BigBOSS Quasars Science Case

Nic Ross (LBNL)

BigBOSS Collaboration Meeting

LBNL

19 November 2009

BigBOSS Quasars Science Case

The Ultimate, "Just how many quasars are there in the Universe?" CVL Quasar Survey.

BigBOSS Quasars Science Case

The Ultimate, "Just how many quasars are there in the Universe?" CVL Quasar Survey.

EVER.

Outline

1. BigBOSS Quasar Cosmology

2. BigBOSS Quasar/AGN Science

Outline

1. BigBOSS Quasar Cosmology

2. BigBOSS Quasar/AGN Science

BAO/BAF - Requirements

- Volume
  - $1.0<z<2.0$ over $24{,}000\,\mathrm{deg}^2$
    $= 105\ h^{-3}\ \mathrm{Gpc}^3$ $(270\ \mathrm{Gpc}^3)$

RA
0°
60°
120°
180°
240°
300°
z
0
1
2

BAO/BAF - Requirements

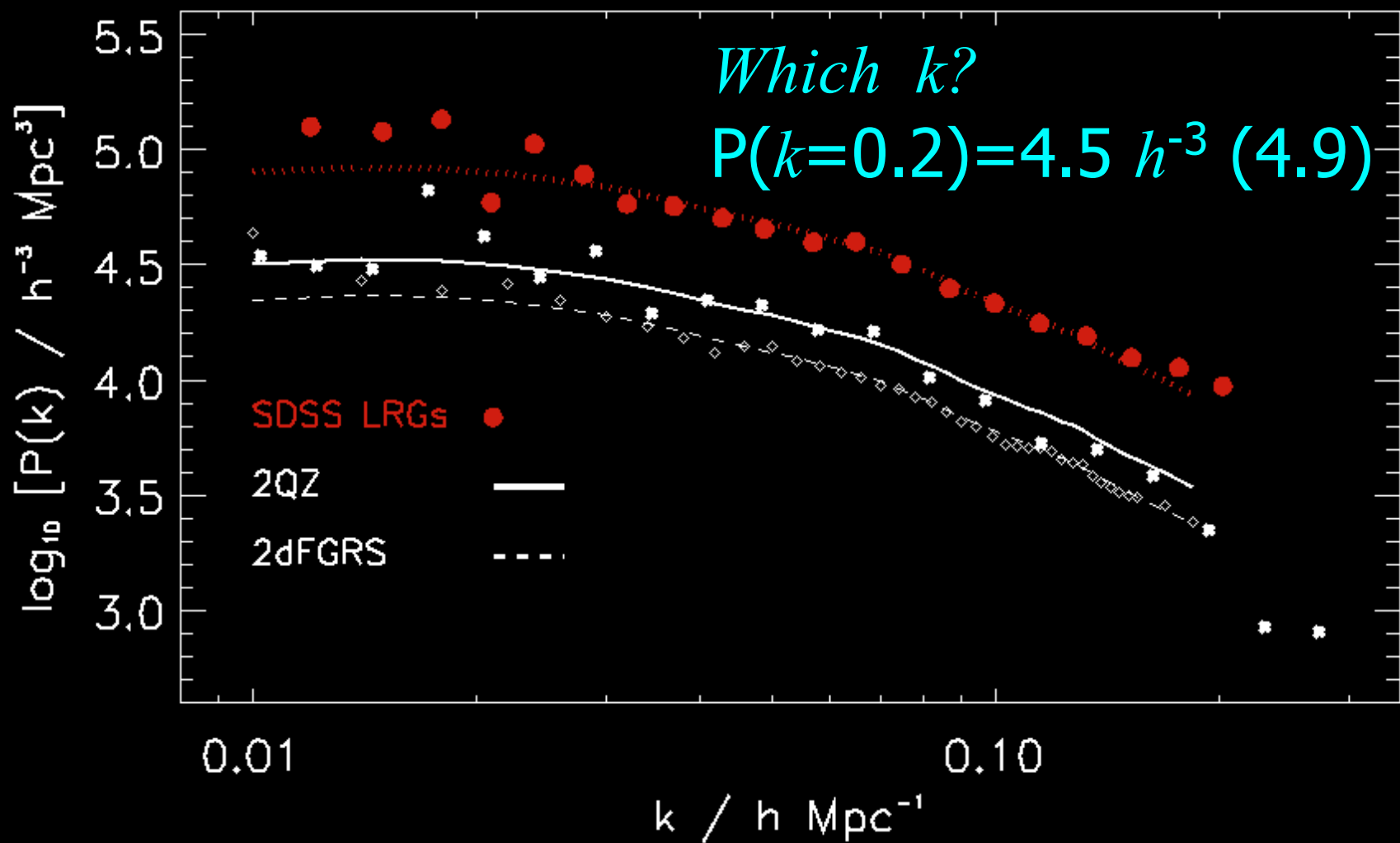
- Volume
  - 1.0<z<2.0 over 24,000deg^2
    = 105 h^{-3} Gpc^3 (270 Gpc^3)

- nP ≥ 1

$$V_{\rm eff}(k) = \left[\frac{nP(k)}{nP(k)+1}\right]^2 V_{\rm s}$$

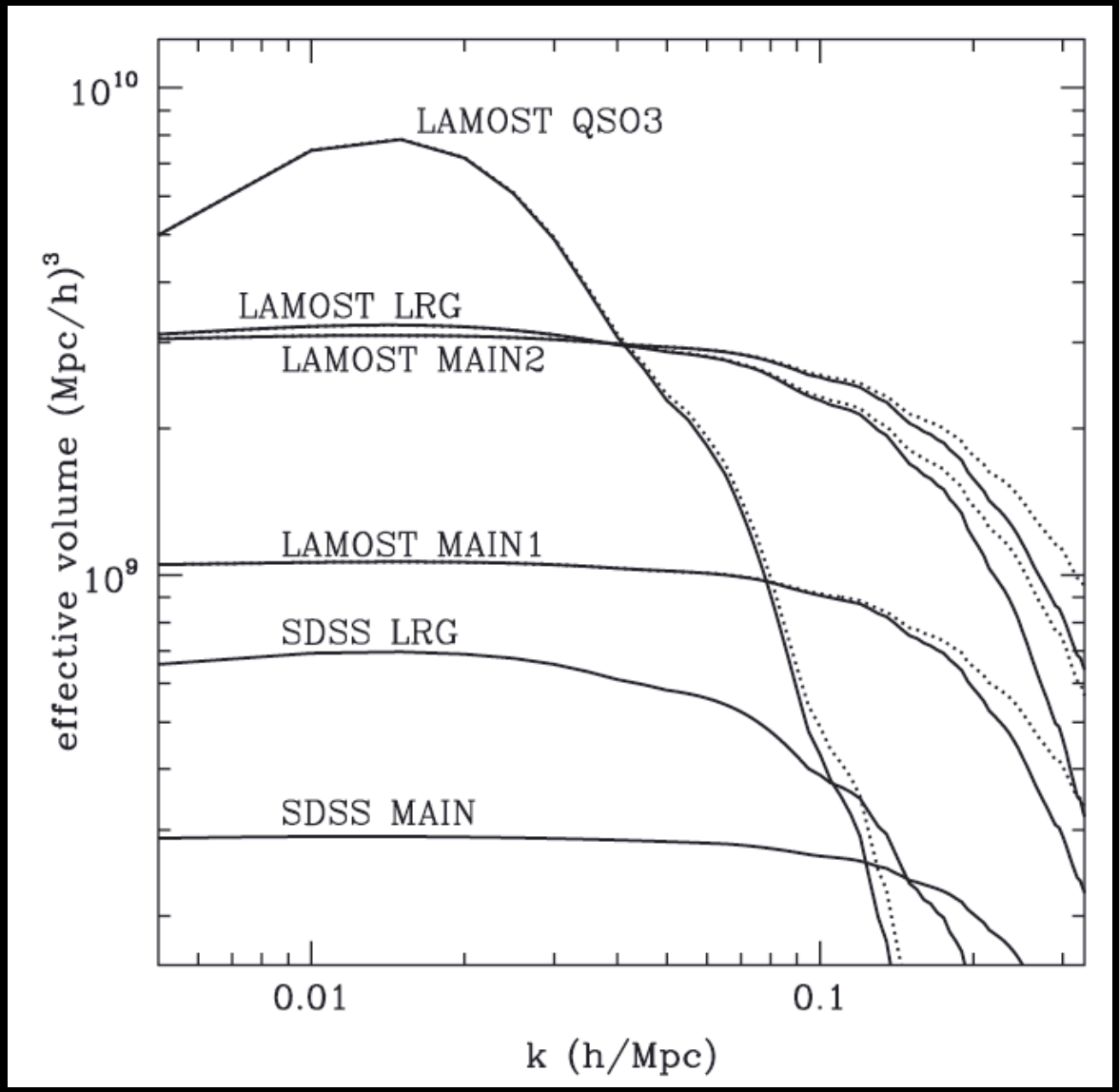
Begin to run into problems...

BAO - Quasar Power Spectrum



Tegmark et al. (2006);
Outram et al. (2003); Cole et al. (2005)

BAO - Quasar Power Spectrum



LAMOST "QSO3"

g=21.65

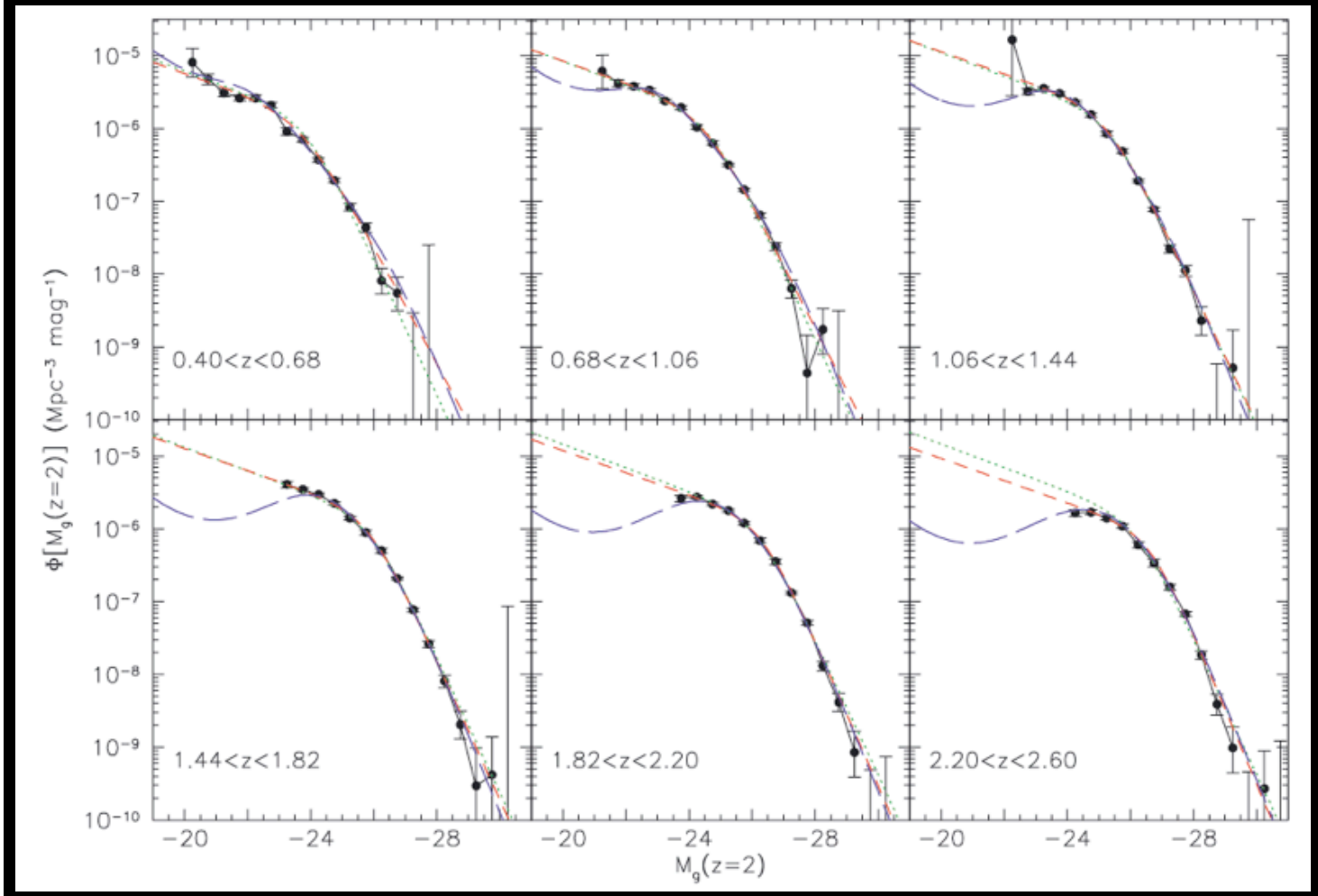
72 deg^{-2} over ~8000 deg^2

N = 576,000

0.4 < z < 2.1

Wang et al. (2009, MNRAS, 394, 1775)

BAO - Quasar Luminosity Func.



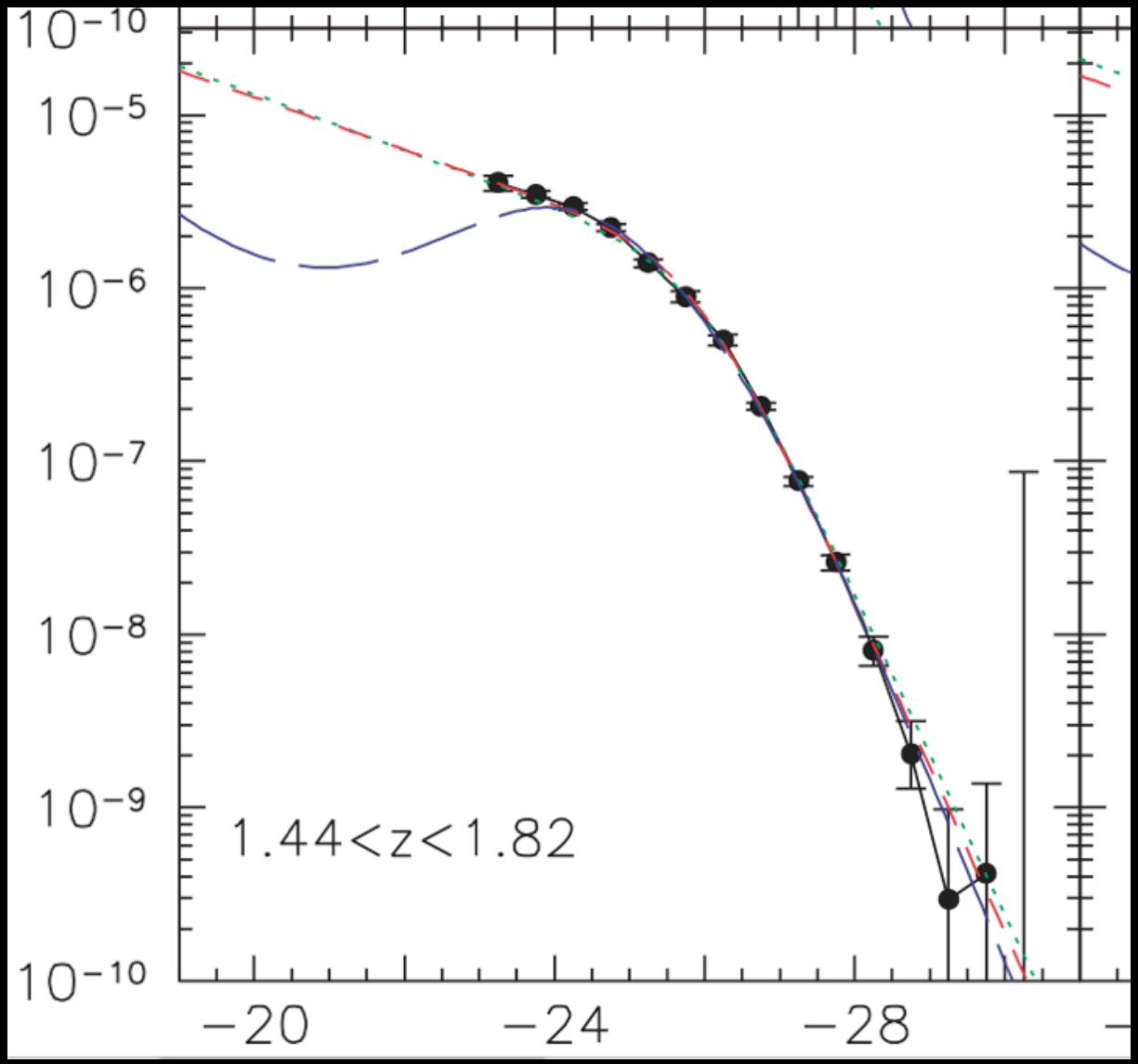
2SLAQ QSOs

N=10,600
192 deg^2

g=21.85

Croom et al. (2009, MNRAS, 399, 1755)

BAO - Quasar Luminosity Func.



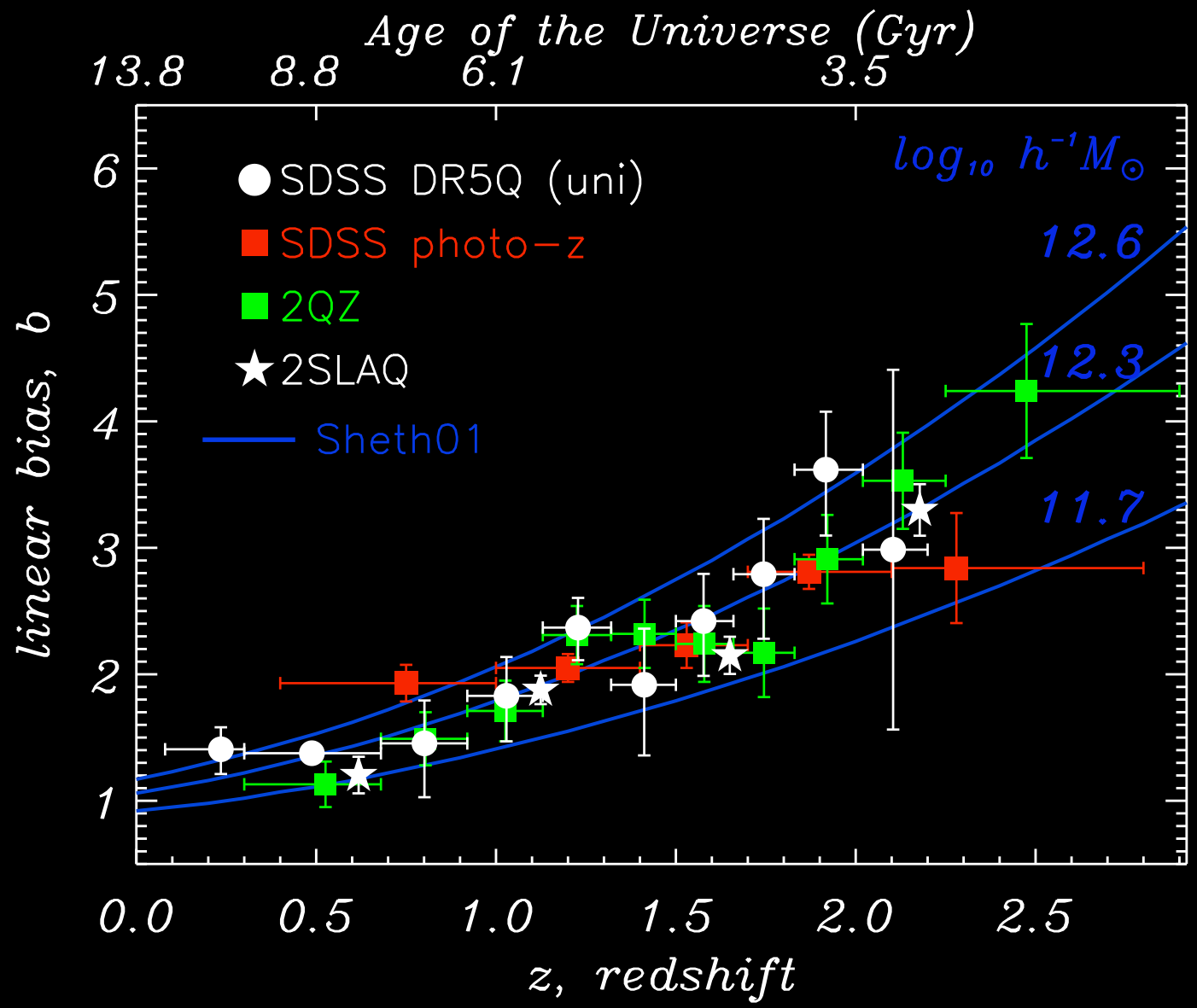
Have to get to M_g=-20.0, or M_i=-20.4

$(g\text{-}i)$=0.4 at z=1-2

to get n~1-2x10^{-5}

Croom et al. (2009, MNRAS, 399, 1755)

Quasar Bias



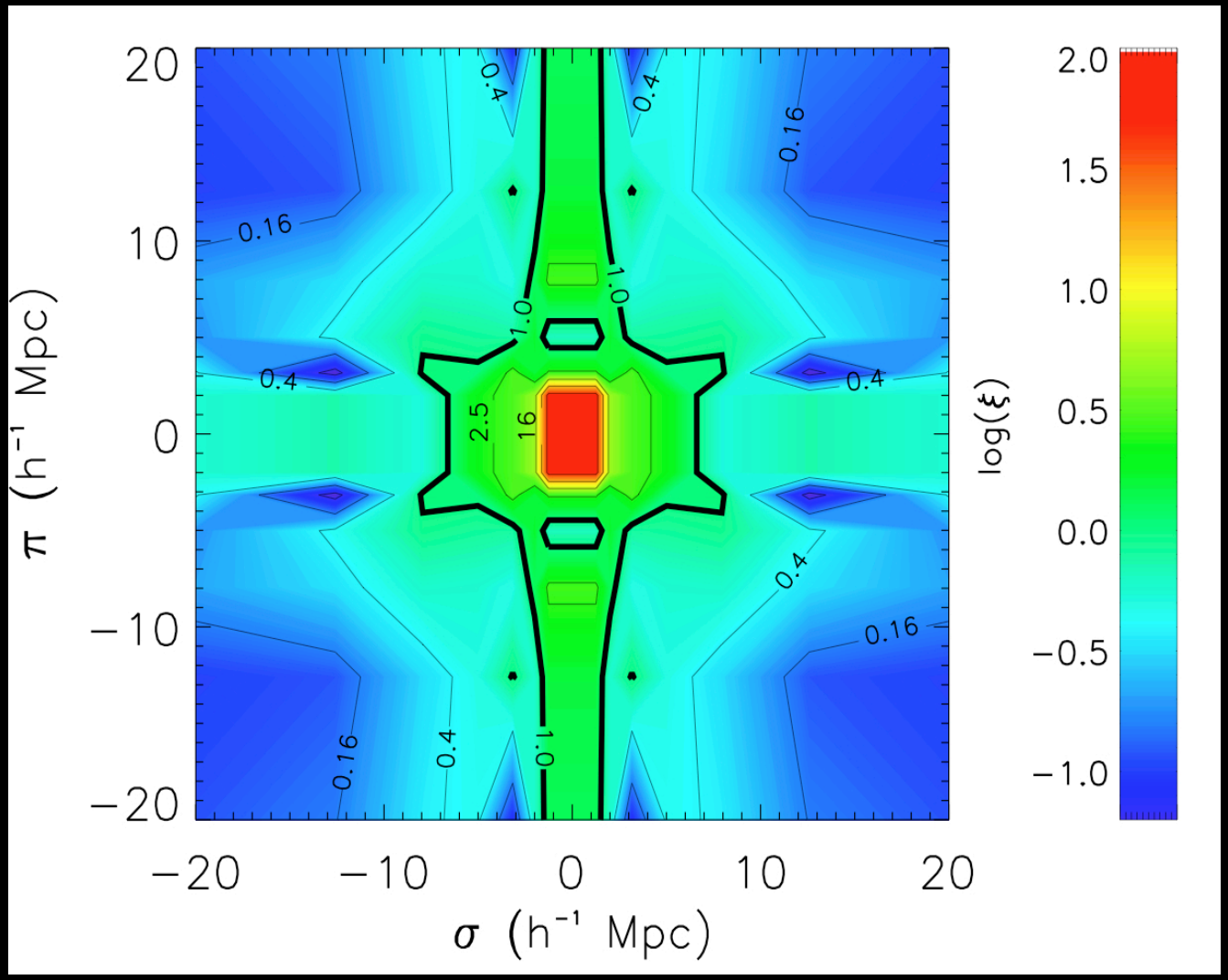
Ross et al. (2009, ApJ, 697, 1634)

BAO/BAF - Take Home Numbers

- $1.0<z<2.0$ (2.2) $\Rightarrow$ 105 (130) h^{-3} Gpc^3
- To get to flat $nP \sim 1$ (with b~2),
  need $n \sim 2$ (.5) x 10^{-5} over $1.0<z<2.0$
  $\Rightarrow$ M_g = -20.0 (-22.5) [Faint QLF is ~flat]
  $\Rightarrow$ g = 25.9 (23.5) or i = 25.5 (23.1)
  (Assume: $(g-i)$=0.4 and $k(z=2)$=0)
  $\Rightarrow$ ~2.7 million objects at ~112 deg^{-2}

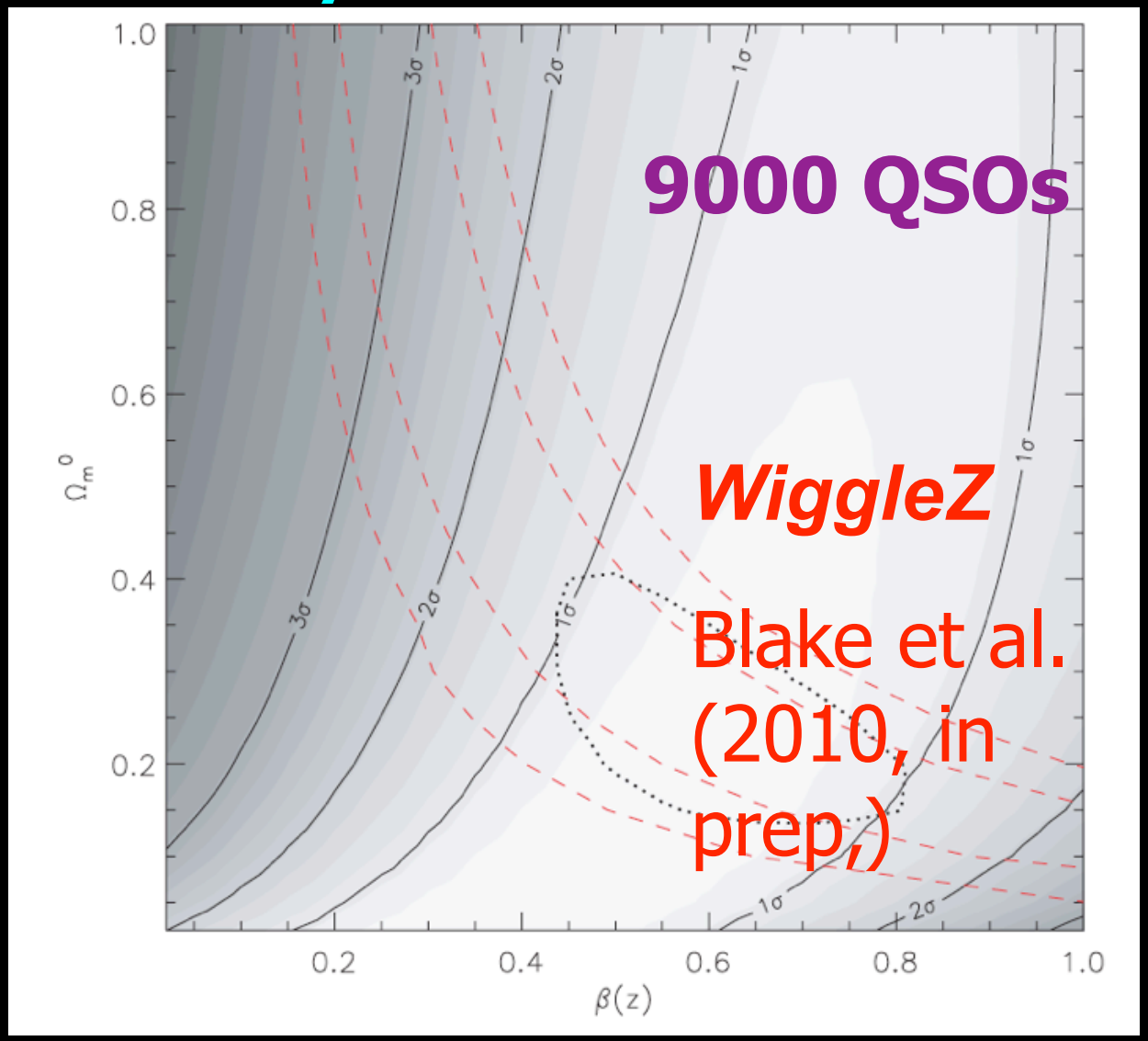
PTF will go to g = 23.5 (P. Nugents talk)

Growth of Structure - RSD



30,000 SDSS spec-z Quasars

Alcock-Paczynski



da Angela et al. (2008, MNRAS, 383, 565)

Gravitational Magnification

Cross-correlation between *Background Population* & *Foreground Population*

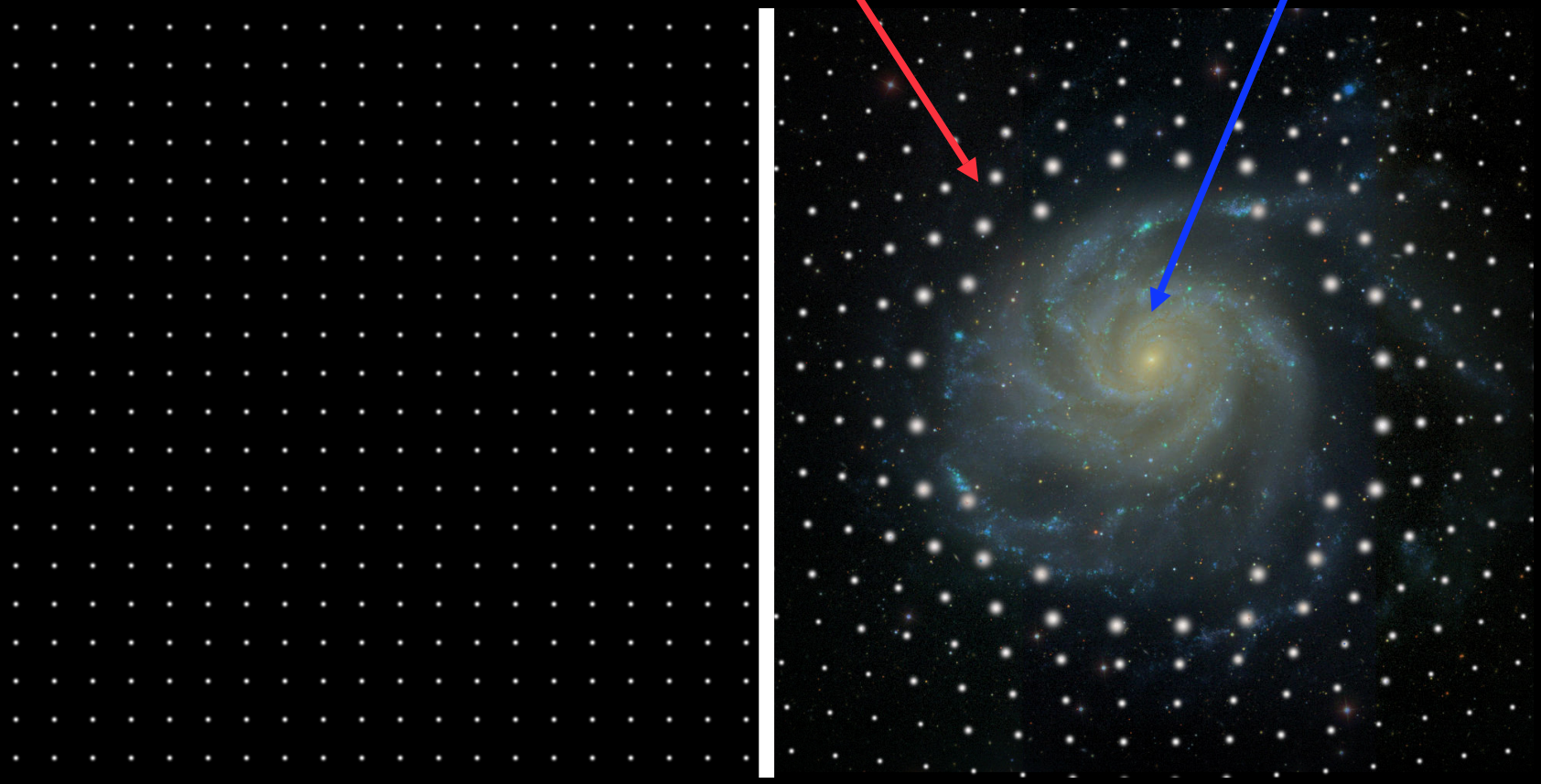


Image credit: Joerg Colberg, Ryan Scranton, Robert Lupton, SDSS

- see Alexi Leauthaud's talk

BigBOSS Quasar Cosmology

- BAO: tricky (maybe very tricky) due to low ***n*, *but still can't be completely ruled out!***

- ***NOTE: b~8 at z~3 and b~16 at z~4.5... (Shen et al. 2007, AJ, 133, 2222)***

- *z*-space distortions: (very) tricky too again due to low ***n*** plus broad lines v=600 kms^{-1}

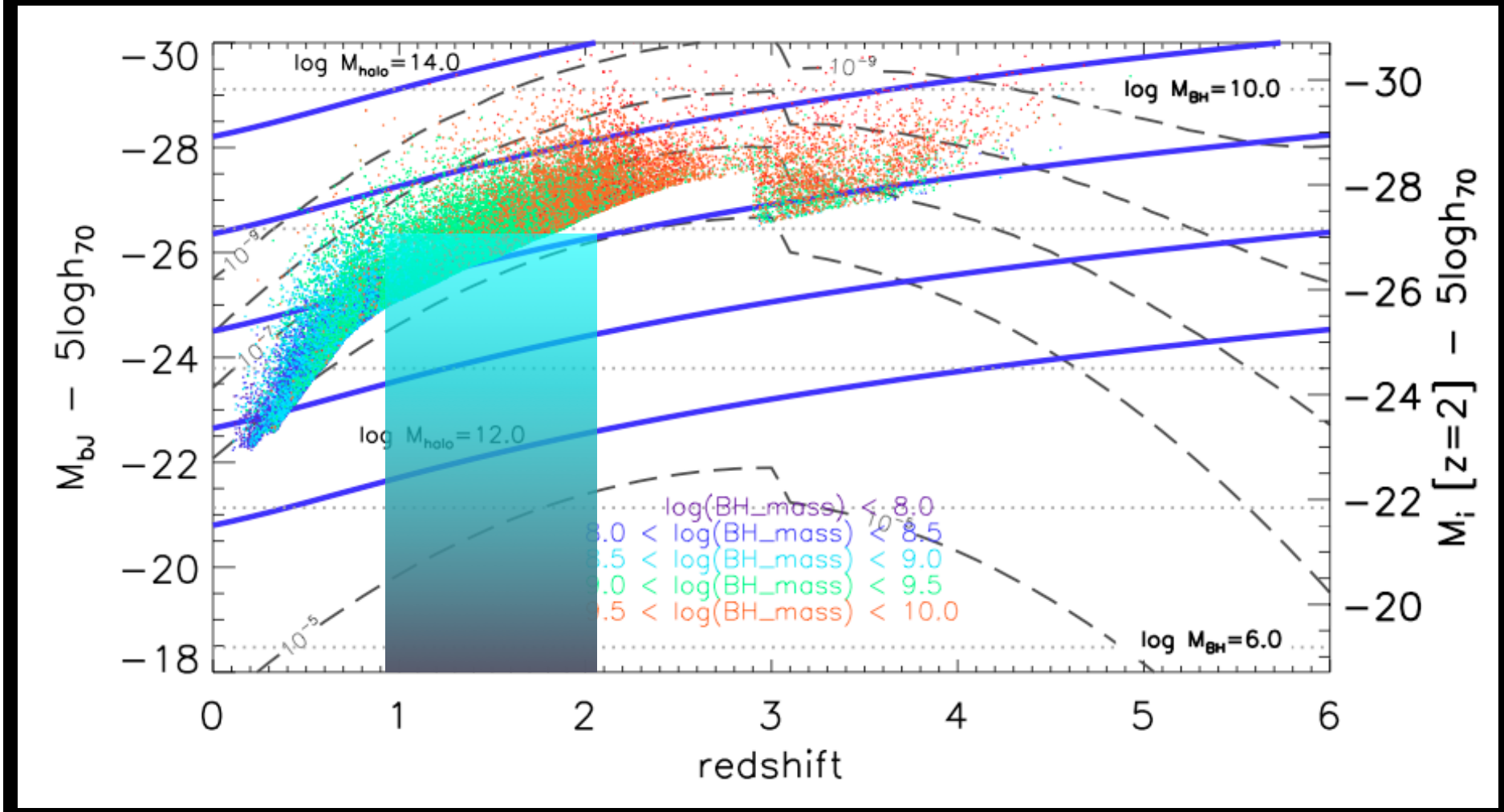
- Alcock-Paczynski ??
- Gravitational Magnification
- *** fNL - see Shirley Ho's talk yesterday

Outline

1. BigBOSS Quasar Cosmology

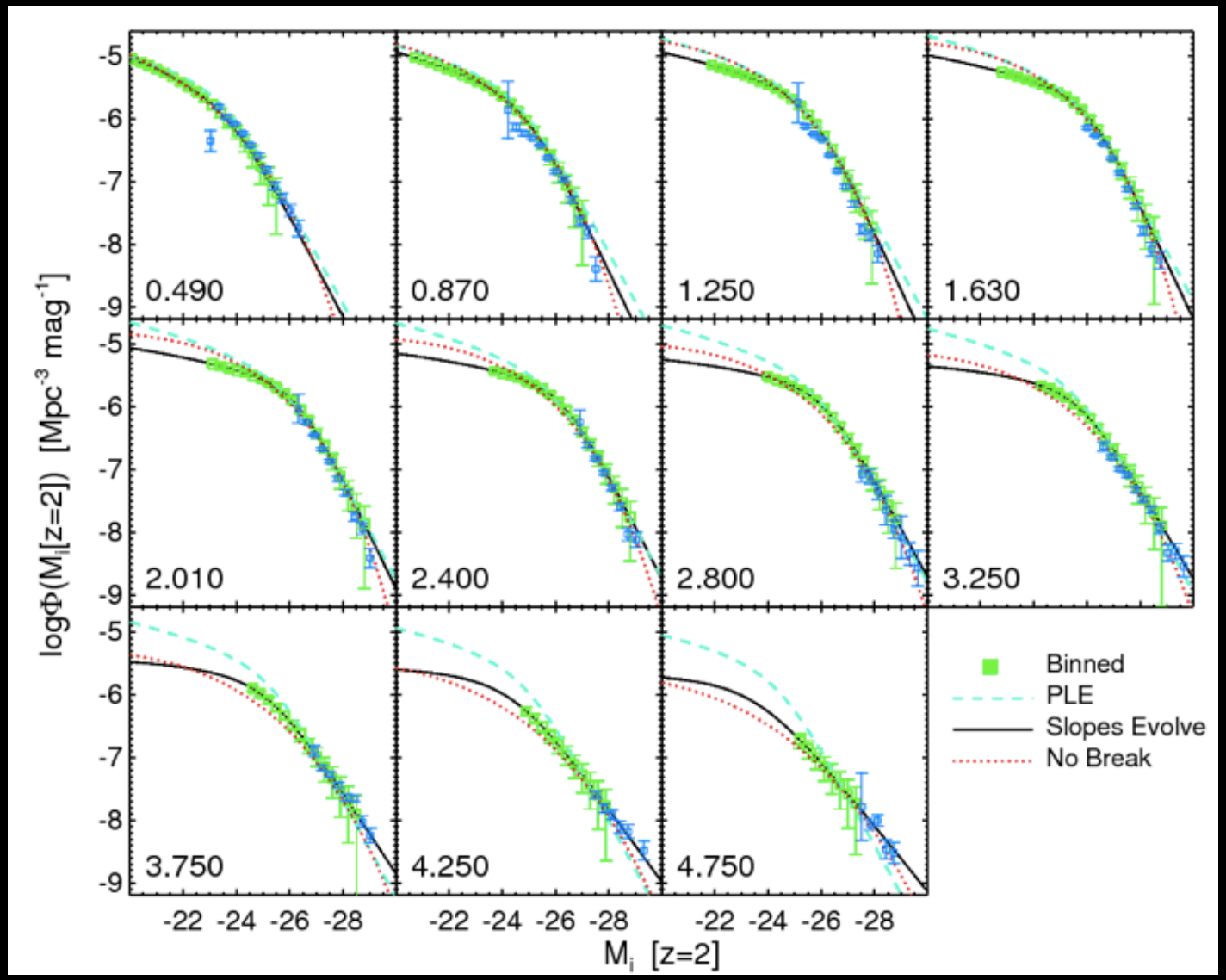
2. BigBOSS Quasar/AGN Science

(Ultimate) Quasar Luminsity Func.



Croton et al. (2009, MNRAS, 394, 1109)

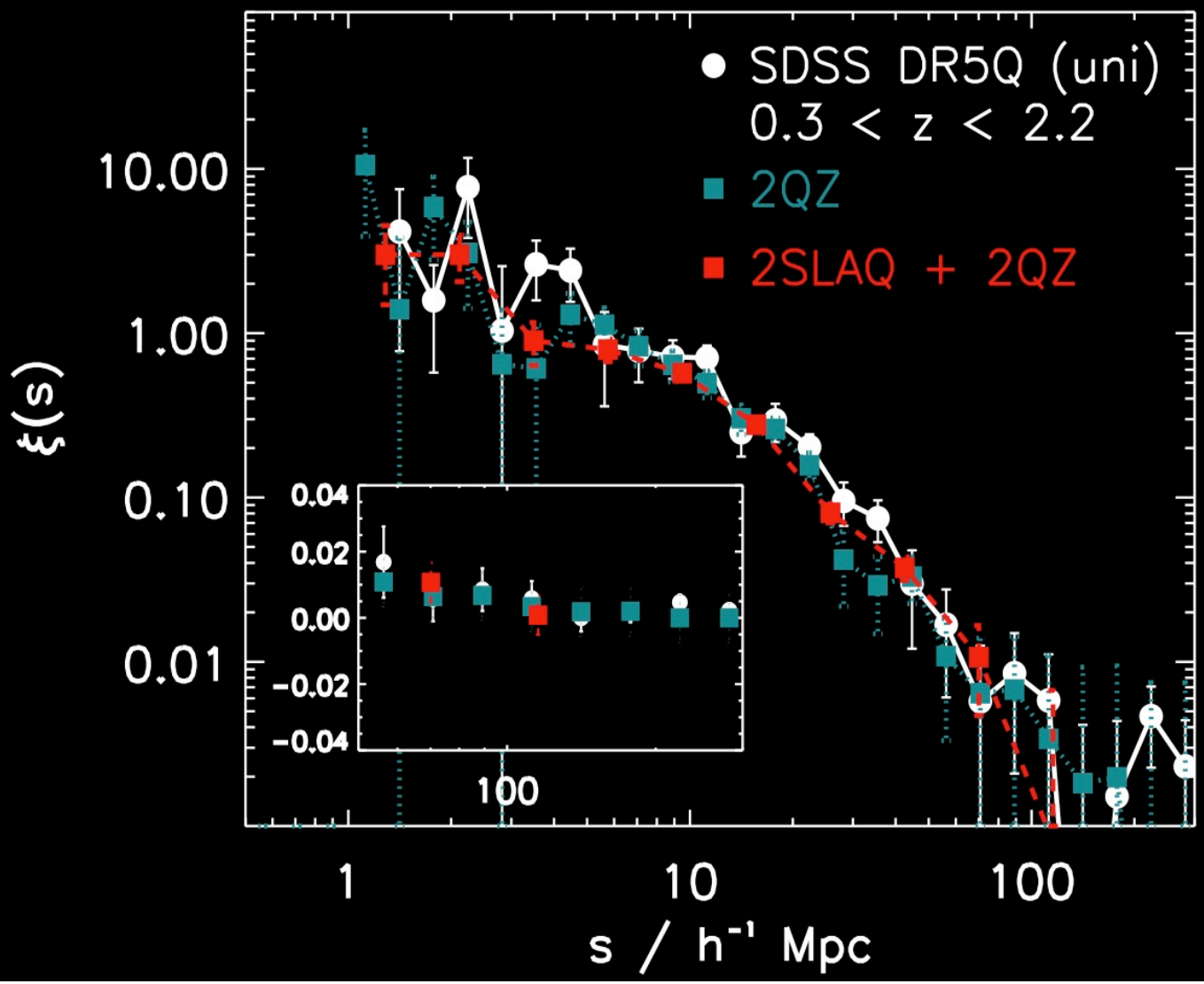
Obscured AGNs



Courtesy: Phil Hopkins

WISE

Clustering, any dependence of luminosity on...



- **SDSS** DR5

$\xi(s)$, i<19.1

s_0=5.95±0.45 h^{-1} Mp

γ=1.16±0.14

- **2QZ (Croom et al. 2005)**

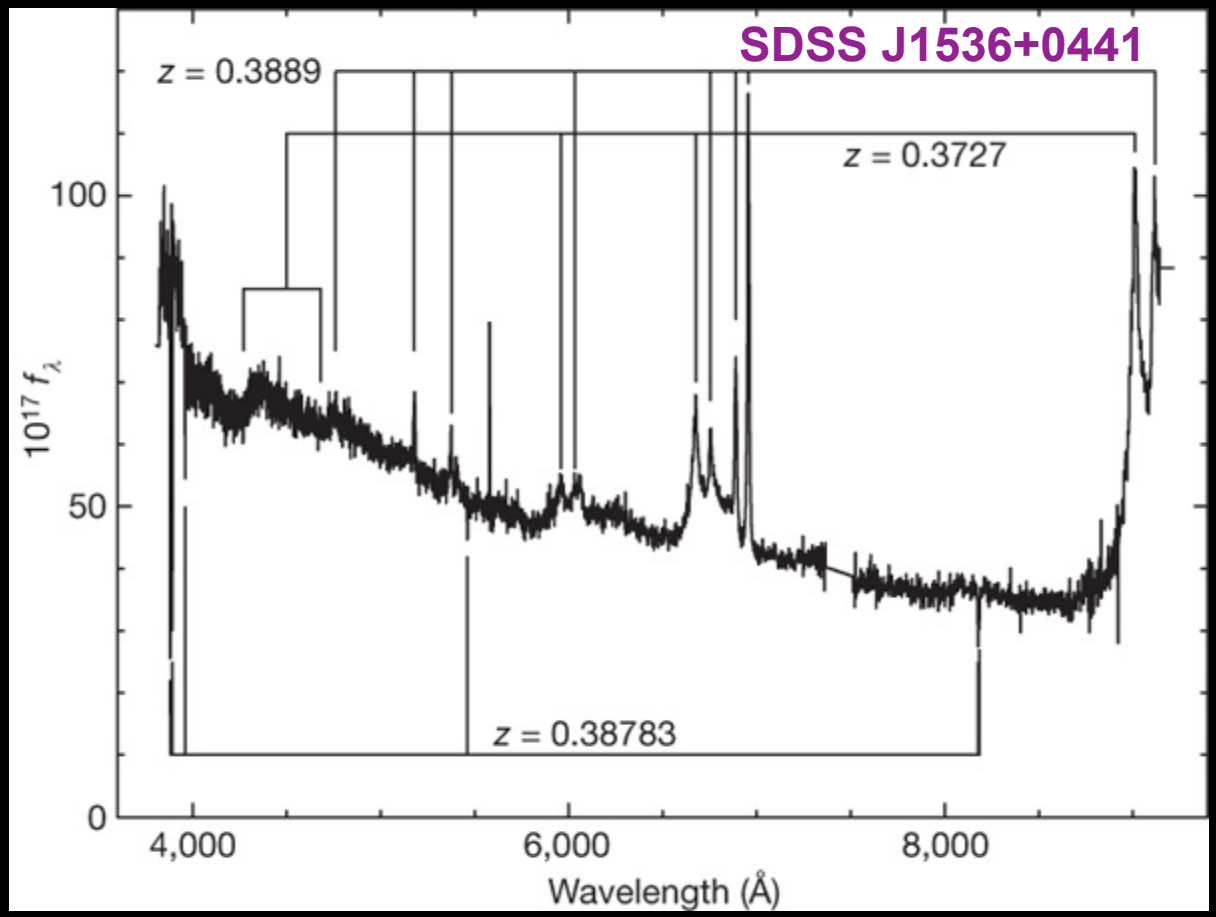
18.25 <b_J<20.85

(g≈20.80, i~20.4)

- **2SLAQ (da Angela et al. '08)**

18 < g < 21.85

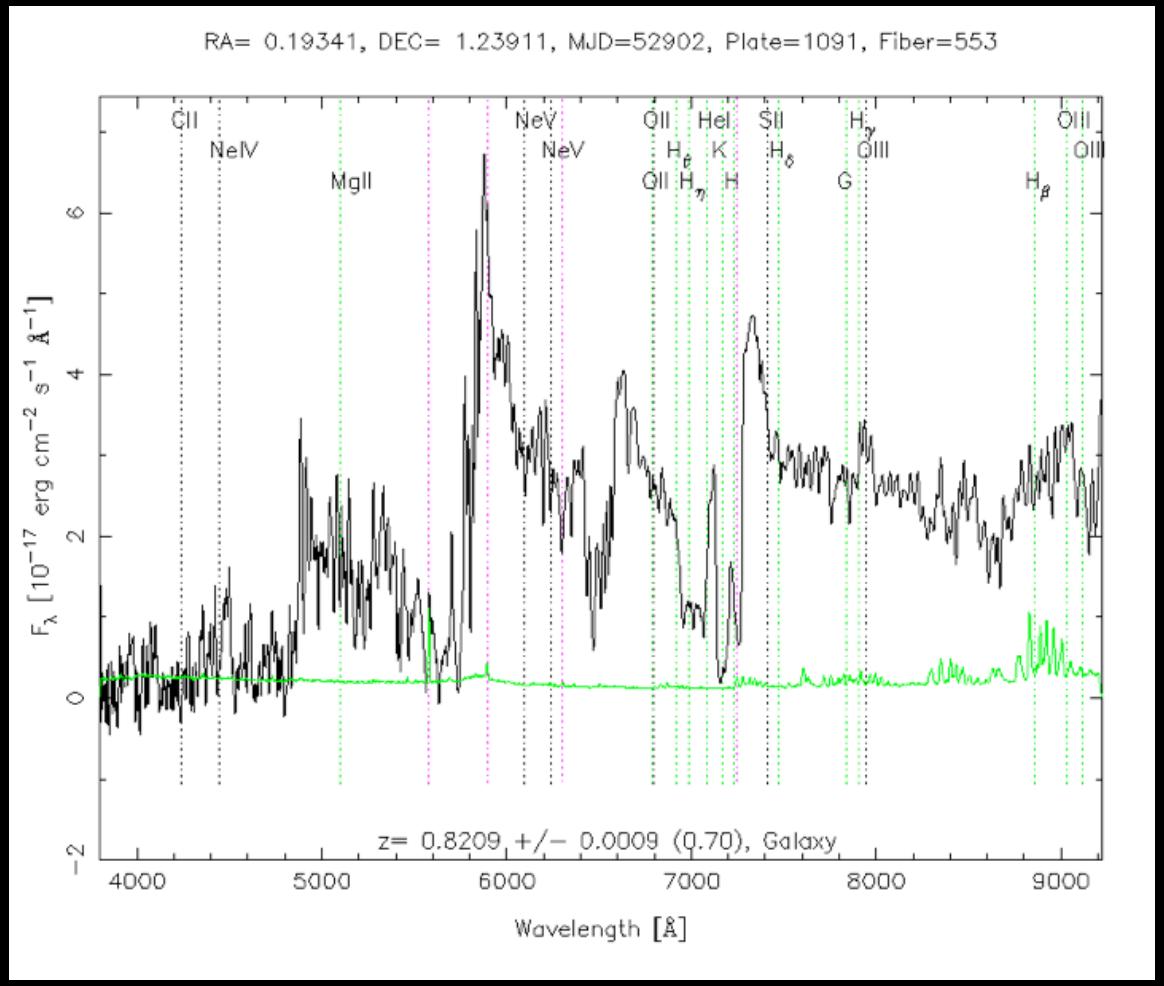
Merging Black Holes



TA Boroson & TR Lauer *Nature*, 2009, *458, 53*

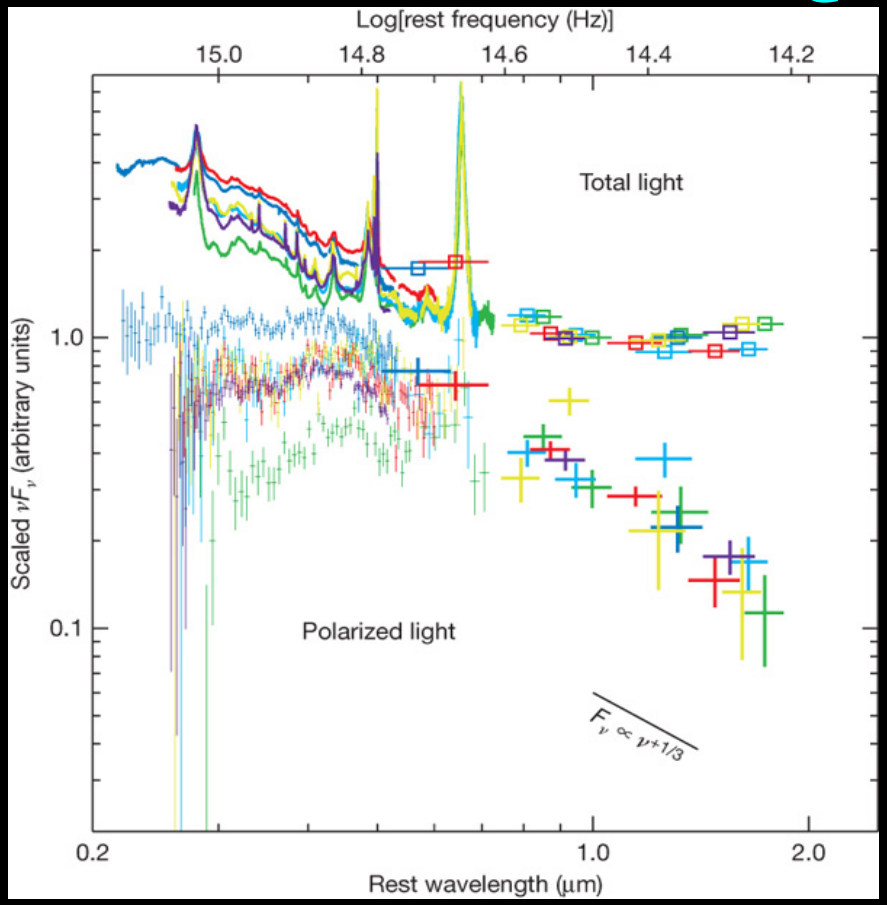
Volonteri et al. (2009) suggests 1 in ~10,000 (z<0.7) SDSS quasars should show BH merging

Broad Absoprtion Lines (z>1.7)



- **energetic / extreme physics**
  - BALs, >2000 km s^{-1}, accelerated up to and beyond 0.1**c** (e.g. Gibson et al. 2009, ApJ, 692, 758)

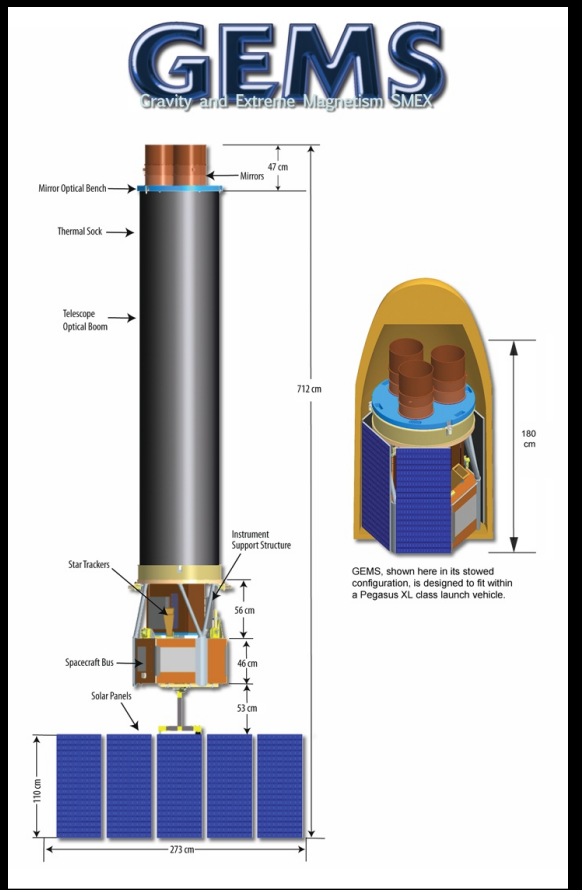
Polarization - QSOs



Overlay of the polarized- and total-light spectra observed in six different quasars.

M Kishimoto *et al.*
Nature, 2008, **454**, 492

Gravity and Extreme Magnetism SMEX
2014 Launch



Overlap with CMB/Planck

- ISW (5' at >=217 GHz ?)

- Extragalactic Radio Sources over 30-857 GHz

- Quasar Radio jets and polarization...??

(see Jim Bartlett's talk...)

Blowing up the Death Star...

- Cloverleaf Quasars...

- High-z counterpart to NGC 4258 H_20 water megamaser...??!!

- Tidal disruptions - once every 10^3–10^5 yr a star in a galaxy will pass within the tidal disruption radius of the central black hole... e.g. Gezari et al. (2009, ApJ, 698, 1376)

- ***"Unknown unknowns..."***

BigBOSS (Quasars) plus...

+ FIRST/NVSS, (SKA)
+ Planck
+ (ALMA)

+ [Spitzer W., Herschel], **WISE**

+ VISTA (e.g. and espec. VHS)
+ (LSST)
+ GALEX

+ Chandra/XMM, NeXT, NuSTAR, (IXO)
+ **LISA**

Nic's Final Thought...

Discuss!