ALERT Track reconstruction progress report

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Outline

Kalman Filter Propagator

Use more than 2 hits per layer

Distance resolution with ADC and Time

Implement the electron vertex

Make the Kalman Filter reusable

Clean bad AHDC hits

AHDC geometry issue

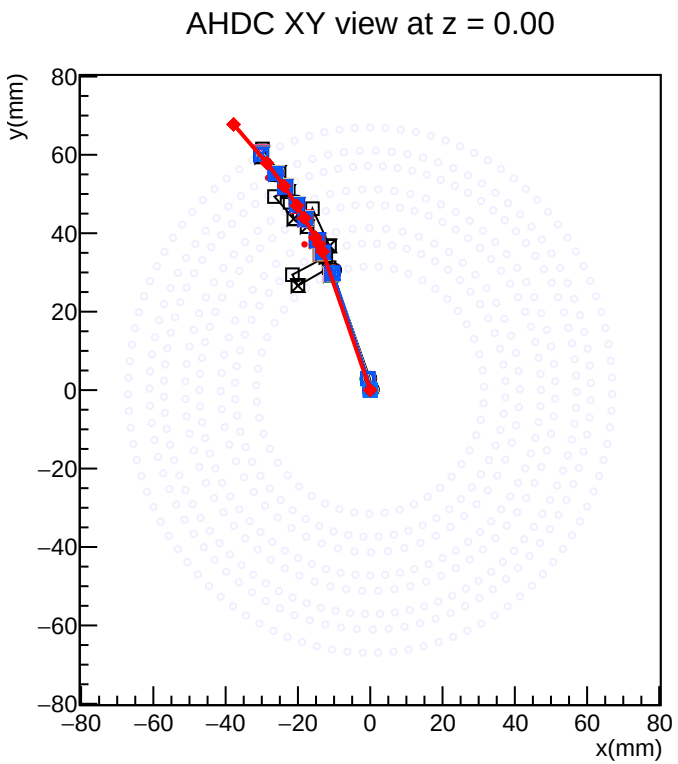
Include the ATOF hits in the KF

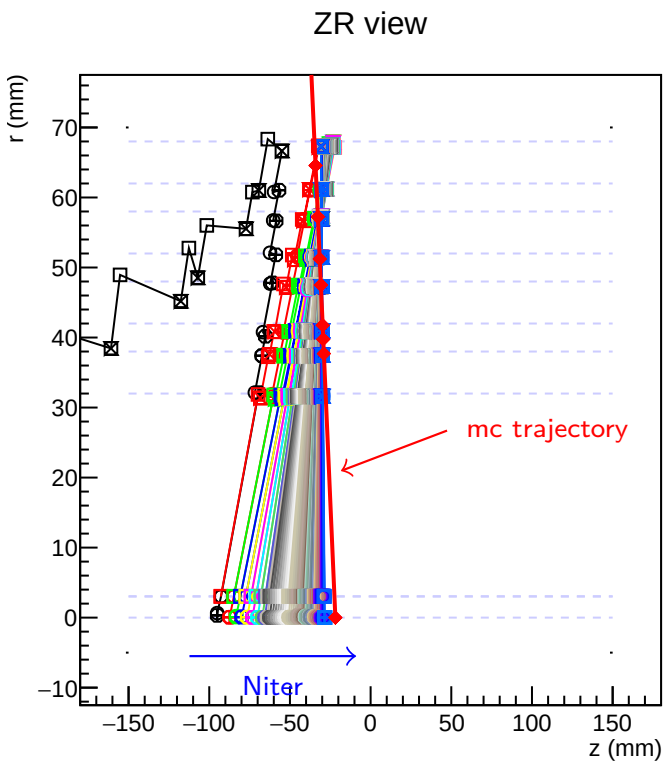
Reconstruction status

Next steps

Kalman Filter Propagator

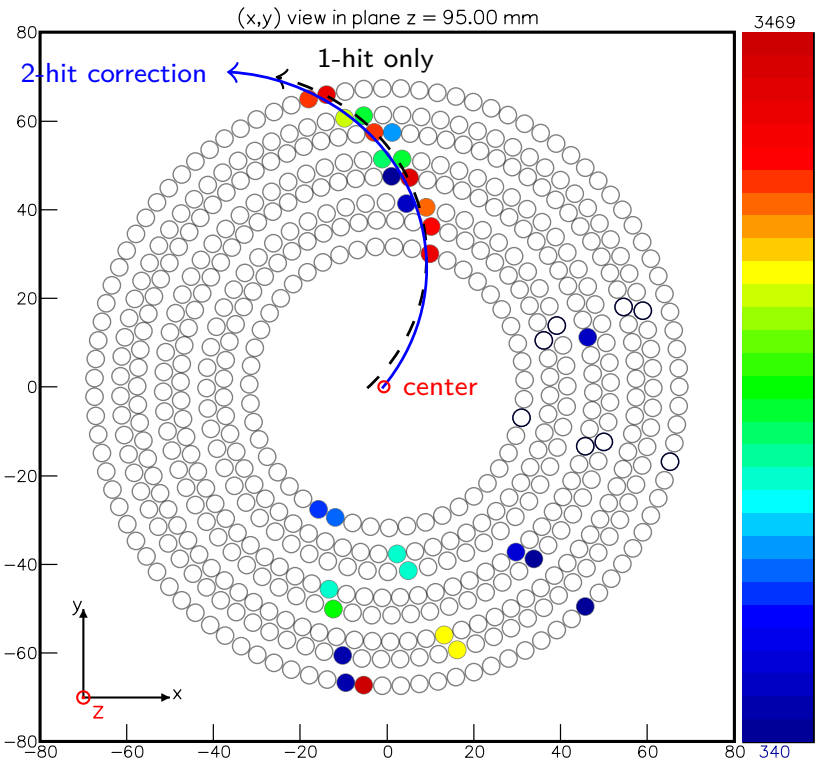
- We noticed that the Kalman Filter needed a lot of iterations in order to converge
- That increased the computation time
- We improved the Propagator algorithm
  - cleaning, object merging
  - better management of the step size of the RK4
- We reduced the initial computing time by a factor 8

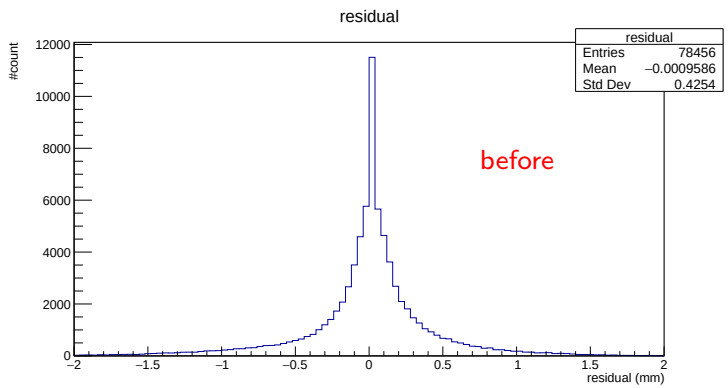


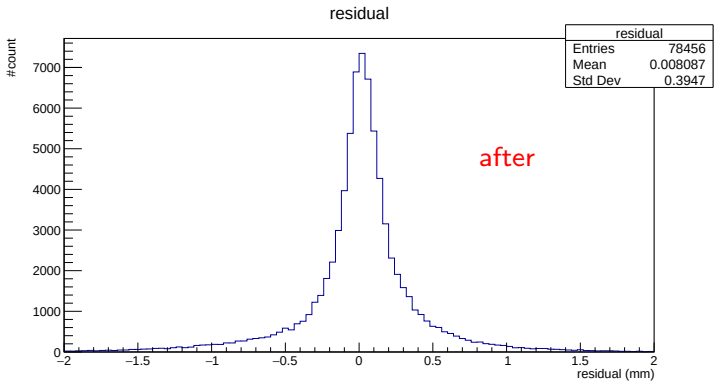


Use more than 2 hits per layer

- Before, the Kalman Filter only managed one hit per layer
- Having two hits on the layer is extra information (see 1-hit only track versus 2-hit correction track; residual before and after for simulation)
- However, now that we can have more than 2 hits per layer, we have to take into the deposited energy of the hits to balance their effect

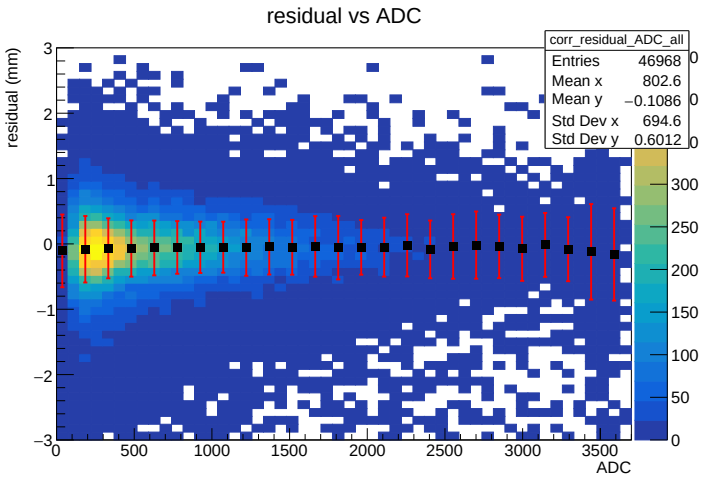


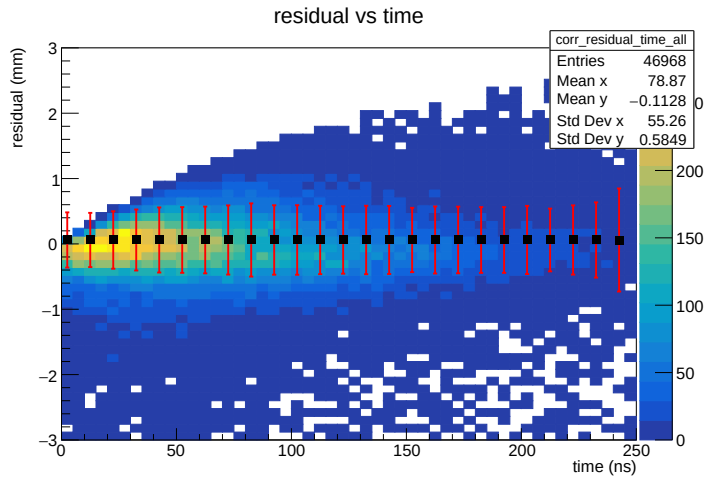


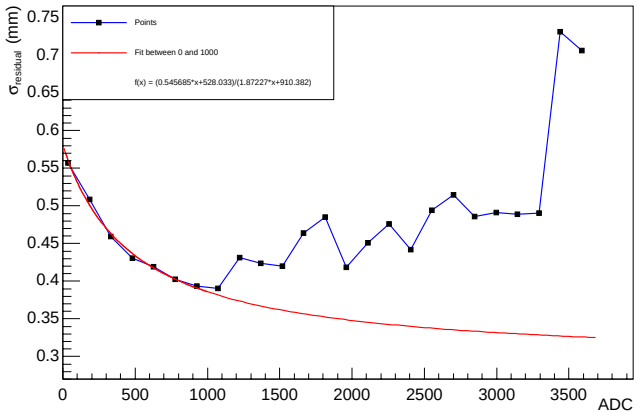


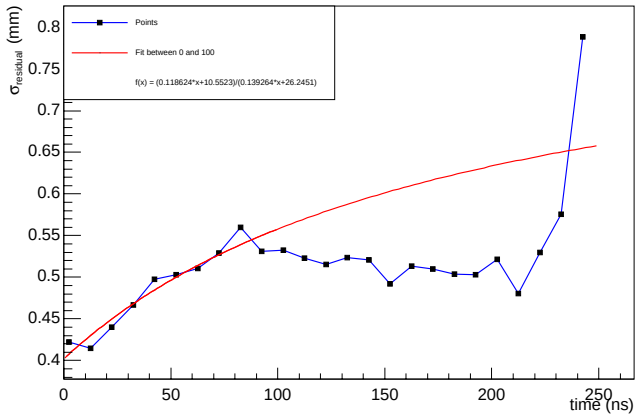
Distance resolution with ADC and Time

- The measurements for the AHDC hits in the Kalman Filter are the distances with respect to the wires provided by the timing information of their signals
- We make the measurement noise varies with ADC and time (fine-tuning remain to be done). Before it was a constant value.



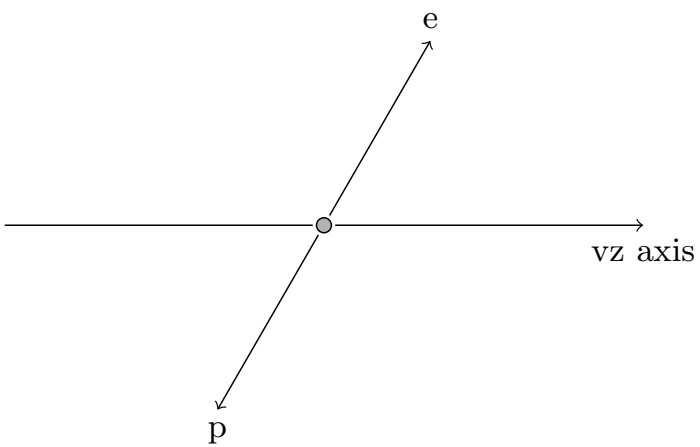






Implement the electron vertex

- The CLAS electron and the AHDC track comes from the same interaction point
- The electron vertex acts as an extra hit for the Kalman Filter
- The resolution in the beamline σ_r^2 and σ_z^2 may depend on p_e and θ_e
- For now we use constant values (0.09 mm^2 and 64 mm^2). A study will be done to give the expressions of $\sigma_r^2(p_e, \theta_e)$ and $\sigma_z^2(p_e, \theta_e)$.



- measurement:

$$z = (0, \phi_{\text{arbitrary}}, v_{z_e})^T$$

- error matrix:

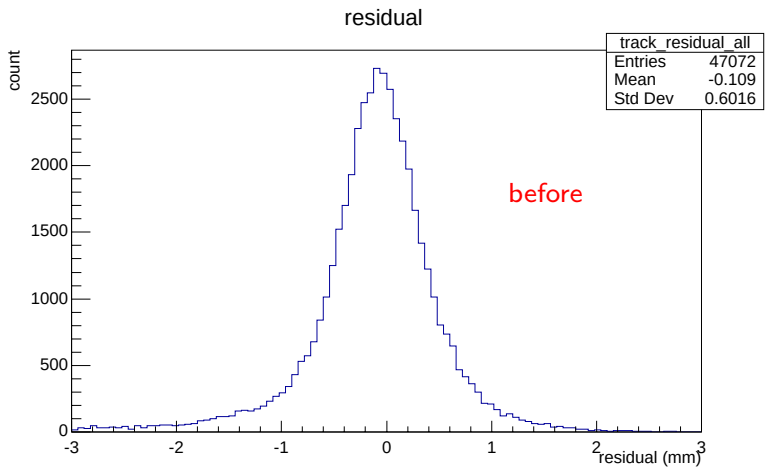
$$\begin{bmatrix} \sigma_r^2(p_e, \theta_e) & 0 & 0 \\ 0 & 1e10 & 0 \\ 0 & 0 & \sigma_z^2(p_e, \theta_e) \end{bmatrix}$$

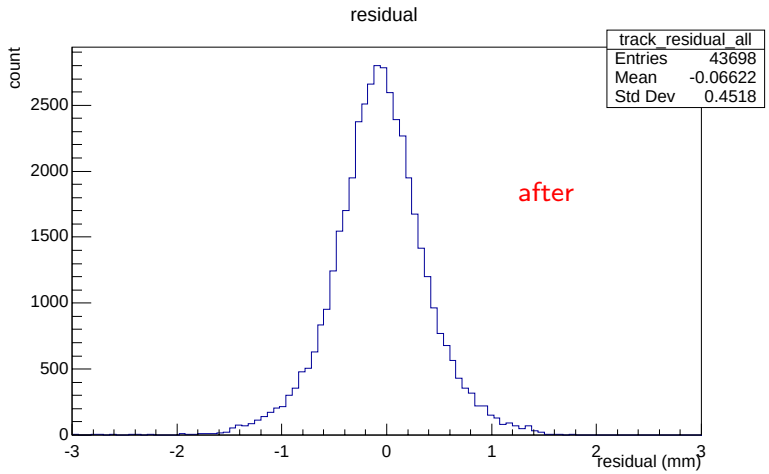
Make the Kalman Filter reusable

- We wanted to run the Kalman Filter at different stage of the tracking reconstruction
- For example, we knew that we would need to remove bad AHDC hits and/or use ATOF hits to improve the AHDC reconstruction
- Initially in the AHDCEngine, the Kalman Filter has been move to the ALERTEngine where it requires the ATOFEngine and the AHDCEngine to have run before
- It keeps track of the error covariance matrix from one use to another

Clean bad AHDC hits

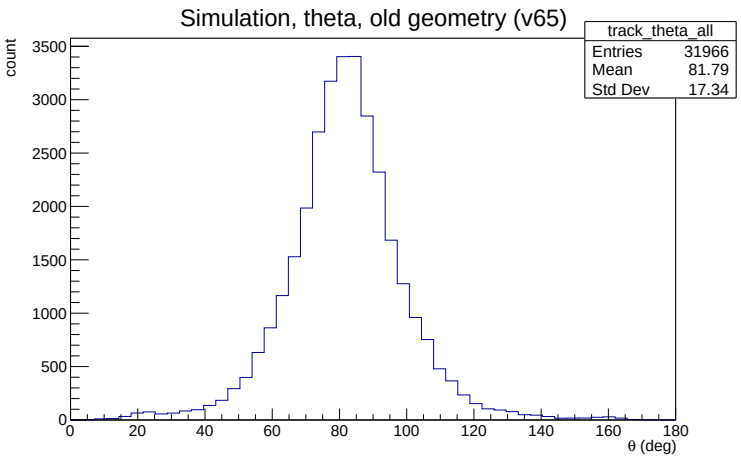
- When the AHDC occupancy is big, some noisy hit can be associated to a track (e.g n $\geq$ 2 hits on the same layer); but now the Kalman Filter consider every hit.
- To fix it:
  - We run the Kalman Filter (KF1) $\rightarrow$ the residuals of all hits are accessible
  - We remove the hits for which the residuals are very big (e.g. ≥ 1.5 mm)
  - We rerun the Kalman Filter on the remaining hits (KF2) with less Niter
- These are distributions for elastic events from run 22712.

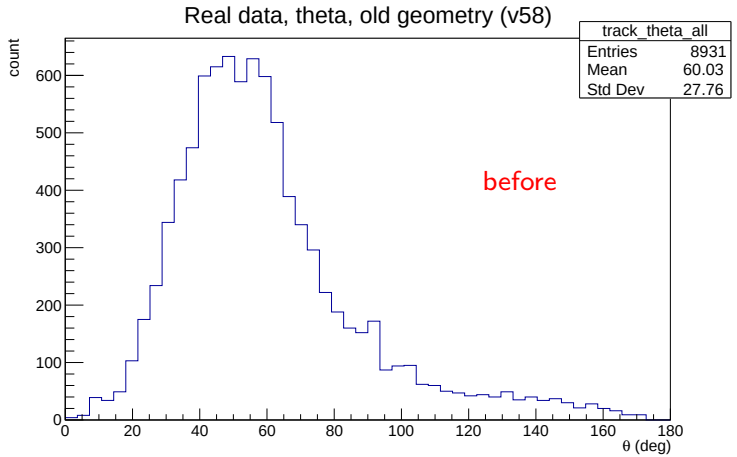


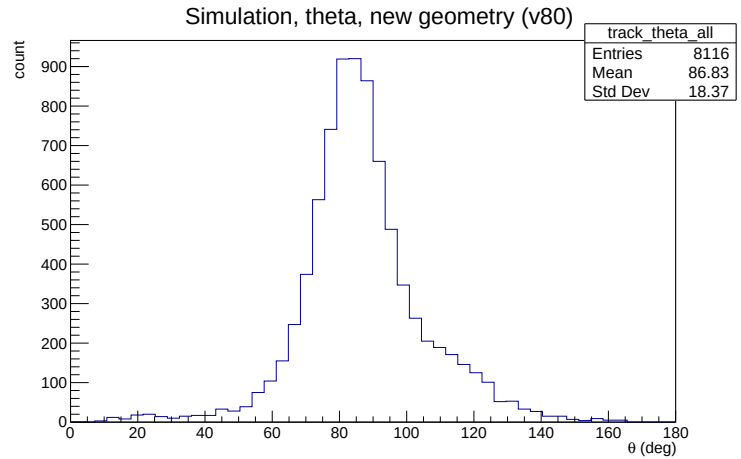


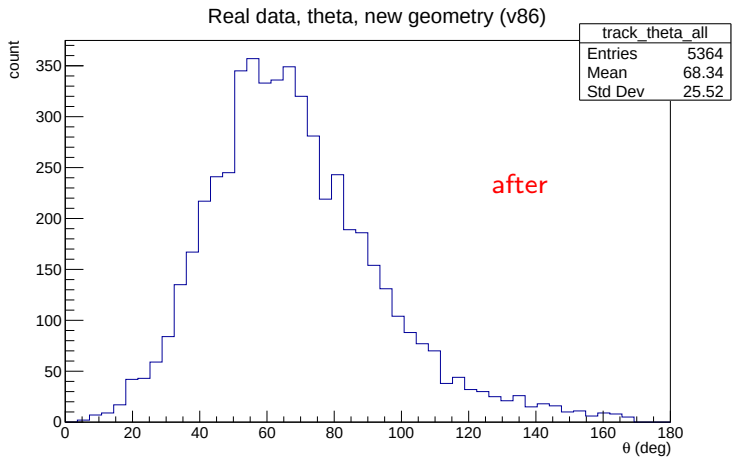
AHDC geometry issue 1/2

- We noticed that the theta reconstruction was much better in simulation compared to real data
- We found that the geometry encoded in coatjava differed from the final designed of the detector



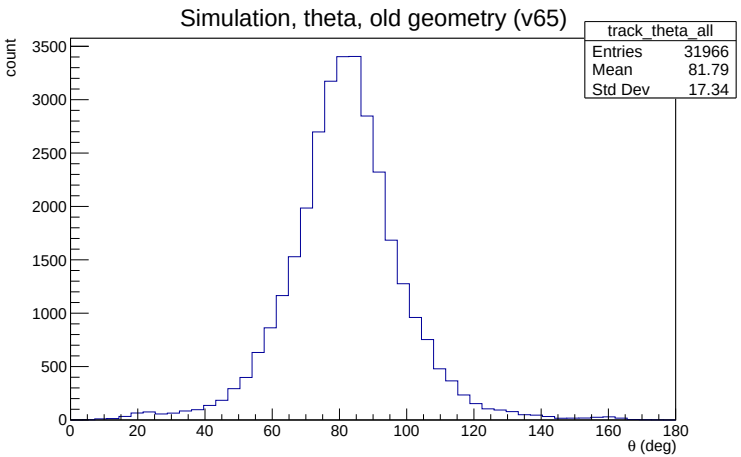


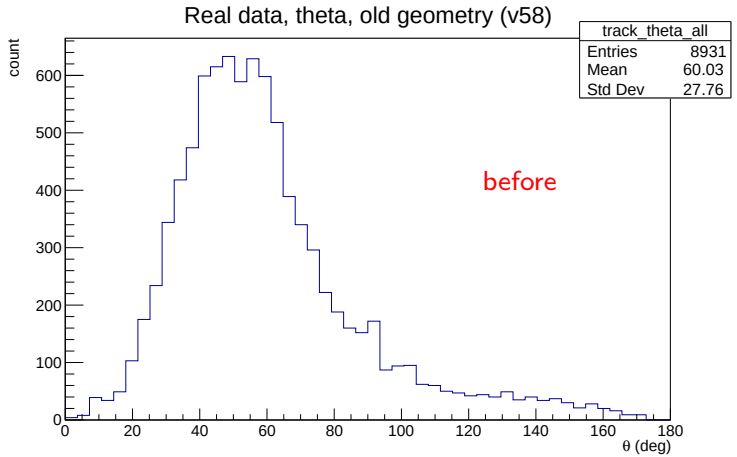


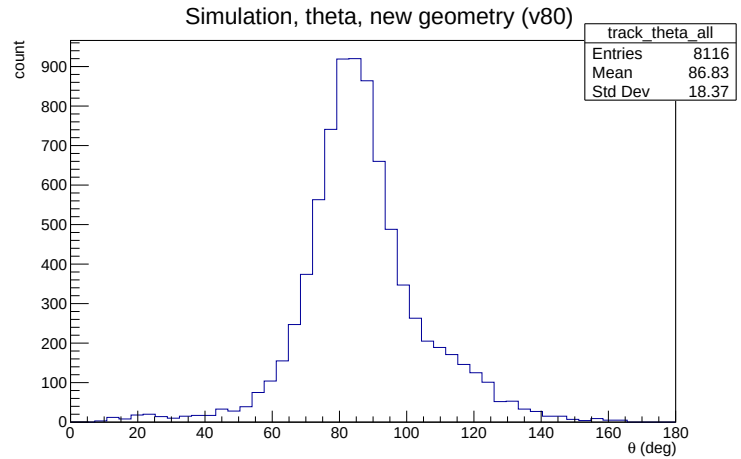


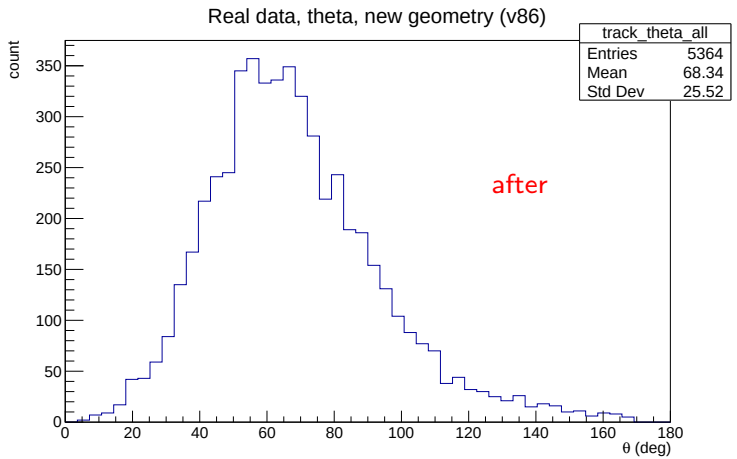
AHDC geometry issue 2/2

- Indeed, the end points of the detector are -188 mm and +162 mm instead of ±150 mm on the z axis. The stereo angles are not exactly 20° but: 19.1489°, 19.2857°, 20.0°, 20.6897°, 20.0° respectively for each super layer
- We saw a small improvement, but still, we were far from the expect value



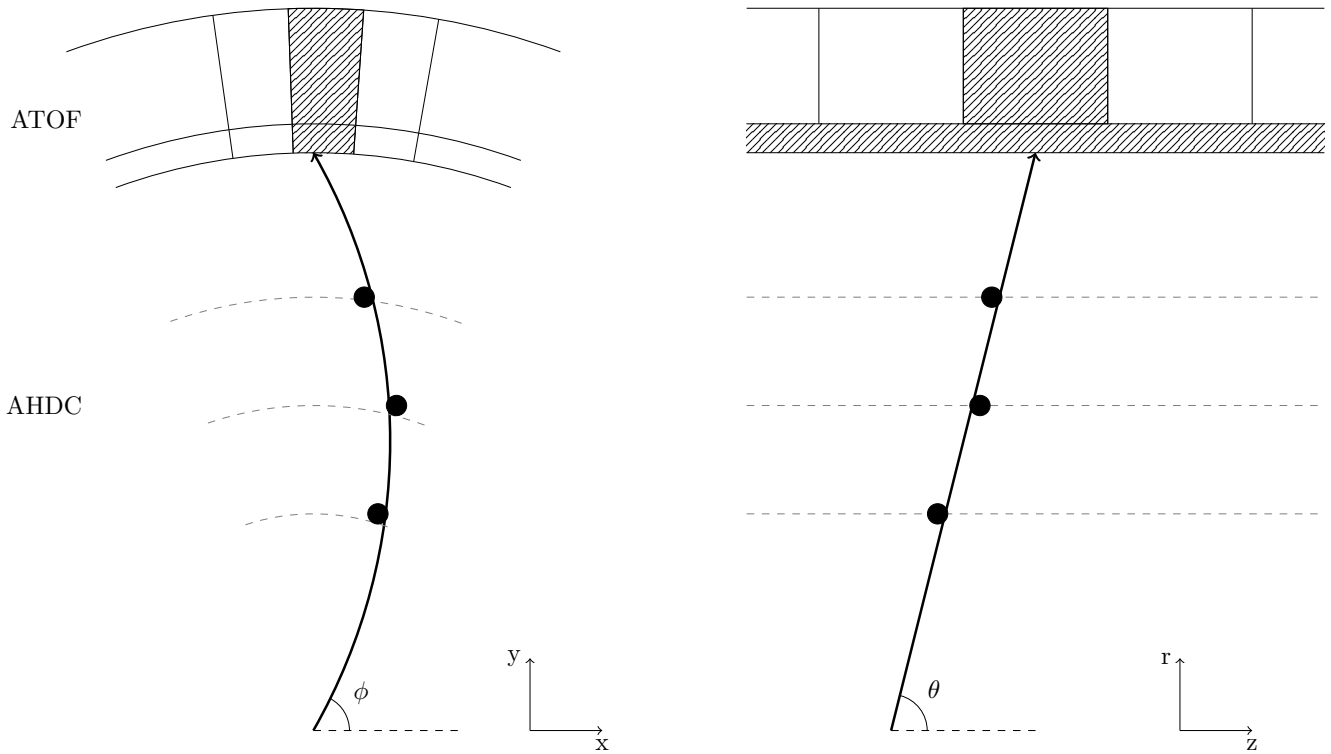






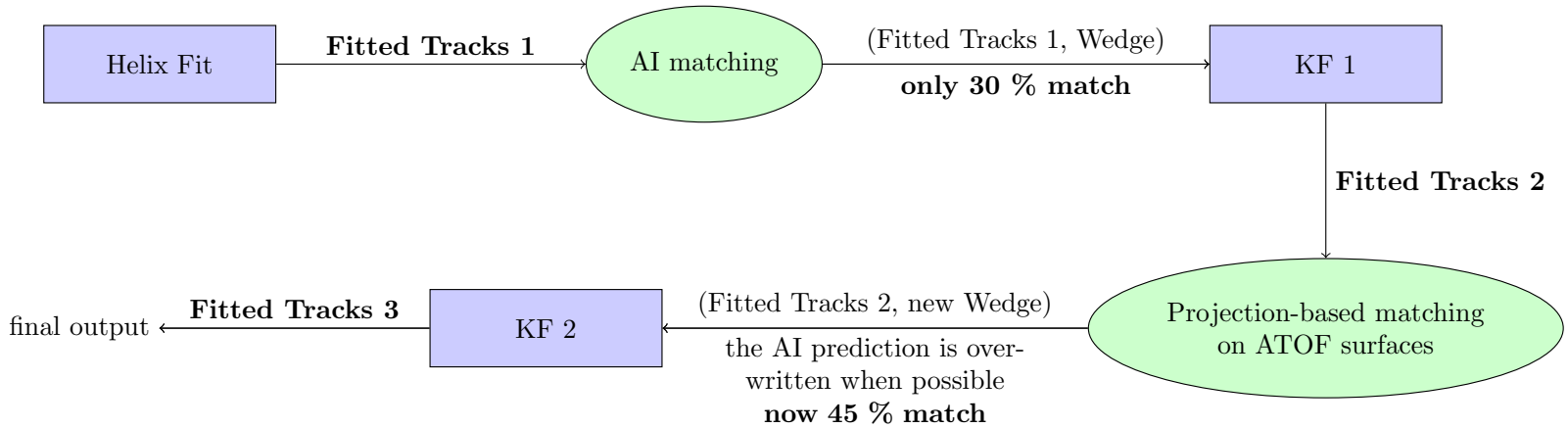
Include the ATOF hits in the KF 1/3

- We decided to use the ATOF hits to improve our theta reconstruction
- We wanted to use the z position given by the ATOF bars, but their resolutions are not good for the moment. So we used the ATOF wedges instead
- The first step was to associate an AHDC track to an ATOF wedge before running the Kalman Filter



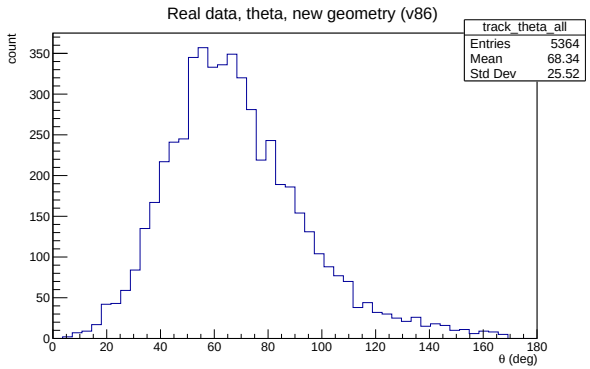
Include the ATOF hits in the KF 2/3

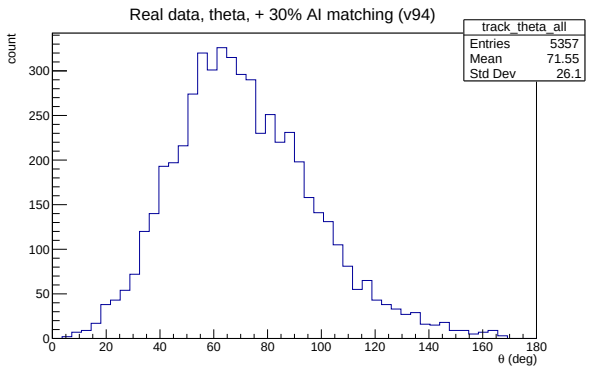
- We used the work on the ALERT AI track matching presented by Mathieu yesterday (link).
- We also wanted to be able to verify the AI prediction and to find new ATOF wedges based on a track projection
- The current strategy is presented in this diagram
- The agreement between the AI matching and the projection-based matching is about 70.16 % (including the $\pm$ 1 indetermination of the wedge)

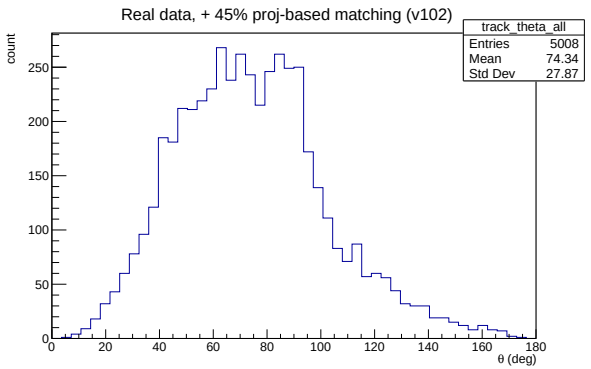


Include the ATOF hits in the KF 3/3

- Evolution of the theta reconstruction
- We have two peaks in the last version of the theta reconstruction
  - The first peak are tracks without ATOF matches
  - The second peak around 86° are tracks with ATOF matches (45 %)
- The final 45 % matches (over the nb. tracks) is low; it is essentially due the current misalignment between the AHDC and ATOF

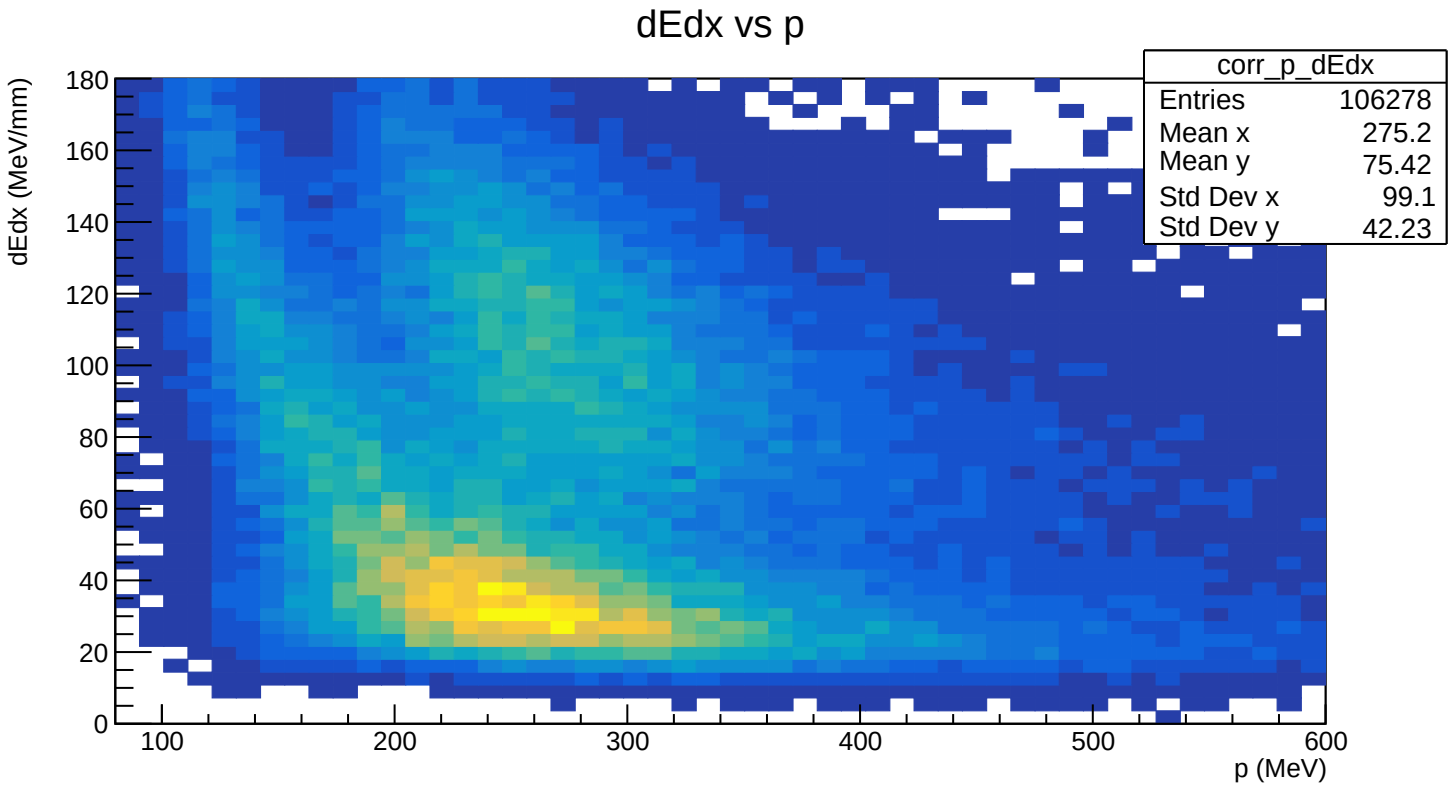






Reconstruction status

- dEdx versus p, run 22712 on D2
- Elastic cuts: 3.5 GeV$^2 < W^2 < 3.8$ GeV^2, $|\Delta\phi| < 20°$, nhits ≥ 6
- Hit cleaning included (work on the ATOF hit not included)



Next steps

- Convenient use of the PID
  - For now, the energy loss and the curvature assume the particle to be a proton
  - We will use the PrePID work of Uditha (link)
- Material verification
  - Correct density for the target straw, target gas, ATOF scintillator
  - Correct use in the Kalman Filter propagator
  - Vary the density of the AHDC gas with the temperature and the pressure condition over the run period
- Fine-tuning
  - Electron vertex resolution on p_e and θ_e
  - Measurement noise of the AHDC hits (ADC and time dependence)
  - ATOF hits resolution for clusters
  - Initial error covariance matrix
- Work on the AHDC alignment
  - With respect to CLAS
  - With respect to ATOF