



Jet, accretion, and feedback in AGNs with SKA

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Outline

- Why use the Square Kilometer Array for AGN studies?
- e-EVN: a SKA pathfinder
- radio loud AGN
 - a case study and SKA science contribution
- radio quiet AGN
 - a case study and SKA science contribution

Radio loud AGNs are generally bright radio sources. Why care about SKA sensitivity?

- jet magnetic field
 - multi- λ images of the polarized, weaker emission (RM)
- particle acceleration and high energy connection
 - **study of faint but intriguing jet features (similar to HST-I in M87)**
- AGN-galaxy feedback
 - continuum and spectral line observations of high-z AGNs
- jet-disc connection
 - **characterization of radio emission in radio quiet AGNs**

eEVN

- The European VLBI Network operates since 1980. It used tapes, then disks, and now it does real time transmission and correlation of the data from the individual stations (eEVN) and it is thus officially recognised as a SKA Pathfinder
- Medicina and Noto participate regularly in the eEVN sessions
- The EVN extends to China, South Africa, and Arecibo - but even just the European baselines alone (<2000km) deliver great science - see the rest of the talk!
- NB eEVN collecting area $\sim 0.03 \text{ km}^2$

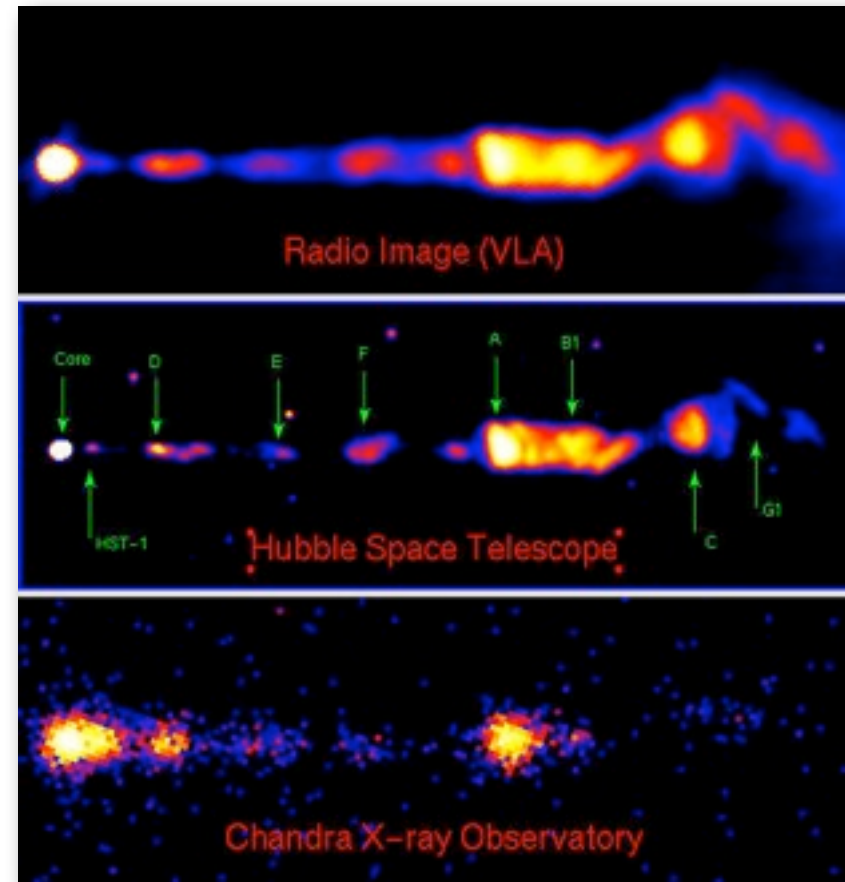


Part I

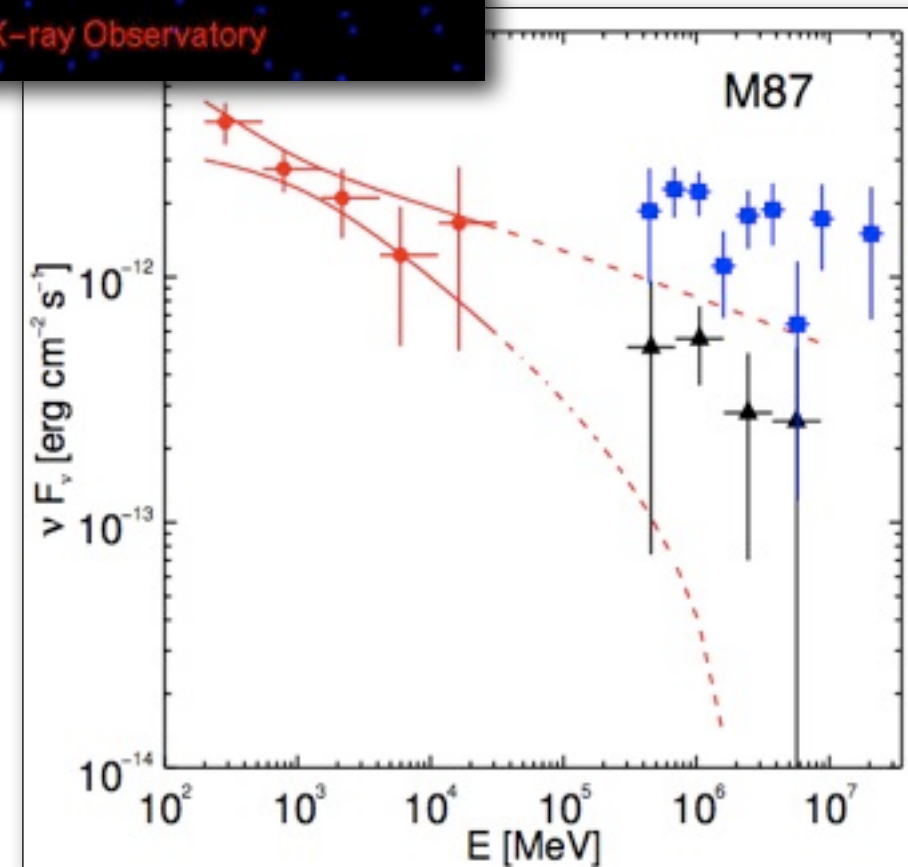
Radio loud AGNs

The radio galaxy M87

- An unremarkable guy ($P=10^{25}$ W Hz⁻¹ at 408 MHz) in a very remarkable location ($d=16$ Mpc)
- kpc scale jet resolved in optical (since 1918) and X-rays
- gamma-ray emission detected by Fermi (MeV/GeV, non variable) and by Cherenkov telescopes (rapid variability in Very High Energy band, VHE)

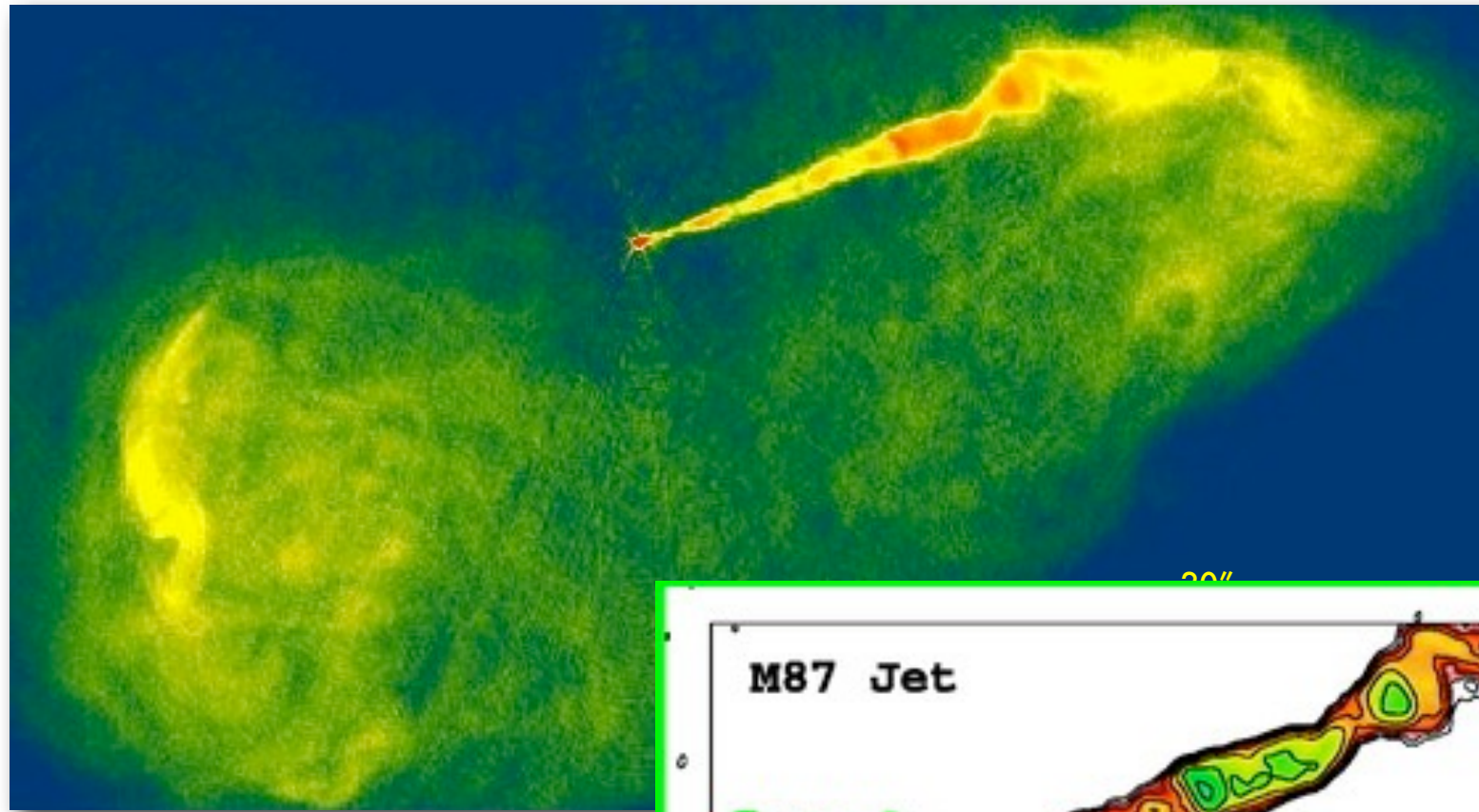


Abdo et al. 2009

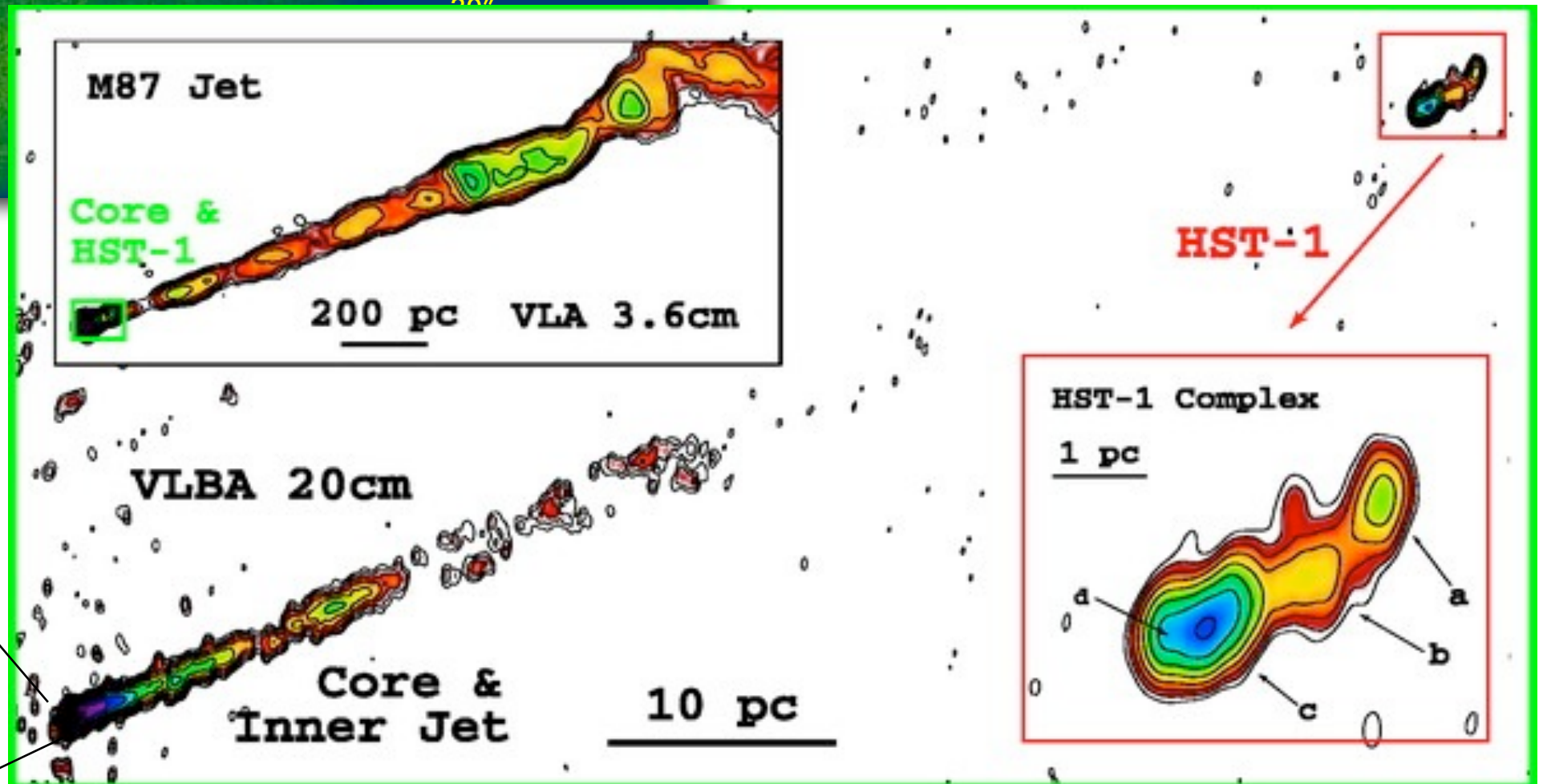


Radio/gamma-ray connection in M87

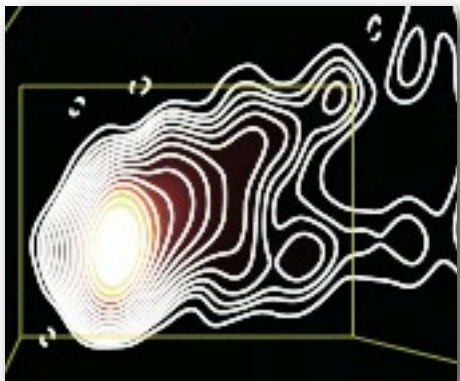
- Three flaring episodes at VHE since 2005
- Counterparts in the radio jet?

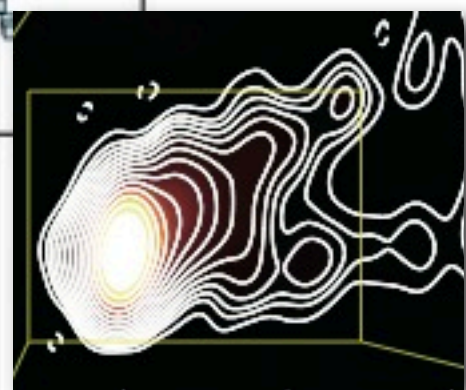
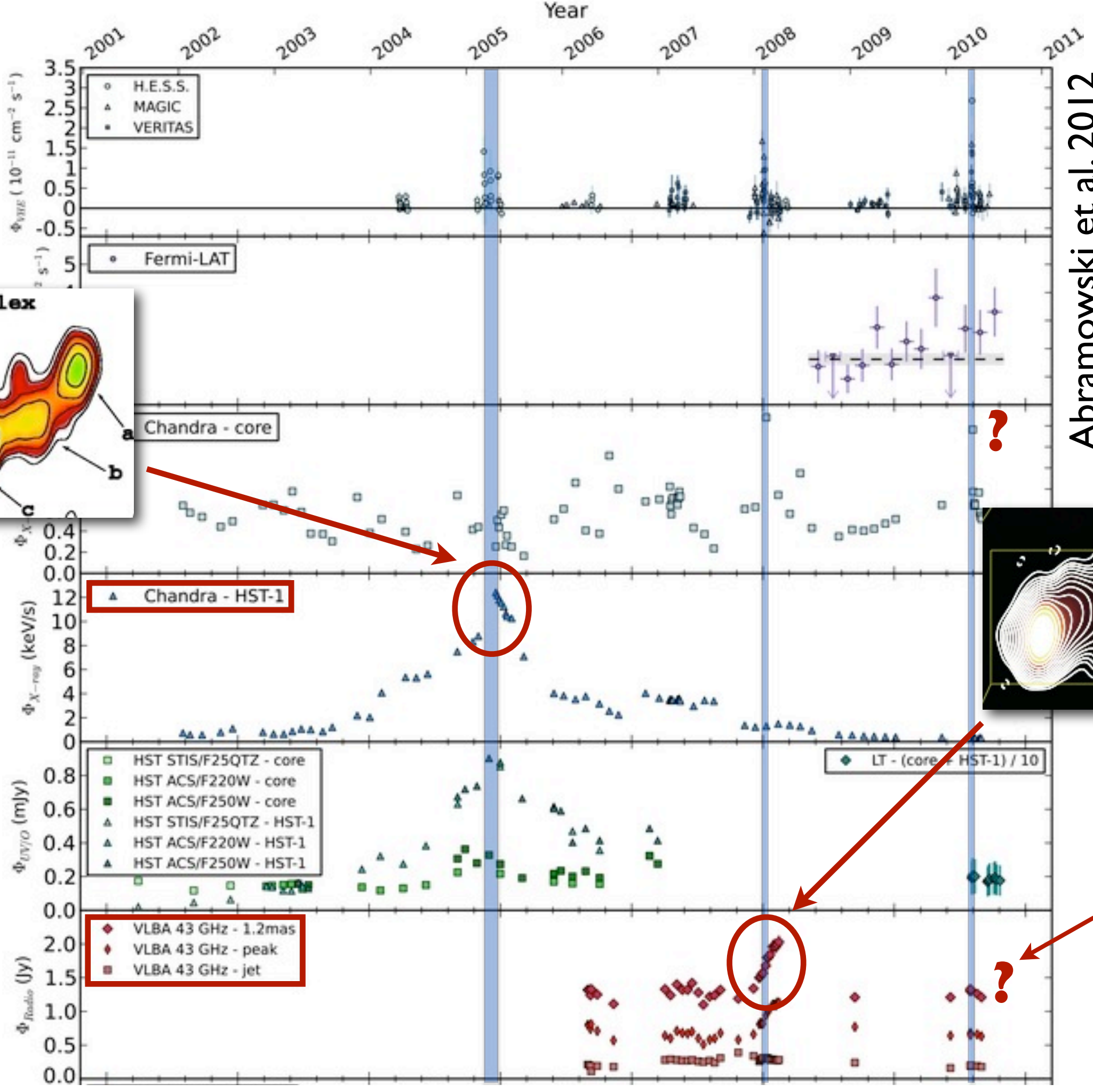


Cheung et al. 2007



Hada et al. 2011



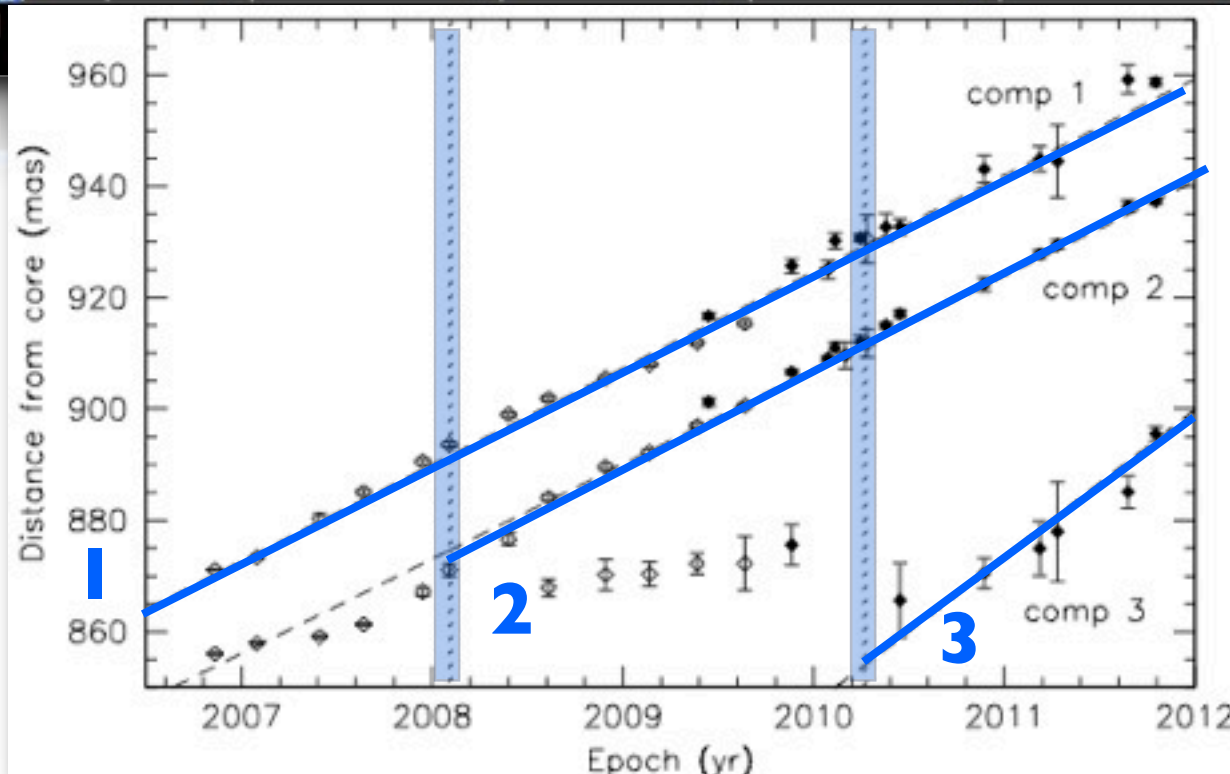


see Hada et al.
(ApJL, subm.)

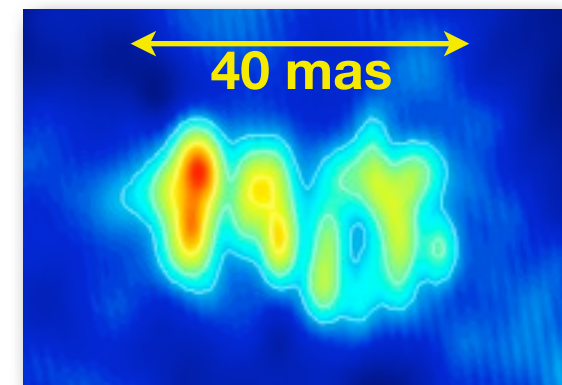
An intriguing scenario

Data from a long monitoring with the eEVN (12 epochs since 2009, plus archival VLBA data) suggest ejection of superluminal components within the jet knot HST-1 is temporally associated to VHE events.

Giroletti et al. 2012

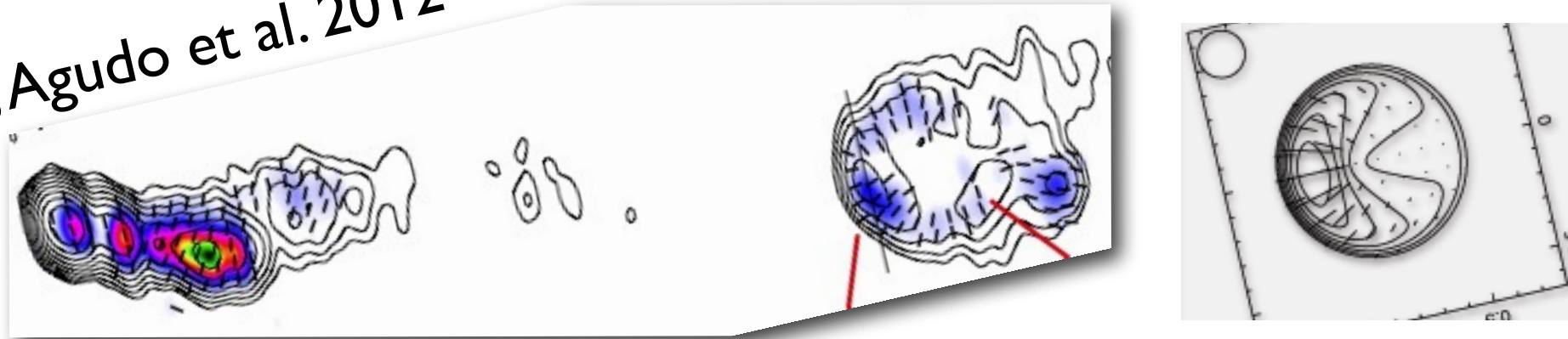


$$v = (4.1 \pm 0.1)c$$
$$\delta = 1.5 - 4.0$$



Perspectives

3C120, Agudo et al. 2012



- Other radio galaxies have similar properties to M87: gamma-ray emission and compact jet knots at ~ 100 pc from the core, with superluminal substructures
- Is this a general feature? Need more radio data, with monitoring and high sensitivity and full polarization information
- ...and more VHE sources: an ideal synergy between SKA and CTA!

Part II

Radio quiet AGNs

Context

- Radio quiet galaxies are not radio silent: mJy radio emission is almost ubiquitous in local LLAGNs (including LINERS, Seyfert galaxies, see Ho&Ulvestad 2001, Nagar et al. 2002, etc.)
- What is the origin?
 - scaled down jets? outflows? thermal emission from corona? ADAF? ...
- How can we tell?
 - Multi frequency, high resolution, polarization sensitive, deep observations = SKA

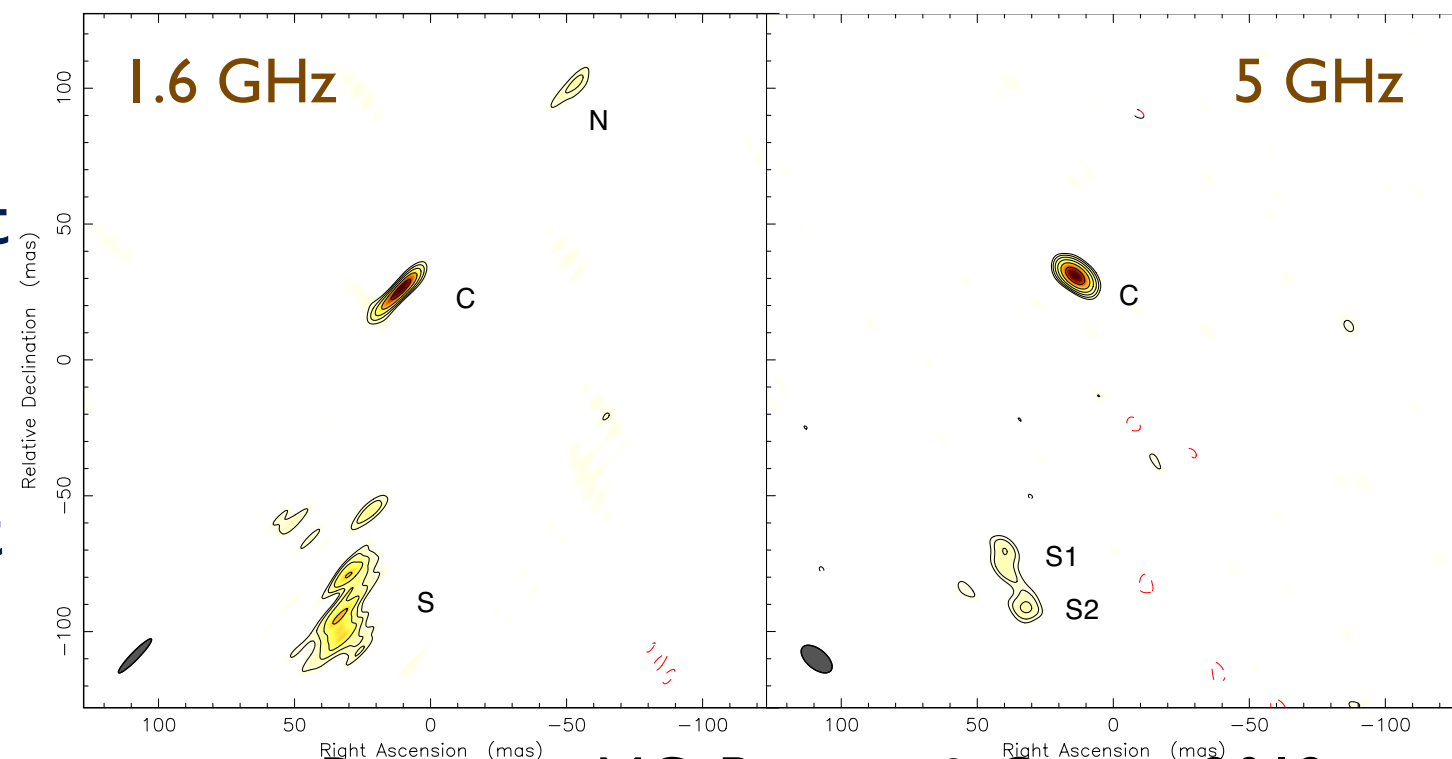
Giroletti & Panessa 2009



A sample of local LLAGNs

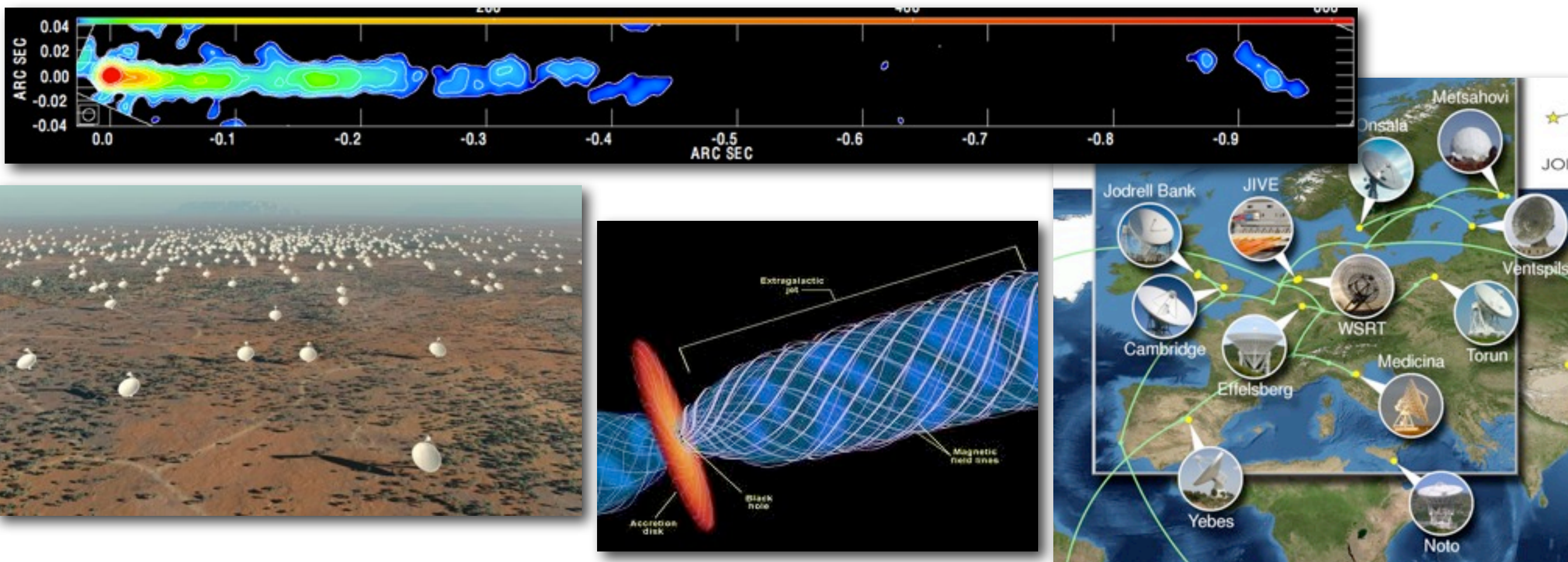
- Cappi et al. (2006) selected a sample of 26 low luminosity AGNs at $d < 22$ Mpc from the optical Ho et al. sample
- VLBI observations available for a good fraction of sources ($\sim 75\%$), with dual frequency information thanks to high sensitivity of the EVN
- In cases like NGC3227, observations reveal a compact, flat spectrum component
- In other cases, the situation is much more complex (detection at just one frequency, or none, weak constraints on T_b etc.)

$$\alpha \sim 0.5$$
$$T_b > 10^{7.5} \text{K}$$
$$L \sim 10^{19.5} \text{W Hz}^{-1}$$
$$B \sim 4.5 \text{ mG}$$



Prospects

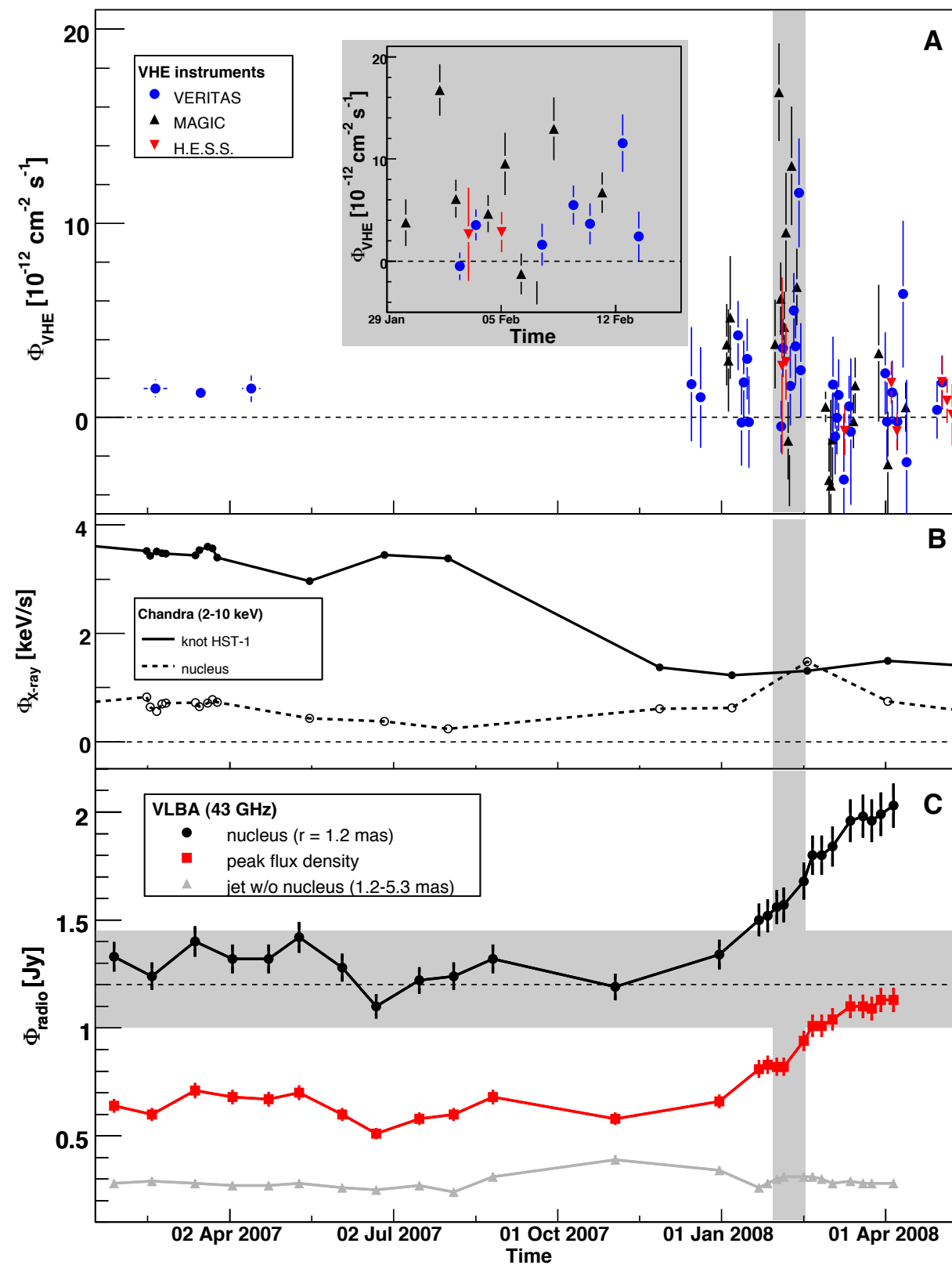
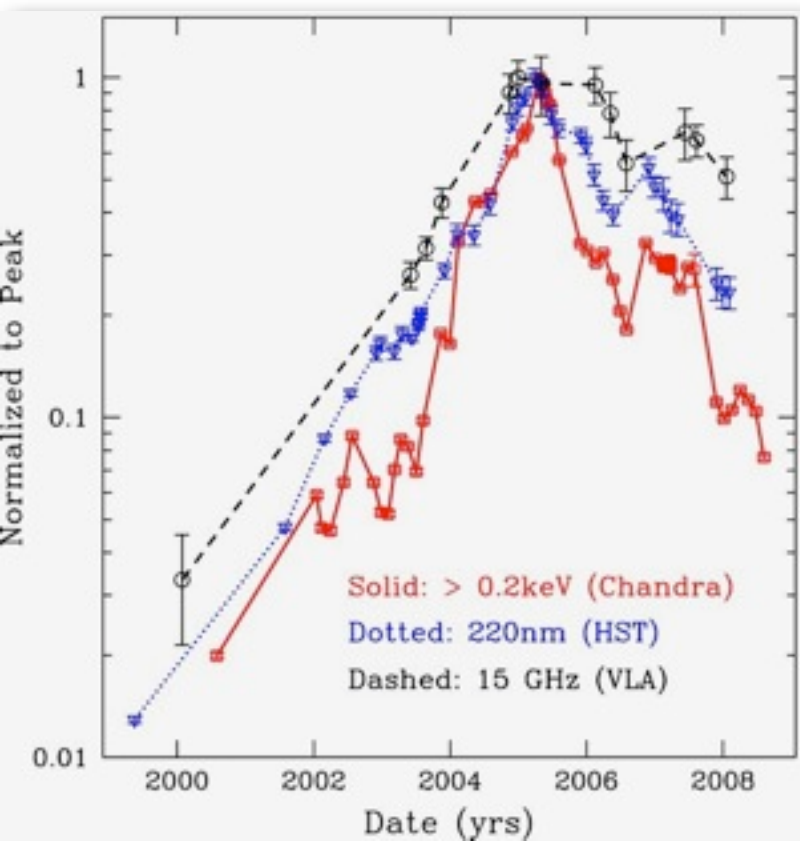
- Current 1.6 and 5 GHz observations with $\sim 0.03 \text{ km}^{-2}$ collecting area and $\sim 2000 \text{ km}$ baselines reach $\sim 10 \text{ microJy hr}^{-1}$
- In the $d < 22 \text{ Mpc}$ complete sample, $\sim 60\%$ detection rate
- ...but θ , α , T_b , L , B , $P\text{Pol}$, etc. (i.e. physics!) remain very poorly constrained in many targets
- SKA can reveal and characterize radio emission in the vicinity of every supermassive black holes in the local universe



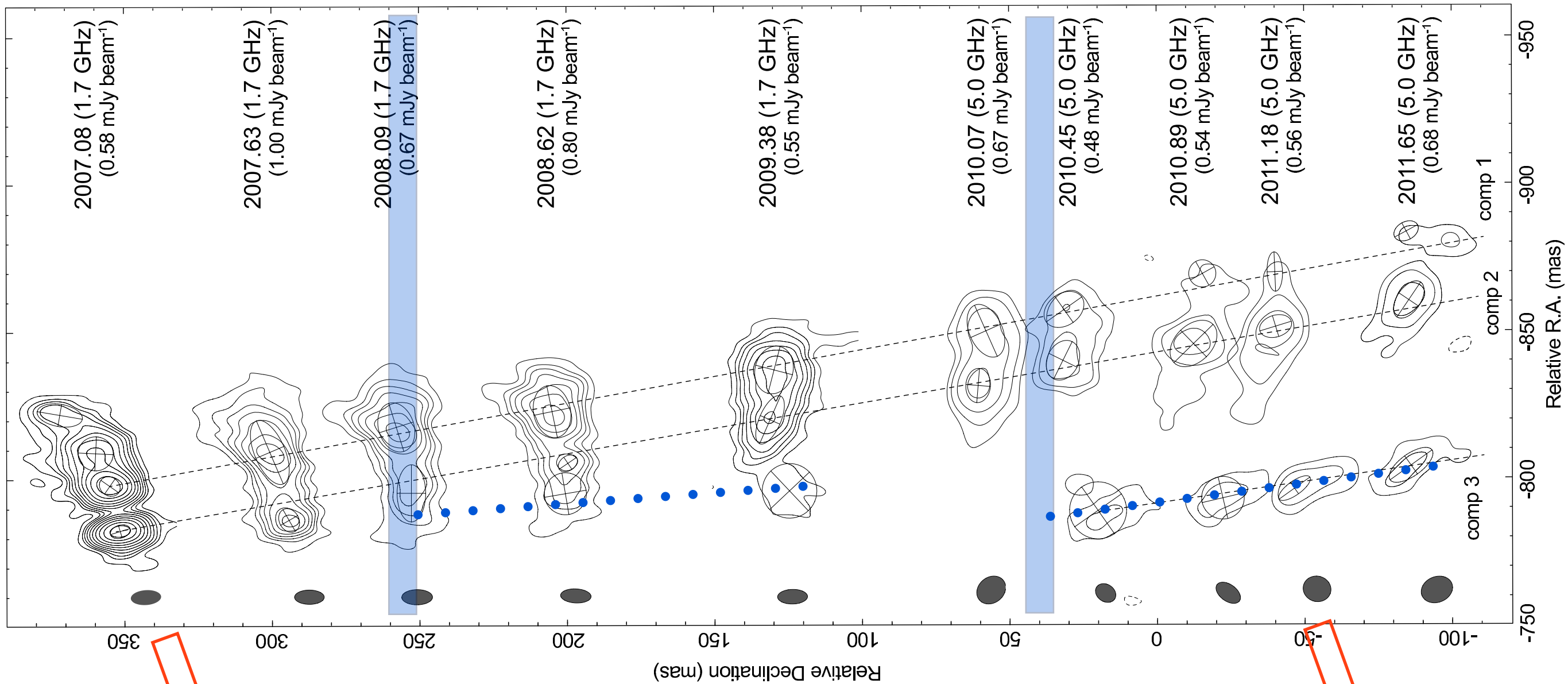
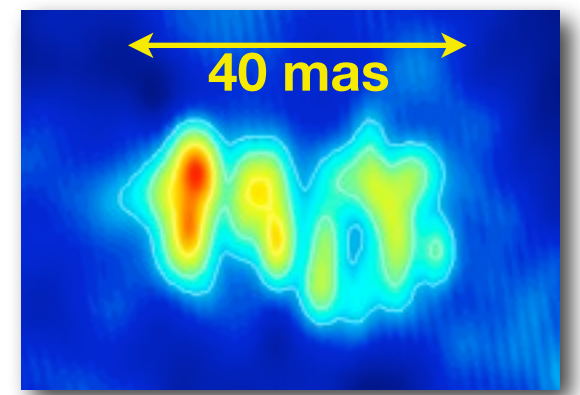
Summary

1. eEVN, a SKA pathfinder, is delivering great science on RL and RQ AGNs (M87, NGC3227, and more...)
2. MWL synergy is essential
3. Huge potential for SKA for AGN physics, too!

Extra stuff



Structural variations in HST-1?



to core

images rotated
by 90deg ccw

to core