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

— A Bachelors Defense —

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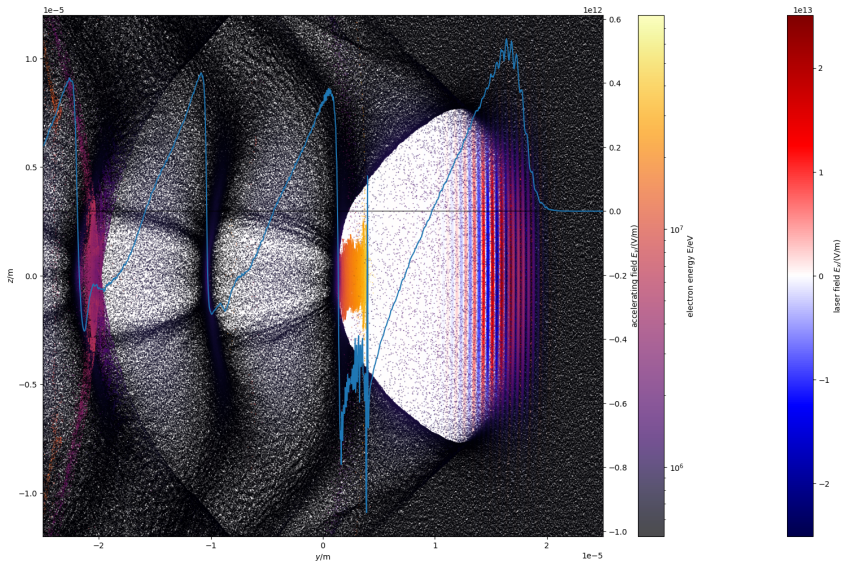
Contents

- 1 DLWFA
- 2 Flying focus lasers in PIconGPU
- 3 Testing the flying focus laser
- 4 Conclusion and Outlook
- 5 References



- Why? DLWFA (mention tweac)
- 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]



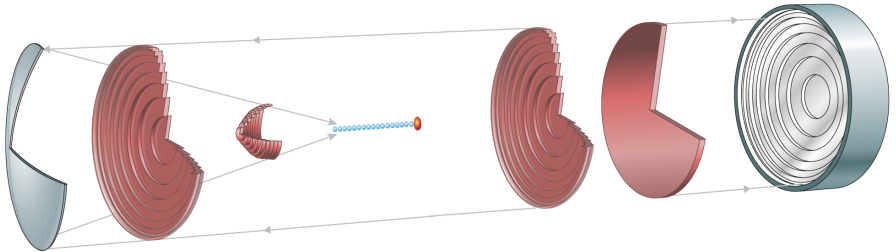
Electric field and electrons in an LWFA simulation.

Properties of flying focus lasers

- tweac
- axiparabola

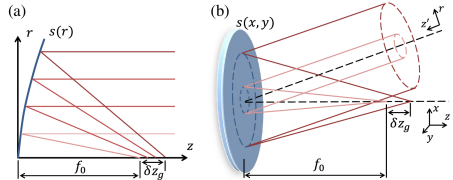
Images:

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:
 - ?

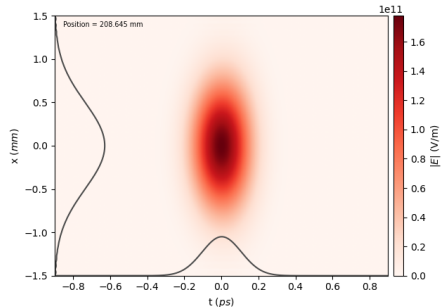
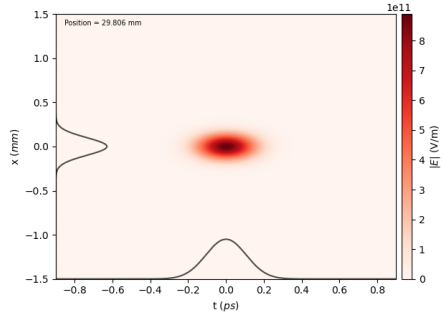


Axiparabola functionality. Image taken from Smartsev et al [4].

Lasy [1]

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

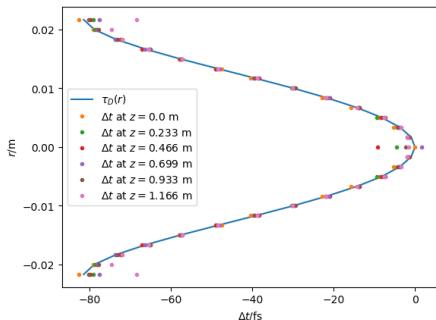
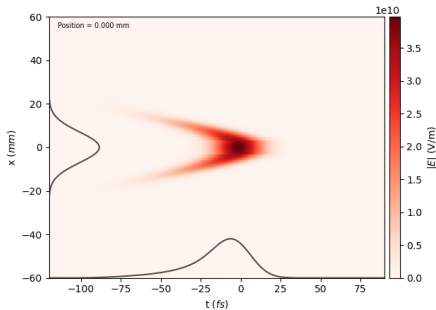
Images: Example of a Gaussian pulse being propagated by Lasy. Top: generated at the focus, Bottom: $6 z_R$ after the focus.



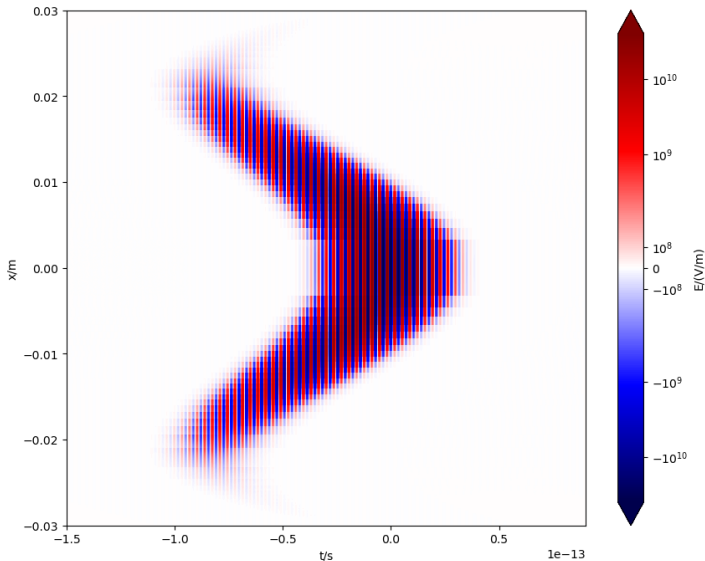
Implementing the flying focus: RGD

- 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

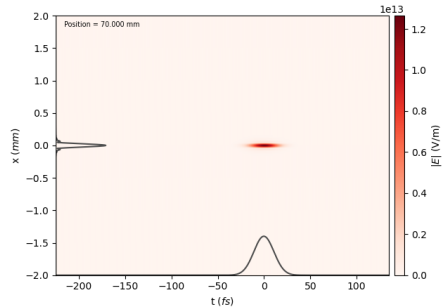
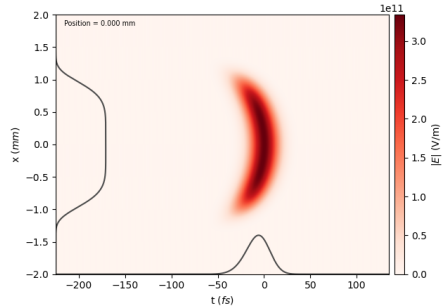


The electric field of the laser after interacting with the RGD.

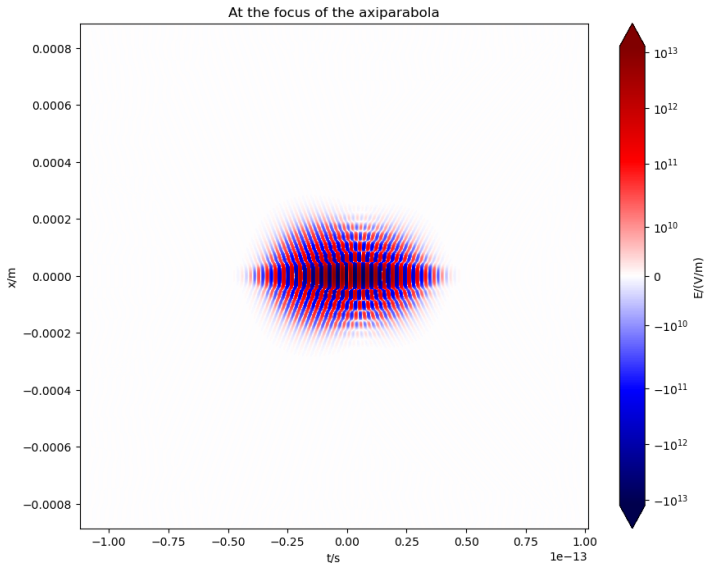
Implementing the flying focus: Axiparabola

- 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



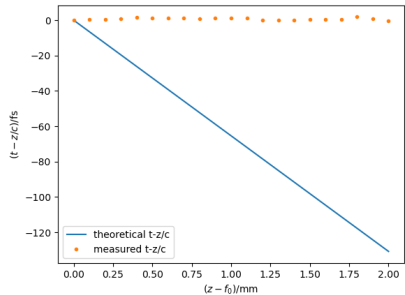
The electric field of the laser at the beginning of the focus region of the axiparabola.

Importing to PIConGPU

- 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

- Lasy lasers available in PIconGPU

→ ...

- LWFA with new laser setups possible

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. Rev. Letters, 124, 2020.



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

Axiparabola: a long-focal-depth, high-resolution mirror for broadband high-intensity lasers.

Optics Letters, 44, 2019.

References (II)



T Tajima and JM Dawson.

Laser electron-accelerator.

Physical Review Letters, 43(4), 1979.