LUSI

Preliminary Instrument Design Review

X-ray Correlation Spectroscopy

Aymeric Robert – XCS Instrument Scientist

July 25, 2008

Outline

- XCS Science and Scientific Scope
- Experimental Technique
- Instrument Layout
- Component Descriptions and Requirements
  - X-ray Optics &Diagnostics
  - Diffractometer System
  - Detector
- Alternative Designs
- Safety
- Major Interfaces to other LCLS Systems

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Contributors

- Team Leaders
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  - Karl Ludwig (Boston U.)
- LUSI Scientists
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  - D. Fritz (XPP)
  - S. Boutet (CXI)
  - Y. Feng (DCO)
  - M. Messerschmidt (XPP)
- Engineering
  - Eric Bong (Lead Eng.)
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  - Jim Delor
  - Ted Osier
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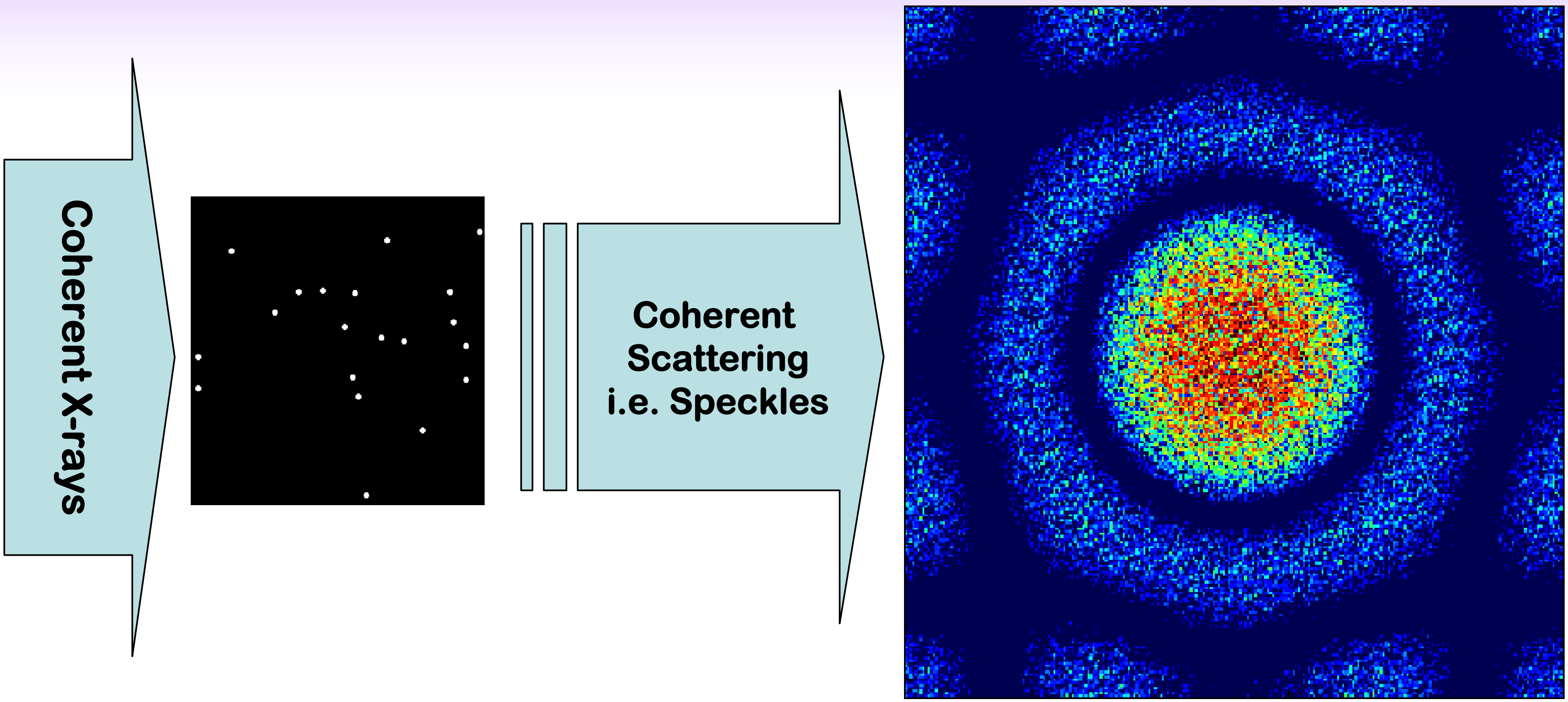
X-ray Correlation Spectroscopy Science



- **Characterizing the time fluctuations of speckle patterns**
(scattering patterns produced by the coherent illumination of the sample)

- **Characterizing the underlying dynamics of the system**

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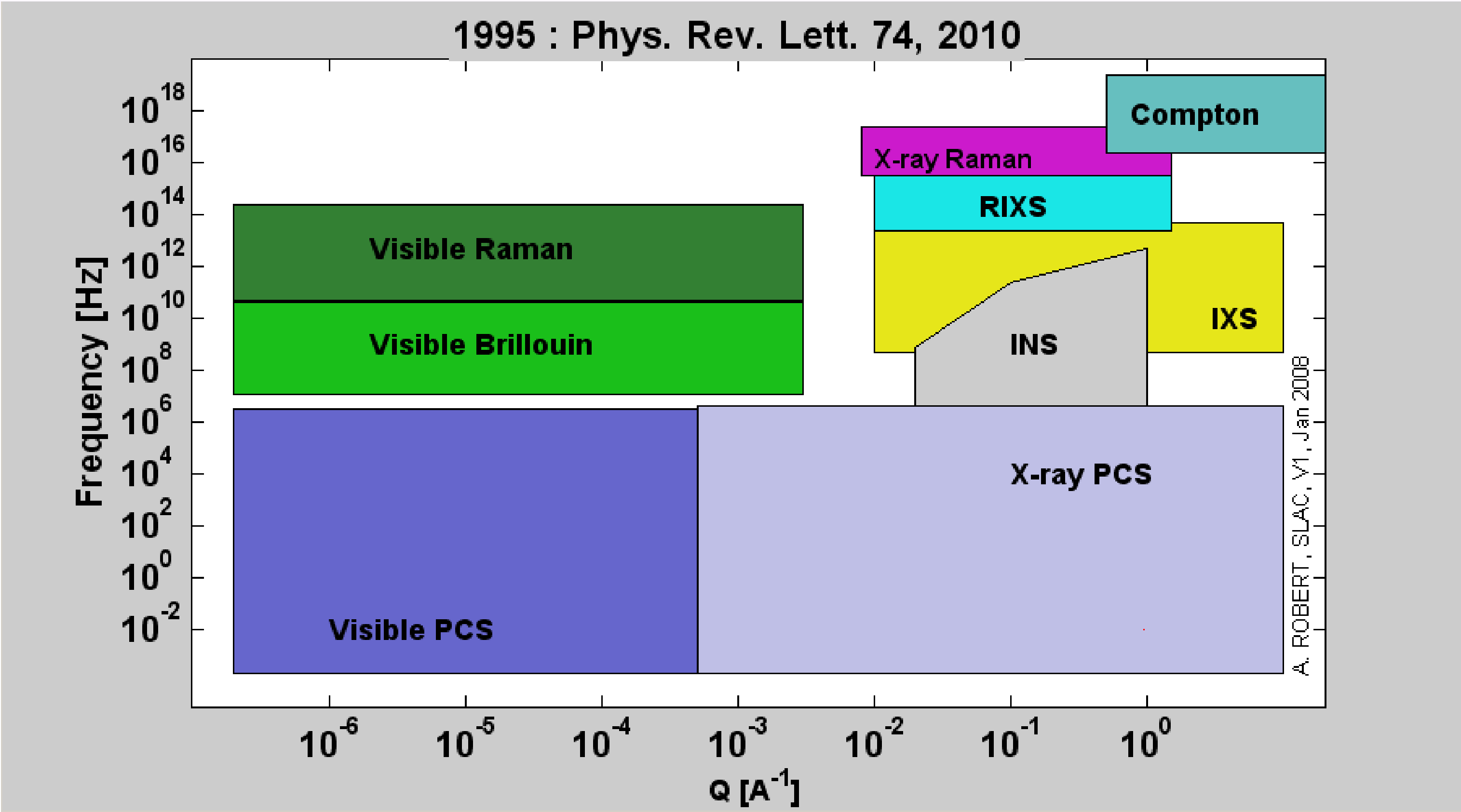
XCS Science : the mystery of the XPCS area



2D-XPCS with CCD

1D-XPCS with autocorrelator

XPCS in Grazing Incidence

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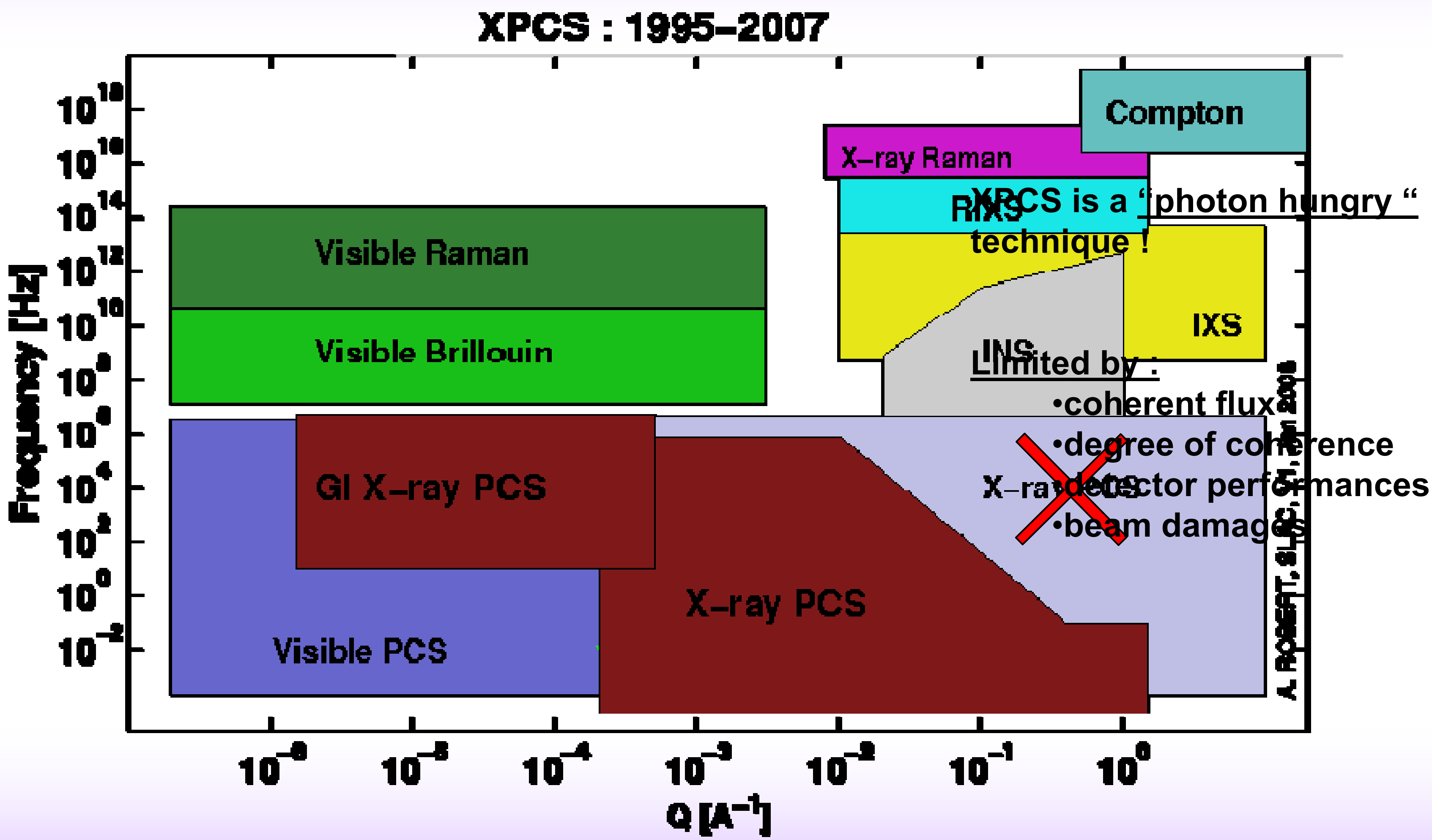
X-ray Correlation Spectroscopy Science



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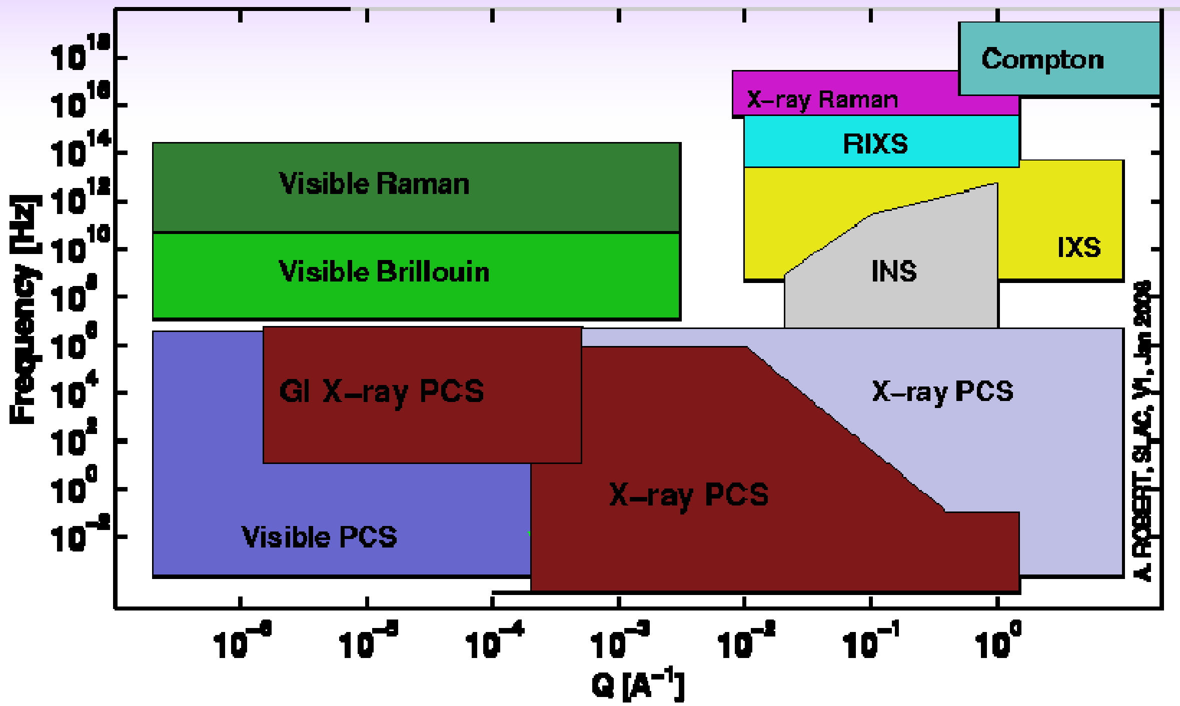
X-ray Correlation Spectroscopy Science



Dynamics of interest	
Ultra-dilute systems (gazes, aerosols, fogs, fumes)	Biological sample dynamics (folding-unfolding transition)
Ionic Liquids, liquids and Transport Theories	Dynamics of condensed matter (Phonons,…)
Nano-systems (nanoscale=sub-ns dynamics)	Hard Condensed Matter Phase transitions (CDW, …)

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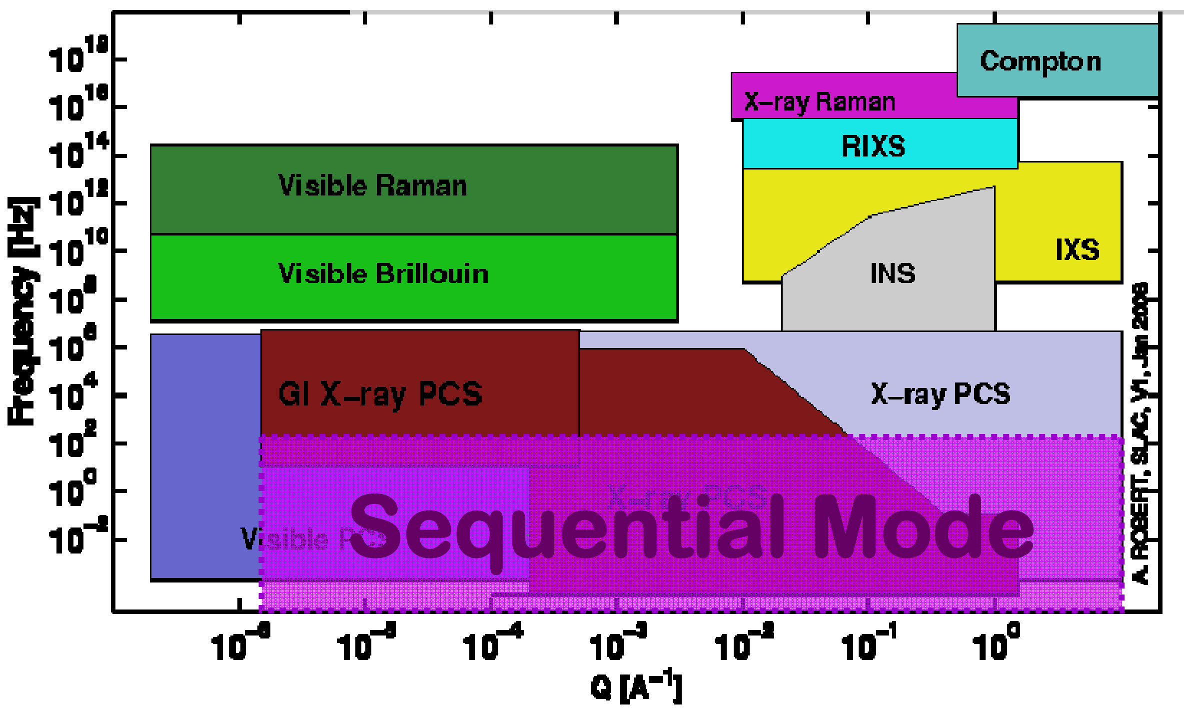
XCS Science @ LCLS



LCLS Parameters

Full Transverse Coherence

8 and 24 keV

High Time–average Brilliance
Rep. Rate 120 Hz

Dedicated 2D-Detector

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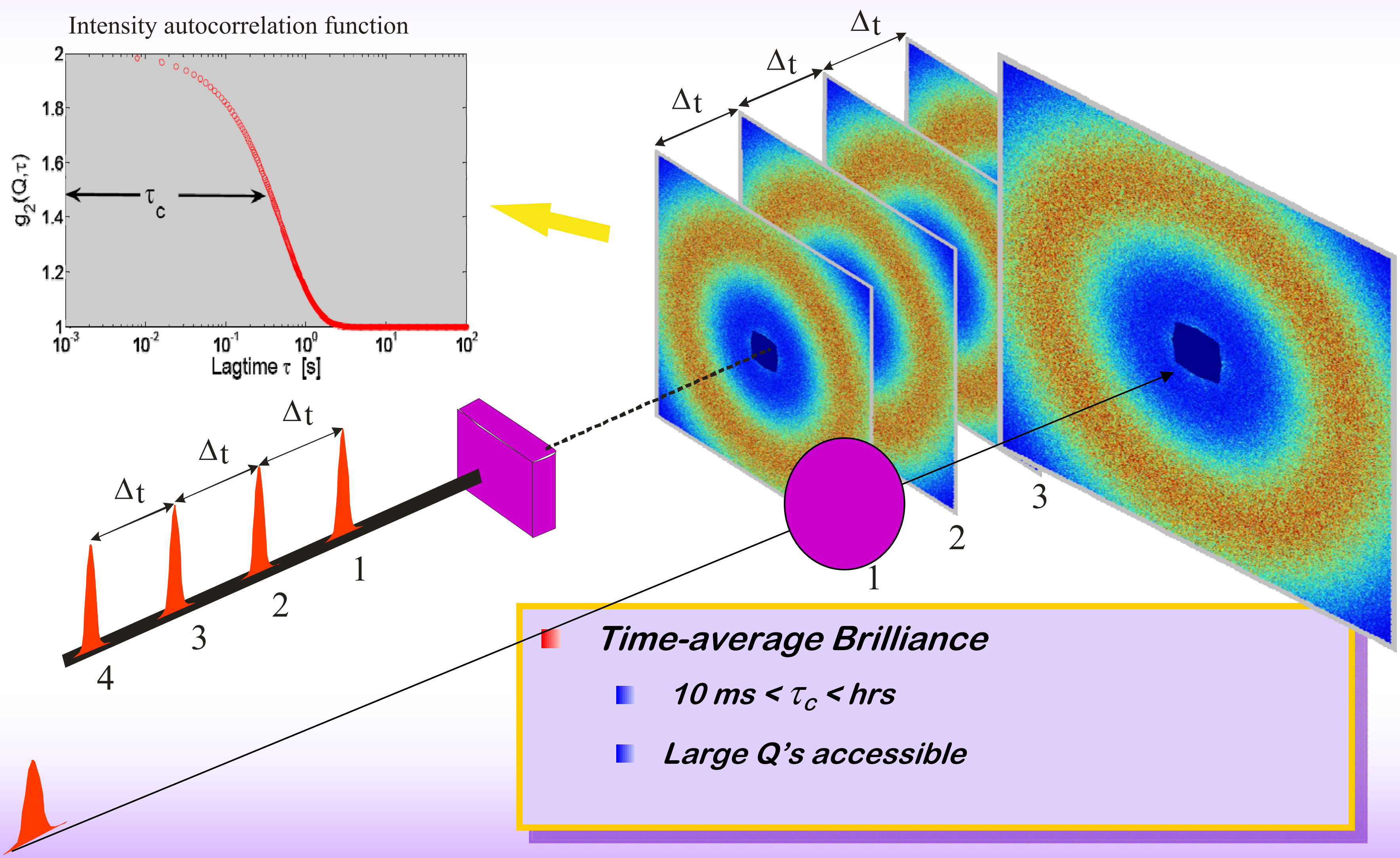
Sequential XCS



- *Time-average Brilliance*
  - *10 ms < τ_c < hrs*
  - *Large Q's accessible*

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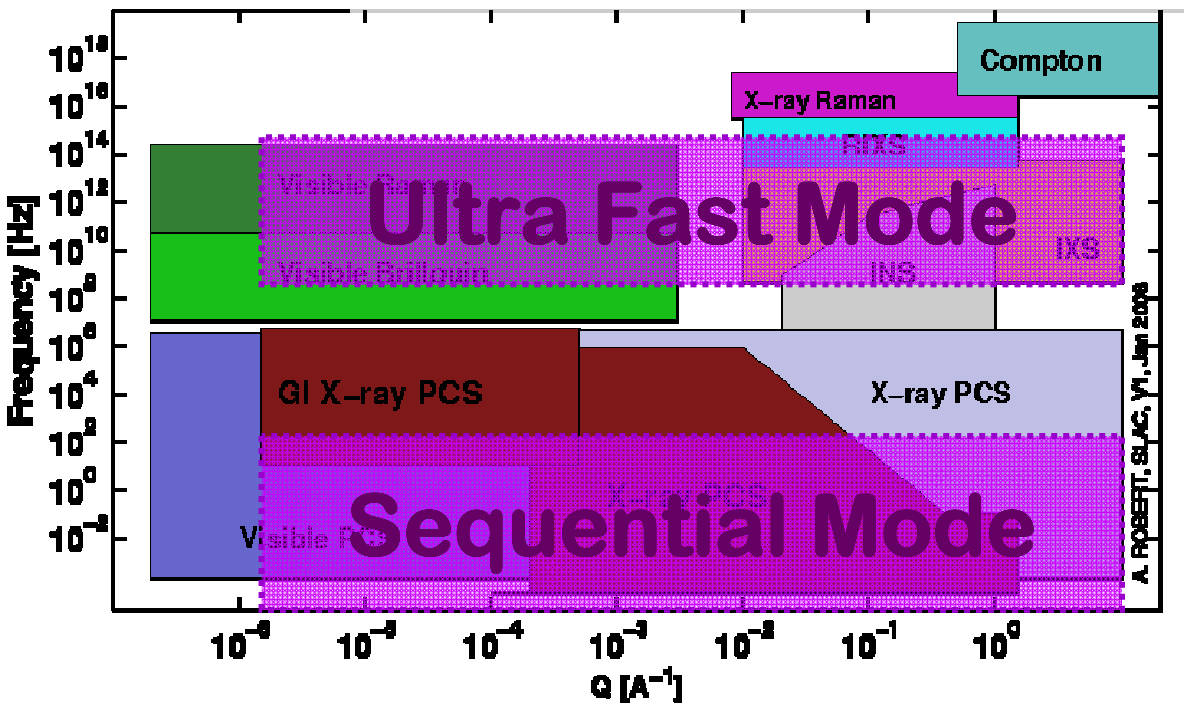
XCS Science @ LCLS



LCLS Parameters

Full Transverse Coherence

8 and 24 keV

High Time–average Brilliance
Rep. Rate 120 Hz

High Peak Brilliance
Short pulse duration 230fs

Dedicated 2D-Detector

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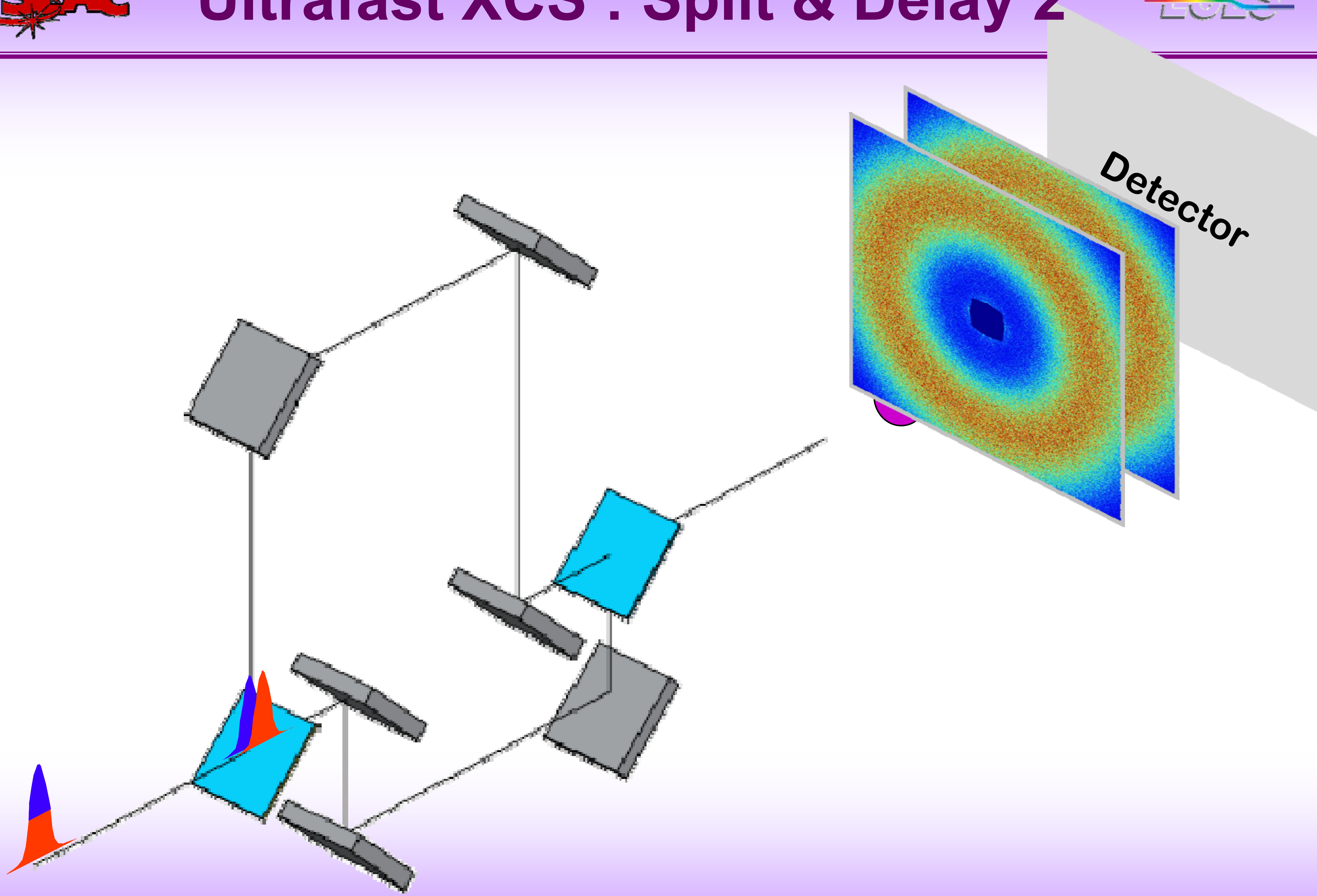
Ultrafast XCS : Split & Delay 2



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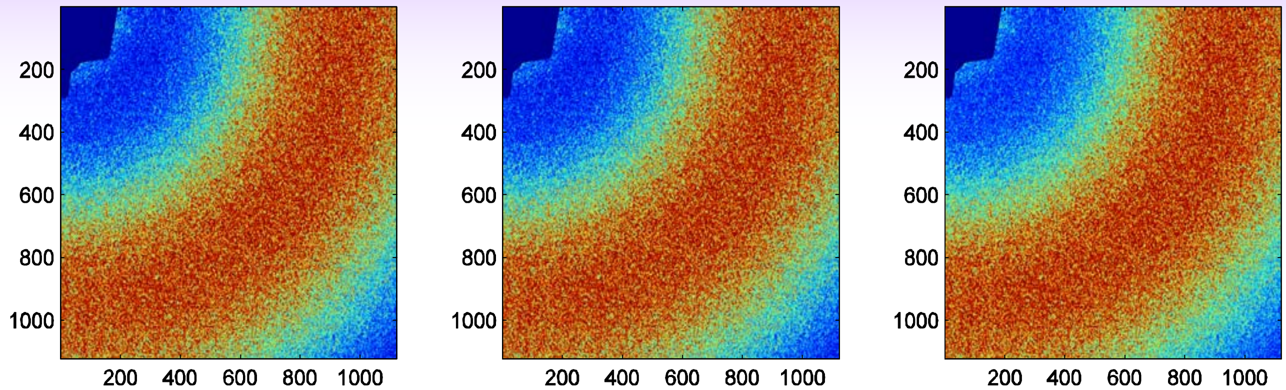
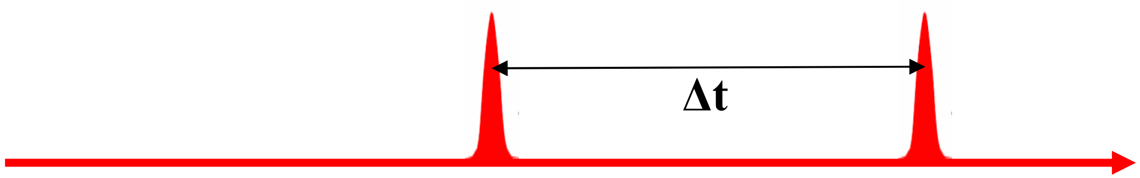
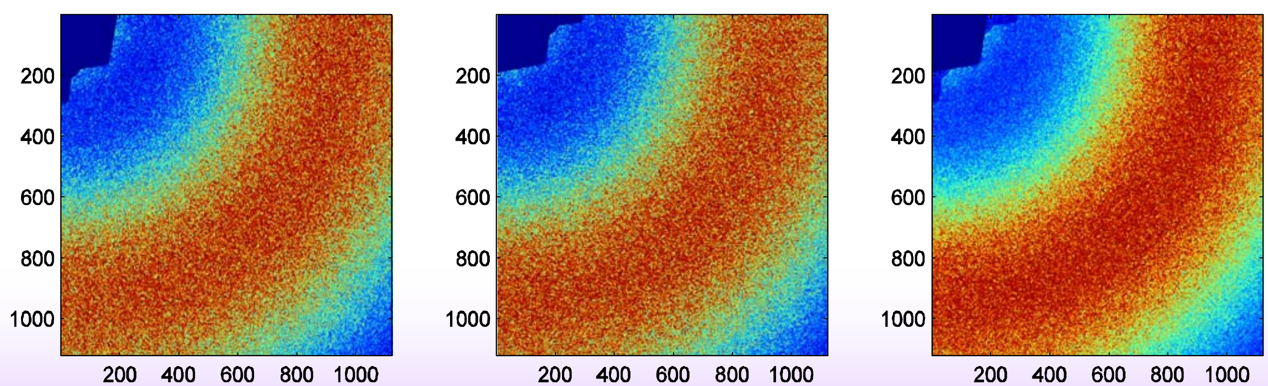
Ultrafast XCS : Split & Delay

No Dynamics
(zero delay)





Dynamics



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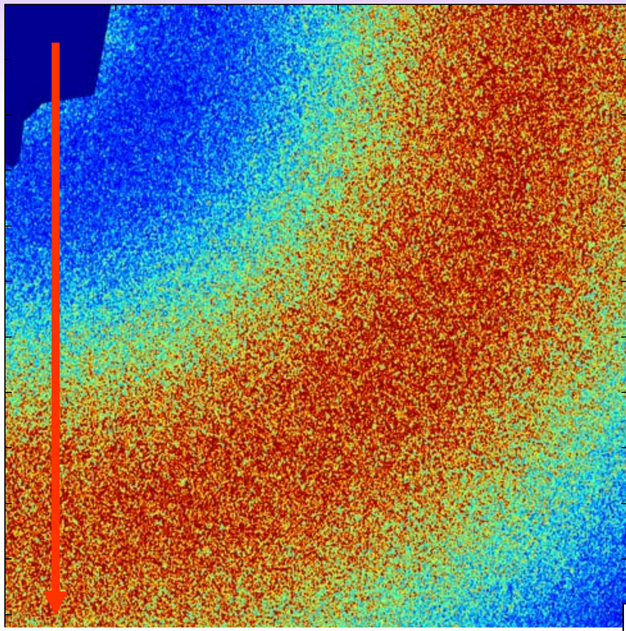
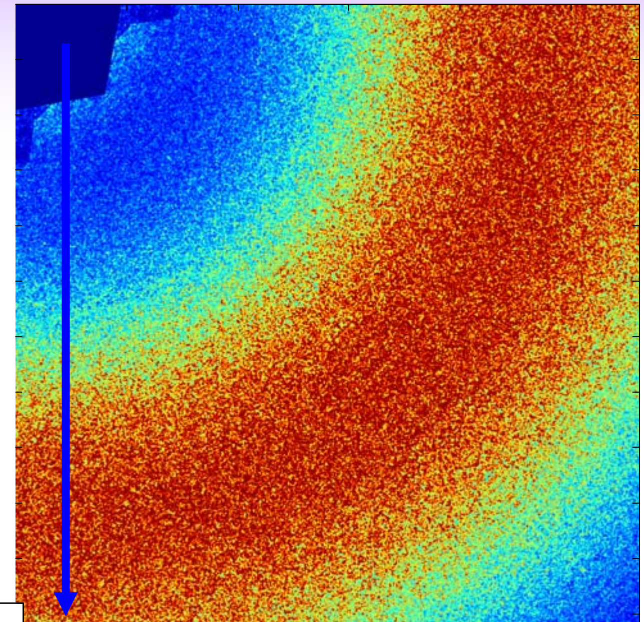
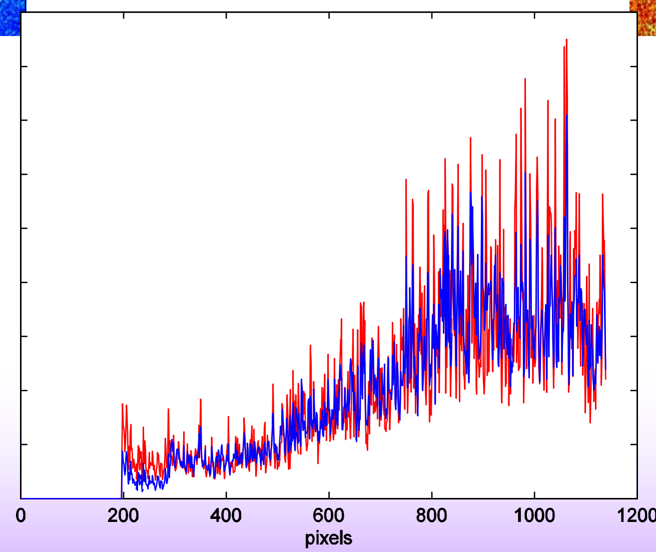
Ultrafast XCS : Split & Delay







No Dynamics over Δt (Zero Delay)

Dynamics over Δt

Reduction of contrast

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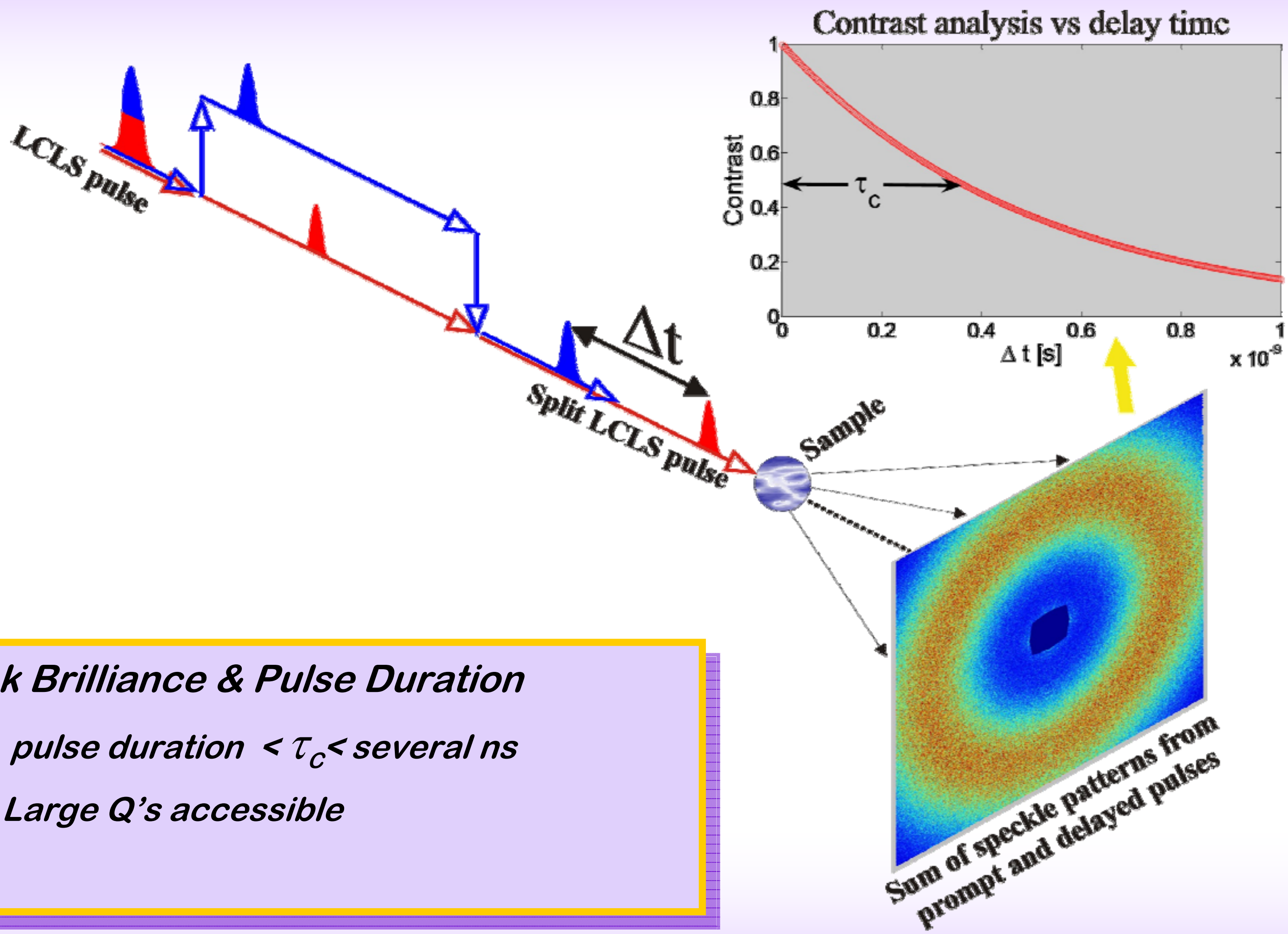
Ultrafast XCS : Split & Delay



- ***Peak Brilliance & Pulse Duration***
  - *pulse duration < τ_c < several ns*
  - *Large Q's accessible*

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Experimental Techniques

- X-ray Photon Correlation Spectroscopy
  - Small Angle X-ray Scattering geometry
  - Diffraction (Wide Angle Diffraction up to $2\theta=55^{\circ}$)
  - Reflectivity
  - Grazing Incidence Diffraction
  - Grazing Incidence SAXS

- Operation both in sequential and split-delay mode

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XCS Instrument Scope

- **Instrument will operate in the 6-25 keV photon energy range**
- **Versatility of the instrumentation**

X-ray Wavelength and Bandwidth	Sample Environments	Scattering Technique
• Monochromatic Fundamental • Monochromatic 3^{rd} Harmonic • $10^{-6} < \Delta\lambda/\lambda < 10^{-4}$	• Room Press. & Room Temp • Temperature Controlled Cryostat • Liquid • Vacuum • Others …	• Wide Angle Scattering • Small Angle Scattering • Reflectivity • Grazing Incidence Diff. • GI-SAXS

Facility Advisory Committee Report Oct. 2007

"… The committee recommends that the XCS staff retain **flexibility** in their designs to facilitate change as opportunities and problems are discovered. …"

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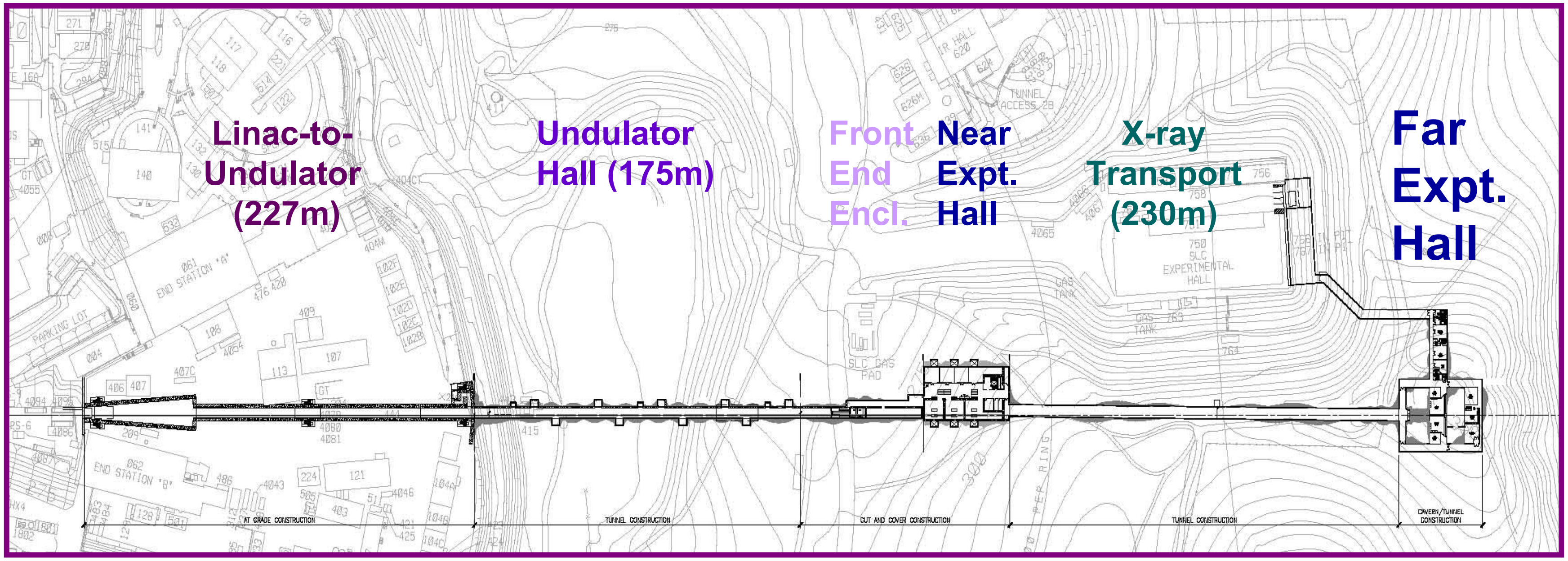
LCLS



Source to Sample distance : ~ 420 m

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Source Parameters

- LCLS energy range (fundamental) : 800 – 8300 eV
  - 3rd harmonic up to 24.9 keV (1% of the fundamental)
- XCS instrument uses hard X-ray branch : ~ 6-25 keV
- Source size and location varies with energy

Parameter	Value	Value	Value	Units
Photon energy	24.813	8.271	6	keV
Wavelength	0.05	0.15	0.21	nm
Source size (FWHM)	60	60	67	µm
XPP Hutch distance from source	420	420	420	meters
Source divergence (FWHM)	0.73	1.1	1.34	µrad
Pulse duration	200	200	200	fs
Number of photons	1.7E+10	1.7E+12	2.7E+12	photons

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Expected Fluctuations of LCLS

Parameter	Value
Pulse intensity fluctuation	~ 30 %
Position & pointing jitter (x, y, α, β)	~ 25 % of beam diameter ~ 25 % of beam divergence
Source point jitter (z)	~ 5 m (leads to variations in apparent source size, or focal point location if focused)
X-ray pulse timing (arrival time) jitter	~ 1 ps FWHM
X-ray pulse width variation	~ 15 %
Center wavelength variation	~ 0.2 % (comparable to FEL bandwidth)

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XPCS Experiments

- Observing speckle patterns
- Fluctuations from the source cannot alter the X-ray scattering pattern for XPCS experiments
- A scheme to minimize the impact of source fluctuation must be realized
- LCLS is a transversely coherent beam
- The LCLS is a serial experiment operation – instrument downtime is not acceptable!
- Experimental efficiency is a top priority - time is extremely precious

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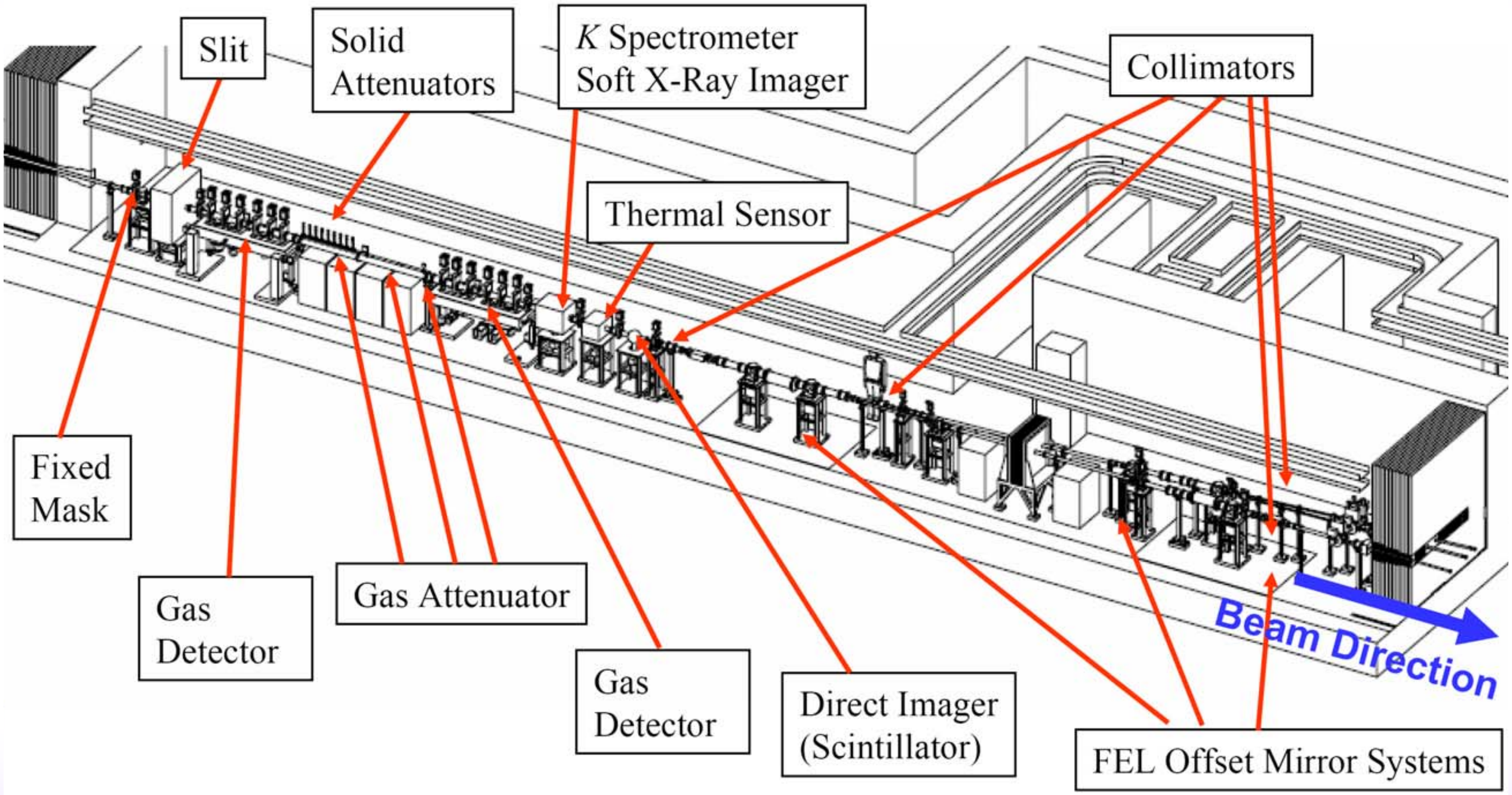
X-ray Optics and Diagnostics in FEE



- Slits and imager's not designed for FEL radiation
- No diagnostics after the offset mirror system

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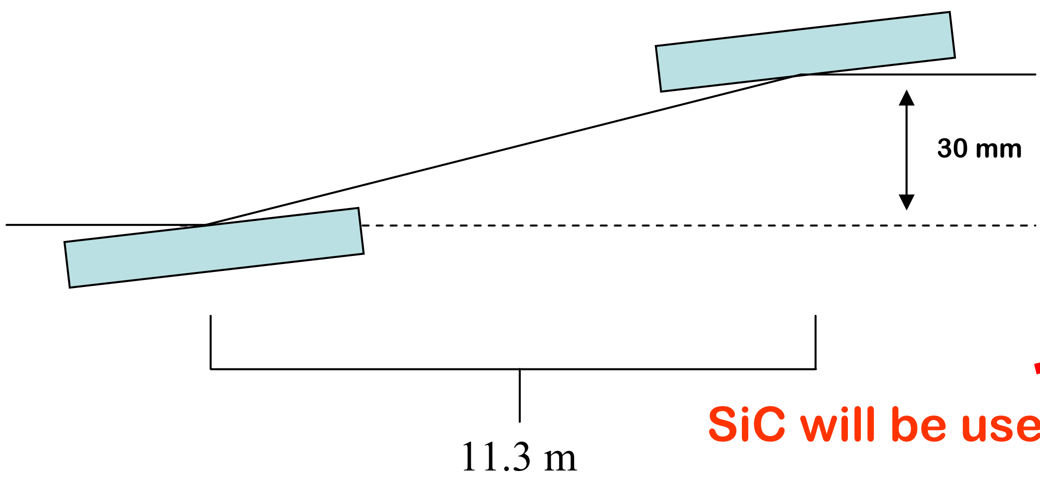
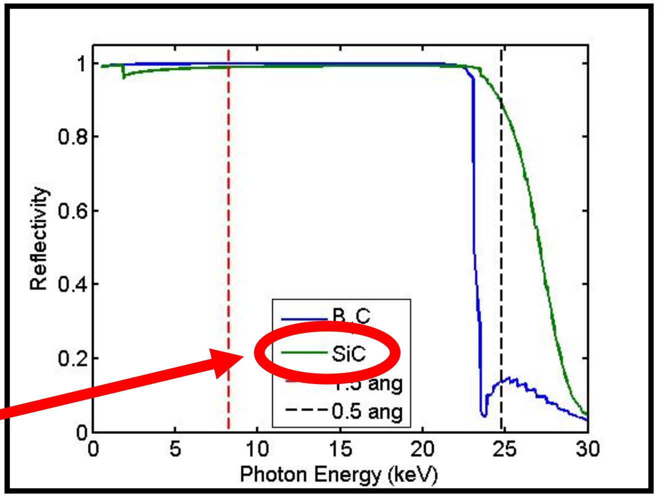
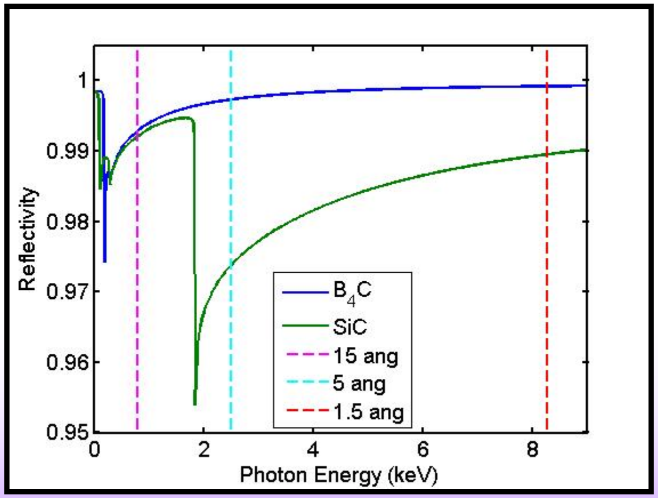
Hard X-ray Offset Mirror System (HOMS)





SiC will be used



Mirror Parameter	**Value**	**units**
l x w	*450 x 30*	mm
Incidence angle	*1.324*	mrad
Coating thickness	40	nm
Surface Roughness	*0.5*	nm

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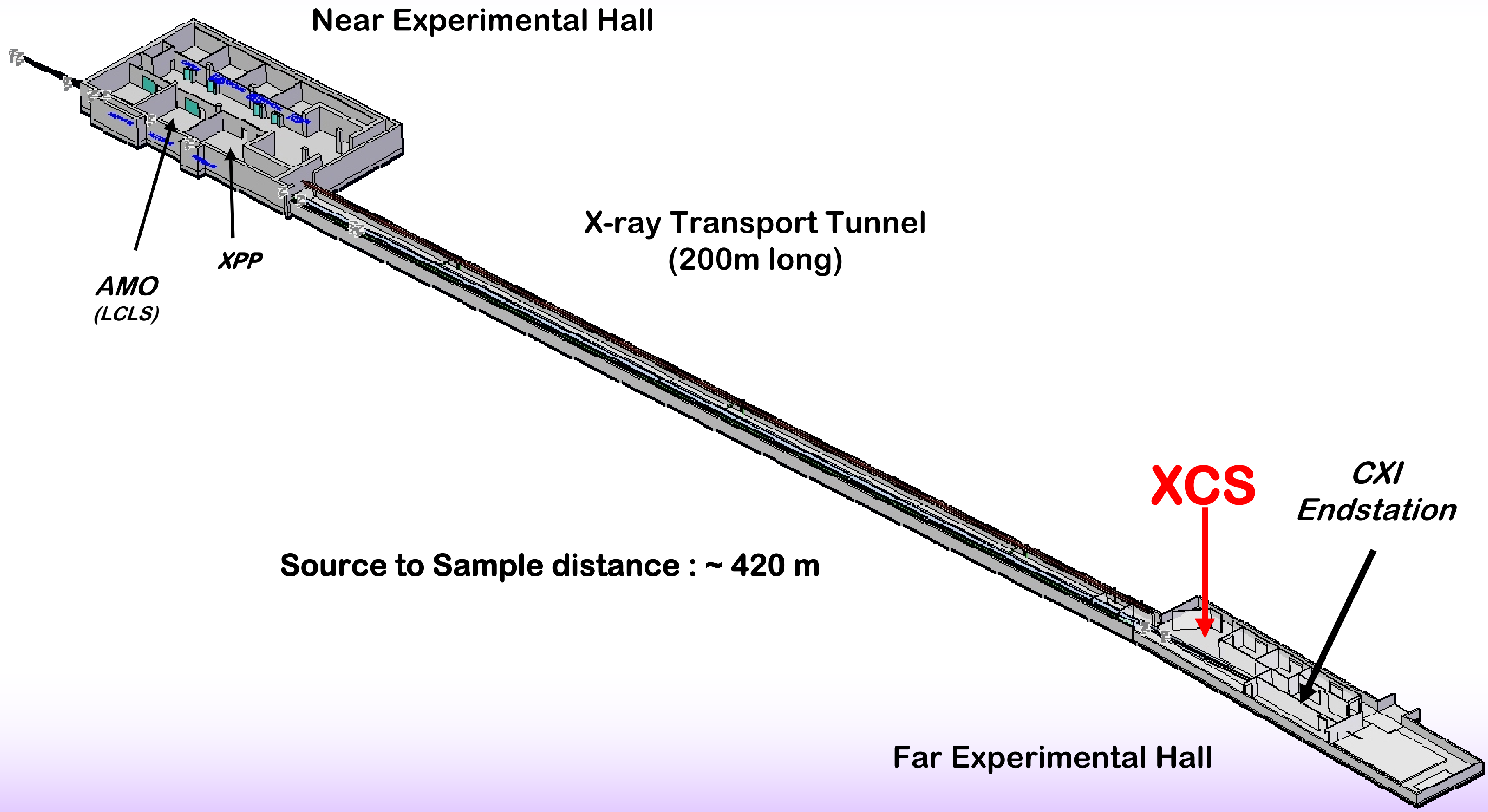
XCS Instrument Location



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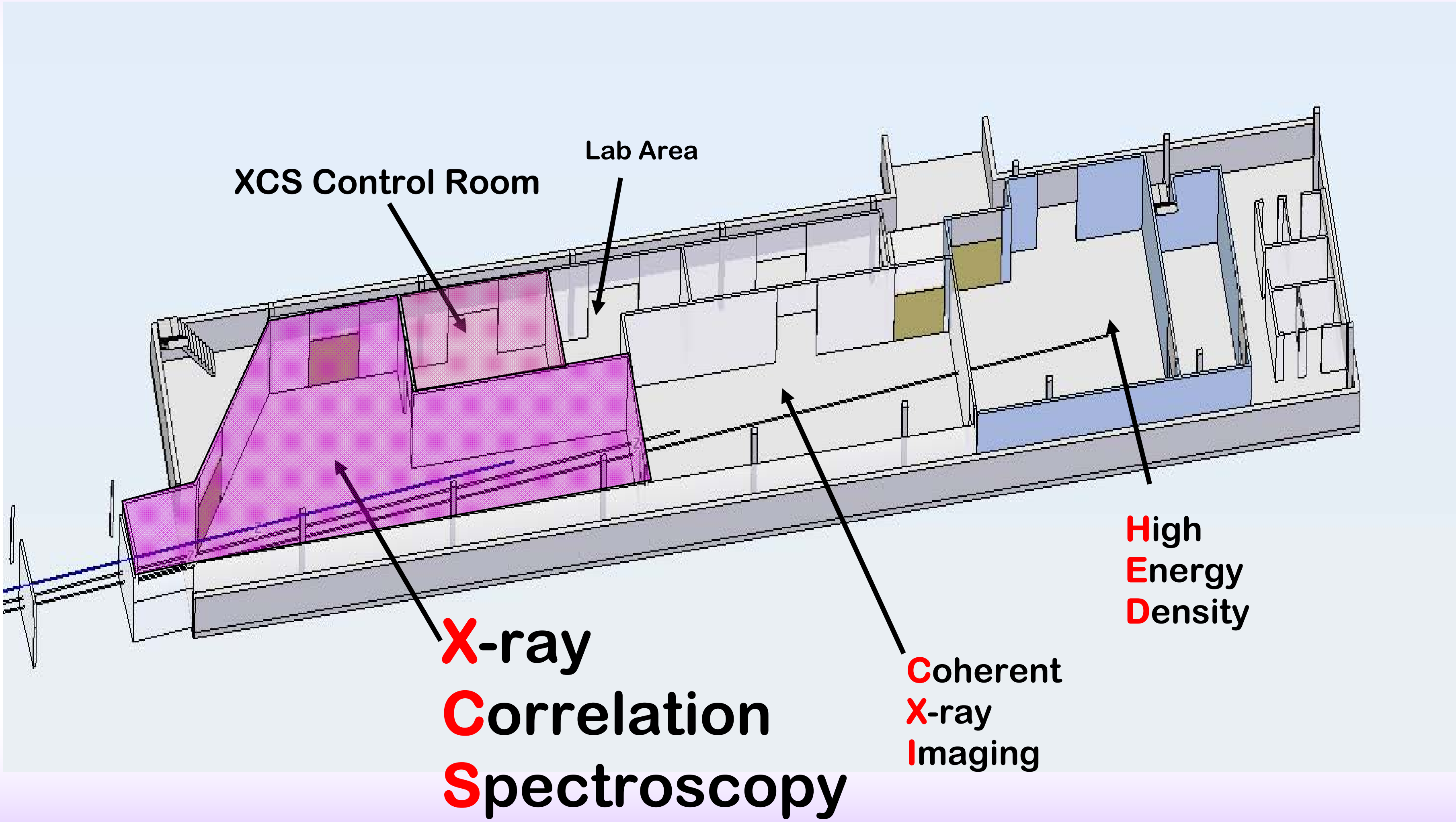
XCS Instrument : FEH Hutch 4



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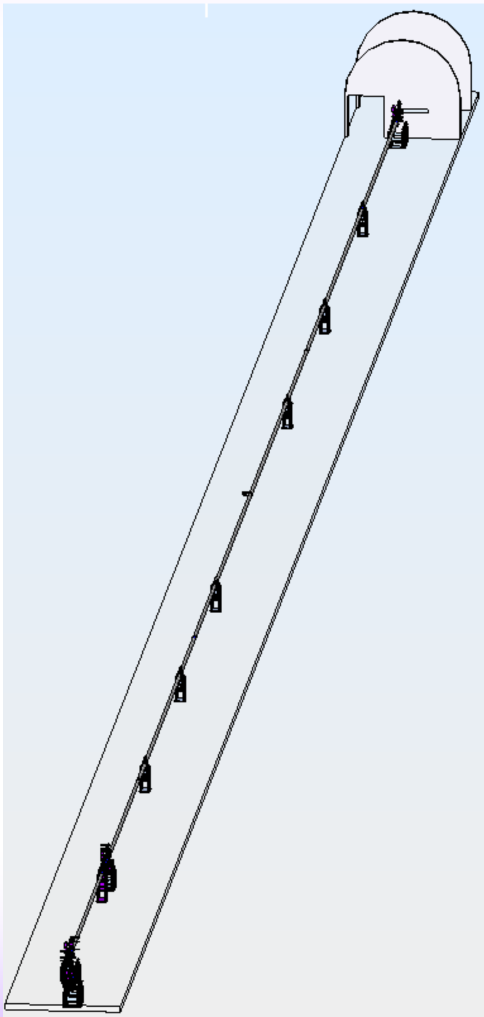
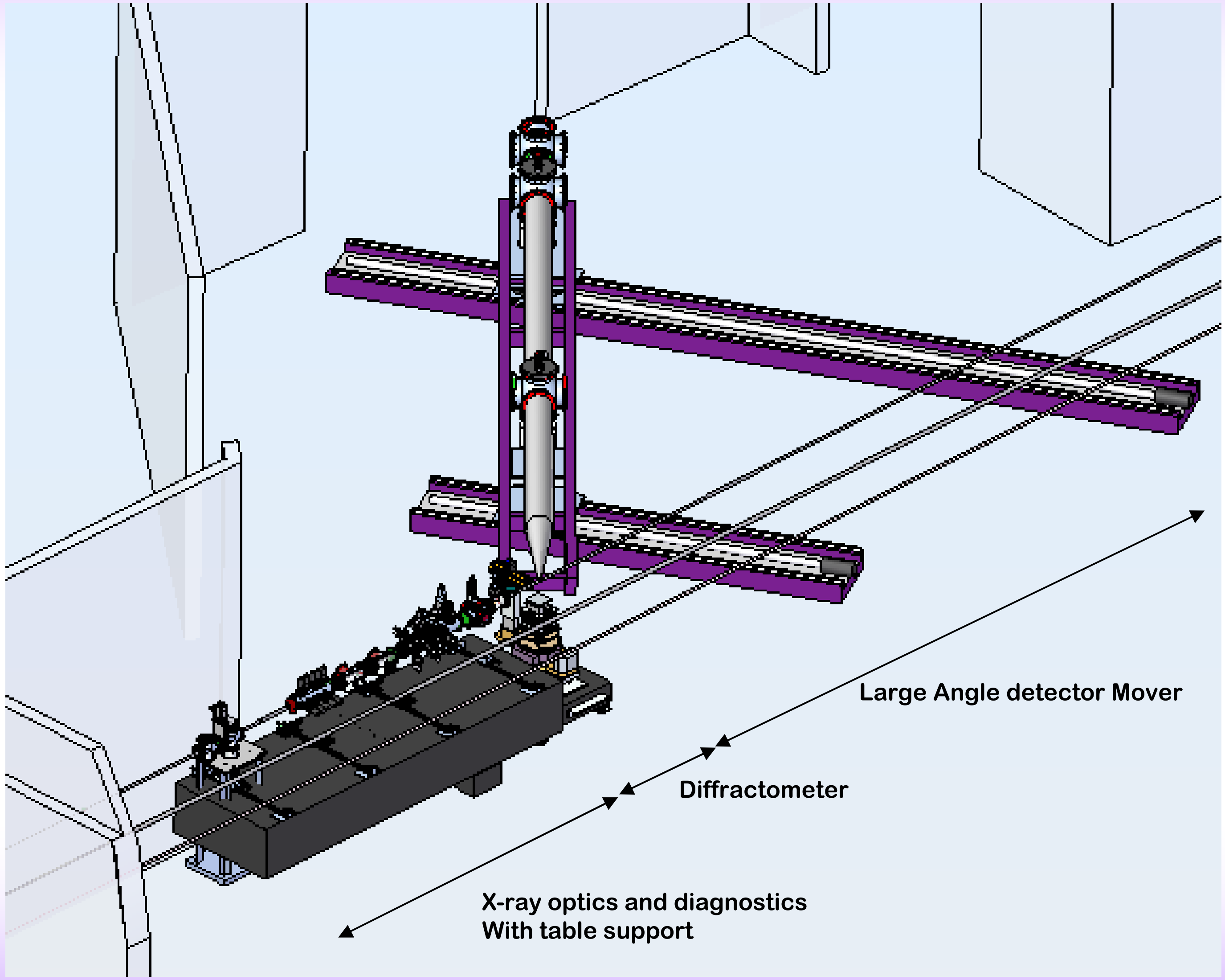
XCS Instrument Design





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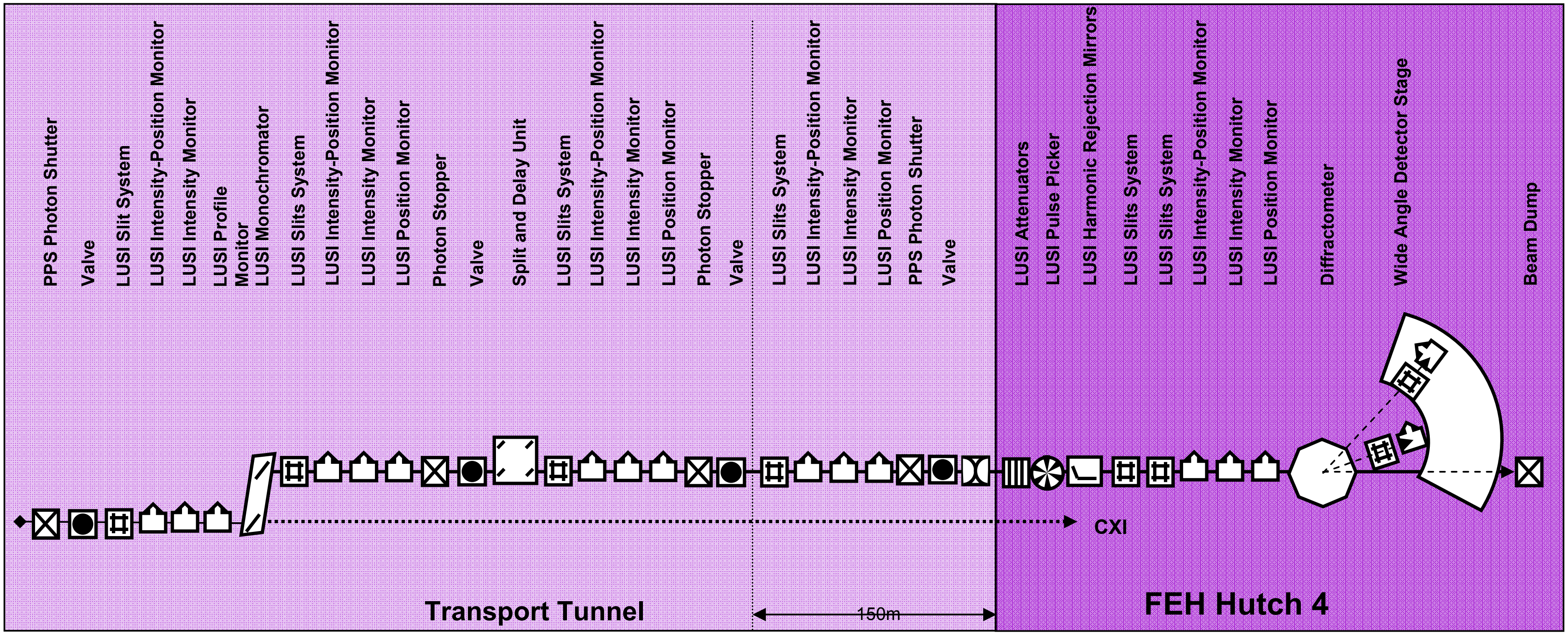
XCS X-ray Instrumentation Diagram



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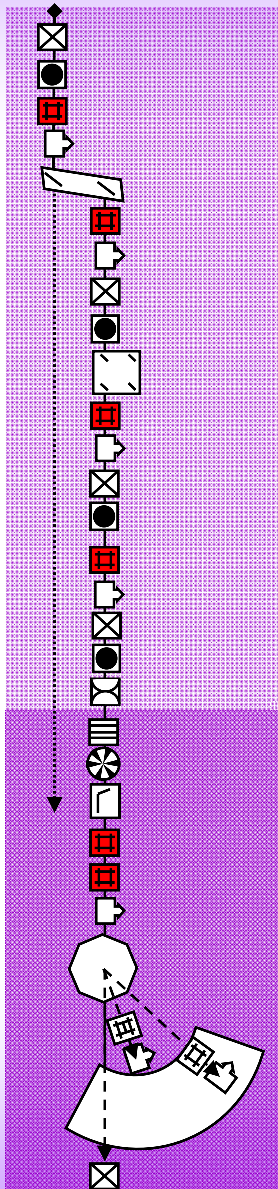
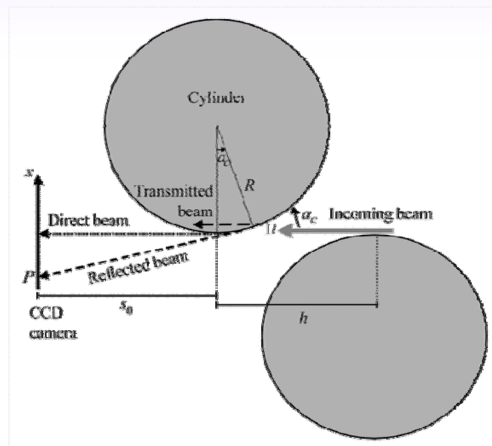
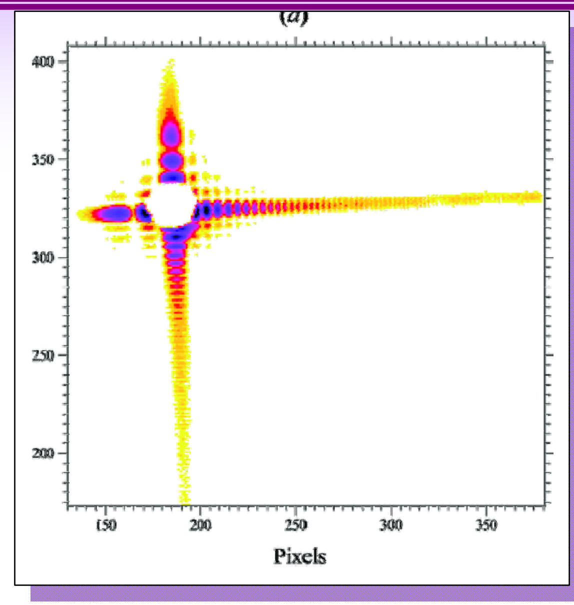
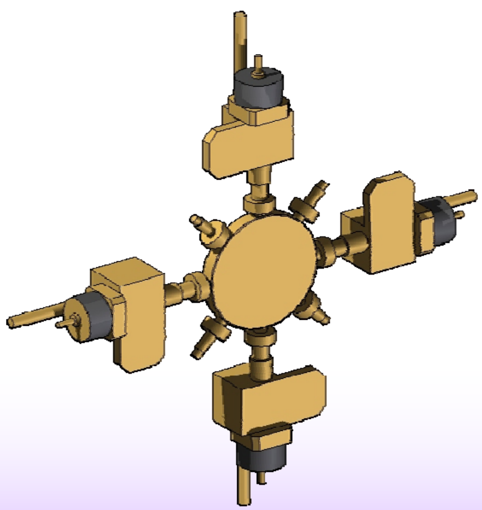
LUSI Slit System







D. Le Bolloc'h et al., *J. Synchrotron Rad.*, **9**, 258-265 (2002).



- **Slit systems requirements**
  - **Primary and mono types**
  - **Precision (0.5 μm) & coarse (5 μm)**
  - **0 – 10 mm gap setting**
  - **10^{-9} in transmission from 2-8.3keV**
  - **10^{-8} in transmission at 25 keV**
  - **Control parasitic scattering from blades**

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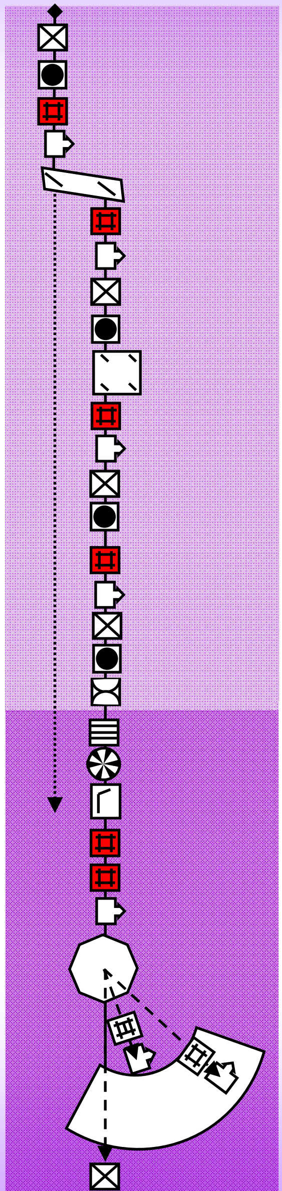
LUSI Slit System



- [PS] Primary Slits Clean up beam halo
  - Define beam for alignment of 1st Xtal
  - Mitigate spatial fluctuations of the beam
- [SS0] Secondary Slits
  - Define beam for Split and Delay
  - Mitigate spatial fluctuations of the beam
- [SS1] Secondary Slits
  - Clean beam halo and define beam for transport
  - Mitigate spatial fluctuations of the beam
- [SS2] Secondary Slits
  - Clean beam halo and define beam (for XFL)
  - Mitigate spatial fluctuations of the beam
- [DS] Defining Slits
  - Define incident beam size
  - Mitigate spatial beam fluctuations
- [GS] Guard Slits
  - Clean beam halo and diffraction from DS

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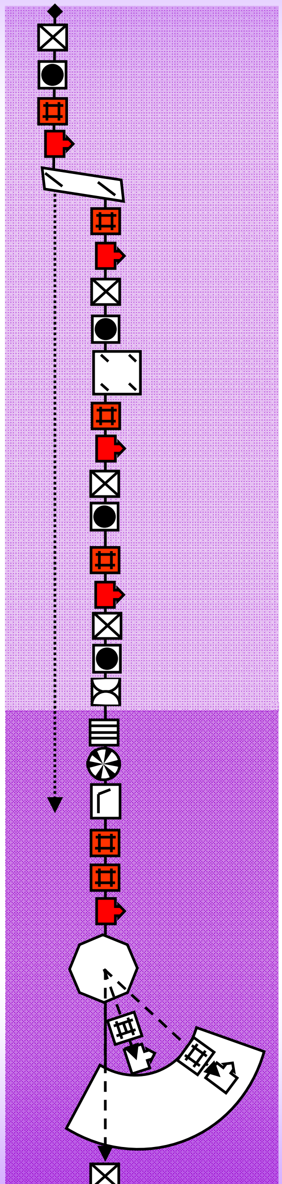
LUSI Diagnostics Suites



PS	: IPM1, PPM1, PIM1
SS0	: IPM2, PPM2, PIM2
SS1	: IPM3, PPM3, PIM3
SS2	: IPM4, PPM4, PIM4
DF, GS	: IPM5, PPM5, PIM5

Each section is equipped with the same diagnostics suite :

- Pairs of Slits
- Intensity Position Monitor [IPM]
- Pop-in Position Monitor [PPM]
- Pop-in Intensity Monitor [PIM]

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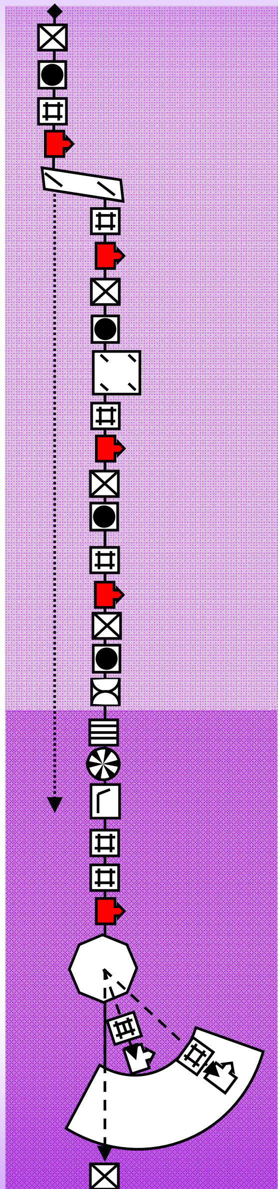
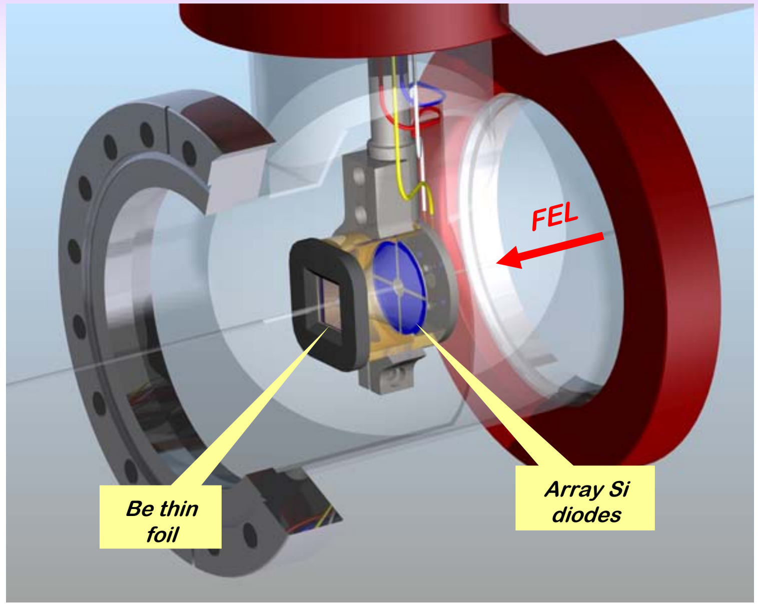
LUSI Intensity-Position Monitor





- Requirements
  - Characterization of the spatial/angular jitter (25%)
  - Preserve transverse coherence
  - In-situ, retractable if necessary
  - Highly transmissive (< 5% loss);
  - Relative accuracy < 0.1%;
  - Dynamic range 1000;
  - Per-pulse op. at 120 Hz;

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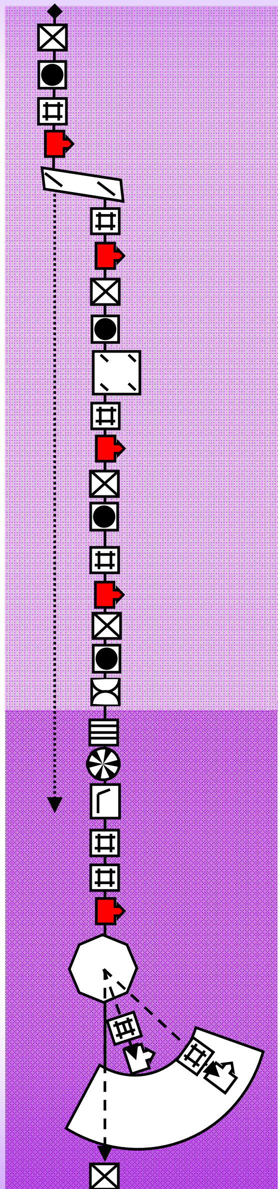
LUSI Intensity-Position Monitor



- **IPM1 Purpose**
  - Characterize incident LCLS intensity (1st diagnostic after XPP)
  - Locate initial beam position in the XRT
  - Normalization for alignment monochromator crystal1
- **IPM2 Purpose**
  - Provide normalization signal for alignment of monochromator
  - Normalization for characterizing Split and Delay, [SS0]
- **IPM3 Purpose**
  - Provide normalization signal for alignment of Split and Delay
  - Normalization for characterizing X-ray Transport[SS1]
- **IPM4 Purpose**
  - Provide normalization signal for X-ray Transport
  - Normalization for characterizing downstream optics (focusing lenses, attenuators, harmonic rejection mirrors, SS2)
- **IPM5 Purpose**
  - Experimental normalization signal

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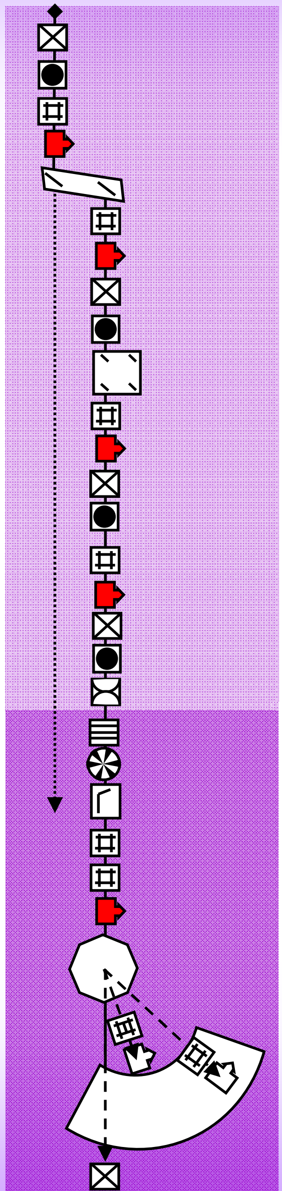
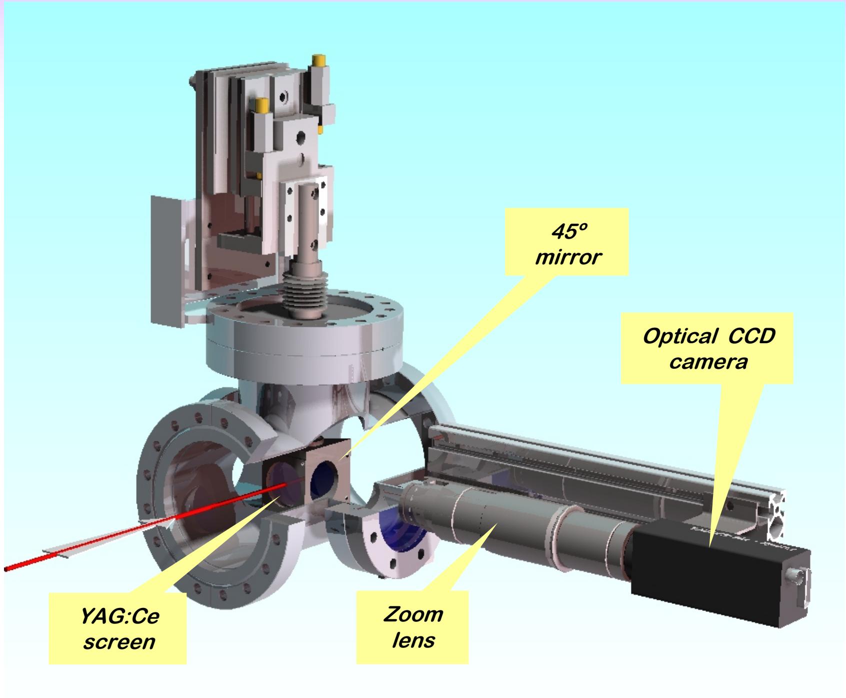
LUSI Pop-in Profile Monitor





- **Requirements**
  - Destructive; Retractable
  - Variable FOV and resolution
    - At 100 μm resolution, 24x24 mm^2 field of view;
    - At 8 μm resolution, 2x2 mm^2 field of view;
  - Capable of per-pulse op. @ 120 Hz

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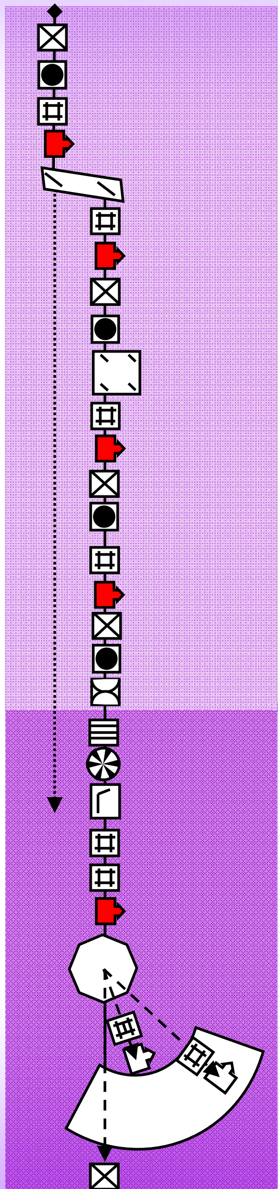
LUSI Pop-in Profile Monitor



- **PPM1 Purpose**
  - Characterize spatial mode of incident beam
- **PPM2 Purpose**
  - Positioning of monochromator crystal 2
  - Steering of monochromator crystal 1
  - Characterize spatial profile of beam after mono
- **PPM3 Purpose**
  - Alignment of IPM2 ,Split and Delay.
  - Characterize spatial profile of beam after Split and Delay
  - Steering of monochromator crystal 2 and Split and Delay
- **PPM4 Purpose**
  - Alignment of IPM3
  - Steering of monochromator crystal 2, Split and Delay
  - Characterize the spatial profile after 150 meter propagation
- **PPM5 Purpose**
  - Alignment of IPM4
  - Steering of focusing lenses, attenuators, harmonic rejection mirror
  - Steering of Guard Slits [GS]
  - Characterize the spatial profile of the incident x-ray

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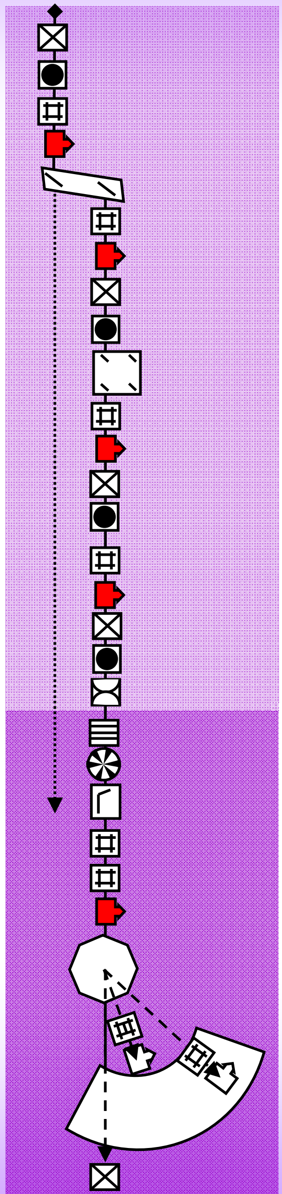
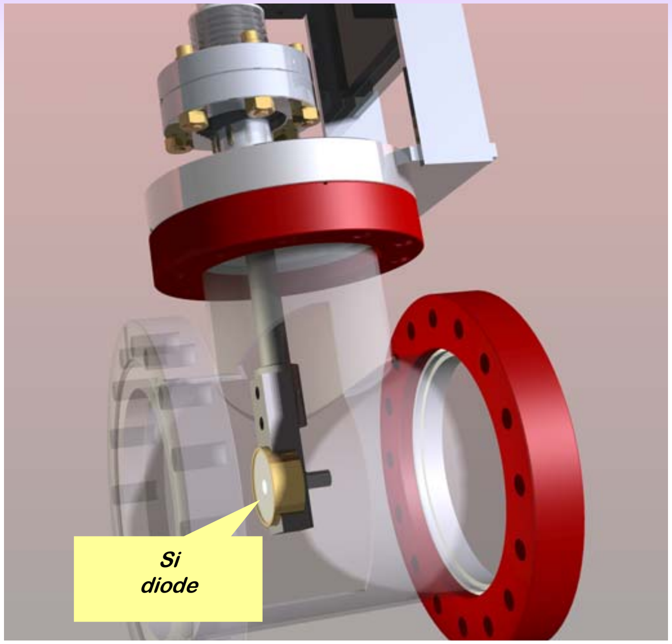
LUSI Pop-in Intensity Monitor





- *Requirements*
  - *Destructive; Retractable;*
  - *Relative accuracy < 1%;*
  - *Dynamic range 100;*
  - *Large working range 20x20 mm^2*
  - *Capable of per-pulse op. @ 120 Hz*

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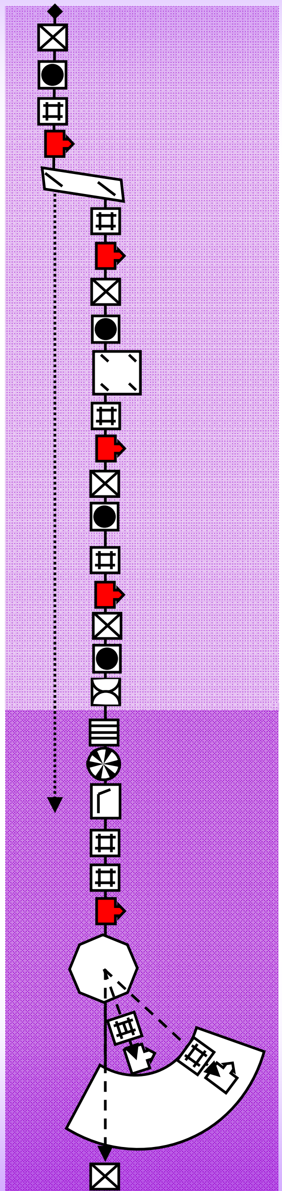
LUSI Pop-in Intensity Monitor



- **PIM1 Purpose**
  - Calibration of PS
  - Calibration of IPM1
- **PIM2 Purpose**
  - Calibration of Monochromator
  - Calibration of SS0, IPM2
- **PIM3 Purpose**
  - Calibration of Split and Delay
  - Calibration of SS1, IPM3
- **PIM4 Purpose**
  - Calibration of upstream optics after transport
  - Calibration of SS2, IPM4
- **PIM5 Purpose**
  - Calibration of upstream optics
  - Calibration of DF, GS, IPM5

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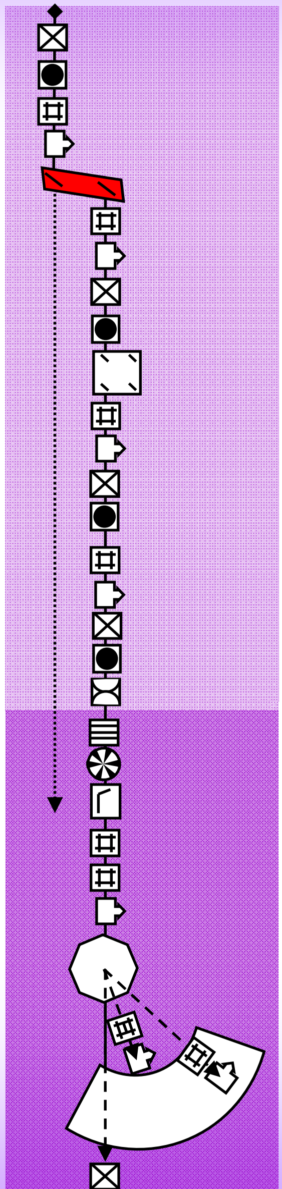
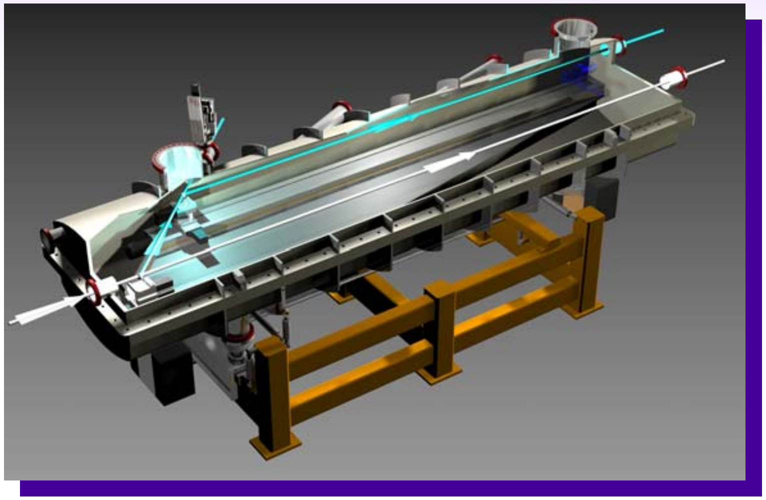
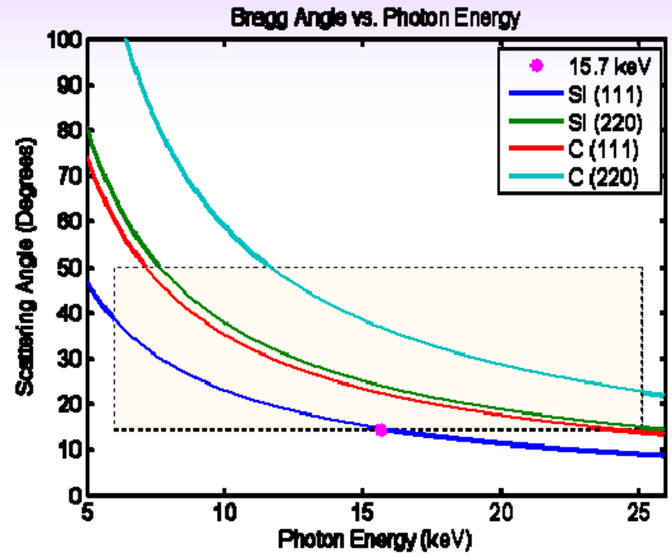
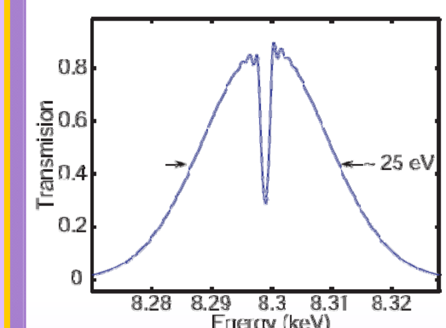
LUSI Offset Monochromator System







- Specifications
  - 6-25keV
  - $10^{-6} < \Delta\lambda/\lambda < 10^{-4}$
  - Large-offset (600mm)
- LUSI Offset Monochromator Purpose
  - Narrow X-ray spectrum
    - Mitigates spectral fluctuations of the LCLS
    - Increase/Control long. coherence length



LUSI LCLS Ultrafast Science Instruments

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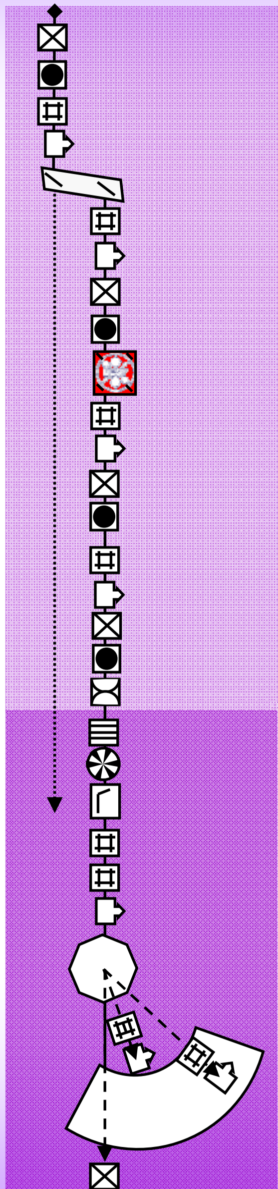
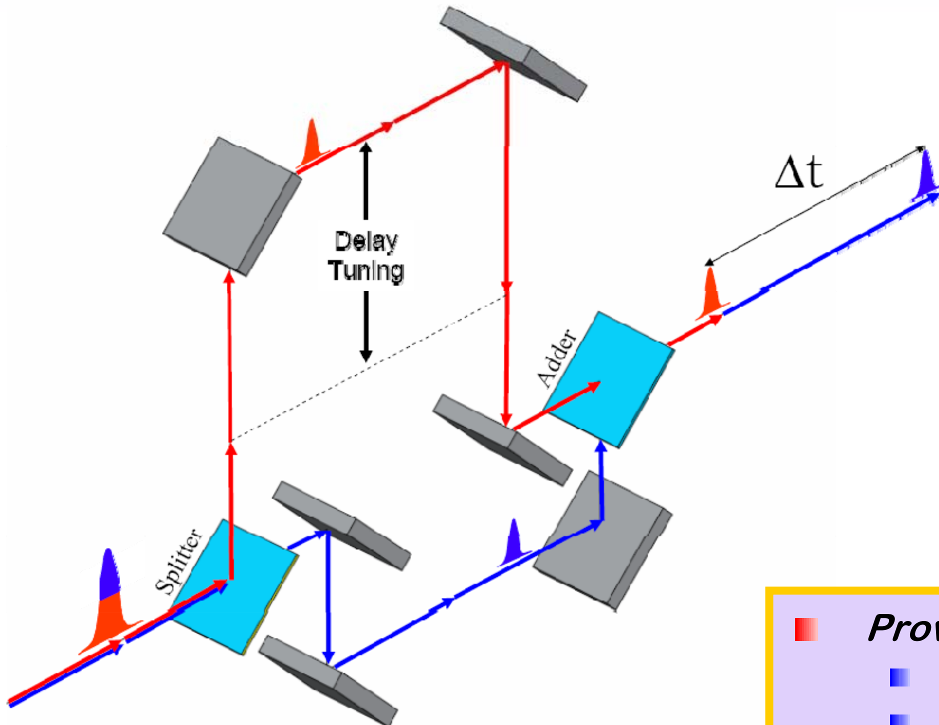


Split and Delay unit in kind contribution DESY, via SLAC/DESY MoU



G. Grübel
W. Roseker

- *Provided by DESY/SLAC MoU*
  - *Prototype existing*
  - *1st Commissioning May 07 (ESRF, Troika beamline)*
  - *pulse duration < delay < 3 ns*
  - *based on* Si (511)
  - *E=8.389 keV*
  - *Last commissioning May 08*

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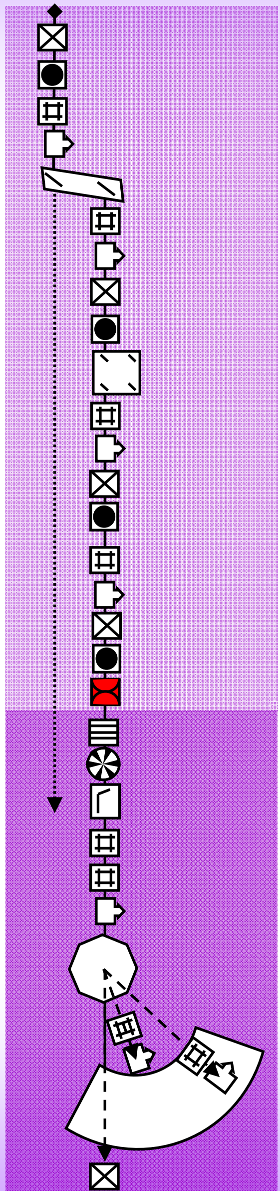
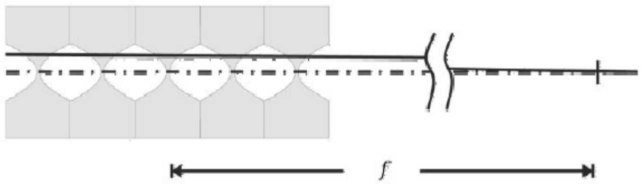
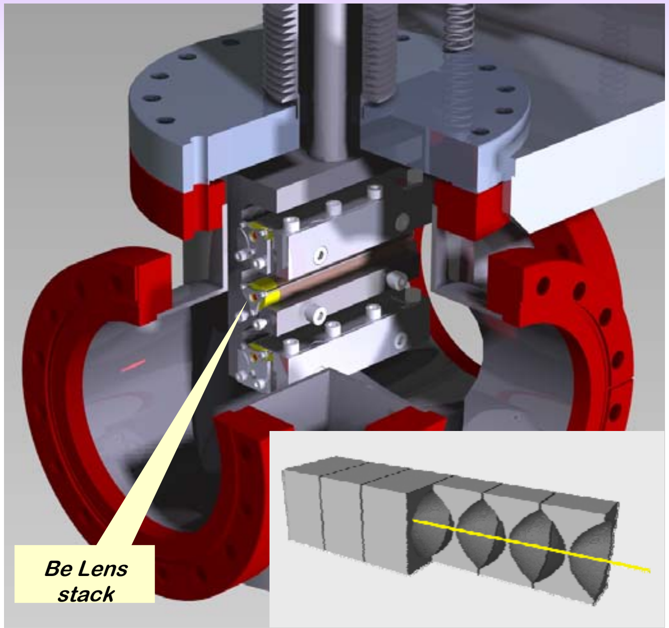
LUSI X-ray Focusing Lens System





B. Lengeler et al., *J. Synchrotron Rad.*, 6, 1153 (1999).



- **LUSI X-ray Focusing Lens Purpose**
  - **Reduce the spot size at the sample while maximizing flux**
- **LUSI X-ray Focusing Lens Requirements**
  - **Produce a smaller spot size between 1-50μm**
  - **Preserve coherence**
  - **Withstand full flux**

LUSI LCLS Ultrafast Science Instruments

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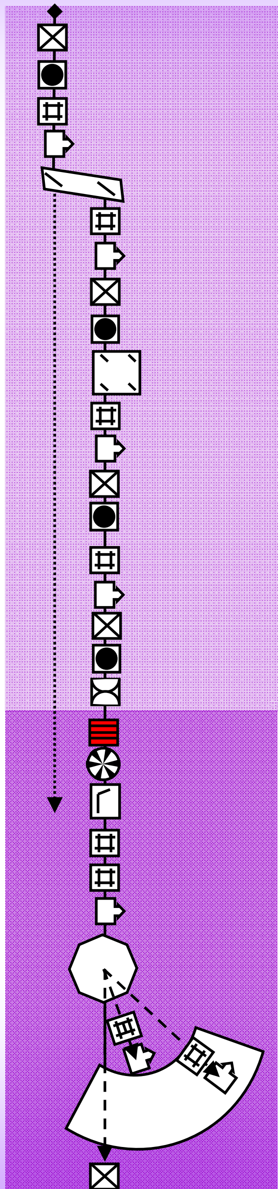
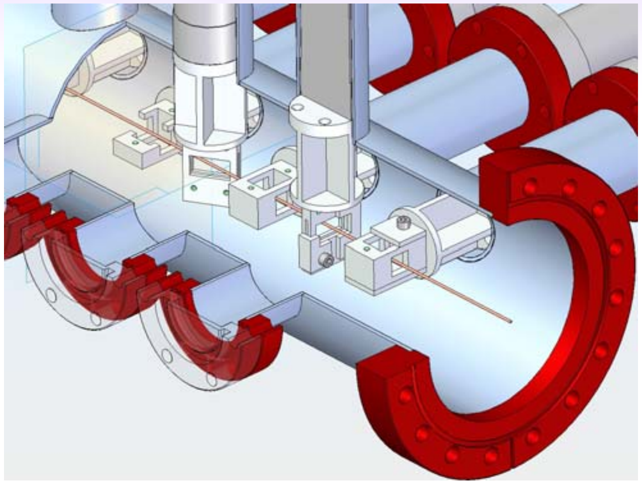
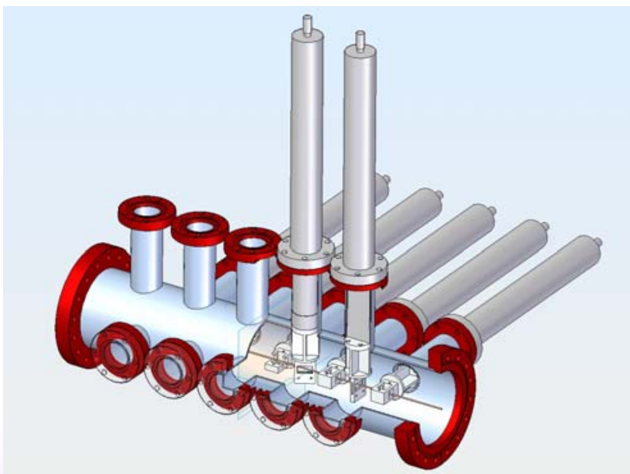
LUSI Attenuator System







- **LUSI Attenuator Purpose**
  - **Reduce incident X-ray flux**
    - **Sample damage**
    - **Detector saturation**
    - **Diagnostic saturation**
    - **Alignment of optics and diagnostics**
- **LUSI Attenuator Requirements**
  - **Preserve coherence**
  - **Withstand unfocused flux**
  - **10^8 attenuation at 8.3 keV**
  - **10^4 attenuation at 24.9 keV**
  - **3 steps per decade**

LUSI LCLS Ultrafast Science Instruments

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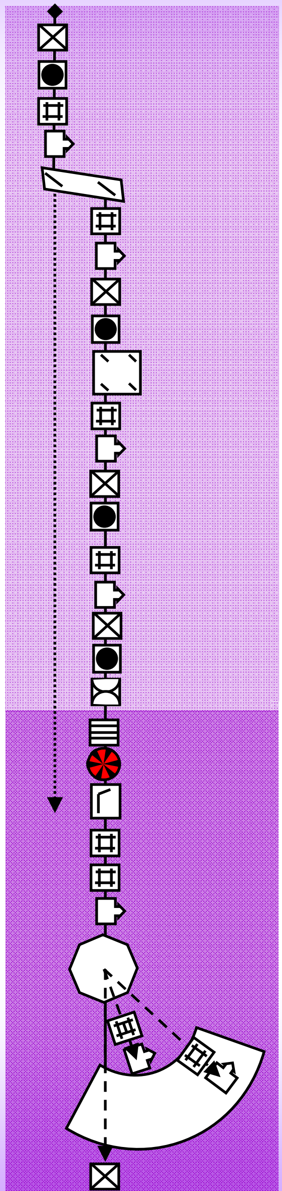
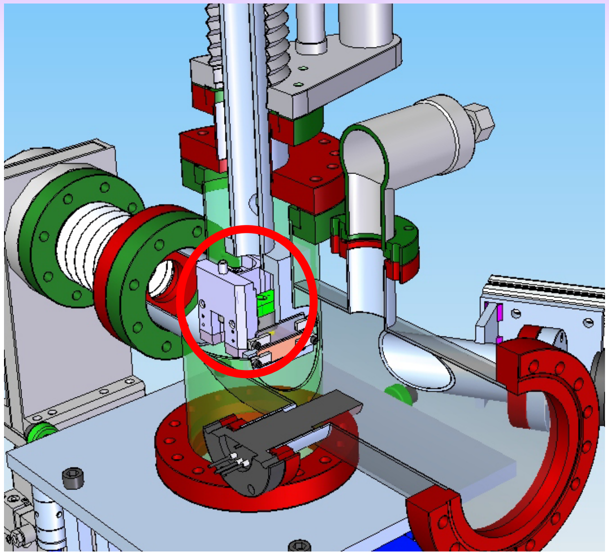
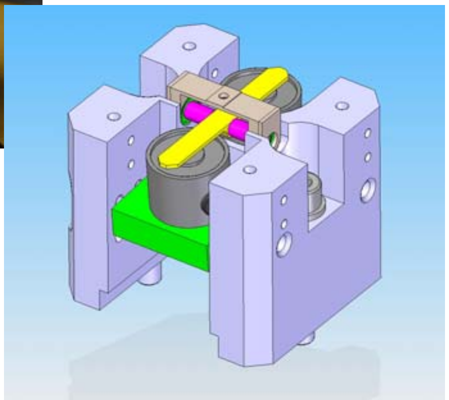
LUSI Pulse Picker





http://www.azsol.ch/



- ***Pulse Picker Purpose***
  - ***Reduce LCLS repetition rate or pick pulse pattern***
    - *Important if longer sample recover time is needed*
    - *Damage experiments - sample needs to be translated*
- ***Pulse Picker Requirements***
  - *< 3 ms switching time*
  - *< 8 ms in close/open cycle time*
  - *<= 10 Hz operation*
  - *Withstand full LCLS flux - unfocused*
  - *Requires 1 mm B4C to protect the steel blade*

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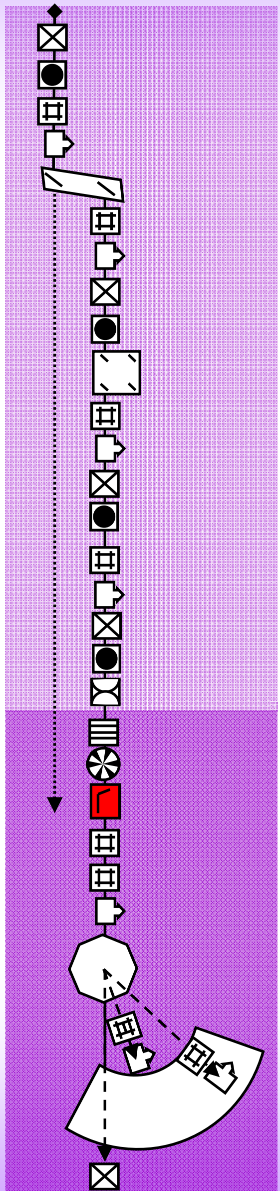
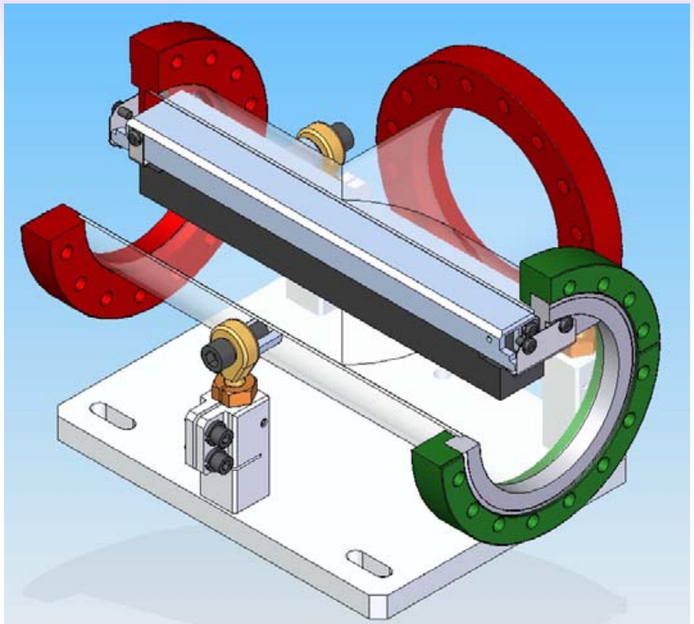
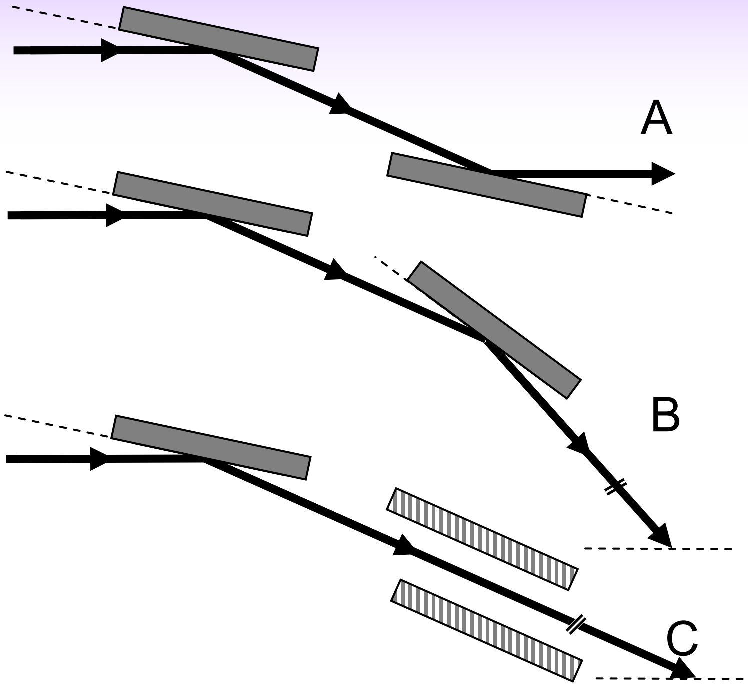
LUSI Harmonic Rejection Mirror System







- **LUSI Harmonic Rejection Mirror Purpose**
  - Isolate fundamental radiation from 3rd harmonic
  - Tilt incident beam downward (GI experiments)
- **LUSI Harmonic Rejection Mirror Requirements**
  - Energy range - 6-8.265 keV
  - 10^4 contrast ratio between fundamental and the 3rd harmonic
  - 80% overall throughput for the fundamental
  - Coherence preservation of the mirrors

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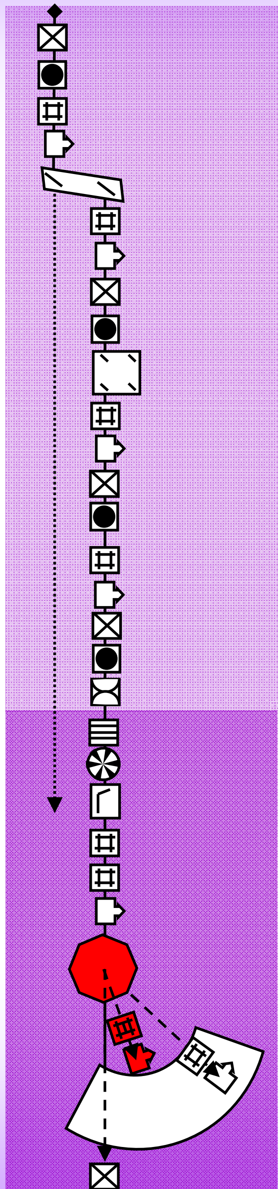
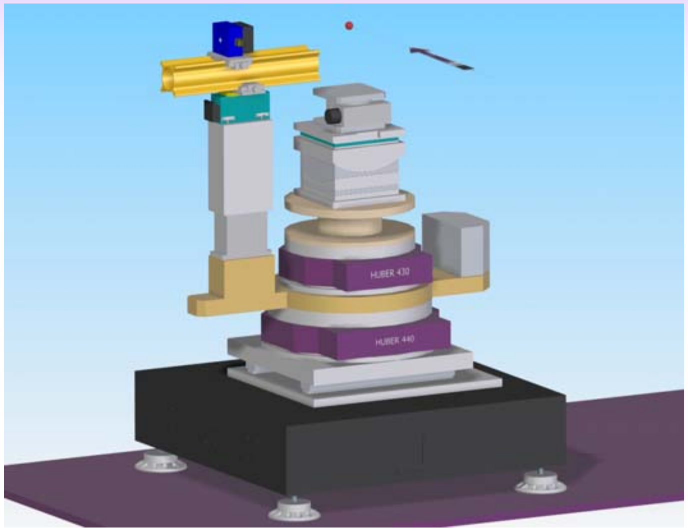
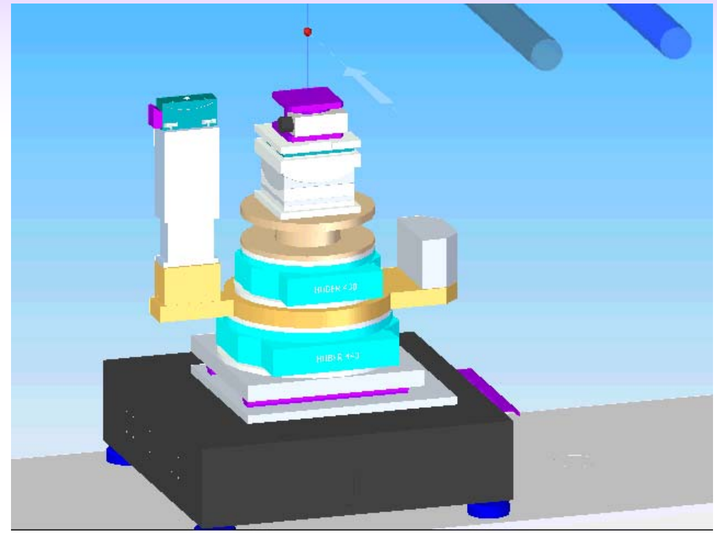
XCS Diffractometer







- **XCS Diffractometer Purpose**
  - Orient and position samples
  - Position local detector for sample alignment

- **XCS Diffractometer Requirements**
  - Horizontal scattering 4-circle diffractometer
  - No interference with CXI beamline (600mm)
  - No interference with Large Angle Detector Stage
  - Identical platform-to-COR distance as XPP diffractometer
  - Removable from beam path to accommodate large sample env.
  - Accommodate large sample environments (up to 50 kg)

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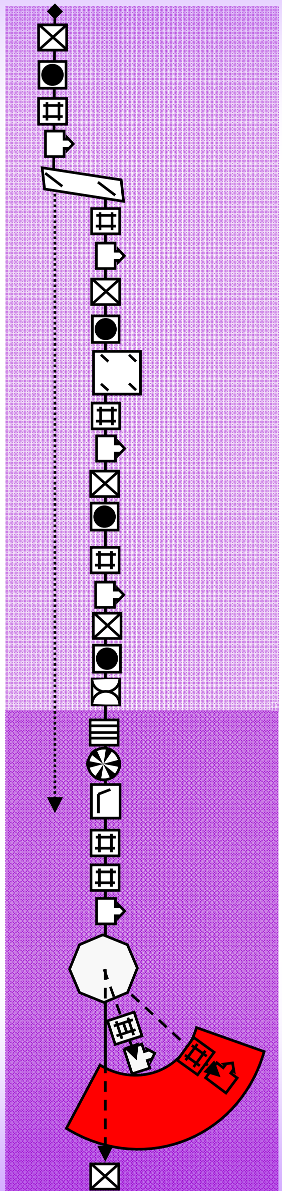
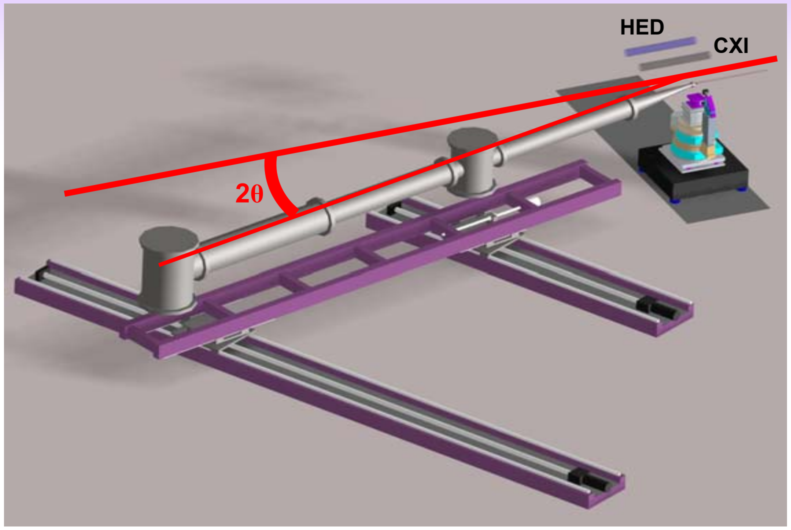
XCS Large Angle Detector Mover





- **XCS Large Angle Detector Mover Purpose**
  - position XCS detector in the region of interest

- **XCS Large Angle Detector Mover Requirements**
  - Horizontal scattering 4-circle diffractometer
  - No interference with CXI beamline (600mm)
  - Sample/detector distance > 7-8m
  - Decoupled from diffractometer
  - SAXS, WAXS, GI
  - 2θ up to 55°
  - -0.5< GI-angle < 2

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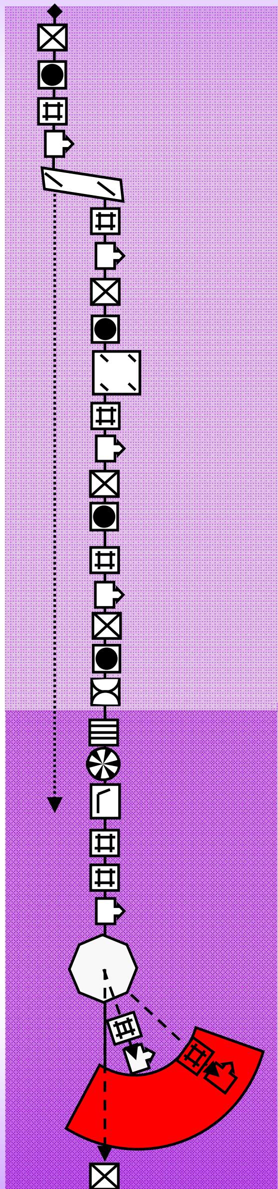
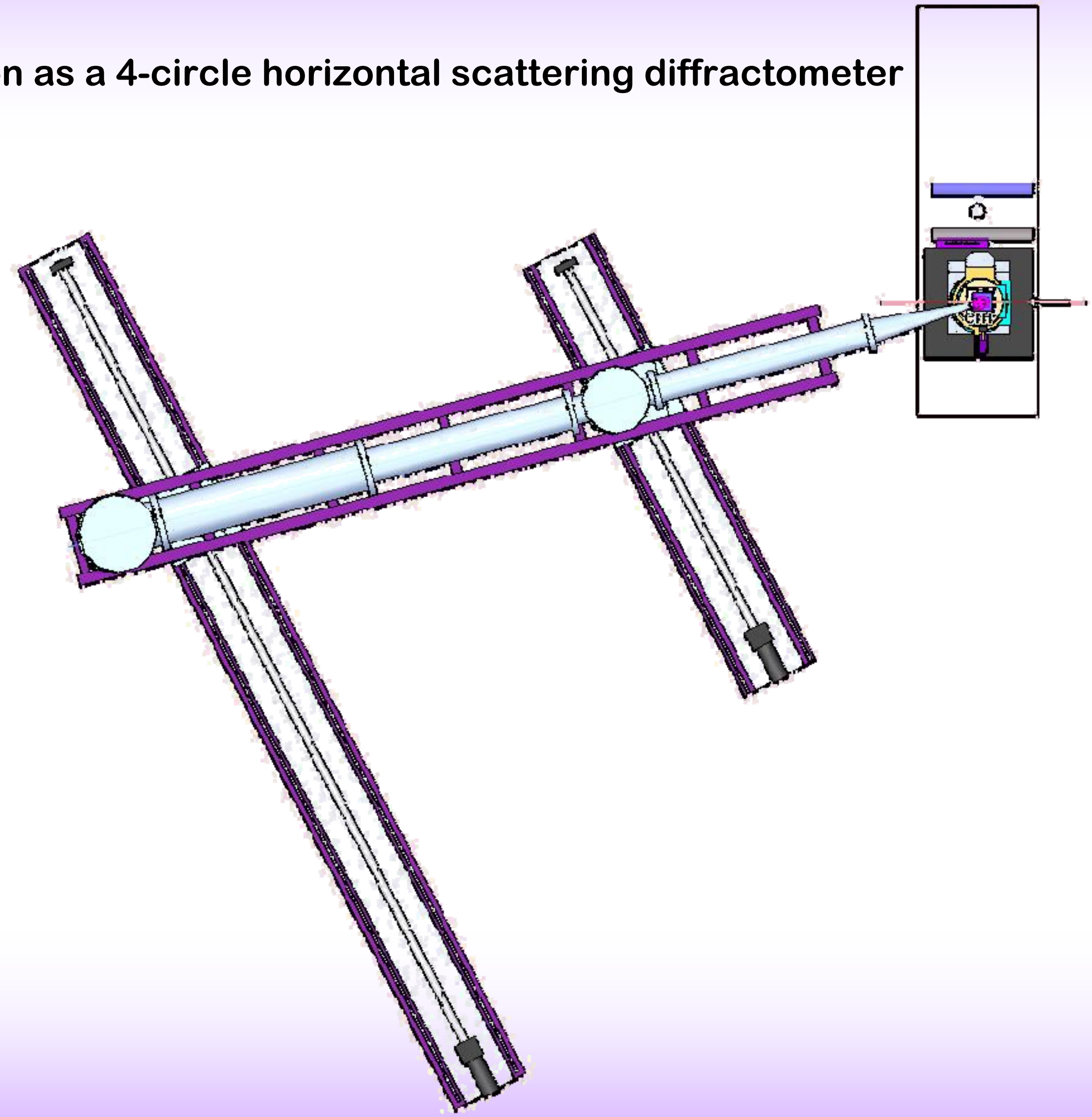
XCS Large Angle Detector Mover



Integration as a 4-circle horizontal scattering diffractometer



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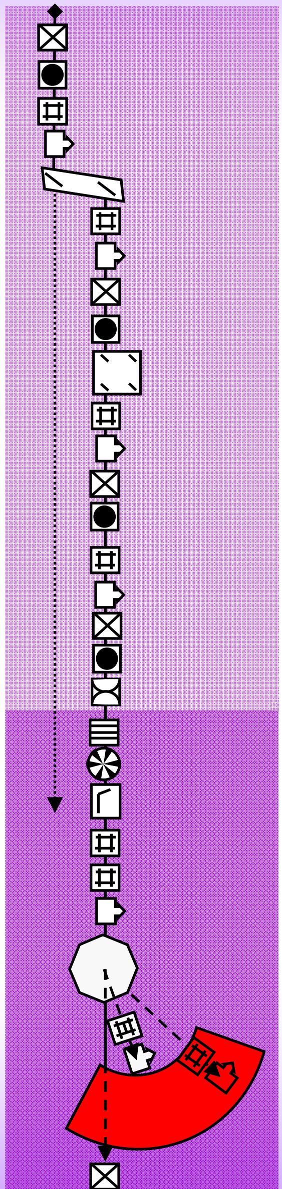
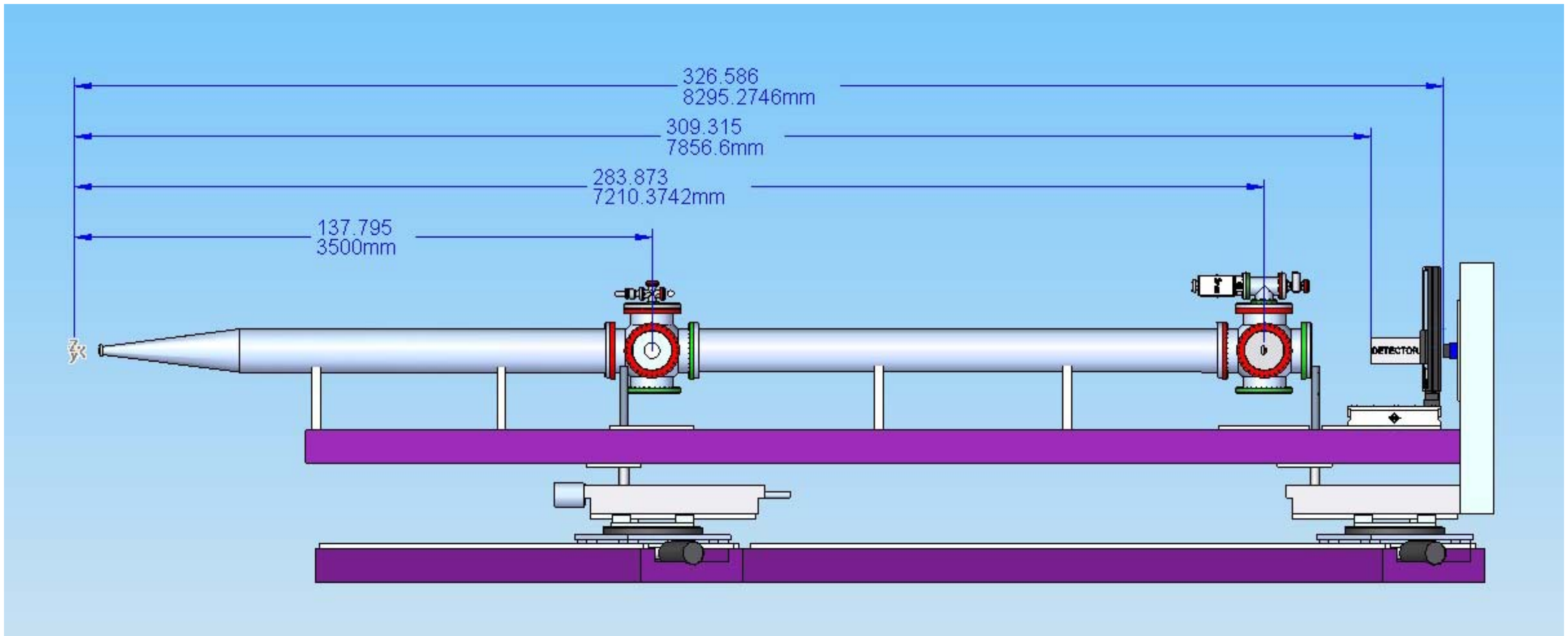
XCS Large Angle Detector Mover





Large Sample-Detector Distance

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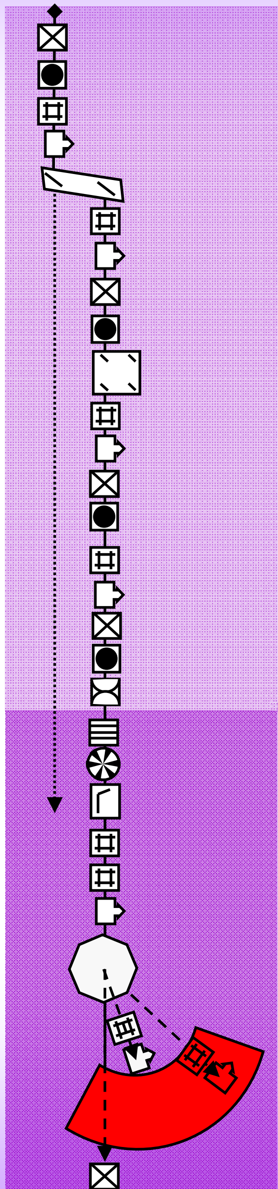
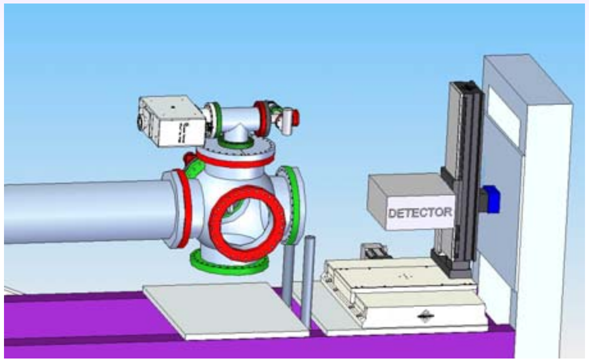
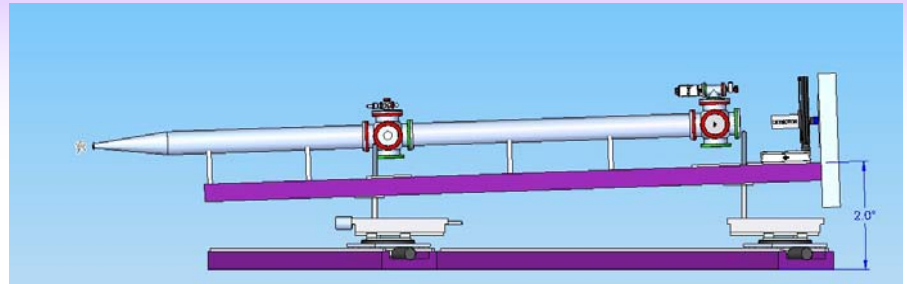
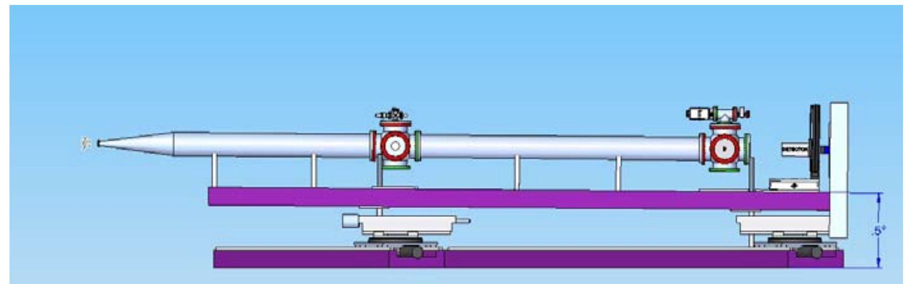
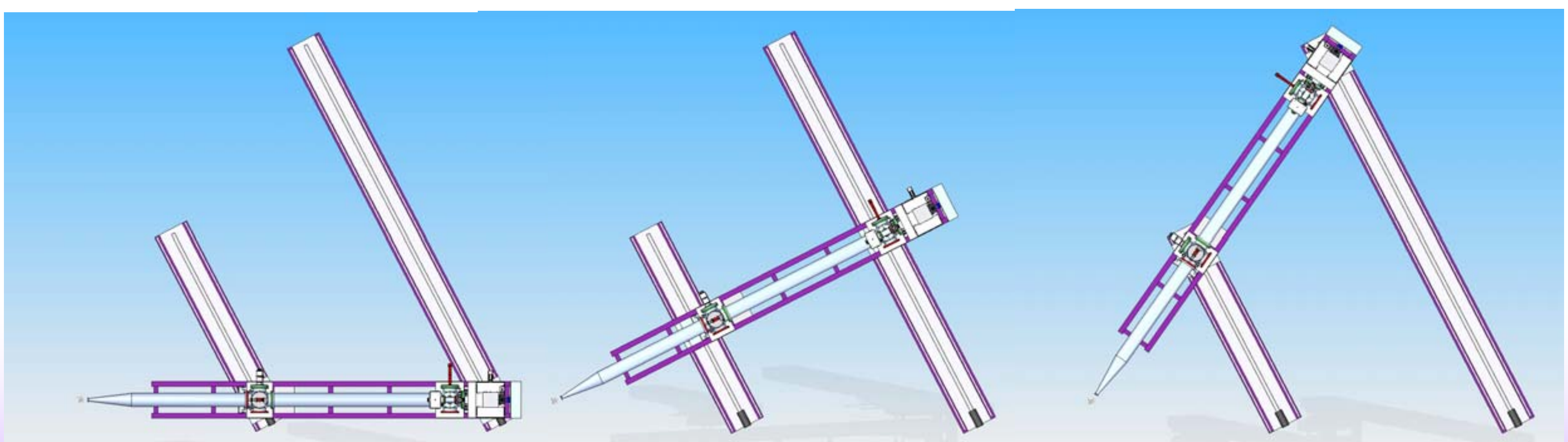
XCS Large Angle Detector Mover











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Global X-ray Beamline Requirements

- Layout Requirements
  - Large offset to reduce setup time of experiments
  - Components placed in the order displayed in block diagram
  - Maximize sample detector distance by placing diffractometer as close to the alcove corner as possible while allowing convenient access
- Mechanical Requirements
  - Stability of X-ray components
    - 5-10 microns for PIM, Slits, Lenses, Mirrors, sample position
    - Monochromator will have special needs
    - 25 microns for everything else for long-terms drifts
- Vacuum Requirements
  - Pressure at the location of any component that intercepts the beam shall be less that 10^{-6}
  - 10 year ion pump lifetime
  - Vacuum better than 10^{-4-5} for the flight path on large detector mover.
- Access Requirement
  - Instrument design shall permit access in FEH Hutch 4 while beam delivered into the CXI/HED.

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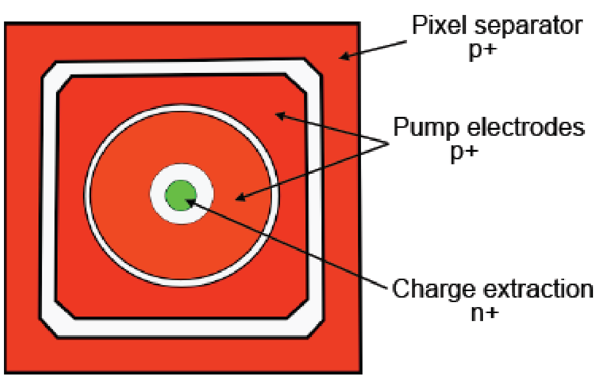
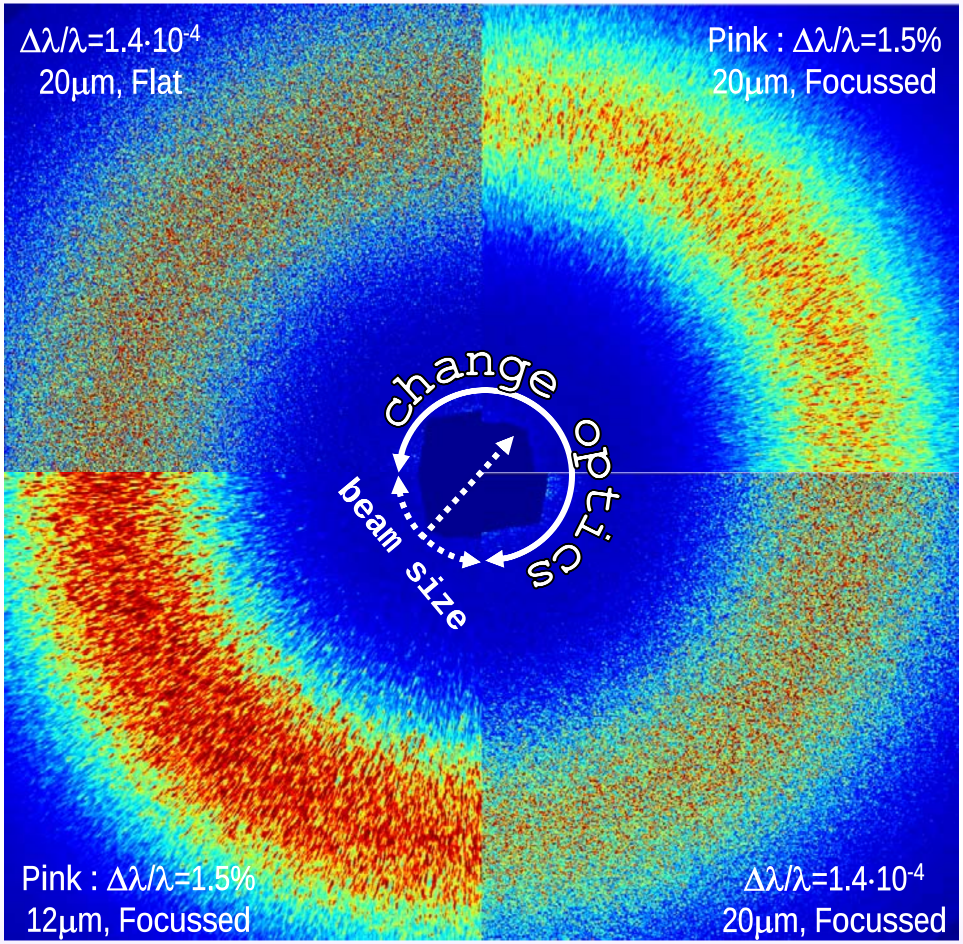
2D Detectors

- *2D detector (BNL)*
  - *Developed at BNL (MoU)*
  - *1024 x 1024 pixels*
  - *35 x 35 μm^2 pixel size*
  - *High DQE*
  - *10^2 dynamic range*
  - *Noise << 1 photon*
  - *120 Hz Readout Rate*





BROOKHAVEN NATIONAL LABORATORY

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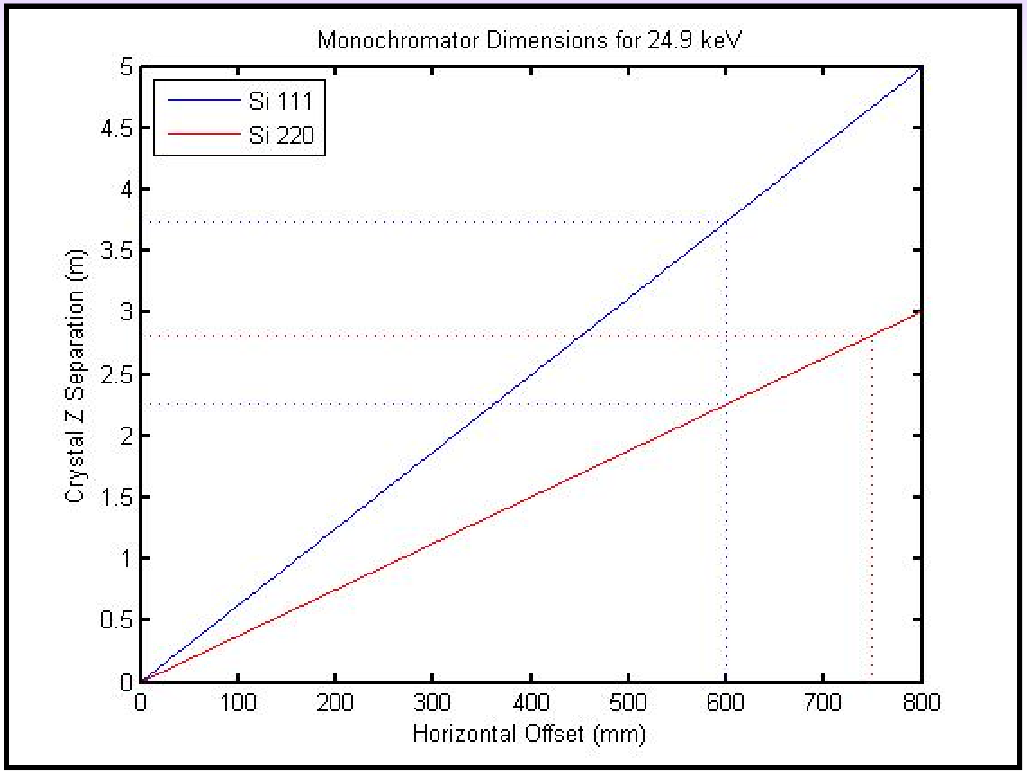
Monochromator Design Choices



- **Trade off between:**
  - **Offset distance**
  - **Low angle that can be reached (3rd harmonic flux)**
  - **Monochromator length (space for other optics)**
- **Decision was made to only reach Si 111 at 24.9 keV and to offset by 600mm**

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Spring-8/ESRF/APS Existing Designs

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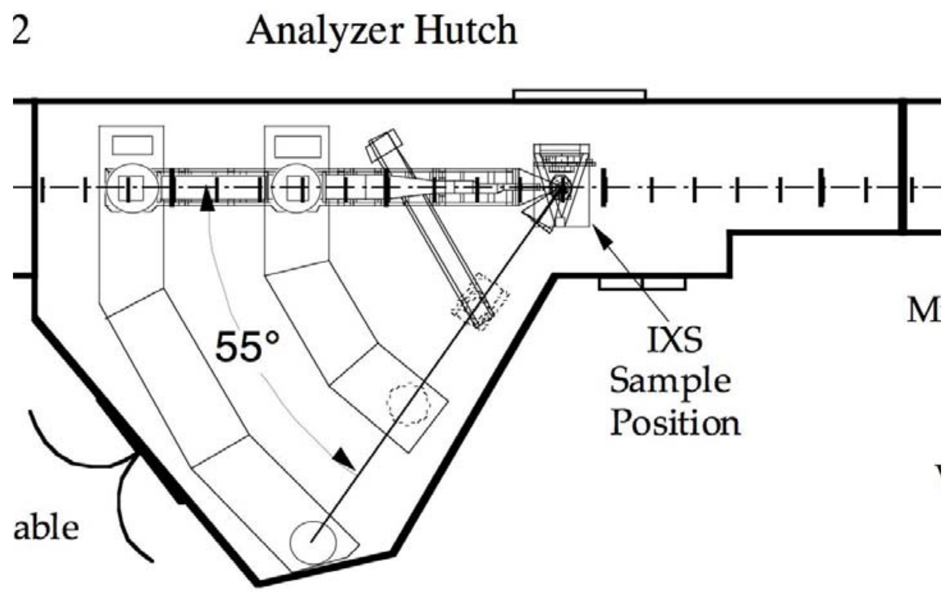
Large Angle Detector Mover Design Choices

A.Q.R. Baron, Y. Tanaka, S. Goto, K. Takeshita, T. Matsushita and T.Ishikawa, The Journal of Physics and Chemistry of Solids **61**, (2000) 461-465.



- 2θ=55°
- 10m long
- Fixed Point of rotation
- Real rotation
- Airpad motion with granite support

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Large Angle Detector Mover Design Choices

ESRF

ID28, IXS

- 2θ≈50°
- 7-12m long
- Point of rotation
- Lateral motion of the point of rotation with diffractometer
- Real rotation
- Translation stages

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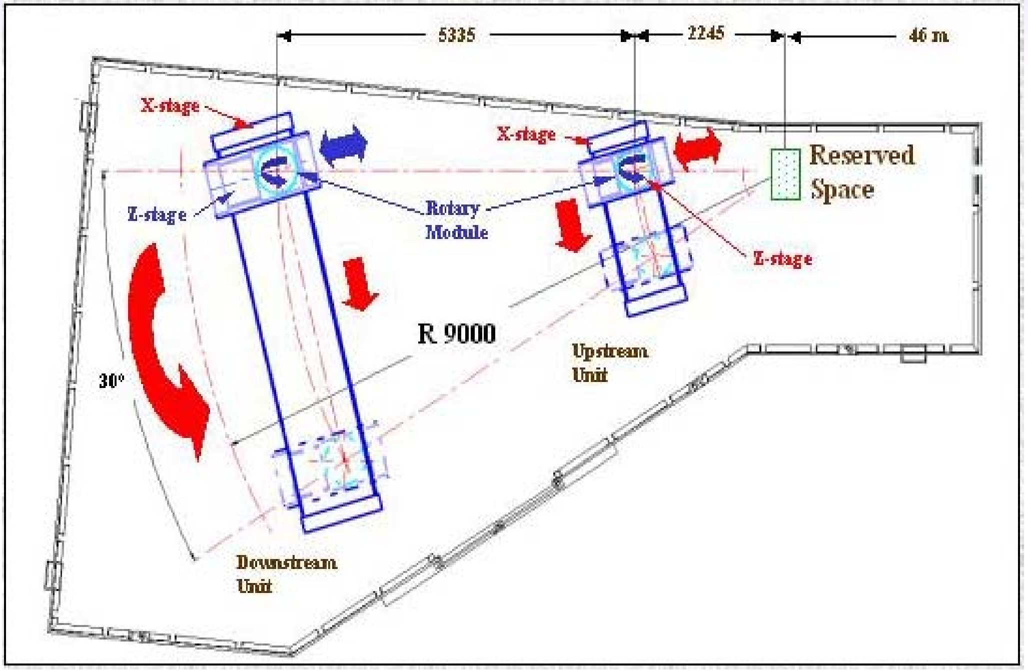
Large Angle Detector Mover Design Choices



- 2θ≈30°
- 9m long
- NO Point of rotation
- Lateral motion of the point of rotation
- Translation stages
- Software control of COR centering

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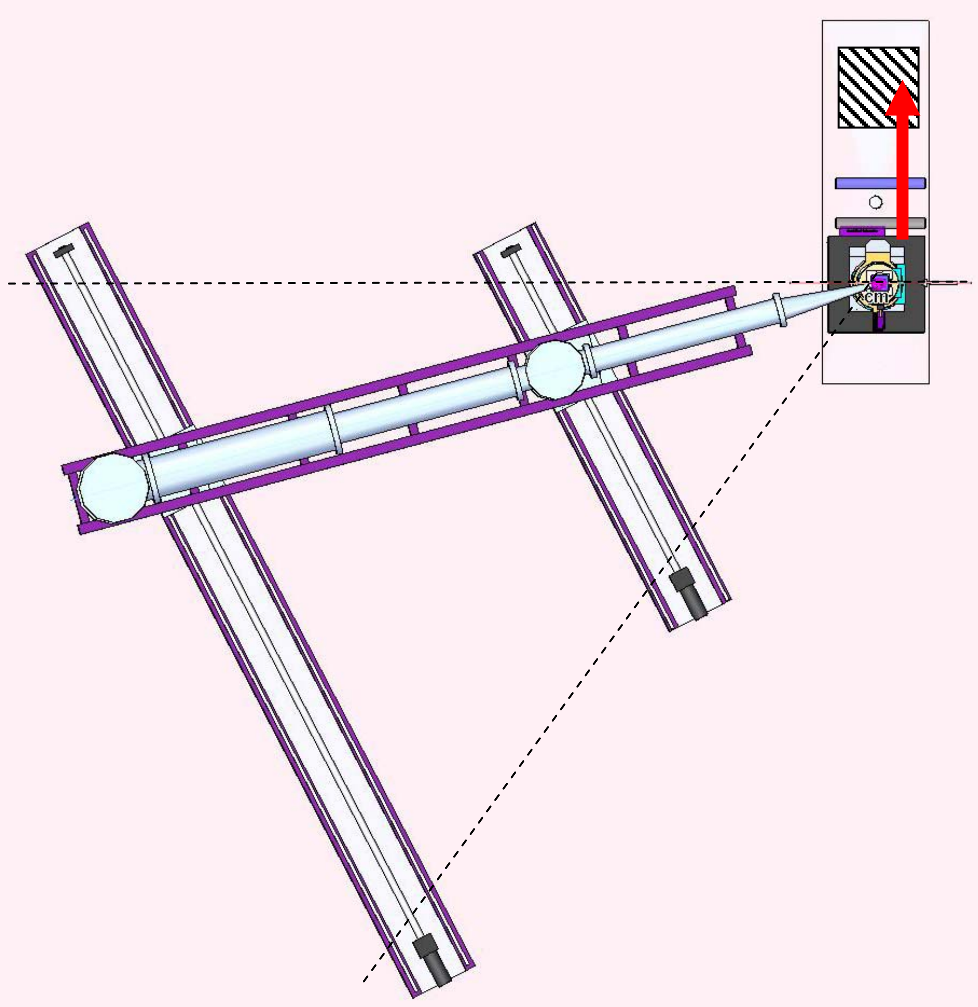
Large Angle Detector Mover Design Choices



- APS-HERIX-Design based
- 2θ up to 55º
- Up to ≈ 8m long
- NO "real" Point of rotation
- Lateral motion of the pseudo point of rotation by software
- Translation stages
- No contact with the diffractometer
- SAXS, WAXS , Refl., GID, GISAXS

<u>Flexible</u> instrument with capability of accommodating any sample environment

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Technical Issues

1. Flexible Diffractometer/LADM Design
   - 4 circle horizontal scattering
   - Diffractometer out of the way if required
   - No interference with other equipment
   - Adjustment of the CoR of the assembly

2. Monochromator Precision Motion
   - 200 nRad motion & stability
   - Long translation of 2nd Xtal
   - Or ½ long translation of each Xtal

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Major System Interfaces

- Controls Group – Actively working with LUSI controls group
  - Responsible G. Haller
  - Working on PRD's for XCS controls
  - XCS has provided controls with a detailed list of planned hardware
  - Weekly Controls meeting with the LUSI group
    - Discuss hardware, standardization, data acquisition, machine protection system, instrumentation, etc.

- BNL Detector
  - Responsible LUSI Physicist – Niels Van Bakel
  - MoU in place
  - PRD is being drafted

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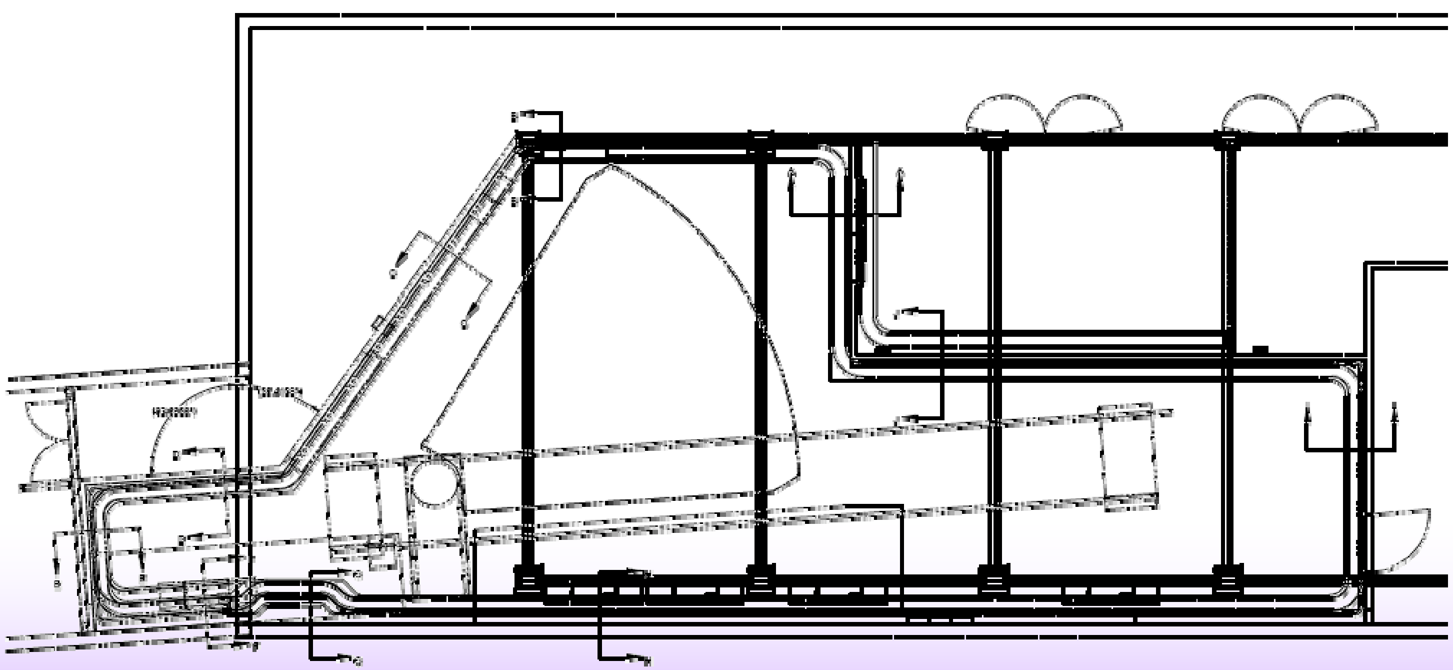
Major System Interfaces (2)

- Conventional Facilities (Hutches and utilities). A. Robert
  - Conventional facilities work is coordinated with XCS team
  - Most design requests from the XCS team are implemented.
  - Remaining responsibilities have been defined
  - Designing overhead crane
  - Responsible engineer – A. Busse



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Major System Interfaces (3)

- LCLS -LUSI Integration
  - Weekly meetings to discuss LUSI and LCLS integration issues
  - Meeting led by Jerry Hastings and John Arthur
  - Attendees – LUSI & LCLS Management, Physicists and System Engineers

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Safety Issues and Interfaces

- **ES&H**
  - General environmental, health and safety issues
  - Safety Overview Committee Review completed December 2006 and identified the following committee reviews:
    - Earthquake Reviews
    - Radiation Safety Reviews
    - Laser Safety Reviews
    - Electrical Safety Reviews
    - Hoisting and Rigging Safety Committee
    - Fire Marshall
    - Hazardous Experimental Equipment Committee

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Safety Issues and Interfaces (2)

- Earthquake Committee
  - Open dialog with the head of the earthquake (S. Debarger) committee to identify components requiring review
  - General standard is all devices weighing over 400 lbs requires a peer review followed by an approval by the Earthquake Committee
  - Responsible Engineer – E. Bong, XCS Lead Engineer

- Radiation Physics
  - All LUSI radiation physics issues are being coordinated by Hal Tomkins. It is the responsibility of the System Manager to monitor the approval process and to provide information as needed
  - Approval required for Personal Protection System (PPS) scenarios and shielding for PPS
  - Radiation Physics Committee led by Sayed Rokni
    - Experimental Systems Radiation Physicist is J. Vollaire

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Safety Issues and Interfaces (3)

- Electrical Safety
  - Current < 5 ma AC /DC or < 10A, < 50V does not require special approval
  - NRTL approved equipment required or SLAC in house program required for approval on non-listed equipment
  - Electrical Safety Committee led by Fred Jones (acting)
  - Responsibility– G. Haller & E.Bong, System Managers

- Hazardous Experimental Equipment Committee (K. Jobe – Chair)
  - Pressure/Cryogenic/Vacuum Systems
    - All vacuum equipment shall be compliant with new DOE Worker Safety and Health Program 10CFR851
    - This will require the use of burst disk and documented procedural practice for using pressure relief valves
    - Engineering analysis, review and committee approval to show that equipment is safe beyond the pressure vessel code
    - Responsibility – E. Bong

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Safety Issues and Interfaces (4)

- Hazardous substances – discussions on approved practices standards with K. Jobe
  - Waste disposal (User samples)
  - Cryogenics
  - Biohazards
  - Compressed gas cylinders
  - Lead
  - Responsibility – A. Robert & E. Bong

- Fabrication, Installation, Hoisting & Rigging
  - Plan the work – develop, review and approve work plans
  - Write up and obtain approvals for standard and special rigging operations.
  - Responsibility – E. Bong

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Summary

- Instrument design emphasizes flexibility
- X-ray scattering techniques
  - WAXS
  - SAXS
  - Reflectivity, Grazing Incidence
- X-ray optics can tailor FEL parameters
- Many sample environments can be accommodated
  - Vacuum
  - Low temperature (cryostat, cryostream)
  - Samples in solution
- Major system interfaces are well defined
- Safety issues are identified

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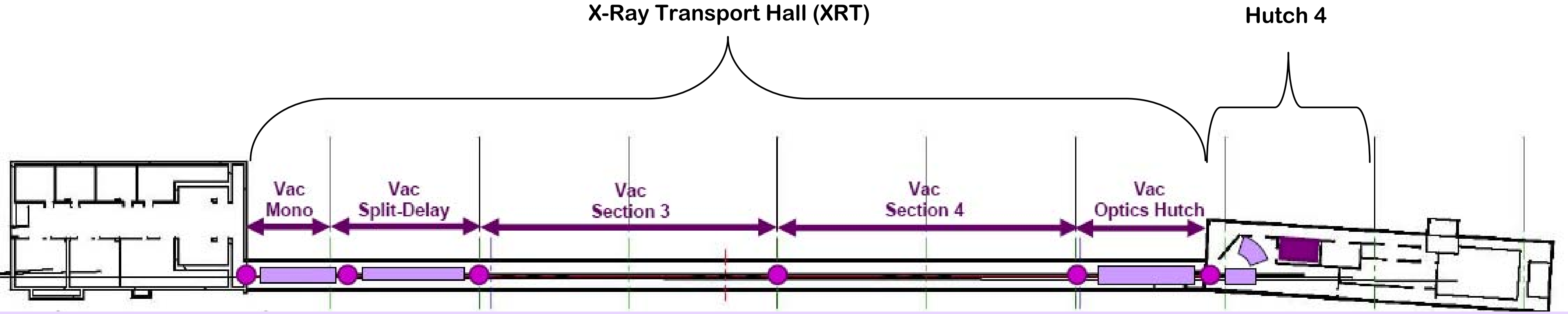
XCS Preliminary Instrument Design Review Engineering

Eric L. Bong

XCS PIDR

July 25, 2008



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Outline

- *Instrument Configuration*
- *Component Sources*
- *Integration*
- *XCS Scope of Design*
  - *XRT (Stands & Vacuum)*
  - *Hutch (Stands, Vacuum & Utilitiess)*
  - *Diffractometer*
  - *Large Angle Mover*
- *Detector (BNL WBS 1.4.3)*
- *Diagnostics & Optics (WBS 1.5)*
- *Controls (WBS 1.6)*
- *Cost & Schedule*

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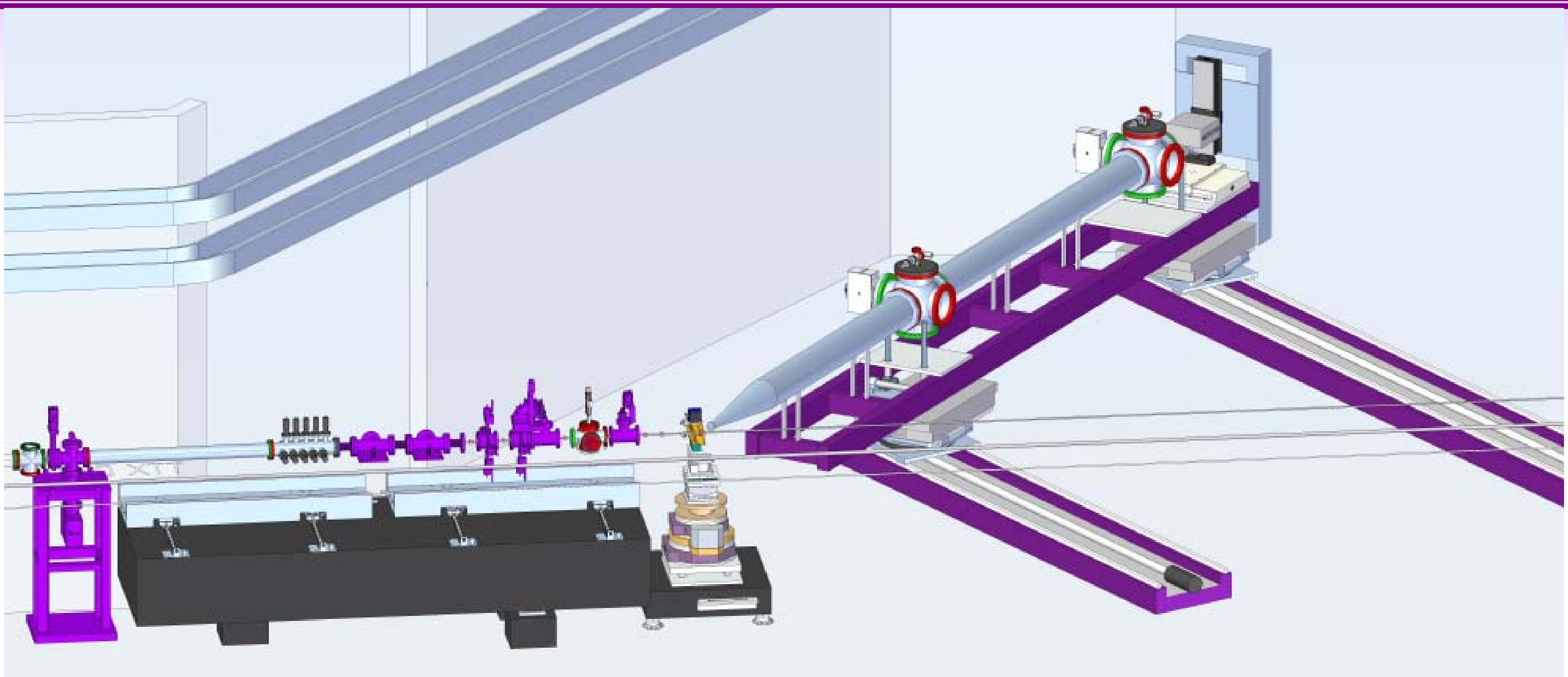
XCS Staff



- ***Instrument Scientist***
  - ***Aymeric Robert***
- ***Engineering Staff***
  - ***Eric Bong - Lead Engineer***
  - ***Don Arnett – Mechanical Design Engineer, XRT & Documentation***
  - ***Jim Delor – Mechanical Design Engineer, Diffractometer***
  - ***Ted Osier – Mechanical Design Engineer, Hutch 4***

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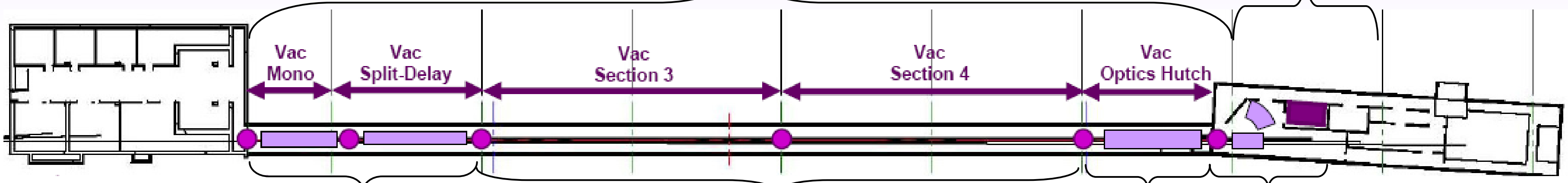
XCS Configuration, Regions



- ***Two major regions; XRT and H4***
  - ***X-Ray Transport Tunnel***
    - ***Monochromator – WBS 1.5 LUSI Diagnostics & Common Optics***
    - ***Split & Delay – Loan From Foreign Laboratory (Not XCS Scope)***
    - ***Diagnostics – WBS 1.5 LUSI Diagnostics & Common Optics***
    - ***Long Drift – WBS 1.4.6.1 XCS Vacuum***
    - ***Vacuum System, Supports & Tables - WBS 1.4.2.1 XCS Supports & 1.4.6.1 XCS Vacuum***
  - ***Hutch 4***
    - ***Optics & Diagnostics - WBS 1.5 (Not XCS Scope)***
    - ***Diffractometer – WBS 1.4.4.1***
    - ***Detector – WBS 1.4.3 (BNL Scope)***
    - ***Large Angle Detector Mover – WBS 1.4.3.3***
    - ***Vacuum System, Supports & Tables - WBS 1.4.2.2 XCS Supports & 1.4.6.2 XCS Vacuum***

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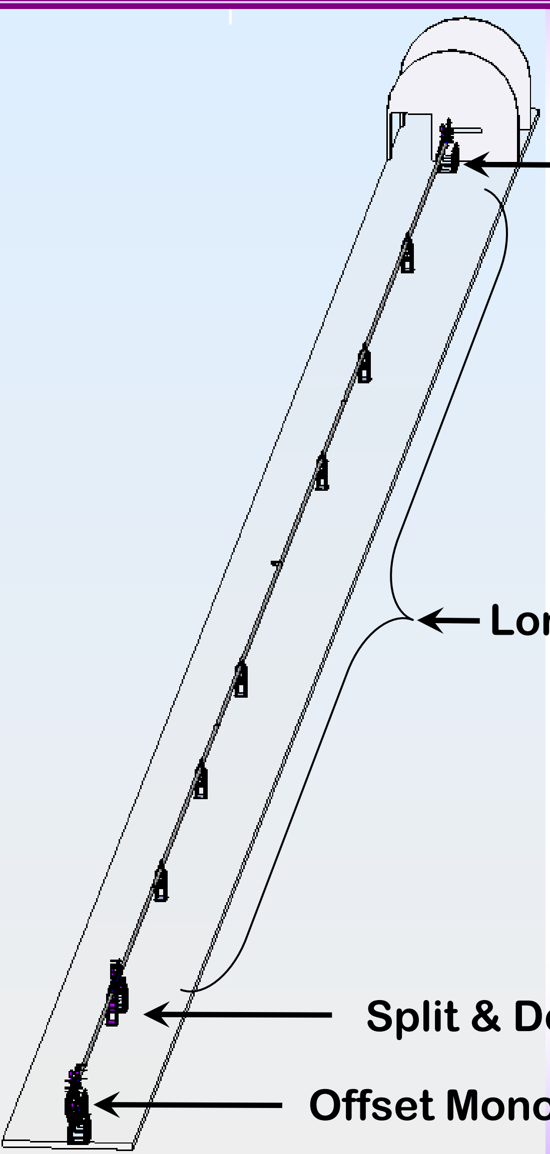
XRT Configuration (1)



XCS X-Ray Transport Tunnel Region

- *Divided into Vacuum Sections*
  - *Sections Bounded by Valves*
  - *Two Pump Minimum per Section*
- *Offset Monochromator Section*
  - *Monochromator and Diagnostics are provided to XCS from WBS 1.5*
- *Split & Delay Section*
  - *Split & Delay On Loan From Foreign Laboratory*
  - *Diagnostics are provided to XCS from WBS 1.5*
- *Long Drift Section*
  - *Long Drift Divided in Two by Valve*
- *Drift-End Diagnostics Section*
  - *Diagnostics are provided to XCS from WBS 1.5*
- *XCS Responsible for Vacuum Equipment, Drifts and Floor Stands, Girders and Stoppers.*

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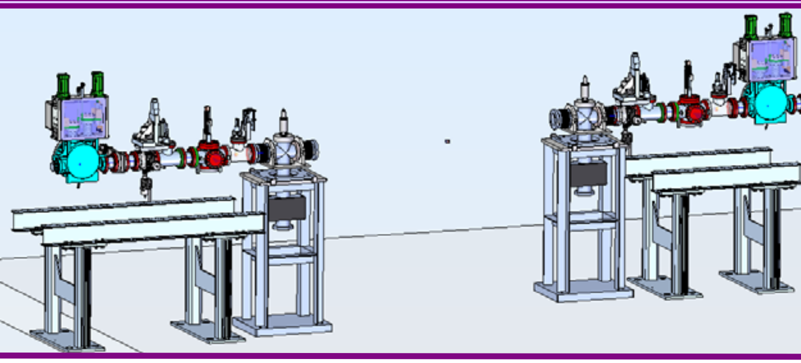
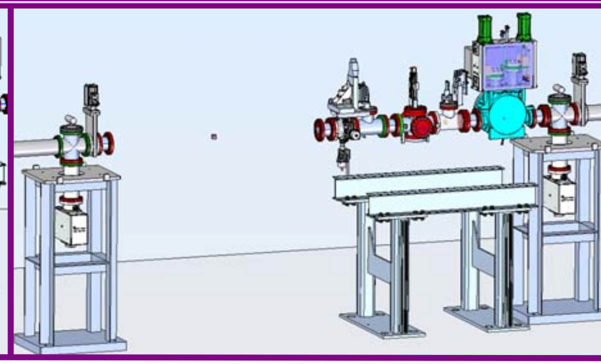
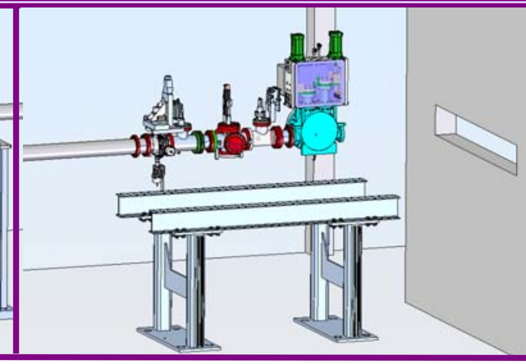
XRT Configuration (2)







Offset Monochrometer Section | **Split & Delay Section** | **Drift-End Section**

- ***Instrument Floor Support Stands***
  - *Modification of SSRL support "rafts"*
- ***Vacuum Component Support Stands***
  - *LLNL Designs approved for SLAC use including earthquake safety approval.*
- ***Vacuum Components***
  - *Consistent with LCLS vacuum system design*
- ***Drift Chamber Support Stands***
  - *LLNL Designs approved for SLAC use including earthquake safety approval.*
- ***Stoppers***
  - *Beginning and end PPS stoppers provided by LCLS*
  - *Between diagnostics stoppers modification of LCLS PPS design*

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XRT Configuration (3)

- ***Long Drift Section – 150 m***
- ***One Valve Breaks the Drift Section Into Two Pumping Regions; Three Pumps Per Region***
- ***LLNL Vacuum Design Approved for 200m***
- ***Use LLNL Designed Components***
  - ***LLNL Pump Supports***
    - ***Design Complete, Reviewed***
  - ***LLNL Drift Tube Supports***
    - ***Design Complete, Reviewed***
  - ***LLNL Valve Supports***
    - ***Design Complete, Reviewed***
- ***LLNL Supports Earthquake Approved***

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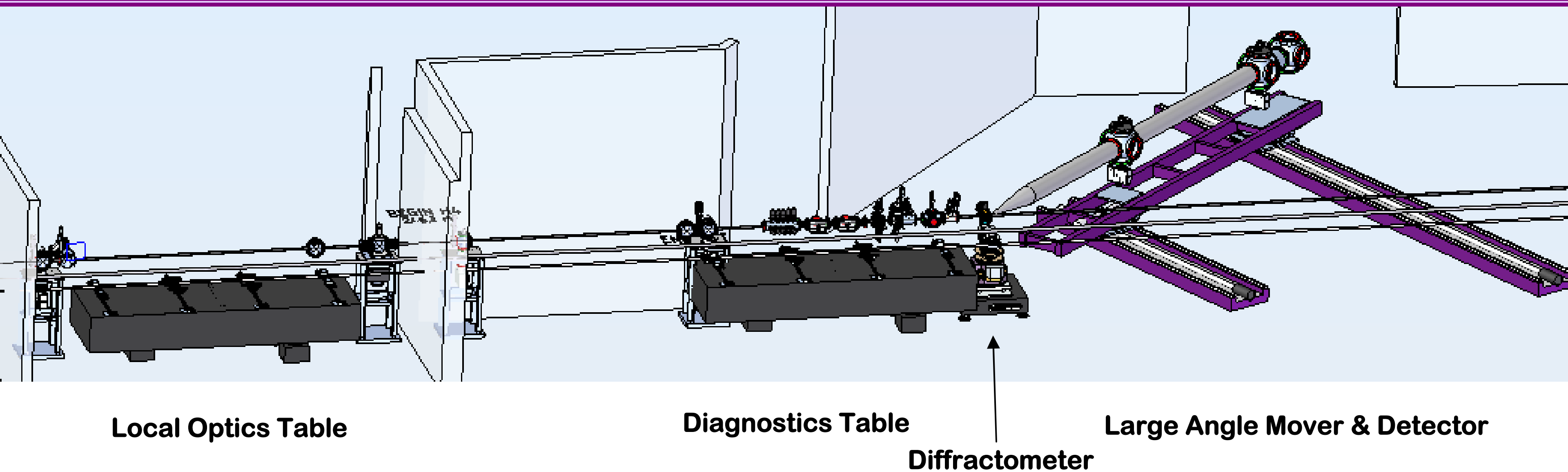
Hutch 4 Configuration (1)



- *Local Optics Table - Provides Location for Experiment Specific Conditioning Optics – uses modification of XPP design*
- *Diagnostics Table – Provides Mounting Location for Final Diagnostics– uses modification of XPP design*
- *Diffractometer – Positions Sample*
- *Large Angle Mover – Positions Detector*
- *Detector - 1024 x 1024 Charge Pump Structure, BNL*
- *LLNL Pump Supports*

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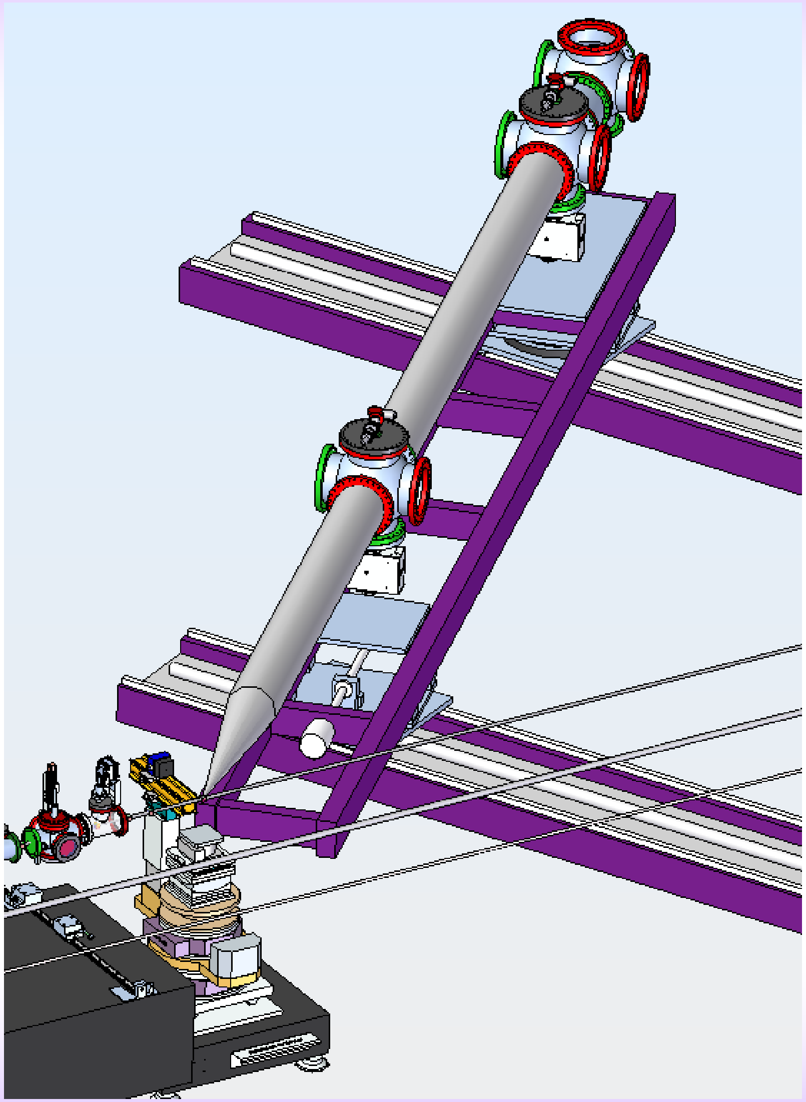
Hutch Configuration (2)



XCS Diffractometer System

- *Diffractometer*
  - *Components sourced from reputable outside vendor with exemplary reputation*
  - *Components assembled at SLAC*
  - *Diffractometer base required to move off beam-line on air-pads, requires marble floor insert*
- *Large Angle Detector Mover*
  - *Includes vacuum system*
  - *Provides mount for BNL detector*
  - *Provides 0 to 55 degrees of rotation of 8 meter detector arm*

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Component Sources Outside XCS

- ***Multiple sources of instrument components come from outside the XCS budgetary and management scope***
- ***Within LUSI – Diagnostics & Common Optics, Controls***
  - ***ICDs, PRDs ESDs Reviews***
- ***Outside LUSI – Split & Delay***
  - ***MOU***

LUSI Diagnostics & Common Optics WBS

WBS	TITLE
1.5	**DIAGNOSTICS & COMMON OPTICS**
1.5.1	Diagnostics & Common Optics System Integration & Design
1.5.2	Diagnostics
1.5.2.1	Pop-in Profile/Wavefront Monitor
1.5.2.2	Pop-In Intensity Monitor
1.5.2.3	Intensity-Position Monitor
1.5.3	Common Optics
1.5.3.1	Monochromator
1.5.3.2	X-ray Focusing Lenses
1.5.3.3	Slit System
1.5.3.4	Attenuators / Filters
1.5.3.5	Pulse Picker
1.5.3.6	Harmonic Rejection Mirrors

LUSI Controls Work Breakdown Structure

WBS	TITLE
1.6	**CONTROLS AND DATA ACQUISITION**
1.6.01	Controls and Data Acquisition System Integration & Design
1.6.02	LUSI Common Controls
1.6.02.01	Photon Beam Feedback
1.6.02.02	Electron Beam Feedback
1.6.02.03	Hutch Environmental Controls
1.6.02.04	FEH DAQ Data Storage
1.6.02.05	DAQ Data Processing
1.6.02.06	Racks & Cabling (Common)
1.6.05	X-ray Correlation Spectroscopy (XCS) Hutch 4 (FEH)
1.6.05.01	XCS H4 Requirements, Design, Setup
1.6.05.01.01	XCS H4 Controls Requirements and Design
1.6.05.01.02	XCS H4 Development Test Setup
1.6.05.02	XCS H4 Standard Hutch Controls
1.6.05.02.01	XCS H4 Cables & Racks
1.6.05.02.02	XCS H4 Workstation
1.6.05.02.03	XCS H4 Beam Line Processor
1.6.05.02.04	XCS H4 Channel Access Gateway
1.6.05.02.05	XCS H4 MPS
1.6.05.03	XCS H4 Specific Controls
1.6.05.03.01	XCS H4 Data Acquisition (DAQ)
1.6.05.03.02	XCS H4 DAQ Hutch Data Management
1.6.05.03.03	XCS H4 Experiment Configuration Control
1.6.05.03.04	XCS H4 Valve Controls
1.6.05.03.05	XCS H4 Vacuum Controls
1.6.05.03.06	XCS H4 Pop-In Profile Monitor Controls
1.6.05.03.07	XCS H4 Pop-In Intensity Monitor Controls
1.6.05.03.08	XCS H4 Intensity-Position Monitor Controls
1.6.05.03.09	XCS H4 Slit Controls
1.6.05.03.10	XCS H4 Attenuator Controls
1.6.05.03.11	XCS H4 Harmonic Rejection Mirrors Controls
1.6.05.03.12	XCS H4 2D Detector Motion Camera Controls
1.6.05.03.13	XCS H4 Diffractometer Controls
1.6.05.03.14	XCS H4 Large Angle Detector Stage Controls
1.6.05.03.15	*RESERVED*
1.6.05.03.16	XCS H4 Controls System Integration Test
1.6.05.03.17	XCS H4 Vision Camera Controls
1.6.05.04	XCS Beam Transport to FEH
1.6.05.04.01	XCS BT to FEH Valve Controls

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XCS Scope

- *Scope of Work*
  - *Integration*
  - *Tables & stands*
  - *Detector System (BNL)*
    - *Sub-contracted to BNL through MOU*
  - *Diffractometer System*
    - *Diffractometer*
    - *Large Angle Detector Mover*
  - *Hutch Facilities*
  - *Vacuum System*
  - *Installation*
- *Work managed through Instrument Scientist and Lead Engineer partnership*
- *Design & fabrication & installation split between SLAC in-house, outside contract and MOU*

LUSI XCS Work Breakdown Structure

WBS	TITLE
1.4	**X-RAY CORRELATION SPECTROSCOPY (XCS)**
1.4.01	XCS System Integration & Design
1.4.02	XCS X-ray Optics and Support Table
1.4.02.01	XCS XRT Supports, Tables and Shielding
1.4.02.02	XCS Hutch Supports, Tables and Shielding
1.4.02.03	XCS Stoppers
1.4.02.04	XCS Local Optics
1.4.03	XCS Detector System (BNL)
1.4.03.01	Detector Support and Integration
1.4.03.02	Detector Sensor
1.4.03.03	Detector Application Specific Integrated Circuits (ASIC)
1.4.03.04	Detector Controls, Electronics and DAQ
1.4.04	XCS Sample Environment & Diffractometer System
1.4.04.01	XCS Diffractometer
1.4.04.02	XCS Sample Environment
1.4.04.03	XCS Large Angle Mover & Chamber
1.4.05	XCS Hutch Facilities
1.4.05.01	XCS Hutch Specification
1.4.05.02	XCS Utilities & Hutch Equipment
1.4.06	XCS Vacuum System
1.4.06.01	XCS XRT Vacuum System
1.4.06.01.01	XCS XRT Vacuum Equipment
1.4.06.01.02	XCS XRT Spools & Bellows
1.4.06.01.03	XCS XRT Vacuum Supports
1.4.06.02	XCS Hutch Vacuum System
1.4.06.02.01	XCS Hutch Vacuum Equipment
1.4.06.02.02	XCS Hutch Spools & Bellows
1.4.06.02.03	XCS Hutch Vacuum Supports
1.4.07	XCS Installation
1.4.07.01	XRT Installation
1.4.07.02	Hutch Installation

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LUSI XCS WBS 1.4 Acquisition Strategy

- ***A variety of sources are used to design – build - install XCS components based on experience and cost (coded in P3).***
- ***Previous designs and Off-The-Shelf components are used whenever available.***

Previous Design/OTS	
SLAC	
BNL	
Domestic Vendor	
Foreign Vendor	
Long Lead Procurement	

XCS Work Breakdown Structure - PM-391-000-96		**Resource Source**		
WBS	**TITLE**	Design	Build	Install
1.4	**X-RAY CORRELATION SPECTROSCOPY (XCS)**			
1.4.01	XCS System Integration & Design			
1.4.02	XCS X-ray Optics, Supports & Tables			
1.4.02.01	XCS XRT Supports, Tables and Shielding			
1.4.02.02	XCS Hutch Supports, Tables and Shielding			
1.4.02.03	XCS Stoppers			
1.4.02.04	XCS Local Optics			
1.4.03	XCS Detector System (BNL)			
1.4.03.01	Detector Support and Integration			
1.4.03.02	Detector Sensor			
1.4.03.03	Detector Application Specific Integrated Circuits (ASIC)			
1.4.03.04	Detector Controls, Electronics and DAQ			
1.4.04	XCS Sample Environment & Diffractometer System			
1.4.04.01	XCS Diffractometer			
1.4.04.02	XCS Sample Environment			
1.4.04.03	XCS Large Angle Mover & Chamber			
1.4.05	XCS Hutch Facilities			
1.4.05.01	XCS Hutch Specification			
1.4.05.02	XCS Utilities & Hutch Equipment			
1.4.06	XCS Vacuum System			
1.4.06.01	XCS XRT Vacuum System			
1.4.06.01.01	XCS XRT Vacuum Equipment			
1.4.06.01.02	XCS XRT Spools & Bellows			
1.4.06.01.03	XCS XRT Vacuum Supports			
1.4.06.02	XCS Hutch Vacuum System			
1.4.06.02.01	XCS Hutch Vacuum Equipment			
1.4.06.02.02	XCS Hutch Spools & Bellows			
1.4.06.02.03	XCS Hutch Vacuum Supports			
1.4.07	XCS Installation			
1.4.07.01	XRT Installation			
1.4.07.02	Hutch Installation			

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Integration

- *Reliance on component design for other instruments*
  - *Diagnostics & Common Optics*
  - *Controls*
  - *Rafts from SSRL*
  - *Hutch Tables from XPP*
  - *Vacuum Supports from LCLS*
- *Monitor engineering on other LUSI instruments & groups*
  - *Participate in generating specifications*
  - *Participation in design reviews*
- *Outside Design within XCS scope*
  - *Diffractometer – Require design reviews to authorize next phase of work*
  - *Large Angle Mover - Require design reviews to authorize next phase of work*
  - *Detector – Empower review committee to validate design*
- *Equipment provided by external laboratory*
  - *Split & Delay – Manage participation through MOU*

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XRT, XCS Scope

- ***Supports & Stoppers WBS 1.4.2***
  - ***XRT Supports & Stoppers – preliminary layout complete, ready for design***
    - ***Utilize modification of existing SSRL "raft" design to support diagnostics components***
    - ***PPS Stoppers provided by LCLS***
    - ***Diagnostics stoppers modification of LCLS design***
  - ***XRT Vacuum System***
    - ***WBS Subsections include vacuum equipment, drift tubes, bellows and supports***
    - ***Cost of vacuum system components from established vendors and from actual costs of previous designs***
    - ***Long drift vacuum system costs same as LCLS XRT system***
- ***Vacuum System WBS 1.4.6***
  - ***XRT Vacuum System***
    - ***WBS Subsections include vacuum equipment, drift tubes, bellows and supports***
    - ***Cost of vacuum system components from established vendors and from actual costs of previous designs***
    - ***Long drift vacuum system costs same as LCLS XRT system***
  - ***Hutch Vacuum System***
    - ***WBS Subsections include vacuum equipment, drift tubes, bellows and supports***
    - ***Cost of vacuum system components from established vendors and from actual costs of previous designs***
    - ***LCLS XRT pump support designs used in Hutch***

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Hutch, XCS Scope (1)

- *Hutch 4 definitive layout complete, ready for preliminary design*
- *Supports*
  - *Utilize modification of XPP support table for fine positioning of diagnostics components*
- *Vacuum*
  - *Conservative vacuum design redundant pumping*
  - *Use LLNL Pump Suppoprts*
- *Diffractometer*
  - *Definitive layout complete*
  - *ESD draft complete*
  - *Meeting with potential vendor conducted June 16th*
    - *Vendor preliminarily agreed to design-build of integrated assembly.*
- *Large Angle Detector Mover*
  - *Similar to ANL HERIX detector mover, without complex chamber*
  - *Received quotes to reproduce HERIX (original vendor)*
  - *Received requests from two additional vendors to be included on bid*
  - *Search performed to establish availability of rails and lead screw*

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Hutch, XCS Scope (2)

- ***Hutch Utilities, WBS 1.4.5***
  - ***Provides infrastructure for XCS instrument not provided for in other LUSI WBS section nor from LCLS***
  - ***Ongoing meetings established to define infrastructure requirements***
  - ***Positions of walls, raised floor, crane, marble floor insert established and incorporated into hutch model***
  - ***Instrument stay-clears defined modeled and incorporated in hutch utility model***
  - ***Detailed cost estimate established for hutch utilities and incorporated into resource loaded schedule***

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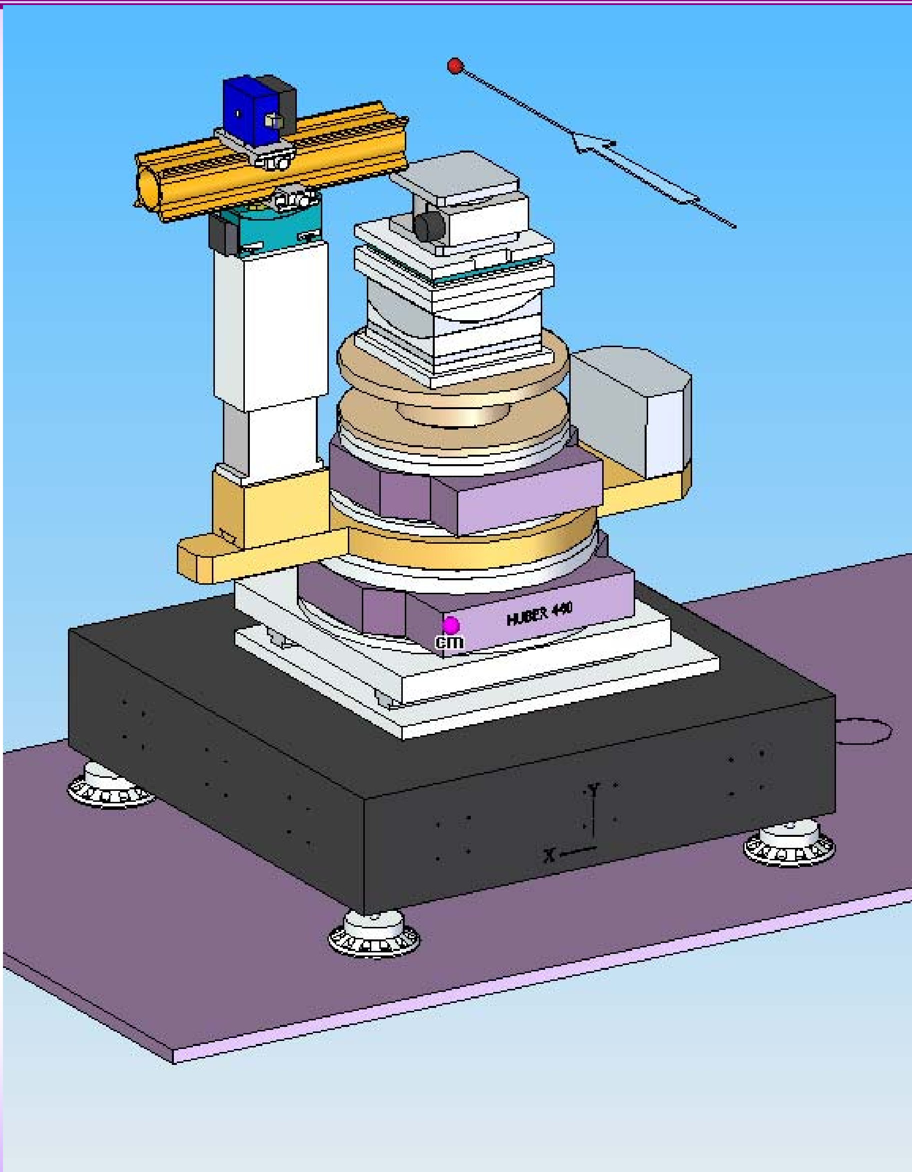
Diffractometer

- ***Diffractometer WBS 1.4.4.1***
  - ***Provides sufficient degrees of freedom to position sample relative to beam***
  - ***Definitive layout complete***
  - ***ESD draft complete***
  - ***SOW in process***
  - ***Components sourced from reputable outside vendor with exemplary reputation***
  - ***Components assembled at SLAC***
  - ***Diffractometer base required to move off beam-line on air-pads, requires marble floor insert***



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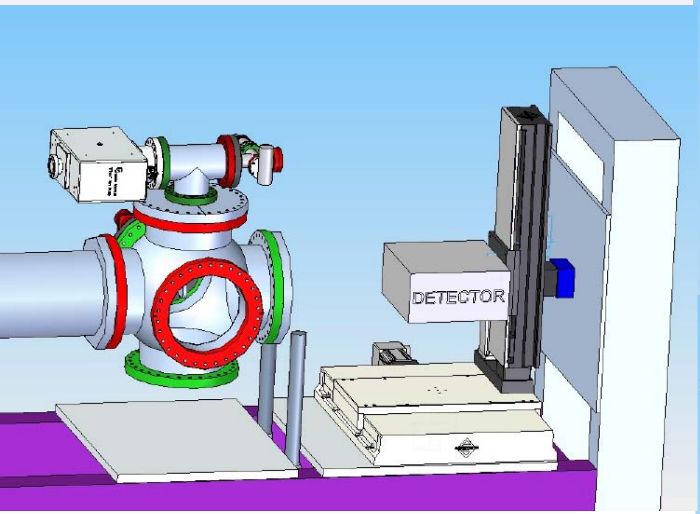
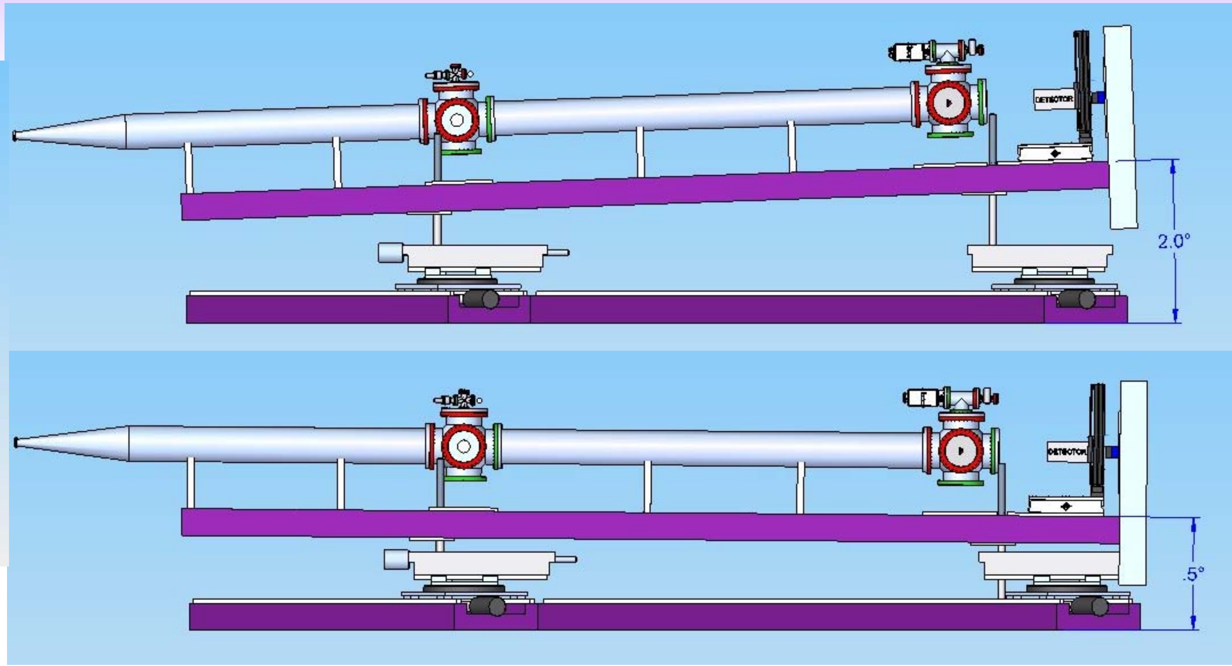
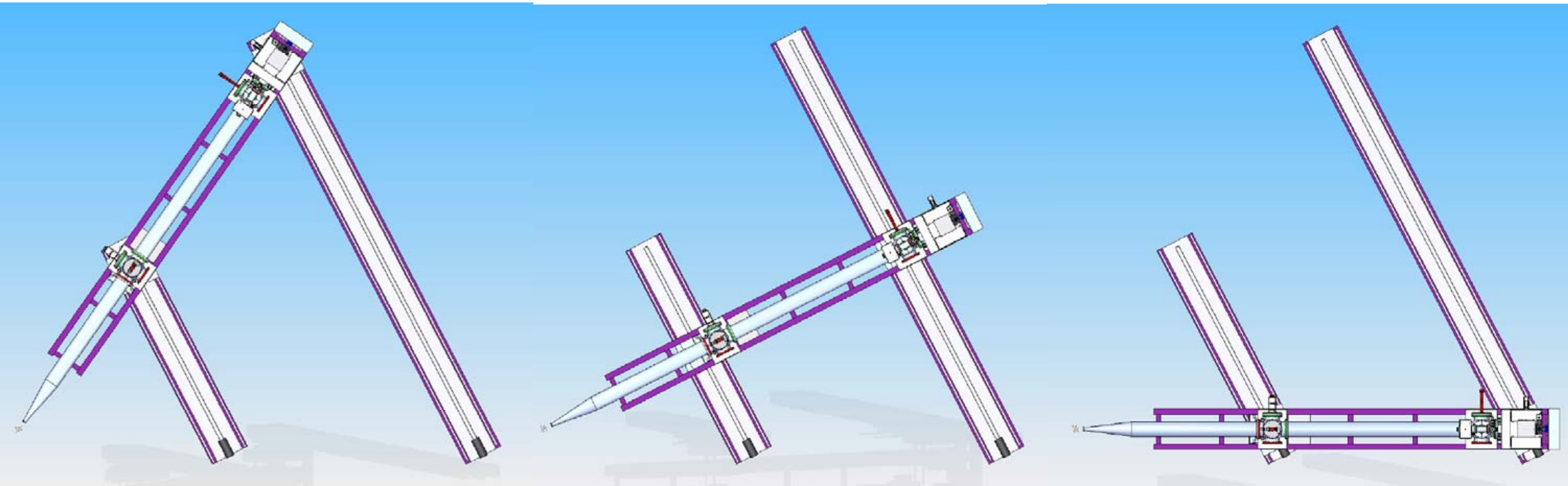
Large Angle Detector Mover Motion







Large Angle Detector Mover

- ***Large Angle Detector Mover WBS 1.4.4.3***
  - *Detector Arm : 8 meters*
  - *Angular Range : 0 to 55 degrees*
  - *Vertical Tilt : -0.5 to +2.0 degrees*
  - *Vertical Offset : +/- 20 mm*
  - *Horizontal Offset : Capable of intercepting the CXI beam-line*
- ***Subsystems***
  - *Vacuum : Initial design for UHV*
  - *Position Diode : Finds maximum signal center*
  - *Stopper : Blocks maximum power at pattern center to detector*
  - *Slits : Defines signal delivered to detector*
  - *Detector Positioner : Translates detector relative to signal pattern*

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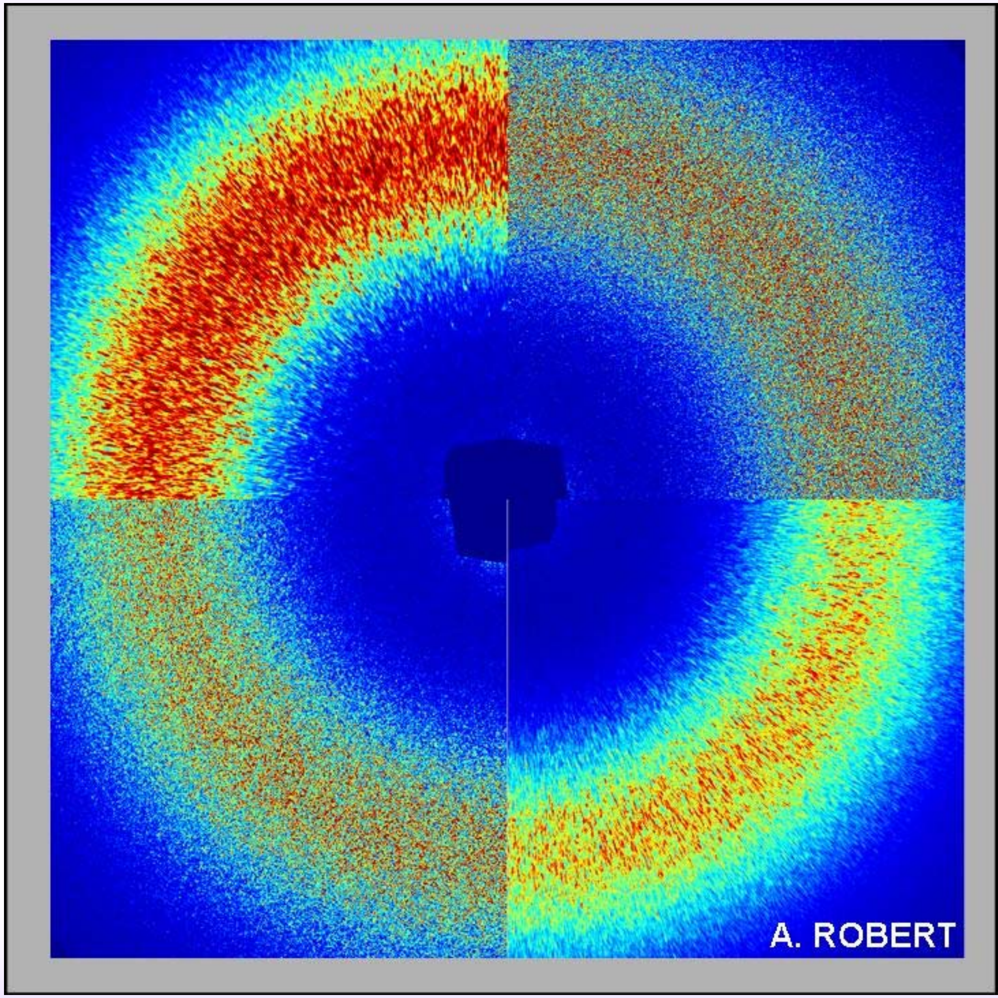
Detector, BNL Scope

- ***XCS Detector***
  - ***Within XCS, WBS 1.4.3***
  - ***MOU with BNL***
  - ***Work managed by BNL***
  - ***LUSI Oversight by (Niels van Bakel)***
  - ***Detector Advisory Committee (LDAQ)***
    - ***Periodic reviews***



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Detector Specification

- ***Image the temporal changes in a speckle patterns that are related to the sample's dynamics. The method takes advantage of the coherence properties of the beam.***
  - ***Energy range 4 - 25 keV***
  - ***Need a high QE (> 90%) to measure the spiky nature of the speckle pattern***
  - ***Total angular range is 2θ = 55°***
  - ***The detector size is determined by the maximum Q value achievable in the small angle regime***
  - ***Angular resolution or pixel size: the pixel size should be ≤ speckle size***
  - ***For L = 7 - 8 m, Db = 10 - 100 μm the speckle size Ds = 11 - 120 μm (@ 8 keV)***
  - ***Number of pixels calculated by the total angular coverage and angular resolution needed for SAXS @ 8m. The basic detector module has 1024 x 1024 pixels***
  - ***Read-out noise << 1 equivalent 8.2 keV photon to allow single photon sensitivity***

Niels Van Bakel

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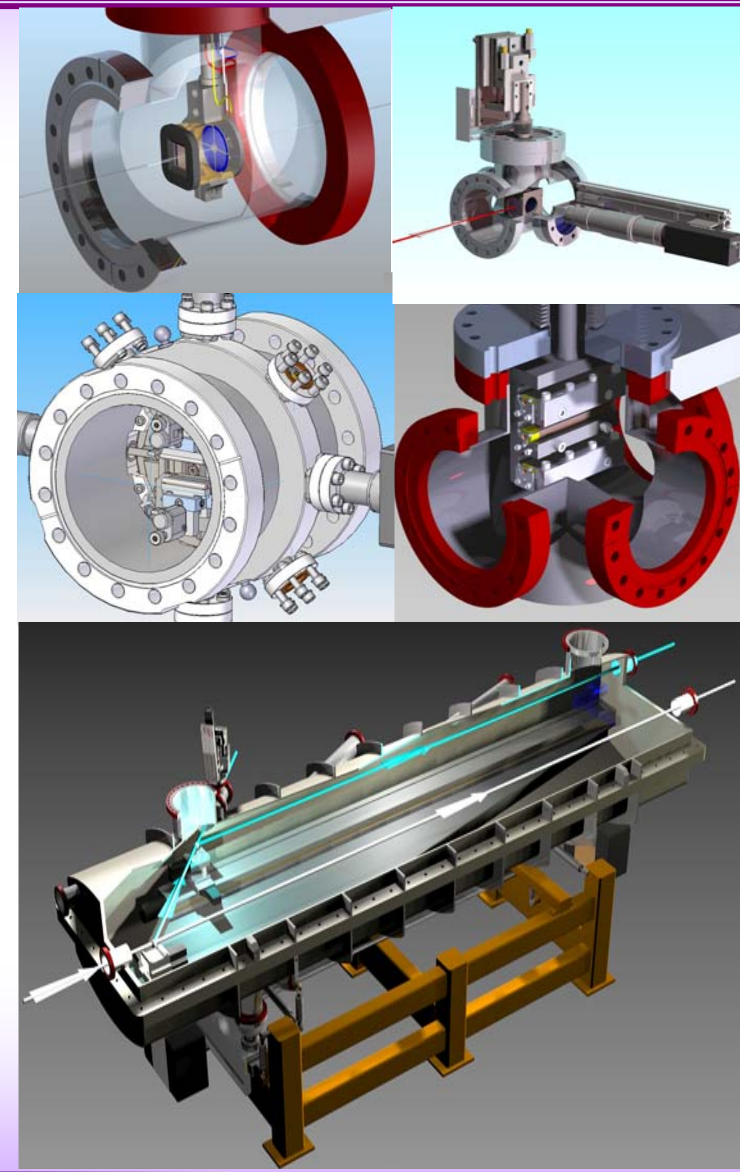
Diagnostics, LUSI WBS 1.5 Scope

- *1.5.2 Diagnostics*
  - *1.5.2.1 Pop-in profile/wave-front monitor*
  - *1.5.2.2 Pop-in intensity monitor*
  - *1.5.2.3 Intensity-position monitor*
- *1.5.3 Common Optics*
  - *1.5.3.1 Monochromator*
  - *1.5.3.2 X-ray focusing lenses*
  - *1.5.3.3 Slit system*
  - *1.5.3.4 Attenuators/Filters*
  - *1.5.3.5 Pulse picker*
  - *1.5.3.6 Harmonic rejection mirrors*
- *Managed as a project similar to LUSI instruments (Lead Engineer, Eliazar Ortiz; Lead Scientist, Yiping Feng)*
- *Requirements specified by the LUSI XPP, CXI and XCS instrument scientists*
- *Periodic reviews with instrument engineer and scientist participation to assure component design meets instrument requirements*



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Controls, LUSI WBS 1.6 Scope

- *Controls (WBS 1.6)*
- *Interface Control document – defines division of responsibility between mechanical device and controls*
  - *Meetings are required to agree and document controls interface to each device*
- *Device control requirements*
  - *Defined per-device through Physics and Engineering requirements documents*
- *System control*
  - *Responsibility of Controls – Vacuum, Personnel Protection*
- *Control integration of vendor provided systems*
  - *Requires participation of the controls group during the component design phase and design reviews.*

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Value Management - XCS

- ***XCS uses outside expert vendors for critical procurements – Diffractometer, Large Angel Mover***
- ***XCS also utilizes expertise in outside labs for specialized equipment – Split & Delay, Detectors***
- ***XCS also intends to use components designed for other LUSI instruments – XPP Tables***
- ***XCS also intends to use components designed for other SLAC departments – SSRL Rafts in XRT***
- ***LUSI schedule places XCS last in schedule allows XCS to choose the best of recent designs in XCS construction.***

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Requirement Documents

- ***All XCS PRD's, ESD's in Draft or Identified***
- ***APP, Risk Reg, all BOE's up to date and complete***

LUSI-XCS (WBS 1.4) REQUIREMENTS STATUS			
TOPIC AREA	CONTACT	REQD	COMP
WBS STRUCTURE & DICTIONARY	Bong	X	X
MILESTONE DICTIONARY	Bong	X	X
BASIS OF ESTIMATE (INCL REVISIONS)	Bong	X	X
RISK REGISTRY ENTRIES	Bong	X	X
COST REVIEW	Bong	X	X
REVISED SCHEDULE	Bong	X	W
INSTRUMENT PRD	Robert	X	Draft
INSTRUMENT ESD	Bong	X	Sched
PRELIMINARY INSTRUMENT DESIGN REVIEW	Robert	X	Sched
PRD LIST AND COMPLETION STATUS	Robert	X	X
ESD LIST AND COMPLETION STATUS	Bong	X	X
INSTRUMENT EQUIPMENT LIST & STATUS	Bong	X	Sched
DESIGN REVIEW LIST & STATUS	Bong	X	X
START-UP TEST PLAN	Robert	X	X

TYPE	PREFIX	DOCUMENT NUMBER	REV.	TITLE	AUTHOR	STATUS	UPDATED
PRD	SP	391-001-17	0	XCS Instrument Start-up Plan	Robert	approvals	3-Jul-08
PRD	SP	391-001-33	0	XCS Wide Angle Detector Stage	Robert	in work	1-Jul-08
ESD	SP	391-001-38	0	Hutch 4 of the FEH	Robert	approvals	9-Jul-08
ESD	SP	391-001-39	0	XCS Room of the FEH	Robert	approvals	9-Jul-08
ESD	SP	391-001-20	0	XCS diffractometer system	Delor	In Work	4-Jun-08
ESD	SP	391-001-30	0	XCS Diffractometer	Delor	in work	25-Jun-08
PRD	SP	391-001-35	0	XCS Instrument	Robert	in work	5-Jul-08
PRD	SP	391-001-32	0	XCS Diffractometer system	Robert	in work-finalize	23-Jun-08
PRD	SP	391-000-98	0	XCS 2D Detector	van Bakel	not started	19-Dec-07
ESD	SP	391-001-29	0	XCS Instrument Specification		not started	25-Jun-08
ESD	SP	391-001-31	0	XCS Detector Mover		not started	25-Jun-08

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Basis of Estimates

- *BOE packages contain*
  - *Description of the Component*
  - *3D model if applicable and available*
  - *Detailed cost estimate*
    - *Part number, drawing number, vendor, notes, weight, qty, cost, risk and contingency analysis, etc.*
  - *Supporting quotations, drawings, catalogs, etc.*
  - *Configuration Controlled with the CD2 baseline*

LUSI XPP Hutch optical support table & Supports
WBS 1.4.2.2

Estimator Bong 6/19/2008

large optics rafts upbeam of the diffractometer. Rigging is not included. Numbers are based on modification of the design developed for XPP.

DESCRIPTION	Part Number	Material	Resource	Hours	QTY	Unit Cost [$]	Direct Total	Source/Status of Estimate	Weight each (lb)	Weight total (lb)	Vendor	Note 1	Note 2
PED													
Sub Total				**1477**			**$93.55K**						
Modify XPP Long Table Support Design													
Preliminary			Engineer	160			$9.19K	Bong					
Preliminary			Designer	160			$10.88K	Bong					
Final			Engineer	80			$4.60K	Bong					
Final			Designer	160			$10.88K	Bong					
Long Table Reviews													
Preliminary			Engineer	44			$2.53K	Bong					
Preliminary			Designer	14			$0.95K	Bong					
Final			Engineer	44			$2.53K	Bong					
Final			Designer	14			$0.95K	Bong					
Long Table Documentation													
Detail (40 drawings)			Designer	160			$10.88K	Bong					
Checking			Designer	80			$5.44K	Bong					
Long Table Procurement													
SOW/Fabrication input			Engineer	80			$4.60K	Bong					
Shielding Design													
Preliminary			Engineer	60			$3.45K	Bong from XPP					
Preliminary			Designer	57			$3.88K	Bong from XPP					
Final			Engineer	17			$0.98K	Bong from XPP					
Final			Designer	31			$2.11K	Bong from XPP					
Shielding Reviews													
Preliminary			Engineer	44			$2.53K	Bong from XPP					
Preliminary			Designer	14			$0.95K	Bong from XPP					
Final			Engineer	44			$2.53K	Bong from XPP					
Final			Designer	14			$0.95K	Bong from XPP					
Documentation													
Detail (20 drawings)			Designer	80			$5.44K	Bong from XPP					
Checking			Designer	40			$2.72K	Bong from XPP					
Shielding Procurement													
SOW/Fabrication input			Engineer	80			$4.60K	Bong from XPP					
MSL													
Sub Total							**$104.56K**						
Procurements							**$78.76K**						
Fab/Assy				**288**			**$25.80K**						
Table: Optics & Diagnostics Raft													
Procurements							**$76.88K**						
48" x 160" x 24" Grade AA 0-Ledge Sierra Gray Granite Surface Plate					2	$ 23,000.00	$46.00K	JDef calculation			Standrige	107ft^3 @ $	From XPP
Delivery Charge					2	$ 3,500.00	$7.00K	Quotation				Standridge (	From XPP
Welded Steel Frame					2	$ 2,000.00	$4.00K	discussion w/ Kurita (from XPP)			Edmund		From XPP
Leveling Jacks					2	$ 1,500.00	$3.00K	Quotation					From XPP
Al Jig Plate					2	$ 600.00	$1.20K	discussion w/ Kurita (from XPP)					From XPP
Grout Plate					12	$ 50.00	$0.60K	discussion w/ Kurita (from XPP)					From XPP
Rails					8	$ 709.00	$5.67K	Cymatix quote for BC2			Cymatix/T	Non-standa	From XPP
Carriages					16	$ 171.00	$2.74K	Cymatix quote for BC2			Cymatix/T	Standard ca	From XPP
Actuator w/ motor					2	$ 3,335.00	$6.67K	Cymatix quote for BC2			Cymatix		From XPP
Labor							**$15.05K**						
Machine Jig Plate			Mech Fab	40			$3.58K	discussion w/ Kurita (from XPP)					From XPP
Assembly			Mech Fab	80			$7.17K	discussion w/ Kurita (from XPP)					From XPP
Drill Holes in Granite			Mech Fab	32			$2.87K	discussion w/ Kurita (from XPP)					From XPP
Install Inserts into Granite			Mech Fab	16			$1.43K	discussion w/ Kurita (from XPP)					From XPP
Shielding													
Procurements							**$1.88K**						
18" X 12" X .5" Steel Plate					4	$ 100.00	$0.40K	discussion w/ Kurita (from XPP)					From XPP
12" X 12" X .5" Steel Plate					4	$ 100.00	$0.40K	discussion w/ Kurita (from XPP)					From XPP
Hole Shields					8	$ 50.00	$0.40K	discussion w/ Kurita (from XPP)					From XPP
Screw Plates					8	$ 20.00	$0.16K	discussion w/ Kurita (from XPP)					From XPP
Lifting Lugs					8	$ 10.00	$0.08K	discussion w/ Kurita (from XPP)					From XPP
Misc Hardware					2	$ 200.00	$0.40K	discussion w/ Kurita (from XPP)					From XPP
PPS Lock					2	$ 20.00	$0.04K	discussion w/ Kurita (from XPP)					From XPP
Labor							**$10.75K**						
Machine Plates			Mech Fab	40			$3.58K	discussion w/ Kurita (from XPP)					From XPP
Assembly/Welding			Mech Fab	80			$7.17K	discussion w/ Kurita (from XPP)					From XPP

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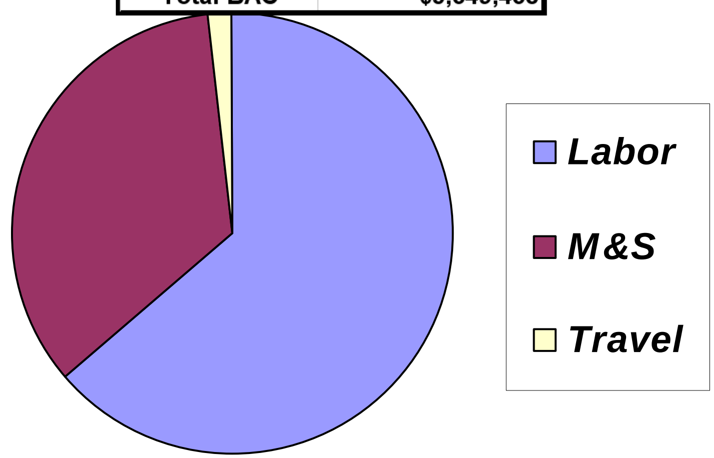
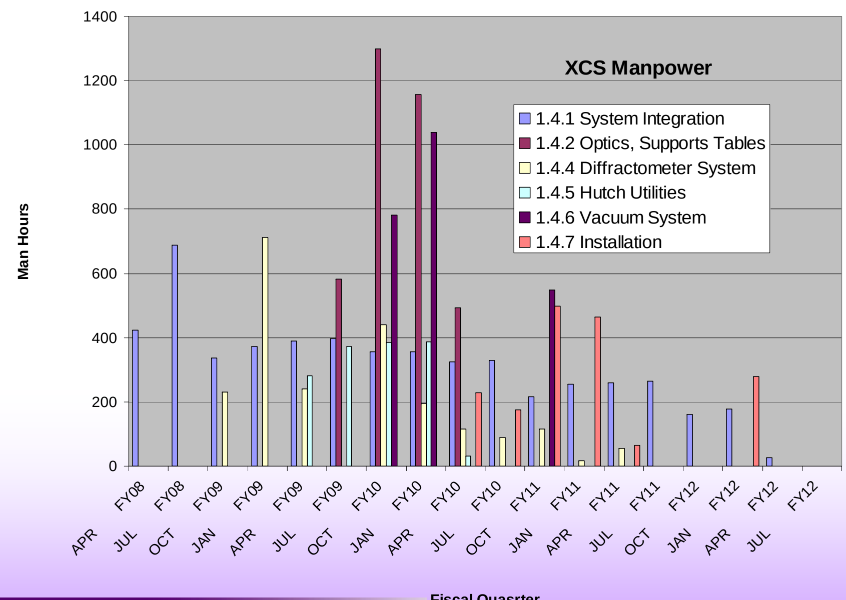
Cost & Schedule (May Data)

- ***XCS budget stats***
  - ***Excludes BNL detector***
  - ***Peak spending = CY11***
  - ***Labor = ~63%***
  - ***M&S = ~35%***

WBS	CY07	CY08	CY09	CY10	CY11	CY12	Cumulative
Eric Bong							
1.4.01 XCS System Integration & Design	$ 53,184	$ 361,128	$ 256,711	$ 221,125	$ 196,102	$ 44,989	$ 1,133,239
1.4.02 XCS X-ray Optics and Support Table	$ -	$ -	$ 210,836	$ 413,629	$ 29,593	$ -	$ 654,058
1.4.04 XCS Sample Environment & Diffractometer System	$ -	$ 24,282	$ 152,622	$ 128,858	$ 712,434	$ 5,793	$ 1,023,989
1.4.05 XCS Hutch Facilities	$ -	$ -	$ 30,348	$ 136,327	$ 116,223	$ -	$ 282,897
1.4.06 XCS Vacuum System	$ -	$ -	$ 90,126	$ 168,451	$ 824,790	$ -	$ 1,083,367
1.4.07 XCS Installation	$ -	$ -	$ -	$ 136,381	$ 630,201	$ 405,305	$ 1,171,888
CAM Totals:	$ 53,184	$ 385,410	$ 740,642	$ 1,204,771	$ 2,509,343	$ 456,087	$ 5,349,438

CAM - Bong	
Resource Type	Value
Labor	$3,402,600
M&S	$1,857,209
Travel	$89,629
Total BAC	$5,349,438





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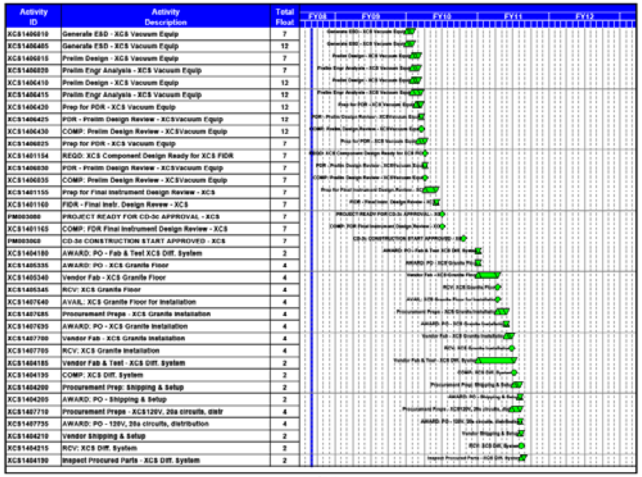
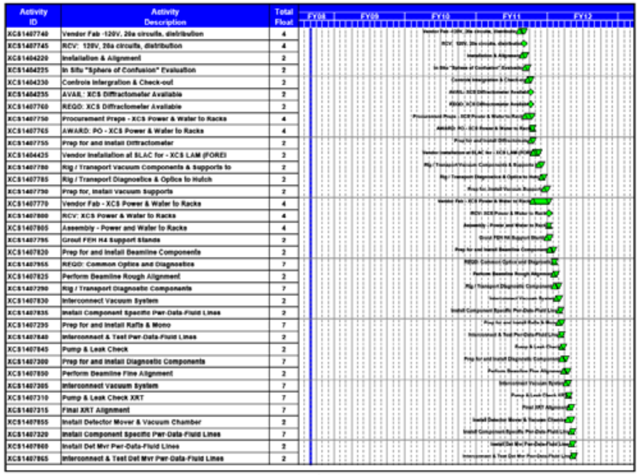
Critical Path

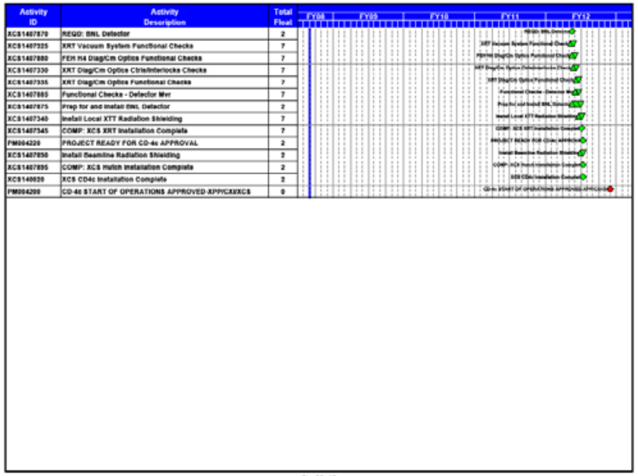
- *Path - Delayed design start, diffractometer acquisition, installation*
- *The Project has establish built in schedule contingency at L2 milestones*
- *"Project Ready" + 40 days is CD-3A Review, Cd-3A + 40 days is approval*
- *"Project Ready" + 60 days is CD-4A review*
- *Besides the project-held schedule float, the XCS Schedule has a minimum of 2 days of float in the installation activities; however, engineering and fabrication in XCS is constrained at the start by funding allocation to fit the LUSI budget profile*
- *Substantial float could be recovered by allocating funds to XCS earlier*
- *TOTAL SCHEDULE "FLOAT" for XCS is 2 + 60 = 62 days.*



Sheet 1 of 3



Sheet 2 of 3



Sheet 3 of 3

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Summary

- *XCS preliminary instrument design is mature to the point where it has been able to:*
  - *Quantify types of components*
  - *Estimate component costs*
  - *Specify acquisition methods*
  - *Establish baseline schedule*
- *Selection of components supports the instrument intended function*
- *Cooperation with other LUSI groups and participation in design reviews is required to meet instrument performance goals*
- *Many of the materials estimates came from vendor quotations, catalogs, previous orders or work performed by other LUSI instrument teams*
- *The XCS Critical Path is dominated by late start of engineering work, constrained by funding*

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The LUSI project conducted a Preliminary Instrument Design Review of the X-ray Correlation Spectroscopy Instrument on Friday, July 25 2008.

The committee consisted of E. Alp (APS), B. Brajuskovic (APS) and T. Rabedeau (SSRL).

The committee was charged to review the project from four perspectives as follows :

1 Scientific Goal

2 Technical Design

3 Value Engineering

4 Opportunities

This documents is the answer from the X-ray Correlation Spectroscopy Instrument Integrated Team (XCS-IIT) to the report of the XCS PIDR (included as attachment at the end of the present document).

1 Scientific Goal

i No Comment

ii The Small and Wide Angle X-ray Scattering sections were always in the scope of the XCS instrument over the full range of the hard X-ray beam produced by LCLS (i.e 8-25keV). For now the SAXS section is however no longer in the scope of the XCS Instrument. The scientific capabilities of the XCS Instrument were refined with the XCS Team Leaders. The high energy range is of importance for the science to be produced for the XCS instrument, as it would allow widening the type of sample that could be experimentally investigated on the XCS instrument, as a result of smaller issues regarding beam damage for higher energies. This will be re-emphasize during the next XCS Team Leader meeting to be held on Oct 19^{th}.

iii The XCS-IIT agrees with the review committee and expressed the request to LUSI management.

iv These issues are understood and were investigated by the XCS-IIT. This justifies the presence of the whole suite of diagnostics and apertures along the beam path, in order to transform any LCLS beam fluctuation into intensity fluctuations. By measuring these fluctuations, with the appropriate diagnostics, one can then normalize the experimentally measured data.

2 Technical Design

i This issues will be discussed with the XCS Team Leaders on Oct 19^{th}. A new approach taking in consideration this recommendation will be presented by the XCS-IIT.

ii The scheme to be presented to the XCS Team Leaders at the next XCS Team Leaders Meeting includes a change in the monochromatization process.

iii The XCS-IIT agrees. The recommended changes will be applied as soon as possible in the design of the XCS instrument.

iv The XCS-IIT appreciates the recommendation. To the extent possible both monochromator systems will be identical for the XCS and XPP instrument. In case the requirements differ, the XCS-IIT is ready to design its own monochromator system.

v This recommendation will be communicated to the Diagnostics and Common Optics Integrated Team in charge of the design of the diagnostics. The XCS-IIT supports strongly this recommendation.

vi The total number of optical elements which may interact with the beam is effectively large, but is required for alignment and commissioning purpose. In running mode of the XCS instrument (i.e while measuring experimental data) the number of such elements is much less (2 bounces monochromator, 2 mirrors and 2 transmission diagnostics only). These are in any case required to conduct the experiment. The optical quality, especially its coherent preservation character is considered in the design of each of these elements, as required to conduct experiment with coherent x-ray beams.

3 Value Engineering

i The XCS-IIT agrees. Even if the Large Angle Detector Mover is based on the design of the HERIX spectrometer of the Inelastic Scattering beamline of the Advanced Photon Source, its specifications are relaxed as compared to it.

ii The XCS-IIT will consider this recommendation in the design to the extent possible. For a certain degree of modularity of the sample-detector distance, it might be convenient and cost-effective to combine both approaches. More engineering design is required to evaluate that concept.

iii The XCS-IIT will also investigate different options and proceed to a detailed value engineering investigation of each option.

iv the XCS-IIT agrees and will discuss this issue with LUSI management.

v No comment.

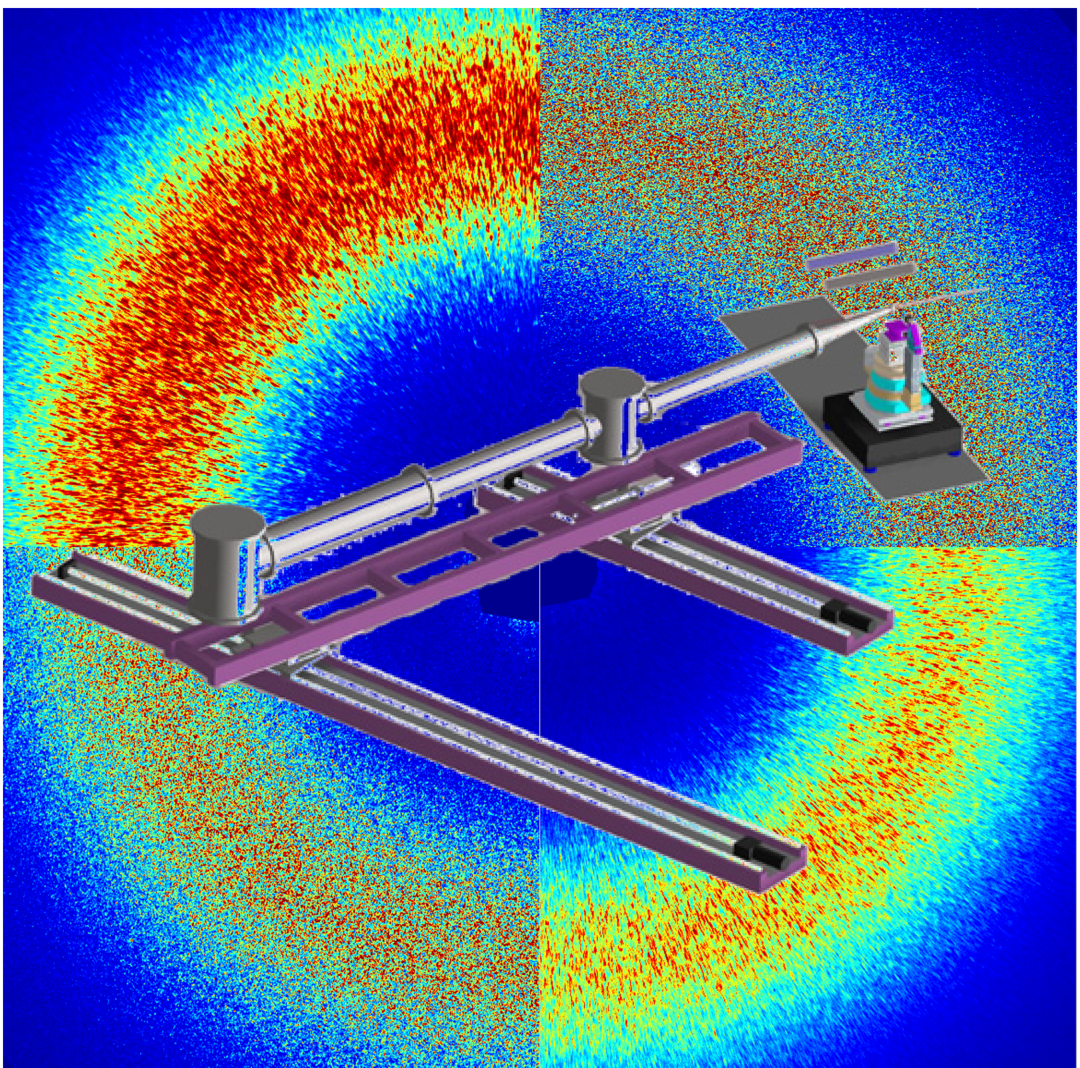
4 Opportunities

i No Comment

ii The current plan for the XCS instrument is to get a first prototype of Split and Delay Unit which perform at fixed energy. This prototype is provided by DESY via a SLAC/DESY MoU. The MoU also states that SLAC and DESY should collaborate regarding the development of the next generation of Split and Delay unit (i.e tunable wavelength). The details of this collaborations are not know yet in terms of its SLAC, LCLS, LUSI contribution. the XCS-IIT will make every effort possible to develop this technology at the laboratory.

Preliminary Instrument Design Review

X-ray Correlation Spectroscopy



07/25/2008

LUSI

LCLS Ultrafast Science Instruments

A. Robert
E. Bong

LUSI-LCLS-XCS Preliminary Design Review, Friday, July 25, 2008
SLAC-KAVLI Building, Room: 222

Reviewers:
E. Alp (APS), B. Brajuskovic (APS), T. Rabedeau (SSRL)

Presenters:
Aymeric Robert
Eric Bong

Also present from LCLS/LUSI: R. Boyce, S. Butet, Y. Feng, T. Fornek, J. Hastings.

Our committee was presented with the technical and scientific aspects of the X-Ray Correlation Spectroscopy Instrument (XCS) as well as budget and WBS.

We were very positively impressed with the technical, budgetary, and scheduling details given at the meeting. It is clear that what was presented is commensurate with the time frame and financial aspects of such a large project. We commend the technical staff and LUSI management for the work they have done so far.

Our committee was charged to review the project from four perspectives as follows:

1. Scientific Goals
2. Technical Design
3. Value Engineering
4. Opportunities

1. Scientific Goals

i) A. Roberts has completed a comprehensive survey of the current worldwide literature to determine the exact energy and momentum transfer map to identify the target domain for the XCS instrument. This survey is the basis of some of the critical scientific decisions with respect to energy and momentum transfer range.

ii) In addition to XCS, the scientific scope has been widened to include small-angle x-ray scattering, SAXS, and wide-angle x-ray scattering, WAXS, over 8-24 keV. This expansion may be difficult to realize with tight budget allocation. It may be advisable to split the low energy part and simplify the high-energy effort. Particularly, the large energy range between 8-24 keV is a major cost-determining factor. The science team is advised to re-visit this issue.

iii) One of the innovative aspects of the scientific program is to extend the time-resolved studies to nanosecond regime by implementing a “split-and-delay” instrument. While this is an exciting prospect, and some early work in Europe proves the feasibility for a fixed-wavelength, it remains to be seen if such an instrument can be developed fully tunable over a large energy range. The committee feels that, if this is part of the scientific program, the “split-and-delay” instrument itself should be included in scope, cost and schedule.

iv) There is a concern that the LCLS electron-beam based source fluctuations may limit the scientific program for XCS.

2. Technical Design

i) The committee was surprised to see the length and the number of optical components needed to bring the beam into the experimental area. Because of the complexity of the LCSL machine, and the need for diagnostics over 450 m length of the beamline, the choice of 60 cm horizontal off-set between XCS and CXI beamlines might drive the cost up. This should be re-visited after the exact locations of the XCS upstream components are determined. In particular, the location of the monochromator at 200 m upstream of the sample position may prove to be too long of a level arm, in addition to creating a need for a separate beam pipe and additional diagnostics.

ii) The need for the horizontal deflecting monochromator to operate between 8-24 continuously should be revisited. A tunable monochromator operating in the larger energy half of this energy range significantly complicates the design of the large offset monochromator, raises the cost of the monochromator, and potentially compromises its stability yet it is not well justified. Instead a fixed energy monochromator operating at some appropriate energy inside this upper energy range should be considered in addition to a tunable large offset monochromator operating in the smaller energy half of the energy range. This approach is more consistent with likely beam split and delay systems that will eventually replace the 8.3keV fixed energy system.

iii) Photon shutters after each diagnostic element is not necessary, and should be replaced with simple commercial actuators with a steel block at the end.

iv) The monochromator is supposed to be a common element, and to be duplicated for the XPS beamline, following a contingency plan. Thus any change in scope or implementation is to be coordinated. It may be better to decouple the two instruments, and if in the end, they turn out to be the same, two instruments can be ordered at once.

v) Position sensitive detectors with 4-PIN diodes may not have the sensitivity at low photon flux. So the diagnostics detectors should be re-considered. APD based system may prove to be a better alternative.

vi) There seems to too many “coherence-reducing” optical elements in the way before the x-ray beam hits the sample. We have counted some 20-bounces or filter transmissions. While the reduction in coherence at each element may be tolerable, when there are so many, the net coherence degradation should be a concern. The team is advised to look at this issue, and reduce the number of elements in the beam to a minimum.

3. Value Engineering

i) The long-arm detector mount, LADM, based on the APS-HERIX design, may be overkill in terms of stability and resolution requirements, and therefore a design simplification is recommended for potential cost savings. Specifically, for the XCS application only the detector position need be carefully controlled while the upstream end of the flight arm can be designed with much coarser position control hence cost. The APS HERIX instrument had to line up five elements (sample, slits, detector array, collimator and the analyzer array), thus the requirements were much more stringent. LUSI_XCS team can relax the resolution and the repeatability requirements for the upstream set of stages, and potentially save money.

ii) For the LADM, pipe dimension should grow as the x-ray beam progresses towards the detector to minimize the total weight.

iii) The granite block to move the diffractometer should be either eliminated or replaced with a cheaper design

iv) It was difficult to get a clean break down between instrument and effort costs, since some of the XCS instruments are common with the other two LUSI beamlines. We advise to remove this uncertainty soon to keep the schedule and cost tractable.

v) 35 % financial contingency is considered appropriate and adequate. Enough floats in the schedule is provided to allow LCLS management to adjust the work load during the simultaneous construction of 3 beamlines assuming the orally presented figure of 100 working days

4. Opportunities

i) The main XCS detector is to be built by BNL. Our review team considers this a wise decision and considers it the right way to go.

ii) The scientific opportunity to implement “split-and-delay” instrument is considered to be very important by our committee, and therefore, every effort should be made to include the construction of this critical component in the main program. However, it is also possible to consider a fixed-wavelength version of the instrument as Phase I, and delay the tunable “split-and-delay” instrument to a later period, after the beamline is completed, and early science experiments are done.