Calibration of the XGS-CAT

IXO

International X-ray Observatory

Norbert S. Schulz and the MIT/CAT Team

Scope:

- Motivation for R =>3000 below 1 keV (do we have science cases?)
- Specifications of the XGS-CAT (what do we have to offer?)
- The optical design on IXO (how does it fit in?)
- Wavelength Calibration on Chandra (how did we do it before?)
- Wavelength Calibration on IXO (how will we do it?)

Motivation for R =>3000 below 1 keV

Science cases [Why $\Delta v \ll 100$ km s^{-1}]::

- Coronal Dynamics at Pre-main-, Main-, and Post-main-Sequence

- Orbital Dynamics at O and C in CVs and X-Ray Binaries

- Dynamics and Turbulence in Cool, Warm, and Hot ISM Phases

- Distribution of Matter in Galaxies: ISM and IGM Phases

- Outflow Dynamics in Starburst Galaxies

- Warm Absorbers at High Redshifts

Coronal Dynamics in Active Stars

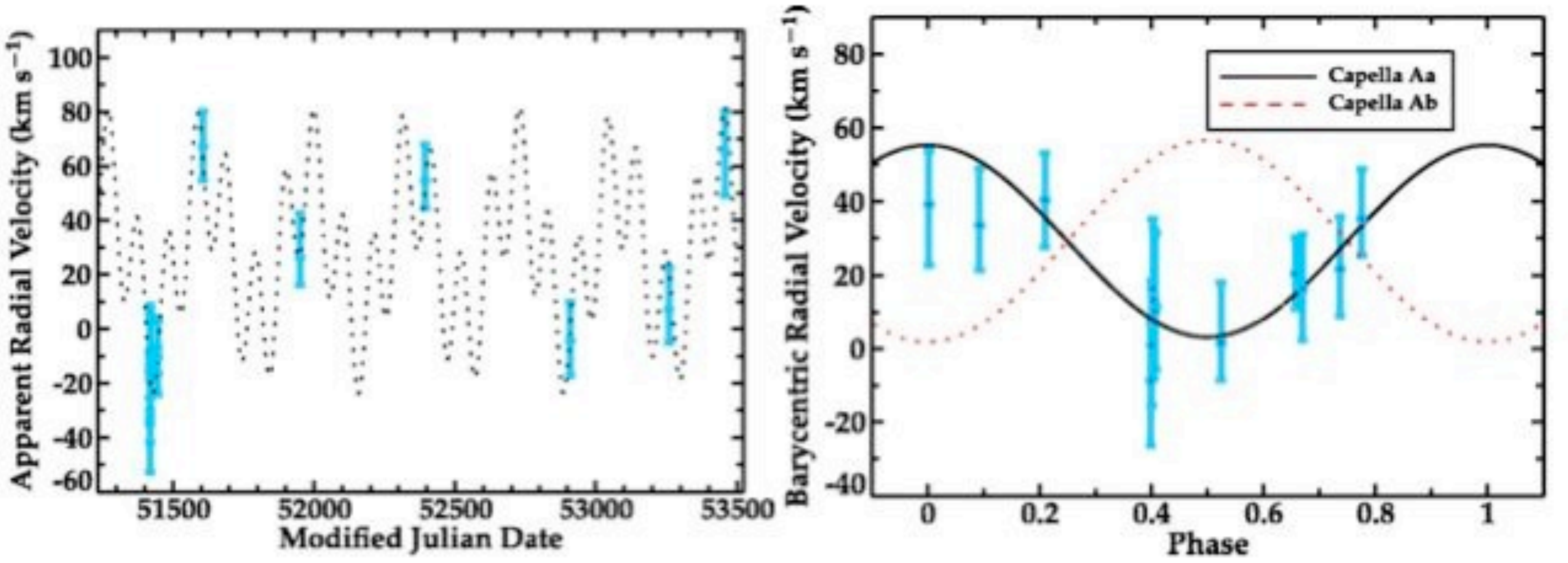
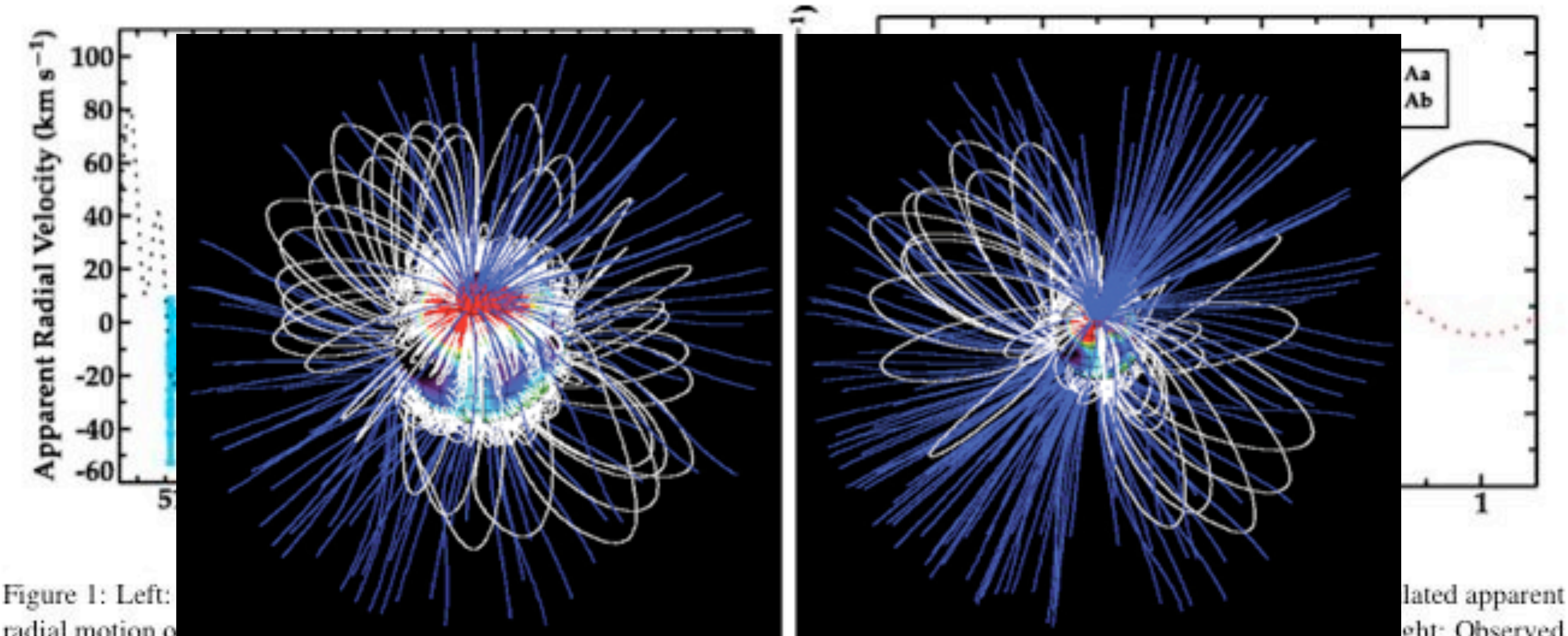


Figure 1: Left: Apparent radial velocities of Capella measured with the Chandra/HETGS. The dotted line shows the calculated apparent radial motion of Capella Aa viewed from Earth (including the barycentric, orbital, and systemic motion of Capella Aa); Right: Observed radial motion of Capella vs. orbital phase after barycentric correction. The measured radial velocity clearly follows the trend of Capella Aa (primary); 3σ error bars are shown in the plots. (Ishibashi et al 2006, ApJL 644, L117)

Motivation for R=>3000 below 1 keV

Coronal Dynamics in Active Stars



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Motivation for R>3000 below 1 keV

Accretion Streams in White Dwarfs

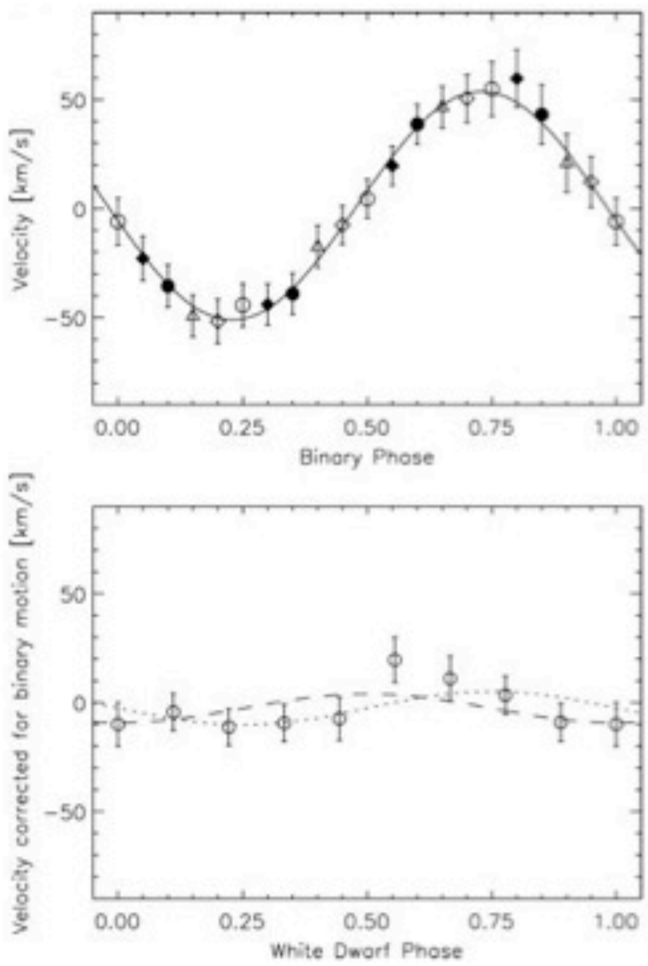


Figure 4: Top: CLP [Composite Line Profile] radial velocity vs. the binary period based on the first-order MEG data. Solid curve represents the sinusoidal fit to the data. The five sets of independent points have been indicated by different symbols (see 3.2). Bottom: CLP radial velocity (corrected for the binary motion) vs. the white dwarf spin period. The dotted curve represents the best-fit velocity curve corresponding to the rotation velocity of the white dwarf, and the dashed line represents the best-fit velocity curve corresponding to the infall velocity in the accretion column (see 3.3). (Hoogerwerf et al 2004 ApJ 610, 411)

Cool, Warm and hot Phases of the ISM:

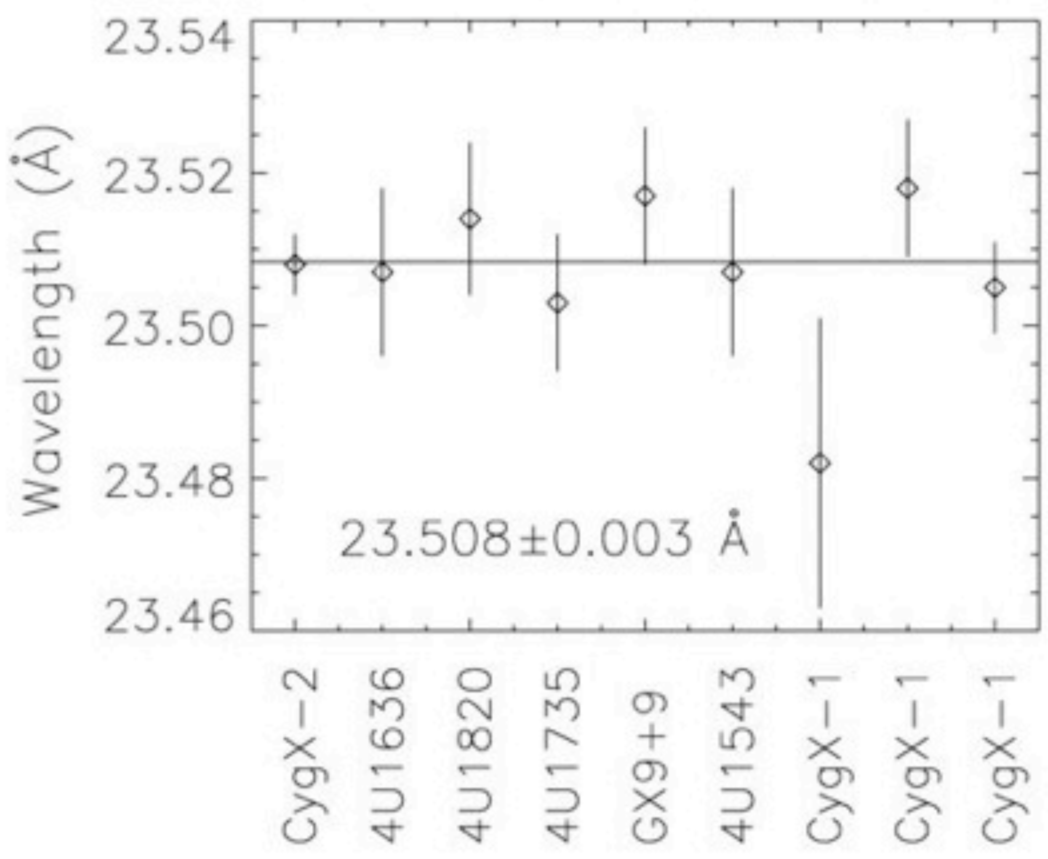
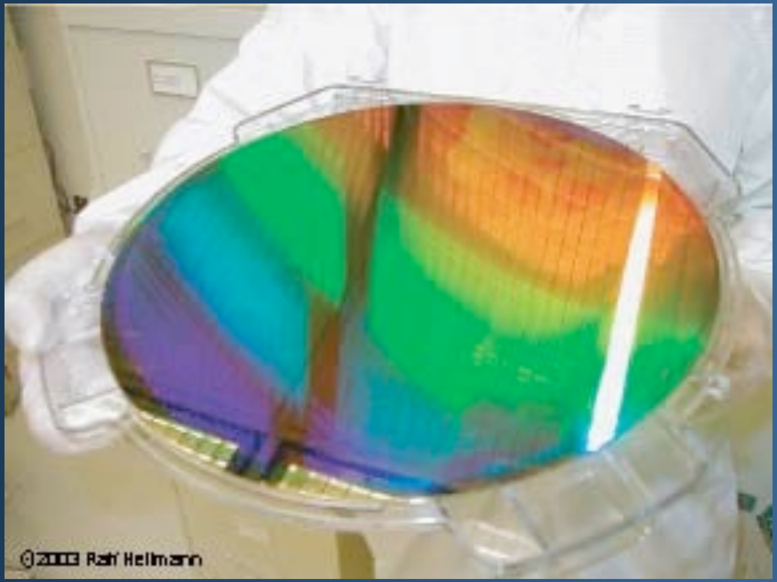
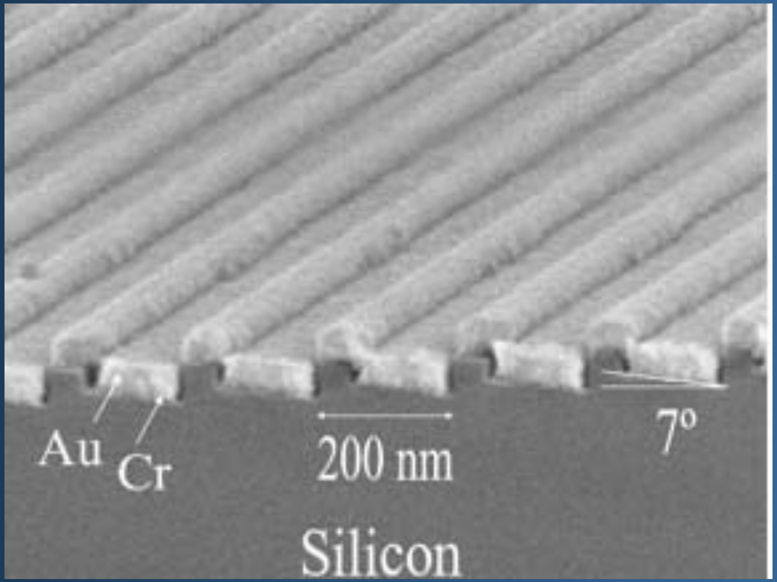
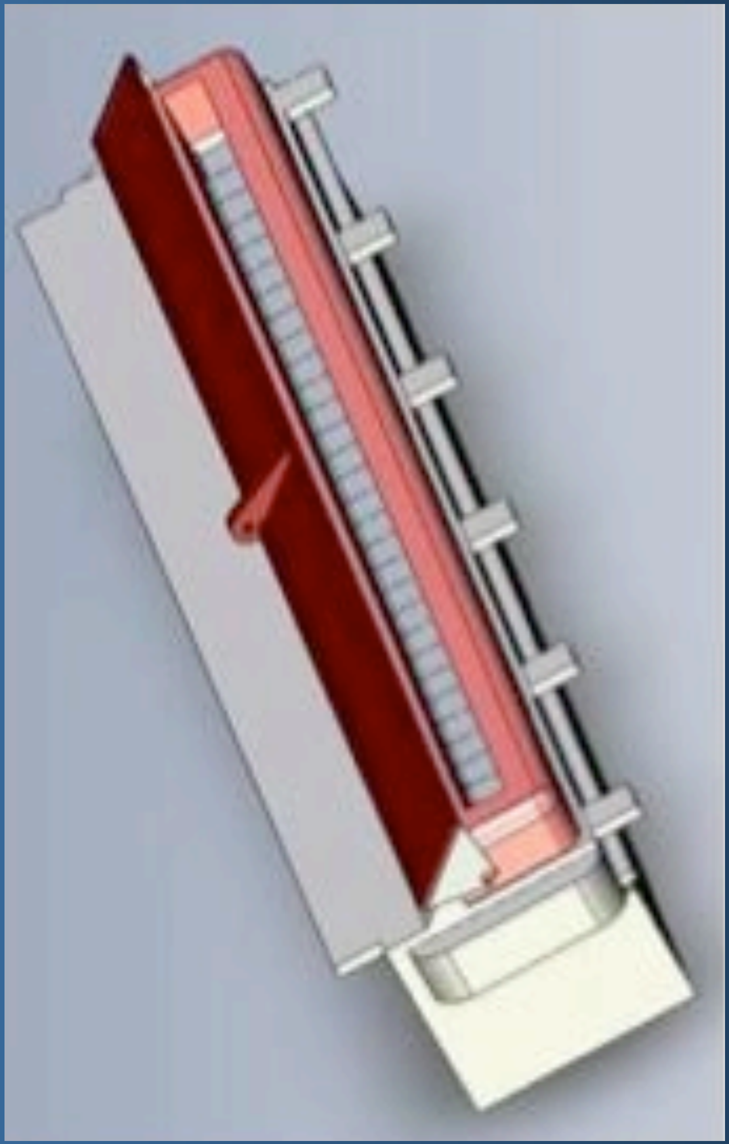


Figure 8: Best-fit position of the 1s2p absorption line from O I. The weighted mean value of the line position is given. The outlier is from the Cyg X-1 ObsID 107 data. All quoted errors are statistical errors only and do not include the instrumental wavelength error of ±0.011 Å (FWHM). (Juett et al 2004 ApJ 612, pp. 308-318) (one minor tick mark is ~ 64 km/s)


©2003 Ralf Hellmann


Au
Cr
200 nm
7°
Silicon



Specifications of the XGS-CAT

1.2 Instrument performance specifications

The performance requirements for the mission that are addressed by the CAT-GS are:

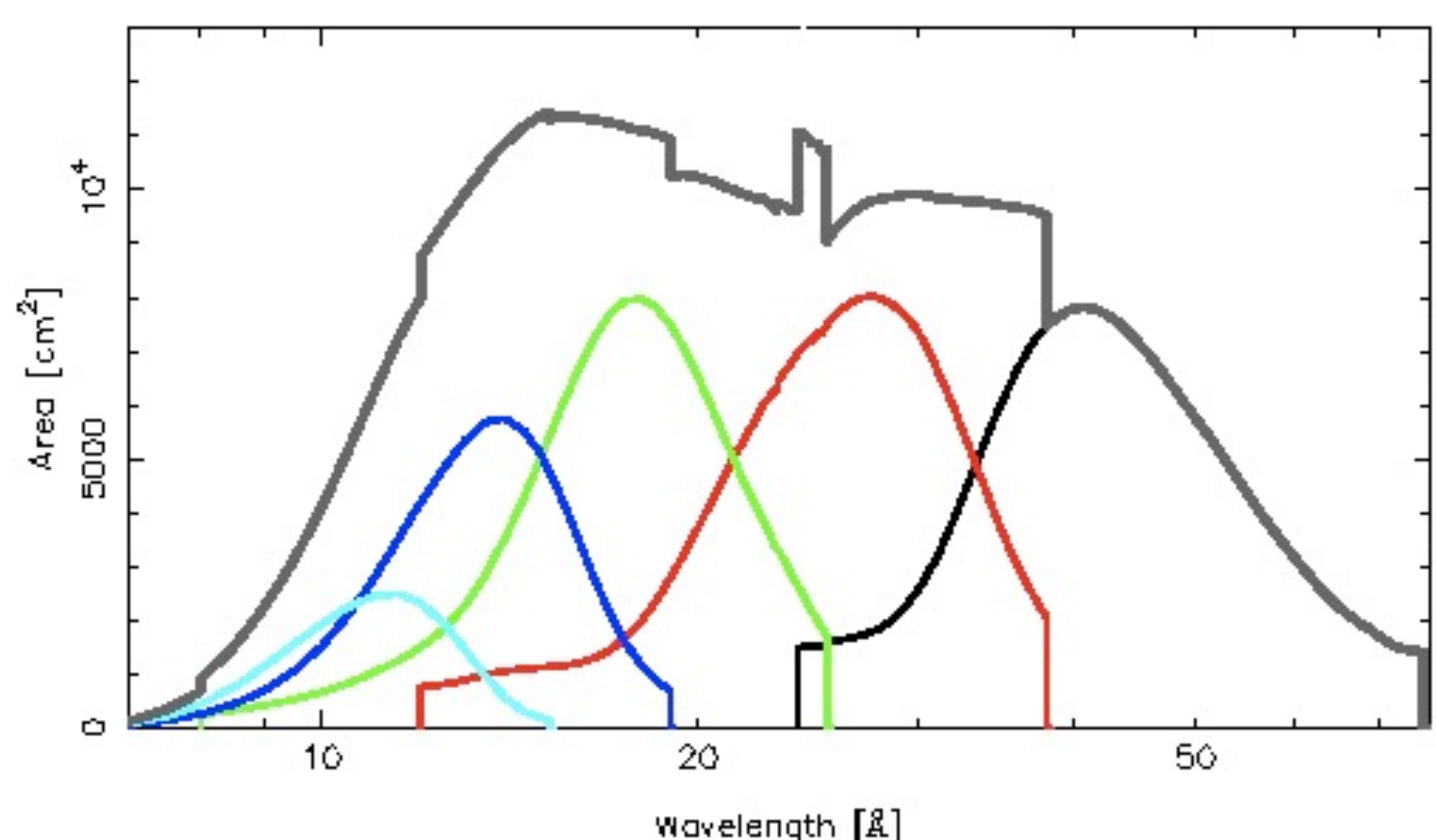
- Spectral resolution E/_E > 3000 (FWHM).
- Effective area > 1000 cm^2.

Both requirements apply to point sources in the energy band 0.3 – 1.0 keV. The CAT-GS will meet and exceed these requirements depending on fulfillment of the following other IXO key requirements:

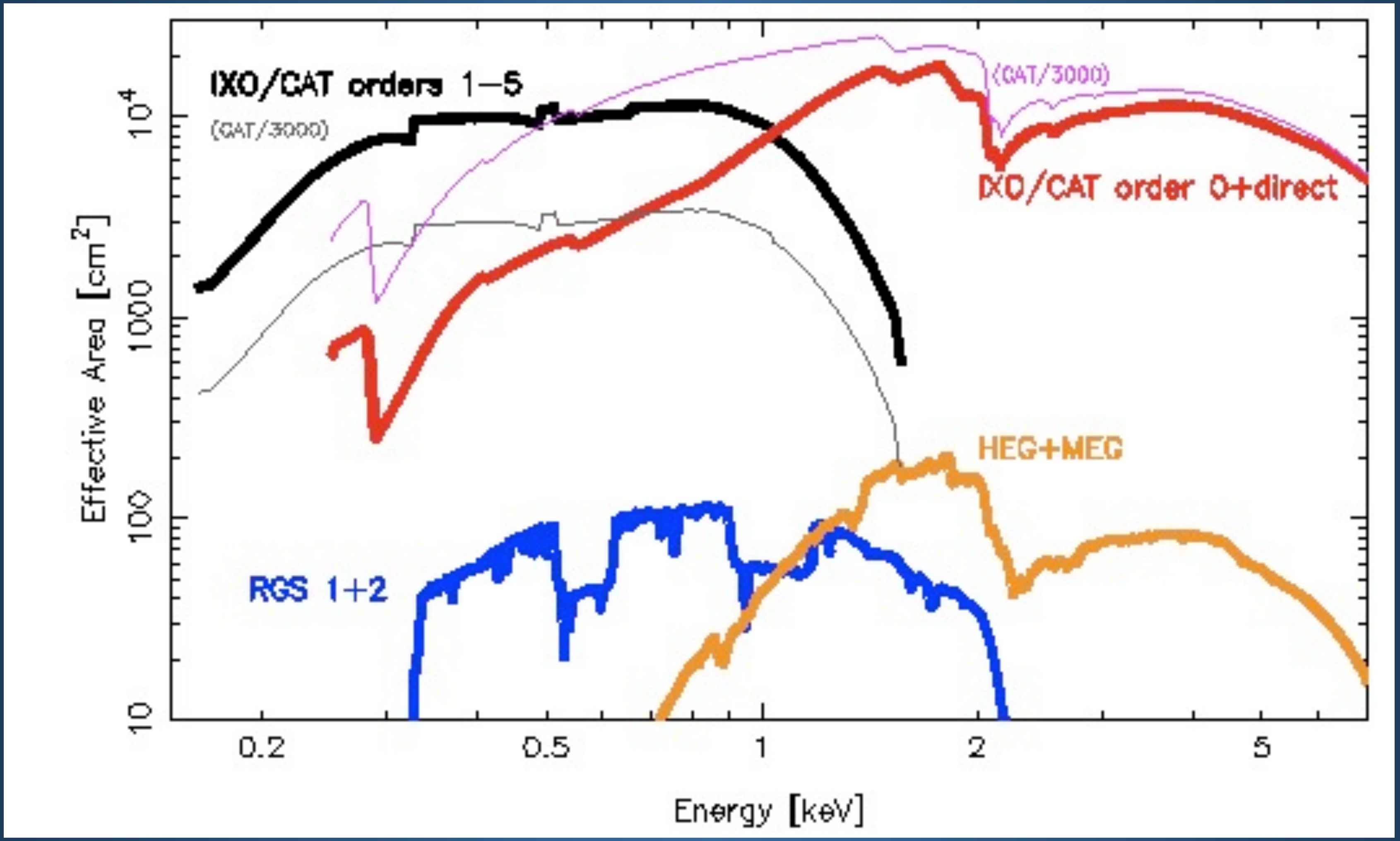
- Mirror effective area > 3 m^2 at 1.25 keV.
- Angular resolution < 5 arcsec (HPD) over the 0.3 – 10 keV range.

Furthermore, the effective area goal of > 3000 cm^2 can easily be obtained by increasing the area of the grating arrays with minimal increase in mass (< 10 additional kg), without any changes to the camera, and without compromising the spectral resolution requirement.

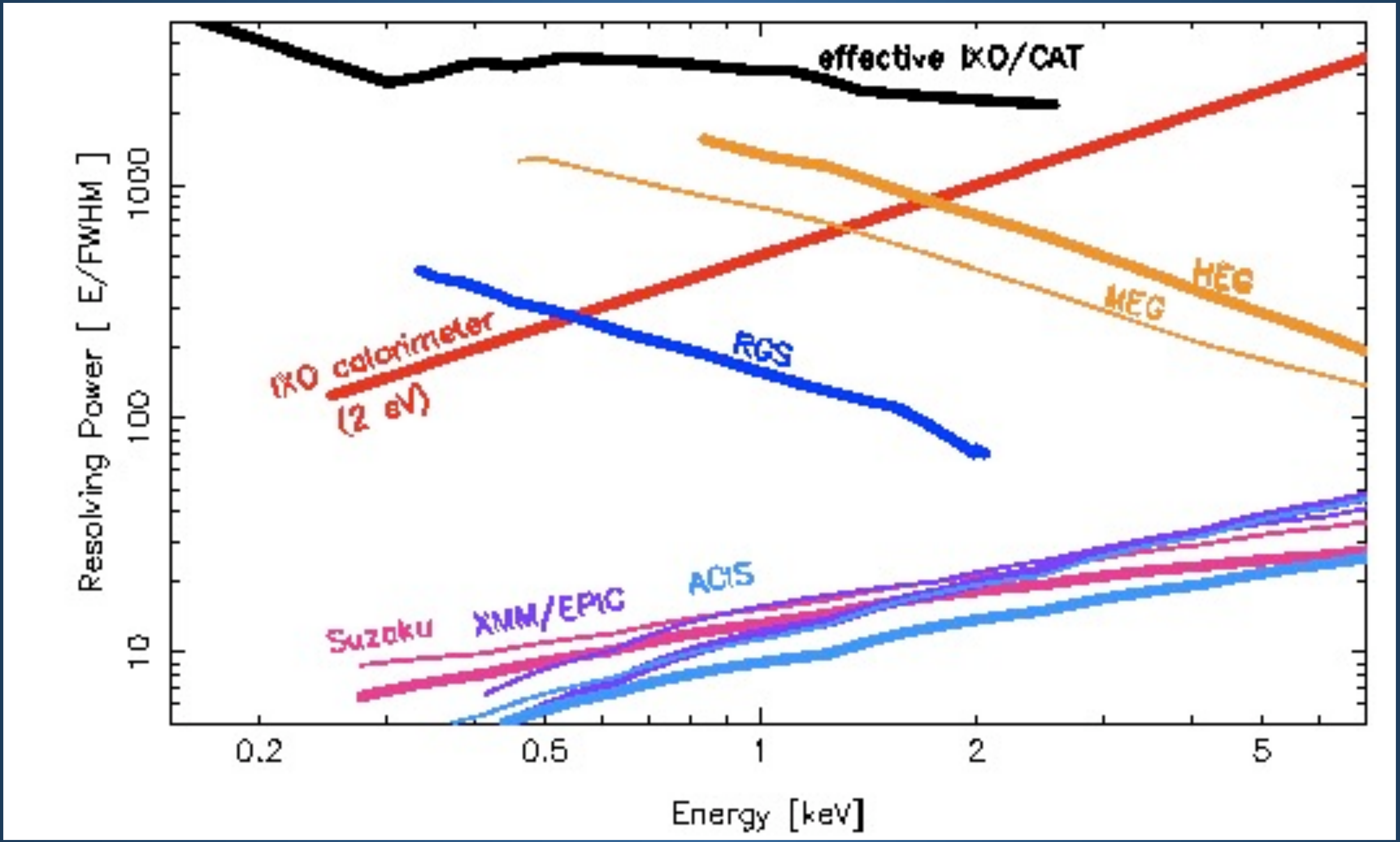
Specifications of the XGS-CAT



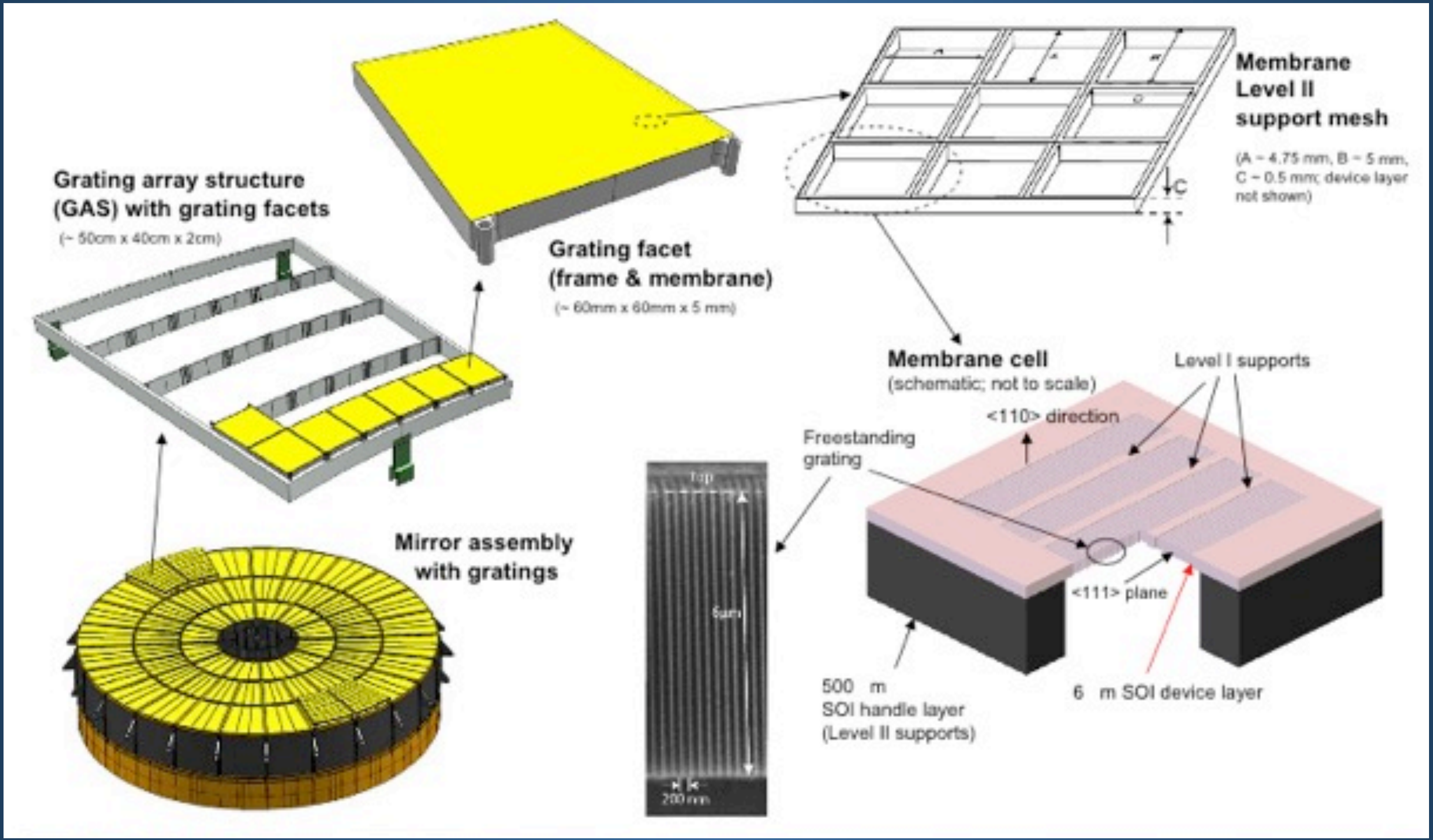
Specifications of the XGS-CAT



Specifications of the XGS-CAT



The optical design on IXO



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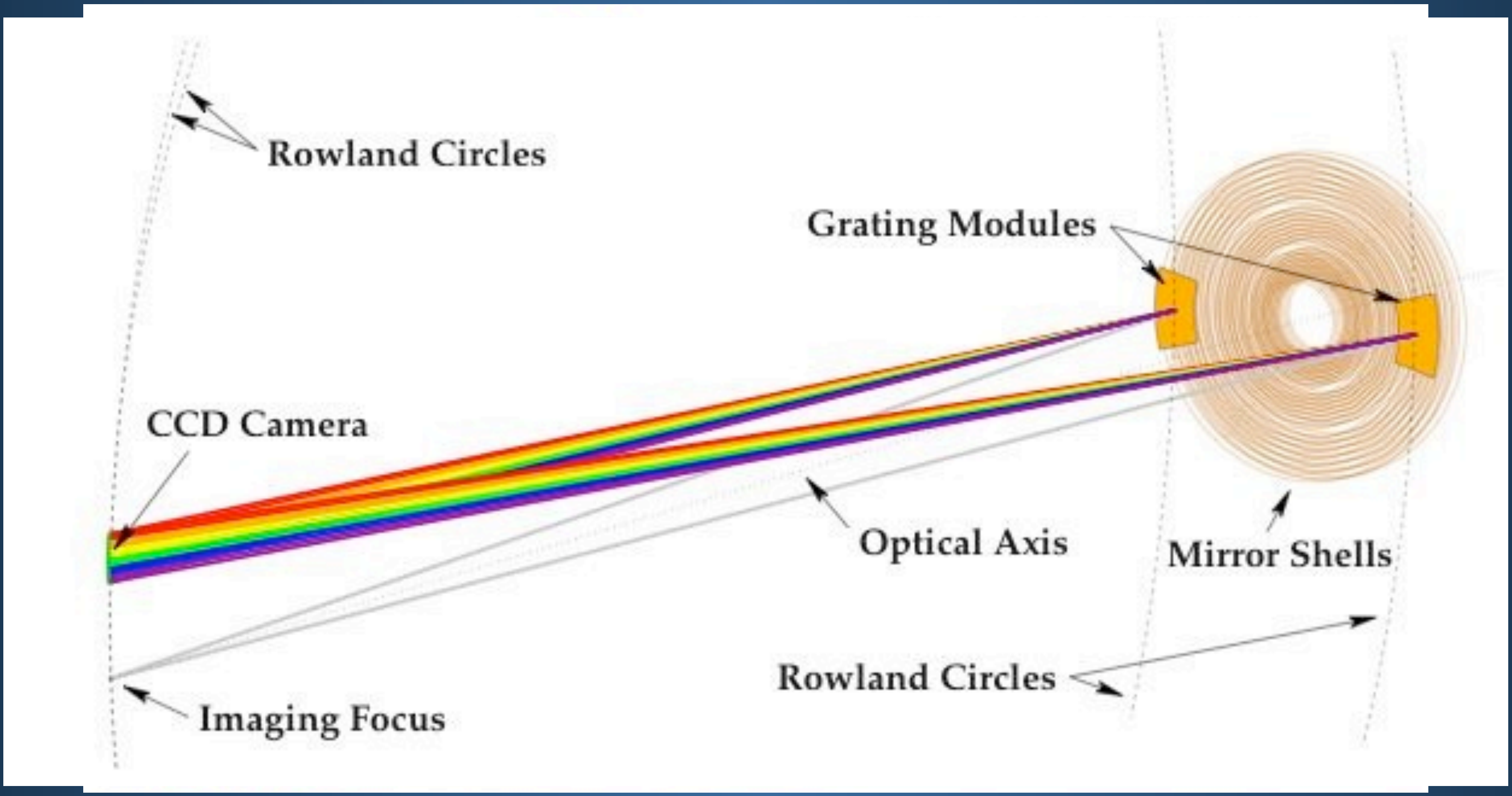

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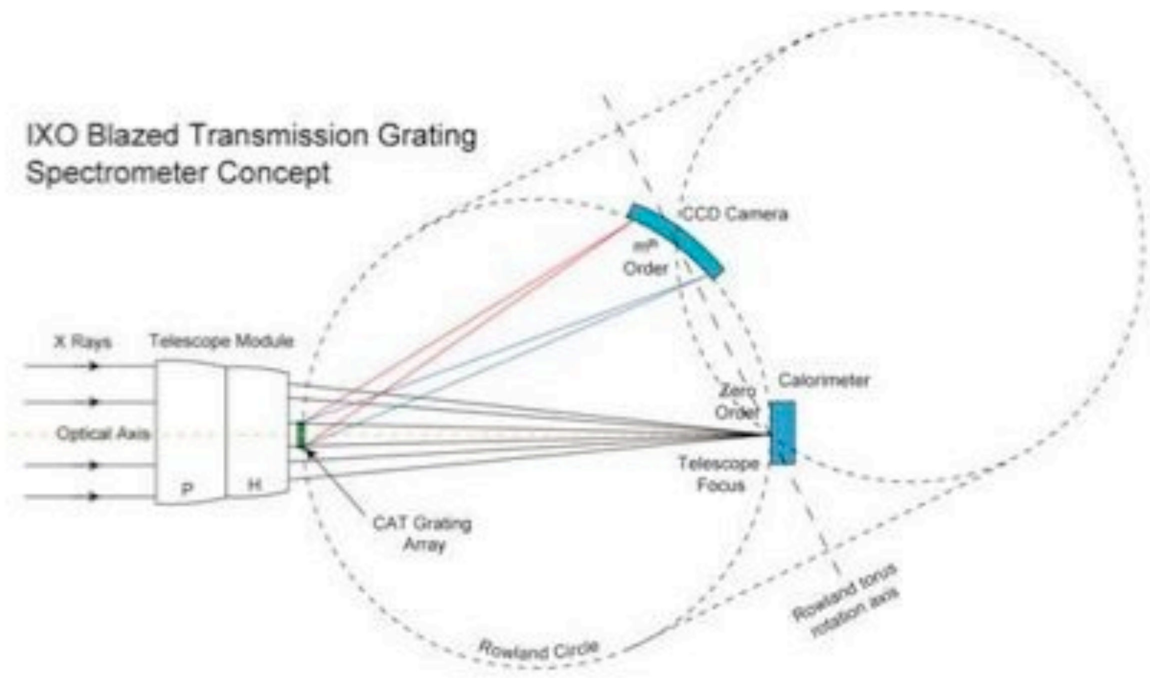
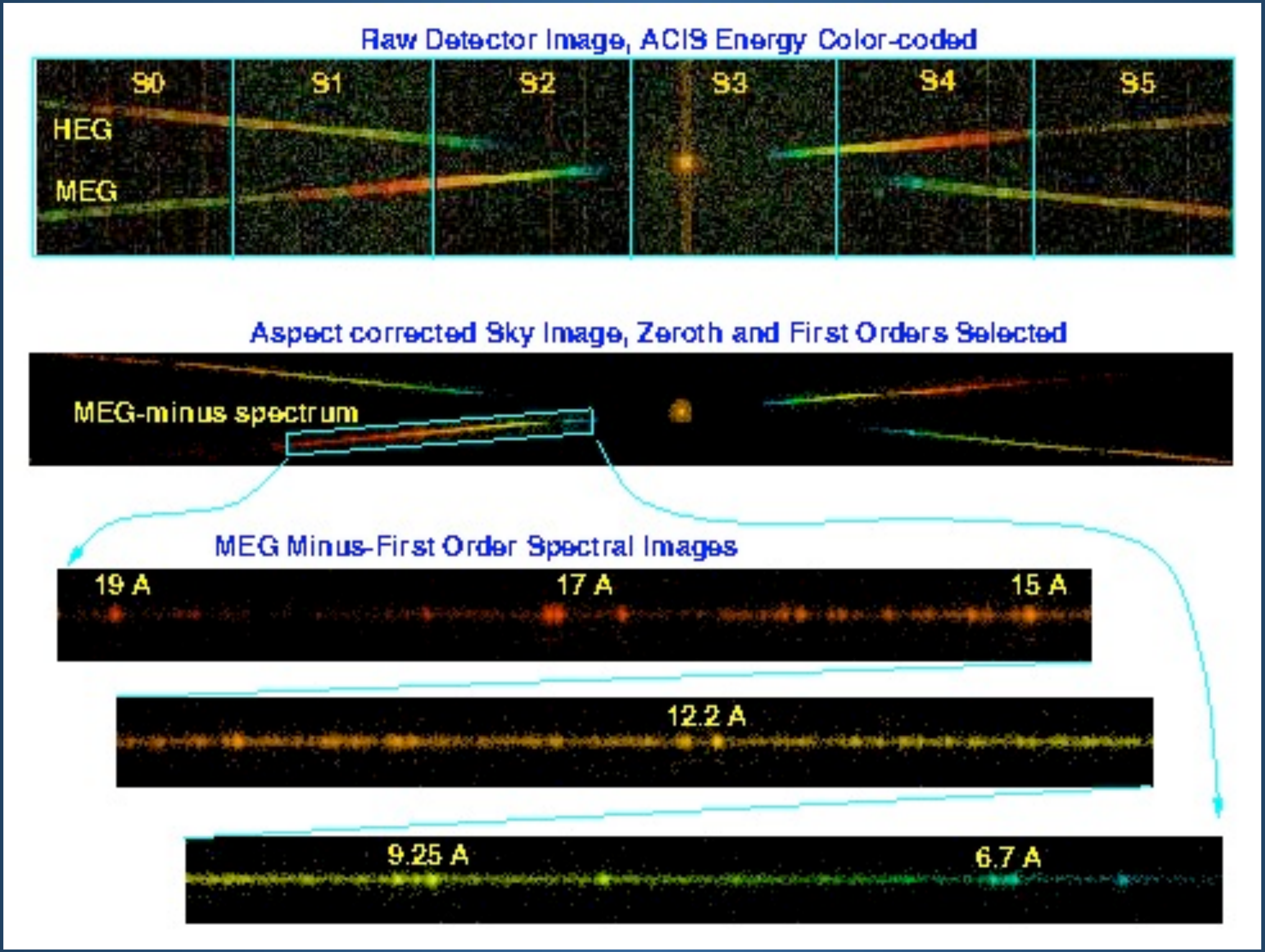
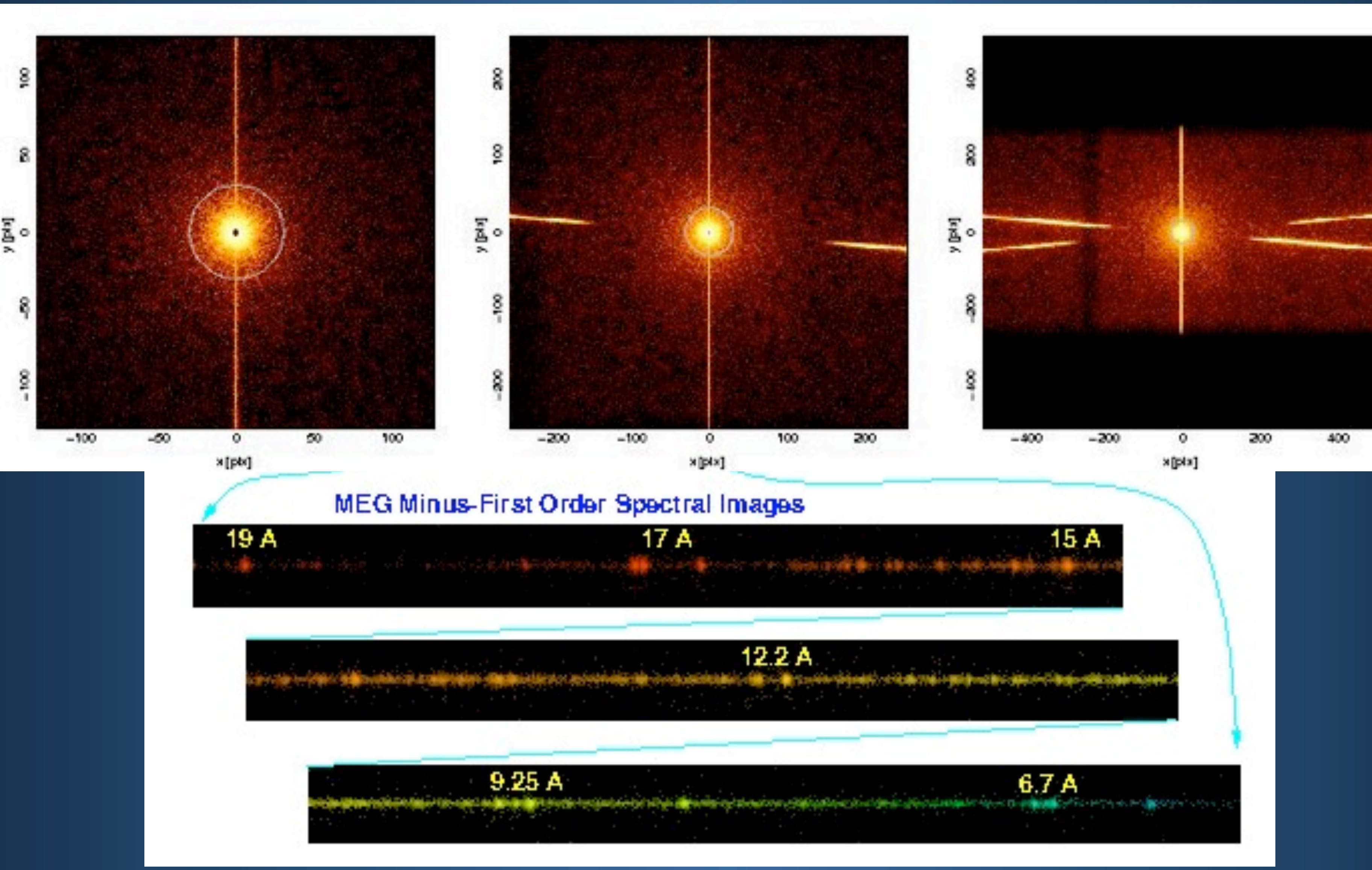
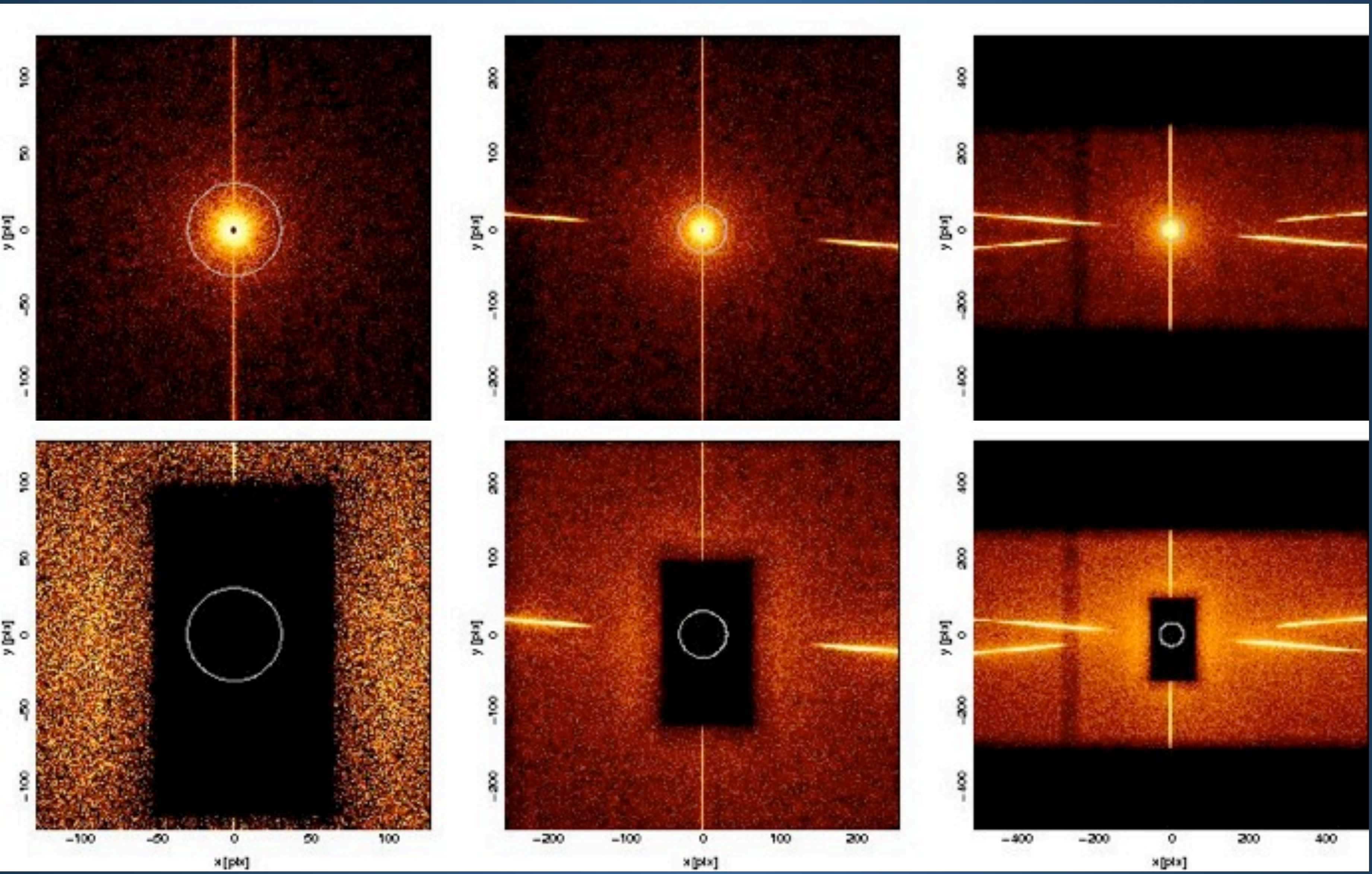


Wavelength Calibration on Chandra



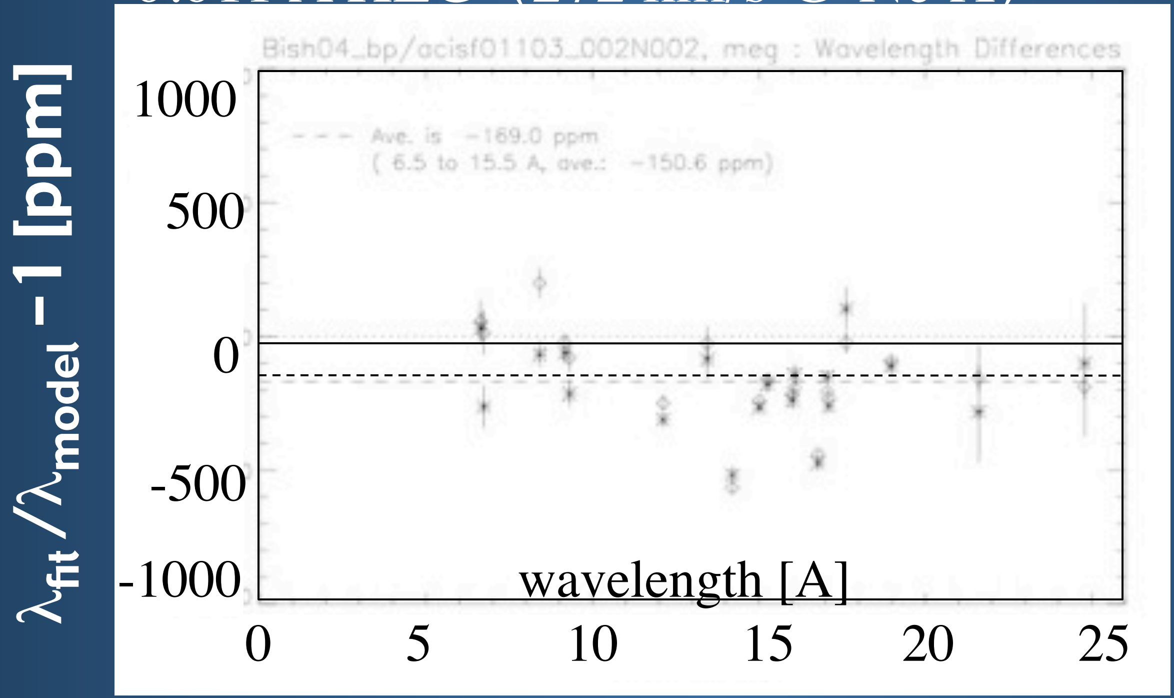
Wavelength Calibration on Chandra




y [pix]
x [pix]
-100
-50
0
50
100
-200
-100
0
100
200
-400
-200
0
200
400

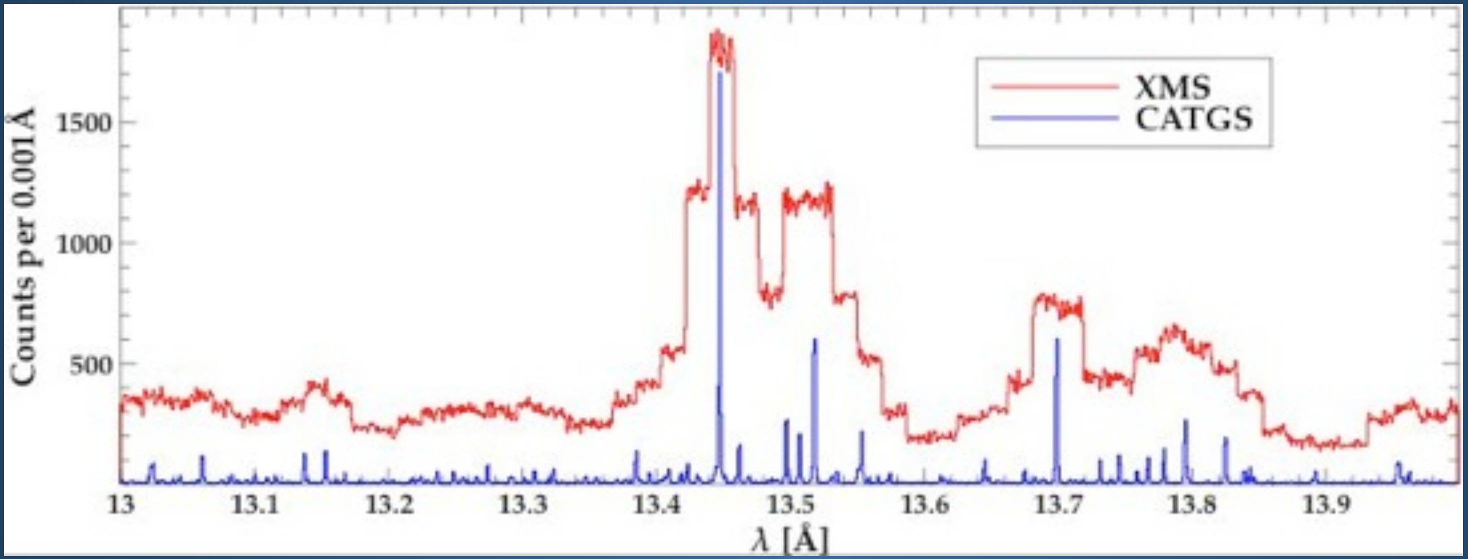
Wavelength Calibration on Chandra

- 2 grating types: MEG (400 nm), HEG (200 nm)
- 2 dispersion directions
- all grating orders on the same detector
- 5 devices with gaps & mis-alignments
- resolution: 0.021 A MEG (332 km/s @ O VIII)
  0.011 A HEG (272 km/s @ Ne X)



Wavelength Calibration on IXO

- 1 grating type: CAT (100 nm or 200 nm)
- 1 dispersion direction
- higher orders integral: wavelengths are a mix of orders
- zero order & grating orders on separate detectors
- 32 devices with gaps & mis-alignments
- dispersion spread over 33000 pixels (35 μm) = 115 cm
- resolution: < 0.007 A CAT 2/3 (110 km/s @ O VIII)
  < 0.007 A CAT 1 (48 km/s @ C edge)



Wavelength Calibration on IXO

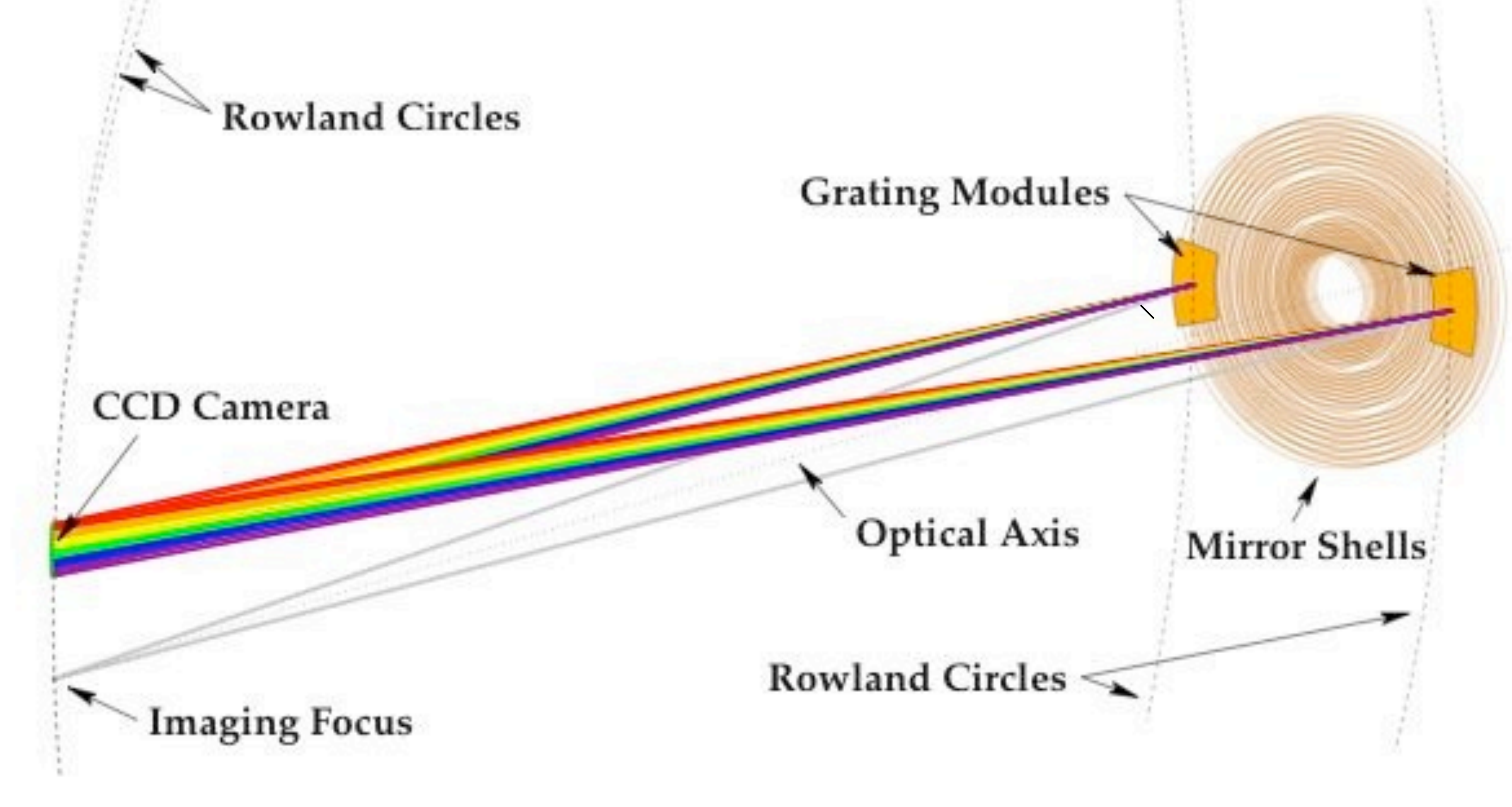
The IXO Science Requirements Traceability Matrix, Rev. 11 (SRTM) identifies an absolute energy knowledge of 0.25 eV (38 km s^{-1}) over the 0.3 - 2 keV (6 - 41 Å) band, and 0.16 keV (24 km s^{-1}) at 0.5 keV (25 Å)

→ wavelength accuracy 50 - 100 ppm

Strategies:

1. Calibrate wavelength scale with remote 0th order
2. Calibrate wavelength scale without 0th order
3. Calibrate wavelength scale with on-site 0th order

Strategies: The Claude Flat



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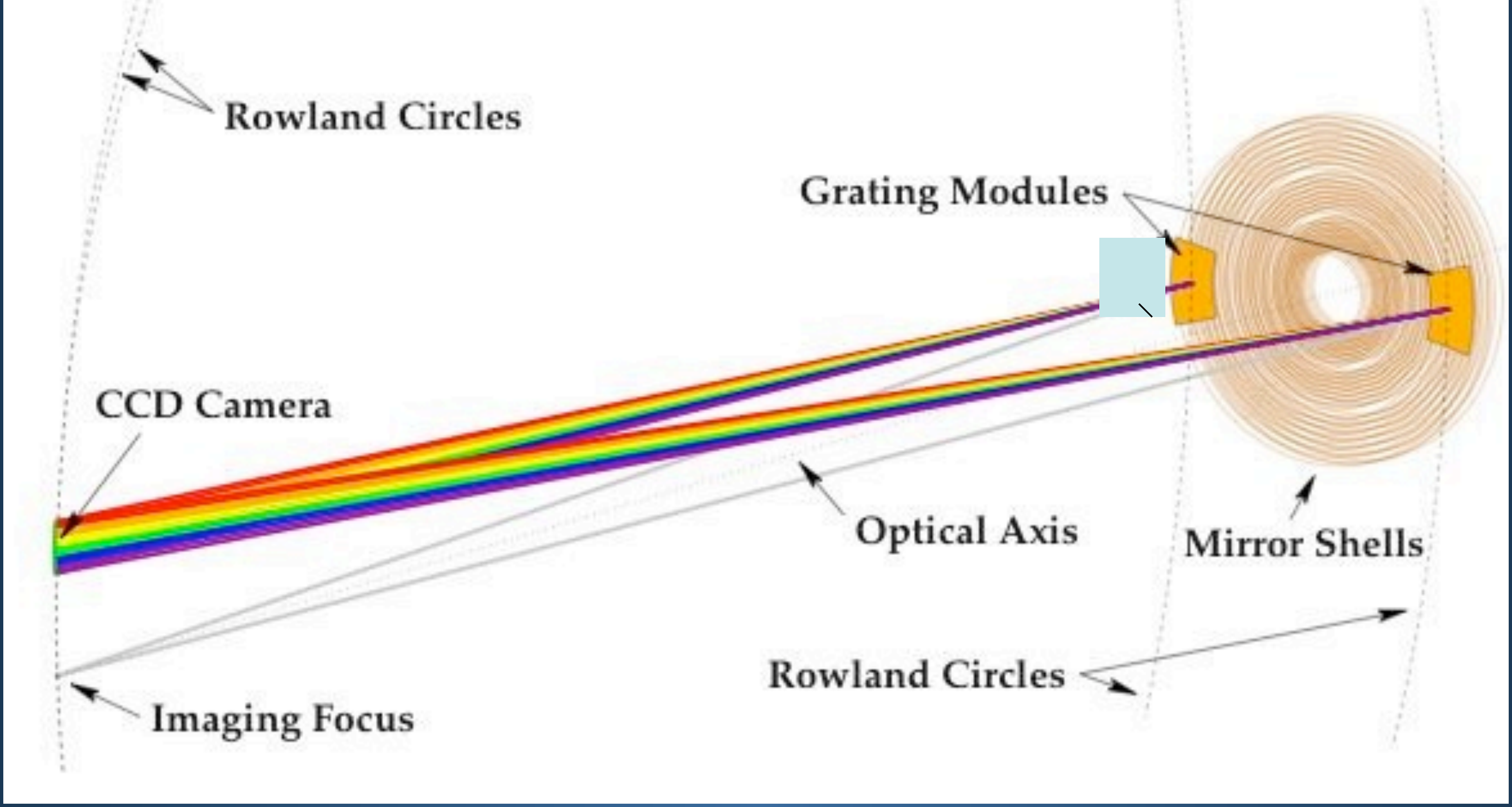

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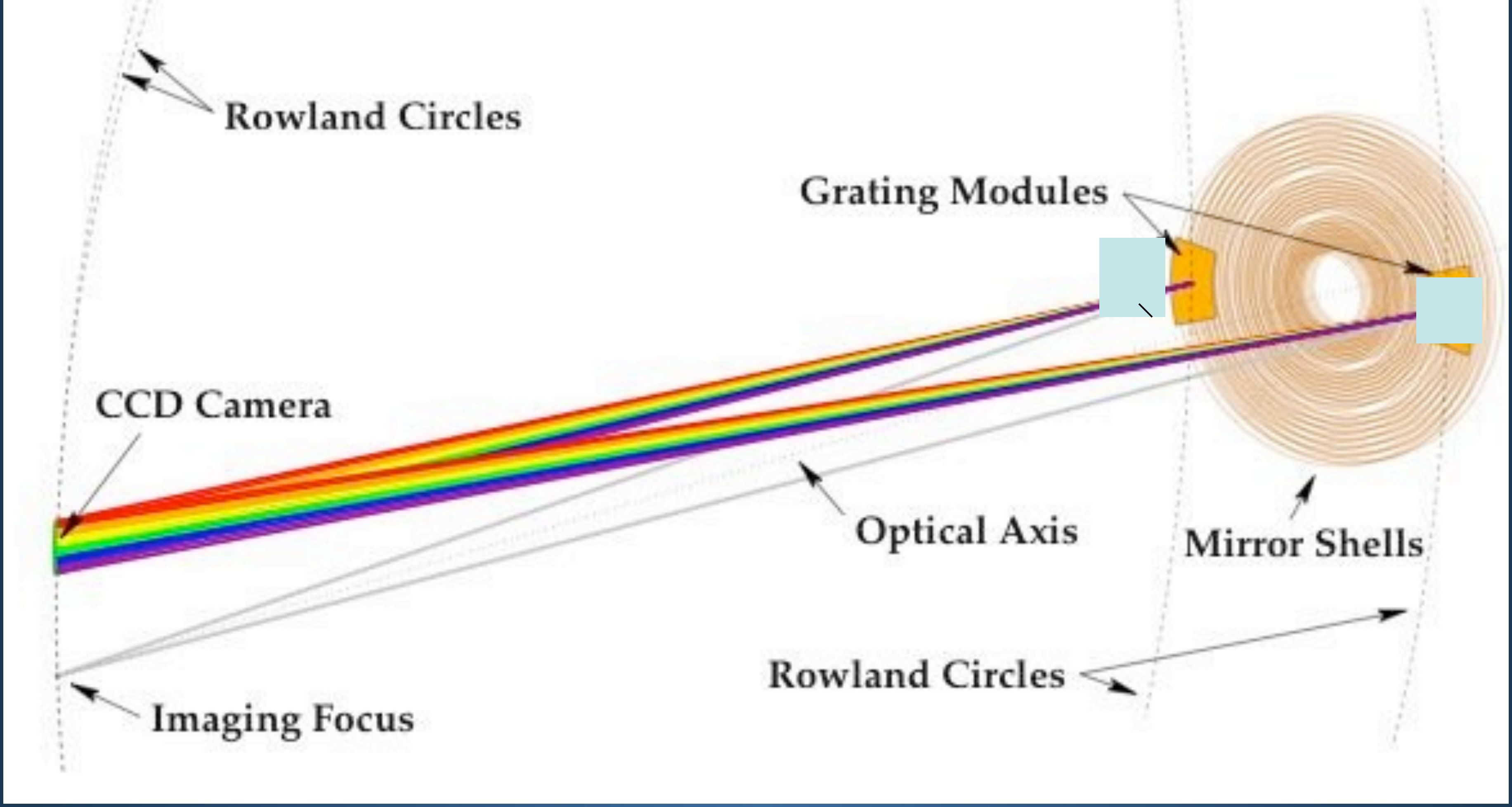

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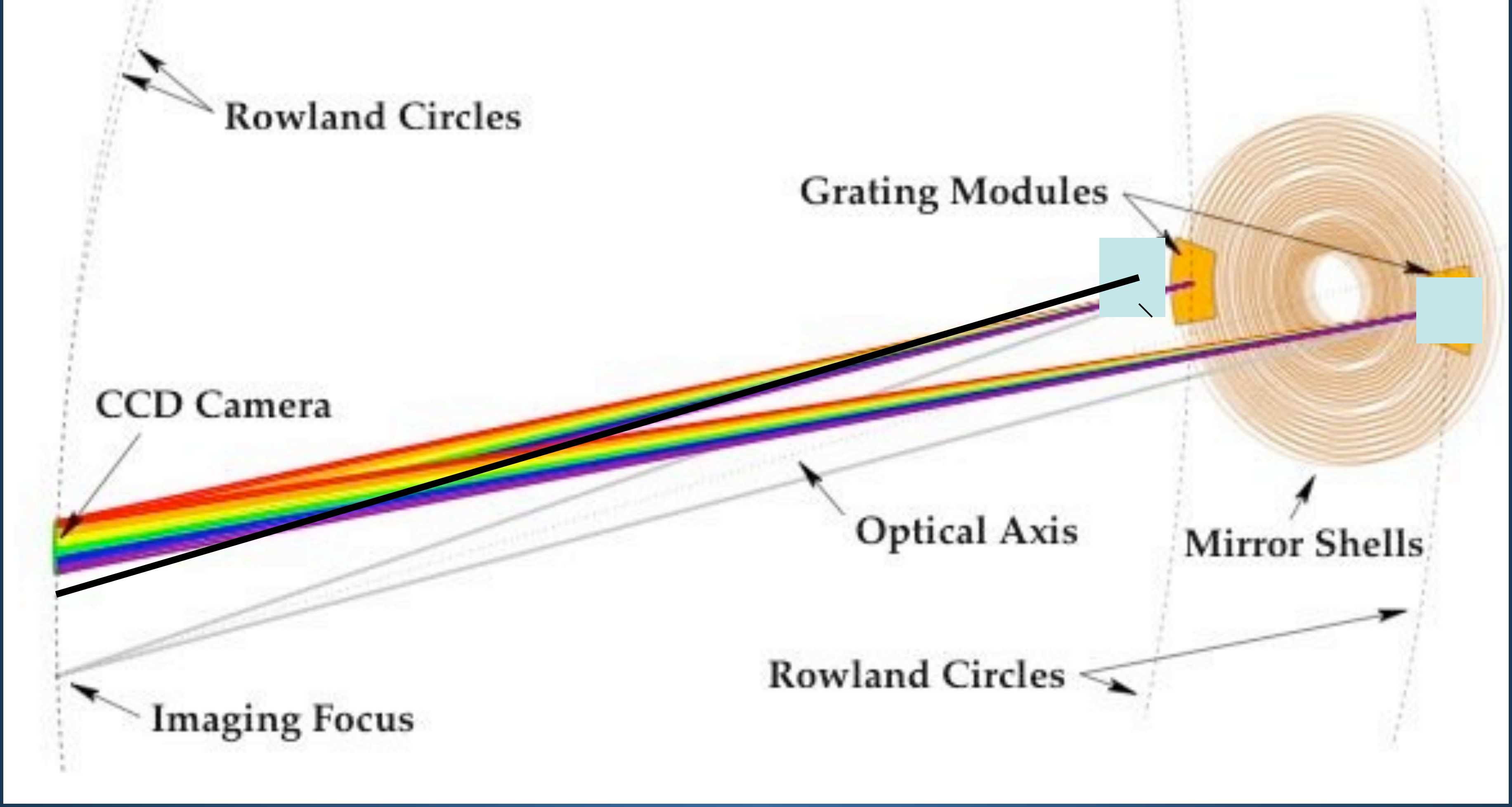

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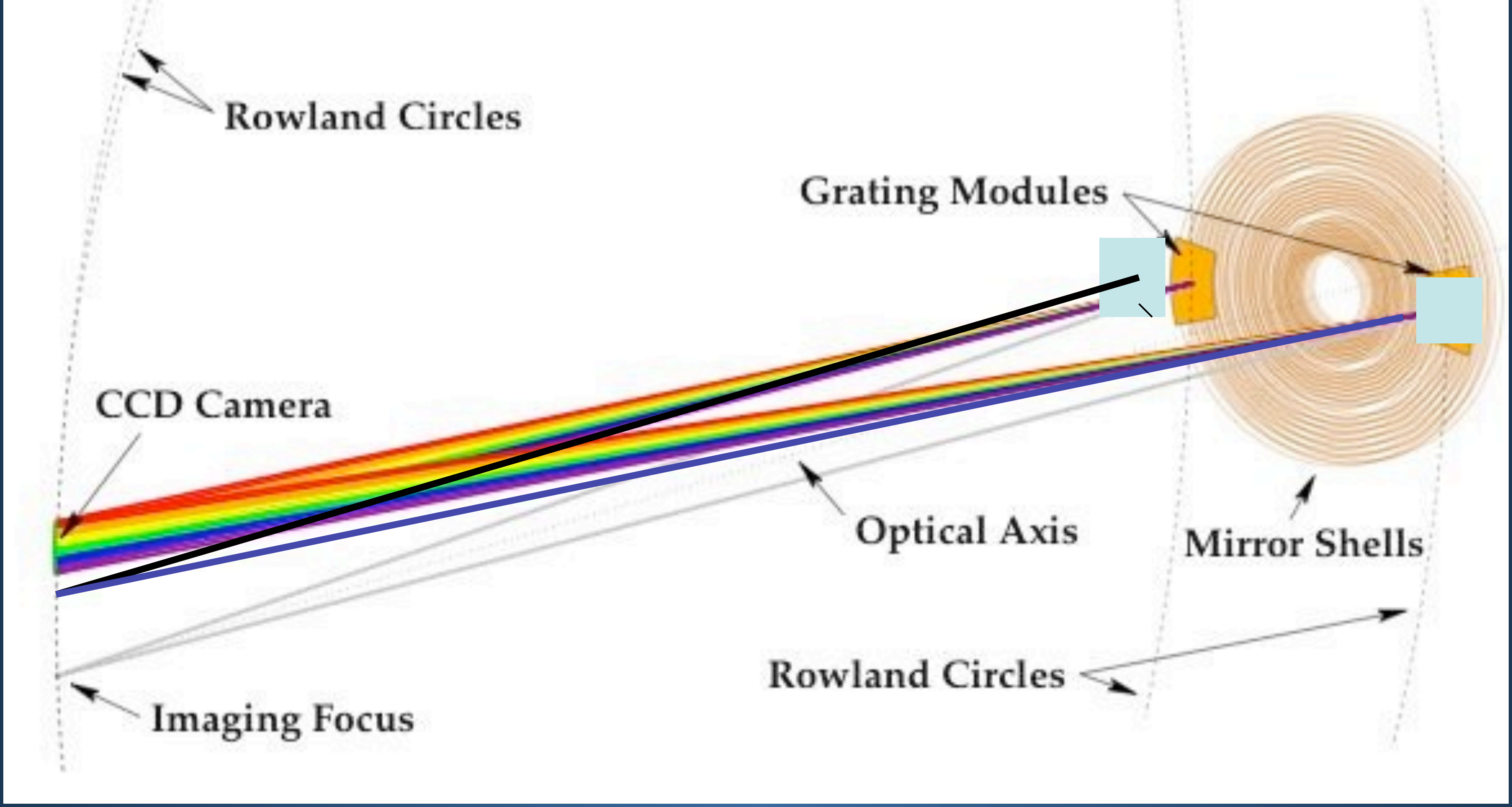

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