HETG/LETG — Status

Chandra Quarterly Review No. 51

21 April 2021

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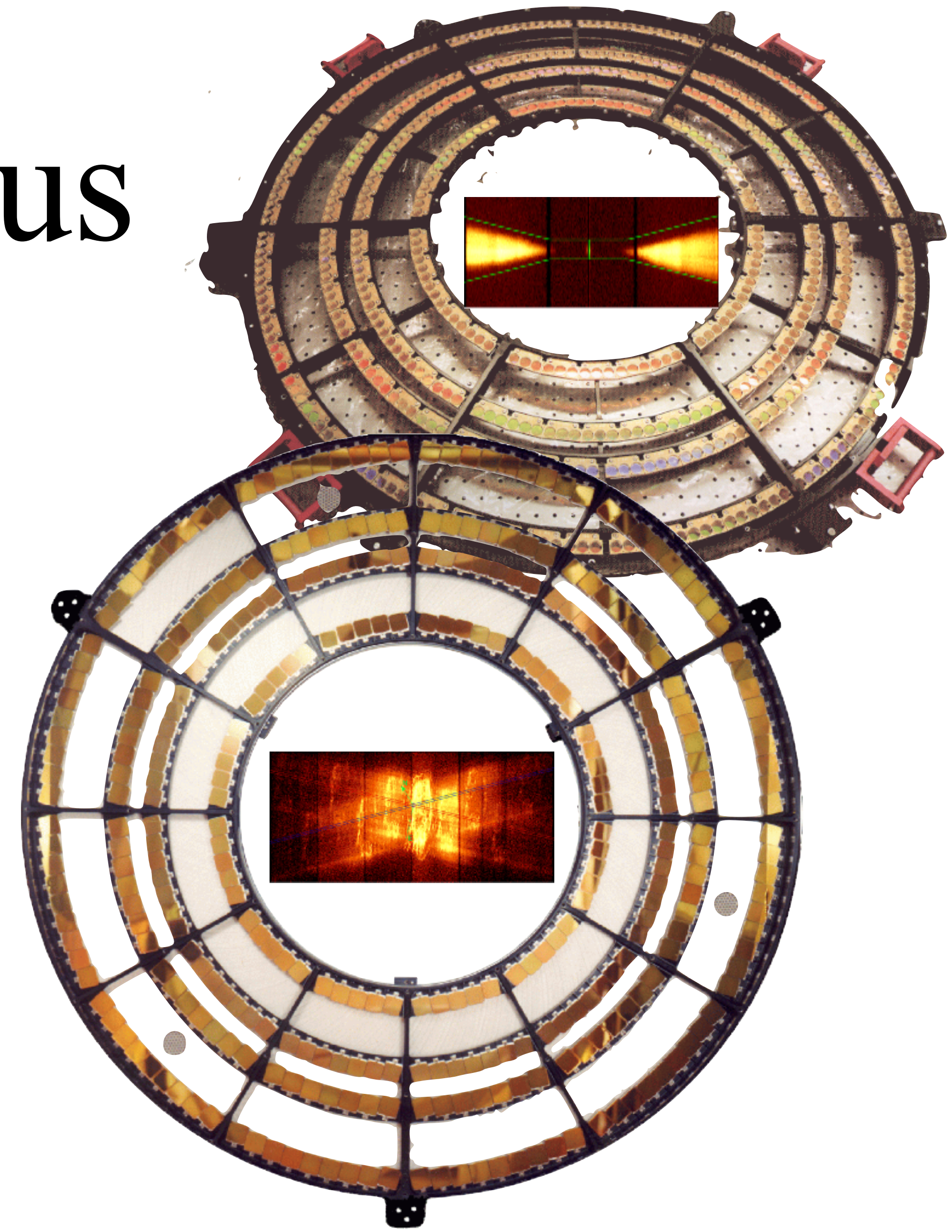
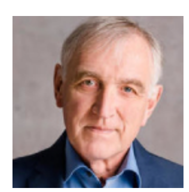
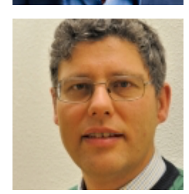


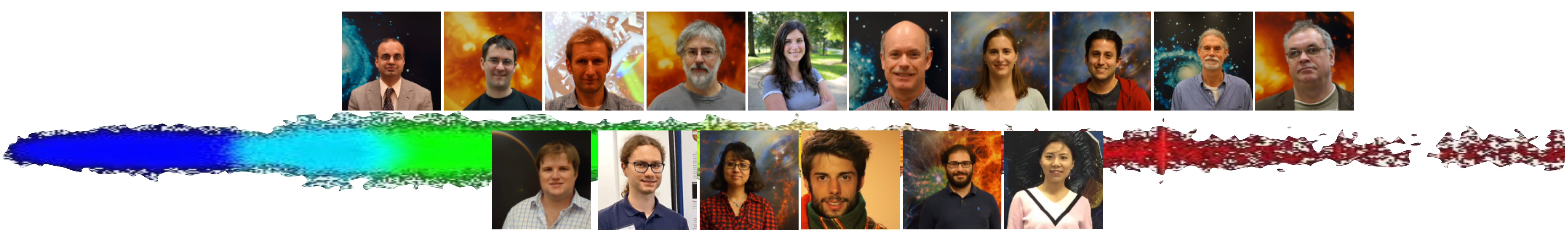
HETG IPI: Prof. C.R. Canizares
MIT Kavli Institute

LETG IPIs: Dr. Peter Predehl
Max Planck Institute



Dr. Jelle Kaastra
SRON





HETG Historical Trends (1)

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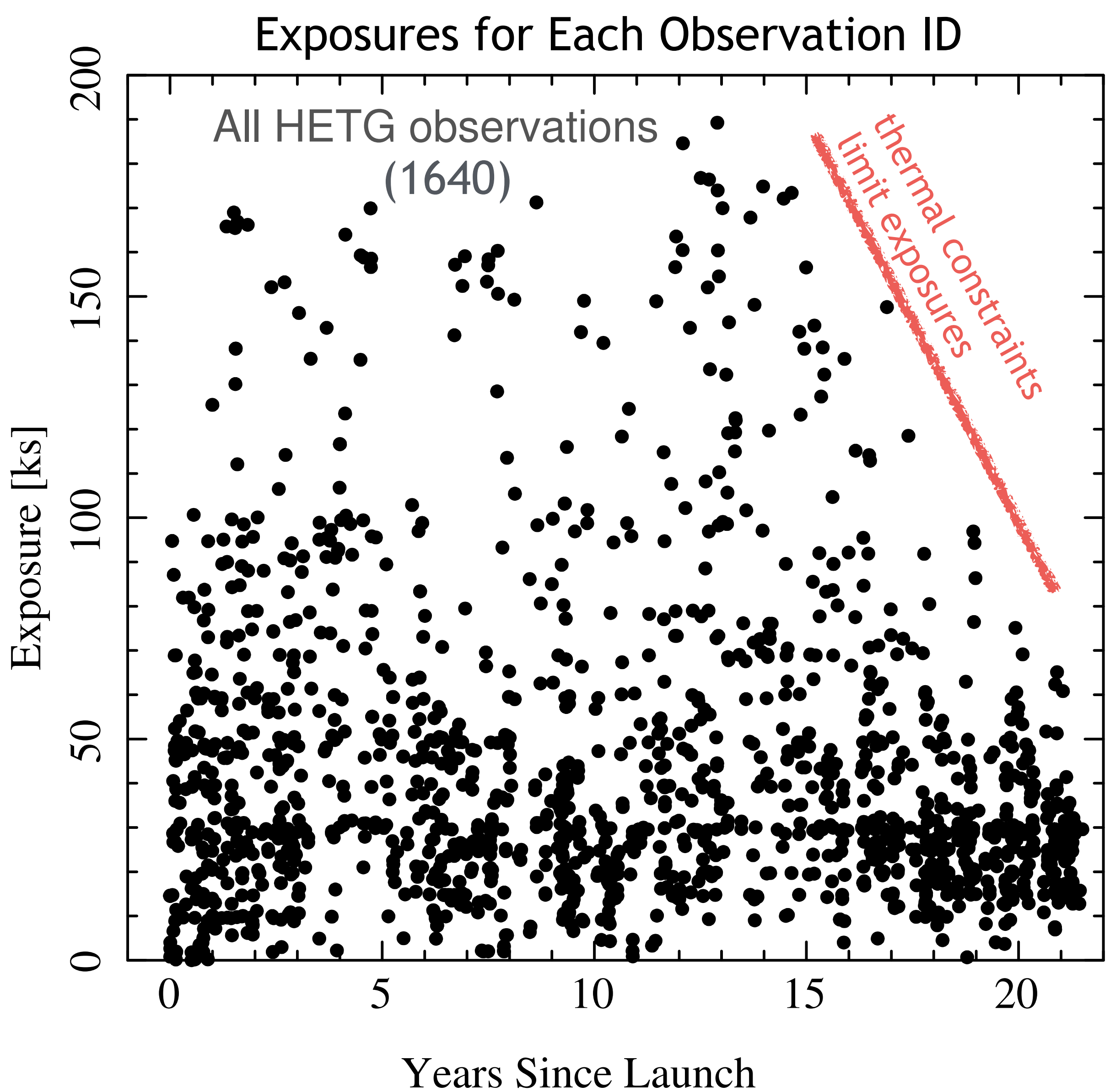
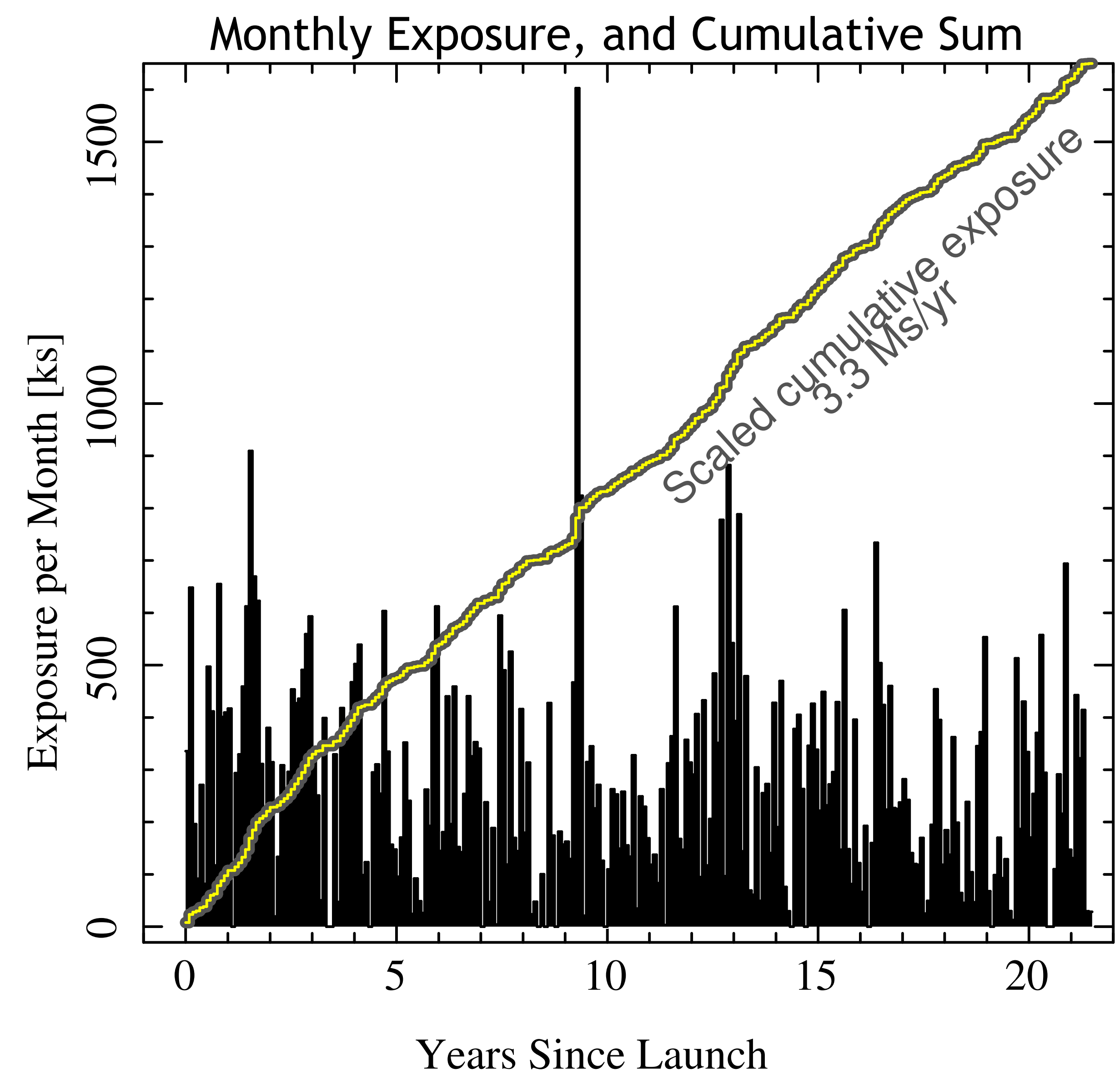
Here are several views of observations and exposure times with HETG and LETG over the history of Chandra (instead of the recent quarter's stats vs grating and type of observation)…



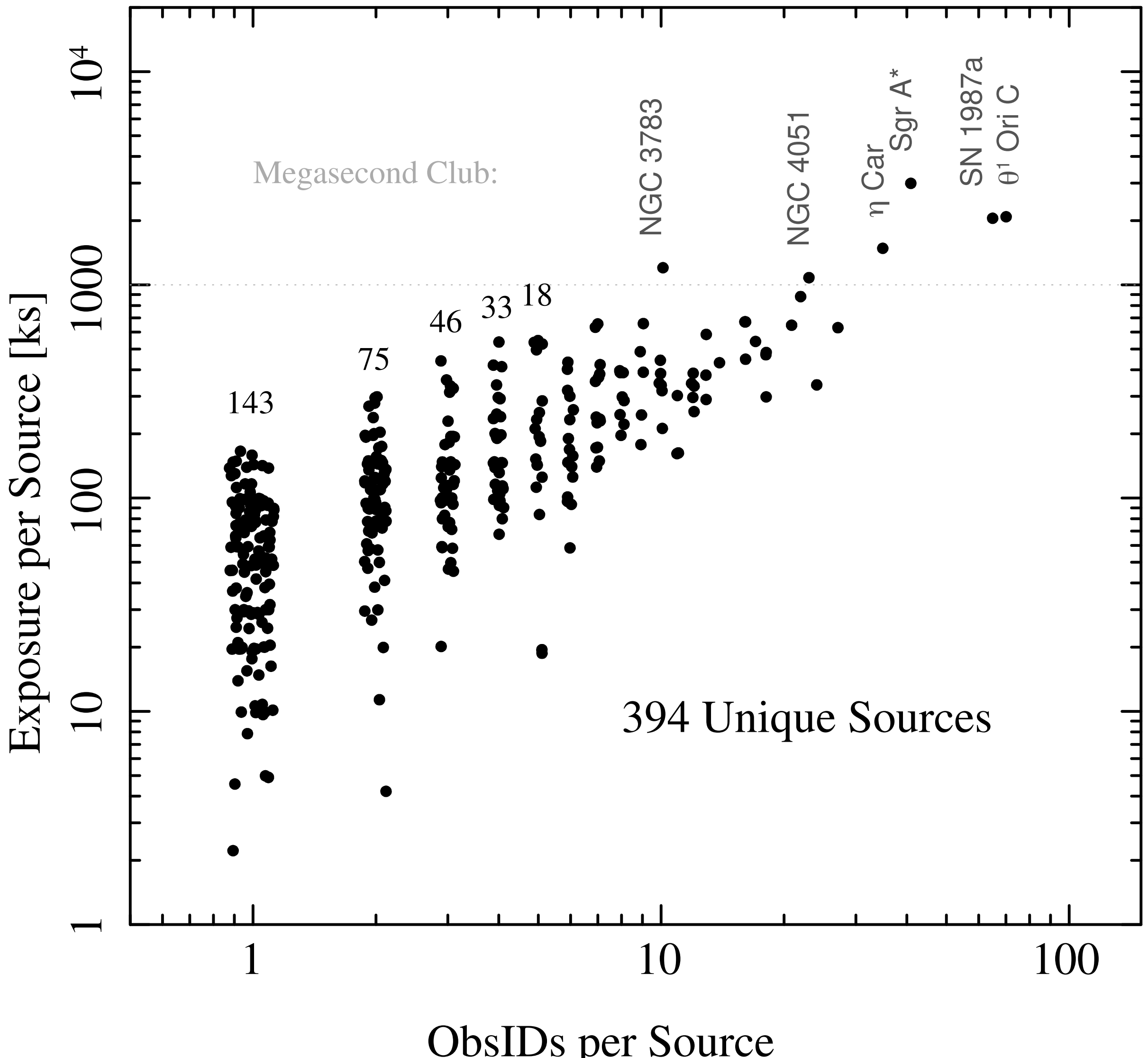


HETG Historical Trends (2)

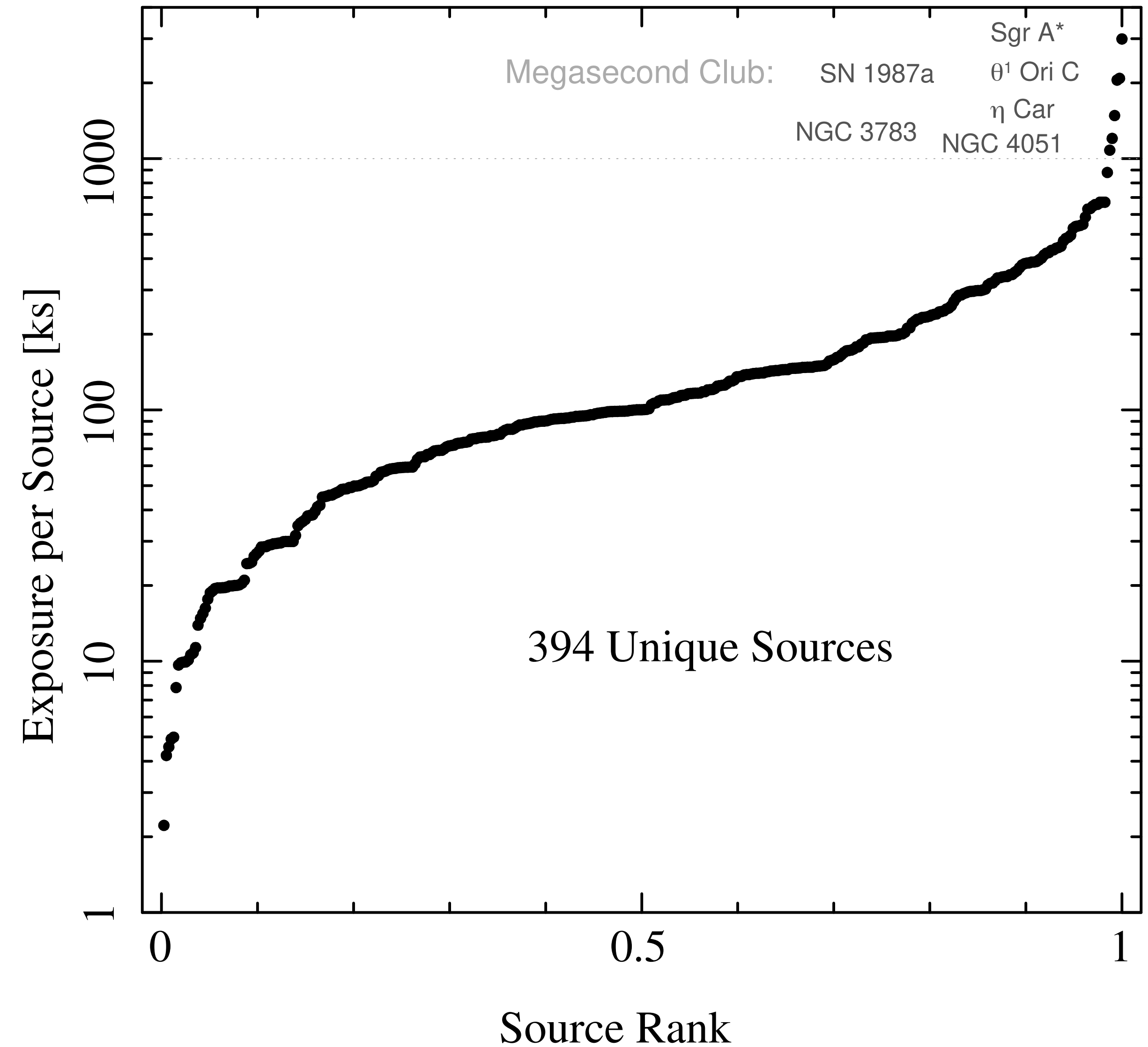
Most sources are completed in one or two visits (which may change with current thermal constraints)

About half the source are observed for more than 100 ks. Several of the deepest exposures are for long-term monitoring.

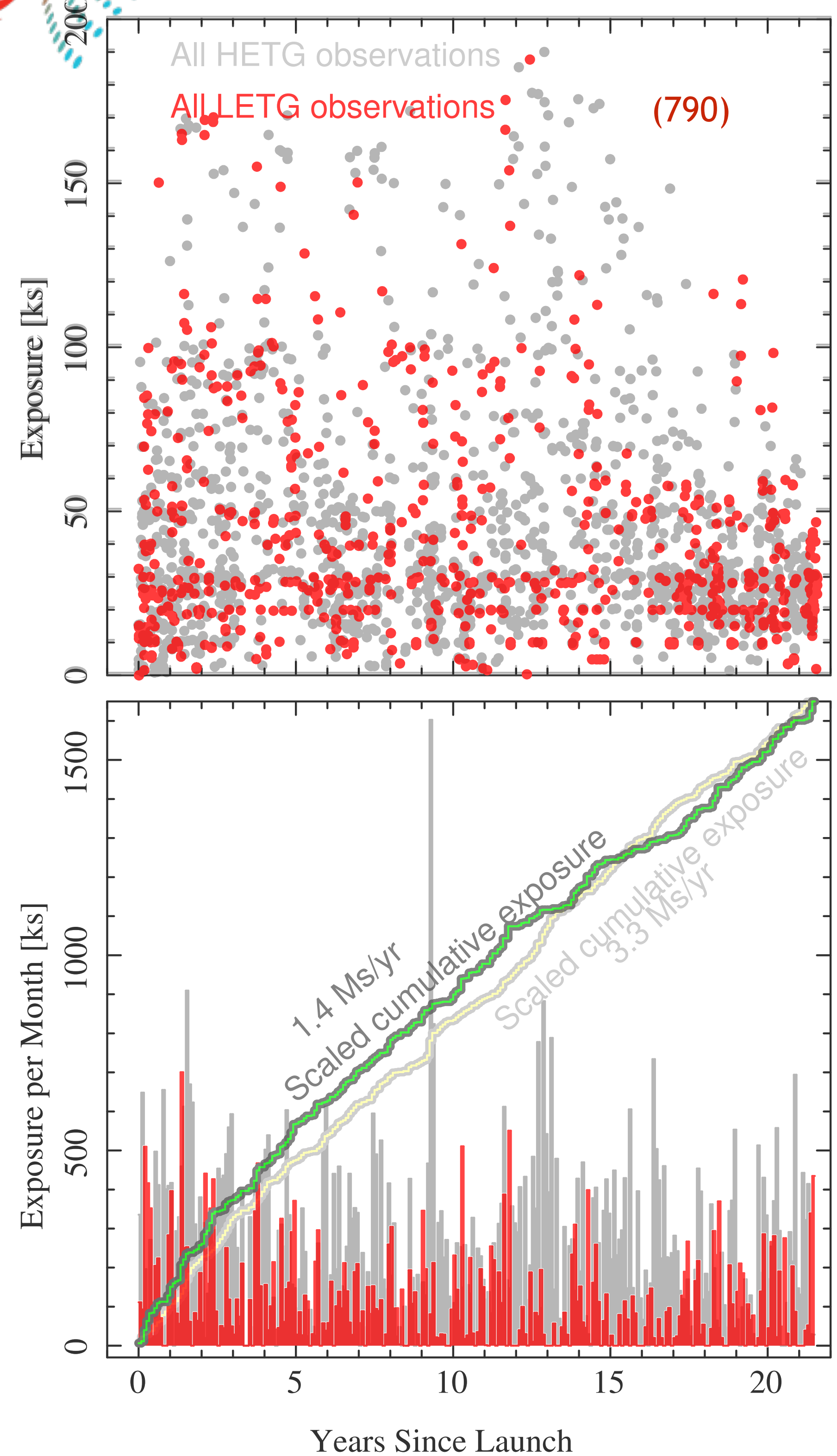
Exposure and Number of Observations for Unique Sources

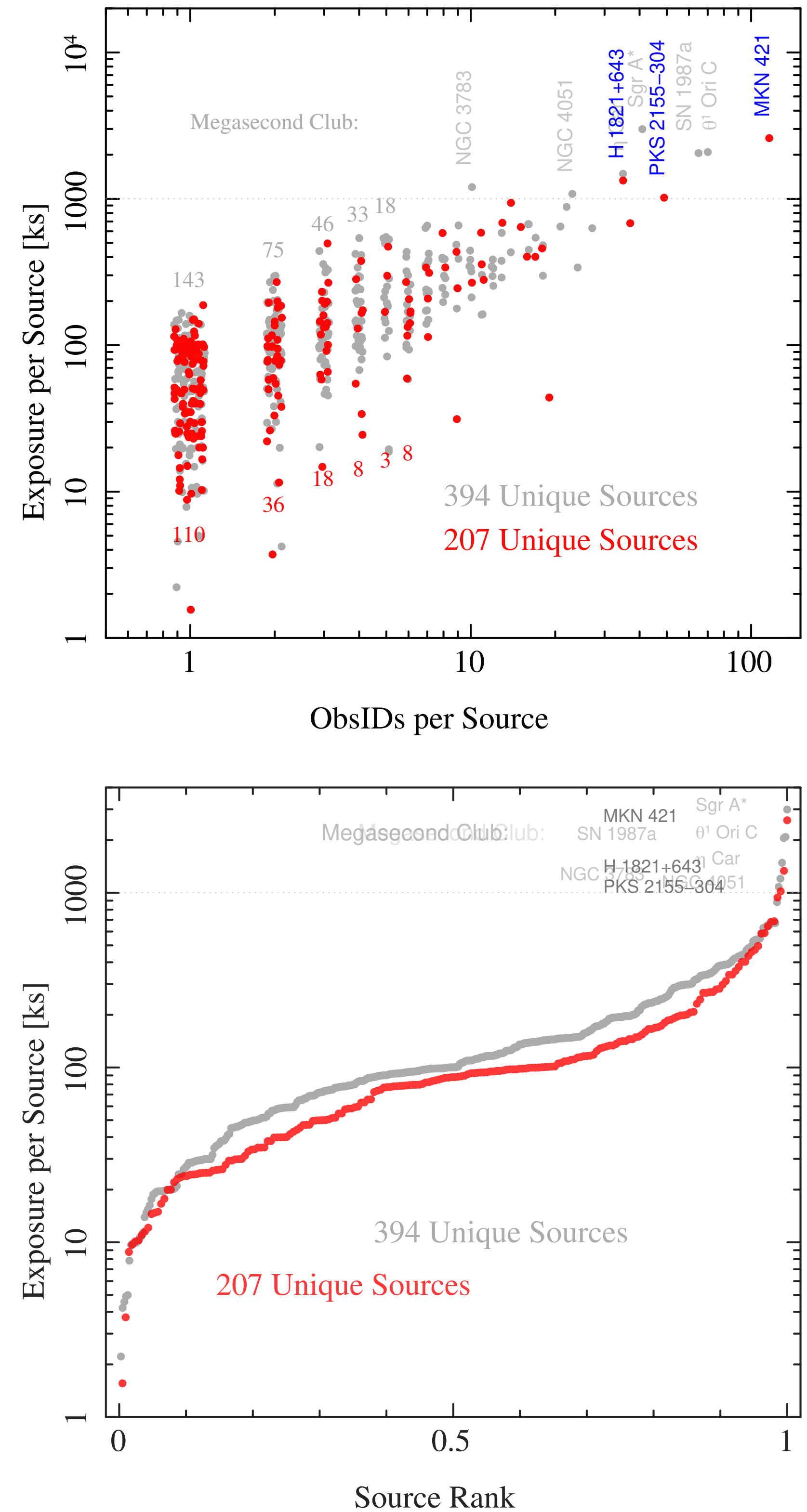


Exposure for Unique Sources, Ordered by Exposure



HETG & LETG Historical Trends Compared





LETG trends look very much like those for HETG, but with about half the number of sources, and about half the exposure. The deepest exposures are also for calibration (Mrk 421, PKS 2155).

Overall usage seems steady.

HETG GTO Science Program

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AGN: Active Galactic Nucleus
BH: Black Hole
ISM: InterStellar Medium
NS: Neutron Star
SN: SuperNova
SNR: SuperNova Remnant
XRB: X-ray Binary

Cycle 20:

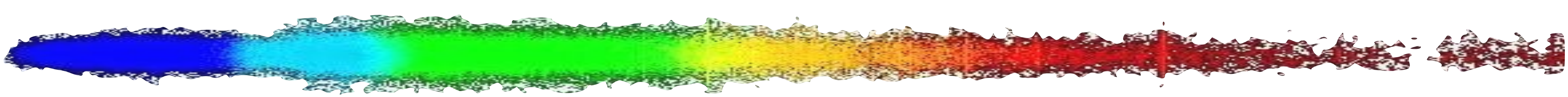
★Stars:	SZ 96	246 ks	Young, low mass stellar accretion
★XRB:	4U 1626-67	48 ks	Neutron star accretion (monitoring)
★SNR:	Cas A	92 ks	Decadal visit — 20 yrs on, dynamics

Cycle 21:

★Stars:	Brey 84	231 ks	Massive stars, stellar winds
★XRB:	IGR J16318-4848	58/250 ks	Fe diagnostics of neutron star accretion
★XRB:	4U 1636-53	0/140 ks	ISM survey, Si edge absorption, scattering.

Cycle 22:

★Stars:	ρ Oph A	0/200 ks	Winds of OB stars; magnetic confinement
★AGN:	Mrk 335	82 ks	Jets, disks, outflows, variability (w/NuSTAR, NICER).
★AGN:	NGC 1365	0/300 ks	Seyfert 1.8 galaxy; outflow, variability.
★BH:	SS 433	0/225 ks	Stellar mass black hole; relativistic jets, variability
★NS:	Terzan 5 X-2	0/200 ks	Neutron Star outburst (TOO)
★NS:	Cen X-4	0/60 ks	Neutron Star outburst (TOO)
★NS:	4U 1820-30	0/250 ks	Neutron Star outburst; gravitational redshift, NS radius (TOO)
★ISM:	GX 3+1	0/100 ks	Silicon K-edge structure and variability
★ISM:	GX 17+2	0/100 ks	Silicon gas-to-dust ratio (part of ISM survey)
★XRB:	4U 1626-67	0/60 ks	Ultra-compact binary; monitor disk line shapes



Cycle 20:

★ NS: (Predehl/MPE) RX J1856.6-3754 166 ks Isolated neutron star, calibration (with eRosita) (LETG/HRC-S)
★ AGN: (Kaastra/SRON) NGC 5548 168 ks AGN outflows, absorption, ionization, obscuration (HETG/ACIS-S)

Cycle 21:

★ AGN: (Kaastra/SRON) Mrk 279 141/175 ks AGN outflows, ionization, absorption (LETG/HRC-S)
★ SN,SNR: (Predehl/MPE) DEM S5 63/97 ks Pulsar wind nebula, morphology, dynamics (ACIS-S)
★ Sol.Sys: (Predehl/MPE) Mars 70 ks Solar wind - atmosphere interaction (LETG/HRC-S)

Cycle 22:

★ Stars (Predehl/MPE) RX J0859.1+0537 60/108 ks Accretion onto white dwarfs (LETG/HRC-S)
★ Stars (Predehl/MPE) RX J1002.2-1925 0/48 ks Accretion onto white dwarfs (LETG/HRC-S)
★ AGN (Predehl/MPE) HSC J092120.56+000722.9 0/20 ks Confirmation of faint z=6.56 eROSITA Quasar (ACIS-S)
★ AGN (Predehl/MPE) 2MASX J09325962+0405062 50 ks Confirmation of eROSITA Compton-thick Seyfert (ACIS-S)
★ AGN (Kaastra/SRON) MR 2251-178 0/175 ks Galaxy outflows, absorption line density diagnostics (LETG/HRC-S)

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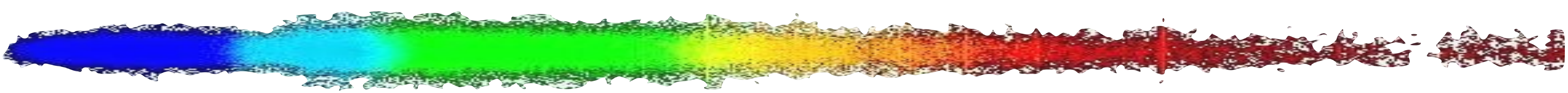

HETG GTO Science Program (continued)

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HETG Postdoc status/activities:

Daniele Rogantini (SRON) - started 16 Oct 2020;

research area: interstellar medium, dust, gas absorption and scattering;

Peter Kosec (U.Cambridge) - started 1 Jan 2021

research area: active galactic nuclei, photoionized plasma line modeling

HETG: Calibration Update (1)

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HETG high order calibration:

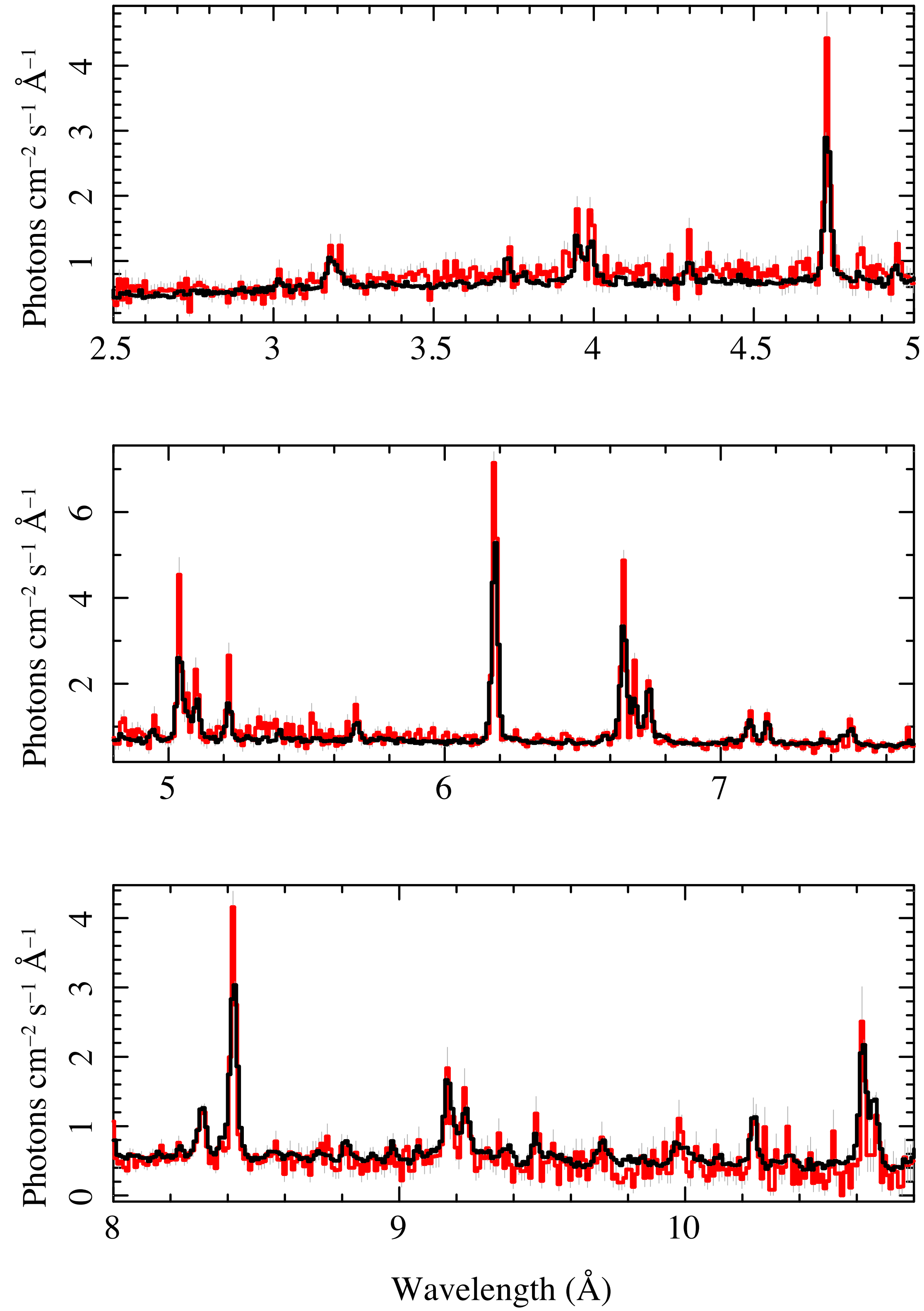
X-ray binaries are too bright for calibration — dispersed spectra are often saturated (“piled up”) and modeling is difficult.

θ^1 Ori C, a bright O-star in the Orion Nebula Cluster, now has 1.5 Ms of exposure, and allows inspection and modeling of the higher orders for an *unsaturated* source.

Higher orders can be useful because they provide proportionally higher spectral resolving power, though with more limited spectral coverage.

The figure shows the star’s flux spectrum in 1st order (black) and 3rd order (red) for MEG. The 3rd order calibration is good to 10% or better (currently under detailed analysis).

(Note: plot flux units scaled up by 1000.)



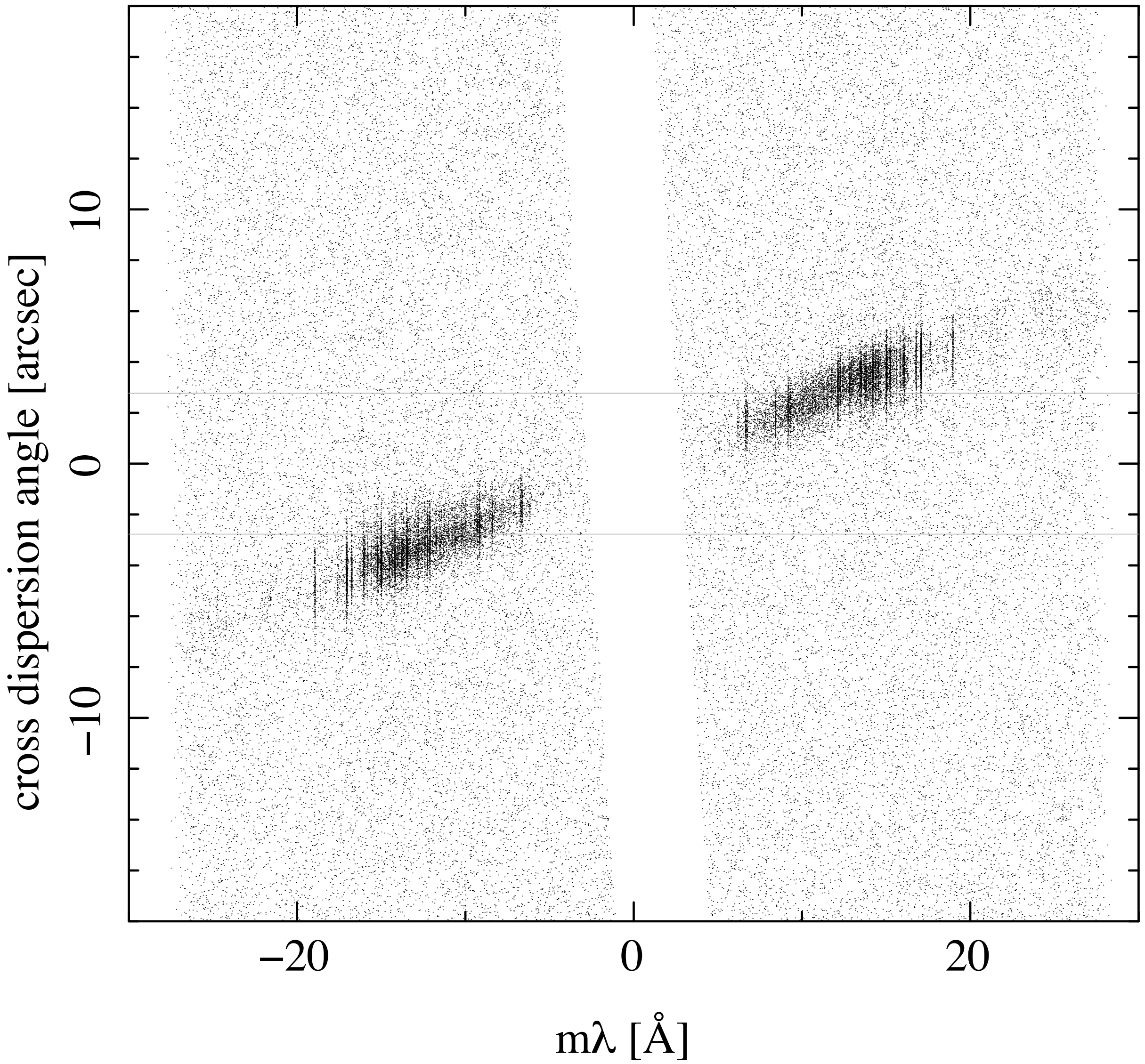
HETG: Calibration Update (2)

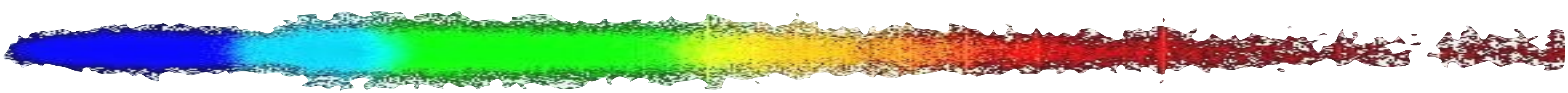
HETG with HRC-I:

We have calibration observations of the star, Capella, to test performance at energies where ACIS-S contamination prohibits use of HETG/ACIS-S, and where HETG's higher resolution is desired.

CIAO processing *mostly* works (see J.McDowell SDS presentation (#11) for details).

Calibration Database grating-to-detector angles are not correct. The MEG spectrum in diffraction coordinates should be horizontal, but shows significant residual tilt.





HETG: Calibration Update (2, continued)

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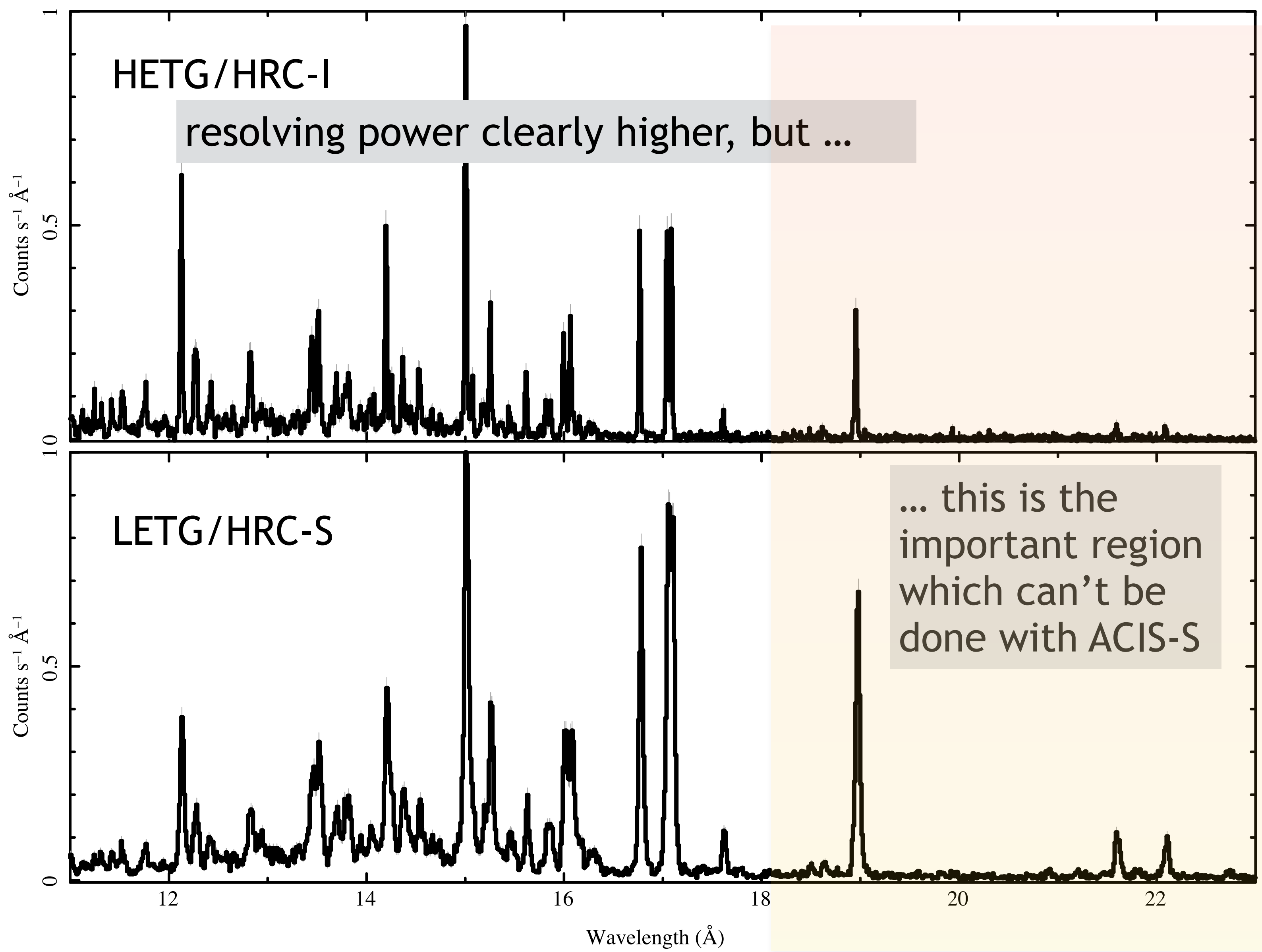
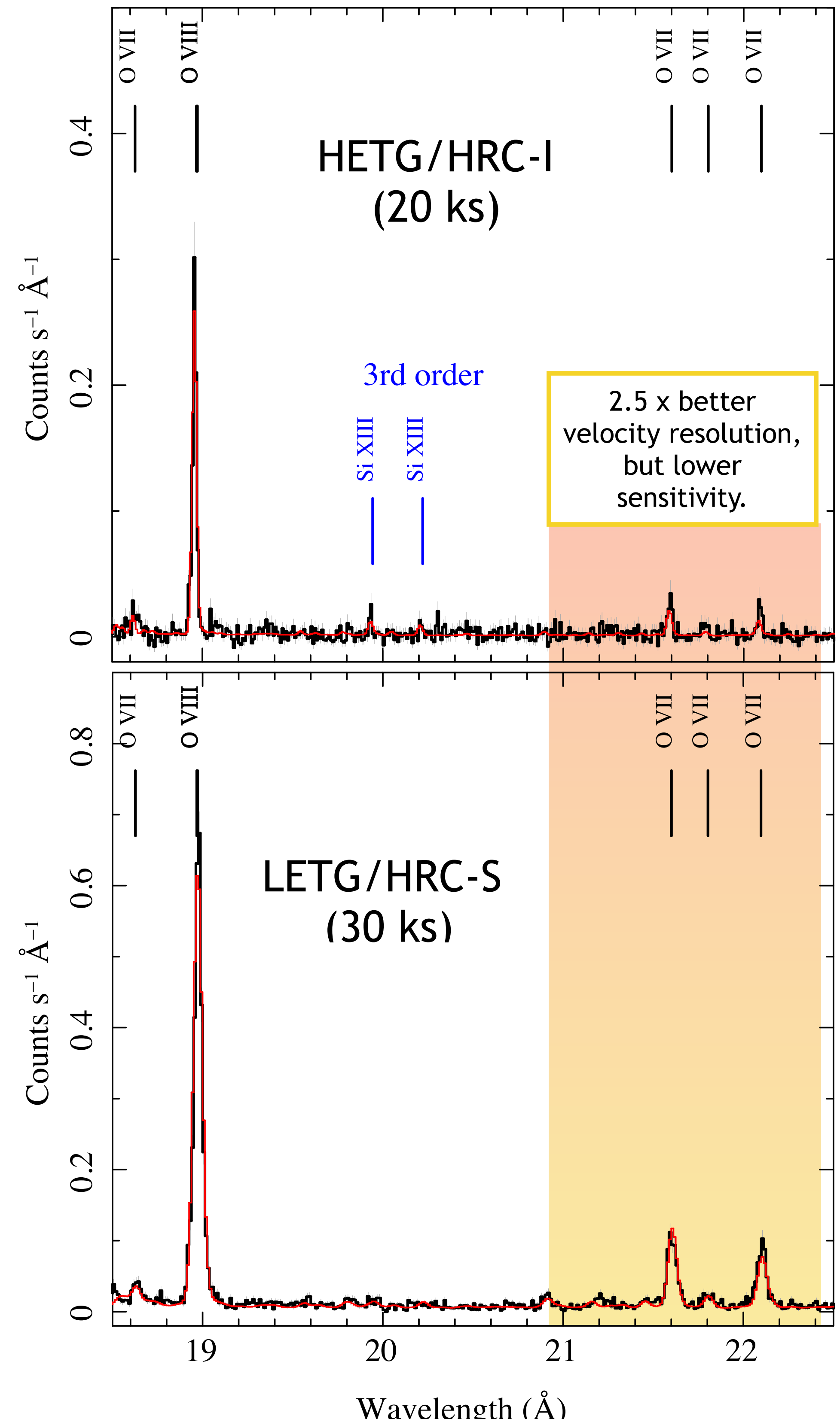
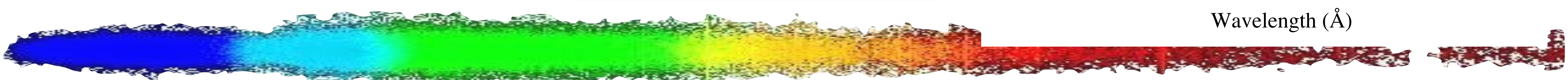
Comparison of HETG/HRC-I to LETG/HRC-S

(after fix for rotation error, processed with some other work-arounds…) (detailed analysis in progress).



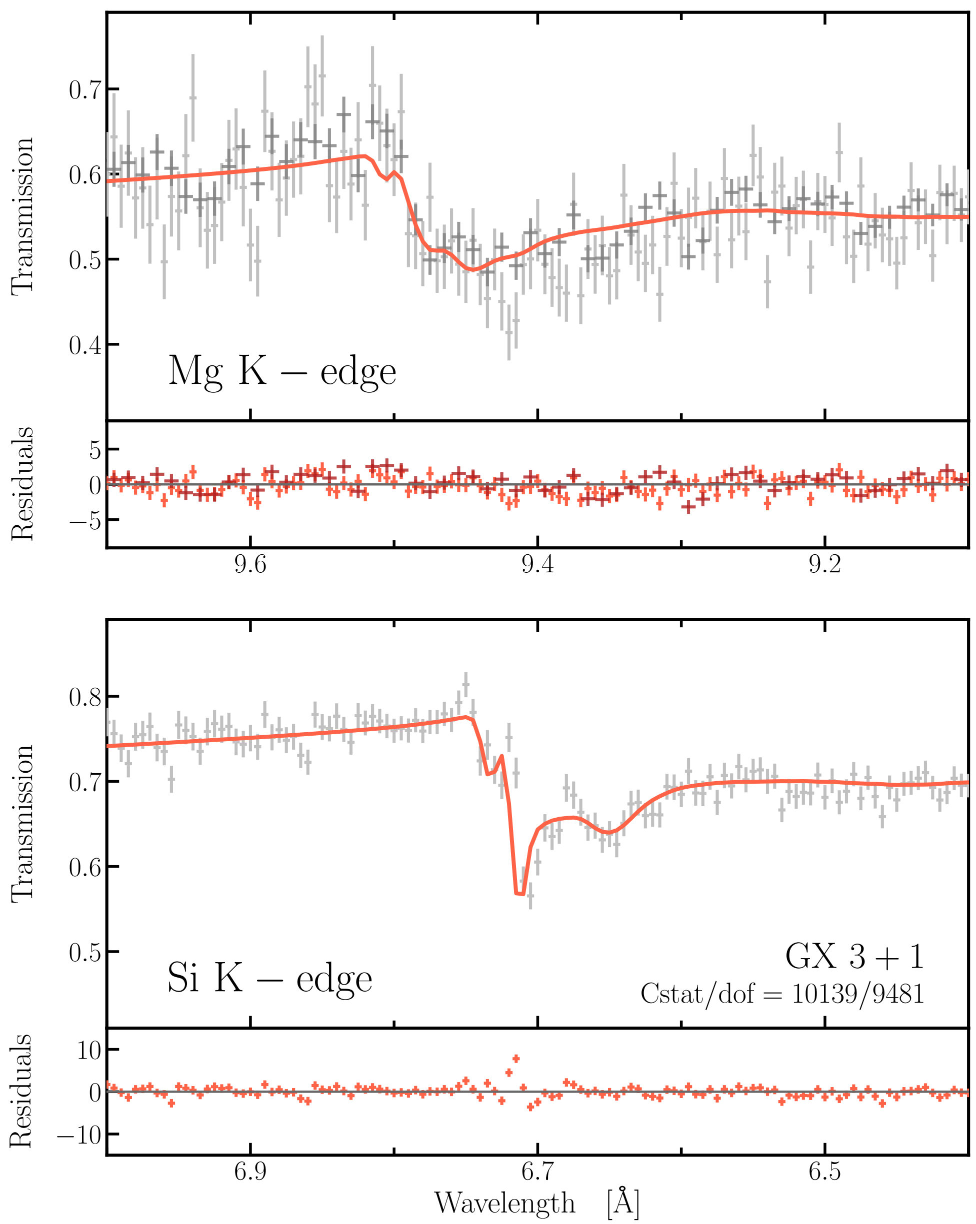




HETG GO Science in the Recent Literature:

Composition of the ISM

Rogantini et al. (2020; A&A, 641, A149) applied extinction cross sections of silicates measured at the synchrotron facility Soleil (France) in order to study common edge properties in bright X-ray binaries. The figure shows the result of these two edges for the case of GX 3+1. The study found that Mg and Si are highly depleted from the gas phase and that amorphous olivine is the most representative compound in all sources.



Low Mass X-ray Binary Disk Dynamics

Trueba et al. (2020 ApJL, 899, L16) present HETGS spectra of 4U 1916–053 with the aim investigating disk atmospheres, winds and wind driving mechanisms. They argue for perhaps the largest gravitational redshift ever detected in absorption at ~250 km s^{-1}.

Top: HETGS data (black) of this highly-inclined system have been used to demonstrate a red-shifted absorption feature (identified in the highly-ionized lines of Si XIV) present in the disk atmosphere (red) that is not present in the outer disk (blue).

Bottom: Schematic showing the Ultra Compact X-ray Binary composed of a neutron star primary with a helium-Rich donor, with the upper and lower graphics corresponding to the upper and lower spectra in the upper part of the figure.