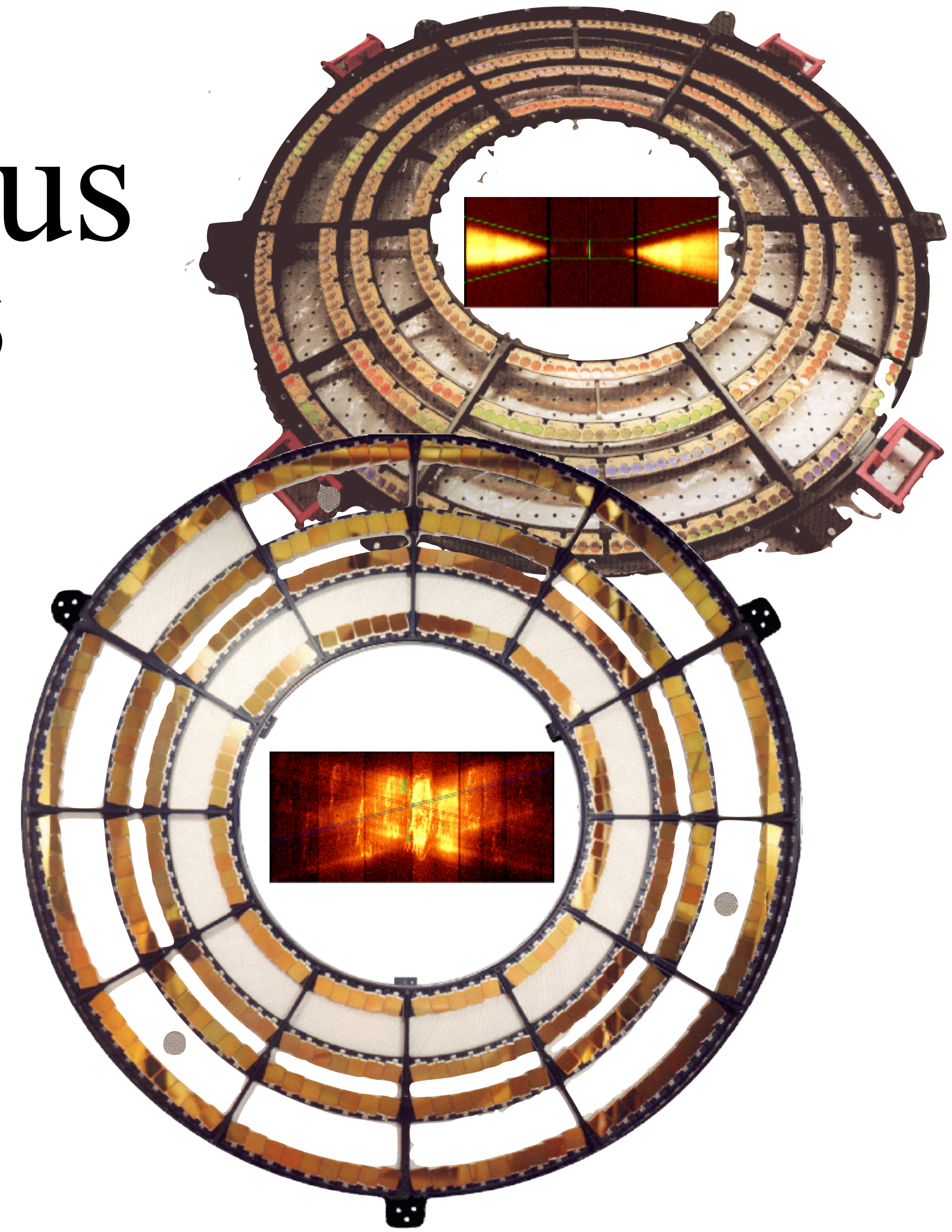
HETG/LETG — Status

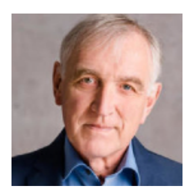
Chandra Quarterly Review No. 56
15 November 2023

David Huenemoerder
dph@space.mit.edu

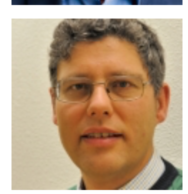


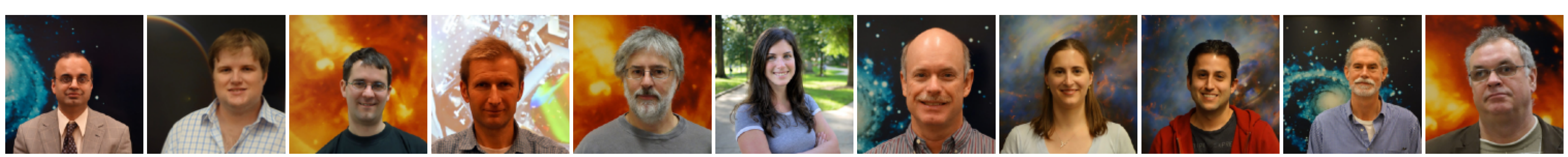
HETG IPI: Prof. Claude R. Canizares
MIT Kavli Institute

LETG IPIs: Dr. Peter Predehl
Max Planck Institute



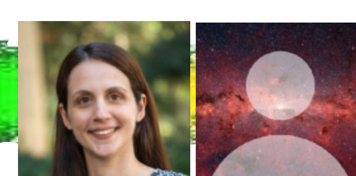
Dr. Jelle Kaastra
SRON



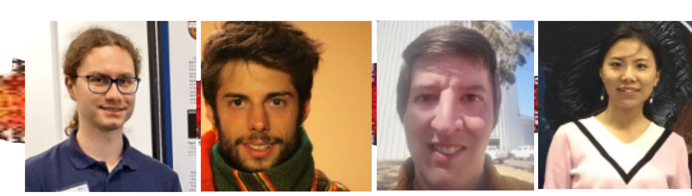


faculty, staff;

postdocs



... current/incoming ...



... moved on ...

HETG GTO Science Program

MIT KAVLI INSTITUTE

CHANDRA X-RAY OBSERVATORY

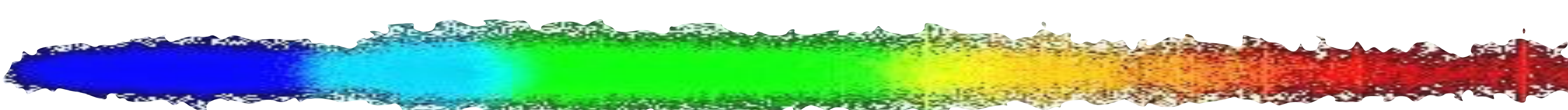
Proposal **Cycle 23** Jan 2022 (637 ks)

★Stars: π Aqr 101 ks Winds of the hottest stars
★AGN: Circinus Galaxy 69 ks Emission lines, morphology, variability (IXPE-coordinated)
★XRB: Cen X-3 61 ks Eclipsing X-ray pulsar; accretion
★XRB: 4U 1626-67 86 ks Ultra-compact binary; monitor Fe lines.
★XRB: GX 1+4 92 ks Low-mass XRB; accretion, Compton shoulder study.
★ISM: GX 340+0 138 ks Cosmic dust composition
★ULX/NS: M33 X-8 90 ks Pulsar wind outflow, absorption

Proposal **Cycle 24** Jan 2023 (77 / 745 ks)

★XRB: 4U 1624-490 29/135 ks Accretion disk structure (with NuSTAR, XRISM)
★XRB: Cen X-3 48 ks Eclipsing X-ray pulsar; accretion (ongoing - low visibility)
★AGN: MCG-6-30-15 0/232 ks Time-dependent photoionisation modeling of outflows
★BH: SS 433 0/60 ks Relativistic jet physics (coordinated with HRC, Swift GO)
★ULX: LMC/SMC X-? 0/70 ks Accretion disk outbursts (TOO)
★NS: Terzan 5 X-2 0/200 ks 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



HETG GTO Science Program (2)

MIT KAVLI INSTITUTE

CHANDRA X-RAY OBSERVATORY

Proposal **Cycle 25** start Jan 2024 (758 ks; or 1208 ks if TOOs trigger)

★XRB:	4U 1626-67	0/190 ks	Accretion disk structure (with NuSTAR, XRISM)
★Star	ζ Puppis	0/190 ks	Stellar Winds, long-term monitoring
★XRB	GRS 1915+105	0/100 ks	micro-Quasar (TOO; coordinated with NICER, NuSTAR)
★ISM	GX 9+9	0/180 ks	Galactic silicon absorption survey
★ULX	M33 X-8	0/85 ks	Pulsar wind outflow, absorption
★XRB	Her X-1	0/50 ks	Neutron star accretion disks (TOO)
★NS:	Terzan 5 X-2	0/200 ks	Neutron Star outburst (TOO)
★BH:	GW Transient	0/300 ks	Gravitational wave event followup (TOO)

Jargon list:
AGN: Active Galactic Nucleus
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LETG GTO Science Program

MIT KAVLI INSTITUTE

CHANDRA X-RAY OBSERVATORY

Proposal **Cycle 23**: (328 ks)

★ Stars (Predehl/MPE)	LTT 1445A	45 ks	High energy environments of terrestrial exoplanets (ACIS-S)
★ Stars (Predehl/MPE)	L 168-9	24 ks	High energy environments of terrestrial exoplanets (ACIS-S)
★ SNR (Predehl/MPE)	Hoinga	59 ks	Distance determination (HRC-I, ACIS-I)
★ AGN (Predehl/MPE)	WISEA J202040.85-621509.3	30 ks	Confirm eRosita detection of a z=5.9 quasar (ACIS-S)
★ Galaxies (Kaastra/SRON)	Abell 141	170 ks	Intercluster temperatures, merger history (ACIS-S)

Proposal **Cycle 24**: start Jan 2023 (0 / 337 ks)

★ AGN: (Predehl/MPE)	WISEA J050222.16-341201.6	0/25 ks	Luminous z>5.6 quasars from eROSITA (ACIS-S)
★AGN: (Predehl/MPE)	WISEA J230341.02-542730.6	0/32	Luminous z>5.6 quasars from eROSITA (ACIS-S)
★AGN: (Predehl/MPE)	WISEA J050411.92-254959.0	0/26	Luminous z>5.6 quasars from eROSITA (ACIS-S)
★ Galaxies: (Predehl/MPE)	eFEDSJ083933	0/88	Shocks in an eROSITA detected galaxy cluster (ACIS-S)
★ AGN: (Kaastra/SRON)	NGC 3783	0/166	Outflows, variability (with XRISM) (ACIS-S)

Proposal **Cycle 25** start Jan 2024 (343 ks)

★ISM: (Predehl/MPE)	HD 115247	0/59 ks	Galactic bubbles absorption (w/ eROSITA)
★ISM: (Predehl/MPE)	HE1338-1423	0/59 ks	Galactic bubbles absorption (w/ eROSITA)
★ISM: (Predehl/MPE)	LEDA407	0/59 ks	Galactic bubbles absorption (w/ eROSITA)
★ AGN: (Kaastra/SRON)	A1550	0/166 ks	Outflows, variability

AGN: Active Galactic Nucleus
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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

HETG/LETG Activities Summary

Performance May 2023 — Oct 2023

HETG/ACIS-S: 842 ks

- 44 observations on 13 targets (26 GO, 9 GTO, 6 TOO, 3 DDT, 0 Cal)

LETG: 603 ks

- 32 LETG/HRC-S observations, 5 targets (368 ks; 14 GO, 11 GTO, 5 TOO)
- 15 LETG/ACIS-S observations, 2 targets (233 ks; 15 Cal — contamination)
- 1 LETG/HRC-I observation, 1 target (2 ks; Cal — low E response)

All instruments: 11,383 ks

Grating performance is nominal.

TGCat Status

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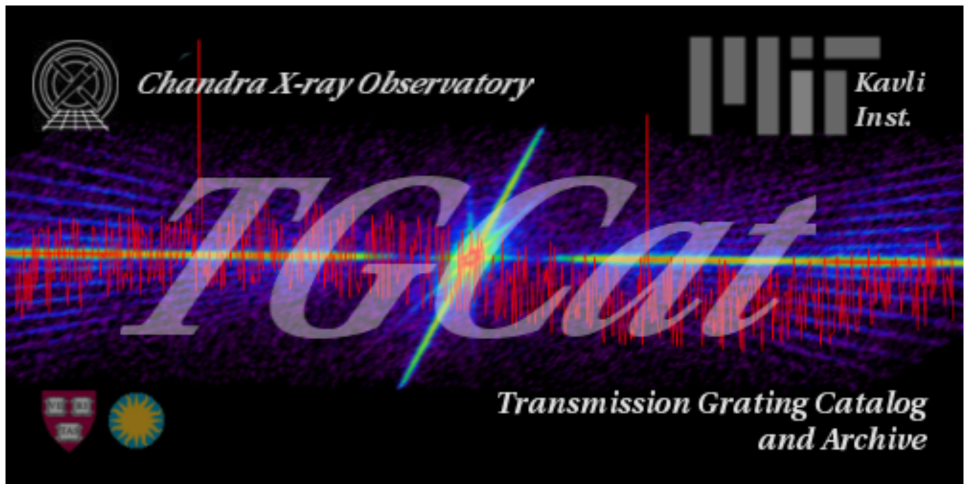
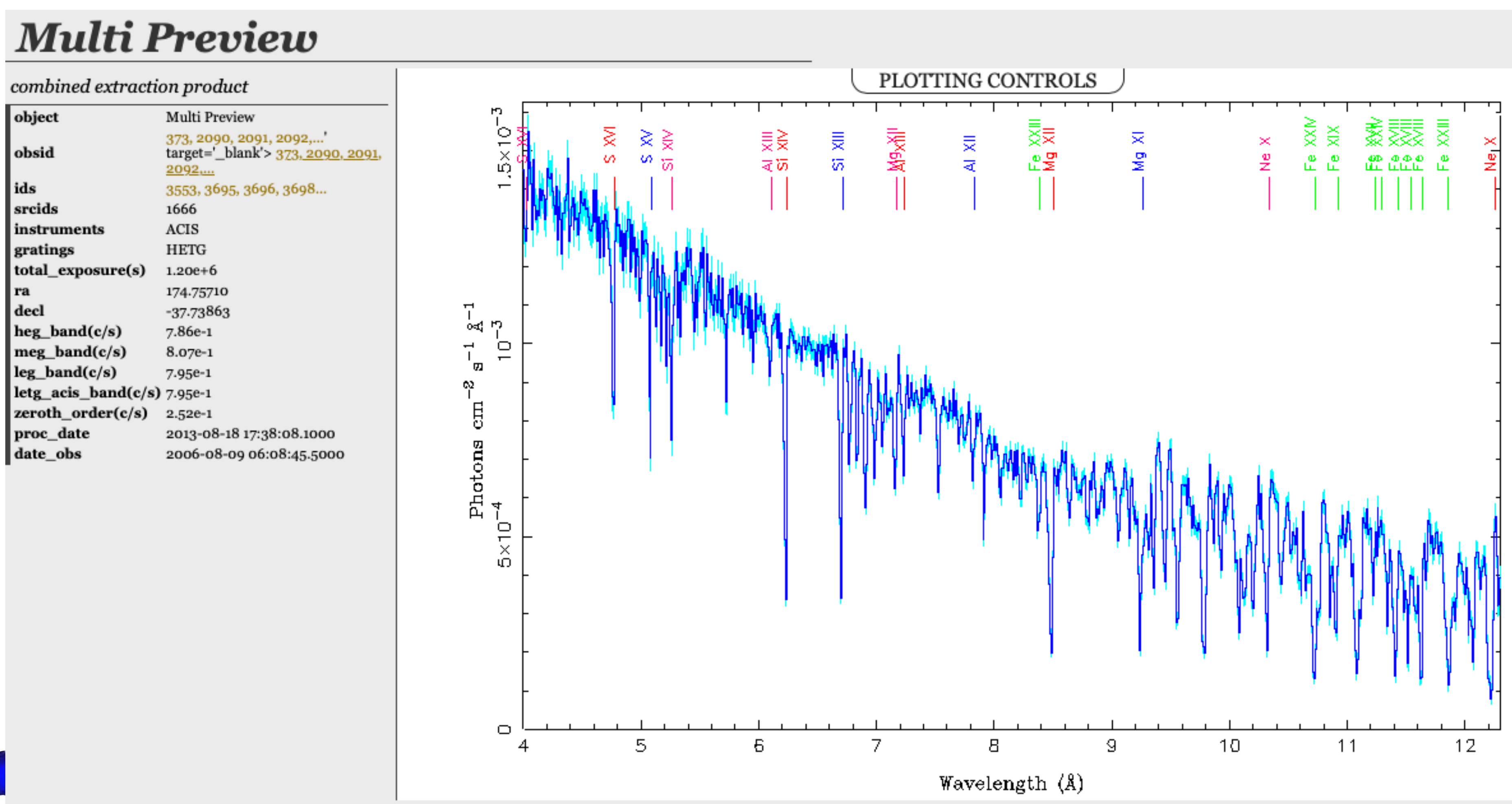


http://tgcat.mit.edu

… has been *off-line Sept—Oct 2023* for maintenance/ system upgrades. It has existed since 2008 — if unfamiliar with it, see Chandra Newsletter #16 (Winter 2009, <https://cxc.harvard.edu/newsletters/news_16/news16_p33.html>) or Huenemoerder et al 2011 (<https://ui.adsabs.harvard.edu/abs/2011AJ....141..129H/abstract>)

Back on-line as of …

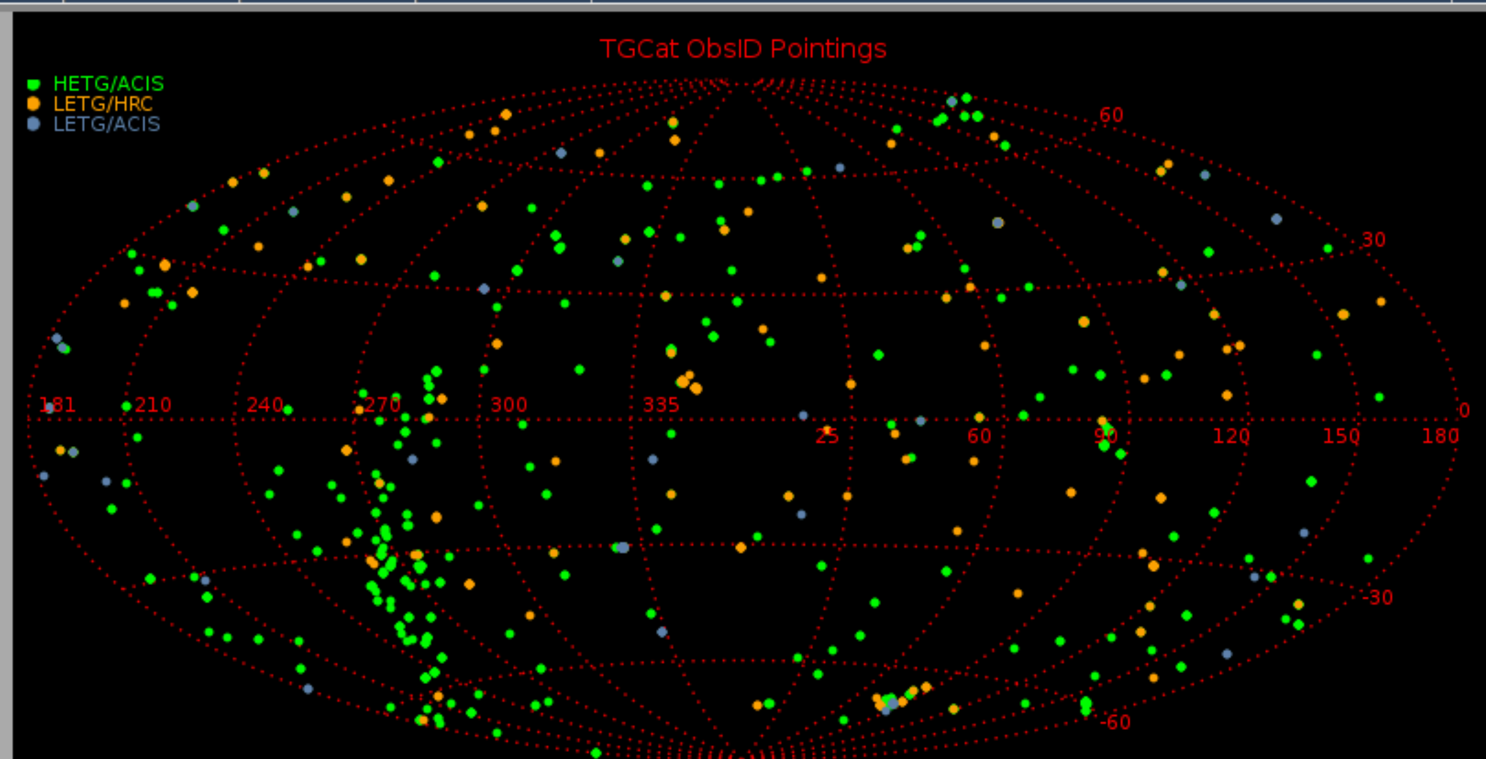


Example interactive plot: NGC 3783, 10 observations with HETG, 1.2 Ms, all-combined flux plot.

TGCat Status

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

TGCat | Query | View | Quick Search | Help

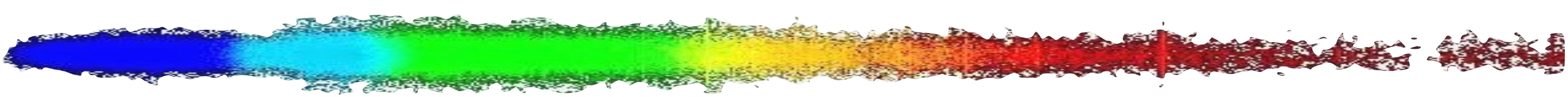


Observations	
Total Obsids:	2724
Distinct Sources:	570
ACIS HETG Observations:	1868
ACIS LETG Observations:	305
HRC LETG Observations:	551
ACIS CONTINUOUS Mode	170
ACIS TIMED Mode	2003

Exposure (s)	
Min Exposure:	40
Max Exposure:	189,255
Mean Exposure:	39,315
Cumulative Exposure:	107,095,258

ZO method	
tgdetect2:	58
tgdetect:	1299
none:	1054
findzo:	313

Archive	
Total Archived Files:	92937
Total Archive Size (GB):	519.42
Space per Obsid (MB):	195.26
Ave File size (MB):	5.72
Number Distinct File Type:	8



Calibration Updates

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ACIS High-T Operations: OK to use HETG
(but for warmest temperatures, offset to low CHIPY).

HETG 2nd and 3rd order efficiencies: in progress.

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

HETG Documents Library

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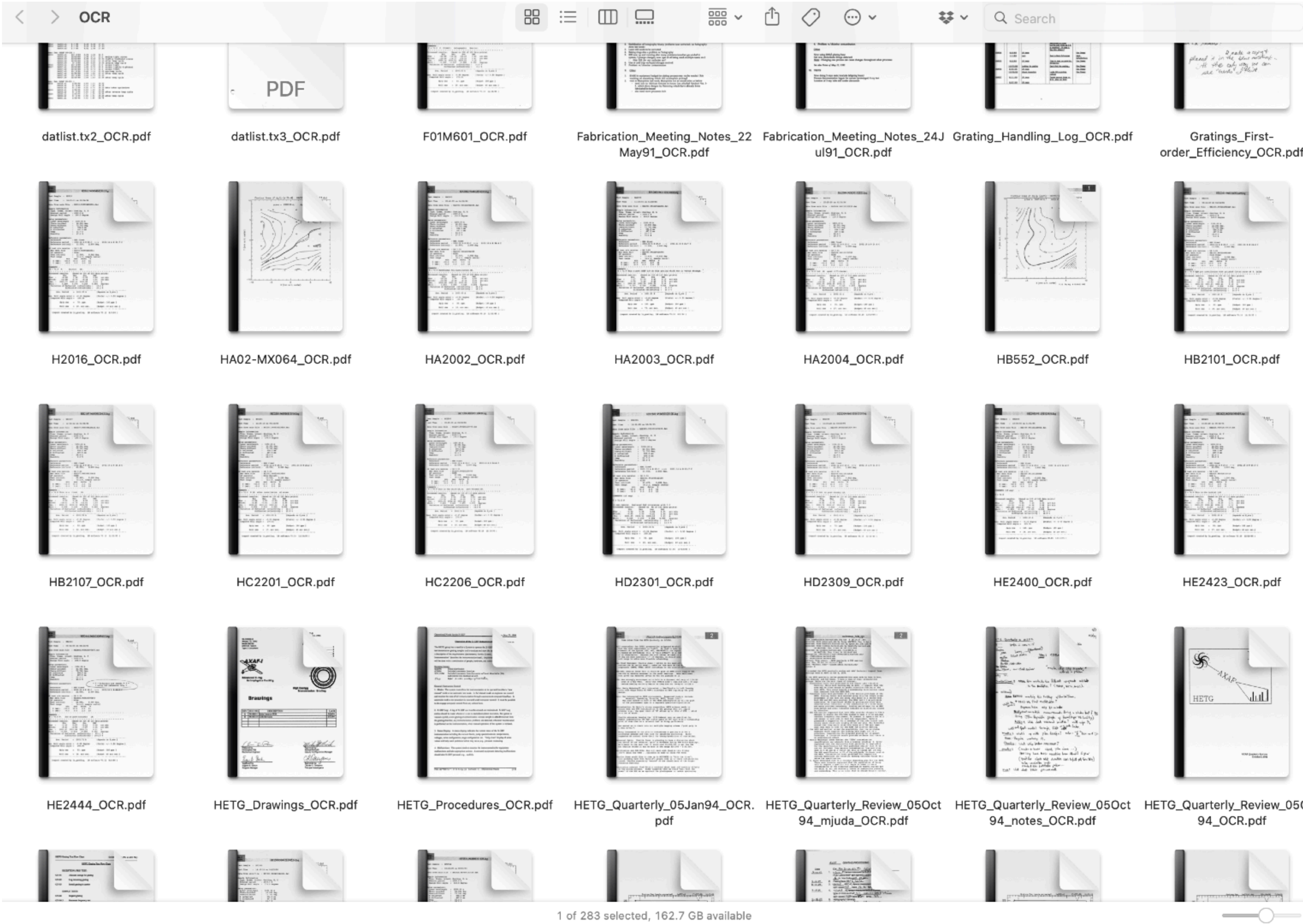
Before scanning … about 30 binders:

HETG Documents Library

MIT KAVLI INSTITUTE

CHANDRA X-RAY OBSERVATORY

… after scanning: 283 searchable pdf files:



HETG Document Library

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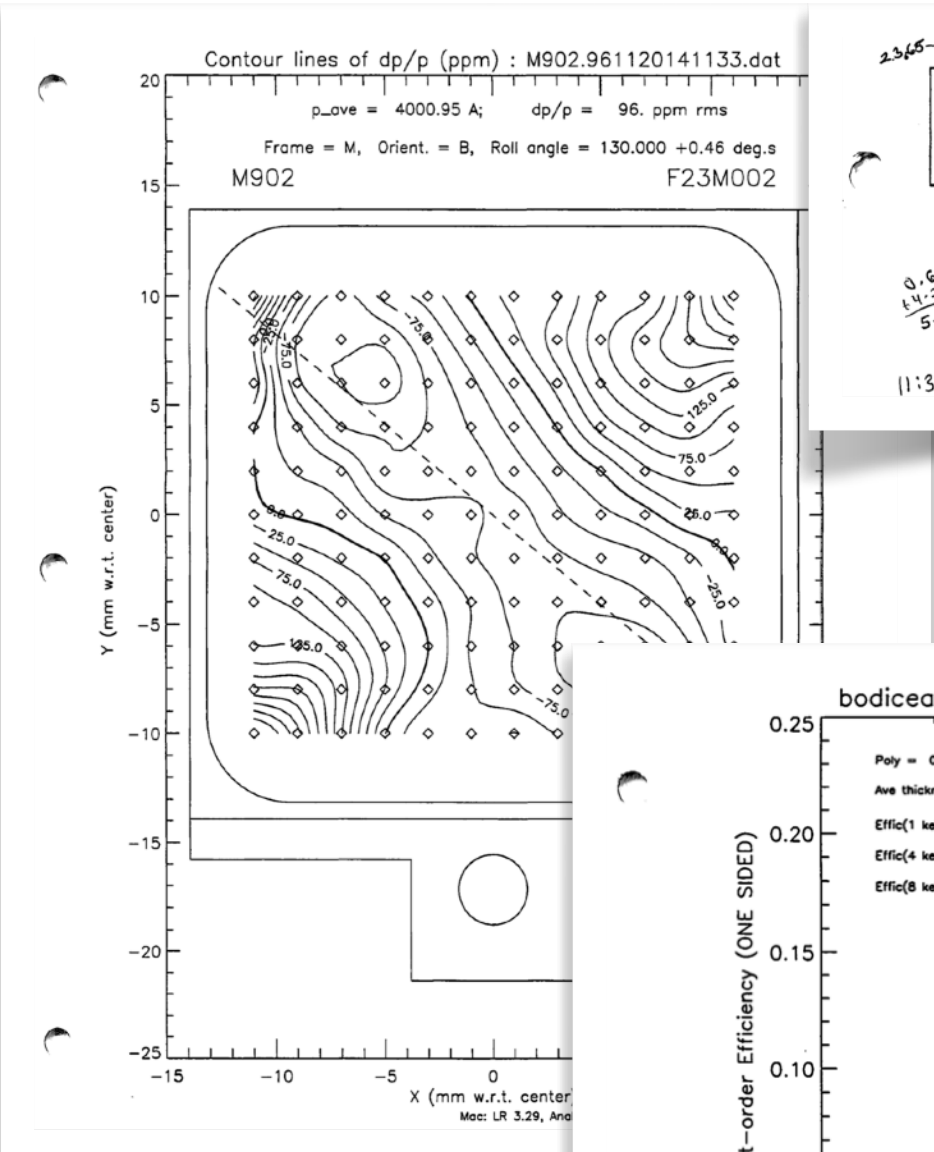
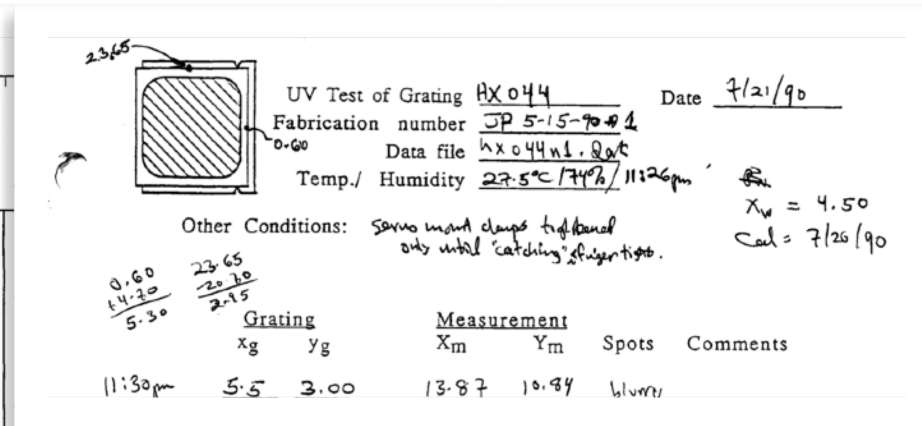
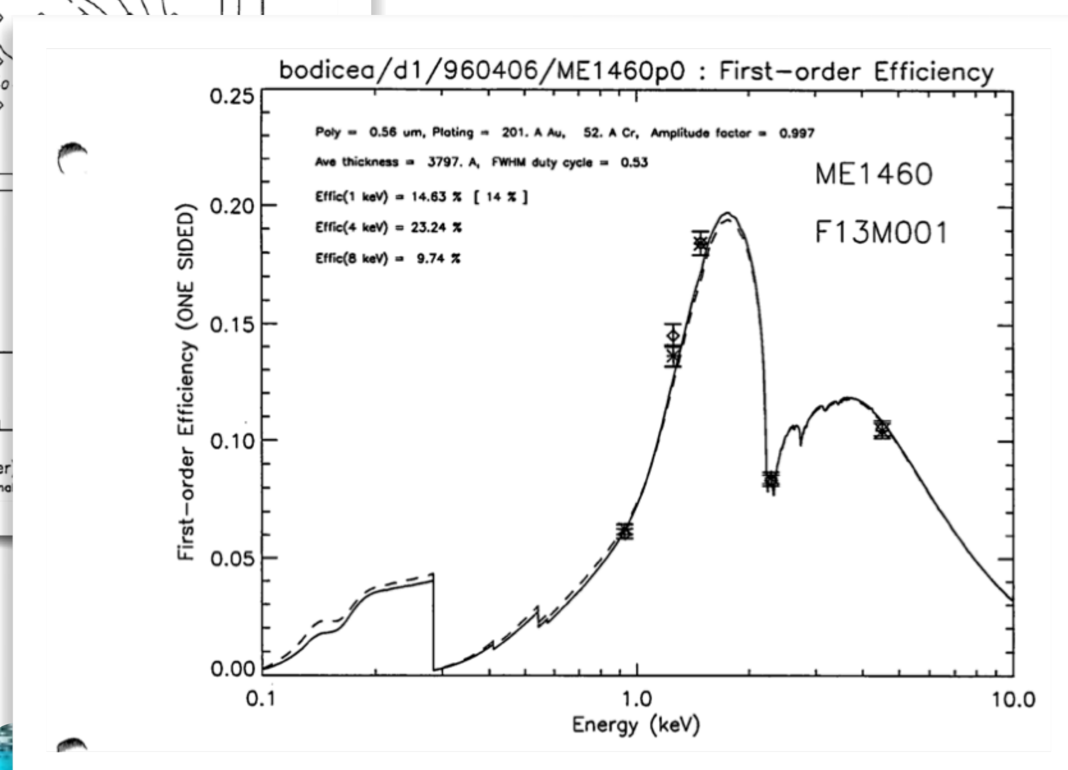
Technical details of grating facet fabrication, measurement, modeling, instrument assembly, test, requirements documents, meeting notes, …

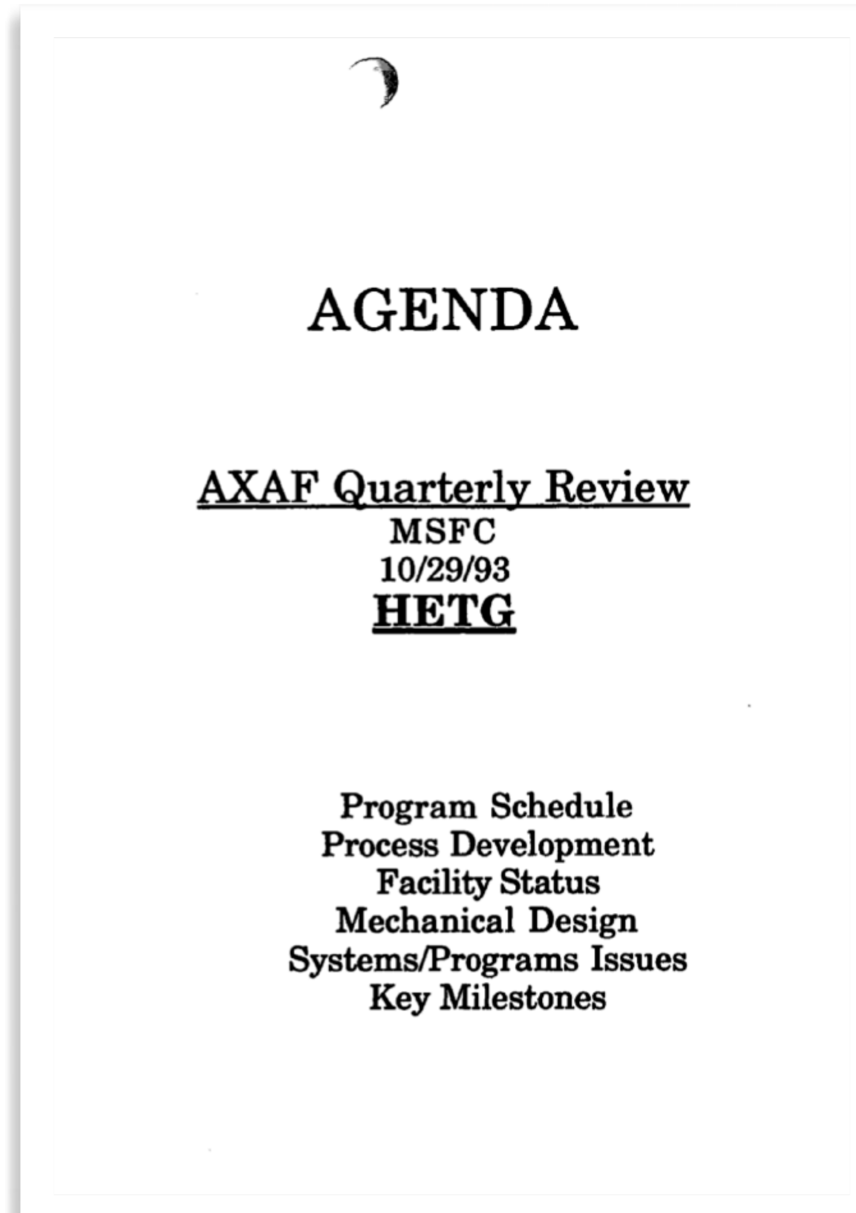



UV Test of Grating AX044 Date 7/21/90
Fabrication number JP 5-15-90 #1
Data file hx044n1.dat
Temp./ Humidity 27.5°C / 74%
Other Conditions:

Grating Xg	Grating Yg	Measurement Xm	Measurement Ym	Spots	Comments
5.5	3.00	13.87	10.84		



Items of historical interest…


AGENDA

AXAF Quarterly Review
MSFC
10/29/93
HETG

Program Schedule
Process Development
Facility Status
Mechanical Design
Systems/Programs Issues
Key Milestones

Some Scientific Results Published in the Past 6 Months (1/2)

The Astrophysical Journal, 956:65 (13pp), 2023 October 10
https://doi.org/10.3847/1538-4357/aced49

Systematic Uncertainties of Atomic Data in Photoionization Modeling

R. Ballhausen[1,2], T. R. Kallman[2], L. Gu[3,4,5], and F. Paerels[6]

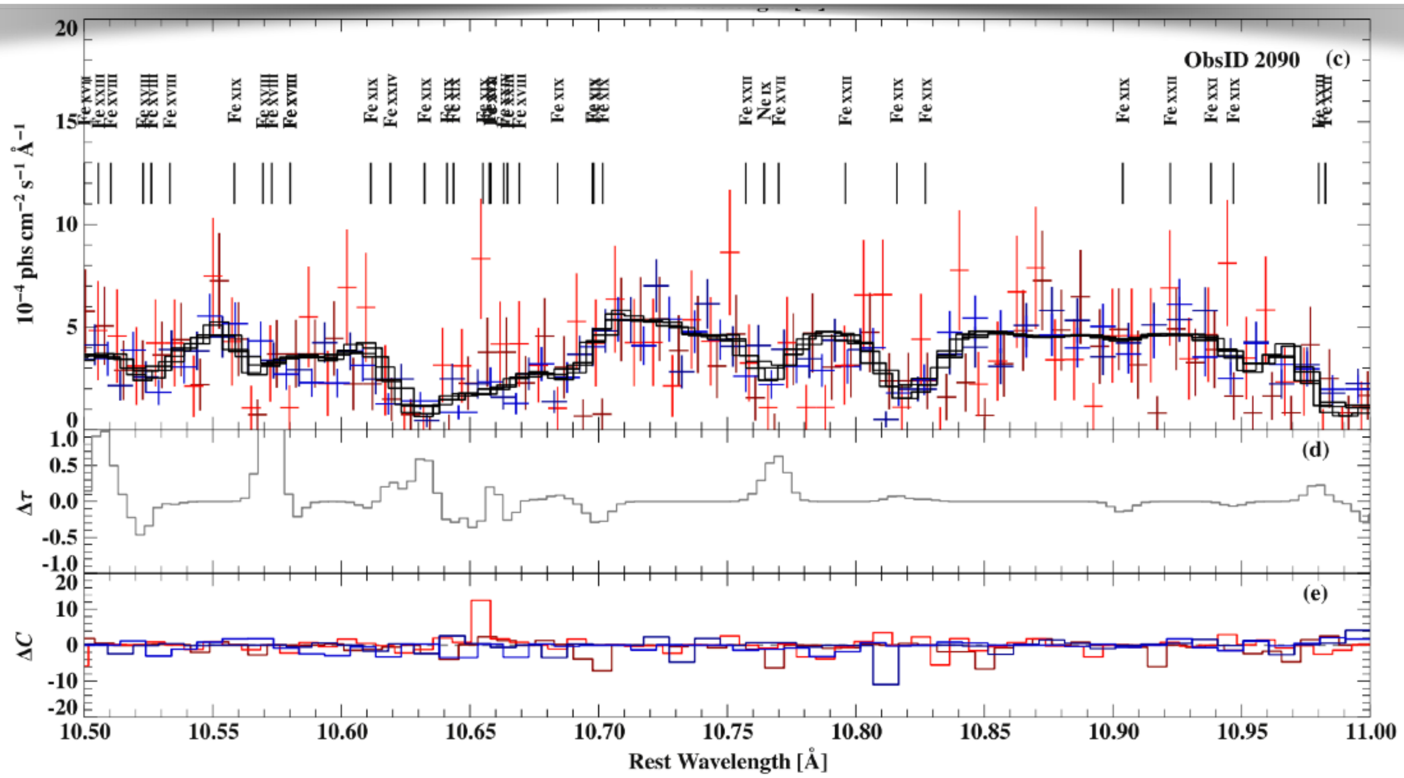
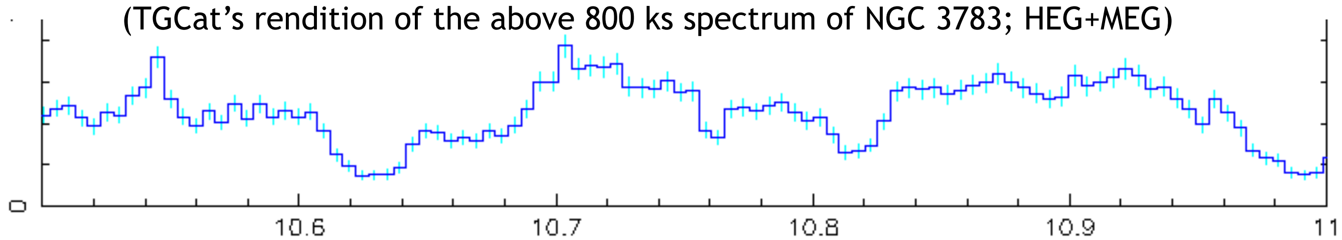


Figure 3. (a) Close-up of the HEG (red) and MEG (blue) 10.5–11.0 Å spectra of the NGC 3783 observation 2090 fitted with a five-component warmabs model (black). (b) C-residuals for the baseline model. (c) Same data as in (a) but with the warmabs model modified by the additional Gaussian lines. (d) Additional optical depth $\Delta\tau$ that is added or removed from each bin by the Gaussian components. (e) C-residuals for the modified model. As shown here and described in Section 5.1, including additional Gaussians—equivalent to modifying A-values for the strongest 500 lines—leads only to minor to moderate improvement of the fit statistics and residuals.

(TGCat's rendition of the above 800 ks spectrum of NGC 3783; HEG+MEG)



Abstract

… **we test whether systematic uncertainties in underlying atomic data can account for data model discrepancies, and whether including model uncertainties during spectral fitting can provide statistically acceptable fits and reasonable parameter estimates. We fit Chandra/ HETG spectra of NGC 3783 with the photoionized absorber model warmabs.**

6. Conclusions and Outlook

We conclude that inaccuracies of radiative transition rates are not a major source of data model discrepancies. Our fits to simulated spectra further show that in the majority of practical cases of currently available observational data, statistical uncertainties dominate the accuracy to which plasma parameters can be constrained.

Some Scientific Results Published in the Past 6 Months (2/2)

MIT KAVLI INSTITUTE

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS 522, L66–L71 (2023) https://doi.org/10.1093/mnrasl/slad040
Advance Access publication 2023 March 25

A detailed analysis of X-ray emission-line velocities of Capella from over 20 yr of *Chandra*/HETG spectroscopy

E. Bozzo[1★], D. P. Huenemoerder,[2] N. Produit[1], M. Falanga[3,4], S. Paltani[1] and E. Costantini[5,6]

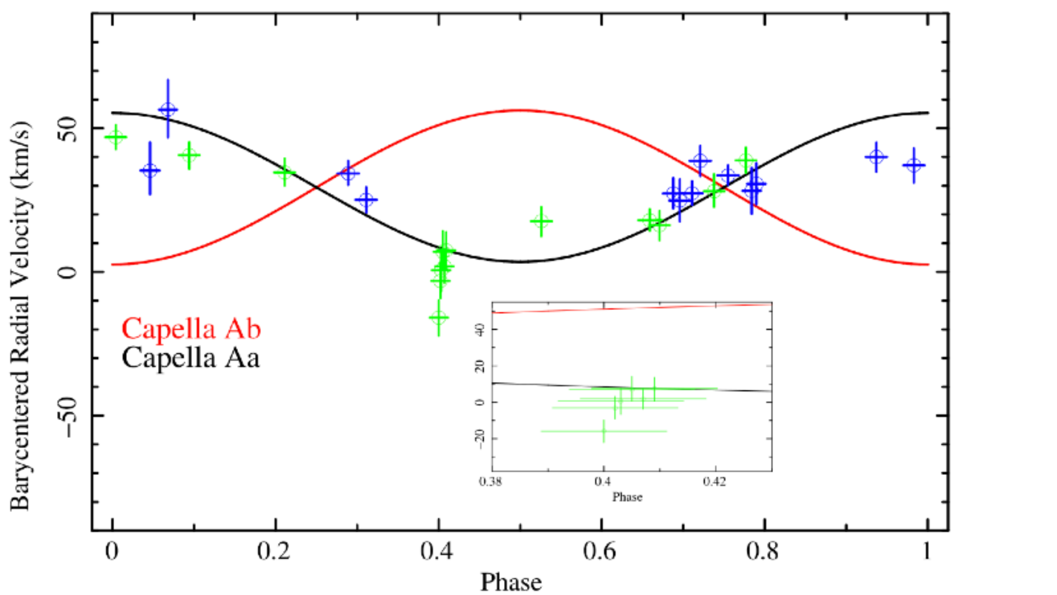


Figure 1. Plot of the barycentred radial velocity measurements (green and blue points) obtained from all available *Chandra*/HETG observations of Capella (see Table 1). The blue points correspond to observations that were not reported before by ISH06. The error bars for each radial velocity measurement are given at 1σ c.l. and are only statistical. The uncertainty on the phase for each green point includes the duration of the observation, as well as the uncertainties associated with the ephemerides. The black and red lines are the expected barycentred radial velocities calculated according to the latest Capella's orbital parameters published by Strassmeier et al. (2020). Uncertainties on these velocities were not included here as they are typically ≪1 km s^{-1}. The phase 0 is assumed as the epoch of passage at the ascending node. The insert shows, for clarity, a zoom around the orbital phase 0.4 showing six observations closely overlapping in phase.

3 RESULTS AND DISCUSSION

"The 13 new observations reported here for the first time strengthen some of the previous conclusions…

… more firmly establishes that Capella Aa is the dominant X-ray emitter

… an overall uncertainty for the averaged barycentered radial velocity that is of other order of ~20 km s^{-1} (at 3σ c.l.).

… **the stability of the instrument (and the accuracy of the performed in-flight calibrations) achieving now a baseline of over 22 yr**."

MNRAS 000, 1–?? (0000) Preprint 2 November 2023 Compiled using MNRAS LaTeX style file v3.0

(submitted)

***Chandra*/HETG Doppler velocity measurements in stellar coronal sources**

E. Bozzo[1★], D. P. Huenemoerder[2], M. Falanga[3,4], S. Paltani[1], E. Costantini[5,6], J. de Plaa[5]

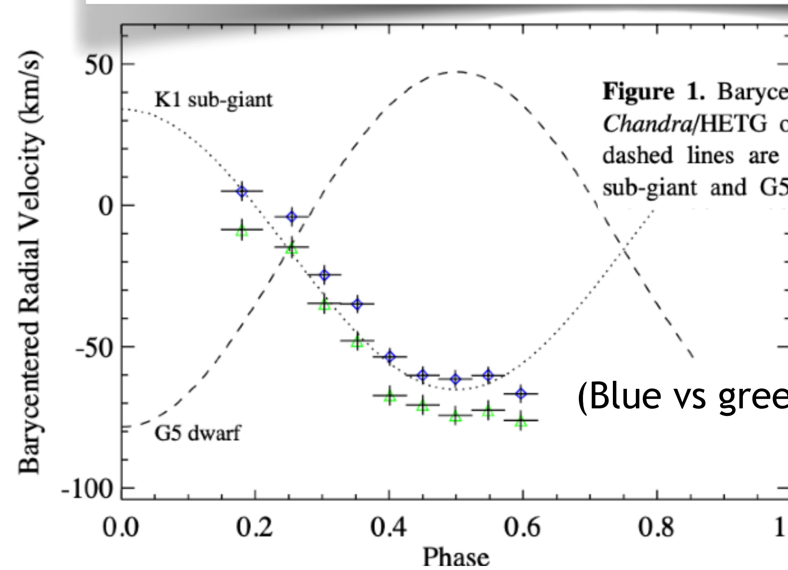


Figure 1. Barycentered radial velocity measurements obtained from the *Chandra*/HETG observations of HR 1099 (see Table 1). The dotted and dashed lines are the expected barycentered radial velocities of the K1 sub-giant and G5 dwarf stars

(Blue vs green: atomic database systematics)