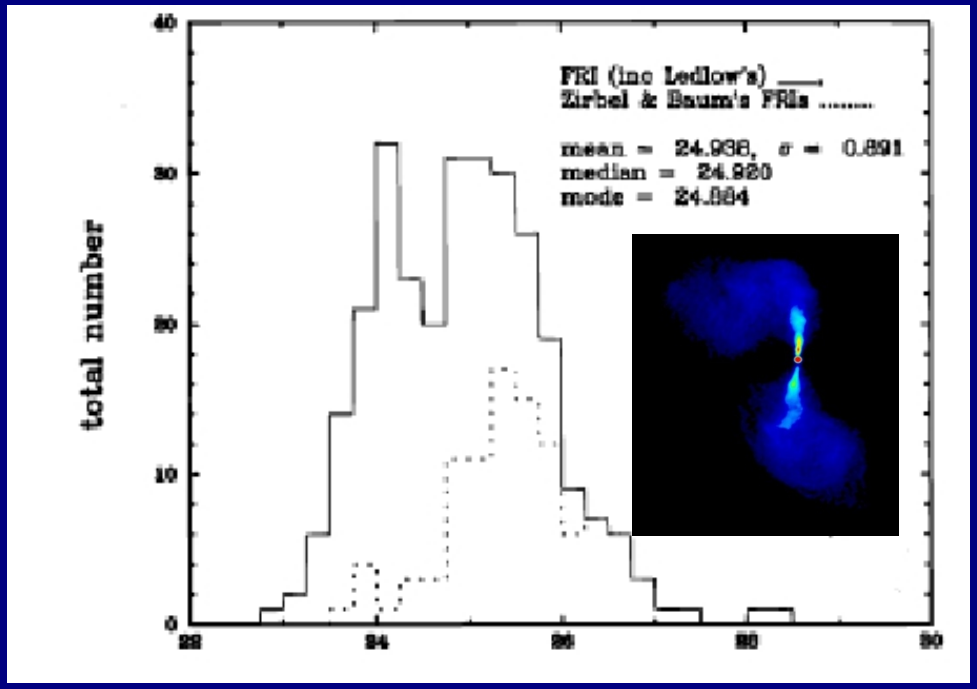
The cluster environment of high redshift FRI radio galaxies

Gianluca Castignani
(SISSA)

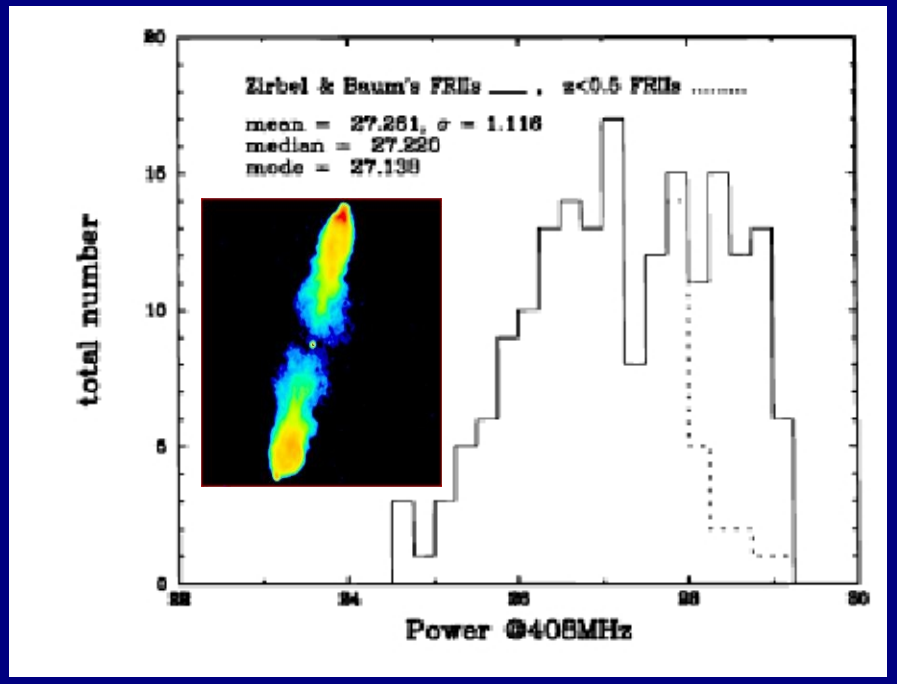
Collaborators:
Marco Chiaberge (STScI, INAF-IRA Bologna), Annalisa Celotti (SISSA), Colin Norman (JHU, STScI), Ranieri Baldi (SISSA)

Radio morphologies, Fanaroff & Riley (1974)

FRIs



FRIIs



Zirbel, 1996

- FRI: Jet decelerates to v << c at ~1kpc
- FRII: Relativistic jet on scales ~100 kpc up to ~1Mpc
- FRI / FRII divide: $L_{178\ MHz} < 2 \times 10^{26}$ W Hz^{-1}

FRIs

Locally:

- **“starved quasar”**: faint optical nuclear emission, Chiaberge et al. 1999, Leiptzki et al. 2009, Baldi et al., 2010
- Host galaxy: mainly **giant elliptical (cD)** with the most massive BHs, Donzelli et al. 2007, Zirbel & Baum 1997,
- **70% of them in rich clusters**, at variance with FRIIs; Hill & Lilly 1991; Zirbel 1997.

At high redshift:

- **The most distant FRI known (z~1)**, Snellen & Best 2001
- **FRIs candidates at z~1-2**, Chiaberge et al. (2009)

FRIs at z~1-2 Why?

Clusters

- **Beacons for HIGH REDSHIFT CLUSTERS**
- **Link between z>~2 protoclusters and clusters**
- Formation and evolution of the **red sequence**

AGN

- **Cosmological evolution** unknown
- Hints for strong evolution up to z~0.7 (Sadler et al., 2007)
- Formation and evolution of the **most massive galaxies and Bhs**
- **Feedback**: BH accretion - environment

The sample

- **FRIs** candidates sample **z~1-2**, Chiaberge et al., 2009 (C09)
- **COSMOS** field (2sq degree)
- Mainly based on **radio (FIRST) and optical selection**, NOT on redshifts

Redshifts

- **Accurate redshifts** (Baldi et al., submitted) are required to **redefined the sample in radio power**
- **A few spectroscopic-z:** zCOSMOS, Lilly et al., 2007; Magellan, Trump et al., 2007
- **Photo-z**: SED modeling (stellar populations and dust components)

Cluster around LLRGs?

Cluster environment around Low Luminous Radio Galaxies? (FRIs)

The C09 sample redefined in radio power

- **22 LLRGs**
- **11** High Luminous Radio Galaxies (HLRGs)

Two cluster candidates

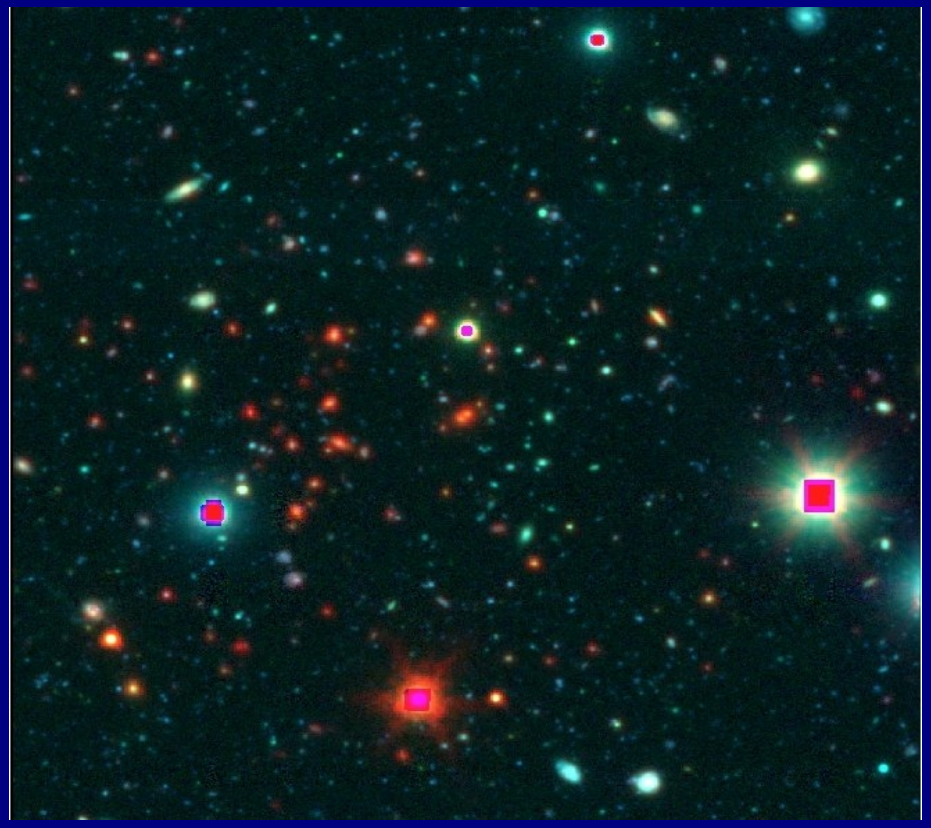


Figure: Field of COSMOS-FRI 01, cluster from visual inspection

Figure: Field of COSMOS-FRI 026, cluster?

RGB images. Red: Spitzer 3.6μm. Green: optical i-band. Blue: optical V-band

Cluster search techniques

- Generally they find **only virialized systems**
- **SZ effect**, only a few at z>1 (e.g. Marriage et al., 2001; Song J. et al., 2012)
- **X-ray** (Rosati et al., 2002): $B \sim (1+z)^{-4}$
- **Red-sequence**: just forming between z~1-2
  - **Color techniques**
    (e.g. Papovich et al, 2008, z>1.2)
  - **Search around radio galaxies**
    (Miley & De Breuck 2008, Galametz et al. 2012)
    only FRIIs adopted

Poisson Probabiliy Method (PPM)

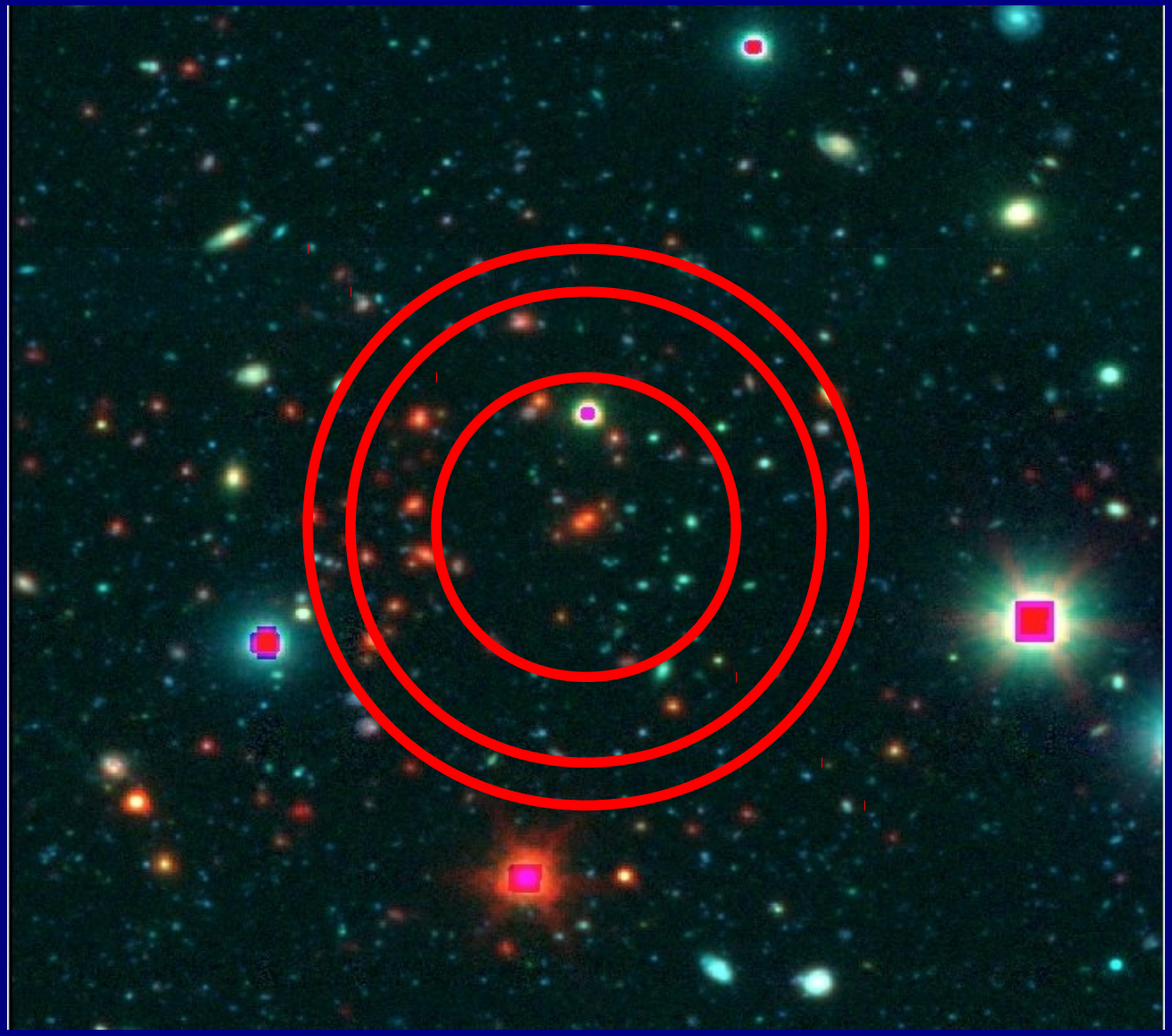
Castignani et al., in prep

A new method is required

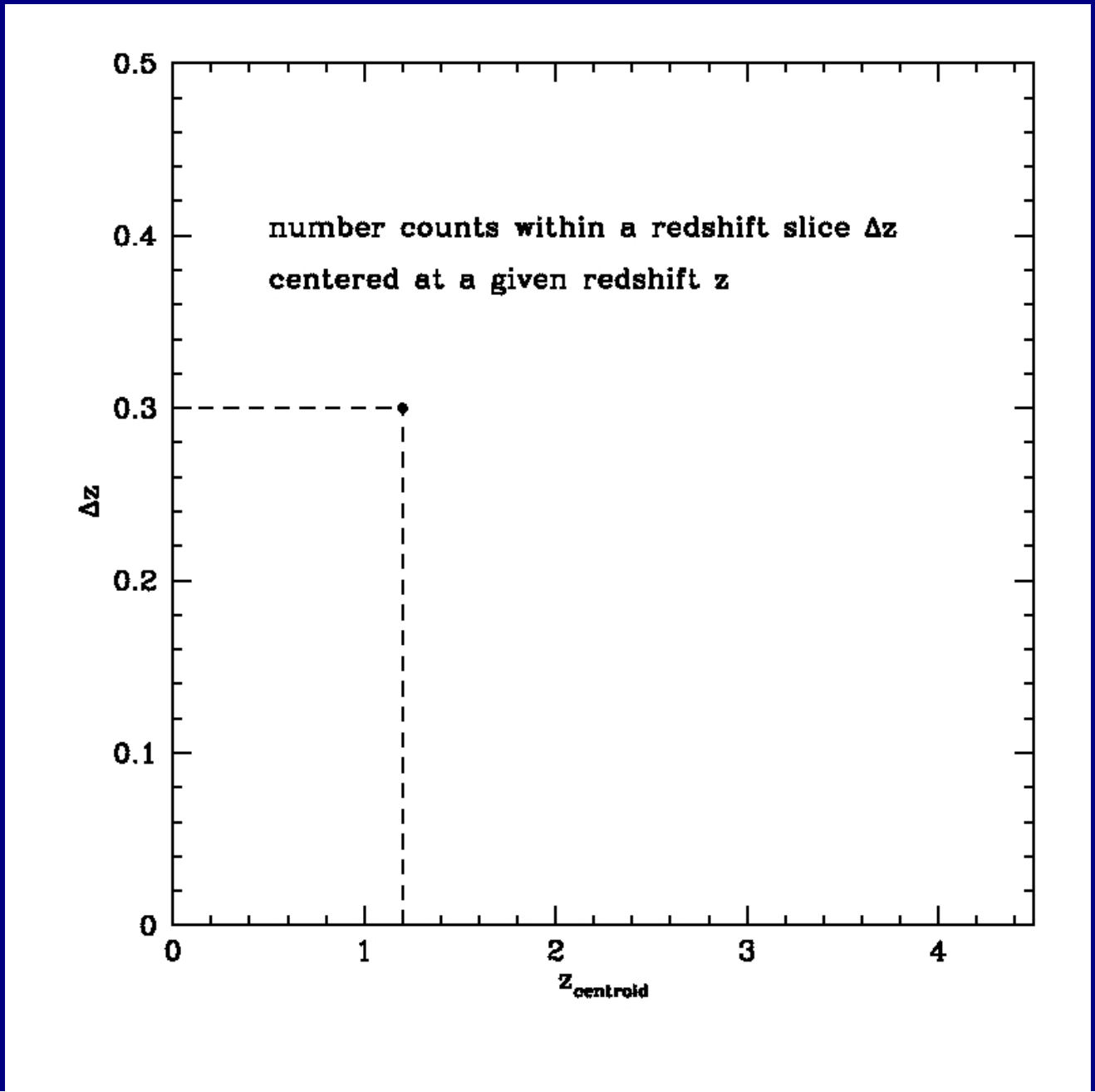
- **Differential counts**: cumulative number counts affected by high Poissonian fluctuations
- **NO virialization** required
- z~1-2: redshift desert → method based on photo-z

PPM → photo-z and differential number counts

PPM, how does it work?



PPM, how does it work?



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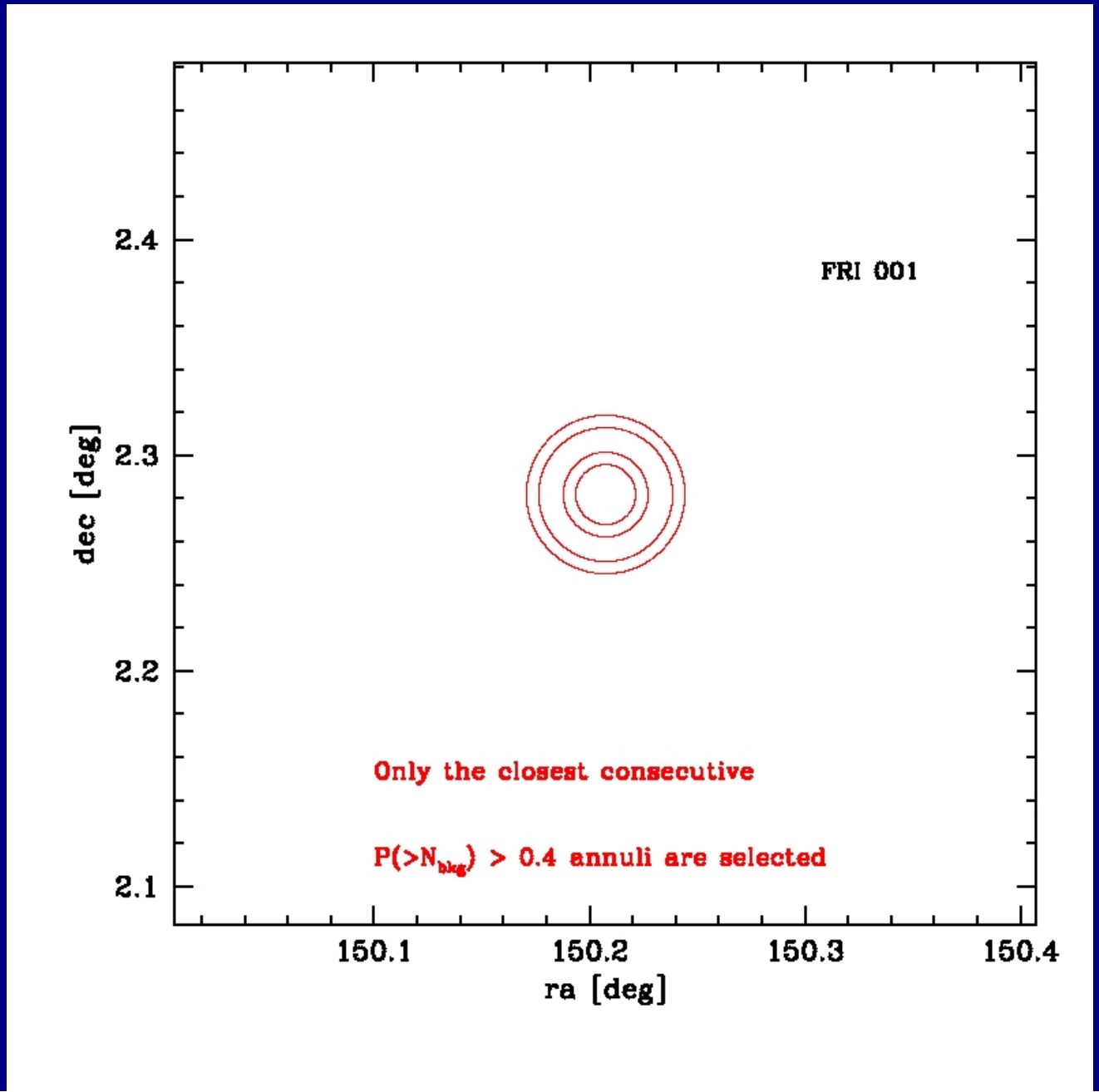

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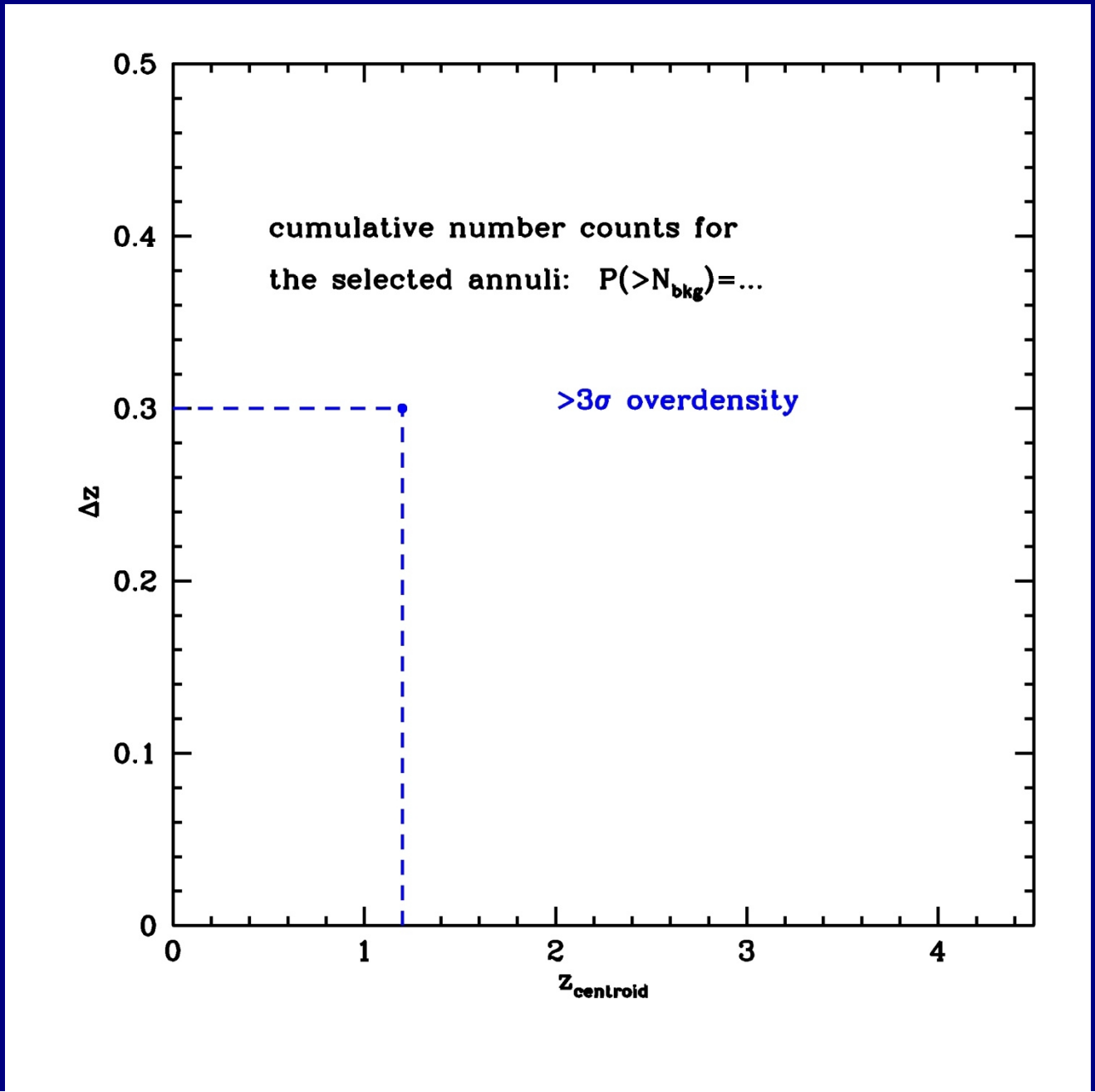
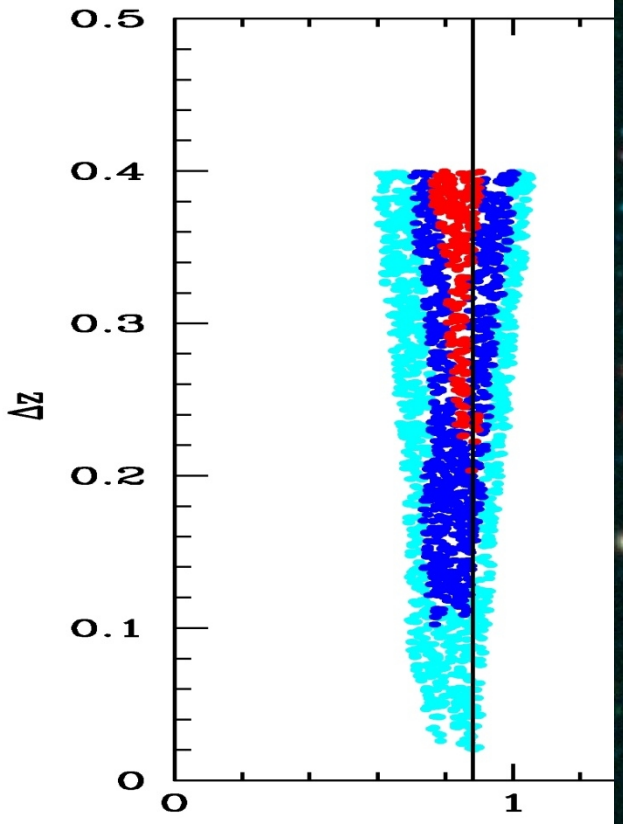


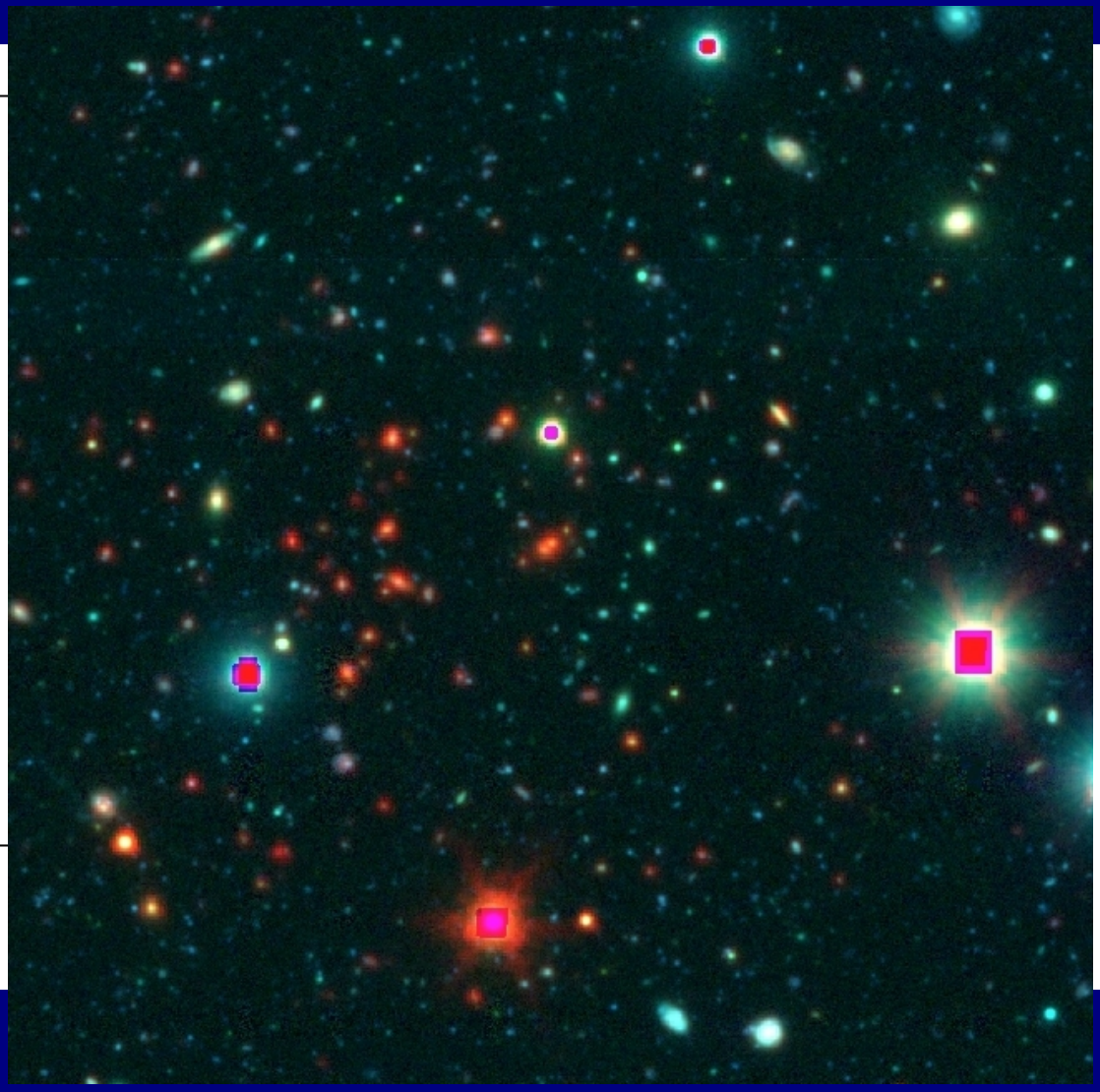
PPM, how does it work?

PPM plot legend: Overdensities

- **> 2 sigma**
- **> 3 sigma**
- **> 4 sigma**

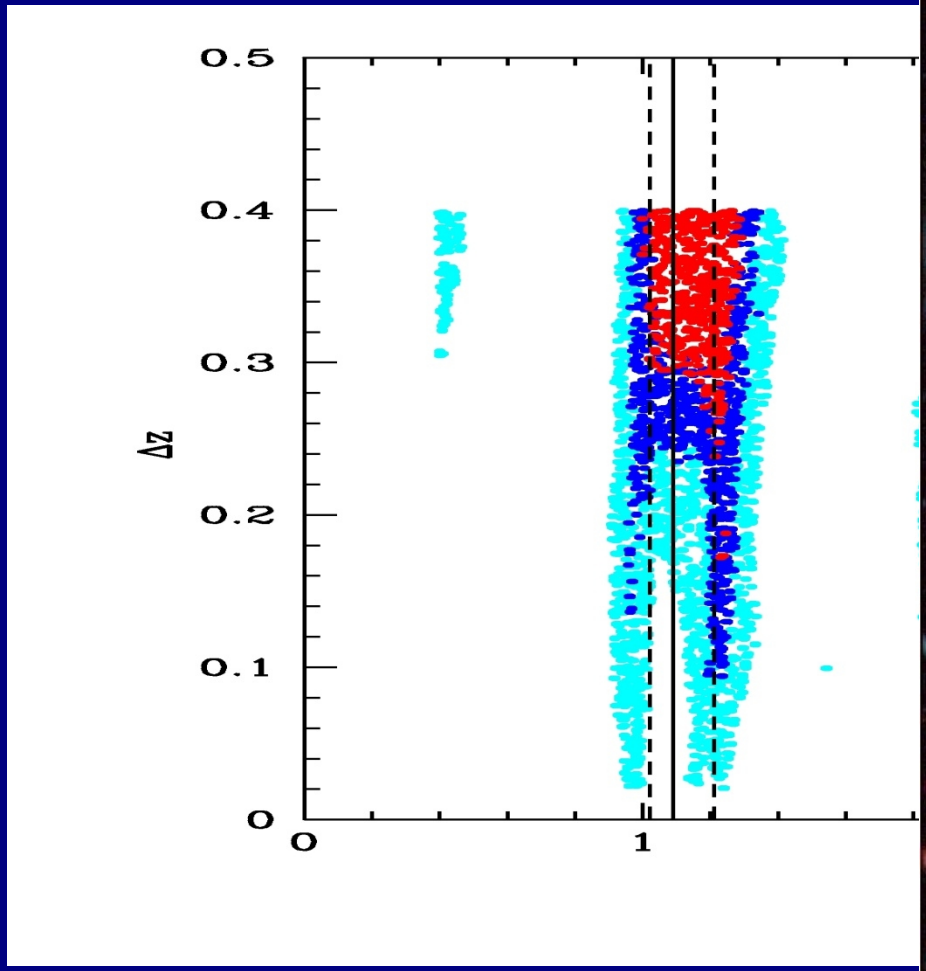
PPM plots

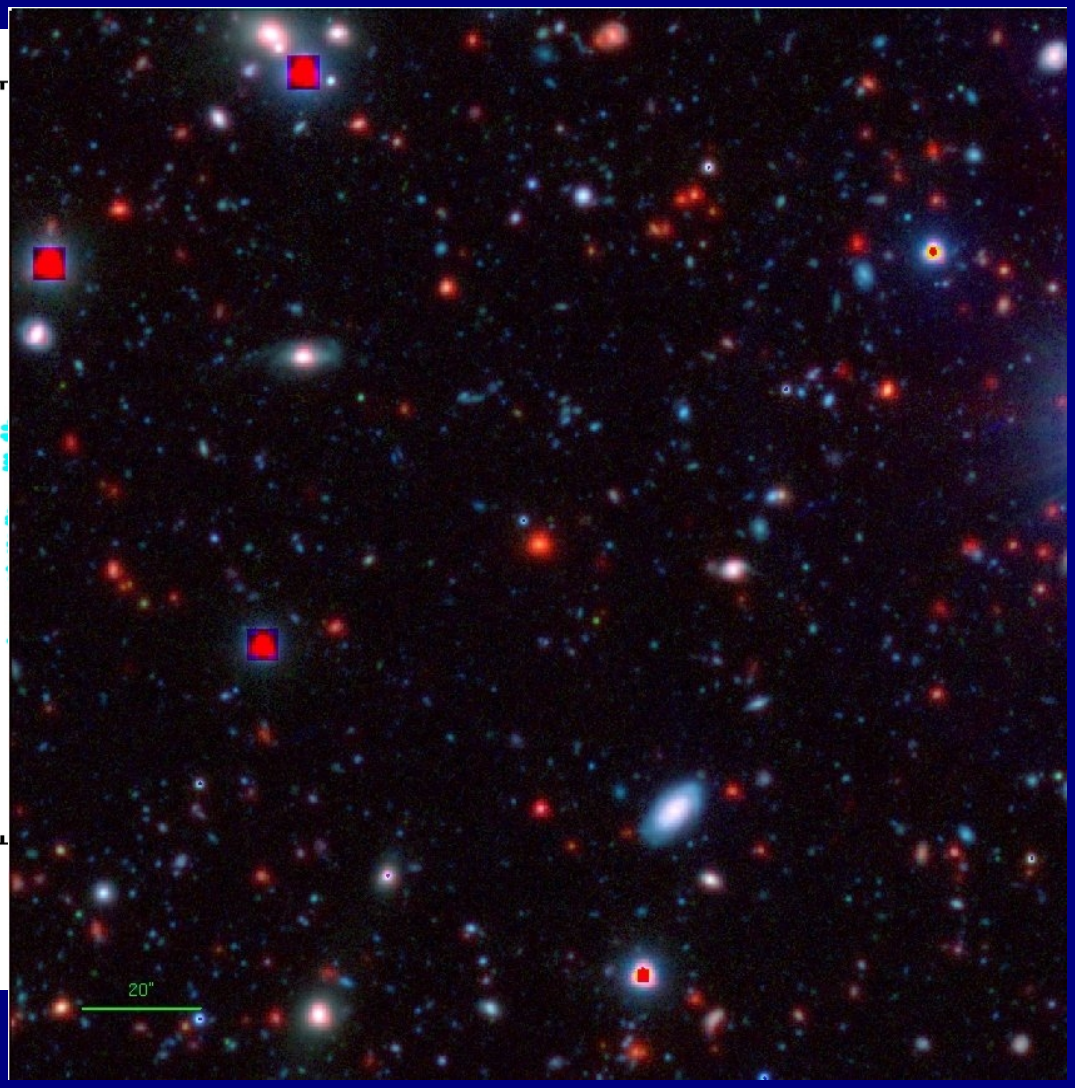




>4σ, LLRG

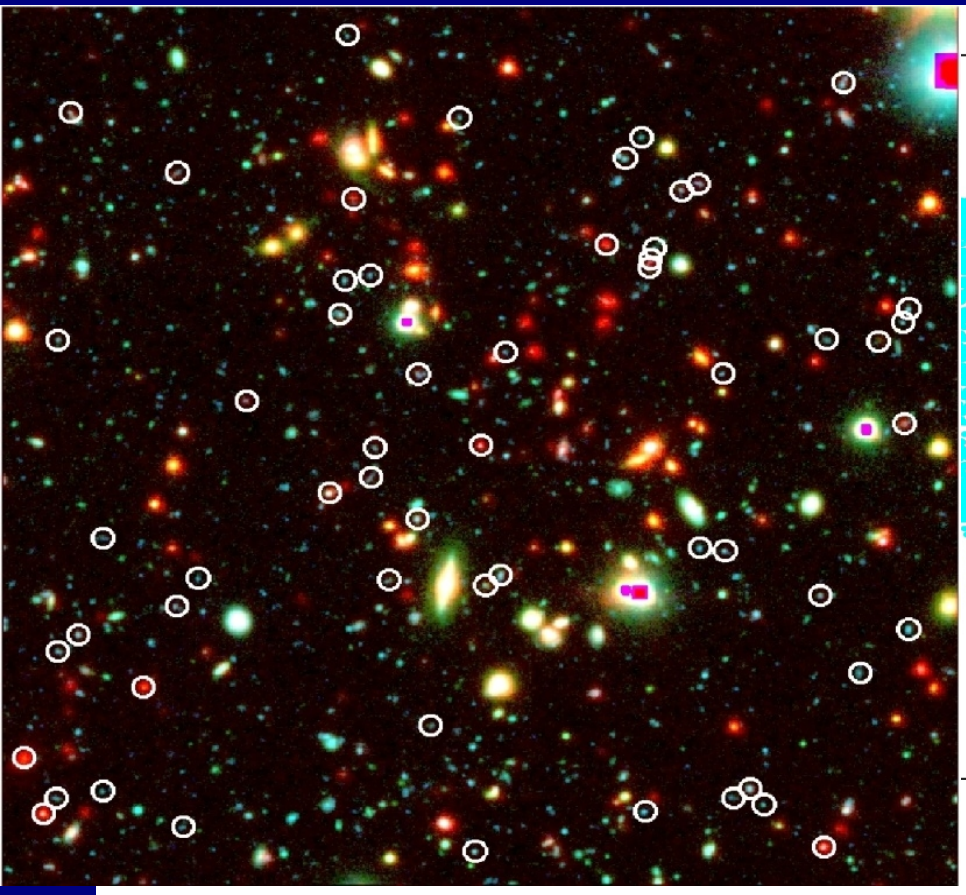
PPM plots

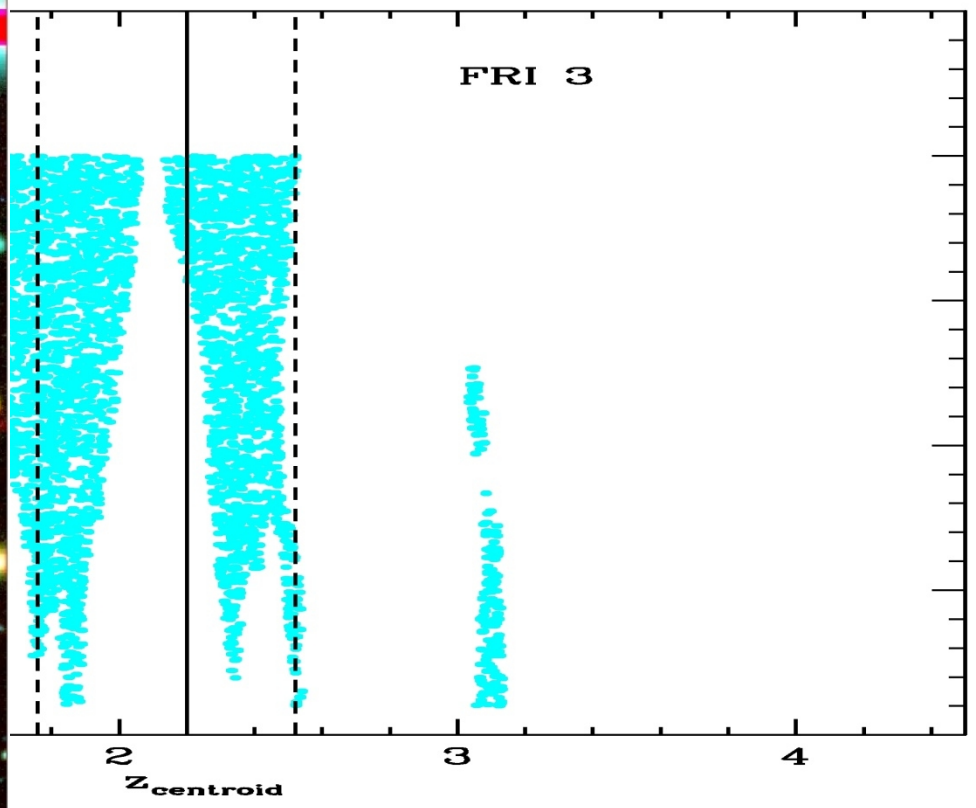




>4σ, LLRG

PPM plots





>2σ, LLRG

Detection results

Technicalities: Smoothing procedure, overdensities evaluated at $\Delta z=0.28$ within photo-z uncertainties

FRIs candidates + PPM:

Highest efficiency in finding high-z clusters!

- LLRGs: 14/22 → **64%**
- HLRGs: 7/11 → 64%
- **...in agreement with what found locally**

Conclusions

FRIs plus PPM → z~1-2 cluster search around FRIs candidates

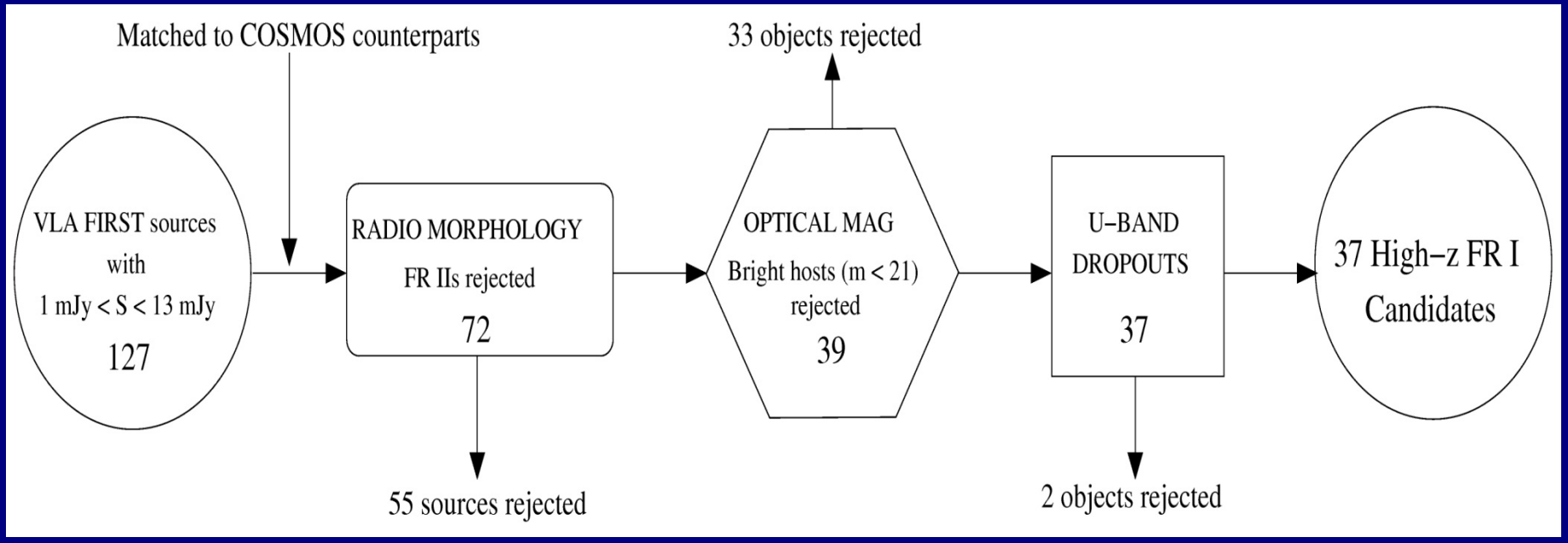
- 64% cluster detection success
- high redshift FRIs are in dense environment, as found locally

Future work...

- **Weak lensing signal from the stacking of our cluster candidates (in progress...)**
- CM plots, red sequence??
- PPM can be applied to wide field surveys, e.g. SDSS
- Chandra Deep field(s) North/South, SDSS Stripe 82 :

~3000 FRIs expected → cosmological and statistical studies

The sample. Chiaberge et al., 2009 (C09)



- L_{radio} vs z scatter plot → flux limited selections fail at z~0.7
- COSMOS (Scoville et al 2007), 2sq deg: deep and broadband
- selection NOT based on redshifts!!!

Gravitational arcs in the field of COSMOS-FRI 01!!

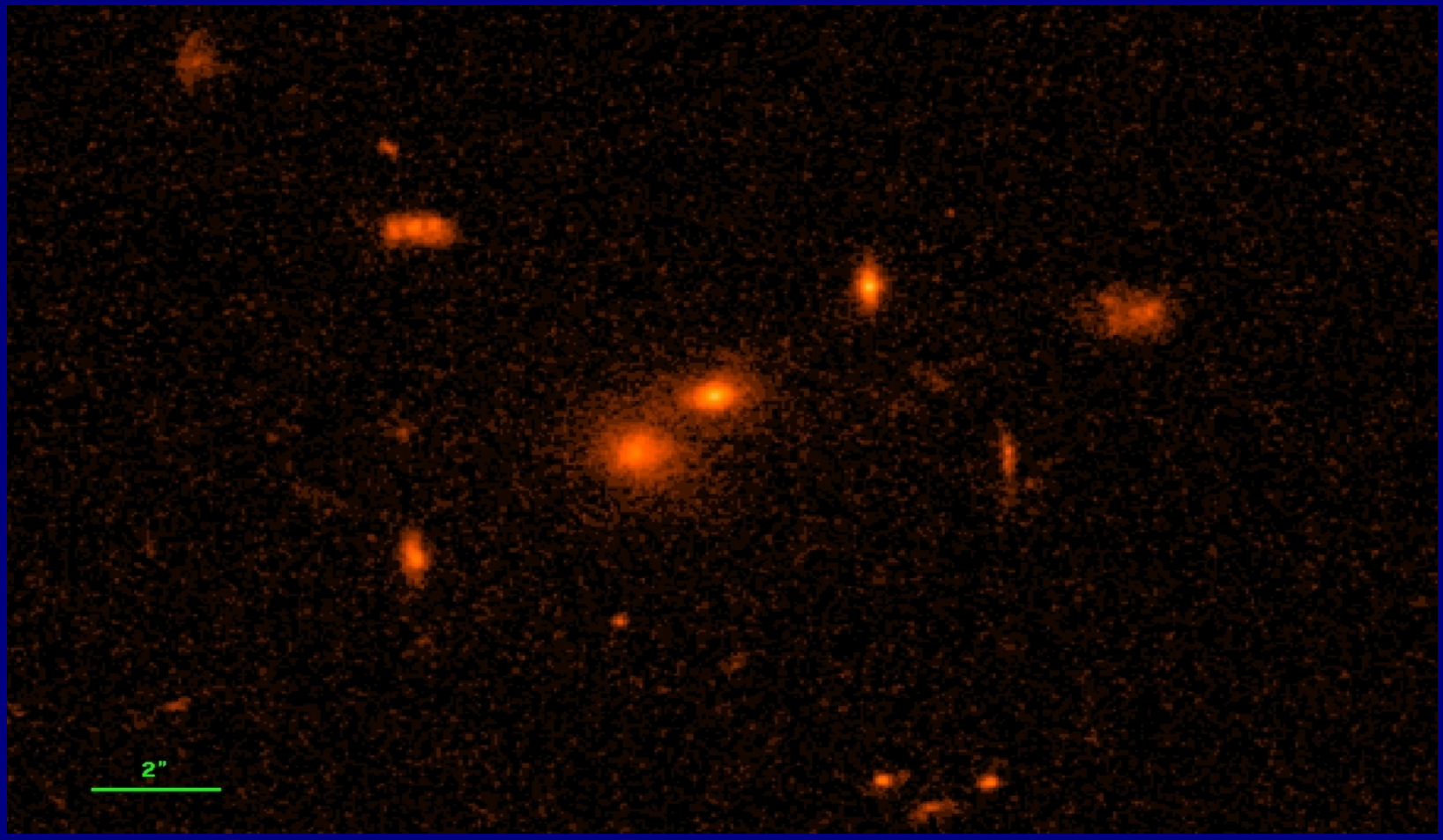


Figure: COSMOS-FRI 01, arcs