Title: Characterizing the SPT cluster selection function

Date: May 01, 2009 10:50 AM

URL: http://pirsa.org/09040040

Abstract: Sunyaev-Zel'dovich Effect (SZE) experiments such as the South Pole Telescope (SPT) are currently surveying a large area of sky searching for clusters via their imprint on the CMB. In order to use the resulting cluster catalogues for cosmology, it is necessary to know the mass- and redshift-dependent cluster selection function. I will describe ongoing work to understand and characterize the current SPT cluster yield, using synthetic SZ sky maps constructed from cosmological simulations and noise models calibrated against SPT data.

Characterizing the SPT cluster yield

(fellow anarcho-syndicalists)

Laurie Shaw (McGill)
Collaborators: Gil Holder, Jon Dudley, Keith Vanderlinde, Paul Bode,
Nicholas Hall, SPT team

SZ Universe : Perimeter Institute : 2009

Characterizing the SPT cluster yield

(fellow anarcho-syndicalists)

Laurie Shaw (McGill)
Collaborators: Gil Holder, Jon Dudley, Keith Vanderlinde, Paul Bode,
Nicholas Hall, SPT team

SZ Universe : Perimeter Institute : 2009

2008 Observations

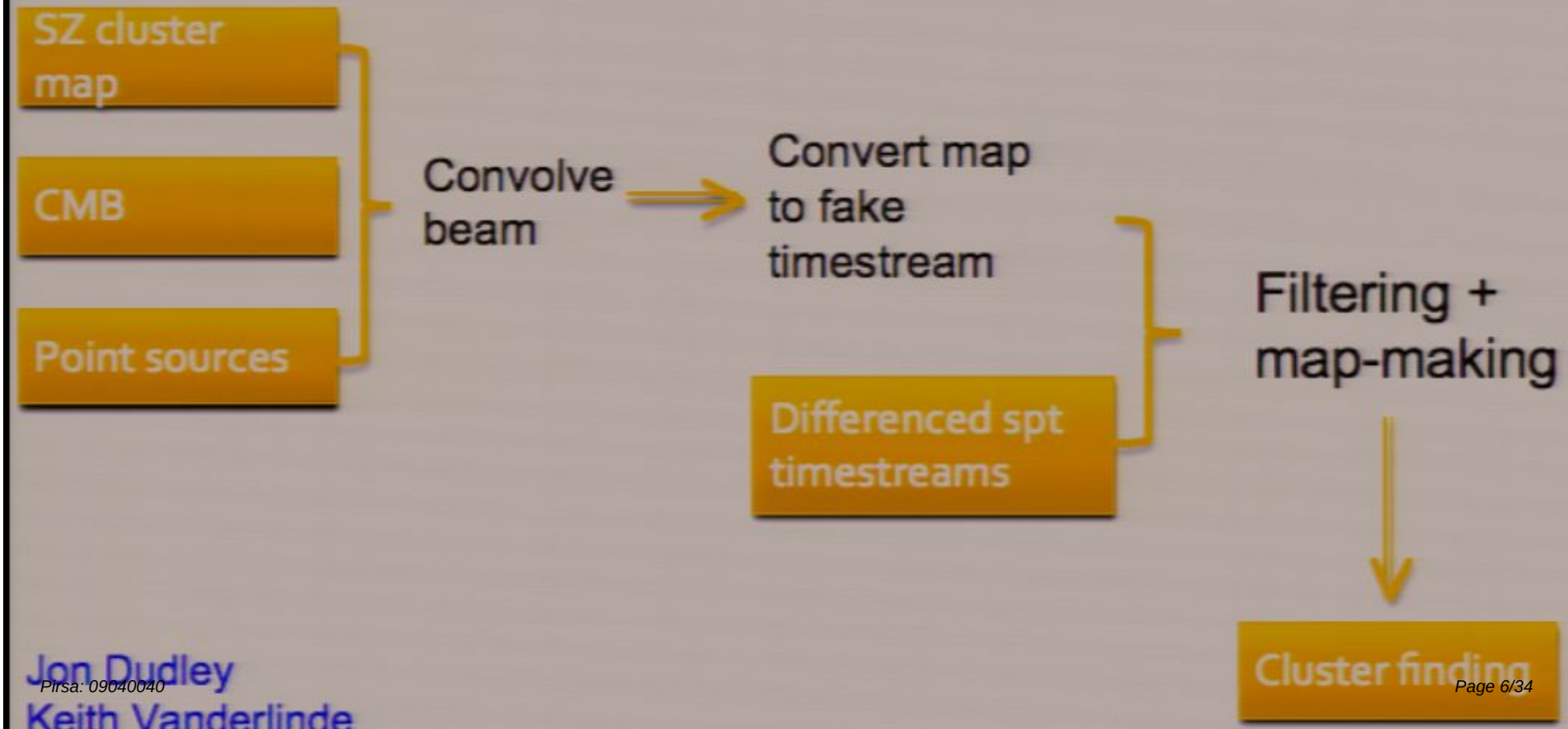
- Surveyed two 100 sq deg fields (23hr and 5hr).
- Apply optimal filters to identify cluster catalogues
  - Total of 20 (48) sources above 5 (4.5) - sigma detection threshold
  - Approximately 0.11 (0.25) deg^-2
- Redshifts obtained via crossmatching with BCS overlap regions or Magellan follow-up
  - Currently 15 (20) clusters with redshift estimates (less than z = 1)

Characterizing Sample

- Understand impact of timestream filtering & mapmaking on cluster signal (and how to optimize this)

- To use cluster yield for number counts, must first
  - Understand selection function (completeness f(M,z), contamination rate f(S/N))
  - Extract cluster mass proxy (e.g. integrated flux)

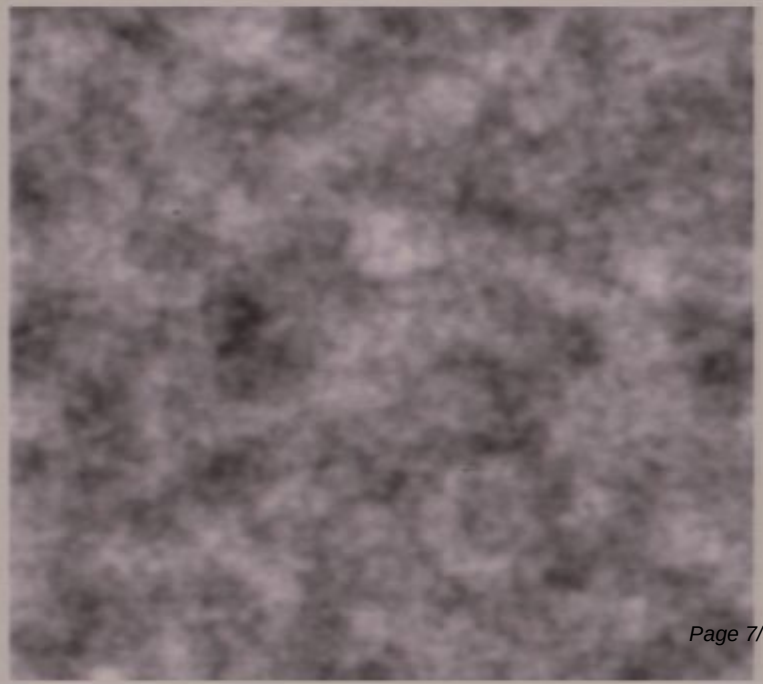
Simulation pipeline



Jon Dudley
Keith Vanderlinde

Cluster maps + CMB

- Apply Bode et al. (07) semi-analytic gas model to output of cosmological lightcone simulation (see talk by P. Bode & N. Sehgal)
- ~4000 deg^2 simulated sky. No signal from $<10^{13}$ M_{sol}/h clusters or filamentary gas.



Point Sources

- Sub-mm (dusty, star-forming galaxies) and radio (AGN) point sources are important astrophysical foregrounds.

- Monte-Carlo point source population from models of Negrello et al (07) and de Zotti (05), extrapolated to 150 Ghz

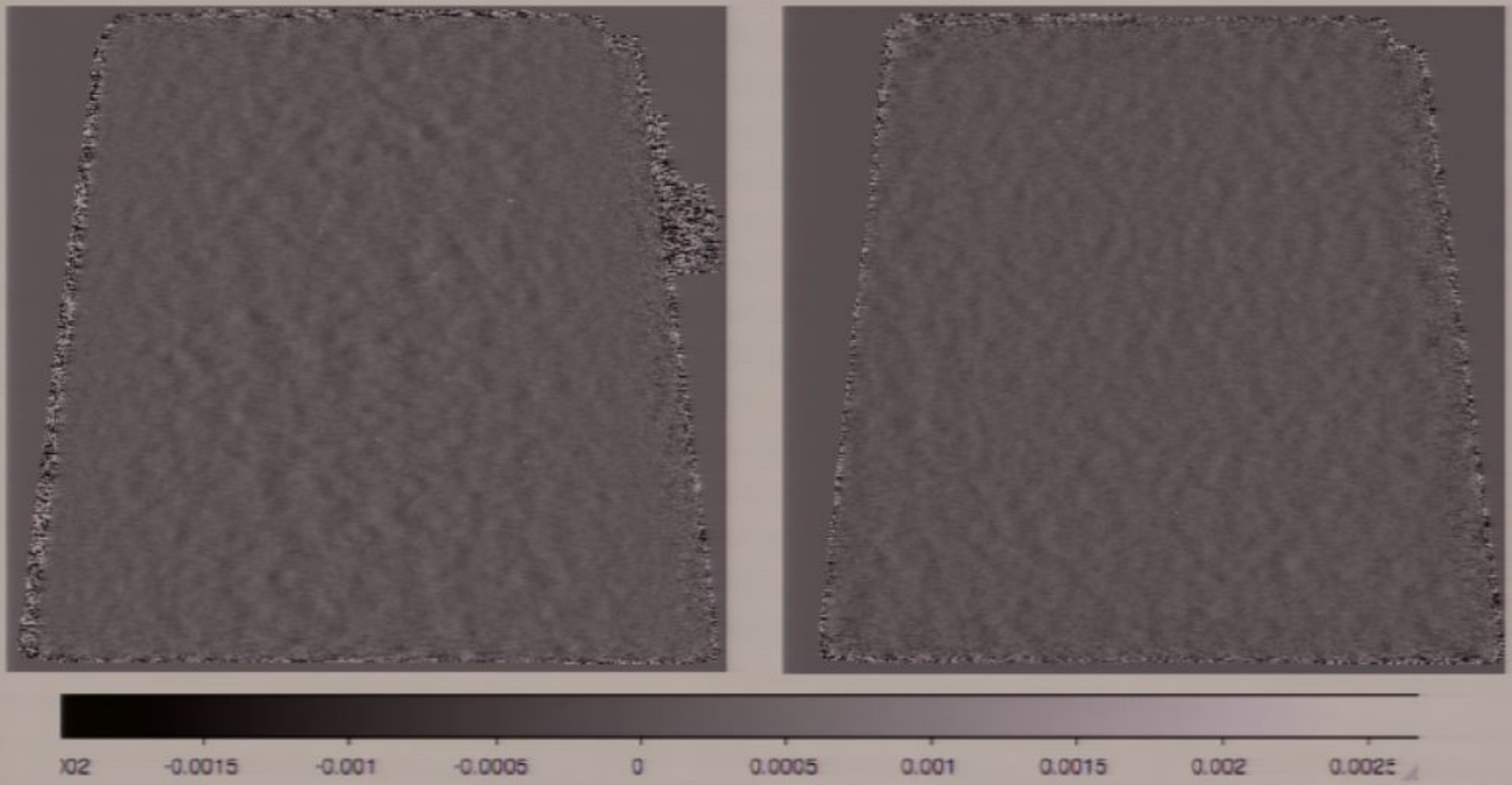
  Protospheroidal galaxies (including lensed component)
  Spirals (late-type gals)
  Radio sources

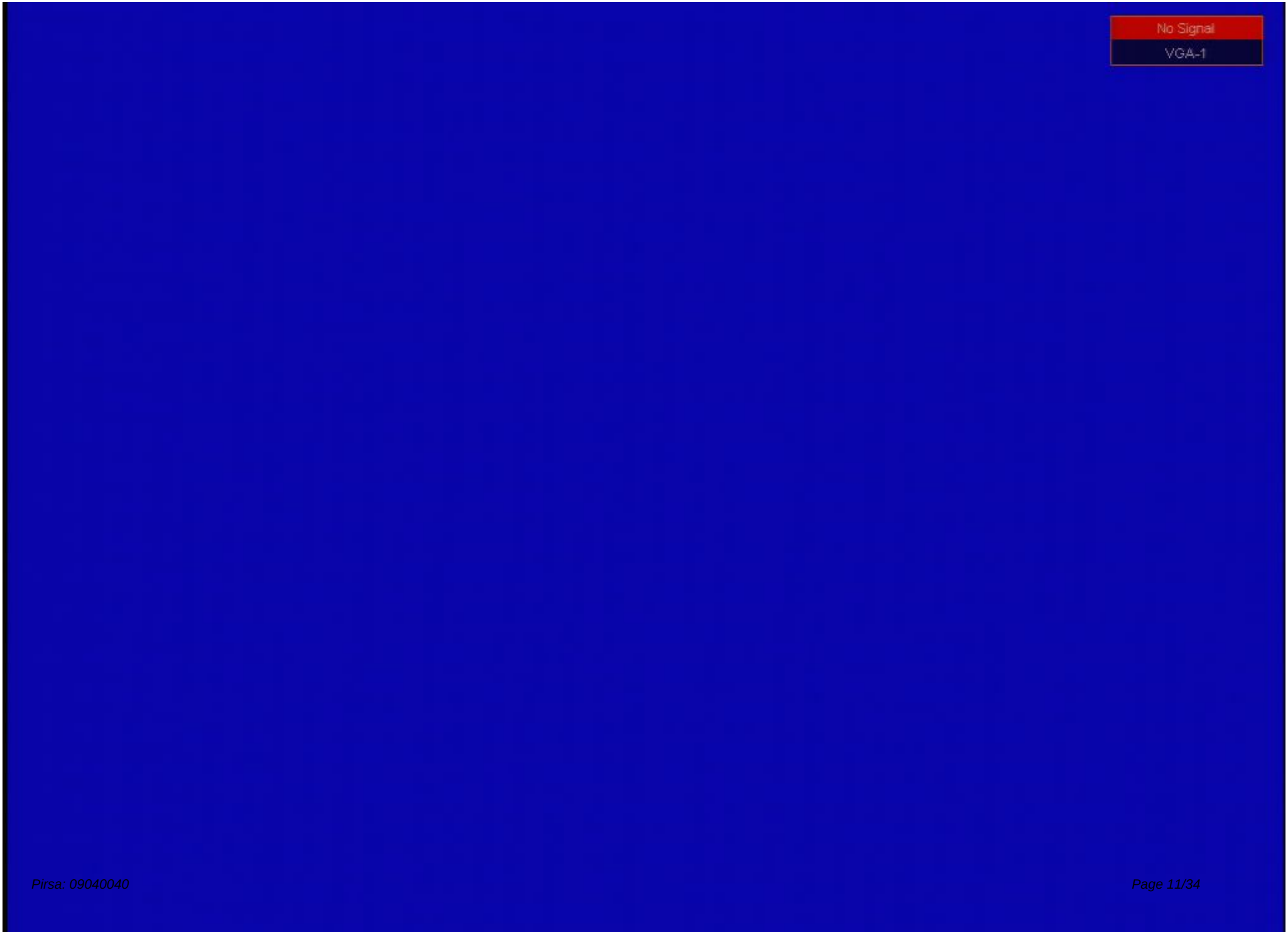
- Correlations between radio sources & clusters, clustering of sub-mm sources are not accounted for. Sources are Poisson distributed in maps.

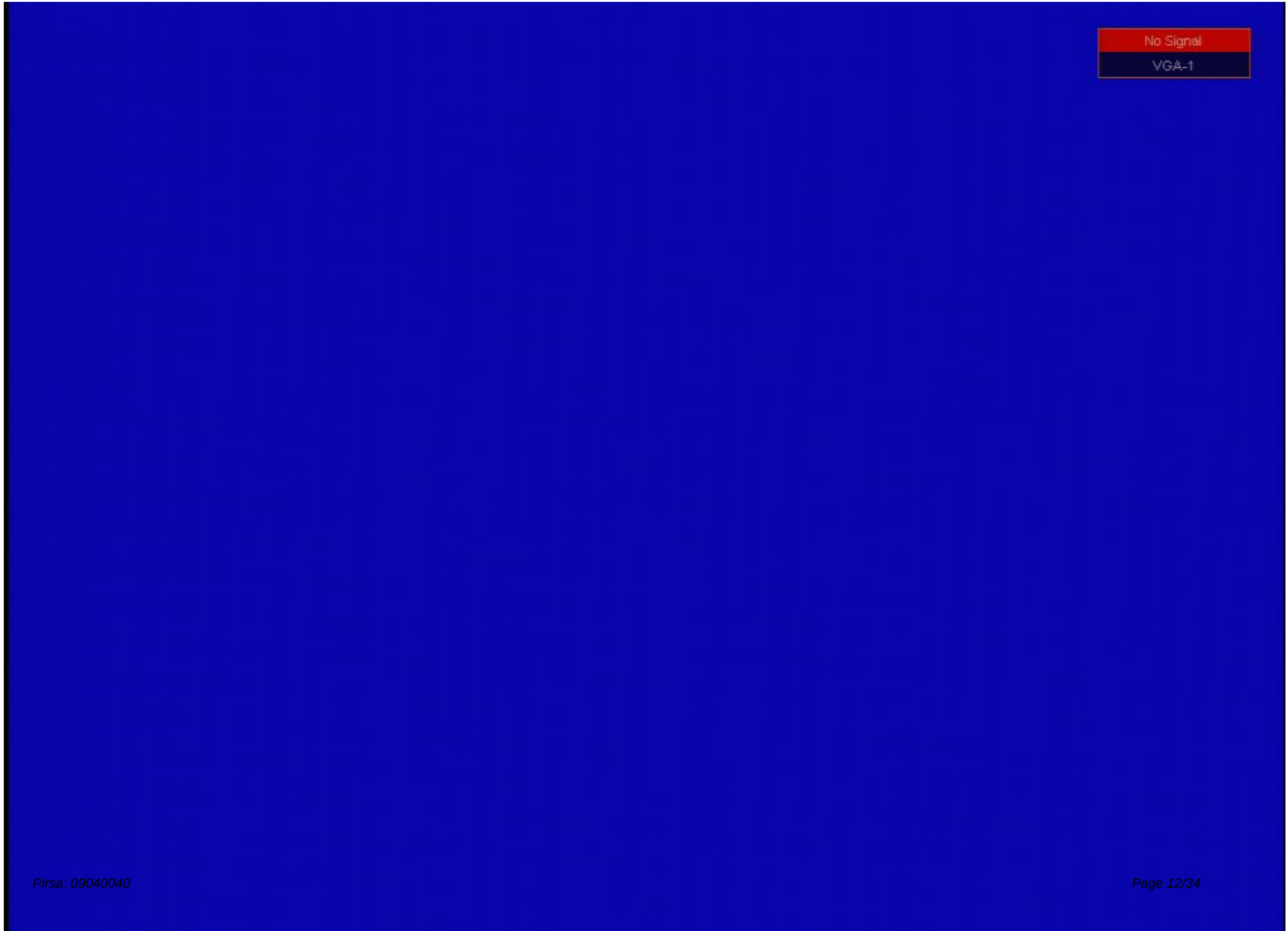
Noise + filtering

- Beam convolve signal maps & generate fake signal timestreams
- Add noise by differencing SPT timestreams
- Apply standard filtering and make maps
  - Common mode
  - Poly subtraction
  - Detector time constant deconvolution
  - Low pass

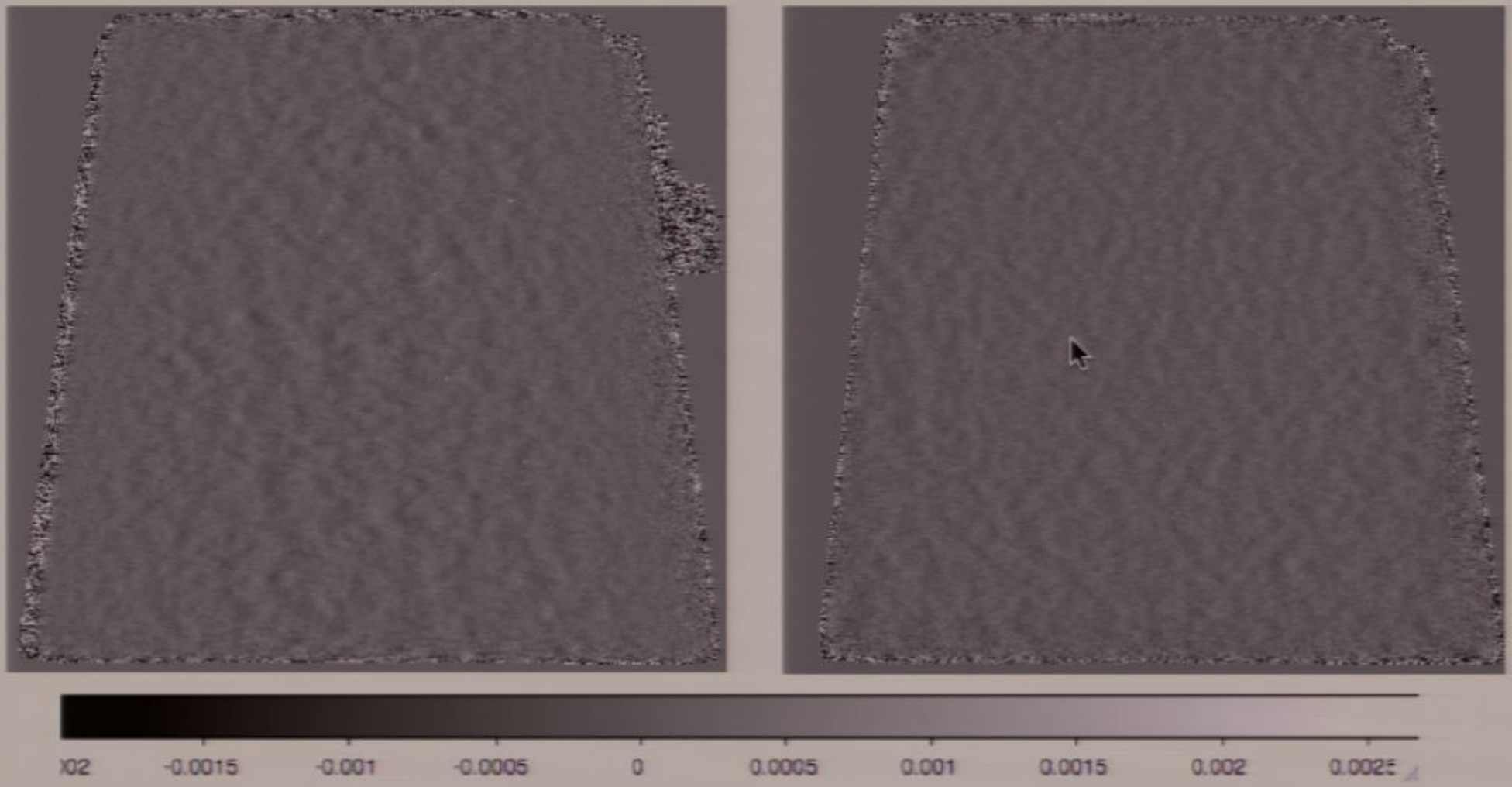
Simulated maps




No Signal
VGA-1

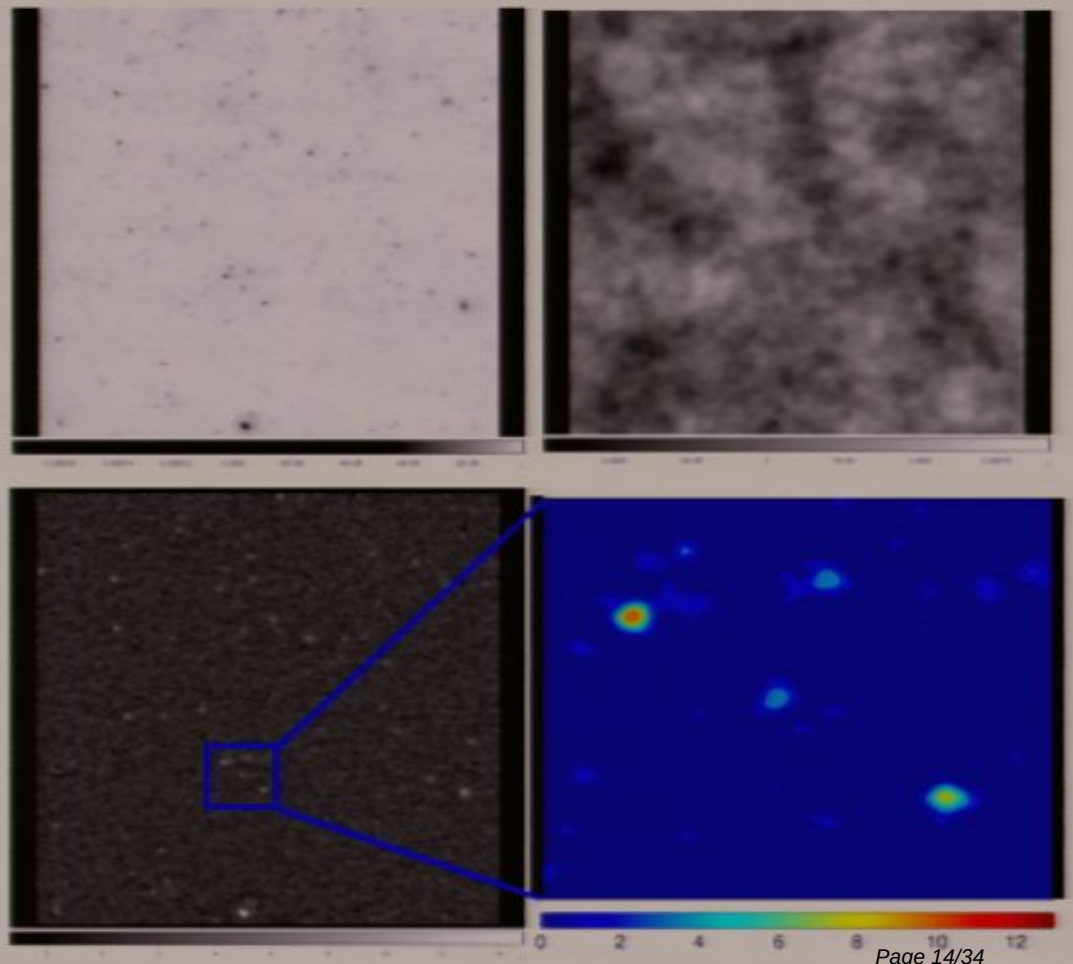

No Signal
VGA-1

Simulated maps



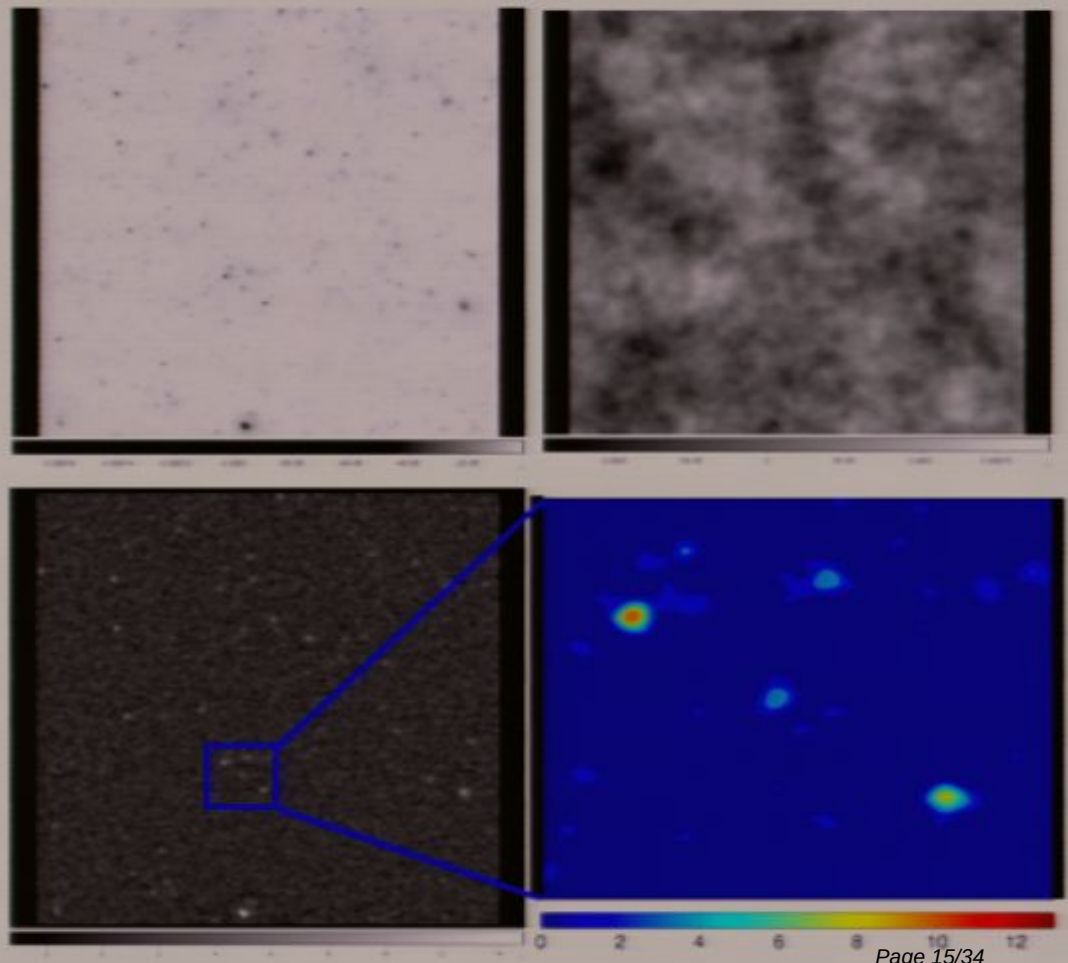
Optimal Filtering & Cross matching

- Apply optimal filter as for real maps
- Cross-match detections against underlying sim. catalogue

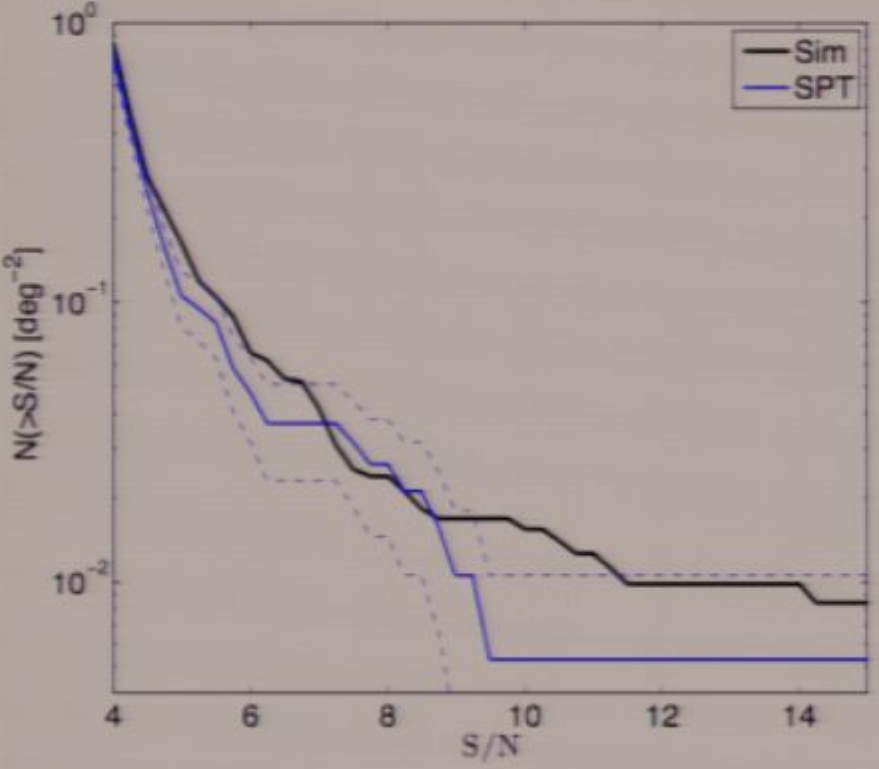


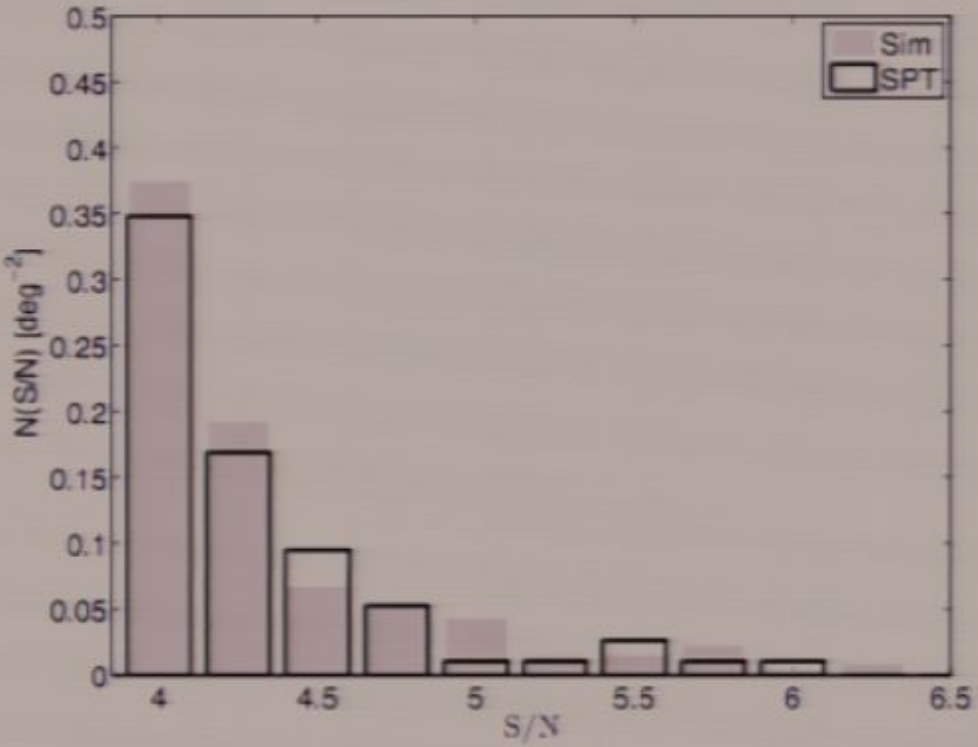
Optimal Filtering & Cross matching

- Apply optimal filter as for real maps
- Cross-match detections against underlying sim. catalogue

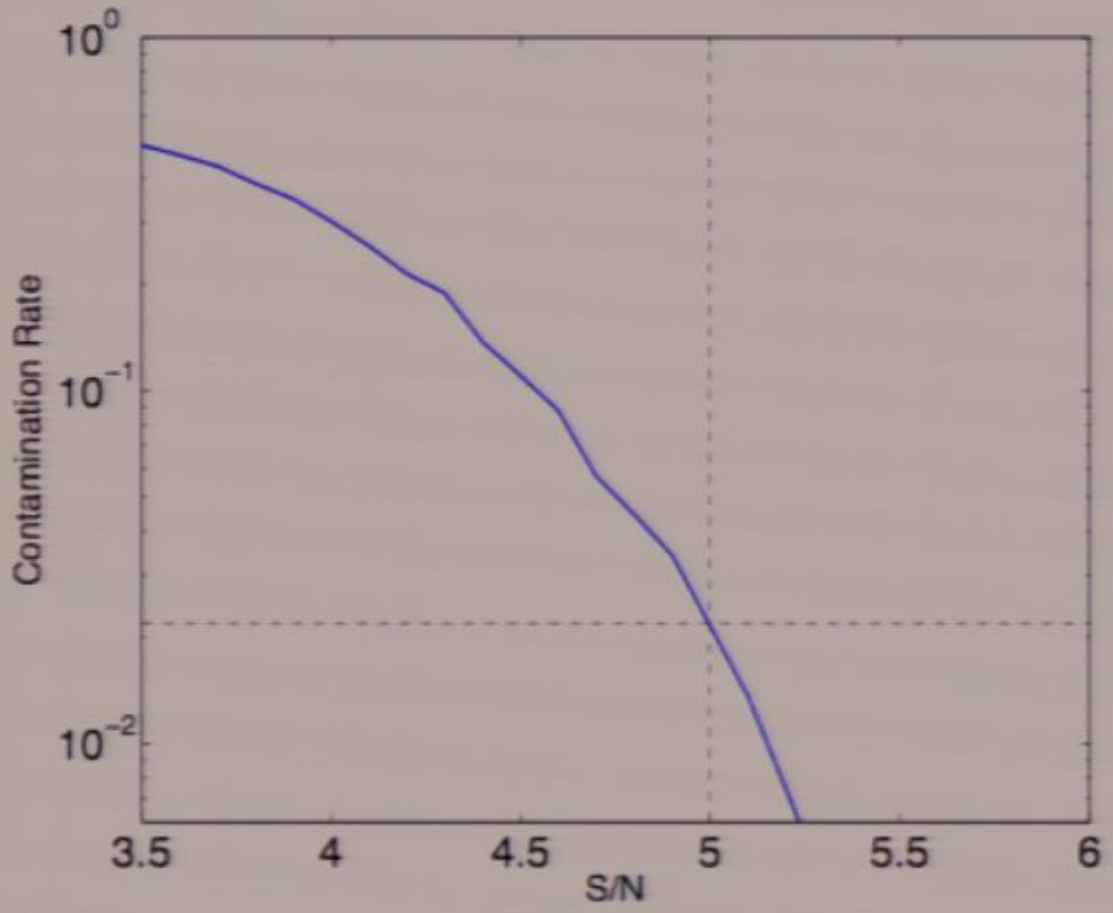


Yield


Sim
SPT
10^0
10^{-1}
10^{-2}
N(>S/N) [deg^{-2}]
4
6
8
10
12
14
S/N


Sim
SPT
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
N(S/N) [deg^{-2}]
4
4.5
5
5.5
6
6.5
S/N

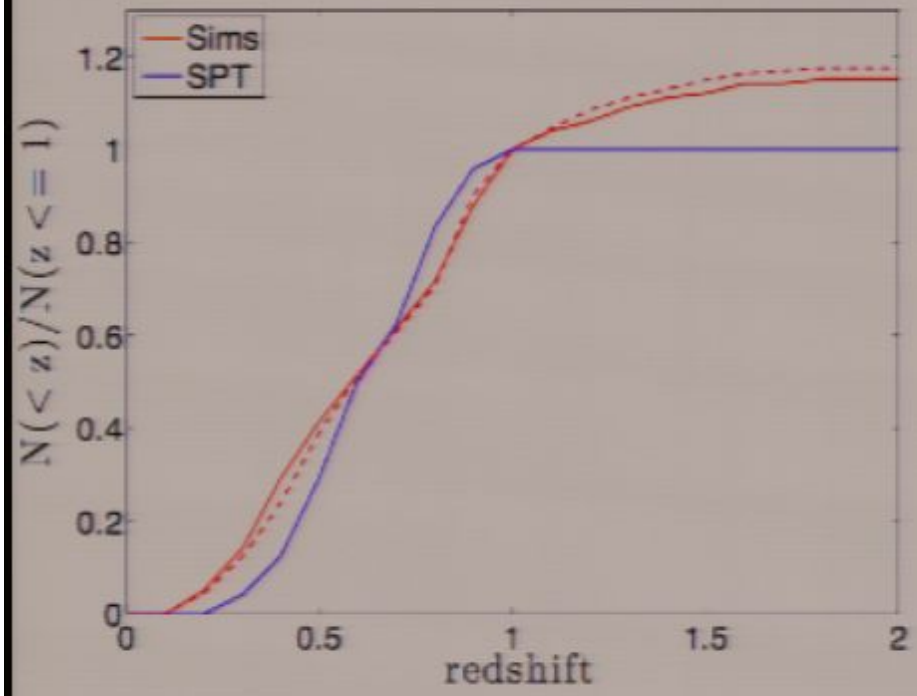
Contamination

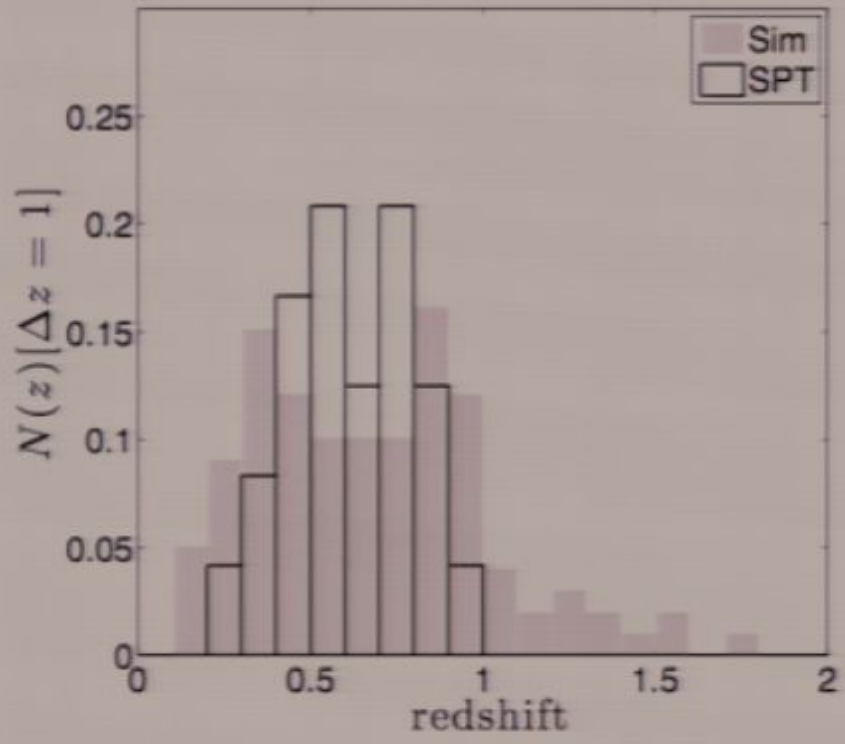


>4.5-sigma
10% false detections

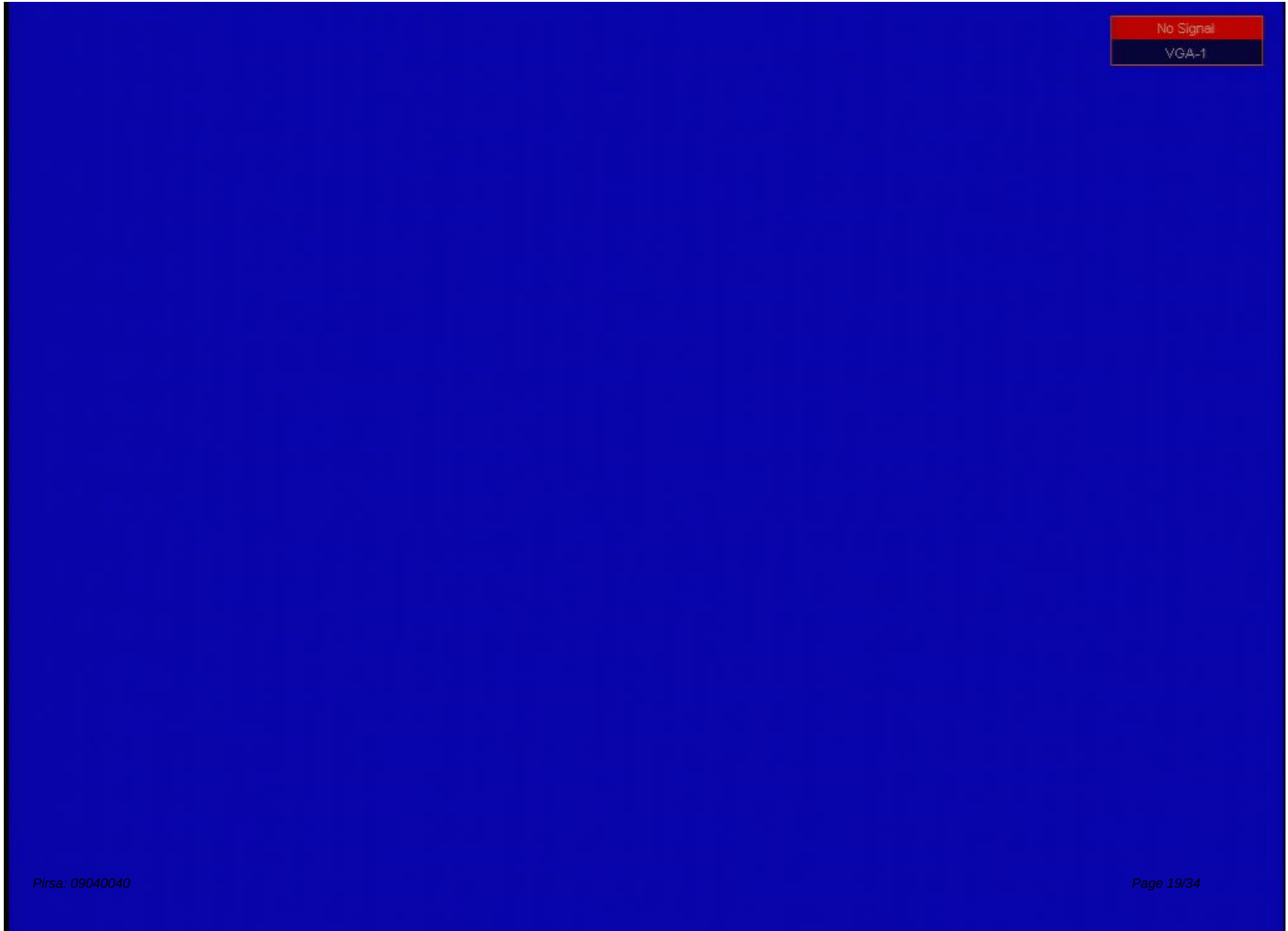
>5-sigma
2% false detections
~0.4 in 2008 catalogue

Redshift Distribution

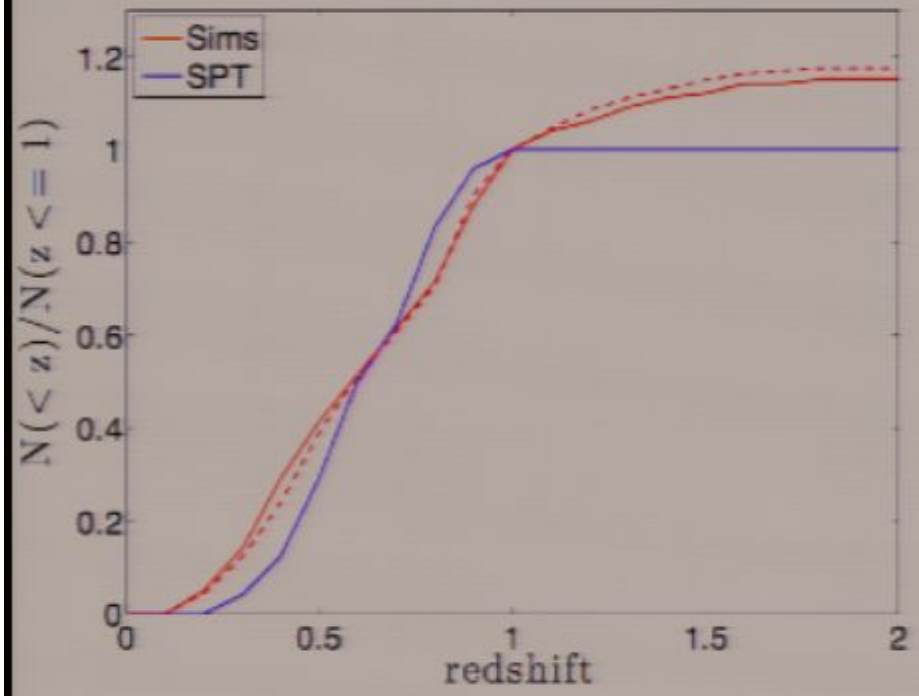


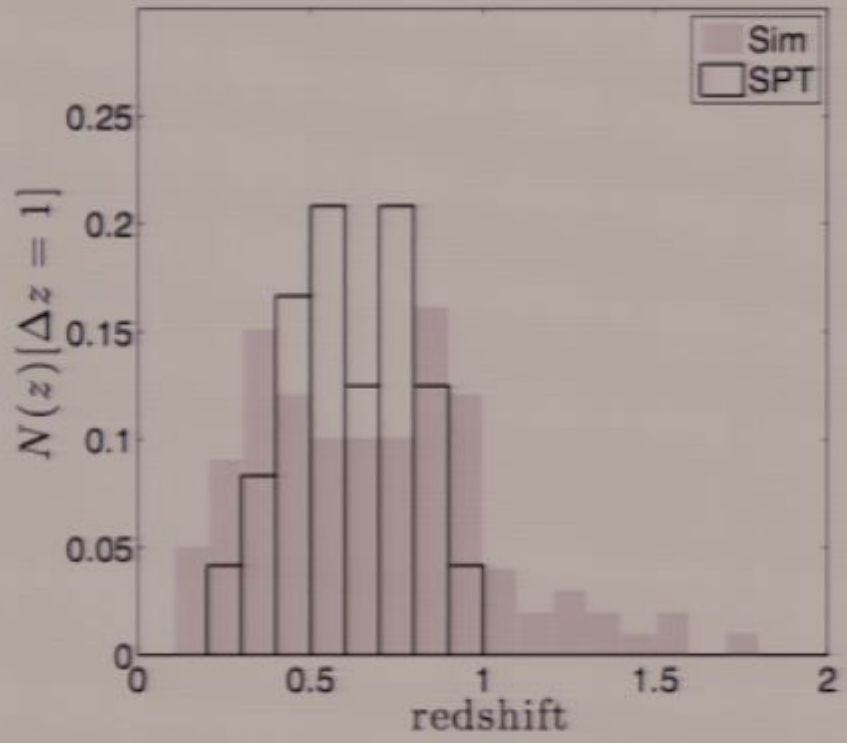


- Expect ~16% clusters to be above z = 1
- 20 clusters total -> we expect ~3 to 4 at z > 1

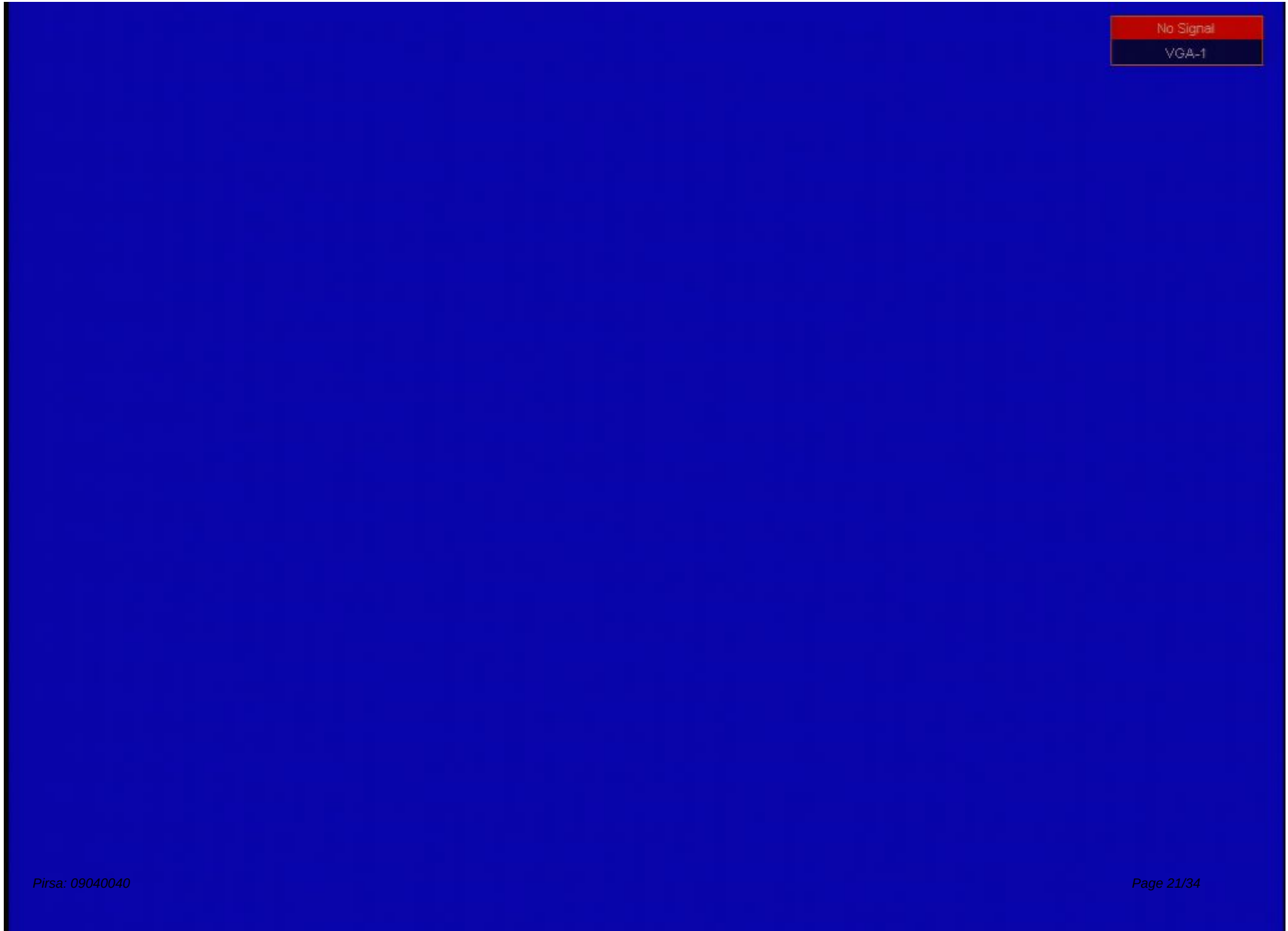

No Signal
VGA-1

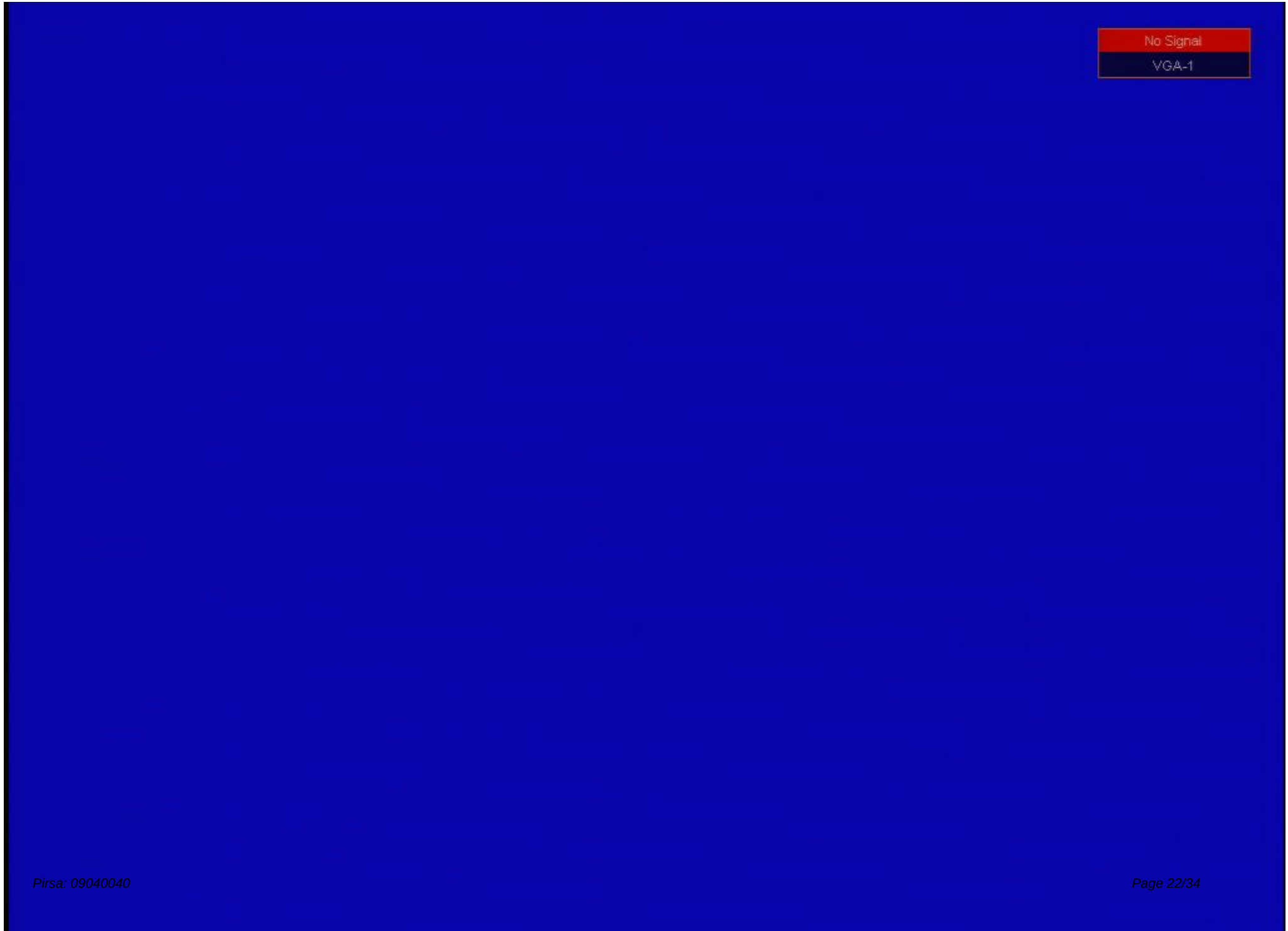
Redshift Distribution

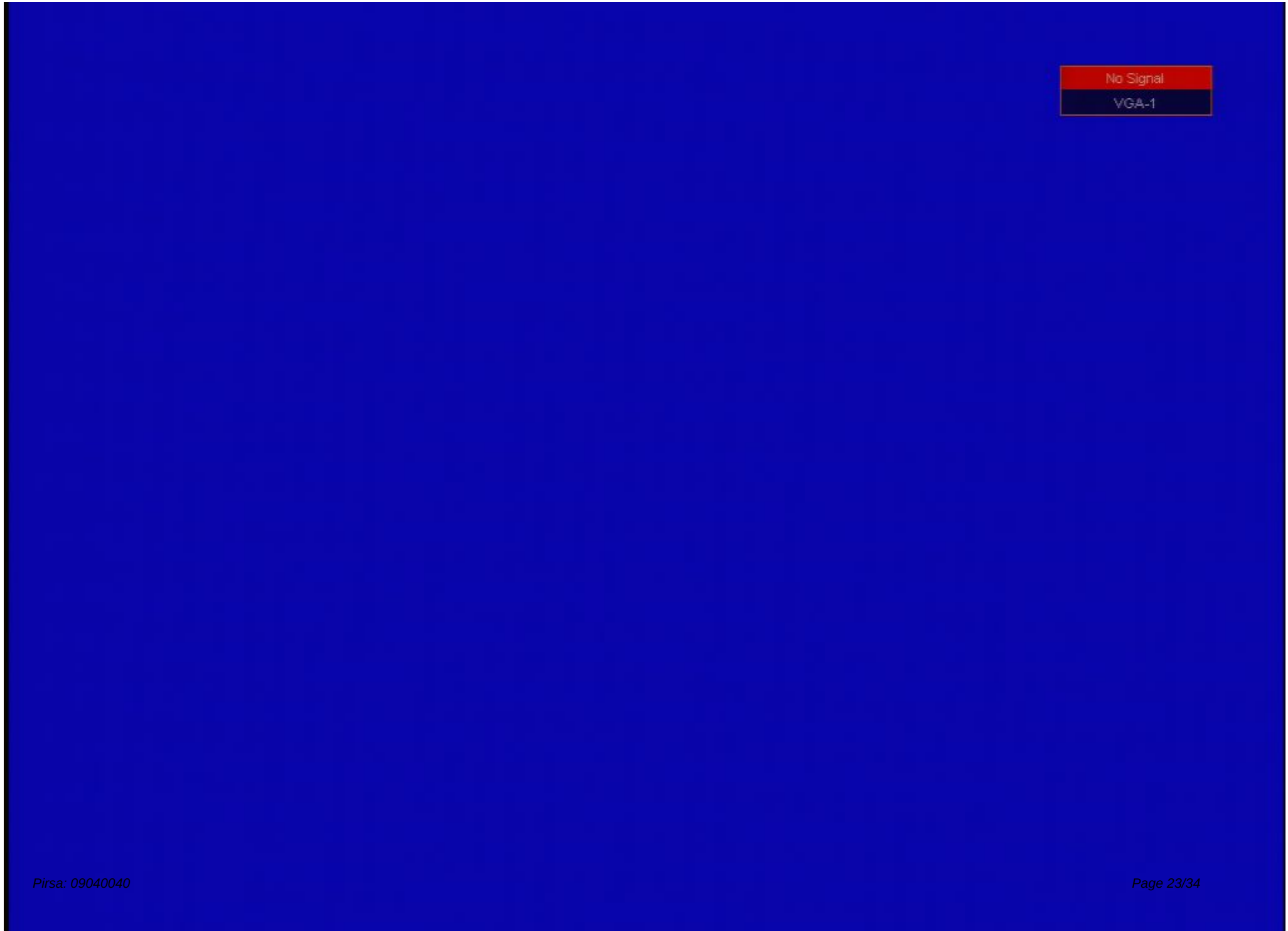




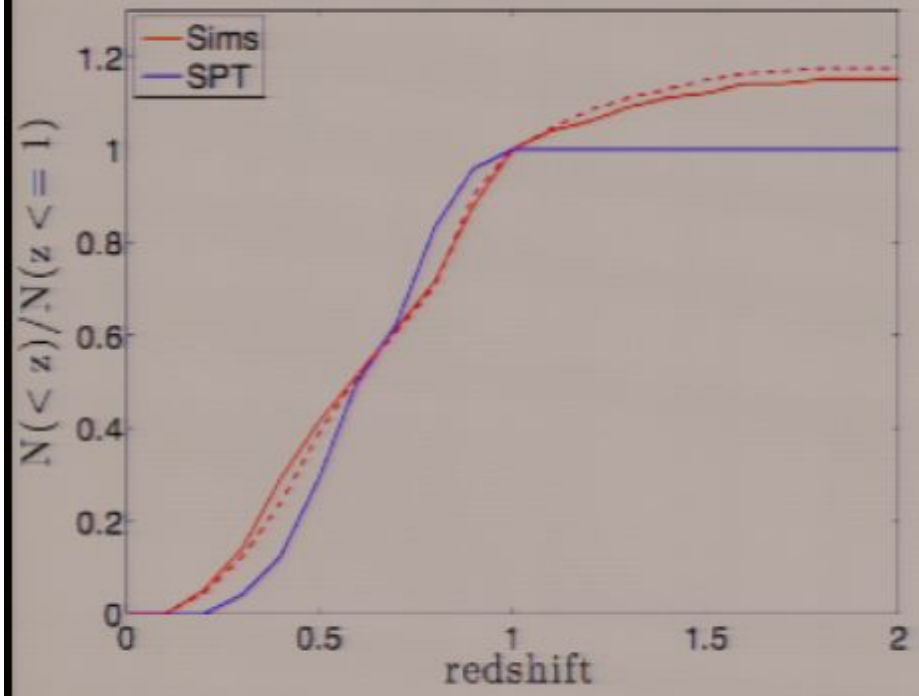
- Expect ~16% clusters to be above z = 1
- 20 clusters total -> we expect ~3 to 4 at z > 1

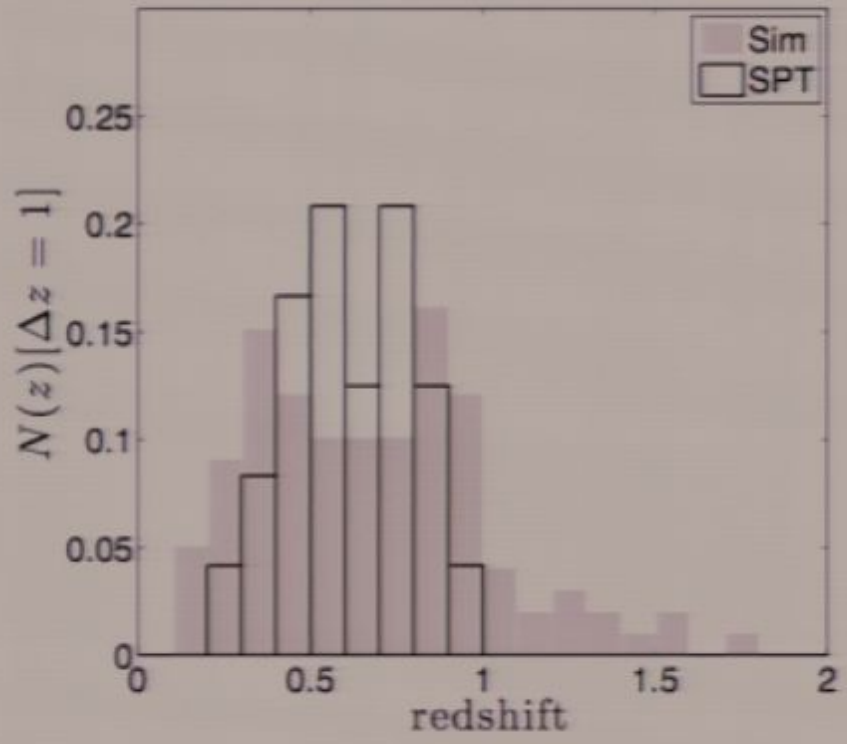

No Signal
VGA-1


No Signal
VGA-1


No Signal
VGA-1

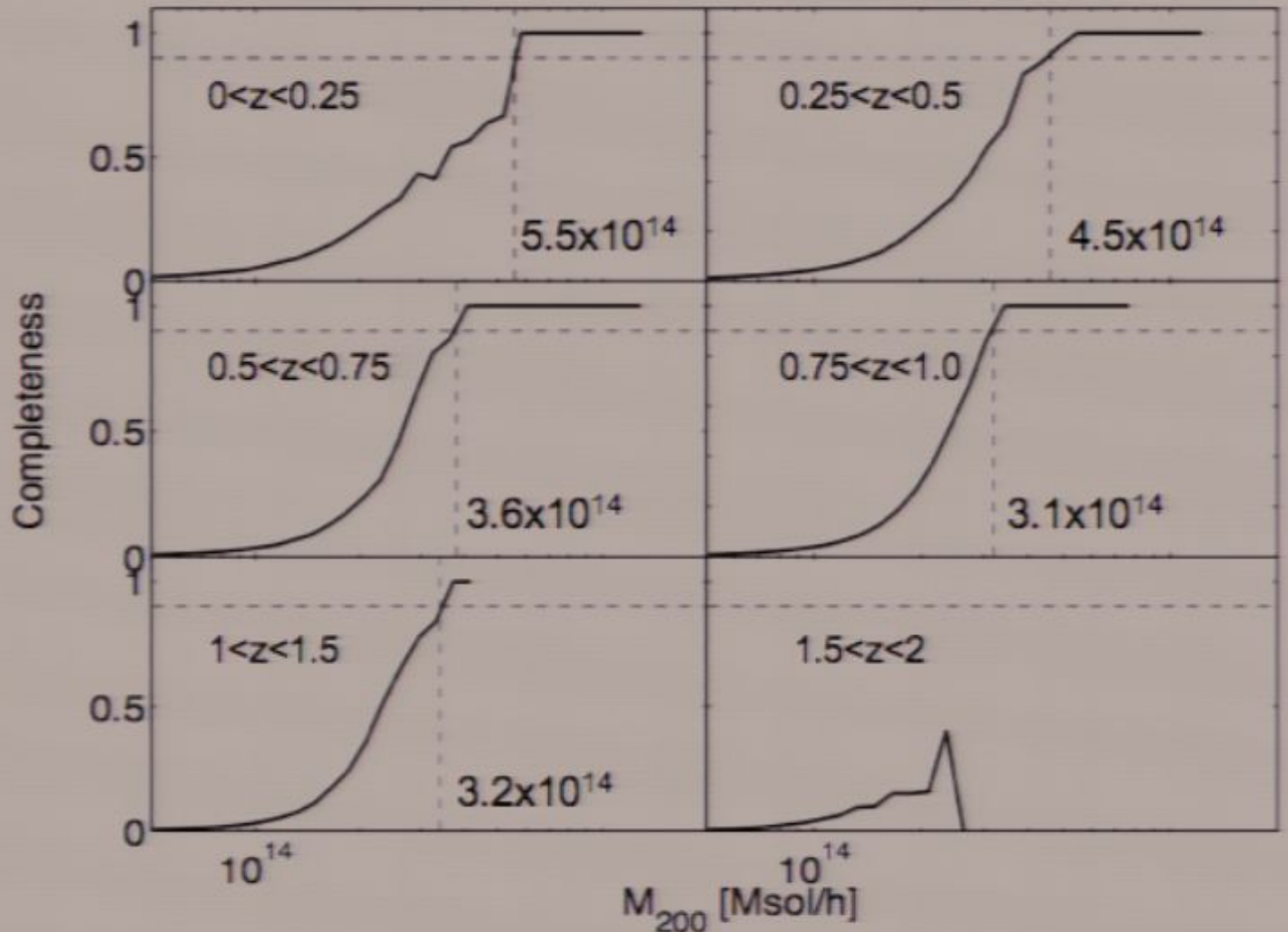
Redshift Distribution





- Expect ~16% clusters to be above z = 1
- 20 clusters total -> we expect ~3 to 4 at z > 1

Completeness



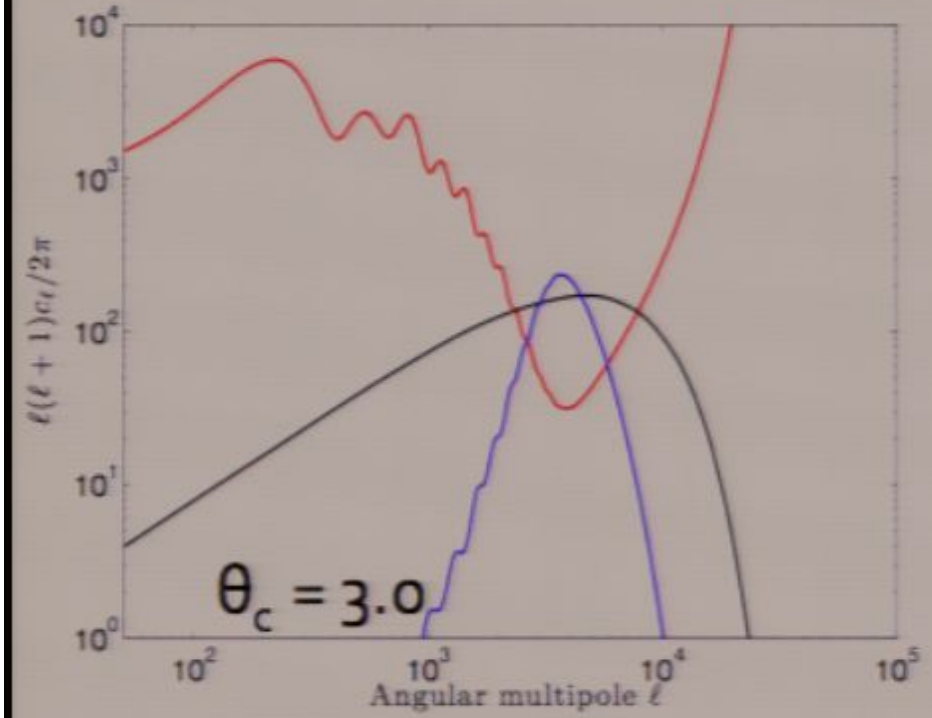
Measuring Flux

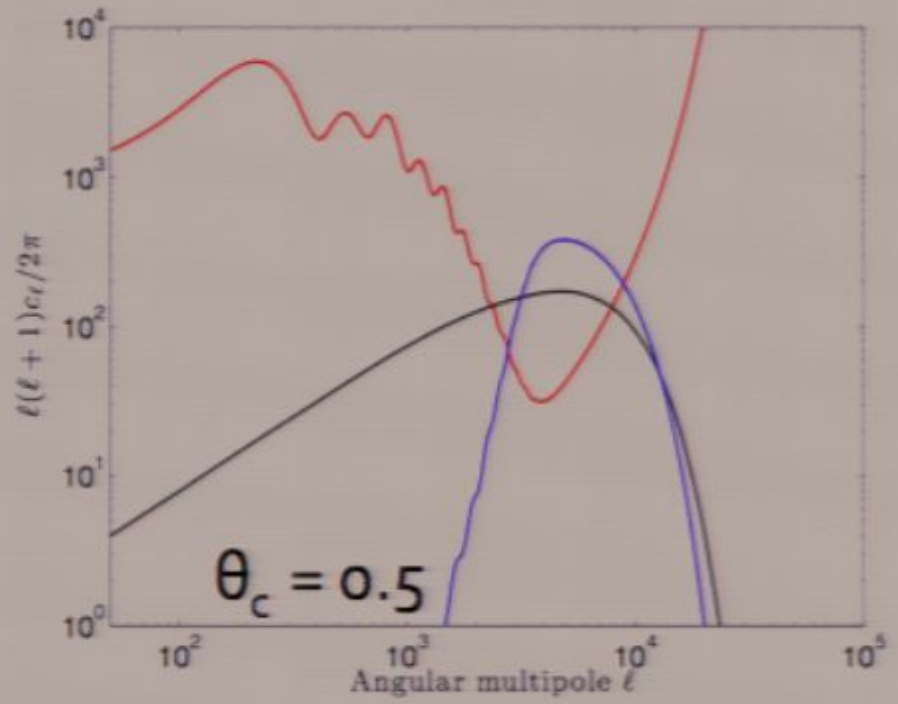
- Optimal filter constructed assuming radial sz profile

$$y(x) = y_0 \left(1 + \left(\frac{x}{\theta_c}\right)^2\right)^{-(3\beta-1)/2}$$

- Iterate application of filter function over discrete range in θ_c. Peak in S/N at best-fit θ_c
- Correctly normalised map gives 'un-beam-smeared' y in central pixel
- Integrate profile to $N_{200}\theta_c$ to get integrated flux.

Reconstructing Y

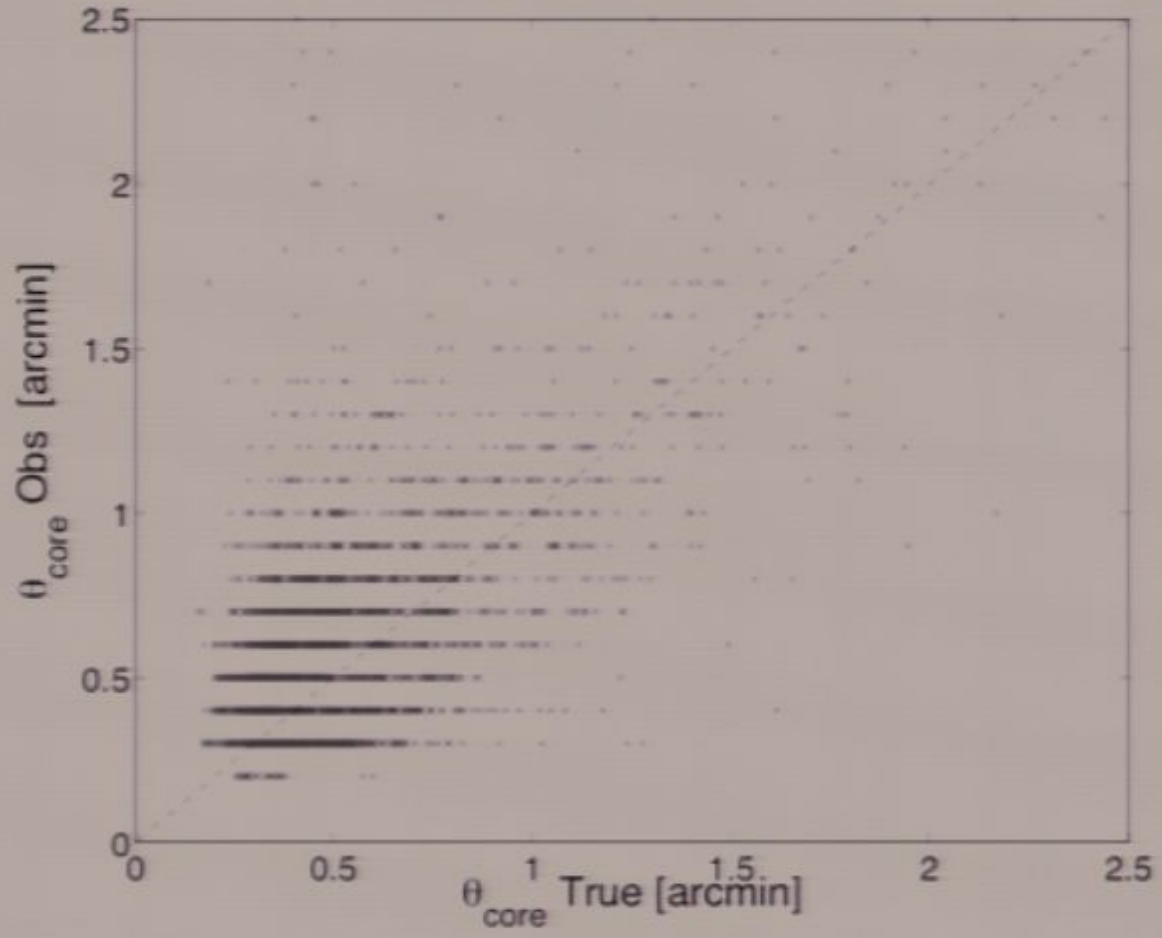




- Cluster core sizes difficult to measure precisely due to limited range in angular scales available to fit

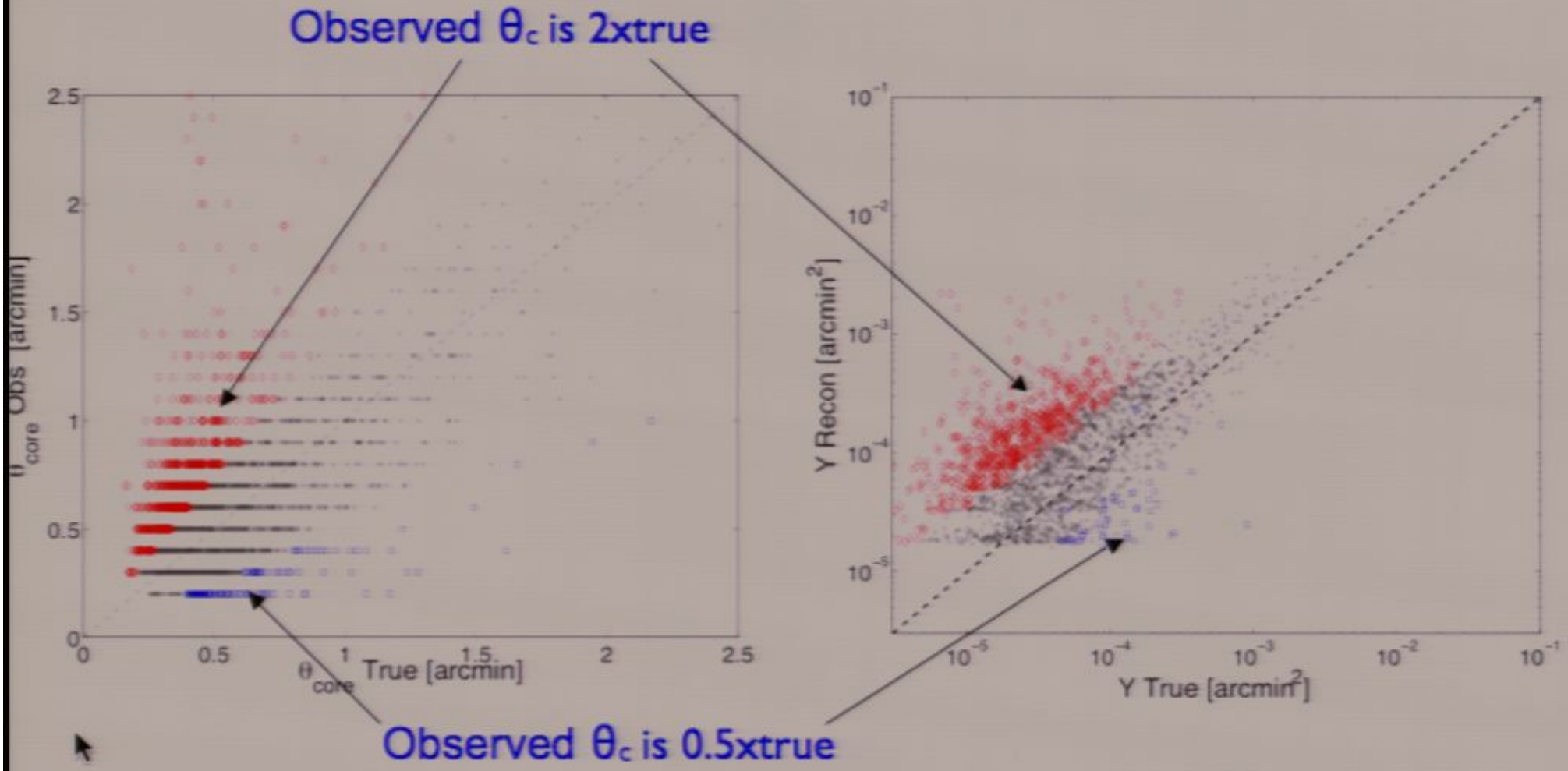
Core measurements

θ_c picked out by opt. filter



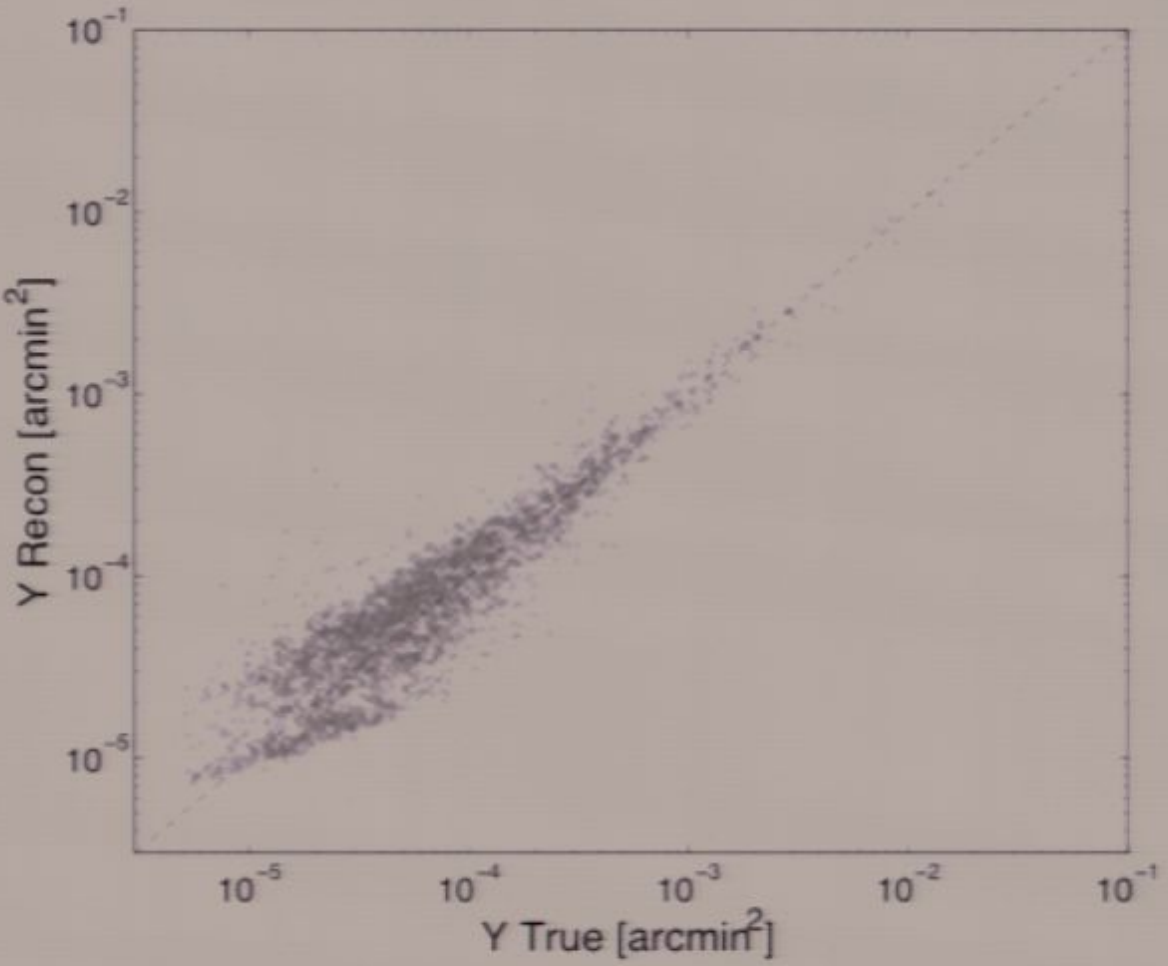
True θ_c in sim

Core measurements



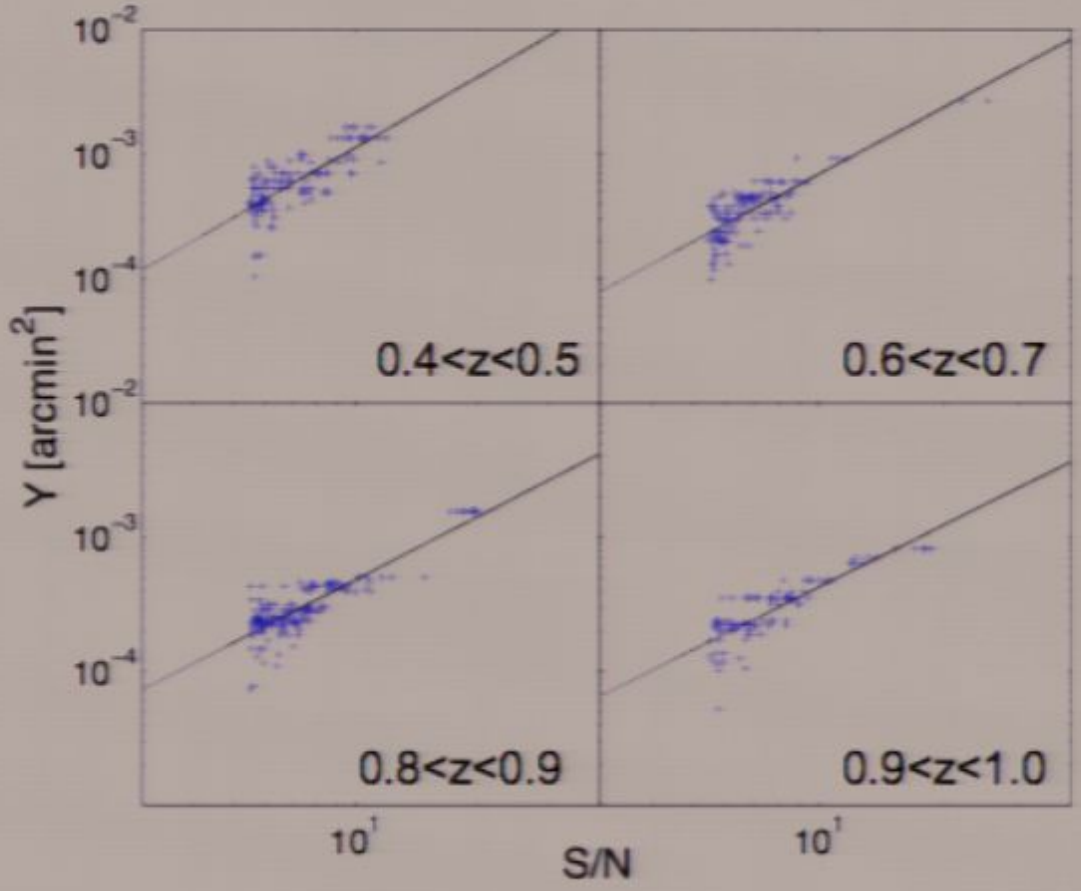
Reconstructing Y

Y with
correct θ_c,
measured y_o



Using correct θ_c produces good estimate of Y

S/N vs Y

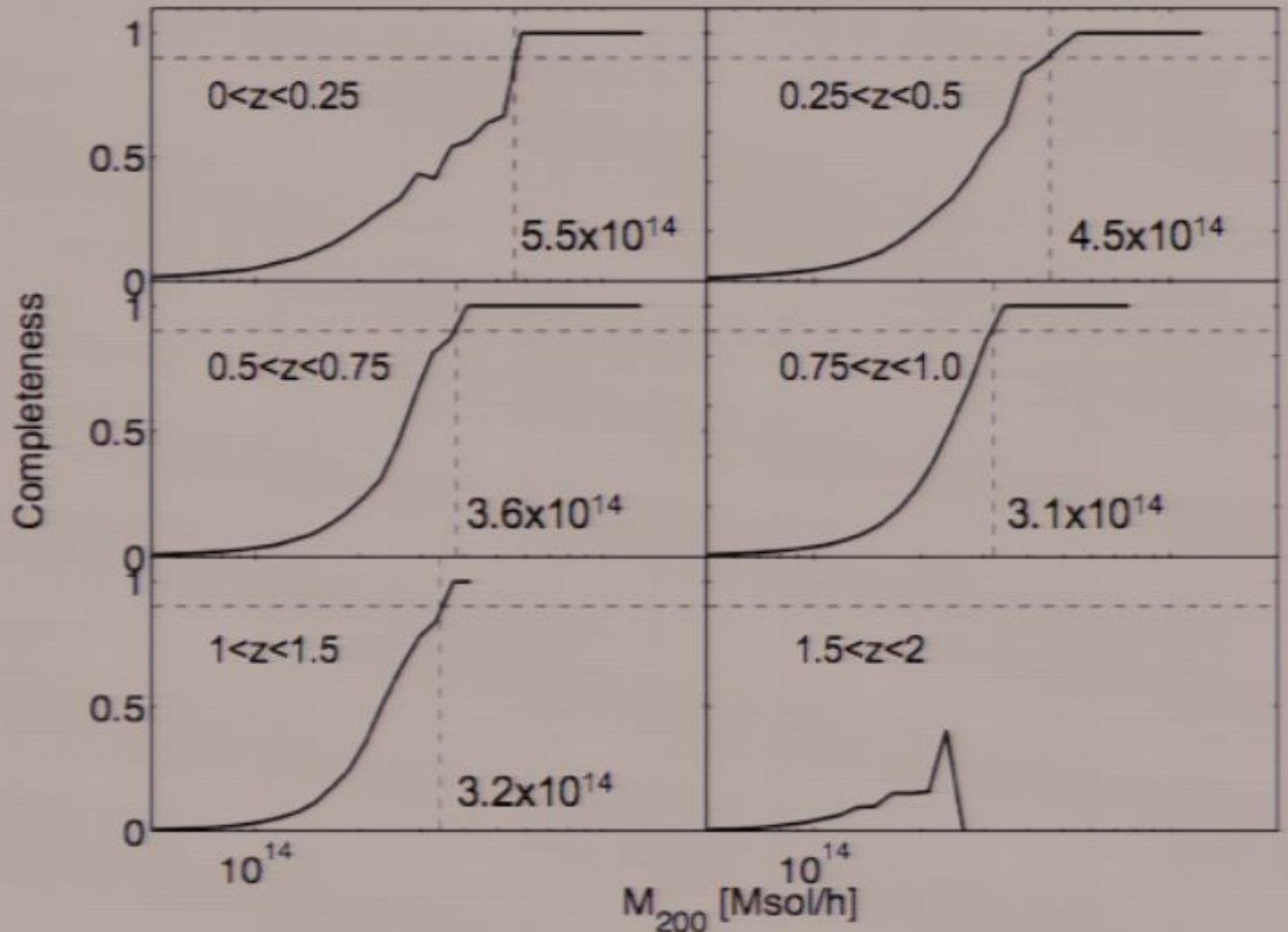


Detection significance provides estimate of beam-smeared flux

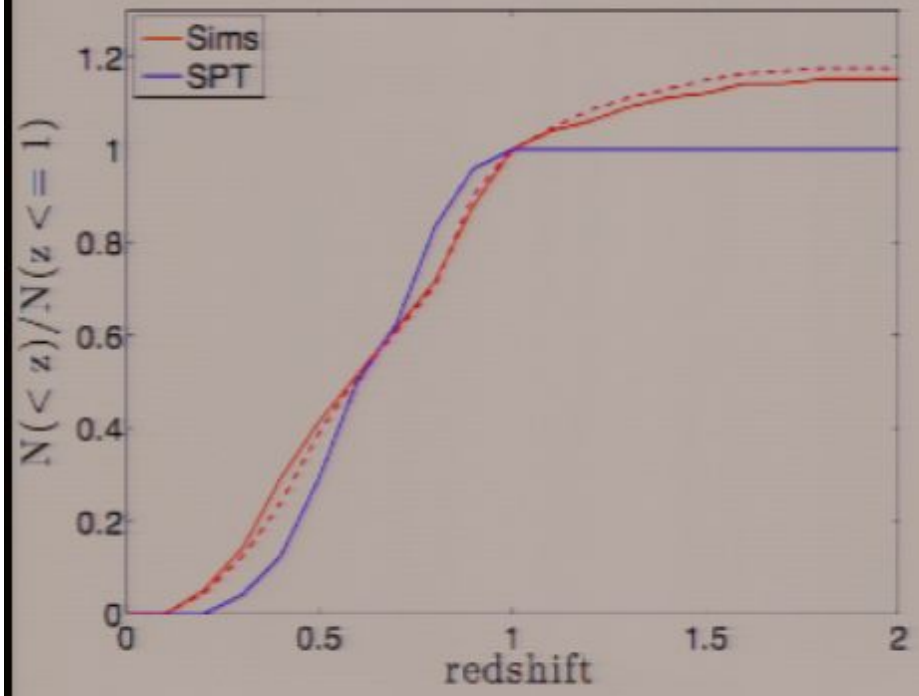
Conclusions

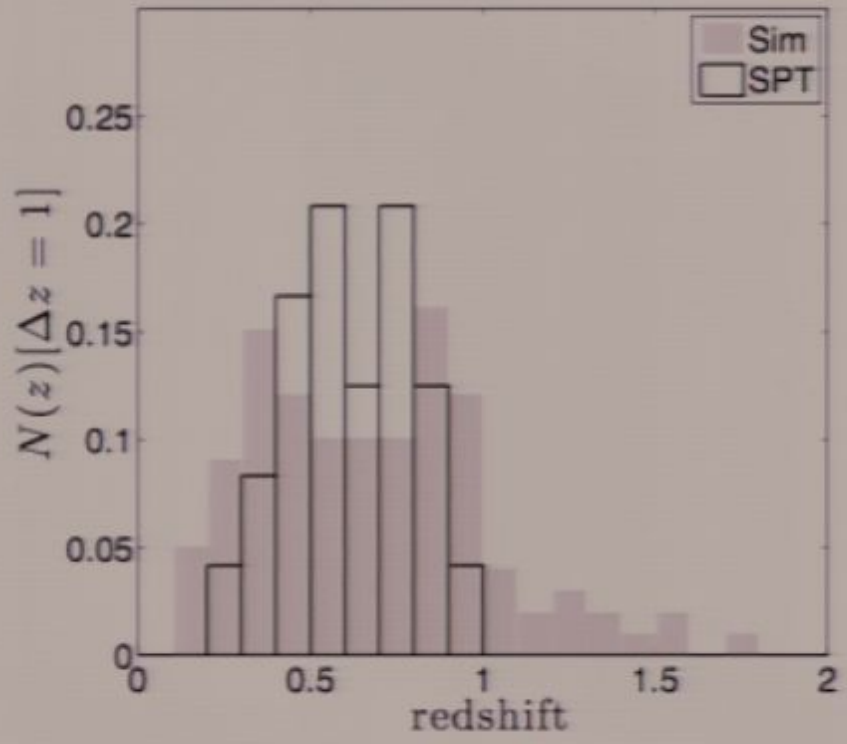
- SPT sample of several dozen *blind-detected* clusters from 2008. Sample size will increase by *at least* a factor of ~4 in 2009.
- Use mock observations to characterize yield (and optimize data processing)
- Sims tell us limiting mass, contamination rate, expected redshift distribution. Everything required to measure dn(z)/dln(M).
- Scale size of clusters poorly constrained. Difficult to get physical Y_A, but can use S/N calibrated from sims for mass proxy.

Completeness



Redshift Distribution





- Expect ~16% clusters to be above z = 1
- 20 clusters total -> we expect ~3 to 4 at z > 1