Evaluation of Position Dependent Performance of 3-inch PMT

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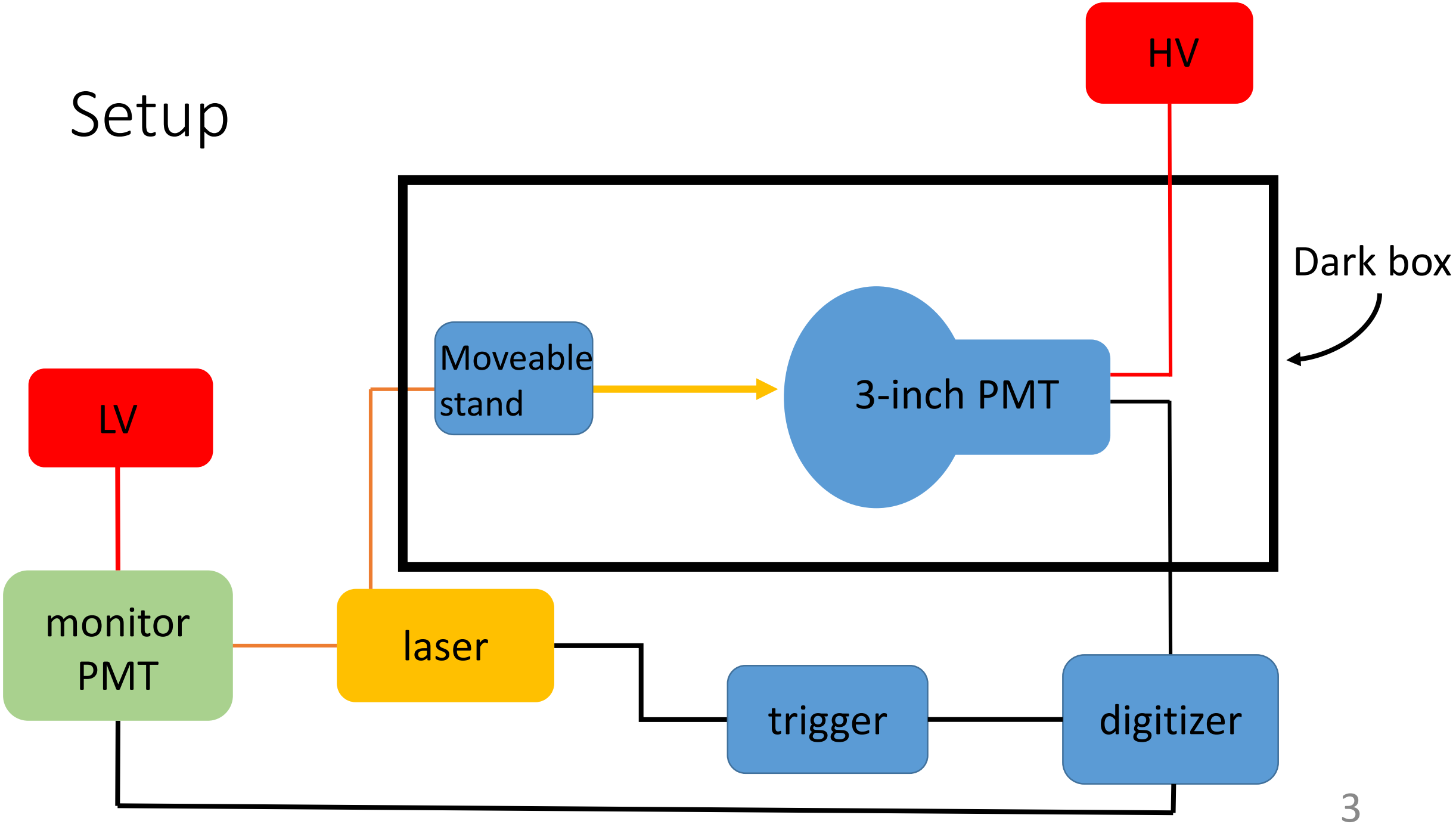
Purpose

- mPMT is currently under development for Hyper-K and IWCD.
- The plan is to use 19 3-inch PMTs.
- We evaluated the position dependent performance with

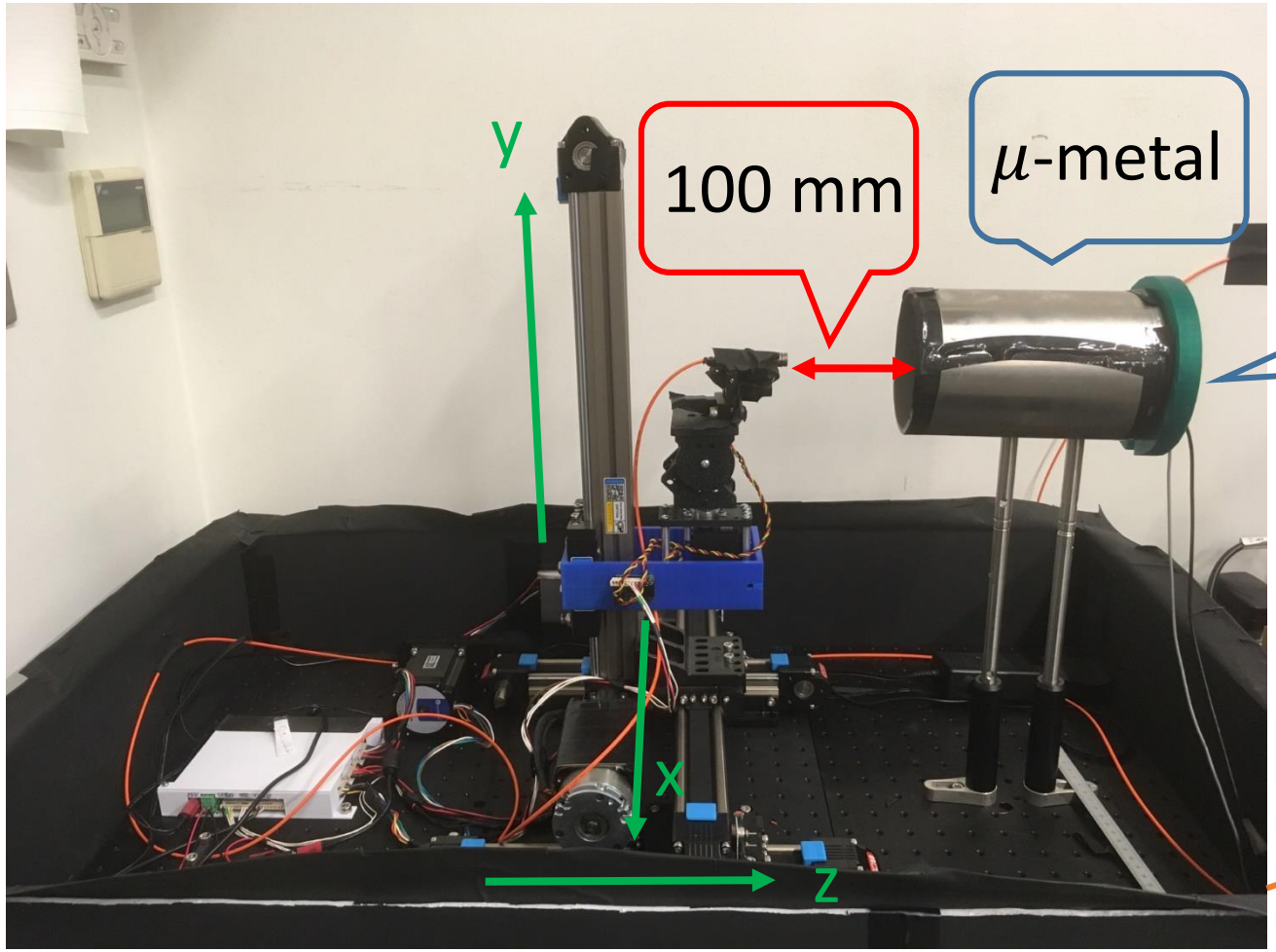
  -2 PMTs (BC0035 and BC0038)

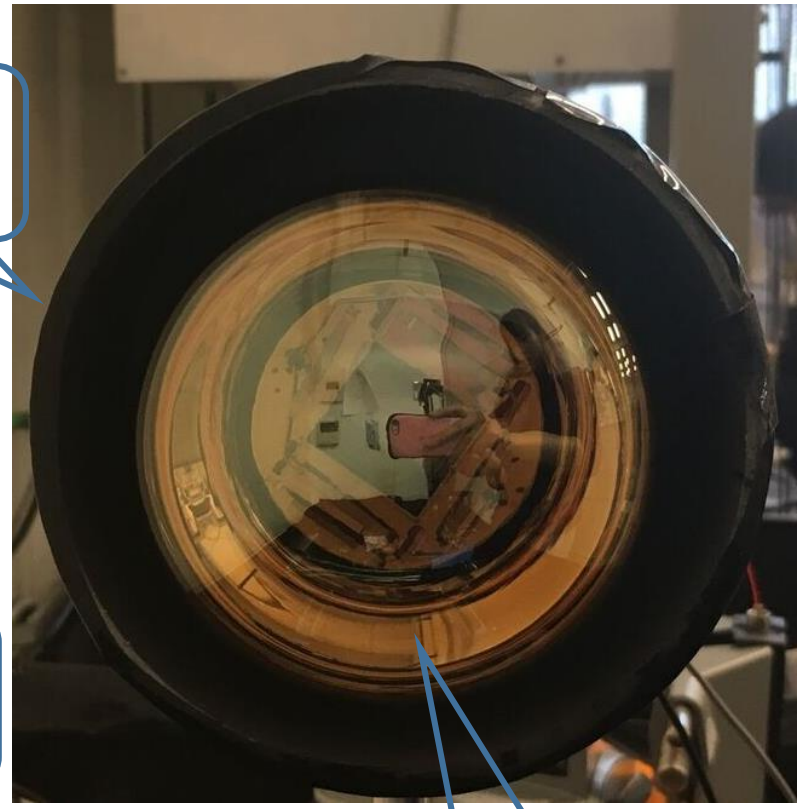
  -positive and negative HV

Setup


HV
Dark box
Moveable stand
3-inch PMT
LV
monitor PMT
laser
trigger
digitizer

Setup

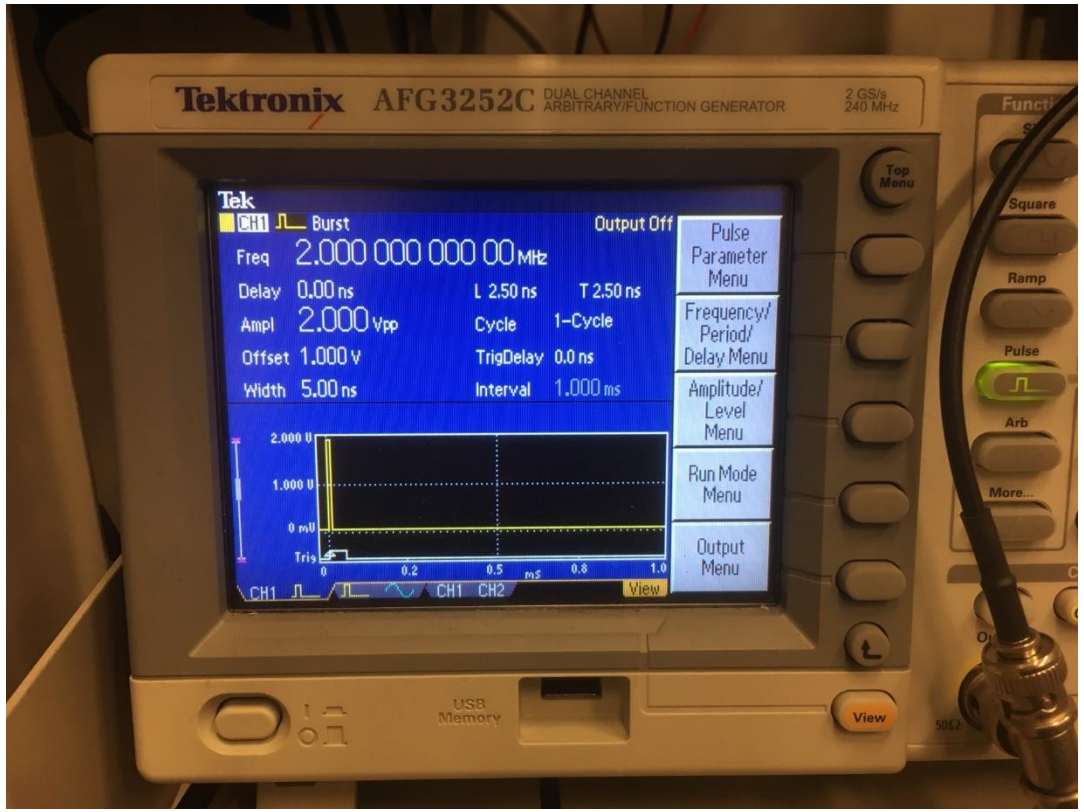


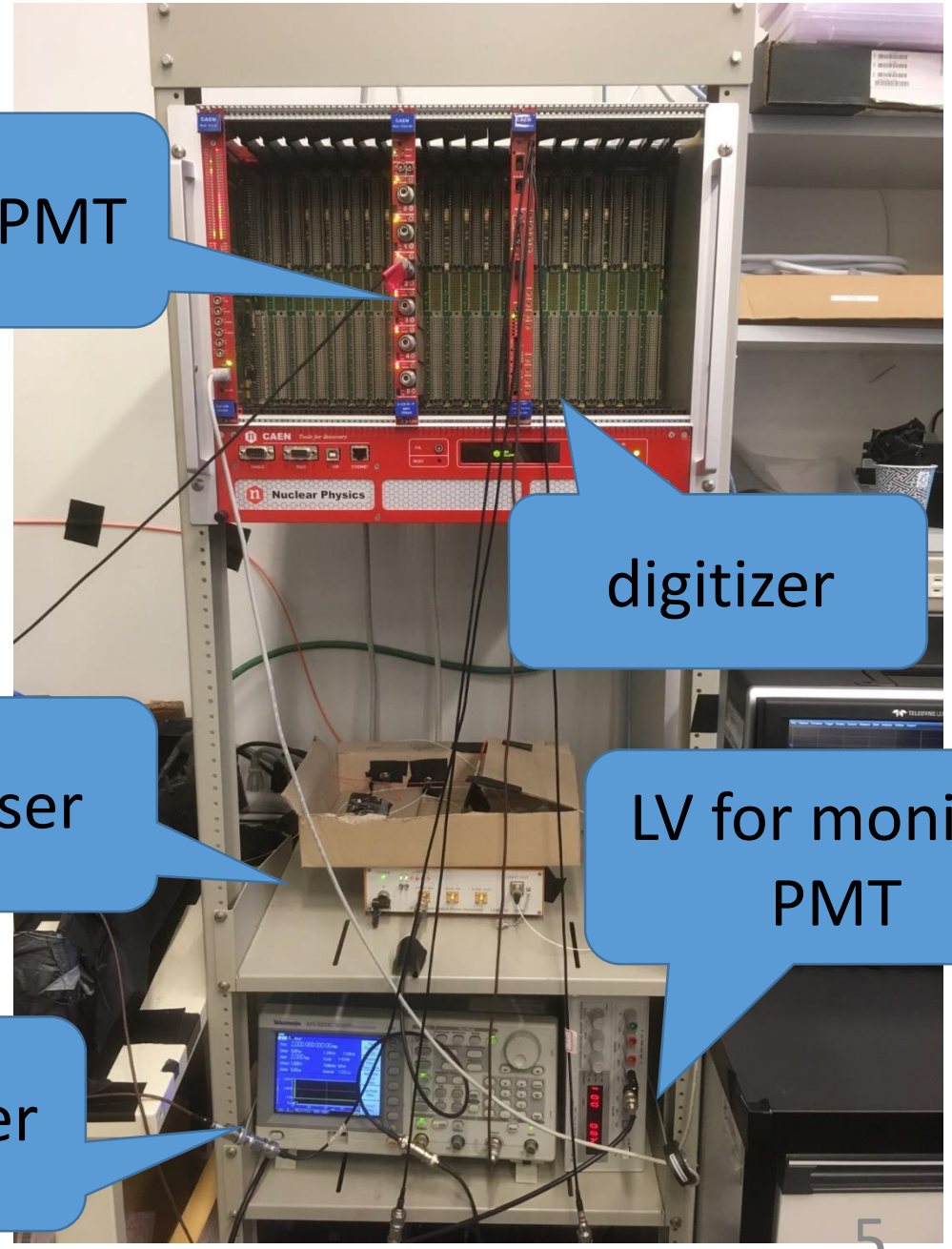


laser

Setup

trigger

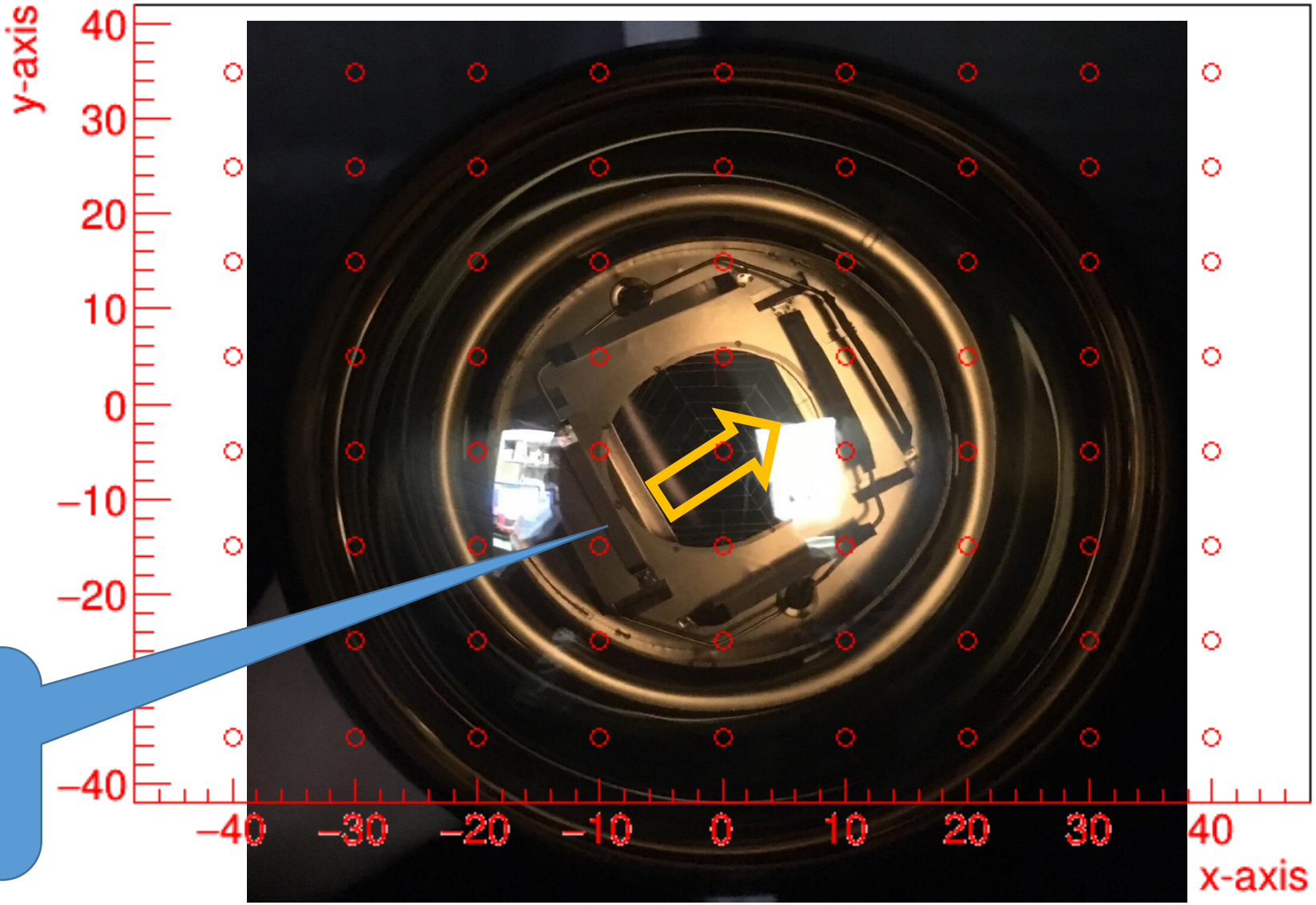




Setup

- X-axis: 9 points
- Y-axis: 8 points
- Total of 72 points

- Range: 10 mm

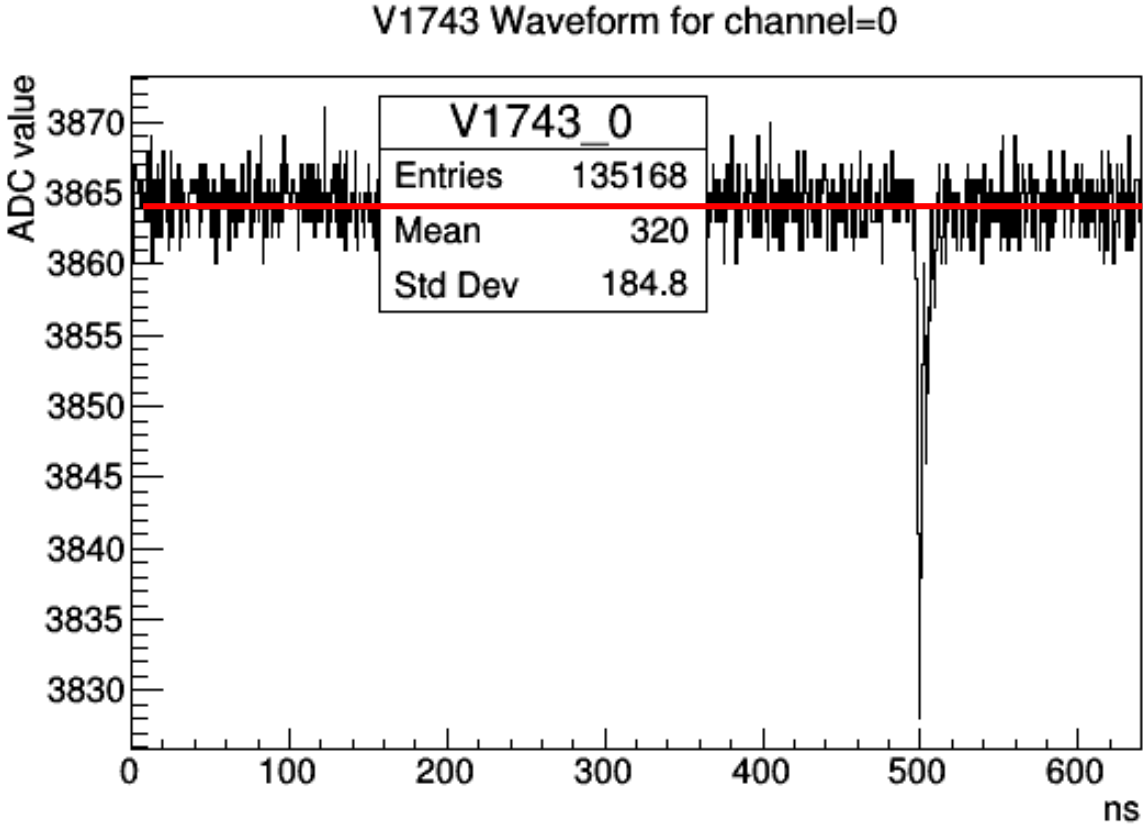


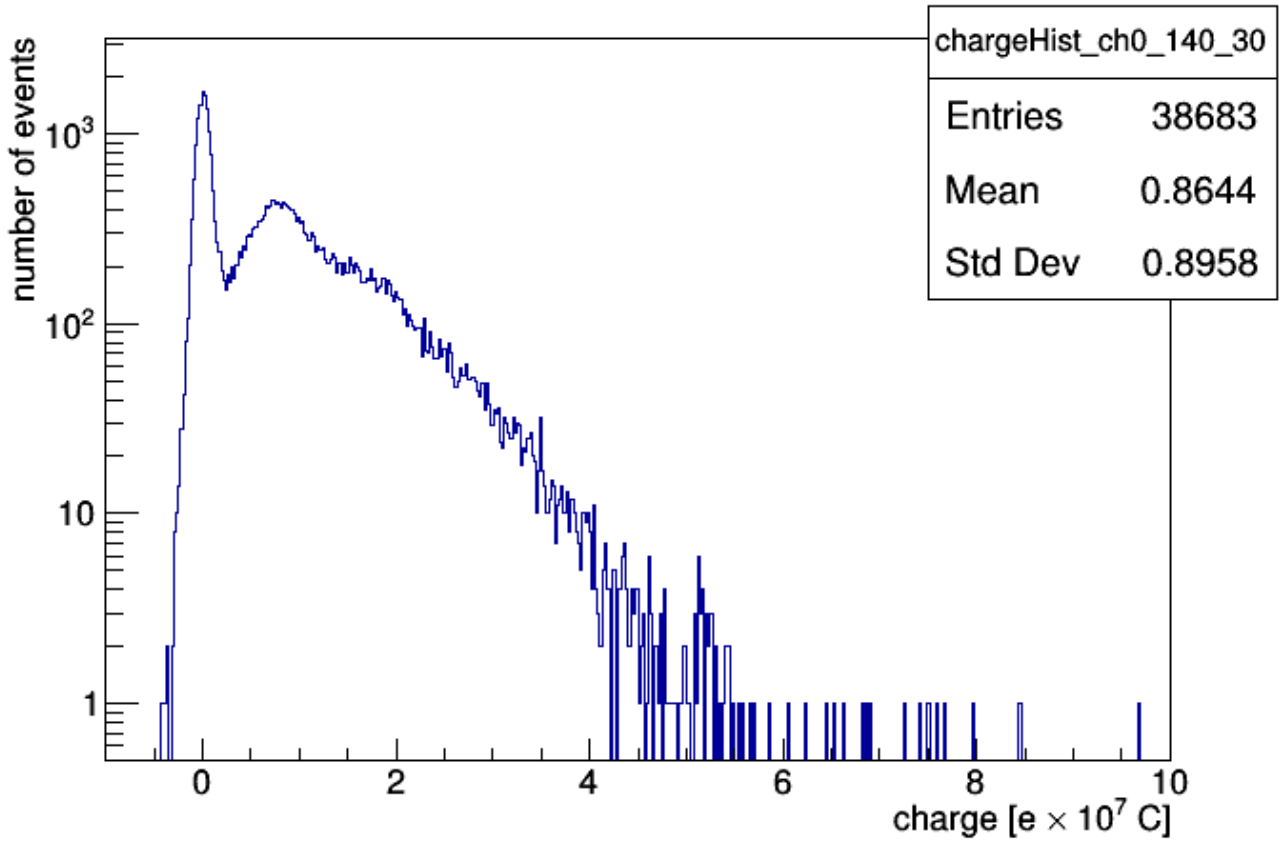
Direction from
1st dynode to
2nd dynode

- Stayed at each position for 100 sec.

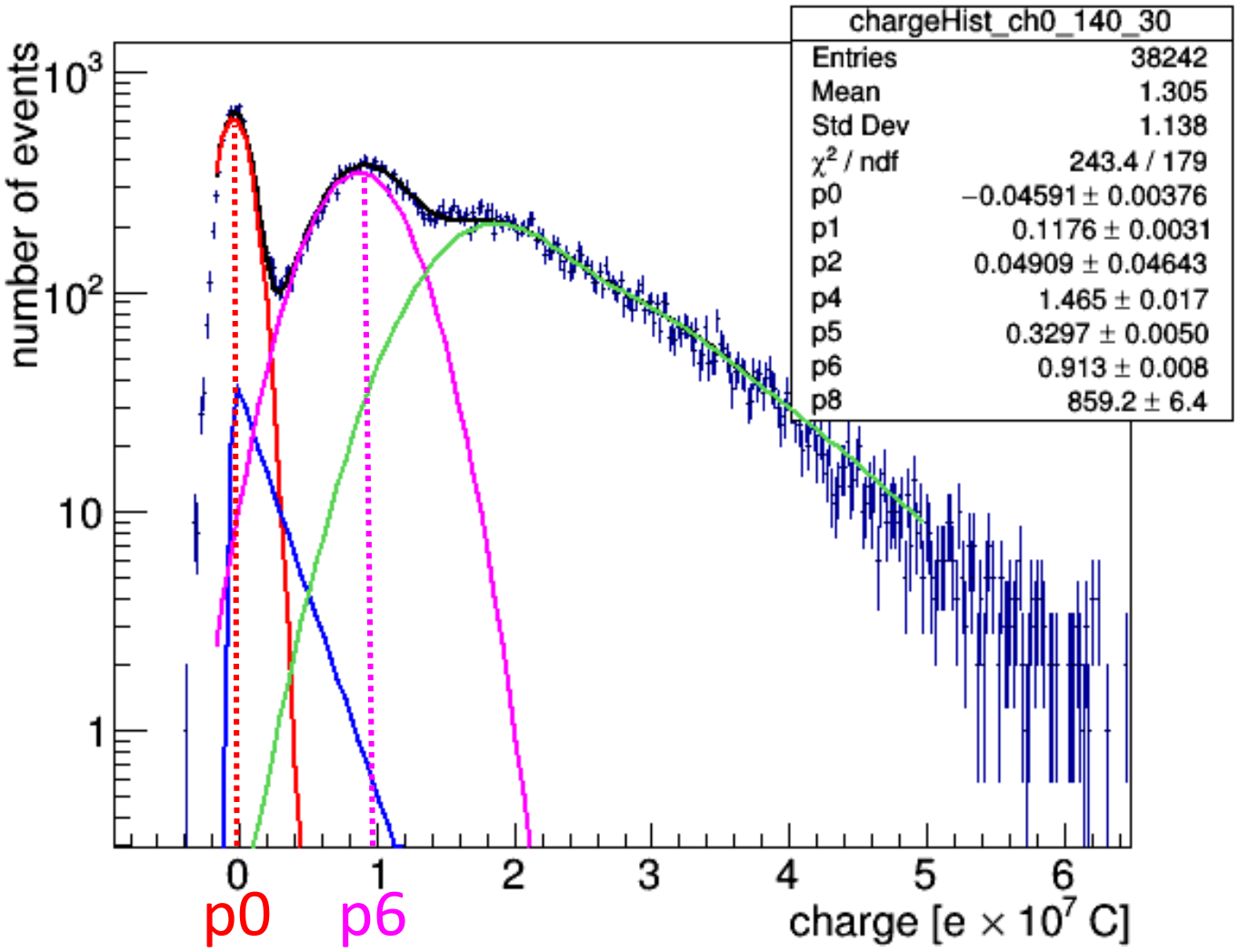
Analysis

integrate





Efficiency



p0: the peak position of pedestal(red) peak

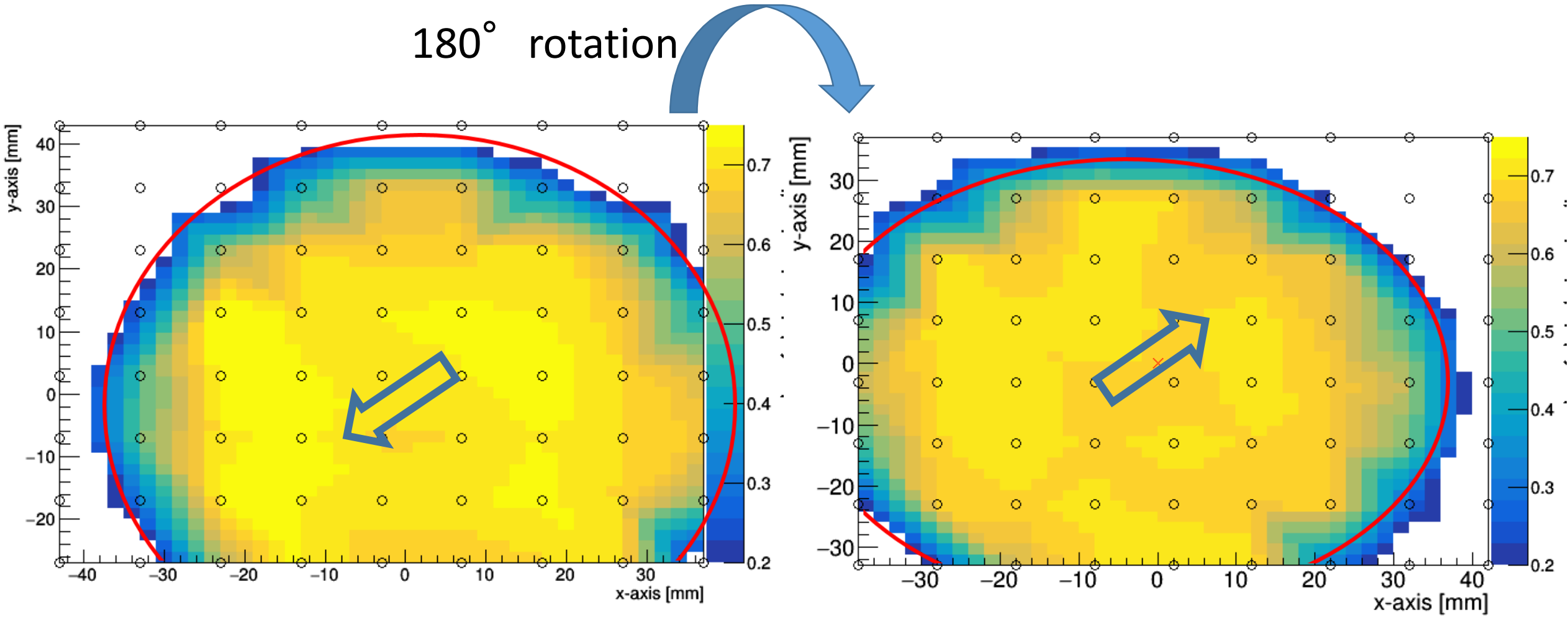
p4: average number of photo electrons

p6: the peak position of 1 p.e. peak

"Efficiency" is defined as p4 divided by the mean charge of monitor PMT.

Efficiency of BC0038/+1200 V

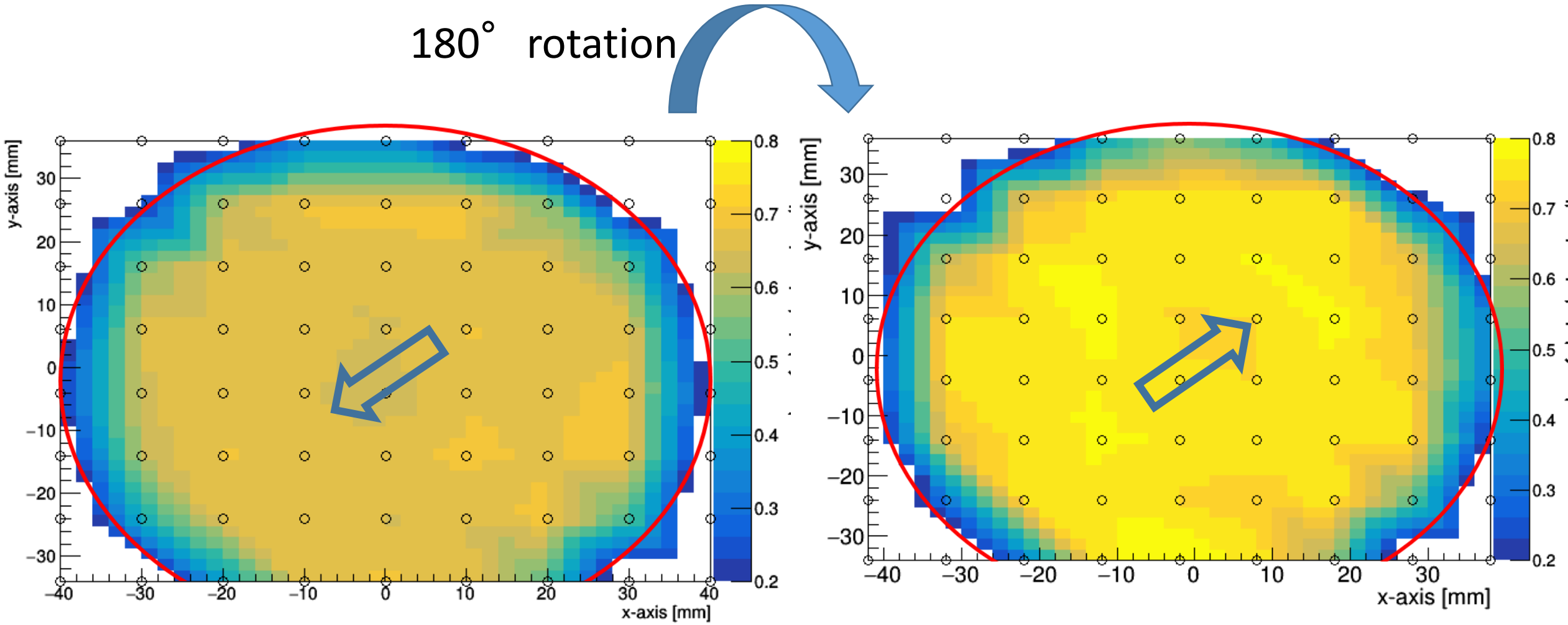
180° rotation



The efficiency is lower at the edge of the PMT, but the efficiency is almost uniform.

Efficiency of BC0038/-1200 V

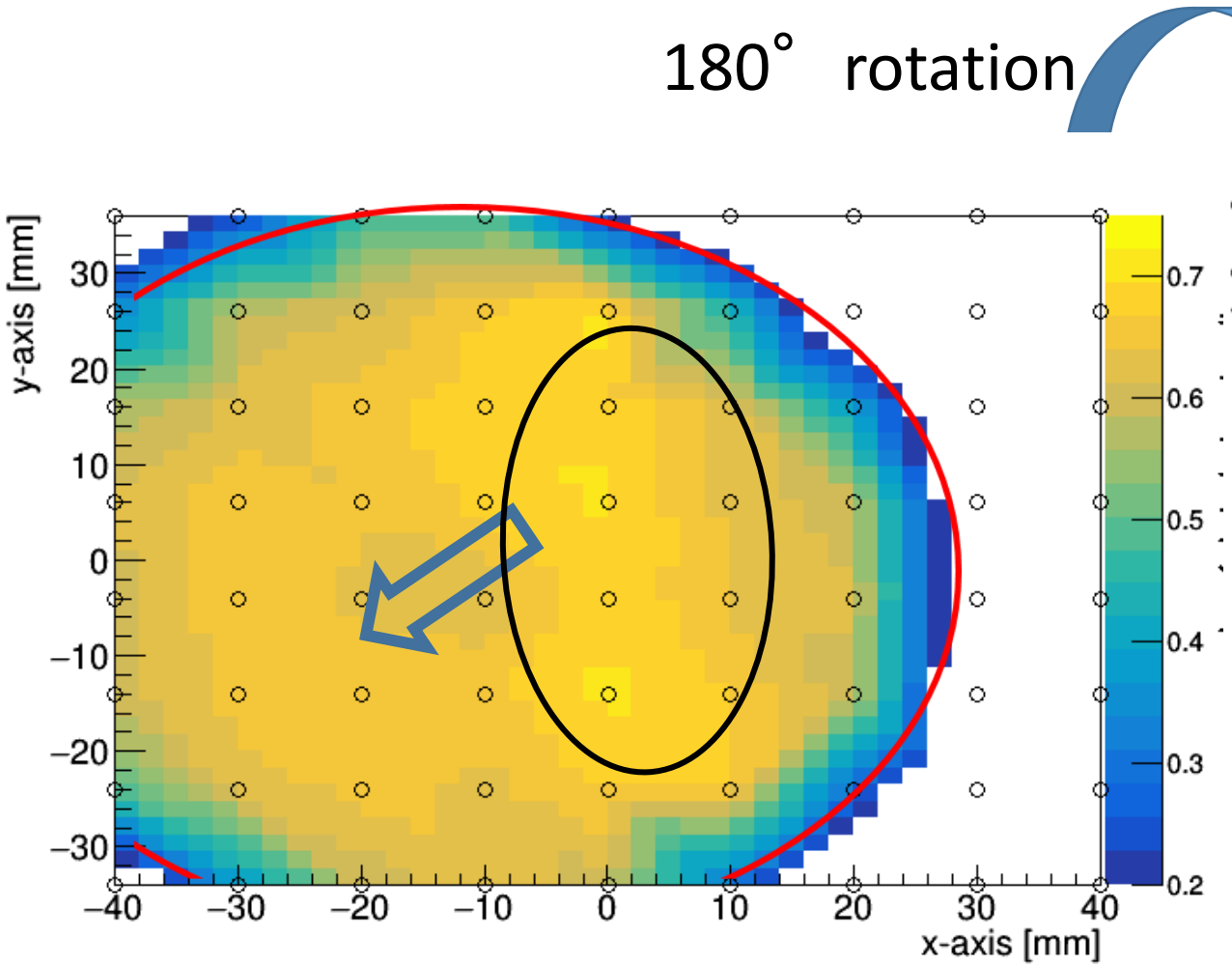
180° rotation

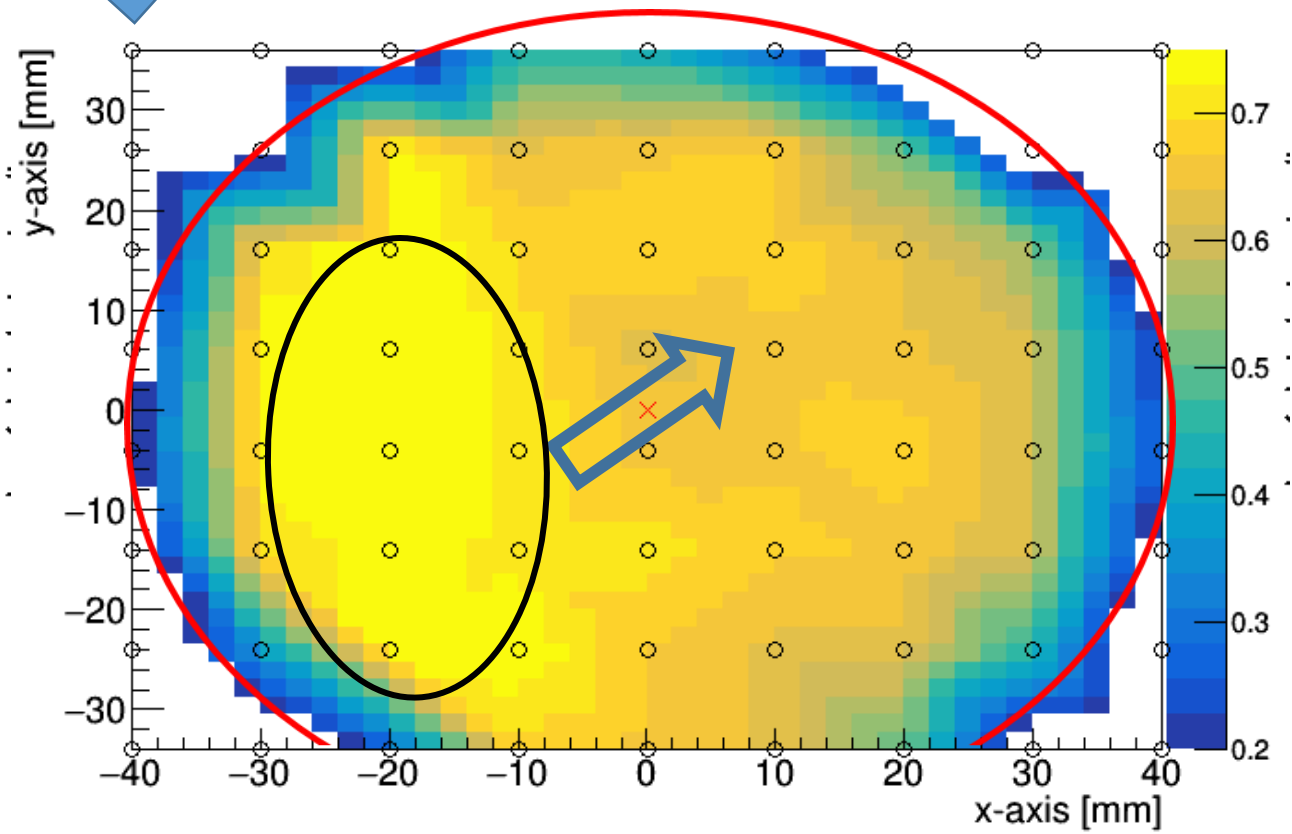


You can recognize the uniformity of the efficiency.

Efficiency of BC0035/+1200 V

180° rotation

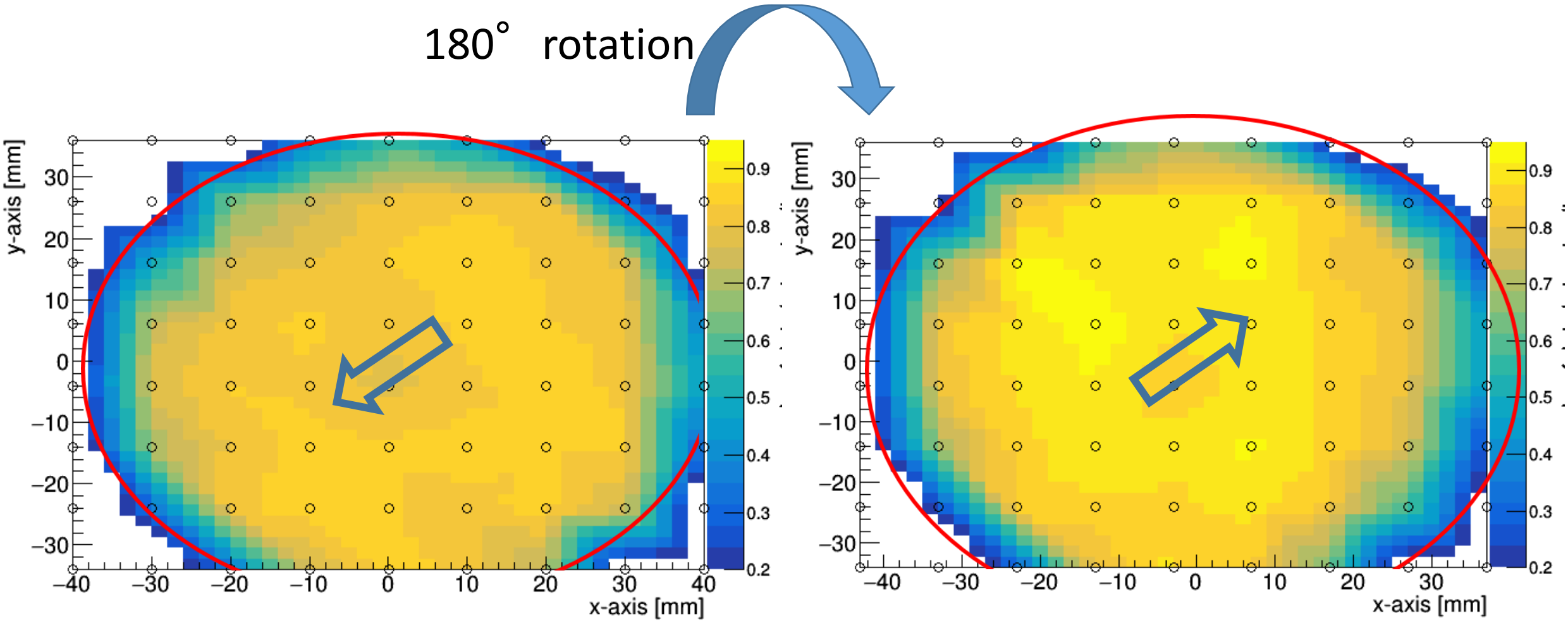




The part with higher efficiency rotated by 180° .

Efficiency of BC0035/-1200 V

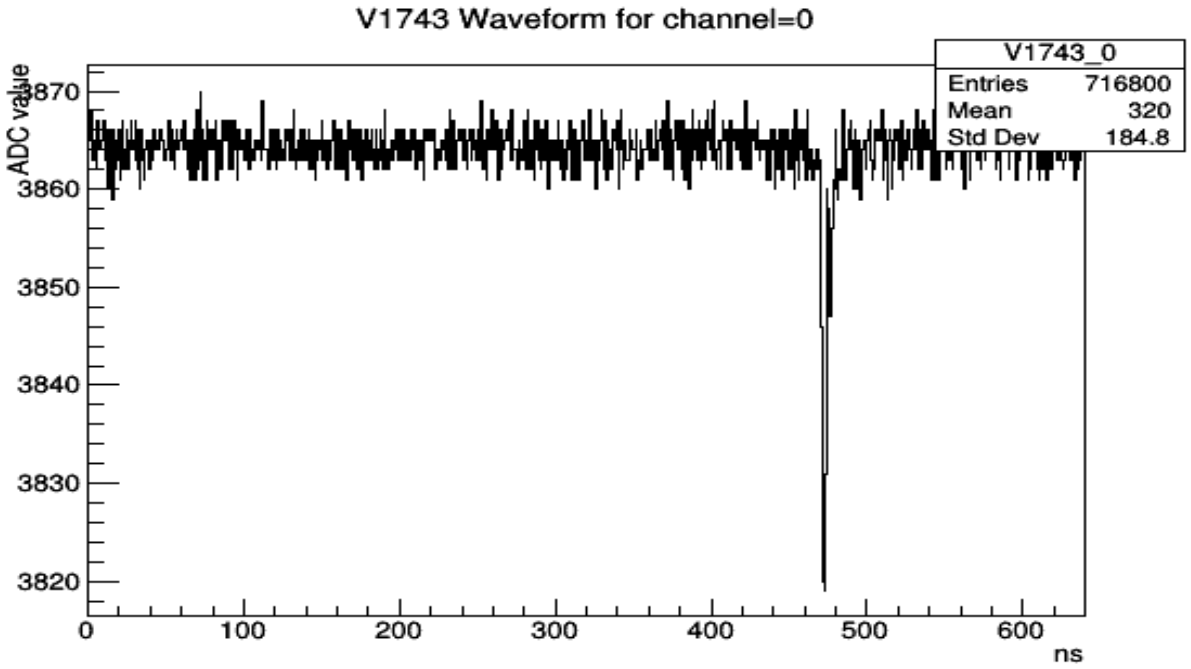
180° rotation



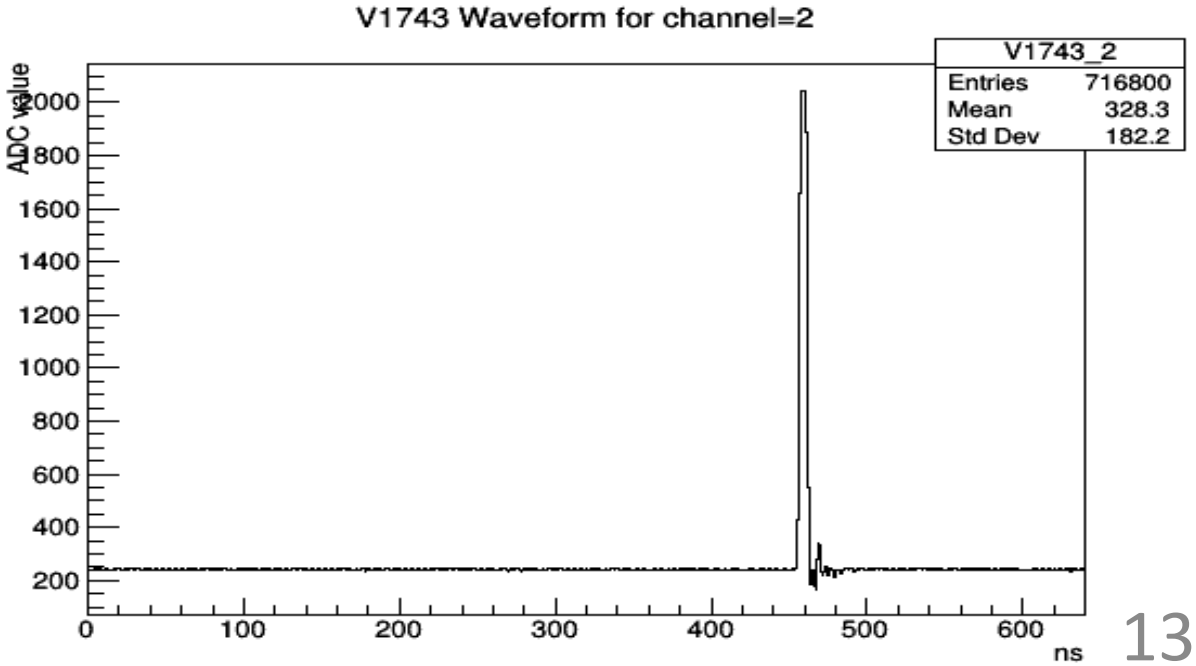
Transit Time

- TT (Transit Time) is defined as a time difference between the trigger signal and the PMT signal.

PMT signal

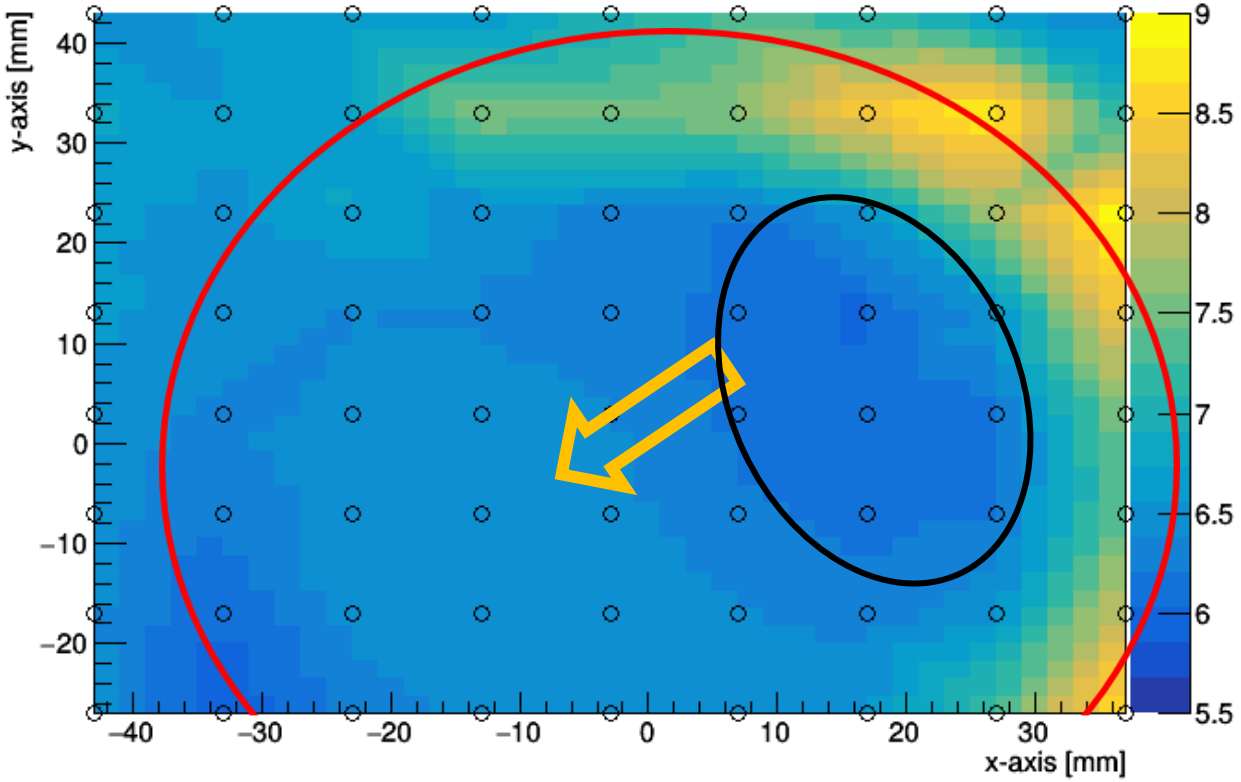


trigger

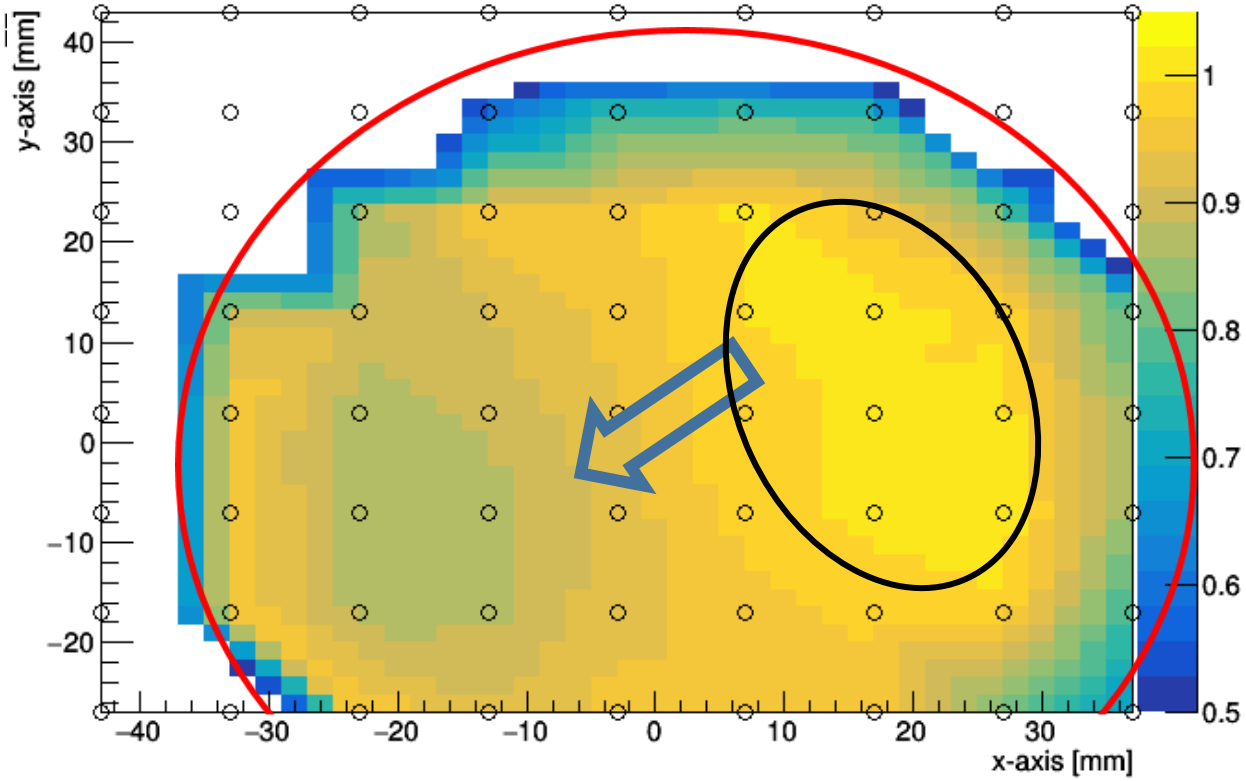


TT and gain of BC0038/+1200 V

TT



gain

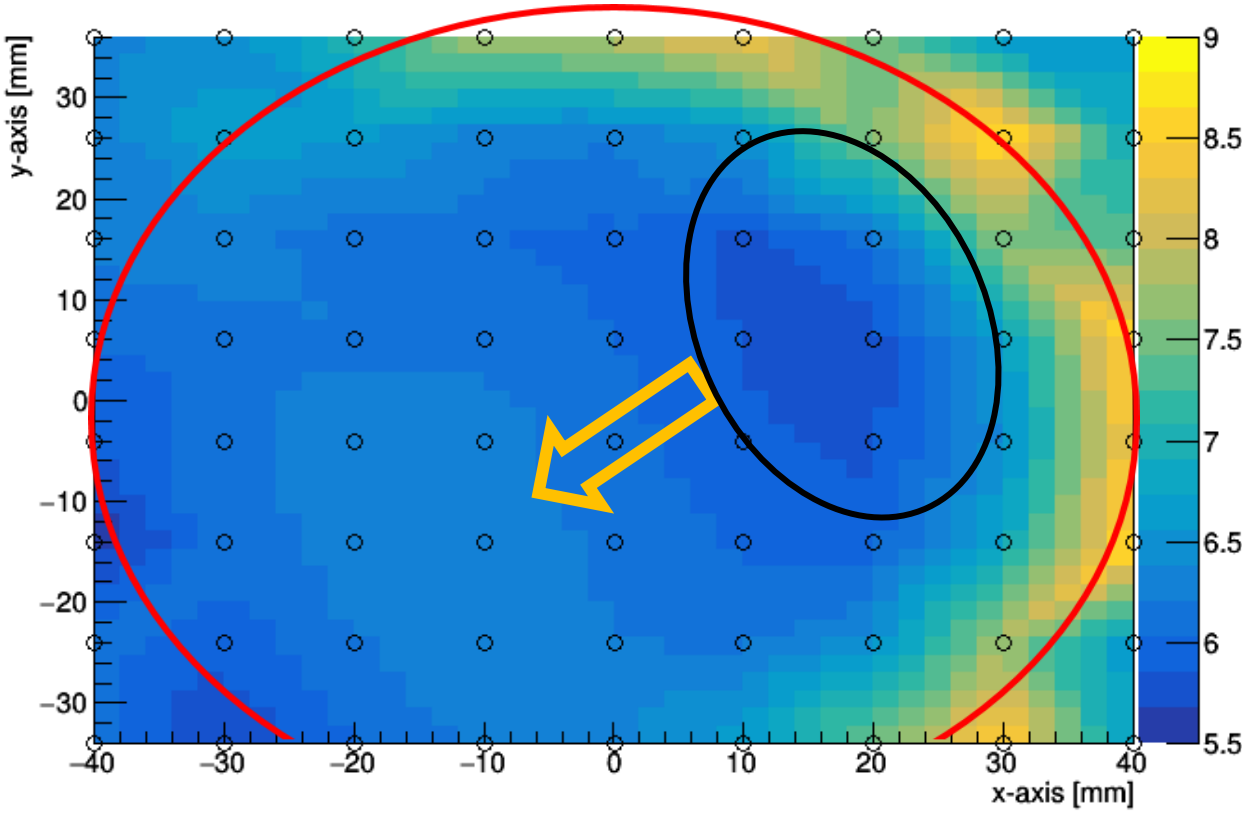


There is a correlation between TT and gain.

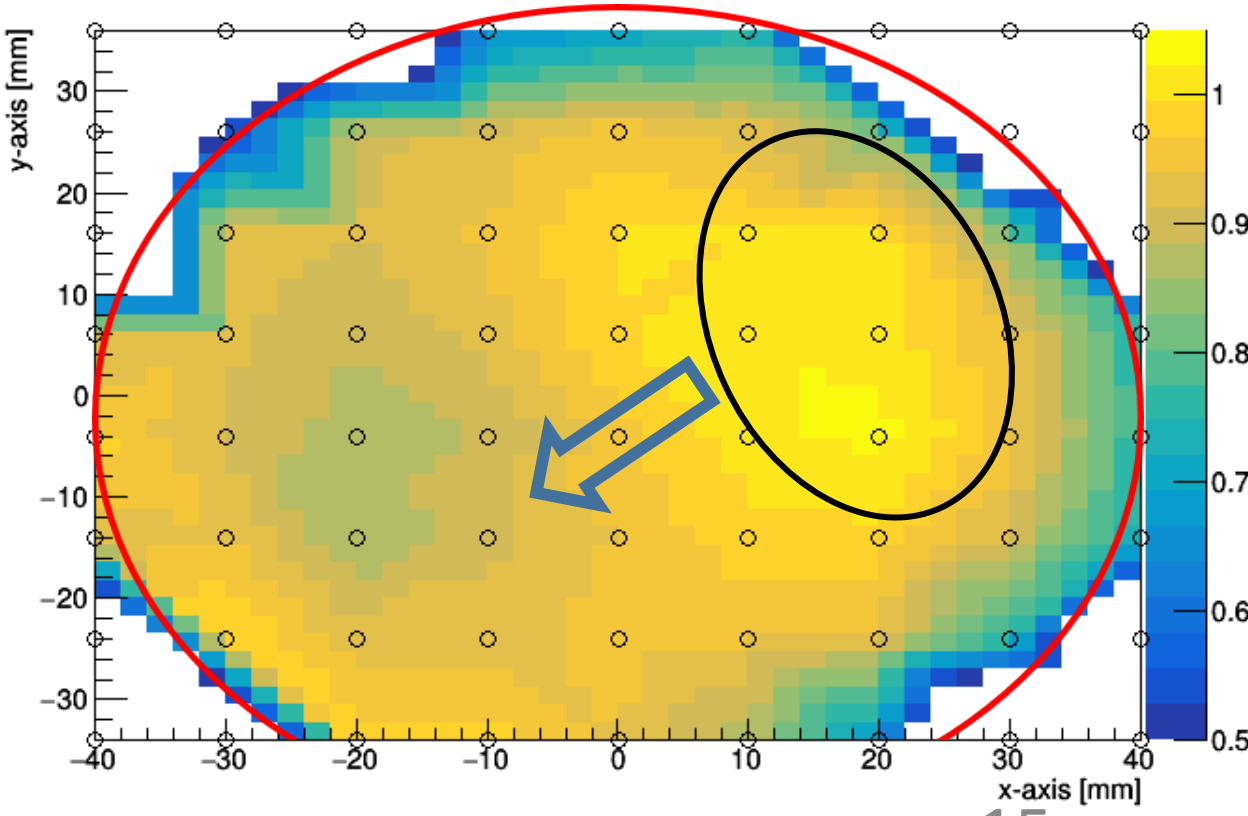
The points with smaller TT have higher efficiency.

TT and gain of BC0038/-1200 V

TT

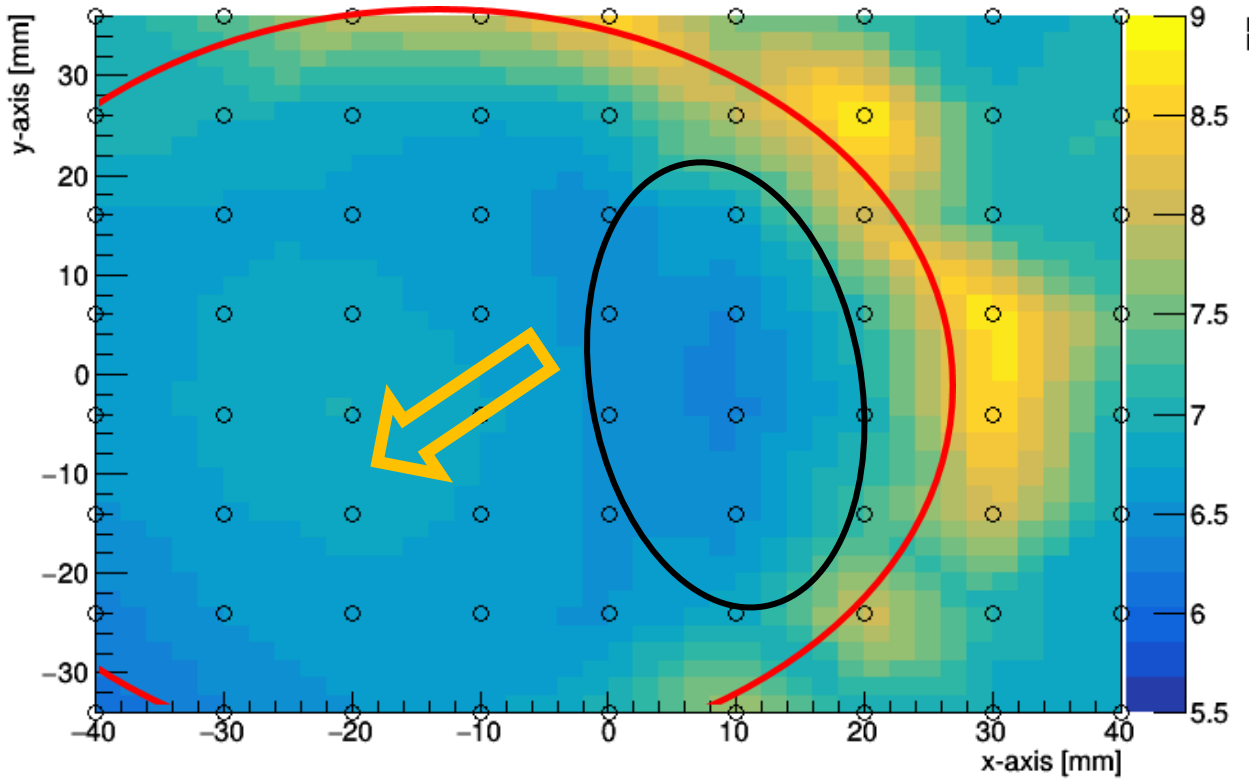


gain

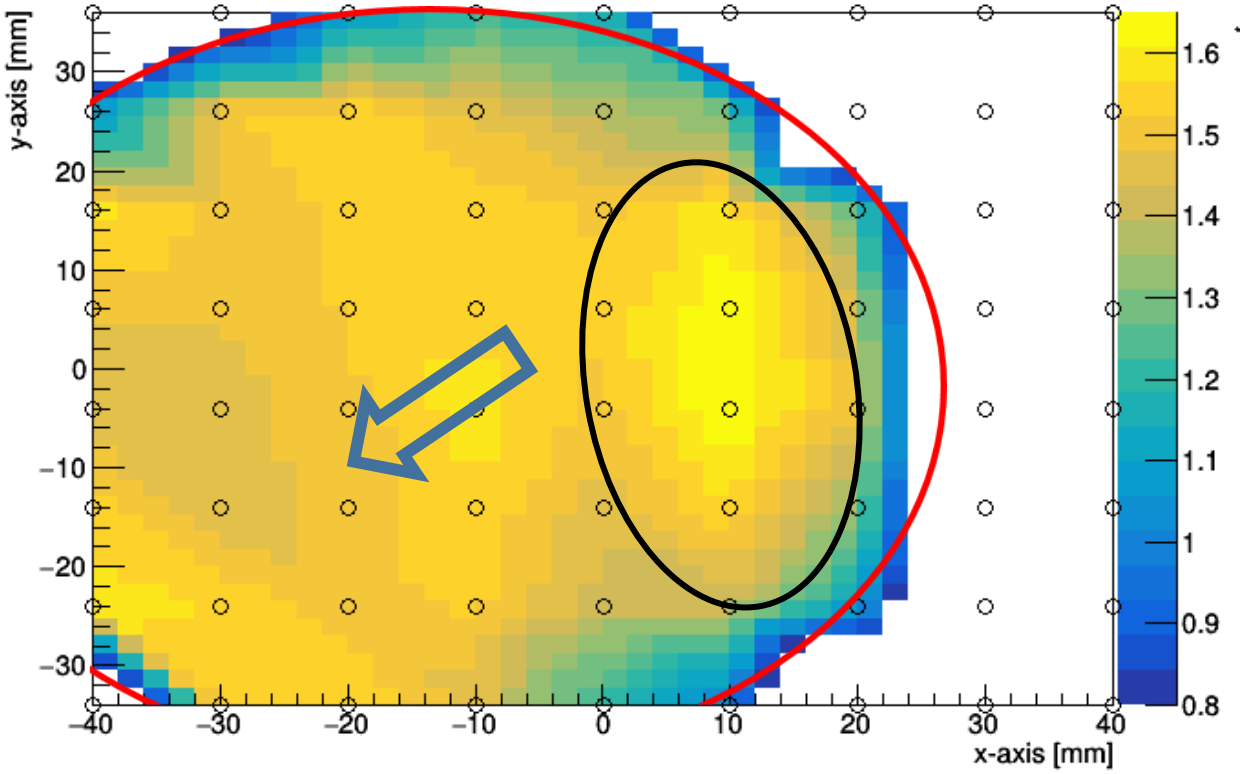


TT and gain of BC0035/+1200 V

TT

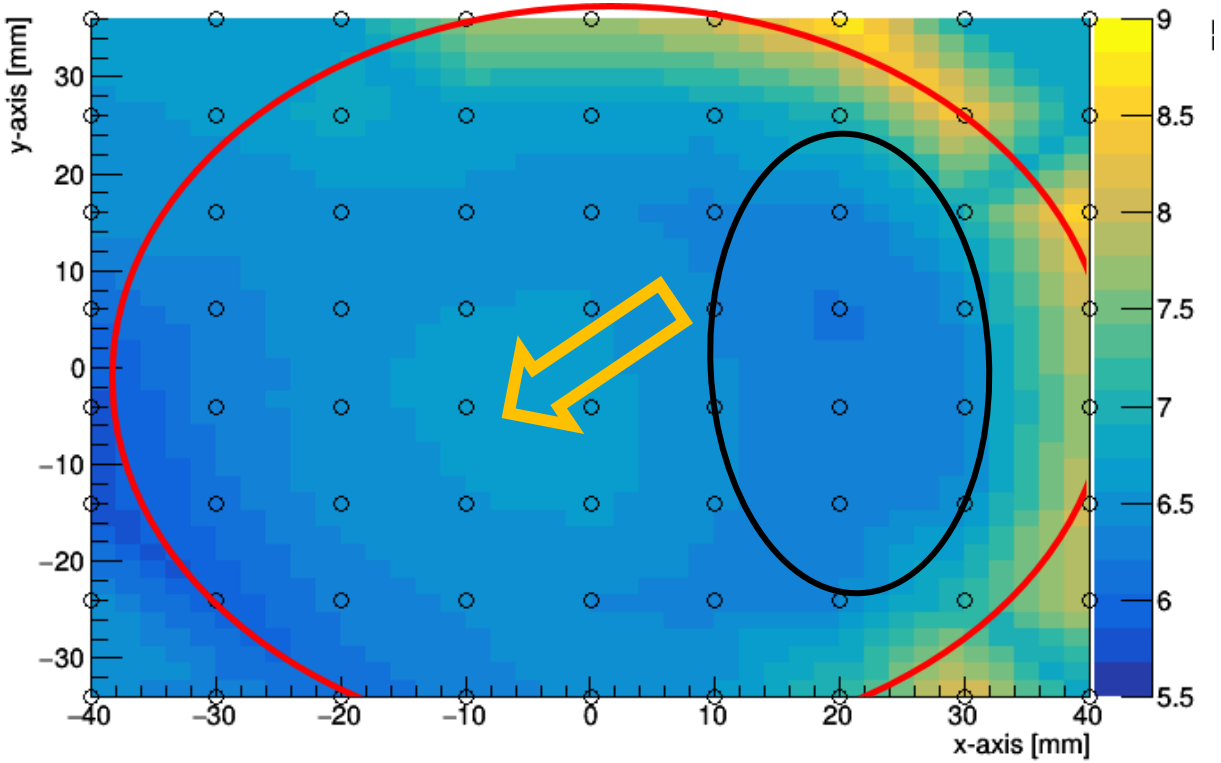


gain

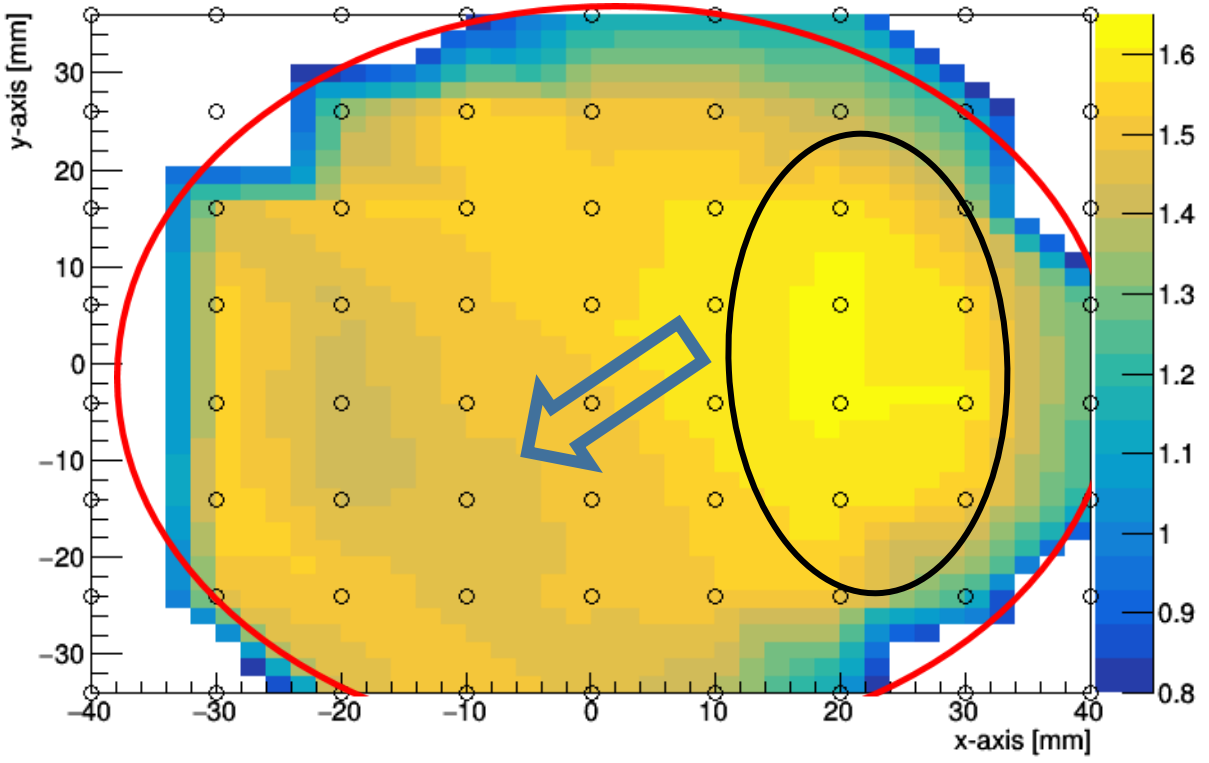


TT and gain of BC0035/-1200 V

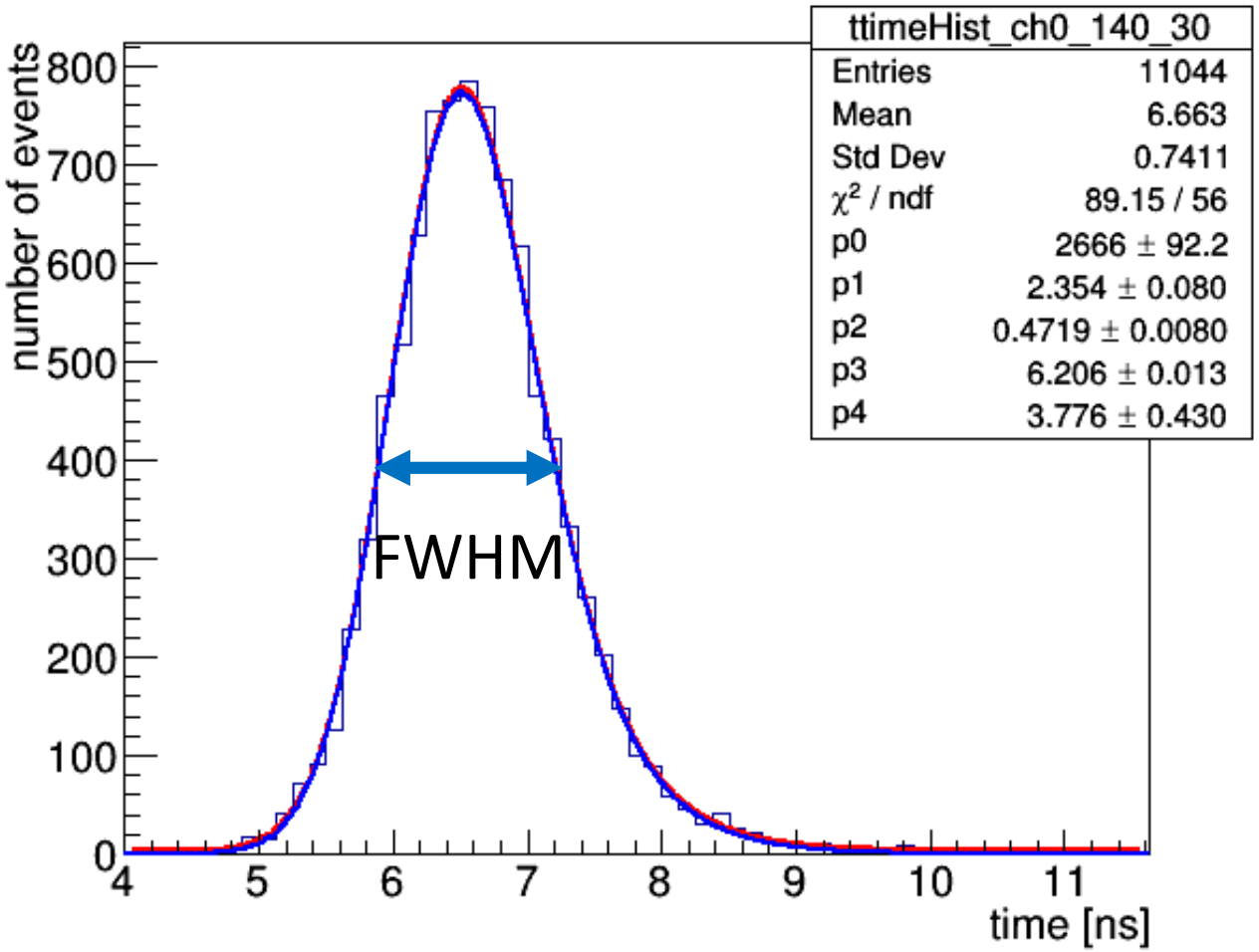
TT



gain

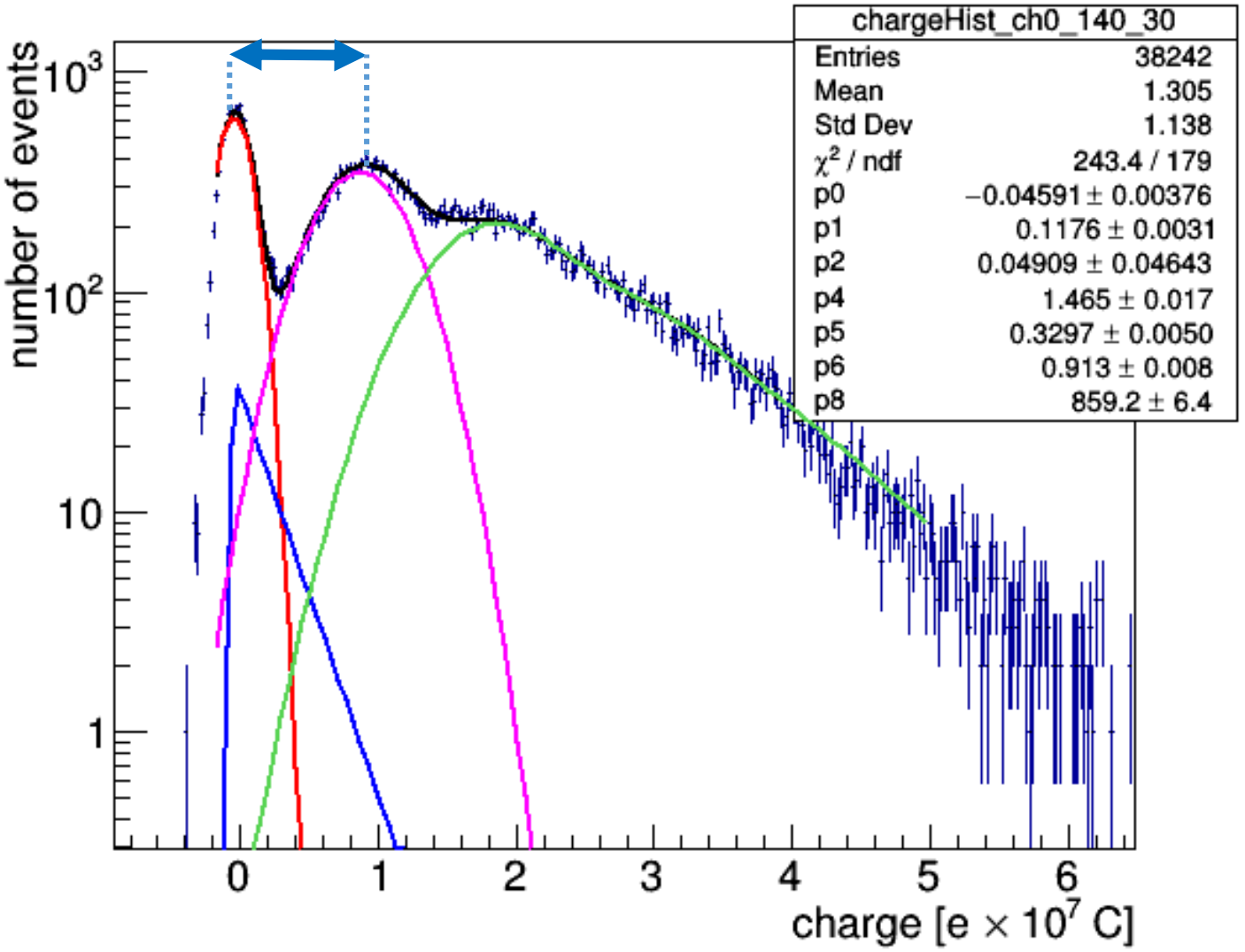


Transit Time Spread



- TTS (Transit Time Spread) is defined as FWHM of TT distribution.
- It is an important parameter to evaluate the error of timing.

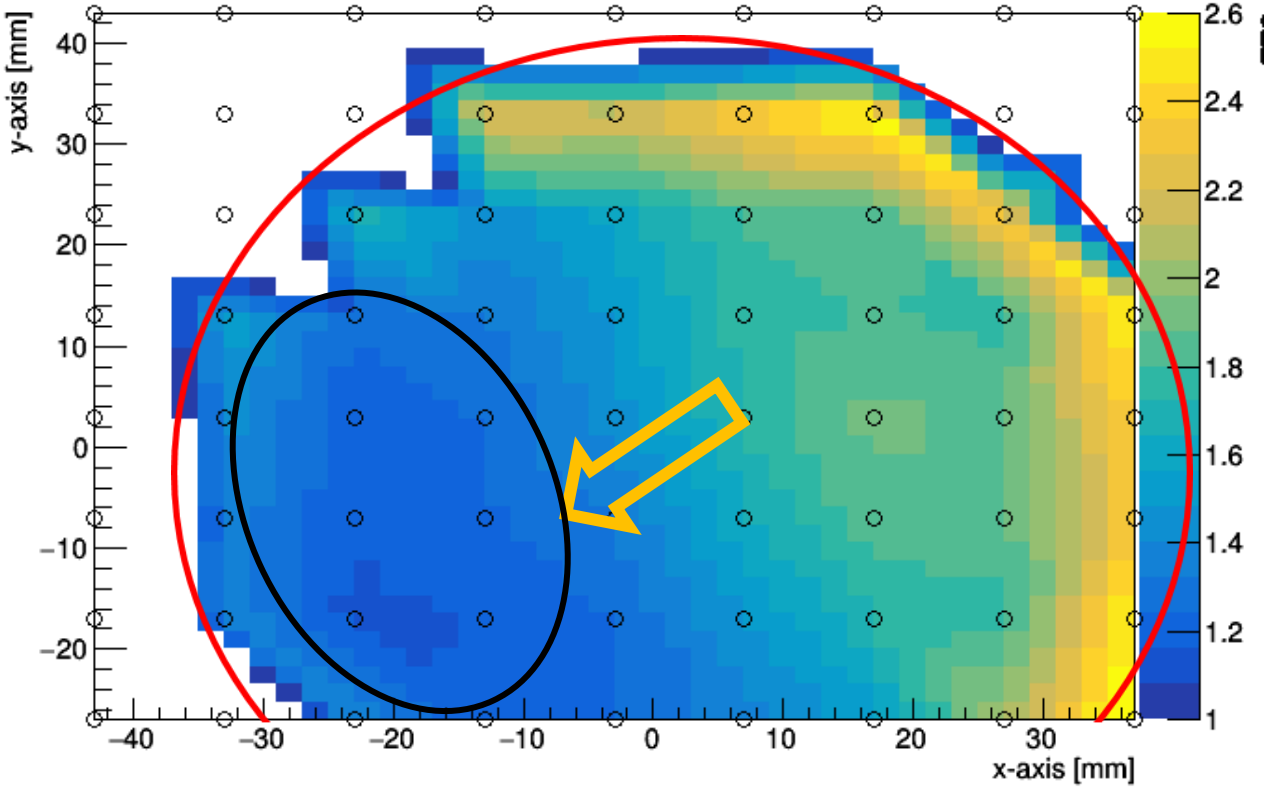
Gain



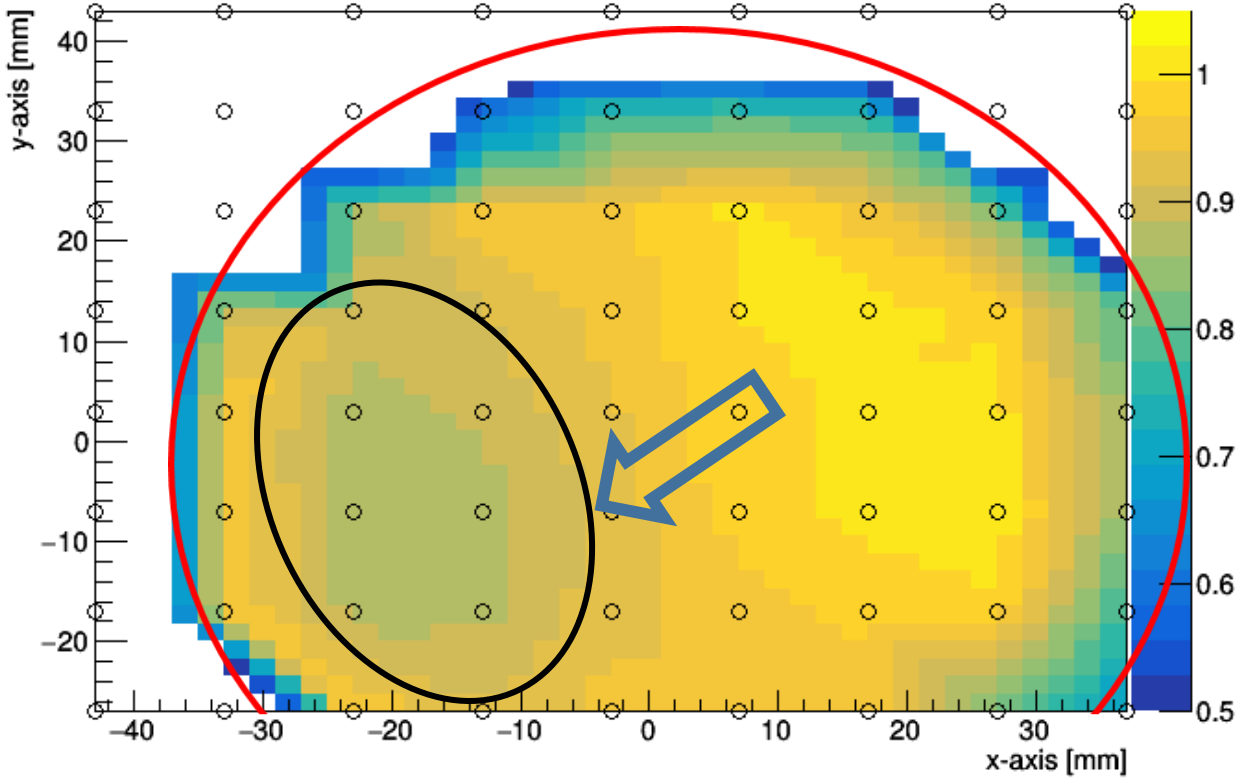
- Gain is a parameter which shows how much the photo electron was amplified.
- It is defined as the difference between 1 p.e. peak position and the pedestal position.

TTS and gain of BC0038/+1200 V

TTS



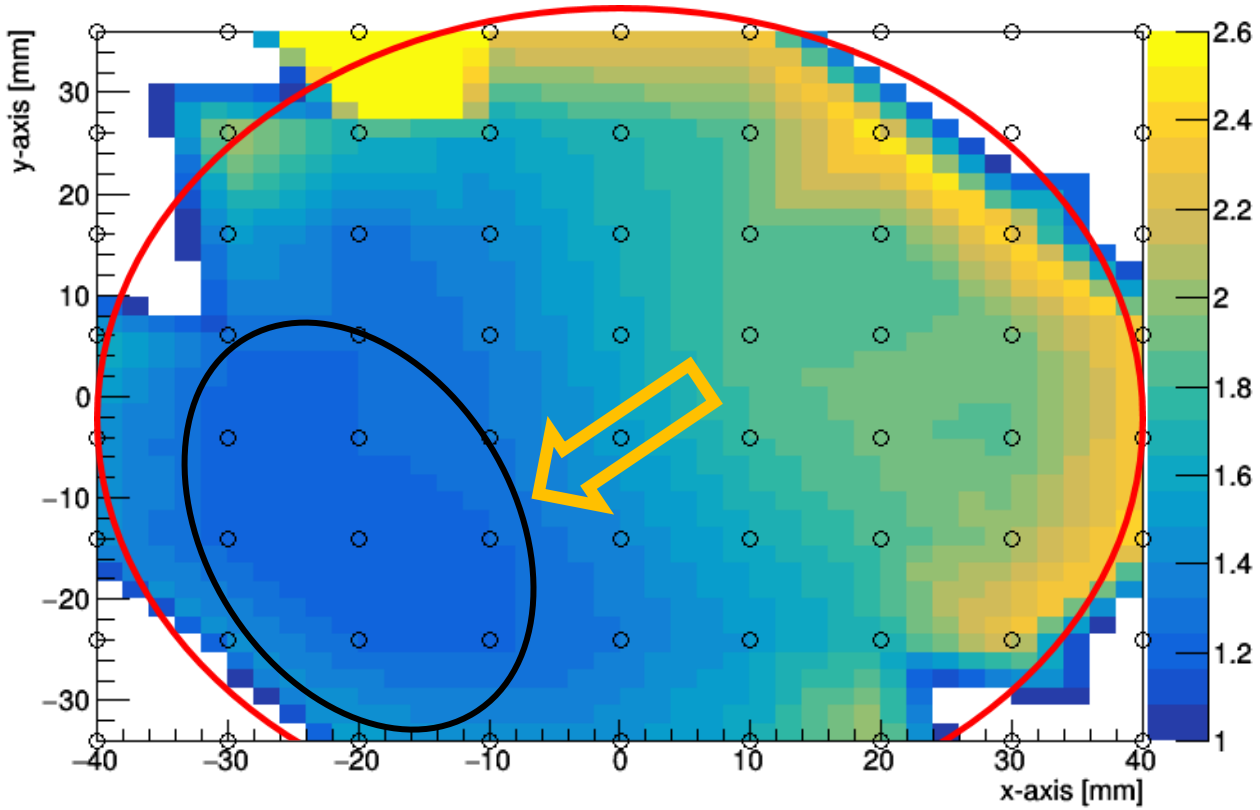
gain



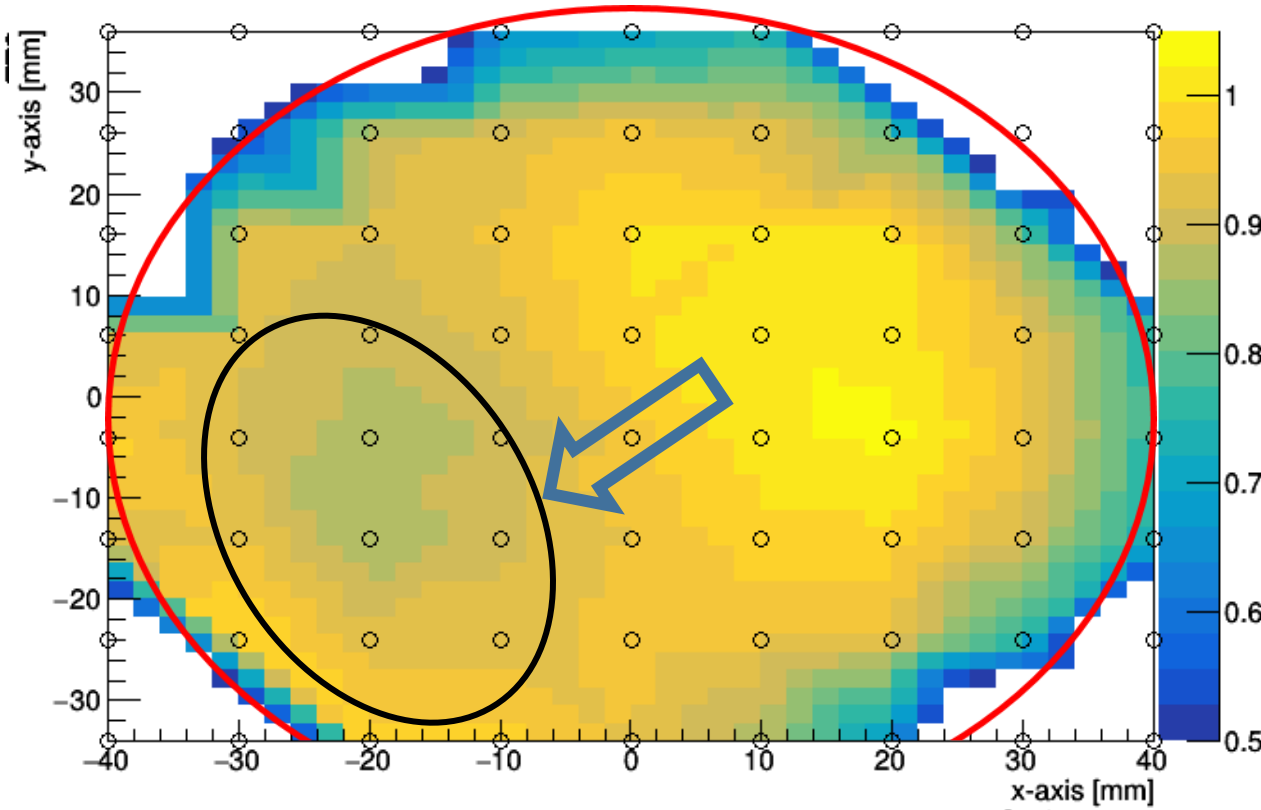
There is a correlation between TTS and gain.
TTS is smaller at points where gain is small.

TTS and gain of BC0038/-1200 V

TTS

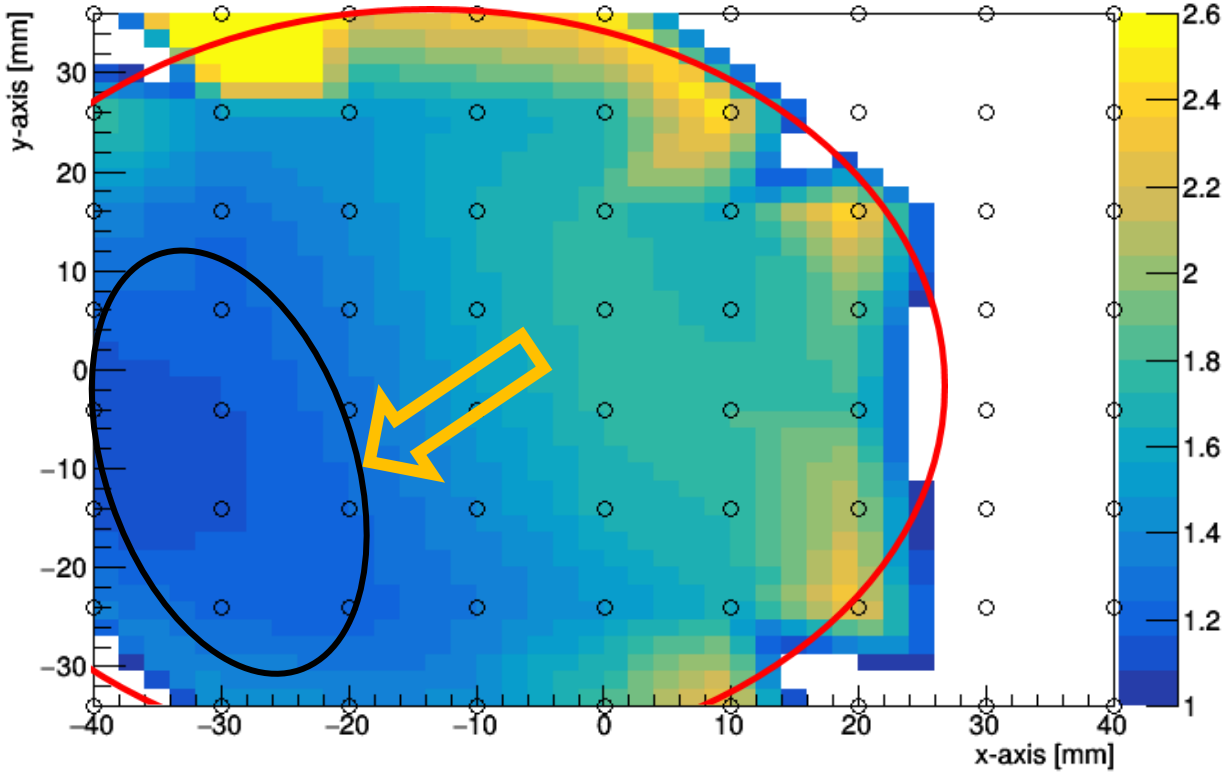


gain

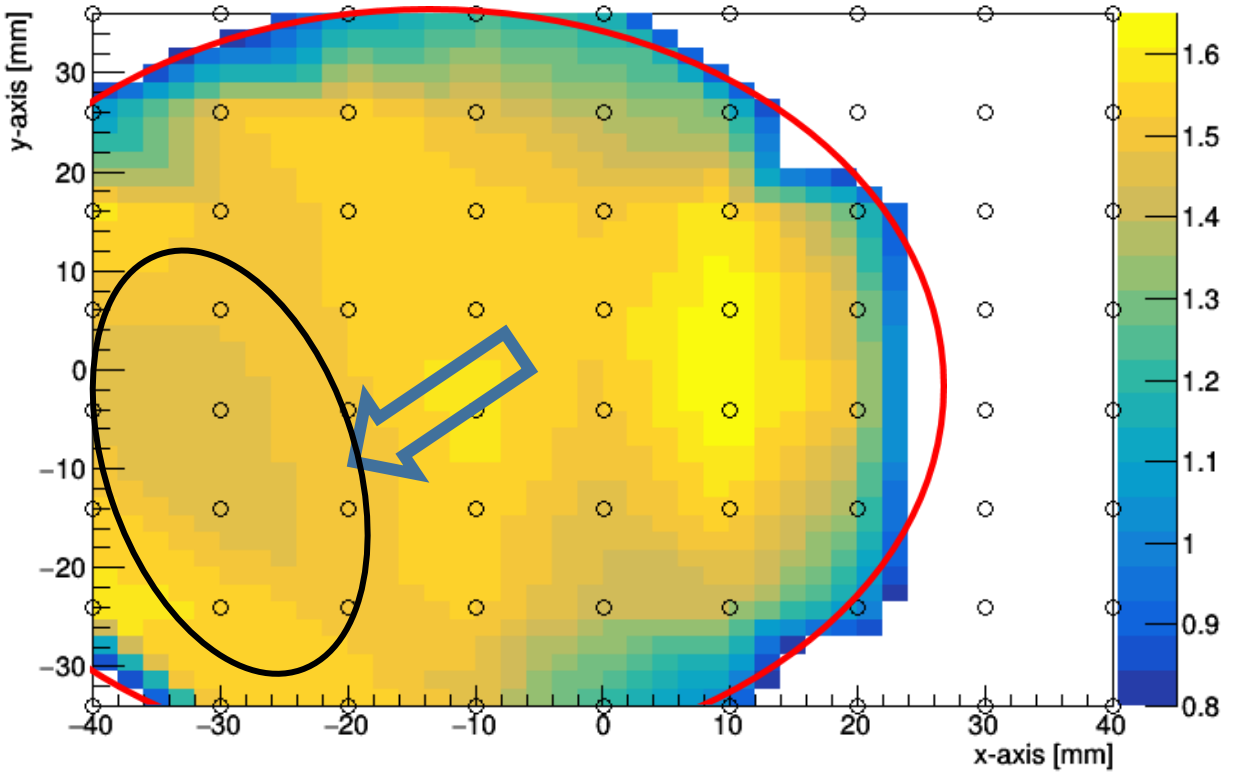


TTS and gain of BC0035/+1200 V

TTS

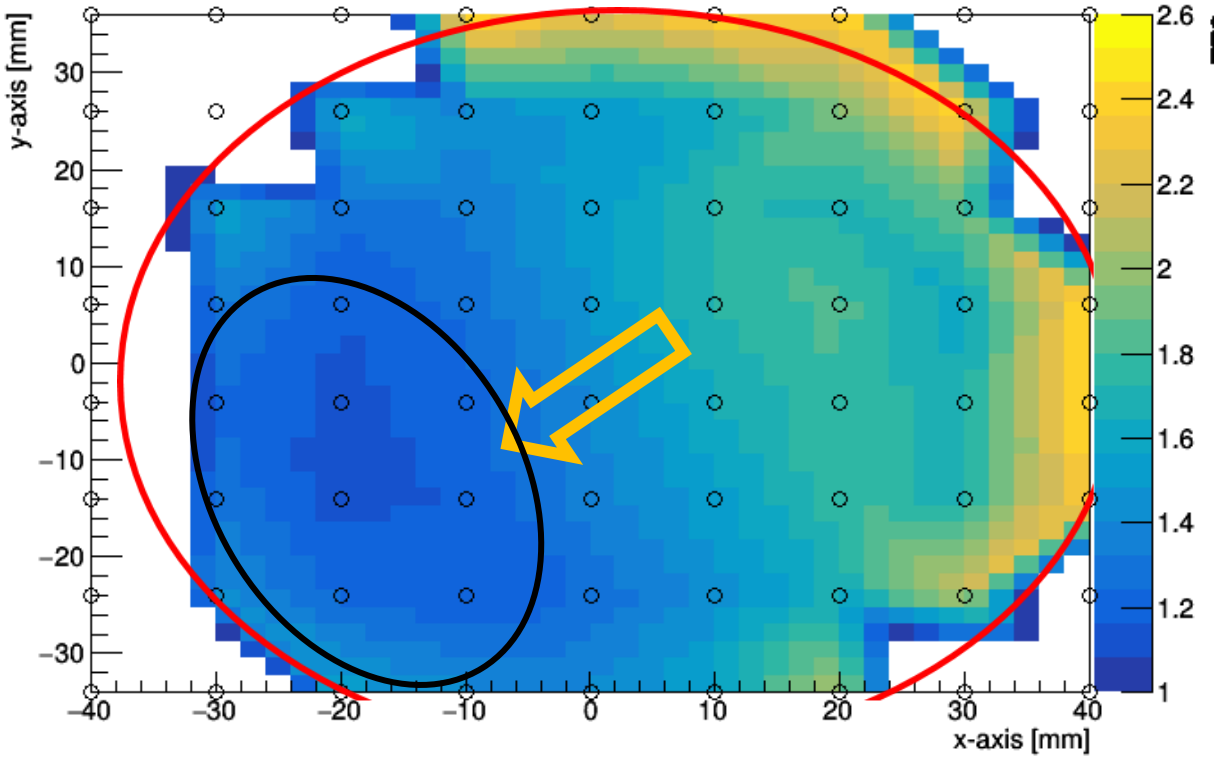


gain

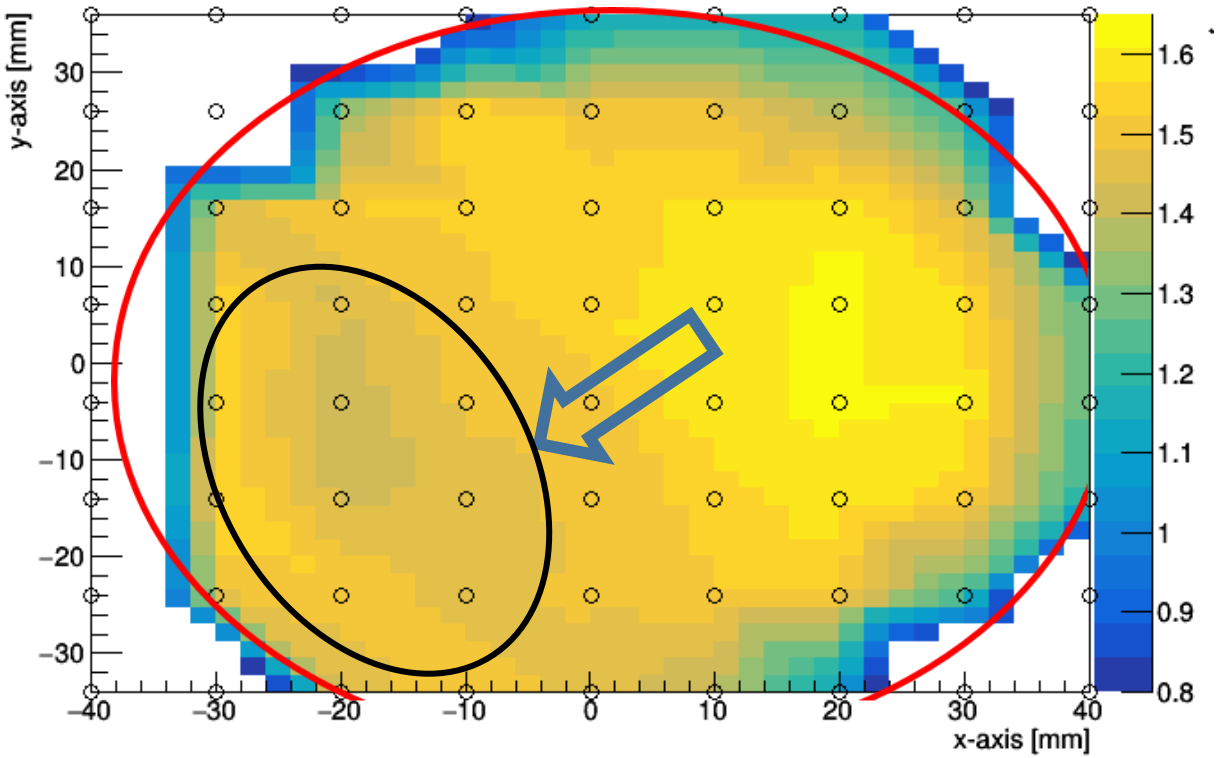


TTS and gain of BC0035/-1200 V

TTS



gain



Summary

- The motorized moving stand is now ready and the first experiment has been done.

- We evaluated the position dependent performance of 3-inch PMTs.

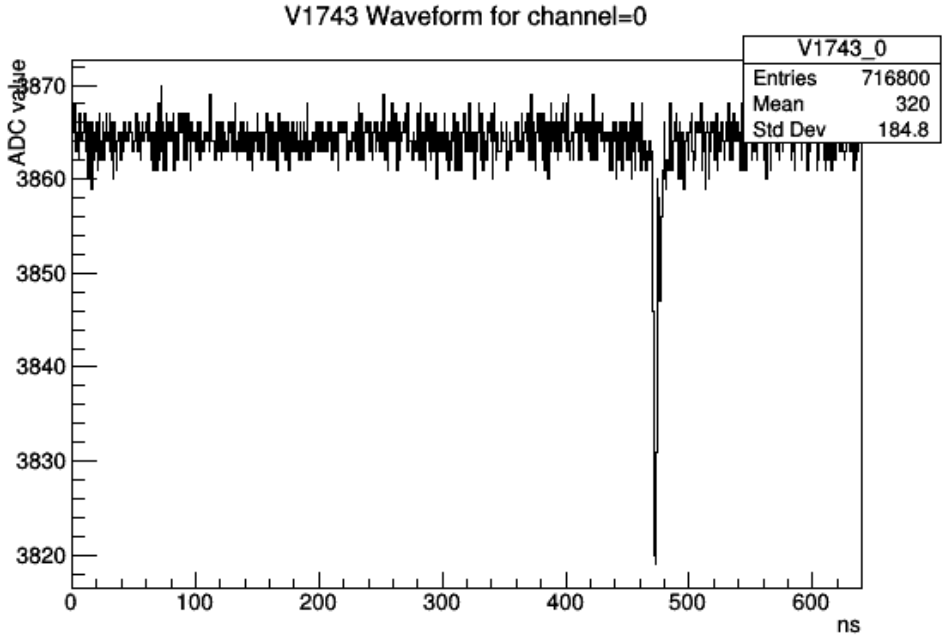
- There are many other interesting measurements we can do with the motorized stand:

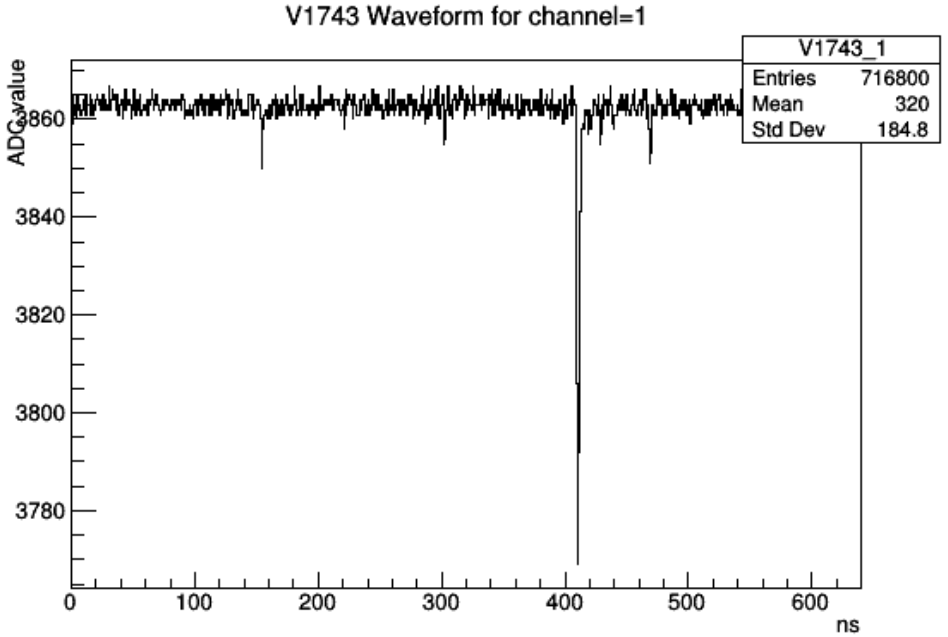
  -measurements with more points

  -measurements with laser always perpendicular to the photocathode

  -measurements with reflectors

Back up


V1743 Waveform for channel=0
V1743_0
Entries 716800
Mean 320
Std Dev 184.8
ADC value
ns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V1743_1
Entries 716800
Mean 320
Std Dev 184.8
ADC value
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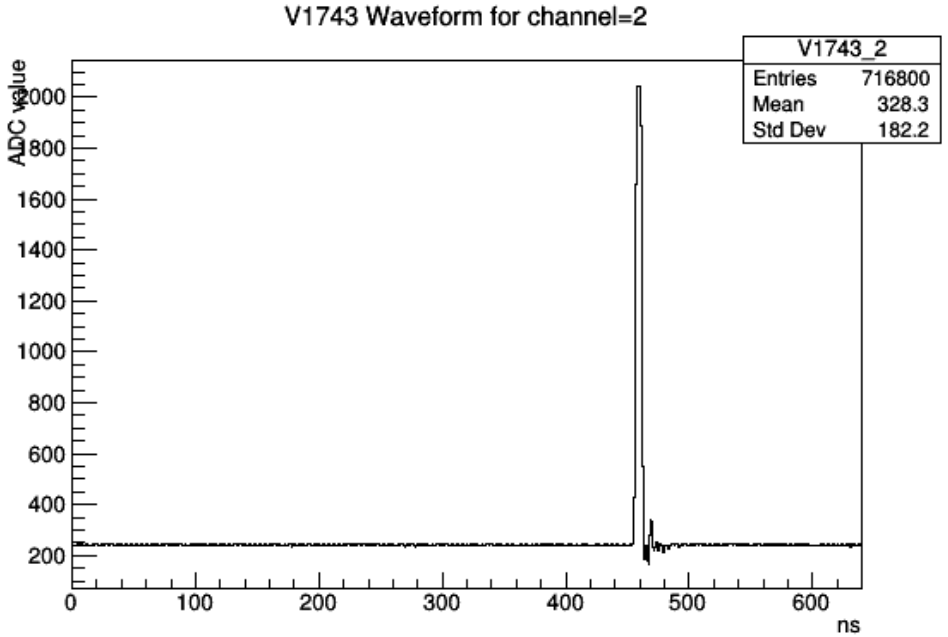
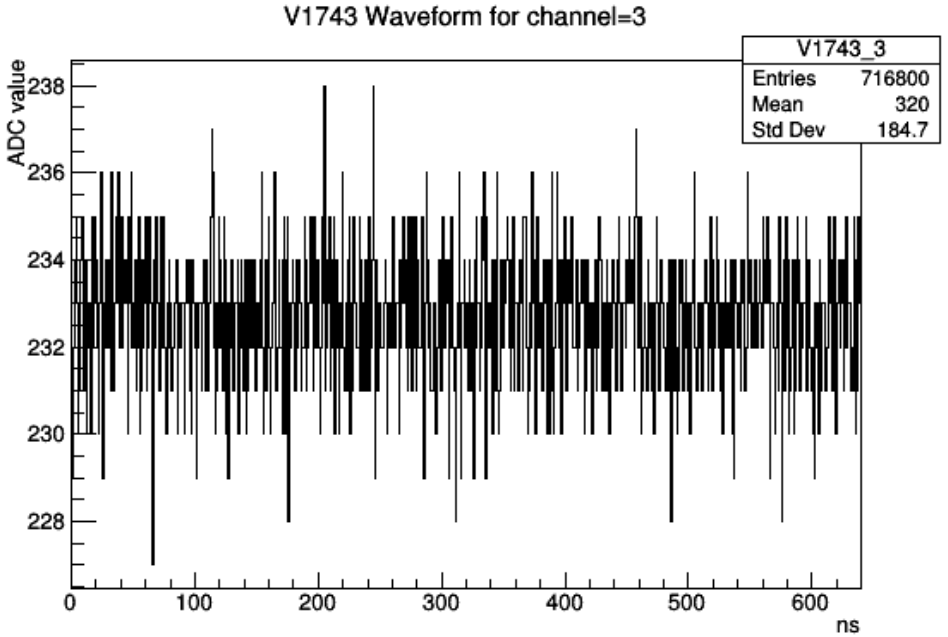

V1743 Waveform for channel=2
V1743_2
Entries 716800
Mean 328.3
Std Dev 182.2
ADC value
ns

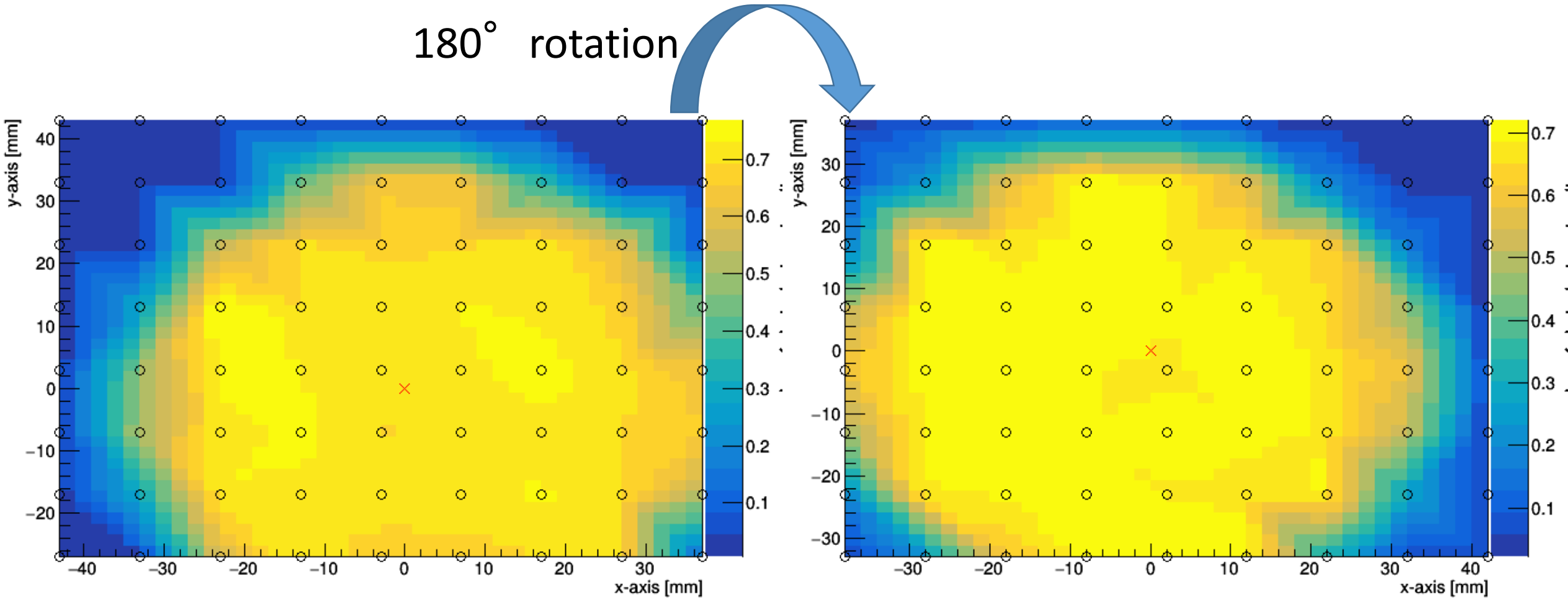

V1743 Waveform for channel=3
V1743_3
Entries 716800
Mean 320
Std Dev 184.7
ADC value
ns

Number of events

- The frequency of trigger is 2 MHz.
- There are about 38,000 events for each position.
- $\frac{38000\ \text{events}}{2\times10^{6}\ \text{Hz}\times100\ \text{sec}} = 0.00019$
- 0.019% of the light emitted is actually detected.

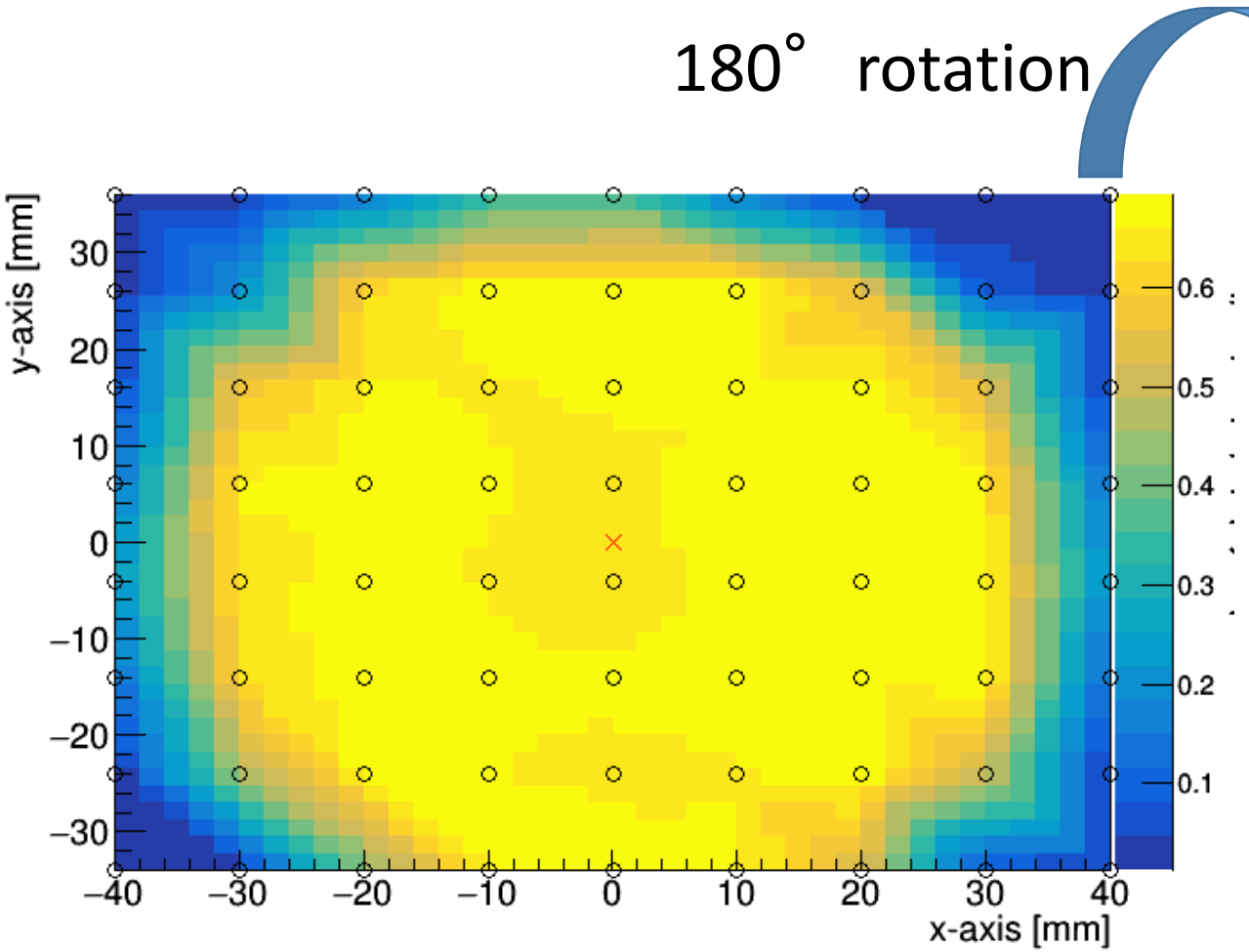
Efficiency of BC0038/+1200 V

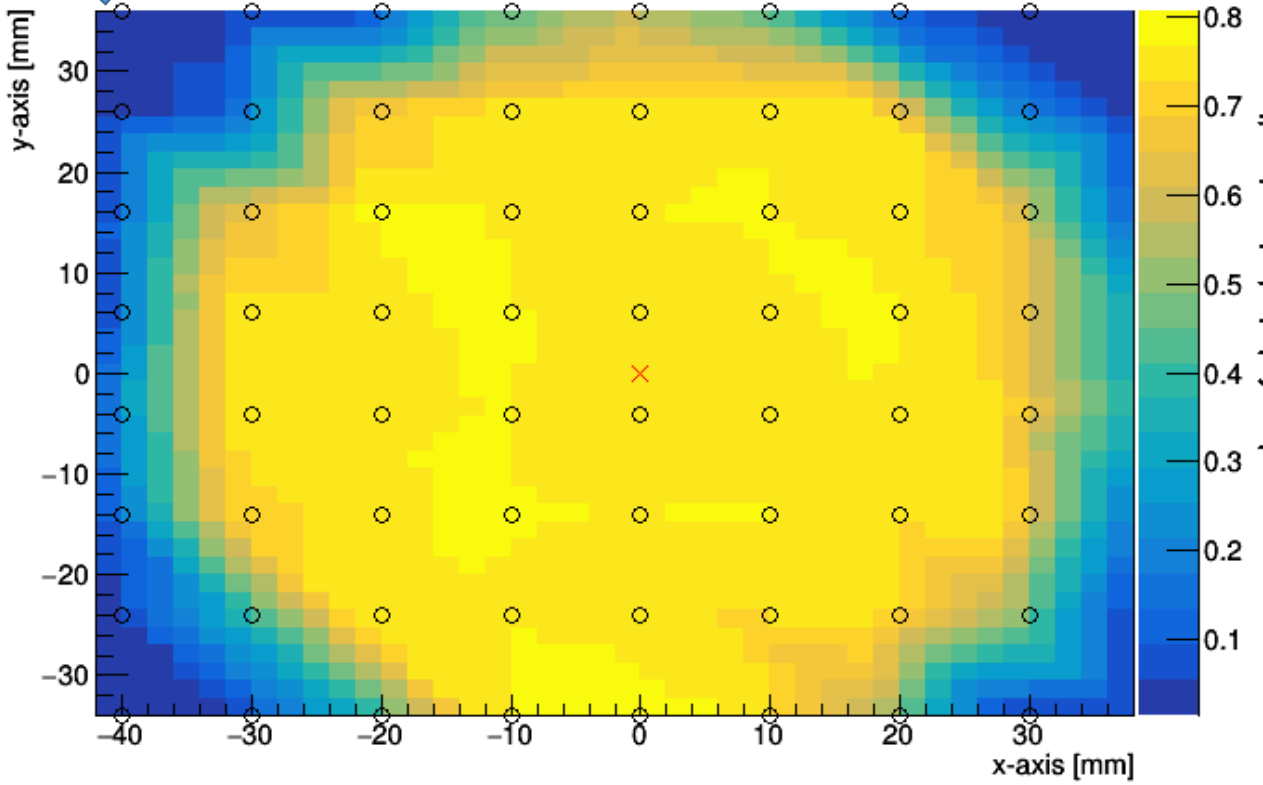
180° rotation



Efficiency of BC0038/-1200 V

180° rotation

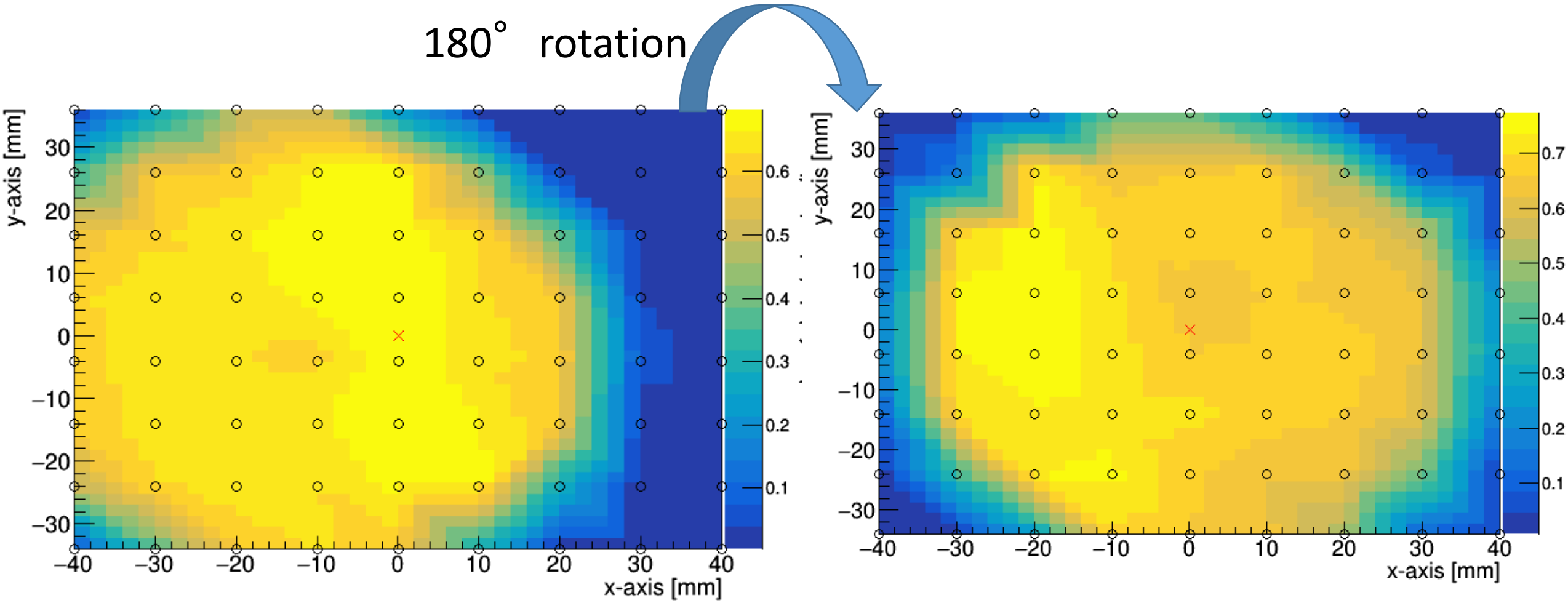




Normal fitting

Efficiency of BC0035/+1200 V

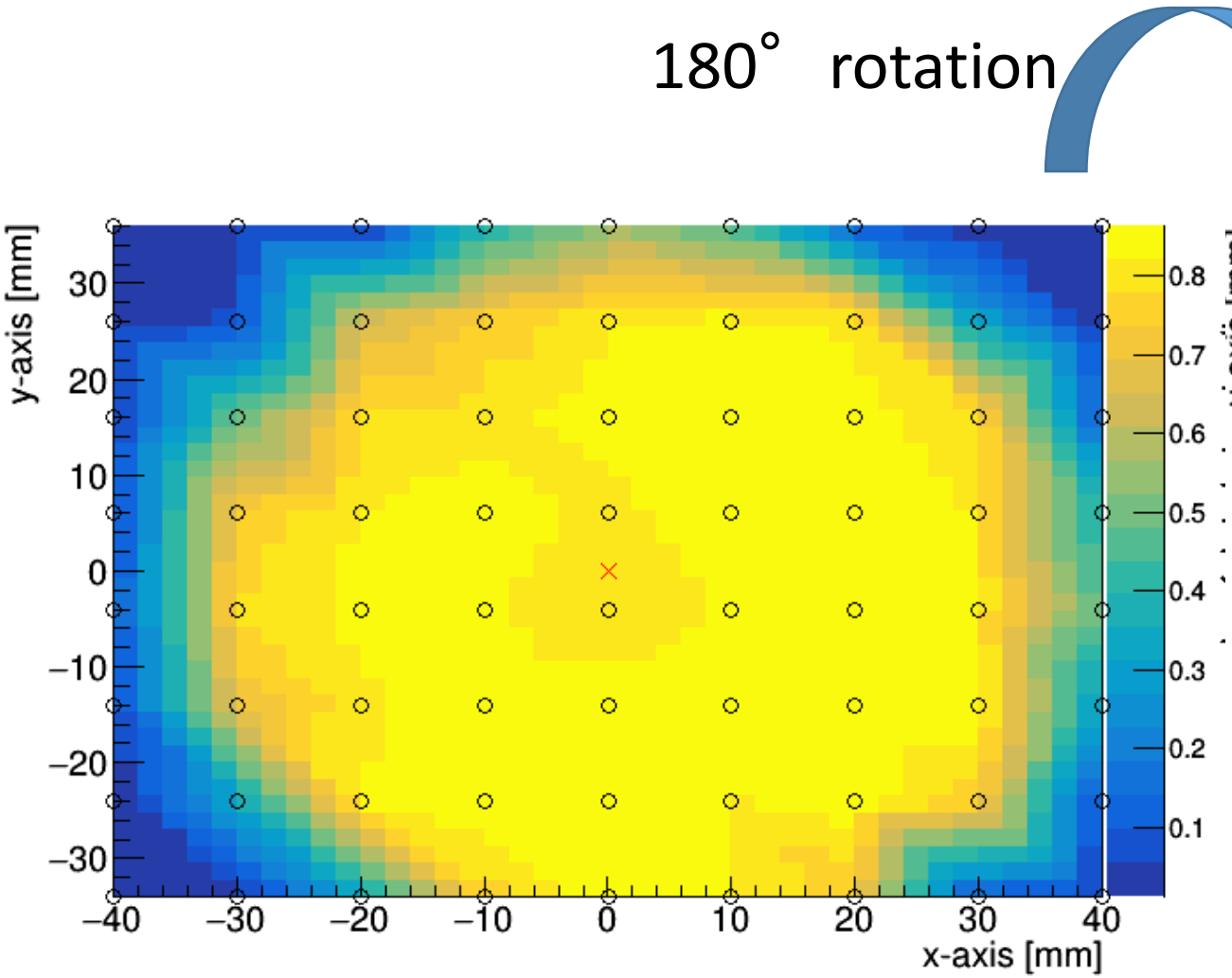
180° rotation

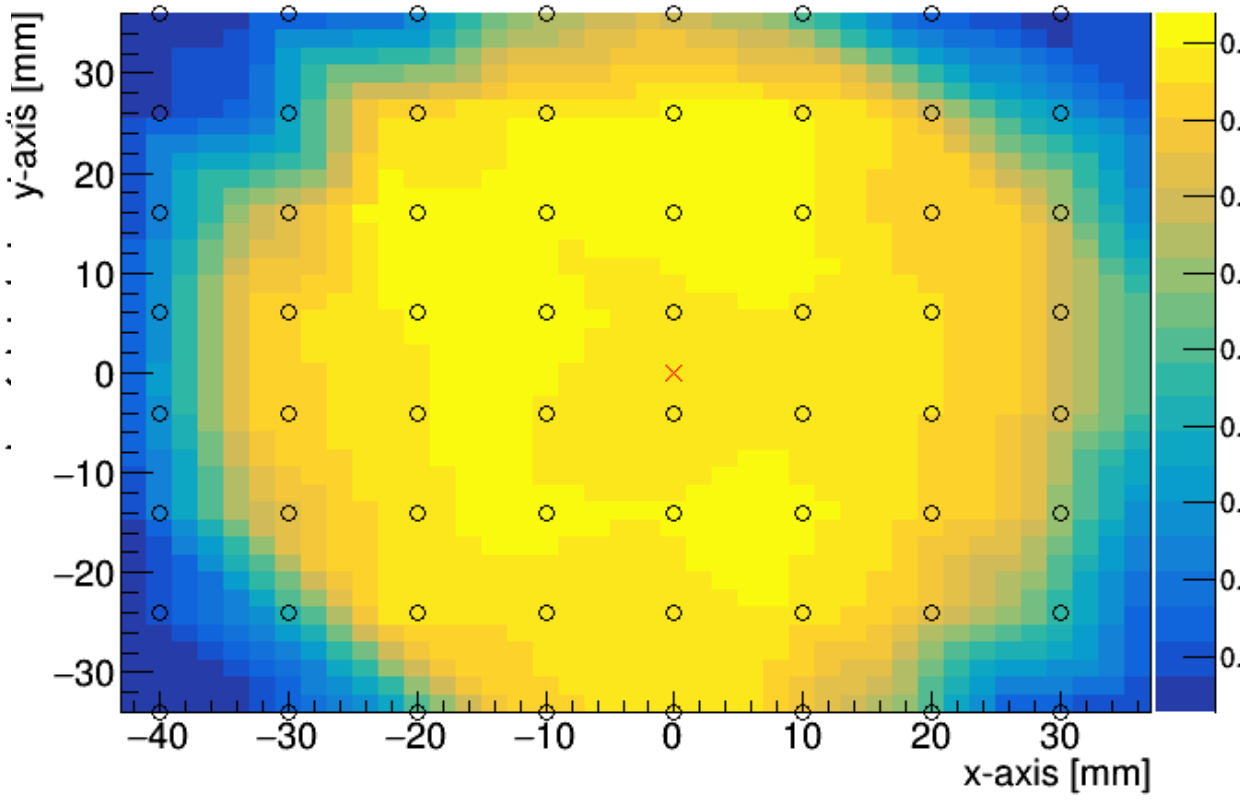


You can see that the part with higher efficiency rotated by 180° .

Efficiency of BC0035/-1200 V

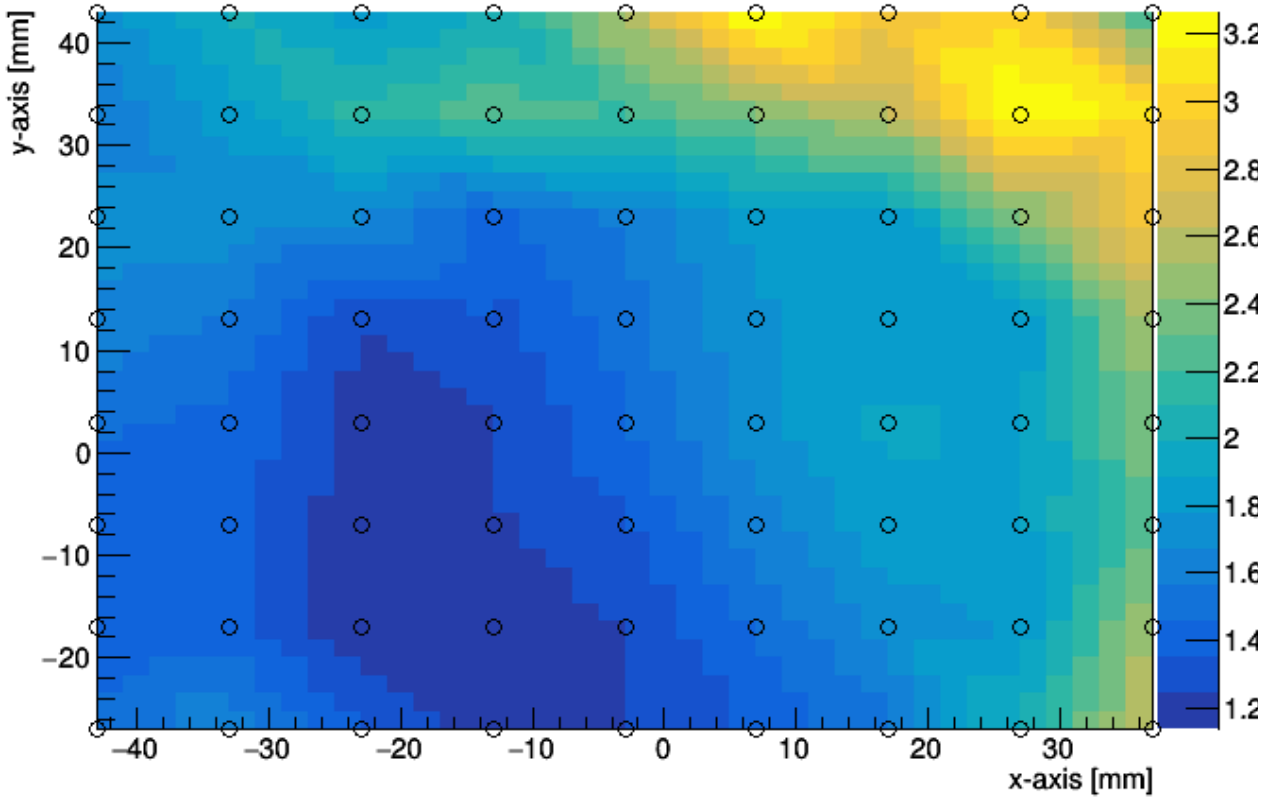
180° rotation



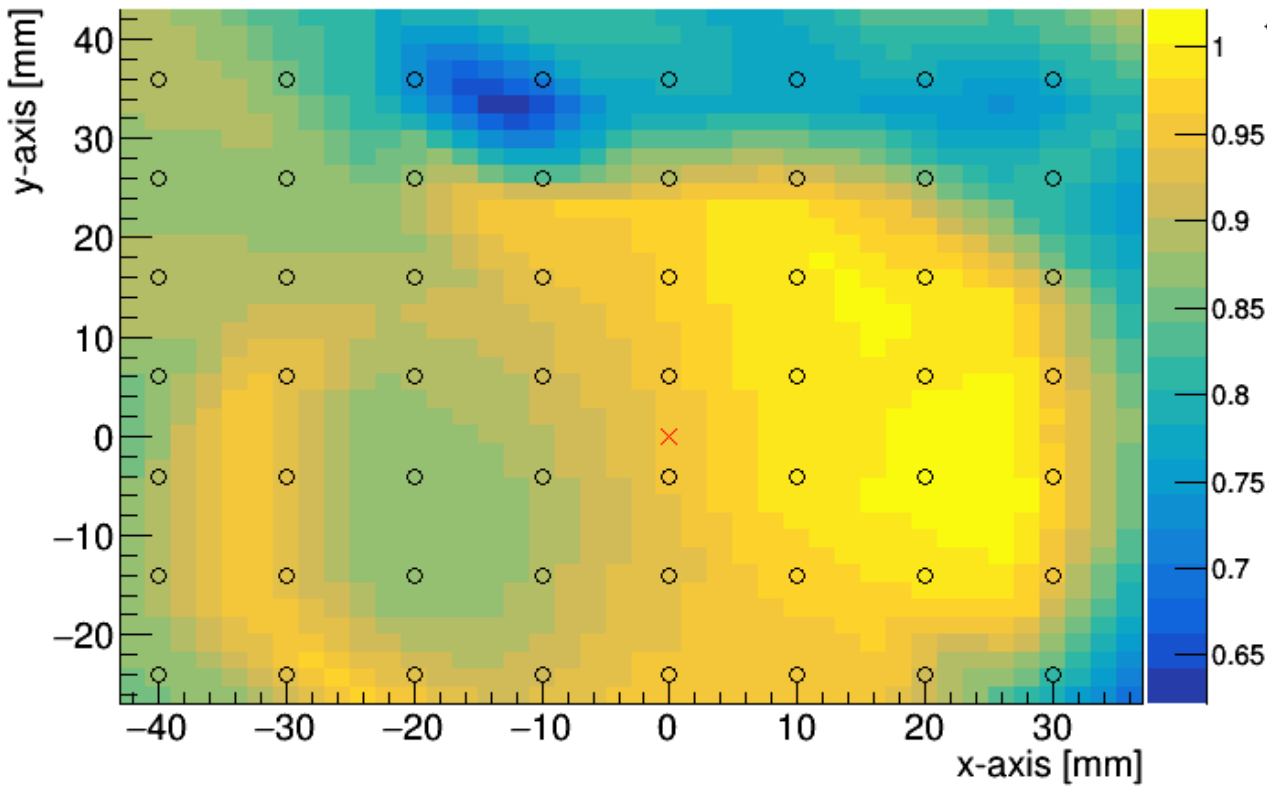


TTS and gain of BC0038/+1200 V

TTS

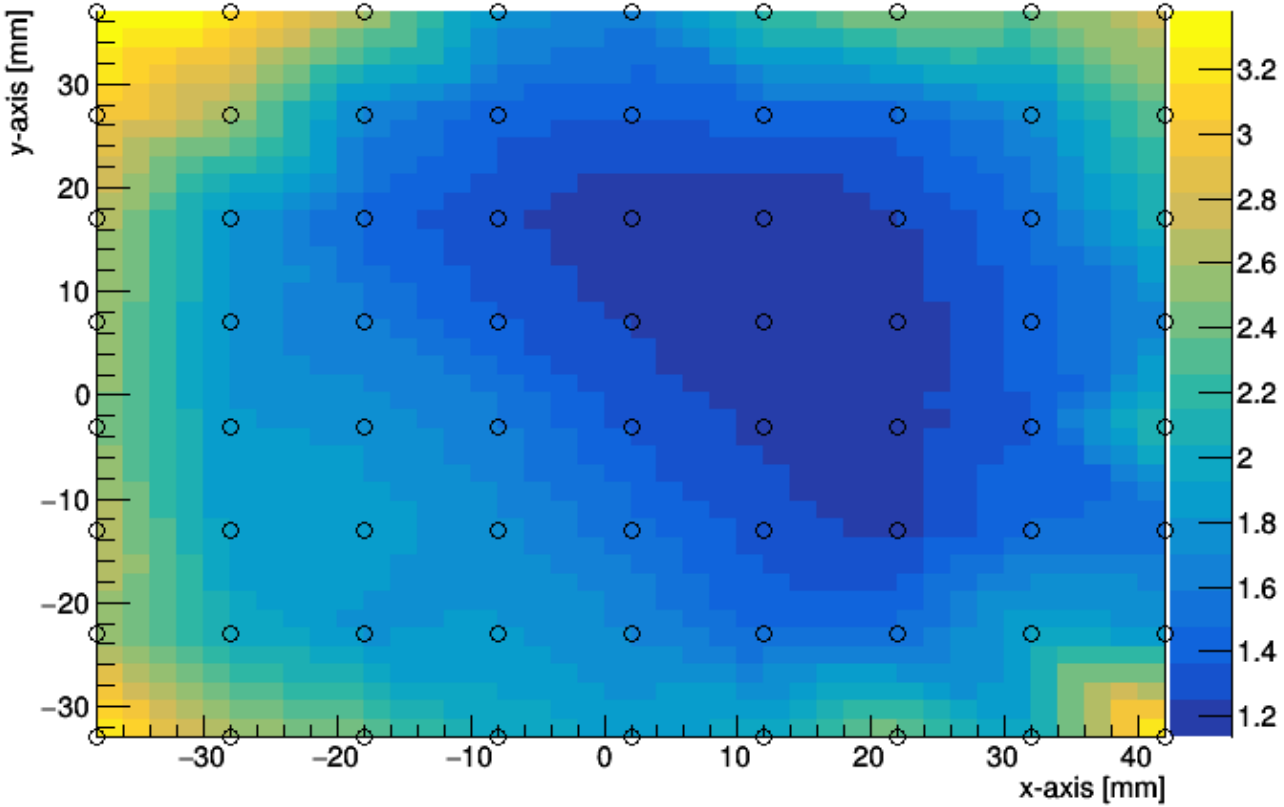


gain

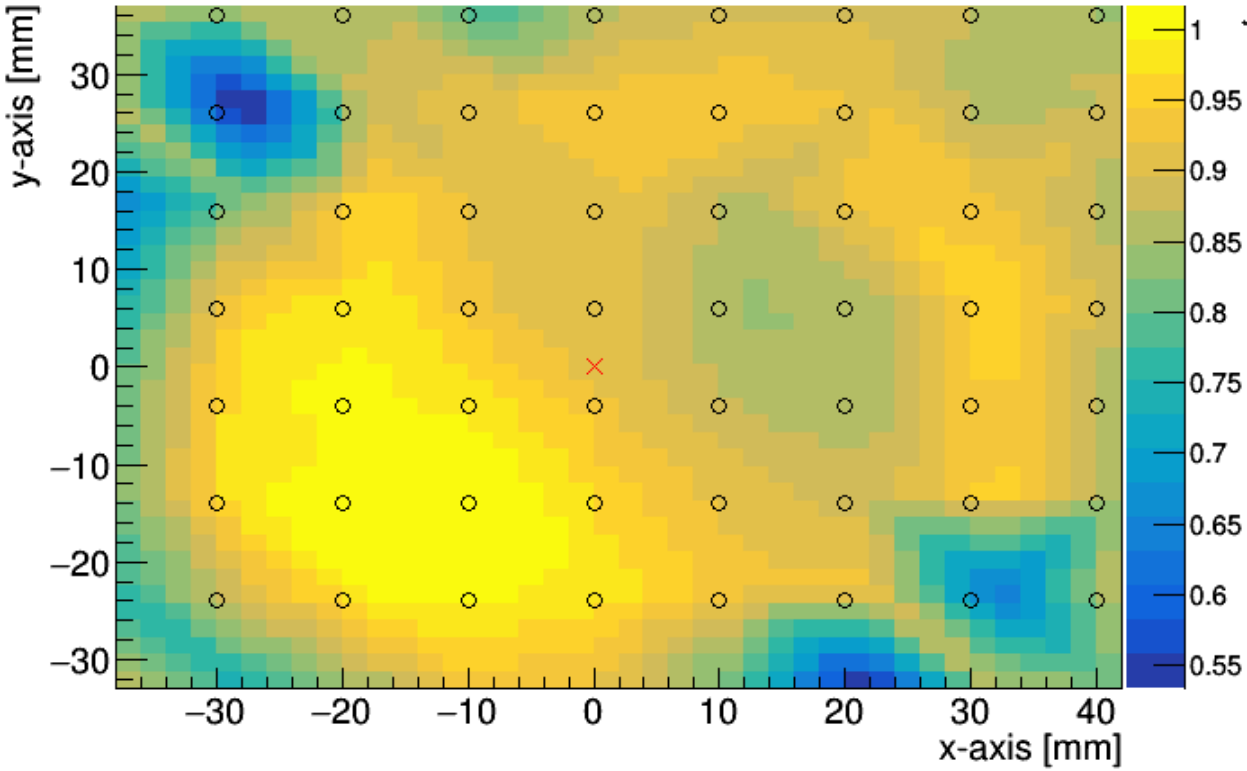


TTS and gain of BC0038/+1200 V

TTS

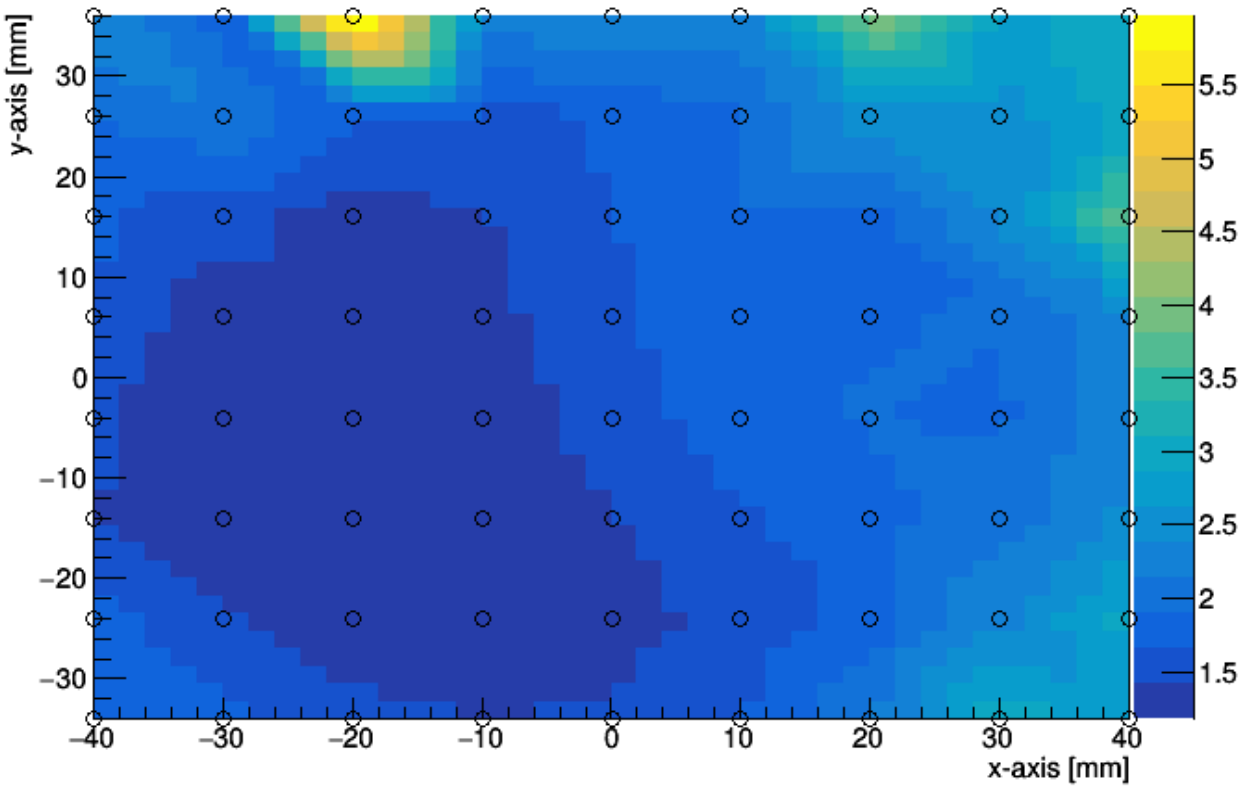


gain

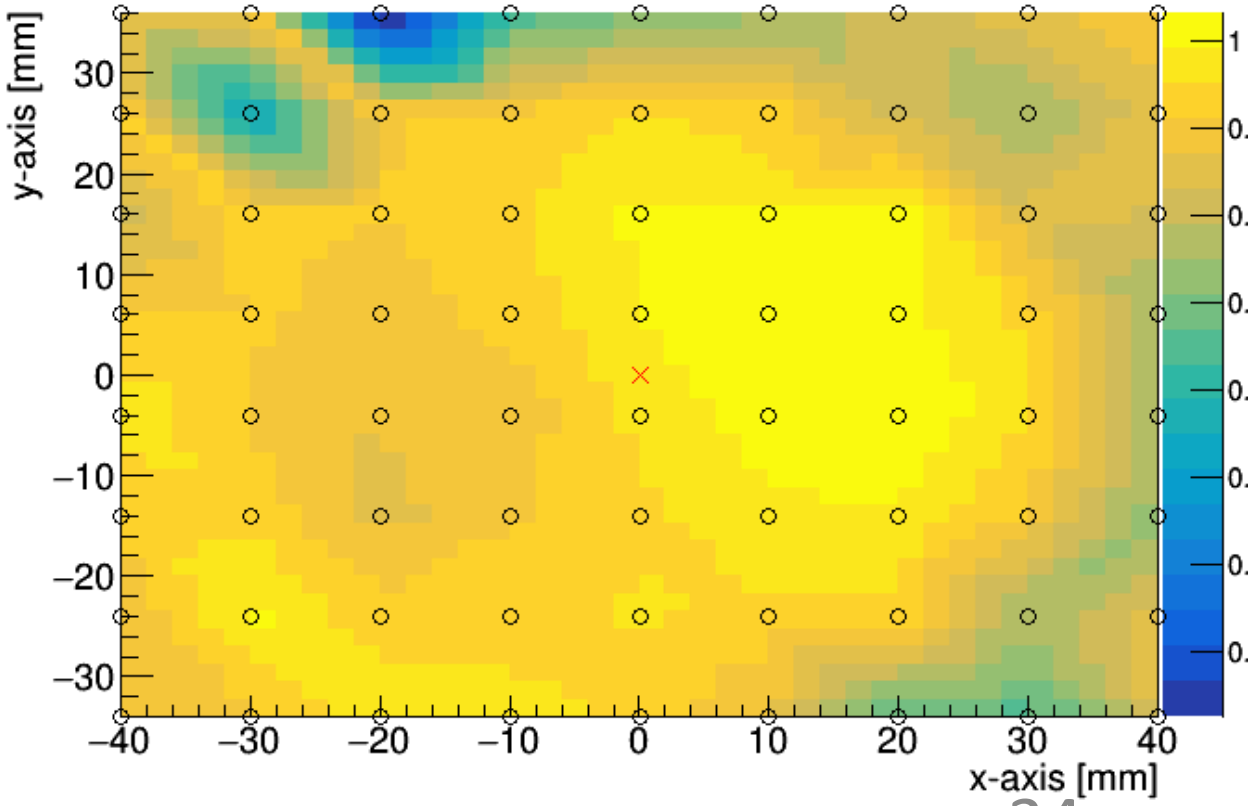


TTS and gain of BC0038/-1200 V

TTS

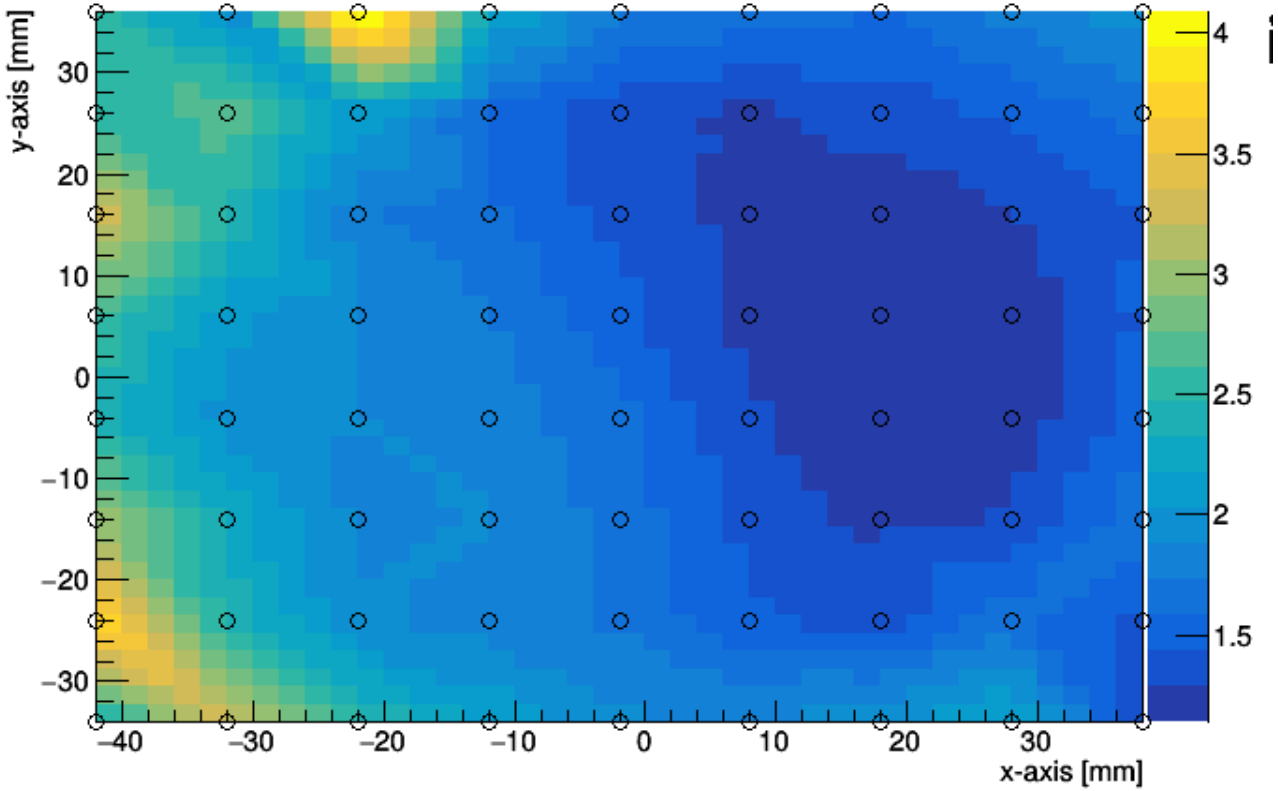


gain

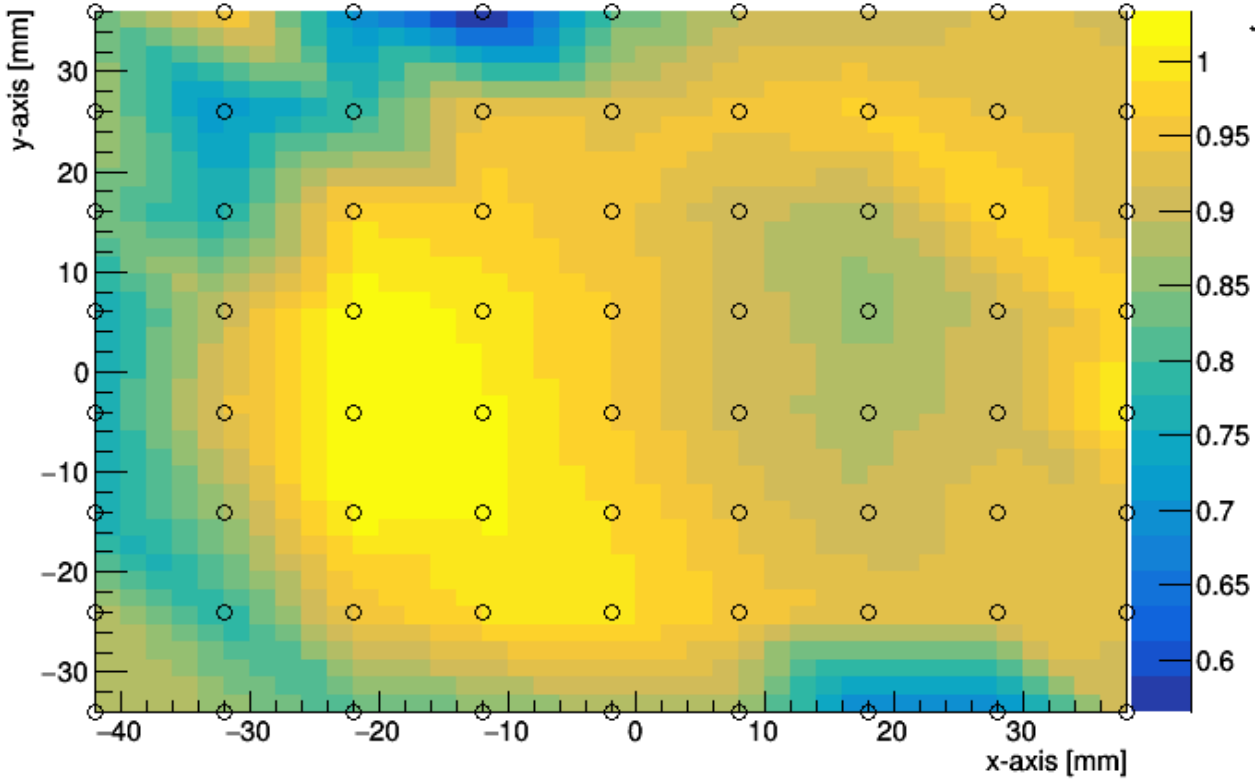


TTS and gain of BC0038/-1200 V

TTS

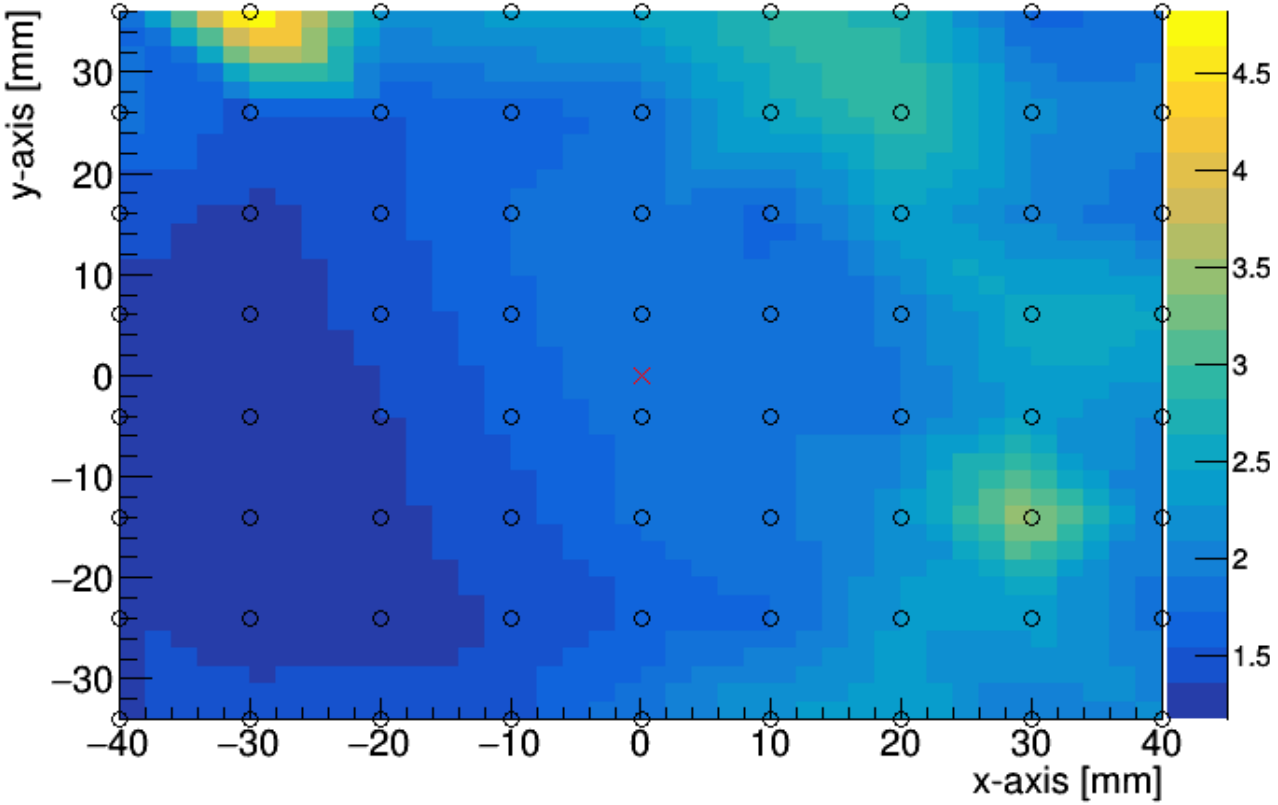


gain

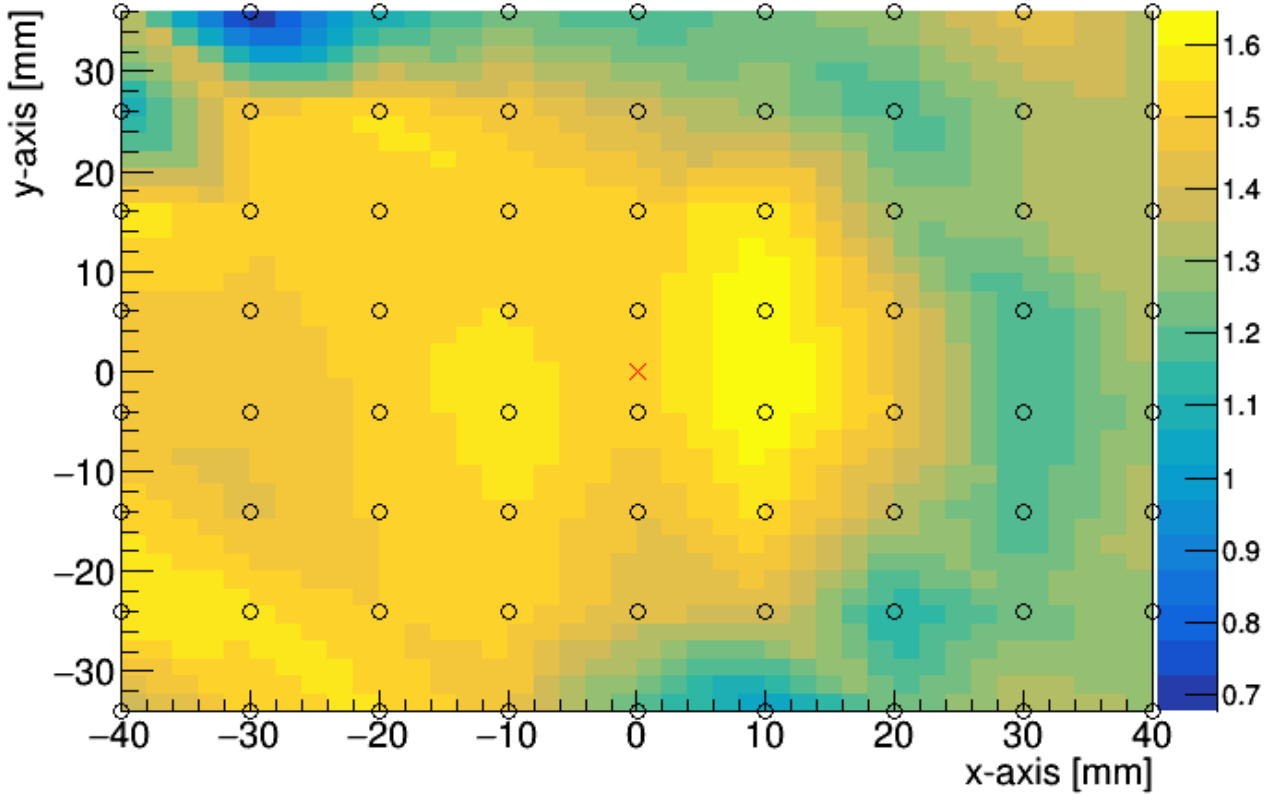


TTS and gain of BC0035/+1200 V

TTS

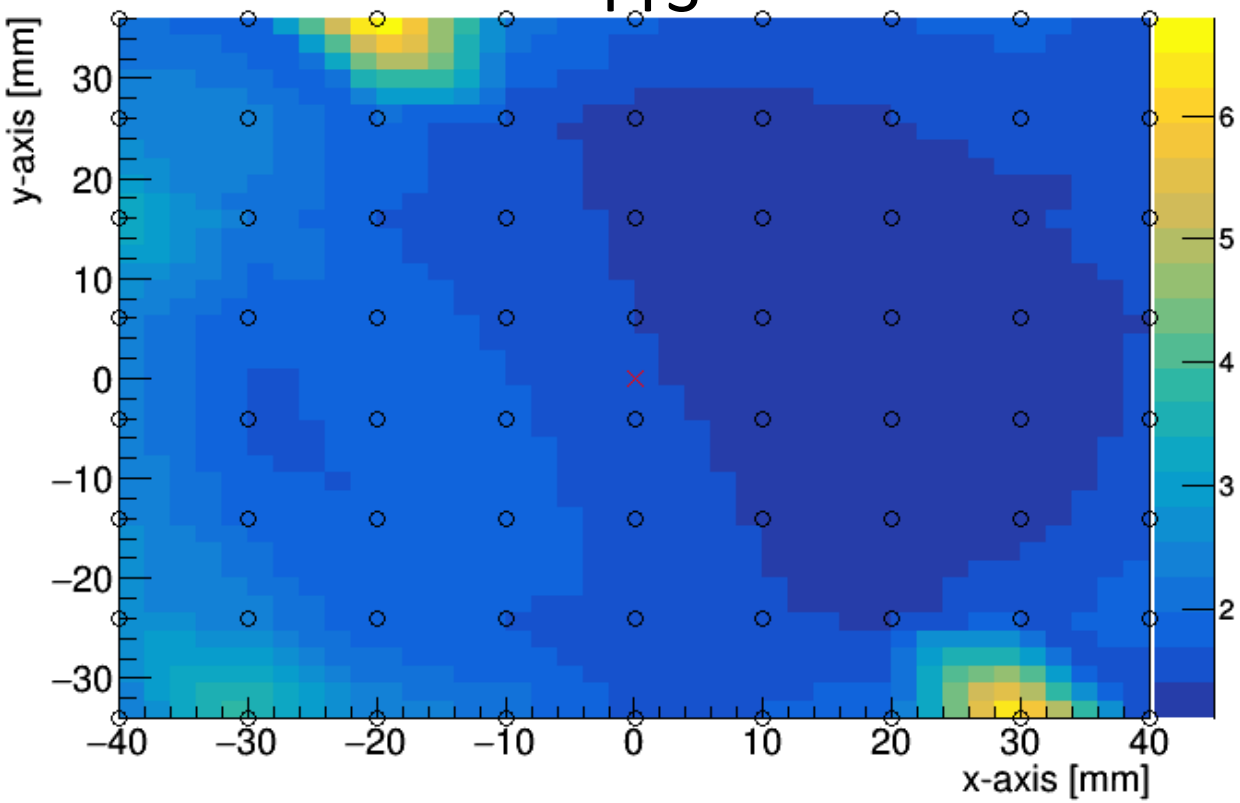


gain

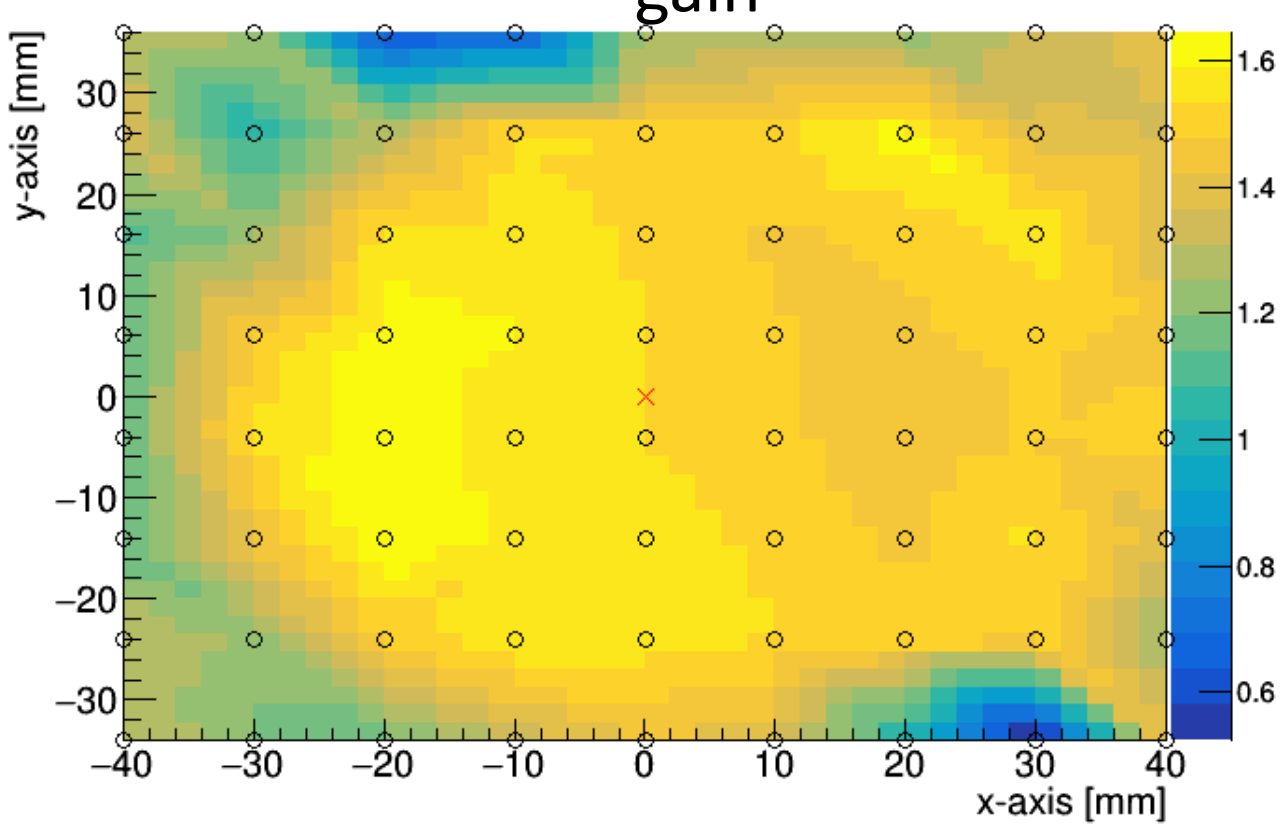


TTS and gain of BC0035/+1200 V

TTS

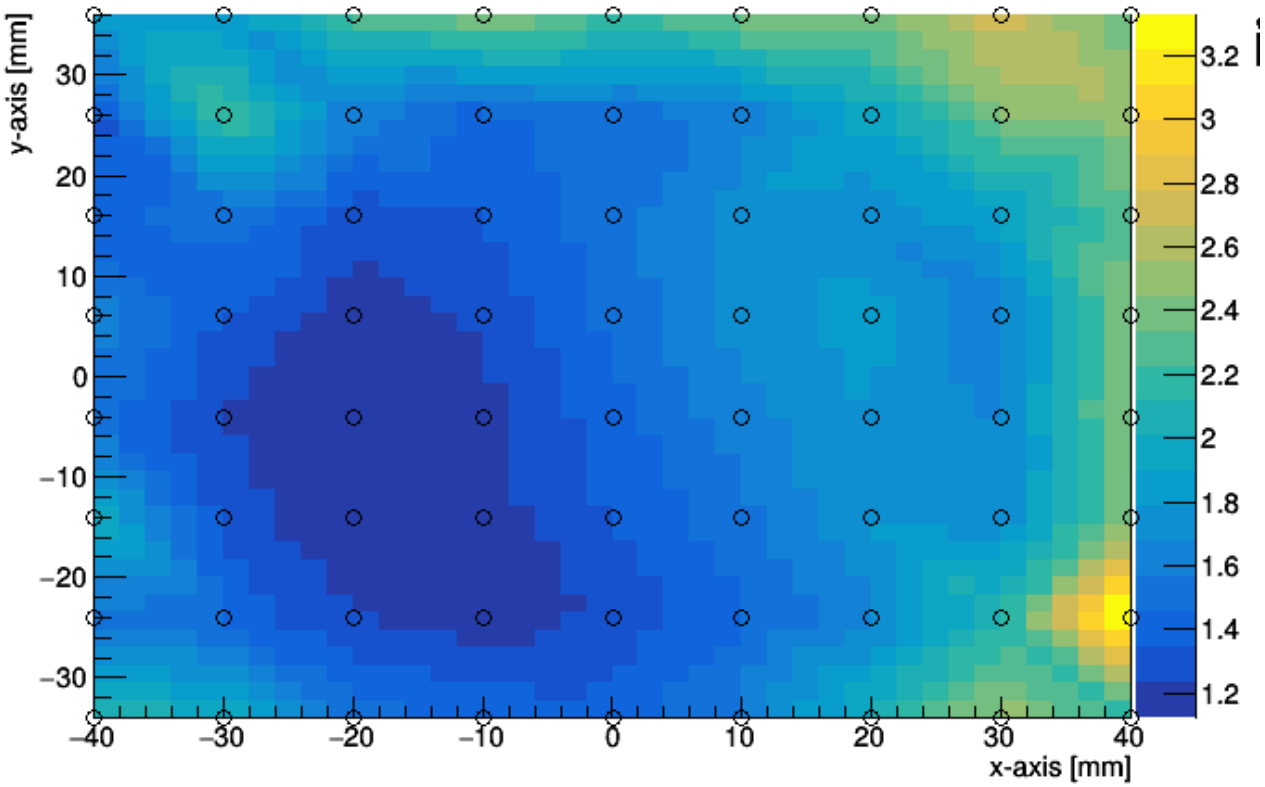


gain

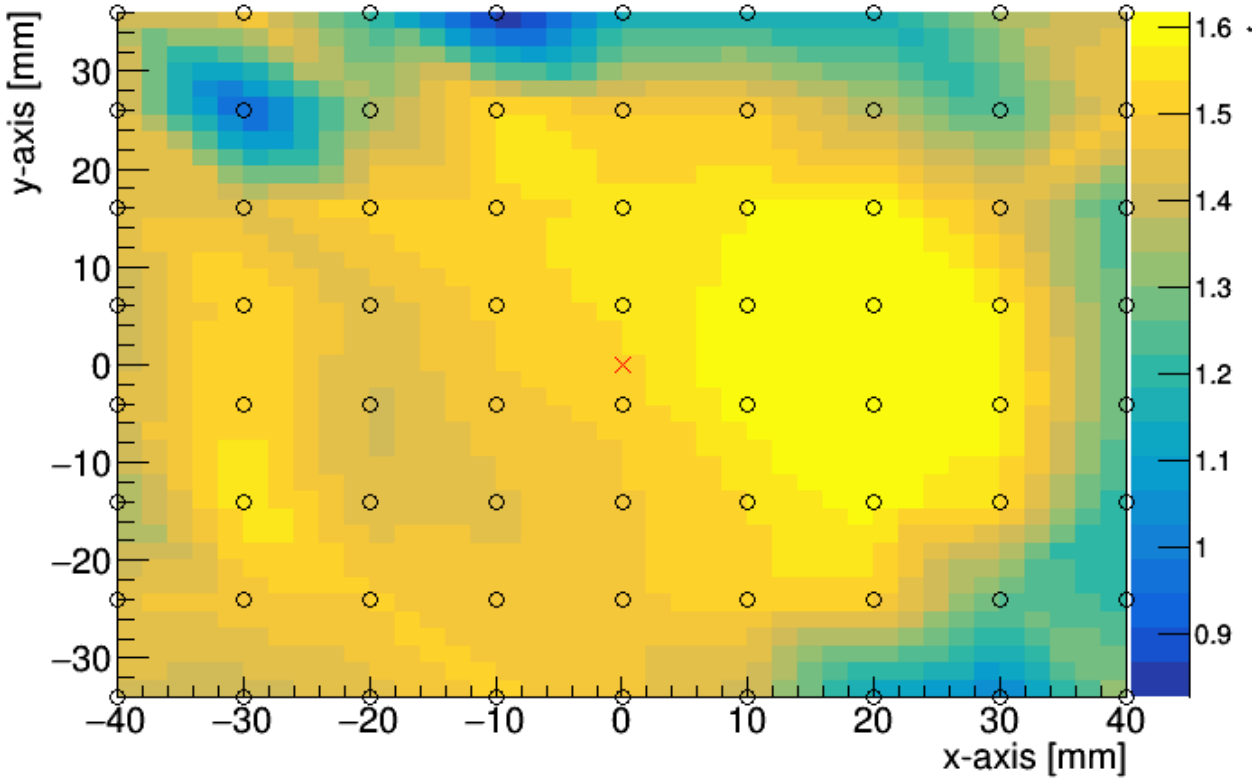


TTS and gain of BC0035/-1200 V

TTS

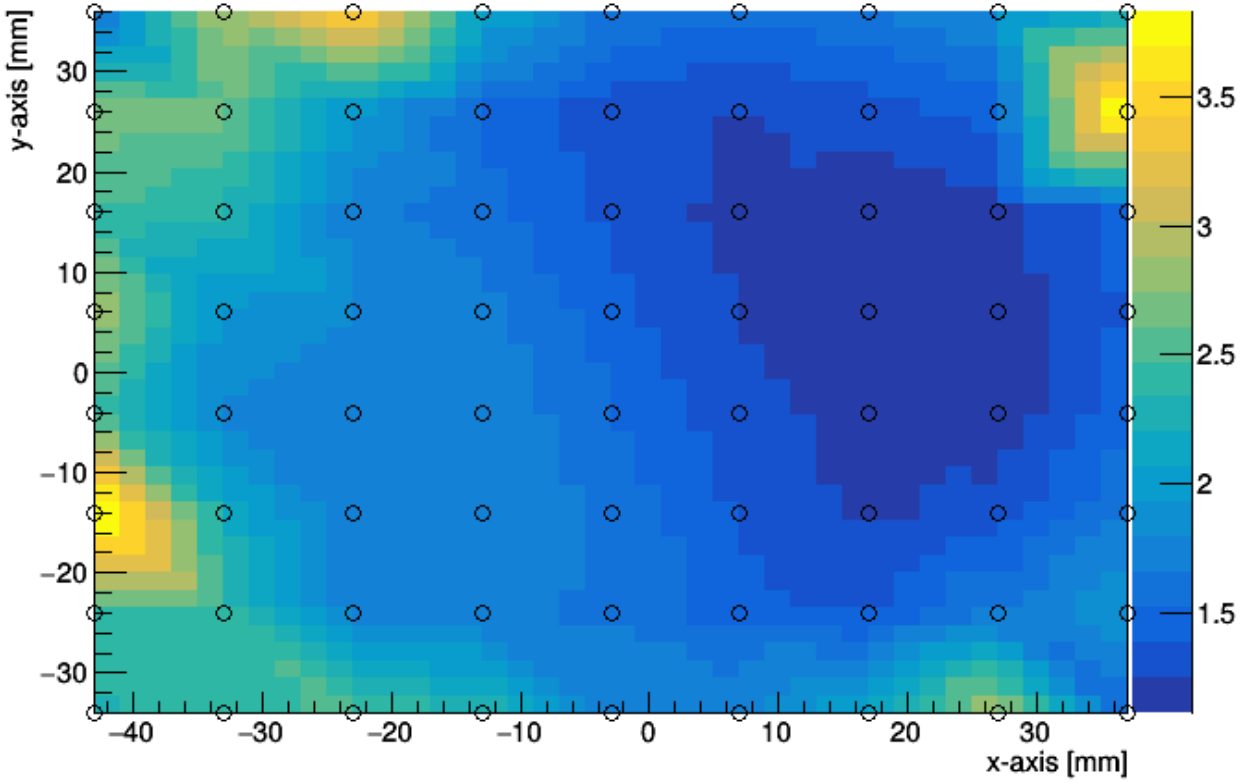


gain

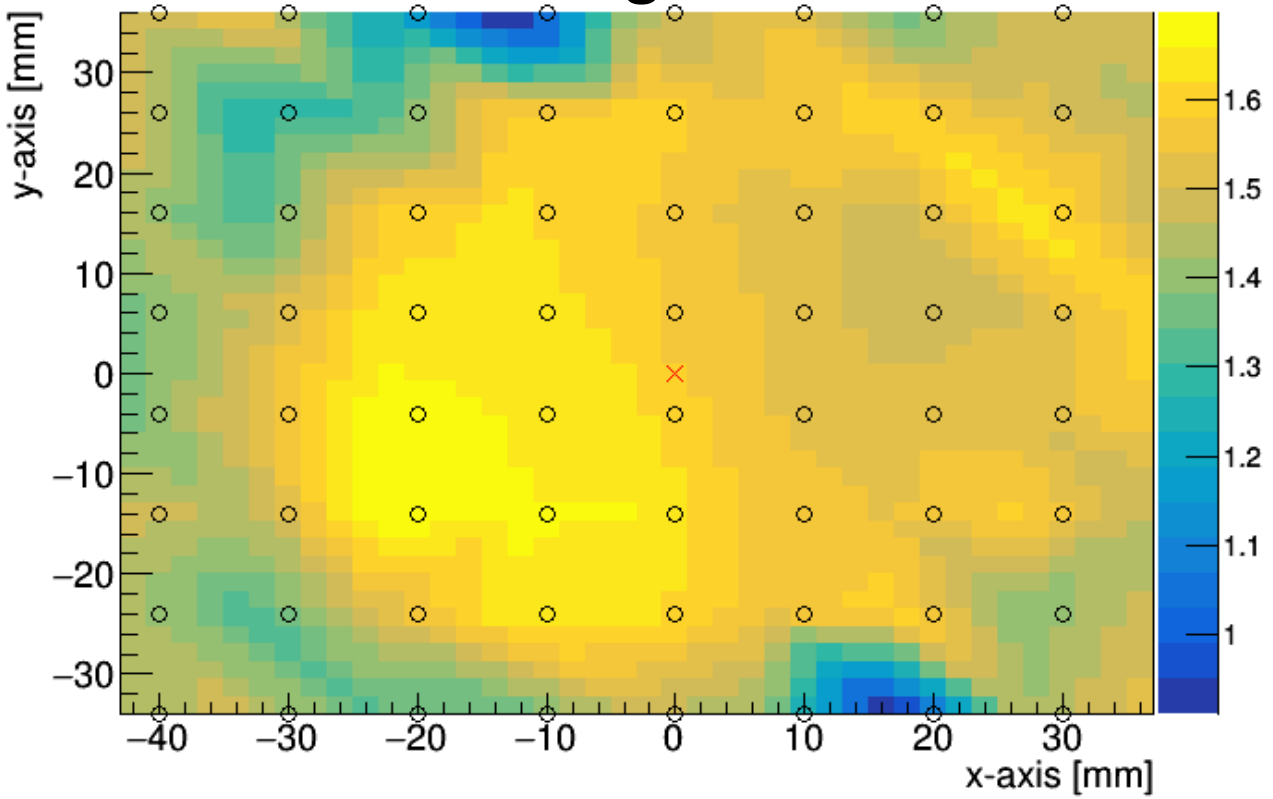


TTS and gain of BC0035/-1200 V

TTS



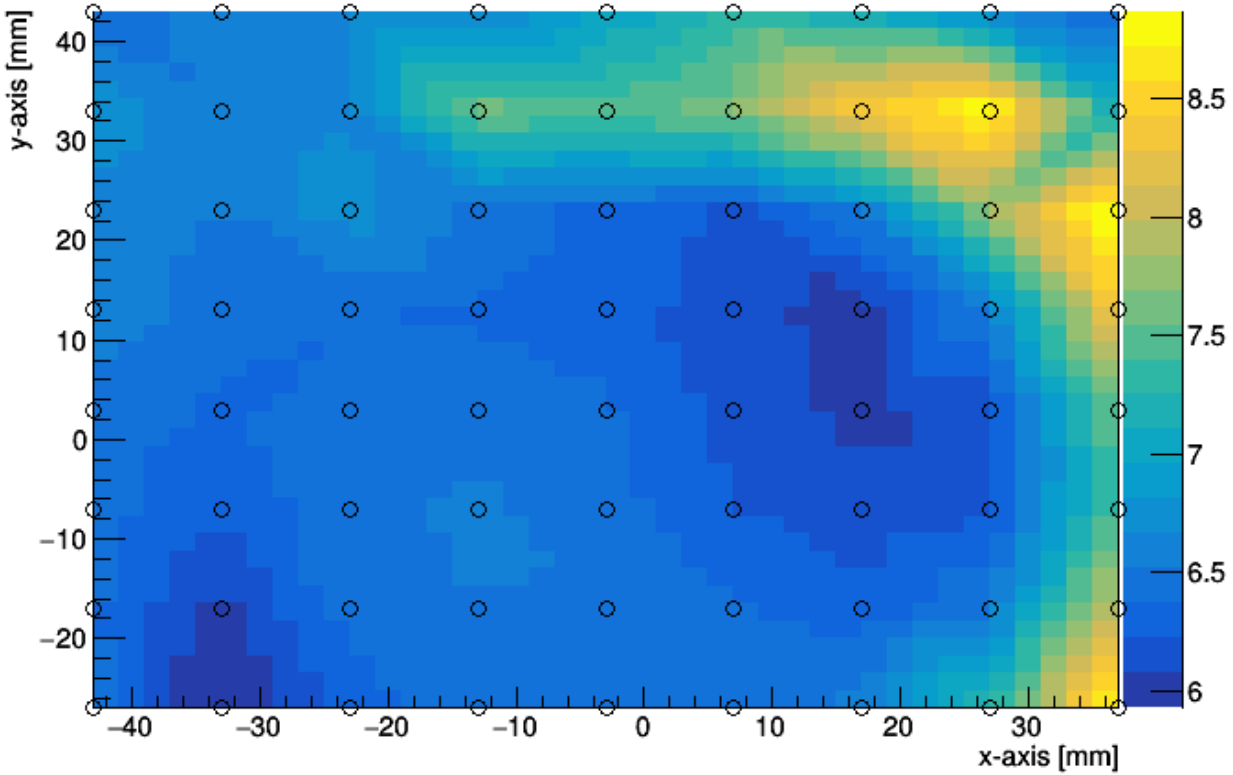
gain



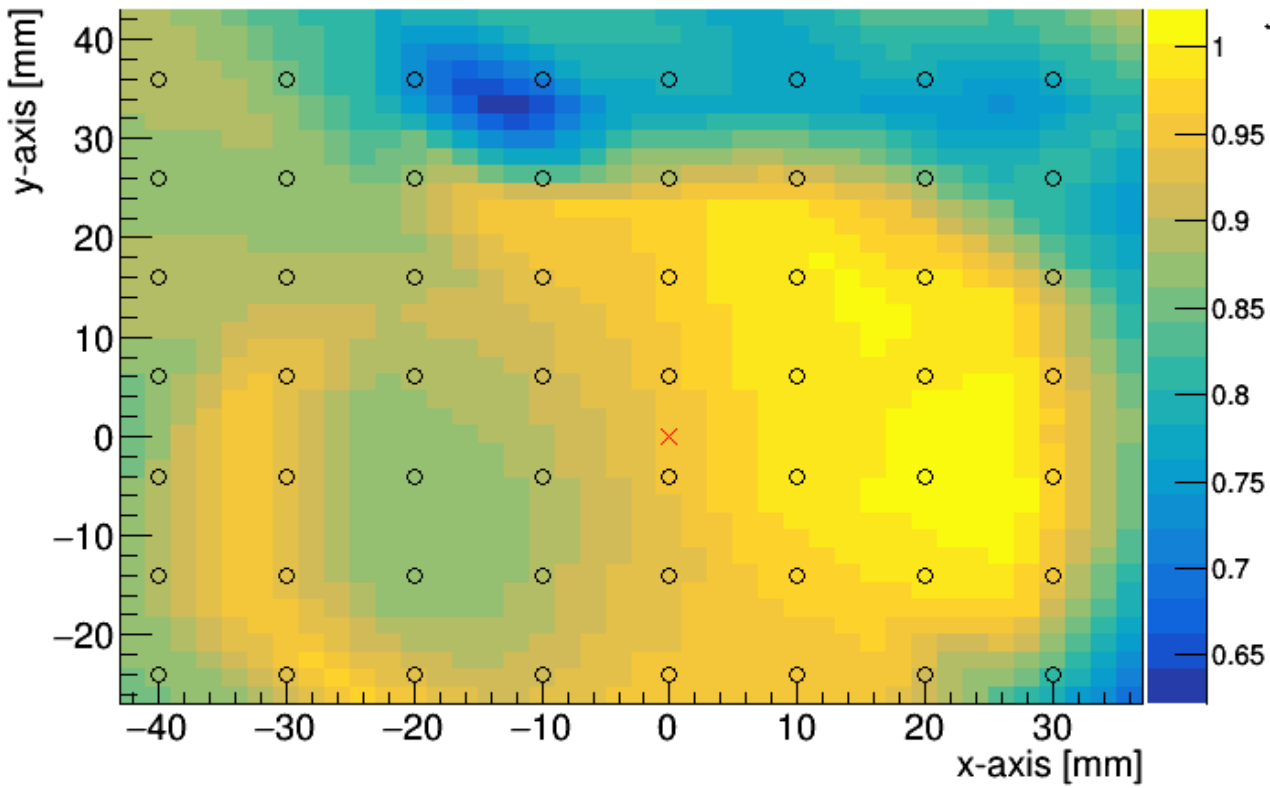
TT and gain

TT and gain of BC0038/+1200 V

TTS

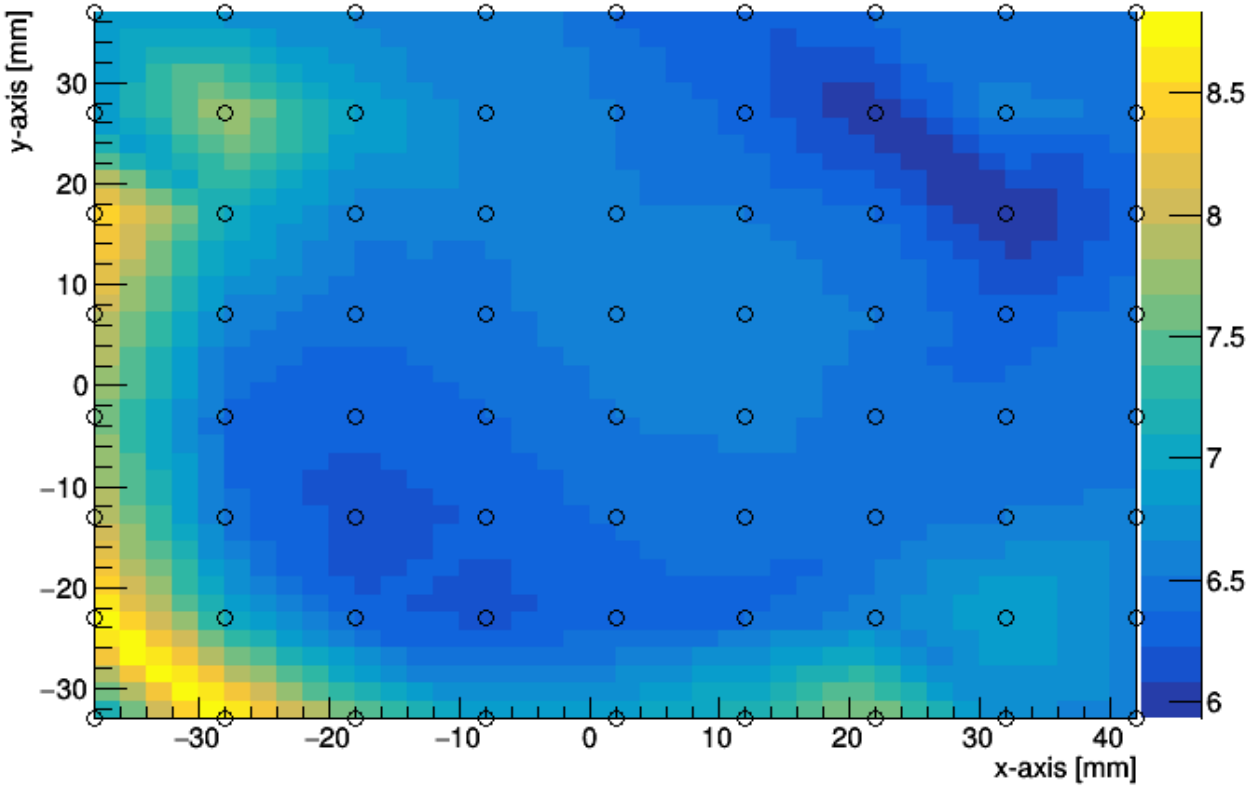


gain

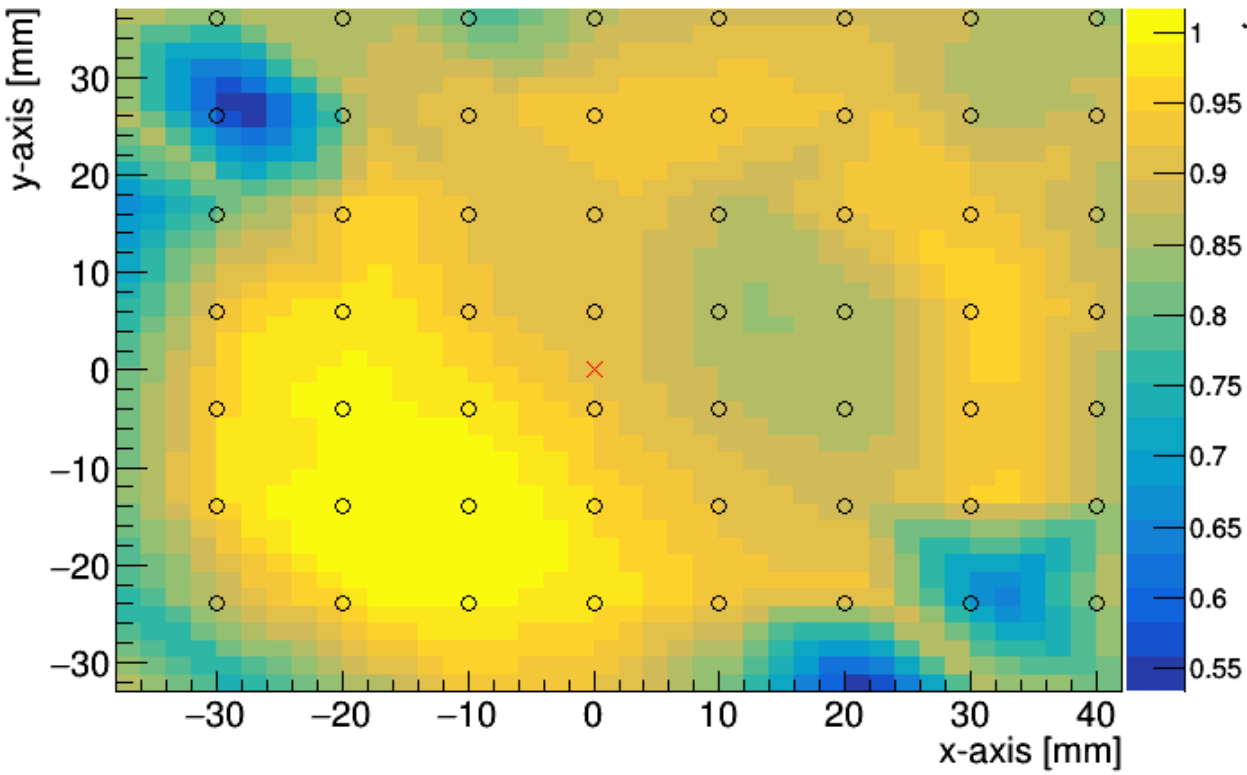


TT and gain of BC0038/+1200 V

TT

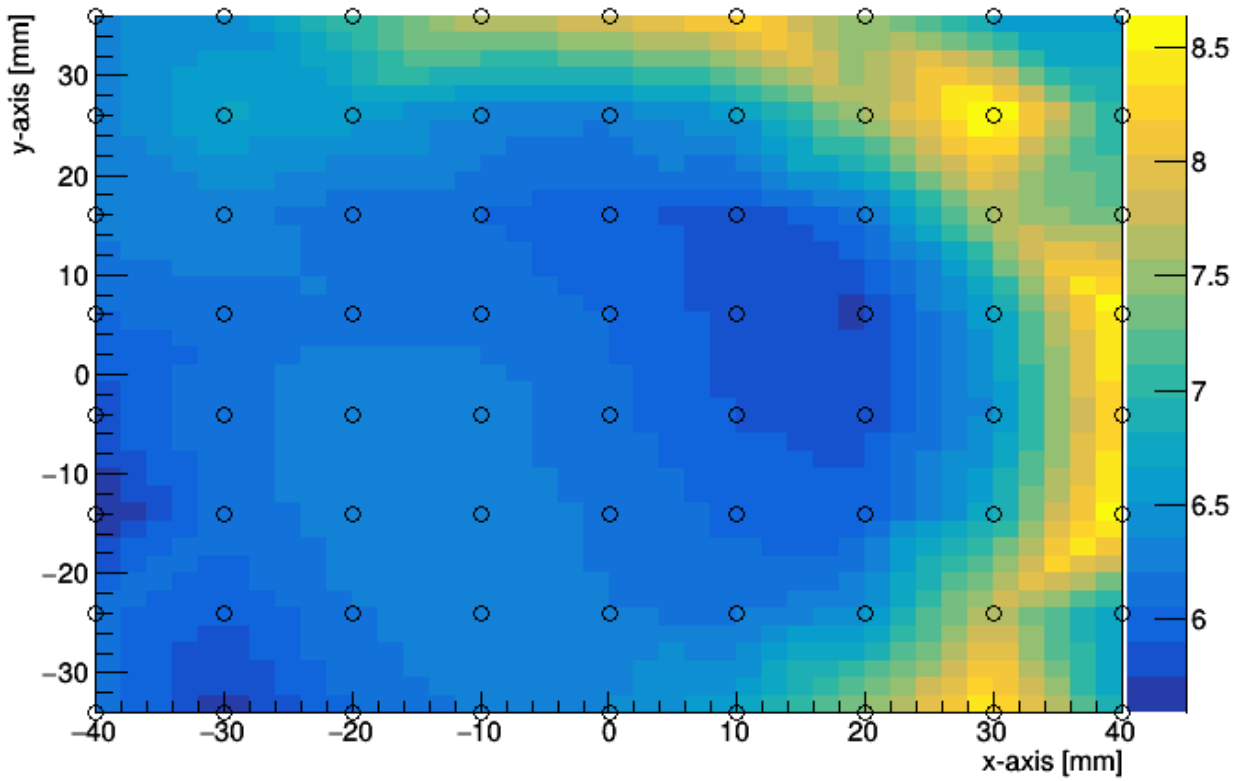


gain

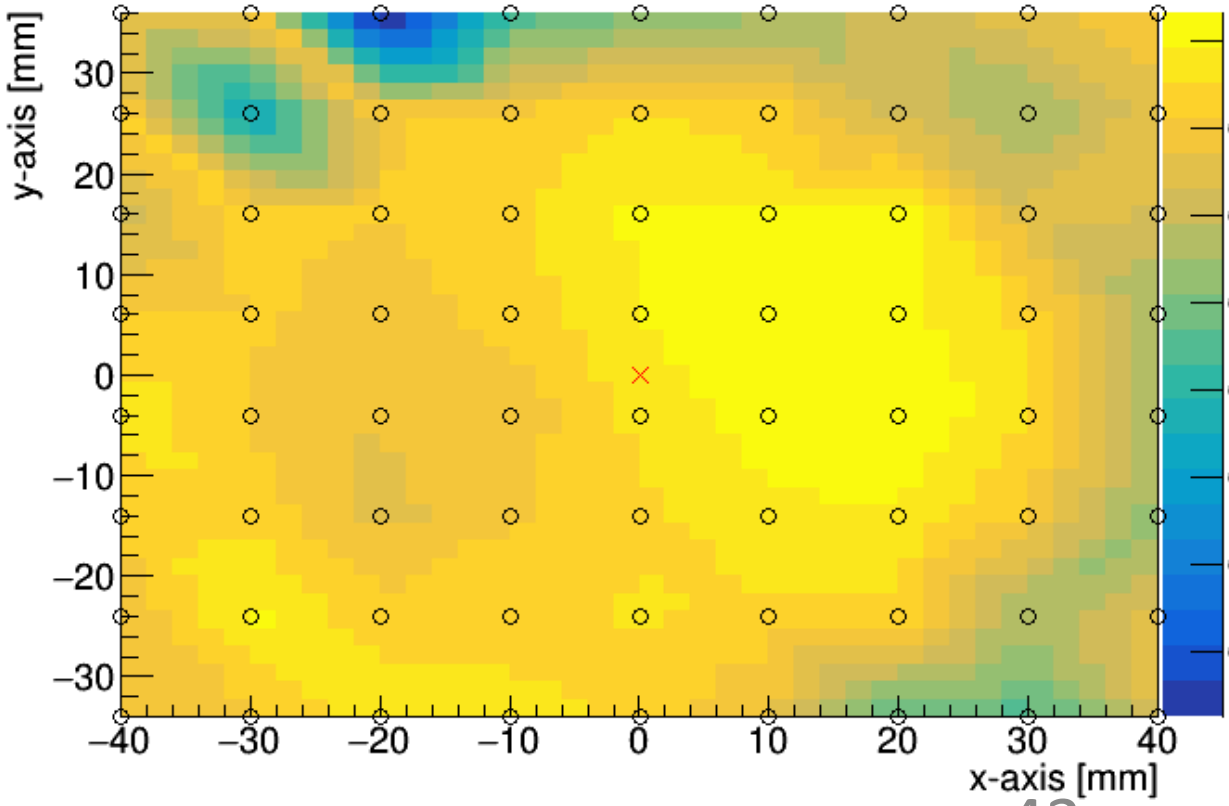


TT and gain of BC0038/-1200 V

TT

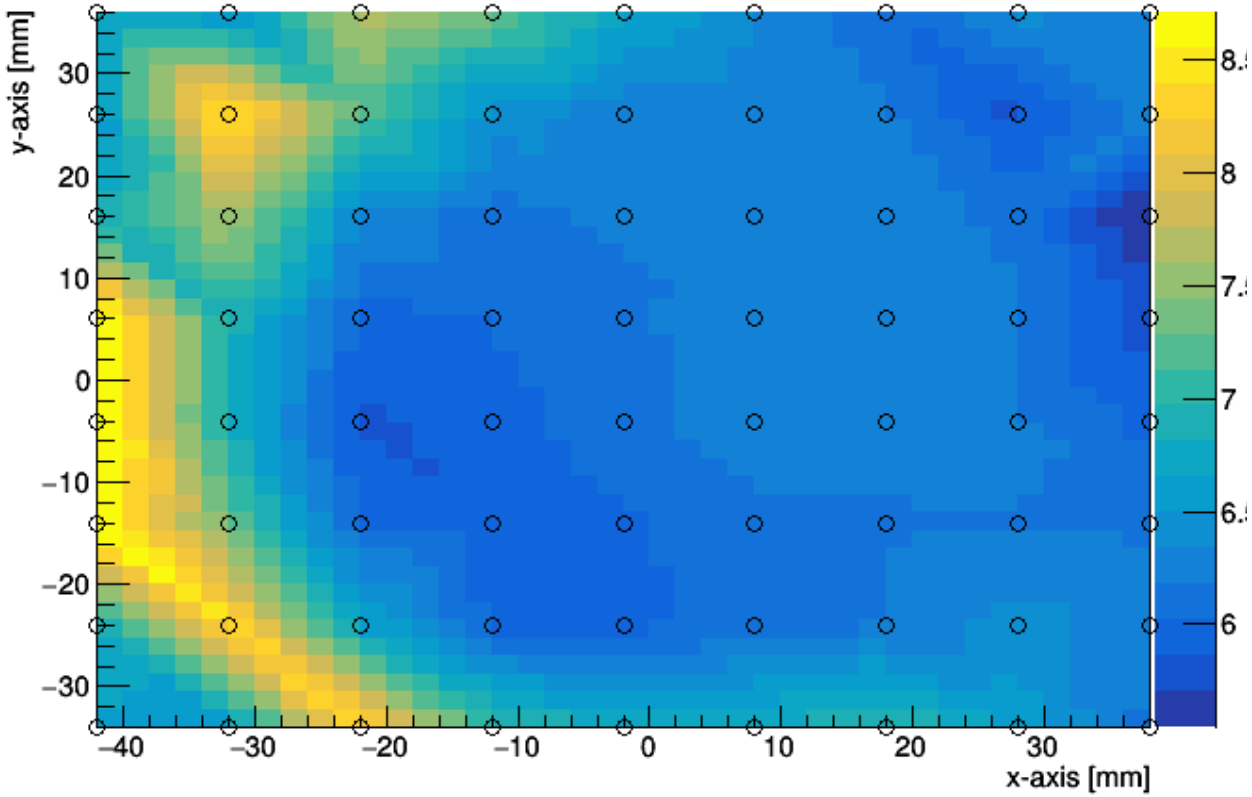


gain

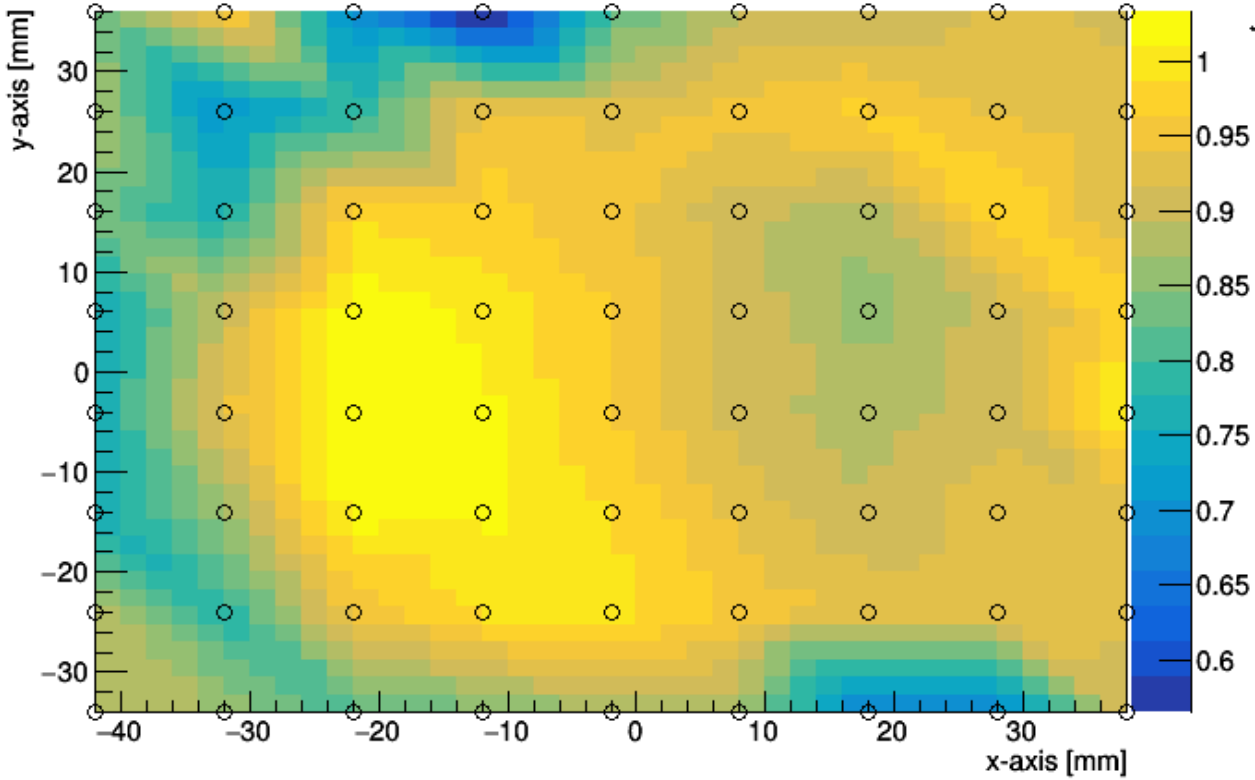


TT and gain of BC0038/-1200 V

TT

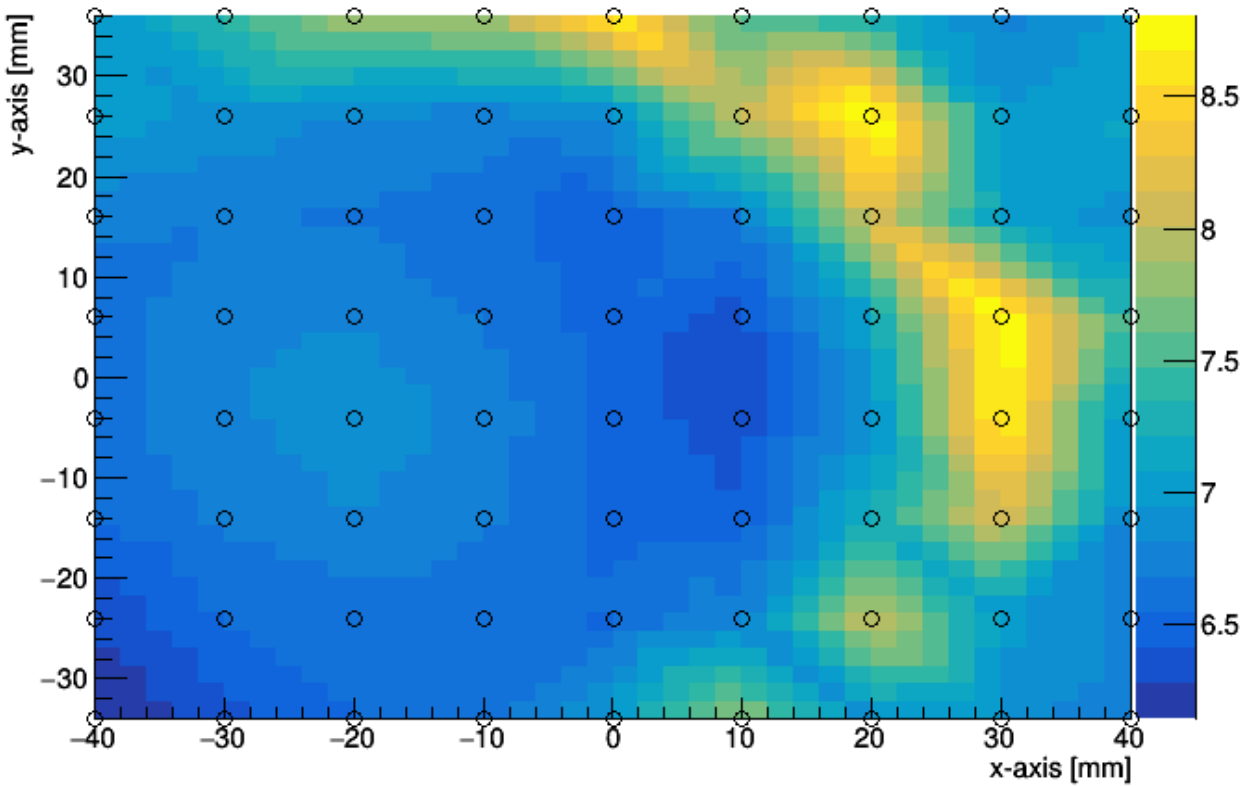


gain

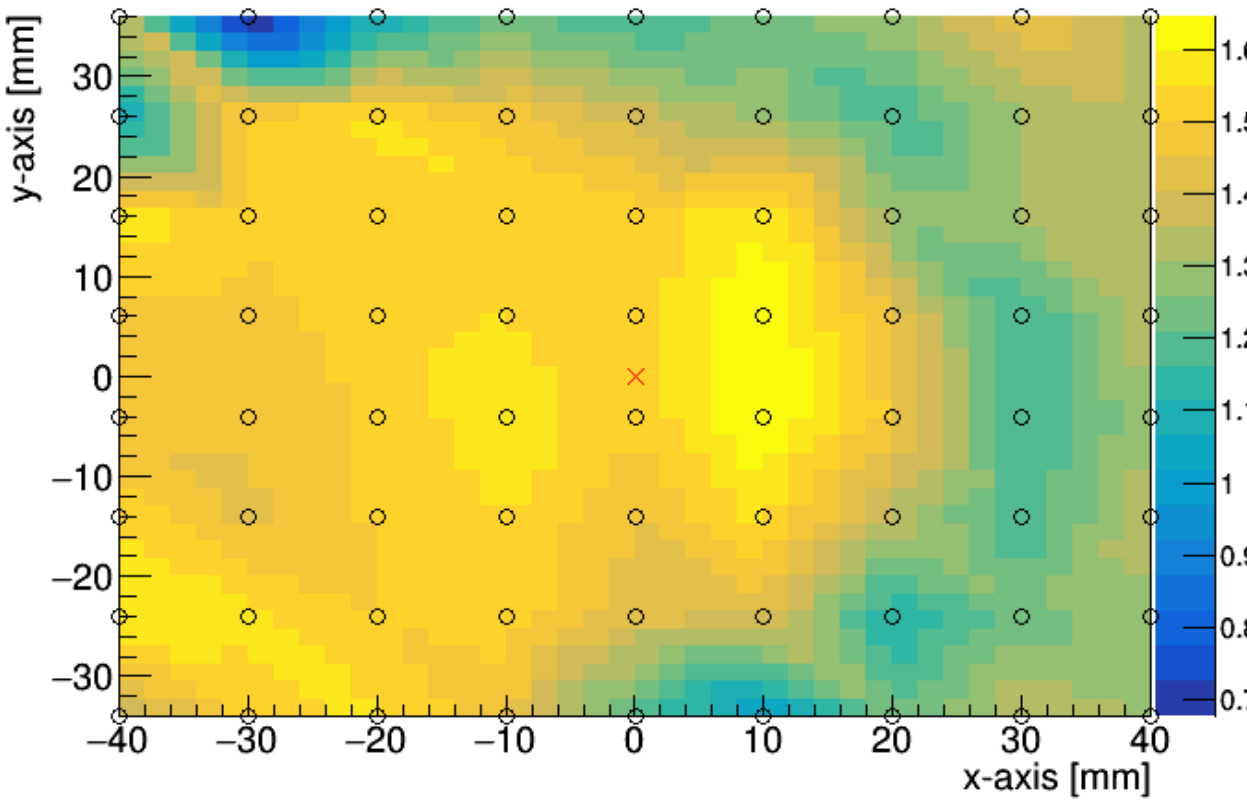


TT and gain of BC0035/+1200 V

TT

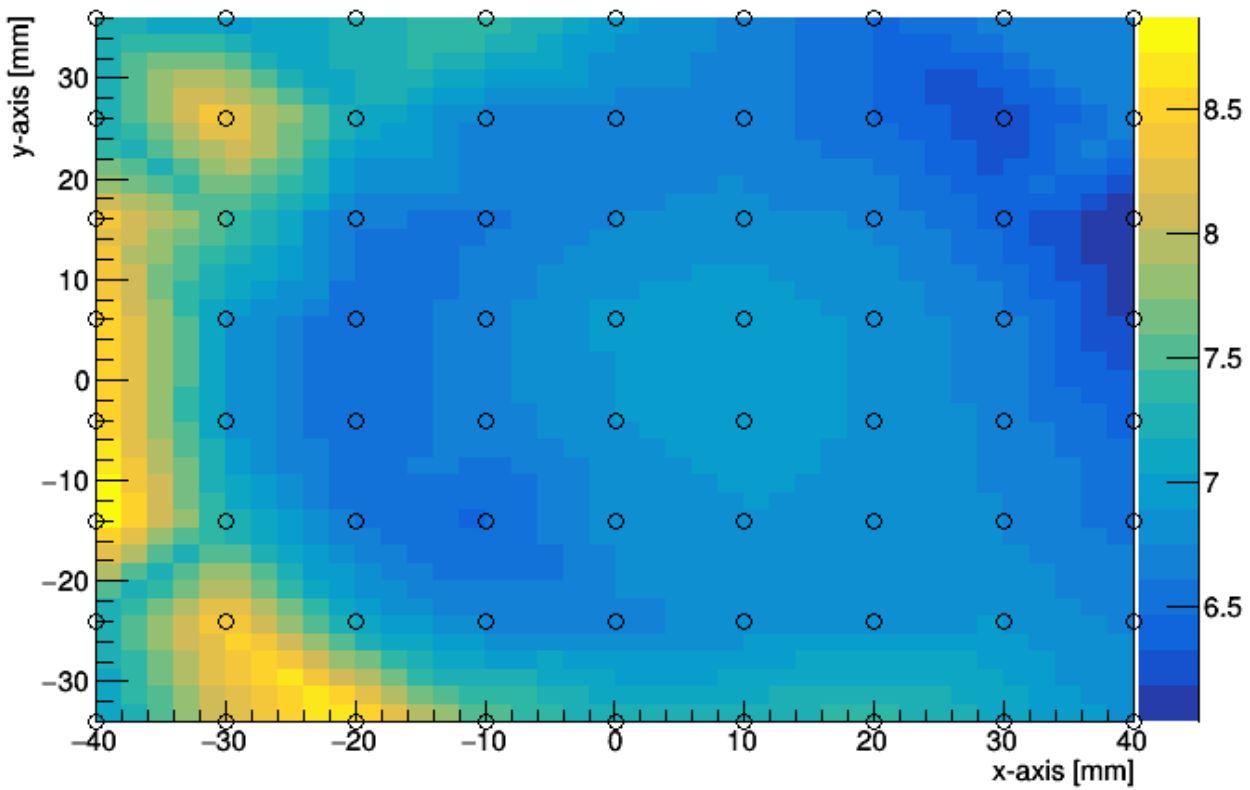


gain

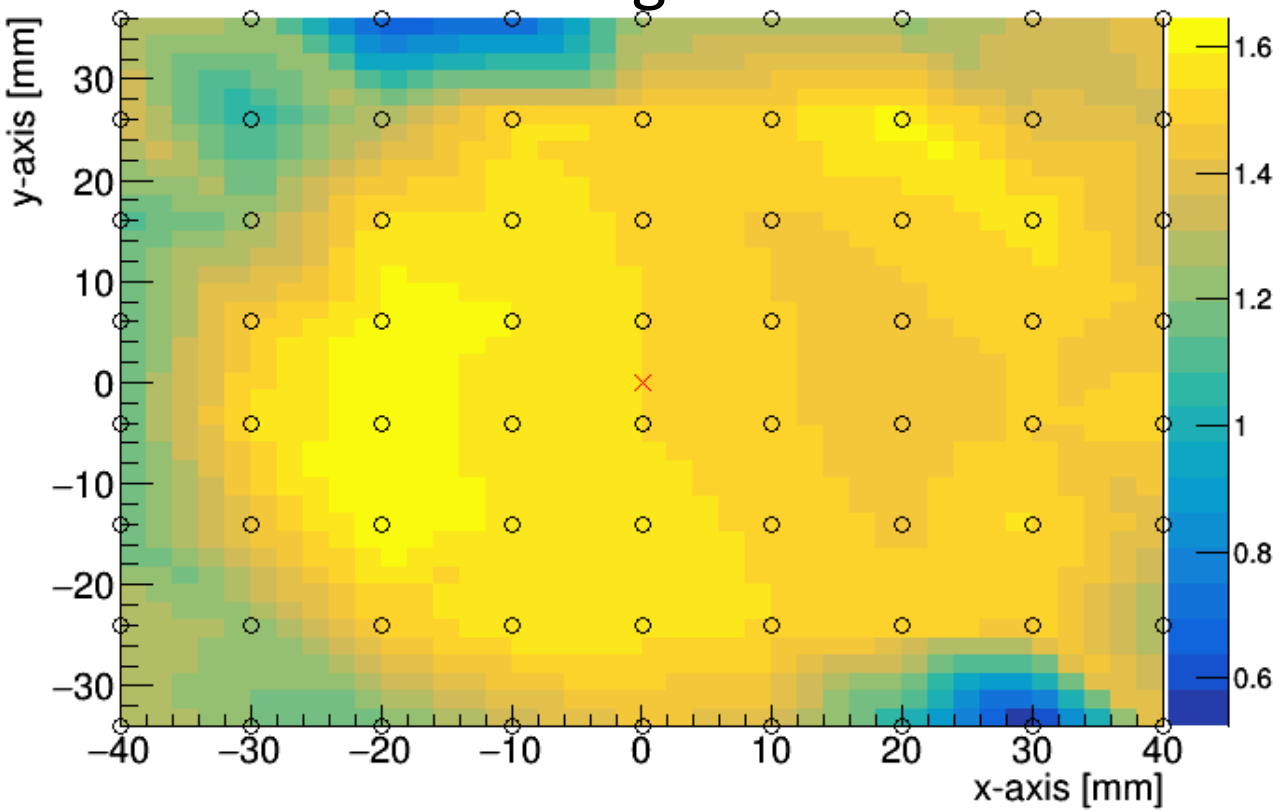


TT and gain of BC0035/+1200 V

TT

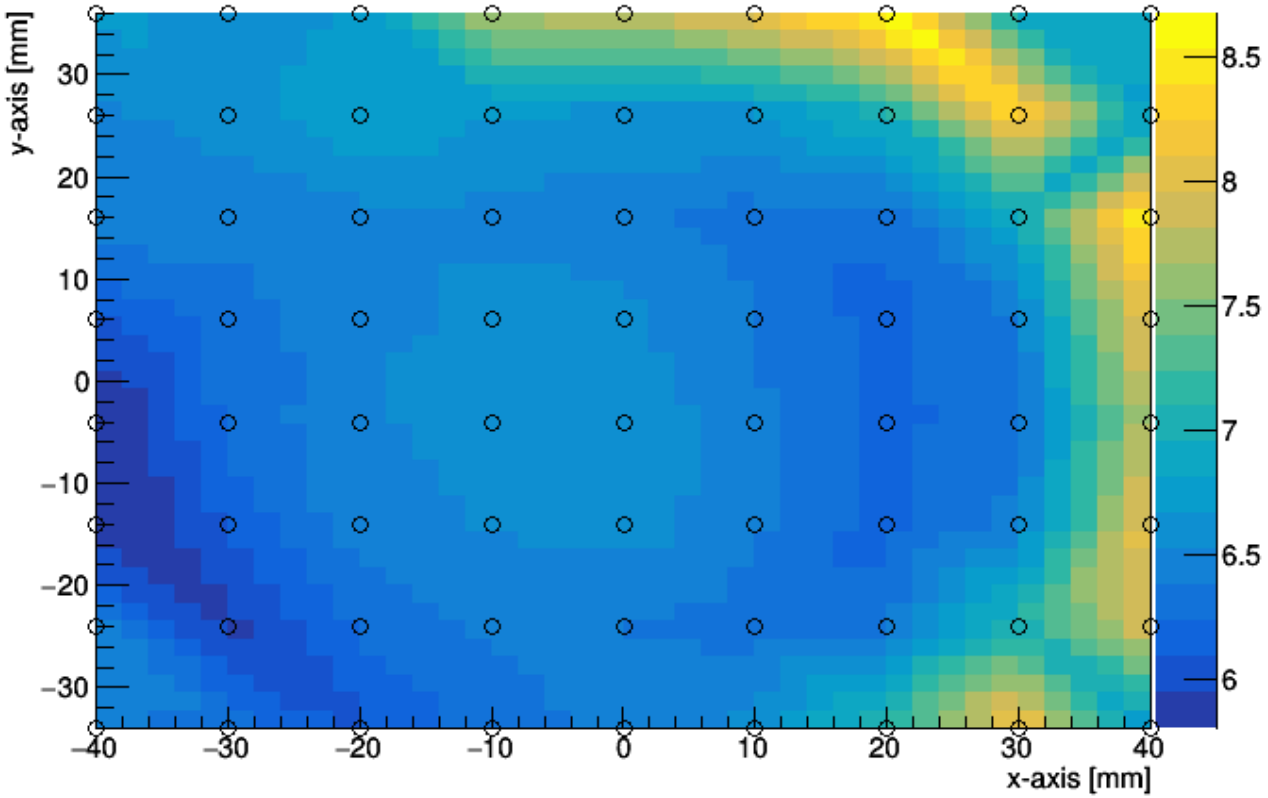


gain

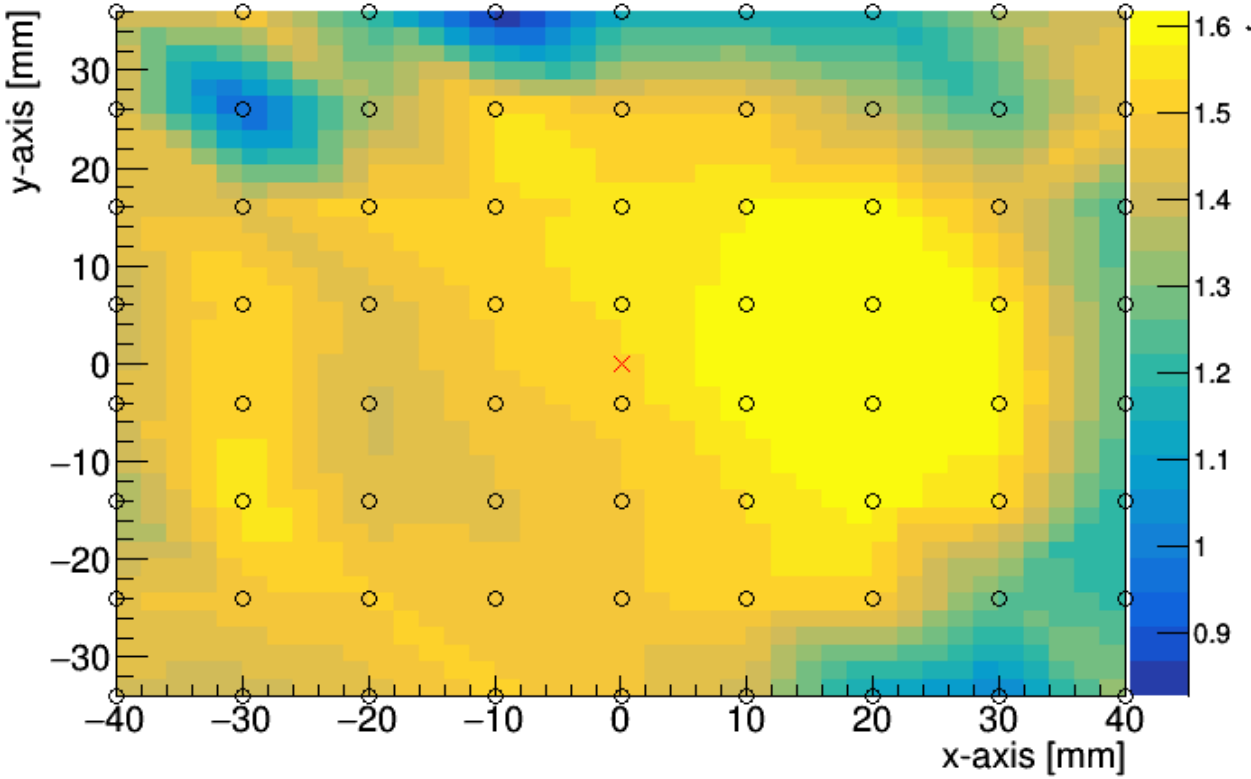


TT and gain of BC0035/-1200 V

TT

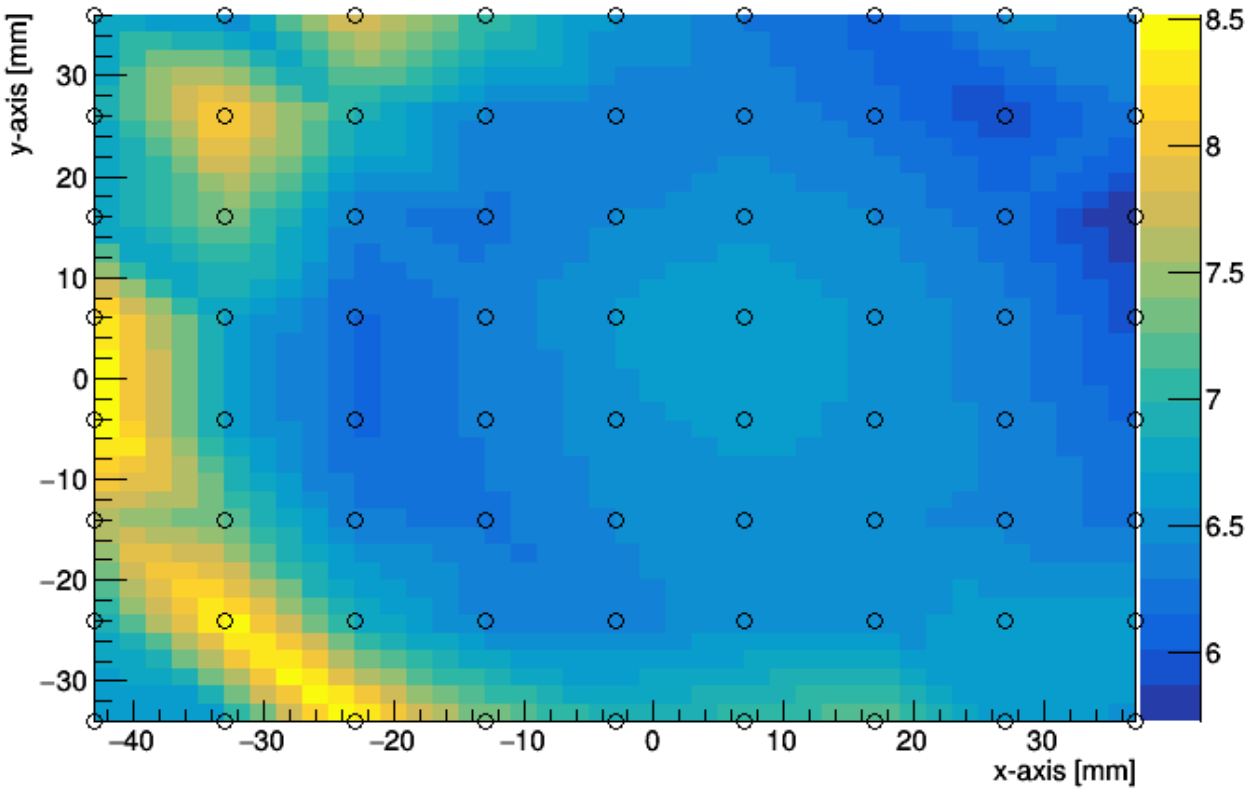


gain

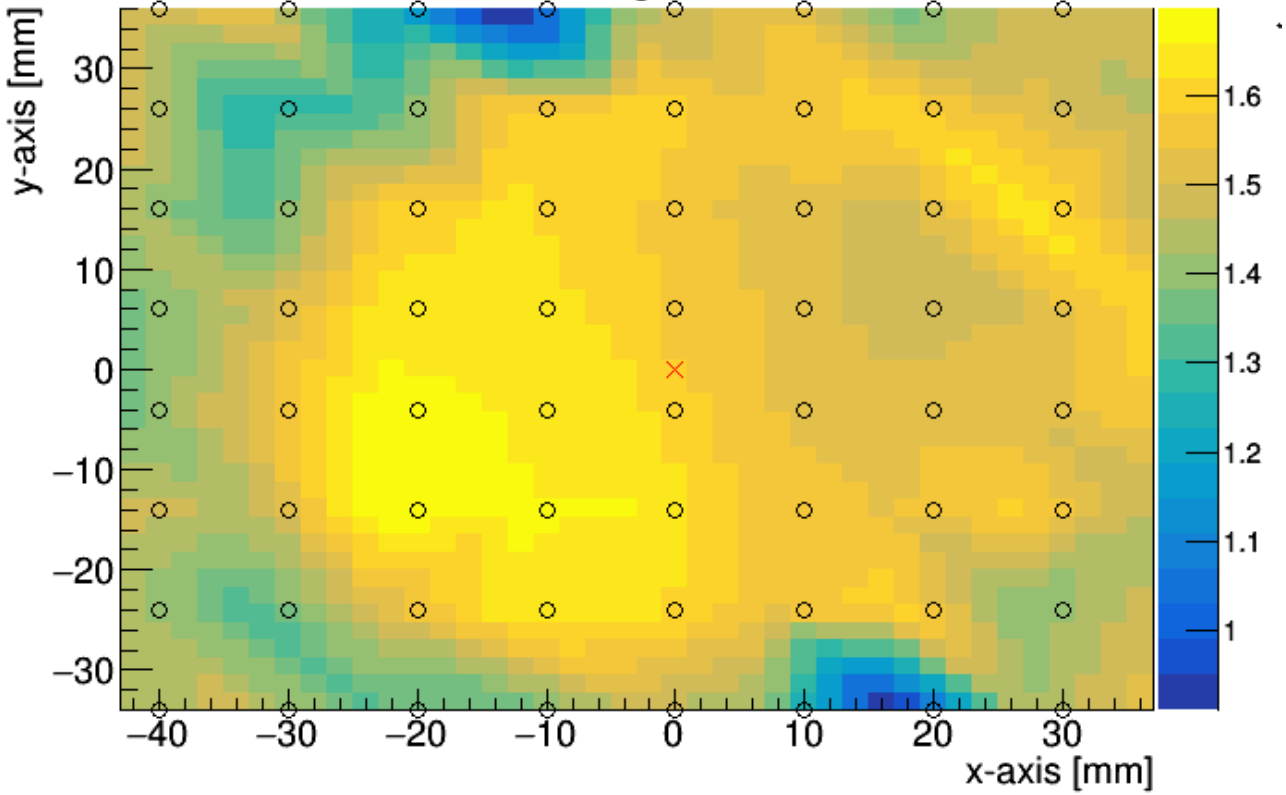


TT and gain of BC0035/-1200 V

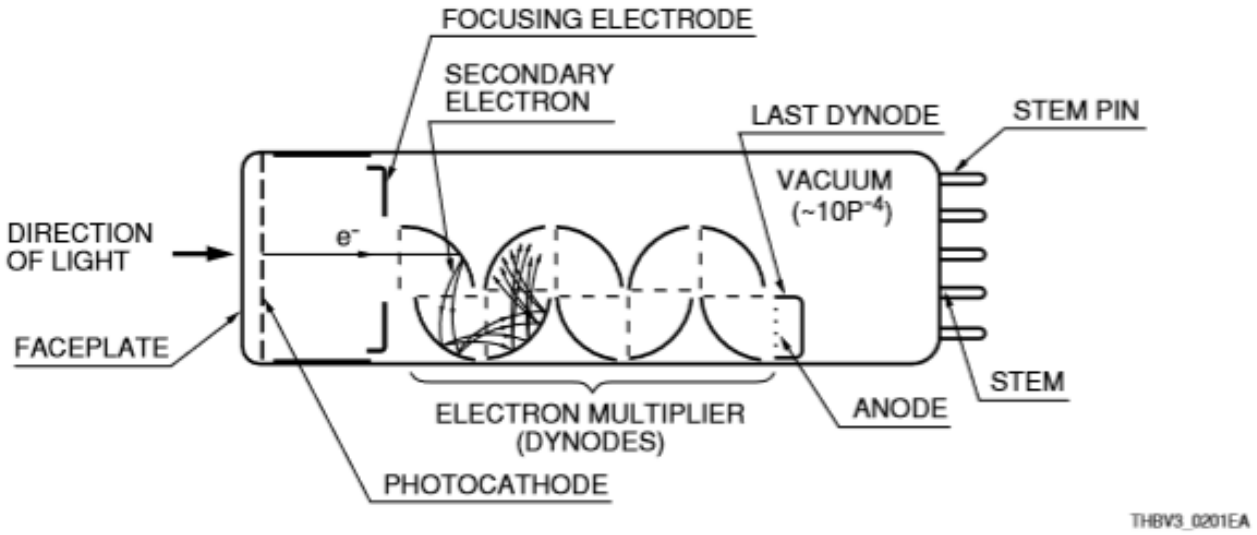
TT



gain



Structure of PMT



Circular-line type