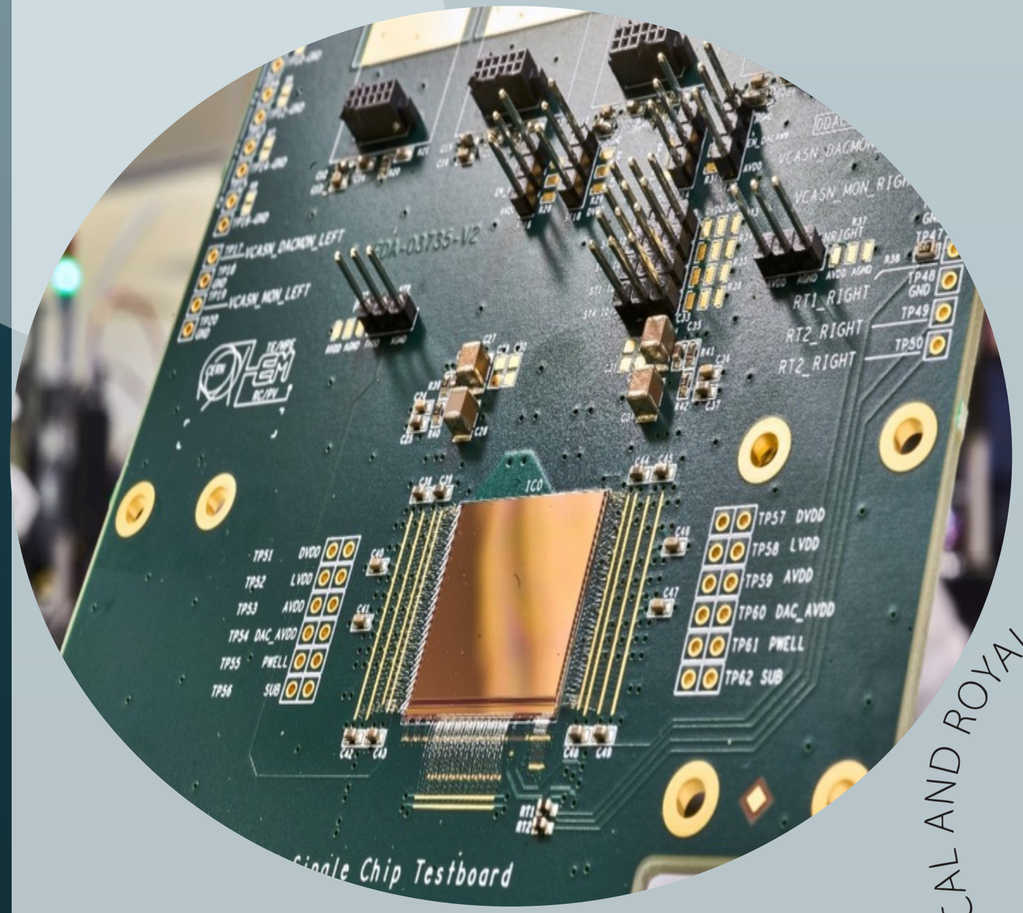


Image Source: Schioppa et.al (2019)

Focusing X-rays using MPOs

Jam Lambert U. Catenza
Supervisor: Carlos Solans

PONTIFICAL AND ROYAL UNIVERSITY OF SANTO TOMAS, MANILA
1611 ®

CERN

ATLAS EXPERIMENT

Research Questions

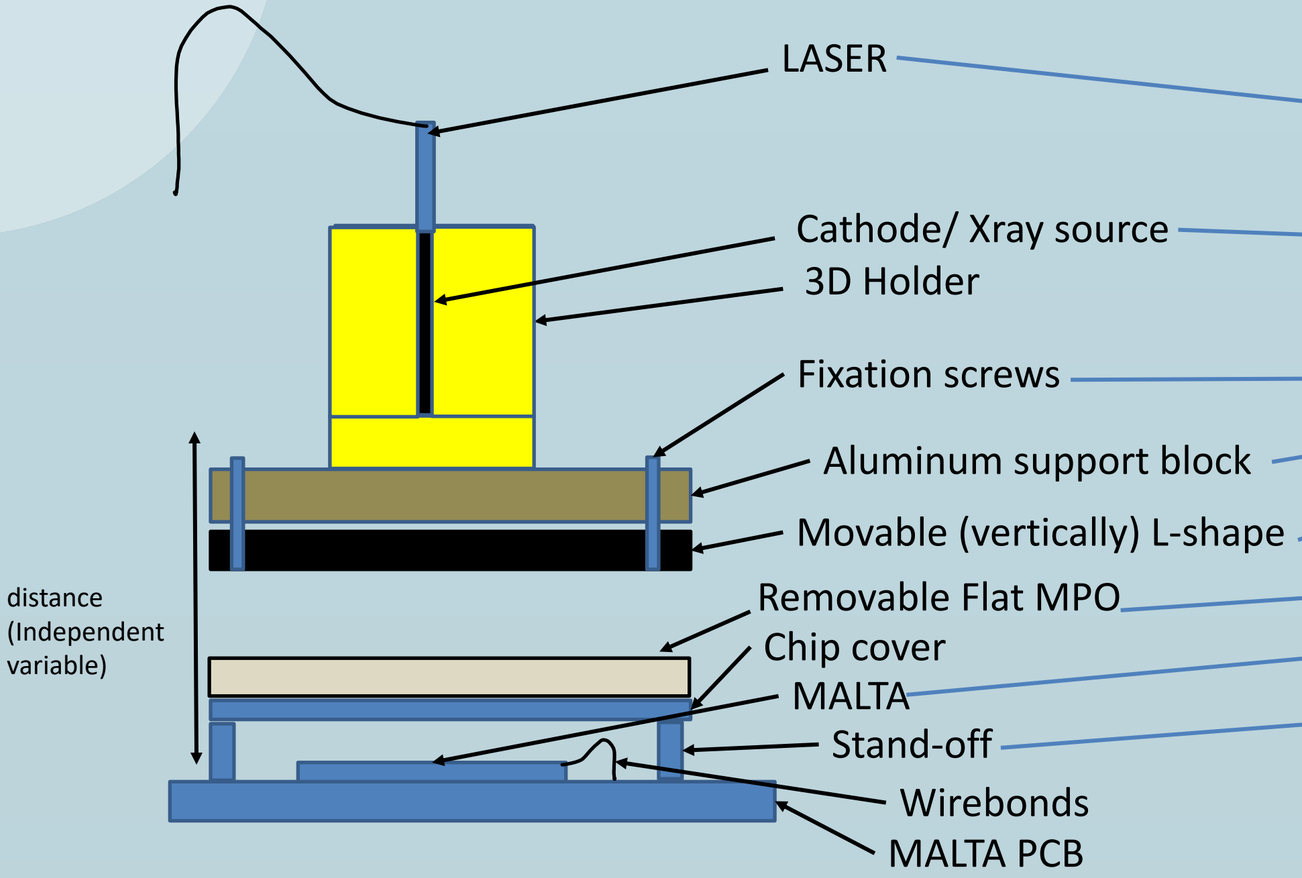
How does the following variables affect the focusing capability of Micropore Optics (MPO)?

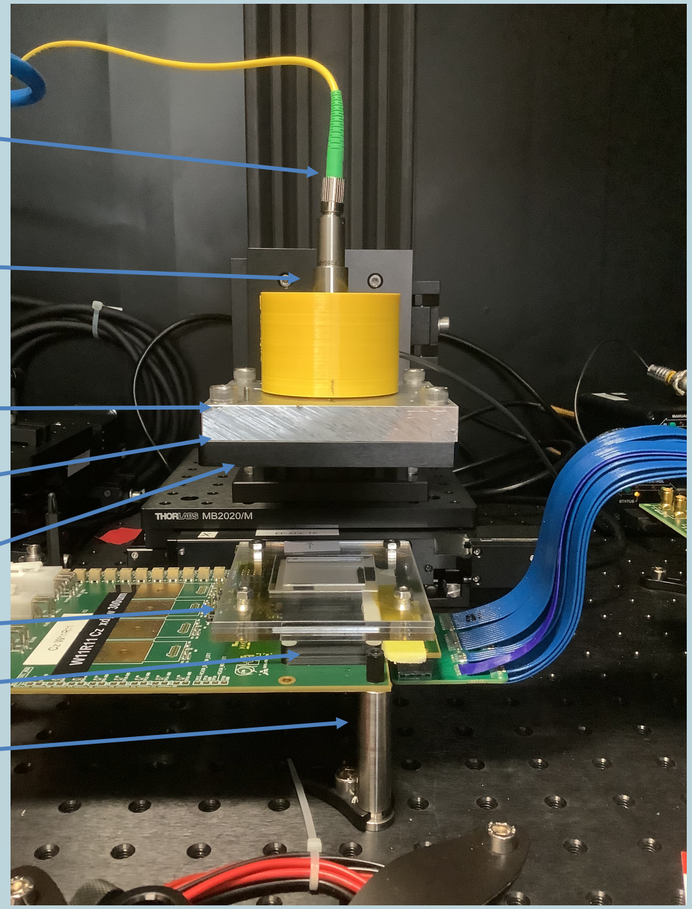
a. Source-detector distance
b. MPO-source distance

Which set-up would result to the highest focused X-ray?

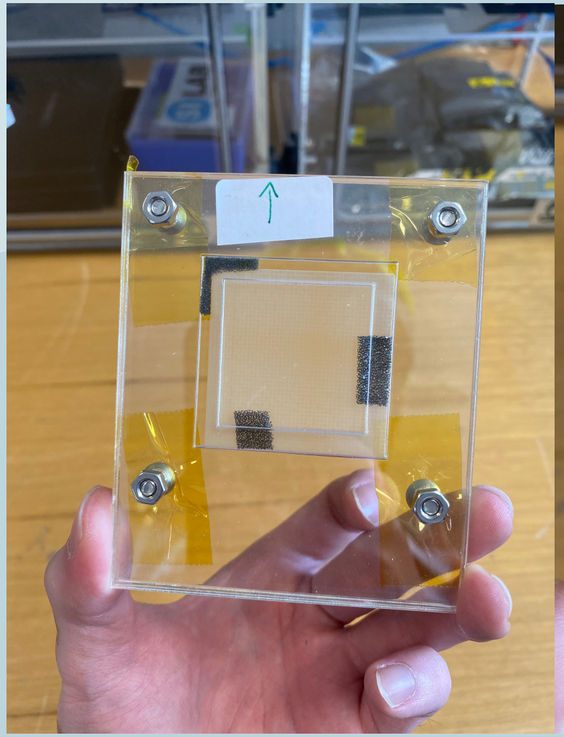
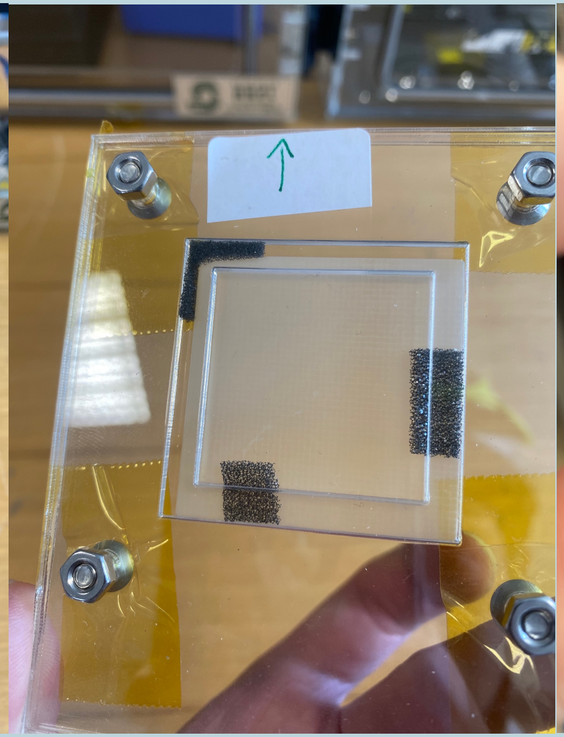
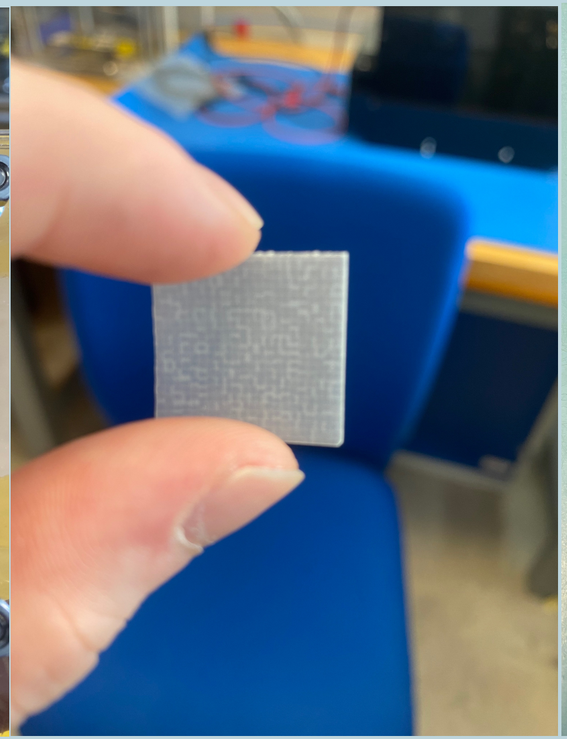
a. MPO in 3-D holder
b. MPO in 3-D holder and near MALTA
c. MPO on MALTA

Set-up


LASER
Cathode/ Xray source
3D Holder
Fixation screws
Aluminum support block
Movable (vertically) L-shape
Removable Flat MPO
Chip cover
MALTA
Stand-off
Wirebonds
MALTA PCB
distance
(Independent
variable)


THORLABS MB2020/M

What are Micropore Optics MPOs?


What are Micropore Optics MPOs?

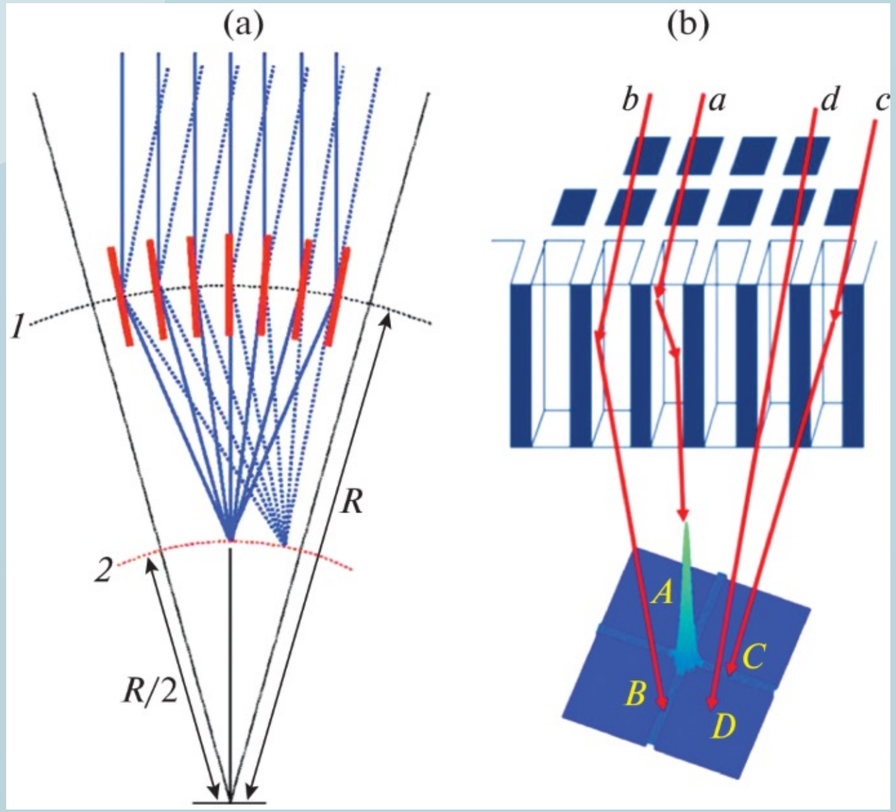


Image Source: Lider, 2022

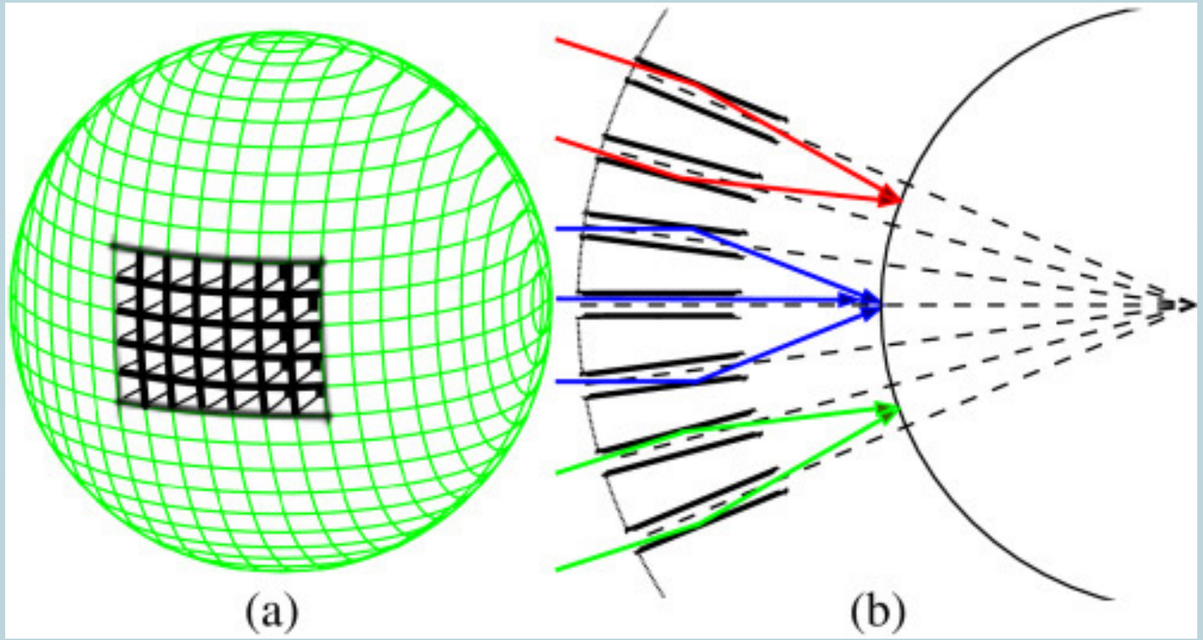
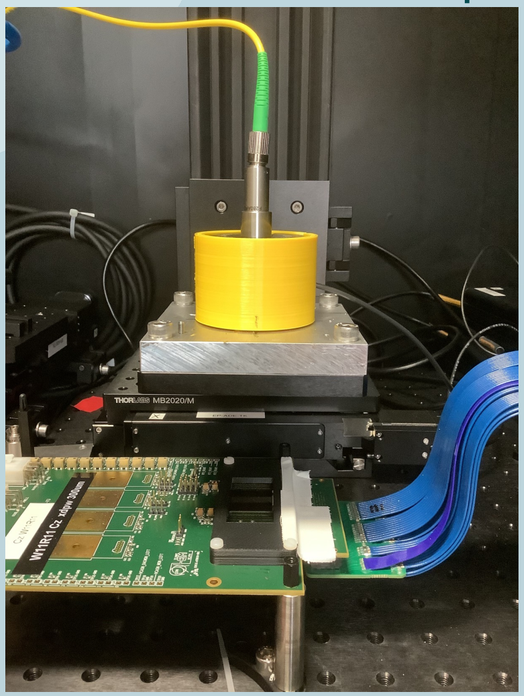


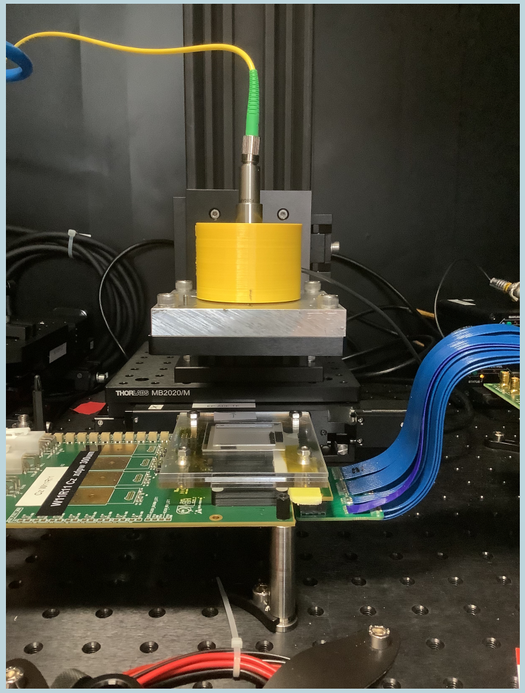
Image Source: Barbour & Erwin, 2014

Note:

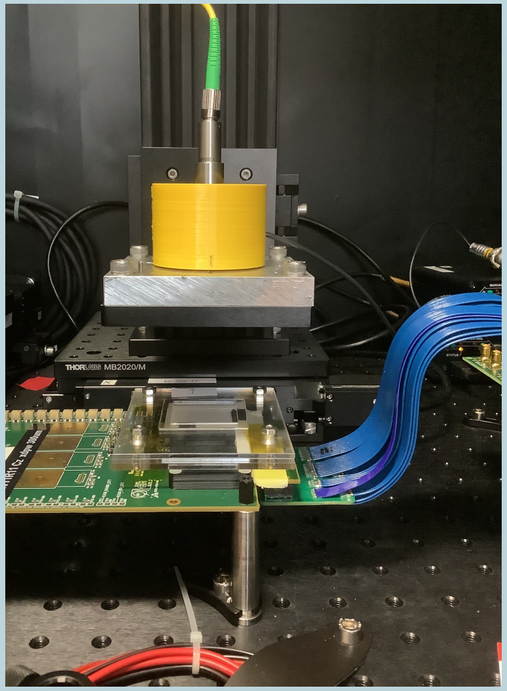
In this experiment, there are four set-ups used:



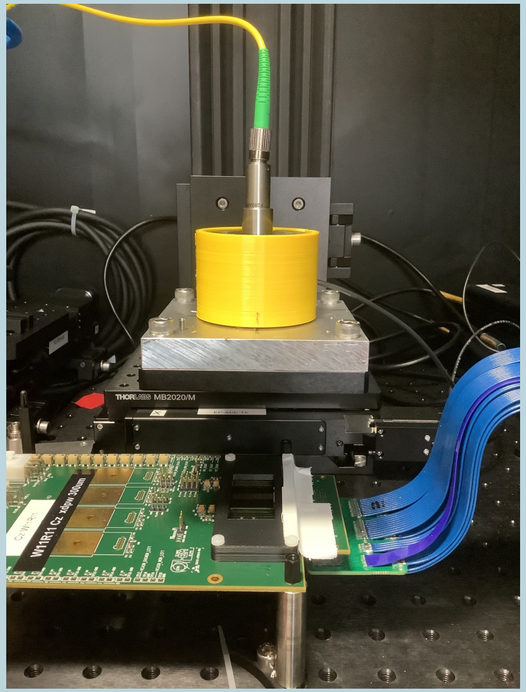
MPO on the holder



MPO on Malta and on the holder



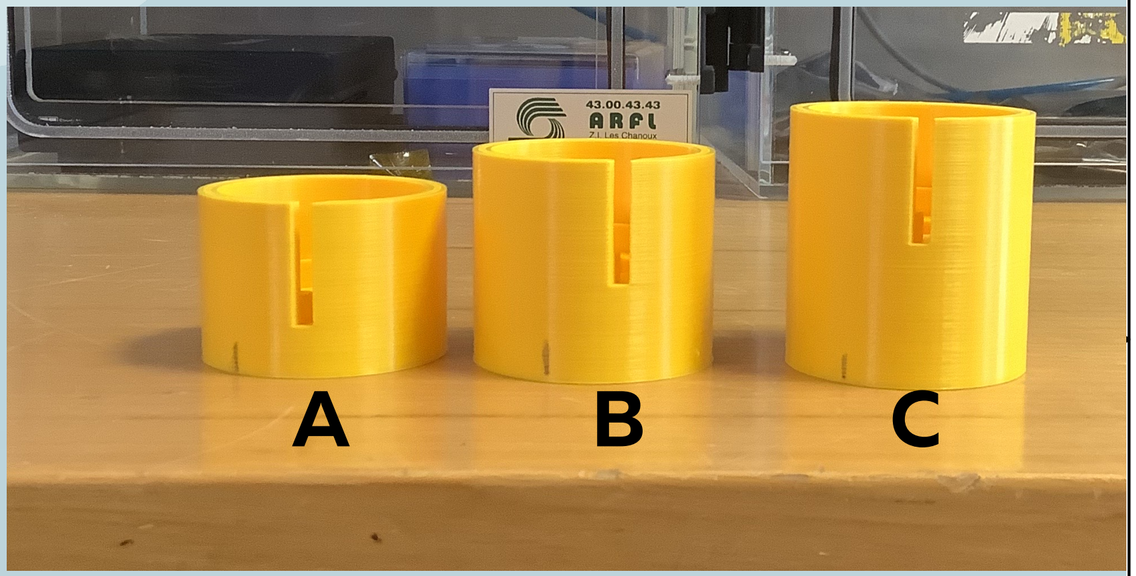
MPO on Malta

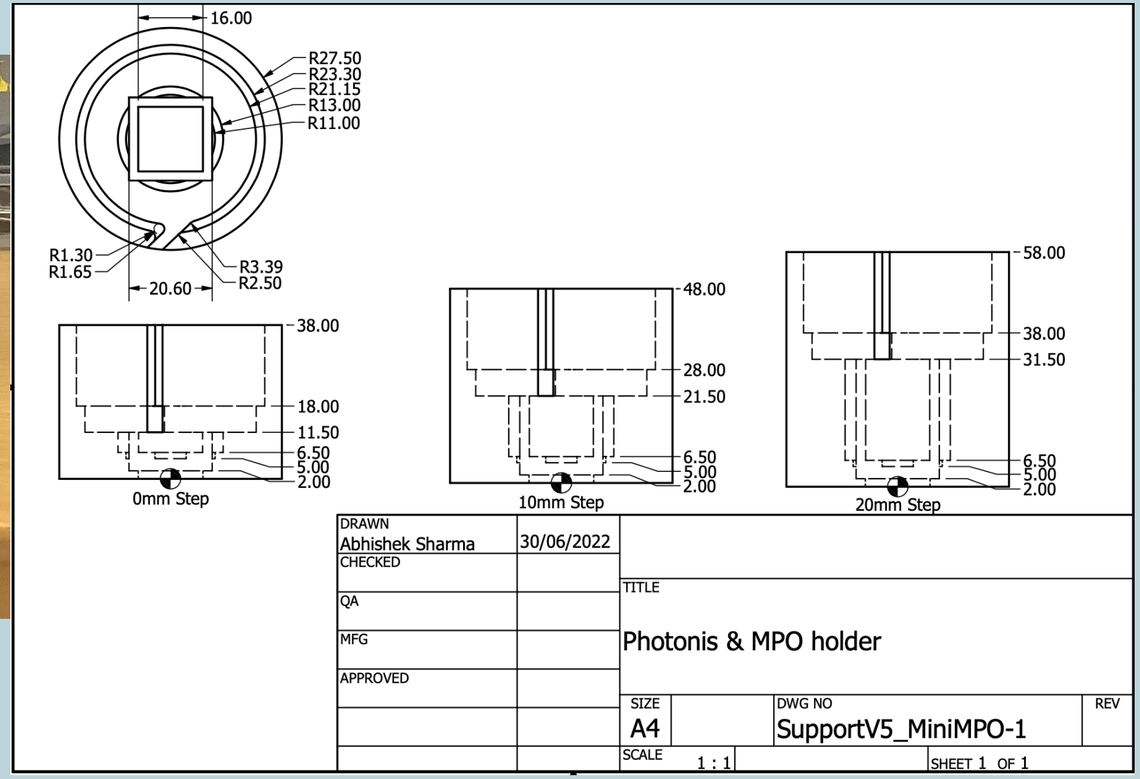


No MPO

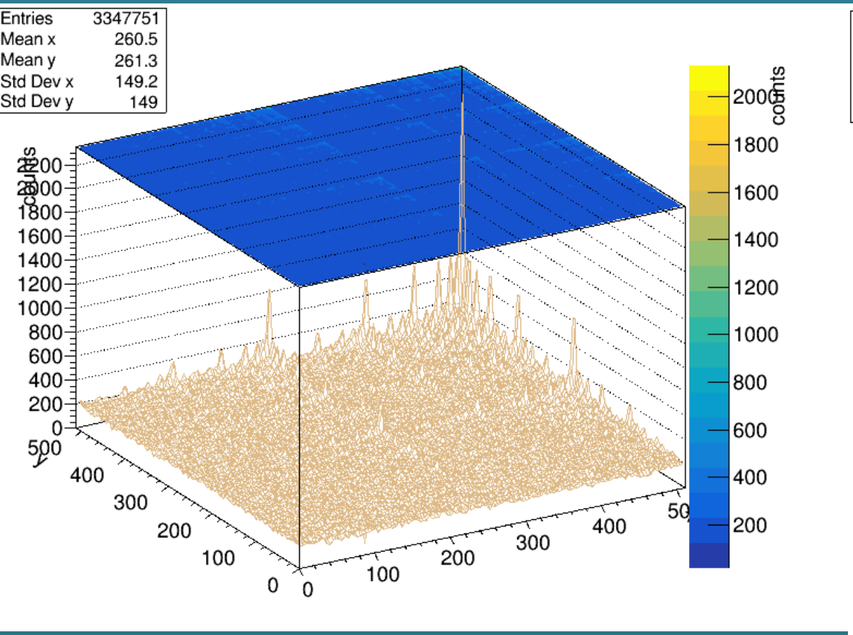
Note:

In order to characterize the effect of the distance of the MPO to the X-ray, the following 3-D printed MPO holders are used:

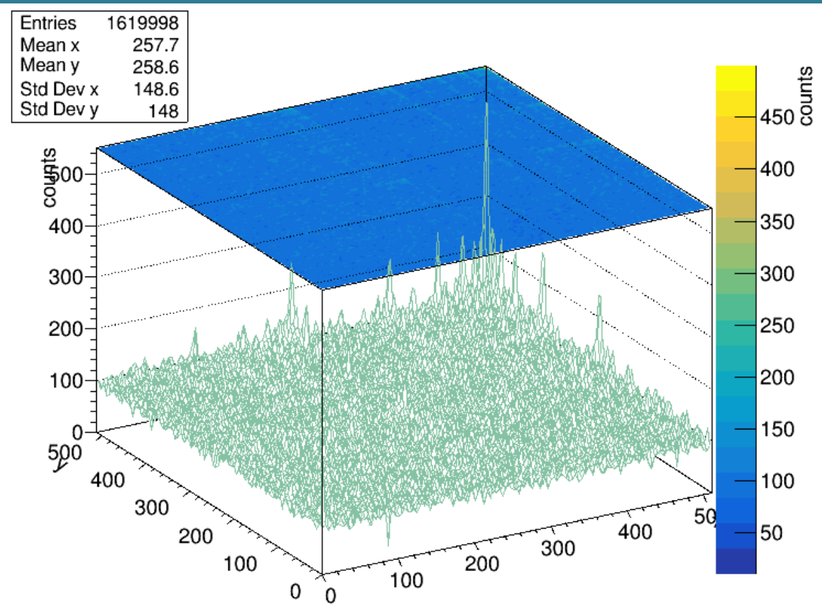




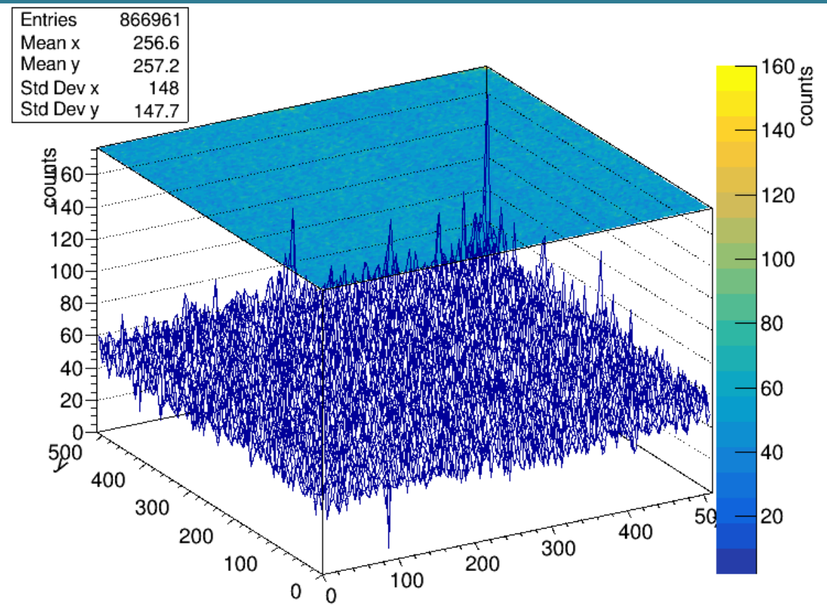
3D Histograms: No MPO*



10 cm



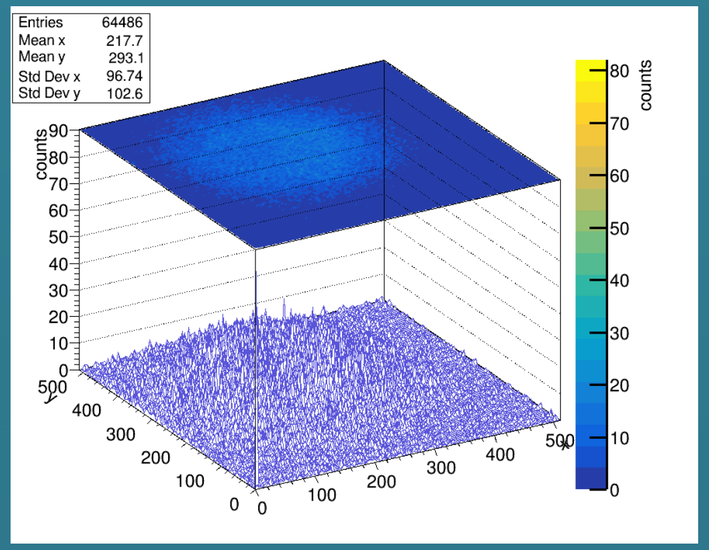
15 cm



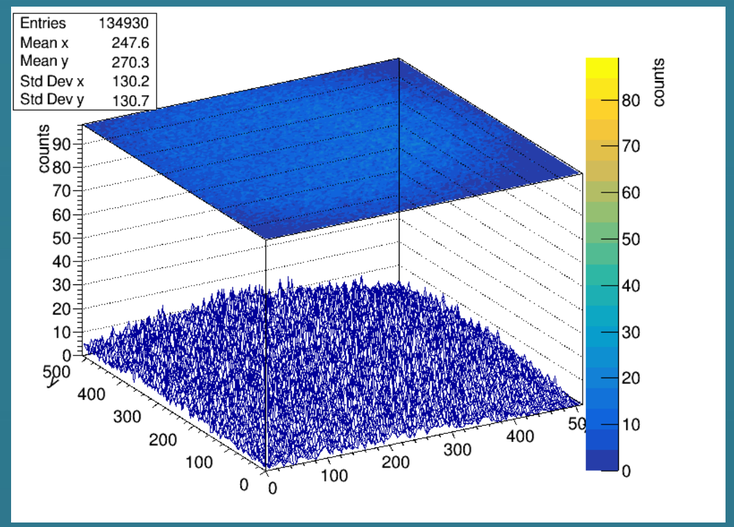
20 cm

*no data for small distances due to saturation

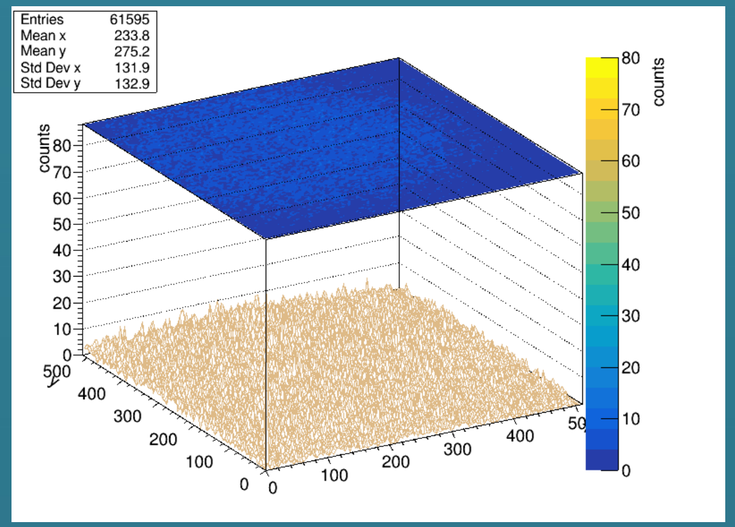
3D Histograms: MPO Holder



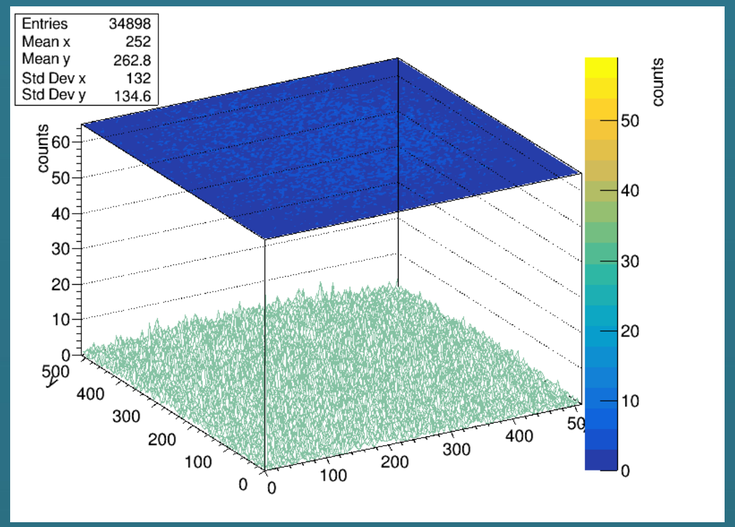
5.0 cm



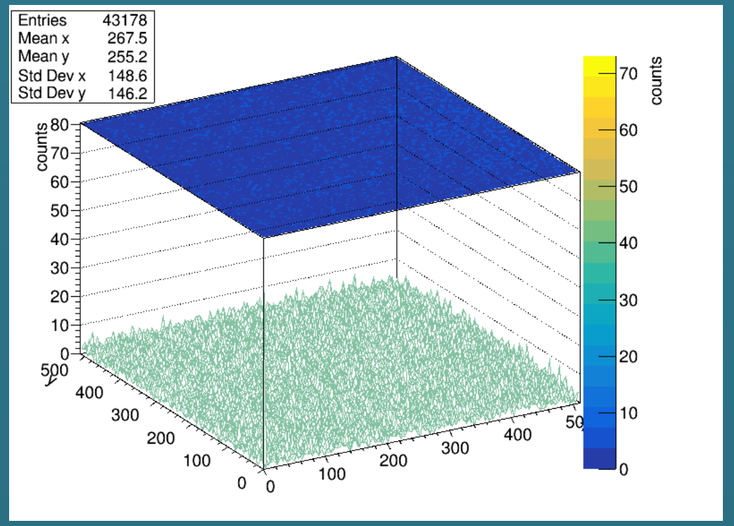
8.3 cm



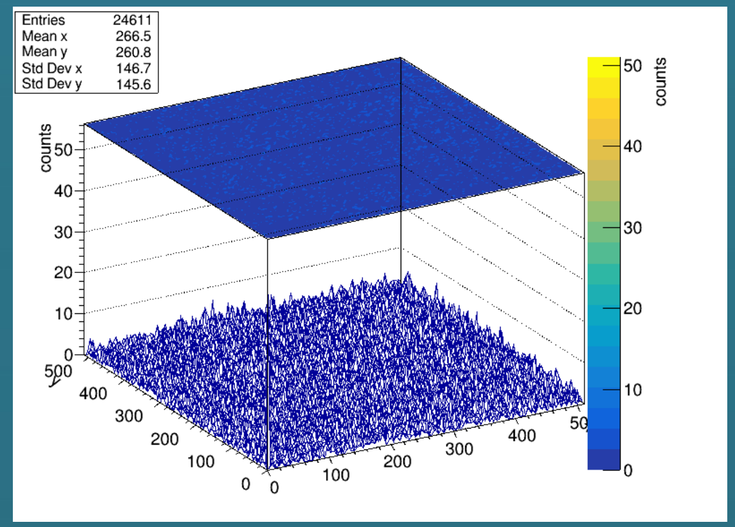
11.7 cm



15.0 cm

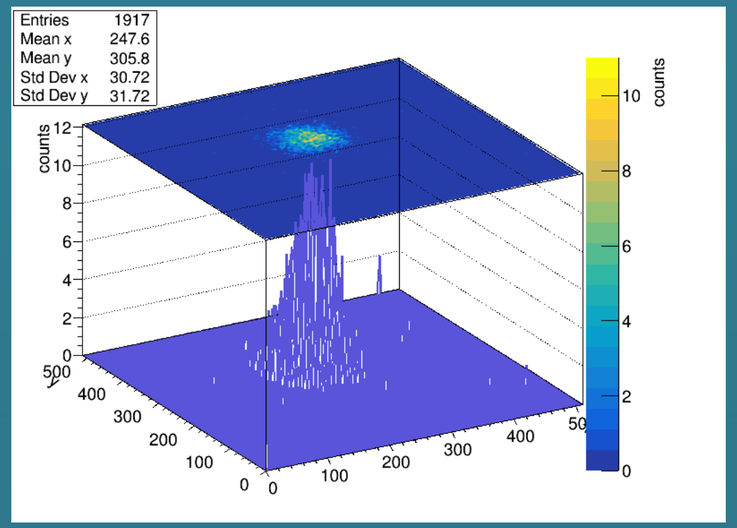


18.4 cm

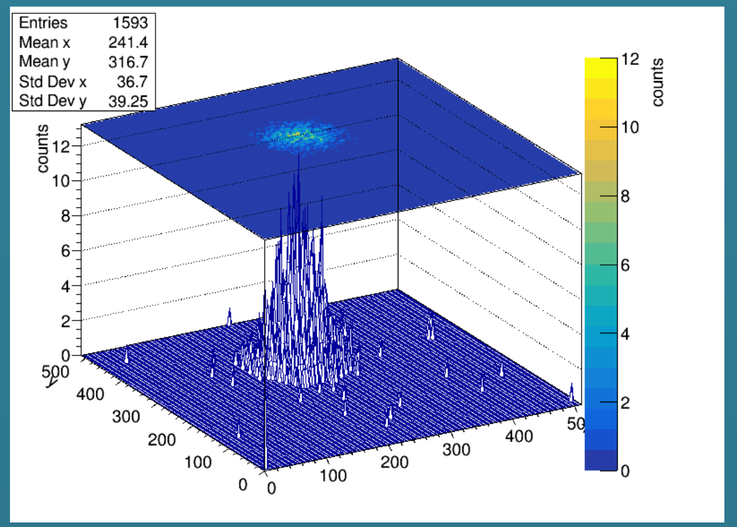


21.7 cm

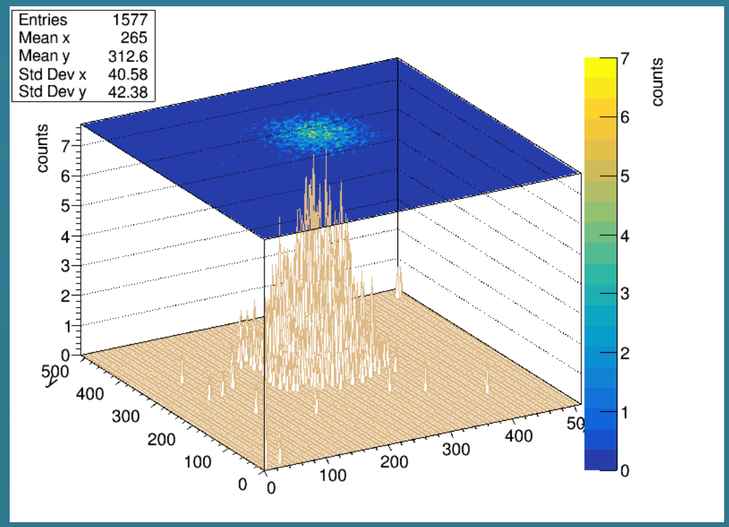
3D Histograms: MPO Holder and on Malta



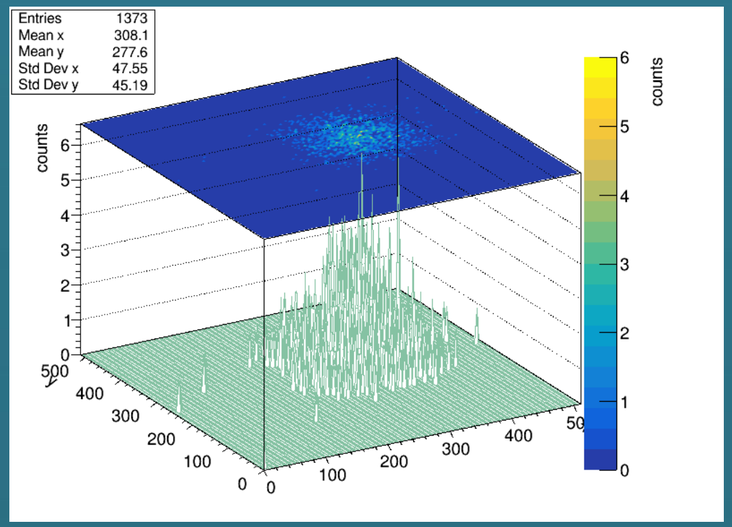
5.0 cm



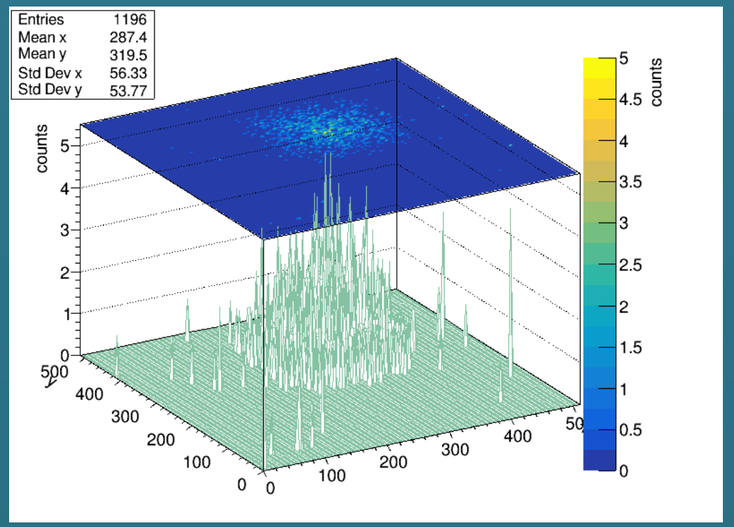
8.3 cm



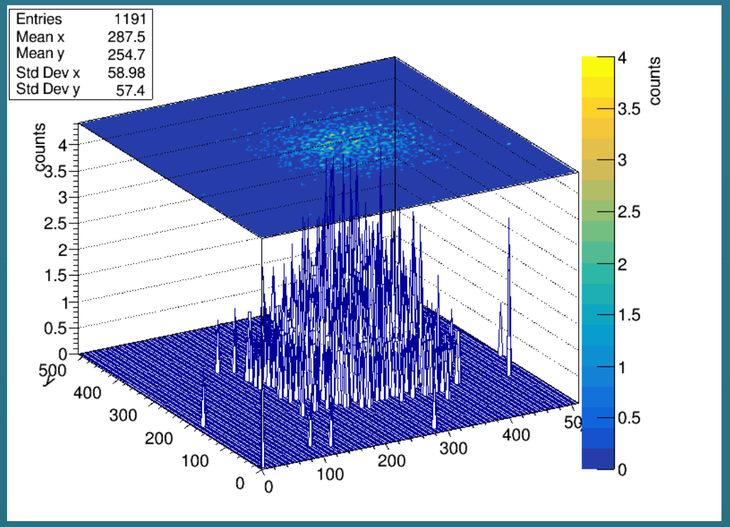
11.7 cm



15.0 cm

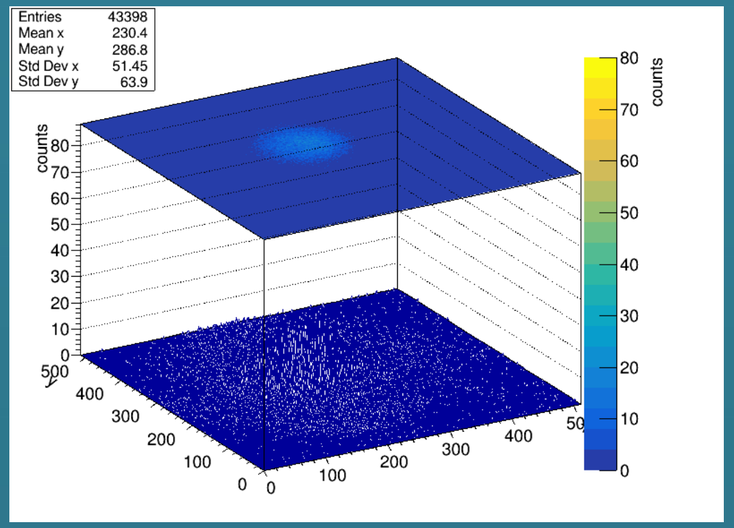


18.4 cm

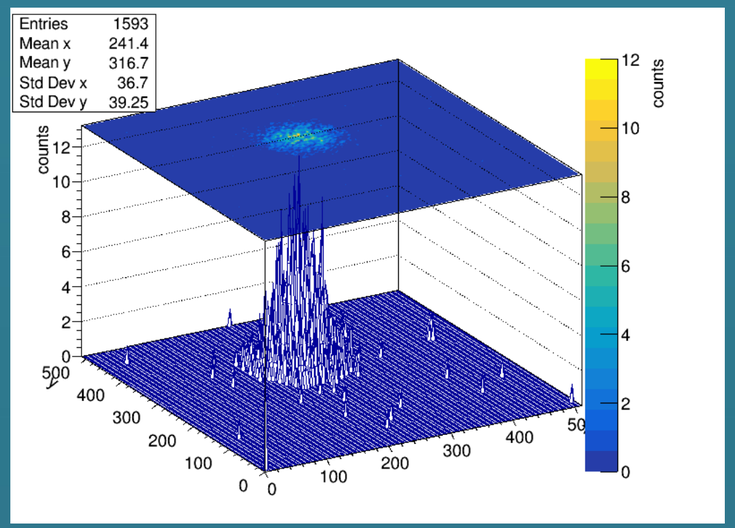


21.7 cm

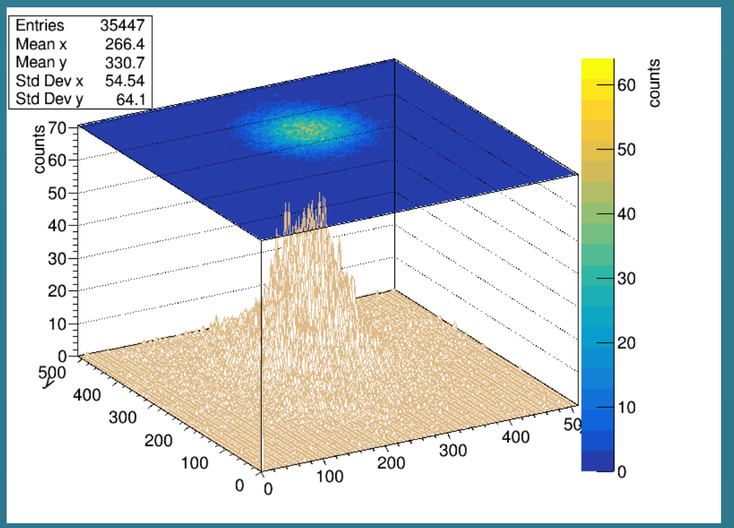
3D Histograms: MPO on Malta



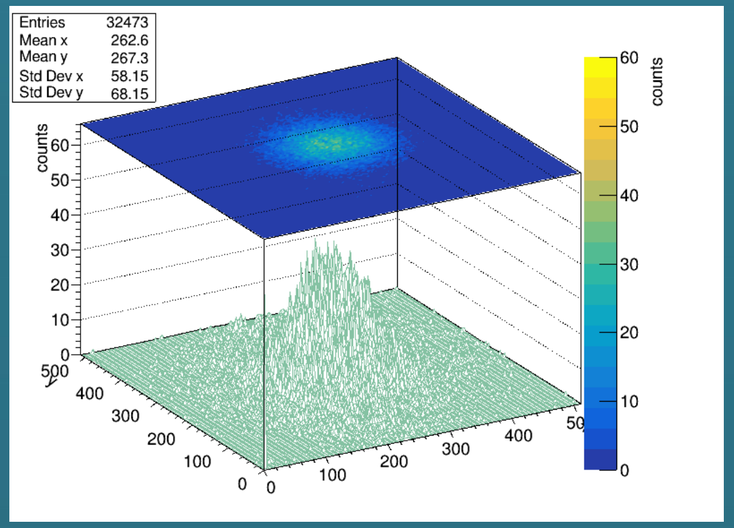
5.0 cm



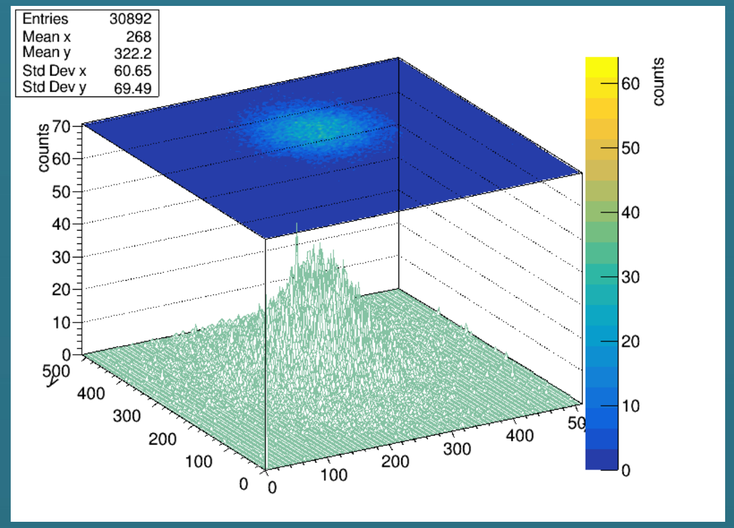
8.3 cm



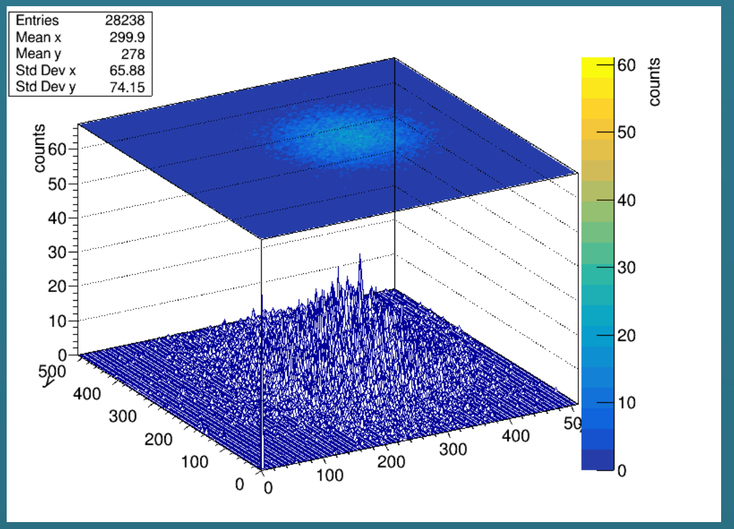
11.7 cm



15.0 cm

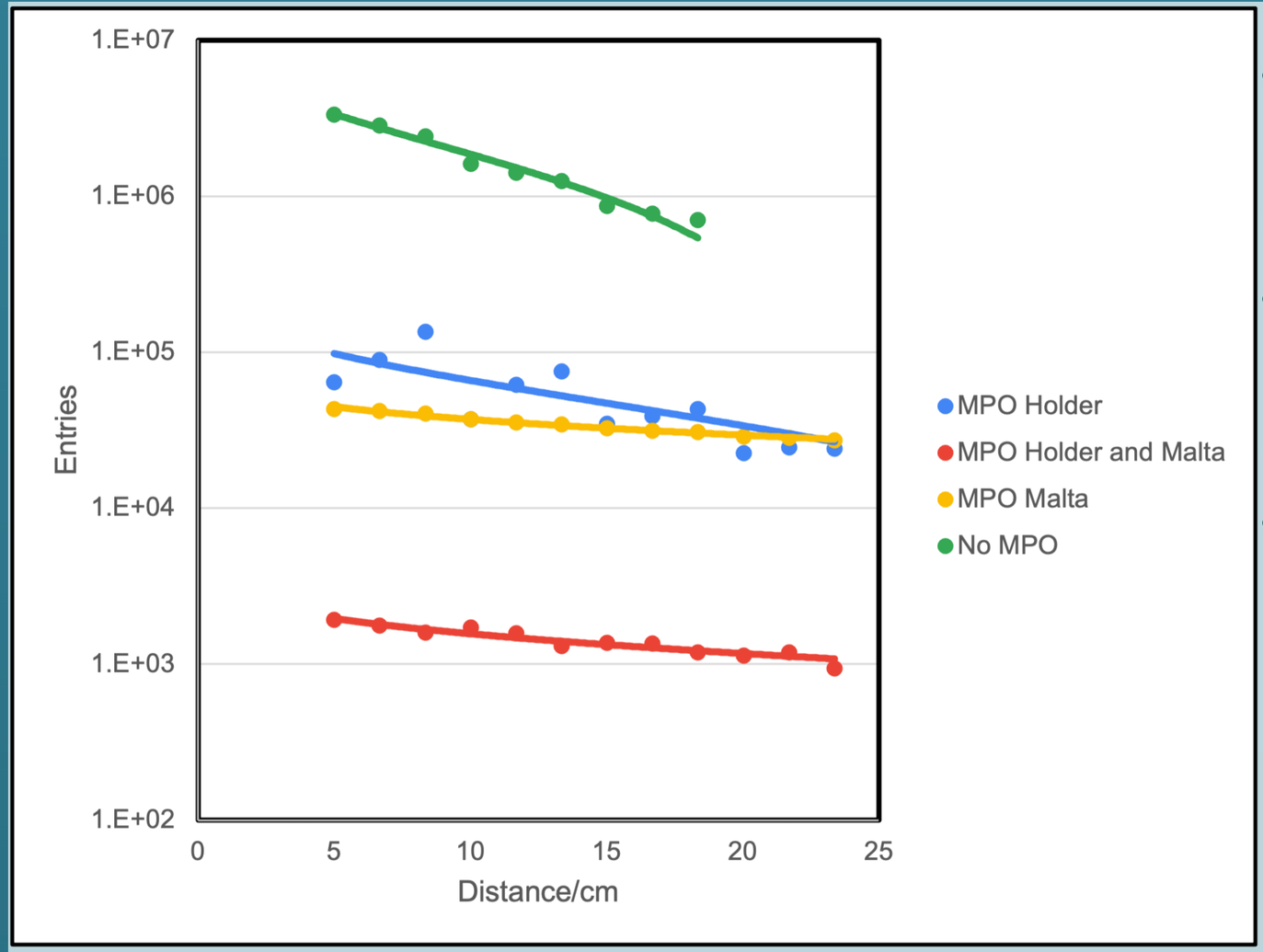


18.4 cm



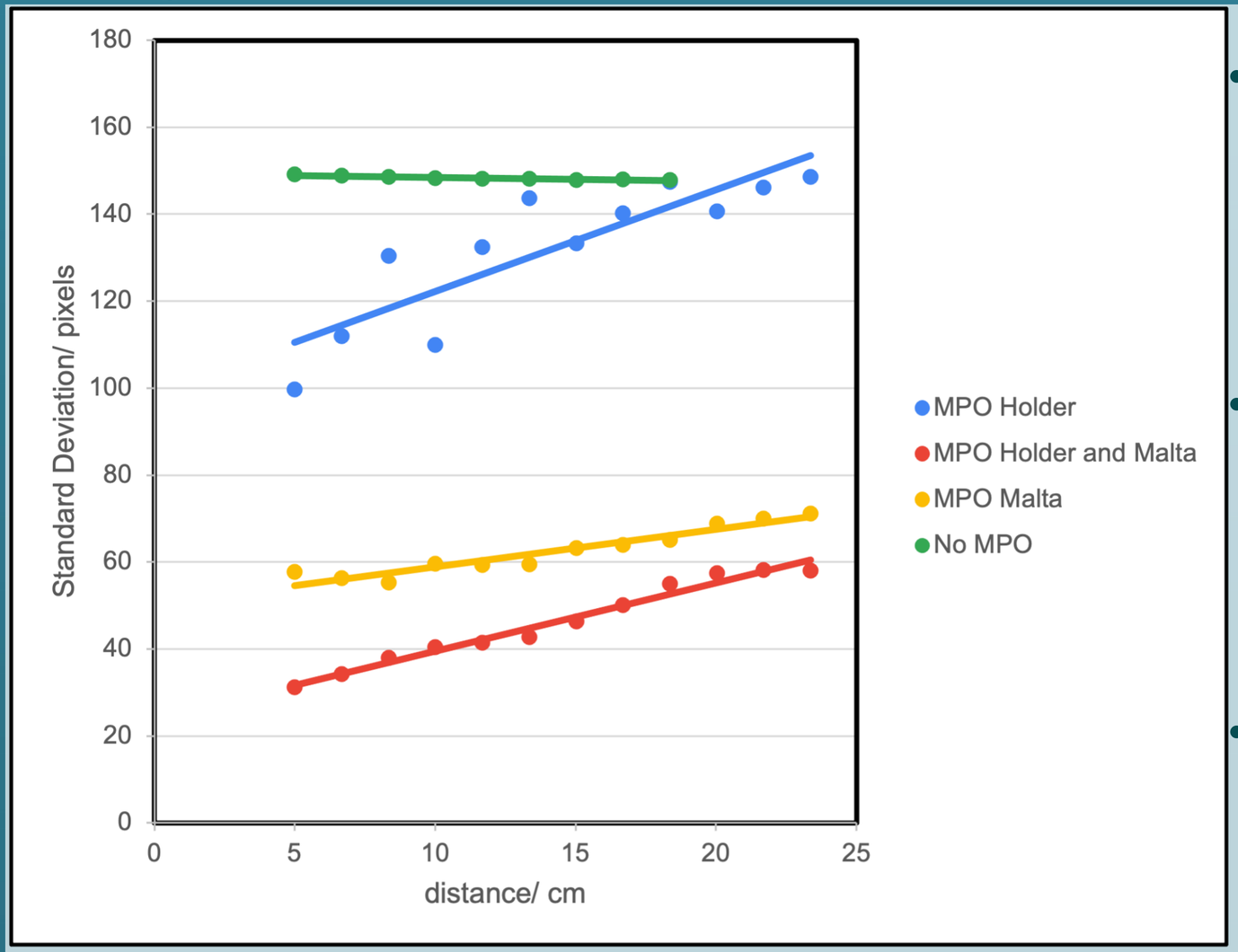
21.7 cm

Analysis: Source-detector distance (Entries)



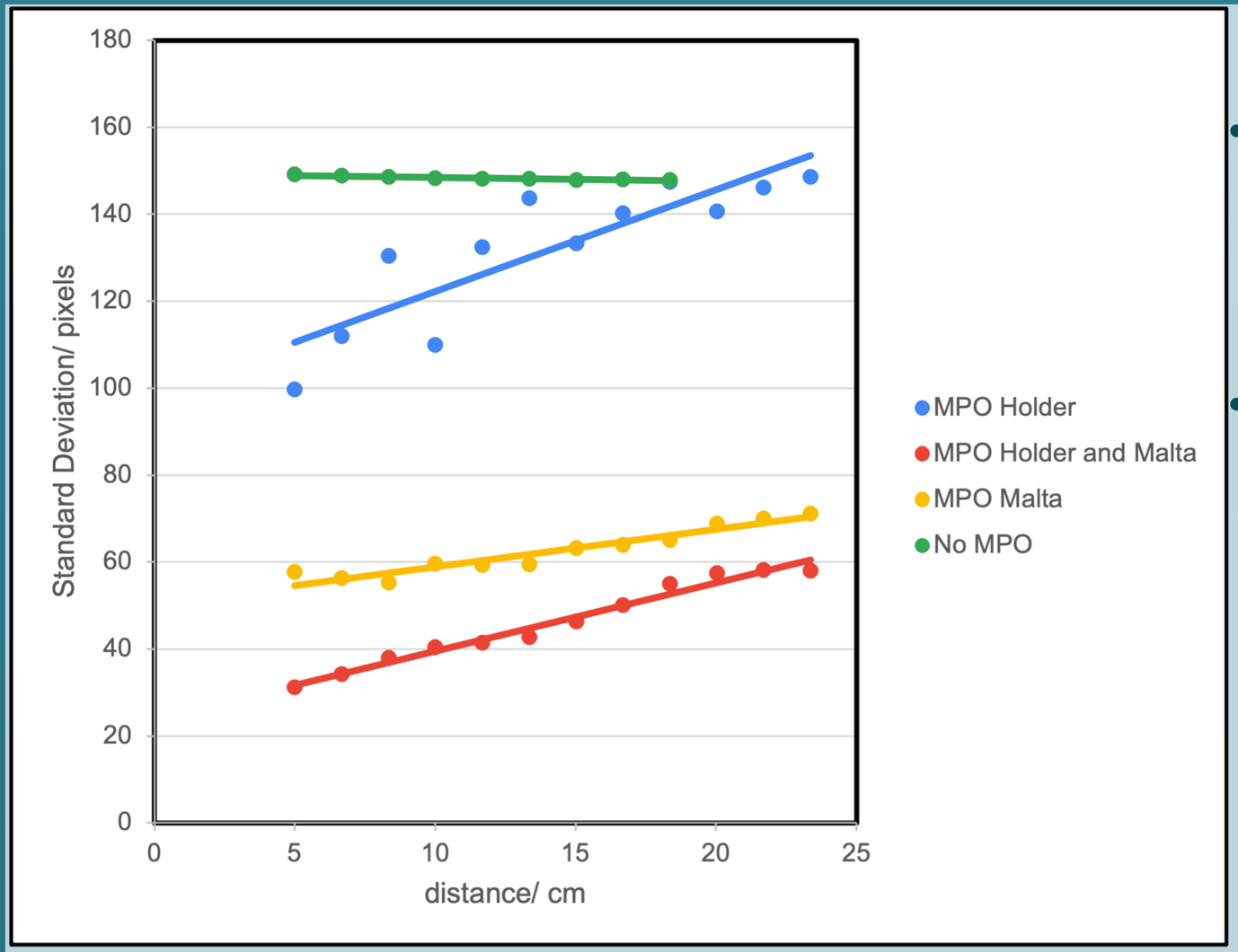
- All set-ups show that the number of entries varies inversely with distance.
- The number of entries significantly decreases as you put MPO between the source and the detector.
- A single MPO has approximately 10^0 to 10^1 times more entries than a two-MPO set-up.

Analysis: Source-detector distance (Std. Deviation)



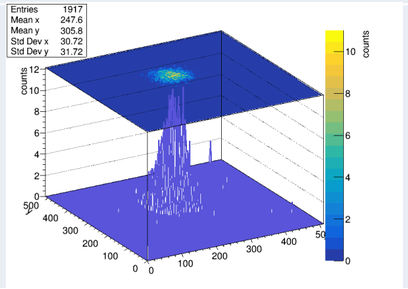
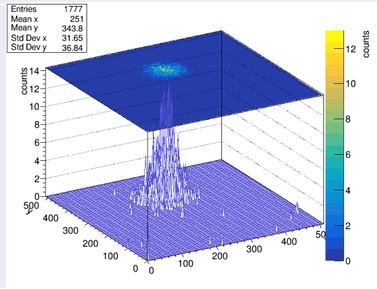
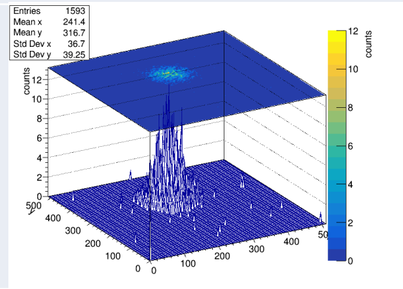
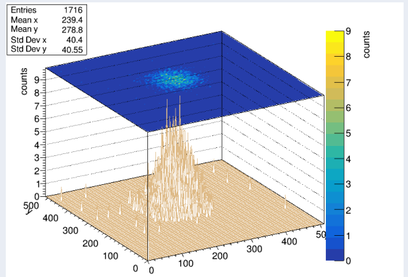
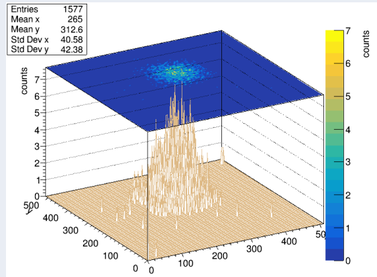
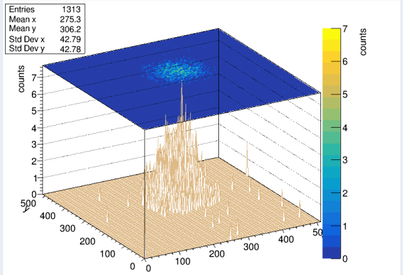
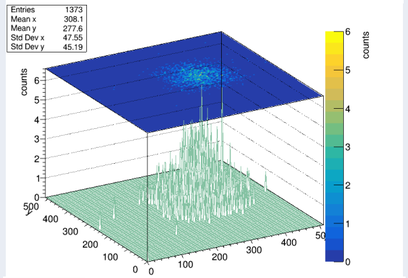
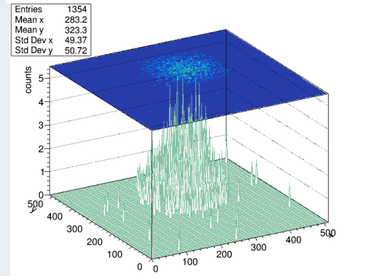
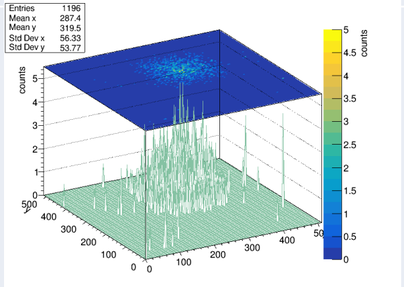
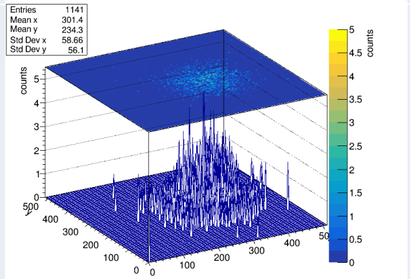
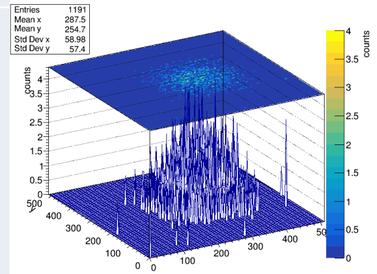
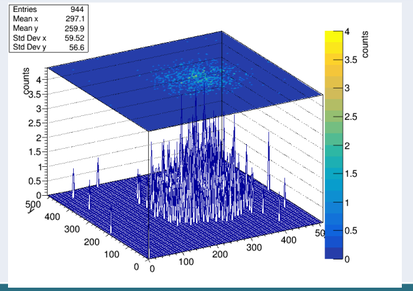
- The standard deviation of no MPO does not vary with distance. Each pixel of the detector has equal probability of being exposed to x-ray photons.
- For MPO set-ups, as the distance of source to the detector increases, the SD increases. This can be attributed to the conical divergence characteristic of X-ray photons.
- The MPO in the holder has the capability of focusing the x-rays. However, beyond a certain threshold distance, the SD is comparable to no MPO set-up.

Analysis: Source-detector distance (Std. Deviation)



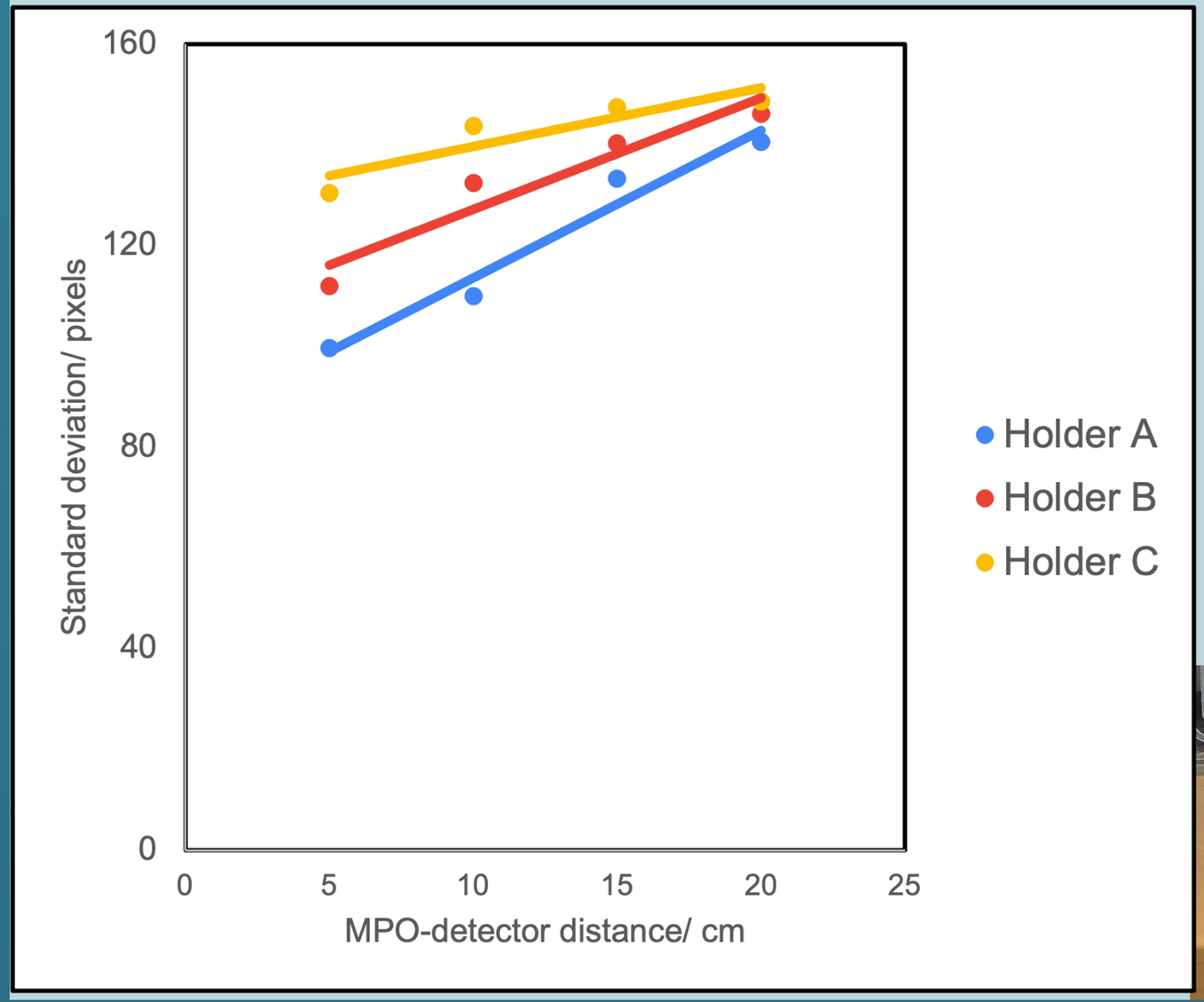
- The two-MPO set-up garnered the lowest SD. Within the given distances, the MPOs worked together in focusing the x-rays toward a smaller point.
- Placing the MPO nearer the detector effectively focuses the X-rays. However, this affects the entries that is being received by the detector.

3D Histograms: Varying MPO-source distance

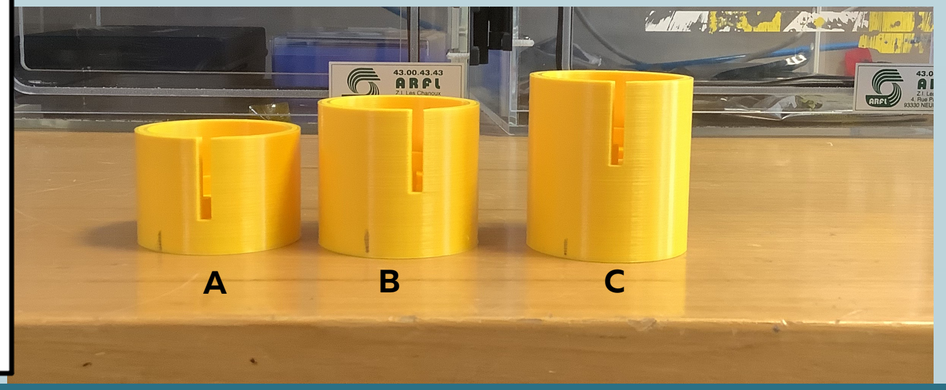
MPO-detector distance (cm)	Holder A	Holder B	Holder C
5			
10			
15			
20			

*set-up: MPO on holder and on MALTA

Analysis: MPO-source distance (Std. Deviation)

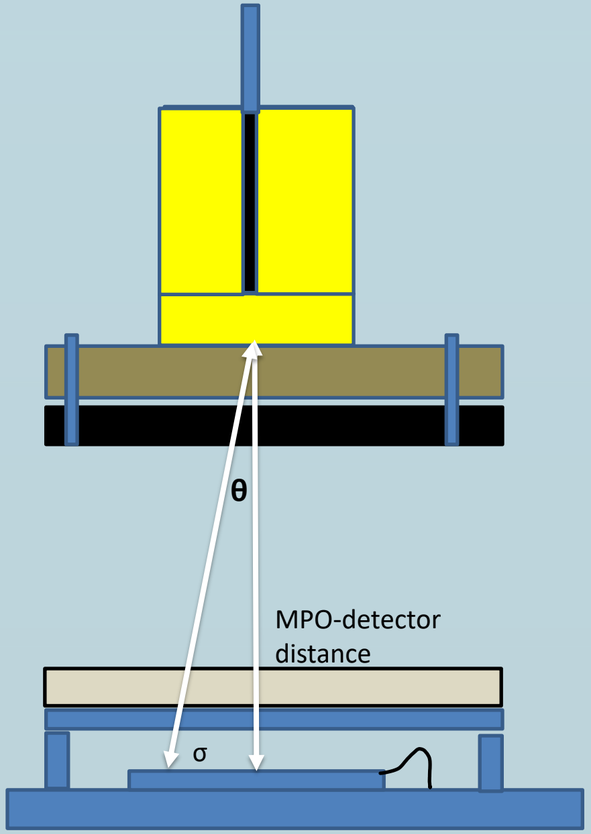


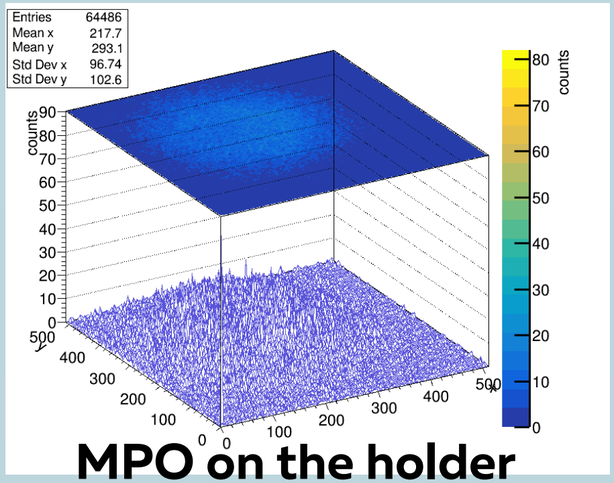
- Holder A sets the smallest distance from the source and the MPO. It provides the smallest standard deviation. the closer the MPO to the source, the smaller the divergence.



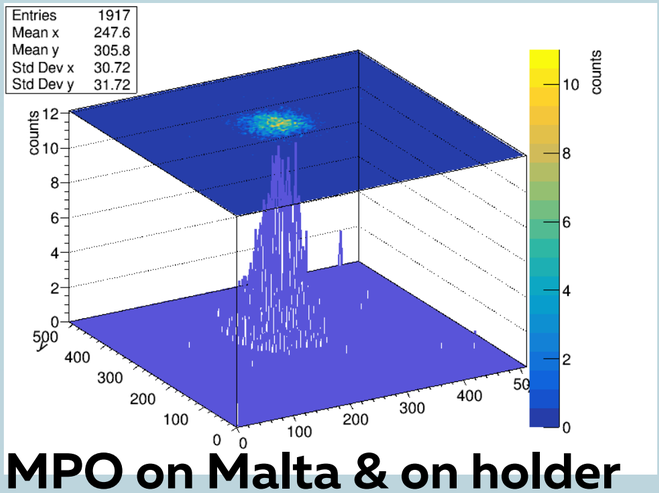
Analysis: Divergence Angle (θ)

- The following diagram defines the divergence angle:

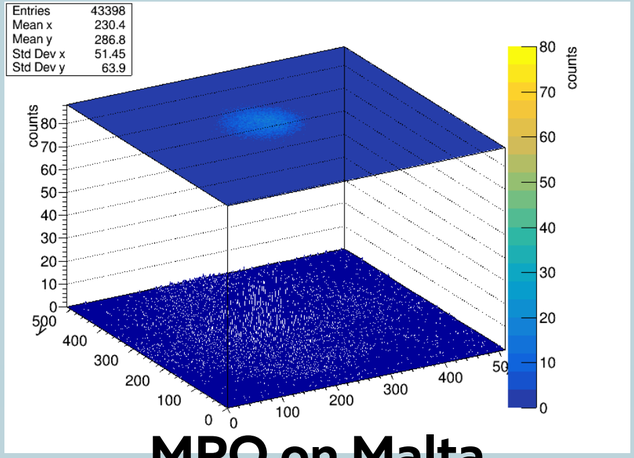




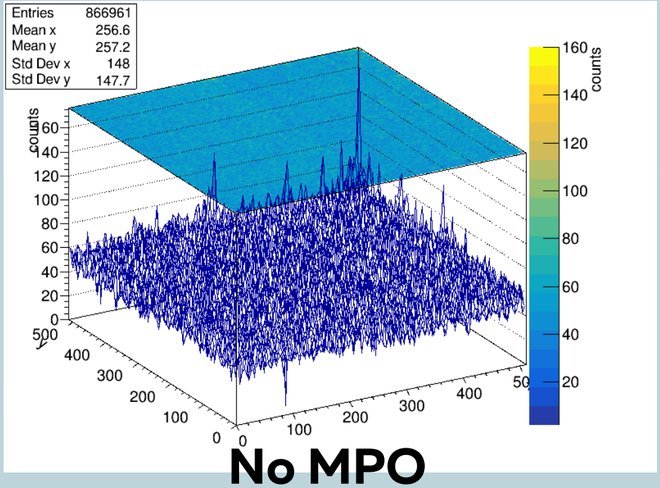
MPO on the holder



MPO on Malta & on holder

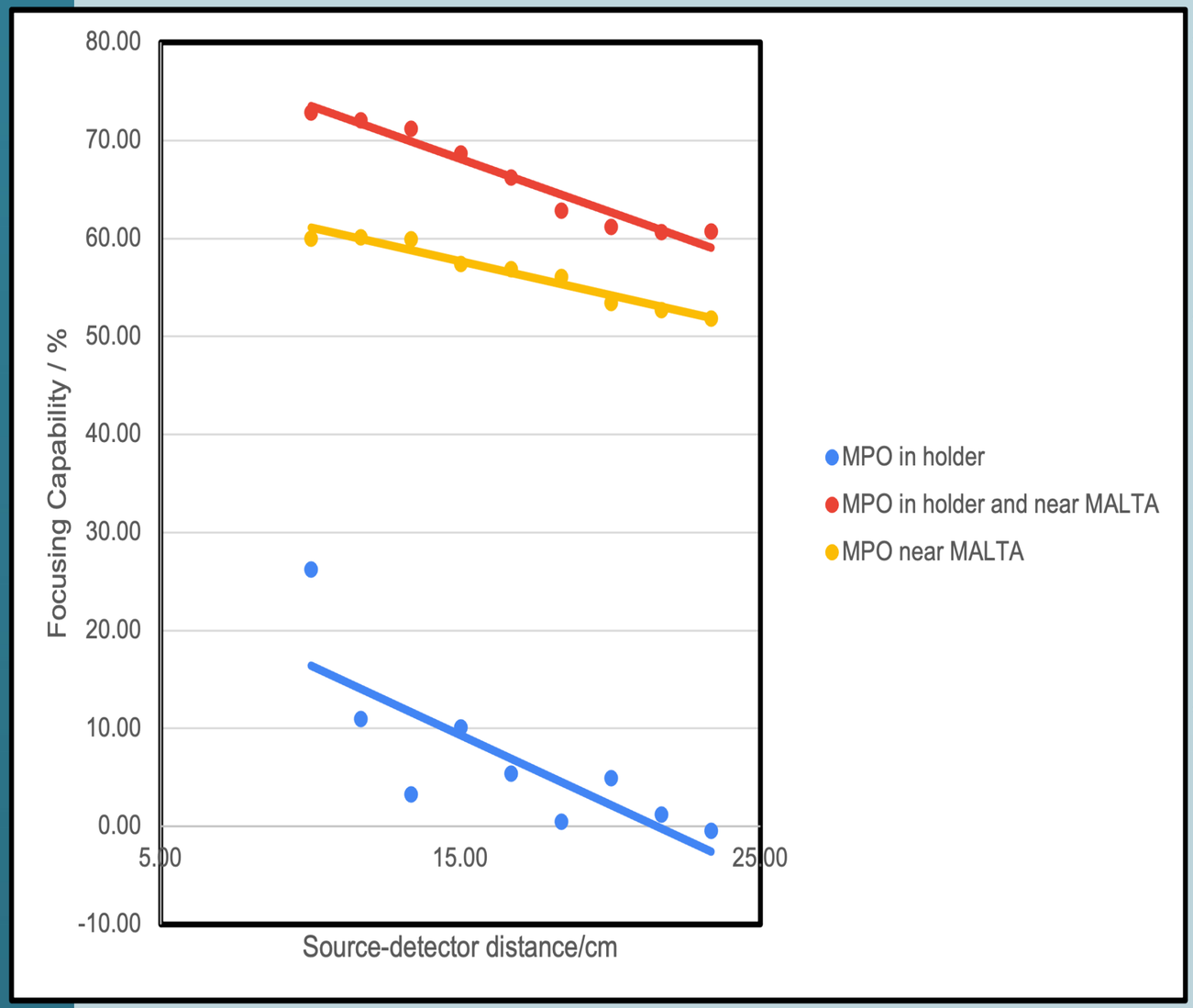


MPO on Malta



No MPO

Analysis: Focusing capability



- Given the distances, using two MPOs yielded ~10% more focusing capability than when using just MPO near MALTA and ~50% more when using MPO in the holder.
- For a single-MPO set-up, it is better if the MPO is placed near the detector. It is noticeable that the MPO-holder setup yielded a low focusing capability compared to when the MPO is placed near the MALTA.
- When the MPO is placed very far from the detector, the X-rays tend to diverge comparable to a non-MPO set-up. This is being manifested by the negative value of the focusing capability of the MPO-holder set-up.

Notable Conclusions

- The distance of the source affects the hits on the detector. The closer the source, the more hits we see. The intensity of the X-ray that reaches the detector significantly decreases by a factor of 100 whenever MPOs are inserted. This can be because the X-ray photons that interact with the MPO are being scattered/reflected.
- The X-rays are more focused when two MPOs are used.
- With the given distances, X-rays are more focused when it interacts with the MPO the as soon as possible.
- verall, placing two MPOs near the source and near the detector yielded the highest average focusing capability of 66.3% followed by the set-up when MPO is placed near the detector that had an average focusing capability of 56.5%. Placing the MPO near the source only yielded 6%.