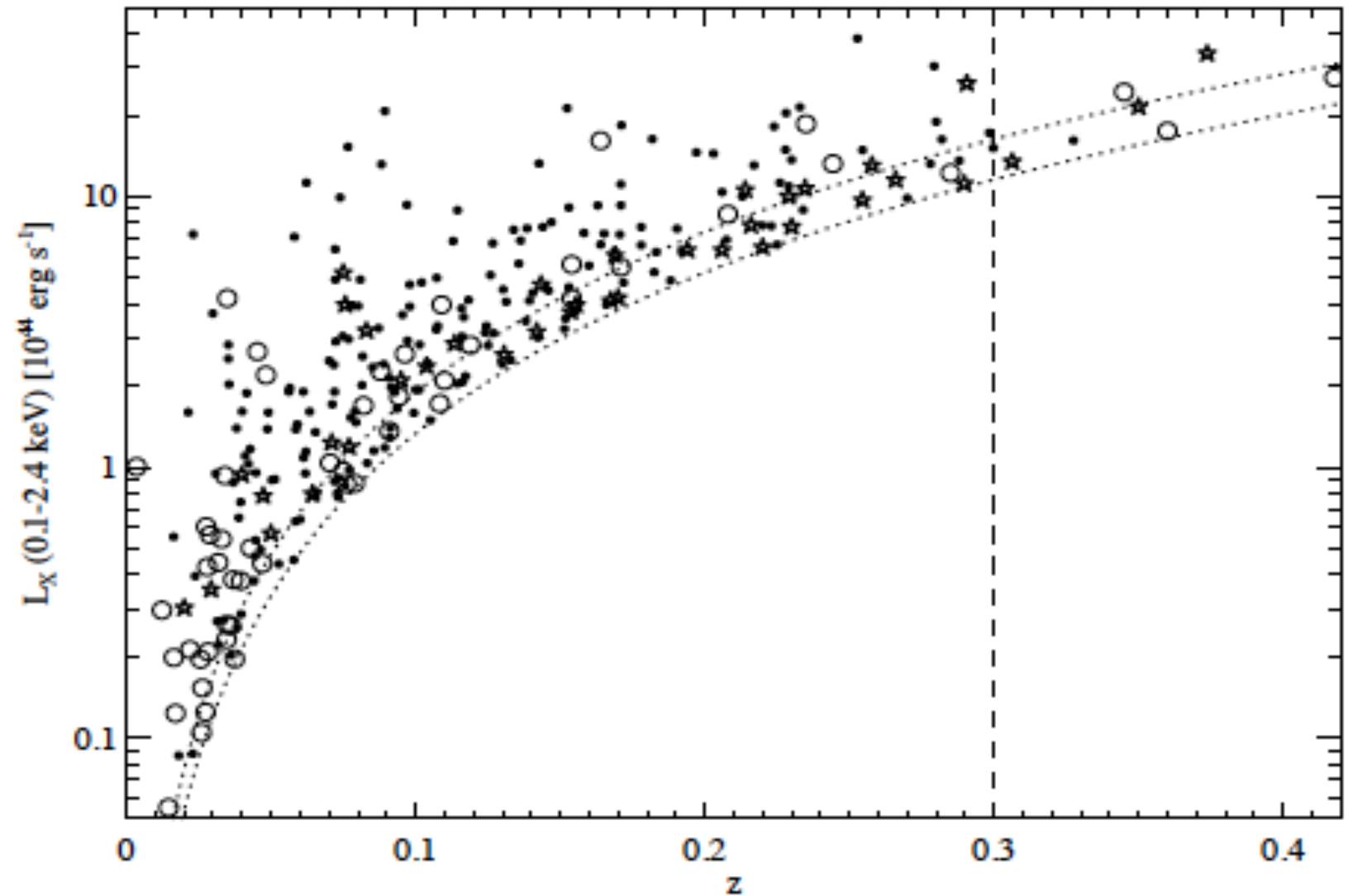


## The ROSAT Brightest Cluster Sample (Ebeling et al 1998)

Flux limited catalog of  
bright X-ray clusters (**N=206**)

(“Flux limited” means that to  
be included in the catalog,  
the cluster must have an X-  
ray flux that is above some  
detection minimum.)

X-ray Luminosity

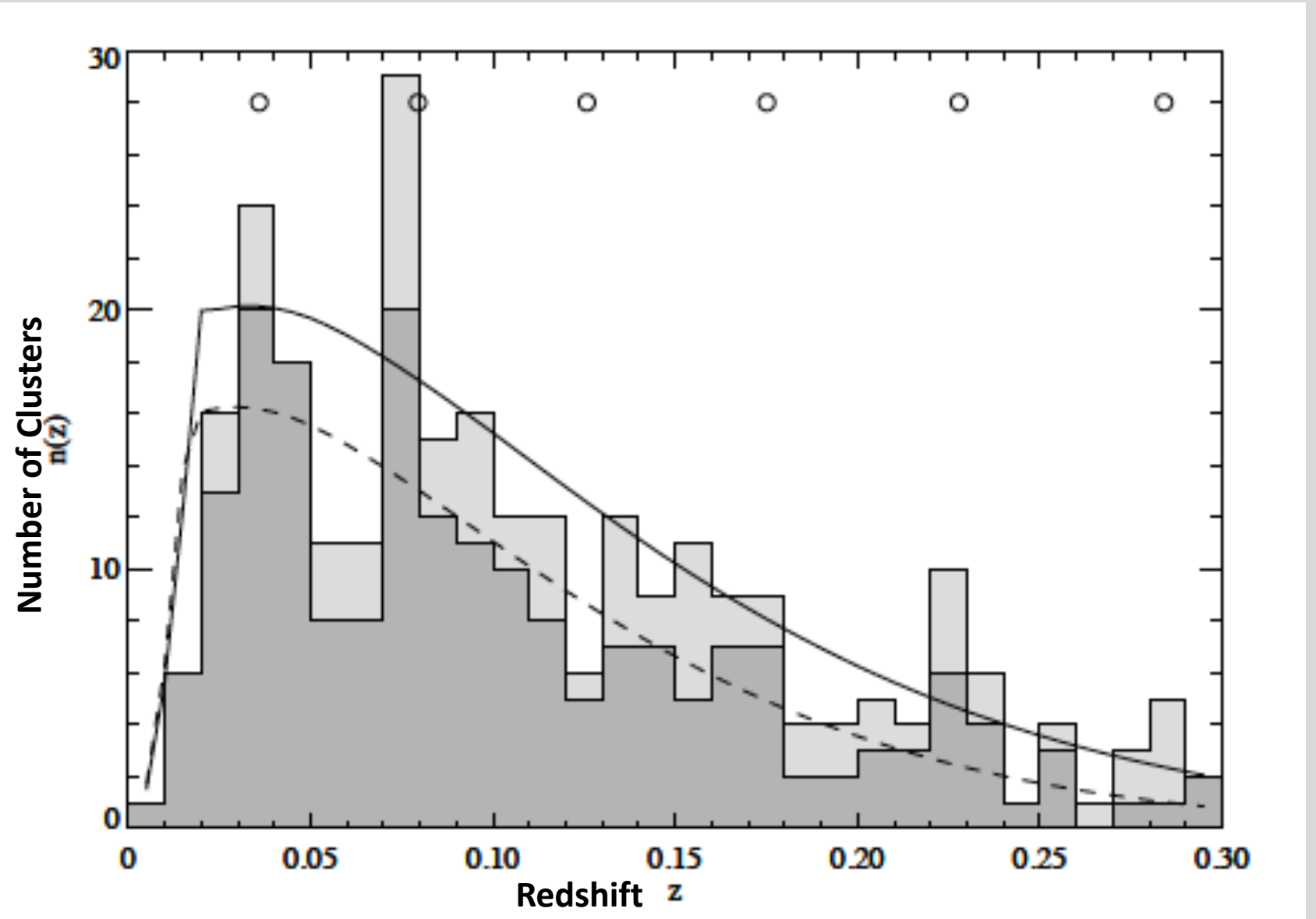


Redshift

## The ROSAT Brightest Cluster Sample (Ebeling et al 1998)

Flux limited catalog of  
bright X-ray clusters (**N=206**)

(“Flux limited” means that to  
be included in the catalog,  
the cluster must have an X-  
ray flux that is above some  
detection minimum.)

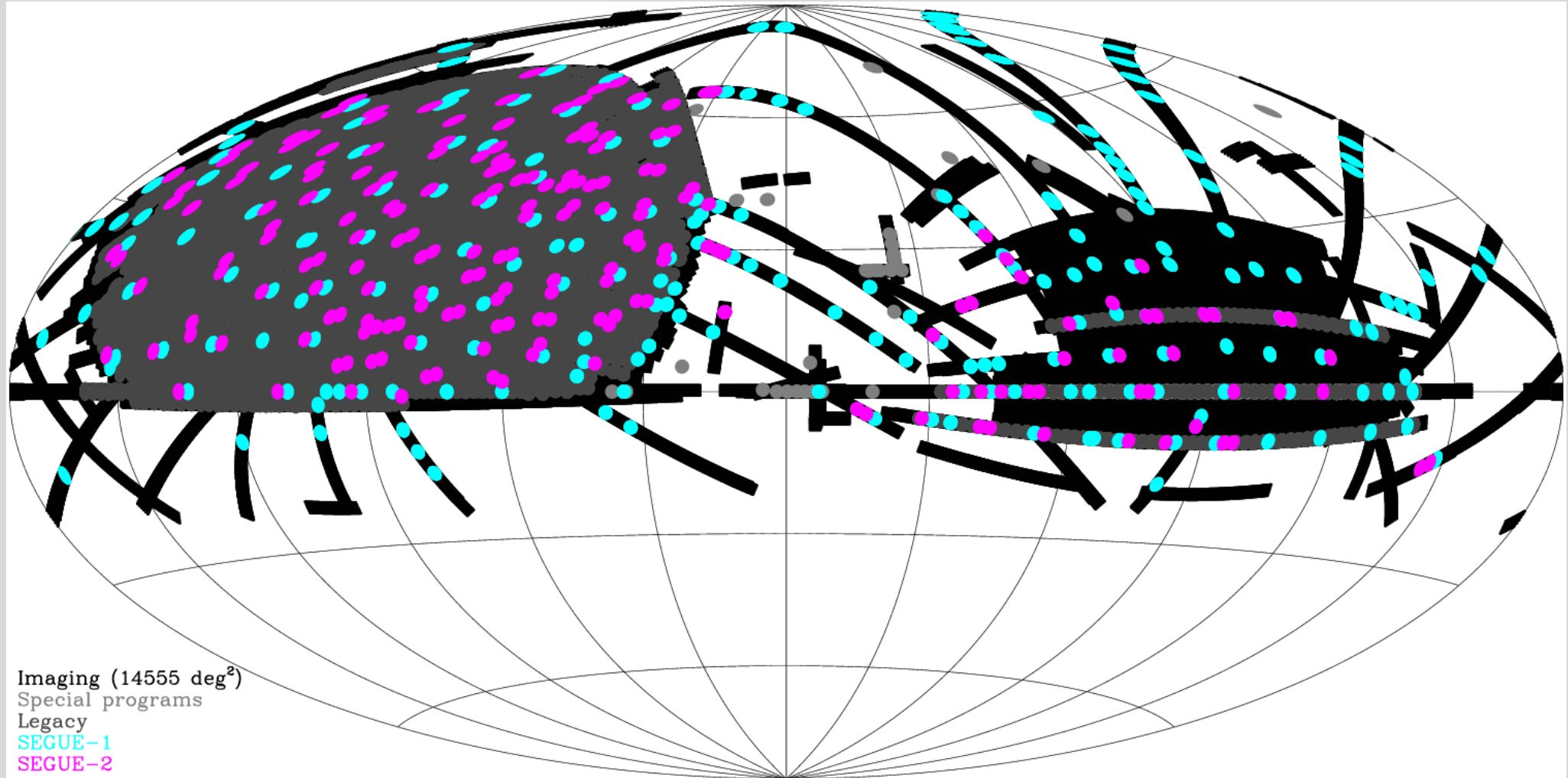


## Picking Clusters from the Rosat catalog

1: Sky position: must be in the SDSS survey area (“footprint”)

(N=206 → N=159)

All sky RA/dec map of SDSS coverage



## Picking Clusters from the Rosat catalog

2: Cluster properties: we want **massive clusters**.

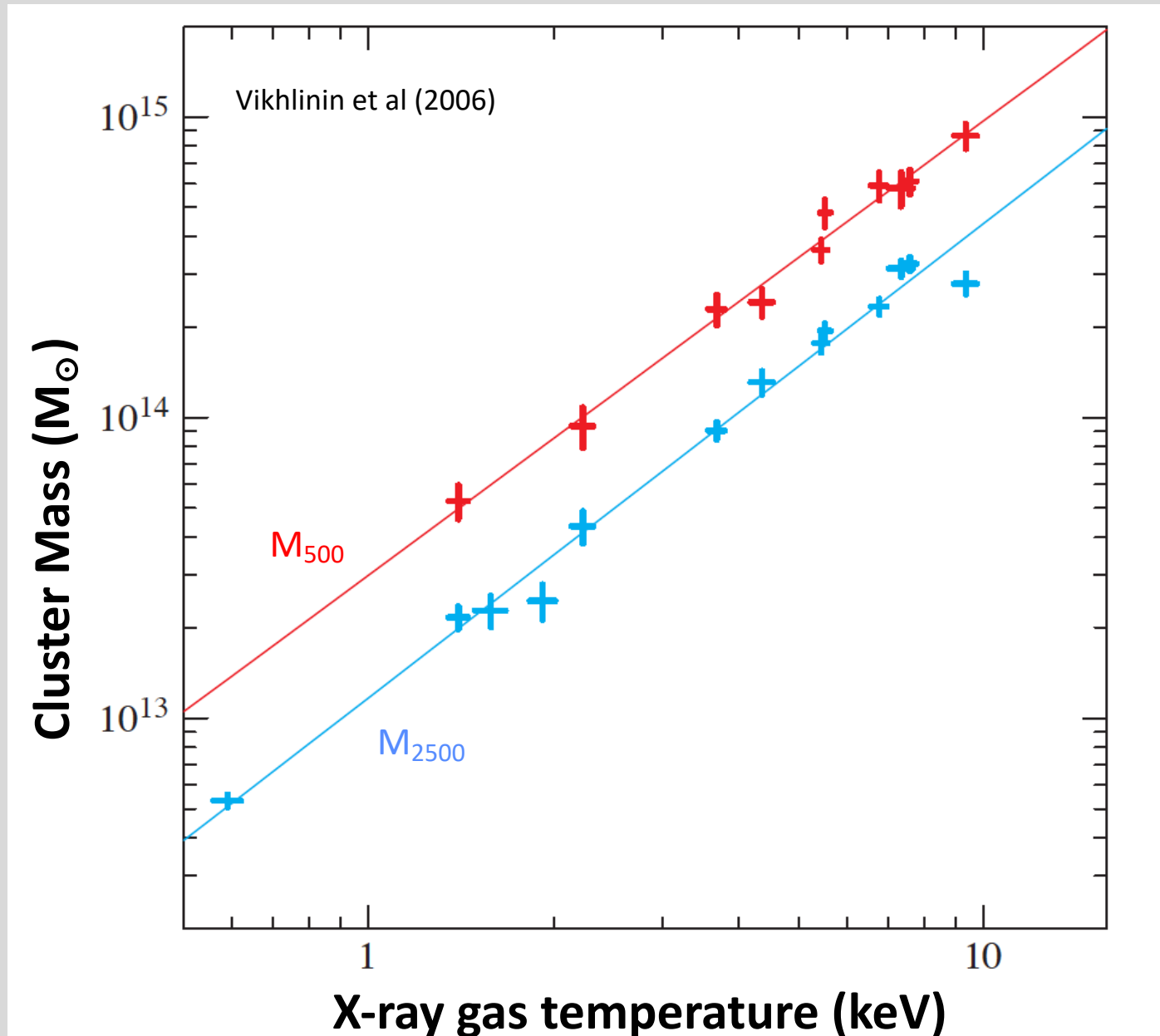
Look at relationship between cluster mass and cluster X-ray temperature. Massive clusters have hotter gas.

$M_N$  = cluster total mass contained within a radius with an density of N times the average density of the universe.

Let's select clusters with mass  $> 10^{14} M_{\text{sun}}$

$$kT > 4 \text{ keV}$$

$$(N=159 \rightarrow N=111)$$



## Picking Clusters from the Rosat catalog

### 3. Distance:

- We want them to fit on Chandra X-ray imager's field of view (array of four 8'x8' CCDs).

$$z > 0.035$$

- We want to understand their optical morphology and nuclear spectra.

(SDSS imaging resolution  $\sim 1''$  and fiber diameter  $\sim 3''$ )

$$z < 0.075$$

$$(N=111 \rightarrow N=14)$$

$D_A$ : angular size distance

$z$	$D_A$ (Mpc)	1 Mpc (arcmin)	1 arcsec (kpc)
0.025	102	34	0.5
0.035	142	24	0.7
0.05	199	17	1.0
0.075	290	12	1.4
0.1	376	8	1.8

The angular size of a 1 Mpc object

The physical size of a 1 arcsec pc object

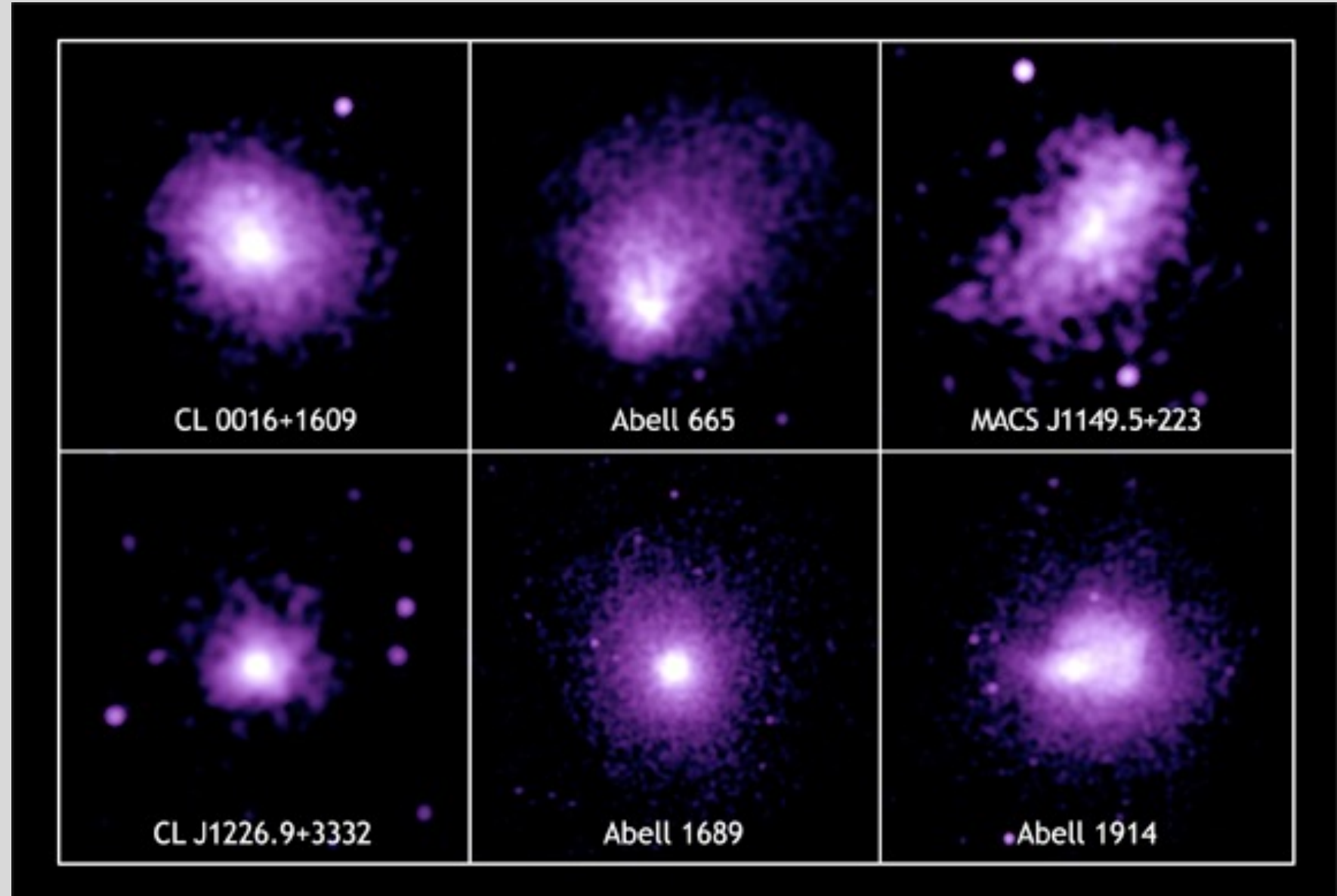
## Picking Clusters from the Rosat catalog

so far....

- SDSS footprint
- $kT > 4 \text{ keV}$
- $0.035 < z < 0.075$

4. There must be X-ray imaging data in the Chandra data archive!

Chandra ACIS pointings



# Final Cluster Targets

Cluster	RA (deg)	Dec (deg)
Abell 2065	230.62156	+27.70763
Abell 2063	230.77116	+08.60859
Abell 1795	207.21886	+26.59160

You will estimate the cluster redshift using data from the SDSS archive.

When calculating intrinsic properties of the cluster or the galaxies (physical sizes, luminosities, etc) remember that at these distances you must use the cosmologically correct luminosity distance ( $D_L$ ) and angular size distance ( $D_A$ ) to do the calculations.

```
from astropy.cosmology import Planck18 as cosmo
redshift = 0.05 # or whatever
DL = cosmo.luminosity_distance(redshift)          # in Mpc
DA = cosmo.angular_diameter_distance(redshift)    # in Mpc
absmag = appmag - 5*np.log10(DL.value*1E6) + 5    # remember magnitude equation needs distance in parsecs!
r_phys = r_arcsec * DA.value / 206265.           # physical size will be in whatever units DA is in
```