Agenda for the HENEX 100% Design Review

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1. Overview (John Seely, john.seely@nrl.navy.mil)
2. Optical Design (Larry Hudson, larry.hudson@nist.gov)
3. Mechanical Design (Layne Marlin, lmarlin@ssd5.nrl.navy.mil)
4. Electronic Design (Rob Atkin,ratkin@tigerinnovations.com)
5. Interface/Sensor (Glenn Holland, gholland@ssd5.nrl.navy.mil)
6. Project (John Seely, john.seely@nrl.navy.mil)

Questions/comments: Please refer to presentation number 2.

REQUIREMENTS: NIF X-ray crystal spectrometer HENEX Survey Instrument

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Specifications as defined by expert user group:

• Energy range of operation	1 - 20 keV
• Temporal resolution	time-integrating
• Energy resolution $E/\Delta E$	≥ 300 (1 to 20 keV)
• Dynamic range	≥ 100
• Signal-to-noise	~ 10 for significant spectral lines
• Field-of-view	5 mm with variable slit
• Detectable fluence	1×10^{-6} J/cm^2
• Data acquisition and analysis time	≤ 1 hour

Recapping from the 65% Design Review

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Review of news from the 65% Design Review

- Using a large area detector, the entire energy range will be covered with 4 reflection spectrometer channels

- The transmission channel will be retained for low resolution redundancy, a center axis pinhole camera, and some information for E > 20 keV

- Instrumental resolution is limited by phosphor broadening ≤ 2 pixels ≤ 0.096 mm

(view in plane of dispersion)

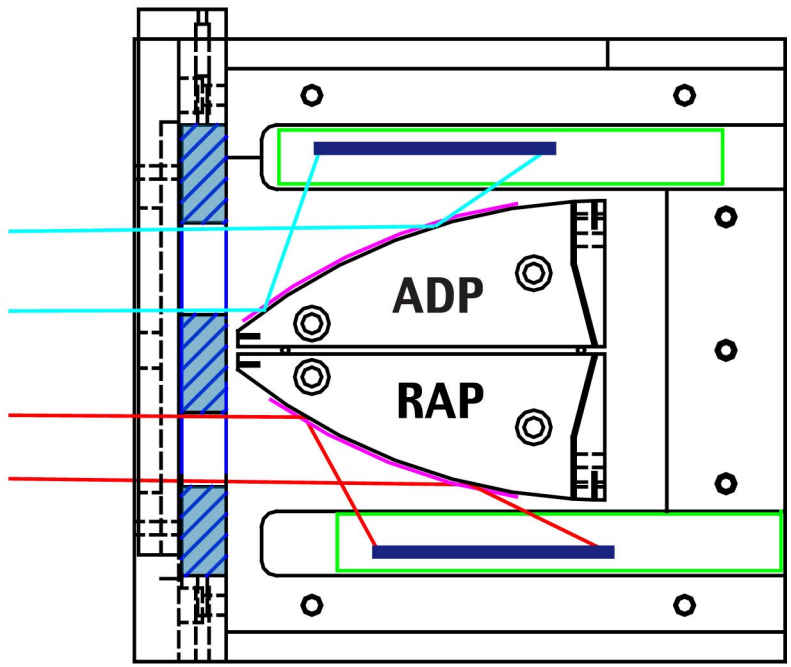
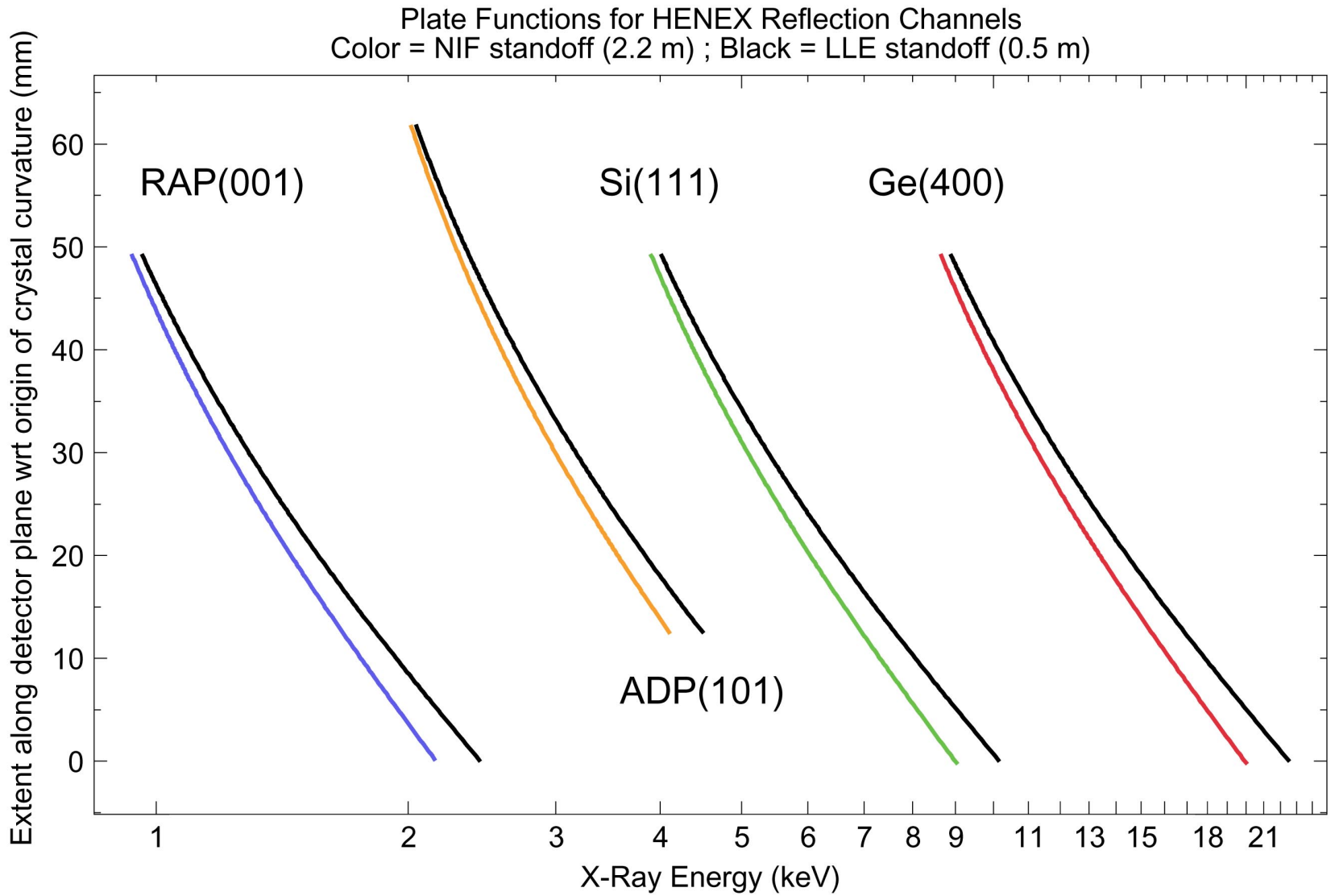
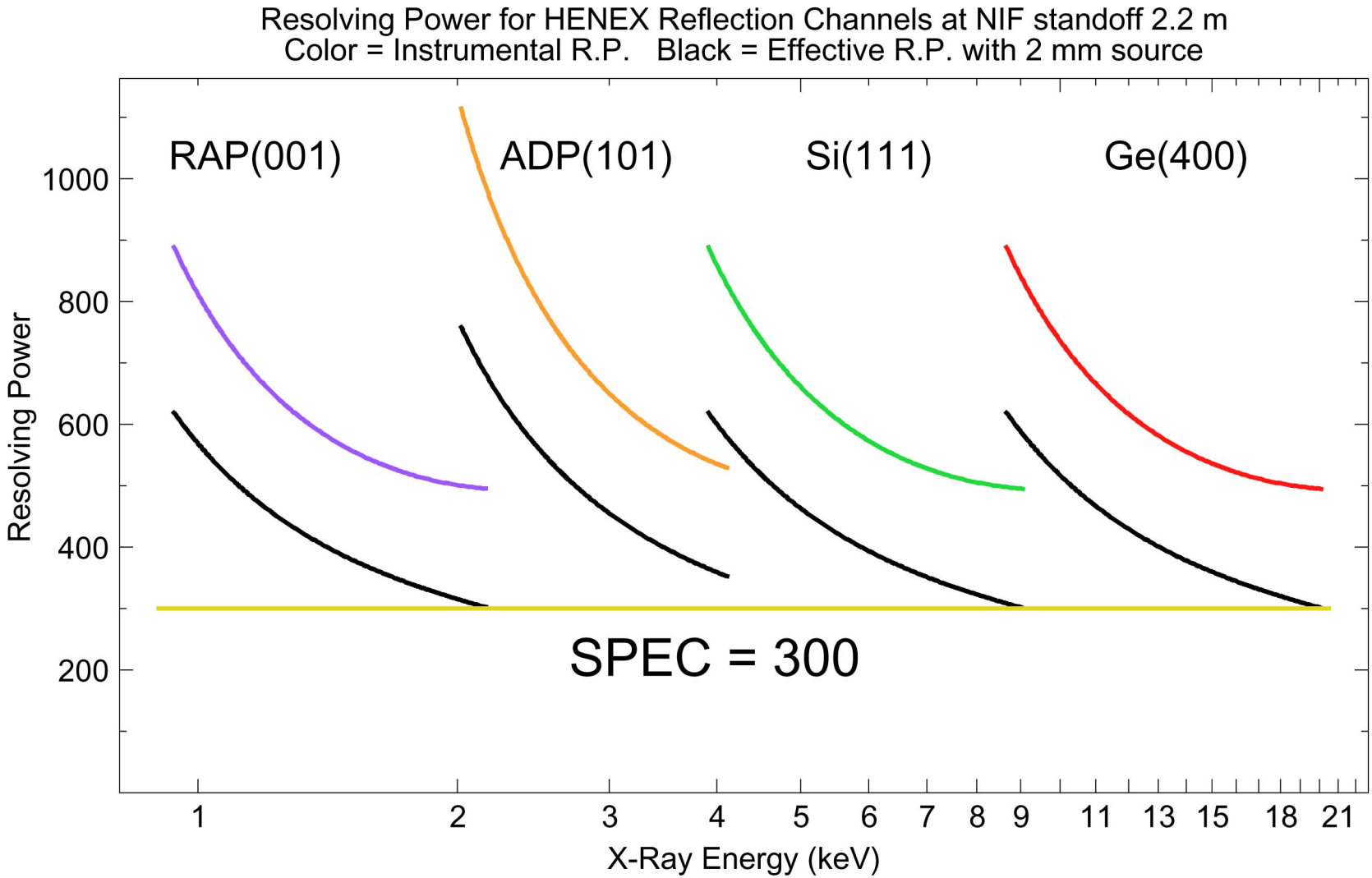


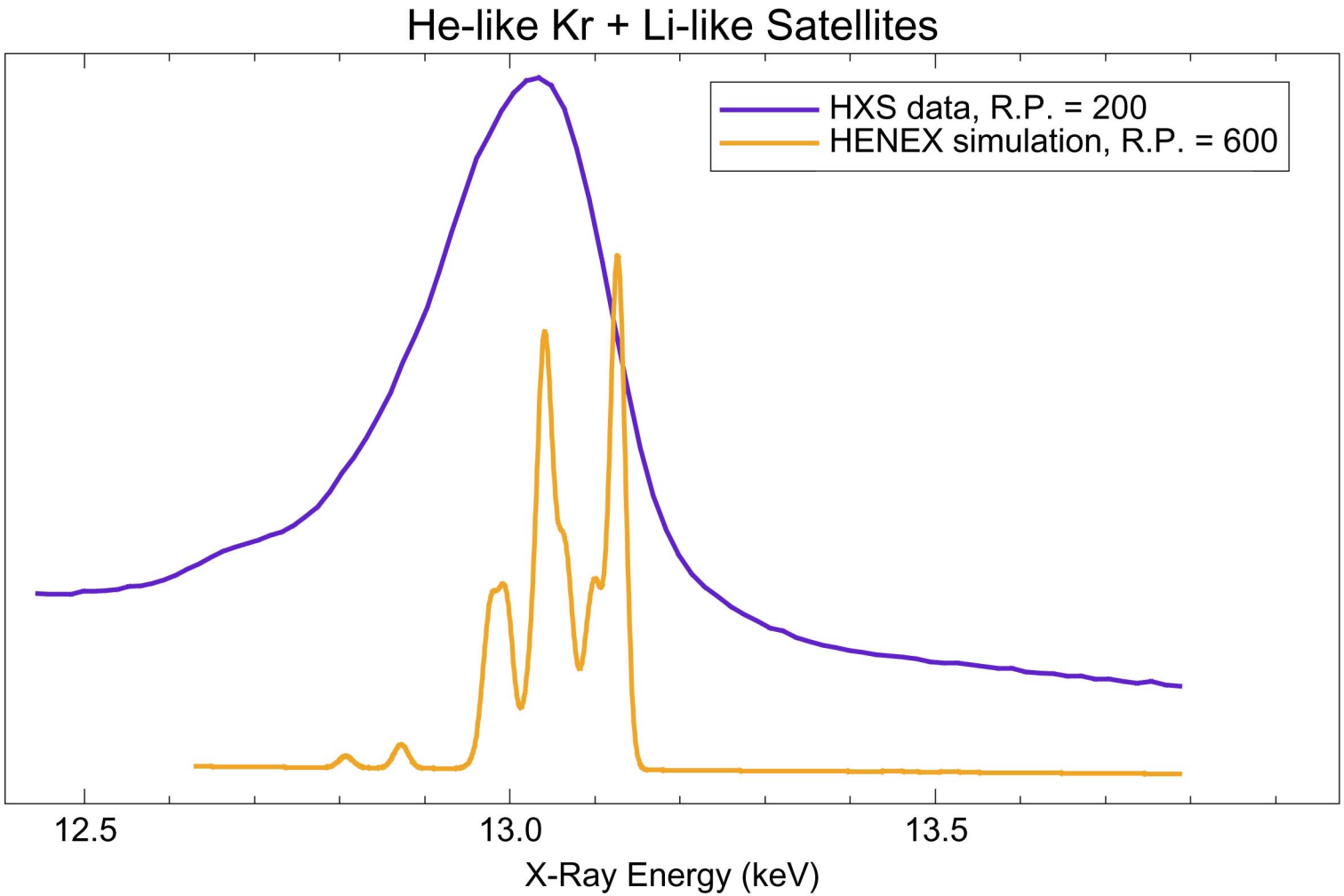
Plate Functions



Resolving Power



Modeling Expected Resolution



Detector Specifications

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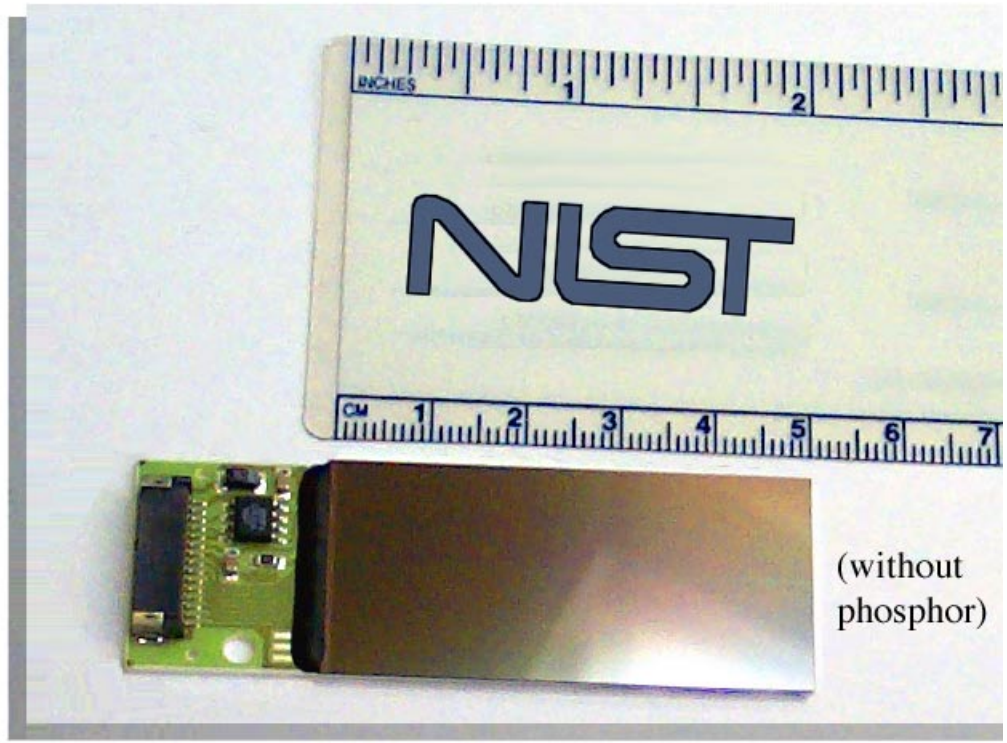
CMOS Detector

- 1024 x 512 pixels, 48 μm (49.2 mm x 24.6 mm)
- Time integrating
- 12-bit dynamic range
- Data acquisition time < 10 mins for all 5 sensors



Comparison of film and CMOS sensitivity

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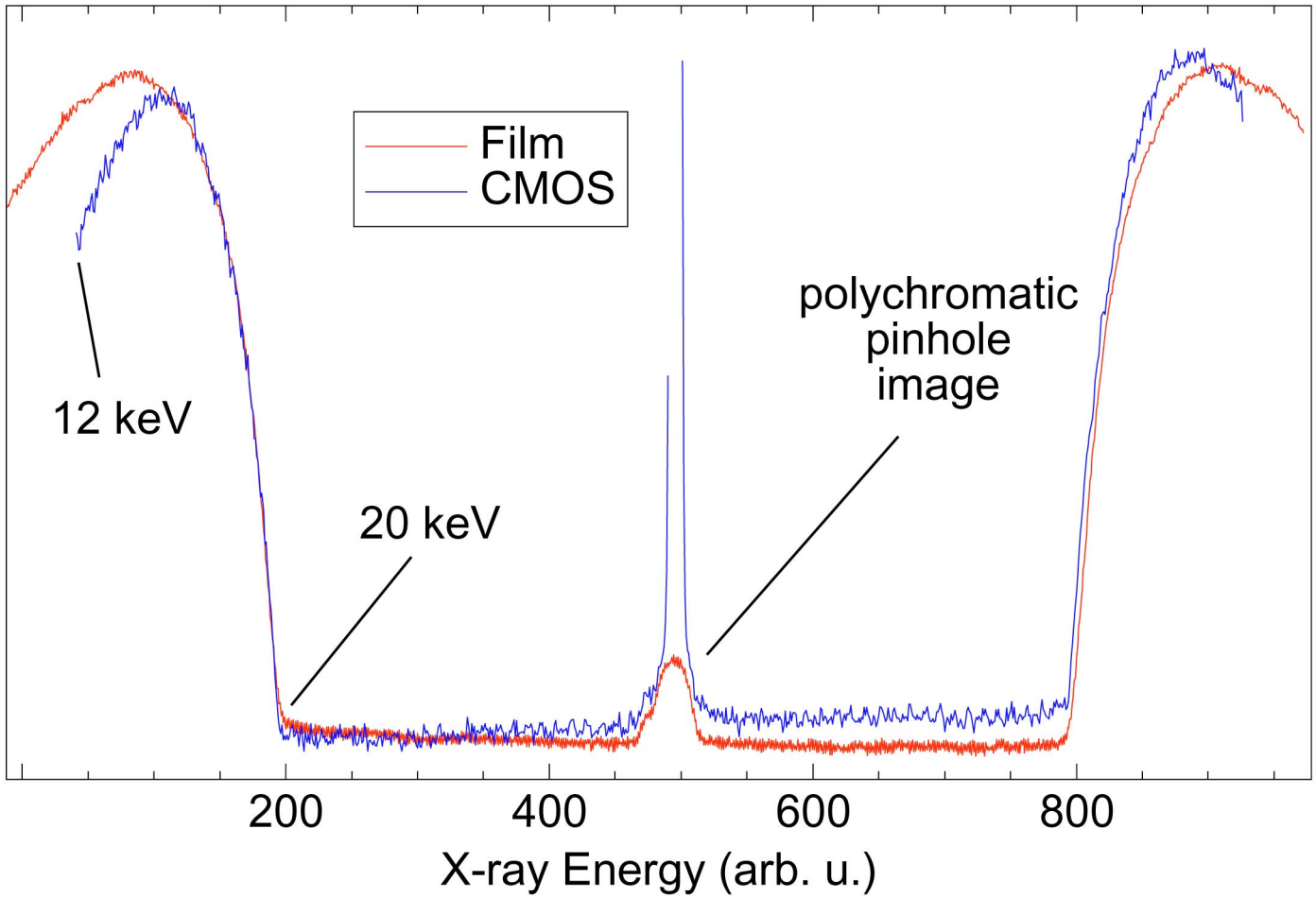
Identical 50 second exposures @ 20 kV , 1.65 mA



Nominal 5 mm Field of View

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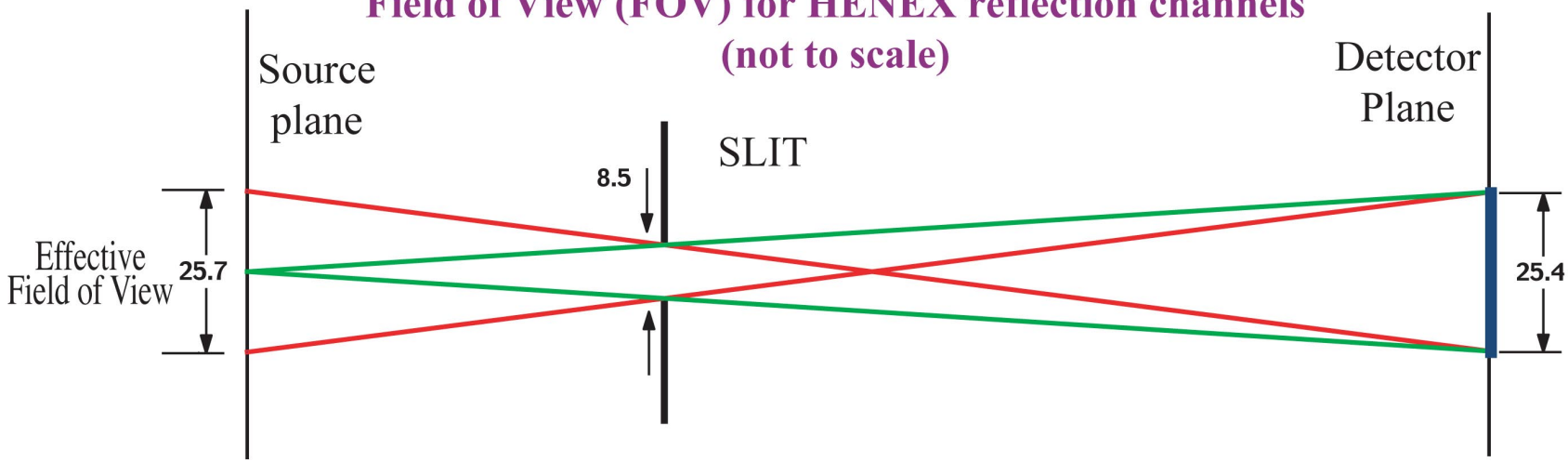
Field of View (FOV) for HENEX reflection channels (not to scale)



Entrance slits will be placed about 0.75 m from NIF TCC and about 18 cm from LLE TCC. They will be dimensioned such that each point from a source with 5 mm extent (nominal FOV specification) will be able to illuminate the entire crystal/detector. There is a much larger 'effective' FOV from which emissions will be partly registered or scattered and partly vingetted by the slits.

Independent variables (mm)				Dependent variables (mm)	
source to detector distance	Projected detector height	Source size	Source to slit distance	Slit size	Effective Field of View
2230 (NIF horizontal)	25.4	0	748.3	8.5	25.7
Effective FOV scales with source size and is much larger than the 5 mm nominal FOV.					
2230 (NIF horizontal)	25.4	5	748.3	11.8	30.7

Summary of the HENEX Optical Design

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HENEX Spectrometer channels at NIF Standoff Distance of 2.2 m

Crystal	Channel Number	Type	Energy Coverage (keV)	Instrumental Resolving Power*	Effective R.P. with 2 mm source size	Effective R.P. with 5 mm source size
RAP(001)	1	Reflection	0.9 – 2.1	888 - 495	619 - 301	322 - 145
ADP(101)	2	Reflection	2.0 – 4.1	1114 - 529	758 - 352	388 - 178
Si(111)	3	Reflection	3.9 – 9.0	888 - 495	619 - 301	322 - 145
Ge(400)	4	Reflection	8.7 – 20.0	888 - 495	619 - 301	322 - 145
Qz(10-11)	5	Transmission	11.4 – 28.0	280 – 100	165 @ 15 keV	158 @ 15 keV

HENEX Spectrometer channels at LLE Standoff Distance of 0.5 m

Crystal	Channel Number	Type	Energy Coverage (keV)	Instrumental Resolving Power*	Effective R.P. with 2 mm source size
RAP(001)	1	Reflection	1.0 – 2.4	803 - 439	185 - 76
ADP(101)	2	Reflection	2.1 – 4.5	1011 - 474	225 - 96
Si(111)	3	Reflection	4.0 – 10.1	803 - 439	185 - 76
Ge(400)	4	Reflection	8.9 – 22.4	803 - 439	185 - 76
Qz(10-11)	5	Transmission	12.9 – 28.0	236 - 100	146 @ 15 keV

Estimated Crystal Sensitivities

Crystal	Bragg angle Range (deg)	Reflectivity (rad) at E specified (for flat crystal geometry)	Relative Reflectivity at LLE standoff (curved crystal)	Relative Reflectivity at NIF standoff (curved crystal)
RAP(001)	12.7 – 30.4	9.0 e-5 @ 1.5 keV	The bent crystal sensitivities differ from that of the flat crystal due to geometrical factors, changes in mosaicity, extinction depths, and, in the case of quartz, the anisotropy of the inelastic stress tensor.	
ADP(101)	16.5 – 35.3	2.5 e-5 @ 3 keV		
Si(111)	12.7 – 30.4	4.6 e-5 @ 6 keV		
Ge(400)	12.7 – 30.4	1.8 e-5 @12 keV		
Qz(10-11)	2.4 – 9.8	2e-5 @ 15 keV		

*Resolving power calculations based upon a two-pixel resolution element (96 μm).

Instrument Validation and Calibration

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- Energy Calibration FY02
- Intensity Calibration FY04
- End-to-End, in vacuo, full cluster with electronics
- Performed at NIF and LLE source-to-diagnostic standoff distances
- De-mountable x-ray source
  - interchangeable microfocus electron guns ($\geq$2 keV & $\leq$30 keV ; 2 mA)
  - interchangeable anode materials
- Detector based radiometry with Ge detector
  - calibrated at BESSY II (PTB)