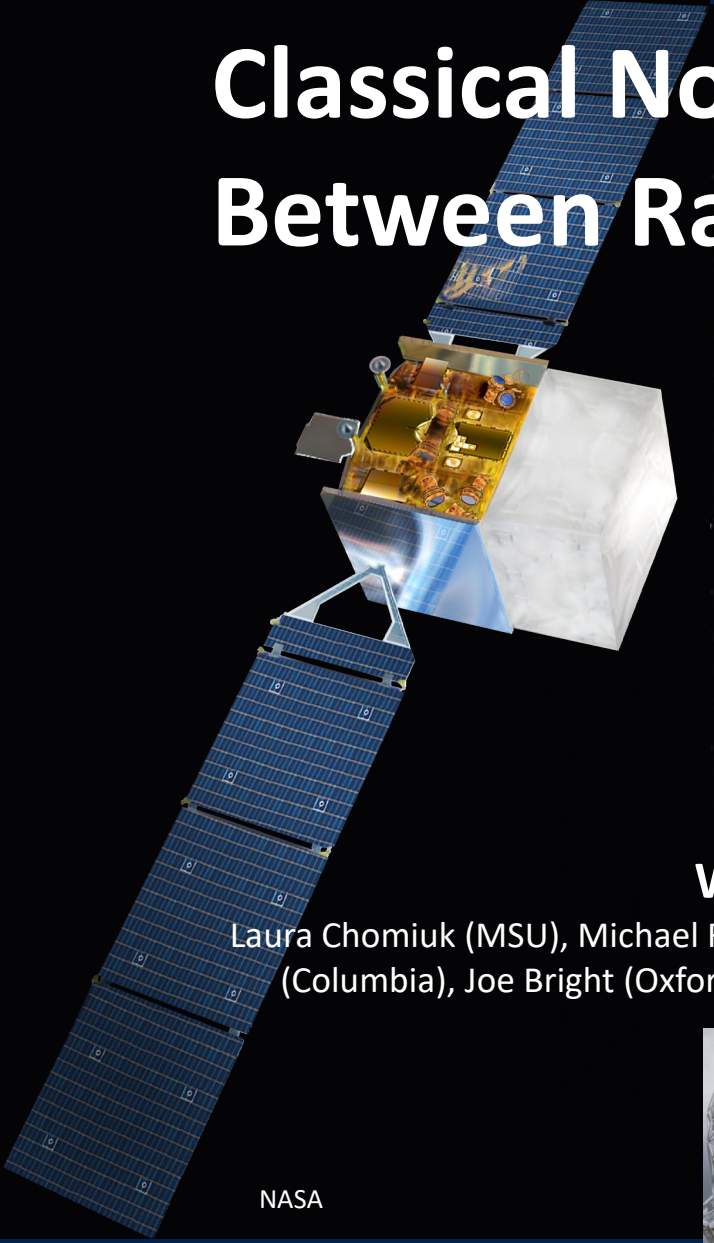
Classical Novae: The Connections Between Radio and Gamma-Rays



NASA

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Cmglee

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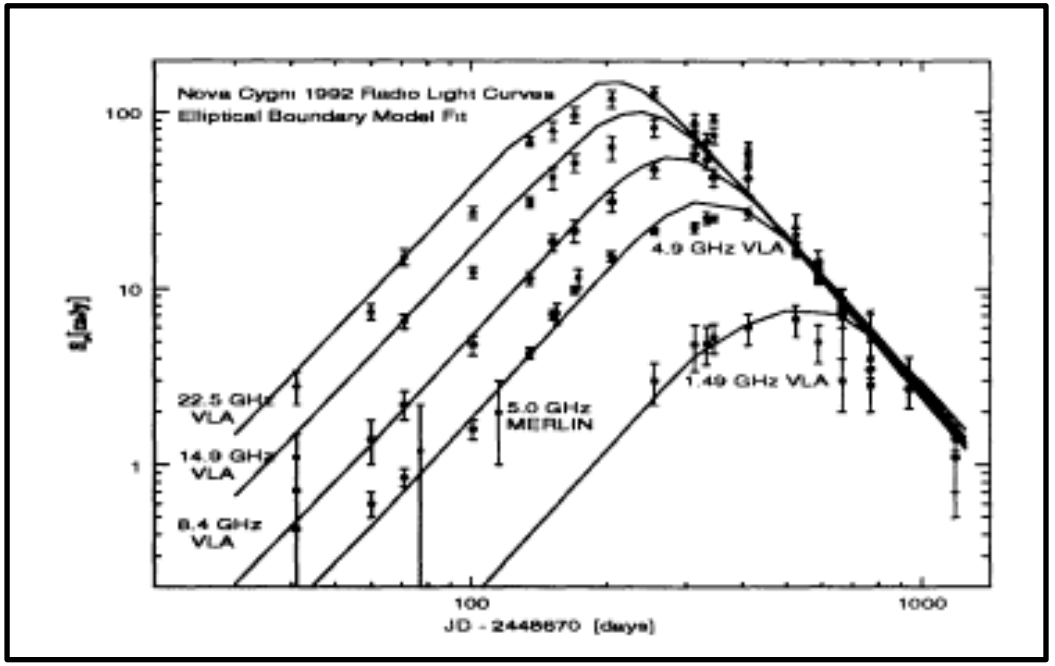
Radio Light Curves



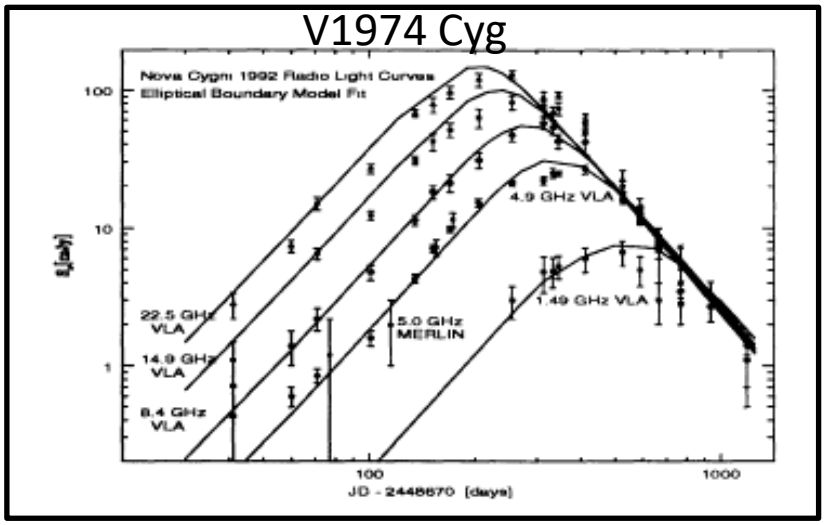
V1974 Cygni VLA light curve
(From Hjellming 1996)

- Radio emission persists for years
- Turnover of radio light curve is dependent on density profile of ejecta
- Can calculate ejecta mass from density profile
- "Typical" ejecta mass: 10^{-5} to 10^{-4} $M_{\odot}$

Radio Light Curves

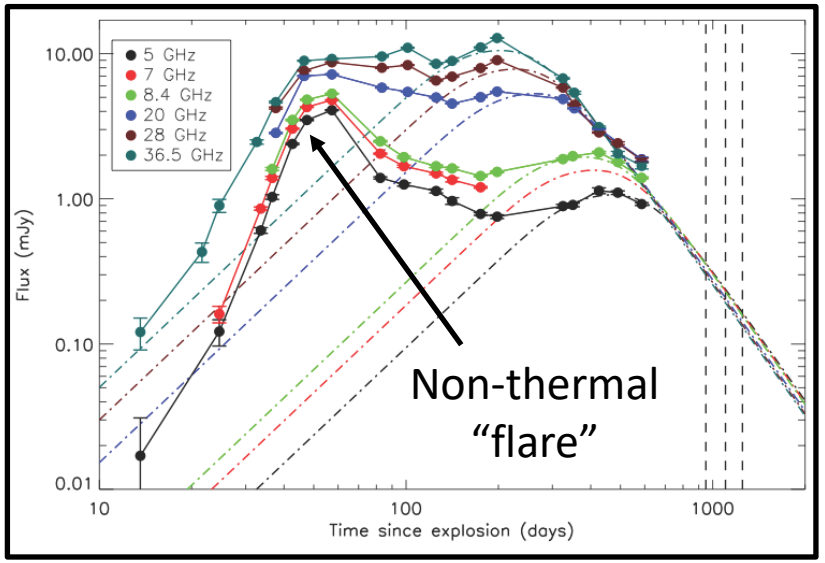
V1974 Cyg

From Hjellming 1996

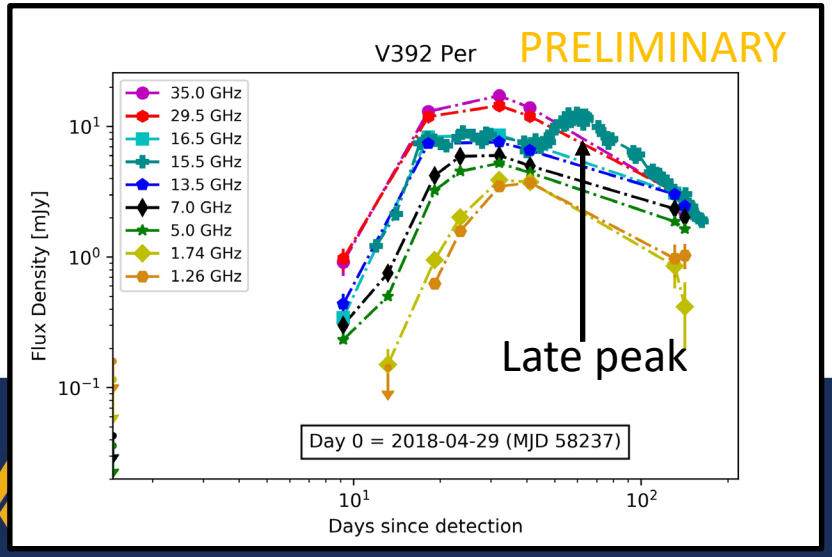


V1723 Aql

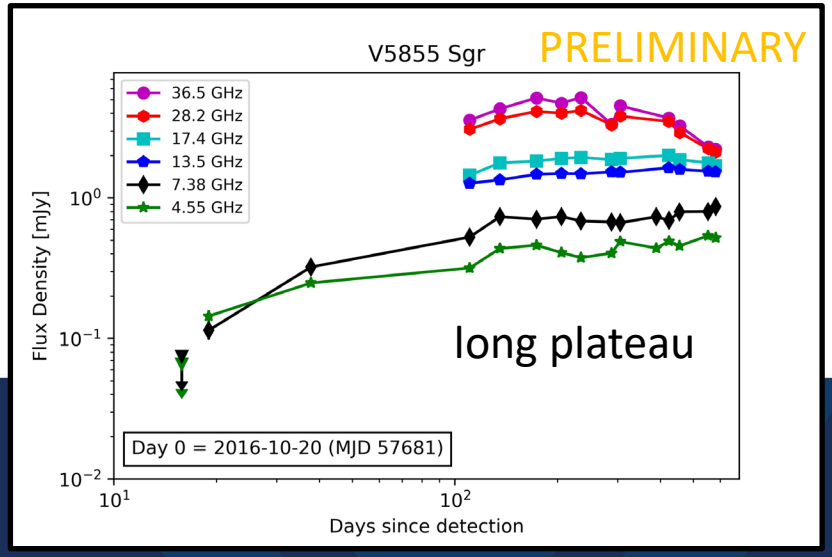
From Weston et al. 2016



V392 Per PRELIMINARY

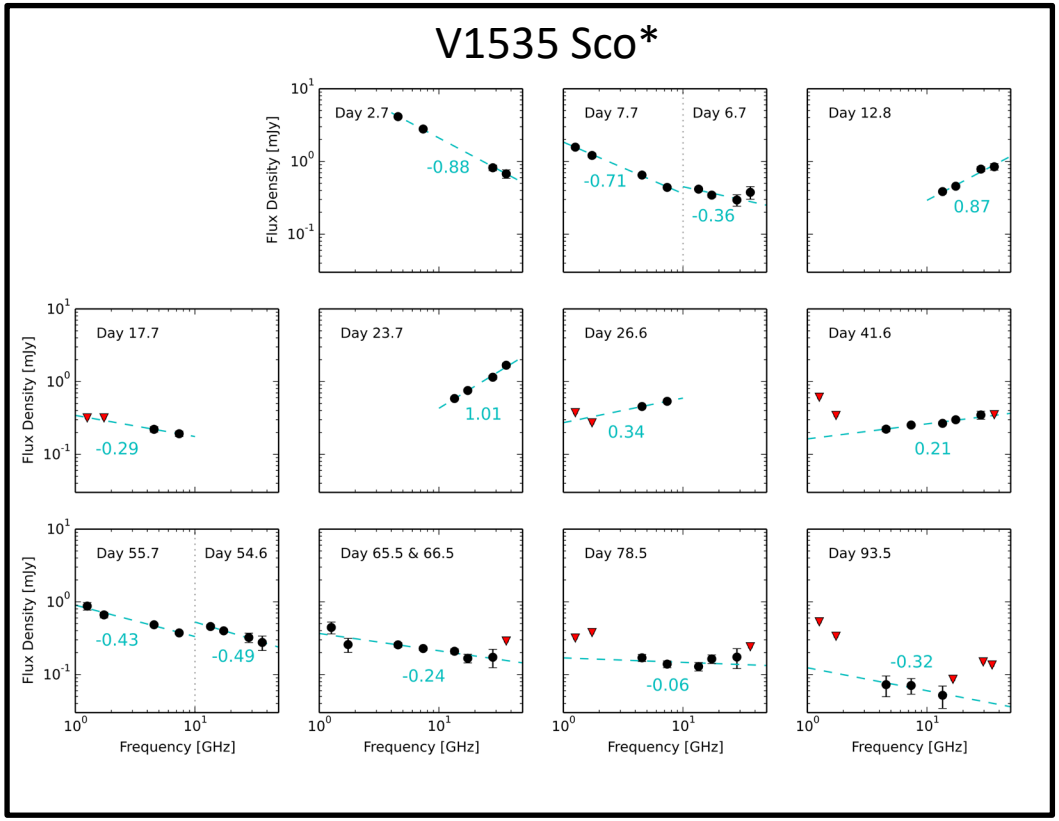


V5855 Sgr PRELIMINARY



Radio Spectral Index: $S_\nu \propto \nu^\alpha$

- In theory, optically thick bremsstrahlung radiation should have α=+2
  - We have never seen this
- Optically thin brehmsstrahlung: α=-0.1
- Optically thin synchrotron: α=-0.7

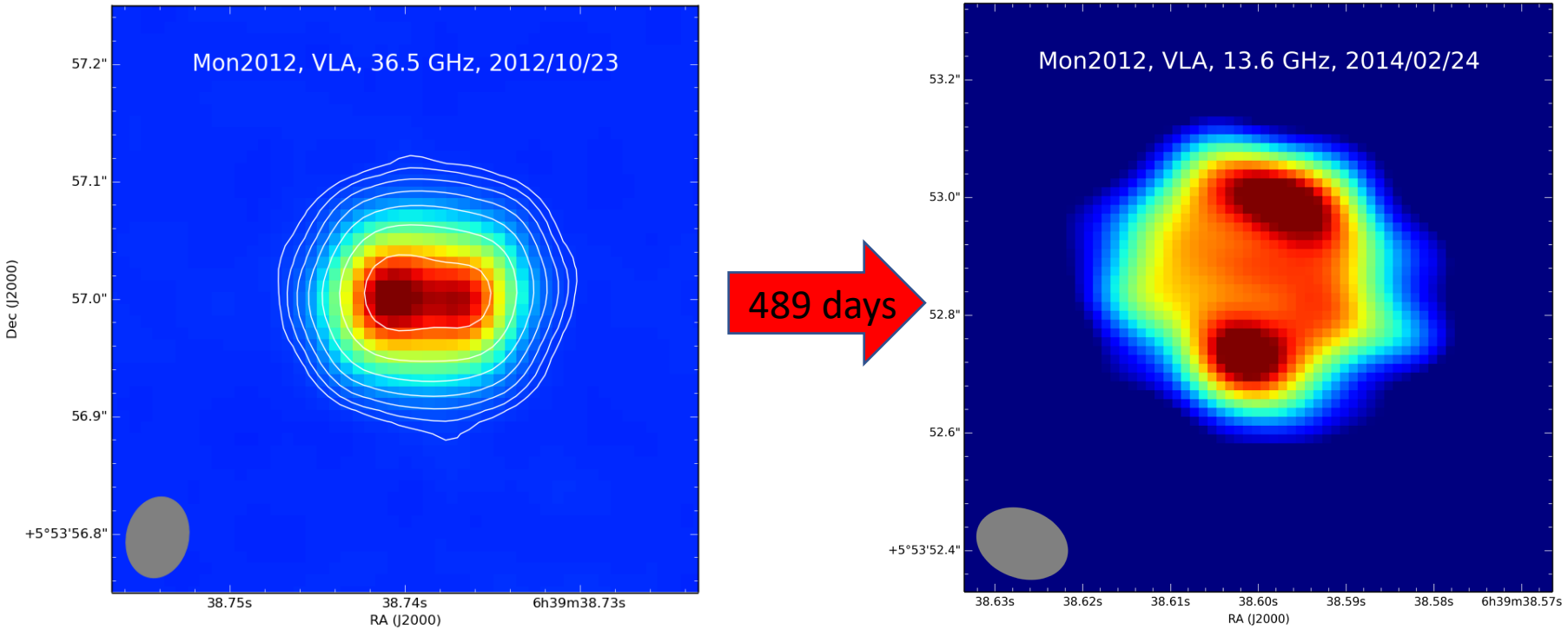


From Linford et al. 2017

*See Franckowiak et al. 2018 for discussion of V1535 Sco as a candidate *Fermi* source

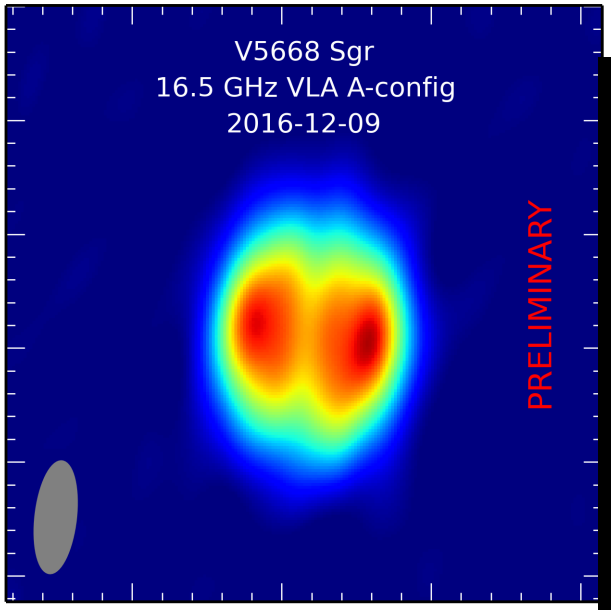
High-Resolution Imaging: VLA

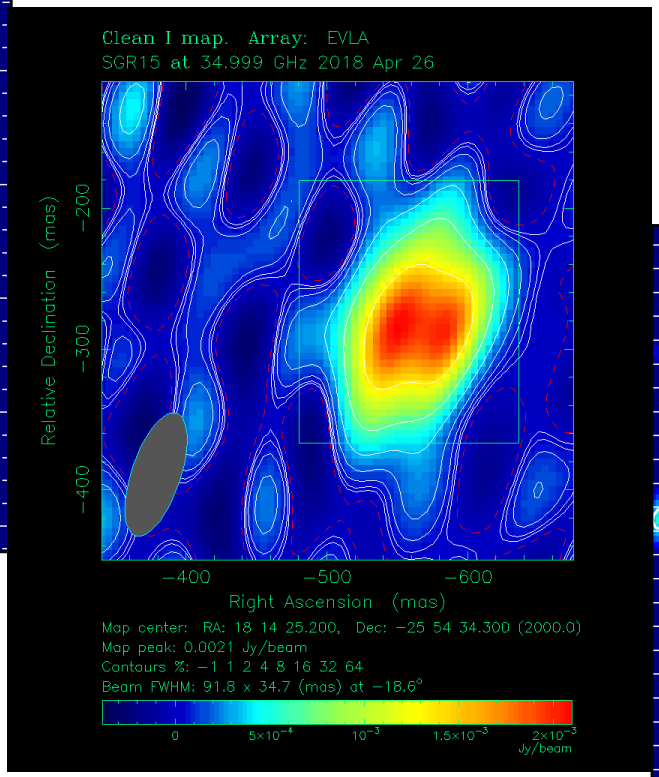
V959 Mon (2012)



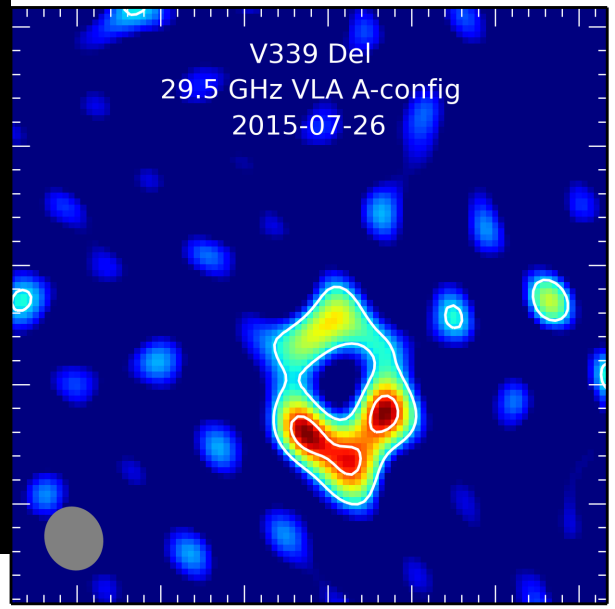
Can get distances with expansion parallax (e.g., Linford et al. 2015)

High-Resolution Imaging: VLA



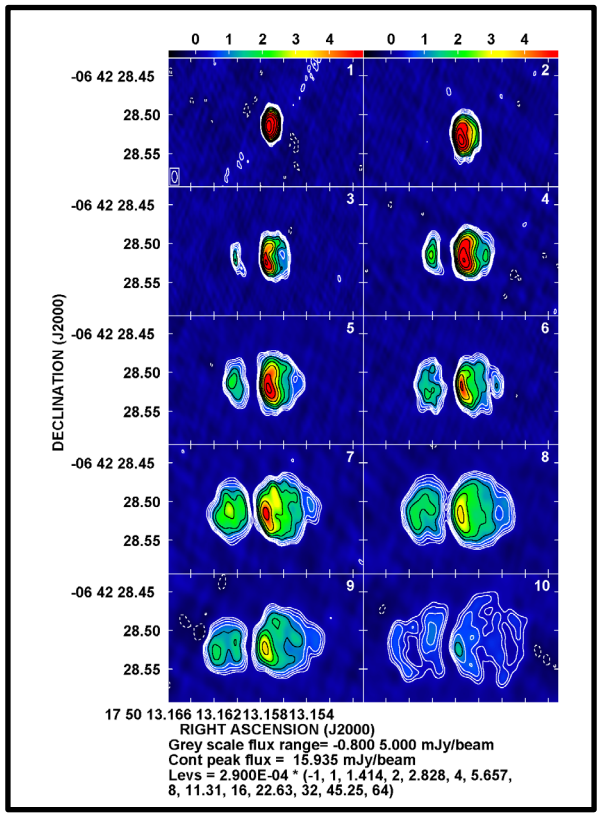


More examples of non-spherical morphology



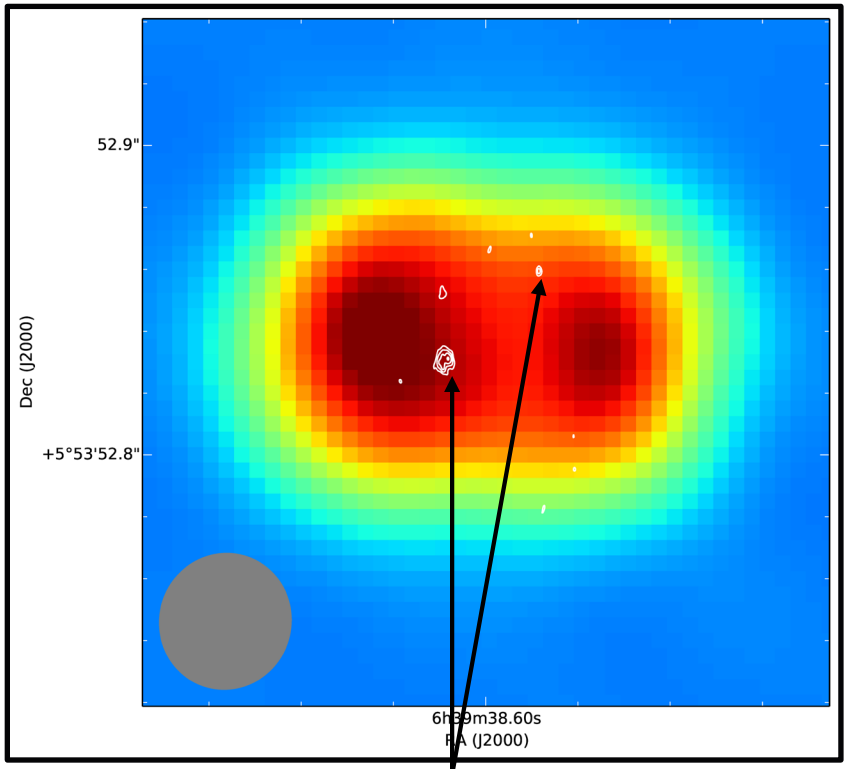
High-Resolution Imaging: VLBI

RS Oph (2006): VLBA



See Rupen et al. 2008, Sokoloski et al. 2008

V959 Mon (2012): VLA + VLBA

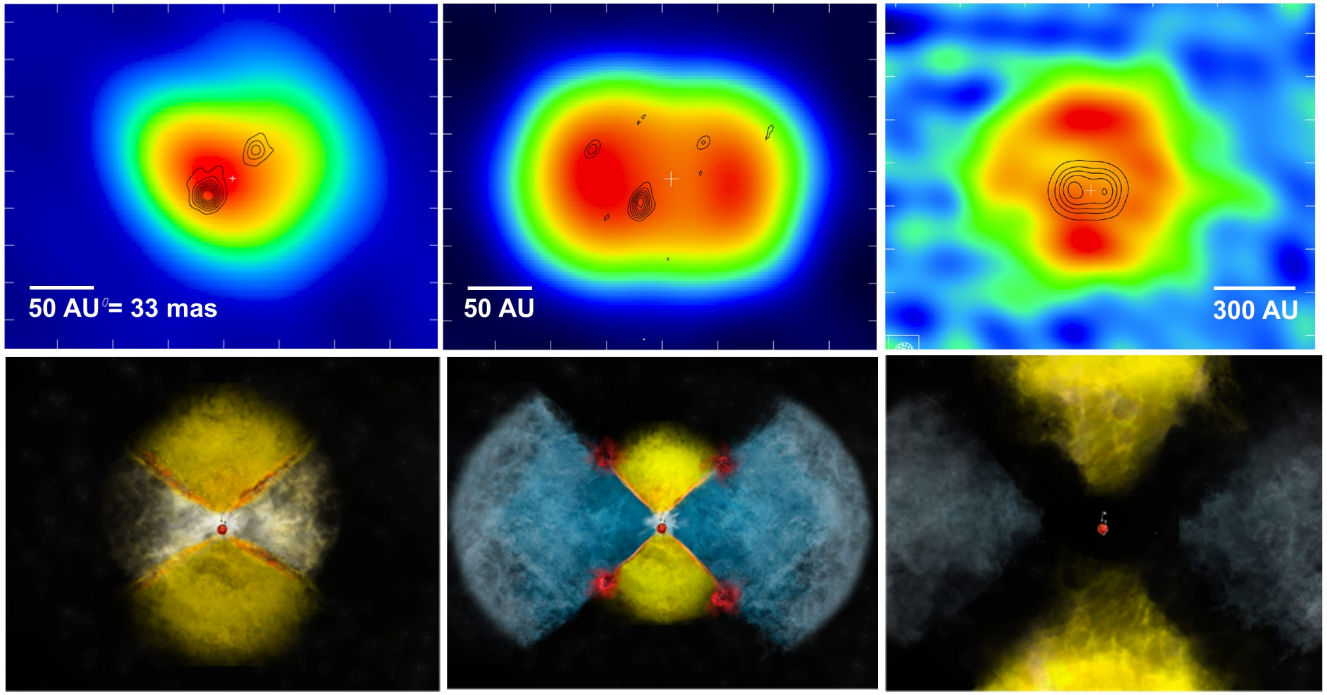


Compact non-thermal knots (VLBA)

See Chomiuk et al. 2014

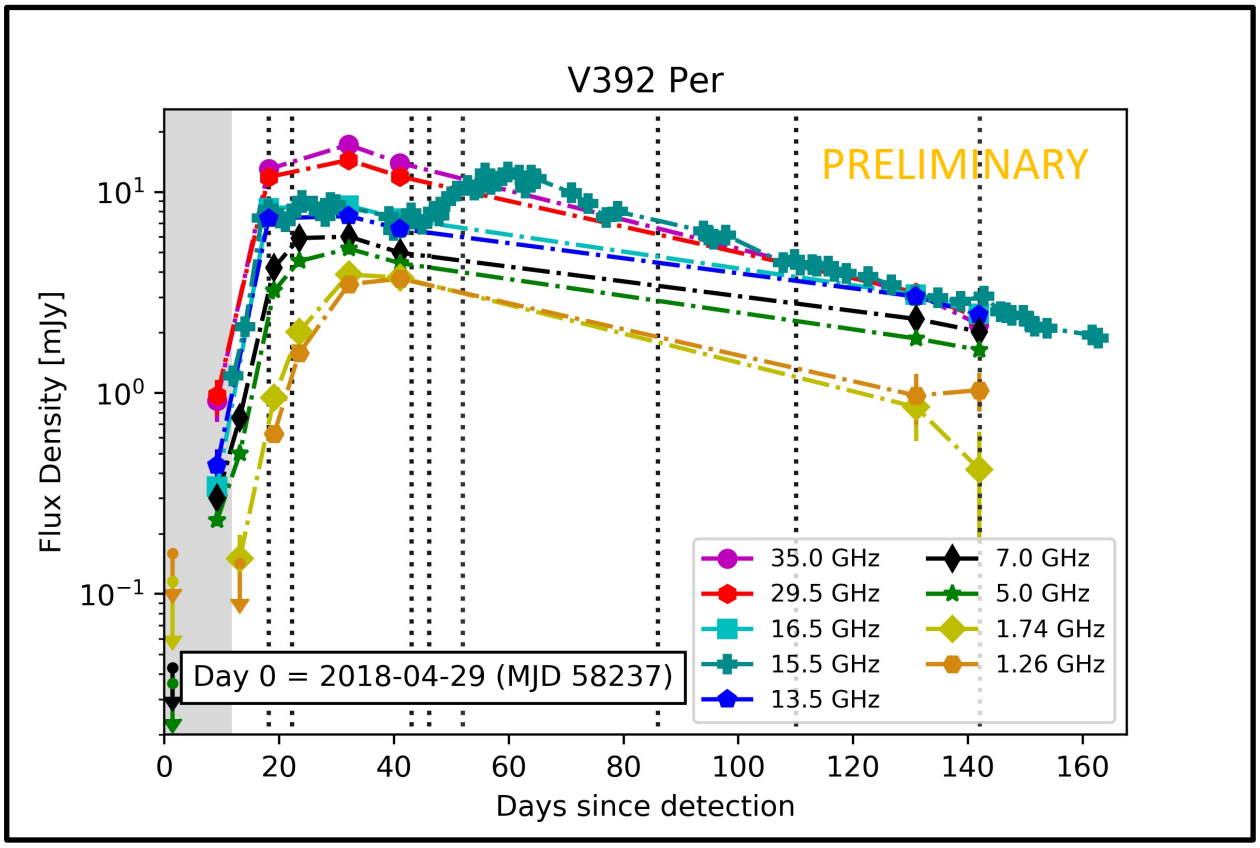
The Two-Flow Model

Color-scale	e-MERLIN Day 87 (54 mas resolution)	VLA Day 126 (43 mas resolution)	VLA Day 615 (106 mas resolution)
Black Contour	EVN Day 91 (7 mas resolution)	EVN Day 113 (7 mas resolution)	VLA Day 126 (43 mas resolution)



See Chomiuk et al. 2014, Metzger et al. 2015, Li et al. 2017, Martin et al. 2018

V392 Per (2018)



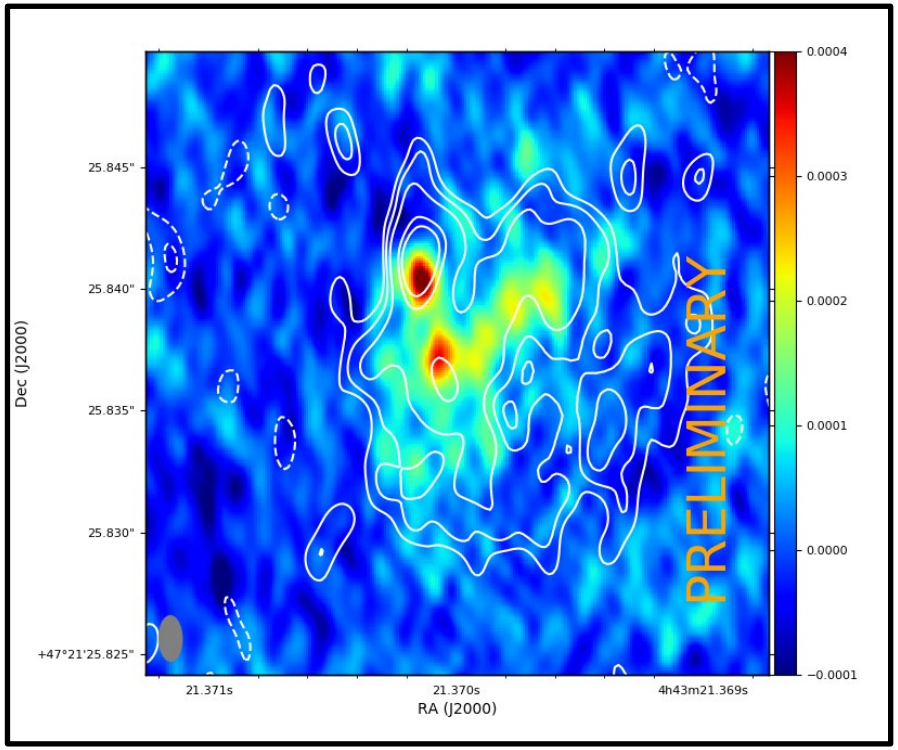
- Nova eruption 2018-04-29
- Known CV
- ~4 kpc (*Gaia* DR2)
- Fermi detections for ~11 days
- VLA, AMI-LA*, VLBA, EVN

Gray region = Fermi detection

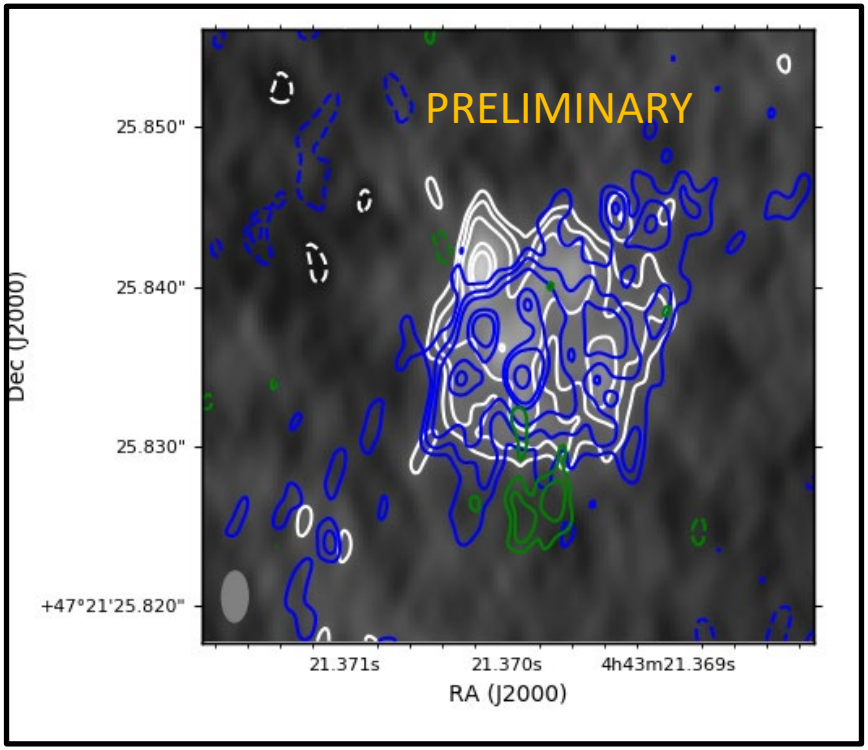
Vertical dotted lines = VBLA/EVN observations

*15.5 GHz Arcminute Microkelvin Imager – Large Array (AMI-LA) data provided by Joe Bright (Oxford)

V392 Per (2018): VLBA



Color = Day 18, 8.4 GHz
Contours = Day 22, 4.9 GHz



White = Day 22, 4.9 GHz
Blue = Day 46, 4.9 GHz
Green = Day 86, 4.9 GHz

Summary: Radio & Gamma-rays

- Radio imaging reveals multiple ejecta components leading to shocks and gives expansion parallax distances
  - Are the *Fermi*-detected novae the nearer ones?
  - Are all *Fermi*-detected novae non-spherical?
  - Are **ALL** novae non-spherical?
- Radio VBLI directly images regions of accelerated particles
  - How much does non-thermal emission contribute to total radio flux density during *Fermi* detection?
- Radio monitoring reveals non-thermal emission
  - Are we missing radio “flares” and “bumps” due to low observing cadence?

Active and Upcoming Programs

- AMI-LA high-cadence monitoring at 15 GHz
- VLA high-cadence monitoring program at 5 GHz begins November 2018
- eMERLIN 5 GHz imaging of V392 Per this month (hopefully)
- EVN observations of V392 Per just completed
- VLA high-resolution imaging proposal for 2019
- VLBA early observation proposal for 2019

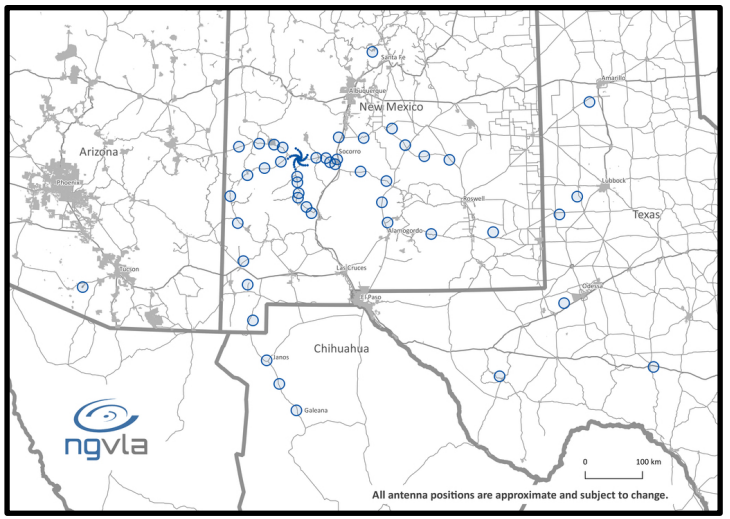
Looking To the Future

- MeerKAT began full operations in July 2018
  - ThunderKAT transient program (PIs: P. Woudt & R. Fender)
  - MeerLICHT 0.65m for simultaneous radio + optical
- SKA1 construction to start in 2019
  - Great sensitivity (~4x VLA collecting area)
  - Great angular resolution (~4x VLA longest baseline)
- AMEGO will be great for novae
  - Good energy range for novae
  - Survey mode
  - See Sylvain Guiriec's talk – Thursday, 3:30

ngvla

Next Generation Very Large Array

Rough Timeline
Design Phase: 2021 – 2024
Construction: 2024 – 2034



- 10x the sensitivity of the VLA
- 10x the resolution of the VLA
  - ALL THE TIME!
  - Every light curve data point is also a frame in an ejecta expansion movie!
- Optimized for thermal emission
- Possibly adding very long baselines