A Multi-band Flare in the M87 Jet 80 pc away from the Central Engine

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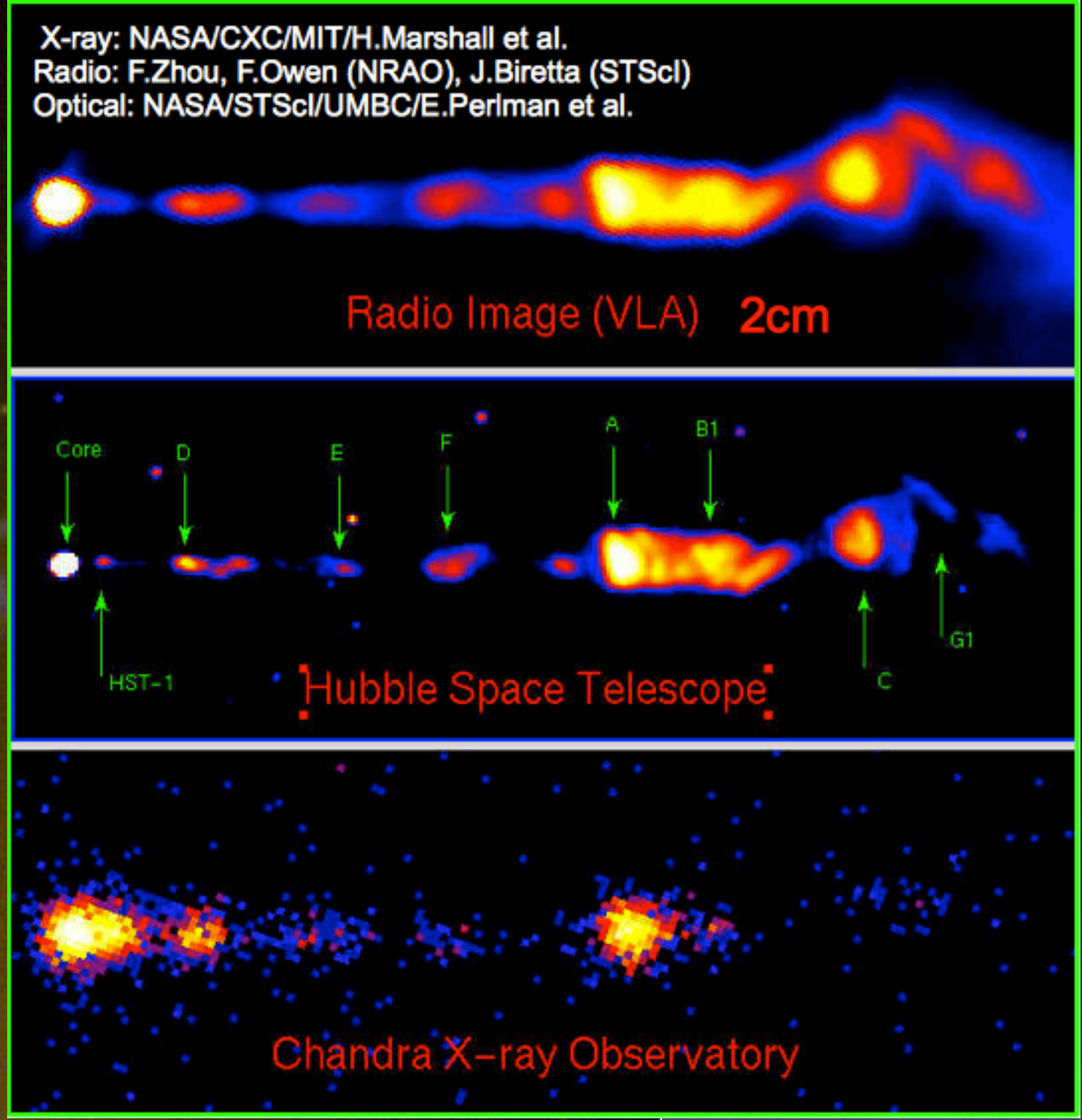
M87

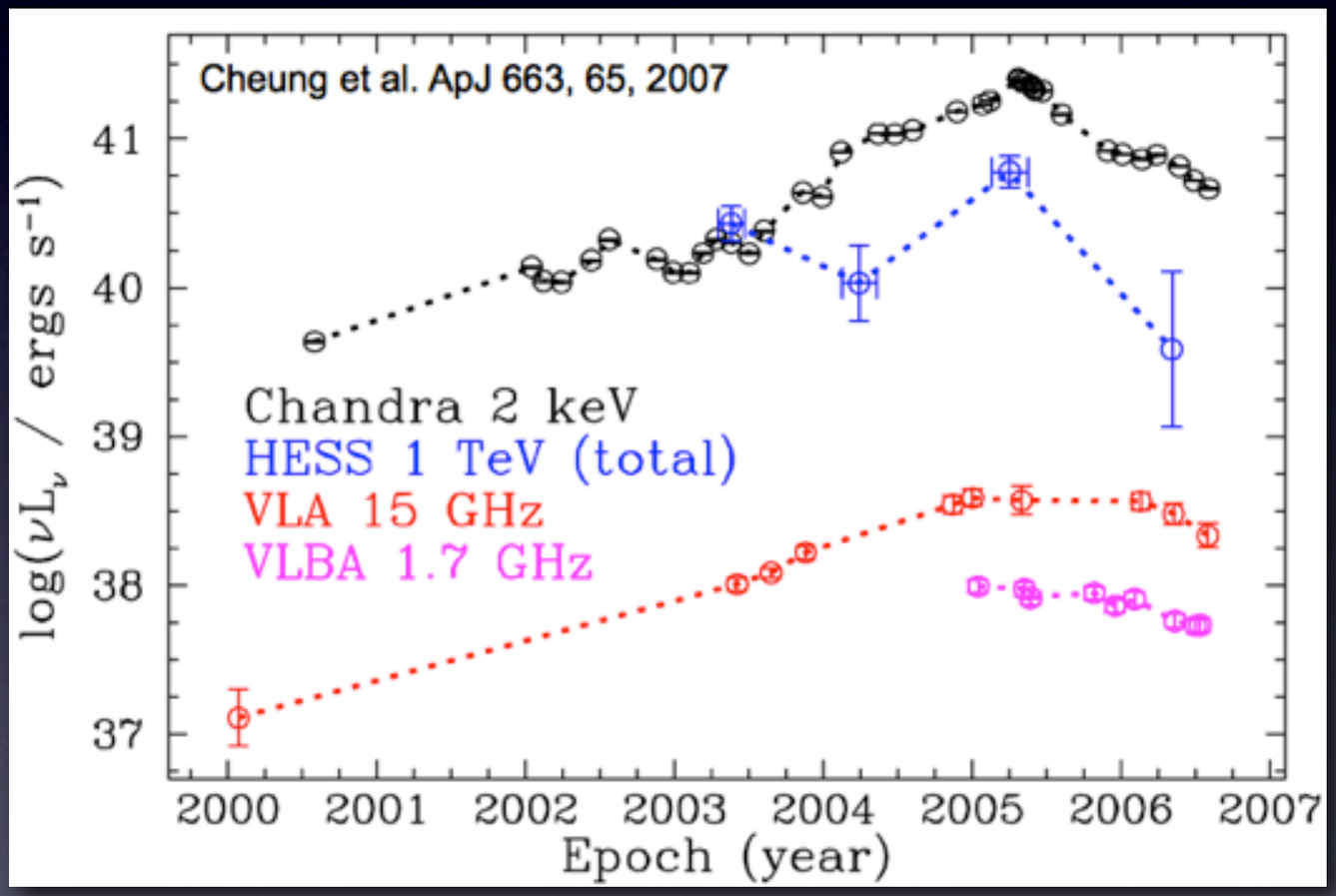
X-ray: NASA/CXC/MIT/H.Marshall et al.
Radio: F.Zhou, F.Owen (NRAO), J.Biretta (STScI)
Optical: NASA/STScI/UMBC/E.Perlman et al.

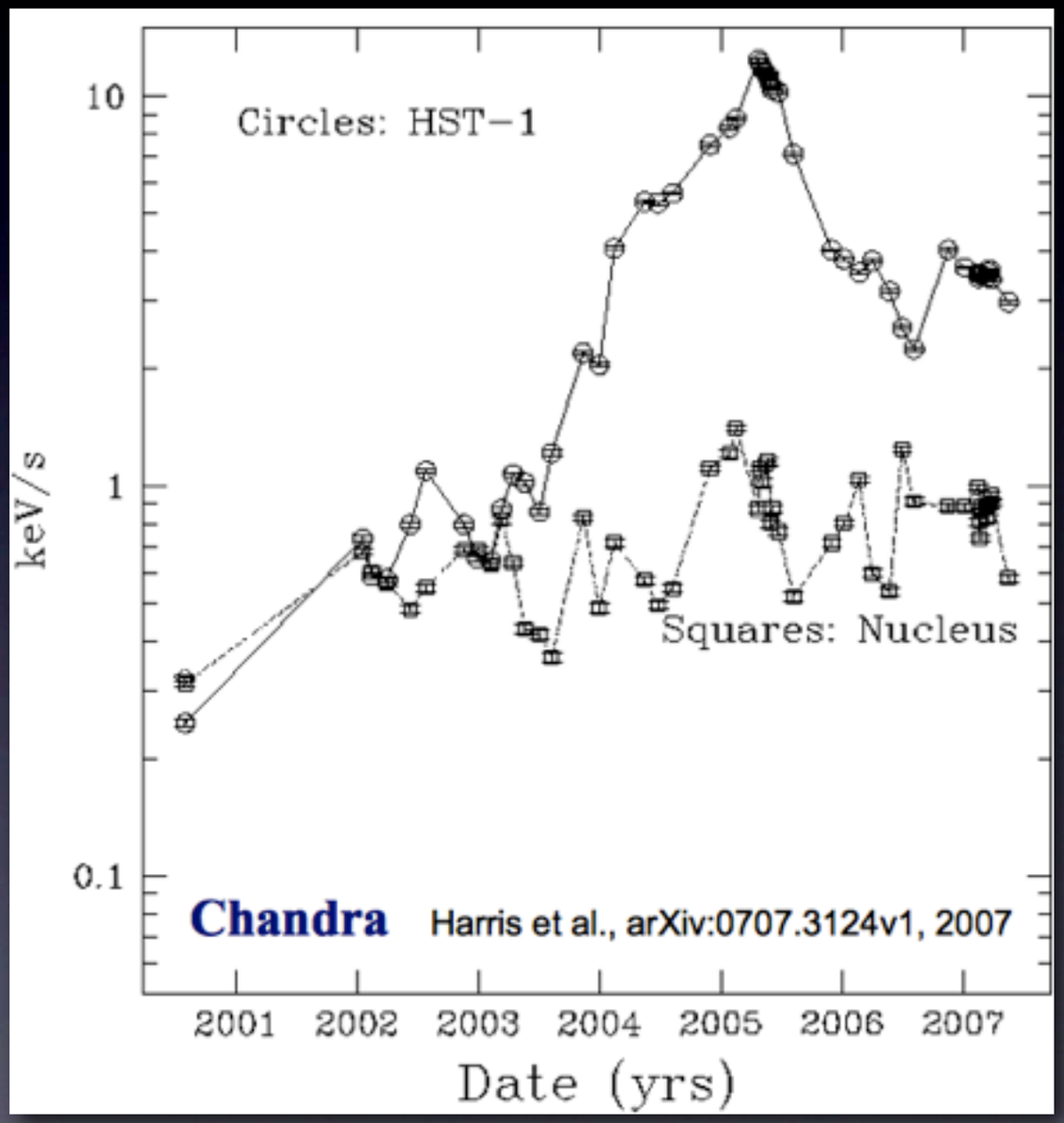


Credit: NASA and The Hubble Heritage Team (STScI/AURA)

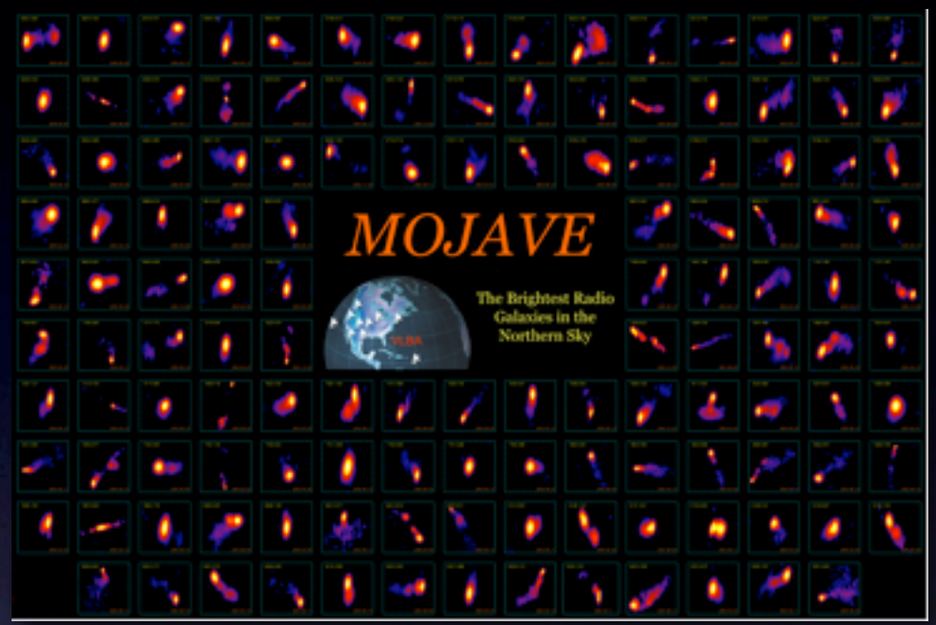
HST-1: a possible source of TeV emission?

Blazar nature??



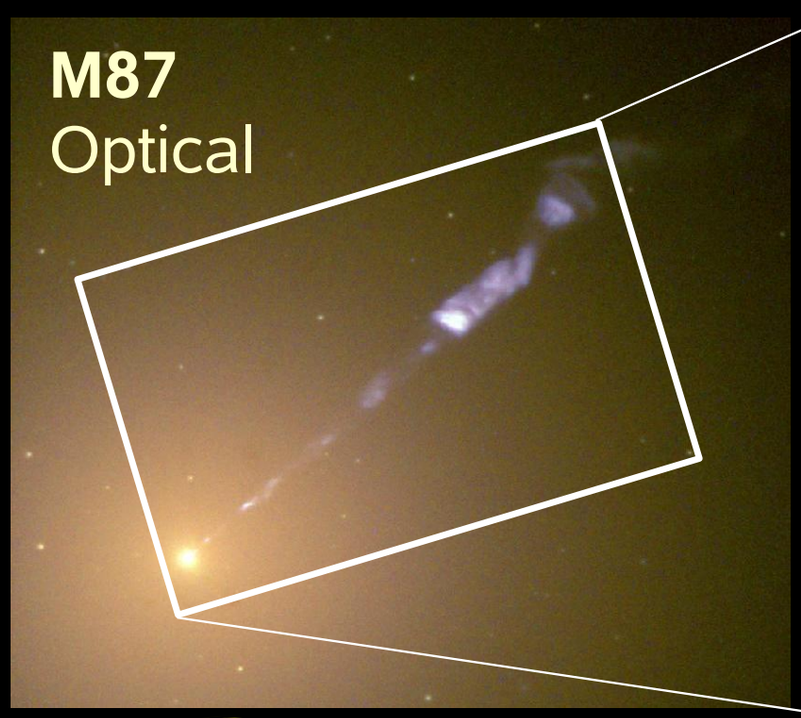


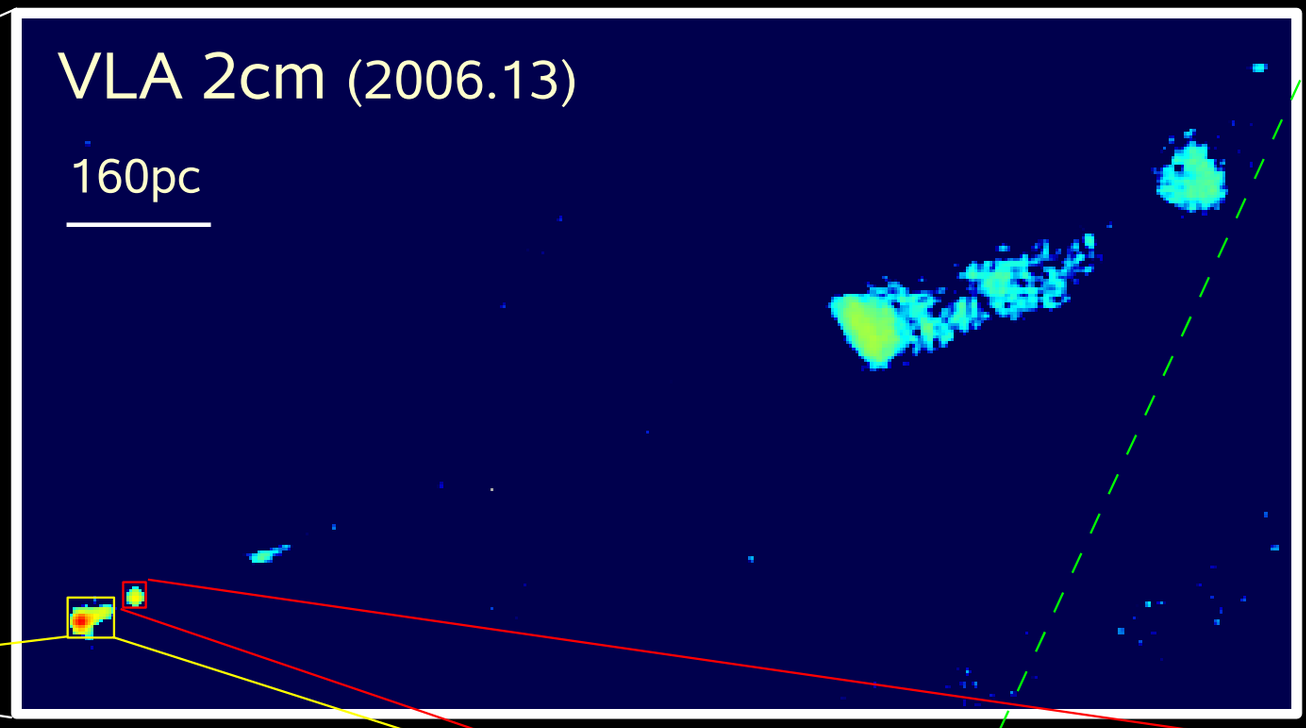
Monitoring **O**f **J**ets in **A**ctive galactic nuclei with **V**LBA **E**xperiments

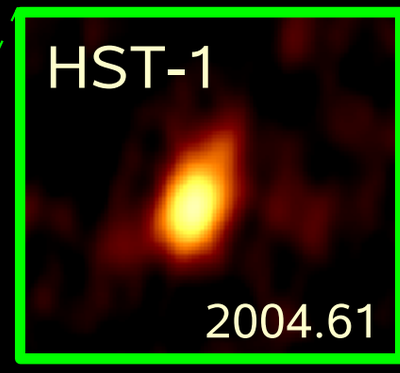


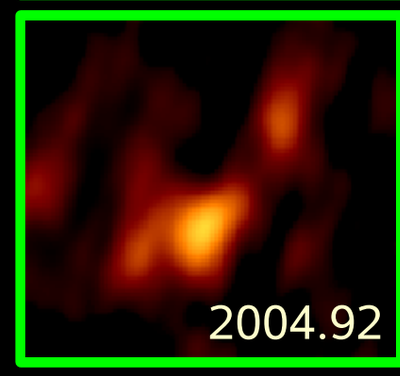
- 15 epoch of MOJAVE/VLBA 2cm data during 2000-2009

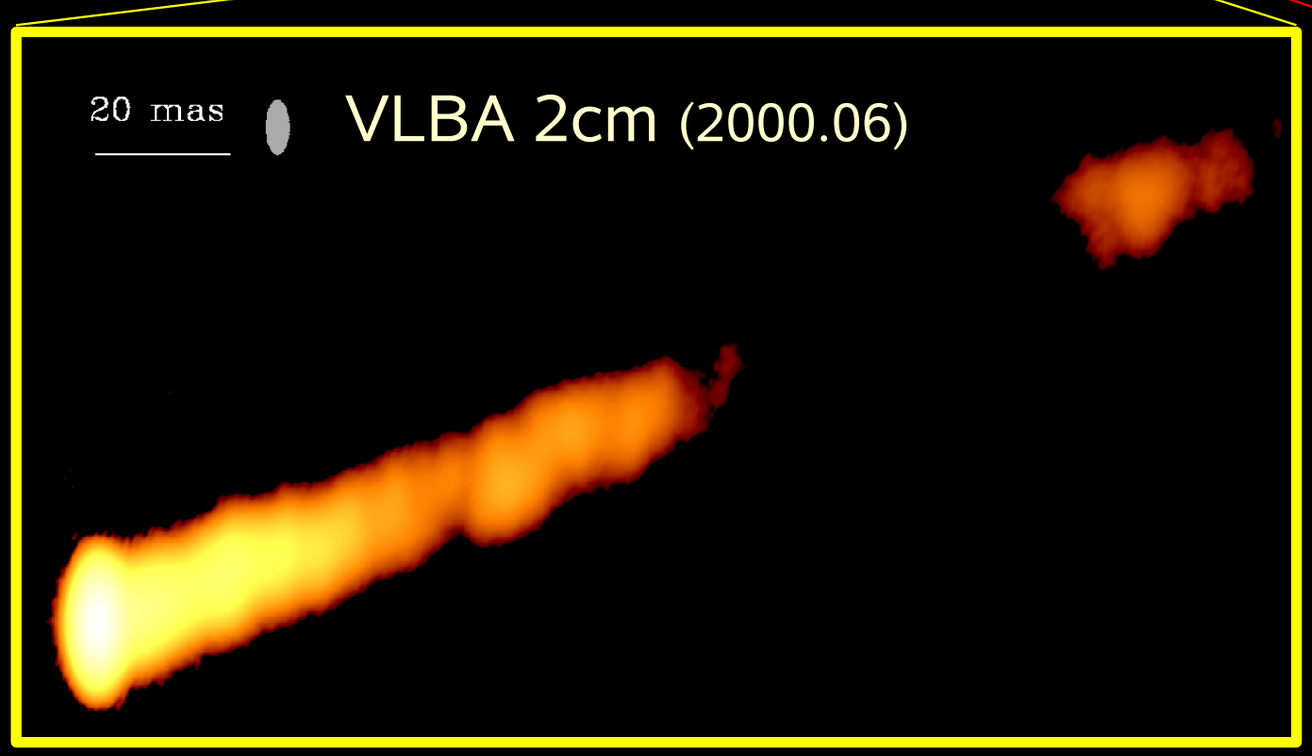
HST-1 in M87 jet

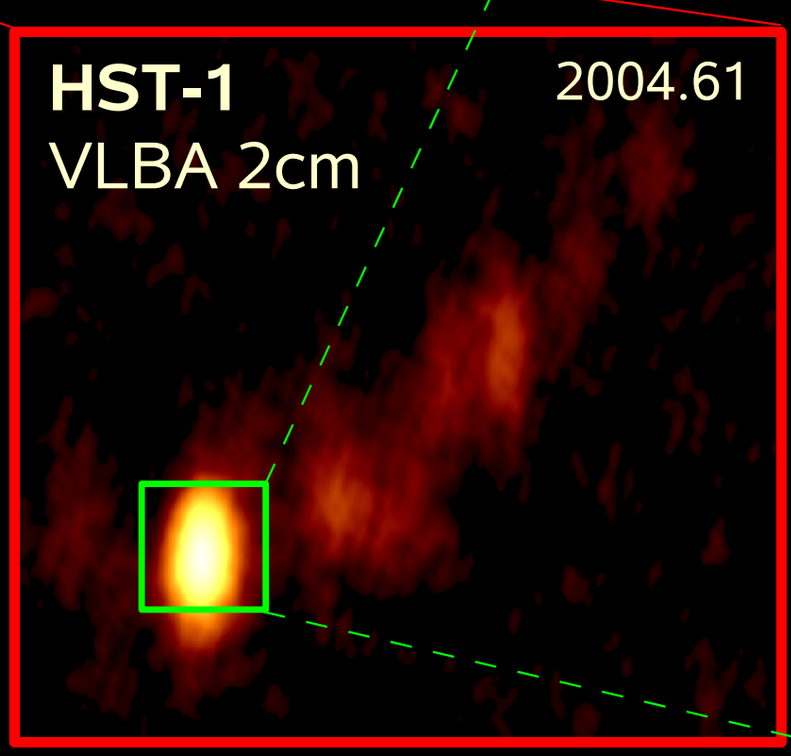


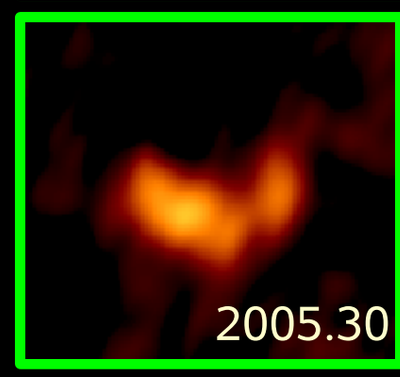


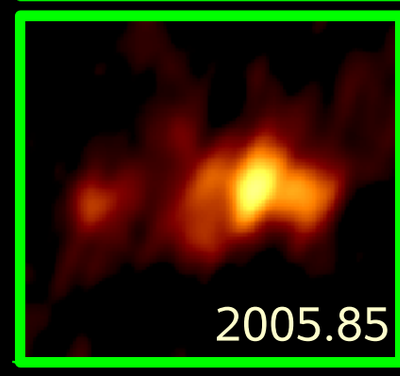








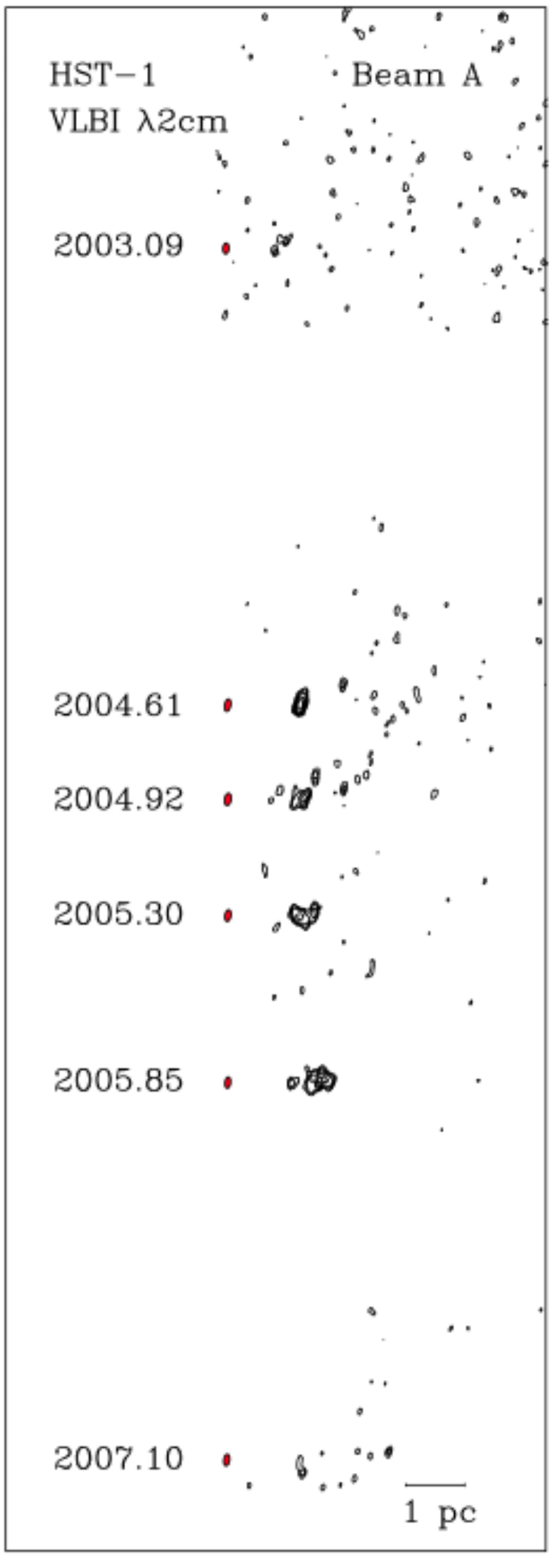


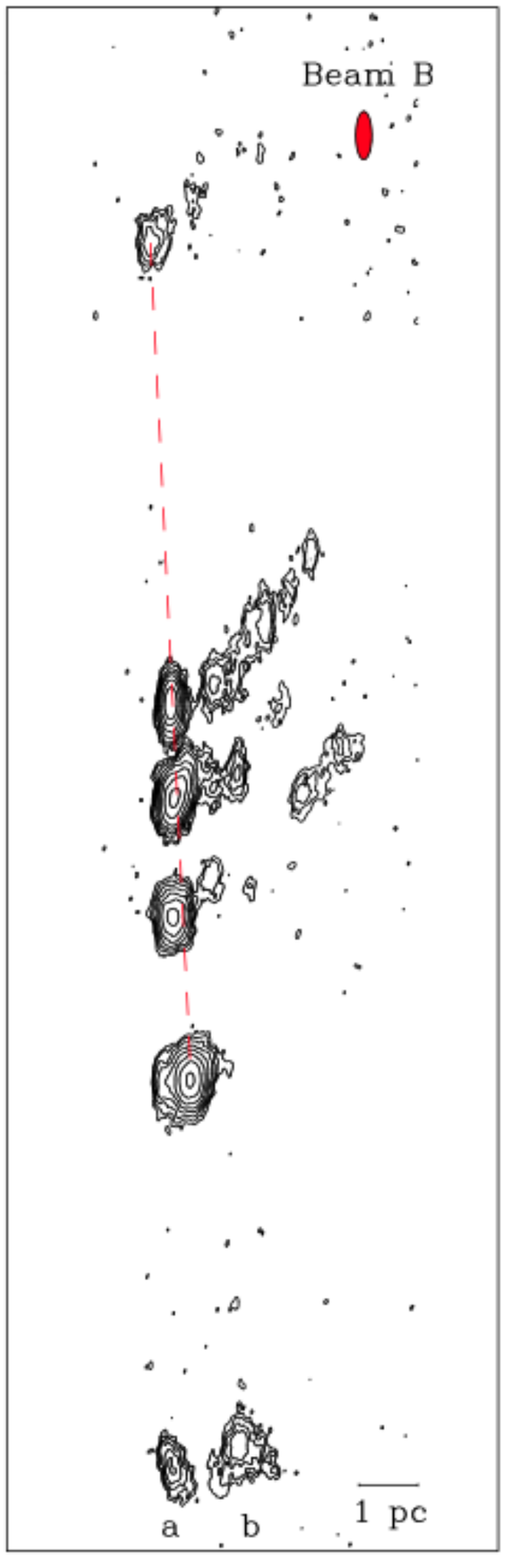


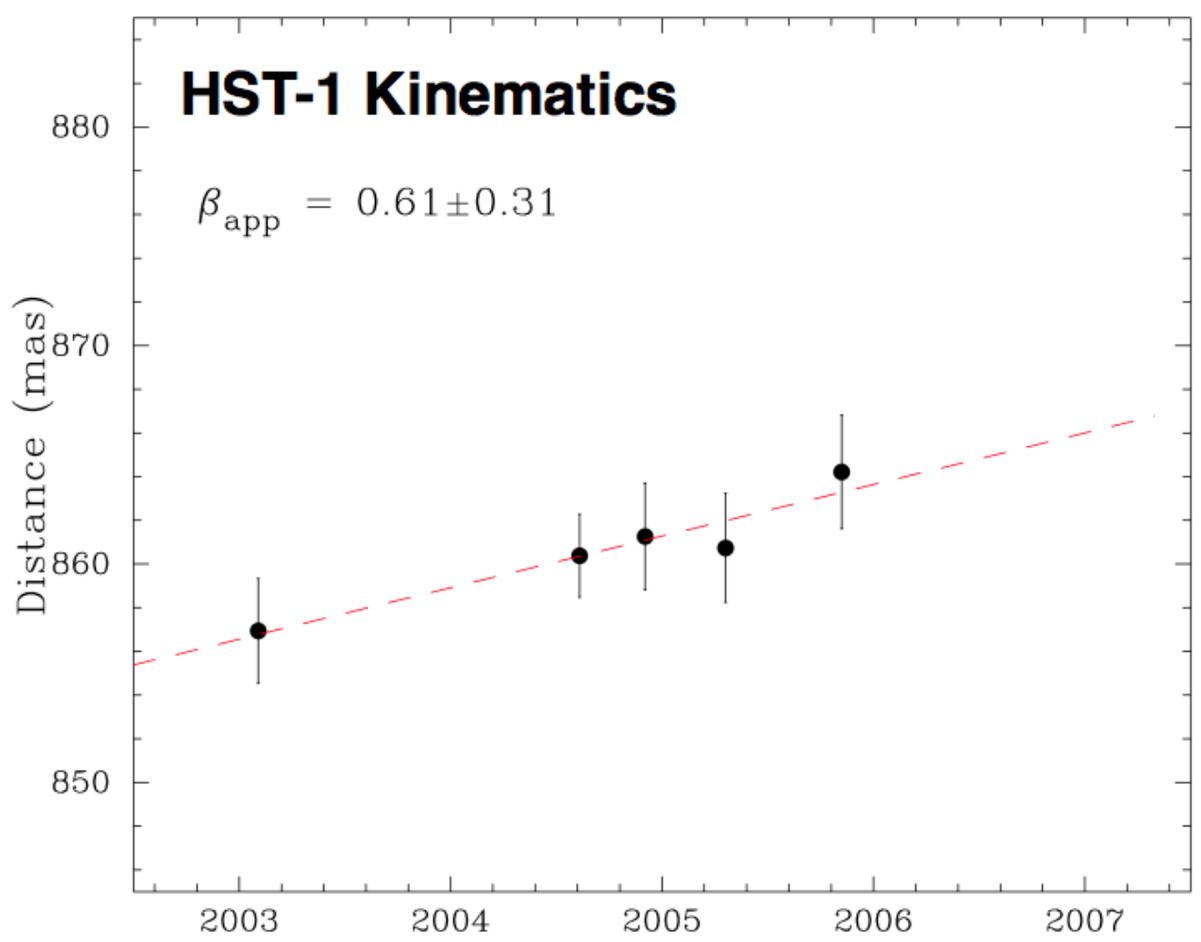
The jet in M87 observed at different resolutions. We analyze the HST-1 region at two resolutions

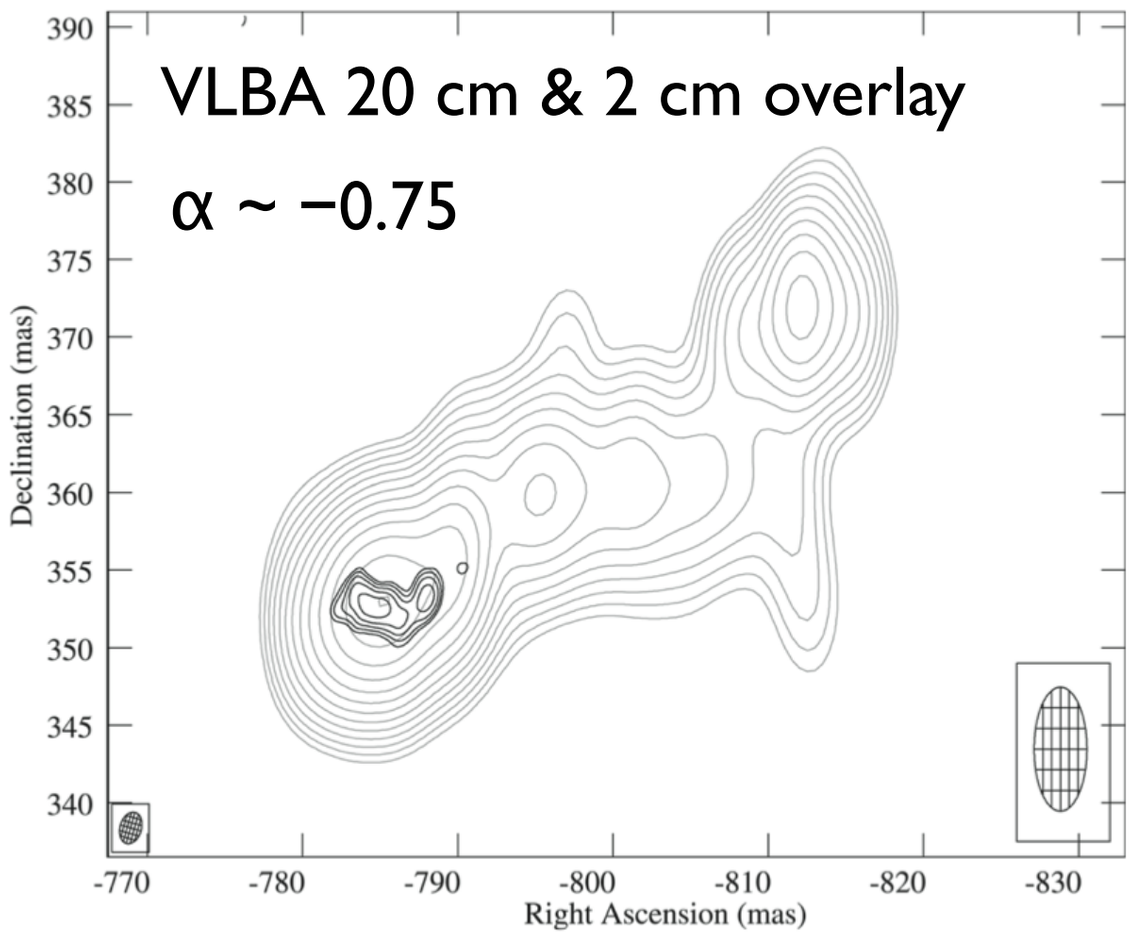
Beam B: 8.0×3.4 mas

Beam A: 1.9×1.2 mas


HST−1
VLBI λ2cm
Beam A
2003.09
2004.61
2004.92
2005.30
2005.85
2007.10
1 pc


Beam B
a
b
1 pc


HST-1 Kinematics
β_{app} = 0.61±0.31
Distance (mas)
880
870
860
850
2003
2004
2005
2006
2007


VLBA 20 cm & 2 cm overlay
α ~ −0.75
Declination (mas)
390
385
380
375
370
365
360
355
350
345
340
-770
-780
-790
-800
-810
-820
-830
Right Ascension (mas)

Summary

- First VLBI 2cm detection of HST-1 (highest resolution)
- Sub-luminal motion (β_{app} = 0.61 ± 0.31)
- Optically thin
- Do not find evidences of HST-1 to have a blazar-nature

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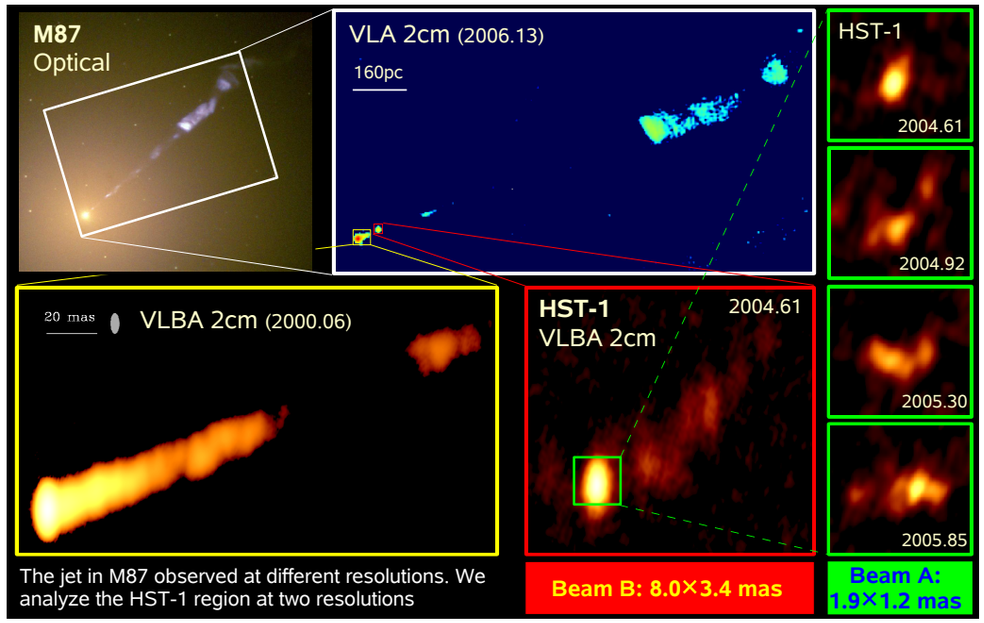
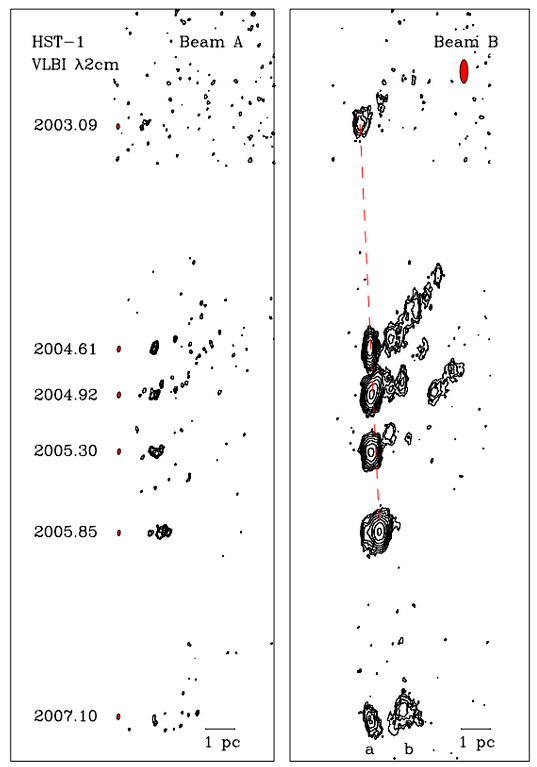


The jet in M87 observed at different resolutions. We analyze the HST-1 region at two resolutions

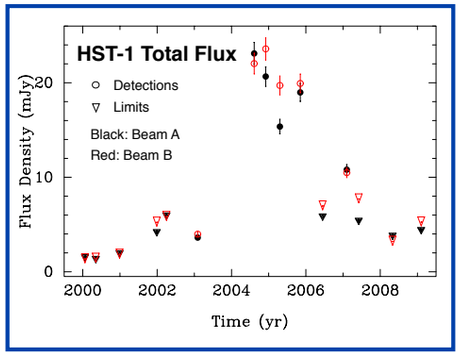
Background The radio-loud active galactic nucleus M87 hosts a powerful jet ejected from a super-massive black hole in its center. A bright feature 80 parsec away from the central engine of M87, labeled HST-1, has shown a multi-band flare peaking in 2005 (Madrid 2009, AJ, 137, 3864; Cheung et al. 2007, ApJ, 663, L65; Harris et al. 2006, ApJ, 640, 211). Early radio, optical, and X-ray observations have suggested that HST-1 is superluminal, and is possibly related to the TeV flare observed by HESS around 2005 (Aharonian et al. 2006, Science, 314, 1424). Therefore, it was suggested that HST-1 shows a blazar-like activity (Harris et al. 2008, ASPC, 386, 80). To examine the blazar-like property for this bright knot, we analyzed VLBA 2cm data of 15 epochs from 2000 to 2009 by applying VLBI wide-field imaging technique.

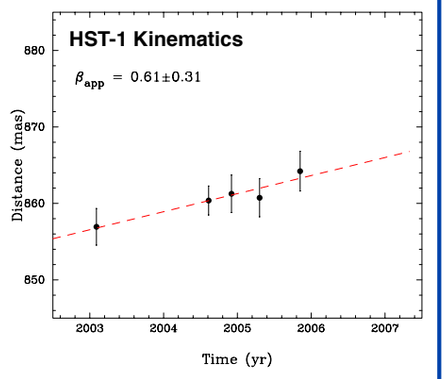
Results HST-1 is successfully detected with milliarcsecond resolutions from 2003 to 2007. We derive brightness temperature, T_b, of the HST-1 region to be no higher than 9×10^6 K (for typical blazar core, $T_b \sim 10^{10} - 10^{12}$ K). Furthermore, our detections show that the structure of HST-1 appears to be extended, shows a steep spectrum, and no compact or rapidly moving features are observed. The blazar scenario for HST-1 is not supported by our results. Moreover, our findings do not support the hypothesis that HST-1 is the region that generated the TeV emission in 2005, although this possibility cannot be completely excluded.

Acknowledgements We thank A. Moré, G. Cimò, S. Mühle, R. Lu, M. Karouzos, C. M. Fromm, N. Kudryavtseva, M. A. Garrett, R. C. Walker, and C. C. Cheung, for valuable comments and inspiring discussions. This research was supported by the EU Framework 6 Marie Curie Early Stage Training program under contract number MEST/CT/2005/19669 "ESTRELA". C. S. Chang is a member of the International Max Planck Research School for Astronomy and Astrophysics. Y. Y. K. was a research fellow of the Alexander von Humboldt Foundation. This research has made use of data from the MOJAVE database that is maintained by the MOJAVE team (Lister et al., 2009, AJ, 137, 3718) . The Very Long Baseline Array is operated by the USA National Radio Astronomy Observatory, which is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.



VLBA contour images of the HST-1 region restored with Beam A and Beam B, spaced by their relative time intervals.





The linear fit of HST-1 proper motions shown as the red dashed line. This plot illustrates the position of HST-1 component peaks w.r.t. the M87 core component from 2003.09 to 2005.85.

Spectral properties of HST-1 We use adjacent epochs of VLBA 20 cm (Cheung et al. 2007, ApJ, 663, L65 & priv. comm.) and 2 cm observations to compute the spectral indices. The feature appears to be optically thin.

HST-1 20 – 2 cm spectral index ($S_\nu \propto \nu^{+\alpha}$)

Epoch		S_ν [mJy]		α
λ2 cm	λ20 cm	λ2 cm	λ20 cm	
2005.30	2005.35	19.7 ± 1.0	111 ± 6[b]	−0.75 ± 0.03
2005.85	2005.82	19.9 ± 1.0	126 ± 6[b]	−0.80 ± 0.02