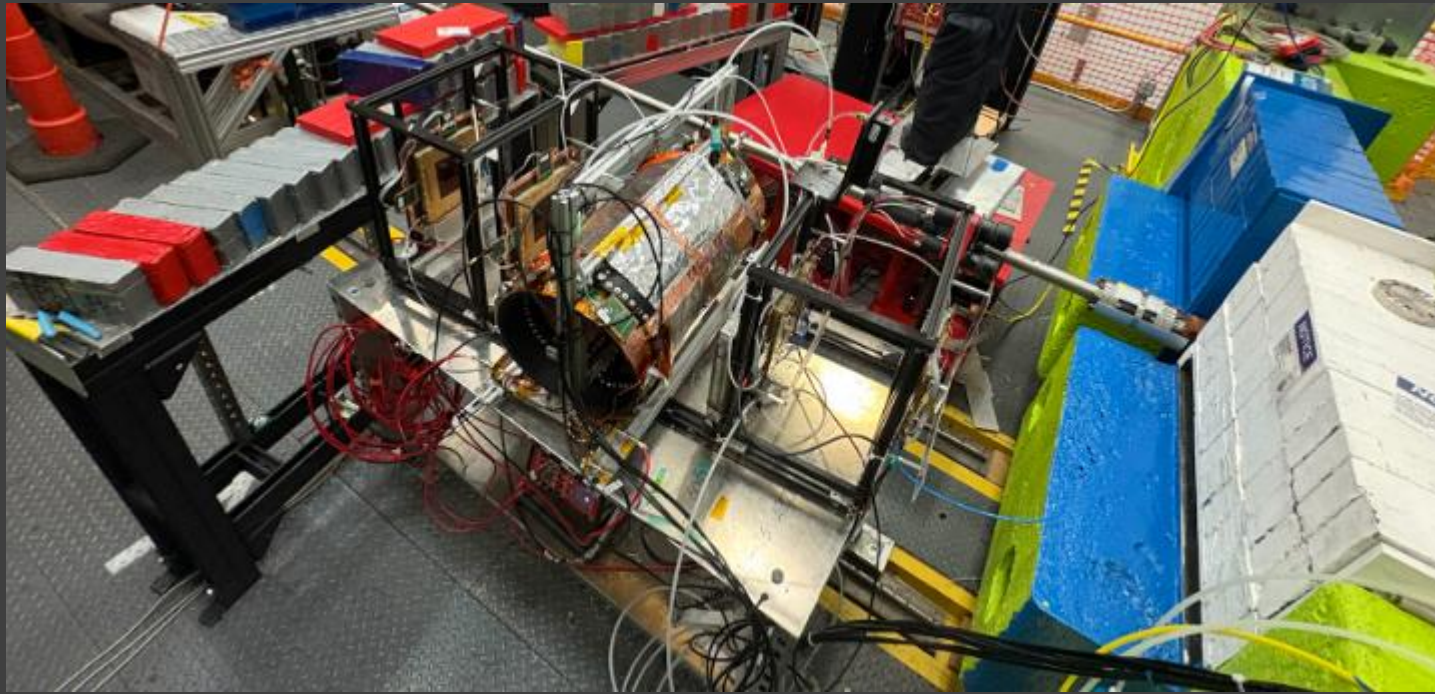




Mapping for a Cylindrical Micro-Resistive Well Detector

Milestone 5

People

Group Members

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Milestone 5 Task Matrix

Task	Completion	Alejandro	Summer	TO DO
I. Apply clustering and iterative offset shift before reconstructing	95%	50%	45%	Iterative shifting to account for the offset
II. Automate beam reconstruction pipeline for multiple root files	50%	40%	10%	Test automation script
III. Do efficiency plots and other requested graphs for analysis	80%	40%	40%	Need comparison plot for det5 residuals

Task- Better Preprocessing

Previous hit selection process:

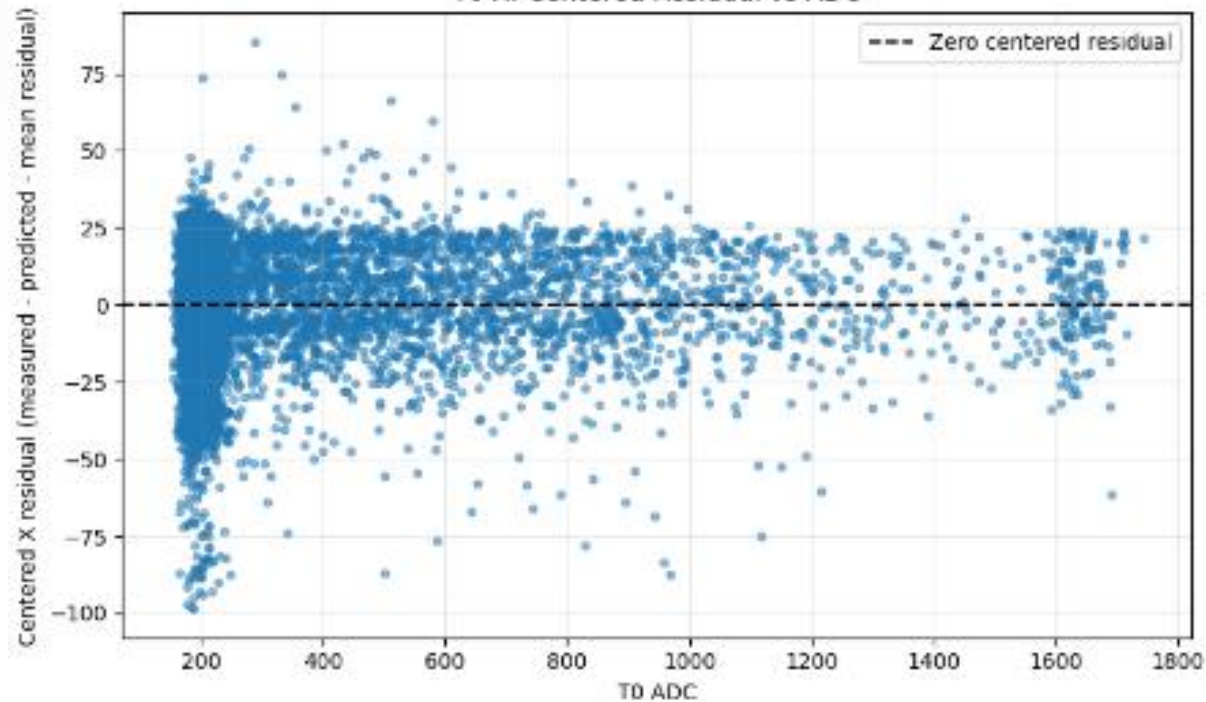
- Select candidate strips where $\max(\text{adc}) > \text{SET_THRESHOLD}$
- Static threshold set to 100 typically
- Calculate positions from raw strip values

Revised hit selection process applied:

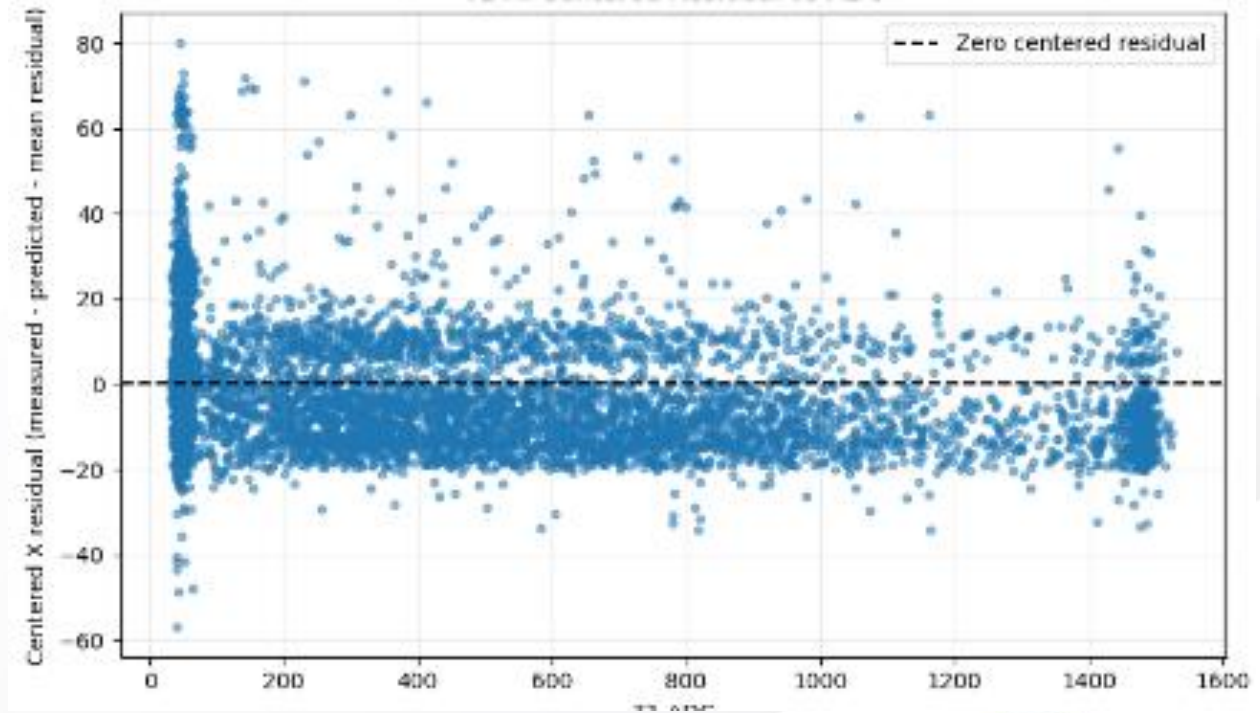
- Calculate μ_{noise} and σ_{noise} for each strip from pedestal run
- Select candidate strips where for each strip $\max(\text{adc}) > \mu_{\text{noise}} + 5\sigma_{\text{noise}}$
- Cluster the candidate strips with multiplicity in range 2-10
- Calculate positions from clusters

Task- Better Preprocessing

T0 X: Centered Residual vs ADC

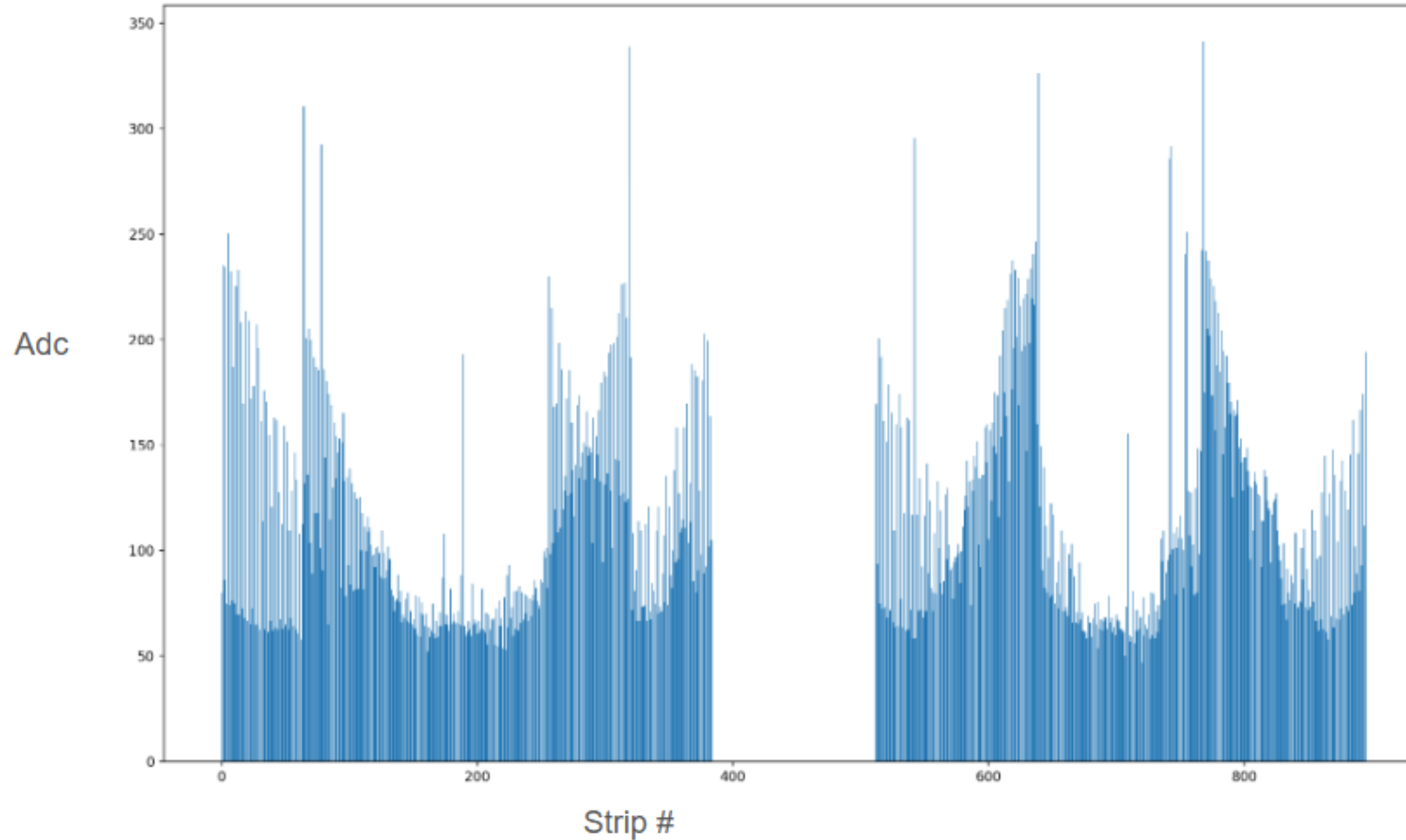


T1 X: Centered Residual vs ADC



Task- Better Preprocessing

Dynamic threshold of each strip (noise + 5σ)



Task- Better Preprocessing

Golden Data: events with exactly one cluster per plane per tracker
-> resulted in only 4 events

Two methods to relax data restrictions:

1. Allowing events with multiple clusters per tracker and plane
 - Per event, fit a separate line trajectory for every combination of available clusters and pick the one with the smallest residual
2. Allowing events with clusters in only the first 3 trackers
 - Assumed the last tracker was noisy

Sigma results for residual distributions

4 golden events: 0.1-0.2mm

Events with multiple clusters per tracker: 3.0-9.0mm

Events with clusters in 3 trackers: 2.0-19.0mm

Task- Better Preprocessing

```
=====
LEAVE-ONE-OUT TRACKER ANALYSIS
=====
Left-out tracker : T1
Coordinate       : X
Valid events     : 4

Trajectory model:

    x(z) = intercept + slope * z

A separate trajectory is reconstructed for each event.
The same fitting procedure is used for every event.

Z positions:
  T0: z = 0.0
  T1: z = 26.6
  T2: z = 85.6
  T3: z = 112.2

-----
RESIDUAL STATISTICS
-----
Mean residual / bias : 6.18828
Sigma                : 0.171332
RMS                  : 6.19006
MAE                  : 6.18828
MSE                  : 38.3169
```

```
=====
LEAVE-ONE-OUT TRACKER ANALYSIS
=====
Left-out tracker : T1
Coordinate       : Y
Valid events     : 4

Trajectory model:

    y(z) = intercept + slope * z

A separate trajectory is reconstructed for each event.
The same fitting procedure is used for every event.

Z positions:
  T0: z = 0.0
  T1: z = 26.6
  T2: z = 85.6
  T3: z = 112.2

-----
RESIDUAL STATISTICS
-----
Mean residual / bias : -0.524846
Sigma                : 0.0988734
RMS                  : 0.531785
MAE                  : 0.524846
MSE                  : 0.282795
```

Task- Automation

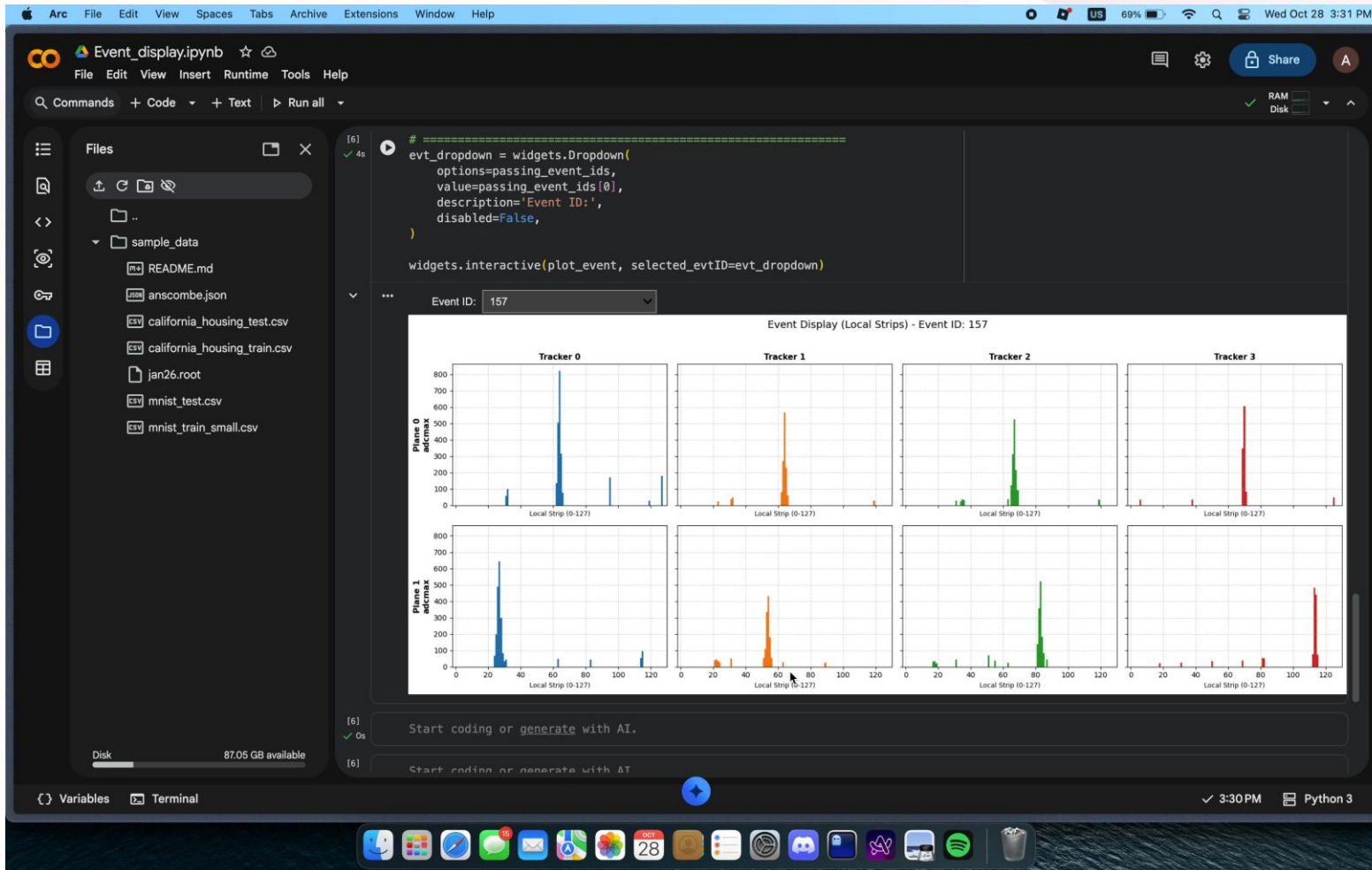
Automating the generation of AMORE-SRS consists of running 4 separate commands:

- First processes the raw pedestal file
- Second and third processes the pedestal data into a root file
- Fourth processes the data file itself into a root file

Our automation script:

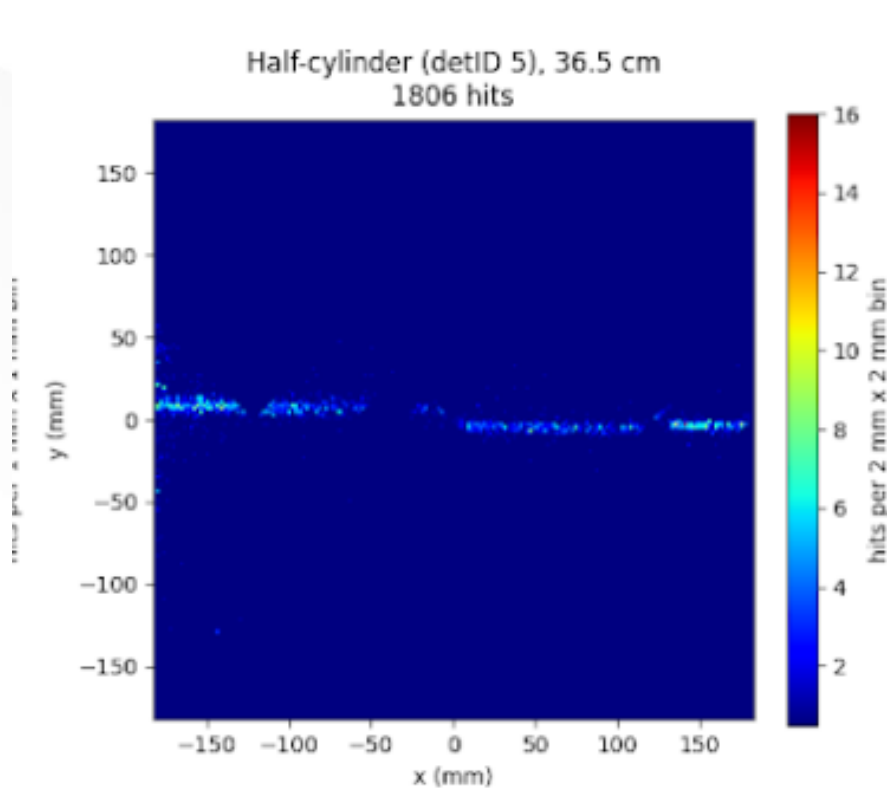
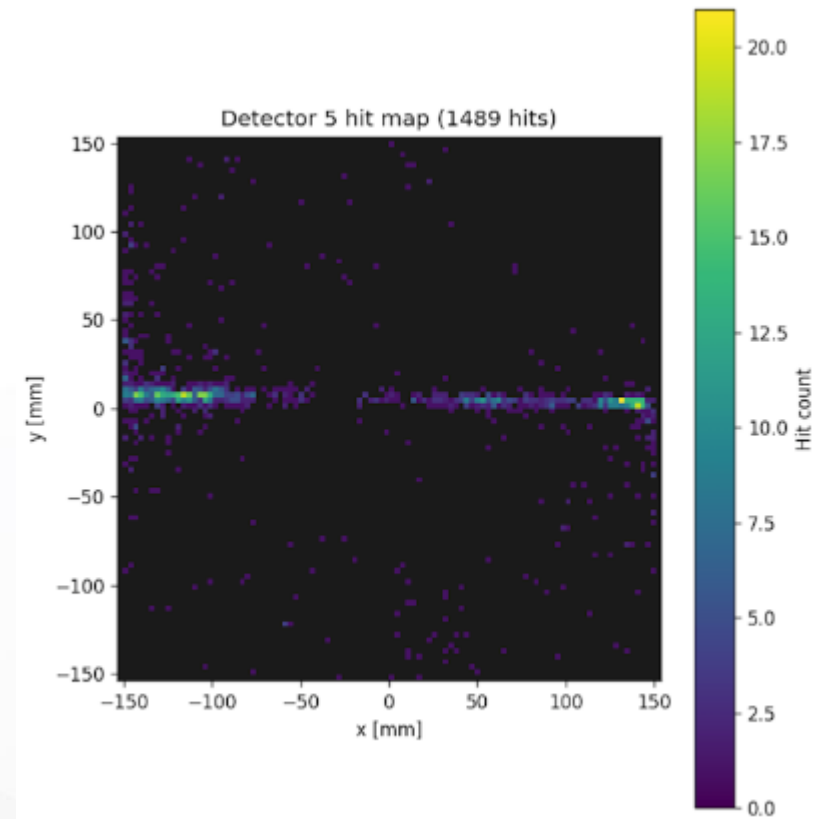
- Runs the four commands above
- Edits the config file in between each run
- Loops over multiple raw data files with different metadata

Demo Video

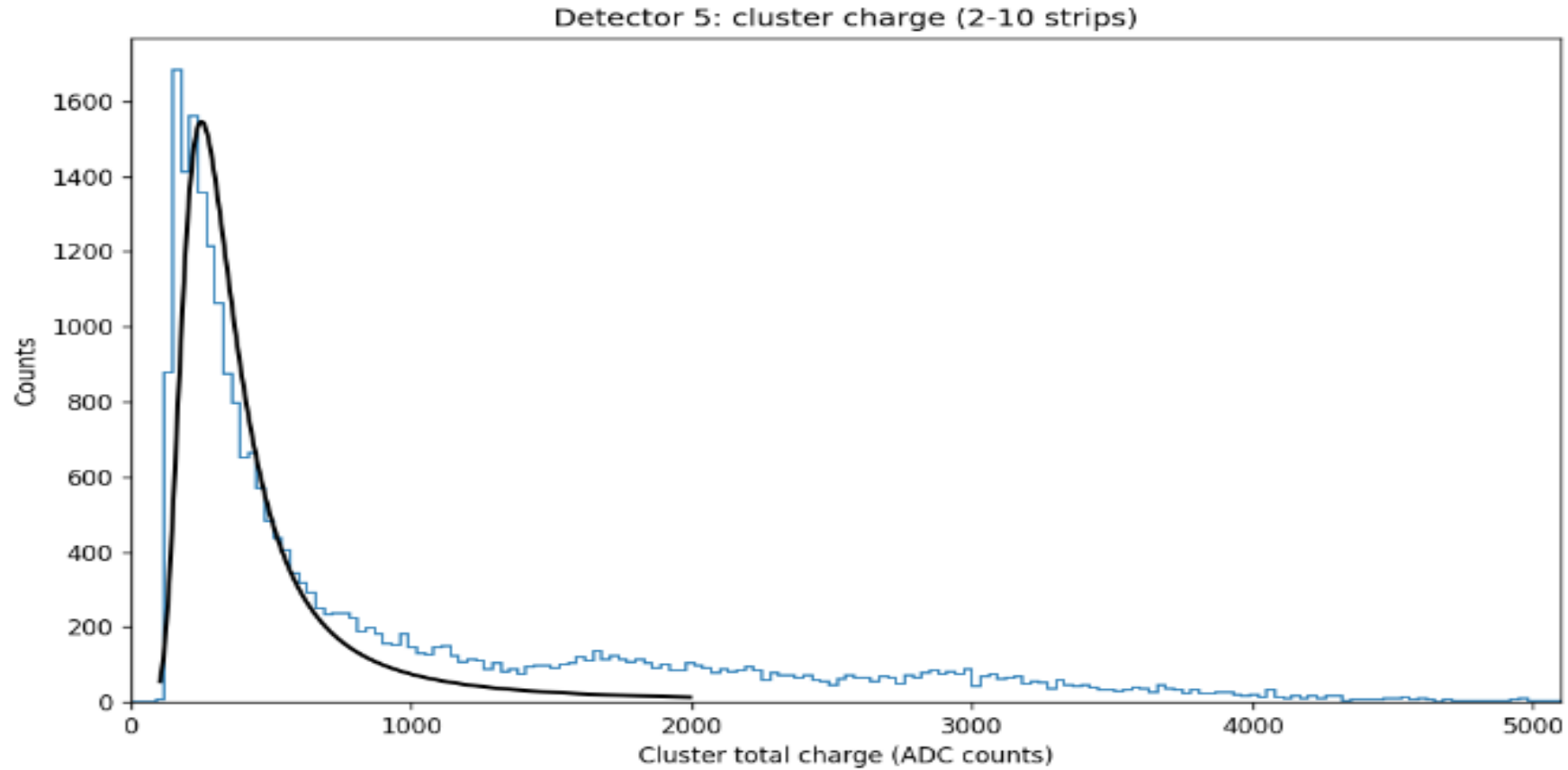


<https://youtu.be/xQhaSkLxa4k>

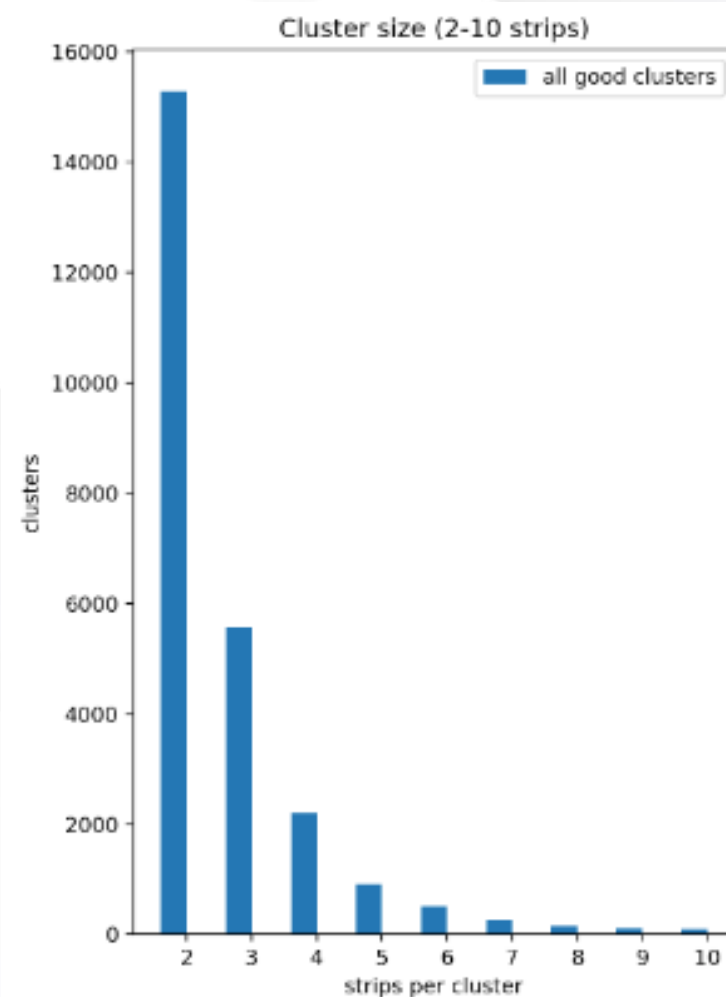
Task- Reconstruction Plot



Task- Total Cluster Charge Plot Cylindrical Detector



Task- Cluster Strip Multiplicity Plot Cylindrical Detector



Milestone 6 Task Matrix

Task		Alejandro	Summer
I.	Demo video	50%	50%
II.	User manual	50%	50%
III.	Automate pipeline for multiple root files	50%	50%

Thank you for listening

Questions?

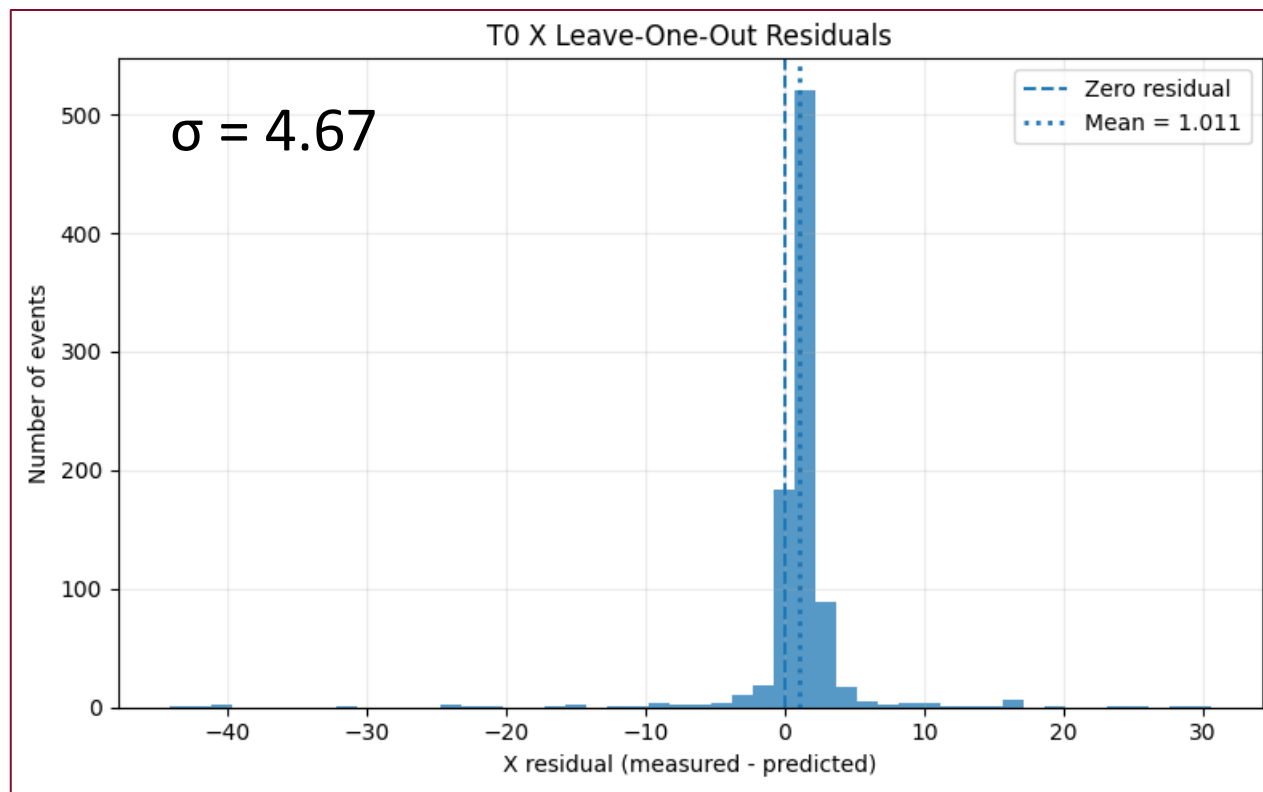
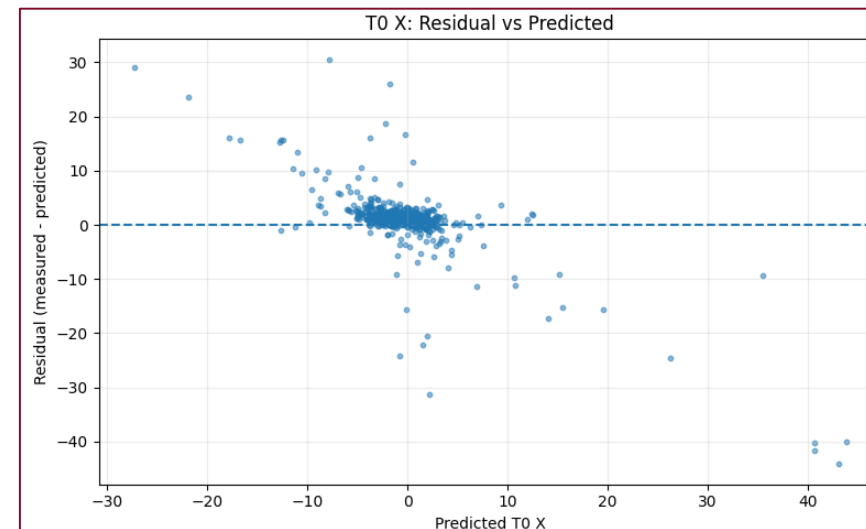
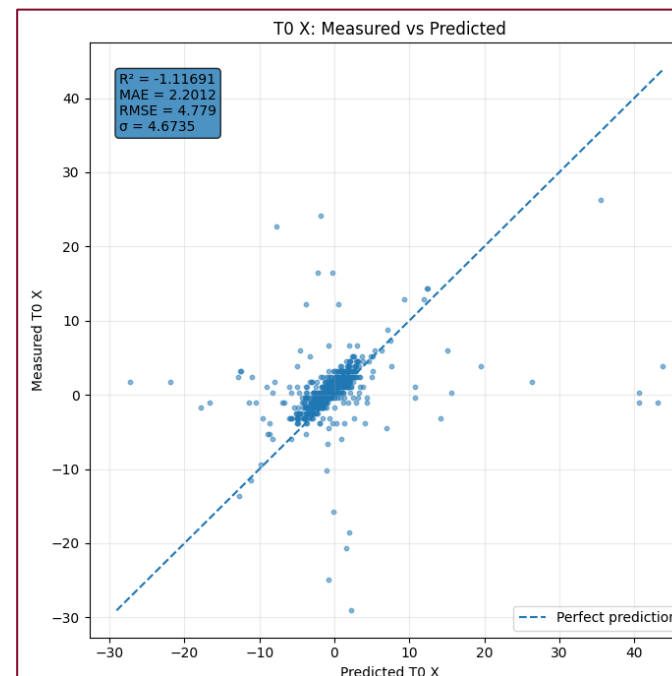
Definitions

- **Detector-** A detector is a device used in particle physics to measure the position of charged particles.
- **μ RWELL (Cylindrical micro-resistive well detector)-** μ RWELL is a type of micro-pattern gaseous detector that combines gas electron multiplication with a resistive protection layer and a segmented readout structure to measure charged particles with high precision [1]. Designing a detector that is cylindrical is the novelty here.
- **Tracker-** In the context of this project, a tracker refers to an external planar detector. Four trackers are used to create a reference system for evaluating the efficiency of the cylindrical detector.
- **Readout board-** A readout board is an electronic circuit board that collects signals from detector channels. The readout board hosts APV chips and interfaces between the detector strips and the data acquisition system. Each readout board can only capture a single plane of the data. So in planar detectors, typically there is one for x and y positions, respectively.
- **Channels/strips-** Channels or strips are the readout elements on the detector surface that collect charge from ionization events. Each strip is connected to a specific APV channel. Strip signals are used to reconstruct particle hit positions.
- **APV chip (Analog Pipeline Voltage chip)-** An APV chip samples analog signals from each channel on the readout board in time bins.
- **Time bin-** A time bin is a discrete time sample recorded by the APV chip. Typically, 12-16 time bins are used to reconstruct the pulse shape of a beam.
- **ADC (Analog to Digital Converter value)-** ADC represents a numerical value for the current recorded on a particular strip.

Definitions cont.

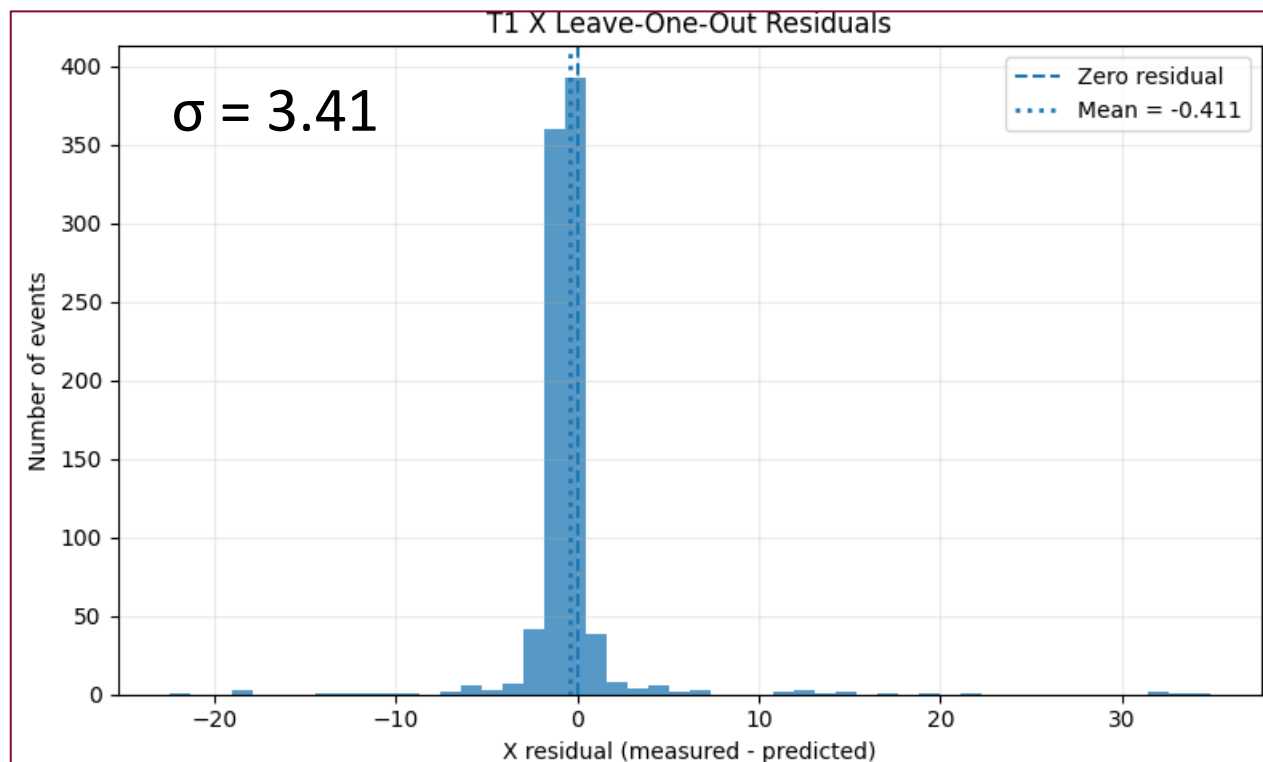
- **AMORE-SRS (Analysis and Monitoring Of Readout Electronics and Scalable Readout System)**- AMORE-SRS is a live data acquisition framework for monitoring and organizing the data from the APV chips into a root file for analysis.
- **Root file**- The root file stores event data such as strip information, ADC values, and metadata. The data is organized into branches that correspond to specific variables.
- **3D Pulse plot**- A 3D pulse plot is a visualization of a single event where the x axis is time bin, the y axis is the strip number, and the z axis is the ADC value.
- **Resolution plot**- A resolution plot is a reconstruction of the 2d hit positions represented as a heat map.
- **Efficiency plot**- Efficiency plots compare the detectors efficiency against other performance characteristics such as amplification or drift field. Efficiency itself is defined as the ratio of the number of events with strip clusters seen in all five detectors divided by the number of events with strip clusters seen in just the four trackers [2].

T0 x Residuals

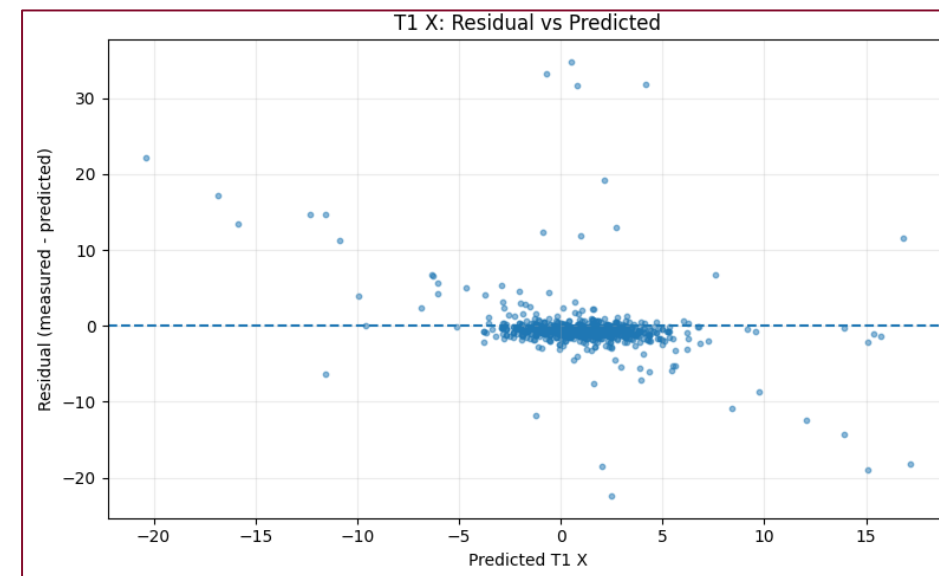
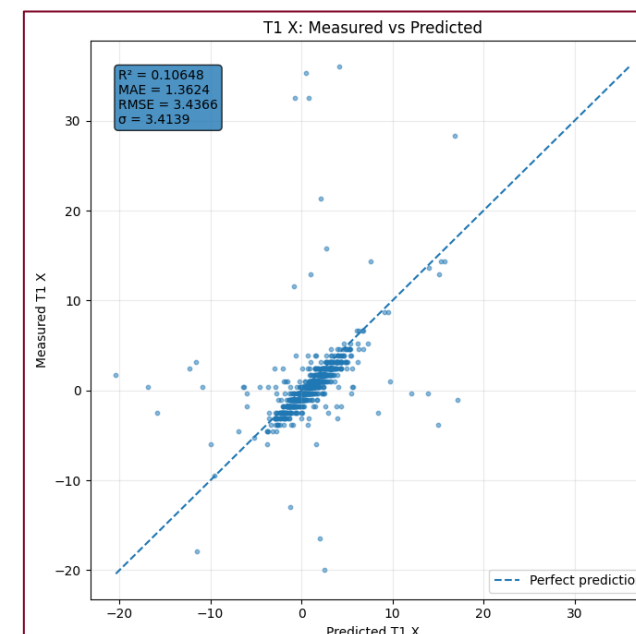


T0 X: mean residual = 1.010579, correction = -1.010579

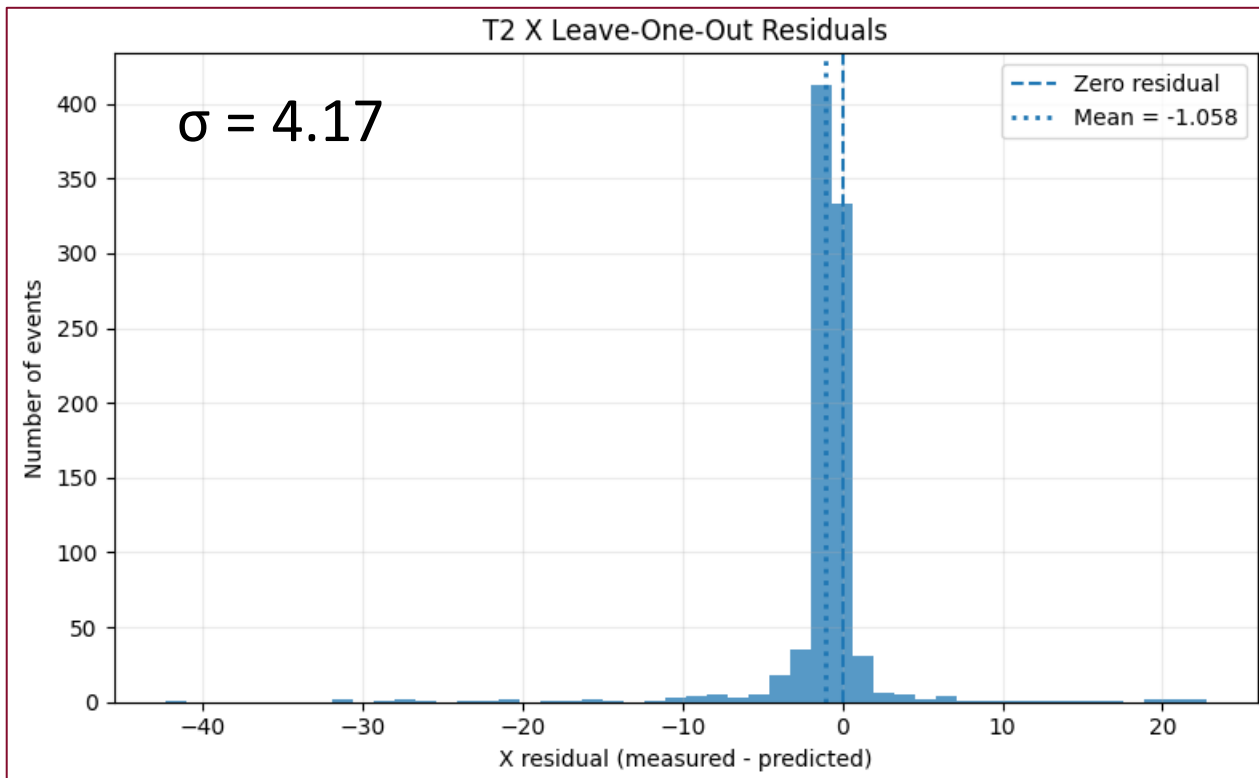
T1 x Residuals



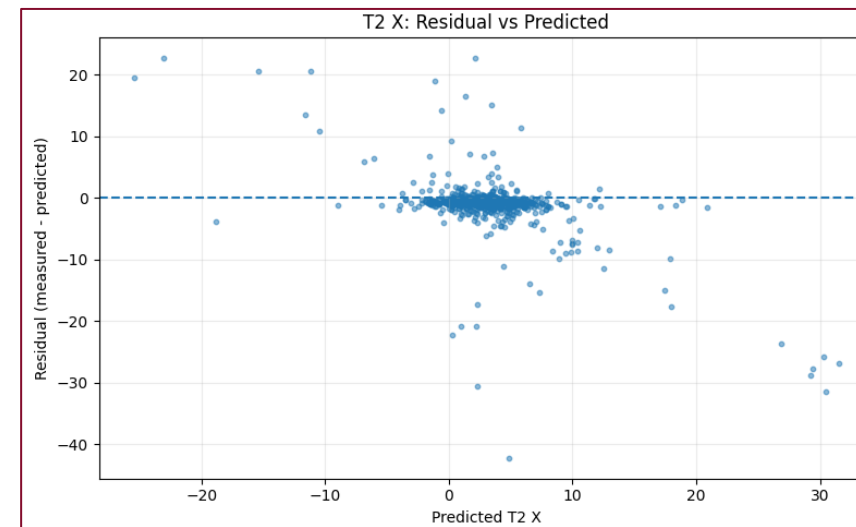
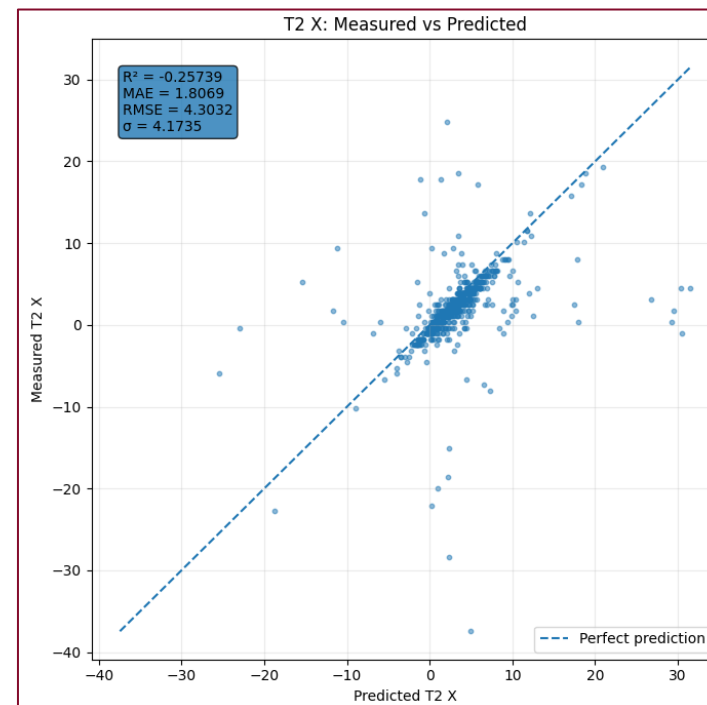
T1 X: mean residual = -0.410962, correction = 0.410962



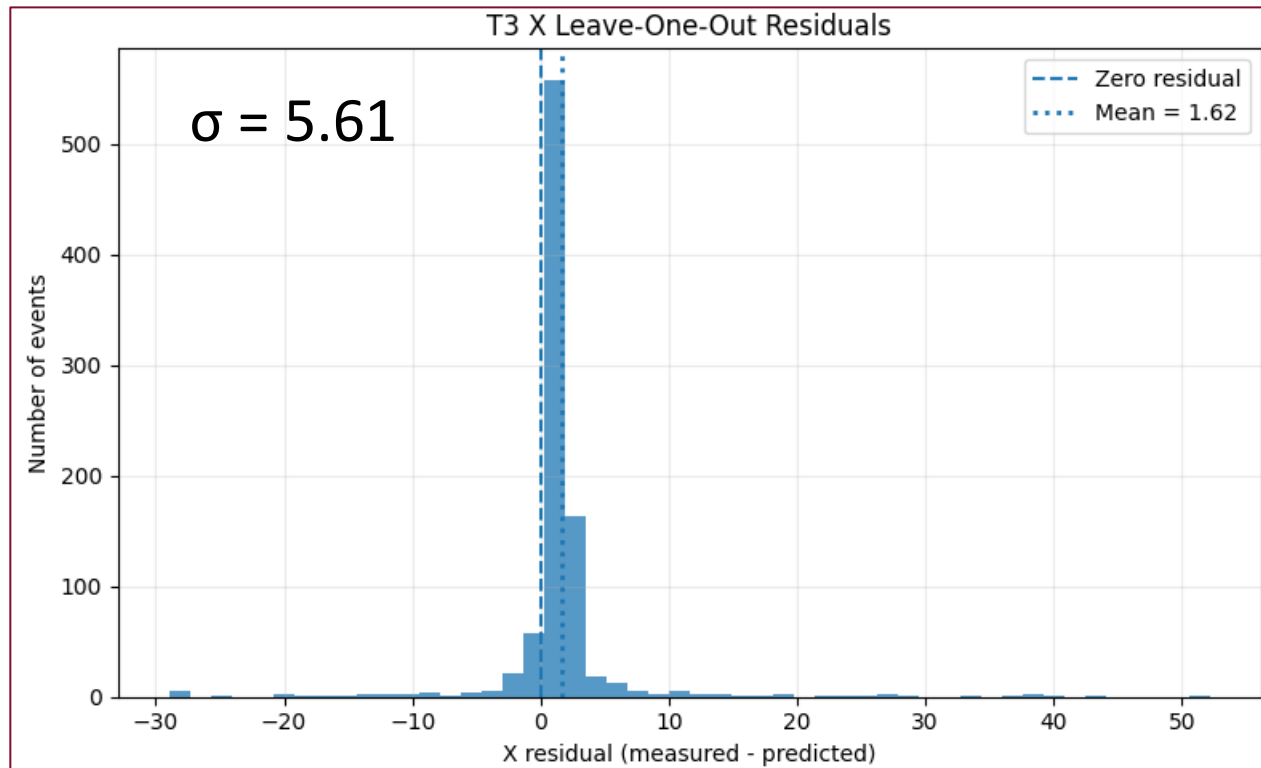
T2 x Residuals



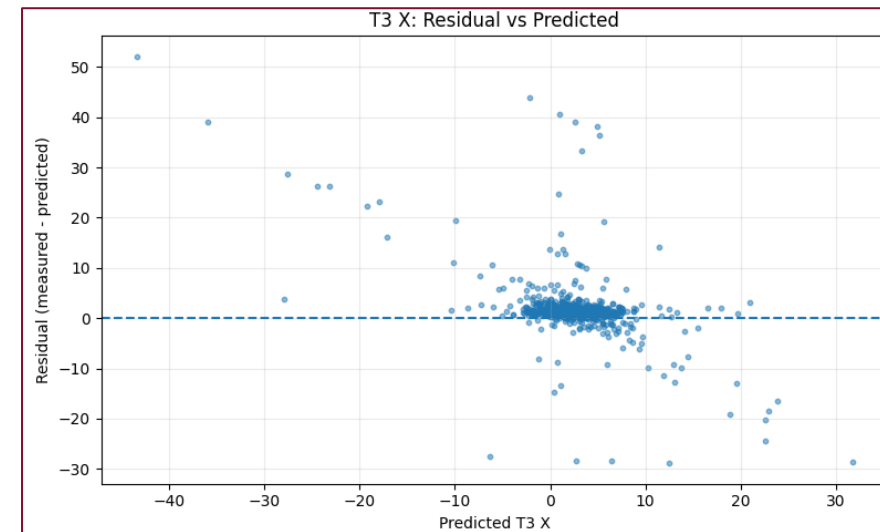
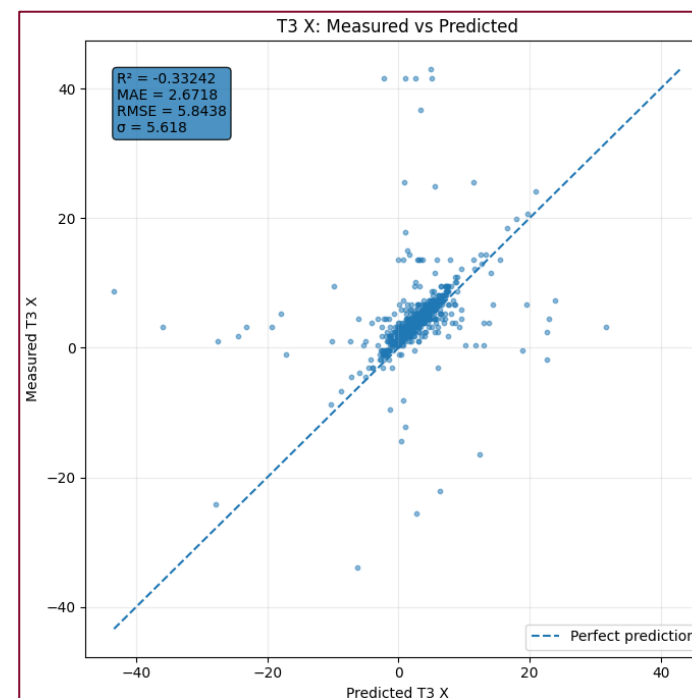
T2 X: mean residual = -1.057699, correction = 1.057699



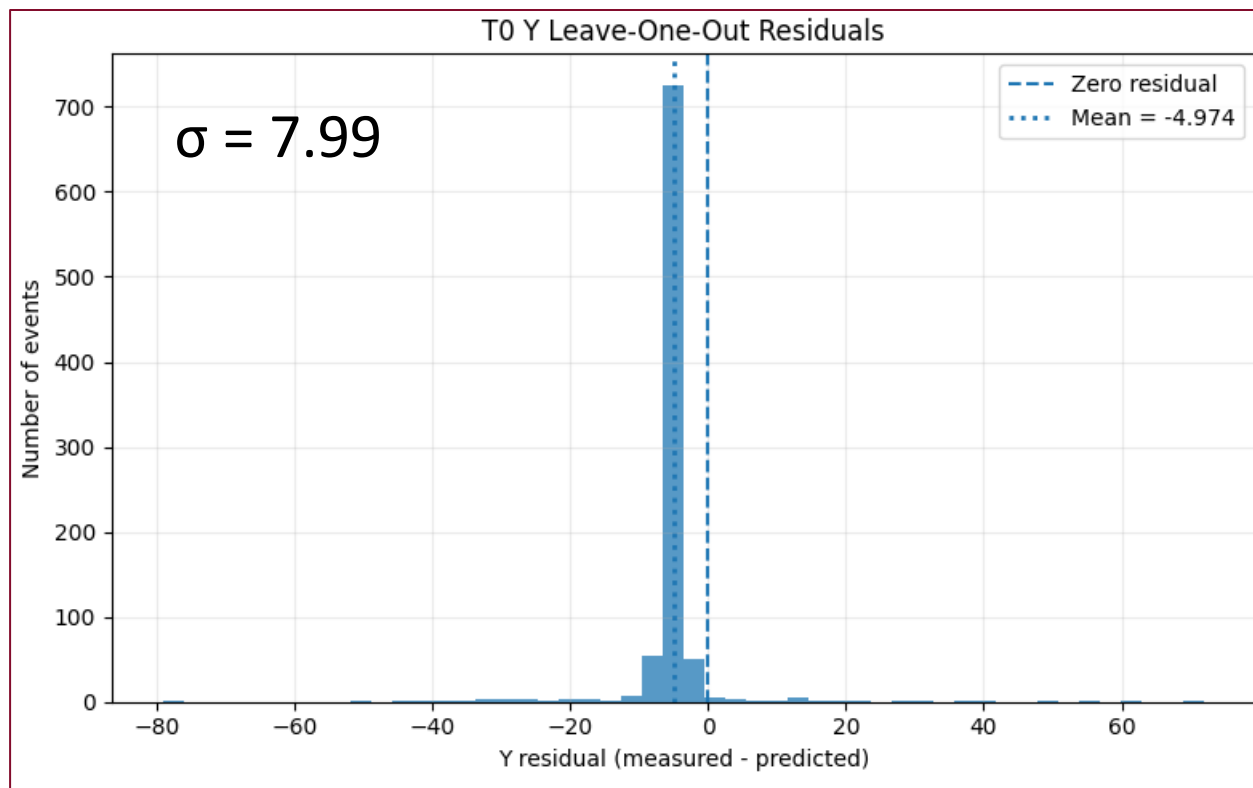
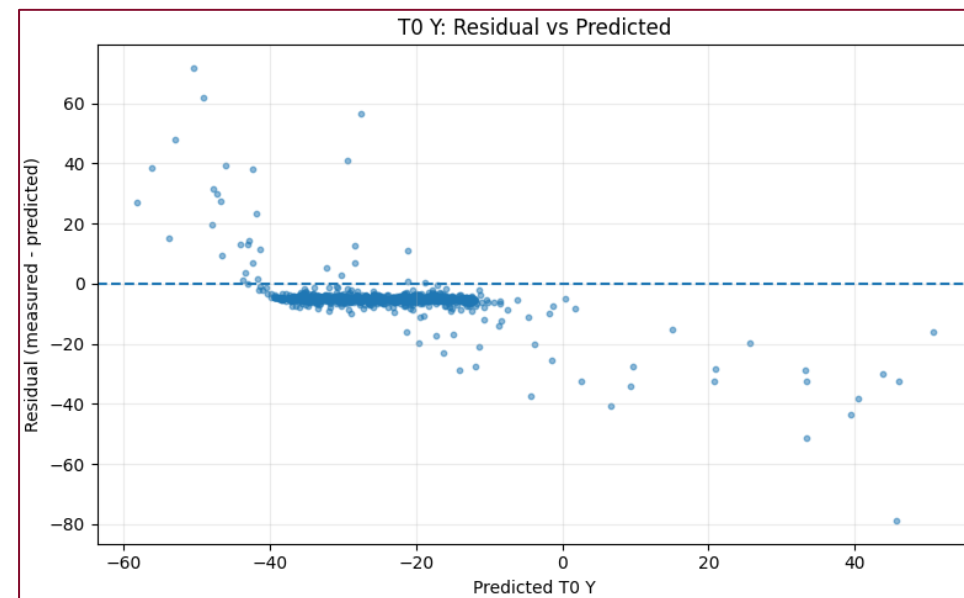
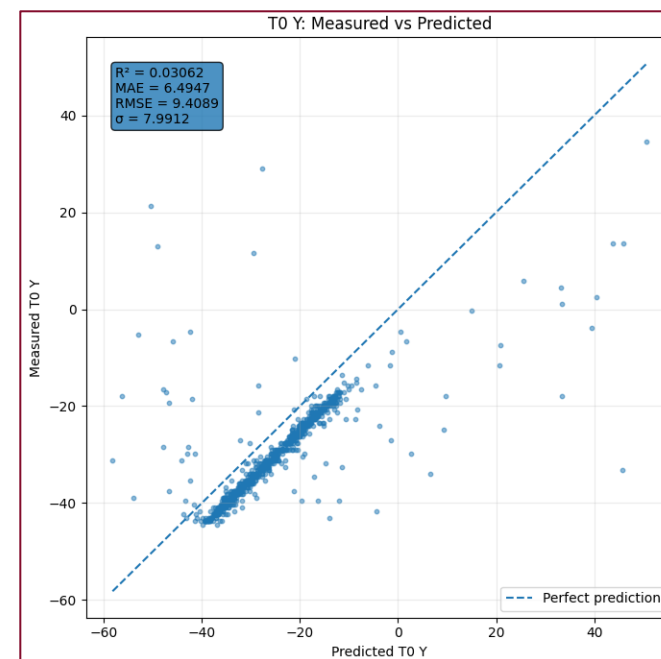
T3 x Residuals



T3 X: mean residual = 1.619634, correction = -1.619634

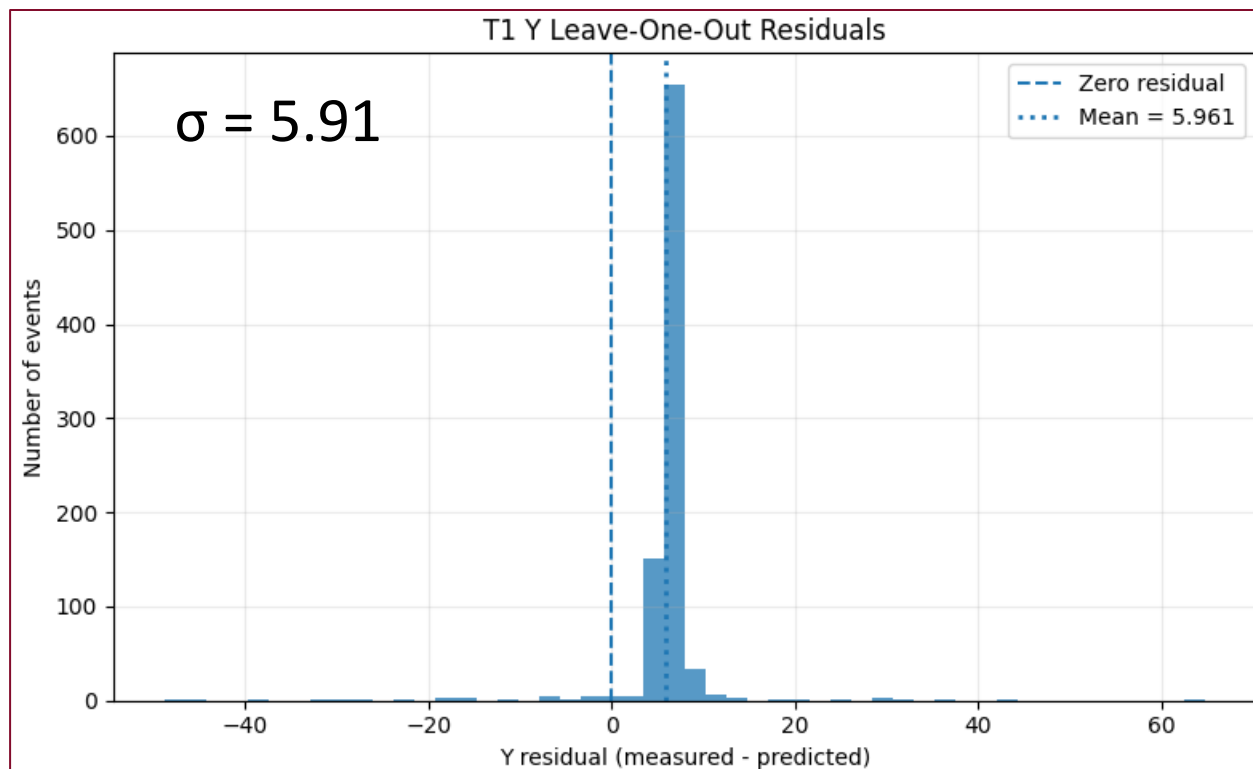


T0 y Residuals

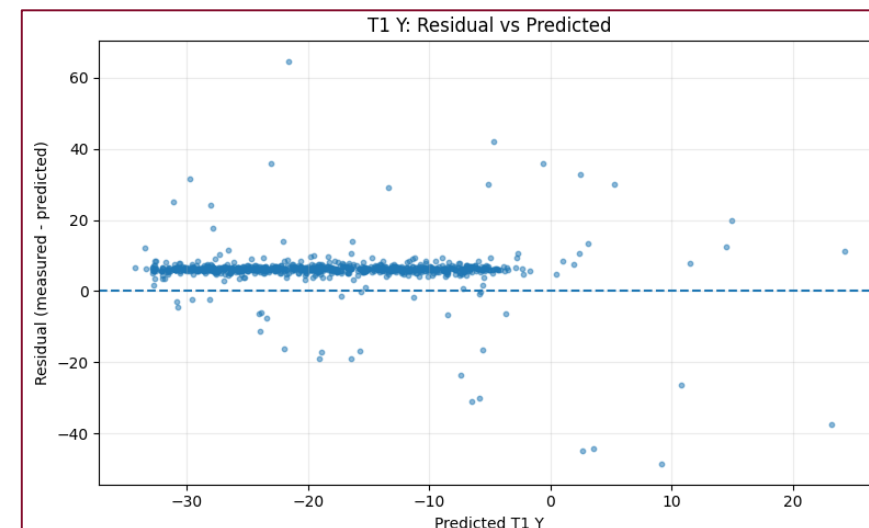
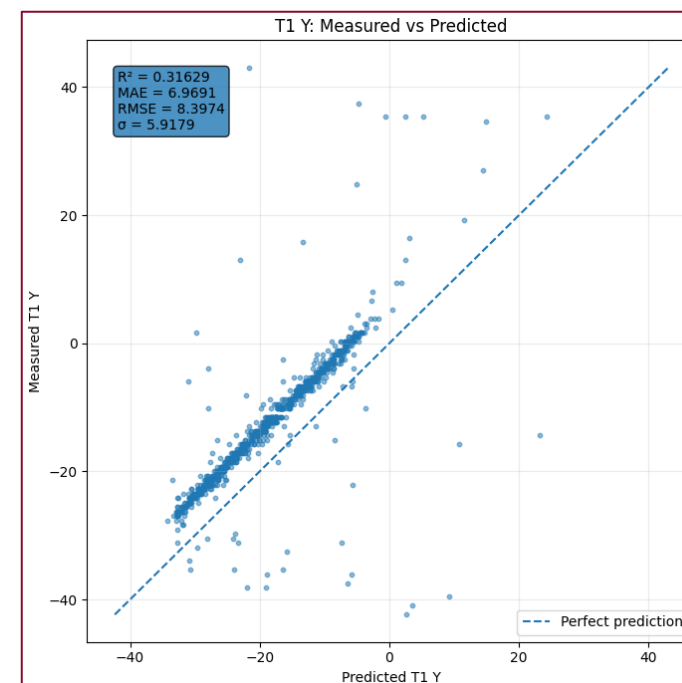


T0 Y: mean residual = -4.973888, correction = 4.973888

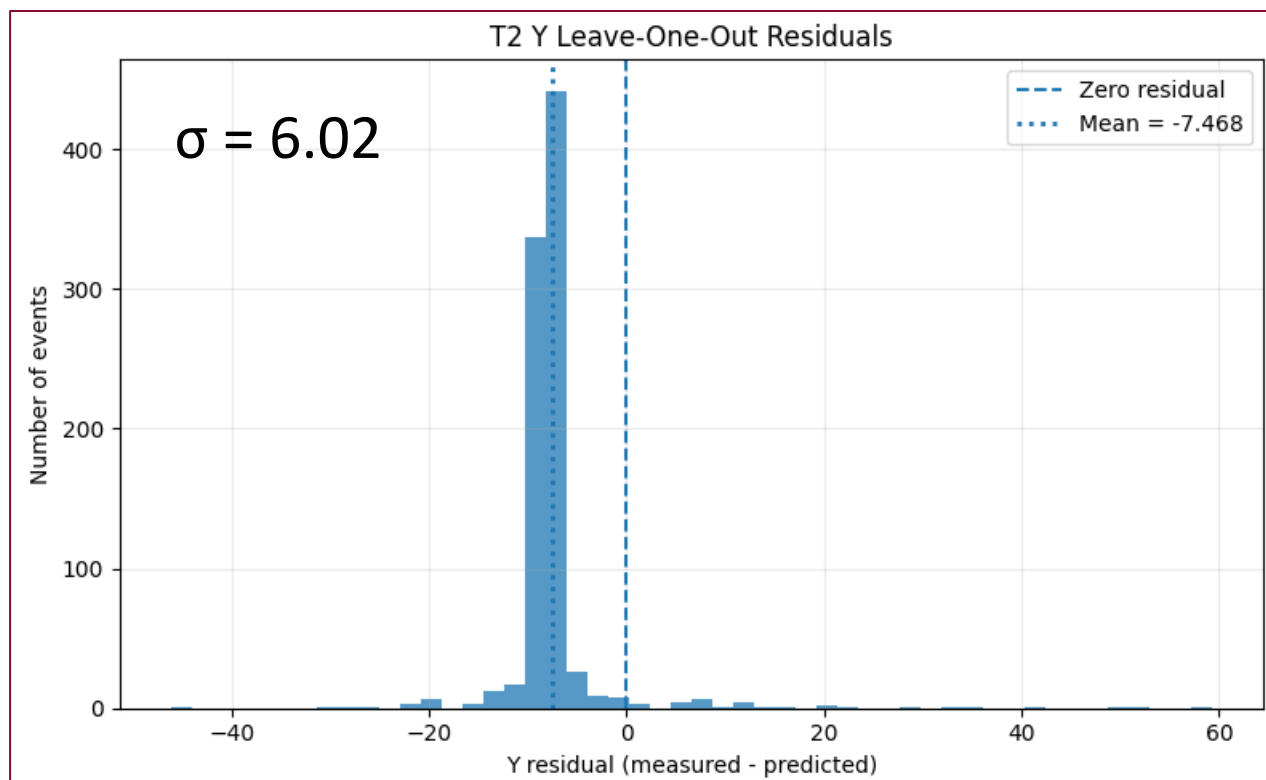
T1 y Residuals



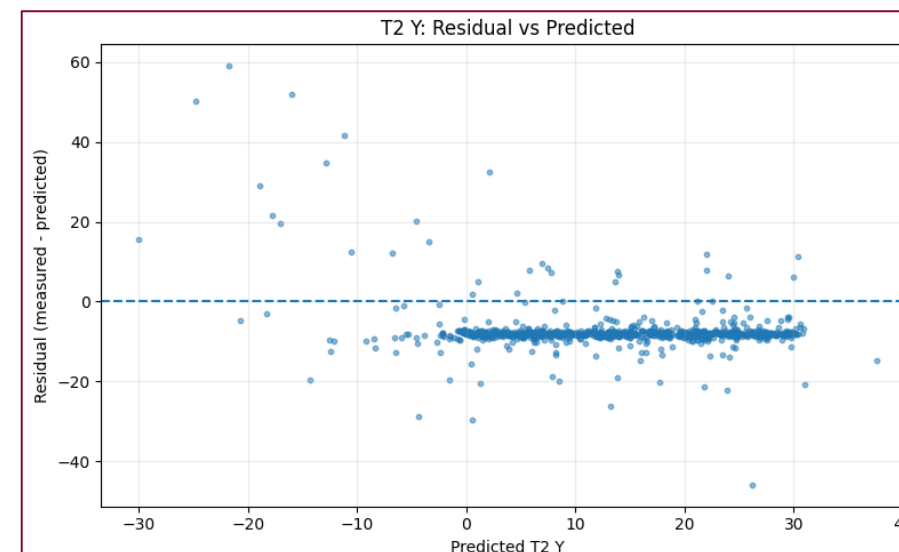
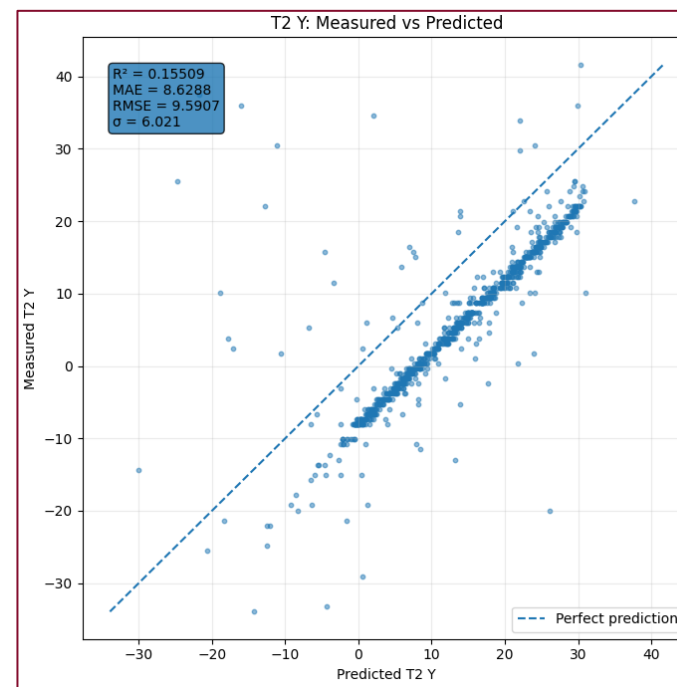
T1 Y: mean residual = 5.961020, correction = -5.961020



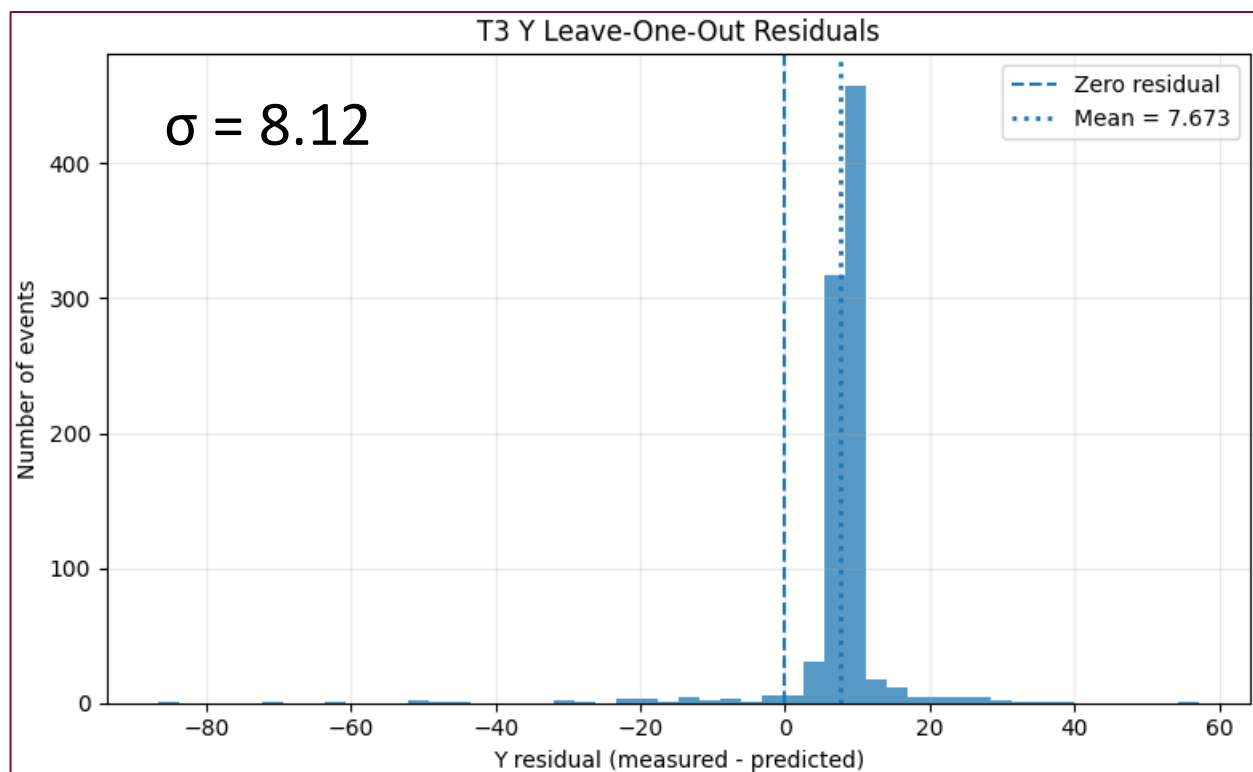
T2 y Residuals



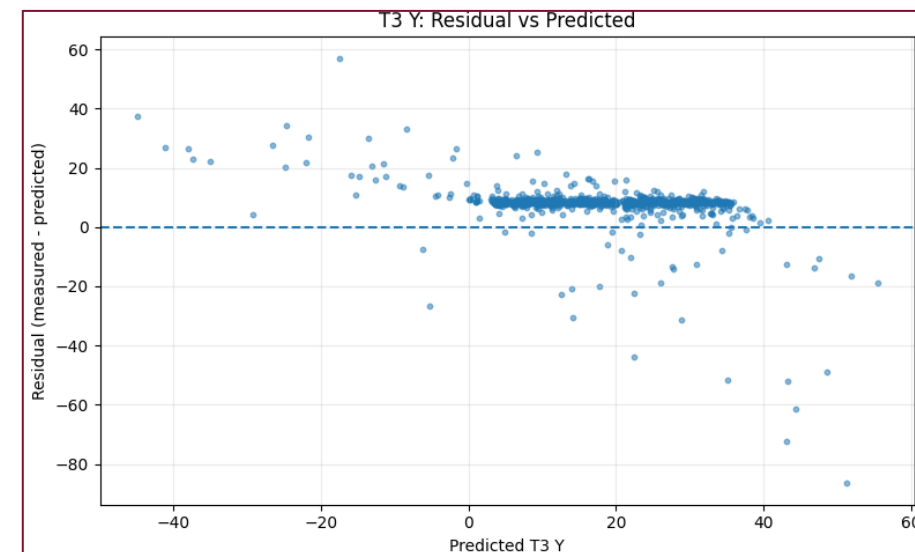
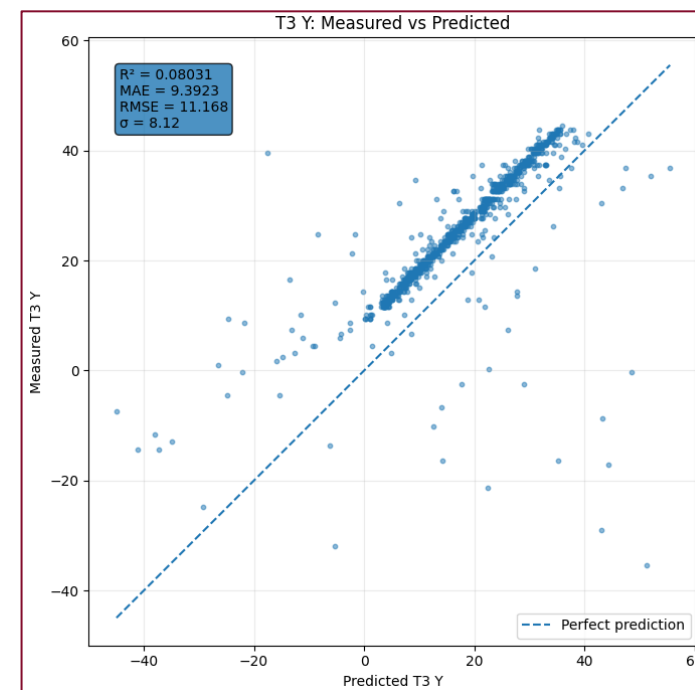
T2 Y: mean residual = -7.467947, correction = 7.467947



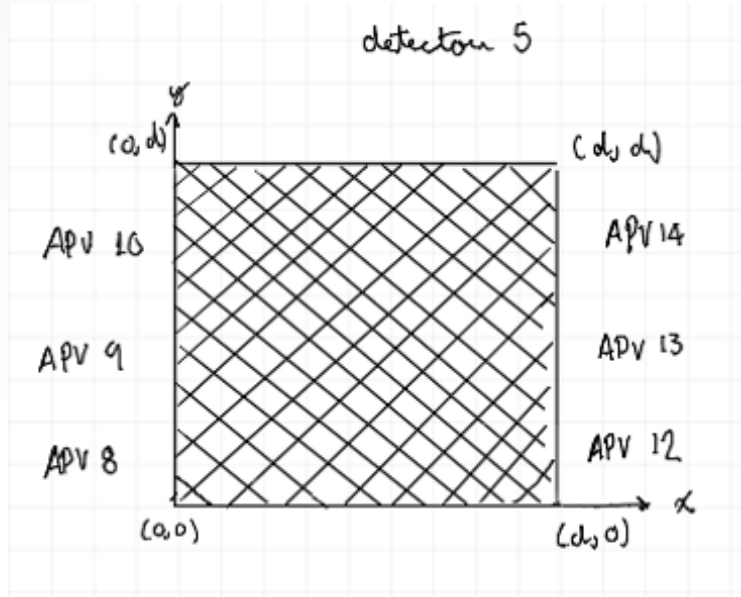
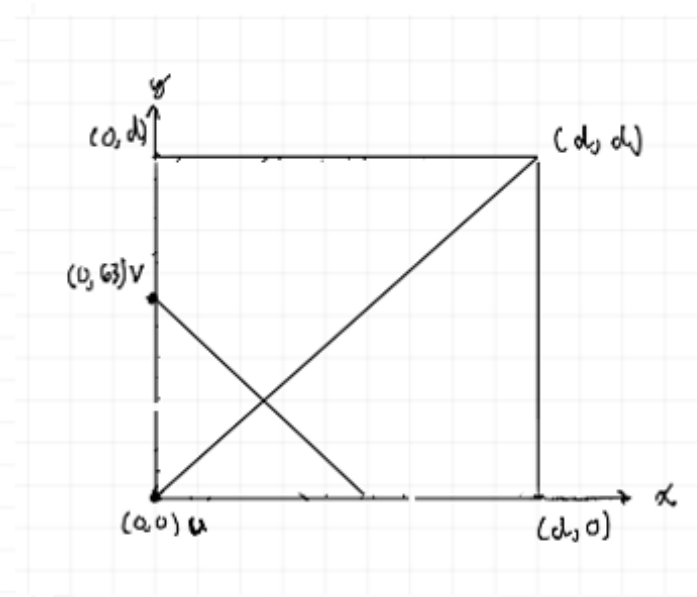
T3 y Residuals



T3 Y: mean residual = 7.672630, correction = -7.672630



Approach- Resolution Plot



$$p_1 = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad d_1 = u = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$p_2 = \begin{bmatrix} 0 \\ d_3 \end{bmatrix} \quad d_2 = v = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

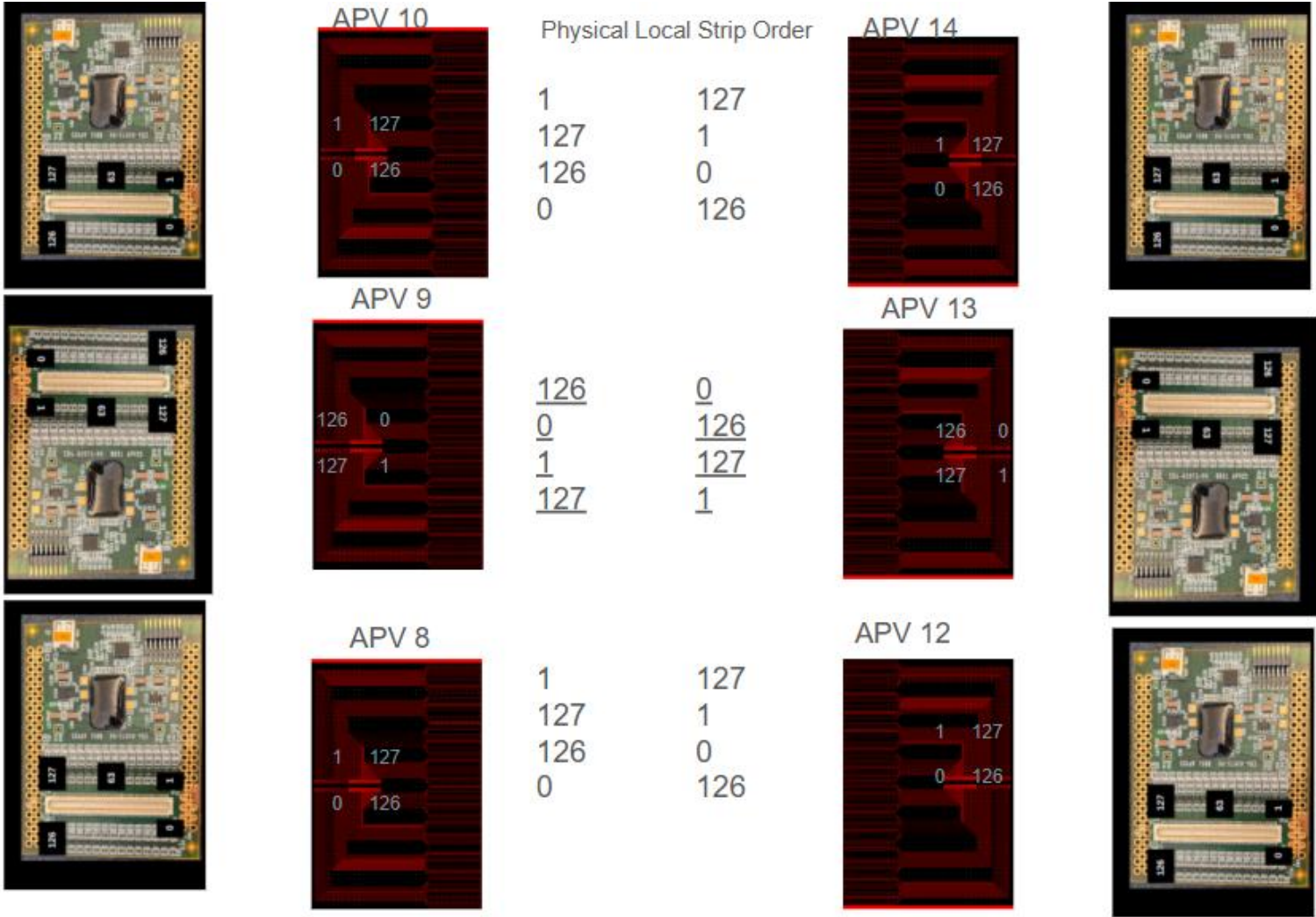
$$l_1 = p_1 + t d_1 \quad l_2 = p_2 + \lambda d_2$$

$$p_1 + t d_1 = p_2 + \lambda d_2$$

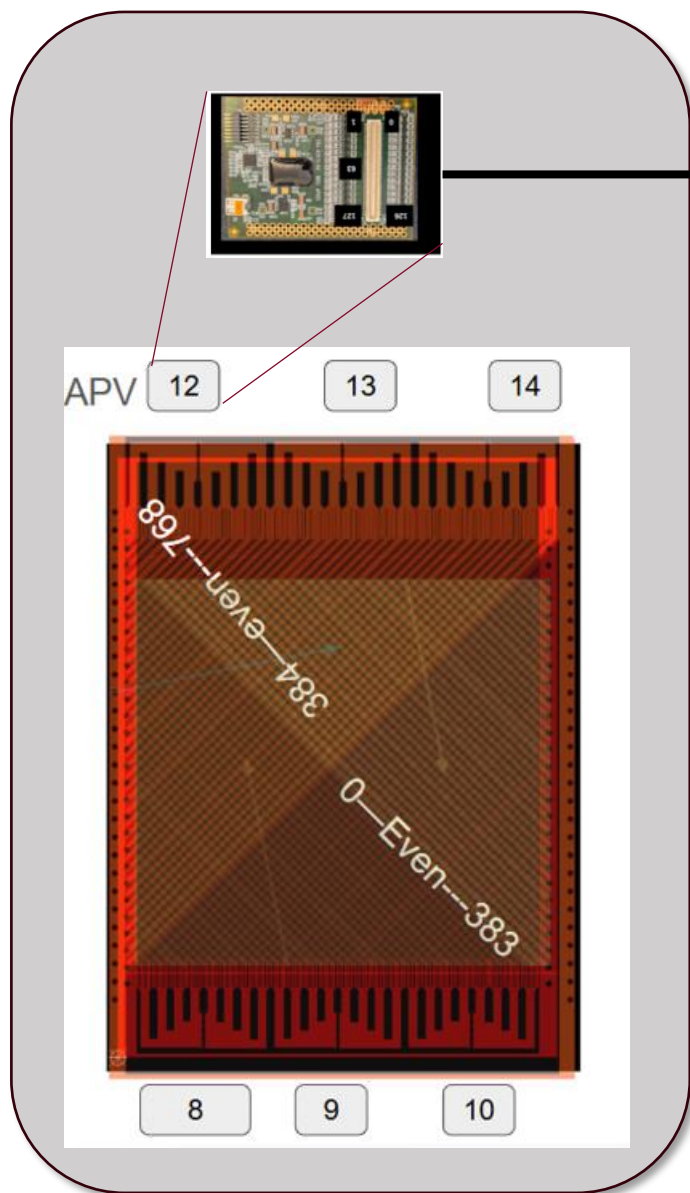
$$t d_1 - \lambda d_2 = p_2 - p_1$$

$$\begin{bmatrix} d_{1x} & -d_{2x} \\ d_{1y} & -d_{2y} \end{bmatrix} \begin{bmatrix} t \\ \lambda \end{bmatrix} = \begin{bmatrix} p_{2x} - p_{1x} \\ p_{2y} - p_{1y} \end{bmatrix}$$

Channel Orientations



Hardware



Software

