FMT Alignment Progress Report

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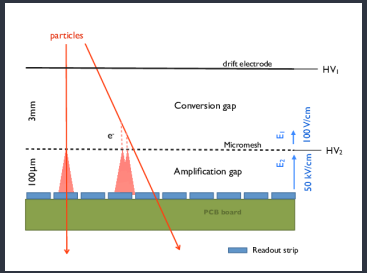
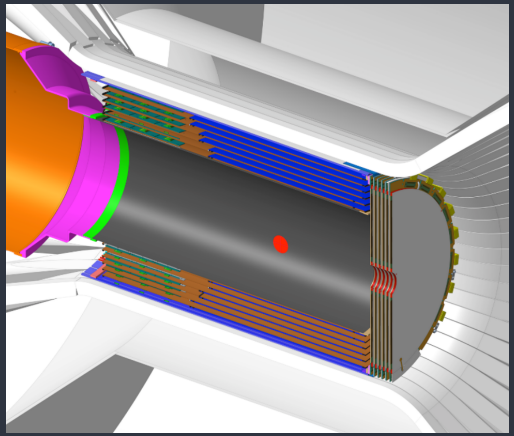
Forward Micromegas Tracker (FMT)

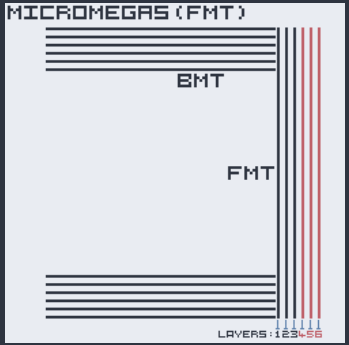
- Part of the Micromegas Vertex Tracker (MVT) used for forward vertex tracking along with the Drift Chambers (DC).
- Detects ionizing particles by using meshes of electrode strips.

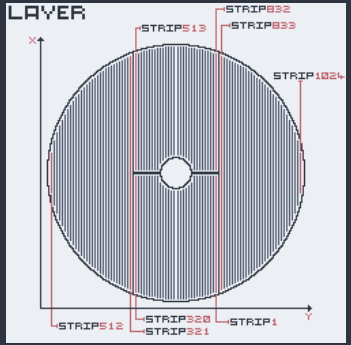


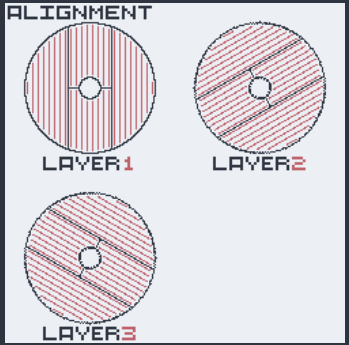


FMT Geometry

- Only the first 3 layers are currently installed.
- Each layer has its own local coordinate system.
- Each layer has 1024 strips. Each strip runs parallel to the x axis in the local coordinate system.
- Each layer is rotated by $\sim 60^\circ$ with respect to the previous one.





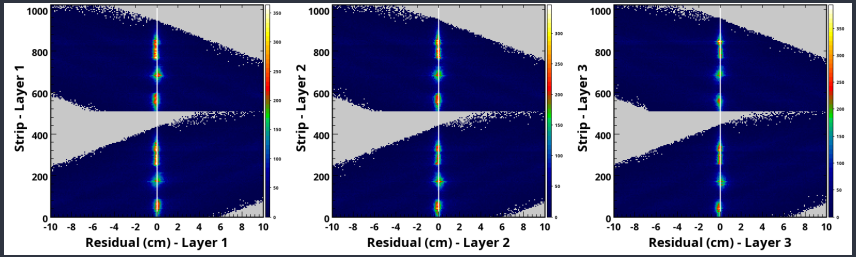


Context

- We're working on the alignment of the FMT detector.
- Alignment of vertex tracking detectors improves their vertex resolution.
- Having a good vertex resolution is relevant to some experiments, especially for cases when two targets are simultaneously exposed to the beam. Examples of this are RG-E and Sebastian Kuhn's group.
- For these experiments the targets should be as close as possible.

Methodology

- We're using data gathered by the RG-F team to perform alignment (Run number 11983).
- A residual is defined as the difference between a DC track and an FMT cluster in the FMT layer's local y axis.
- A DC track is the reconstructed trajectory of a particle, generated by the DC detector.
- An FMT cluster is a set of hits that happened at very close times in adjacent FMT strips.

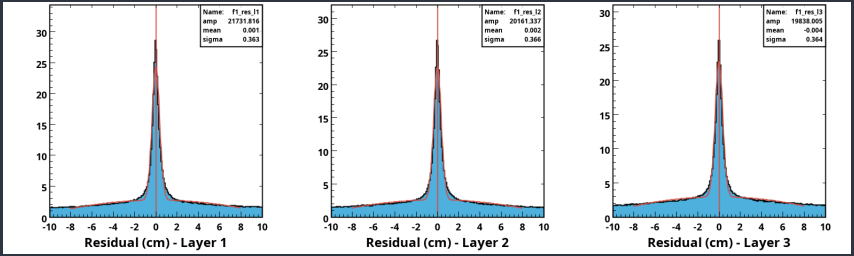


Methodology

- A Gaussian fit is done to a residuals distribution after a certain alignment shift is applied:

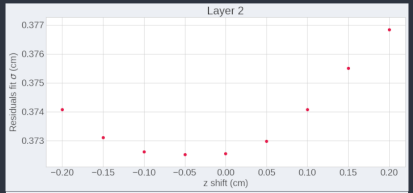
$$\underbrace{\Big(\text{amp} \cdot \text{gaus}(\mu, \sigma)\Big)}_{\text{gaussian}} + \underbrace{\Big(p_0 + p_1 \cdot x + p_2 \cdot x^2\Big)}_{\text{background}}$$

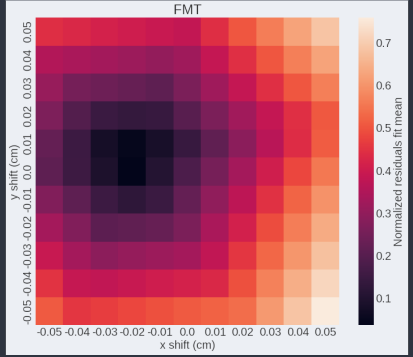
- Alignment is performed by minimizing the mean and width of the this fit for each FMT layer.



Methodology

- Six types of shifts are applied, `deltaX`, `deltaY`, `deltaZ`, `rotX`, `rotY`, and `rotZ`.
- From our analysis, we realized that `deltaZ` and `rotZ` are strongly correlated to the fit's width, while the other shifts are correlated to its mean.
- We used a heuristic approach to select the best shifts, simply by looking at the plots and picking the shift with the smallest mean and widths.





Fiducial Cuts for DC Tracks

- `track.z` $<$ `layer.z`: Remove tracks further downstream than the FMT layer before swimming.
- $|$ `track.z` $-$ `layer.z` $| <$ 0.05cm: Remove tracks too far from the FMT layer after swimming. This cut was defined due to a swimming error that was fixed in Coatjava release 6.5.8.
- 5cm $< \sqrt{x^2 + y^2} <$ 25cm: Remove tracks outside of the layer's active region. The region used is smaller than the actual active region to only use the best tracks.
- $\theta <$ 66.5°: Remove tracks with a θ angle too high. When this happens, the same particle is affecting many strips, which reduces the detector's reliability.

Fiducial Cuts for FMT Clusters

- $0 \leq \texttt{strips} \leq 1023$: Check that the hit's strip number is valid, just in case.
- $50\text{ns} < T_{min} < 500\text{ns}$: Cut clusters with an illogical T_{min}. This is attributed to noise.
- $\texttt{size} > 1 \;||\; E > 100$: Cut small clusters with high energy, which are considered noisy.
- $\texttt{size} < 5$: Cut large clusters, which are considered bad.

Results

Layer	Axis	Shift
Layer 1	deltaZ	-34.5 ± 0.5mm
Layer 2	deltaZ	-37.0 ± 0.5mm
Layer 3	deltaZ	-36.0 ± 0.5mm
FMT	deltaX	-0.2 ± 0.1mm
FMT	deltaY	1.5 ± 0.1mm

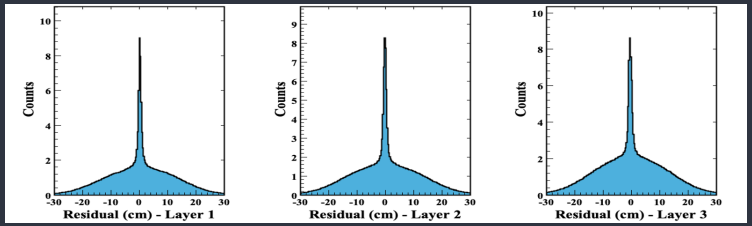
Layer	Axis	Shift
Layer 1	rotZ	$-0.25 \pm 0.05°$
Layer 2	rotZ	$-0.55 \pm 0.05°$
Layer 3	rotZ	$-0.35 \pm 0.05°$
FMT	rotX*	$0.15 \pm 0.05°$
FMT	rotY*	$0.10 \pm 0.05°$

sector	layer	component	deltaX	deltaY	deltaZ	rotX	rotY	rotZ
0	1	0	-0.2	1.5	-34.5	0.0	0.0	-0.25
0	2	0	-0.2	1.5	-37.0	0.0	0.0	-0.55
0	3	0	-0.2	1.5	-36.0	0.0	0.0	-0.35
0	4	0	0.0	0.0	0.0	0.0	0.0	0.0
0	5	0	0.0	0.0	0.0	0.0	0.0	0.0
0	6	0	0.0	0.0	0.0	0.0	0.0	0.0

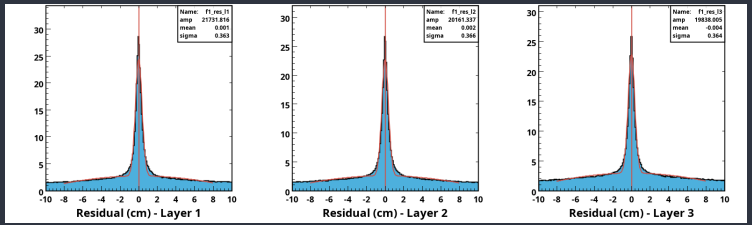
Showing 1 to 6 of 6 entries First Previous 1 Next Last

* The resolution improvement from these shifts is very small, so they will only be added to the CCDB after more tests are performed.

Results



Residuals before applying shifts

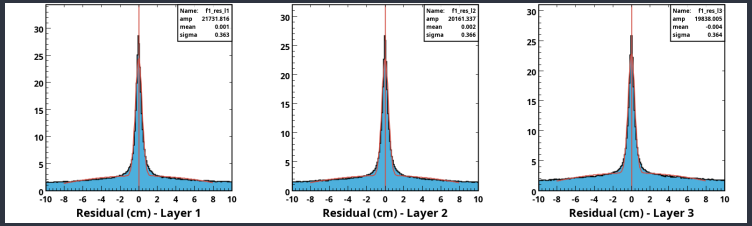


Residuals after applying shifts

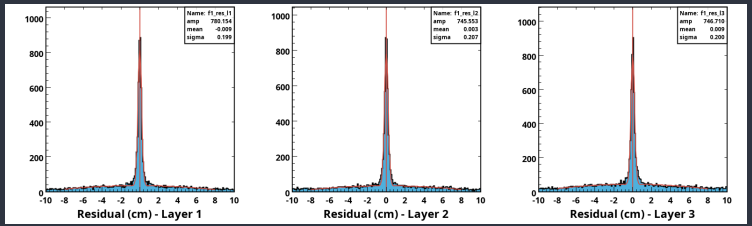
Future Work

- Cross-check current results via reconstruction and simulation (currently in progress).
- Implement a minimizer for a generalized alignment procedure.
- Write documentation and improve the package's README.
- Re-run alignment code after FMT is reinstalled.
- Write new vertex reconstruction procedure in an attempt to improve resolution.

Future Work

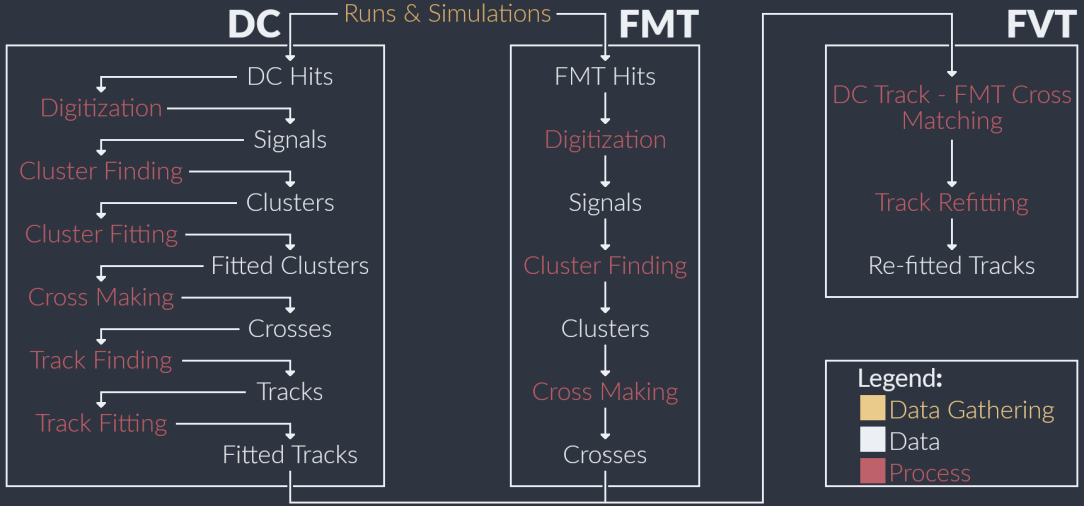


Current best results

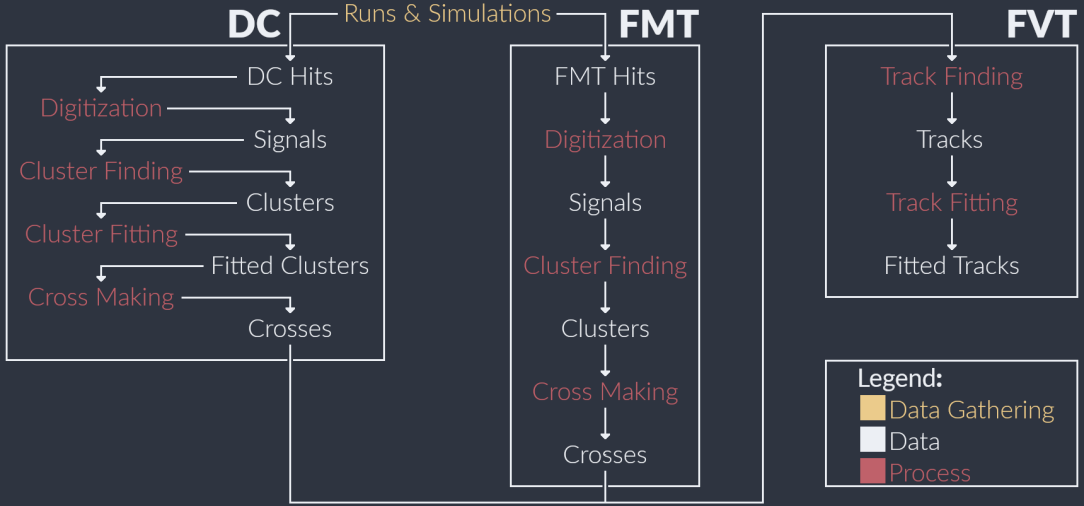


GEMC simulation with background

CURRENT VERTEX RECONSTRUCTION



PLANNED VERTEX RECONSTRUCTION



Repository

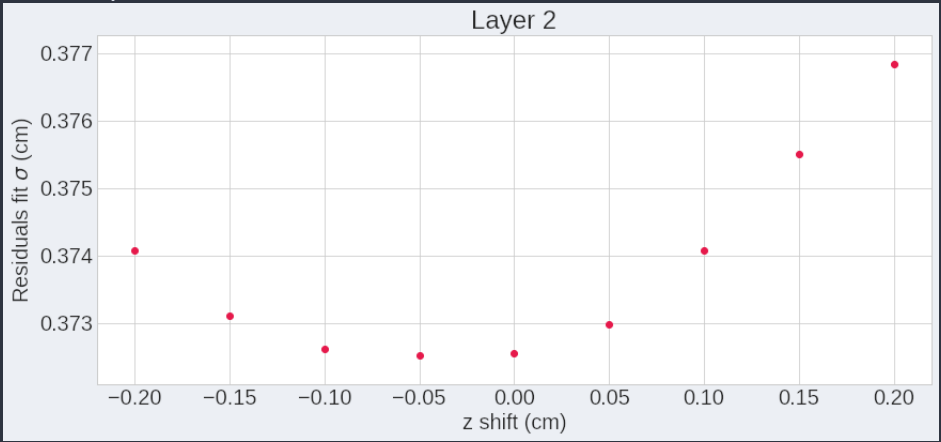
The repository is public on github, so anyone is welcome to continue with alignment work, cross-check, or simply check it out:

https://github.com/JeffersonLab/clas12alignment

Addendums

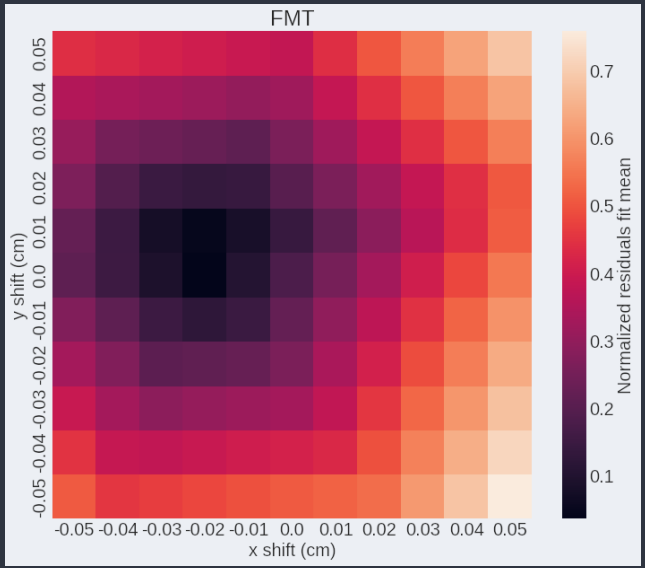
z Alignment

We measure how good a z shift is by measuring the σ of a Gaussian fit applied to the residuals plot.



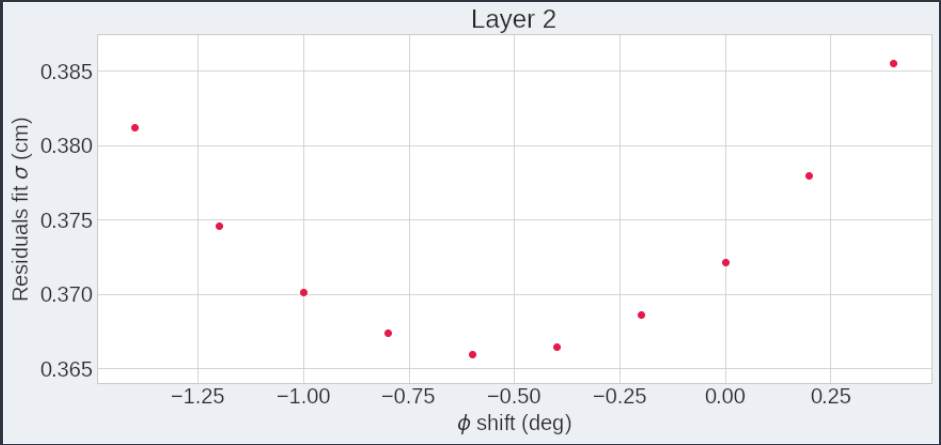
xy Alignment

We measure the quality of an xy shift by measuring the mean of the fit.



ϕ Alignment

The goodness of a ϕ shift is measured using the σ of the fit.



Pitch & Yaw Alignment

We measure the quality of a pitch-yaw shift by measuring the mean of the fit.