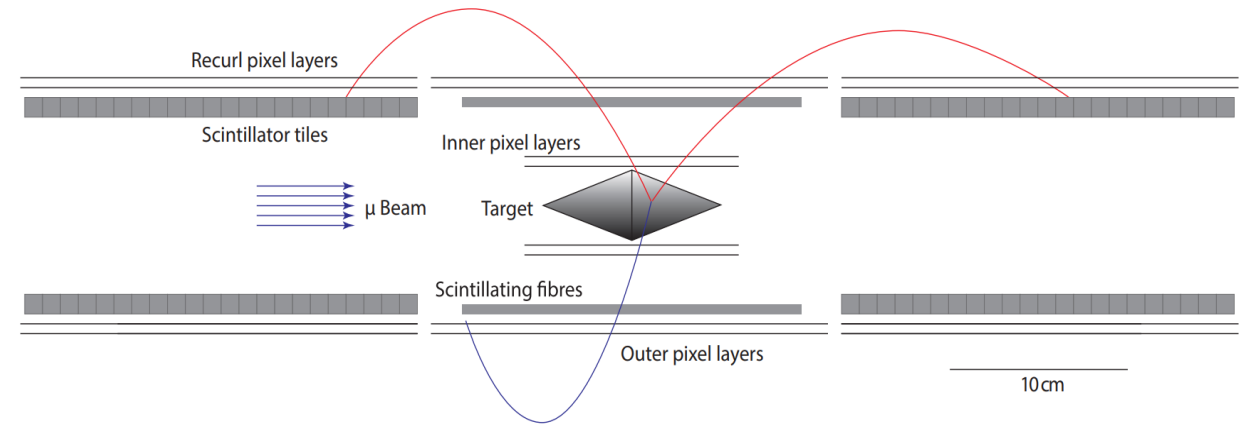


Introduction

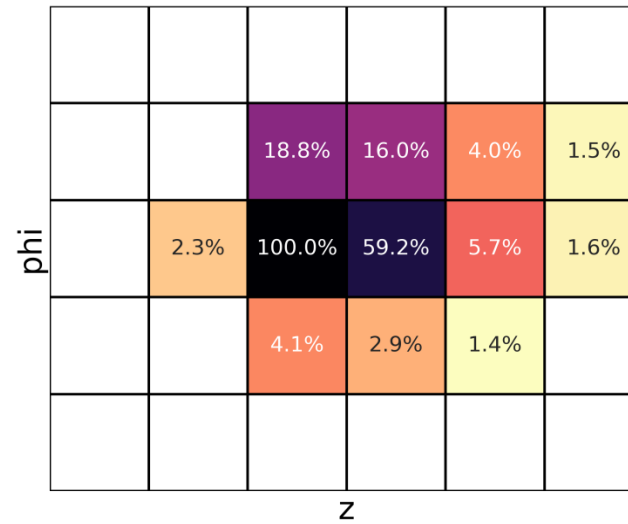
Cluster hits on detector plane



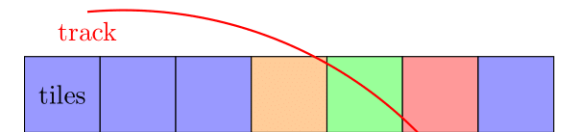
Schematics of the Mu3e detector



Downstream cluster map



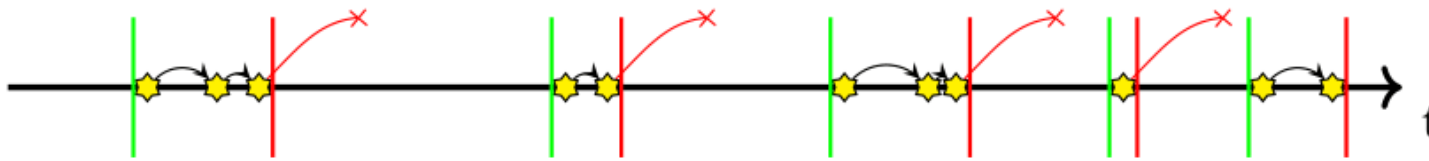
Cluster creation



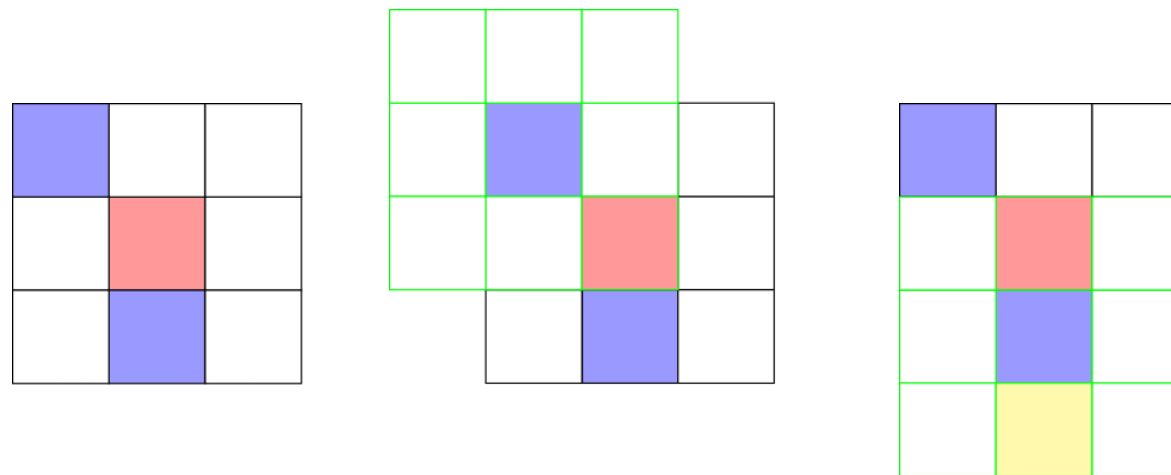


Clustering algorithm

1. Simple time segmentation using threshold to next hit



2. Spatial clustering using the time clusters as first "rough" cut



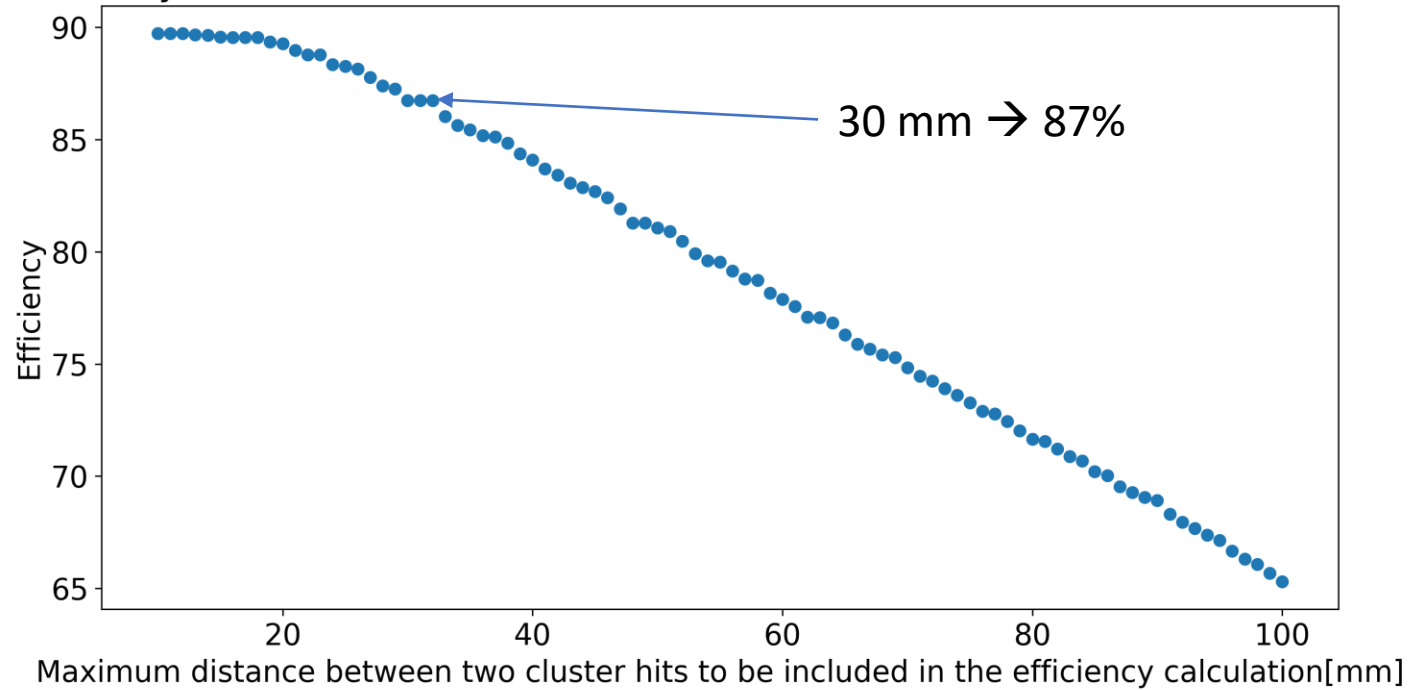


Clustering results

Efficiency:

Percentage of hits that have been assigned to the correct cluster/ Track ID

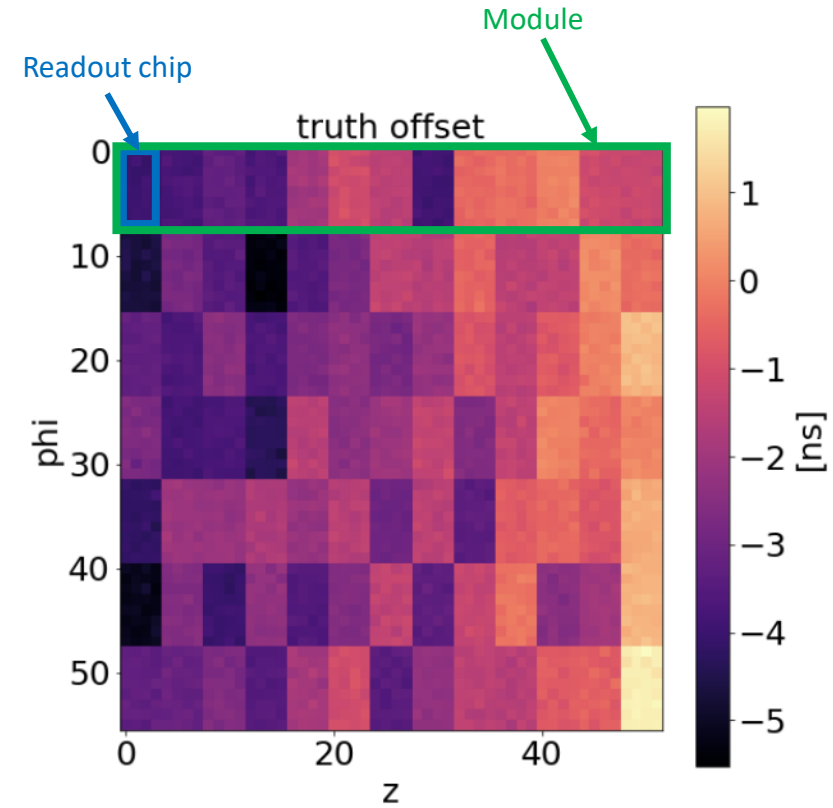
Efficiency as function of the maximum distance between clusters with same TID





Time alignment – Motivation and Requirements

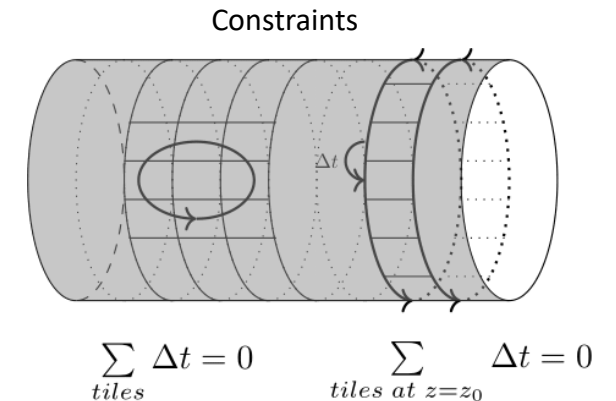
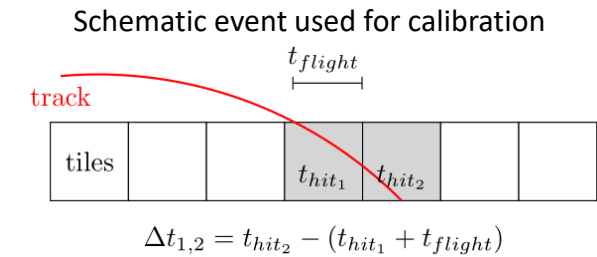
- Time delay in each channel is different
 - Wire length / electronic delays
- All channels need to be aligned to a reference
 - Accuracy must meet the timing requirement $O(10ps)$
- Miscalibration model implements different offsets for:
 - Channels/Pixels
 - Readout chips
 - Modules
 - Stations





Time alignment

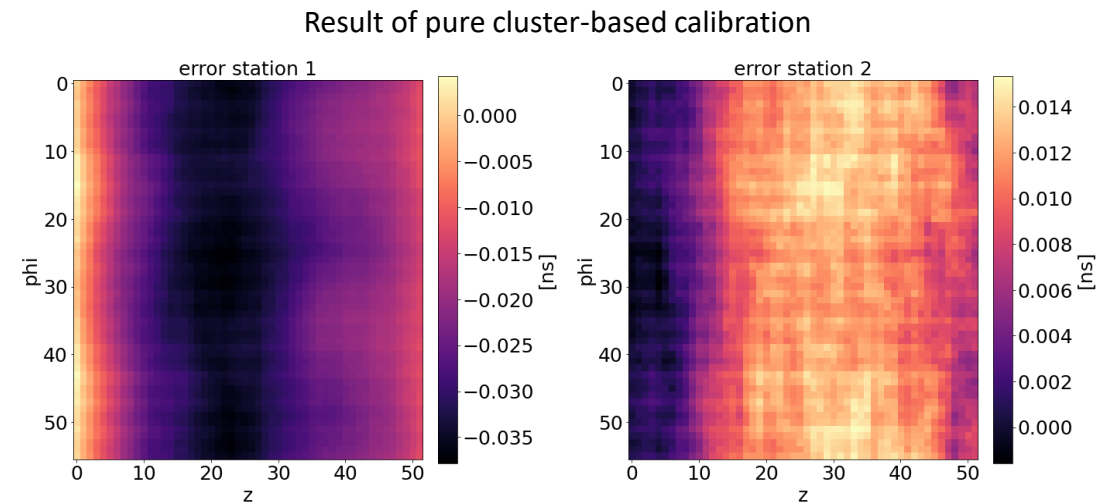
- Alignment is high order minimization problem
- Using the time difference between two hits in neighboring tiles
- This results in only correlations between directly neighboring tiles
- Need for constraints to minimize systematic errors





Time alignment

- Result for cluster-based calibration with improvements with constraints:
 - Max deviation to truth: ± 15 ps
- Error in z direction dominates due to the lack of an accurate time-of-flight correction model

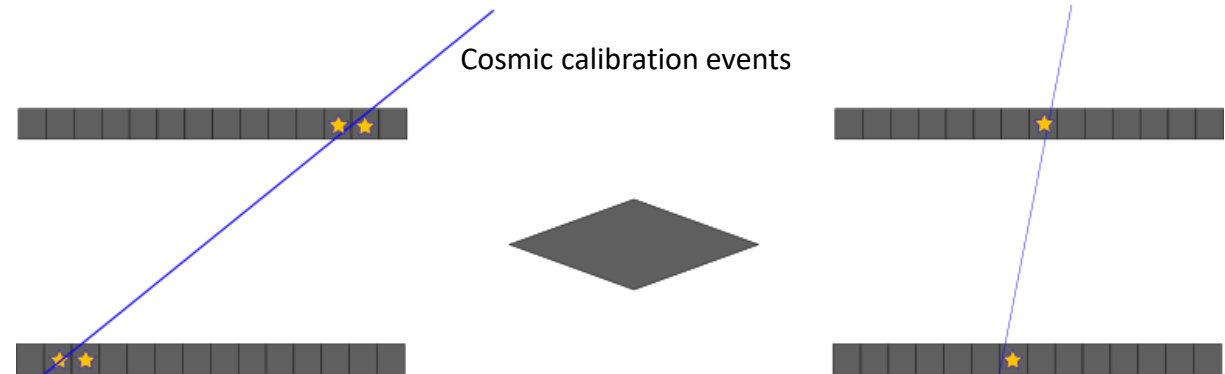
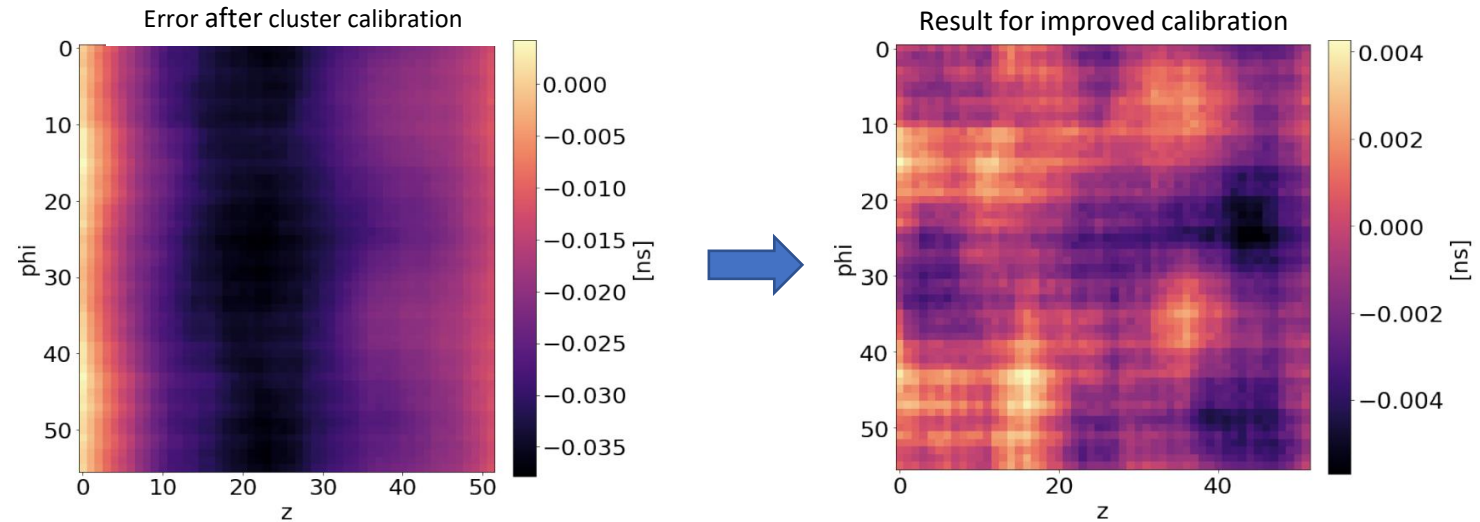




Time alignment – Correction using cosmics

$$F(z) = \sum_{i=0}^{N=3} \left(s_i * \sin\left(\pi \frac{z}{52} * i\right) + c_i * \cos\left(\pi \frac{z}{52} * i\right) \right)$$

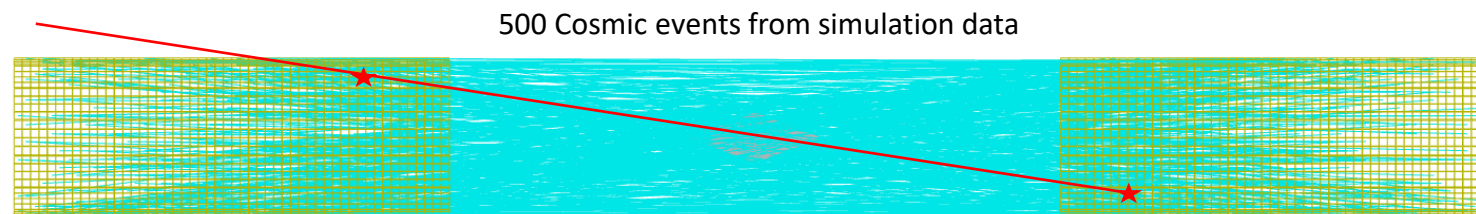
- Correcting calibration with cosmics:
 - At least 4 hours of data needed
 - Max deviation: $\pm 5ps$
 - Sigma deviation: $\sigma = 1.6ps$





Inter-station alignment

- Inter-station offset is only remaining degree of freedom
 - Only 100 events needed for $\sigma \leq 10ps$
- Cosmic muons with hits in both stations can be used to calculate the inter-station offset
- Expected muon rate, which fulfills the condition to hit both stations is $R = 0.009 Hz$
 - Enough statistics within a few hours of data taking





Summary



- Clustering of tile hits using spatial and temporal information:
 - Efficiency of 87% for MC truth clusters limited to a size of 30 mm
 - Possible future improvements using tracking
- Time alignment:
 - Cluster-based calibration achieves good results (± 15 ps)
 - Cluster-based calibration combined with cosmics improves this to ± 5 ps
 - Inter-station calibration with cosmics is possible
 - Possible future improvements using other subdetectors



Backup



Time alignment

