X-Ray selected Superclusters derived from the REFLEX Cluster Sample

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Outline

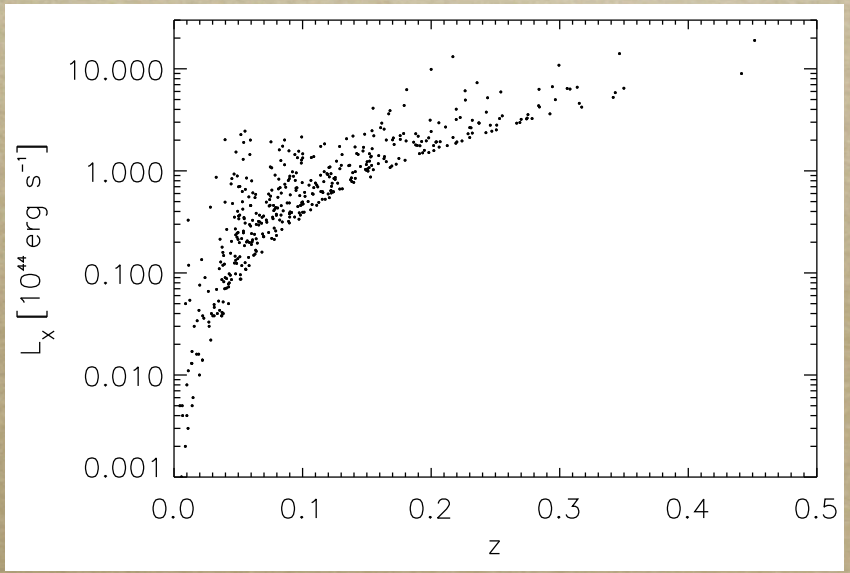
- Construction of a supercluster catalogue based on a complete and homogeneous sample of X-ray clusters
- Comparison of cluster properties, in particular the X-ray luminosity of field clusters and supercluster members

Motivation

- First supercluster catalogue based on a complete and homogeneously selected sample of X-ray clusters
- Analysing the physics of superclusters: Are superclusters astrophysical objects? Do the properties of clusters in SC differ from clusters in the field?

The Sample

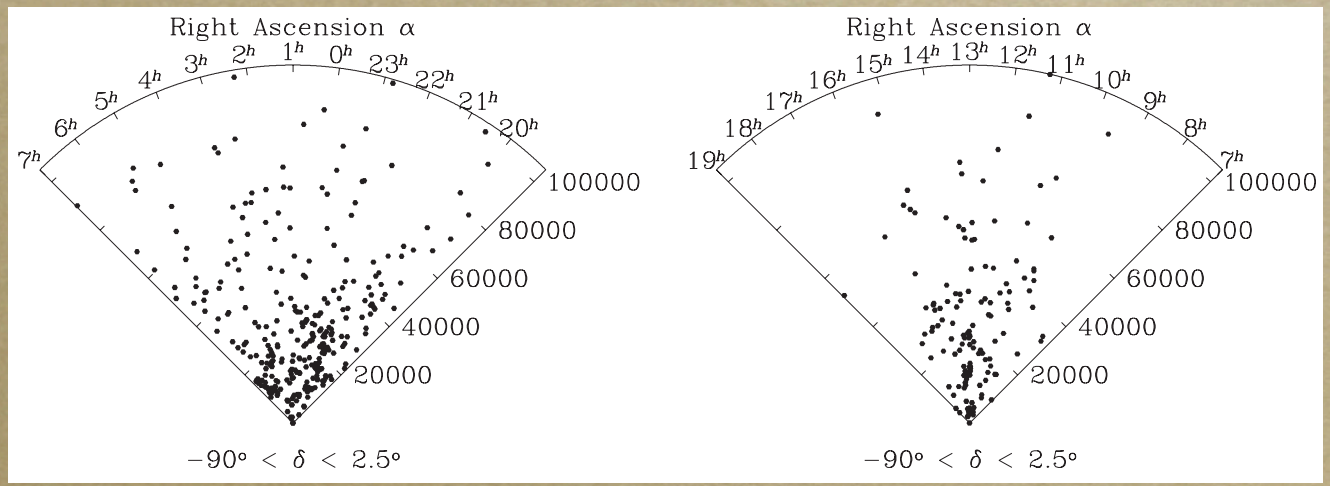
- REFLEX: 448 clusters at z<0.5 with a flux limit of
  $f_X \geq 3.0 \times 10^{-12}\,\mathrm{erg\,s^{-1}\,cm^{-2}}\,(0.1\text{–}2.4\,\mathrm{keV})$
- Selection by mass
- Easier background subtraction
- Projection effects less important



The Supercluster Catalogue

I. Construction

- First SC catalogue based on X-ray selected cluster sample
- Method of selection: Friends-of-friends algorithm with varying linking length (cf. Zucca et al. 1993)

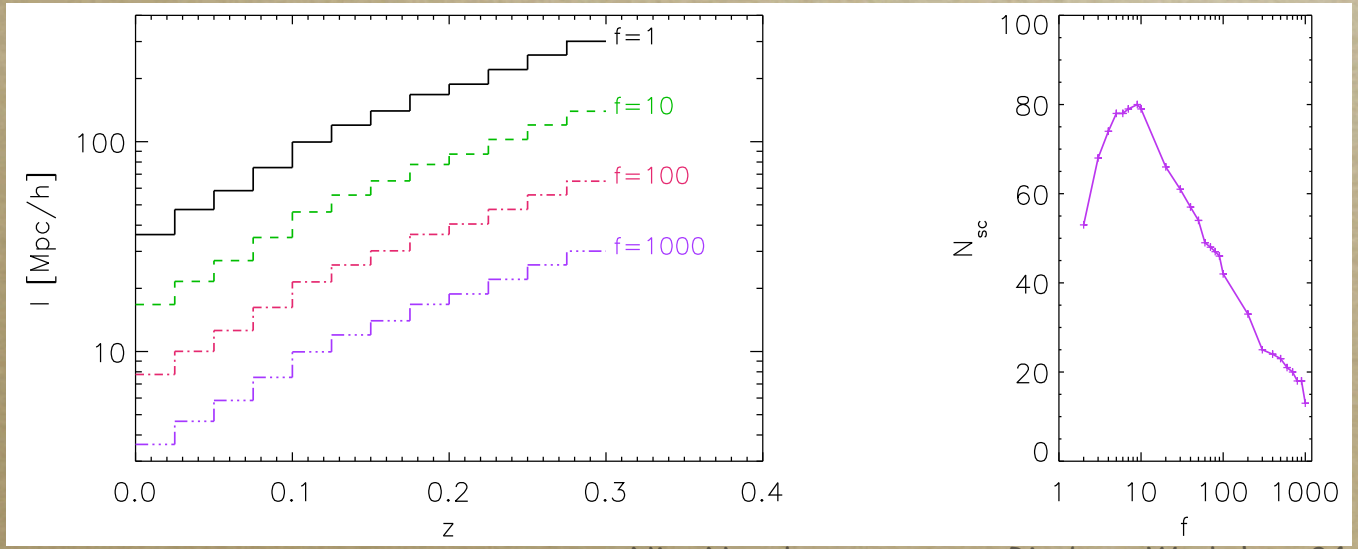


Schuecker et al. 2001

The Supercluster Catalogue

I. Construction

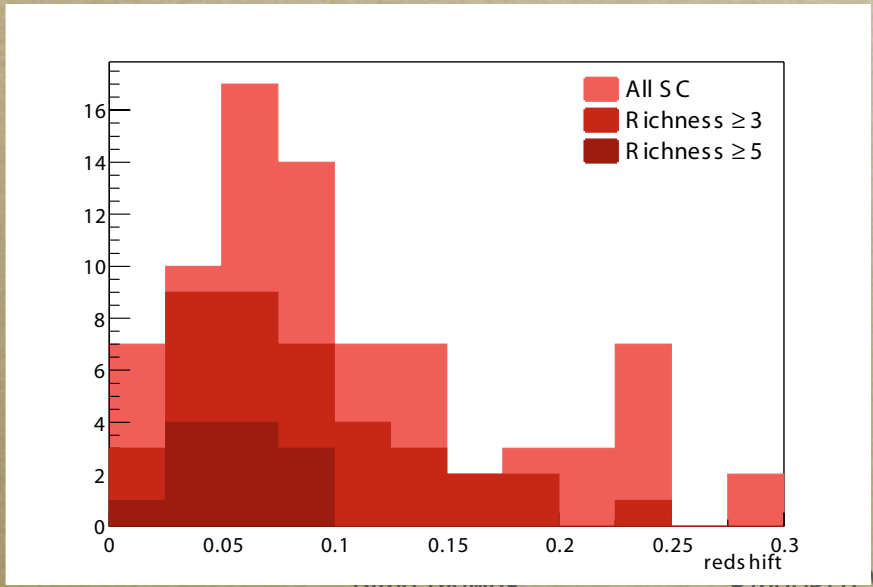
- overdensity $f = \dfrac{n}{n_0}$
- linking length $l = (n_0 f)^{-1/3}$
- $f = 10$ chosen as reference overdensity



The Supercluster Catalogue

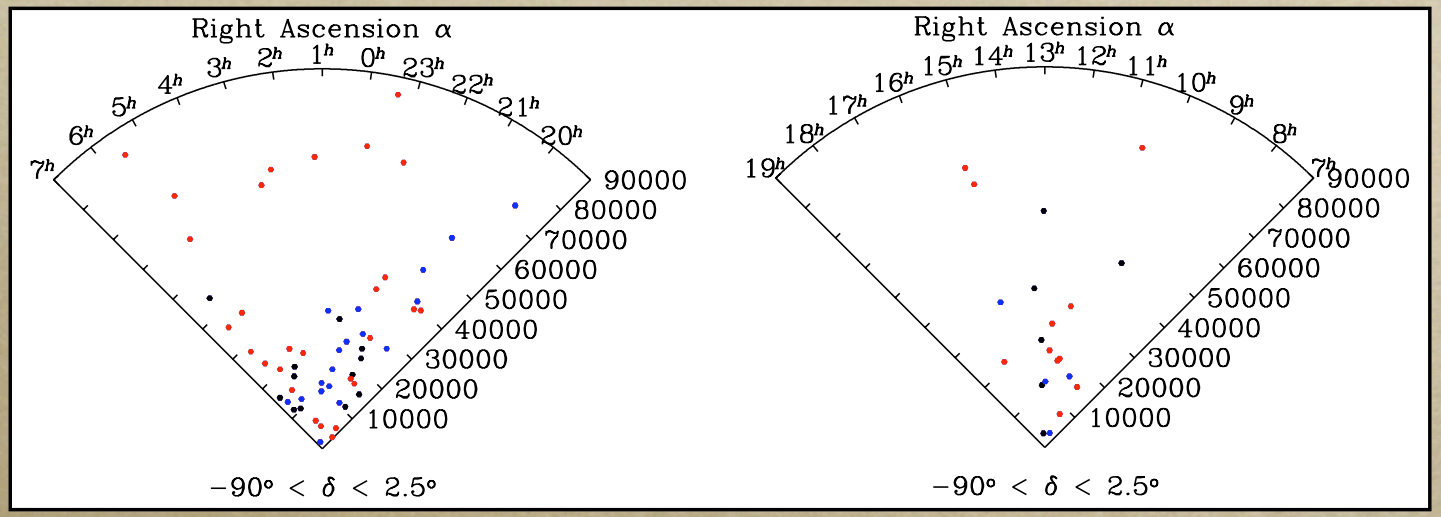
II. The Catalogue

- 79 superclusters at z<0.3
- about half of the superclusters known
- rich superclusters only at z<0.1



SC	Redshift	R	Name
RXSCJ0001-2806	0.0632	3	Pisces-Cetus
RXSCJ0009-3435	0.0496	3	
RXSCJ0040-2714	0.1091	3	Sculptor
RXSCJ0104-1251	0.0519	3	Pisces-Cetus
RXSCJ0107+0026	0.0453	3	Pisces-Cetus
RXSCJ0112-2549	0.2305	2	
RXSCJ0126+0011	0.0178	2	
RXSCJ0223-4012	0.2241	2	
RXSCJ0230-3319	0.0770	2	
RXSCJ0242-0001	0.0227	2	
RXSCJ0244-2400	0.2135	2	
RXSCJ0304-2236	0.0054	3	
RXSCJ0325-5427	0.0830	2	
RXSCJ0328-4335	0.0683	5	Horologium-Reticulum
RXSCJ0349-5541	0.0612	5	Horologium-Reticulum
RXSCJ0401-5436	0.0424	3	
RXSCJ0437-3823	0.0521	2	
RXSCJ0444-2117	0.0709	2	
RXSCJ0445-1300	0.0360	5	
RXSCJ0502-0908	0.2312	2	
RXSCJ0505-0044	0.1246	2	
RXSCJ0518-4617	0.1956	2	
RXSCJ0531-4206	0.0810	2	
RXSCJ0531-3815	0.2793	2	
RXSCJ0548-3113	0.0380	6	Lepus
RXSCJ0551-3756	0.0458	3	
RXSCJ0551-2129	0.0951	2	
RXSCJ0555-3410	0.1483	4	
RXSCJ0601-4752	0.1210	2	
RXSCJ0617-5219	0.0522	6	
RXSCJ0914-1053	0.0540	2	
RXSCJ0946-1810	0.0288	2	
RXSCJ0958-1054	0.1574	4	
RXSCJ1024-2033	0.0120	3	
RXSCJ1026-0838	0.0593	3	Sextans
RXSCJ1035-2626	0.2484	2	
RXSCJ1136-1326	0.1132	2	
RXSCJ1143-1455	0.0709	2	
RXSCJ1153-3255	0.0691	2	
RXSCJ1232-1237	0.0978	2	
RXSCJ1237-3443	0.0766	2	
RXSCJ1255-1509	0.0520	3	Shapley
RXSCJ1302-0427	0.1865	4	
RXSCJ1314-0202	0.0848	8	
RXSCJ1320-3237	0.0491	18	Shapley
RXSCJ1330-2435	0.1256	4	
RXSCJ1340-2130	0.0111	11	Hydra-Centaurus
RXSCJ1500-0419	0.2147	2	
RXSCJ1507-1647	0.2291	2	
RXSCJ1515-0047	0.1195	3	
RXSCJ1622-8253	0.0745	2	
RXSCJ1929-5552	0.0120	2	
RXSCJ1952-5126	0.2452	3	
RXSCJ2015-8043	0.1341	2	
RXSCJ2025-5132	0.0518	9	
RXSCJ2027-3308	0.0195	2	
RXSCJ2033-3501	0.1318	2	
RXSCJ2037-5446	0.1384	3	
RXSCJ2037-3549	0.0940	3	Microscopium
RXSCJ2047-2240	0.1956	3	
RXSCJ2104-4022	0.1622	3	
RXSCJ2109-2507	0.0378	5	
RXSCJ2129-7321	0.0573	2	
RXSCJ2152-1938	0.0953	2	
RXSCJ2153-5622	0.0776	6	
RXSCJ2201-2132	0.0632	4	Aquarius-Cetus
RXSCJ2202-0642	0.0597	2	Aquarius-Cetus
RXSCJ2206-0811	0.0850	11	Aquarius B
RXSCJ2215-5736	0.0387	3	
RXSCJ2218-3719	0.1441	2	
RXSCJ2223-6311	0.0961	3	
RXSCJ2230-1848	0.1330	2	
RXSCJ2253-3255	0.2350	2	
RXSCJ2304-1743	0.1138	3	
RXSCJ2317-2146	0.0867	3	
RXSCJ2323-0057	0.2859	2	
RXSCJ2341-0858	0.0789	3	
RXSCJ2352-0733	0.2415	2	
RXSCJ2359-3628	0.1033	4	

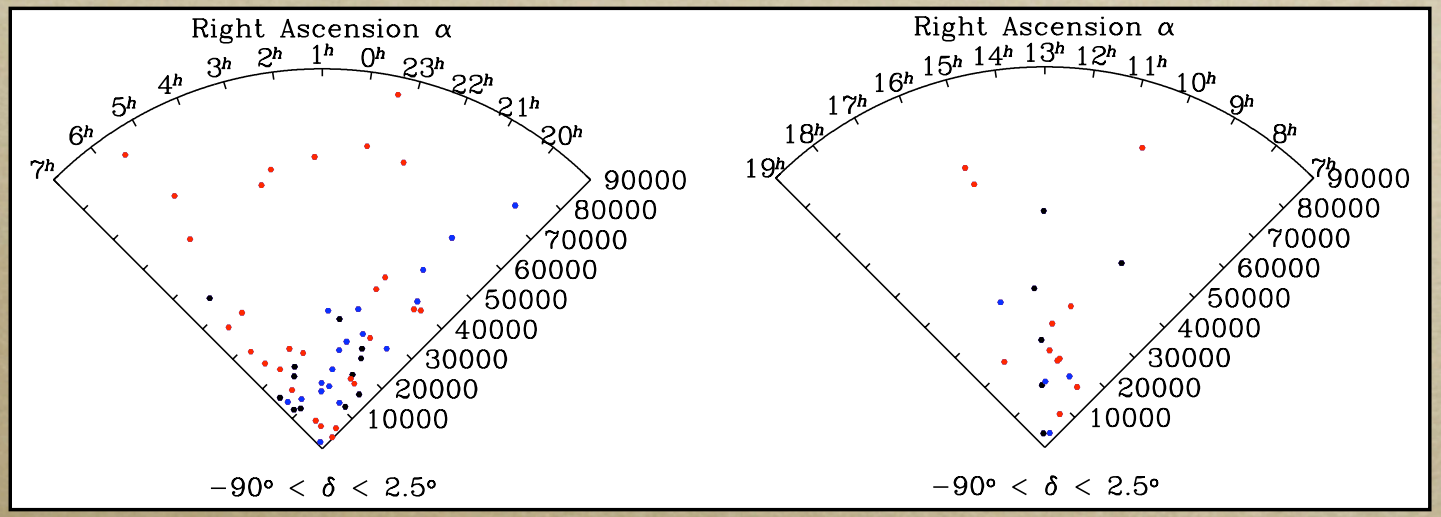
Spatial Distribution



- Large underdense region between z=0.15 and z=0.225. Real or statistical effect?
- Inhomogeneous distribution also at low z

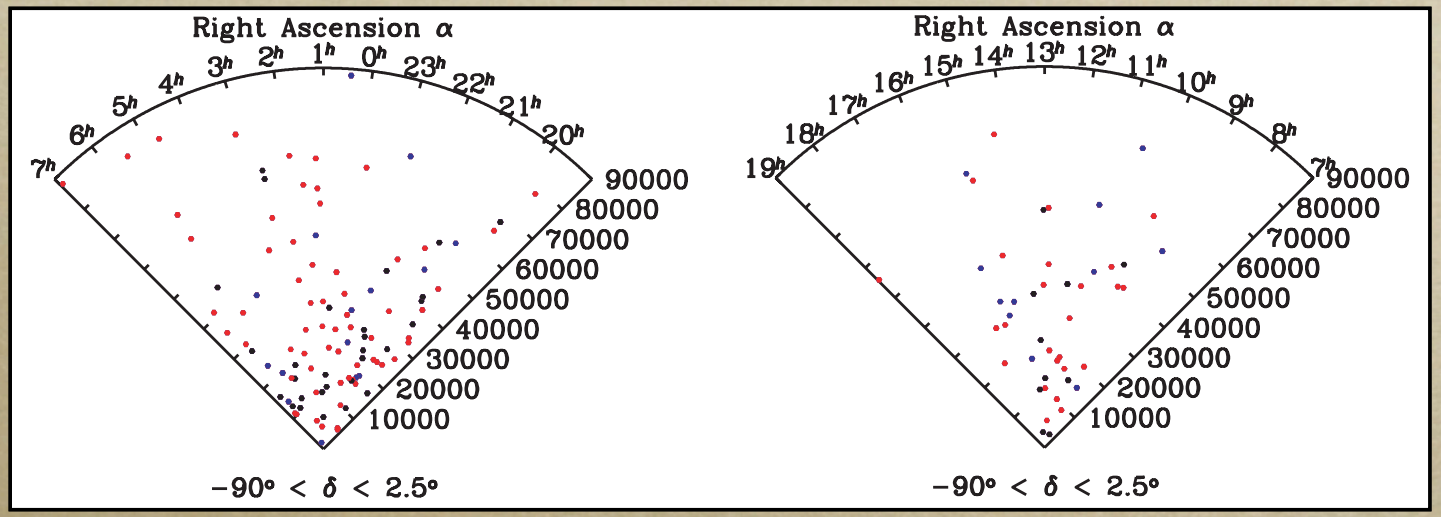
  → analyse two-point correlation function

Spatial Distribution



- REFLEX-II: 842 galaxy clusters at z<0.55 with a flux limit of $f_X \geq 1.8 \times 10^{-12}$ erg s^{-1} cm^{-2}

Spatial Distribution

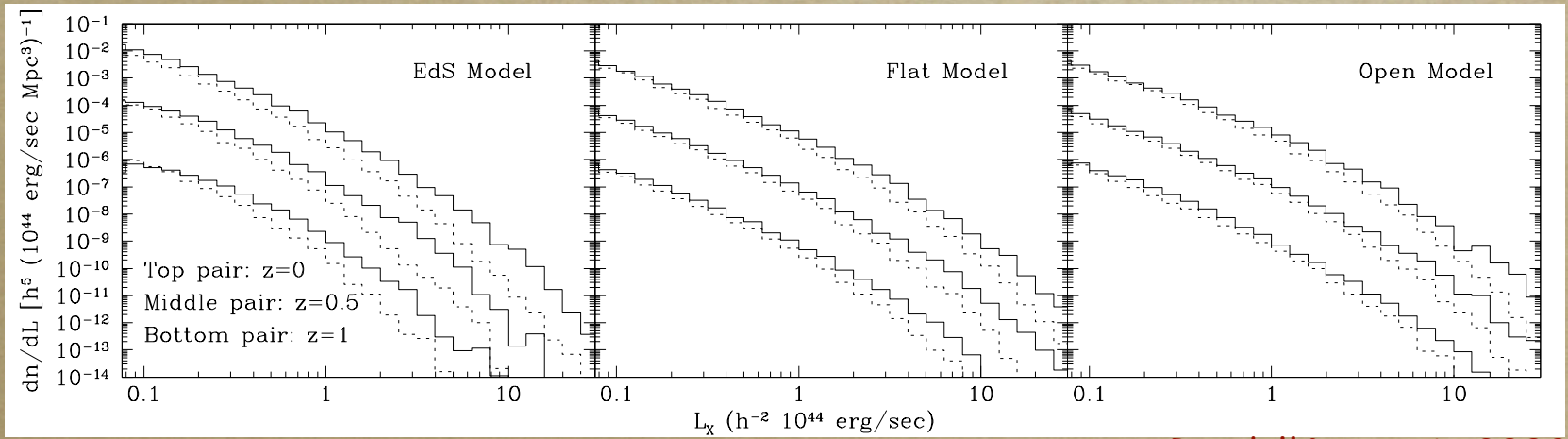


- REFLEX-II: 842 galaxy clusters at z<0.55 with a flux limit of $f_X \geq 1.8 \times 10^{-12}$ erg s^{-1} cm^{-2}

➡ Large underdense region in the spatial distribution of the REFLEX superclusters was just a statistical effect!

Merger Boosts

- Randall&Sarazin 2002: Merging clusters can boost XLF
- possible changes in Ω_M and σ_8



Randall&Sarazin 2002

Substructure

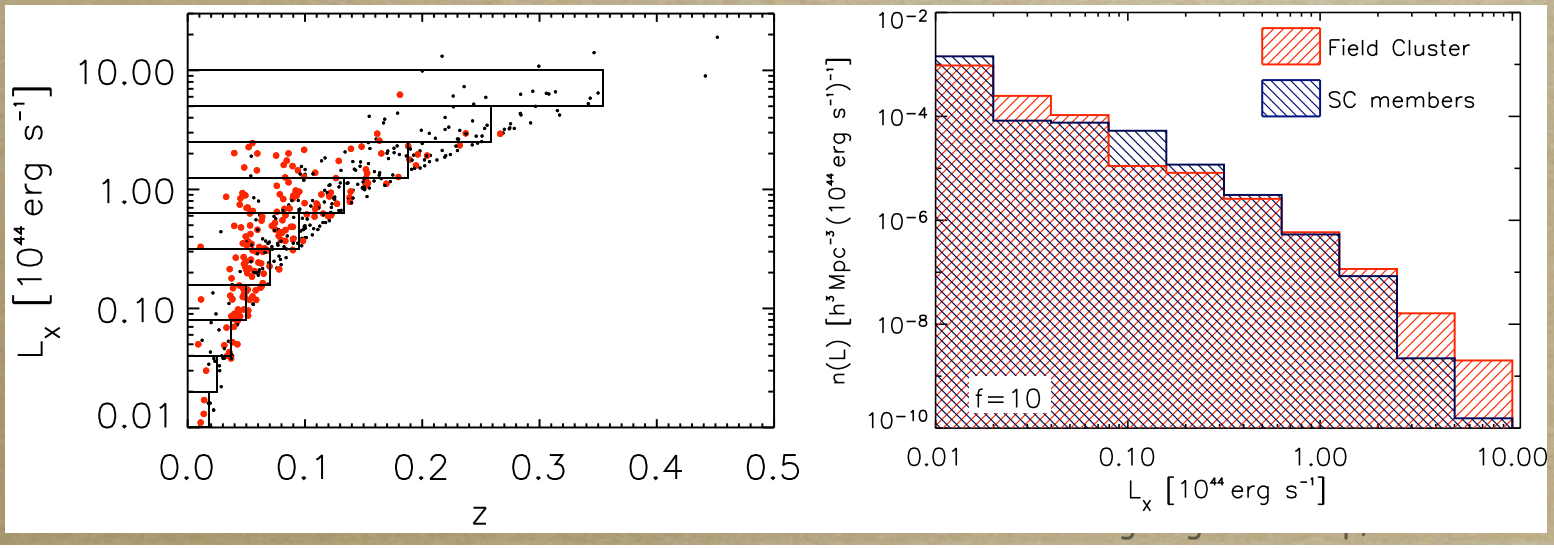
Schuecker et al. 2001: Substructure-density relation of clusters: Higher fraction of substructured clusters in superclusters

➡ Are the XLFs of cluster in SC and clusters in the field different?

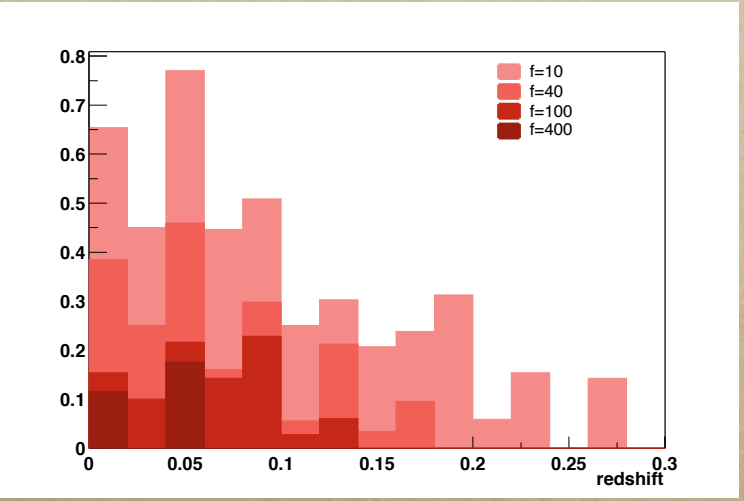
X-Ray Luminosities

- Comparison of the XLs of Clusters in SC and Field Clusters
- First approach: XLF using all REFLEX clusters

$$n(L) = \frac{N(\Delta L_i)}{V(L)\Delta L}$$



Subsamples

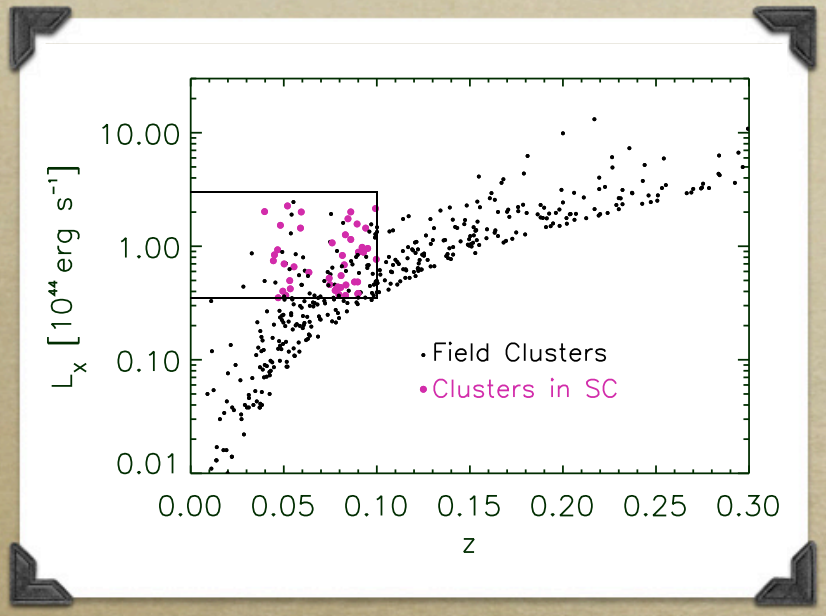


- Selection effect due to flux limit

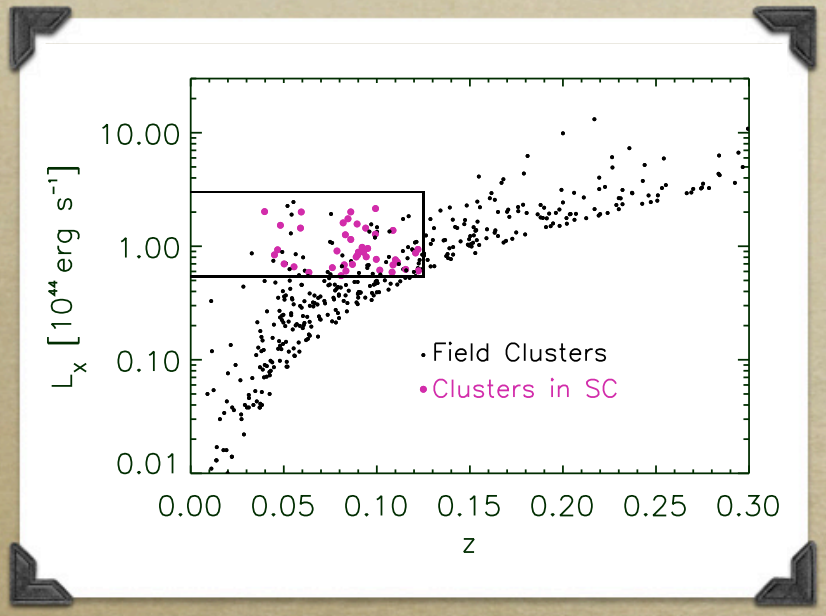
➡ use volume-limited subsamples!

- Advantages:
  - no selection effect
  - constant linking length
  - all SC in same dynamical state

- Disadvantages:
  - small number of clusters



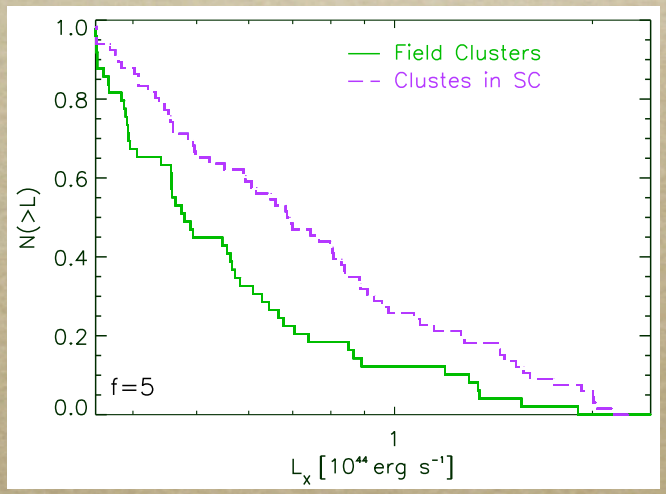
Chosen Subsamples

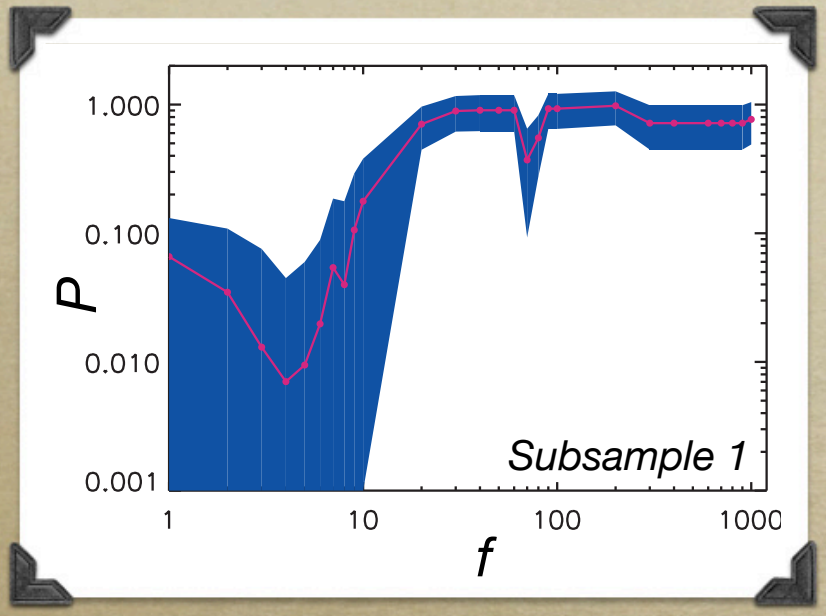


Chosen Subsamples

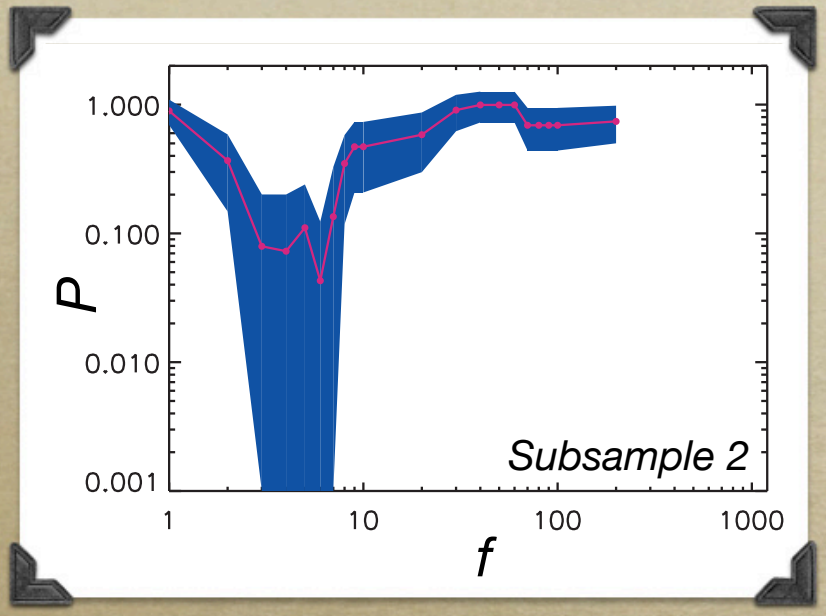
Comparison of the Luminosities

- Cumulative distribution function of the cluster luminosities + Kolmogorov-Smirnov test for all subsamples
  - in the overdensity range f = 1 ... 1000
  - using only SC with >2 members
- Test of stability using bootstrap





Resulting KS probabilities within an 1σ error interval



Resulting KS probabilities within an 1σ error interval

Results

- Larger fraction of more luminous clusters in SC
- Largest difference around f = 3 ... 7
- SC with f = 3 ... 7 are most distinct from the field
- Larger volume-limited samples are needed to study how significant the detected difference is

Conclusions and Outlook

- REFLEX supercluster catalogue: 79 members, f=10, z<0.3
  - ➔ test effectivity of method using random cluster samples
  - ➔ minimal spanning tree instead of FoF
- Spatial distribution of REFLEX superclusters inhomogeneous at low redshifts
  - ➔ Two-point correlation function for superclusters

Conclusions and Outlook

- Higher XL in SC either due to luminosity boost in merging clusters or to a more evolved luminosity function in the high density environment ⇒ SC and field environment are astrophysically different
  - ➔ Compare XLs for volume-limited subsamples of REFLEX-II
  - ➔ Study other phenomena that depend on the environment