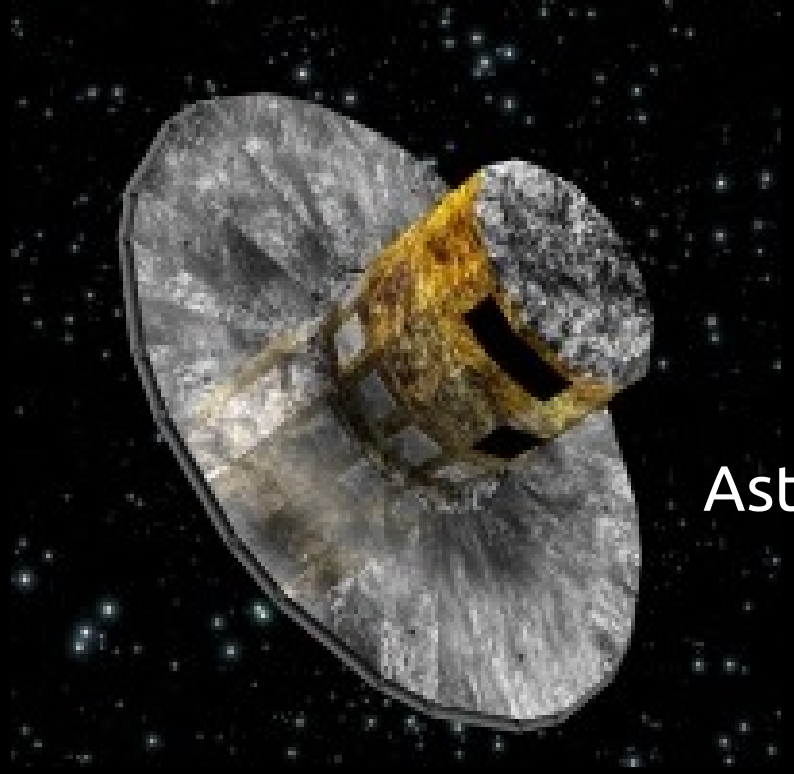


Astrometry and AGNs in the Gaia-SKA era

Sonia Antón
IAA-CSIC (Spain) & CICGE-UP (Portugal)

gaia mission

Microarsec astrometry

Photometry up to 20 mag

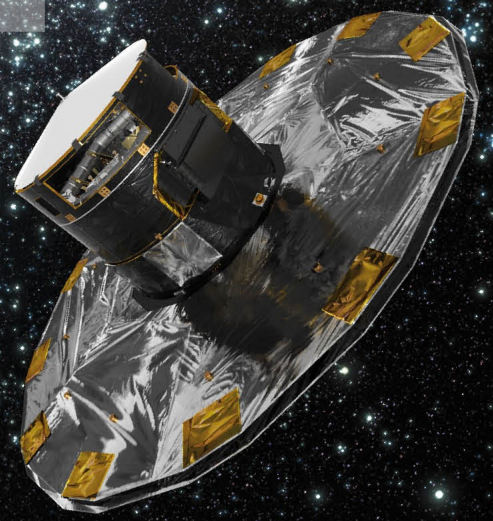
Multi-epoch

Gaia will provide for the first time a unique combination of astrometric accuracy and multi-epoch optical photometry in an all-sky flux limited survey

esa

gaia

→ THE BILLION STAR SURVEYOR



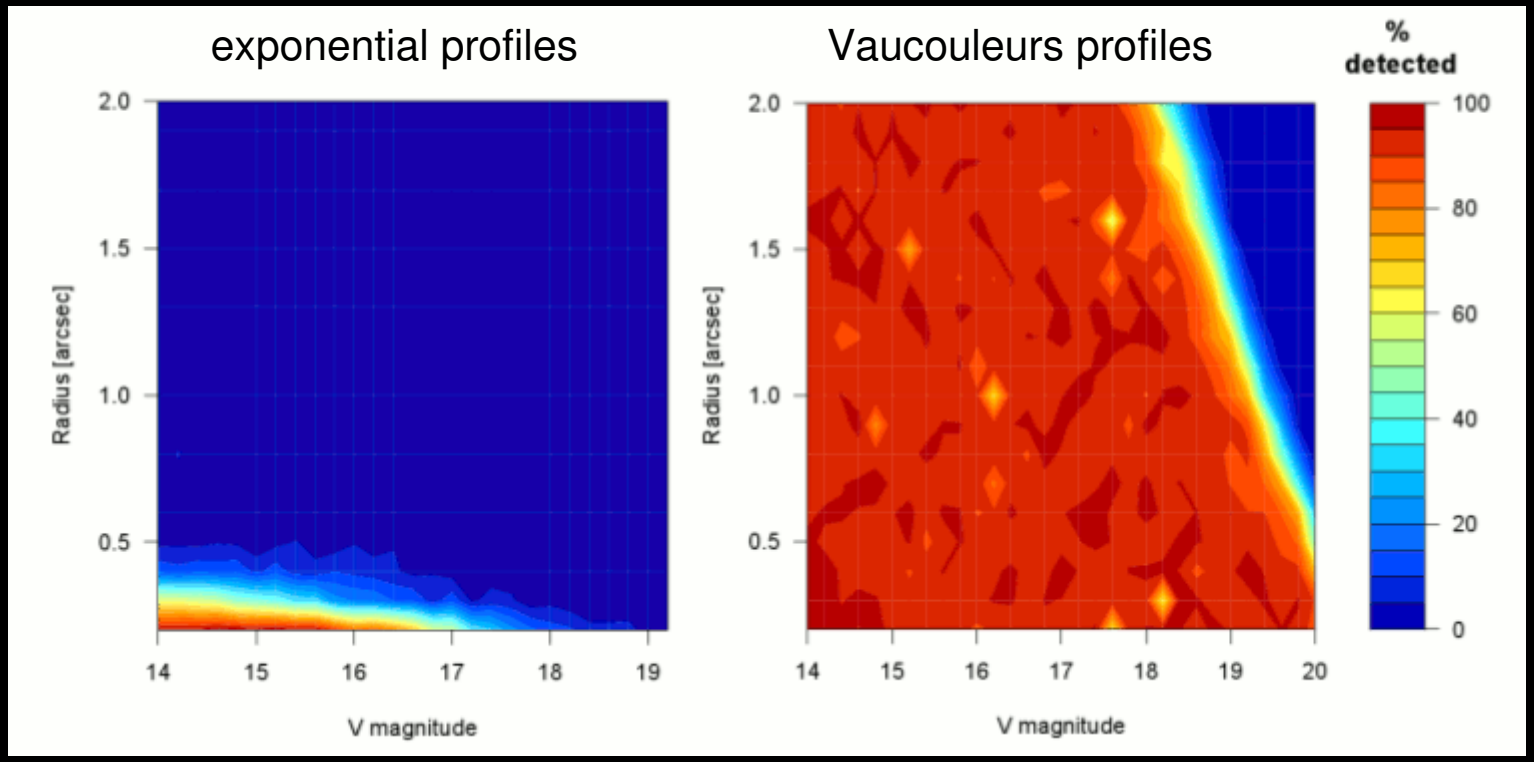
Background image: ESO/S. Brunier

www.esa.int

European Space Agency

gaia mission

~ 10^6 Galaxies



Efficiency detection maps of simulated brightness profiles at the Sky Mappers produced by the Gaia VPA Prototype implemented in GIBIS

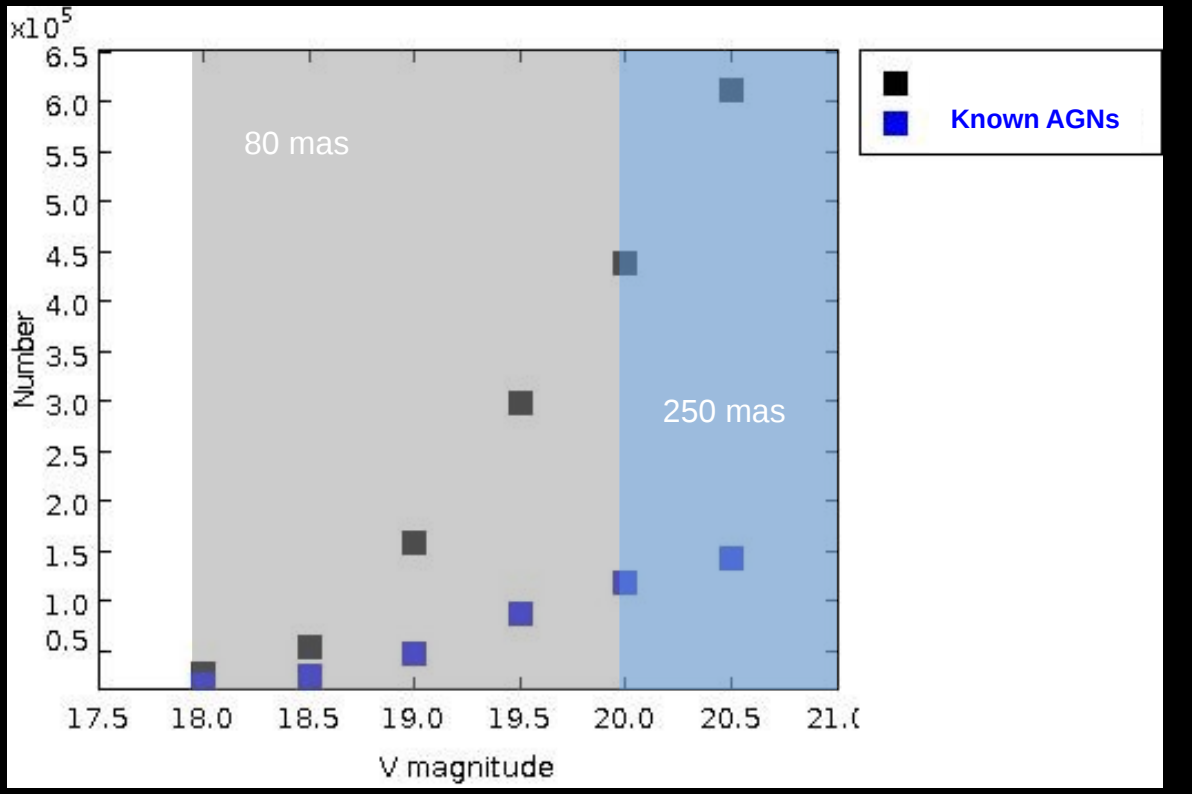
- most of the (20 000) ellipticals up to 170 Mpc are in condition to be observed by Gaia.
  ~ two thirds of objects up to 600 Mpc could also be detected

  → total sample to half a million objects including ellipticals and bulges

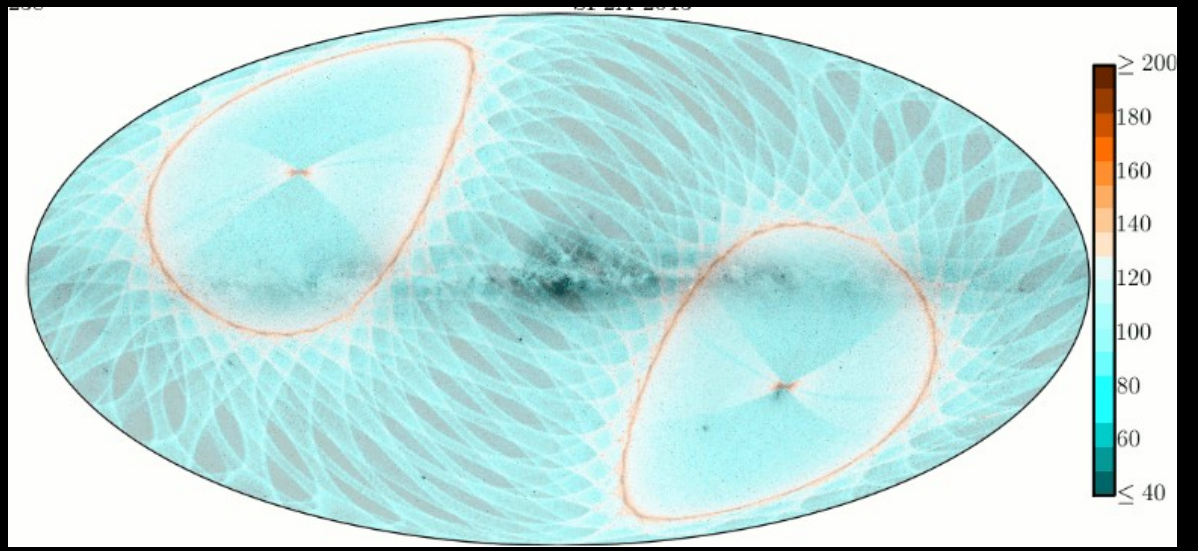
de Souza et al 2014

gaia mission

10^5 – 10^6 AGNs



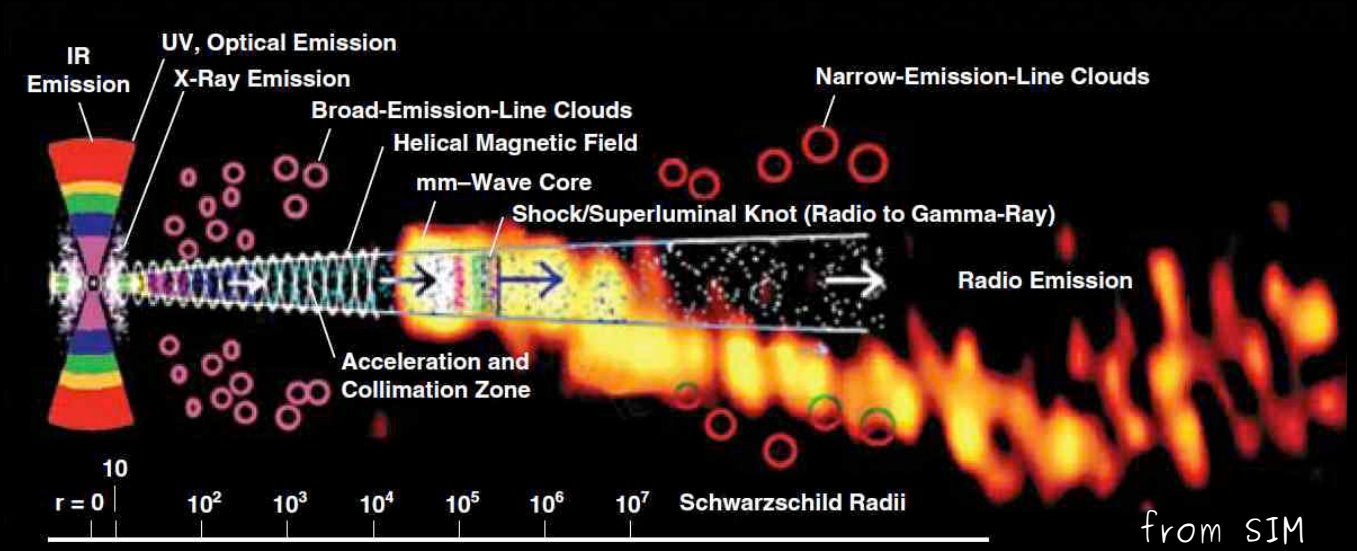
from Mignard 2012



will scan whole sky each ~ 6 months

on average, each source will be observed 70x along the 5 yrs (not uniformly across sky)

AGNS:
non-steady
phenomena



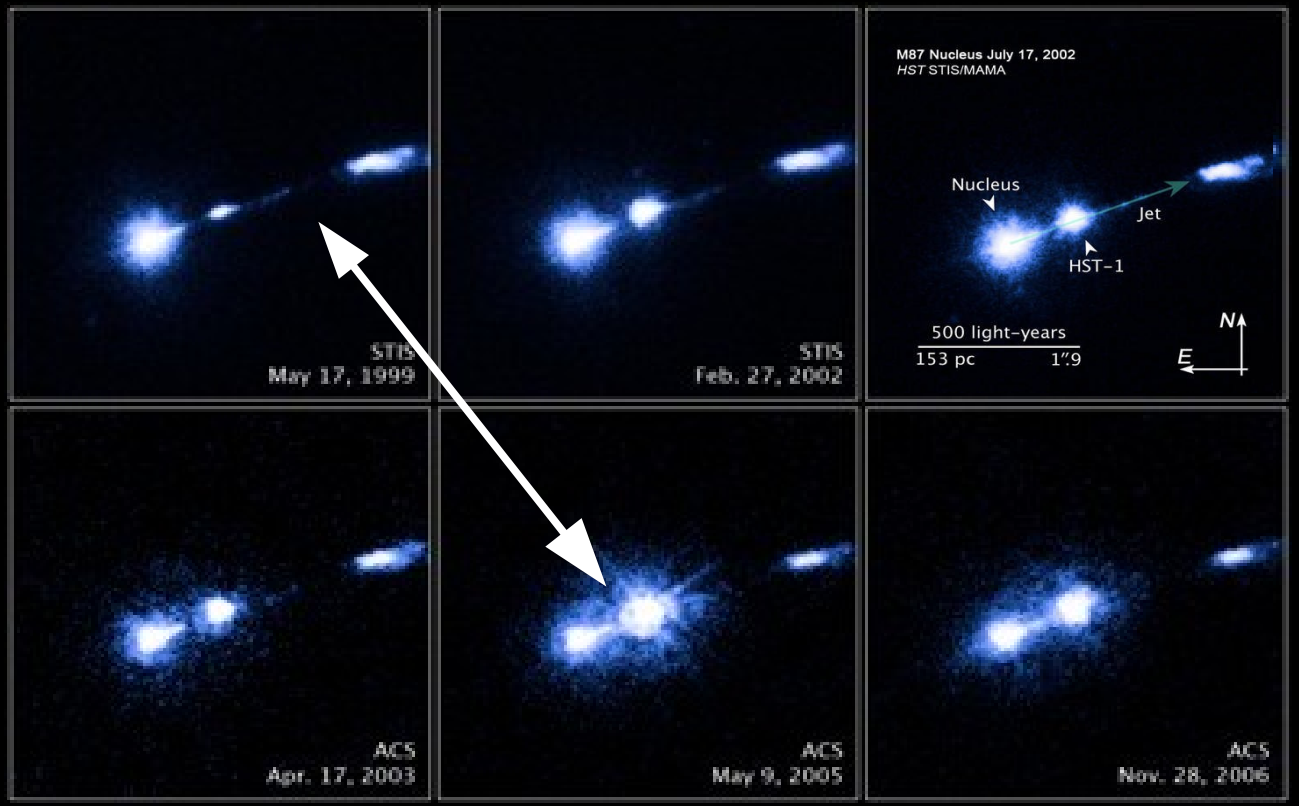
~0.1pc $M_{BH} = 10^9 M_{sun}$ ~1 kpc

Photocentre variability
Flux variability

M87 – HST multi-epoch data

Jet knot @ 0.85 arcsec from nucleus
90x brighter in 7 yrs

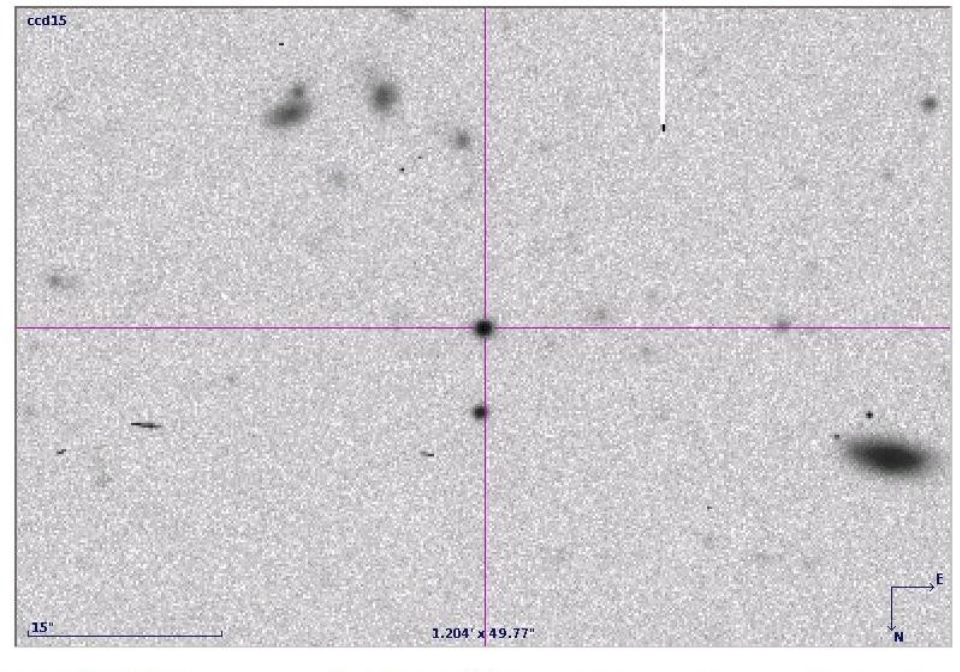
Madrid 2009

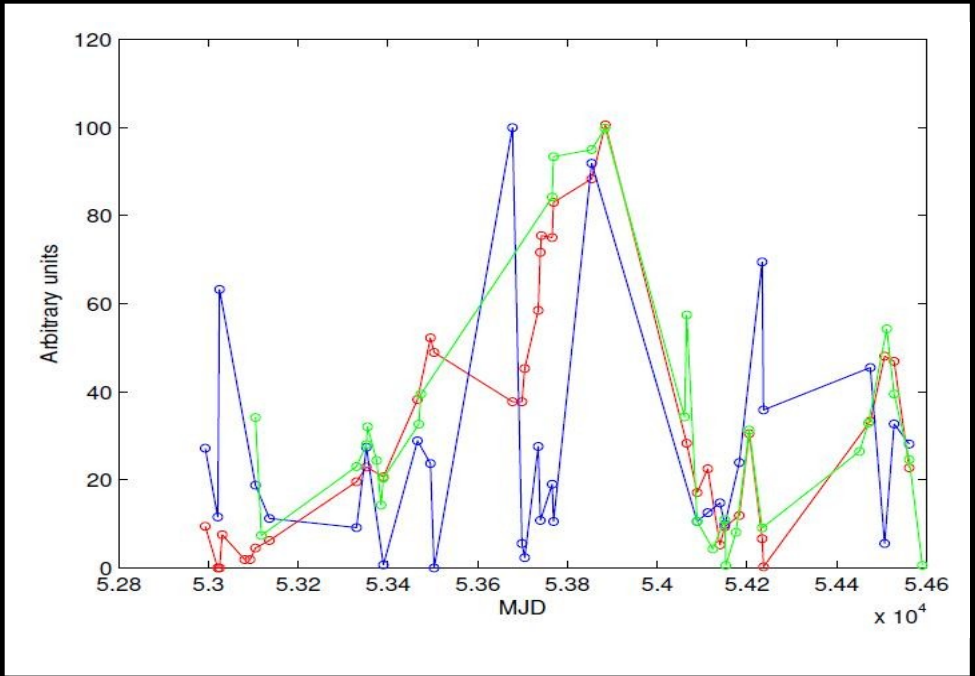


Photocentre variability
Flux variability
Example

QSO 39436
CFHT multi-epoch with a nearby star [5” south]

Taris et al 2011





Photocenter variation

B mag variation

R mag variation

Photocentre variability
Flux variability
more examples

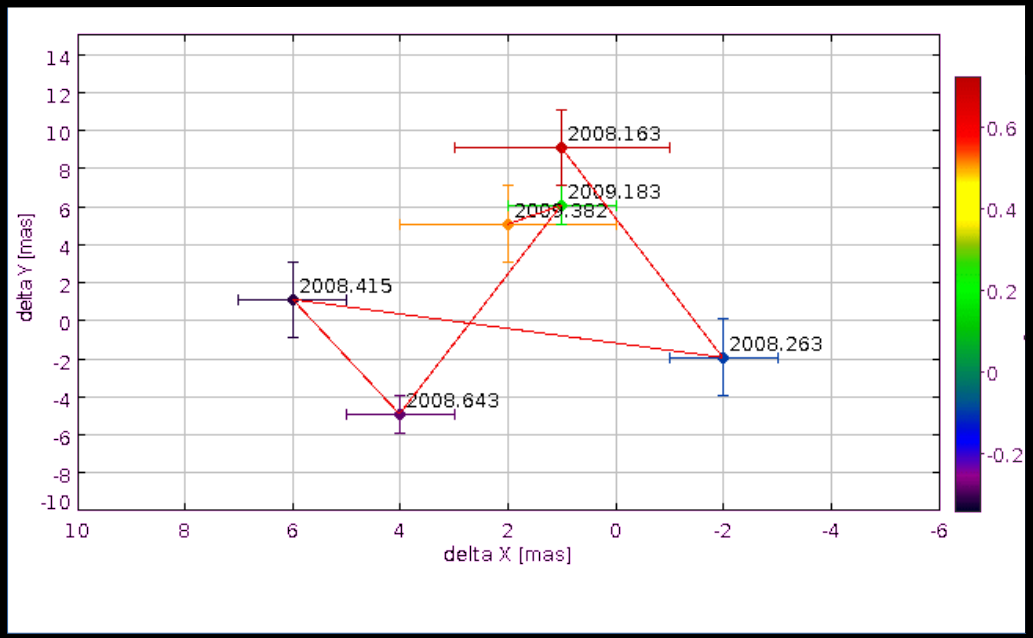
ESO Max Planck 2.2 m project – Andrei et al 2012

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

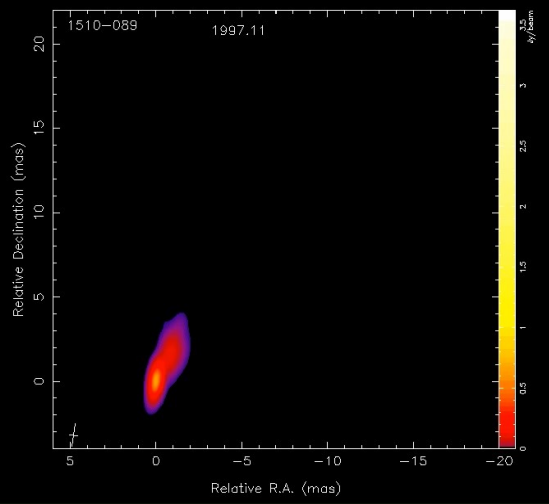
Photocenter astrometric position and magnitude [relative quantities to a set of reference stars]

- Jitter of the photocenter along time, mas scale [tens of pc]
- Most of the cases there is a preferred direction
- In some correlation between magnitude variability and photocenter variability

What's the origin?

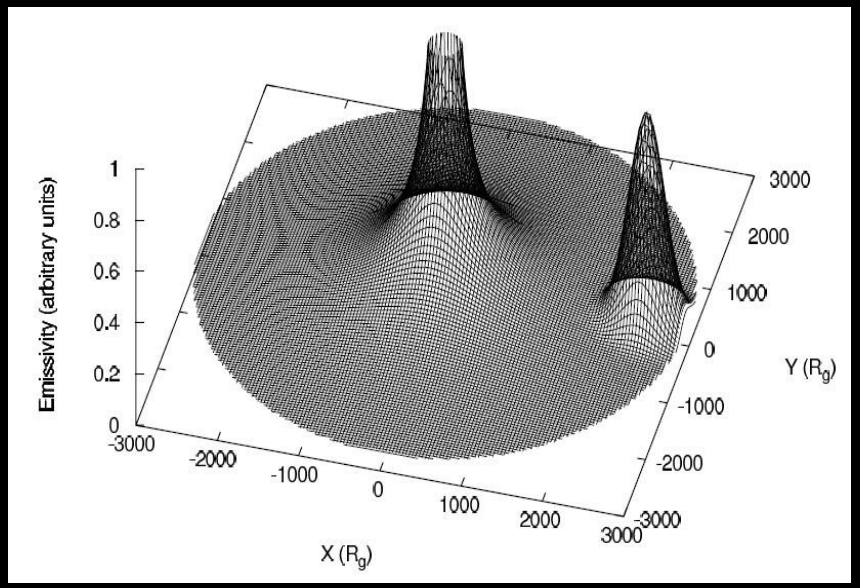


related with jet components like M87?
Anton et al 2012



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

Photocentre variability
Flux variability
more examples



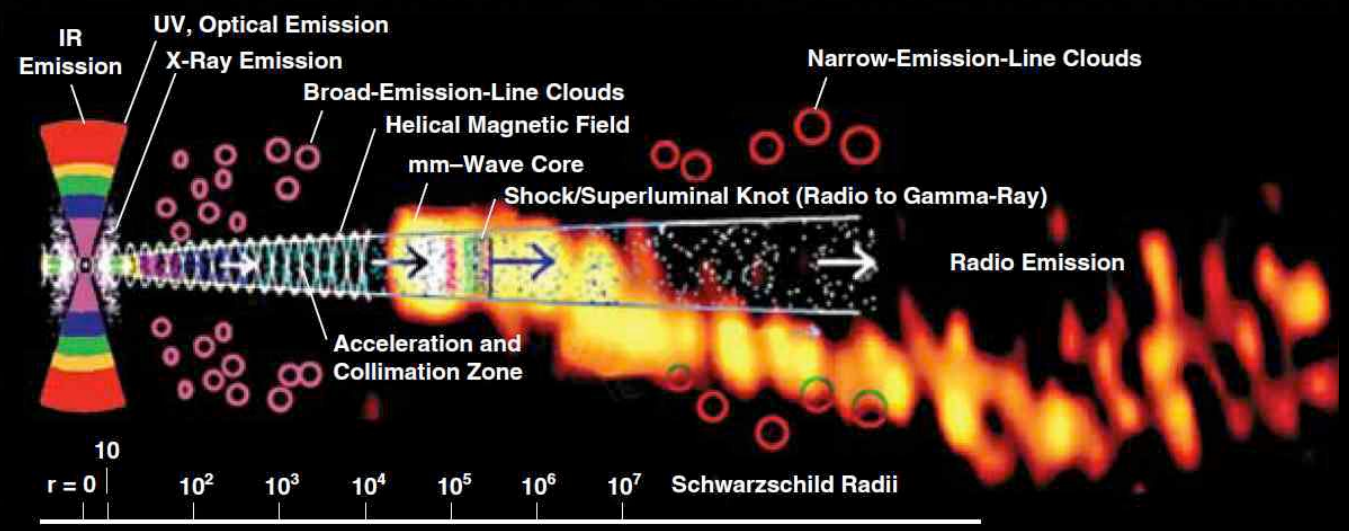
Related with accretion disc instabilities?
Popovic et al 2012

Simulated displacements of photocenter due to a perturbation in the accretion disk emissivity → several mas → so might be detected in bright low redshift objects

Multi-epoch Photometry (up to 20 mag) Microarcsec astrometry

Gaia will provide for the first time a unique combination of astrometric accuracy and multi-epoch optical photometry in an all-sky flux limited survey

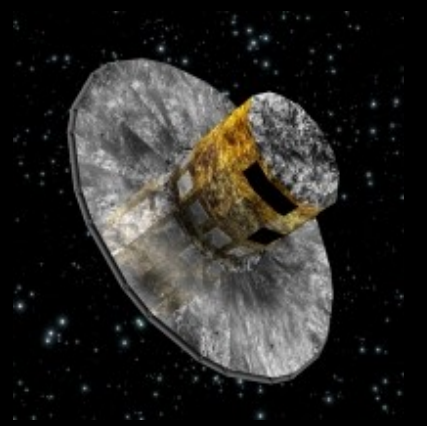
Astrometrically probing an unsteady region, along 5 years



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

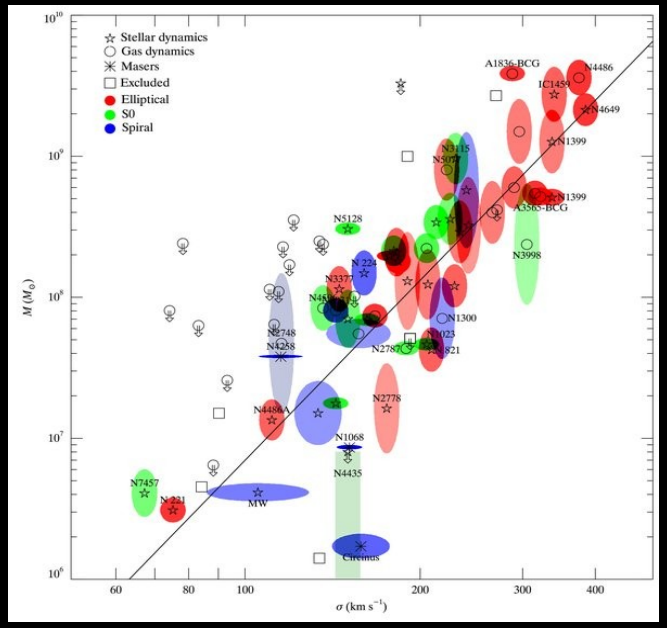
z=0.05 → 0.9pc/mas z=0.1 → 1.8pc/mas z=1 → 8pc/mas

Compare optical photocentres with radio centres



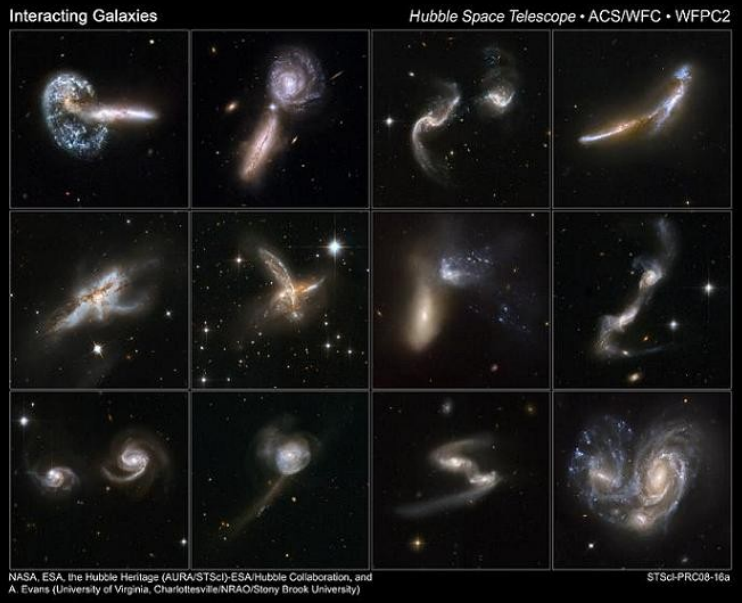
Offset Galaxies

- Nearly all galaxies (with a bulge) contain SMBH in their cores
- Merging is common in galaxy formation



M-σ relation for galaxies with dynamicalmeasurements

Gültekin et al. 2009

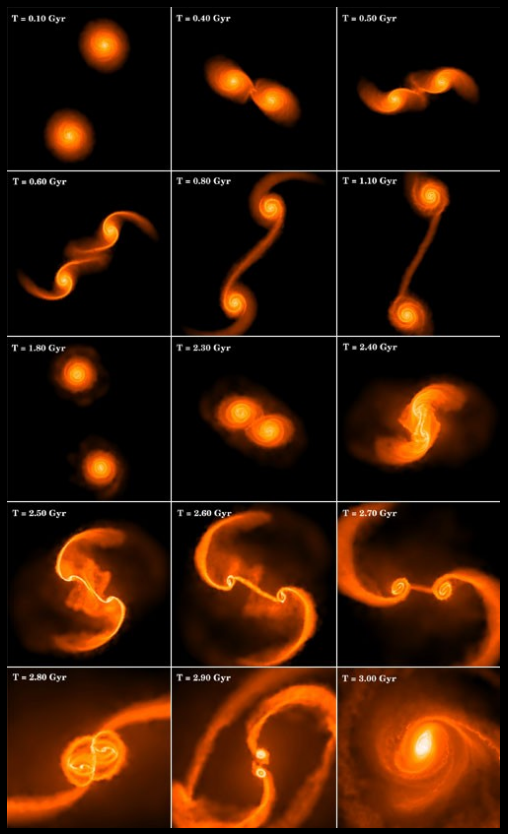


Interacting/Merging Systems

Astrometry & AGNs

- Nearly all galaxies (with a bulge) contain SMBH in their cores
- Merging is common in galaxy formation
- if both have SMBH → Binary SMBH (Begelman 1980)

Offset Galaxies



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

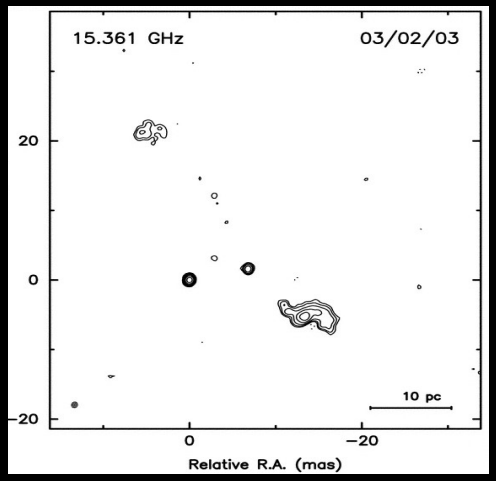
Kazantzidis et al 2007

Komossa&Merritt 2008

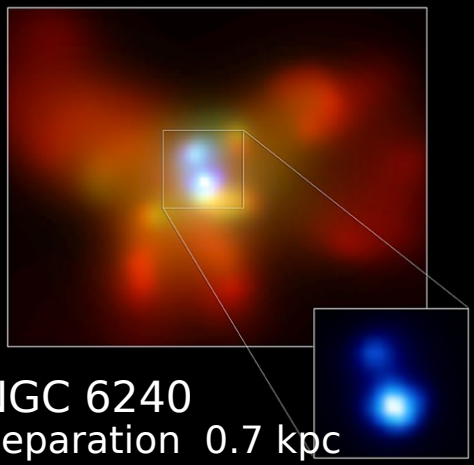
Very few Binary Systems have been detected

Spolaor et al
2000 VLBI maps:
only re-discovered 0402+379

Browne et al
16000 VLA maps:
23 lenses but no binaries

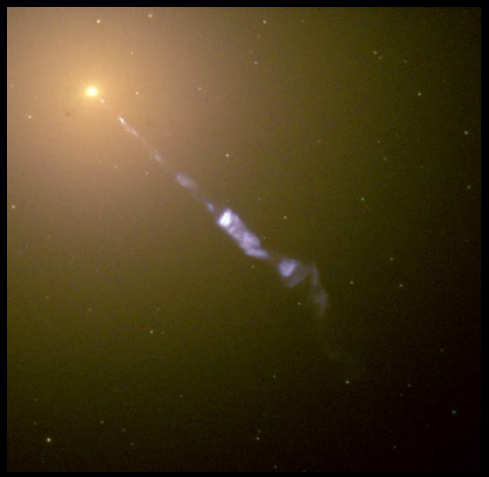


Maness et al 2004
Rodriguez et al 2006
separation 7.3 pc



NGC 6240
separation 0.7 kpc
1.8”

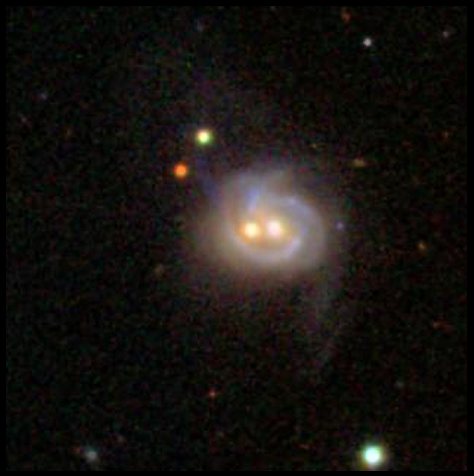
Komossa et al 2003



M87 a kicked SMBH?

nuclear point source &
photocenter (isophotal fitting)
displaced by 0.1” == 6.8 pc

Batcheldor et al
2010

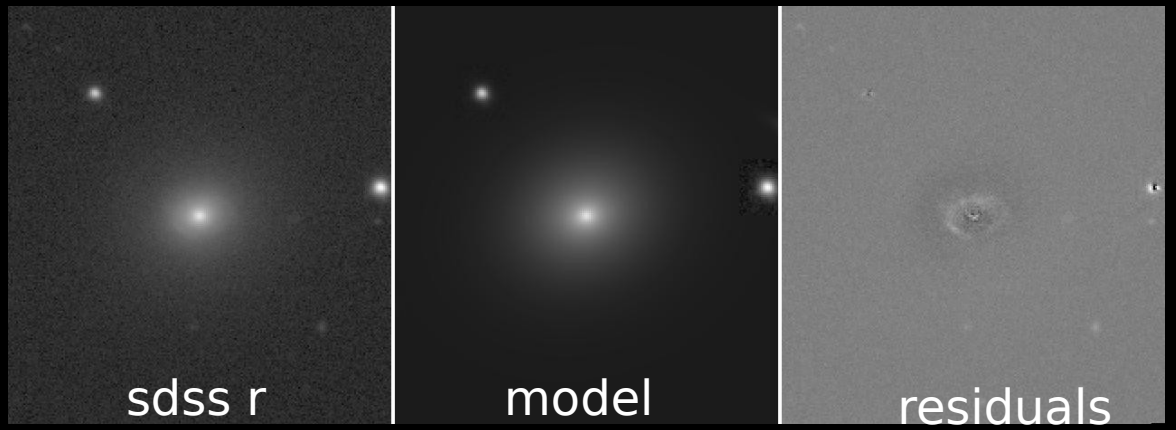


separation 3.4 kpc
5.8”

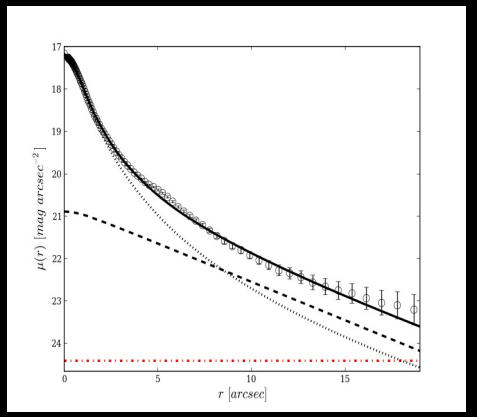
Koss et al 2011

Pilot project e-MERLIN obs (astrometry 1 mas) 28 galaxies (FIRST SDSS sources) Anton, Browne, Garrington

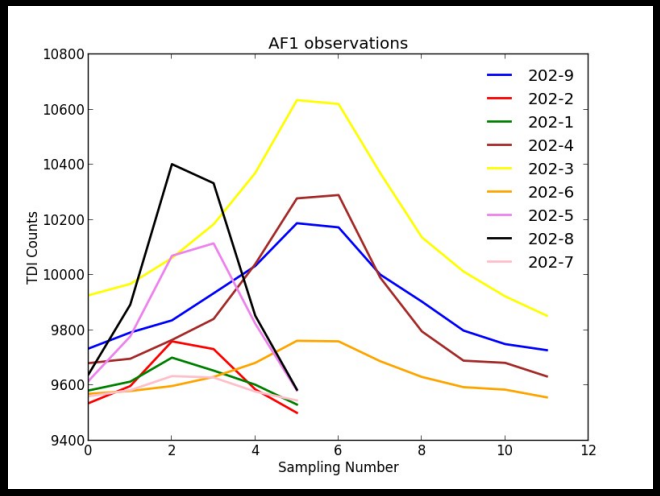
2-D host galaxy modeling Galfit (Peng 08)

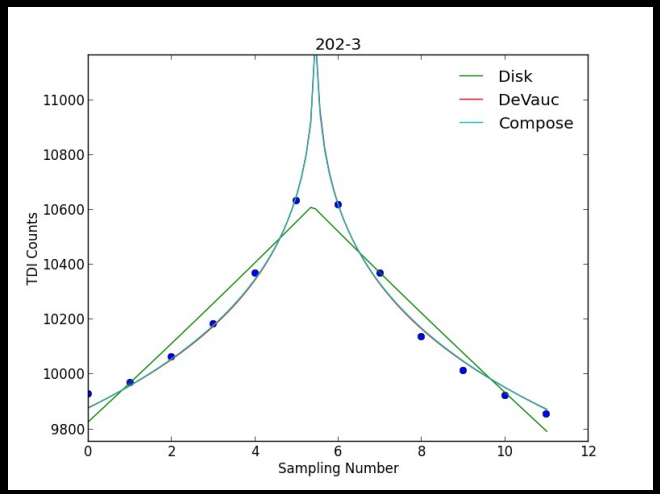


SDSS DR9 data



Gaia Instrument and Basic Image Simulator (GIBIS)



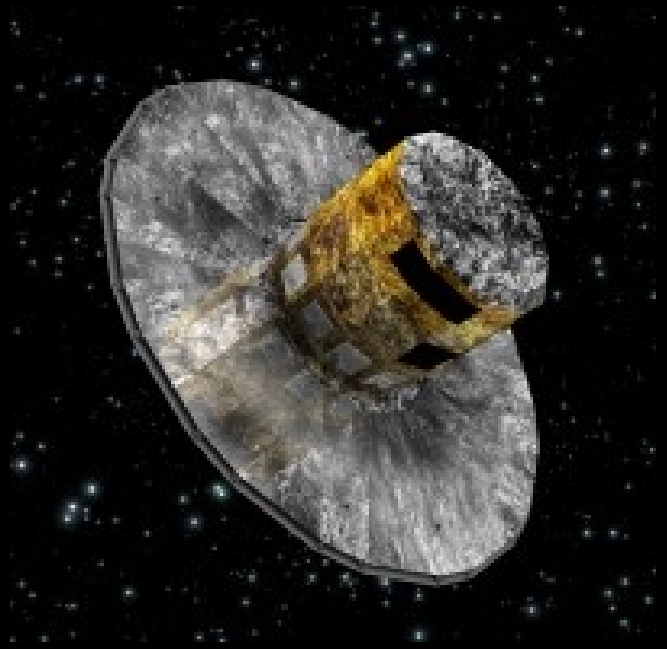


Ana Afonso

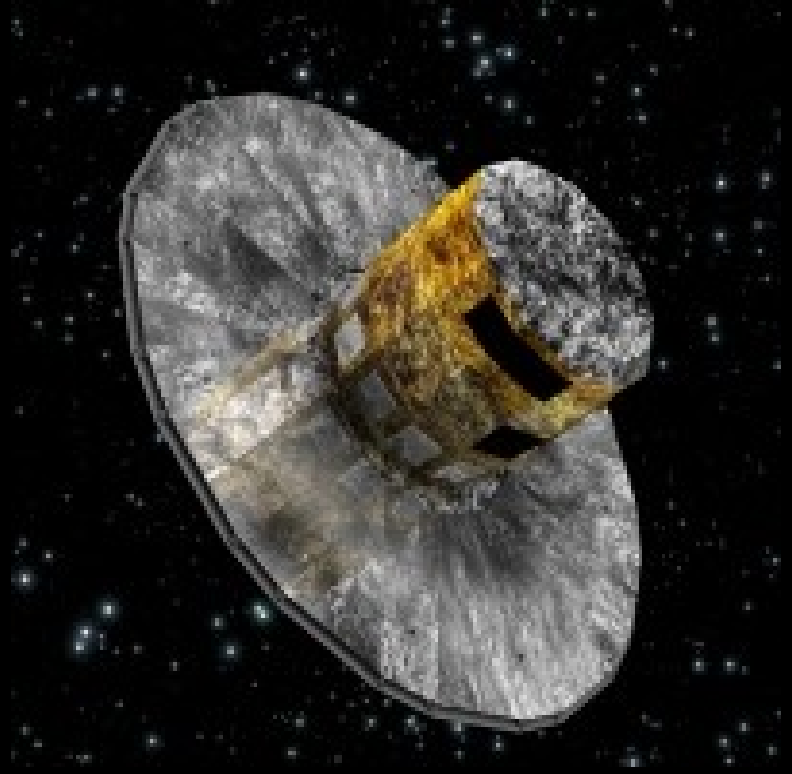
work in progress

Any offset SMBH system?

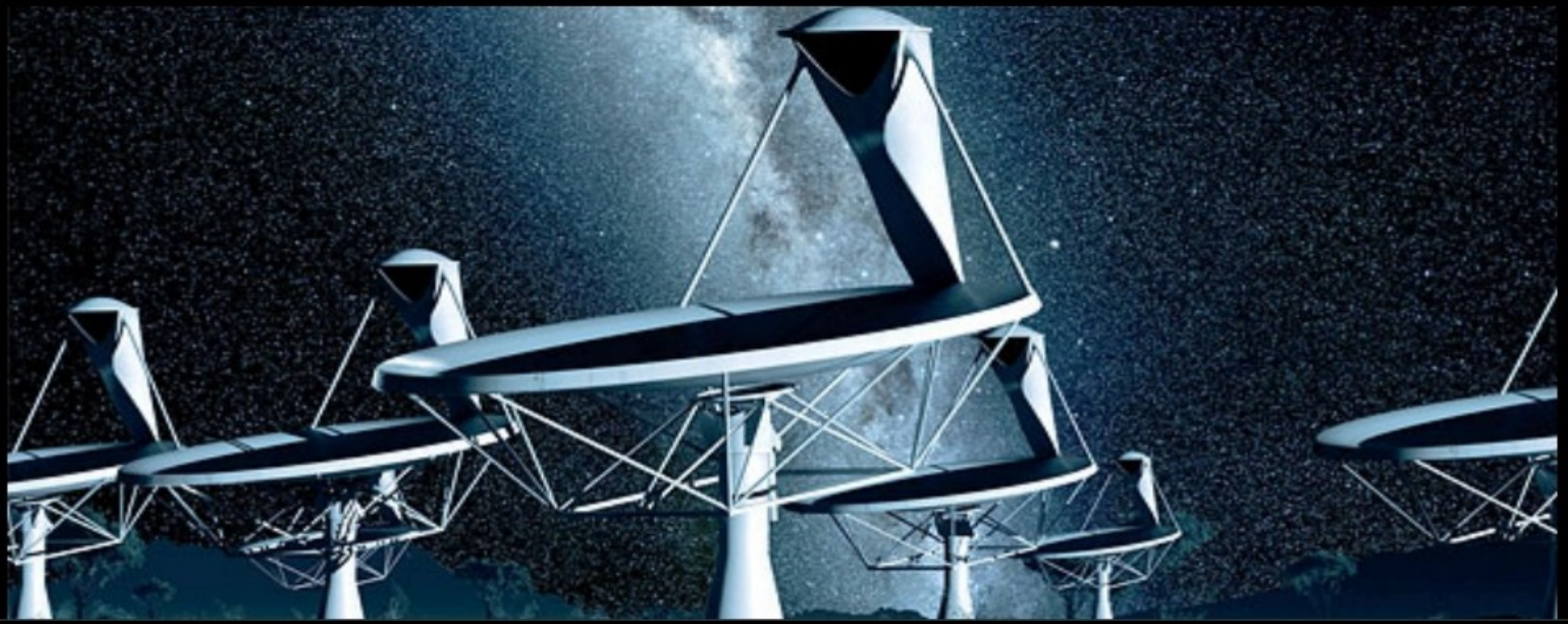
SKA astrometry ?



Gaia astrometry



thank you



First release (Launch + 22 months):

Positions and magnitudes of the 90 percent of the sky with acceptable precisions. In particular the stars observed in common with Hipparcos mission will also be delivered in order to allow the comparison with the data of 1989-1993.

Second release (Launch + 28 months):

Integrated BP/RP photometry, mean radial velocities for those objects with constant radial velocity and astrophysical parameters derived with good accuracy are delivered.

Third release (Launch + 40 months):

Orbital solutions of binary systems. BP/RP/RVS spectra delivered for those objects with good astrophysical parameters determined.

Fourth release (Launch + 65 months):

Variable stars classification with epoch photometry, orbital solutions for Solar System objects and non-single objects catalogue.

Final release (End of mission + 3 years):

The catalogue will be consisting of:

Full astrometric, photometric, and radial-velocity catalogues.

All available variable-star and non-single-star solutions.

Source classifications (probabilities) plus multiple astrophysical parameters (derived from BP/RP, RVS, and astrometry) for stars, unresolved binaries, galaxies, and quasars. Some parameters may not be available for faint(er) stars.

A list of exoplanets.

All epoch and transit data for all sources.

All ground-based observations made for data-processing purposes.