X TOD Overview

FAC X-TOD Breakout
April 23, 2007
XTOD Scope: Front End Enclosure (FEE)

- Wall penetration
- Slit
- Solid Attenuators
- K Spectrometer
- Indirect Imager
- Collimators
- Wall penetration
- Fixed Mask
- Gas Detector
- Gas Attenuator
- Thermal Sensor
- Gas Detector
- Direct Imager (Scintillator)
- FEL Offset Mirror Systems
- Beam Direction
XTOD Scope: NEH

- Wall penetrations/collimators
- Beam stay-clear enclosure
- NEH imager
XTOD Scope: Tunnel

Single vacuum beam line through tunnel
XTOD Scope: Fall Hall

FEH imager
XTOD Optics and Diagnostics in FEE

- Gas Attenuator
- Solid Attenuator
- Slit
- Gas Detector
- Hard x-ray Monochromator (K Spectrometer)
- Indirect Imager
- Total Energy Thermal Detector
- Direct Imager
- NFOV
- WFOV
- Soft X-Ray Offset mirror system
- Hard X-Ray Offset mirror system
- Start of Experimental Hutches
- Muon Shield

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Slit and Fixed Mask Define Maximum Beam Spatial Extent

Fixed Mask

Status:
- PRD done
- SCR done
- PDR done
- ESD done
- ESD done
- FDR done
- Procurement begun

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Gas Detector / Attenuator Conceptual Configuration

- 3 mm diameter holes in B₄C disks allow 880 μm (FWHM), 827 eV FEL to pass unobstructed
- 4.5 meter long, high pressure N₂ section
- Differential pumping sections separated by 3 mm apertures
- Gas detector

Status Attenuator:
- PRD done
- SCR done
- Prototype done
- ESD done
- PDR done
- FDR in preparation

Green line carries exhaust to surface
Gas Attenuator prototype with Gas Detector cell

- Attenuator gas inlet
- Dector gas inlet
- Gas Attenuator High Pressure Cell
- Stage 2
- Gas Detector Cell
- Last Stage (Stage 6)
Gas detectors share differential pumping with the Gas Attenuator

**Gas Feed And Pressure Control**

**Differential Pumping Section**

**Low-Reflectivity Coating**

**Photodiode**

**Bandpass Filter**

**3 mm apertures along beam path**

**Magnet Coils**

**Cylindrical Vessel**

**Magnet Power Supply and Controller**

**Beam / Gas Interaction Region** (~0.1 – 2 Torr N₂)

**Status Gas Detector:**
- PRD done
- SCR done
- ESD done
- PDR done
- Prototype in preparation

LCLS X rays cause N₂ molecules to fluoresce in the near UV
Gas detector SSRL prototype

- Photo Multiplier Tube
- Magnet Coils
- Be window
- Port for pumping
- Gas Feed And Pressure Control
- Avalanche Photodiode
- Port for LED illuminator and florescence samples

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Indirect imager finds spontaneous core

Raw soft spontaneous

Figure 3: Spontaneous Fluence at Direct Imager: Soft X-Ray FEL Setting, 0.79 nC

<table>
<thead>
<tr>
<th>Photon Energy Range</th>
<th>Counts</th>
<th>Energy</th>
<th>J/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 eV &lt; E &lt; 1000 eV</td>
<td>2.5 x 10¹⁰</td>
<td>3.1 x 10⁶</td>
<td>7.8 x 10⁻⁷</td>
</tr>
</tbody>
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<tbody>
<tr>
<td>840 eV &lt; E &lt; 860 eV</td>
<td>2 x 10¹⁰</td>
<td>2.6 x 10⁶</td>
<td>7.8 x 10⁻⁷</td>
</tr>
</tbody>
</table>

Princeton Instruments back illuminated CCD camera
25 x 25 mm chip, 20 um pixel size

ML mirror 0.1% reflectivity, 1% bandwidth

Vacuum chamber

Status Indirect Imager: PRD in progress
Channel-cut Si Monochromometer will be used to measure relative $K$ of two undulator segments.

Monochrometer

Linac E variation and measurement

Detector

monochromometer measures intensity at a single point

Use linac E variation and measurement to obtain other points along curve

Status K Spectrometer: PRD in progress

Two undulator spontaneous spectrum. Falloff of high energy tail is independent of aperture

Two undulator spontaneous high energy falloff has highest slope when $\Delta K/K = 0$. 
Total Energy (Thermal) Sensor provides calibrated measurement of FEL pulse energy

Measures FEL energy deposition through temperature rise

- Cu heat sink
- FEL pulse
- 0.5 mm Si substrate
- Thermistors $\text{Nd}_{0.66}\text{Sr}_{0.33}\text{MnO}_3$ (On back of substrate)

Sensor Temperature Rise

Status Thermal Sensor:
- PRD done
- SCR done
- PDR done
- Prototype under study
Thermal sensor prototype

- 532 nm laser
- Pulse tube cooler
- Optics for measuring, focusing, and steering laser beam
- Sensor cryostat
Thermal sensor signal at 1mJ

2 volt bias

V1

0 volt bias

V1

Scope voltage vs. time

V2

Scope voltage vs. time

V2
Signal amplitude at 2 msec

2 volt bias

0 volt bias
Thermal Detector and Direct Imager

- Direct Imager
- Thermal Detector
- Calibration Laser
- Laser Energy Meter
- Beam Direction
Direct Imager

30 fps CCD Camera

ND filter wheel

High resolution lens

Scintillators on movable shaft

4 Scintillators:
- Thin, stops 8 keV FEL. Find soft x-ray FEL.
- Very thin, stops 826 eV FEL. Find soft x-ray FEL.
- Thick, stops spontaneous studies. + one other for tests diamond.

Photodiode for K measurement

Low resolution lens

30 fps CCD Camera

Stops FEL

Transmits spontaneous
Direct Imager

Single shot measurement of $f(x,y)$, $x$, $y$, $u$

Camera

Scintillators

Status Direct Imager:
PRD done
SCR done
Prototype in preparation
Prototype Direct Imager testing

- Flat field testing of camera only
- Enclosure

CCD

Integrating Sphere

- WFOV Optic
- Camera
- YAG

Pulsed UV laser testing with YAG

- N2 Laser
- UV beam splitter
- Photodiode
- Lens
- ND filter
- Insertable photodiode
\[ \sigma^2 = G \cdot \bar{d} + \sigma^2_{\text{Readout}} \]

**Our fit:**
\[ \sigma_{\text{Readout}} = (5 \pm 50) \cdot e^{-} \]
\[ G = \frac{1}{(13 \cdot e^{-} / \text{gray})} \]

**Manufacturer:**
\[ \sigma_{\text{Readout}} = 75 \cdot e^{-} \]
\[ G = \frac{1}{(12 \cdot e^{-} / \text{gray})} \]
Direct Imager image of N\textsubscript{2} laser excited YAG scintillator at 20 Hz

YAG excited by N\textsubscript{2} laser

Boundary of 10 mm dia. YAG disk
FEL Offset Mirror Systems

Full Offset Mirror System: SOMS + HOMS

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Bidirectional Popup Viewer

Light Source

Camera Lens

Polarizing Beam Splitter

Scintillator

Quarter Wave Plate

Mirror

To CCD

Collimator
We are studying expected signal levels in the Pop-in cameras

Low Energy, All undulator modules
100% Spontaneous
Propagated through fixed mask, pipes
12 Boron Carbide windows are open
Slit is open
No attenuation, no gas detector
Photons absorbed in 1 mm YAG,
Full Well: 200,000

# photoelectrons ~
5660 per pixel
Wall penetration FEE to NEH

- SOMS M3 M4
- Collimators
- Steel shield
- Taperd slot filled with steel blocks

Status:
SCR done
Delayed by Continuing Resolution until FY08

- NEH Mechanical and Vacuum
- NEH imager
- Tunnel Vacuum Transport
- FEH imager
Summary

- Most major XTOD systems on schedule:
  - Procurement - Slit, Fixed Mask, Tunnel
  - FDR – Attenuator, Gas Detector, Thermal Detector
  - PDR – Direct Imager, SOMS, Wall Penetrations
  - SCR – K-Spectrometer
  - PRD – HOMS, Indirect Imager

- Some systems not essential for commissioning delayed by CR