*This file contains all reviewer reports in order by version, followed by all author rebuttals in order by version.*

nature portfolio

# Peer Review File

# Optimizing Photon Capture: Advancements in amorphous silicon-based microchannel plates

Corresponding Author: Dr Samira Frey

Version 0:

Reviewer comments:

Reviewer #1

(Remarks to the Author)
The authors reported a new type microchannel plate made by silicon. This is a new idea been carried out and showing promising results. The topic is of great interest for the community, would definitely draw attention from readers. The reported AMCPs exhibited great timing resolution, can be used in many applications. Authors also simulated the gain of the AMCP, and demonstrated expected results. The manuscript is a well written paper, I would recommend to accept for publication.

Reviewer #2

(Remarks to the Author)
Microchannel plates (MCPs) are wildly used detectors in applications such as night vision devices, mass spectrometry, biotechnology, nuclear physics, and many others. However, they are also subject to limitations such as limited detection efficiency and expensive fabrication procedures. In this paper, the authors demonstrated significant improvements in AMCP technology by developing funnel-shaped channel openings. The detection efficiency and timing resolution have been markedly enhanced. The paper is interesting and well written. I recommend this paper could be accepted with minor revisions.

1. In Part Time Resolution Measurements, these results seem to be all about the timing resolution of the AMCP, what about the timing characteristics of the f-AMCPs. In Fig. 3 (d), the risetime of the waveform seems to much shorter than the other three. Why? Does the risetime have an impact on the final time resolution? For better comparison, the measurement with an external amplifier connected; the gold photocathode was removed, AMCP Bias= 300 V, laser intensity = 2 μJ should be added. Line 339 “This fact can be explained by the relationship between the SNR and the time resolution [26].” How about the SNR of the AMCP in the measurement of Fig.3.
2. Line 350 “Hence, at the lowest beam intensity, there should be, on average, less than one photoelectron per channel” Does this indicate that this MCP is capable of single-photon detection?
3. As the authors mentioned “SiPMs are the dominant photodetectors used in ToF PET.” It is advised that a comprehensive performance comparison be conducted between SiPM and MCP for specific applications.

Version 1:

Reviewer comments:

Reviewer #1

(Remarks to the Author)
The manuscript has been revised in line with the previous comments, and all concerns have been thoroughly addressed. The revised version is well-written and presents the research clearly and effectively. I recommend accepting the manuscript for publication.

Reviewer #2

(Remarks to the Author)
I think this article has been revised in accordance with the comments and recommend that it be accepted.

Manuscript COMMSENG-24-0343-T
Response to Reviewers

We appreciate the time and effort that the reviewers dedicated to providing feedback on our manuscript and are grateful for the insightful comments on and valuable improvements to our paper. We have incorporated all of the suggestions made by the reviewers. Those changes are highlighted within the manuscript. Please see below, in blue, for a point-by-point response to the reviewers' comments and concerns.

## Reviewers' Comments to the Authors:

### Reviewer 1

The authors reported a new type of microchannel plate made of silicon. This is a new idea been carried out and showing promising results. The topic is of great interest for the community, would definitely draw attention from readers. The reported AMCPs exhibited great timing resolution, can be used in many applications. Authors also simulated the gain of the AMCP, and demonstrated expected results. The manuscript is a well written paper, I would recommend to accept for publication.

Thank you, we are happy to hear that our work is being appreciated.

### Reviewer 2

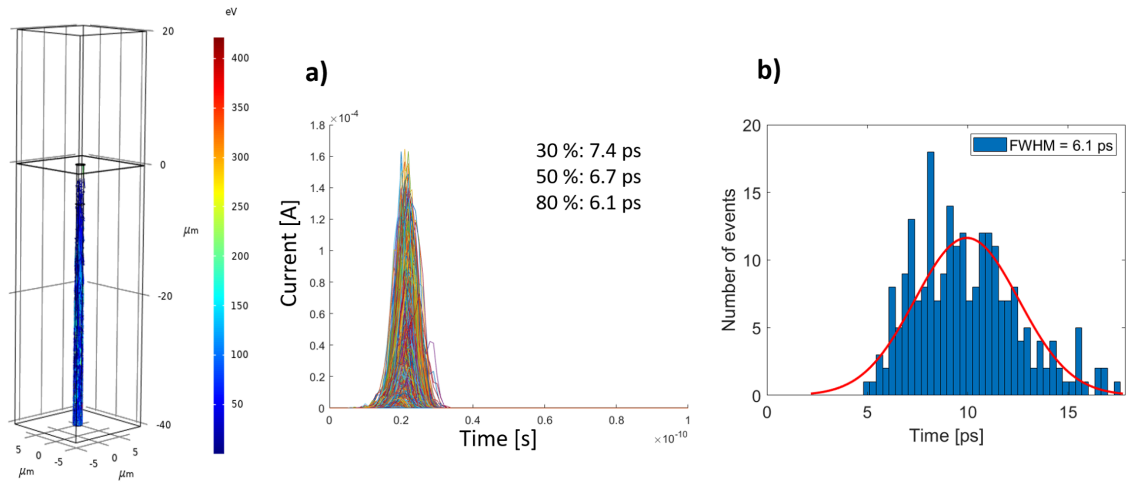
Microchannel plates (MCPs) are widely used detectors in applications such as night vision devices, mass spectrometry, biotechnology, nuclear physics, and many others. However, they are also subject to limitations such as limited detection efficiency and expensive fabrication procedures. In this paper, the authors demonstrated significant improvements in AMCP technology by developing funnel-shaped channel openings. The detection efficiency and timing resolution have been markedly enhanced. The paper is interesting and well written. I recommend this paper could be accepted with minor revisions.

Thank you, we are happy to hear that our work is being appreciated.

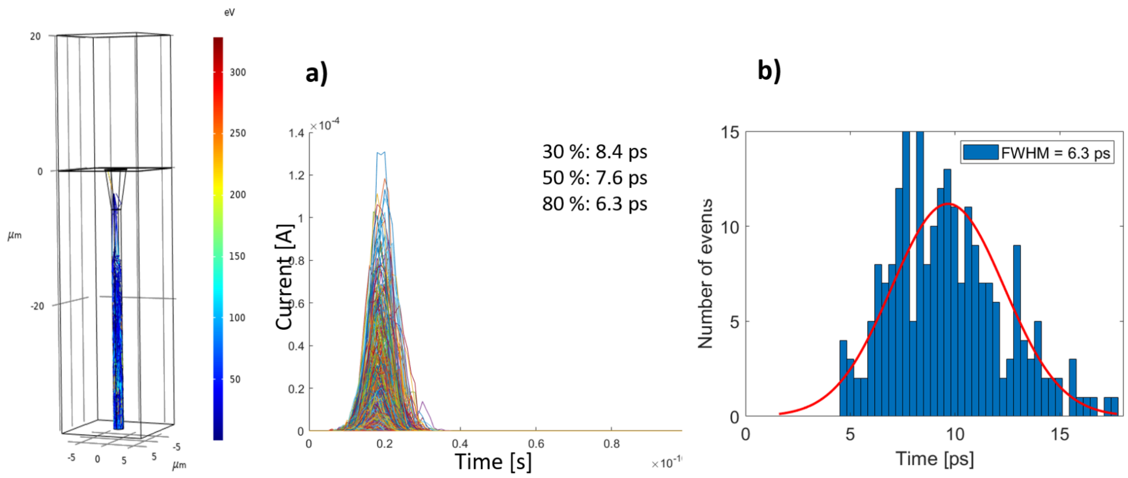
1. In Part Time Resolution Measurements, these results seem to be all about the timing resolution of the AMCP, what about the timing characteristics of the f-AMCPs.

Thank you for your question regarding the timing characteristics of the funnel-shaped AMCPs (f-AMCPs). At the time these measurements were conducted the f-AMCPs were not yet ready for measuring. Timing measurements on the f-AMCPs are planned for the near future; however, it is essential to first address the issue of electrical breakdown to ensure safe operation and to protect sensitive equipment, such as amplifiers, during these measurements. So far, simulations indicate that the current funnel diameter should not significantly impact timing resolution. We have added a few sentences about the timing characteristics of the f-AMCP in the conclusion section and added the simulation results to the supplementary material.

Additionally, you can see them here: Simulation of the timing characteristics of straight channel AMCP and f-AMCPs.




Simulation results for an AMCP with aspect ratio 25. The geometry and particle trajectories for one run can be seen in the left image. a.): Resulting current for each run and calculated time resolution. b.): Arrival time distribution at a threshold of 80 \% of the signal amplitude.




Simulation of a funnel AMCP without any additional coatings. Left: Geometry and example of a particle trajectory. a.): Resulting current for each run and calculated time resolution. b.): Arrival time distribution at a threshold of 80 \% of the signal amplitude.

In Fig. 3 (d), the rise time of the waveform seems to be much shorter than the other three. Why?

The shorter rise time observed in this configuration is due to the placement of the amplifier directly inside the vacuum chamber, close to the AMCP output. This proximity minimises the influence of stray capacitances on the signal and hence leads to a shorter rise time. Additionally, it is important to note that two different amplifiers were used, the second being a custom-built amplifier. We added a brief note on this fact in the manuscript.

Does the risetime have an impact on the final time resolution?

Yes, the rise time of the signal directly influences the timing resolution, as a faster rise time reduces the uncertainty in determining the threshold crossing point. We made sure to emphasise this further in the manuscript.

For better comparison, the measurement with an external amplifier connected; the gold photocathode was removed, AMCP Bias= 300 V, laser intensity = 2 μJ should be added.

We appreciate the suggestion to include a measurement with these conditions (external amplifier, no gold photocathode, AMCP bias 300V, laser intensity 2 uJ). However, these specific measurement conditions were not tested during the study since our AMCPs are usually operated at -500V bias during all measurements. The choice of only using 300V in the fourth measurement was to prevent potential shorts and protect the custom-built LNA used in this configuration. Future studies will explore a broader range of conditions to achieve a more complete picture. Despite this, we believe that the measurements we have presented still provide strong evidence that the time resolution is significantly improved with an internal amplifier since we were able to achieve resolutions comparable to the best results obtained with the external amplifier despite the gain being significantly lower.

Line 339 “This fact can be explained by the relationship between the SNR and the time resolution [26].” How about the SNR of the AMCP in the measurement of Fig.3.

We added all the Signal-to-Noise Ratios to Fig.3

2. Line 350 “Hence, at the lowest beam intensity, there should be, on average, less than one photoelectron per channel” Does this indicate that this MCP is capable of single-photon detection?

In this experimental setup, while conditions were achieved where less than one photoelectron per channel was expected on average, the signal was generated by measuring several thousand channels in parallel. True single-photon detection has not yet been realised with the current version of AMCPs. Although theoretically feasible, current limitations—such as the low detection efficiency in straight-channel AMCPs—pose challenges. Additionally, achieving reliable single-photon detection would require higher gain to ensure a sufficient signal-to-noise ratio. Ongoing advancements aim to overcome these obstacles by enhancing AMCP gain, introducing funnel-shaped channel architectures, and integrating high-efficiency photocathodes, paving the way for single-photon detection in future iterations of the technology. We clarified this point in the discussion part of the manuscript.

3. As the authors mentioned “SiPMs are the dominant photodetectors used in ToF PET.” It is advised that a comprehensive performance comparison be conducted between SiPM and MCP for specific applications.

We have rewritten parts of the discussion section to make a more comprehensive comparison between the two technologies.

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

The manuscript has been revised in line with the previous comments, and all concerns have been thoroughly addressed. The revised version is well-written and presents the research clearly and effectively. I recommend accepting the manuscript for publication.

Reviewer #2 (Remarks to the Author):

I think this article has been revised in accordance with the comments and recommend that it be accepted.

We again thank the reviewers for their time and effort- There are no more issues to be addressed.