

Generating and testing flying focus laser pulses with Lasy for PICoGPU simulations

—A Bachelors Defense—

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Plan

- Why? DLWFA (mention tweac)

- Flying focus in PICoGPU

- Lasy + implementation

- Flying focus doesn't work - why?

- tests

- tests

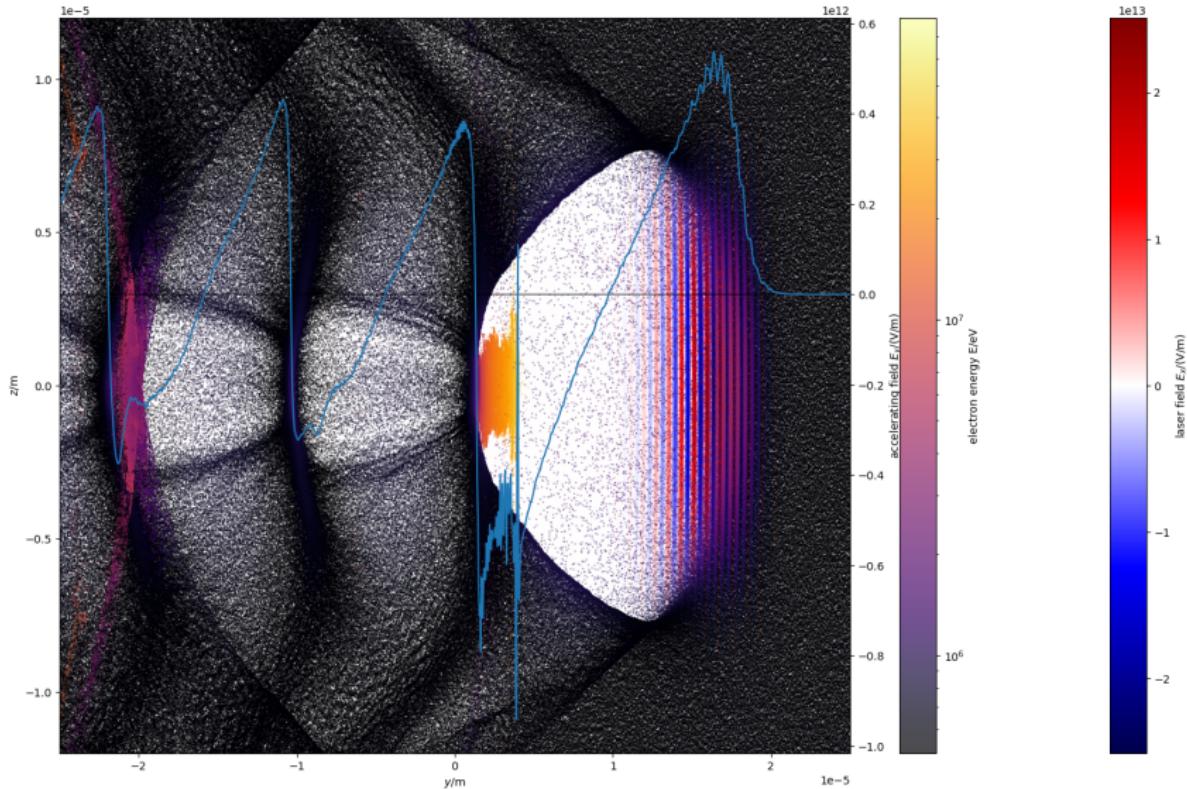
- Conclusion

- why doesn't it work

- Now Lasy lasers available in
PICoGPU

- back to LWFA

LWFA [5]



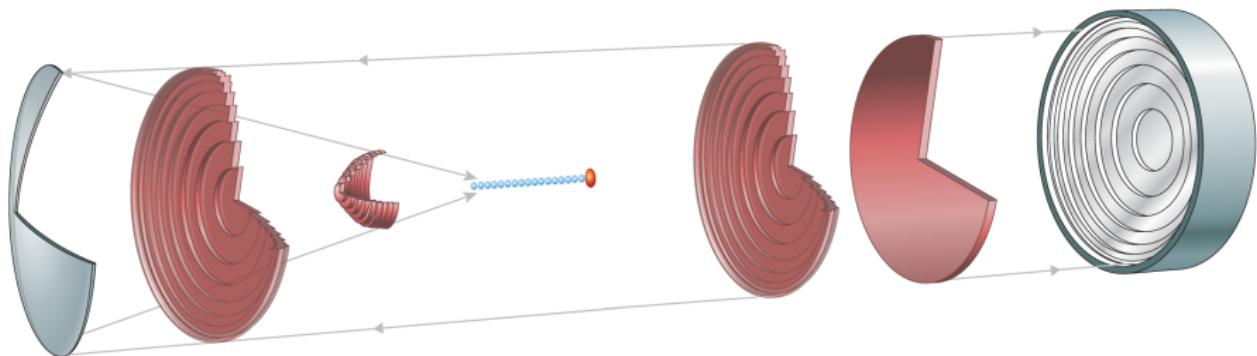
Electric field and electrons in an LWFA simulation.

Properties of flying focus lasers

- tweac
- axiparabola

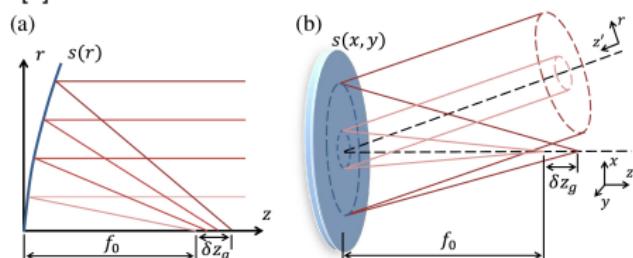
Images:

Flying focus lasers



The flying focus setup. Image taken from Palastro et al [3].

- Built from an axiparabola and a radial group delay echelon (RGD)
- Axiparabola:
 - Focuses light onto a line
 - ?
- RGD:
 - ?

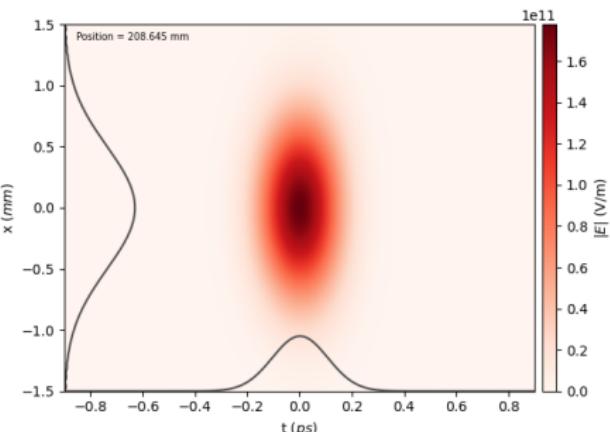
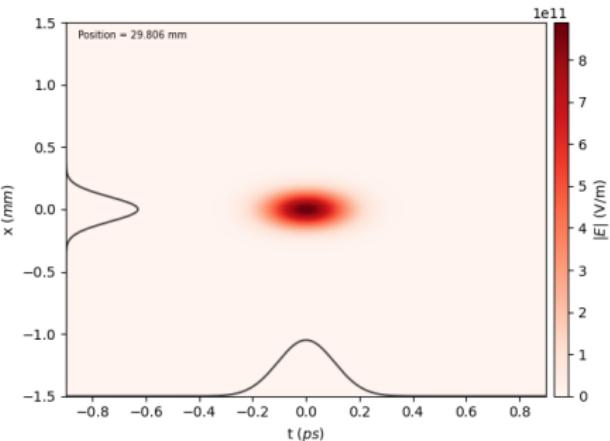


Axiparabola functionality. Image taken from Smartsev et al [4].

Lasy [1]

- A python library for simulating Laser pulses in a vacuum
- Uses complex envelope of the laser field
- angular spectrum propagation

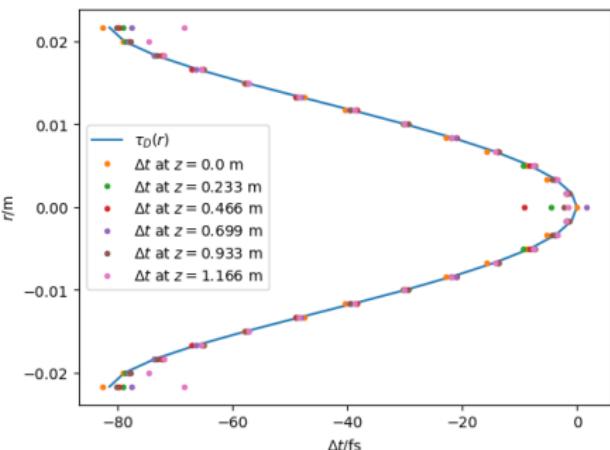
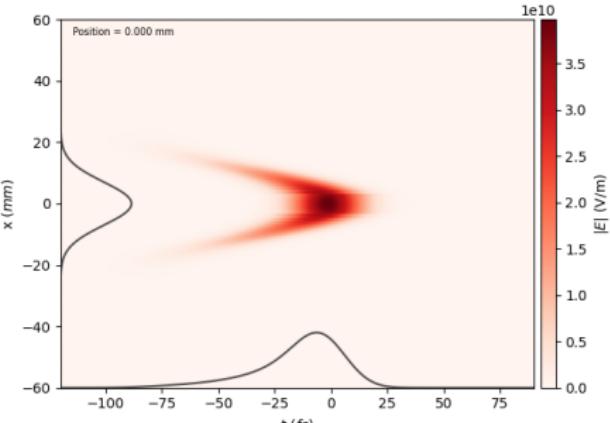
Images: Example of a Gaussian pulse being propagated by Lasy. Top: generated at the focus, Bottom: $6 z_R$ after the focus.



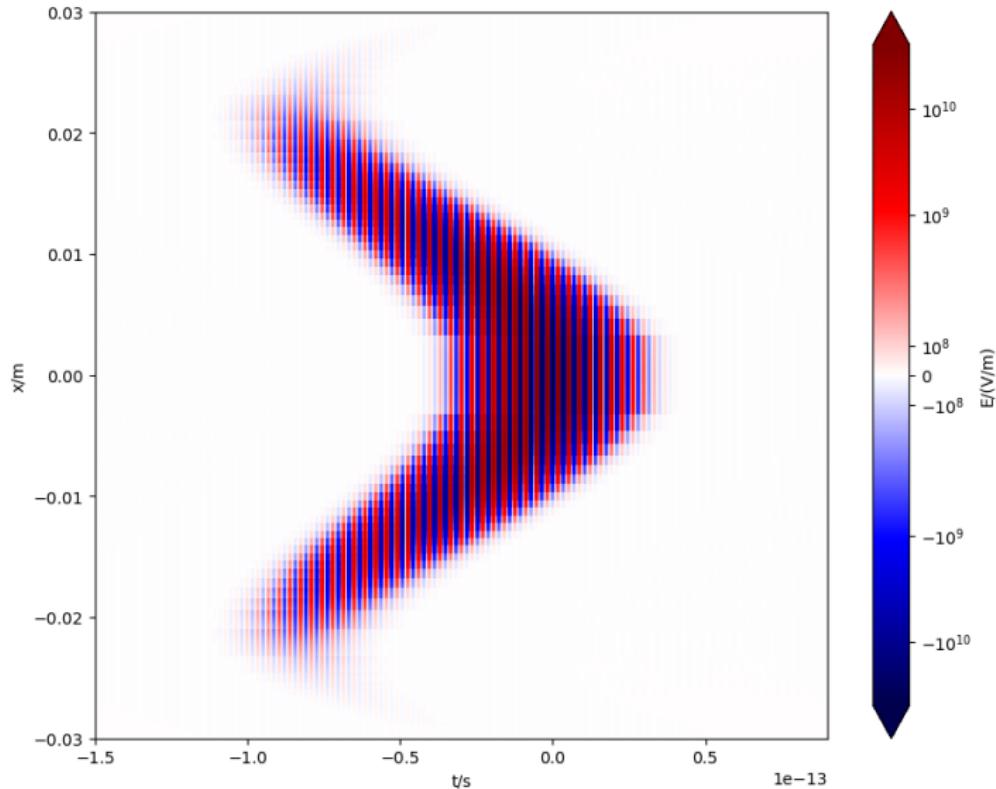
Implementing the flying focus: RGD

- Implemented from scratch as Lasy optical element
- Following the description by Ambat et al [2]
- Shapes the pulse temporally without focusing or defocussing

Images: A Gaussian pulse after interacting with the RGD. Top: field envelope, Bottom: Test results. even after long distances the shape still holds.



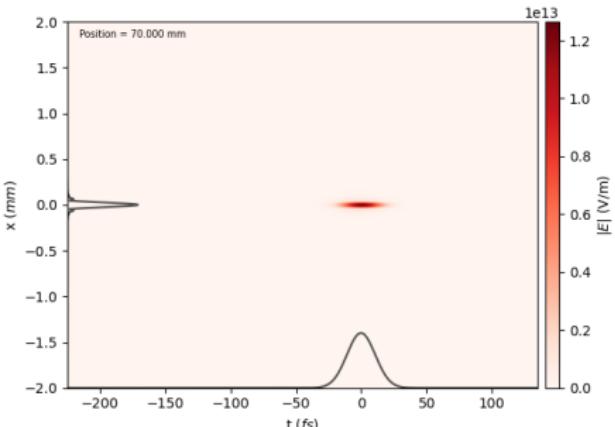
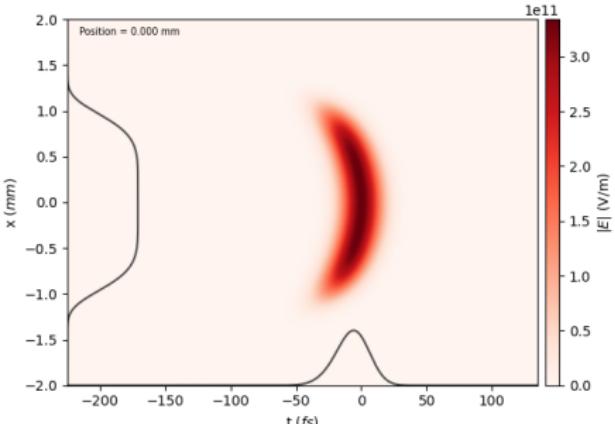
Implementing the flying focus: RGD



The electric field of the laser after interacting with the RGD.

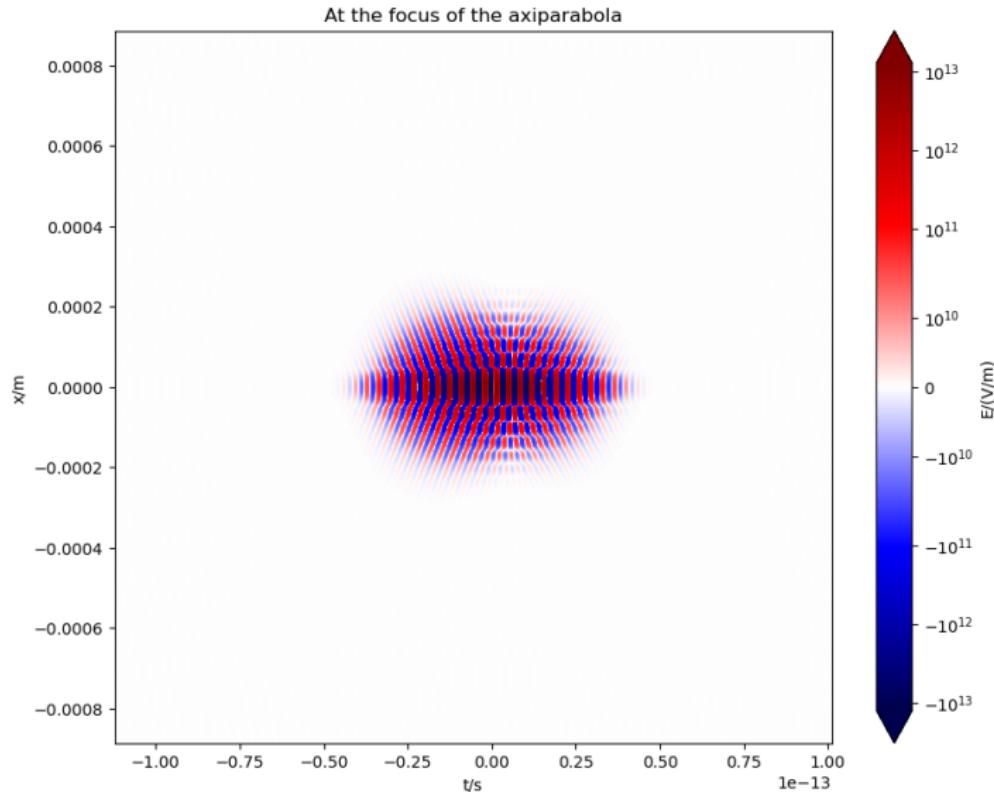
Implementing the flying focus: Axiparabola

- Included in Lasy
- Following Smartsev et al [4]
- ?



Images: A super-Gaussian laser pulse after reflecting off the axiparabola. Top: in the near field, Bottom: in the far field at the beginning of the focus region.

Implementing the flying focus: Axiparabola



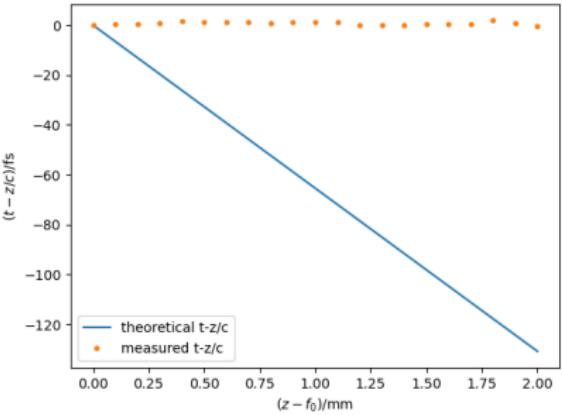
The electric field of the laser at the beginning of the focus region of the axiparabola.

Importing to PICoGPU

- New module `full_field`
- Generates full electric field and saves it using openPMD-api
-

Images:

Testing the flying focus laser: First results



Testing the flying focus laser:

Remaining Possible reasons for failure

- The Axiparabola
- The Propagation
- The Findings in the other papers

Outlook

- Lasy lasers available in PICoGPU

→ ...

- LWFA with new laser setups
possible

References (I)

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Accessed october 2025.
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Phys. Rev. Letters, 124, 2020.
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