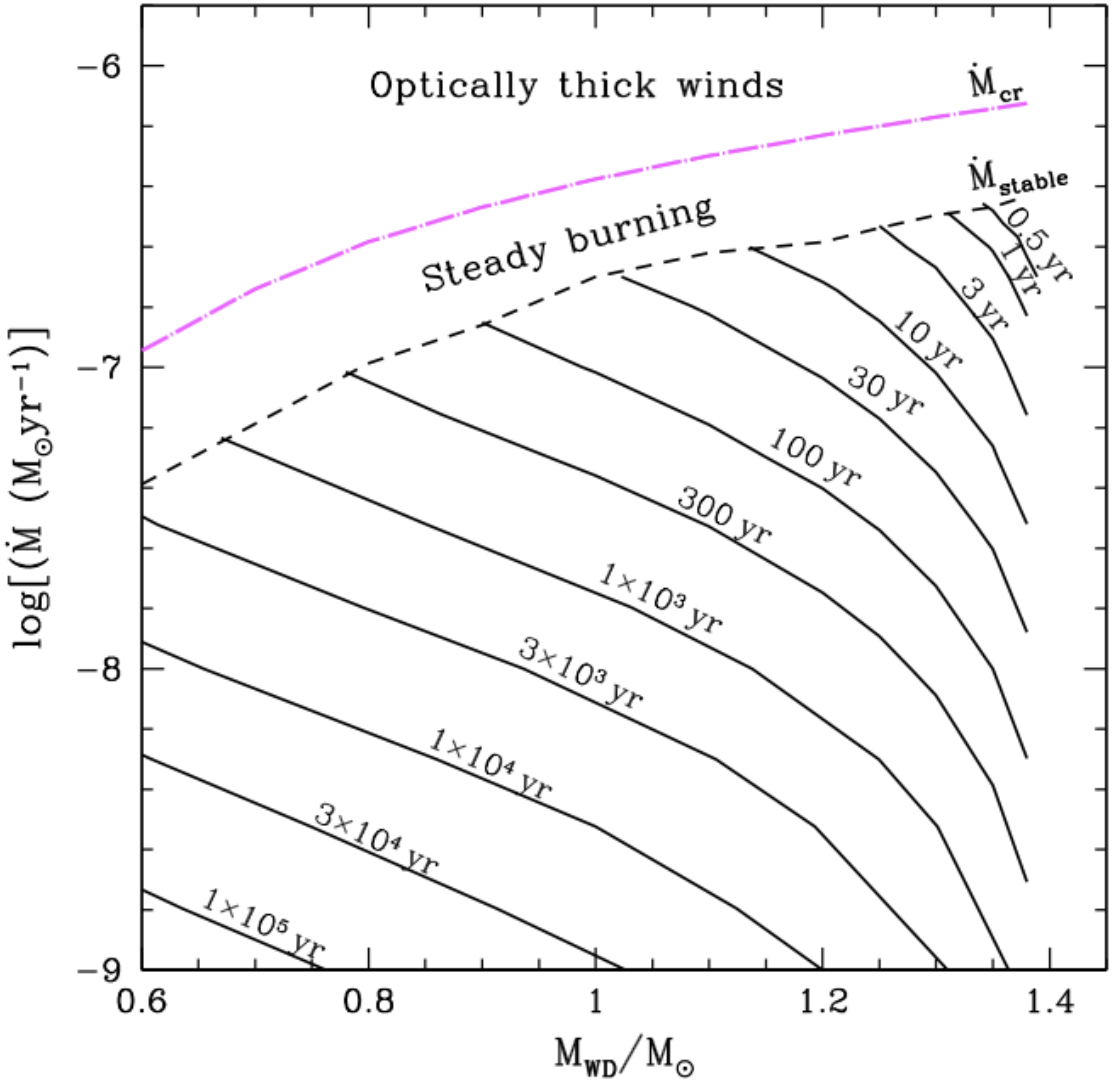
Recurrent Novae!

- Galactically (Schaefer 2010)
  - RG-nova: RS Oph – 20 yrs
  - SG-nova: U Sco – 10 yrs
- LMC
  - LMCN 1968-12a – 6 years (Kuin+ in prep)
- M31 (Shafter+ 2015)
  - M31N 2007-11f – 9 yrs (Sin+ 2016)
  - M31N 1990-10a – 8/9 yrs (Henze+ 2016)
  - M31N 1984-07a – 8 yrs (Pietsch+ 2007)
  - M31N 2006-11c – 8 yrs
  - M31N 1963-09c – 5 yrs (Henze+ in prep)
  - M31N 1997-11k – 4 yrs

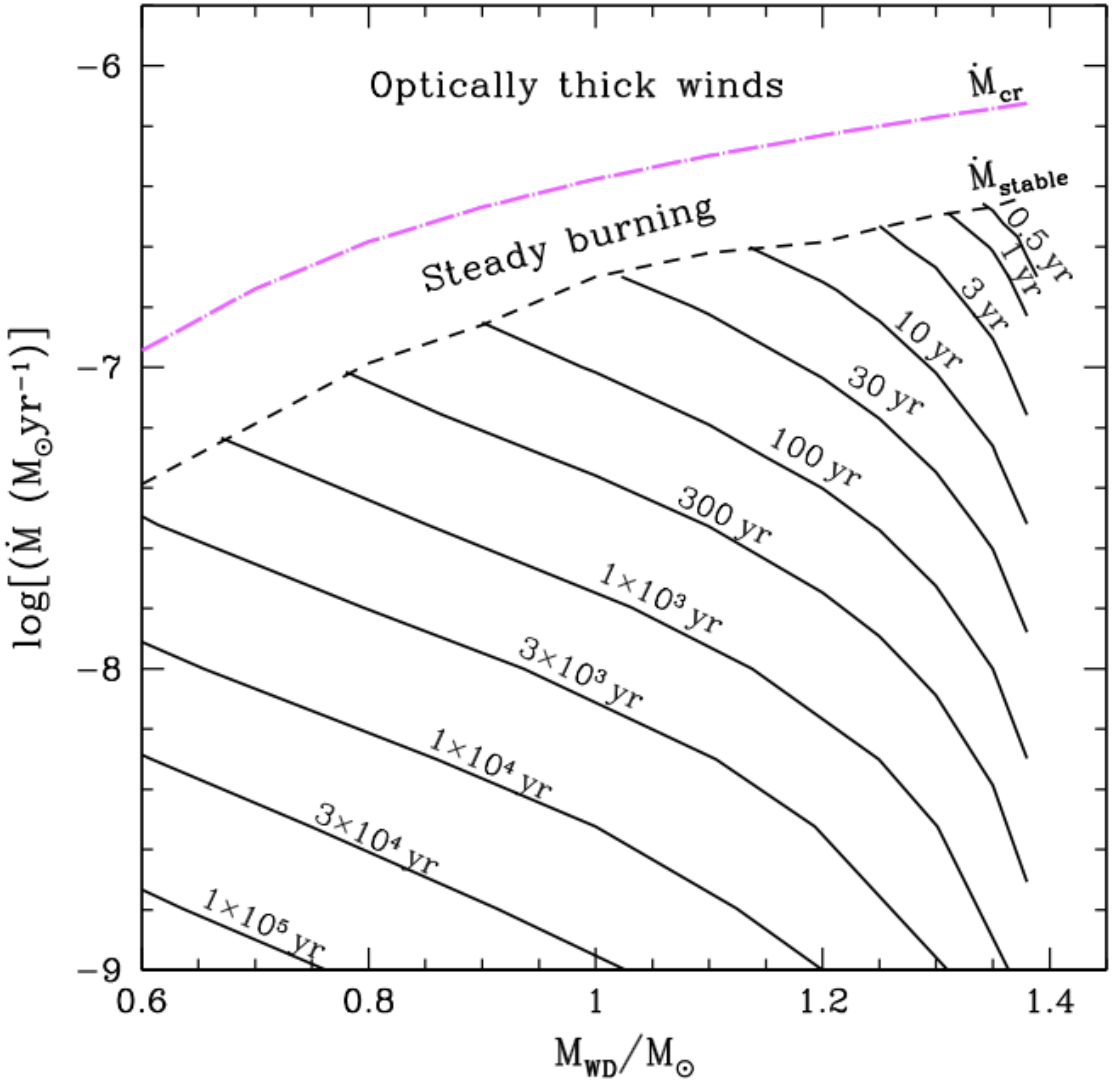
Kato+ 2014, ApJ, 793, 136



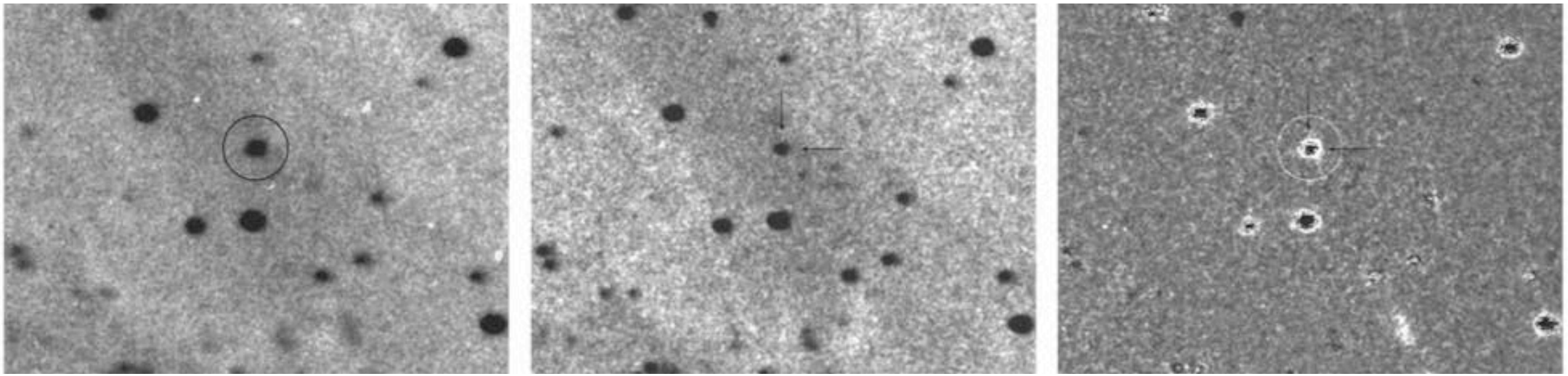
Recurrent Novae!

- But wouldn't it be nice to find something more extreme?!
- A system much closer to the 50 day "limit"?

Kato+ 2014, ApJ, 793, 136



M31N 1966-08a (Rosino 1973 / Shafter+ 2015)



- Two eruptions:
  - M31N 1966-08a: August 11 1966
  - M31N 1968-10c: October 24 1968
- Very rapid evolution
- Never seen again!

- A two(.2) year RN? Surely not?
- A foreground dwarf nova outburst?
- Coincident novae? Very low probability

M31N 2008-12a – The remarkable recurrent nova!

2008 M31 transient discovered

2009 Eruption announced
(PTF; Tang+ 2014)

2010 Eruption recovered
(Henze+ 2015)

2011 Erupted again

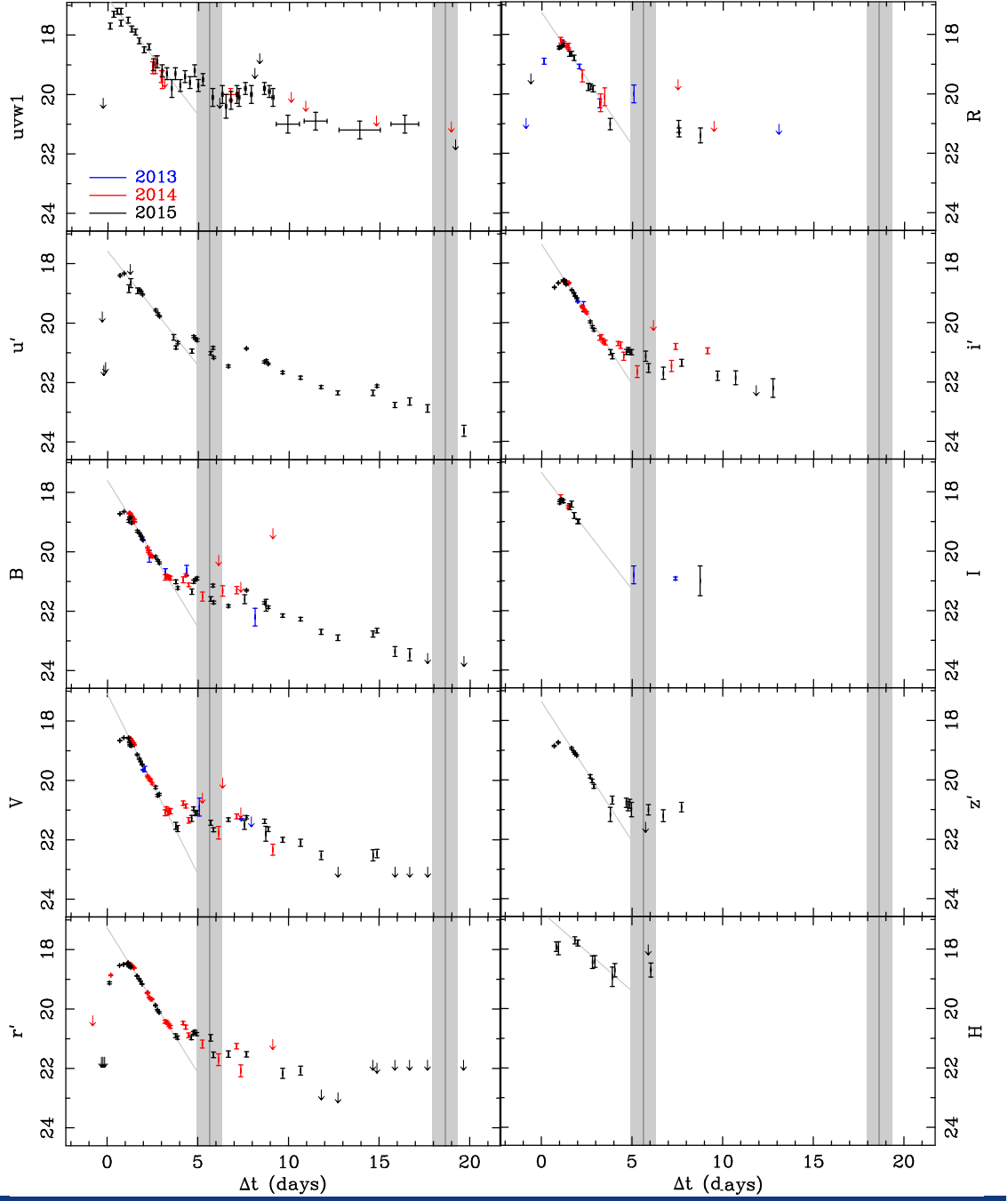
2012 Spectroscopically confirmed

2013 iPTF discover eruption (Darnley+/Tang+ 2014)

2014 LT detects predicted eruption (Darnley+ 2015)

2015 LCOGT detects predicted eruption (Darnley+ 2016)

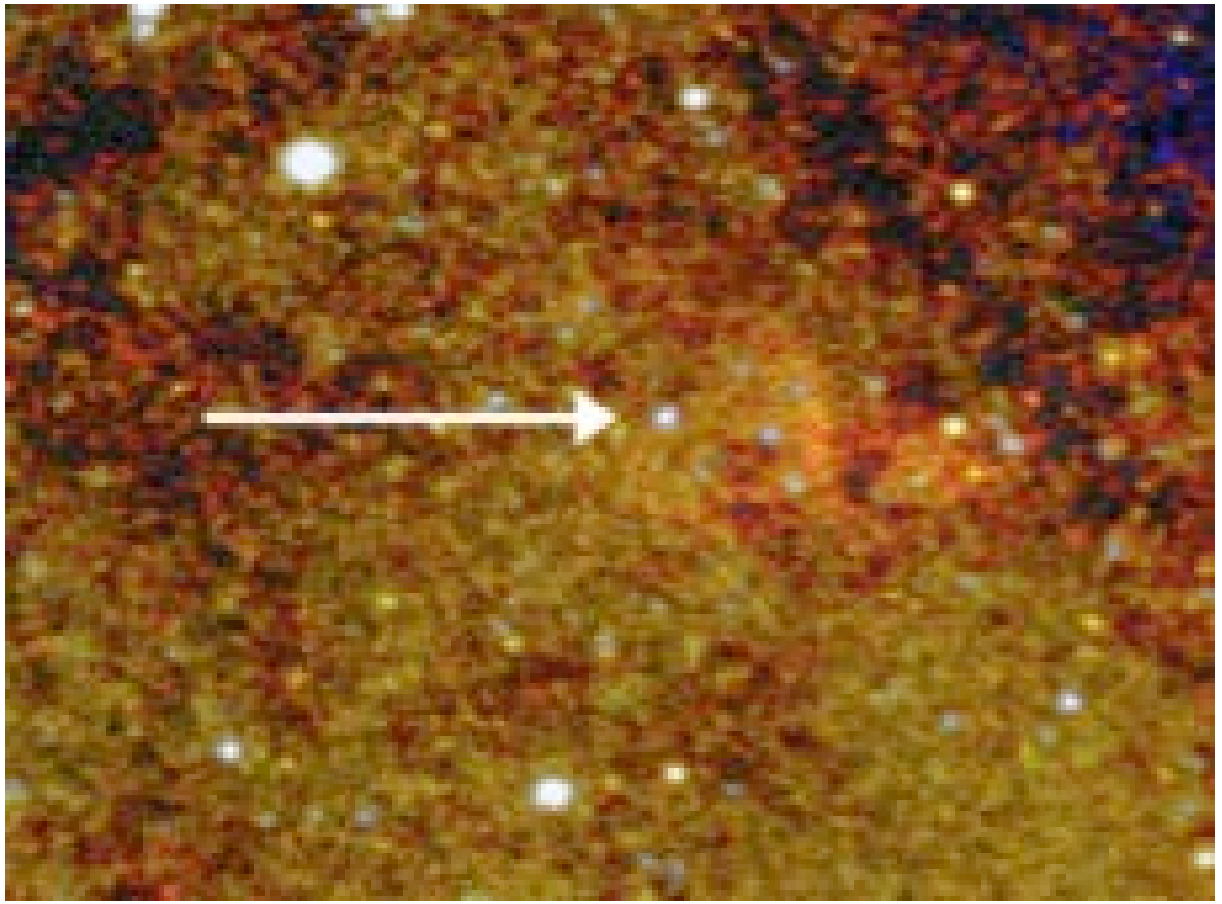
- Transient X-ray detections (Henze+/Tang+ 2014):
1992, 1993, and 2001



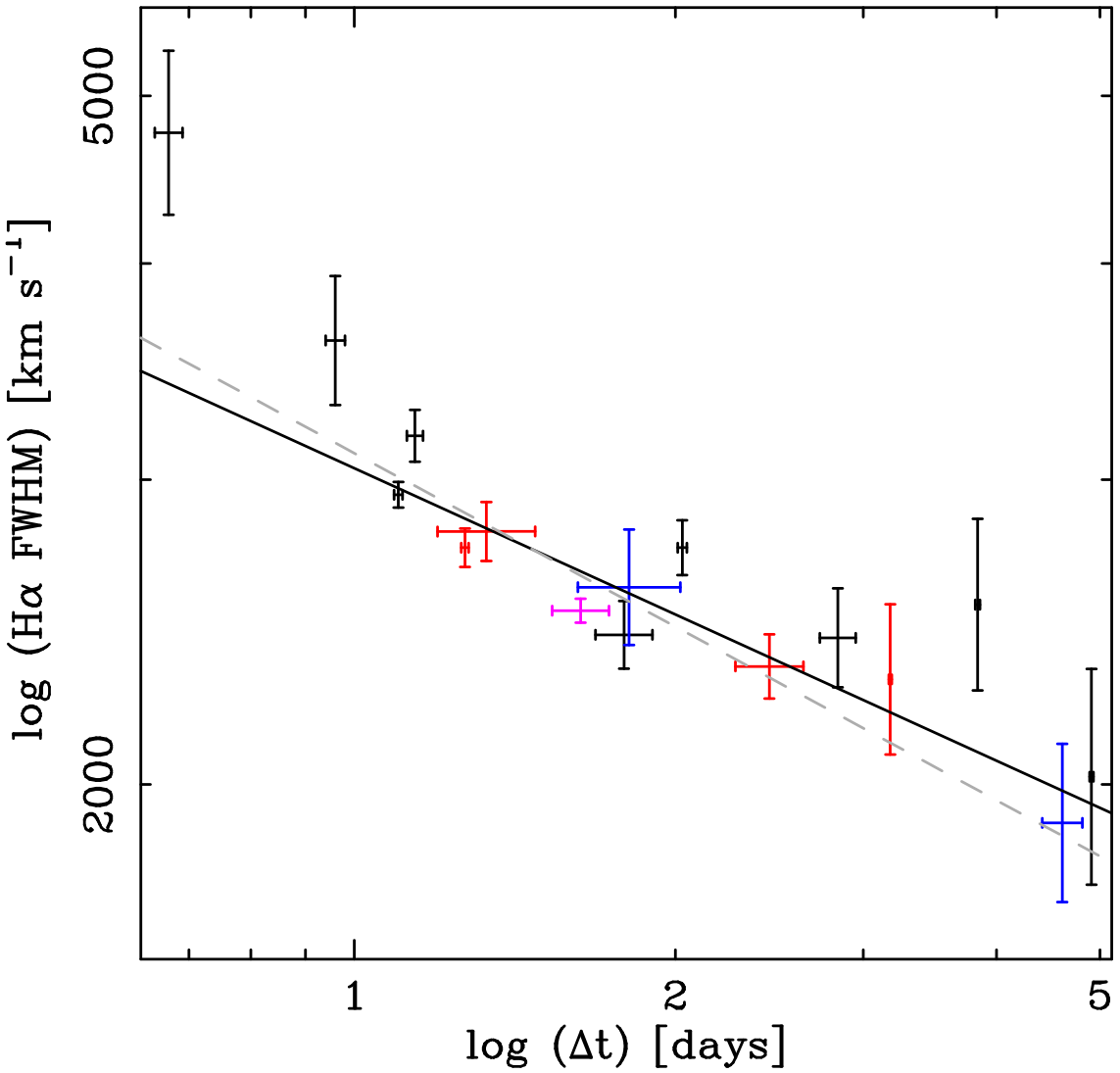
M31N 2008-12a – The remarkable recurrent nova in M31 (Darnley+ 2016)

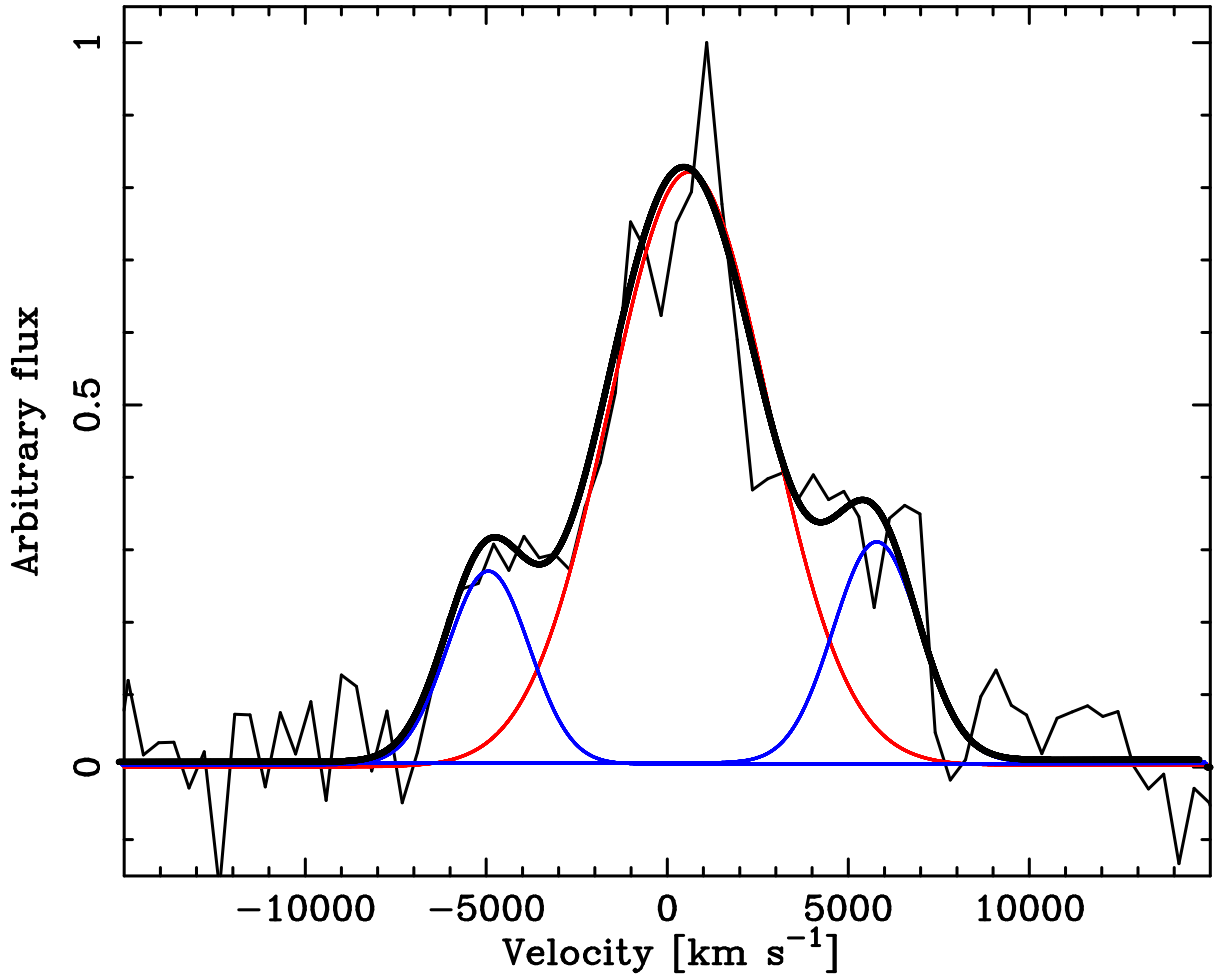
- Eruptions every year for the last nine years! P_{rec}=347±10 days
- The fastest evolving nova ever observed (t_3=2.5 days)
- Some of the highest ejection velocities seen in a nova ~13,000 km/s
- 2012—2015 eruptions 'identical'
- All powered by the highest mass accreting WD known 1.38 M_{sun} (Kato+ 2015)
- With the highest accretion rate known ~$2x10^{-7}$ M_{sun}/yr (Kato+ 2015)
- Ejecting ~$6x10^{-8}$ M_{sun}/yr (Kato+ 2015)

The leading pre-explosion SN Ia candidate?

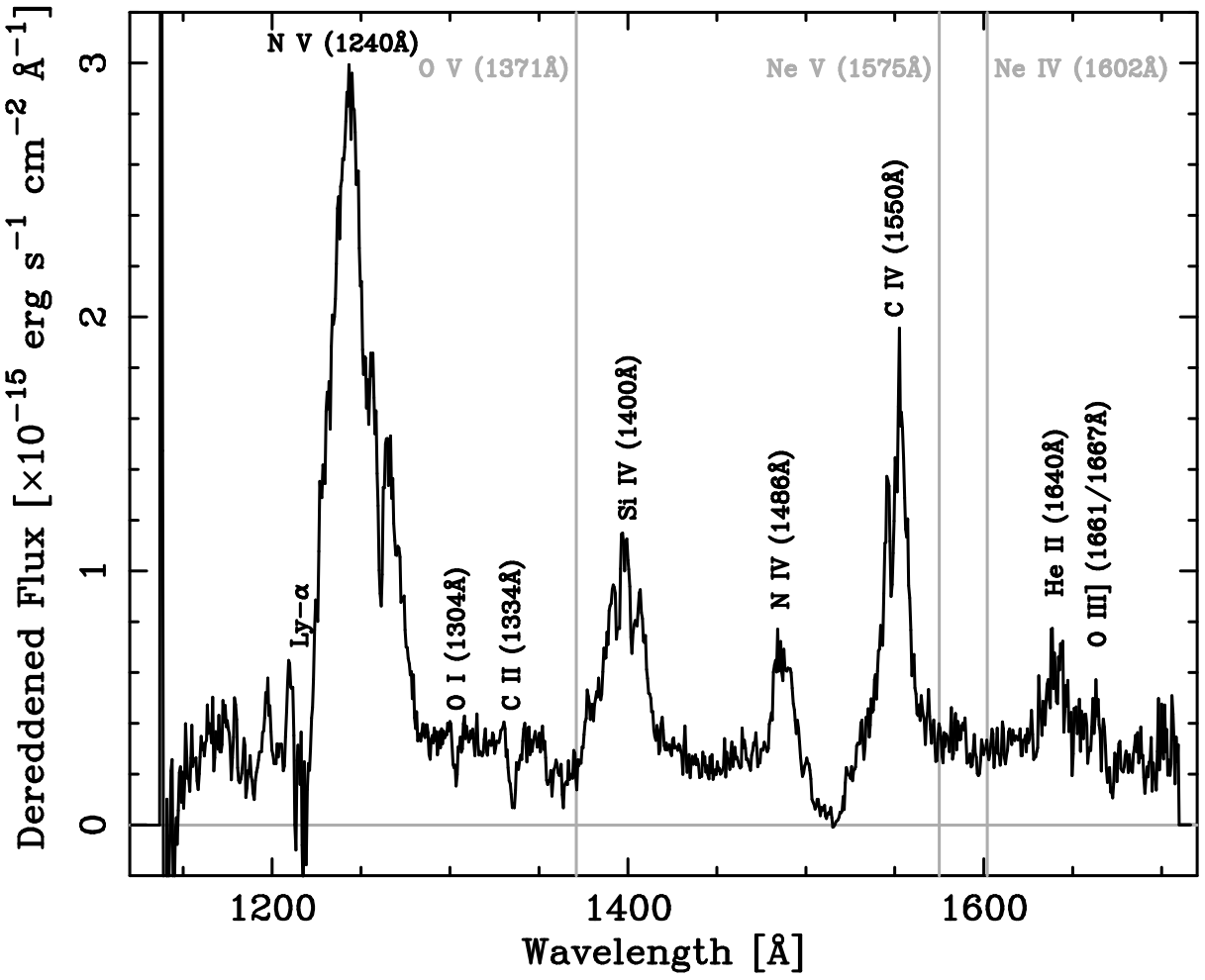


M31N 2008-12a: Hα Development (Darnley+ 2016)



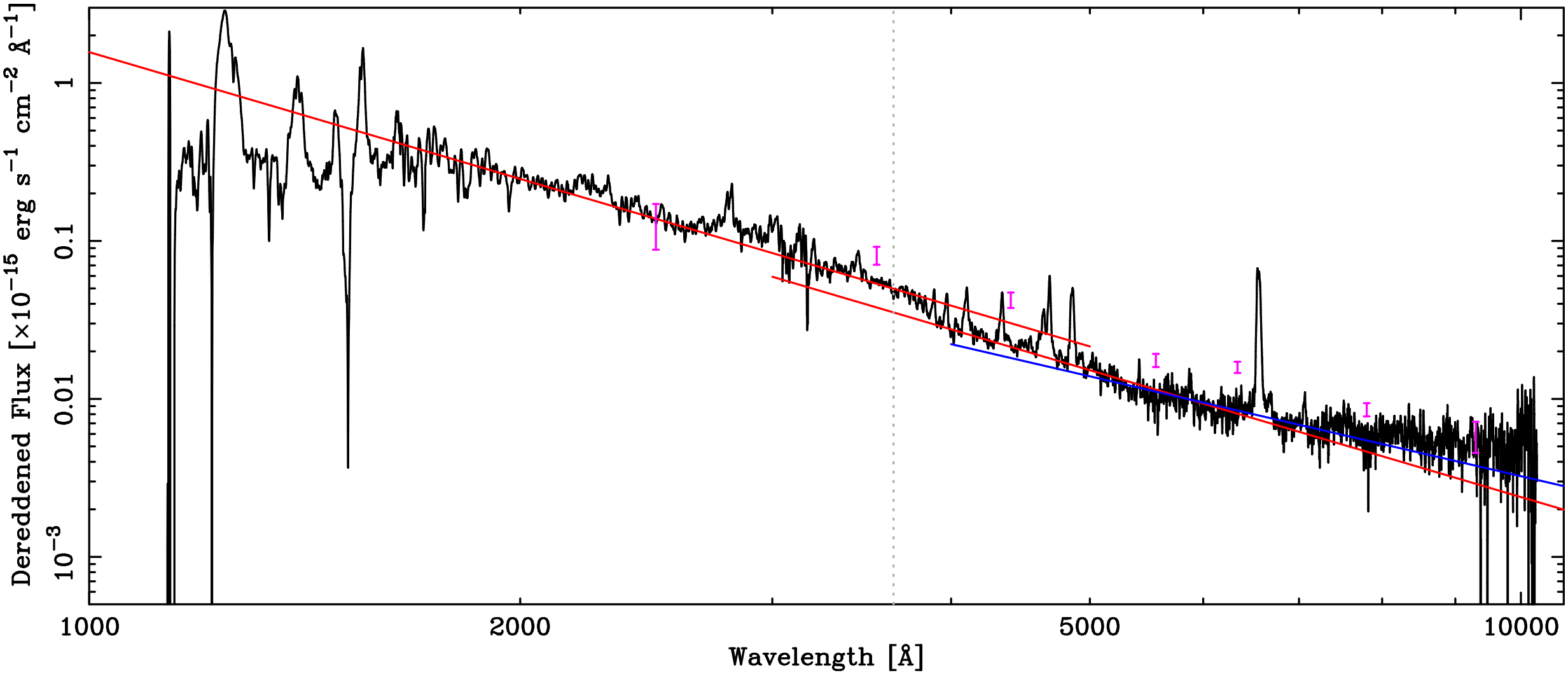


M31N 2008-12a: 2015 Eruption HST Campaign – FUV spectrum (Darnley+ in prep)

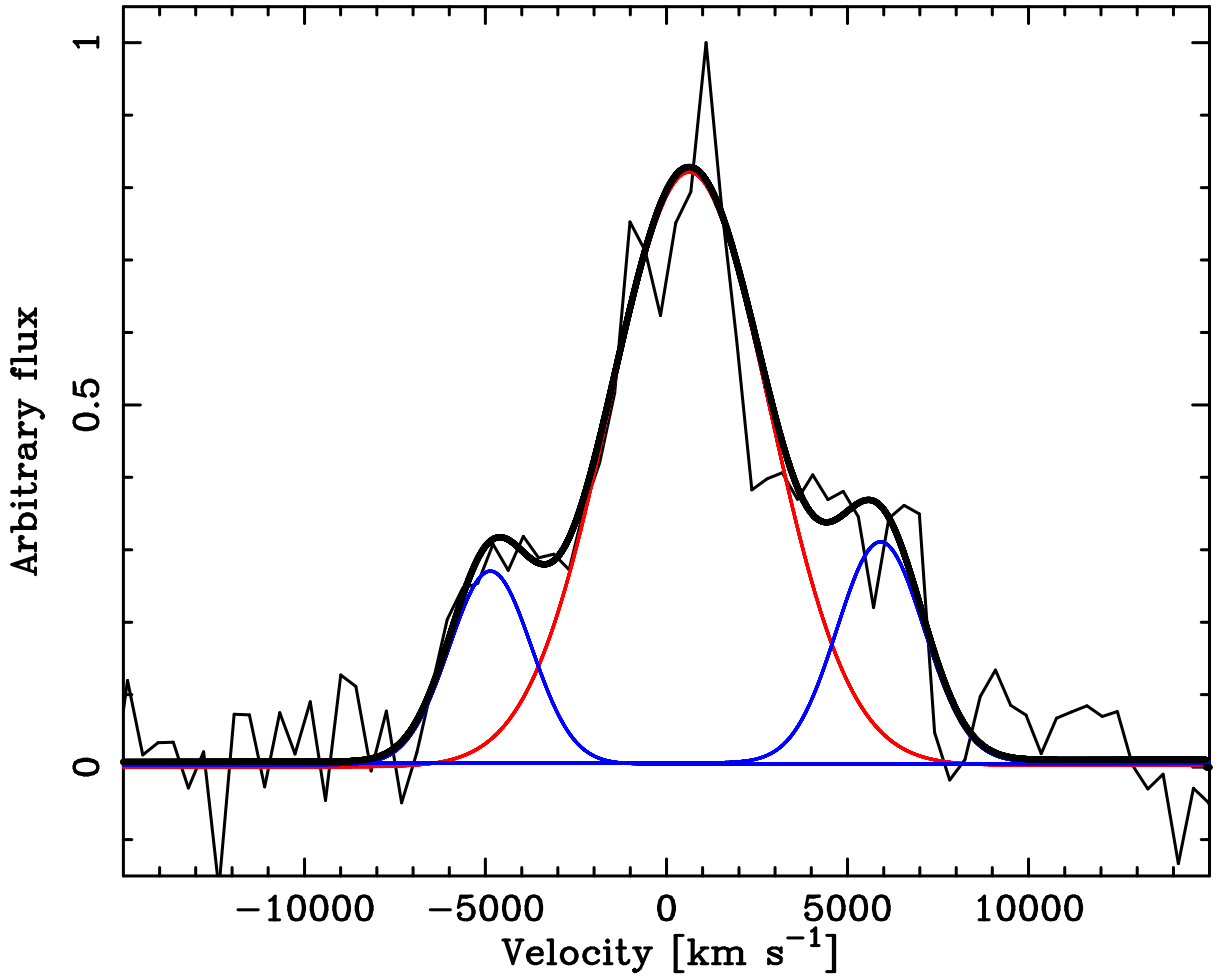


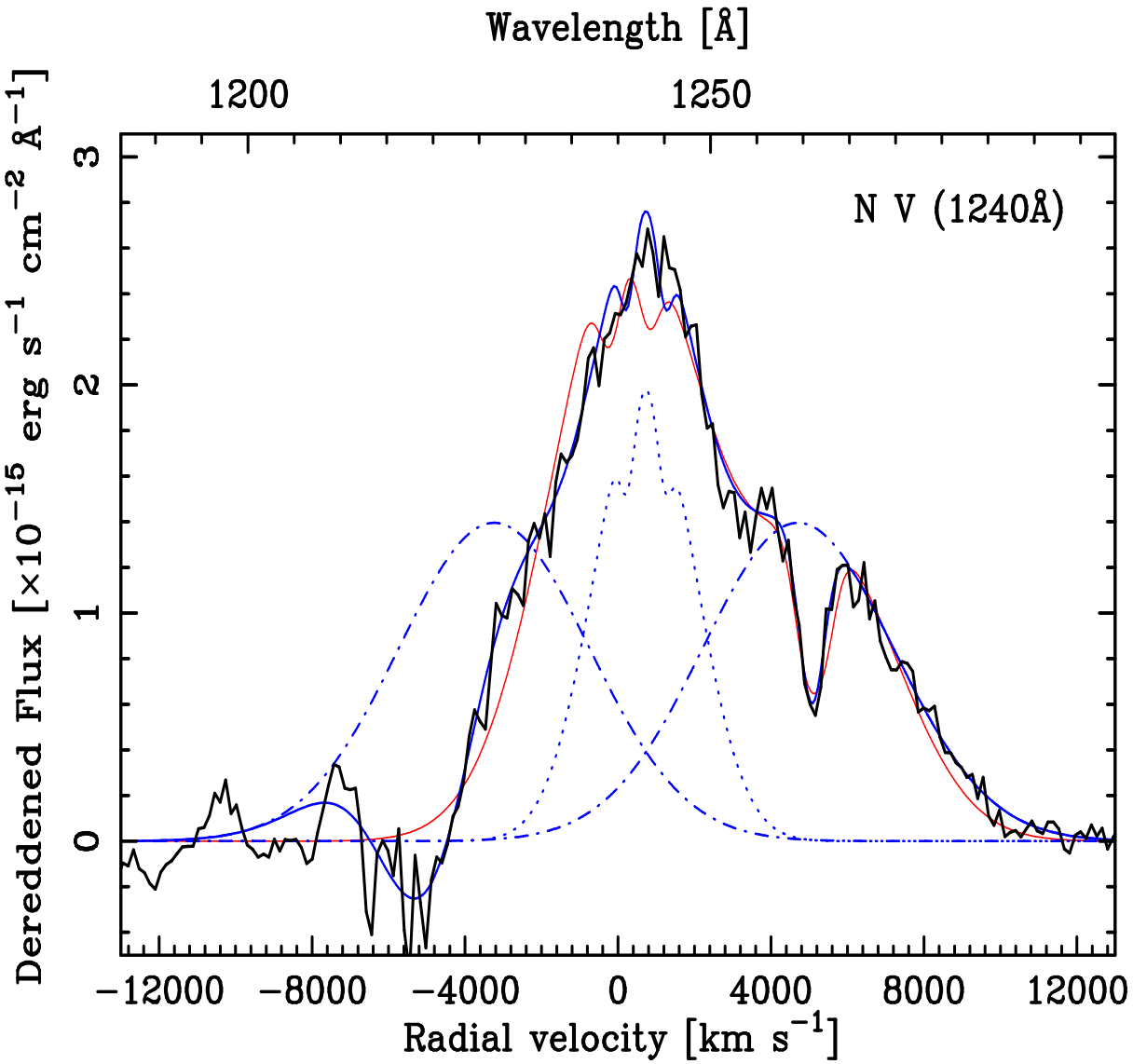
- Post-Fe curtain phase
- N V (1240), Si IV (1400), C IV (1550) resonance doublets strongest lines & optically thick
- He II (1640), O III] (1667), N IV (1486) also detected
- No O I (1305) / C II (1334) emission (just *interstellar* absorption
- He II line profile (+ absorption lines) used to model all emission features
- Absolutely no Neon, whatsoever…
- No O IV (1400) or O V (1371)

M31N 2008-12a: 2015 Eruption HST – HST + Keck (Darnley+ in prep)

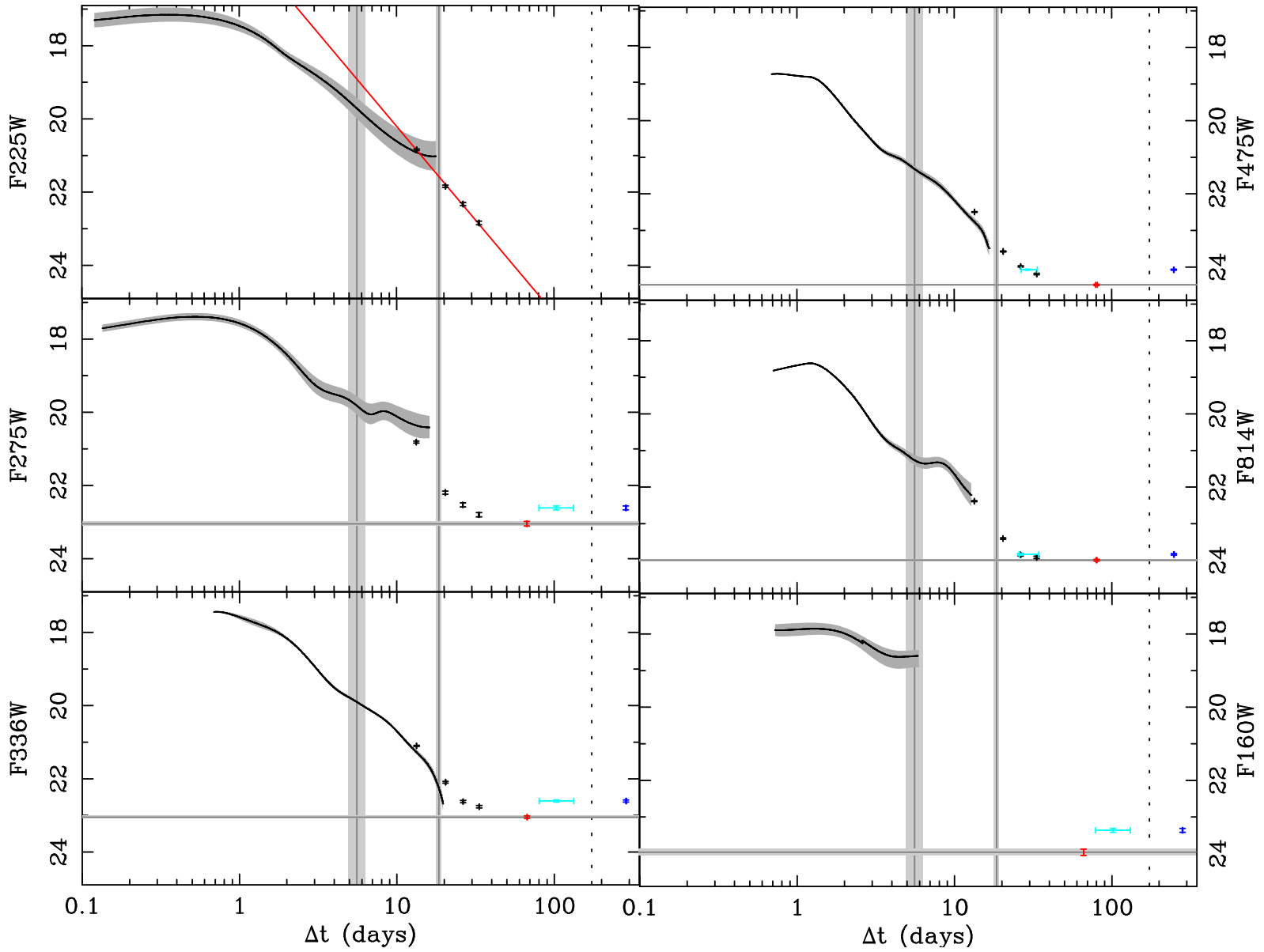


M31N 2008-12a: Jets again? Hα versus N V – (Darnley+ in prep)

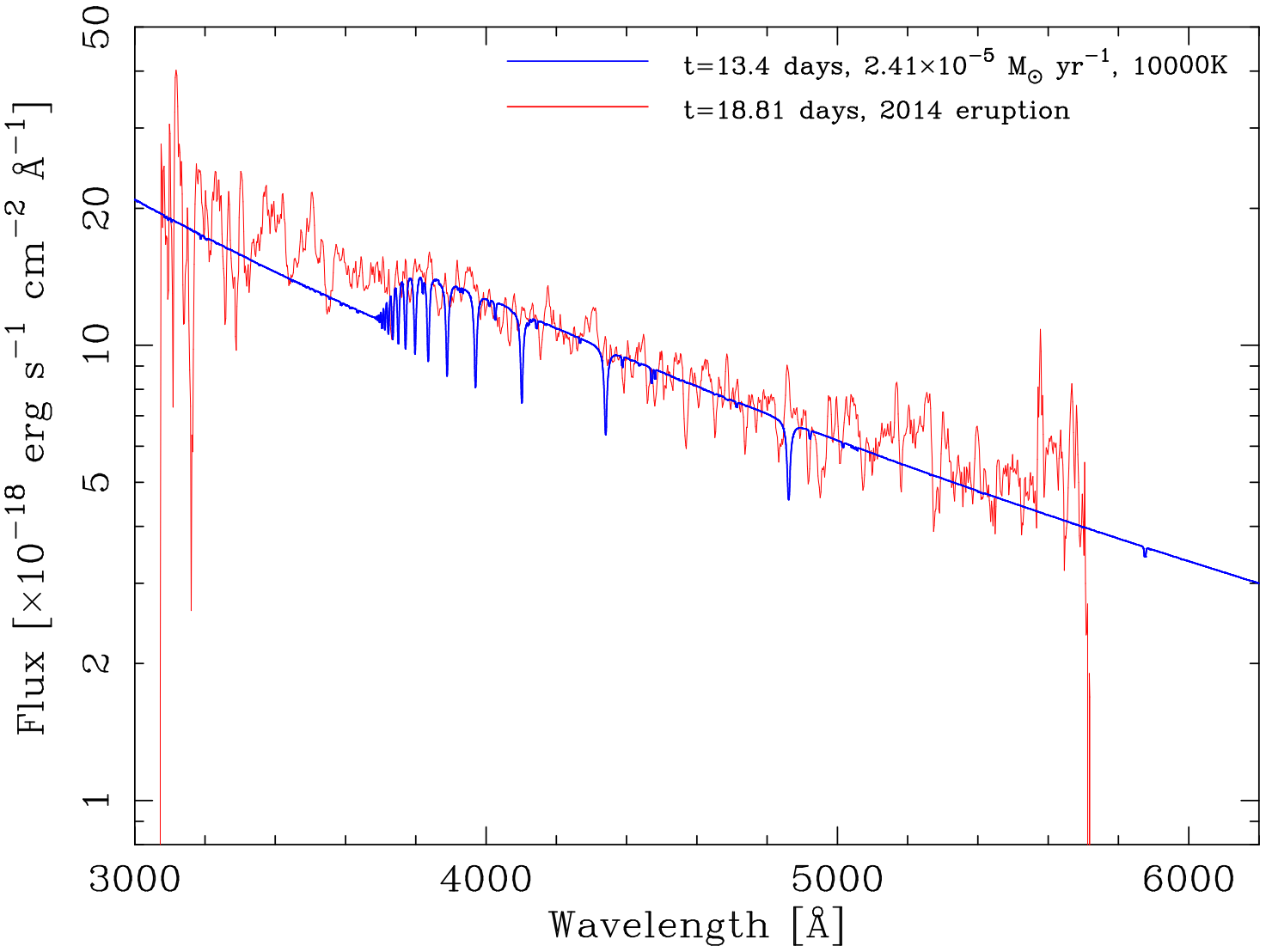




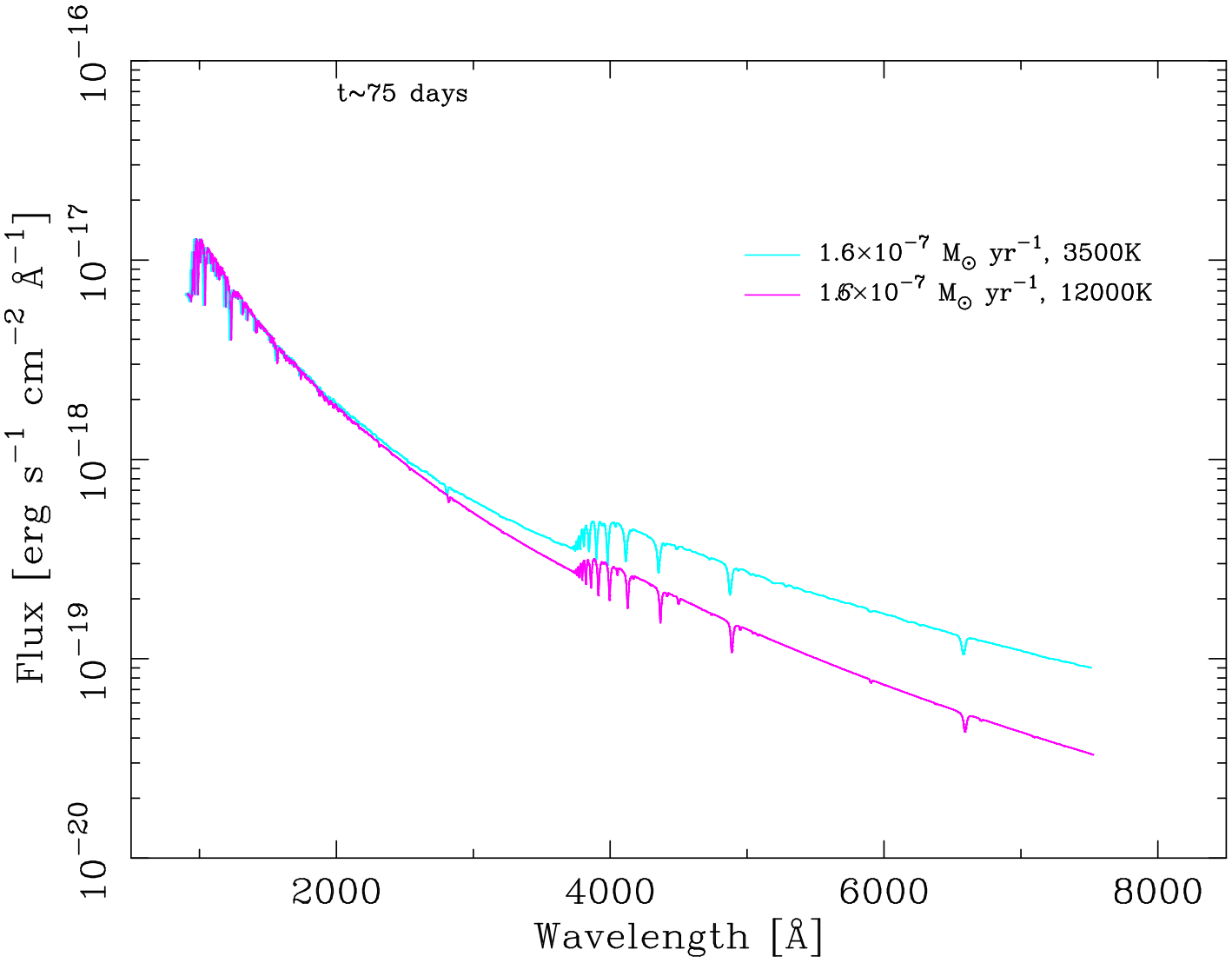
M31N 2008-12a – The 2015 eruption from HST (Darnley+ in prep)



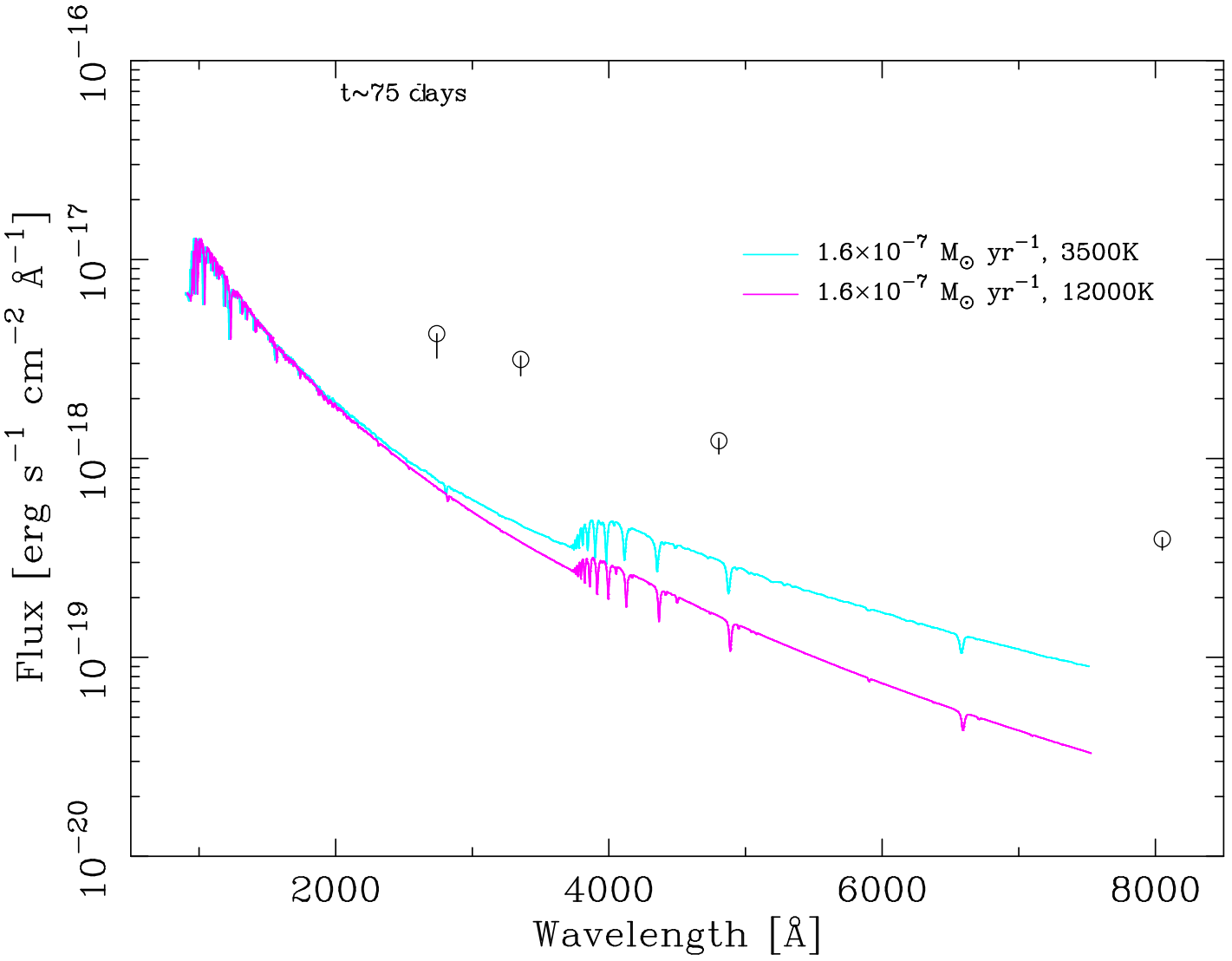
M31N 2008-12a – Accretion disk modelling – t=18 days (Darnley+ in prep)



M31N 2008-12a – Accretion disk modelling – Quiescence (Darnley+ in prep)



M31N 2008-12a – Accretion disk modelling – Quiescence (Darnley+ in prep)



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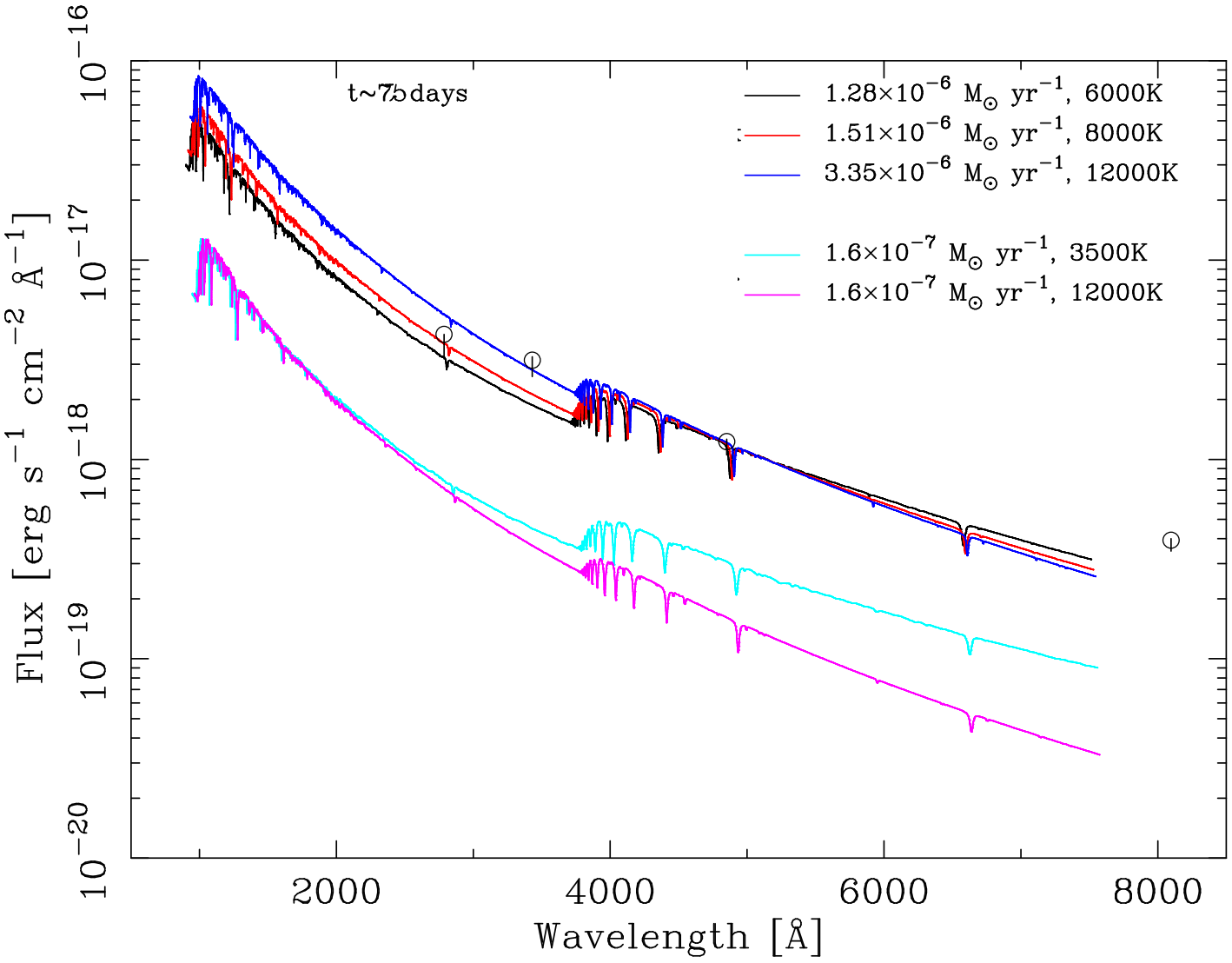


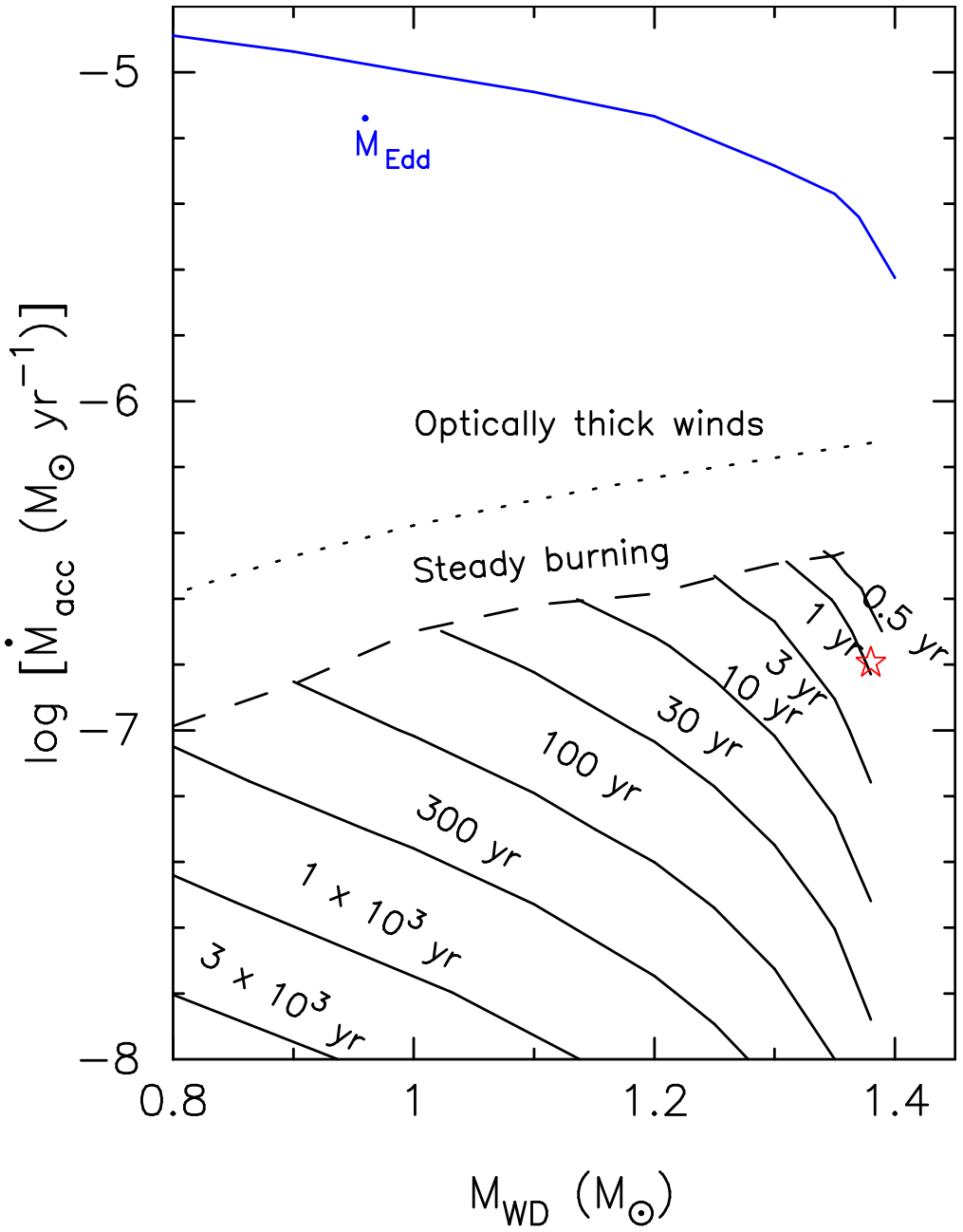
M31N 2008-12a – The accretion rate & fate

- Disk mass loss rate at t=75days:
  Mdot = 1.3 x 10^{-6} M_{sun}/yr
- Disk mass loss rate at t=270 days:
  Mdot = 2.8 x 10^{-6} M_{sun}/yr

- Strong disk winds lead to minimum WD accretion rate: 6.4 x 10^{-7} M_{sun}/yr

- Coupled with ejected mass (6 x 10^{-8} M_{sun}) gives accretion efficiency > 90%

- Time to Chandrasekhar mass < 40 kyr



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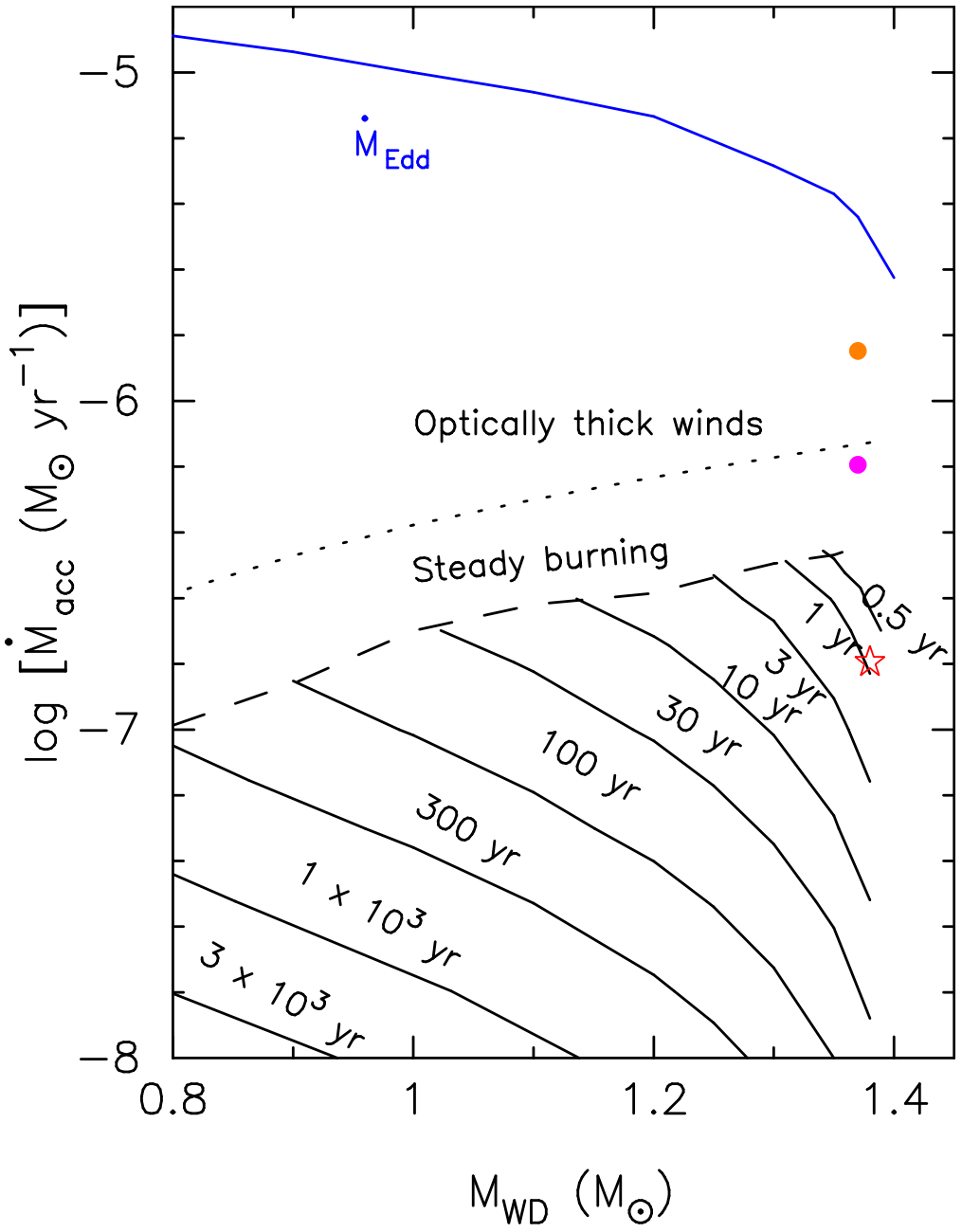


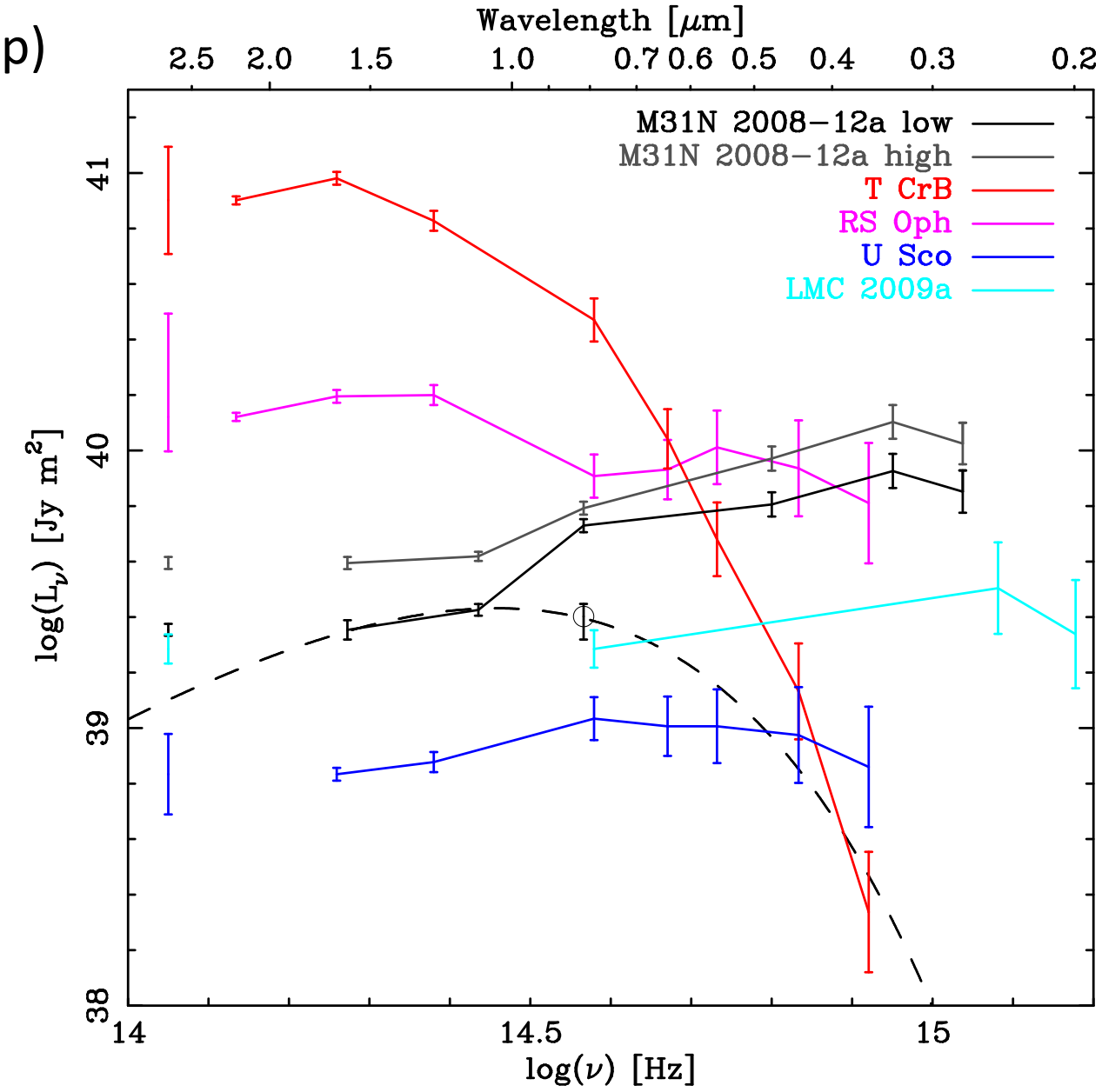
M31N 2008-12a – The donor? (Darnley+ in prep)

- J & H points from HST – no accretion disk contribution – fits a blackbody well (obvs.)

- I-band excess from disk fitting is consistent with the same BB

- $L_{donor} = 103 \pm 12\ L_{sun}$
- $R_{donor} = 14.14 \pm 0.47\ R_{sun}$
- $T_{eff,donor} = 4890 \pm 110$ K

- M31 red clump
- $P_{orb} > 5$ days



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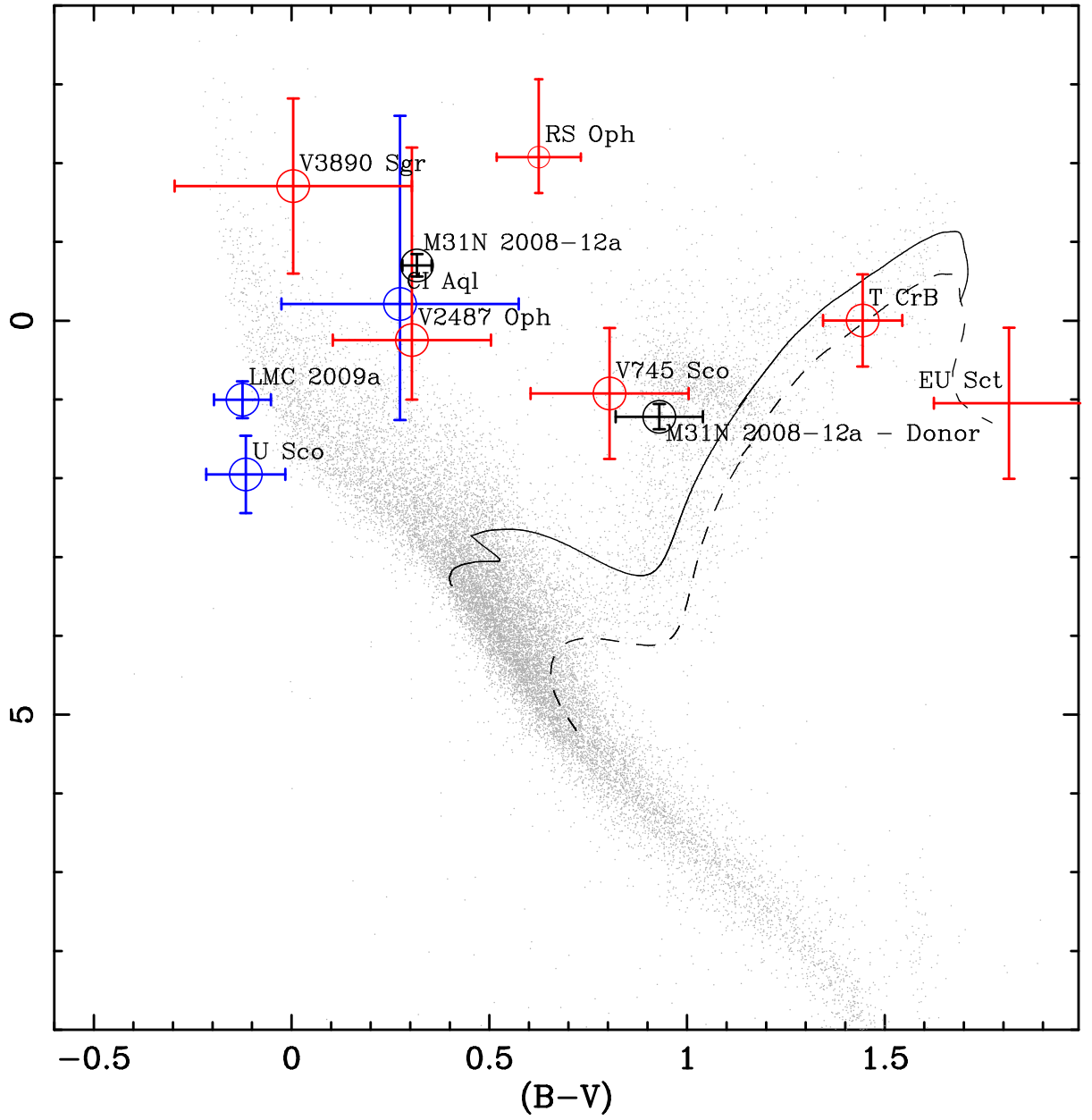
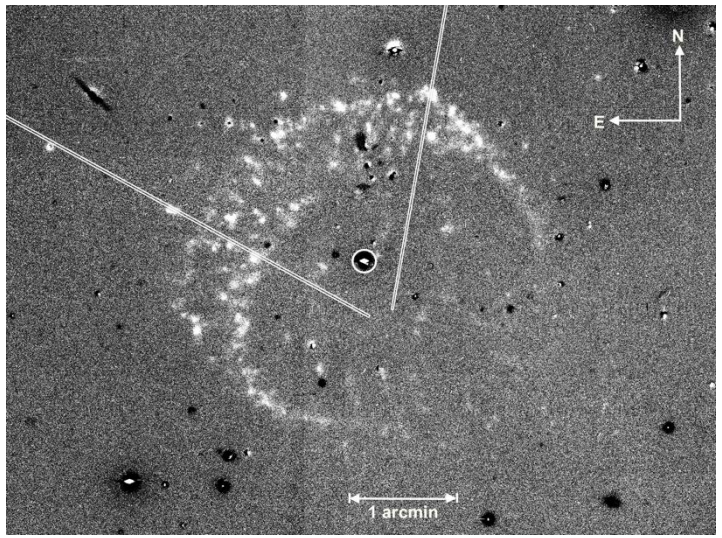
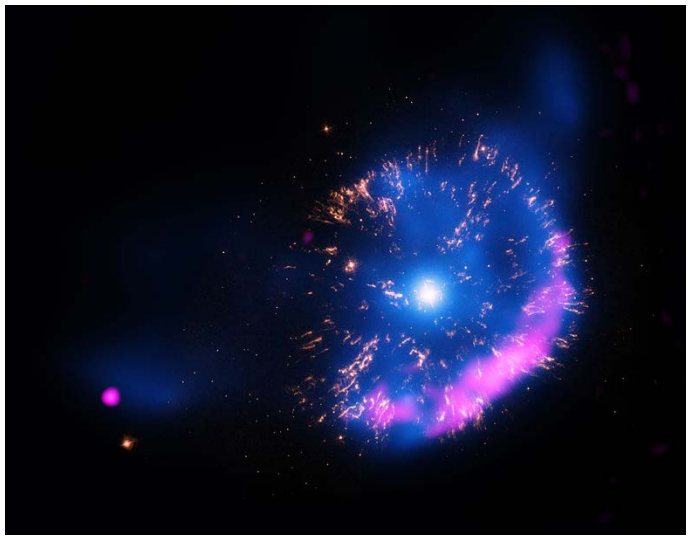
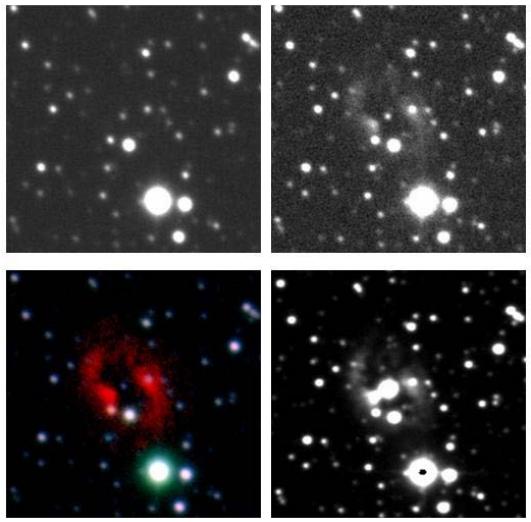
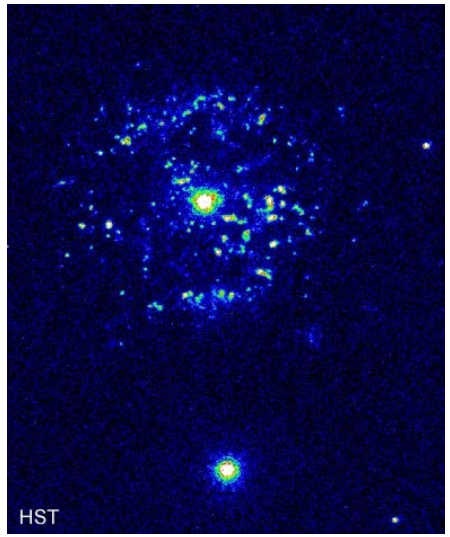


Thought experiment – what does the remnant of a ’rapid recurrent nova’ look like?

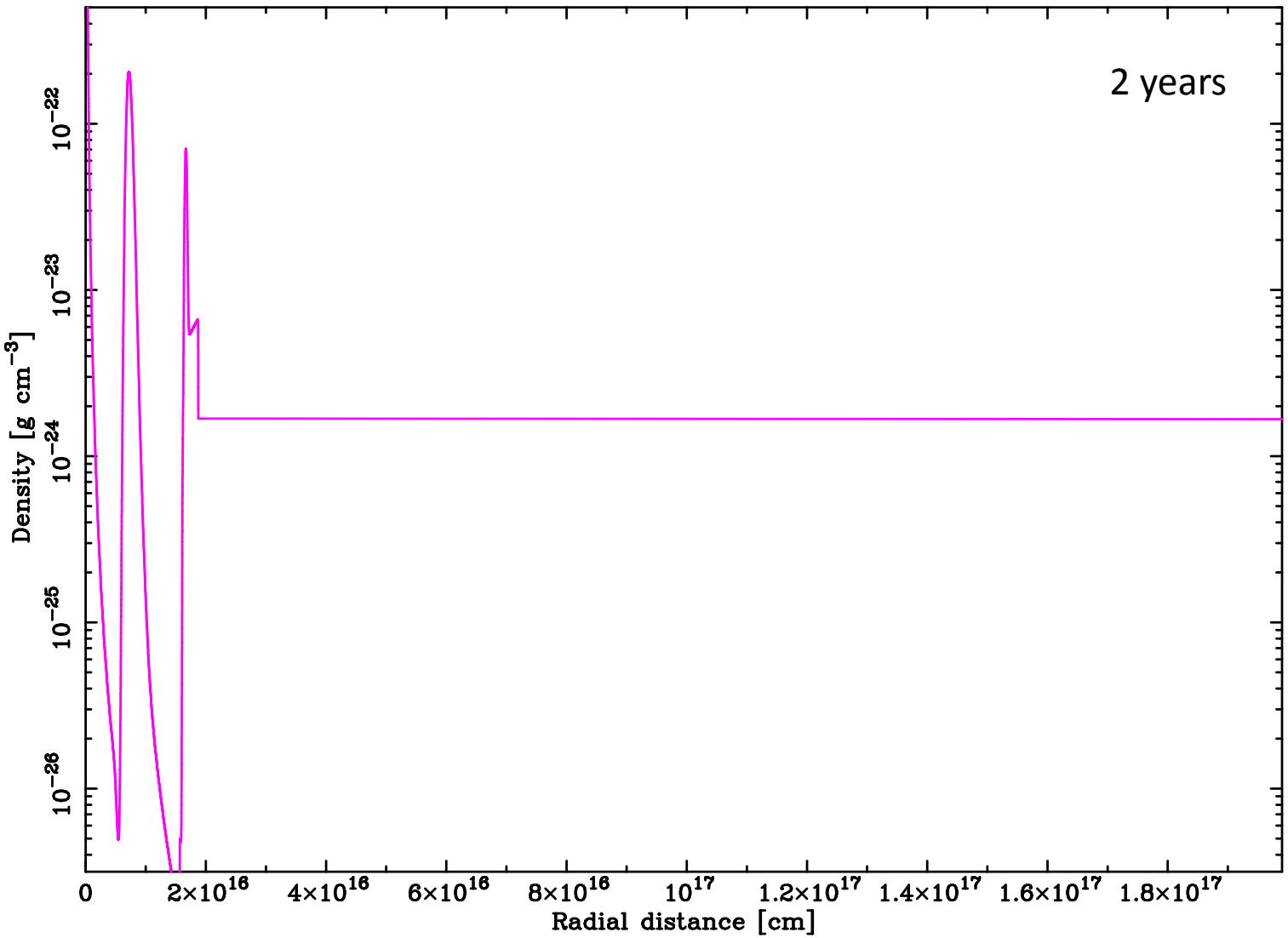








The environment around ultra-rapid recurrent novae (Darnley+, in prep)



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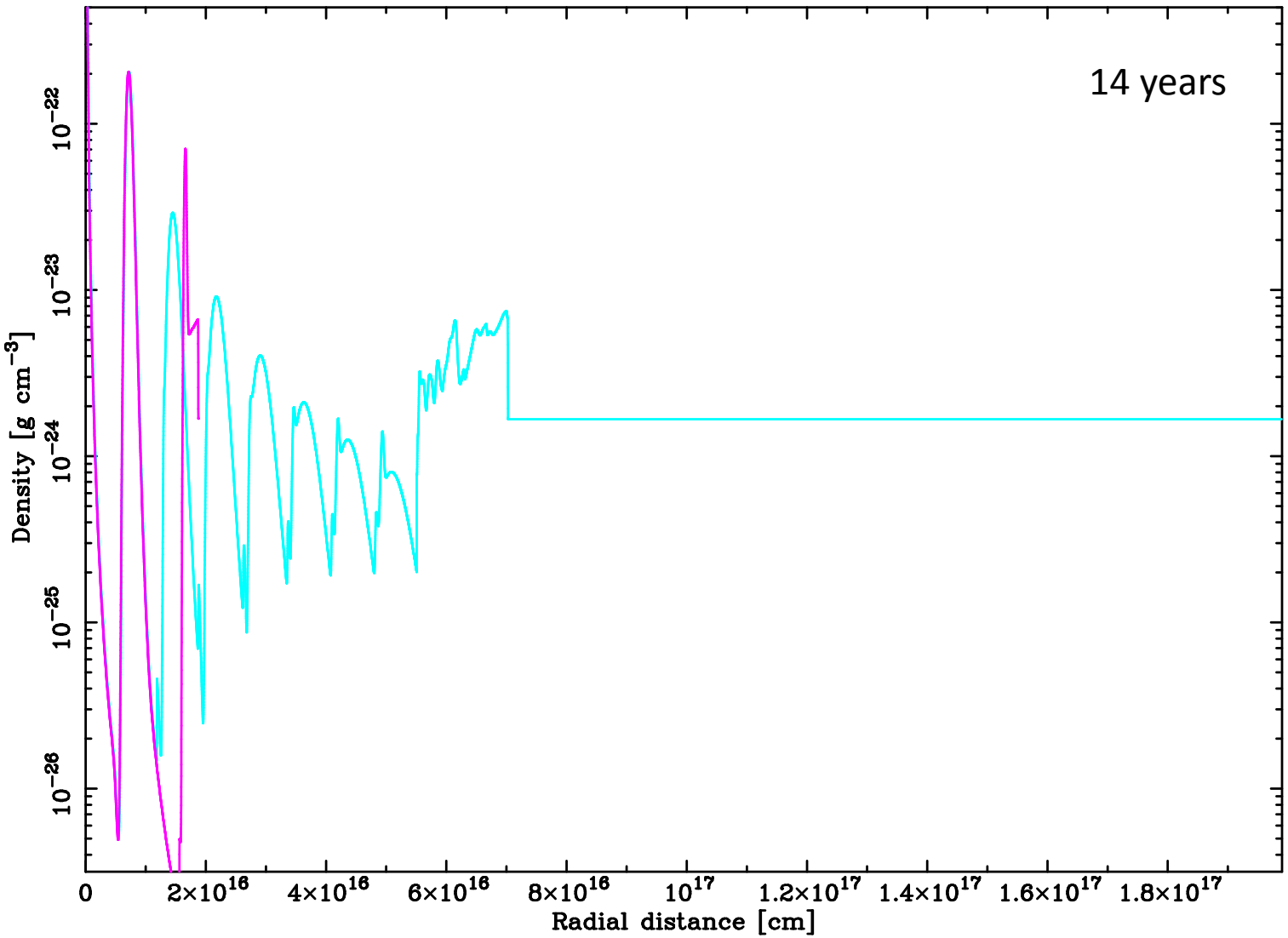

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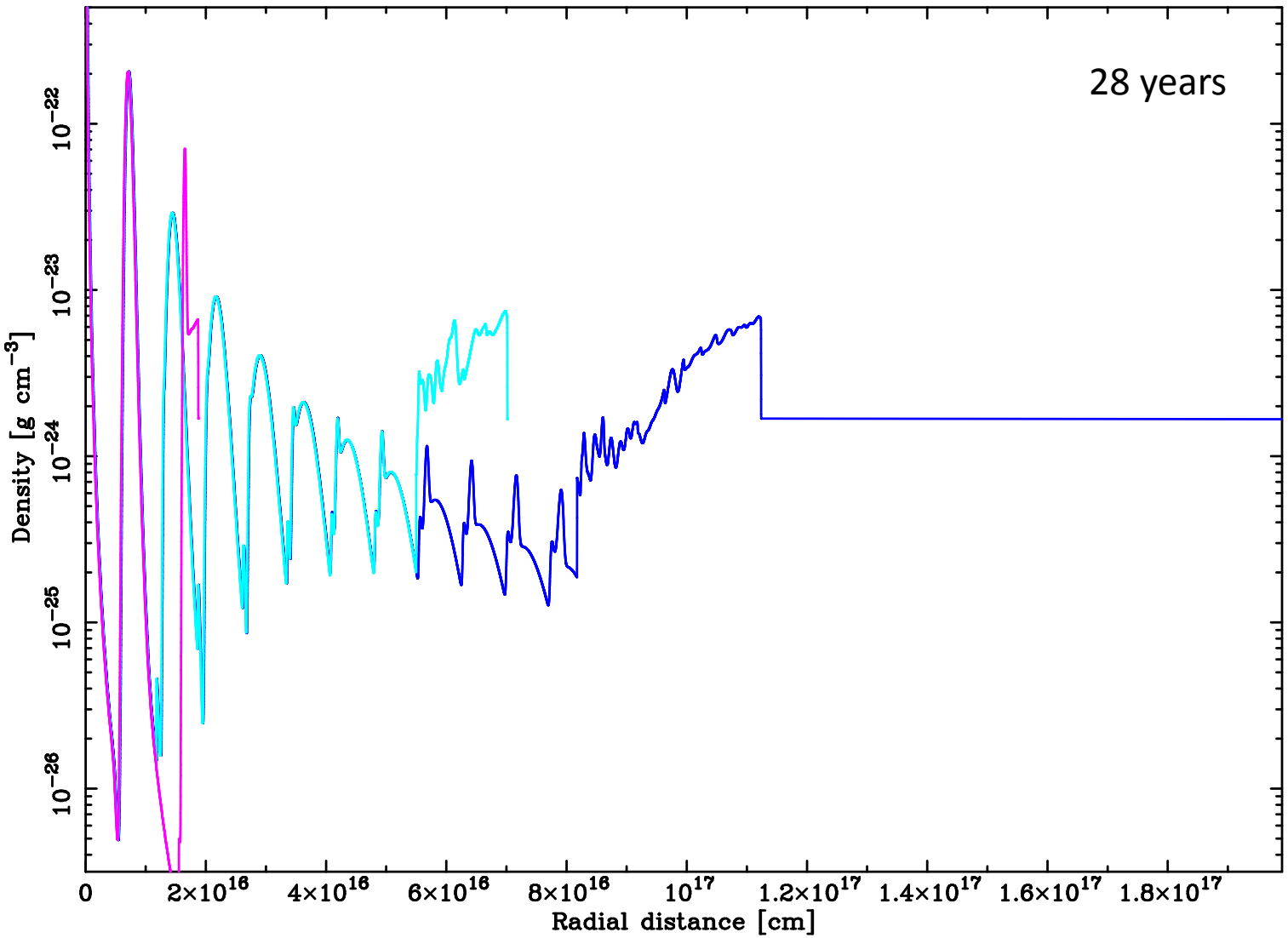

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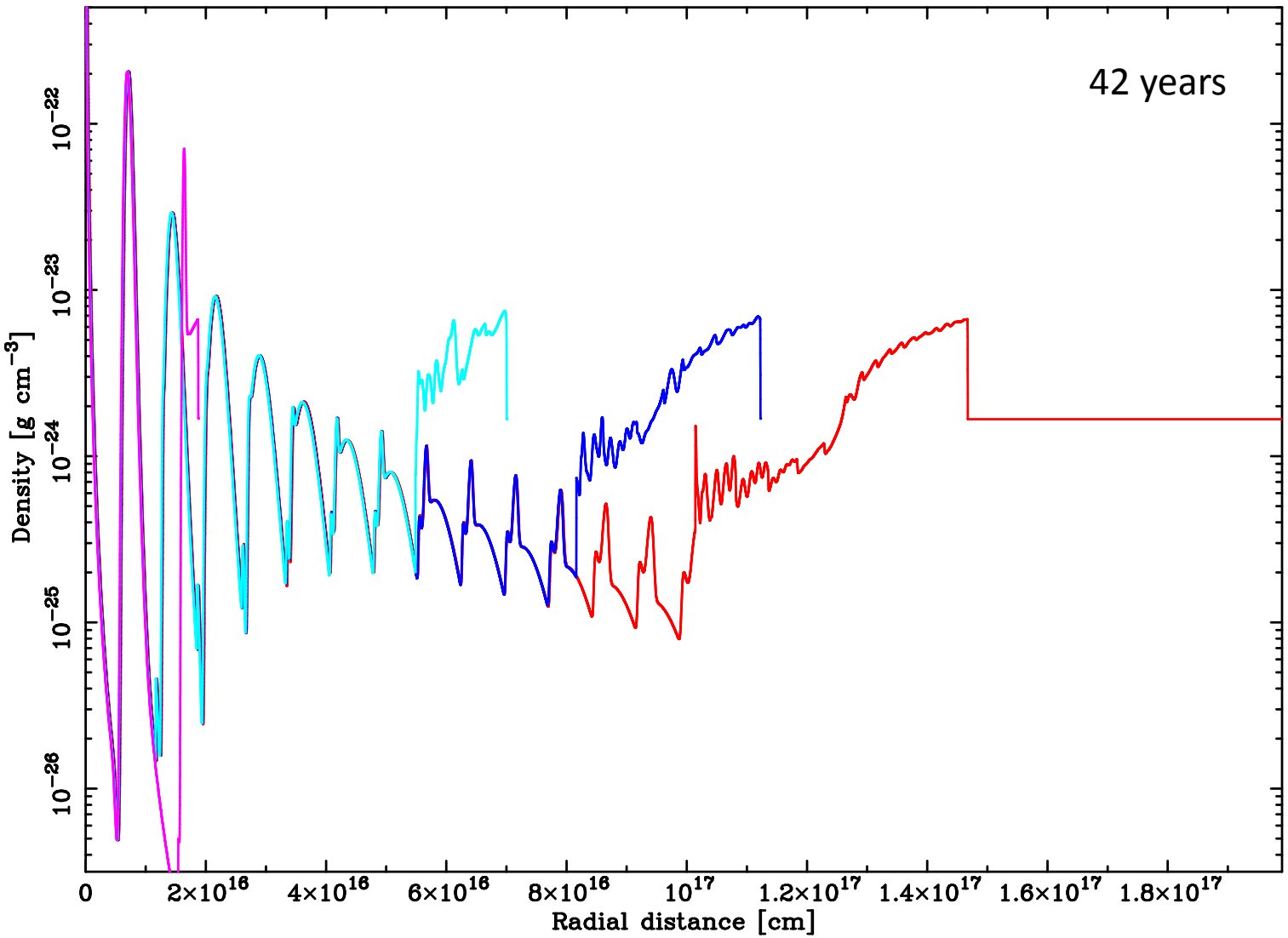

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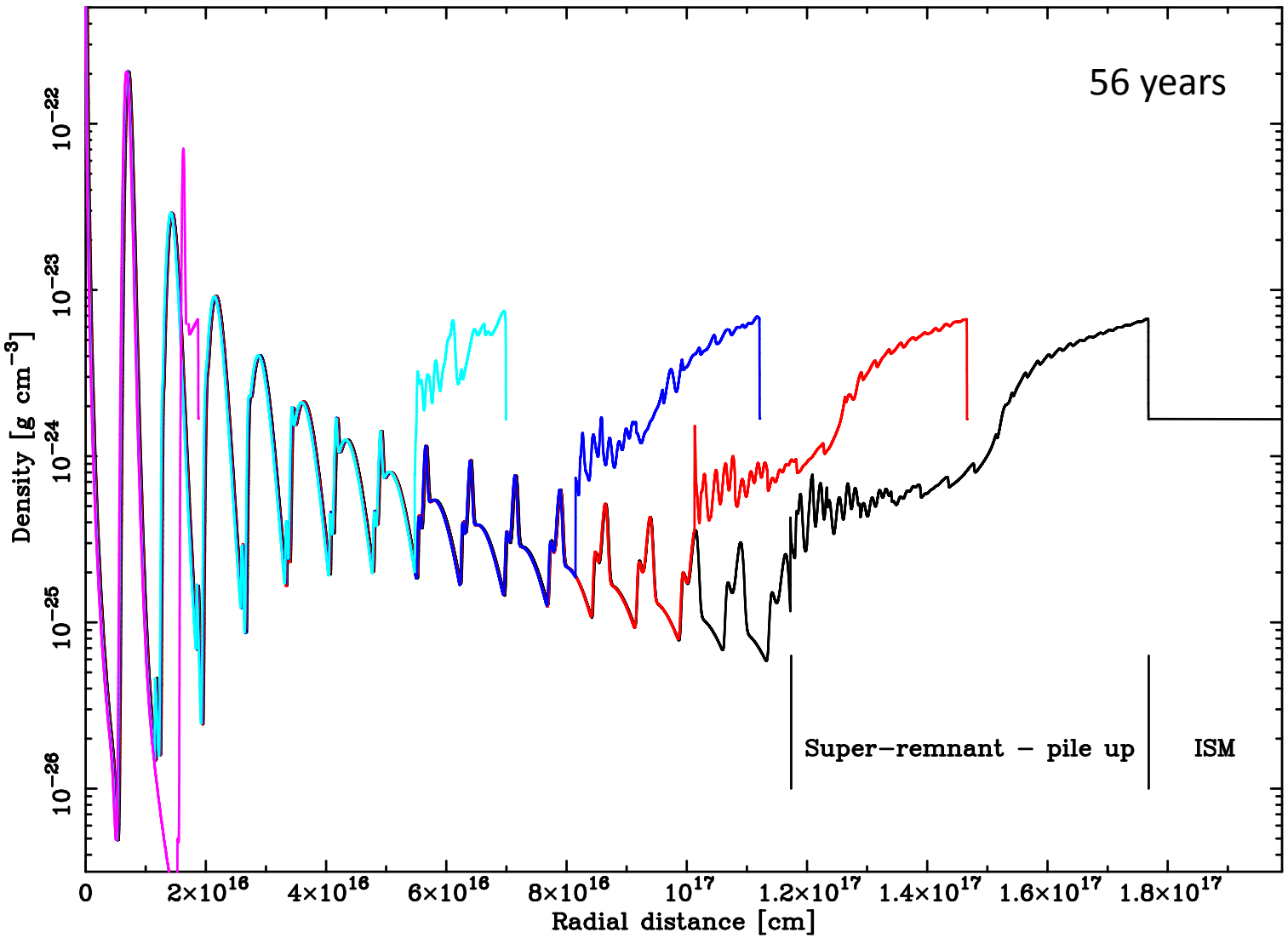
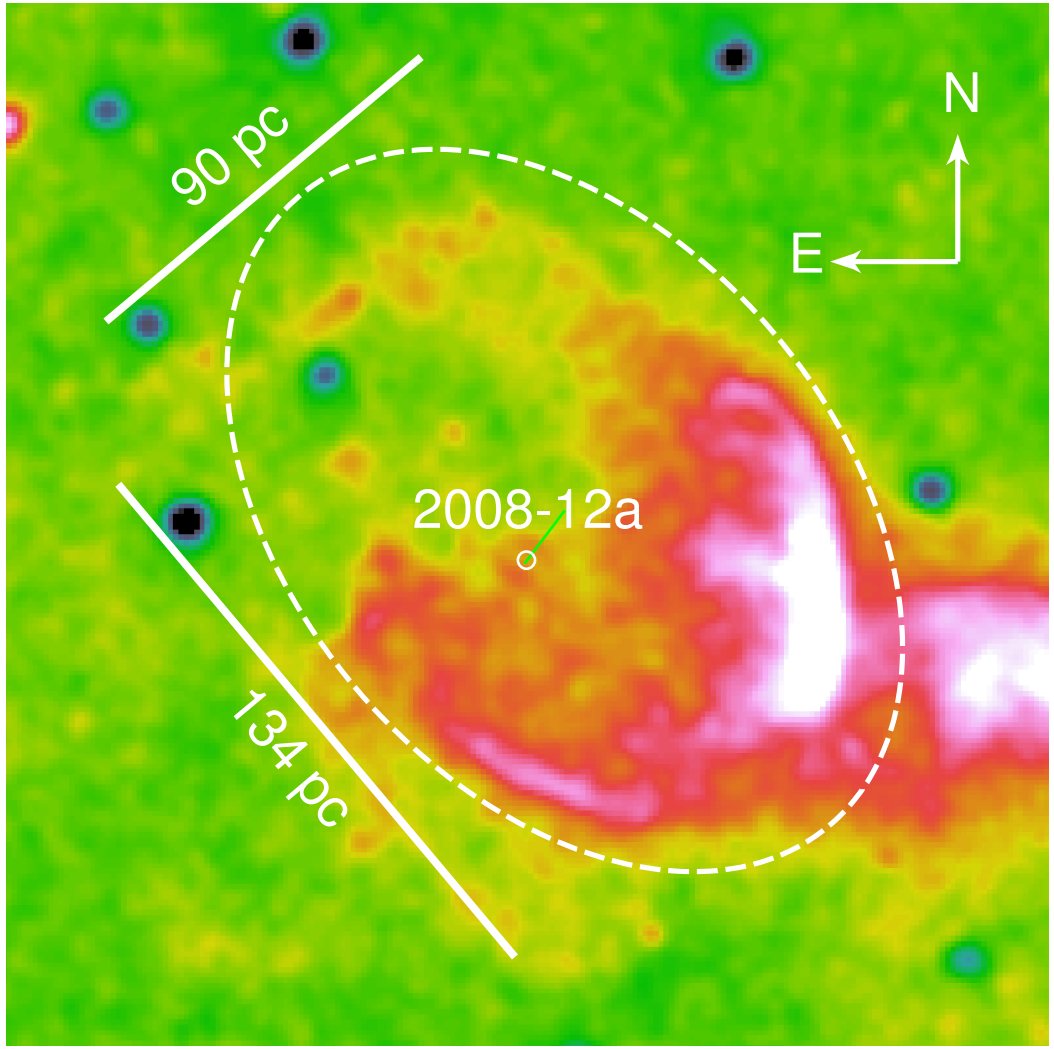
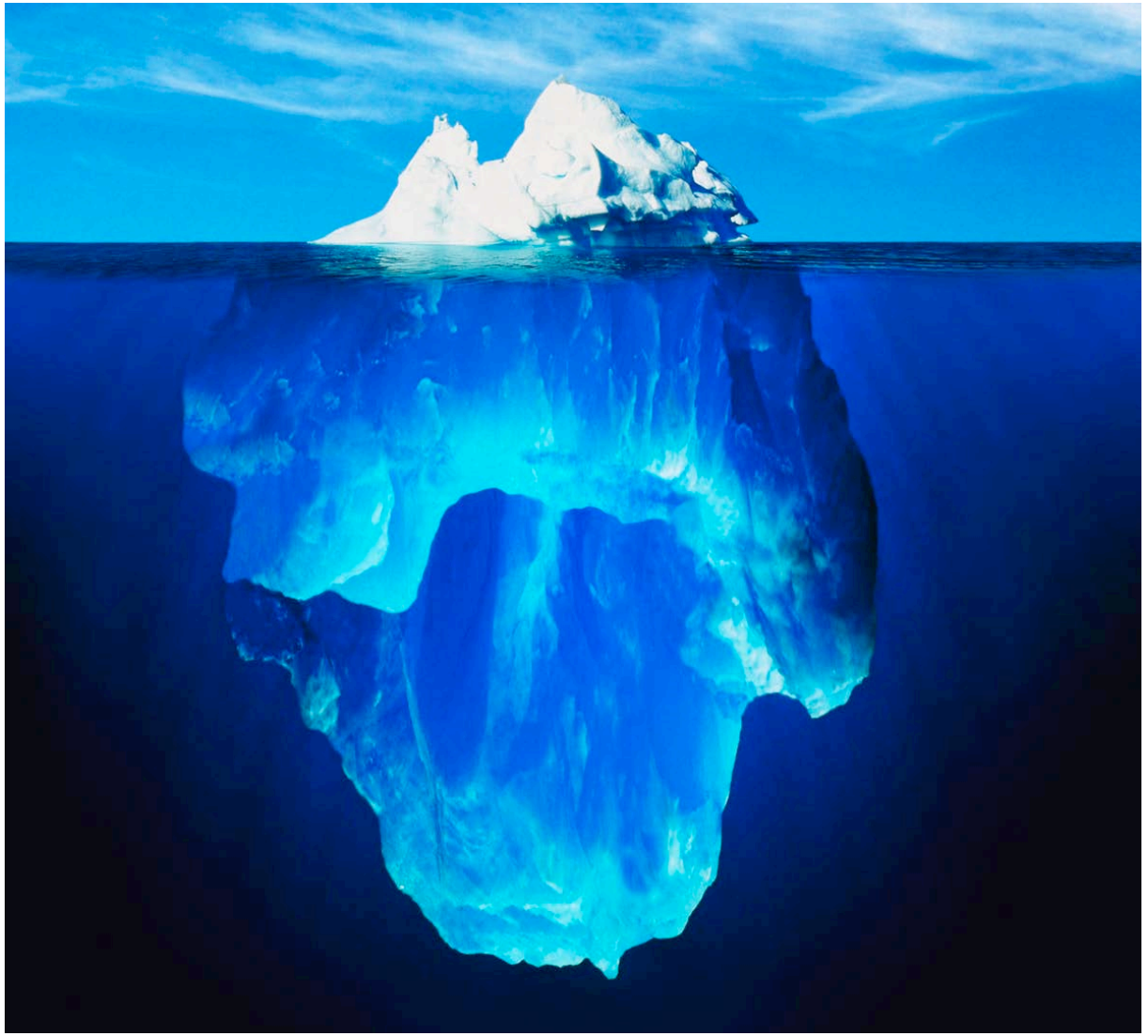


M31N 2008-12a – Nova Super Remnant!



M31N 2008-12a – A Remarkable Recurrent Nova

- 1 year RN driven by high mass WD and high mass accretion rate
- Rapid RNe probe the extremes of WD mass and accretion rate
- Provide compelling pre-explosion SN Ia candidate systems beyond Milky Way
- Discovering new RNe at a rate of knots…
- But are they rare, or have we just uncovered the tip of the iceberg?
- Are there still surprises out there?



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