TUPD68

Feasibility study of a single-shot 3D electron bunch charge distribution monitor with a polarized probe laser at SPring-8 photoinjector

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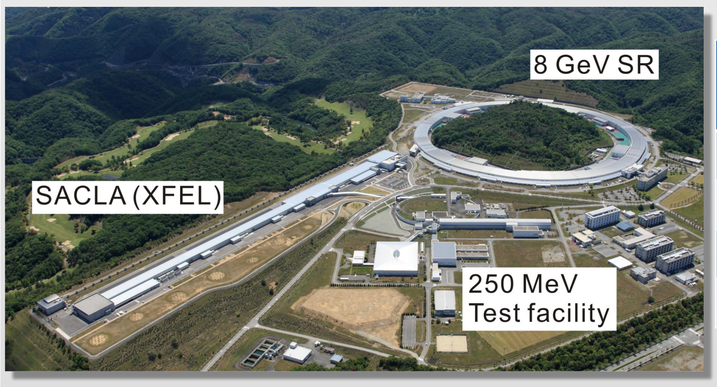
Introduction

SACLA (SPring-8 Angstrom Compact free electron Laser)

- **Construction completed in end of 2010 & user op. in end of 2011**
- **Highly compressed electron bunch required [1]**



Electron bunch parameters (sliced)	
Energy	8 GeV
Beam size	40 um (rms)
Bunch duration	30 fs (FWHM)
Charge	100 pC

Non-destructive & real time bunch monitor required

Thus, we introduce...

"3D bunch shape monitor (3D-BSM)"

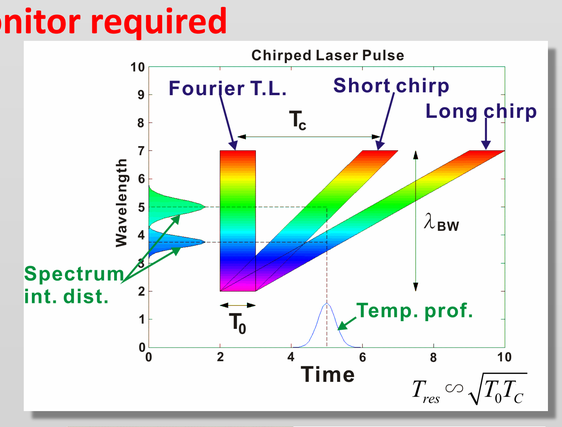
1 Non-destractive
→ based on EO method [2]

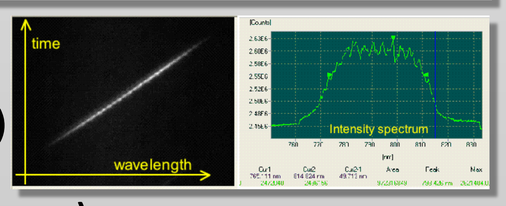
2 Single-shot
→ spectral decoding
w/ multi-ch. spectrometer

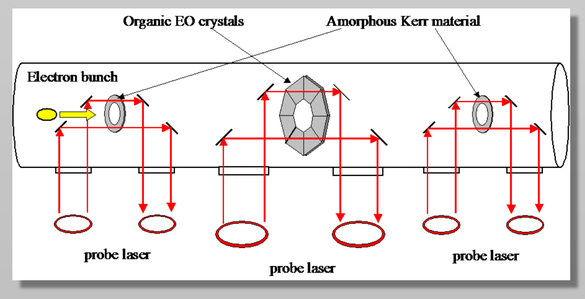
3 real-time
→ rectangular spectrum
& linearly chirped probe laser

3 High temp. resolution (< 30 fs [FWHM])
→ > 400 nm bandwidth
w/ organic EO crystals (ultra-fast response)

4 3D bunch shape monitor w/ high resolution (longitudinal)
→ radial pol. hollow laser & radially allocated EO crystals (transverse)

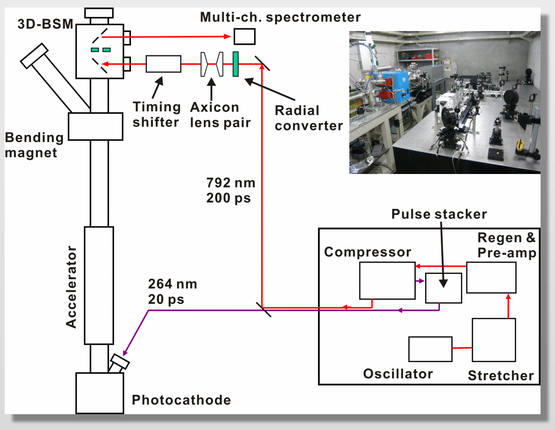


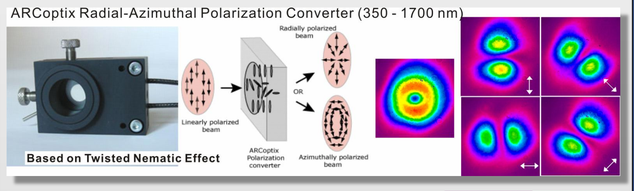


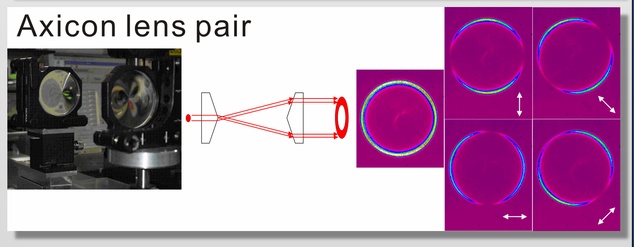


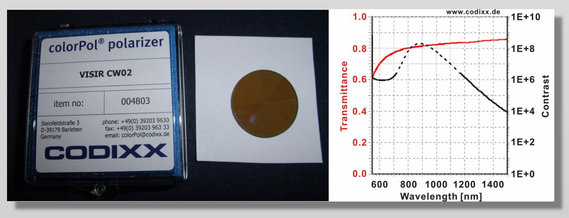
- **Kerr-EO material is preparing. (amorphous material candidate)**

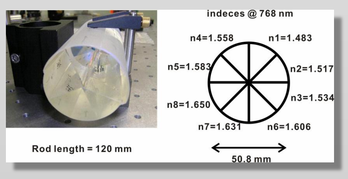
Feasibility test @ SPring-8 photoinjector test facility, 2010

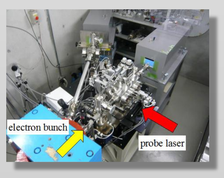




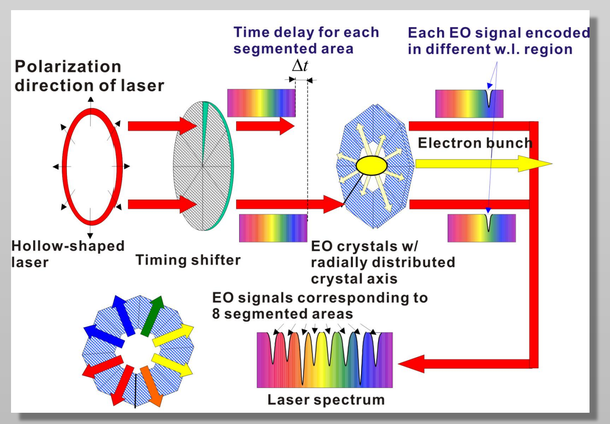


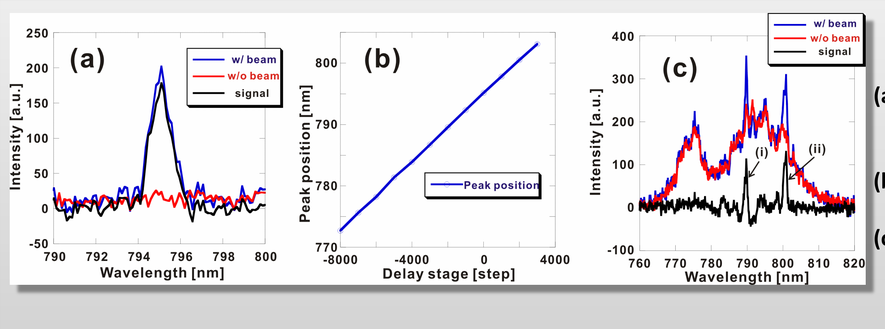






Beam energy	~25 MeV
Beam size	~100 um (rms)
Bunch duration	6 – 10 ps (FWHM)
Charge	~1.5 nC
EO crystal	ZnTe x 2; 10 x 10 x 1 mm^3 (4 mm from beam axis)
Laser bandwidth	775 – 795 nm
Laser pulse width	200 ps (FWHM)



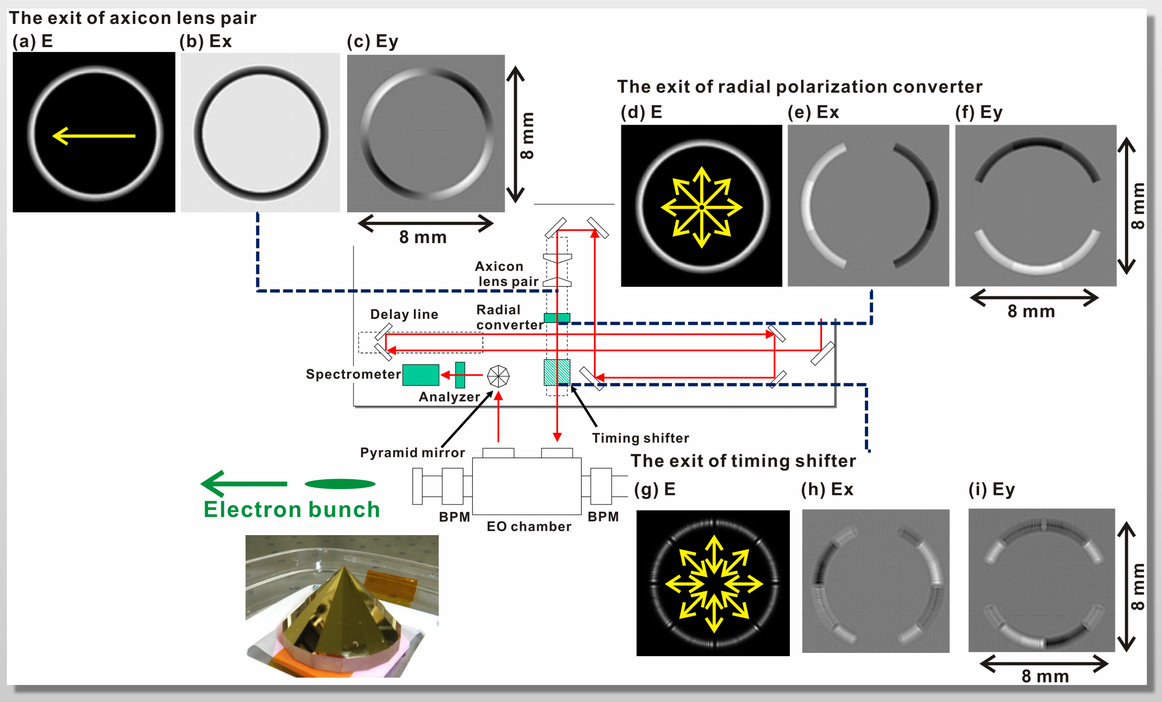


(a) EO signal @ laser incident RF phase ϕ = 80 degs (sine func.)
(b) Chirp linearity of the probe laser
(c) EO signals probed 2 ZnTe crystals simultaneously

- **Chirp linearity scan gave 9.58 ps/nm conversion factor.**
- **Staggered double signal peak observed thru the timing shifter.**
- **10.8 ps (FWHM) electron bunch width measured.**

3D-BSM w/ radial polarized & hollow-shaped probe laser works well !!

Numerical calculation (w/ VirtualLab, www.lighttrans.com)



Calc. condition (input laser specs) :

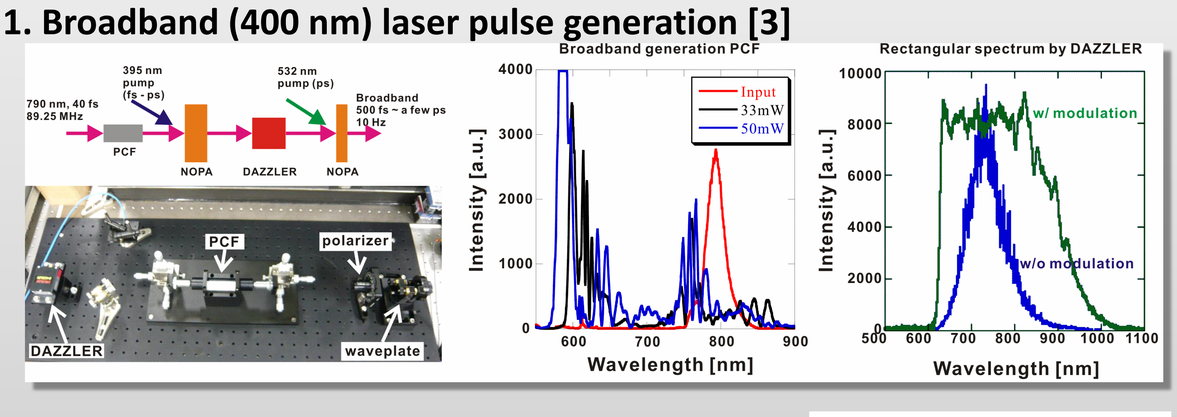
Laser size	ϕ2 mm [FWHM]
Bandwidth	775 – 795 nm
Polarization	linear
Pulse duration	200 ps (FWHM)

- Laser propagates actual transport path length ~20 m.
- Focal length of axicon lens pair adjusted to be 35 mm to obtain ϕ8 mm hollow shape

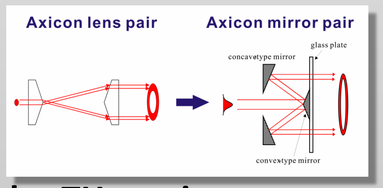
Radial polarization obtained & confirmed at the exit of timing shifter !!

Toward to 30 fs resolution

1. Broadband (400 nm) laser pulse generation [3]

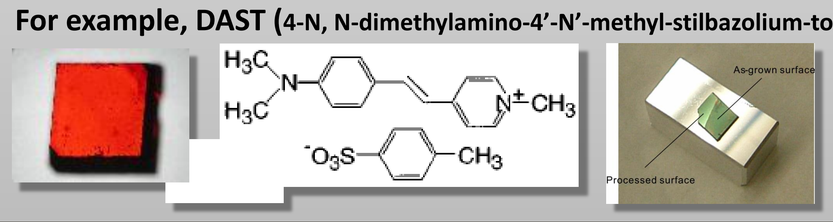


1) Broadband laser by PCF (Photonic Crystal Fiber)
2) Broadband amplification w/ NOPA (SHG of Ti:S & YAG)
3) Higher dispersion control w/ DAZZLER & NOPA
4) Axicon lens → Axicon mirror



2. Organic EO crystals for ultra-fast response in wider THz region

For example, DAST (4-N, N-dimethylamino-4'-N'-methyl-stilbazolium-tosylate) crystal [4]:



High qualified DAST collaborated w/ H. Minamide (RIKEN)

References

[1] H. Tanaka, T. Hara and K. Togawa, private communication
[2] H. Tomizawa et al., in Proceedings of FEL2007, Novosibirsk, Russia, (2007) 472
[3] S. Matsubara et al., in Proceedings of FEL2009, Liverpool, UK, (2009) 269
[4] F. Pan et al., Appl. Phys. Lett. 69 (1996) 13