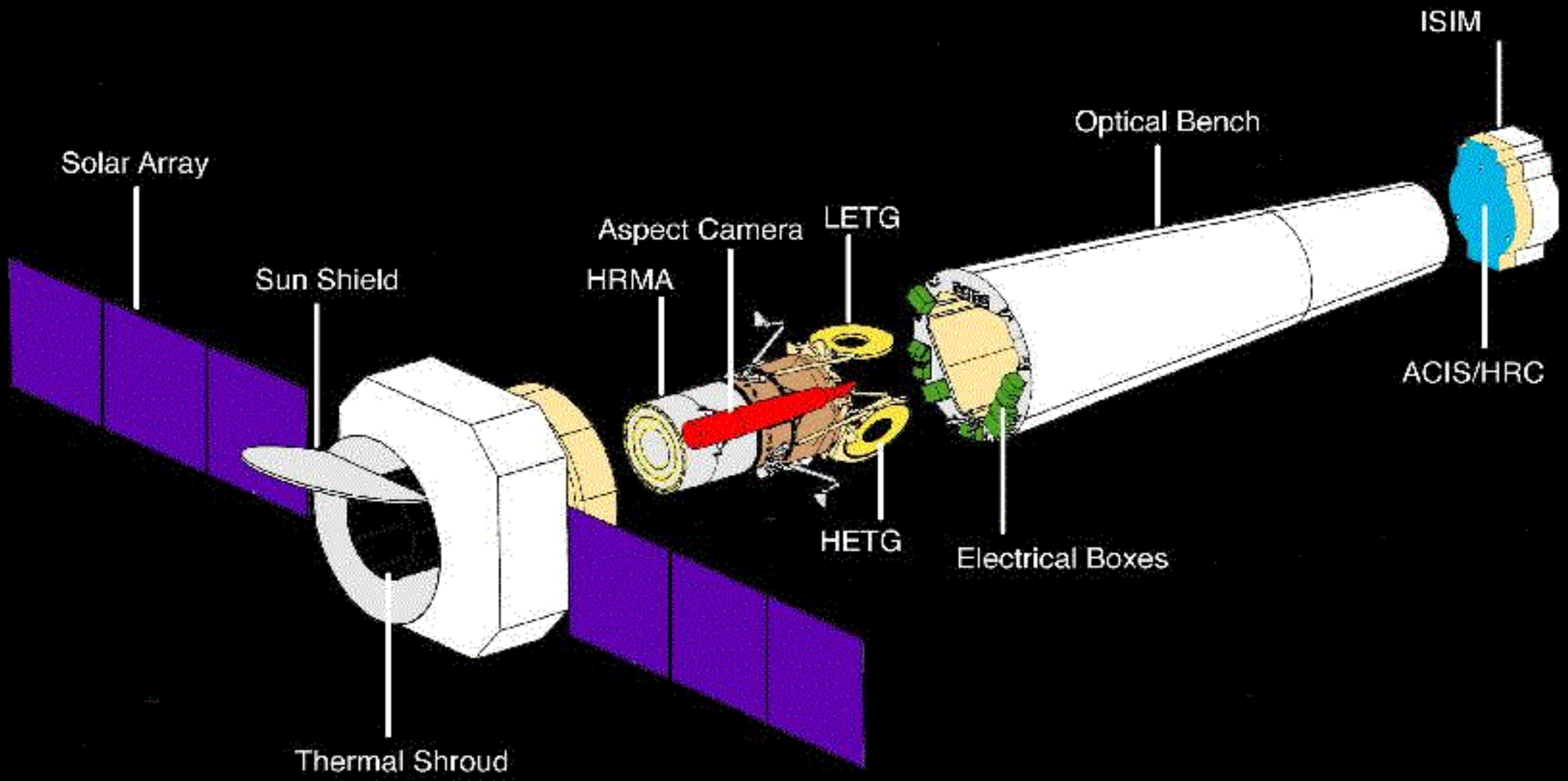
Chandra X-ray Observatory

Lynne Valencic
(JHU/NASA-GSFC)

Mission Description

- Launch: 23 July 1999
- Minimum lifetime: 5 years (planned for 10)
- Two gratings (LETG, HETG), two detectors (ACIS, HRC)
- energy band = 0.1-10 keV
- high spatial resolution (0.5'') and high res spectroscopy

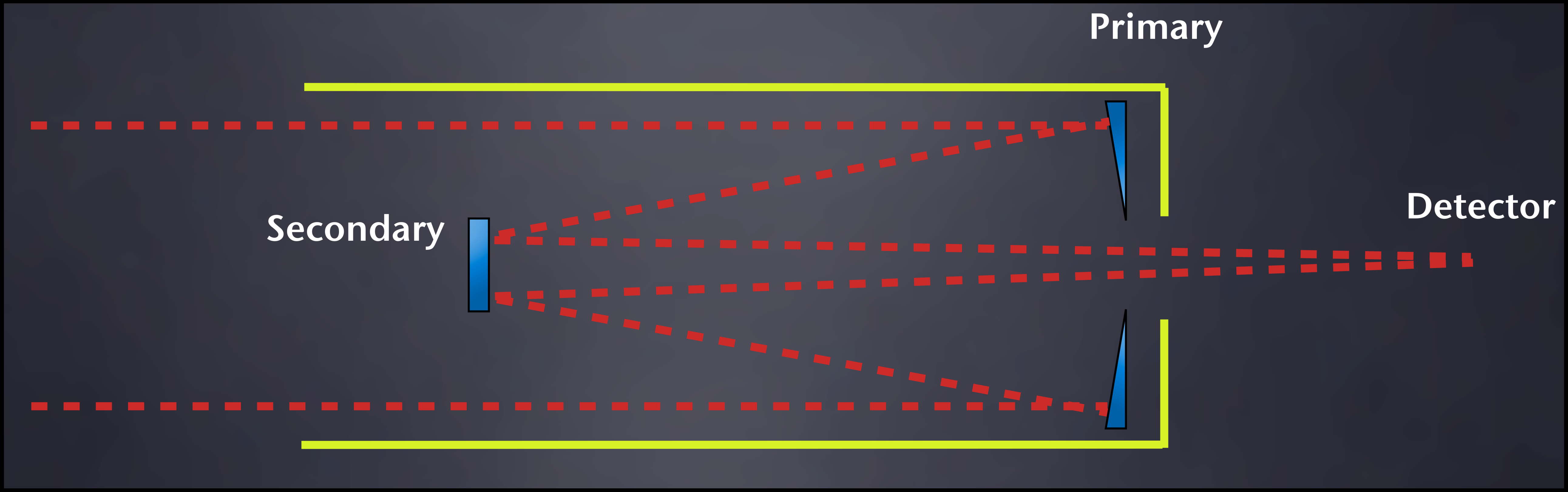
Observatory Description

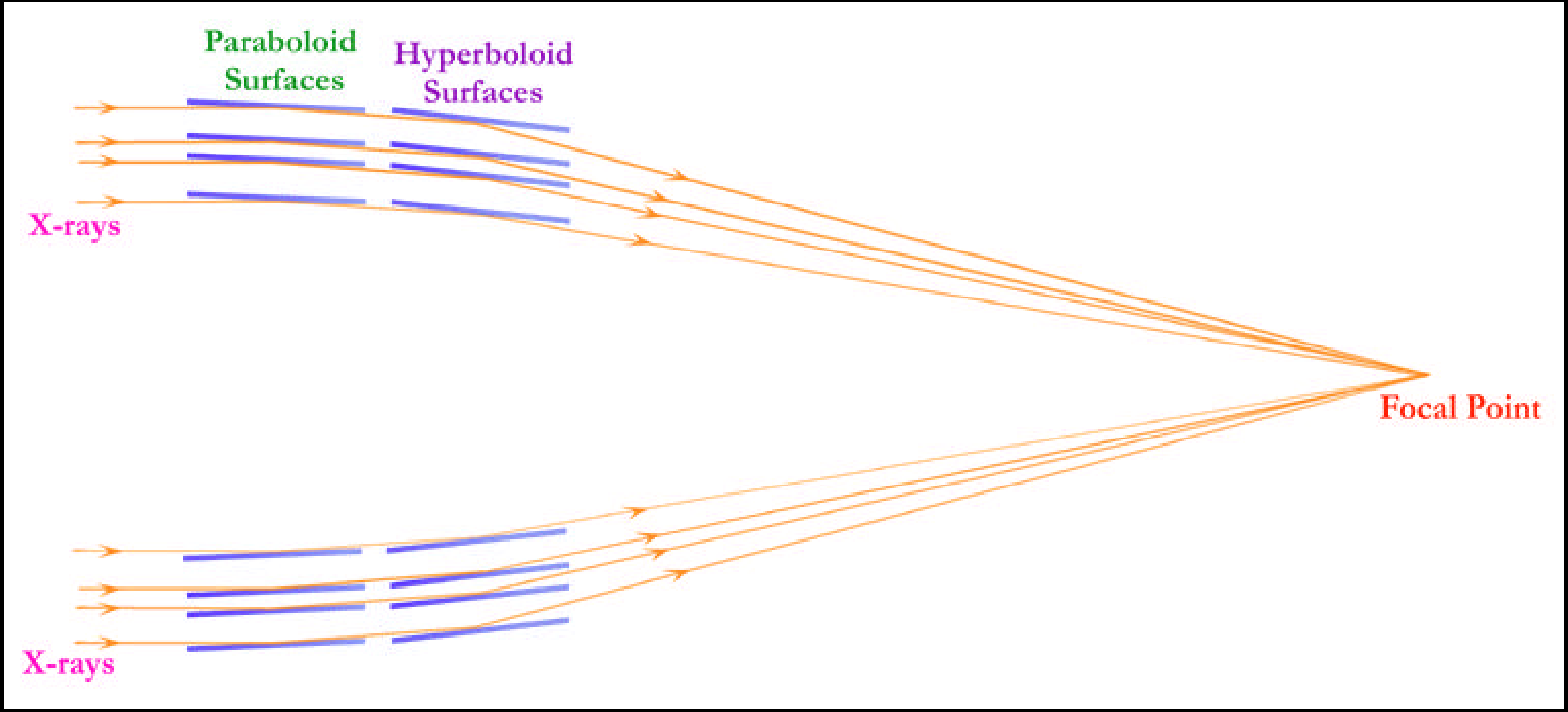


High Resolution Mirror Assembly

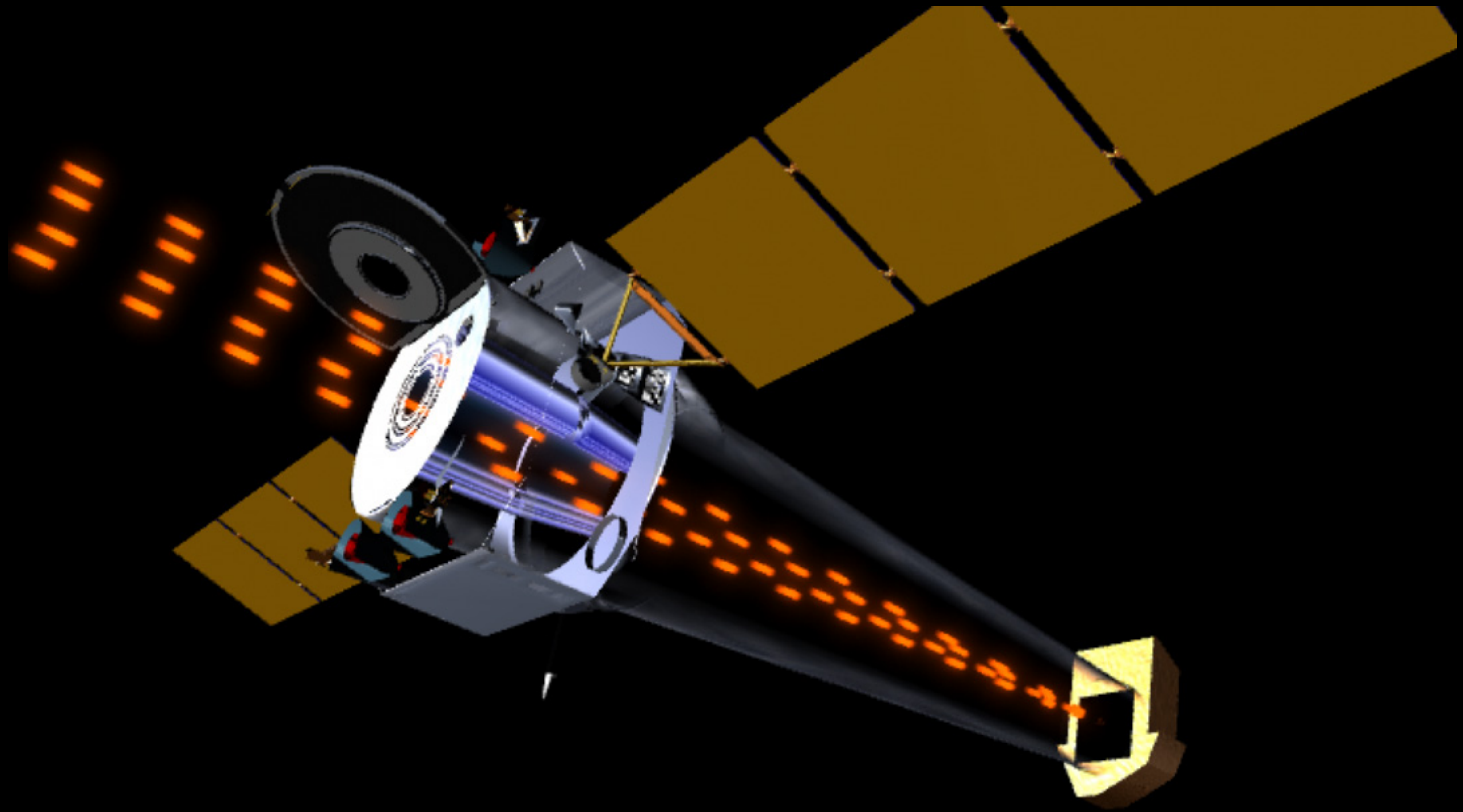
- 4 pairs of concentric thin-walled zerodur glass, grazing incidence Wolter Type-I mirrors, giving large area (800 cm^2) at E<2 keV
- polished extremely smooth (to 3 Å); low scattering and high dynamic range
- designed to spatial resolution 0.5'' FWMH
- focal length = 10 m; response to 10 keV

Optical Cassegrain mirror:




Paraboloid
Surfaces
Hyperboloid
Surfaces
X-rays
Focal Point
X-rays

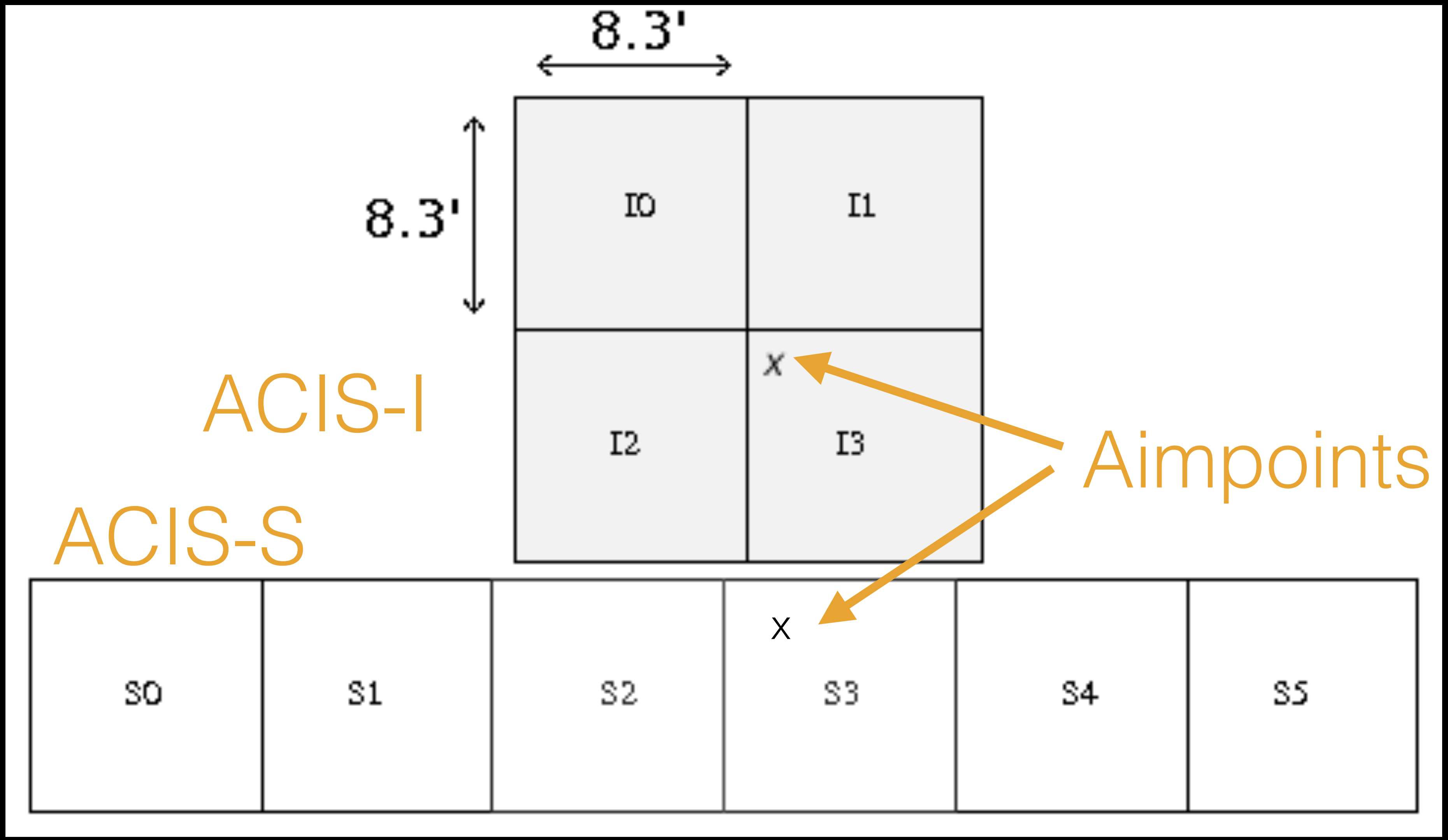
Focusing X-rays



Instrumentation

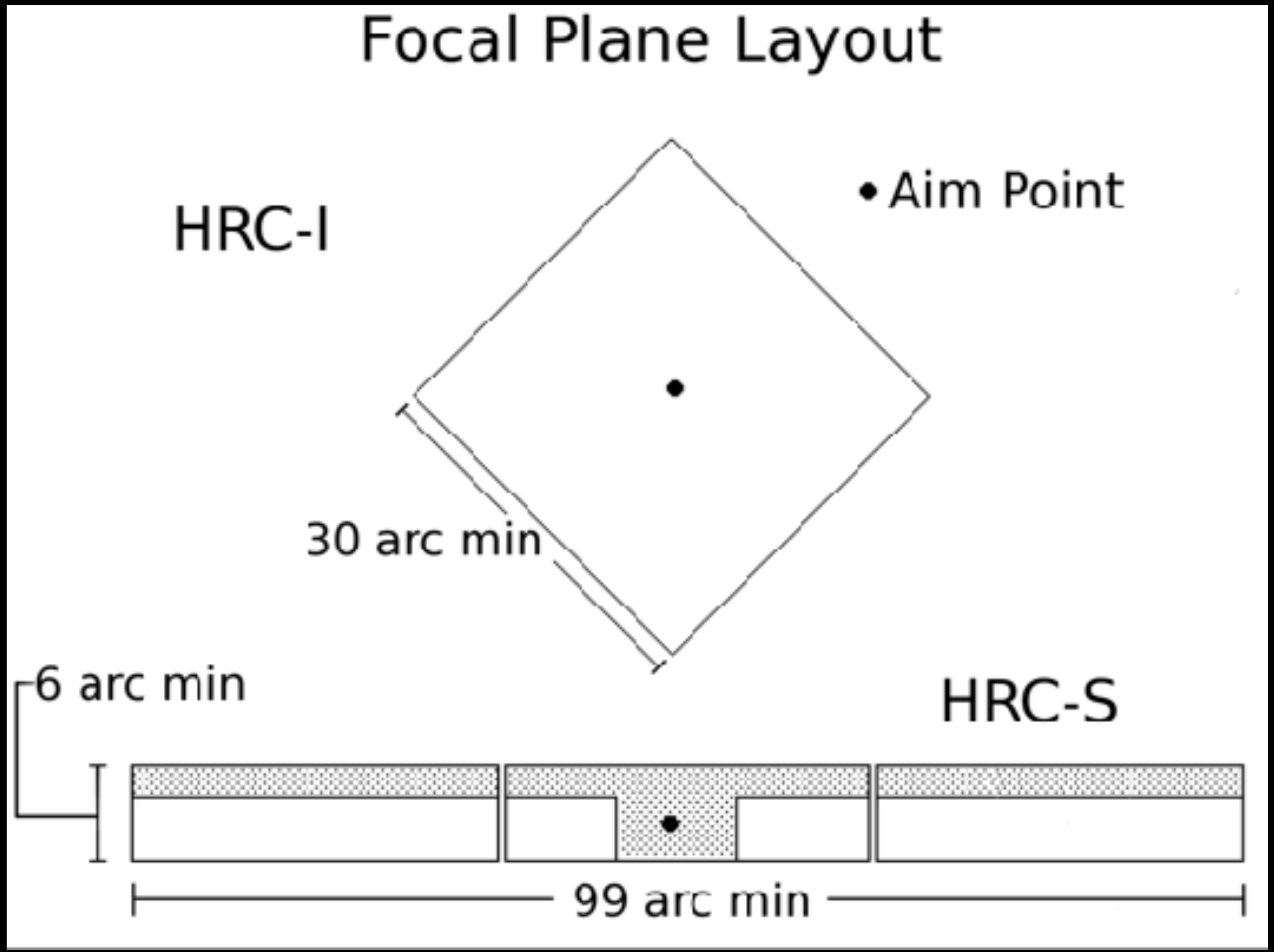
- Advanced CCD Imaging Spectrometer (ACIS)
- High Resolution Camera (HRC)
- High Energy Transmission Grating (HETG)
- Low Energy Transmission Grating (LETG)

The Advanced CCD Imaging Spectroscopy (ACIS) Arrays



- 1024x1024 pixel CCD arrays; energy resolution ~100 eV; can do imaging spectroscopy
- ACIS-I: array with 16’x16’ FoV. Front illuminated
- ACIS-S: grating readout array (can also do imaging).S1, S3 back illuminated; good low E quantum efficiency and higher throughput

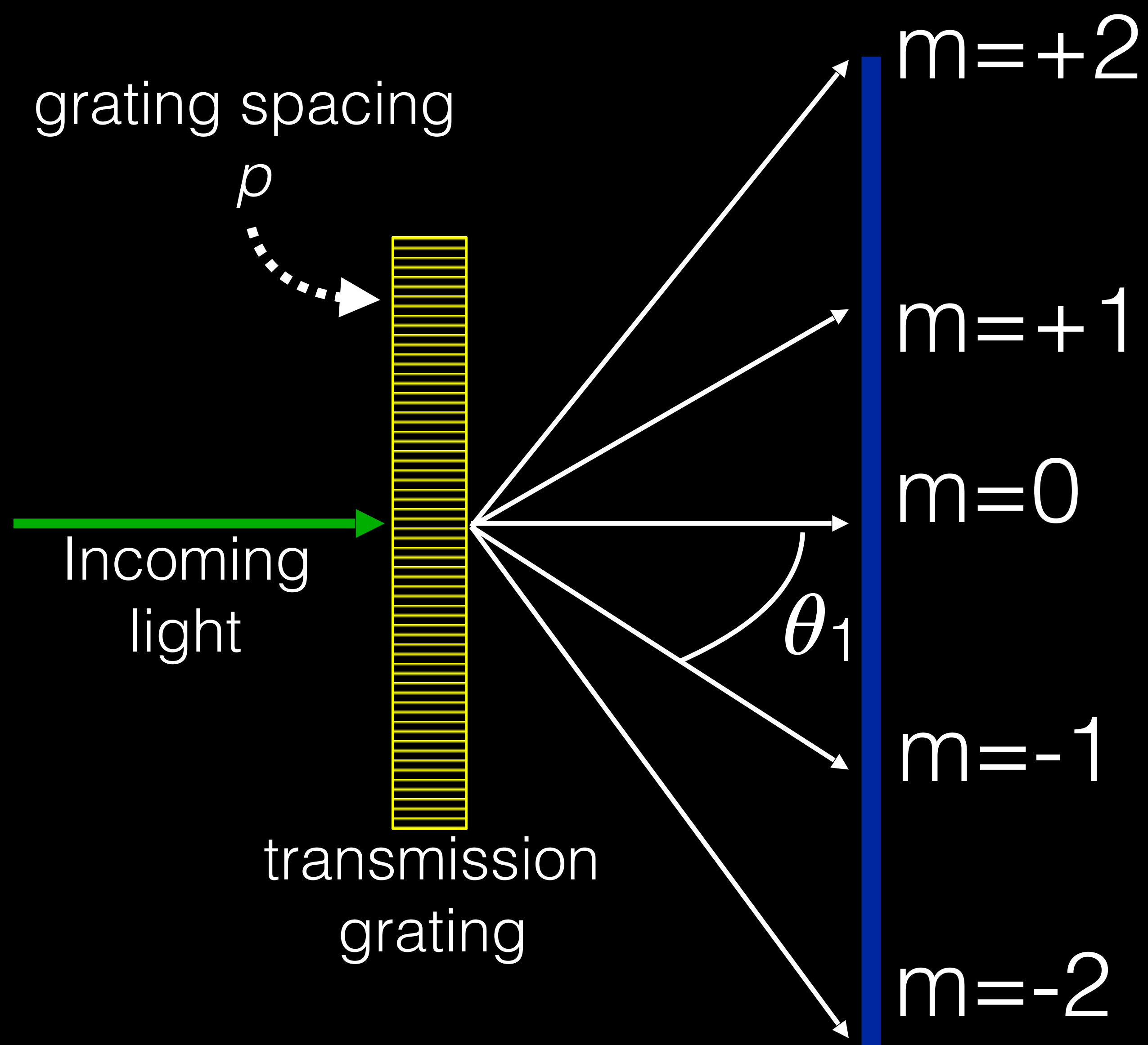
The High Resolution Camera (HRC)

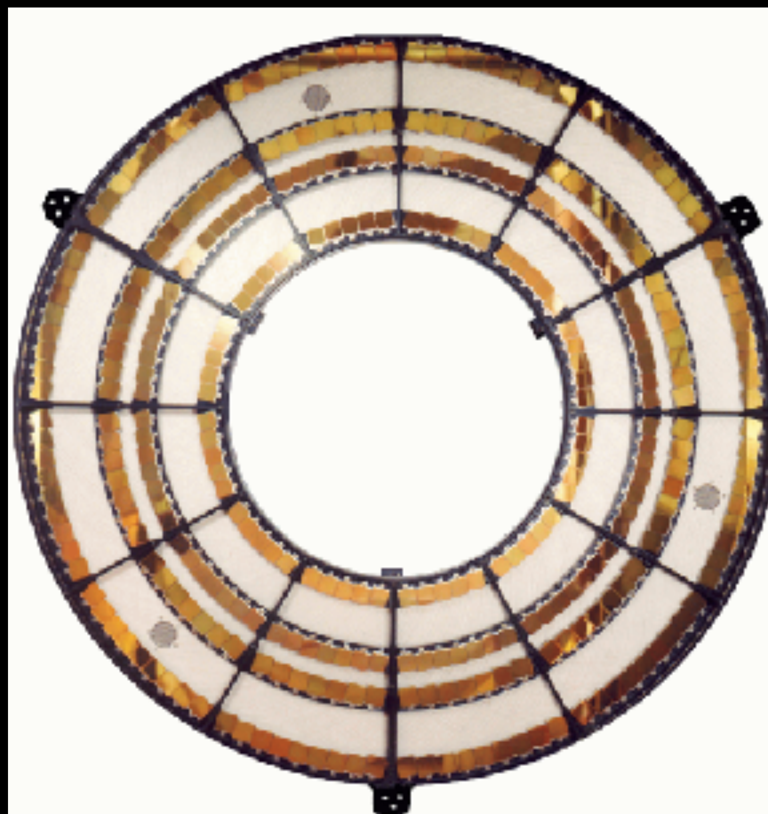


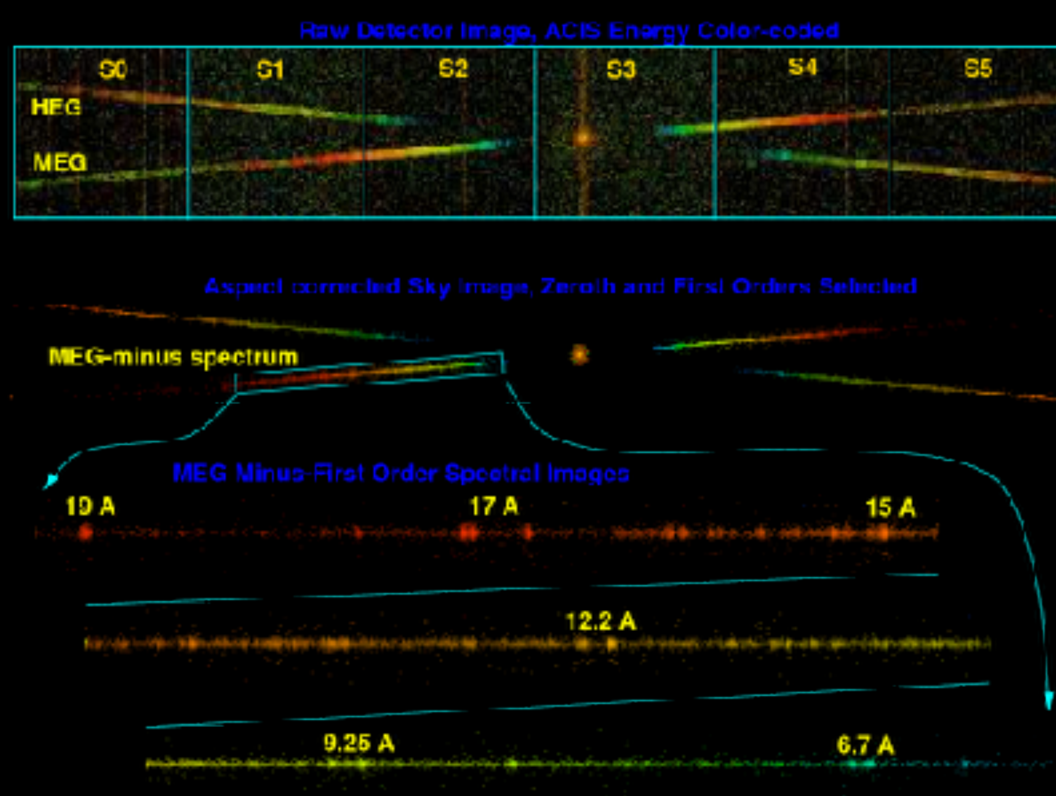
- HRC-I: 30’x30’ FoV microchannel plate imager; energy resolving power *R* (=ΔE/E) ~ 1

- HRC-S: low energy grating readout array; time resolution: 16 μs; paired with LETG, *R* > 1000

Gratings Reminder





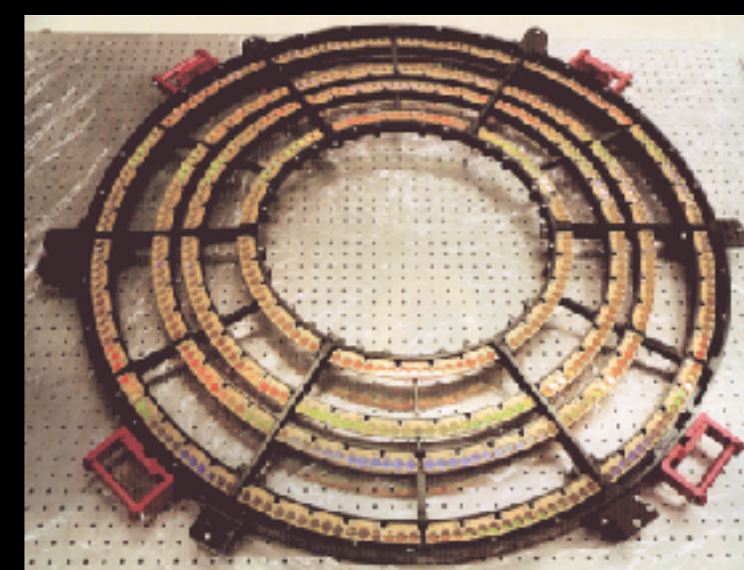


$$p \sin(\theta) = m\lambda$$

HETG

- 336 gold facets
- inner 2 rings: High Energy Grating; outer 2 rings: Medium Energy Grating
- mounted at different angles to give “X”
- designed for use with ACIS-S
- $R = \lambda/\Delta\lambda \sim 1000$; λ=1.2-15 Å

LETG



- 540 gold facets
- $R > 1000$, λ=50-160 Å; R=20xλ, λ=3-50 Å

Common Pairings

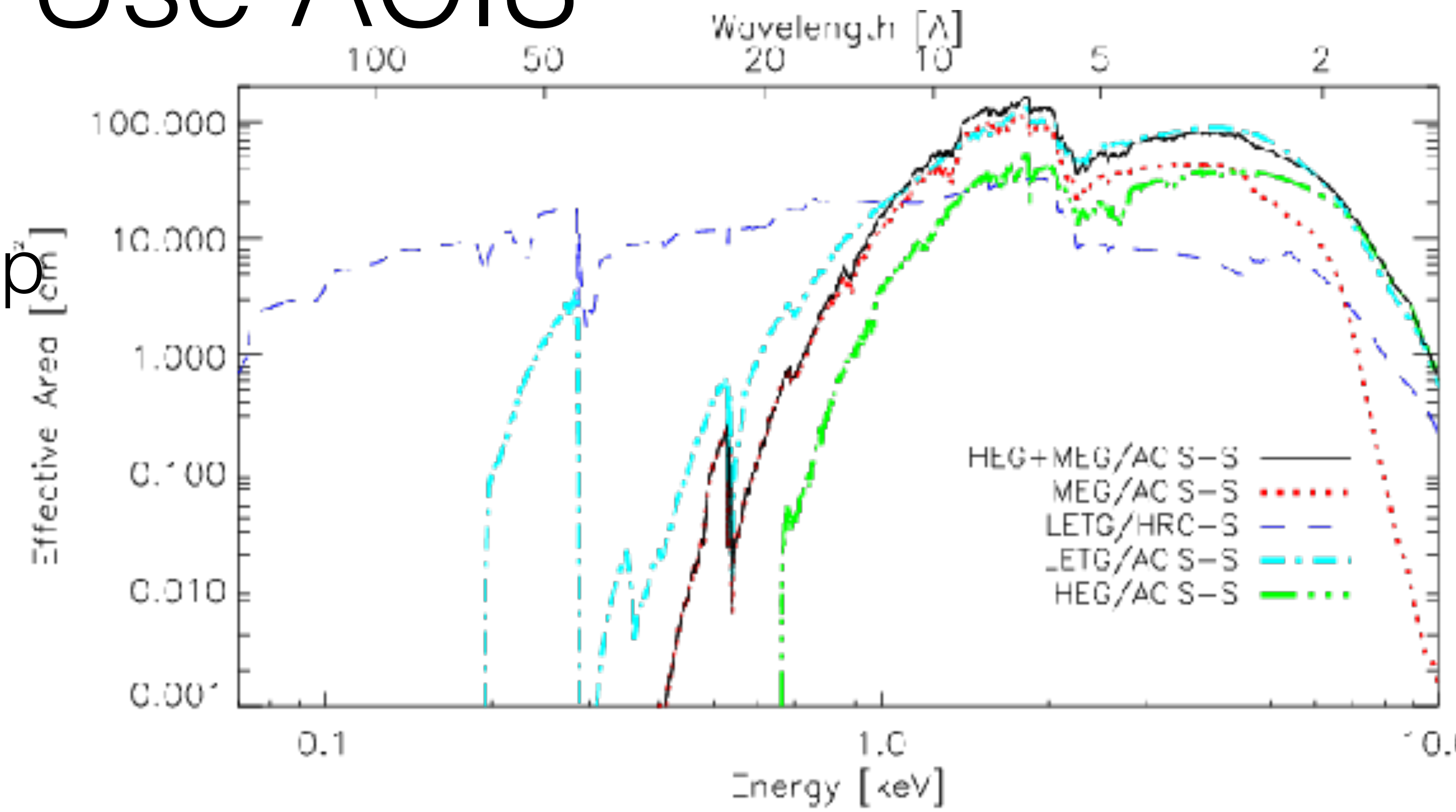
- LETG/HRC-S: usually for soft sources (E<1 keV) like stellar coronae, white dwarf atmospheres, cataclysmic variables
- LETG/ACIS-S: usually for harder sources like AGN and X-ray binaries, though still with E< 1 keV (though not any more…)
- HETG/ACIS-S: hard sources (E>1 keV)

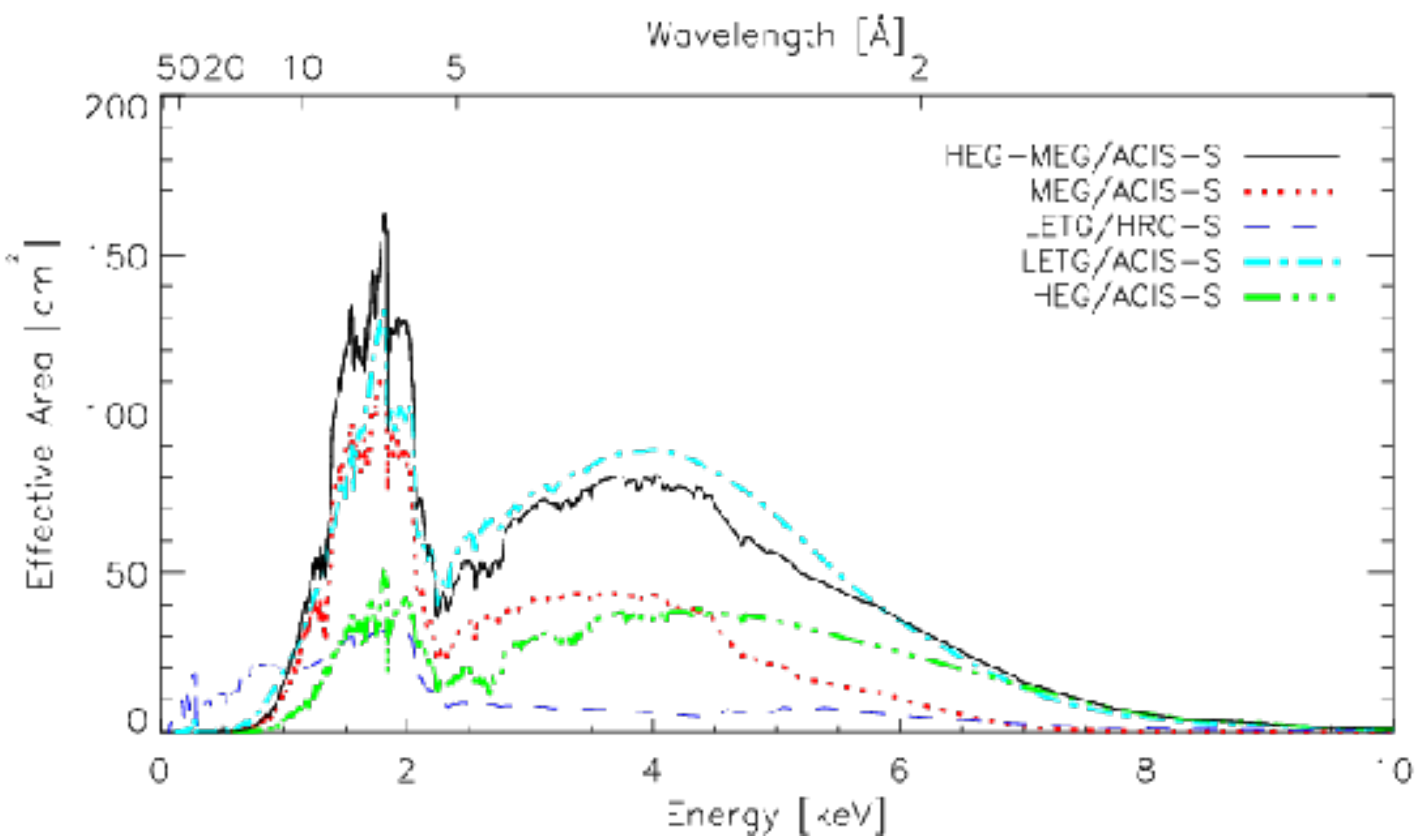
Things You Need to be Aware of if You Use ACIS

- the front-illuminated chips took proton damage shortly after launch and have degraded energy resolution. CTI correction restores linearity and most (not all) of the worse energy resolution
- the readout time is 3.2 s in full frame mode (standard). For sources with high count rates (>0.1 c/s), “pile up” will happen.
    - artificially lowered count rate and spectrum shifted to higher energies
    - quick and easy way to see if an image is piled: look for low flux at the center

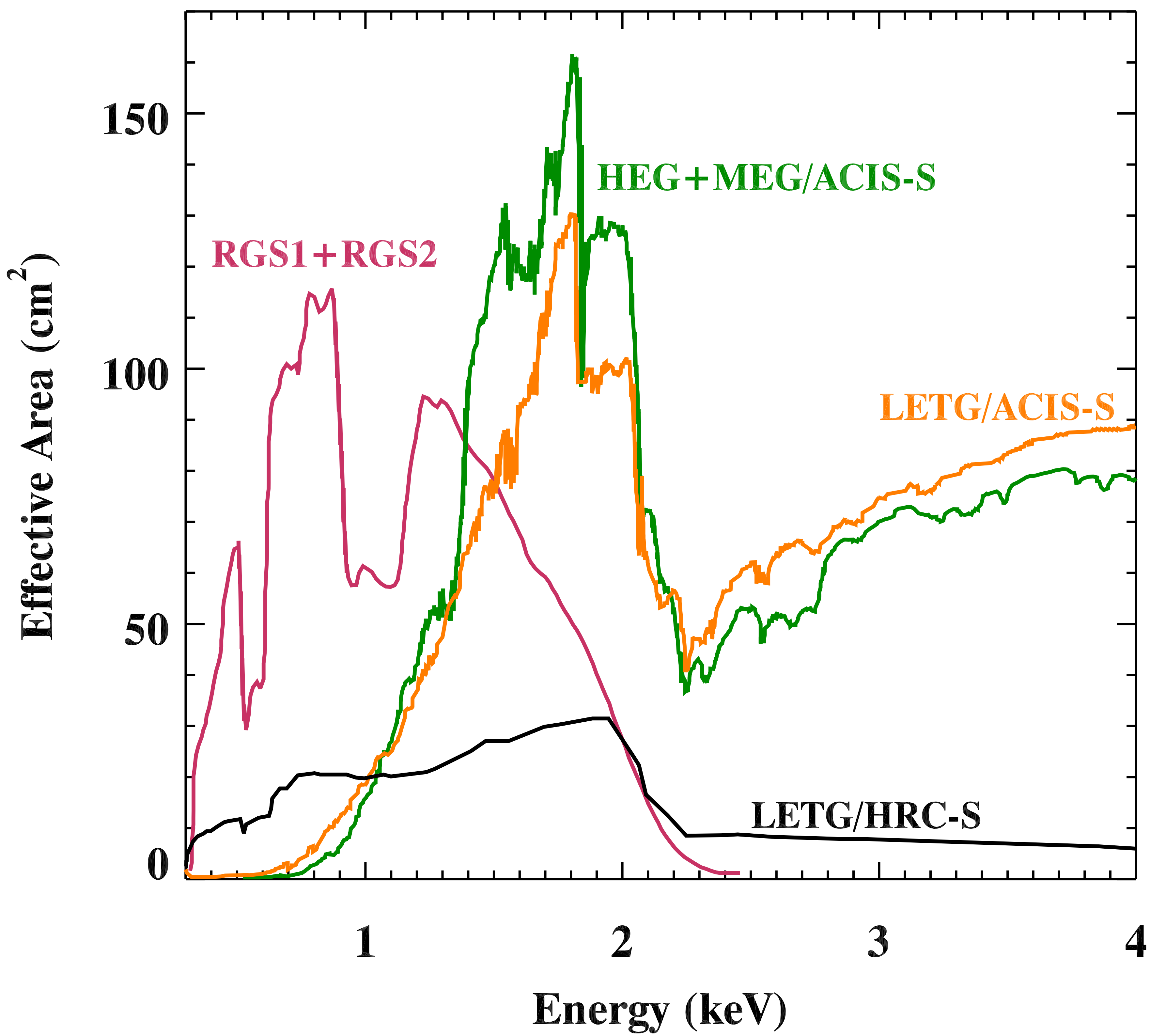
Things You Need to be Aware of if You Use ACIS

- Since launch, out-gassed gunk building up on ACIS' cold (-60 C) optical blocking filters; affects E<2 keV
- HRC at higher temp, no sign of build up
- Growth of contaminant on ACIS means very low effective area at low energy (E<1 keV)!





Things You Need to be Aware of if You Use ACIS



Things You Need to be Aware of, Generally

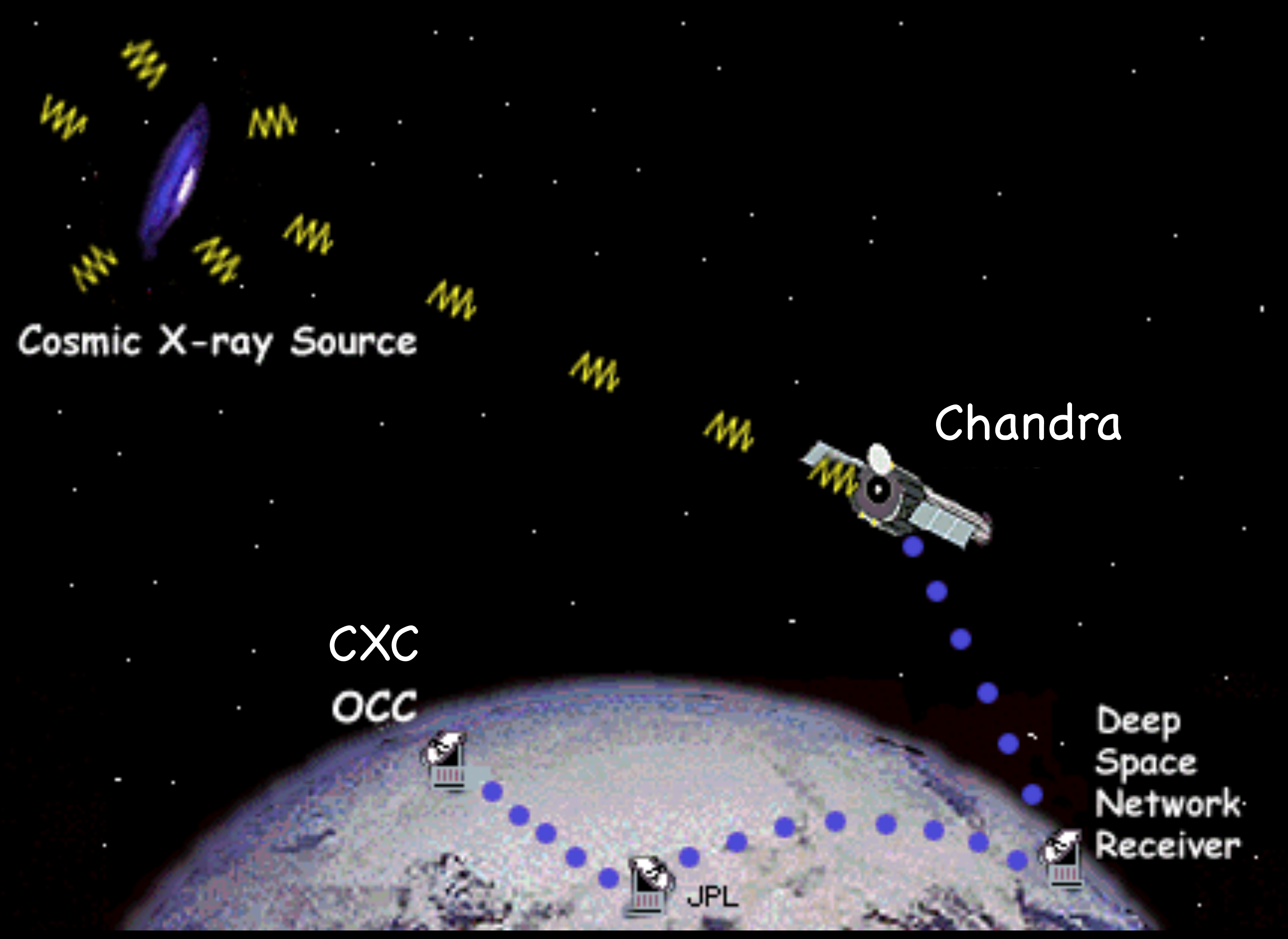
- Thermal issues are a big problem!
- In some orientations, craft can warm up outside of the desired range
- CXC mitigates by rescheduling for a better pitch angle, splitting up observations, turning off 1 or more optional CCDs
    - can’t do long stares, single or joint with other missions
- Observations longer than 50 ks and pitch angle > 135^{o} will be done with *at most* 4 CCDs

Observing Cycle

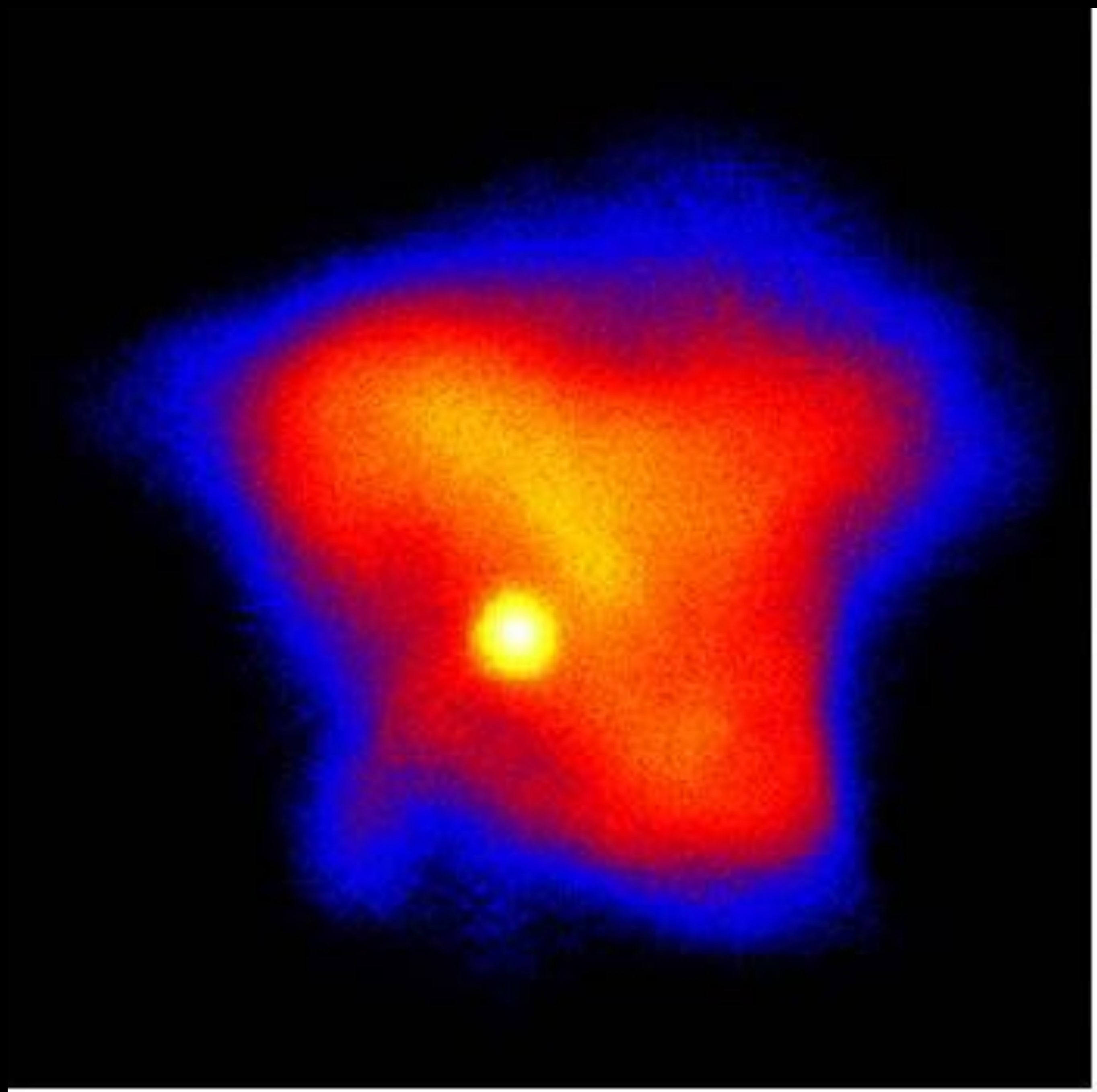
- Proposal deadline is every mid-March. This year, it's **14 March 2019**
- All kinds of on-line tools to help you simulate data, count rates, find exposure times, etc. Proposal document templates, too!

http://cxc.harvard.edu/proposer/

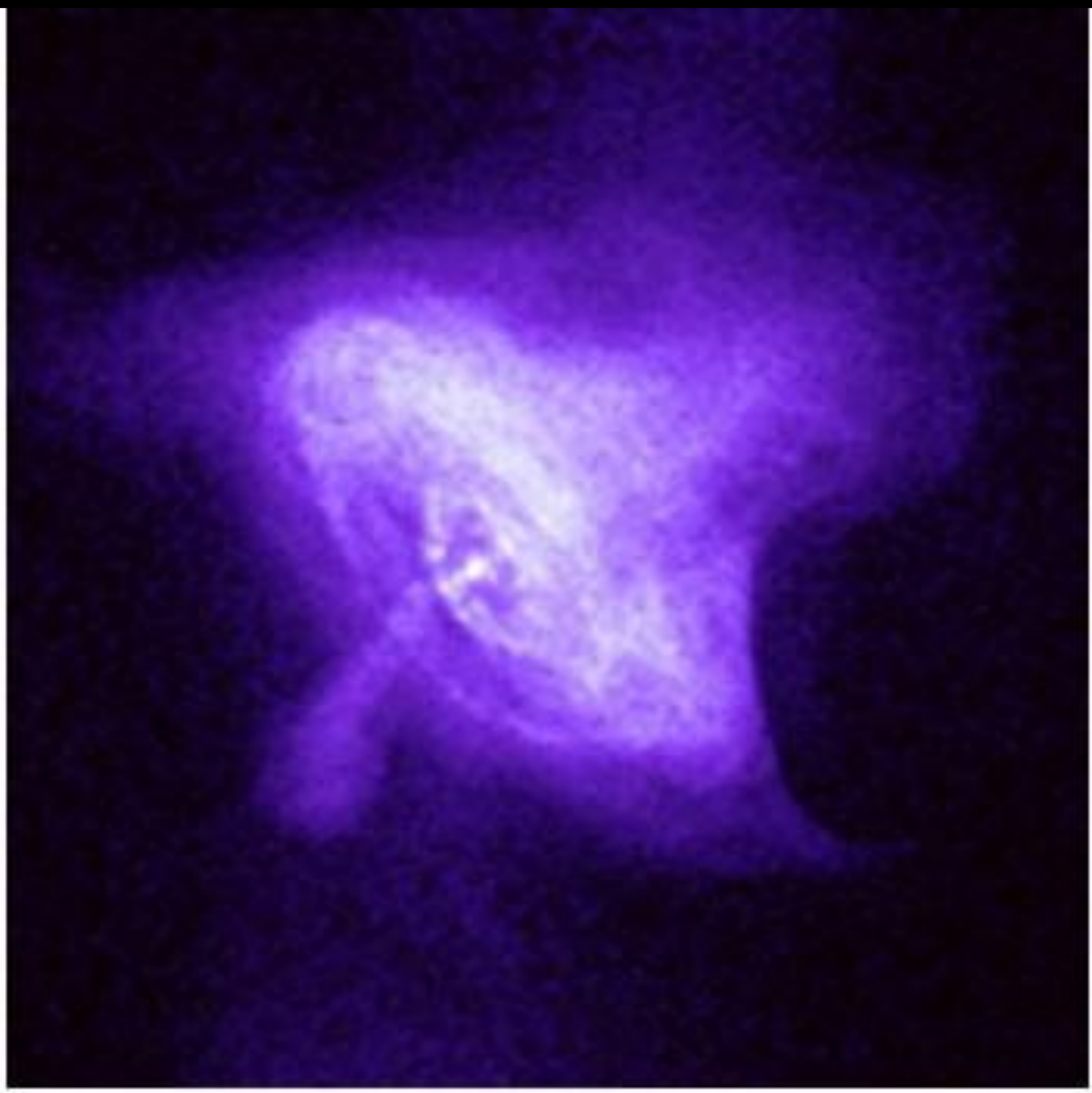
How This Whole Thing Works



- Mission science team at OCC (CXC) plans observations; converts plan to commands for uploading to Chandra
- Ground contact every 8 hours via DSN
- Uploading done in pieces of up to 72 hours of stored commands to ensure continuity
- Download the data that's been stored on the craft, upload the new set of commands
- Send the data to OCC for processing



Crab Nebula, Rosat



Crab Nebula, Chandra

http://cxc.harvard.edu/

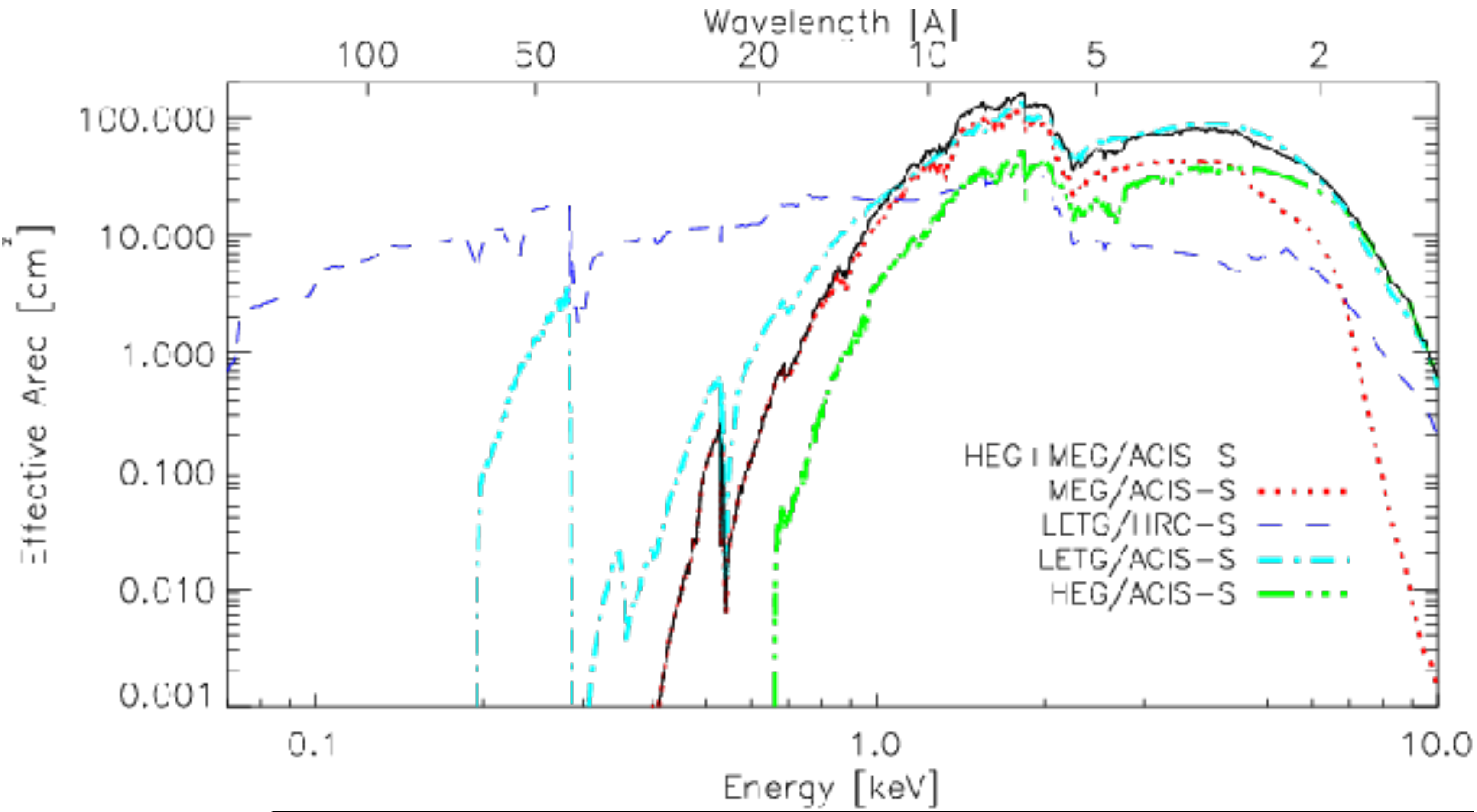
Backups

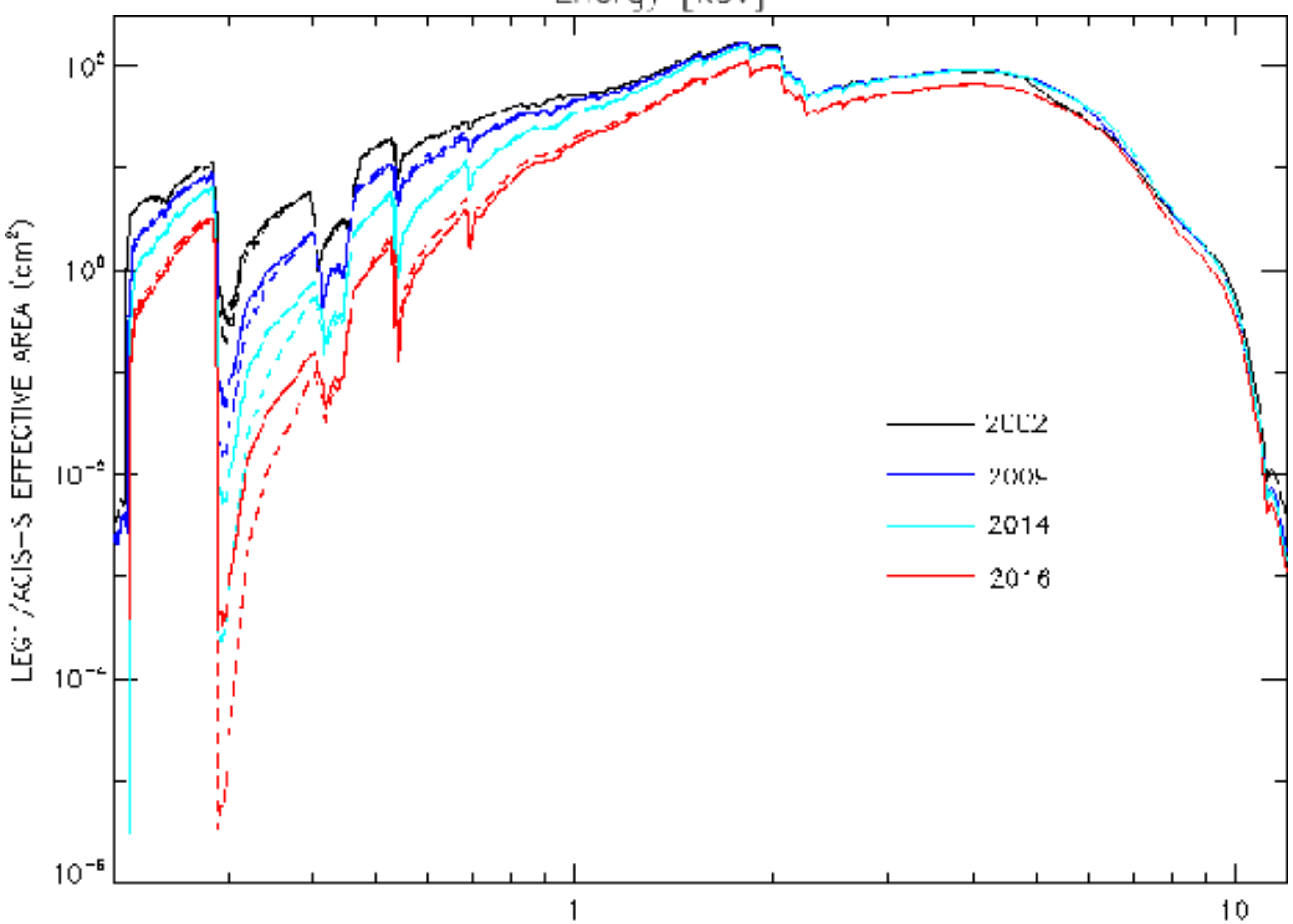
Things You Need to be Aware of if You Use HRC

- HRC has a llinearity limit. Exceeding it voids the effective area calibration. (It also has brightness and telemetry limits, like ACIS.)

More Useful Things

- Data Archives at NASA, MIT:
    - http://heasarc.gsfc.nasa.gov/docs/archive.html
    - http://tgcat.mit.edu/
- Walk-throughs with CIAO and Sherpa (Chandra’s software suite):
    - http://cxc.harvard.edu/ciao/
    - http://cxc.harvard.edu/sherpa/





Today's EA is far less than at launch.