Matter and the Universe *Topic 1: Fundamental particles and forces*

Low-emittance electron bunches accelerated in plasma wakefields

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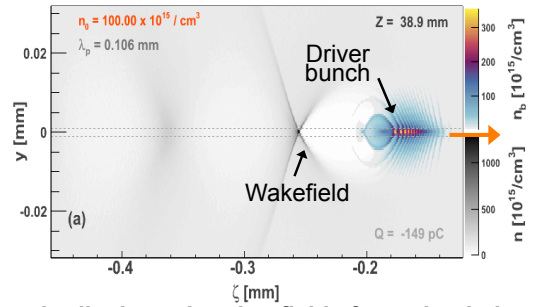
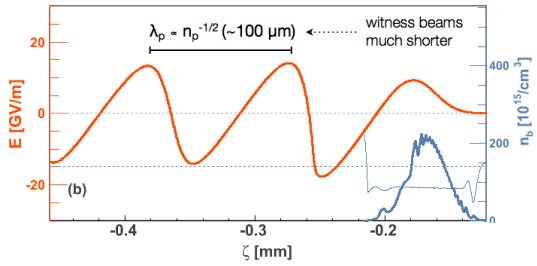
Simulated density plot of wakefield:



Longitudinal accelerating fields from simulation:



Plasma-based particle acceleration

What happens during plasma wakefield electron acceleration?

1. Driver bunch pushes electrons aside.
2. Charge separation fields pull electrons back.
3. Electrons overshoot and oscillate forming wakefield.
4. Witness bunch accelerated and focused by fields.

Why are plasma-based accelerators exciting?

- Plasma formation limits accelerating gradient of RF accelerators.
- Plasma medium ⟶ Breakdown not a problem
  ⟶ **accelerating gradients several 10 GV/m.**
- Witness **bunch duration** intrinsically short **< 10 fs ≪ λ_p**

Why use a particle driver rather than a laser?

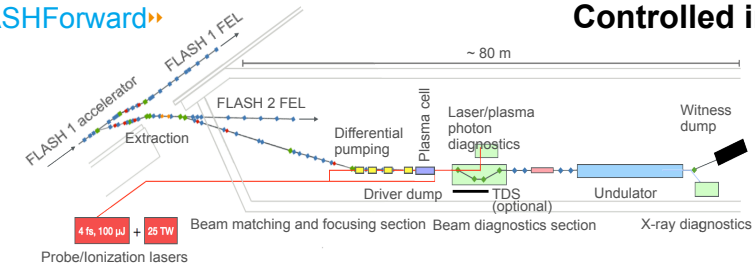
- Lower normalised emittance predicted below a few 100 nm
- Higher average power
- Higher efficiency

} Required for good **luminosity**

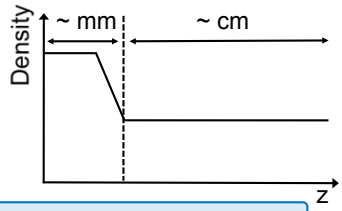
Bunch properties strongly dependent on injection into wakefield. Control over injection essential for high quality bunches.

FLASHForward

Controlled injection at DESY: Density Downramp



Electrons injected during sharp decrease in density.

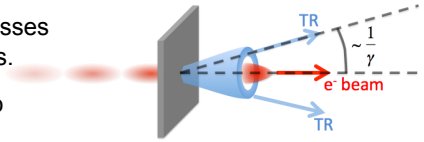


Bunch parameters from simulation:

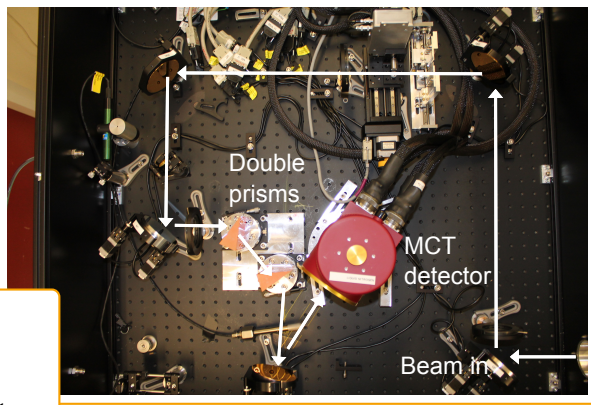
- Energy spread < 0.5%,
- Normalised emittance < 0.2 µm
- Peak current ~0.8 kA.

Transition radiation diagnostics

- Important to characterise electron bunches to determine:
  - Effectiveness of controlled injection technique
  - Stability of bunch parameters
  - Suitability for applications i.e. generation of short x-ray pulses
- Diagnosis of **femtosecond duration** electron bunches is challenging
  ⟶ **Transition radiation as longitudinal bunch diagnostic.**
- Generated when a charge crosses an interface between materials.
- Radiation properties related to characteristics of charge.



Broadband transition radiation spectrometer



Current experimental work:

- **Broadband spectrometer** (400 – 20,000 nm) under testing at **STFC Rutherford Appleton Lab**.
- Incoherent radiation diagnostics under development for use in **Helmholtz Center Jena** in Summer 2014.

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