Quasars, characterization, morphology, properties

Sonia Antón

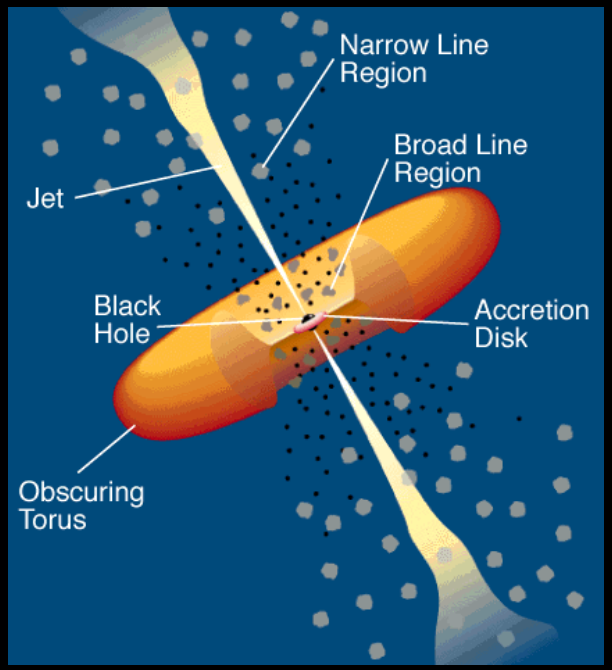
CICGE – Fac. Sciences Porto
SIM-Fac Sciences Lisbon

Active Galactic Nuclei

Radio jets
up to 10^6 light-years
scales

- output up to 10^{46} erg s^{-1}
- broadband emitters

Narrow Emission Line Region
scales of 10pc – 1kpc
clouds of 10^{10} – 10^{12} m^{-3}



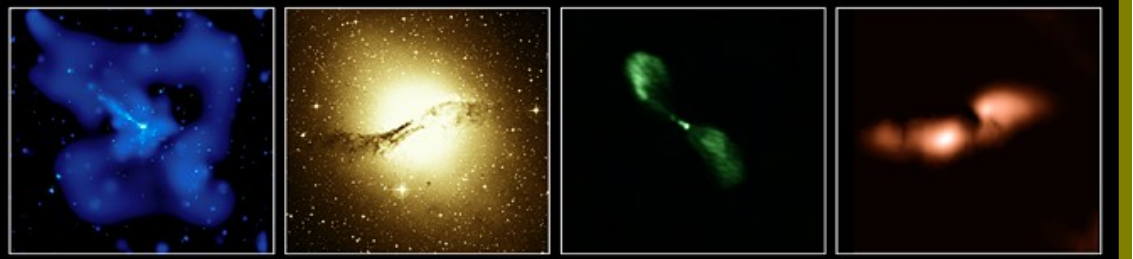
Broad Emission line Region
10^{15} - 10^{17}m
small dense clouds (10^{16} m^{-3})

Accretion Disk:
3-1000 R_S
(10^{12} - 10^{14} m)

Teff = 10^5 K

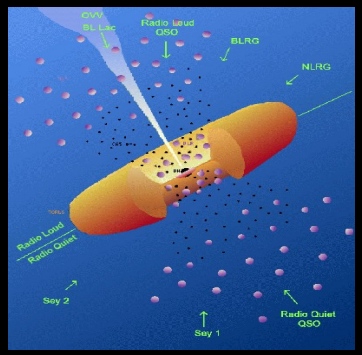
Black Hole
10^6-10^{10} M_{SUN}
R_S ~ 10^9- 10^{13} m
(Schwarzchild radius = $2GM/c^2$)

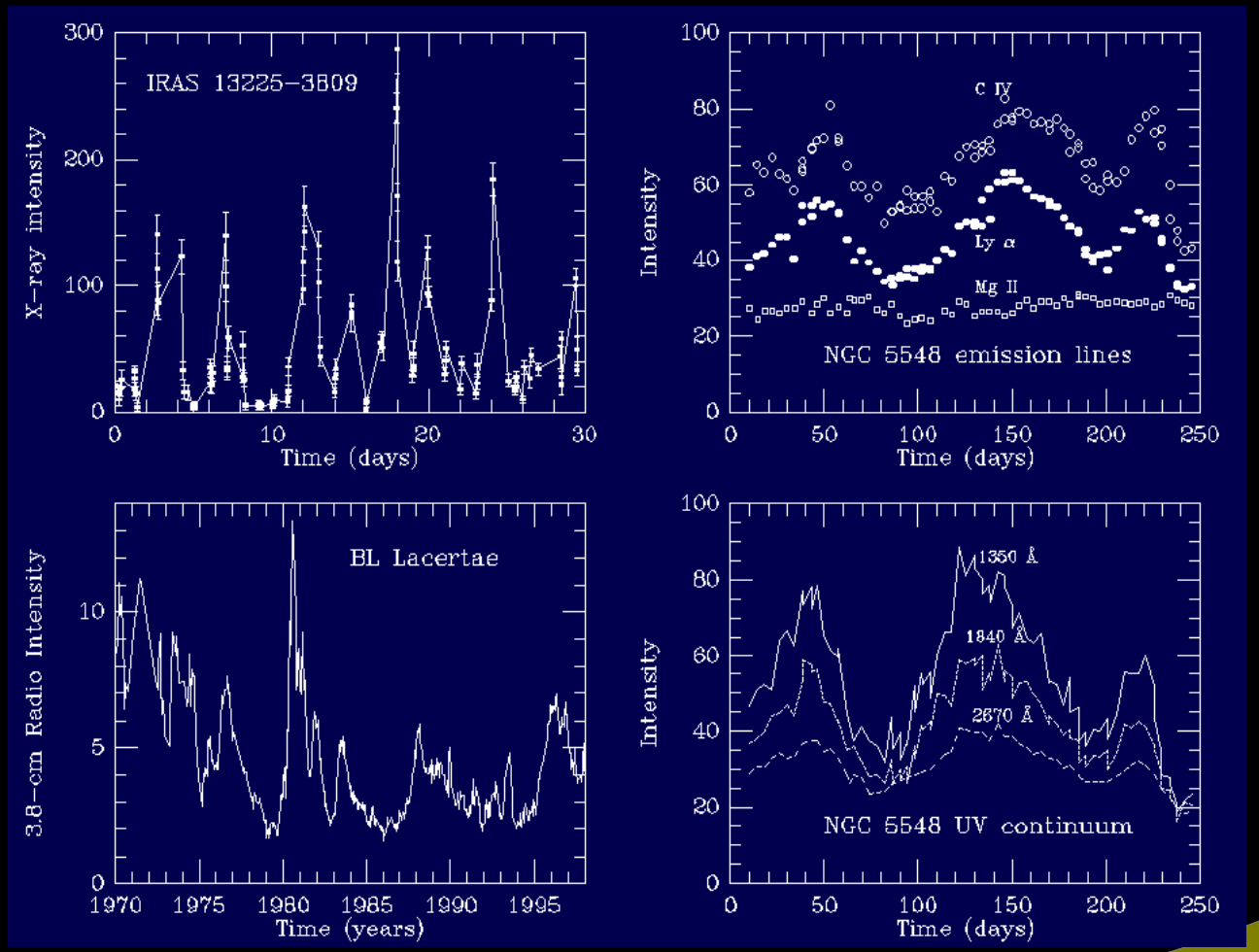




Active Galactic Nuclei

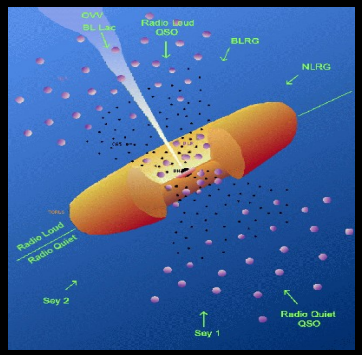
- variability on scales short as hours to years



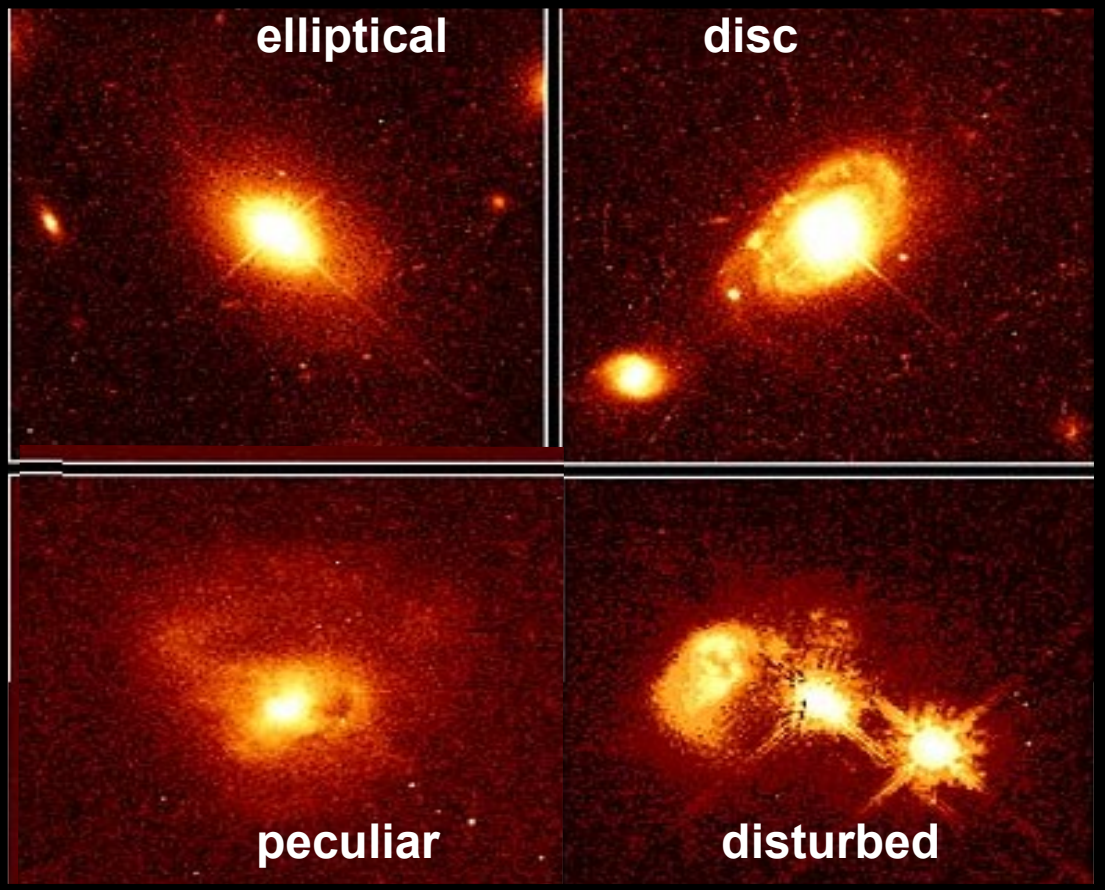


Active Galactic Nuclei

- hosted by large galaxies



morphology

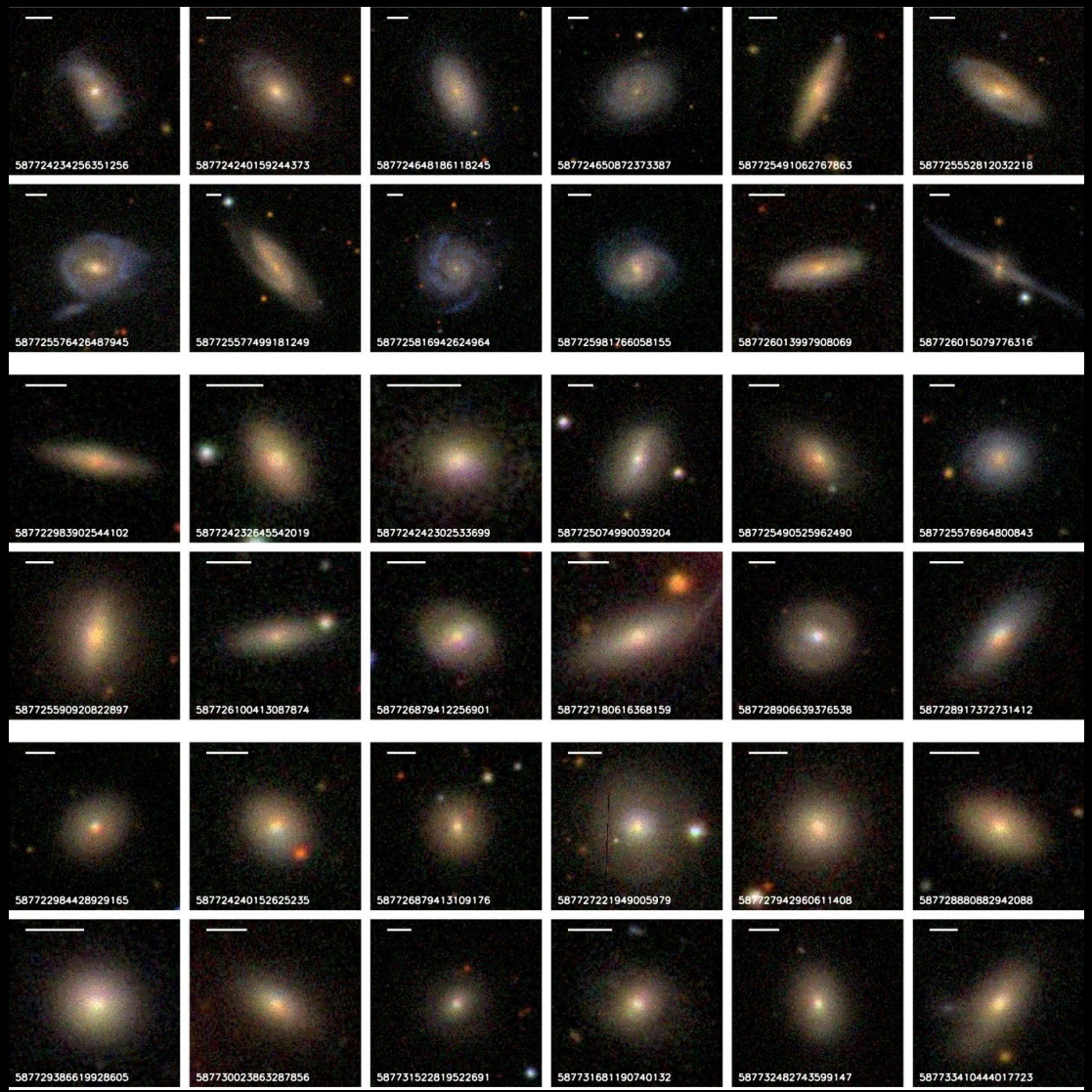


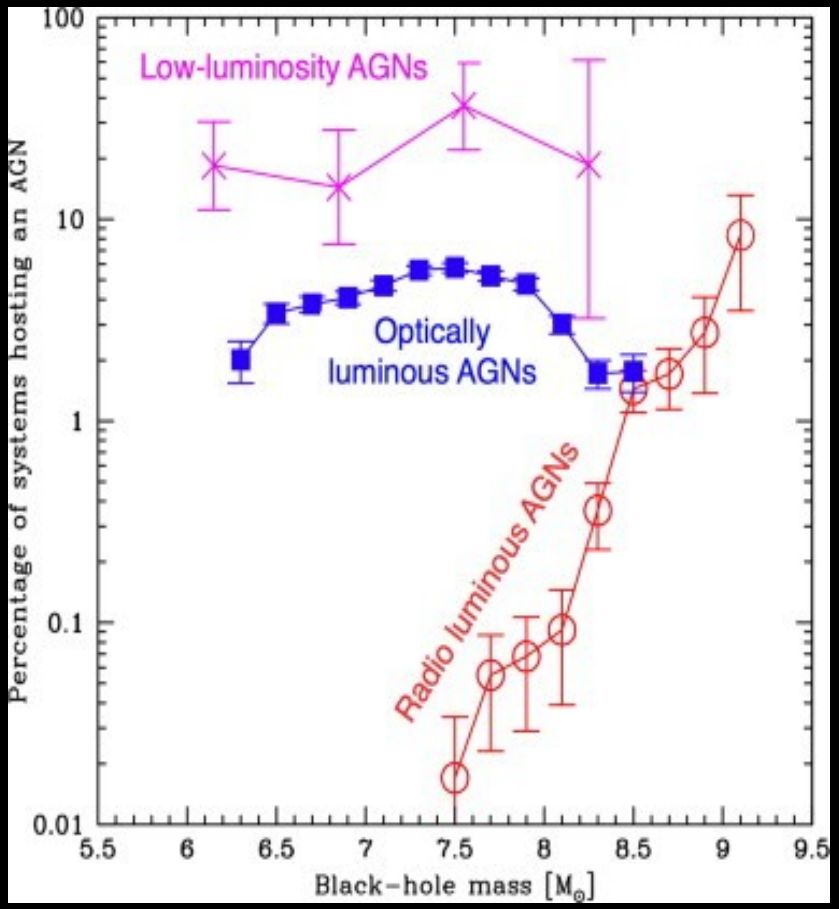
Galaxy Zoo: AGN Host Galaxies

z<0.05
Schawinski et al 2010

late-type host galaxies

early-type host galaxies





Alexander & Hickox 2012
(data from Best et al 2005, Goulding et al 2010)

Initial QSO Catalogue for Gaia

Alexandre Andrei (Obs Nacional/MCT/UFRJ/INAF/Obs Turin/SYRTE/Obs Paris)
Christophe Barache (SYRTE/Obs Paris)
Dario da Silva Neto (UEZO)
François Taris (SYRTE/Obs Paris)
Geraldine Bourda (Obs Bordeaux)
Jean-François Le Campion (Ob Bordeaux)
Jean Souchay (SYRTE/Obs Paris)
José Osório (CICGE/Fac Porto)
Júlio Camargo (Obs Nacional/MCT)
Marcelo Assafin (Obs Valongo/UFRJ)
Roberto Martins (Obs Nacional/MCT)
Sébastien Bouquillon (SYRTE/Obs Paris)
Sébastien Lambert (SYRTE/Observatoire de Paris),
Sonia Antón (CICGE/Fac Porto/SIM)
Patrick Charlot (Obs Bordeaux)

+ Ana Afonso (CICGE/SIM)
  Bruno Coelho (CICGE/Fac. Porto)



I.Q.C.G.

The Catalogue: 136 643 SDSS spectroscopic redshift QSOs, for which, 102 403 have morphological indexes @ *ugriz* bands

Contents:

– redshift
– magnitude
– **morphological parameters**

– flag on type
– flag on reliability

– flag on **variability** *work in progress*

– > might hamper top astrometric accuracy if not accounted for

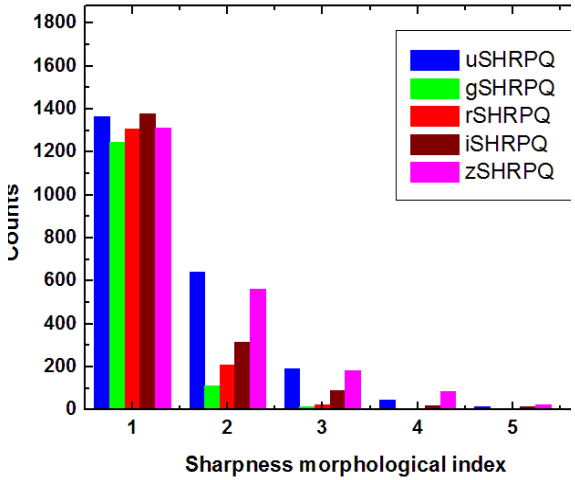
• Implemented exponential model routines for photometric variability

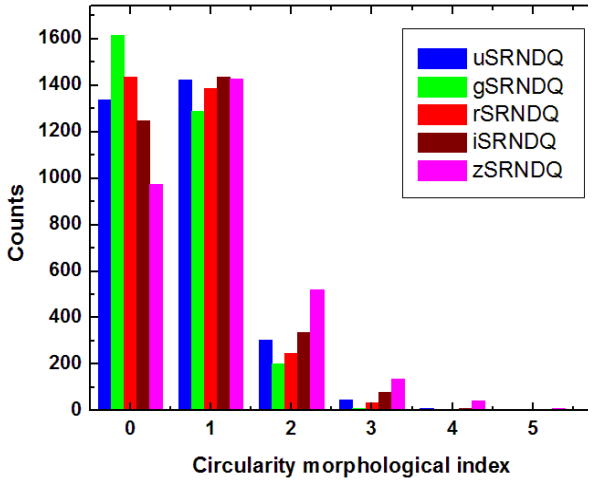
▪ Dedicated, long term light curve observations at Chile, Australia, Haute Provence, and Calern, plus re-analysis of the CFHT Legacy survey
• **F**orthcoming observation campaigns: NOT and CFHT

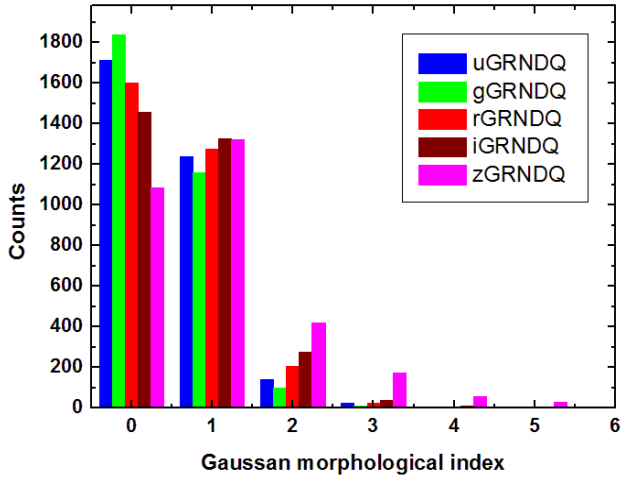


Morphology and the signature of the host galaxy

Extracted 2048 × 1489 pixels (at 0”.396 arcsec/pixel →13’.5 secδ× 9”.8) regions containing the **105,783 spectroscopically confirmed QSOs** in the latest catalog of the SDSS (2010) for the five *ugriz* colors.



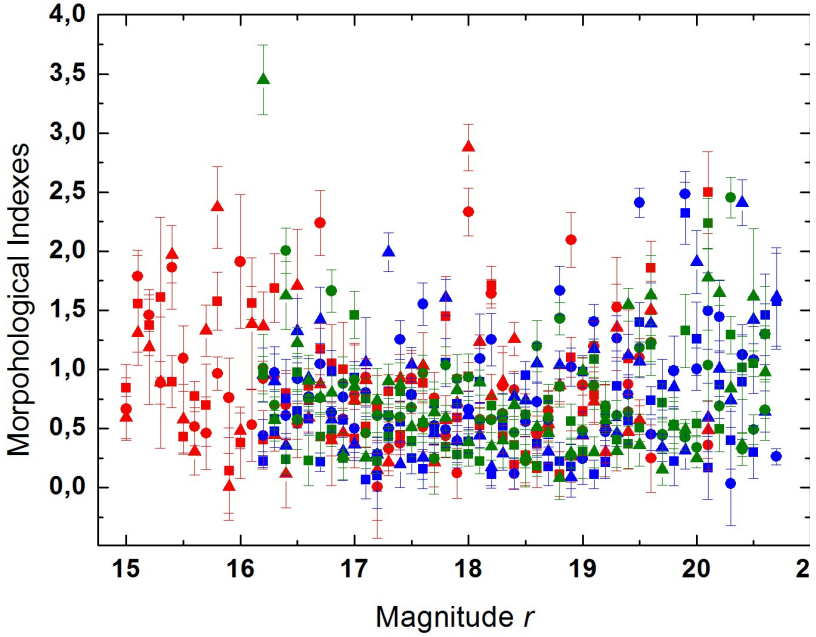


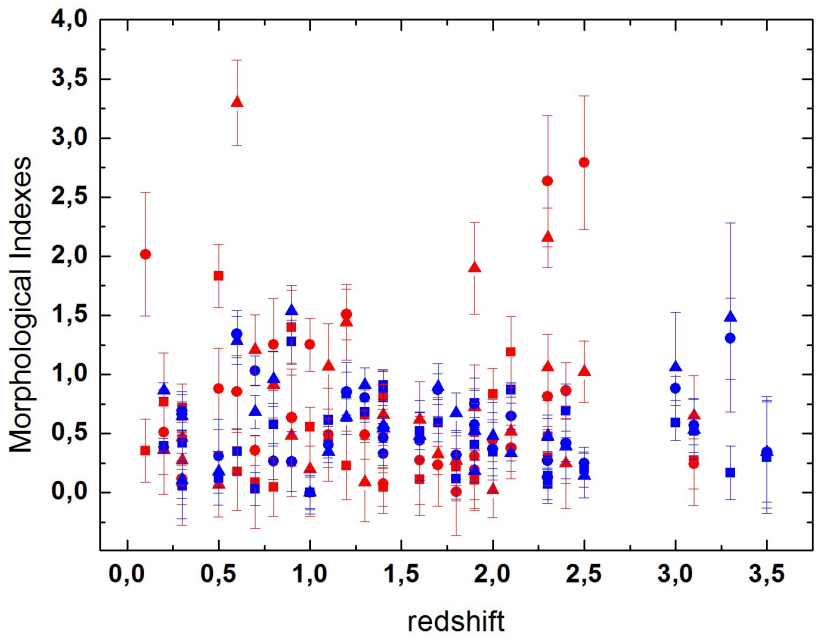


Coelho et al 2012

Morphology and the signature of the host galaxy *ugriz* comparative analyses by magnitude and redshift classes

SDSS *r* magnitude Morphological indexes IRAF's SHARP, SROUND, and GROUND, calculated by comparing the QSO's PSF against the mean surrounding PSF. Each point is the average for 10 objects randomly chosen to represent the class





■ SHARP	RED	z=0.2
● SROUND	BLUE	z=0.8
▲ GROUND	GREEN	z=1.4

■ SHARP	RED	*r* =17.3
● SROUND	BLUE	*r* =18.7
▲ GROUND		



Andrei et al

Photometric Variability

root-mean-square magnitude difference on a one year timescale

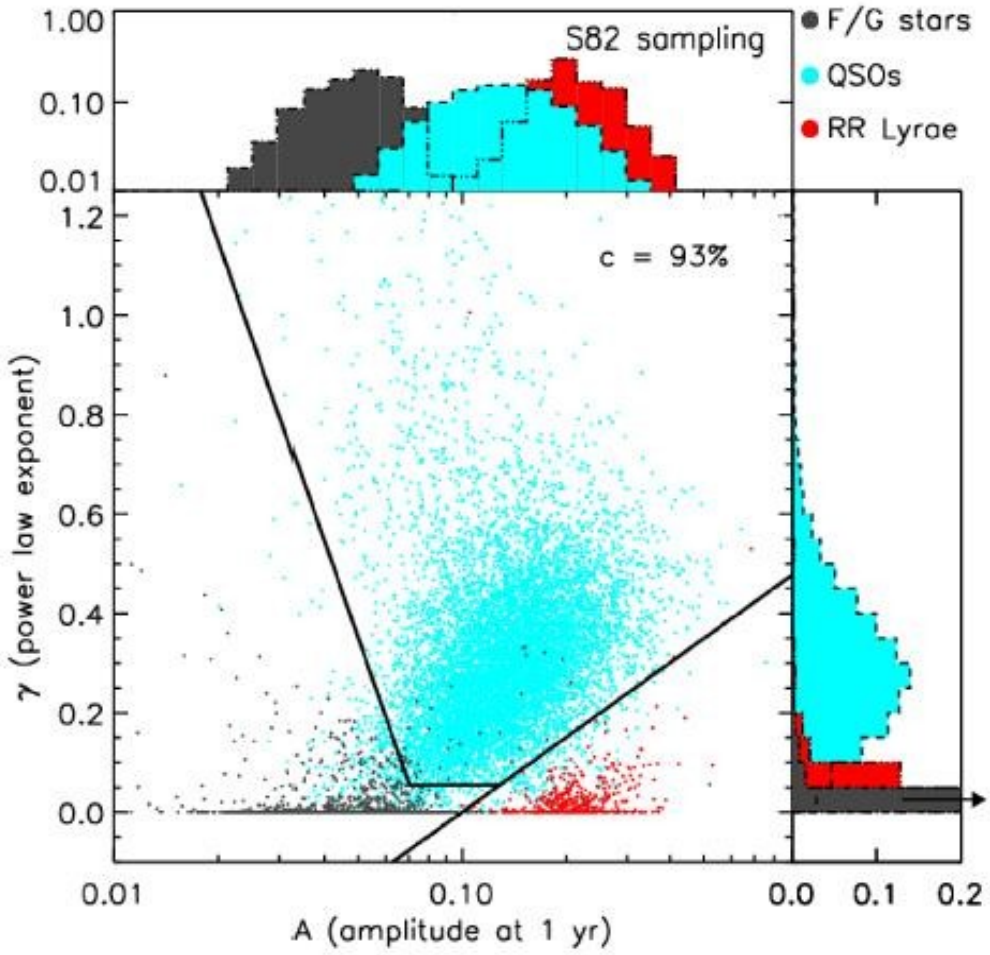
$$V \sim A \ (\Delta t / yr)^{\gamma}$$

variability index

SDSS stripe 82 – 15000 objects
60 epochs of imaging data, ~5 years

UV-excess selected objects
identification of quasars with a completeness of 90% and a purity of 95%

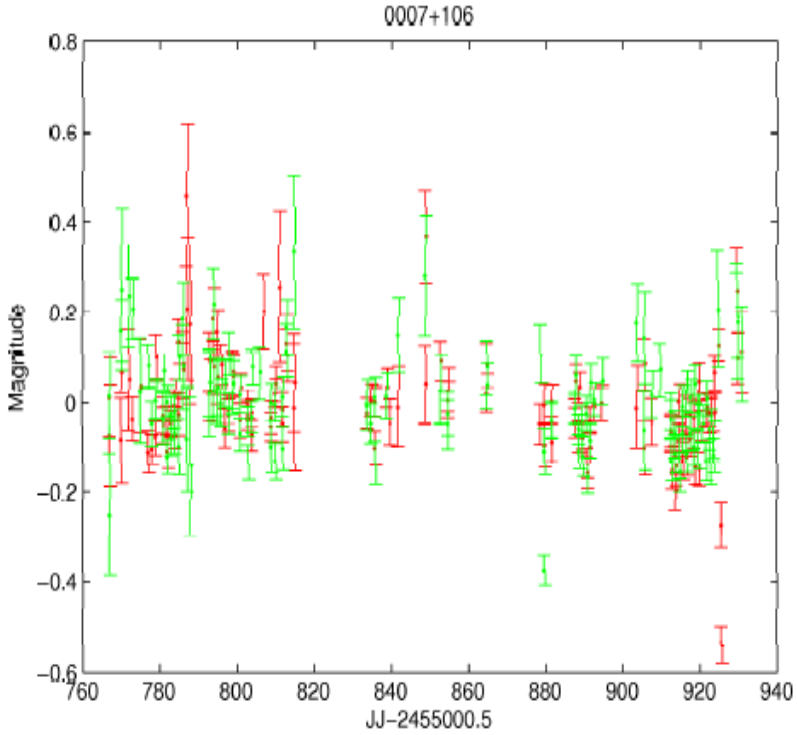
2.5 < z < 3, variability can select quasars with a completeness of 90% and a purity of 96%

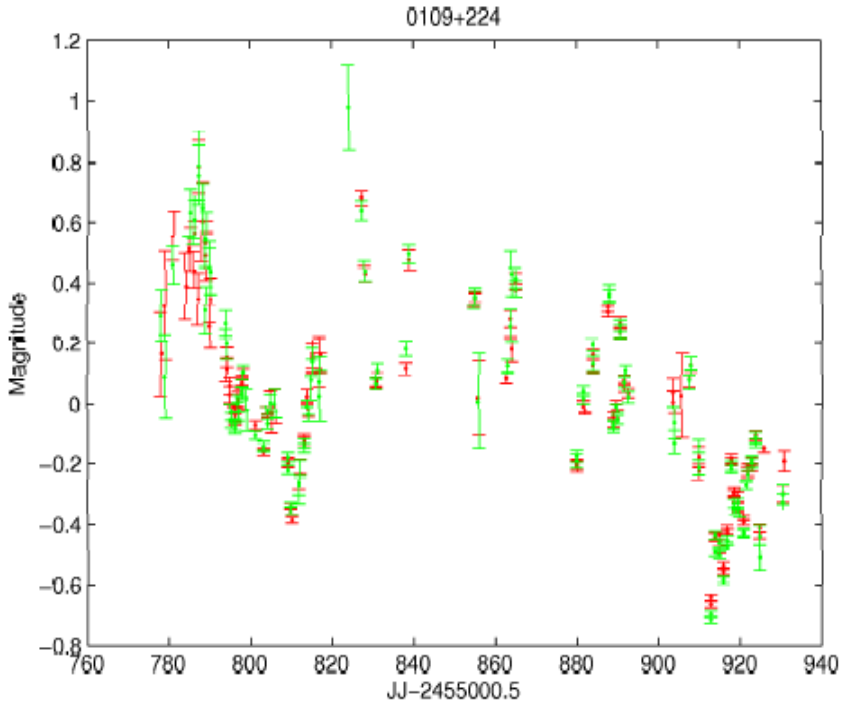


Schmidt et al (2010)

- spectroscopically confirmed quasars – blue points
- confirmed RR Lyrae – red points
- F/G stars – grey points
- solid lines: quasar completeness 93%.

Photometric Variability
Monitoring Programs





A = 0.348 ±0.006

γ = 0.484 ±0.0009

G,R mag

Zadko telescope

A = 0.394 ±0.003

γ = 0.558 ±0.0003

Alexandre Andrei

GAIA

Multi-epoch

Photometry (up to 20 mag)

Microarcsec astrometry

for the first time a unique combination of astrometric accuracy + multi-epoch optical photometry *in an all-sky flux limited survey*



Jittery Quasars

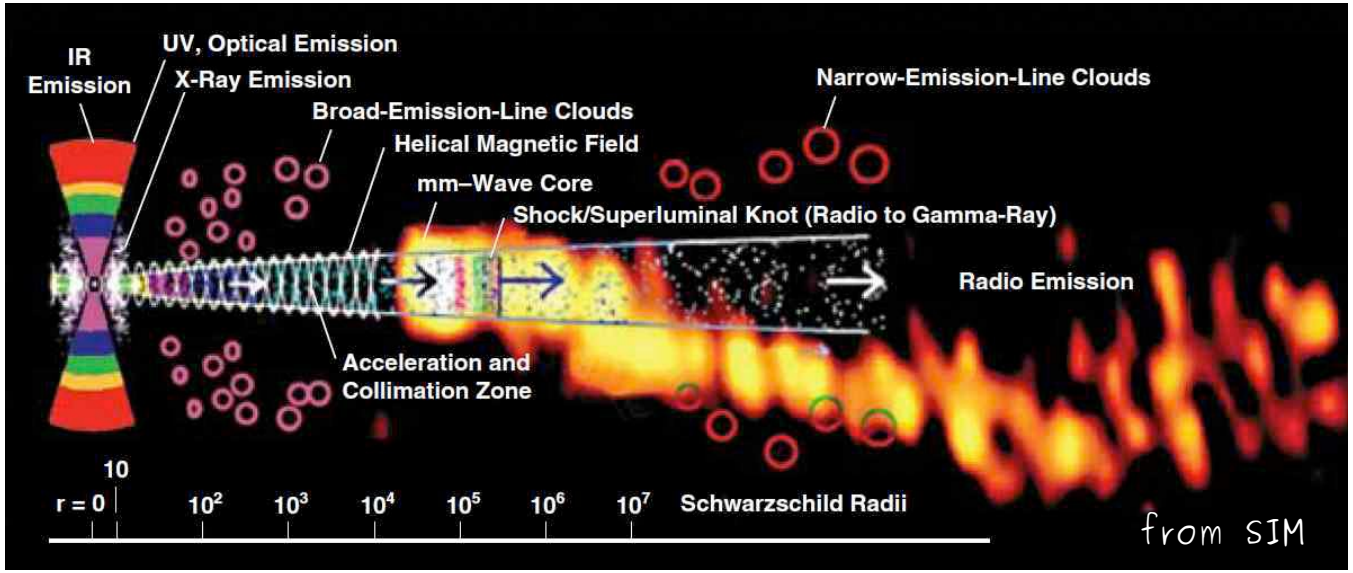
Alexandre Andrei

Francois Taris
Obs Paris Obs Turin Obs Rio

Luka Popovic
Obs Belgrado



Gaia: 5 year astrometric look at the non-thermal jet

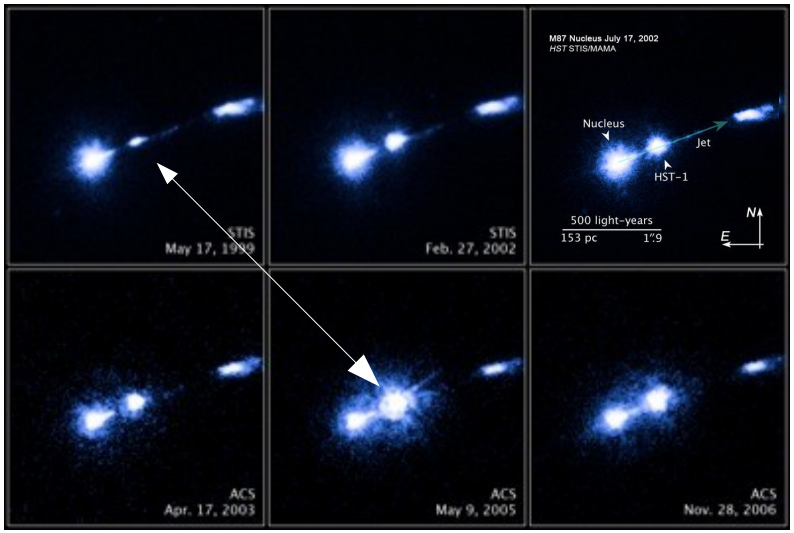


~0.1pc $M_{BH} = 10^9 M_{sun}$ ~1 kpc

z=0.05 → 0.9pc/mas **z=0.1 → 1.8pc/mas** **z=1 → 8pc/mas**

M87 – HST multi-epoch data
jet knot @ 0.85" from nucleus:
90x brighter in 7 yrs

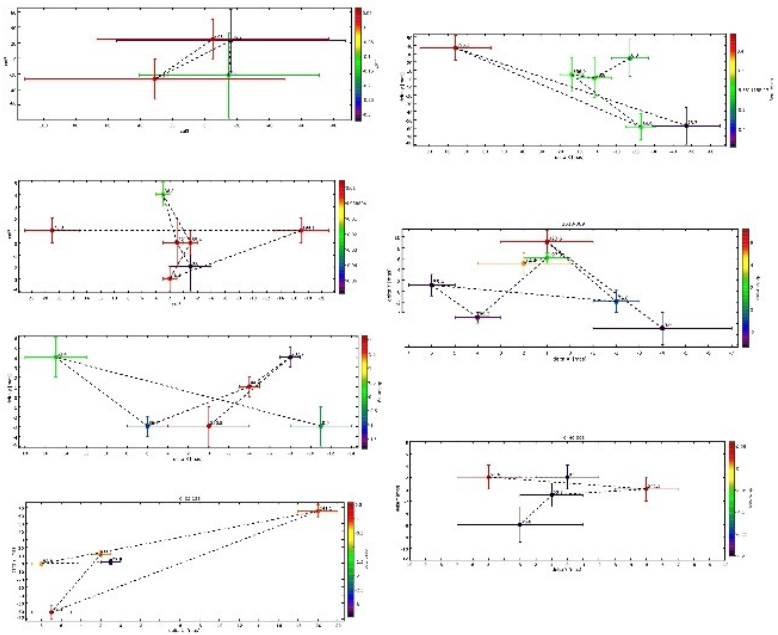
Madrid 2009

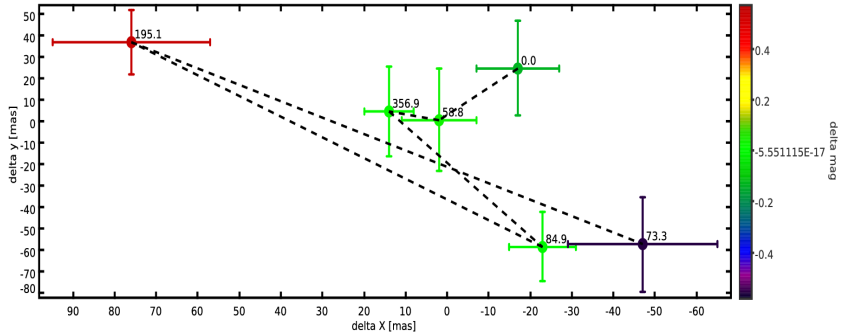


ESO Max Planck 2.2 m project – Andrei et al

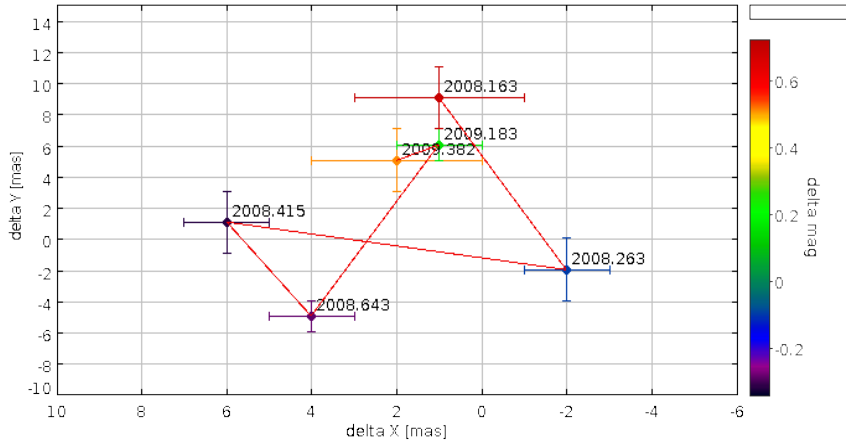
2.5 year campaign; 20 blazars from Teerikorpi (2000) + Maccacaro (1987)

photocenter astrometric position and magnitude are **relative quantities to a set of reference stars**





1510-089

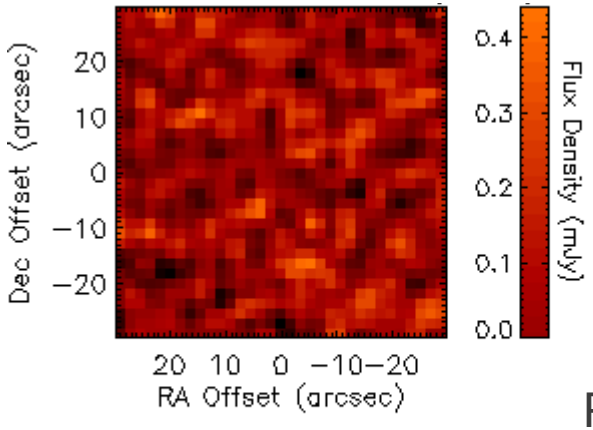


Most of the cases, there is a preferred direction of the jitter; mas scale

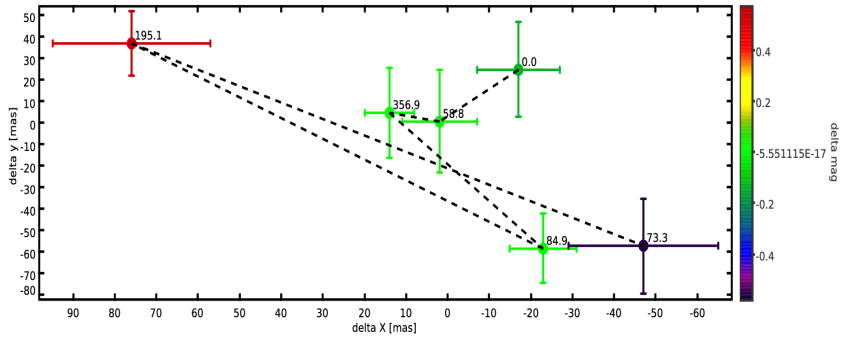
translates to tens of pc in most of the cases. What's the origin?

1.4 GHz

radio-counterparts

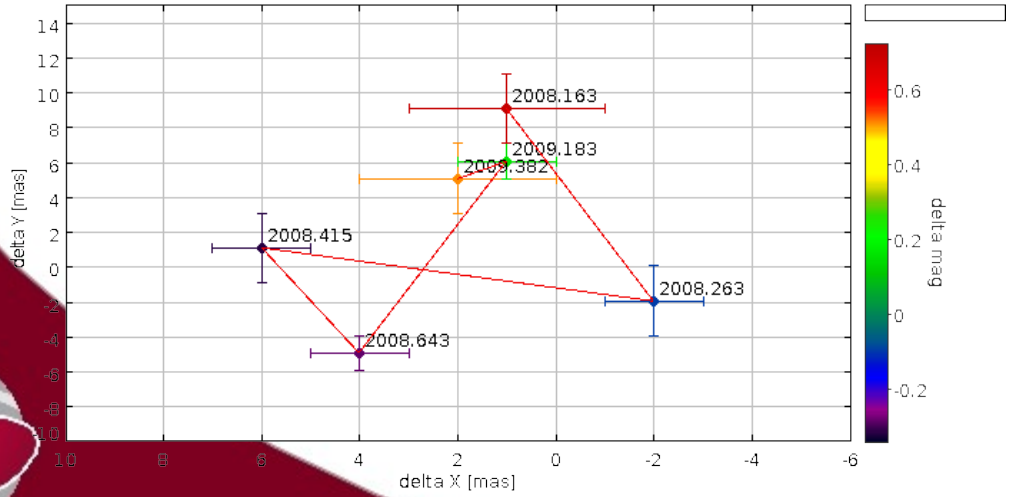


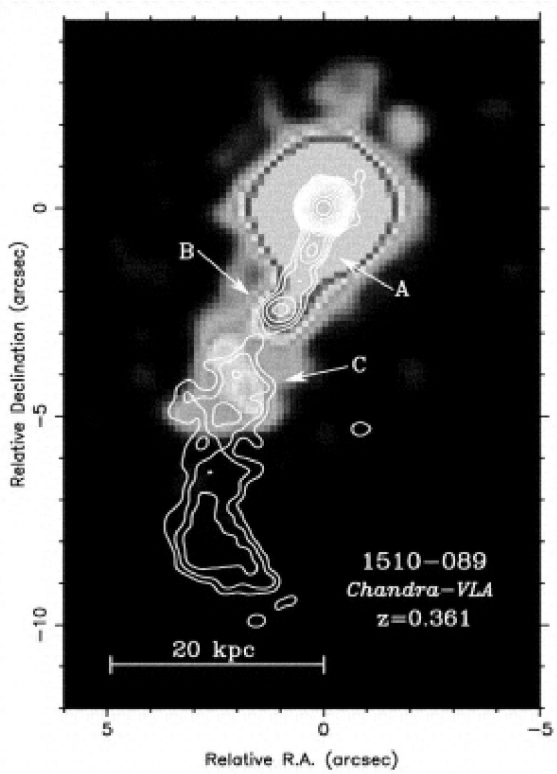
1620+17



Popovic et al 2012

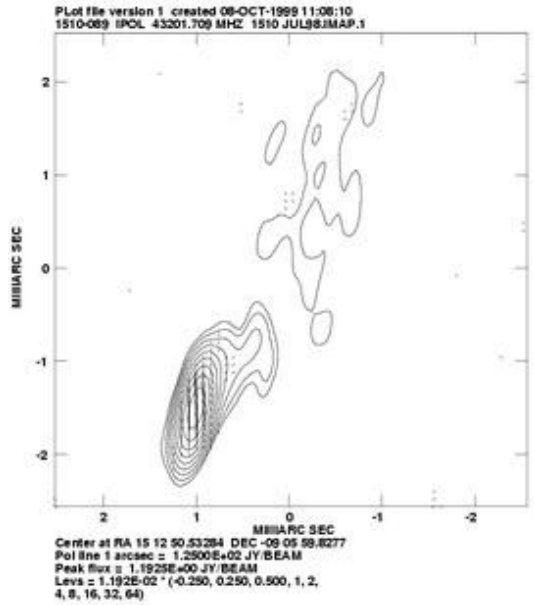
radio-loud
core-one sided jet





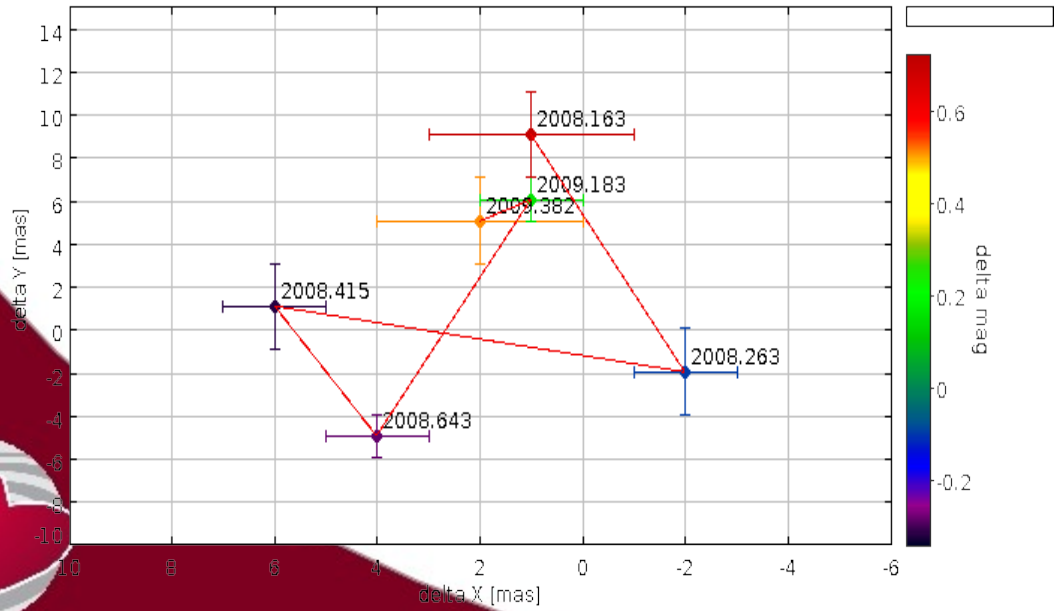
Anton et al 2012

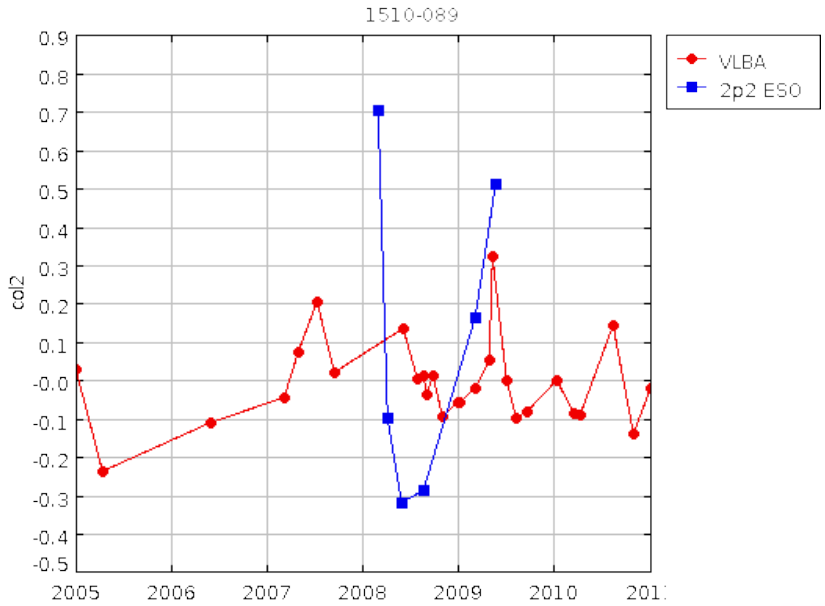
1510-089 – a radio loud, core-jet object





interpolated animations of the parsec-scale jet evolution in the MOJAVE AGN; the pseudocolors represent 15 GHz total intensity (VLBA) – from MOJAVE page





Offset Galaxies

Ian Browne

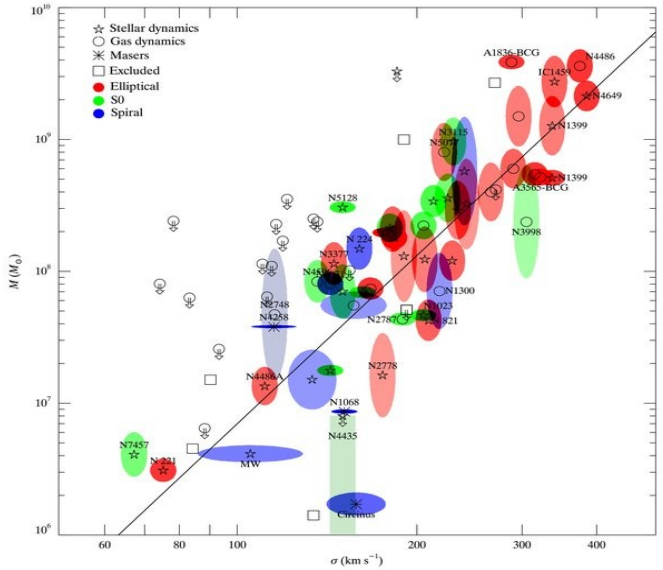
Simon Garrington
Jodrell Bank Obs-
Manchester

Ana Afonso
CICGE & SIM

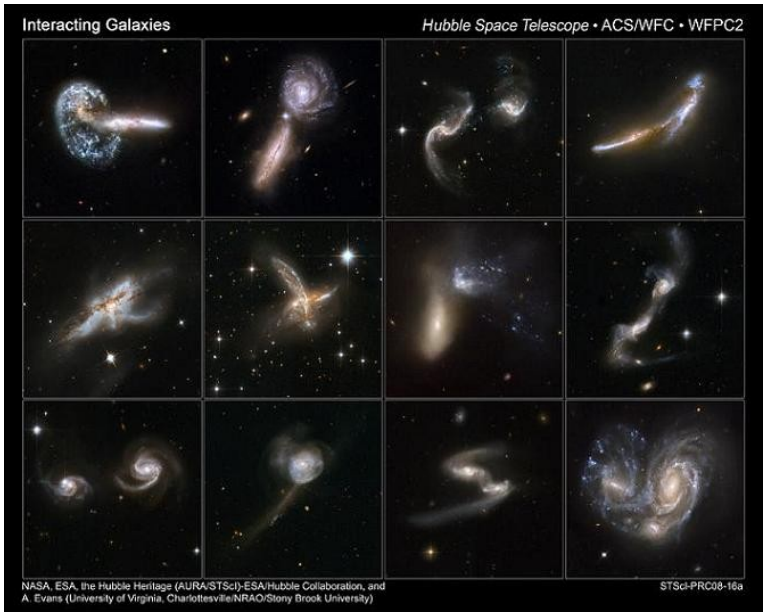


Nearly all galaxies (with a bulge) contain SMBH in their cores

M-σ relation for galaxies with dynamical measurements

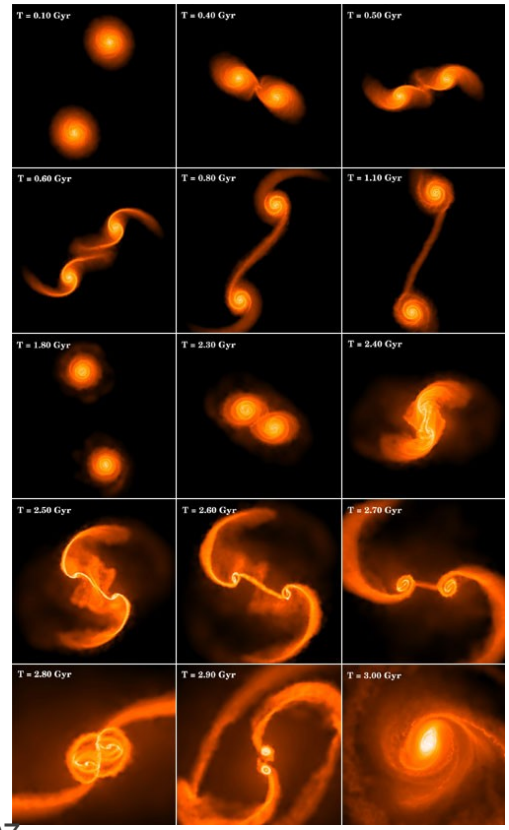


Merging is common in galaxy formation



if both have SMBH → Binary SMBH (Begelman 1980)

Binary SMBH should be common



Kazantzidis et al 2007

binary SMBHs

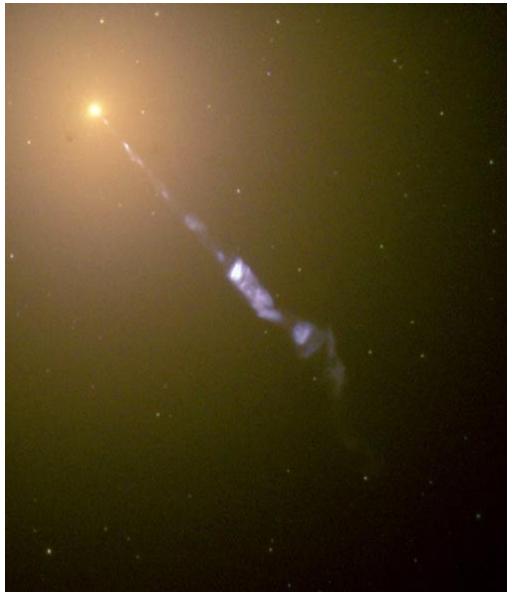
system stalls ?

system coalesces
anisotropic emission of grav. waves kicks SMBH

single SMBH recoils
kick V ~500kms^{-1}
→ 200pc offset
oscillation 10^7 yrs
Komossa&Merritt 2008

Spolaor et al 2000 VLBI maps and only re-discovered 0402+379
Browne et al 16000 VLA maps. 23 lenses but no binaries

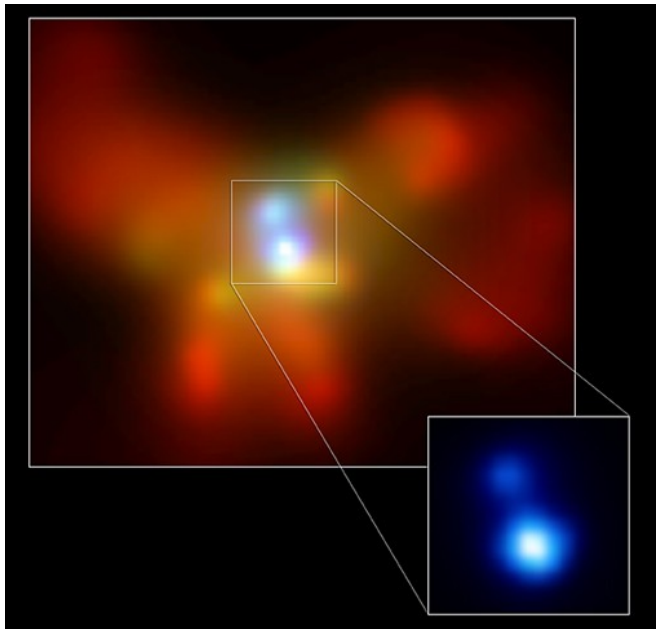
M87 a kicked SMBH?



nuclear point source and
photocenter (isophotal fitting)
displaced by 0.”1 == 6.8 pc

Batcheldor et al 2010

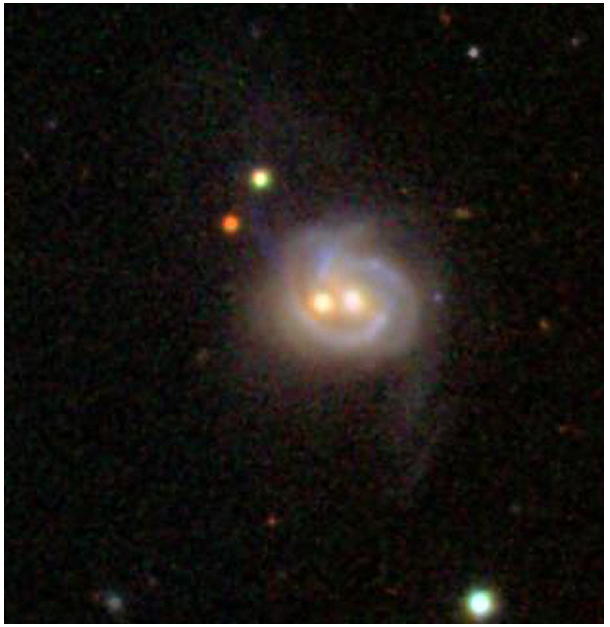
NGC 6240



separation 1.8”
0.7 kpc

Komossa et al 2003

Mrk 739

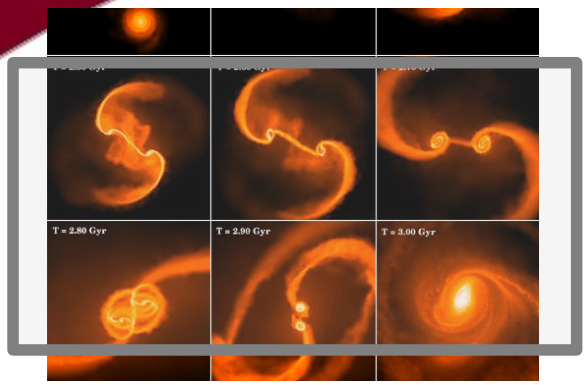


separation 5.8”
3.4 kpc

Koss et al 2011

Very few Binary Systems have been detected

low z



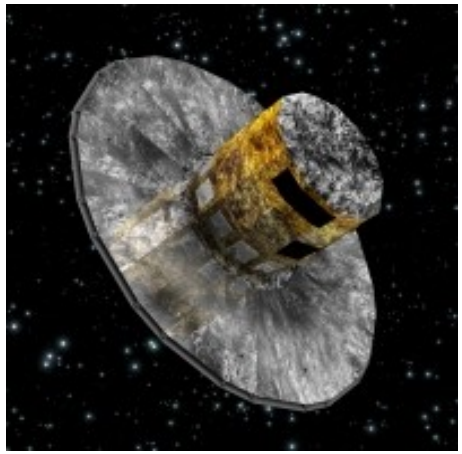
Passive Elliptical Galaxies
“opticallly”
old, red bulgy galaxies & “non active” at optical bands
@ GHz band:
compact radio emission mJy level

Any offset SMBH system?

e-MERLIN astrometry
SMBH position



Gaia astrometry
centre of mass position



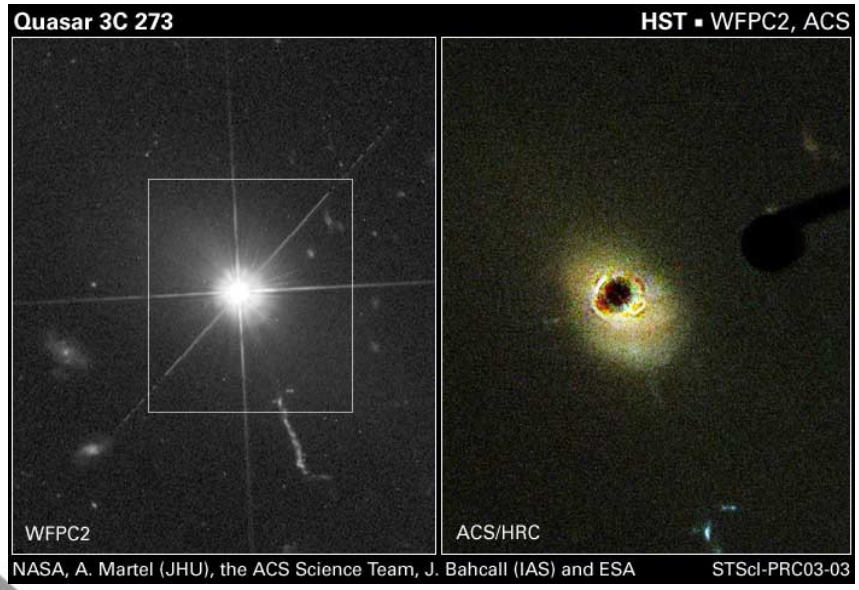
Pilot project:
e-MERLIN obs (astrometry 1 mas) 28 galaxies (FIRST SDSS sources)
compare e-MERLIN pos. with SDSS (GALFIT) pos.

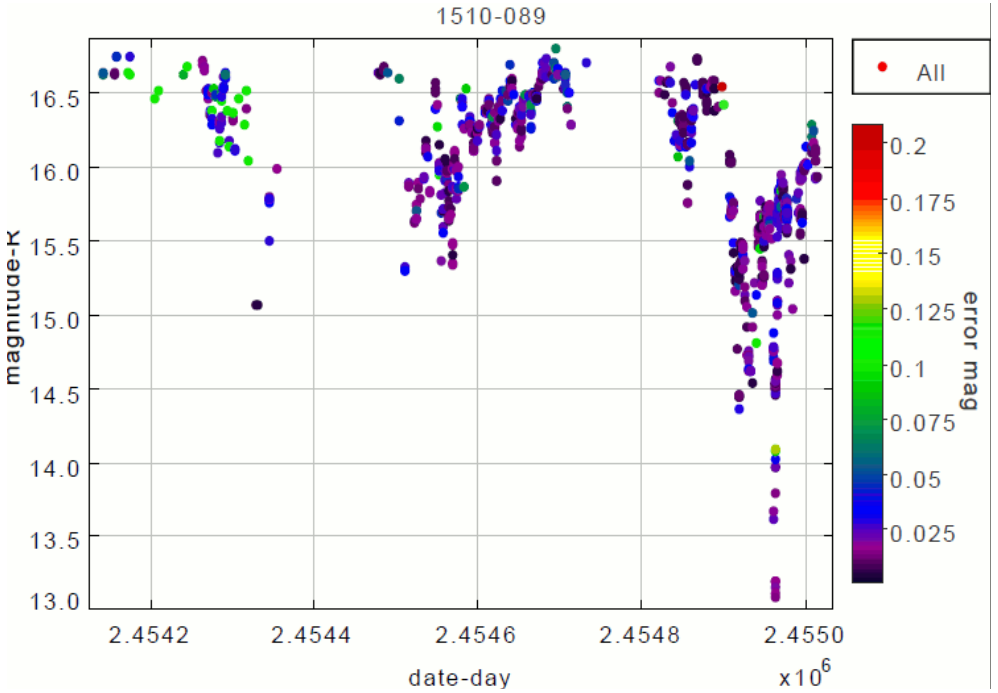
if suceed (ie radio &optical centres are within 10 mas) than:
~ 10 000 radio positions for ellipticals z<0.4

Combine image and variability analysis



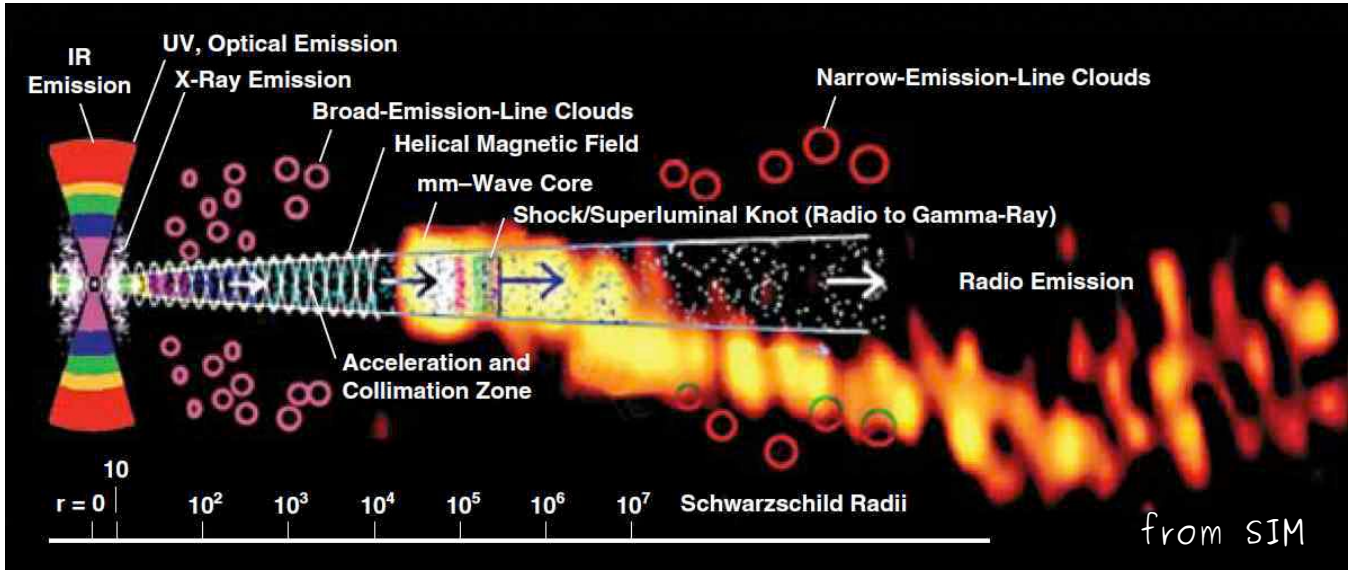
as auxiliary means for QSOs GAIA recognition





2007 **2009**

Gaia: 5 year astrometric look at the non-thermal jet – short and long time scale

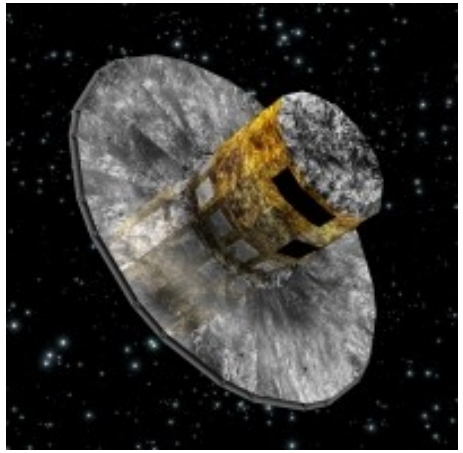


~0.1pc $M_{BH} = 10^9 M_{sun}$ ~1 kpc

z=0.05 → 0.9pc/mas **z=0.1 → 1.8pc/mas** **z=1 → 8pc/mas**

Gaia: flux limited all-sky astrometric look: off centres among non-optically active AGNs





Quasars, characterization, morphology, properties

Sonia Antón

CICGE – Fac. Sciences Porto
SIM-Fac Sciences Lisbon