Machine Performance, Stability, Recovery, and Uptime

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May 14, 2009

Diagnostics – how we know what we know

- FEE X-ray diagnostics not ready for beam, using temporary diagnostics
  - Measurements somewhat suspect
- Electron beam diagnostics in good shape
  - We believe the measurements
  - Except – COTR still prevents use of OTR diagnostics
- Beam recovery and uptime from operations records
  - Operation not really like user beam delivery, so can't make a direct comparison.

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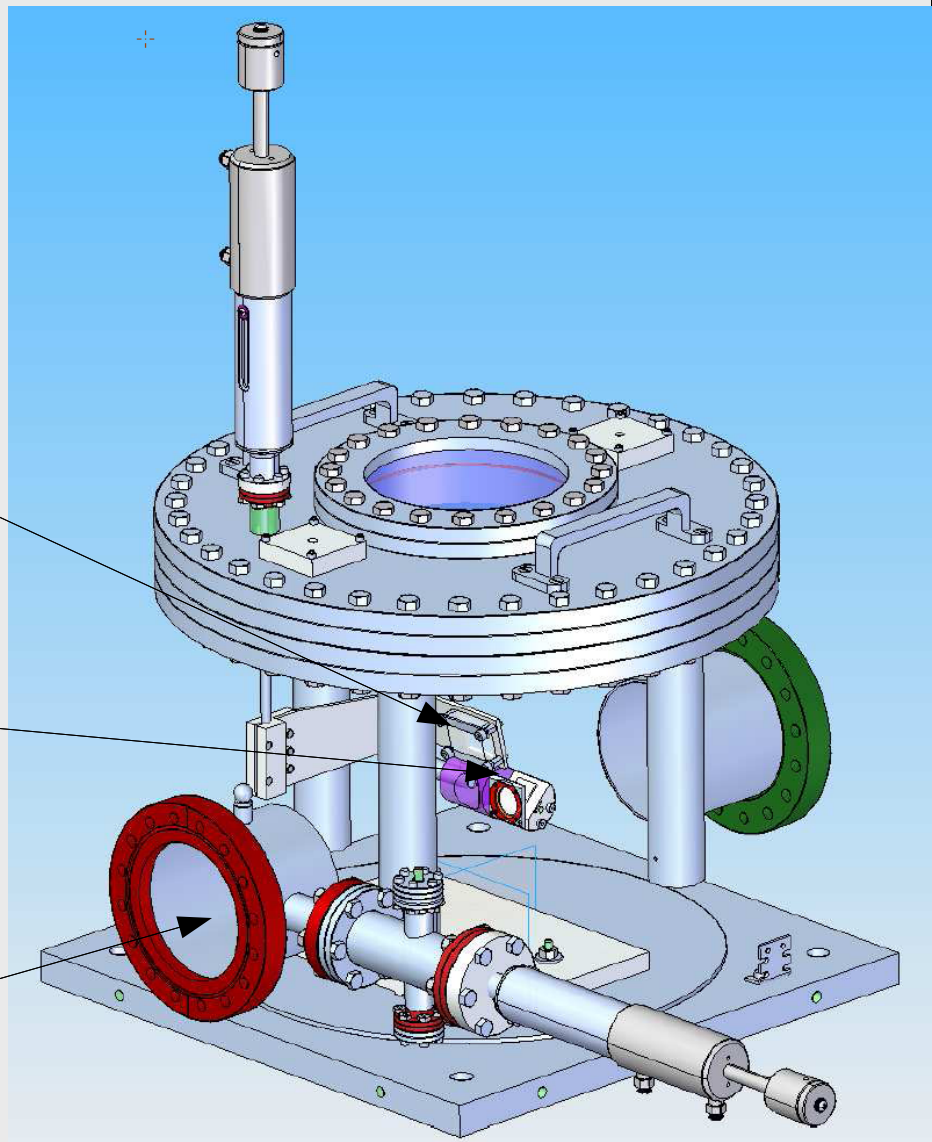
Temporary Diagnostics

Ni or B4C

YAG screen

Be Coherent visible radiation blocking foil



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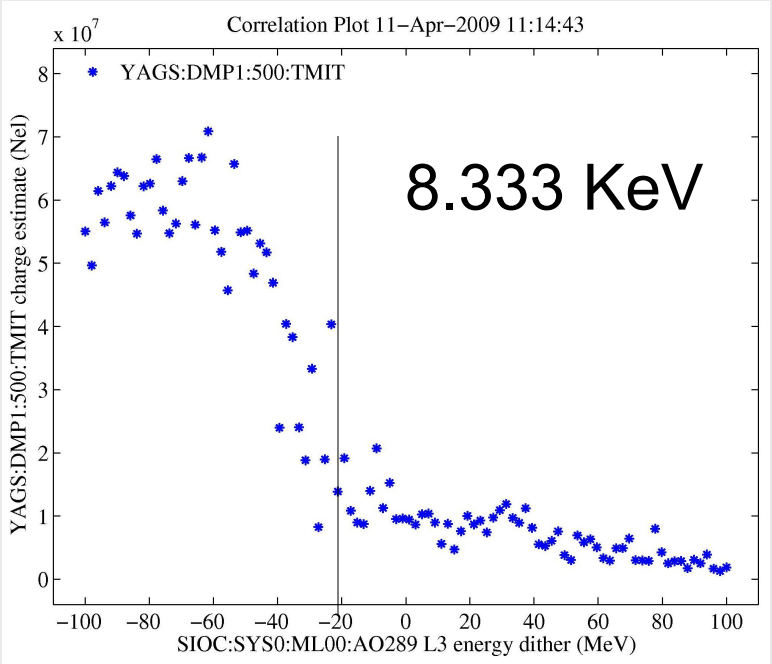
Operating Wavelength

- Highest X-ray energy: 8.66 KeV
- Have not tried to lase at low energy – concern about damage to YAG screen

Ni foil K-edge used to measure wavelength

8.333KeV at 13.73 GeV



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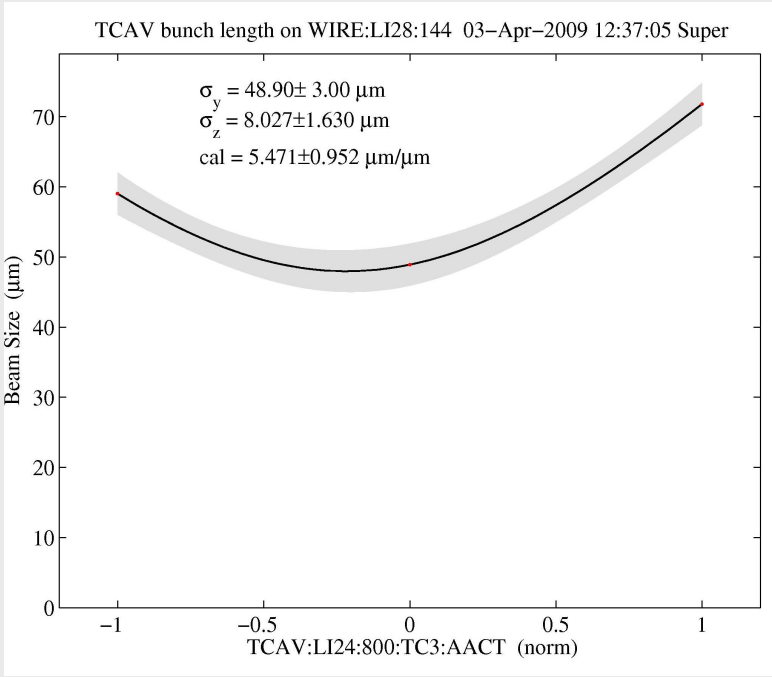
Pulse Length

- 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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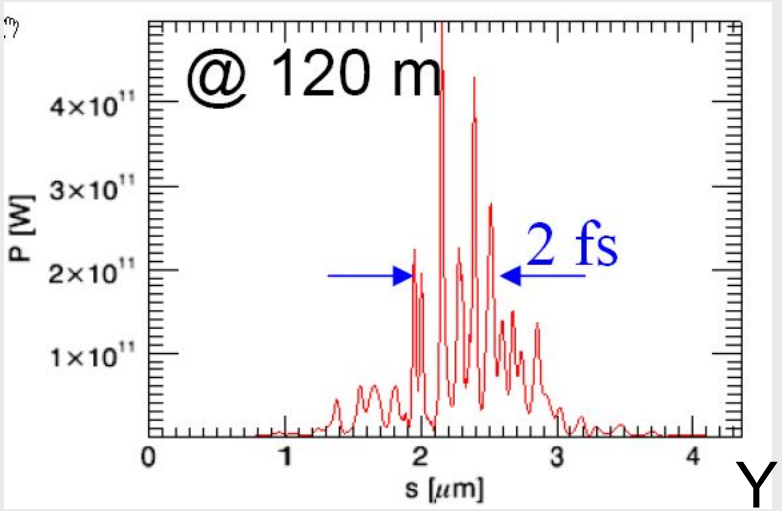
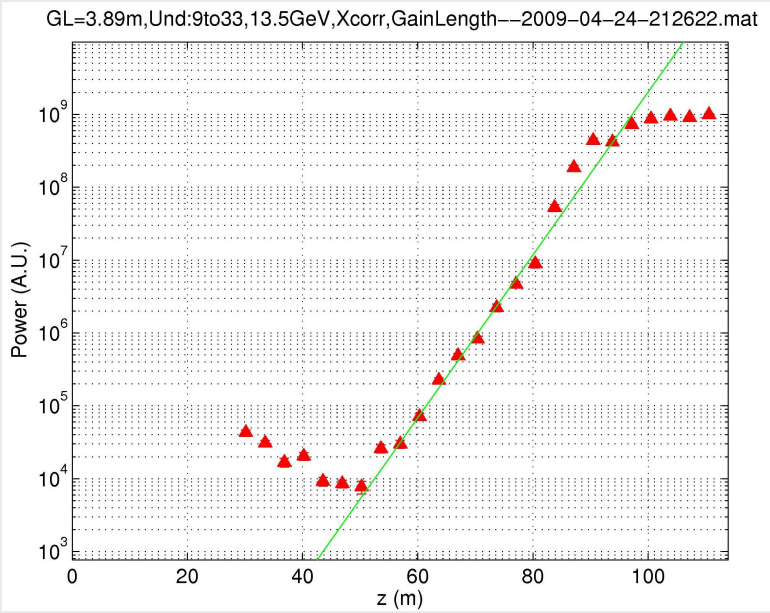
Pulse Length – Ultra Short

- Saturated with 20pC
- Simulations suggest bunches as short as 2fs FWHM, but NO DIRECT MEASUREMENT
- Saturation at 20pC implies fairly short bunch



Y. Ding

SIMULATION of ultra short FEL beam from 20pC bunch



20pC saturation

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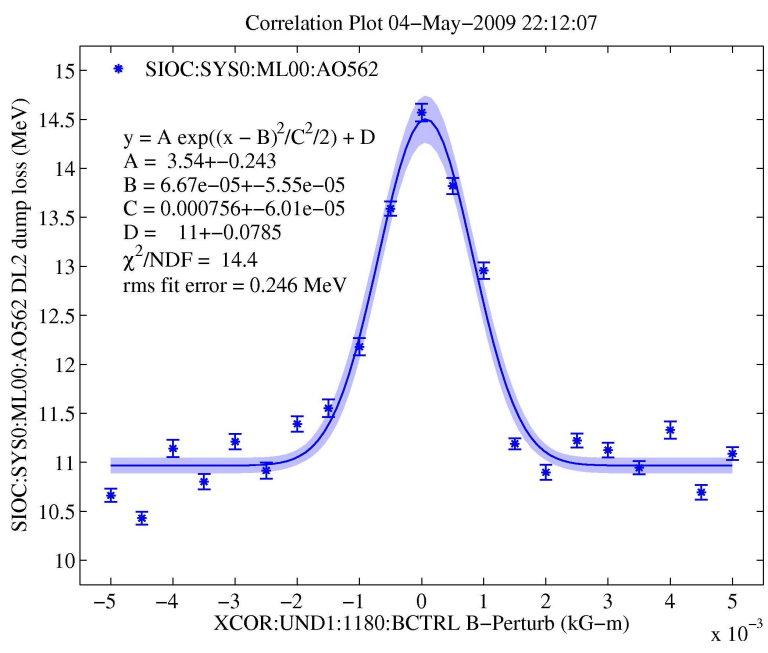
FEL Energy Measurement

- No direct FEL energy measurement,
- use electron energy loss
  - Measure energy at DL2 and and dump
  - Correct for transverse orbit
  - Correct for changes in peak current -> changes in wakefield loss
  - Compare energy loss with FEL on and off
- ~1mJ normal conditions



Energy loss as a function of corrector kick in undulator

FEL energy measurement -other

- Compare YAG intensity for lasing beam to spontaneous radiation: 1-5 mJ
- Partial saturation of YAG screen: 0.5-1.2mJ
- Ni foil burn-through in minutes, but not single pulse: 300uJ to 3mJ
- Simulation with observed gain gives ~1mJ
- It would be nice to have a direct thermal measurement, but we think we know the energy.

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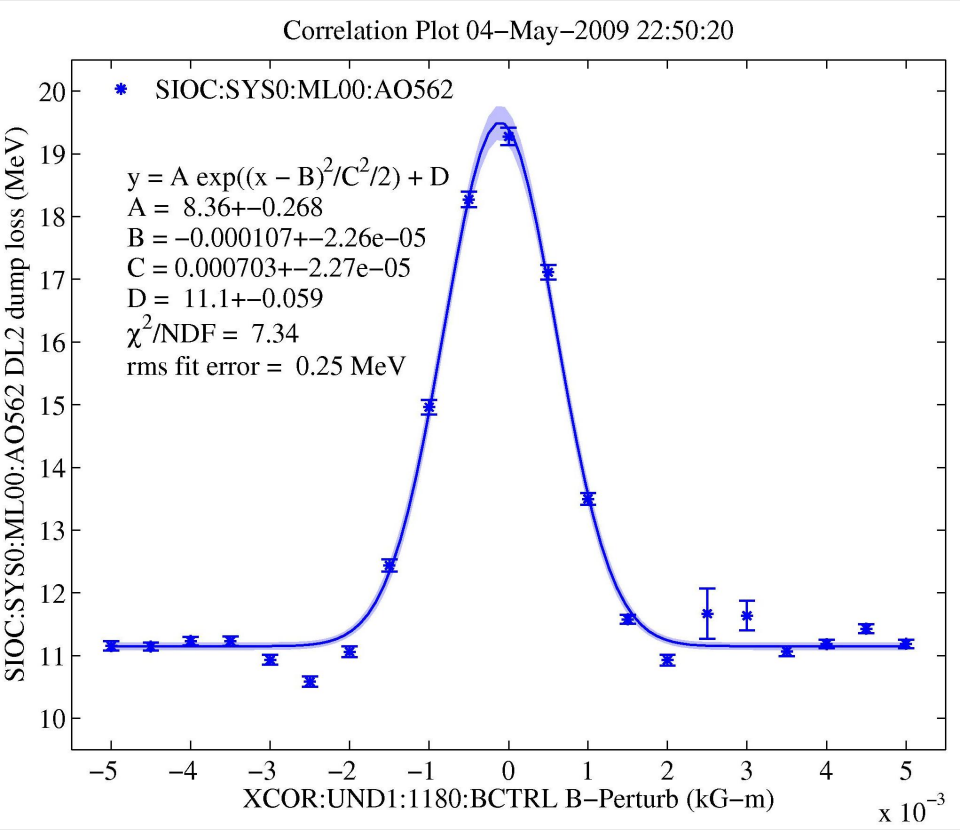
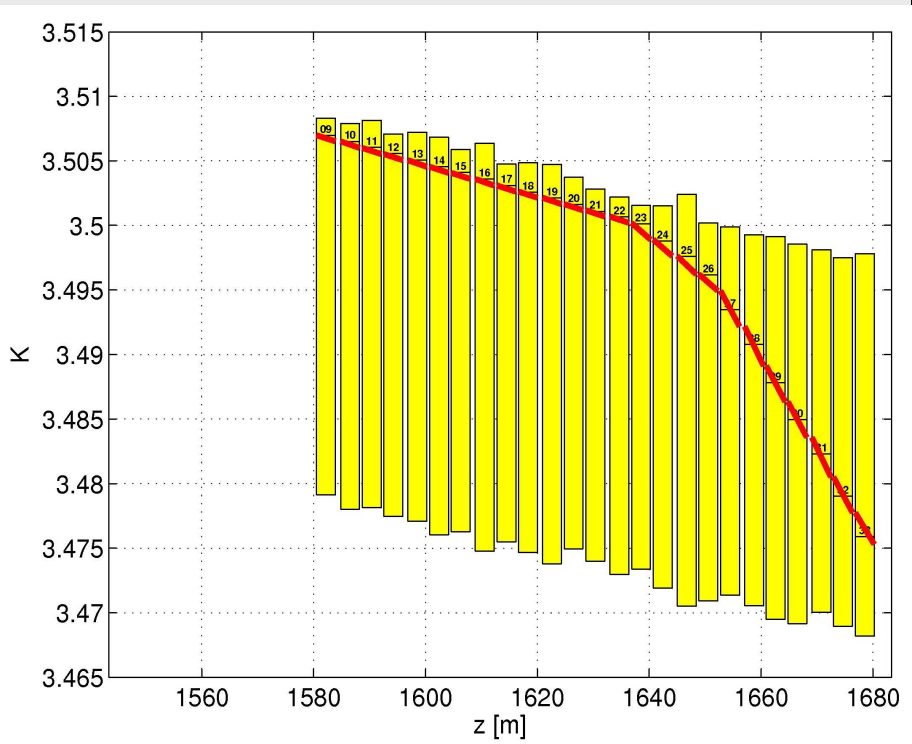
Maximum output energy

- Undulator tapering increases output power
- Best so far is 2.1mJ beam energy loss) (Z. Huang. D. Ratner)

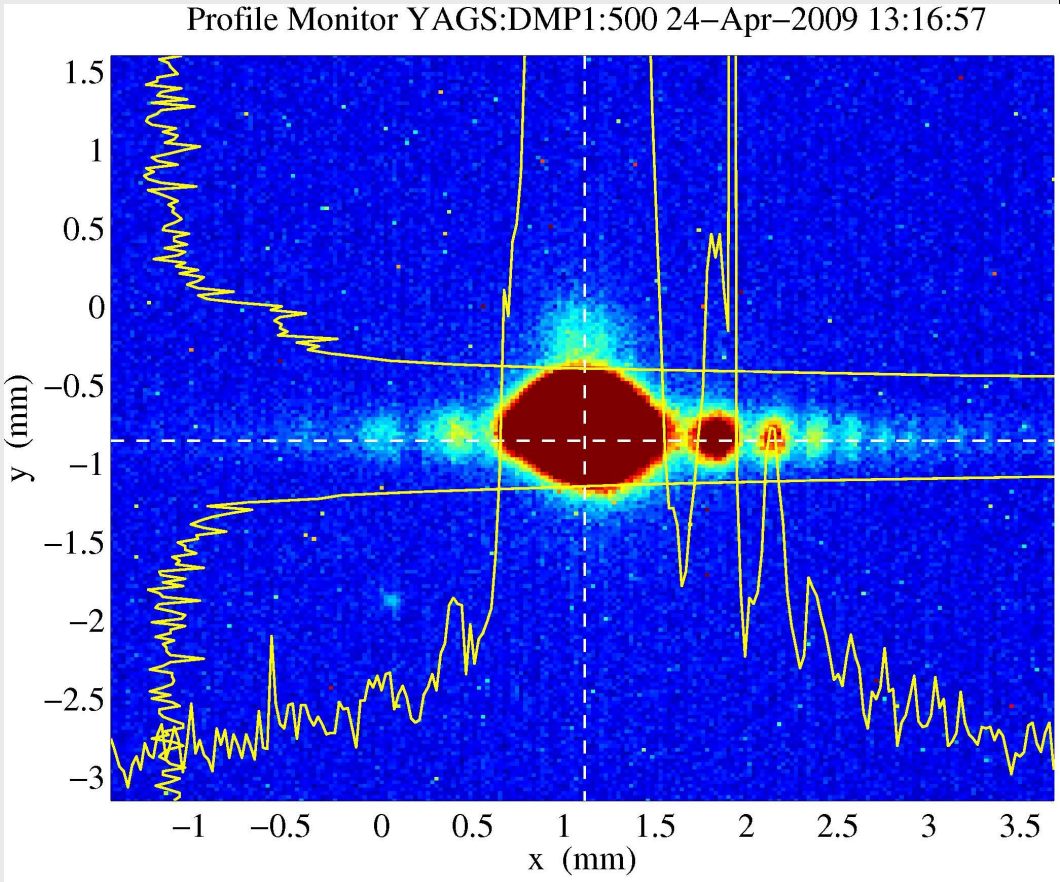




Coherence

- Fringes observed with beam-finder wire in FEL beam.

Data still being analyzed



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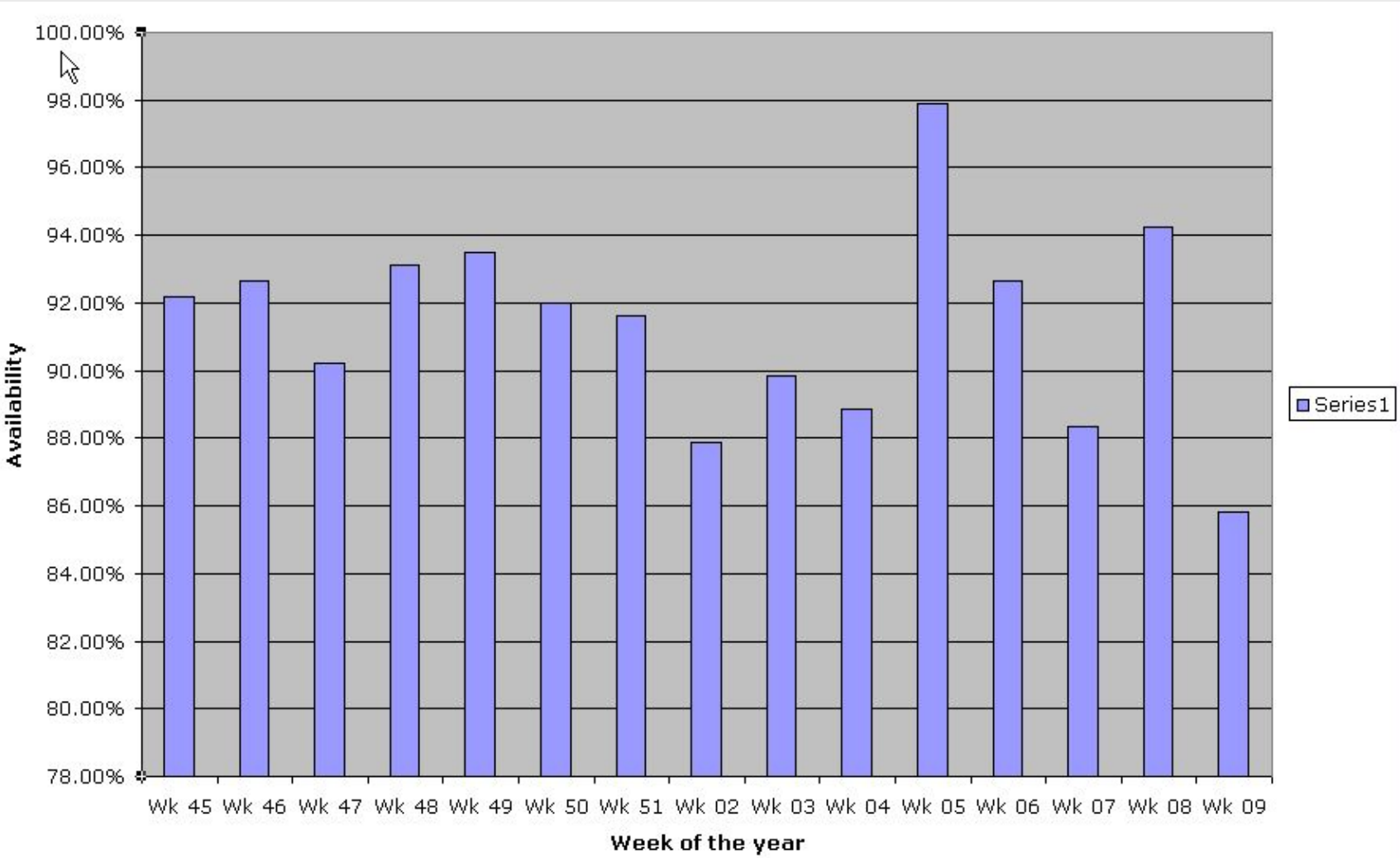
Stability

- YAG screen saturates, underestimates the jitter on the FEL intensity
- Measured intensity jitter ~5%, real jitter probably < 20%
- Measured position jitter < 20% of spot sigma
- Energy stability at DL2 0.06% RMS, wavelength stability ~0.12%
  - K-edge measurement gives similar wavelegth jitter measurement

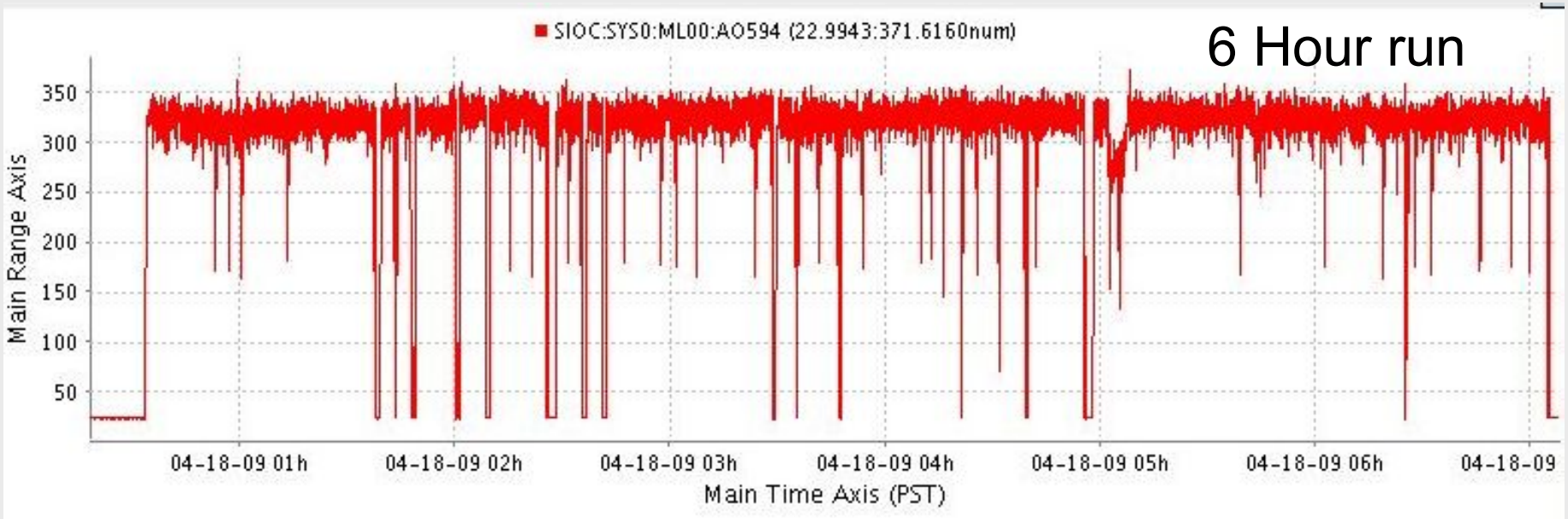
Uptime

Approx 90% uptime, but commissioning is not the same as operation



Uptime - FEL

- No attempts at long term stable operation.
- FEL operates for hours without intervention



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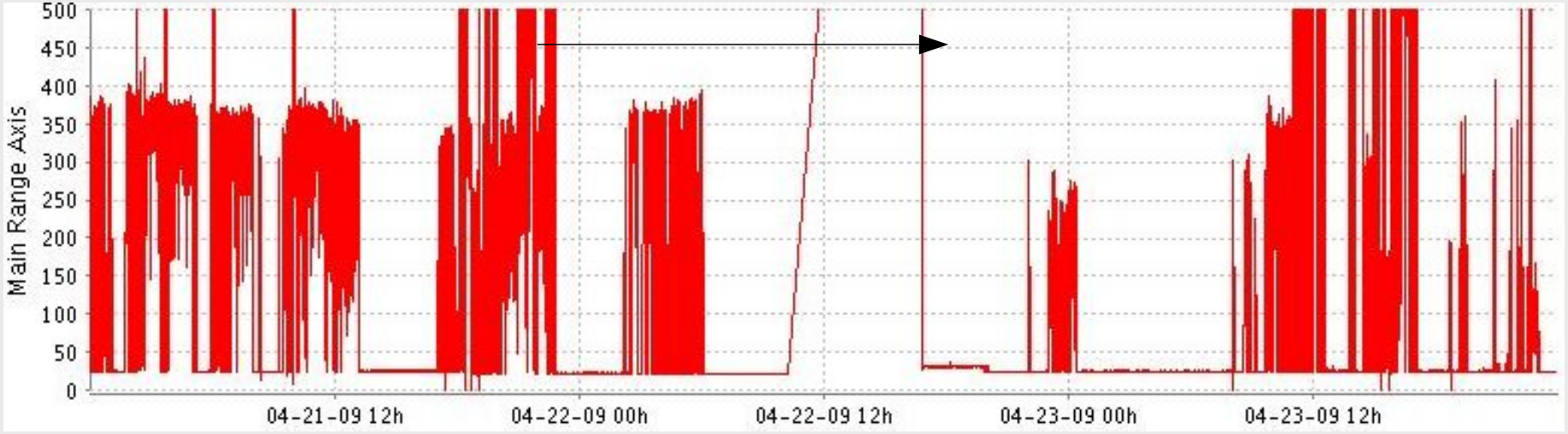
Downtime Recovery

- Typically takes 1 full shift for recovery from ROD (repair opportunity day).
- No users so far, so typically are not aggressive about performance recovery on owl shift



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Wavelength Tuning

- Have not attempted to lase at longer wavelengths due to possible damage.
- Beam Based Alignment:
  - Approximately 6 hours to change: 13.6, 9.25, 7.0, 4.3, return to 13.6 GeV.
  - 4.3 GeV is most difficult, others are 10-15 minutes
- Need to develop saved configs to allow faster wavelength changes.
- Small changes (2% wavelength) are <1second.

Overall

- Good X-ray performance demonstrated at 0.15nm, expect similar over full wavelength range.
- No long term running, but expect ~90% uptimes.
- Need to commission FEE diagnostics