

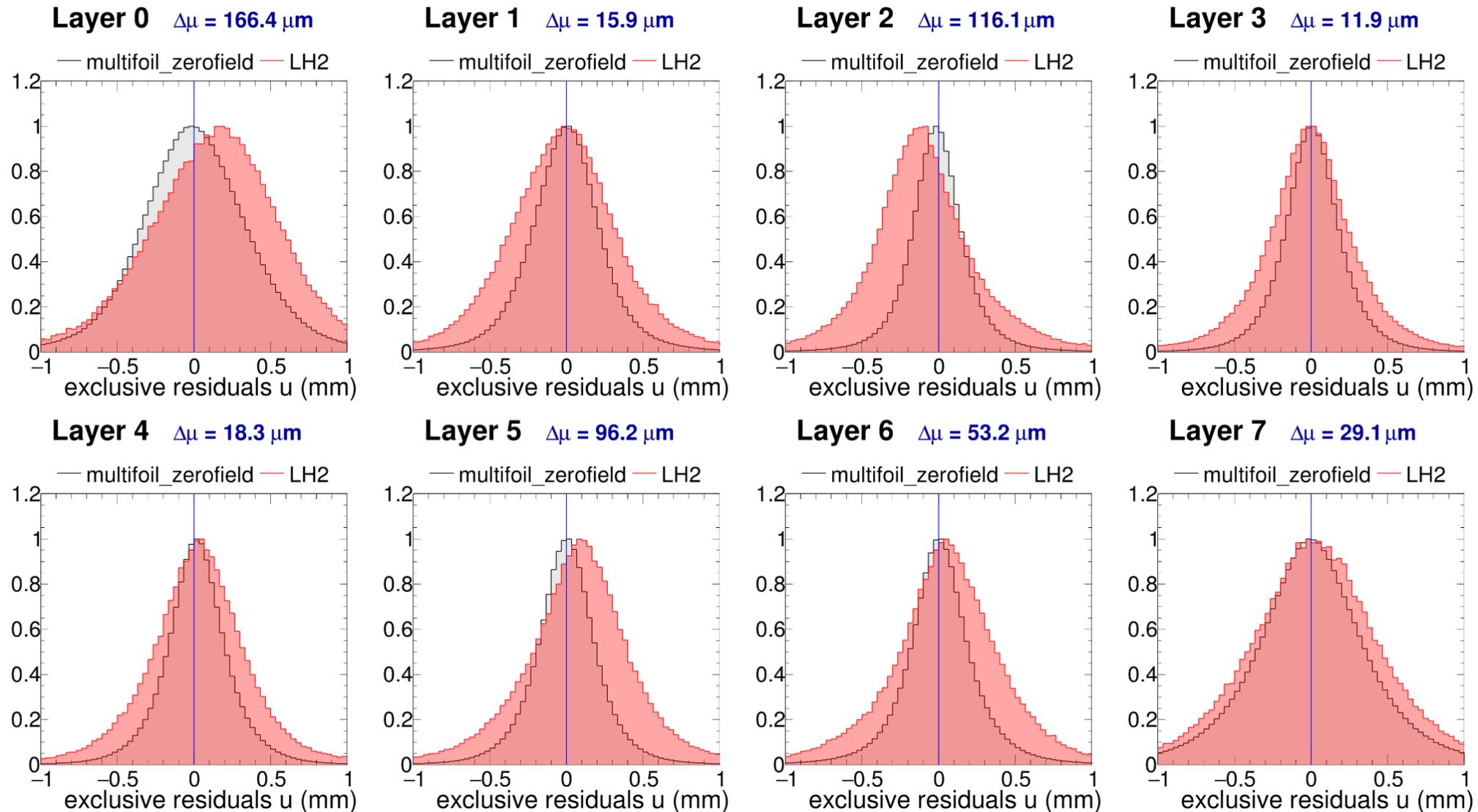
Internal Alignment of the GEM Tracking Detector of GEp-V

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SBS Collaboration Meeting
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SBS Fringe Field Effects

Shown below are comparison of the track-based exclusive residuals of SBS field-OFF multifoil optics data(Grey) and field-ON LH2(Red) data replayed in a common alignment done using field-OFF single foil optics data.



LH2 residual mean shifts are in the order of GEM resolution.

We see similar results (also same pattern) for field-OFF multifoil vs field-OFF multifoil.

Conclusion: We will use field-on data to improve the internal GEM alignment.

General Concept Behind an Alignment Algorithm

We assume that the layers are roughly aligned and perform a track fit.

$$\frac{\partial \chi^2}{\partial \pi} = 0 \implies \frac{\partial r^T}{\partial \pi} V^{-1} r = 0$$



The algorithm works with a Chi square function sensitive misalignments which is built from the track residuals.

$$\chi^2 = \sum_{\text{tracks}} r^T V^{-1} r \quad r_i \equiv (\vec{m}_i - \vec{e}_i(\pi, a)) \cdot \hat{k}$$

\vec{m}_i : measured hit $\vec{e}_i(\pi, a)$: track intersection π : track parameters a : alignment parameters

In a proper alignment, chi square have a minimum with respect to alignment parameters.

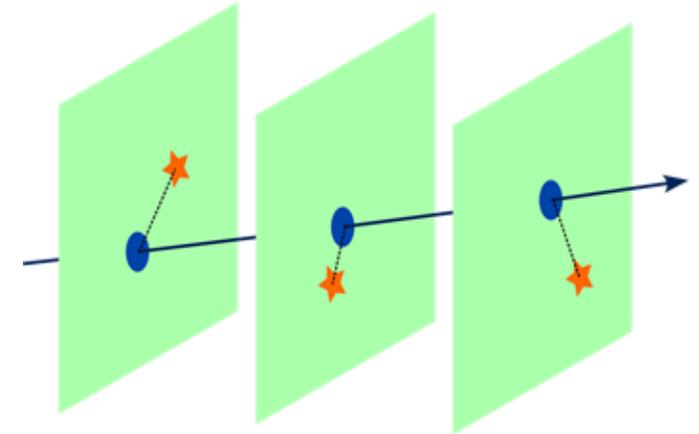
$$\frac{d\chi^2}{da} = 0 \implies \sum_{\text{tracks}} \frac{dr^T}{da} V^{-1} r = 0$$



Correction to the alignment parameters are

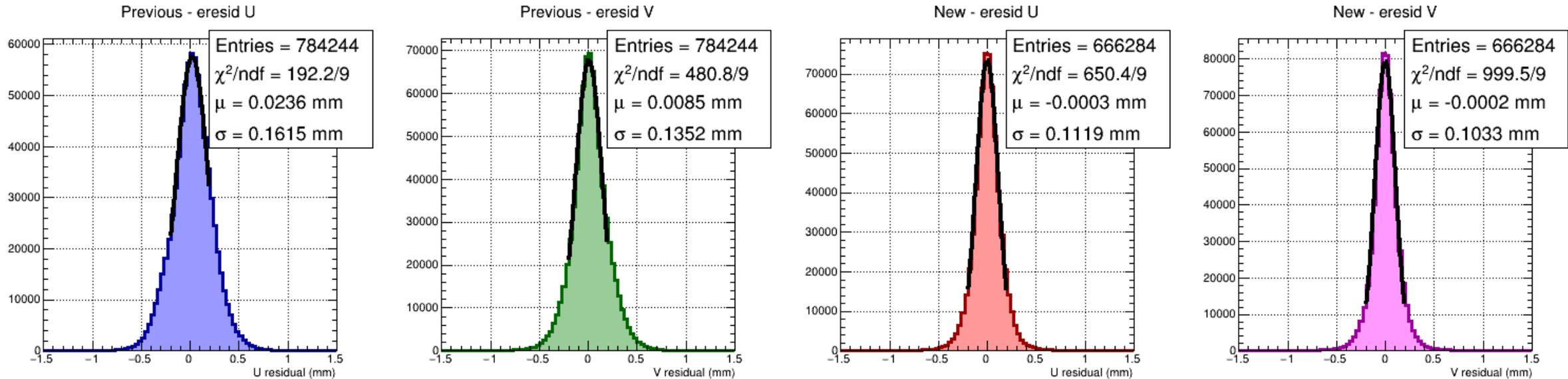
$$\delta a = - \left(\sum_{\text{tracks}} \frac{\partial r^T}{\partial a} W \frac{\partial r}{\partial a} \right)^{-1} \sum_{\text{tracks}} \frac{\partial r^T}{\partial a} W r(\pi, a)$$

W has the information of the covariance matrix and track parameters



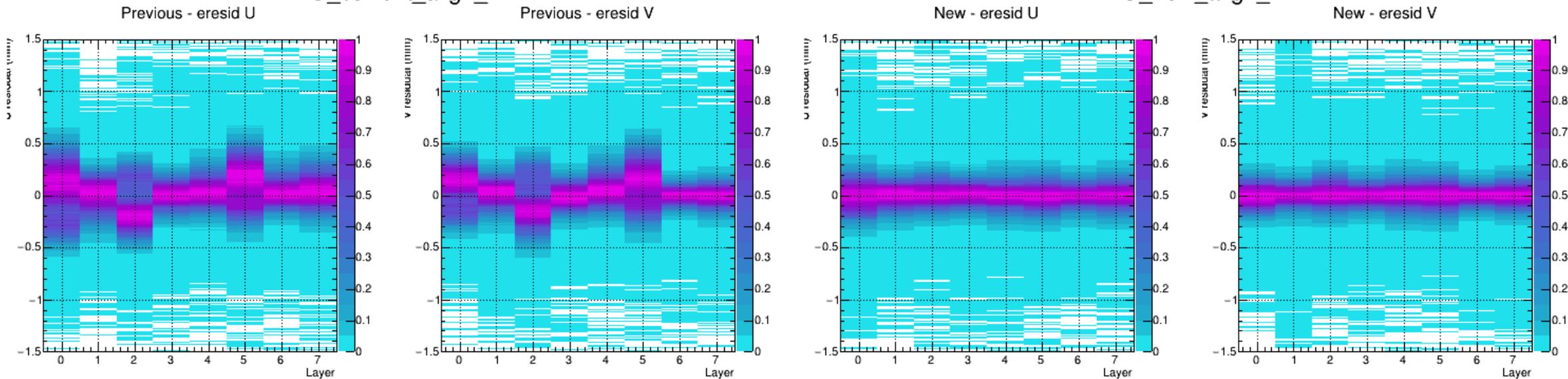
Alignment script developed by Prof. Andrew Puckett (UConn).

Front Tracker Kin3: Before and After Realignment with Field-On Optics Data

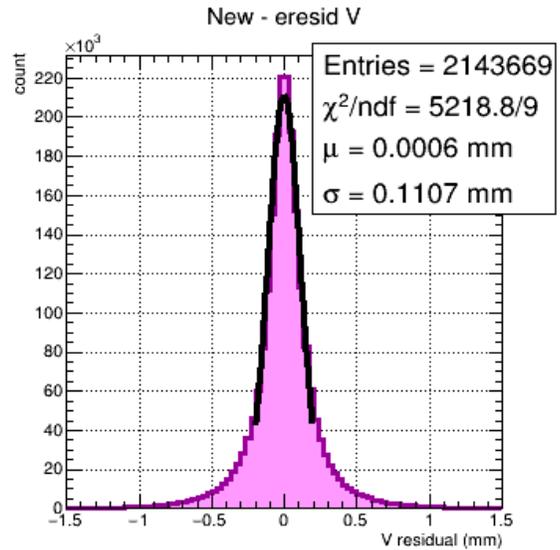
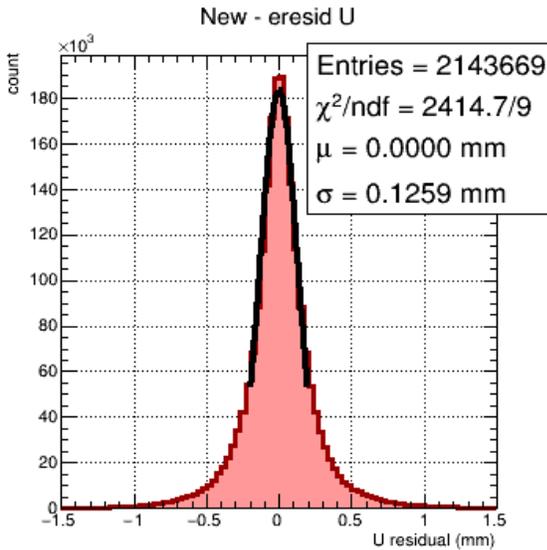
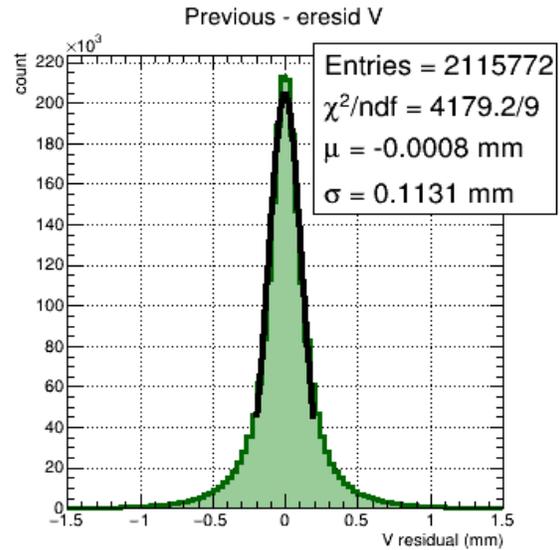
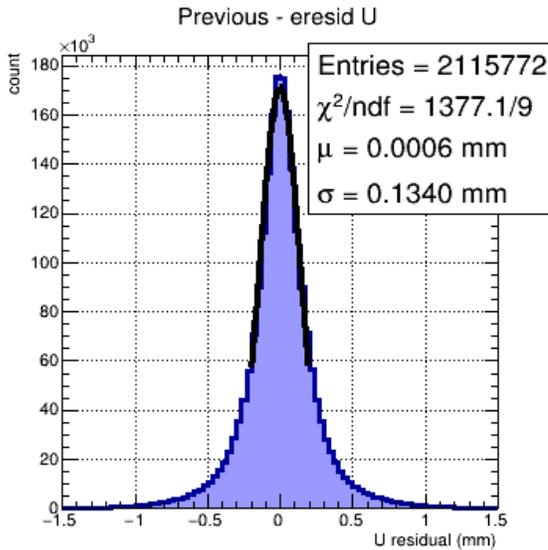


MFFO_current_align_FT

MFFO_new_align_FT

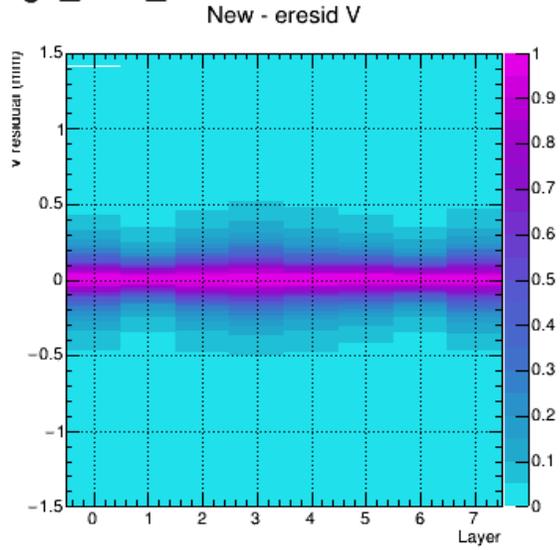
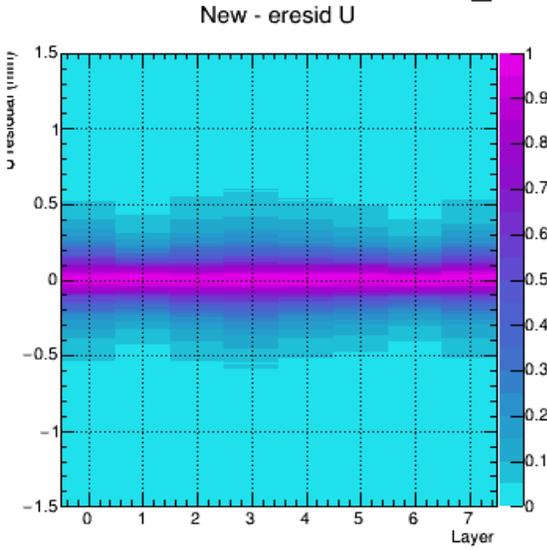
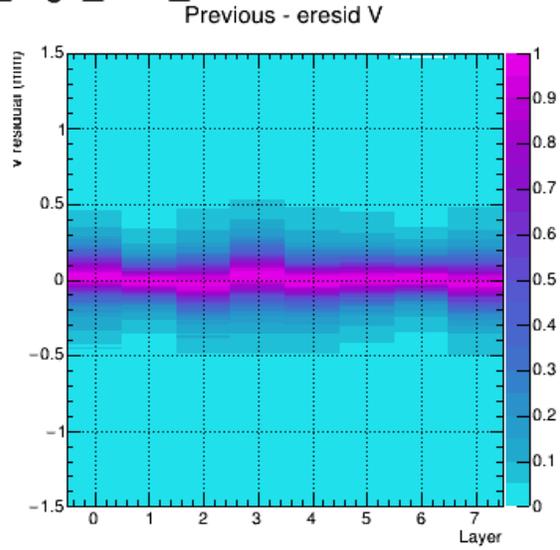
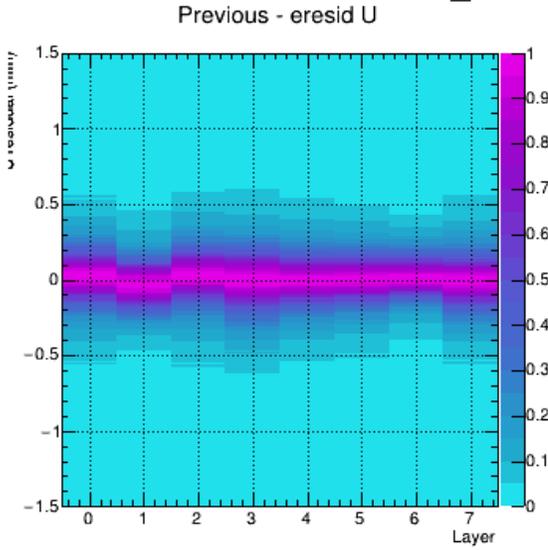


Back Tracker Kin3: Before and After Realignment with Field-On Optics Data

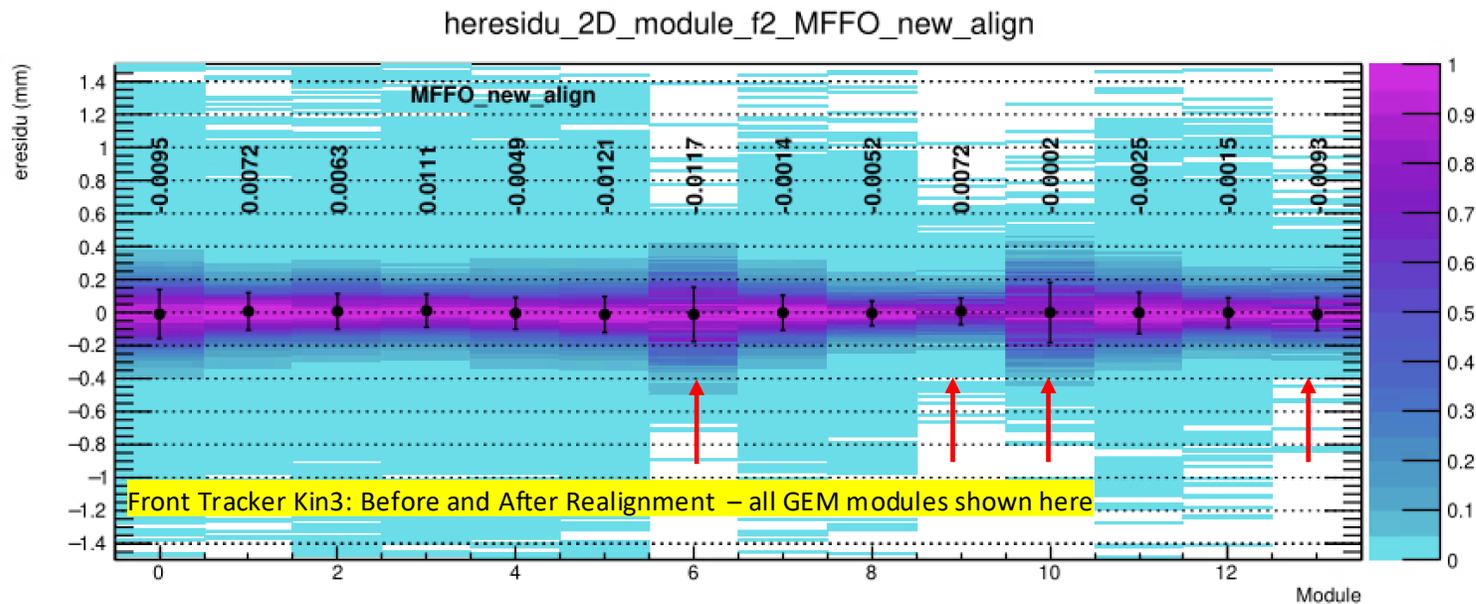
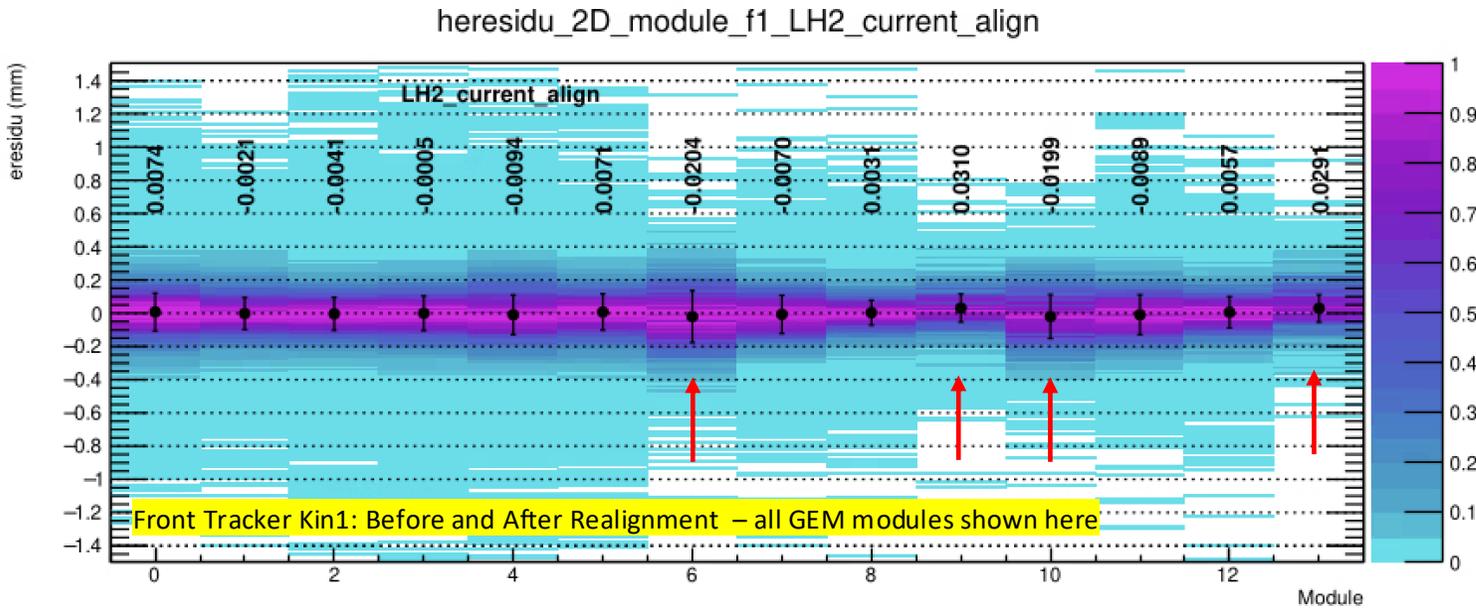


MFFO_current_align_FPP_B

MFFO_new_align_FPP_B

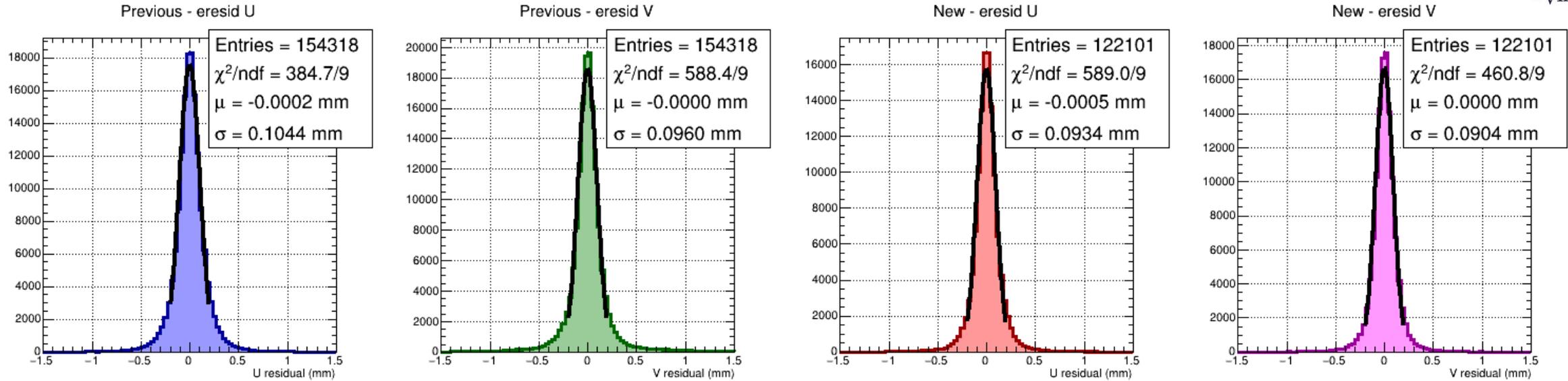


Front Tracker Kin1: Room for improvement.



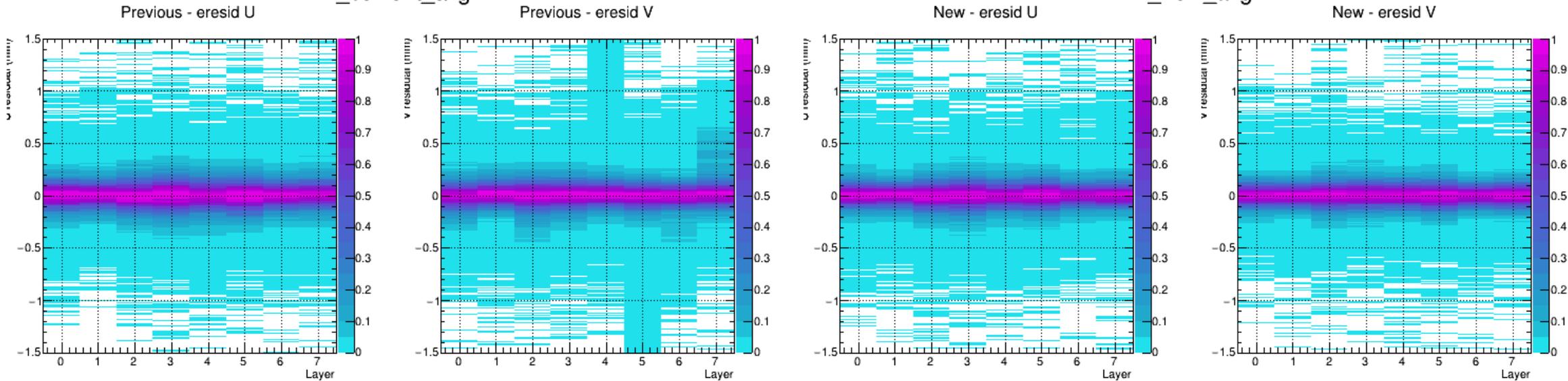
- The modules 6 through 9 and 10 through 13 belongs to last two layers of FT.
- Notice the negative shift in the mean for module 6 and the positive shift for module 9. A similar pattern appears for modules 10 and 13.
- This could point to a small rotation/translation that the χ^2 minimization doesn't strongly sensitive.
- Since these modules are at the edge of the layer, they are less illuminated than the two in the middle.
- Similar problem was there for FT during Kin3
- Fix: Used straight through alignment parameters from the start of the experiment as starting point.

Back Tracker Kin1: Before and After Realignment with LH2 Data



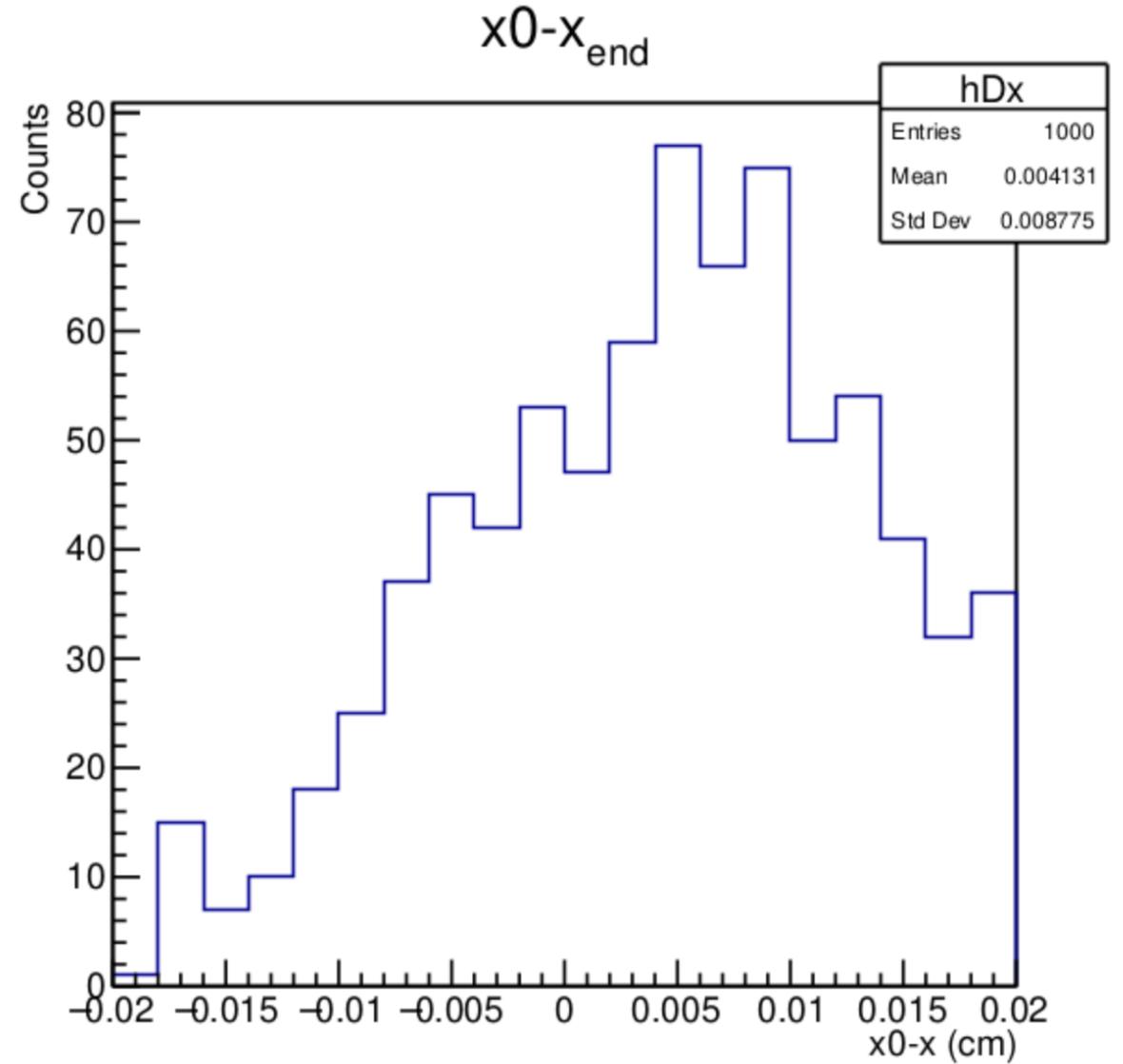
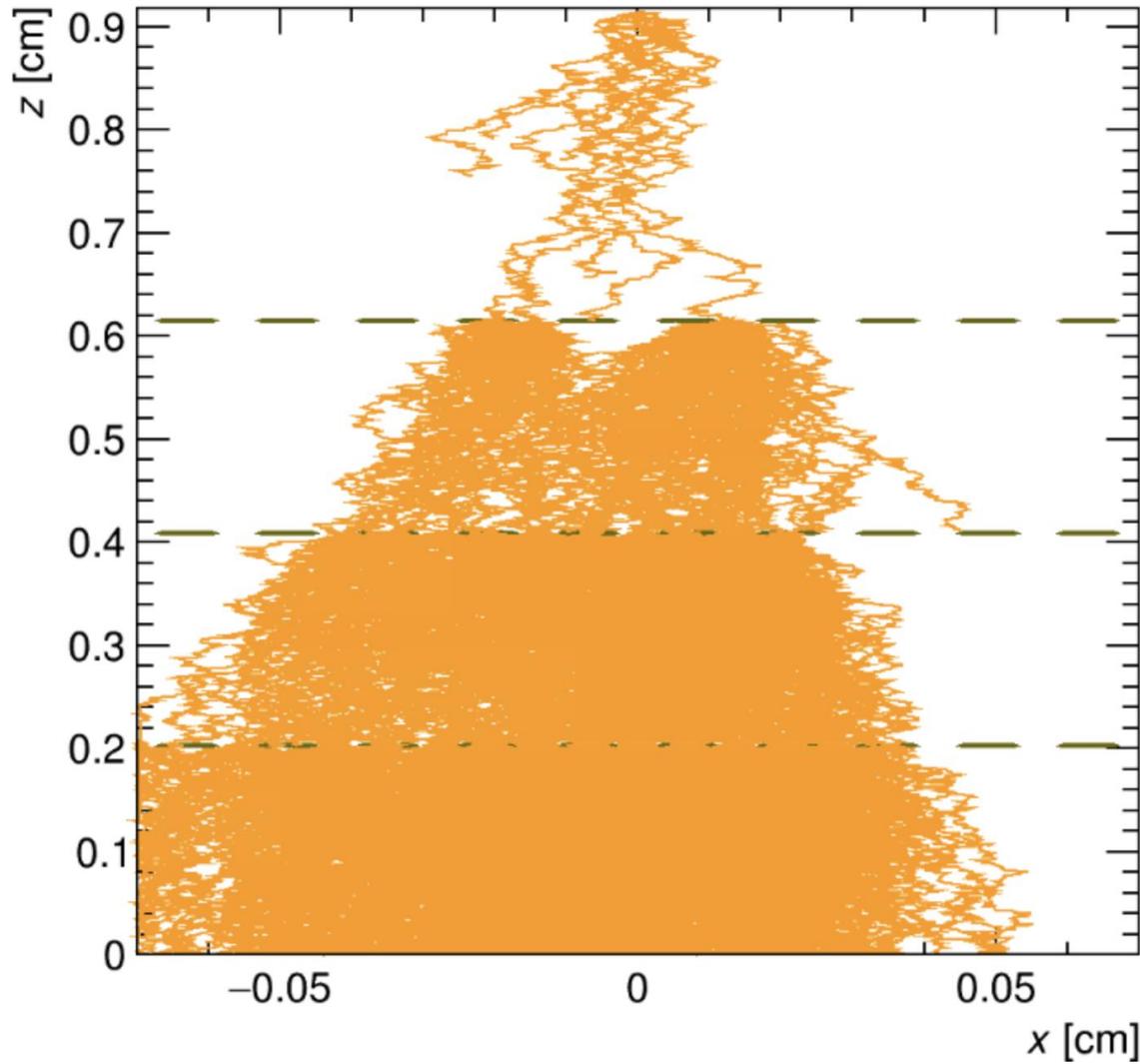
LH2_current_align

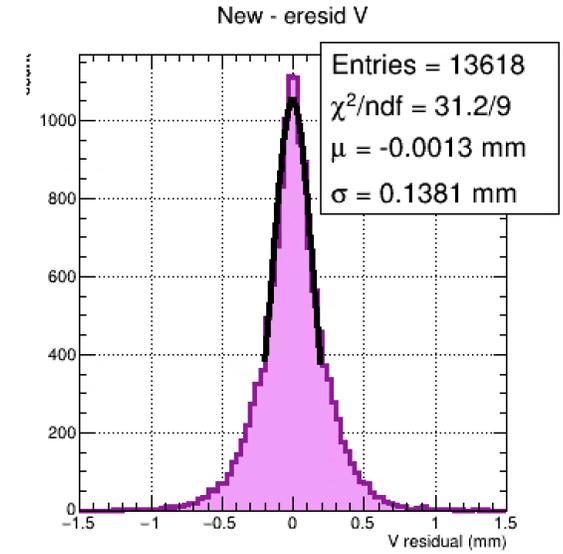
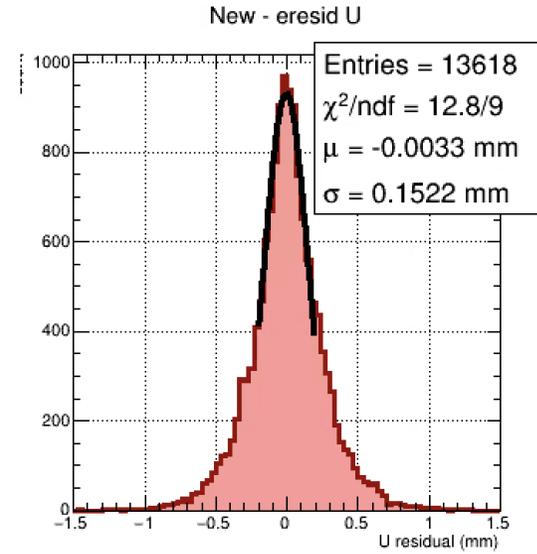
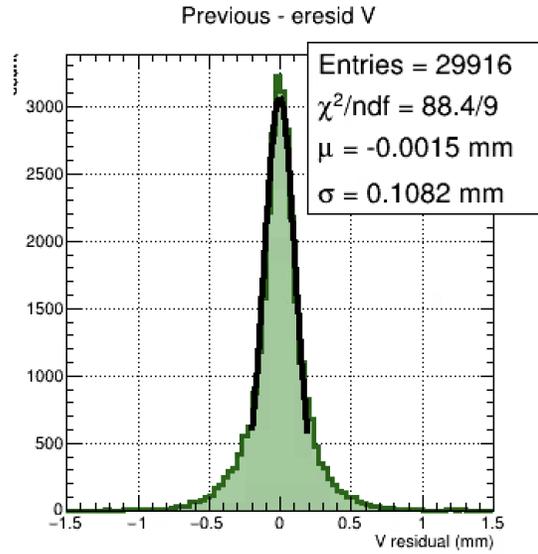
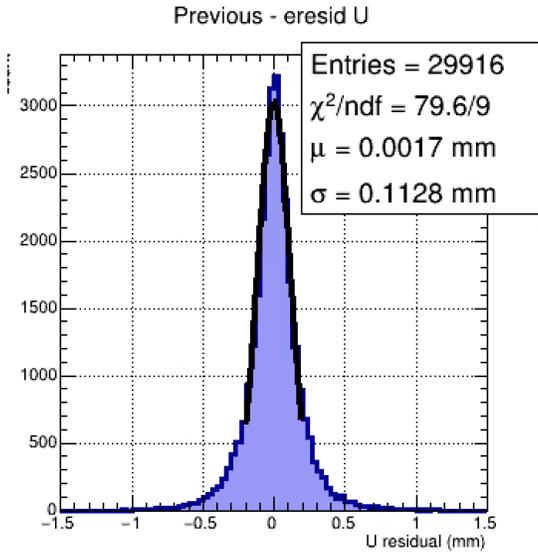
LH2_new_align



Thank you!

Backup





LH2_current_align_FPP_A

LH2_new_align_FPP_A

