TECHNISCHE UNIVERSITÄT DARMSTADT

Results for Laser Measurement of HYDRA-TPC in GLAD

Lian-Cheng Ji, TU Darmstadt

R^3B Collaboration Meeting

July 10th, 2024

CONTENT

TECHNISCHE UNIVERSITÄT DARMSTADT

1. Laser measurement in GLAD in November, 2023
   a) Overview
   b) Waveform analysis
   c) Laser track reconstruction
   d) Track displacement under magnetic fields
2. Laser measurement in GLAD in February, 2024

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OVERVIEW OF LASER MEASUREMENT IN NOVEMBER

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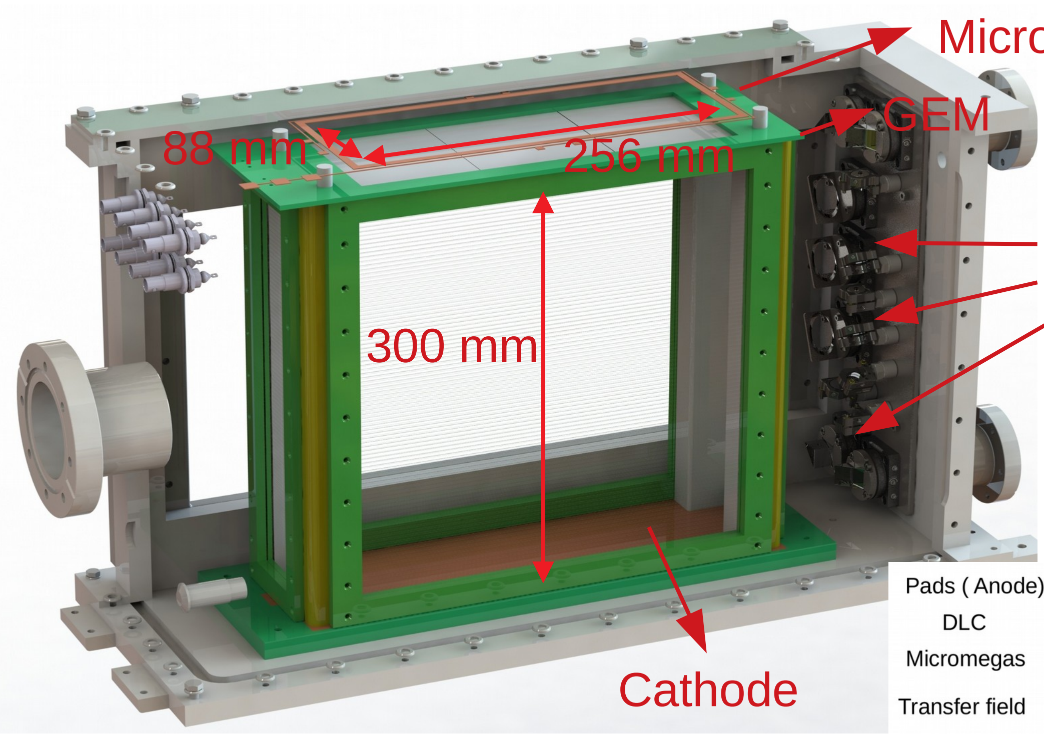
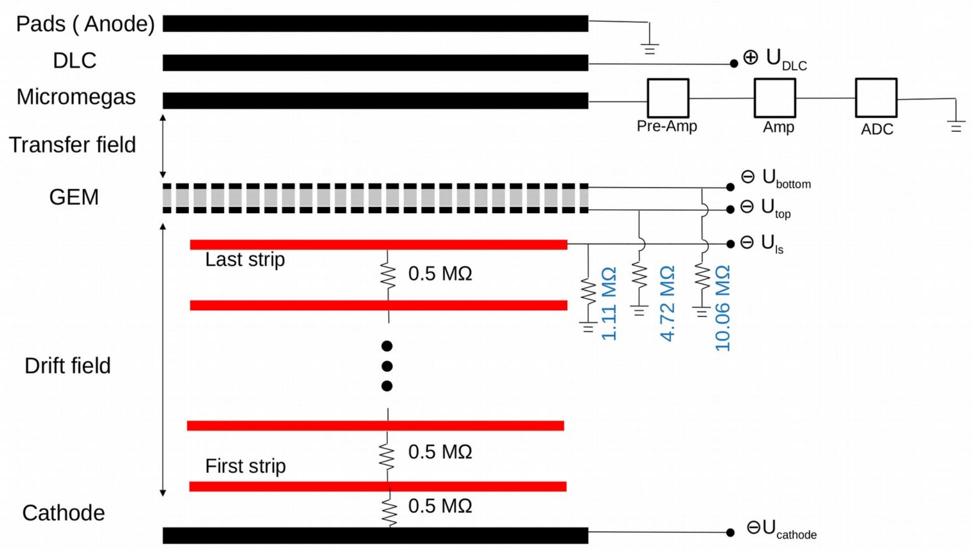


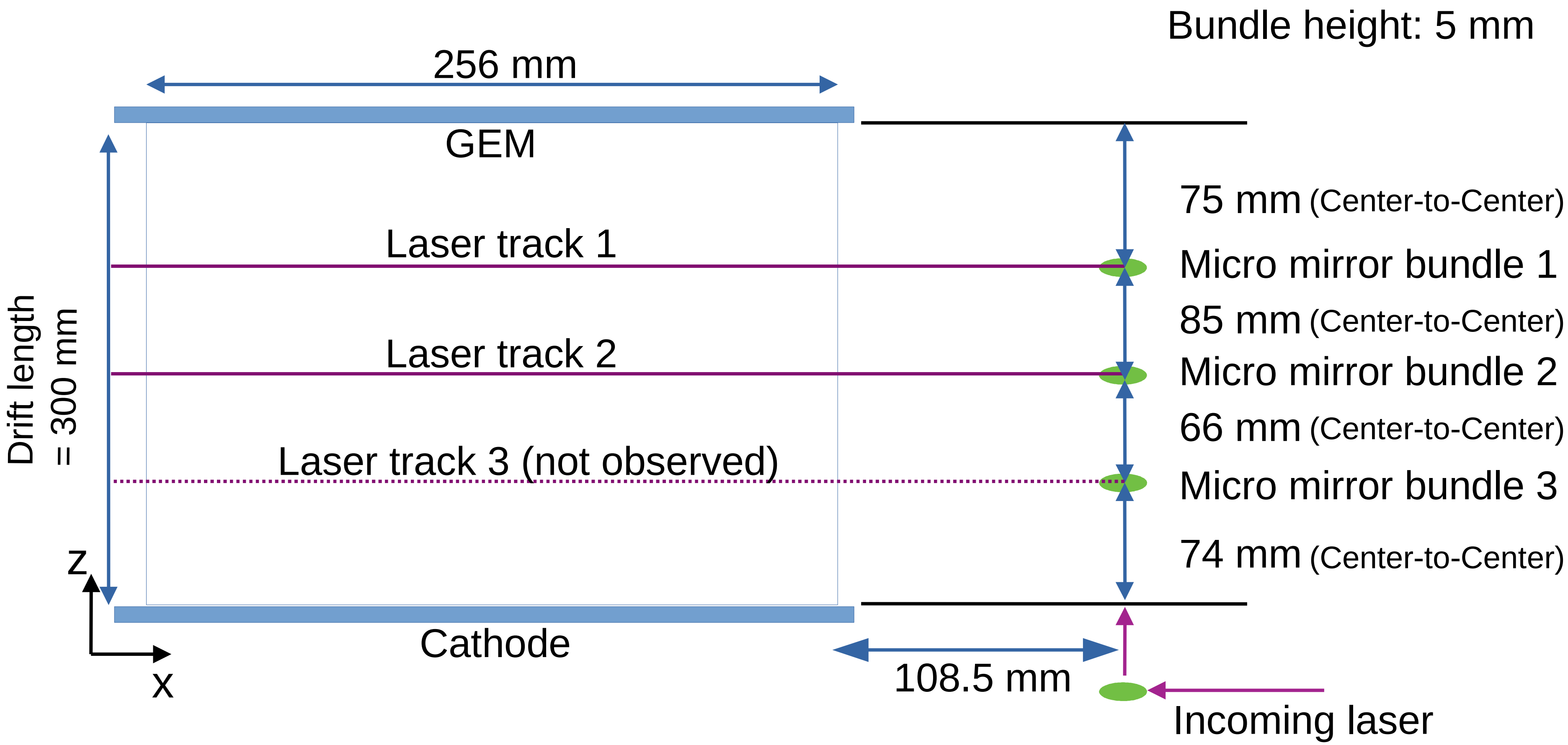
Micro mirrors

Drift field:
22 V/mm
Transfer field:
100 V/mm
Amplification voltage:
GEM: 380 V
MMG: 400 V



Gas mixture: 90% Ar + 10% CO_2
@ Atmospheric pressure

OVERVIEW OF LASER MEASUREMENT IN NOVEMBER



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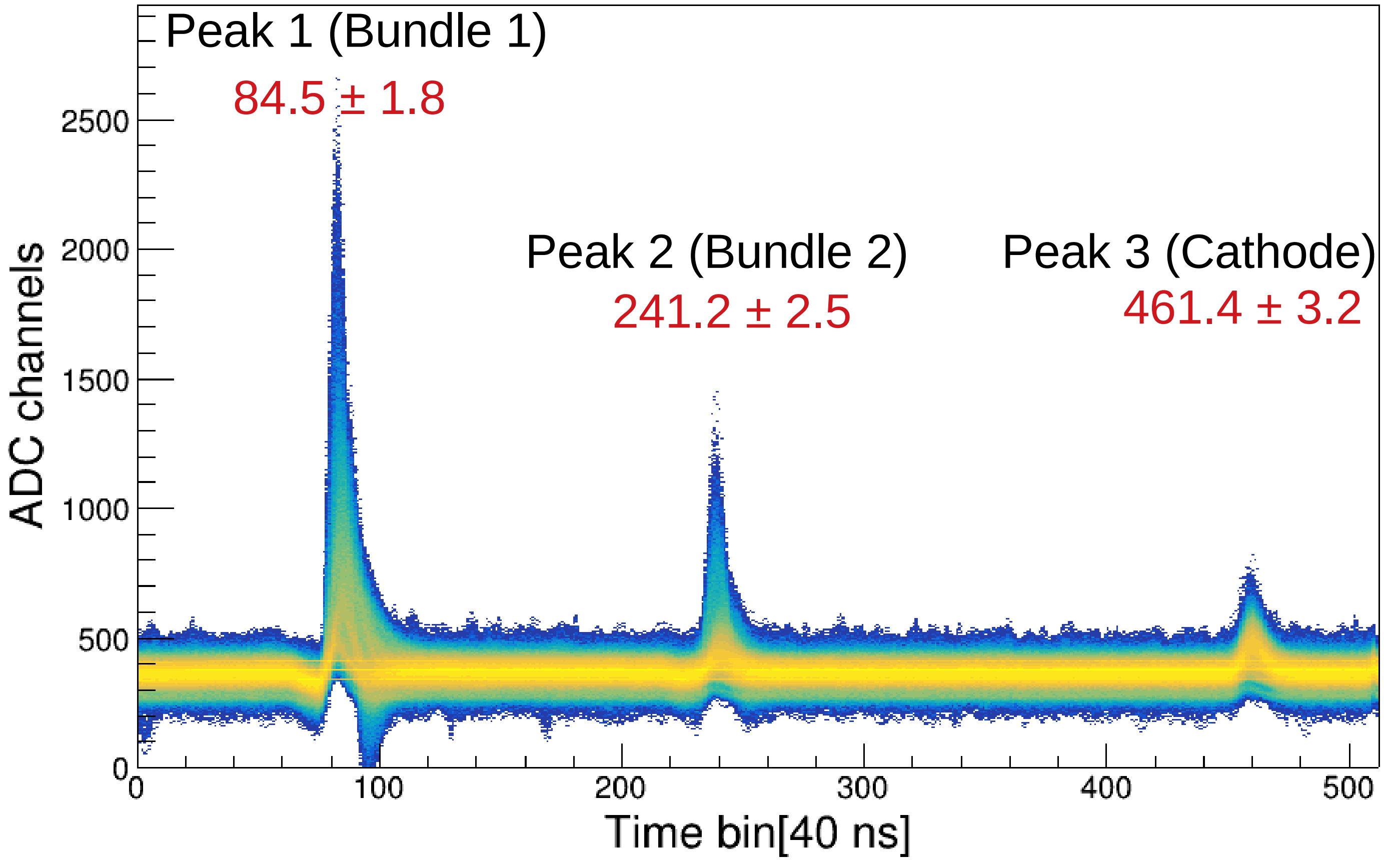
RAW WAVEFORM OF 1265 EVENTS



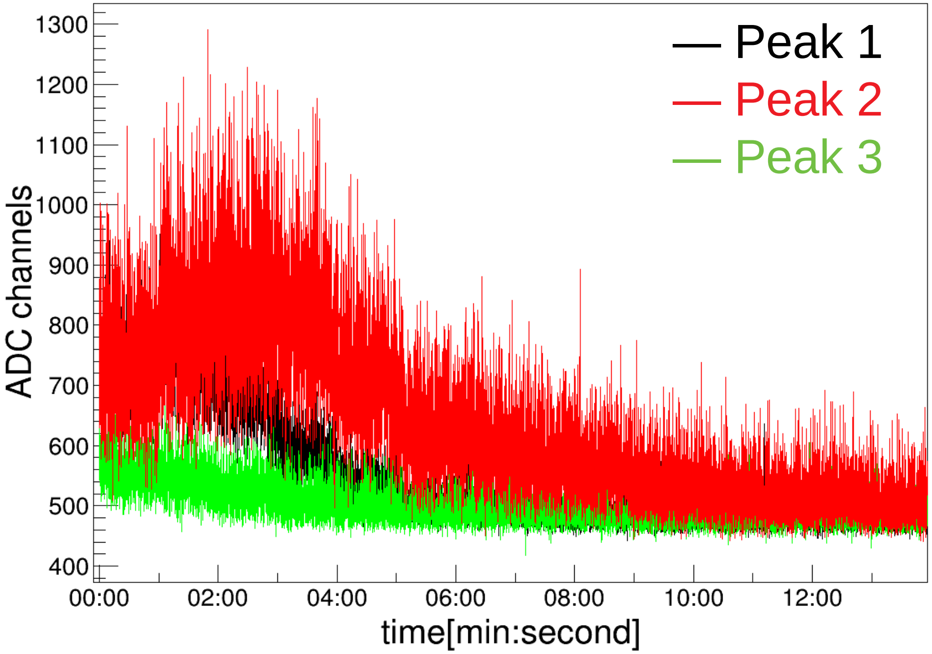
Waveform from Aget 2, Asad 0, CoBo 1

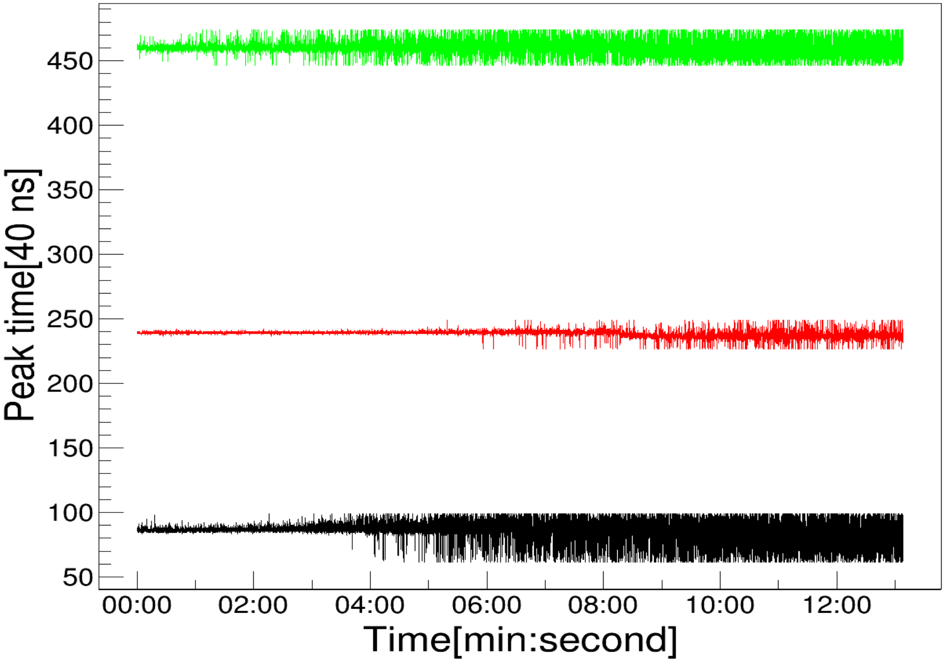
2 CoBos = 2 × 2 Asads = 4 × 4 Agets = 16 × 64 channels

Electronics Clock frequency = 25 MHz

PEAK AMPLITUDE AND POSITION EVOLUTION

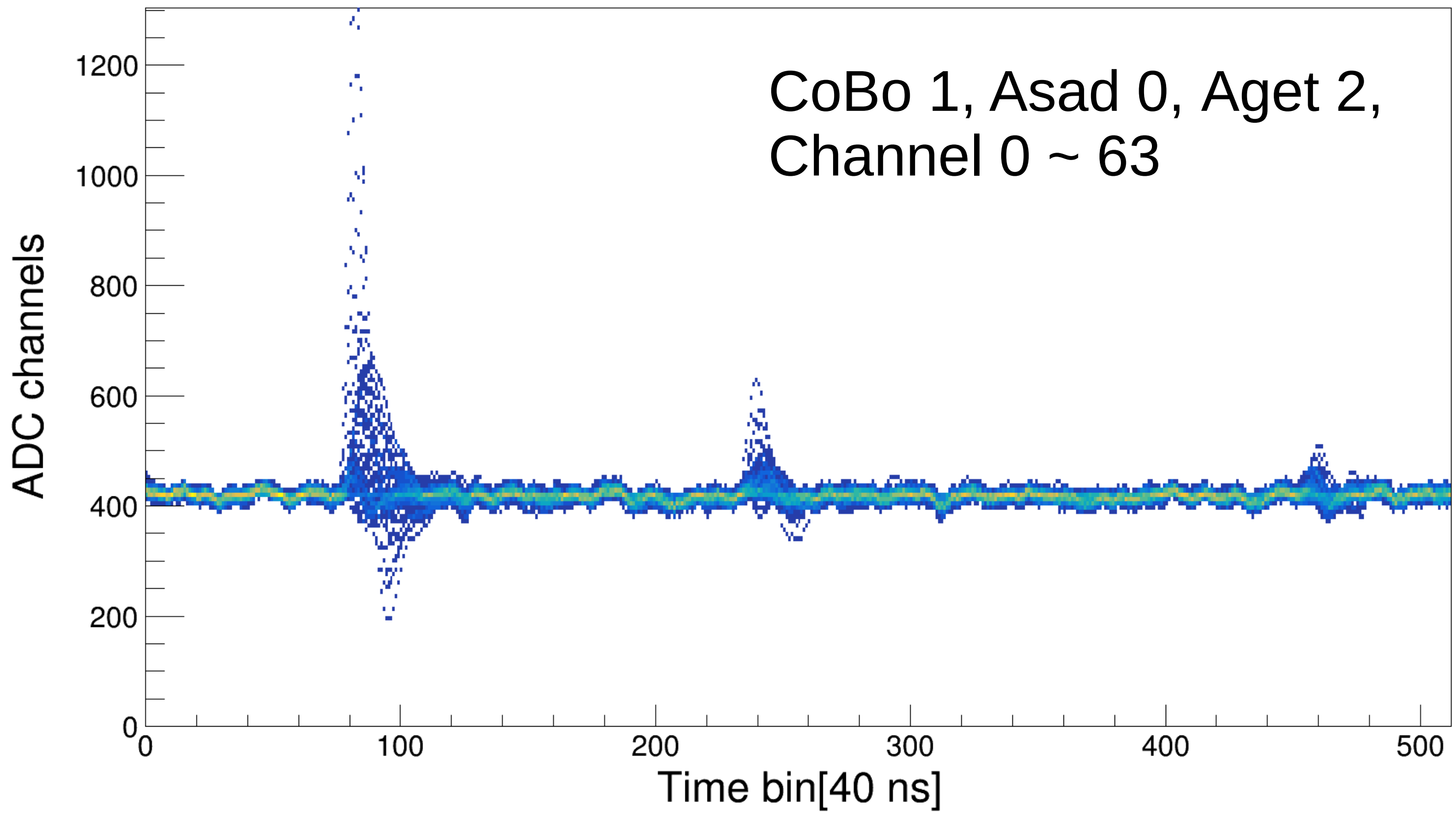
CoBo 1, Asad 0, Aget 2, Channel 52





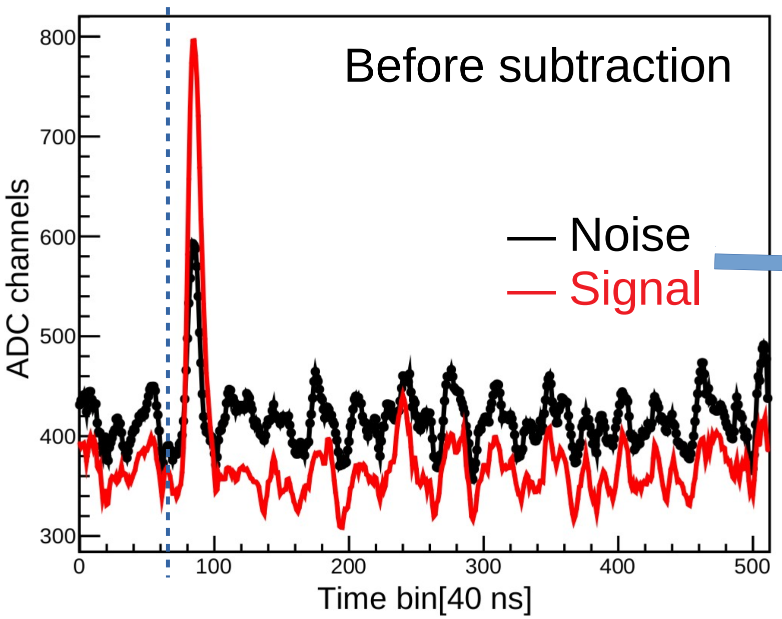
1. The laser peak amplitude is quenched over time.
2. Peak positions stay stable during measurement.

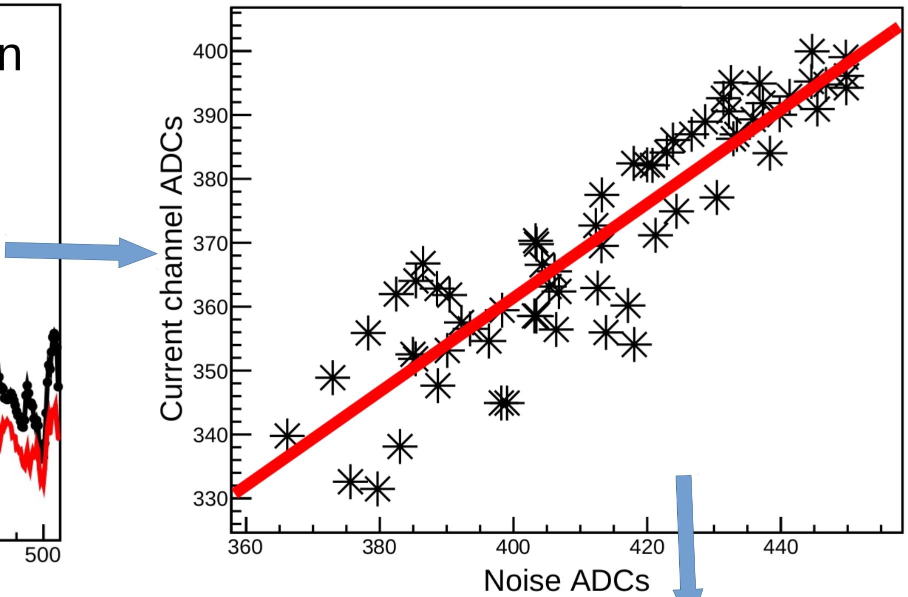
RAW WAVEFORM OF ONE EVENT

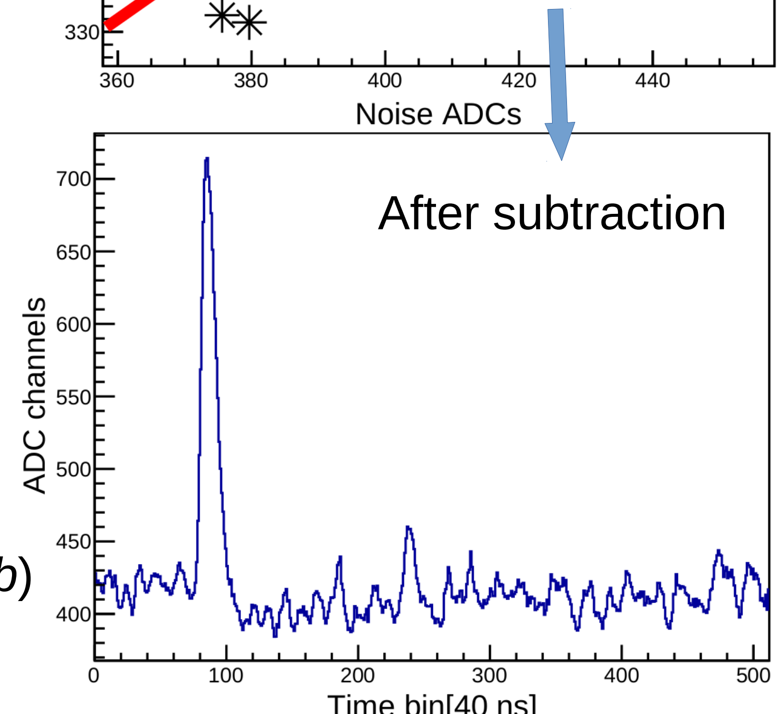


1. Inside one event, one Aget, all channels share a similar noise pattern.
2. The noise is from the electronics system.

NOISE SUBTRACTION METHOD







1. For each channel, in the baseline range (bin 0 to 65), fit linearly the relation between the signal and noise;
2. Extract the slope *a* and the intercept *b*;
3. Subtract the noise from the signal:

$$ADC_{signal,corrected} = ADC_{signal,raw} - (a \cdot ADC_{noise} + b)$$

CORRECTED WAVEFORM

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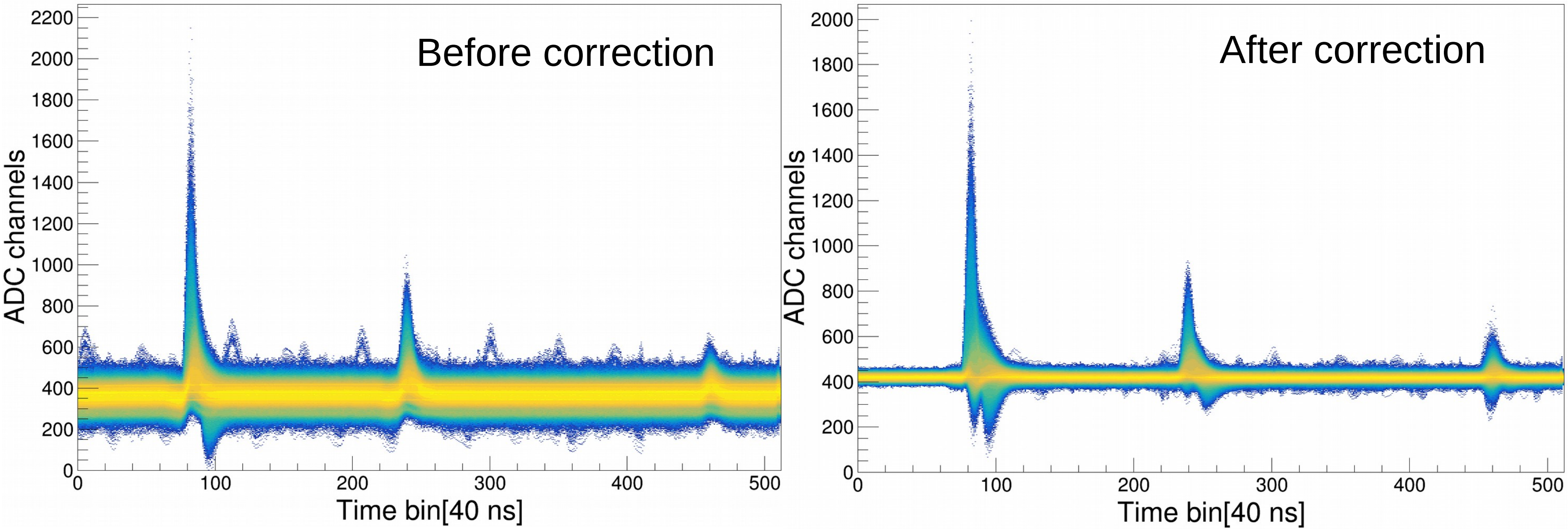

Waveform taken in Aget 2, Asad 0, CoBo 1

BKG σ: 36.6 → BKG σ: 12.5

Peaks amplitude and positions are extracted after correction.

CONTENT

MULTIPLEXING SCHEME AND MAPPING

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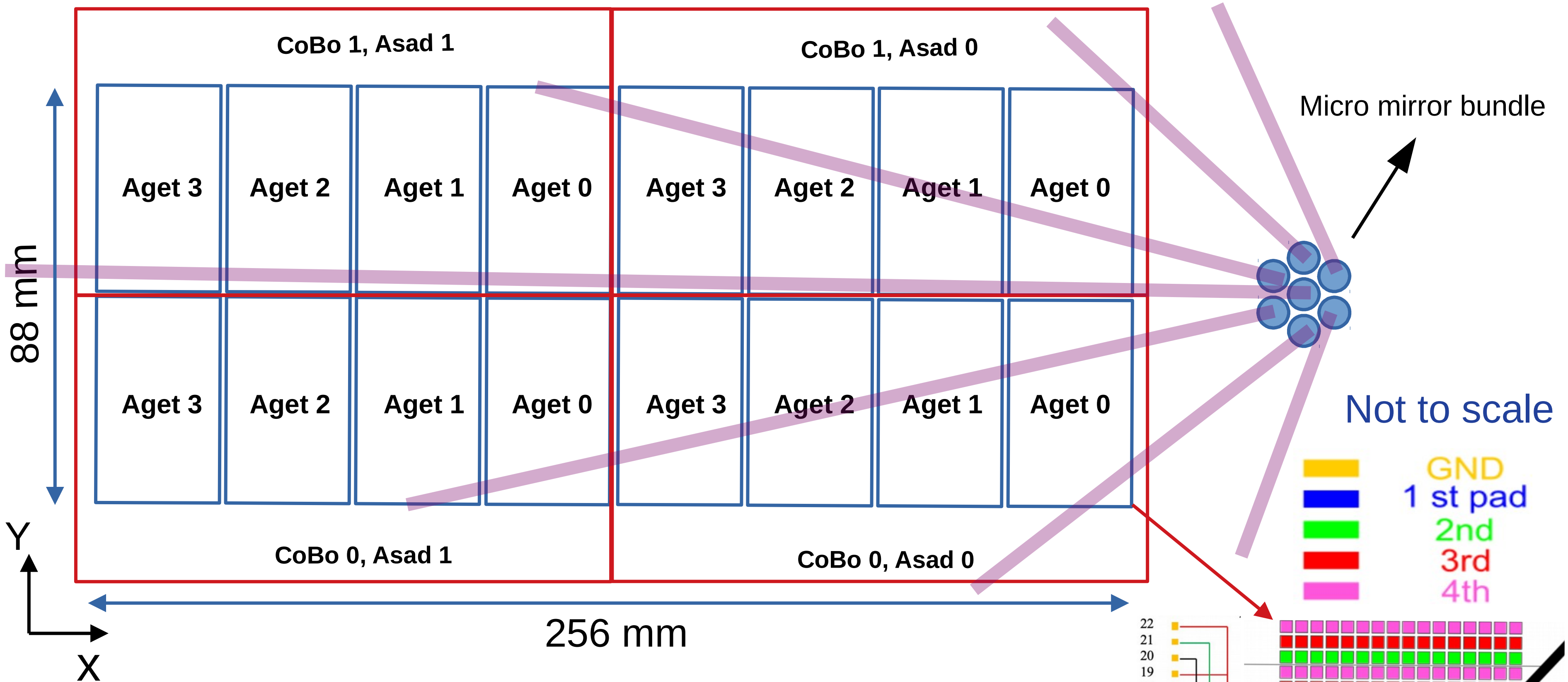
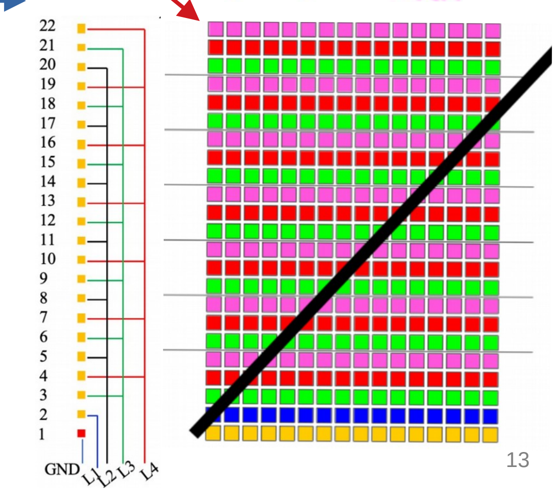
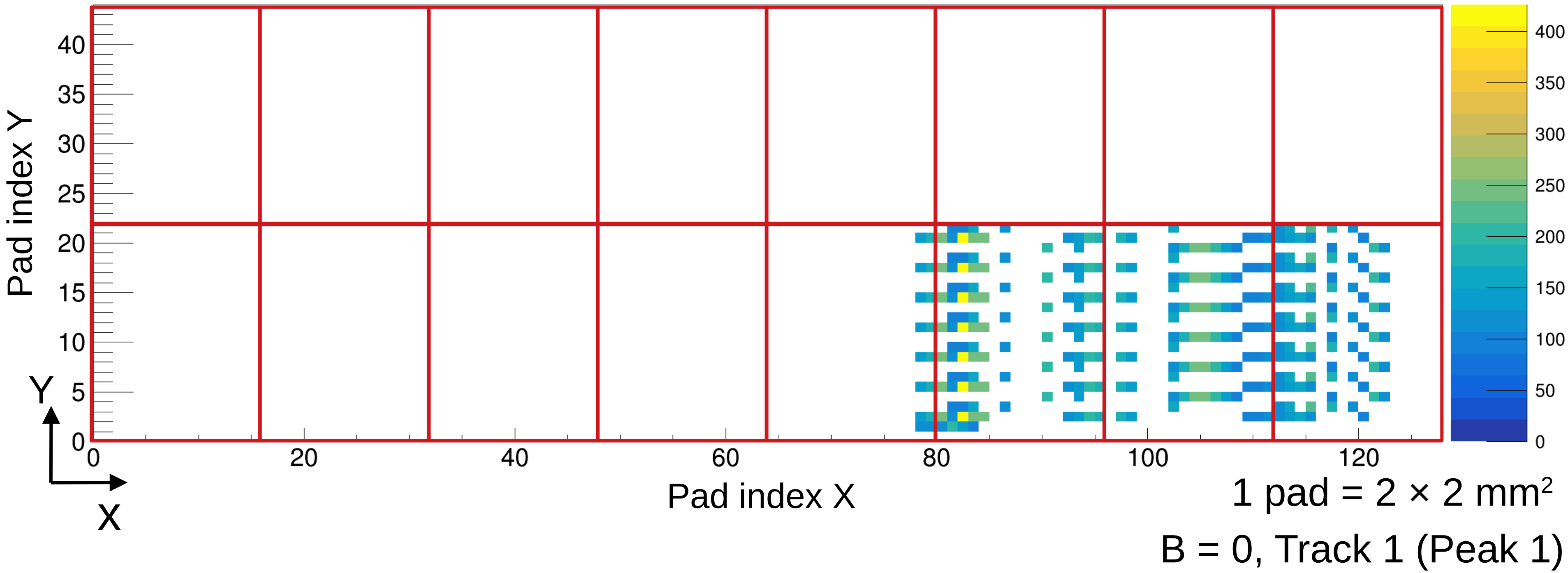




1. Micro mirror bundle radius: 1.5 mm.
2. Primary laser is aligned with the central micro mirror, σ: 0.453 mm.

HITS OF ONE EVENT ON THE PAD PLANE



1. Within three peak regions, extract the max amplitude above the threshold (80) and the position per channel;
2. According to the map, fill the pad plane with extracted max values as hits.

TRACK RECONSTRUCTION METHOD

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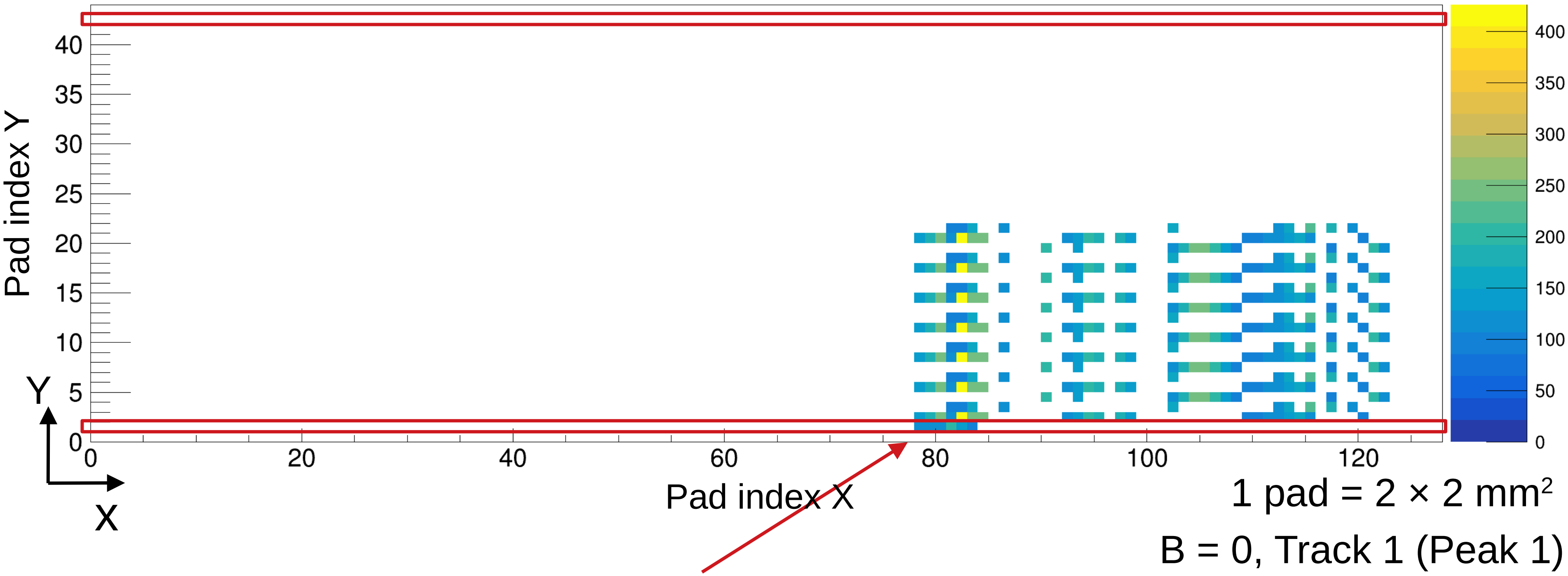

1 pad = 2 × 2 mm^2

B = 0, Track 1 (Peak 1)

1. Find hits on non-multiplexed pads;

TRACK RECONSTRUCTION METHOD

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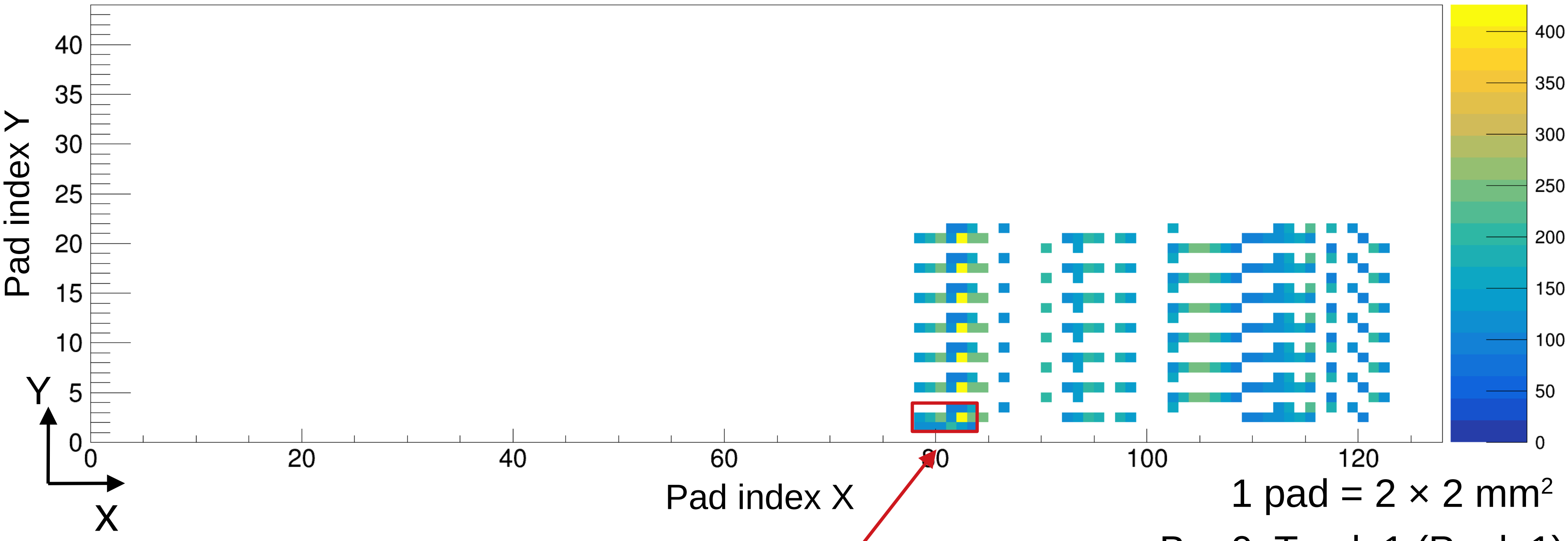

1 pad = 2 × 2 mm^2

B = 0, Track 1 (Peak 1)

1. Find hits on non-multiplexed pads;
2. Calculate centroid of charge for all pads neighboring these non-multiplexed pads along the X axis:

$$Y = \frac{\Sigma\, Q_i \cdot Y_i}{\Sigma\, Q_i}$$

TRACK RECONSTRUCTION METHOD

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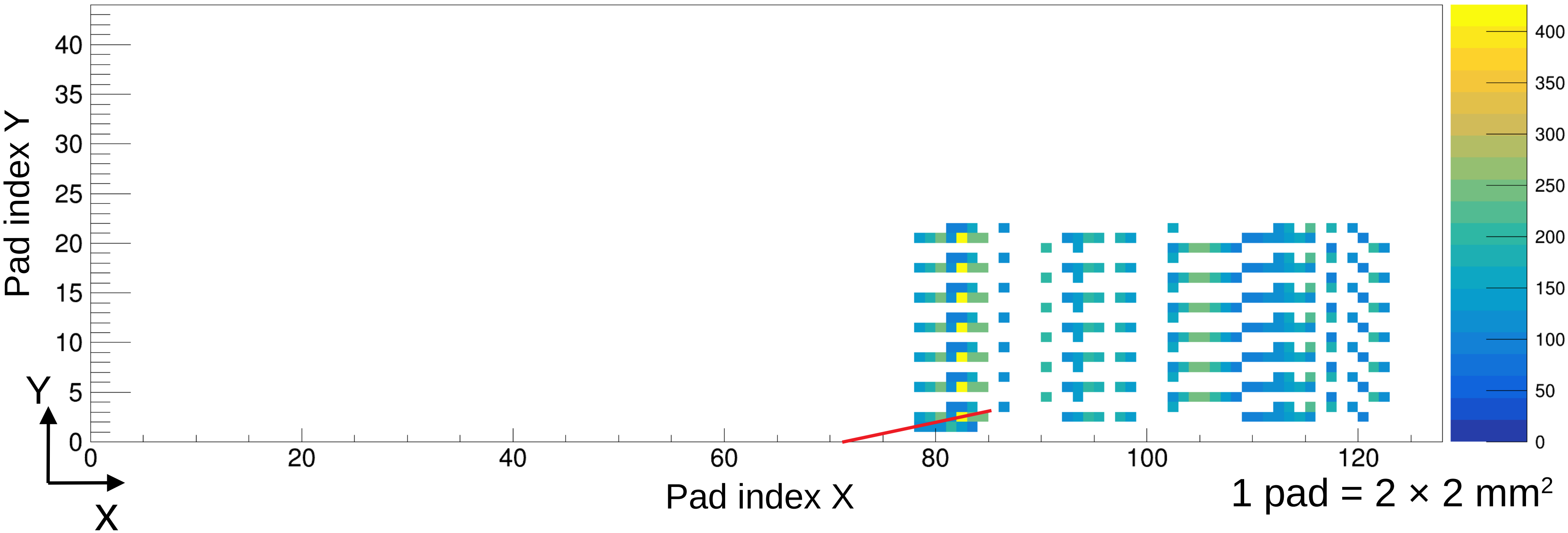

1 pad = 2 × 2 mm^2

B = 0, Track 1 (Peak 1)

1. Find hits on non-multiplexed pads;
2. Calculate centroid of charge for all pads neighboring these non-multiplexed pads along the X axis:
3. Fit calculated centroids with a linear function;

TRACK RECONSTRUCTION METHOD

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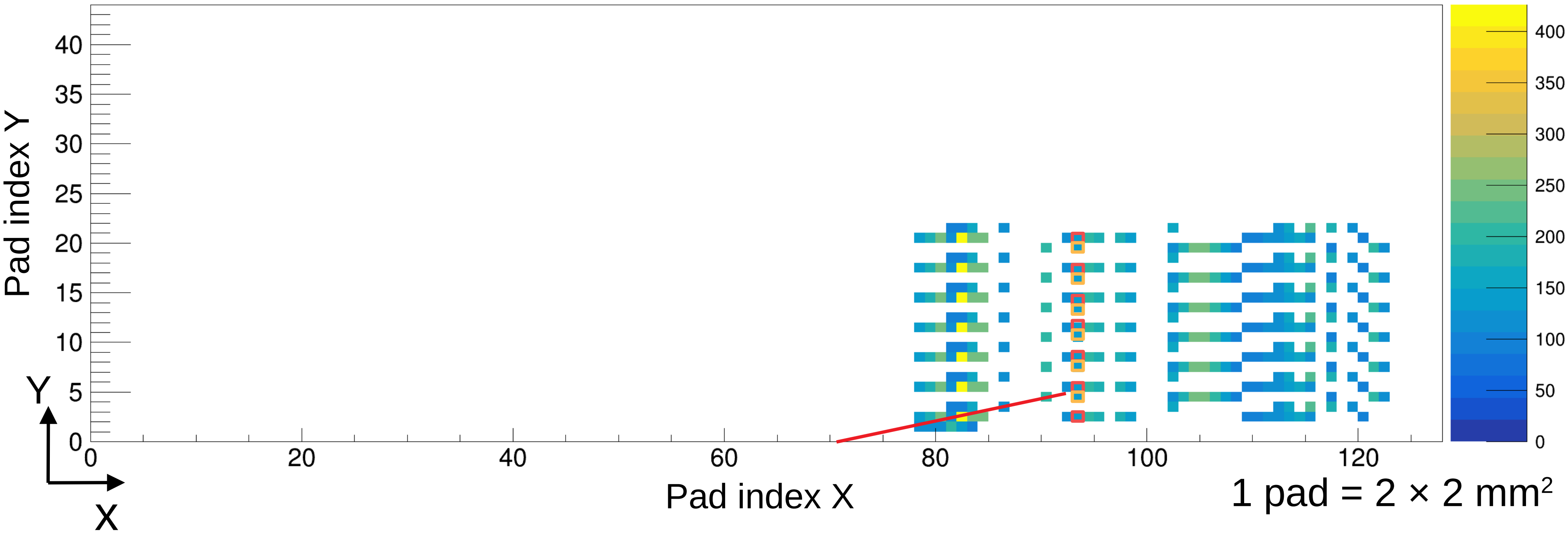

1 pad = 2 × 2 mm^2

B = 0, Track 1 (Peak 1)

1. Find hits on non-multiplexed pads;
2. Calculate centroid of charge for all pads neighboring these non-multiplexed pads along the X axis:
3. Fit calculated centroids with a linear function;
4. Extrapolate the fit line to next pads along the X axis and choose the closest pads among the multiplexed pads;

TRACK RECONSTRUCTION METHOD

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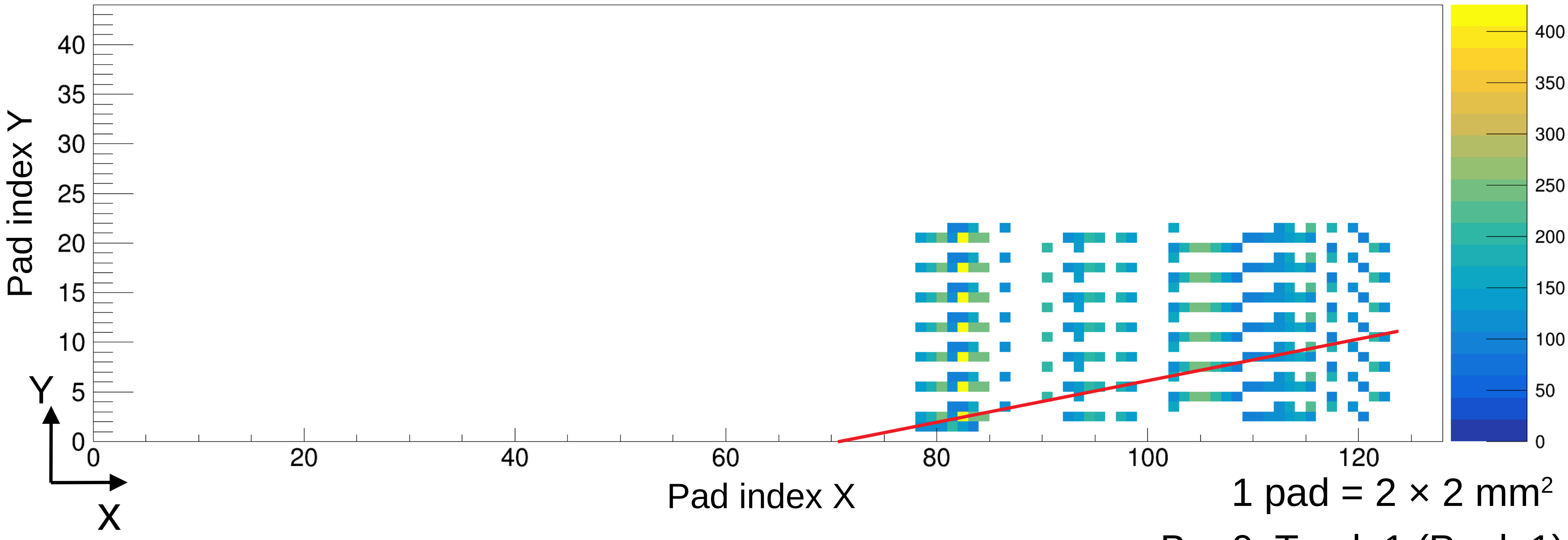

1 pad = 2 × 2 mm^2

B = 0, Track 1 (Peak 1)

1. Find hits on non-multiplexed pads;
2. Calculate centroid of charge for all pads neighboring these non-multiplexed pads along the X axis:
3. Fit calculated centroids with a linear function;
4. Extrapolate the fit line to next pads along the X axis and choose the closest pads among the multiplexed pads;
5. Repeat the 3th-4th step until the line reaches the end of the pads.

TRACK RECONSTRUCTION METHOD

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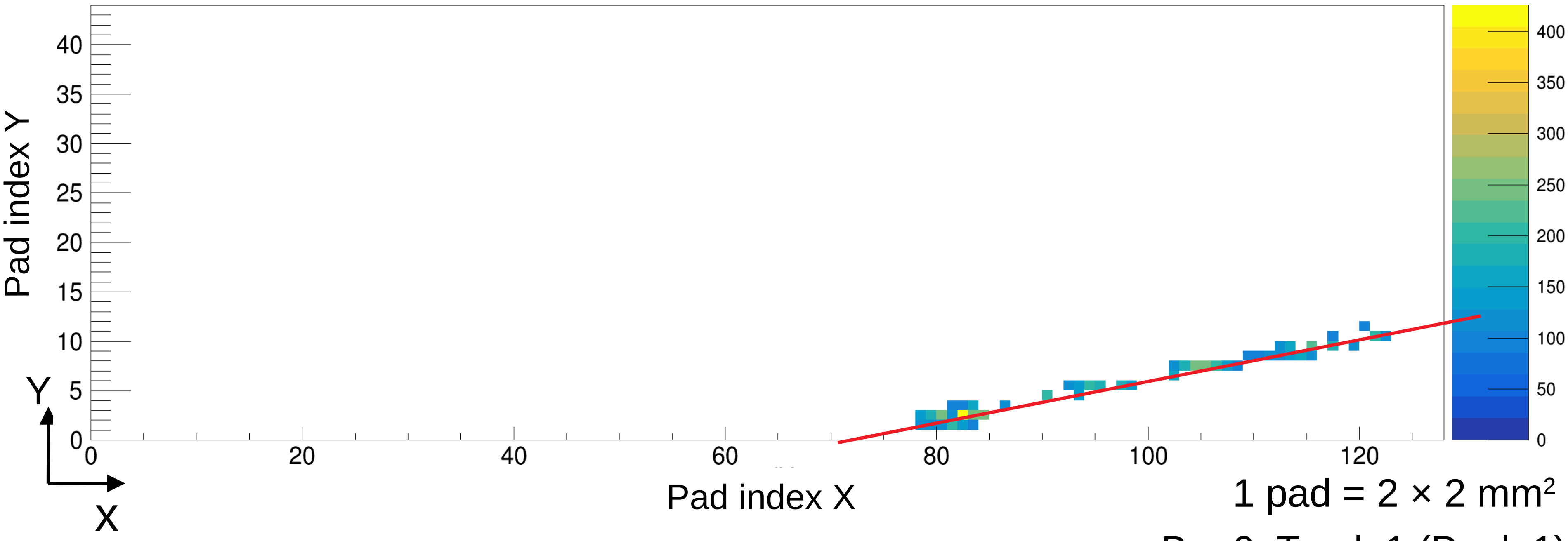


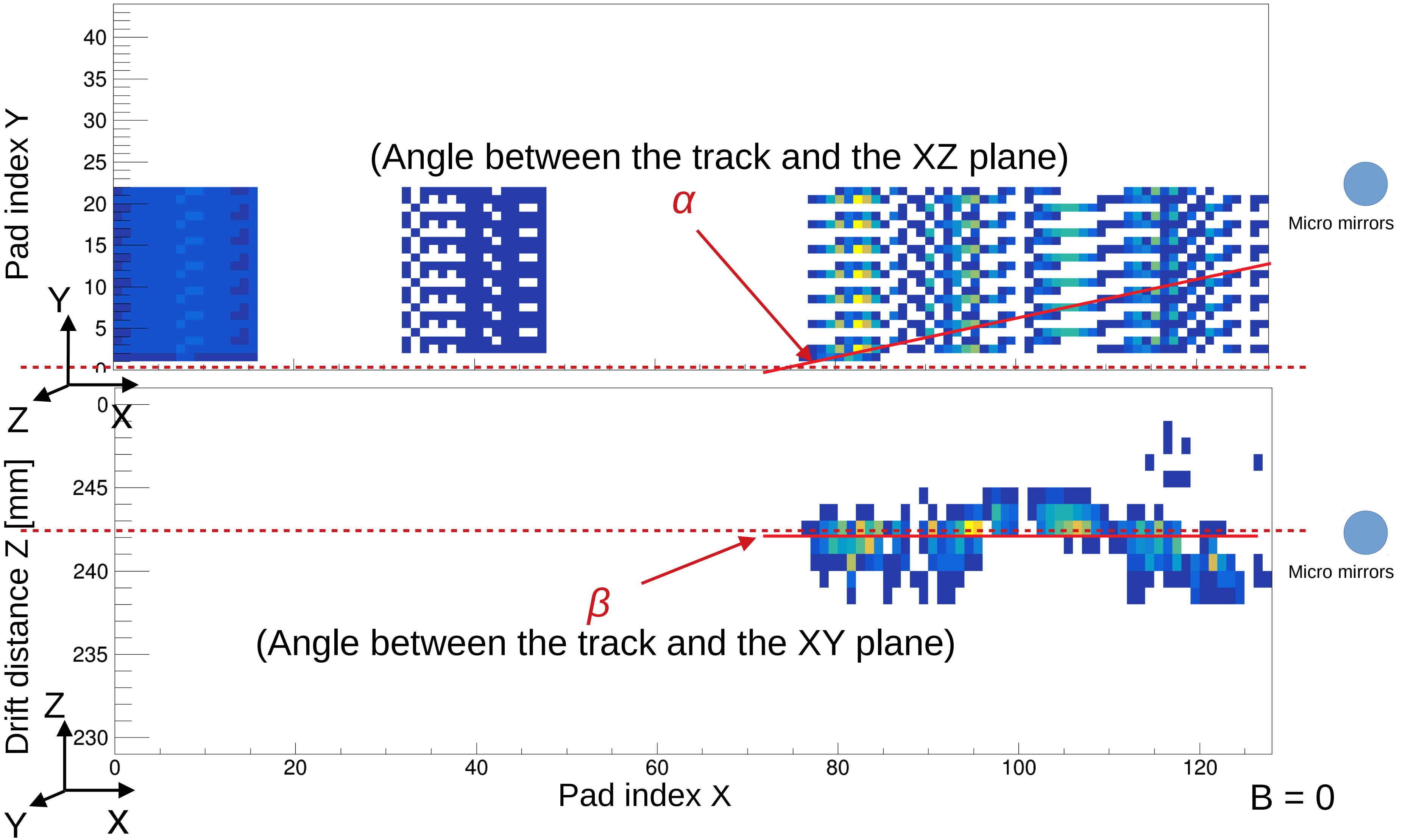
1 pad = 2 × 2 mm^2

B = 0, Track 1 (Peak 1)

There are some uncertainties for this track reconstruction method:

1. Centroid of charge is calculated for charge clusters within only one X pad;
2. Outside the active area, some charges are not collected thus not considered in the centroid calculation;
3. There is no gain calibration for the GET system.

TRACK RECONSTRUCTION RESULTS FOR TRACK 1



TRACK RECONSTRUCTION RESULTS FOR TRACK 1

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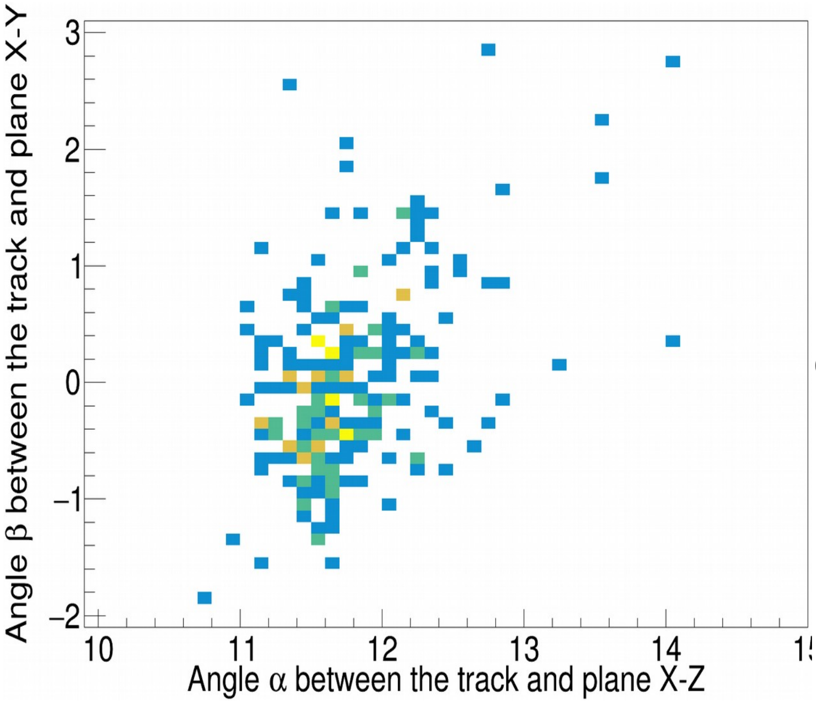

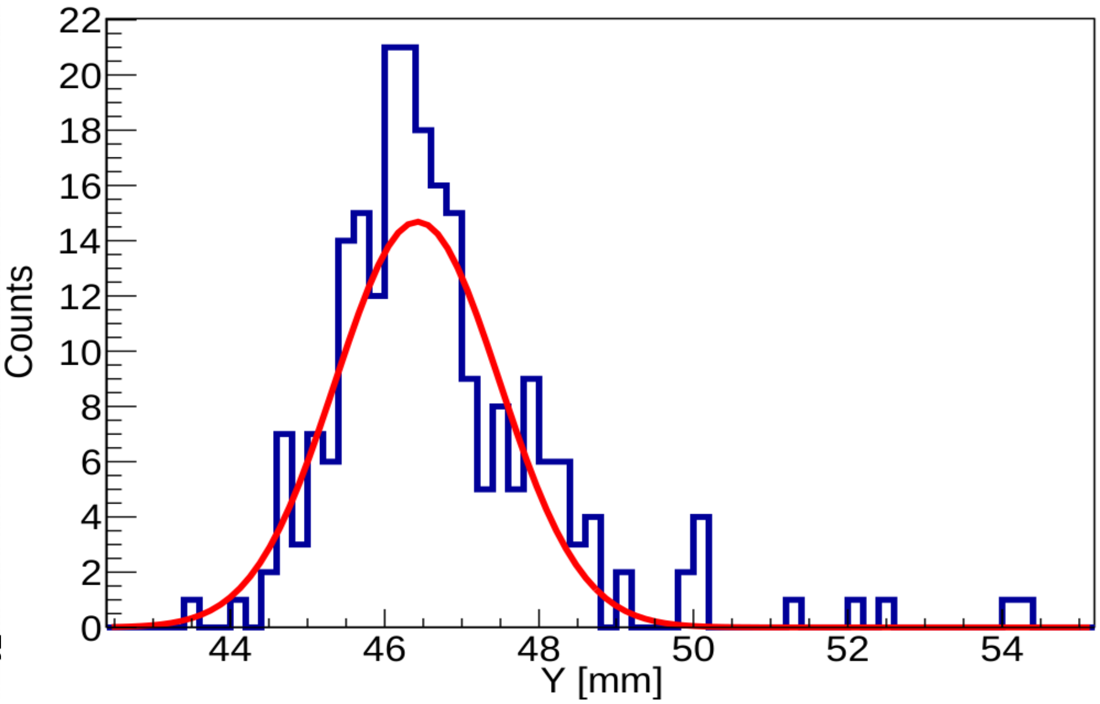

α = 11.8° ± 0.5°
β = 0.0° ± 0.7°

Extrapolated micro mirror Y position
= 46.4 ± 1.0 mm
Theoretical micro mirror Y position
= 44 ± 1.5 mm

B = 0

TRACK RECONSTRUCTION RESULTS FOR TRACK 2

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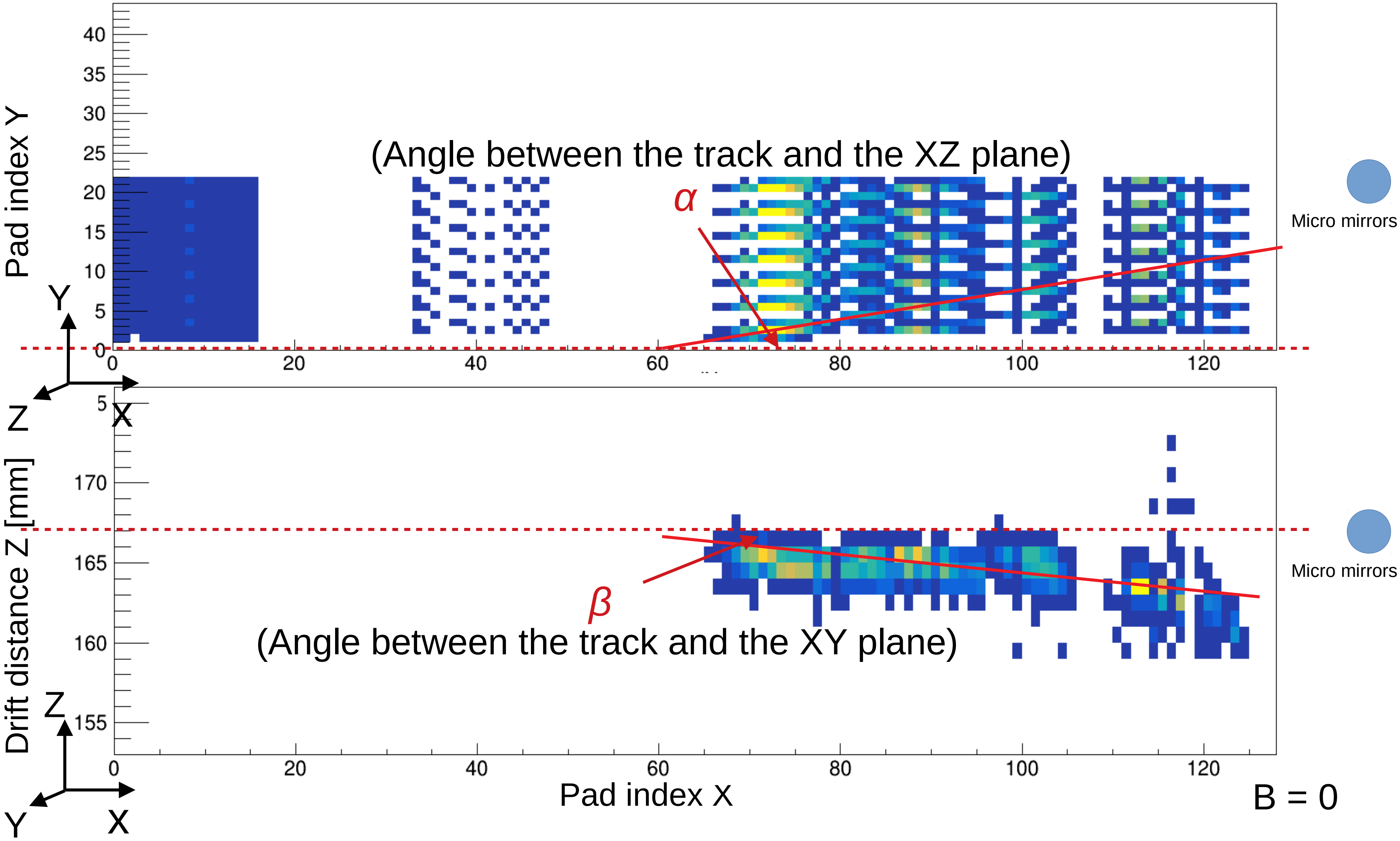

TRACK RECONSTRUCTION RESULTS FOR TRACK 2

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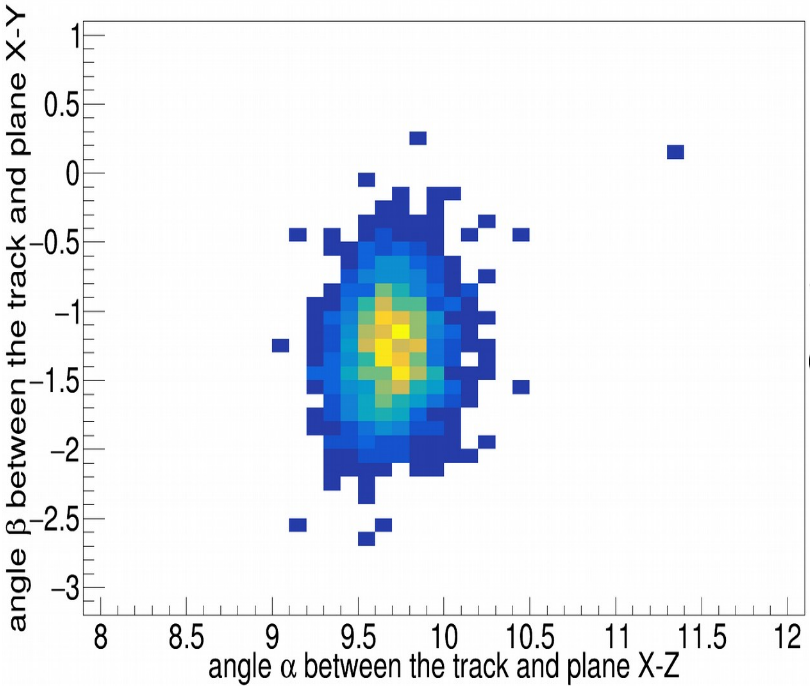

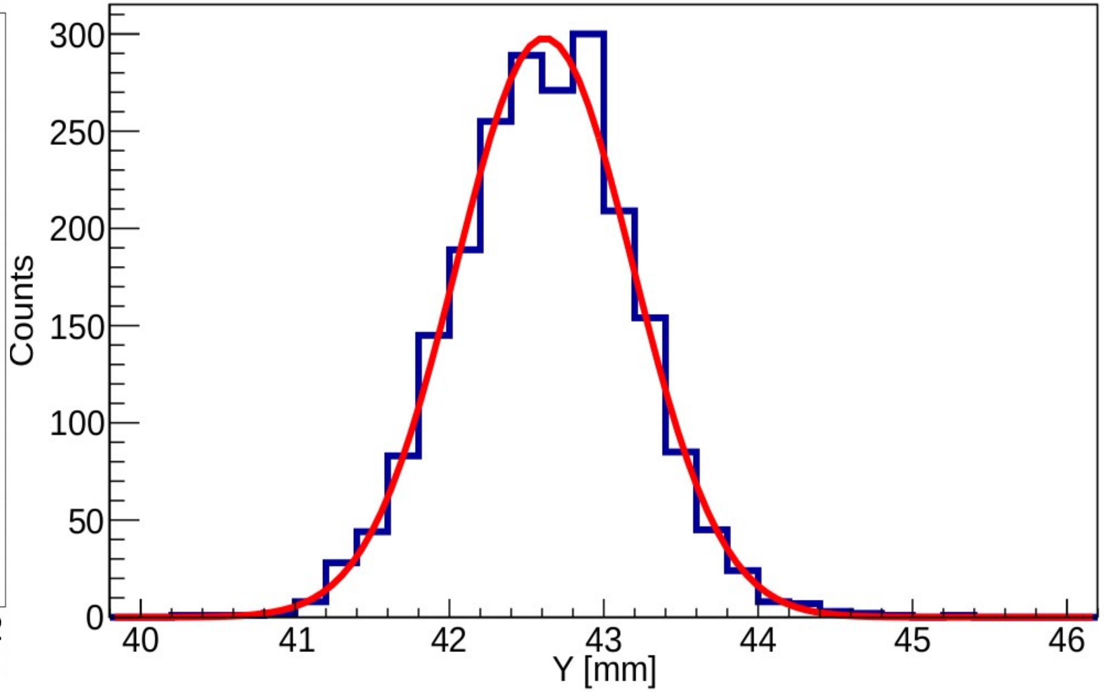

α = 9.7° ± 0.2°
β = -1.2° ± 0.3°

Extrapolated micro mirror Y position = 42.6 ± 0.6 mm
Theoretical micro mirror Y position = 44 ± 1.5 mm

B = 0

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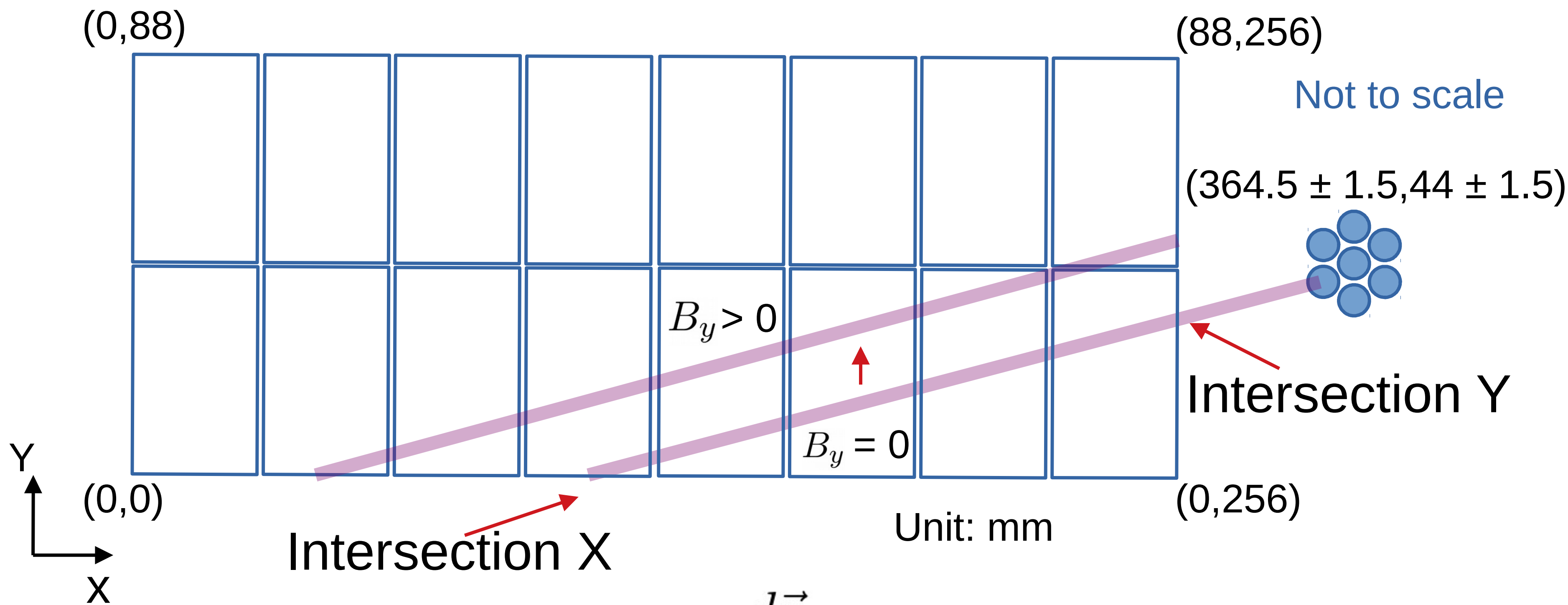
INFLUENCE OF B-FIELD ON ELECTRON DRIFTING



The Langevin equation: $m\frac{d\vec{u}}{dt} = q\vec{E} + q[\vec{u} \times \vec{B}] - k\vec{u}$

For $\vec{B} = (0, B_y, B_z)\ (B_y \ll B_z)$, $\vec{E} = (0, 0, E_z)$, $\Delta X = L\frac{u_x}{u_z} \Delta Y = L\frac{u_y}{u_z}$

Drift distance

$u_z = u_E$, u_x and u_y depend on $\frac{B_y}{B_z}u_E$ and the gas property

INTERSECTIONS FOR TRACK 2

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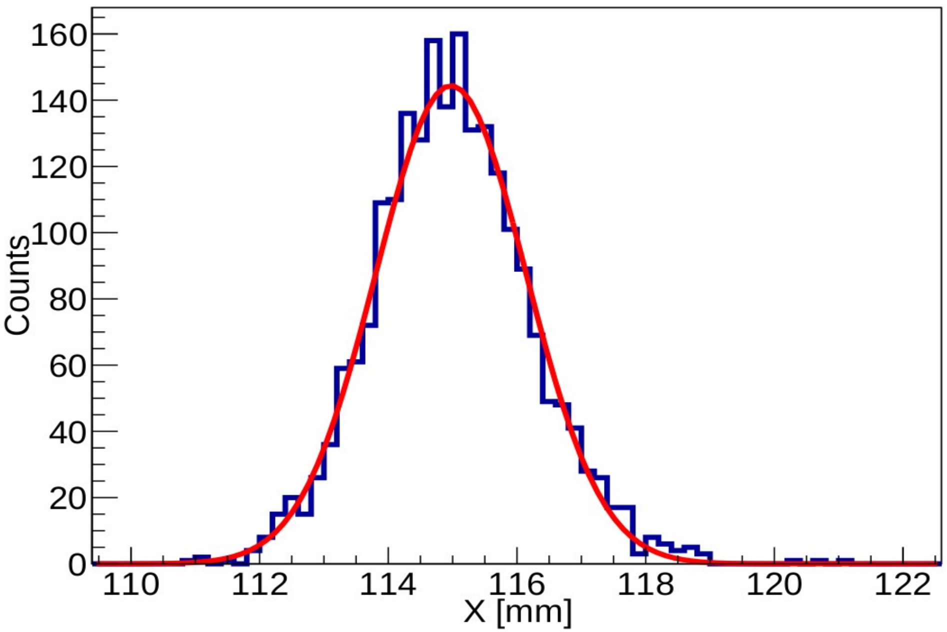

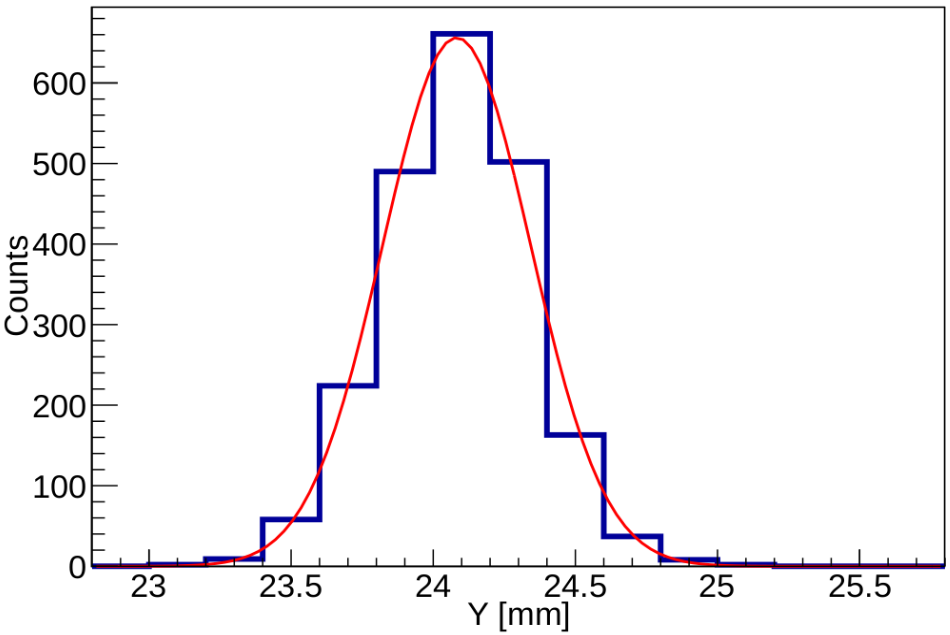

Intersection X
= 115.0 ± 1.2 mm

Intersection Y
= 24.0 ± 0.2 mm

B = 0

TRACKS DISPLACEMENT UNDER B-FIELDS

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Displacement of Track 1

B field	Angle α (°)	Angle β (°)	Intersection X (mm)	Intersection Y (mm)
0	11.8 ± 0.5	0.0 ± 0.7	139.6 ± 2.2	24.0 ± 0.4
500 A	11.7 ± 0.3	-0.5 ± 0.5	138.6 ± 1.4	24.4 ± 0.4
1500 A	11.8 ± 0.3	-0.3 ± 0.6	135.4 ± 1.4	25.2 ± 0.4

1. The angles of tracks are basically not changed.
2. Intersections are shifted indicating the displacement of the track.
3. Deviation of intersections gets greater under larger B-field.

Comparison with simulation is ongoing.

TRACKS DISPLACEMENT UNDER B-FIELDS

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Displacement of Track 2

B field	Angle α (°)	Angle β (°)	Intersection X (mm)	Intersection Y (mm)
0	9.7 ± 0.2	-1.2 ± 0.3	115.0 ± 1.2	24.0 ± 0.2
500 A	9.7 ± 0.5	-1.2 ± 0.5	114.0 ± 1.2	24.2 ± 0.2
1500 A	9.7 ± 0.2	-1.4 ± 0.4	109.4 ± 1.8	25.2 ± 0.4

1. The angles of tracks are basically not changed.
2. Intersections are shifted indicating the displacement of the track.
3. Deviation of intersections gets greater under larger B-field.

Comparison with simulation is ongoing.

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RAW WAVEFORM FOR FEBRUARY LASER MEASUREMENT

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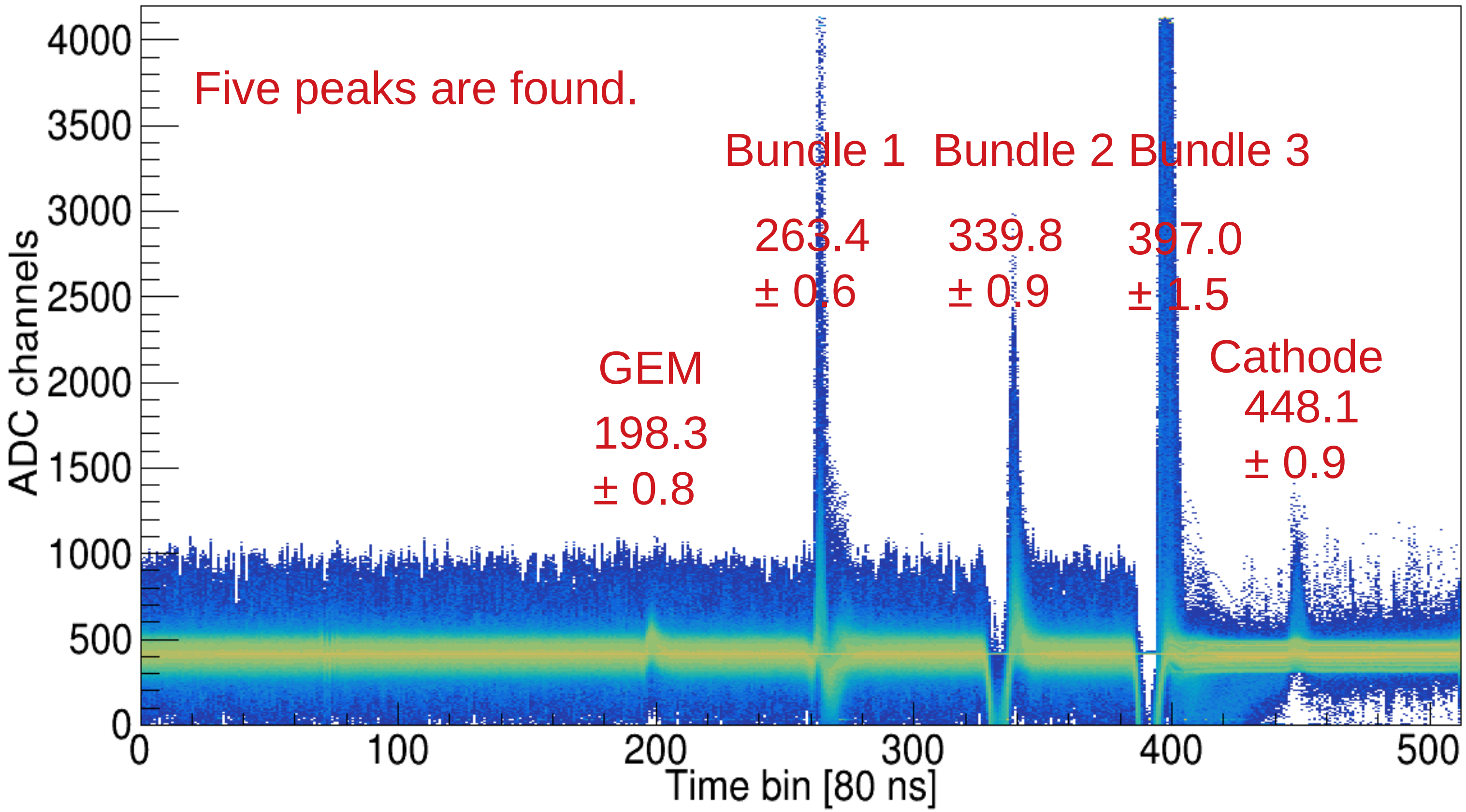

Electronics Clock frequency = 12.5 MHz
Waveform is taken from Aget 2, Asad 1, CoBo 0. B = 0 A

Further analysis is ongoing.

SUMMARY

1. Laser measurement with HYDRA-TPC in GLAD was successfully performed.
2. Laser tracks after reconstruction correspond to physical tracks within the estimated uncertainties.
3. Millimetric displacement of tracks under various magnetic fields are observed.

OUTLOOK

1. Comparison between analysis results and simulation.
2. Refinement of the track reconstruction method.
3. Analysis of February data.