Electro-optical Detector for the Temporal Characterization of Picosecond and Femtosecond Beam Bunches

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Outline

Motivation
Method
Data/Results
Future

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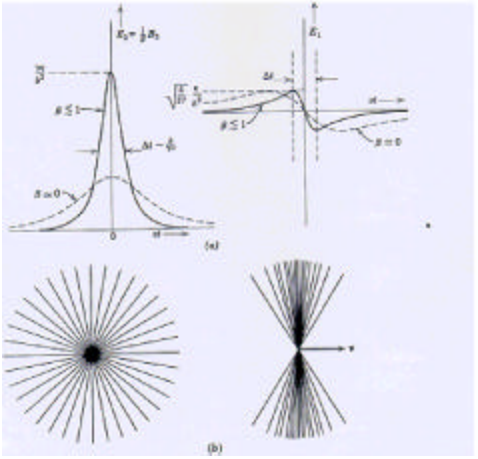
Motivation:

- Develop a Charged Particle Beam Detector
- Temporal Resolution ps to sub-ps
- Non-destructive
- Single Shot
- Simple



Method: Electro-optical Effect

- In amorphous optical media: Kerr effect $f = 2pKE^2d$
- In Uniaxial Crystals: Pockels effect $f = (2p/l)pEl$
- E-field from a charged particle beam:

$$E = gN_e \frac{q}{4pe_0e_r r^2} = gN_e \times 2\times 10^{-6}\ \text{V/m}$$

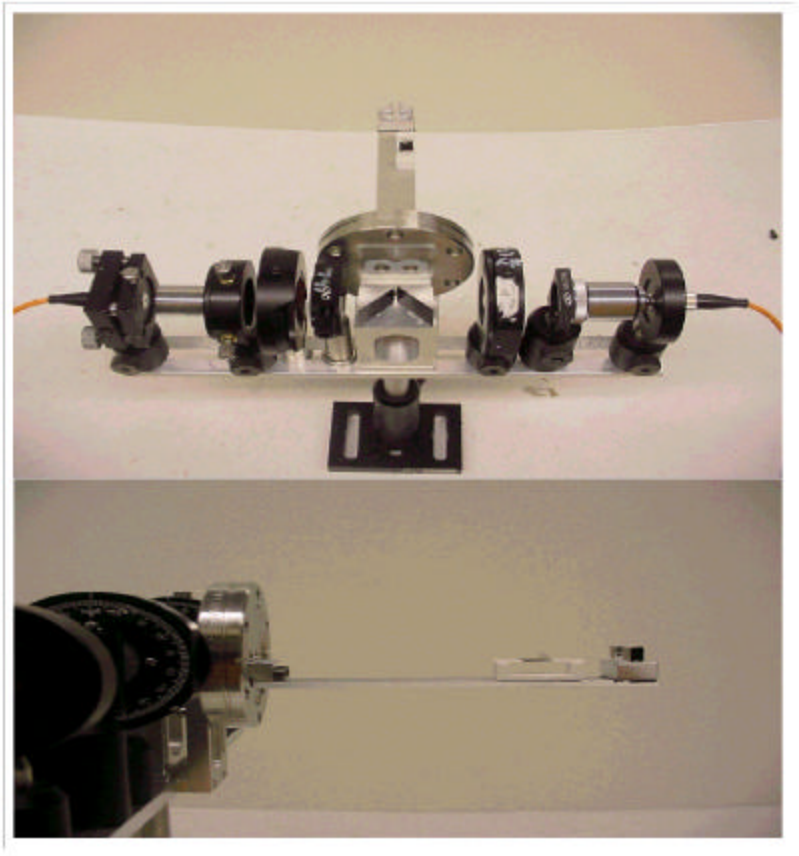
$$\text{for } \Delta t = \frac{r}{gu} = \frac{17}{g}\ \text{ps}, \quad \text{for } r = 5\text{mm}$$

$$f = \frac{qpN_e}{2e_0e_r nr\,l} = N_e \times 10^{-12}\ \text{rad}$$

$$\approx 3\text{mrad for } 0.5\text{nC of Beam.}$$

10^{10} Electron Pulsed Beam, 10-15ps long, 1mm diameter, 1.5 Hz from ATF of BNL

$LiNbO_3$ Crystal as E-field Sensor



10^{10} Electron Pulsed Beam, 10-15ps long, 1mm diameter, 1.5 Hz from ATF of BNL

$LiNbO_3$ Crystal as E-field Sensor

Readout with Conventional Electronics

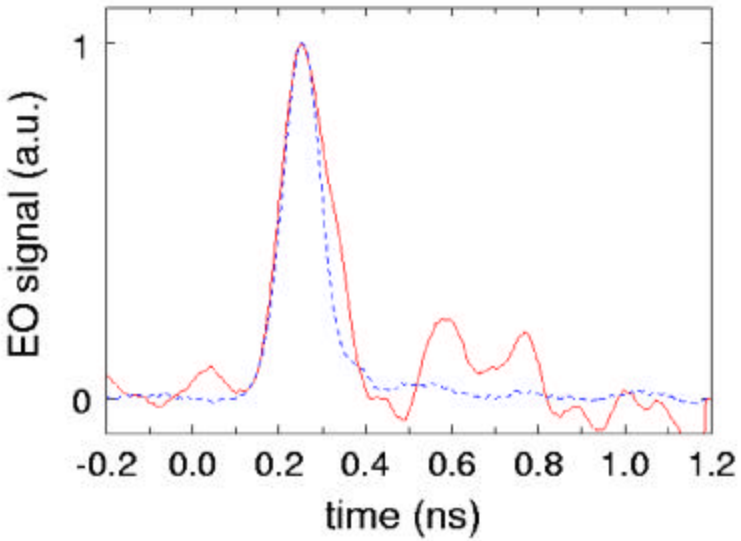


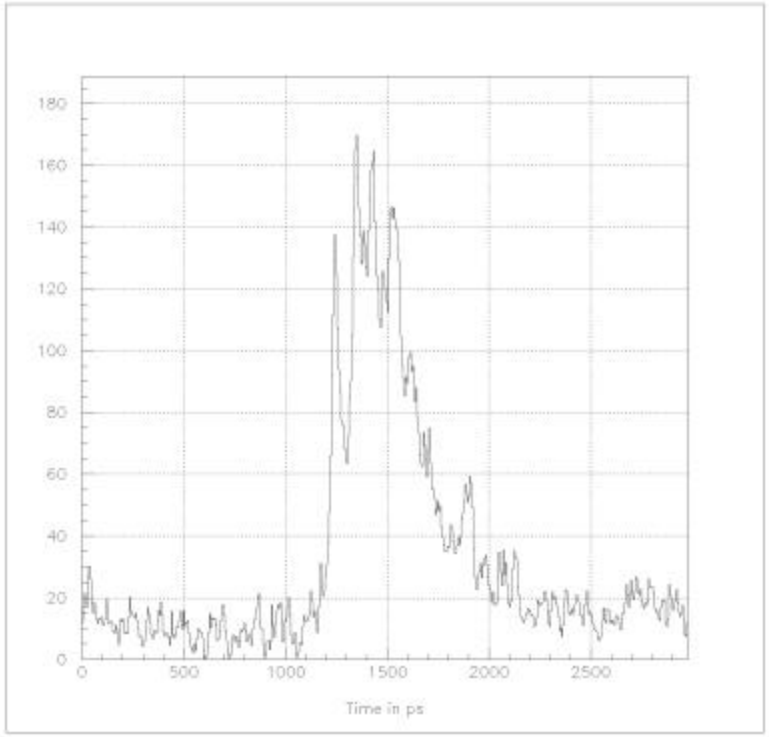
Fig.

10^{10} electron pulsed beam, 10-15ps long, 1mm diameter, 1.5 Hz from ATF of BNL

$LiNbO_3$ crystal as E-field sensor

Streak Camera

Single Shot

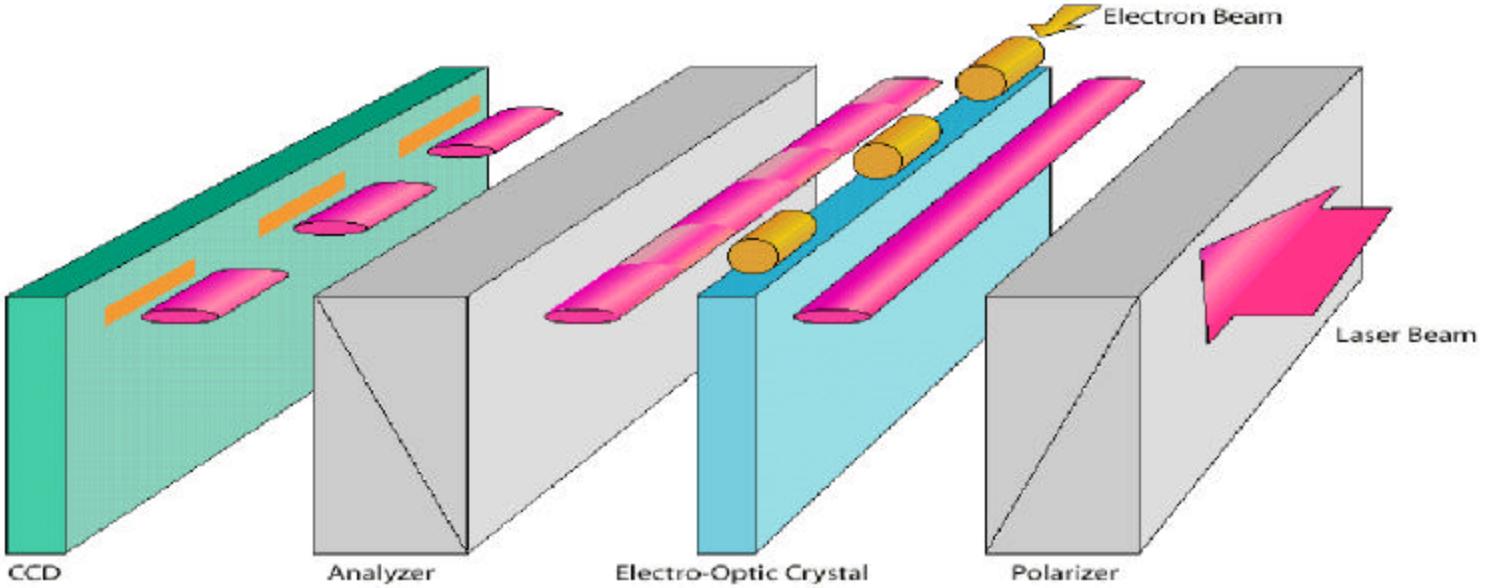


Future:

Electro-optical Effect with Flash Photography

- Temporal Resolution better than 100fs
- Transformation of time distribution to spatial avoids electronic time resolution limitations
- Convenient real time measurement characterizing individual beam bunches in single shot
- Promising Diagnostic Technique for Linear Collider and Free Electron Laser Development

Electro-optical Effect with Flash Photography



Publications:

Charged Particle Beam Detection via Electro-optical Effects

•Y.K. Semertzidis *et al.*, Proceedings of the 1999 Particle Accelerator Conference, 490 (1999).

•D.M. Lazarus *et al.*, Proceedings of the International Europhysics Conference on High Energy Physics, 993 (1999).

•Y.K. Semertzidis *et al.*, Nucl. Inst. Meth. {\bf A452}, 396 (2000).

•T. Tsang *et al.*, J. Appl. Phys., {\bf 89}, 4921 (2001).

•T. Srinivasan-Rao *et al.*, 21st ICFA Beam Dynamics Workshop on Laser-Beam Interactions (2001). Proceedings to be published in the Physical Review Special Topics.

Conclusion:

- **Proof of Principle of Electro-optic Effect with Beams (BNL LDRD, work at ATF)**
- **Promising New Method with Temporal Resolution better than 100fs (proposal to DOE)**
- **Non-destructive**
- **Single Shot**
- **Simple**