Time resolved measurements at SR sources

- **bunch clock**
- Undulator
- Optics
- Chopper
- e- ring
- Femtosecond laser source
  - 800nm fundamental, 896 Hz

2D detector

Fast timing diode
Synchronization

- X-ray induced electron emission
- Tuned to signature $e^-$ energy
- Position sensitive detector
- 80 fs X-ray pulse
- Many psec range with fsec resolution
- Timing jitter is not a limitation
- Measurement of X-ray Timing Using Spatial Coincidence With Probe Laser

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IMMW13 May 19, 2003

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Synchronization with crystals

Asymmetric cut crystal

800 nm 10 fsec laser pulse

CCD Detector

Intensity

Position (Time)

-1 0 1 2 3 4 5 10 20 30 40 50 60 70 80 90 100

Integrated reflectivity

0.2 J/cm²

0.4 J/cm²

Delay time [ps]
Principal of Electro Optic Detection

- Electric field from bunch modulates transmission of chirped laser pulse

Diagram:
- Beam pipe
- Electron bunch
- Co-propagating Laser pulse
- Polarizer
- EO Crystal
- Analyzer
- Spectrometer

Graphs:
- Initial laser chirp
- Bunch charge
- Gated spectral signal
Bunch Length Diagnostics

Add 12-meter chicane compressor in linac at 1/3-point (9 GeV)

Existing bends compress to <100 fsec

EO Diag.

X-ray exp

Laser

FFTBLaser

SLAC Linac

1 GeV

9 ps

0.4 ps

20-50 GeV

50 ps

RTL

Add 12-meter chicane compressor in linac at 1/3-point (9 GeV)

Existing bends compress to <100 fsec

~1 Å

Laser

X-ray exp

EO Diag.
Linac Coherent Light Source

1992: Proposal (C. Pellegrini)
1998: Preliminary Design Study Completed
1999: R&D funded at $1.5M/year
2001: CD-0
2003: Project Engineering Design begins
2005: Long-Lead Procurements begin
2006: Construction begins

**2007: First Light**
2008: Project completion

Two Chicanes for bunch compression
How bright are different light sources?

- **Undulators**
- **Bending Magnets**

**Graph:**
- X-ray tubes
- 1st generation
- 2nd generation
- 3rd generation
- FELs

**Vertical Axis:** Log Peak Brilliance

**Horizontal Axis:** Log Beam Brilliance

**Legend:**
- 1900
- 20
- 40
- 60
- 80
- 2000
- '20
- '40

**Data Points:**
- 5
- 10
- 15
- 20
- 25
- 30
- 35
FELs are UNIQUE X-Ray Sources

- **Peak brightness** exceeds existing x-ray sources by $> 10^9$

  Brightness $B$ determines coherence degeneracy parameter: $\Delta \sim B \times \lambda^3$

  3rd gen. beam line
  
  coherence volume $1 \times 5 \times 50\mu m$
  
  contains < 1 photon

  XFEL source
  
  coherence volume $0.1 \times 100 \times 100\mu m$
  
  contains $10^9$ photons

  All present experiments are based on one photon processes, FELs have $10^9$ equivalent photons

- **Time resolution** exceeds 3rd gen. synchrotron sources by a factor $10^3$

  50ps $\cdots$ $\cdots$ $\cdots$ 50 – 250 fs

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