Focusing X-rays using MPOs

Jam Lambert U. Catenza
Supervisor: Carlos Solans

Image Source: Schioppa et.al (2019)
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)
What are Micropore Optics MPOs?
What are Micropore Optics MPOs?

Image Source: Barbour & Erwin, 2014

Image Source: Lider, 2022
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
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:

Note:
3D Histograms: No MPO*

*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
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.
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.
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

<table>
<thead>
<tr>
<th>MPO-detector distance (cm)</th>
<th>Holder A</th>
<th>Holder B</th>
<th>Holder C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
<tr>
<td>10</td>
<td><img src="image4.png" alt="Graph" /></td>
<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="Graph" /></td>
</tr>
<tr>
<td>15</td>
<td><img src="image7.png" alt="Graph" /></td>
<td><img src="image8.png" alt="Graph" /></td>
<td><img src="image9.png" alt="Graph" /></td>
</tr>
<tr>
<td>20</td>
<td><img src="image10.png" alt="Graph" /></td>
<td><img src="image11.png" alt="Graph" /></td>
<td><img src="image12.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

*Set-up: MPO on holder and on MALTA*
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 ($\theta$)

• The following diagram defines the divergence angle:

![Diagram showing the divergence angle](image-url)
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.
• Overall, 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%.