Undulator Spectra as a Diagnostic for Electron Beam Energy Spread and Emittance

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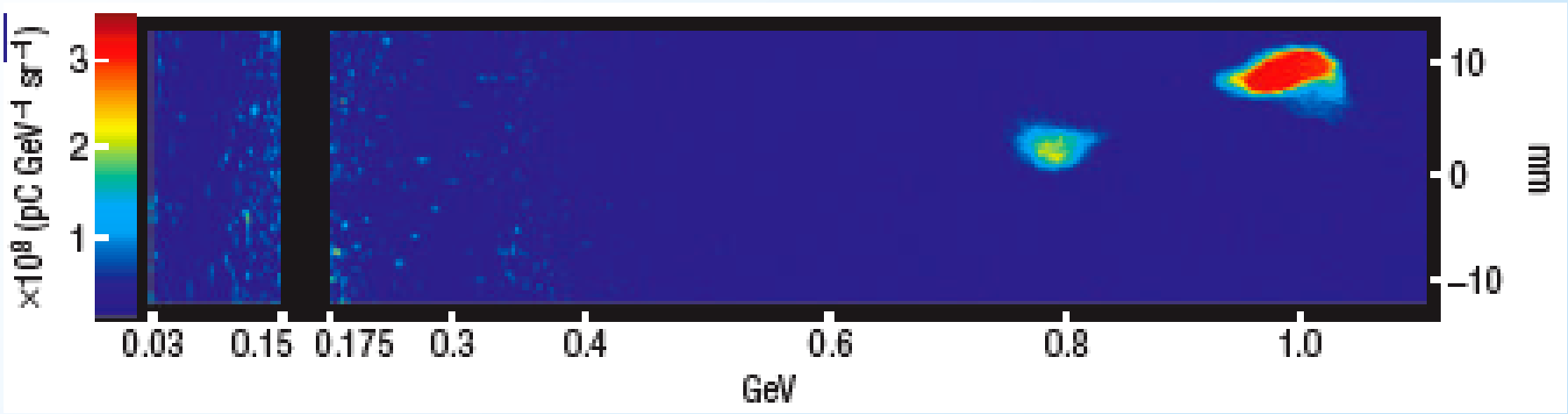
Introduction

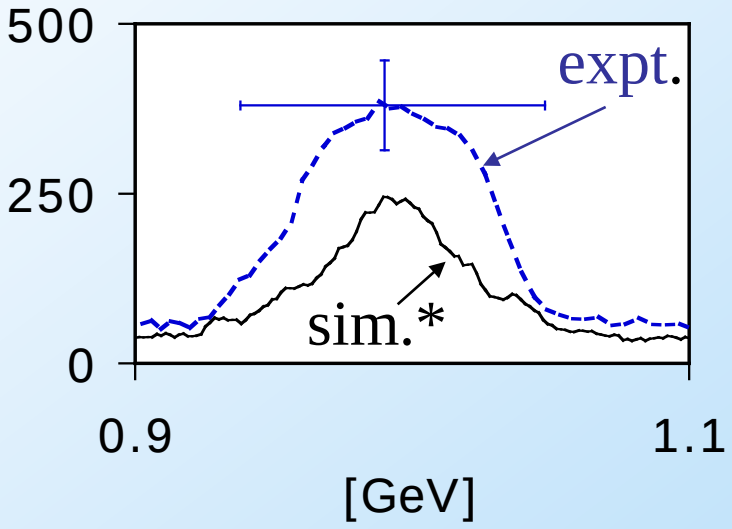
- Loasis 1GeV Laser Wakefield Accelerator
- Undulator Radiation as a beam diagnostic
- THUNDER Undulator Characterization
- Quadrupole Electron Beam Transport
- XUV Spectrometer Design and Calibration
- Conclusions and Future Work

First GeV Electron Beam from LWFA

- Laser: a_0 ~ 1.46 (40 TW, 37 fs)
- Capillary: D = 312 μm; L = 33 mm

1 GeV beam





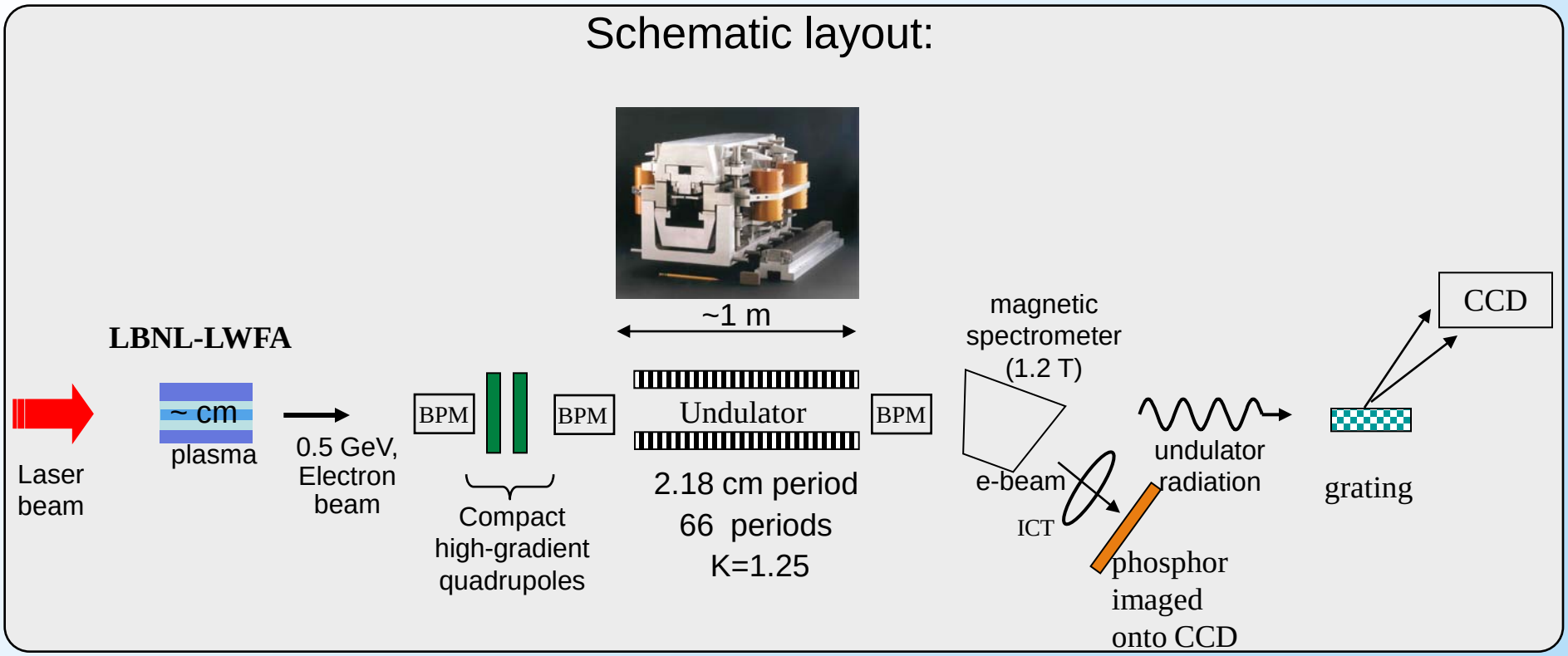
	Sim	Expt
Q (pC)	25-60	35
E (GeV)	1.0	1.1
dE/E RMS (%)	4	2.5
div. (mrad)	2.4	1.6

W.P. Leemans et. al, *Nature Physics* 2 (2006) 696; *Simulation using VORPAL

Undulator Radiation Diagnostic to Measure Emittance and Energy Spread

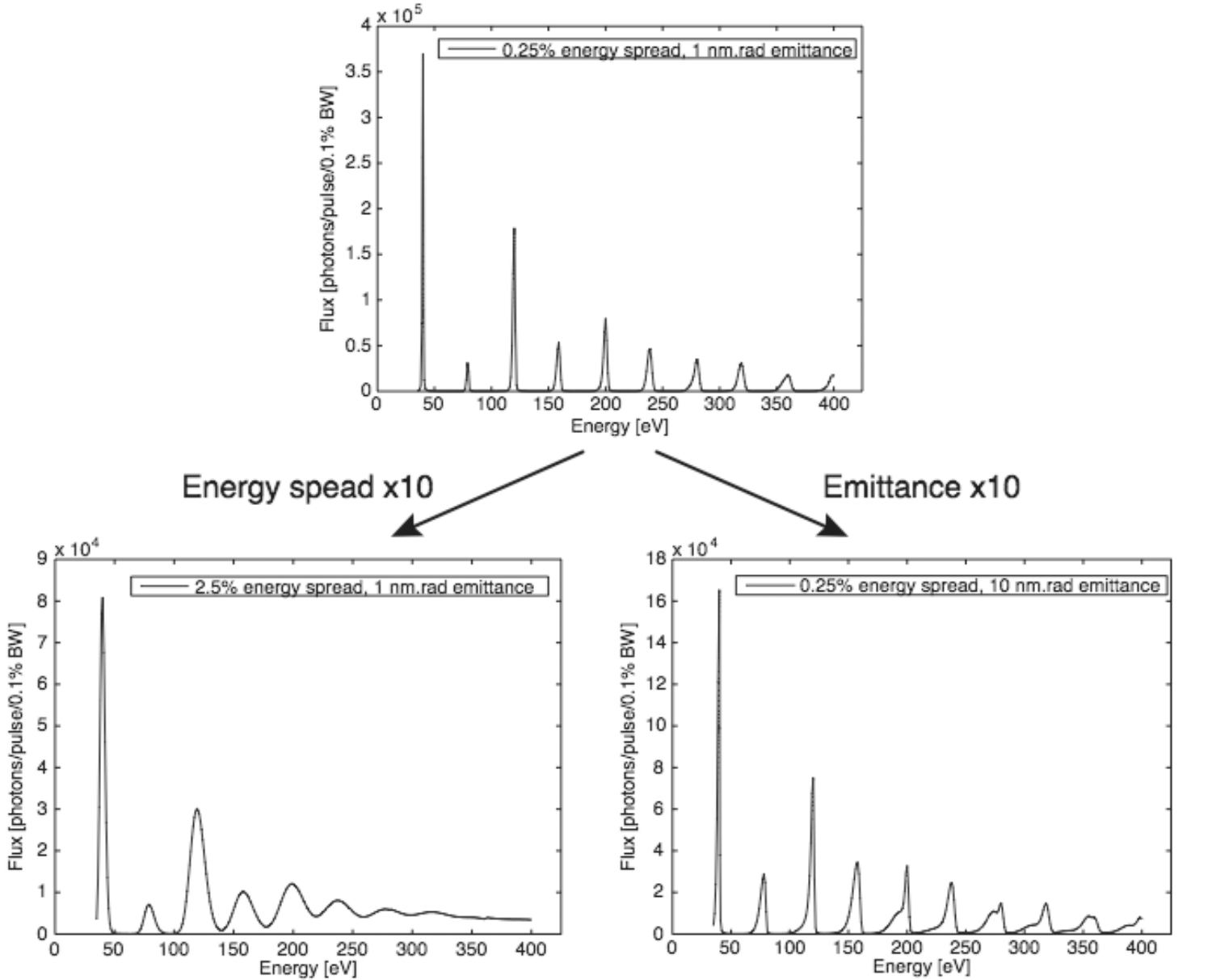
- Single shot electron beam measurements:
  - charge, energy, energy spread, transverse emittance

Schematic layout:



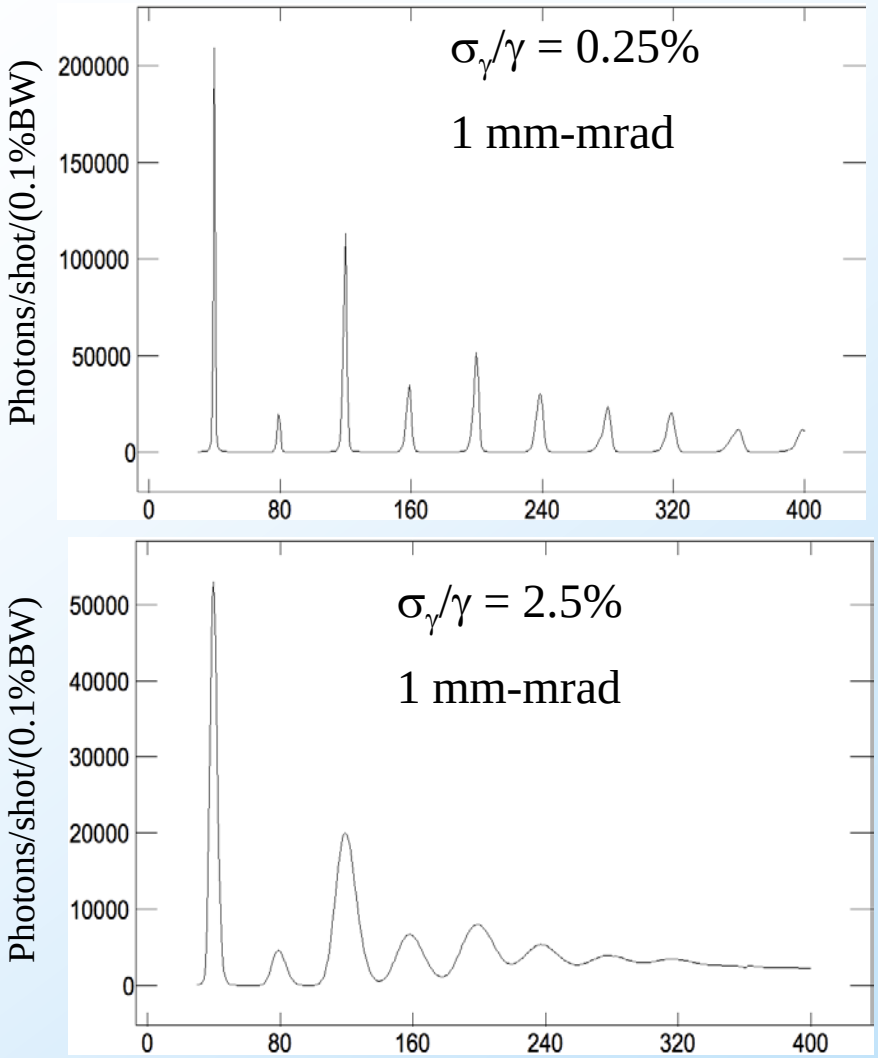
- Supporting systems:
  - Quads for refocusing
  - BPMs for positioning
  - OTR, phosphor screens

Emittance and energy spread affect the undulator spectra

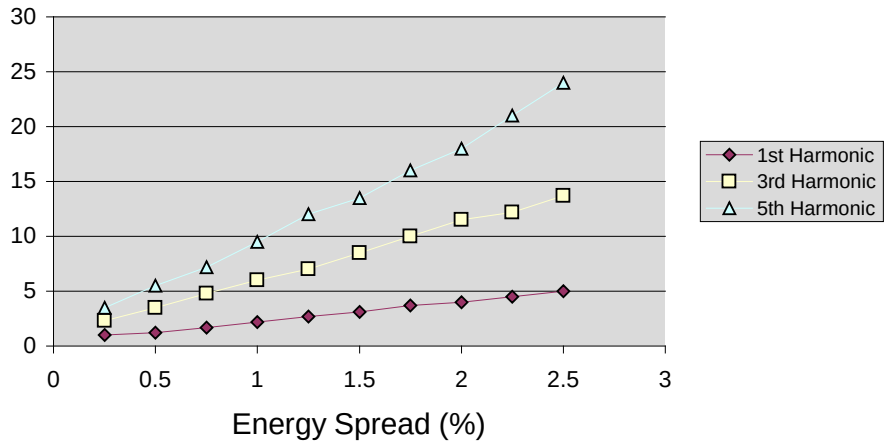


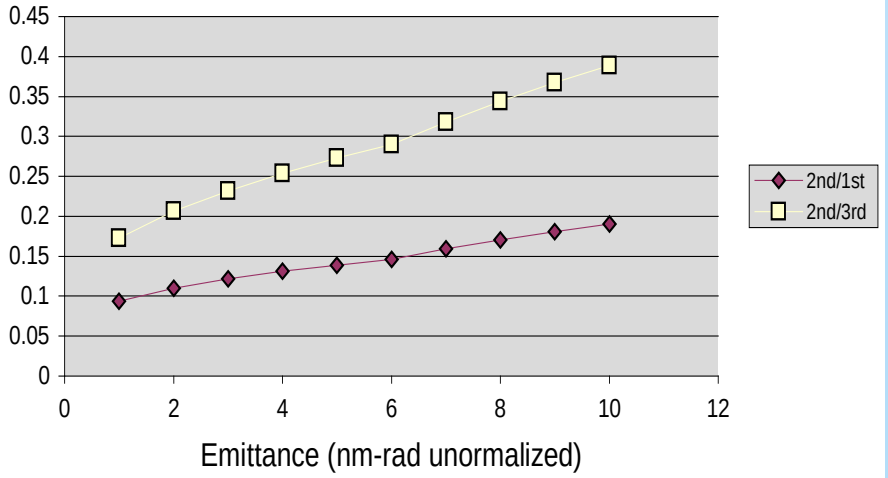
Undulator radiation based diagnostic will allow for single shot ΔE/E and ε measurement

Changing energy spread

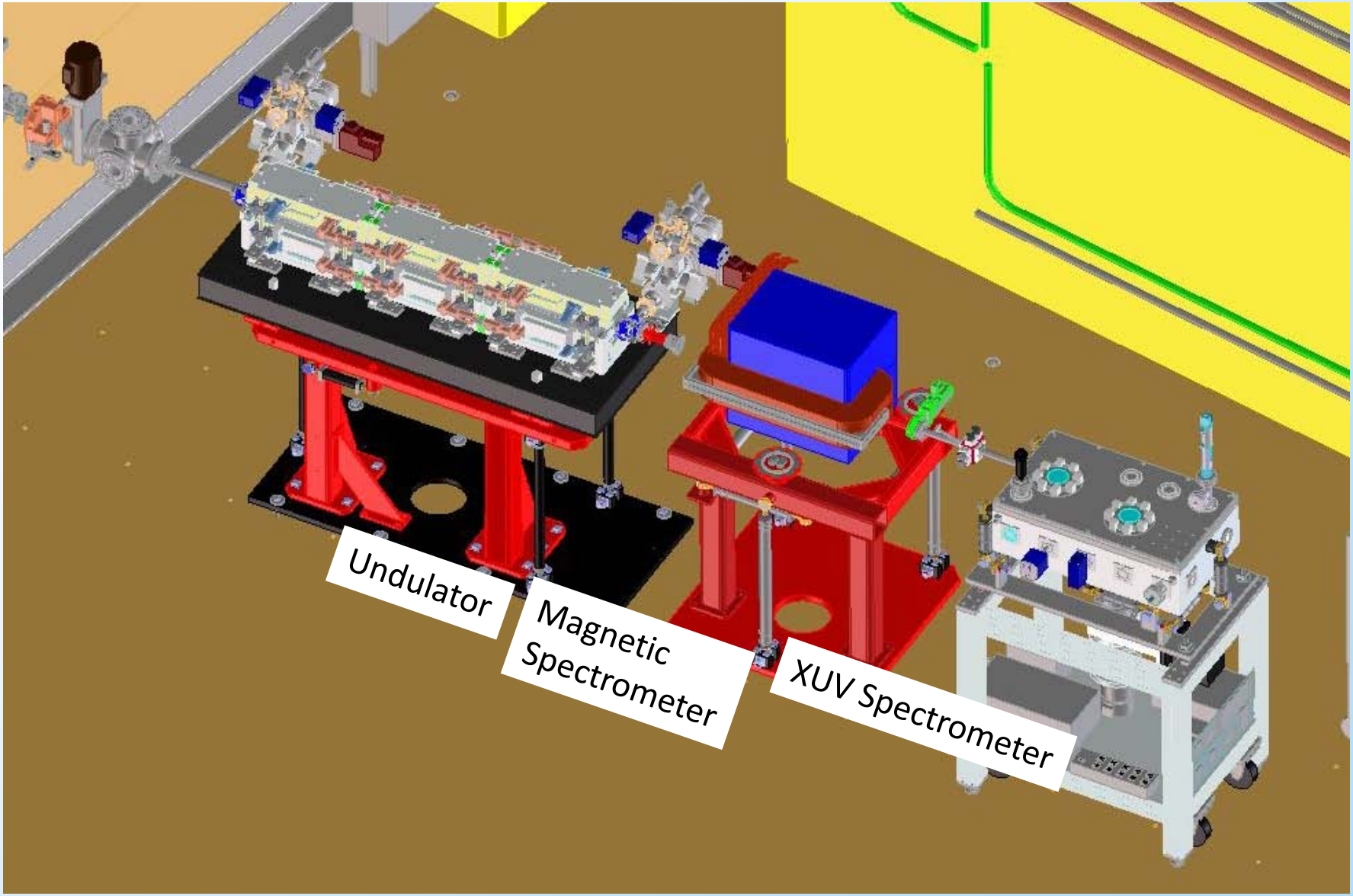


Line Width vs. Energy Spread





Experimental Setup in the Loasis lab

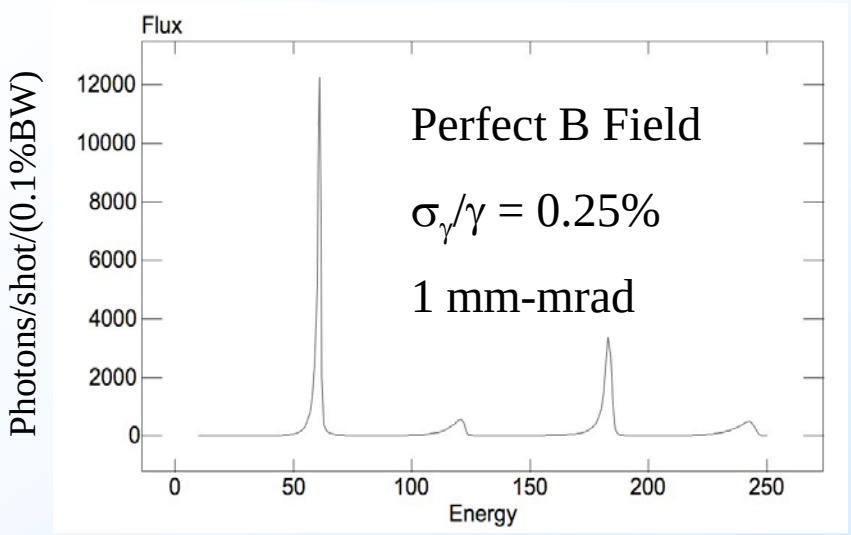


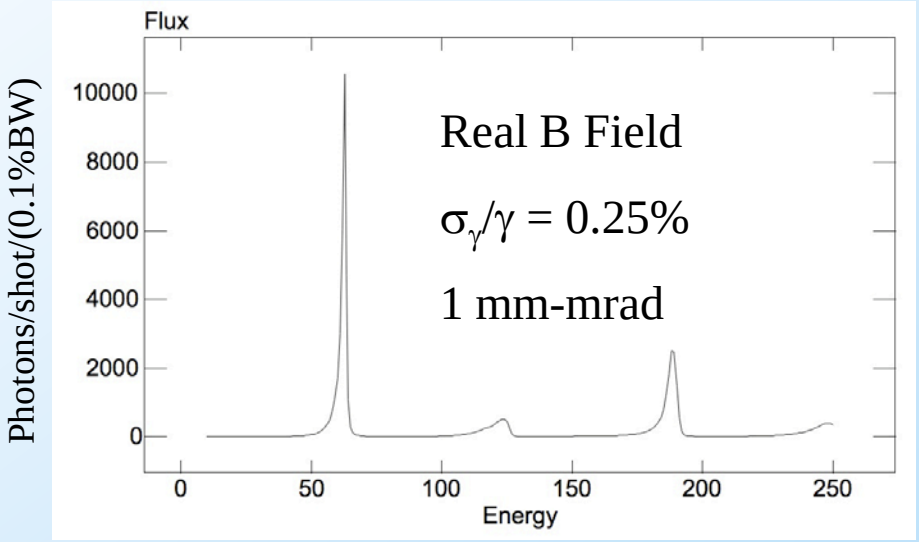
THUNDER Undulator Magnetic Properties

Magnetic Characteristics

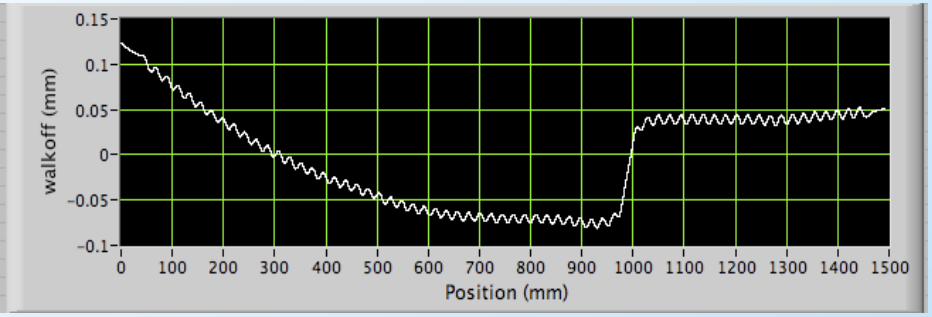
- Length = 1.5m
- Magnetic period = 2.18cm
- Number of periods = 66
- Peak Field = 0.61T
- Wiggler Parameter K = 1.25
- Betatron period = 3.7m

THUNDER tuned and characterized with the Spring-8 SPECTRA code

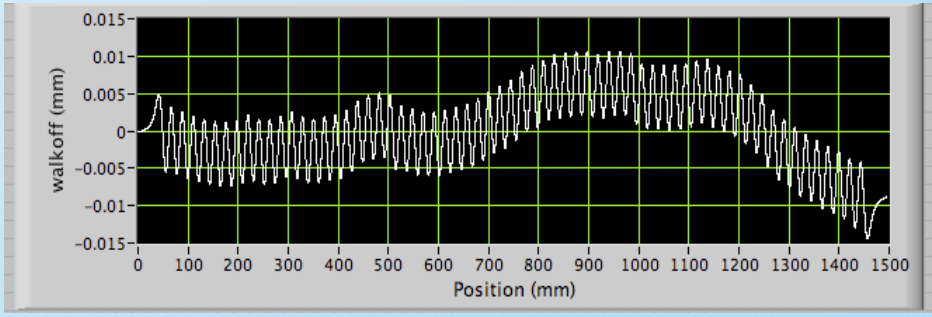




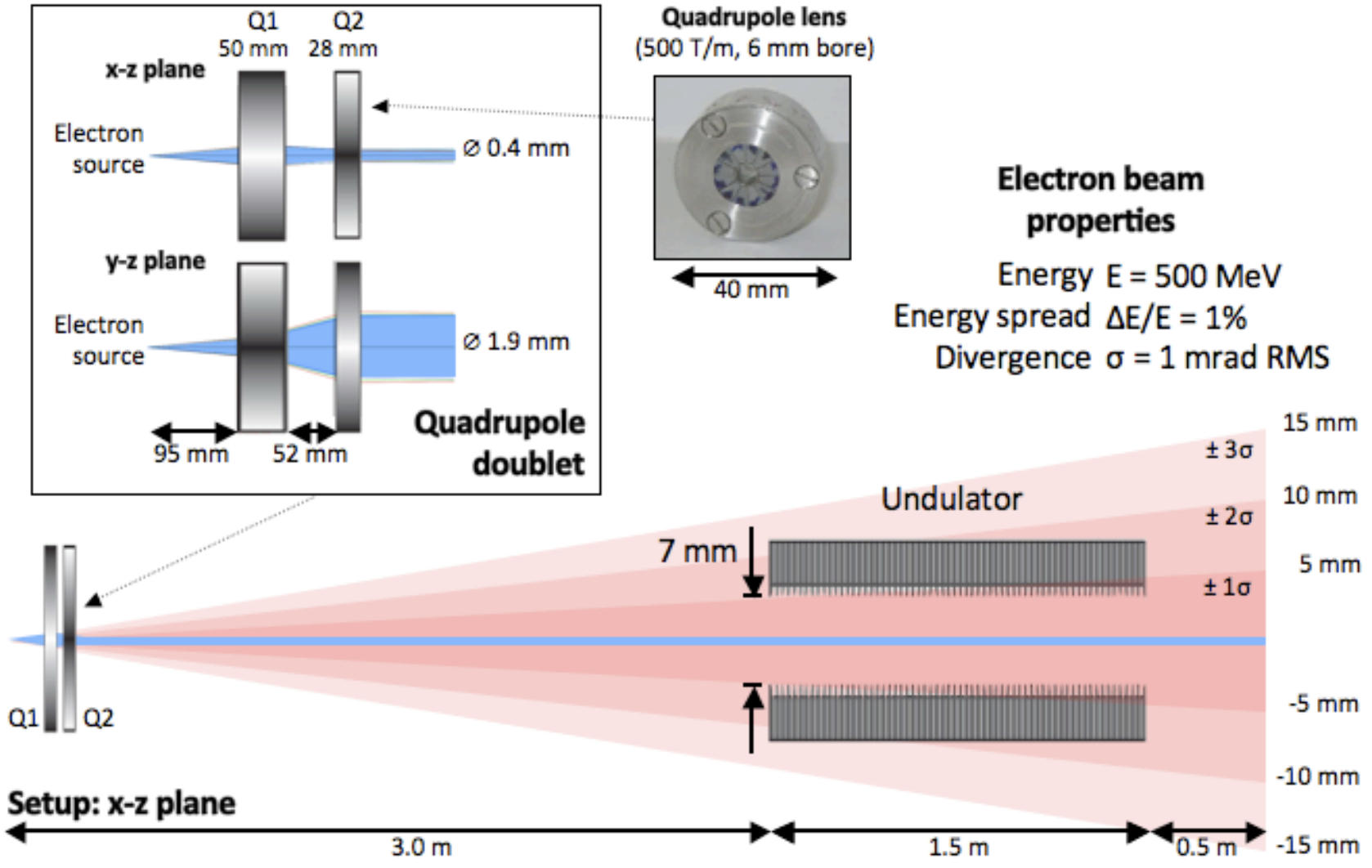
E-beam trajectory before tuning



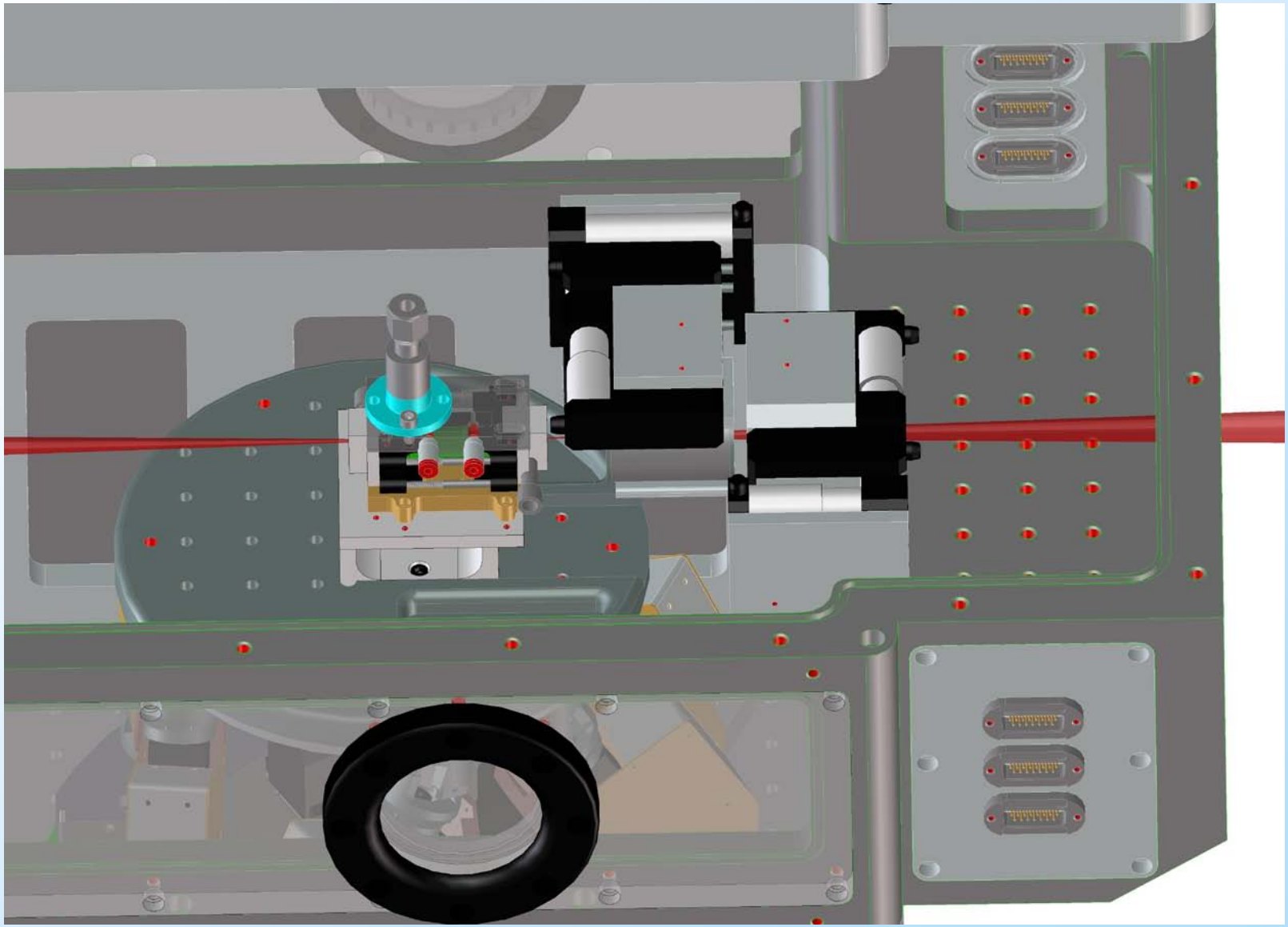
E-beam trajectory after tuning



Quadrupoles transport E-beam to undulator



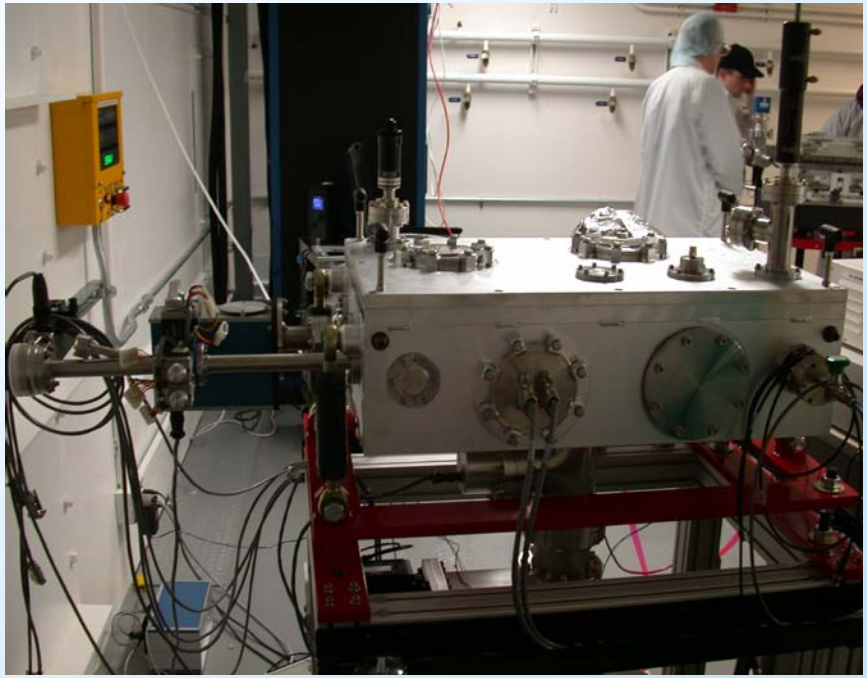
New capillary chamber designed to fit quads and stages



Micro-Channel Plate Based Spectrometer from 8 - 62nm

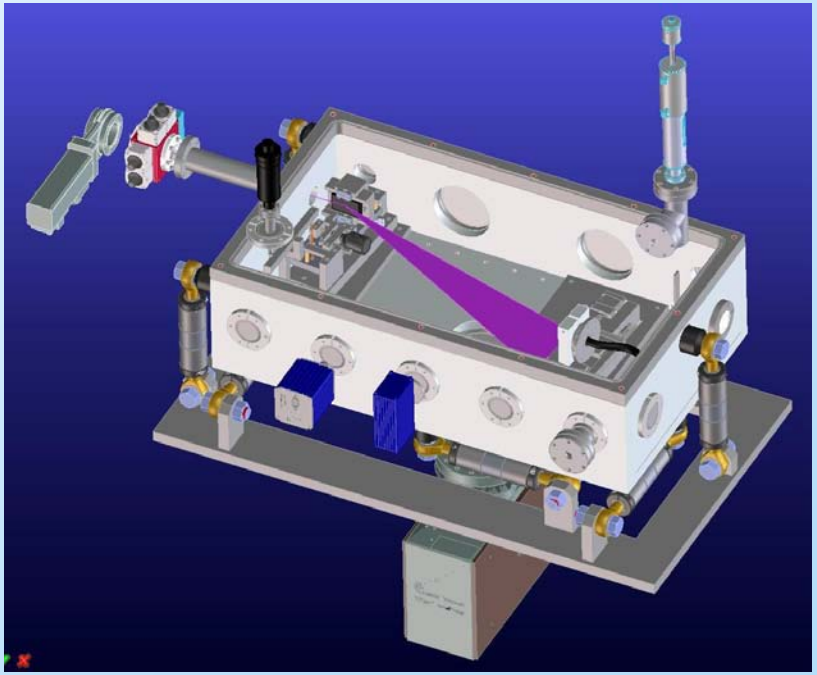
Optical Characteristics

- First harmonic = 20nm
- Natural divergence = 1 mrad
- Pulse length = < 25 fs
- First harmonic flux = $1x10^5$

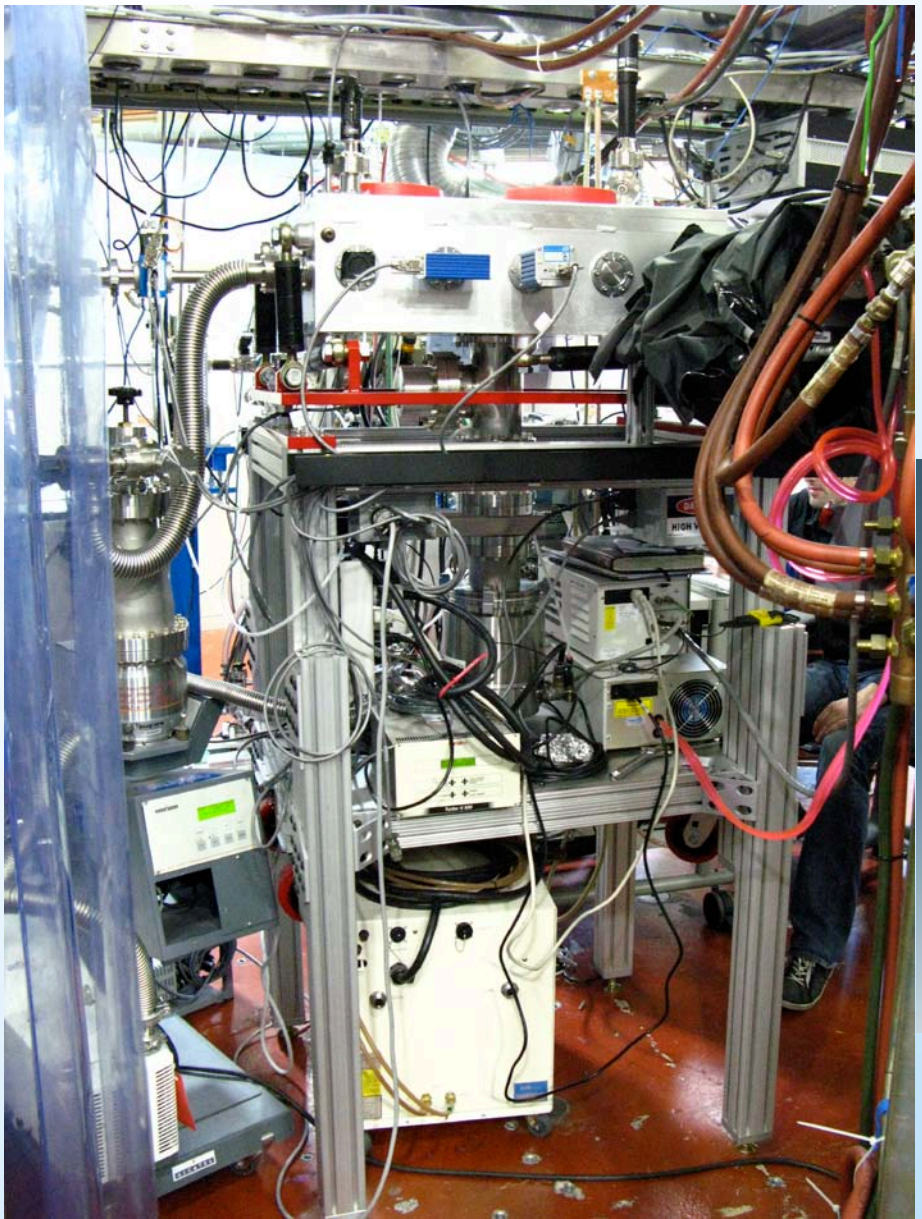


XUV Spectrometer properties

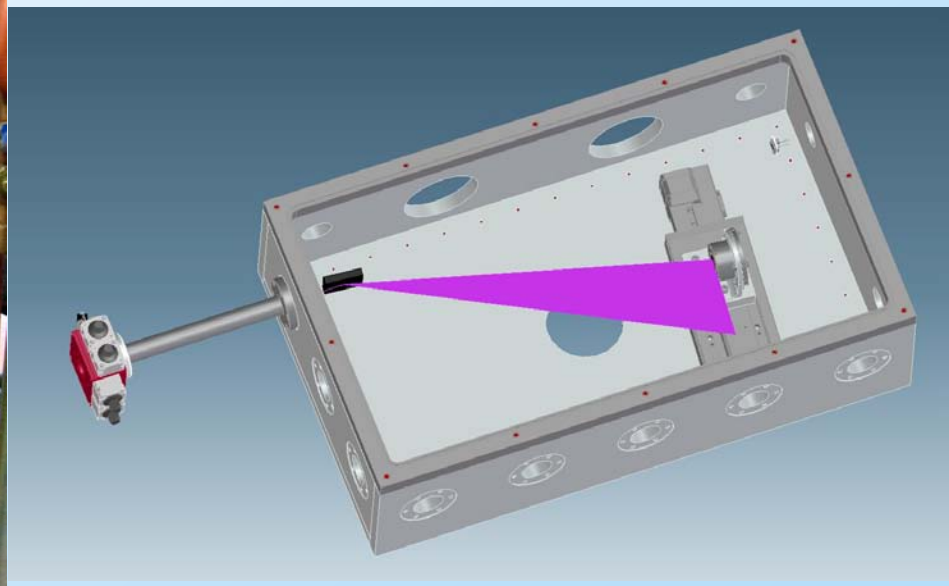
- 8-62nm spectral range
- Four jaw Aperture System
- MCP detector with CsI photocathode
- Aberration corrected concave grating



Characterization completed at the Advanced Light Source

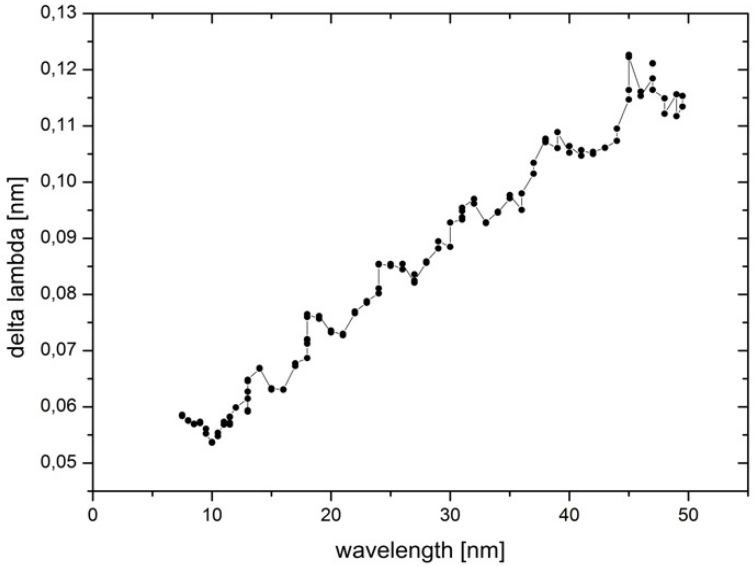


- Characterized on beamline 6.3.2
- 8-62nm Spectral Range
- 0.07nm resolution at 20nm
- Hitachi Aberration Corrected Concave Grating

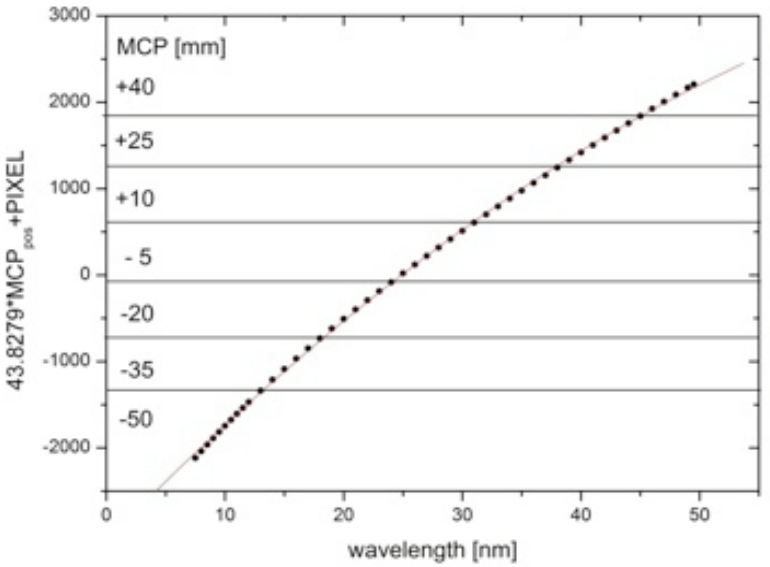


XUV Spectrometer Calibration

Spectral Resolution vs. Wavelength



Wavelength vs. Detector Position



Conclusions and Future Work

First experiments to begin this spring at Loasis

- Undulator radiation can be used as a singe shot emittance and energy spread beam diagnostic
- Experiments will be conducted using the Loasis LWFA at 500MeV
- Undulator characterized and installed on beamline
- XUV spectrometer built and characterized
- Quadrupoles and magnetic spectrometer will be installed this spring

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