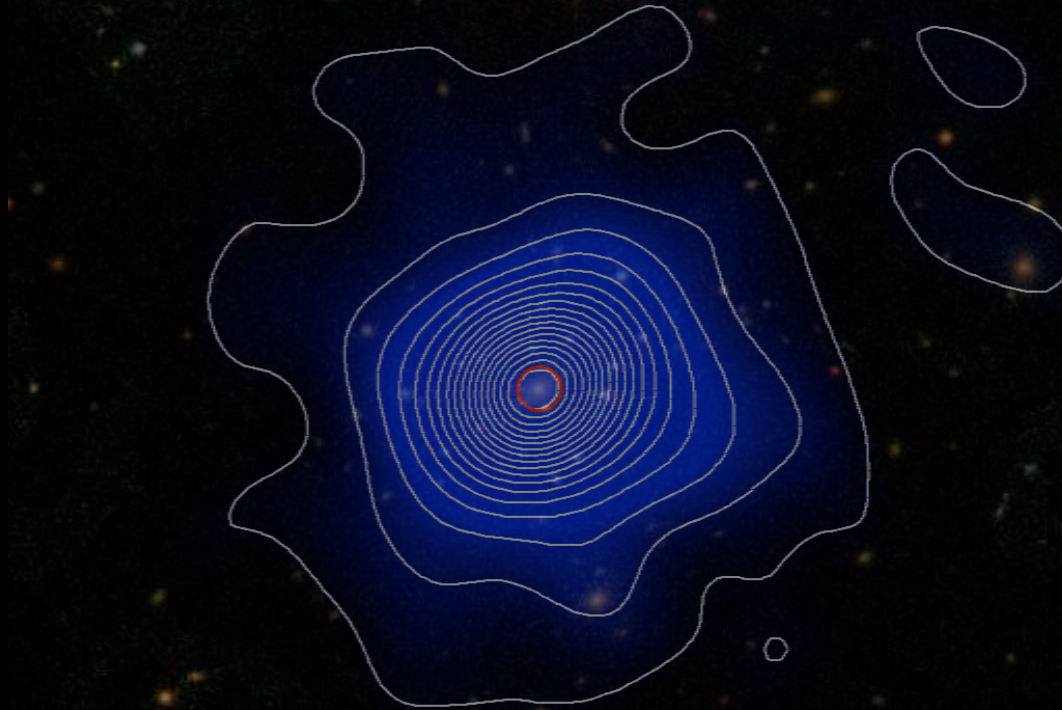


Local XBONGs: Fossil Groups, X-ray Variables, and AGN



NORTHWESTERN
UNIVERSITY

C I E R A



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CIERA Fellow

Energetics of Accreting Compact Objects (AGN/XRB)

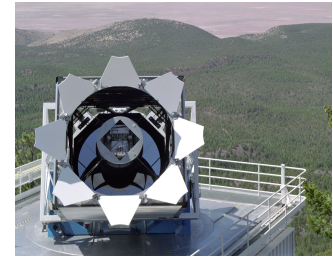
- **AGN Fraction** (ChaMP, SDSS): mass, redshift, color, environment
- **BAL QSO** spectro variability (7 cadences over 6 years)
- AGN in the **time domain** (AS3, PanSTARRS, LSST)
- **XBONGS** (ROSAT+Chandra, SDSS; $z < 0.3$)
- **LLAGN – XRB** connections (CSC, SDSS-I/II/III, BOSS ancillary)
- **ω Centauri**: 300 ks (!) with *Chandra*, IMBH?
- **AM CVn** double-degenerate WD binaries
- **ALMA**: star formation, AGN

XBONG Collaborators

- James Madison University
 - Anca Constantin
- Harvard-Smithsonian Center for Astrophysics
 - Paul J. Green
 - Dong-Woo Kim
- University of Washington
 - Scott F. Anderson
- University of Birmingham
 - Ewan O’Sullivan
- Evanston Township High School
 - Talia Weiss



ROSAT



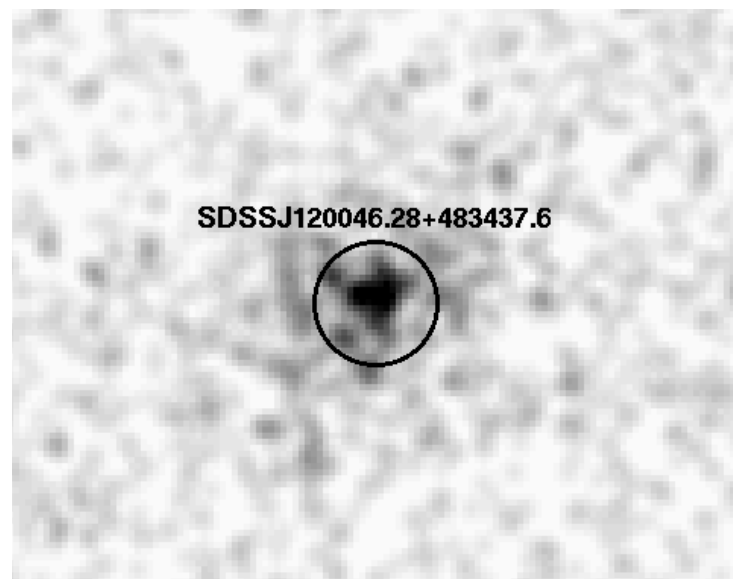
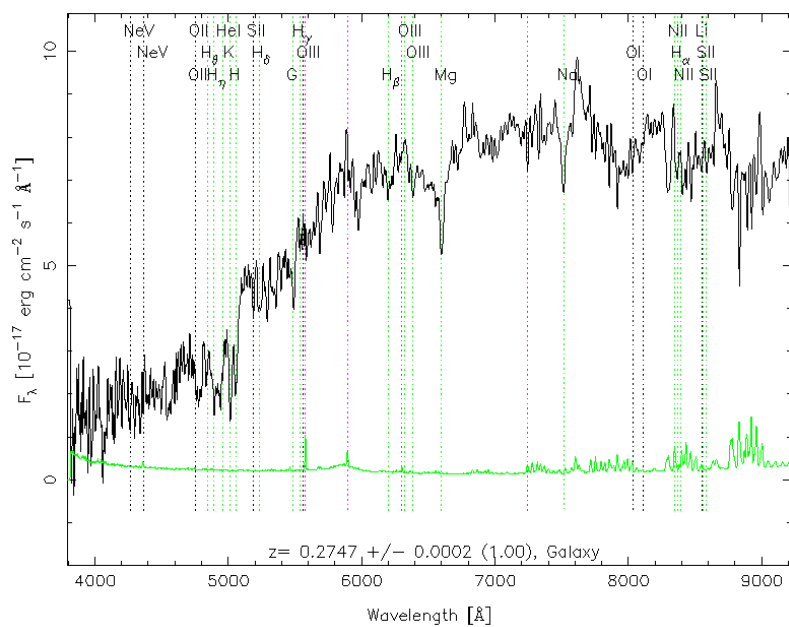
SDSS



Chandra

X-ray Bright, Optically Normal Galaxies

- XBONG (a.k.a. optically “dull” X-ray bright gals)
 - Substantial (AGN-like) X-ray luminosity e.g., Elvis *et al.* 1981
 - No narrow or broad optical emission lines



X-ray Bright, Optically Normal Galaxies

- Why no AGN-like optical emission lines?
 - **Dilution**: AGN emission diluted by host starlight
Moran *et al.* 2002; Caccianiga *et al.* 2007; Trump *et al.* 2009
 - **Obscuration**: Both broad & narrow line regions obscured
Comastri *et al.* 2002; Rigby *et al.* 2006
 - **Inefficient Accretion**: RIAFs with truncated disks (little optical/UV)
Yuan & Narayan *et al.* 2004; Trump *et al.* 2009
 - **Variability**: data not coeval; tidal disruptions
Komassa *et al.* 2004; Gezari *et al.* 2006
 - **Extended hot gas**: poor or “fossil” galaxy groups
Jones *et al.* 2003; Georgantopoulos & Georgakakis *et al.* 2005

Why low- z XBONGs?

A low-redshift ($z < 0.37$) sample enables:

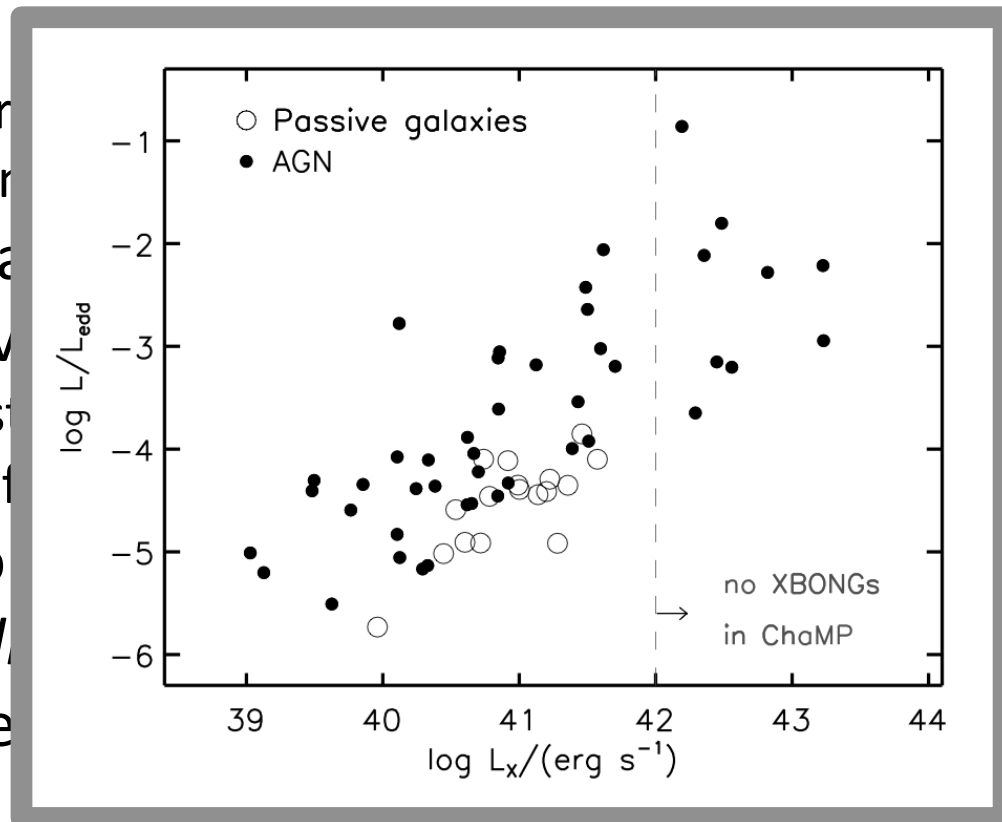
- High X-ray S/N
 - spectral constraints
 - spatial modeling
- $H\alpha$ in the optical spectrum
- Deep, multiwavelength optical data
 - environment studies (via photometric redshifts)
 - spectroscopic follow-up
- Host galaxy morphology
- *ROSAT* + *Chandra* enables variability analysis
- Unique, high-resolution look at a rare population



Why low- z XBONGs?

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 - spectroscopic f
- Host galaxy mo
- *ROSAT* + *Chandra*
- Unique, high-re



Sample Selection

8 local targets selected for Chandra follow-up:

Name (SDSS)	r (mag)	z	RASS (cnts/s)	log L _x (erg/s)	match conf (%)
J0814+3827	17.92	0.3133	0.033	44.00	89
J0854+3053	17.94	0.3086	0.026	43.88	78
J1058+4108	18.16	0.3236	0.066	44.34	78
J1200+4834	17.29	0.2747	0.019	43.63	90
J1308+5538	19.07	0.3675	0.020	43.94	89
J1452+4431	18.10	0.2866	0.028	43.85	87
J2047-0619	17.71	0.2520	0.023	43.63	87
J2124+1147	17.56	0.3000	0.019	43.72	79

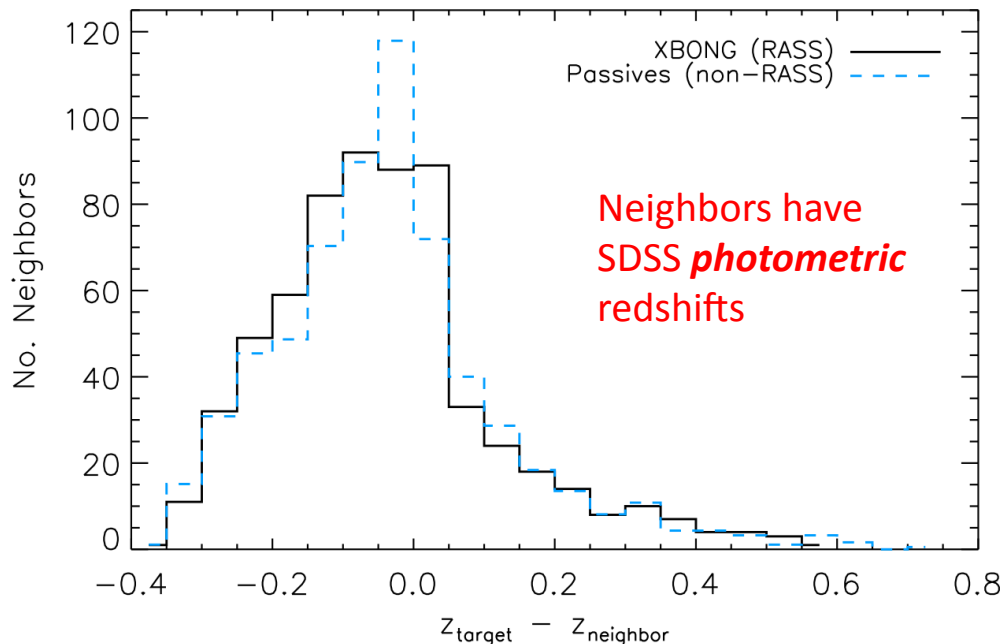
Sample Selection

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No *Measurable* Clustering

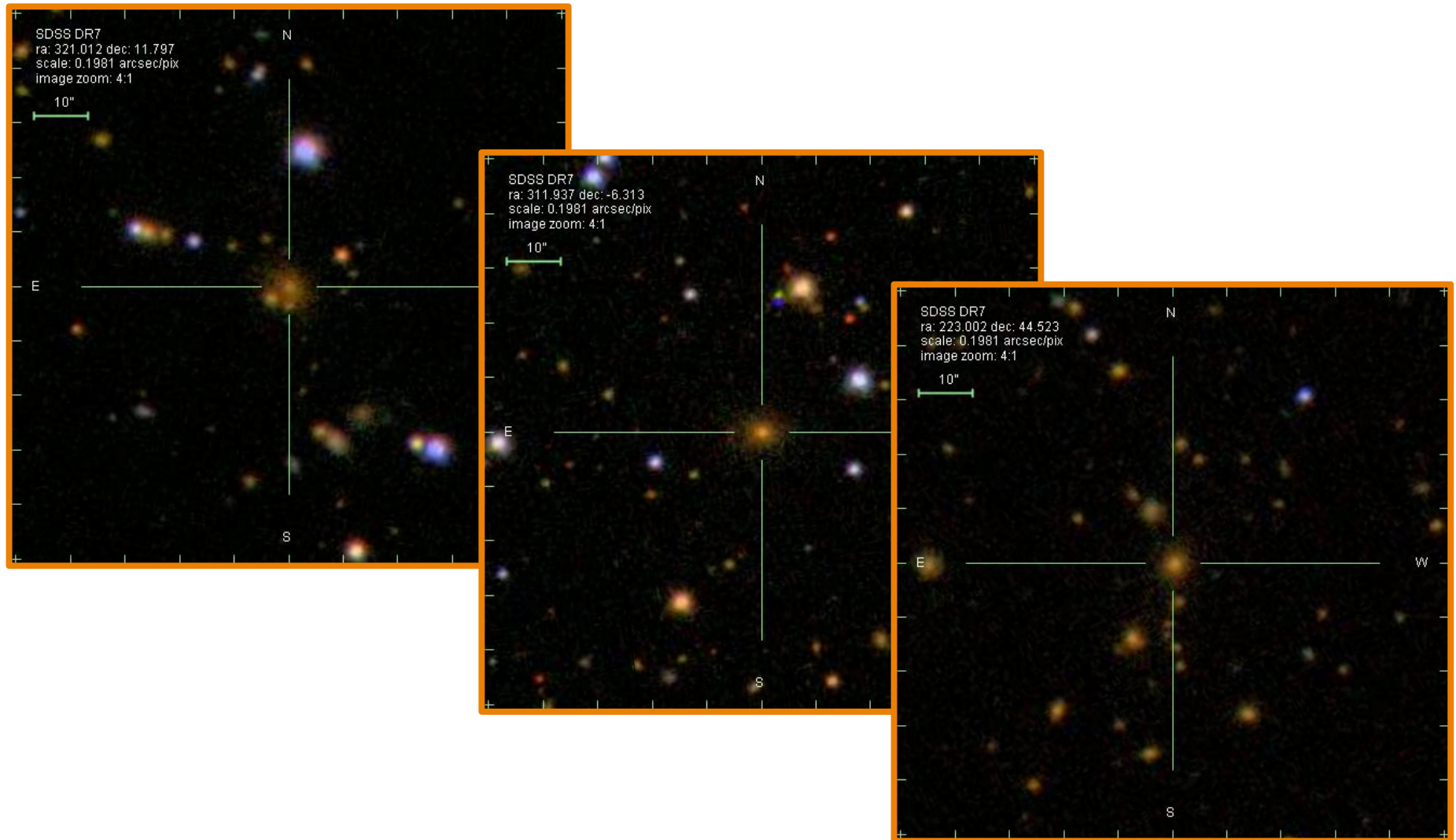
- Association with groups and clusters possible
 - RASS sources not reliably extended until 1', but 97% of sources above 20" extent excluded

Bohringer *et al.* 2000



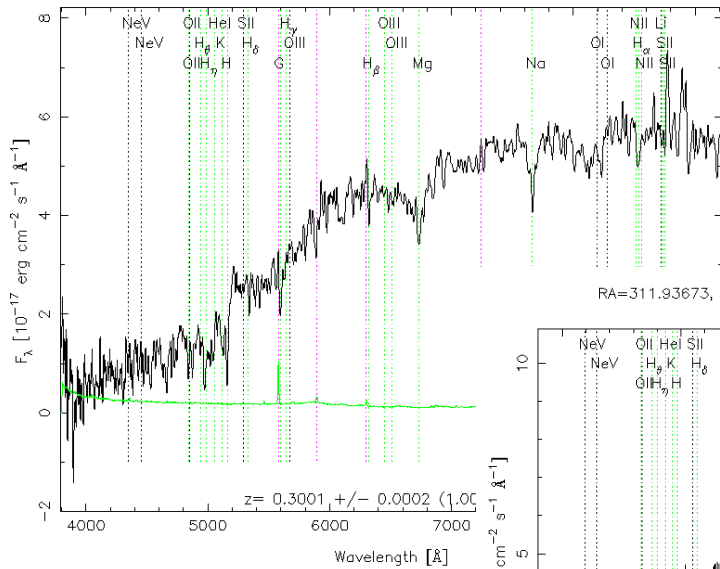
- Eliminate catalog matches
- RASS XBONG cands no more clustered than non-RASS passives

SDSS Imaging

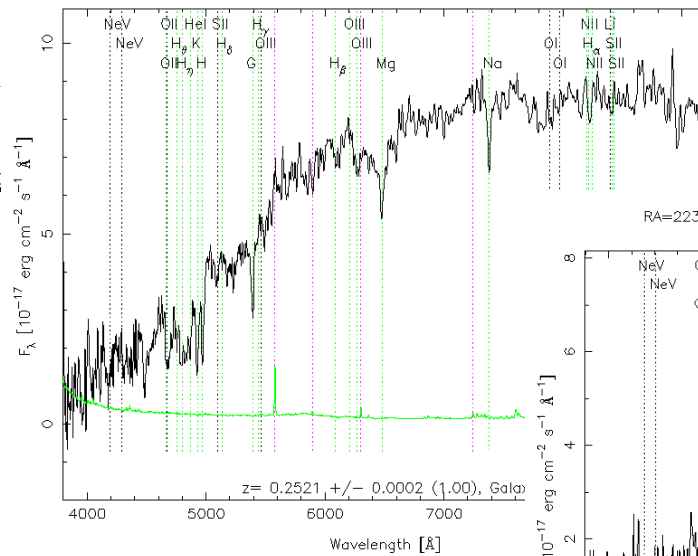


SDSS Spectroscopy

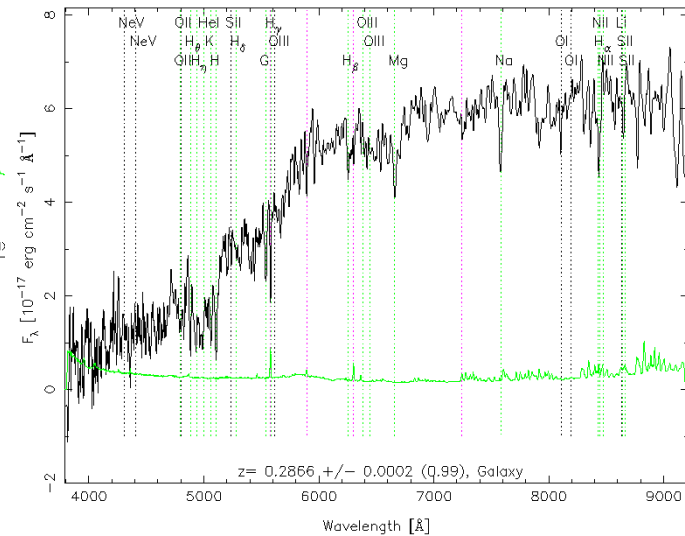
RA=321.01241, DEC=11.79734, MJD=52466, Plate= 730, Fiber=367

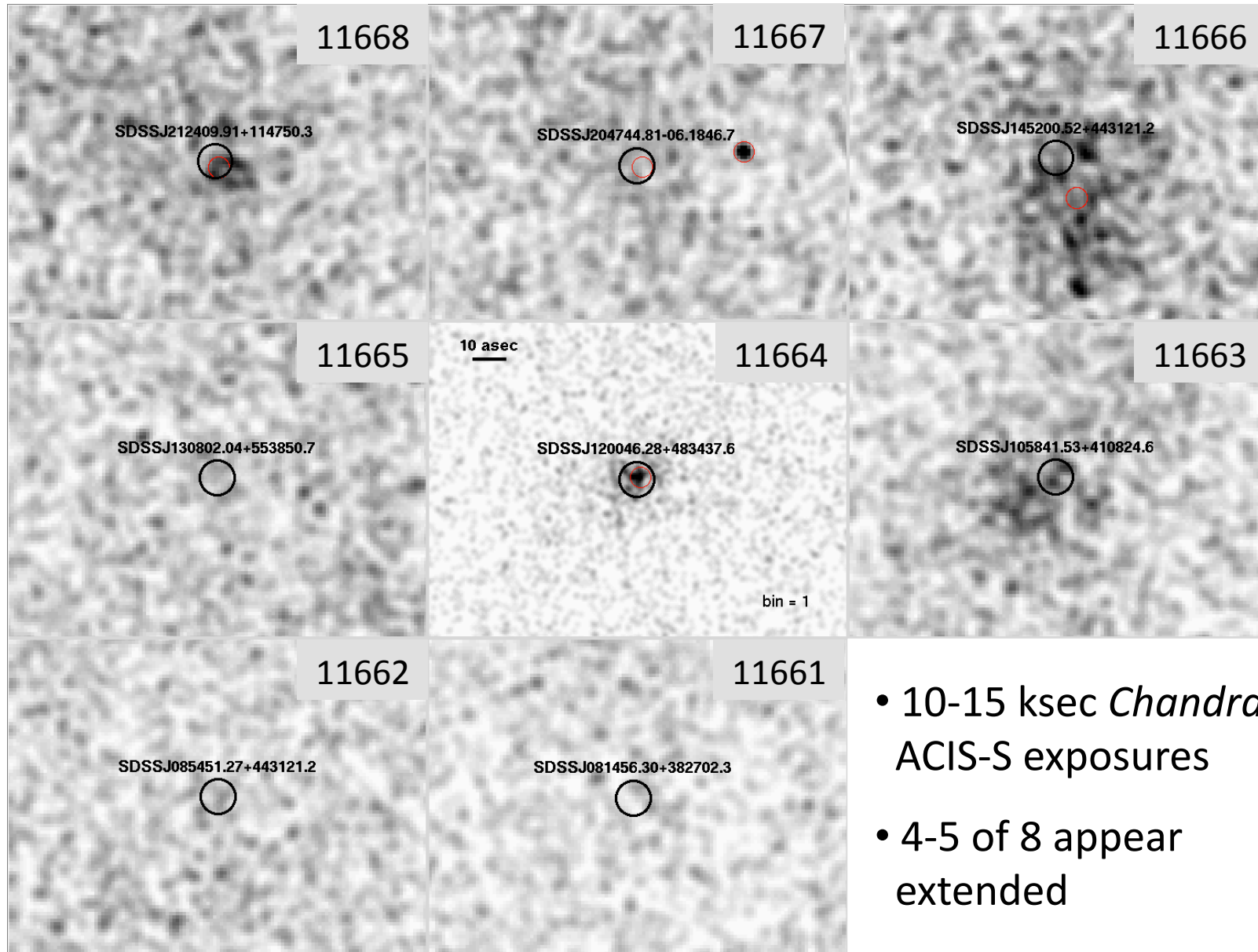


RA=311.93673, DEC=-6.31298, MJD=52145, Plate= 635, Fiber=135

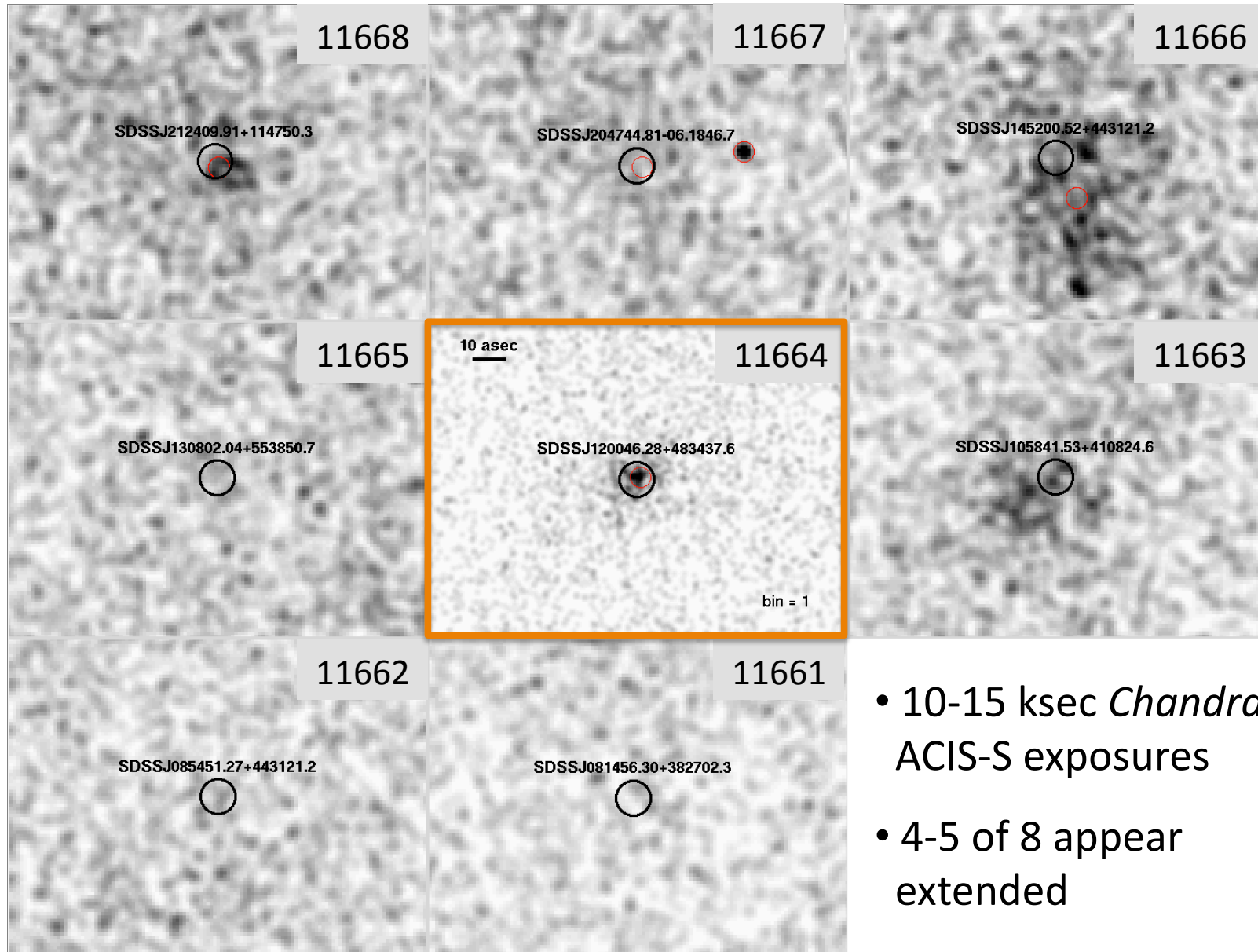


RA=223.00217, DEC=44.52258, MJD=53147, Plate=1676, Fiber=284





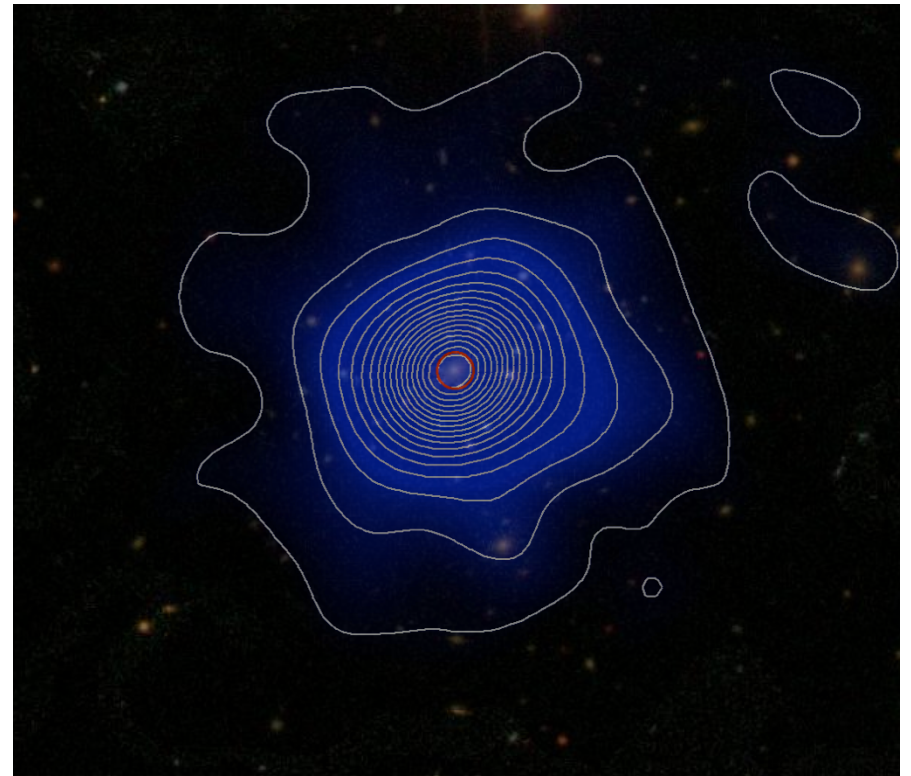
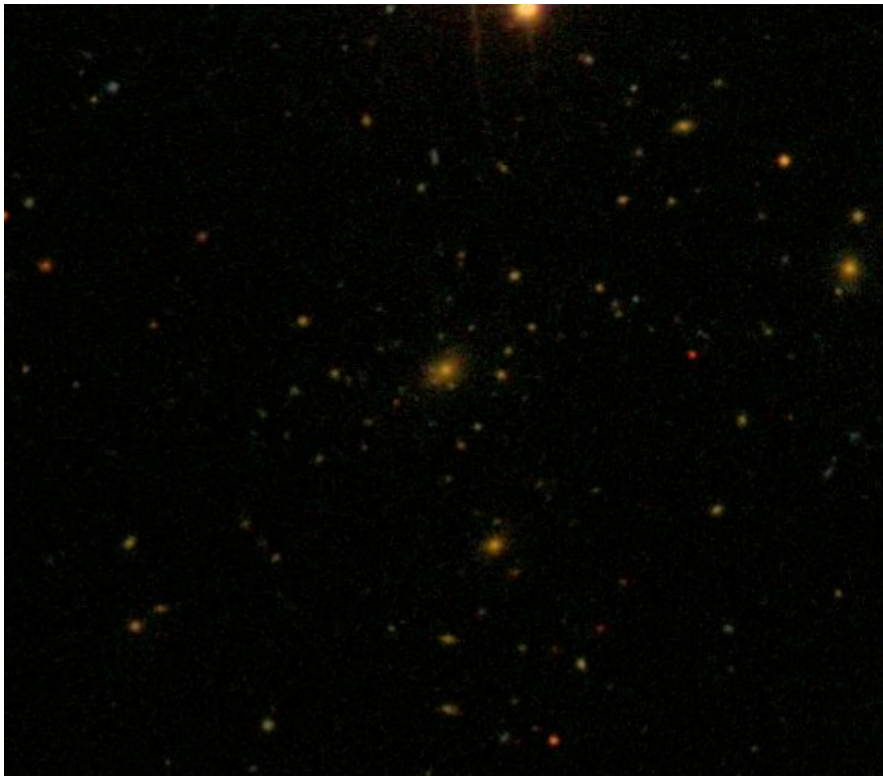
- 10-15 ksec *Chandra* ACIS-S exposures
- 4-5 of 8 appear extended



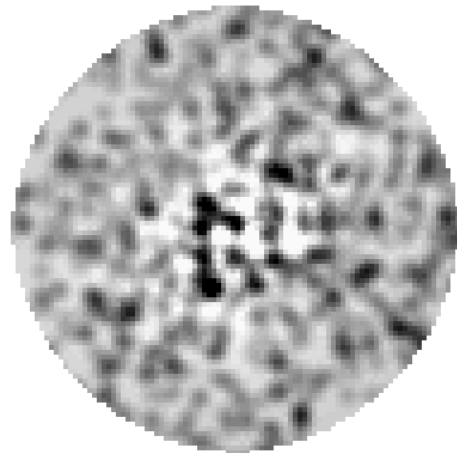
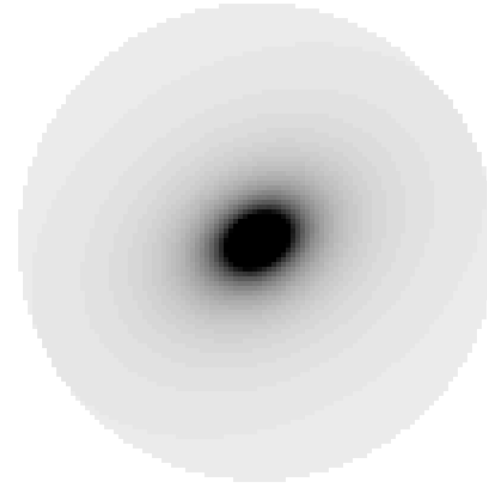
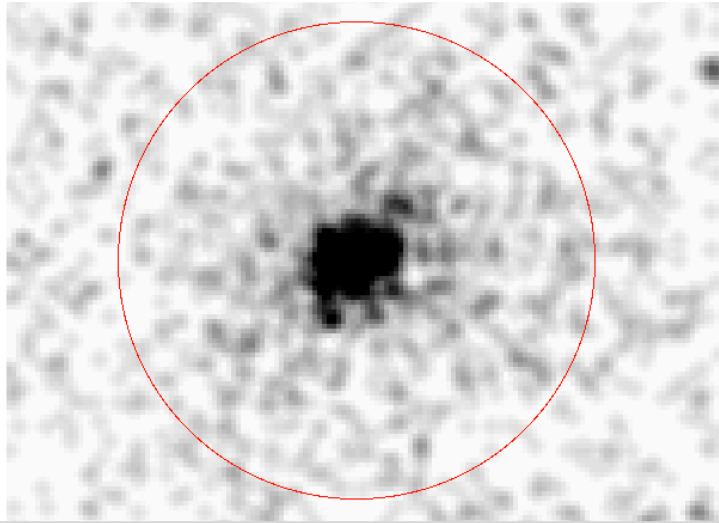
- 10-15 ksec *Chandra* ACIS-S exposures
- 4-5 of 8 appear extended

SDSS J1200+4834

Extended hot gas!?



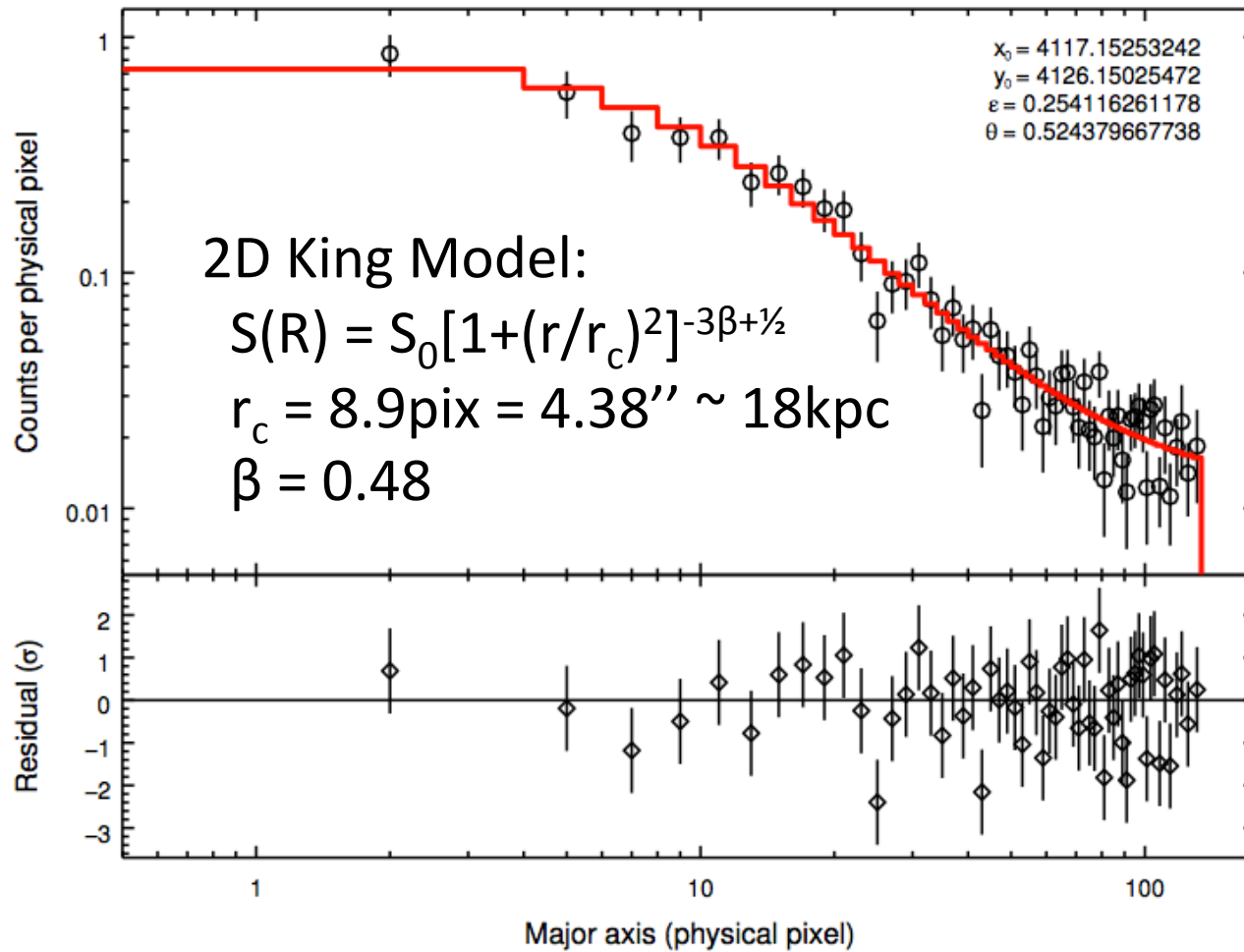
SDSS J1200+4834



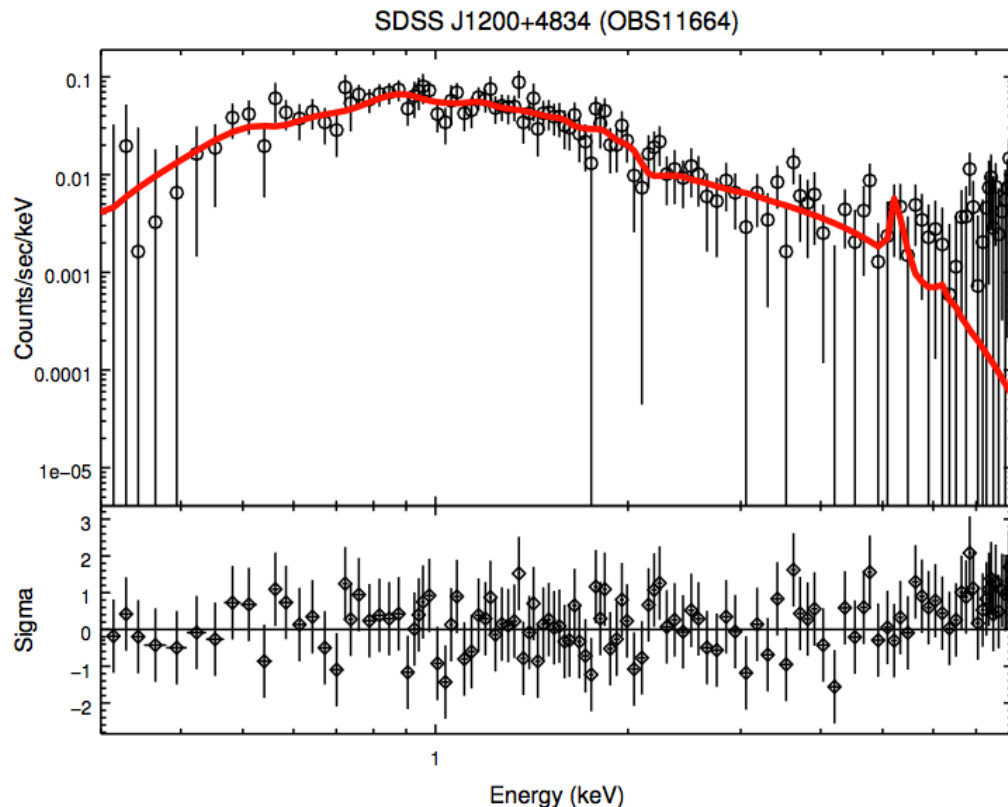
- Radial profile:
 - 2D King Model
 - radius of 150 pix
 $\sim 70''$ ($\sim r_{500}/2$)

Sanderson et al. 2006

SDSS J1200+4834



SDSS1200+4834

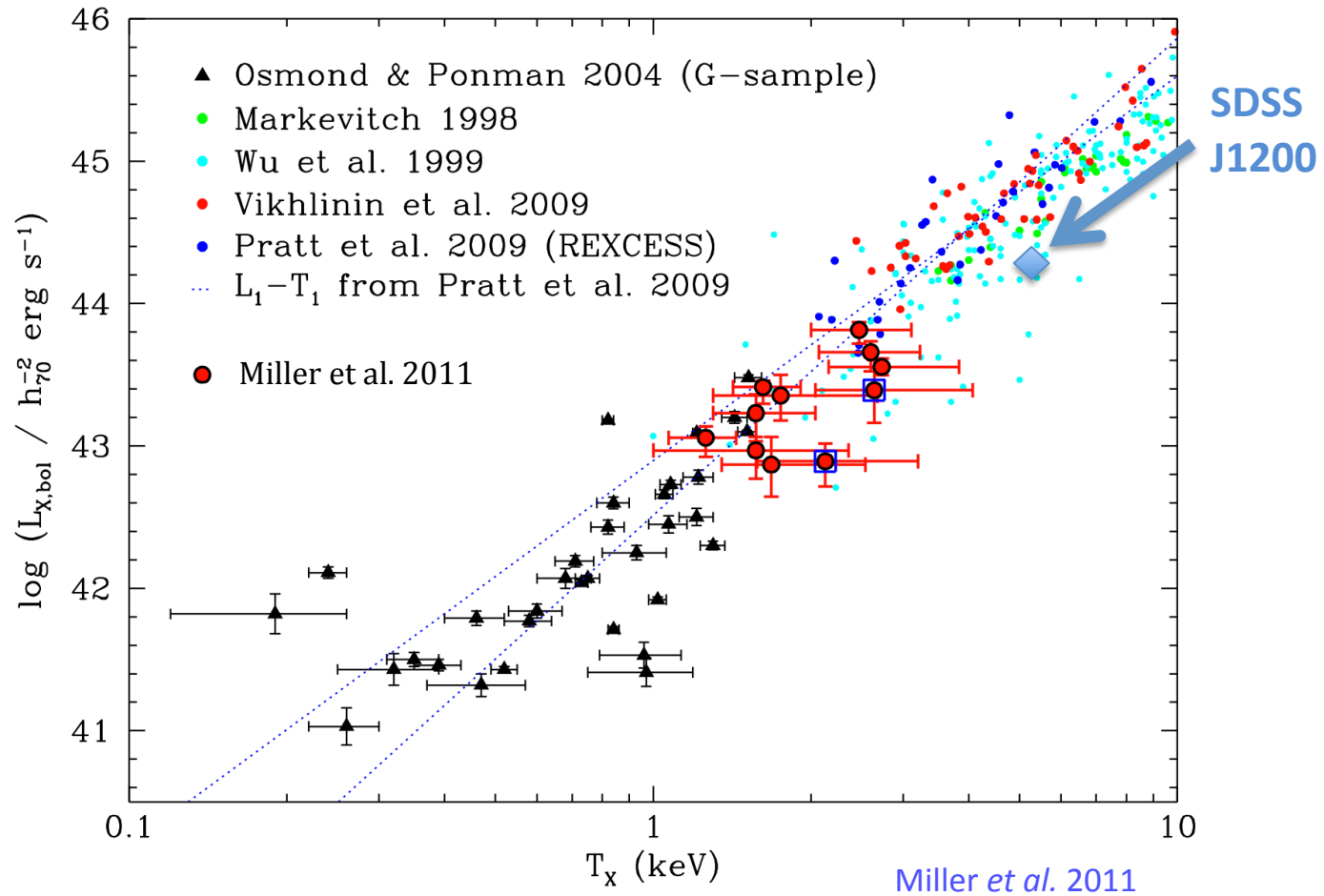


- MEKAL thermal plasma model fit to X-ray spectrum
 - ~1400 counts
 - $kT = 5.17 \pm 1.0$ keV
 - Abund = 0.64 ± 0.4 solar
 - $f_{0.3-8\text{keV}} = 6.15 \times 10^{-13} \text{ erg s}^{-1} \text{ cm}^{-2}$
 - $L_{0.3-8\text{keV}} = 1.47 \times 10^{44} \text{ erg s}^{-1}$

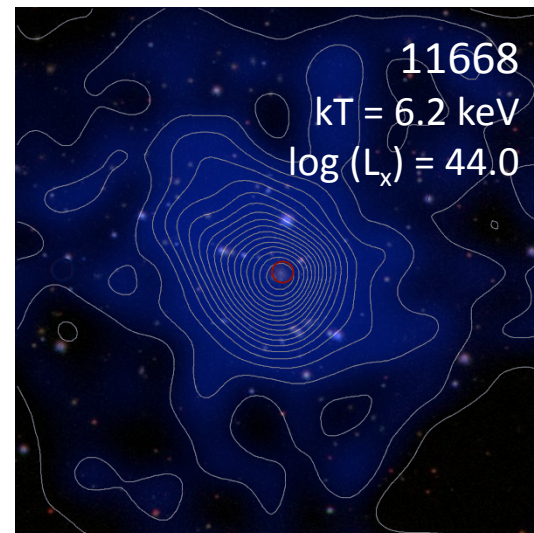
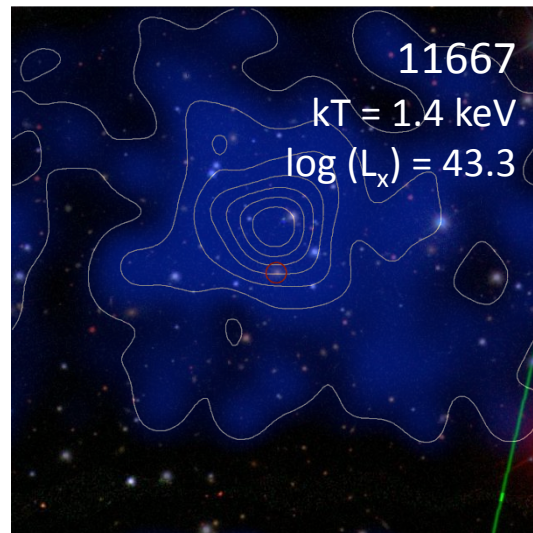
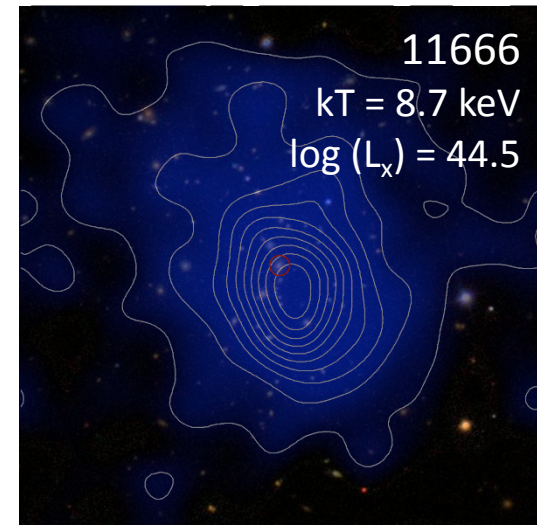
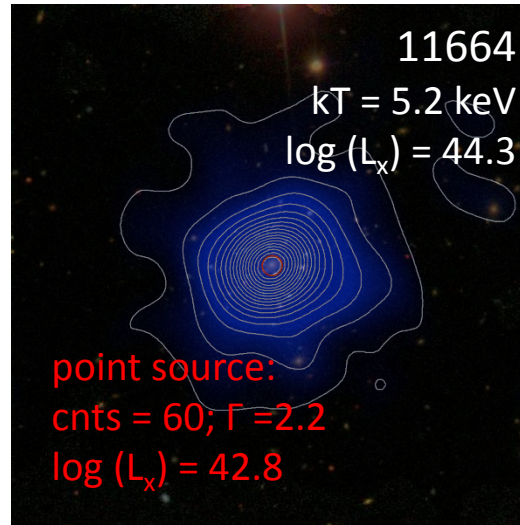
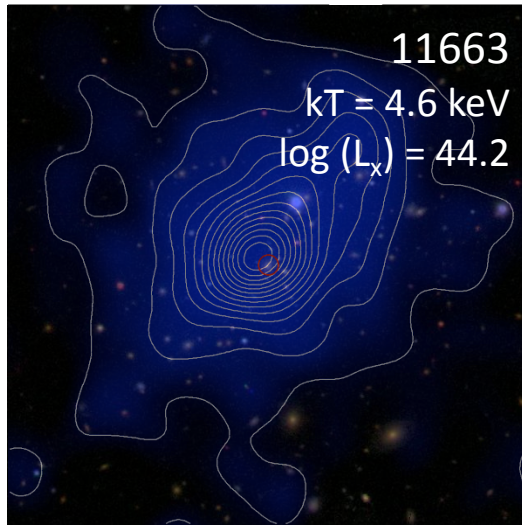
$$z = 0.2747$$

$$nH = 2.58 \times 10^{20} \text{ atm/cm}^2$$

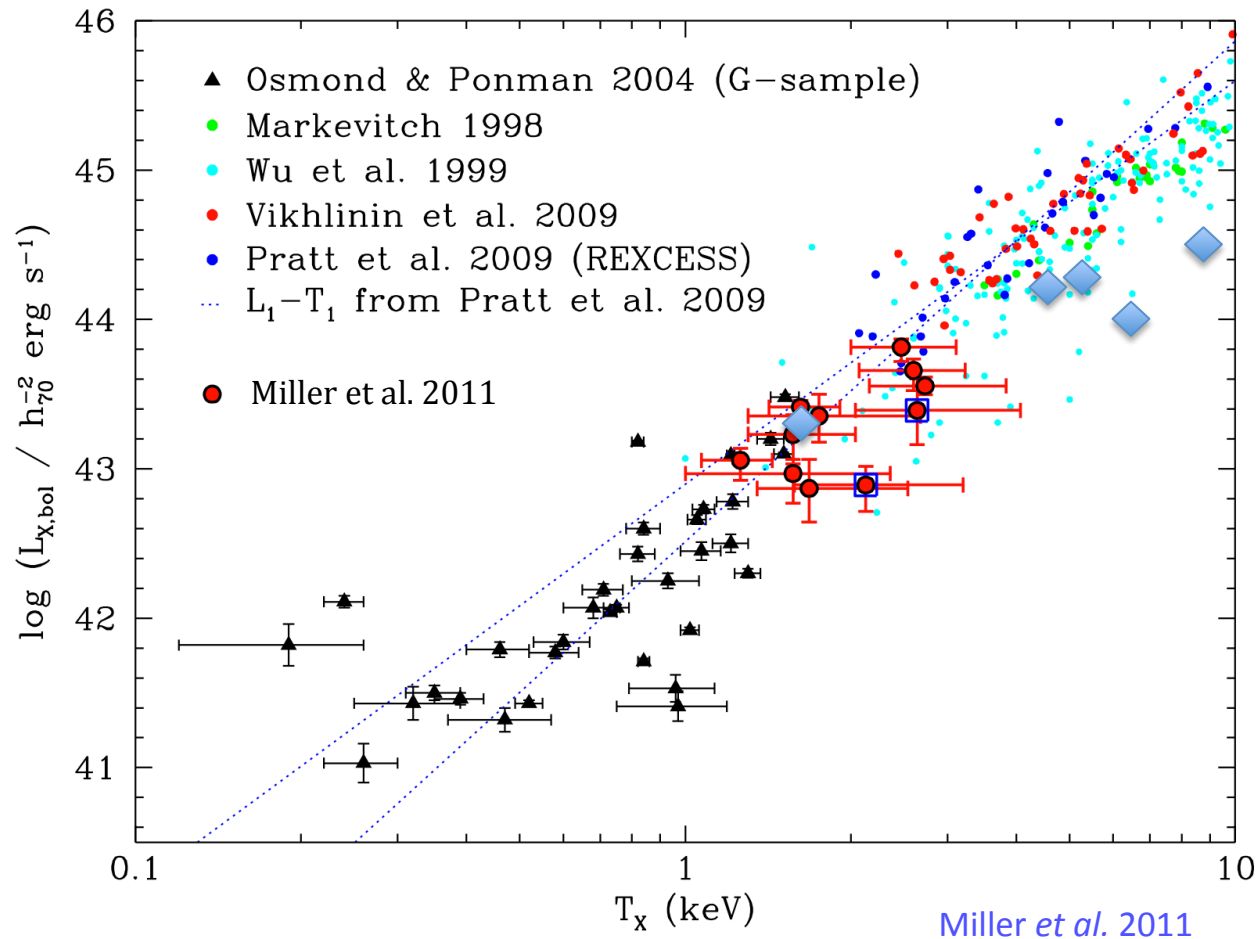
L_X - T_X Relation for Clusters/Groups



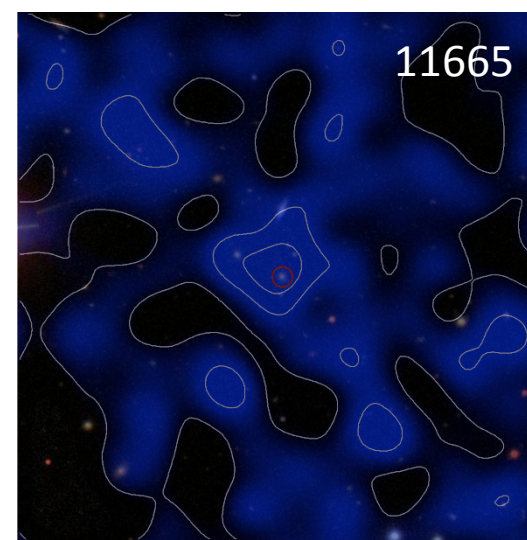
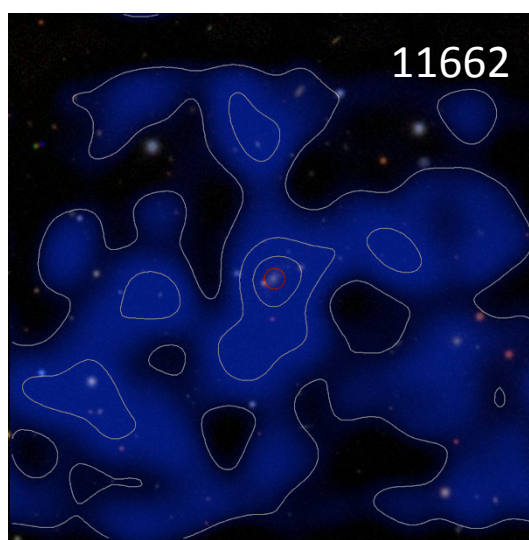
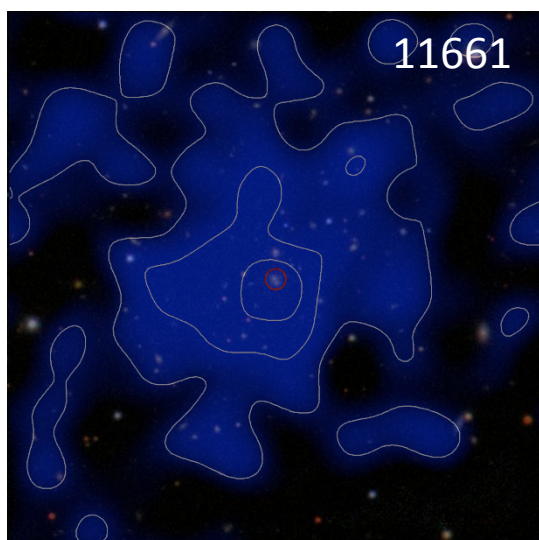
Extended X-ray Emission



L_X - T_X Relation for Clusters/Groups

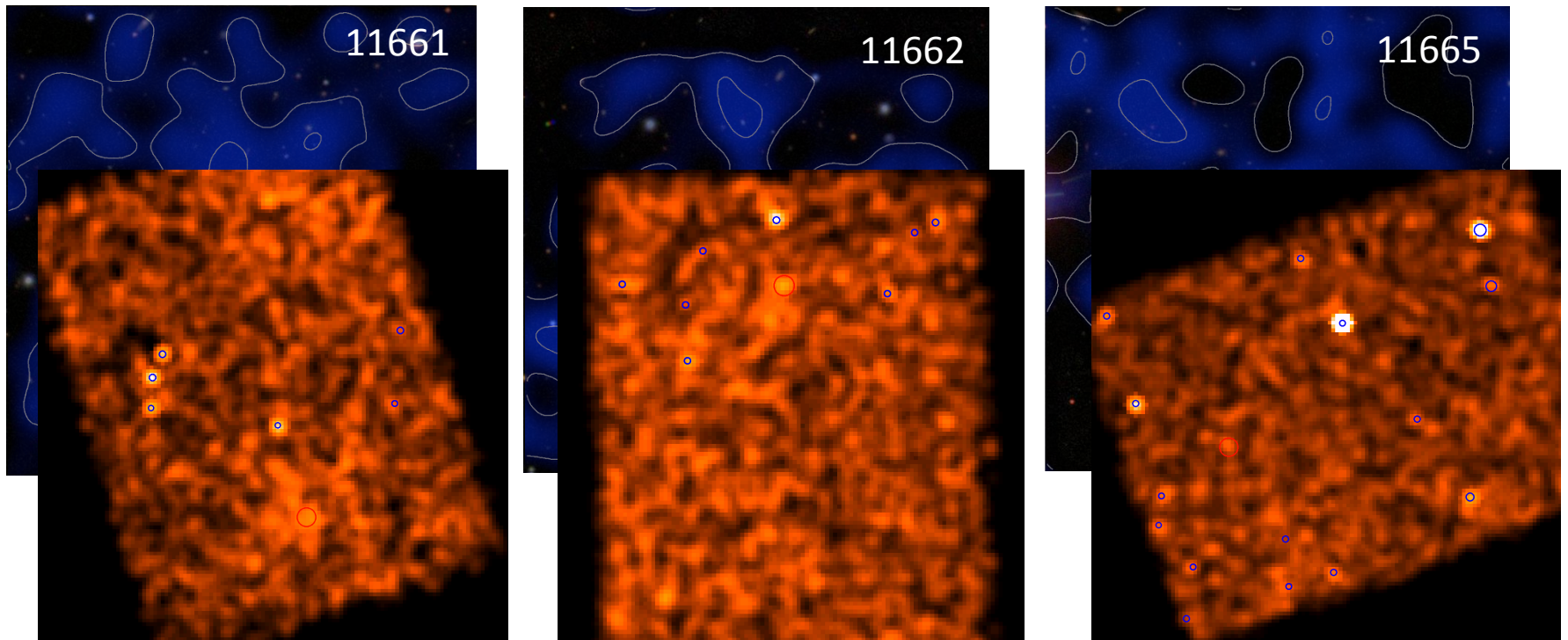


Marginal Detections



- RIAF or X-ray Variability possible.
- Host dilution unlikely.

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Summary

- At higher- z ($0 < z < 1$) XBONGS are a heterogeneous population
 - COSMOS (48): 70% diluted by host; 30% likely RIAFs Trump *et al.* 2009
 - Xbootes (~ 250): dilution at low- z (< 0.3); some obscuration; RIAF likely ($z > 0.3$); some BL Lac Forman *et al.* 2006; Hickox *et al.* 2009
- We perform one of the first low- z (< 0.37) *Chandra* surveys of XBONG candidates

Summary

- 8 low-z XBONGs:
 - 4 to 5 extended (!) in the X-ray
 - SDSS J1200+4834: radial profile and X-ray spectrum consistent with a (fossil?) group or X-ray cluster
 - 2 to 3 show no strong X-ray emission, possibly due to X-ray variability (tidal disruption events?)
- Spectroscopic confirmation of group/cluster environment necessary
- High quality (XMM) spectra to constrain T_x
- May prove a successful selection technique for optically poor, low-z clusters and groups

