

eEVN monitoring of M87

Marcello Giroletti

INAF Istituto di Radioastronomia

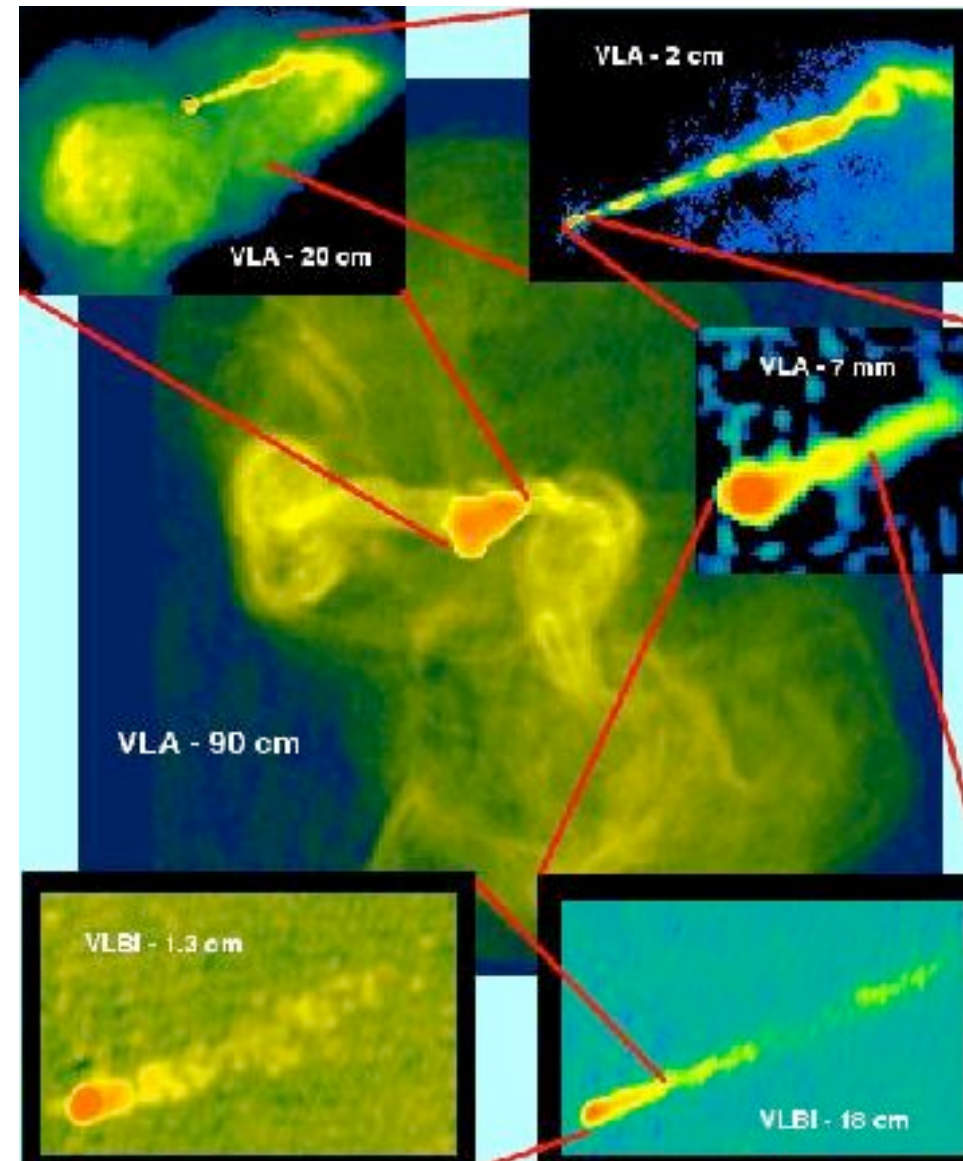
and

G. Giovannini, C. Casadio, M. Beilecke, A. Cesarini, H. Krawczynski



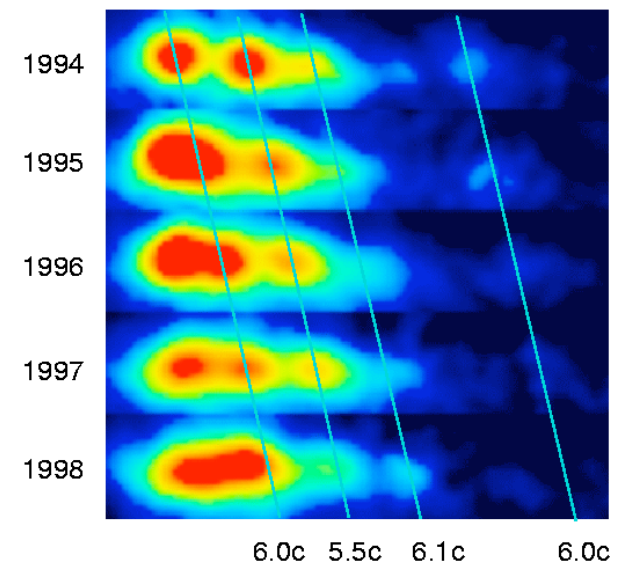
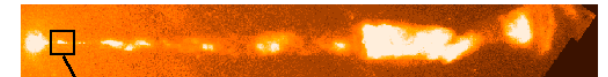
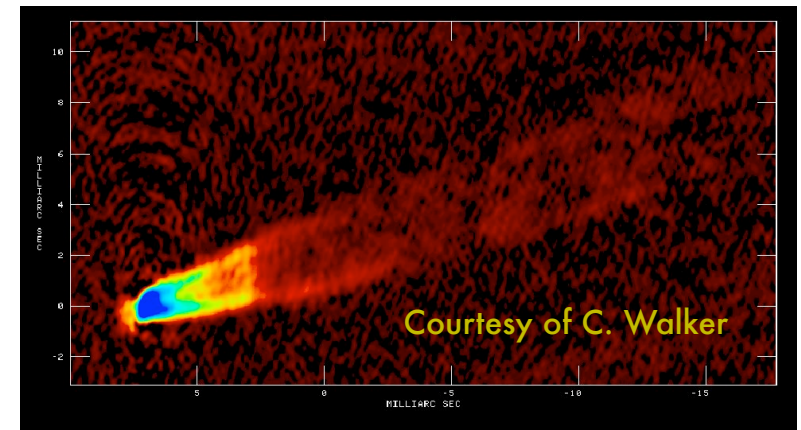
Background: M87, or 3C274, or Virgo A

- Nearby FR1 radio galaxy, hosting massive black hole:
 - $d=16.7$ Mpc,
 - $M_{\text{BH}} \sim 6 \times 10^9 M_{\text{sun}}$
 - Scale: $1 \text{ mas} = 0.081 \text{ pc} = 140 R_s$
 - Radio power $\sim 10^{25} \text{ W Hz}^{-1}$ (@408 MHz)



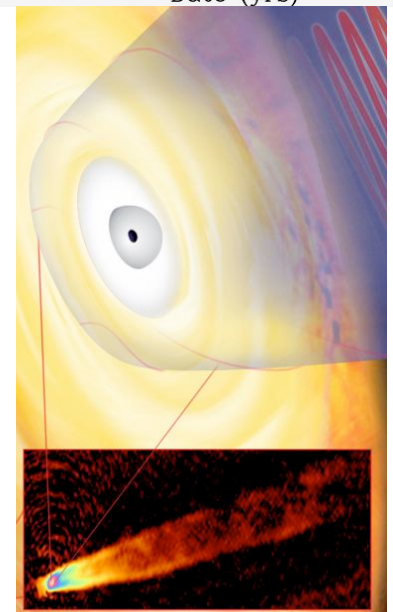
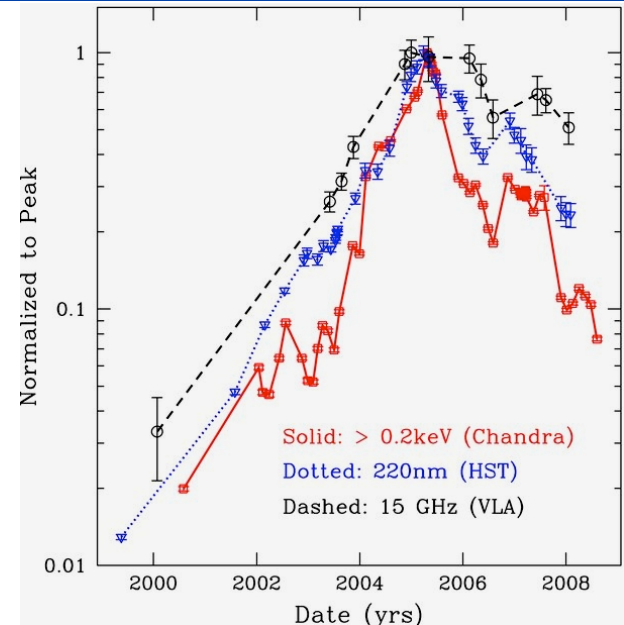
M87: radio jet

- Inner jet shows limb brightened structure, no well defined proper motion
- Superluminal motions are detected downstream the jet with HST / VLA / VLBA
 - eg feature HST-1
~0.8'' (~70pc) from core



M87 at high energy

- Only resolved in X-rays by Chandra
- Detected -- not resolved -- by Fermi-LAT and TeV observatories (MAGIC, VERITAS, HESS)
- 2005: TeV activity, X-ray, optical, radio flare in superluminal HST-1 (Acciari et al. 2008, Harris et al. 2009)
- 2008: TeV flare, radio core flux density increase, quiescence in HST-1 (Acciari et al. 2009)



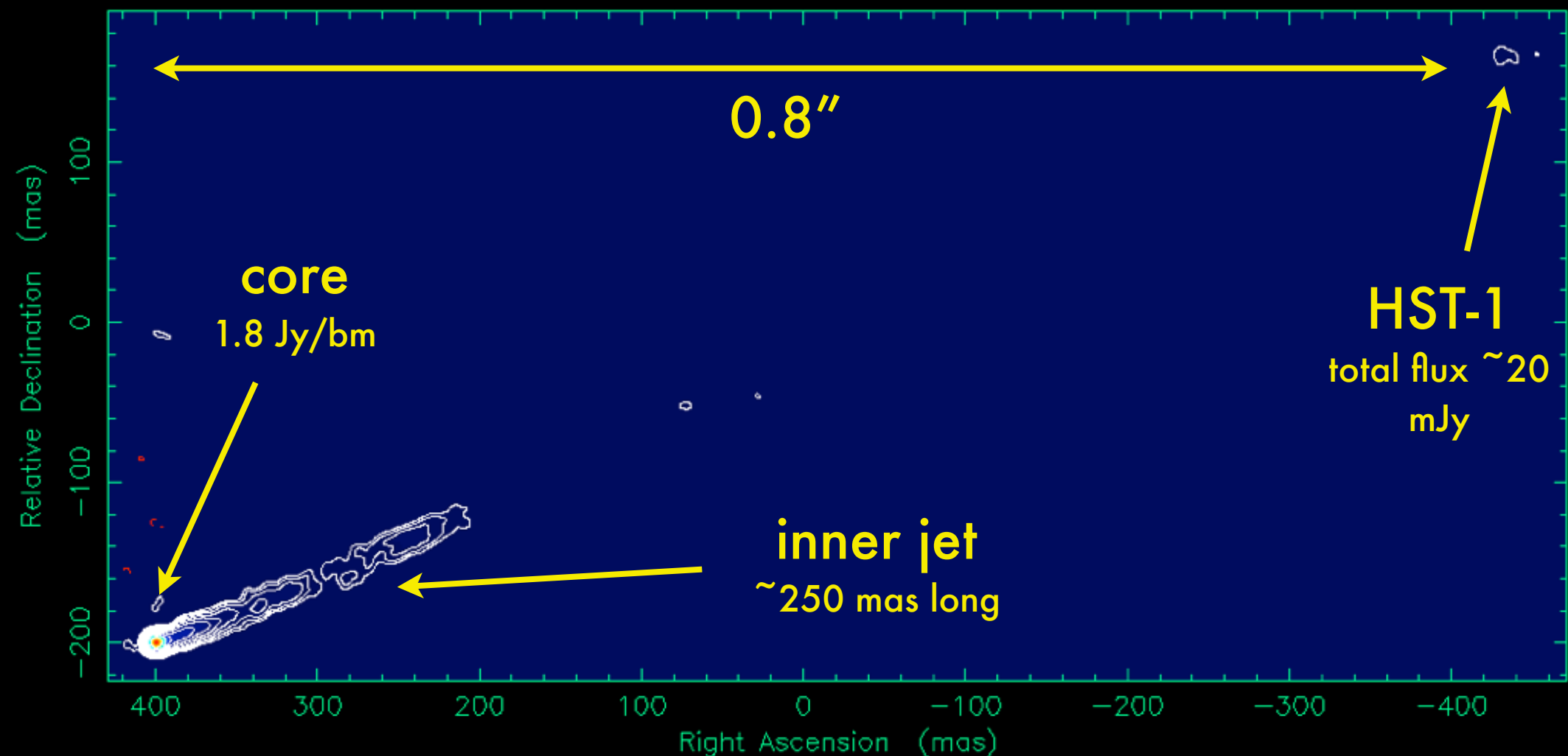
How to solve this?!

- Need a coordinated TeV+radio monitoring
- In radio, high sensitivity, good resolution, large field of view are needed
- EVN (with Shanghai, Arecibo) at 6cm
- in eVLBI mode to get good time sampling and prompt results
- 6-8 hours observations on 2009 Nov, 2010 Jan, Feb, Mar



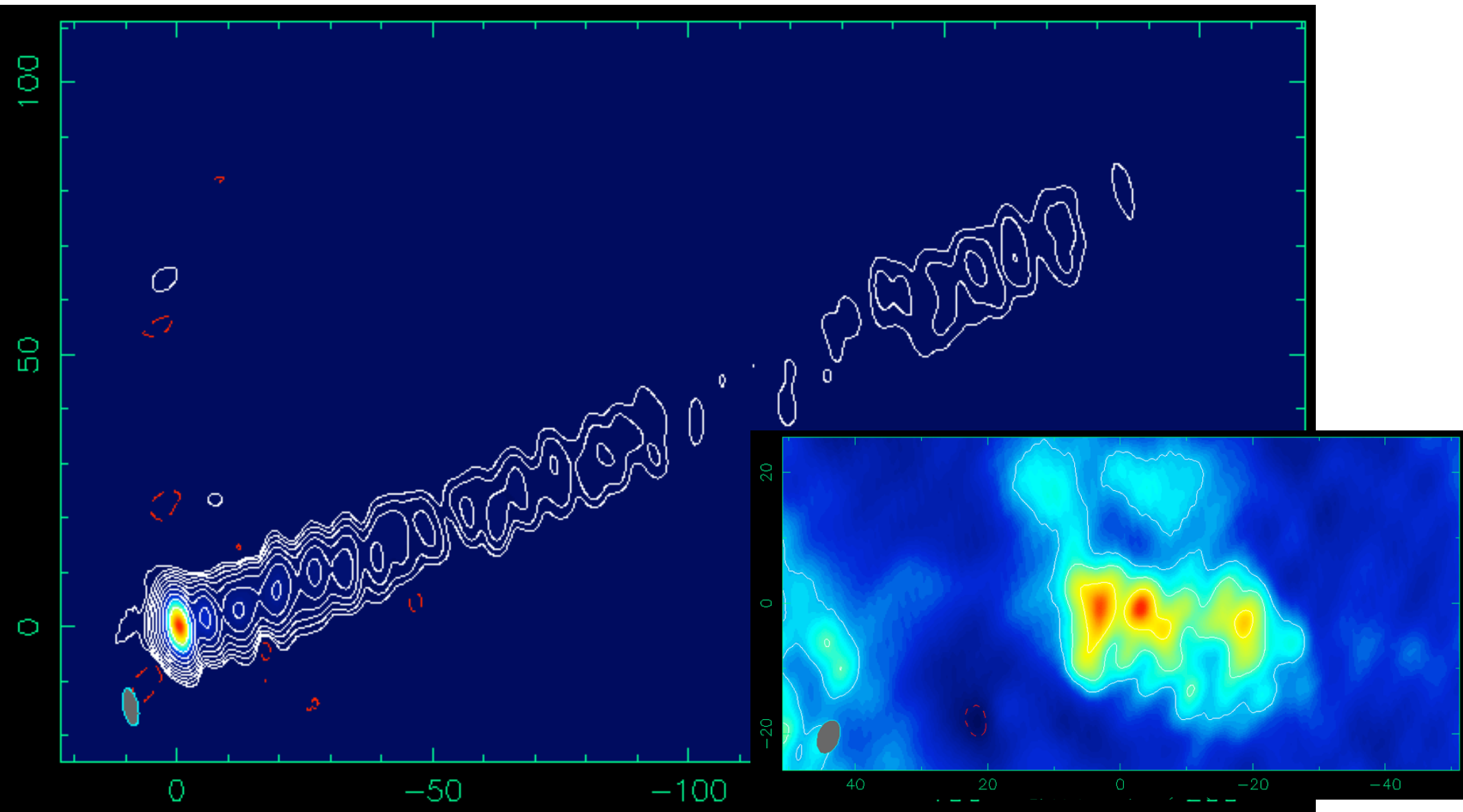
EVN images

Clean I map. Array: EVN
M87 at 5.004 GHz 2010 Jan 27



Map center: RA: 12 30 49.396, Dec: +12 23 28.244 (2000.0)

EVN images, zoom



Radio-VHE, the campaign

- As we had hoped, TeV flares are detected!
February 9th (ATel #2431), April 8-10
(ATel #2542)
- First flare is almost simultaneous (within 24hr) to our 2nd EVN epoch - core and HST-1 well behaved
- Additional observations extend monitoring until June

Radio data, basic numbers

No significant increase of flux density in either core or HST-1, so far

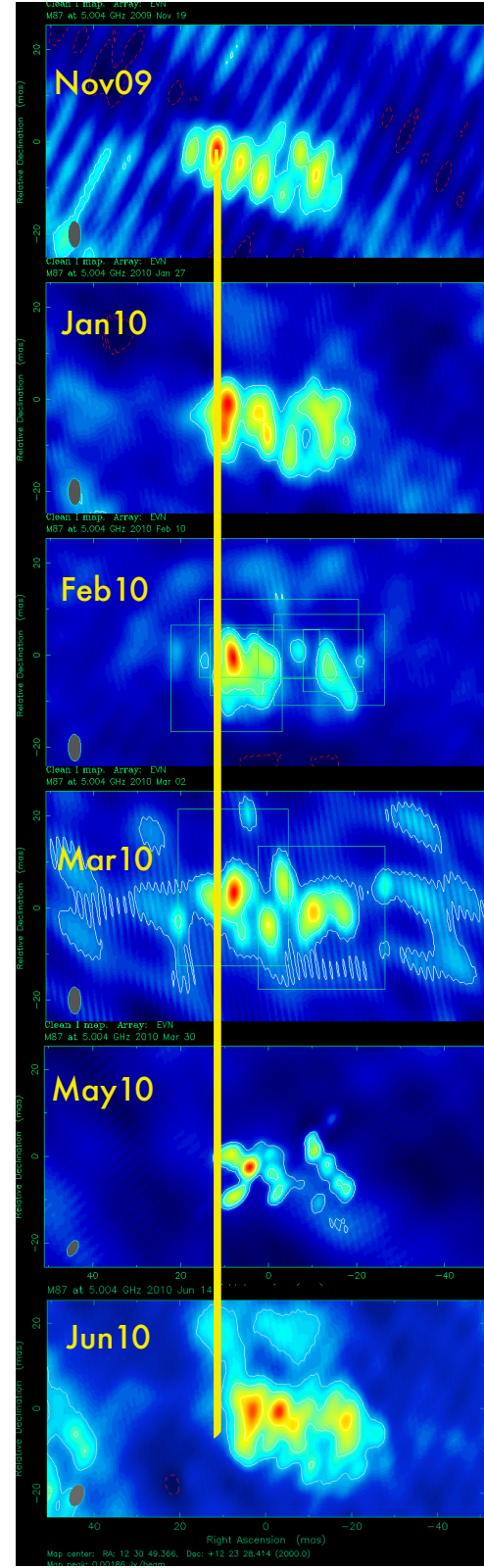
Epoch	Core (Jy)	HST-1 Peak (mJy/bm)
Nov 19 - 2009	1.81 $\pm$ 0.03	3.5 mJy/beam
Jan 27 - 2010	1.81	2.7 VHE activity
Feb 10 - 2010	1.80	3.0
Mar 6 - 2010	1.89	4.6
Mar 28 - 2010	2.01	3.4
VHE activity Apr. 9th		
May 18 - 2010	1.93	2.8
Jun 9 - 2010	1.93	2.6

Radio-VHE sum up

- Episodes of very high energy activity detected in 2005, 2008, 2010
- Simultaneous lower energy activity reported in jet feature (HST-1, 2005), core (2008) or none (2010)
- Coincidence or different mechanisms
- What is HST-1 anyway?

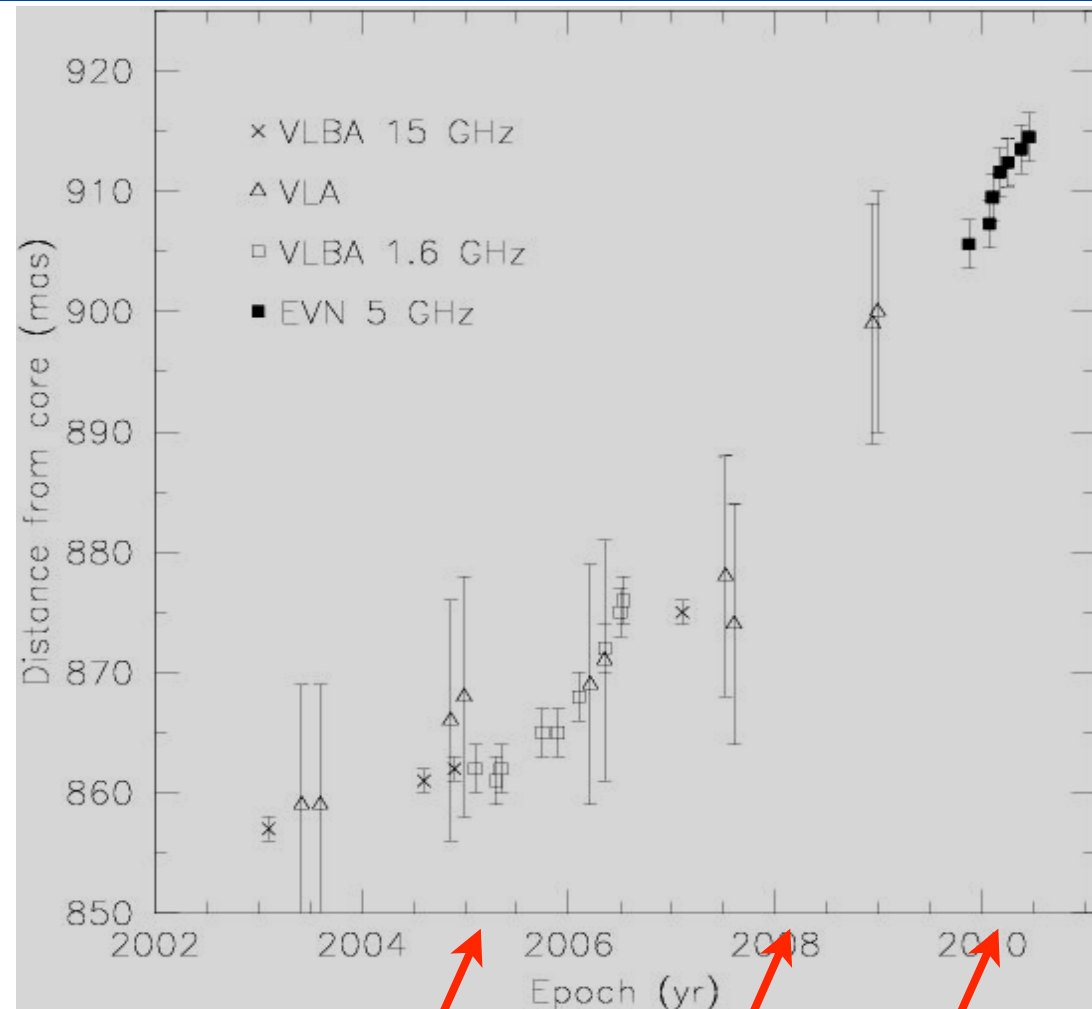
HST-1 kinematics

- Superluminal proper motion well measured in HST-1
- Different orientation wrt to inner jet and older observations
- Worth continuing to monitor



Additional data on HST-1 kinematics

- Additional observations available in the literature/archives:
- Cheung et al. 2007: VLBA @1.6 GHz
- Chang et al. 2010: VLBA @15 GHz
- VLA archives at 15-22 GHz
- Post-2005 apparent speed $\sim 2.7c$



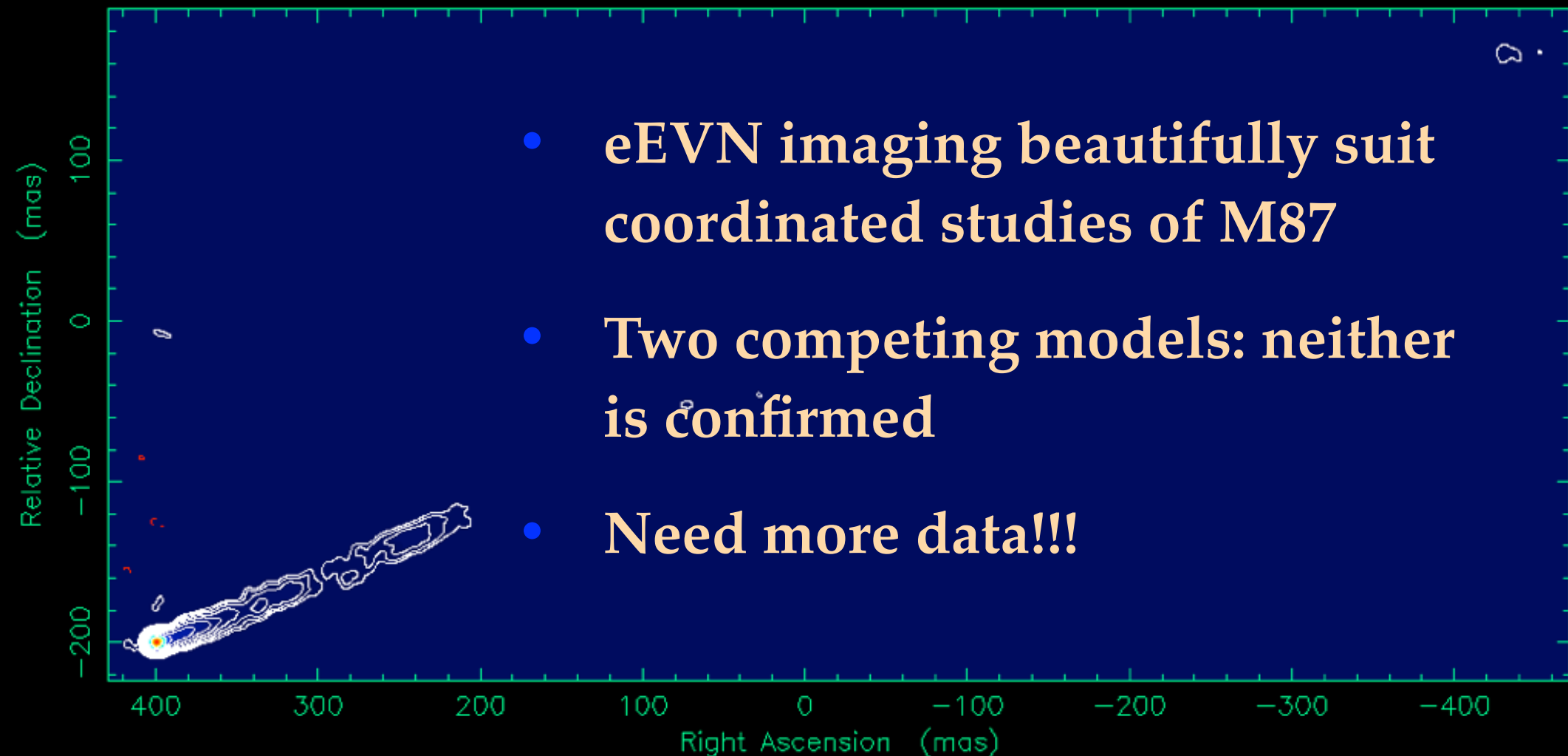
TeV, HST-1 flare

TeV, radio core flare

TeV

Take home notes

Clean I map. Array: EVN
M87 at 5.004 GHz 2010 Jan 27



Map center: RA: 12 30 49.396, Dec: +12 23 28.244 (2000.0)