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

— A Bachelors Defense —

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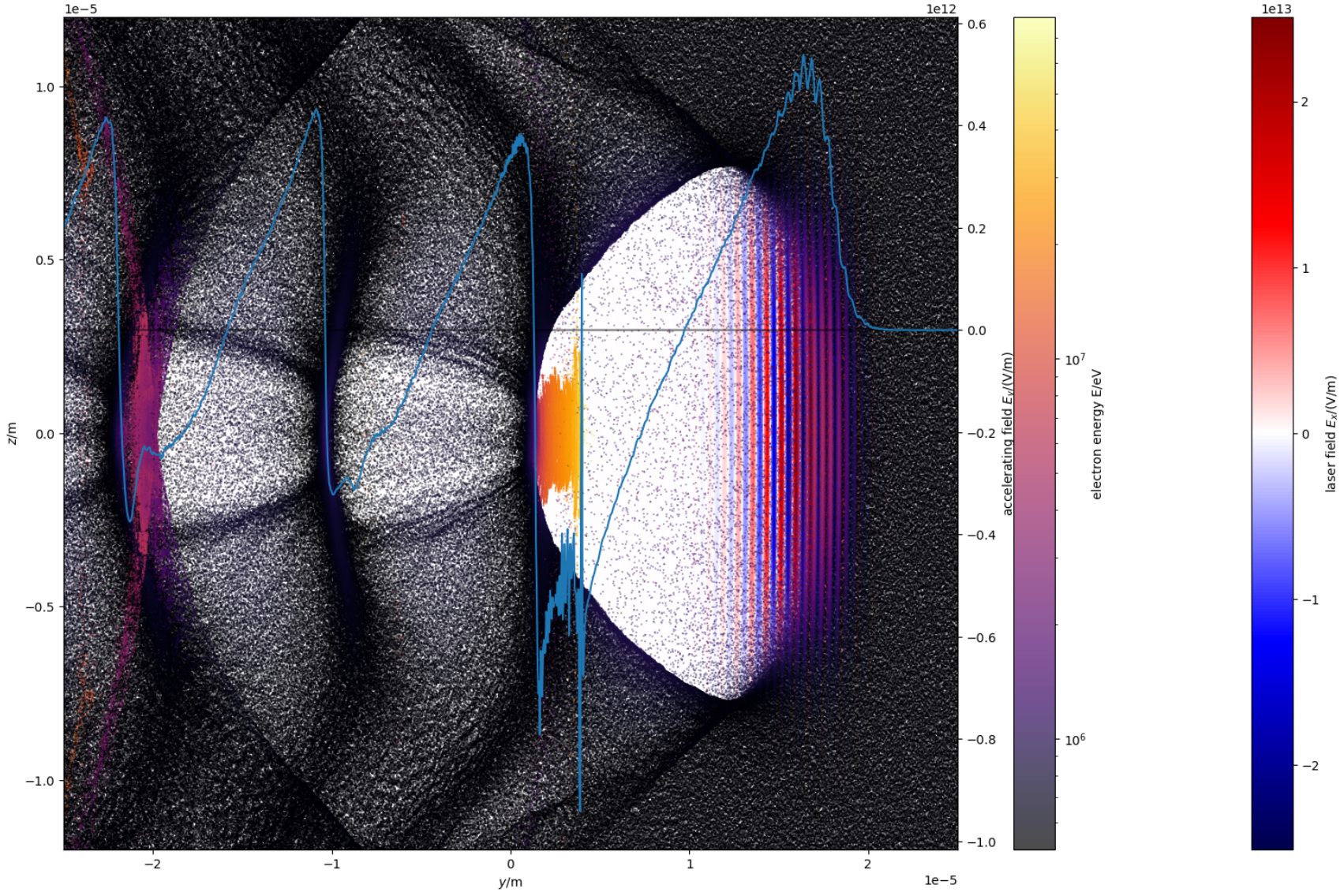
Laser WakeField Acceleration (LWFA) [6]



Electric field and electrons in an LWFA simulation.

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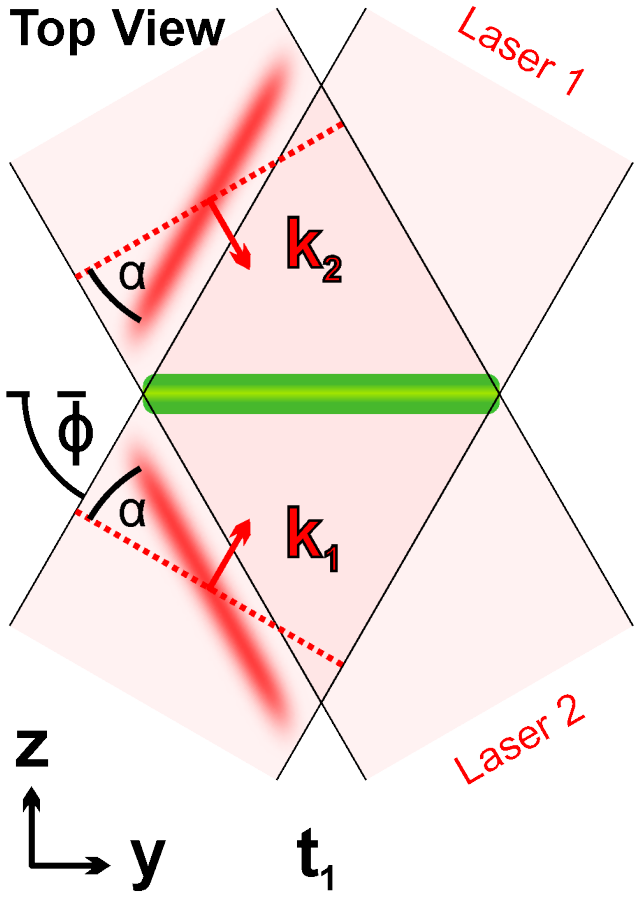
Flying focus lasers – solving the Problem of Dephasing

1. TWEAC

- tweac [2]
- traveling-wave electron accelerator



Images: TWEAC setup using two laser pulses. Image taken from Debus et al [2]

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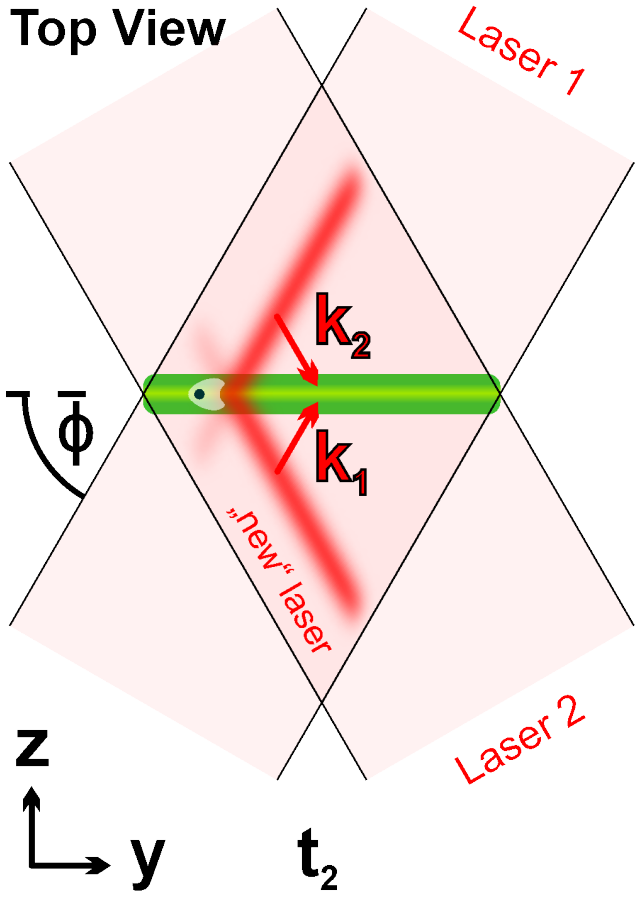

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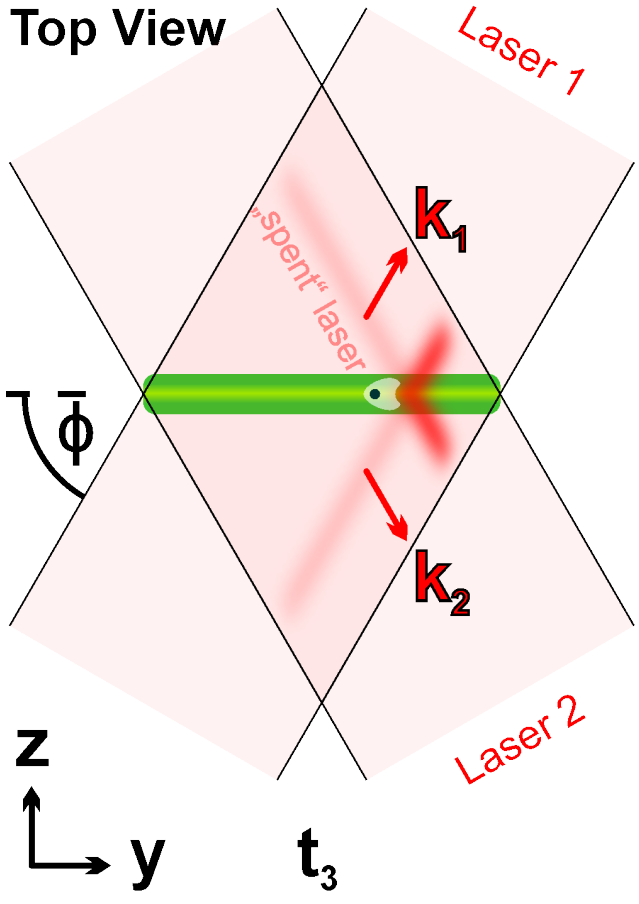

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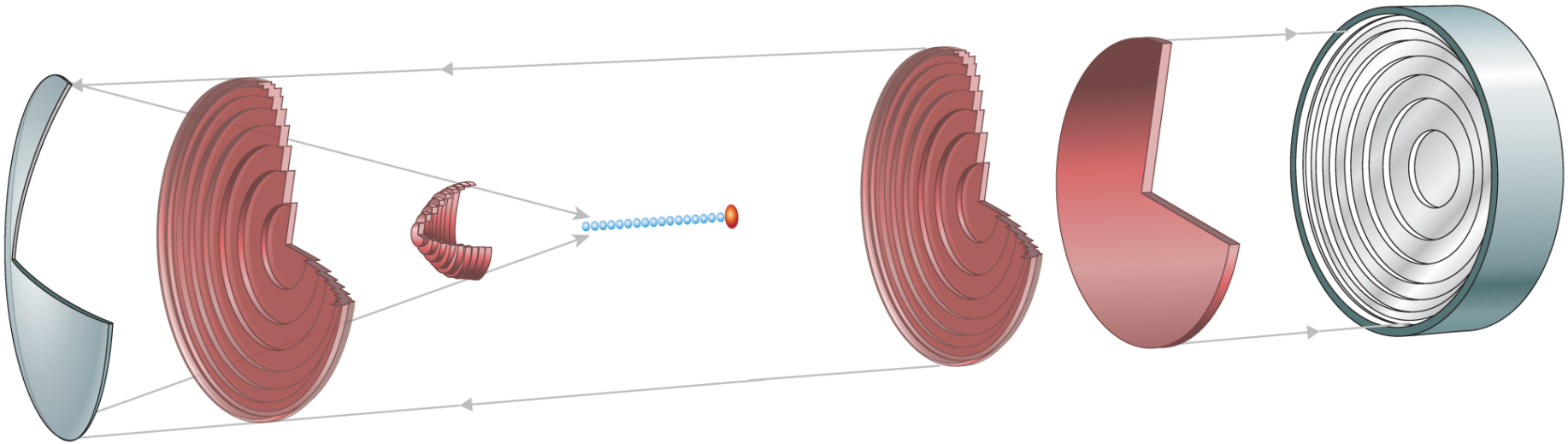
Flying focus lasers – solving the Problem of Dephasing

2. Axiparabola laser

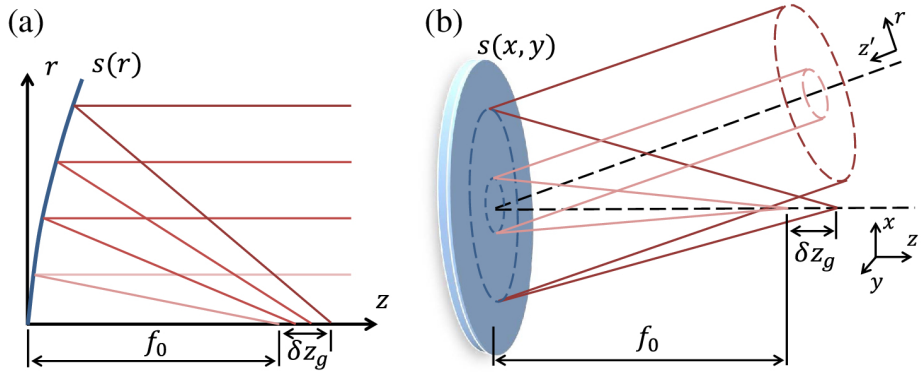


The flying focus setup. Two optical elements: The Axiparabola (left) and the RadialGroup Delay echelon (RGD) (right). Image taken from Palastro et al [4].

Flying focus lasers – solving the Problem of Dephasing

2. Axiparabola laser

- Axiparabola:
  - Focuses light onto a line
  - ?
- RGD:
  - ?

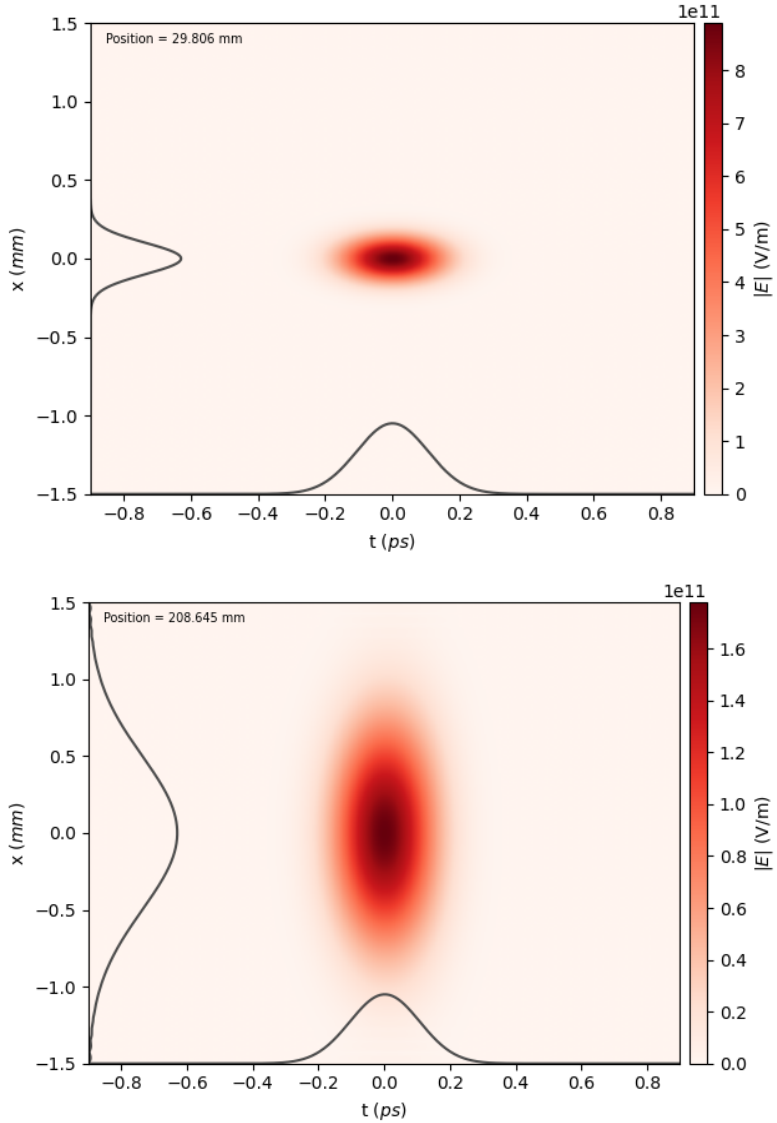


Axiparabola functionality. Image taken from Smartsev et al [5].

Images:

Lasy [3]
A python library

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

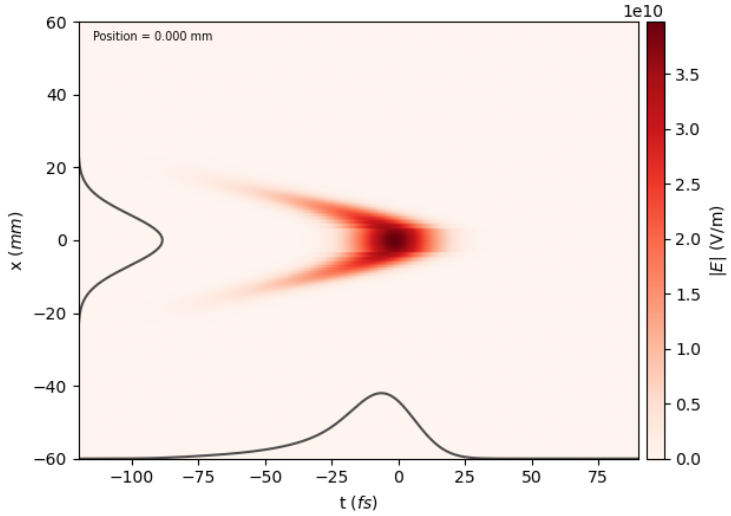


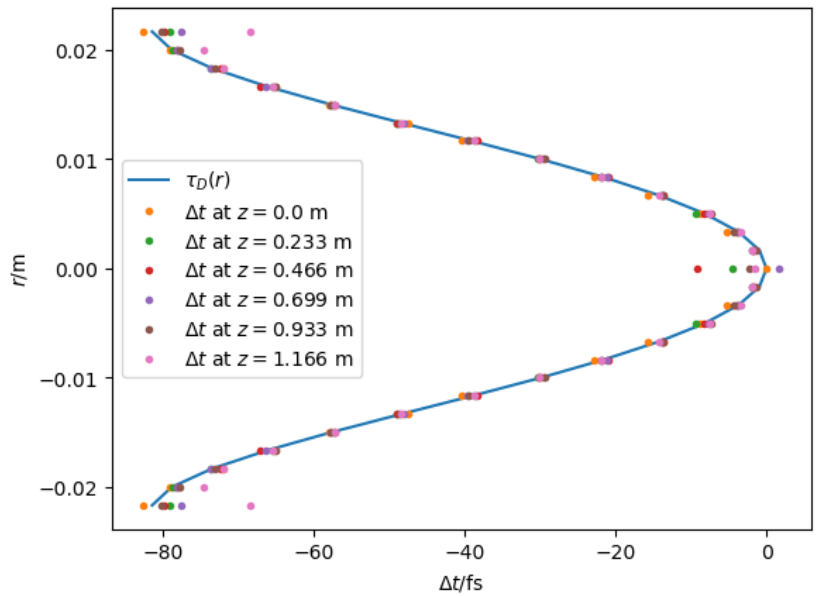
Images: Example of a Gaussian pulse being propagated by Lasy. Top: generated at the focus, Bottom: 6 z_R after the focus.

Implementing the flying focus

1. The Radial Group delay echelon (RGD)

- Implemented from scratch as Lasy optical element
- Following the description by Ambat et al [1]
- 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.

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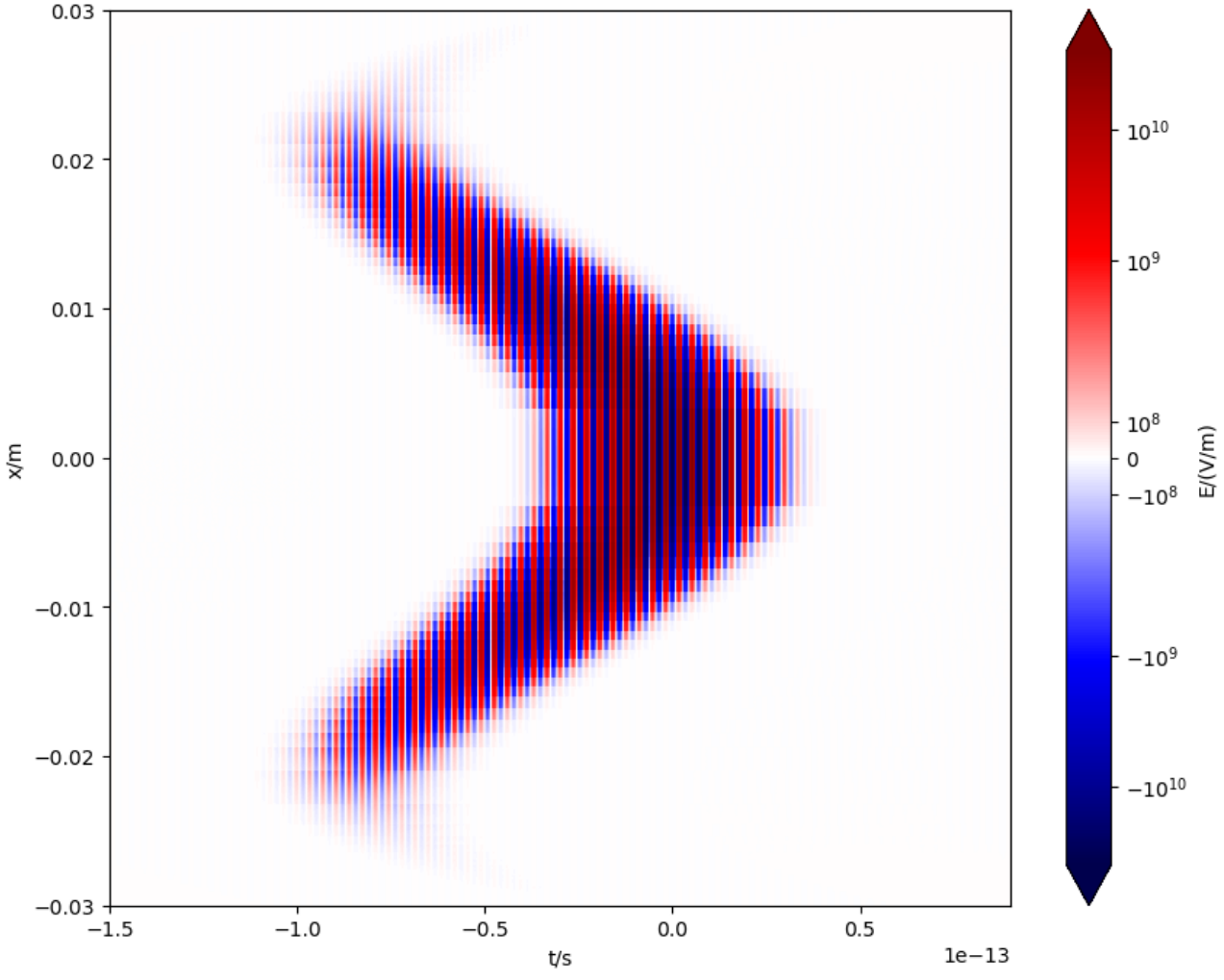
Implementing the flying focus

1. The Radial Group delay echelon (RGD)

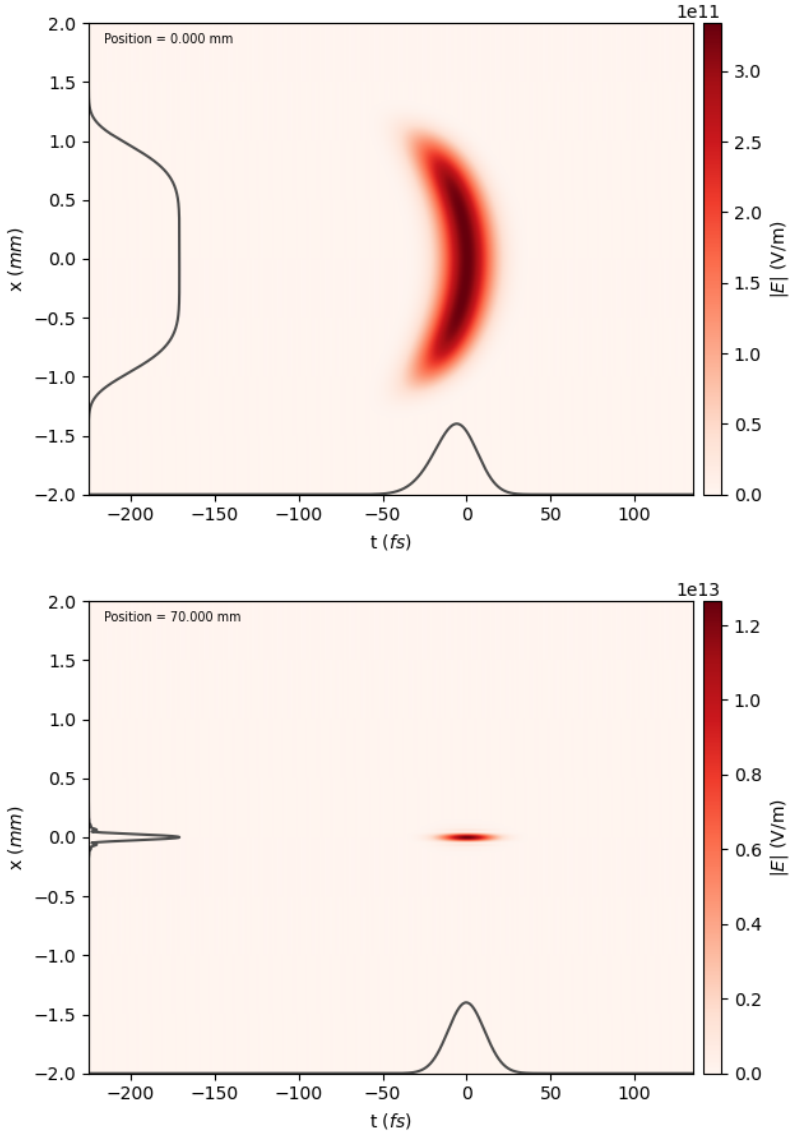


The electric field of the laser after interacting with the RGD.

Implementing the flying focus

2. The Axiparabola

- Included in Lasy
- Following Smartsev et al [5]
- ?



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.

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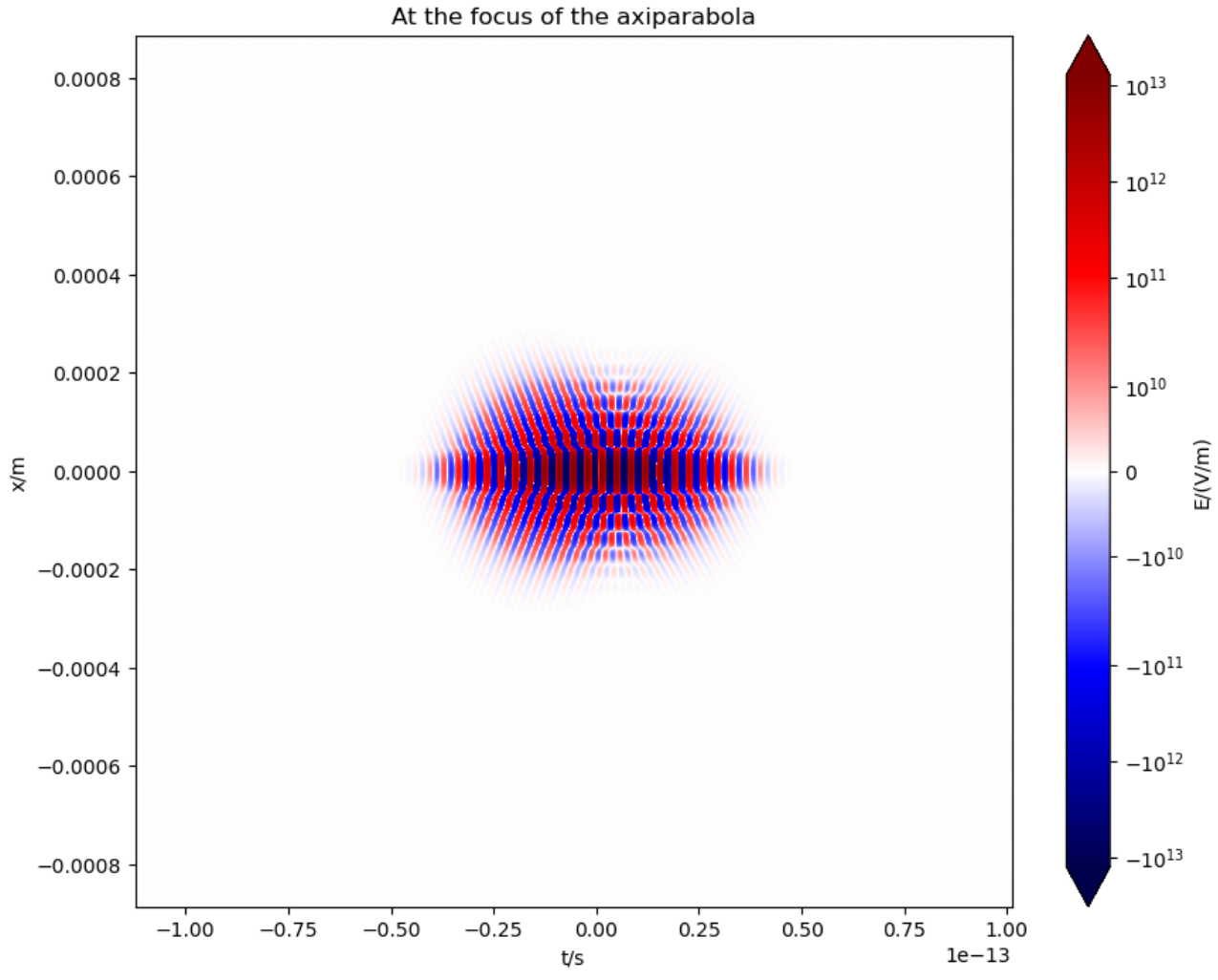
Implementing the flying focus

2. The Axiparabola



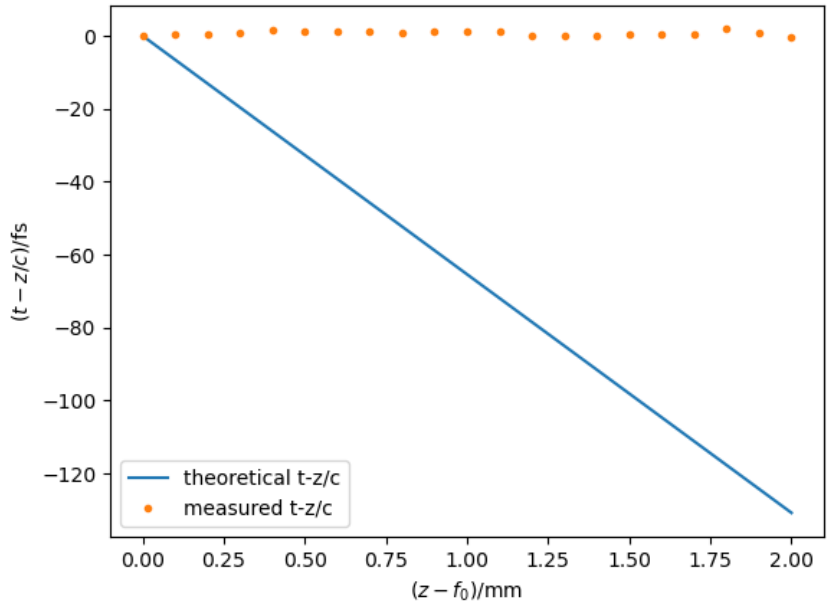
The electric field of the laser at the beginning of the focus region of the axiparabola.

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:

Conclusion

Remaining Possible reasons for failure

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

Outlook

?

- Lasy lasers available in PIConGPU

→ ...

- LWFA with new laser setups possible

References (I)


M. V. Ambat, J. L. Shaw, J. J. Pigeon, K. G. Miller, T. T. Simpson, D. H. Froula, and J. P. Palastro.
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References (II)

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