# Large Energy Depletion of a Beam Driver in a Plasma-Wakefield Accelerator

F. Peña\*, C. A. Lindstrøm, J. Beinortaite, J. Björklund Svensson, L. Boulton, S. Diederichs, J. M. Garland, P. González, G. Loisch, S. Schröder, M. Thévenet, S. Wesch, J. Wood, J. Osterhoff, and R. D'Arcy

1. Importance of efficiency

Accelerating gradients

- State-of-the-art radiofrequency accelerators: 100 MV/m
- Plasma-Wakefield Accelerators: 10 GV/m

 $\rightarrow$  Construction costs can be greatly reduced

## 2. What happens when the first driver electrons are energy depleted?

#### Simulation results with HiPACE++ [3]

Energy depleted electrons slip backwards into the accelerating phase

 $\rightarrow$  Electrons are captured in the accelerating phase and trapped

Reacceleration is deleterious for a witness bunch  $\rightarrow$  Reacceleration is a limit of driver energy depletion





**FLASH**FORWARD

But also running costs need to be low:

Need high total energy transfer efficiency

Combined requirements:

- Efficient driver and witness creation  $\sqrt{}$  (beam driven) •
- High driver to witness energy transfer efficiency  $\sqrt{[1,2]}$

Driver energy depletion **\*** — This poster 



## 4. Properly imaging the energy spectrum

Experimental results



### 3. Energy spectrum of a strongly depleted driver

Experimental results



Need to reconstruct the spectrum with an imaging energy scan

## 5. Drive bunch energy depletion

Experimental results



#### 6. Conclusions

#### Electron reacceleration

- Limit of driver energy depletion and thus overall • energy efficiency in beam-driven PWFA
- Avoidable by shaping the drive bunch •

#### References:

[1] M. Litos et al. (Nature 515, 92-95) 2014 [2] C. A. Lindstrøm et al. (PRL 126, 014801) 2021 [3] S. Diederichs et al., (CPC 278, 108421) 2022

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• Develop charge loss model to correct for charge loss

\* pena@desy.de \_ http://forward.desy.de

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Need proper beam driver beam loading

Charge loss needs to be modelled to better estimate drive bunch energy depletion

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