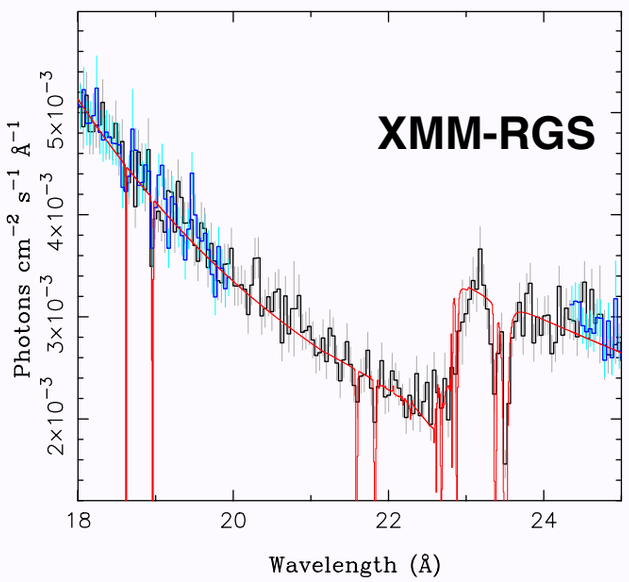
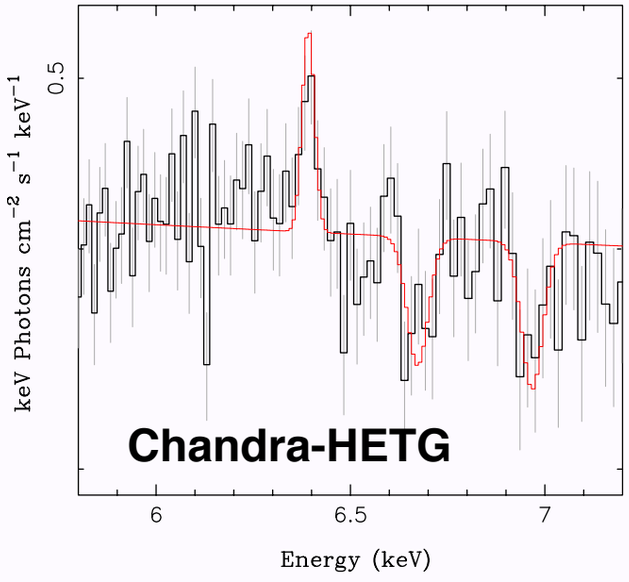
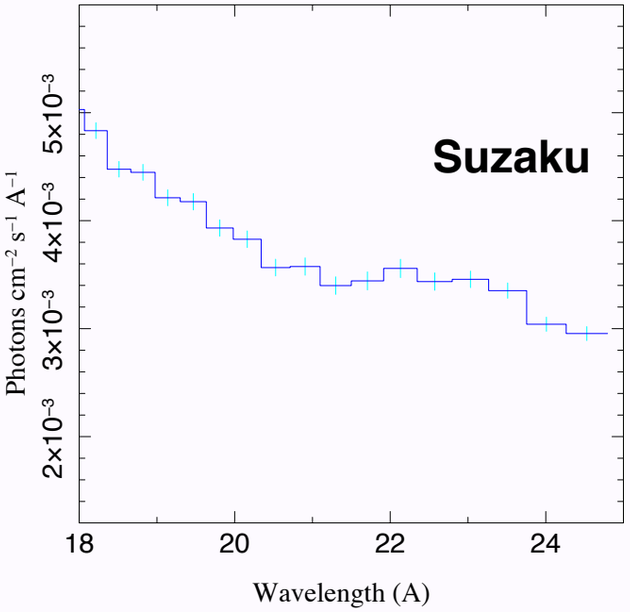
High Resolution X-ray Spectroscopy and TGCat

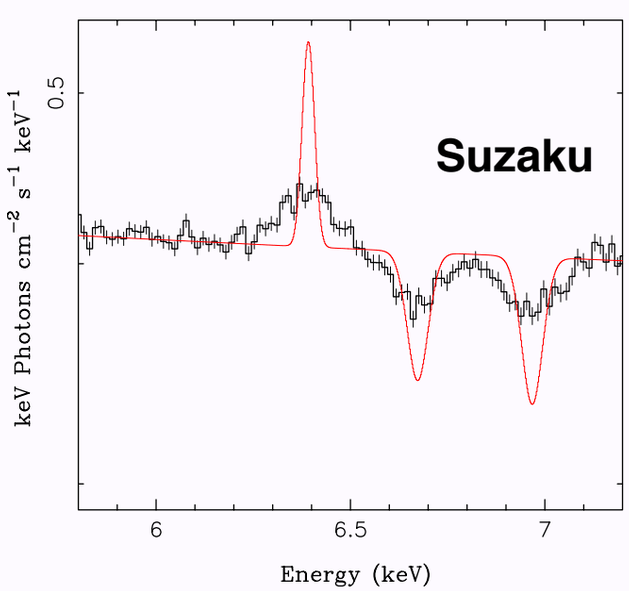
Hans Moritz Günther (MIT)
with material from
Michael A. Nowak (Washington University St. Louis)

Resolution









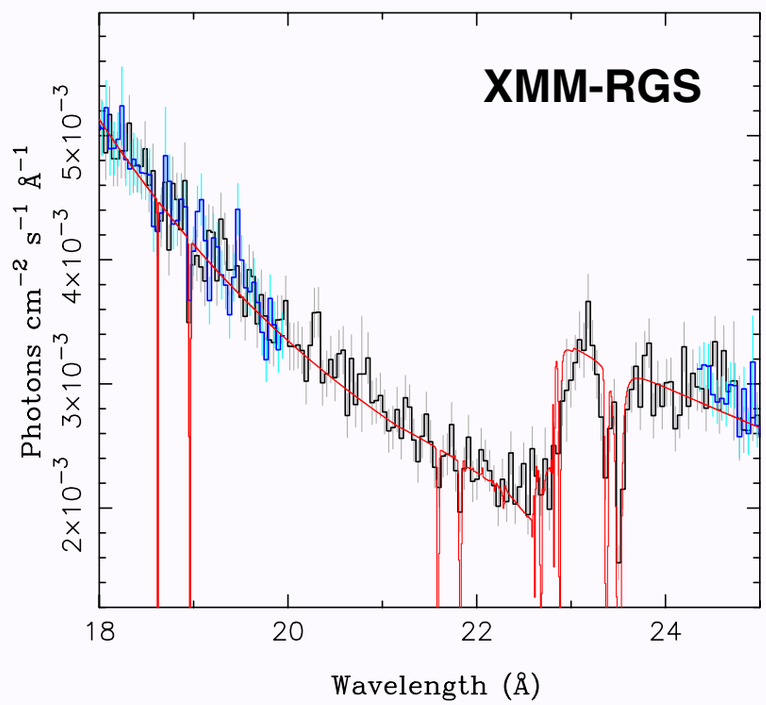
(Simulation)

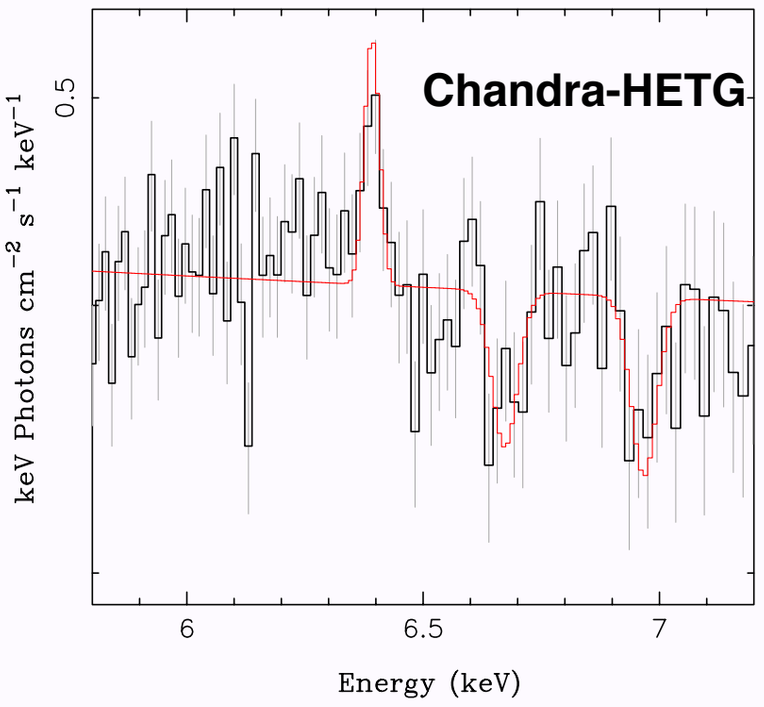
$$R = \frac{\lambda}{\Delta\lambda} = \frac{E}{\Delta E}$$

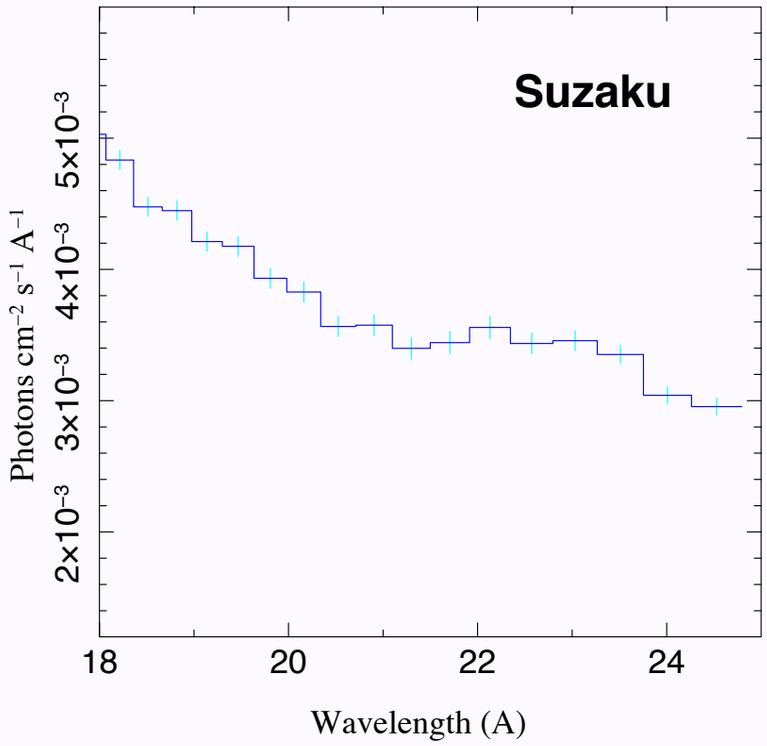
What Do We Mean by High Resolution?

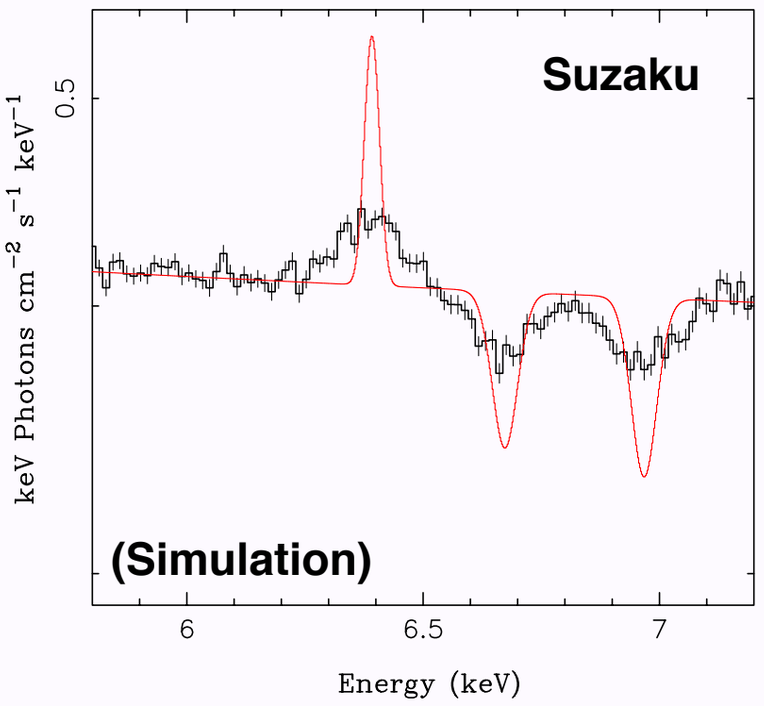
- **CCD Spectral Resolution (Suzaku):**
  $E/\Delta E_{FWHM}$ ~18 @1 keV, ~46 @6.4 keV (scales as $E^{0.5}$)
- **Gratings Spectral Resolution:**
  $E/\Delta E_{FWHM}$ ~314 @1 keV (XMM-RGS)
  $E/\Delta E_{FWHM}$ ~1350 @1 keV, ~214 @6.4 keV (Chandra-HETG)
- **Scales as E^{-1} (explanation coming up...)**
- **To date, X-ray High Resolution Means Gratings – Chandra-Low/High Energy Transmission Gratings & XMM-Reflection Gratings Spectrometer**
- **Near future: X-ray Calorimetry**
  ΔE_{FWHM} ~5–7 eV, $E/\Delta E_{FWHM}$ ~1000 @6.4 keV (scales as E)

High/Low Res Comparison

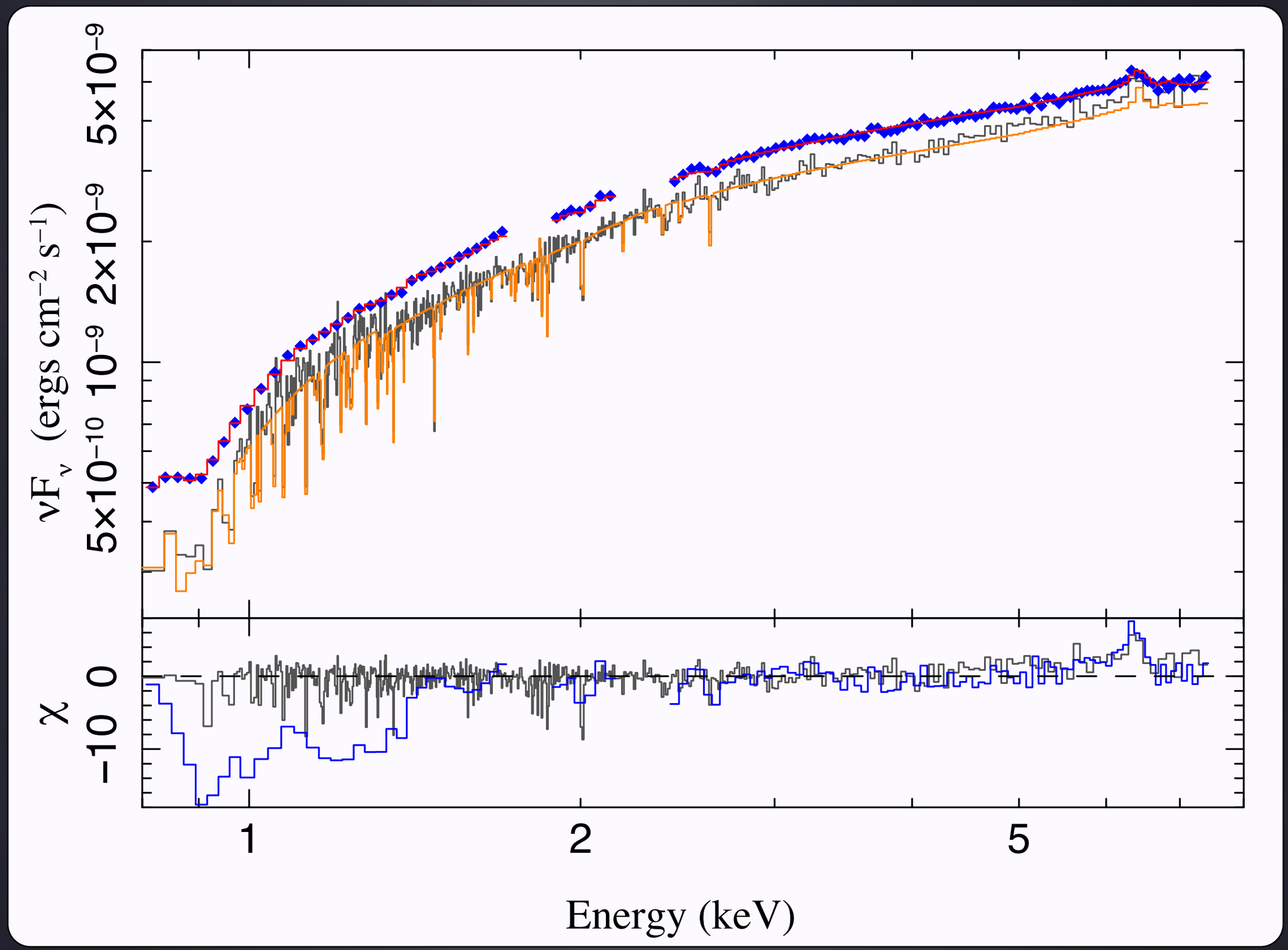




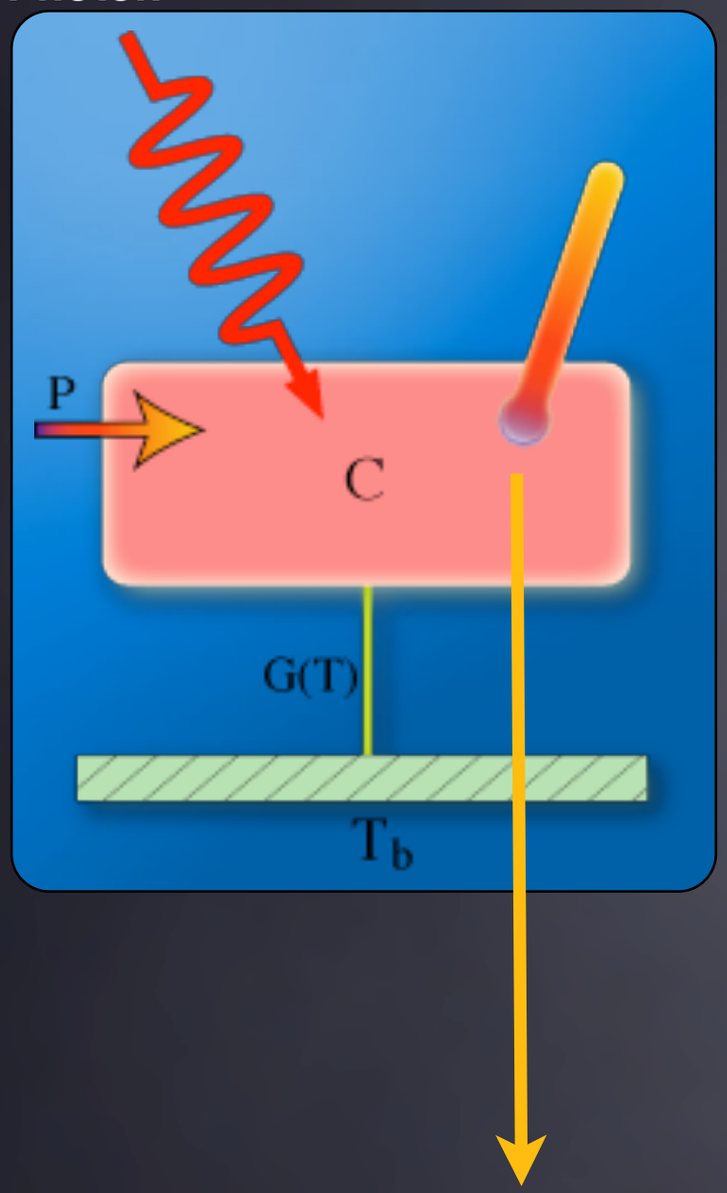




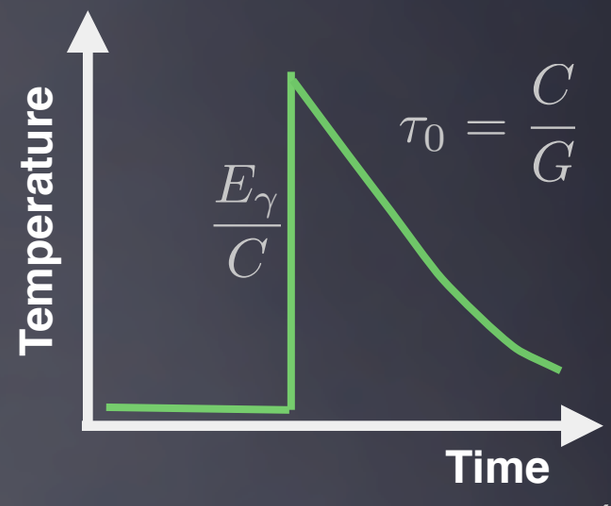
High/Low Res Comparison



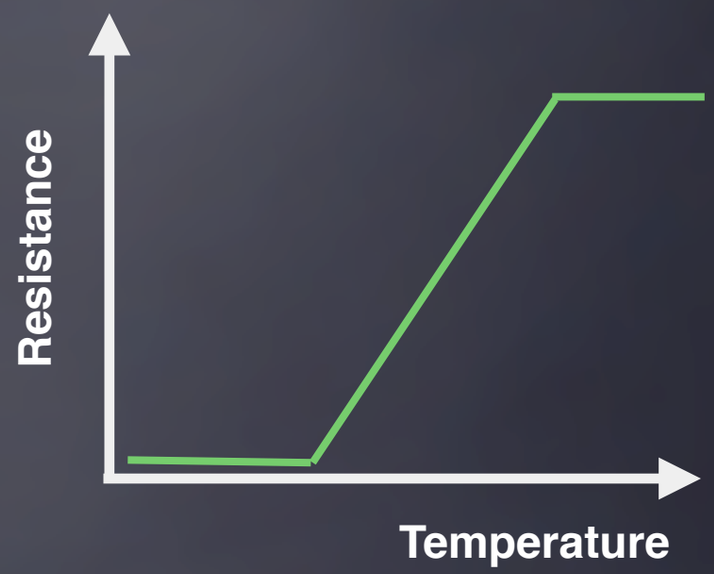
Calorimeter



$$C\frac{dT}{dt} = P - G(T - T_b) + E_\gamma \delta(t)$$



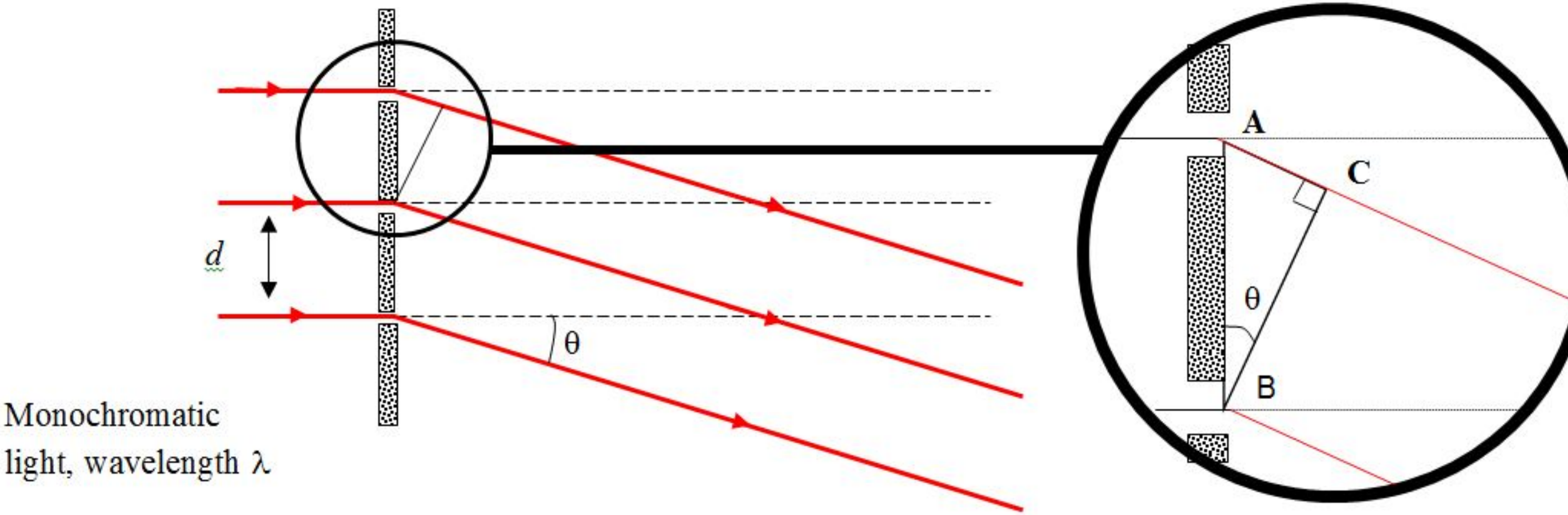
$$T(t) = \frac{E_\gamma}{C} exp(-t/\tau_0) + \left(\frac{P}{G} + T_b\right)$$



(See http://web.mit.edu/figueroagroup/ucal/ucal_basics/index.html)

Gratings

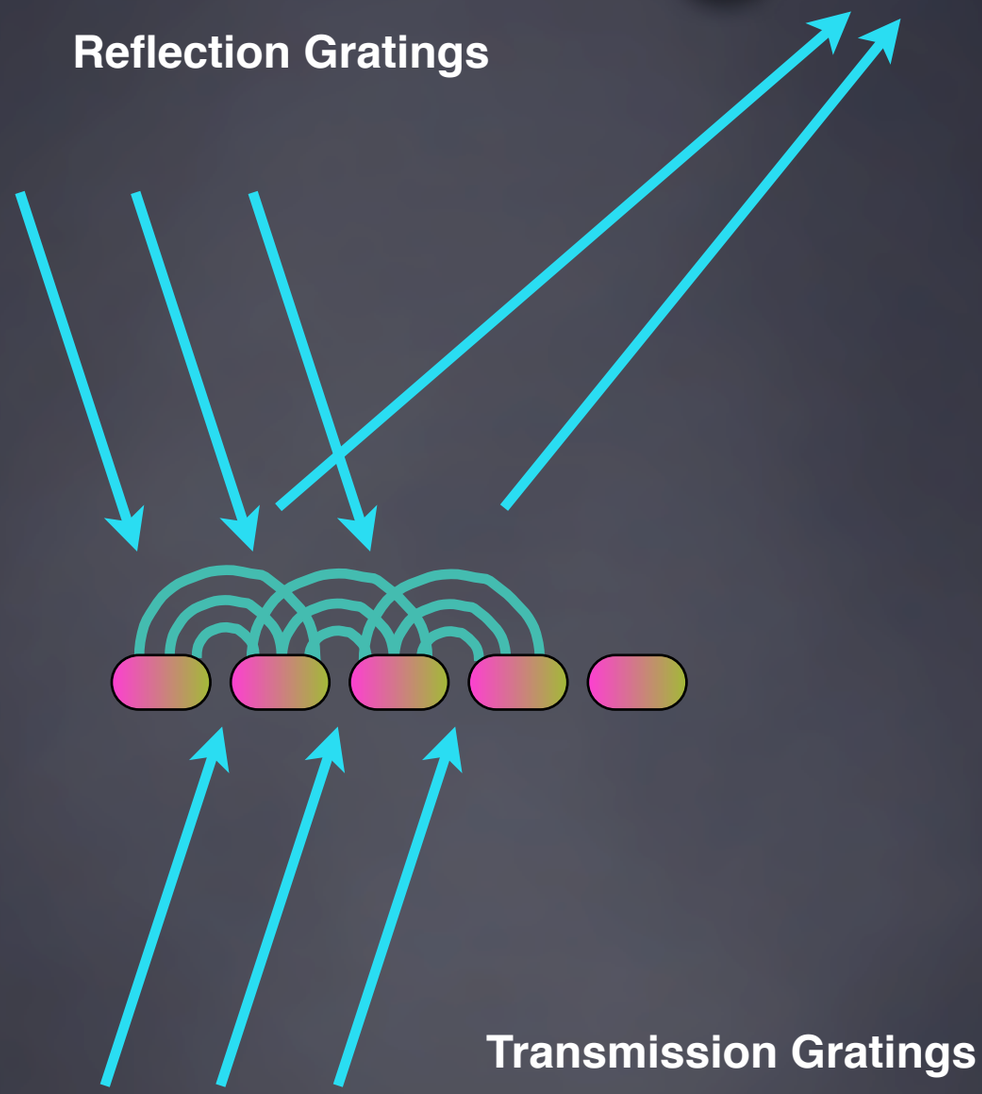
Figure taken from Antonine education website (which no longer exists)



Grating Equation:

$$n\lambda = n\frac{hc}{E} = d\sin\theta \approx d\theta$$

Gratings

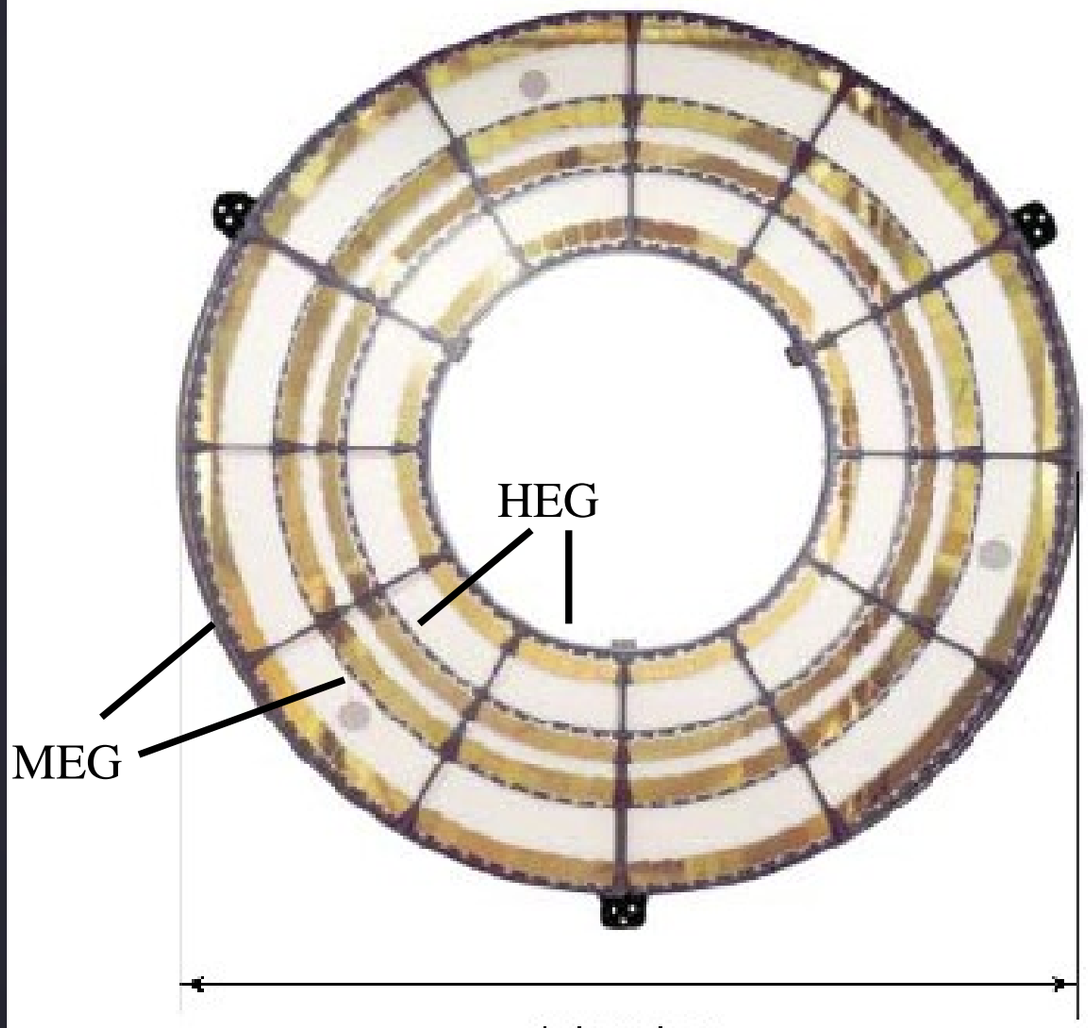


Grating Equation:

$$n\lambda = n\frac{hc}{E} = d\sin\theta \approx d\theta$$

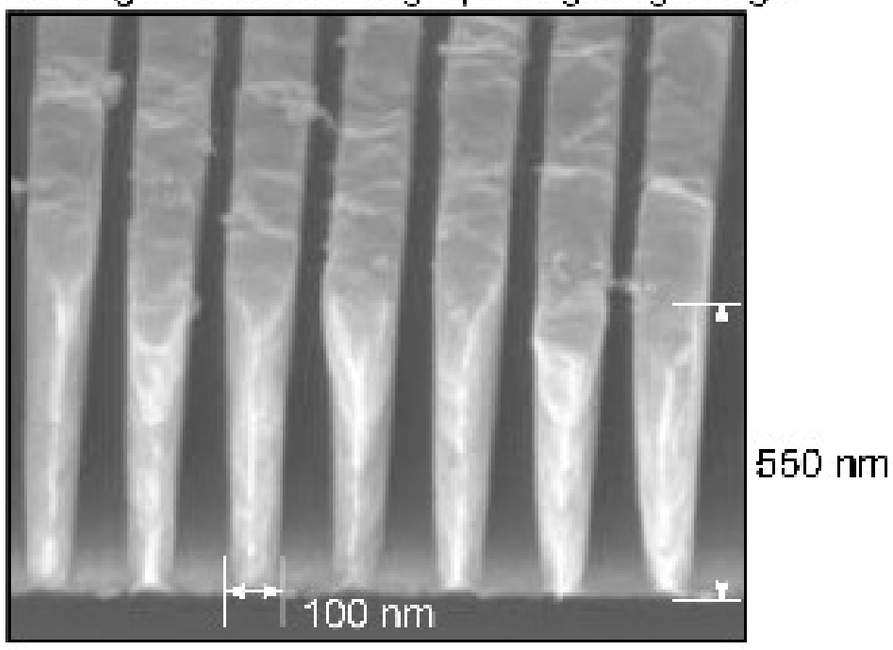
Chandra-HETG

HETGS instrument.

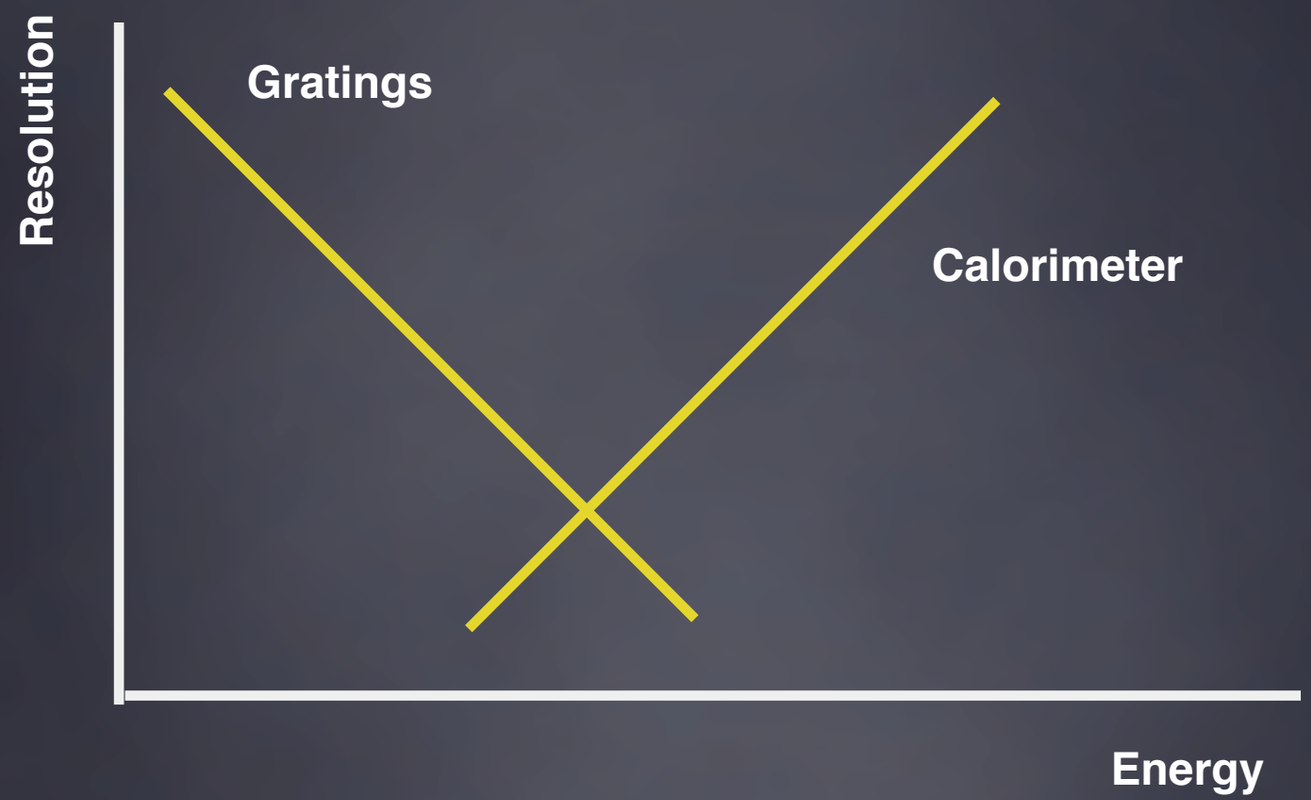


Invar grating frame.

Scanning electron micrograph of gold grating.



A Wistful Dream...



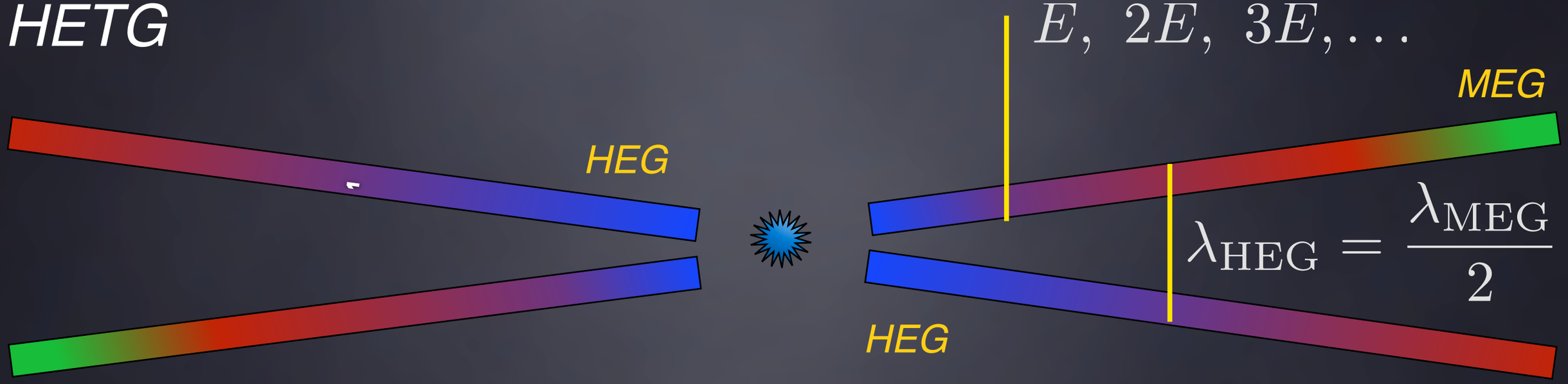
Lynx?

$$n\lambda = n\frac{hc}{E} = d\sin\theta \approx d\theta$$

LETG

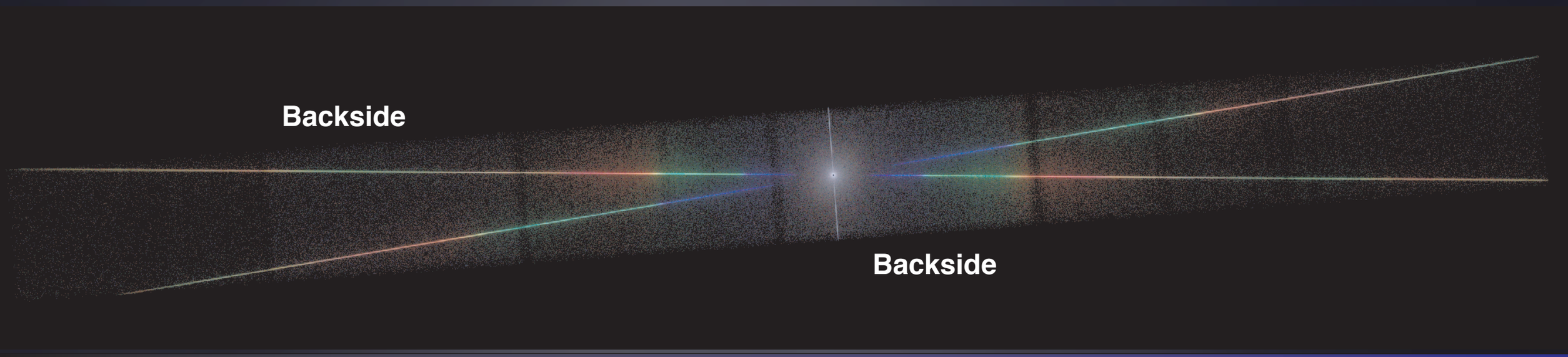
$$\lambda,\ \frac{\lambda}{2},\ \frac{\lambda}{3},\ldots$$

HETG



Greater Distance = Higher Resolution
Resolution Limited by CCDs & Gratings Accuracy

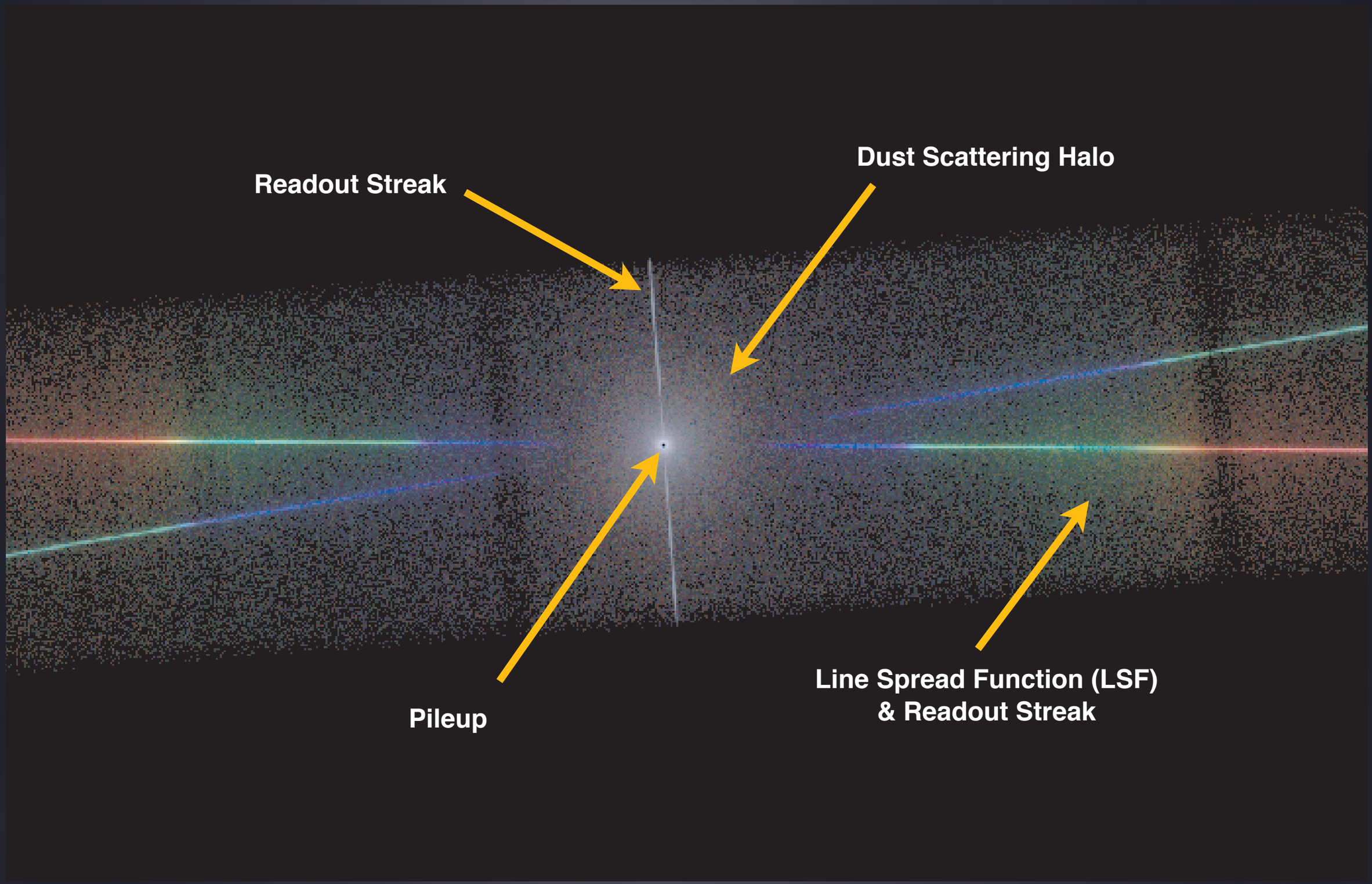
Chandra HETG



Chandra (ACIS) LETG

- 0th order shows diffraction from coarse support structure
- “Whiskers” are diffraction from fine support structure

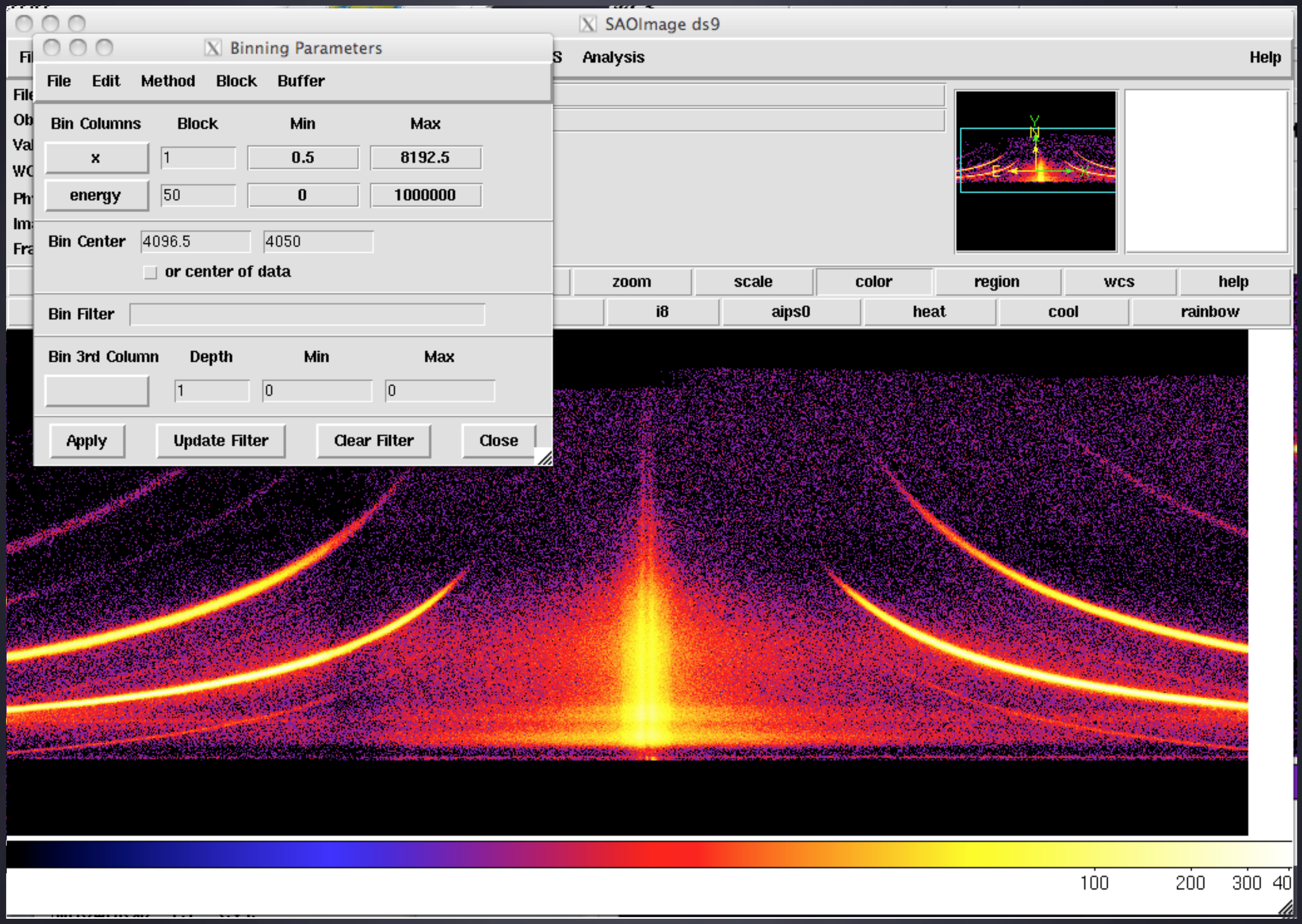
Chandra HETG



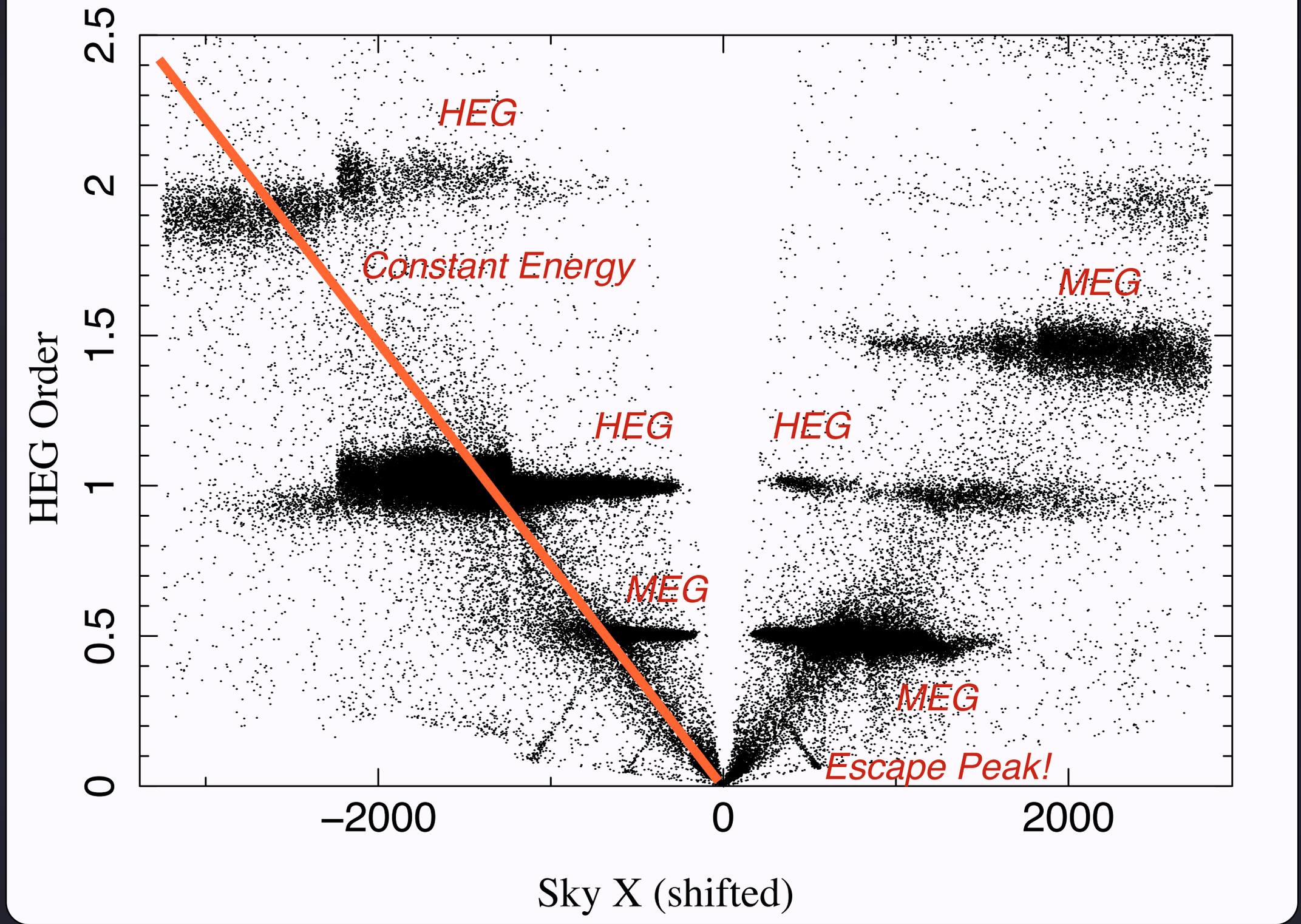
Order Sorting (aka Banana Plots)

- Multiple orders land on the same detector location
- CCD resolution is sufficient to separate these!
- Plotting E_{CCD} vs. $n\lambda$ should show “bananas”
- Or we can plot $n\ \lambda$ vs. $E_{CCD}\ n\ \lambda/hc$
- $E_{CCD}\ n\ \lambda/hc$ is the “order”

unix%> ds9 acisf11044N002_evt2.fits.gz &



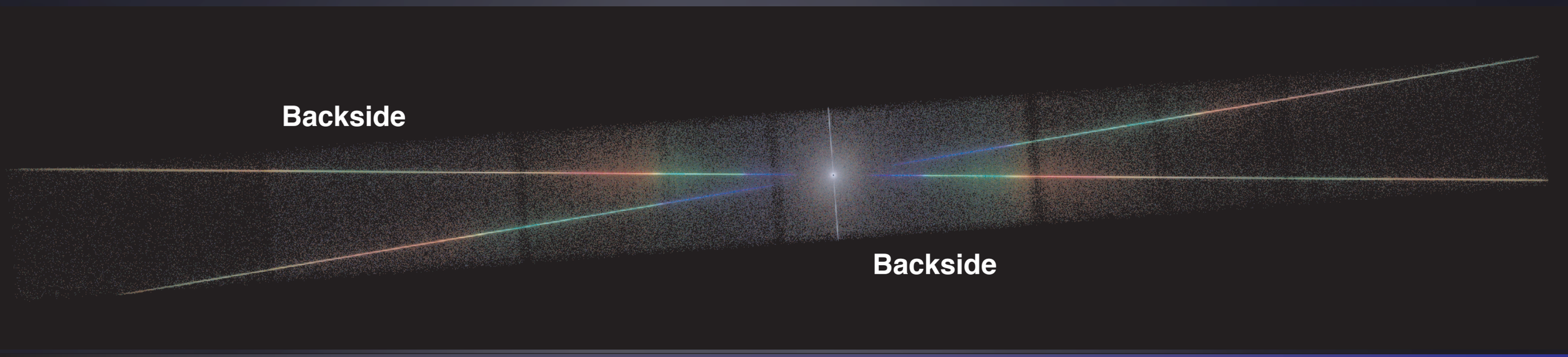
Order Sorting Plot



Data Extraction Tasks

- All these can be accomplished with CIAO tools
  - (Select time intervals, “clean” the data)
- Where is my source?
  - tg_detect2 – or – “by hand”
- What regions should be assigned orders?
  - tg_create_mask
- Which events should be assigned to which orders?
  - tg_resolve_events
- What region (width) should I extract?
  - tg_extract
- Create Response (RMF and ARF files)
  - mkgrmf, asphist & mkgarf – or – fullgarf

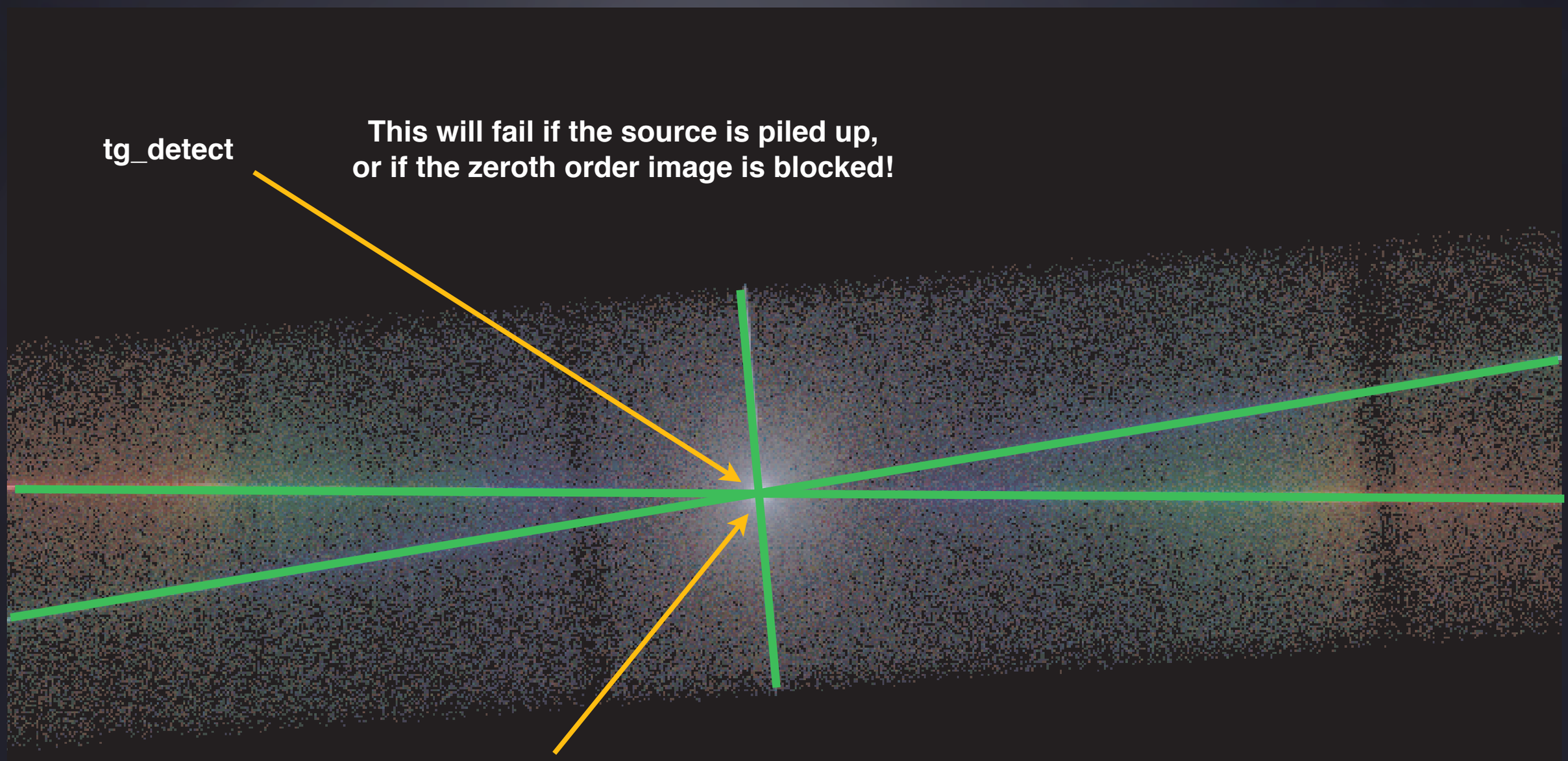
Chandra HETG



Chandra (ACIS) LETG

- 0th order shows diffraction from coarse support structure
- “Whiskers” are diffraction from fine support structure

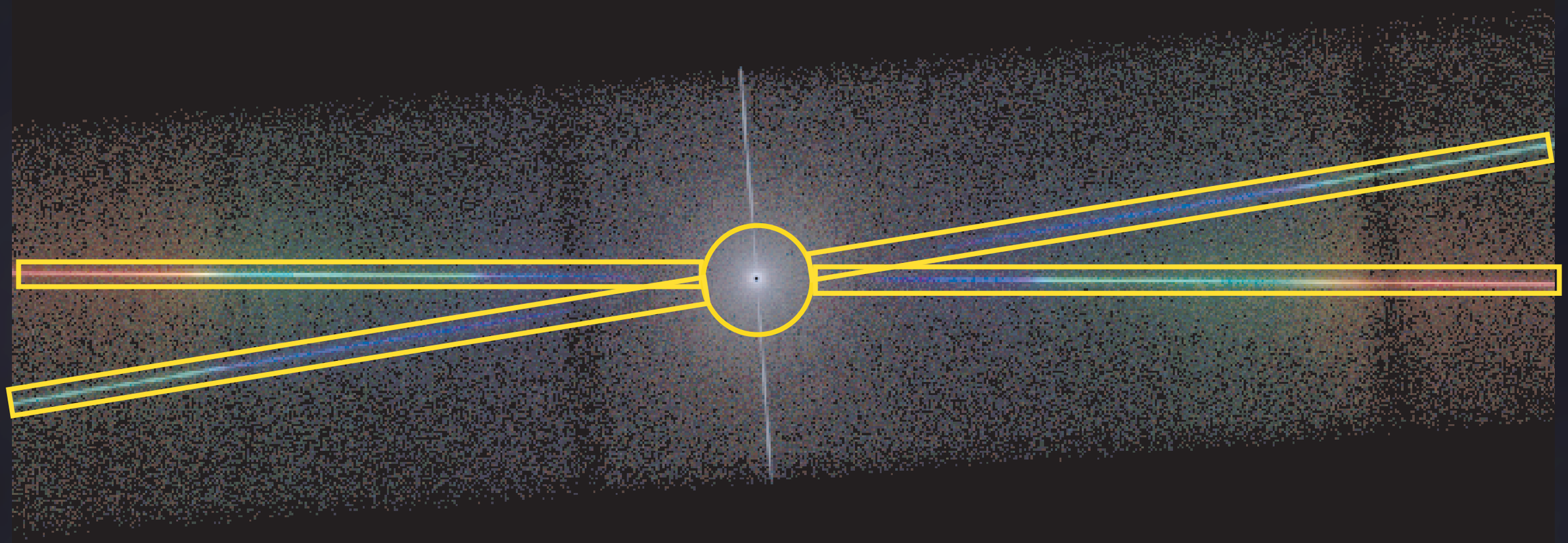
Where is my source?



Accuracy can be as good as 0.1 pixels

tg_create_mask

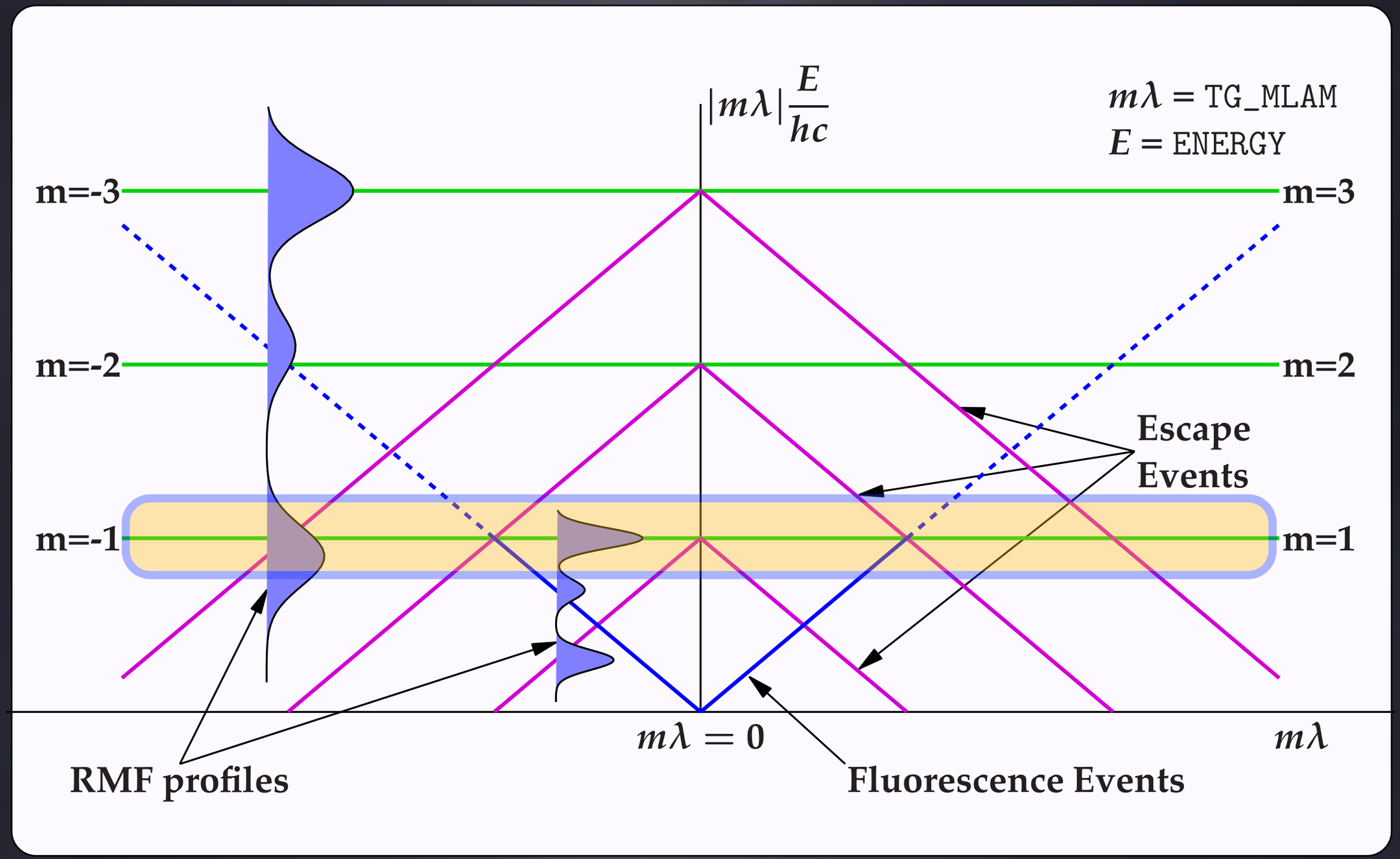
Hierarchy: 0th Order > MEG > HEG



CIAO defaults are a bit too wide, so MEG "clips" HEG high energy for "Continuum" Sources

These are the ***Potential*** *Gratings Events*

“Resolving” Events



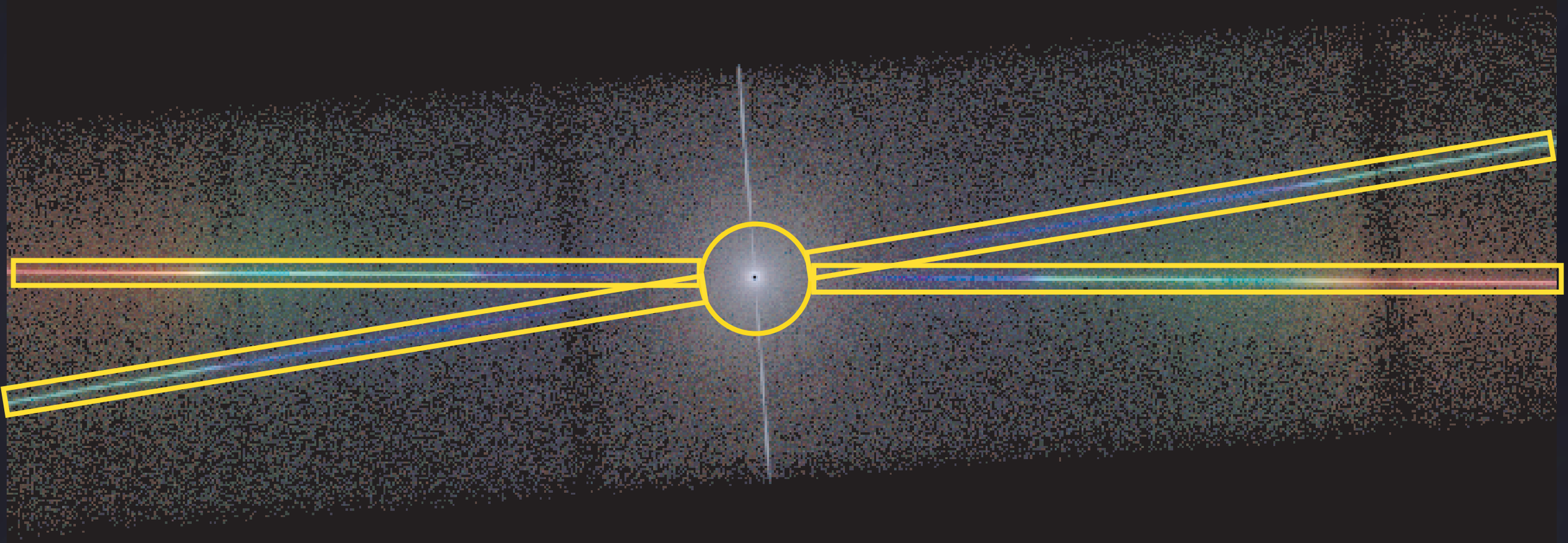
Fraction of RMF is the “Order Sorting Integrated Probability” (OSIP) and is Incorporated into ARF

Order Sorting

- *For Chandra, there are two choices:*
  - *“Standard” (which varies with wavelength) with a pre-calculated OSIP*
  - *“Flat”, with the user choosing a fixed ratio, e.g.,* **E_{CCD} m /hcλ = 0.8–1.3 and OSIP assumed to be 1**
  - **Flat is usually the choice for “Continuous Clocking” mode**
- **To be a gratings photon, it has to be at the right place with the expected energy**
  - **Greatly reduces background!**

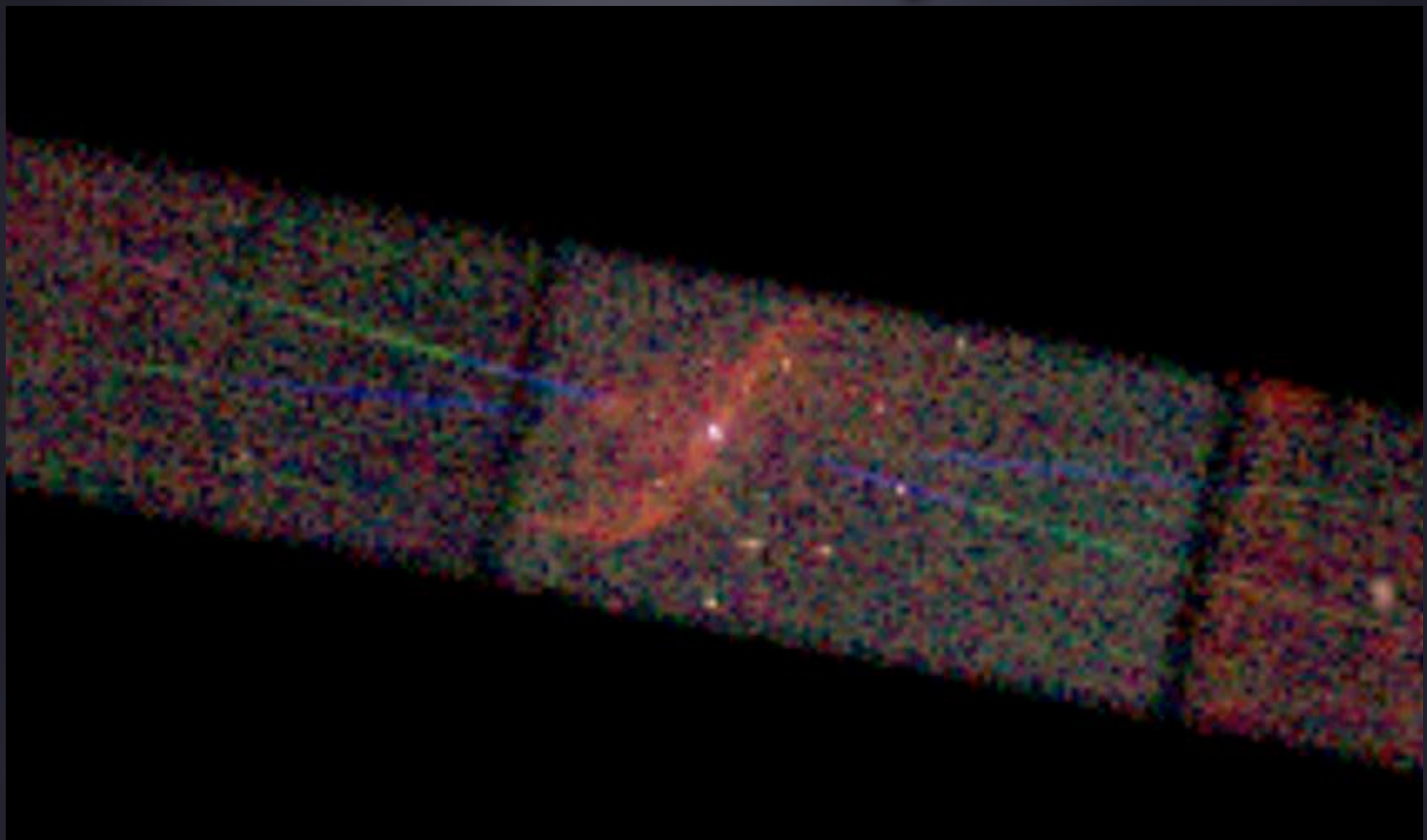
tg_extract_events

Isolated Source, Defaults are Fine

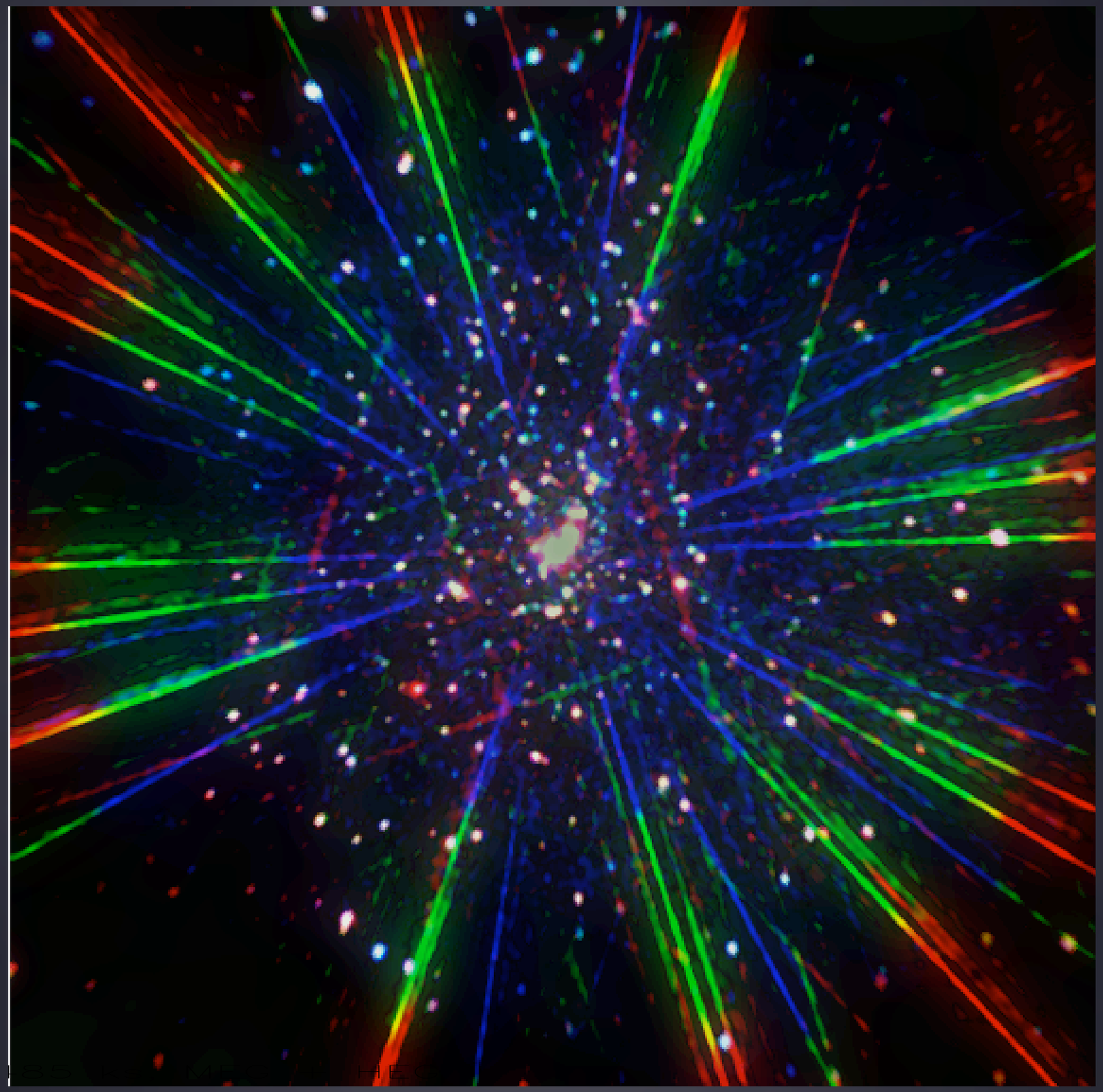


Fraction of LSF is Incorporated in RMF

Narrower is Sometimes Necessary



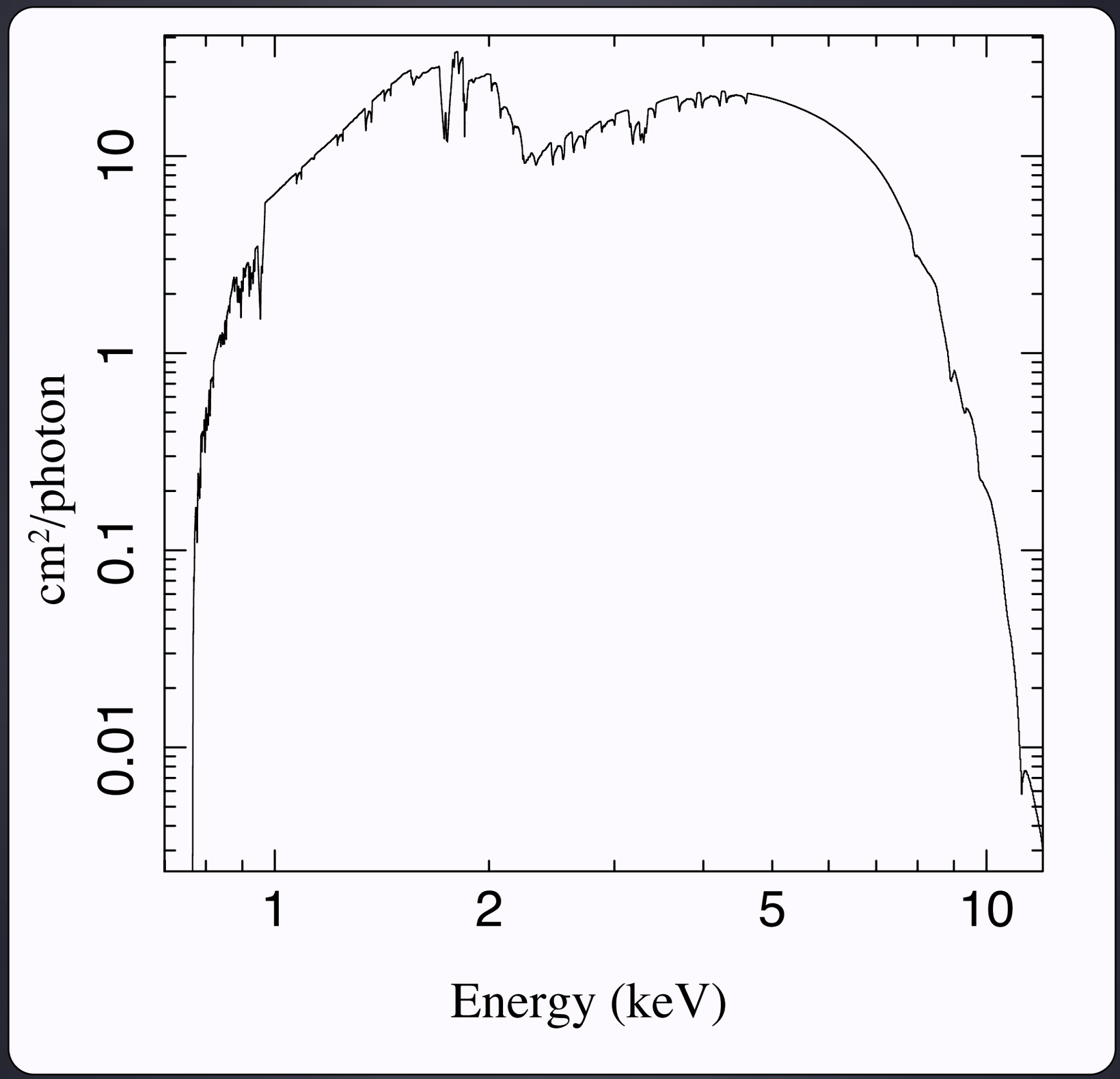
Orion Star Cluster



Response Matrices & ARF

- *If you've extracted the standard width, the standard RMF is sufficient*
- *ARF (effective area file) has to incorporate spatial information about the detector. Not only chip gaps, but also bad pixels & columns*
- *Standard tools: mkgrmf, asphist & mkgarf, fullgarf*

Sample Gratings ARF



And Now Analysis Begins!

- *You have extracted spectra and created response matrices/ effective area files*
- *Analyze in any standard program: ISIS, XSPEC, Sherpa, SPEX*
- *The standard is to extract 1st, 2nd, 3rd (+/-) orders*
  - *Higher orders have less flux, and less accurate responses – difficult to use for continuum*
  - *Line dominated sources, good for separating blends of lines*

Complex

- *Pileup – Less likely to happen, but it can ...*
  - *pile-up model for ISIS/Sherpa (XSPEC?)*
- *Continuous Clocking Mode (CC-mode)*
- *Sources with spatial structure*
- *Sources with spatial structure and CC-mode*

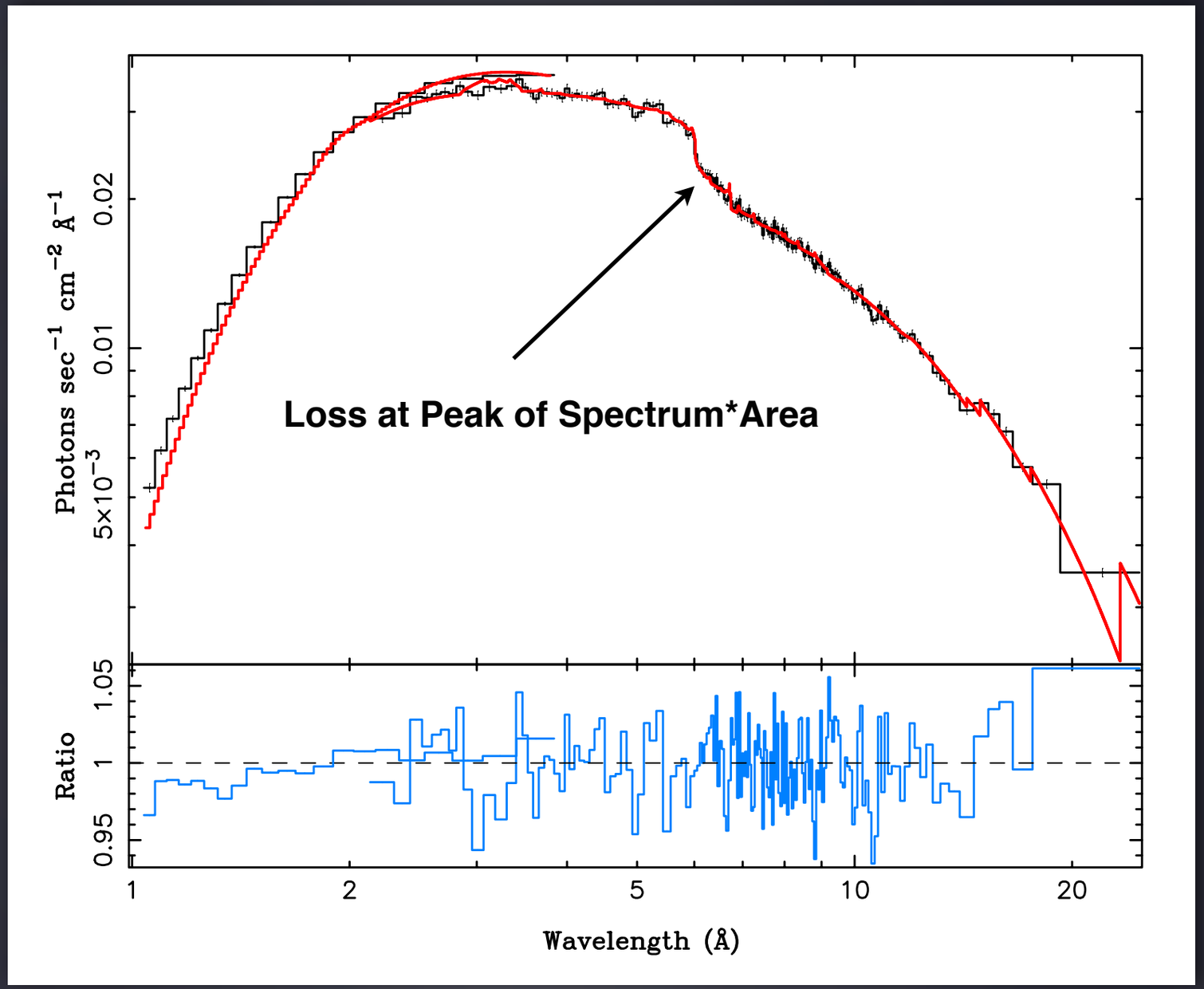
Time Intervals & Data Cleaning

- *You can do a time slice with dmcopy:*

  dmcopy “evt1_file[stdevt][time=5.1096500e8:5.1098000e8]” evt1_new

- *You can then run the chandra_repro script on this new file, and proceed from there*
  - *Removes bad pixels*
  - *Applies Good Time Intervals (GTI)*
  - *Removes “streaks” (S4 Chip)*
  - *Selects “Good Grades”*

Pileup in Gratings Spectrum



Most Significant in MEG (Higher Effective Area, Less Dispersion)

Continuous Clocking

- *Image collapsed to one dimension*
- *But, MEG 2nd orders are suppressed, so HEG 1st order is always assumed*
- *Extraction width is assumed to be 100%, and OSIP is chosen to be flat (~0.8–1.3) and assumed 100%*
- ***No source is piled up in this mode – we've looked at Sco X-1! (The Chandra team was *not* happy!)***
- *But, there are still issues at the few % level...*
- *We recommend putting MEG -1 and HEG+1 off the chips*

A Note About Exposures

- *Different Chips Can Have Different Exposures*
  - *Especially True for Bright Sources with Data Loss*
- *Data files will have the mean exposure of all the chips*
- *Effective Area files will have the mean exposure of the chips associated with that detector*
- *None of these numbers may actually be the “true” exposure at a specific wavelength region*
  - *The issues are incorporated into the ARF*
  - *But might not be adequate when doing lightcurves*

TGCAT: TRANSMISSION GRATINGS CATALOG

- Location: http://tgcat.mit.edu/
- Description: Huenemoerder et al. 2011, AJ, 141, 129
- Examples & video demos: http://tgcat.mit.edu/tgHelp.php?guide=help/tgcat_demos.html
- Help desk: tgcat@space.mit.edu

WHY TGCAT?

- saves you time
- We provide human-vetted extractions, spectra, lightcurves, fluxes in bands of interest, and diagnostic plots
  - If the summed spectra is all you need, you can start and stop with *TGCat*.
- Plots! In many different units for different astronomers (wavelength, energy, frequency).
  - Ability to sum spectra and visually search for features.
  - Summed spectra *almost* good enough to fit

WORKED EXAMPLE: M81*

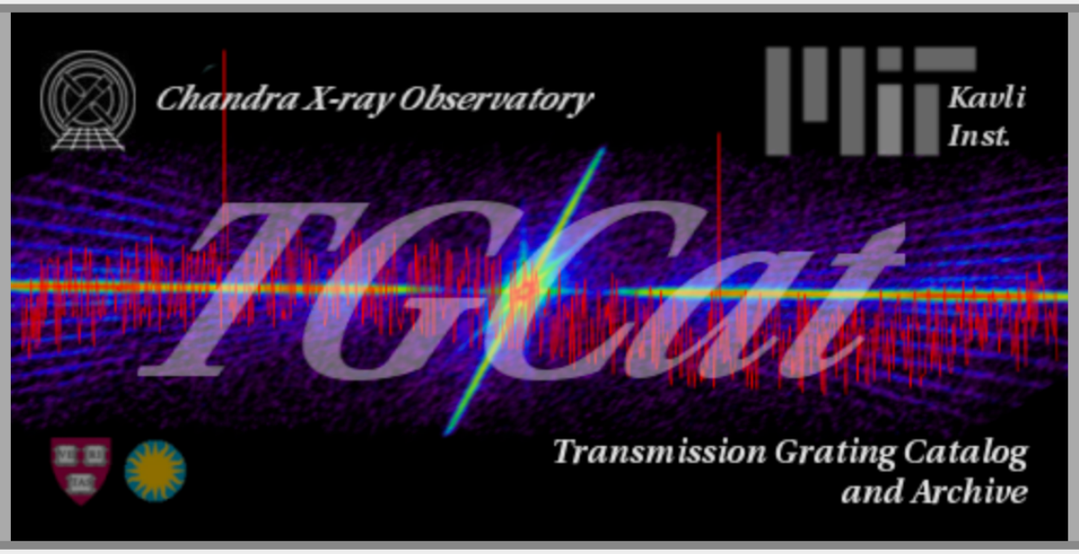
- Search for the source.
- Identify multiple observations.
- Look at them individually
  - Visually judge long term variability
- Sum the observations, and look at the combined plot
  - Visually identify weak features
- Download the Data Products

TGCat | Query | Quick Search | Help Topics | Help

- Name
- Cone Search
- Type
- Spectral Properties
- Obsid
- Arbitrary Extraction Column
- Arbitrary Source Column
- ----------
- Latest Query Results
- My Recent Queries

Start H… Select functionality from menu items

If you use ***TGCat*** in your research, please cite: Huenemoerder et al. 2011 (AJ, 141, 129).



TGCat Announcements [all]

2017-10-23 23:30:03 - posted by tgcat

2 new extractions reviewed and added to the archive Show Me

Serendipitous Source Extraction Request Form

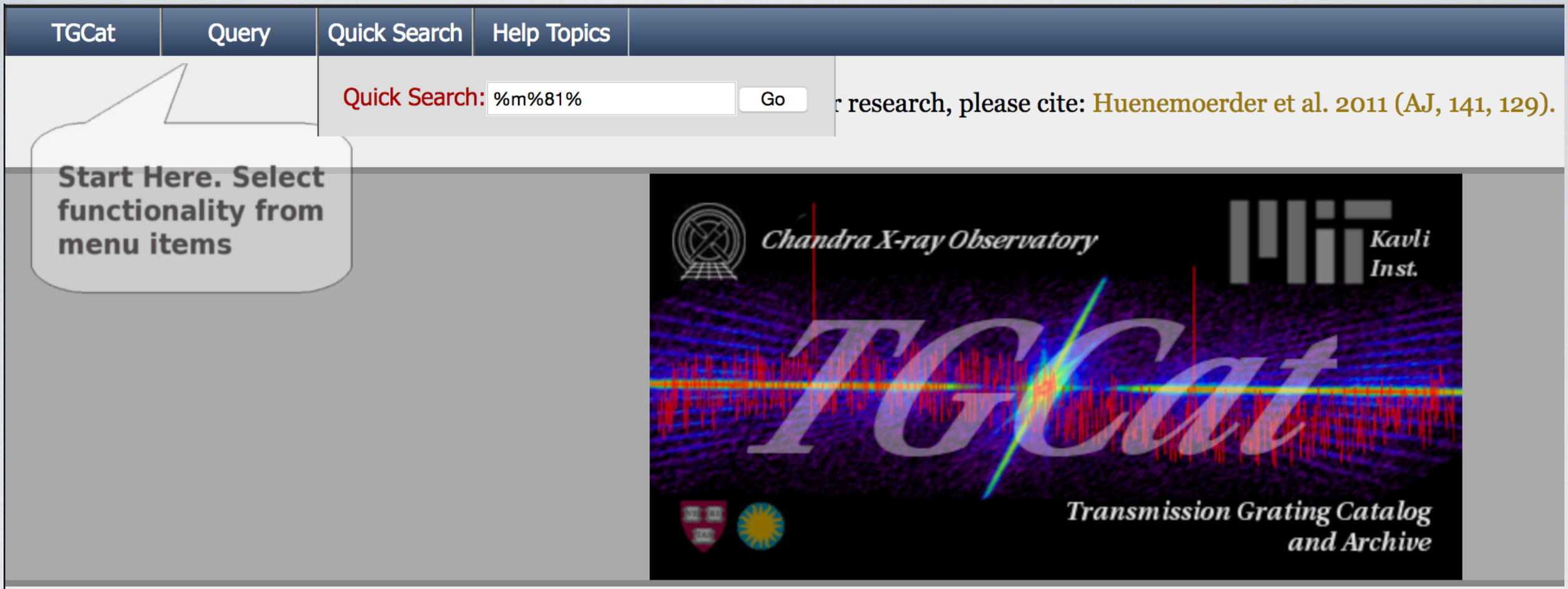
If you use *TGCat* in your research, please cite: Huenemoerder et al. 2011 (AJ, 141, 129).

ISIS CIAO Powered by MySQL php

Related Catalog Projects:
CSC X-Atlas BiRD HotGAS MAST

NVO SCS SIA

Many Choices for Search – We'll Use *Quick Search*



% is a Wild Card – be generous with its use, since we might not have spelled it the way you are expecting!

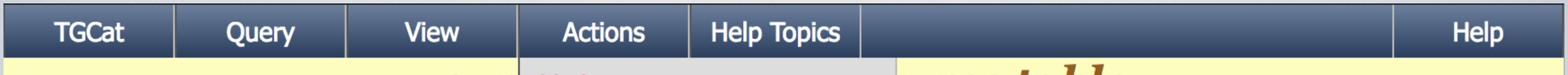
TGCat | Query | View | Actions | Help Topics | Help

---- currently viewing source table ----

+/-	Links	object	simbad_ID	ra (h:m:s)	decl (d:m:s)	pType	other_types	num_extractions
☐	s d b i	LS Com (HD 111812)	V* LS Com	12:51:41.930	+27:32:26.592	V*	*, IR, UV, V*, X	1
☐	s d b i	M 81*	M 81	09:55:33.170	+69:03:55.116	LIN	AGN, G, GiG, GiP, IR, LIN, QSO, Rad, X	15
☐	s d b i	Nova CSS081007	[DDM2009] CSS081007 J030559+054715	03:05:58.538	+05:47:14.748	No*	No*	1

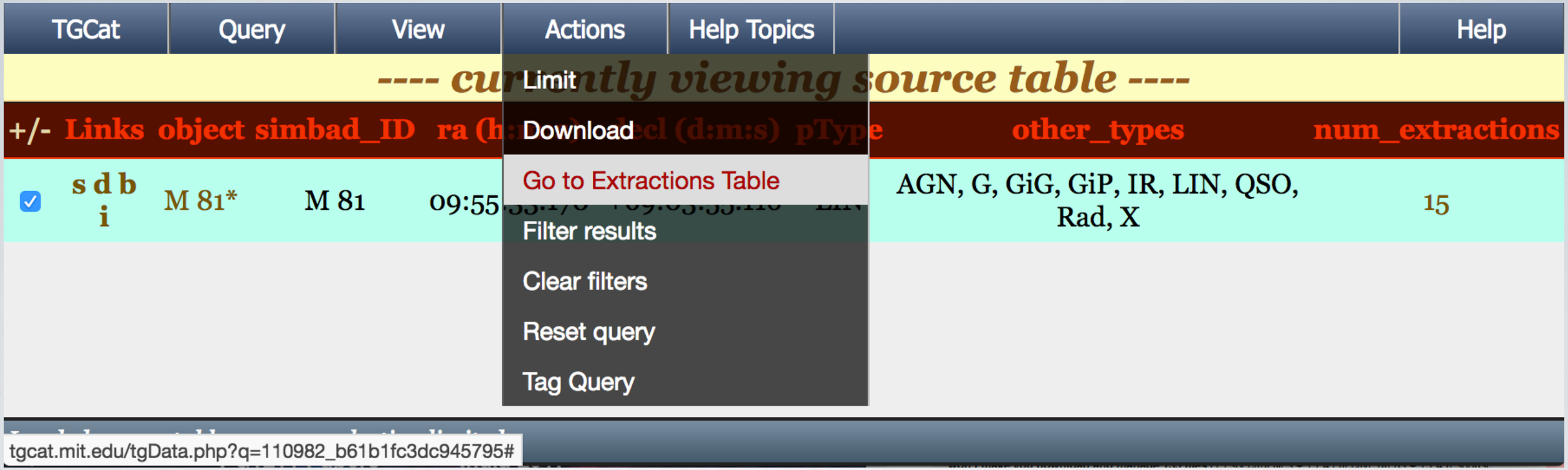
Loaded source table: 3 rows; selection limited

Three Sets of Targets Come Up – Choose the Middle, Consisting of 15 Observations



tgcat.mit.edu/tgData.php?q=110980_64cfa242aebb8a96#

Use *Actions* Tab and *Limit*



Then View the List of Extractions

TGCat | Query | View | Actions | Help Topics | Help

---- currently viewing extractions table ----

+/-	Links	obsid	object	instrument	grating	ra (h:m:s)	decl (d:m:s)	date_obs (y-m-d t)	exposure (s)
☐	o p v s	5600	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.188	2005-08-14 09:51:46	37727.6
☐	o p v s	5601	M 81*	ACIS	HETG	09:55:33.194	+69:03:55.080	2005-07-19 14:26:03	83362.2
☐	o p v s	6174	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.152	2005-02-24 06:56:59	46038
☐	o p v s	6346	M 81*	ACIS	HETG	09:55:33.163	+69:03:54.972	2005-07-14 01:44:55	54492.1
☐	o p v s	6347	M 81*	ACIS	HETG	09:55:33.175	+69:03:55.008	2005-07-14 19:26:08	63877.6
☐	o p v s	6892	M 81*	ACIS	HETG	09:55:33.202	+69:03:55.224	2006-02-08 20:21:15	14764.7
☐	o p v s	6893	M 81*	ACIS	HETG	09:55:33.211	+69:03:55.260	2006-03-05 23:42:33	14764.7
☐	o p v s	6894	M 81*	ACIS	HETG	09:55:33.194	+69:03:55.224	2006-04-01 10:38:21	14767.9
☐	o p v s	6895	M 81*	ACIS	HETG	09:55:33.178	+69:03:55.116	2006-04-24 08:18:52	14563
☐	o p v s	6896	M 81*	ACIS	HETG	09:55:33.154	+69:03:55.188	2006-05-14 13:01:03	14767.8
☐	o p v s	6897	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.044	2006-06-09 18:14:02	14764.6
☐	o p v s	6898	M 81*	ACIS	HETG	09:55:33.163	+69:03:55.152	2006-06-28 23:36:01	14857.4
☐	o p v s	6899	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.080	2006-07-13 13:41:33	15199.8
☐	o p v s	6900	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.152	2006-07-28 11:10:19	14415.8
☐	o p v s	6901	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.080	2006-08-12 16:15:46	14767.8

Loaded extractions table: 15 rows; selection limited

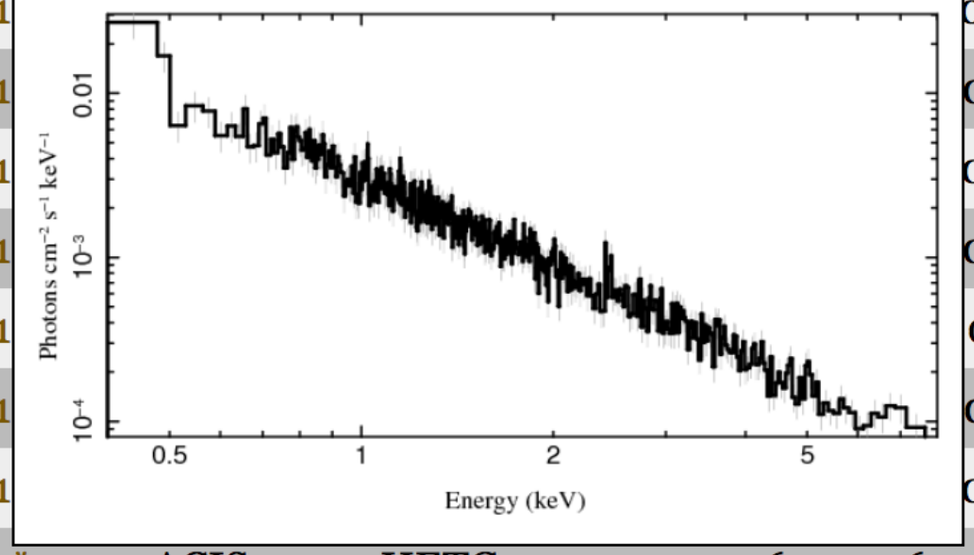
Basic List of Observation Properties Given

TGCat | Query | View | Actions | Help Topics | Help

---- currently viewing extractions table ----

+/-	Links	obsid	object	instrument	grating	ra (h:m:s)	decl (d:m:s)	date_obs (y-m-d t)	exposure (s)
☐	o p v s	5600	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.188	2005-08-14 09:51:46	37727.6
☐	o p v s	5601	M 81*	ACIS	HETG	09:55:33.194	+69:03:55.080	2005-07-19 14:26:03	83362.2
☐	o p v s	6174	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.152	2005-02-24 06:56:59	46038
☐	o p v s	6346	M 81*	ACIS	HETG	09:55:33.163	+69:03:54.972	2005-07-14 01:44:55	54492.1
☐	o p v s	6347	M 81				03:55.008	2005-07-14 19:26:08	63877.6
☐	o p v s	6892	M 81				03:55.224	2006-02-08 20:21:15	14764.7
☐	o p v s	6893	M 81				03:55.260	2006-03-05 23:42:33	14764.7
☐	o p v s	6894	M 81				03:55.224	2006-04-01 10:38:21	14767.9
☐	o p v s	6895	M 81				03:55.116	2006-04-24 08:18:52	14563
☐	o p v s	6896	M 81				03:55.188	2006-05-14 13:01:03	14767.8
☐	o p v s	6897	M 81				03:55.044	2006-06-09 18:14:02	14764.6
☐	o p v s	6898	M 81*	ACIS	HETG	09:55:33.163	+69:03:55.152	2006-06-28 23:36:01	14857.4
☐	o p v s	6899	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.080	2006-07-13 13:41:33	15199.8
☐	o p v s	6900	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.152	2006-07-28 11:10:19	14415.8
☐	o p v s	6901	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.080	2006-08-12 16:15:46	14767.8

Flux Spectrum - **(Click Object For More Plots)**



ws; selection limited

tgcat.mit.edu/tgPlot.php?t=P&i=3969

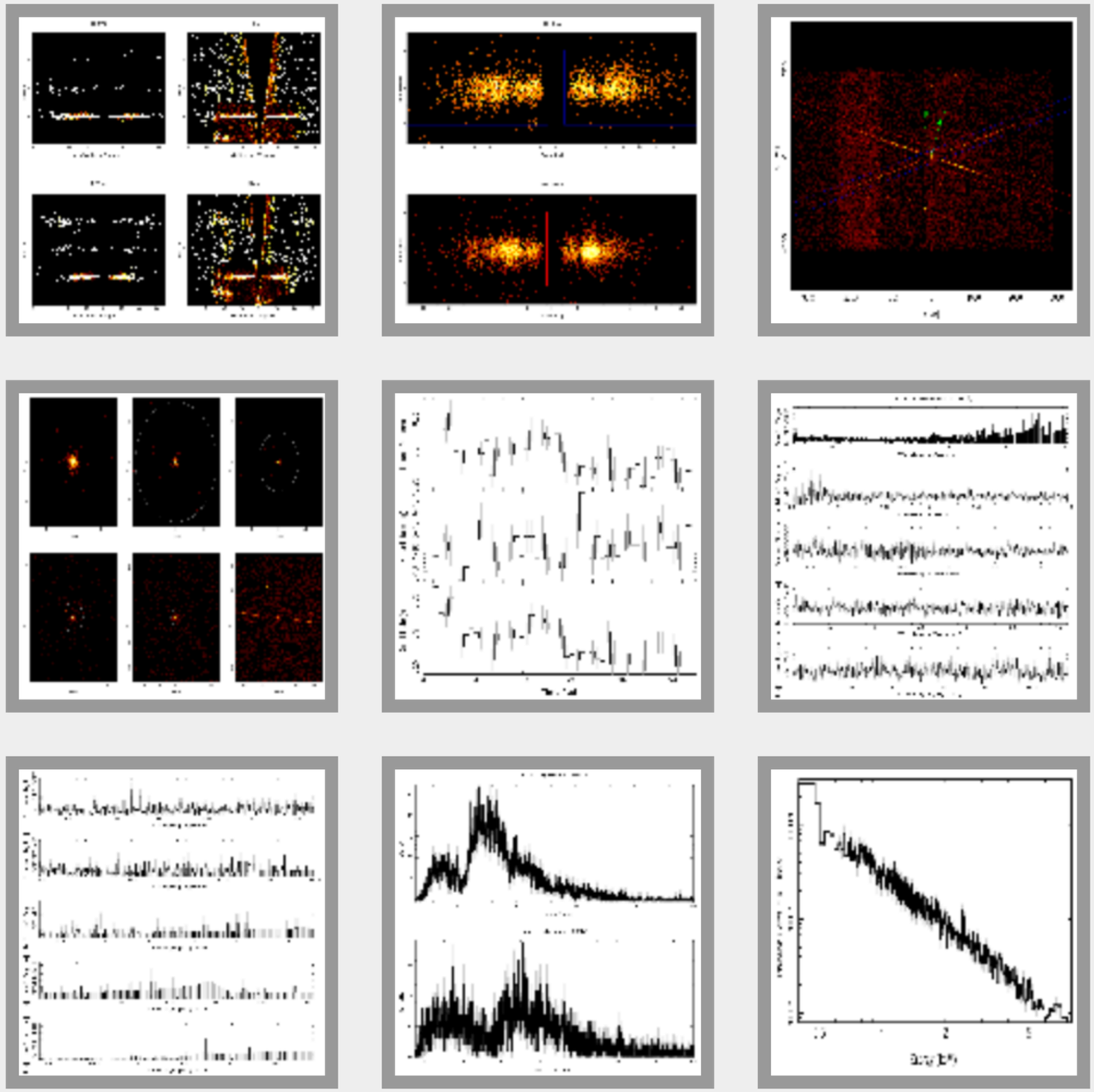
Hovering Shows a Spectral Plot

TGCat | Query | View | Help Topics | Help

*M 81**

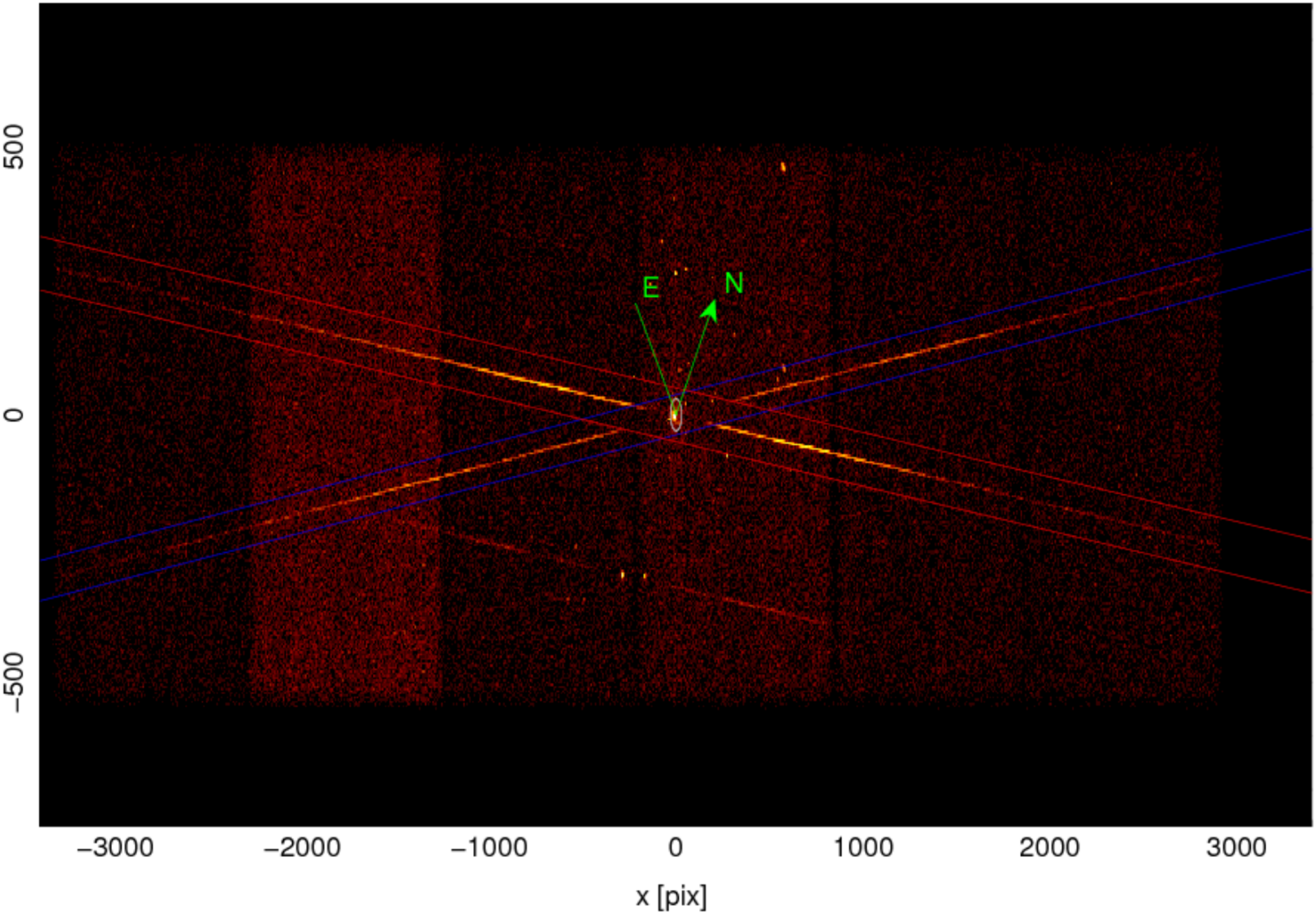
single extraction product

id	3969
srcid	1859
obsid	6346
review	good
obi	1
target	M81*
object	M 81*
simbad_ID	M 81
instrument	ACIS
grating	HETG
exposure(s)	5.4e+4
ra	148.88818
decl	69.06527
heg_band(c/s)	2.9e-1
meg_band(c/s)	3.0e-1
leg_band(c/s)	3.0e-1
letg_acis_band(c/s)	3.0e-1
zero_order(c/s)	1.8e-1
readmode	TIMED
datamode	FAINT
proc_date	2012-02-03 06:59:03
zo_method	tgdetect
date_obs	2005-07-14 01:44:55



Clicking on an Observation Brings Up Summary

TGCat | Query | View | Hel close | description | full size | Help



Note Other Objects in Field

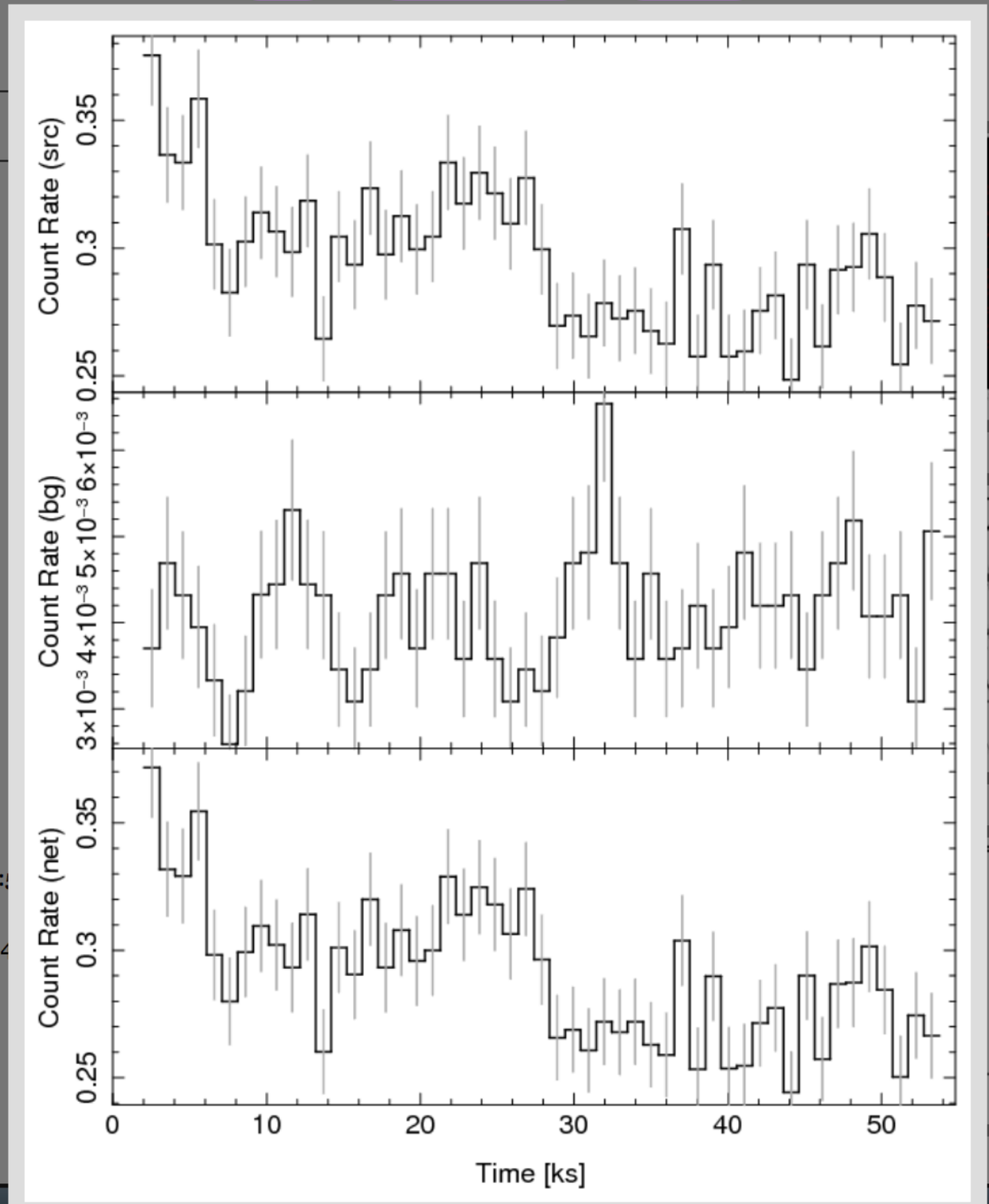
TGCat | Query | View | Help

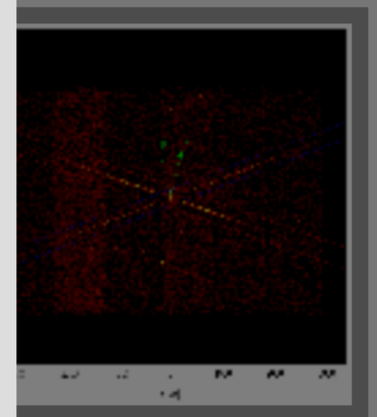
close | description | full size

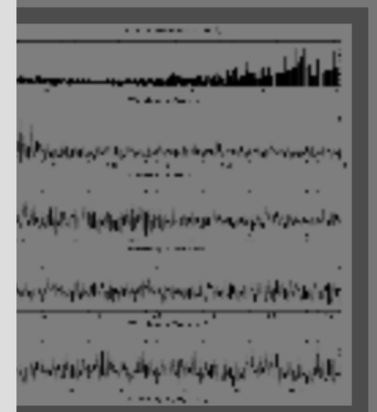
M 81*

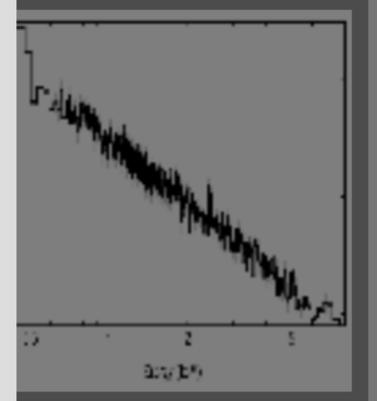
single extraction product

id	3969
srcid	1859
obsid	6346
review	good
obi	1
target	M81*
object	M 81*
simbad_ID	M 81
instrument	ACIS
grating	HETG
exposure(s)	5.4e+4
ra	148.88818
decl	69.06527
heg_band(c/s)	2.9e-1
meg_band(c/s)	3.0e-1
leg_band(c/s)	3.0e-1
letg_acis_band(c/s)	3.0e-1
zero_order(c/s)	1.8e-1
readmode	TIMED
datamode	FAINT
proc_date	2012-02-03 06:
zo_method	tgdetect
date_obs	2005-07-14 01:









Some Lightcurve Variability

TGCat | Query | View | Actions | Help Topics | Help

---- currently viewing extractions table ----

- Limit
- Download
- Go to Source Table
- Plot (Combined)
- Plot (Multiple)
- Filter results
- Clear filters
- Reset query
- Tag Query

+/-	Links	obsid	object	instrument	grating	ra (h:m:s)	decl (d:m:s)	date_obs (y-m-d t)	exposure (s)
☑	o p v s	5600	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.188	2005-08-14 09:51:46	37727.6
☑	o p v s	5601	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.080	2005-07-19 14:26:03	83362.2
☑	o p v s	6174	M 81*	ACIS	HETG	09:55:33.170	+69:03:55.152	2005-02-24 06:56:59	46038
☑	o p v s	6346	M 81*	ACIS	HETG	09:55:33.163	+69:03:54.972	2005-07-14 01:44:55	54492.1
☑	o p v s	6347	M 81*	ACIS	HETG	09:55:33.175	+69:03:55.008	2005-07-14 19:26:08	63877.6
☑	o p v s	6892	M 81*	ACIS	HETG	09:55:33.202	+69:03:55.224	2006-02-08 20:21:15	14764.7
☑	o p v s	6893	M 81*	ACIS	HETG	09:55:33.211	+69:03:55.260	2006-03-05 23:42:33	14764.7
☑	o p v s	6894	M 81*	ACIS	HETG	09:55:33.194	+69:03:55.224	2006-04-01 10:38:21	14767.9
☑	o p v s	6895	M 81*	ACIS	HETG	09:55:33.178	+69:03:55.116	2006-04-24 08:18:52	14563
☑	o p v s	6896	M 81*	ACIS	HETG	09:55:33.154	+69:03:55.188	2006-05-14 13:01:03	14767.8
☑	o p v s	6897	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.044	2006-06-09 18:14:02	14764.6
☑	o p v s	6898	M 81*	ACIS	HETG	09:55:33.163	+69:03:55.152	2006-06-28 23:36:01	14857.4
☑	o p v s	6899	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.080	2006-07-13 13:41:33	15199.8
☑	o p v s	6900	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.152	2006-07-28 11:10:19	14415.8
☑	o p v s	6901	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.080	2006-08-12 16:15:46	14767.8

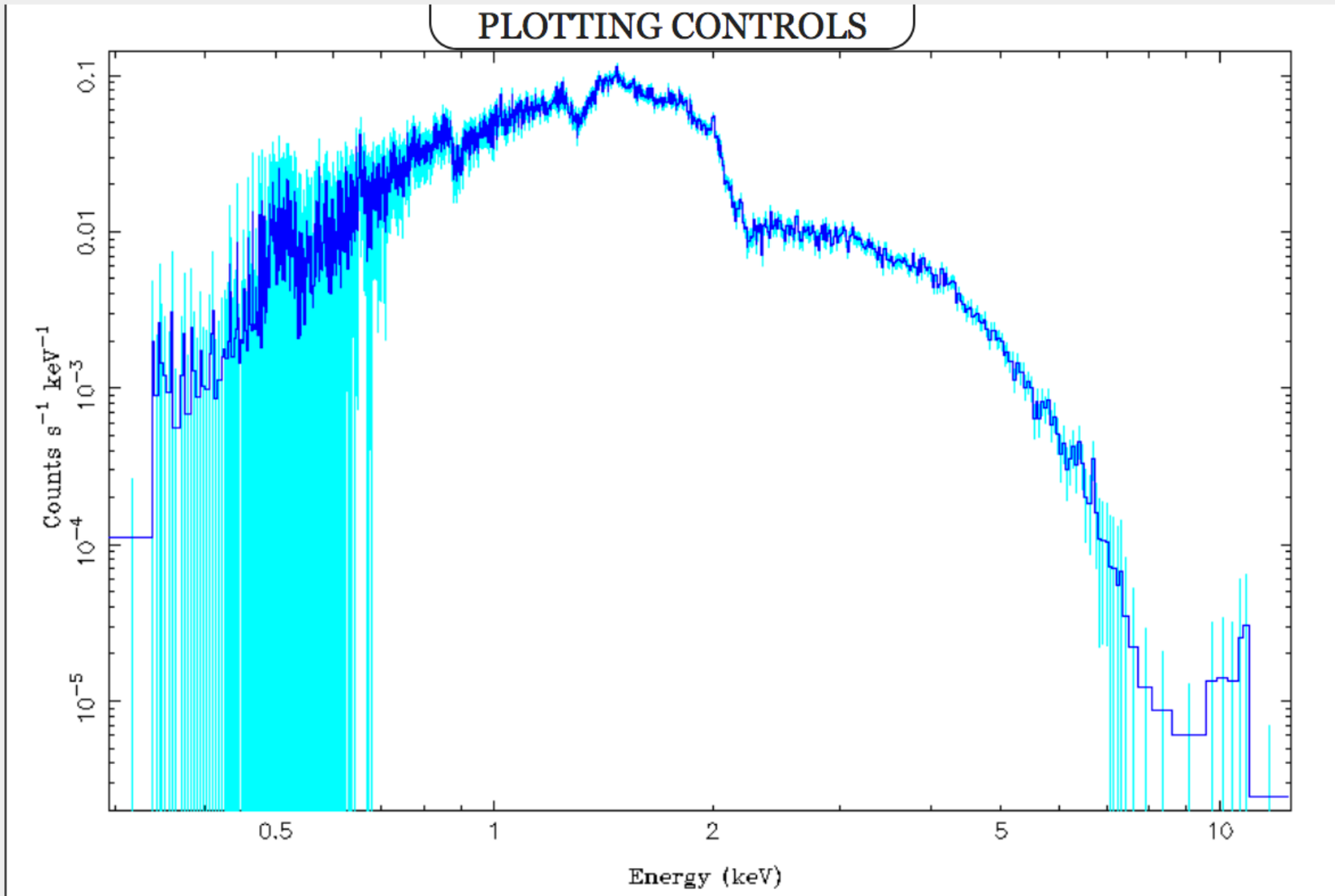
Go Back to Extractions Window, Choose All Observations, Choose *Actions* Tab and *Plot (Combined)*

TGCat | Query | View | Help Topics | Help

Multi Preview

combined extraction product

object	Multi Preview
obsid	5600, 5601, 6174, 6346...' target='_blank'> 5600, 5601, 6174, 6346...
ids	3938, 3940, 3951, 3969...
srcids	1859
instruments	ACIS
gratings	HETG
total_exposure(s)	4.3e+5
ra	148.88822
decl	69.06531
heg_band(c/s)	3.0e-1
meg_band(c/s)	3.1e-1
leg_band(c/s)	3.1e-1
letg_acis_band(c/s)	3.1e-1
zeroth_order(c/s)	1.9e-1
proc_date	2012-02-03 16:09:25
date_obs	2006-01-30 19:45:42

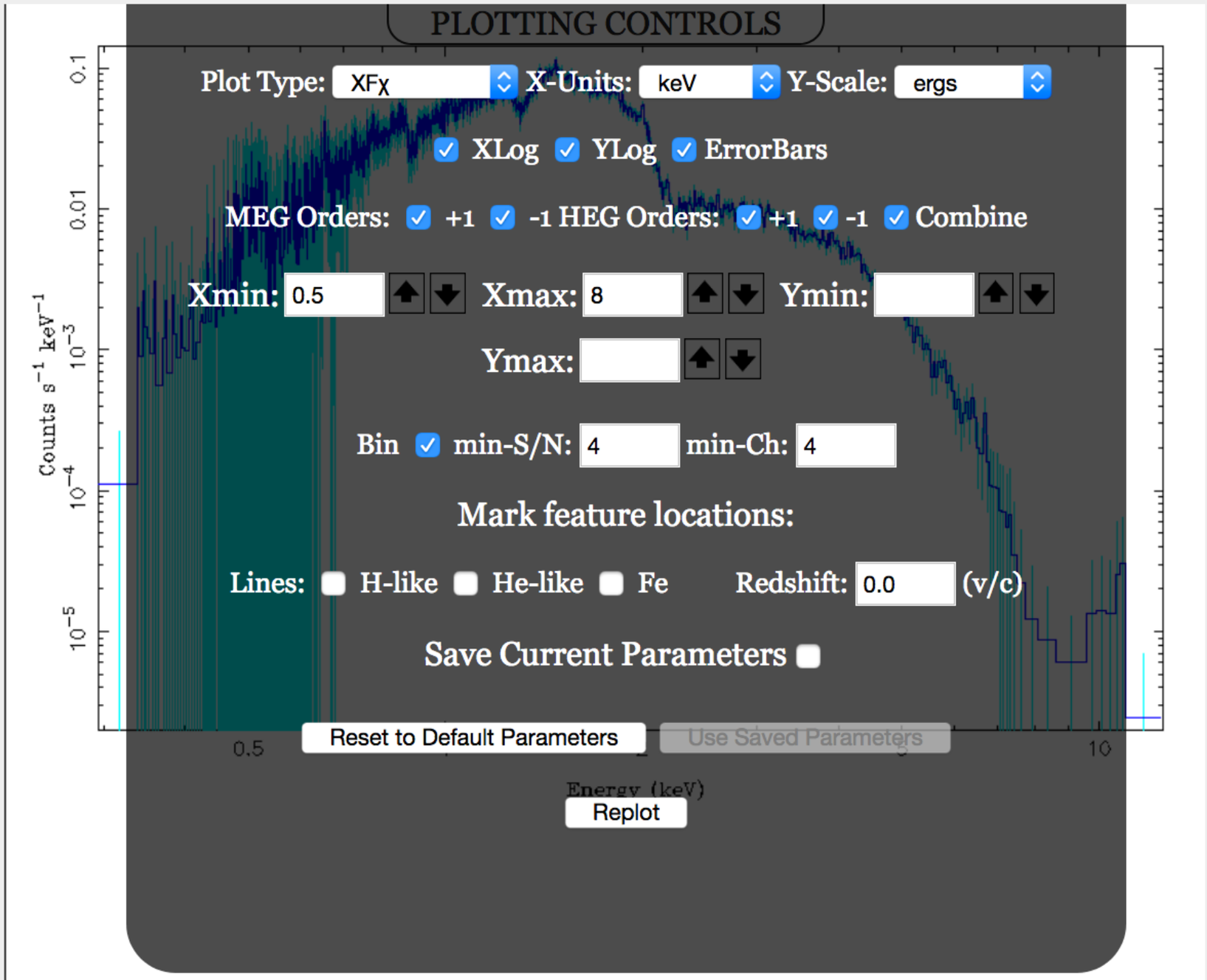


Preliminary Plot of All Data Combined

Multi Preview

combined extraction product

object	Multi Preview
obsid	5600, 5601, 6174, 6346...' target='_blank'> 5600, 5601, 6174, 6346...
ids	3938, 3940, 3951, 3969...
srcids	1859
instruments	ACIS
gratings	HETG
total_exposure(s)	4.3e+5
ra	148.88822
decl	69.06531
heg_band(c/s)	3.0e-1
meg_band(c/s)	3.1e-1
leg_band(c/s)	3.1e-1
letg_acis_band(c/s)	3.1e-1
zeroth_order(c/s)	1.9e-1
proc_date	2012-02-03 16:09:25
date_obs	2006-01-30 19:45:42

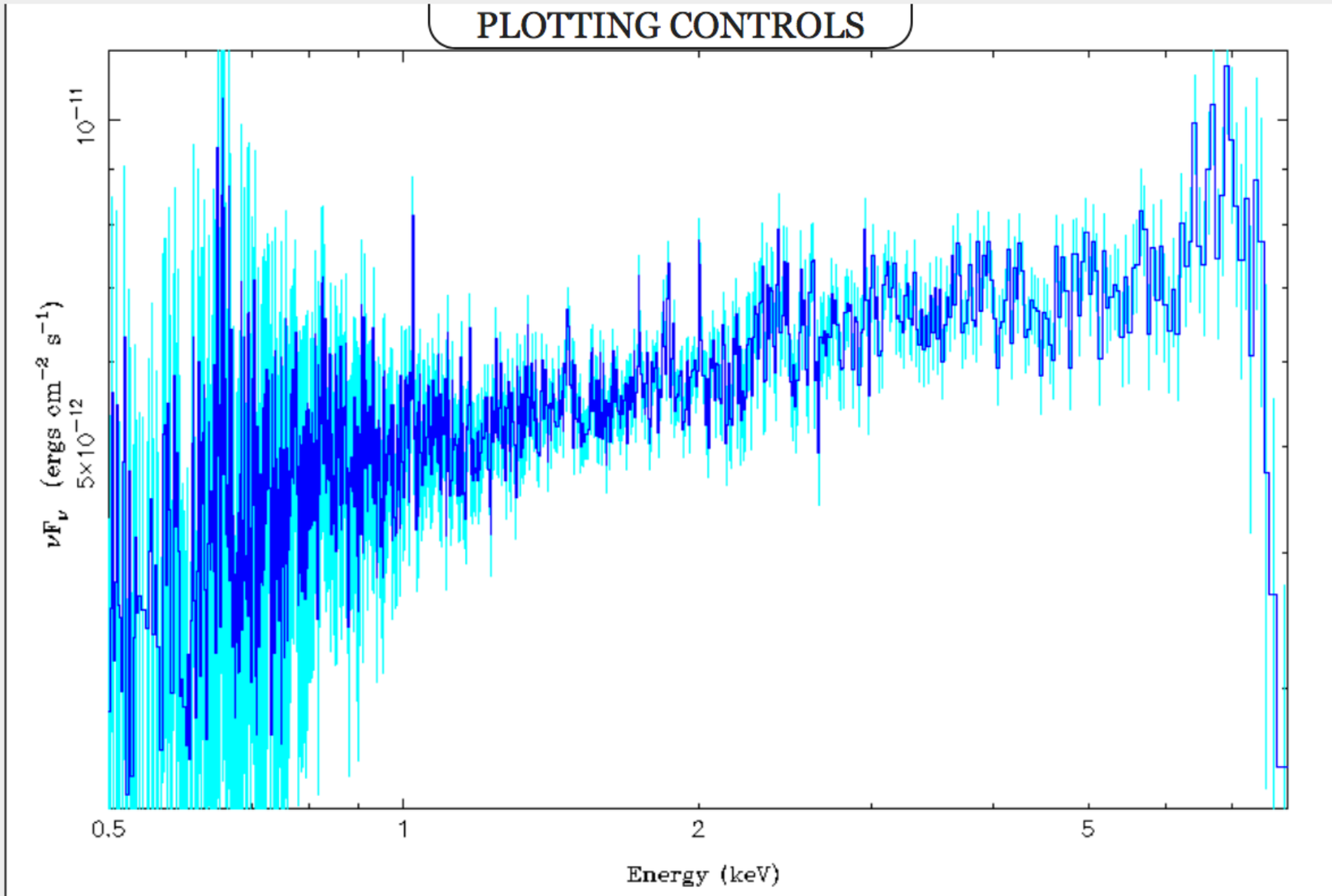


Change the Plot Defaults, and Plot Flux

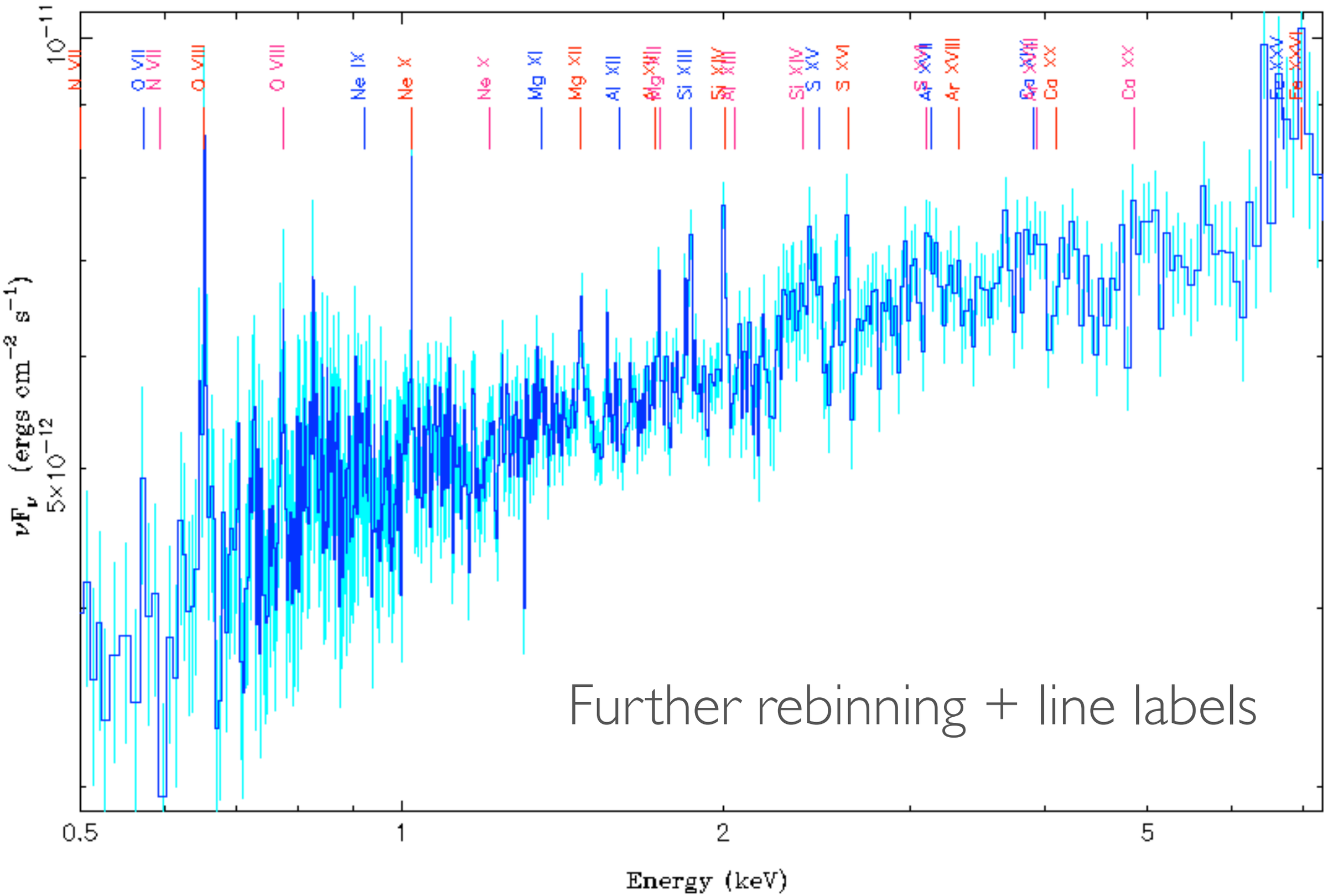
Multi Preview

combined extraction product

object	Multi Preview
obsid	5600, 5601, 6174, 6346...' target='_blank'> 5600, 5601, 6174, 6346...
ids	3938, 3940, 3951, 3969...
srcids	1859
instruments	ACIS
gratings	HETG
total_exposure(s)	4.3e+5
ra	148.88822
decl	69.06531
heg_band(c/s)	3.0e-1
meg_band(c/s)	3.1e-1
leg_band(c/s)	3.1e-1
letg_acis_band(c/s)	3.1e-1
zeroth_order(c/s)	1.9e-1
proc_date	2012-02-03 16:09:25
date_obs	2006-01-30 19:45:42



Note the Fe Kα, Fe XXV, and Fe XXVI Lines
Rebin Some More, Label Lines, Replot



Further rebinning + line labels

TGCat | Query | View | Actions | Help Topics | Help

---- currently viewing extractions table ----

+/-	Links	obsid	object	instrument	grating	ra (h:m:s)	decl (d:m:s)	date_obs (y-m-d t)	exposure (s)
☑	o								7.6
☑	o								2.2
☑	o								38
☑	o								2.1
☑	o								7.6
☑	o								4.7
☑	o								4.7
☑	o								7.9
☑	o								63
☑	o								7.8
☑	o								4.6
☑	o p v s	6898	M 81*	ACIS	HETG	09:55:33.163	+69:03:55.152	2006-06-28 23:36:01	14857.4
☑	o p v s	6899	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.080	2006-07-13 13:41:33	15199.8
☑	o p v s	6900	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.152	2006-07-28 11:10:19	14415.8
☑	o p v s	6901	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.080	2006-08-12 16:15:46	14767.8

Please select the products you wish to download:

default:

- ☐ PHA2 (Level 2 counts spectrum file)
- ☑ PHA1 (Column format spectrum)
- ☑ RMF (Response matrix file)
- ☑ ARF (Ancillary response file)

auxillary:

- ☐ EVT2 (Level 2 event file)
- ☐ LTC (Binned light curve file)
- ☐ OBSPAR (Observation parameter file)
- ☐ SUM (Summary image/tables)

email address: *OR* tag:

Apply | Close

Go Back to Extractions Window, Choose All Observations, Choose *Actions* Tab and *Download*

☐	opvs	6900	M 81*	ACIS	HETG	09:55:33.149	+69:03:55.152	2006-07-28 11:10:19	14415.8
☐	opvs	6901	M 81*	ACIS	HETG	09:55:33.156	+69:03:55.080	2006-08-12 16:15:46	14767.8

Loaded extractions table: 15 rows; selection limited; ■ package queued, your pkgid is 1653 ■ Go to Download Area

Look at Bottom of Page to See Link to
Go to Download Area

TGCat | Query | Quick Search | Help Topics | Help

Current Available Packages

	pkg-id	queue time	tag	status	size(kB)	objects	obsids	file-types
	1653	10/25/17-20:46	-	COMPLETED	731,984	M 81*	5600, 5...(15)	arf, ph...(3)

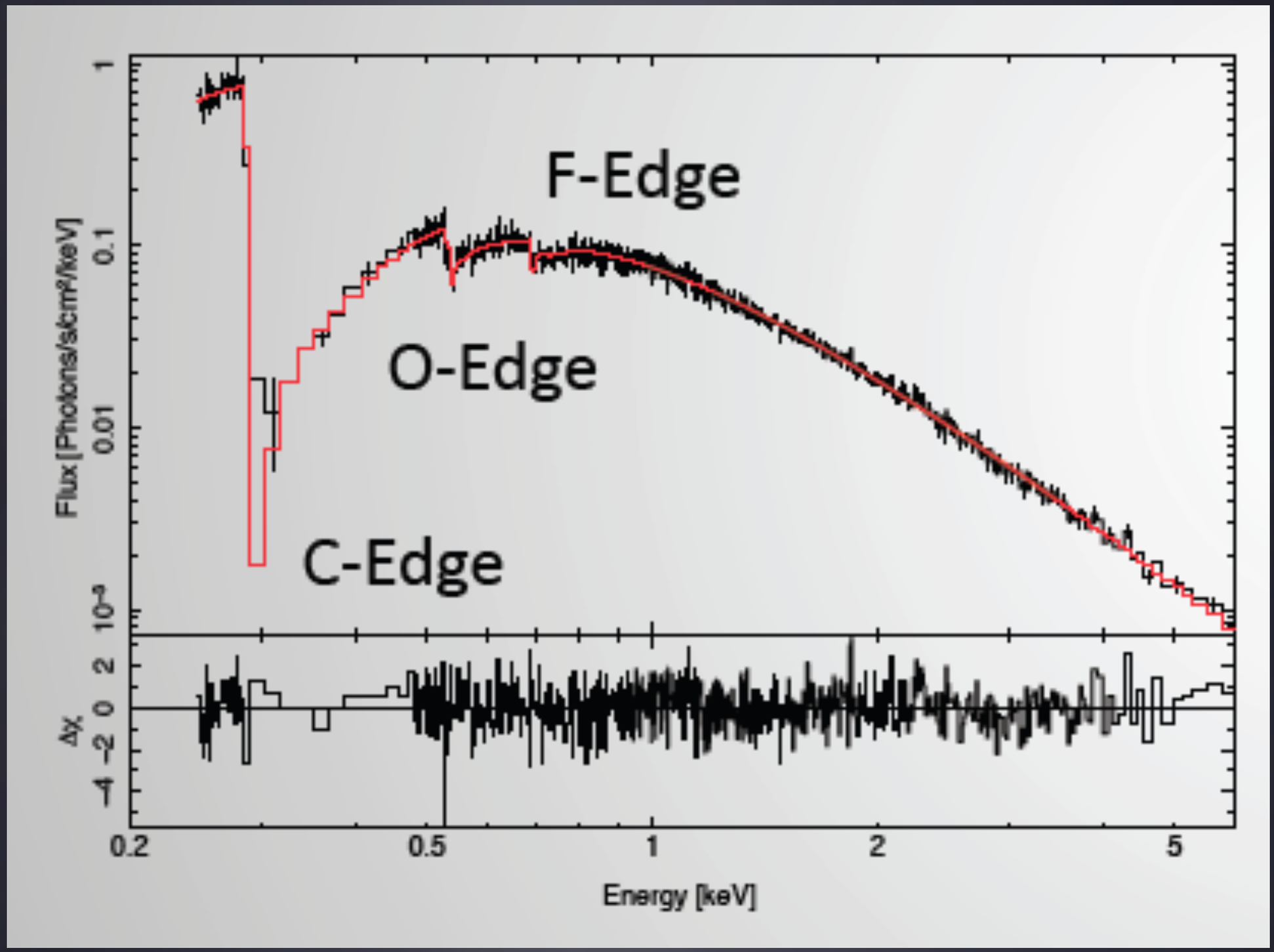
1 package currently staged; note that packages stage only ~1 day; this page auto-refreshes every 30s (last: 20:54:35)

Download When the Package is Ready!

OTHER ASPECTS OF TGCAT:

- Upon request, we will do custom extractions of other sources in the fields
  - e.g., stellar fields might have multiple possible sources
  - The M81* field has a ULX with dispersed spectra

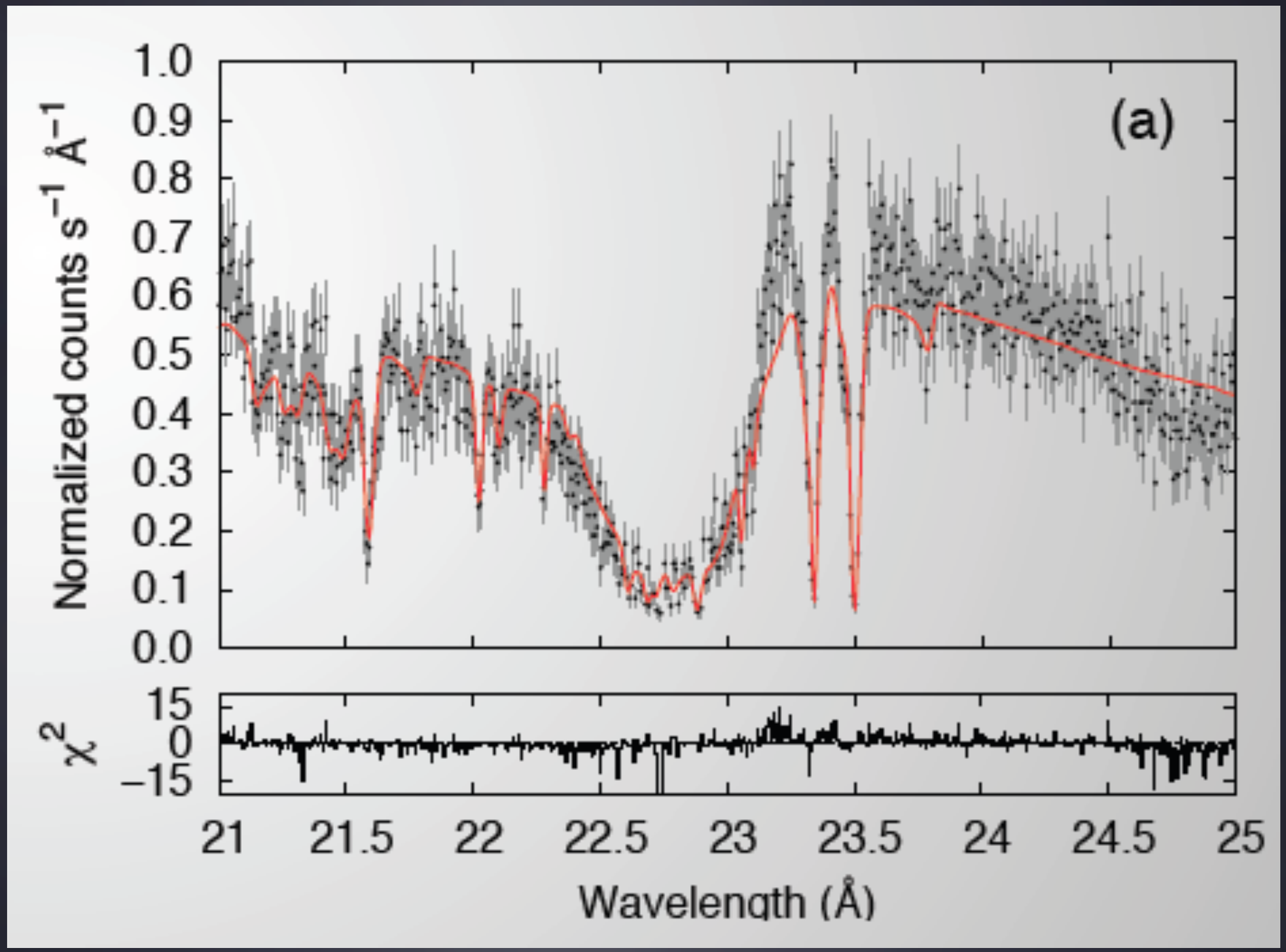
Science



(H. Marshall)

Tracking Contaminant on Chandra-ACIS

Science

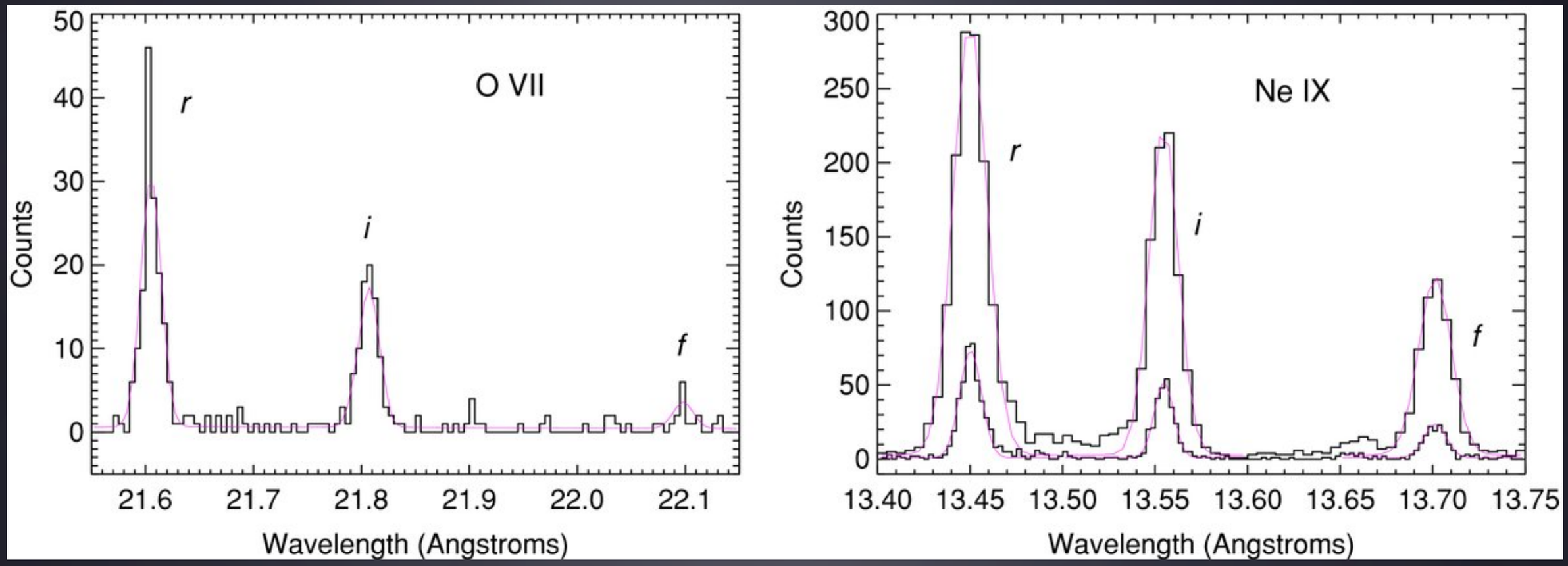


(XMM-RGS)

Interstellar Medium Studies

Science

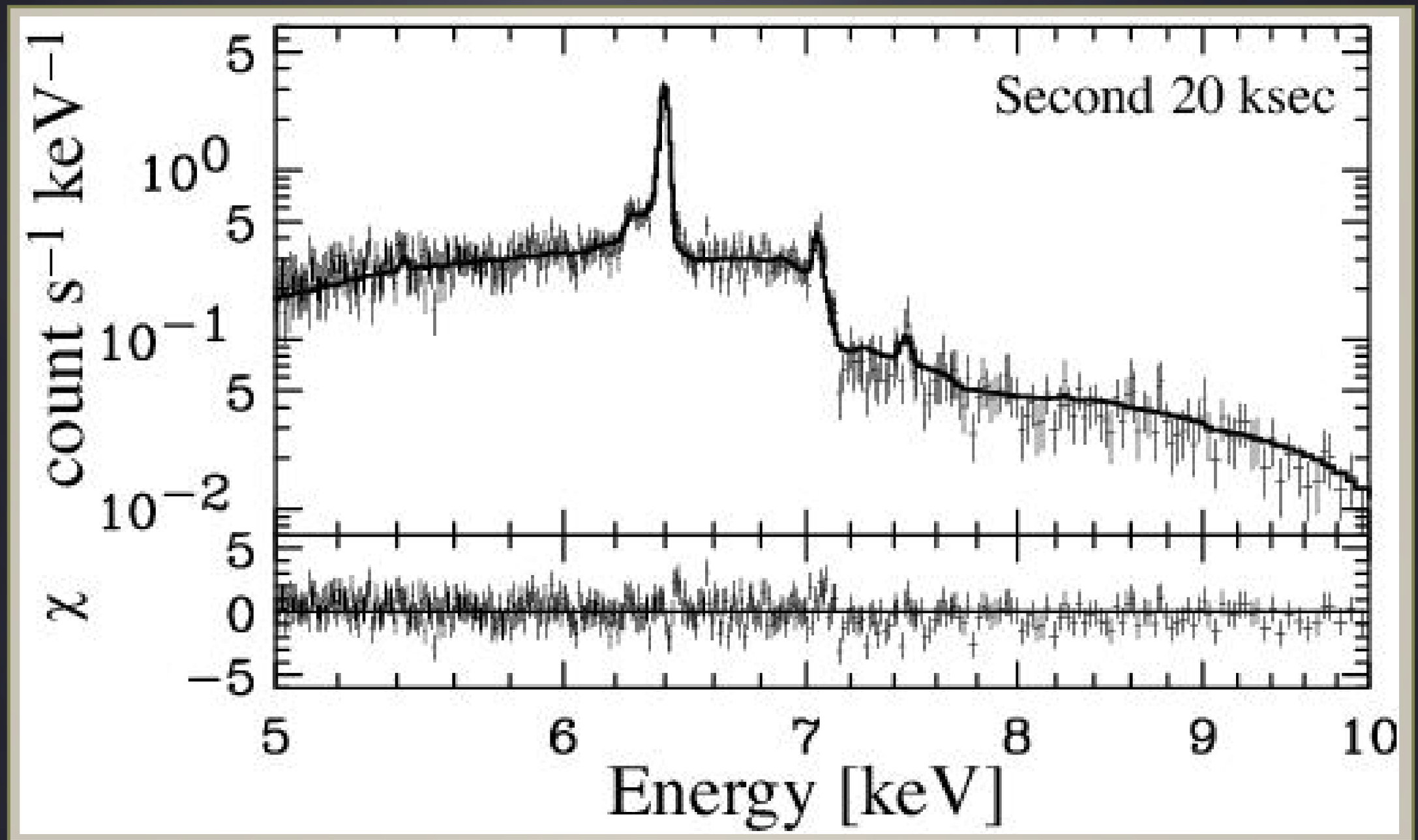
TW Hya



(Brickhouse et al. 2010)

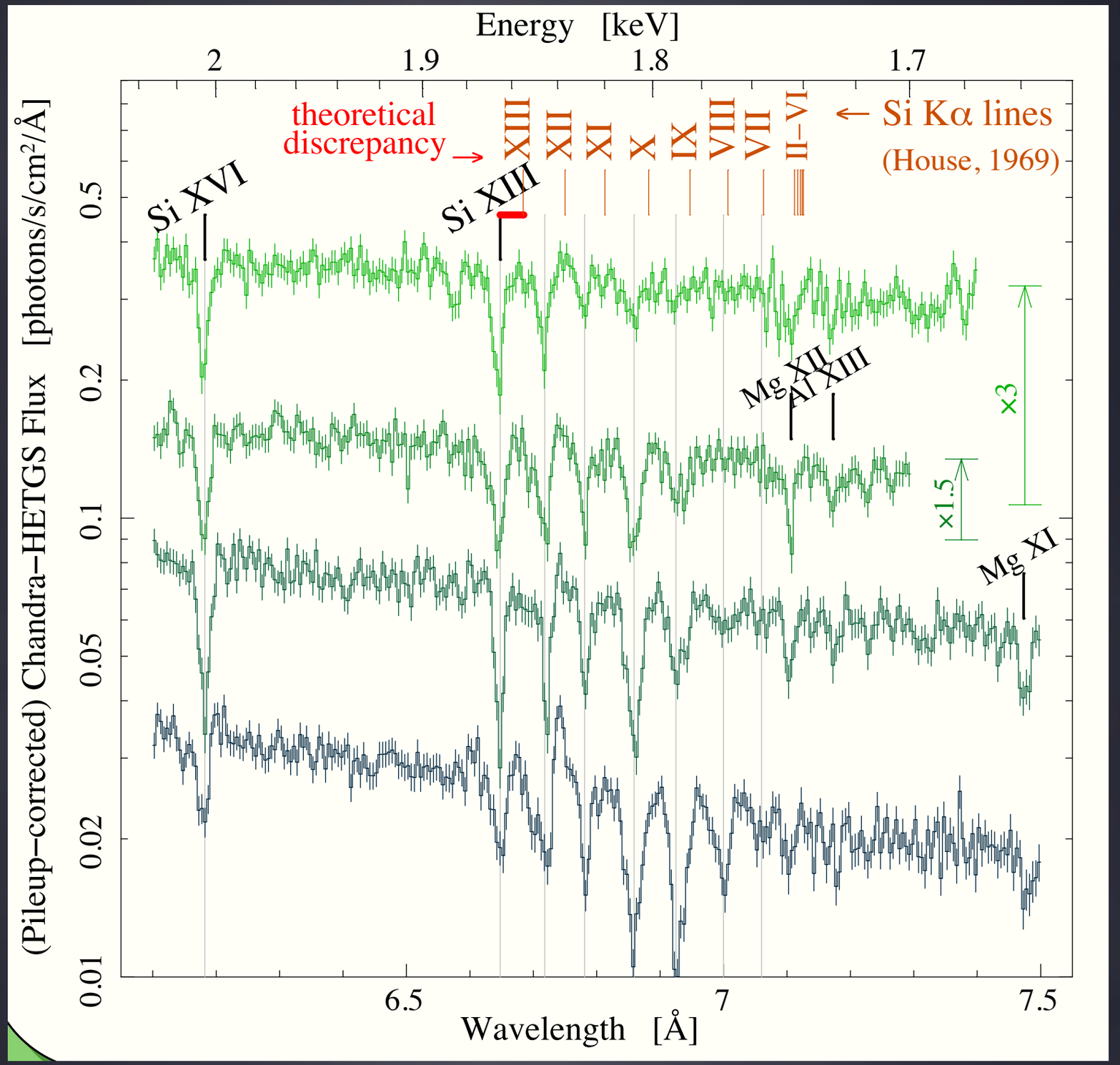
Science

GX 301-2



(Watanabe et al. 2004)

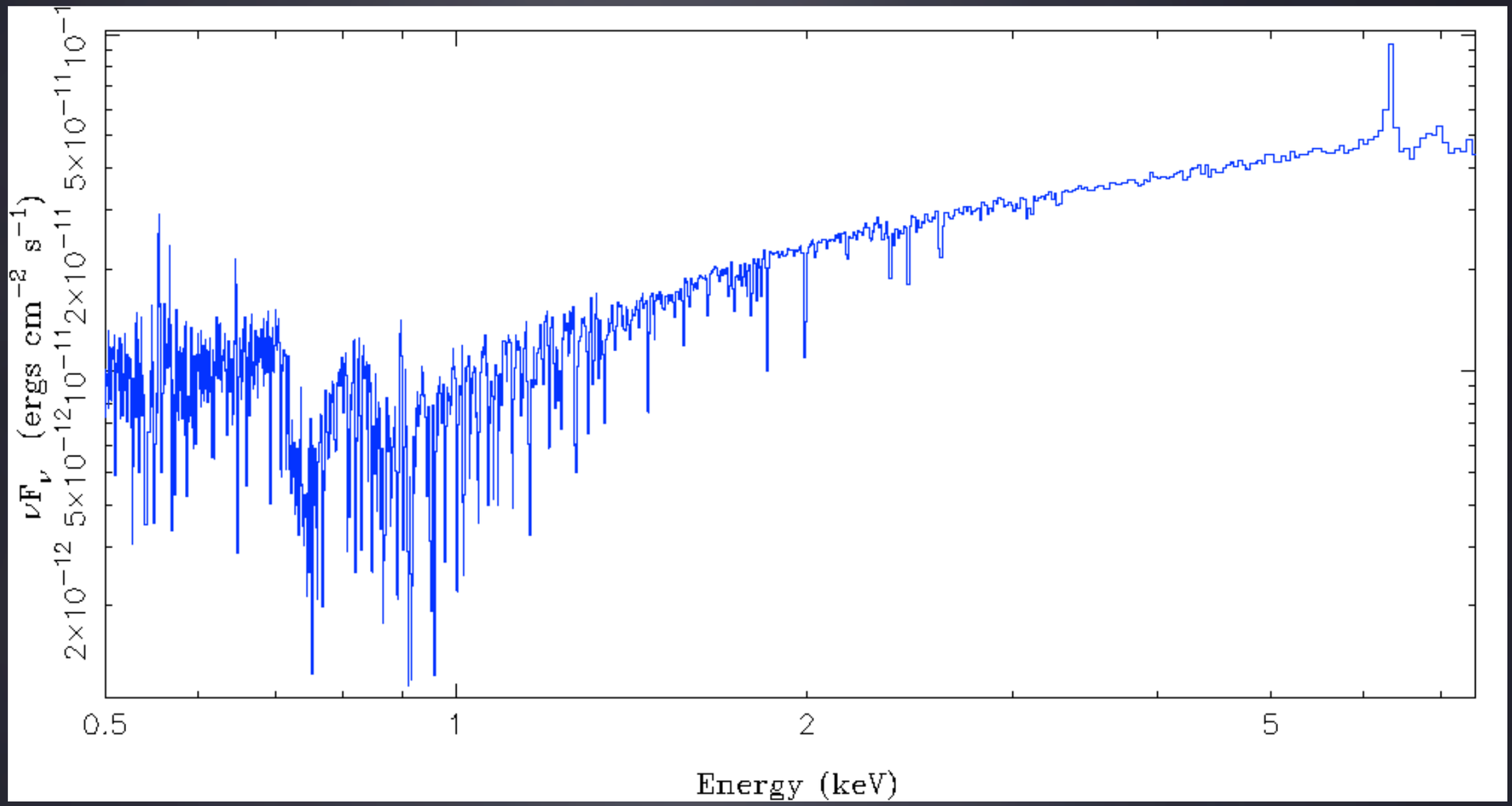
Science



Stellar Winds (Cyg X-1 HMXB Wind)

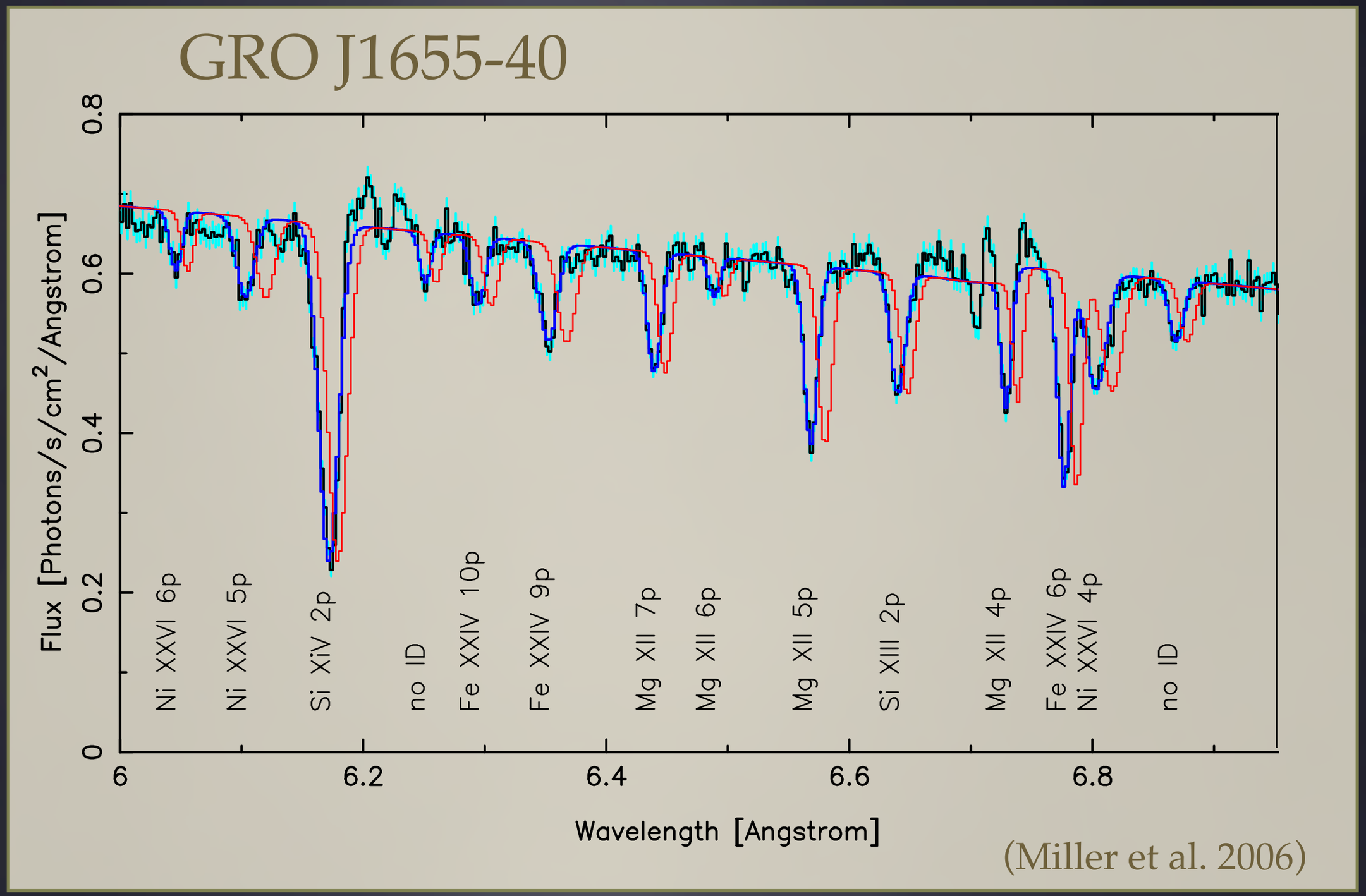
Science

NGC 3783 from the TGCat Catalog



AGN Warm Absorbers

Science



Magnetized Accretion Disk Winds