

HETG/LETG — Status

Chandra Quarterly Review No. 58

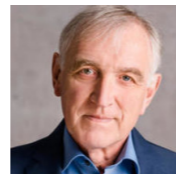
6 May 2025

David Huenemoerder
dph@space.mit.edu

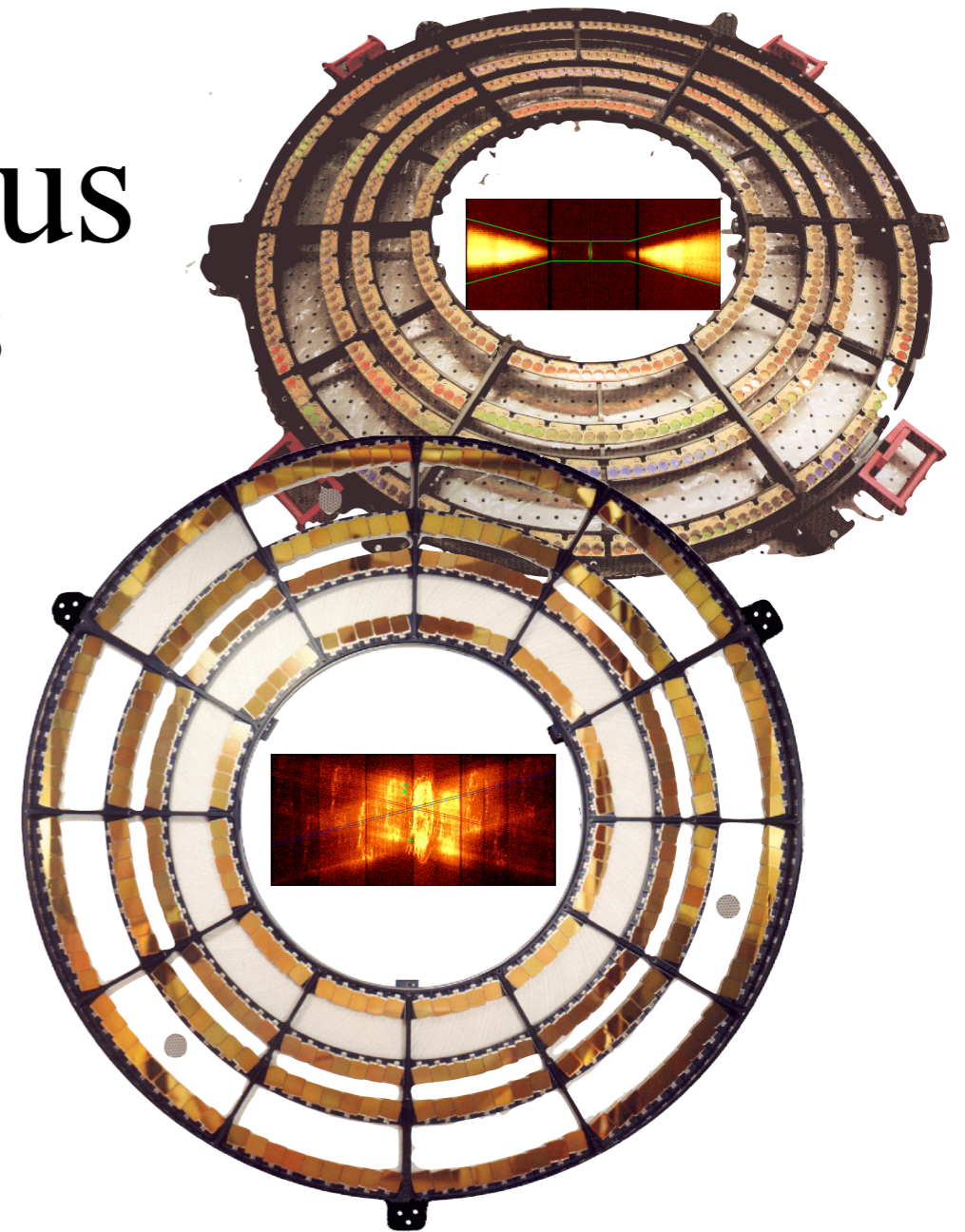
HETG IPI: Prof. Claude R. Canizares
MIT Kavli Institute



LETG IPIs: Dr. Peter Predehl
Max Planck Institute

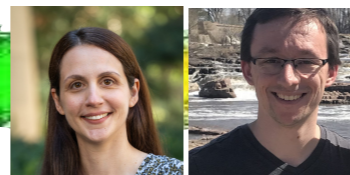


Dr. Jelle Kaastra
SRON



faculty, staff;

CXC staff



postdocs

HETG GTO Science Program



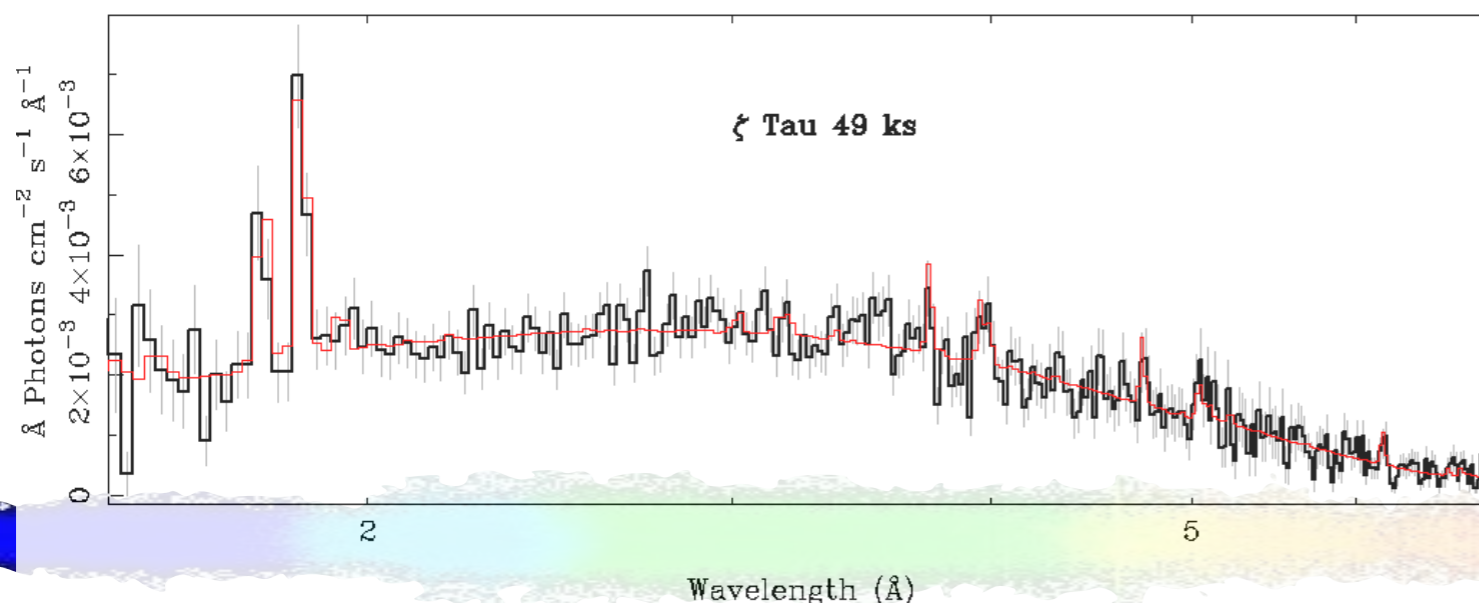
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Proposal Cycle 25 Jan 2024 (463 / 608 ks)

- ★ ULX/NS: M33 X-8 45/85 ks Pulsar wind outflow, absorption lines
- ★ Stars: ζ Puppis 150/190 ks Stellar winds, long-term monitoring
- ★ XRB: 4U 1626-67 58/94 ks Ultra-compact binary pulsar line shapes and torque-reversal
- ★ XRB: Her X-1 49/50 ks Pulsar accretion disk/wind dynamics during outburst (TOO)
- ★ ISM: GX 9+9 82/190 ks Galactic silicon absorption edge survey

Proposal Cycle 26 Jan 2025 (151 / 639 ks)

- ☆ XRB 4U 1626-67 29.3 100.0 Ultra-compact binary pulsar line shapes and torque-reversal
- ☆ XRB Cyg X-2 15.9 139.0 Low-mass X-ray binary
- ☆ XRB Vela X-1 56.8 150.0 Monitor as NS orbits in the wind
- ☆ Stars γ² Vel 0.0 100.0 Colliding wind binary
- ☆ Stars ζ Tau 48.8 100.0 γ-Cas type Be star, phase dependent emission?
- ☆ BH GW Transient 0.0 300.0 LIGO source followup (TOO)
- ☆ NS Terzan 5 X-2 0.0 200.0 Neutron Star outburst (TOO)



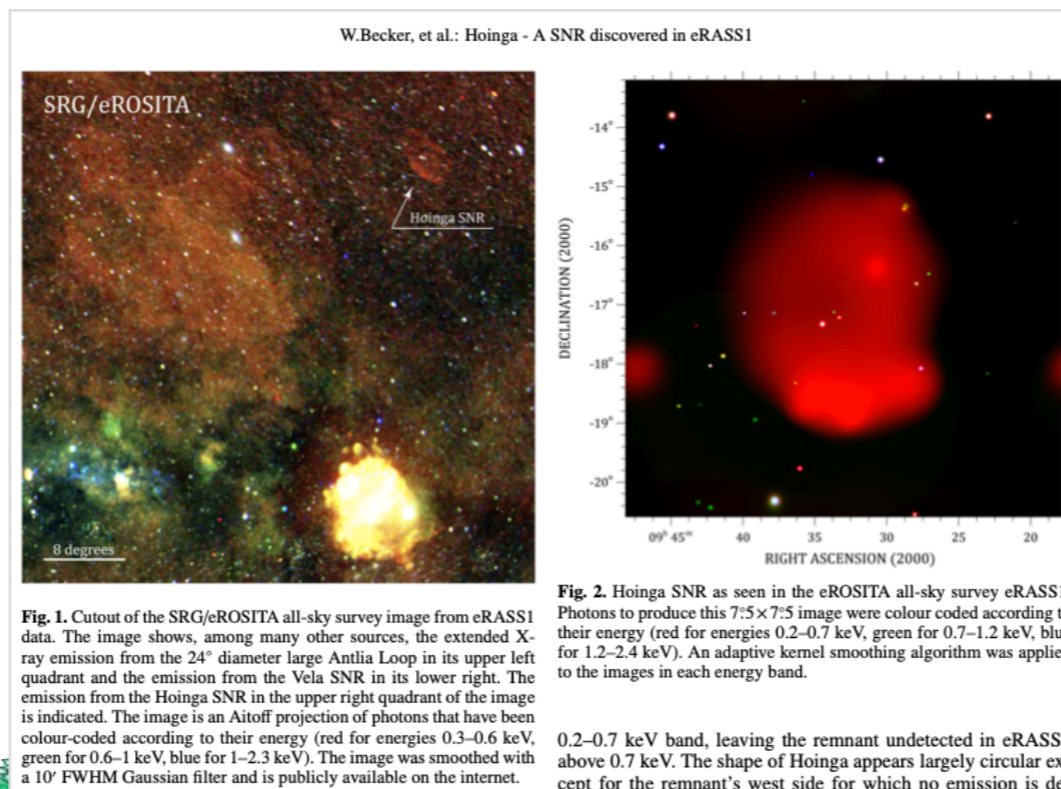
Jargon list:
 AGN: Active Galactic Nucleus
 BH: Black Hole
 ISM: InterStellar Medium
 NS: Neutron Star
 SN: SuperNova
 ULX: Ultra-Luminous X-ray source
 SNR: SuperNova Remnant
 XRB: X-ray Binary
 LMXB: Low Mass XRB

Cycle 25 start Jan 2024 (171 / 343 ks)

★ISM: (Predehl/MPE)	HD 115247	57/59 ks	Galactic bubbles absorption (LETG/HRC-S; w/ eROSITA)
★ISM: (Predehl/MPE)	HE1338-1423	58/59 ks	Galactic bubbles absorption (LETG/HRC-S; w/ eROSITA)
★ISM: (Predehl/MPE)	LEDA407	28/59 ks	Galactic bubbles absorption (LETG/HRC-S; w/ eROSITA)
★AGN: (Kaastra/SRON)	A1550	27/166 ks	Outflows, variability

Proposal Cycle 26 start Jan 2025 (118 / 280 ks)

★ SBR (Predehl/MPE)	Hoinga	0/70	SNR, eRosita discovered (ACIS-I/NONE)
★ SNR (Predehl/MPE)	PWN j1631-4721	0/70	Pulsar wind nebula morphology (ACIS-S/NONE)
★ AGN (Kaastra/SRON)	NGC 5548	118/125	Outflows, variability (HRC-S/LETG; w/ Xrism, XMM, NuSTAR, HST)
★ AGN (Kaastra/SRON)	RXJ 1131-1231	0/15	Quasar microlensing (ACIS-I/NONE; w/ALMA)



Hoinga

- AGN: Active Galactic Nucleus
- BH: Black Hole
- ISM: InterStellar Medium
- NS: Neutron Star
- SN: SuperNova
- ULX: Ultra-Luminous X-ray source
- SNR: SuperNova Remnant
- XRБ: X-ray Binary
- LMXB: Low Mass XRБ

Performance July 2024 — April 2025

HETG/ACIS-S: 1526 ks

- 70 observations on 24 targets (20 GO, 37 GTO, 1 DDT, 11 TOO, 1 CAL)

HETG/HRC-I: 29ks

- 2 observations on 1 target (Cal)

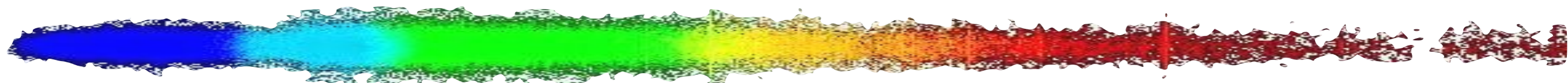
LETG:

- LETG/HRC-S: 263 ks, 23 observations, 5 targets (4 GO, 13 GTO, 6 CAL)
- LETG/ACIS-S: 263 ks, 15 observations, 4 targets (2 GO, 13 Cal)
- LETG/HRC-I: 2 ks, 1 observation, 1 target (Cal)

All instruments: 11.03 Ms (84%) 768 observations, 352 targets
(499 GO, 64 GTO, 27 DDT, 29 TOO, 59 CAL)

Grating instruments: 2.08 Ms (16%) 111 observations, 32 targets
(26 GO, 50 GTO, 1 DDT, 11 TOO, 23 CAL)

Grating performance is nominal.

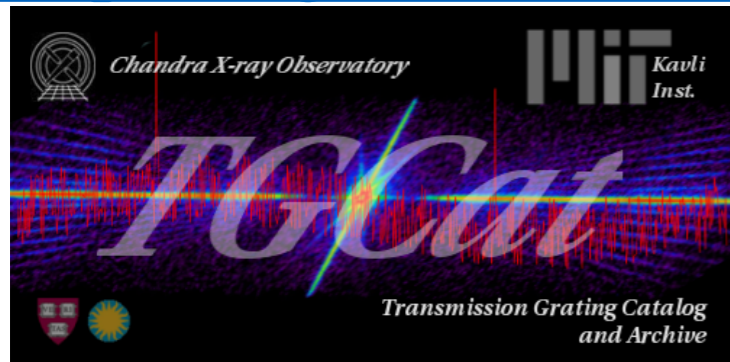




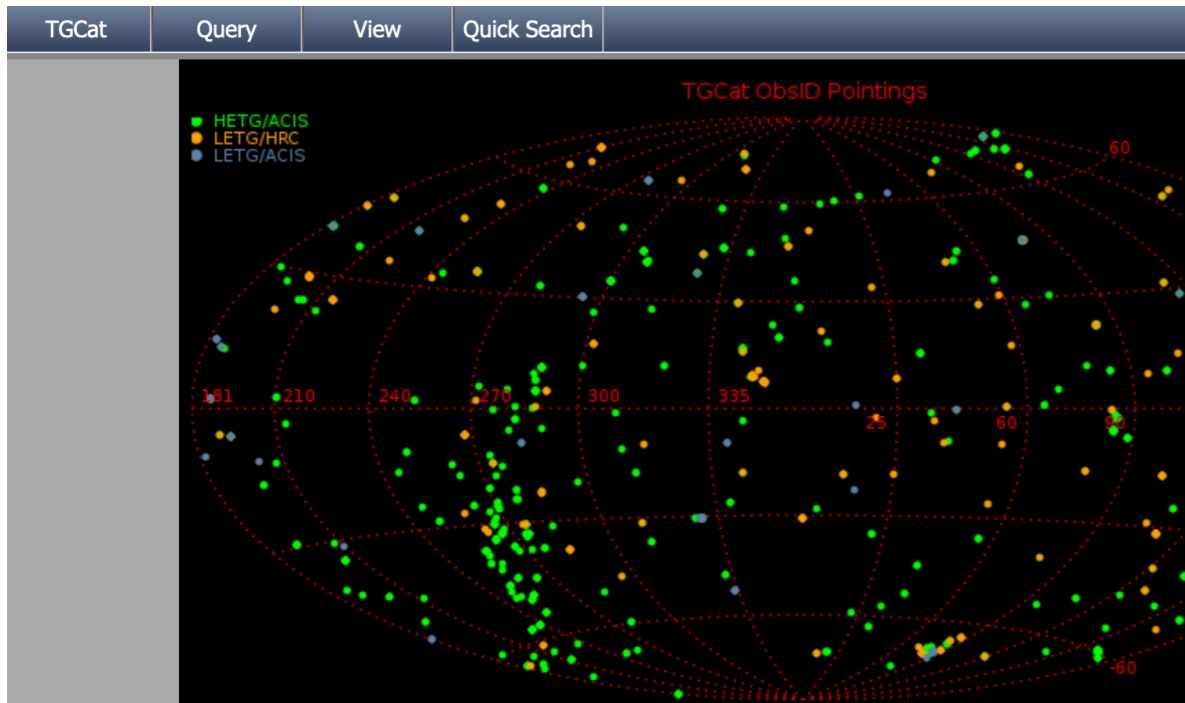
TGCat Status



<http://tgcats.mit.edu>



<<http://tgcats.mit.edu/dev/tgcats/tgTrend.php>



Browser window showing tgcats.mit.edu/tgPlot.php?t=P&i=4122

Navigation: TGCat | Query | View | Help Topics | Help

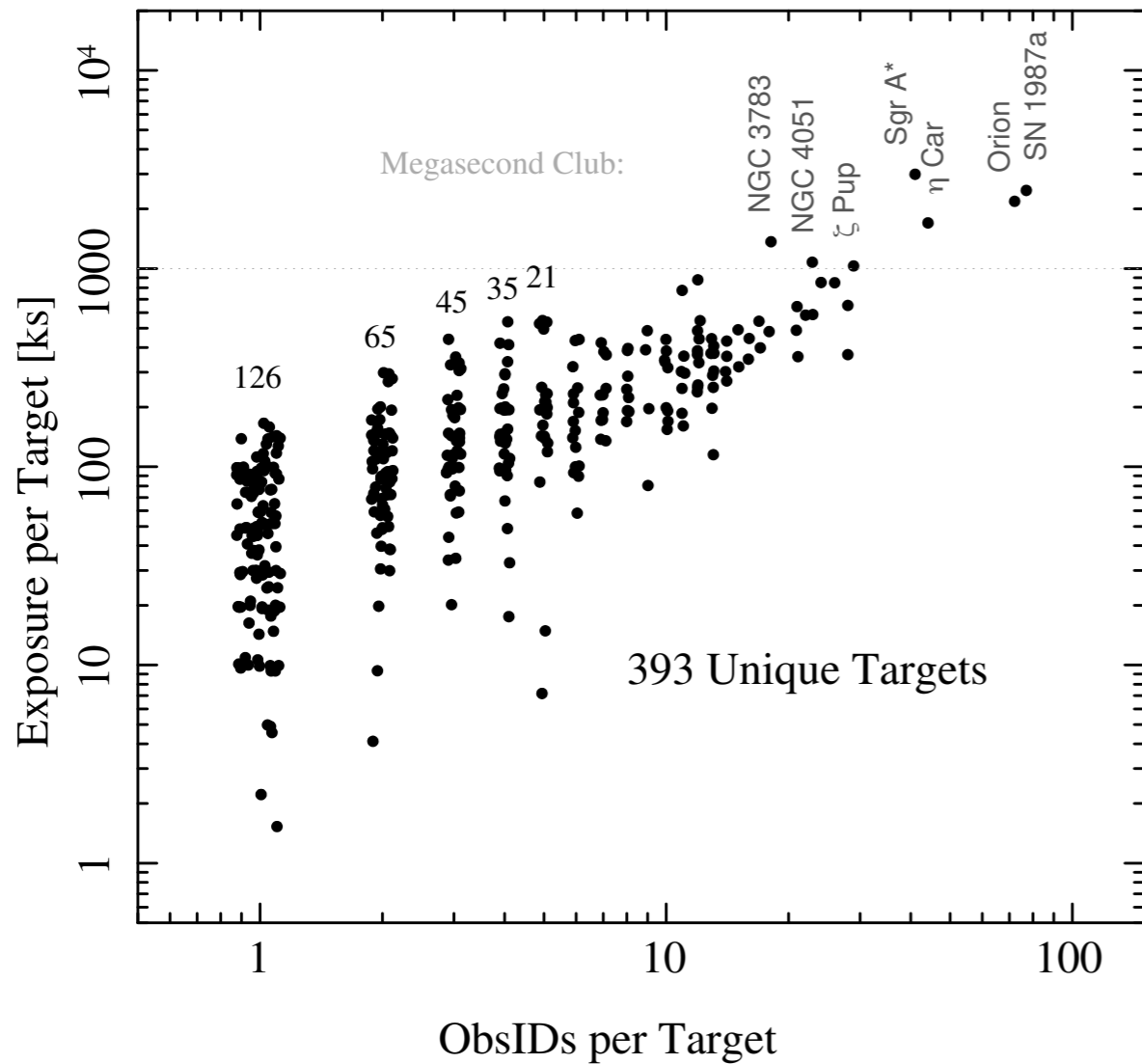
NGC 1068

single extraction product

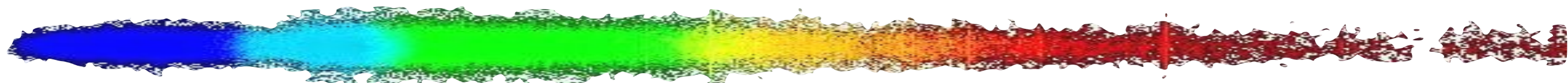
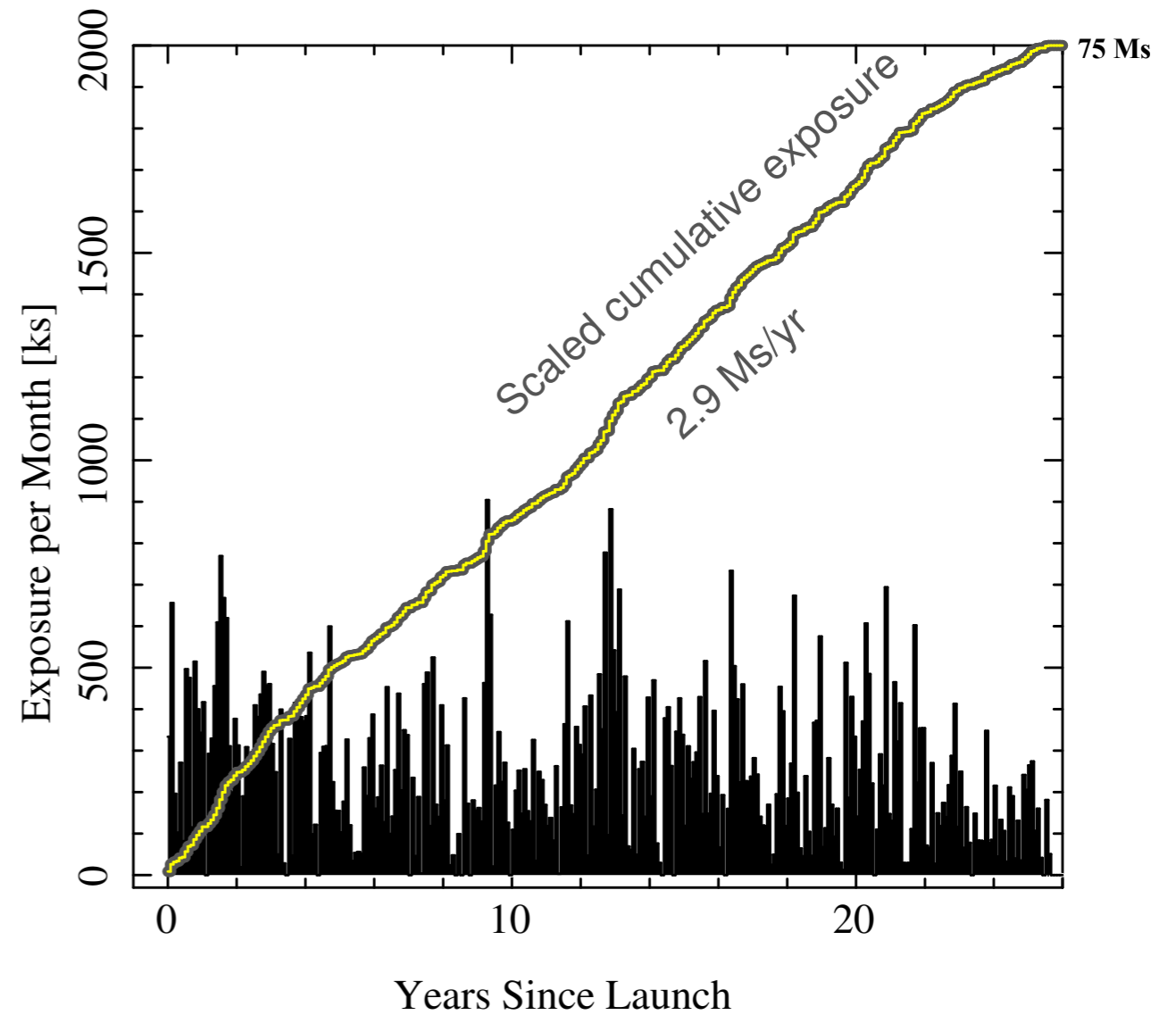
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srcid	1874
obsid	9148
review	good
obi	0
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object	NGC 1068
simbad_ID	4C-00.13
instrument	ACIS
grating	HETG
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ra	40.66963
decl	-0.01322
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meg_band(c/s)	1.51e-1
leg_band(c/s)	1.49e-1
letg_acis_band(c/s)	1.49e-1
zero_order(c/s)	2.26e-1
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datamode	FAINT
proc_date	2012-02-04 13:54:04
zo_method	tgdetect
date_obs	2008-12-05 08:24:45

Observations	Exposure (s)	ZO method	Archive
Total Obsids: 2932	Min Exposure: 40	tgdetect2: 177	Total Archived Files: 100443
Distinct Sources: 597	Max Exposure: 189,255	tgdetect: 1361	Total Archive Size (GB): 546.77
ACIS HETG Observations: 1990	Mean Exposure: 37,820	none: 1081	Space per Obsid (MB): 190.96
ACIS LETG Observations: 329	Cumulative Exposure: 110,888,334	findzo: 313	Ave File size (MB): 5.57
HRC LETG Observations: 613			Number Distinct File Type: 8
ACIS CONTINUOUS Mode: 176			
ACIS TIMED Mode: 2143			

Exposure per target, and number of visits



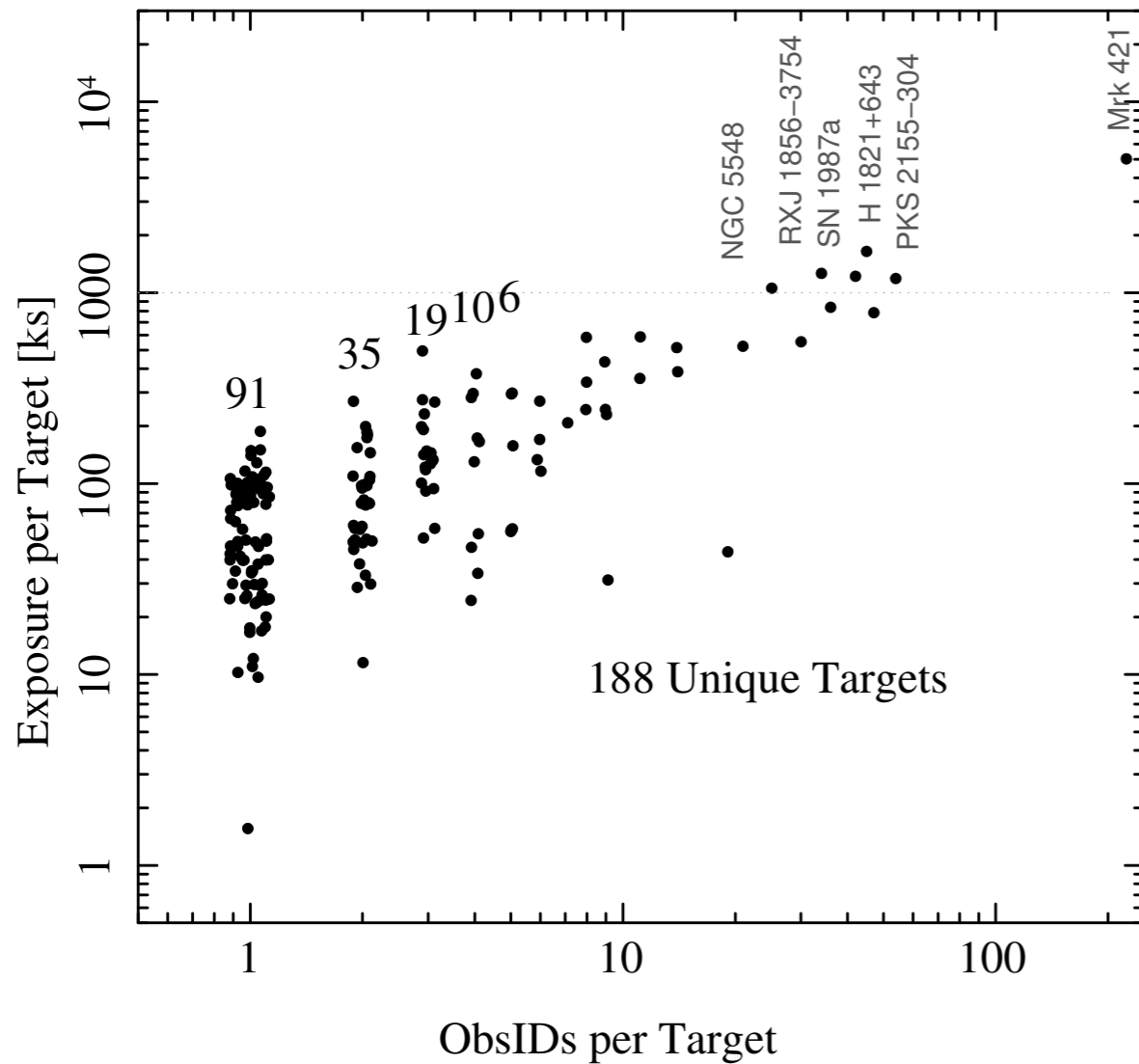
Exposure per month, and cumulative exposure



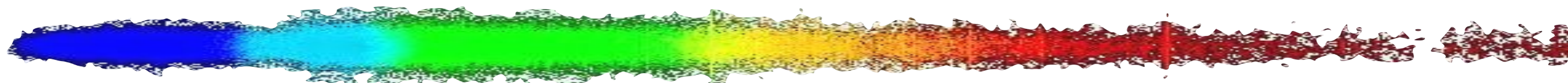
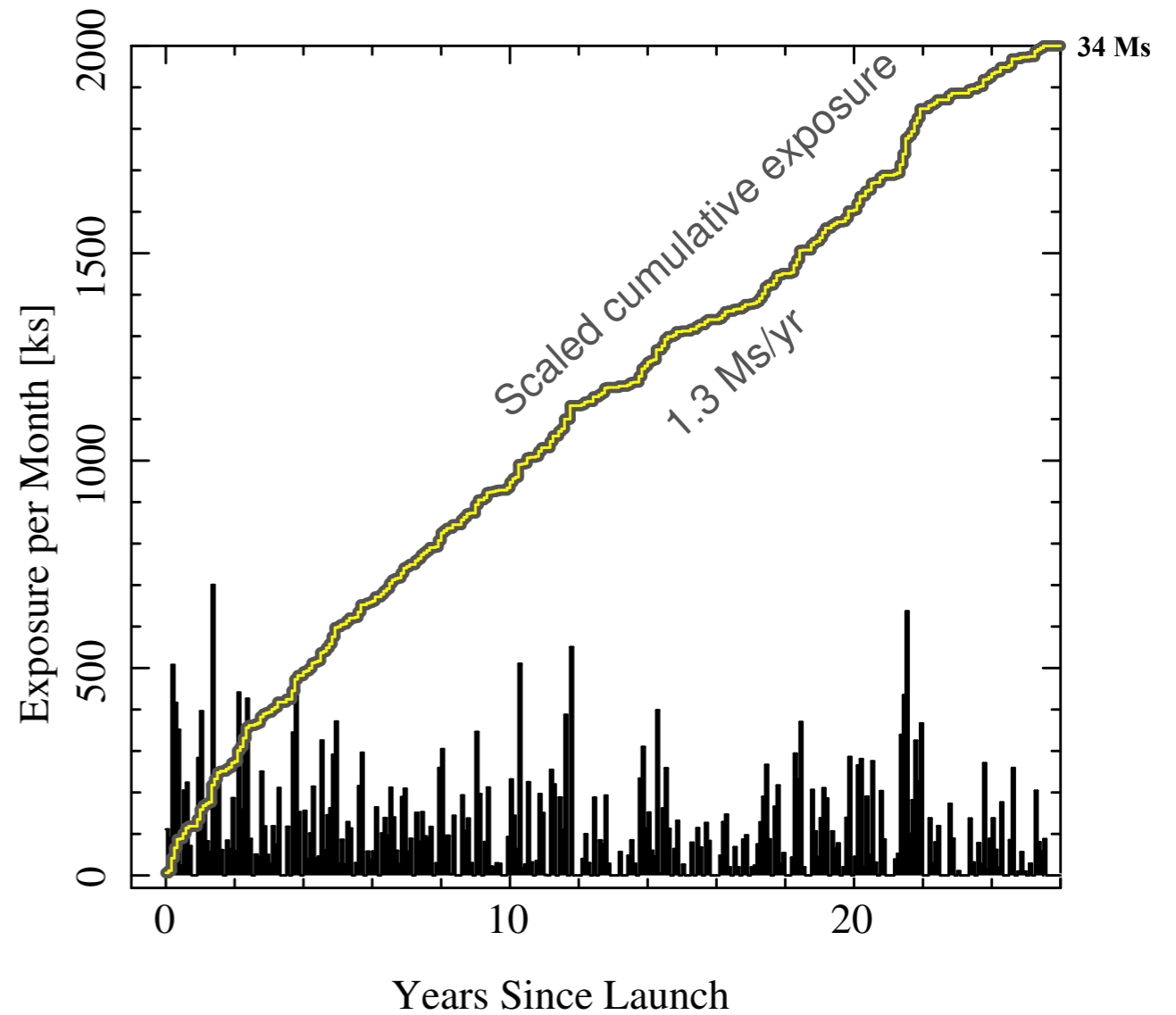
LETG Observations Historical Trends



Exposure per target, and number of visits



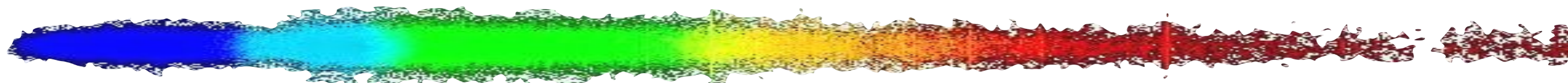
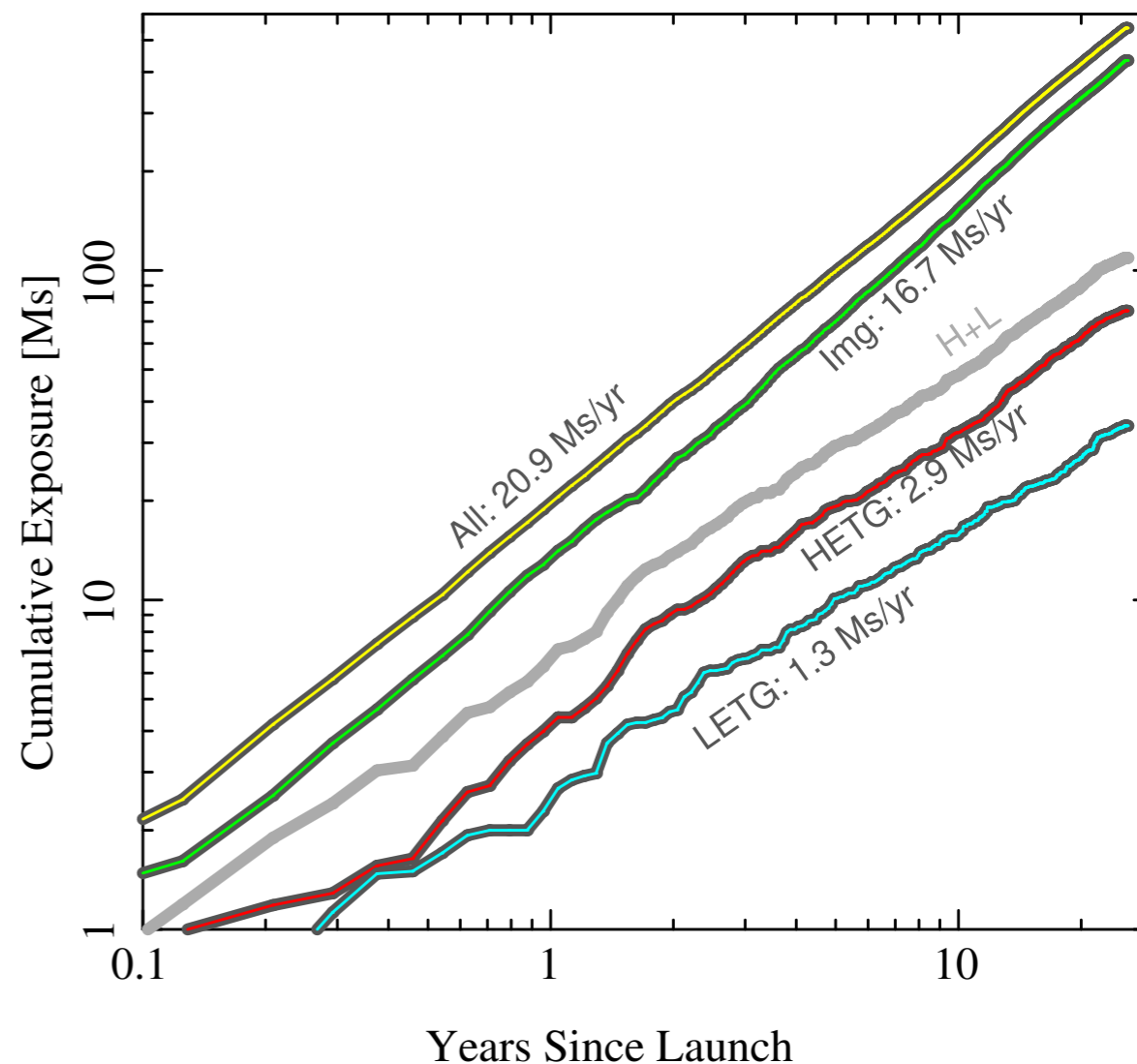
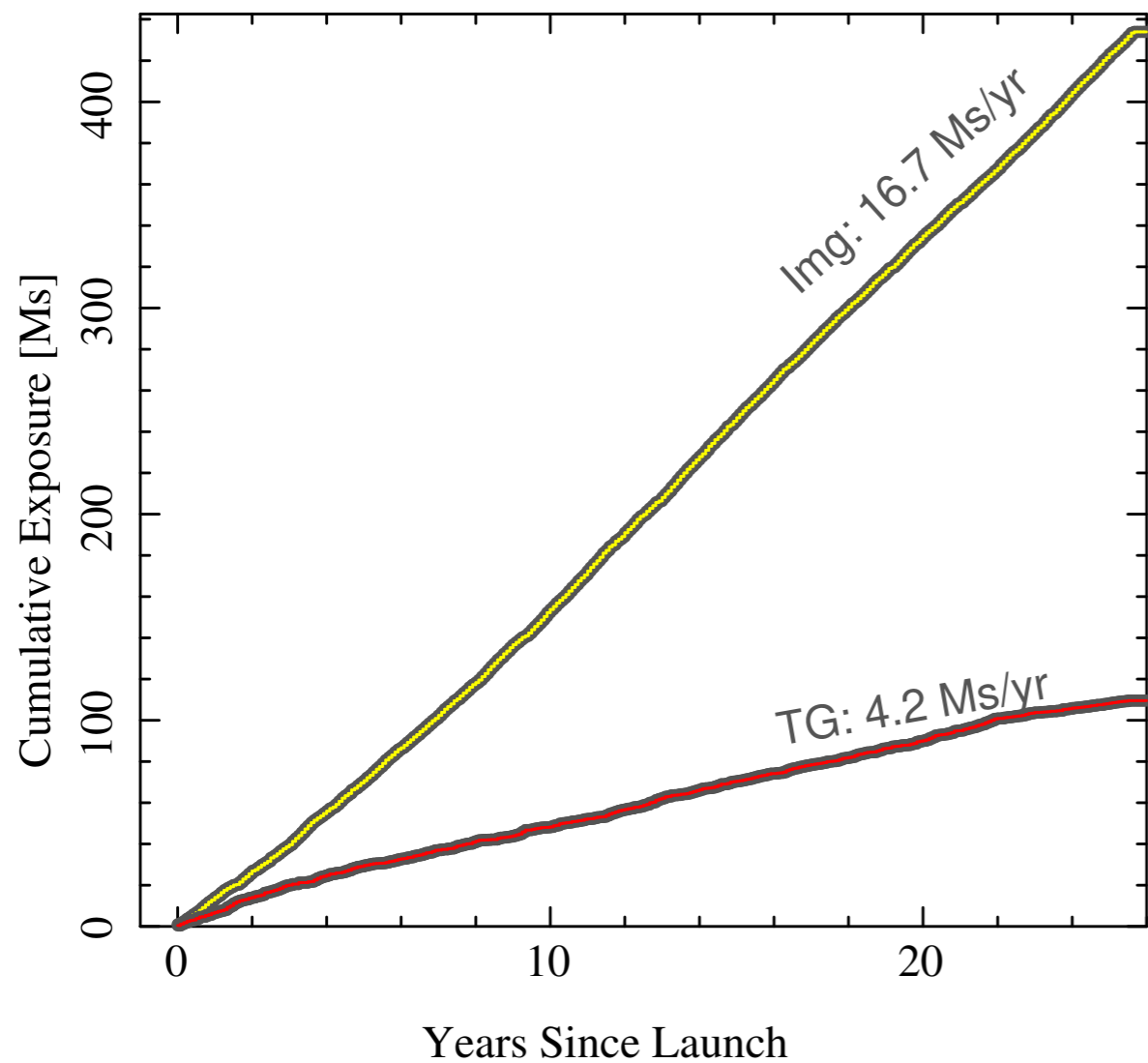
Exposure per month, and cumulative exposure



Historical Trends: Cumulative Exposures



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ACIS High-T Operations: OK to use HETG

(but for warmest temperatures, offset to low CHIPY).

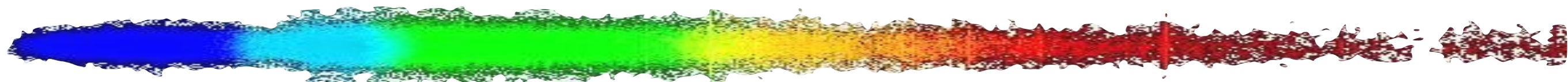
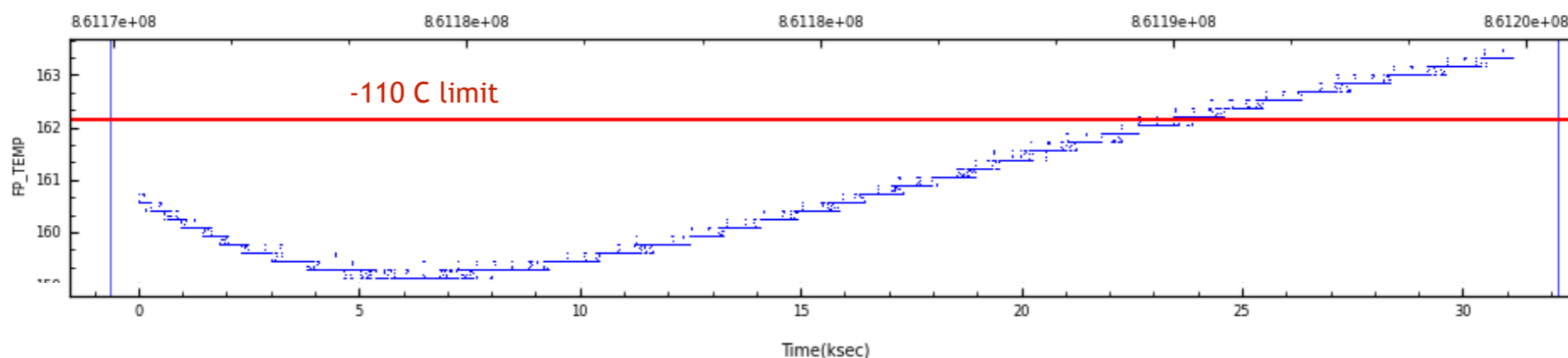
A warning is given in the Verification & Validation report if limits are exceeded.

Software changes for intra-observation temperature variations is under investigation.

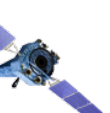
HETG 2nd and 3rd order efficiency calibration: in progress.

Line-spread-function parameters for HETG/HRC-I and off-axis pointings: in progress.

Example of ACIS focal plane temperature excursions during an observation:



Some Scientific Results Published in the Past 10 Months (1/3)



A&A, 690, A360 (2024)
<https://doi.org/10.1051/0004-6361/202449724>
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**Astronomy
&
Astrophysics**

Revealing the state transition of Cen X-3 at high spectral resolution with *Chandra*

G. Sanjurjo-Ferrín^{1,*}, J. M. Torrejón¹, L. Oskinova², K. Postnov³, J. J. Rodes-Roca¹, N. Schulz⁴, and M. Nowak⁵

A&A, 690, A9 (2024)
<https://doi.org/10.1051/0004-6361/202450101>
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**Astronomy
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Astrophysics**

High-resolution X-ray spectra of the compact binary supersoft X-ray source CAL 87

Songpeng Pei^{1,*}, Xiaowan Zhang¹, Qiang Li^{2,3}, and Ziwei Ou⁴

MNRAS **538**, 2186–2203 (2025)
Advance Access publication 2025 March 13

<https://doi.org/10.1093/mnras/staf420>

Temporal variability and obscuration effects in the X-ray emission of classical nova V339 Delphini (Nova Delphini 2013)

Songpeng Pei^{1,*}, Nataly Ospina², Xiaowan Zhang¹, Qiang Li^{3,4}, Ziwei Ou⁵, Taozhi Yang⁶ and Yongzhi Cai^{7,8,9}

THE ASTROPHYSICAL JOURNAL, 972:109 (16pp), 2024 September 1
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<https://doi.org/10.3847/1538-4357/ad5cf6>

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X-Ray Variability in the Symbiotic Binary RT Cru: Principal Component Analysis

A. Danehkar¹, J. J. Drake², and G. J. M. Luna³

THE ASTROPHYSICAL JOURNAL, 982:8 (15pp), 2025 March 20
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<https://doi.org/10.3847/1538-4357/adb3a5>

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Where is the Supercritical Gas? II. Insight from the Survey of Galactic Sightlines

Manami Roy^{1,2}, Smita Mathur^{1,2}, Sanskriti Das^{3,6}, Armando Lara-Díez⁴, Yair Krongold⁴, and Anjali Gupta⁵

THE ASTROPHYSICAL JOURNAL, 969:110 (10pp), 2024 July 10
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The High-resolution Fe K Spectrum of Cygnus X-3

Aswath Suryanarayanan¹, Frits Paerels¹, and Maurice Leutenegger²

THE ASTROPHYSICAL JOURNAL, 981:137 (10pp), 2025 March 10
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Connecting Dust and Outflows in Active Galactic Nuclei: The Intriguing Case of NGC 6860

I. Psaradaki^{1,2}, M. Mehdipour³, D. Rogantini⁴, E. Costantini^{2,5}, N. Schulz¹, S. Zeegers⁶, and E. Caruso^{2,5}

A&A, 694, A73 (2025)
<https://doi.org/10.1051/0004-6361/202453039>
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**Astronomy
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Examining the evolution of the supersoft X-ray source RX J0513.9 – 6951

A. Tavleev^{*}, V. F. Suleimanov^{*}, K. Werner^{*}, and A. Santangelo^{*}

THE ASTROPHYSICAL JOURNAL, 978:105 (15pp), 2025 January 01
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A Time-dependent Spectral Analysis of γ Cassiopeiae

Sean J. Gunderson¹, David P. Huenemoerder¹, José M. Torrejón², Dustin K. Swann³, Joy S. Nichols⁴, Pragati Pradhan⁵, Richard Ignace⁶, Hans Moritz Guenther¹, A. M. T. Pollock⁷, and Norbert S. Schulz¹

THE ASTROPHYSICAL JOURNAL, 982:25 (13pp), 2025 March 20
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Accretion-disk Reflection in the Seyfert 1 Galaxy NGC 3783 as Viewed by *Chandra* Grating Spectroscopy

THE ASTRONOMICAL JOURNAL, 169:2 (11pp), 2025 January
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<https://doi.org/10.3847/1538-3881/ad86b8>

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Unfolding X-Ray Spectral Data: Conditions and Applications

Sean J. Gunderson^{*} and David P. Huenemoerder^{*}

THE ASTROPHYSICAL JOURNAL, 970:190 (32pp), 2024 August 1
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<https://doi.org/10.3847/1538-4357/ad47c2>

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The Nature of X-Rays from Young Stellar Objects in the Orion Nebula Cluster—A *Chandra* HETGS Legacy Project

Norbert S. Schulz¹, David P. Huenemoerder¹, David A. Principe¹, Marc Gagne², Hans Moritz Günther¹, Joel Kastner³, Joy Nichols⁴, Andrew Pollock⁵, Thomas Preibisch⁶, Paola Testa⁴, Fabio Reale⁷, Fabio Favata^{8,9}, and Claude R. Canizares¹

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<https://doi.org/10.3847/1538-4357/ad6c08>

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Multistructured Accretion Flow of Sgr A*. I. Examination of a Radiatively Inefficient Accretion Flow Model

Mayura Balakrishnan¹, Lia Corrales¹, Sera Markoff², Michael Nowak³, Daryl Haggard⁴, Q. Daniel Wang⁵, Joey Neilsen⁶, Christopher M. P. Russell⁷, Diego Calderón⁸, Jorge Cuadra^{9,10}, and Frederick Baganoff¹¹

A&A, 693, A266 (2025)
<https://doi.org/10.1051/0004-6361/202452599>
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**Astronomy
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Chandra high-resolution spectra of Apep Plume: Exploring the colliding-wind picture in X-rays

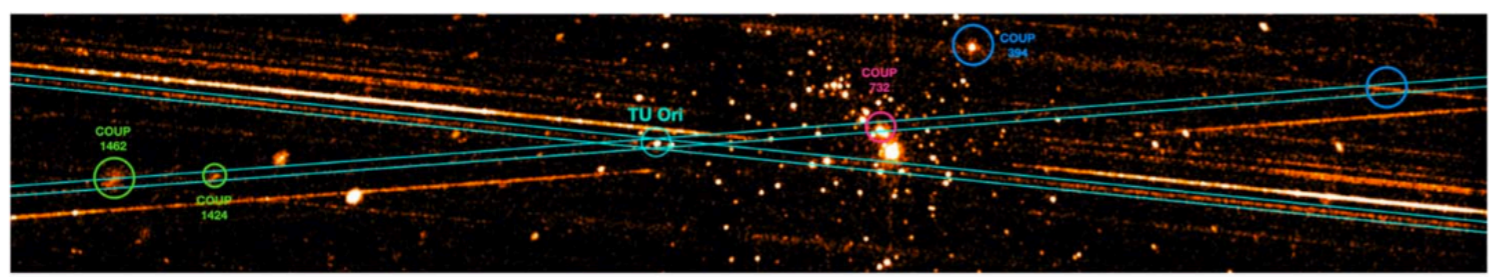
Svetozar A. Zhekov^{*} and Blagovest V. Petrov^{*}

THE ASTROPHYSICAL JOURNAL, 970:190 (32pp), 2024 August 1
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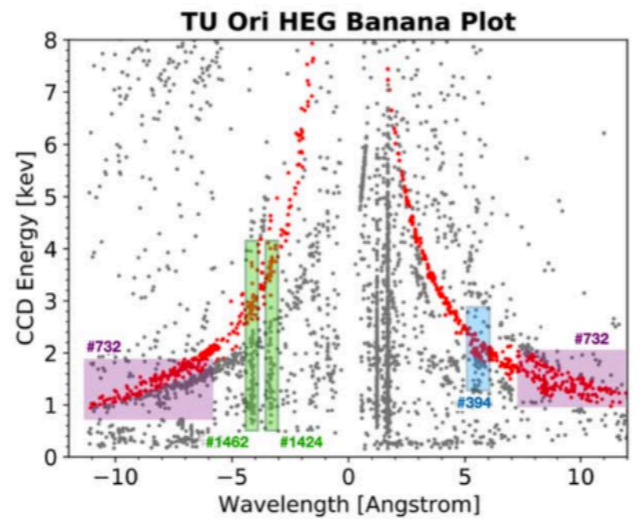
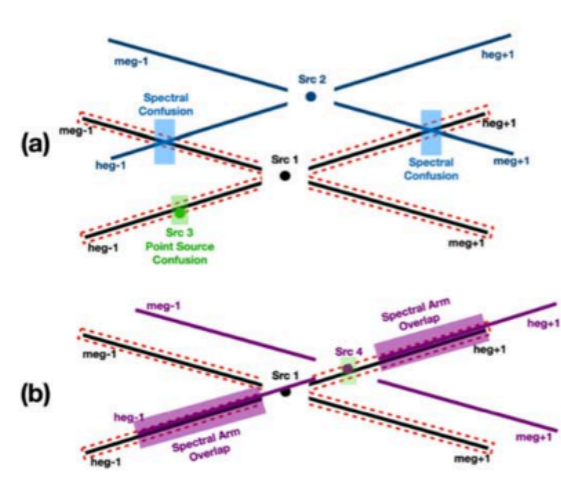
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The Nature of X-Rays from Young Stellar Objects in the Orion Nebula Cluster—A Chandra HETGS Legacy Project

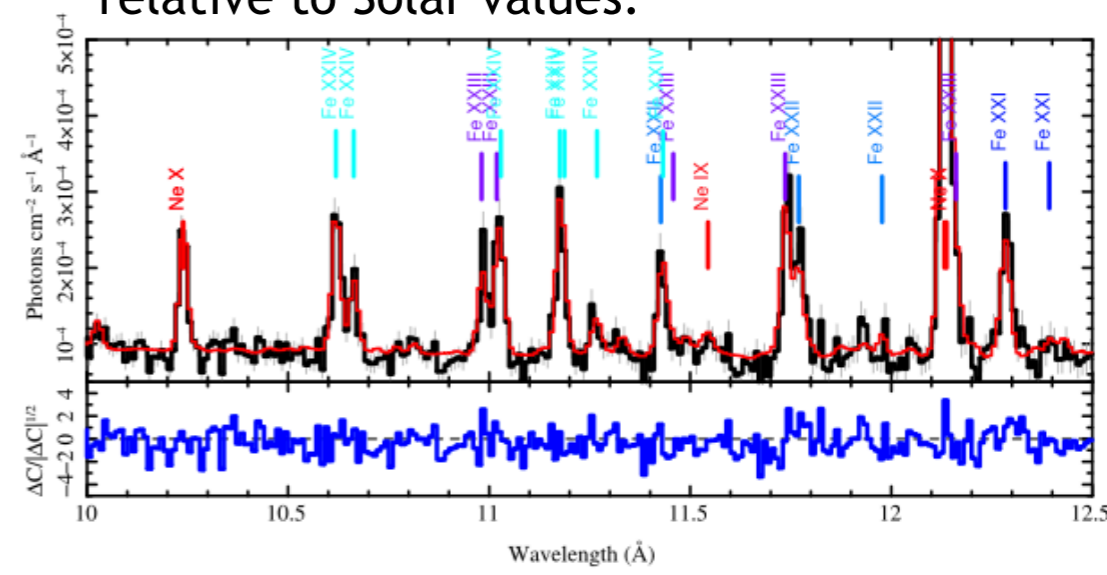
Norbert S. Schulz¹, David P. Huenemoerder¹, David A. Principe¹, Marc Gagne², Hans Moritz Günther¹, Joel Kastner³, Joy Nichols⁴, Andrew Pollock⁵, Thomas Preibisch⁶, Paola Testa⁴, Fabio Reale⁷, Fabio Favata^{8,9}, and Claude R. Canizares¹



How to de-confuse dispersed spectra – several types of overlaps (handled by “criss-cross” code from David Principe.)



θ Ori E 1.5 Ms when cleaned; Fe and Ni lines show significant under-abundance relative to Solar values.



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<https://doi.org/10.3847/1538-3881/ad86b8>
 CrossMark
Unfolding X-Ray Spectral Data: Conditions and Applications
 Sean J. Gunderson  and David P. Huenemoerder 

“Forward folding” (convolution), and “unfolding” (approximately, division by a response).

Bottom line: unfolding helps one be guided by *source physics*, rather than detector features. Unfolding is very good for *visualization* of high-resolution spectra (gratings), and “good enough” for much low-res spectra *IF DONE RIGHT!*

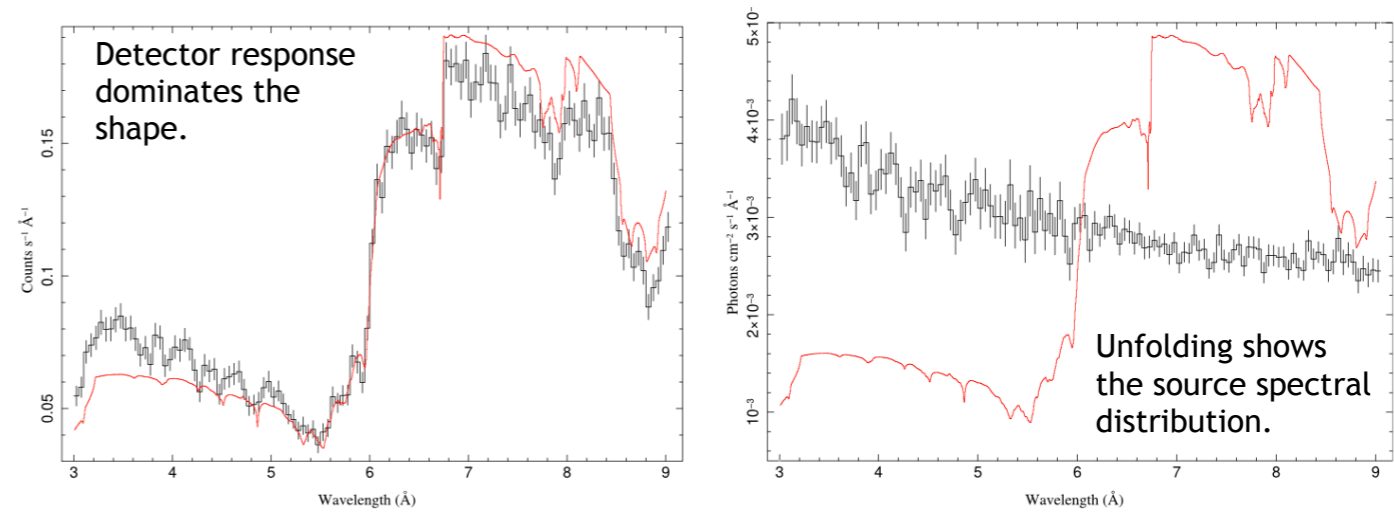


Figure 7. Chandra MEG observation of 3C 273 showing of how unfolding can remove features in spectra caused by the detector. The left panel is the counts spectr while the right panel is the unfolded version. In both panels, the black histogram is the spectrum binned by a constant factor of 10, and the scaled ARF values at in red.

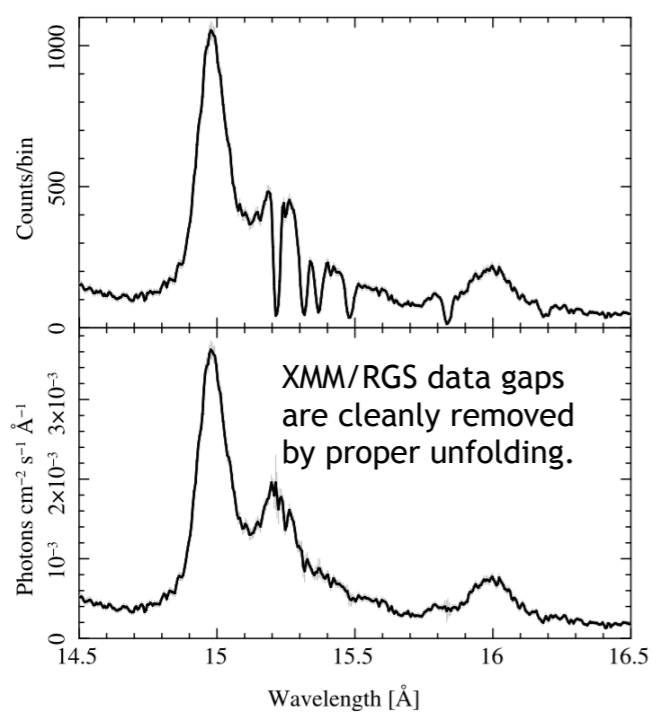


Figure 8. This combination of 18 XMM/RGS1 observations, nearly 1 Ms exposure of ζ Puppis demonstrates how dropouts in the count spectrum—the

Unfolding helps compare different instruments, even low-res NuSTAR to Chandra/HETG – the offset is real (larger than unfolding uncertainties) and shows source variability between observations.

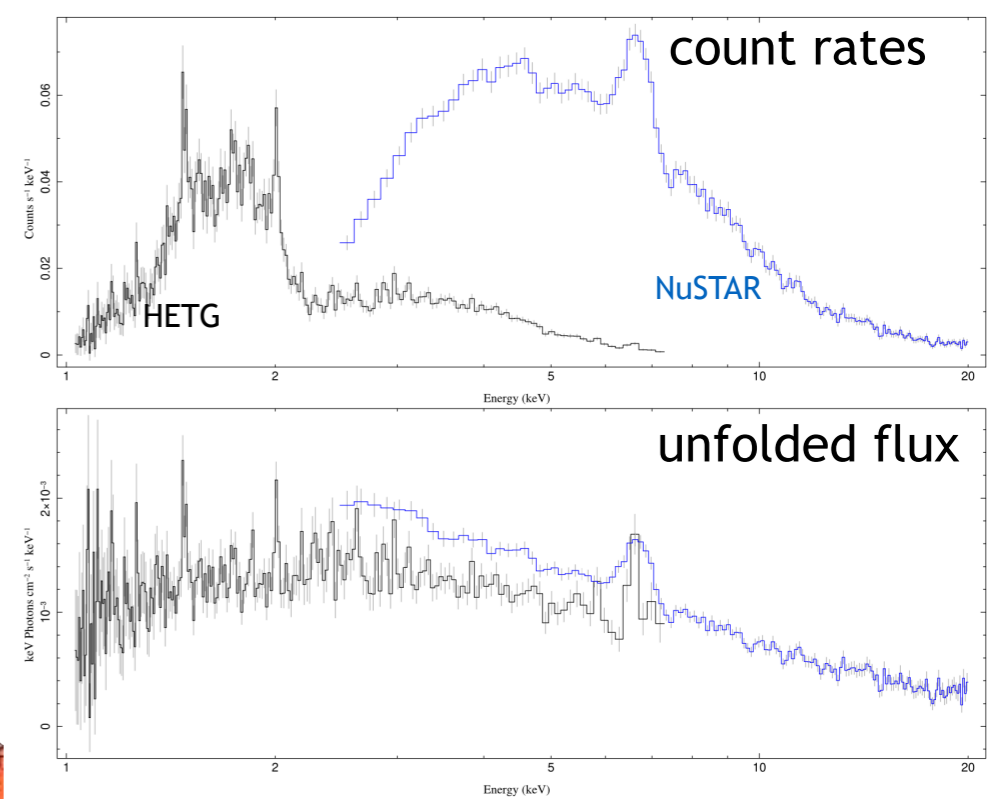


Figure 9. Count rate (top) and unfolded (bottom) spectra of π Aqr from Chandra’s HETG (black) and NuSTAR (blue). The HETG spectrum is the HEG + MEG plotted on the MEG grid and binned by a constant factor of 10. The NuSTAR spectrum is telescopes A + B plotted on A’s grid and binned by a constant factor of 3.



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