Commissioning Status and Plans

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June 08, 2009
Undulator Installed and Operating

Commissioning status and plans
FAC June 2009
Commissioning Status

- Laser heater commissioned December 10, 2008
- First lasing at 1.5A April 10, 2009
- Saturation at 1.5 A April 14
- Observe transverse coherence April 23
- Operation with 20pC short pulse April 24
- Operation with FEL taper April 26
- Operation at 15A May 14
Until FEE is ready, we have been using a simple diagnostic with limited capabilities.

- Ni or B4C
- YAG screen
- Be Coherent visible radiation blocking foil
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FEL Performance - Gain

250pC, 3 kA
13uJ heater
Linear Taper
13.5 GeV
E–Loss=8.11±0.24 MeV (2.06 mJ), 01–JUN–2009 02:39:47 (13.70 GeV)

N–photons = 1.55e+12
E–photon  = 8.34 keV

FEL energy assumed equal to e-beam energy loss

Taper for energy extraction
Highest energy demonstrated: 8.66 KeV

Lowest energy demonstrated: 820 eV (wavelength not measured)

FEL energy at 820 eV
6 MeV loss, 1.5 mJ

Ni K-edge is at 8.333 KeV corresponds to 13.72 GeV
Linewidth ~ $7 \times 10^{-3}$ FWHM.
Jitter $1.5 \times 10^{-3}$ RMS

Measure YAG intensity behind Ni foil.

Energy Offset from 13.7 GeV
Put Carbon beam finder wire in FEL beam, look on YAG screen
See interference fringes – data still needs to be analyzed

Simulated Diffraction Image

Real Diffraction Image
Stability

- YAG screen saturates, underestimates the jitter on the FEL intensity

- Measured intensity jitter ~5%, real jitter probably < 10%
  - 11% observed with low charge, YAG unsaturated

- Measured position jitter < 20% of spot sigma

- Energy stability at DL2 0.06% RMS, wavelength stability ~0.12%
  - K-edge measurement gives similar wavelength jitter measurement
For normal 250pC operation can measure bunch length using transverse cavity

8 micron (24 fs) RMS bunch length for electron beam

Expect FEL to be similar but no measurement

Bunch length measurement with TCAV3 and wire scanner
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@ 120 m

SIMULATION

2 fs

Simulation of FEL with 20pc Electron bunch (Y. Ding)

Measured gain length 3.94M at 20pc full compression High gain implies short bunch

FEL OFF

FEL ON

Dump Screen, Dispersion vertical

Energy loss 6.2 MeV at full compression ~10^{11} Photons at 8.3 KeV

So far no way to measure bunch length.
90% uptime during commissioning – but commissioning isn't the same as user beam

Source laser power – cathode is not degrading over last 3 months

6 Hour run – so far no attempts at long term operation
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Laser Heater


YAGS2
RF deflector ON

energy

time

Laser OFF
\( \sigma_E/E < 12 \text{ keV} \)


YAGS2

Laser: 40 \( \mu \text{J} \)
\( \sigma_E/E \approx 45 \text{ keV} \)

Heater improves FEL gain!


Laser: 230 \( \mu \text{J} \)
\( \sigma_E/E \approx 120 \text{ keV} \)

758 nm laser (44 \( \mu \text{J}, 20 \text{ ps} \))

1840 mm
\( \leq 550 \text{ mm} \)

100 mm

85 mm

\( \geq 100 \text{ mm} \)

100 mm

85 mm

180 mm

TCAV

Impact

Laser Heater

improves FEL gain!
Beam Based Alignment

BBA round 1
Scal 100um

BBA round 1
Scale 20um

BBA Corrections
Scale 50um

Take orbit data in undulator at 13.6, 9.25, 7.0 and 4.3 GeV, Correct Quad positions and BPM offsets

So far have been doing BBA about 1/week.
Miscellaneous Issues

Coherent Optical radiation ring on YAG screen with X-ray beam centered

True-color coherent optical ring image (blue-white)

Laser heater “trickle heat” mode
Increased energy spread at very low energies (coherent effect?)
Not well understood

Due to YAG saturation, no good spot
Size measurements yet
B4C stopper expose to 4M pulses at 820 eV, max power.

Dark area looks like deposit on surface, not material damage

Sample has been removed, testing with SEM, profilometer, visible microscope

We will have a B4C shutter with a camera to monitor, interlocked to MPS to protect the downstream PPS stoppers.

If we do see damage we can switch to a Beryllium shutter – but with obvious toxicity problems
Commissioning – Still to go

- FEE X-ray diagnostics
  - Expect start operation July 2009

- User Operations
  - Expect September 2009
  - Far Hall first light April 2010
  - Project Complete July 2010

- LCLS Operational issues
  - Wavelength tuning still slow – need to improve automation
  - Lots of “physicist” software still in use

- 120 Hz Operation - Controls