Contribution ID: **83** Type: **poster**

Broadband transition radiation measurements for the temporal diagnosis of ultra-short plasma-accelerated electron bunches

Wednesday, 16 September 2015 19:30 (30 minutes)

We report on the development of a broadband transition radiation (TR) diagnostic for use during plasma wakefield experiments at FLASHForward. Here, 1~GeV, 50~fs electron bunches will drive a plasma wakefield accelerator, generating ultra-short ($\sim$ fs) 'witness' electron bunches with energies $\leq$ 5~GeV.

TR is generated whenever a charged particle travels between materials with different dielectric constants. Broadband spectral measurements of coherent TR can be used to obtain information about the longitudinal charge distribution. DESY has developed several broadband spectrometers, for this purpose, with spectral sensitivity in the range 0.7-150~THz.

Stable generation of electron bunches from plasma wakefield acceleration is an area of research. Therefore, for accurate diagnosis of bunch parameters, not only should the spectral range be sufficiently broad to support phase retrieval and the upper frequency limit be sufficiently high to resolve the femtosecond bunch durations expected, but the diagnostic should be able to perform single shot measurements.

We present the proposed setup to combine these novel broadband spectrometers and extend the high-frequency limit, to form a single shot diagnostic covering the range 0.7-1000~THz. We consider both the general technical challenges and specific issues affecting plasma wakefield accelerators.

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Session Classification: Poster Session 2 (WG5-WG6-WG7) and Wine

Track Classification: WG5 - High-gradient plasma structures/Advanced beam diagnostics