



# X-Ray Diagnostics Commissioning at the LCLS

- Selected Studies -

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### **Commissioning Studies**

- Microbunching Instability
- Laser Heater tune-up
- Gas Attenuator alignment
- Ondulator Taper optimization
- Undulator Segment alignment
- Ondulator Longitudinal Wakefields
- High Fluence Damage

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   Fisher, J. Frisch, Z. Huang, R. Iverson, H. Loos, M.
   Messerschmidt, S. Moeller, H-D. Nuhn, D. Ratner,
   P. Stefan, J. Turner, H. Tompkins, S. Weathersby, J.
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- STEL: J. Gruenert, H. Sinn

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#### "FEE" and Surroundings



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Z. Huang et. al., Phys. Rev. ST-AB 7, 074401 (2004)

- Electron beam has extremely small initial slice energy spread: 2-3 keV.
- Such "cold" beams can undergo a microbunching instability in bunch compressors which can degrade beam quality.
- A Laser Heater device was developed to add a controlled amount of energy spread: enough to suppress the instability, but not enough to degrade the FEL performance.



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#### Turn Laser Heater Off



#### **SXR** Spectrometer

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#### Turn Laser Heater Off



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#### Laser Heater ON – No Instability



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## Measuring Laser Heater Gain Curves



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#### Laser Heater

 6 Gain Curves, one for each level of Laser Heater Power

 Optical filters used to extend dynamic range.



From Yuantao Ding

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# GA Alignment



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## GA Aperture Alignment



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## GA Aperture Alignment



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## GA Aperture Alignment



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## FEL Spectrum – K Monochromator

- Designed for Undulator K measurements using SR
- Can also measure FEL spectrum
- Passes only one energy
   8.234 keV at one angle
- Spectra obtained by scanning electron beam energy.



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#### Undulator Taper



H-D. Nuhn

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#### Undulator Taper

 Spectra measured for different settings a linear taper.

 Highest spectral power and narrowest BW occurs for a taper with ~20 MeV loss



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- Vertical alignment is determined by measuring ΔK as a function of vertical position.
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- Spectra of SR from single segments are taken with data concentrated on the steepest slope
- ΔK is varied by adjusting the relative horizontal position of the segments and interpolated to the 0 position. A slight wedge in the gap provides the tuning range.



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- Theoretical dependence based on K < B <  $cosh(2\pi y/\lambda_u)$  is  $10^4x\Delta K/K = 2.19e^{-4} y^2$
- Vertical tolerance is only 100 microns
- Undulator is physically moved with the electron beam at a constant position near 0.



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## Undulator Wakefields



- Set K's equal and measure spectrum with K-monochromator
- Wakefield depends on bunch charge and current.



#### 250 pC, 2000 A

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"ST0 Can"

Ni foil YAG

#### Damage

- Ni foil was used to try to better calibrate the Xray wavelength
- Foil was not visible in ST-0

FOIL is retracted

 Coherent Edge Radiation used to illuminate regions of foil.

e- Y Vertical Bend Magnet



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#### Damage

#### When inserted the Foil blocks CER

 But holes in foil would let CER show!

 Foil was removed and inspected. Holes were confirmed. Profile Monitor YAGS:DMP1:500 05-May-2009 15:12:01



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x (mm)

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#### Conclusion

- X-Ray diagnostics provided a means of investigating a wide variety of interesting phenomena and optimizing the LCLS performance during commissioning,...
- ... but we still have a lot to learn about what more they can do.

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