The Re-Acceleration of the Shockwave from SN 1987A

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@whereisyvette

/r/Andromeda321

A Complex Environment

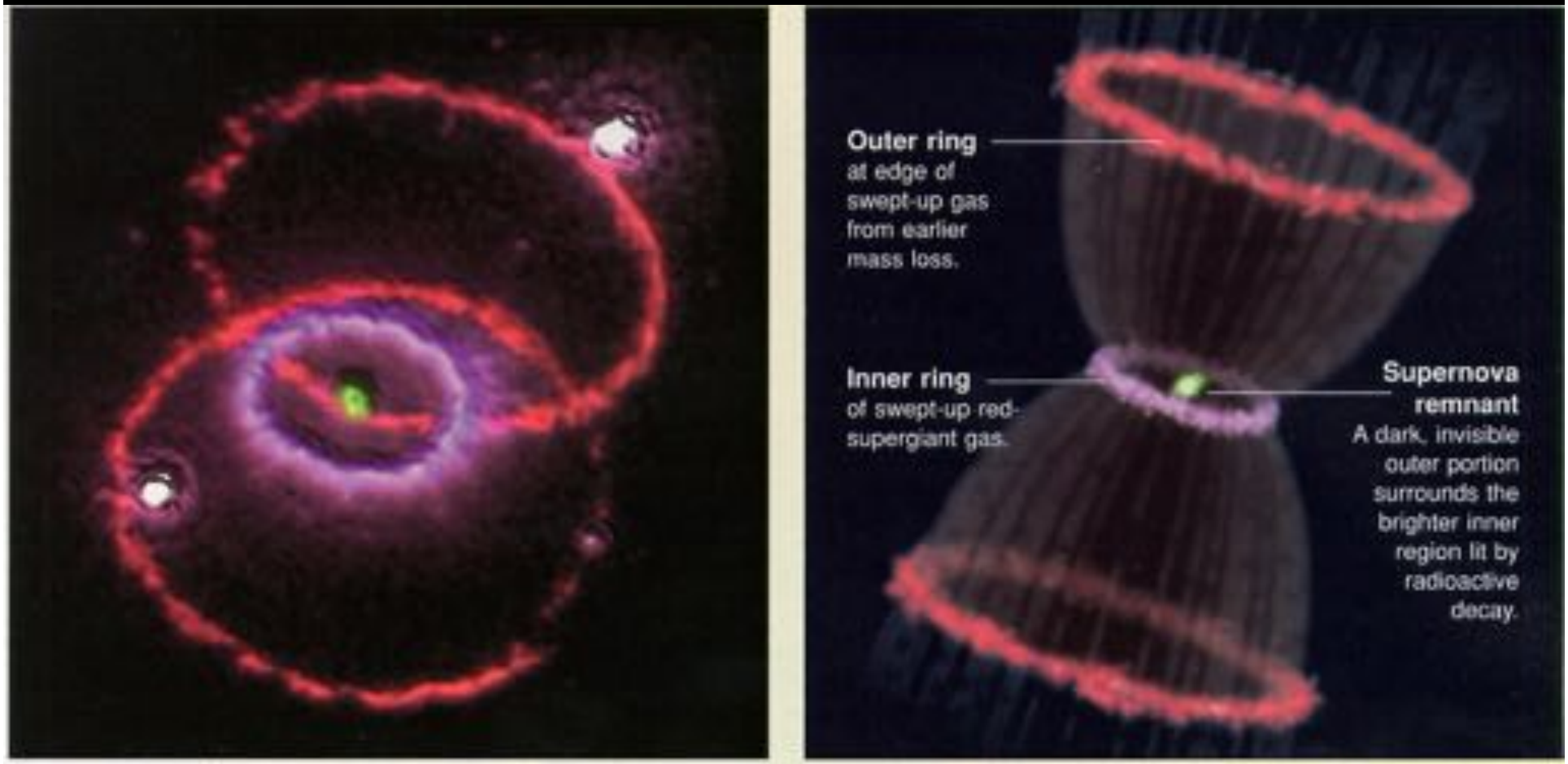


Image credit: Sky & Telescope

A Complex Environment

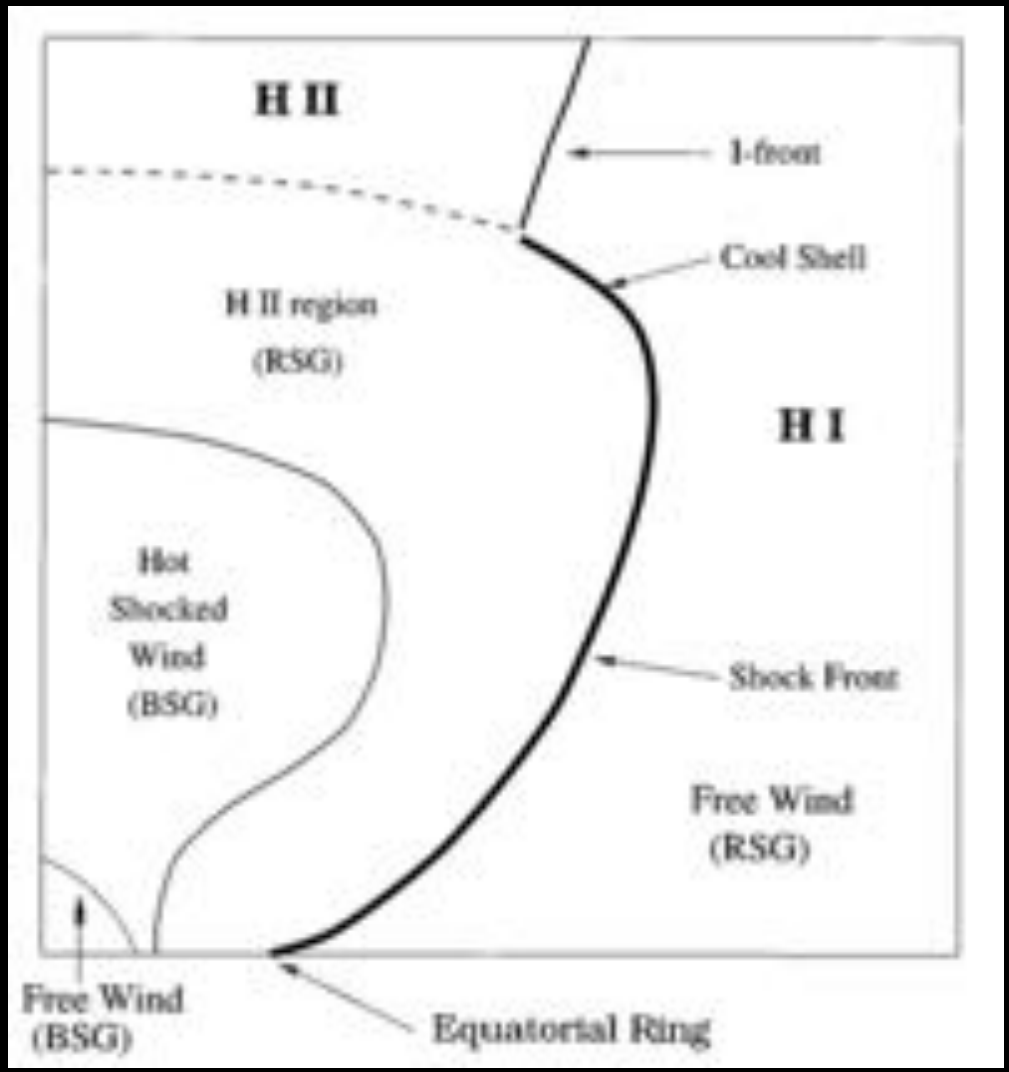


Image credit:
Chevalier et al. (1995)

Continuous Radio Monitoring

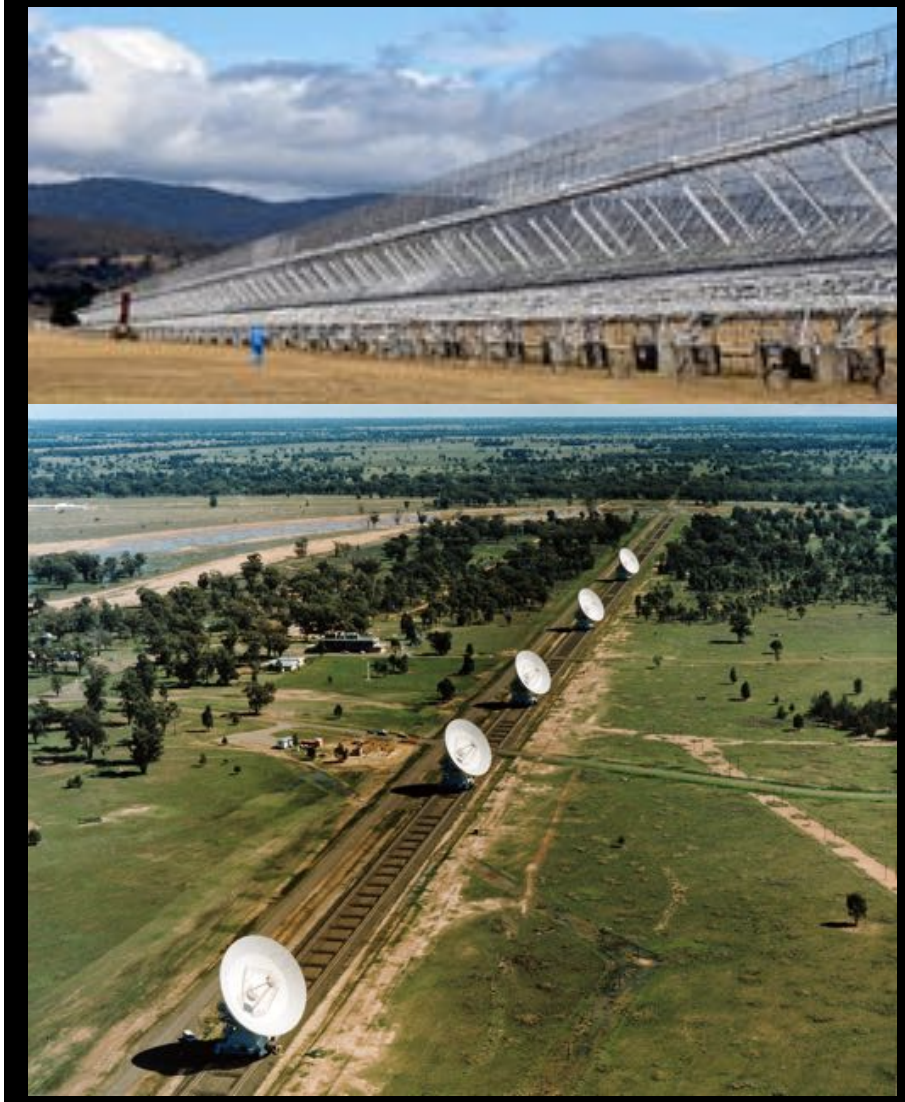
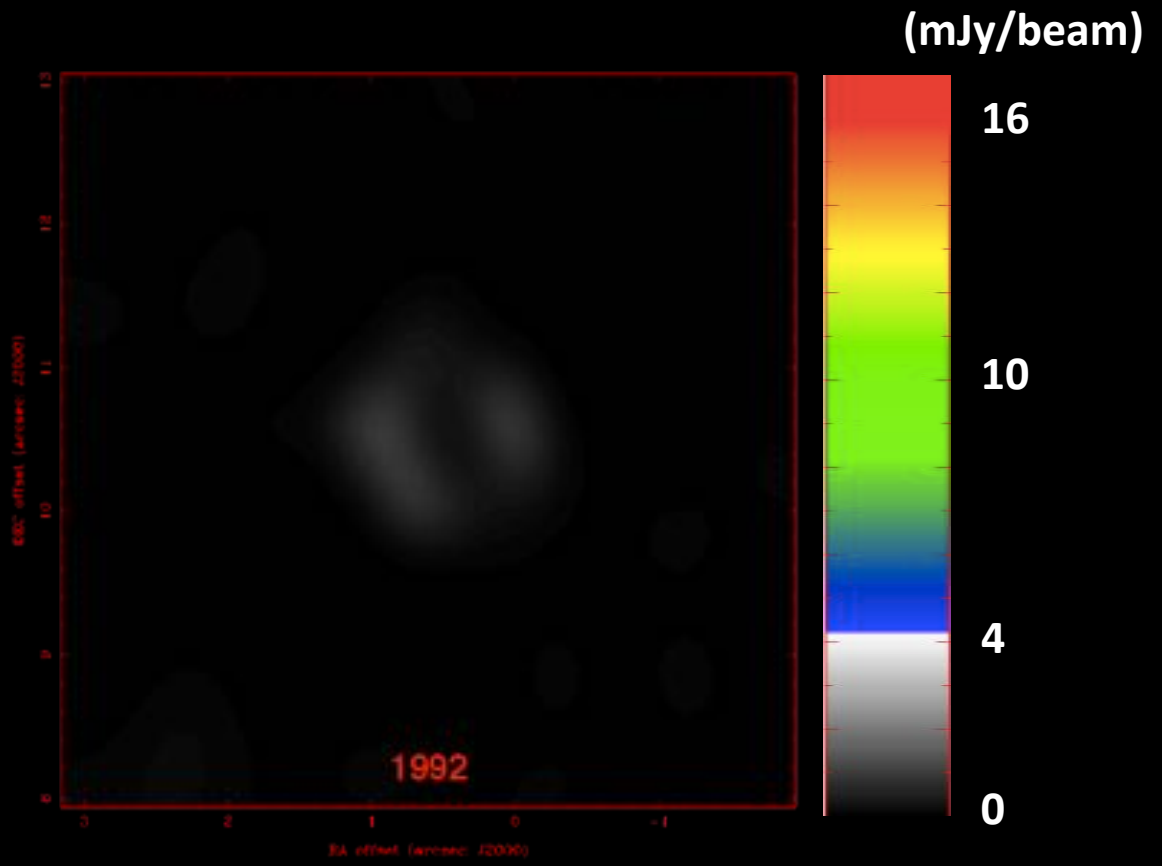


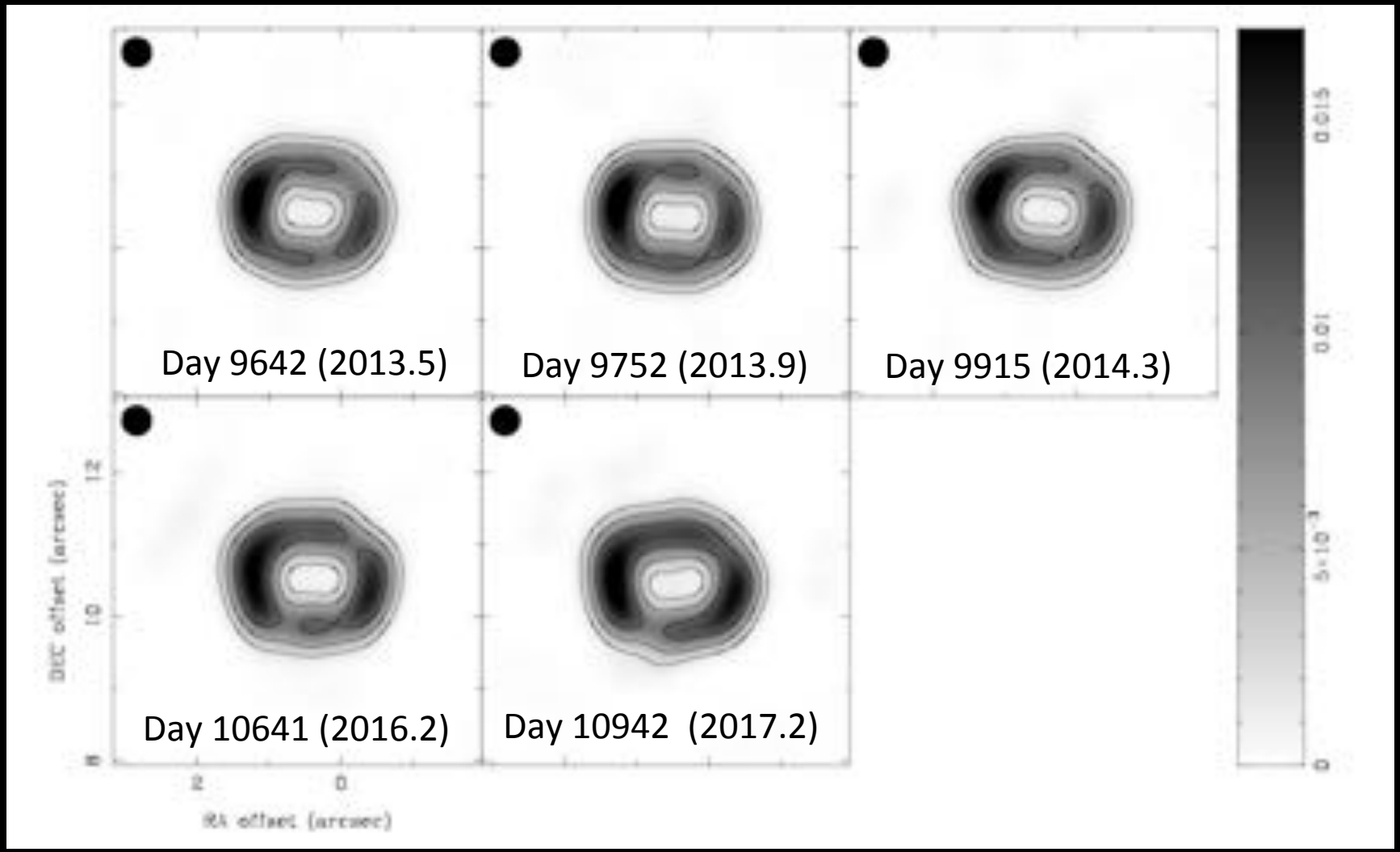
Image credit: Molonglo, ATCA

- Molonglo Observatory Synthesis Telescope (MOST) detected radio emission at Day 2, peaked at Day 4, faded by Day 150
- ATCA, MOST redetected radio emission in July 1990 (Day ~1200)
- Since then, deep 9 GHz ATCA observations every 6-12 months (last update: Ng et al. (2013))

Radio Observations @9 GHz

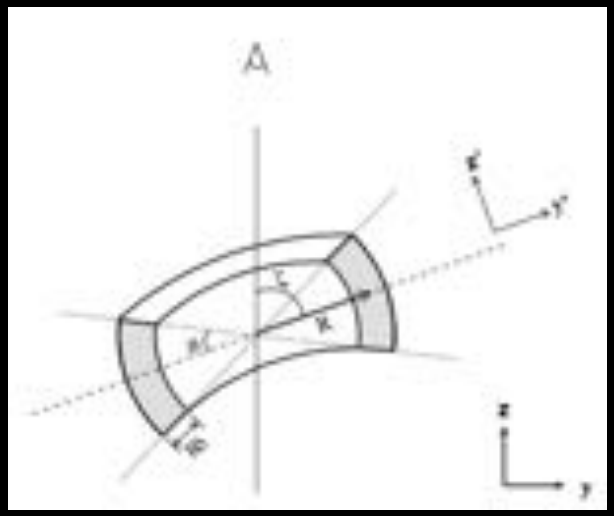


Most Recent Observations

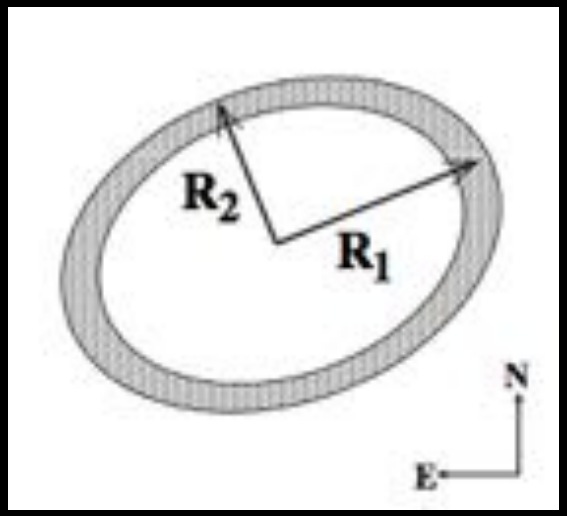


Modeling the Remnant

- Track size vs time in u-v plane: fit to torus (donut), and ring model to match X-Ray
- Chi-squared fits indicate torus is more accurate model in radio



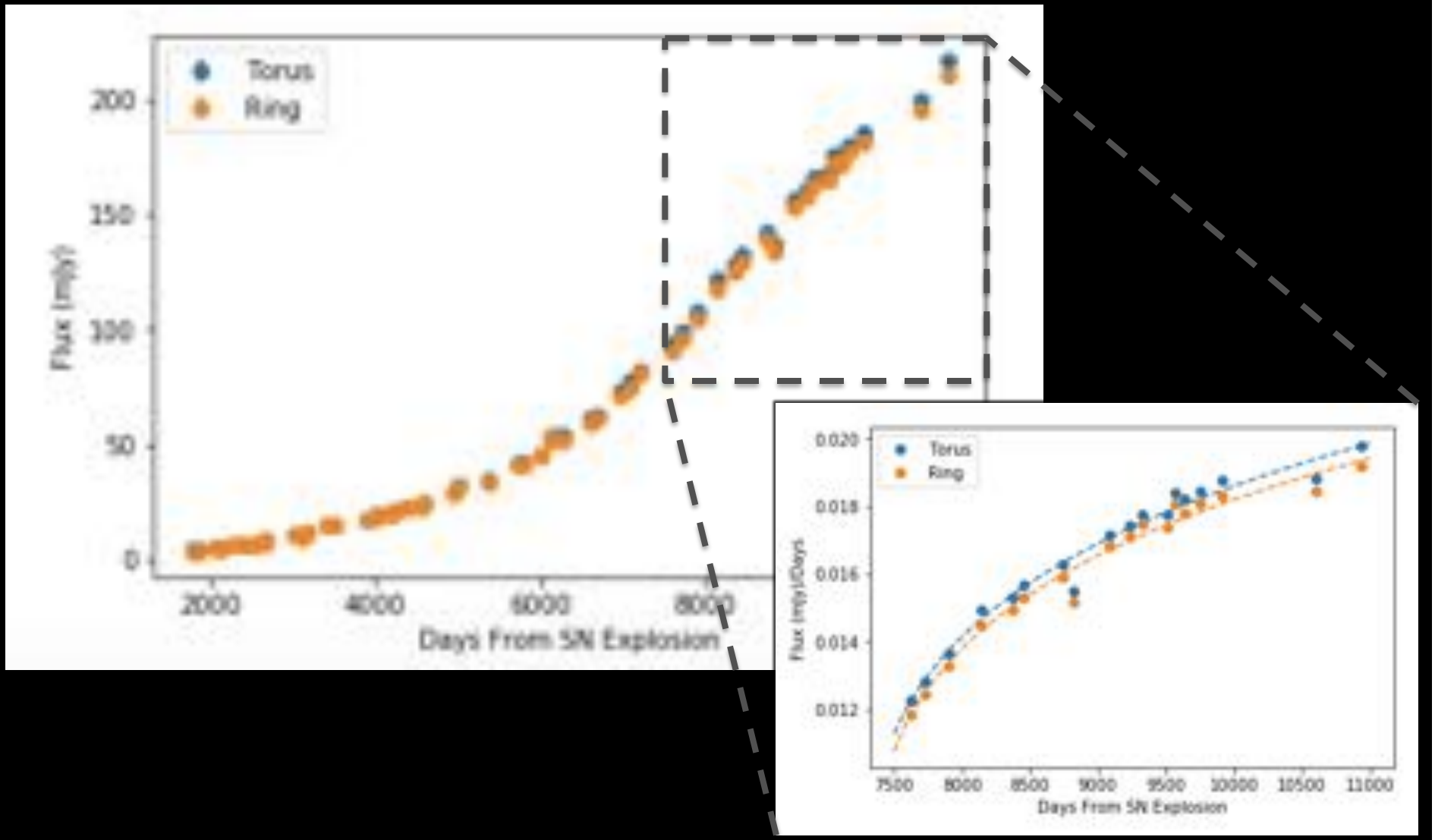
Torus model



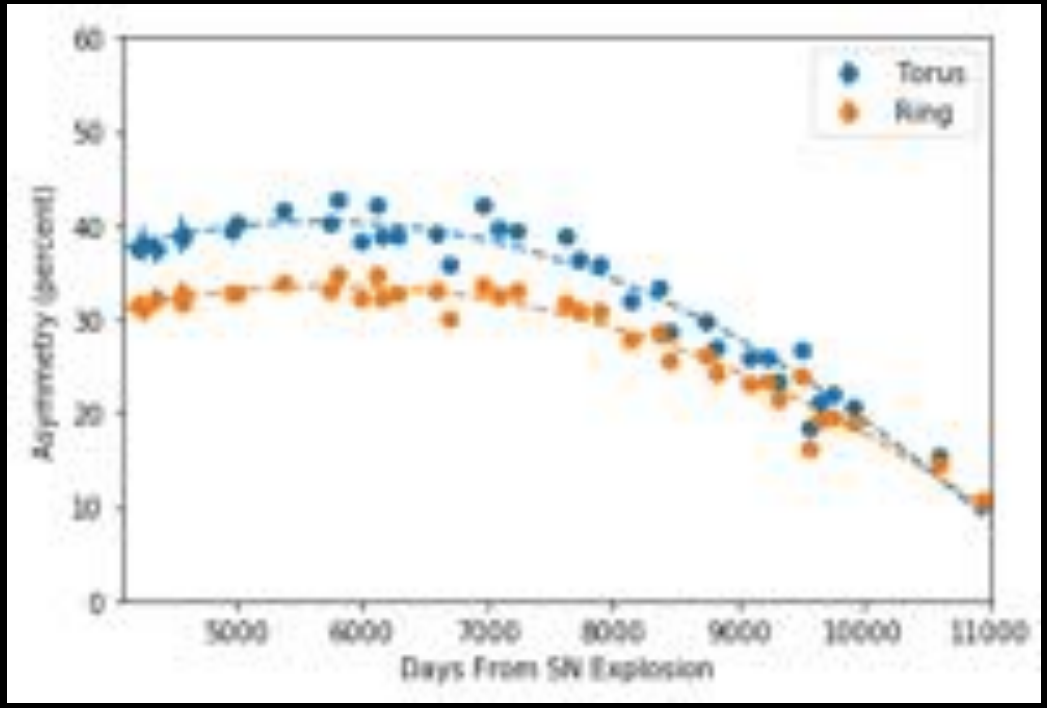
Ring model

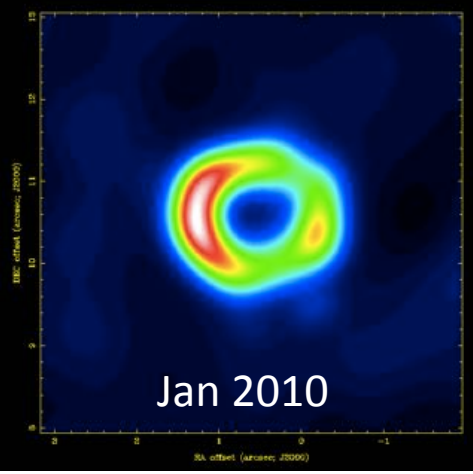
Image credit: Ng et al. (2013)

Flux Over Time

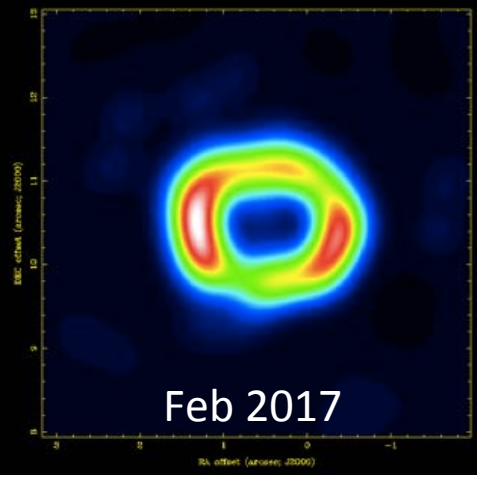


Asymmetry Is Decreasing…





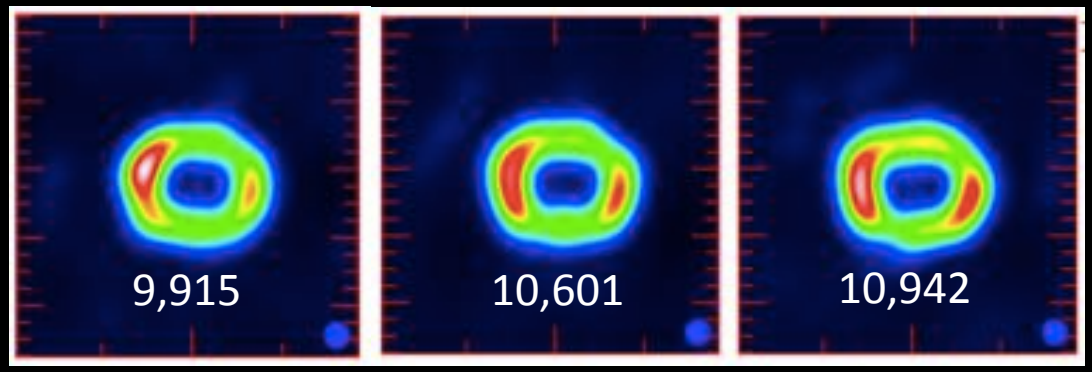
Jan 2010



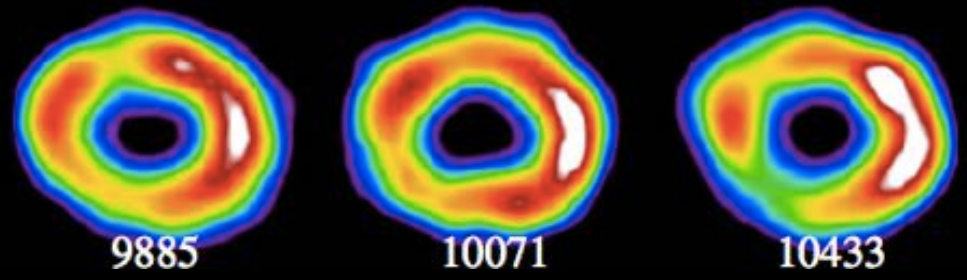
Feb 2017

Multi-Wavelength Asymmetry

Optical (HST)
Fransson et al. (2015)



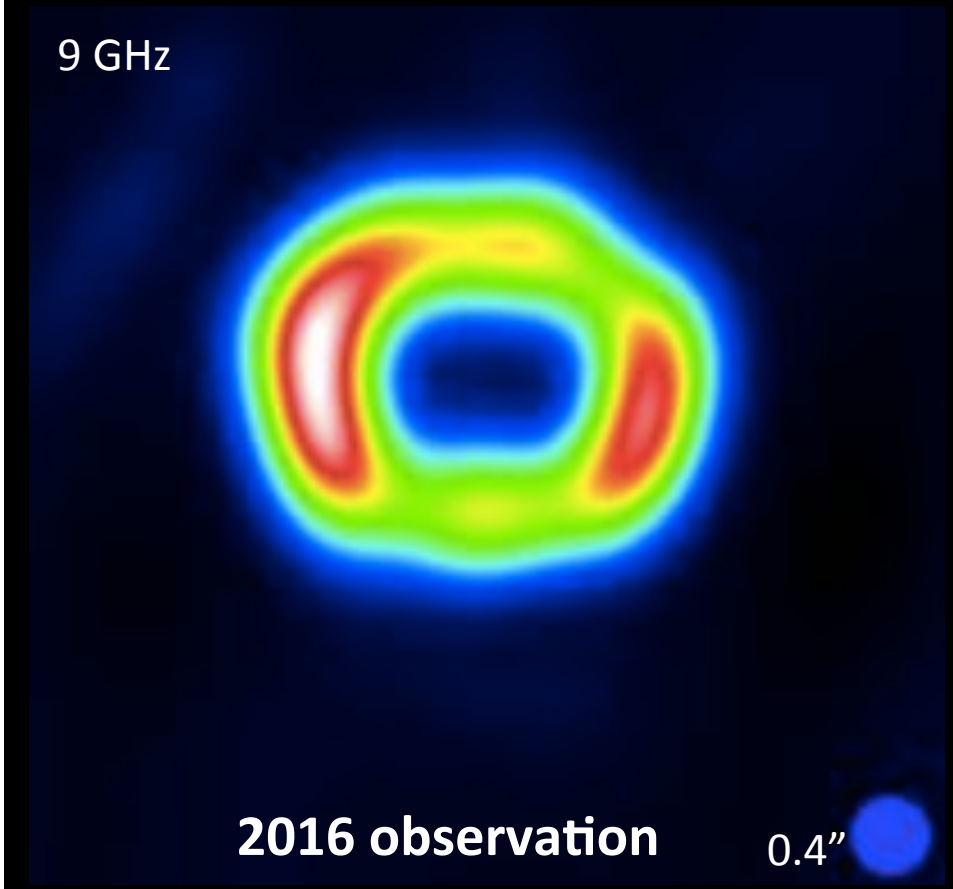
Radio (9 GHz)



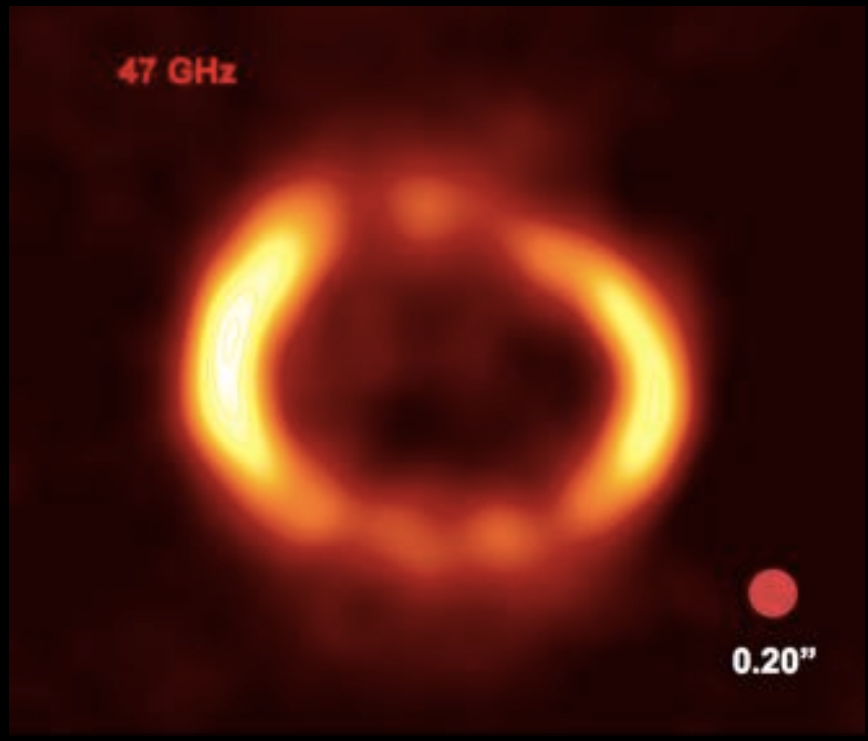
X-Ray (8 keV)
Frank et al. (2016)

High-Latitude Emission

- At 47 GHz, Zanardo et al. (submitted to *ApJL*)

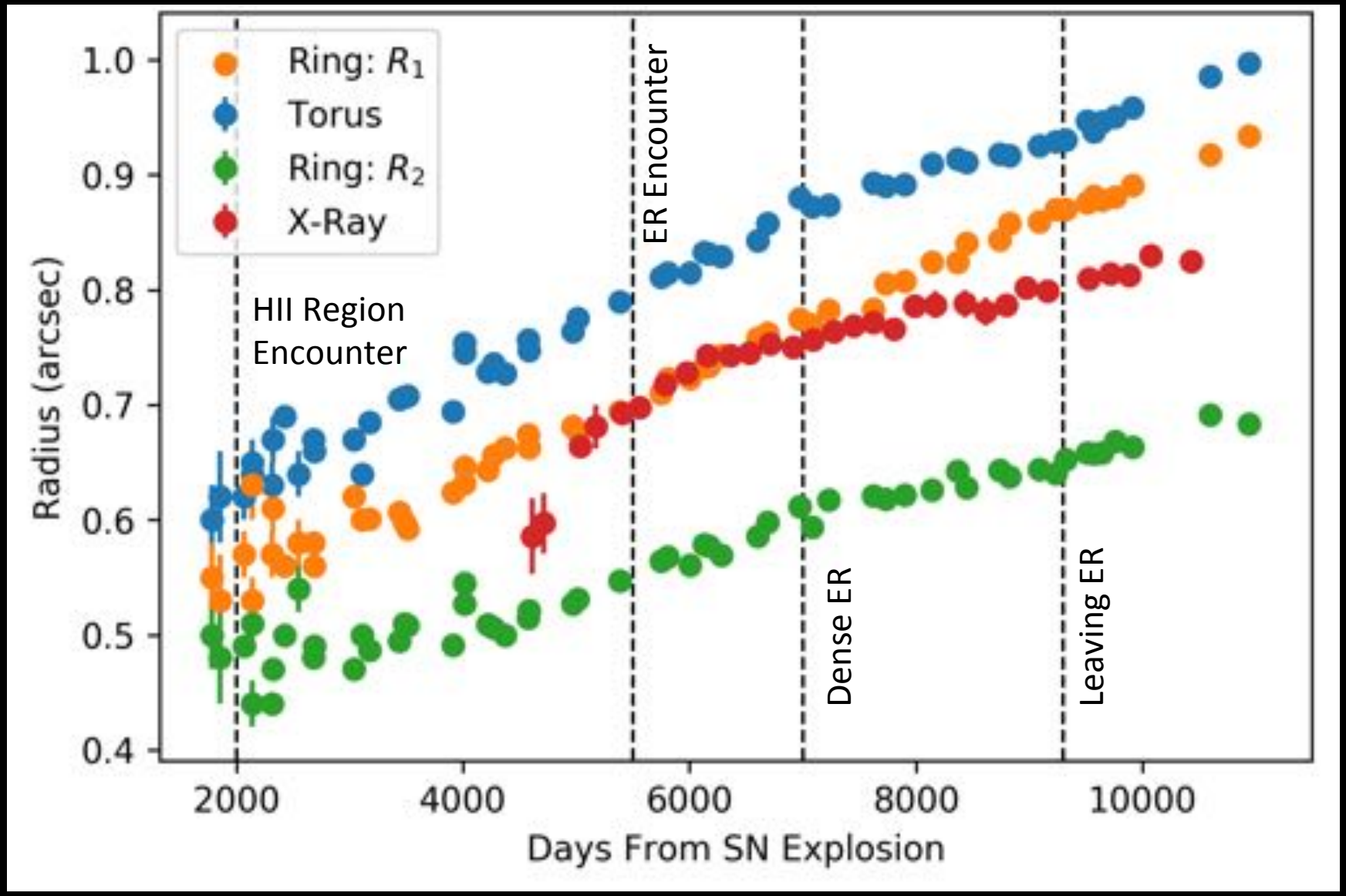


2016 observation



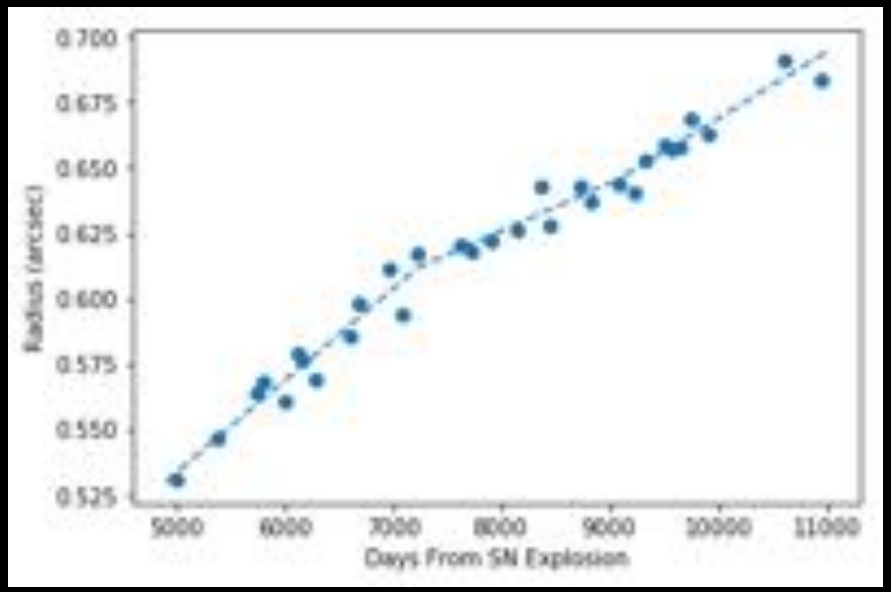
2015/2016 composite

Expansion Over Time

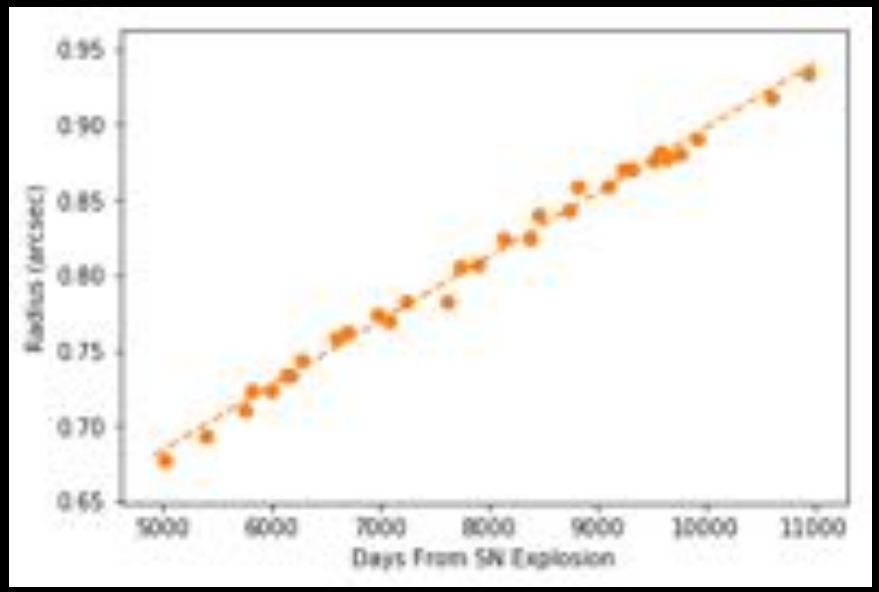


Expansion Over Time- Detailed

Torus



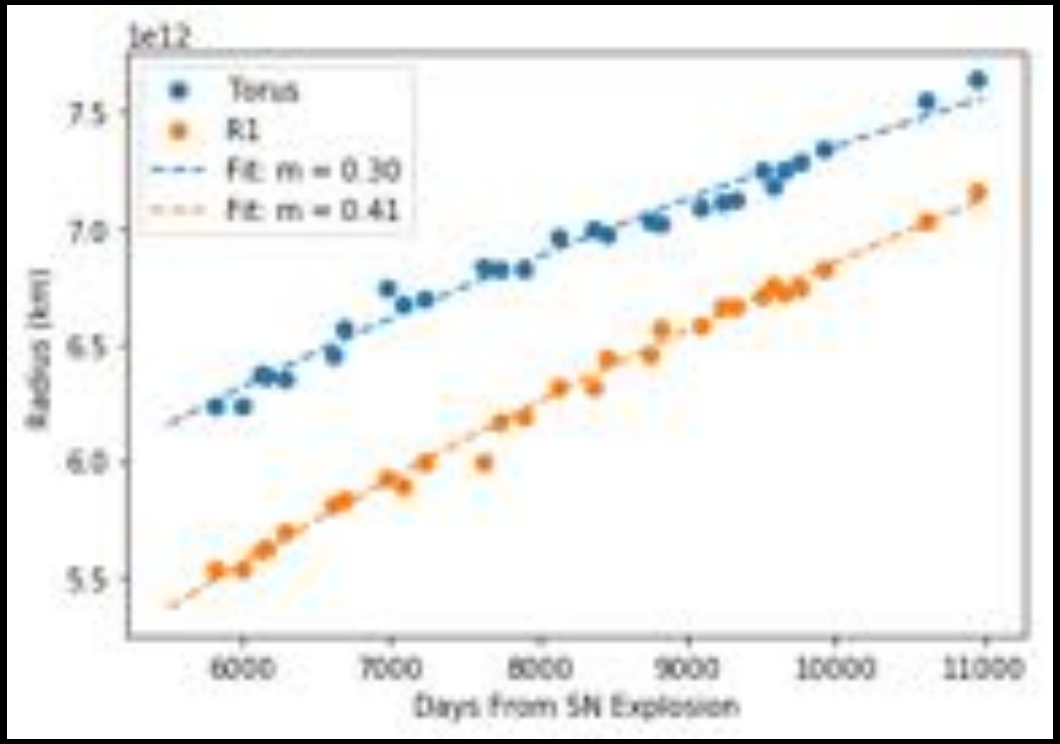
Ring: Semi-Major (R1)



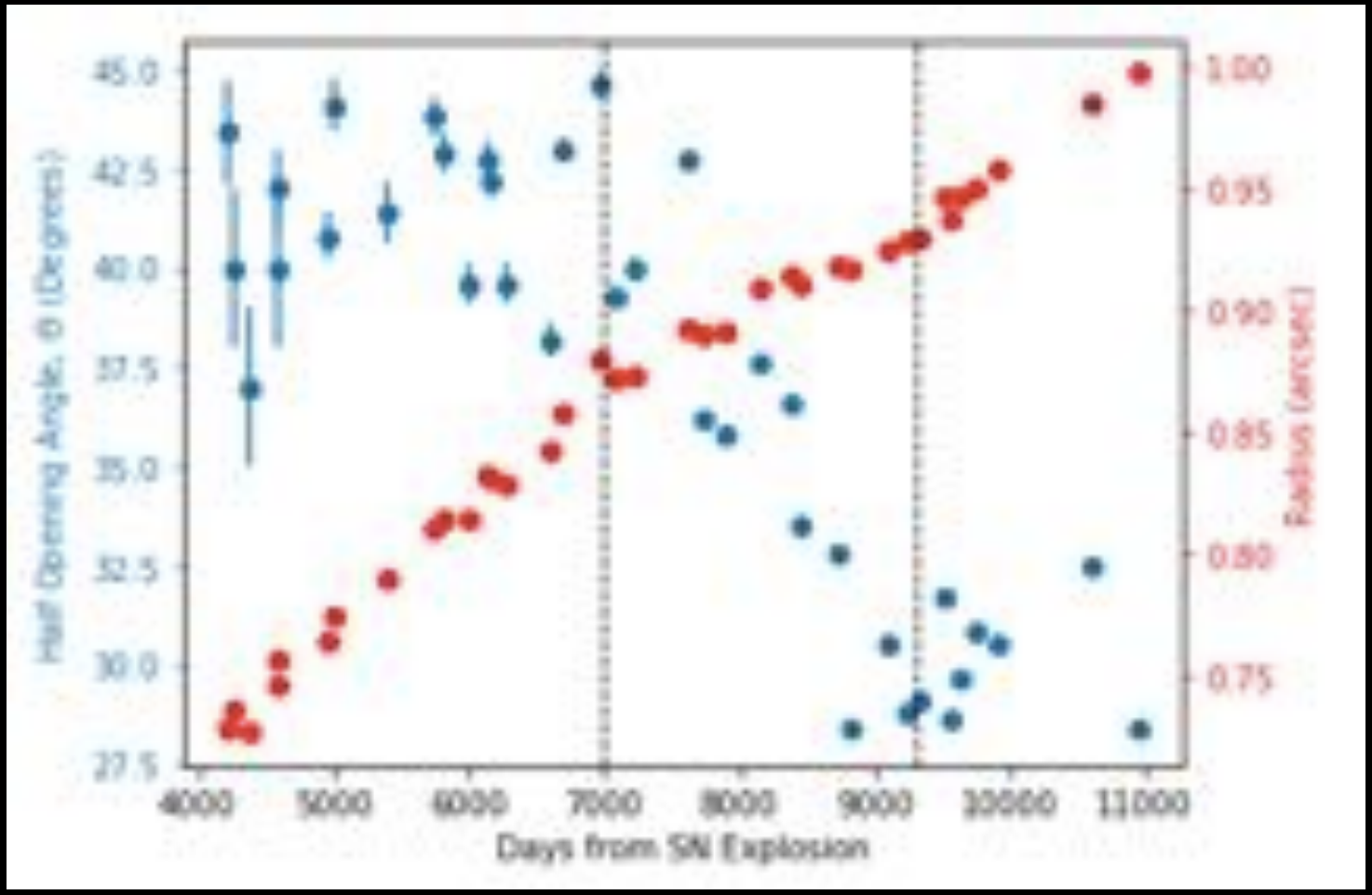
- Torus model is statistically a better fit
- Transition points were calculated by a piecewise function
- R1 constant at 3,800 ± 460 km/s
- Torus slowed from 4,600 ± 200 km/s to 2,300 ± 200 km/s, now 3,610 ± 240 km/s

Expansion Index

- SN expands as $r \sim t^{m}$ (see Chevalier (1982))
- Expansion driven by forward shock, expect to slow over time
- Pre-ER, m = 0.2 (Stavely-Smith et al. (1993))



Radius (r) and Half-Opening Angle of Torus (Θ) are Linked



Conclusions

- Shockwave is now leaving the dense ER region, current speed is 3,610 ± 240 km/s (was 2,600 ± 200 km/s in dense ER)
- Asymmetry in ER should reverse by 2020 (as seen in Xray, optical)
- Compact object (Alp+2018), or PWN (Zanardo+2014)? Still unknown
- Monitoring will continue as the shockwave will now probe the area beyond the ring

Image credit: HST