

Probing Transient Fields

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Plasma Wakefield Accelerator Group (FLA-PWA)

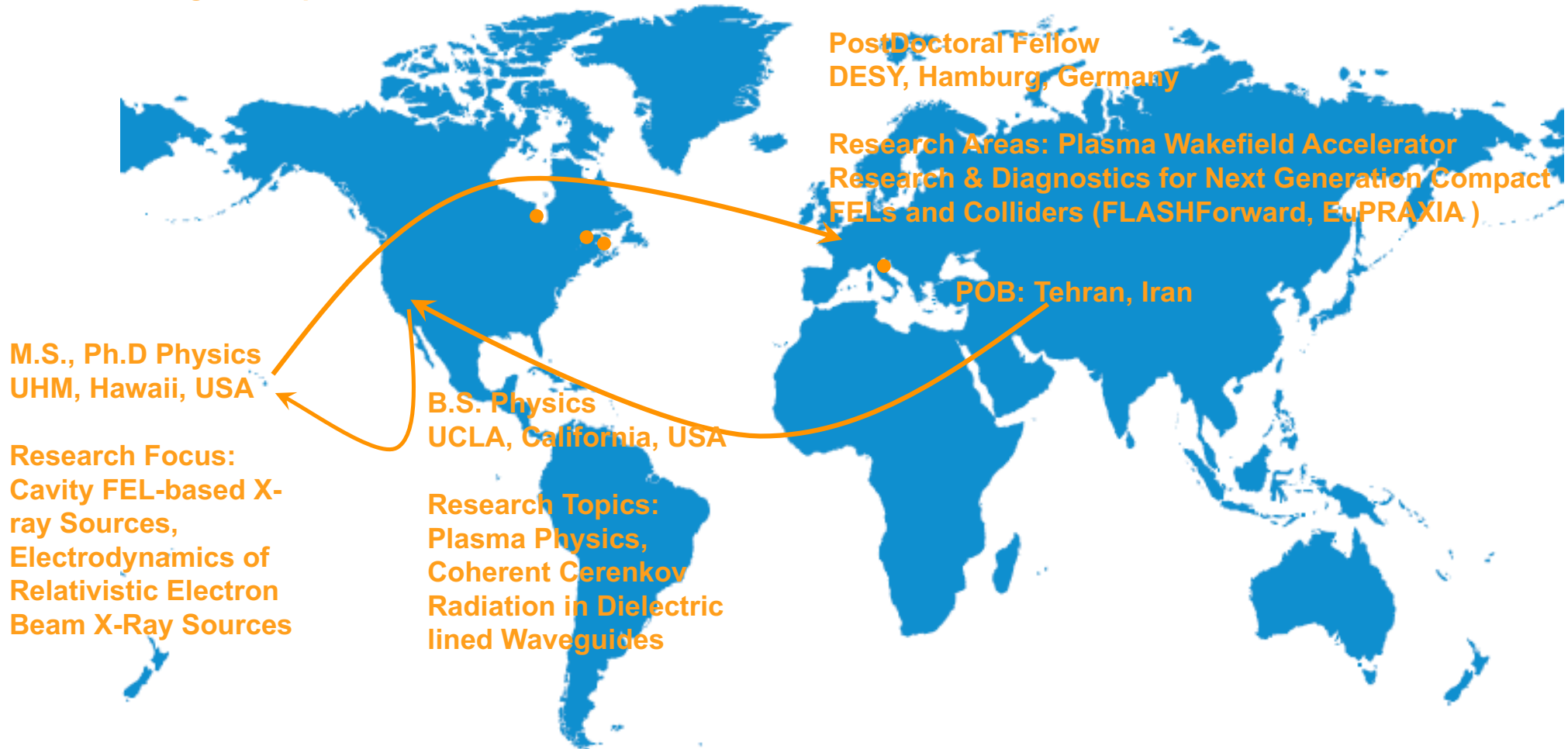
DESY FH Fellow Day

Friday 1 February 2019




What happens when you keep taking the path less travelled:

Background: past activities and adventures



Plasma Wakefield Accelerators and FELs



Plasma Wakefield Acceleration

To have an intuition about the underlying physical mechanisms of the plasma wakefield acceleration we can consider a surfer in the **ocean**:

- If the **surfer** stands still, the **waves** just pass by him and his surfboard,
- To catch the wave, it is essential for the surfer to start paddling at the right time and gain speed,
- Once the surfer has "caught the wave" he gets energy from the wave and continues to "**ride**" the wave

A parallel explanation for plasma-wakefield acceleration is as follows:

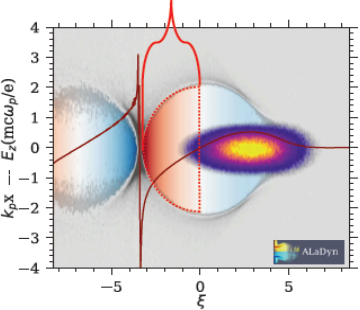
- A driver, which can be either a laser pulse or a charged particle beam, produces the plasma wave by pushing the electrons of a **pre-ionized gas** outward.
- This process creates a bubble regime with self-sustaining electric fields, wakefields, which can reach extreme values.
- If a second bunch, **the witness**, is placed near the high-density area in the back of the **wake**, it will experience acceleration and **travels with the wave until it reaches the speed of the wakefield**.

Within the EuPRAXIA consortium, the focus of **Working-Group 9** is on the **beam-driven approach by external injection**, where:

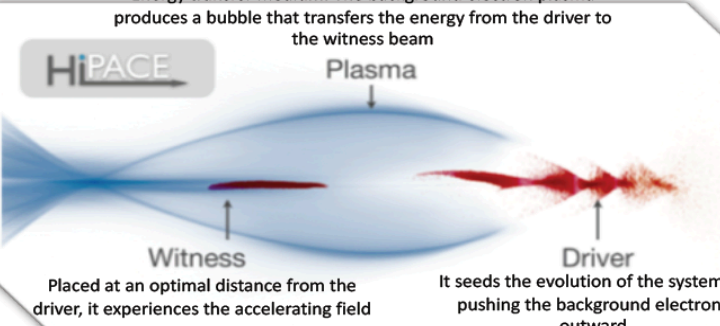
- ❖ the driver is an electron bunch: which prevents dephasing with the witness
- ❖ high brightness bunches are created and shaped by the photo-injector
- ❖ the bunches are pre-accelerated and manipulated with an RF structure

Final goal: A high quality 5 GeV electron beam suitable for FEL lasing

Accelerating volume: the micron-size region suitable for accelerating the witness beam

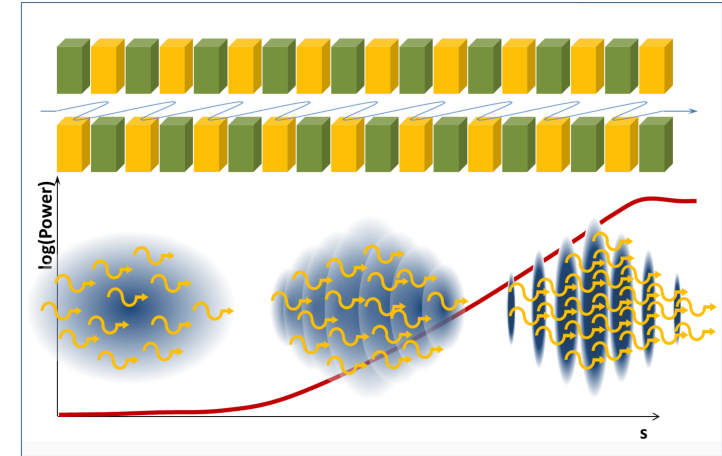


Energy transfer medium: The background electron plasma produces a bubble that transfers the energy from the driver to the witness beam

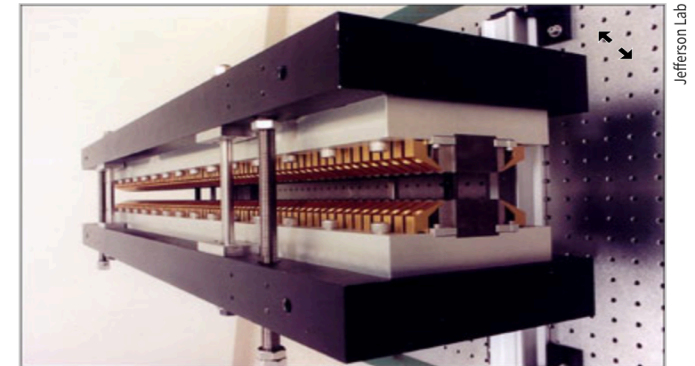


Witness
Placed at an optimal distance from the driver, it experiences the accelerating field

Driver
It seeds the evolution of the system by pushing the background electrons outward



Source: <https://www.helmholtz-berlin.de>



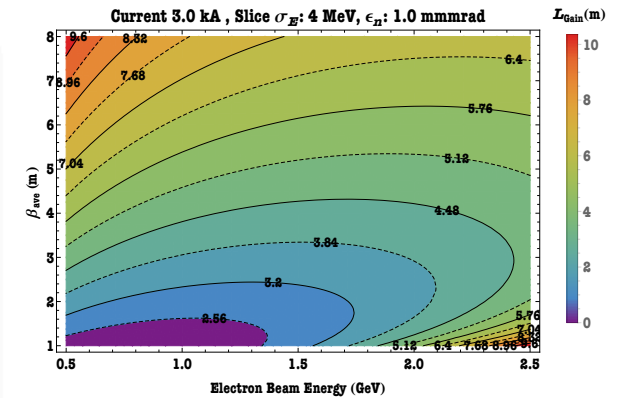
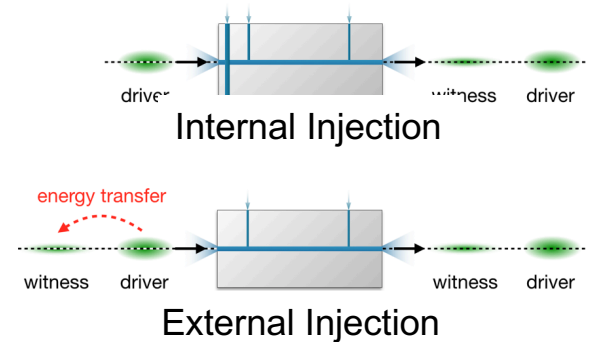
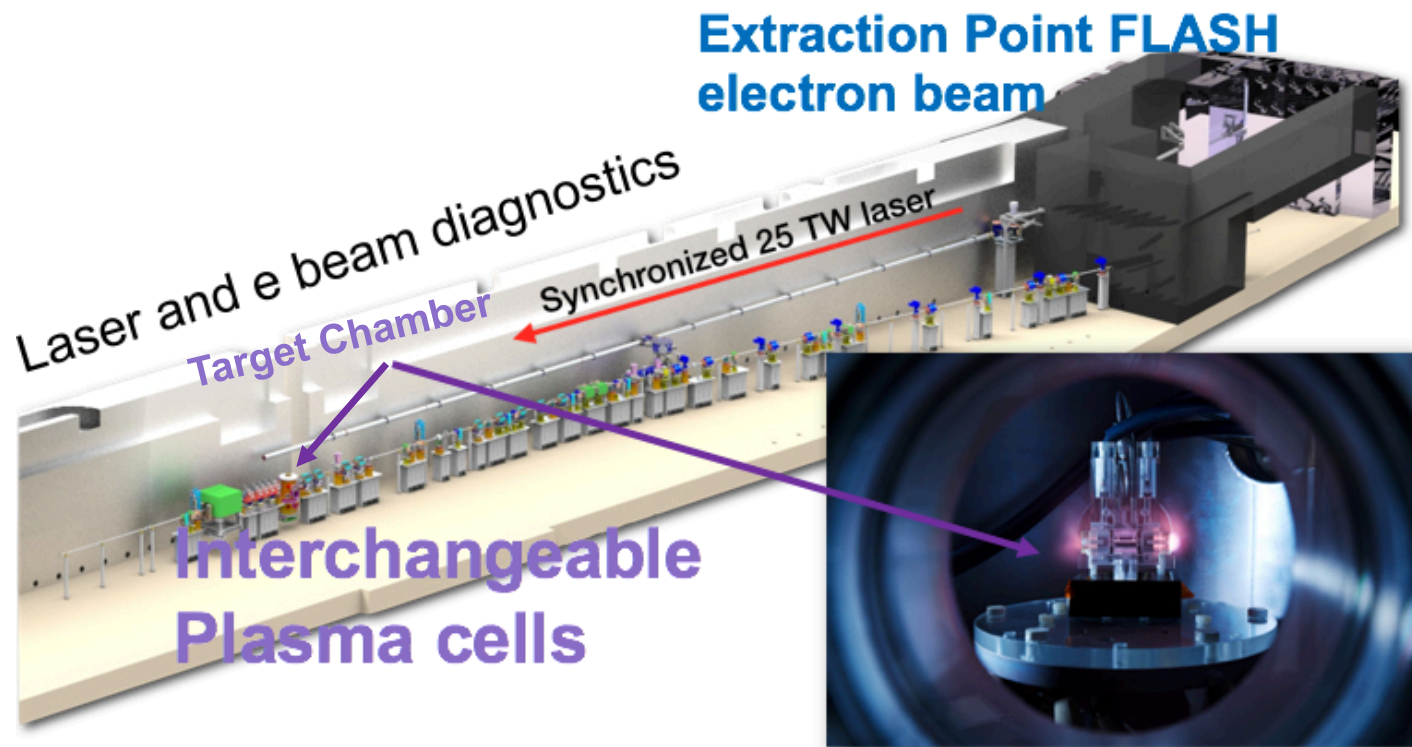
Source: <https://physics.aps.org/story/v25/st10>

A Beam Driven Plasma Wakefield Accelerator at DESY

Researching Different Injection Mechanism and Developing Novel Diagnostics For Future Plasma Accelerators

FLASHForward ▶▶

Future-oriented wakefield-accelerator research and development at FLASH



Probing Transient Fields

Developing Diagnostics For Future Plasma Accelerators at FLASHForward

- Using light to probe matter: Measuring Faraday Rotation of a Laser Passing through the Interaction Point

Background Physics: Rotation angle depends on

- **(1) Plasma Density**
- **(2) Electron Beam B-Field (Beam Current)**

Reference: A. Buck et al., Nature Physics, 2011

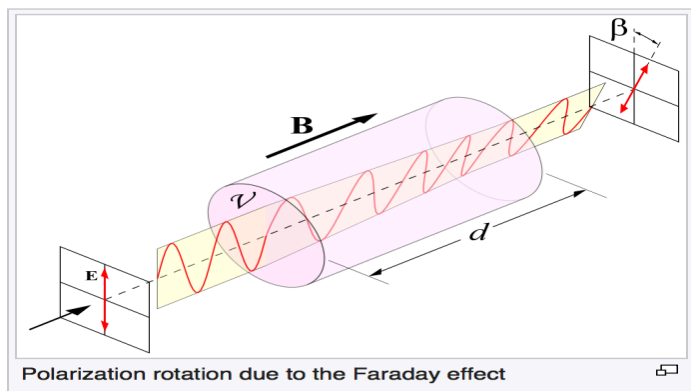


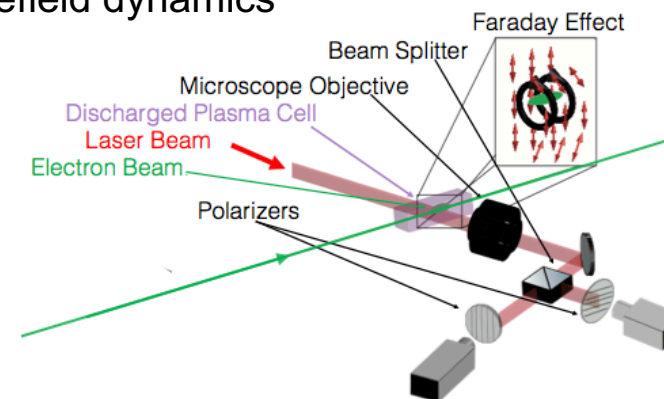
Image from Wikipedia

• Now @ FLASHForward:

- Measure longitudinal bunch profile
- Setup and Design of Required Diagnostics
- Measure electron beam to laser jitter

• Future

- Study wakefield dynamics



P. Niknejadi et al 2018 J. Phys.: Conf. Ser. **1067** 042010

Chaotic or Nonchaotic Universe?

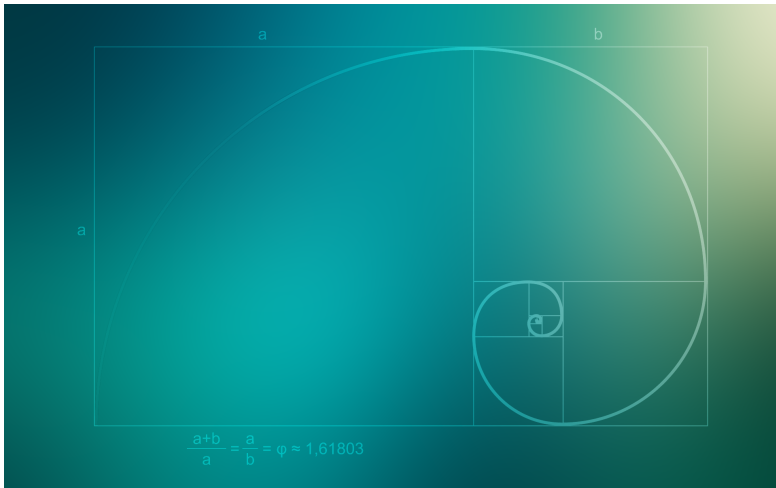


Image From: http://wallpaper.com/images/00/39/60/34/spiral-golden_00396034.png



Image From: <https://www.quantamagazine.org/variable-stars-have-strange-nonchaotic-attractors-20150310>

Reference article: **Strange Nonchaotic Stars, Phys. Rev. Lett. 114, 054101 – Published 3 February 2015**