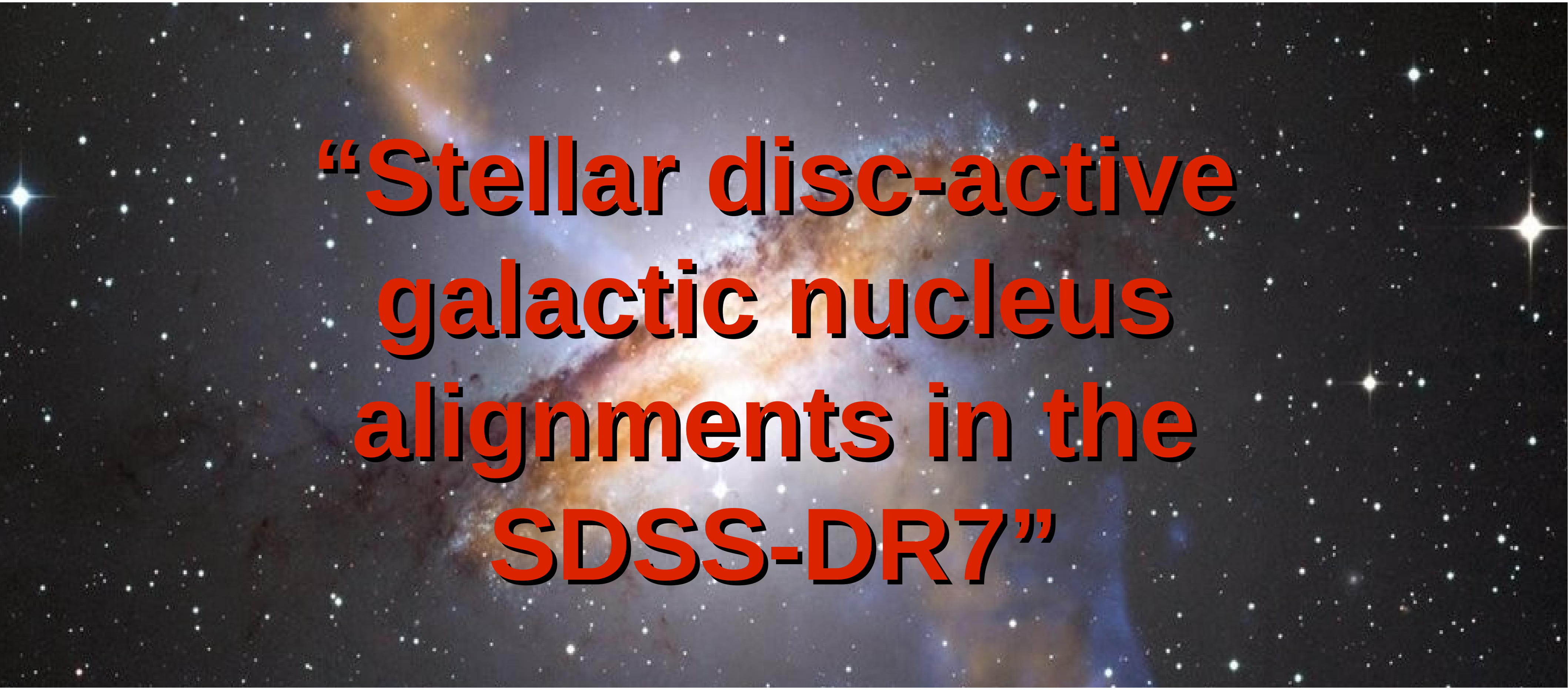
Durham University

ICC Institute for Computational Cosmology

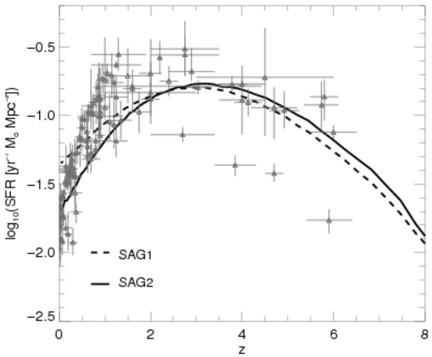


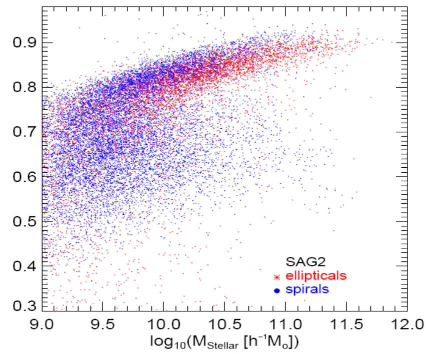
"Stellar disc-active galactic nucleus alignments in the SDSS-DR7"

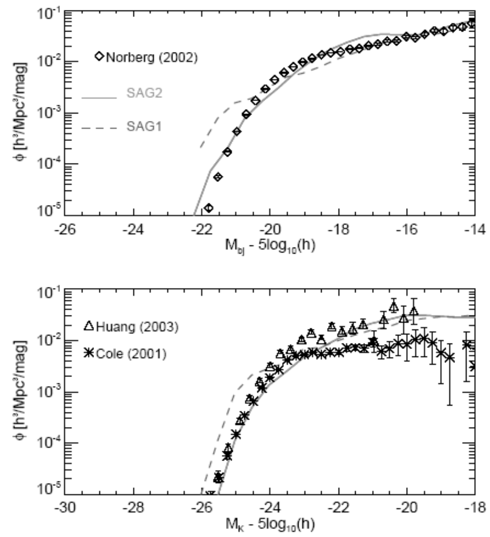
Claudia Lagos (ICC, Durham), Nelson Padilla (PUC, Chile), Michael Strauss (Princeton), Sofía Cora (UNLP, Argentina) & Lei Hao (Shangai Observatory)

"AGN workshop", Birmingham, September, 2010

AGN: Implications on galaxy formation and evolution

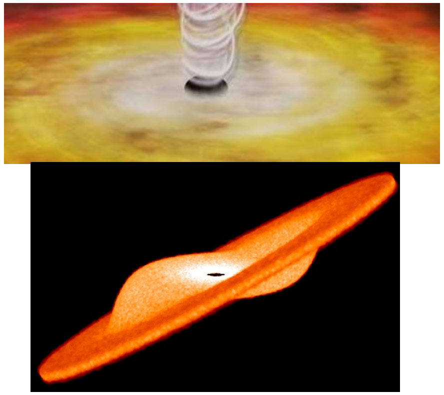




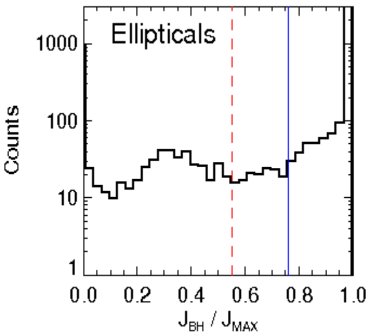


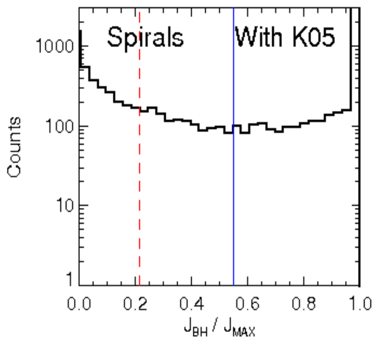
Lagos, Cora & Padilla (2008, MNRAS 388, 587)
Cattaneo et al (2008), Somerville et al. (2008), Croton et al. (2006), Bower et al. (2006)

Lagos, Padilla & Cora (2009a) MNRAS, 395, 625,



Two scenarios: coherent/random (galactic/accretion disc orientation)





Ell/Spi dichotomy: insensitive to model choices

Massive BHs → large spins (a>0.9, coherent), (a<0.7, random, King et al. 05, 0.8, Fanidakis et al. 2010)

CONTRADICTORY RESULTS: position angles, naive inclination angle determinations

NO ALIGNMENTS: Kinney et al. (2000); Schmitt et al. (2002); Greenhill et al. (2009)

ALIGNMENTS SIGNAL: Dumas et al. (2007); Battye & Browne (2009)

A novel approach to study inclination angles of AGN in the SDSS DR7

Large number statistics

Comprehensive way to determine orientations

(Lagos, Padilla, Strauss, Cora & Hao, 2010, soon)

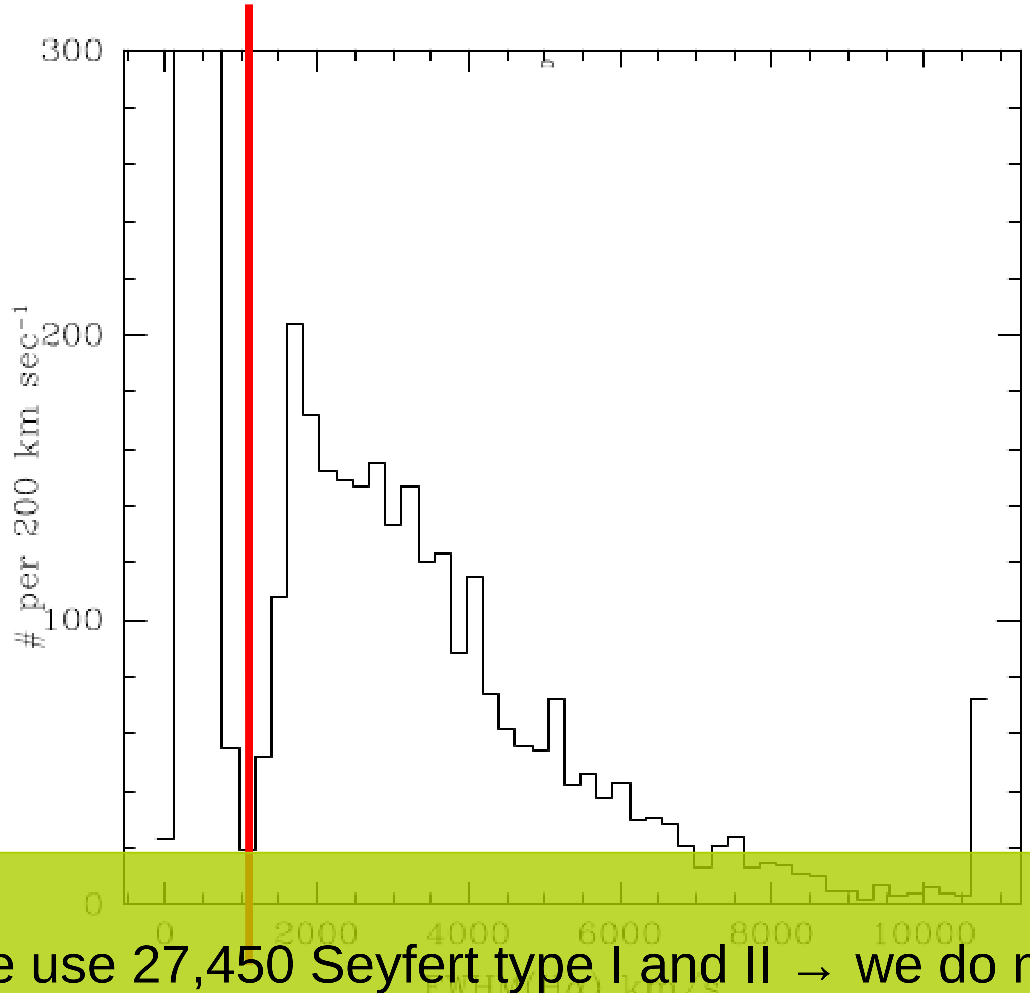
→ Tested AGN unified model/accretion models (Lagos et al. 2009)

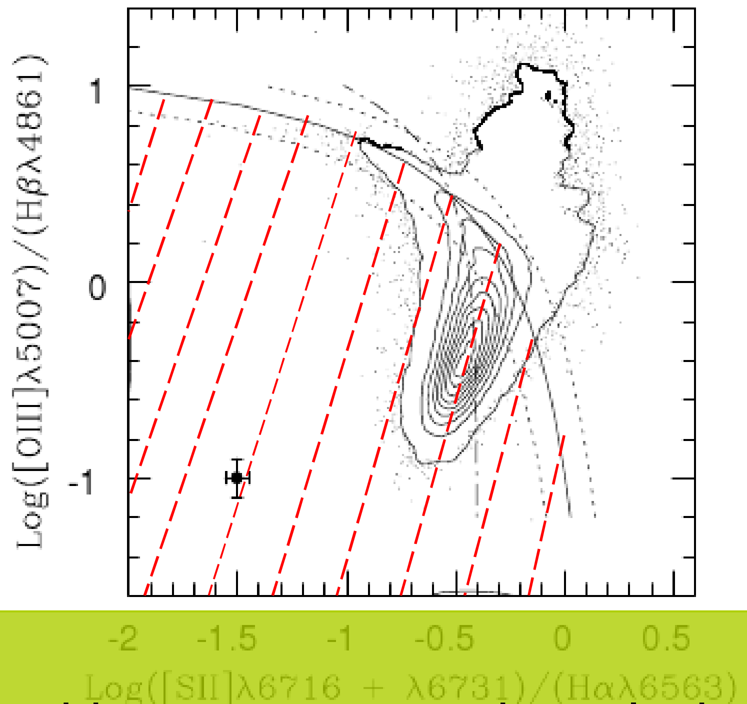
→ **We determined a high-significance degree of alignment between the host galaxy and AGN (torus/jets)**

AGN catalogue from the SDSS DR7 spectroscopic sample

AGN catalogue by Hao et al. (2005a). SDSS DR4.

→ Line diagnostic by Kauffmann et al. (2003) and Kewley et al. (2001)

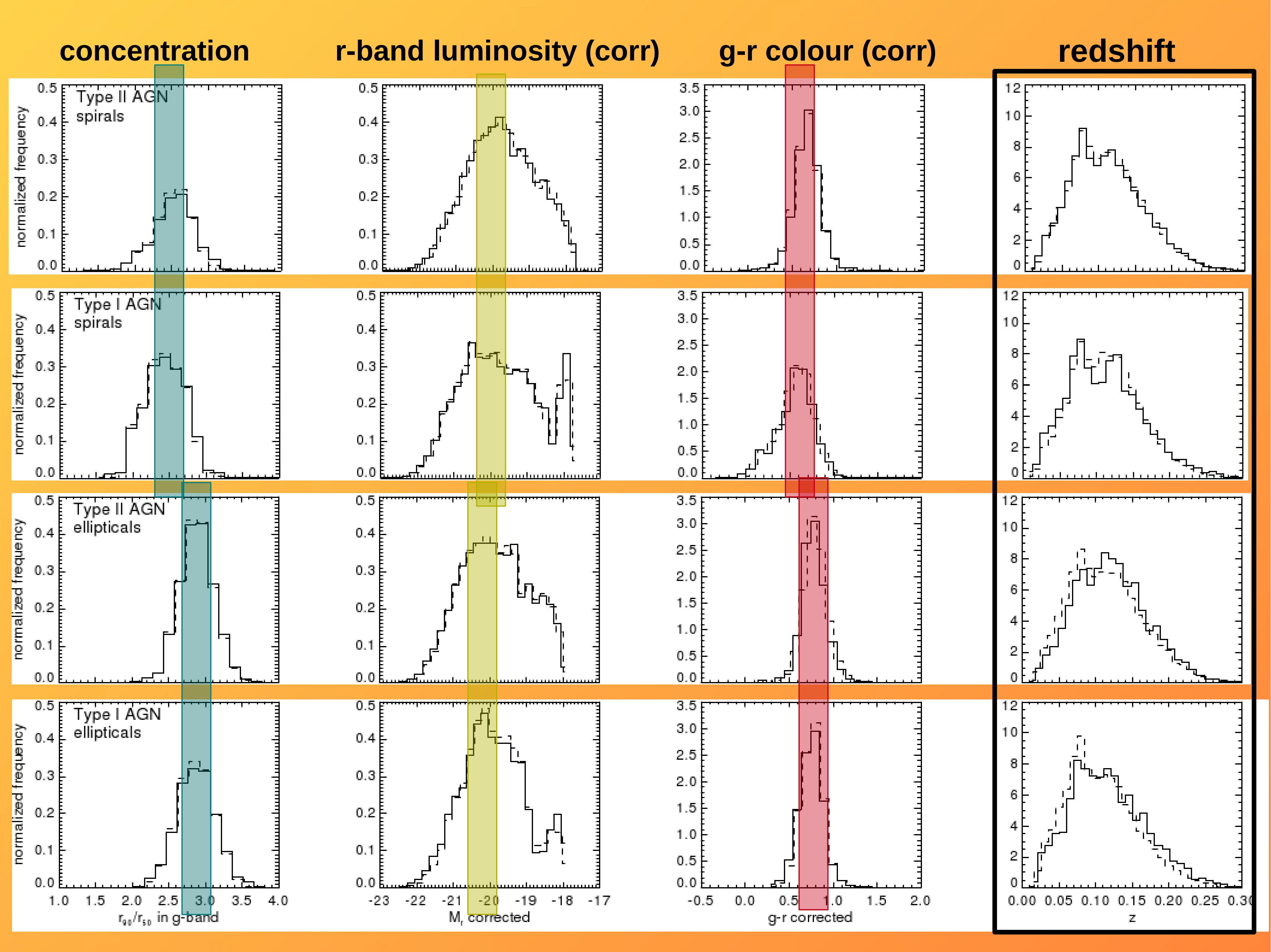




We use 27,450 Seyfert type I and II → we do not consider SF or composite galaxies

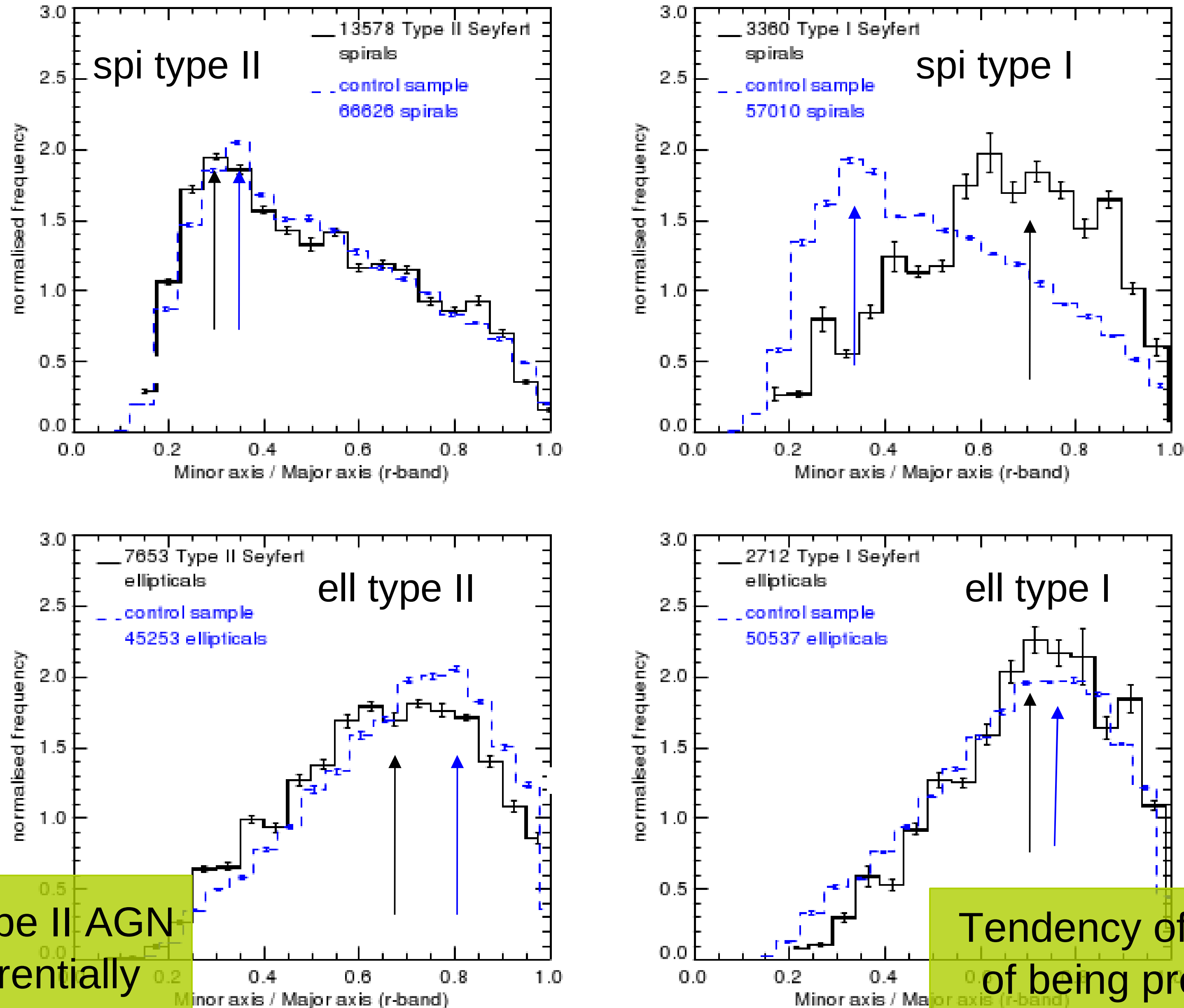
control samples → normal galaxies that mimic AGN hosts

ASSUMPTION: AGN galaxies have the same shapes than normal galaxies



concentration
r-band luminosity (corr)
g-r colour (corr)
redshift
Type II AGN
spirals
Type I AGN
spirals
Type II AGN
ellipticals
Type I AGN
ellipticals
normalized frequency
r90/r50 in g-band
Mr corrected
g-r corrected
z

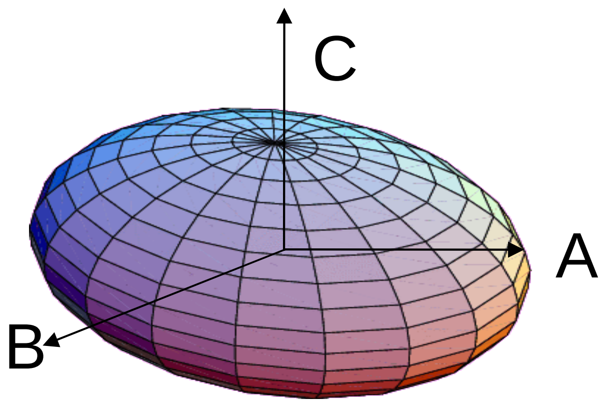
Projected shapes: AGN vs control samples

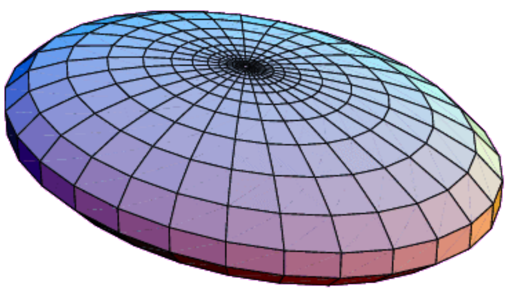


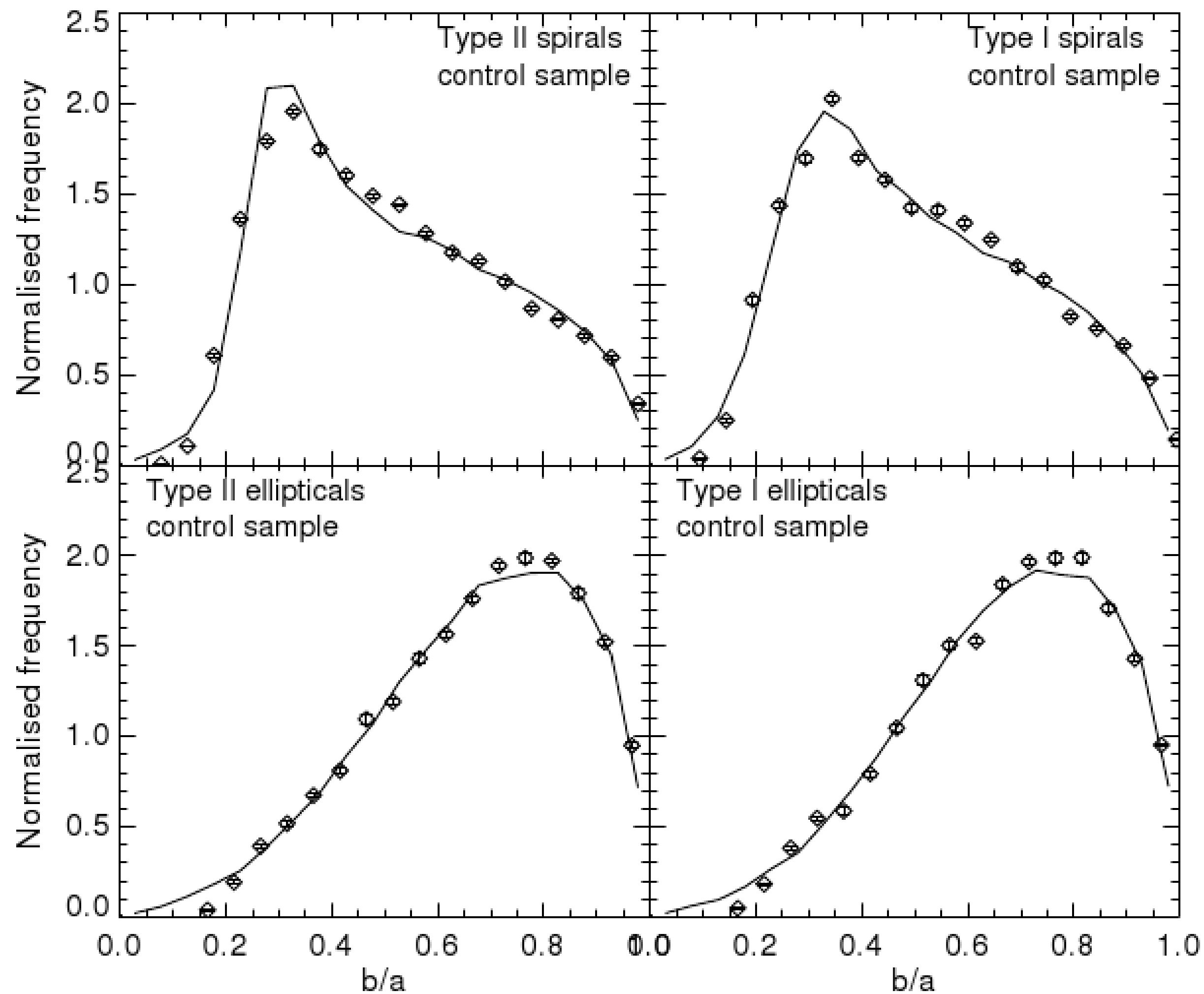
Tendency of type II AGN of being preferentially **elongated**

Tendency of type I AGN of being preferentially **round**

Characterization of the 3-D shapes of control samples (Padilla & Strauss 2008)







→ $\log_{10}(1- B/A)$ → Gaussian μ σ

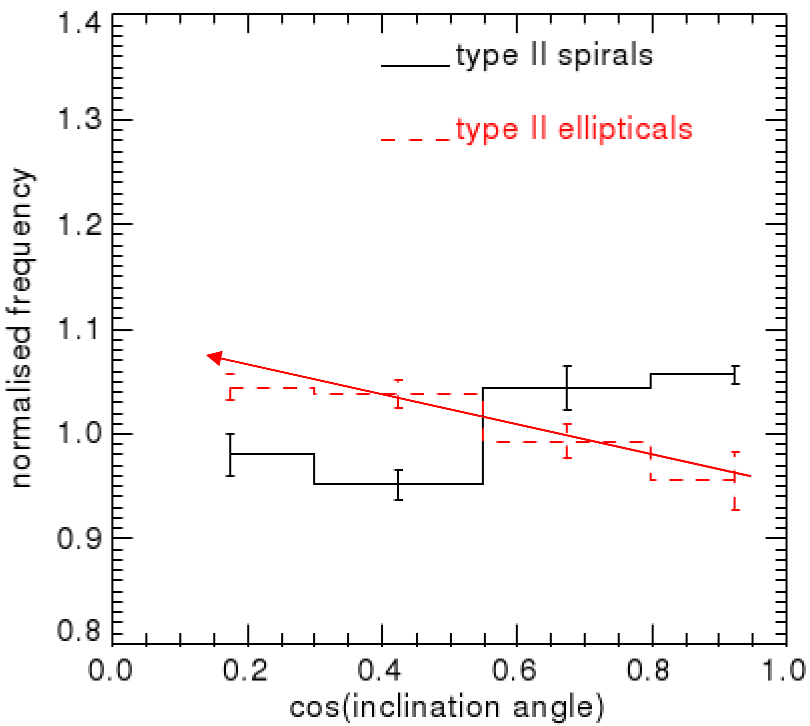
→ 1-C/B → Gaussian γ ▪ $\sigma\gamma$

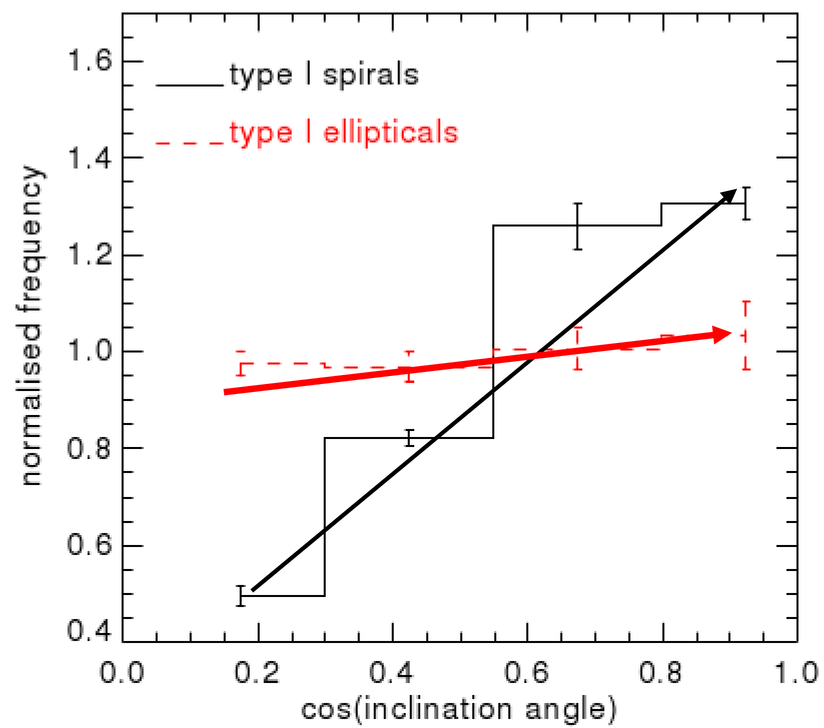
→ Median extinction (spirals) → E_0

→ $(g-r)/M_r$ distribution functions

Sample	E_0	μ	σ	γ	σ_γ	$P_{\max}$
Type I ellipticals	0.0	-0.9 ± 0.5	2.3 ± 0.6	0.45 ± 0.03	0.21 ± 0.04	0.86
Type II ellipticals	0.0	-1.35 ± 0.4	1.7 ± 0.5	0.45 ± 0.03	0.23 ± 0.04	0.88
Type I spirals	0.3 ± 0.3	-0.85 ± 0.35	1.7 ± 0.2	0.75 ± 0.02	0.07 ± 0.03	0.25
Type II spirals	0.3 ± 0.3	-0.25 ± 0.3	2.2 ± 0.2	0.75 ± 0.02	0.04 ± 0.02	0.33

Viewing angle distributions: from 3D information
(control samples → random orientations)





Edge-on tendency!

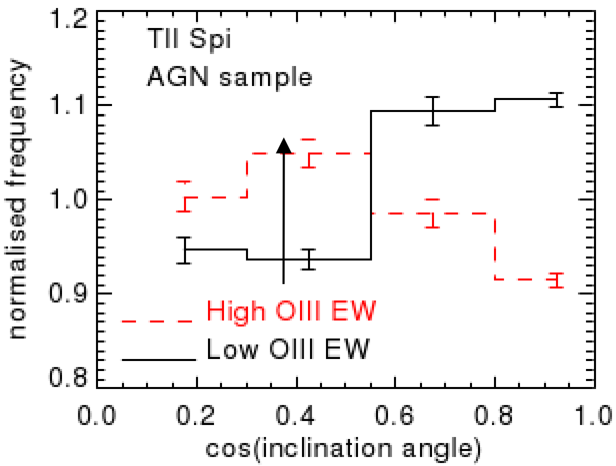
Face-on tendency!

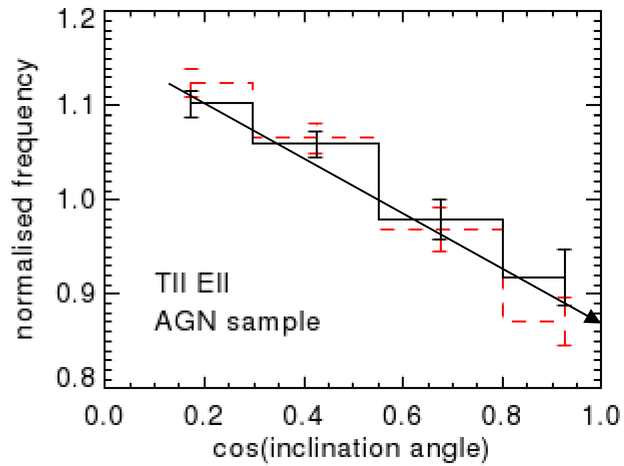
Random orientations are
ruled-out with a confidence of $\delta\chi^2>10$ (spi TI, ell TII)
$\delta\chi^2\sim2$ (spi TII, ell TI)

Either or both:
→ Alignment between the galaxy disk and the torus?
→ Galactic disk is producing the absorption

Orientation alignments:
Is the galactic disk responsible for the absorption?

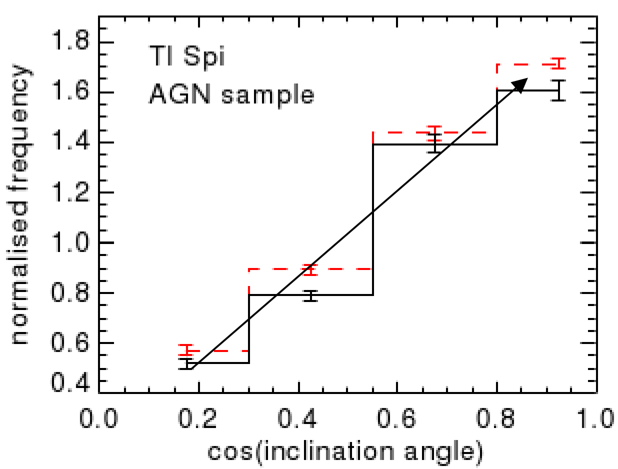
Repeat the process for [OIII] EW subsamples:
relative [OIII] line strength to the continuum

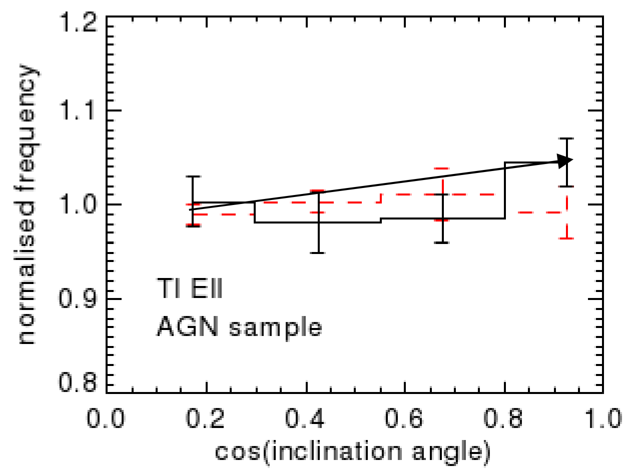




→ Low [OIII] incomplete
(Goulding et al. 2009, 2010; Juneu et al. 2010);
>**20% missed dust/strong continuum**
→ High [OIII]: alignments galactic disk/torus

Elliptical galaxies: low gas co
SF → alignments galaxy/torus

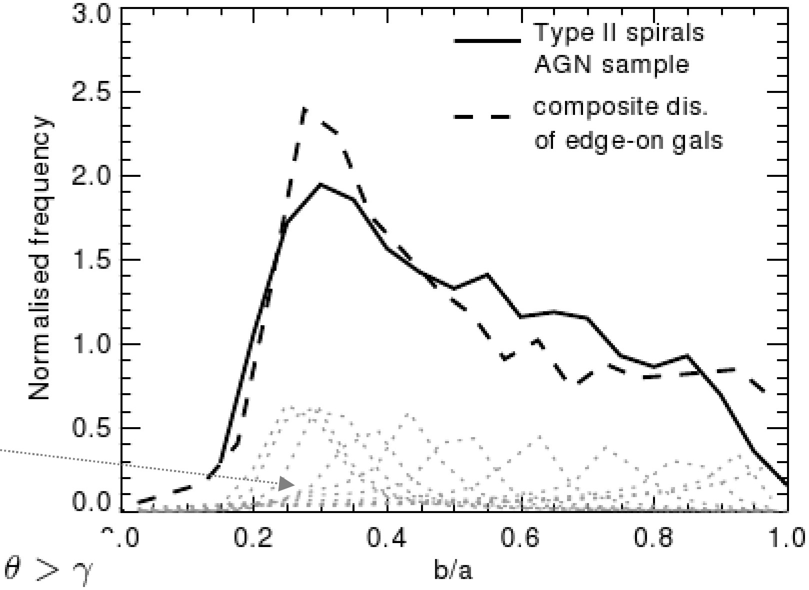


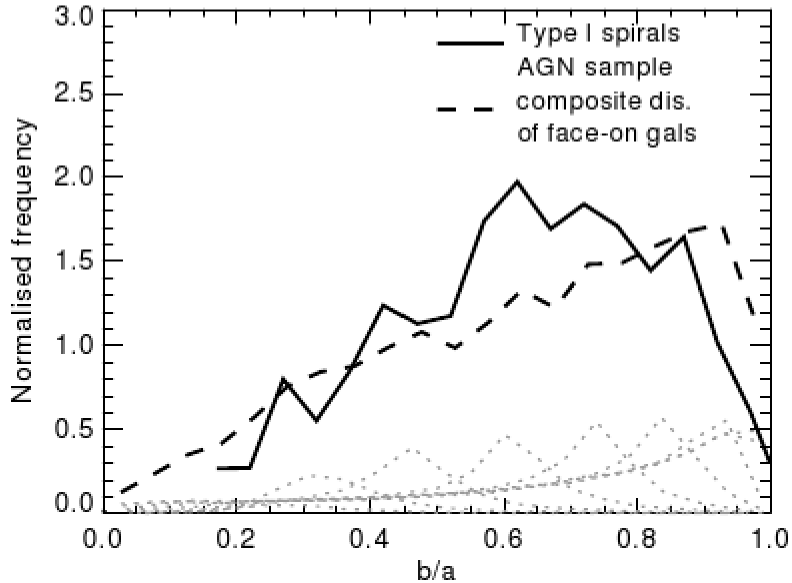


Orientation alignments:
The galactic disk is not enough to explain b/a

3D information: AGN samples at different inclination angles (θ)

$$f_{\rm cov}(\theta) = \begin{cases} f_0 \times 10^{(\gamma - \cos\theta)}, \text{if } \cos\theta > \gamma \\ f_0, \text{if } \cos\theta < \gamma \end{cases}$$



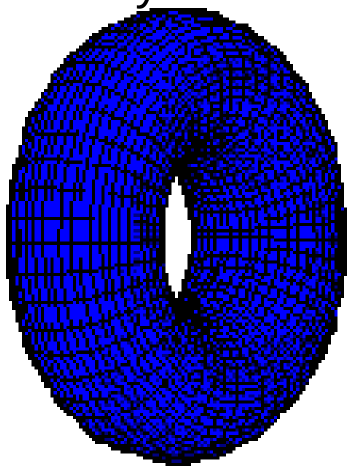


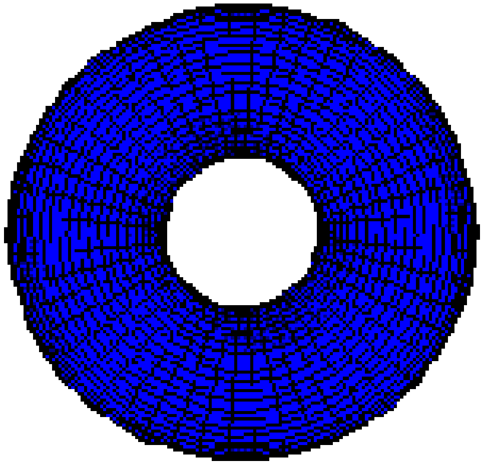
Composite b/a distribution is more edge-on (type II) or face-on (type I)

→ an 'extra' absorbing object is, at least, needed (torus)

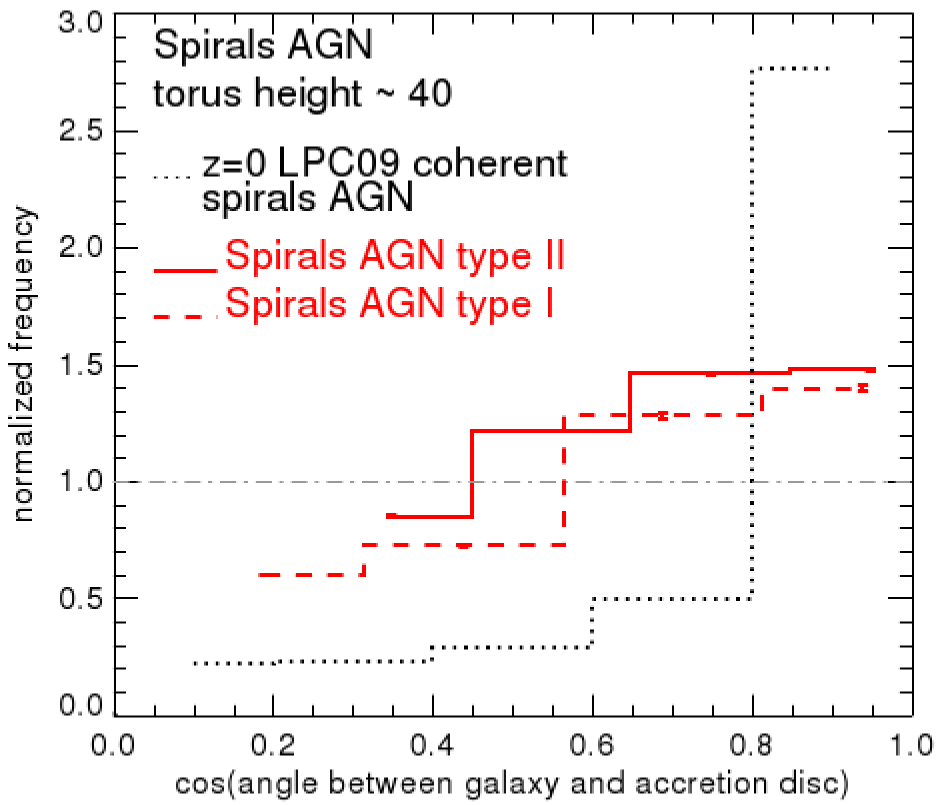
Orientation alignments:
the galaxy disc vs the torus

Seyfert II





Seyfert I



→ Similar level of alignment supports the unified AGN model
→ **'Reality' somewhere in the middle**

→ **Non-negligible degree of alignment between the obscuring torus and the galaxy**
(even after consider edge-on disk as an extra absorption object)

→ **Alignments inner AGN (jets) and galaxy (from FIRST match)**

What have we learned from this approach?

(Padilla & Strauss 2008;
Lagos, Padilla & Cora 2009;
Lagos, Padilla, Strauss, Cora & Hao 2010 soon)

→ **Type II AGN hosts → elongated objects → edge-on tendency**

→ **Type I AGN hosts → round objects → face-on tendency**

→ **Random orientations ruled-out by $\delta\chi^2>10$** for the type I spirals, type II ellipticals and subsample of high [OIII] EW type II spirals.

→ From information high/low [OIII] EW in spirals type II → **at least 20% of edge-on type II are misclassified** (composite objects, Goulding et al. 2009, 2010; Juneau et al. 2010).

→ Obscuration from the galactic disk cannot explain observed b/a distributions (also supported by ellipticals) **→ non-negligible degree of alignment between galaxy and obscuring torus (and inner AGN structure → FIRST counterparts).**

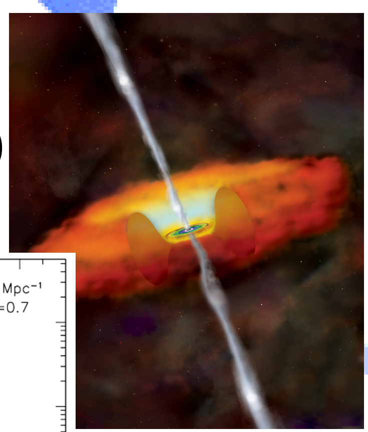
Lagos, Padilla & Cora (2009a) MNRAS, 395, 625
Fanidakis et al. (2009, arXiv:0911:1128)

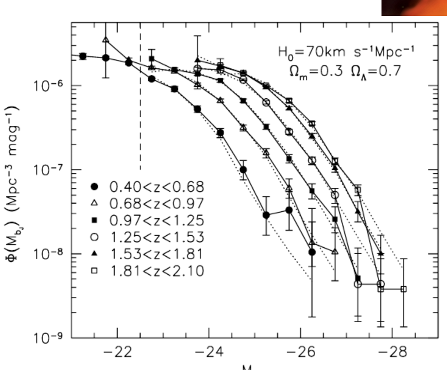
THANKS!

AEGIS mosaic

Lagos, Cora & Padilla (2008, MNRAS 388, 587)
Cattaneo et al (2008)   Somervil
et al. (2008)   Croton et al. (2006)   Bower et al. (2006

Marconi et al. (2004)
Sikora et al. (2007)

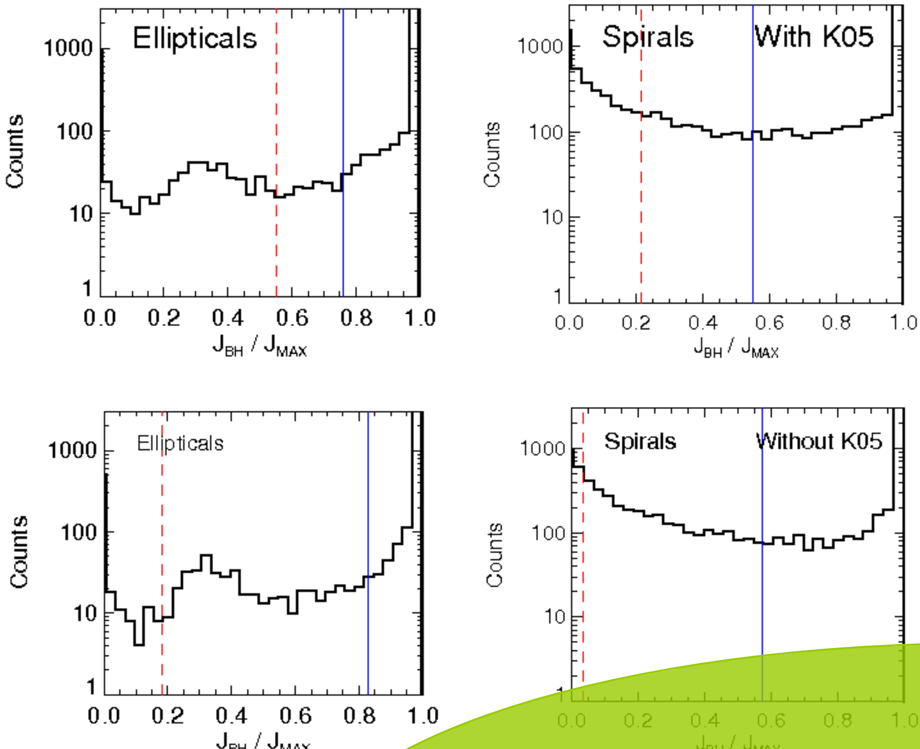


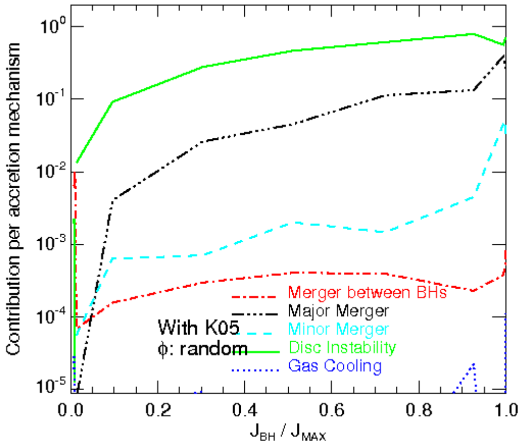


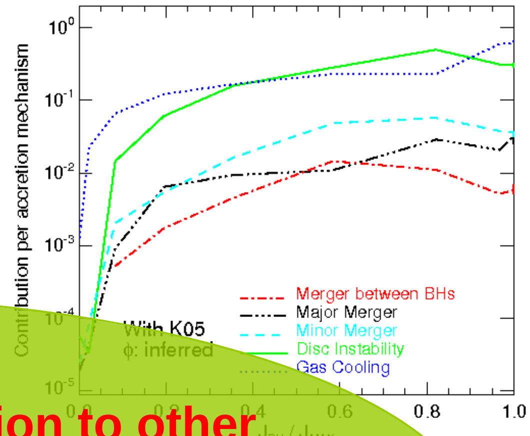
Croom et al. (2004)

Implications of such kind of alignments:
the theoretical point of view

Lagos, Padilla & Cora (2009a) MNRAS, 395, 625







Sensitivity of the spin distribution to other physical processes changes strongly under alignment assumption

→ η and jet production (e.g. Marconi et al. 2004 & Sikora et al. 2007)

Selection of control samples

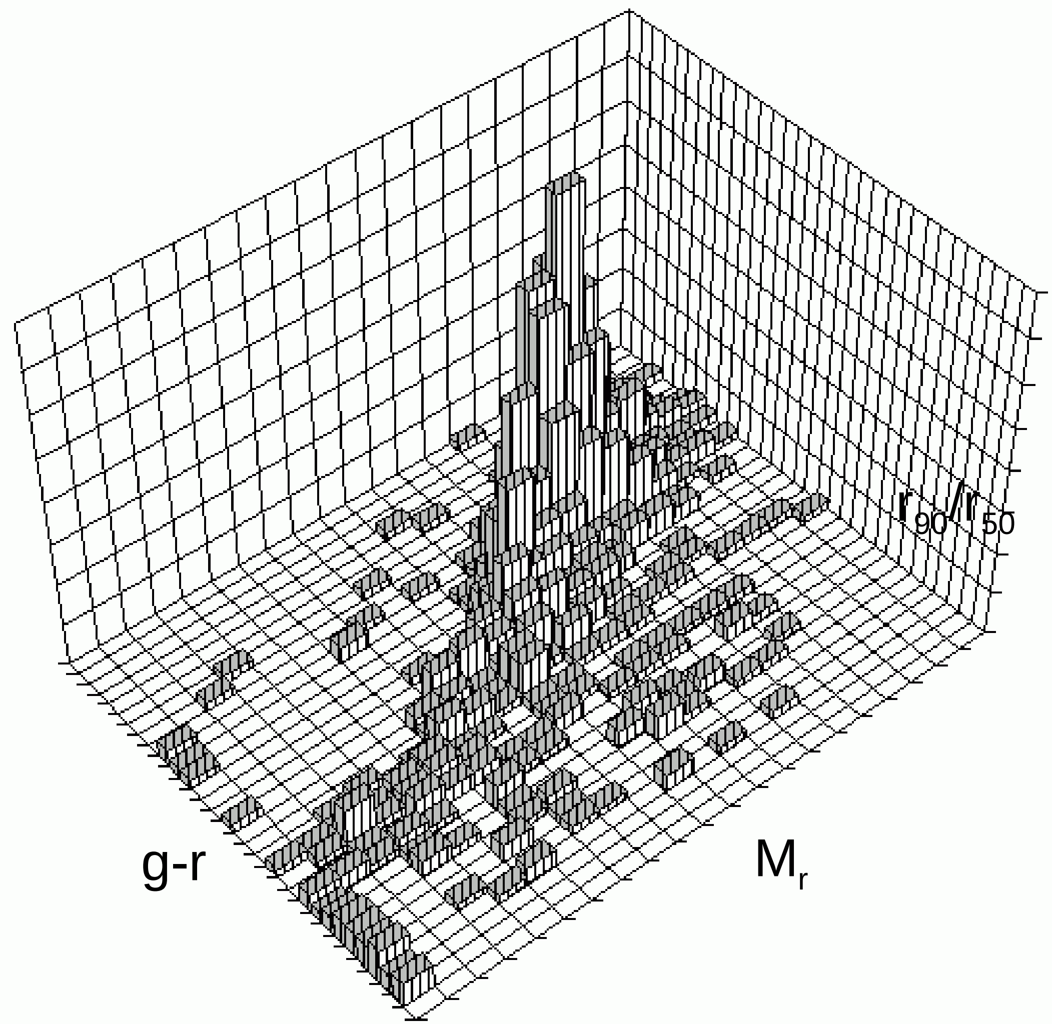
Type I → Spirals
Type I → Ellipticals

Type II → Spirals
Type II → Ellipticals

Four control samples

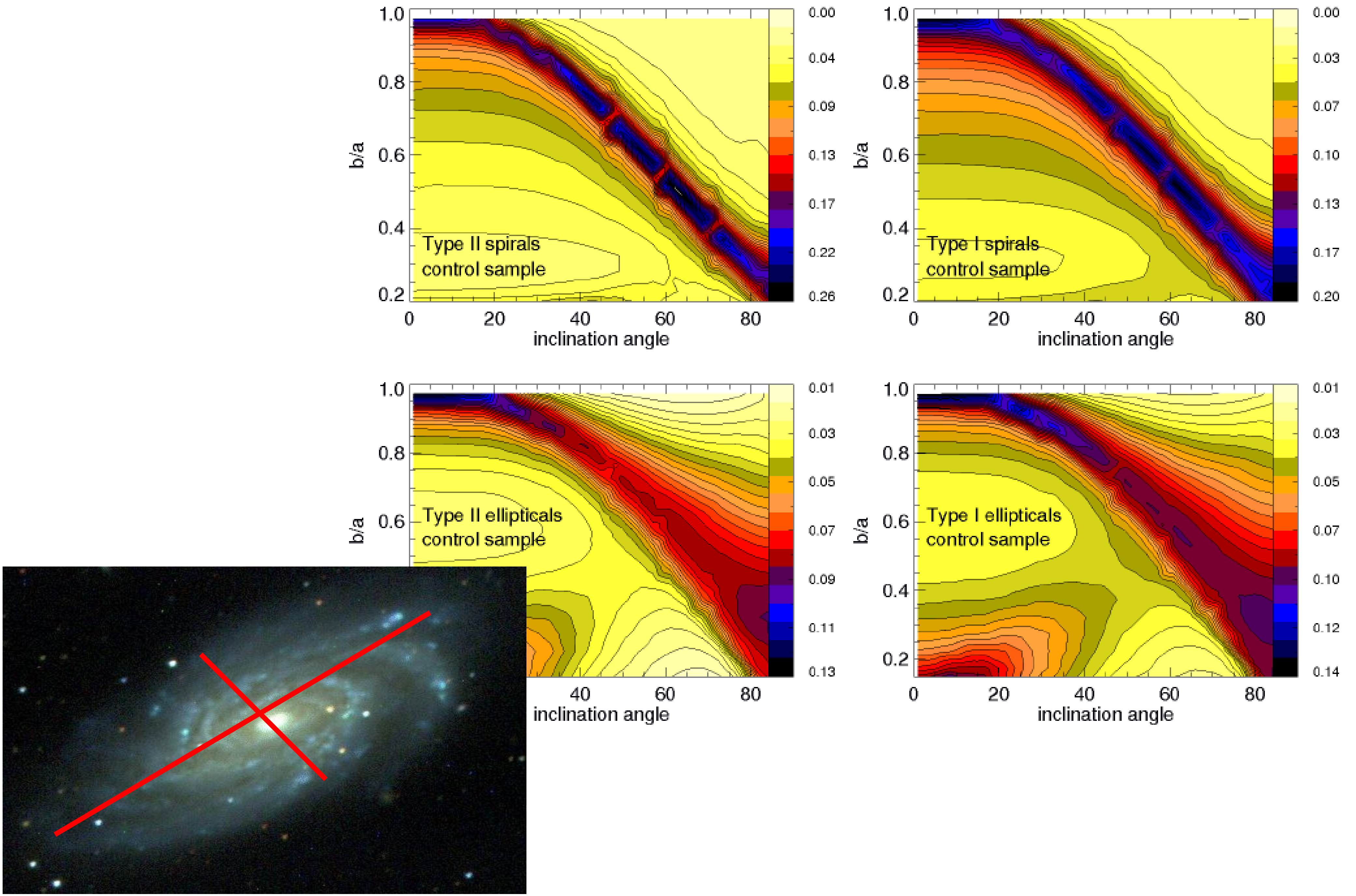
→ **morphological type**
***fracdev*≥0.9**

→ **corrected *g-r* colour**
→ **corrected M_r luminosity**
→ **light concentration r_{90}/r_{50}**

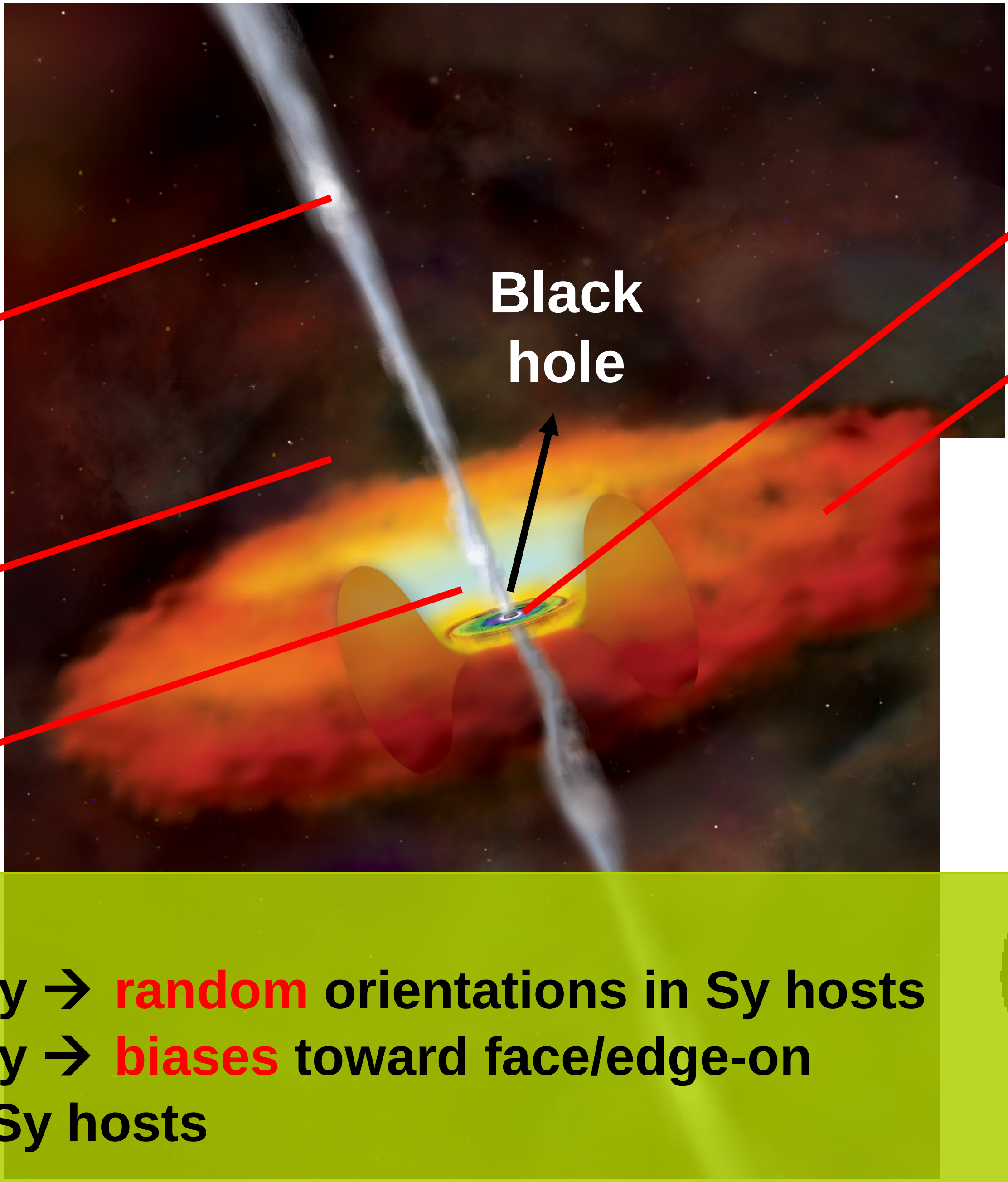


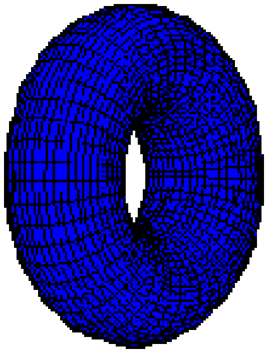
Weighted by maximum volume, V_{MAX}

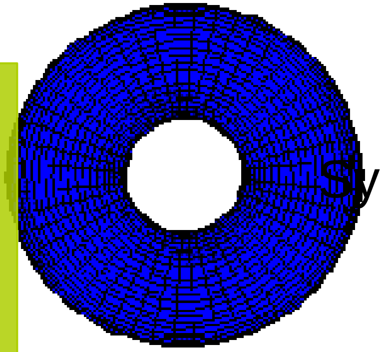
Calculation of the AGN viewing angle distribution



The unified AGN model (Antonucci 1993)



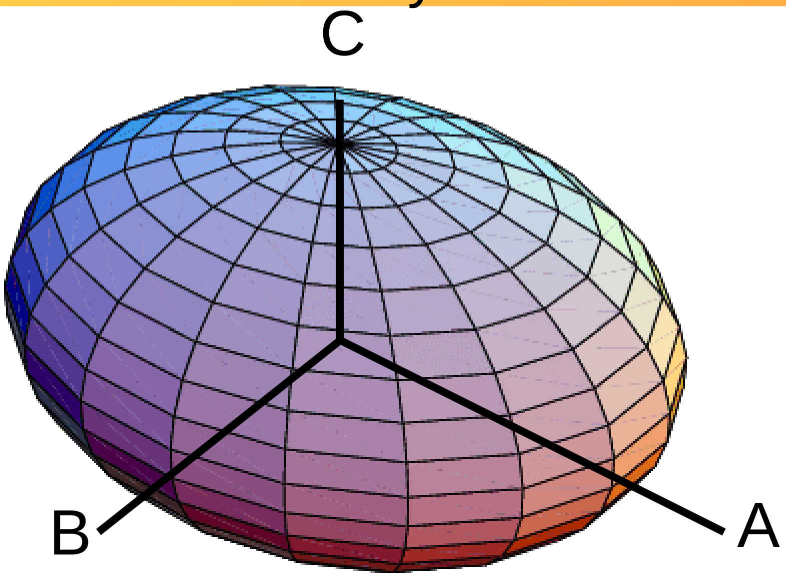


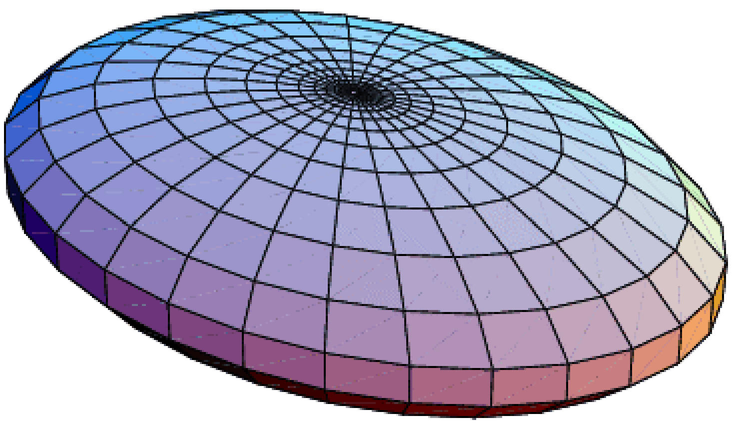


(i) AGN ≠ galaxy → random orientations in Sy hosts
(ii) AGN ≈ galaxy → biases toward face/edge-on orientations in Sy hosts

Characterization of three-dimensional shapes

Model by Padilla & Strauss (2008, MNRAS, 388, 1321)



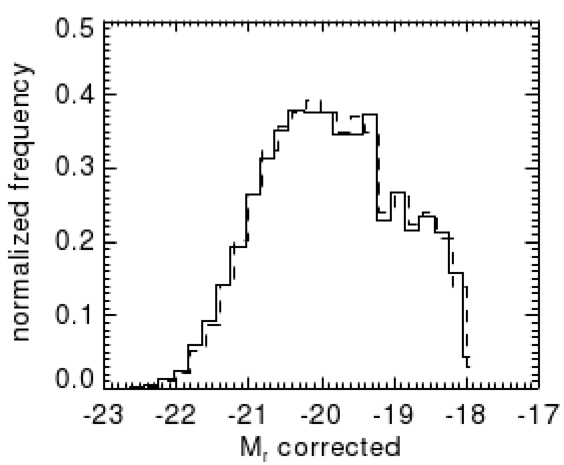


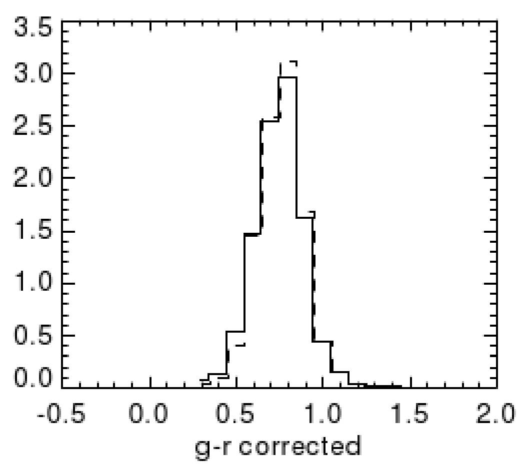
Population → $\log_{10}(1- B/A)$ → gaussian μ σ

→ 1-C/B → gaussian [γ, σγ]

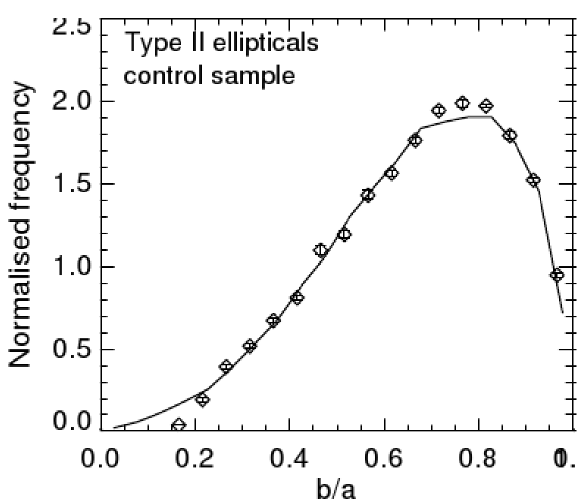
→ Median extinction (spirals) → E_0

Inputs:

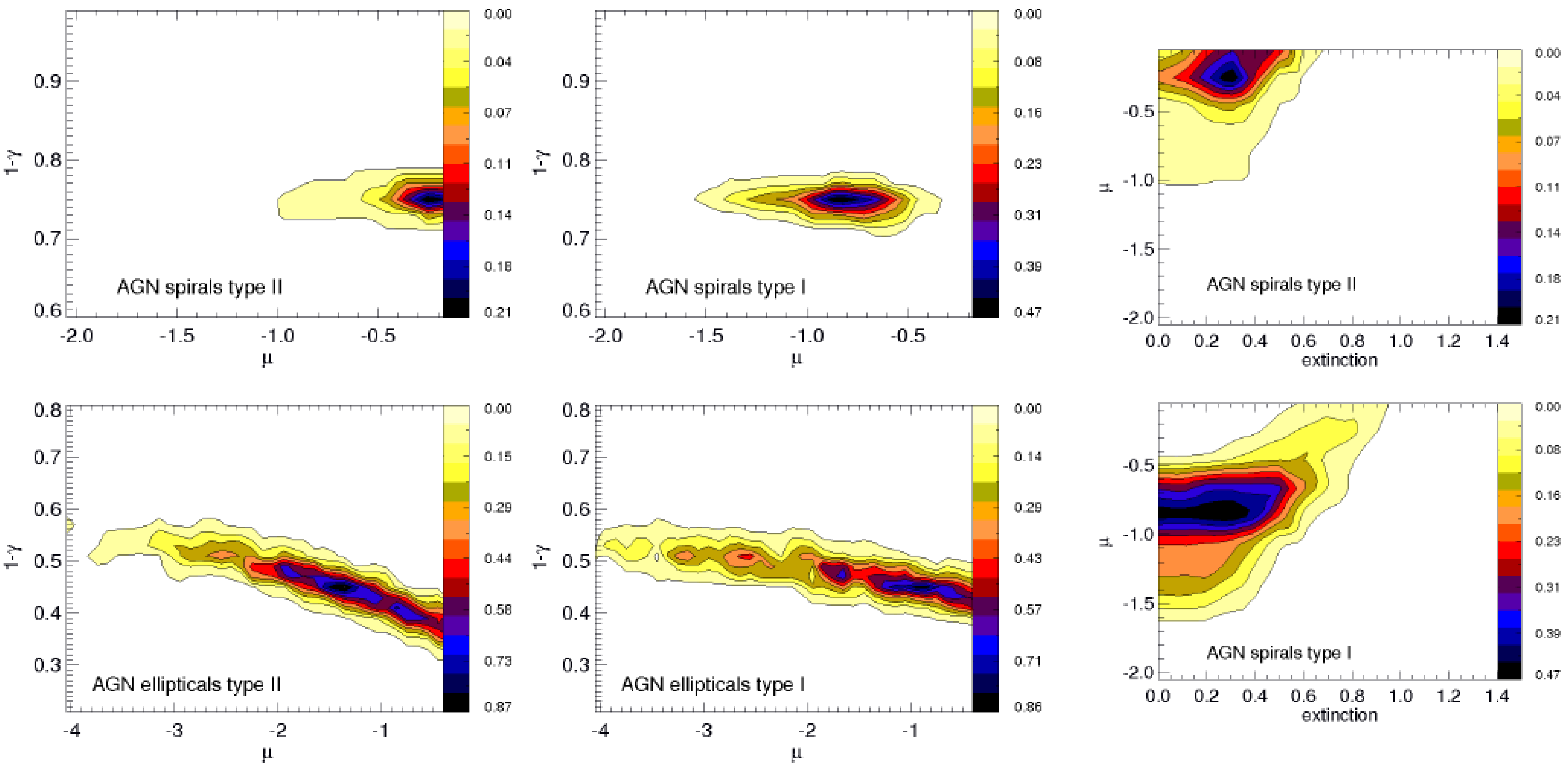




$\xrightarrow[\chi^2]{\psi(\theta)}$



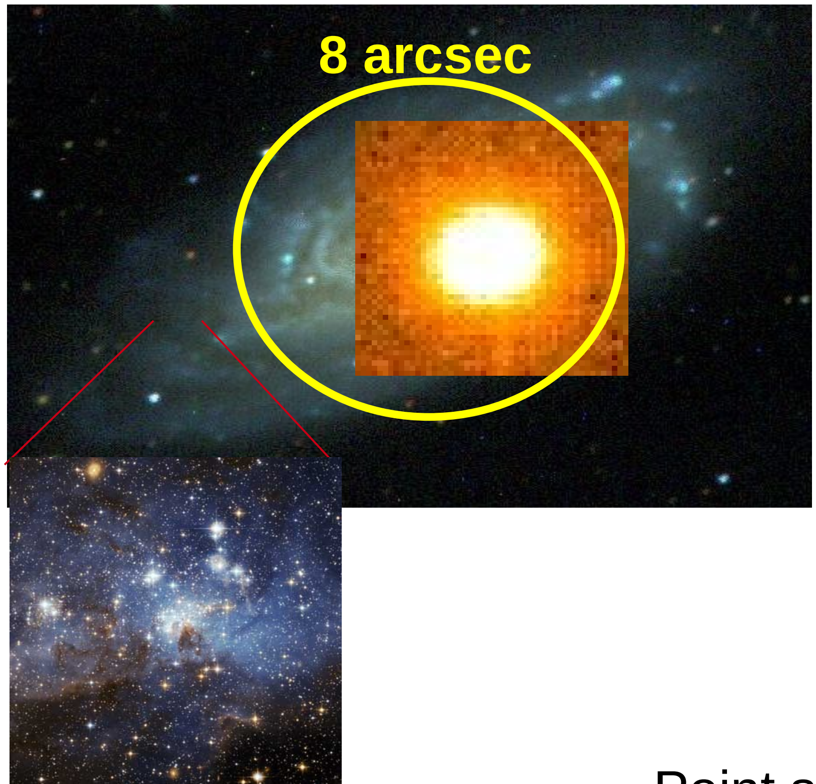
Degeneracy of structural parameters

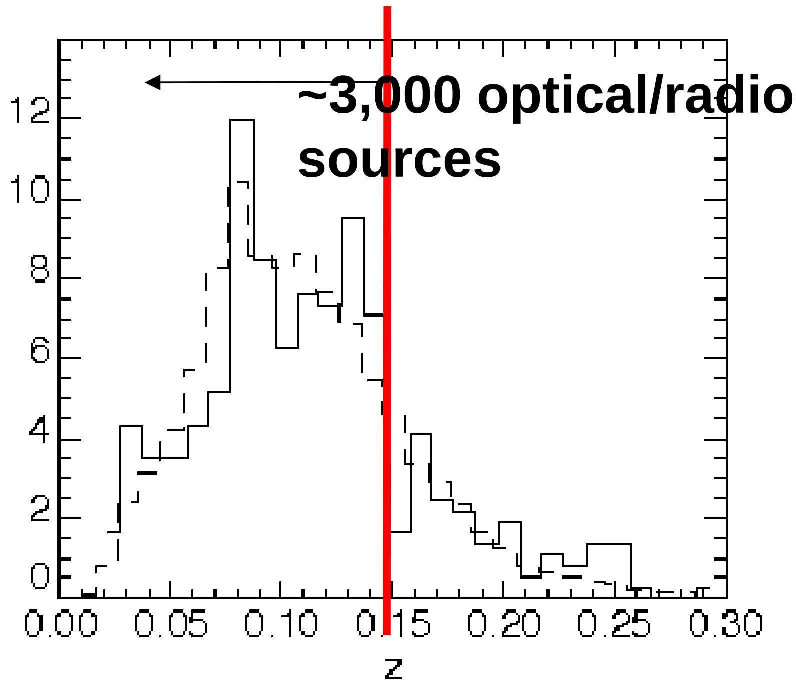


Spirals/Elliptical type I/II have consistent shapes → morphology is the main parameter instead of Seyfert type

Orientation alignments:
the galaxy vs radio jets

→ Match between our optical Seyfert galaxies with the FIRST radio survey





→ **Optical/Radio All Sy**

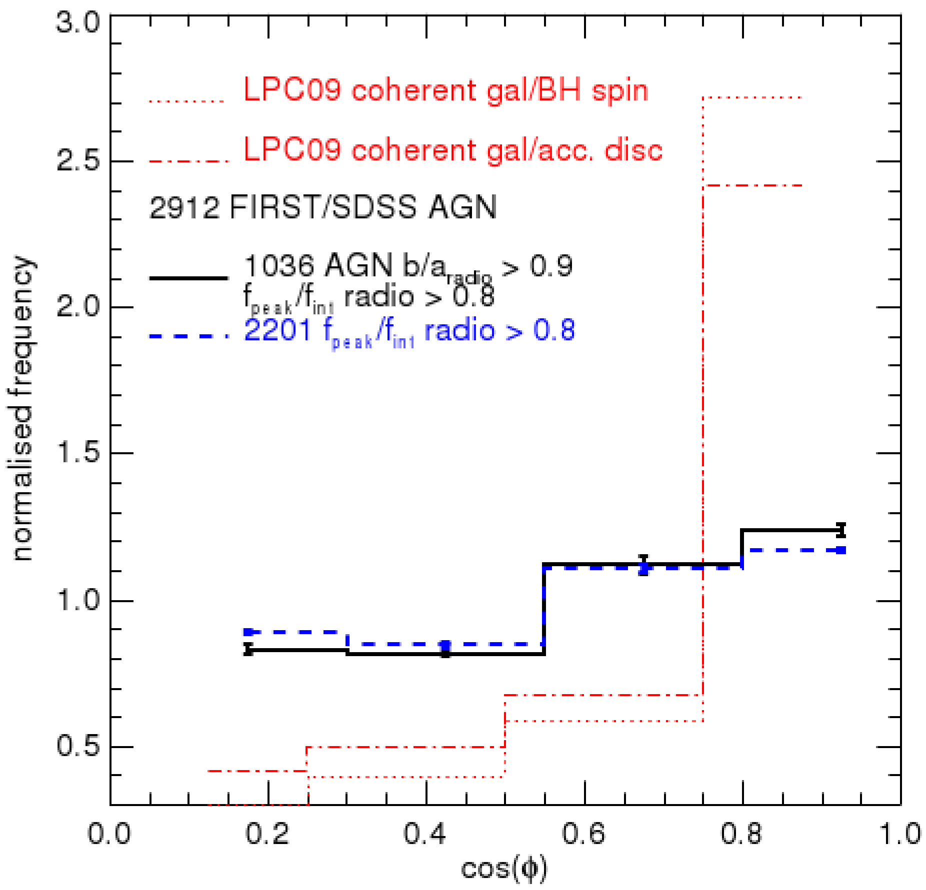
Point sources

→ **jets emitted close the line of sight**

→ Fpeak/Fint$_{radio}$ > 0.8

→ + fitted b/a$_{radio}$ > 0.9

Orientation alignments: the galaxy vs radio jets

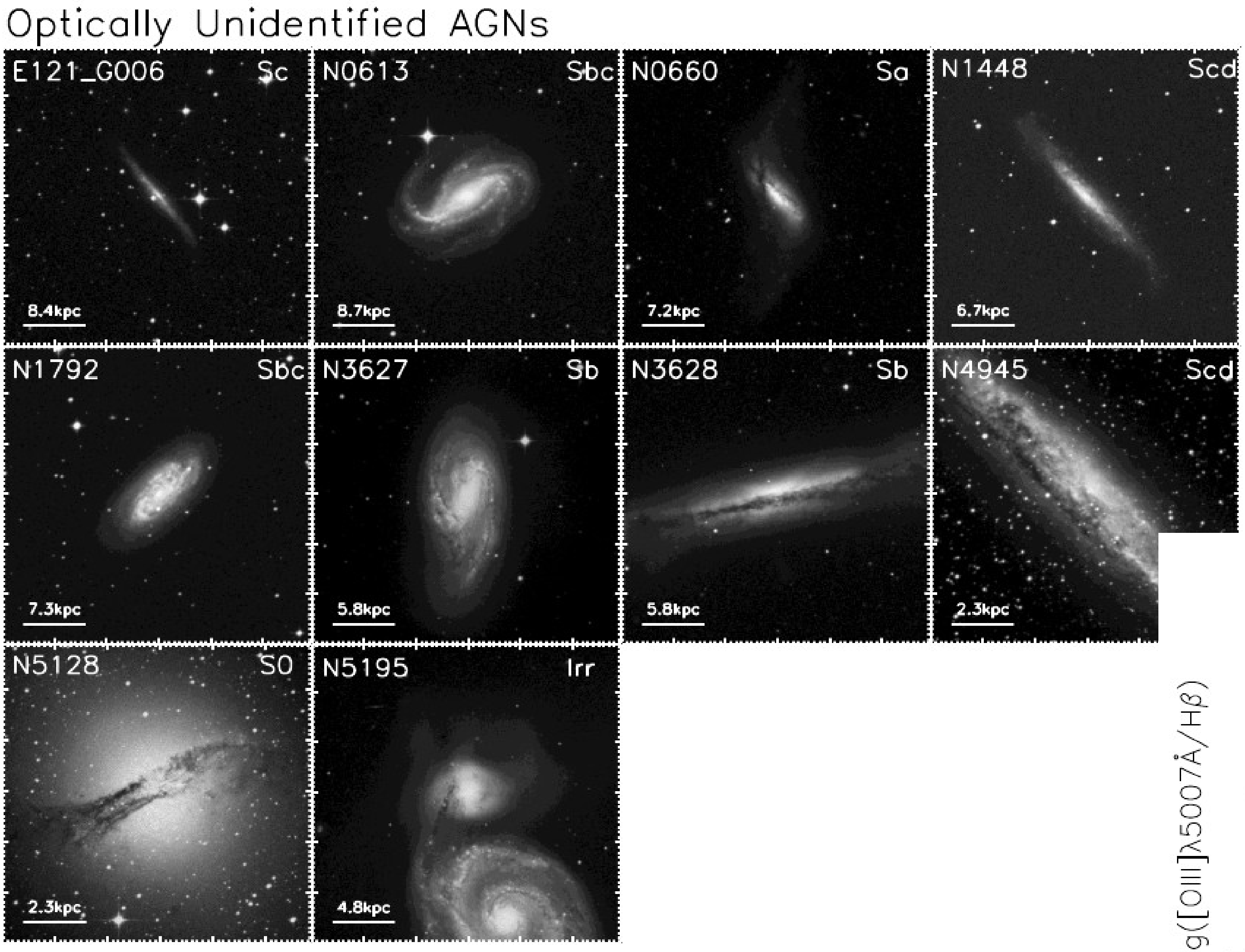


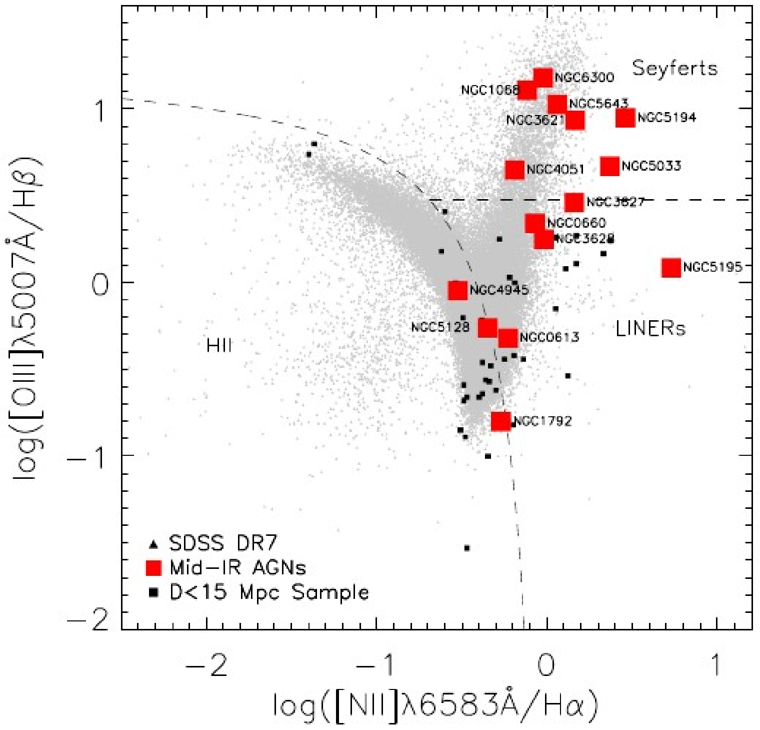
~ orientation of optical sources

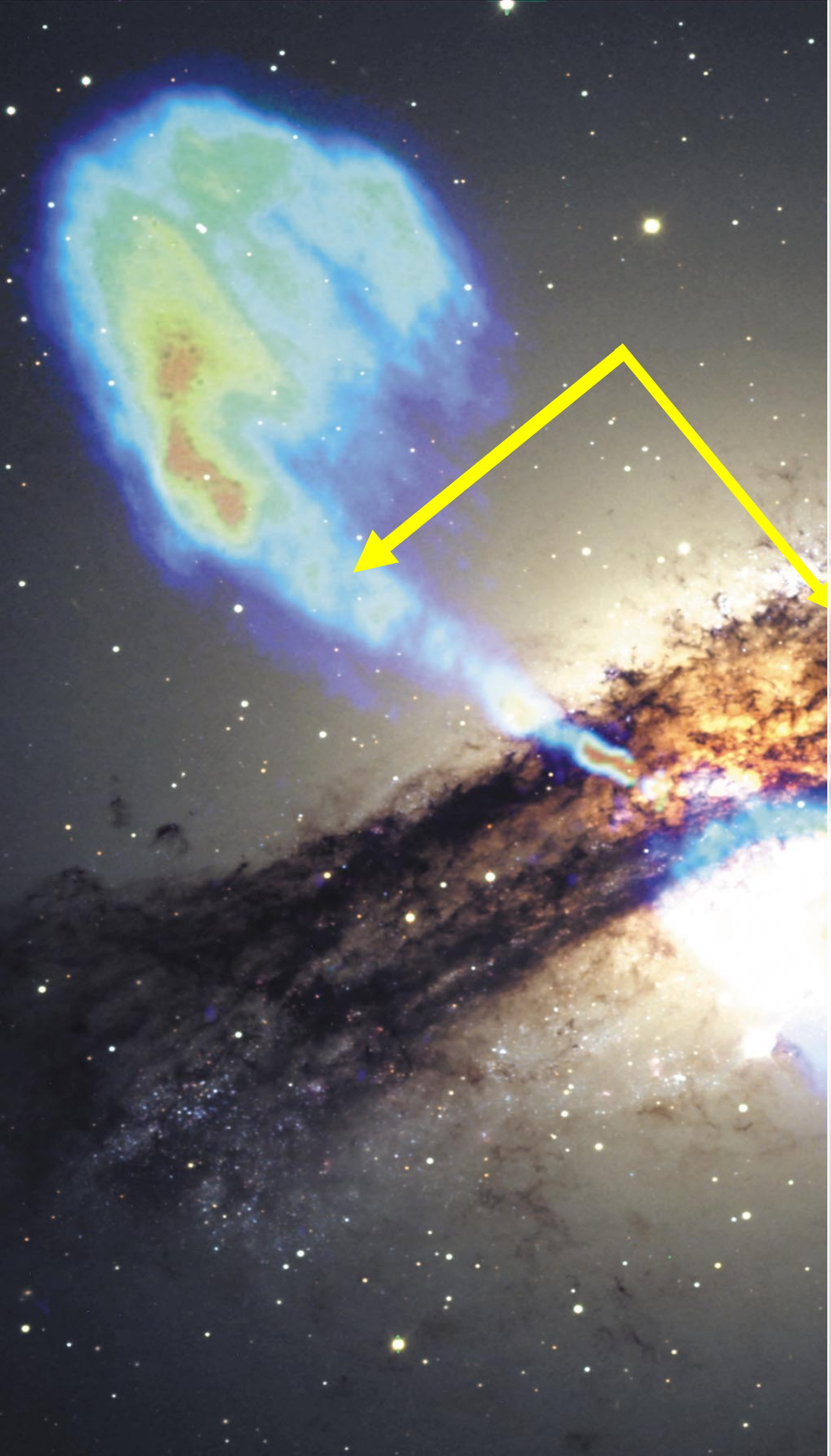
Face-on tendency is conserved! $\delta\chi^2 \sim 100$

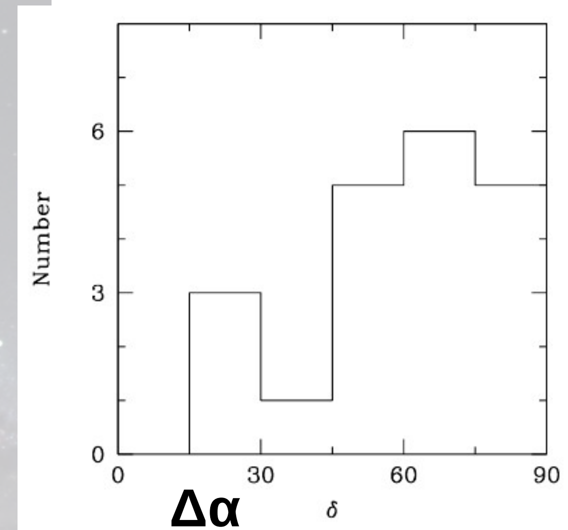
→ radio jets in the line-of-sight → alignment galaxy/jets

Obscuration from the galactic disk (Goulding & Alexander 2009)



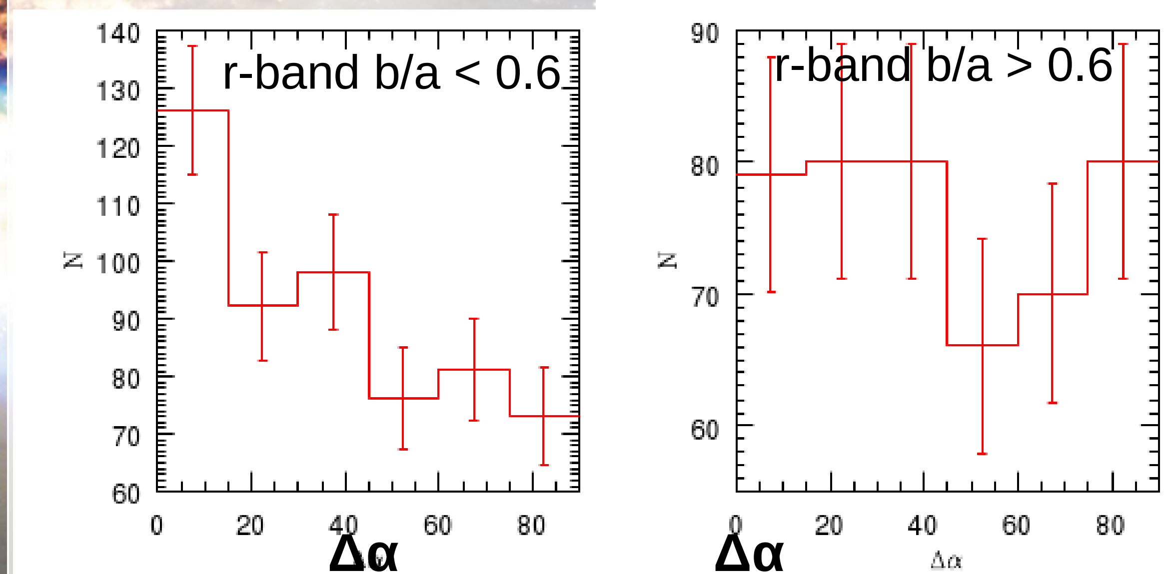






Schmitt et al. (2002): 20 radio galaxies → dust disc vs radio jets

Kinney et al. (2000), Greenhill et al. (2009)



Battye & Browne (2009): 14,300 optical/radio galaxies → optical light vs radio jets

Dumas et al. (2007)