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Generation of high-quality electron beams from trojan horse injection in a compact plasma accelerator powered by laser-accelerated electron beams

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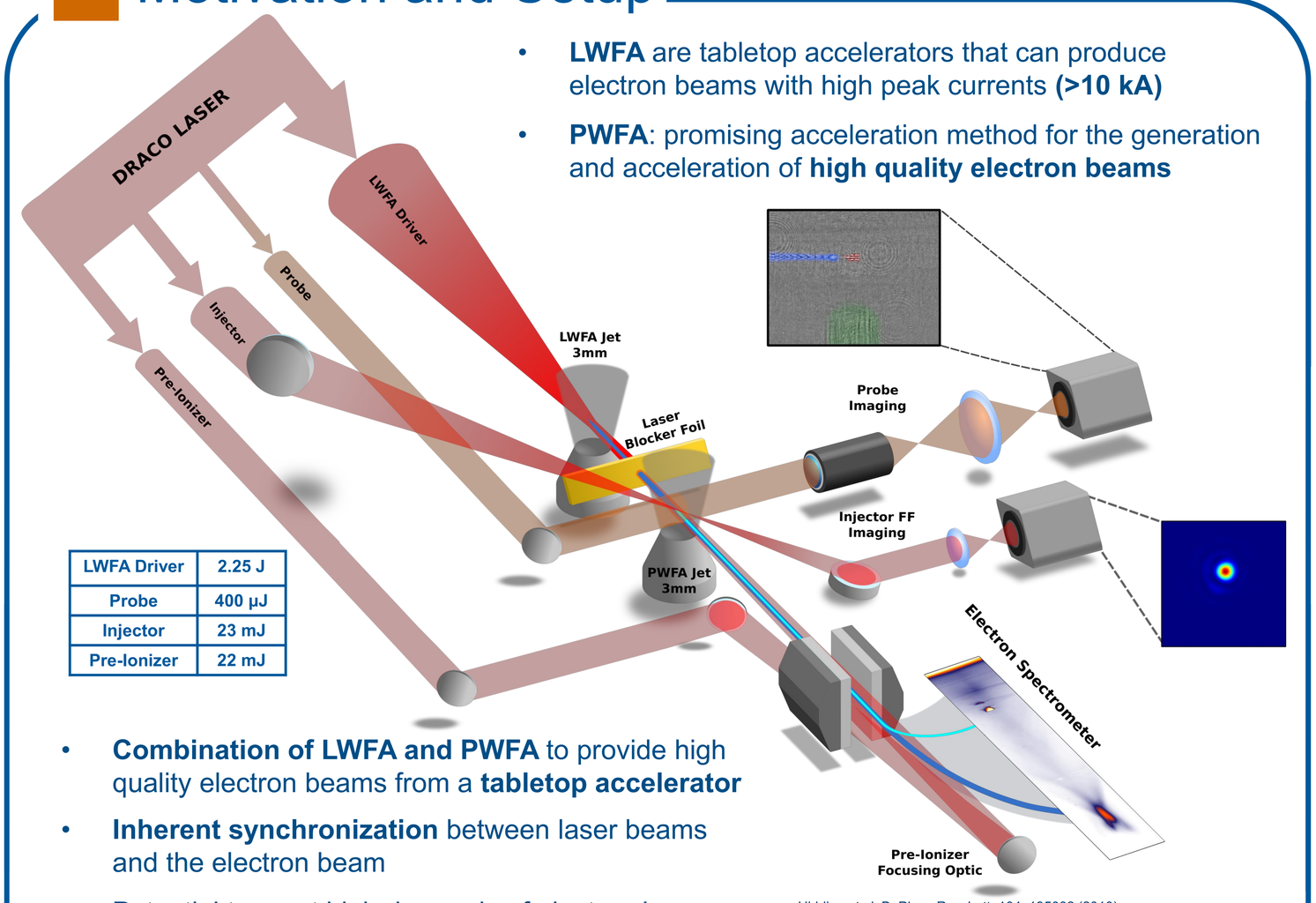
Motivation and Setup



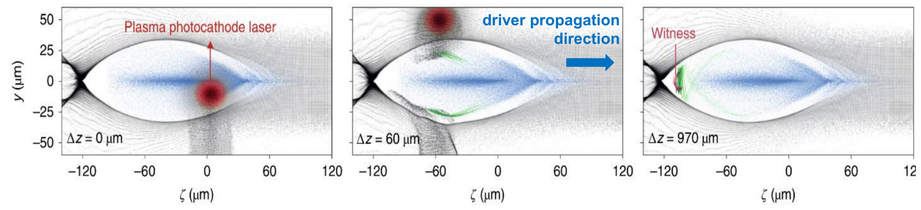
LWFA Driver	2.25 J
Probe	400 µJ
Injector	23 mJ
Pre-Ionizer	22 mJ

- **LWFA** are tabletop accelerators that can produce electron beams with high peak currents **(>10 kA)**
- **PWFA**: promising acceleration method for the generation and acceleration of **high quality electron beams**
- **Combination of LWFA and PWFA** to provide high quality electron beams from a **tabletop accelerator**
- **Inherent synchronization** between laser beams and the electron beam
- Potential to meet high demands of electron beams for **secondary light sources** such as FEL

• Hidding et al. B. Phys. Rev. Lett. 104, 195002 (2010)
• de la Ossa et al. Phil. Trans. R. Soc. A. 0175 (2019)
• Hidding et al, Appl. Sci., 9(13), 2626 (2019)
• J.P. Couperus Cabadağ, et al., Phys. Rev. Research 3, L042005 (2021)
• T. Kurz, T. Heinemann, et al., Nat. Comm. 12, 2895 (2021)

Trojan Horse Injection

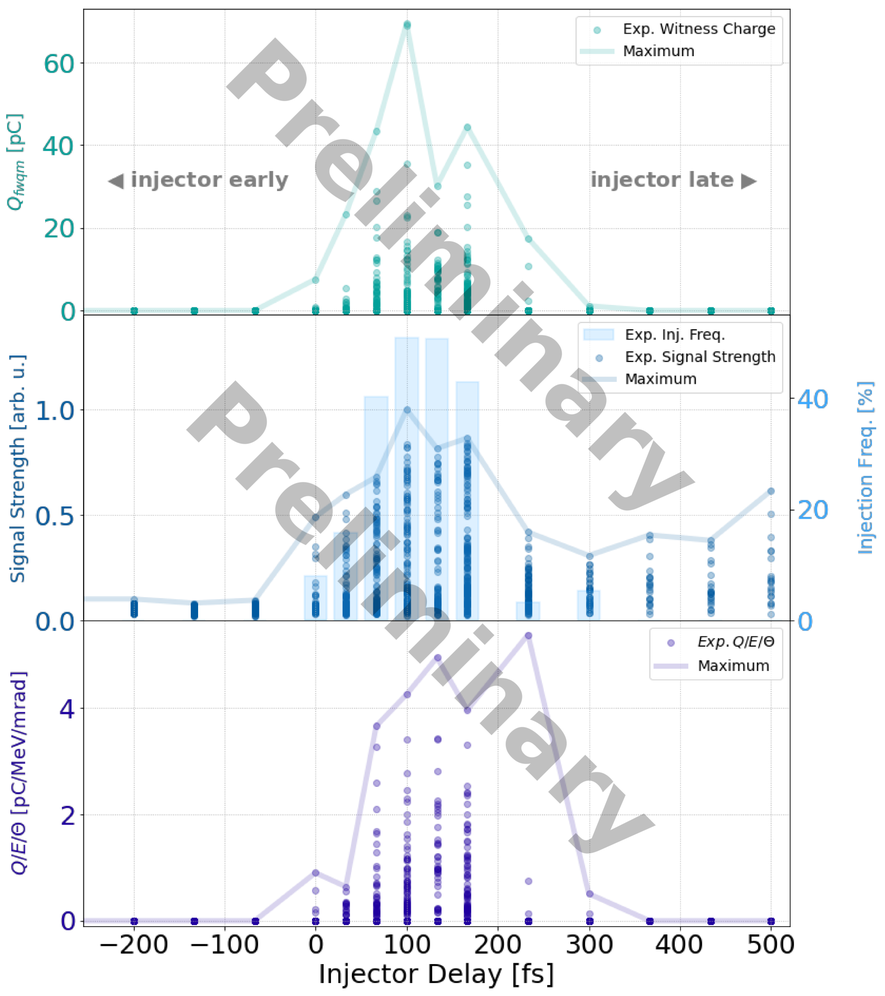
- **Ionization level** in target medium (H + He) **unionized by pre-ionizer** (2nd level of He)
- **Injector laser**, with an intensity j**ust above** this threshold**,** intercepts the **first cavity** of the wakefield (different geometries possible)
- **Electrons** released in the **center of the wakefield** where field strength is zero → injection independent of wakefield excitation
- **low residual momentum** of released electrons allows for the generation of **very low emittance beams**
- Tuning of injector laser properties gives **enhanced injection control**
- High quality witness beams → potential candidate for FEL driver

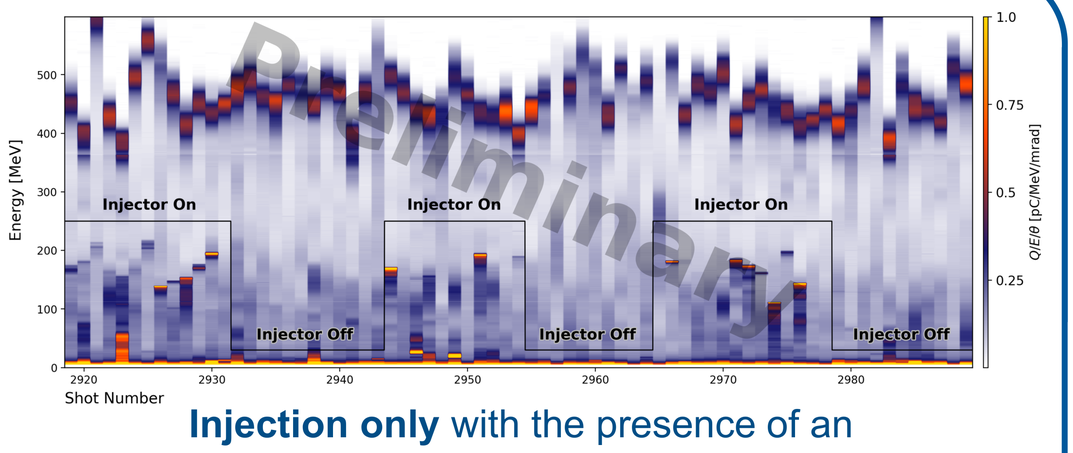


• Deng, et al., Nat. Phys. 15, 1156 (2019)
• Wittig et al. Phys. Rev. ST Accel. Beams 18, 081304 (2015)

Experimental Results

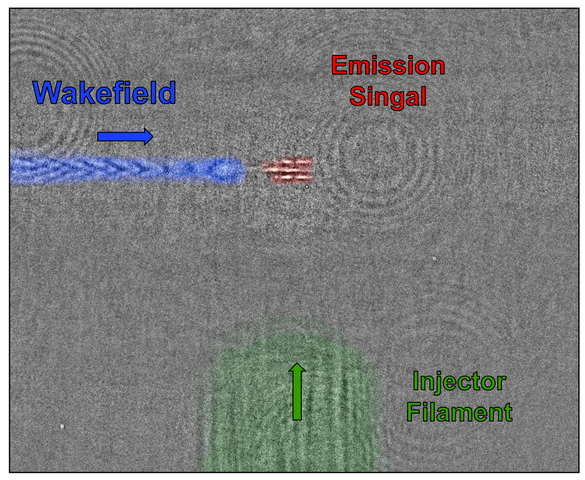
- **Injection** of witness beams in the PWFA stage in a **150fs window** of injector laser timing
- Timing window size corresponds to an **overlap** of **injector laser** and **first cavity** of the wakefield
- **Overlap** of injector laser and cavity **confirmed** with **imaging of the filaments** with a probe beam and with the **emission signal**





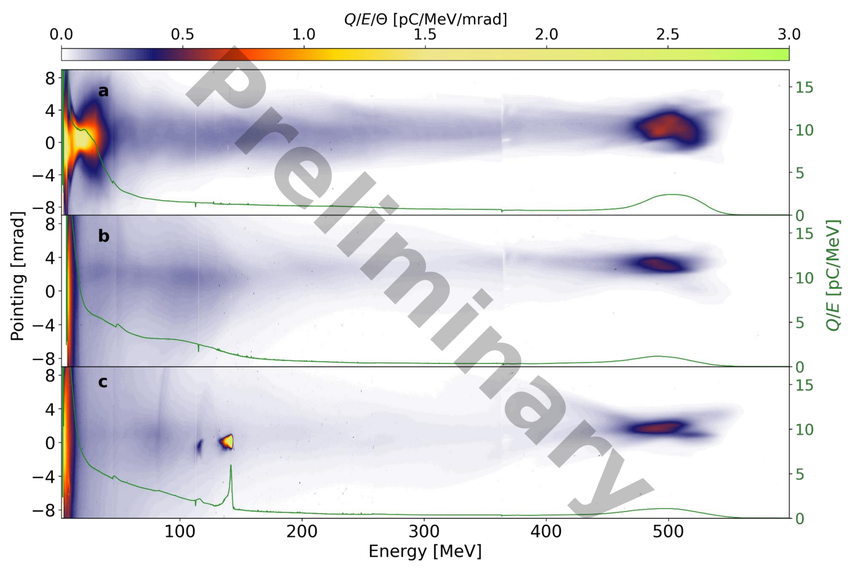
Injection only with the presence of an **ionizable species (He)** and only when the **injector laser** is interacting with the wakefield

Emission signal appearing **probe diagnostic** when injector laser is interacting with the wakefield used as **temporal and spatial alignment tool**



Conclusions

- **First experimental results** of **Trojan Horse injection** in a hybrid LPWFA accelerator
- **Witness beam quality promising** for future usage of the LPWFA concept in apllications like free electron lasers
- **Next step:** improving the **control and stability** of the witness paramters (energy, charge, ionization levels, etc.)



Witness Parameters:

Mean energy:
142 MeV

Energy spread:
2 MeV

Charge (fwhm):
7.8 pC

Divergence (rms):
0.41 mrad

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