Bachelors defense

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Contents

Plan

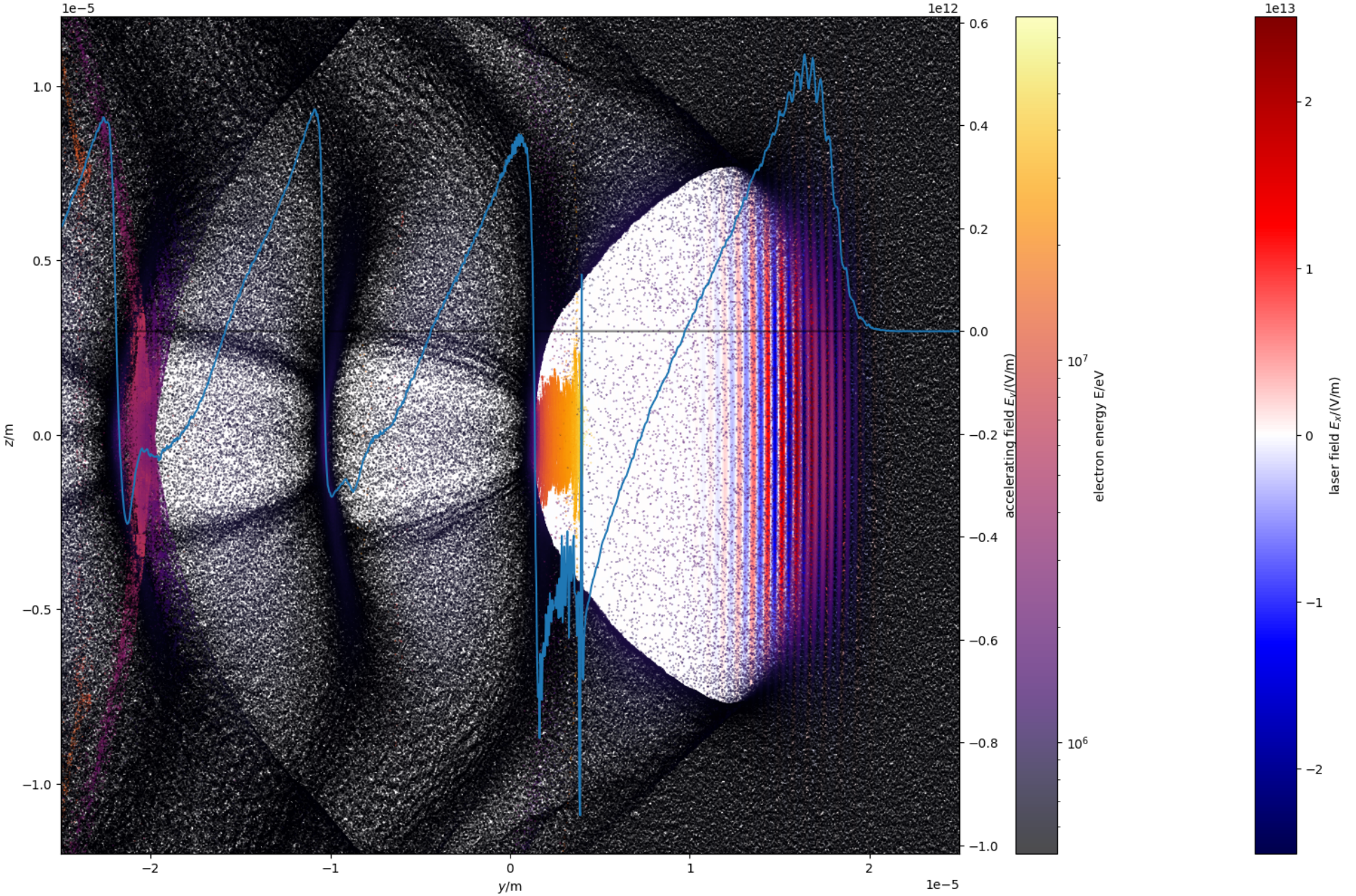
My idea

- Motivation LWFA
- Flying focus as solution?
- programs
- Lasy lasers in PIConGPU
- flying focus laser simulations
- Summary
- What now?

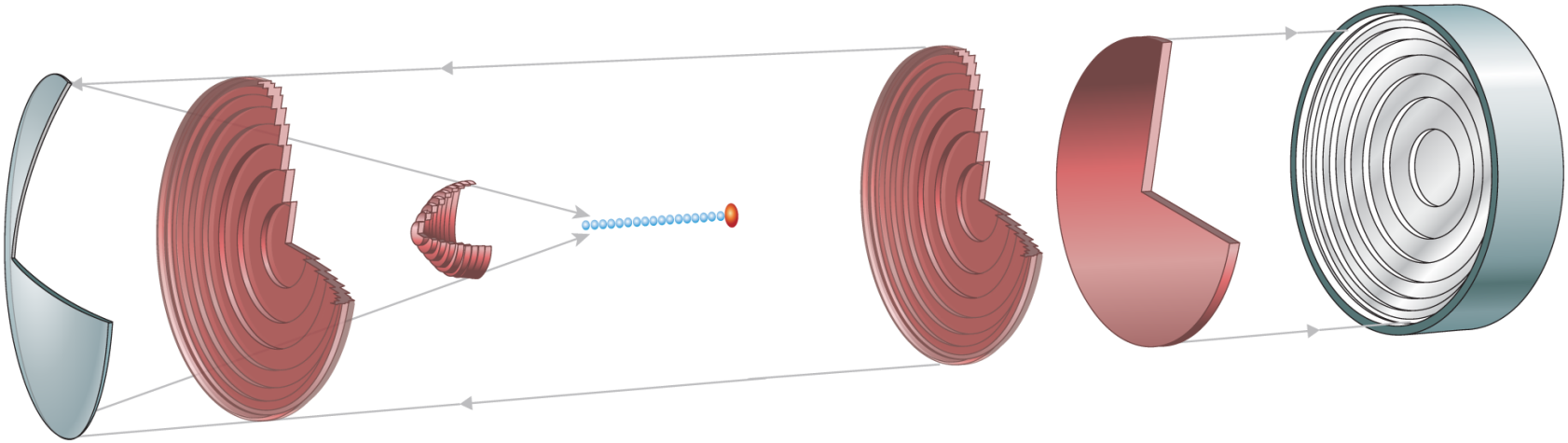
With Jessicas help

- Why? DLWFA
- Flying focus in PIConGPU
- Lasy + implementation
- Flying focus doesnt work - why?
  - tests
  - tests
- Conclusion
  - why doesnt it work
  - Now Lasy lasers available in PIConGPU
  - back to LWFA

LWFA [5]

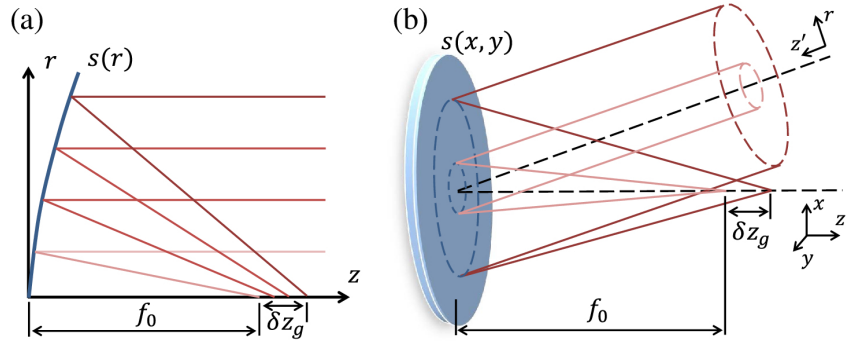

1e−5
1e12
1e13
1.0
0.5
0.0
−0.5
−1.0
z/m
−2
−1
0
1
2
y/m
1e−5
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
accelerating field E_x/(V/m)
10^7
10^6
electron energy E/eV
2
1
0
−1
−2
laser field E_x/(V/m)

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:
  - ?

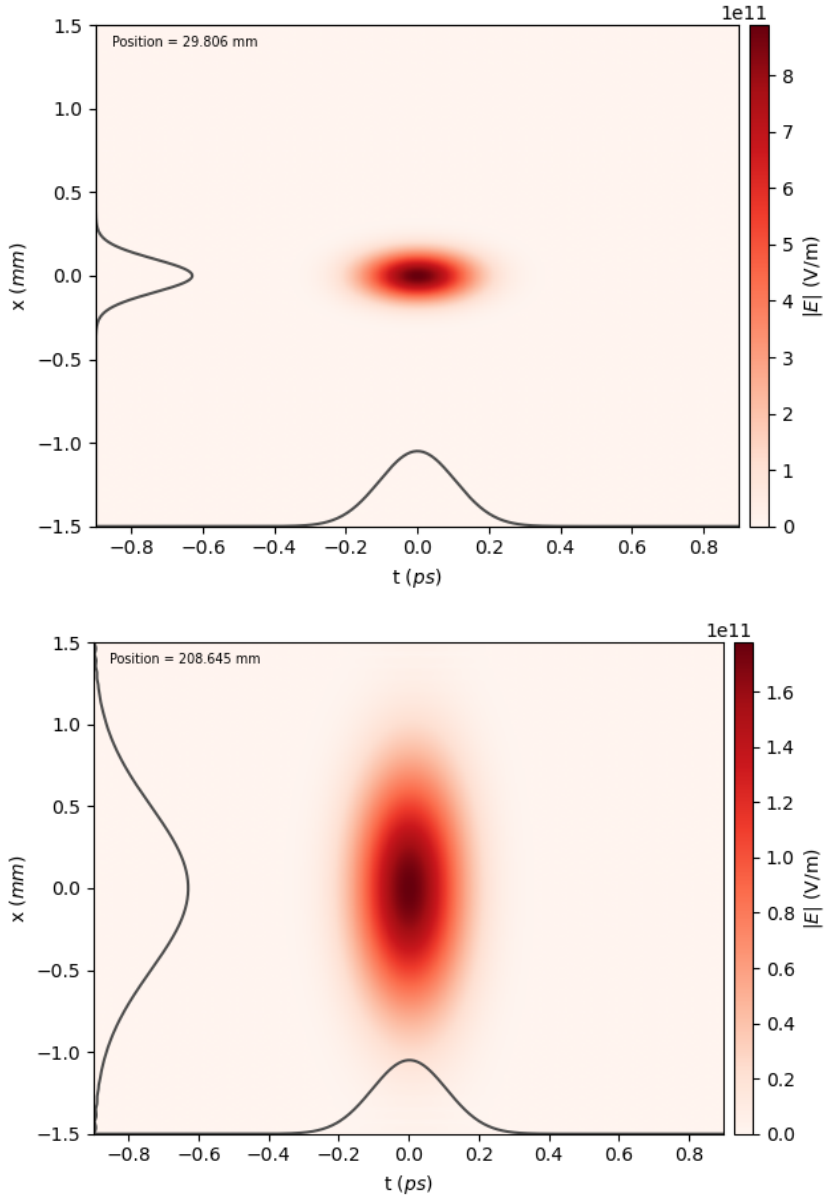


Axiparabola functionality. Image taken from Smartsev et al [4].

More flying focus stuff?

Lasy [1]

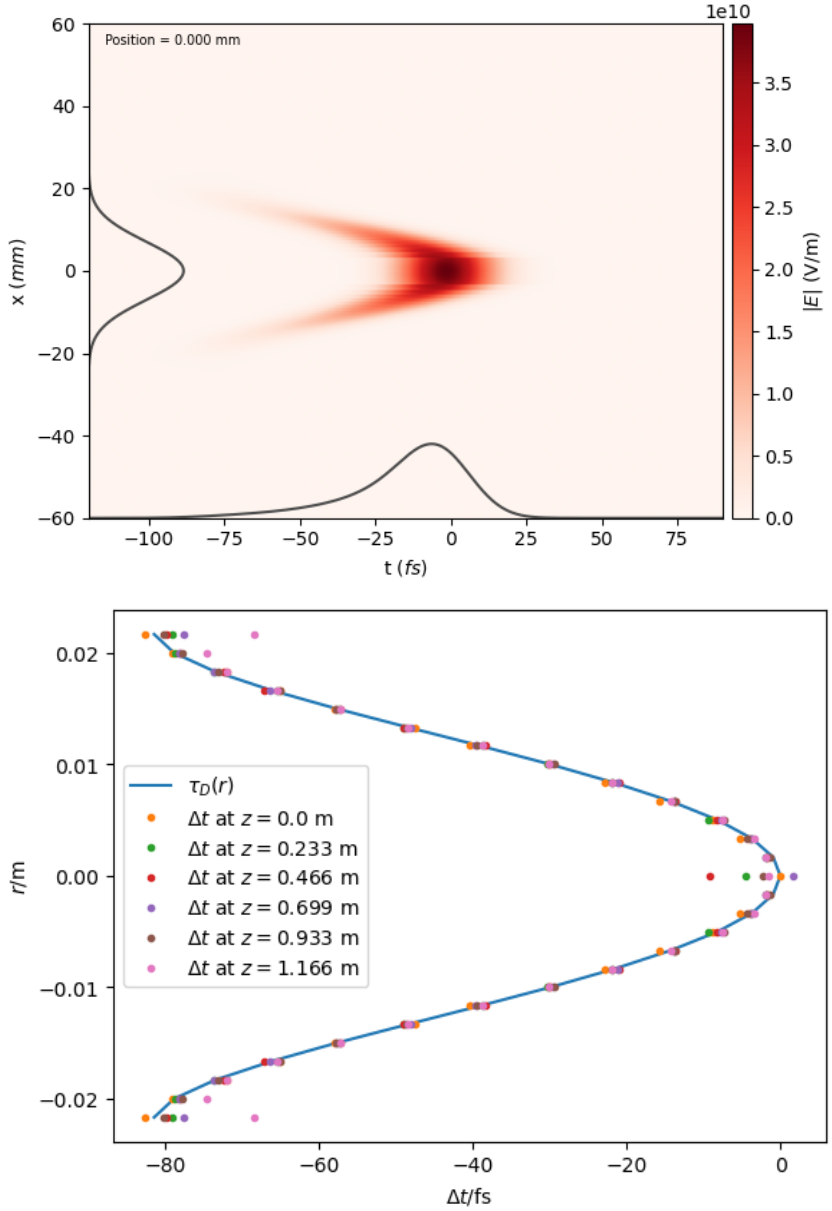
- A python library for simulating Laser pulses in a vacuum
- Uses complex envelope of the laser field
- angular spectrum propagation



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

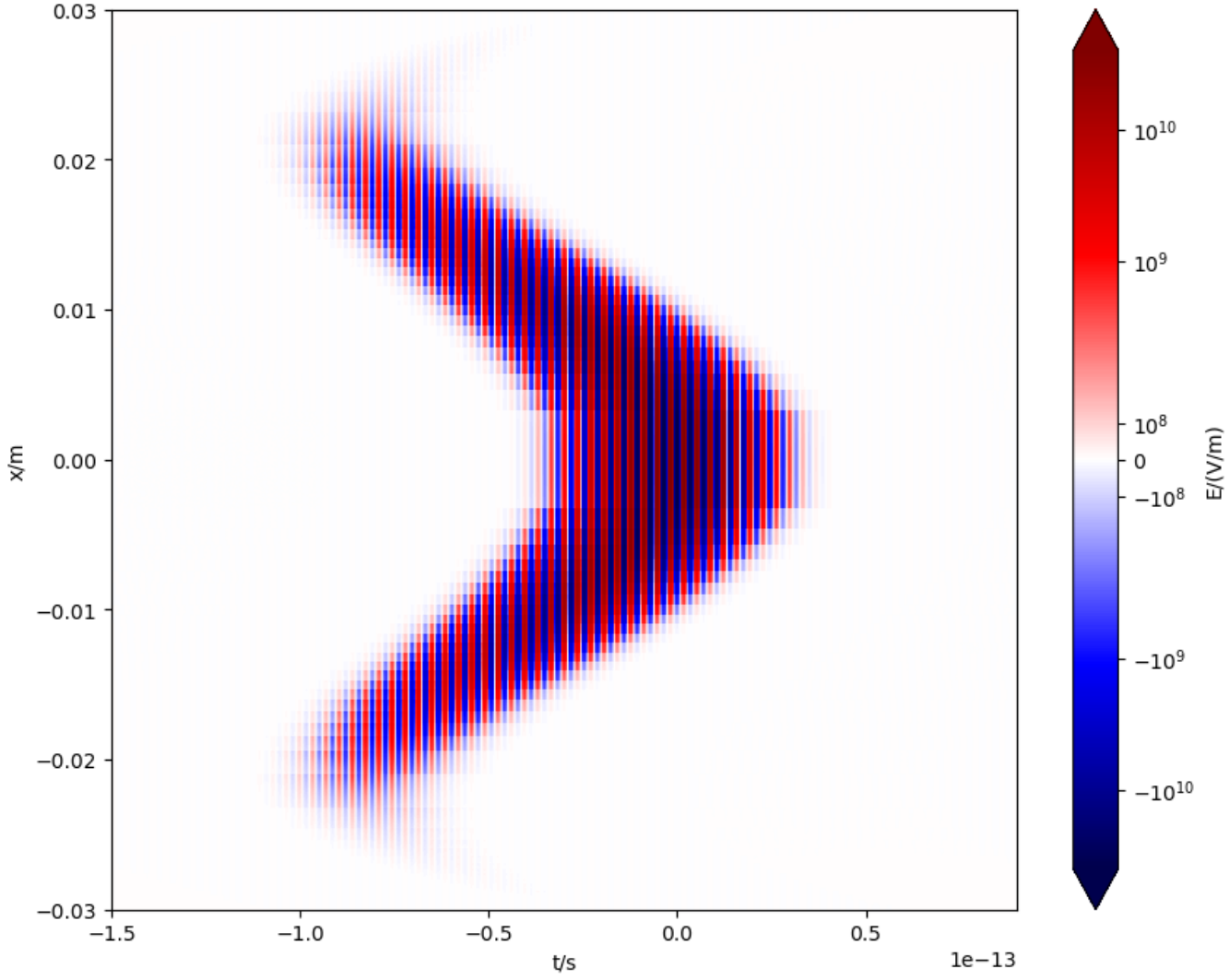
Implementing the flying focus: RGD

- 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.

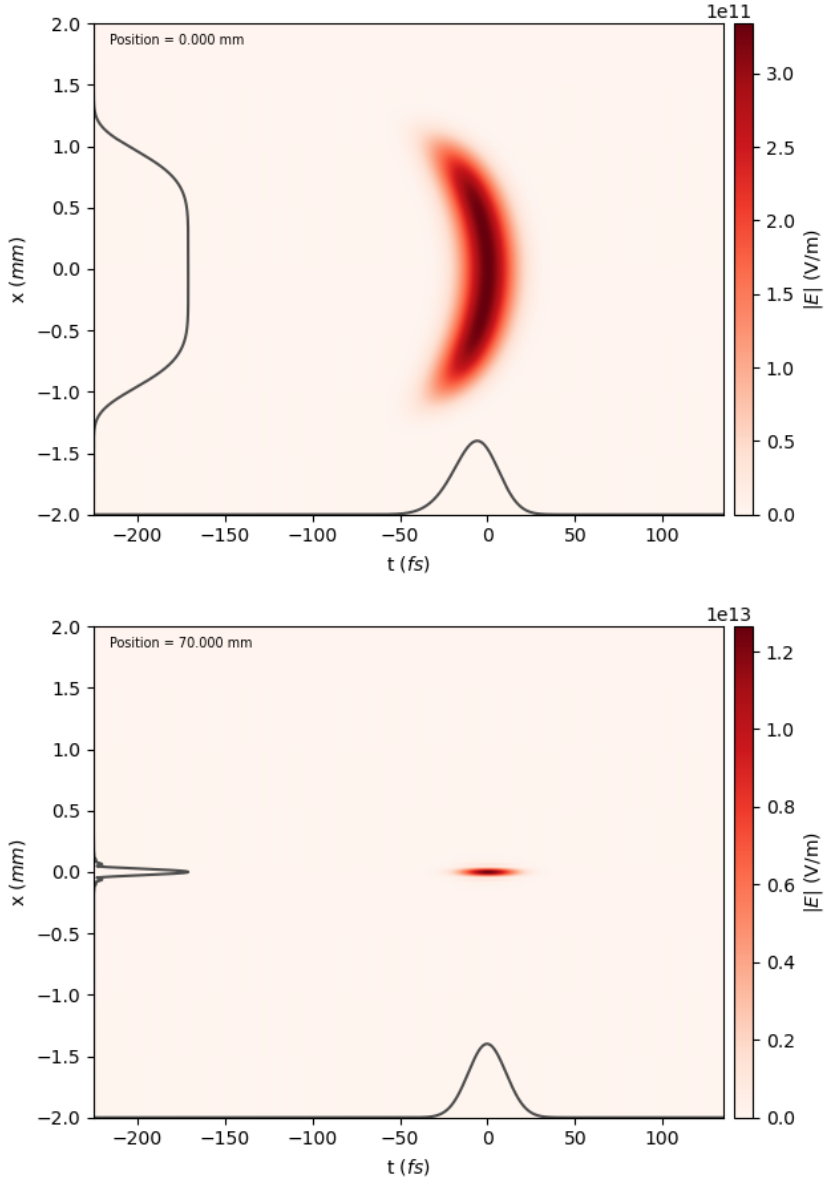
Implementing the flying focus: RGD



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

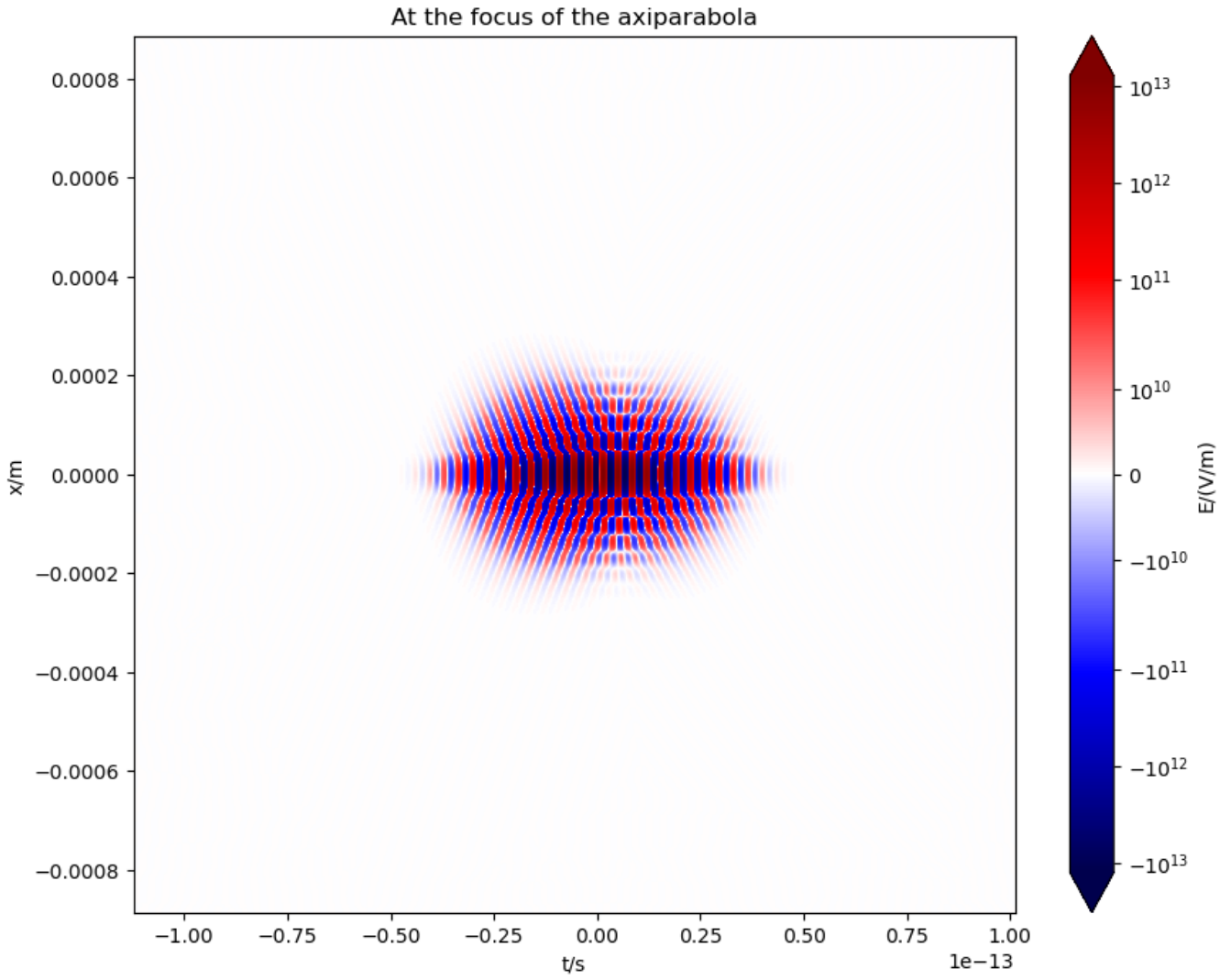
Implementing the flying focus: Axiparabola

- 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 PIConGPU

- New module `full_field`
- ...

Test 1

Test 2

Remaining Possible reasons for failure

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

Now Lasy lasers available in PIConGPU

Back to LWFA?

References I


Lasy 0.6.2 documentation.
`https://lasydoc.readthedocs.io/en/latest`.
Accessed october 2025.


M. V. Ambat, J. L. Shaw, J. J. Pigeon, K. G. Miller, T. T. Simpson, D. H. Froula, and J. P. Palastro.
Programmable-trajectory ultrafast flying focus pulses.
Optics Express, 31(19), 2023.


J. P. Palastro, J. L. Shaw, P. Franke, D. Ramsey, T. T. Simpson, and D. H. Froula.
Dephasingless laser wakefield acceleration.
Phys. Rew. Letters, 124, 2020.

References II

Slava Smartsev, Clement Caizergues, Kosta Oubrerie, Julien Gautier, Jean-Philippe Goddet, Amar Tafzi, Kim Ta Phuoc, Victor Malka, and Cedric Thaury.
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Optics Letters, 44, 2019.

T Tajima and JM Dawson.
Laser electron-accelerator.
Physical Review Letters, 43(4), 1979.