



**The Abdus Salam
International Centre for Theoretical Physics**



2419-1

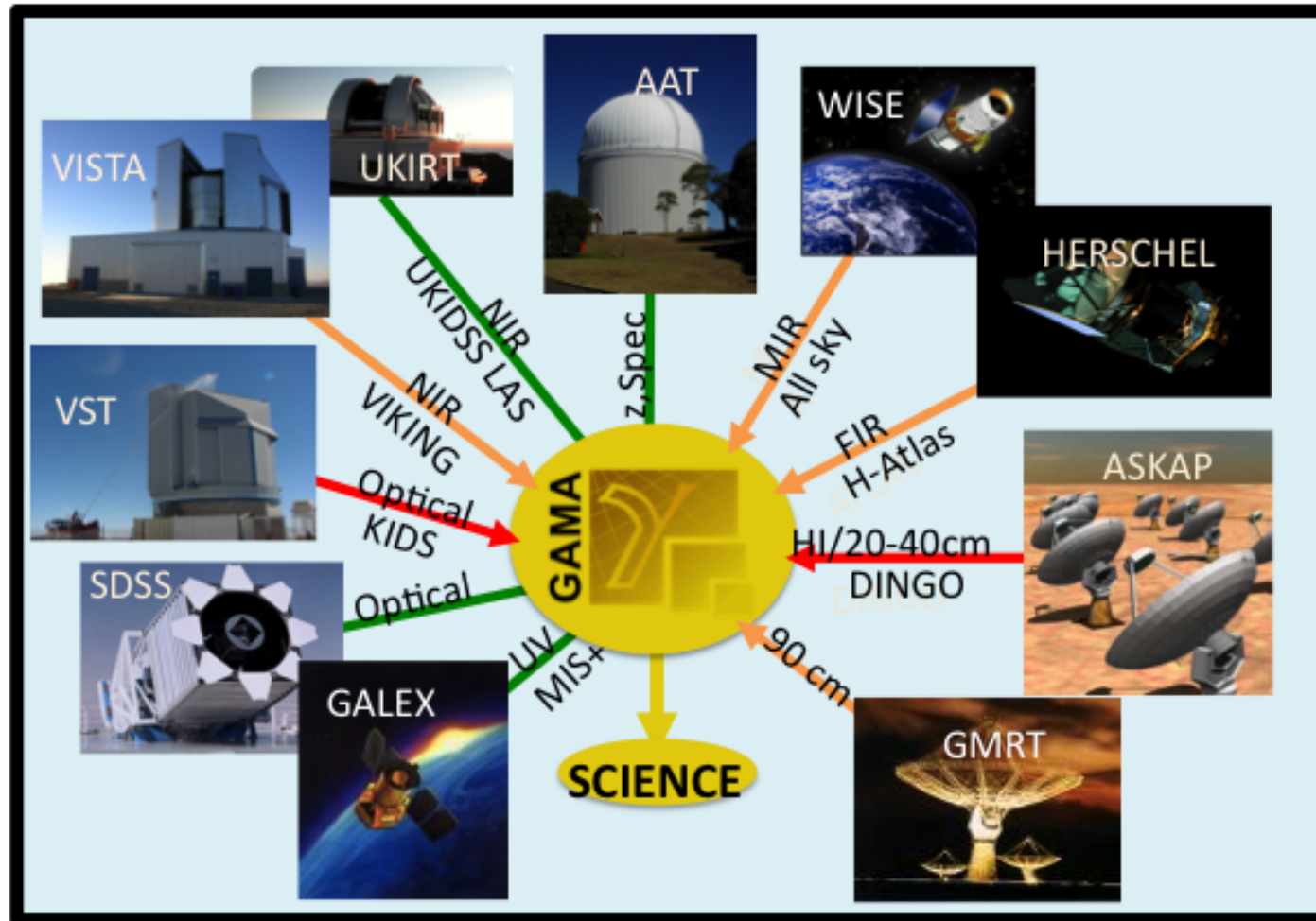
Workshop on Large Scale Structure

30 July - 2 August, 2012

Large scale structure and galaxy formation studies with GAMA

P. Norberg
Durham University

Large scale structure and galaxy formation studies with the Galaxy And Mass Assembly survey



Peder Norberg

Institute for Computational Cosmology, Durham University

Talk Overview

- Introduction to GAMA
- LSS with GAMA:
 - Angular clustering with GAMA calibrated z_{ph}
 - sensitivity to data systematics (in SDSS)
 - Redshift space clustering as $f(z, M_*, \text{colour})$
 - test for systematics in f_g modelling
 - [Galaxy groups with spatially complete GAMA
 - test of Λ CDM and the halo model]
- Beyond LSS with GAMA:
 - why GAMA is “the” galaxy formation survey

Talk Overview

- Introduction to GAMA
- LSS with GAMA:
 - Angular clustering with GAMA calibrated z_{ph}
→ sensitivity to data systematics (in SDSS)
 - Redshift space clustering as $f(z, M_*, \text{colour})$
→ test for systematics in f_g modelling
- Beyond LSS with GAMA:
 - why GAMA is more a galaxy formation survey
- LSS and errors from data:
 - Jackknife/Bootstrap: size justification?

GAMA Team/Collaboration



Galaxy And Mass Assembly Survey: ***the redshift survey in a nutshell (2008-201?)***

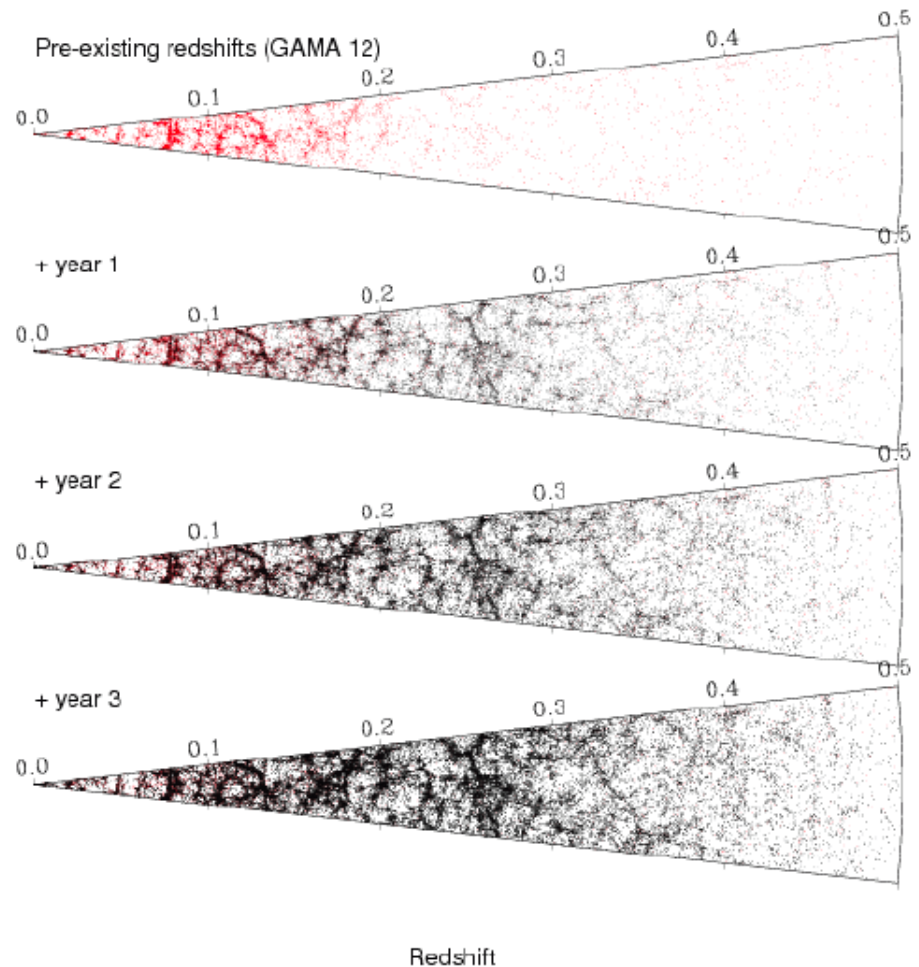
z-survey 2mags
deeper than SDSS

5/6 regions all RA

350,000 galaxies

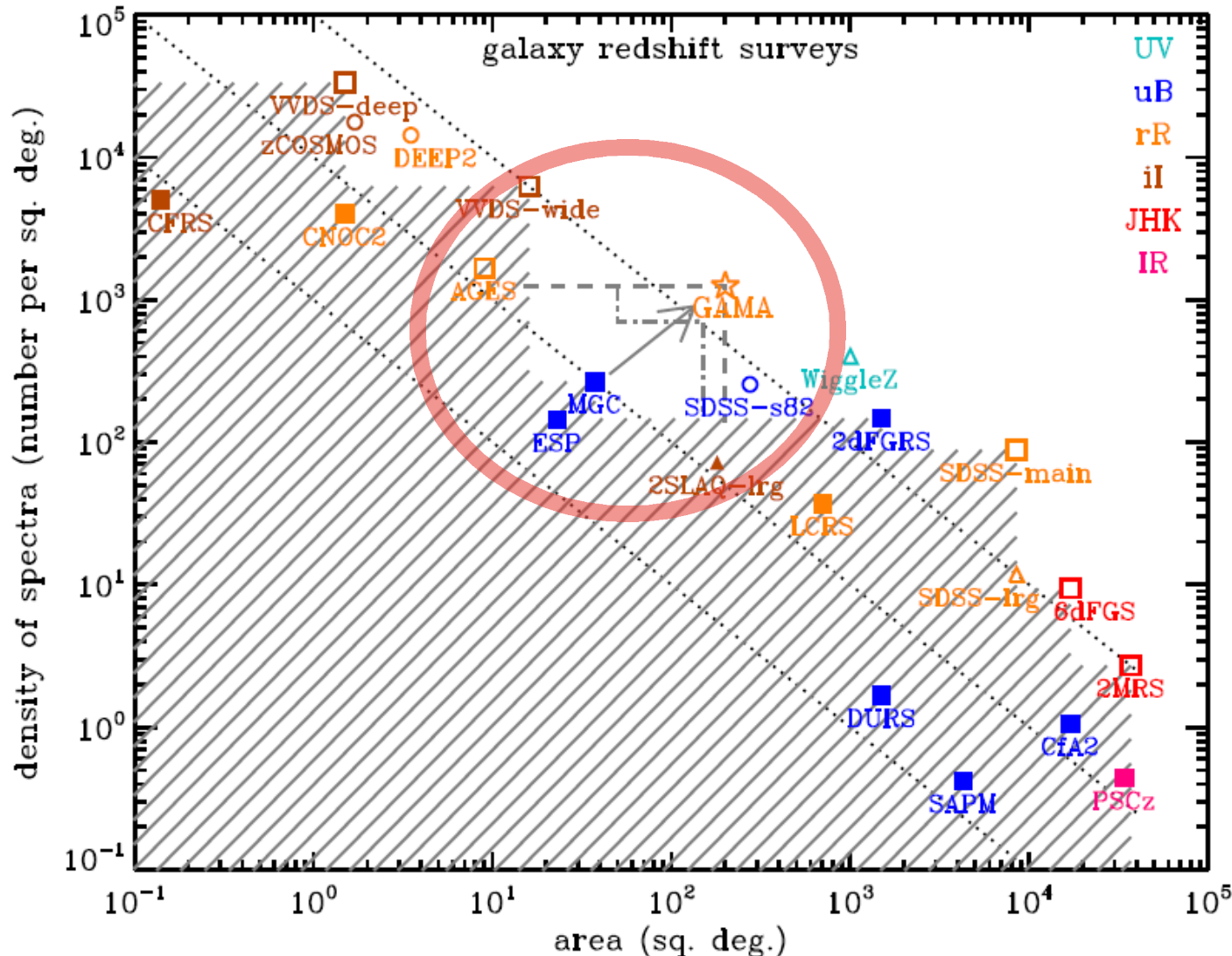
$z < 0.5$

Giants to LMC range

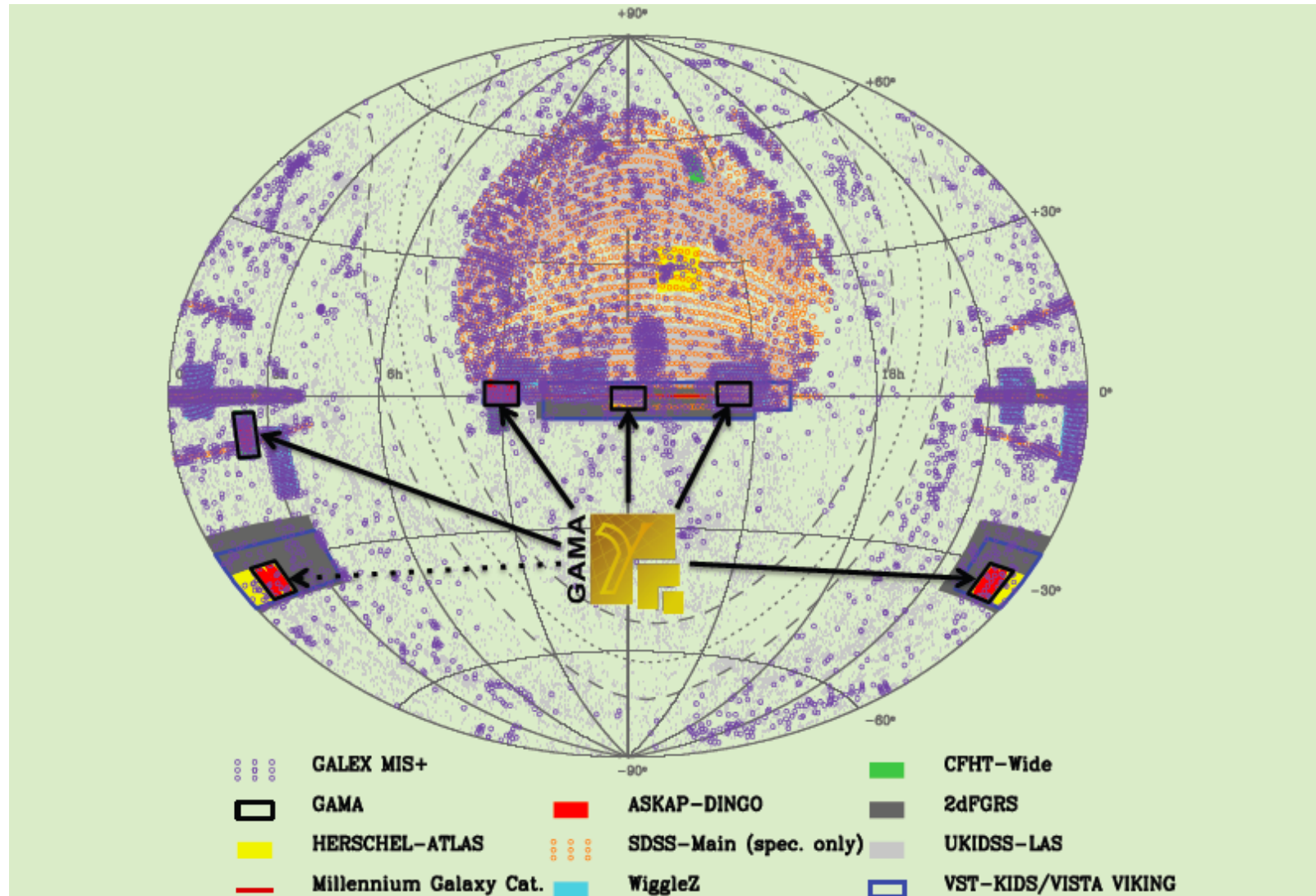


Galaxy And Mass Assembly Survey:

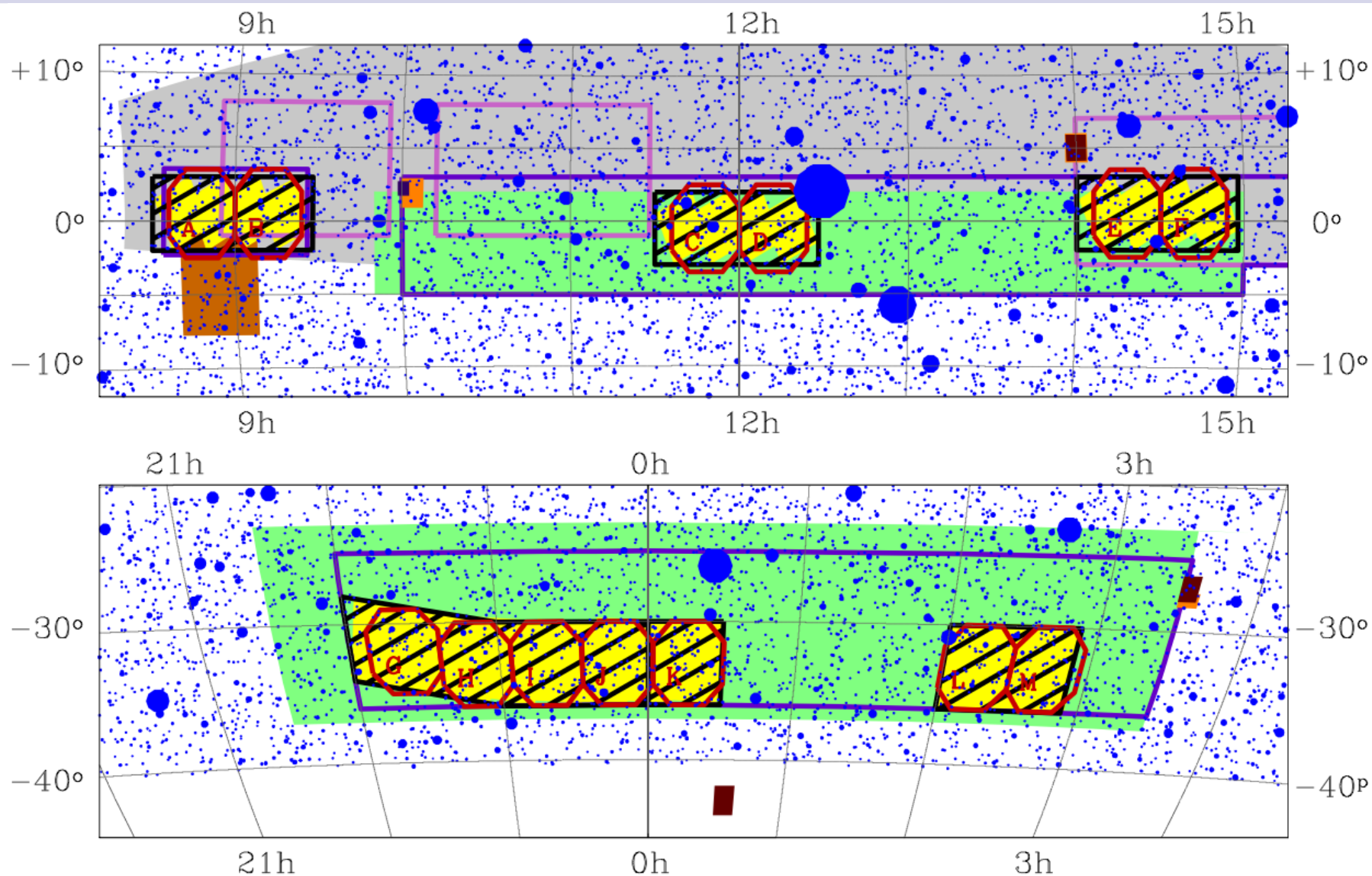
germane connection between shallow-wide & deep-narrow



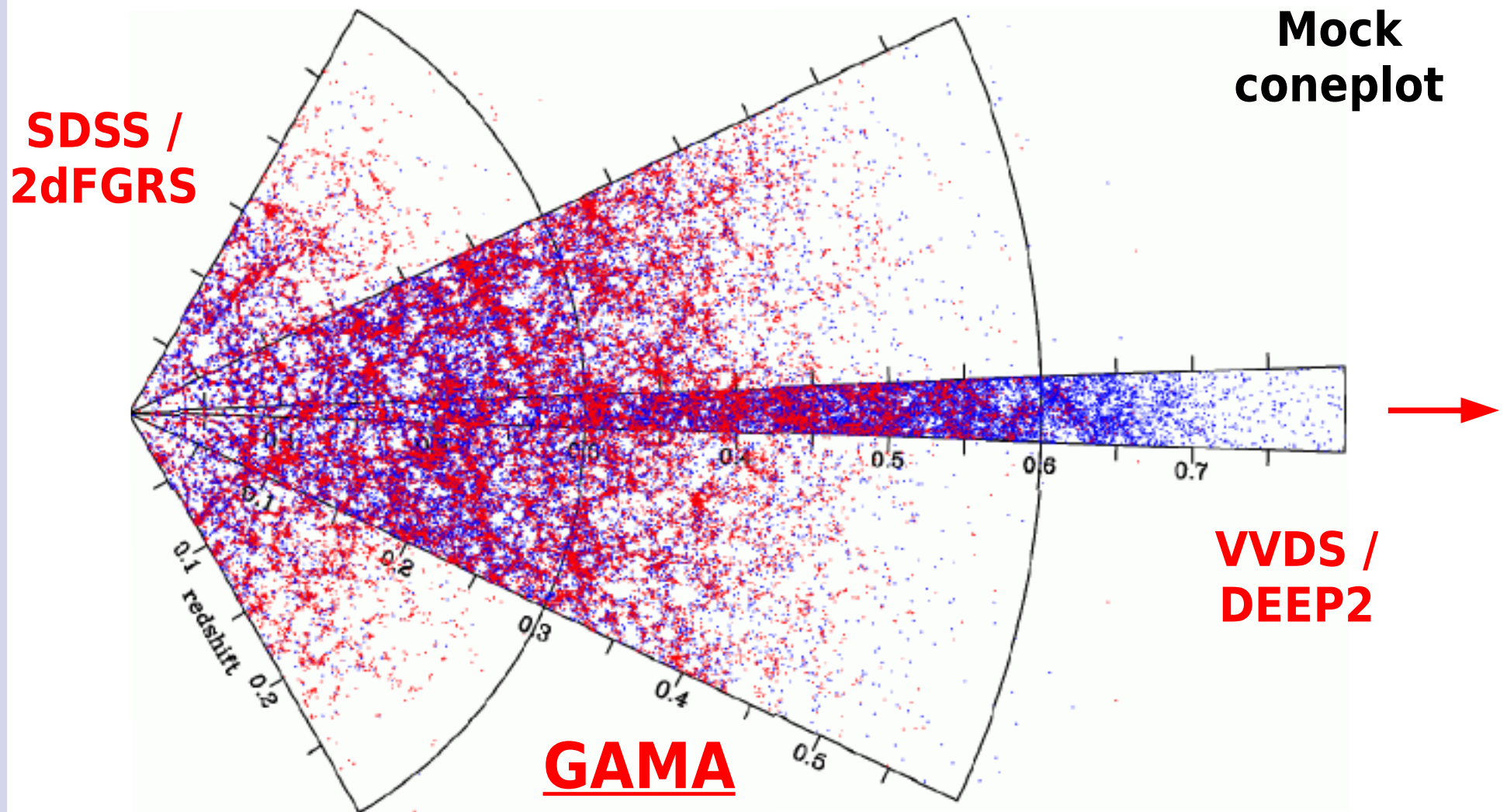
Galaxy And Mass Assembly Survey: where are the fields?

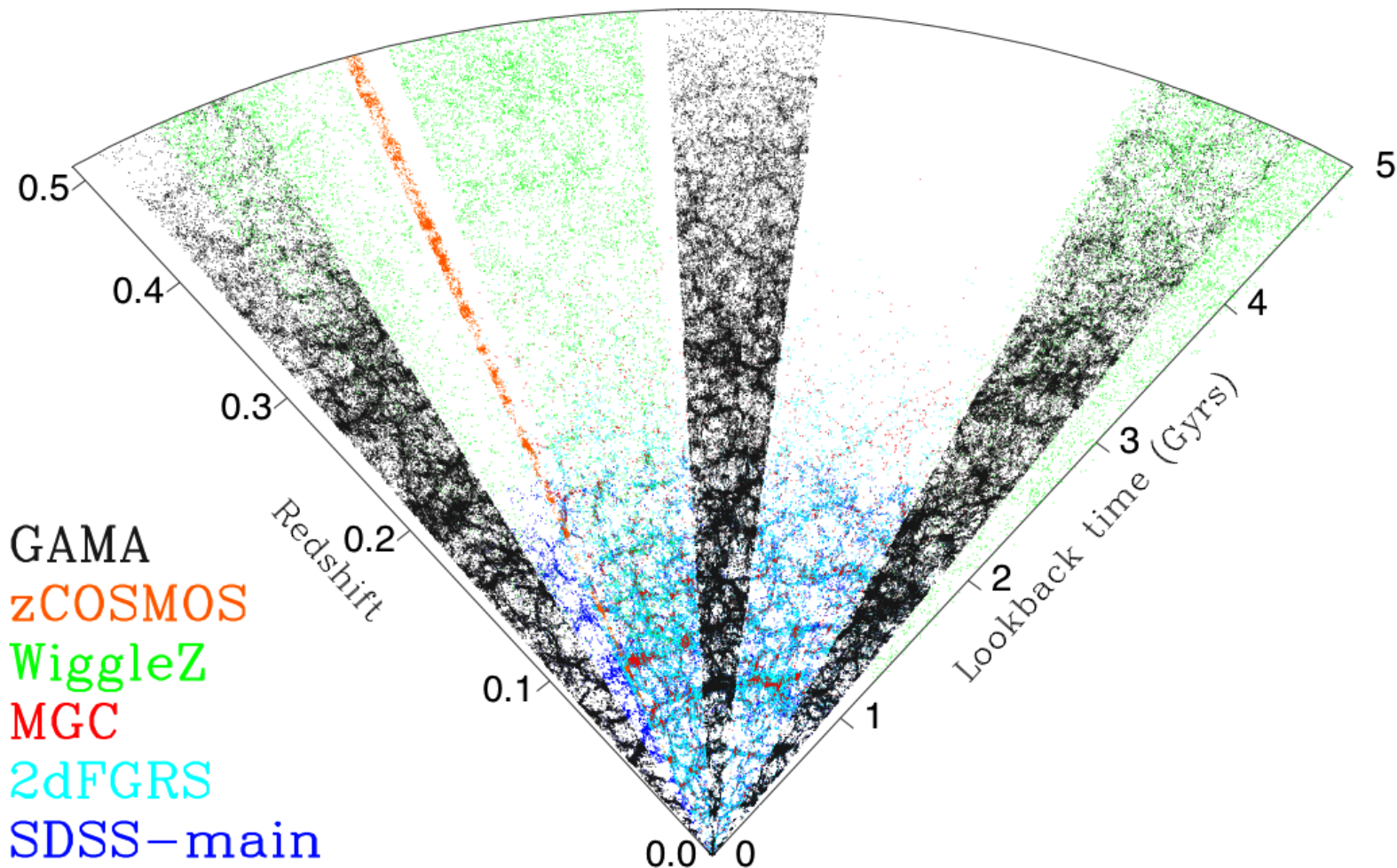
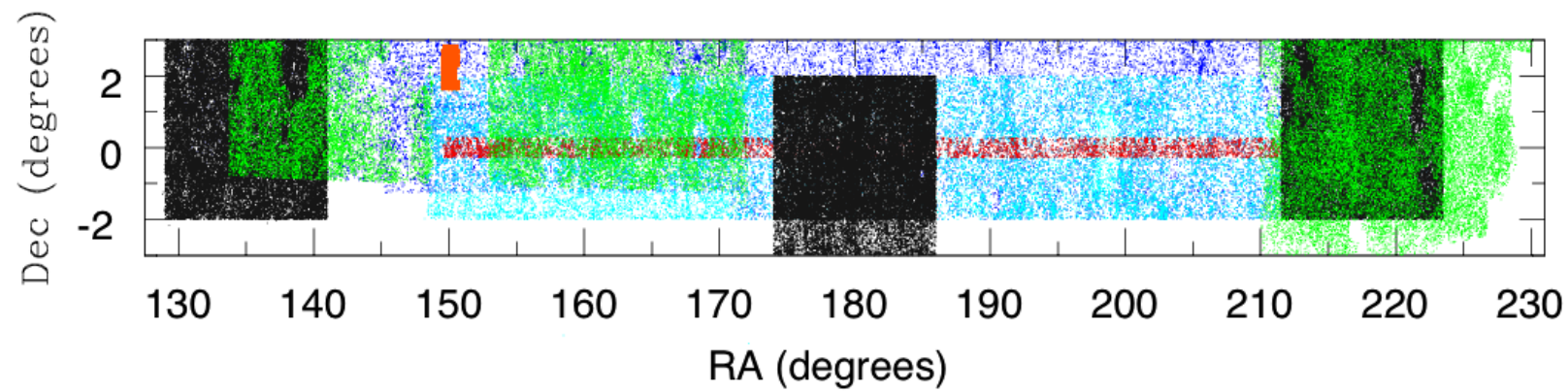


Galaxy And Mass Assembly Survey: where are the fields?



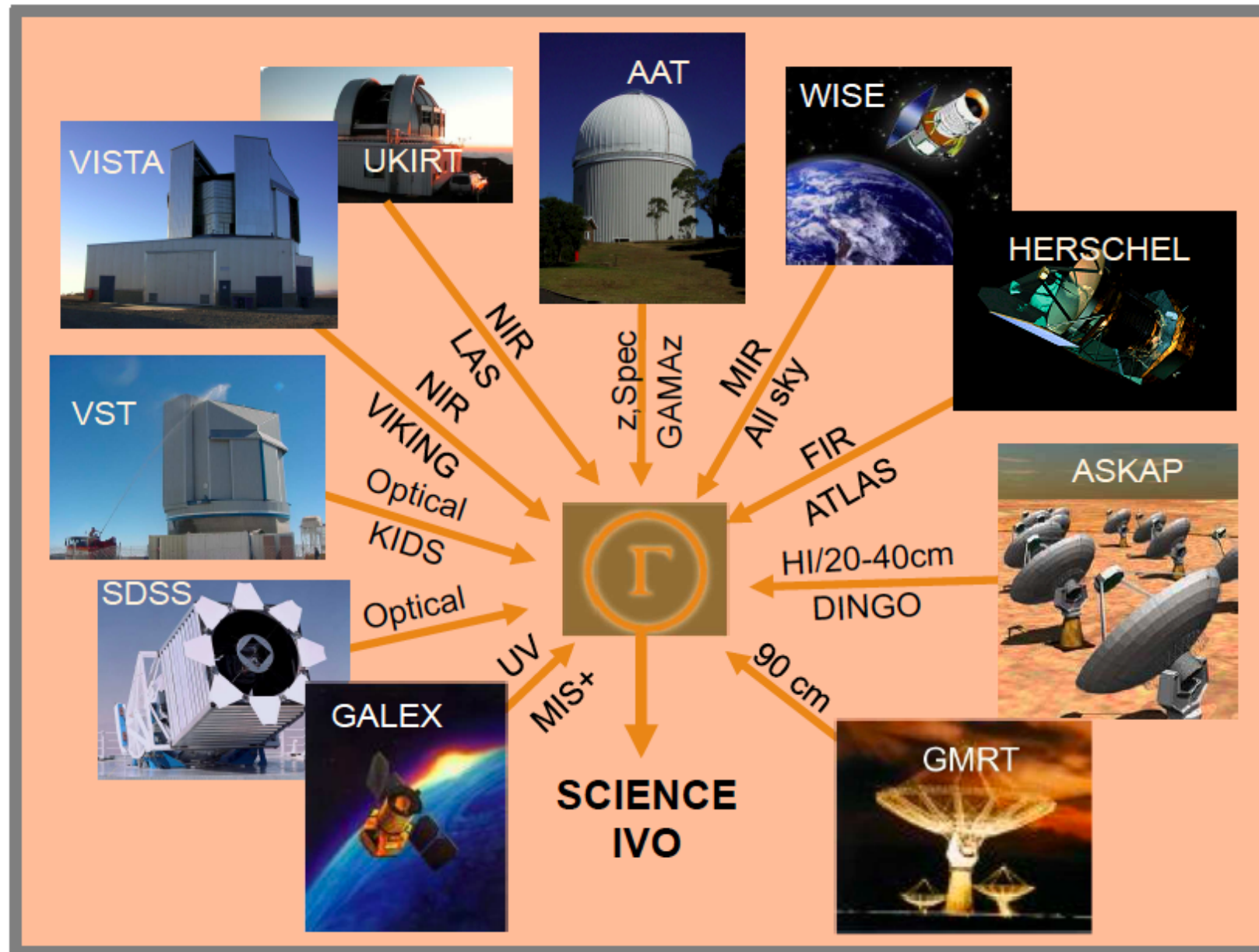
Galaxy And Mass Assembly Survey: ***germane connection between shallow-wide & deep-narrow***





G
A
M
A
I

GAMA: Contributing Facilities



GAMA: Contributing Facilities

The Anglo-Australian Telescope

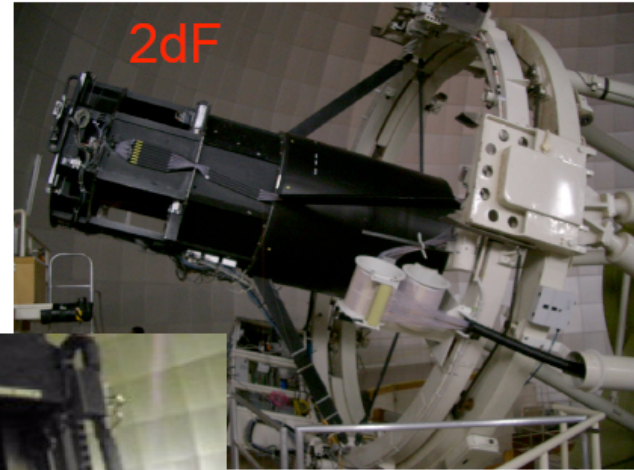


AAT

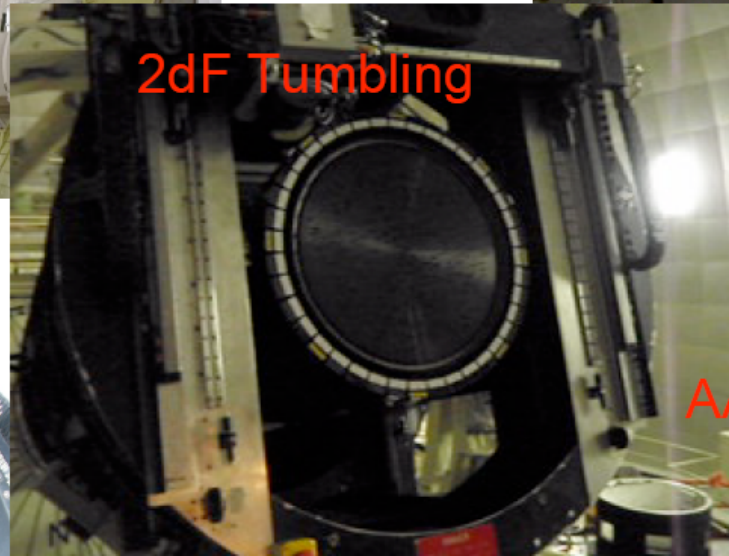


Robotic positioner

(3.9m)

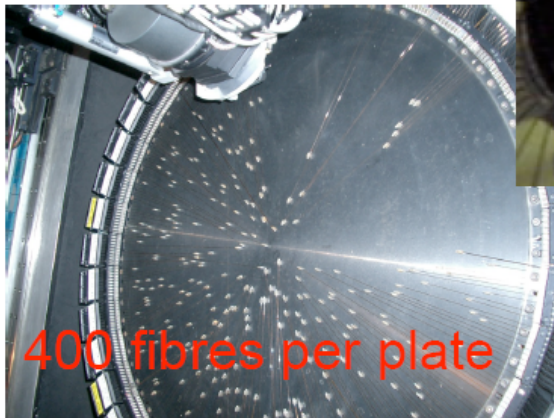


2dF



2dF Tumbling

Double-beam spectrograph



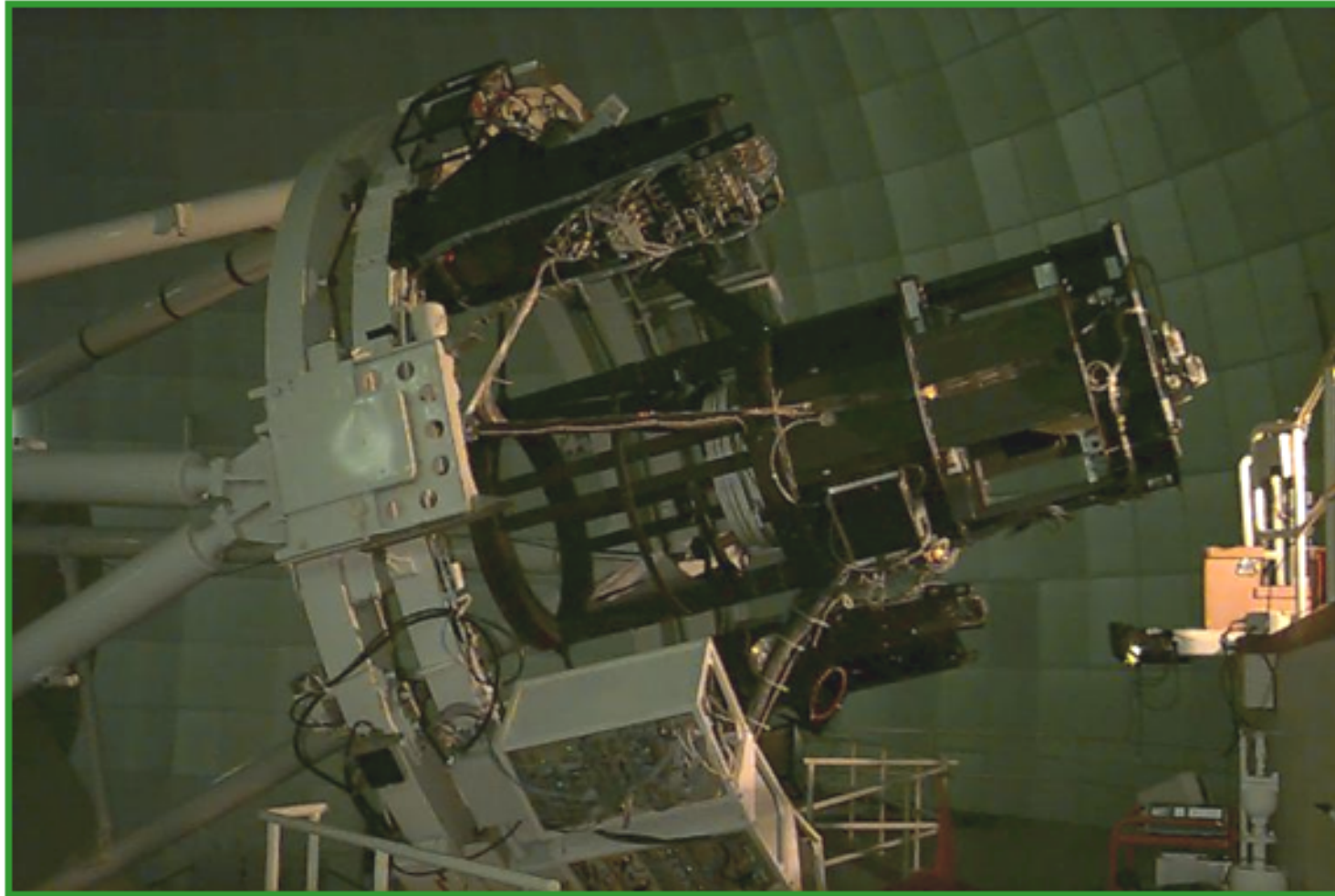
400 fibres per plate

2.5k redshifts per night via two 400 fibre plates!

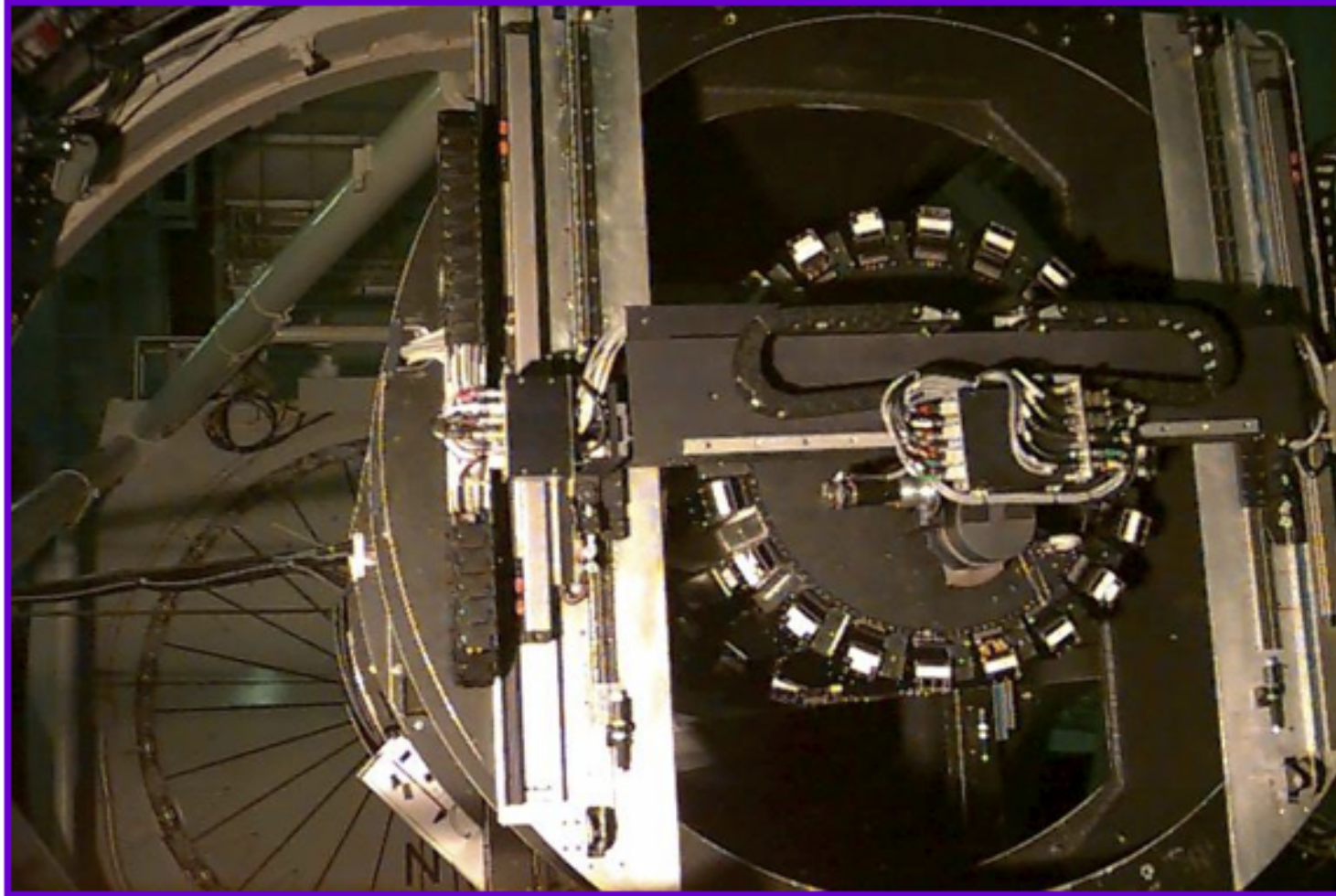


AAO Spectrograph

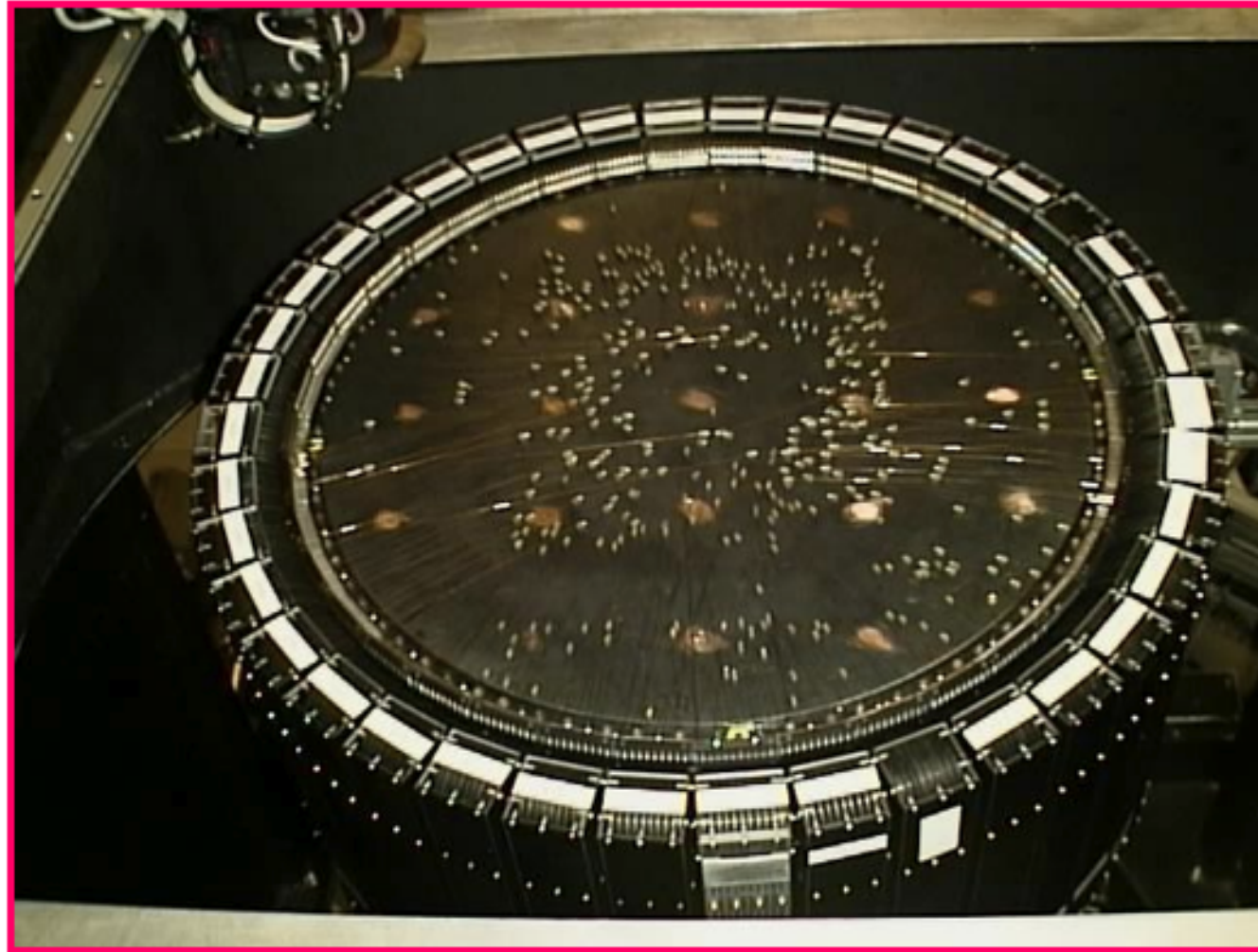
GAMA: Contributing Facilities



GAMA: Contributing Facilities



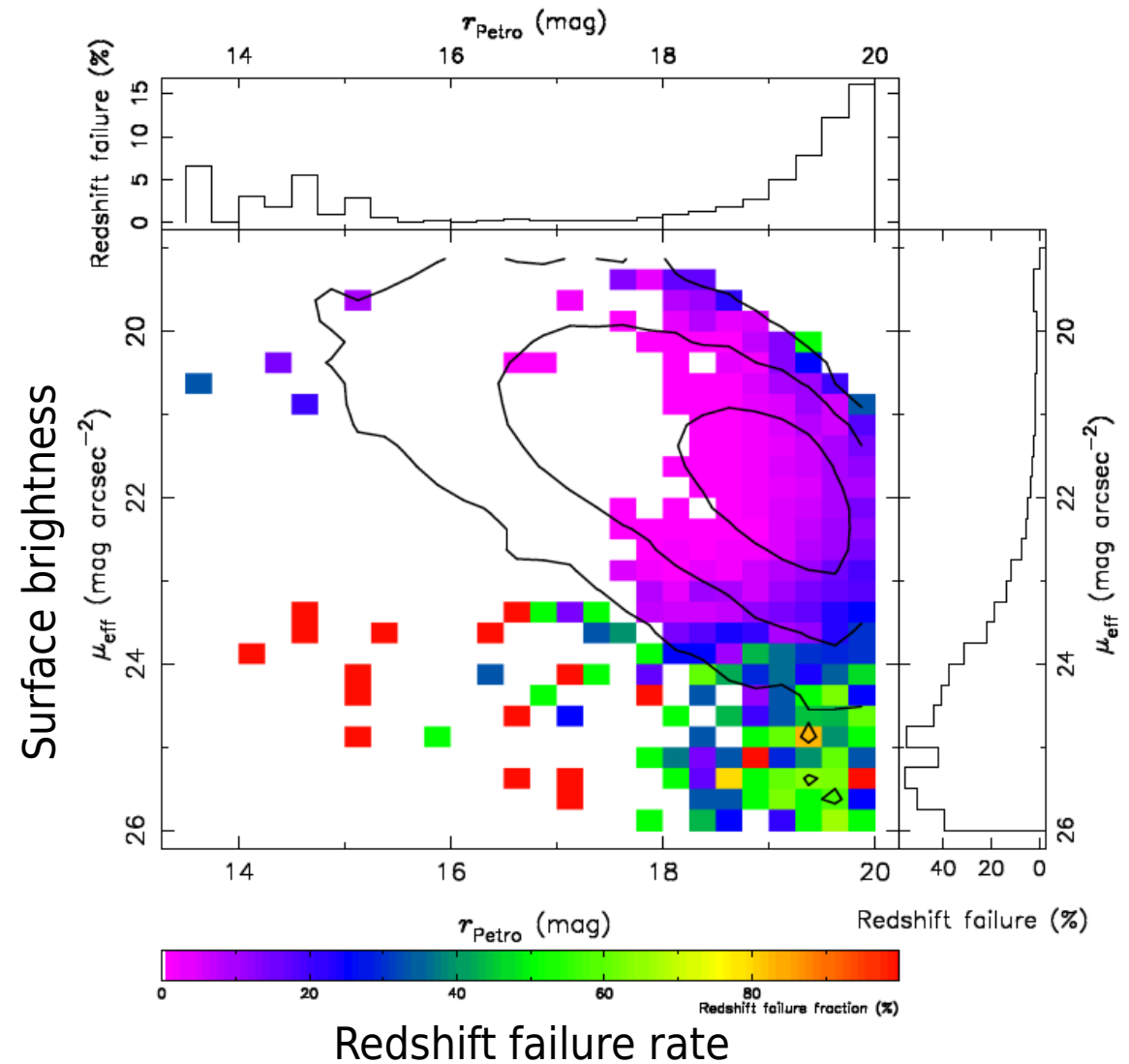
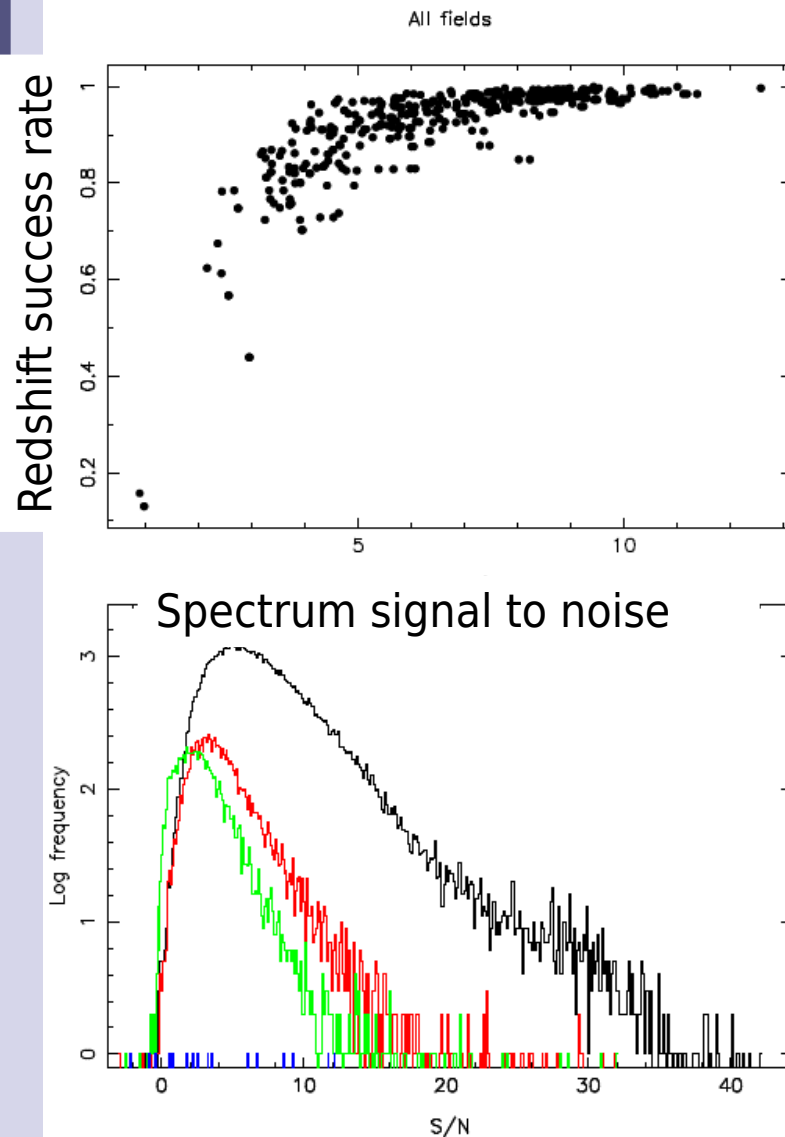
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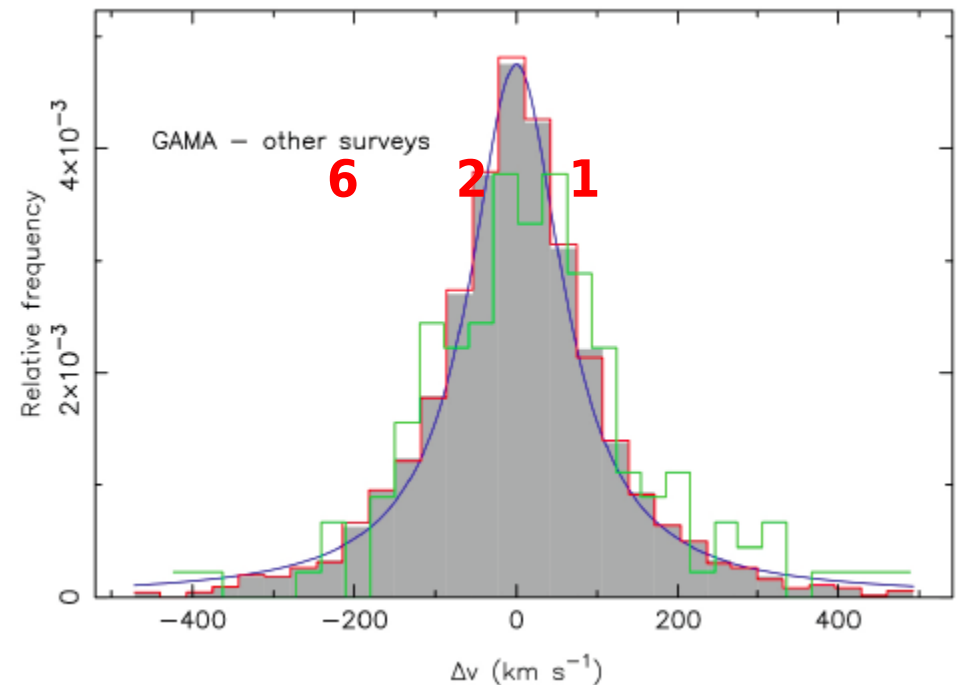
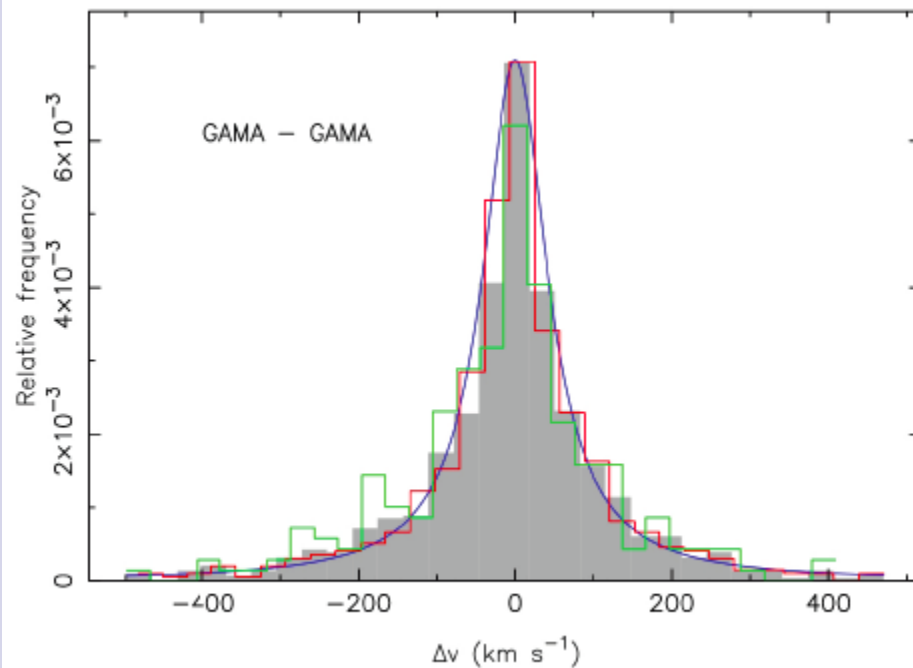


GAMA: spectra quality & redshift success rate...



Liske et al. (in prep)

GAMA: redshift accuracy, quality & completeness

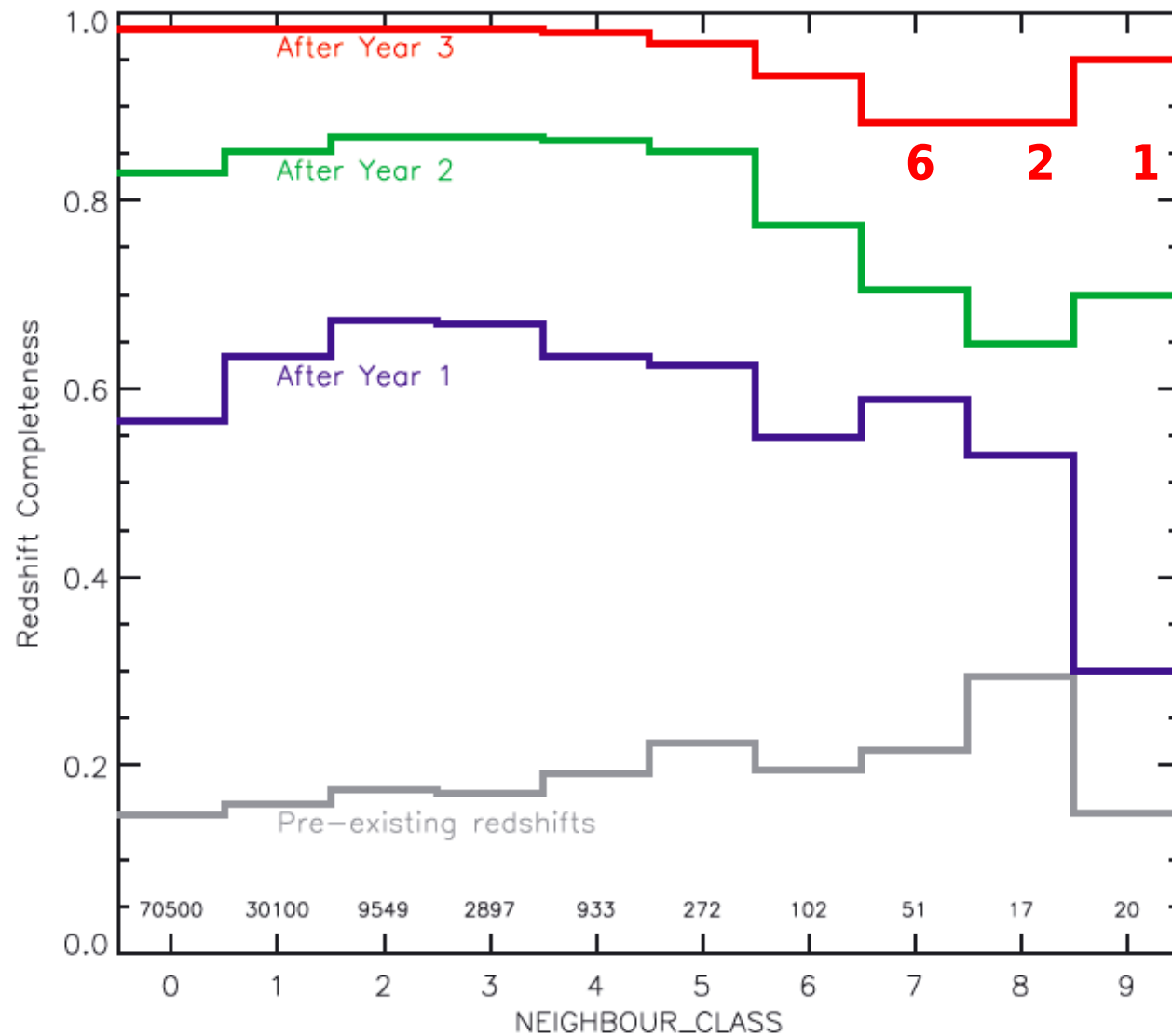


Redshift accuracy:

- GAMA-GAMA: $\gamma \sim 50 \text{ km/s}$**
- GAMA-Other: $\gamma \sim 70 \text{ km/s}$**

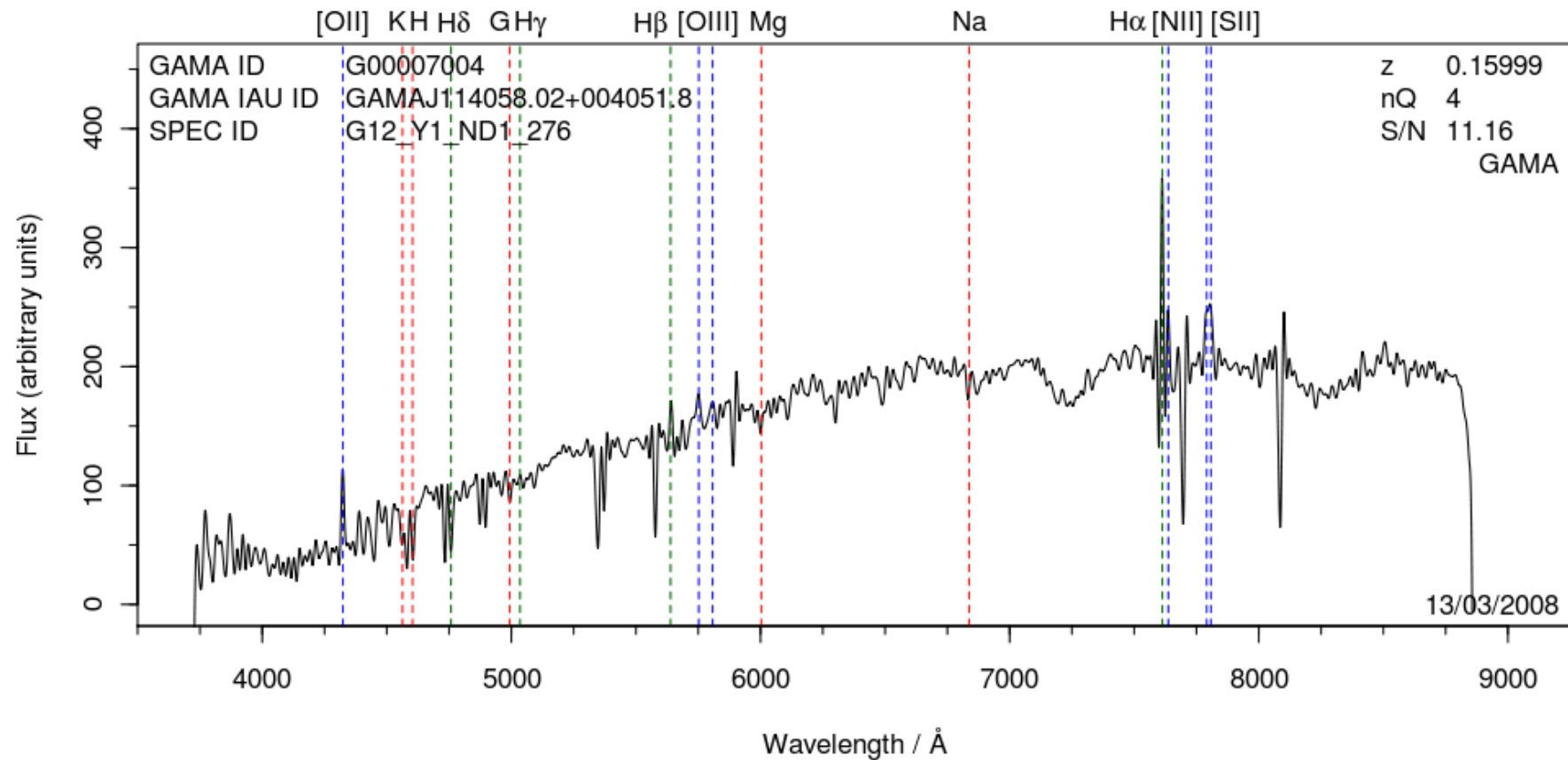
Driver et al. (2011)

GAMA: redshift accuracy, quality & completeness

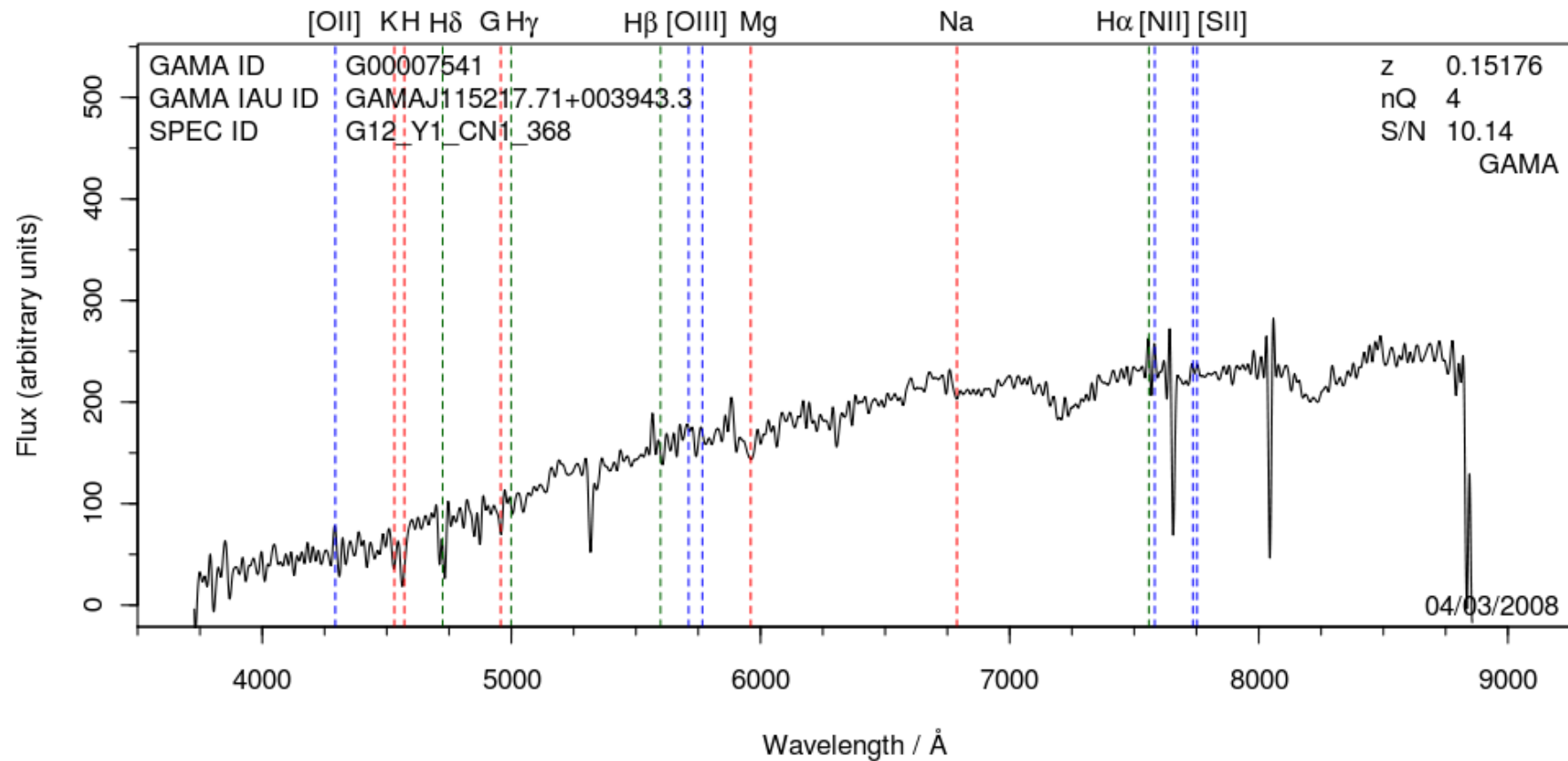


Driver et al. (2011)

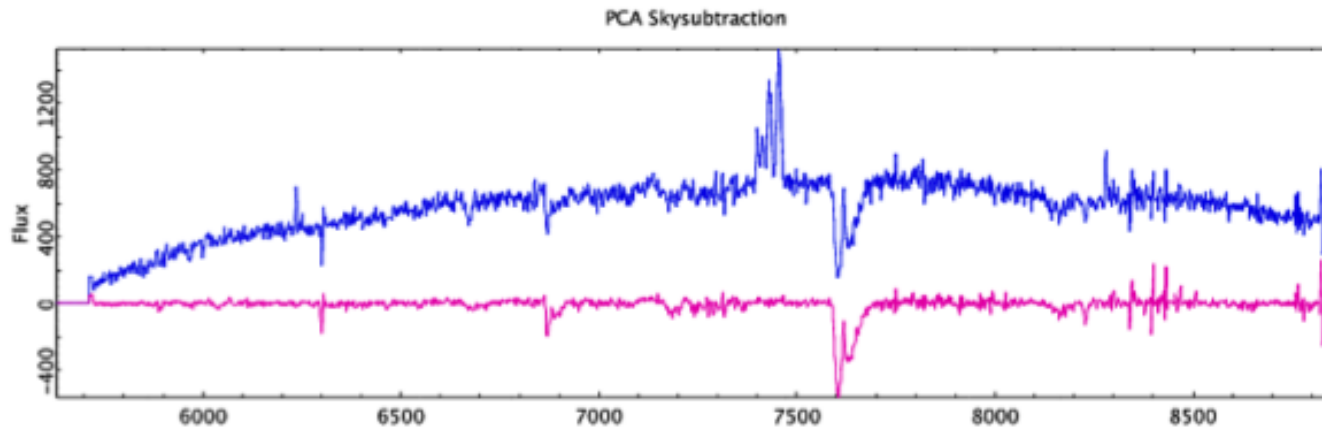
GAMA: example spectra (improved with PCA sky-subtraction)



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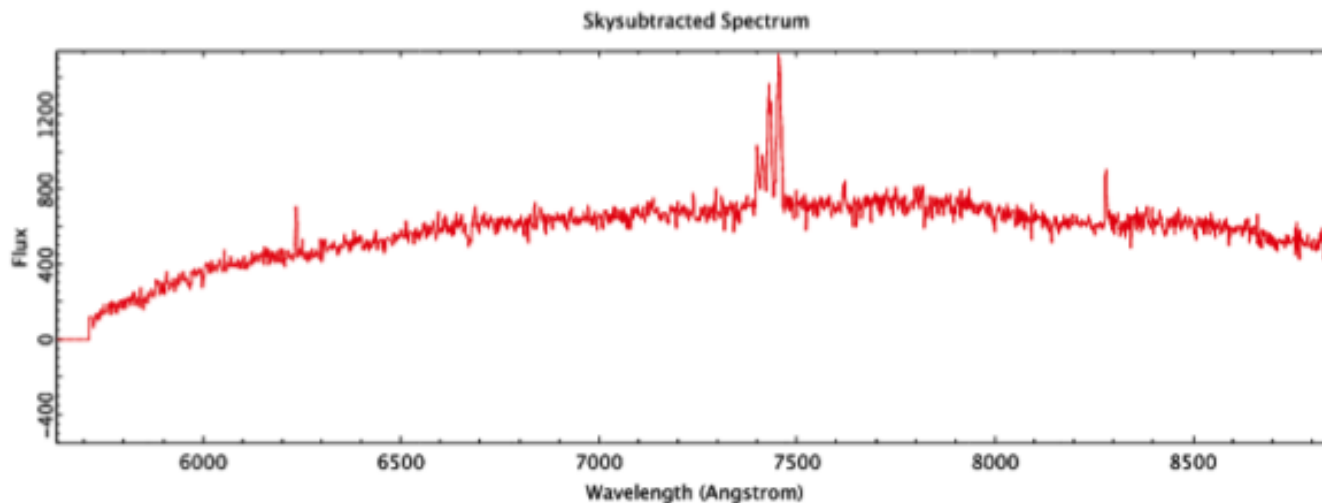


GAMA: improved sky-subtraction with PCA



**Before
Sky-subtraction**

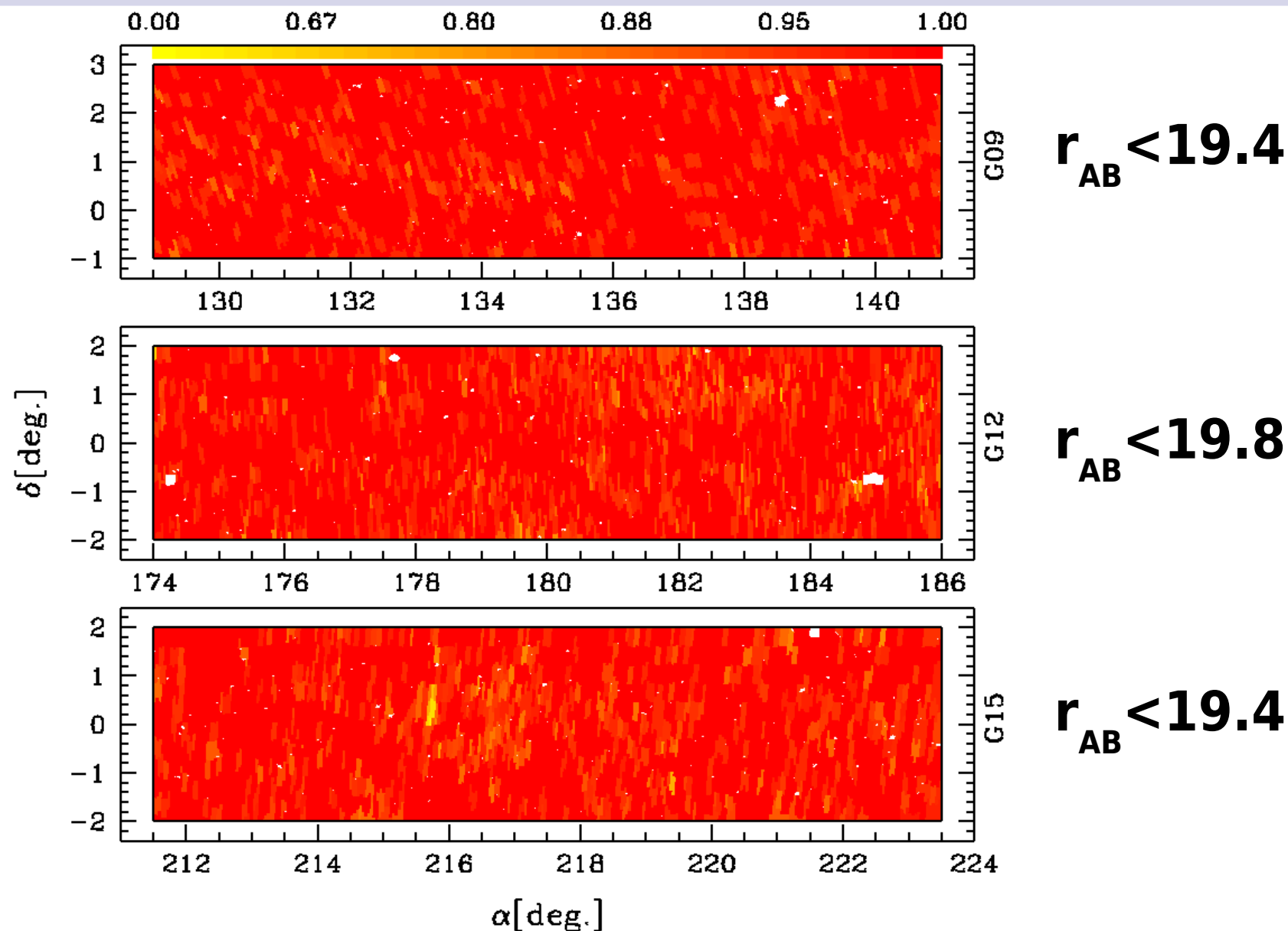
PCA sky



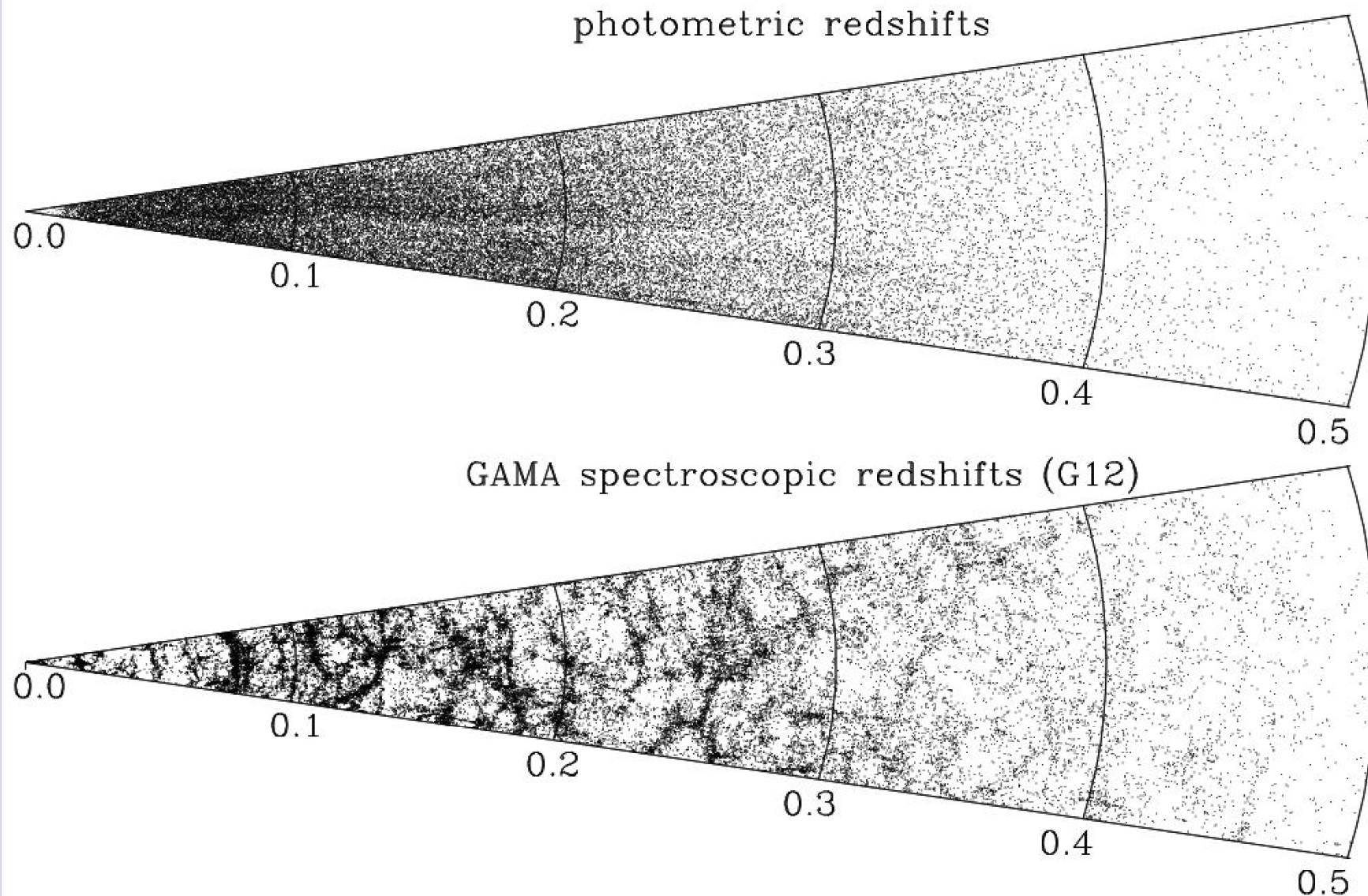
**Properly
Sky-subtracted
Galaxy spectrum**

Parkinson et al. (in prep)

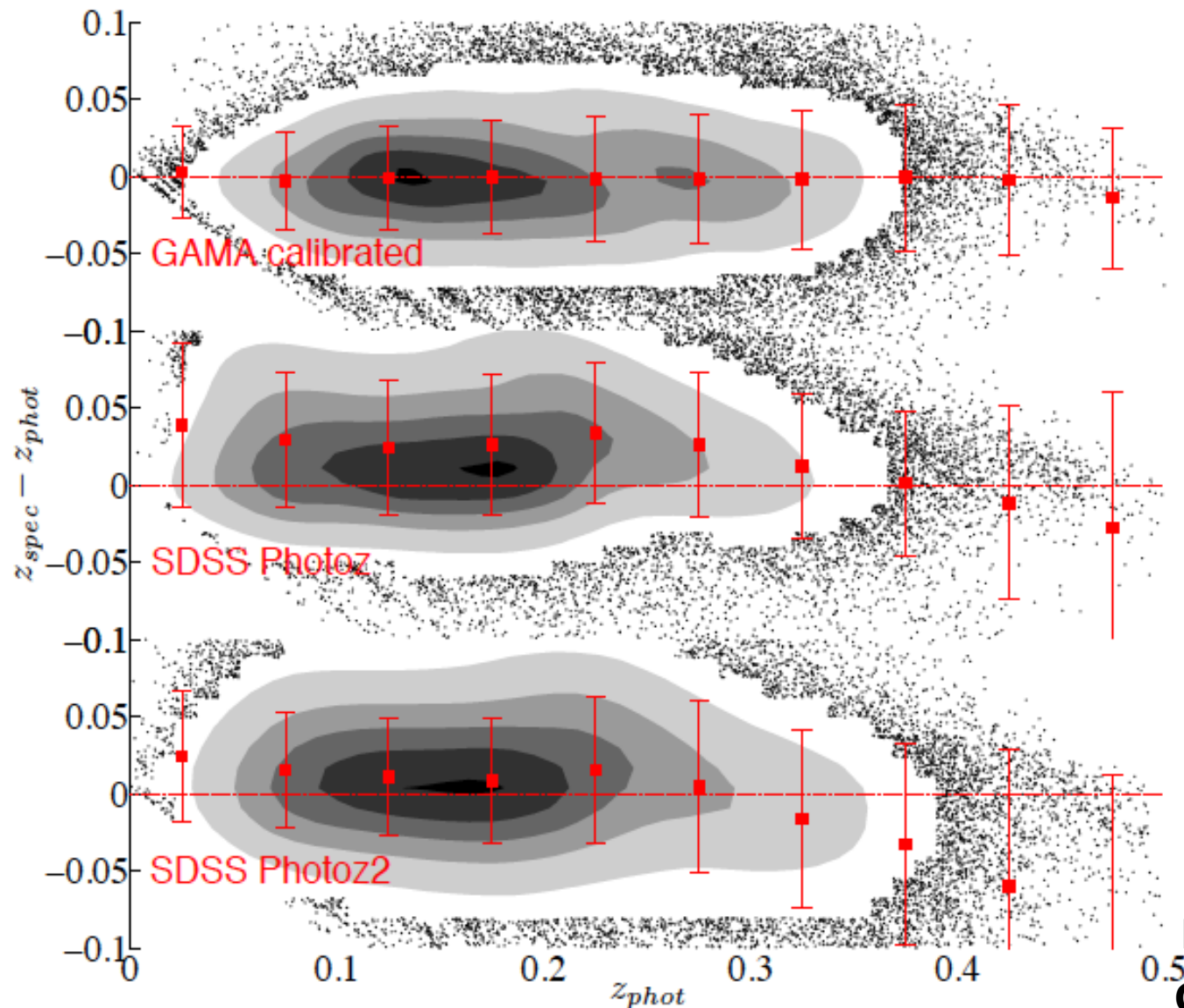
GAMA-I: redshift completeness...~98%!



GAMA: improved photometric redshifts ($r < 19.8$)



GAMA: improved photometric redshifts ($r < 19.8$)



GAMA
vs
SDSS DR7

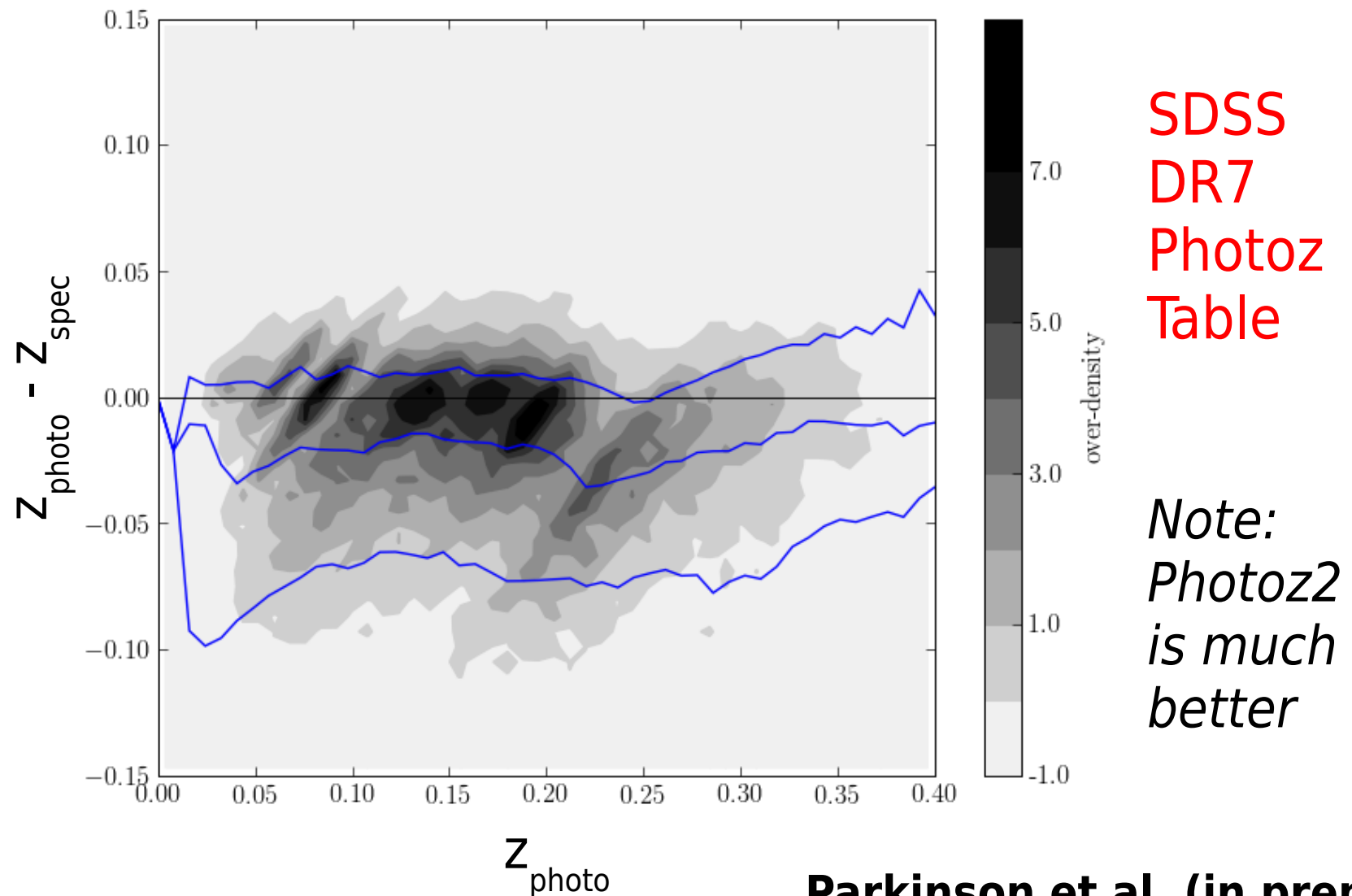
Photoz
Table 1

&

Photoz
Table 2

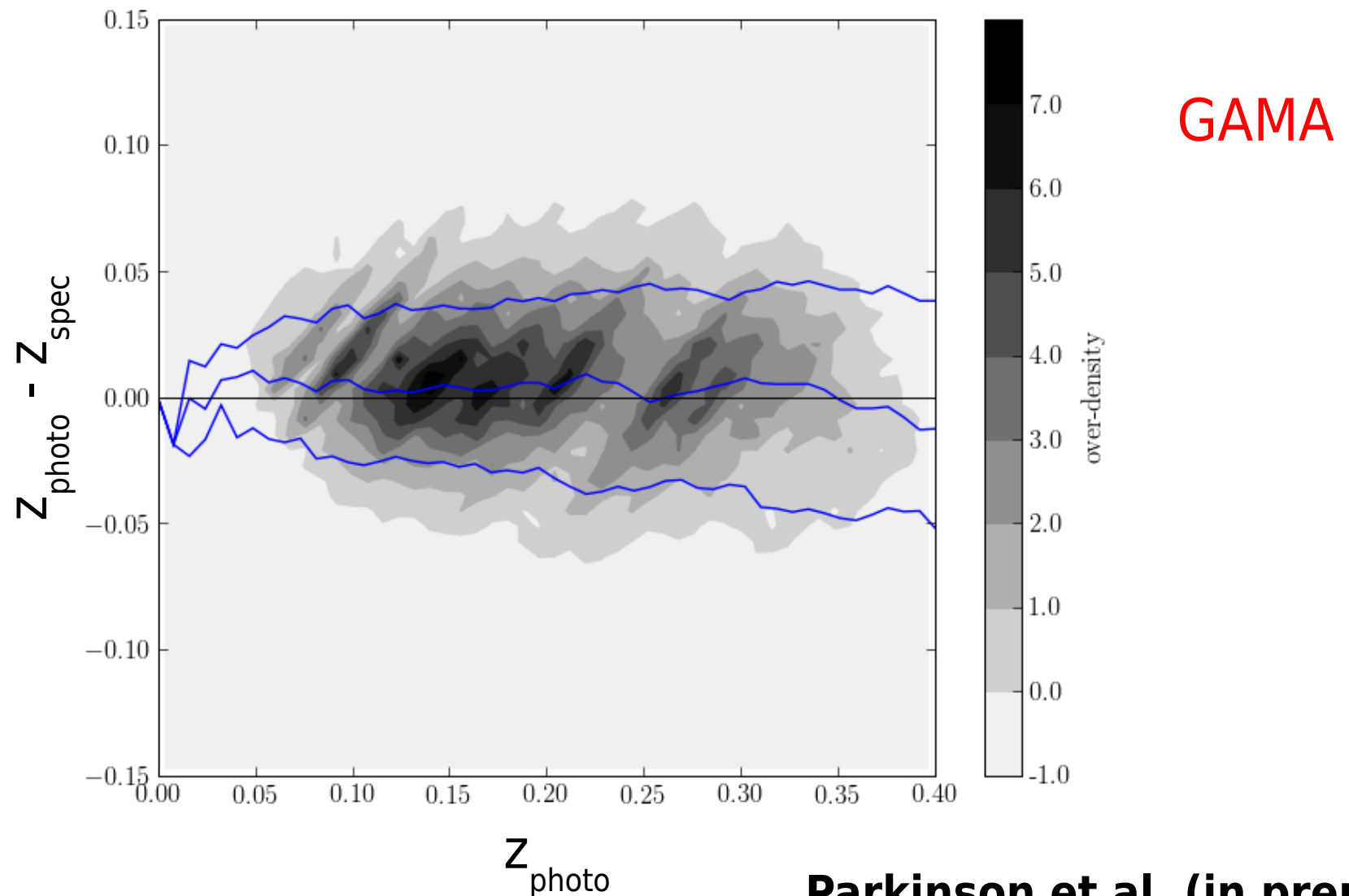
Parkinson (in prep)
Christodoulou et al.

GAMA: improved photometric redshifts



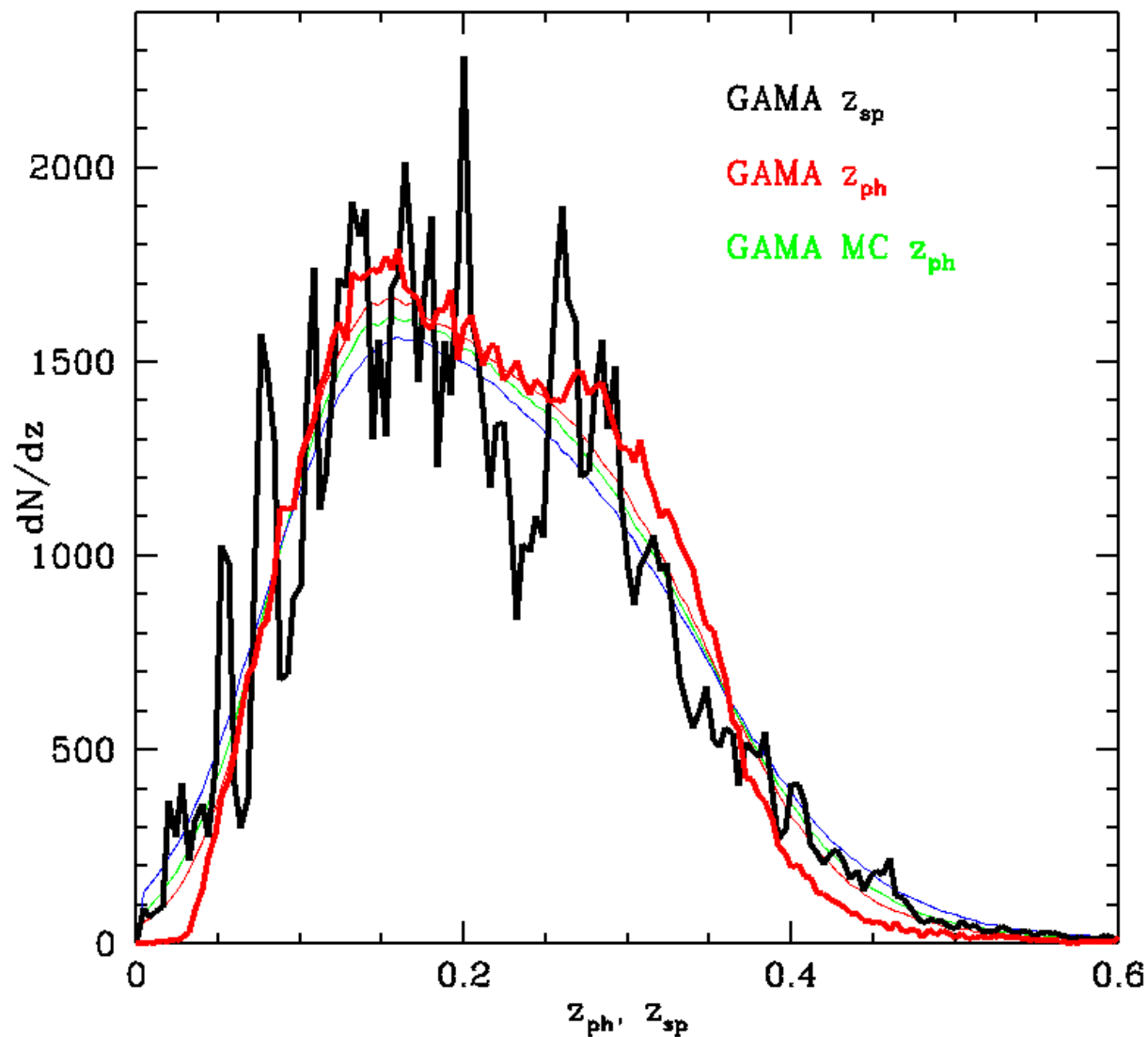
Parkinson et al. (in prep)

GAMA: improved photometric redshifts



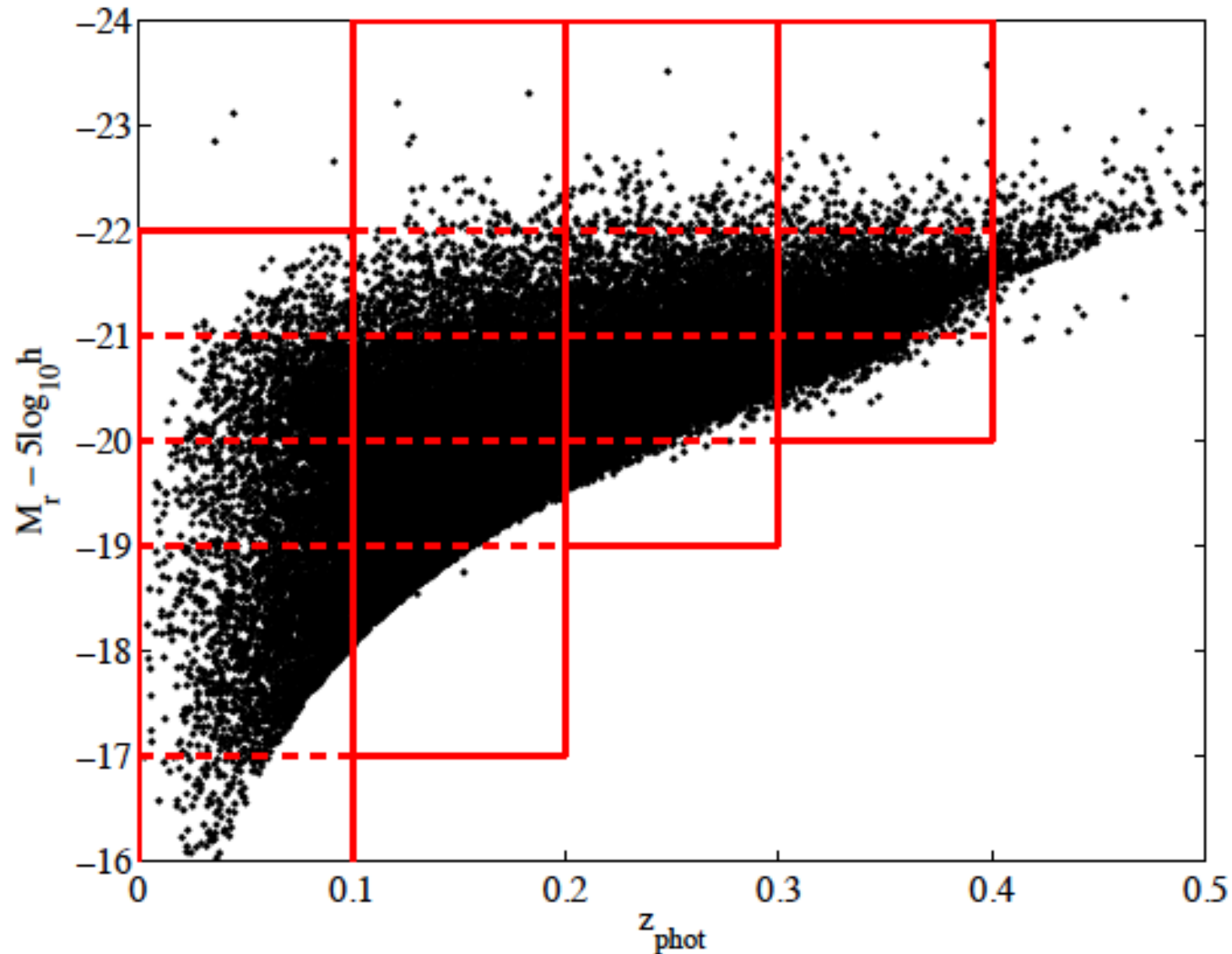
Parkinson et al. (in prep)

GAMA: $N(z)$ for z_{spec} and z_{ph}



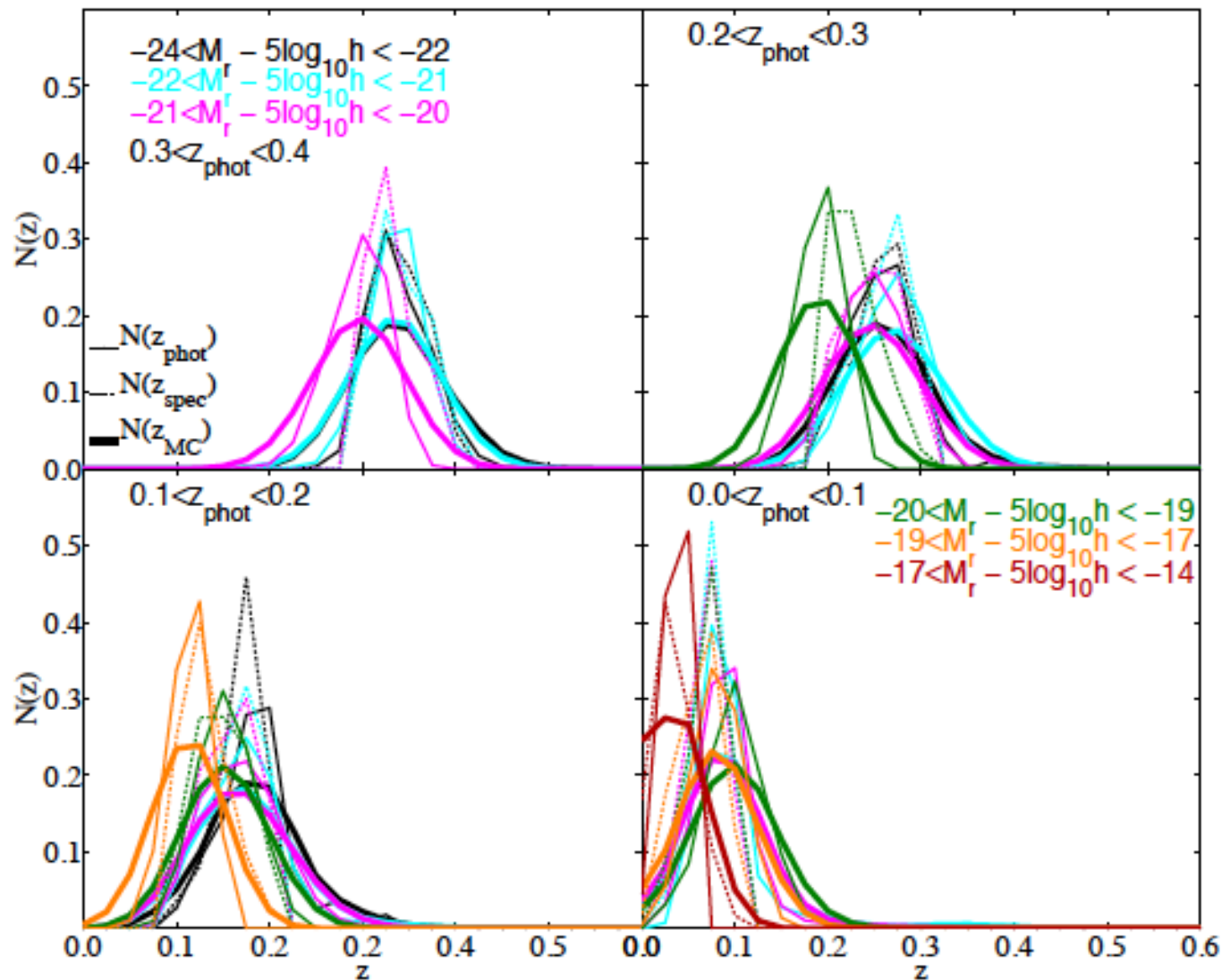
Driver et al. (2011)
Christodoulou et al.

SDSS: clustering split by z_{ph} & $M_r(z_{ph})$



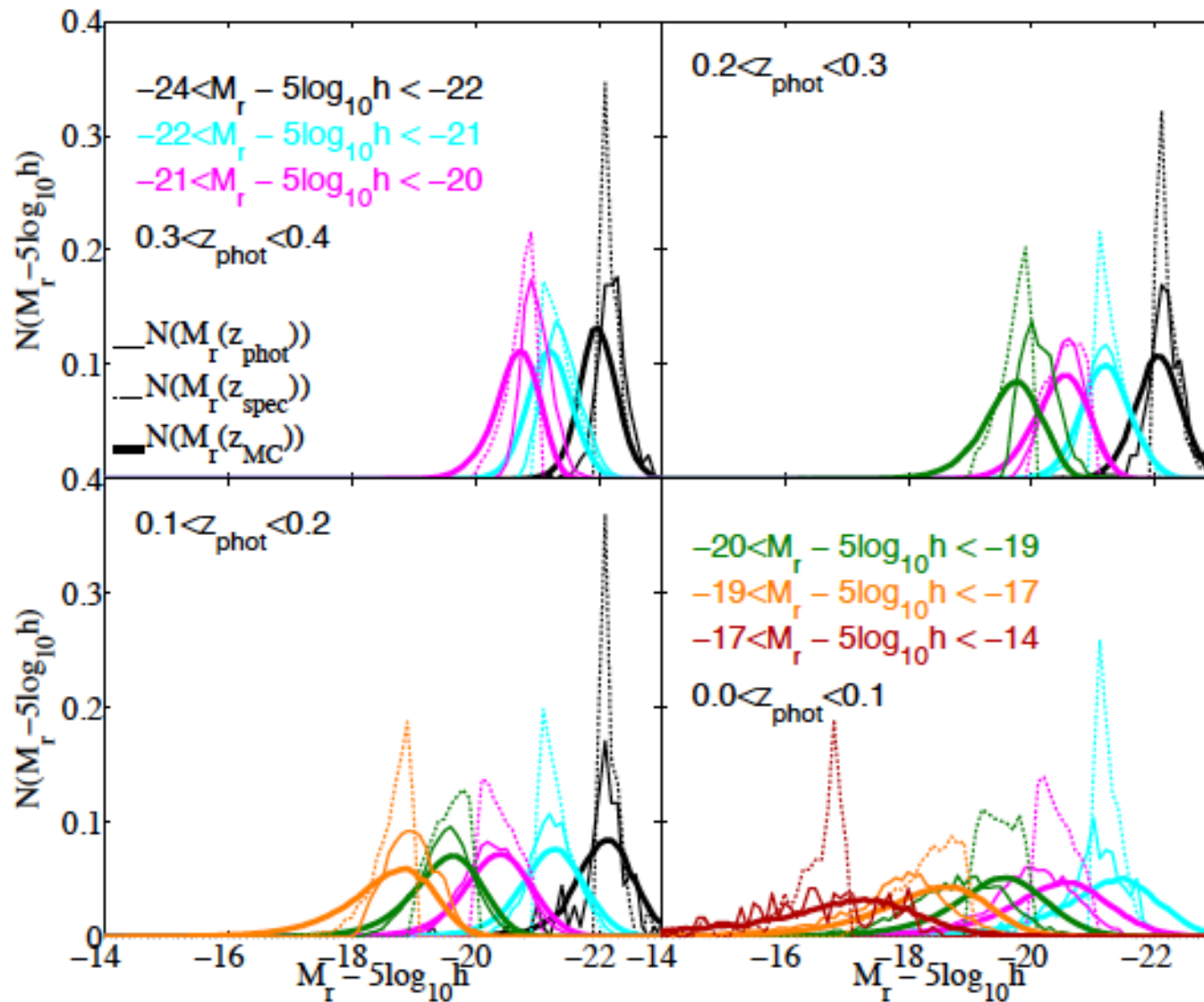
Christodoulou et al.

GAMA: $N(z)$ for samples split by z_{phot} & $M_r(z_{\text{phot}})$



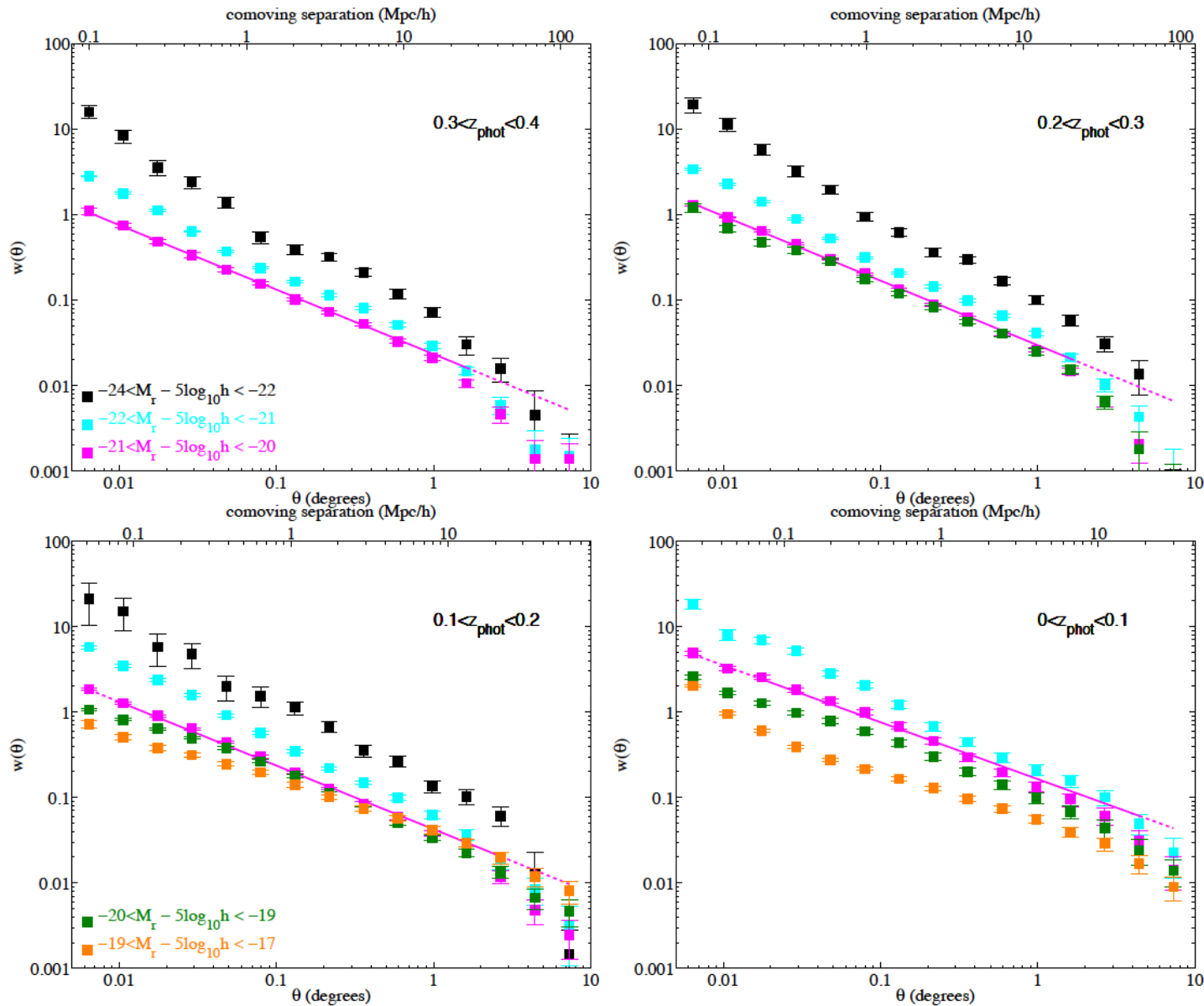
Christodoulou et al.

GAMA: $N(M_r)$ for samples split by z_{ph} & $M_r(z_{ph})$



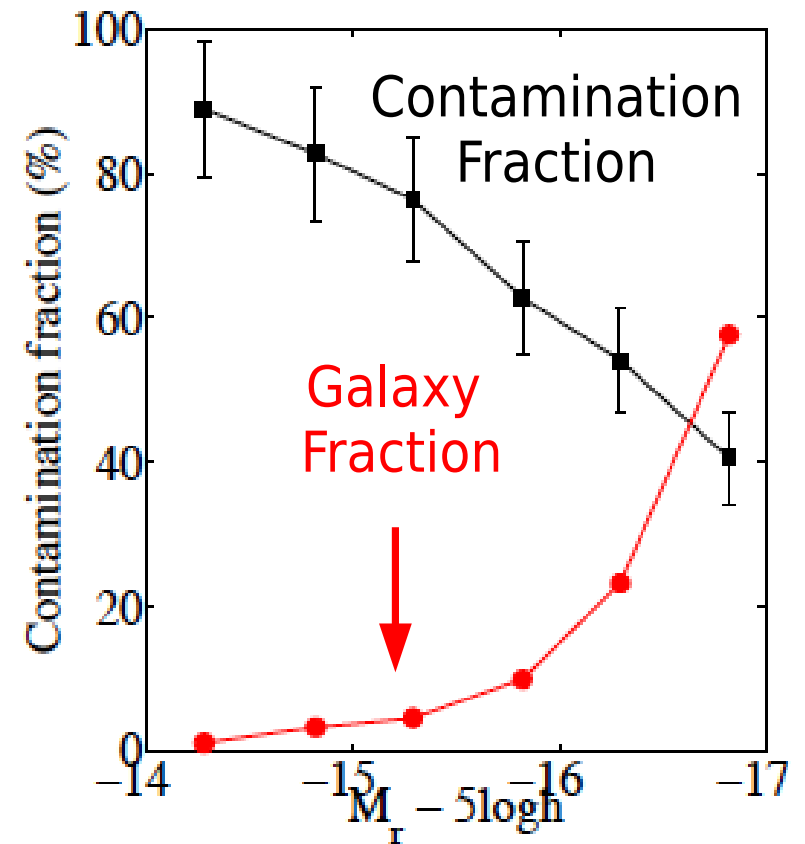
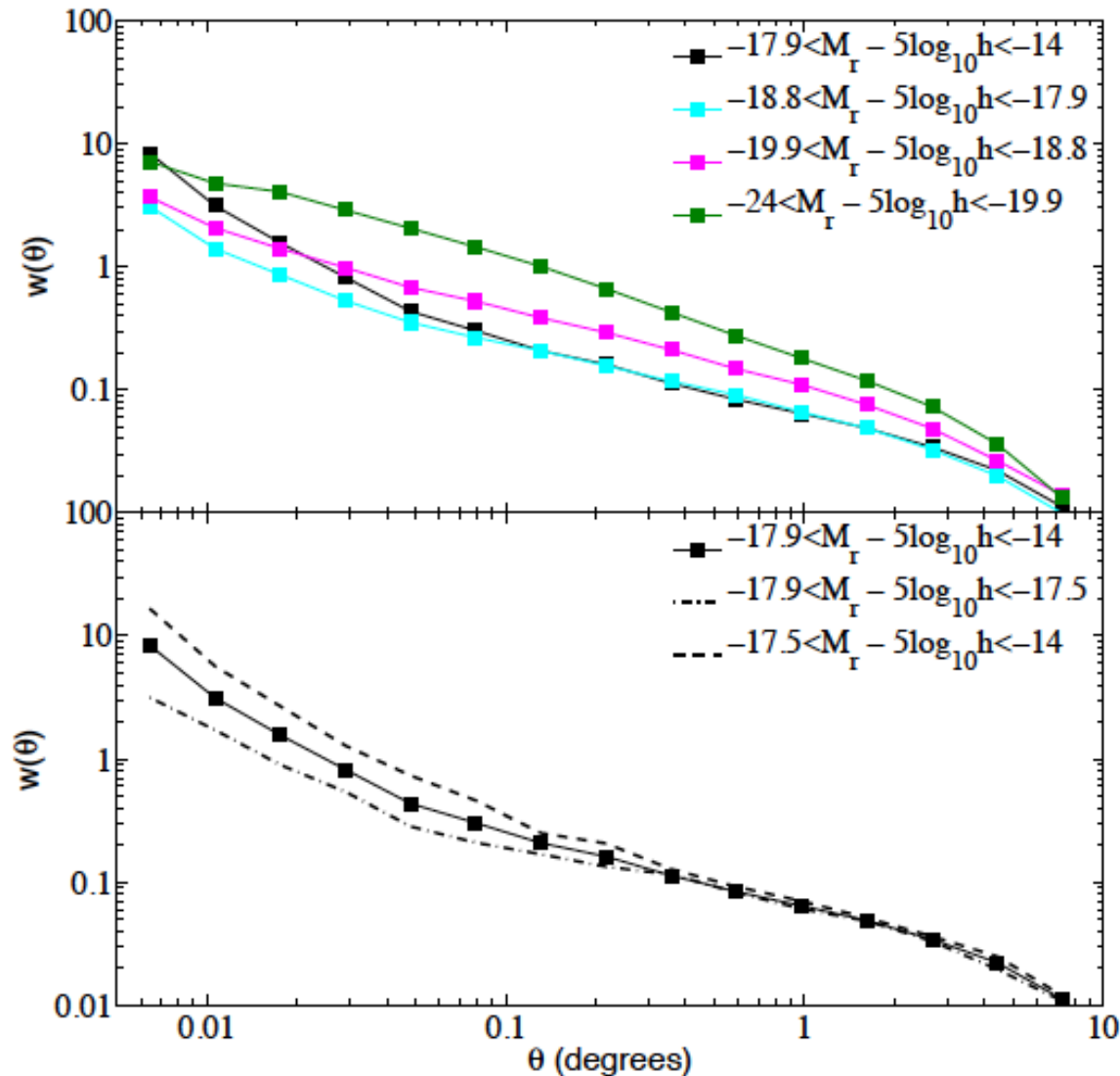
Christodoulou et al.

SDSS: $w(\theta)$ split by z_{ph} & $M_r(z_{ph})$



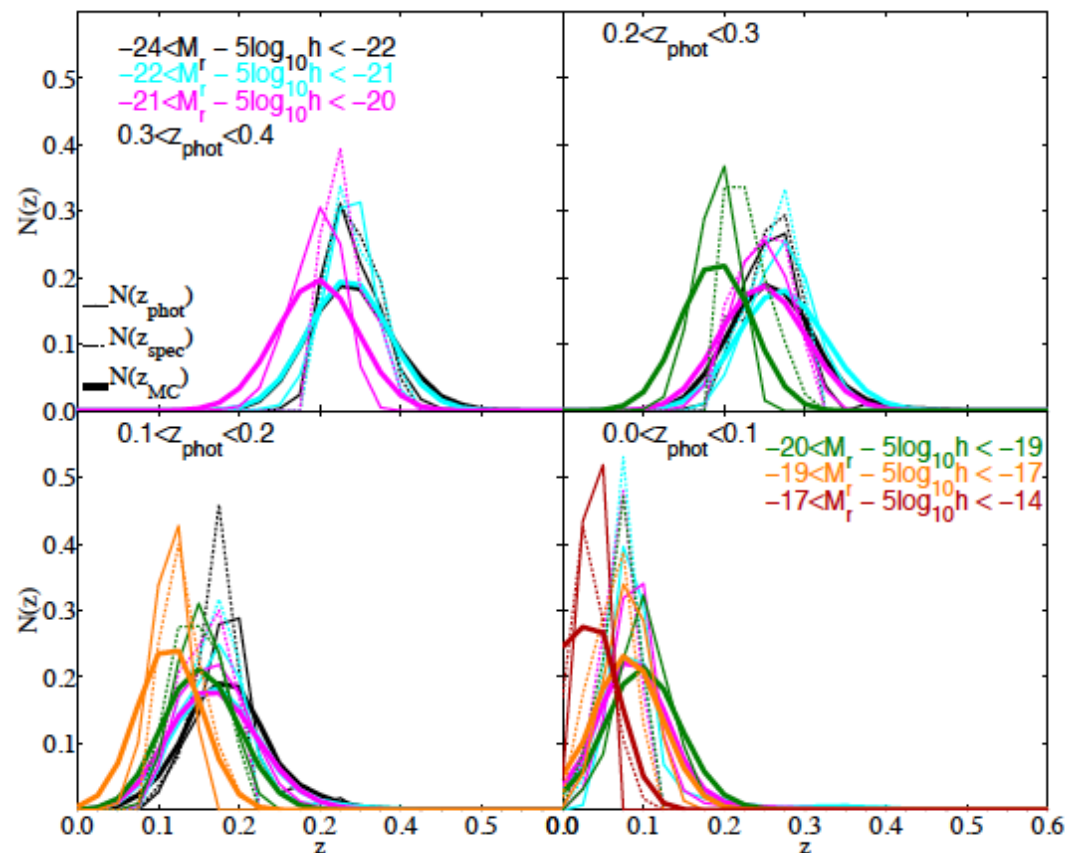
Christodoulou et al.

SDSS: $w(\theta)$ for faint galaxies, split by $M_r(z_{ph})$

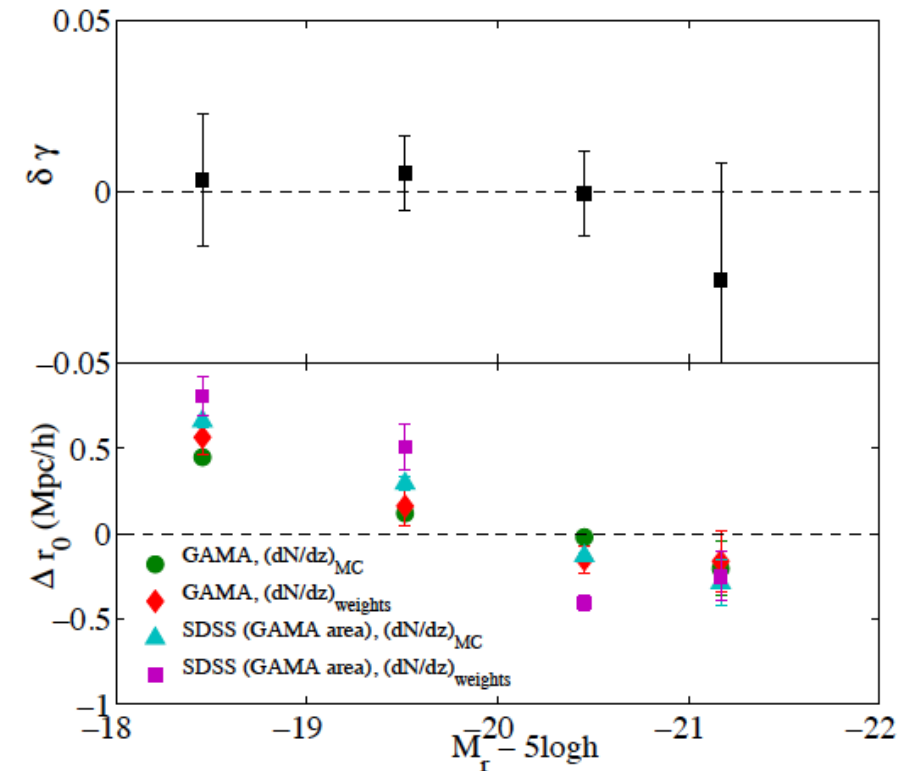


Christodoulou et al.

GAMA: more systematics with data split by z_{ph}



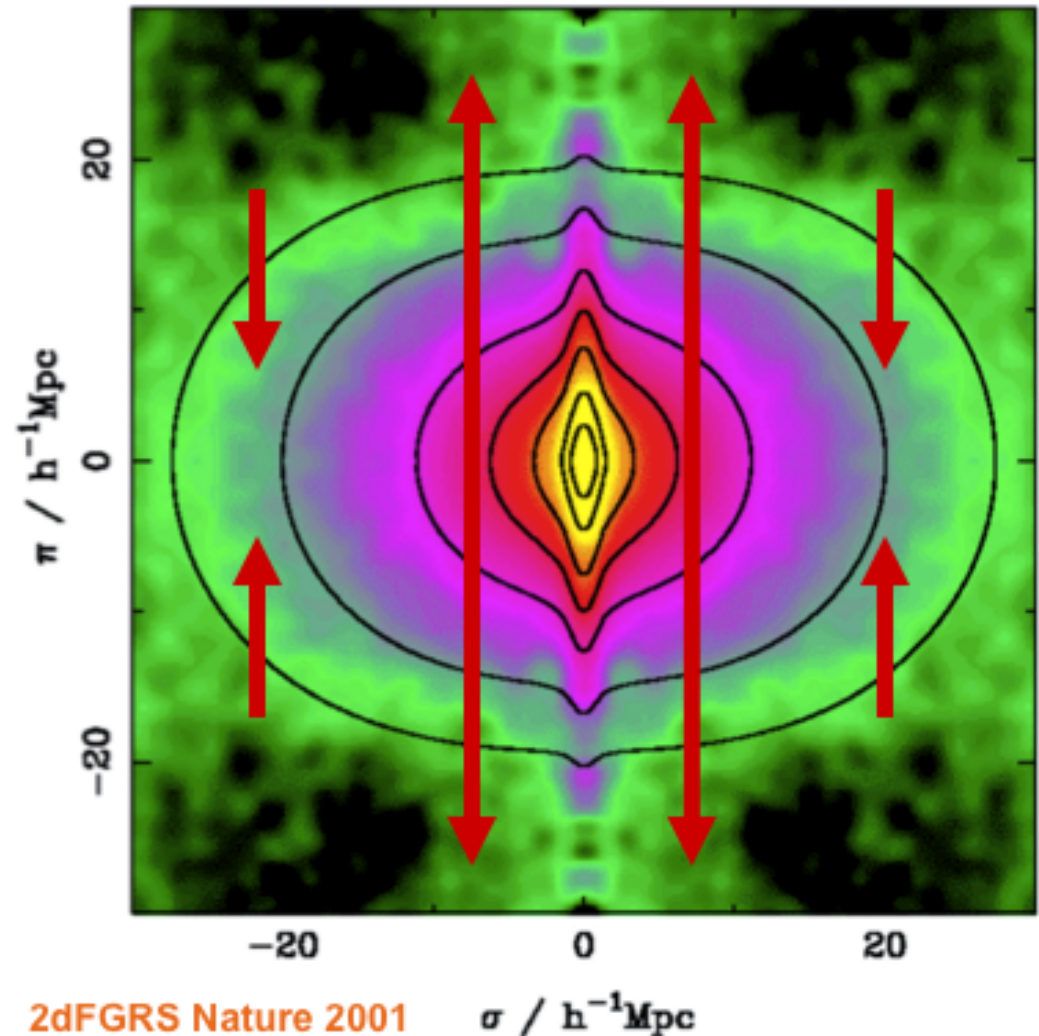
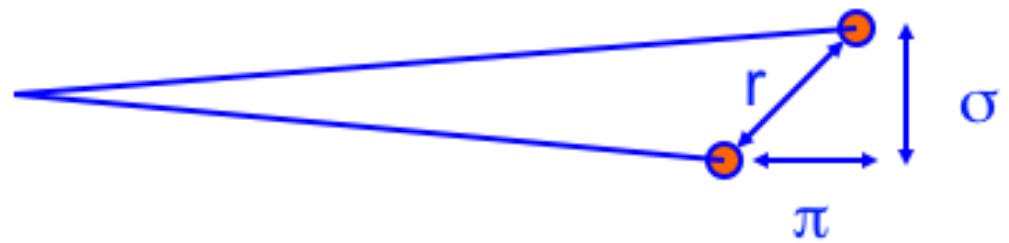
N(z) reconstruction



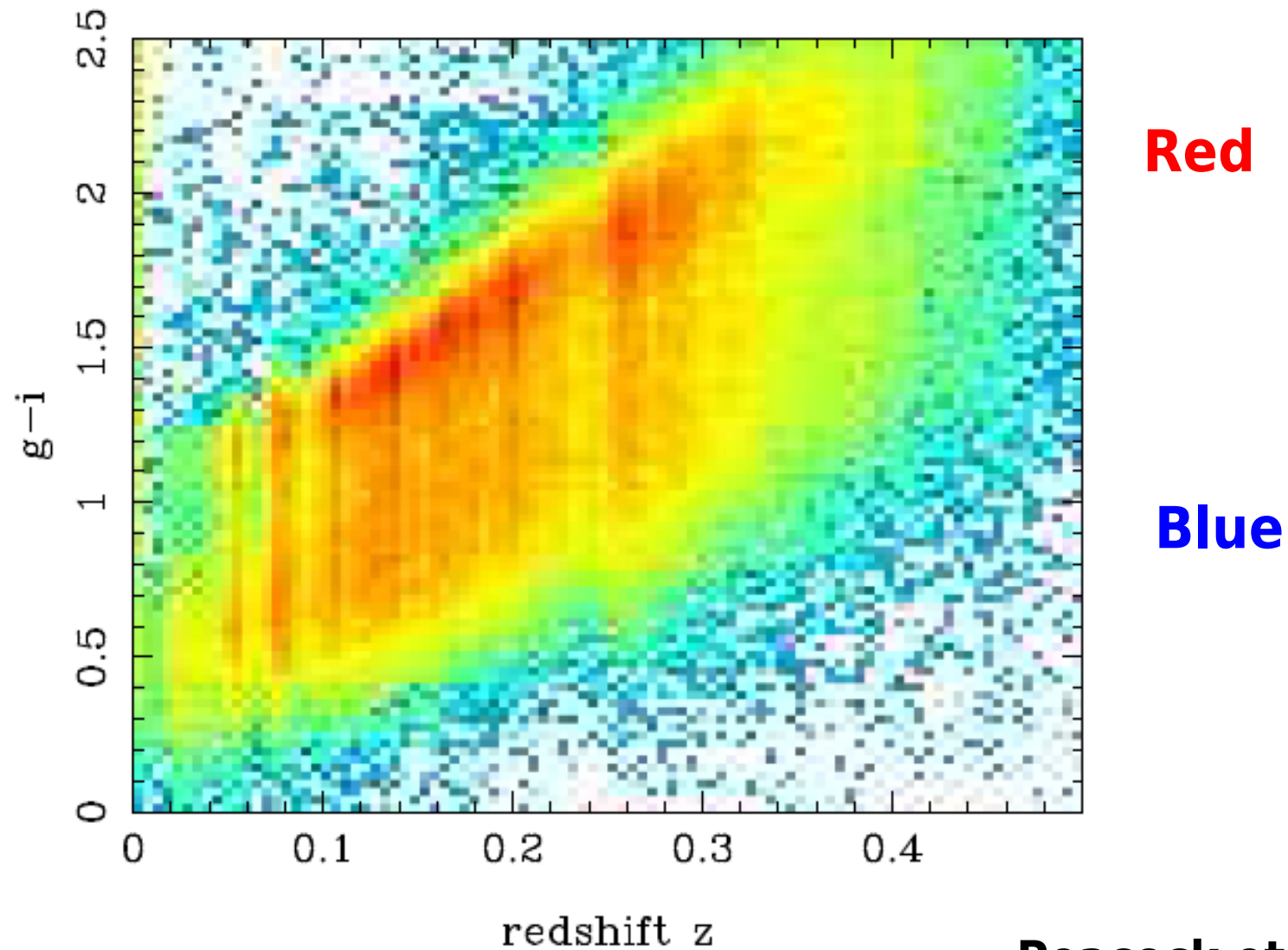
Christodoulou et al.

Redshift-Space Distortions

- RSD due to peculiar velocities are quantified by correlation fn $\xi(\sigma, \pi)$.
- Two effects visible:
 - Small separations on sky: ‘Finger-of-God’;
 - Large separations on sky: flattening along line of sight.

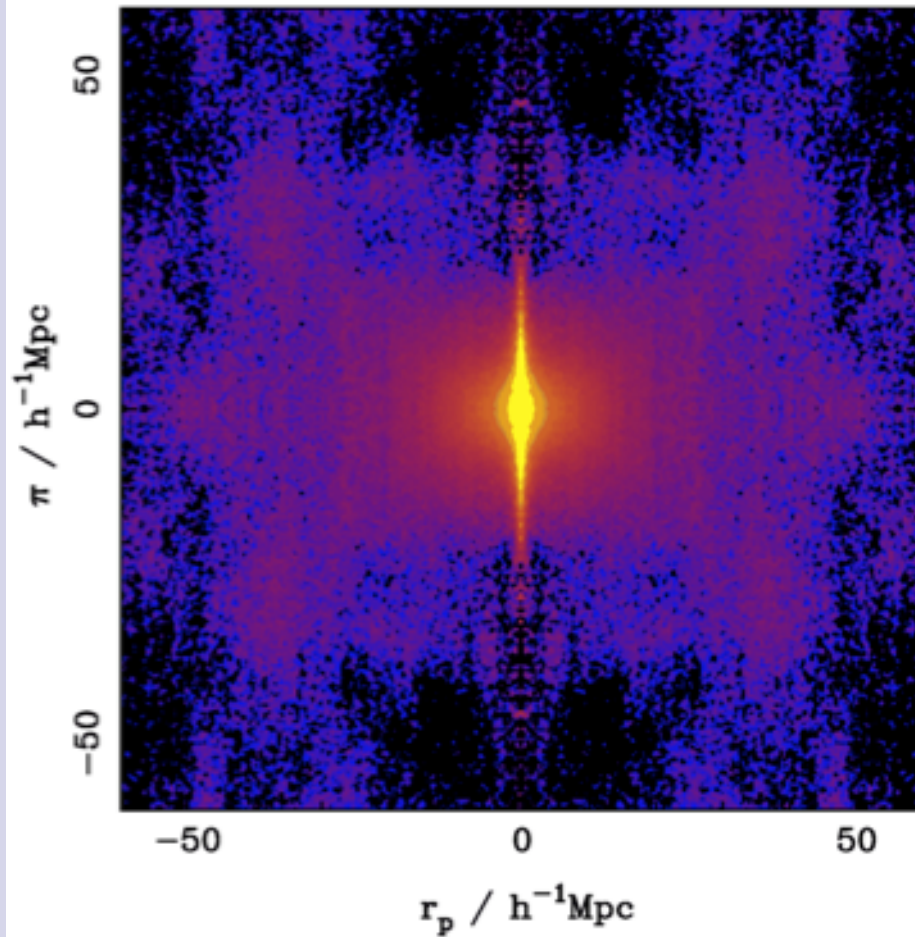


GAMA-I: clustering by colour & redshift

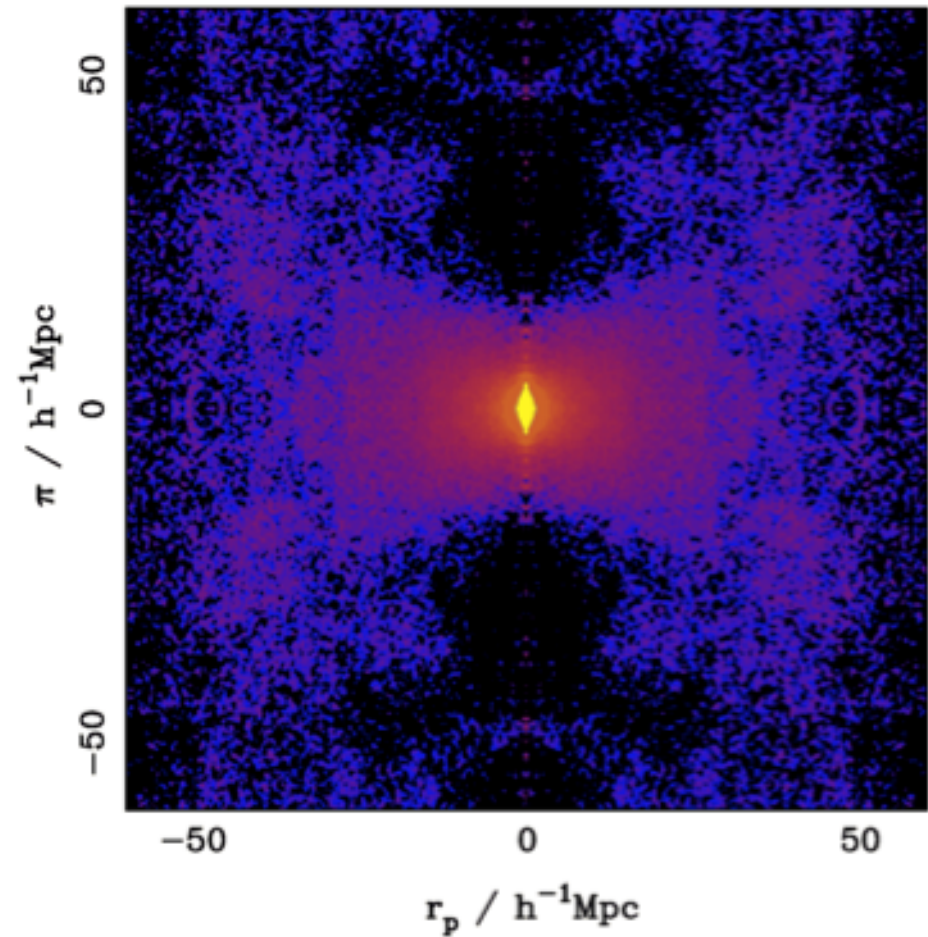


Peacock et al. (in prep)

GAMA-I: Redshift Space Distortions (data)

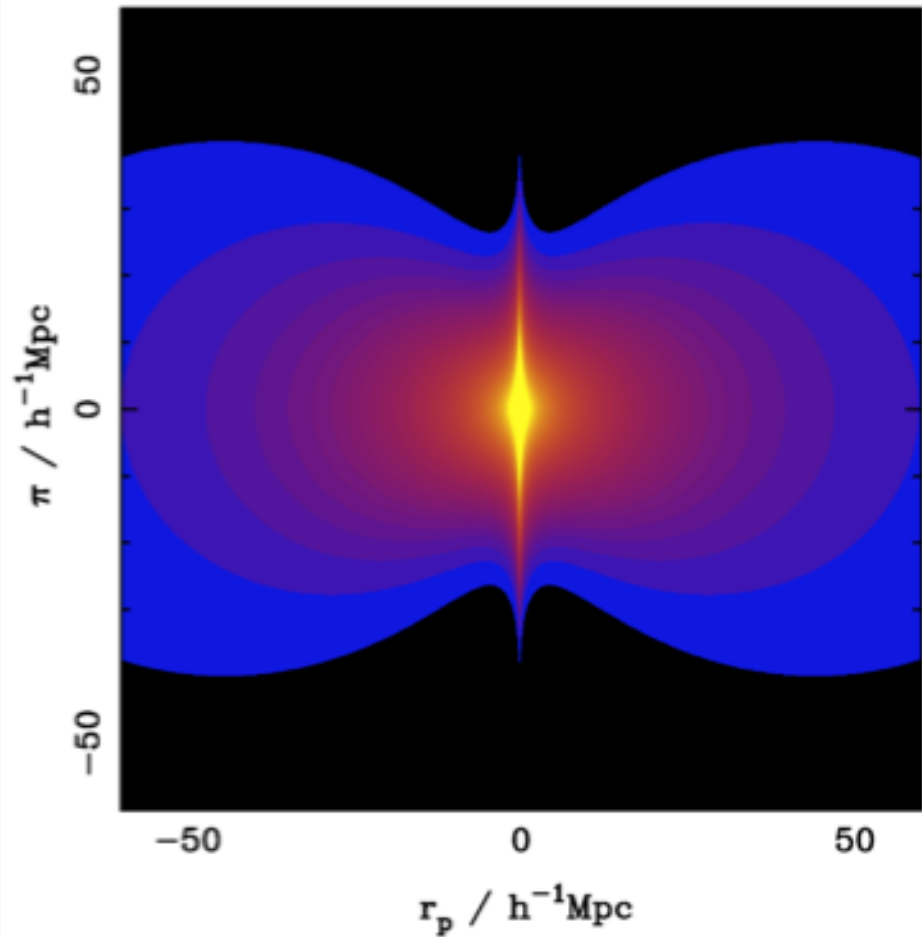


Red

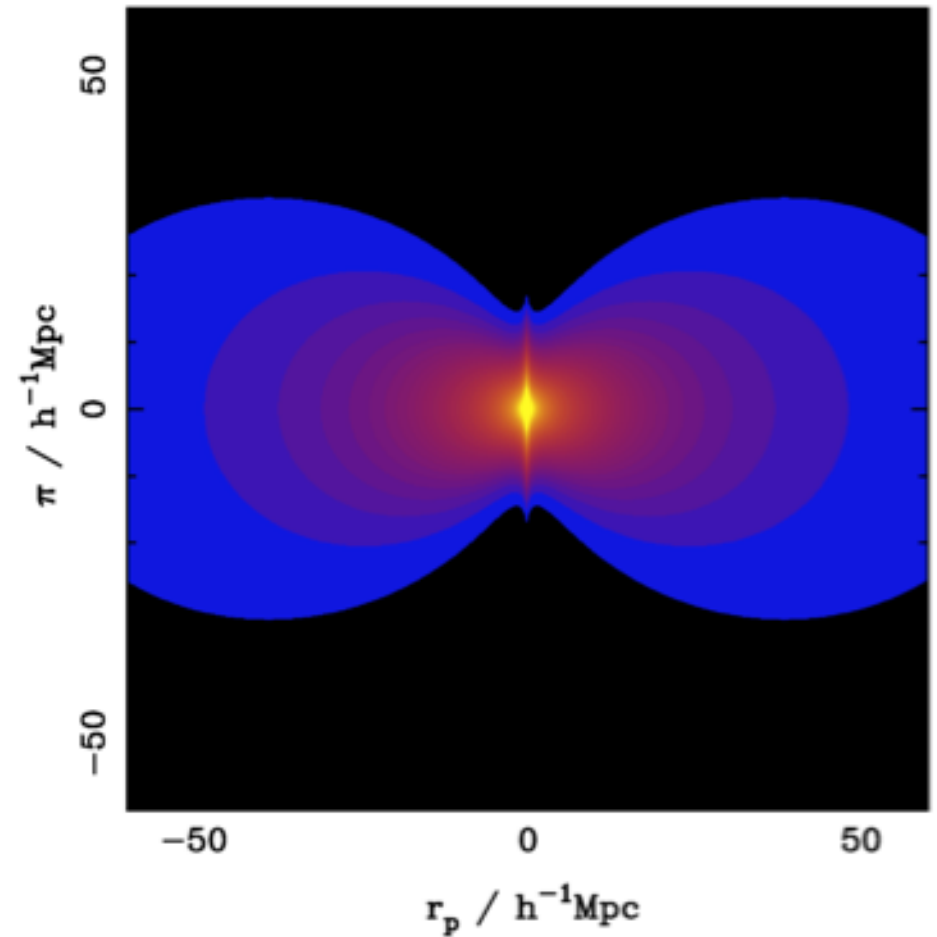


Blue

GAMA-I: Redshift Space Distortions (model)

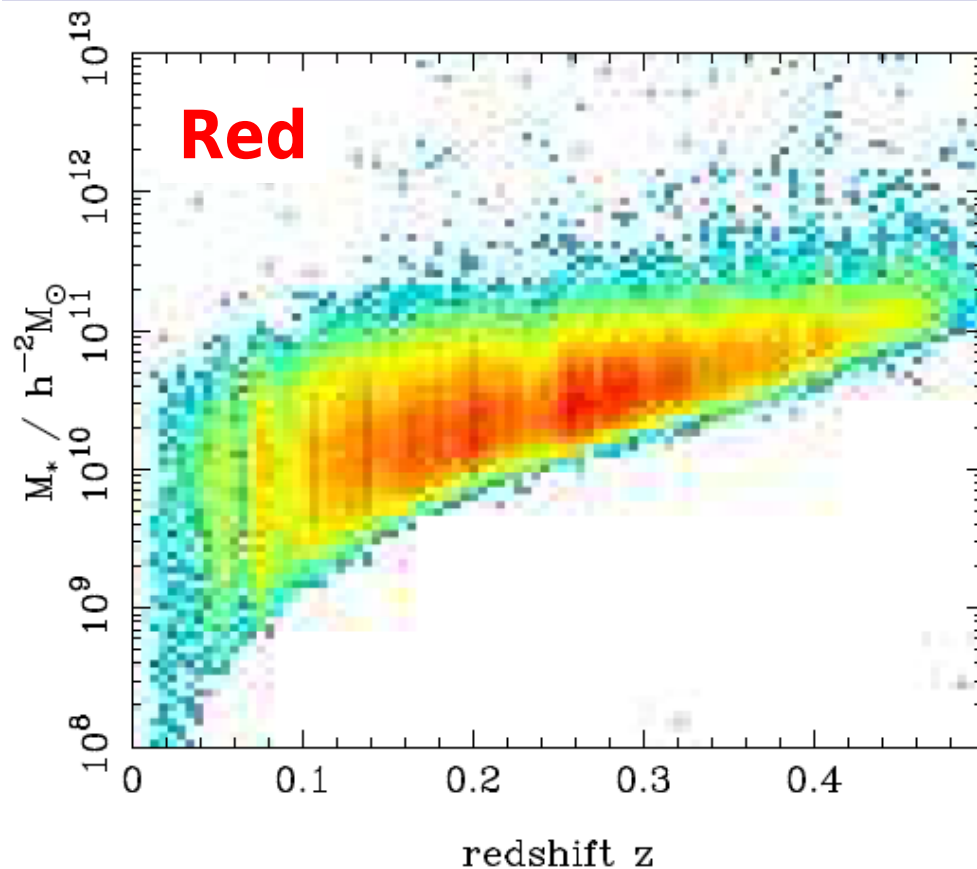


Red



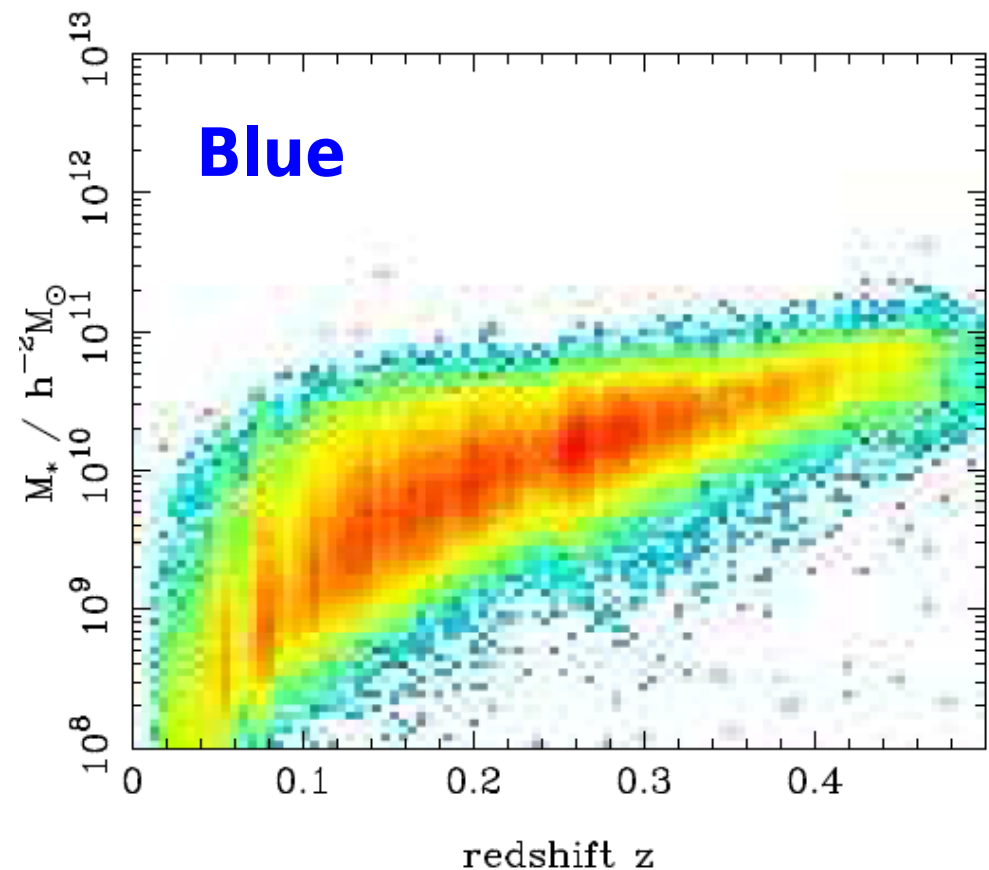
Blue

GAMA-I: clustering by colour, stellar mass, redshift



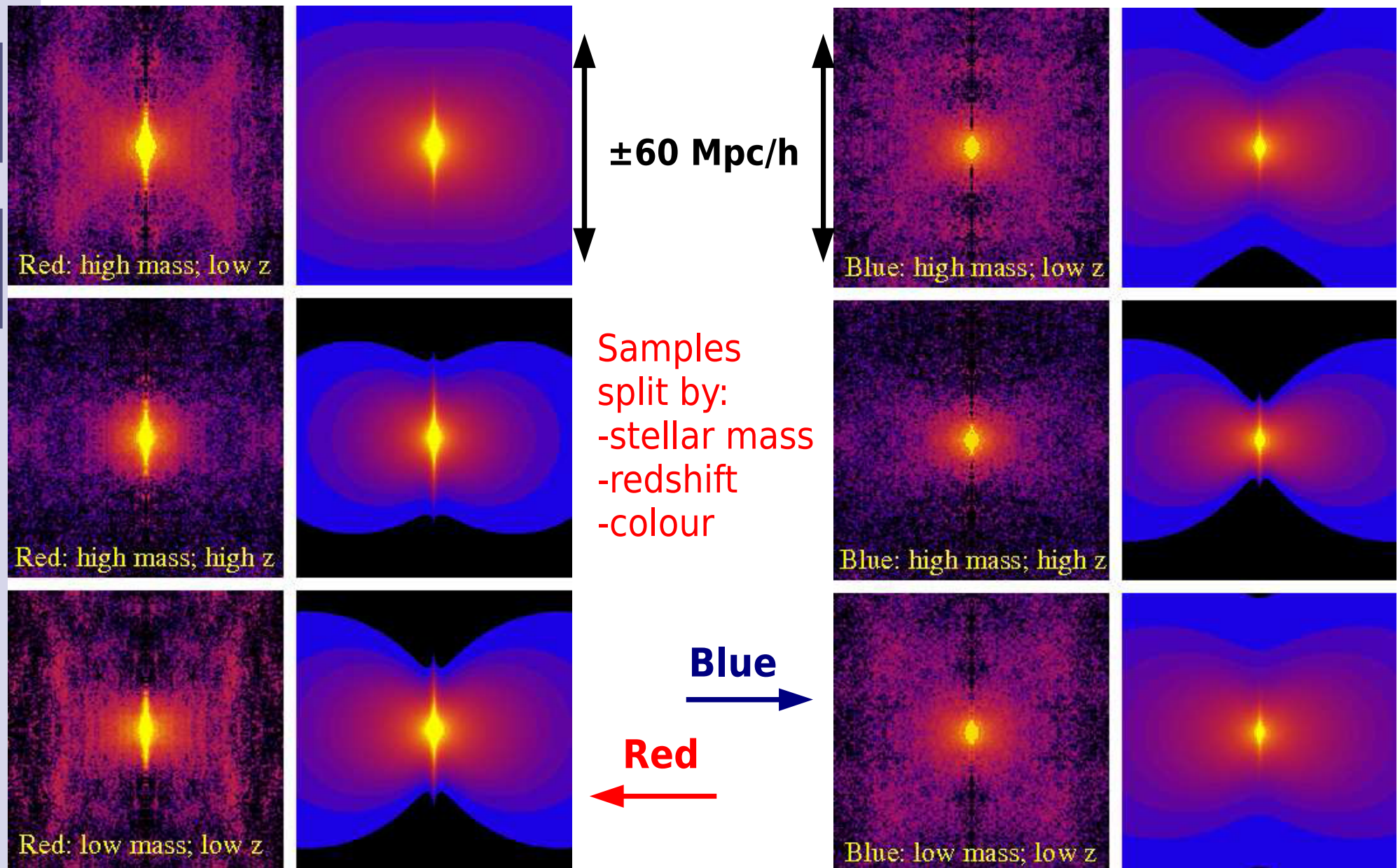
$$\log_{10}(M_*/h^{-2}M_\odot) = 1.15 + 0.70(M_g - M_i) - 0.4(M_i + 5\log_{10} h)$$

Taylor et al. (2011)

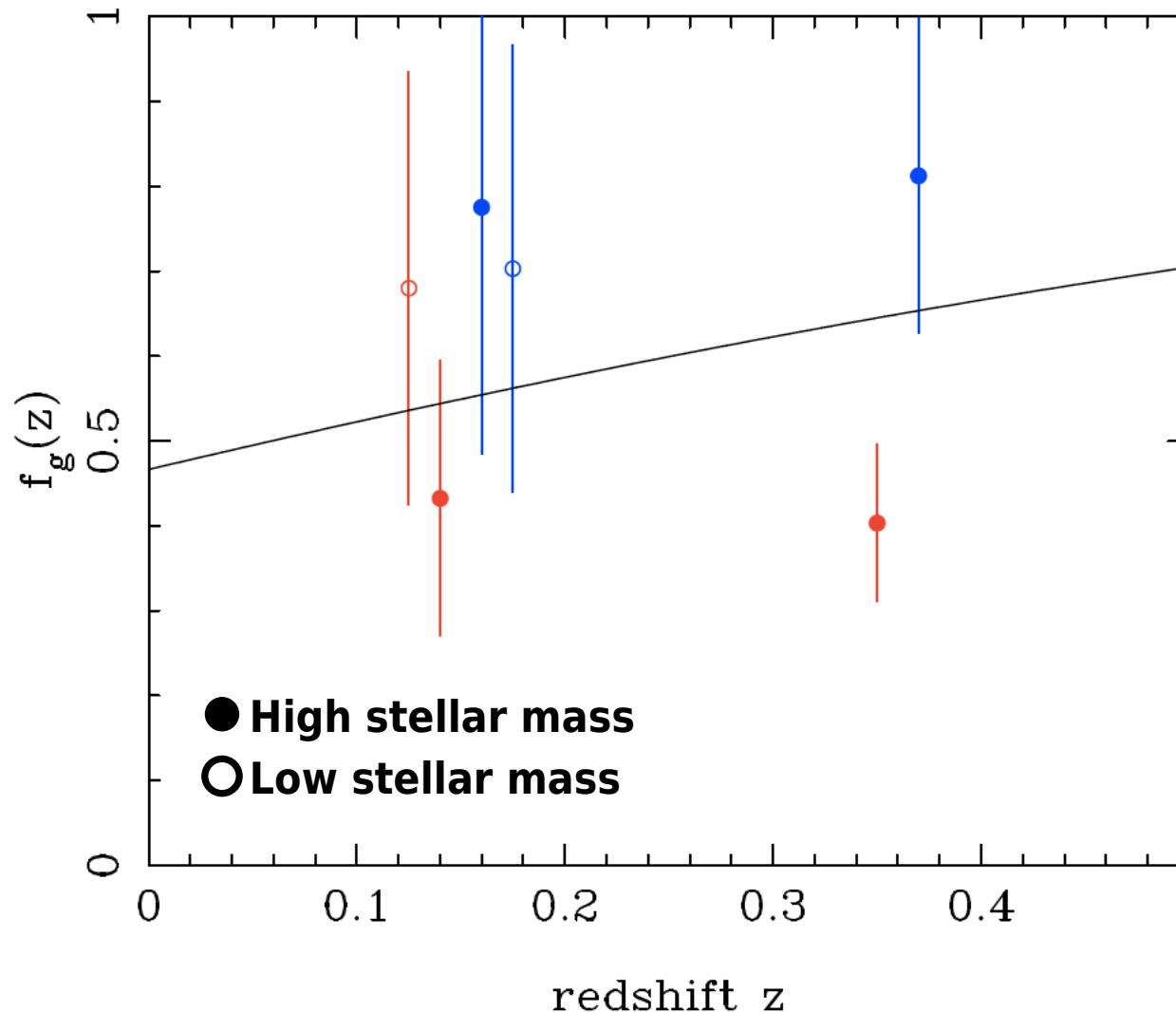


Peacock et al. (in prep)

GAMA-I: Clustering & Redshift Space Distortions



GAMA-I: Growth rate (assuming Kaiser formalism)....



$$f_g(z) = \Omega_m^\gamma(z)$$

Tension:

Tracers dependent growth rates....

2 options (at least):

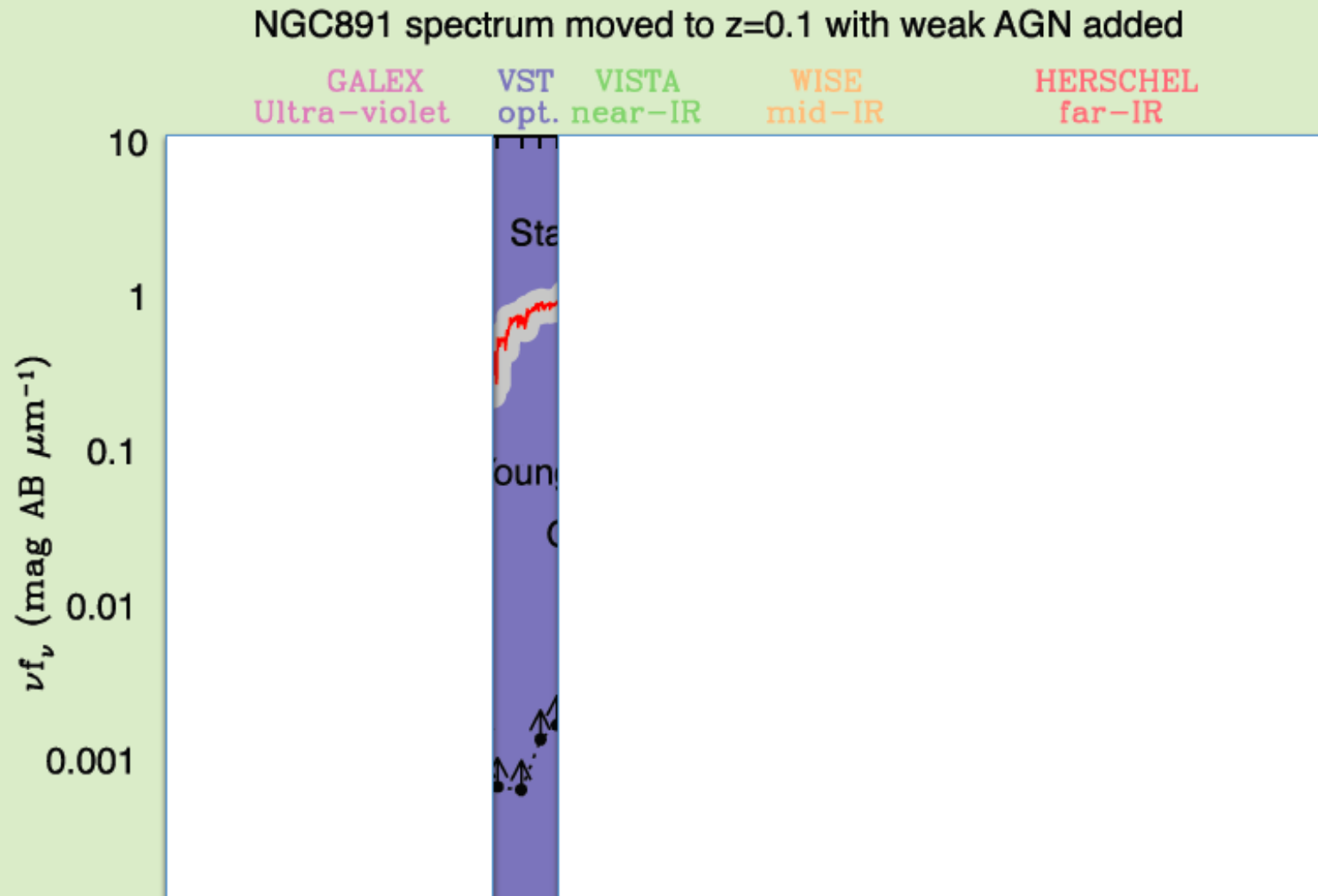
- a. residual systematics
- b. inappropriate f_g modelling

Main suspect: (b)

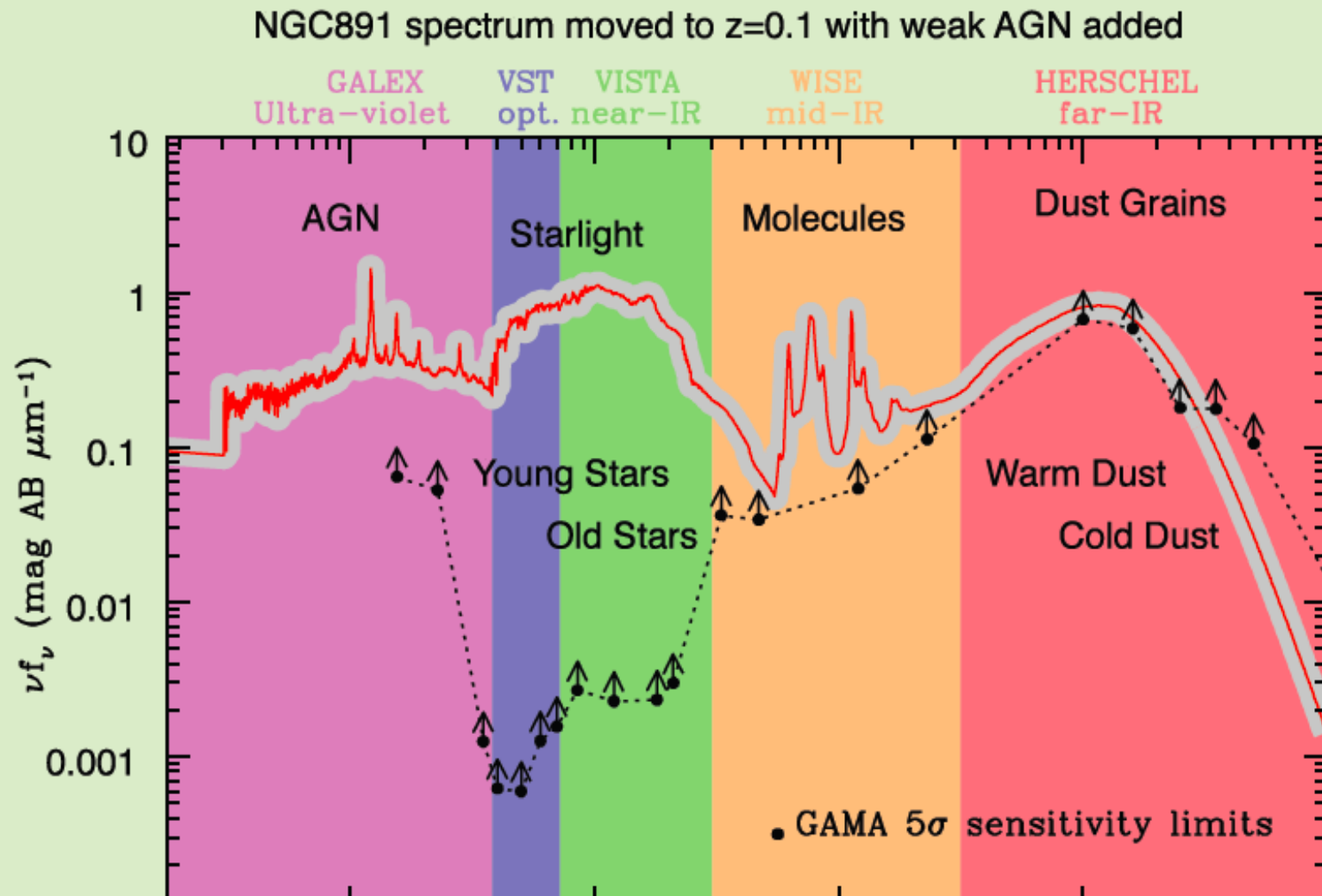
[Kwan et al. 2011 model seems the way forward...]

Peacock et al. (in prep)

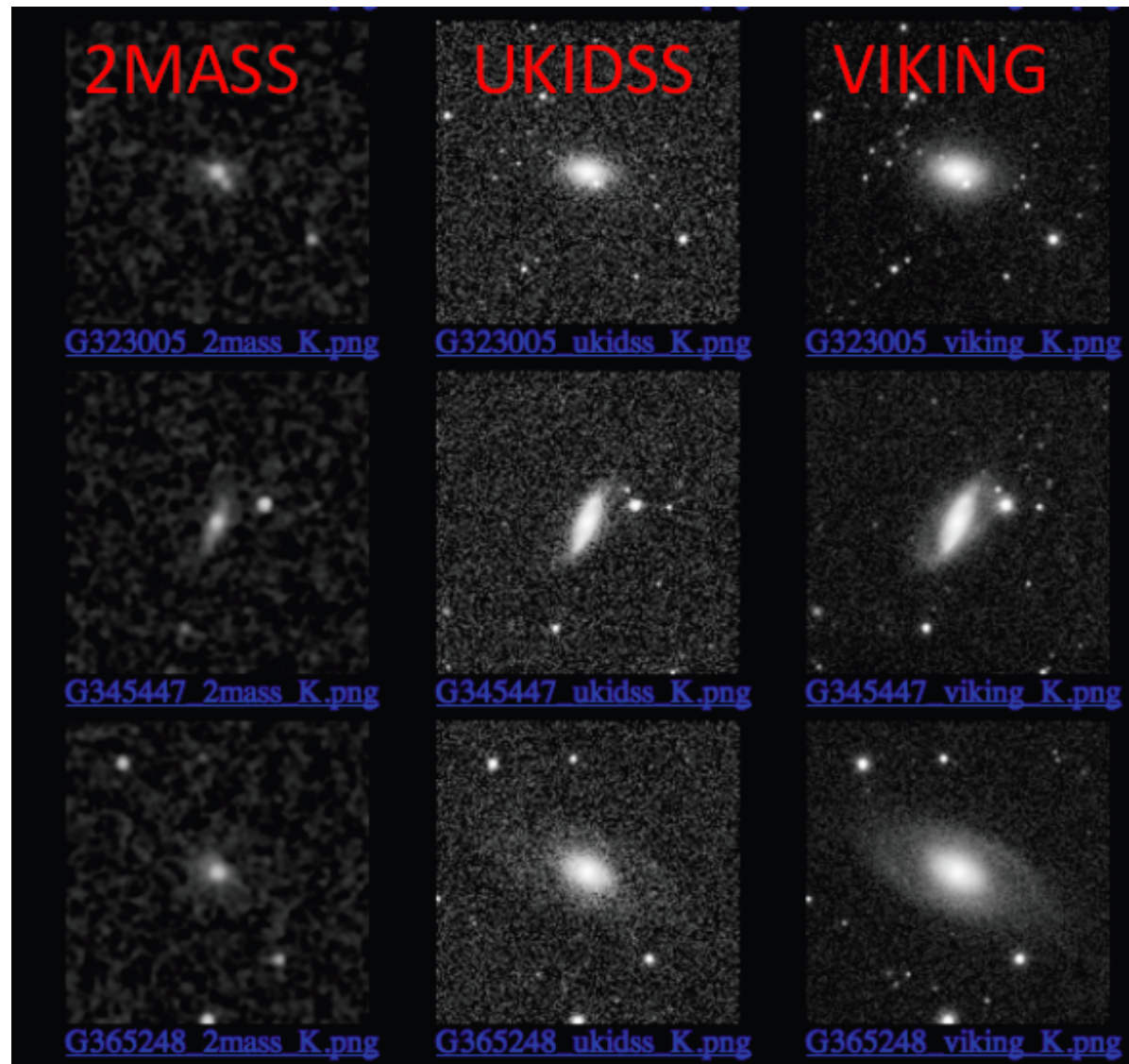
GAMA beyond LSS: 'the' galaxy formation survey with UV to far-IR SEDs



GAMA beyond LSS: 'the' galaxy formation survey with UV to far-IR SEDs

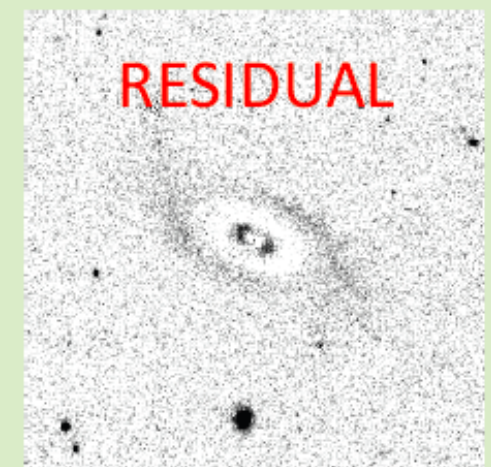
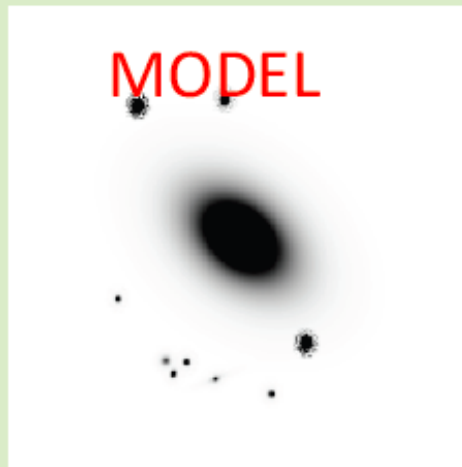
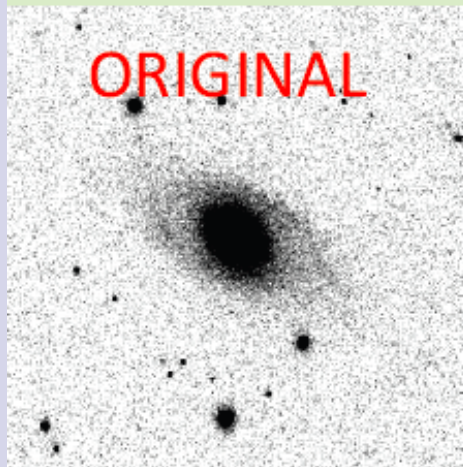


GAMA beyond LSS: 'the' galaxy formation survey with improved spatial resolution



GAMA beyond LSS: 'the' galaxy formation survey with improved spatial resolution

All $z < 0.1$ galaxies in all bands



GAMA: THE DATABASE (I)

All (~250k):

General: GAMA ID : SDSS ID : z (heliocentric) : z quality

Flux: UV : optical : near-IR : mid-IR : far-IR : Radio (20,rest-21,30,40,90cm)

Shape: CAS : Sersic index: half-light radii : b/a : PA in $ugrizYJHK$

Opacity: $\tau_{UV,ugriz,YJHK}$

Spectral features: Emission: $H\alpha, H\beta, H\gamma, H\delta, OII, OIII, NII$

Abs.: $Dn4000, Ca4227, H\alpha, H\beta, H\gamma, H\delta, Mgb, Fe$

SFR: UV : $H\alpha$: far-IR : Radio continuum

Fossil record: Age : SFH : element abundance

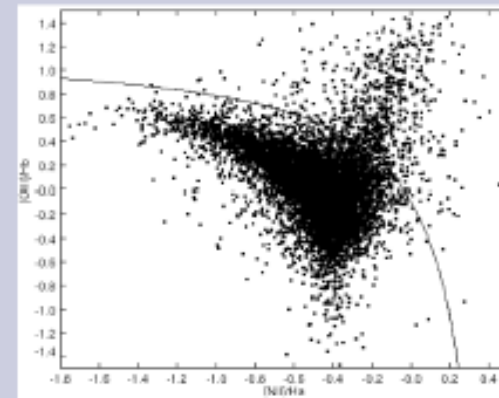
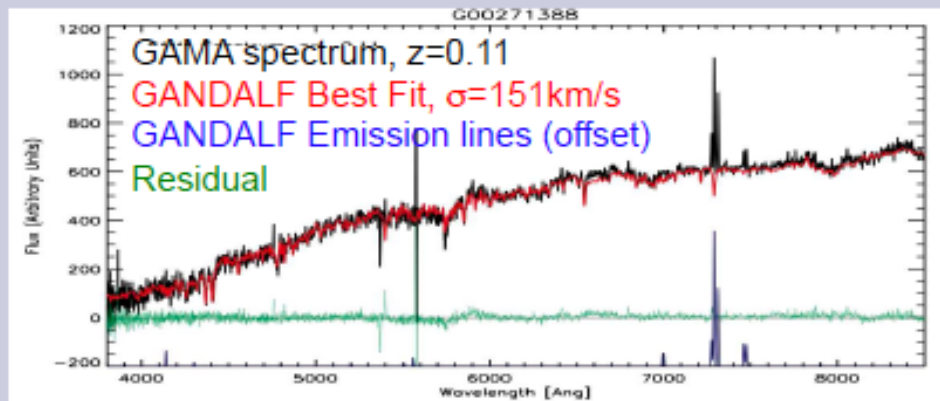
AGN: BPT diagnostics : type : strength : ionisation state

Dynamics: σ_{spec} (GANDALF) : W_{21} : HI line profile

Distances: Tully-Fisher : Faber-Jackson

Masses: Stellar : SMBH : HI : Dust : Baryon : Dynamical

Environment/Halo: Local density : Group membership : Group halo mass



GAMA: THE DATABASE (II)

For $z < 0.1$ (~30k):

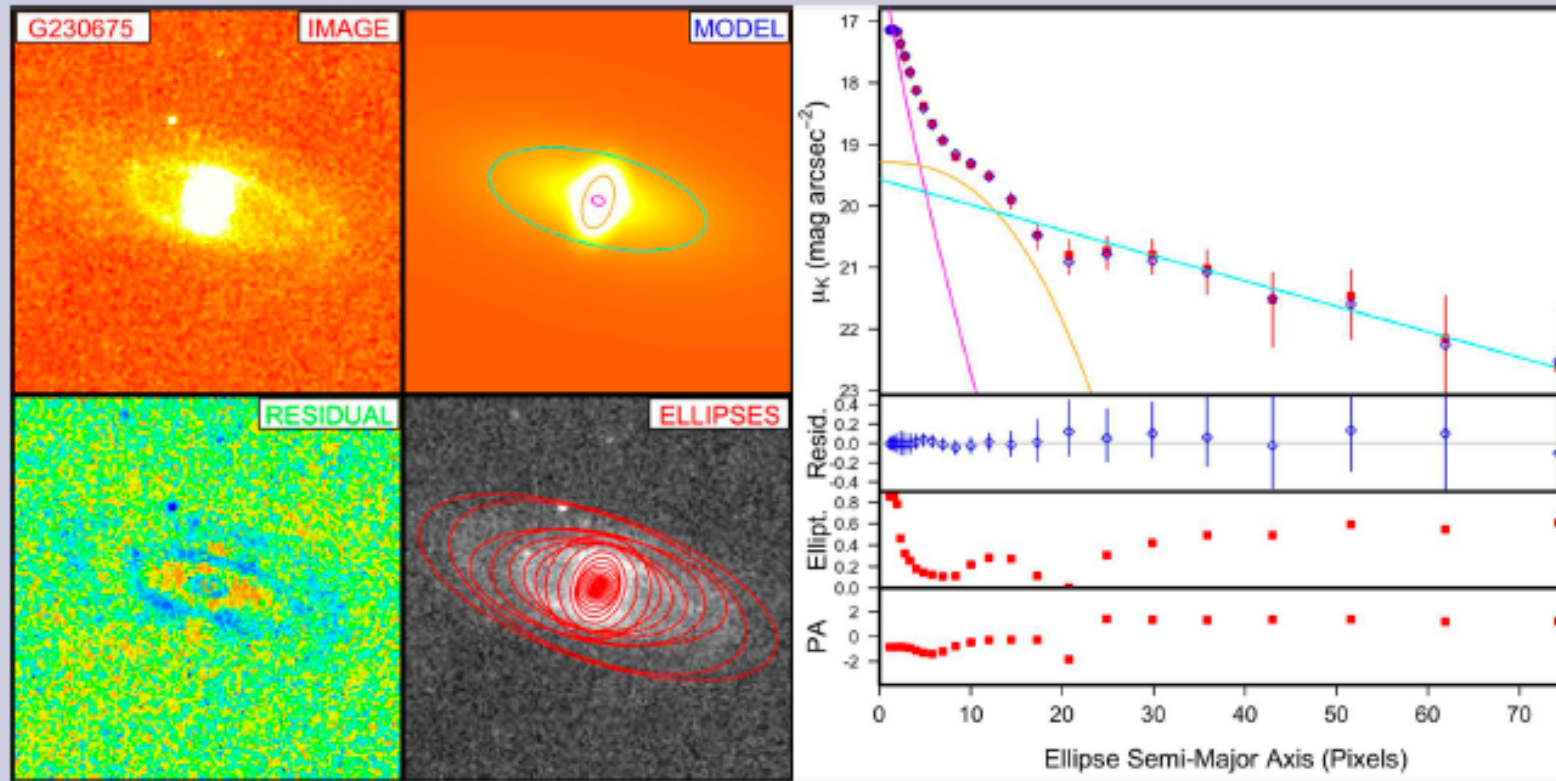
Structural: Bulge/Bar/Disc decomp. in $ugrizYJHK$ (GALFIT3)

Bulge: Sersic index, half light radius, Pos. Angle, Ellipticity

Bar: Sersic index, half light radius, scale-length

Disc: Scalelength, PA, b/a

SMBH Mass: via $M-\sigma$, $M-L$, $M-n$ relations



Conclusions

- **GAMA is a unique multi-wavelength survey:**
 - 200k redshifts so far (aim: 350k)
 - Very high completeness ($\sim 98\%$ to $r < 19.8$)
 - 21 bands (far-UV to far-IR + X-ray + Radio)
- **GAMA LSS is ideal to test for systematics:**
 - via improved photo-z (unbiased)
 - by identifying catalogue contaminations
 - in theoretical clustering models
- **Main GAMA strength:**
 - Test galaxy formation models (far-UV to far-IR)