VLBI imaging of the starburst galaxy Arp 220 at MHz and GHz frequencies

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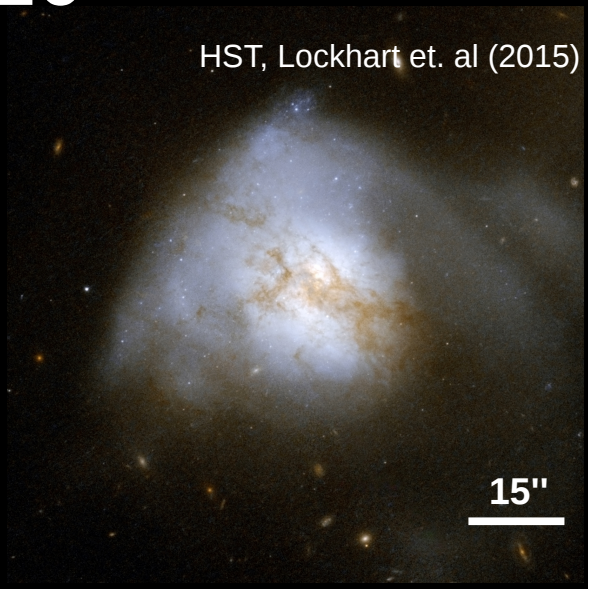
+ many collaborators across the world
(see referenced papers)

Outline

- Arp 220: What and why?
- Results from MHz-VLBI with LOFAR
- Results from global GHz-VLBI

The starburst galaxy Arp 220



d=77 Mpc

What?

- Extreme environment (ULIRG: $L_{IR}>10^{12}L_{sun}$)
- Merger with two nuclei 1" apart
- Starburst: ~230 M_{sun} per year

Why?

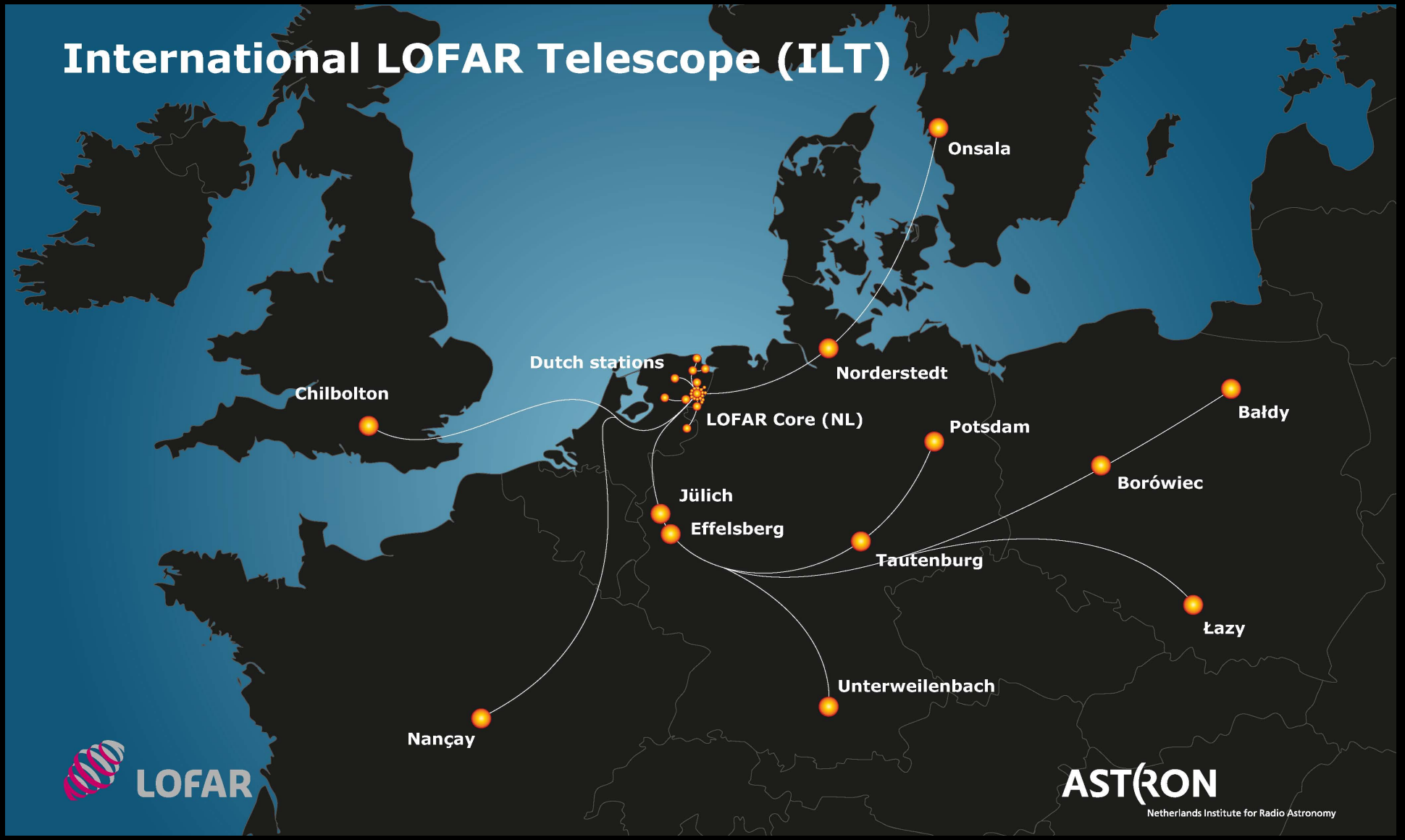
MHz frequencies:

- Steep spectrum emission ?
- Free-free absorption in LIRGs ?
- MHz FIR-radio correlation (LOFAR,SKA) ?

GHz frequencies:

- Study SNe/SNRs/AGNs(?)
  i.e. the origin of the radio emission

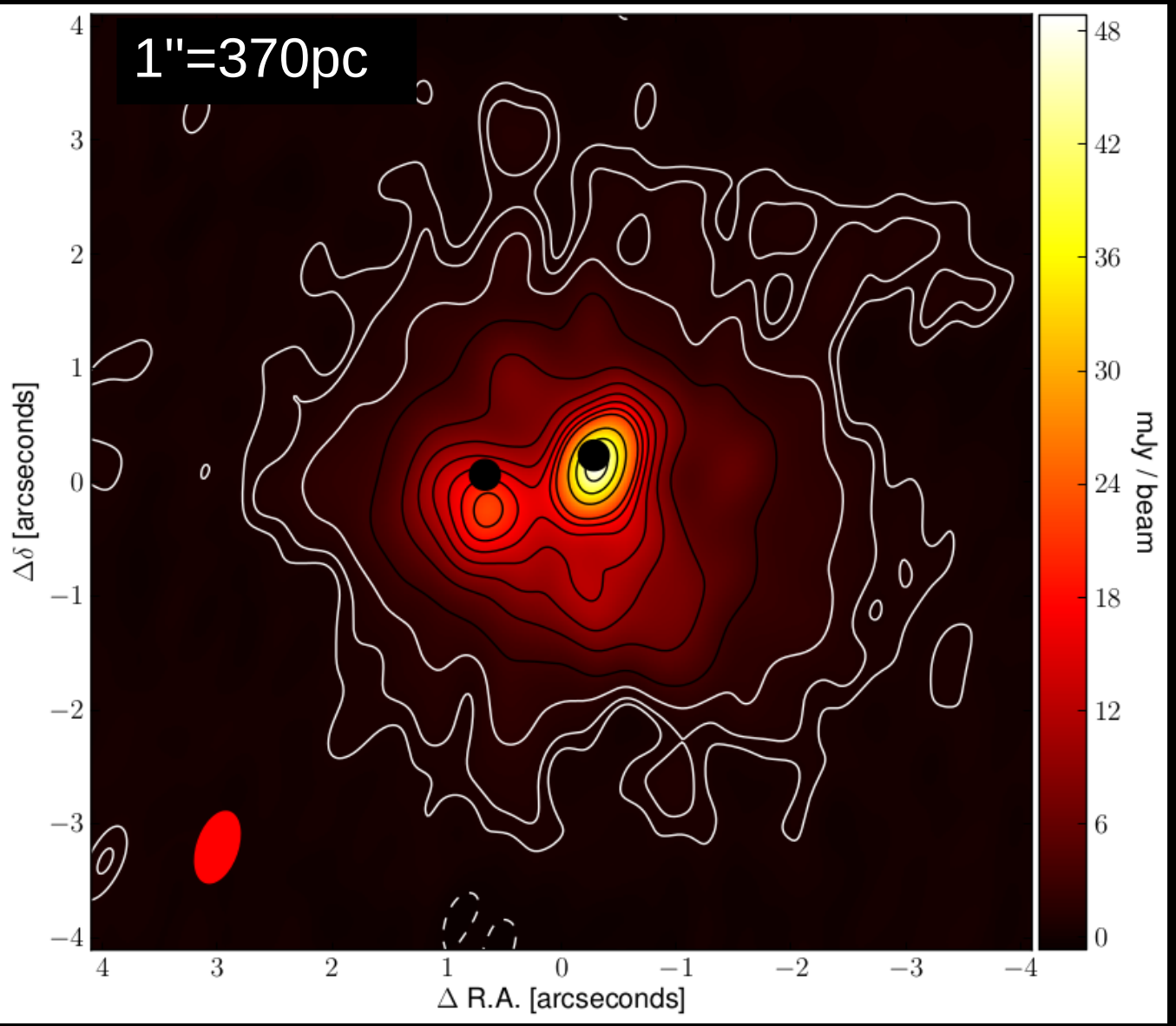
LOFAR -> 0.3" resolution at 150 MHz (!)

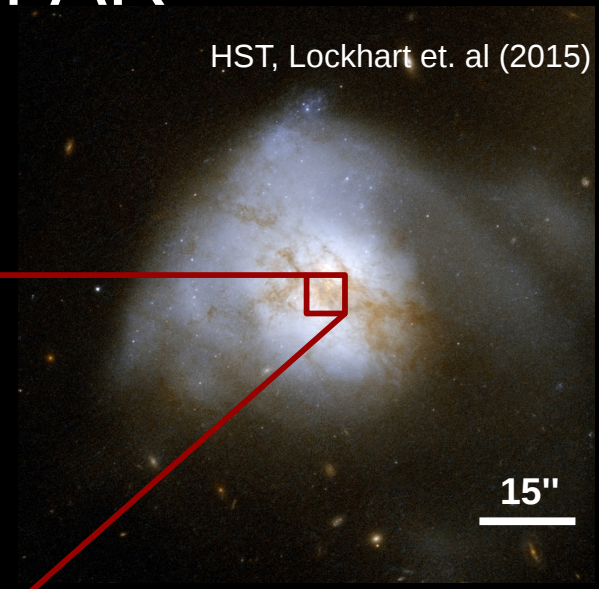


Record in image resolution! See Varenius et al. 2015 on M82.

Arp 220 at 150 MHz with LOFAR

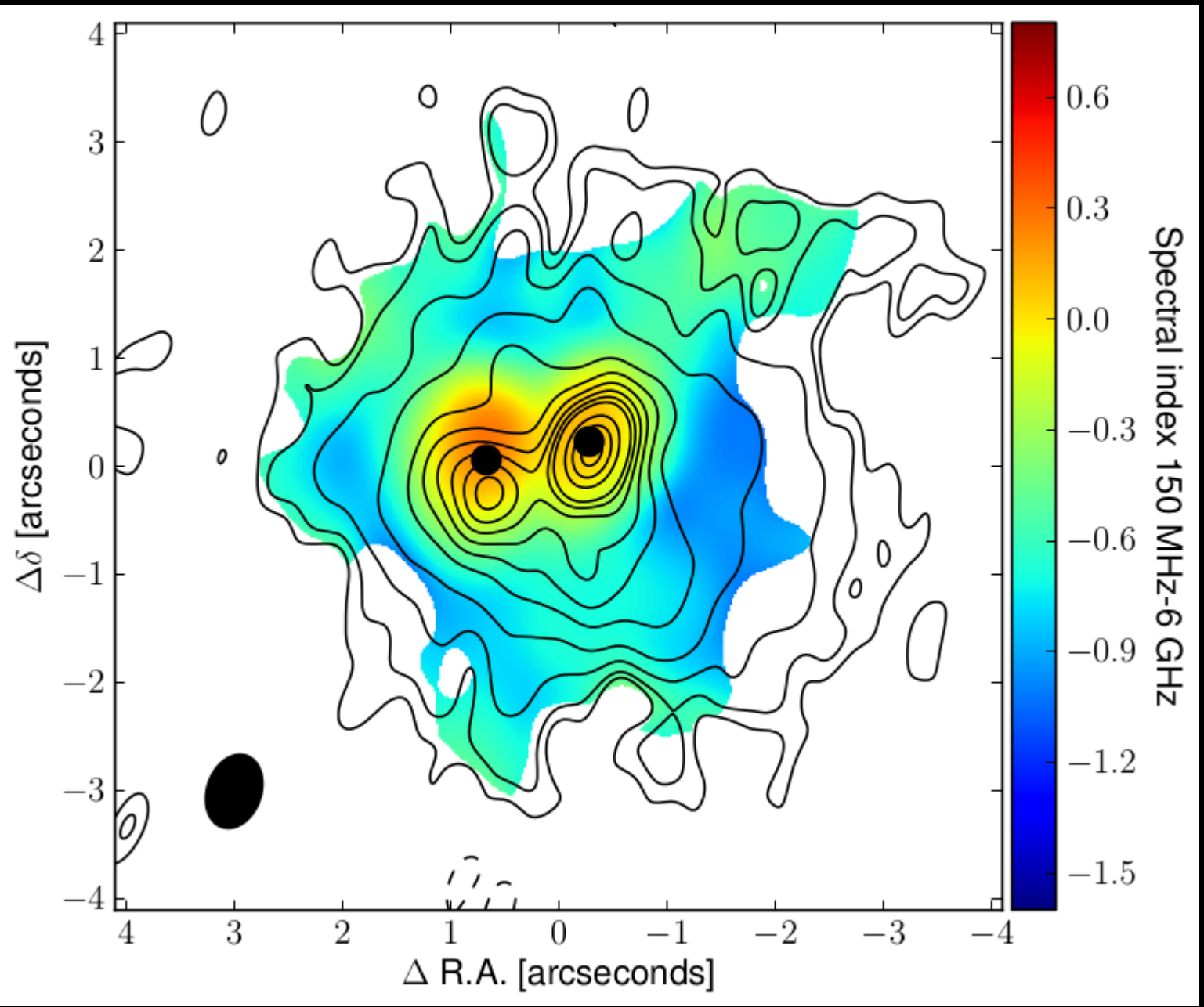
48 MHz bandwidth, 6 hours.
Resolution 0.65"x0.35", noise 0.15 mJy/beam.





Varenius et al. 2016, accepted in A&A

Spectral index 150 MHz to 6 GHz



Contour:

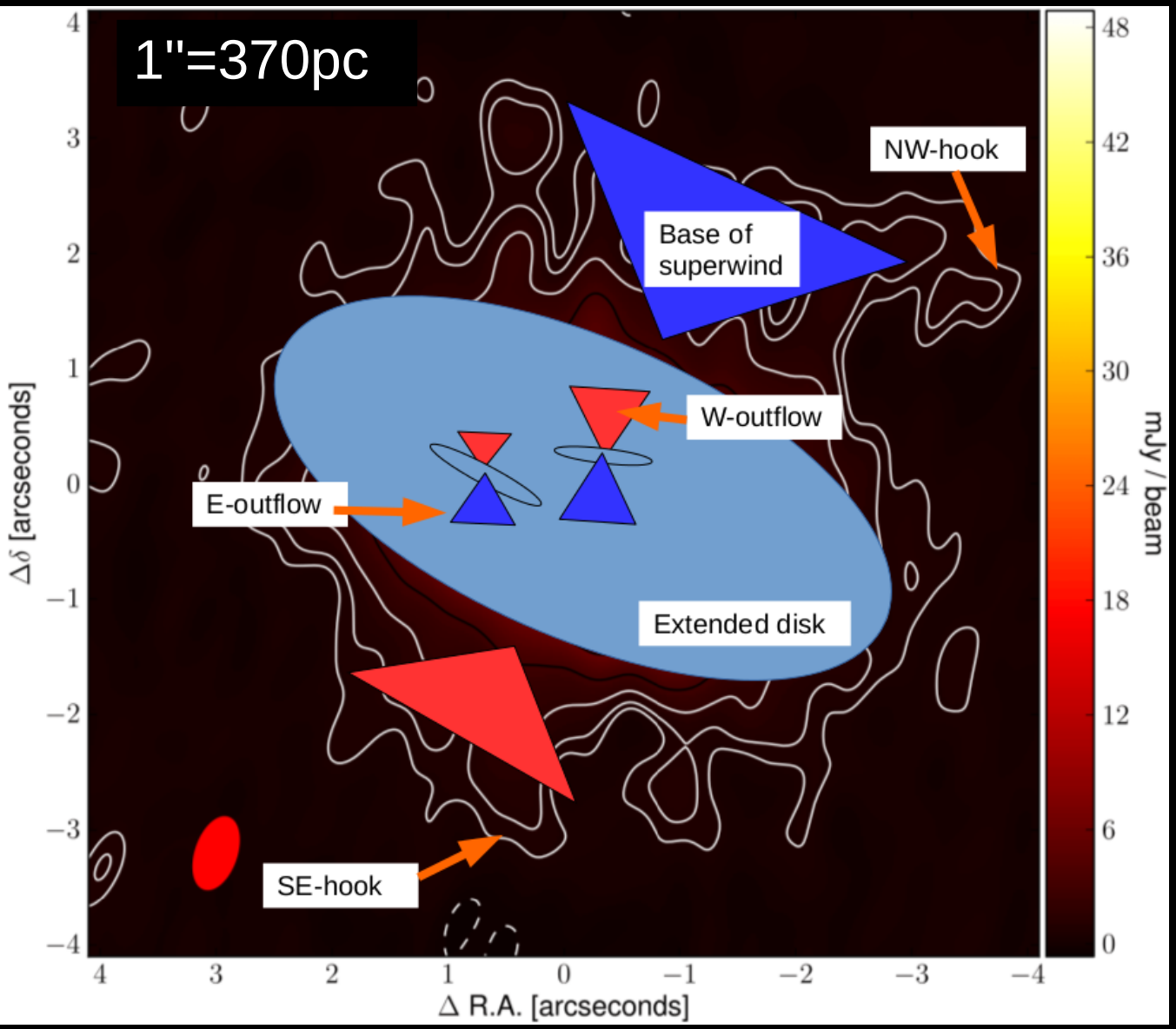
150MHz

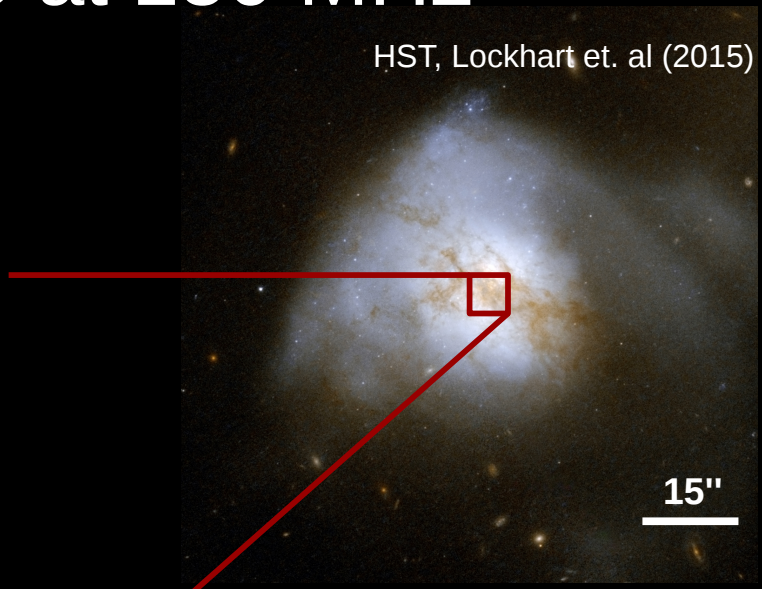
continuum

3σ, 5σ, 10σ ...

Varenius et al. 2016
accepted in A&A

A “simple” sketch of Arp 220 at 150 MHz

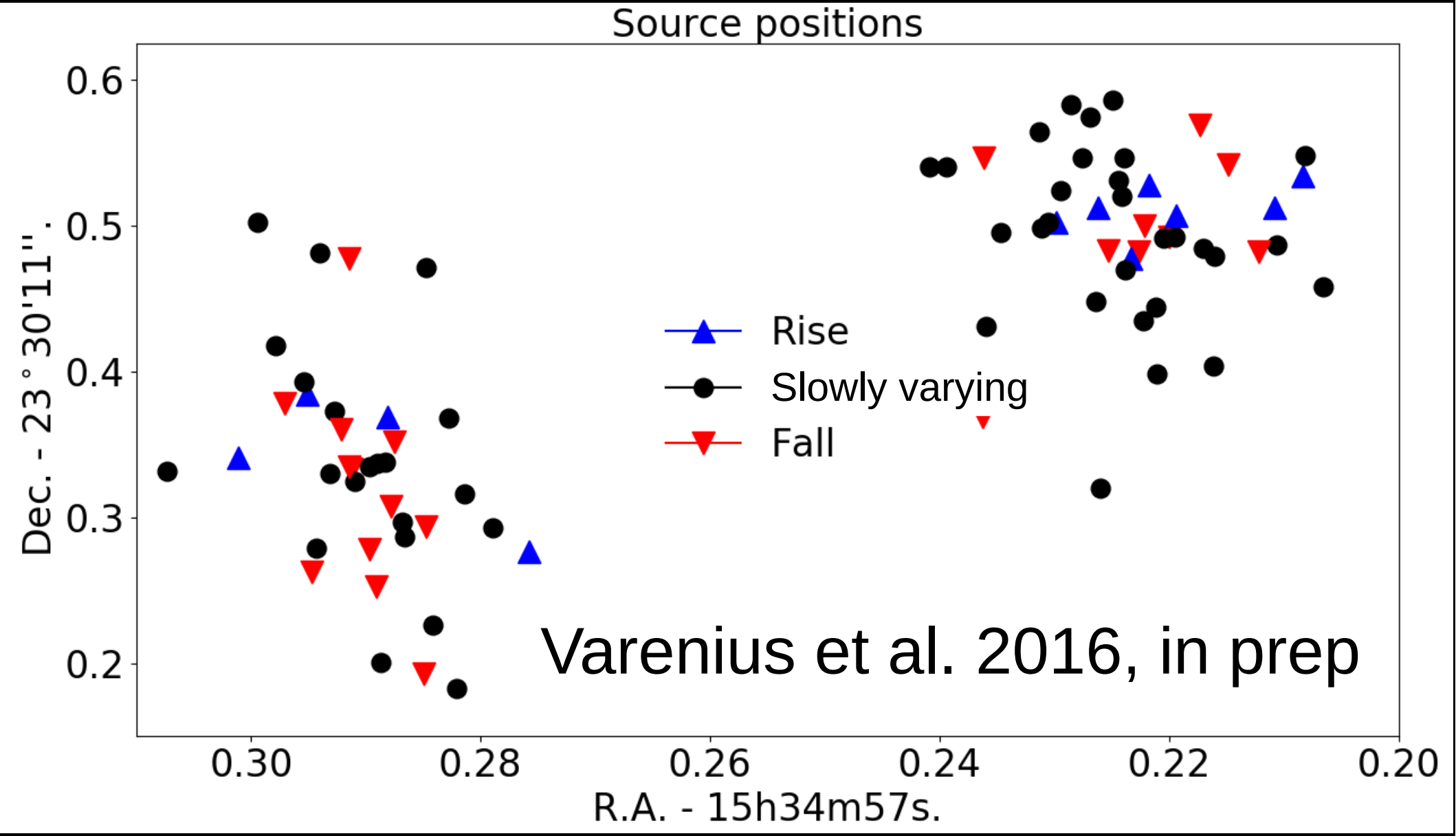




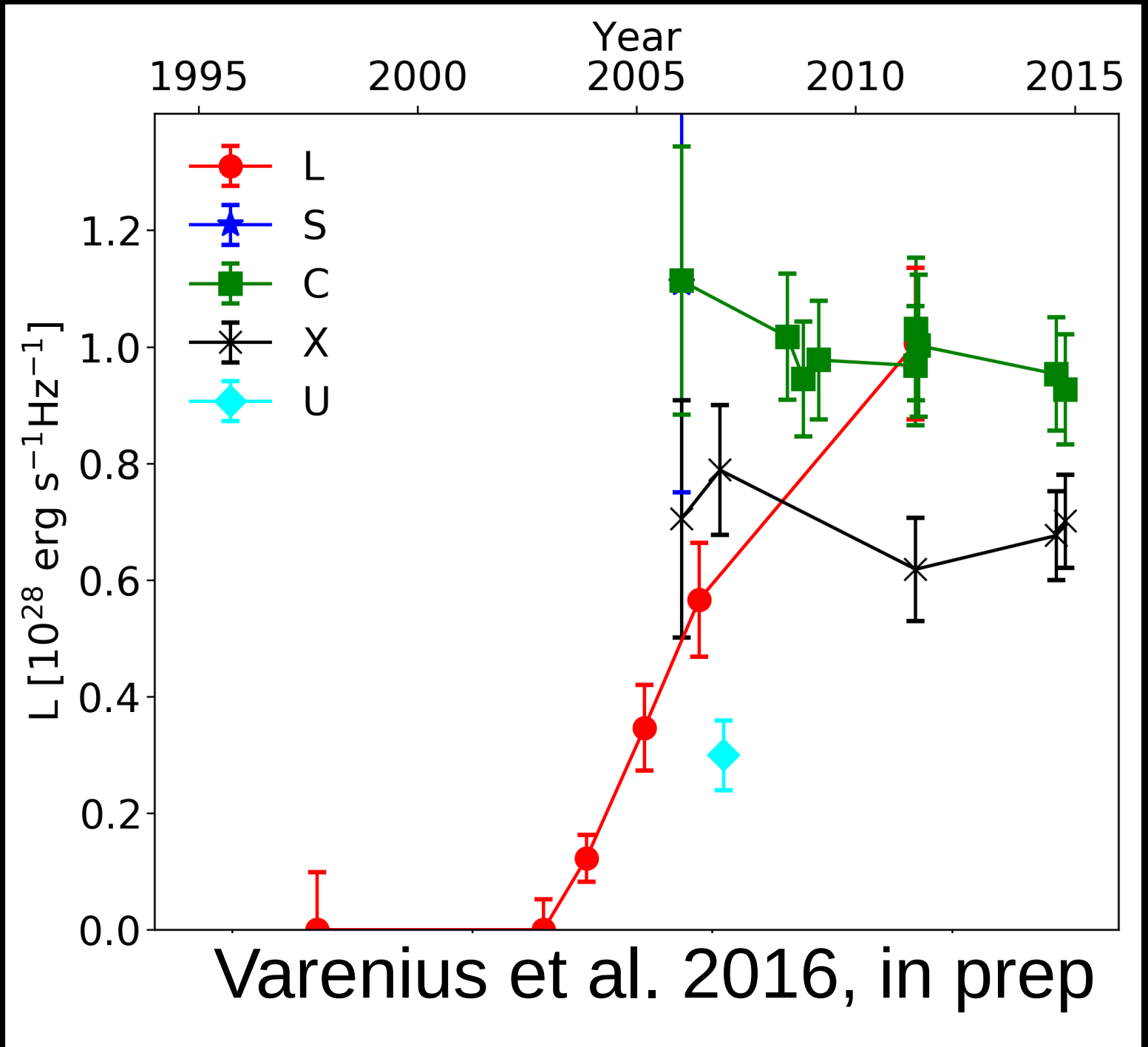
Varenius et al. 2016, accepted in A&A

17 years of Global GHz-VLBI:

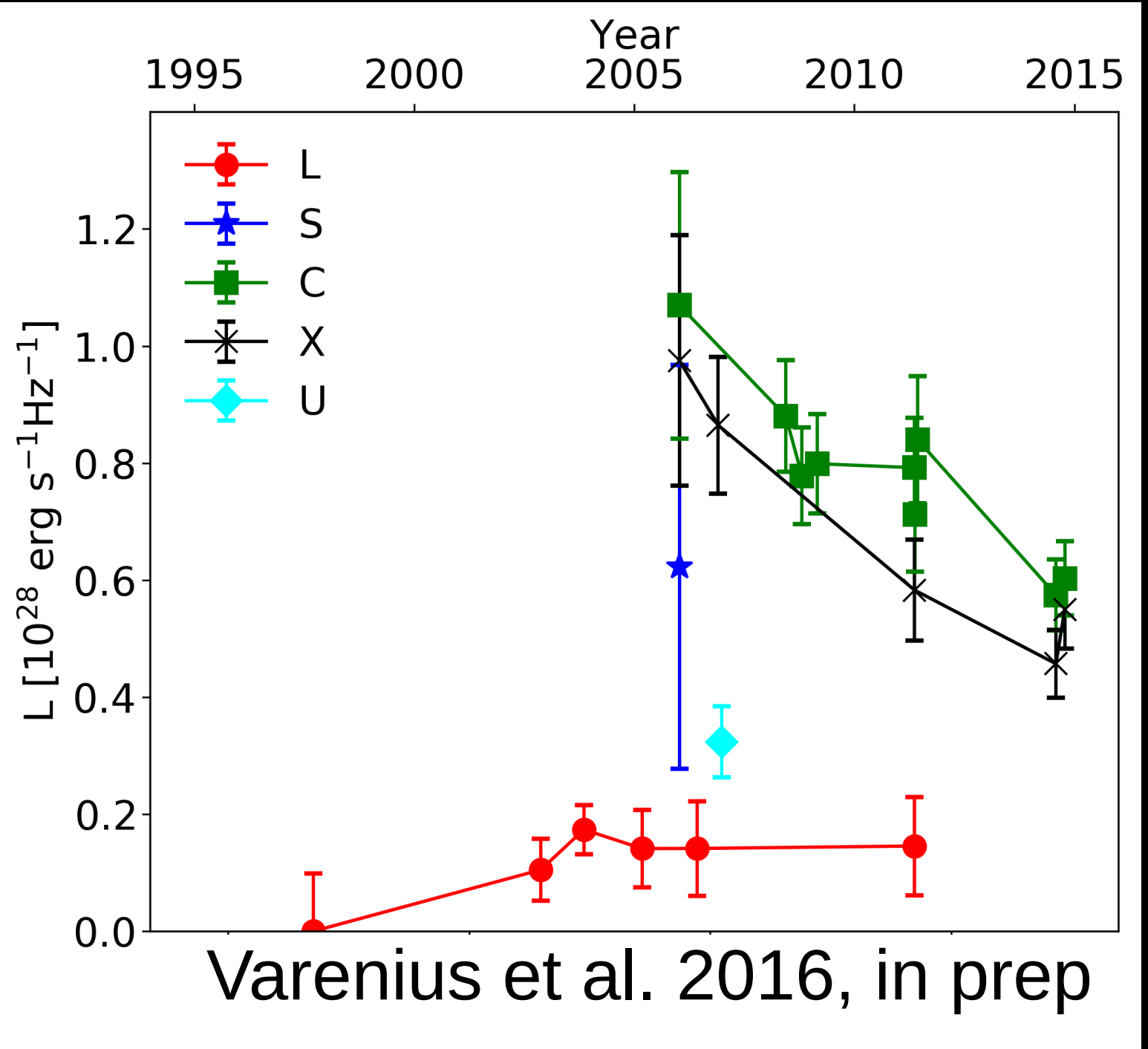
82 compact sources detected in the two nuclei!



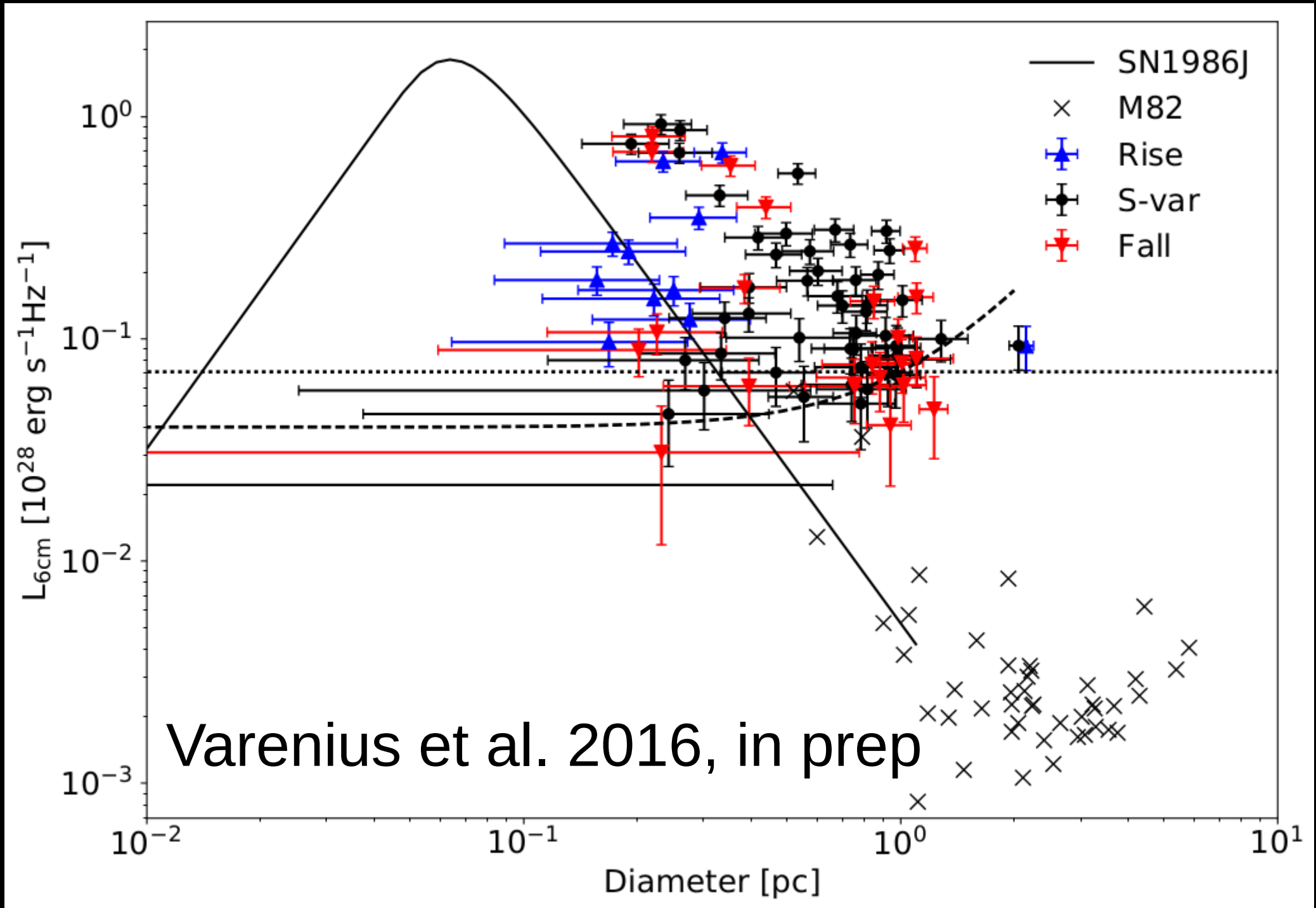
Example lightcurve 1



Example lightcurve 2



Luminosity vs diameter



Summary

- LOFAR can produce 0.3'' images at 150MHz (See e.g. Varenius et al. 2015 on M82)

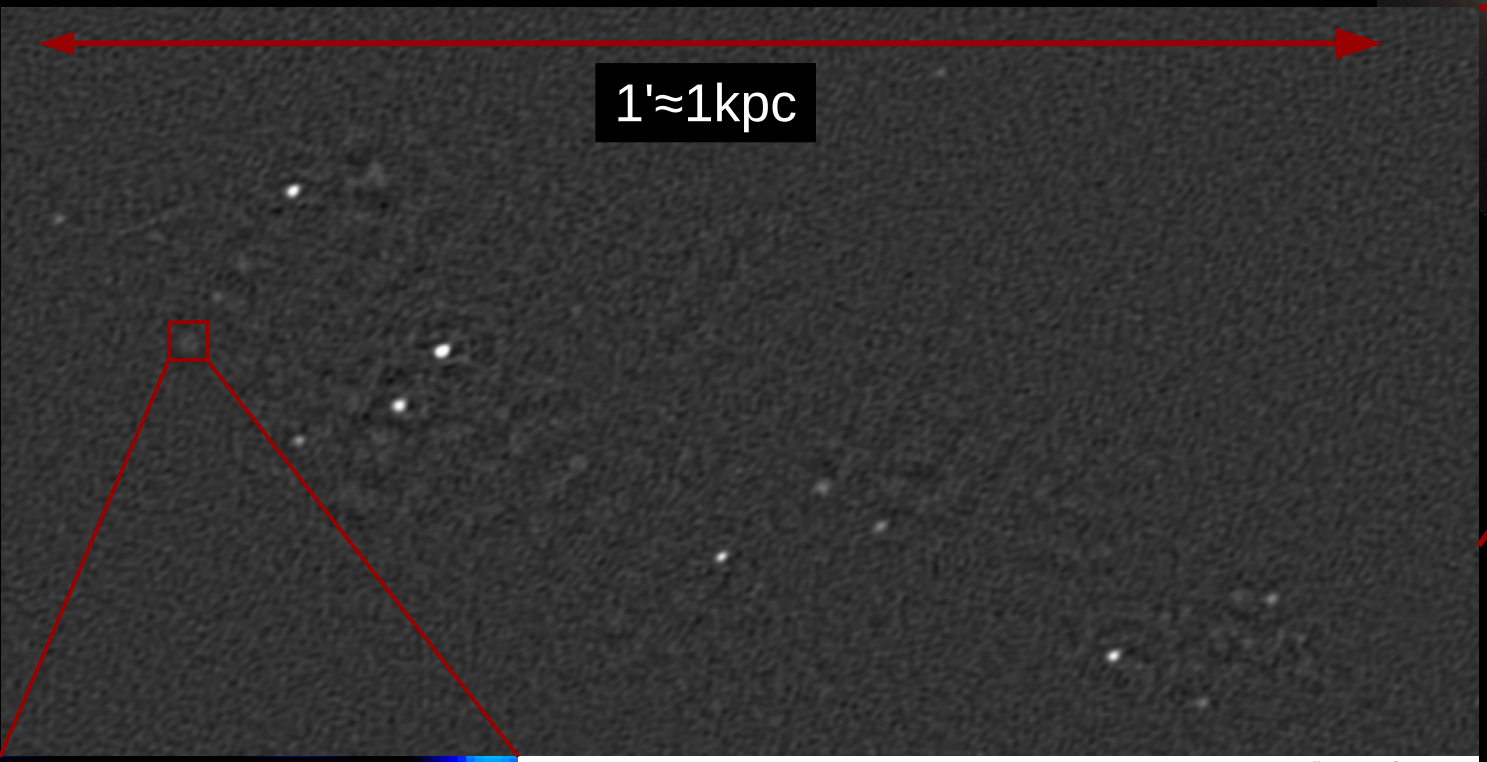
- MHz-VLBI with LOFAR resolves Arp 220: nuclei surrounded by steep spectrum halo (See Varenius et al. 2016, accepted in A&A)

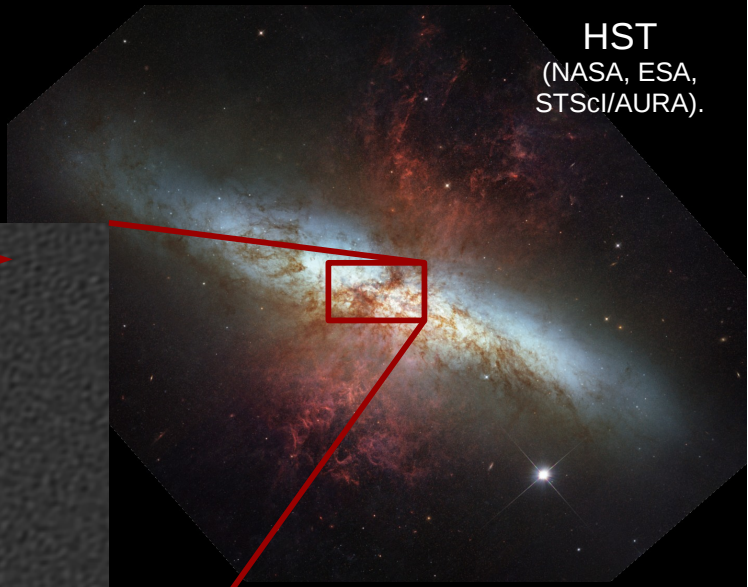
- GHz-VLBI detect 82 sources over 17 years, most with lightcurves and diameters. Final analysis ongoing... (Varenius et al. 2016, in prep)

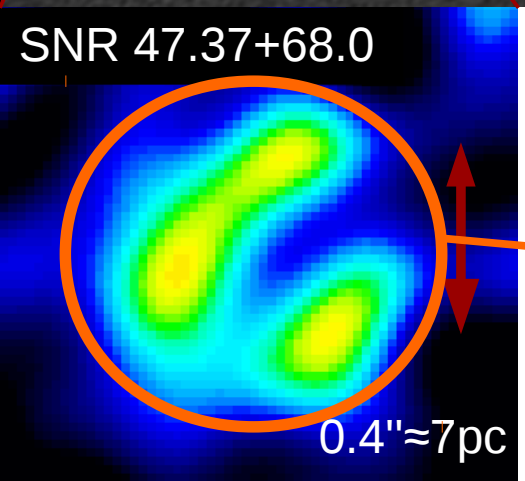
EXTRA: M82 at 150 MHz with LOFAR

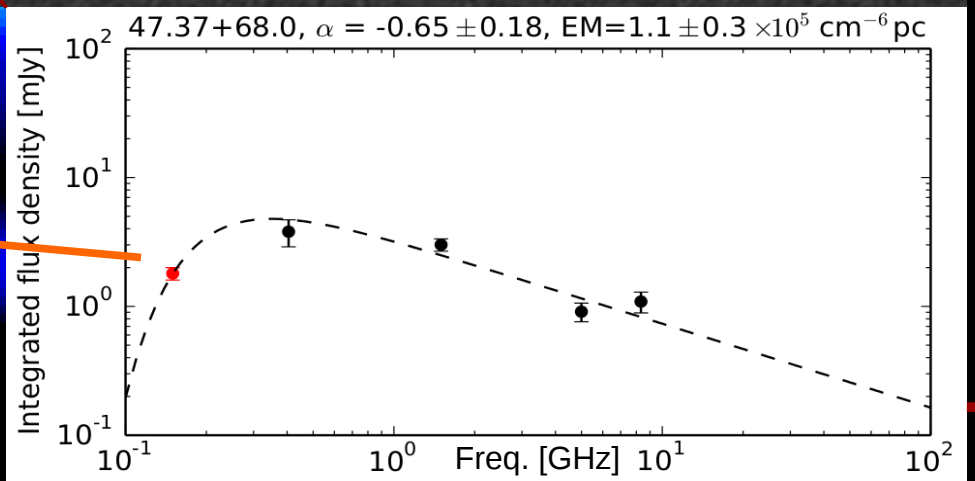
16 MHz bandwidth, 16 hours.

Resolution 0.3", rms noise 0.15 mJy/beam.









Results:

- Detect 16 objects (7 new)
- Resolve SNR shells
- Probe ISM structure through low-freq turnovers in SNR spectra.

Varenius et al. (2015), A&A.