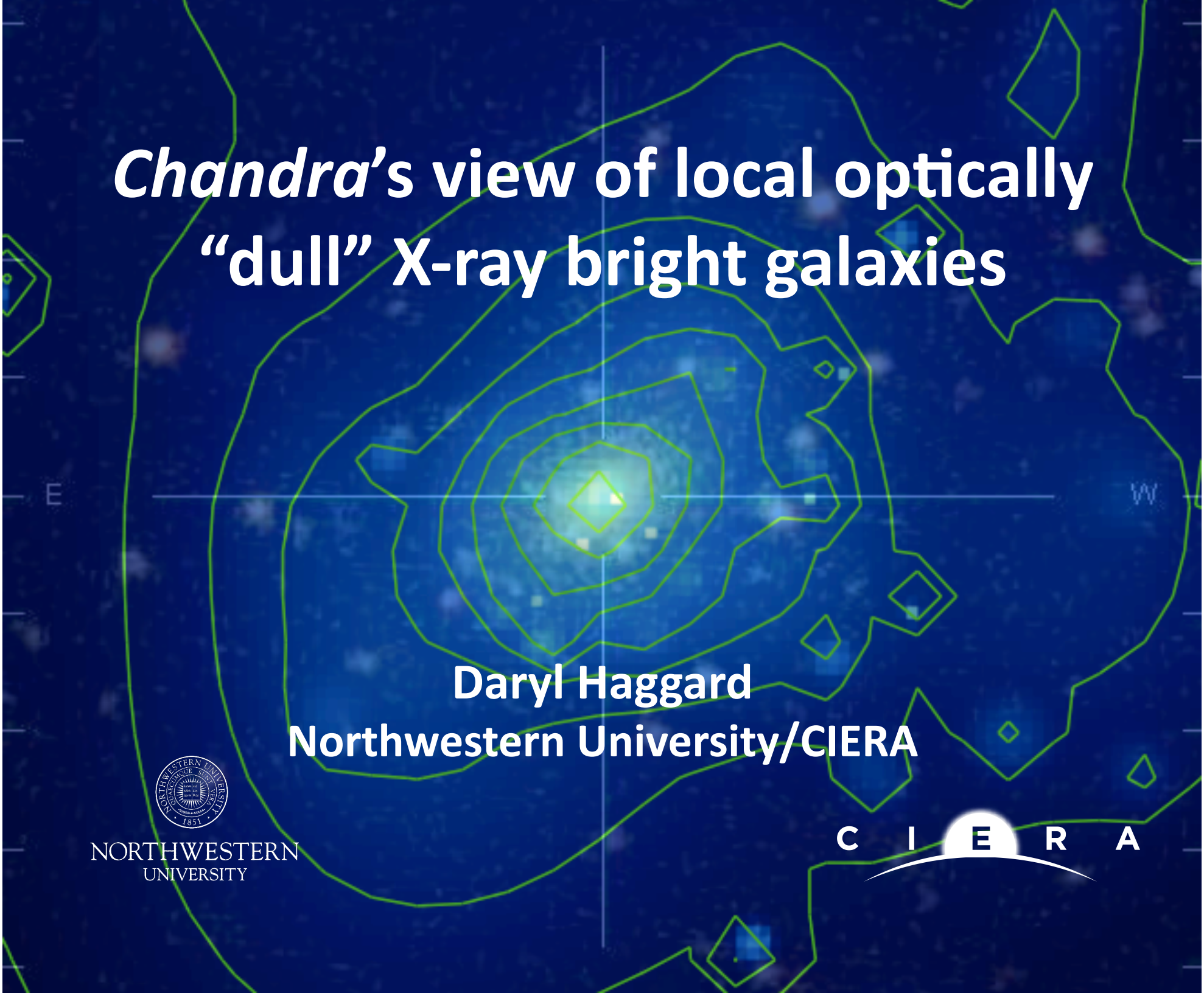

Chandra's view of local optically "dull" X-ray bright galaxies

Daryl Haggard

Northwestern University/CIERA

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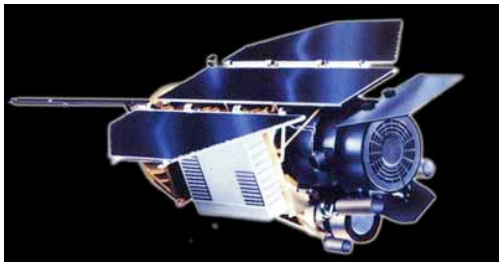
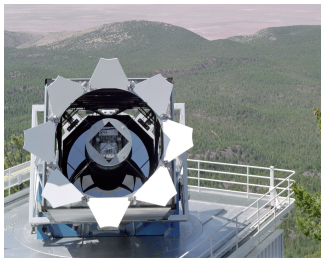
CIERA

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



ROSAT



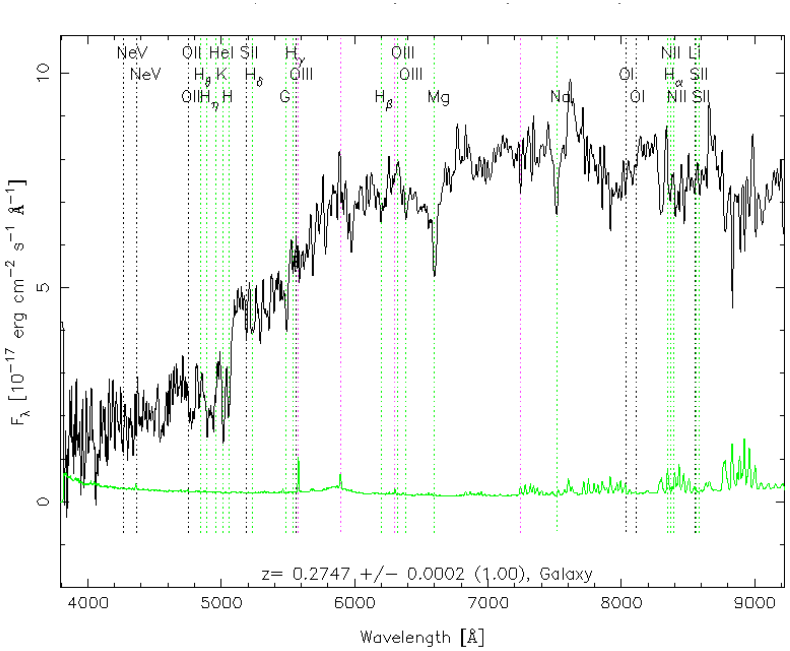
SDSS

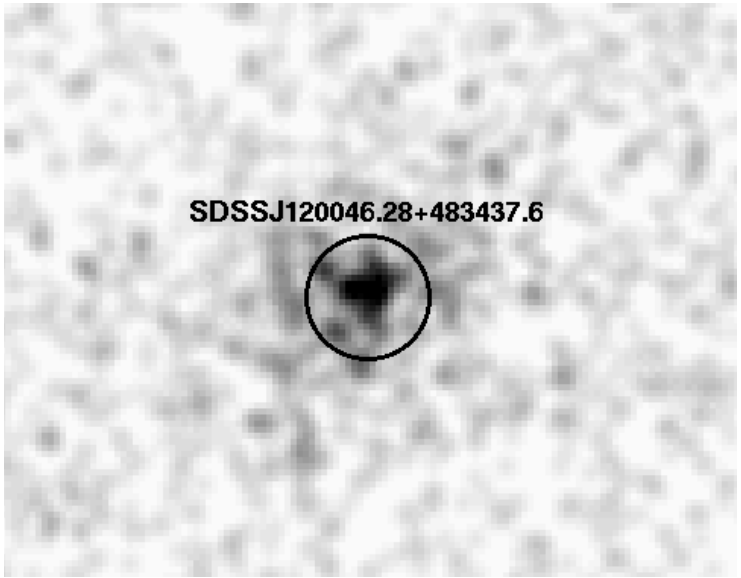
Chandra

X-ray Bright, Optically Normal Galaxies

- XBONG (a.k.a. optically "dull" X-ray bright gals)
  - Substantial (AGN-like) X-ray luminosity
  - No narrow or broad optical emission lines

e.g., Elvis *et al.* 1981





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

Motivation

- Low-z (<0.37) *Chandra* sample
  - X-ray spectral constraints and spatial modeling
  - High S/N
  - Hα in the optical spectrum
  - Deep, multivaelength optical imaging for environment studies (via photometric redshifts)
  - Host galaxy morphology
  - *ROSAT* + *Chandra* enables some variability analysis
  - Unique look at a rare population

Motivation

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  - X-ray spectral con
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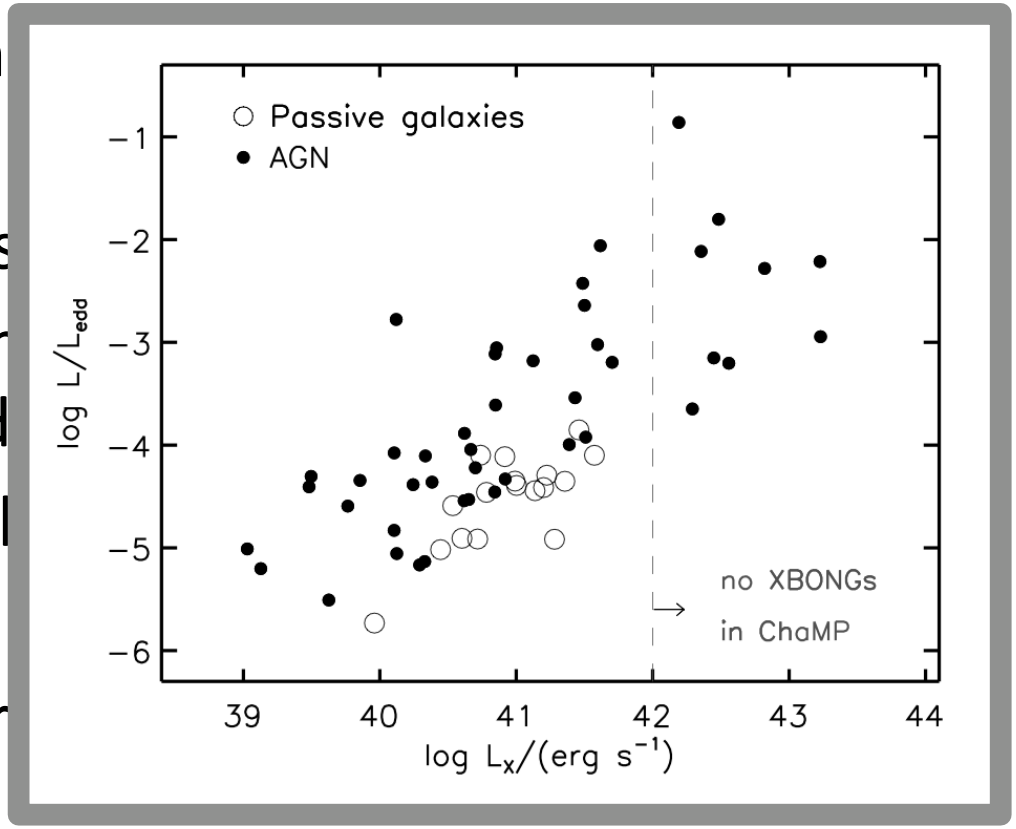

Sample Selection

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+4431	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

	SDSS spec	z ~ 0.3		RASS bright	
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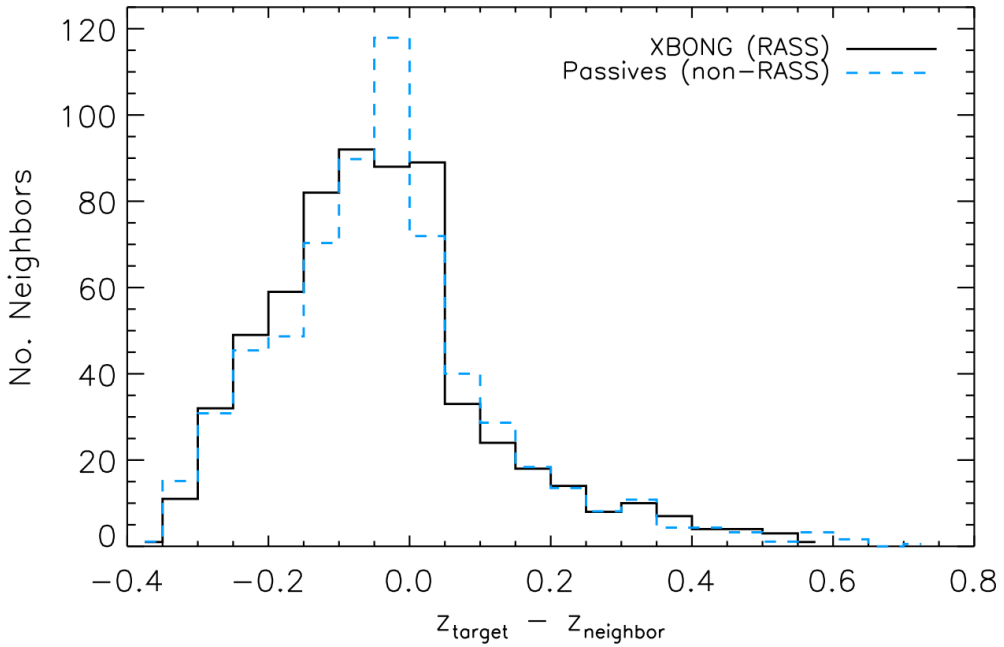
No *Measurable* Clustering

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

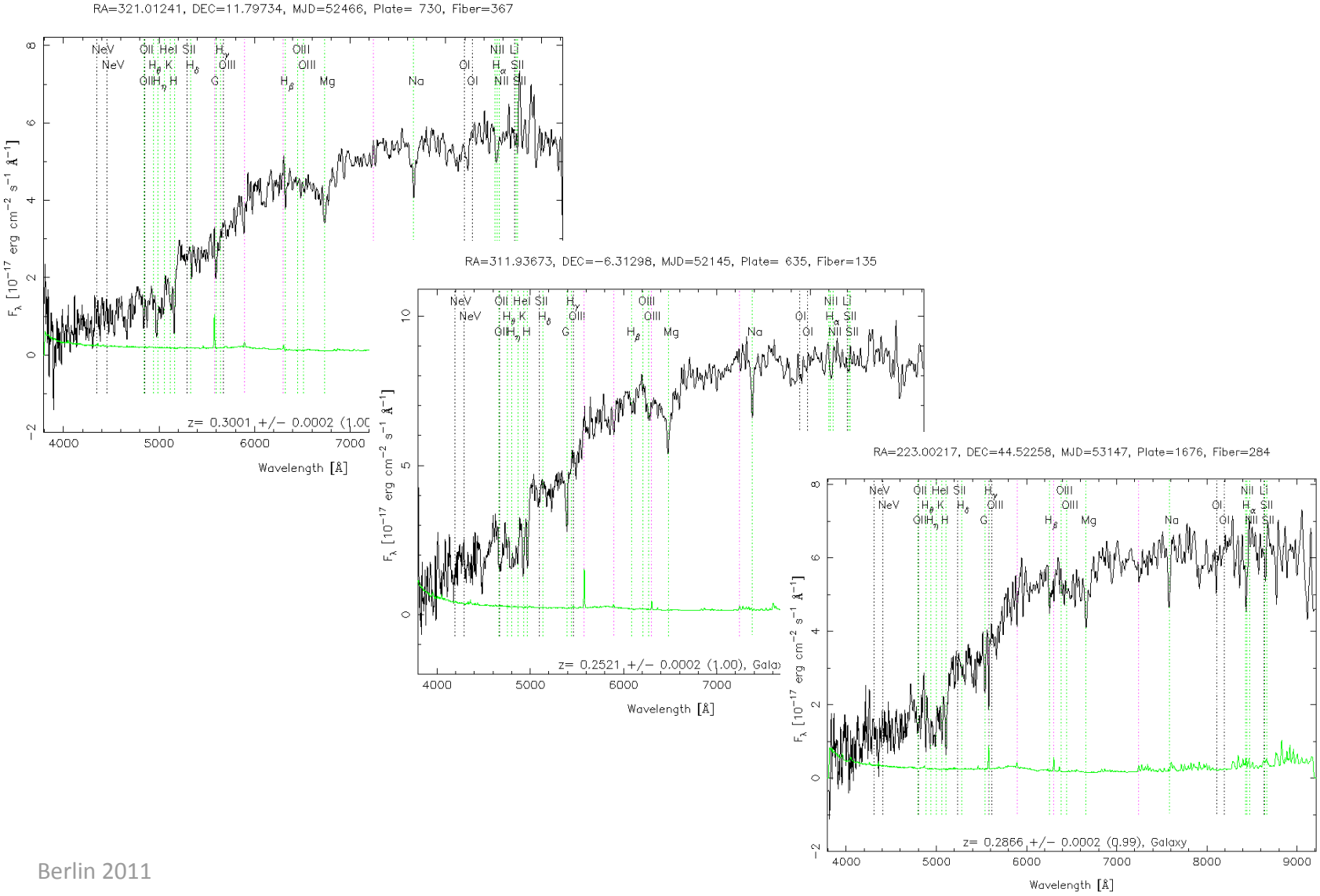
Bohringer *et al.* 2000

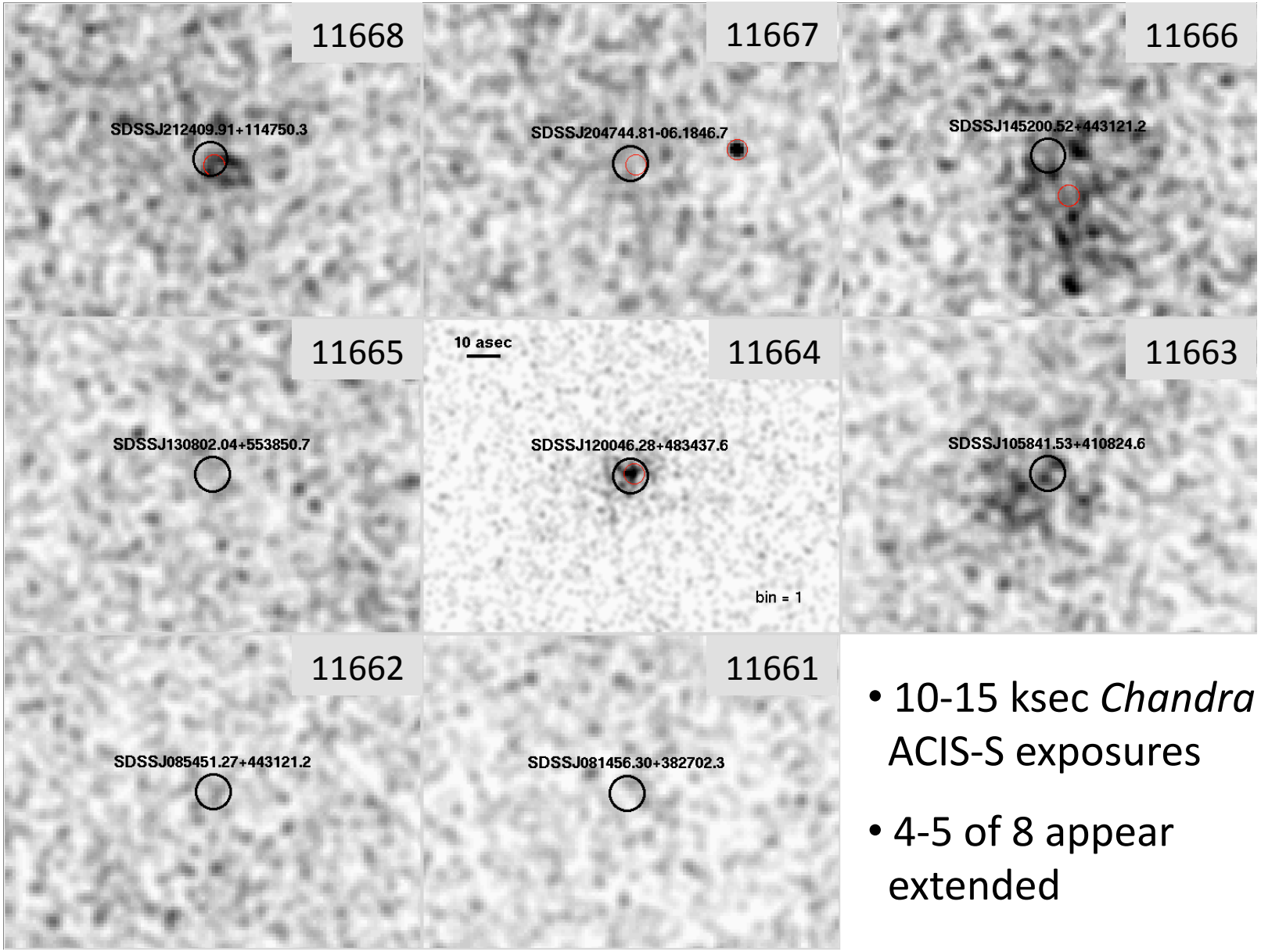


- Eliminate catalog matches
- RASS XBONG cands no more clustered than non-RASS passives

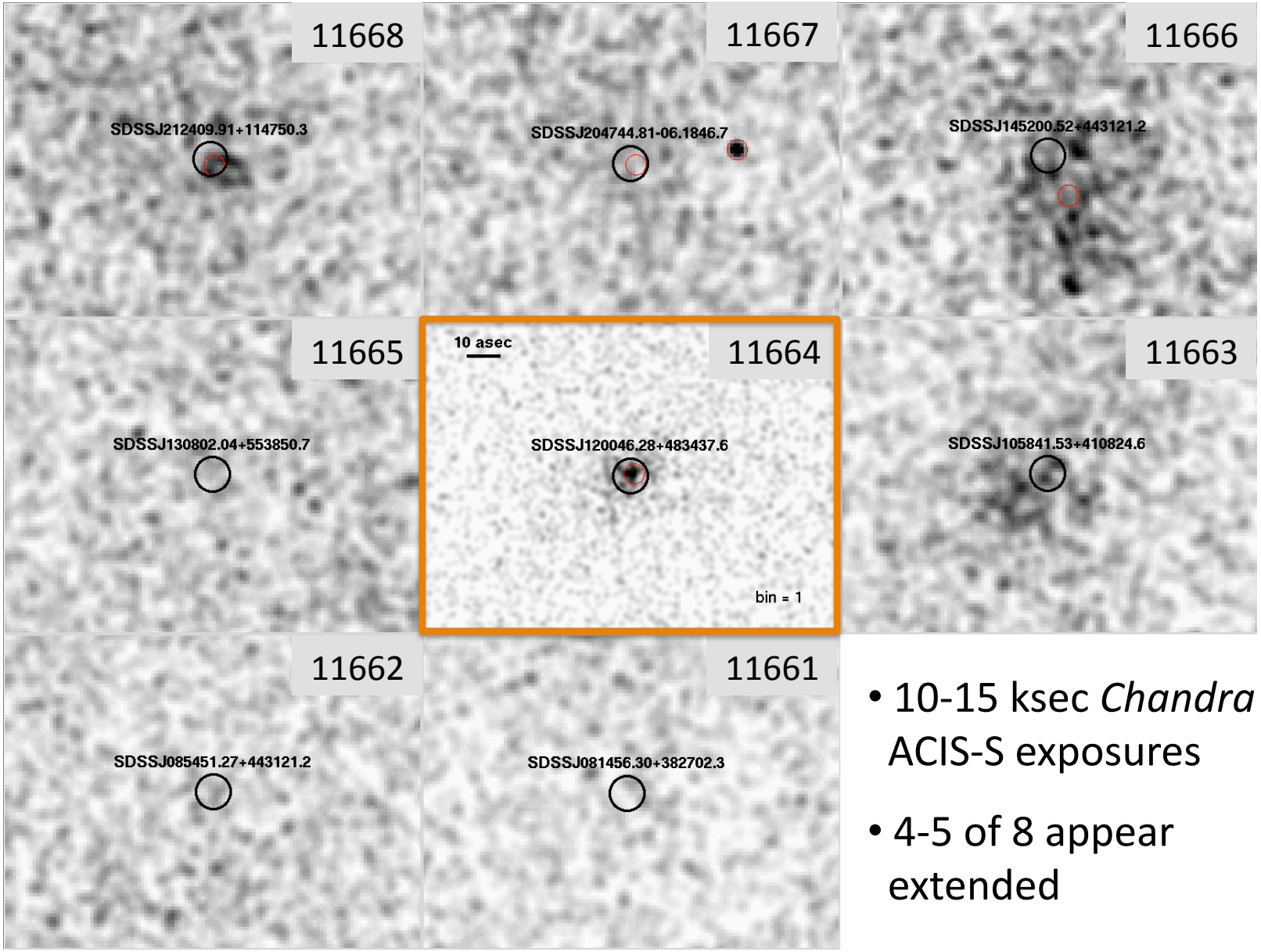
SDSS Imaging

SDSS Spectroscopy





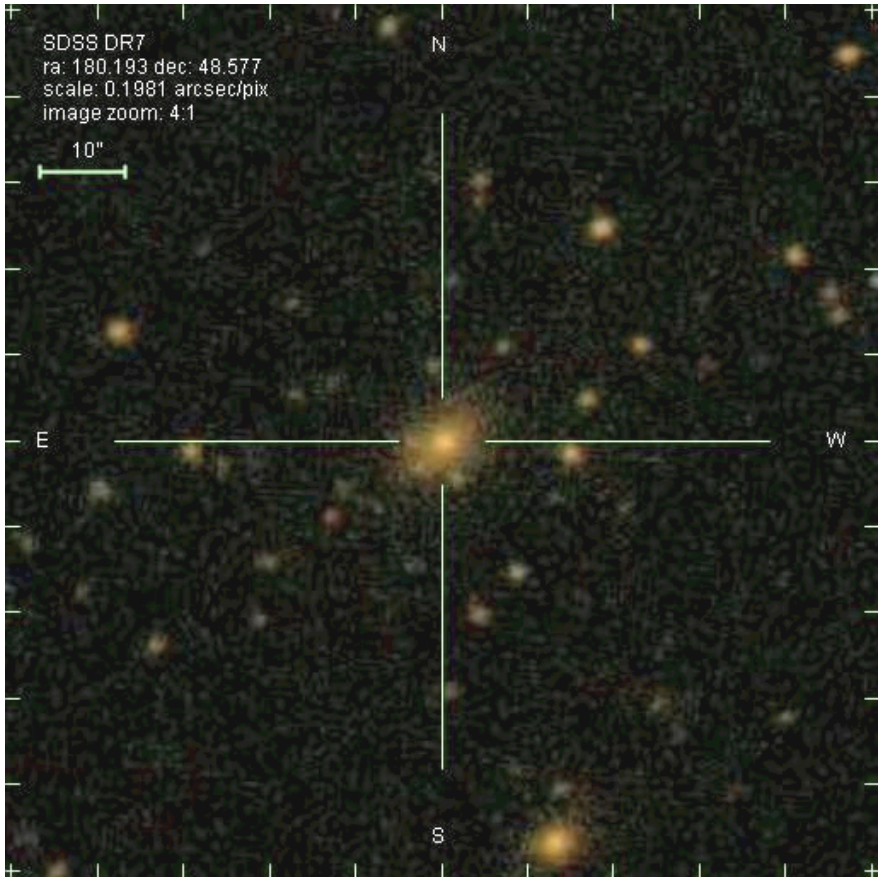
- 10-15 ksec *Chandra* ACIS-S exposures
- 4-5 of 8 appear extended

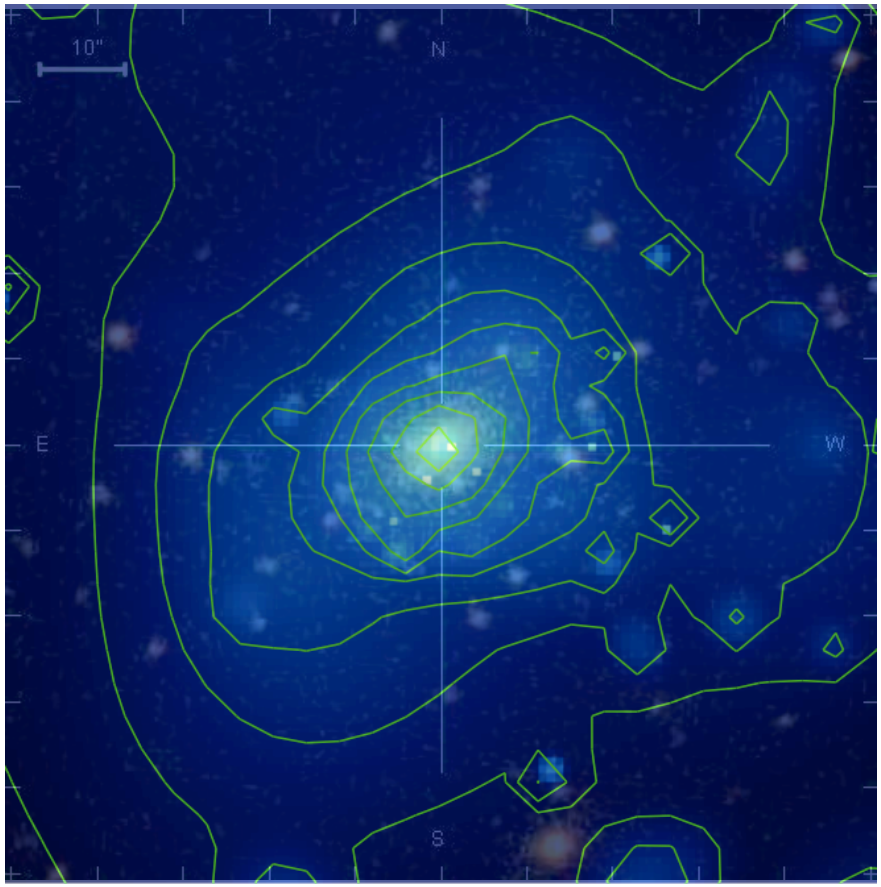


- 10-15 ksec *Chandra* ACIS-S exposures
- 4-5 of 8 appear extended

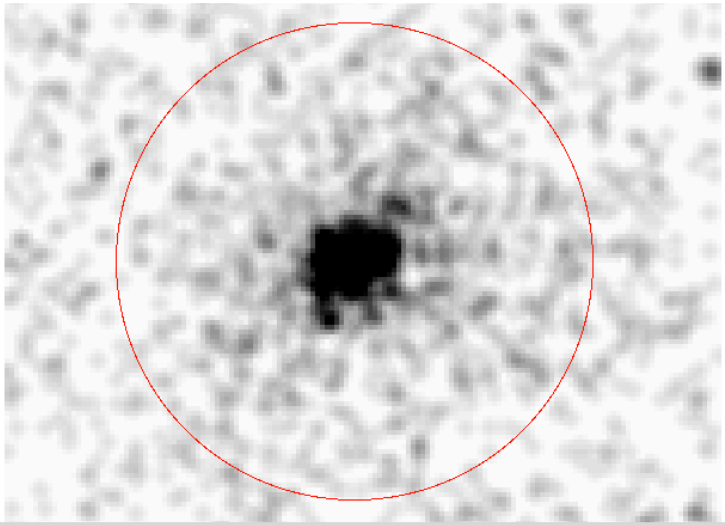
SDSS J1200+4834

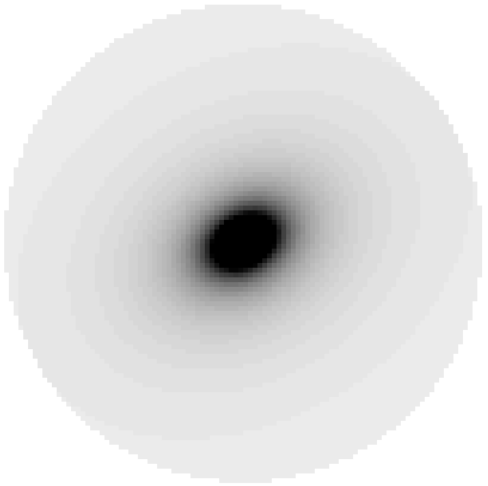
Extended hot gas!?

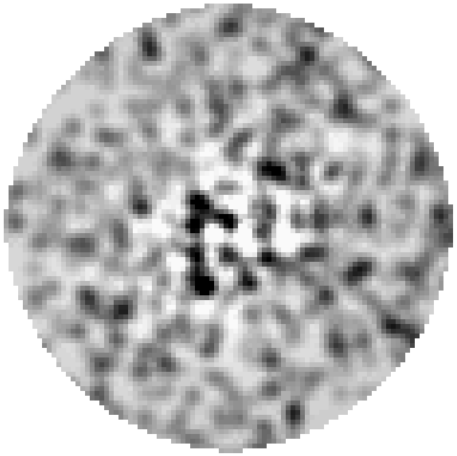




SDSS J1200+4834



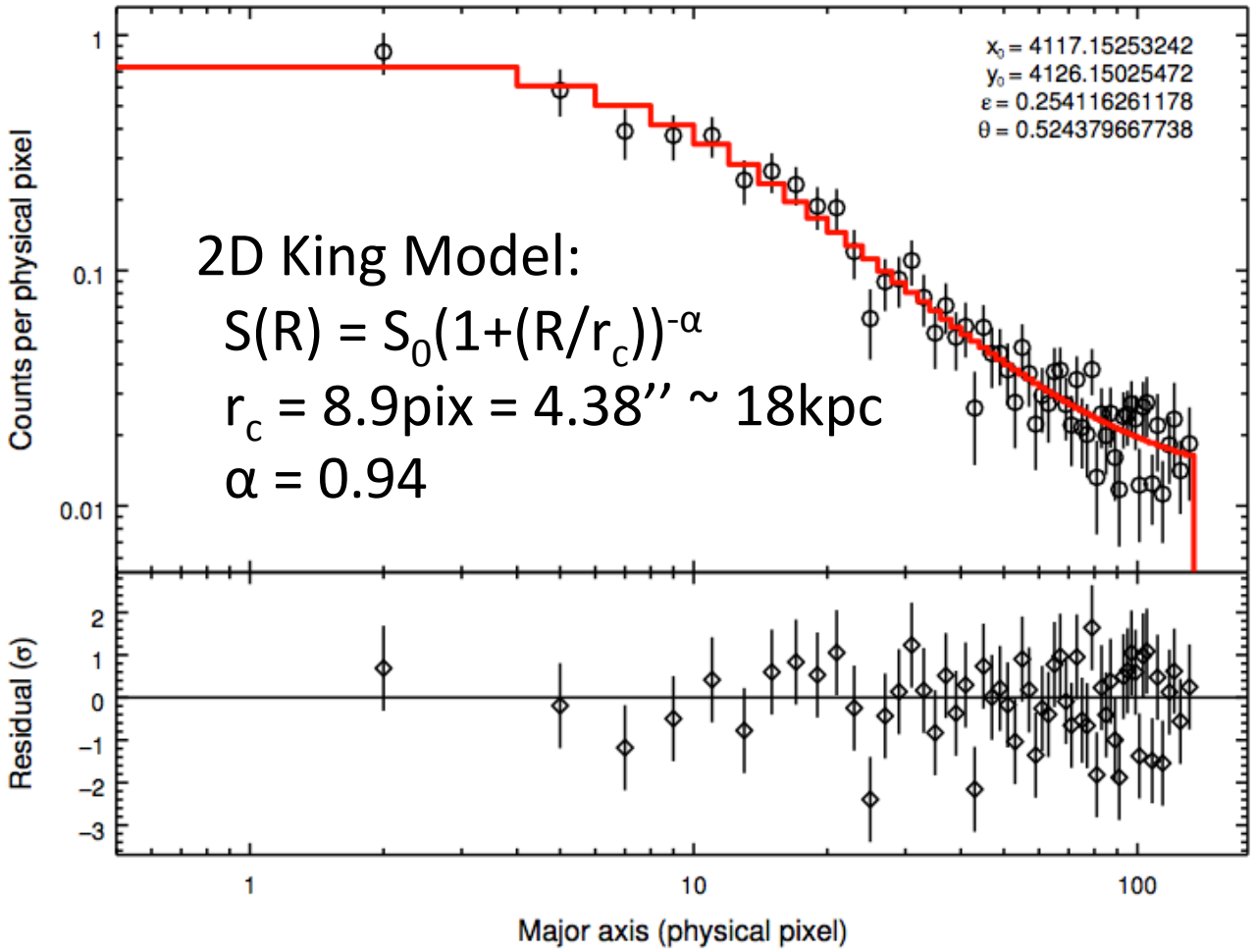




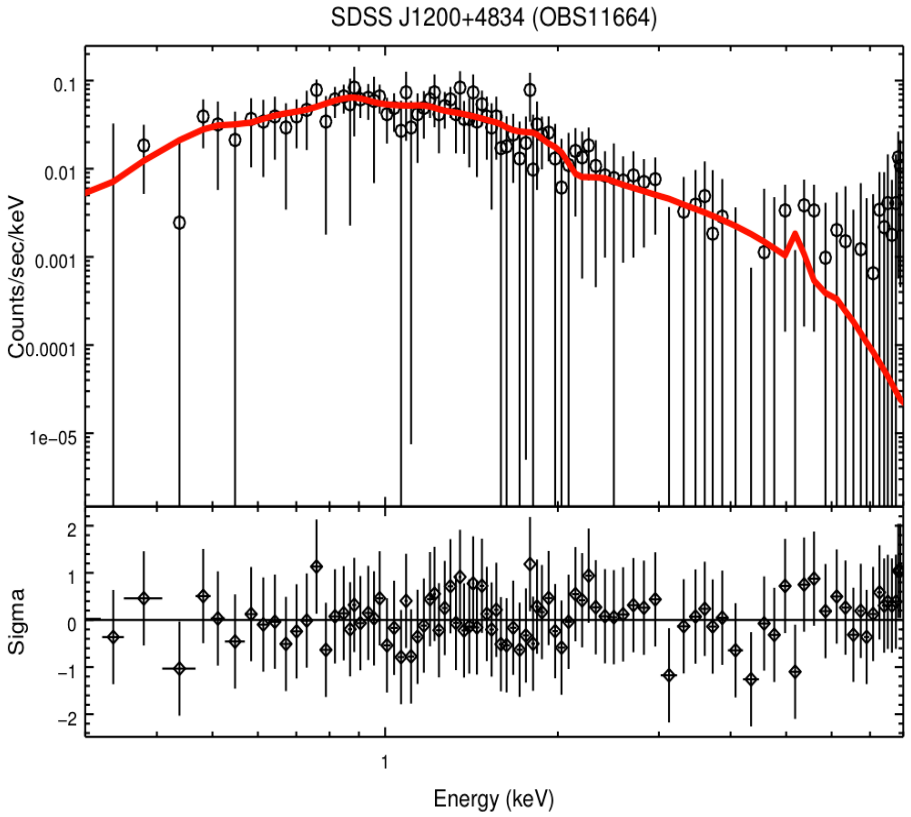
- Radial profile:
  - 2D King Model
  - radius of 150 pix ~70” (~$r_{500}/2$)

Sanderson *et al.* 2006

SDSS J1200+4834



SDSS1200+4834

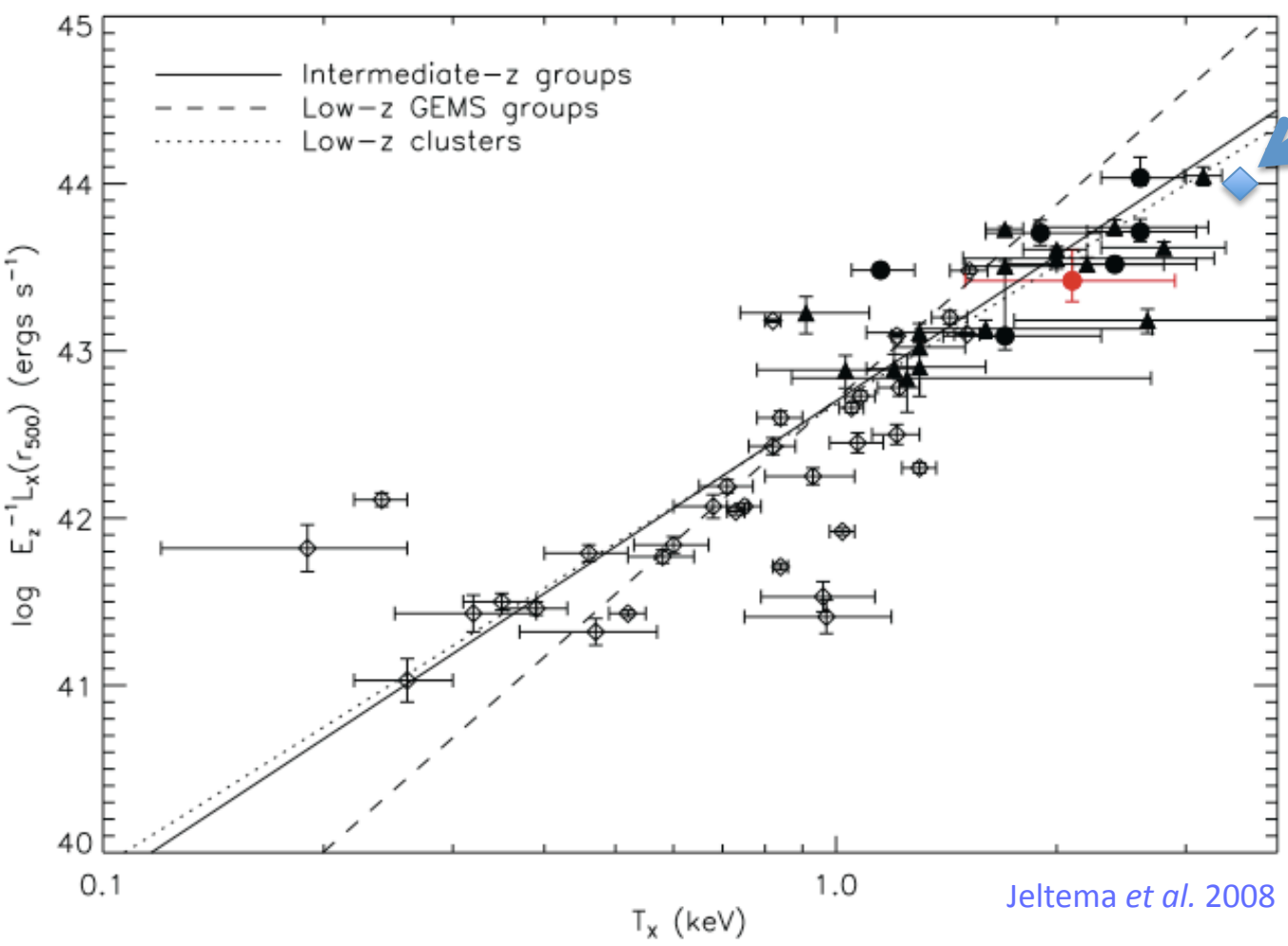


z = 0.2747

nH = 0.0256×10^{22} atm/cm^2

- Fit MEKAL model to X-ray spectrum
  - ~1100 counts
  - kT = 3.45 keV
  - Abund = 0.3174 solar
  - $f_{0.3\text{-}8keV}$ = 4.81×10^{-13} erg/s/cm^2
  - $L_{0.3\text{-}8keV}$ = 1.14×10^{44} erg/s

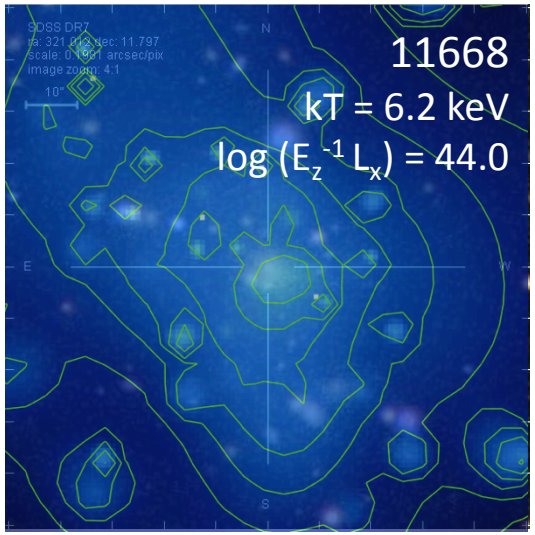
L_x-T_x Relation for Clusters/Groups

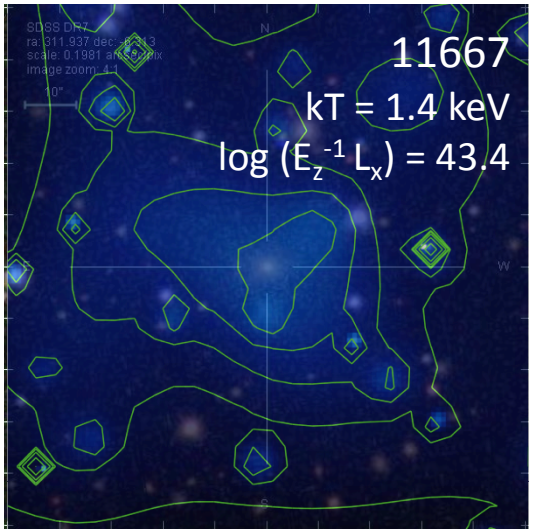


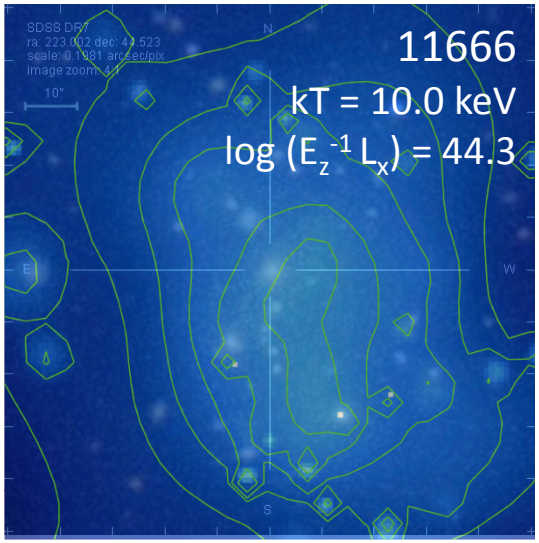
SDSS J1200

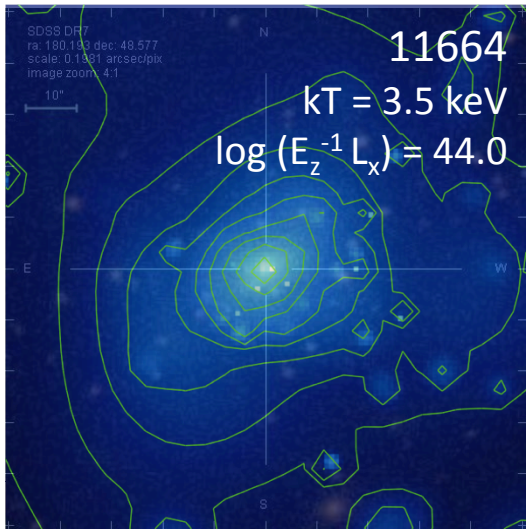
Jeltema *et al.* 2008

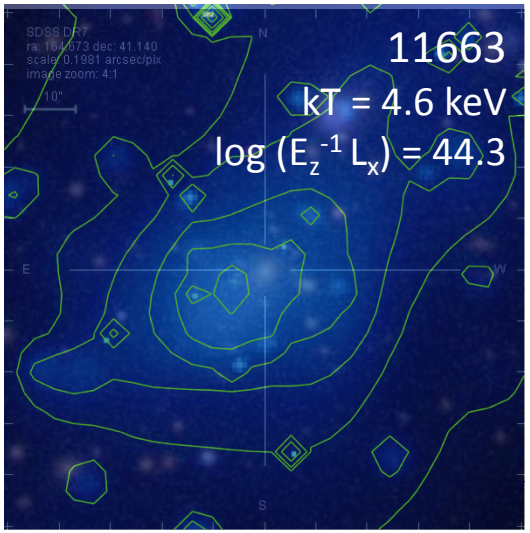
Extended X-ray Emission



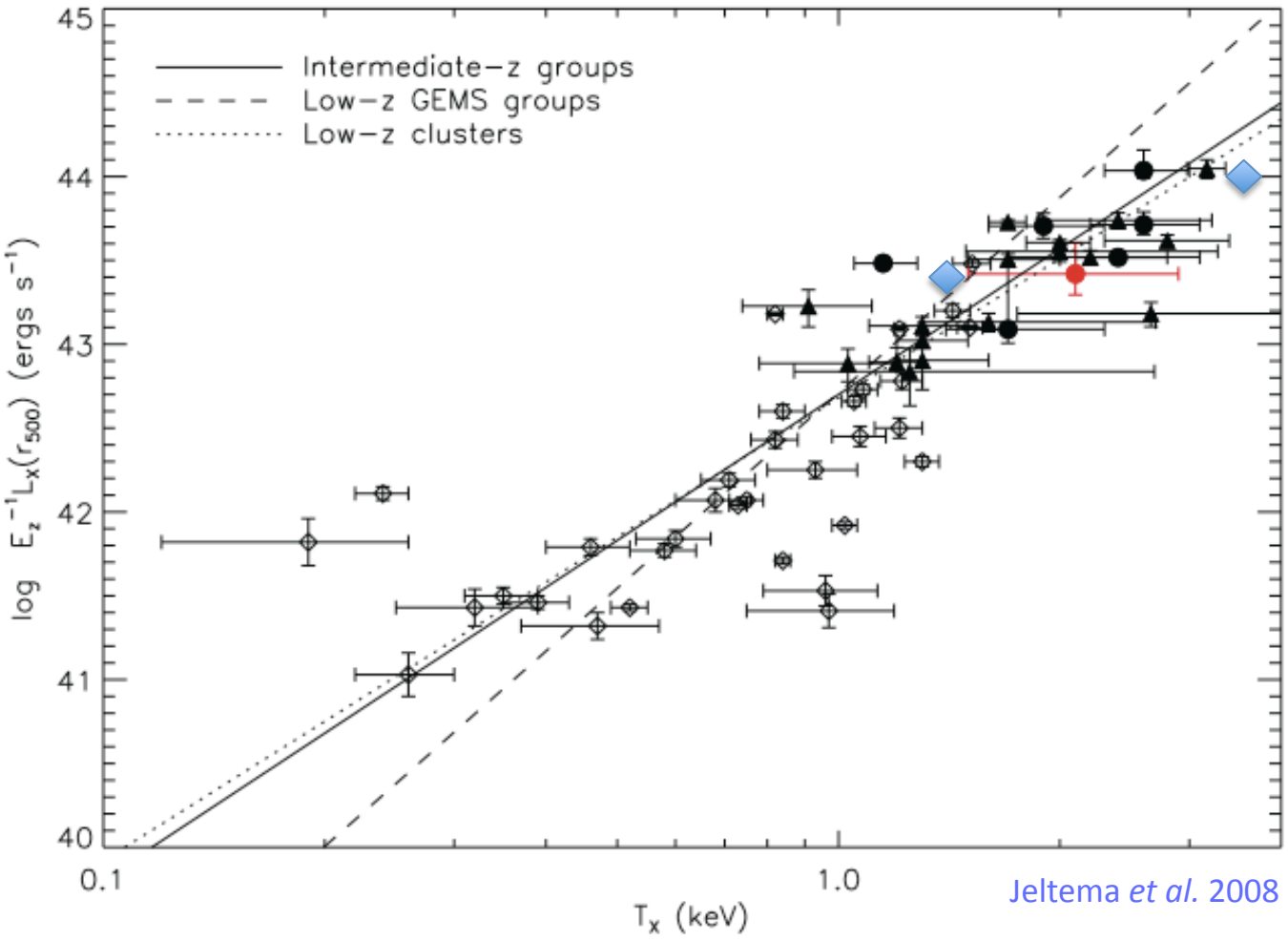






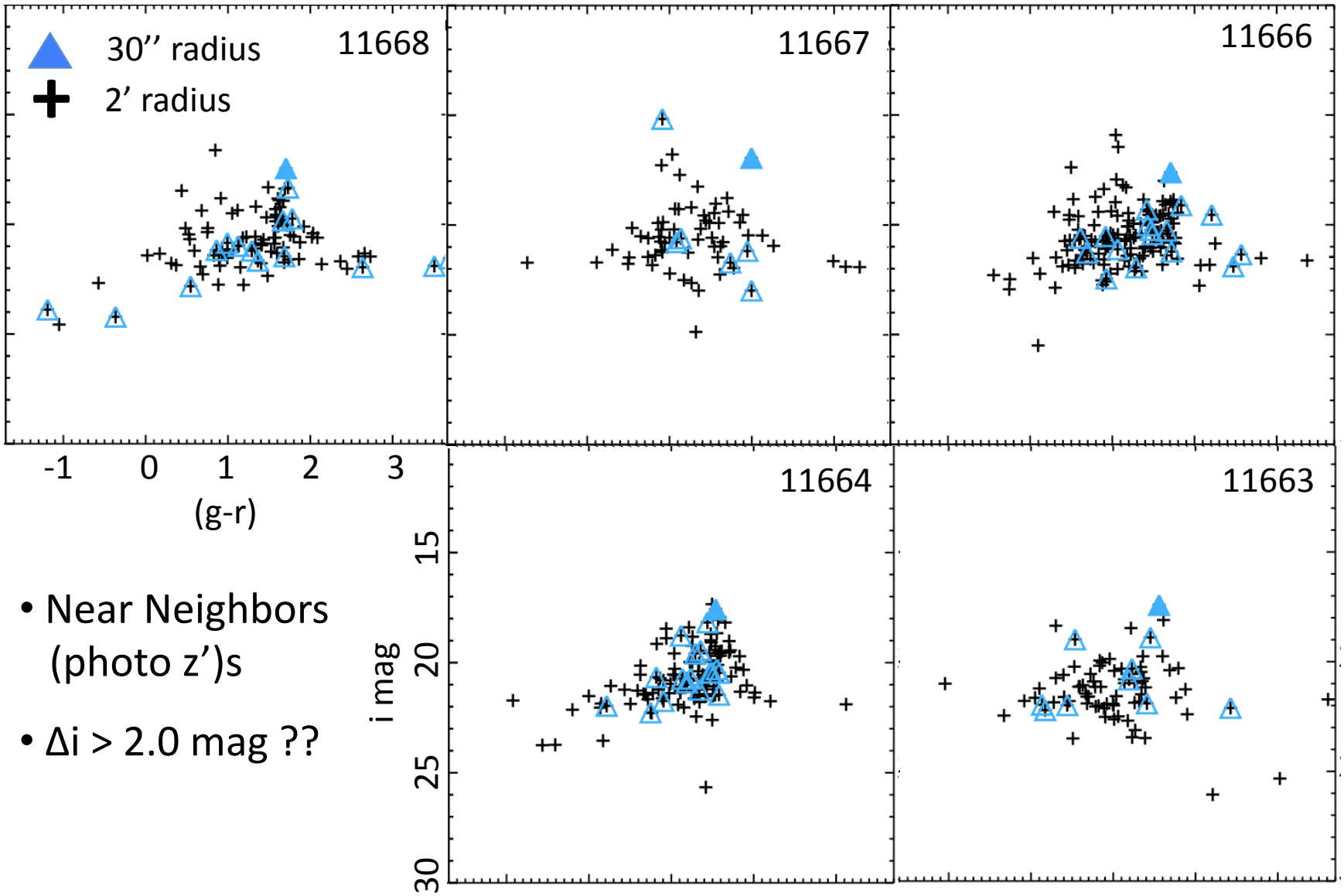


L_x-T_x Relation for Clusters/Groups



Jeltema *et al.* 2008

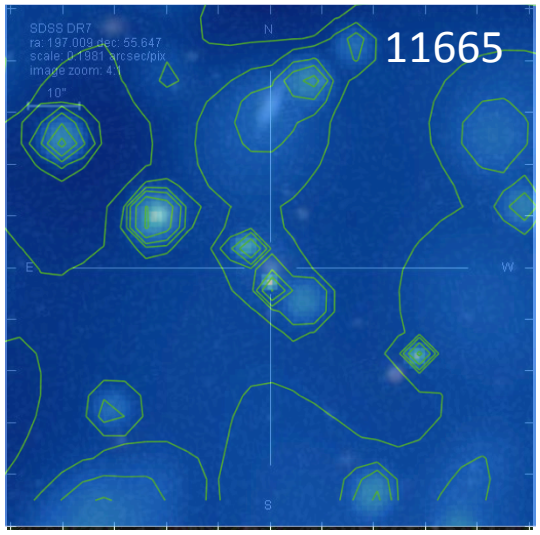
SDSS (g-r) vs. I CMD

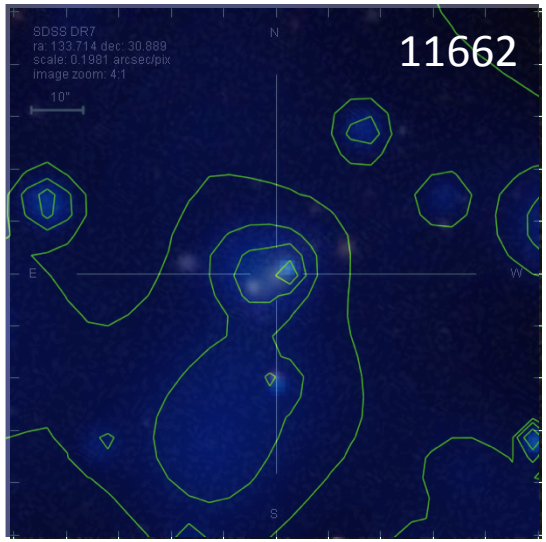


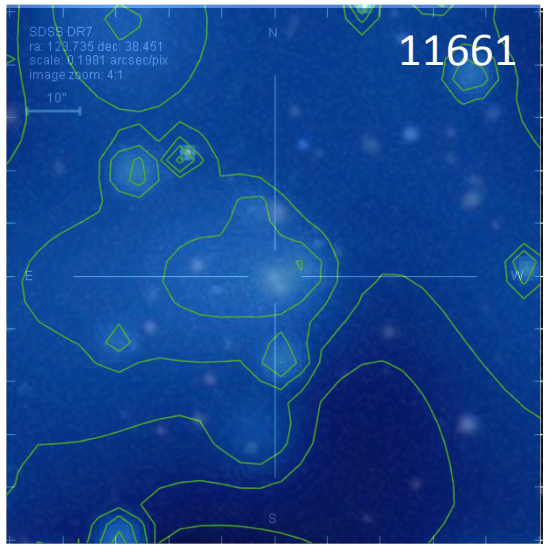
- Near Neighbors (photo z')s
- Δi > 2.0 mag ??

Point Sources/Marginal Detections

Radiatively Inefficient Accretion and/or X-ray Variables







… host dilution also possible.

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 or 5 extended in the X-ray
    - SDSS J1200+4834: radial profile and X-ray spectrum consistent with a (fossil?) group
  - 1 with point-like X-ray emission may be explained by RIAF or host dilution
  - 2 or 3 show no strong X-ray emission, possibly due to X-ray variability (tidal disruption events?)
- Need larger X-ray sample at low-z + high-quality redshifts to study environment