Lessons from WiggleZ

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Australian Government
Australian Research Council

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Talk

- WiggeZ: first hi-z BAO survey
  - 0.5<z<1 [2% BAO distance to z=0.7]
  - 67% complete
- Lessons from WiggleZ
  - The Devilish Details
    - Selection of targets
    - The World's most fiendish selection function
  - Early results (5 min highlights)

Team

University of Queensland. Kevin Pimbblet, Michael Drinkwater, Russell Jurek, Tamara Davis

Swinburne University. Chris Blake, Karl Glazebrook, Warrick Couch, Greg Poole, Sarah Brough

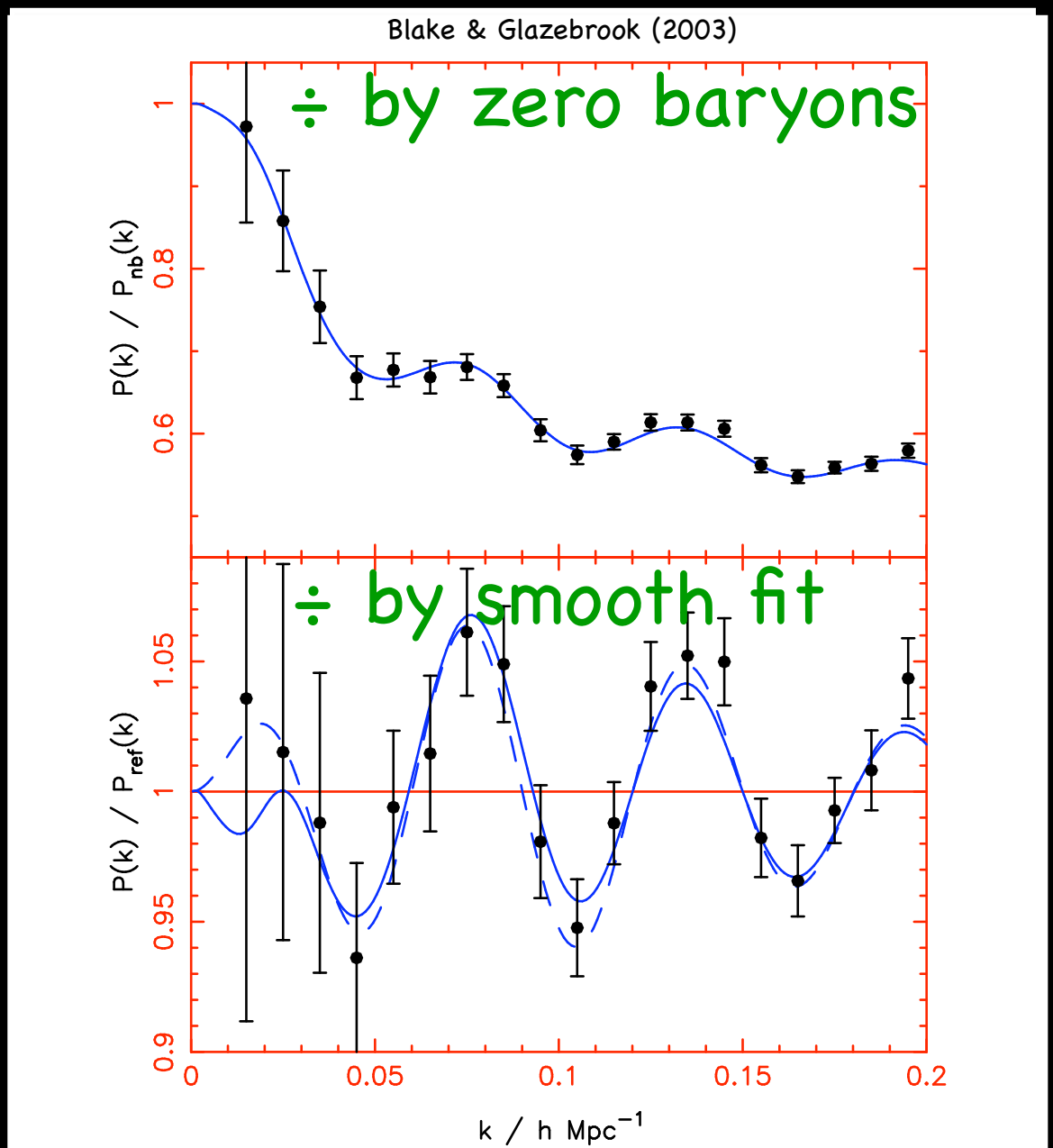
GALEX. Barry Madore, Chris Martin, Ted Wyder

AAO. Matthew Colless, Rob Sharp

+ David Woods (UNSW), Michael Pracy (ANU), Scott Croom (USyd)

Baryon oscillations in matter

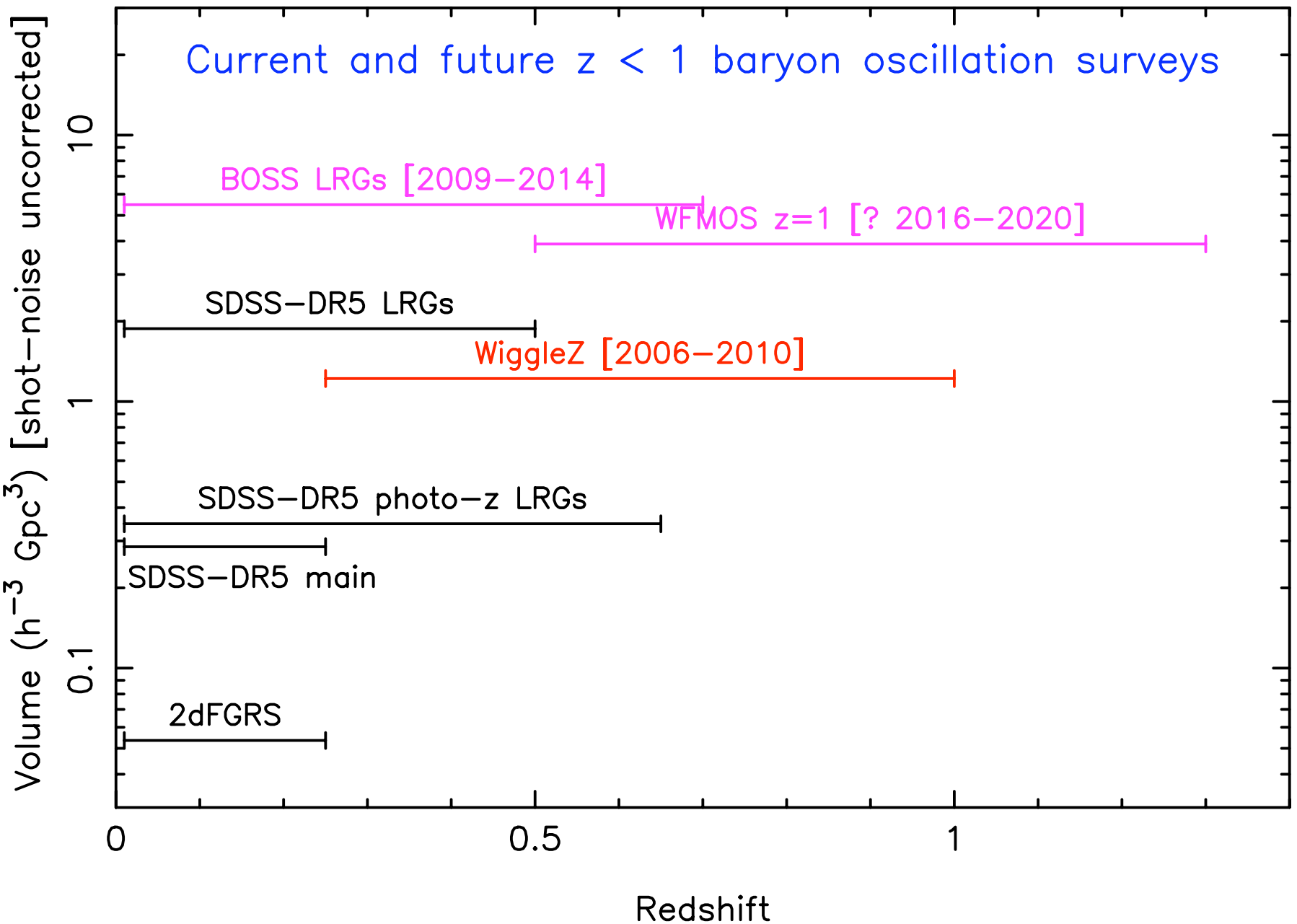
- Imprint of acoustic waves before recombination in matter distribution
- GALAXIES trace these
- LINEAR Features in galaxy clustering
- Show up in large scale galaxy P(k)
- Acc. Std. ruler



Why BAO?

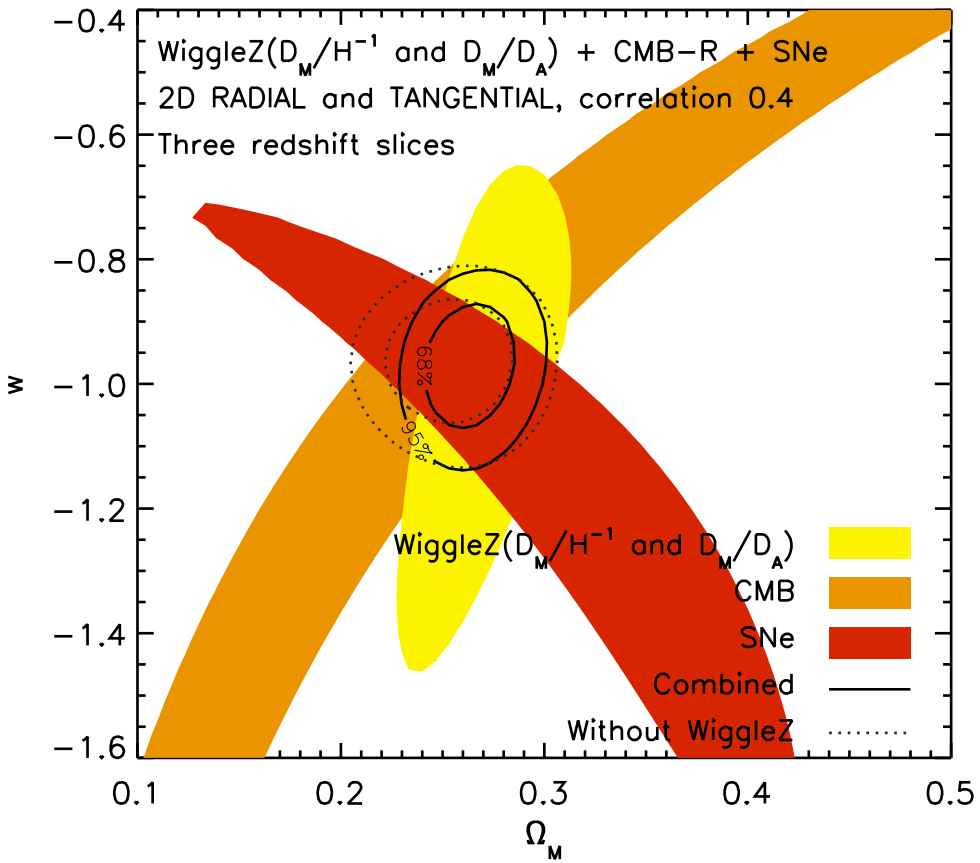
- Independent/Complementary/ Constraining test of Accelerating Universe paradigm
- Sensitivity to detect subtle deviation from ‘vanilla’ ($w \neq -1$)

Survey design



Parameter forecasts

Measurements of $(w_{\rm cons}, \Omega_{\rm m})$ combining with supernovae



(Plot credit: Tamara Davis)

$$\sigma(w_{\rm cons}) = 0.07$$
$$\sigma(\Omega_{\rm m}) = 0.02$$

Assumes : (1) flat cosmology + constant equation-of-state ;
(2) latest supernova observations from Essence, SNLS and HST ;
(3) WMAP measurement of shift parameter R

History

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- 2002: WFMOS BAO ideas

  z~1 SDSS survey (high-quality spectra)

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  1<z<1.7 Hα survey [Totani-san talk]

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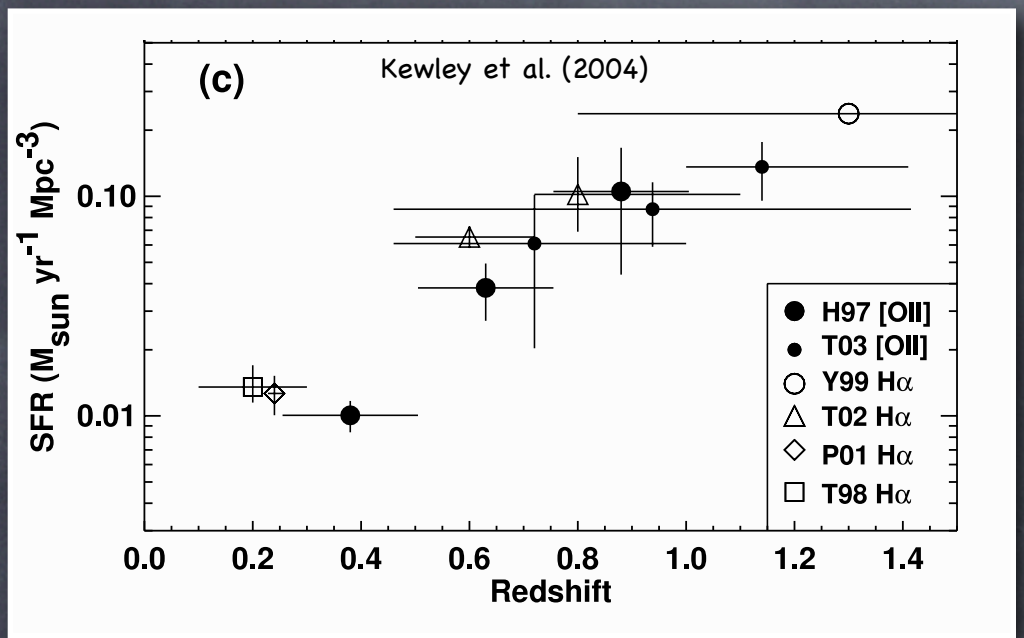
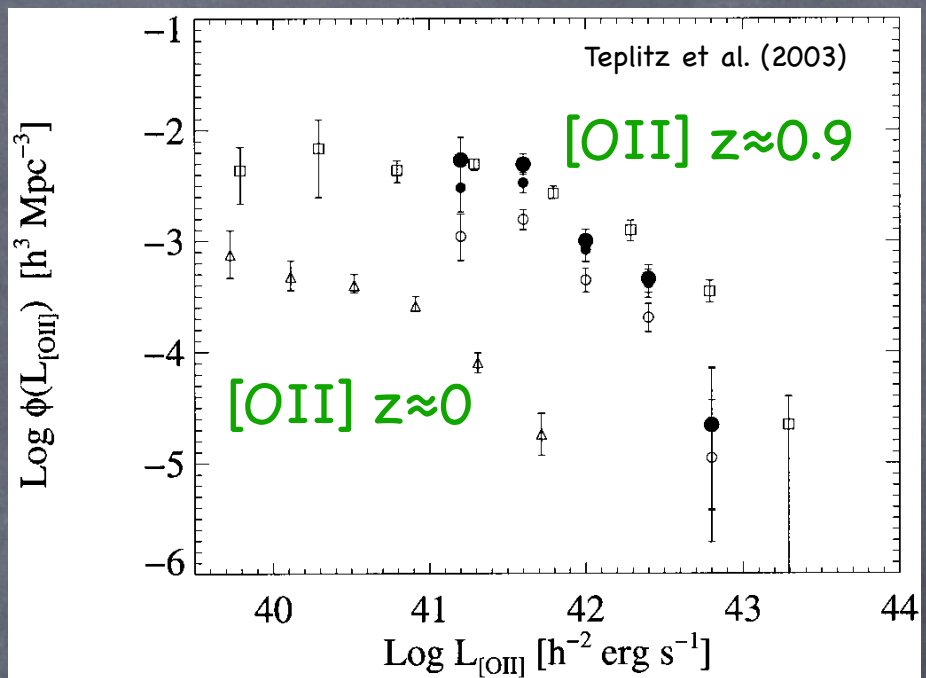
- 2003: AAOmega (4m AAT) Optical emission line survey concept

  0.5<z<1 [OII] survey, 1000 deg^2

  One Hour exposures!!

Exp times - starformers

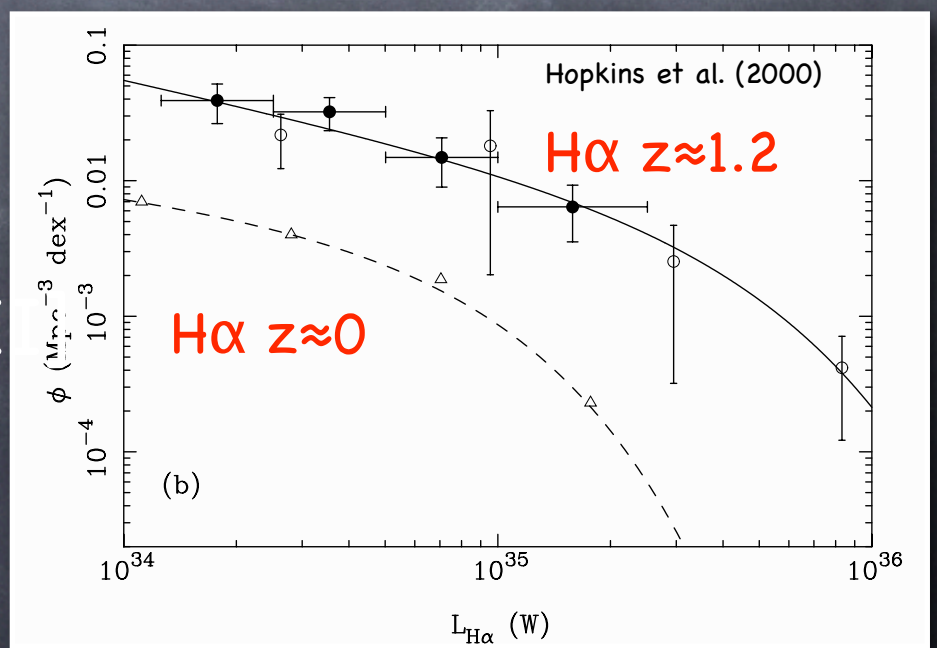




Strong SFR-z evolution counteracts $D_L(z)^2$

At z=1.2 critical density [OI

flux = 2×10^{-16}ergs cm^2 s^{-2} cm^{-1} s^{-1} [$\equiv$1.8 L^*_{line}]



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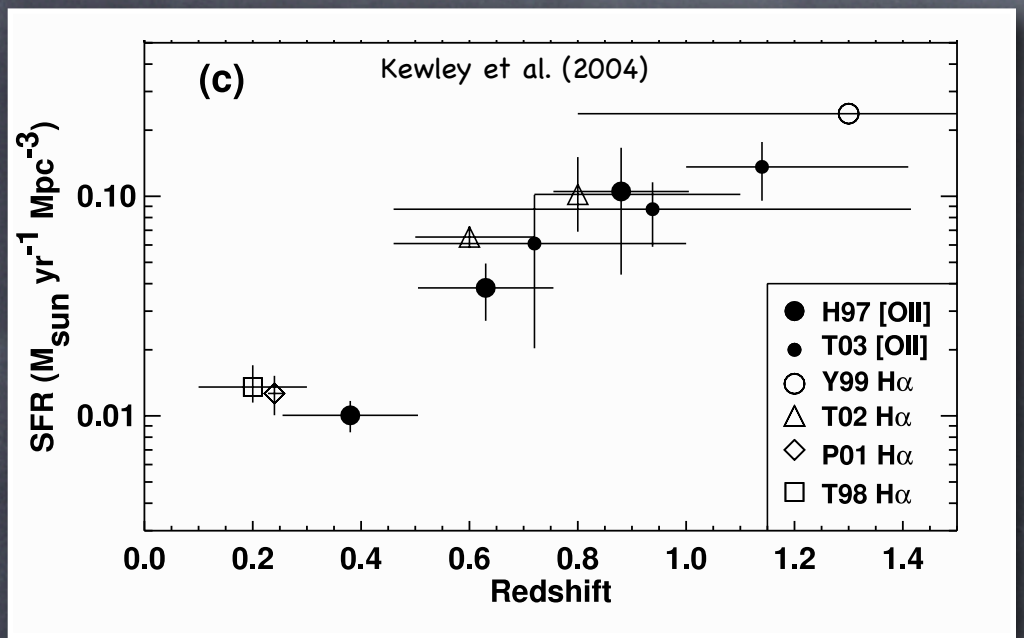

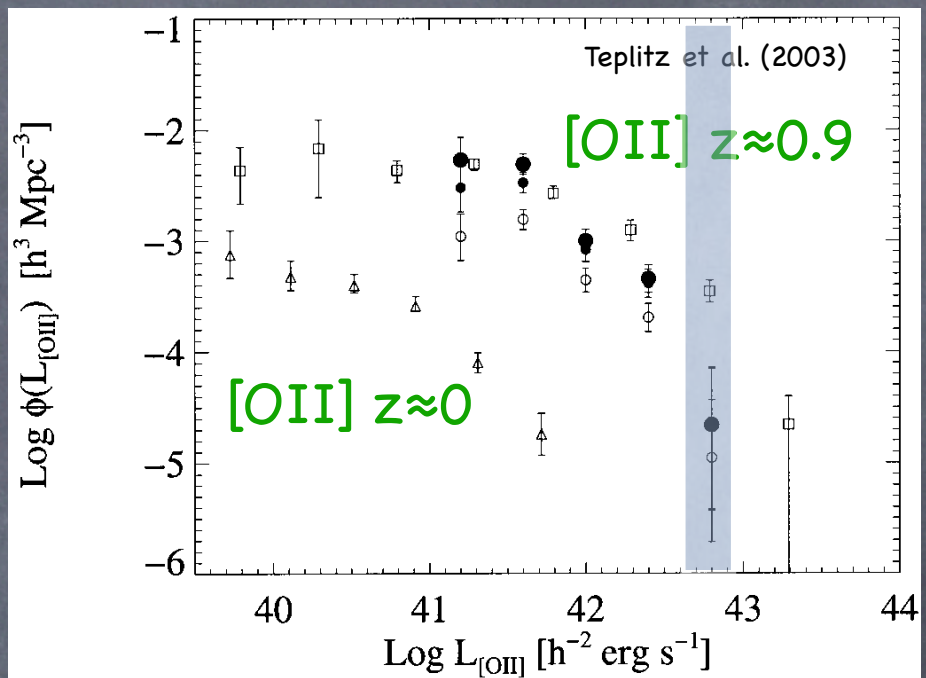

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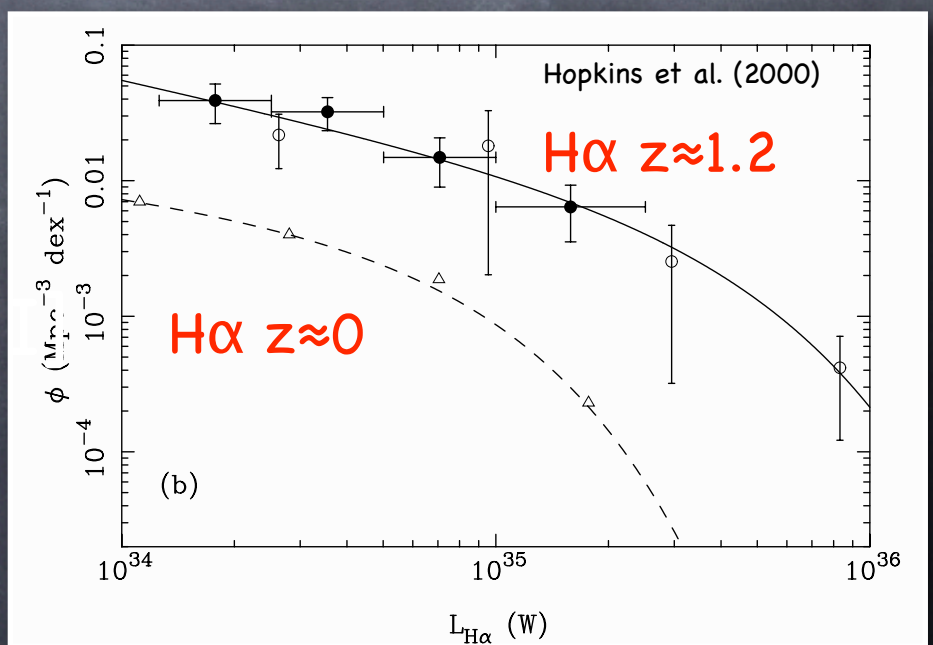

AAΩ S/N calc

Wavelength	**8200**	Angstroms
Galaxy mag at wavelength	**22**	mags
Line Flux in SRE	**20**	1e-17 ergs/cm2/s
Fraction of light in aperture (fudge)	**0.7**	e.g. 0.7 for slit width ~ seeing
Mag in slit	22.3872549	mags
Fnu from object cuum	4028.323027	nJy/m^2
Flambda from object cuum	1.79729E-21	W/m^2/A
Photons from object cuum	0.007409637	ph/m^2/A/sec
Photons from object line	0.57717446	ph/m^2/sec
Telescope area	**9.5**	m^2
System efficiency atm->detector	**18**	%
Exposure time for one integration	**1200**	***seconds on target***
Spectral SRE size	8	Angstroms
SRE size along slit	1.75	arcsec
Slit width	1.75	arcsec
Detected object electrons	121.6365942	per SRE
Detected line electrons	1184.361991	per SRE
Cuum Signal/noise per integratio	**1.282686074**	**per SRE**
Line Signal/noise per integration	**11.81096257**	**per SRE**
Number of integrations	**3**	
Total exposure	3600	secs
Cuum Final Signal/noise	**2.22167745**	**per SRE**
Line Final Signal/noise	**20.45718726**	**per SRE**

Mag zero point	**3631**	Jy (AB mags)
Sky brightness	**19.8**	mags/arcsec^2
Fnu from sky	43654.22162	nJy/m^2/arcsec^2
Flambda from sky	1.94769E-20	W/m^2/A/arcsec^2
Photons from sky	0.080296916	ph/m^2/A/sec/arcsec^2
Pixel spatial size	**0.35**	arcsecs
Pixel spectral size	**1.6**	Angstroms
Object spatial size	**5**	pixels
Slit width	**5**	pixels
Dark count rate	**0**	electrons/sec/pix
Scattered OH rate	**0**	electrons/sec/pix
True sky	0.134561573	electrons/sec/pix
Readnoise	4	electrons/sec/pix
Det .back. electrons	4036.84718	per SRE
Back. noise	66.60966281	per SRE
Sky subtraction fac.	**1.414**	sqrt(2) or 1
Sky/Object cuum	**33.18776891**	**per SRE**
Spec Resolution R=	1025	

AAΩ S/N calc

Average I-band sky (no inter-OH)

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- Select galaxies using GALEX (UV)

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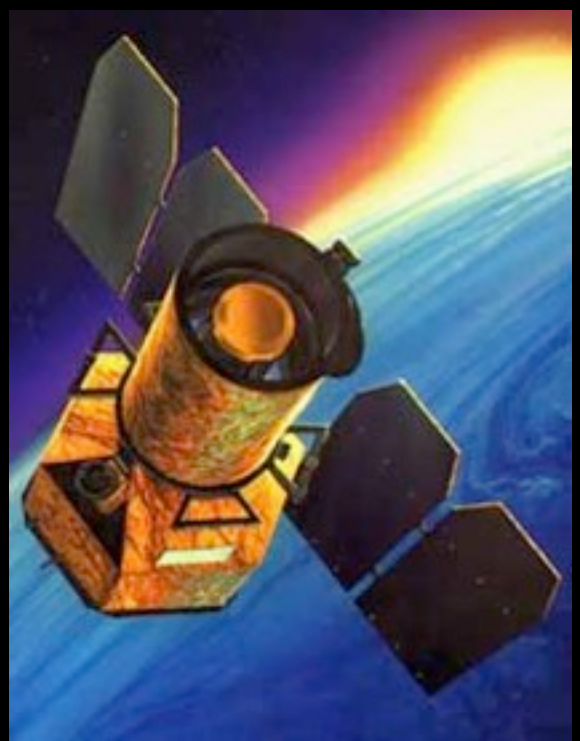

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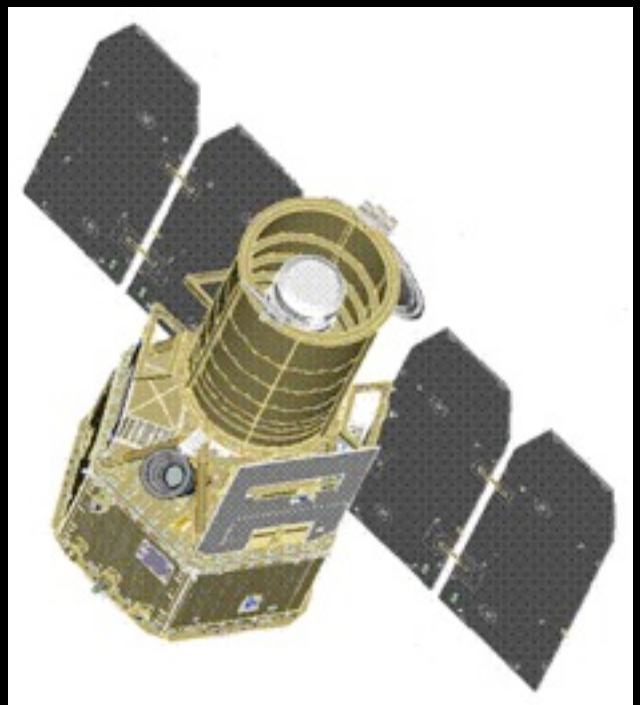
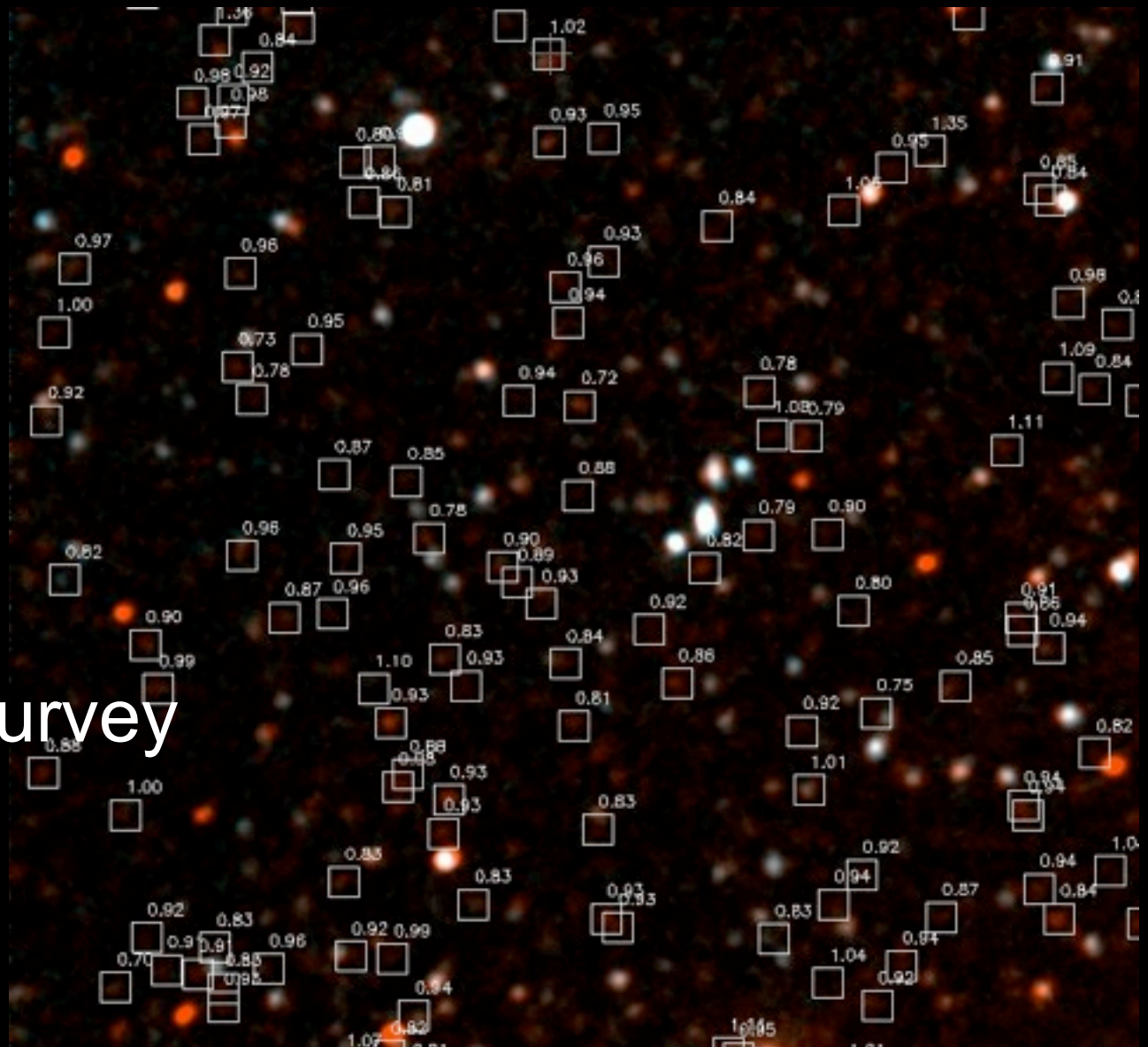
GALEX





Medium imaging survey
One orbit depth
FUV, NUV filters
NUV<23

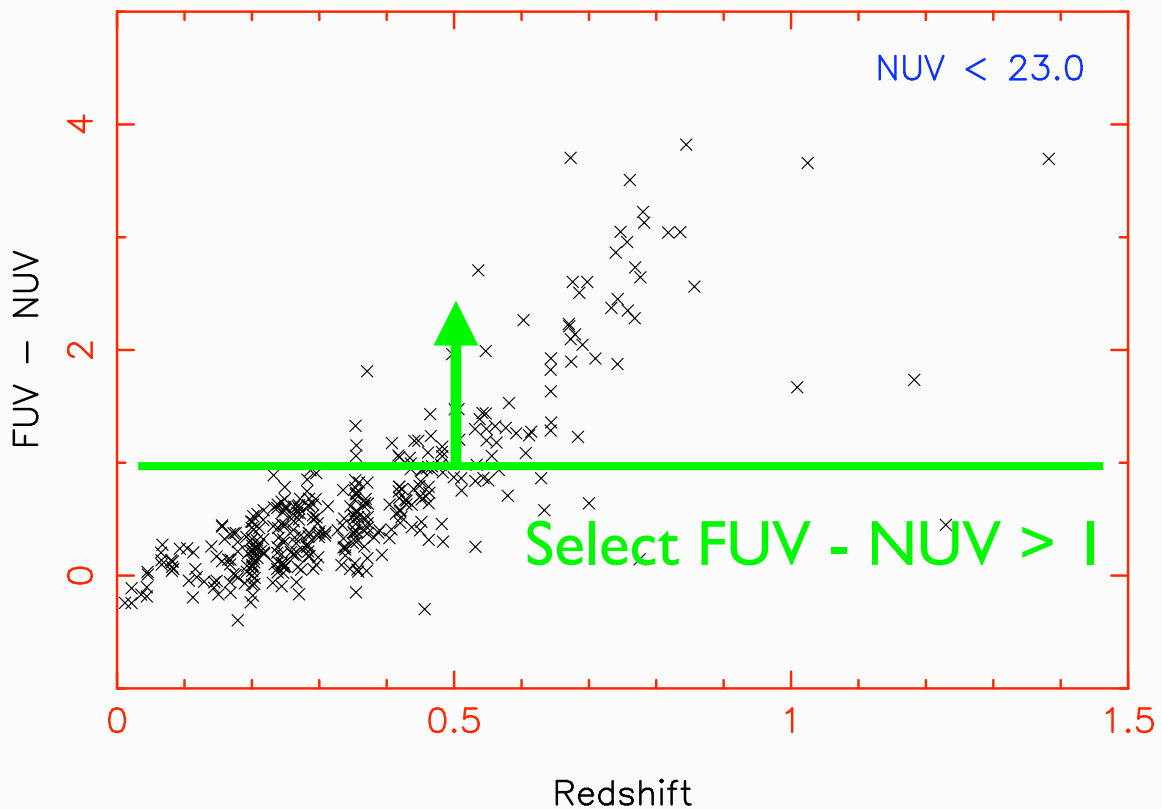
z>0.5 blue galaxy

Red: FUV-NUV>1 (or dropout)

Blue: -0.5< NUV-r(SDSS) <2

20<r<22.5 NUV<22.8 (& SN>3)

Matching < 2.5 arcsec



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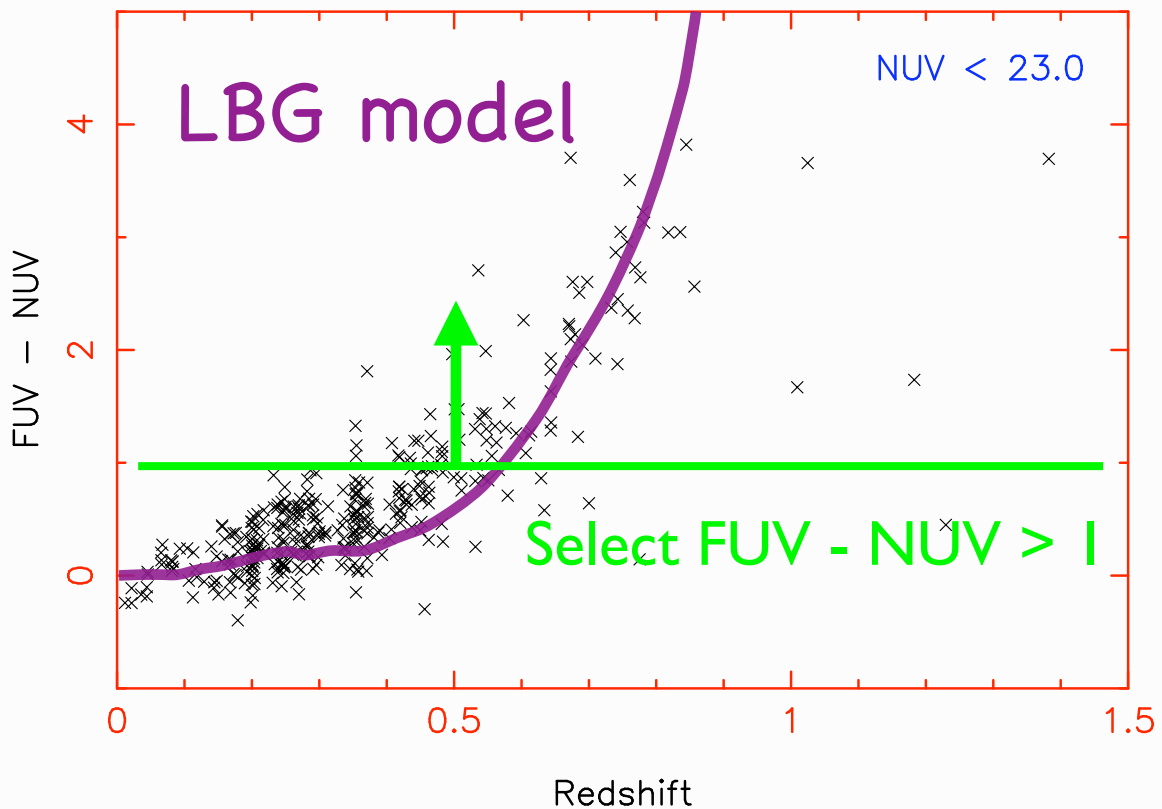
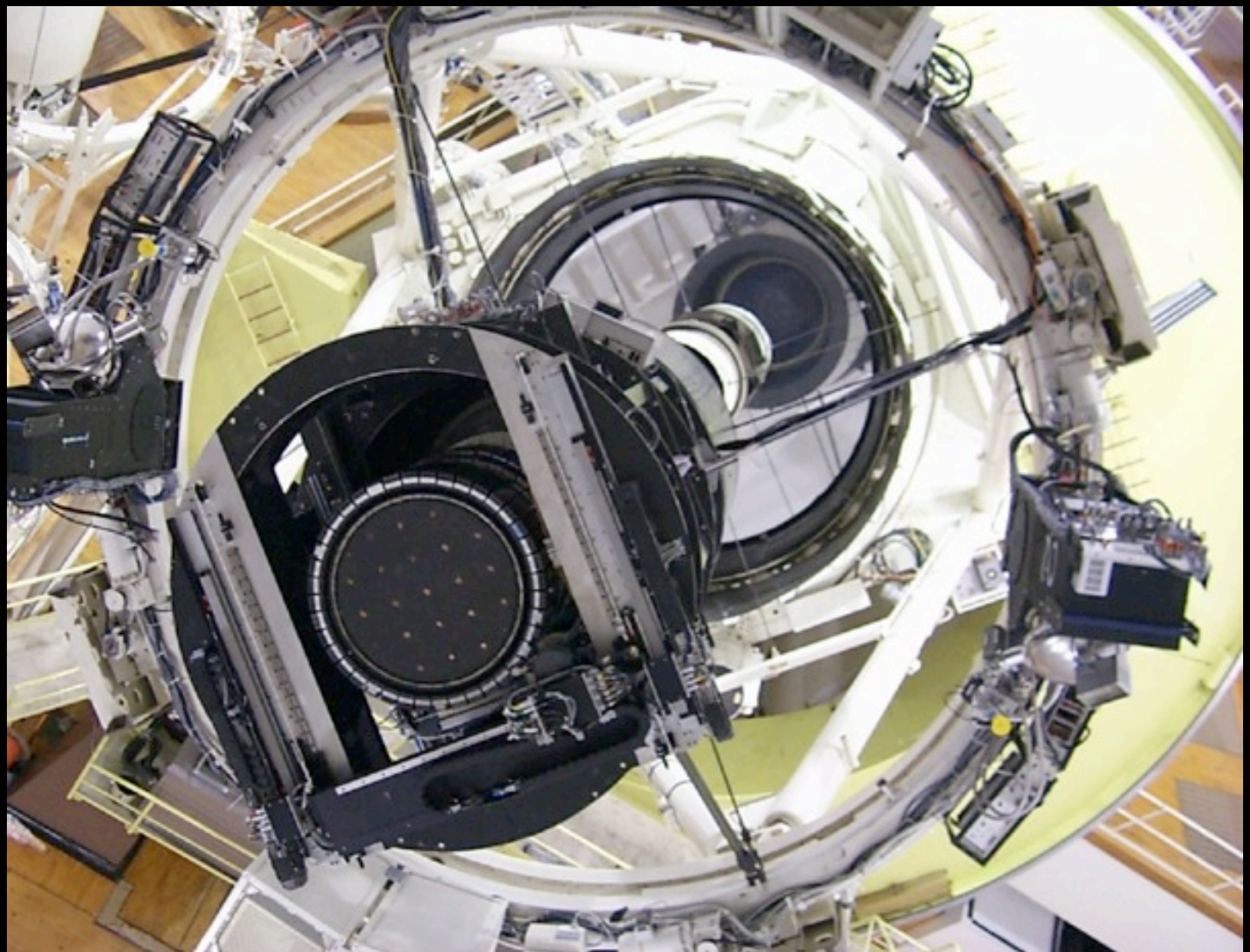


What is AAΩ?



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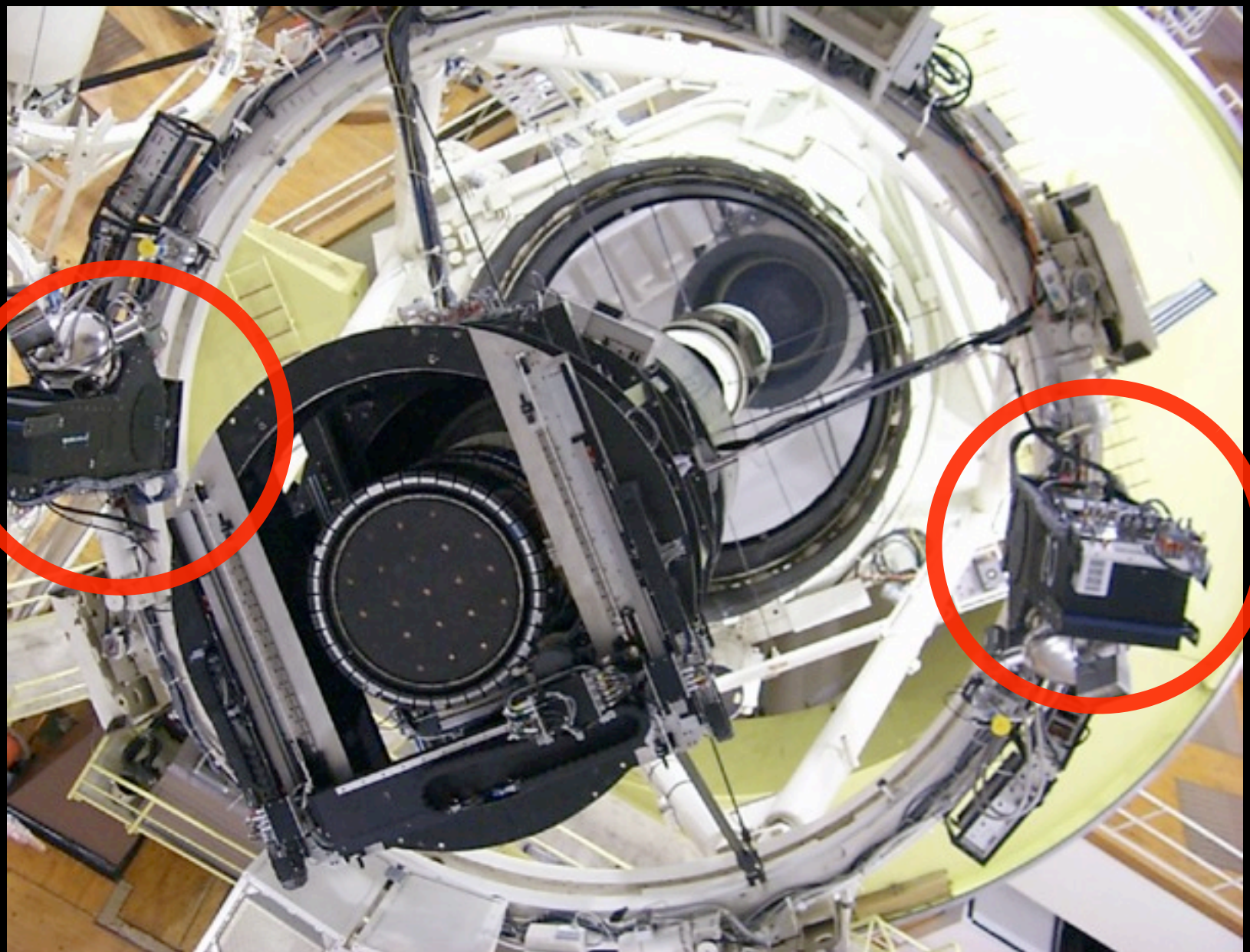
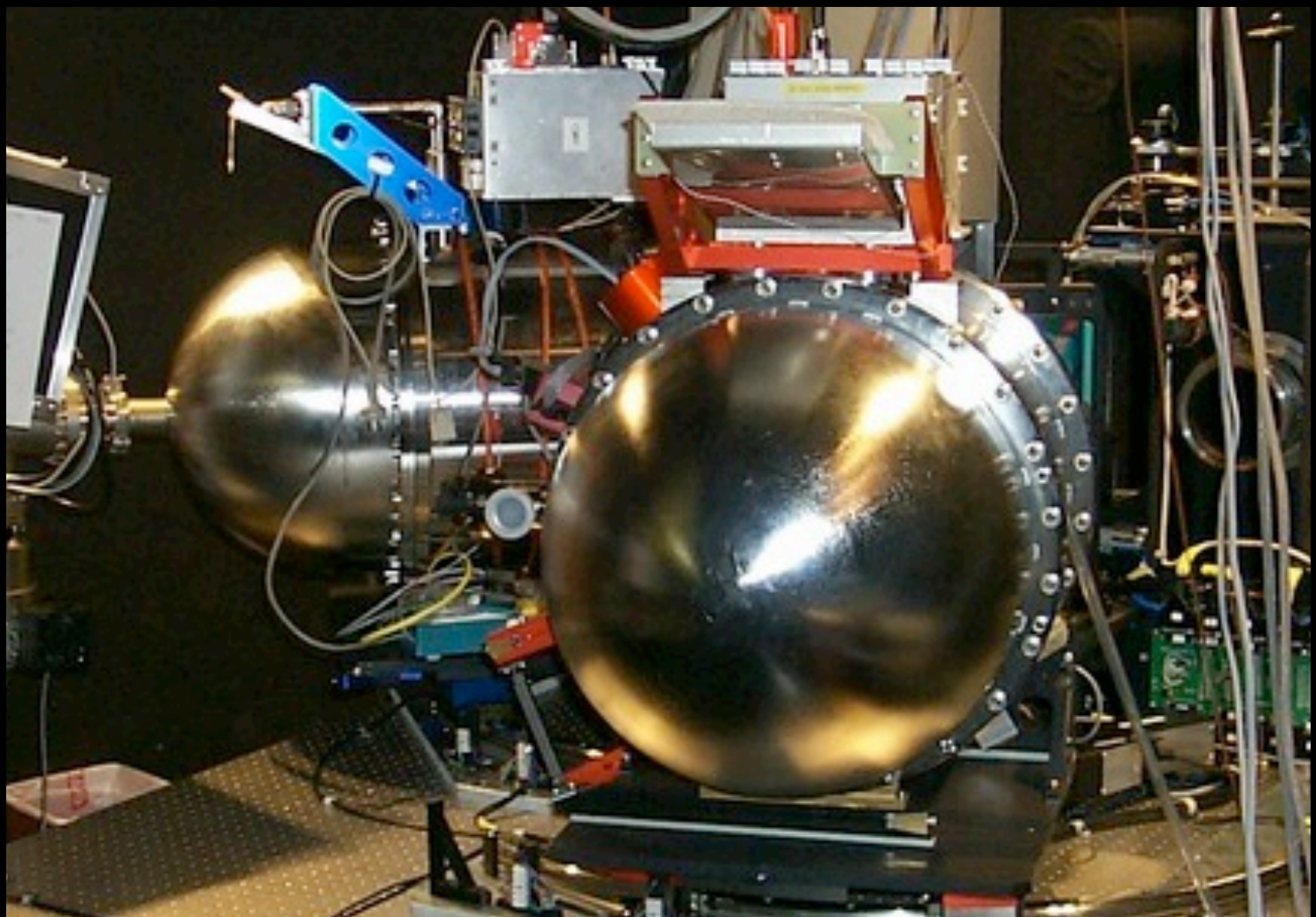
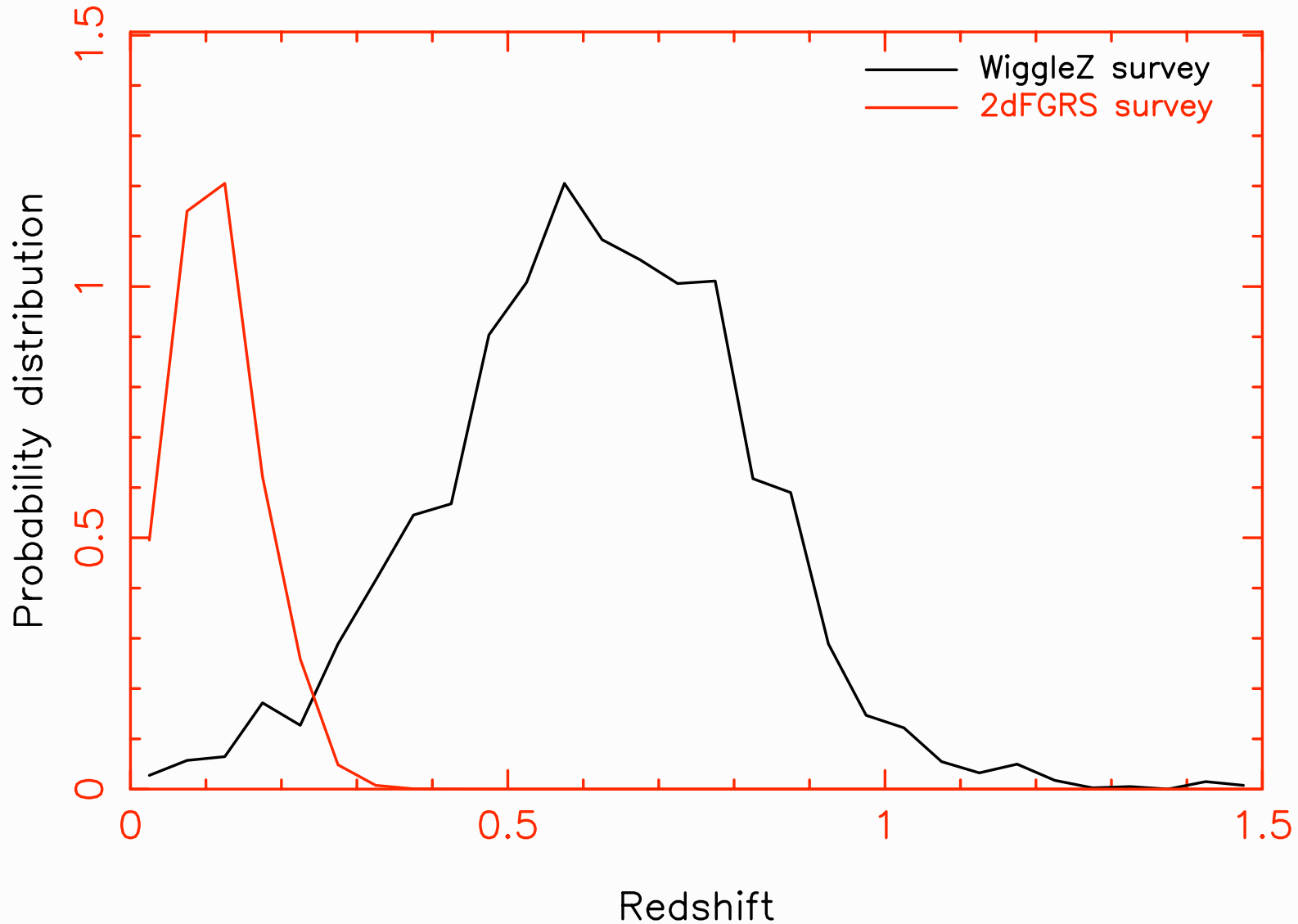


AAΩ hardware

Peak 21% end-to-end throughput



Redshift distribution



But...

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  - MIS too patchy
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- Getting the UV data over 1000 deg^2
  - MIS too patchy
  - Barely deep enough
- Getting the optical data
  - SDSS only sufficiently complete in NGP
  - SDSS barely deep enough (RCS2 extension...)
- Spectroscopy
  - SNR<1 (continuum) spectra
  - Chasing the GALEX imaging

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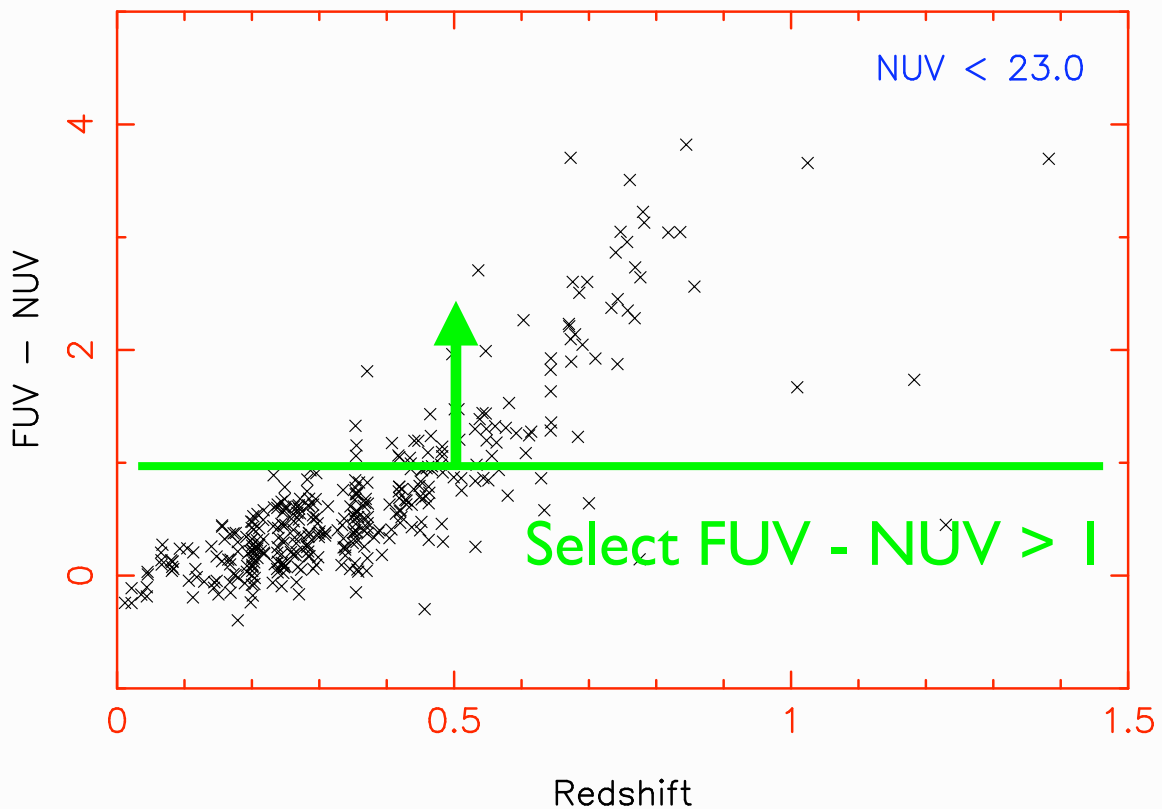

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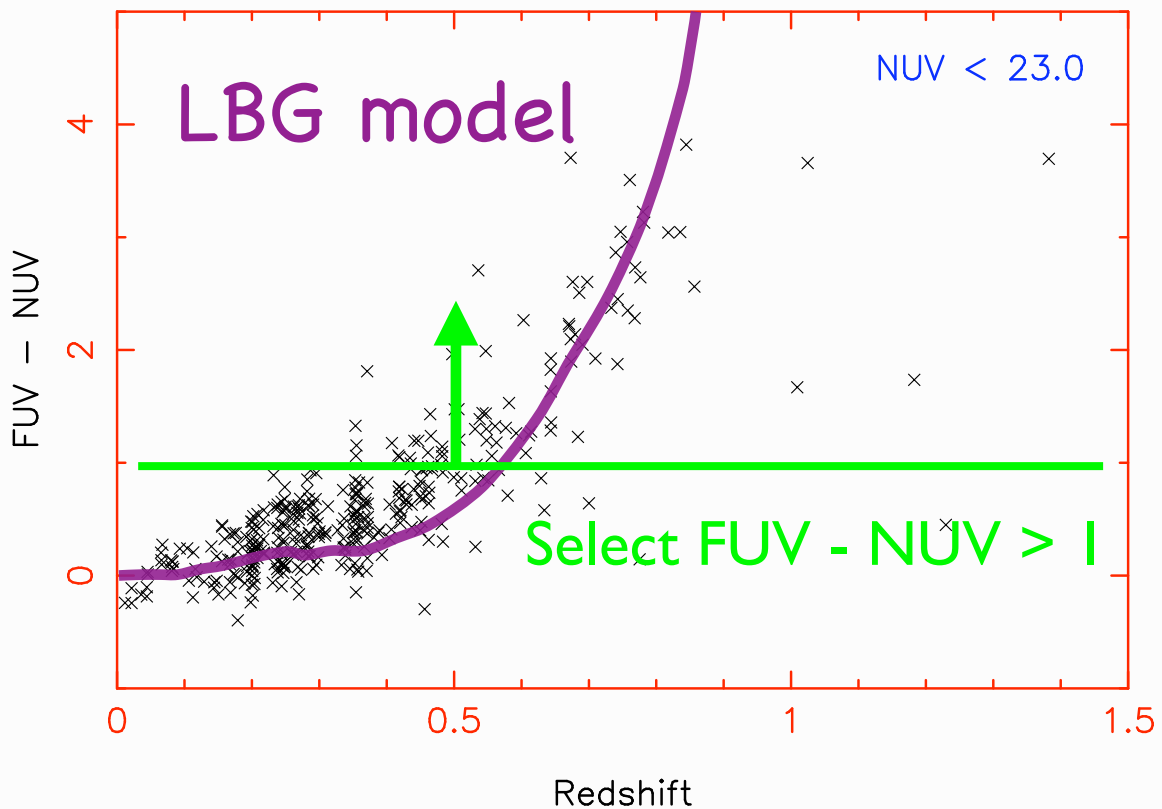
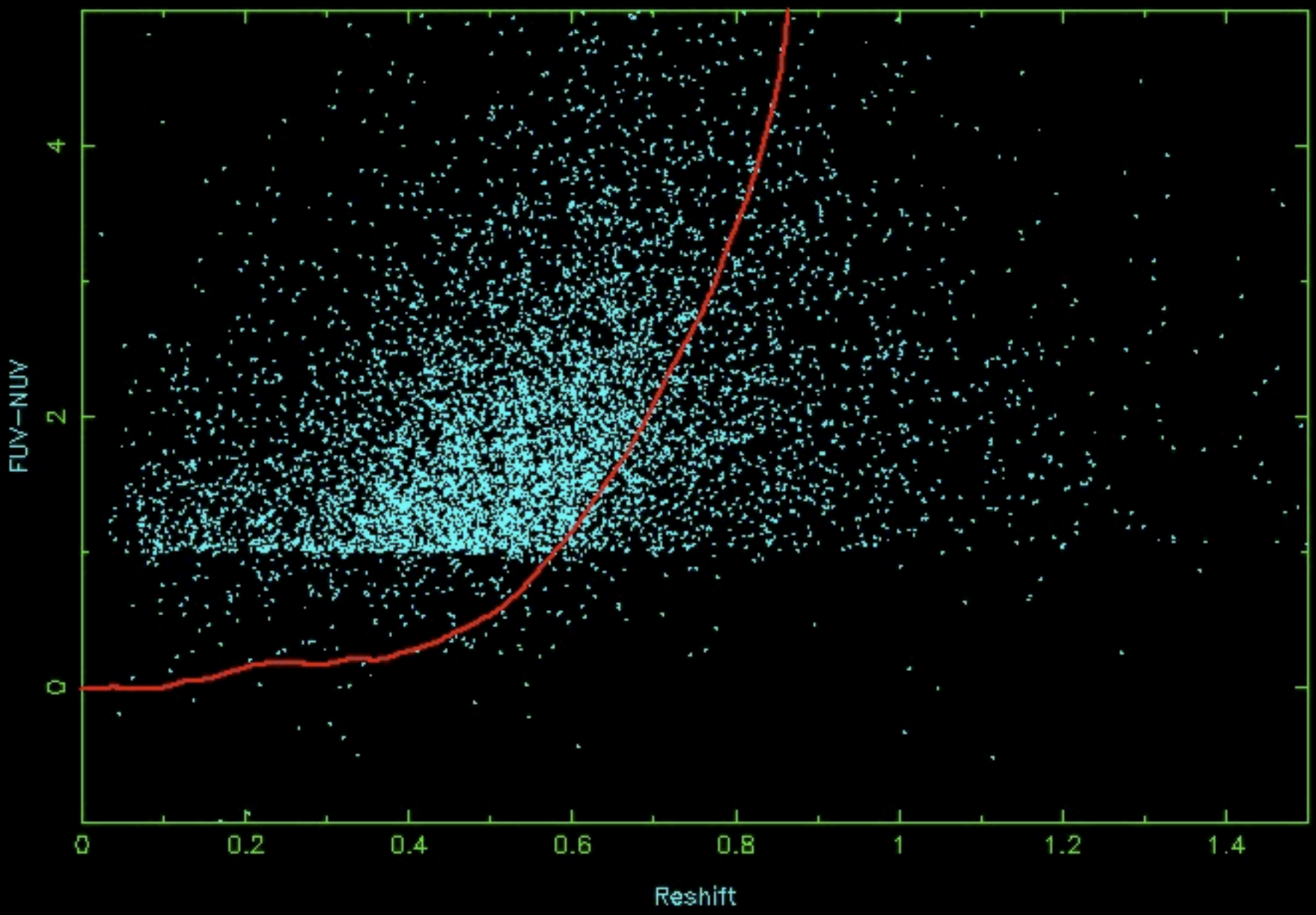
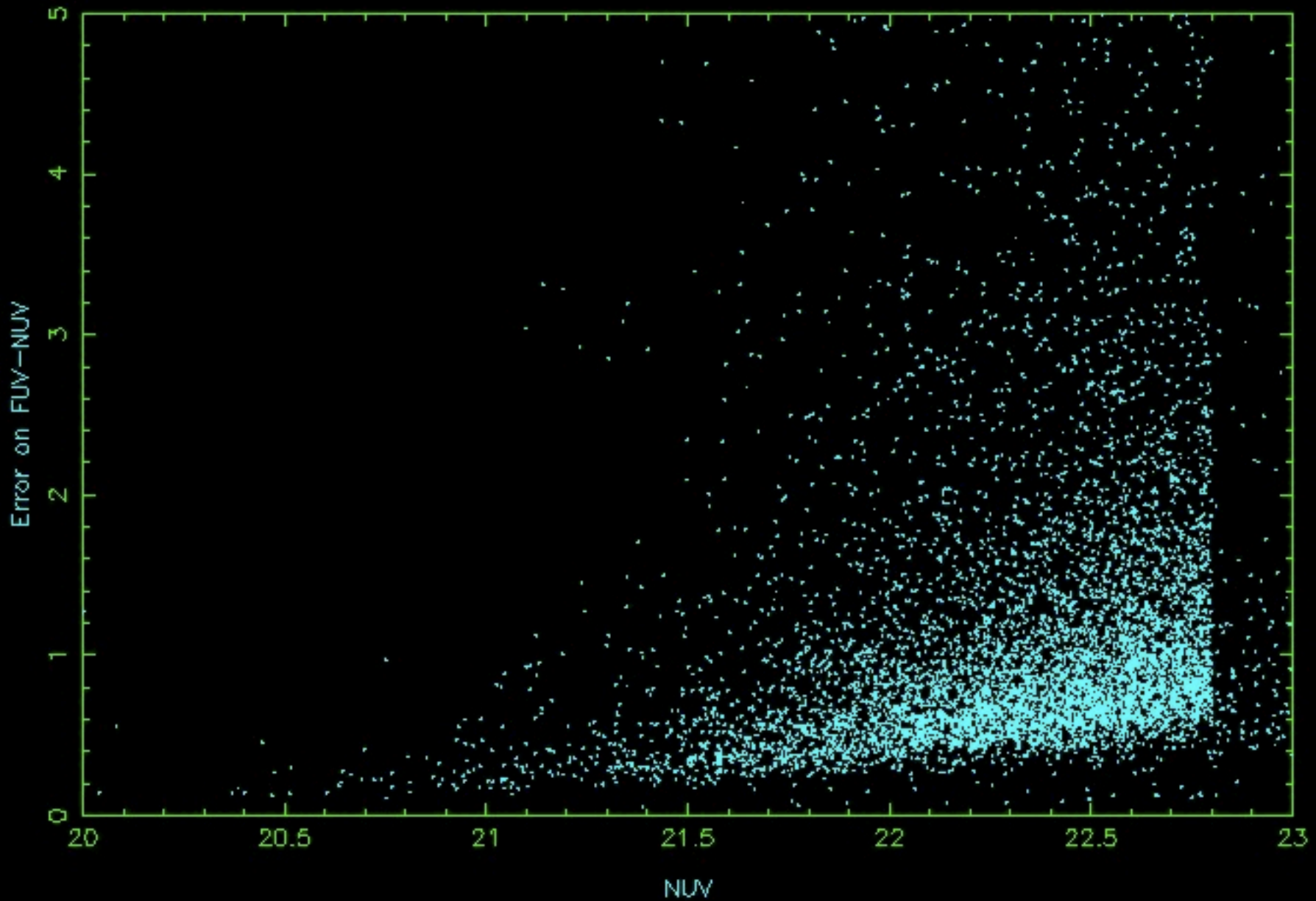


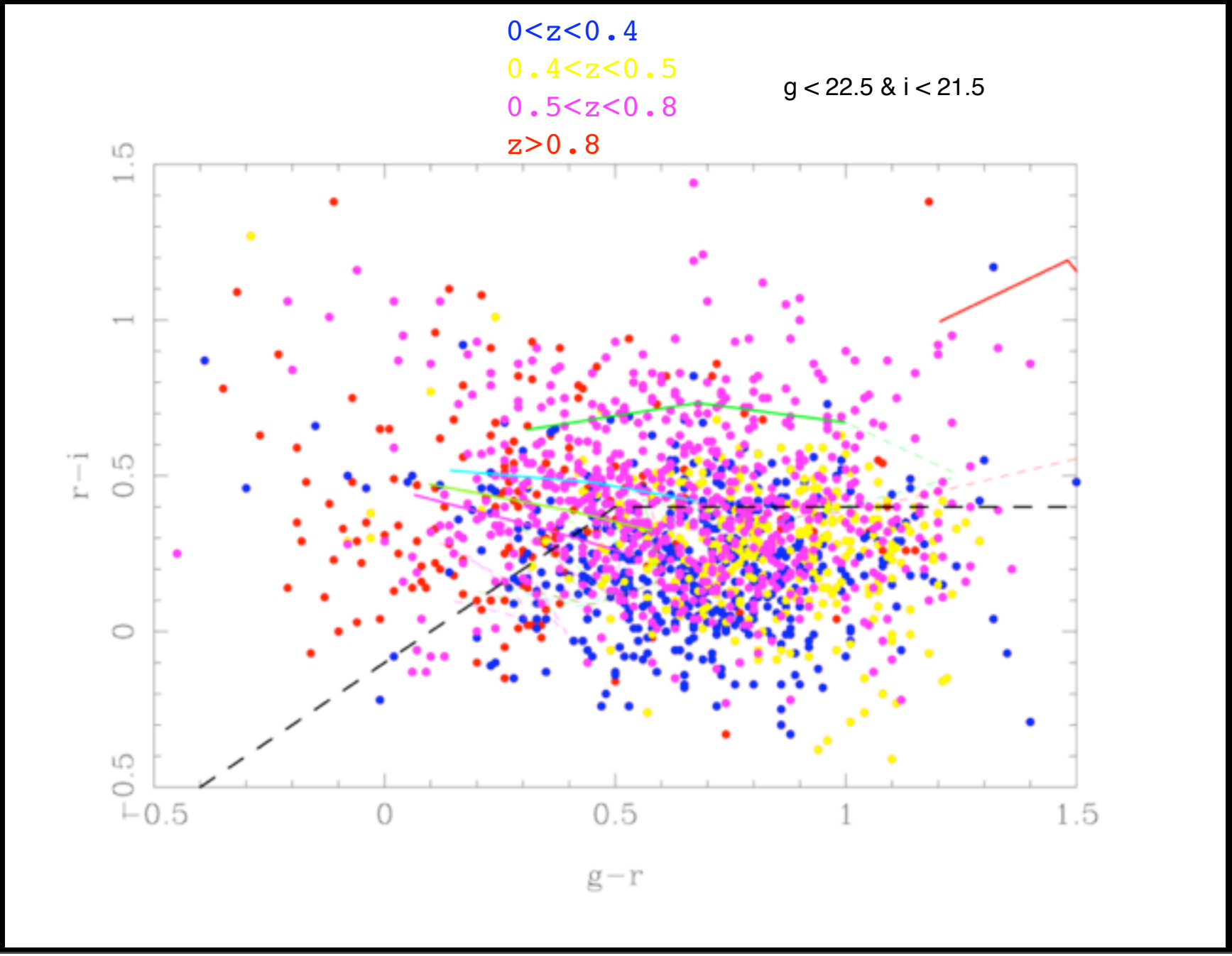
In reality...



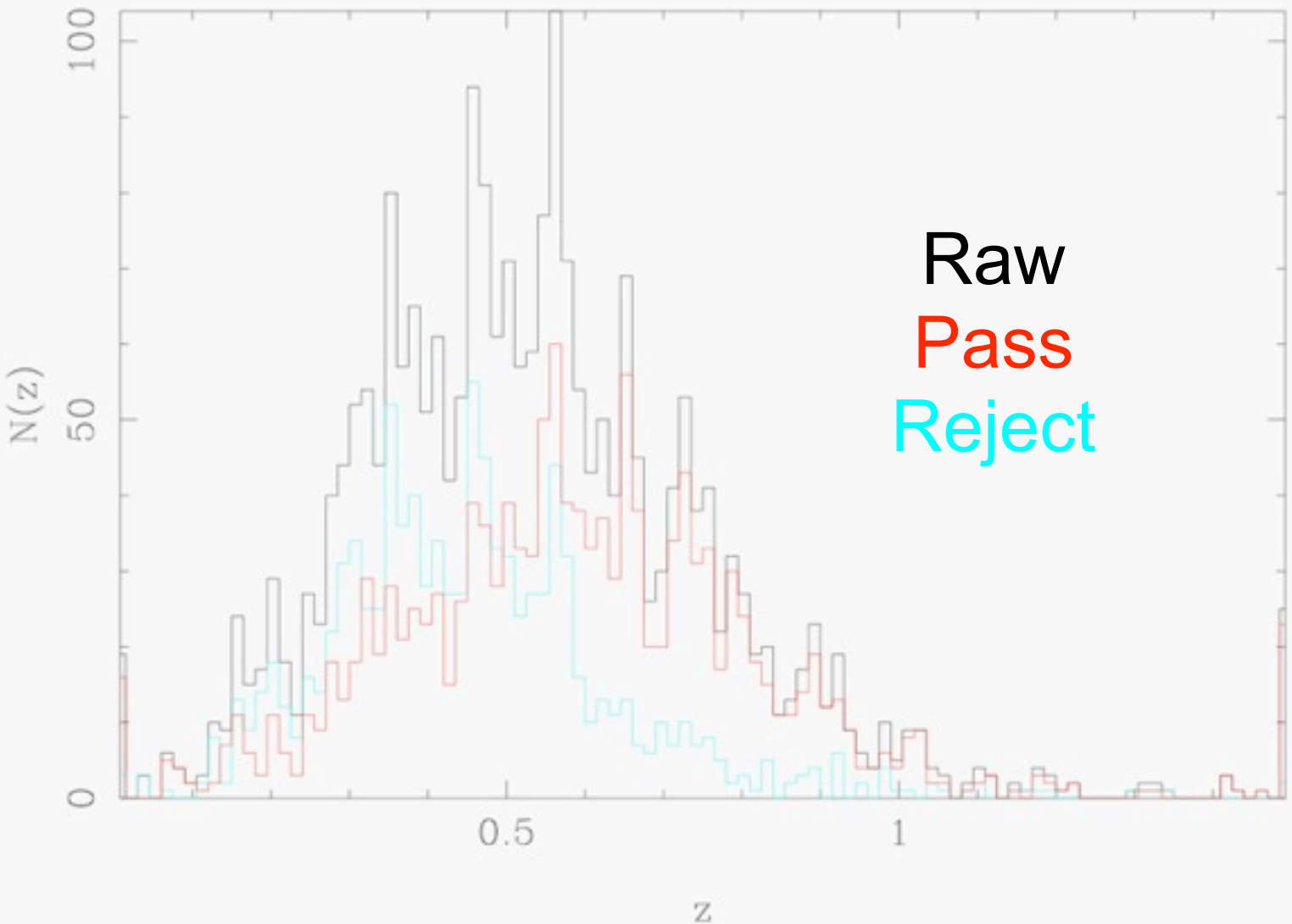
Errors



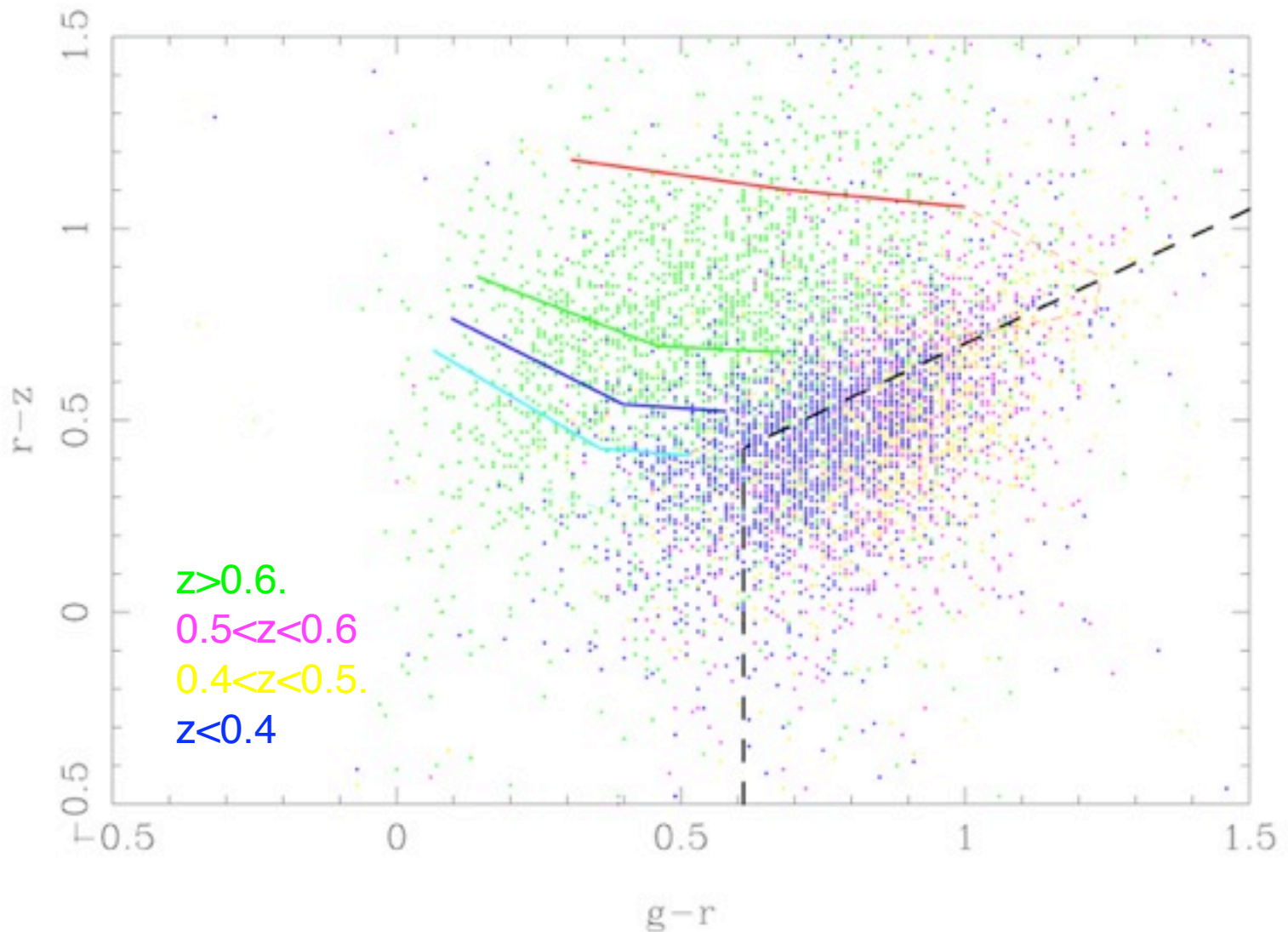
‘Karlcut’



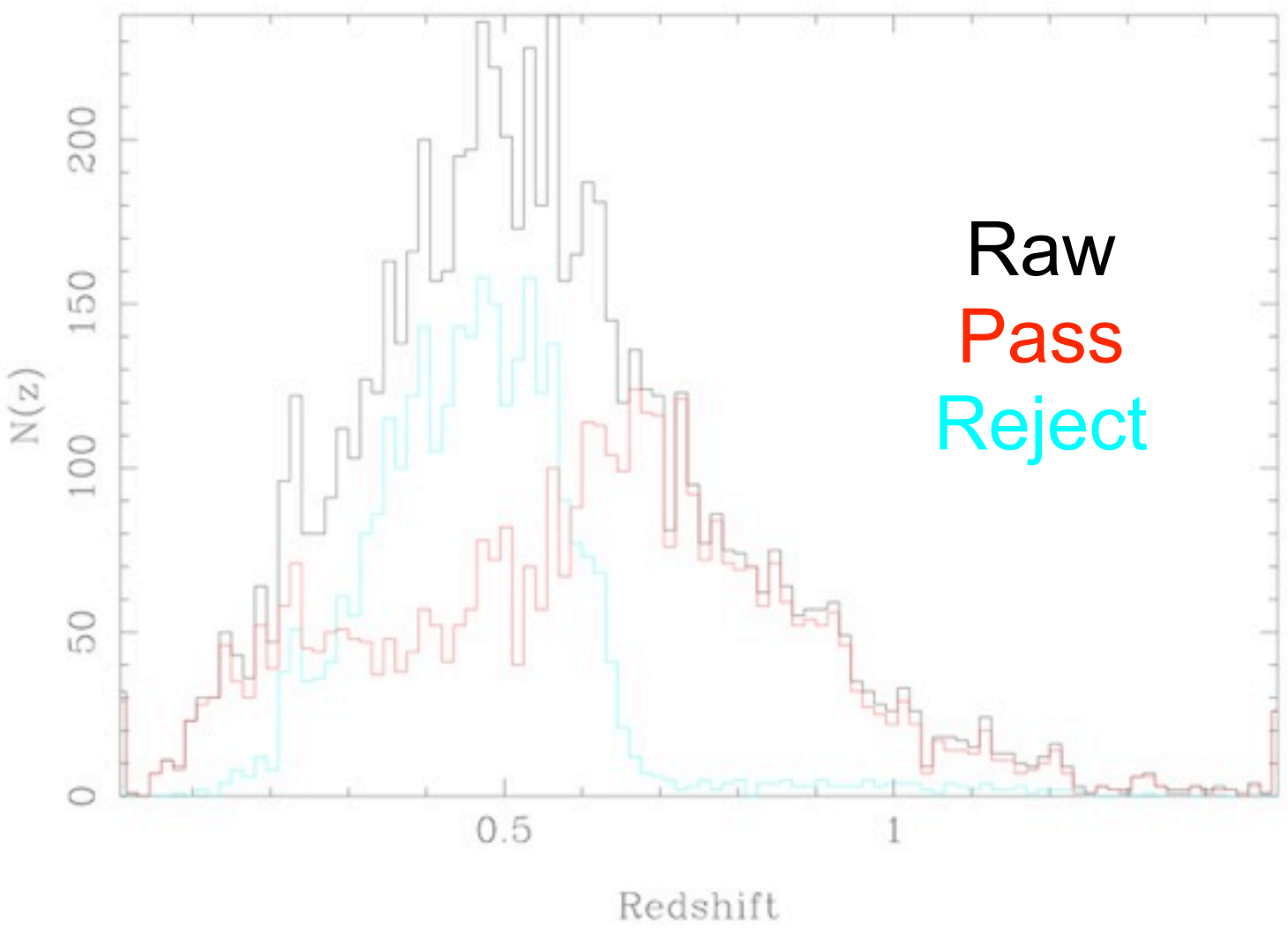
KarlCut – effect



Karlcut – RCS2



KarIcut – RCS2 effect



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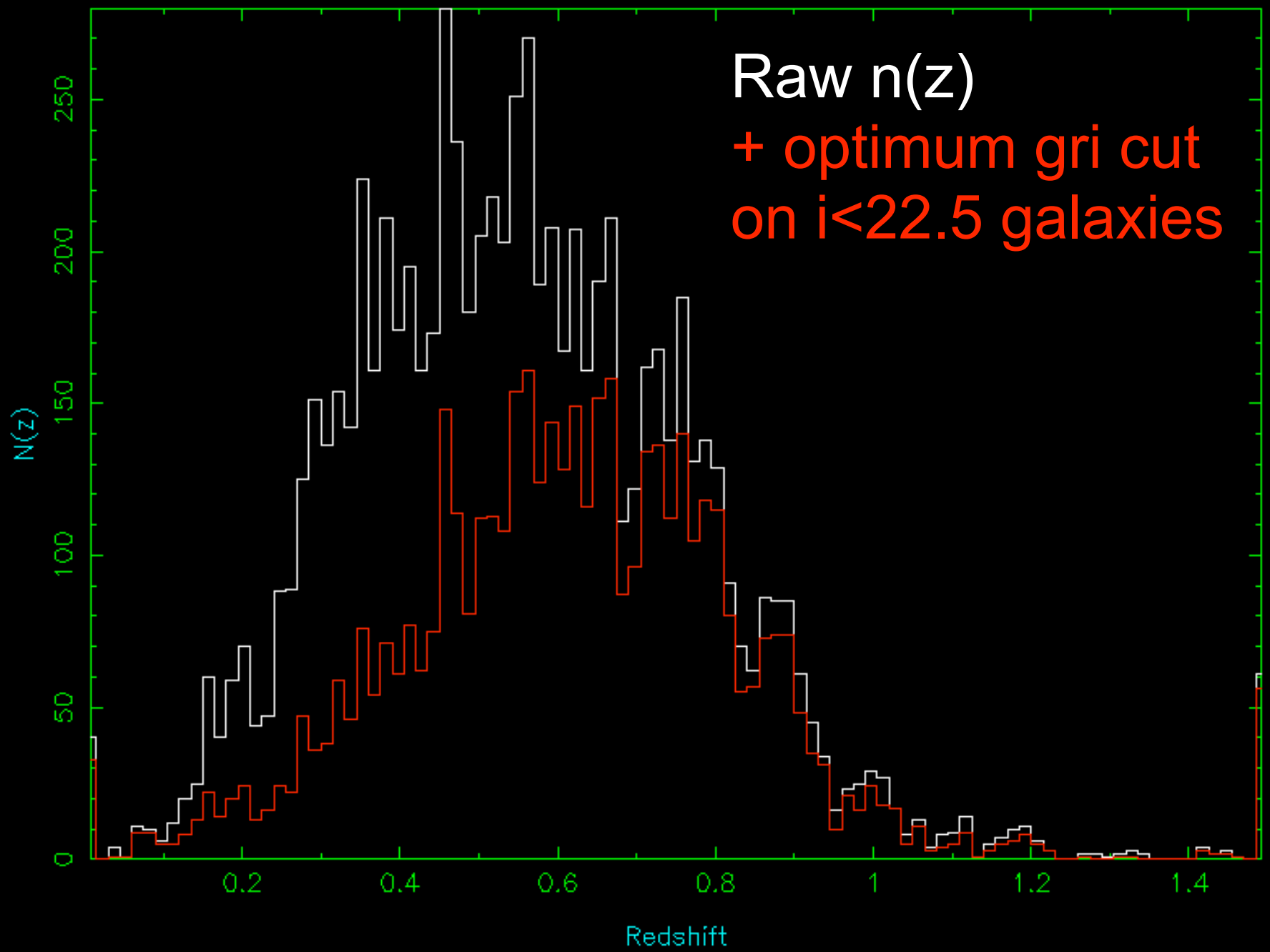
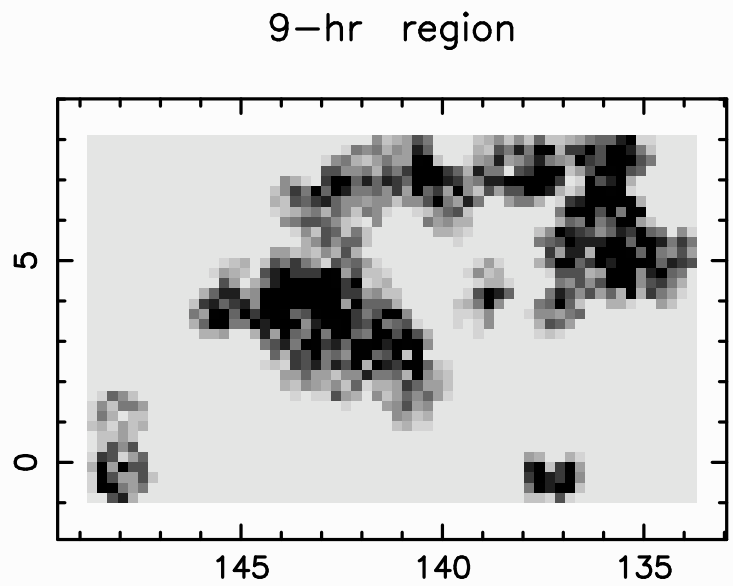
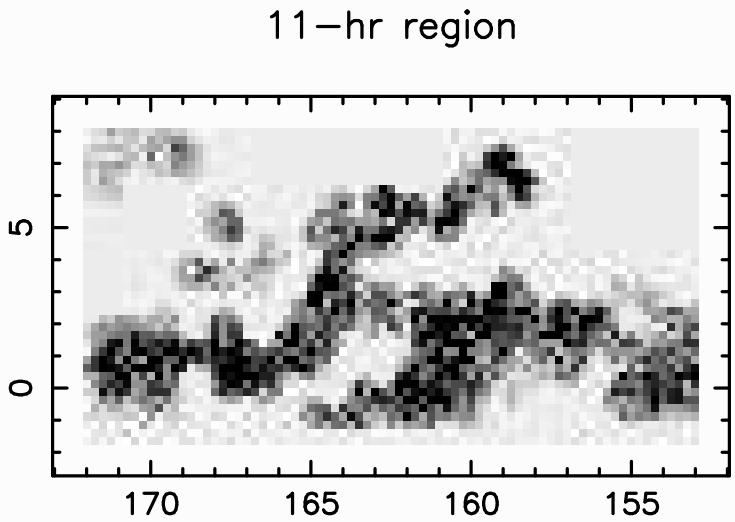
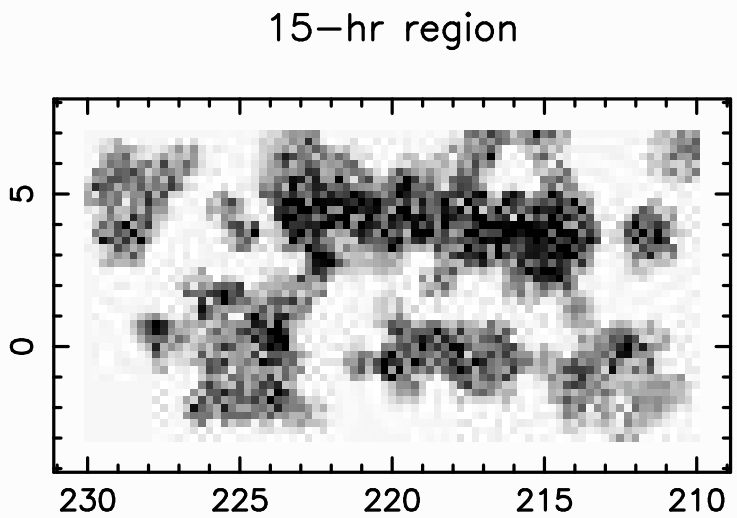
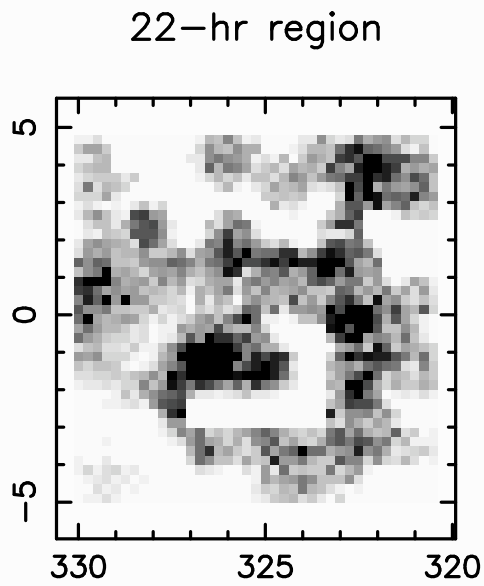


Angular Mask

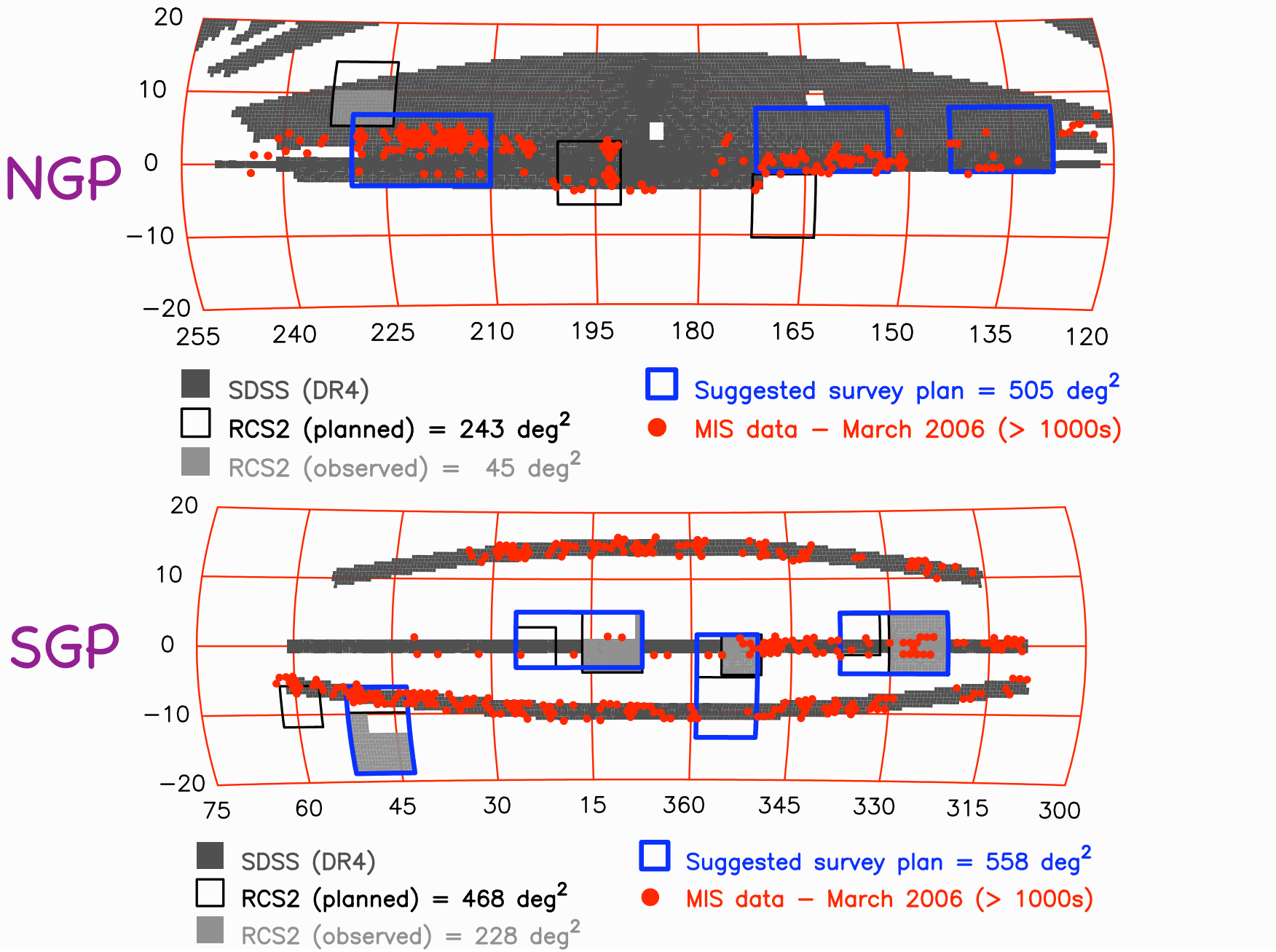




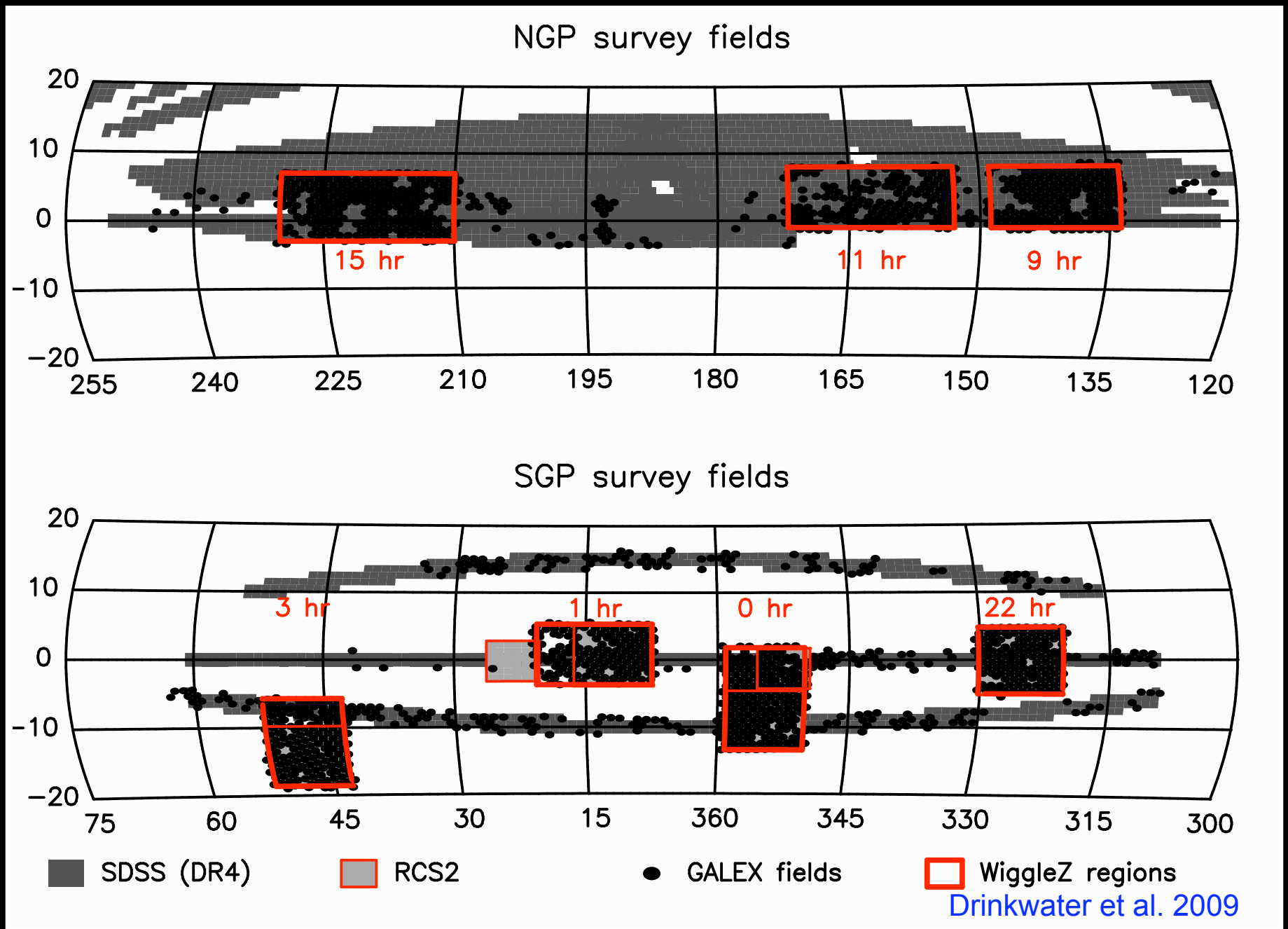




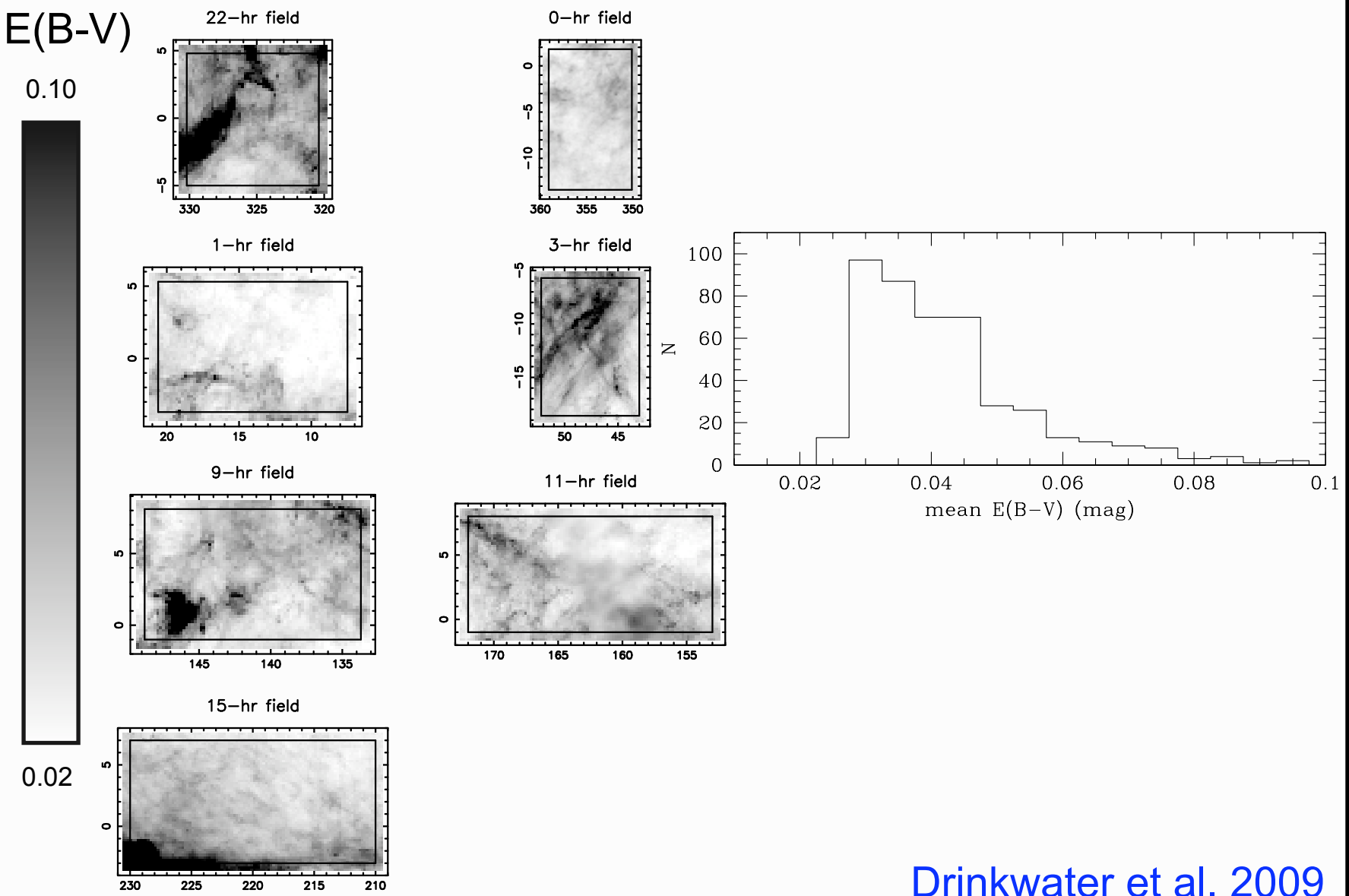
Fields: 2006 start



Fields (Dec 2009)



GALEX: dust

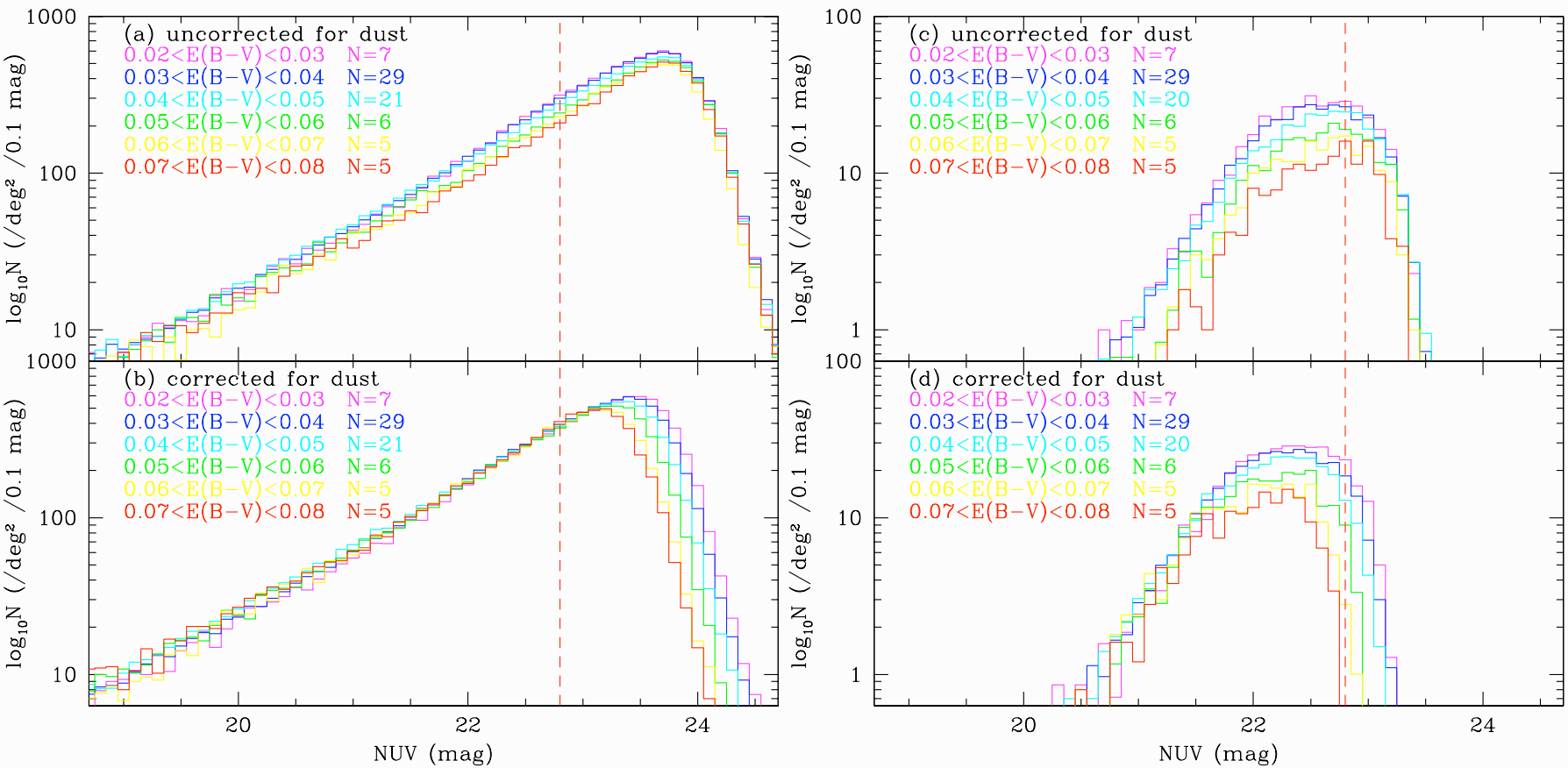


Drinkwater et al. 2009

GALEX: dust

All

WiggleZ selected



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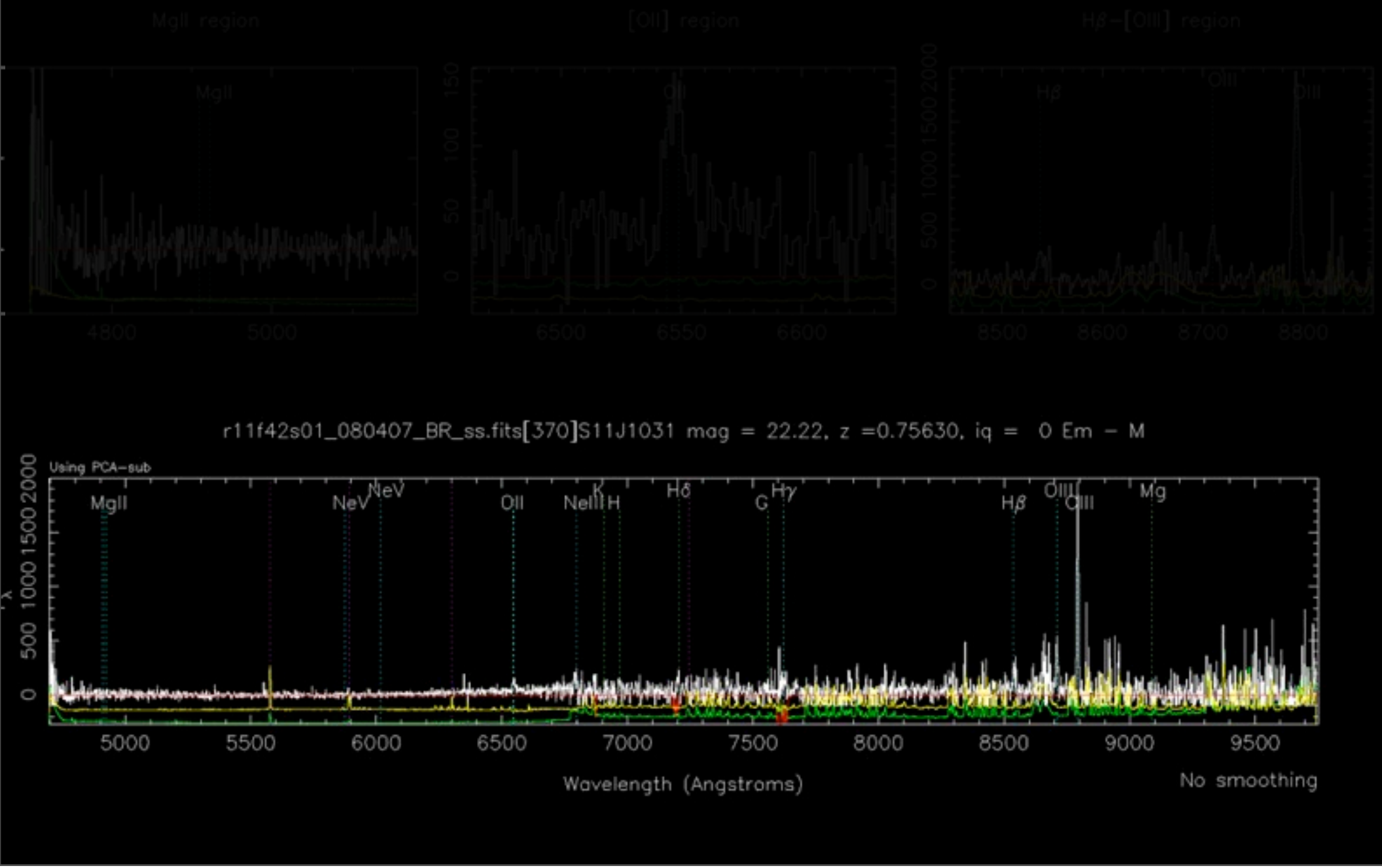
Easy spectrum



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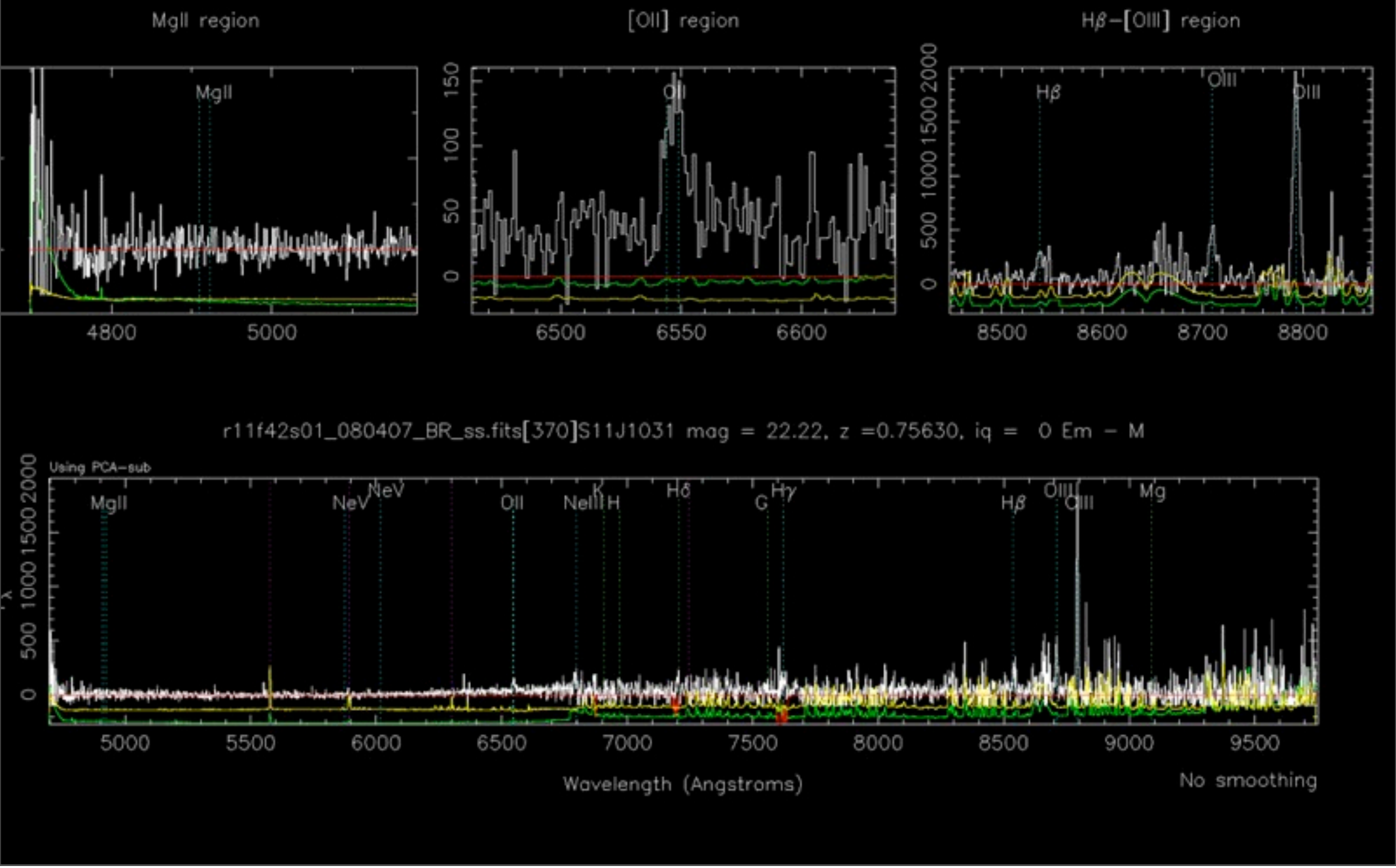
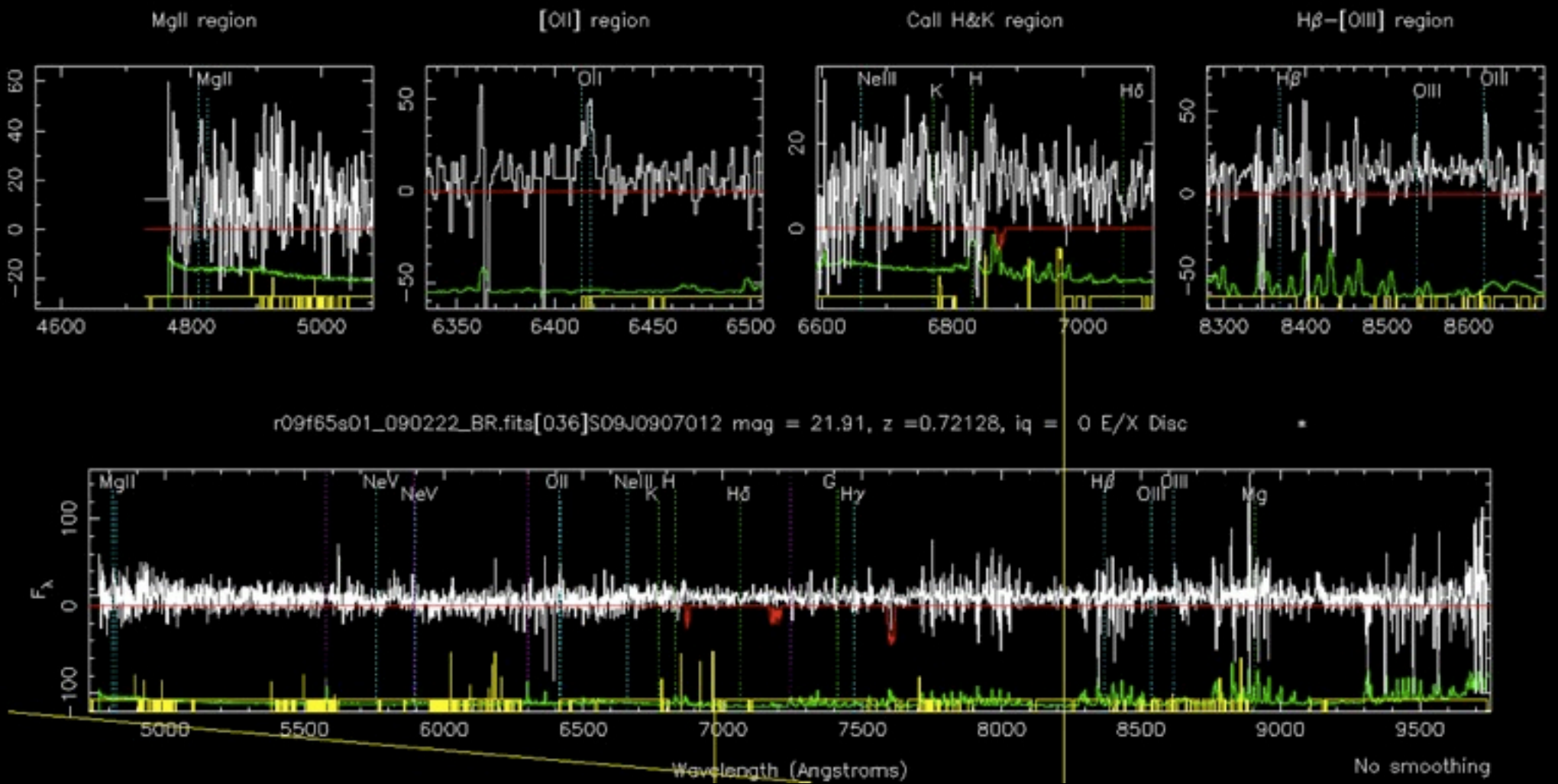
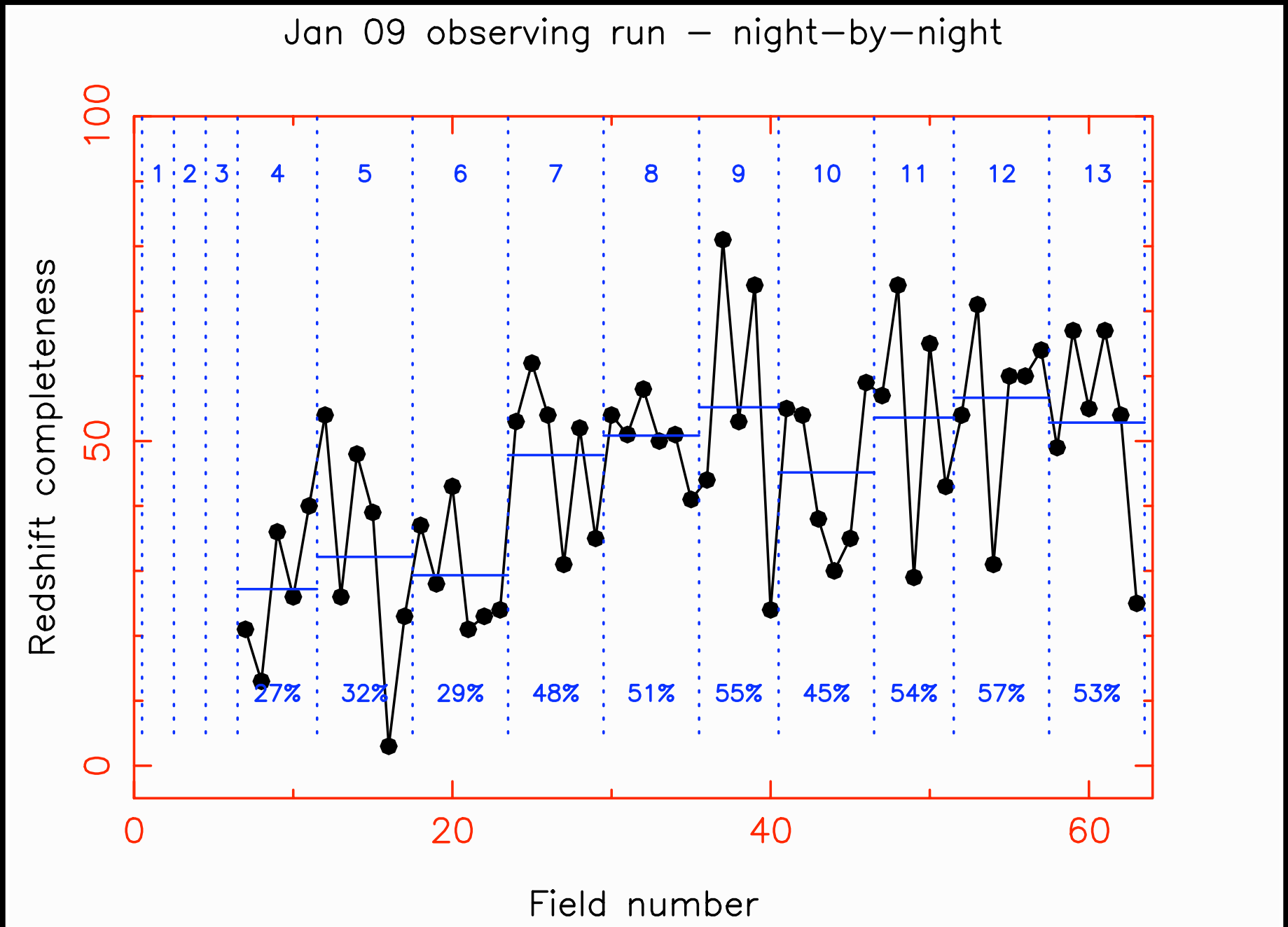


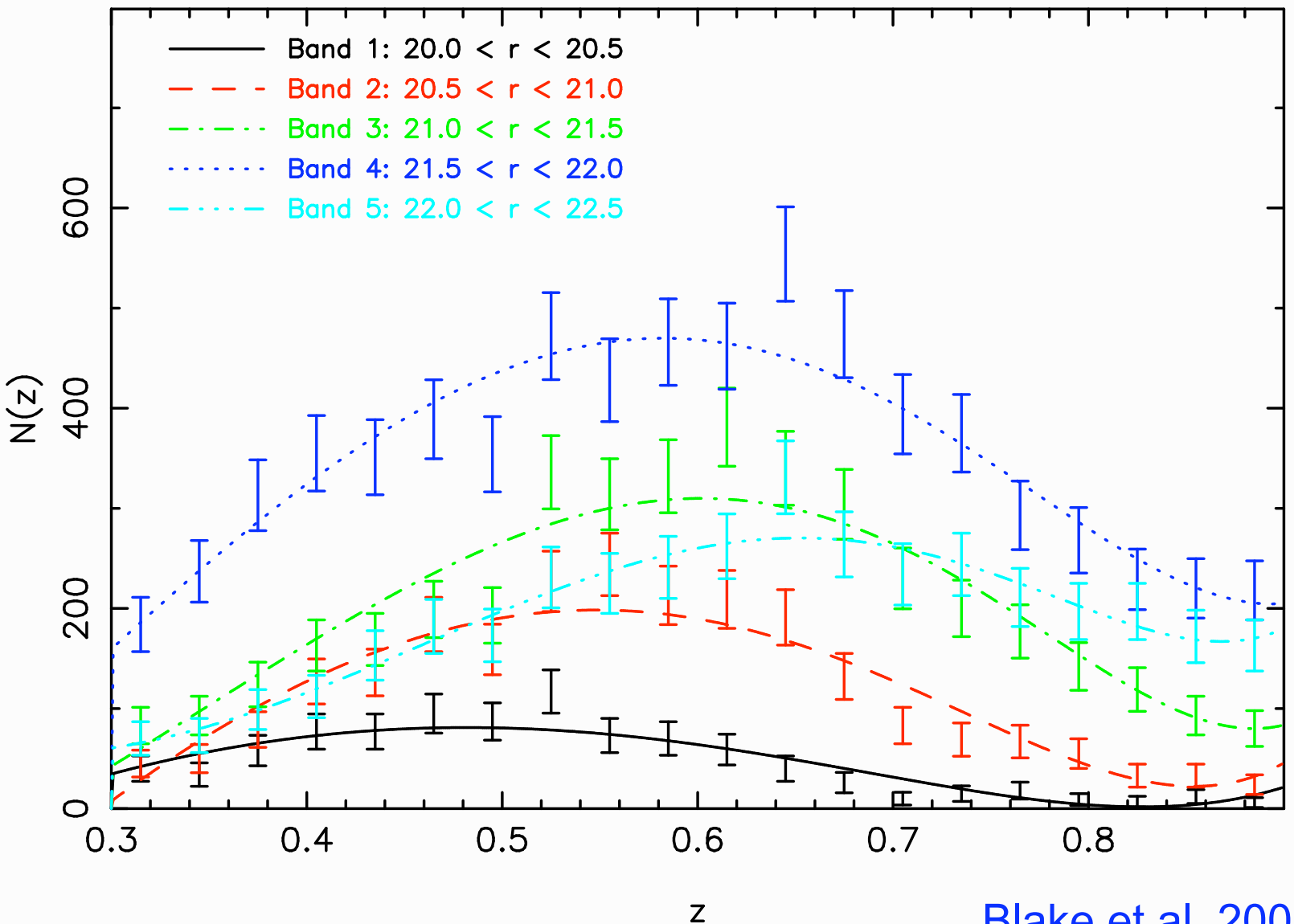
Hard Spectrum



Weather

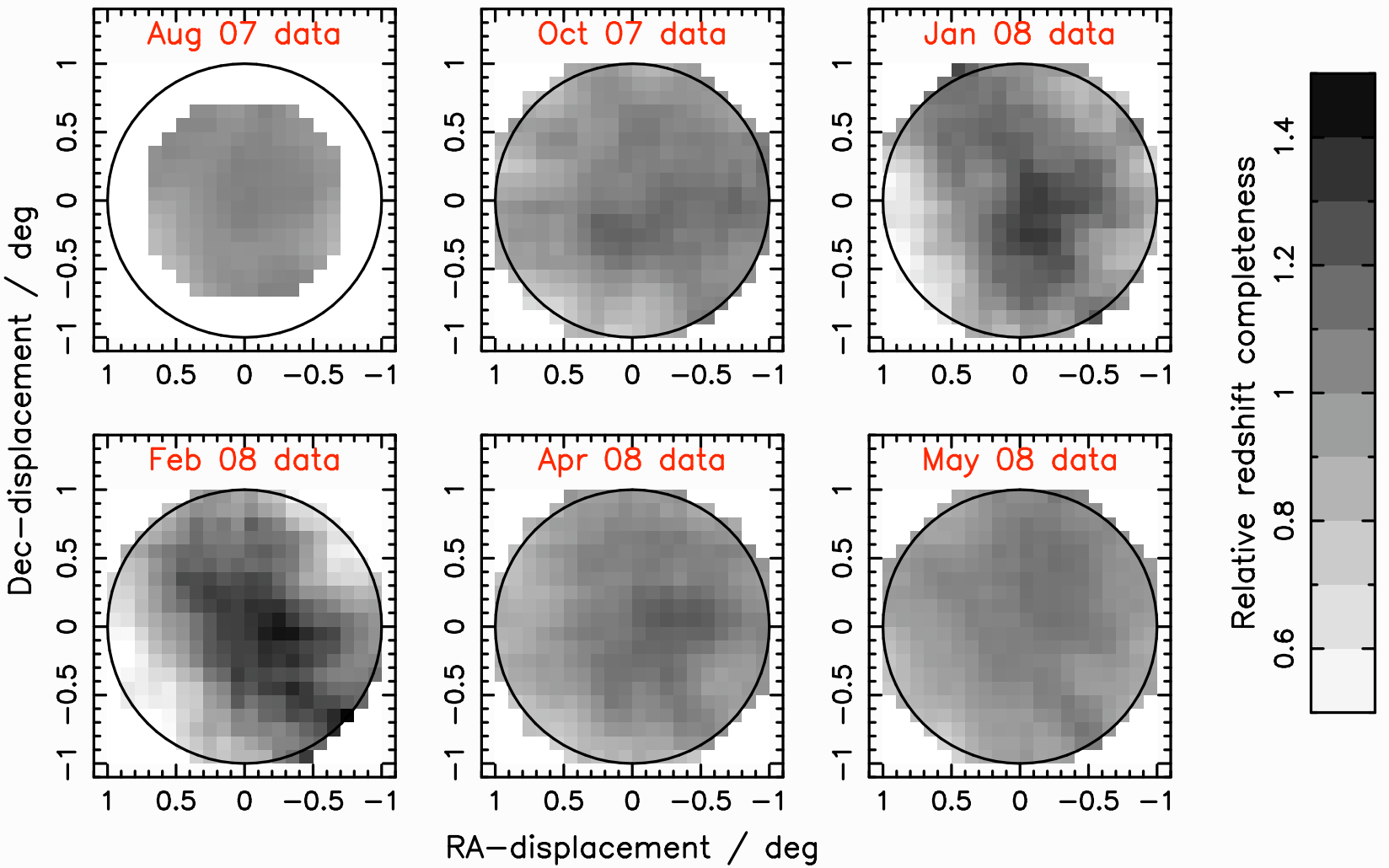

Jan 09 observing run – night–by–night
Redshift completeness
Field number
0
50
100
0
20
40
60
1
2
3
4
5
6
7
8
9
10
11
12
13
27%
32%
29%
48%
51%
55%
45%
54%
57%
53%

n(z) – mag completeness



Blake et al. 2009

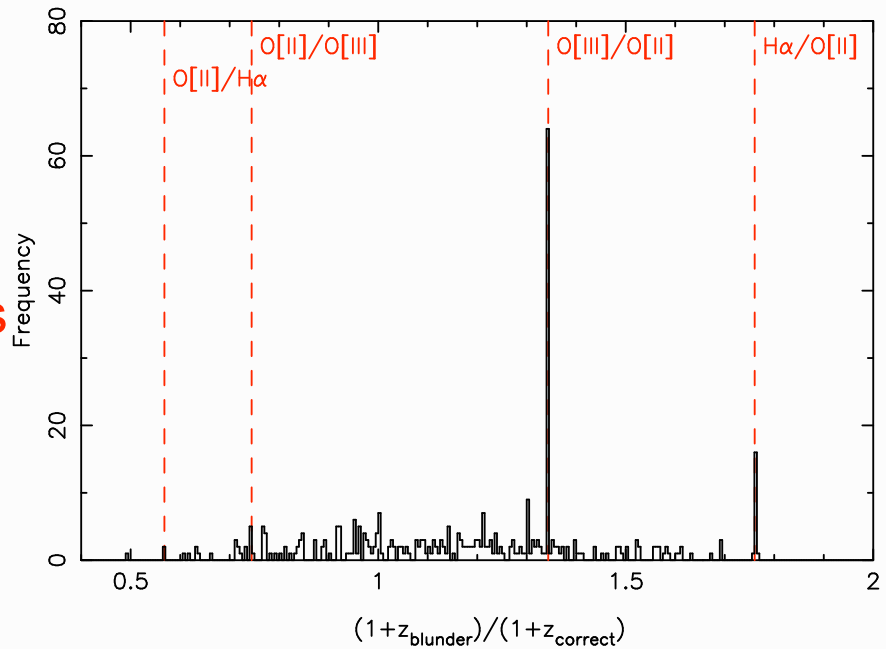
Field-radial z-completeness



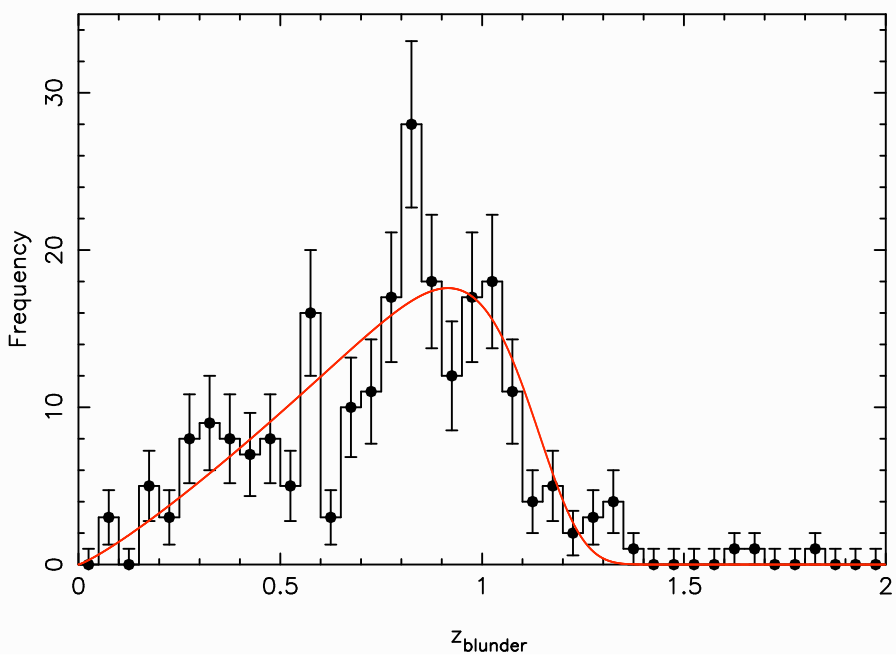
Blake et al. 2009

z Blunders – 5%!

MAIN:
line mis-IDs



Secondary:
sky mis-IDs



Blake et al. 2009

Additional effects

- GALEX variations due to mild exposure time variations

  (additional ‘hairy edge’ effect)

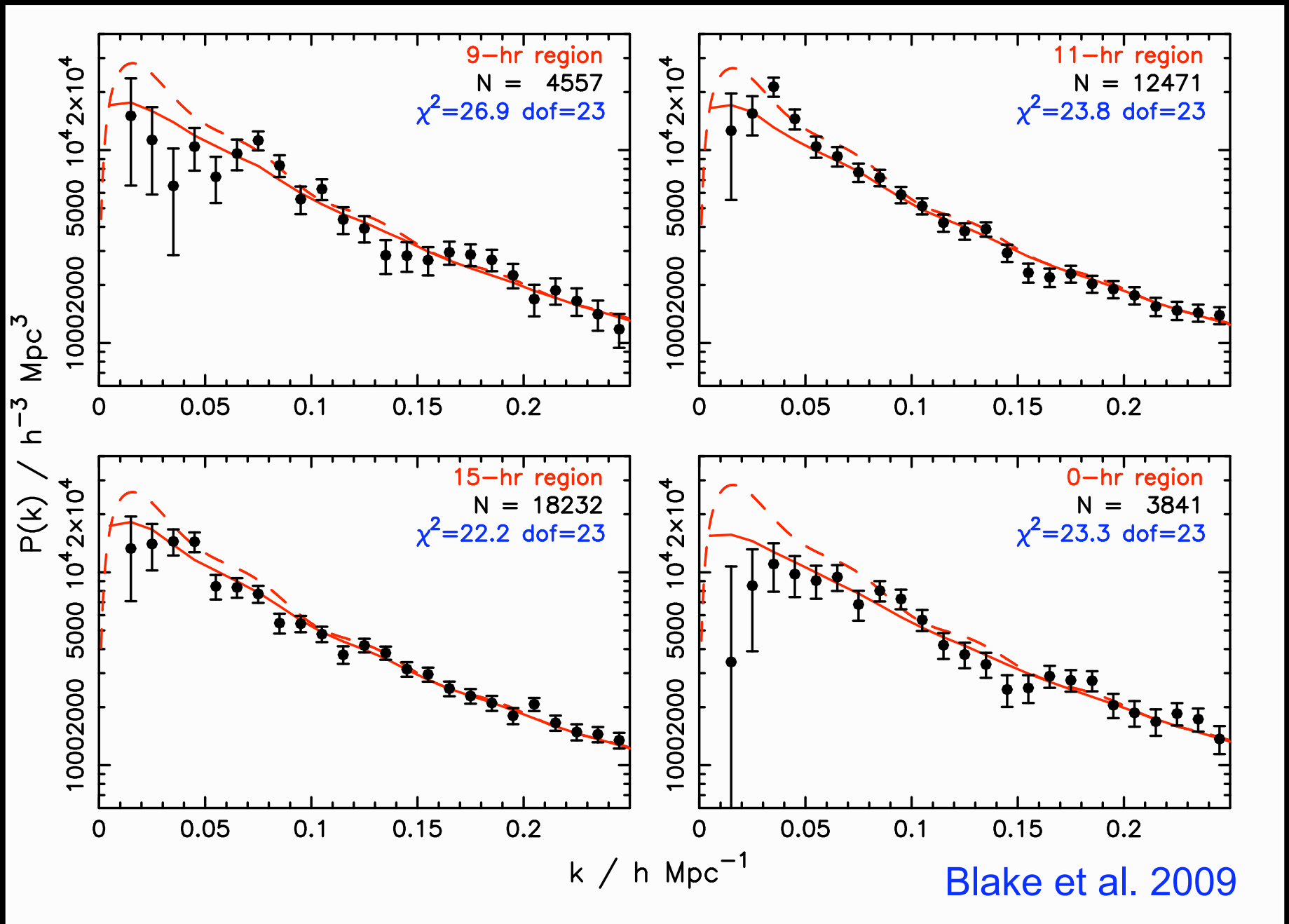
- Changing photometry as RCS2 data is refined.
- Target prioritization mag bands

Does it work?

Results from the first 39000 redshifts...

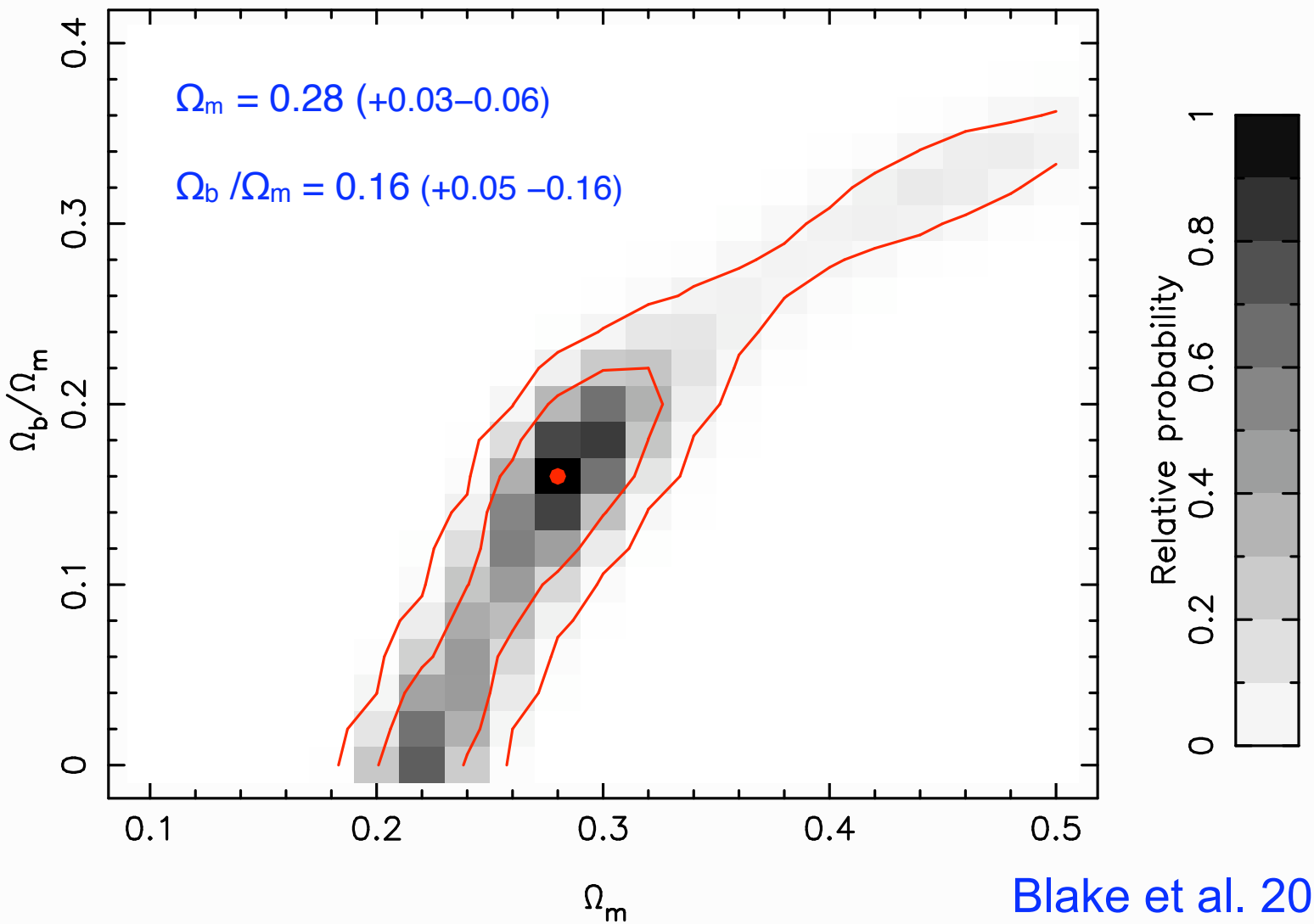
(SDSS only)

P(k)



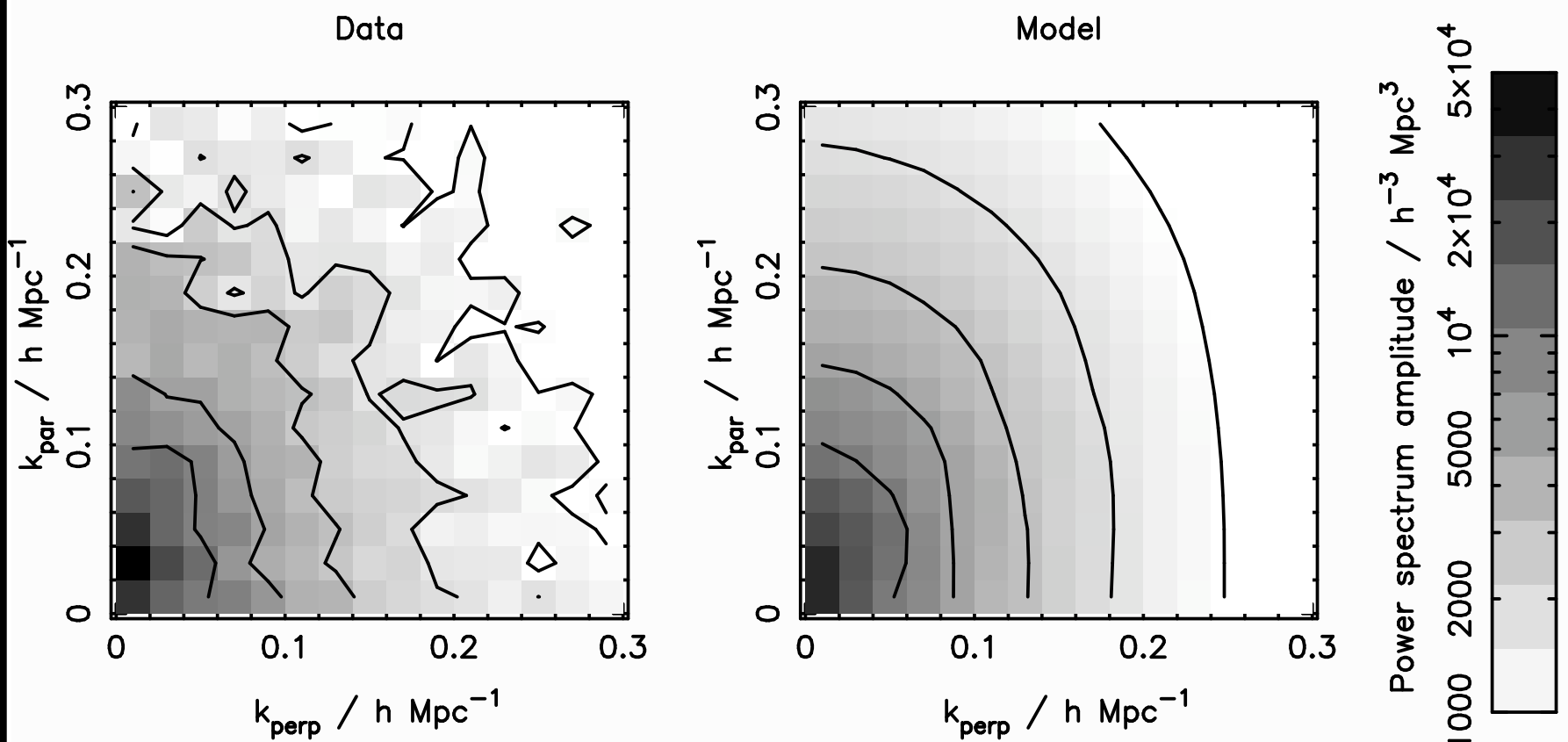
Blake et al. 2009

P(k) cosmological fits



Blake et al. 2009

2d P(k)

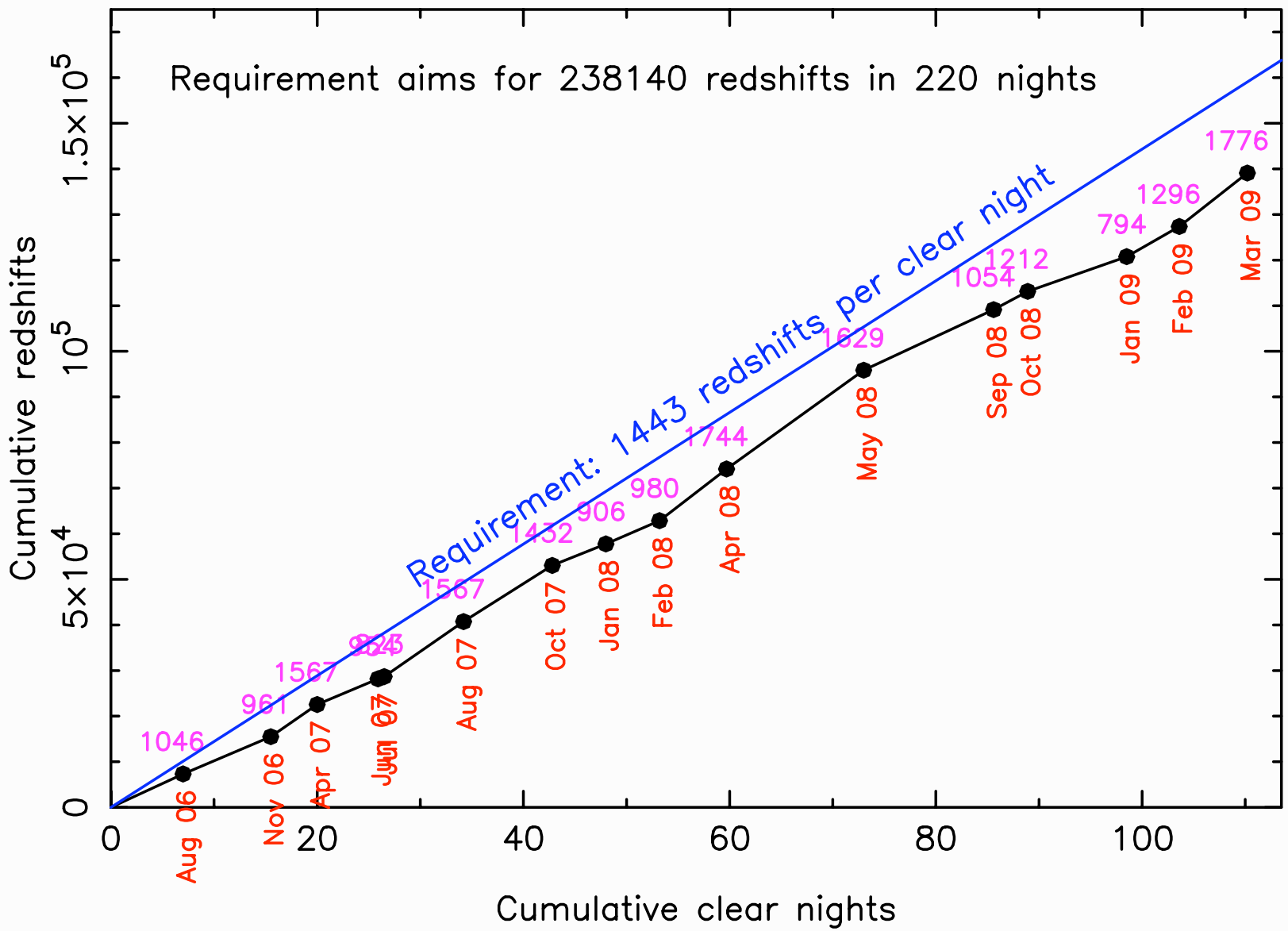


$\beta = 0.50 \pm 0.06$

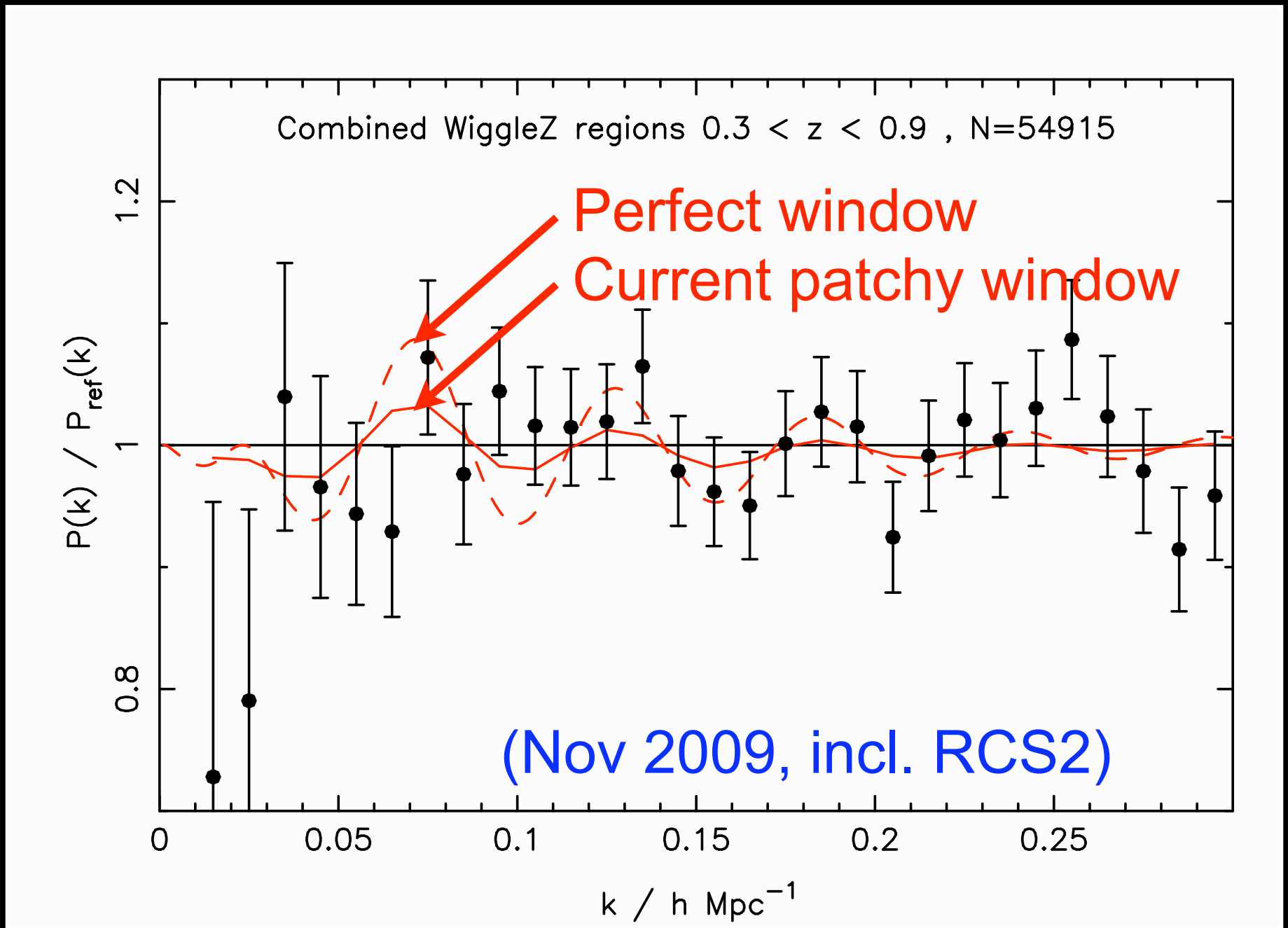
$\Omega_m = 0.274$, $\Omega_b / \Omega_m = 0.166$, $h = 0.7$,
$n_s = 1$ $\beta = 0.5$.

Blake et al. 2009

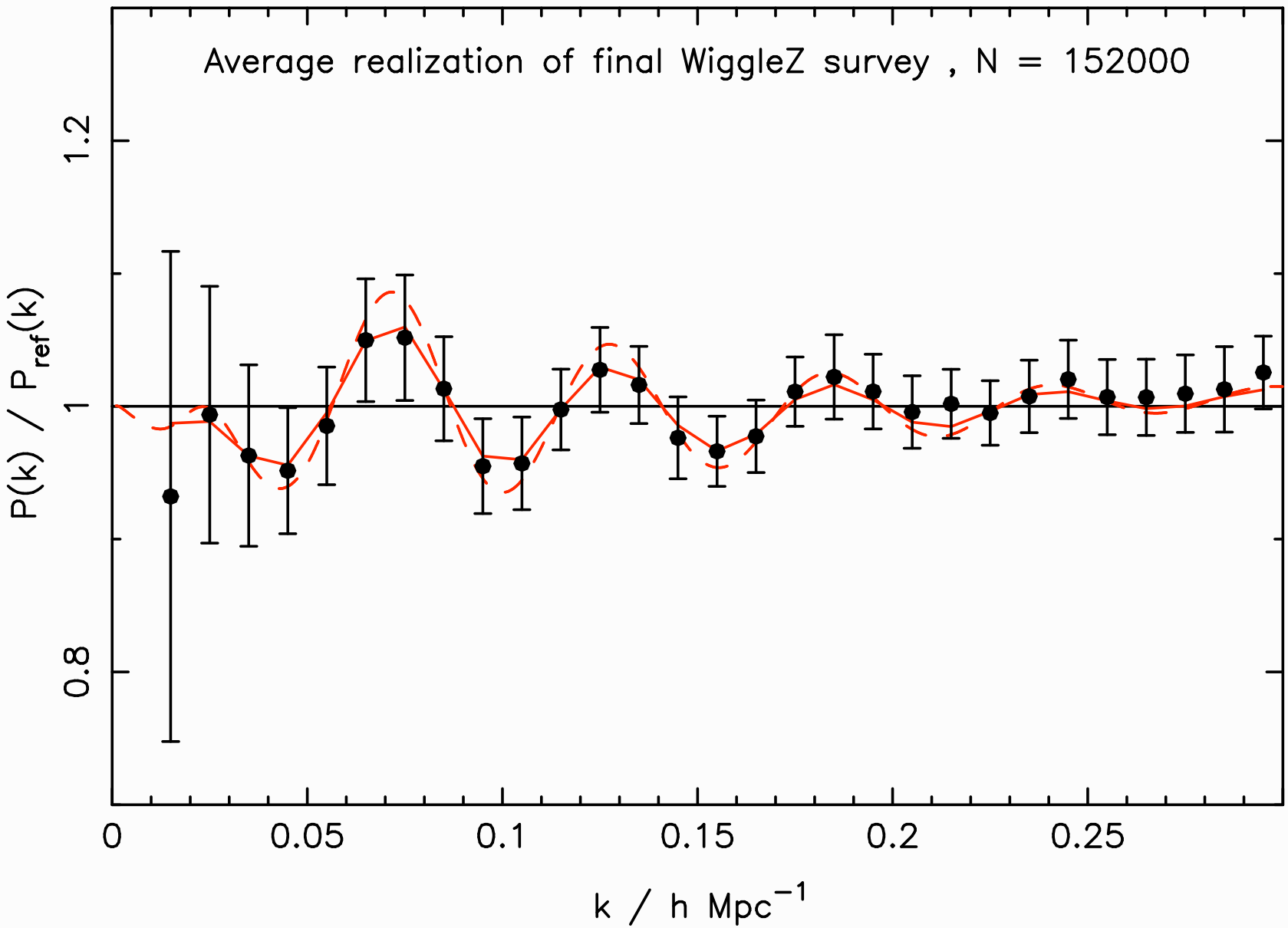
Where WiggleZ is...



Status


Combined WiggleZ regions 0.3 < z < 0.9 , N=54915
Perfect window
Current patchy window
(Nov 2009, incl. RCS2)
P(k) / P_ref(k)
1.2
1
0.8
0
0.05
0.1
0.15
0.2
0.25
k / h Mpc^-1

Forecast


Average realization of final WiggleZ survey , N = 152000
P(k) / P_ref(k)
1.2
1
0.8
0
0.05
0.1
0.15
0.2
0.25
k / h Mpc^-1

Lessons

- Get your good, well calibrated images first!
  - Or do a lot more work...
- Start with a pilot survey
  - Refine colour selections with real results
  - Be prepared to dispose of first 10%
- Redshifting will be hard
  - Or you are not doing BAO right...
- Just about anything is fixable for cosmology...

The real lesson...

After
2dFGRS

Before
WiggleZ