Detectability of Galaxies with Gaia

Christine Ducourant, LAB, Bordeaux

DPAC - DU470 Team :

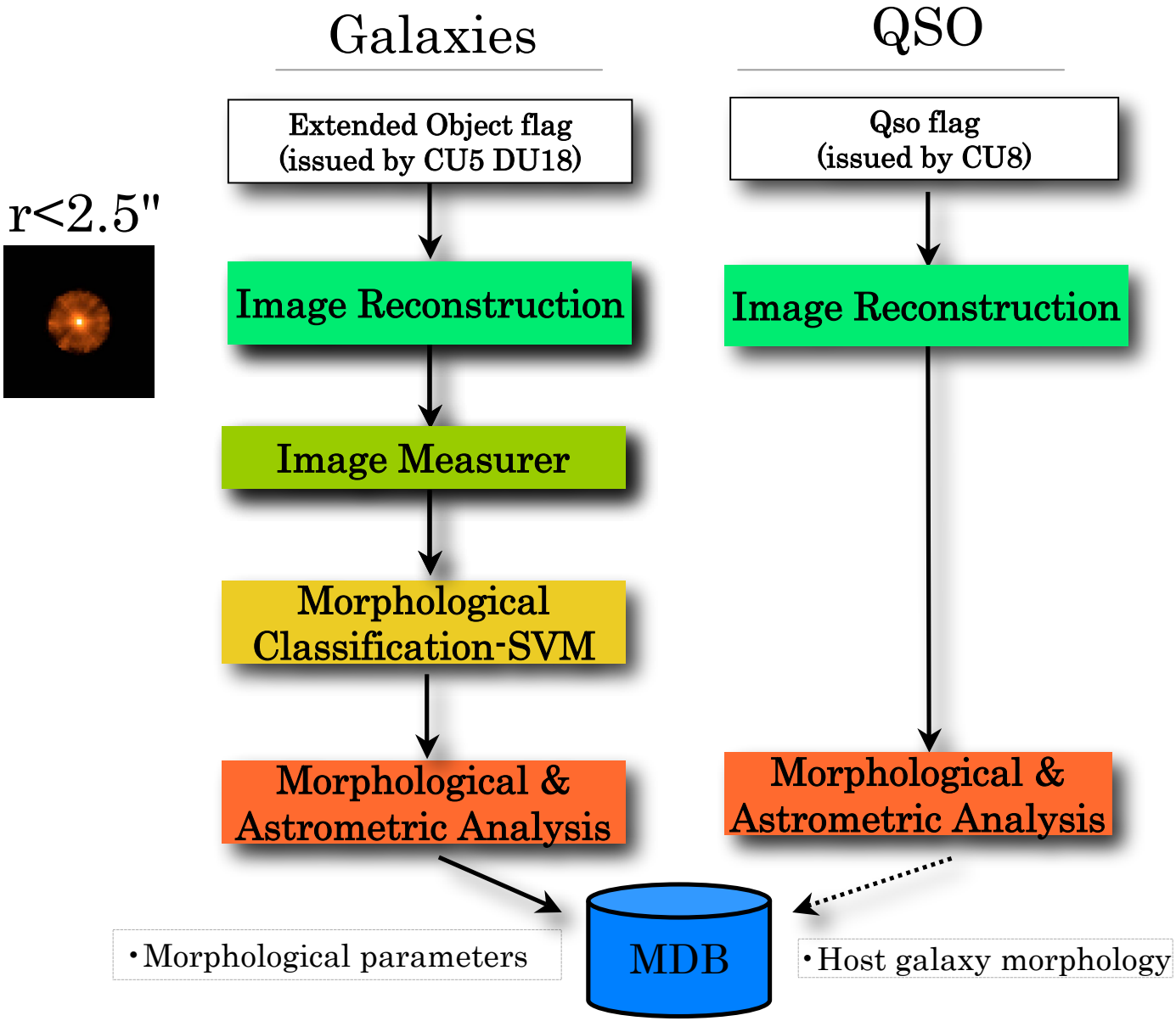
Bordeaux/Lisboa/São Paulo
- F. Billebaud
- C. Ducourant
- A. Krone-Martins
- R. Teixeira
- S. Dos Anjos
- R. De Souza

Toulouse CNES
- G. Prat

Nice
- L. Galluccio
- C. Ordenovic
- A. Bijaoui

Paris
- P. Gavras

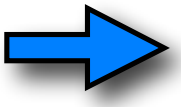
DU470 - Extended Objects treatment



Questions

- How many Galaxies to process ?
- Which types of galaxies in which proportions?
- Is the structure of QSO's host galaxy detectable ?

Outline



•What is up there : GUMS (Gaia Universe model Snapshot) ?

Plan

- What is up there : GUMS (Gaia Universe model Snapshot) ?
- What can be detected (theory+photometry) ?

Plan

- •What is up there : GUMS (Gaia Universe model Snapshot) ?
- •What can be detected (theory+ photometry) ?
- • What should be detected after onboard VPA (Video Processing Algorithm) selection ?

Plan

- •What is up there : GUMS (Gaia Universe model Snapshot) ?
- •What can be detected (theory+photometry) ?
- • What should be detected after onboard VPA (Video Processing Algorithm) selection ?
- • Structure of host galaxies of QSOs detectable ?

What is up there ?

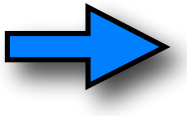
(GUMS : Gaia Universe model Snapshot)

How frequent are galaxies (GUMS)?

(P. Gavras)

- Gaia Universe Model Snapshot (*Robin et al. 2012*)
  - Stuff (catalogue generation) and

(codes from *Bertin (2009)*, adapted to Gaia by *Dollet (2004)* and *Krone-Martins et al. (2008)*)

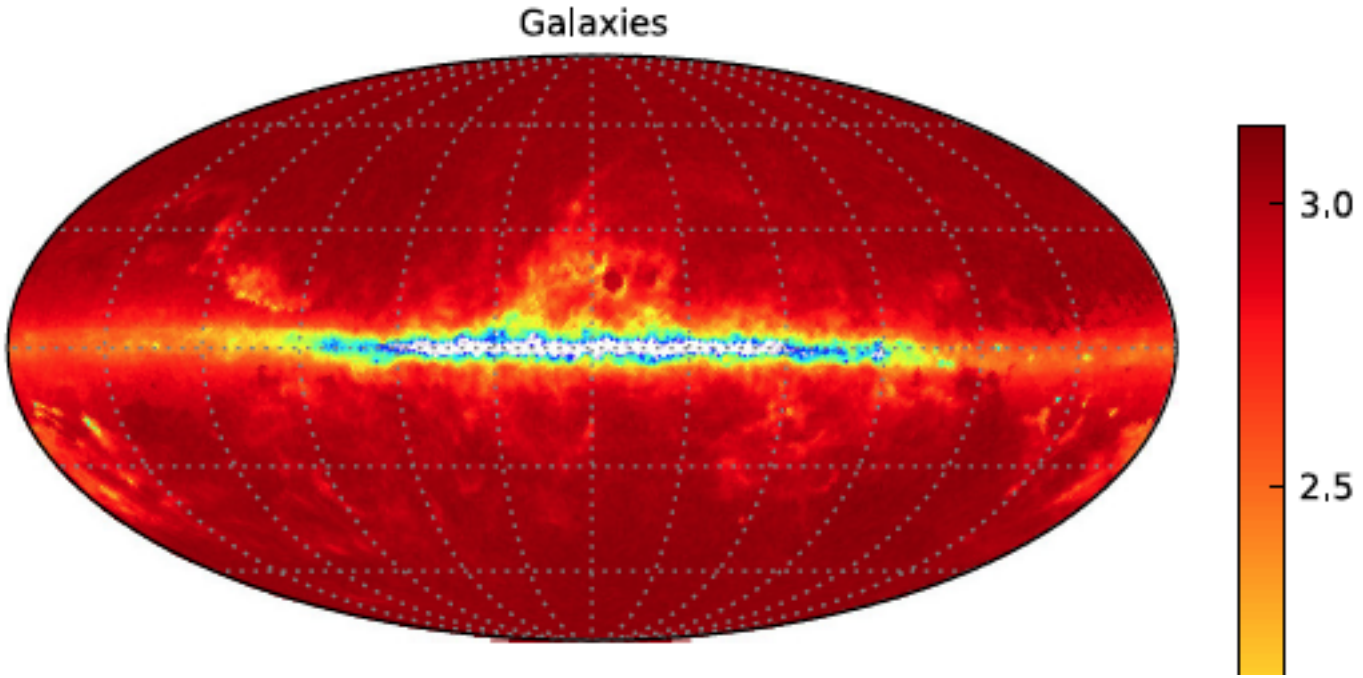


- 38 M gal
- G<20

- Position
- Mag, V-I
- B/T
- Disc size
- Bulge size
- Bulge flatness
- Redshift
- Position angle

Spatial distribution (GUMS)

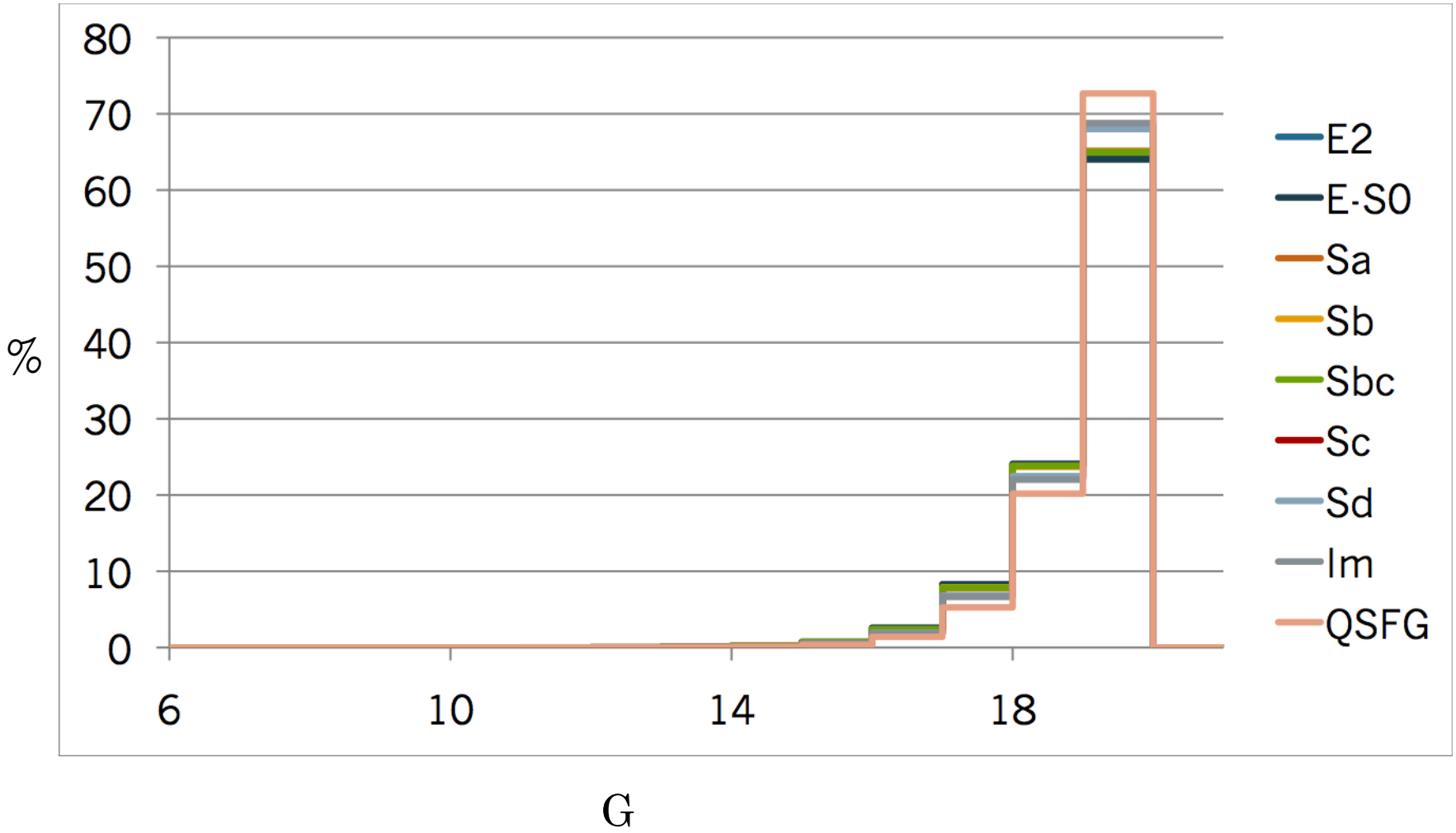
2D uniform distribution



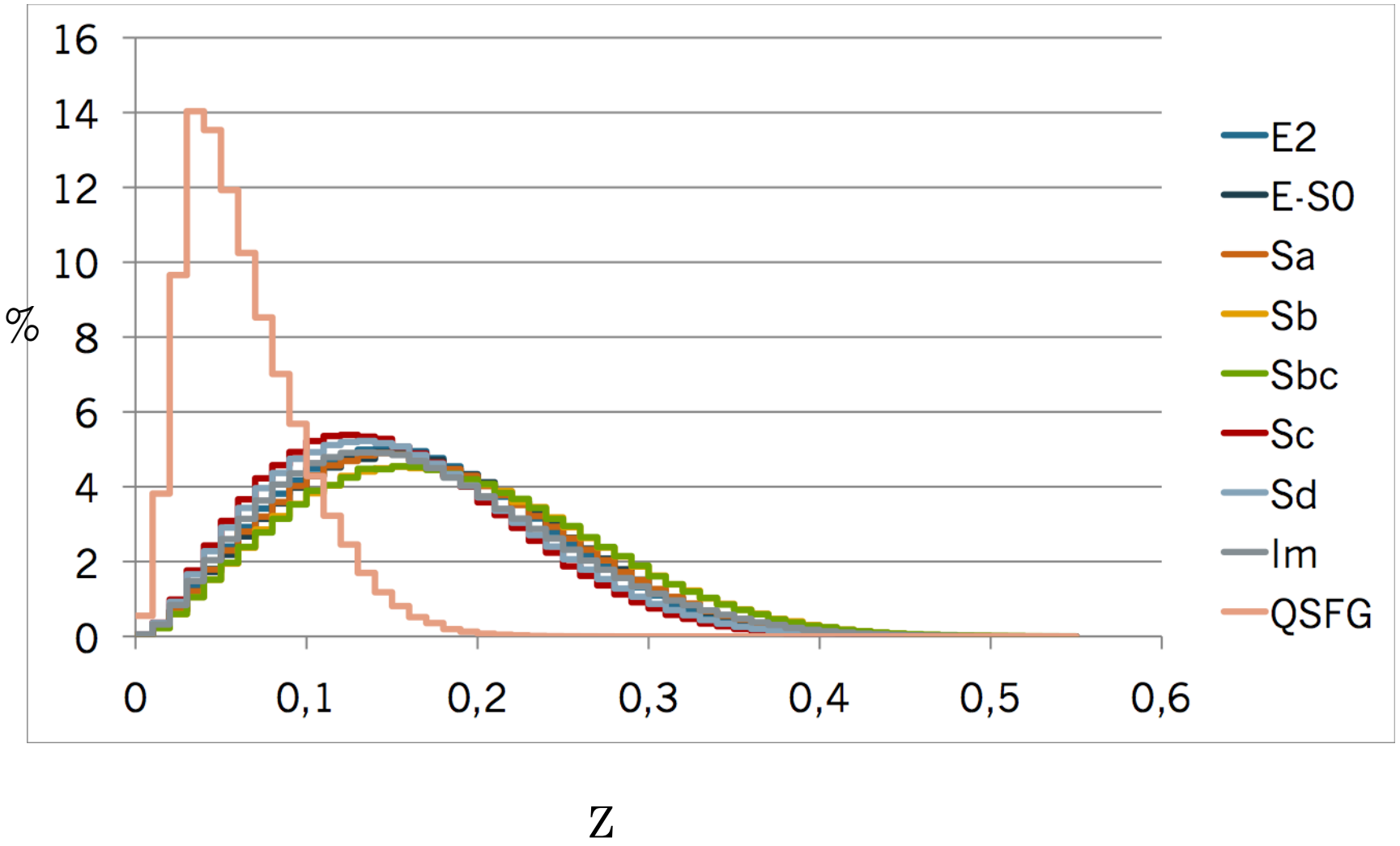
Log_{10}(Nb/square degree)

Robin et al. 2012

Magnitude (GUMS)

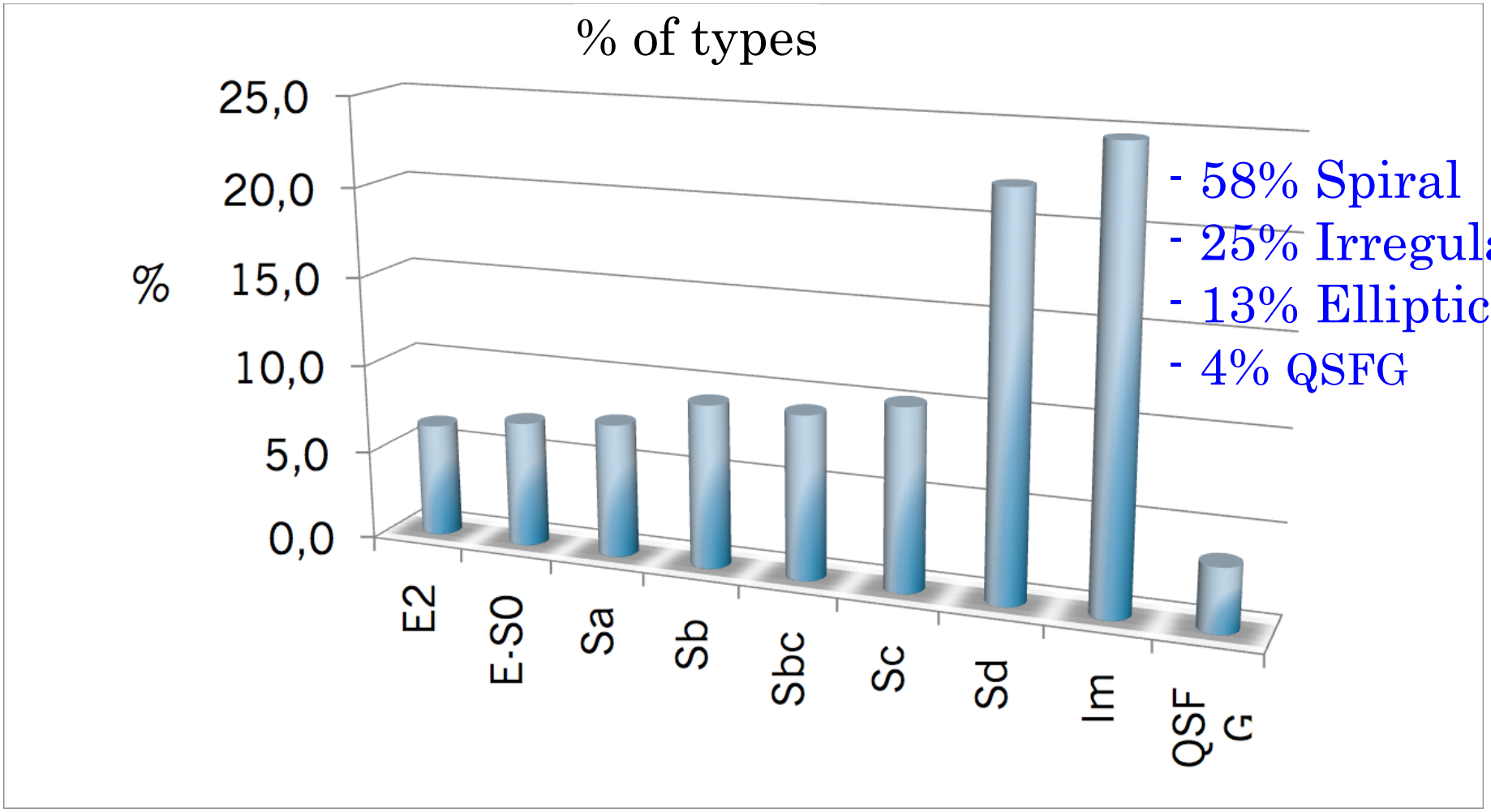


Redshift (GUMS)

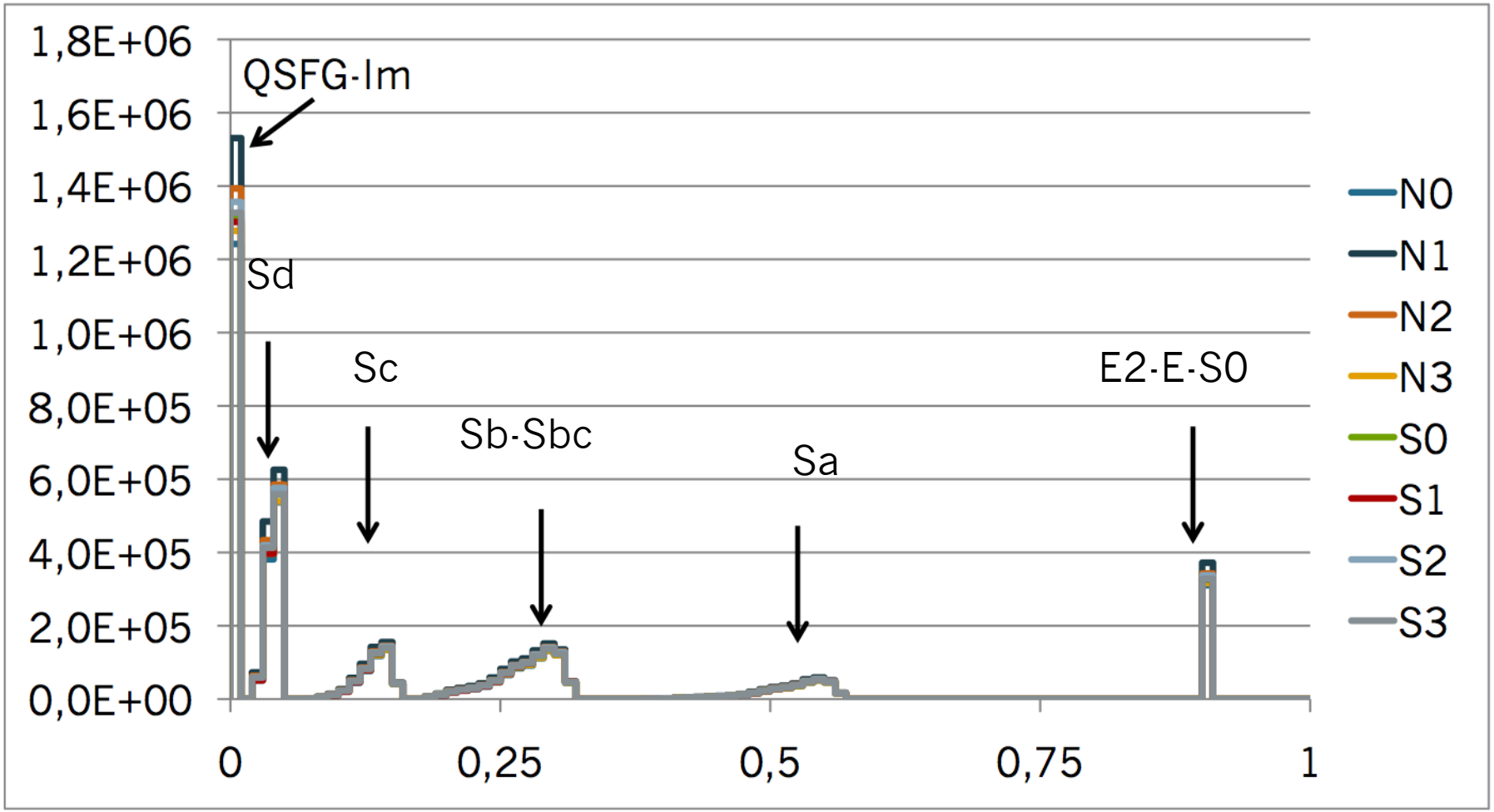


Hubble types (GUMS)

Number density distrib in each Hubble type (Schechter's LF) *(Fioc & Rocca-Volmerange 1999)*

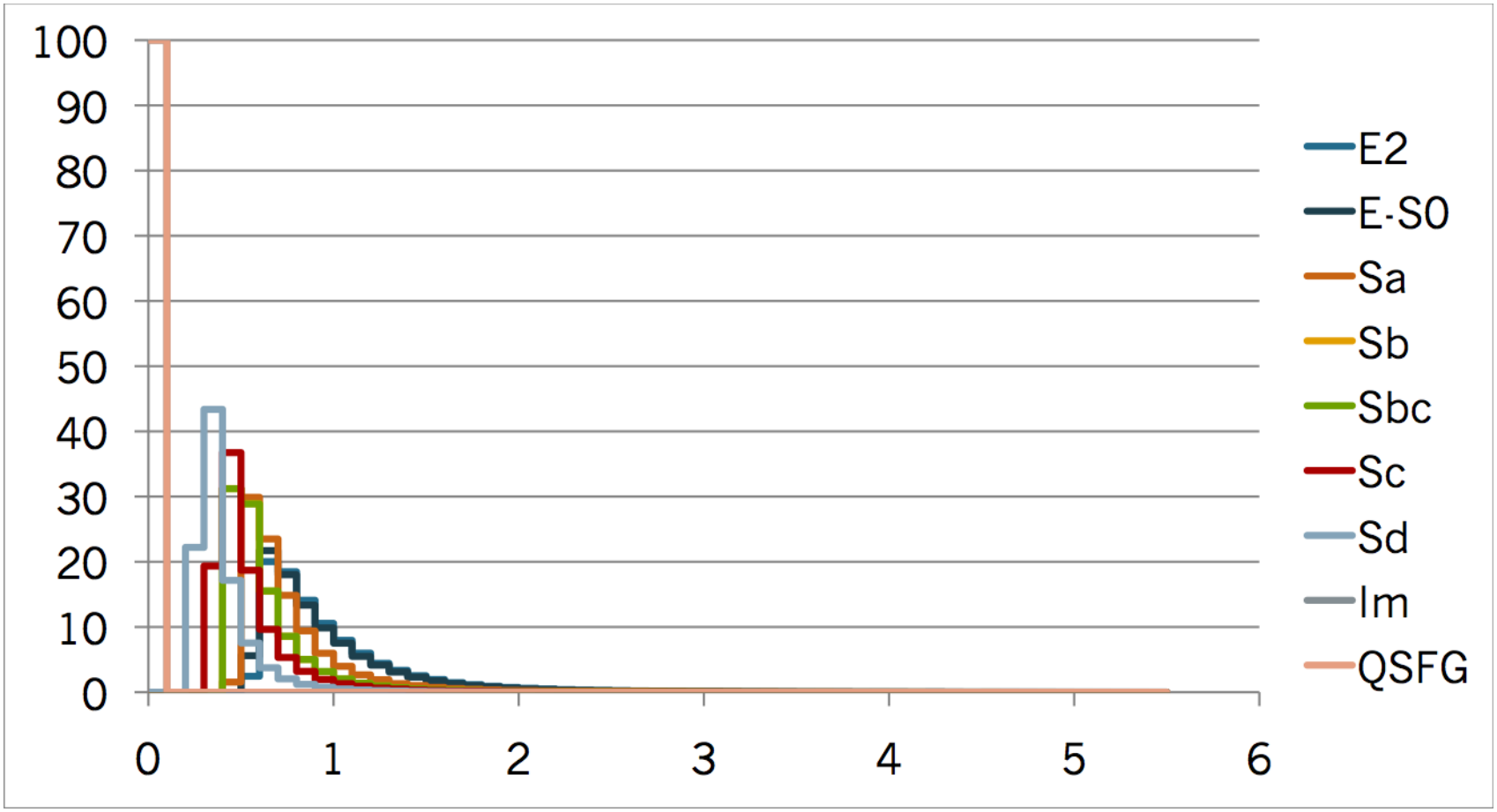


Bulge to galaxy flux (GUMS)



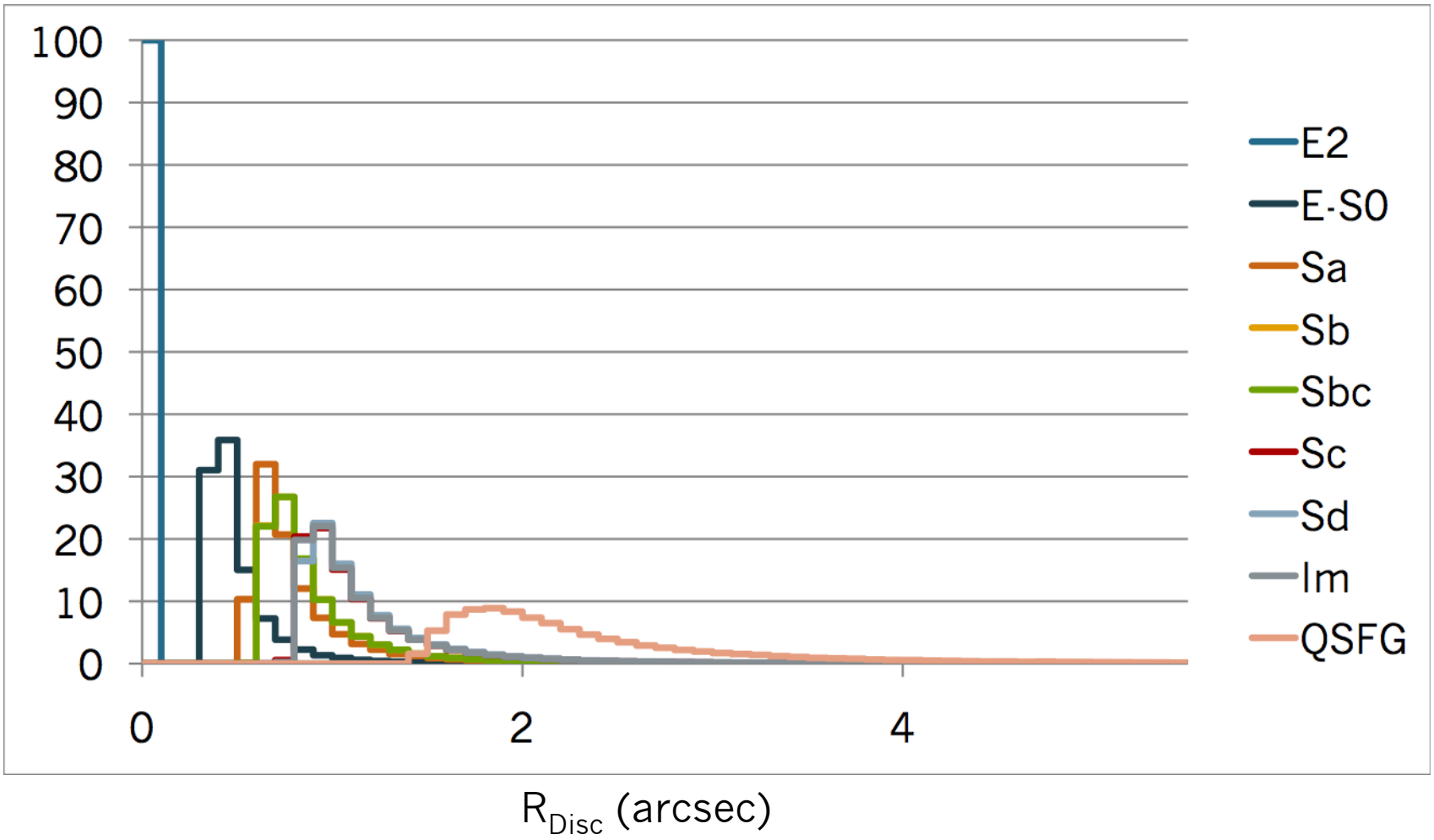
Bulge to galaxy flux

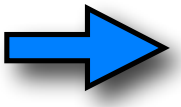
Bulge radius (GUMS)



R_{Bulge} (arcsec)

Disc radius (GUMS)





- 38 M galaxies
- Different spread of light

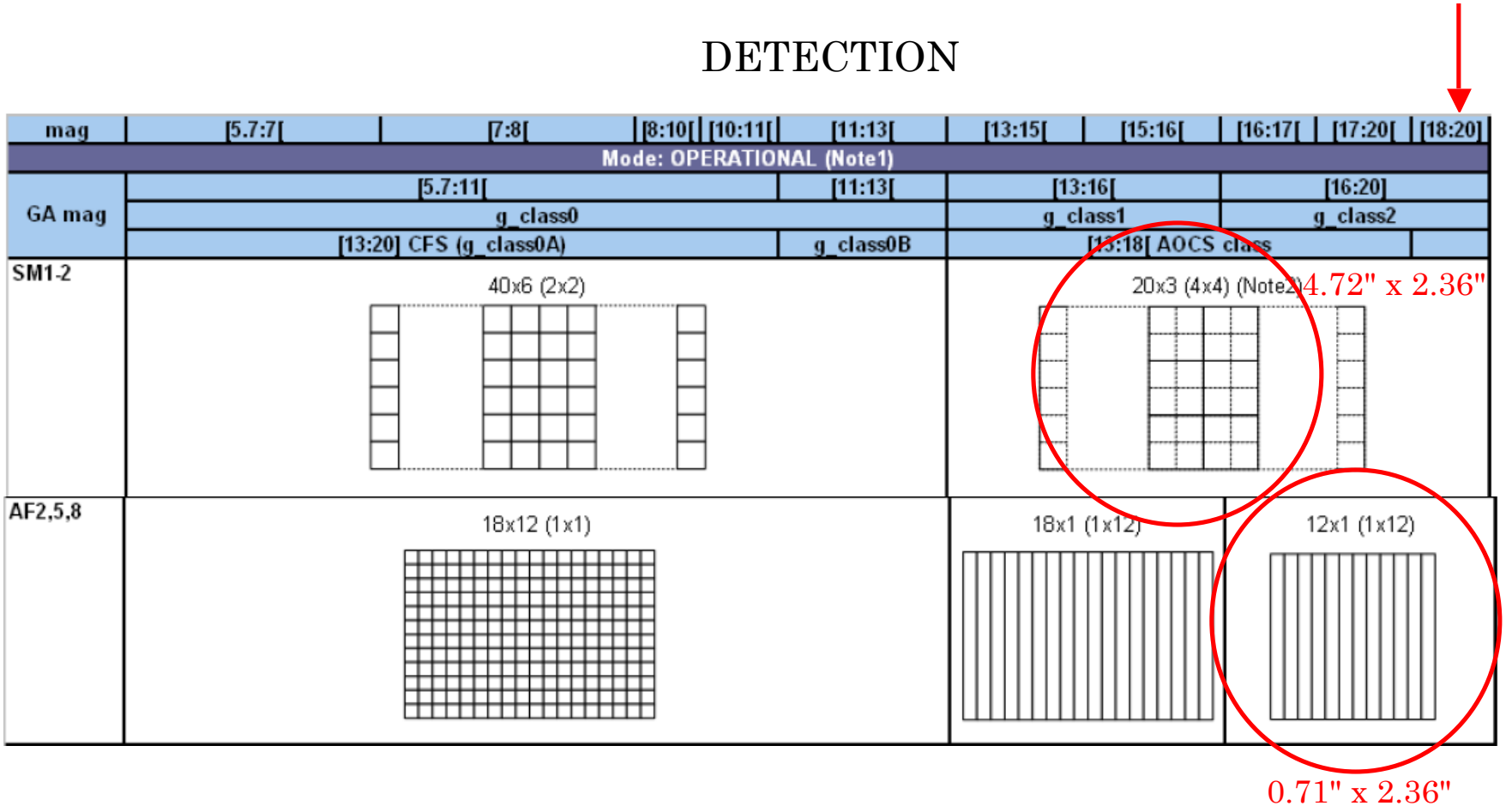
  --> detection
- $R_{Bulge} < 2''$
- $R_{disc} < 3''$

  --> morphologic analysis possible by DU470

What can be detected ?

(photometry + theory)

What can be detected by Gaia?



Detection if signal sufficient in at least 1 AF pixel and profile almost point-like

What can be detected by Gaia?

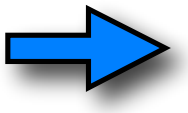
(R. De Souza, S. dos Anjos, R. Teixeira)

◆Surface brightness :

$$\mu = m + 5\log_{10}(R_e) \qquad (\text{mag/arcsec}^2)$$

◆ Gaia detection limitations :

- AF pixel size : 0.060" x 0.180 "
- G_{lim} = 20 mag



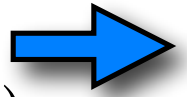
Limiting Surface Brightness

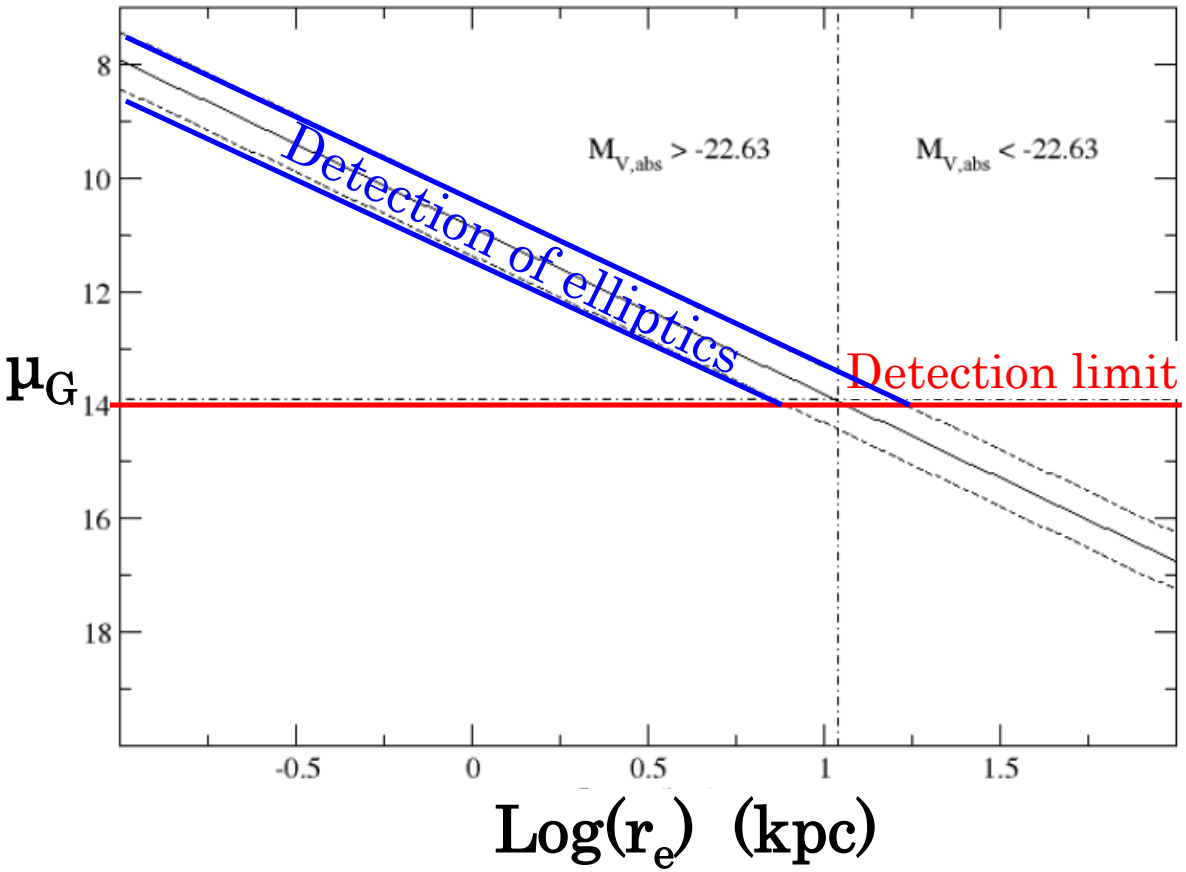
$$\mu_{G\ lim} \sim G_{lim} + 5\log_{10}(0.060)$$

$$\mu_{G\ lim} \sim 14.0\ (\text{mag/arcsec}^2)$$

Detection if $\mu < \mu_{G\ lim}$

What can be detected by Gaia?

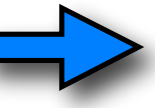
- Elliptical + Sb, Sa, S0 :  $9.4 < \mu_G < 17.4$ (mag/arcsec^2)
  - De Vaucouleur profile ($r^{1/4}$)



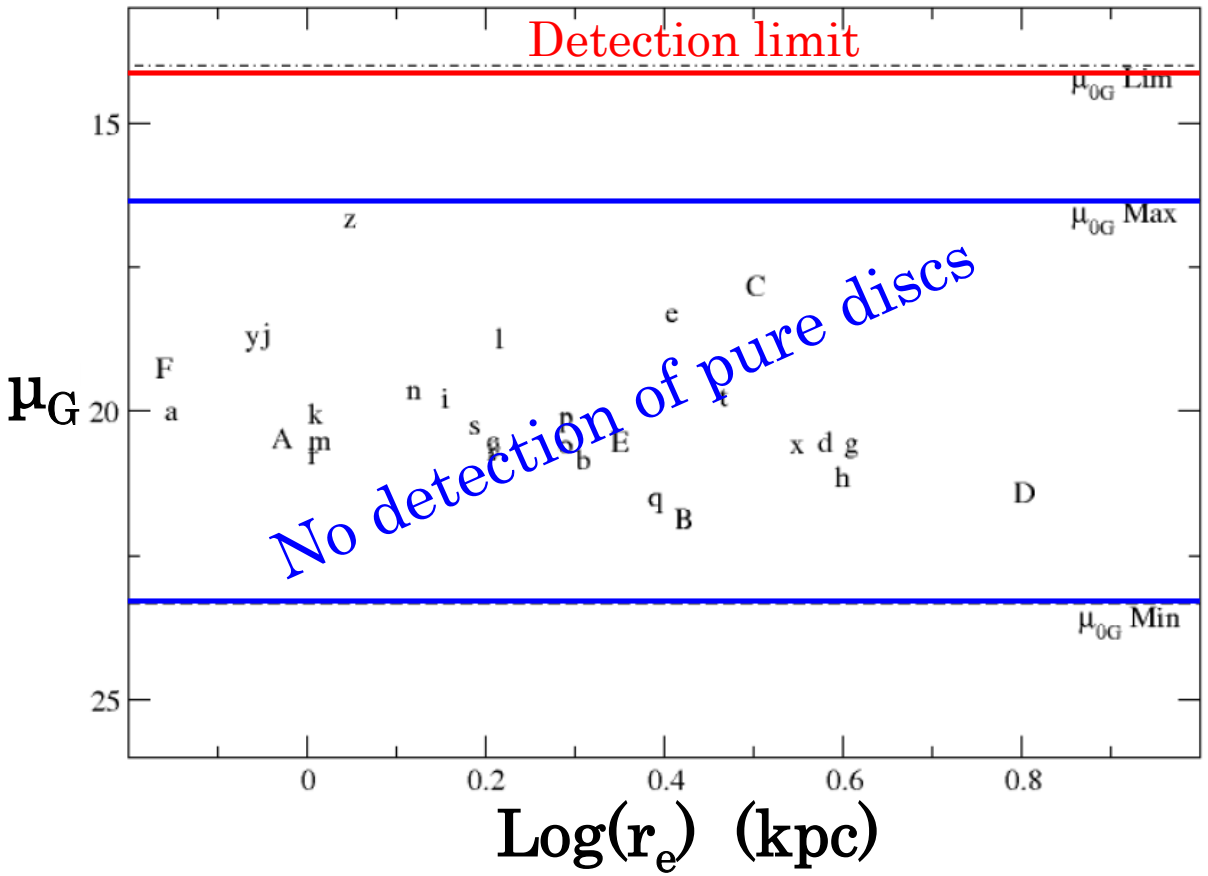
Small galaxies

What can be detected by Gaia?

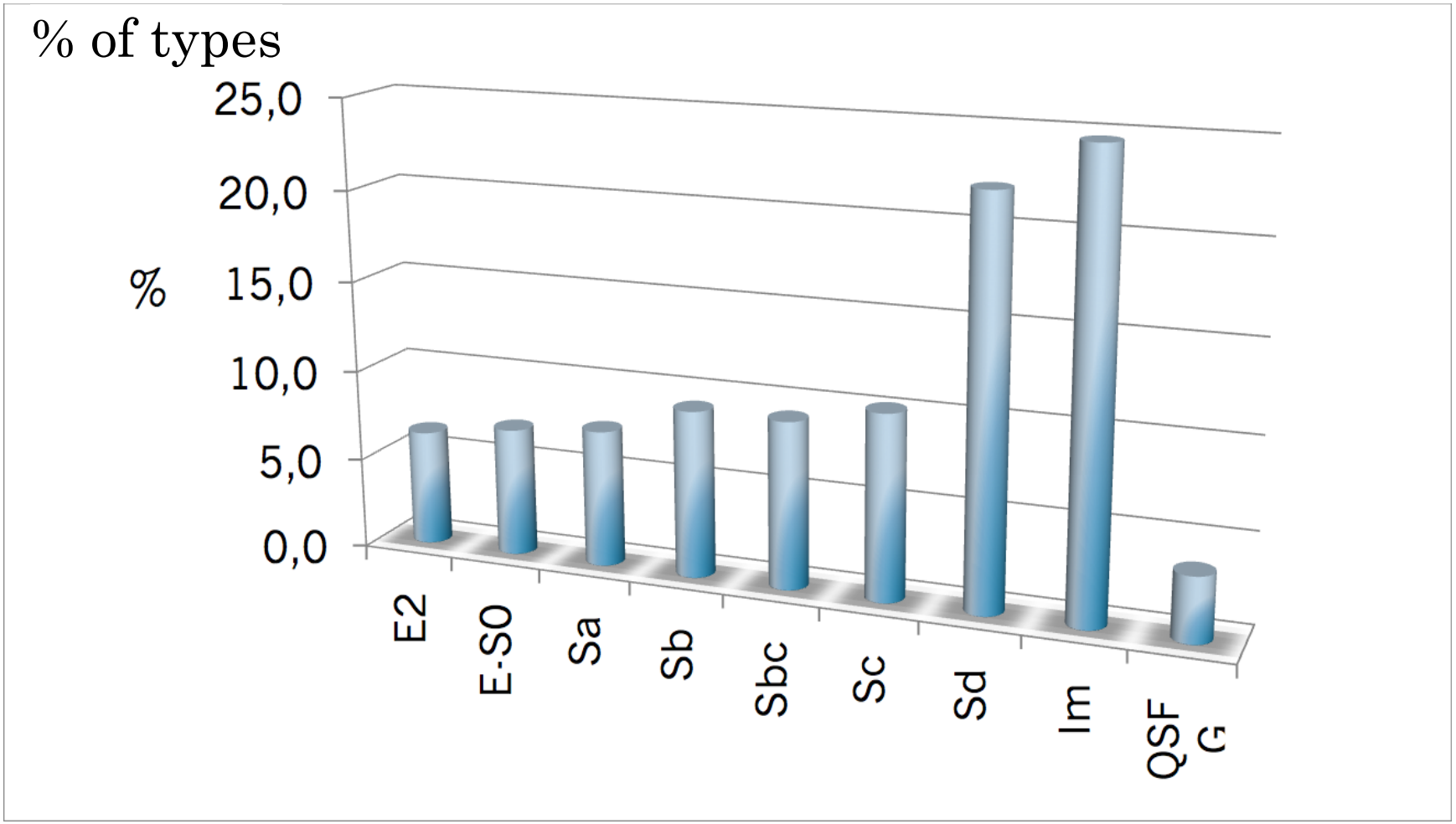
- Spiral (Sc and later) :
  - Exponential profile (e^{-r})



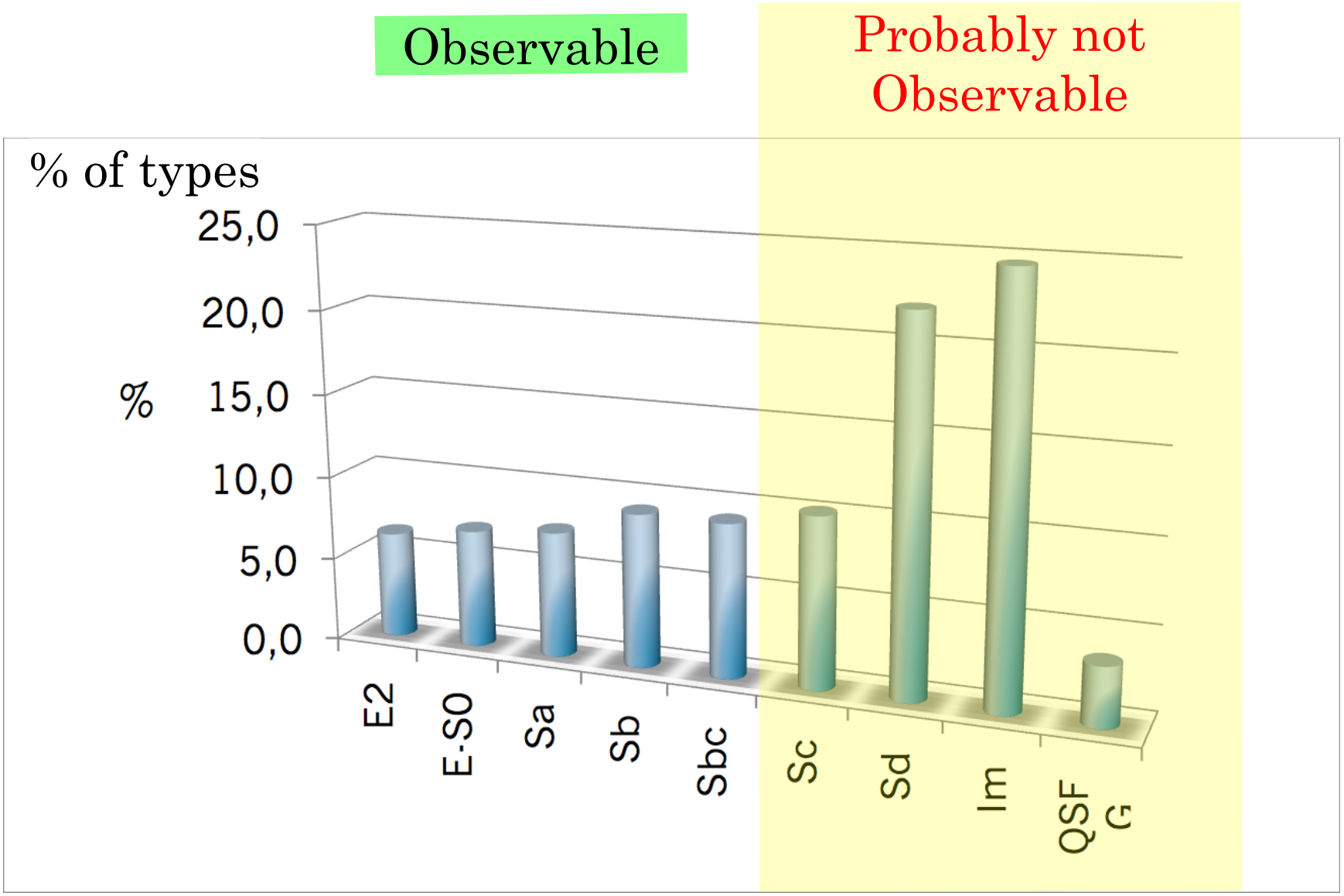
$16.3 < \mu_G < 23.3$ (mag/arcsec^2)



What can be detected by Gaia?



What can be detected by Gaia?



What can be detected by Gaia?

Galaxies	$G < 20$ mag	
E2	6.36%	2.4 M
E-S0	7.03%	2.7 M
Sa	7.51%	2.8 M
Sb	9.21%	3.5 M
Sc	10.21%	3.9 M
Sd	22.08%	--------
Sbc	9.21%	15 M
Im	24.77%	
QSFG	3.61%	

Robin et al. 2012

38 M

- Many Ellipticals
- Few Spirals
- Very few irregulars

What will be detected after Video Processing Algorithm (VPA) selection ?

Which galaxies will be observed (VPA)?

(A. Krone-Martins)

Questions :

- What are the VPA detection limits for galaxies?
- Properties of detected galaxies (type, size, magnitude)
- Dependence on position on the sky?

Answer :

- Test of detection (Skymaker + Gibis(VPA))

VPA detection capabilities GAIA.A8F.BG.PLM.00015 oct/2008

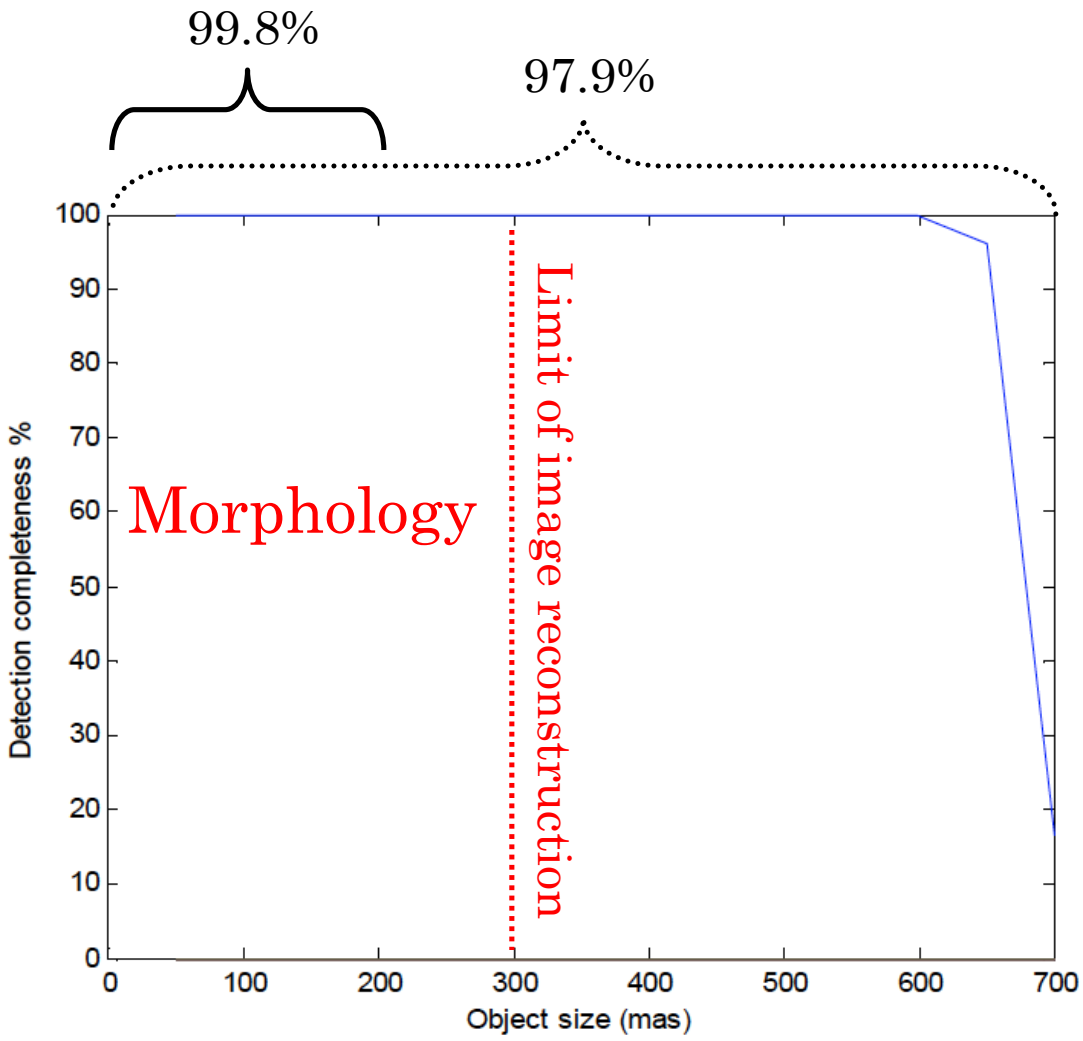
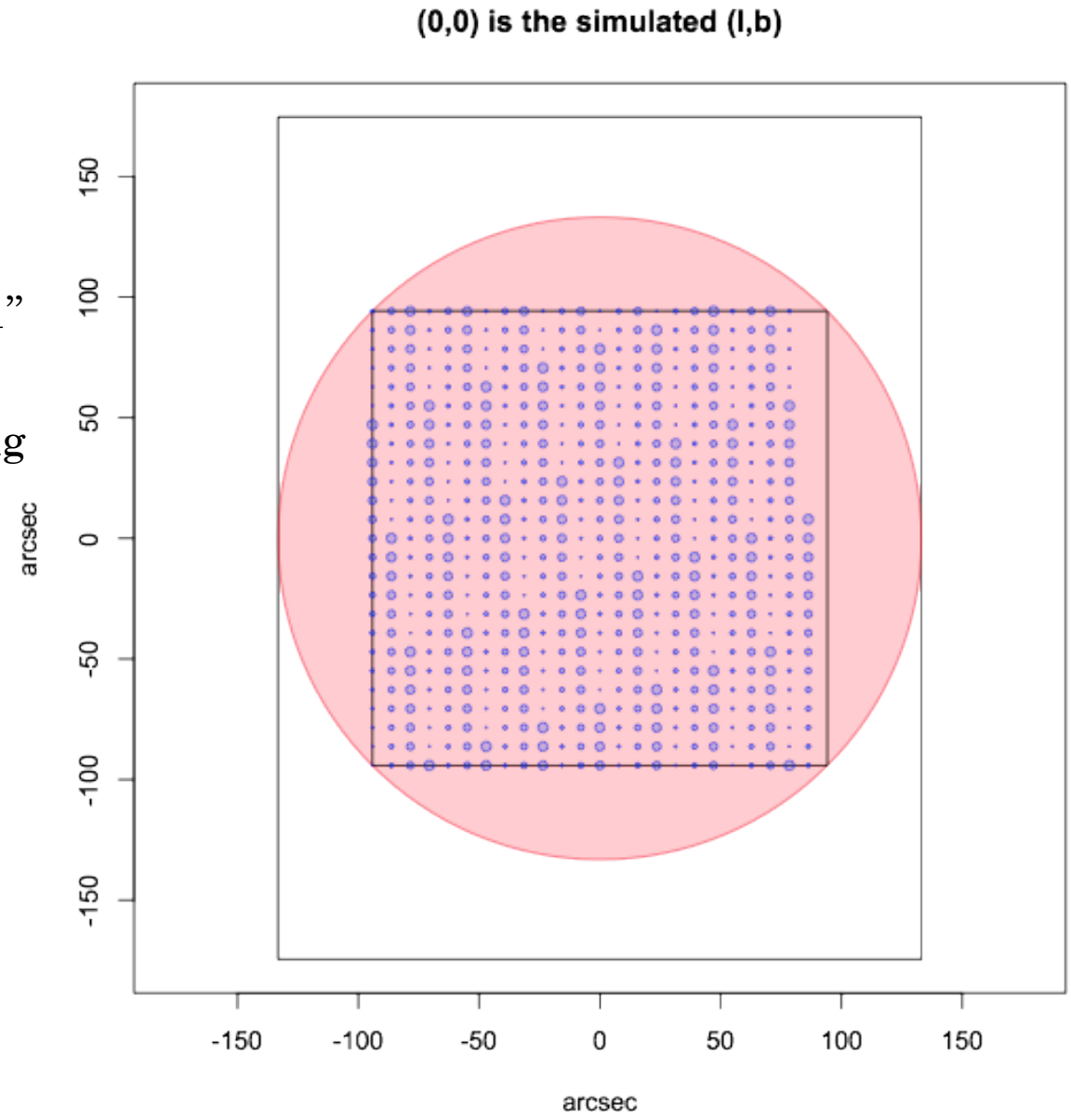


Figure 16 : Detection completeness vs. object apparent size

Simulation of pure disc and pure bulge galaxies

- 10 000 galaxies
- R_D = **0.2" - 2.0"**, step: 0.1"
- G = **14 - 20**, step: 0.2 mag
- Nominal scanning law

obs: no additional effects (CRs, CTI, etc.) are being considered in these simulations

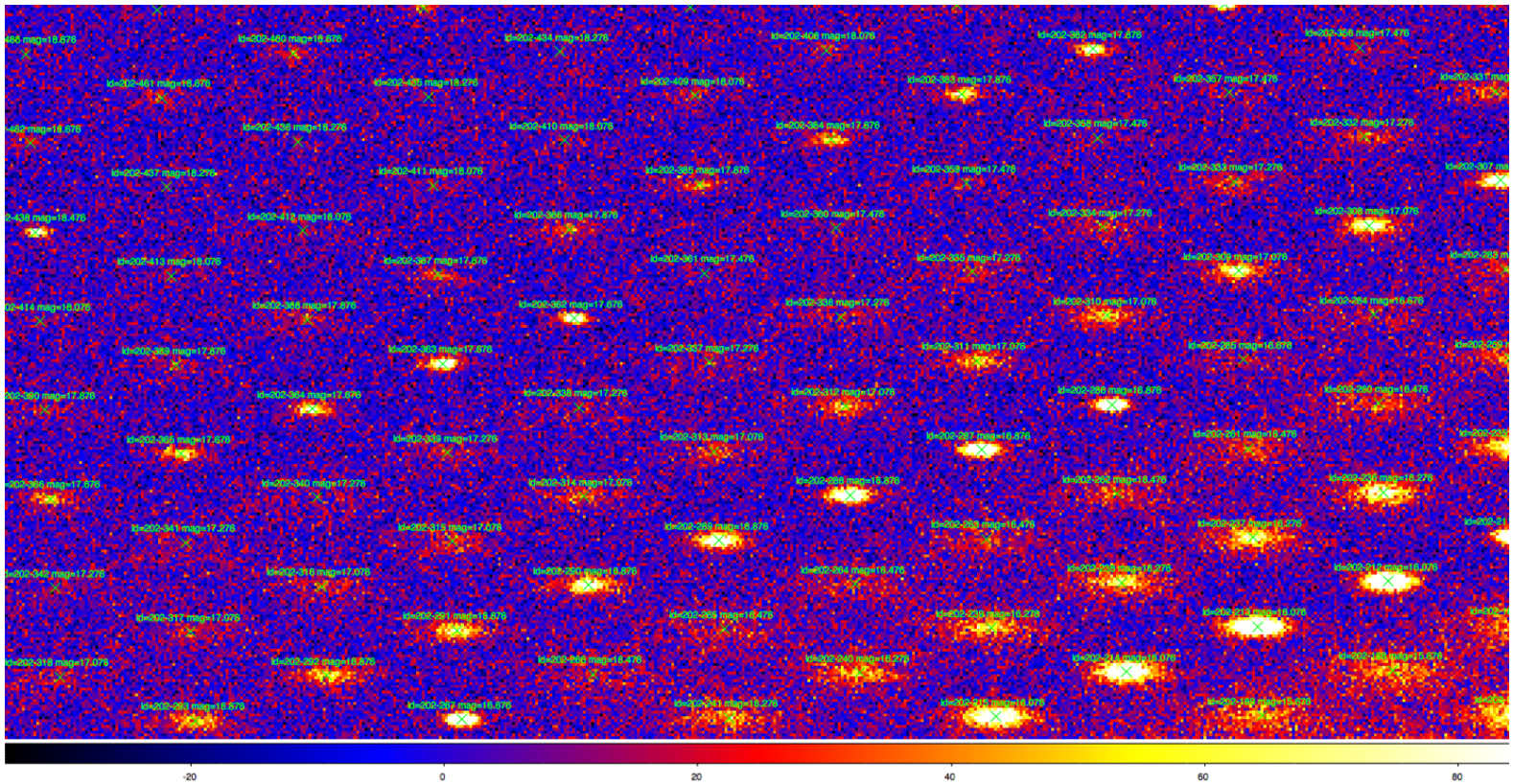


Simulation of galaxies

GIBIS+Skymaker Simulation

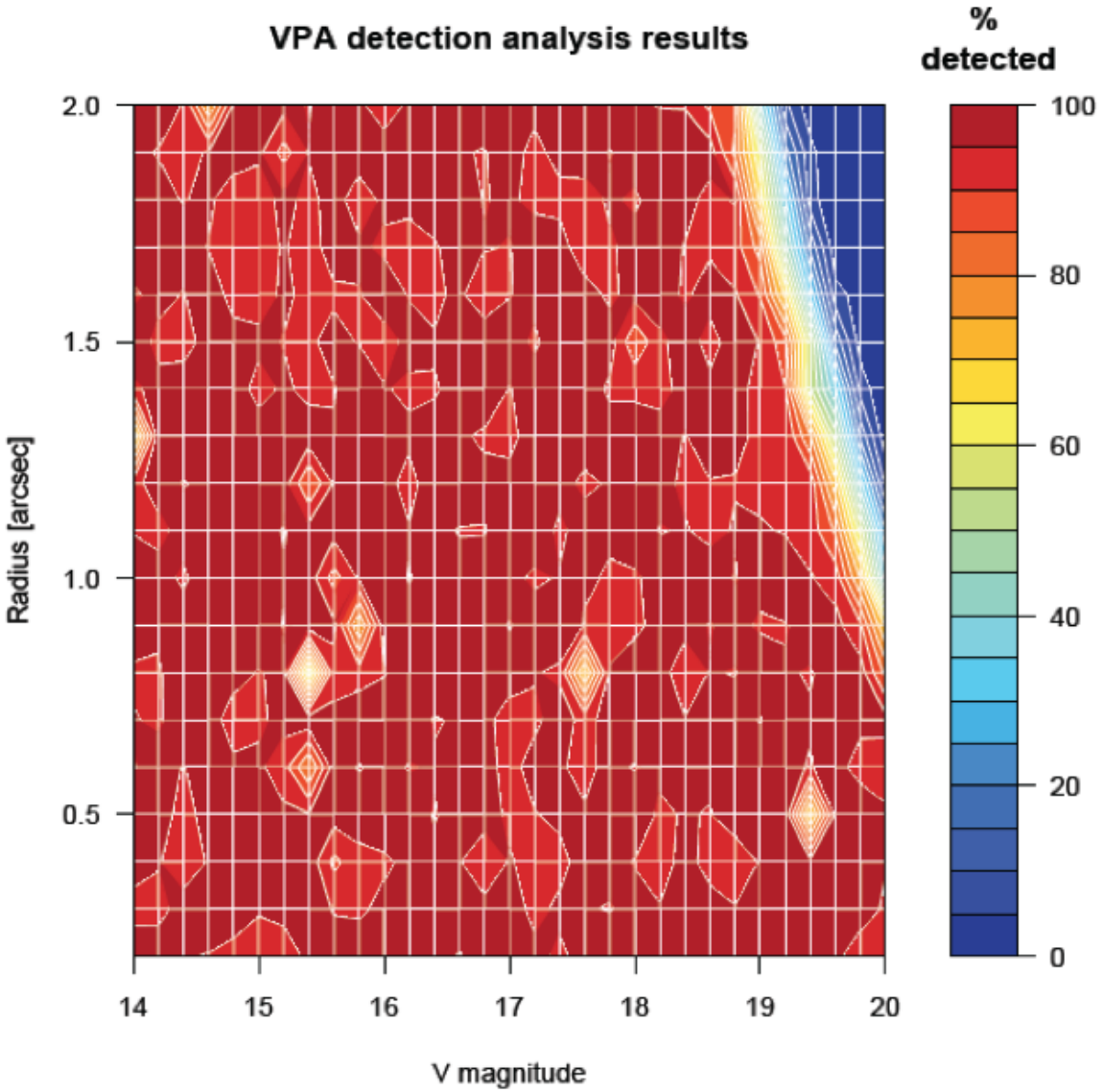
R_D step: 0.1”

V_{mag} step: 0.2 mag



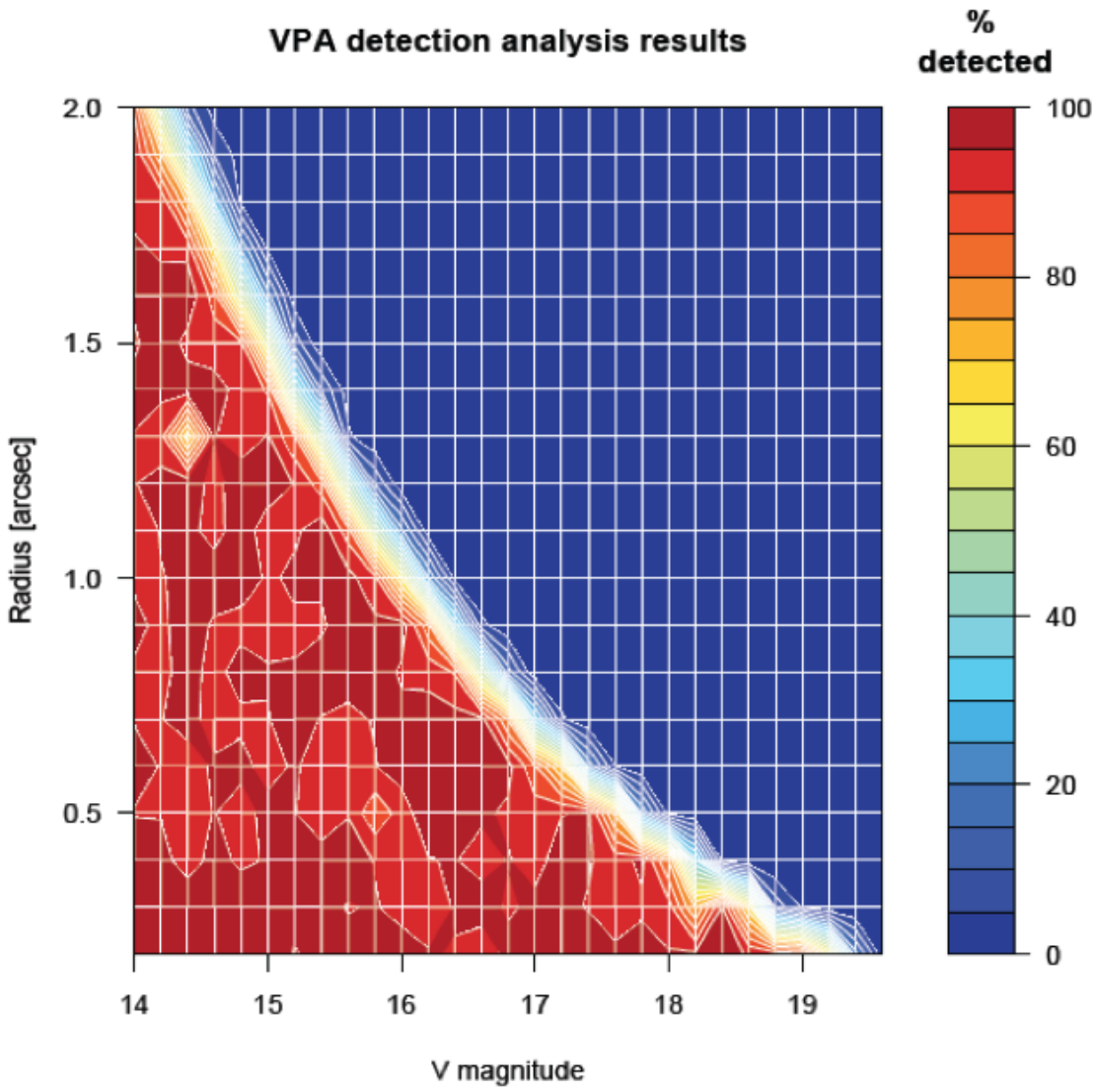
Which galaxies will be observed (VPA)?

Ellipticals (pure bulge)

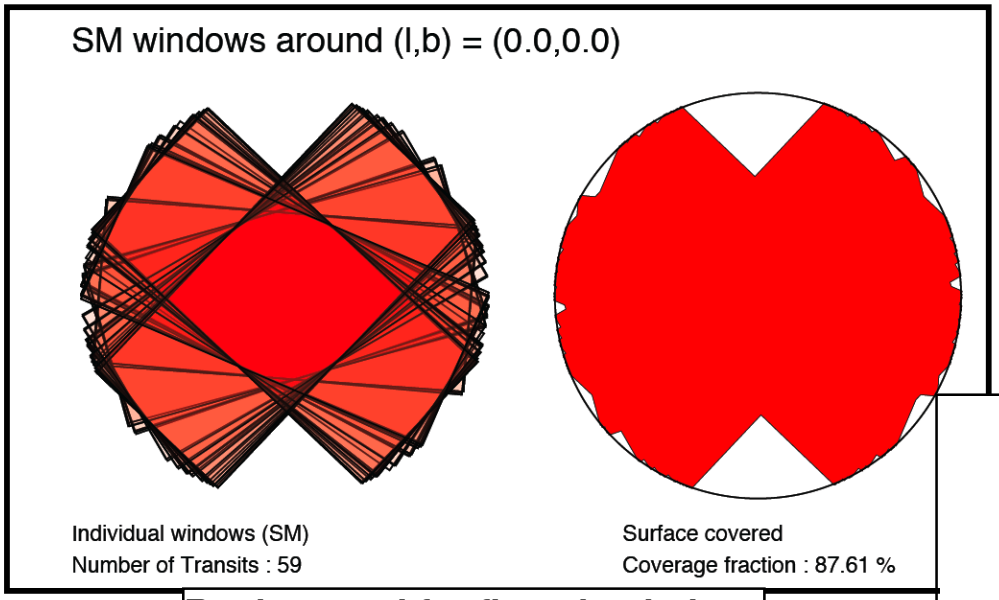


Which galaxies will be observed (VPA)?

Spirals (pure disc)

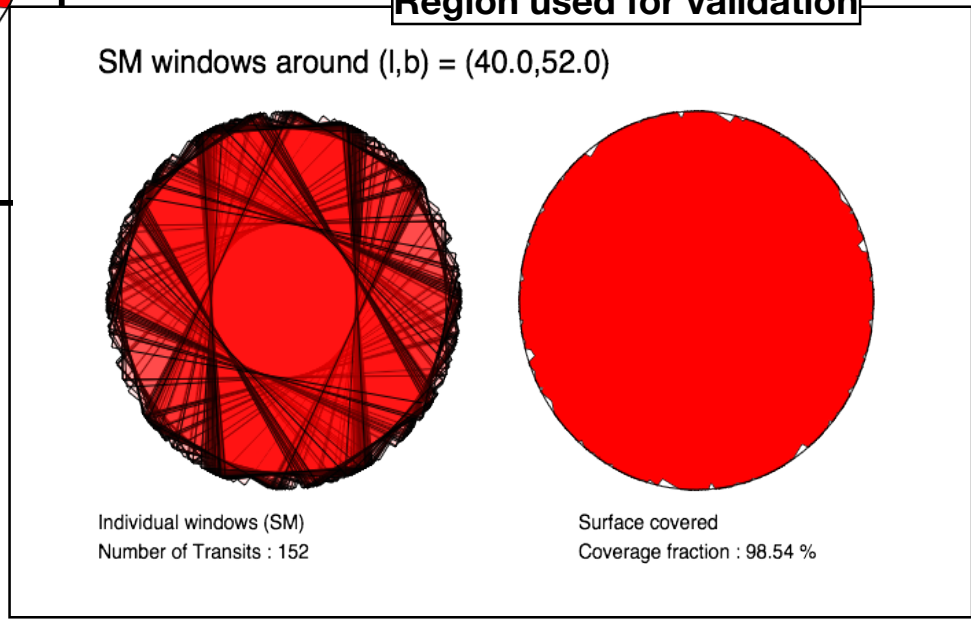


Which galaxies will be observed (VPA)?



Region used for first simulations

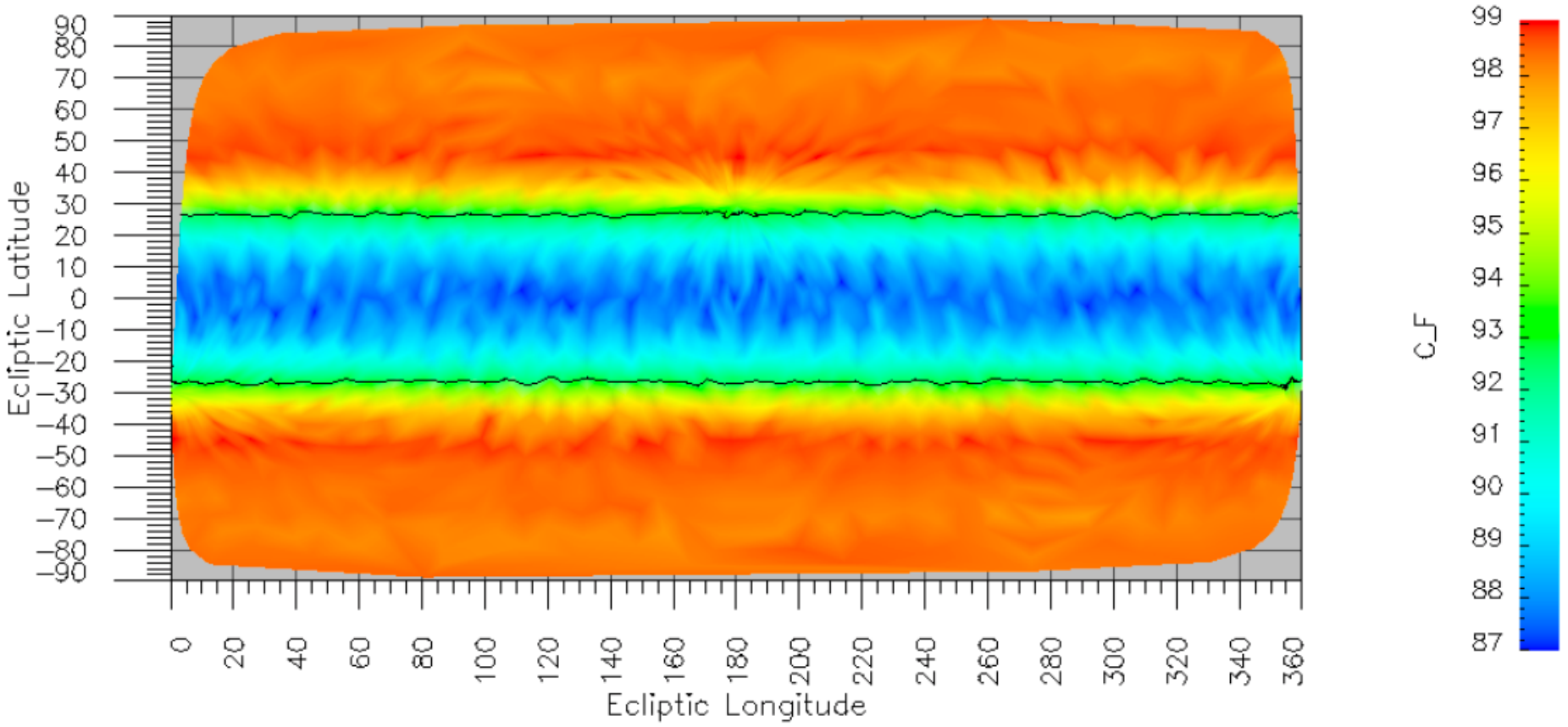
Region used for validation



Dependence on nominal scanning law
for morphologic analysis

Which galaxies will be observed (VPA)?

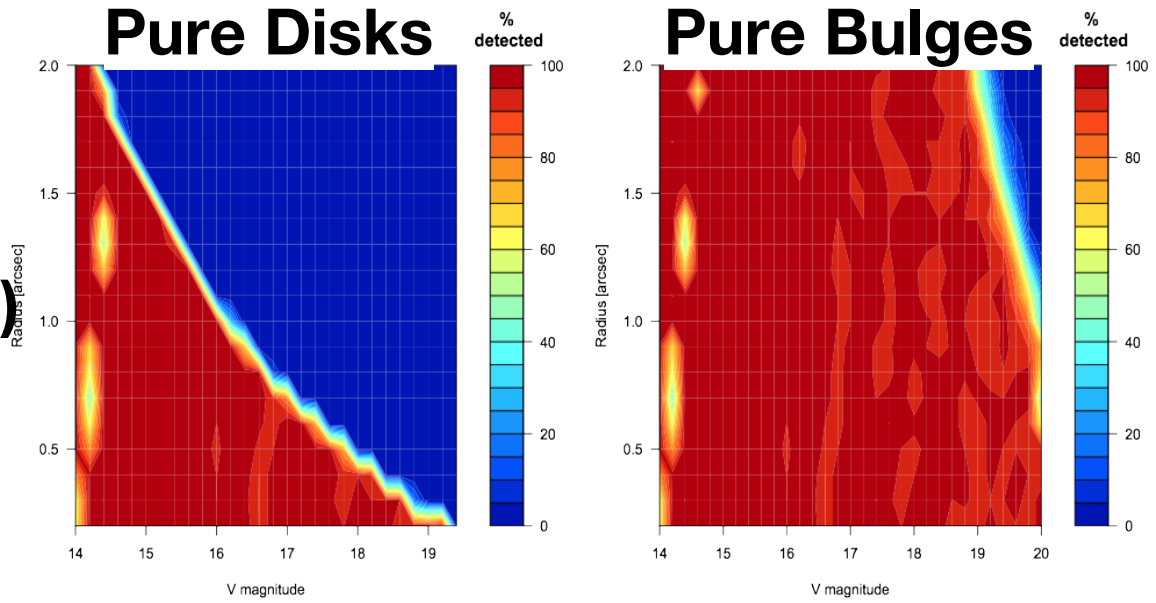
Sky coverage



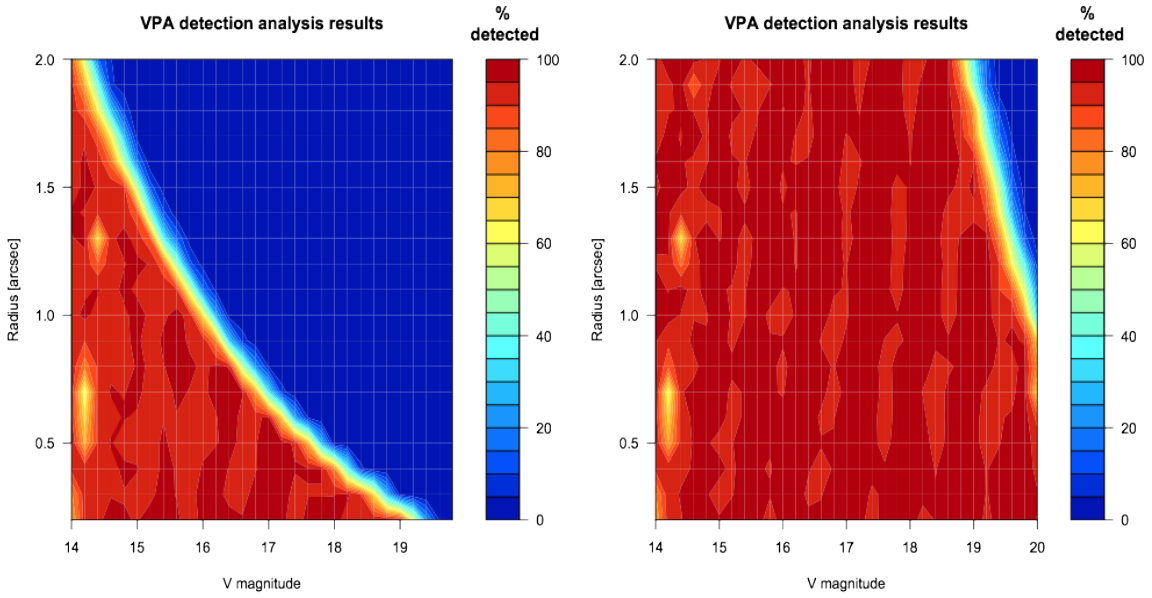
Dependence on sky location

Which galaxies will be observed (VPA)?

(l,b)=(40,52)



(l,b)=(0,0)



• Confirmation of theoretical evaluation of detectability :

✓Elliptical

- 100% detection : G<19 0.2"<rad<2"
- 70% detection : 19<G<20 0.2"<rad<1.2"

✓Spiral bulge-less hardly detected

✓Light dependence on sky location

• Very dependent on VPA parameters

Structure of host galaxies of QSOs detectable ?

Perturbing structures around QSOs?

(C. Ducourant, K. Bougis, E. Capitaine,)

HST and Spitzer View of Post-Starburst Quasars

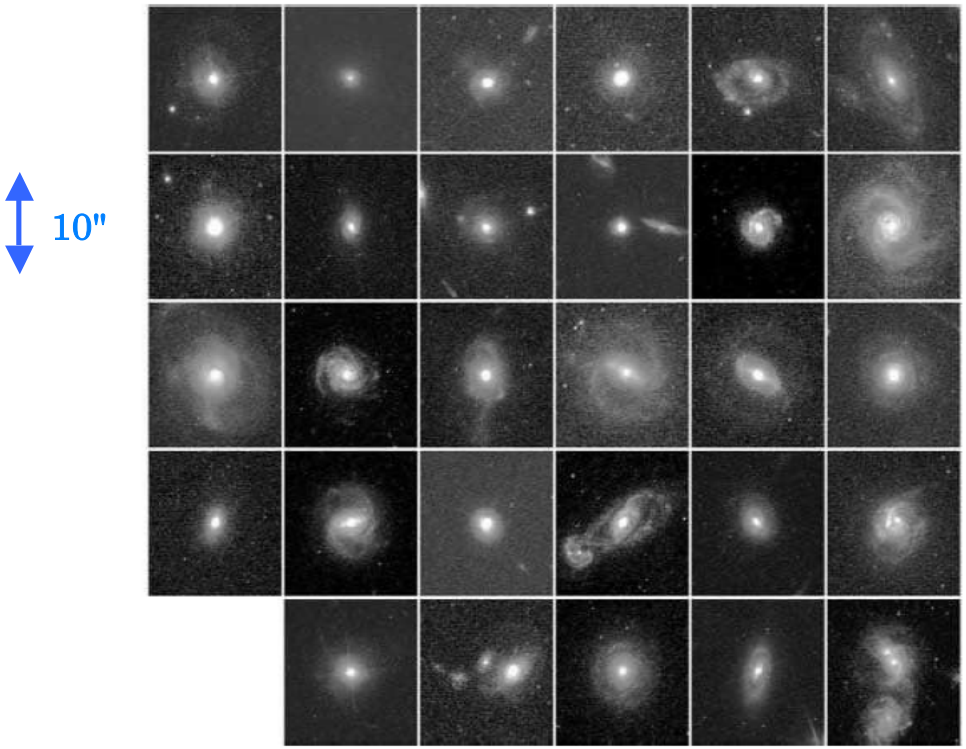


Figure 2. Our HST ACS F606W snapshot images, 10″ on a side, which is about 50 kpc at these redshifts. Note double nuclei, star-forming knots, and other structures too small to resolve from the ground such as nuclear dust lanes. Faint tidal tails and shells are apparent in many images, too.

Zhaohui Shang,et al. ASP Conference Series, Vol. 408, 2009

- 0.5 M QSOs
- Secure the link with Gaia-ICRF with point-like QSOs

Question :

- Structure of host galaxies detectable by Gaia?
- Astrometry will be perturbed?

If yes



DU470 - EO : Diagnostic of Morphology necessary

Perturbing structures around QSOs?

"Photocentric variability of quasars caused by variations in their inner structure: consequences for Gaia" Popovic et al, 2012

Simulation

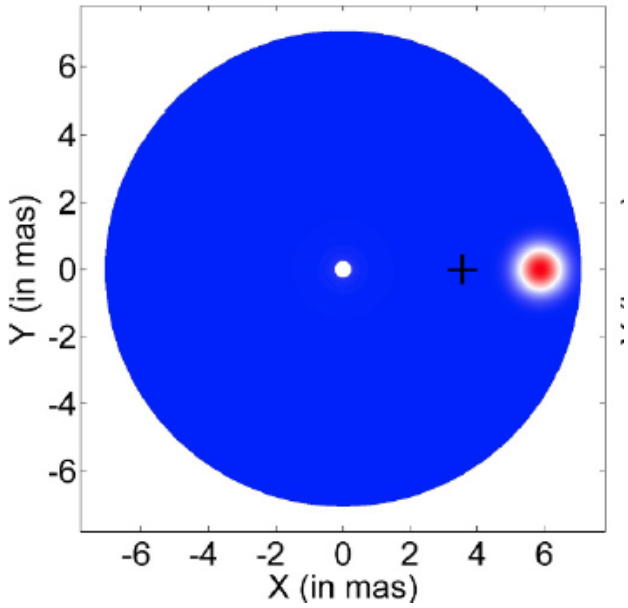


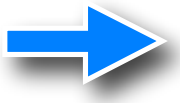
Table 1. The simulated offsets of photocenter (in mas) caused by perturbation to the accretion disk emissivity.

M_{BH}	z				
($M_\odot$)	0.01	0.05	0.10	0.15	0.20
10^8	0.036	0.007	0.004	0.003	0.002
10^9	0.355	0.074	0.039	0.028	0.022
10^{10}	3.550	0.744	0.394	0.278	0.220

Perturbing structures around QSOs?

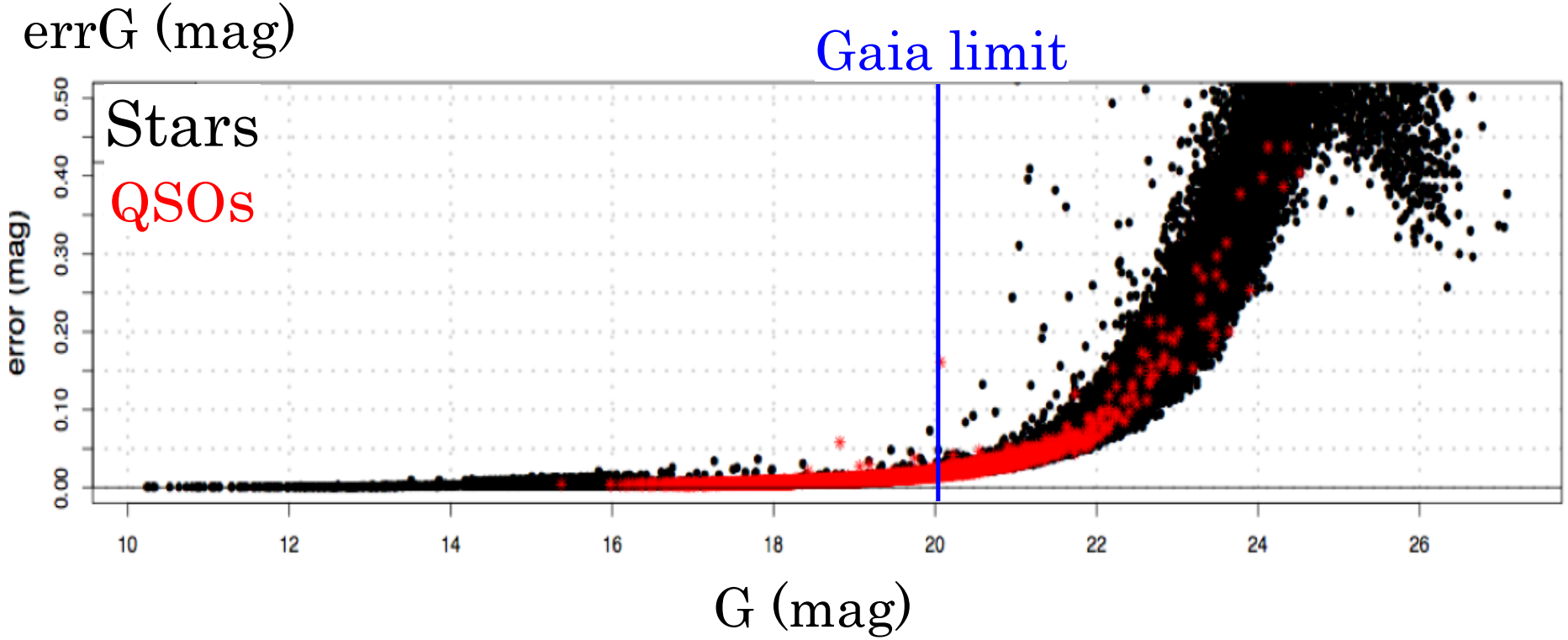
SDSS

9000 QSO's (spectroscopy) +36000 surrounding stars

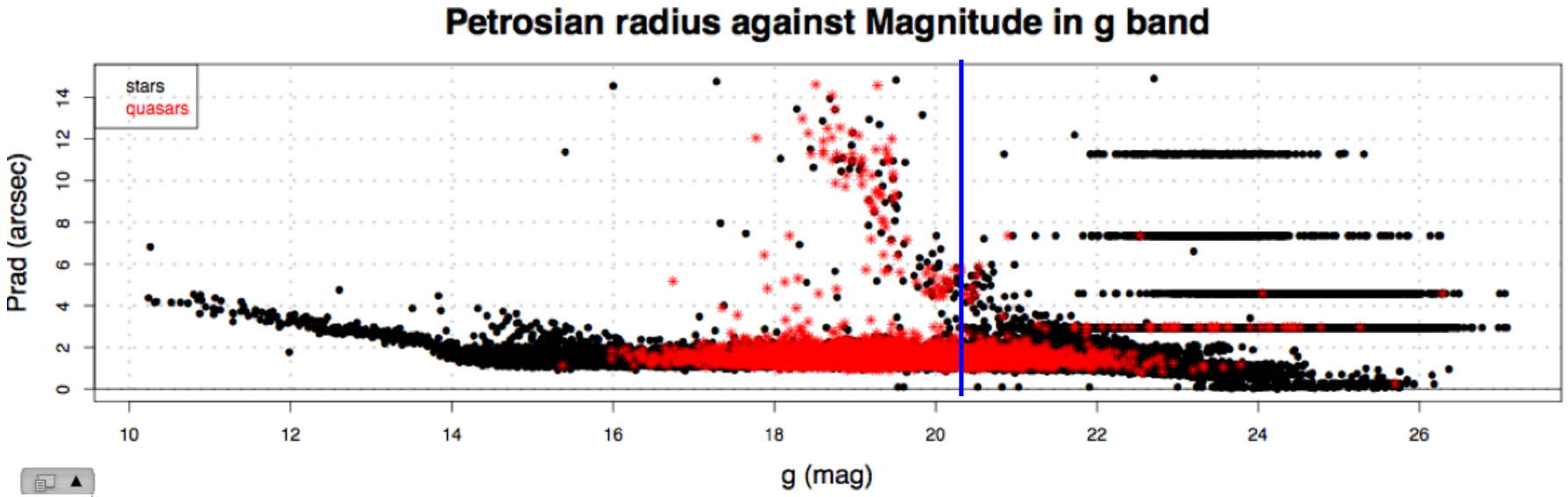


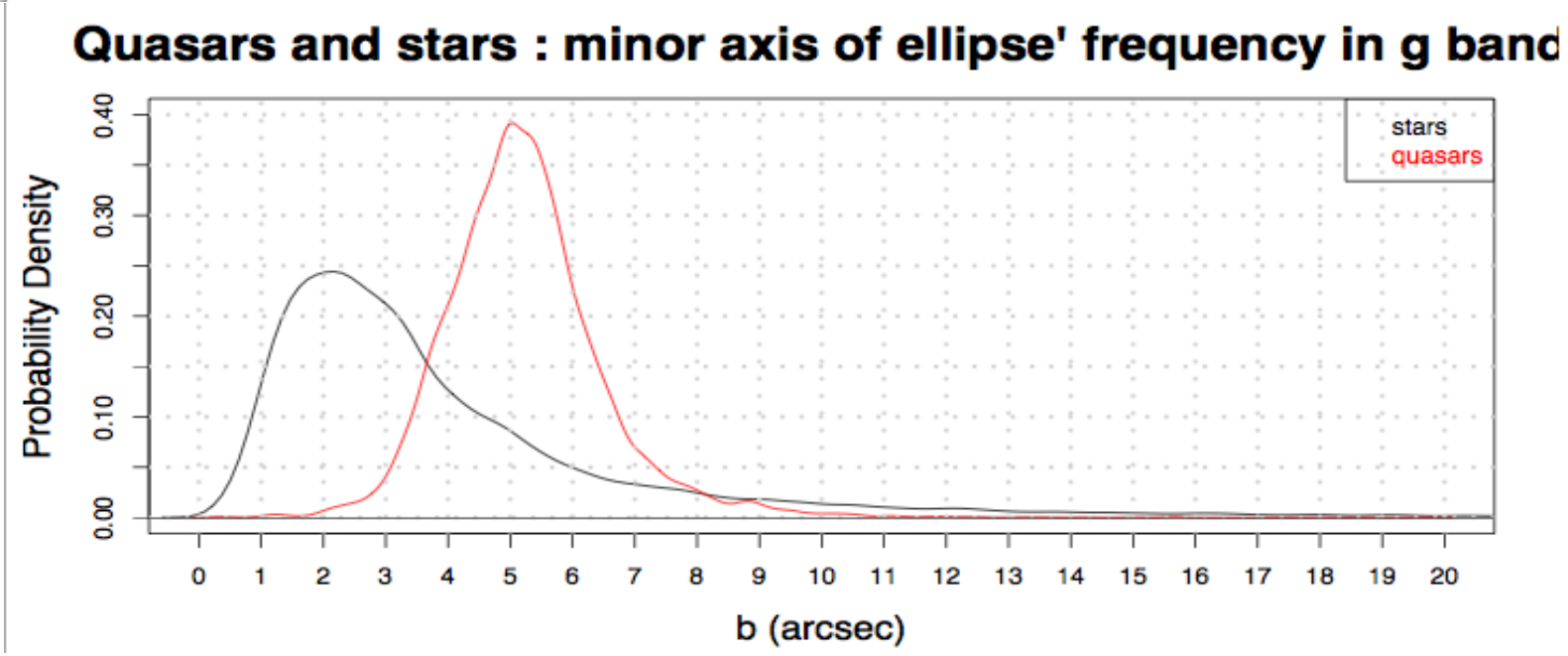
- *photometry* (u,g,r,i,z)
- *shape param.* (a, b, FWHM, Petrossian radius (annulus with 20% flux)

Perturbing structures around QSOs?

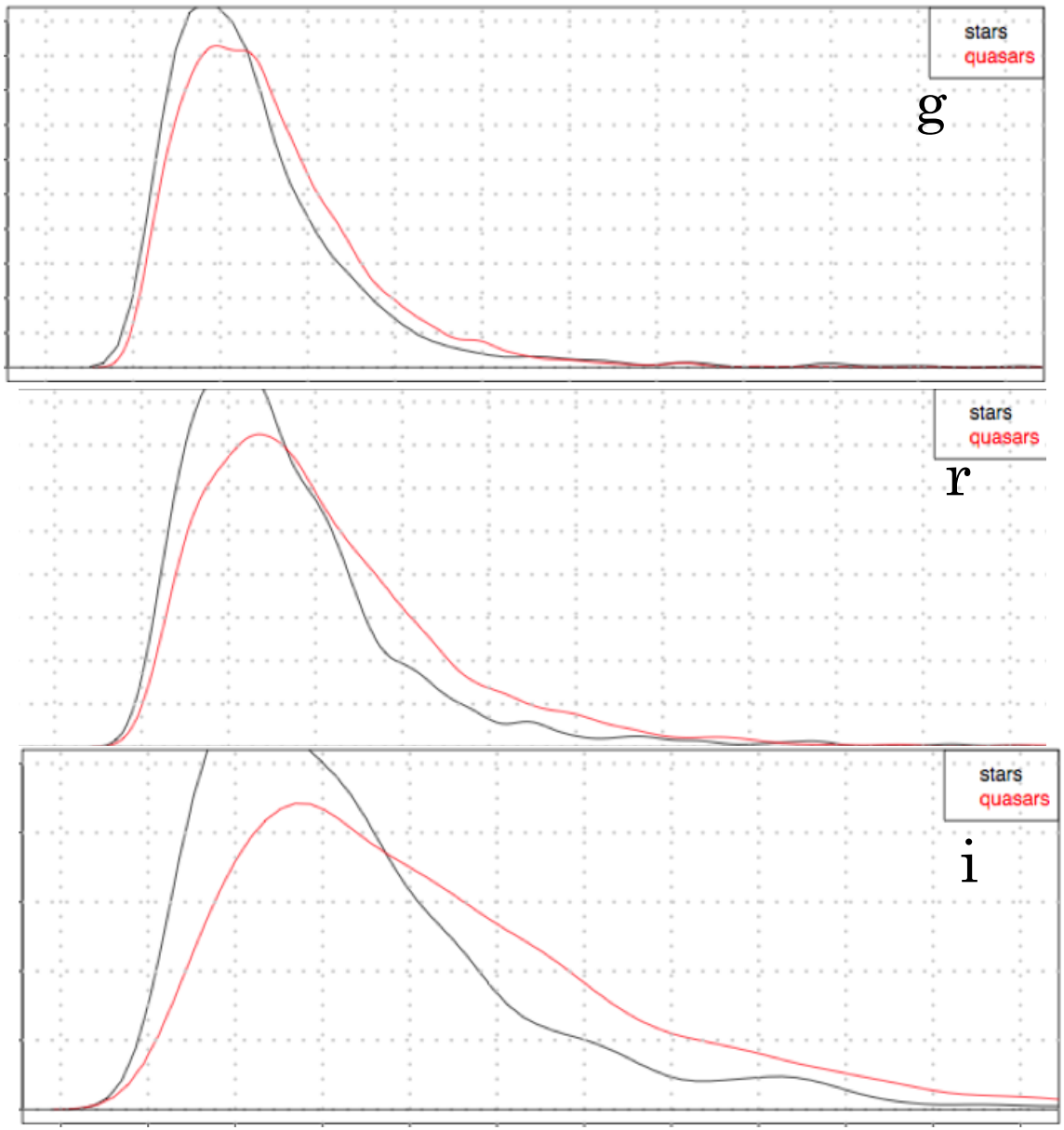


Perturbing structures around QSOs?





Perturbing structures around QSOs?



1-B/A = elongation

Perturbing structures around QSOs?

SDSS (ground-based)

→Hints about enlargement of QSOs
→Hints abouts effects linked to color
→Hints about elongation

Perturbing structures around QSOs?

HST observations of 27 post starburst QSOs

- DAOPHOT (PSF)
  - sharp, chi
- Sextractor (Gaussian)
  - a, b, FWHM,
  - Petr. radius

HST and Spitzer View of Post-Starburst Quasars

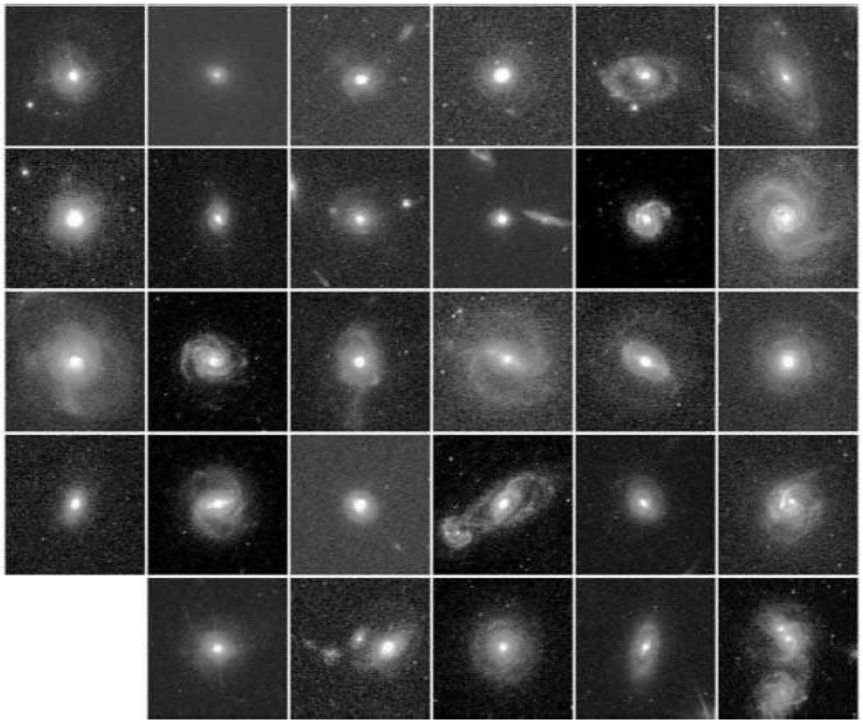
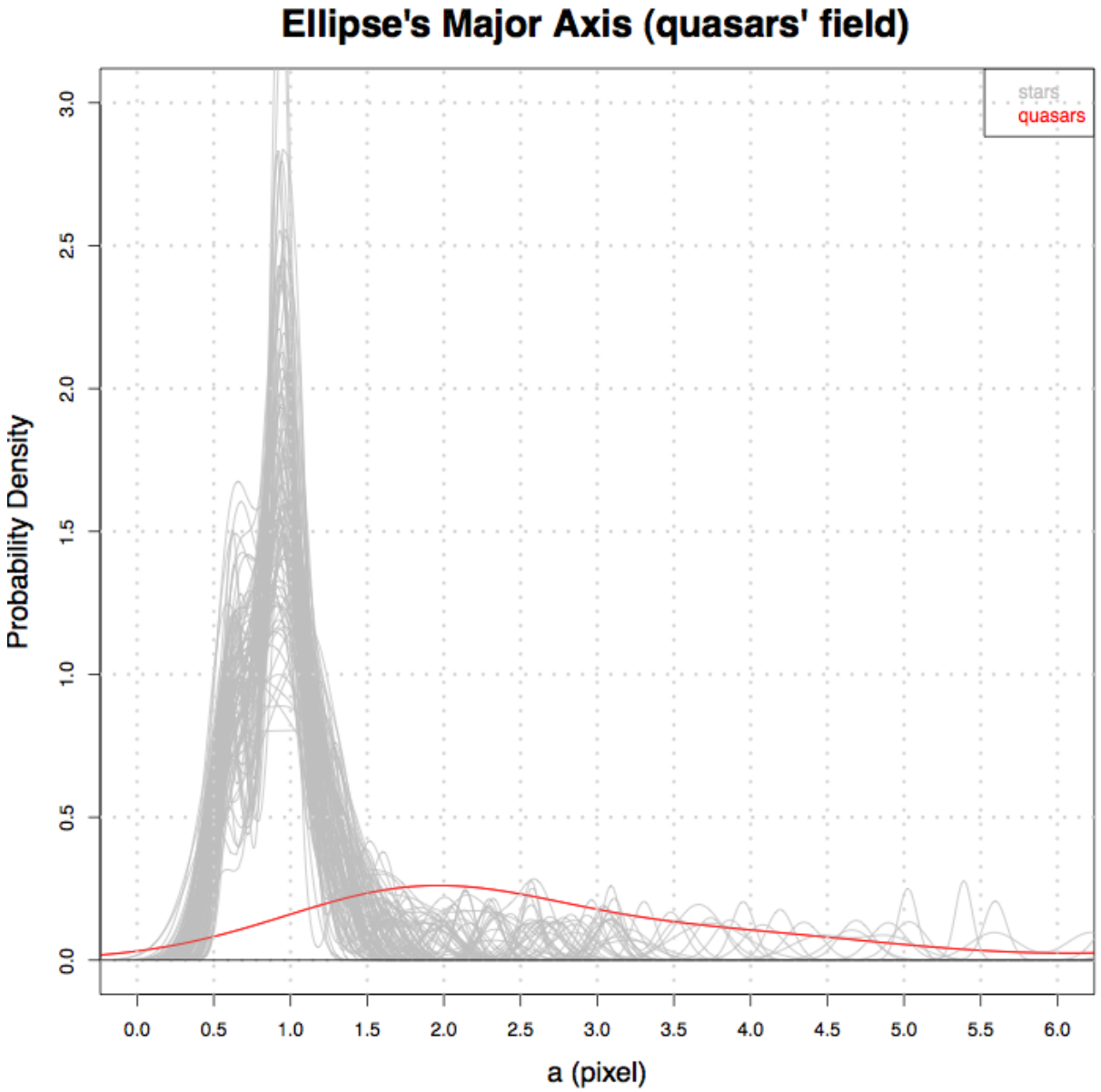
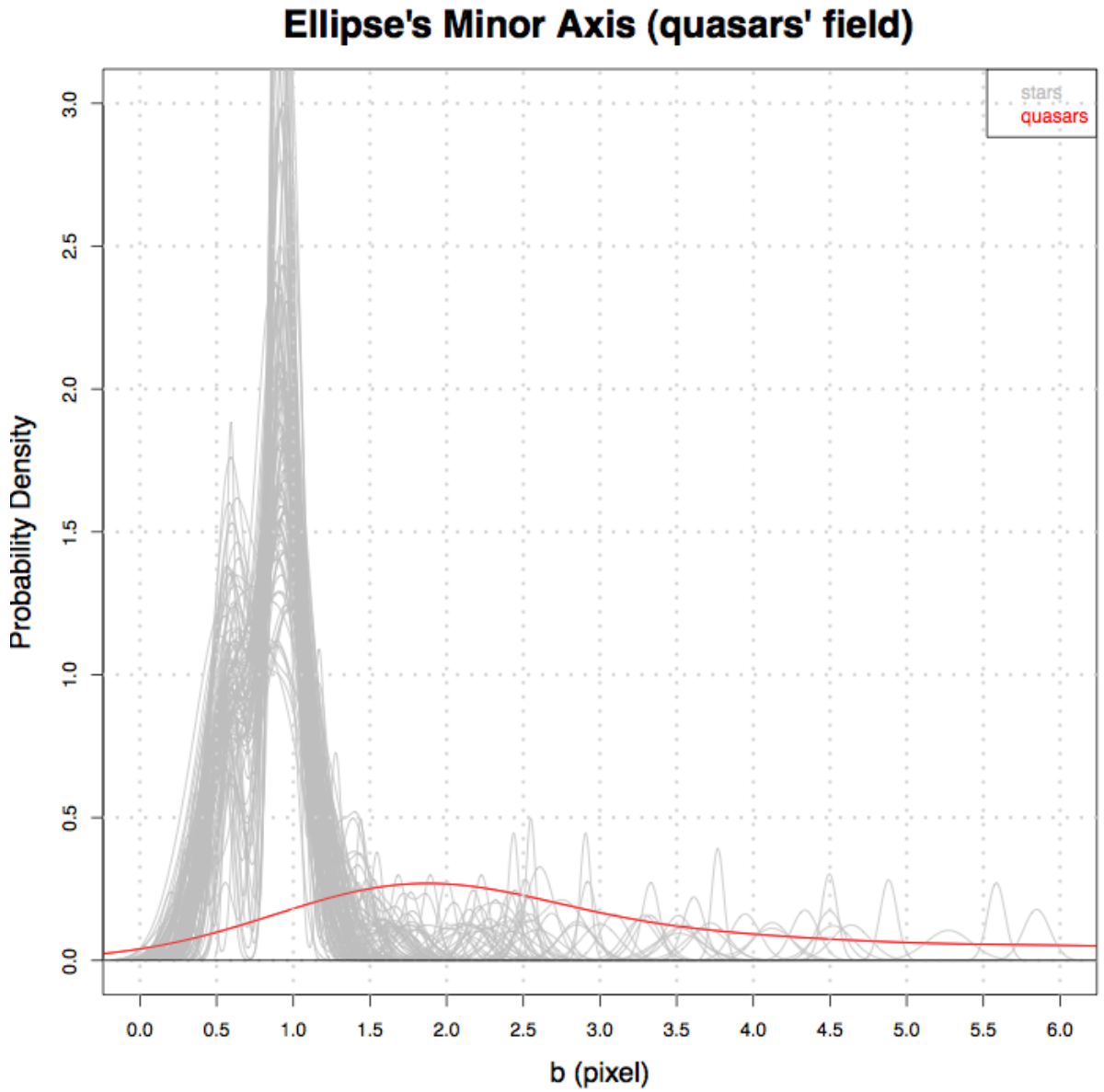


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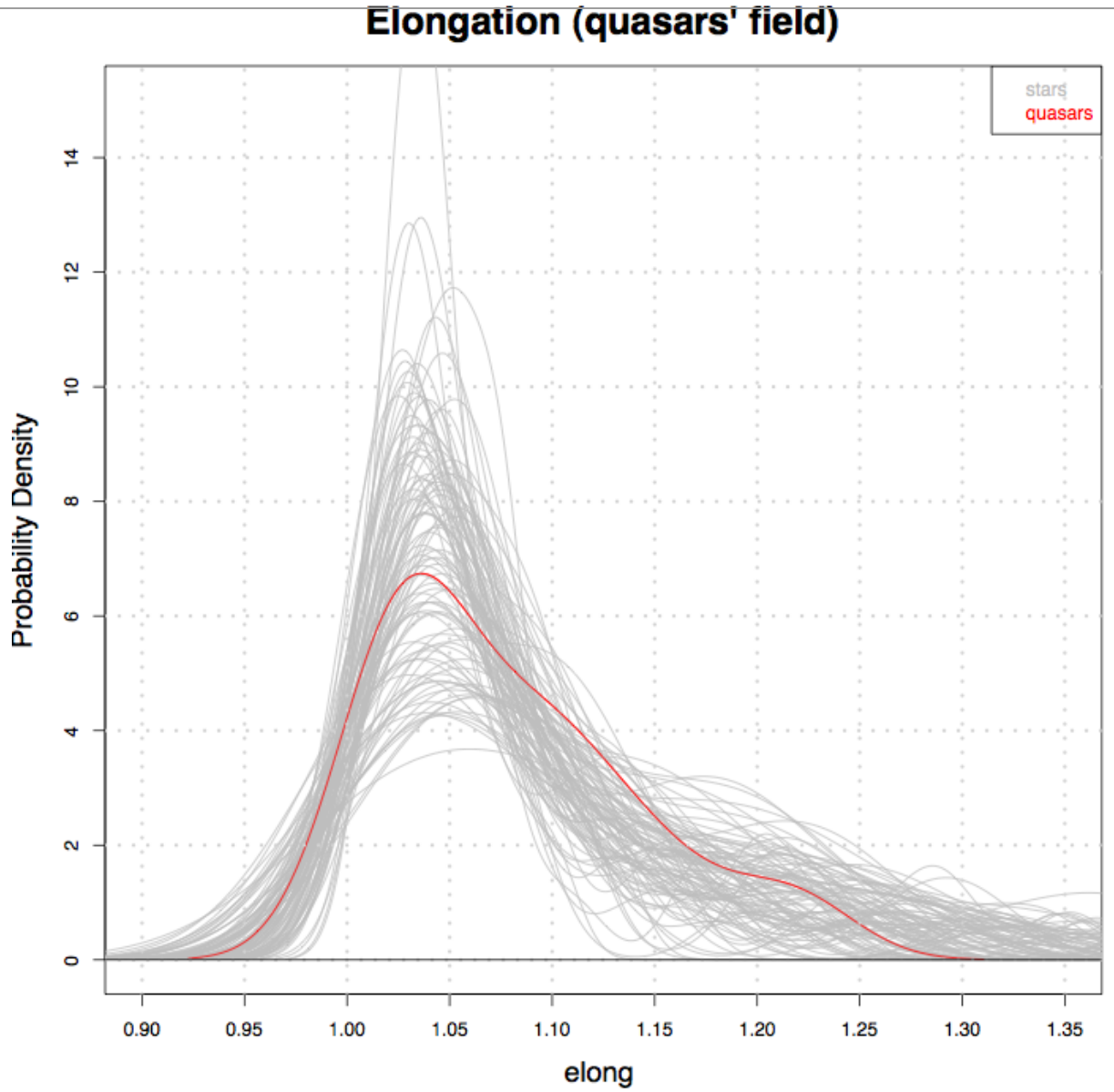
Perturbing structures around QSOs?



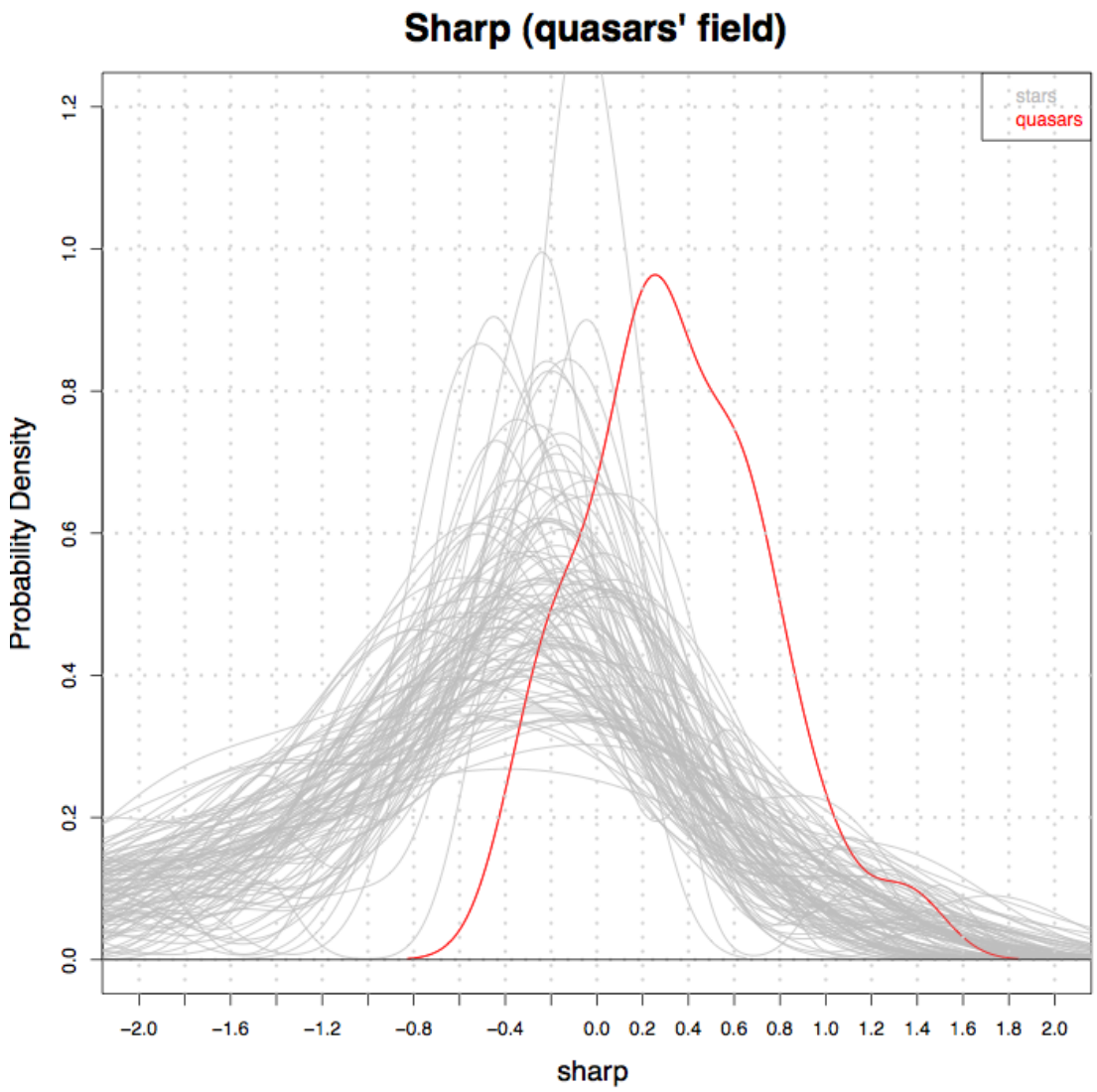
Perturbing structures around QSOs?



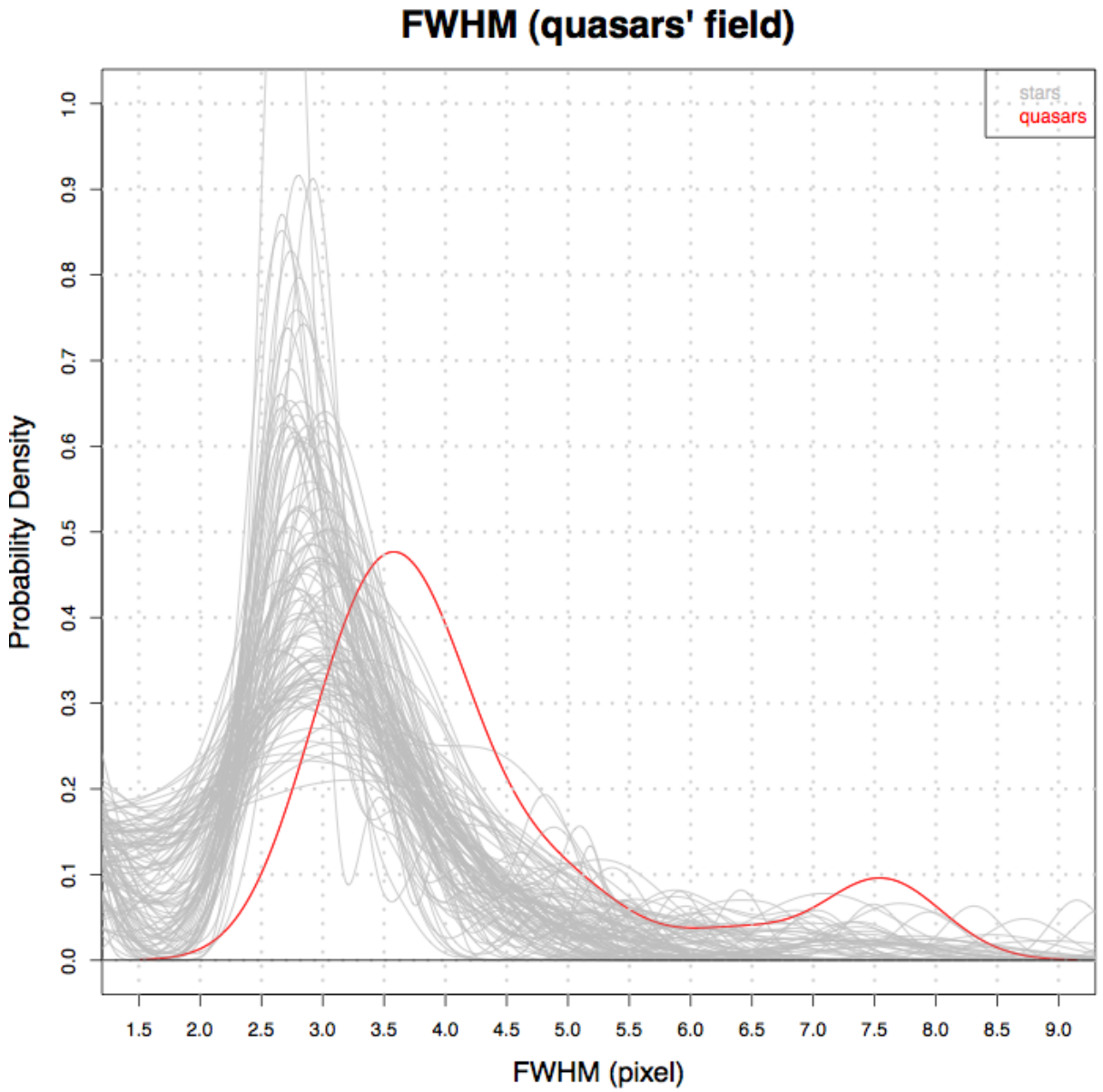
Perturbing structures around QSOs?



Perturbing structures around QSOs?



Perturbing structures around QSOs?



Perturbing structures around QSOs?

HST (space)

→Confirmation of Enlargement of QSOs

Question :

- Structure of host galaxies detectable by Gaia?
- Astrometry will be perturbed?

Question :

- Structure of host galaxies detectable by Gaia? → **yes**
- Astrometry will be perturbed?

Question :

- Structure of host galaxies detectable by Gaia? → **yes**
- Astrometry will be perturbed? → **possibly**

Conclusion : what can be detected by Gaia?

⇒ Galaxies

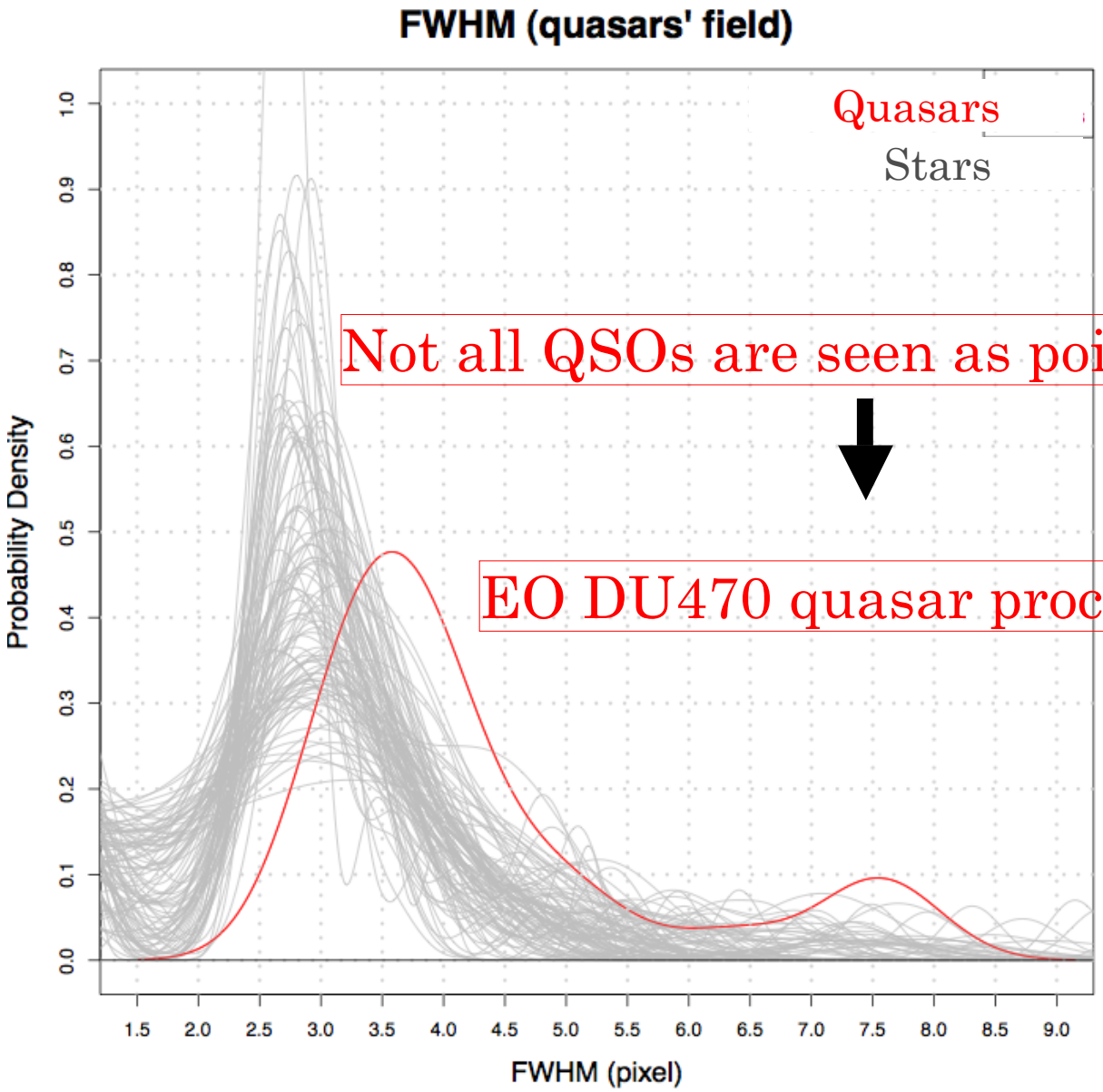
- 38 M galaxies up there (Gums)
- 15 M accessible (theory + photometry)
- Many elliptic, few spirals, very few irr. (VPA)

⇒ QSOs

- 0.5-1 M QSOs
- Host galaxies detectable (ground+space)
- Possible astrometric impact


Merci!

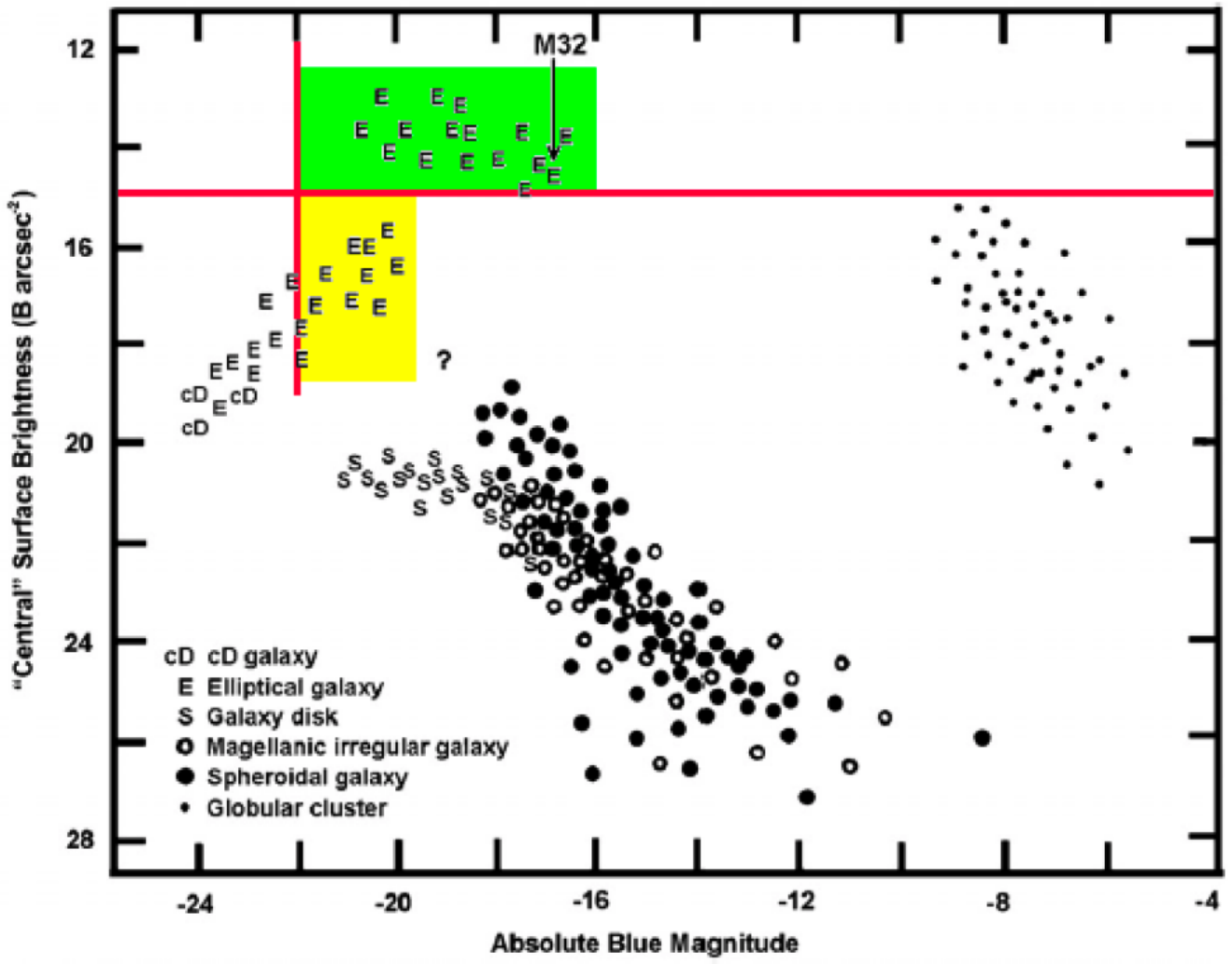
Perturbing structures around quasars?



Not all QSOs are seen as point sources!

EO DU470 quasar processing

Photometry : what can be detected by Gaia?



Kormendy et al. 2009

VPA detection capabilities

Apparent size :

- Non trivial
- Radius of half-light R_e



Spiral



Elliptic

Detection if :

- R_e > 1 pixel of SM
- Flux in SM 1,2,3 Pixels > thresh Detection
- Flux in AF1 1 pixel > thresh Detection