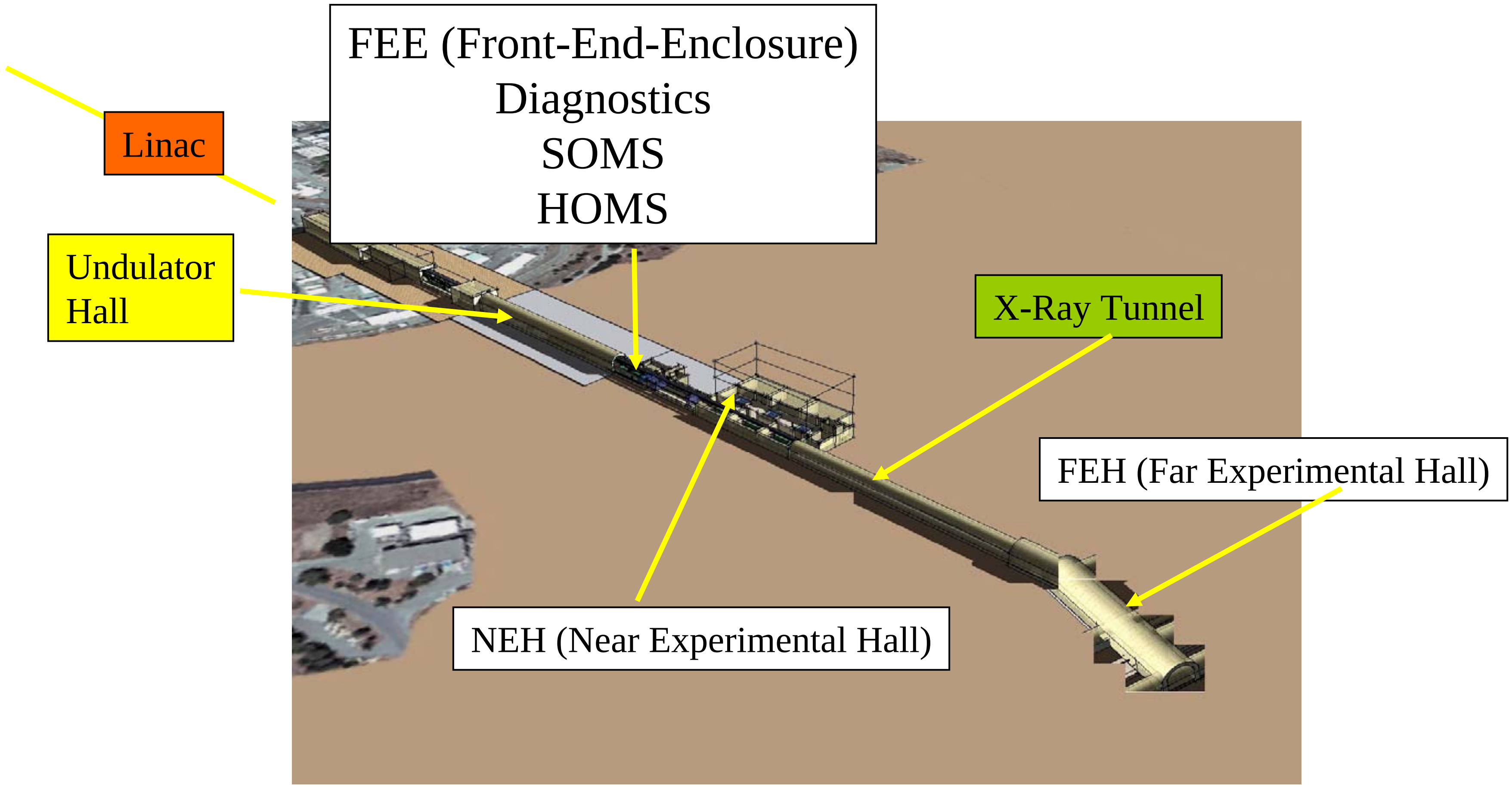
XTOD Update

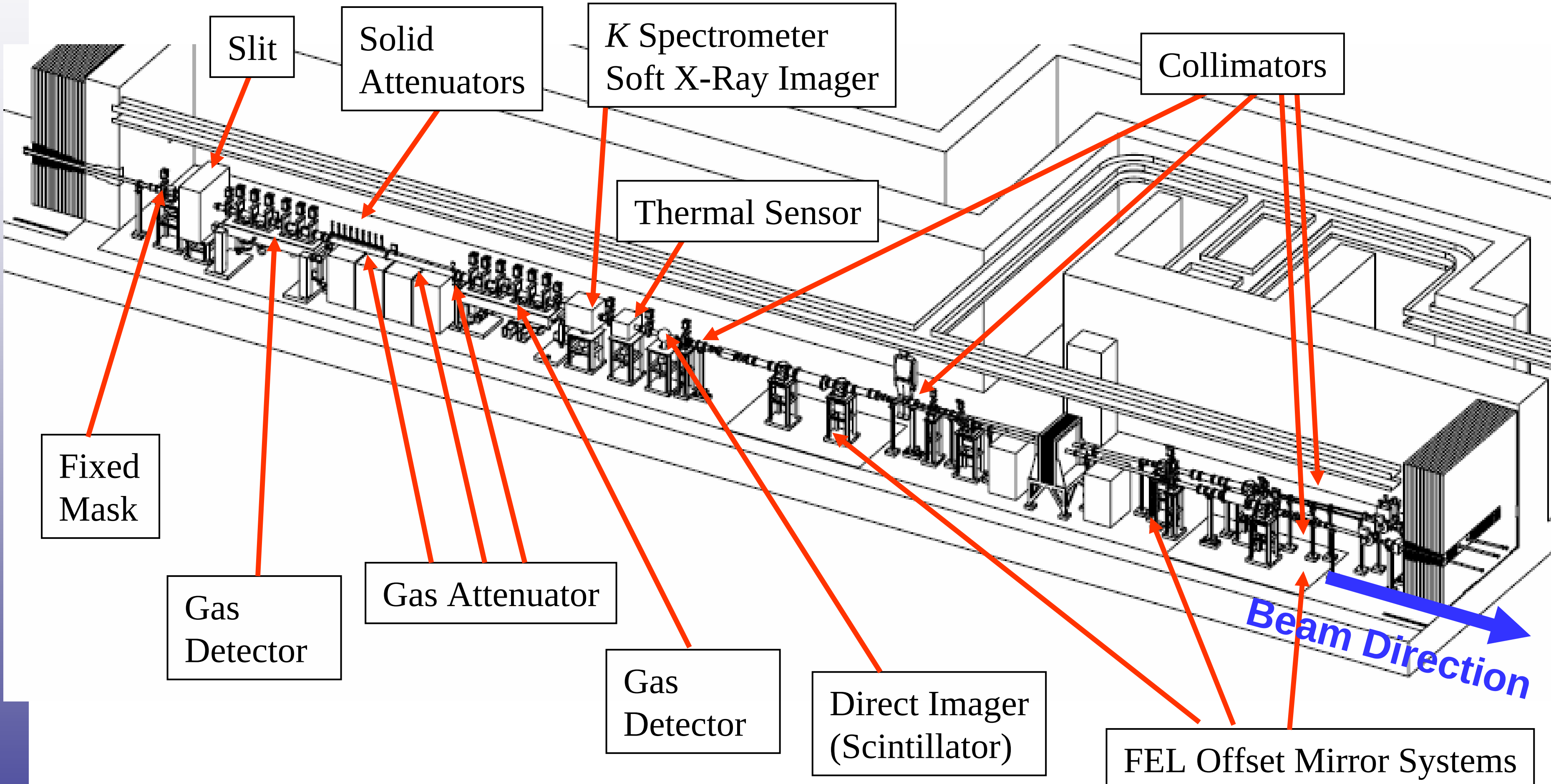
Facility Advisory Committee
Photon Breakout Session
October 30, 2007

Richard M. Bionta
bionta1@llnl.gov

LCLS Layout


FEE (Front-End-Enclosure)
Diagnostics
SOMS
HOMS
Linac
Undulator Hall
X-Ray Tunnel
FEH (Far Experimental Hall)
NEH (Near Experimental Hall)

XTOD Commissioning Diagnostics and Offset Mirrors in the Front End Enclosure (FEE)

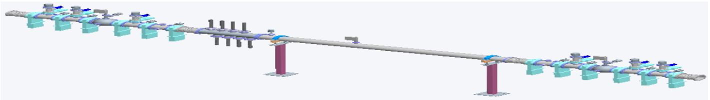


Richard M. Bionta
bionta1@llnl.gov

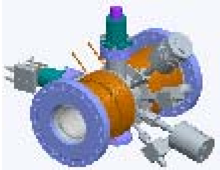
FEE Diagnostic Hardware

- Fixed Mask / Slit – On order

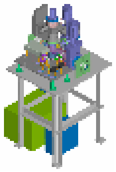
- Attenuator – On order



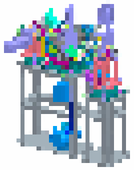
- Gas Detector – On order (see prototype results)
- K Measurement / Soft X-Ray imager



  - Need to redo SCR
- Thermal Sensor – in final design



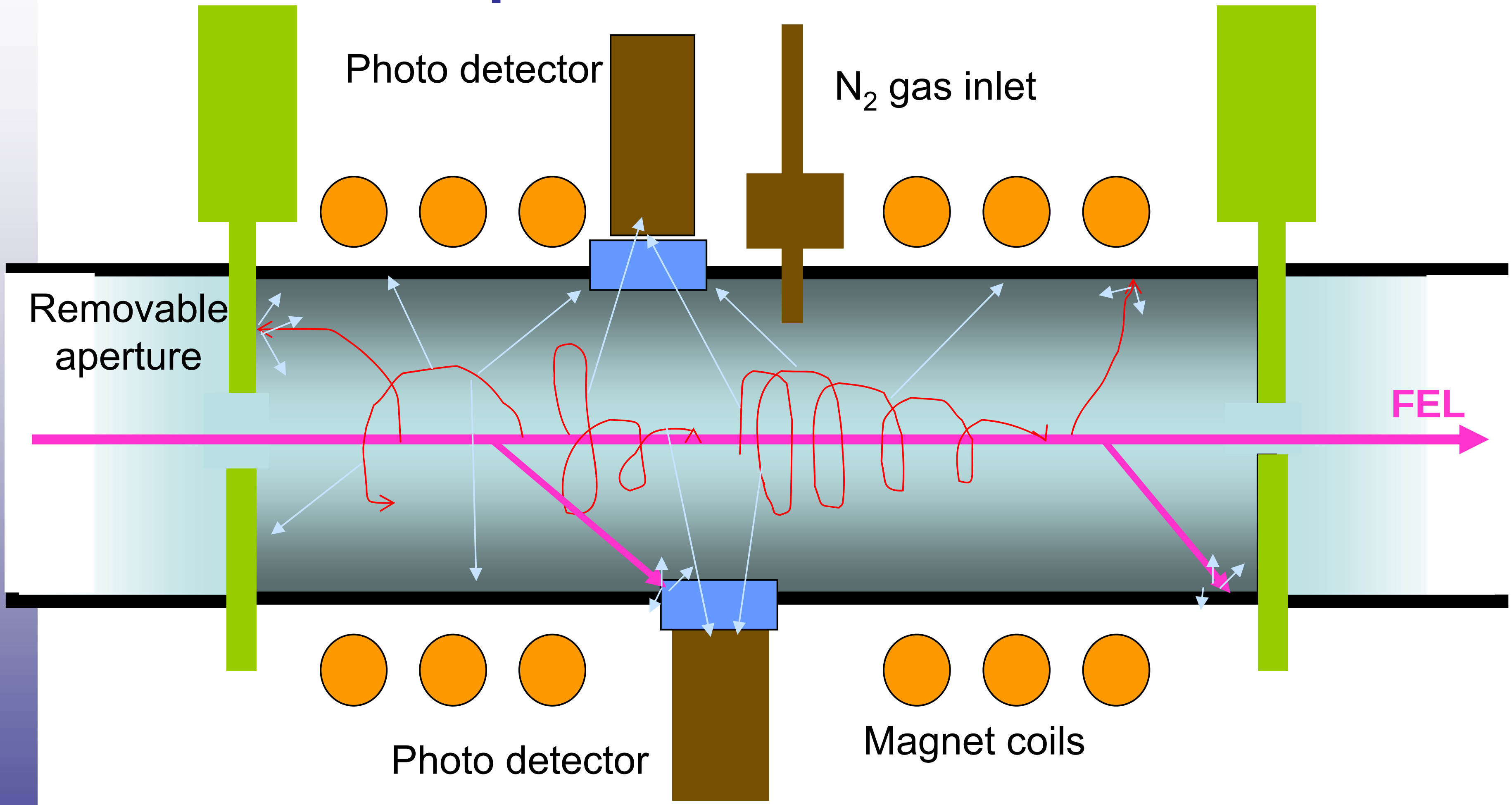
- Direct imager – in final design



- Controls – Mostly procured

Richard M. Bionta
bionta1@llnl.gov

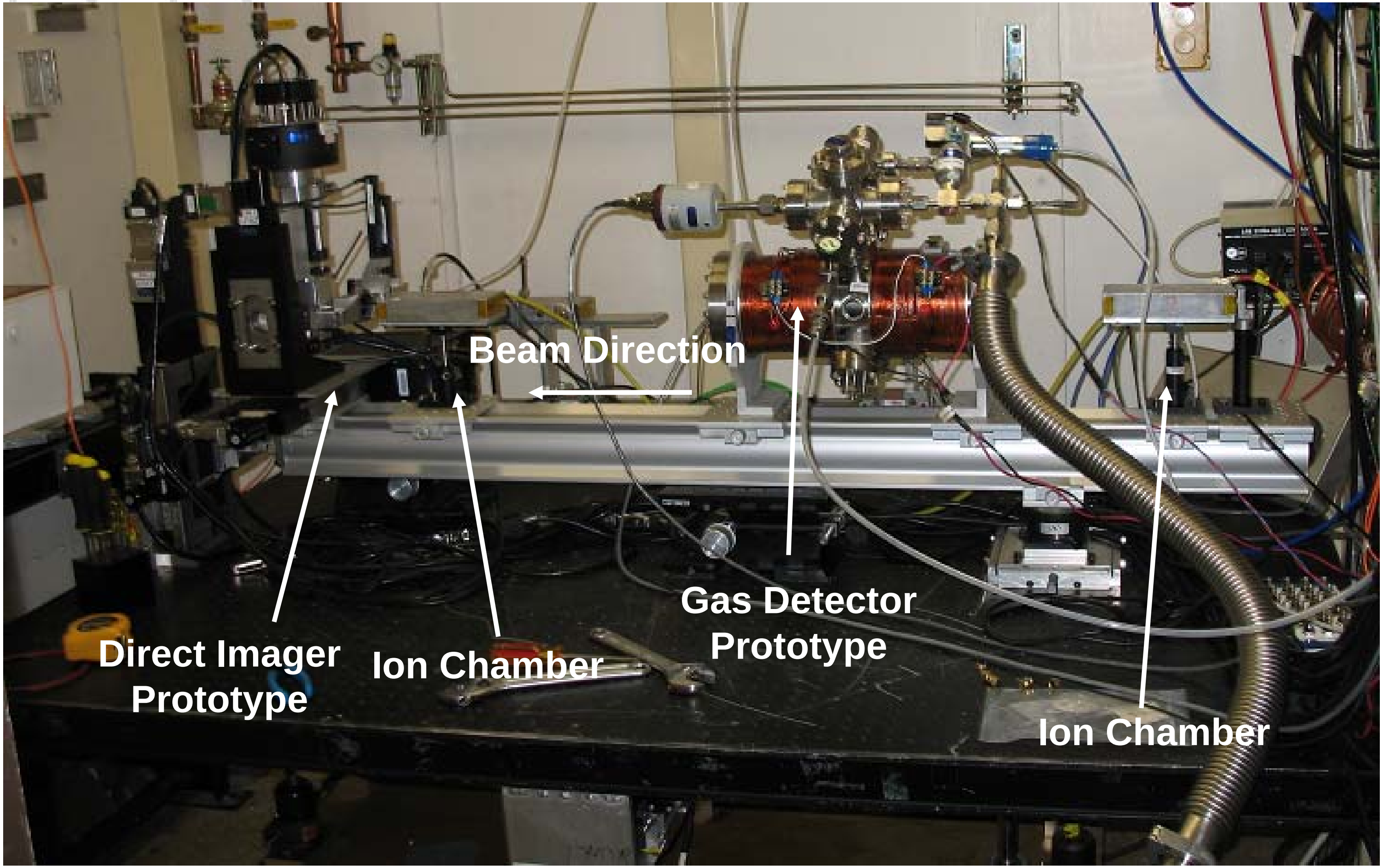
Windowless gas detector exploits N_2 photoluminescence



Primary photoelectrons cause N_2 molecules to fluoresce in the near UV

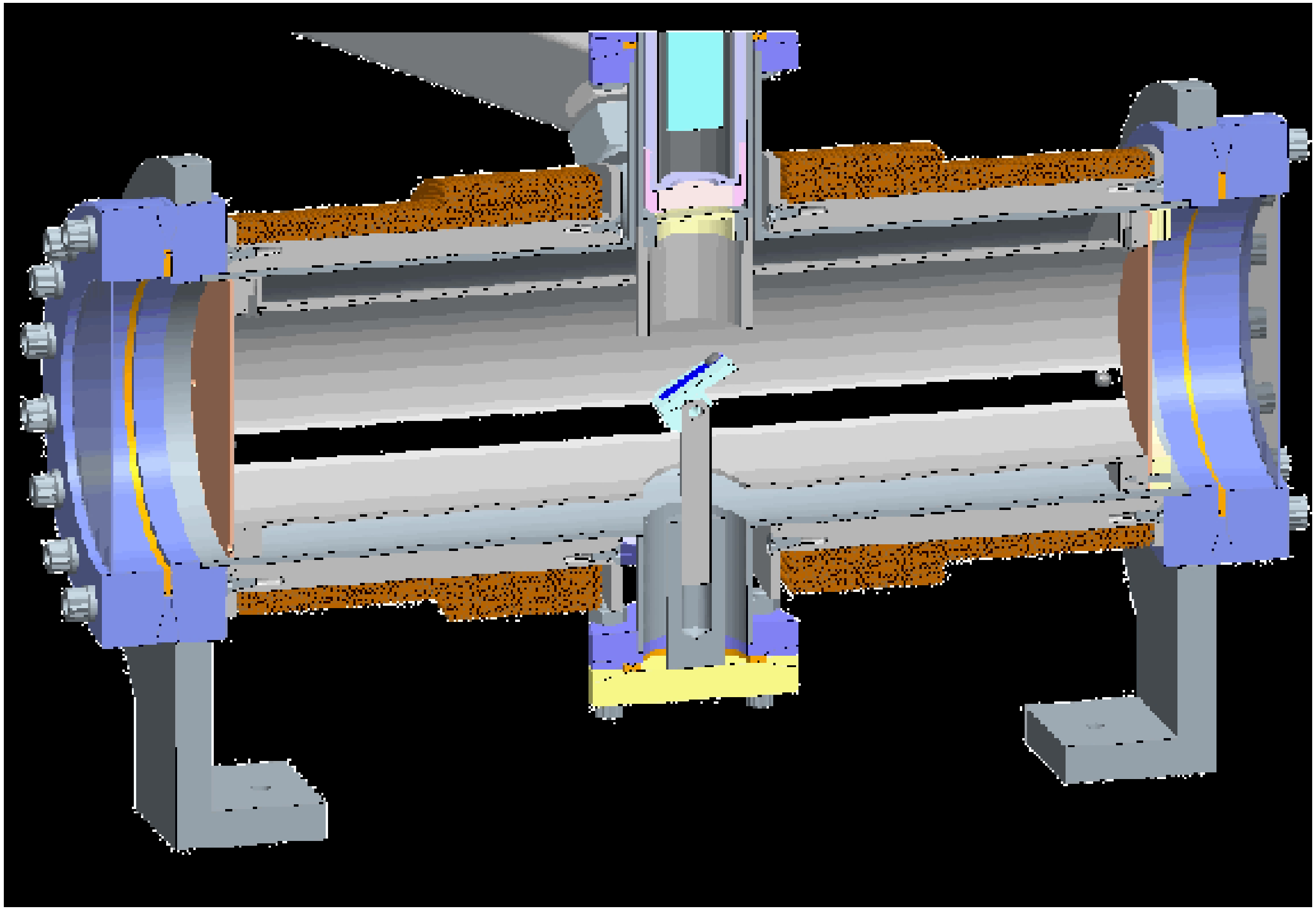
Richard M. Bionta
bionta1@llnl.gov

Gas Detector Prototype under test at SSRL



Richard M. Bionta
bionta1@llnl.gov

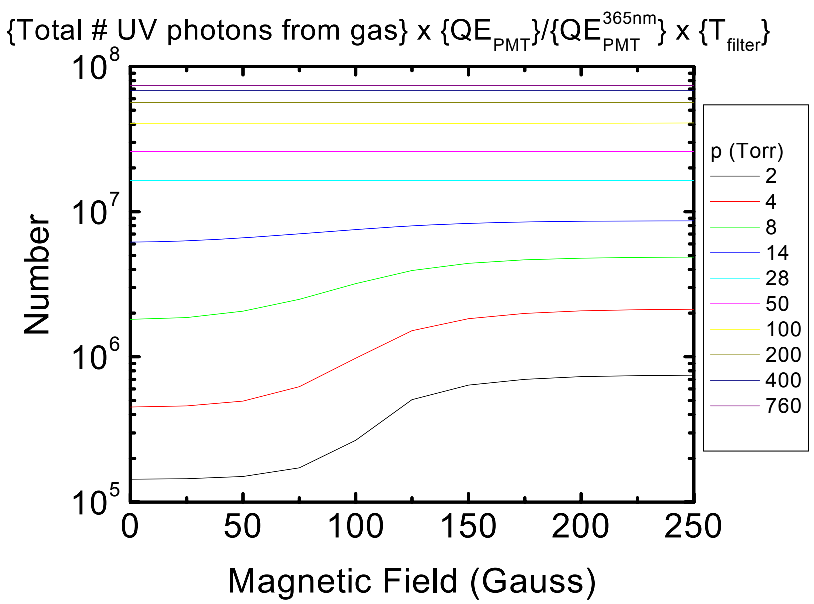
Prototype Gas Detector insert for measuring x ray induced photoemission of candidate wall materials



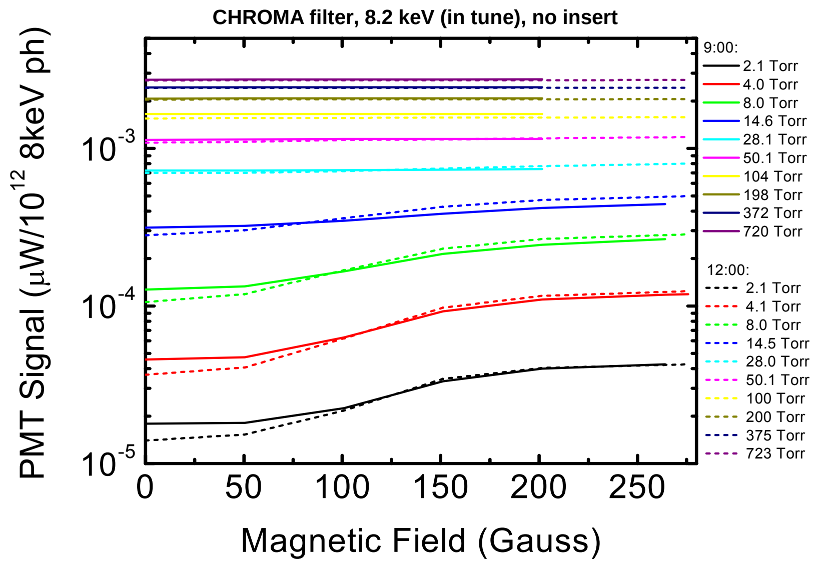
Richard M. Bionta
bionta1@llnl.gov

Gas Detector signal vs. magnetic field at various pressures

Simulated



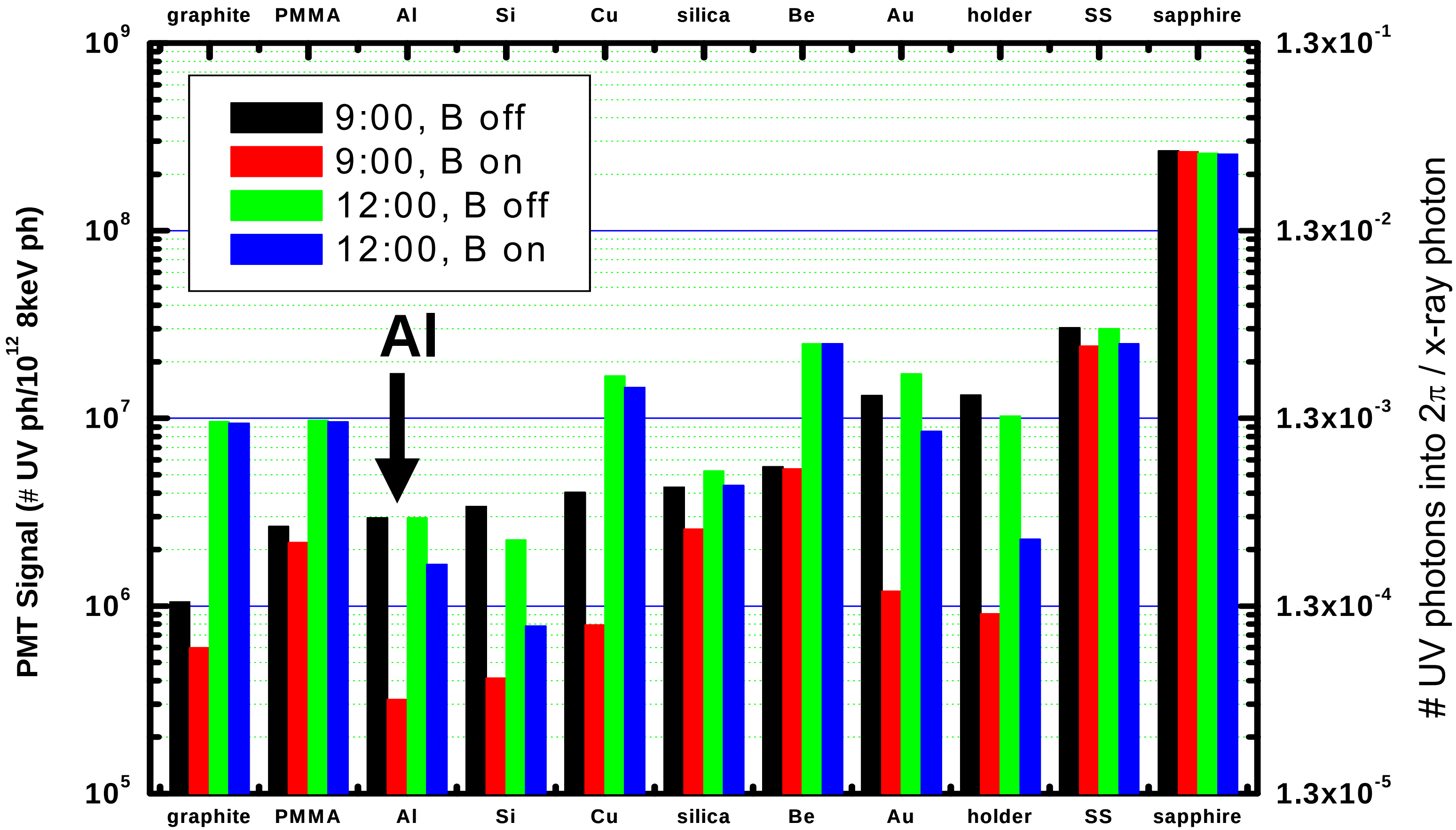
Measured



Simulation and measurement, when expressed in units of number of UV photons at detector, agree to within a factor of 2

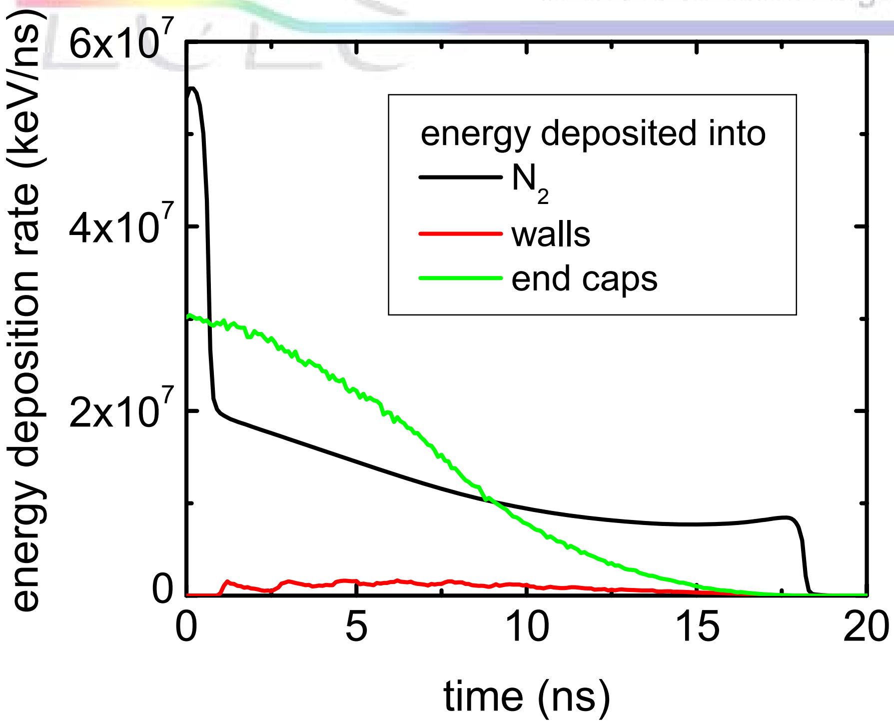
Richard M. Bionta
bionta1@llnl.gov

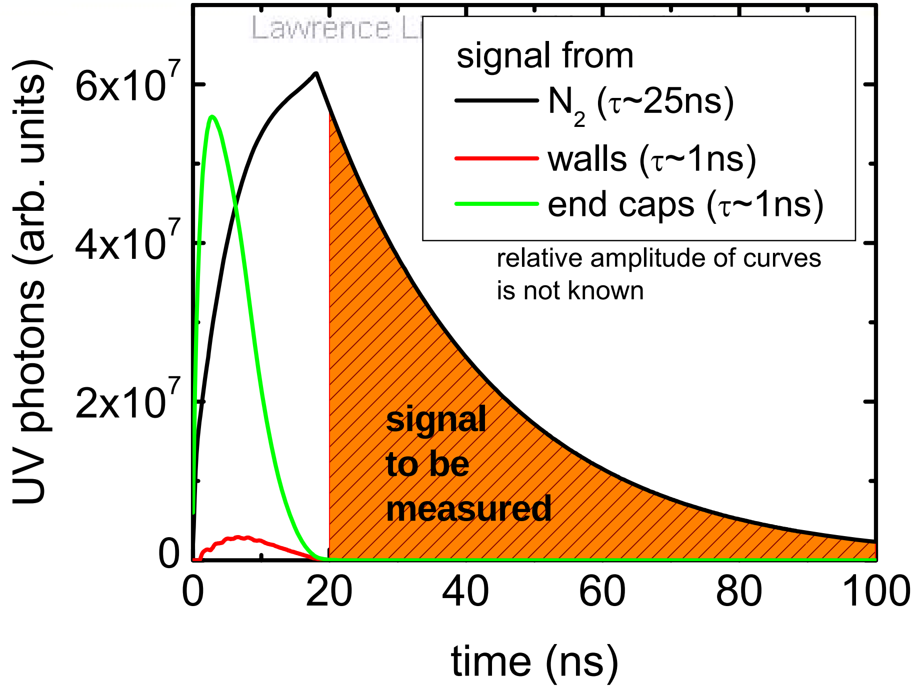
Measured luminescence of solids at 8 keV



UV signal closely represented by 9:00, B on (red): **Al is the best**

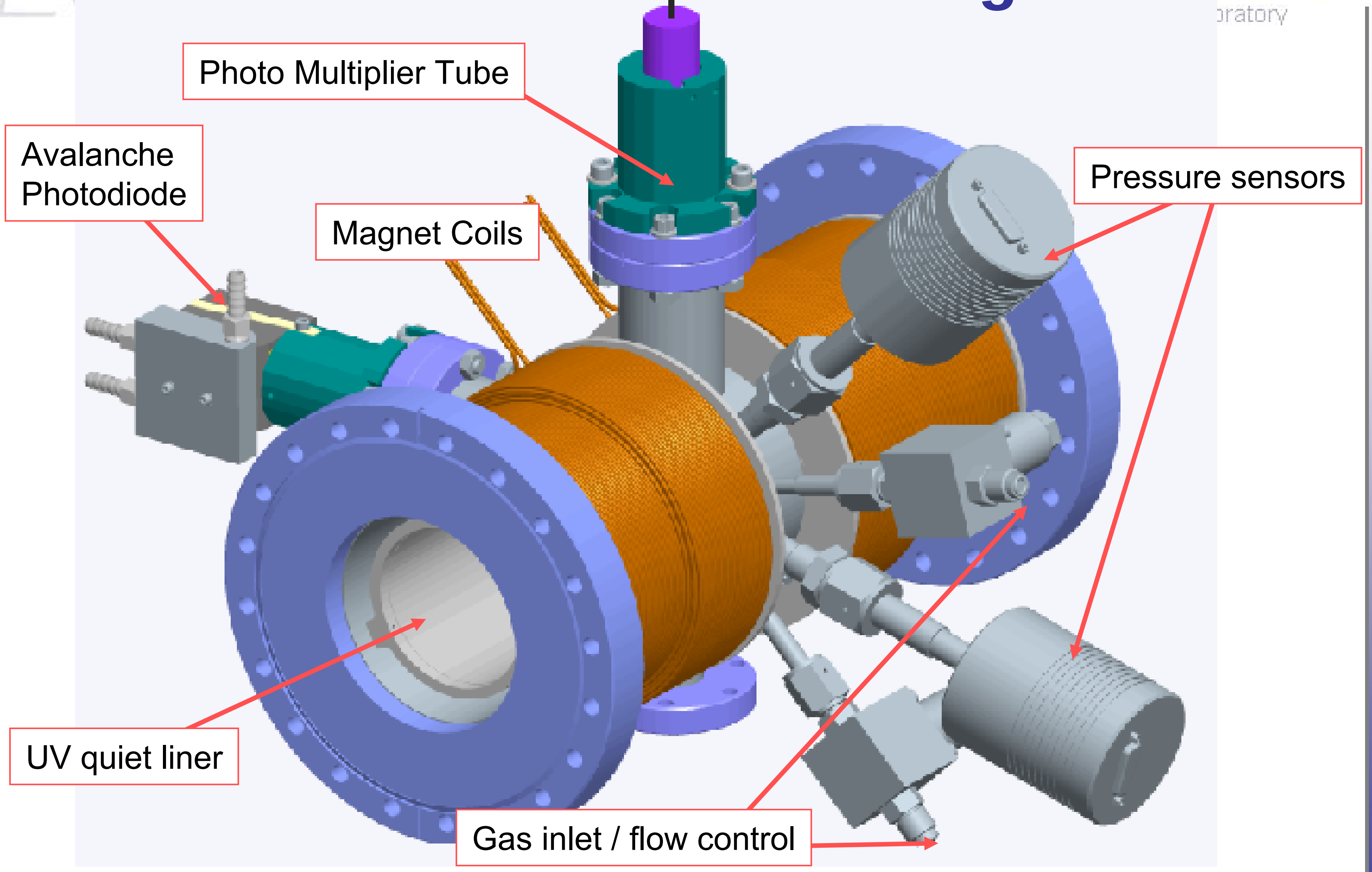
Time dependence of gas detector signal from the 8keV fundamental





	UV signal within
X rays scattered into walls	~ 1 ns
X rays scattered into detector window	?
Photoelectrons hitting walls	0 – 18 ns
Photoelectrons hitting end caps	0 – 15 ns
Secondaries hitting walls and end caps	0 – 200 ns (?)
Energy of photoelectrons deposited into N_2	0 – 45 ns

Gas Detector Final Design

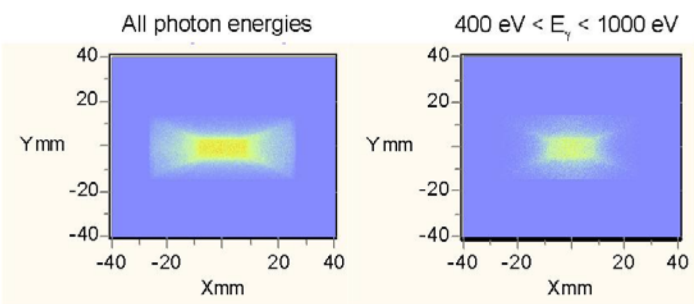


Richard M. Bionta
bionta1@llnl.gov

Indirect imager finds spontaneous core

Raw soft spontaneous

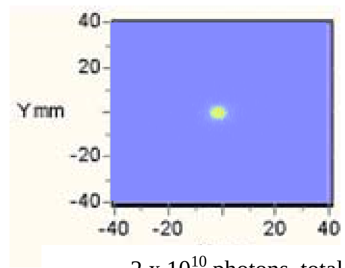
Figure 3: Spontaneous Fluence at Direct Imager:
Soft X-Ray FEL Setting, 0.79 nC



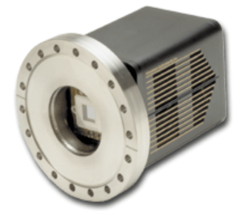
All photon energies	400 eV < E_γ < 1000 eV
2.1×10^{11} photons, total	2.5×10^{10} photons, total
3.8×10^{-4} J, total	3.1×10^{-6} J, total
9.1×10^{-5} J/cm^2, center	7.8×10^{-7} J/cm^2, center

After reflection

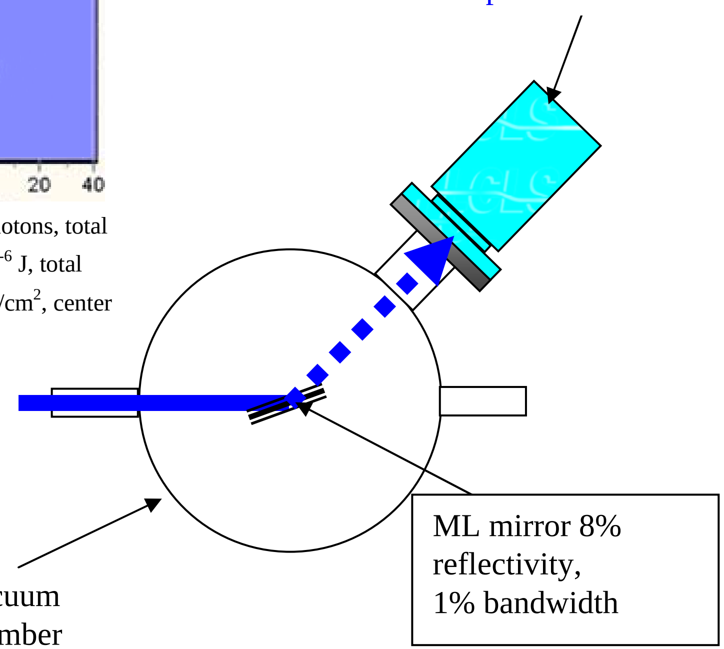
840 eV < E_γ < 860 eV
$h\nu_1$ = 844.6 eV
effective bandwidth = 5.5×10^{-3}



2×10^{10} photons, total
2.6×10^{-6} J, total
7.8×10^{-7} J/cm^2, center



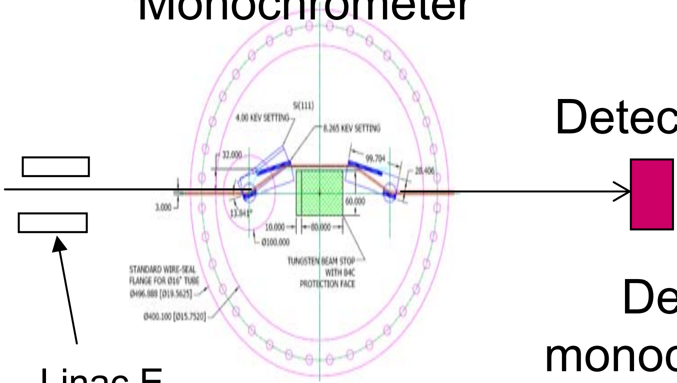
Princeton Instruments back illuminated CCD camera
25 x 25 mm chip, 20 um pixel size



Status Indirect Imager:
PRD done
SCR redo

Channel-cut Si Monochrometer will be used to measure relative K of two undulator segments

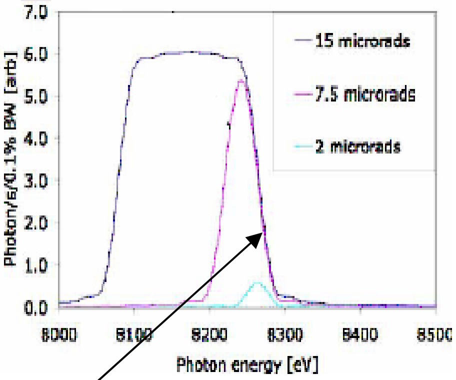
Monochrometer



Detector

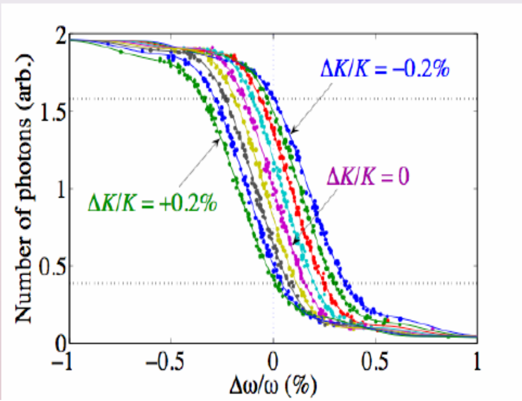
Linac E variation and measurement

Detector monochrometer measures intensity at a single point



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

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



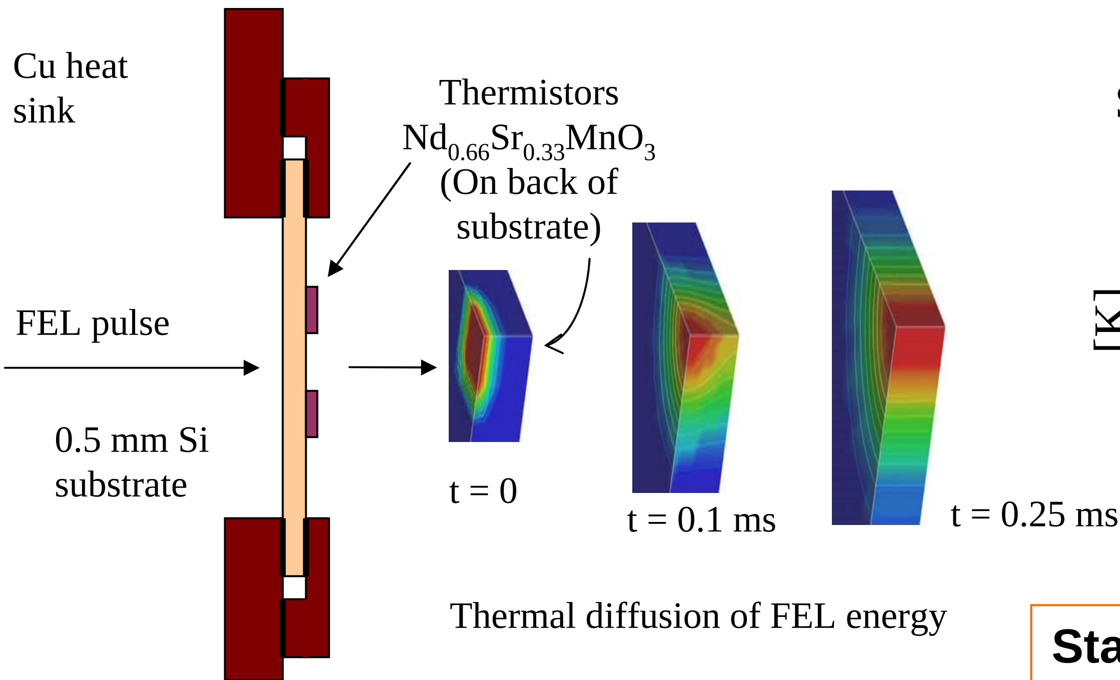
Two undulator spontaneous high energy falloff has highest slope when $\Delta K/K=0$.

Status K Spectrometer:
PRD done
SCR redo

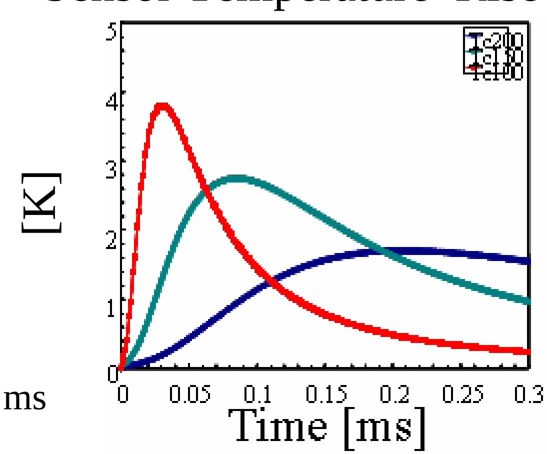
Richard M. Bionta
bionta1@llnl.gov

Total Energy (Thermal) Sensor provides calibrated measurement of FEL pulse energy

Measures FEL energy deposition through temperature rise

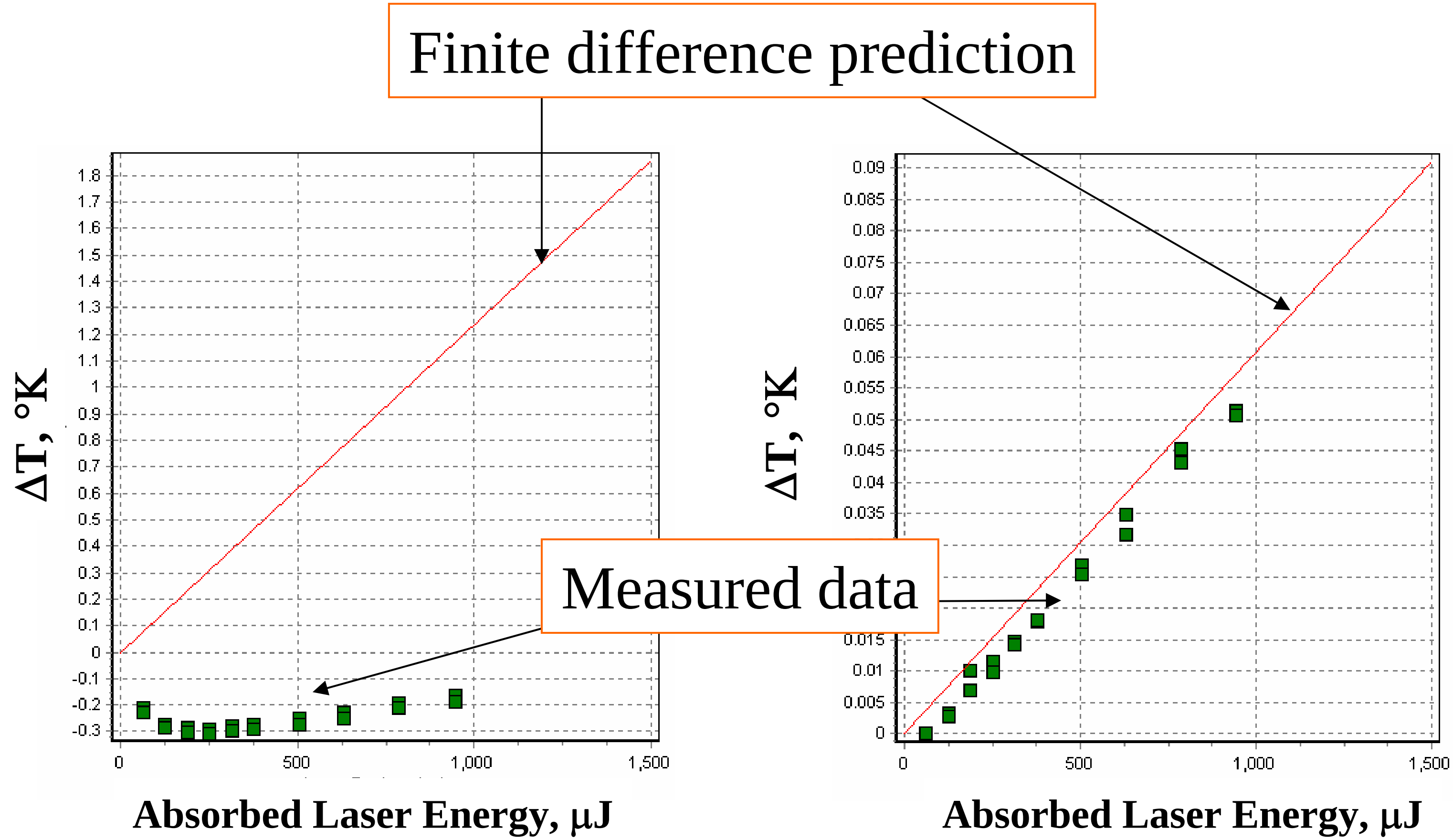


Thermal diffusion of FEL energy



Status Thermal Sensor:
PRD done
SCR done
PDR done
Prototype done
FDR in progress

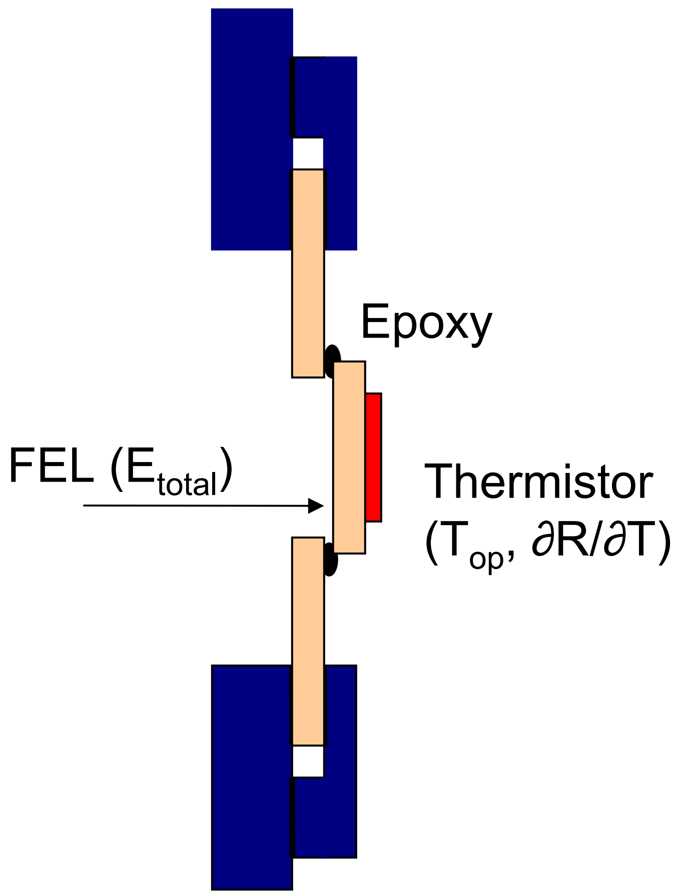
Thermal sensor plagued by "prompt" pulse that is difficult to suppress



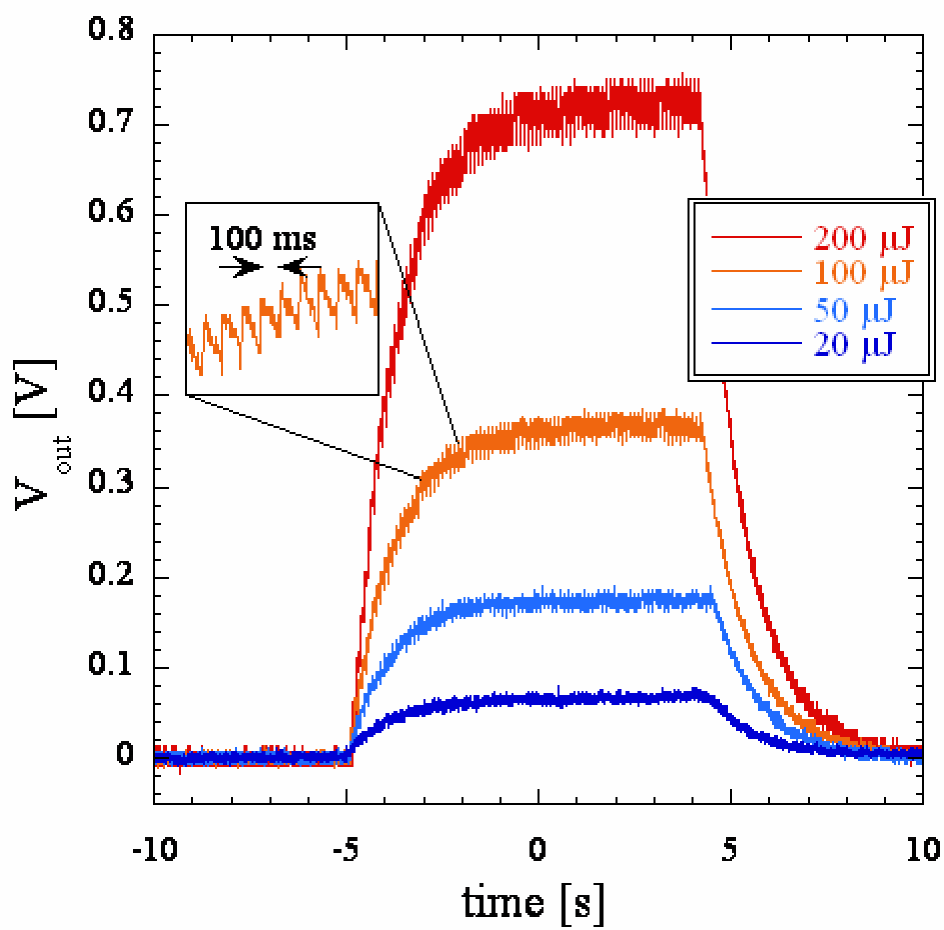
At 100 µsec

At 3 msec

Backup thermal sensor: Slow down response, average pulses



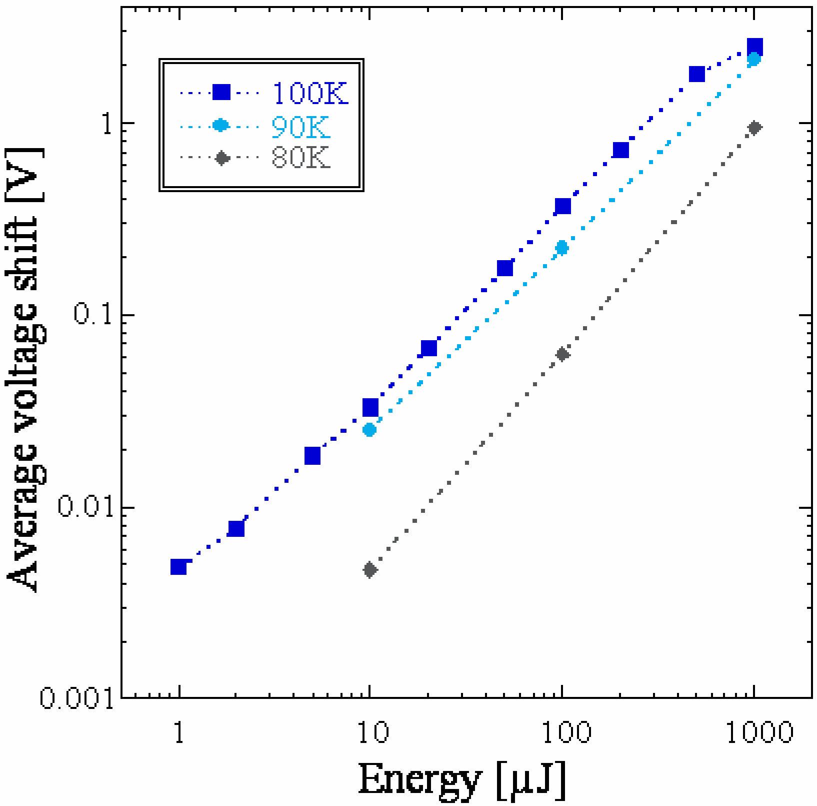
Slow Thermal Sensor:
Slow speed with epoxy joint



Richard M. Bionta
bionta1@llnl.gov

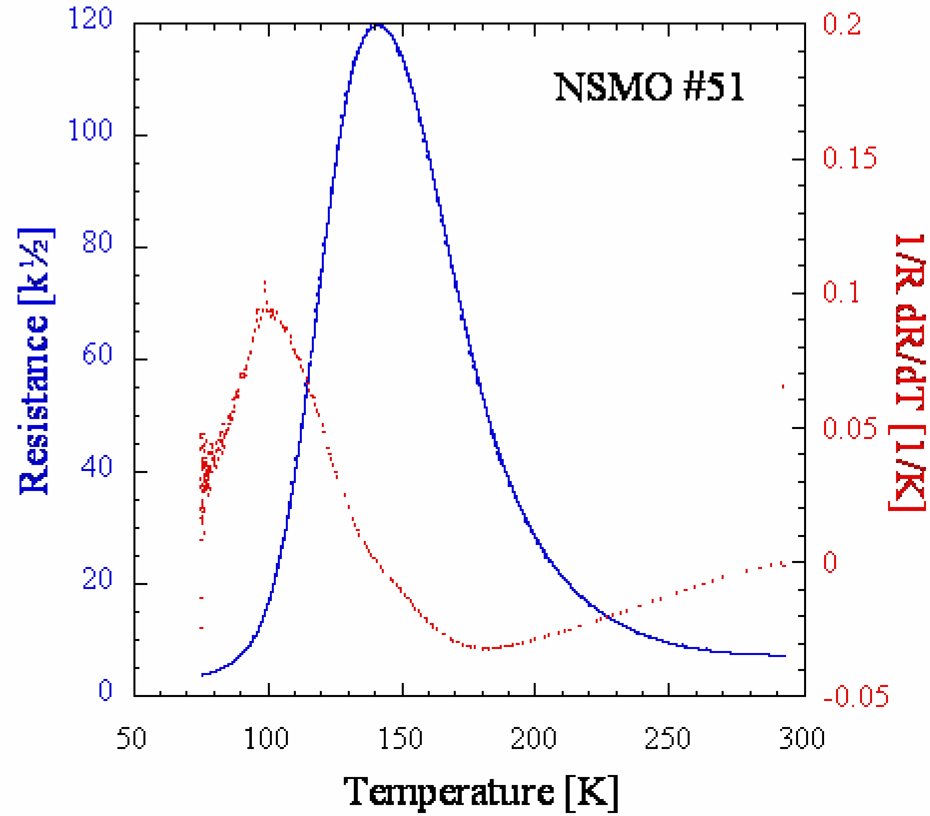
Slow sensor: Response is thermal, and linear with E

Peak Temperature vs. Laser Pulse Energy



Response linear over three decades

Sensor Resistance vs. Temperature



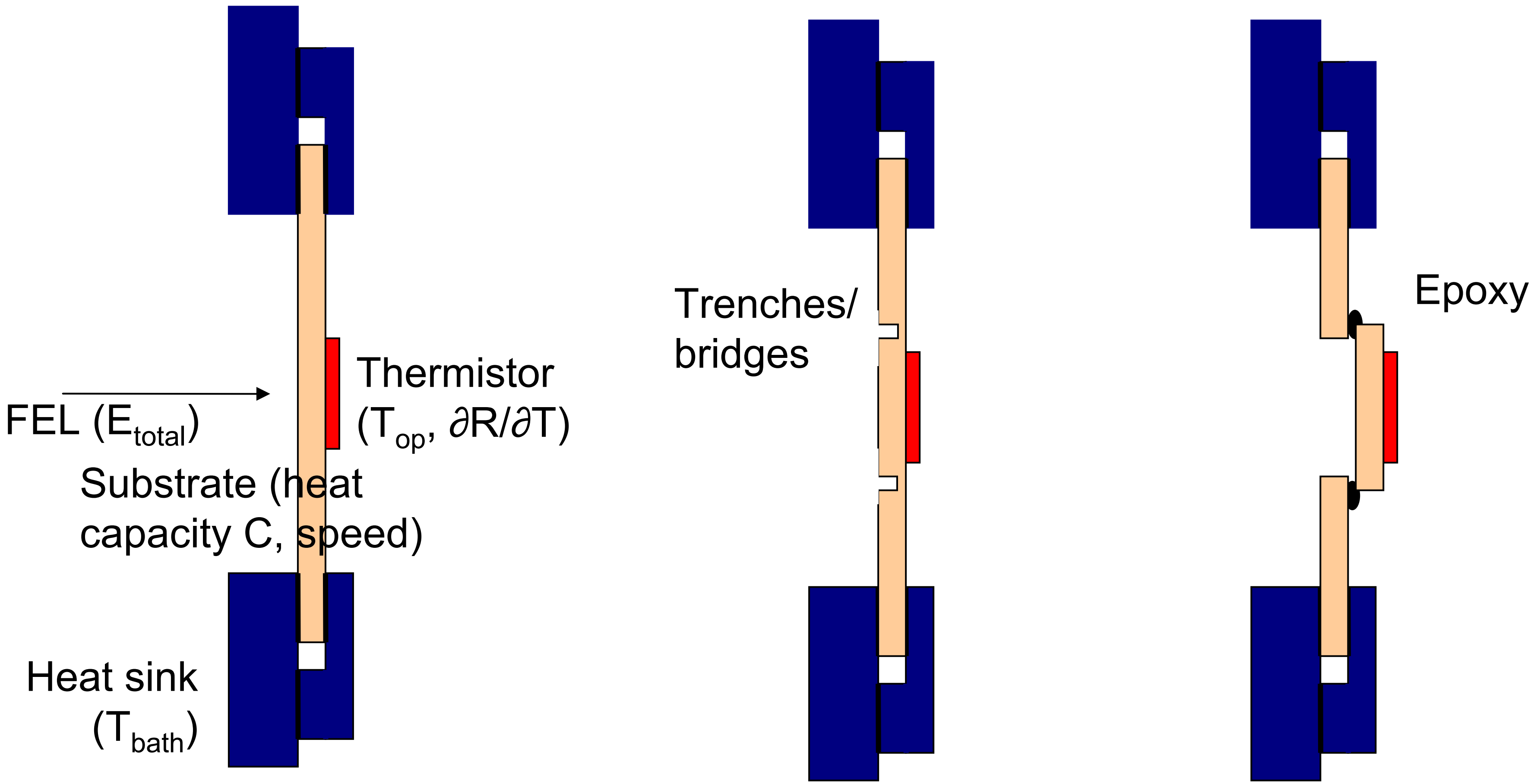
Response changes with TCR

The Options: Same sensor technology, different speeds

Basic TEM design:
fast, sensitive, rad hard,
but affected by artifacts

Medium speed TEM:
~100 µm bridges.
slow enough?

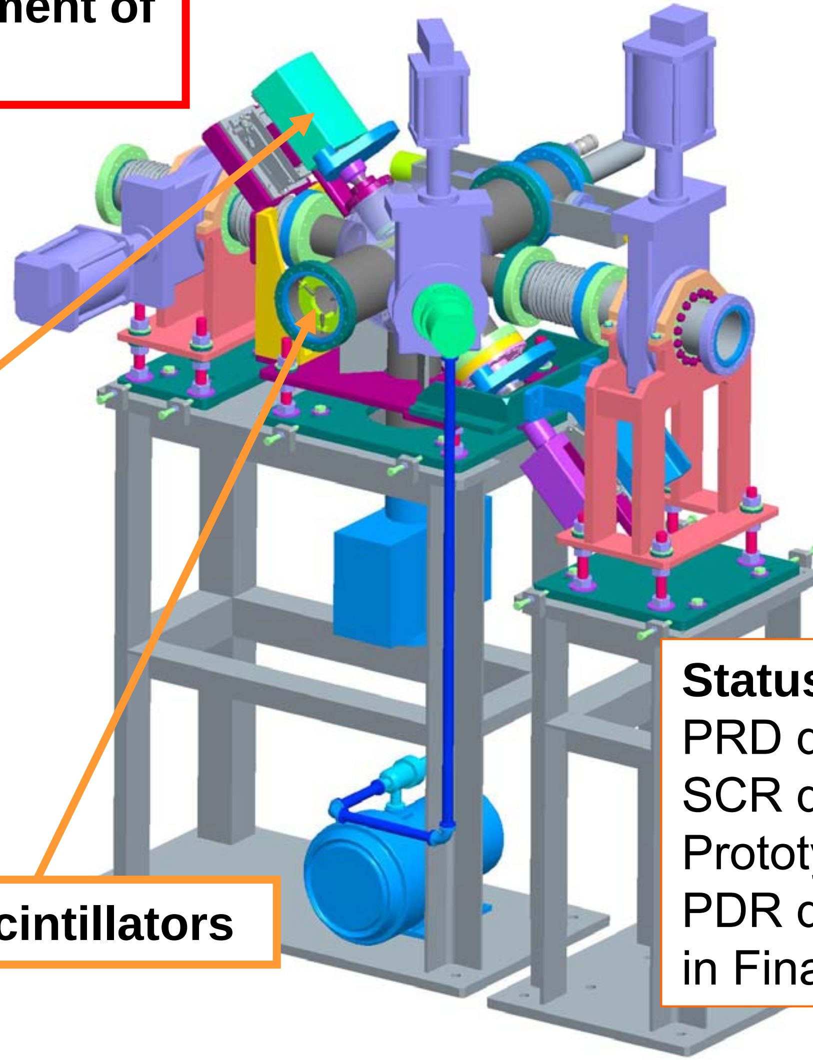
Slow TEM:
Adjust speed with epoxy.
too slow?



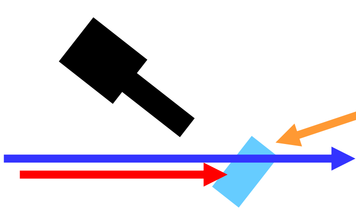
Richard M. Bionta
bionta1@llnl.gov

Direct Imager, preliminary design

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



Camera



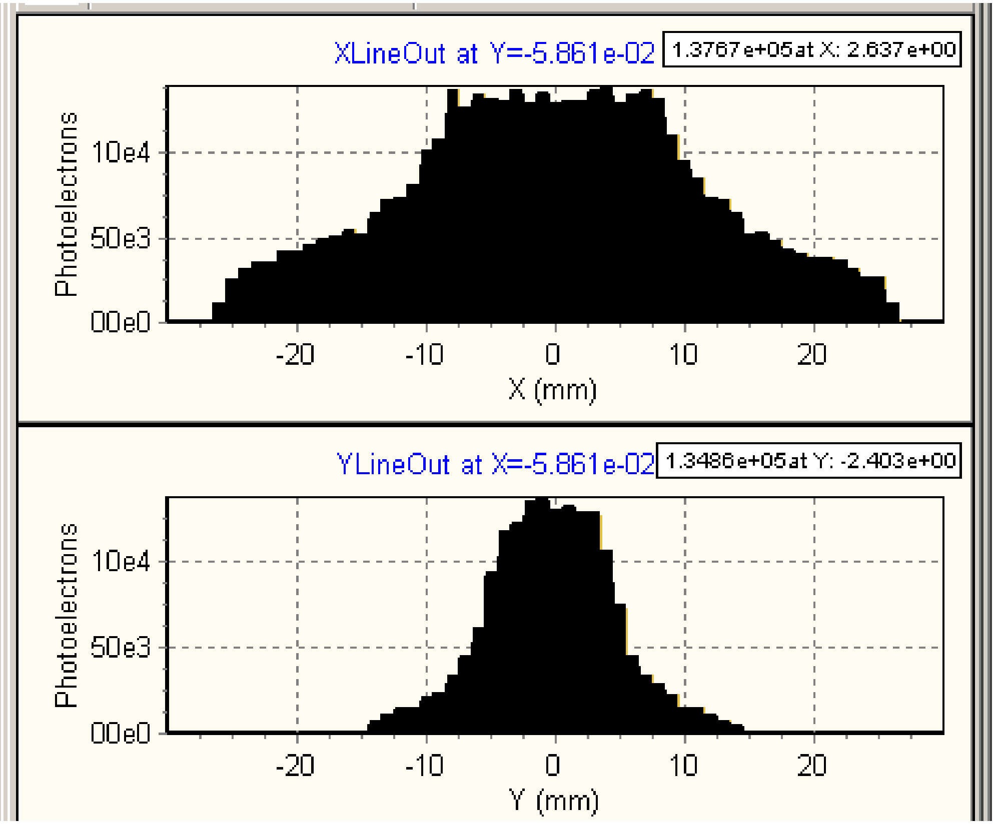
Scintillators

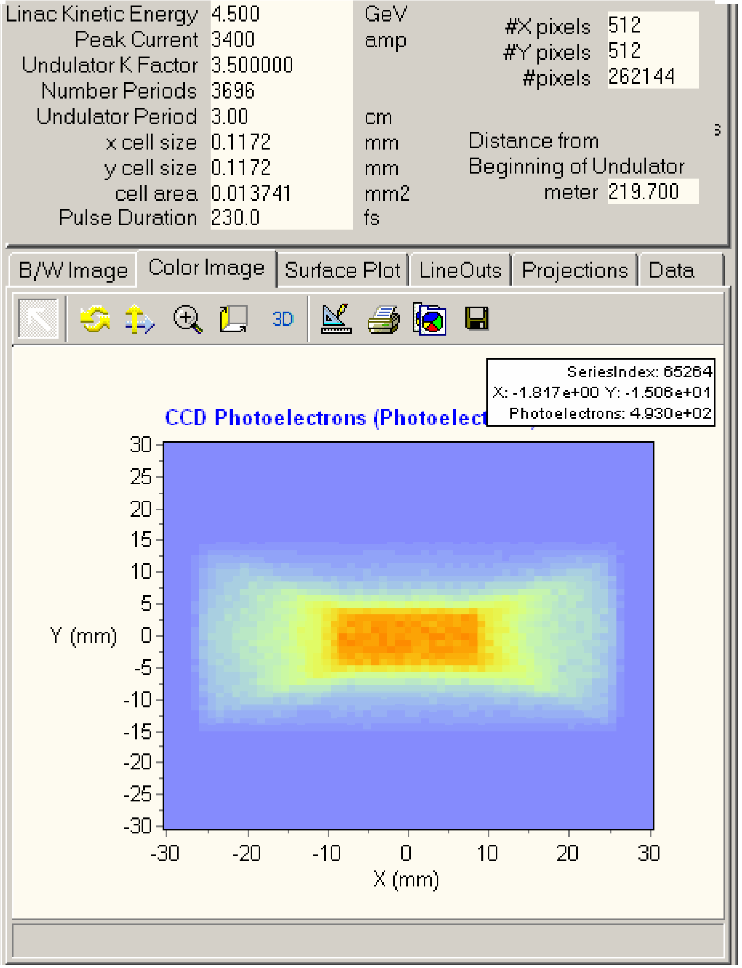
Status Direct Imager:
PRD done
SCR done
Prototype done
PDR done
in Final Design

Richard M. Bionta
bionta1@llnl.gov

Soft X-Ray spontaneous, all undulator segments, thick scintillator

Absorbed in 1 mm YAG,
Maximum ~ 140,000 photoelectrons/pixel
Full Well: 200,000
Camera: Photometrics 512B
Objective: Navitar Platinum 50
Power: 0.1365
NA: 0.060



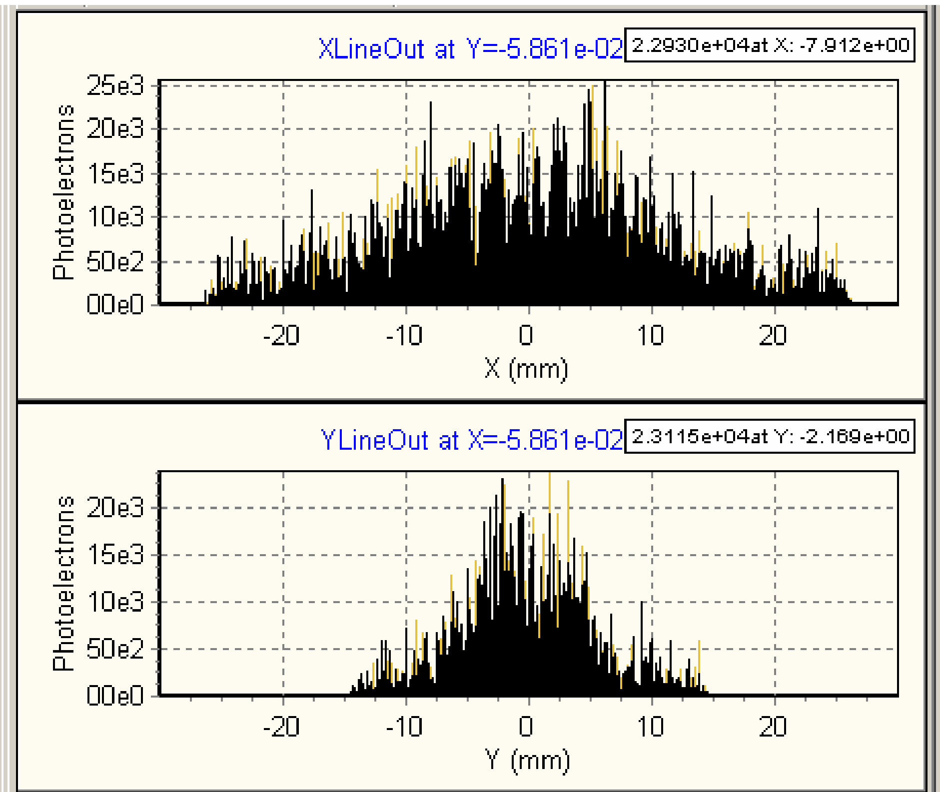


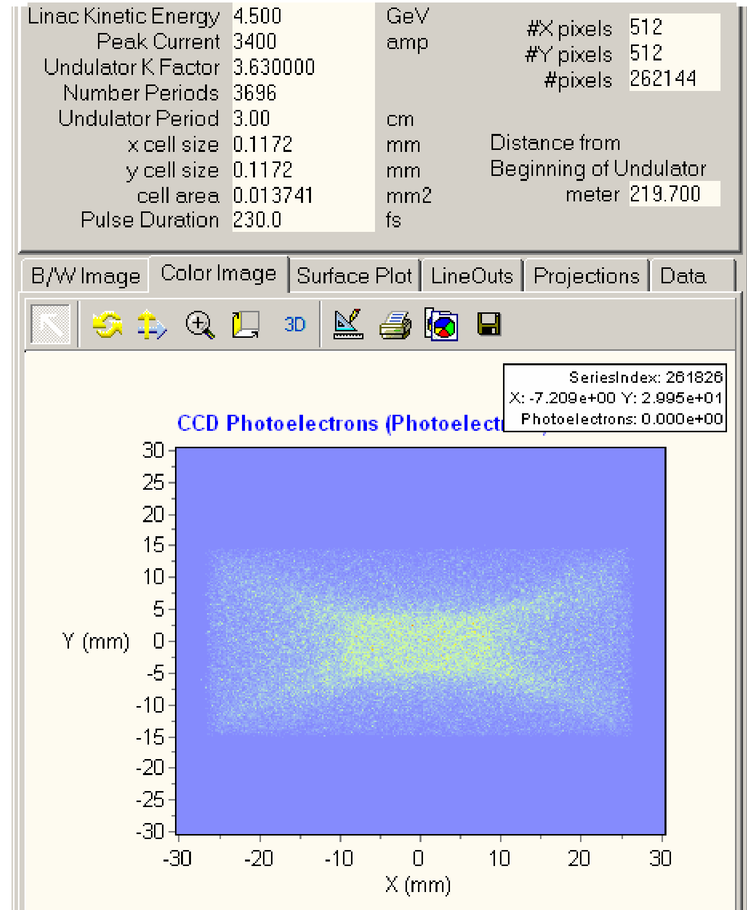
Soft X-Ray Spontaneous all undulator segments, thin scintillator

Absorbed in 5 um YAG,
Maximum ~ 20,000 photoelectrons/pixel

Camera: Photometrics 512B

Objective: Navitar Platinum 50
Power: 0.1365
NA: 0.060



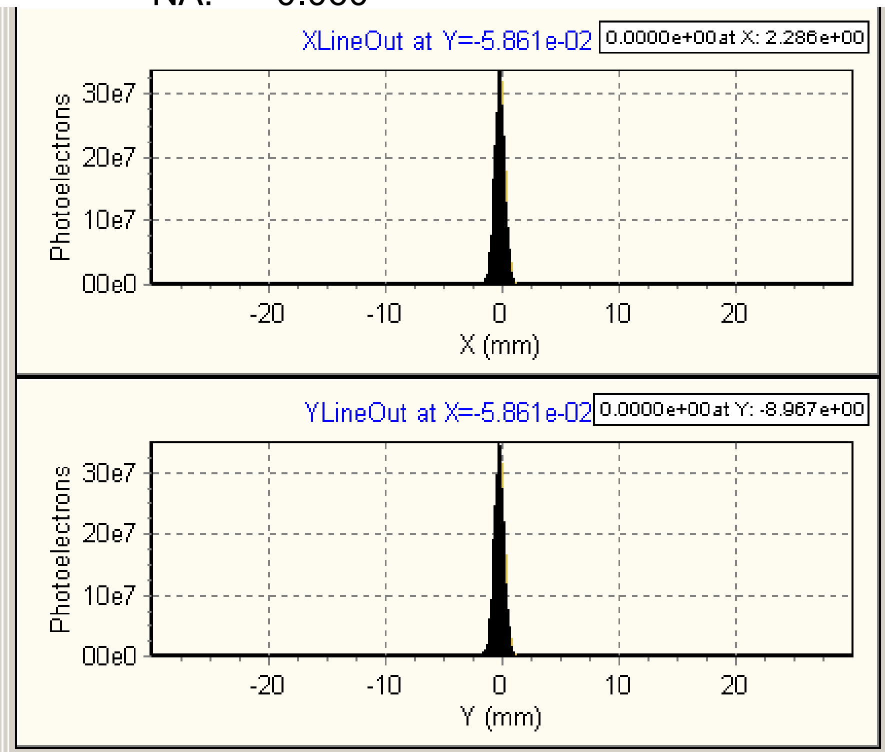


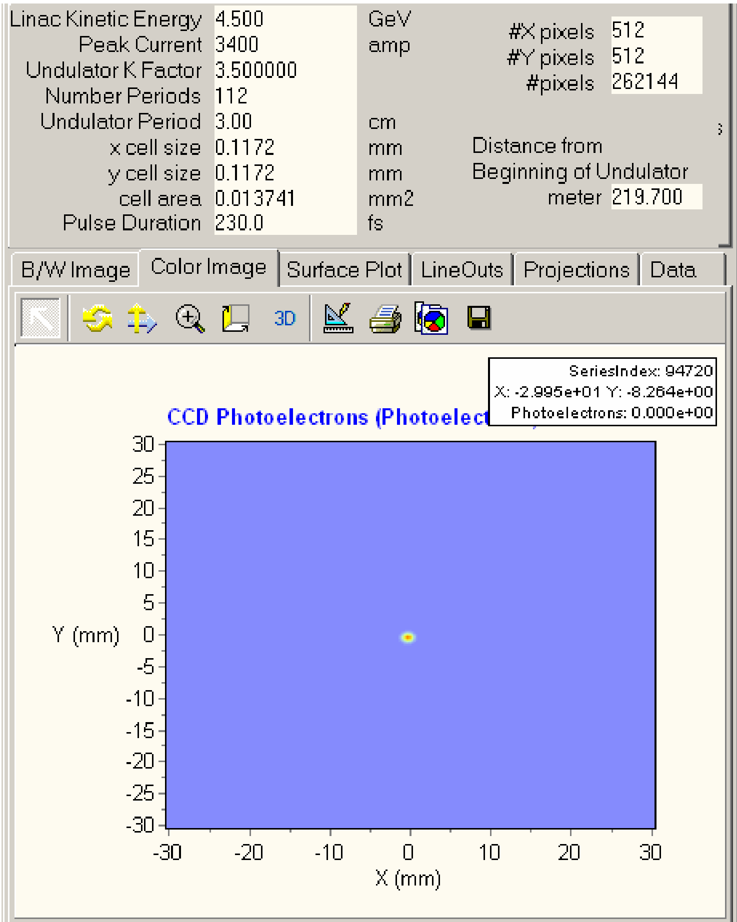
Soft X-Ray FEL signal, thin scintillator

Absorbed in 5 um YAG,
Maximum ~ 3.7e+8 photoelectrons/pixel

Camera: Photometrics 512B

Objective: Navitar Platinum 50
Power: 0.1365
NA: 0.060

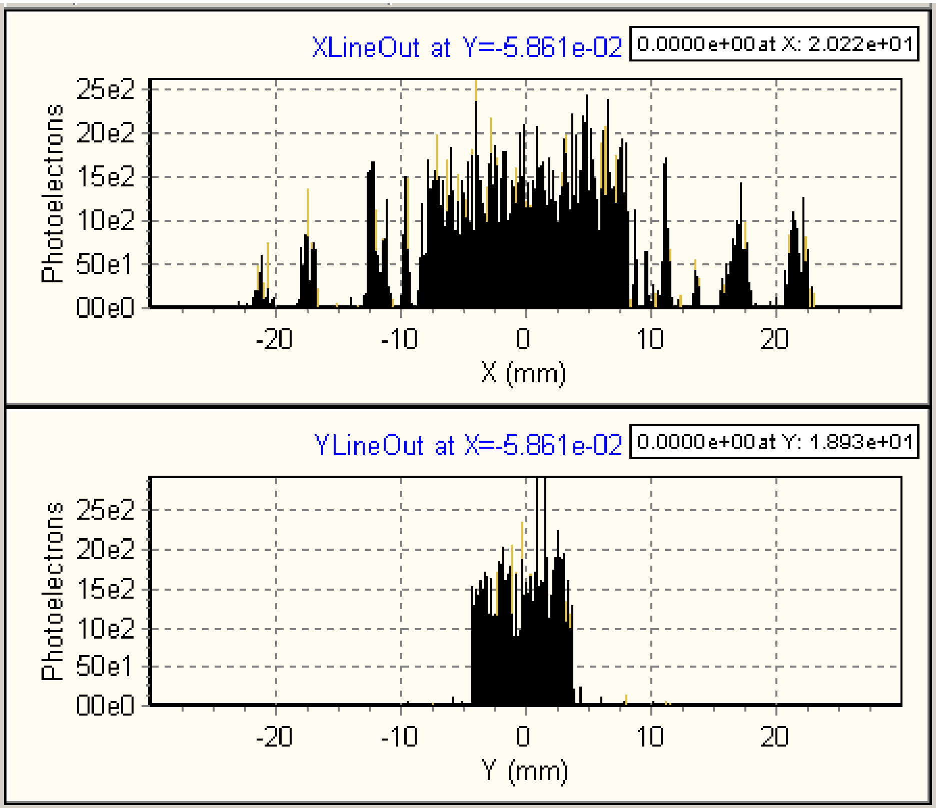




Richard M. Bionta
bionta1@llnl.gov

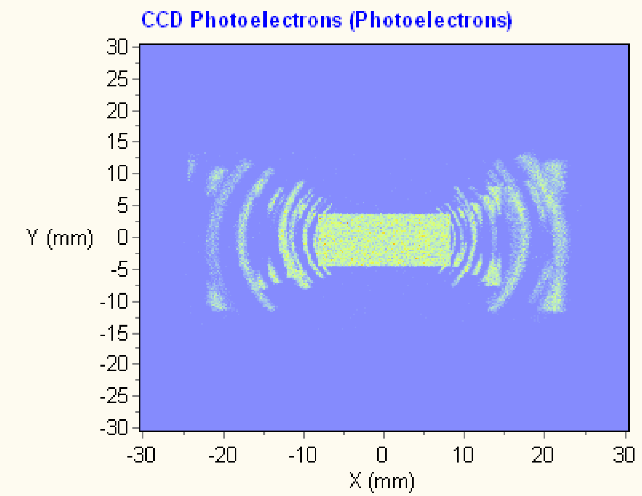
Soft x-ray spontaneous, first undulator segment, thick scintillator

Absorbed in 1 mm YAG,
Maximum ~ 1,800 photoelectrons/pixel
Full Well: 200,000
Camera: Photometrics 512B
Objective: Navitar Platinum 50
Power: 0.1365
NA: 0.060



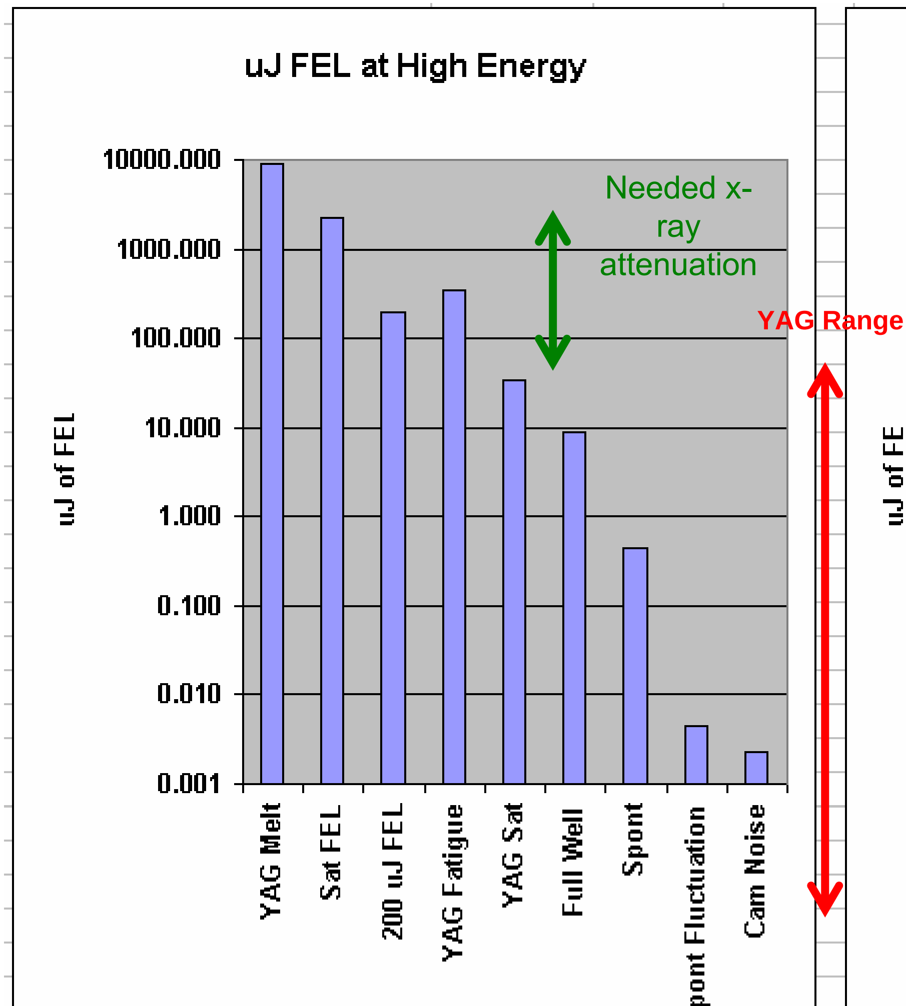
Linac Kinetic Energy	4.360	GeV	#X pixels	512
Peak Current	3400	amp	#Y pixels	512
Undulator K Factor	3.500000		#pixels	262144
Number Periods	112			
Undulator Period	3.00	cm		
x cell size	0.1172	mm	Distance from	
y cell size	0.1172	mm	Beginning of Undulator	
cell area	0.013741	mm2	meter	221.655
Pulse Duration	230.0	fs		

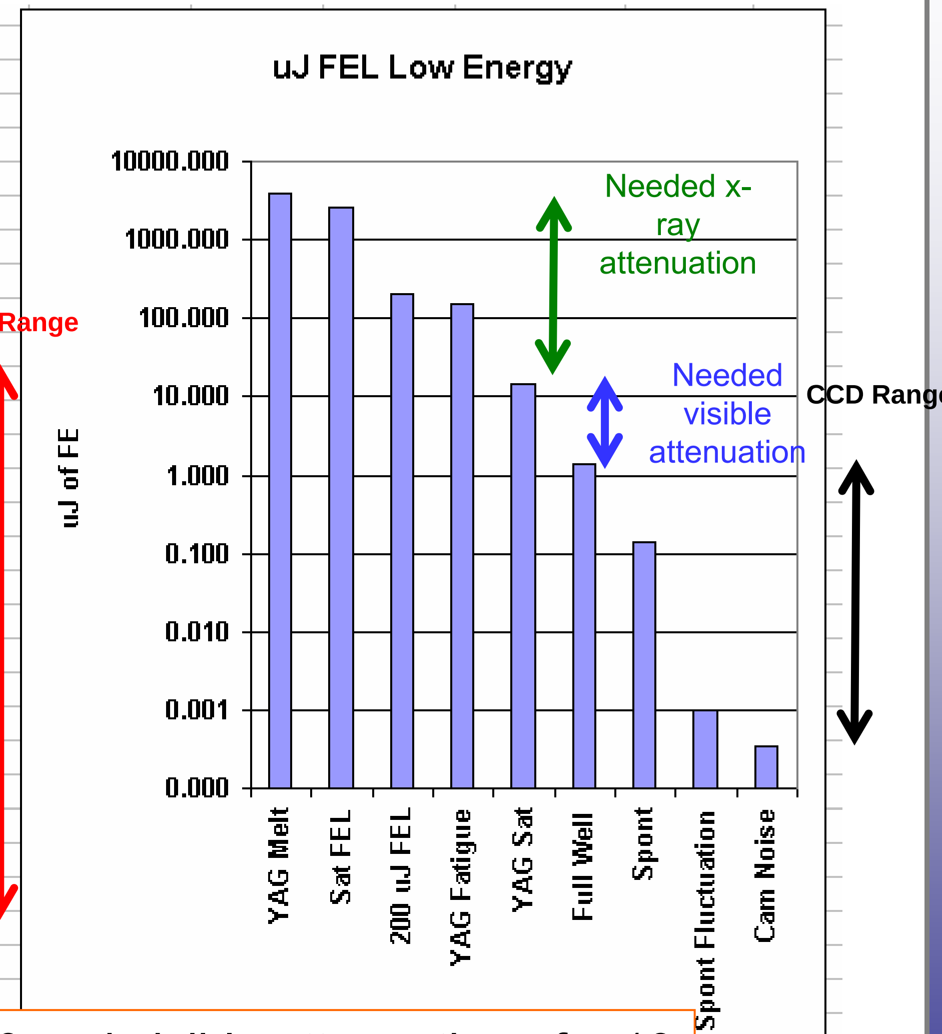
B/W Image | Color Image | Surface Plot | LineOuts | Projections | Data



Richard M. Bionta
bionta1@llnl.gov

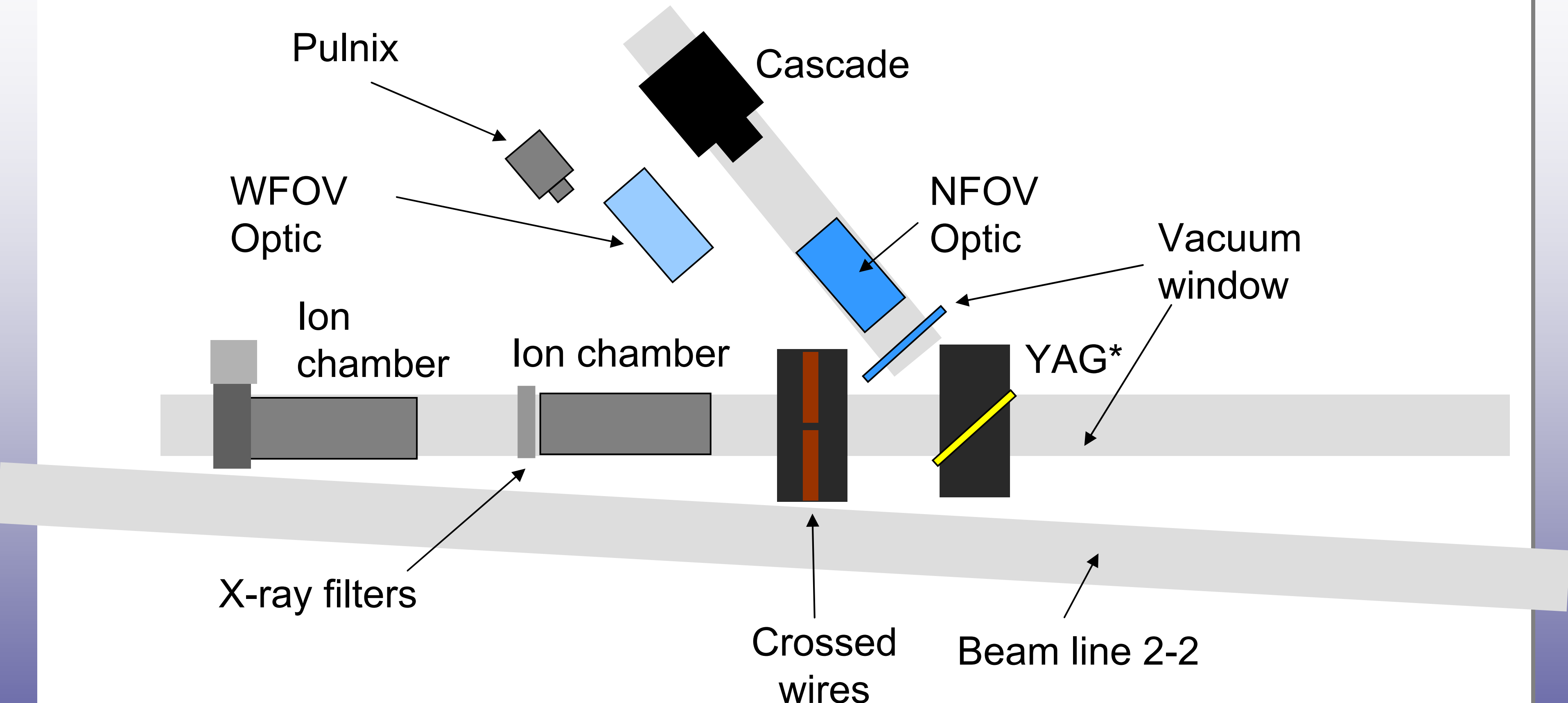
Scintillator signals in FEL equivalents





Need x-ray attenuation of > 100 and visible attenuation of > 10

Direct Imager SSRL Run to measure YAG::Ce yield, Nov. 6-8, 2007



*YAGs are the parts from Sant-Goban

1) 12 mm x 12 mm x 1 mm

2) 25 mm x 25 mm 5 micron

FEE Racks are being loaded and wired

Richard M. Bionta
bionta1@llnl.gov

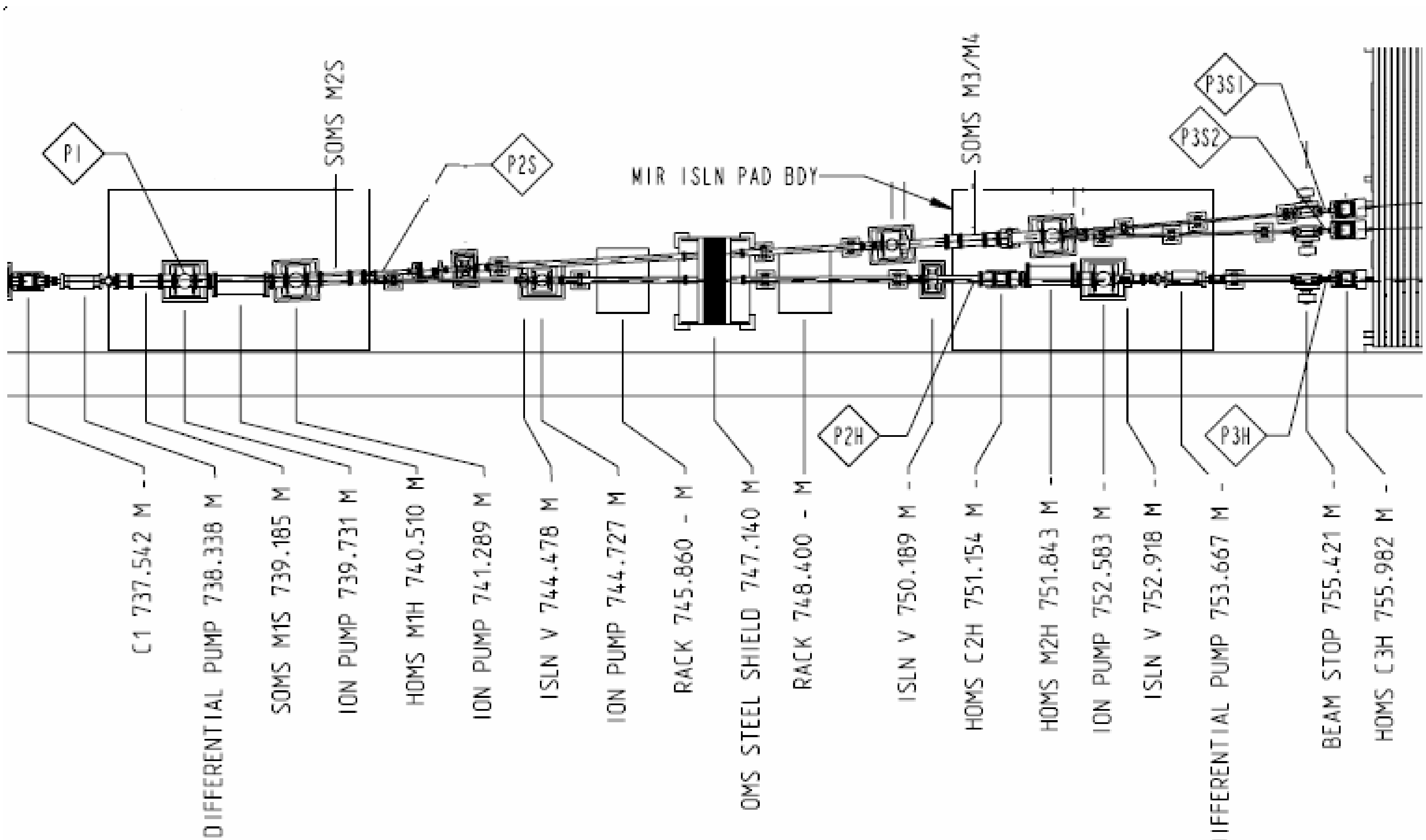
Offset Mirror System

- Collimators – in final design
- SOMS – Mirrors purchased June 1st
  - Mount will follow HOMS design
- HOMS
  - Mirrors in final design
    - Plan to purchase by December 30
  - Mount in preliminary design
    - Problems with 50 nRad stability requirement
- Pop-in Alignment Cameras
  - Procurement delayed until FY09
  - FOV's and positions established
  - Pulnix 4200 camera under test at LLNL
  - Conceptual hardware design in progress

Richard M. Bionta
bionta1@llnl.gov

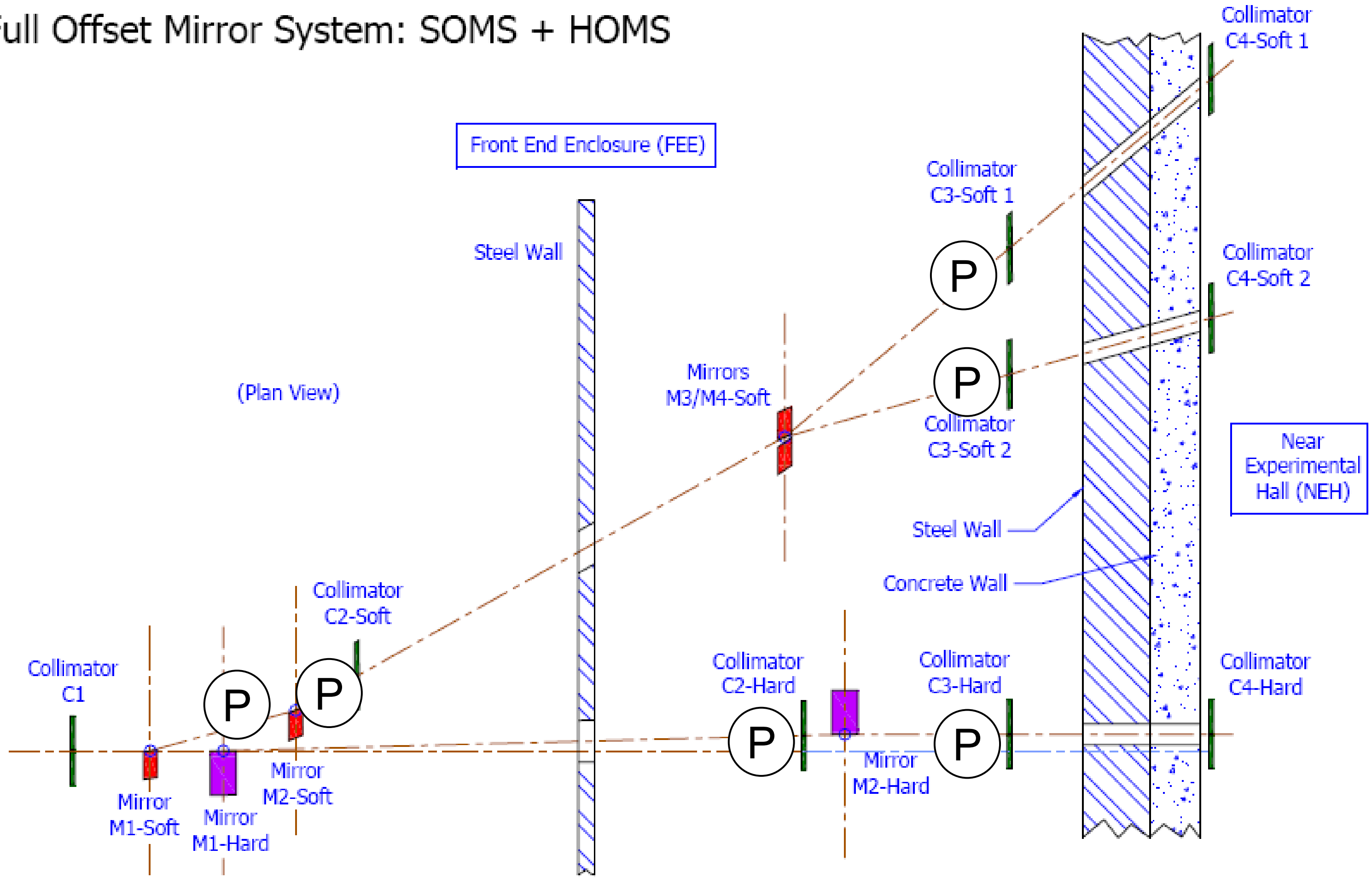
FEL Offset Mirror Systems

SOMS and HOMS reflect horizontally



FEL Offset Mirror Systems and "Pop-in" imagers for alignment

Full Offset Mirror System: SOMS + HOMS

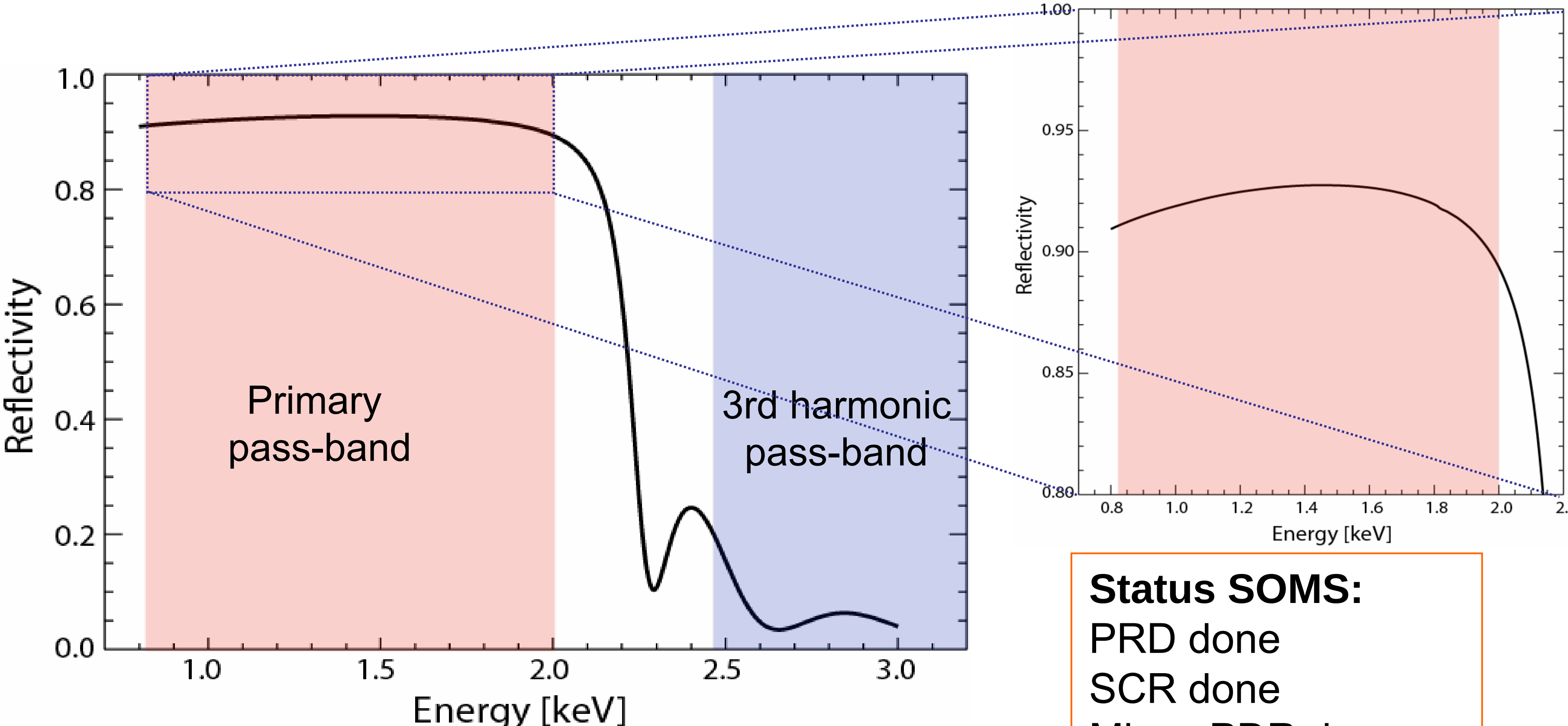


Differences between FEL offset mirrors and synchrotron mirrors

- Multi KW power loading seen at synchrotrons not an issue at LCLS
  - Instead we worry about single shot damage from FEL
- Active bending of Mirrors
  - Used at synchrotrons to make 100m radii for focusing
  - Needed at LCLS (HOMS) to maintain > 1 Mm radii so as to not change FEL divergence
- Pointing stability
  - Stringent requirements for HOMS for a steady beam in the FEH

Richard M. Bionta
bionta1@llnl.gov

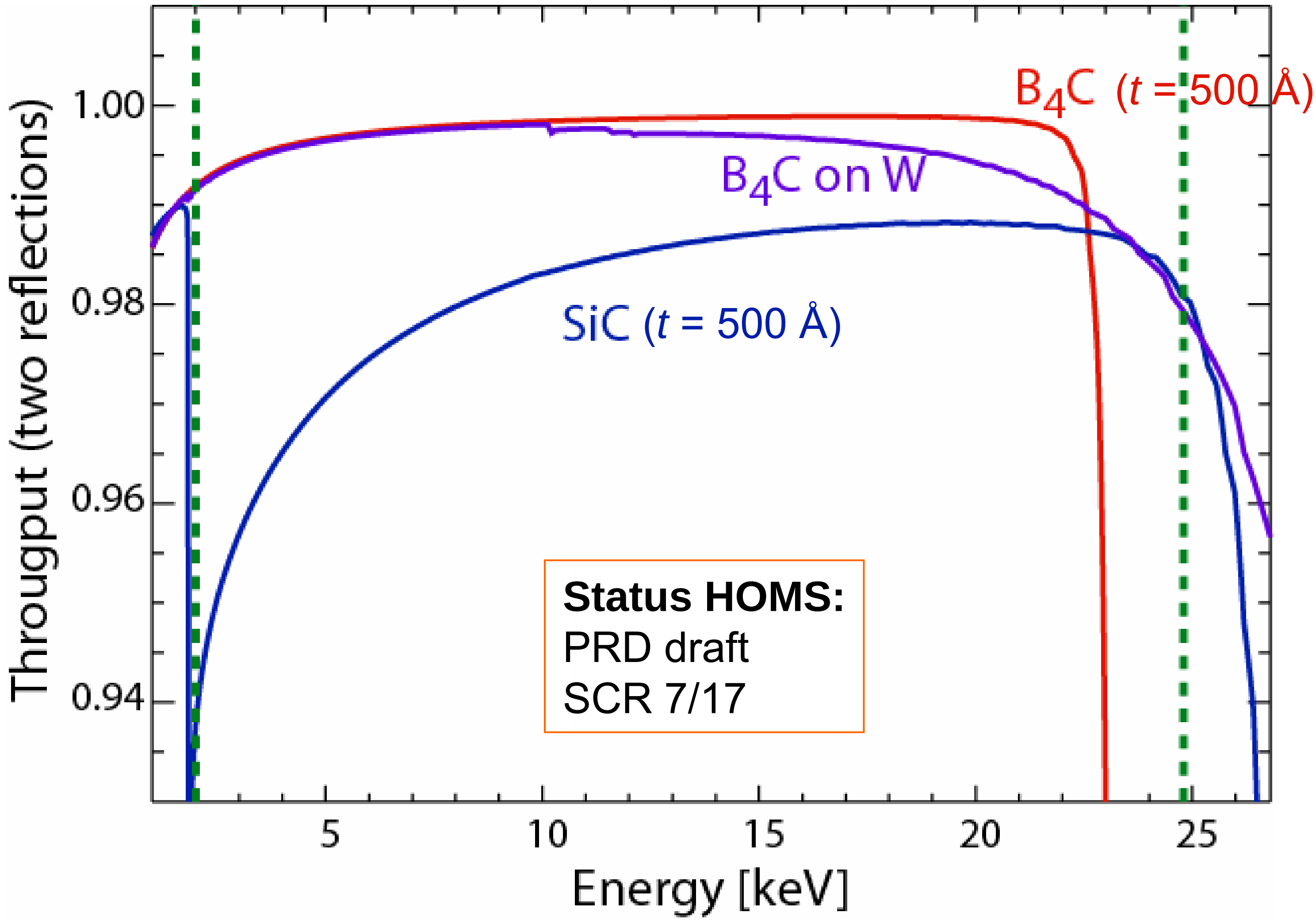
SOMS mirrors are coated with B_4C



- t = 500 Å, θ = 13.9 mrad, σ = 4.5 Å
- At least ~ 90% up to 2.0 keV
- Good 3rd harmonic rejection

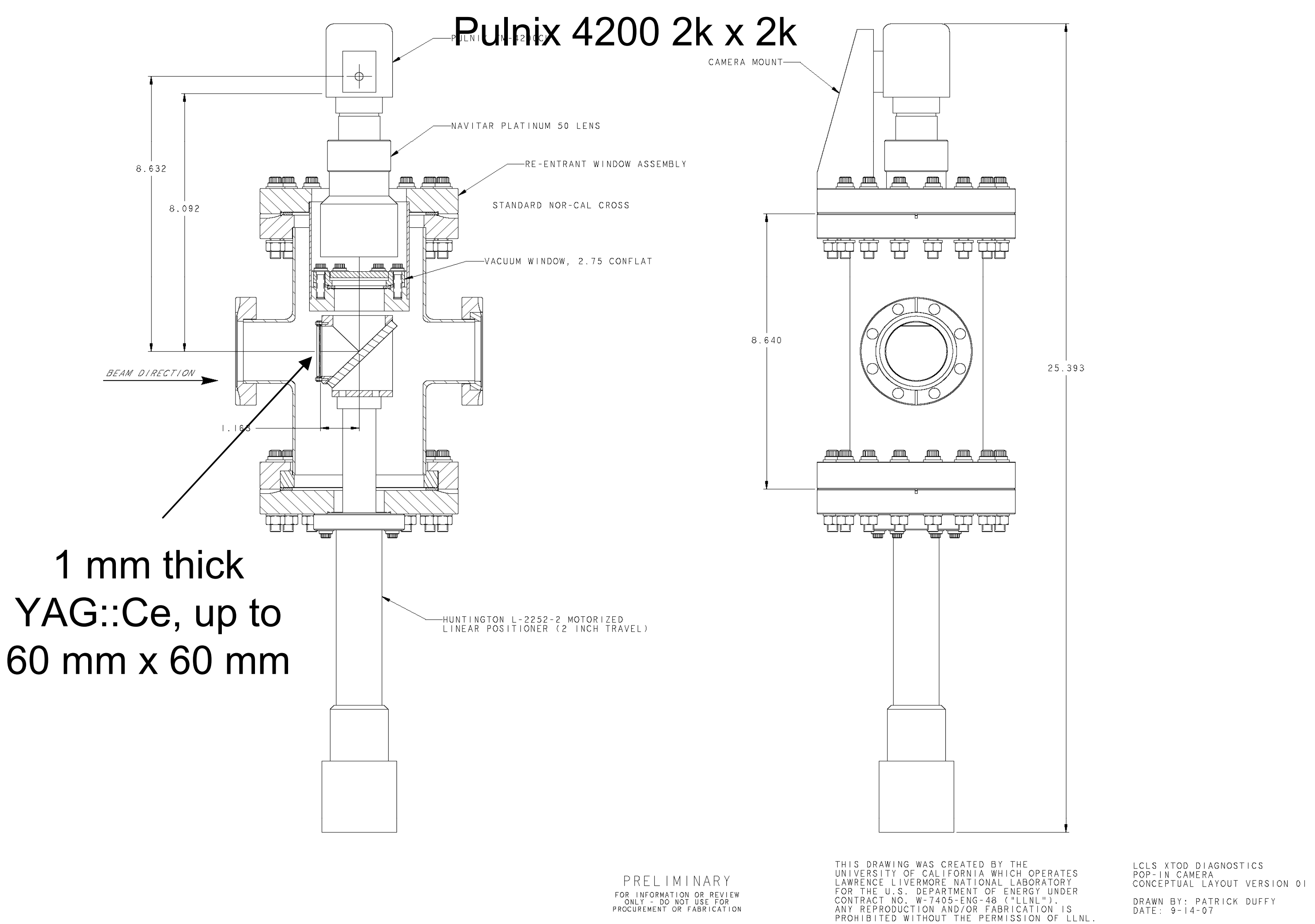
Status SOMS:
PRD done
SCR done
Mirror PDR done
Mirror FDR done
Mirrors in Purchase / Fabrication

HOMS mirrors will be coated with SiC



Status HOMS:
PRD draft
SCR 7/17

Pop-in alignment cameras



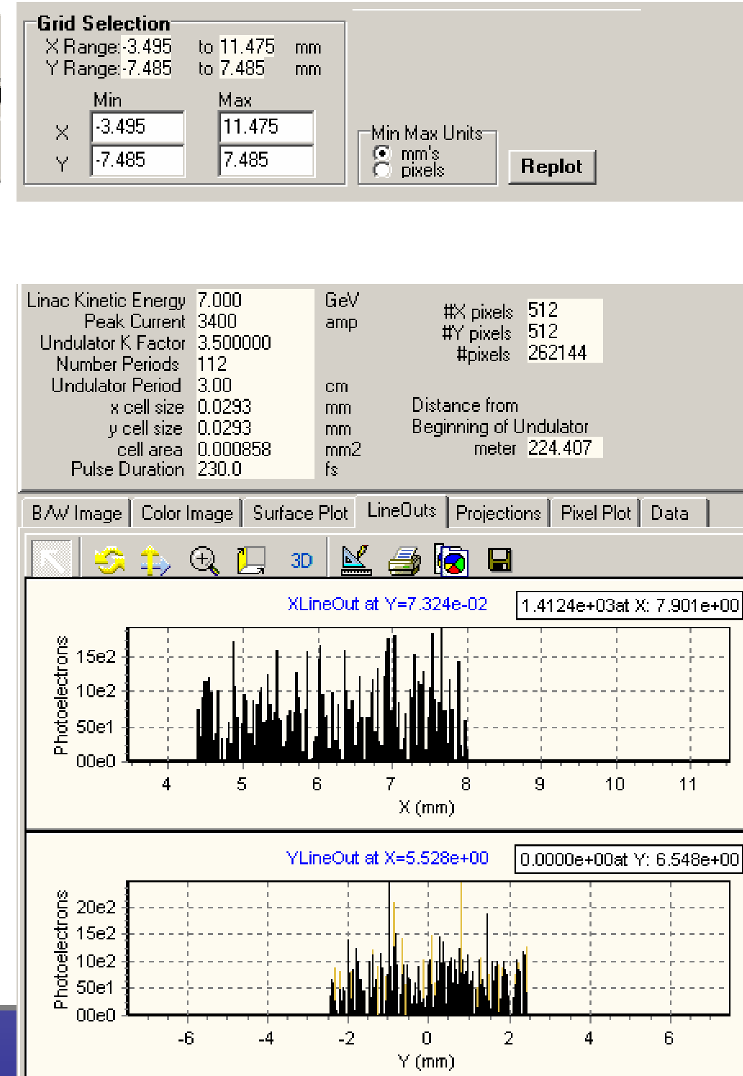
We are studying expected signal levels in the Pop-in cameras

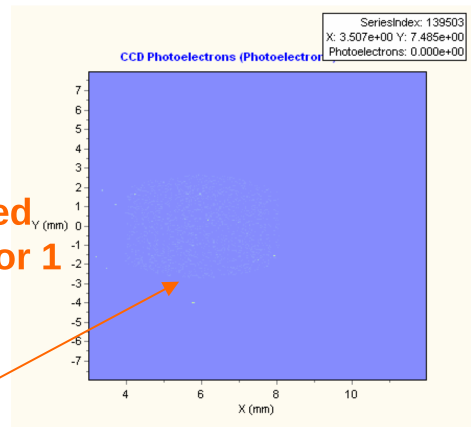
2 keV fundamental
1 mm YAG,
Full Well: 40,000

Camera: Pulnix TM-4100GE

Lens:
Schneider Navitar Platinum 50
Power: 0.2526
NA: 0.100

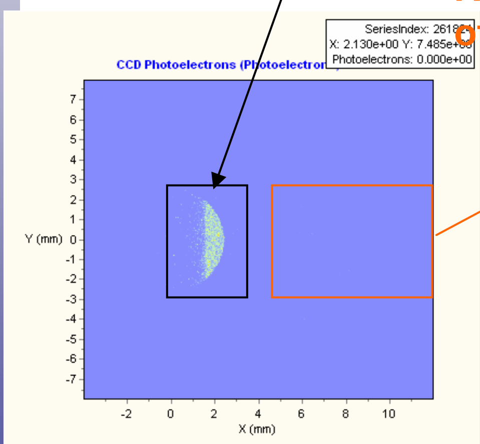
Pop-in 1 (After SOMS Mirror 1)





Misses Mirror 1

Reflected off Mirror 1



~1000 photoelectrons / per pixel / pulse, likely need to integrate over 10 pulses

SOMS Run025

Pop-in 2 (After SOMS Mirror 2)

2 keV fundamental
1 mm YAG,
Full Well: 40,000

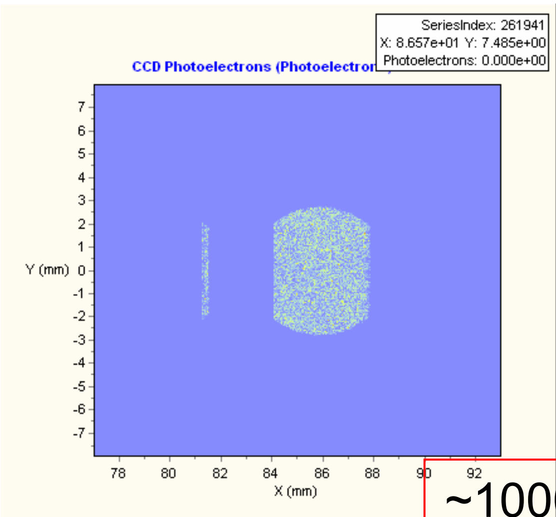
Camera: Pulnix TM-4100GE

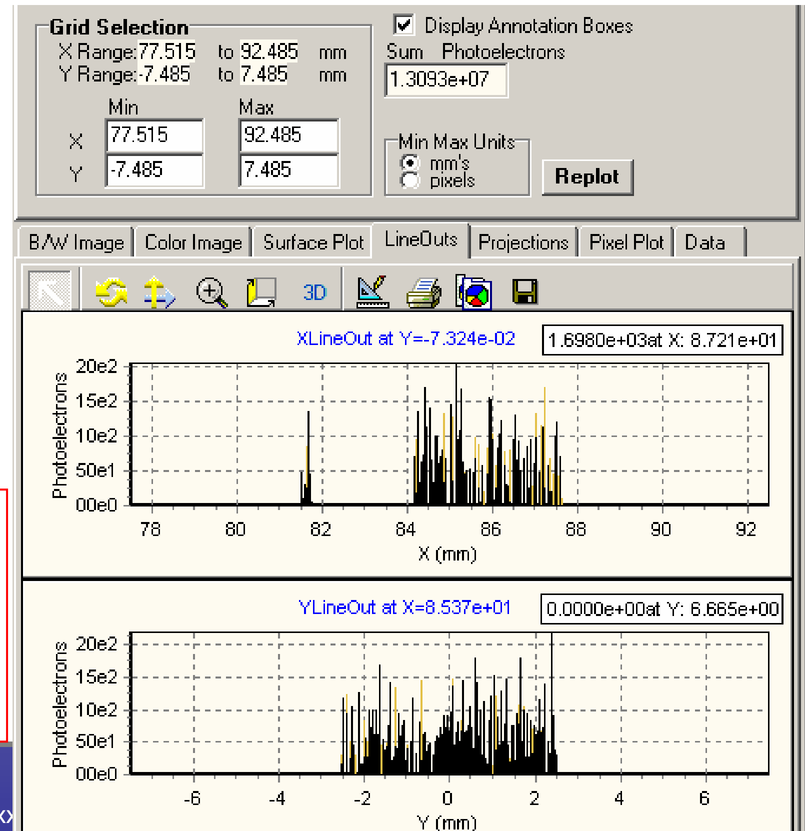
Lens:
Schneider Navitar Platinum 50
Power: 0.2526
NA: 0.100

7.553E-04	Solid Angle Fraction
0.2824	Quantum Efficiency (QE)
8.347e+16	Visible Photons Per Joule

Linac Kinetic Energy	7.000	GeV
Peak Current	3400	amp
Undulator K Factor	3.500000	
Number Periods	112	
Undulator Period	3.00	cm
x cell size	0.0293	mm
y cell size	0.0293	mm
cell area	0.000858	mm2
Pulse Duration	230.0	fs

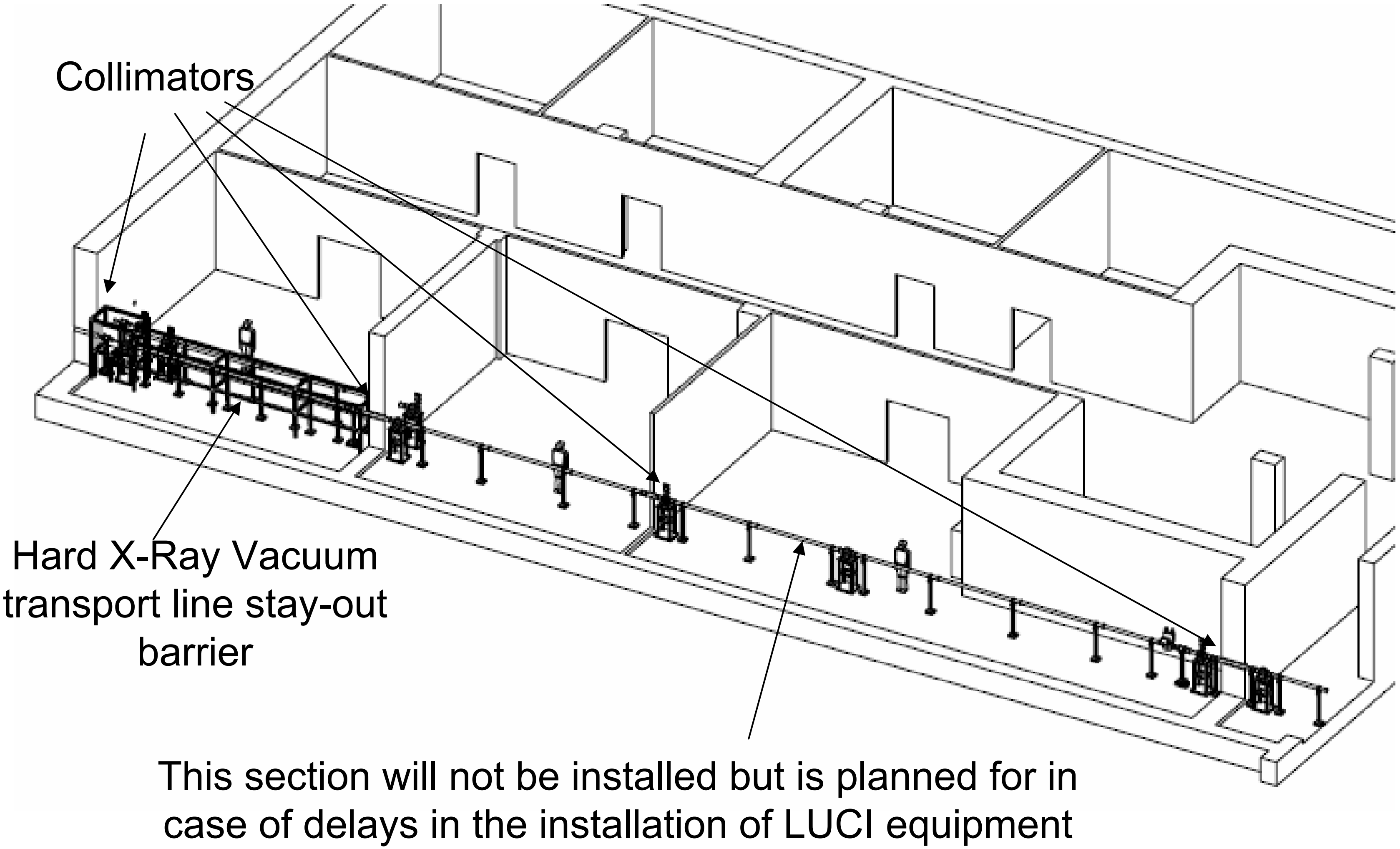
Distance from Beginning of Undulator meter 227.057



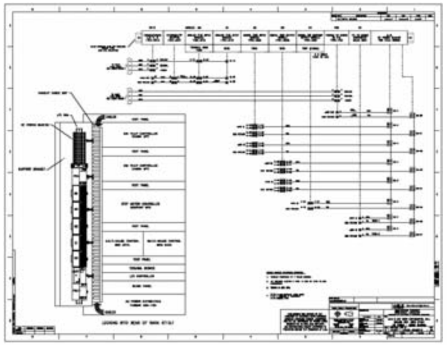


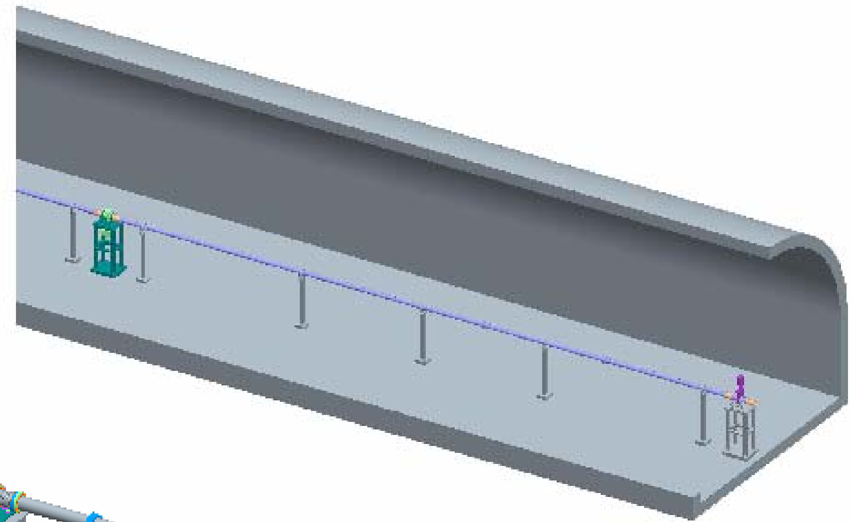
~1000 photoelectrons / per pixel / pulse, likely need to integrate over 10 pulses

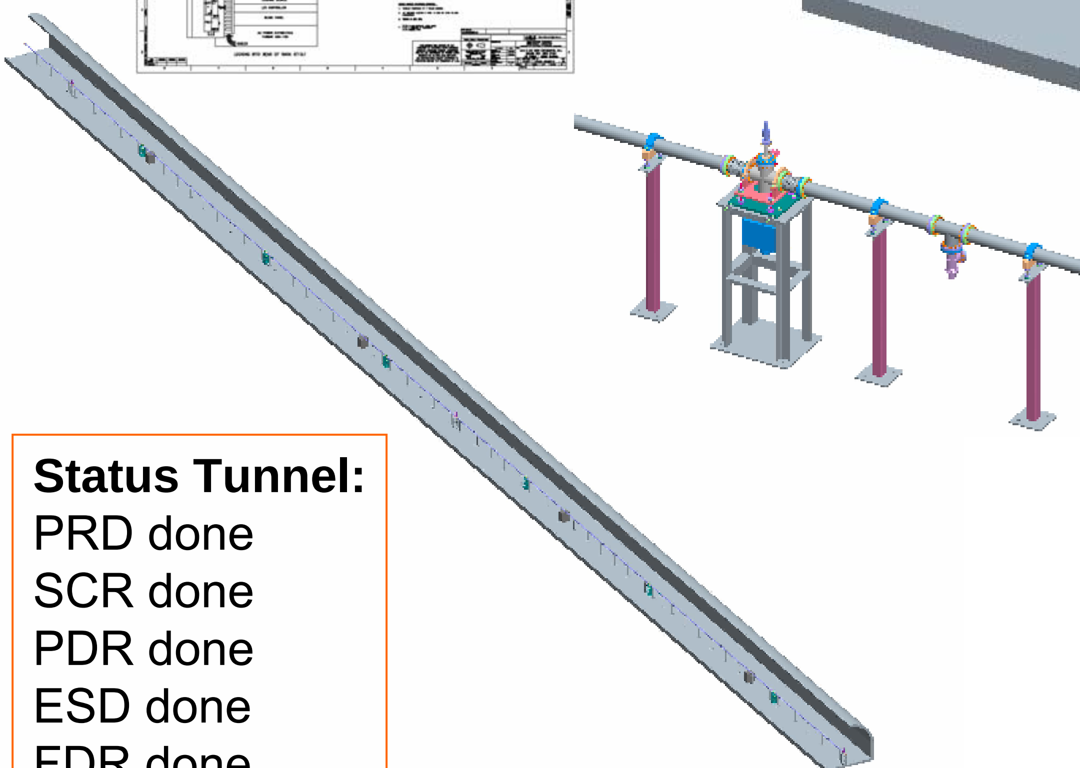
XTOD elements in Near Hall

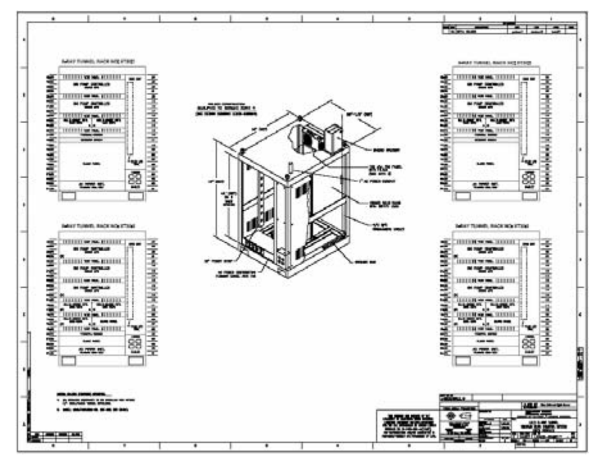


XTOD Tunnel Design Complete



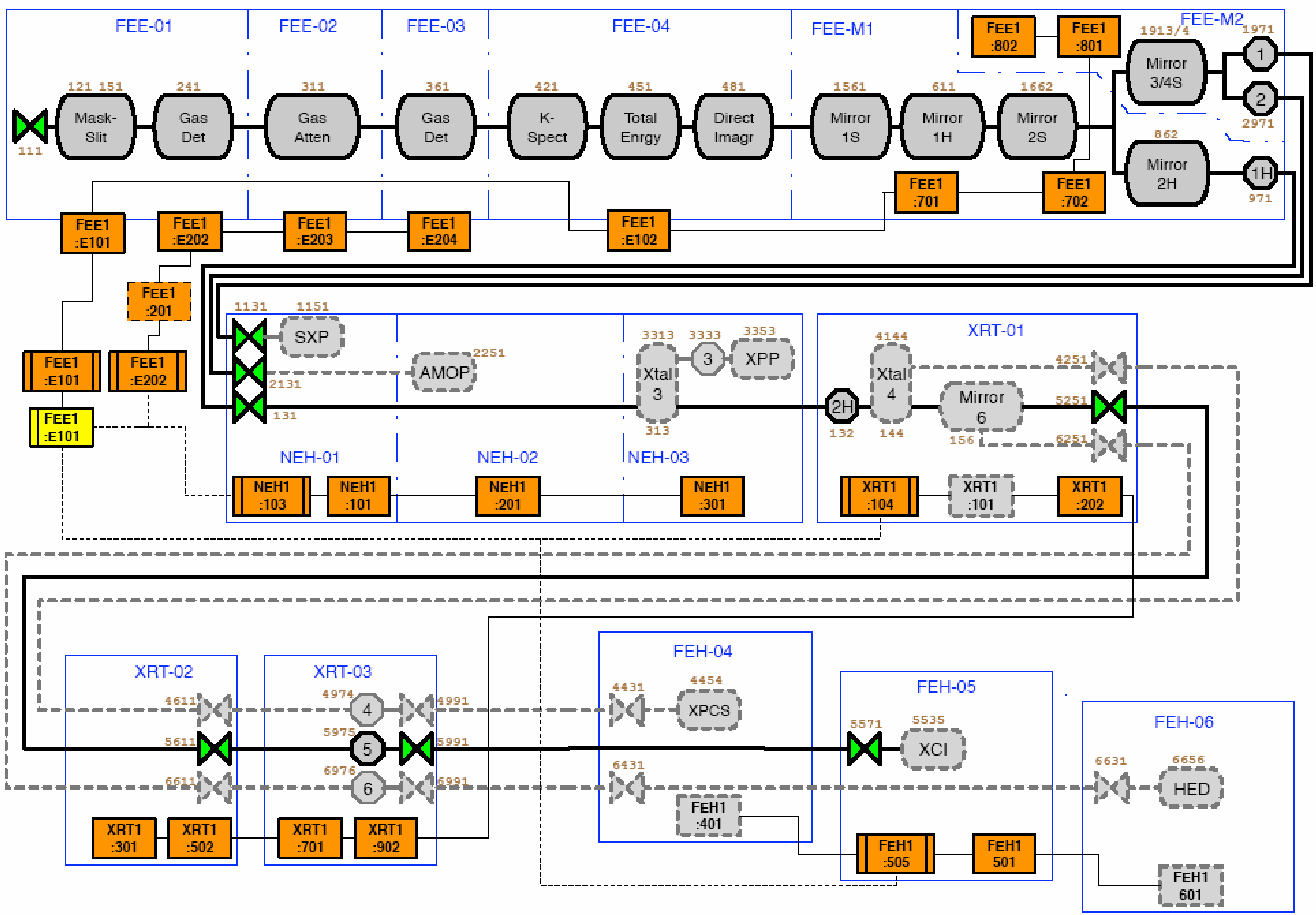






Status Tunnel:
PRD done
SCR done
PDR done
ESD done
FDR done

Integrated EPICS control system for XTOD has been designed



Summary

- Progress continues on XTOD :
  - Procurement - Slit, Fixed Mask, Attenuator, Gas Detector
  - In final design– Direct Imager, Thermal Detector, collimators, HOMS mirrors
  - In preliminary design – Mirror mechanical,
  - In conceptual design – K Spectrometer, Soft x-ray imager, Pop-in Alignment system
- Problem areas
  - Thermal sensor signal degraded by non-thermal prompt signal
  - Soft x-ray imager and K spectrometer design lagging
  - HOMS pointing stability challenging
- FEE diagnostic instrumentation will be ready for instillation in 2008