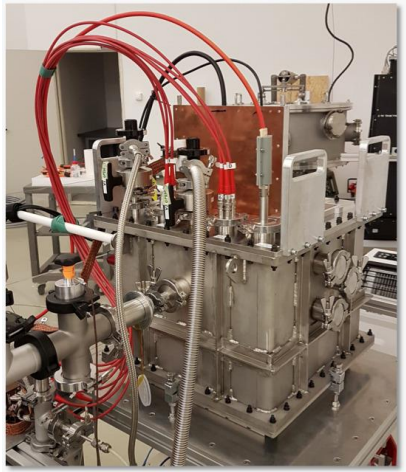
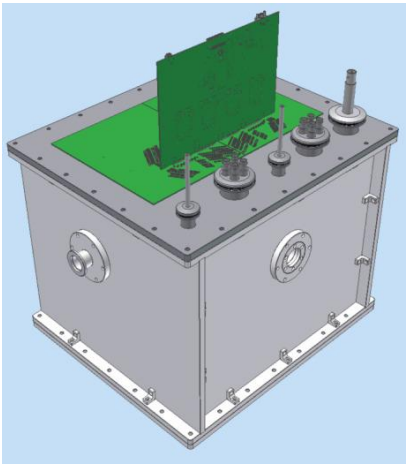
# TPC data analysis (analysis of frames) in ROOT: how to approach

Niculae Stefan

# What is the TPC?

- The mini-eTPC is a gas-based time-projection chamber investigating photonuclear reactions.
- It has a Gas Electron Multiplier based read-out system.
- It can be used to form a reconstruction of certain interactions that happen within the gas.



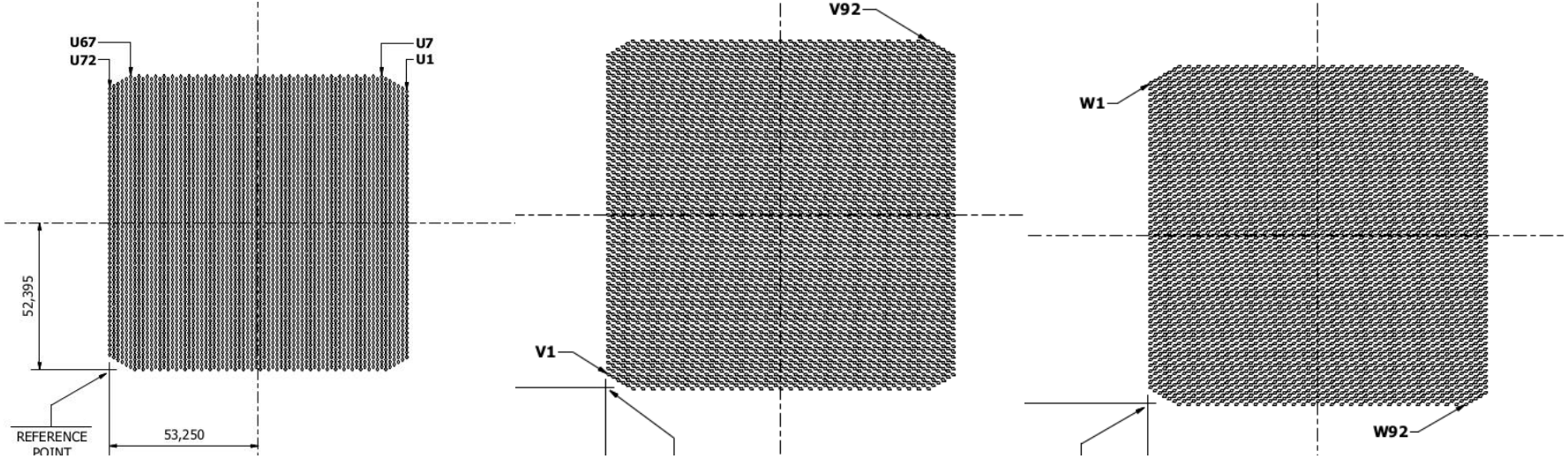


# What do we want?

- A high volume of data was acquired using the TPC from an experiment featuring a neutron beam directed at a CO2 target.
- The data needs to be analysed, identifying reactions.
- Statistics need to be calculated from the analysed data.

# Introduction to TPC data

- The TPC uses 3 parallel planes that contain detector strips.
- The signals are detected from each strip for each plane.



# Introduction to TPC data

- Each event is represented by a plane id, a strip number and a signal value (512 bins).
- Each trigger contains one event for each strip on each plane (72 + 92 + 92 for mini-eTPC).

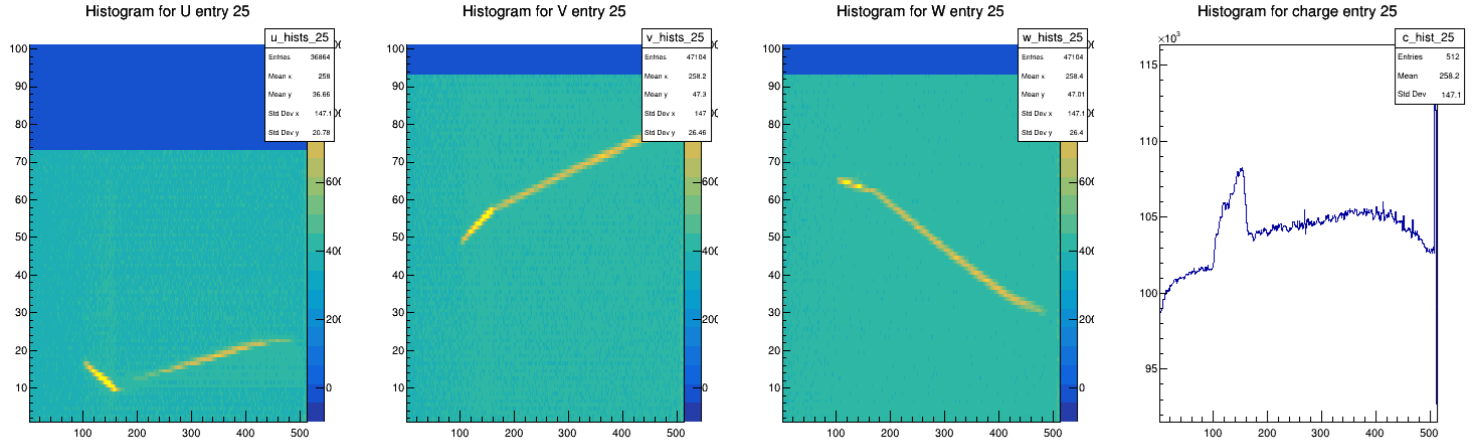
```
/// @brief The plane the signal belongs to. 0 is U plane, 1 is V plane, 2 is
/// W plane.
int plane_id = INT32_MAX;

/// @brief The number of the strip.
int strip_nr = INT32_MAX;

/// @brief The signal vector.
std::vector<double> signal_val;
```

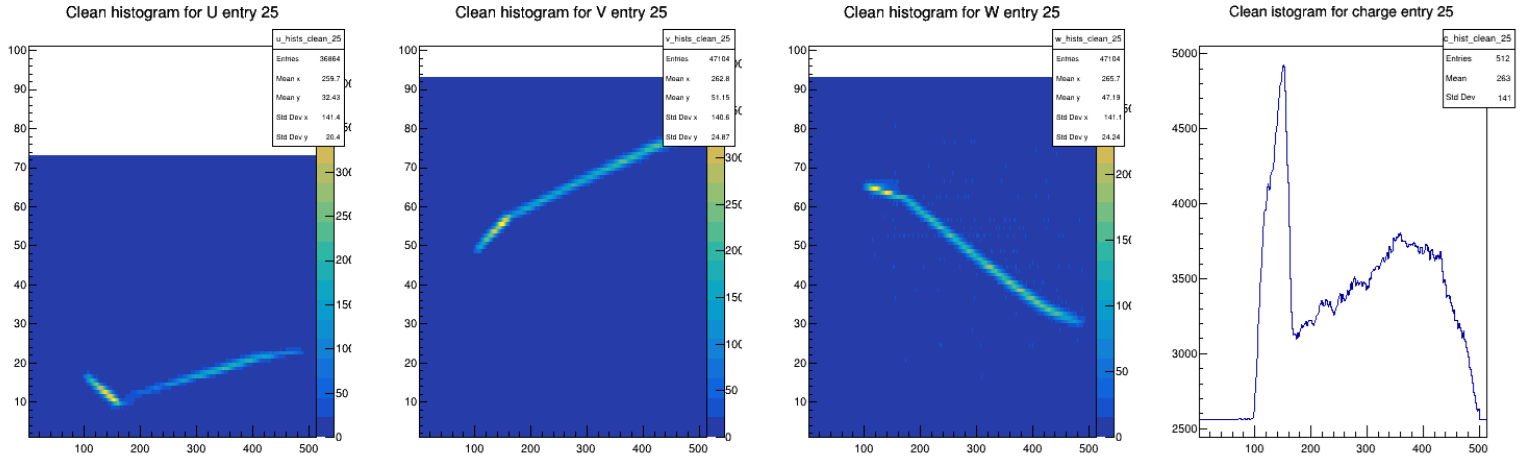
# Introduction to TPC data

- The data is used to generate images on which image processing algorithms will be used.
- The data is goes to preprocessing in order to ensure image quality.

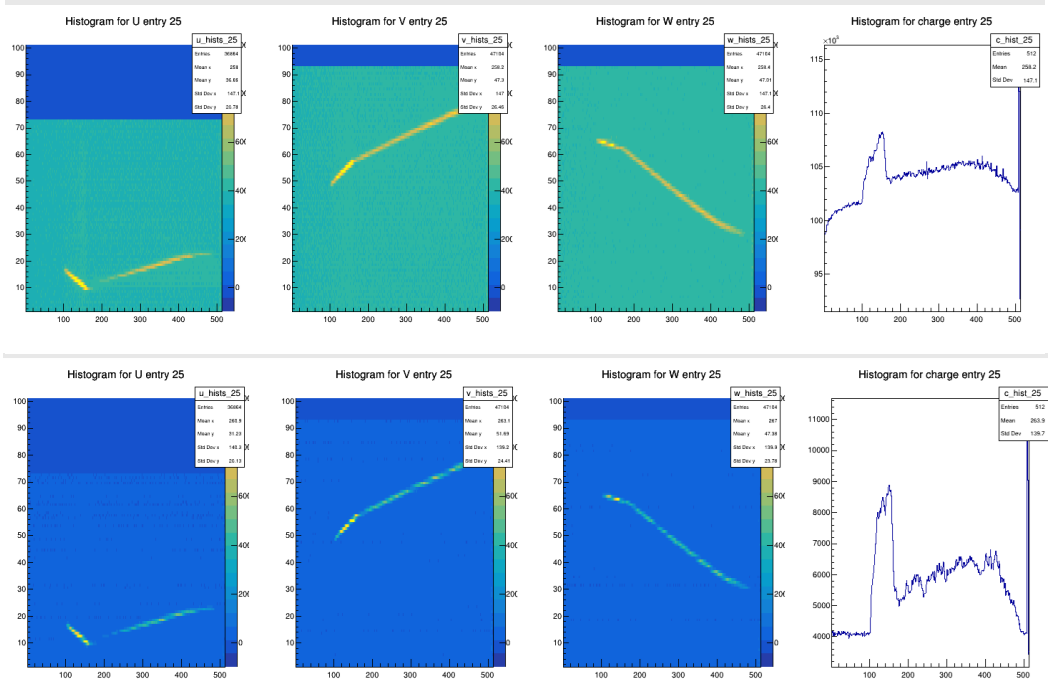


# Image preprocessing

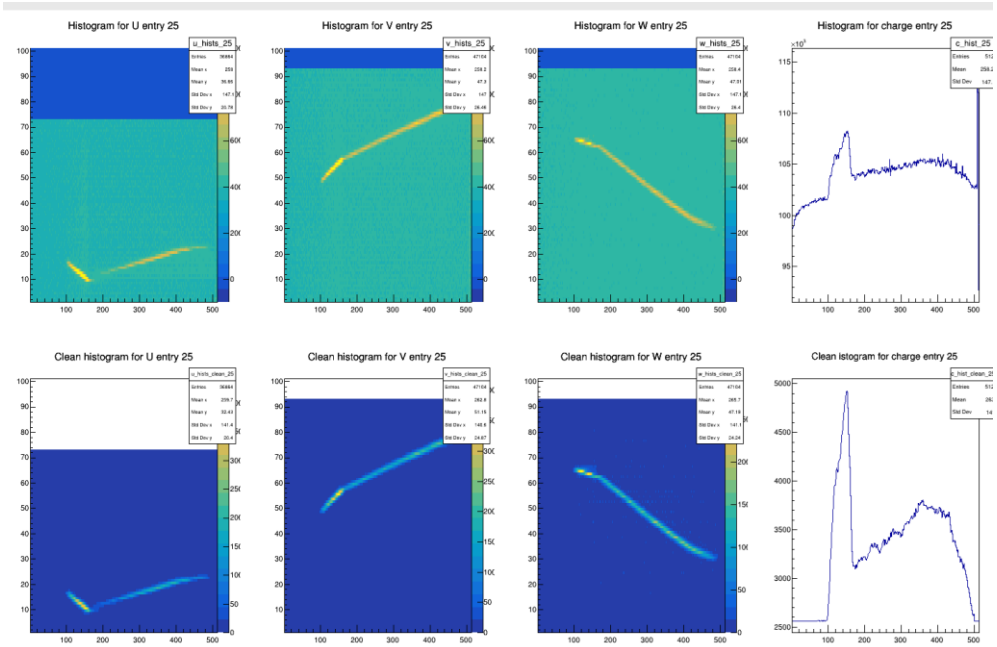
- The data contains noise that needs to be extracted.
- Fixed Pattern Noise (FPN) channels can be used to help with the noise extraction.
- The baseline can be further extracted in order to improve the contrast.



# Image preprocessing - FPN removal

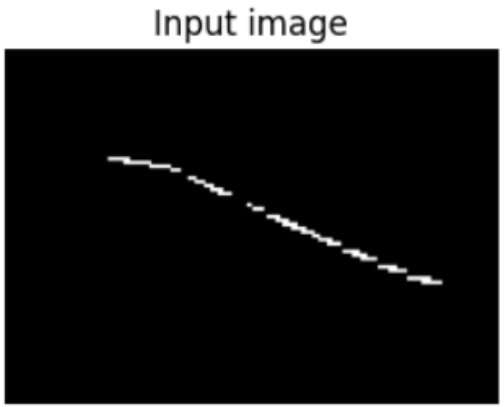


# Image preprocessing - final result



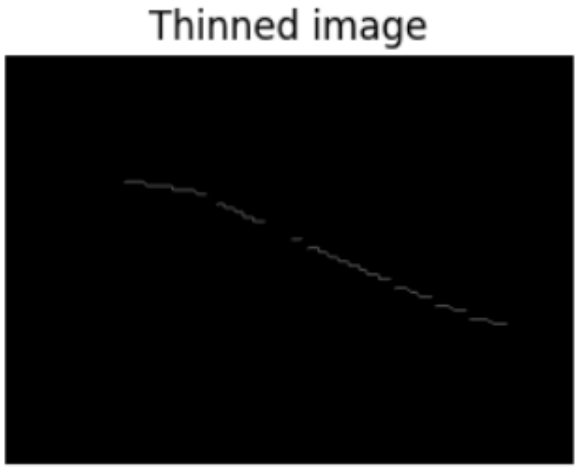
# Image analysis process

- Matplotlib and Numpy are used to import the images in python.
- The RGB image is converted to grayscale (0 to 1 value representing black to white).
- All points above a certain value are considered part of the trace.

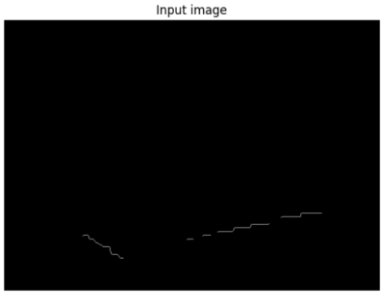


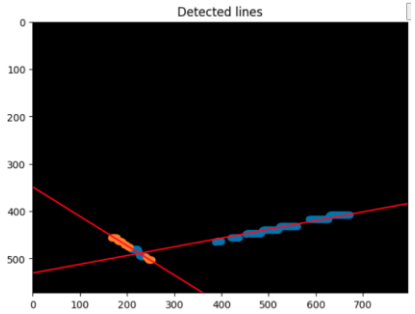
# Image analysis process

- Small shapes are considered noise and removed.
- The shapes are turned into 1 pixel width lines.

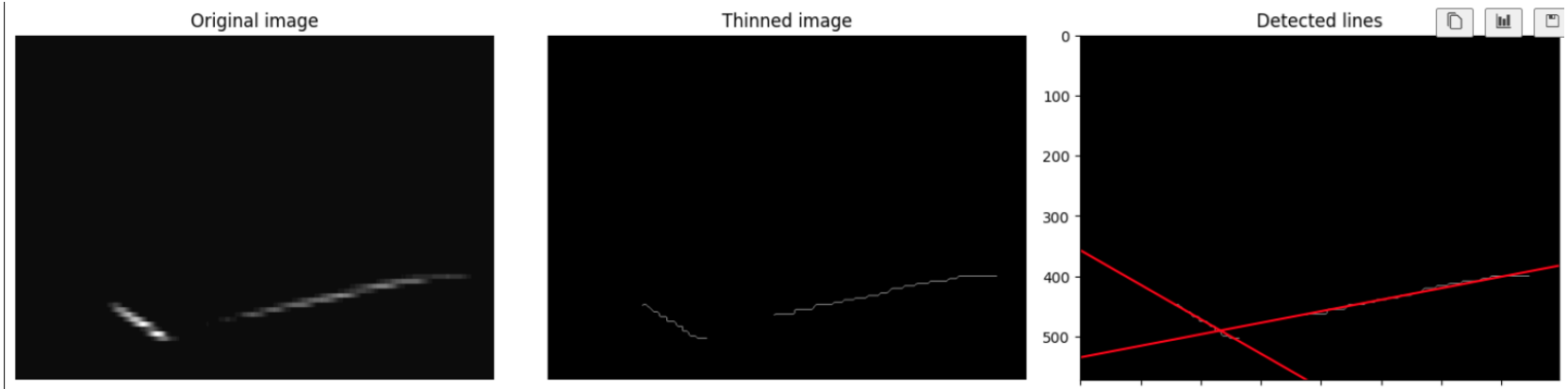


# Image analysis process



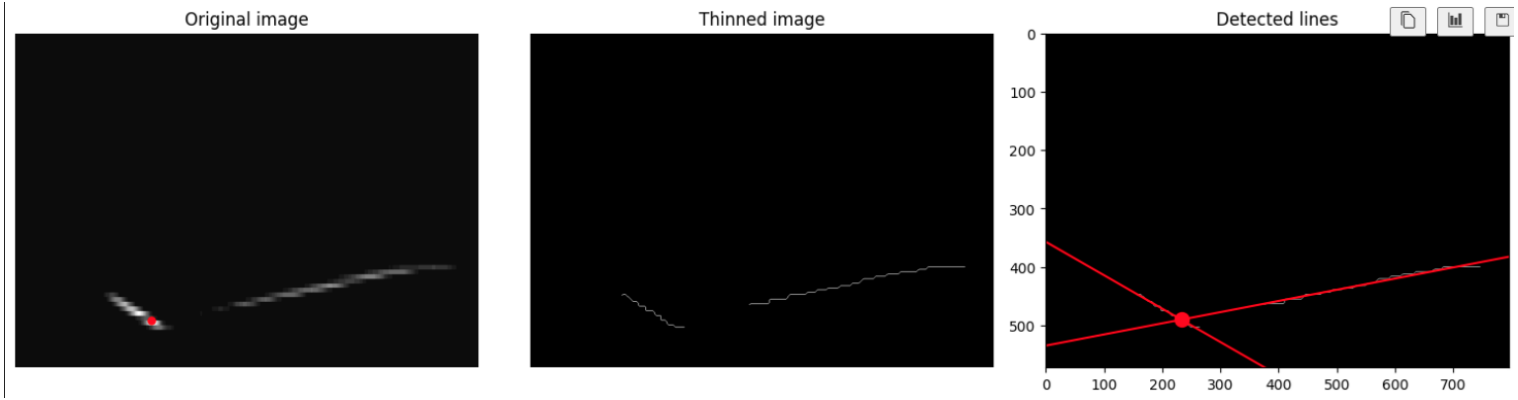



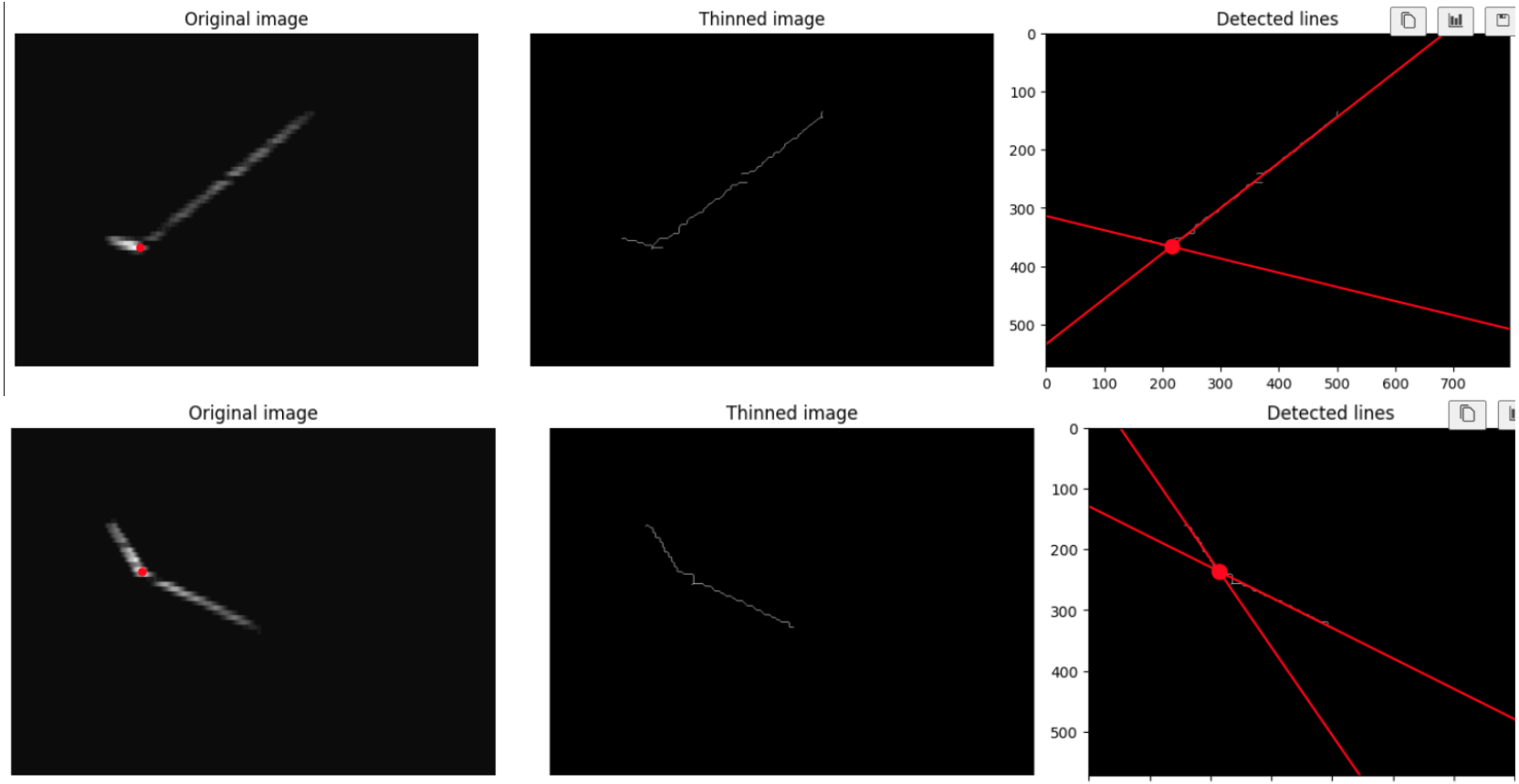

- Multiple RANSAC iterations are used to compute the line equations.
- Due to the randomness of the RANSAC algorithm, the equations are calculated multiple times with different seeds and averaged.
- Invalid events can be filtered and valid ones can be split into lines, 2-prong and 3-prong.



# Image analysis process

- The average of the intersection points is considered the reaction point.




Original image
Thinned image
Detected lines
0
100
200
300
400
500
0
100
200
300
400
500
600
700
Original image
Thinned image
Detected lines
0
100
200
300
400
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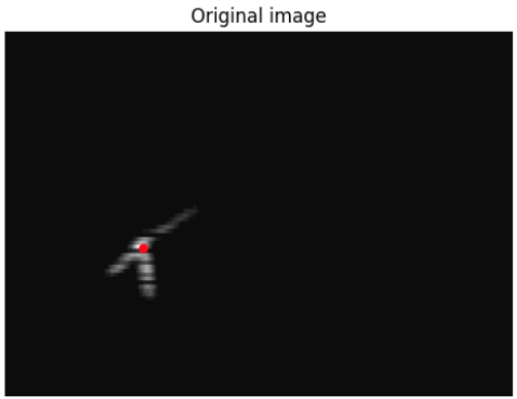
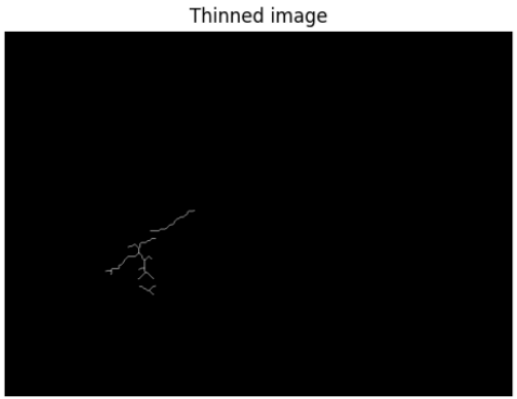
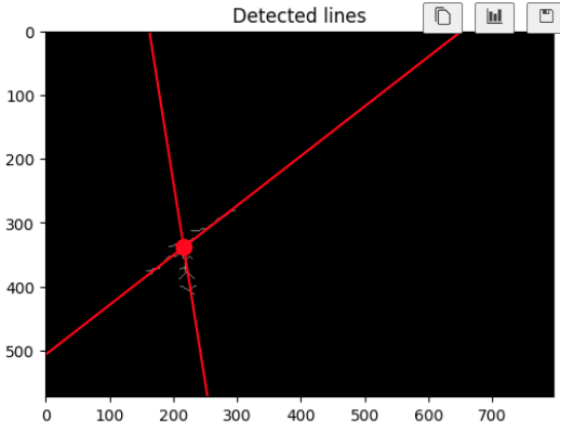
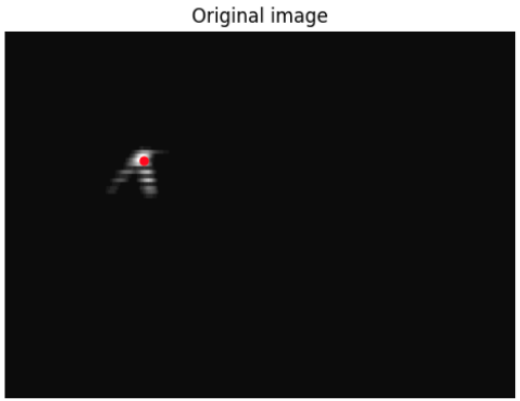
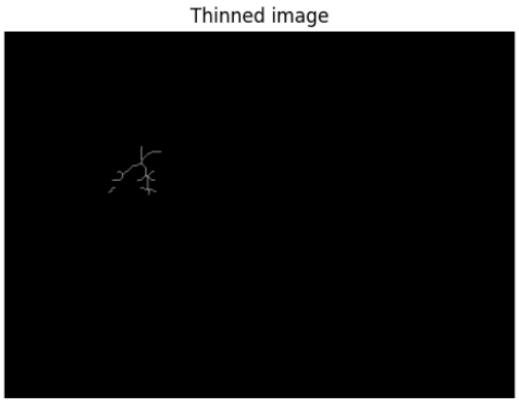
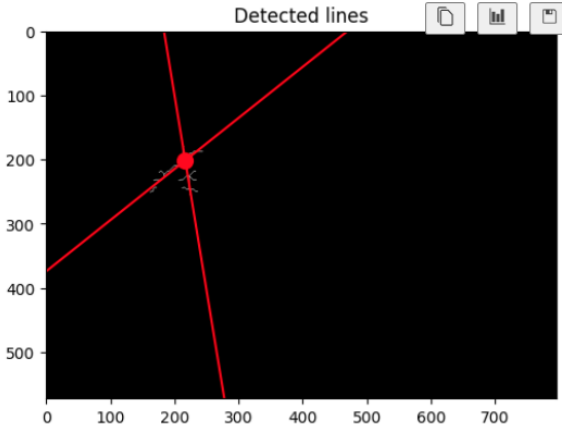

Original image


Thinned image


Detected lines
0
100
200
300
400
500
0
100
200
300
400
500
600
700


Original image

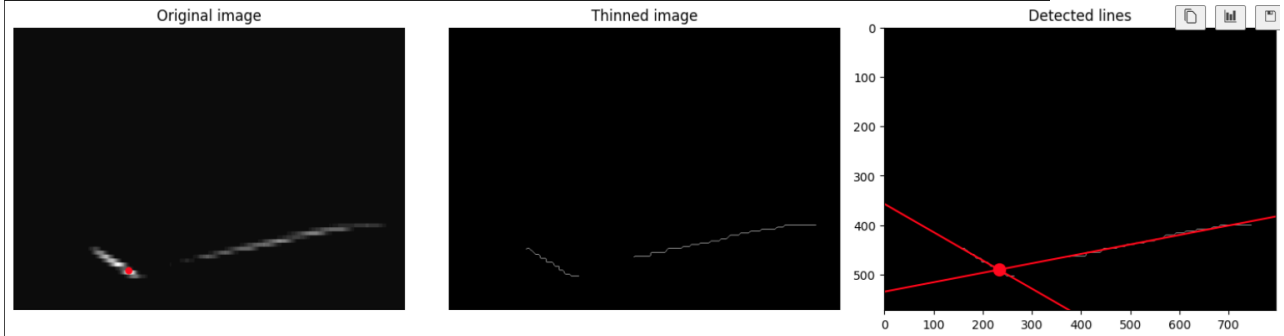

Thinned image


Detected lines
0
100
200
300
400
500
0
100
200
300
400
500
600
700

# Output

- The result is:
  - The equations for all of the detected lines, which represent the traces left by the particles.
  - The location of the interaction point.
- This result can be used to calculate the relevant statistics.

```
Line 0: y = -0.19121158929023446 * x + 534.4567258114923
Line 1: y = 0.5718471247143562 * x + 356.86545165931443
 Intersection at (232.7360541106533, 489.9548950198563)
```



# Conclusion and ongoing activities

- The program can parse through data and find valid events, which are further analyzed in order to reconstruct the interaction.
- The time needed to analyze the large data set can be significantly reduced.
- Improvements to the accuracy of the computed interaction points can be made by using the amplitude of the signals.
- General improvements to the accuracy of the line detection algorithms can be made for 2-prong and 3-prong events.

# THANK YOU