Angular momentum
Expectations vs. Observations

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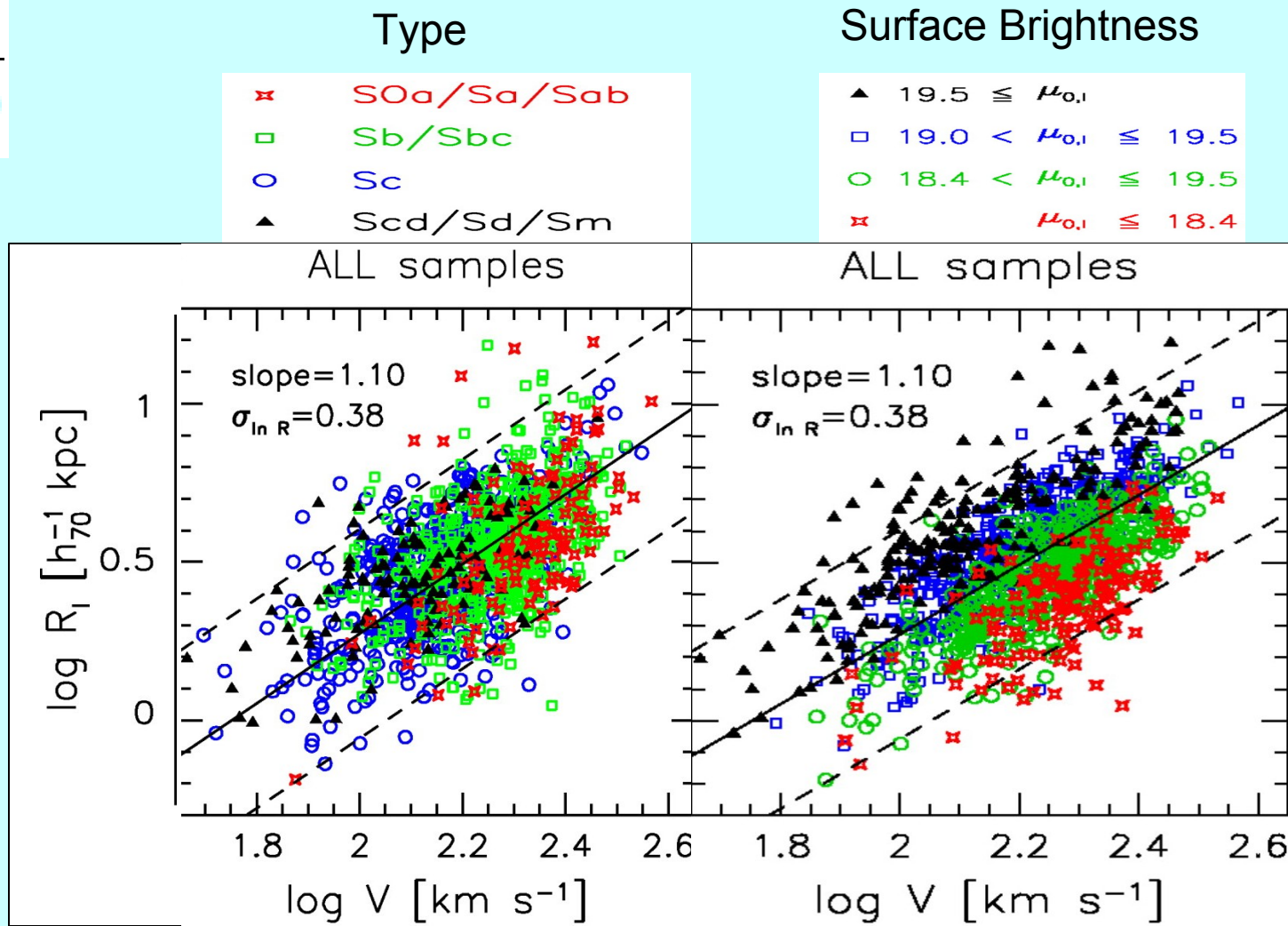
V-Size Relation

Courteau et al (1997),2007

$$R_d \propto \lambda \frac{V_c}{H_0} \frac{H_0}{H(z)}$$



Theoretical Scaling Relation

ISO:

$$R_{\rm d} \propto \lambda \frac{V_{\rm c}}{H_0} \frac{H_0}{H(z)}$$

NFW:

$$R_{\rm d} = \frac{1}{\sqrt{2}} \left(\frac{j_{\rm d}}{m_{\rm d}} \right) \lambda r_{200} f_{\rm c}^{-1/2} f_R(\lambda, c, m_{\rm d}, j_{\rm d})$$

→ Surface Brightness

$$\Sigma_0 \approx 4.8 \times 10^{22} h \, {\rm cm}^{-2} m_{\rm H} \left(\frac{m_{\rm d}}{0.05} \right) \left(\frac{\lambda}{0.05} \right)^{-2} \times \left(\frac{V_{\rm c}}{250 \, {\rm km \, s^{-1}}} \right) \left[\frac{H(z)}{H_0} \right] \left(\frac{m_{\rm d}}{j_{\rm d}} \right)^2$$

Mo Mao White 98

Holy grail

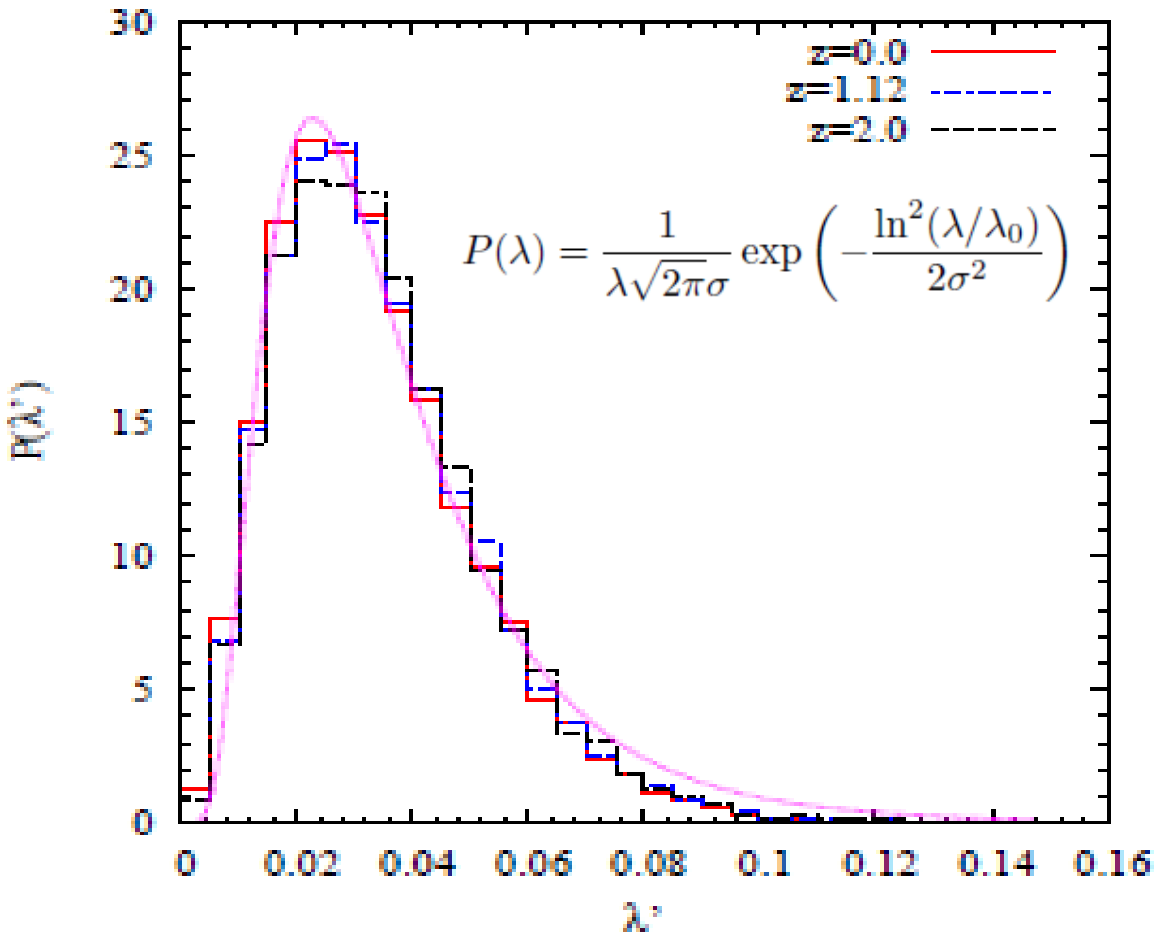
$$\bar{\lambda} \equiv \frac{J\sqrt{E}}{GM^{5/2}}$$

Peebles 1969

$$\lambda = \frac{J}{\sqrt{2}MVR}$$

Bullock 2001

No Mass; No redshift dependence



Bullock 2001; Maller, Dekel 2002;D'Onghia & Burkert;
Hetznecker & Burkert 2006; Maccio 2006; MunozCuertas 2010

#1 Is there convergence?

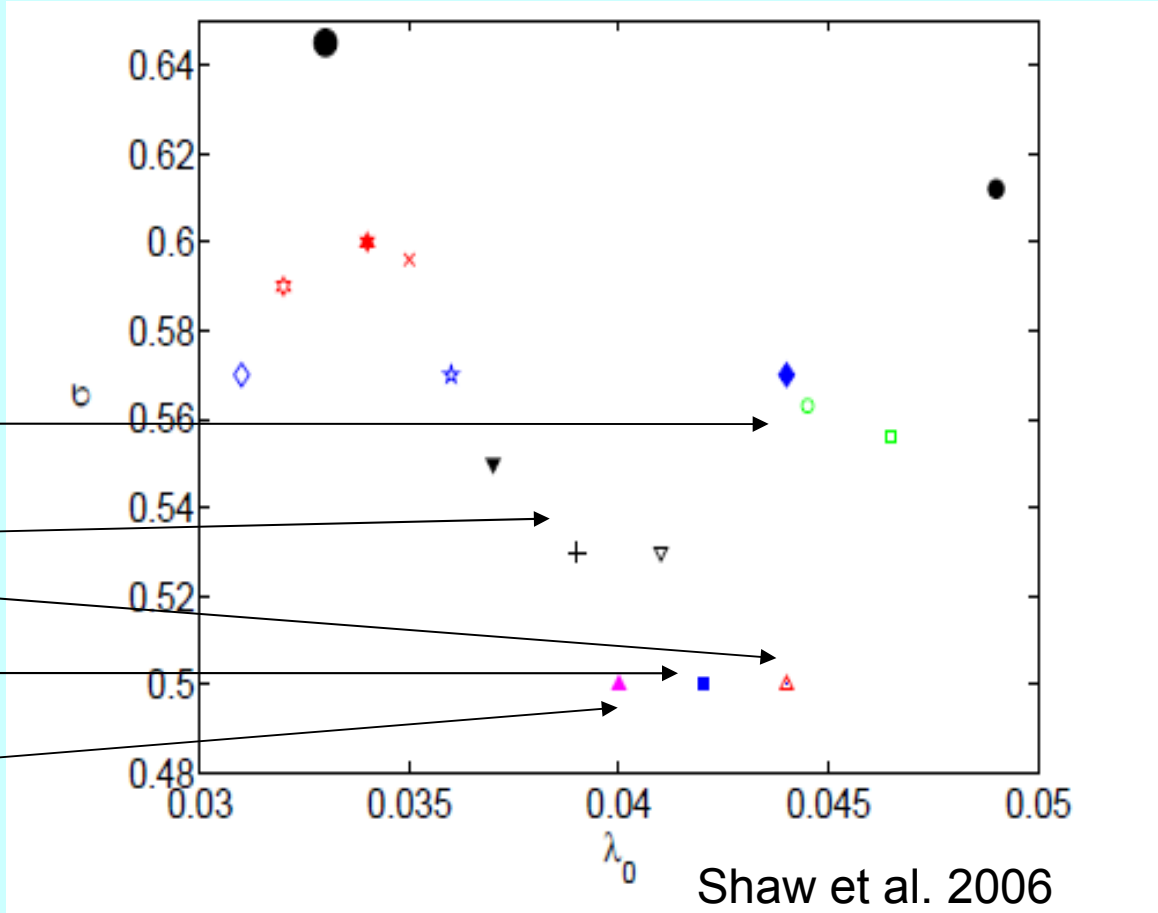
Vitviska 2002

Hetznecker Burkert 2006

Gardner 2001

Bullock 2001

Maller 2001



Shaw et al. 2006

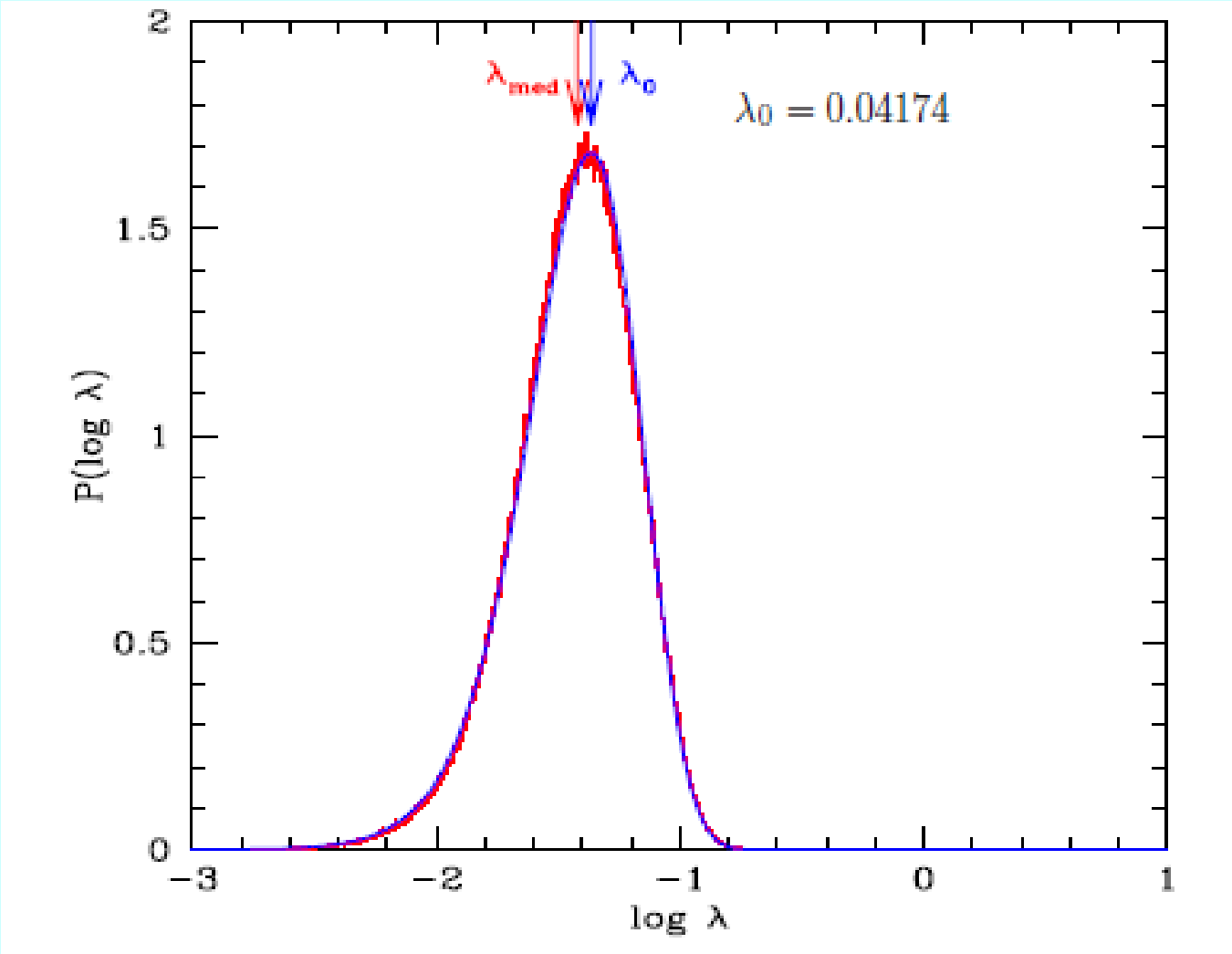
Holy grail

$$\bar{\lambda} \equiv \frac{J\sqrt{E}}{GM^{5/2}}$$

Peebles 1969

$$\lambda = \frac{J}{\sqrt{2}MVR}$$

Bullock 2001

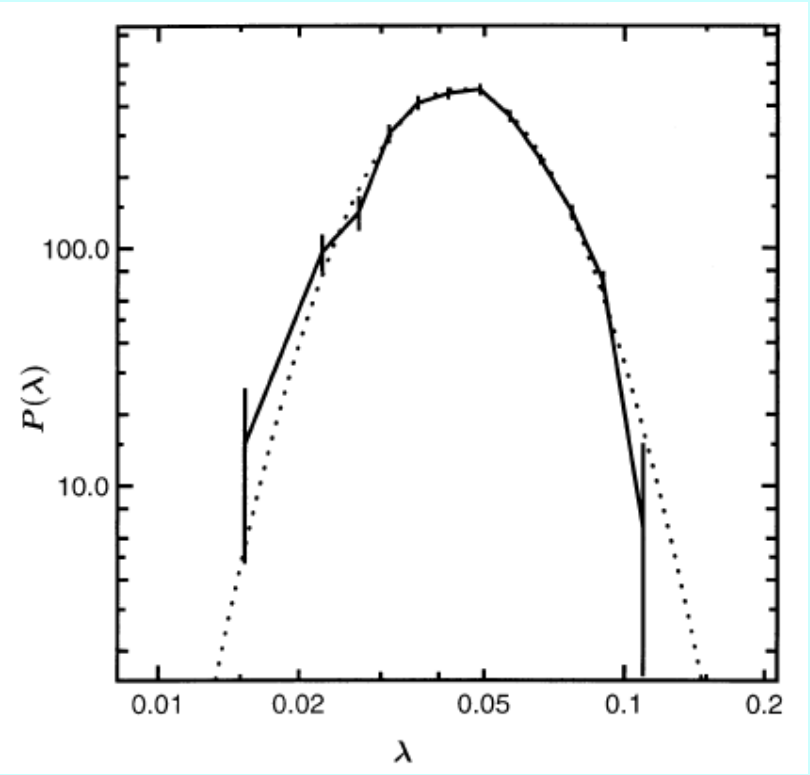


Bett et al. 2007 ('**Clean**' Millennium)

Can λ be observed?

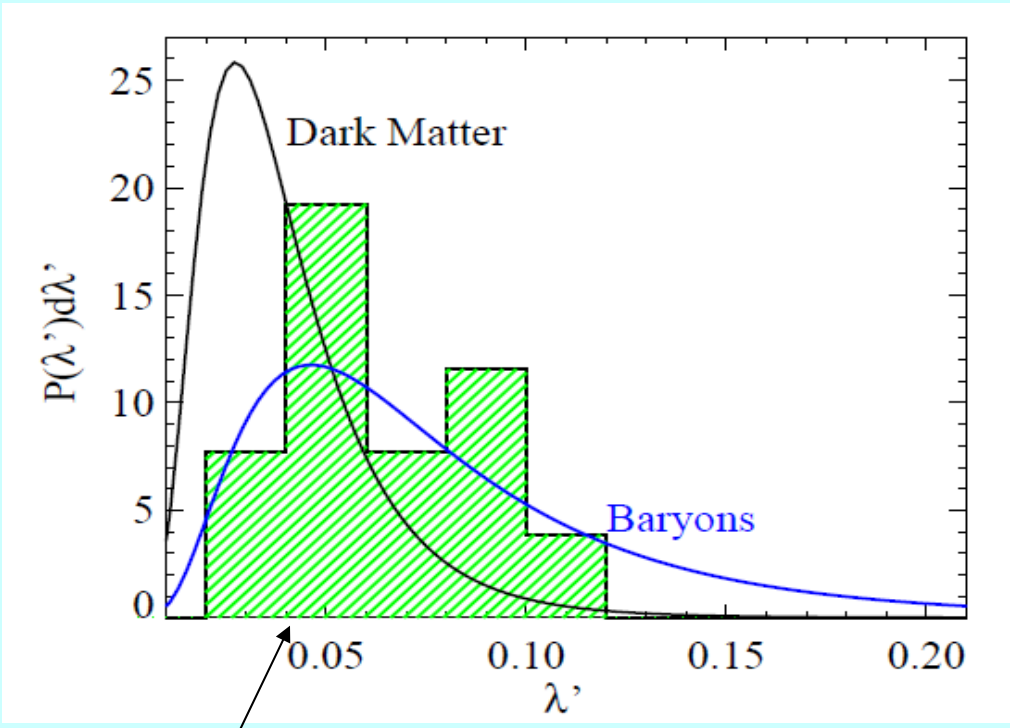
Can λ be observed?

Based on 2500 Spirals



Syer, Mo Mao 1999

Based on 14 dwarfs...



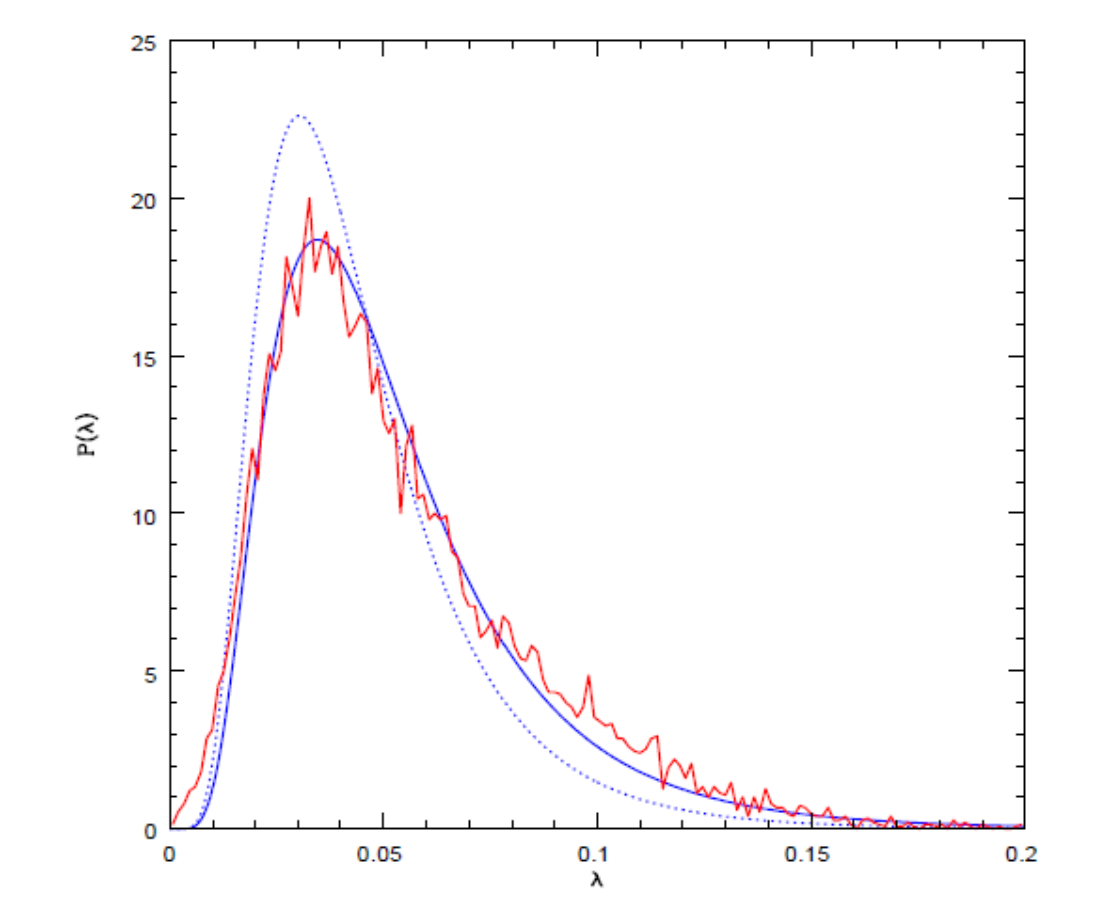
Maller & Dekel 2002

Van den Bosch, Burkert, Swaters 2001

Can λ be observed?

Hernandez 2007/ Cervantes-Sodi 2008

11,597 galaxies (SDSS DR5);
7754 Spirals



Can λ be observed?

Syer et al. 1999;
Hernandez 2007/ Cervantes-Sodi 2008

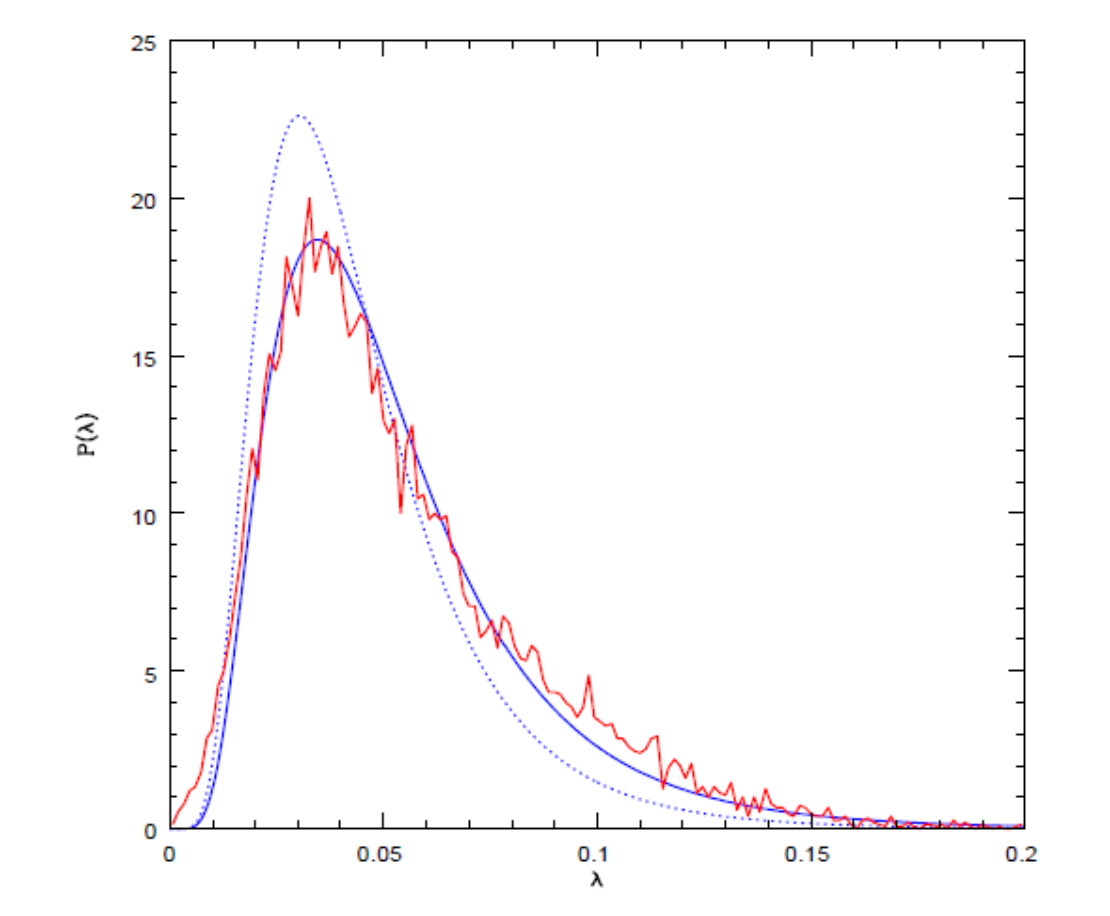
11,597 galaxies (SDSS DR5);
7754 Spirals

Raw:

$$\lambda_0 = 0.046 \text{ and } \sigma_\lambda = 0.535$$

Intrinsic:

$$\lambda_0 = 0.0394 \text{ and } \sigma_\lambda = 0.509$$



How did they do it?

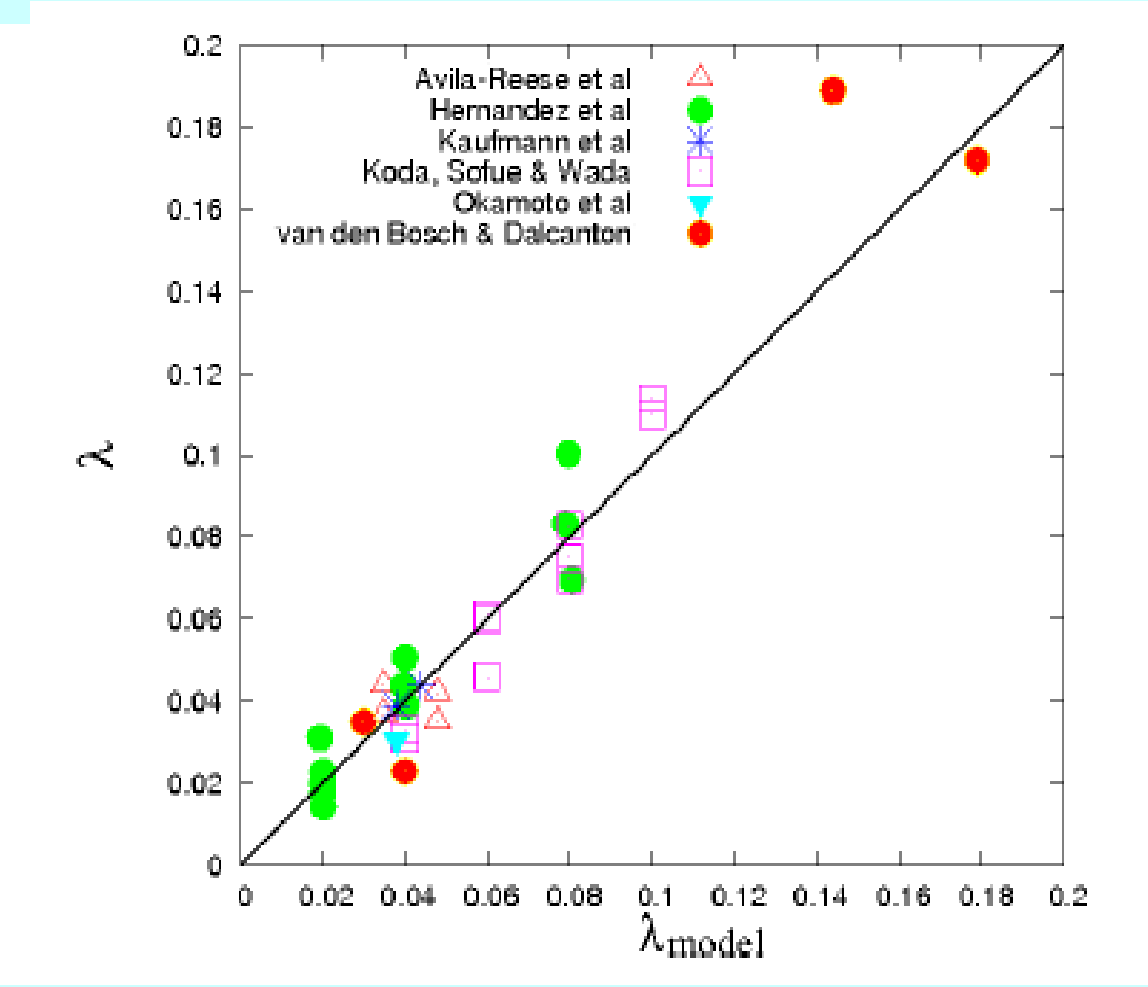
Hernandez 2007/ Cervantes-Sodi 2008

1) $j_d \sim j_{halo}$

2) Cst disk fraction

3) TF $\rightarrow$ V

$$\lambda = 21.8 \frac{R_d/kpc}{(V_d/kms^{-1})^{3/2}}.$$



Ang. momentum

1) Are the systematics under controlled

2) What is the distribution for massive disks?

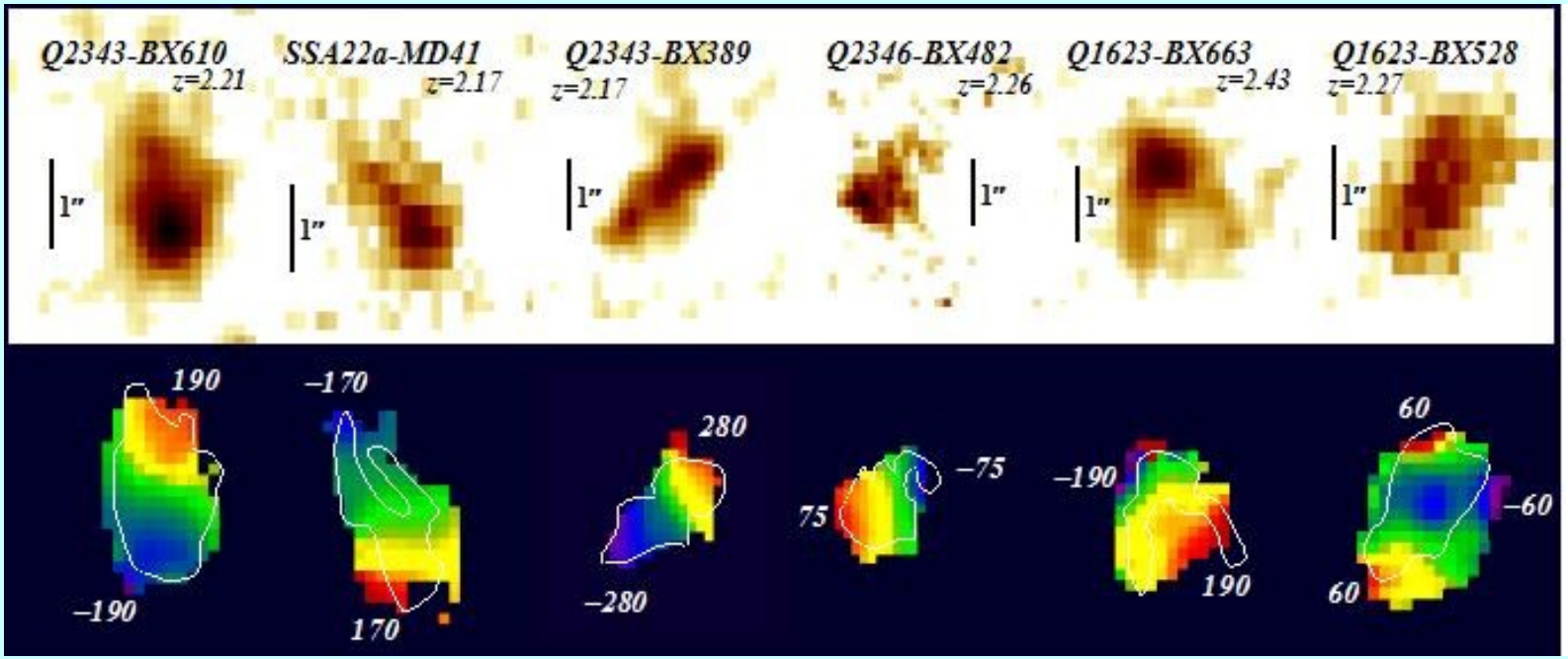
3) What is impact of feedback?

What about at z=2?

Largest data set (~80 galaxies):

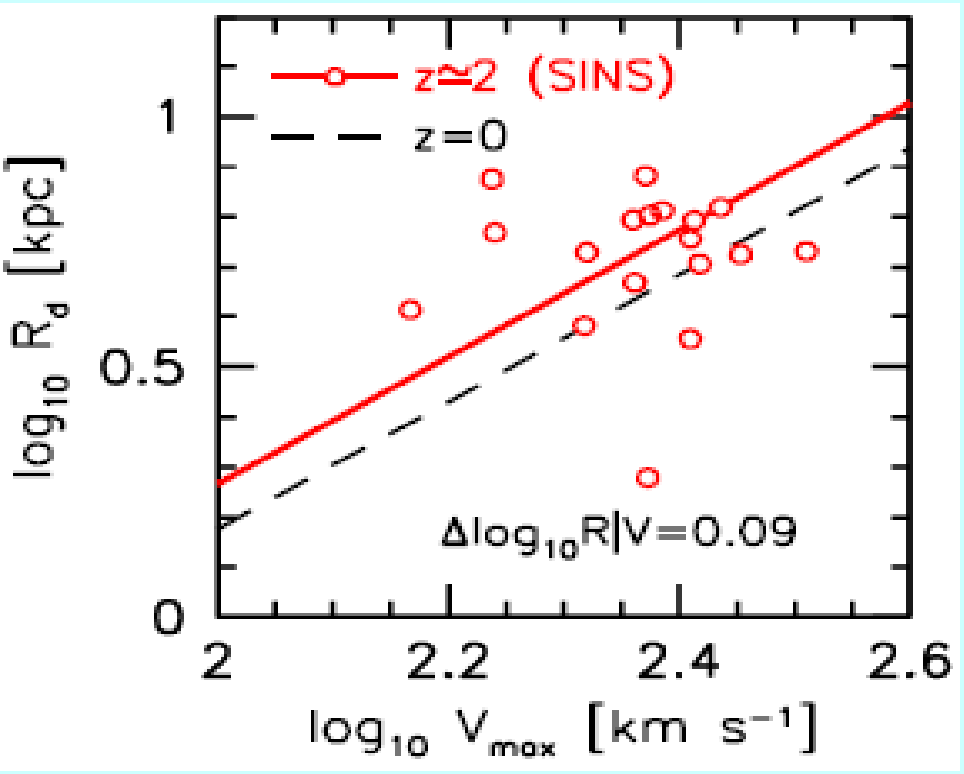
SINFONI SINS survey

(Genzel et al; Forster Schreiber et al;)

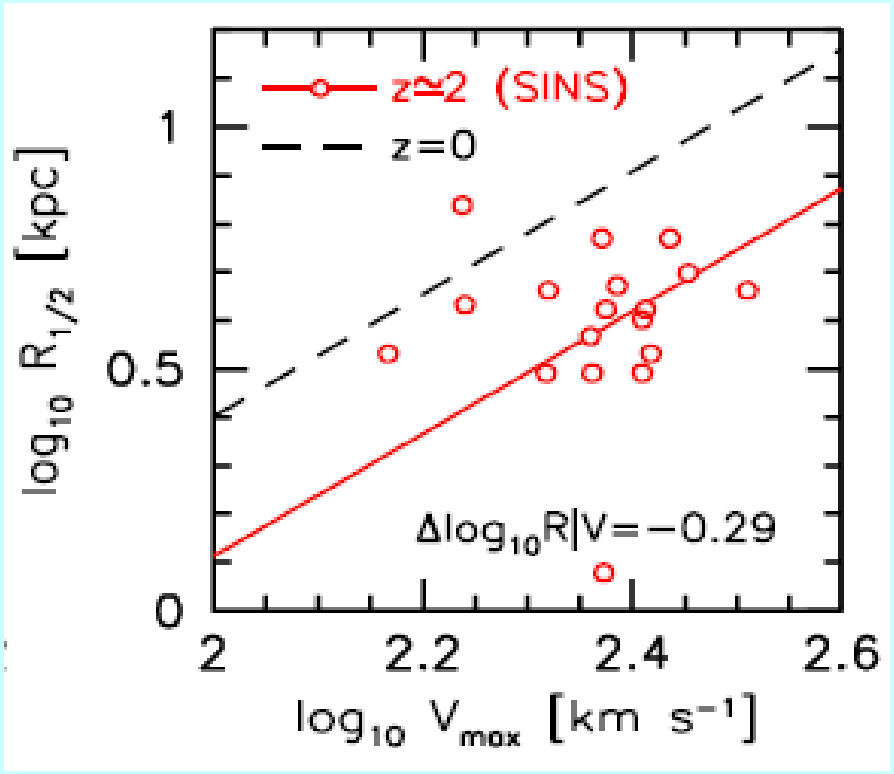


Redshift evolution?

Dutton et al. 2010

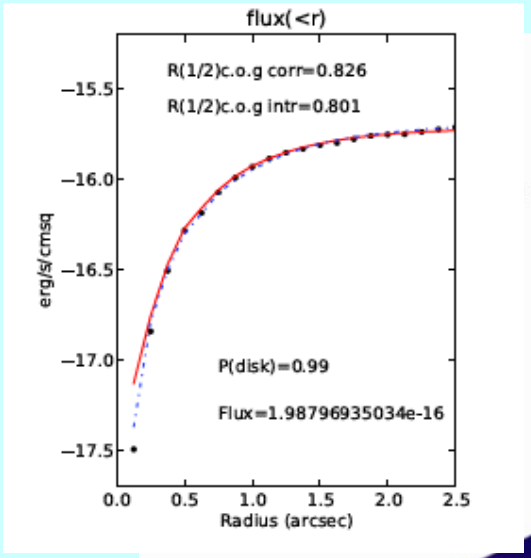


These are not Rd



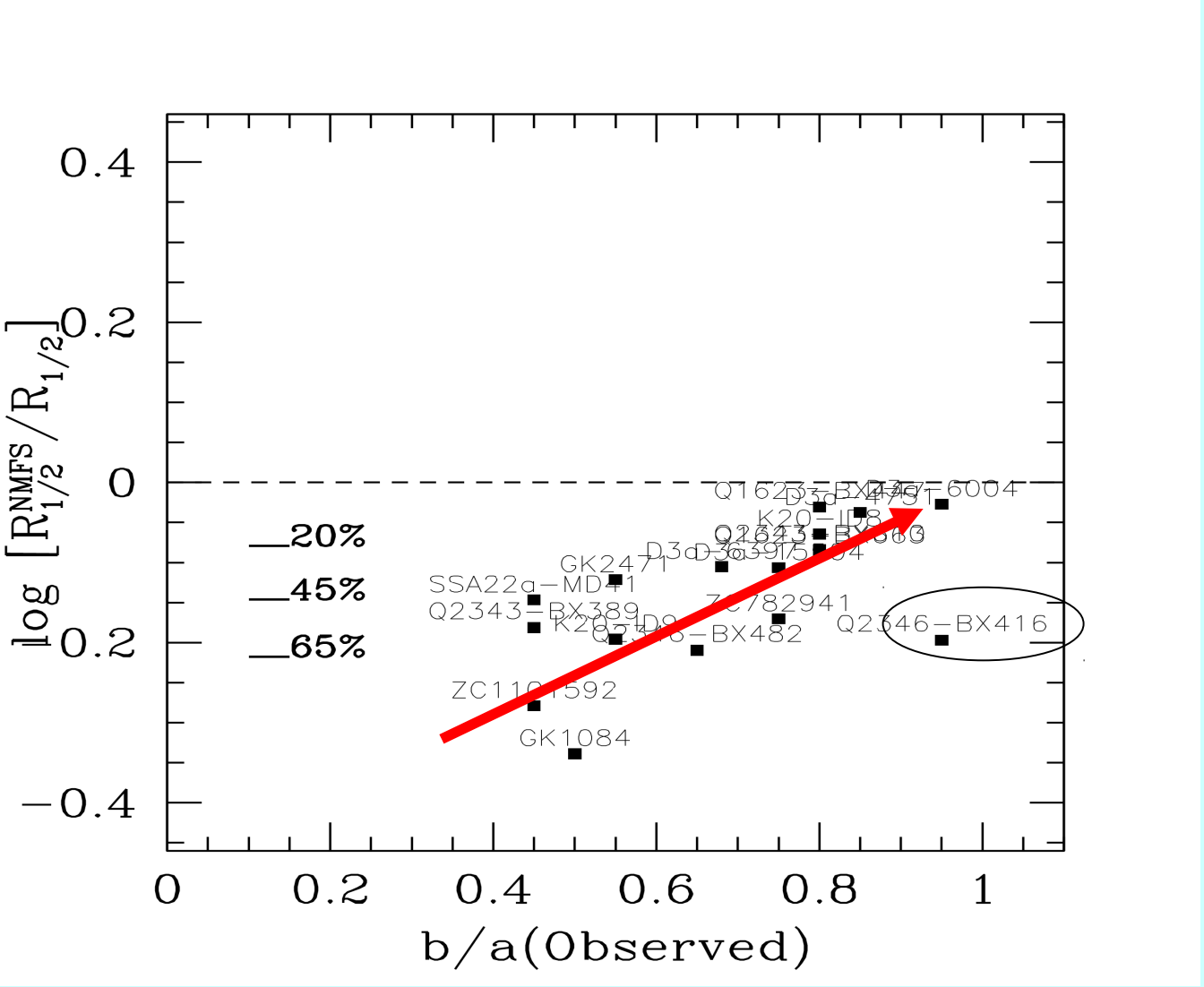
Biased [circular apertures]

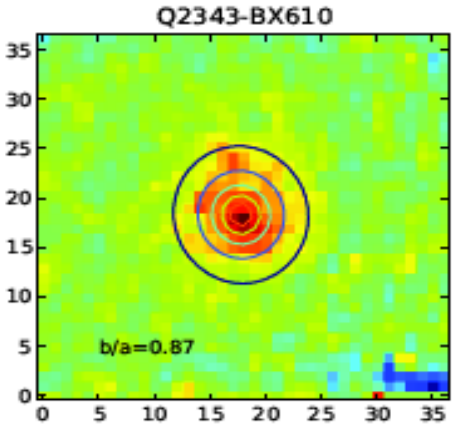
Measuring sizes is HARD

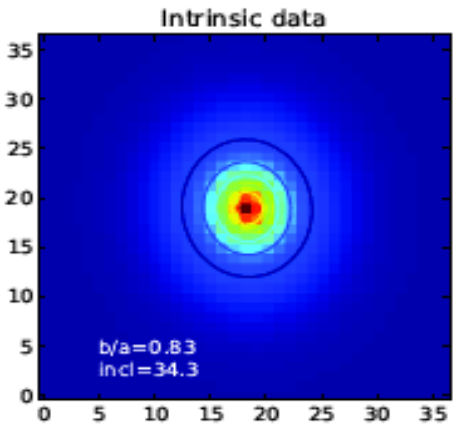


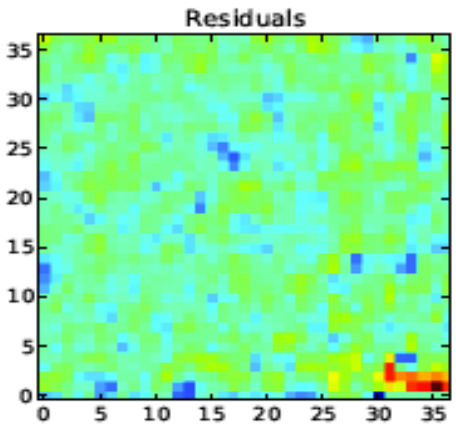
Typically 1e/s AND 300 pixels
–> <SN/pix> few [2-4]

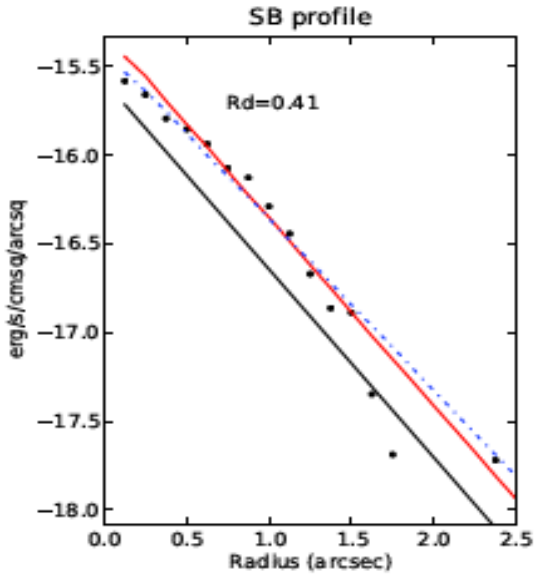
Aperture Matters

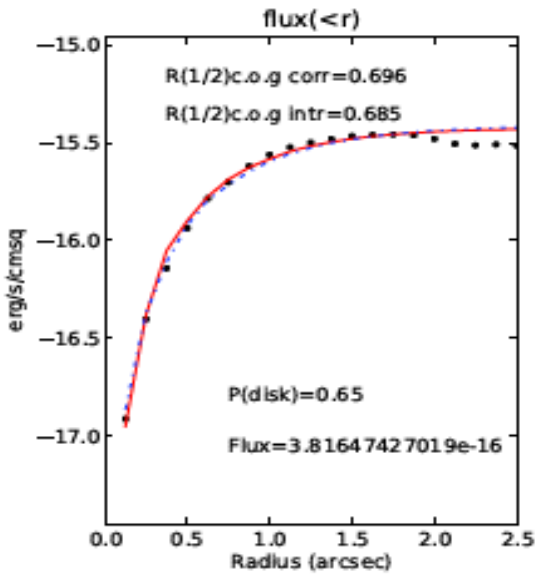


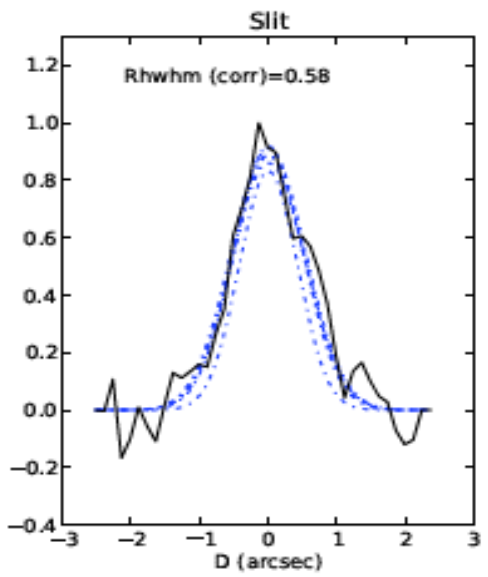

Q2343-BX610
b/a=0.87

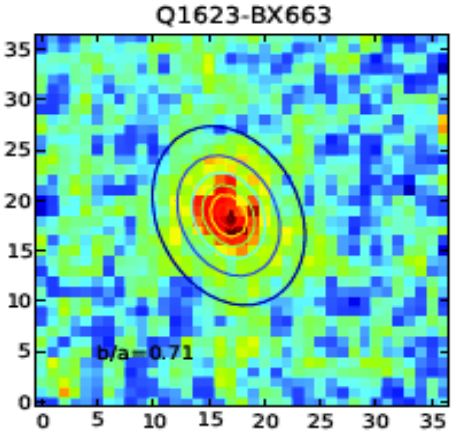

Intrinsic data
b/a=0.83
incl=34.3

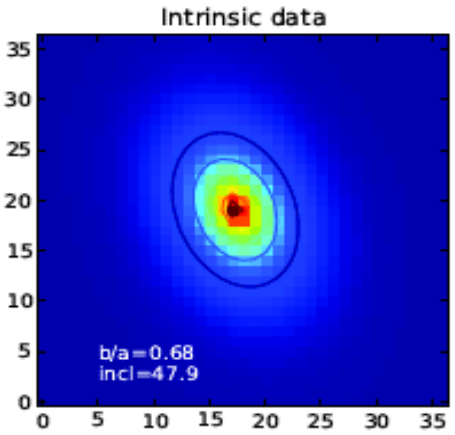

Residuals

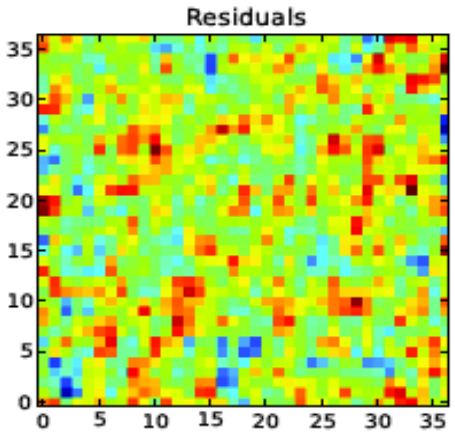

SB profile
Rd=0.41
erg/s/cmsq/arcsq
Radius (arcsec)

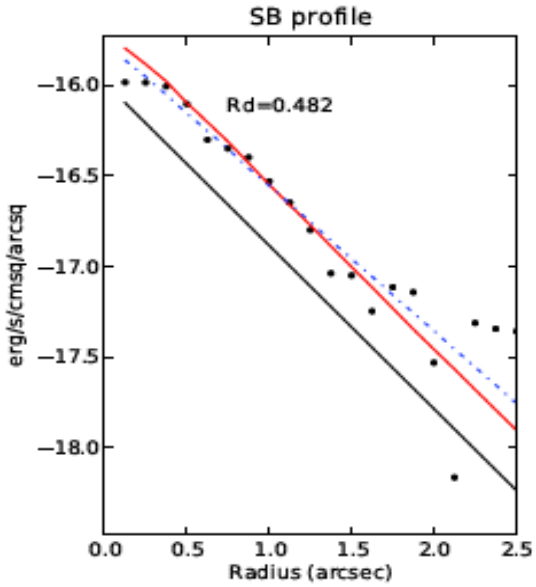

flux(<r)
R(1/2)c.o.g corr=0.696
R(1/2)c.o.g intr=0.685
P(disk)=0.65
Flux=3.8164742701 9e-16
erg/s/cmsq
Radius (arcsec)

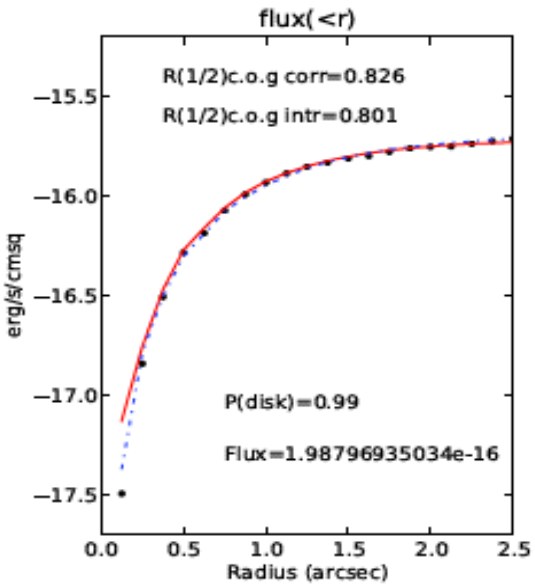

Slit
Rhwhm (corr)=0.58
D (arcsec)

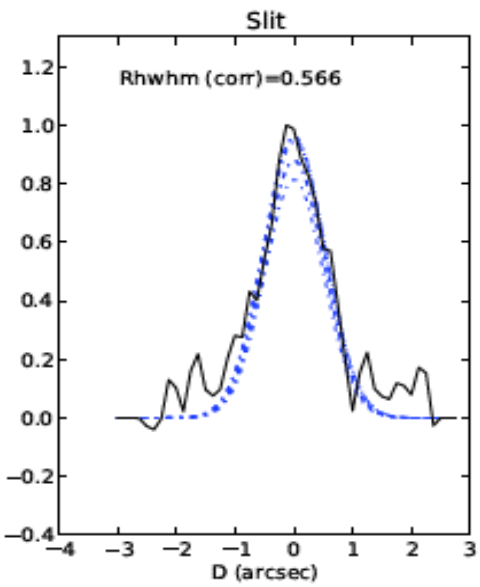

Q1623-BX663
b/a=0.71


Intrinsic data
b/a=0.68
incl=47.9

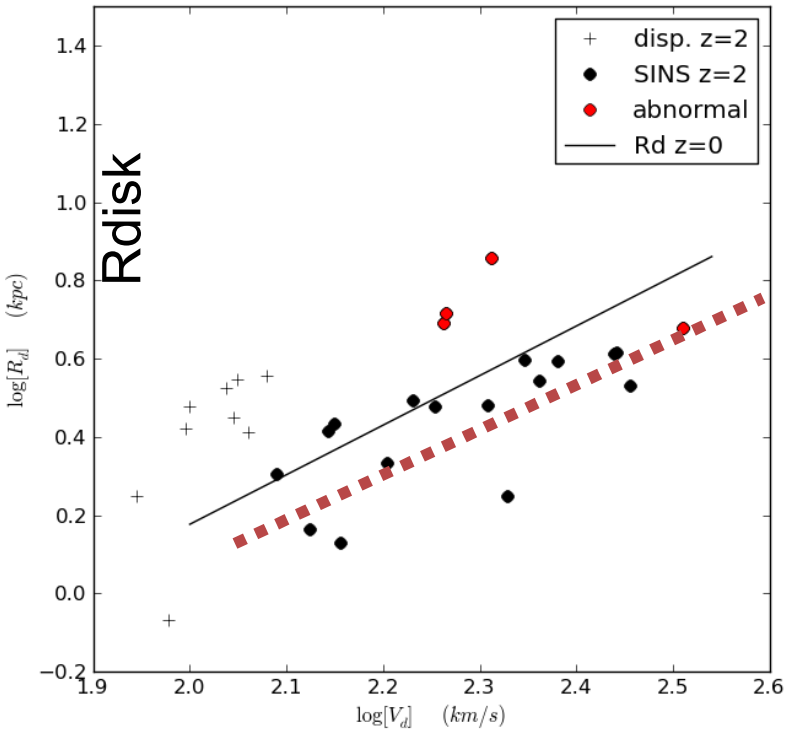

Residuals


SB profile
Rd=0.482
erg/s/cmsq/arcsq
Radius (arcsec)

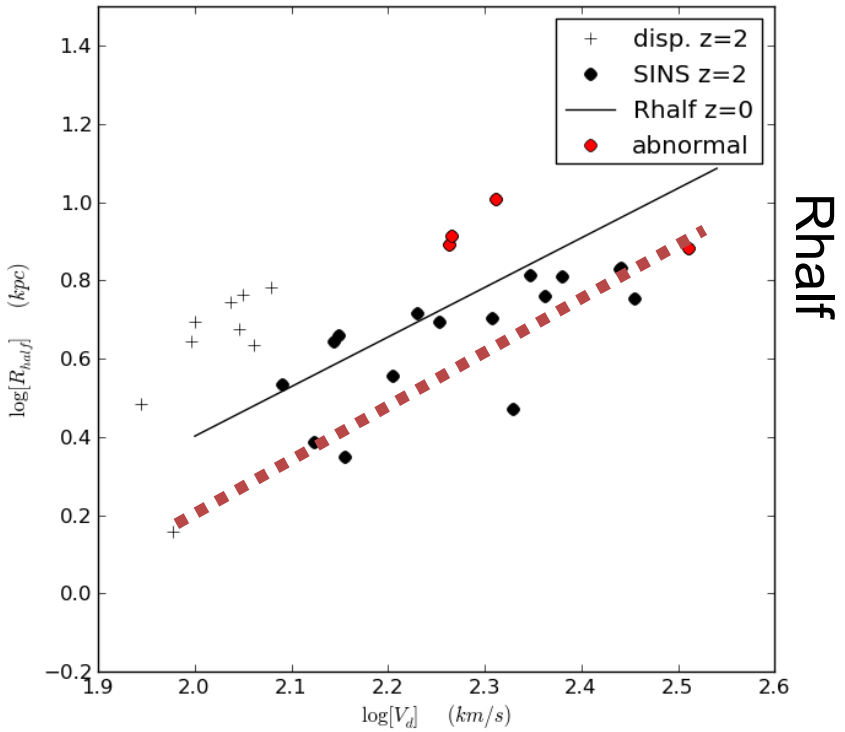

flux(<r)
R(1/2)c.o.g corr=0.826
R(1/2)c.o.g intr=0.801
P(disk)=0.99
Flux=1.98796935034e-16
erg/s/cmsq
Radius (arcsec)


Slit
Rhwhm (corr)=0.566
D (arcsec)

Slight redshift evolution: 0.2dex



Vd

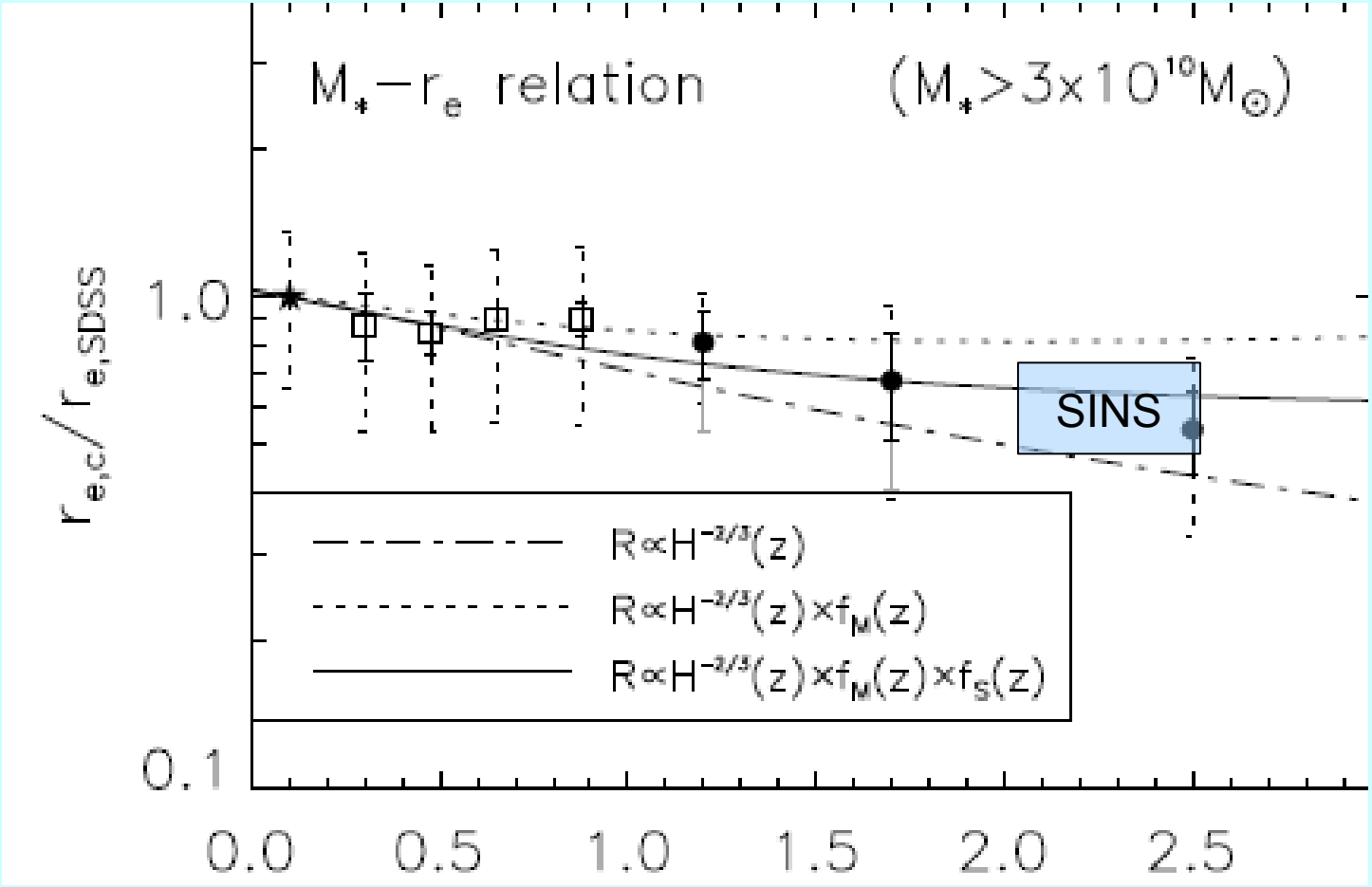


Vd

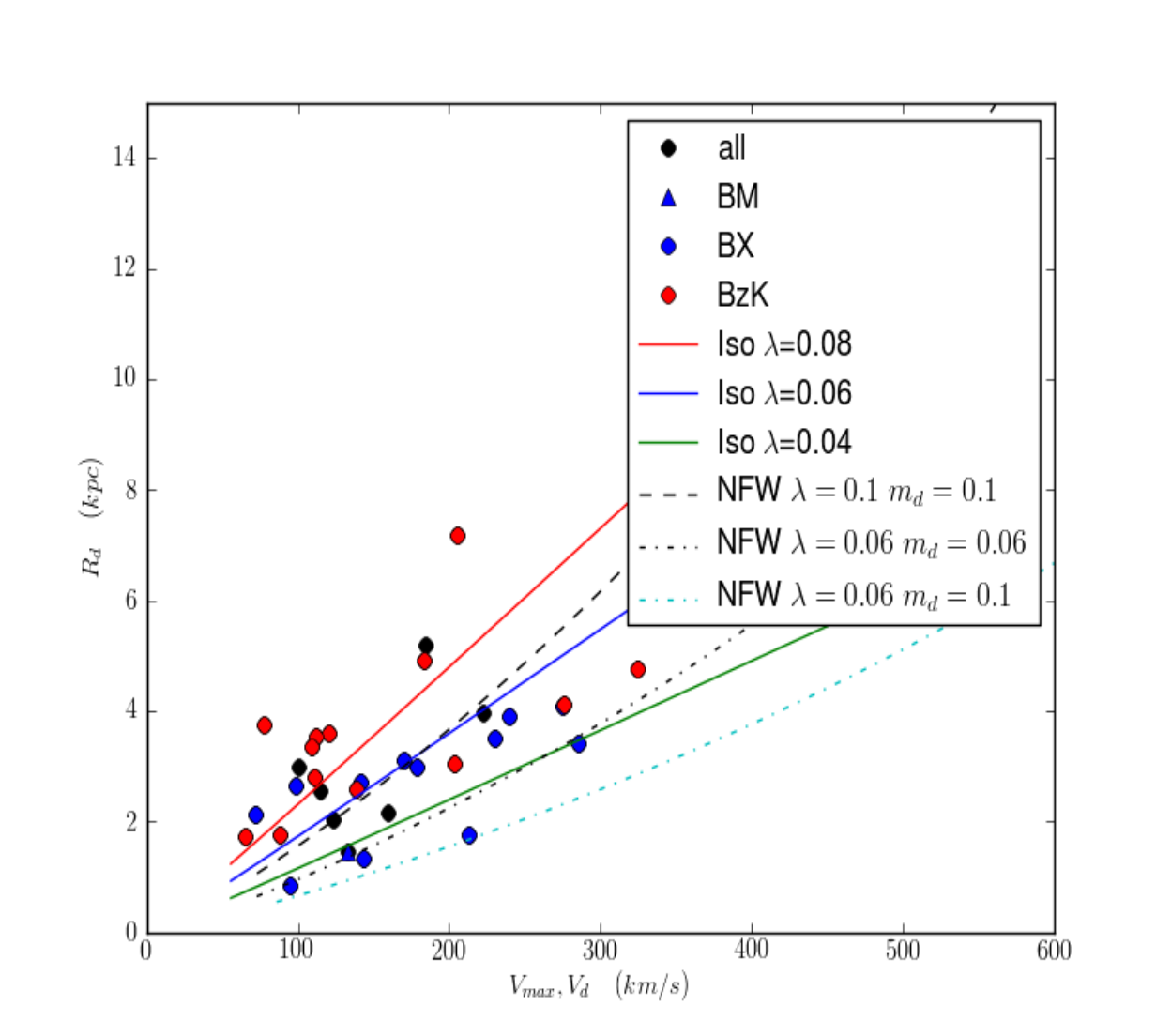
Z=0: Courteau et al. 2007; Dutton et al. 2007

Redshift Evolution

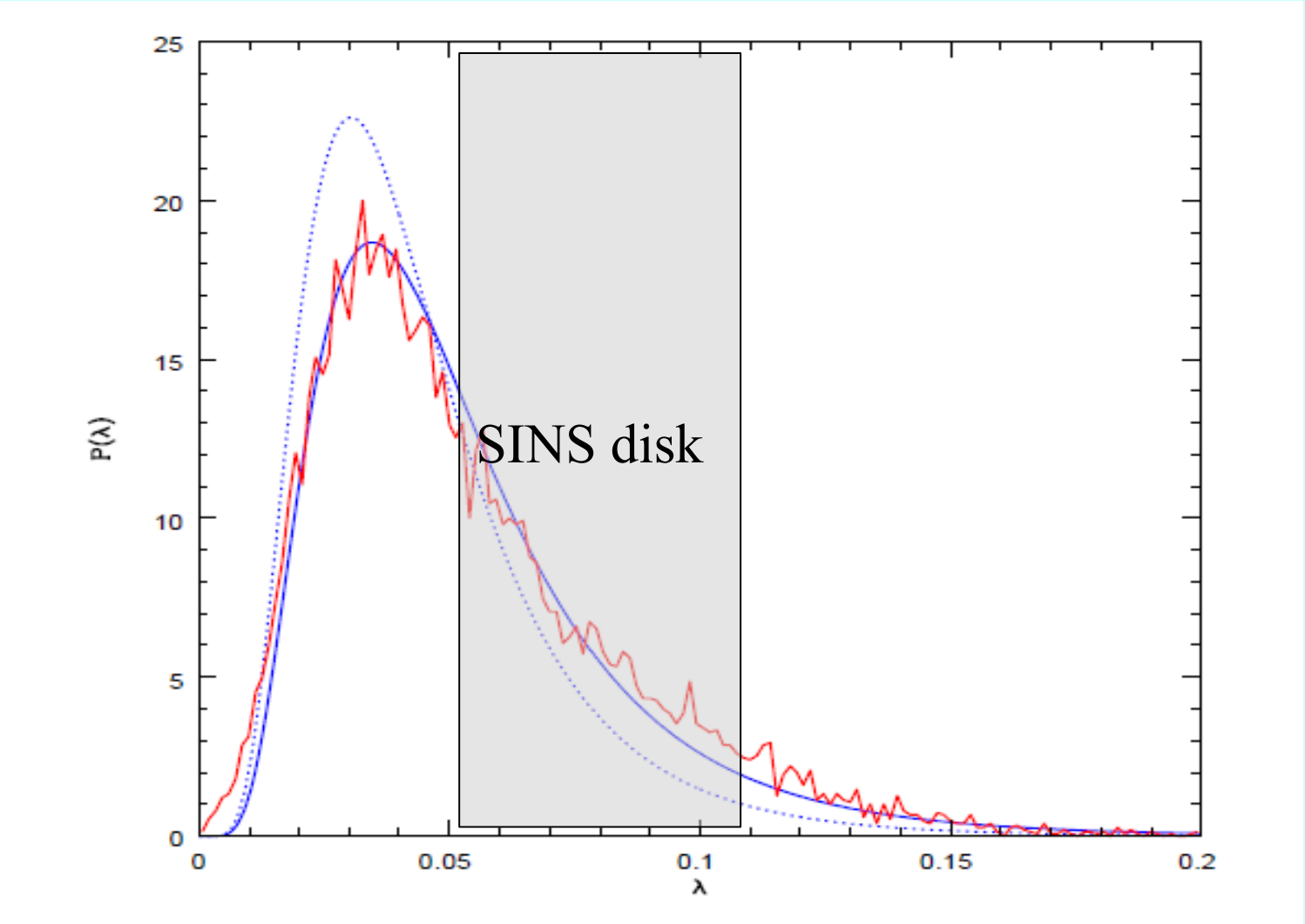
Trujillo et al. 2006



Spin paramter ~> 0.06



Comparison z=0 and z=2



Conclusions

- Mild size evolution from z=2 to z=0 / 0.2dex
- Spin λ 'relatively' large >0.06
- What is λ expected for Sp?
- To be continued...