Dundee - Daresbury Diagnostic Group Activities

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Collaborations:

FELIX
FLASH
ALPHA-X

Activities:

Electron bunch measurements using Electro-Optic (E-O) detection
Successful measurements at FELIX and FLASH
Setup at Daresbury on ALICE for measurement of the energy-recovered electron beam
Fibre laser development for timing & synchronisation in accelerators and light sources
Electron energy measurements in the ALPHA-X experiment at Strathclyde University

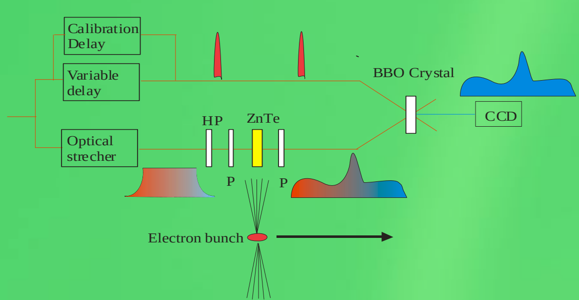
Electro-Optic Detection

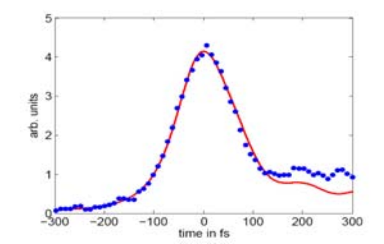
In electro-optic detection a femtosecond laser is used to probe the birefringence induced in a GaP crystal by the bunch Colomb field. For the measurements achieved here, the laser is an amplified Ti:Sapphire laser (pulse length 30 fs, wavelength 800 nm, pulse energy 0.8 mJ, repetition rate 1 kHz) that is actively synchronised to the accelerator. The EO technique offers the advantage of being non destructive which offers the possibility of correlating the measurements with processes observed further downstream.

Temporal Decoding

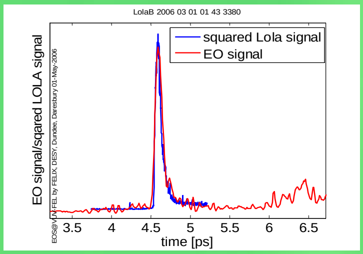
Temporal decoding: the optical beam is split into two beams, a probe and a gate. The probe pulse is passed through grating pair to stretch the pulse to 20 ps , a length that is significantly longer then the electron bunch duration. This samples the birefringence in the electro-optic crystal. The gate beam itself is split into two to provide a exact timing calibration for signal reconstruction. The original gate beam serves as a short-pulse reference in the cross correlation. Probe pulse passes through a half-wave plate and a linear polarizer and is focussed on to a GaP electro-optic crystal. This 65 μm thick <110> GaP crystal is placed inside the accelerator beam pipe. The phase retardation induced in the crystal by the bunch field is translated into an intensity modulation on the stretched pulse by passing through an arrangement of polarisers. This encoded intensity is then cross-correlated with the gate pulse in a Beta-Barium Borate (BBO) crystal. The non-collinear nature of the cross correlation geometry provides a mapping of time on to spatial position in the BBO crystal and the CCD. This is shown in more detail in the diagram below :-

Temporal decoding method

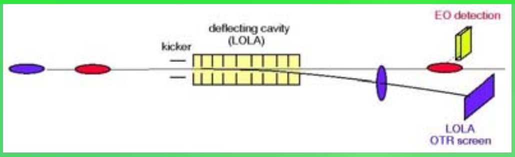




The best time resolution obtained in E-O analysis of ultra-short electron bunches at FLASH

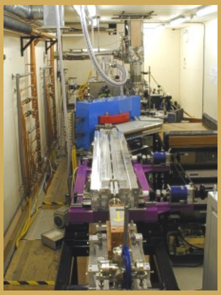


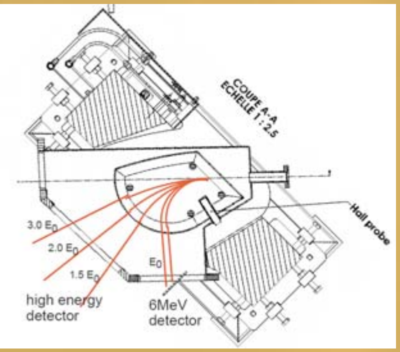
Comparison between the LOLA signal and the EO signal showing good agreement

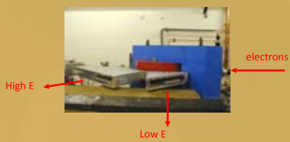


Schematic of arrangement of transverse deflecting cavity and EO detection at FLASH

Alpha-X electron energy spectrometer (Strathclyde)

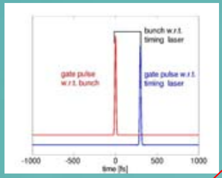




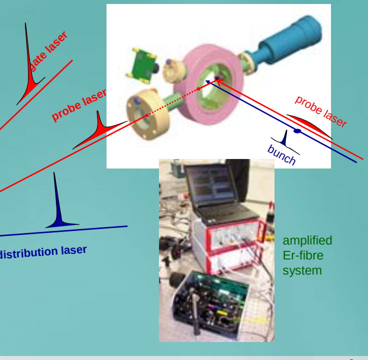


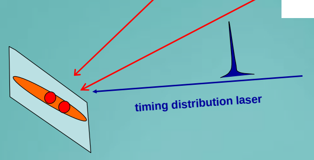
Broad-range Brown-Buechner spectrometer

Integration with accelerator timing distribution systems...



to be tested on ALICE



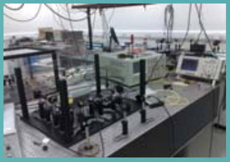


Migration of EO capability to fibre laser technology…

- Robustness & reliability
- Potential Integration into accelerator timing systems
- Arrival time information for photon sources

Erbium doped systems: 1.55μm; likely timing distribution system frequency doubled to 770nm => similar to Ti:S

Ytterbium doped systems: 1030 nm phase matched with Gallium Phosphide (GaP) E.O. material



Er and Yb fibre systems under construction at Daresbury

References

1 G.Berden et al, Phys. Rev.Lett. 99, 164801 (2007)
2 G.Berden et al Phys. Rev. Lett. 93, 114802 (2004)
3 S.P. Jamison et al. Opt. Lett. 31, 1753 (2006)

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