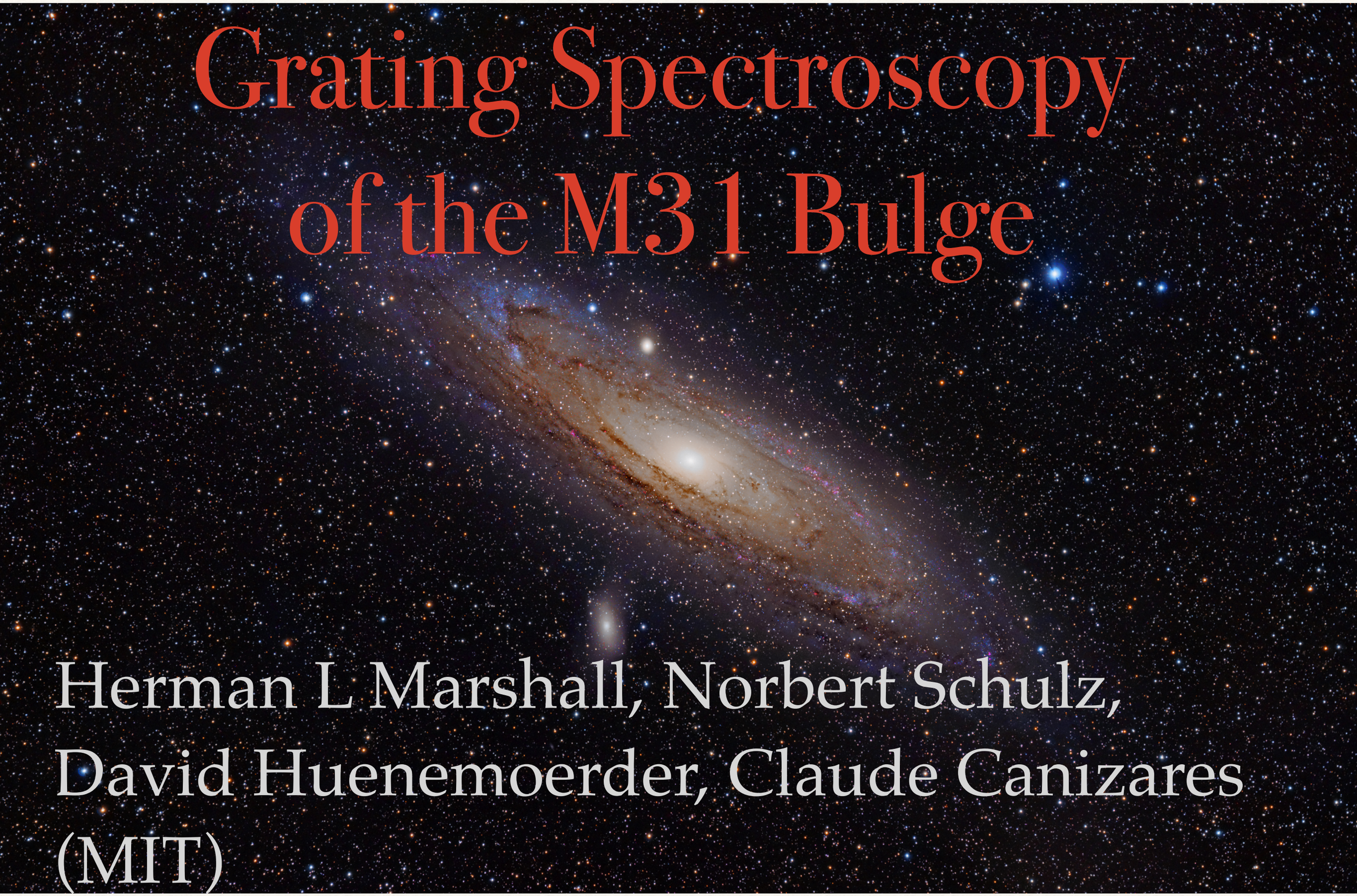
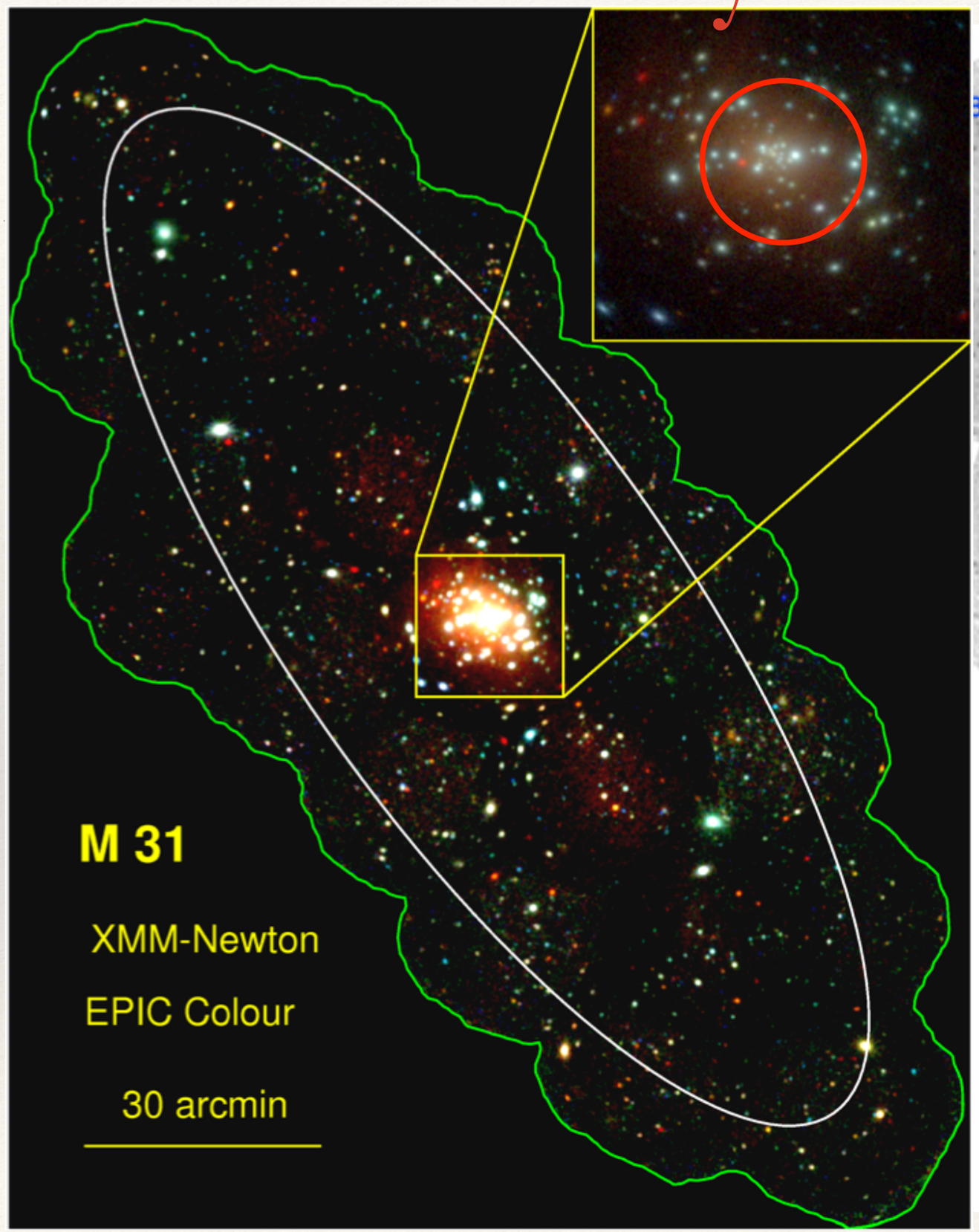
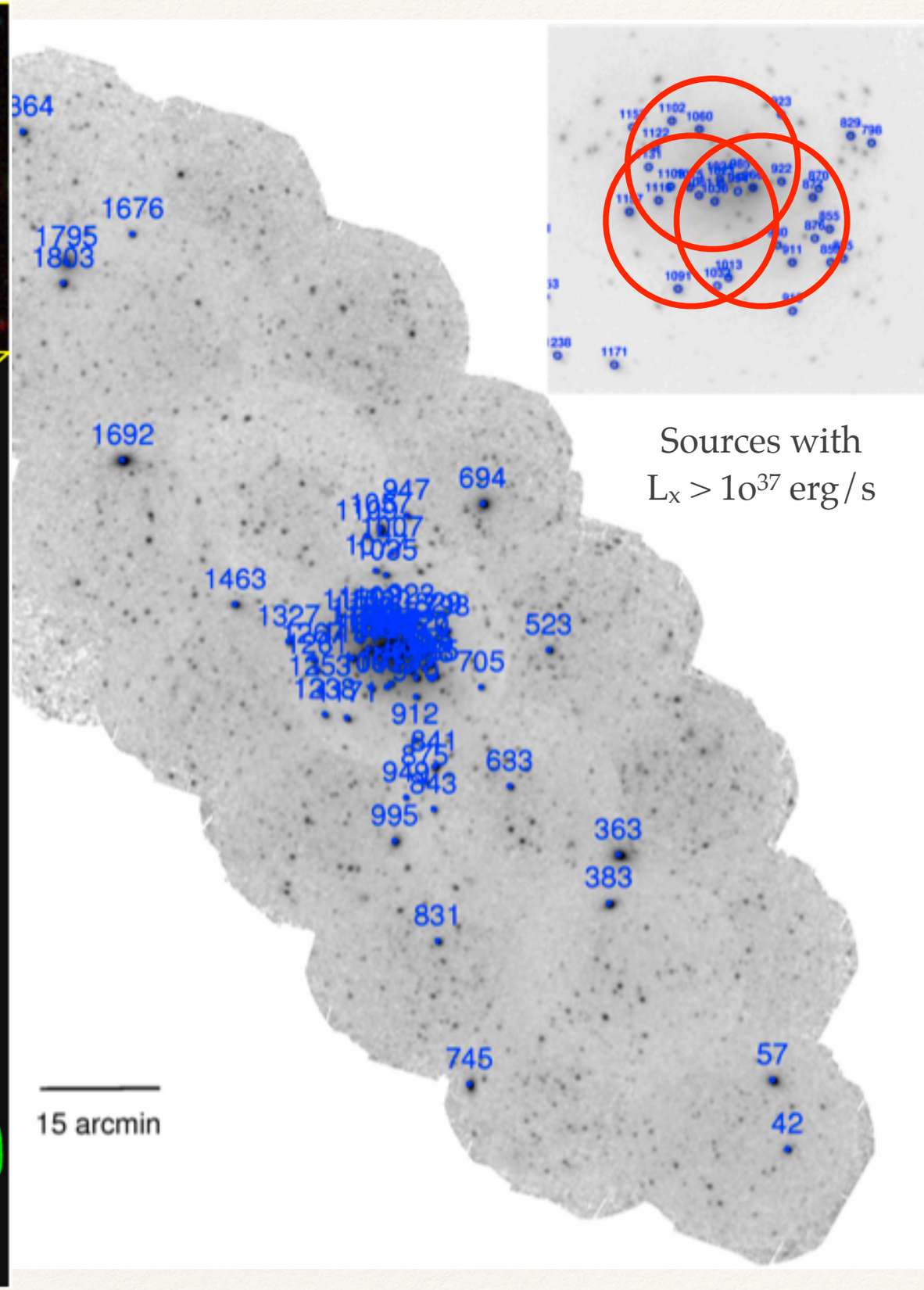
Grating Spectroscopy of the M31 Bulge



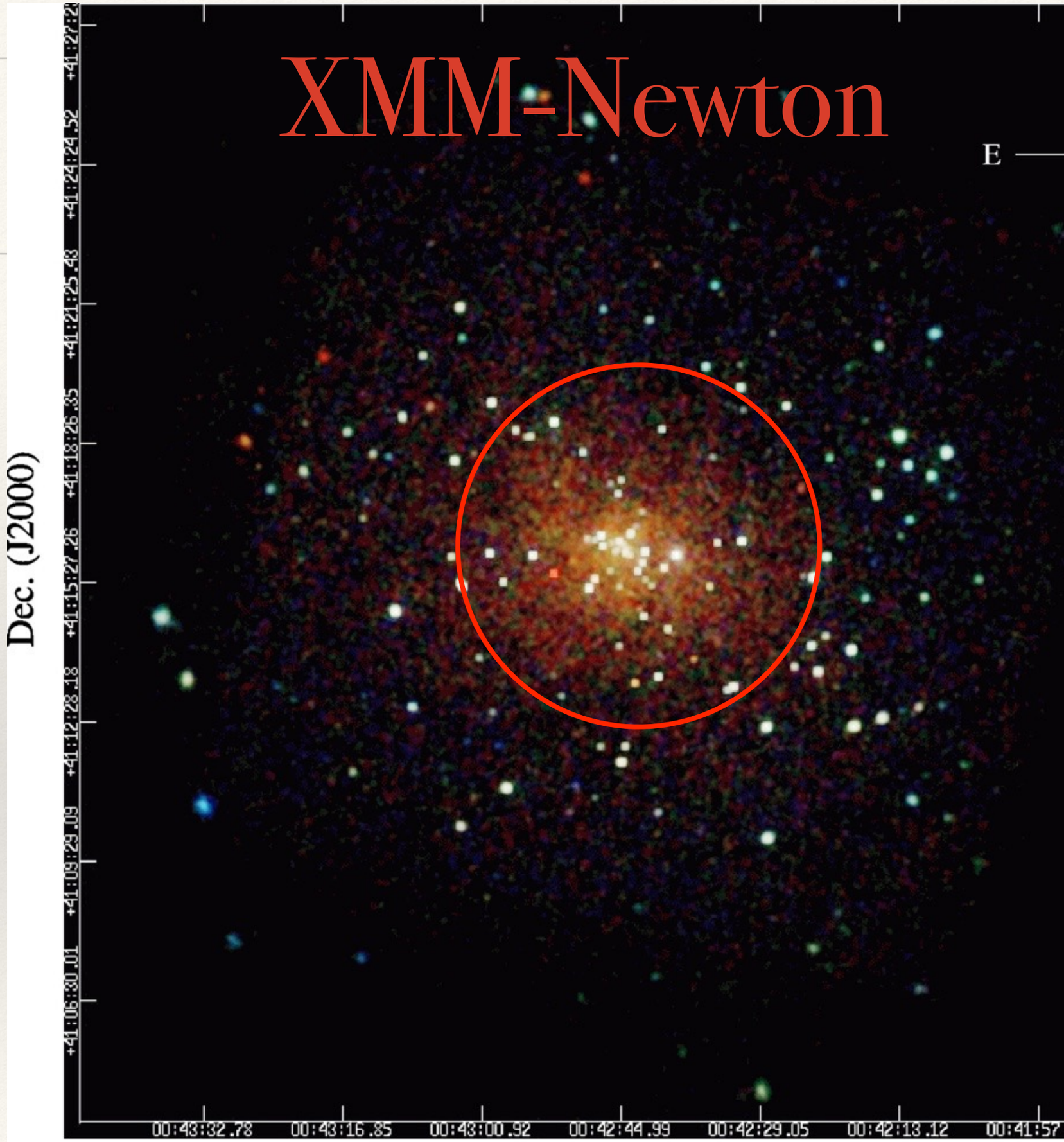
Herman L Marshall, Norbert Schulz, David Huenemoerder, Claude Canizares (MIT)

An X-ray View of M 31

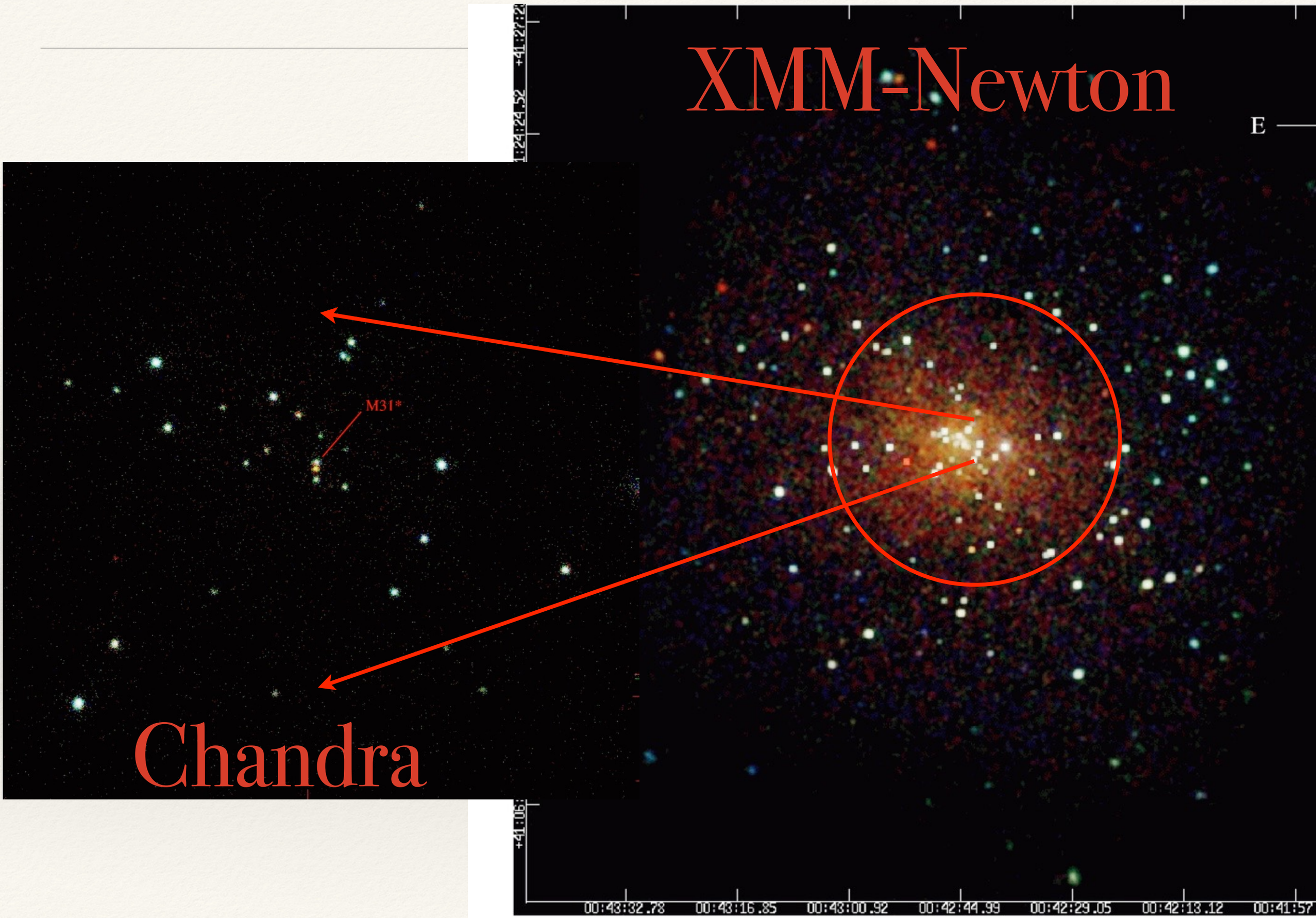




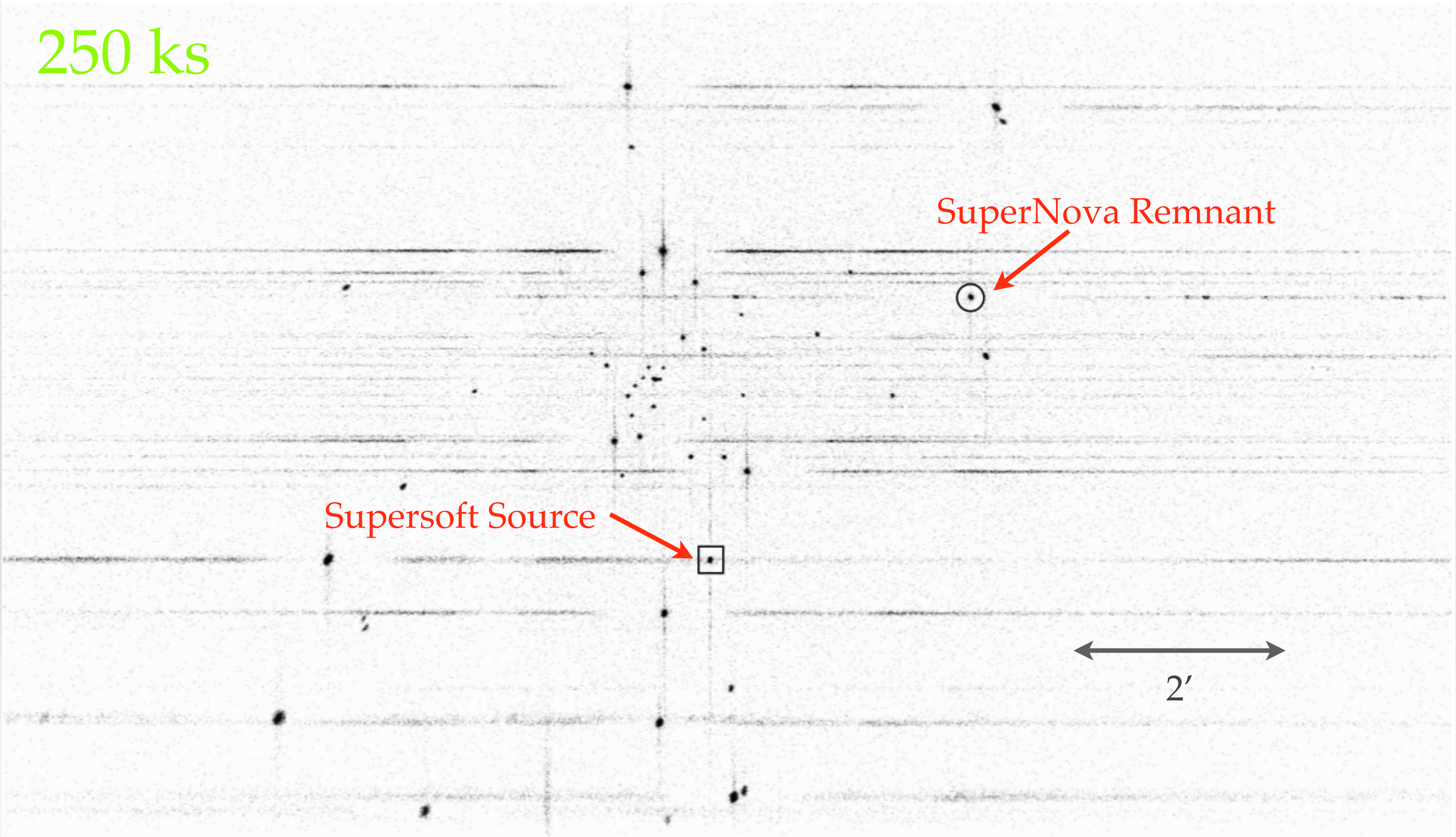
Sources with
$L_x > 10^{37}$ erg/s



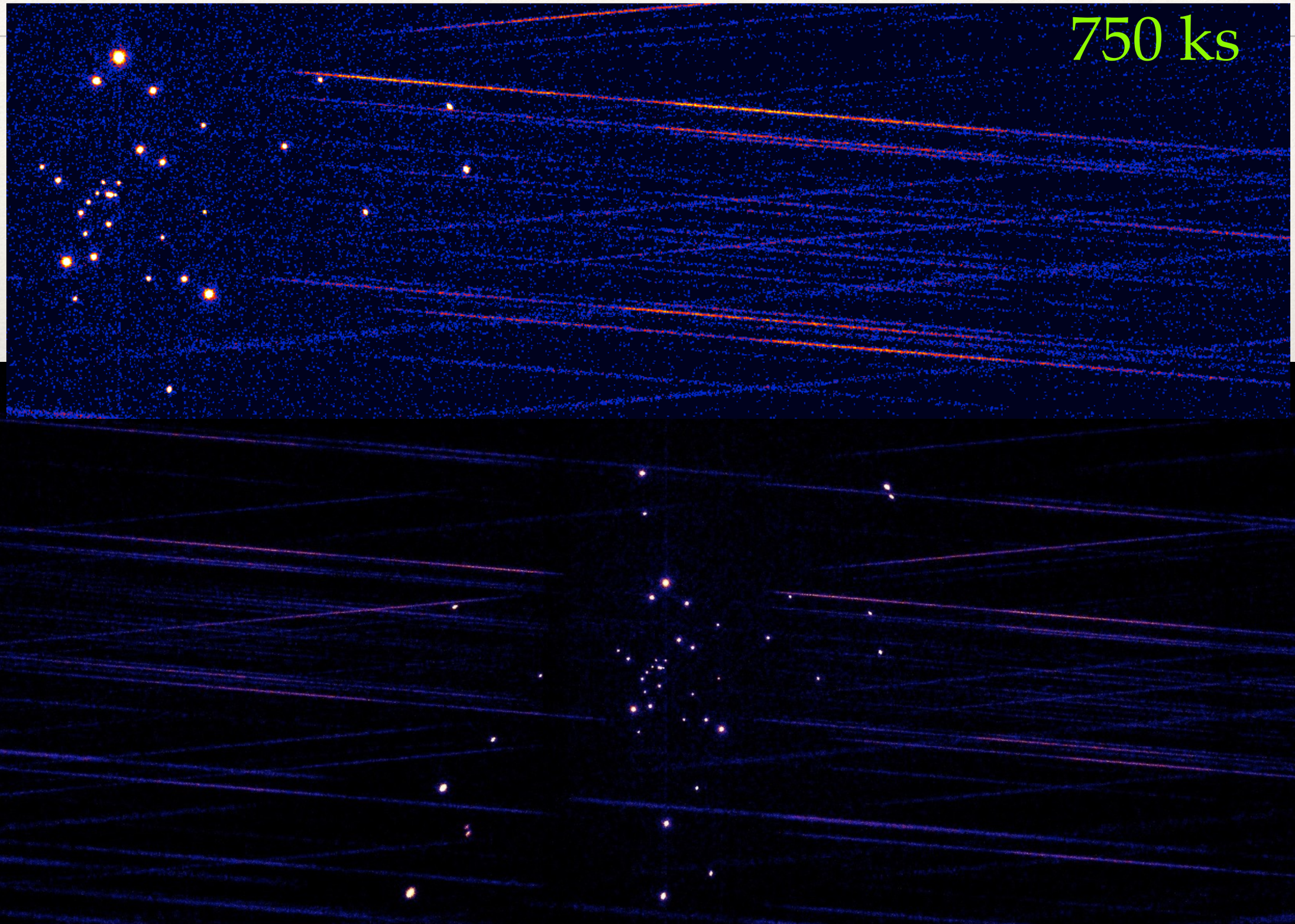
H.L. Marshall — M 31 HETGS


XMM-Newton
E
M31*
Chandra
00:43:32.78
00:43:16.85
00:43:00.92
00:42:44.99
00:42:29.05
00:42:13.12
00:41:57
R.A. (J2000)

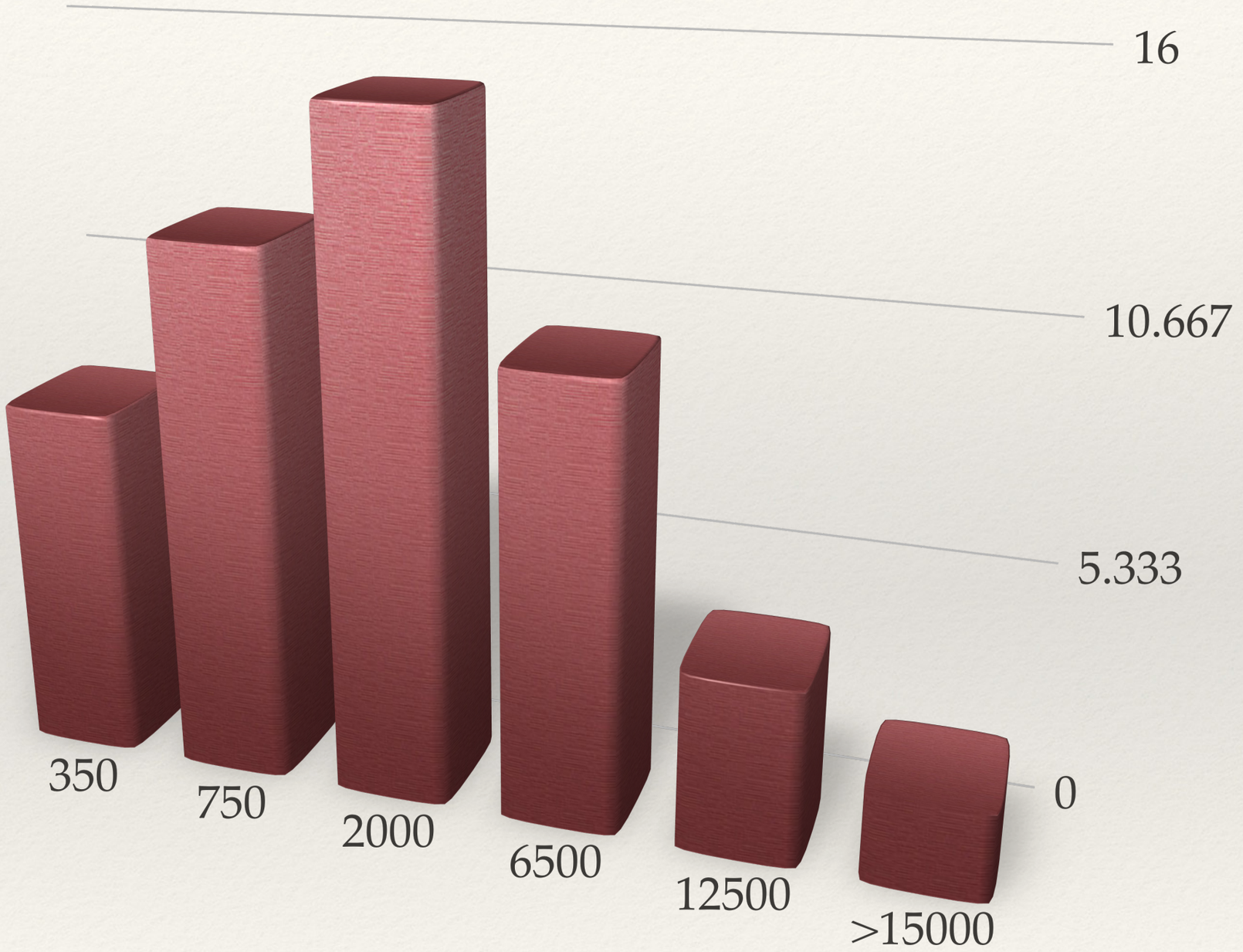
LETG/ACIS Simulation



HETGS Simulation

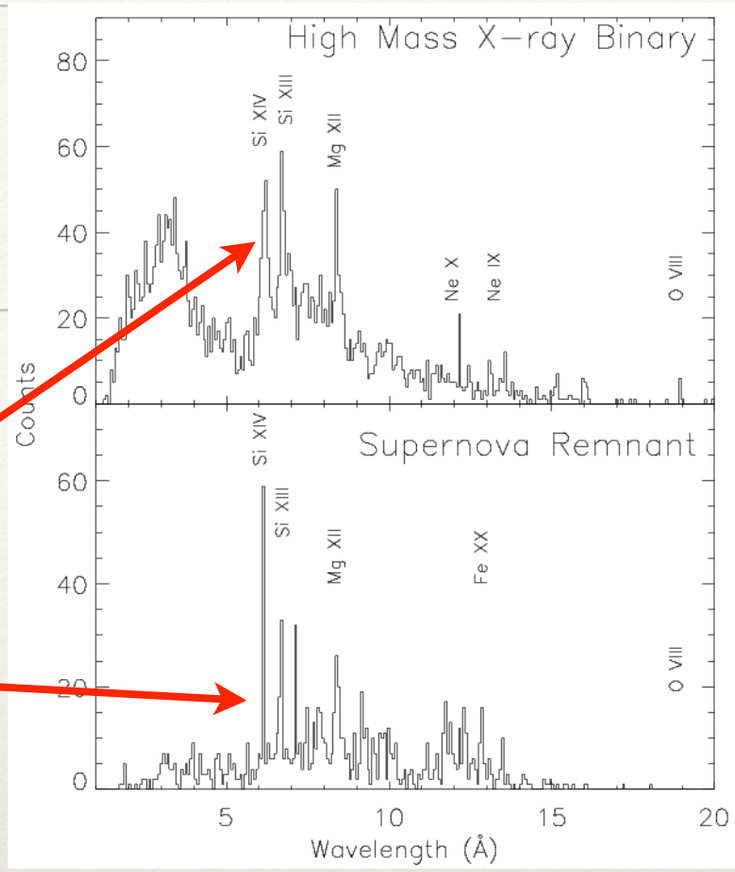


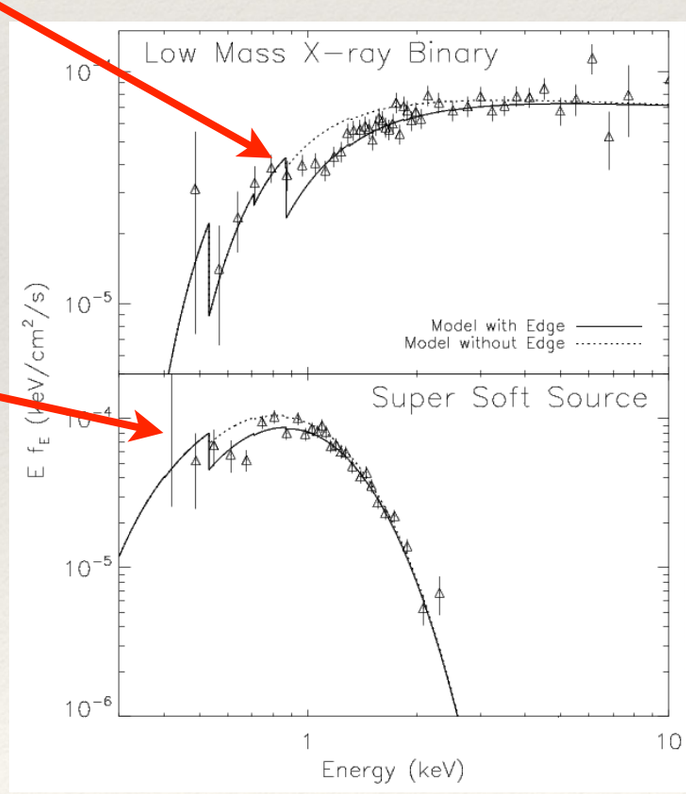
Expected HETGS Counts



Science Goals

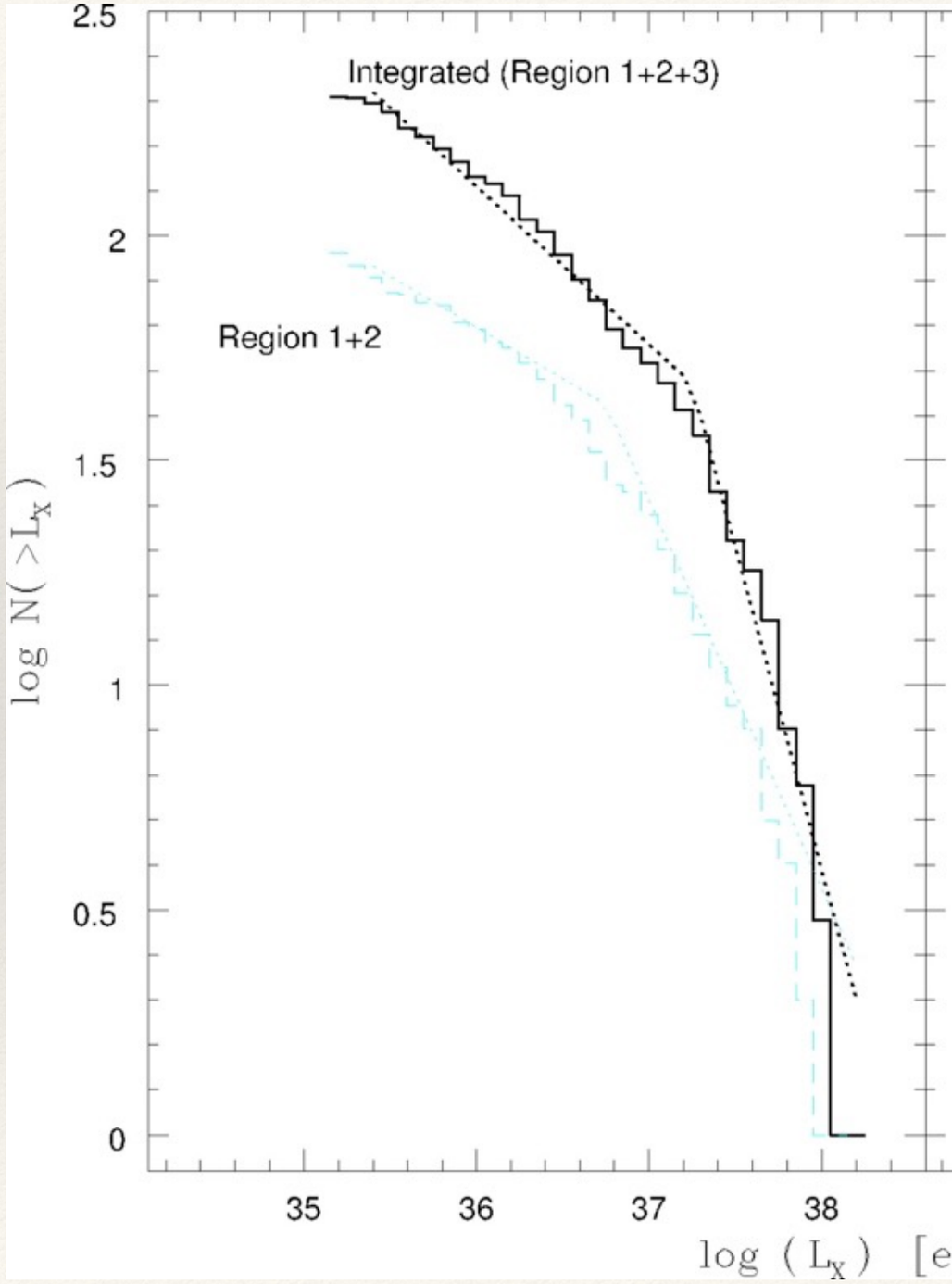
- Emission Lines from HMXRB winds
- Emission Lines in SNR
- ISM Edges in LMXRB
- Abundances in LMXRBs
- SuperSoft Sources
- 1000s of X-ray bursts
- Oddities: SS 433, Cir X-1



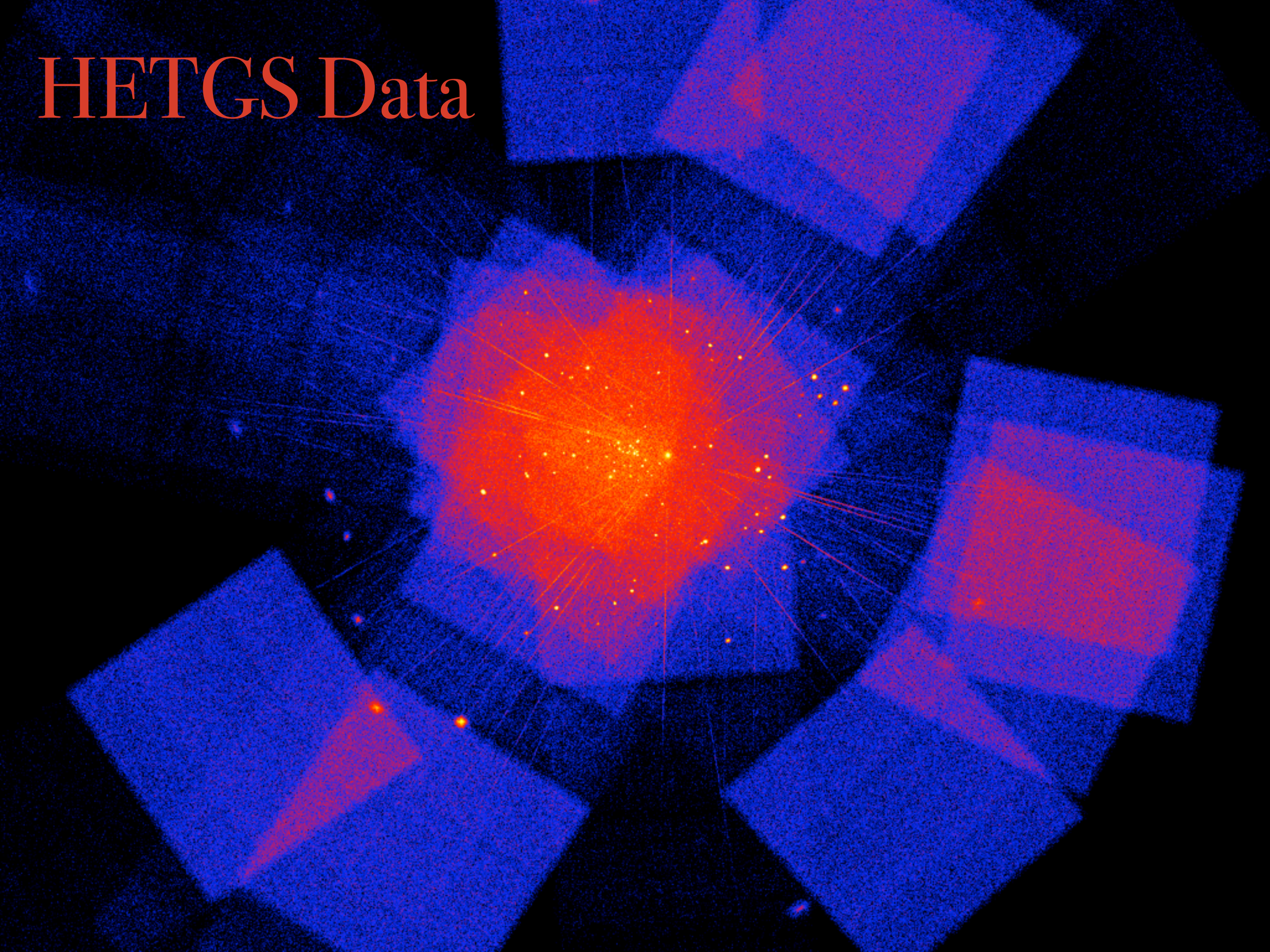


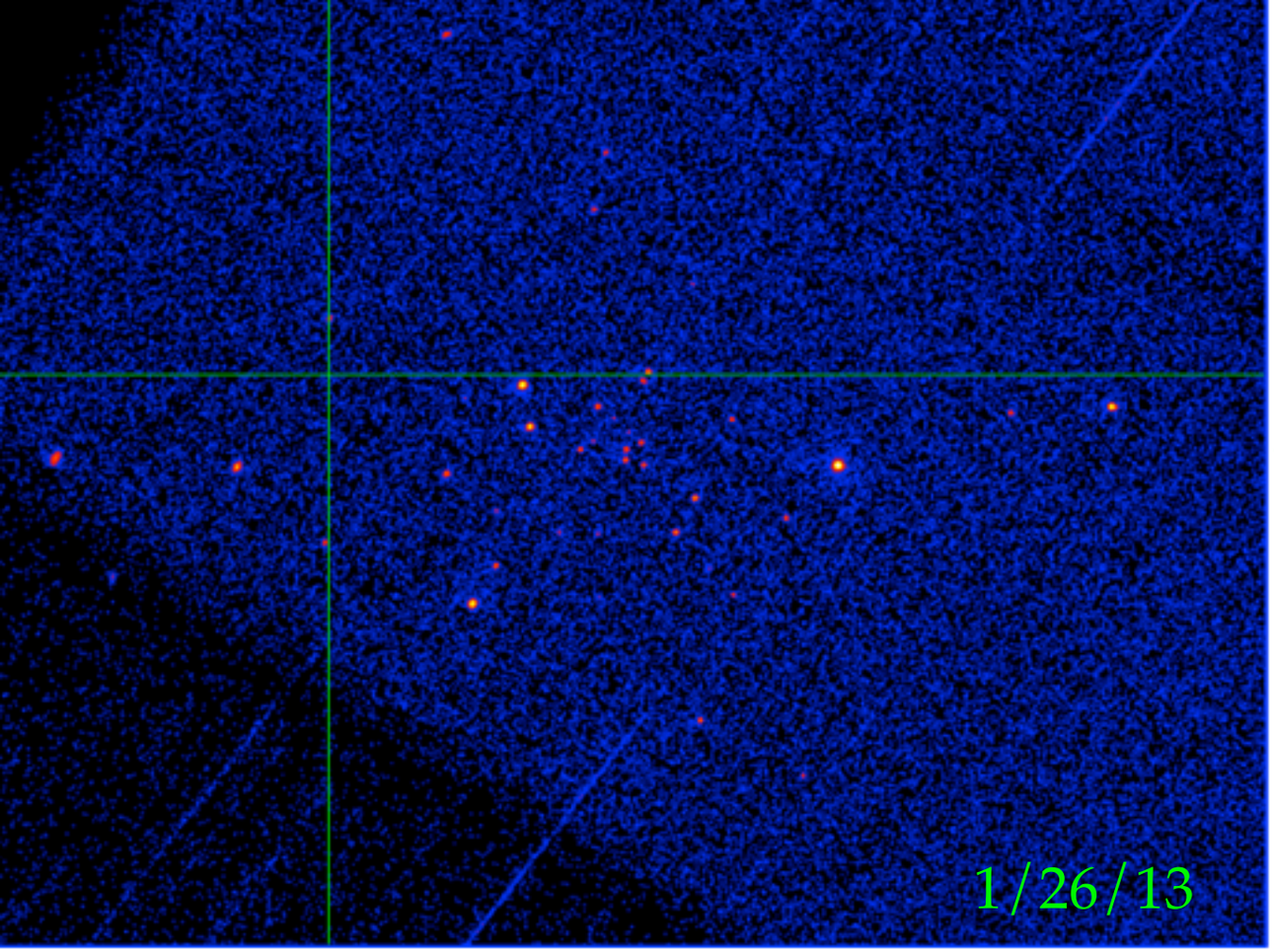
Luminosity Functions

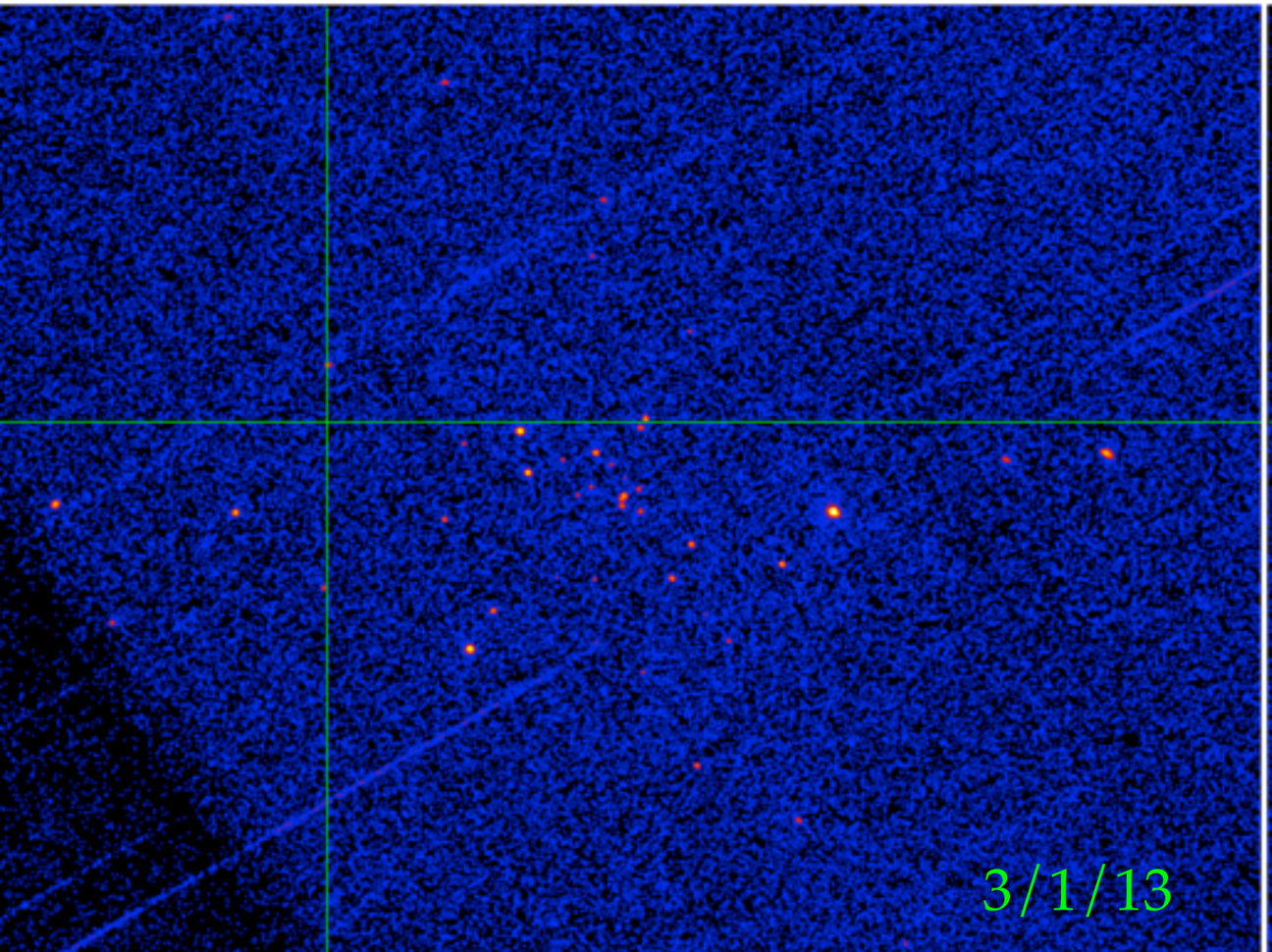
- Inner Bulge (region 1): 2′ x 2′
- Full bulge (Region 2): 8′ x 8′
- Bulge LF break: 5 x 10^{36} erg/s
- HETGS: 2000 counts per 10^{37} erg/s in 700 ks
- Brightest SNR at 6 x 10^{36} erg/s
- >20,000 count for NS with L = L_{edd}

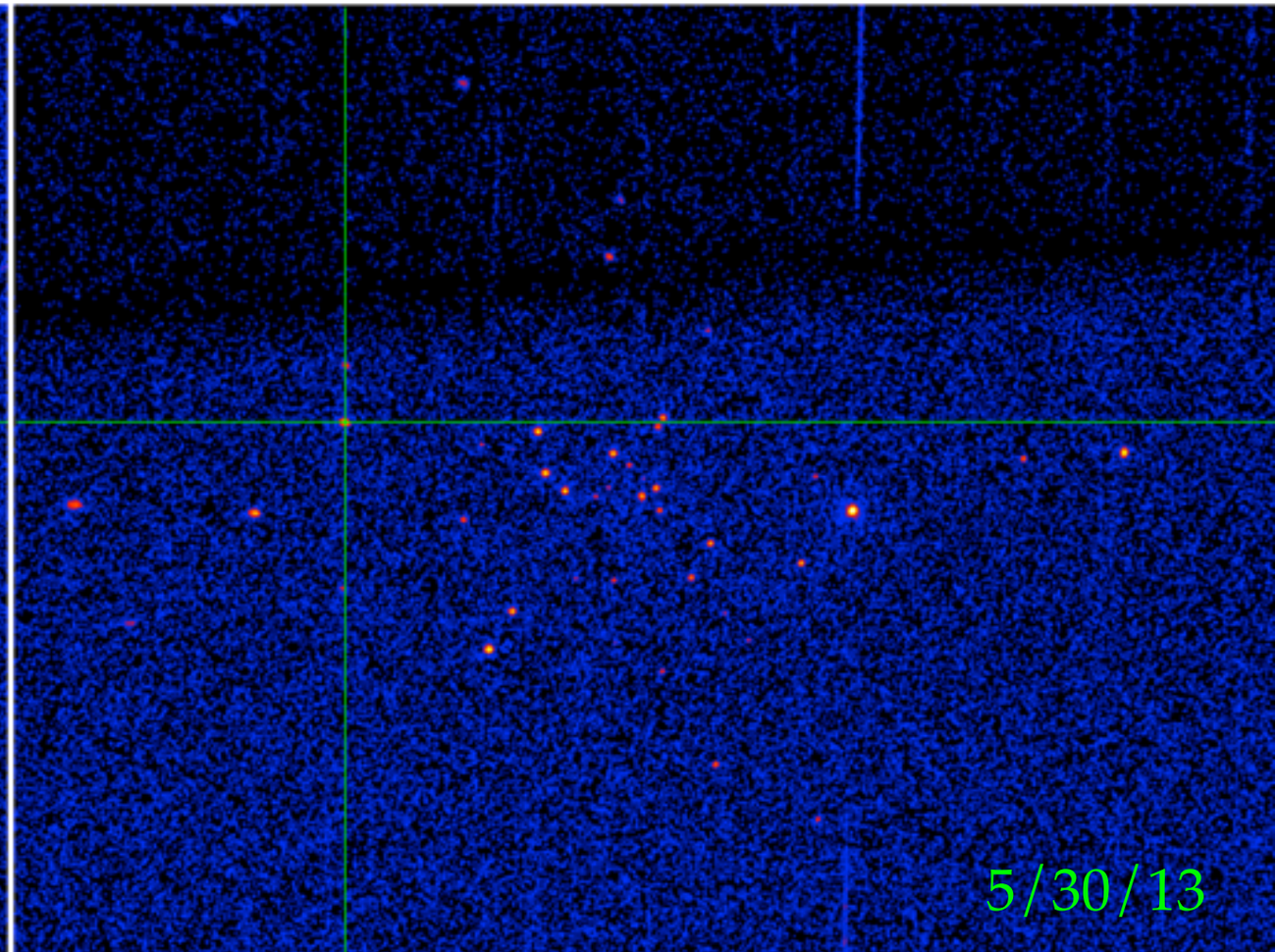


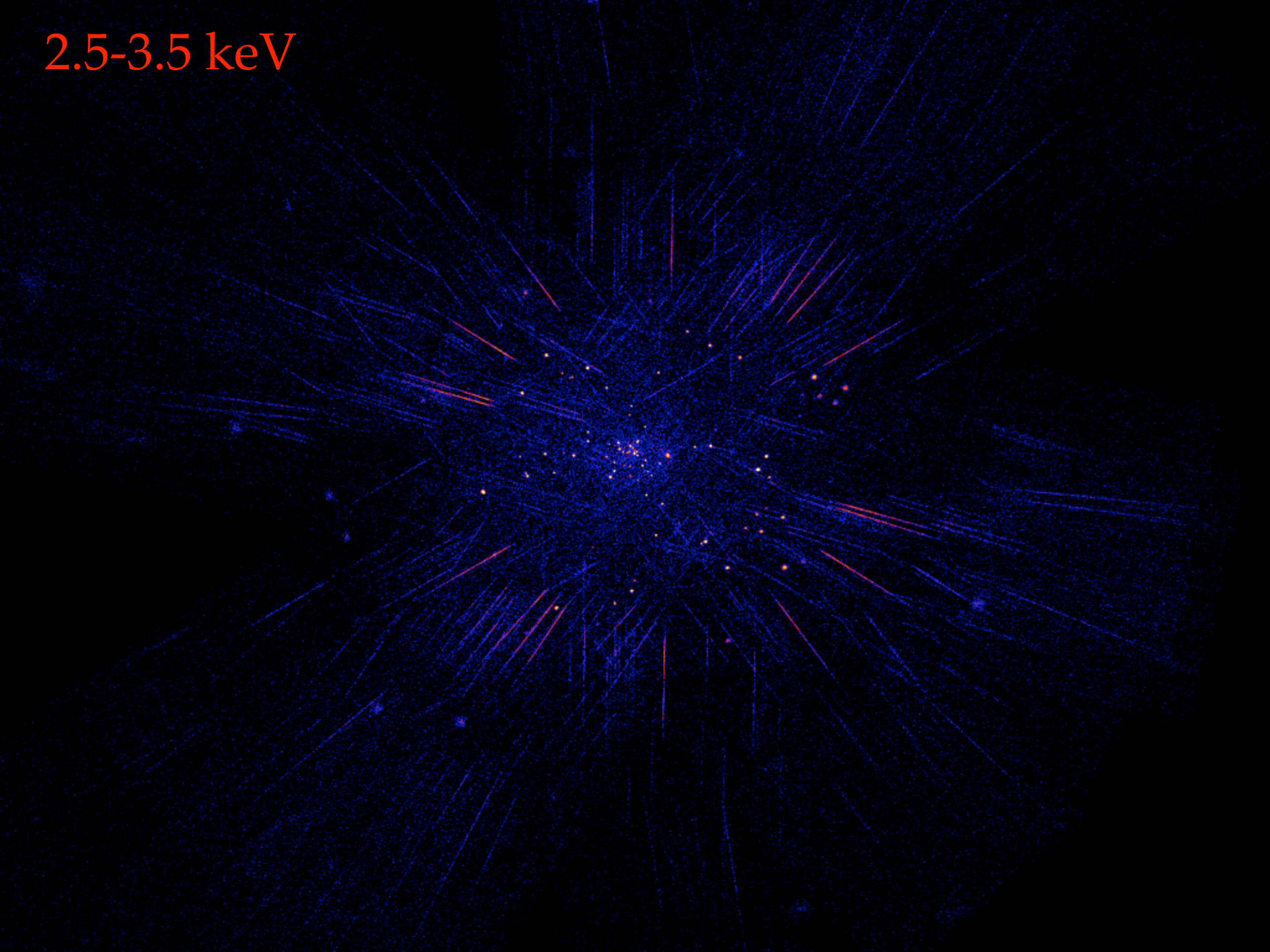
HETGS Data



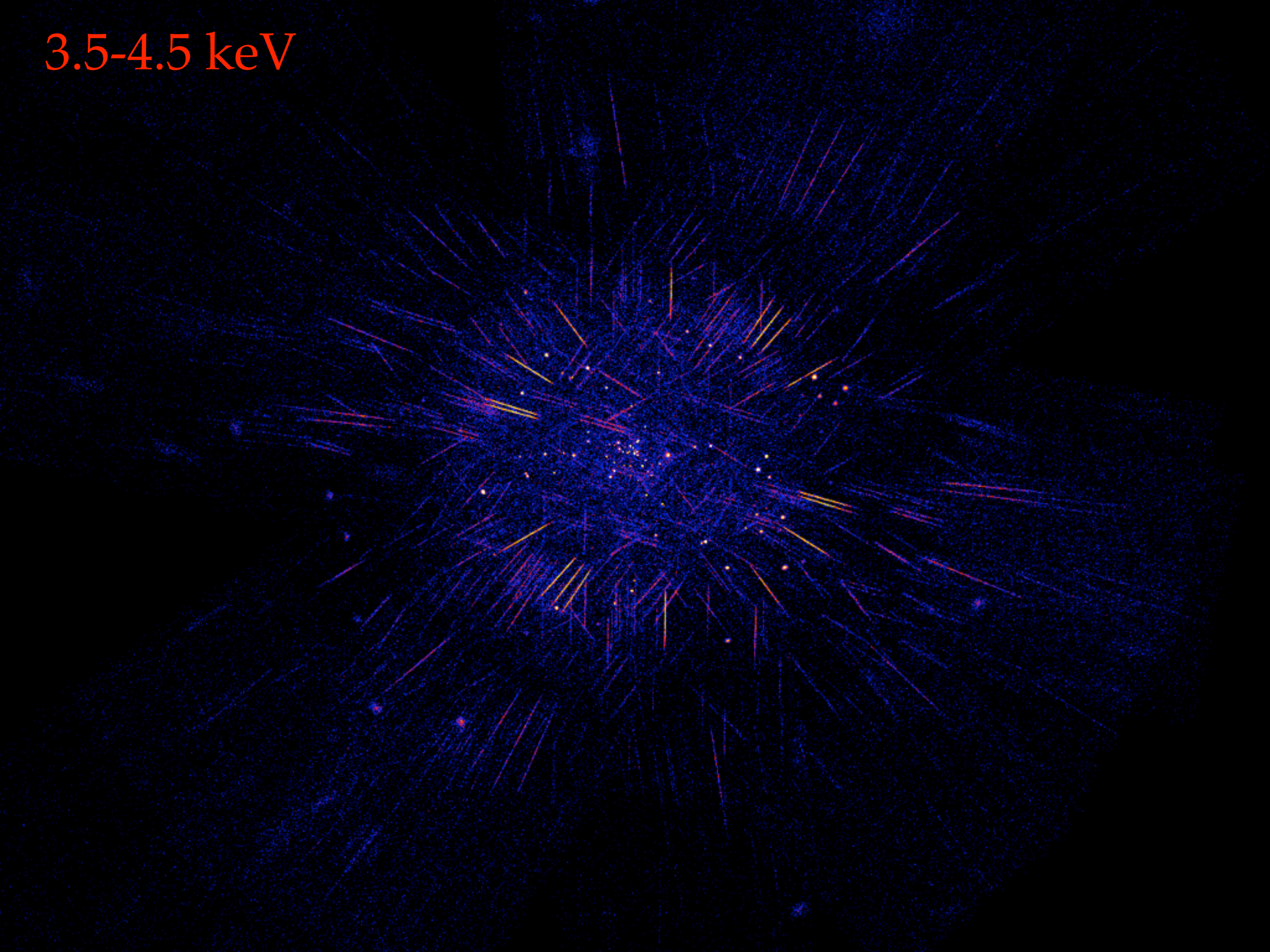

1/26/13


3/1/13


5/30/13

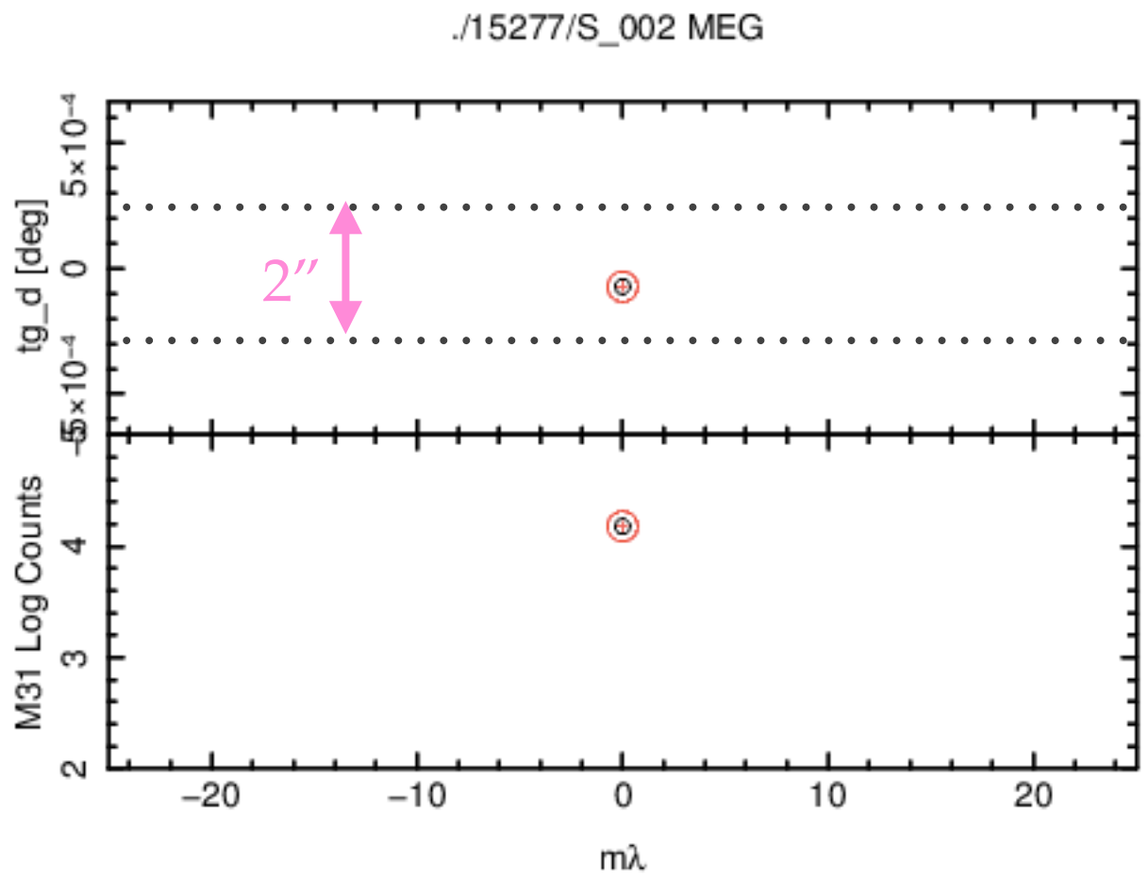

2.5-3.5 keV

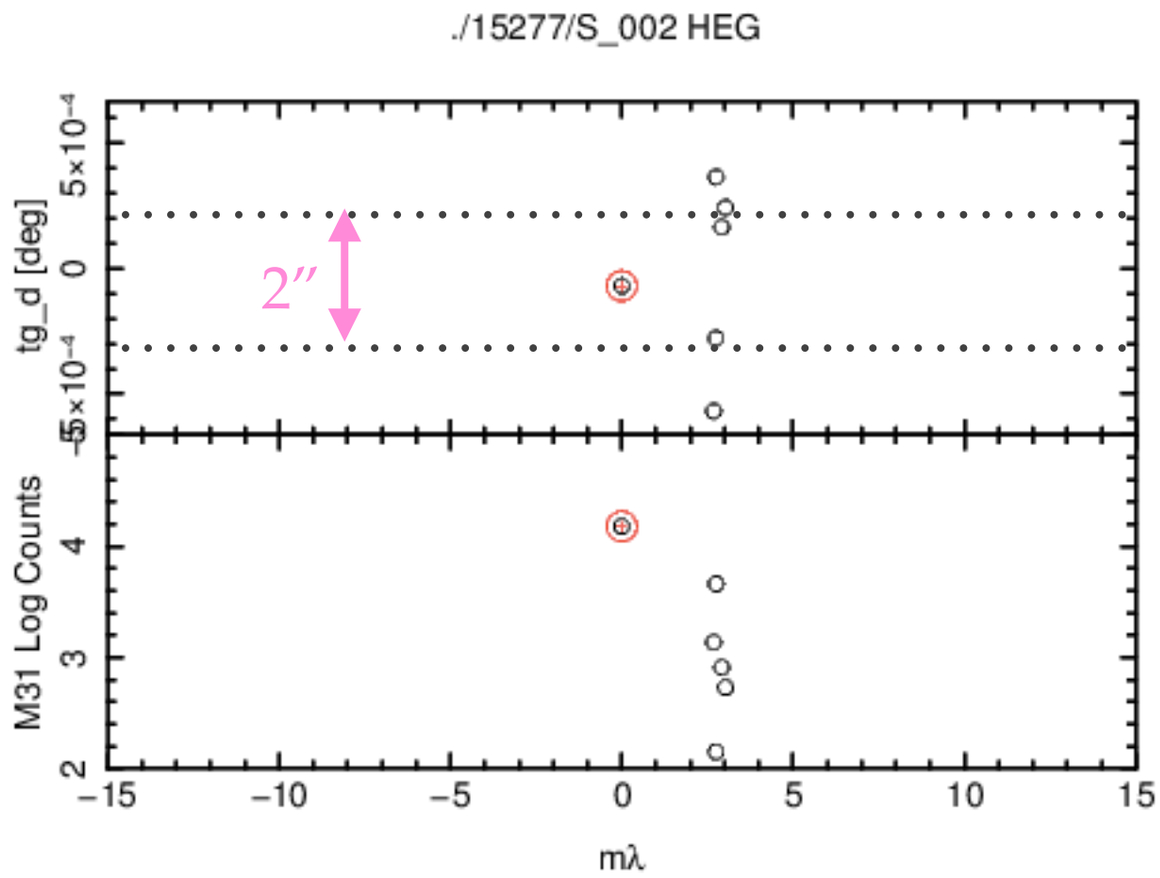
3.5-4.5 keV

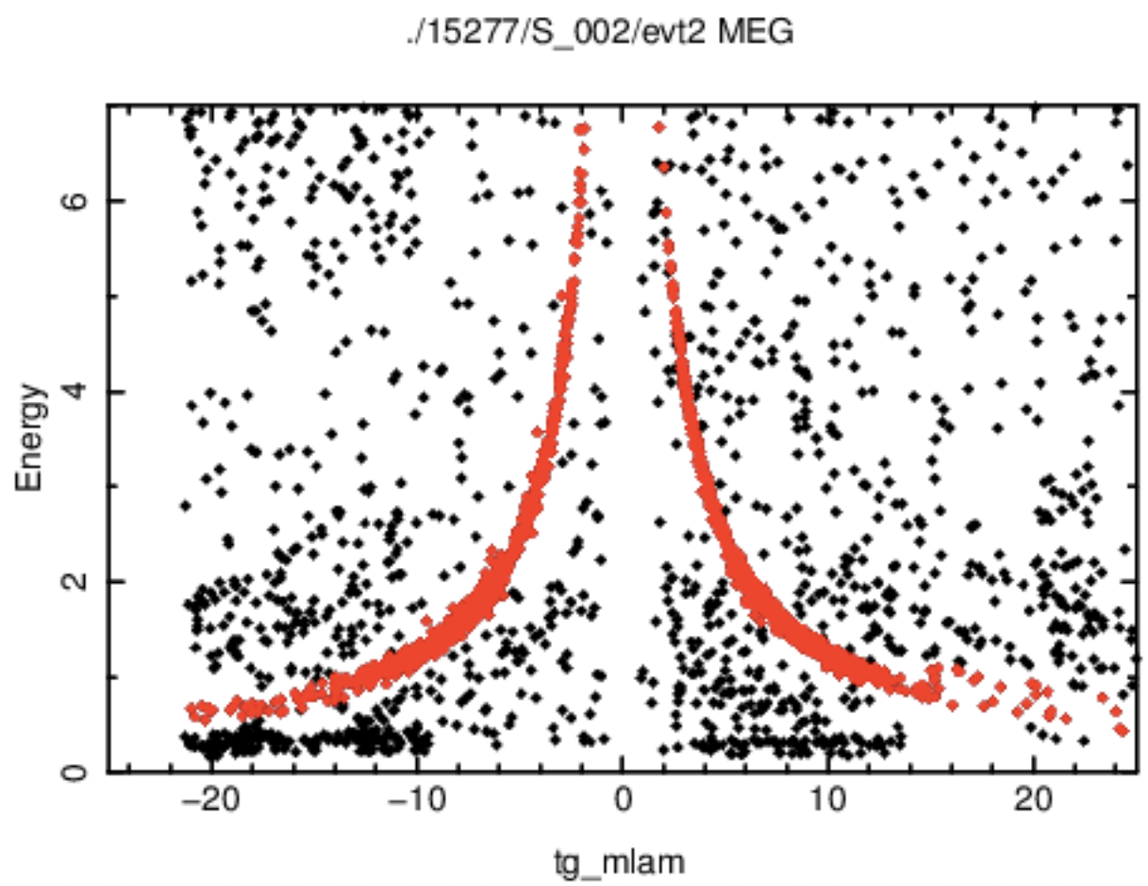


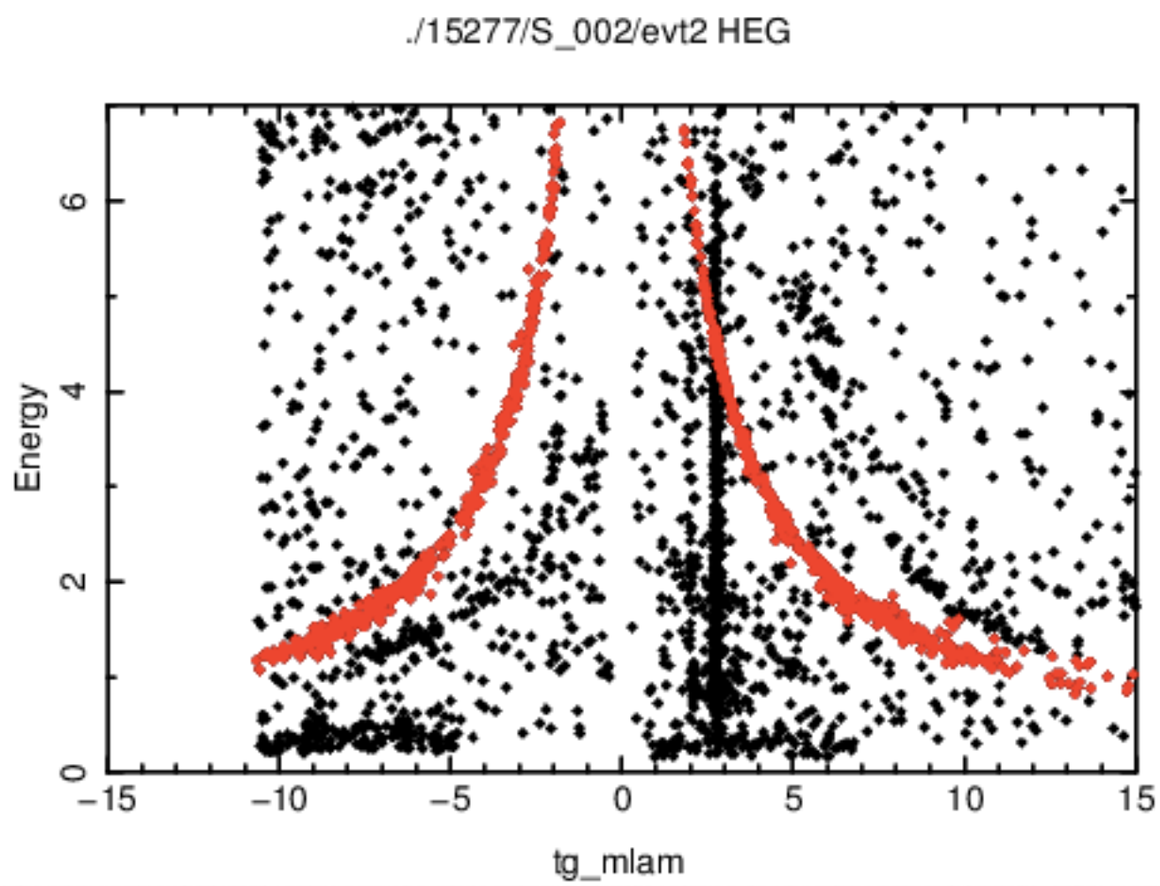
Extracting Spectra

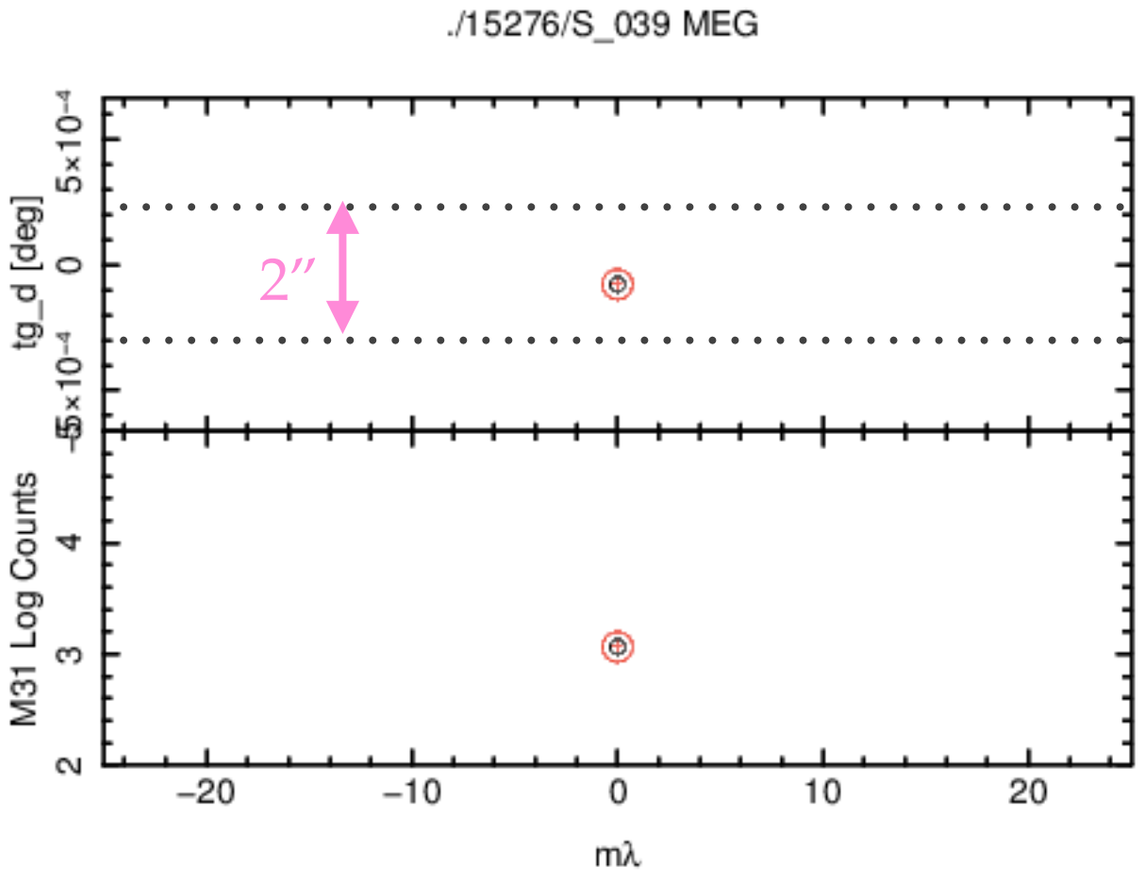
- Easy Part: PHA2, ARF, RMF for 9 obsIDs, 105 sources, 4 arms (HeG, MEG, +1, -1) = ~3800 spectra
- Hard Part: overlapping spectra of A against B
  - Biggest issue: 0th order of A overlaps TG of B
    - See “confusion plots”
    - make “ignore(obsid/<M,H>EG/<+/->1, E1, E2)”
  - MEG rarely overlaps with MEG (parallel!)
- HETGS GTO team is prototyping data handling

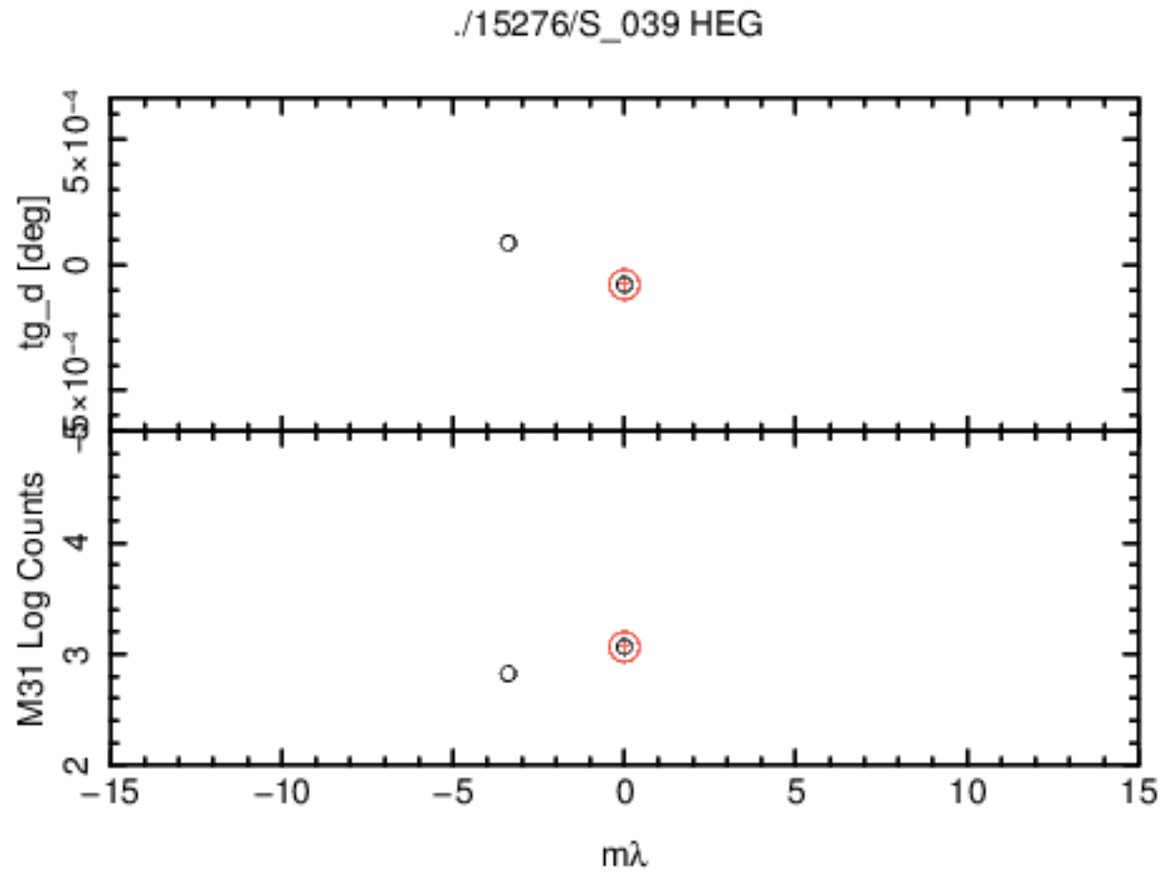

./15277/S_002 MEG
tg_d [deg]
5×10⁻⁴
0
−5×10⁻⁴
2″
M31 Log Counts
4
3
2
−20
−10
0
10
20
mλ

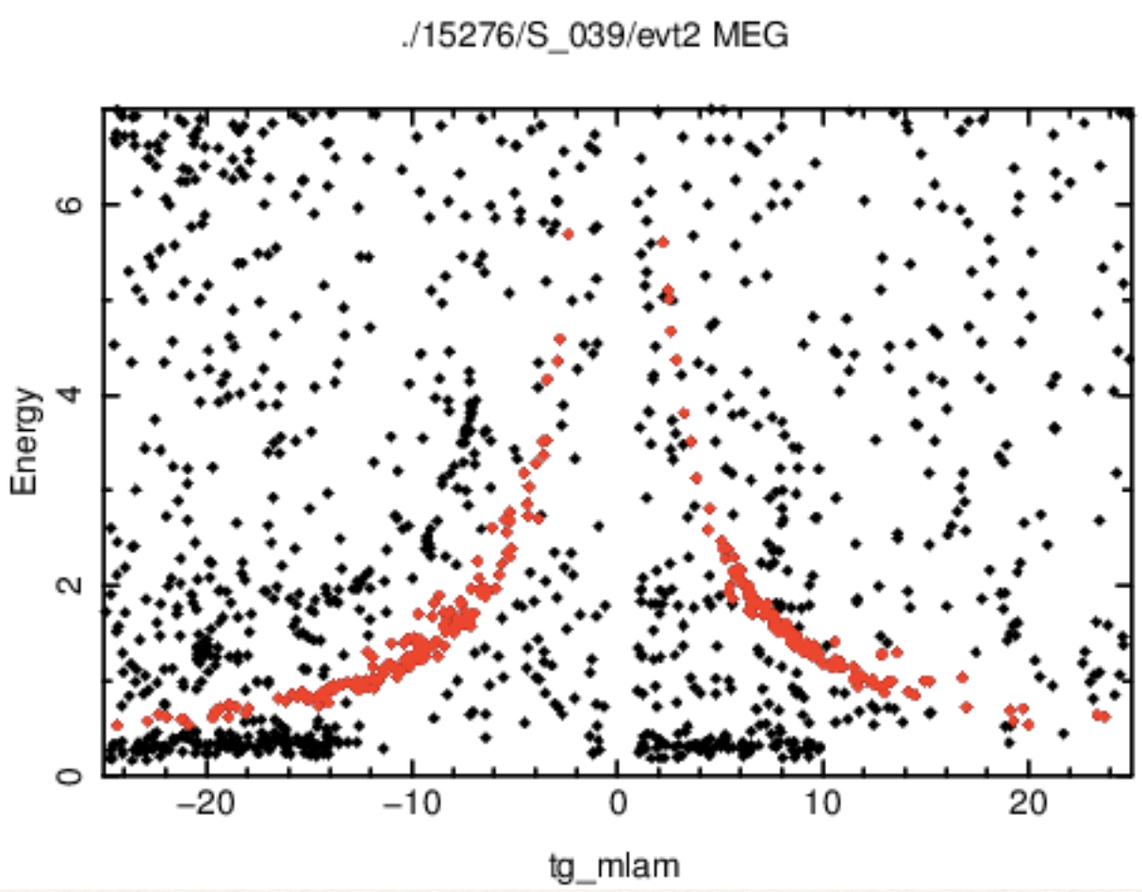

./15277/S_002 HEG
tg_d [deg]
5×10⁻⁴
0
−5×10⁻⁴
2″
M31 Log Counts
4
3
2
−15
−10
−5
0
5
10
15
mλ

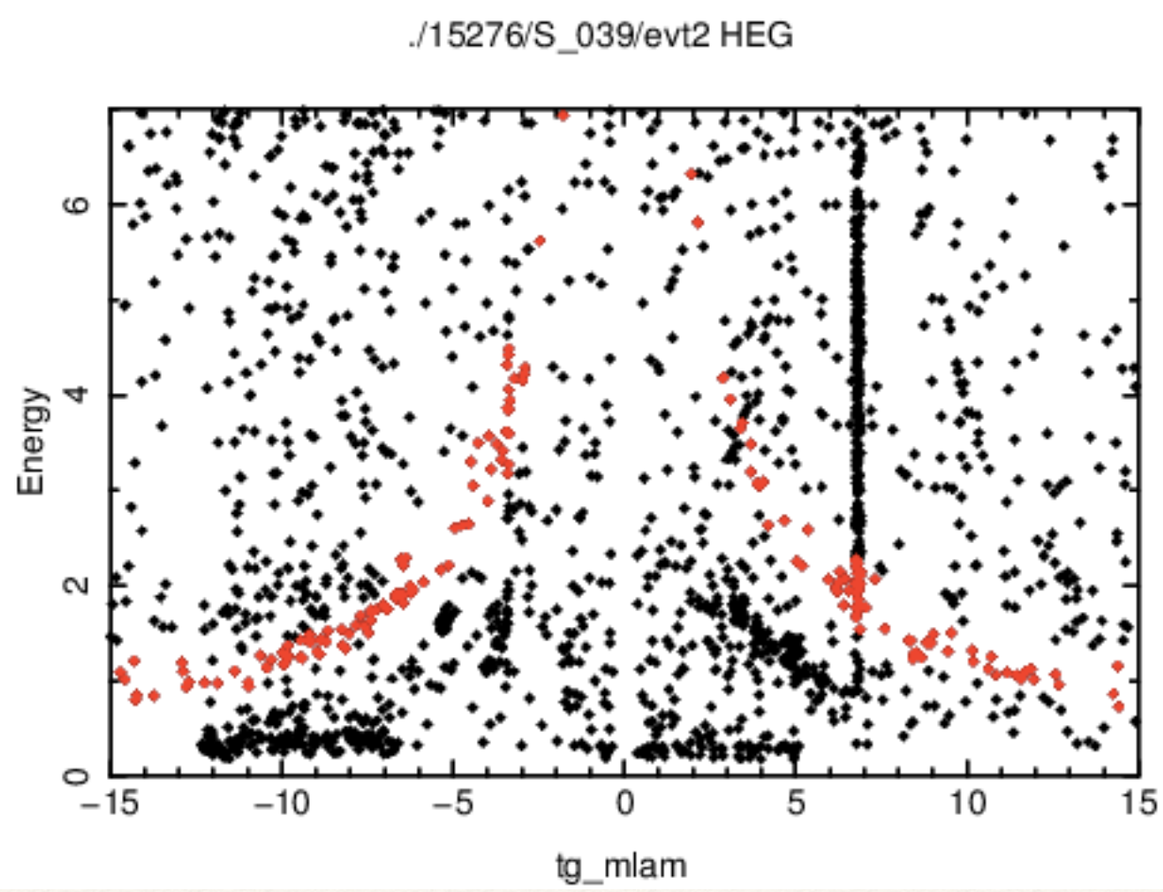

./15277/S_002/evt2 MEG
Energy
6
4
2
0
−20
−10
0
10
20
tg_mlam


./15277/S_002/evt2 HEG
Energy
6
4
2
0
−15
−10
−5
0
5
10
15
tg_mlam


./15276/S_039 MEG
tg_d [deg]
5×10⁻⁴
0
−5×10⁻⁴
2″
M31 Log Counts
4
3
2
−20
−10
0
10
20
mλ

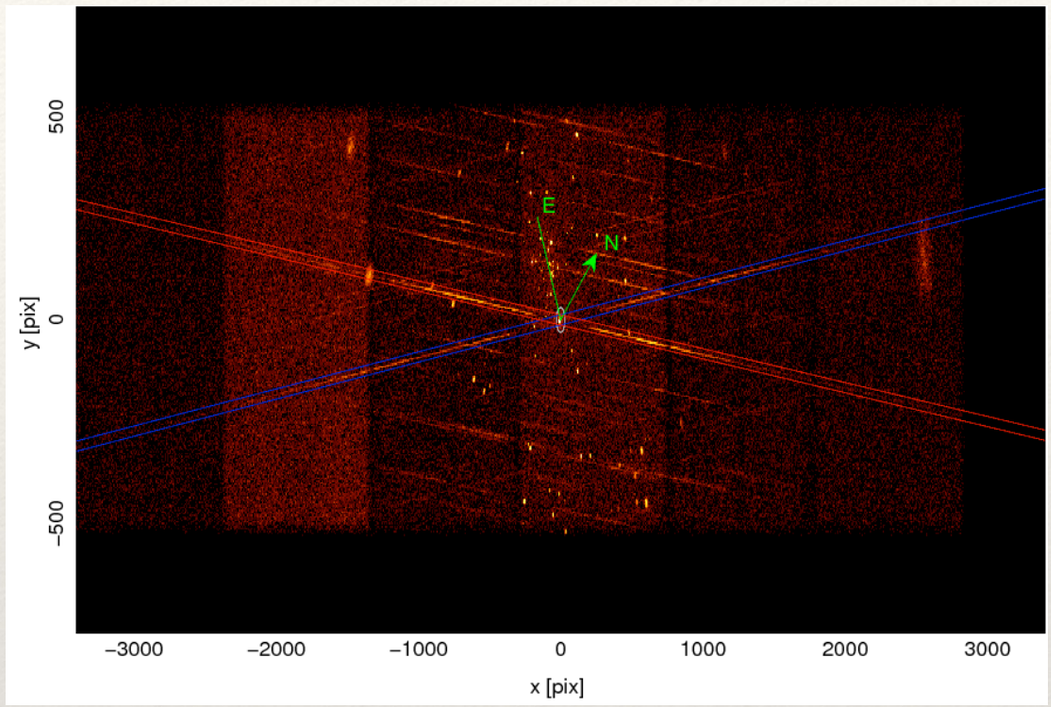

./15276/S_039 HEG
tg_d [deg]
5×10⁻⁴
0
−5×10⁻⁴
M31 Log Counts
4
3
2
−15
−10
−5
0
5
10
15
mλ

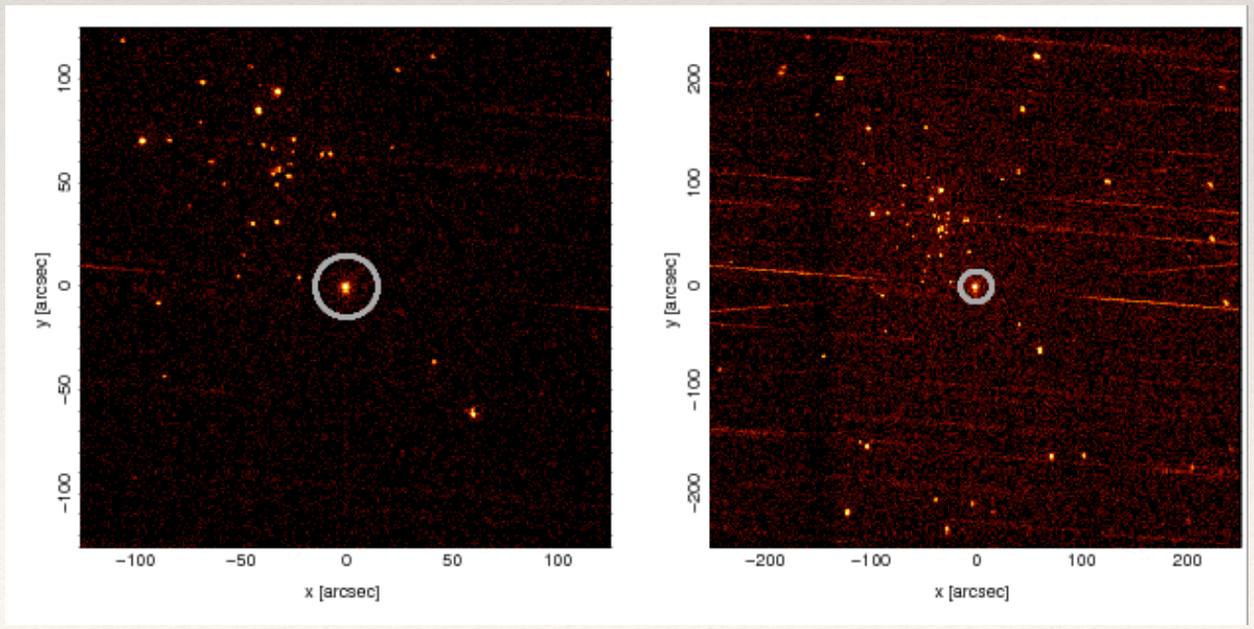

./15276/S_039/evt2 MEG
Energy
6
4
2
0
−20
−10
0
10
20
tg_mlam

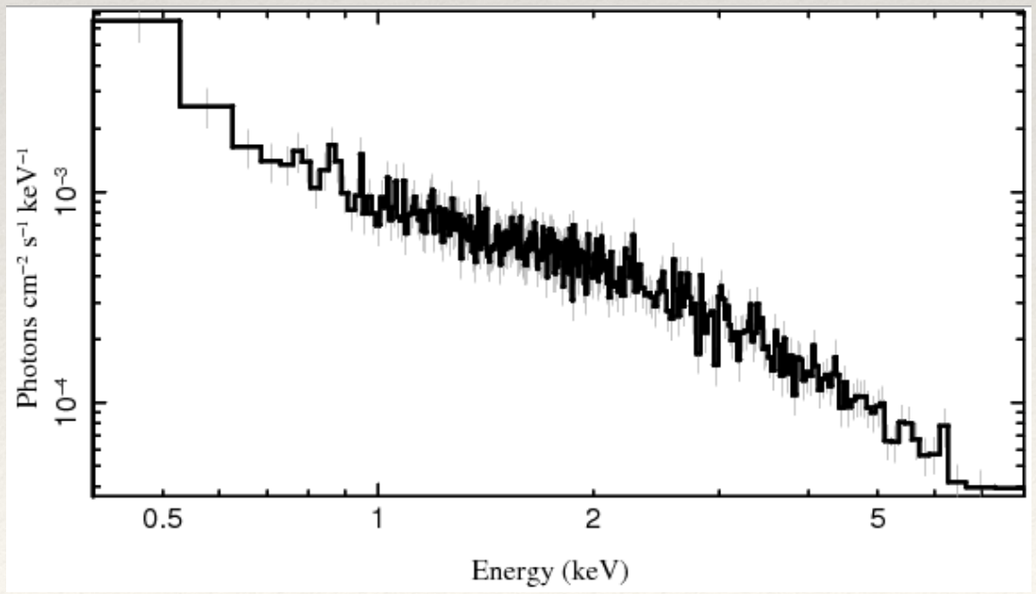

./15276/S_039/evt2 HEG
Energy
6
4
2
0
−15
−10
−5
0
5
10
15
tg_mlam

Brightest Source

- r2-26 (Kong+ ’02 catalog)
- 0.12 cps (MEG+HEG) --> 8,300 counts in 1st obsID
- PL fit: $\Gamma = 1.6$, $N_H = 1.4e21$

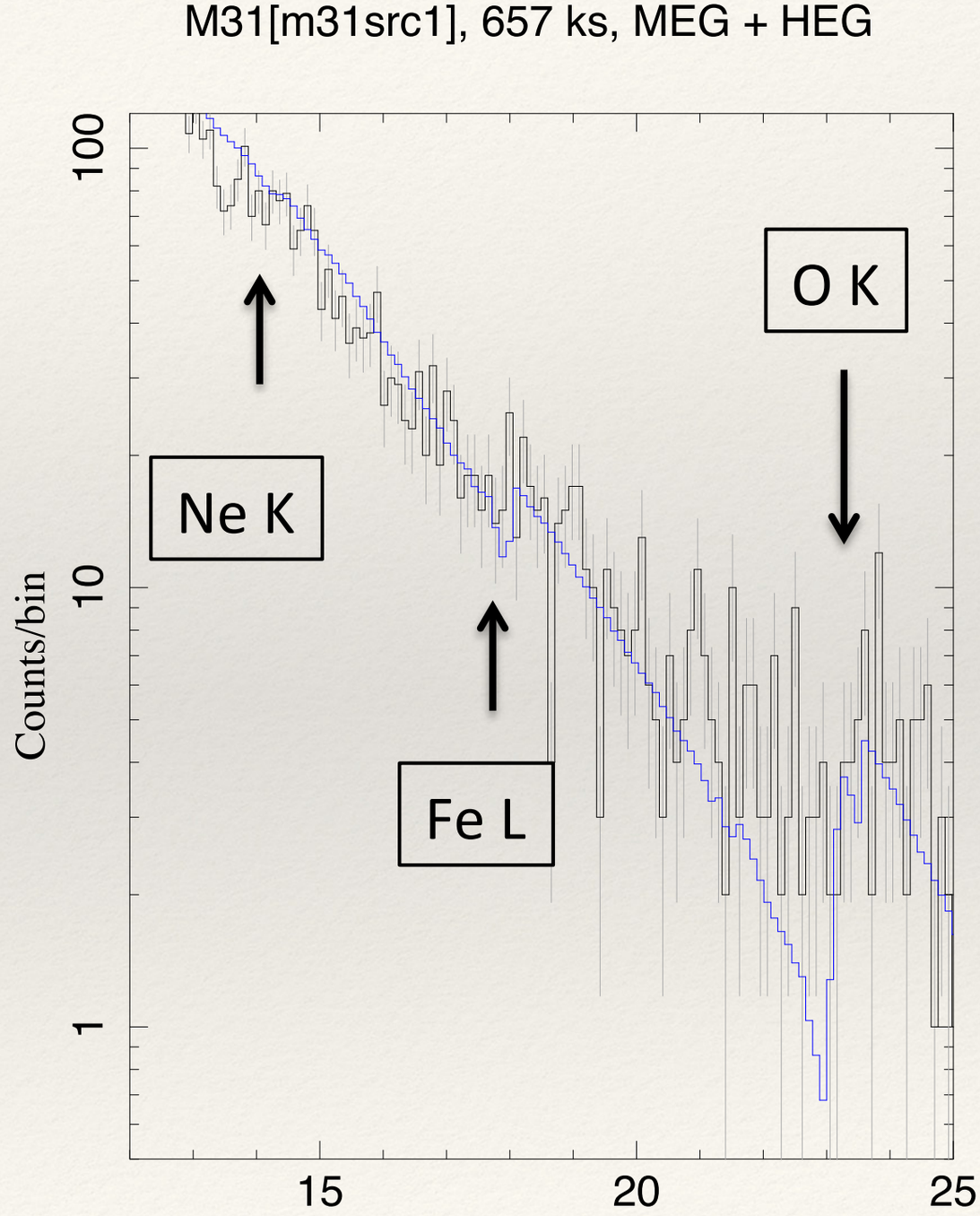




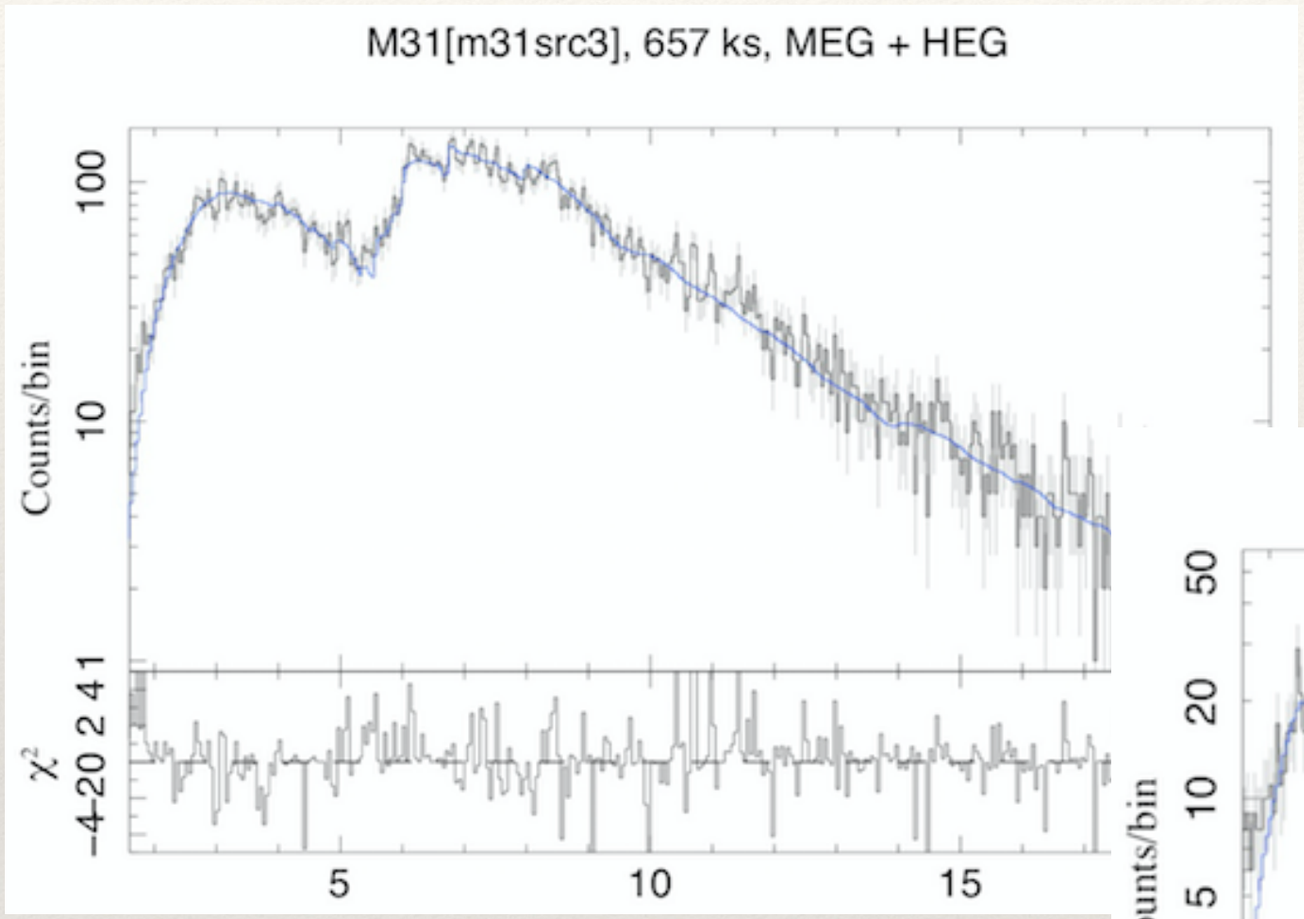


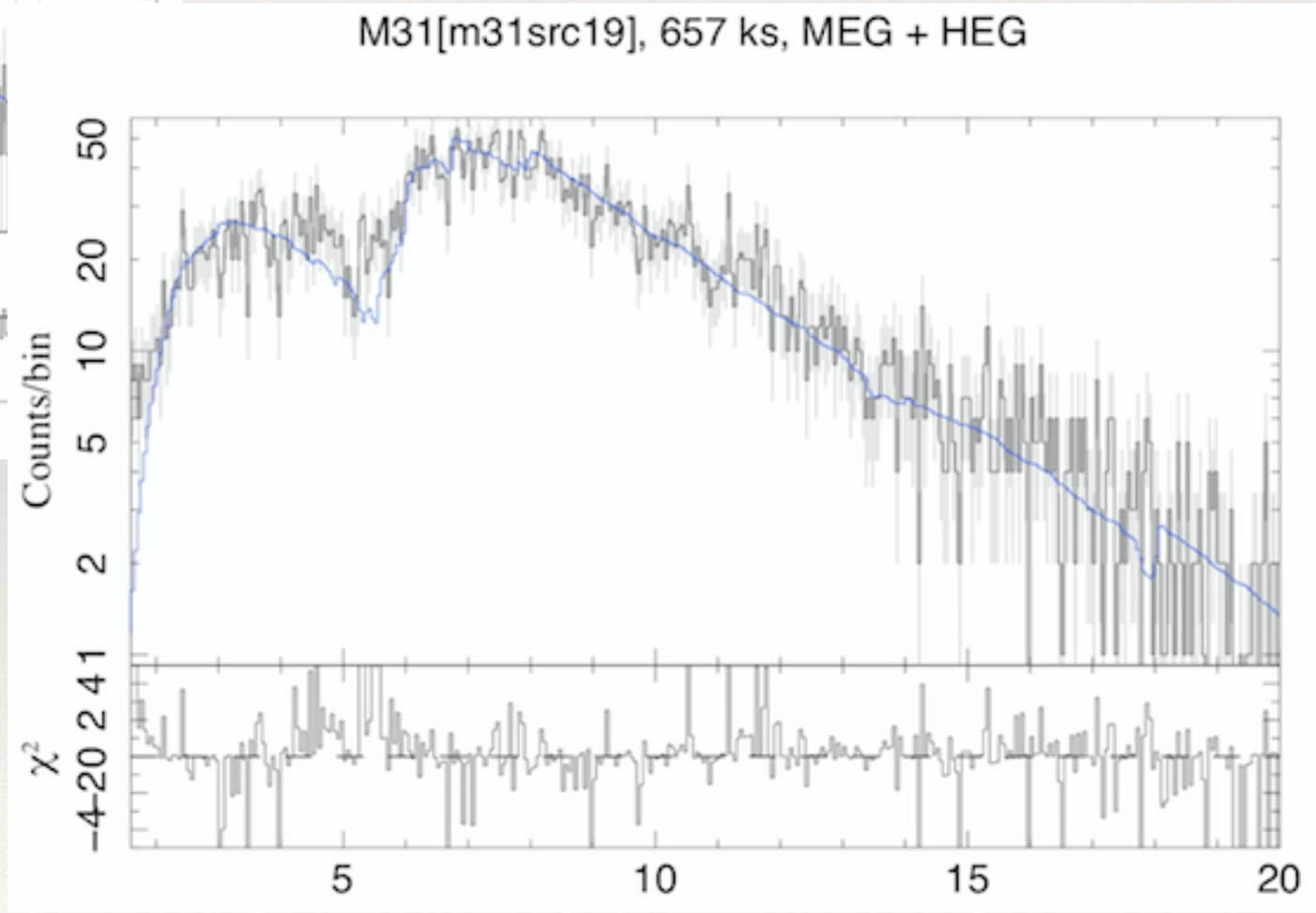
ISM Probes

- Brightest Source in M31
  - 21 cm: $N_{H,21} = 1.6$
  - XMM: $N_{H,21} = 2.8 \pm 1.2$
  - HETGS: $N_{H,21} = 3.2 \pm 1.4$
- In progress:
  - N_H for other XRBs
  - Compare Fe L (dust!) to O-K
  - Test against MW



Many More Sources





Future of Chandra and You

- How can YOU get involved (before Athena, Surveyor)?
  - AGN?, then M 31* spectra, variability
  - XRBs?, then
    - Transient spectroscopy w/o pileup
    - All bulge XRBs observed as a population
  - ISM?: Edges give elemental abundances, spatial variation
  - SNRs? (better line SNRs!)
    - Examine soft lines and ionization states
    - Add pointing to arm of M 31!
  - Challenging analysis? (timing, diffuse emission, isis —> python)
- Exposure time goal: consider 10% of Chandra's (remaining) lifetime!
  - >3 Ms for M 31? 5 Ms for M33, 10 Ms on NGC 300, others?
- Get ready for Surveyor!
  - (PS: Ask me about the REDSoX Polarimeter!)