Extragalactic Synchrotron Transients with the EVN

Miguel Pérez-Torres (IAA-CSIC, Granada)

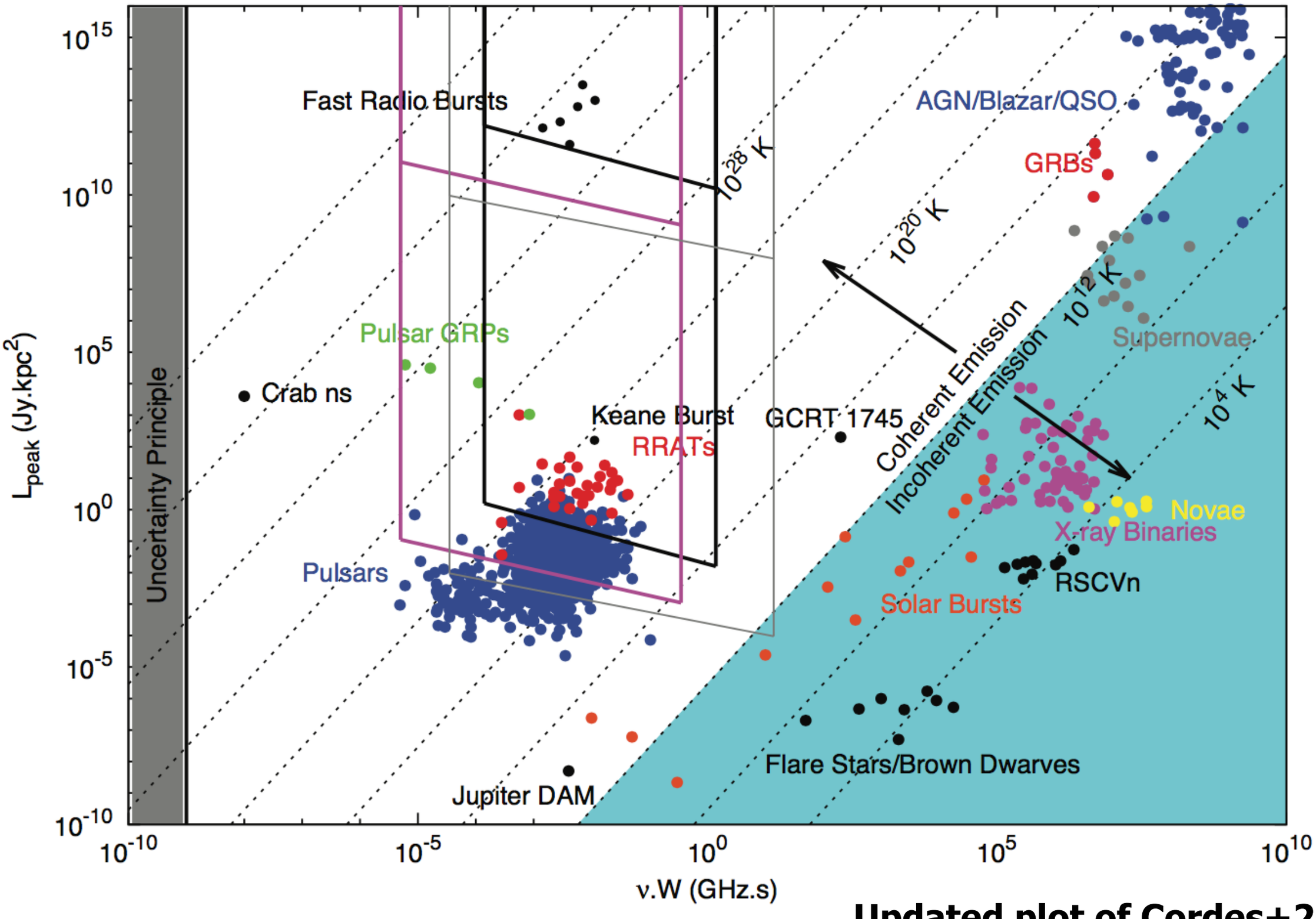
SS11 - EWASS 2018, Liverpool, 4 April 2018

EVN: the European VLBI Network

providing the sharpest view on the Universe

Image by Paul Boven (boven@jive.eu). Satellite image: Blue Marble Next Generation, courtesy of Nasa Visible Earth (visibleearth.nasa.gov).

The transient parameter space



Updated plot of Cordes+2004

What can the EVN do for your pet transient?

- Target location: mas-to-muas precision and accuracy
- Target imaging: Images at mas-scales with large FoV
- Ultra-high sensitivity: Needed both for location of faint compact targets, as well as diffuse, extended emission.

Galactic transients

Novae

White dwarf + Main Sequence/Red Giant companion

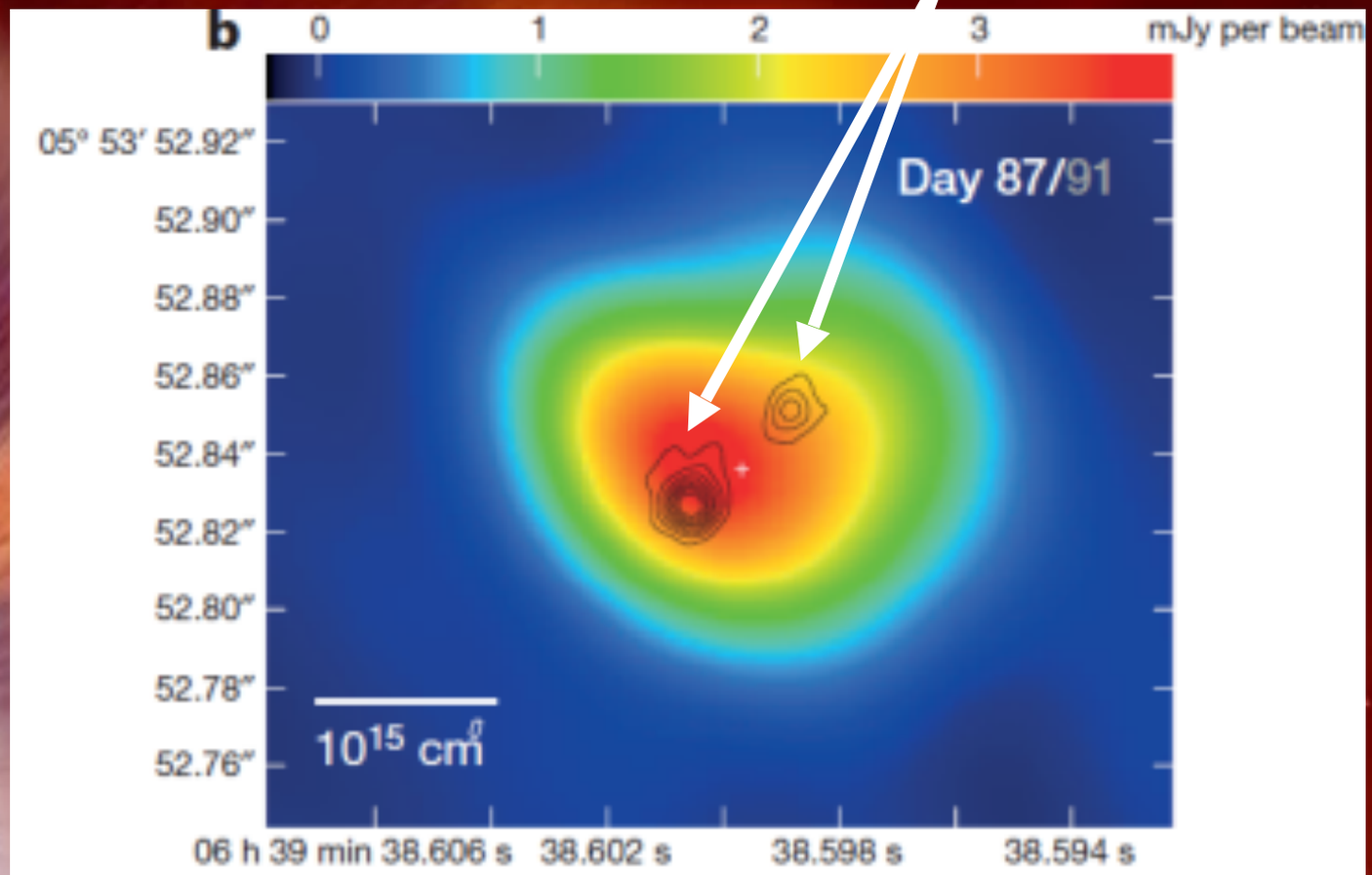
- Outbursts due to thermonuclear runaway in accreted material on WD surface.
- The white dwarf is not destroyed and another nova outburst may occur ~1 to 1000’s of years later.

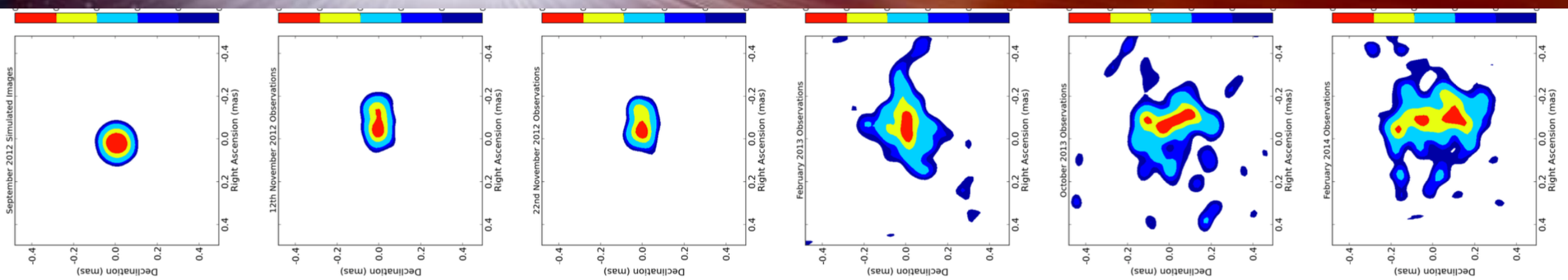
Novae

- High-resolution radio imaging of their expanding aspherical remnants to understand their ejection geometry, including jets
- Combining radio, X-ray and gamma-ray observations to understand role of shocks in particle acceleration
- Understanding explosions on massive WDs and their link to Type Ia SNe

Gamma-ray nova V959 Mon (Chomiuk et al 2014)

Expanding non-thermal components seen with EVN



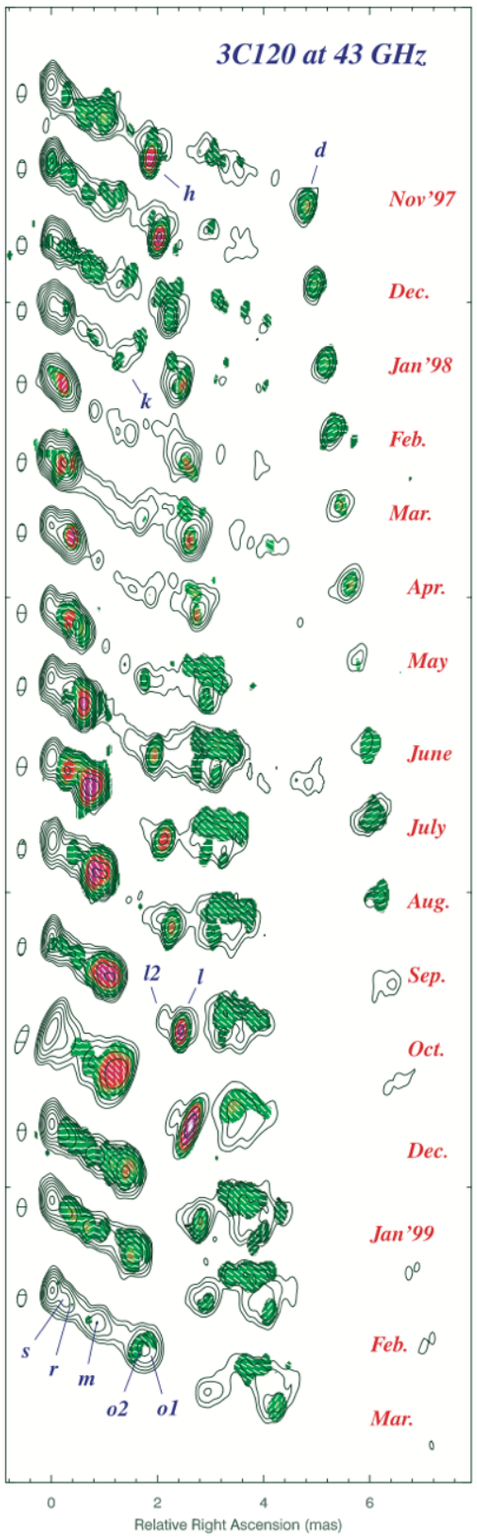


e-MERLIN imaging of V959 Mon (Healy et al 2017)

Microquasars: AGN for the impatient

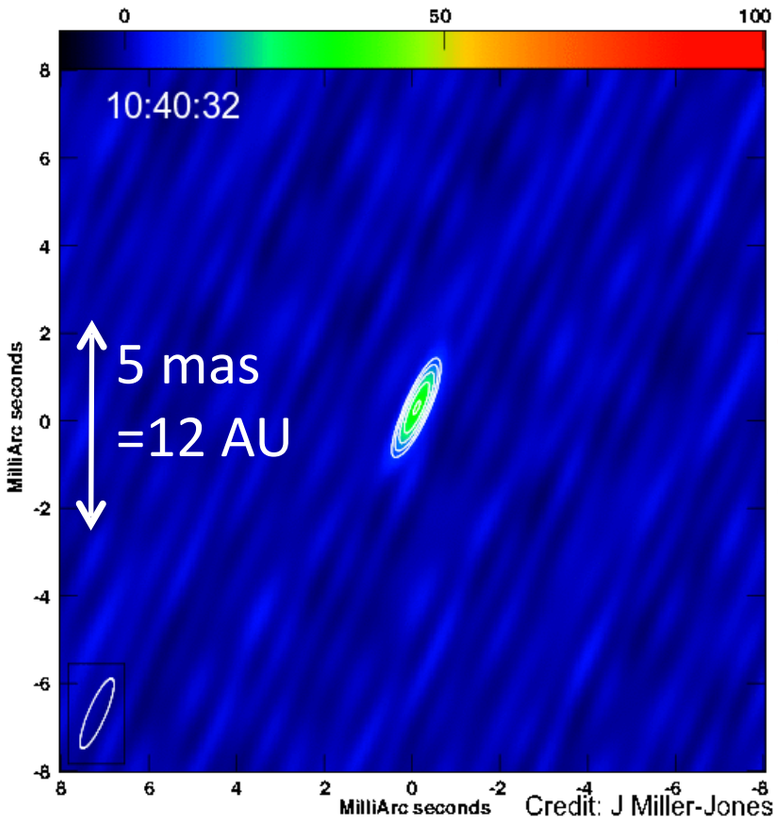
Real-time jet evolution

- ***How relativistic are XRB jets?***
  - Accurate distances essential
- ***How do jets couple to accretion flow?***
  - VLBI proper motions give ejection time
  - Tie to X-ray spectral / timing signatures



18 months

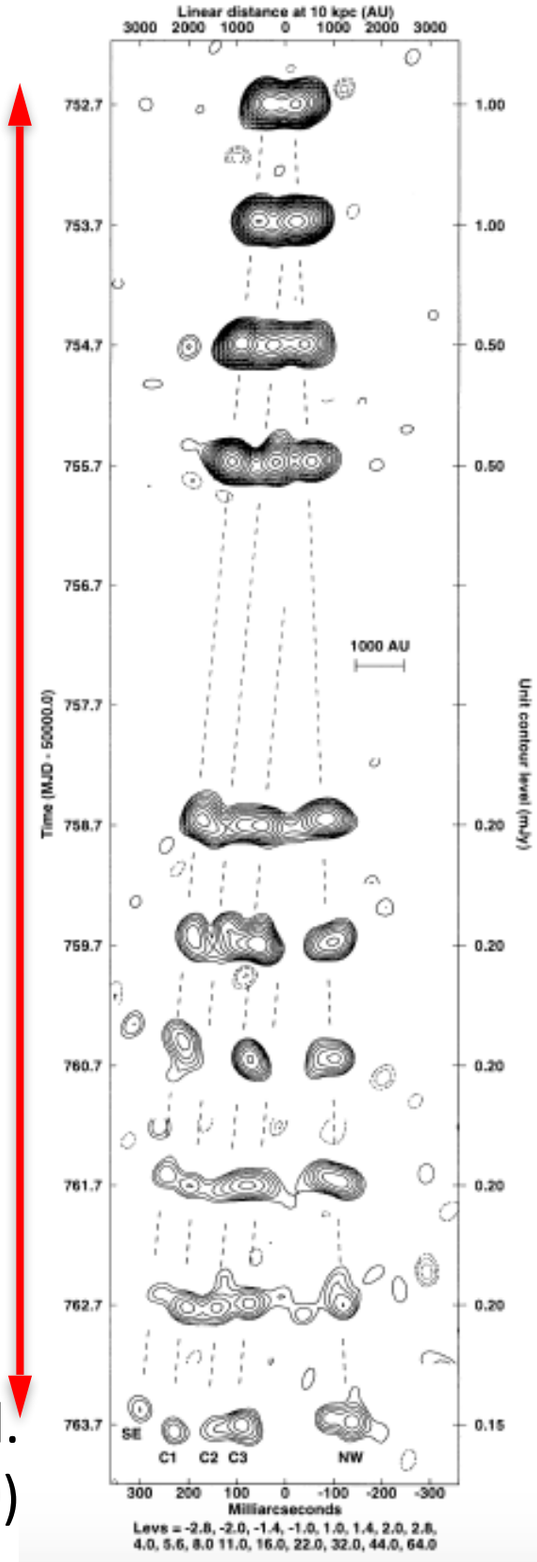
Gomez et al. (2001)



4 hours

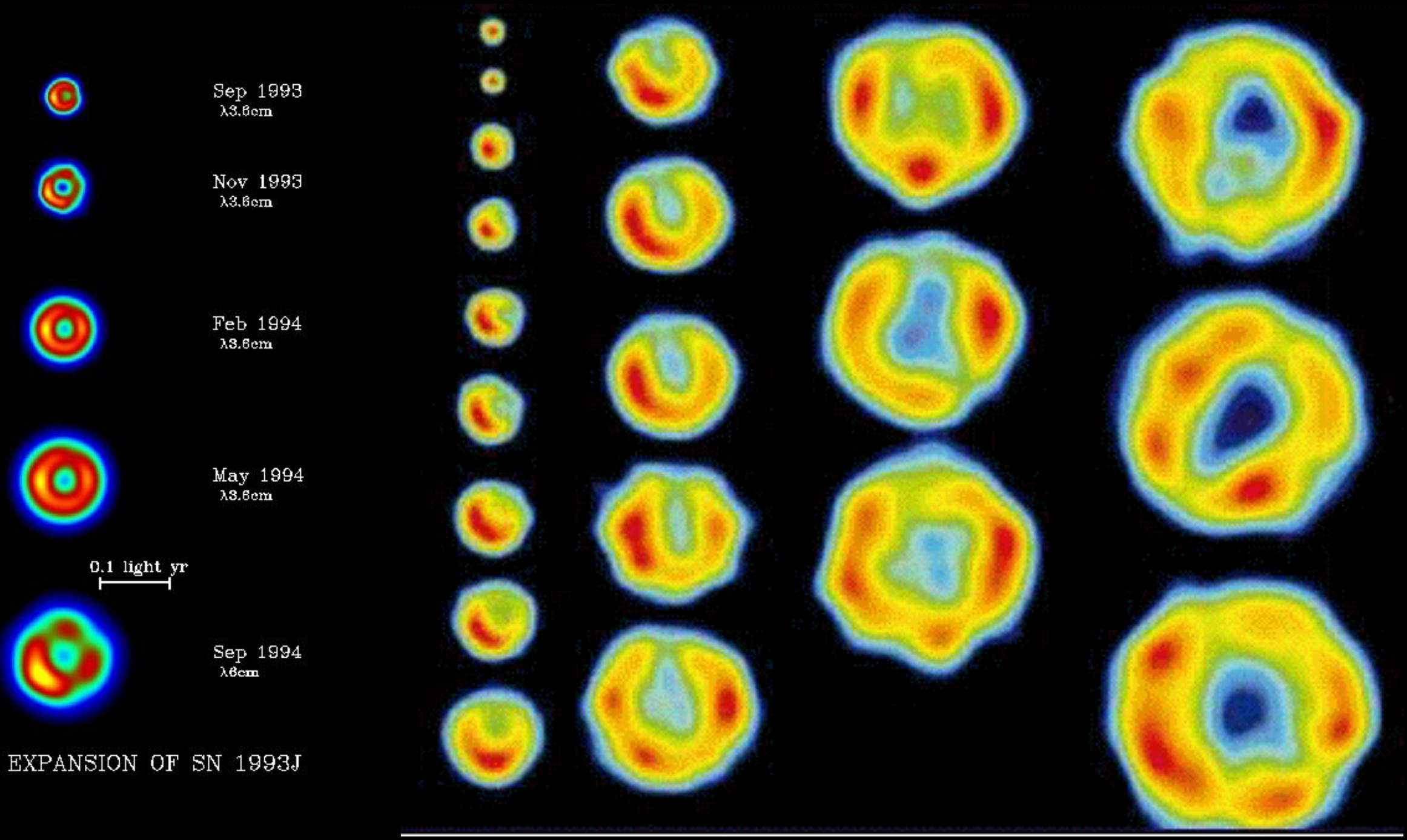
Miller-Jones et al. (2018)

Fender et al. (1999)



Extragalactic SNe and GRBs

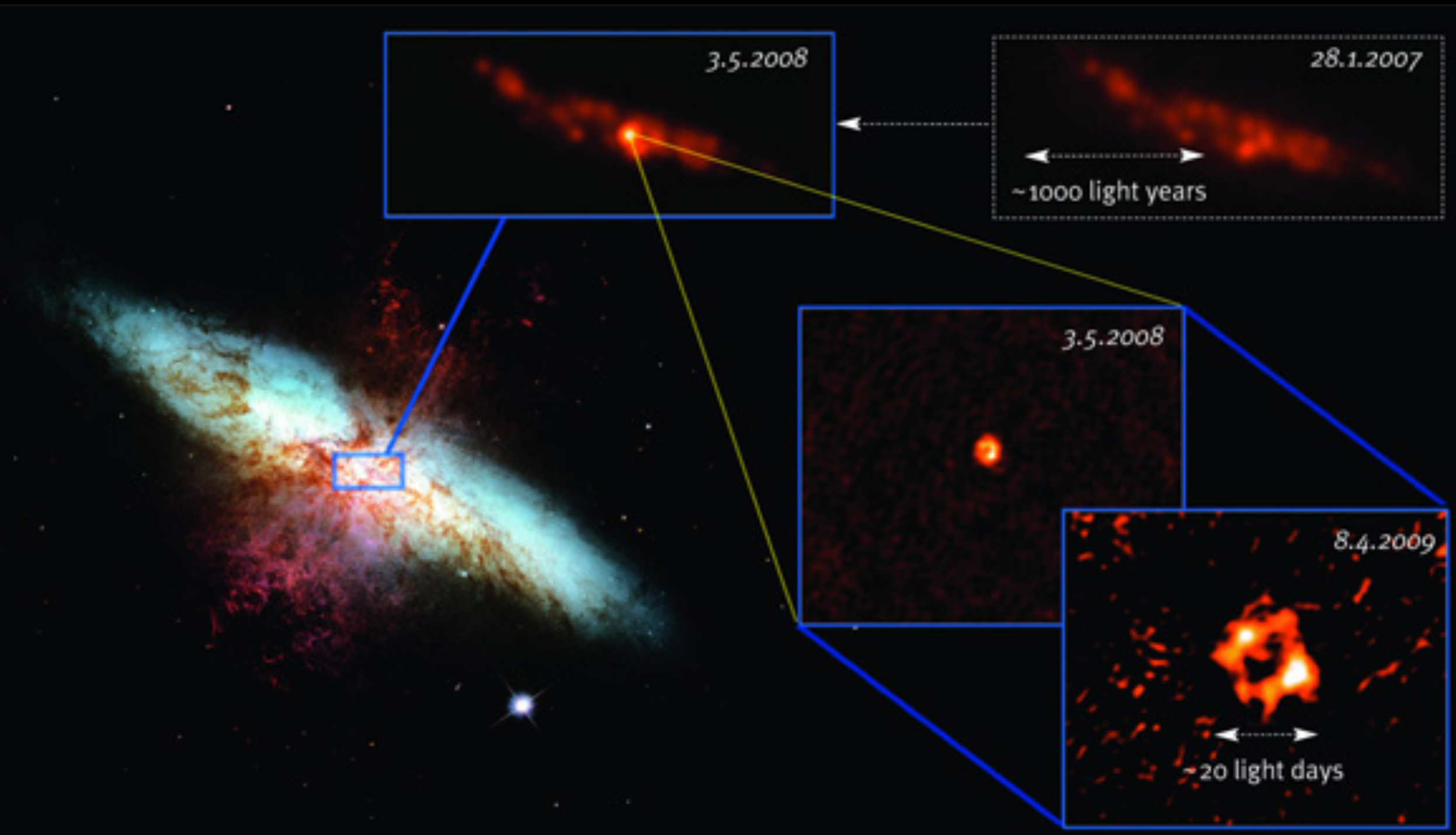
SN1993J in M81



(Marcaide+1995)

(Bartel+2000)

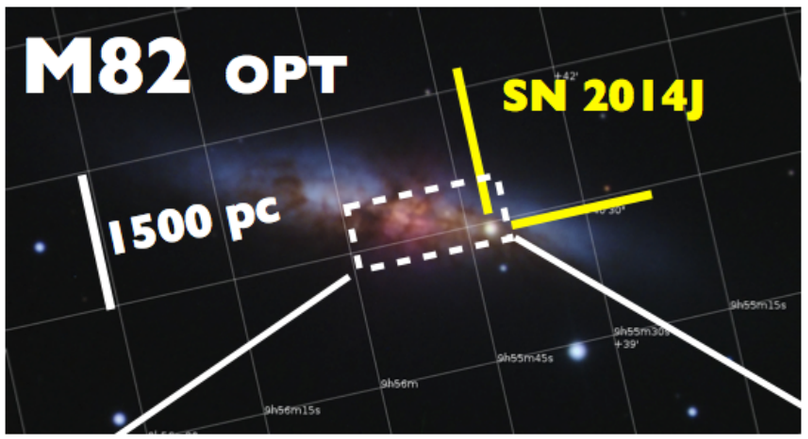
CCSNe

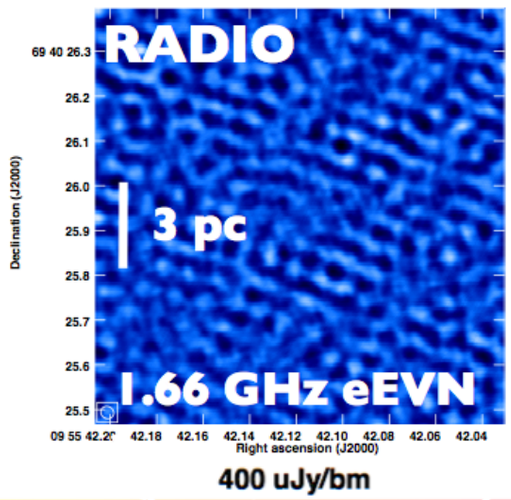


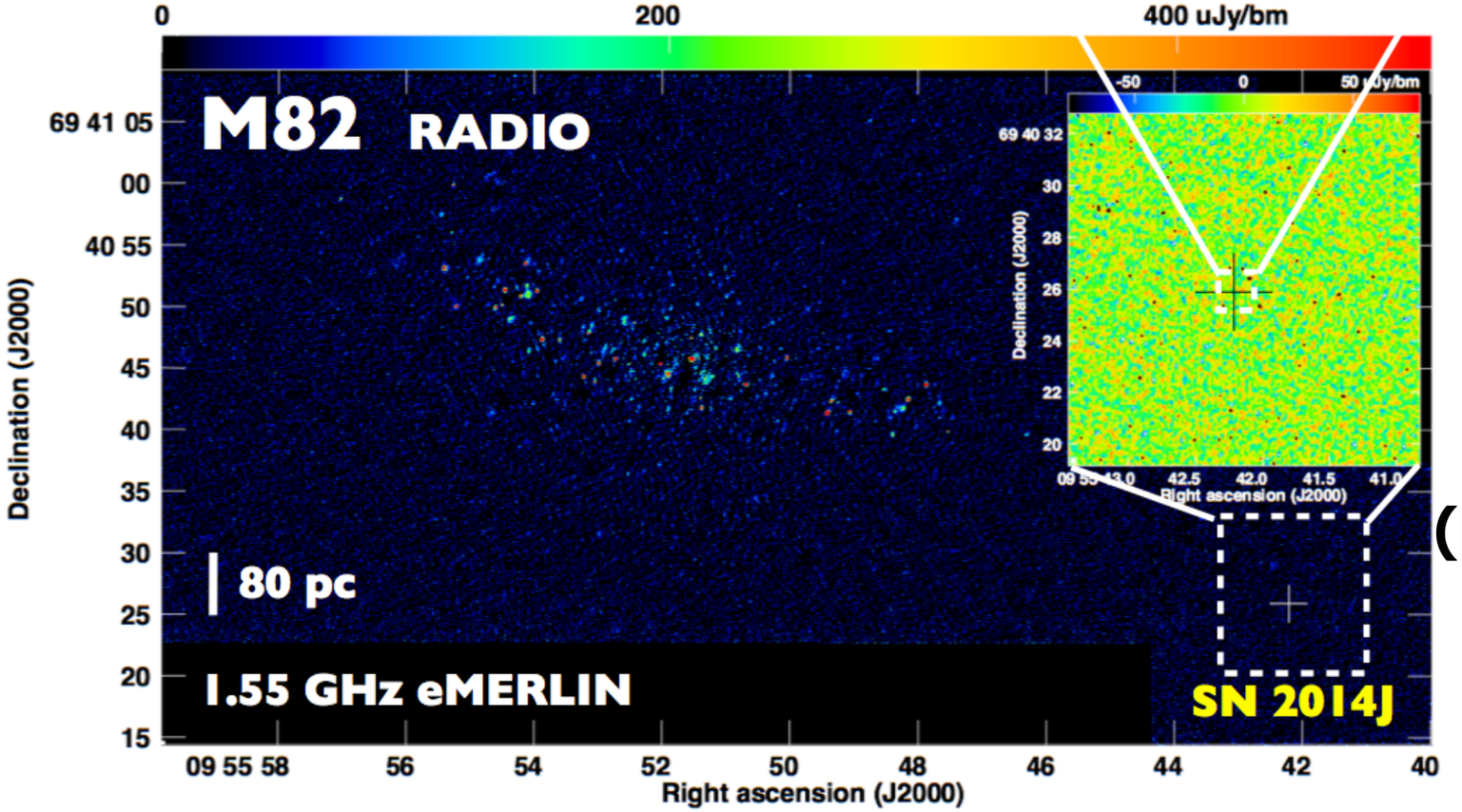
Expansion of SN2008iz in M82 imaged with VLBI (Brunthaler+2010)

Type Ia SNe

- What are their progenitors?
  - Single degenerate (SD) channel=> Prompt radio emission
  - Double-Degenerate (DD) channel => No prompt radio emission

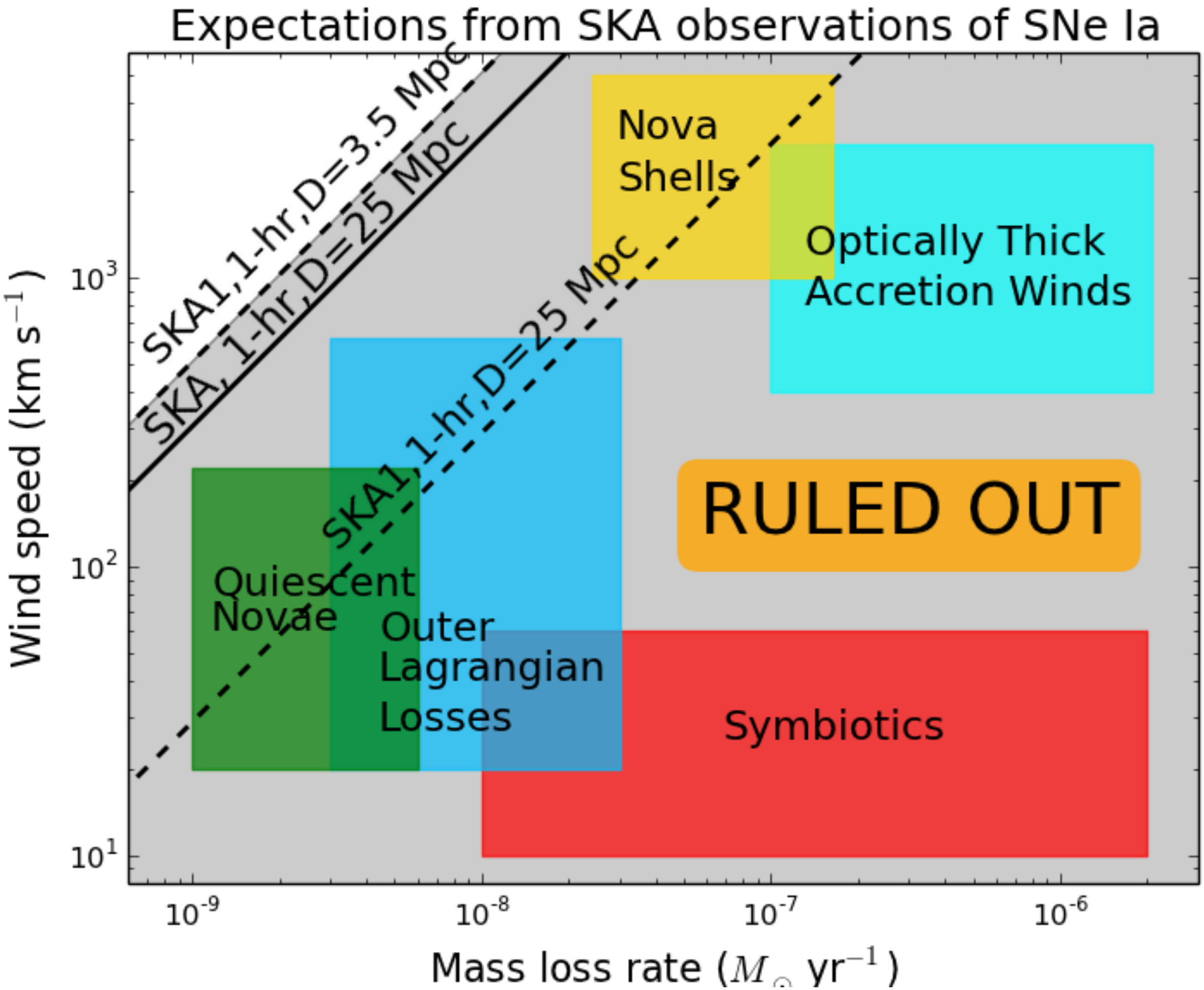






(Pérez-Torres+2015)

Type Ia SN progenitors - SD channel



SKA chapter on SNe (Pérez-Torres+2015).
Plot adapted from Pérez-Torres+2014

GRBs

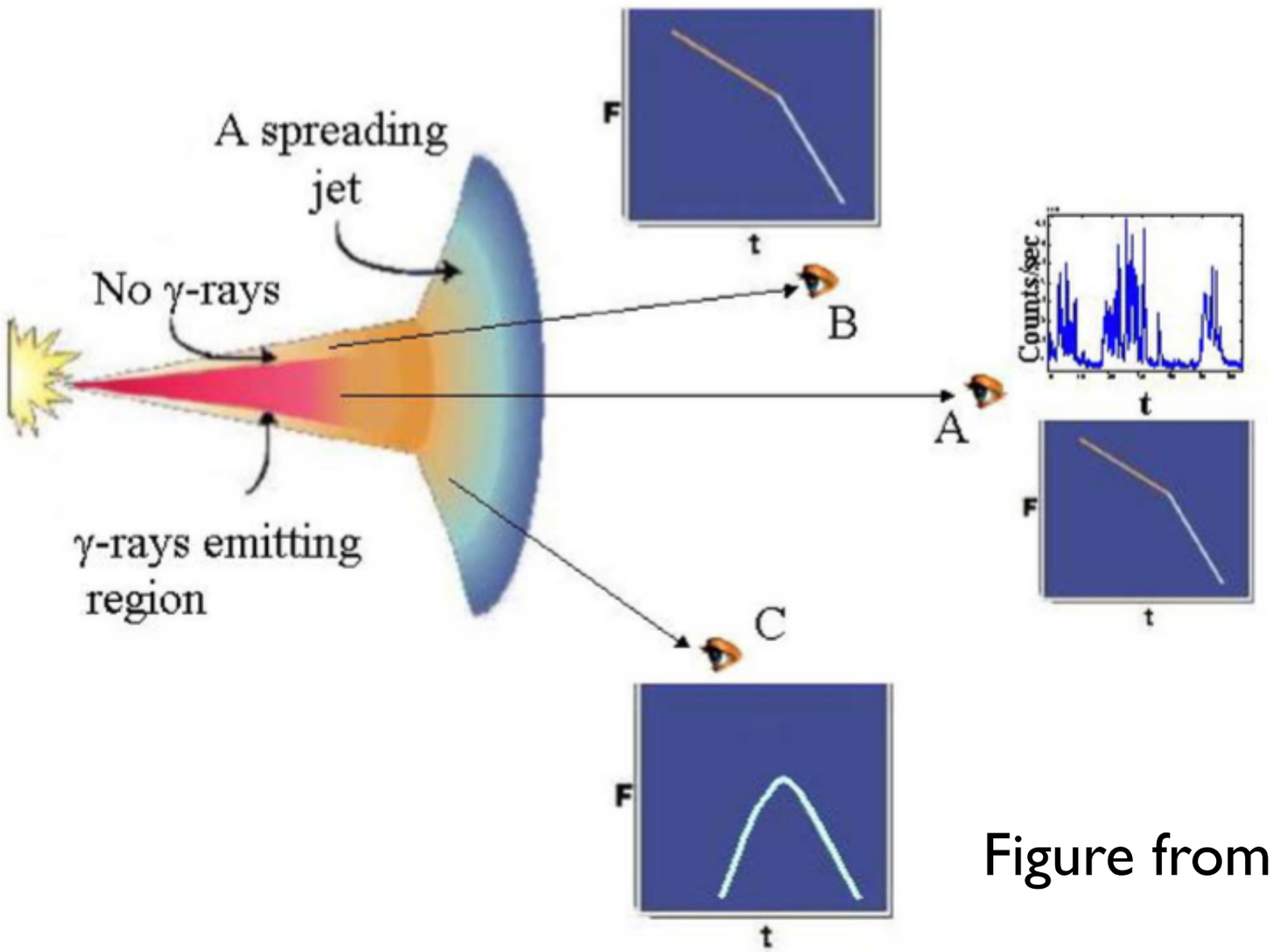


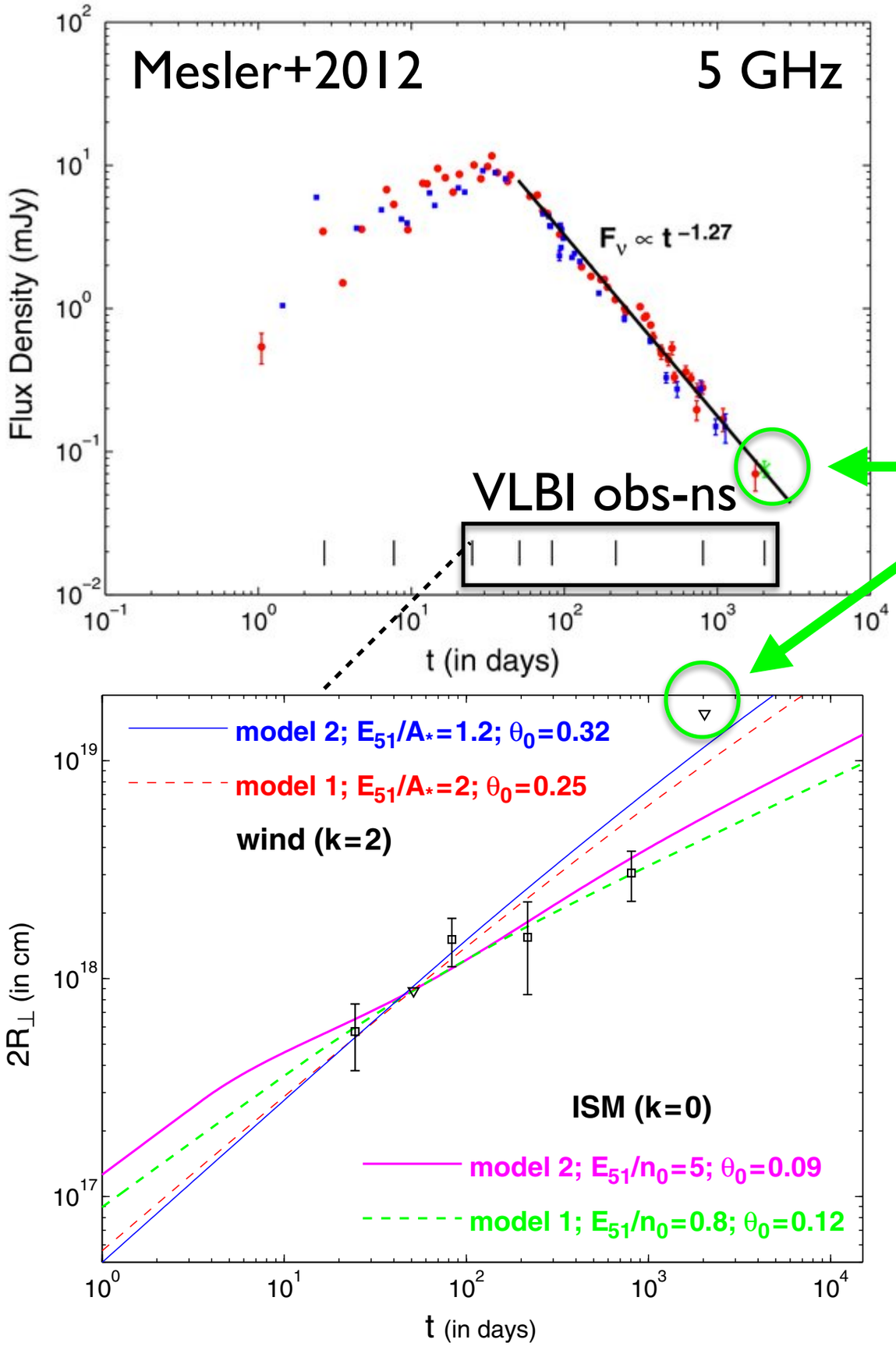
Figure from Nakar & Piran (1993)

VLBI obs-ns extremely useful

=> Deep flux measurements + resolution

- Jet properties (structure, dynamics, orientation)
- Shock properties (e.g. energy spectrum of e-),
- Environment (ISM, wind)

GRBs



GRB 030329: the best ever radio characterization (bright and close)

VLBI observations crucial to disentangle GRB environment

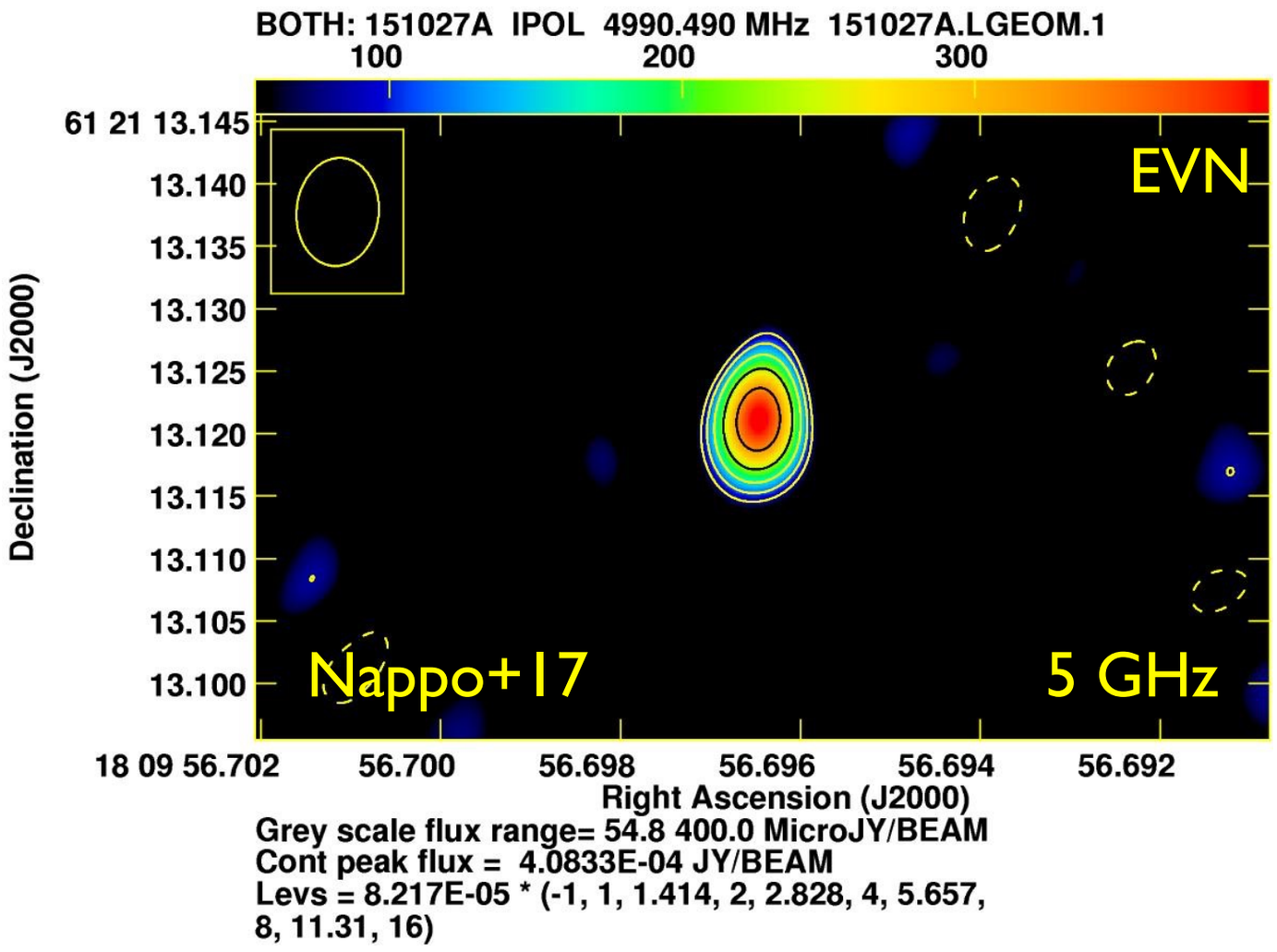
Global VLBI obs-ns (t=5.5 yr!)

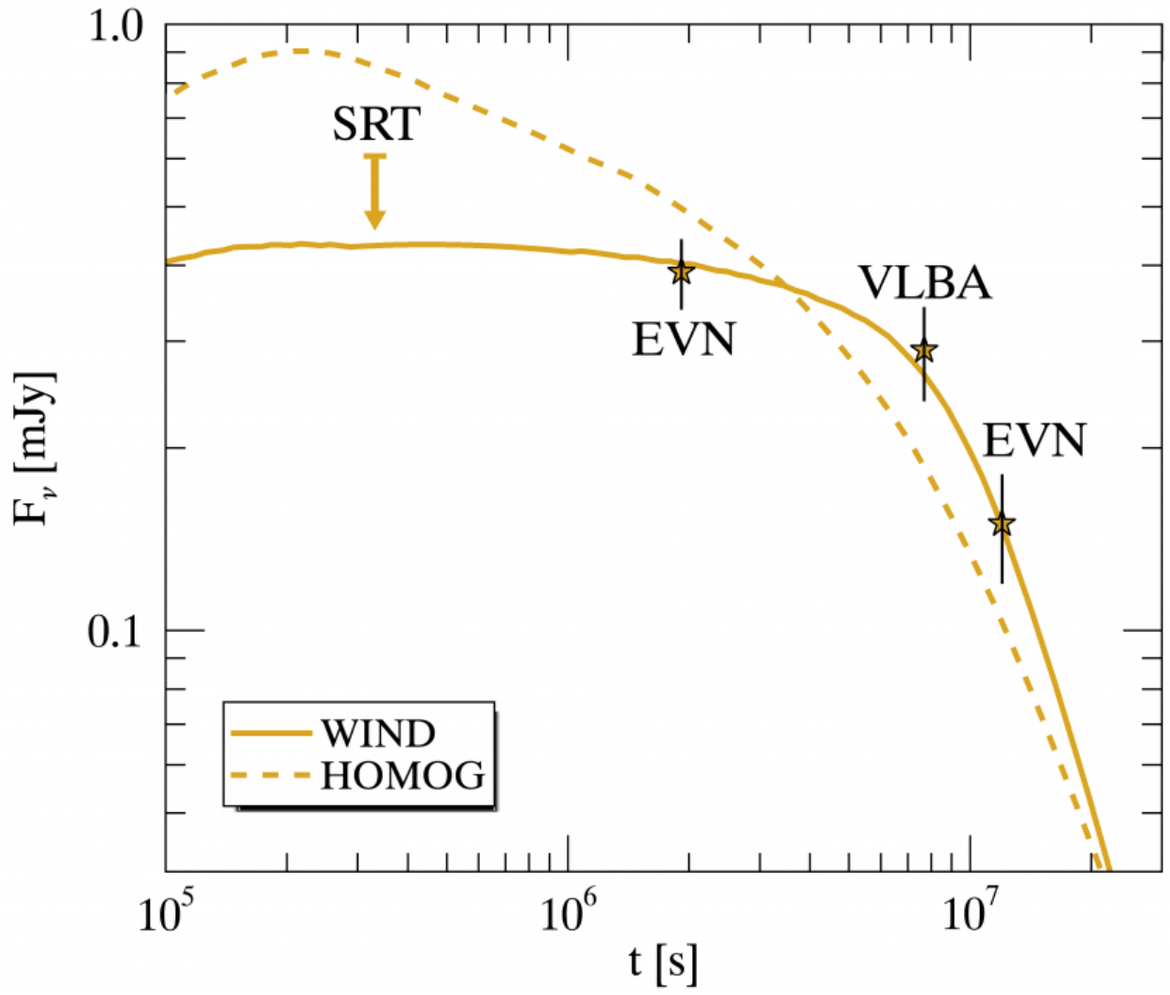
- Single power-law decay ($t^{-1.27}$)
- Proper motion < 0.067 mas yr^{-1}
- Size evolution

- Jet seen close to the LOS
- Expansion in the ISM
- Emission due to external shock, accelerated electrons (p=2.5)

GRBs

GRB151027A





Nuclear transients

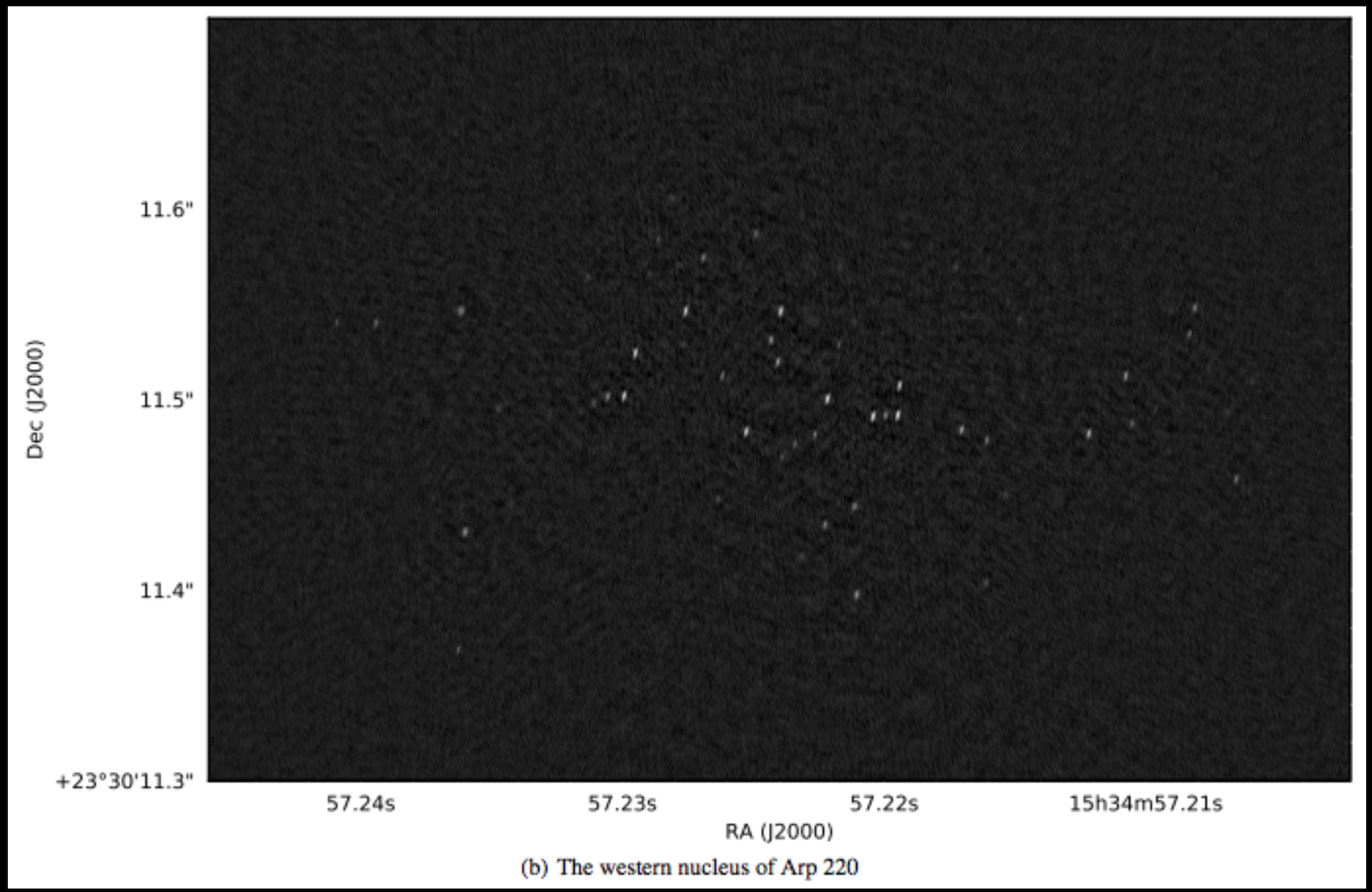
An extremely prolific SN factory in Arp 299A: The movie

Based on EVN & eEVN obs-ns @ 5 GHz

© Miguel Pérez-Torres (IAA-CSIC, Granada)
Rubén Herrero-Illana (IAA-CSIC, Granada)
Antxon Alberdi (IAA-CSIC, Granada)
Marco Bondi (IRA-INAF, Bologna)

Pérez-Torres et al. (2009, A&A Letters)
Pérez-Torres et al. (2010, A&A Letters)
Bondi, Pérez-Torres et al. (2012, A&A)
Pérez-Torres et al. (tbs to A&A)

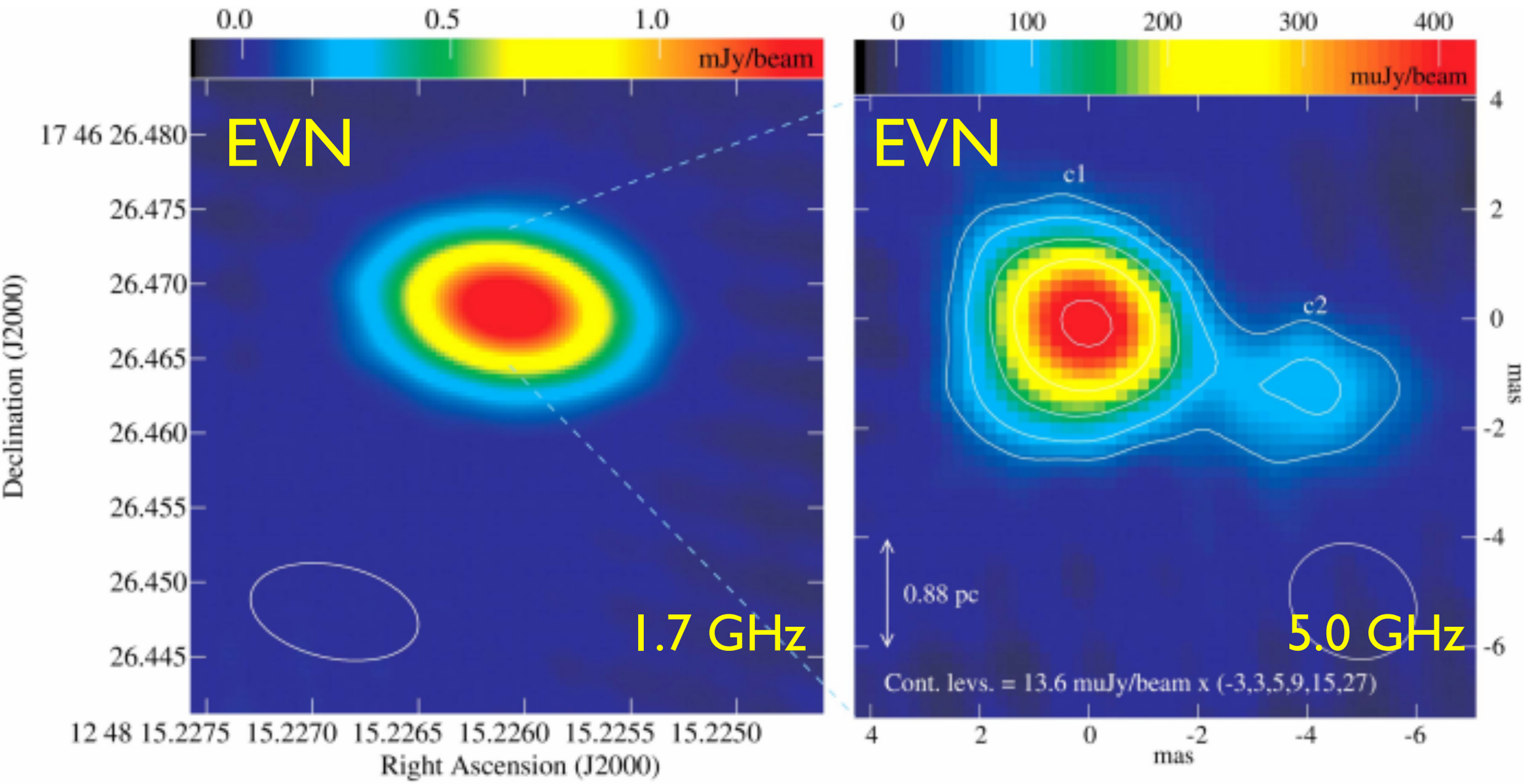
The SN factory in Arp220



(b) The western nucleus of Arp 220

(Varenius+2017: arXiv:1702.04772)

Tidal Disruption Events (TDEs)

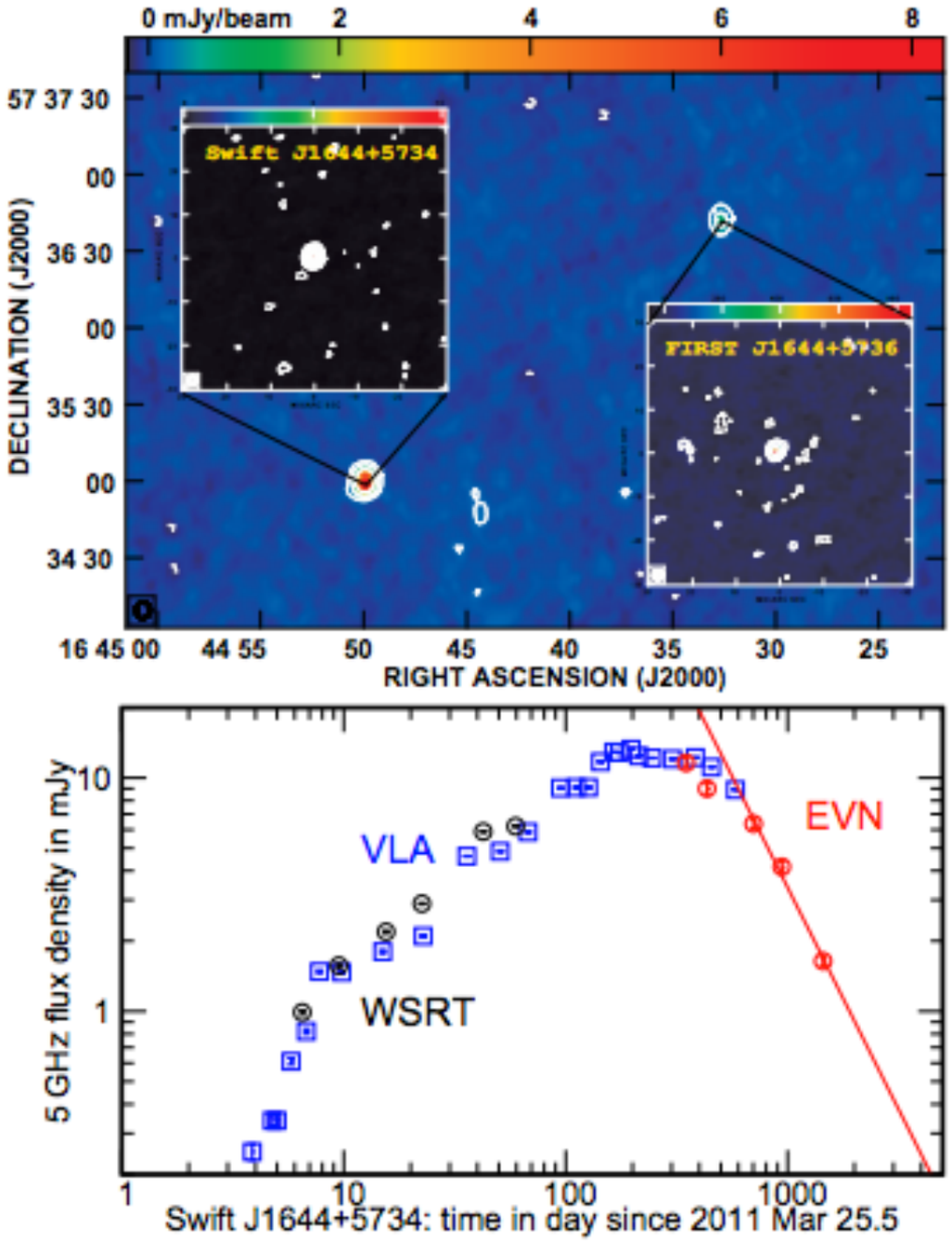


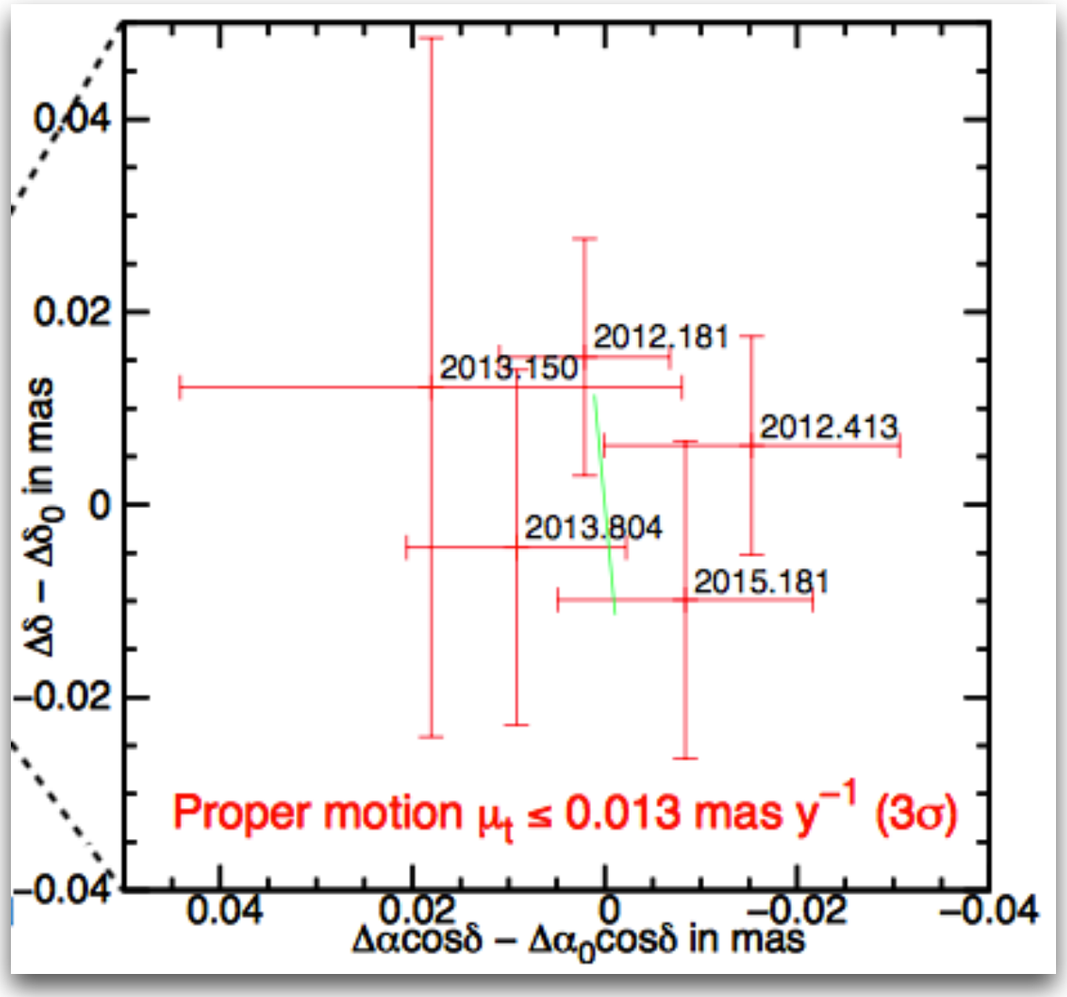
ASSASN-14li resolved at pc-scales with the EVN (Romero-Cañizales+2016)

Source nature unclear:

- Core-relativistic jet?
- Core-non-relativistic jet?
- BBH?

Tidal Disruption Events (TDEs)





No apparent superluminal motion in Sw J1644+5734 unveiled with the EVN (Yang+2016)

The EVN challenge for the next decade

Towards a 1 microJy/b sensitivity, frequency agile, multi-scale, prompt-response VLBI array

Remember… the EVN provides you with

- Unprecedented target location and astrometric capabilities (mas-to-muas precision)
- Extraordinary imaging capabilities: Huge angular resolution (~mas) and relatively large FoV (x few 1000 beams)
- Ultra-high-sensitivity (few muJy)- Detection of extremely faint sources

JIVE: Joint Institute for VLBI ERIC

- EVN processing & operations
- Support from idea to successful observation
- Find us at EWASS!