

Luminous Red Novae

Arne Rau (Caltech)



Structure

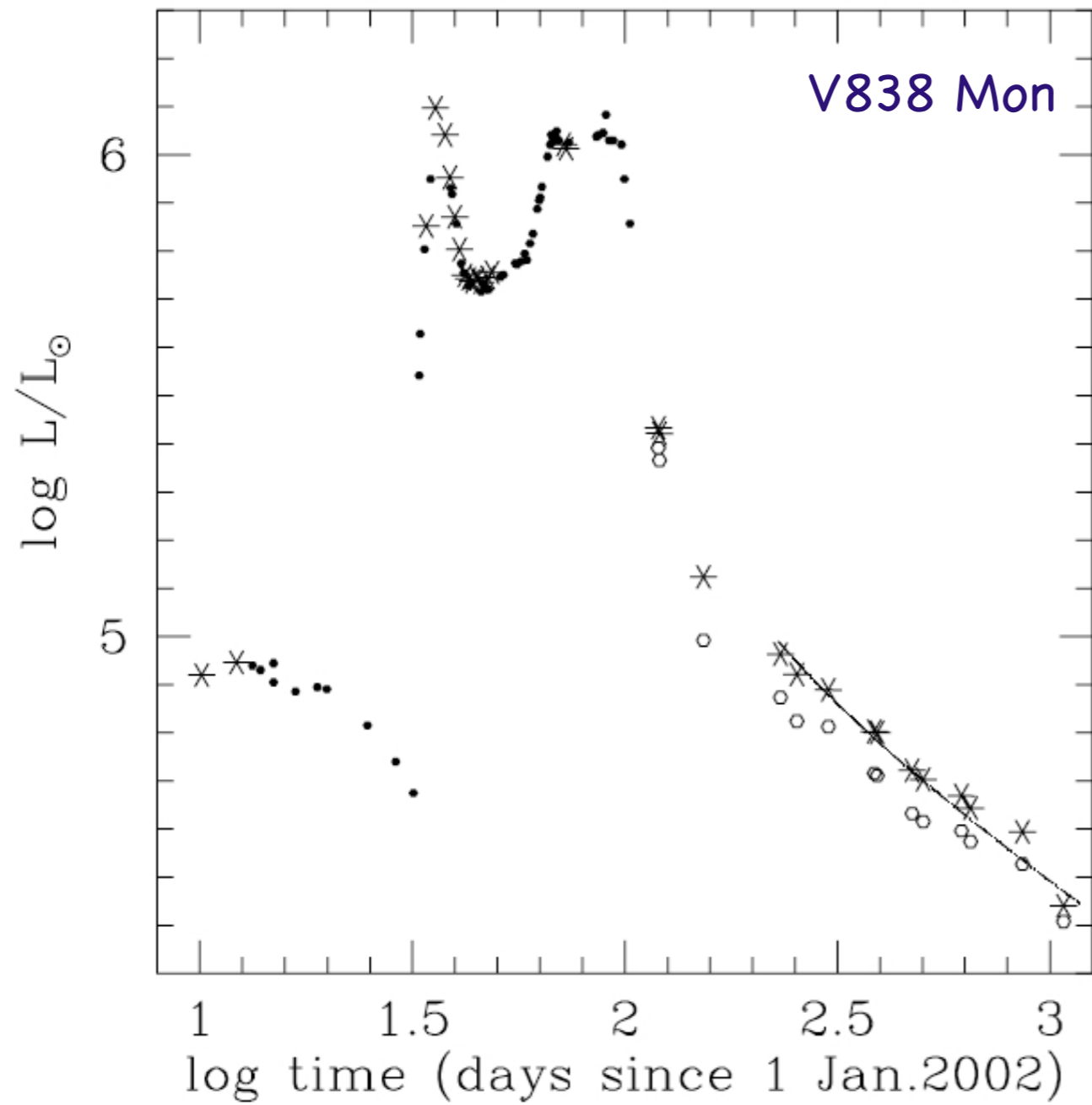
- ① Source Sample
- ① Observational Properties
- ① Theoretical Models
- ① Open Questions
- ① Searches Methods

The Current Sample

	M_{peak}	Distance	Progenitor	Reference
M31RV	< -9.8	M31	bulge pop. ?	Rich et al. 1989
V4332 Sgr	-3 to -8 *	1.2-13	KOV-F8III	Martini et al. 1999
V838 Mon	-9.7	$6.2 \pm 1.2 \text{ kpc}$	B-star cluster	Brown et al. 2002
Var Crux	[R=9.3]	?	?	Tabur et al. 2003
M85OT2006-1	-12	M85	$< 7M_{\odot}$	Kulkarni et al. 2007

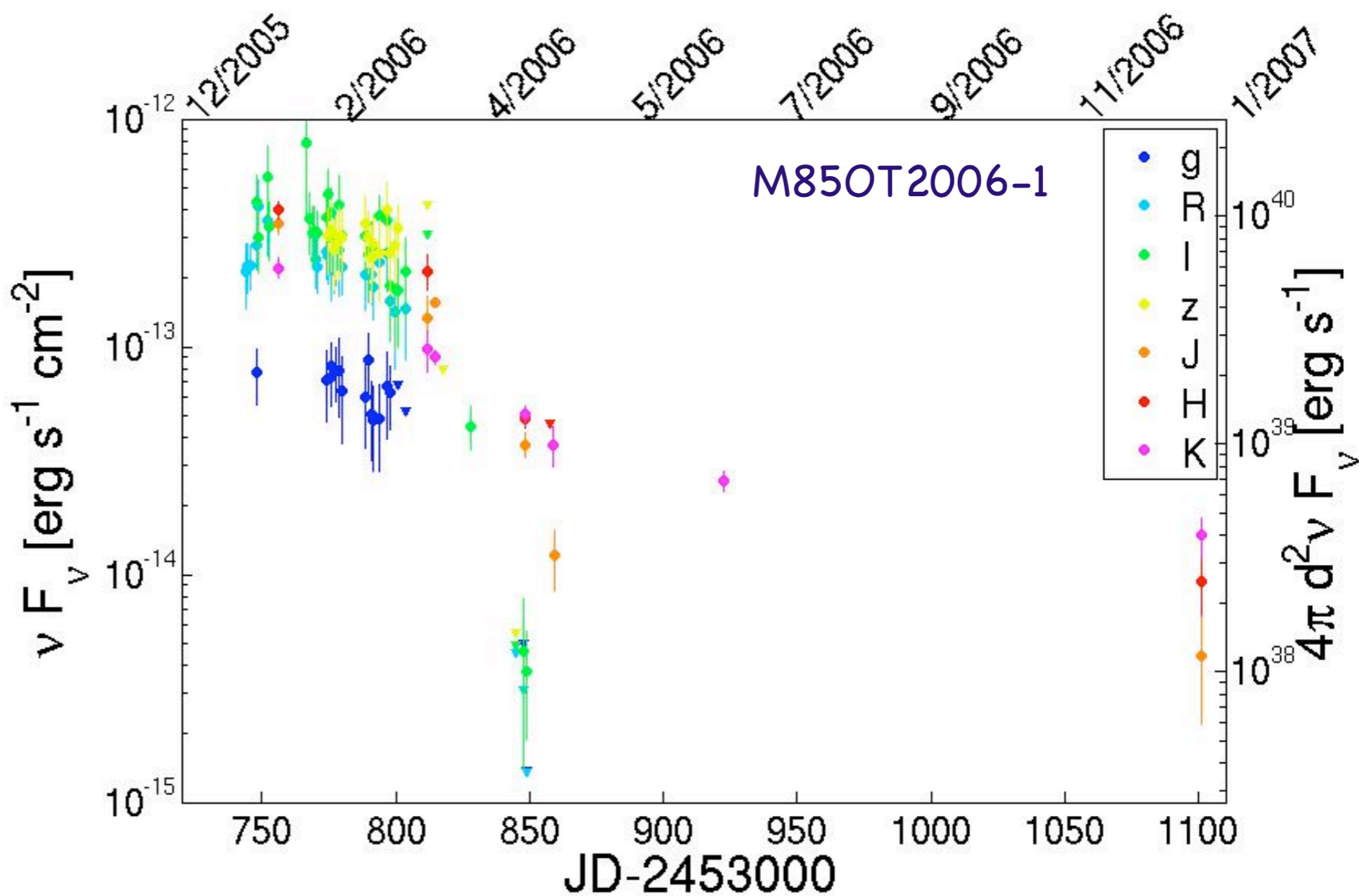
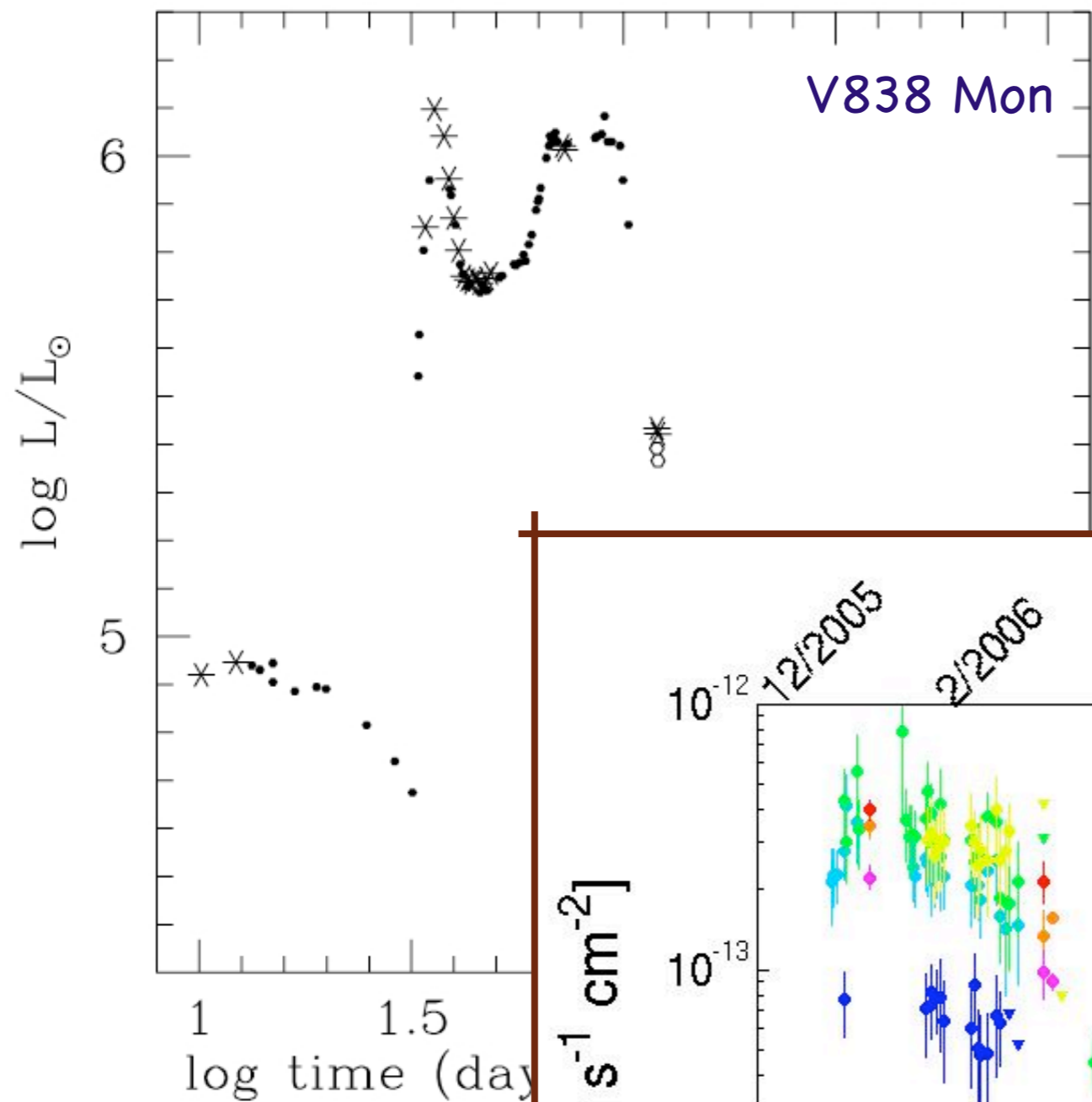
* $E(B-V)=0.32$ (Tylenda et al. 2005)

Photometric Evolution



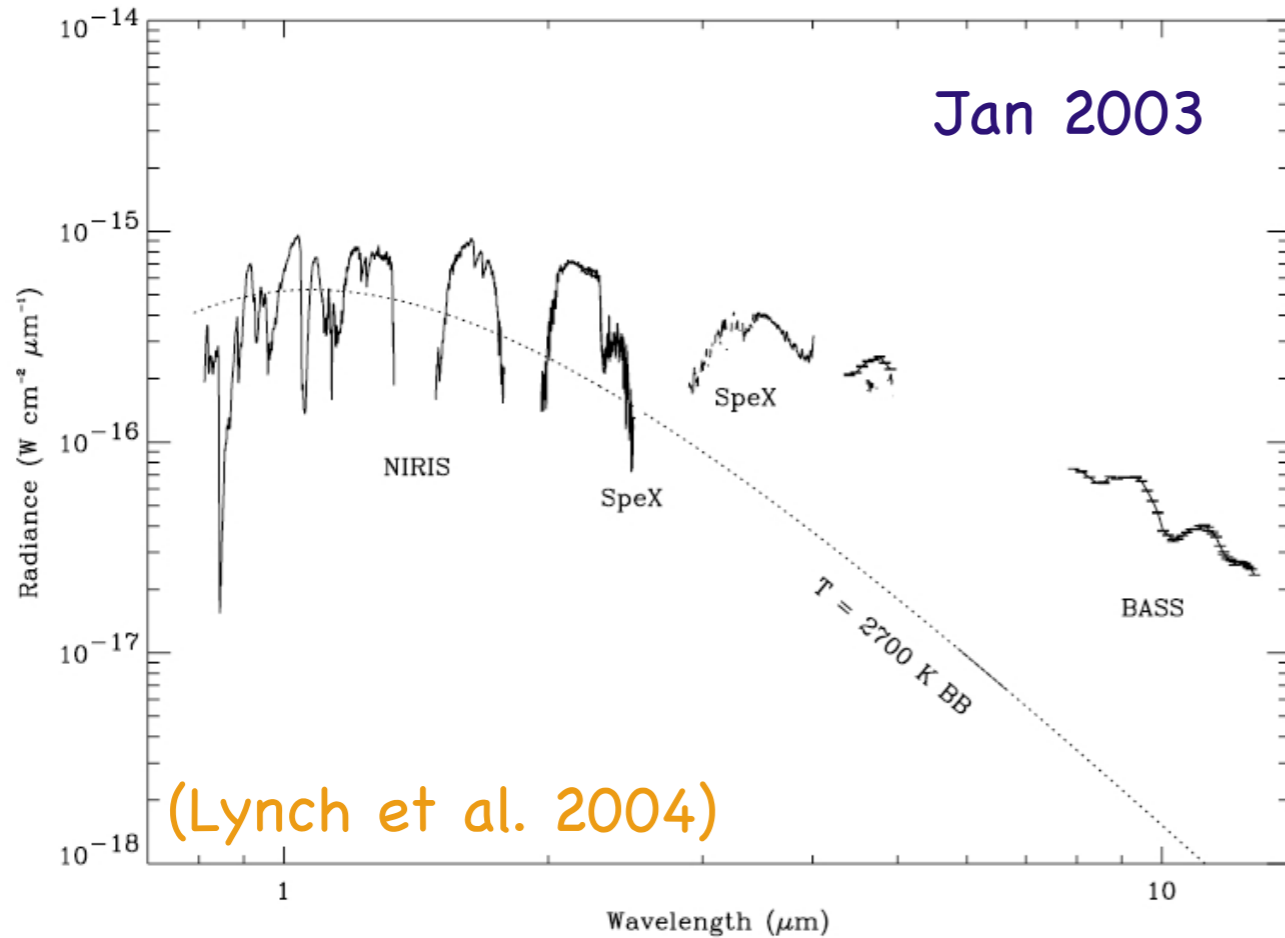
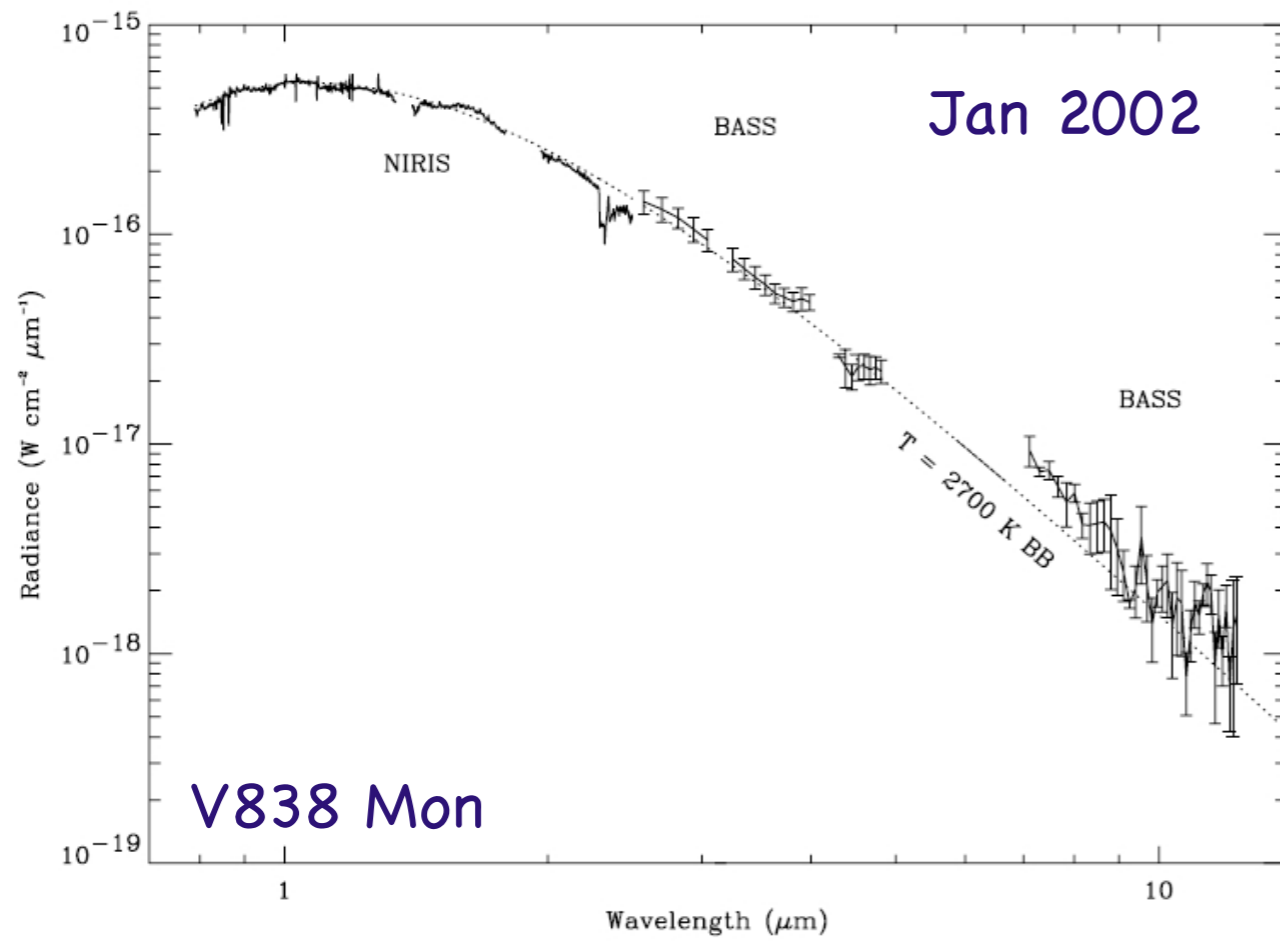
(Tylenda 2005)

Photometric Evolution

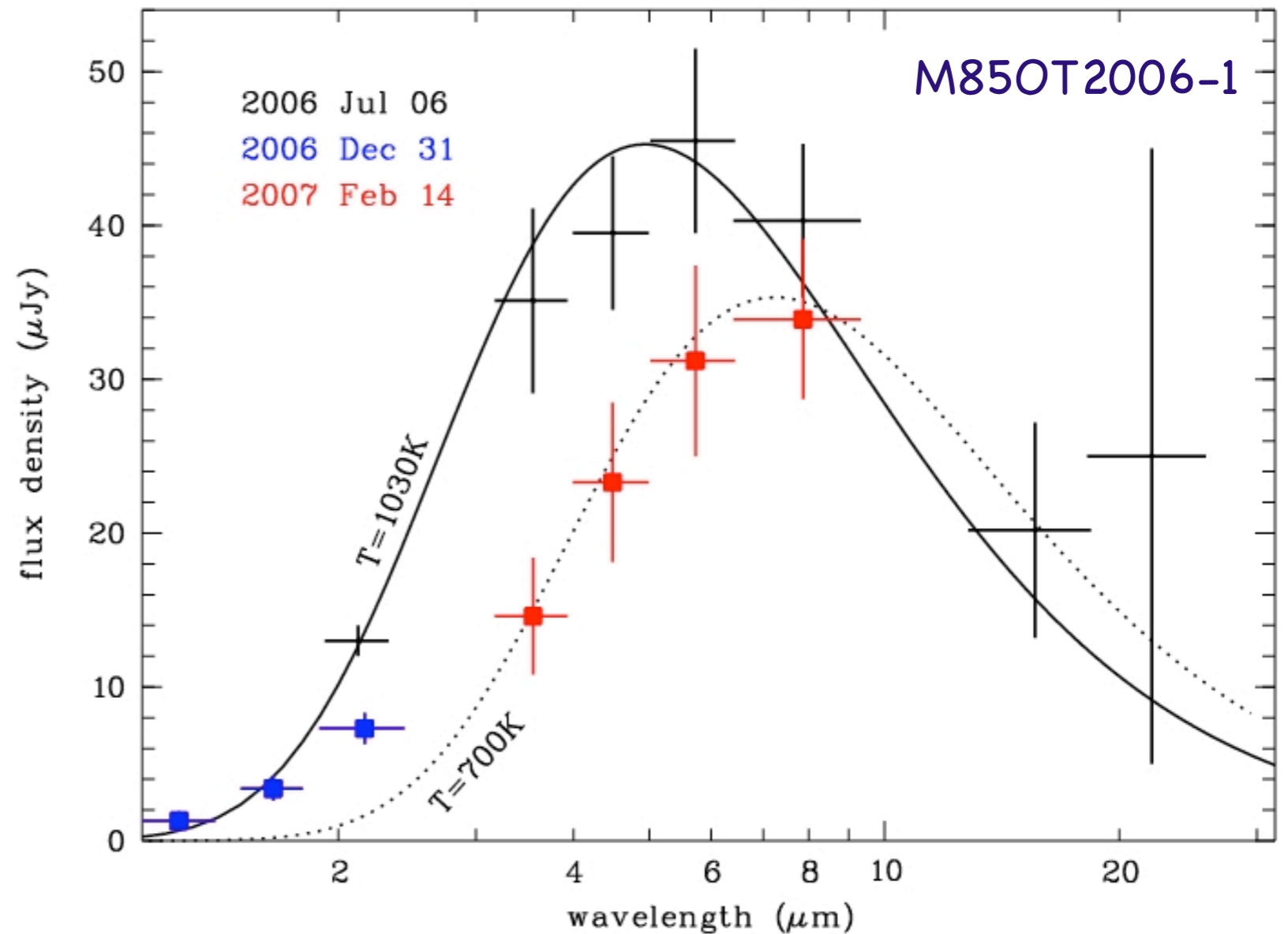
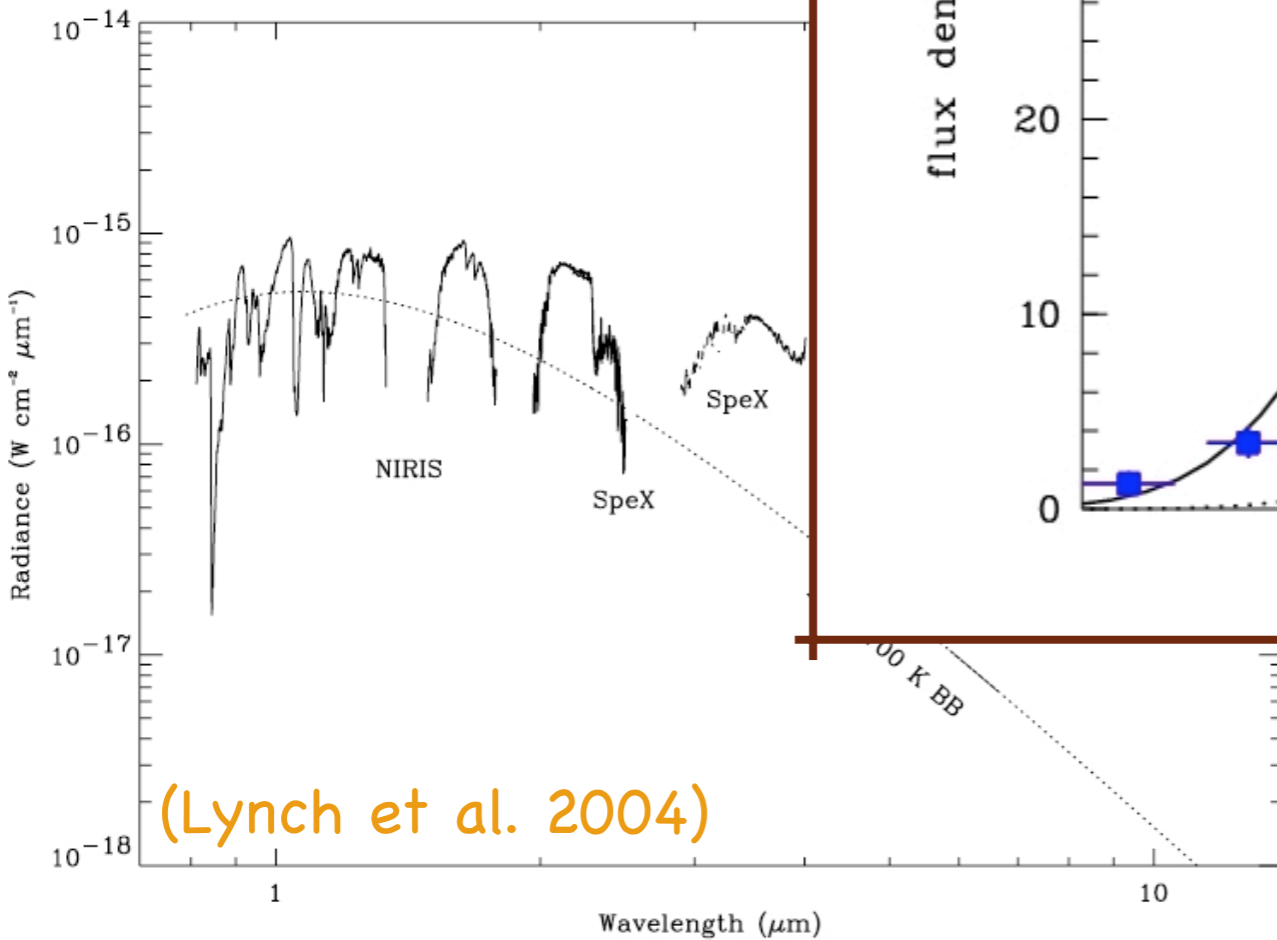
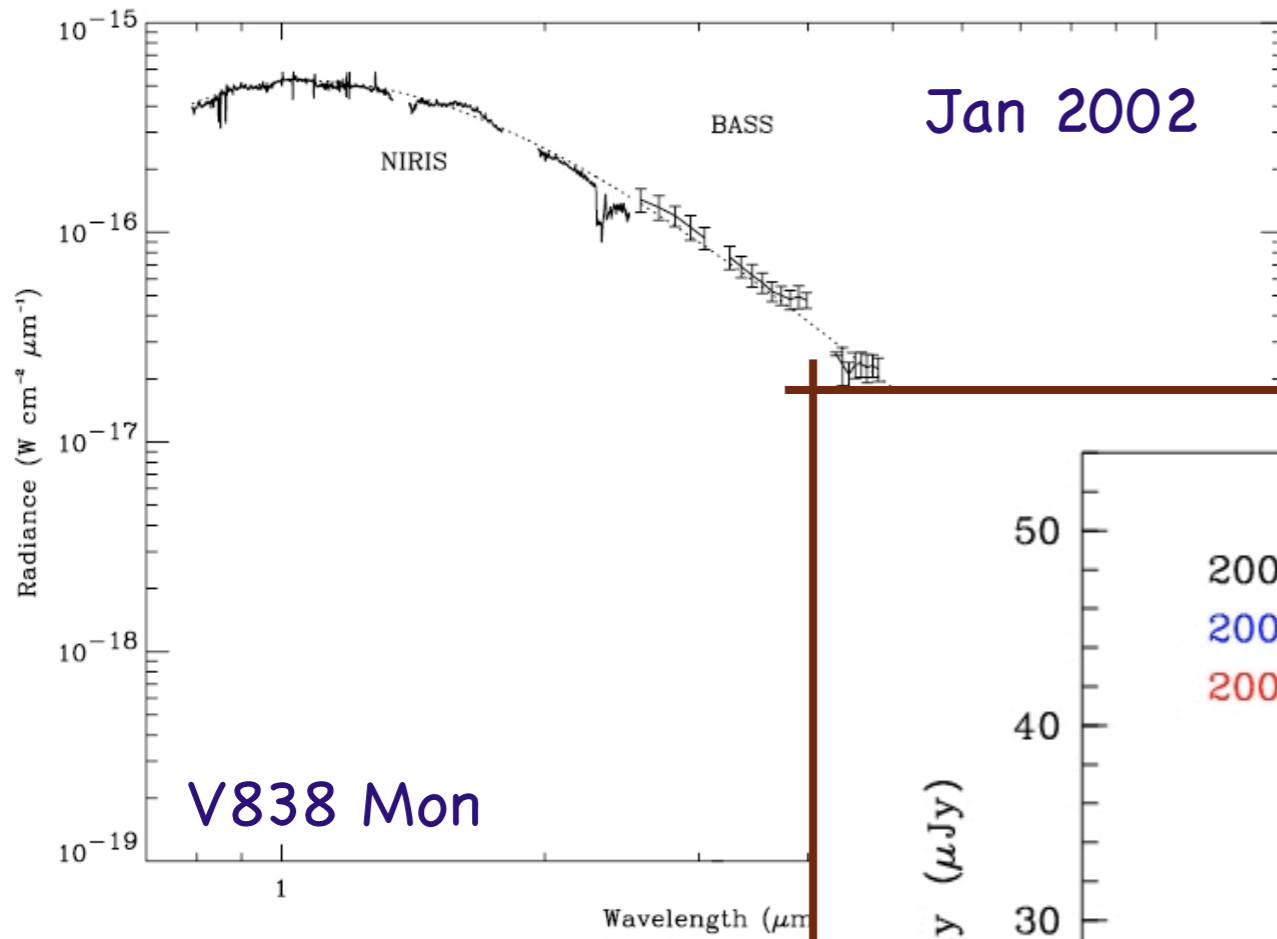


(Tylenda 2005)

An Emerging IR Component



An Emerging IR Component

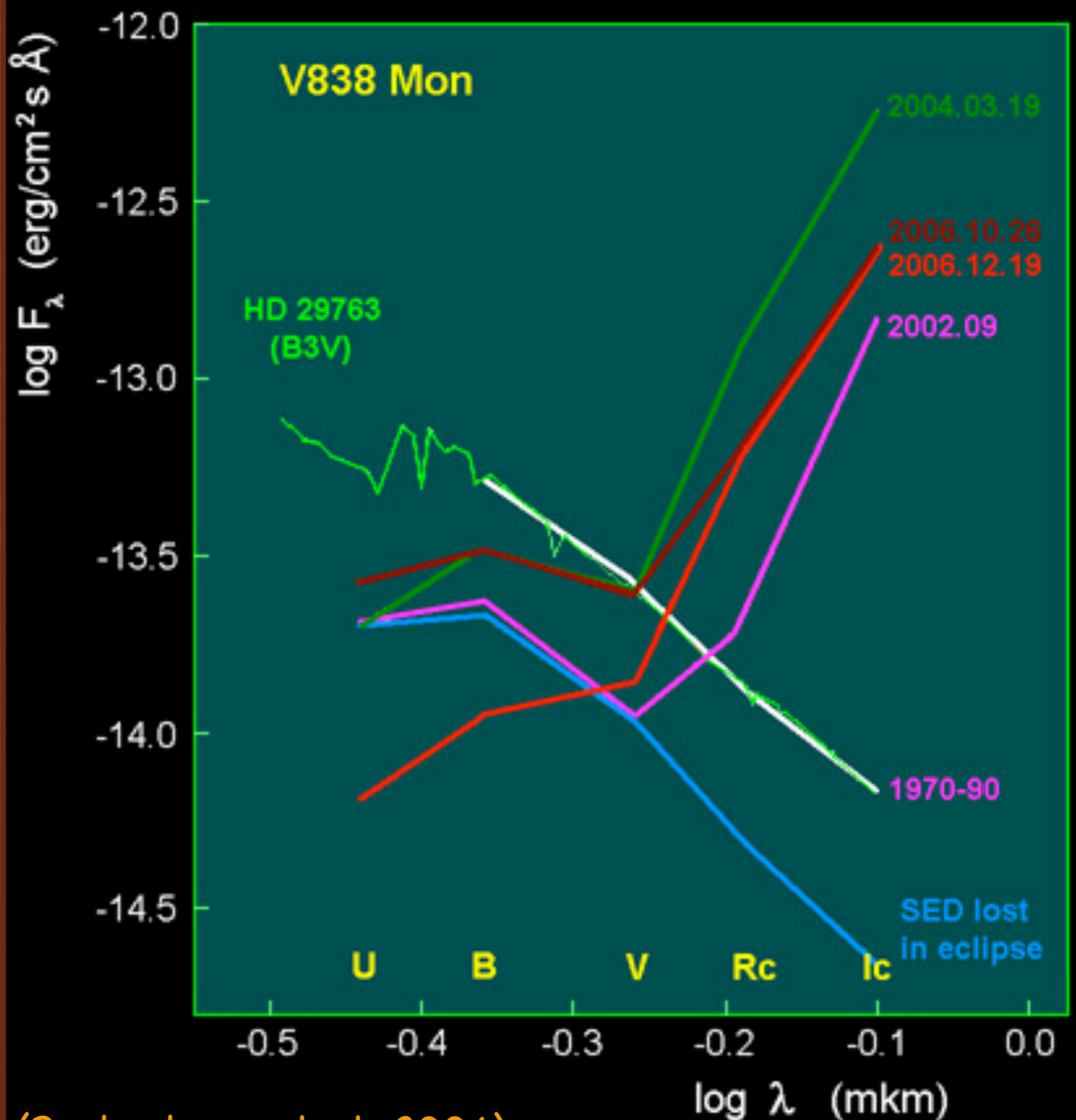


$L_{t=6\text{month}} = 10^{39} \text{ erg/s}$

$R_{t=6\text{month}} = 20000 R_{\odot}$

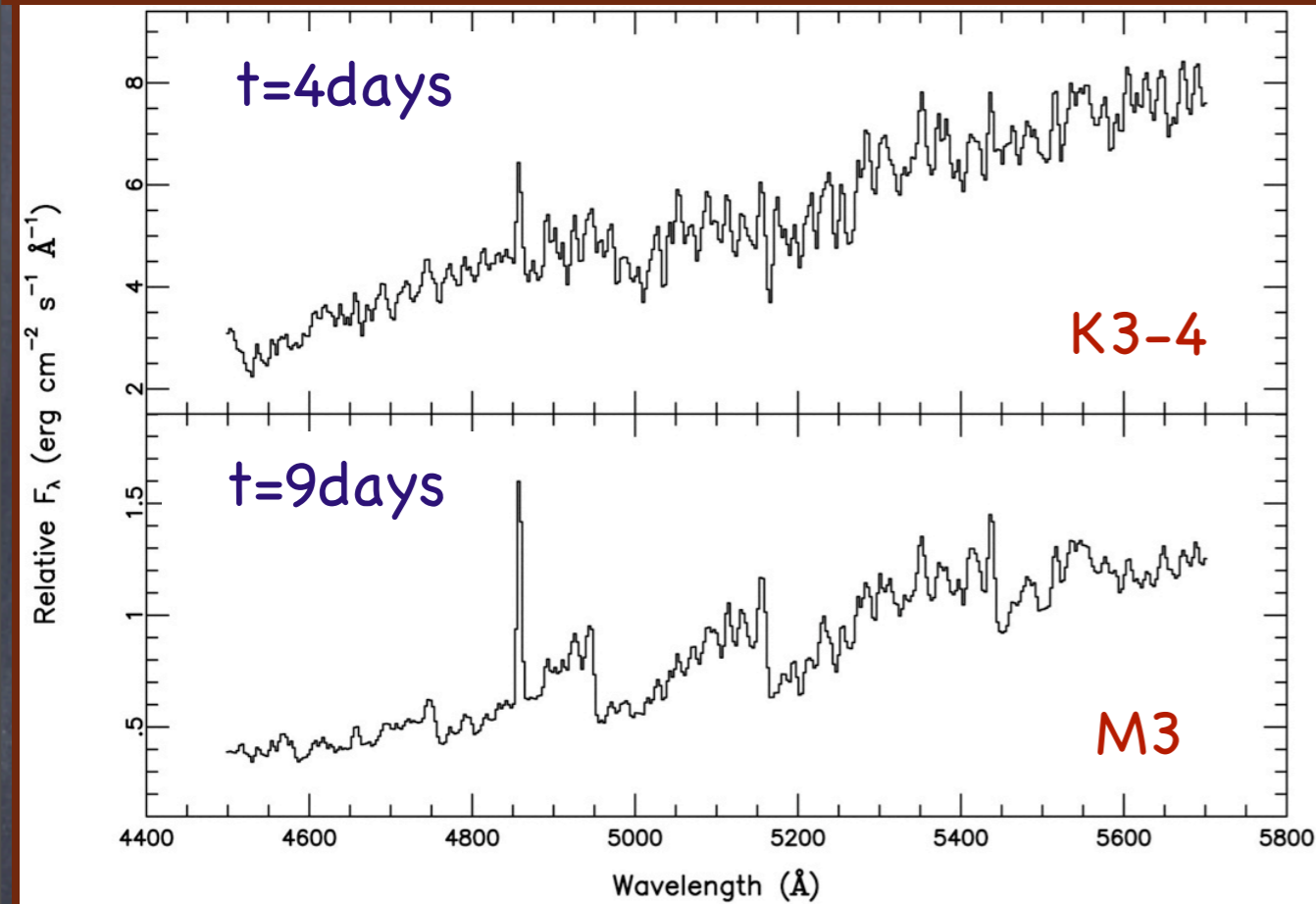
Long-term Evolution

- pre-OB: B3V
- post-OB: B3V + sgL
- eclipse: mainly sgL
- ejecta engulfs companion
- excess emission from ionization of ejecta by B3V

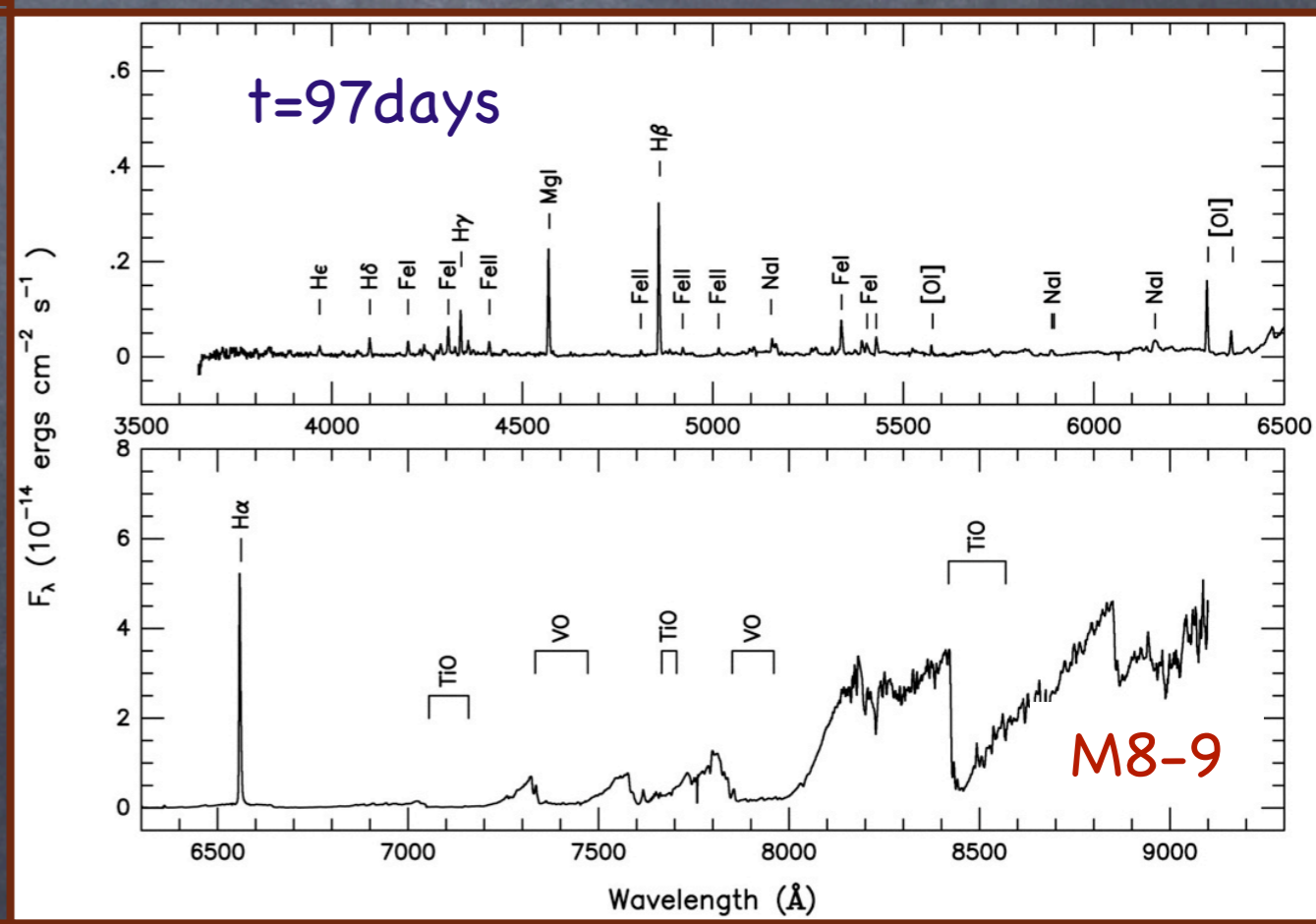
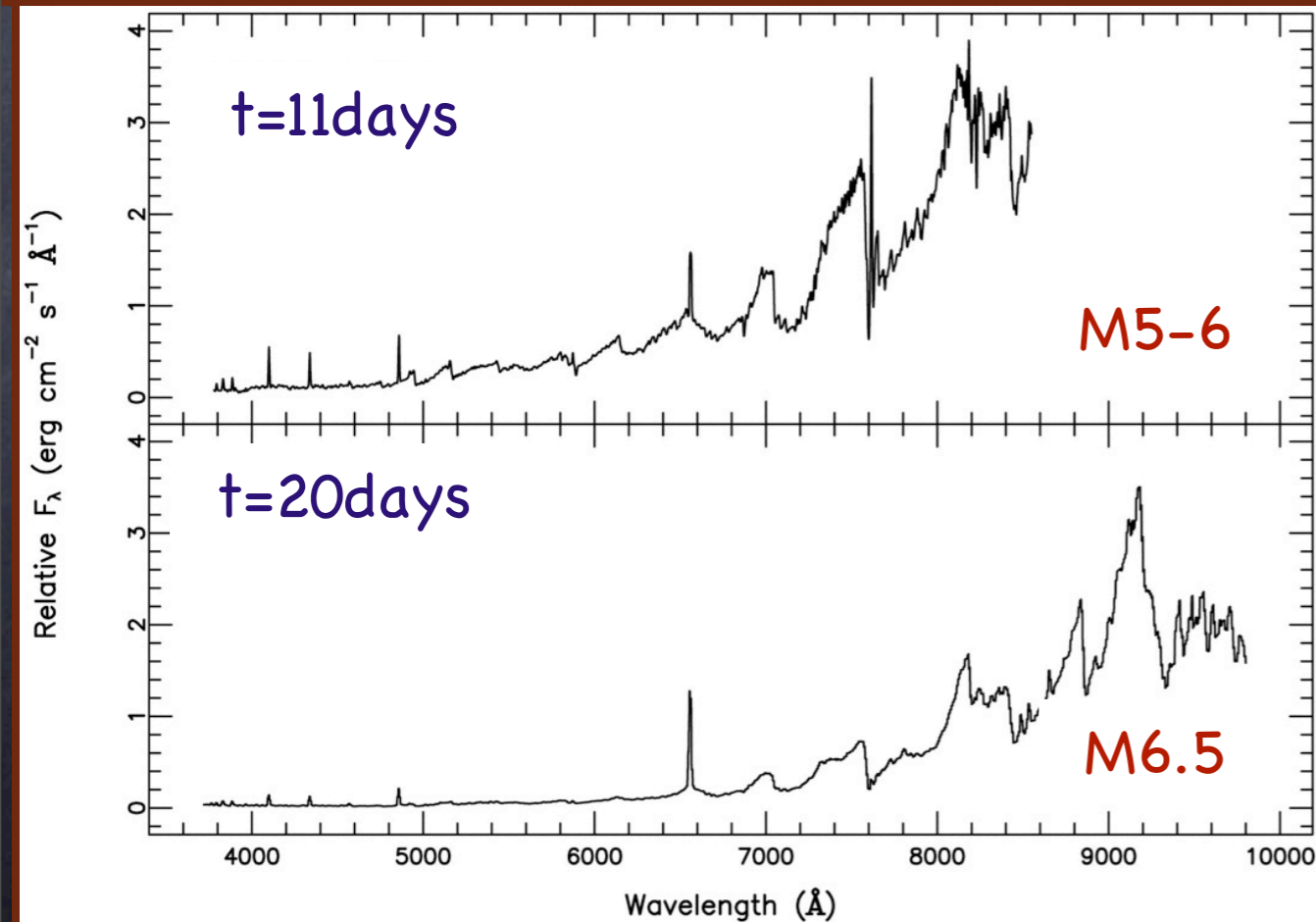


(Barksukova et al. 2004)

Spectral Evolution (V4332 Sgr)



- $H\alpha/H\beta$ (11days) = 2.4
- $H\alpha/H\beta$ (97days) = 17
- $N_e = 10^{8-9} \text{ cm}^{-3}$
- KI, RbI, TiO, ScO emission after 9 years



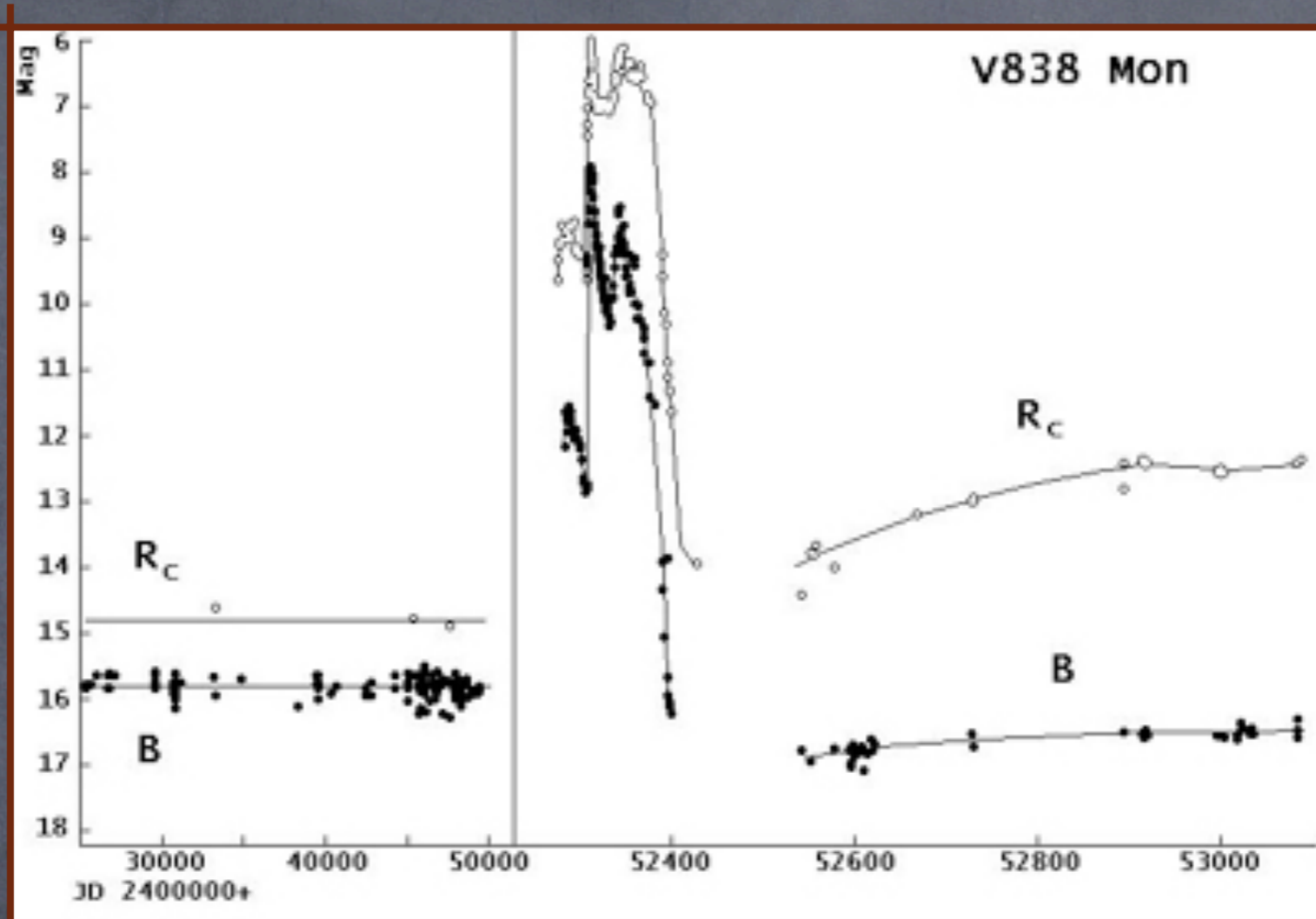
V838 Mon HST Light Echo



(Bond et al. 2003)

Stellar Merger

(V838 Mon) (Tylenda & Soker et al. 2005)

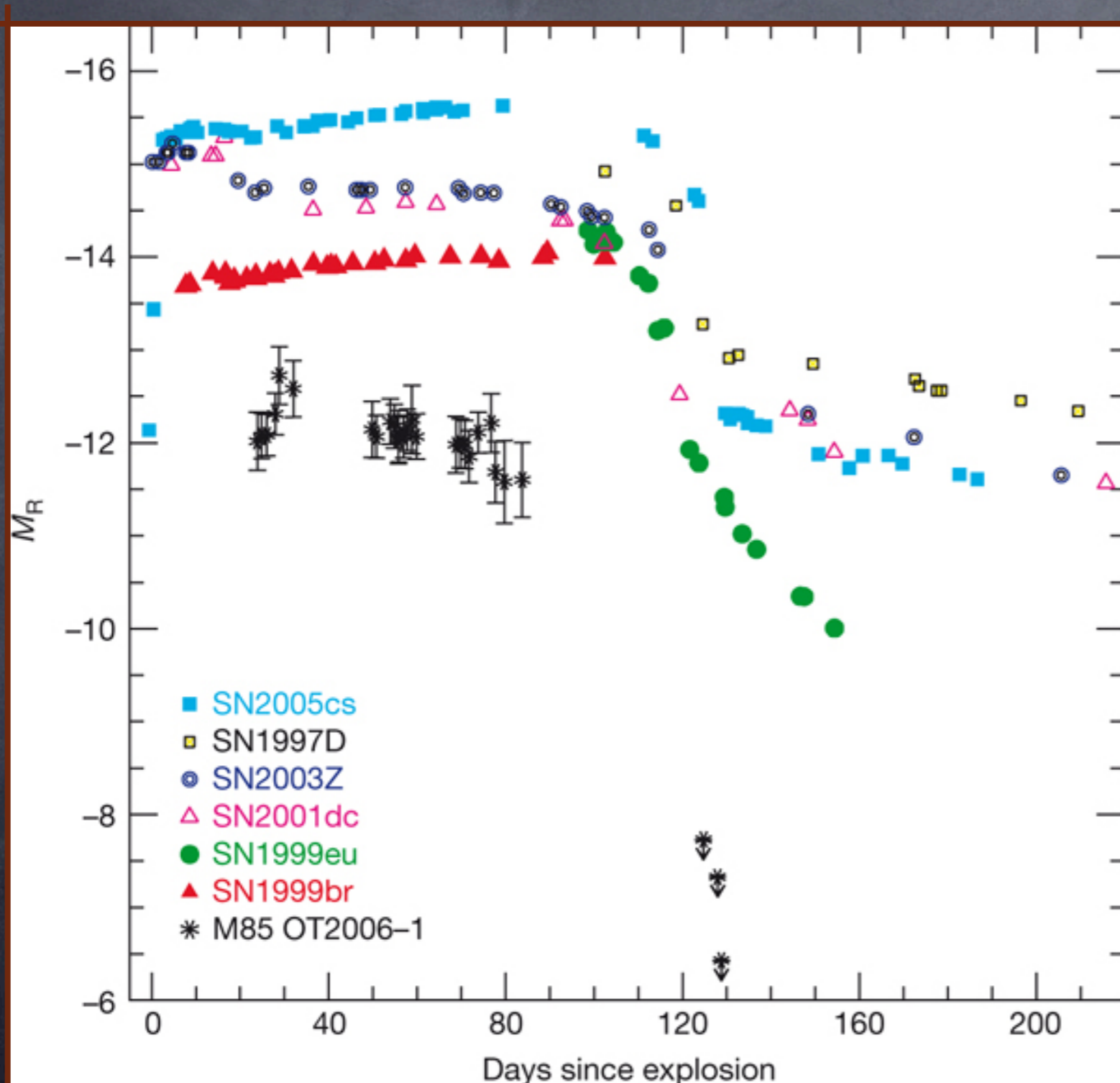


(Barksukova et al. 2004)

- triple system (MS+B3V+0.1–0.5M_☉ companion)
- low mass star accreted and forms inflated envelope
- multi-episode accretion as companion disrupts
- earlier periastron encounter may cause minor outbursts (seen in V4332 Sgr)

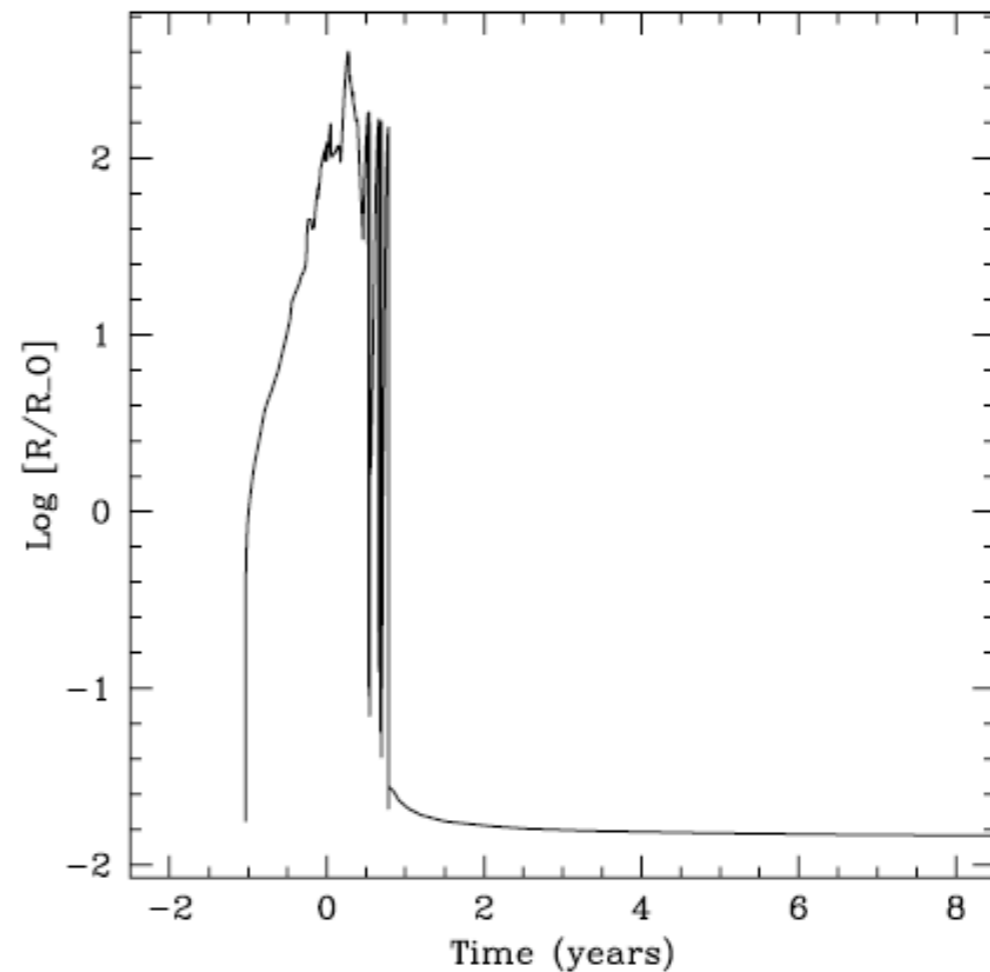
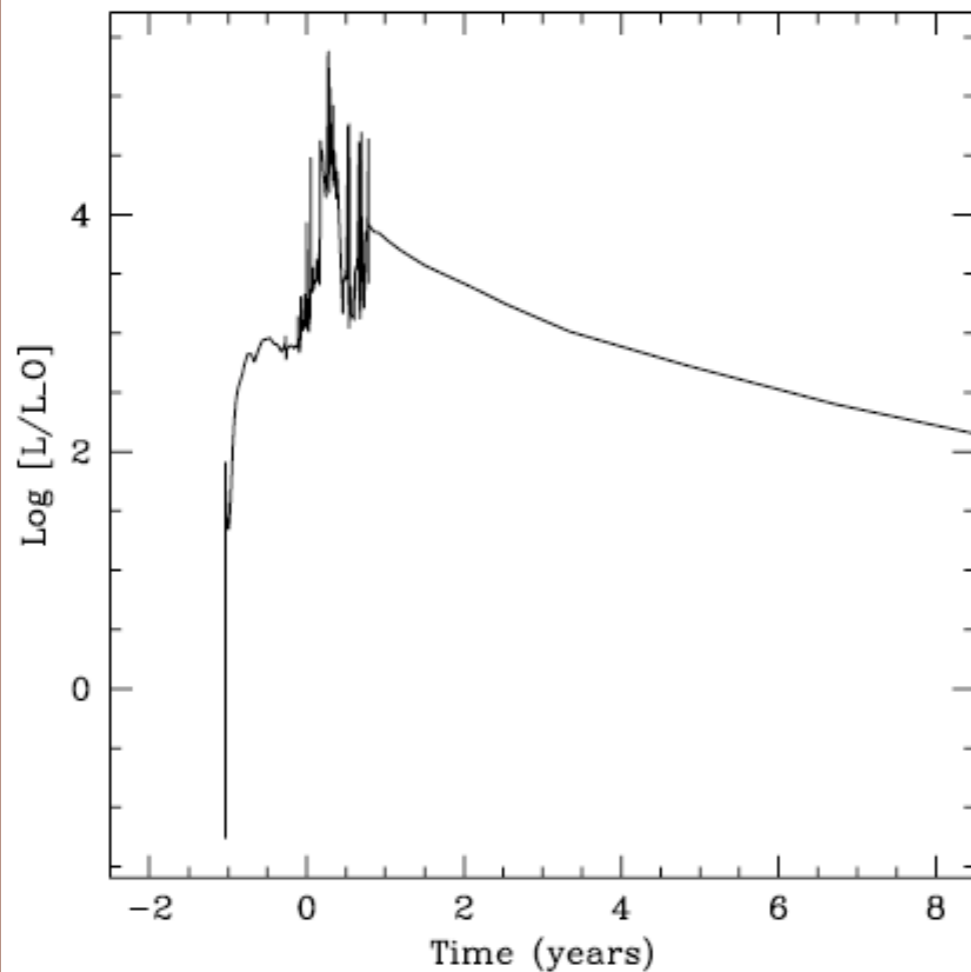
Low Luminosity type II-plateau SN

(for M85OT2006-1) (Pastorello et al. 2007)



- narrow (800+300 km/s) H α lines
- $N_i < 10^{-3} M_{\odot}$, 6-9 M_{\odot} ejected
- progenitor <12-15 M_{\odot} (B-M supergiant) from HST

Extreme Classical Novae (Shara et al. 2007)



- low mass ($0.5M_{\odot}$), cold ($2-4 \times 10^6 \text{K}$), low M_{acc} ($10^{-10} M_{\odot}/\text{yr}$)
- massive ($10^{-3..5} M_{\odot}$) H-rich envelopes
- massive ($10^{-3} M_{\odot}$) low- v (100-400 km/s) ejecta - dust/molecule formation
- predicts high-O abundances (as in V838 Mon) and $T > 10^6 \text{K}$ WD remnant (claimed for M31RV)

Open Questions

Observations

- large peak brightness range (-3 to -12)
- single vs multiple outburst
- late time differences (photometric and spectroscopic)
- P Cyg lines in all but V4332 Sgr (inverse)
- old (M85OT, M31RV, V4332 Sgr) vs young (V838 Mon) stellar population

Theory

- stellar merger vs massive novae vs faint CCSNe vs ...

Search Methods - Optical

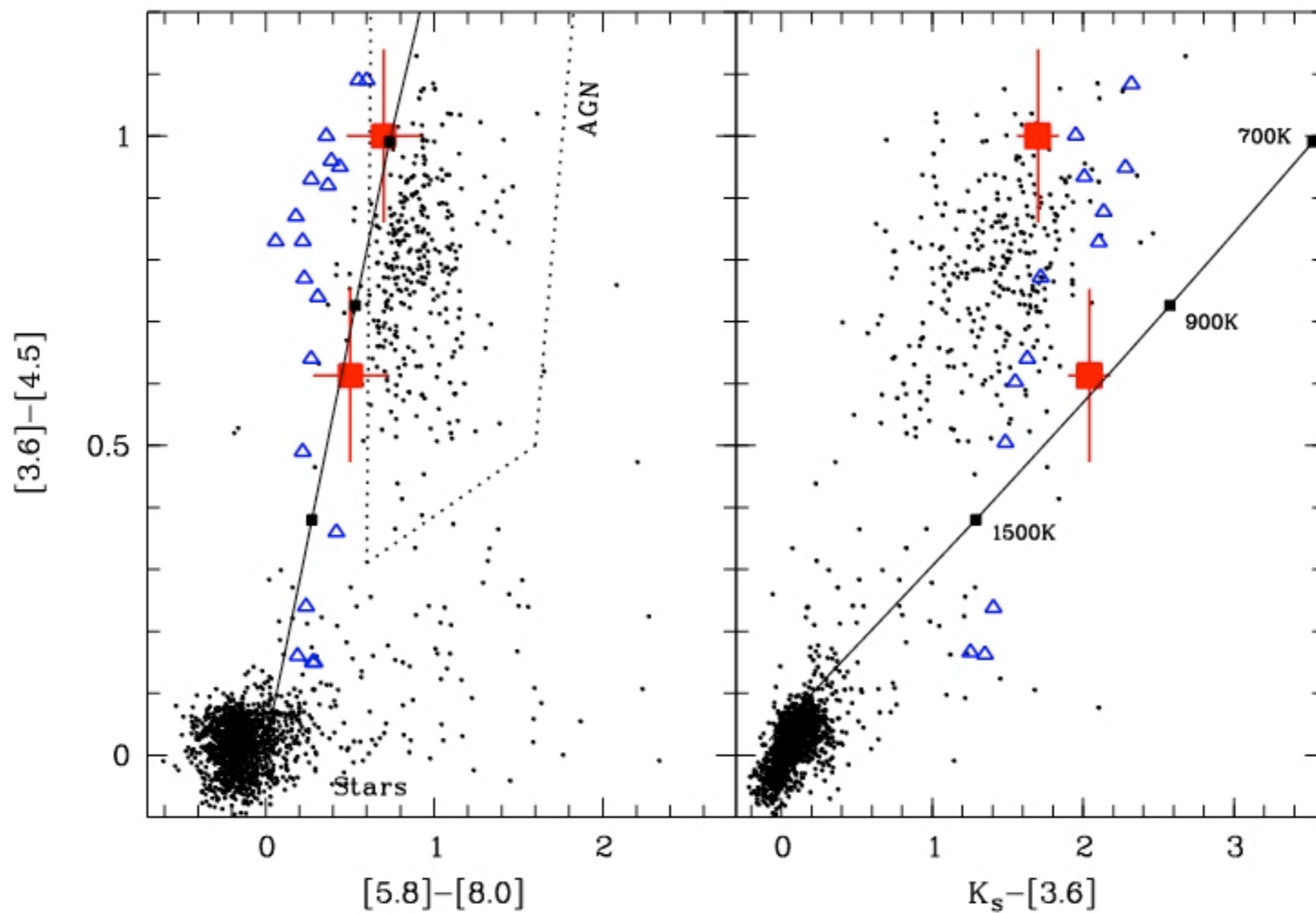
- **Rates:** $0.016 \text{ yr}^{-1} L_{\text{MW}}^{-1}$ from known number of events (Ofek et al. 2007) and theory of stellar mergers (Soker & Tylenda 2006)

	r_{lim}	Distance (Mpc)	events year ⁻¹
PTF (optimistic*)	20	40	>10
LSST (optimistic*)	24	150	~3500
LSST (realistic**)	23	40	~70

*optimistic = M85OT-like

**realistic = V838Mon-like

Search Methods - Infrared



(Rau et al. 2007)

Summary

- **very small sample** of long-lasting transients in brightness gap between novae and supernovae
- **low velocity** ejecta with strong **redward evolution** indicating dust condensation
- explosion mechanism **independent of stellar population?**
- merging stars, unusual bright novae or faint supernovae
- **1 event every 10-50 years** per MW-like galaxy
- $10-10^3$ events with PTF to LSST

