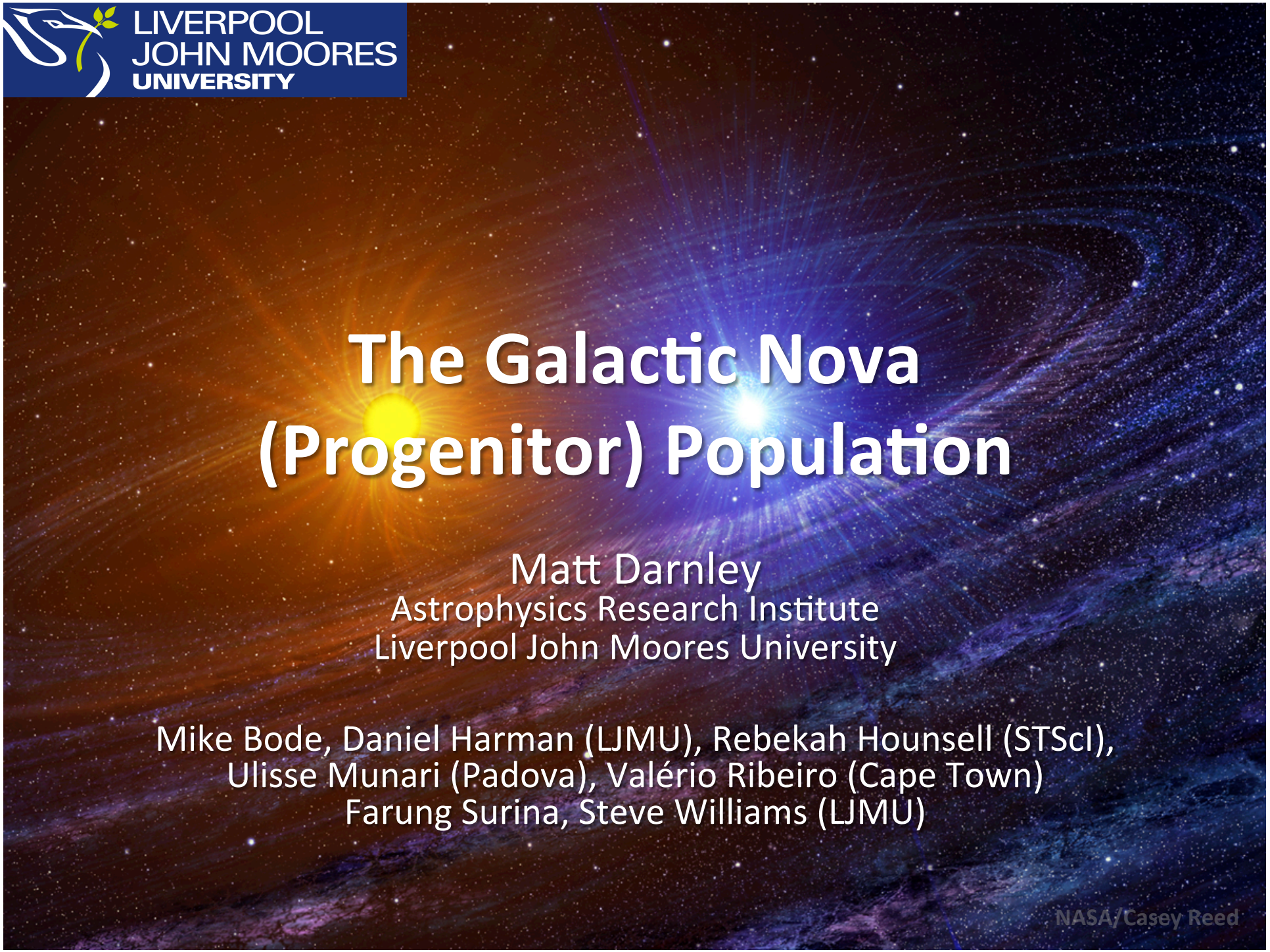

LIVERPOOL
JOHN MOORES
UNIVERSITY
The Galactic Nova
(Progenitor) Population
Matt Darnley
Astrophysics Research Institute
Liverpool John Moores University
Mike Bode, Daniel Harman (LJMU), Rebekah Hounsell (STScI),
Ulisse Munari (Padova), Valério Ribeiro (Cape Town)
Farung Surina, Steve Williams (LJMU)
NASA/Casey Reed

Talk Contents

- Introduction
- Novae with SMEI
- Classical vs Recurrent Novae
- M31N 2007-12b – Extragalactic RN(?) Progenitor
- Galactic Recurrent Nova Candidates
- LMC Recurrent Nova Progenitor
- Galactic Progenitor Population
- Link to Type Ia Supernova Progenitors
- Relevance to Extragalactic Studies

SMEI

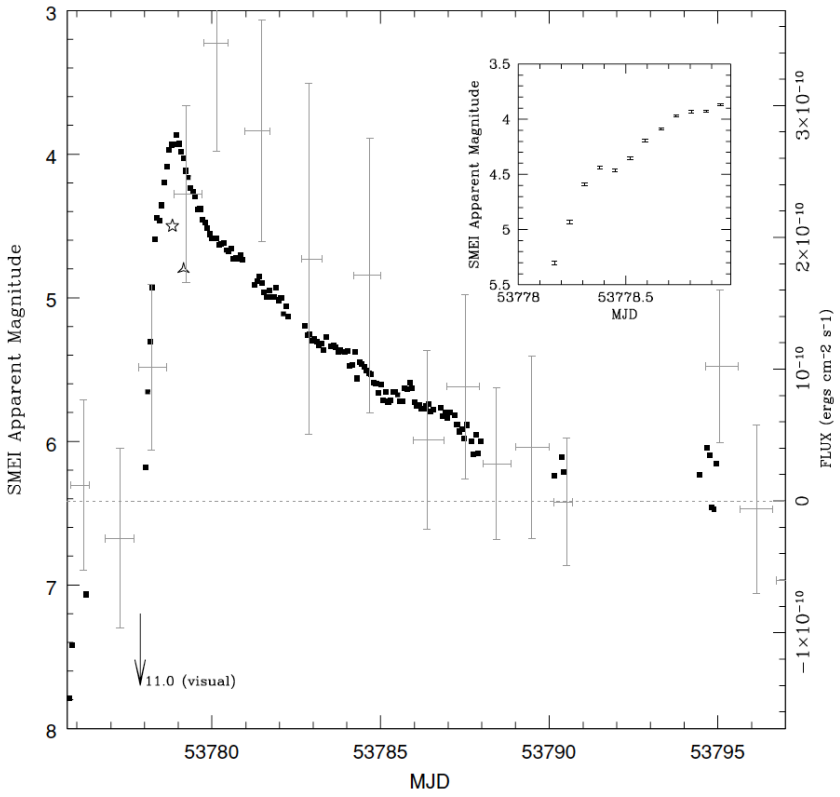
Solar Mass Ejection Imager

- SMEI – the Solar Mass Ejection Imager onboard the Coriolis satellite was launched in January 2003
- Until recently it monitored the *entire* sky in white light with an uninterrupted cadence of 102 minutes
- SMEI provided reliable photometry of point sources down to ~8th magnitude
- Contained within its data archive were some exquisite nova light curves.

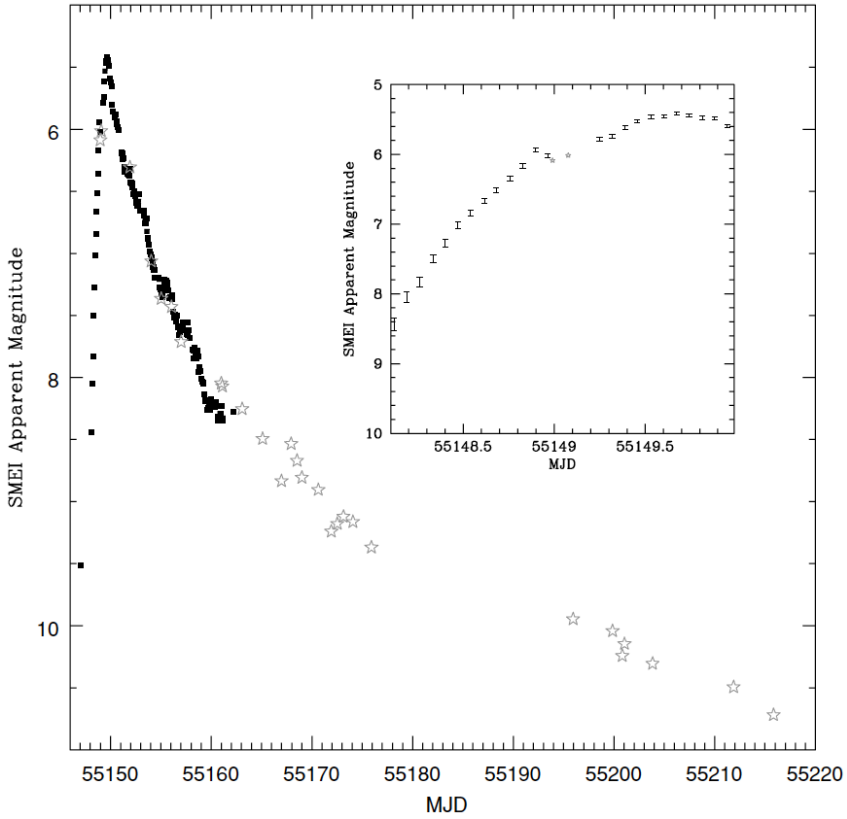
SMEI – Nova Light-curve Examples

Hounsell et al., 2010

RS Ophiuchi



KT Eridani



Classical vs. Recurrent Novae

An idealistic viewpoint

Classical Novae

- Only one observed outburst
- Recurrence timescales few thousand – million years
- Secondaries – main sequence stars
- Low mass transfer/accretion rates
- Range of WD masses
- Range of evolution speeds
- Fe II and He/N spectra
- >350 Galactic systems (900 M31)

Recurrent Novae

- >1 observed outburst
- Recurrence timescales 10-100 years
- Secondaries – sub-giants (U Sco) or red giants (RS Oph)
- High mass transfer/accretion rates
- High WD Masses
- Fast eruption evolution
- He/N spectra
- 10 Galactic systems (a few confirmed in LMC & M31)

Classical vs. Recurrent Novae

An idealistic viewpoint – ruined

Classical Novae

- Only one observed outburst
- Recur… thous…
- Secon… stars
- Low m… rates
- Range…
- Range…
- Fe II a…
- >350 (… M31)

Recurrent Novae

- >1 observed outburst
- Recurrence timescales 10-100

The problematic systems

- GK Per – classical nova hosting a sub-giant secondary
- T Pyx – recurrent nova hosting a main sequence secondary and a lower mass WD, exhibiting slowly evolving outbursts and an Fe II spectrum
- Plus many others!

…U Sco)

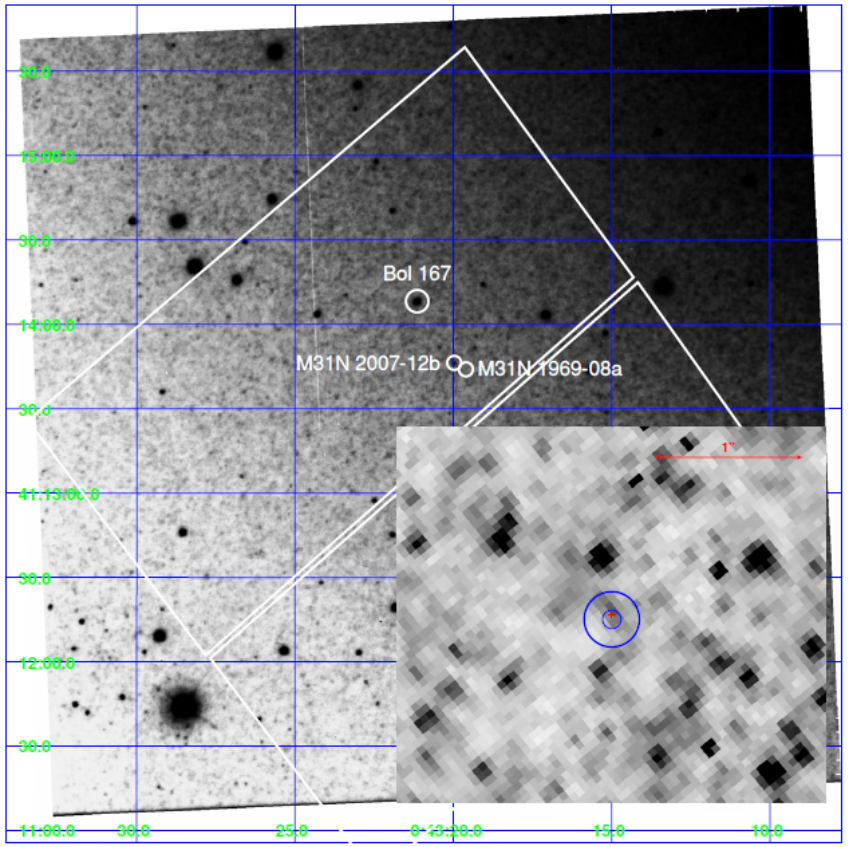
…ion

…confirmed in LMC & M31)

M31N 2007-12b

Bode et al., 2009

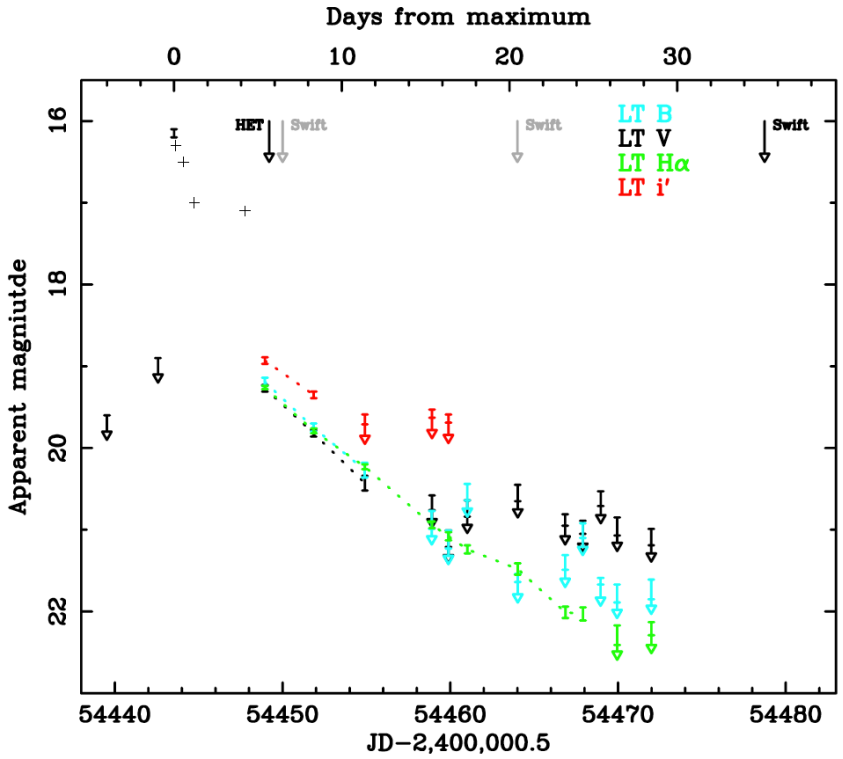
- Initially thought to be recurrent due to a positional “coincidence”
- X-ray observations and optical spectra were both consistent with recurrent nova
- HST archive search revealed progenitor system – red giant secondary



M31N 2007-12b – X-rays

Bode et al., 2009

- Initially thought to be recurrent due to a positional “coincidence”
- X-ray observations and optical spectra were both consistent with recurrent nova
- HST archive search revealed progenitor system – red giant secondary

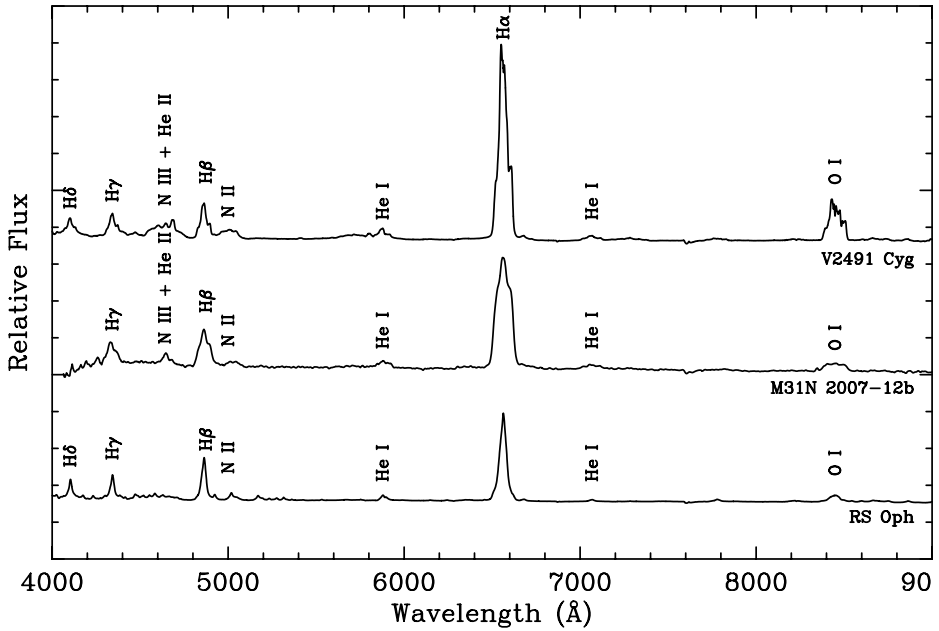


(SSS then undetected by Swift at *t* = 169d)

M31N 2007-12b – Spectra

Bode et al., 2009

- Initially thought to be recurrent due to a positional "coincidence"
- X-ray observations and optical spectra were both consistent with recurrent nova
- HST archive search revealed progenitor system – red giant secondary

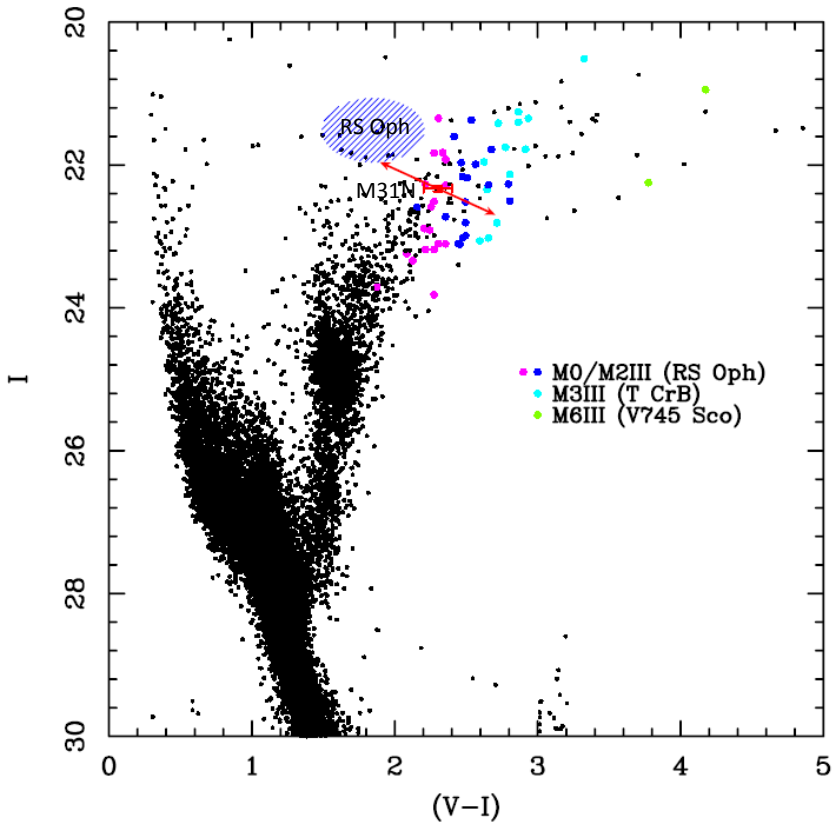


Optical spectra at *t* = 5.2d (M31N), ~6d (RS Oph), ~17-18d (V2491 Cyg)

M31N 2007-12b – Progenitor

Bode et al., 2009

- Initially thought to be recurrent due to a positional “coincidence”
- X-ray observations and optical spectra were both consistent with recurrent nova
- HST archive search revealed progenitor system – red giant secondary



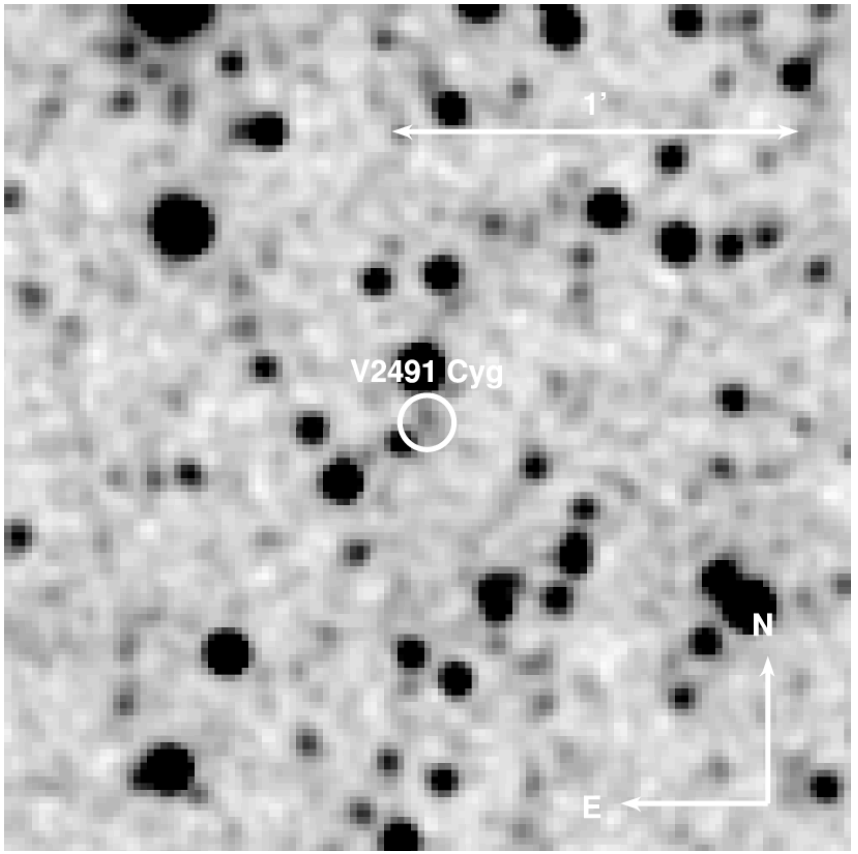
Galactic "Recurrent" Candidates

- A number of recent Galactic novae have looked "recurrent-like" – despite just one recorded outburst
- E.g. follow-up studies have indicated evolved secondaries:
  - V2672 Oph (SG; Munari et al., 2011)
  - V2491 Cyg (SG; Darnley et al., 2011)
  - V1721 Aql (SG; Hounsell et al., 2011)
  - KT Eri (RG; Jurdana-Šepić et al., 2012)
- …and in one case a previous outburst:
  - V2487 Oph (SG?; Pagnotta et al., 2009)

V2491 Cygni (2008)

Darnley et al., 2011

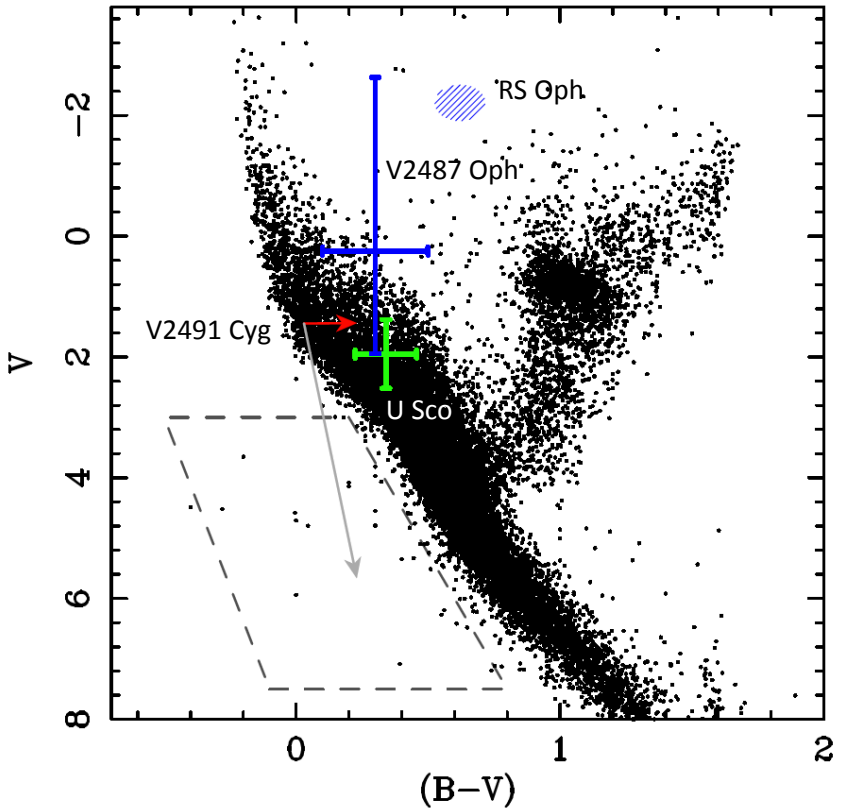
- As V2487 Oph, detected in X-rays pre-outburst
- Initial outburst variability led to proposal of 0.1d orbital period
- No evidence at quiescence supporting such a period
- Progenitor recovered via 2MASS archival data
- Inferred distance range of 10.5 – 14 kpc implies a sub-giant secondary



V2491 Cygni (2008)

Darnley et al., 2011

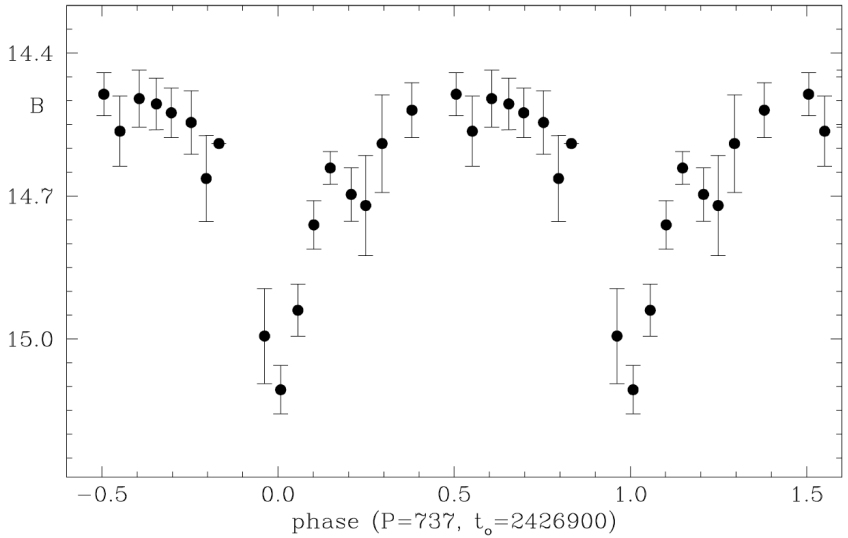
- As V2487 Oph, detected in X-rays pre-outburst
- Initial outburst variability led to proposal of 0.1d orbital period
- No evidence at quiescence supporting such a period
- Progenitor recovered via 2MASS archival data
- Inferred distance range of 10.5 – 14 kpc implies a sub-giant secondary



KT Eridani (2009)

Jurdana-Šepić et al., 2012

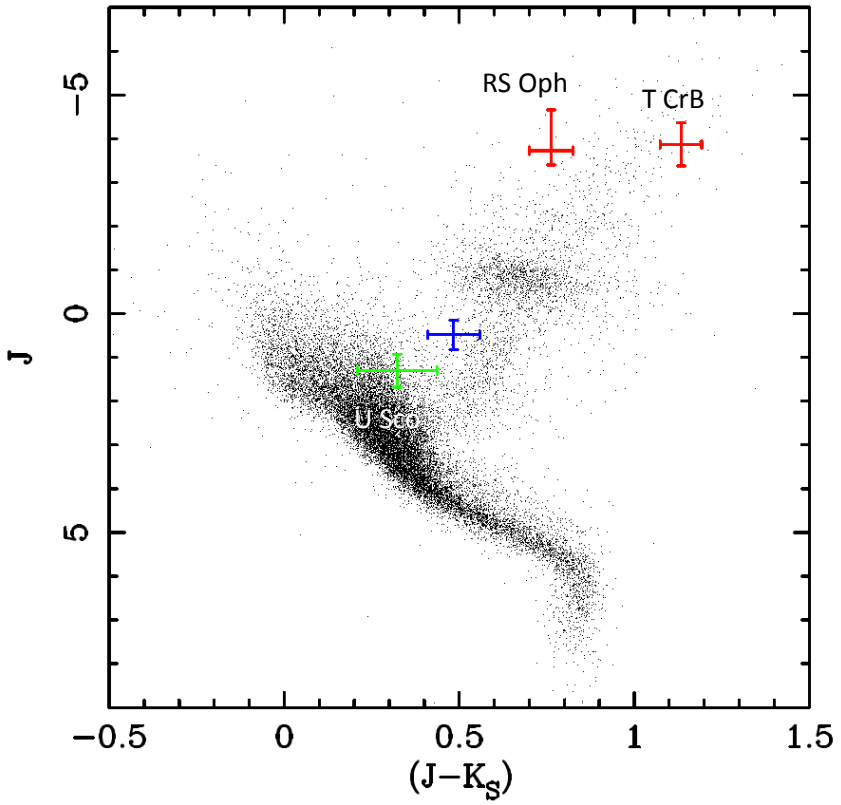
- Harvard College Observatory archive yielded the progenitor and around 70 years of data from ~1890-1960
- Analysis revealed no previous outbursts
- Recurrence timescale of 41y could not be ruled out
- Periodicity of 737d evident in the data, reminiscent of reflection/ eclipse effects
- Progenitor photometry, distance (6.5 kpc) and "orbital" period implies a (low luminosity) red giant secondary



KT Eridani (2009)

Jurdana-Šepić et al., 2012

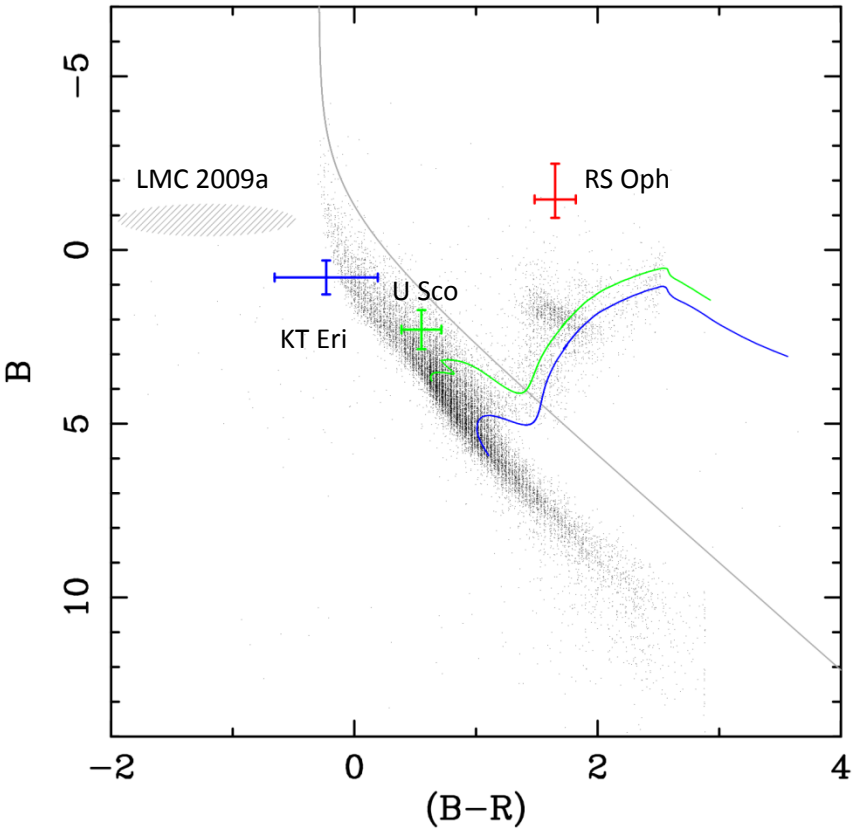
- Harvard College Observatory archive yielded the progenitor and around 70 years of data from ~1890-1960
- Analysis revealed no previous outbursts
- Recurrence timescale of 41y could not be ruled out
- Periodicity of 737d evident in the data, reminiscent of reflection/ eclipse effects
- Progenitor photometry, distance (6.5 kpc) and “orbital” period implies a (low luminosity) red giant secondary



LMC Recurrent Nova Progenitor

Bode et al., in prep

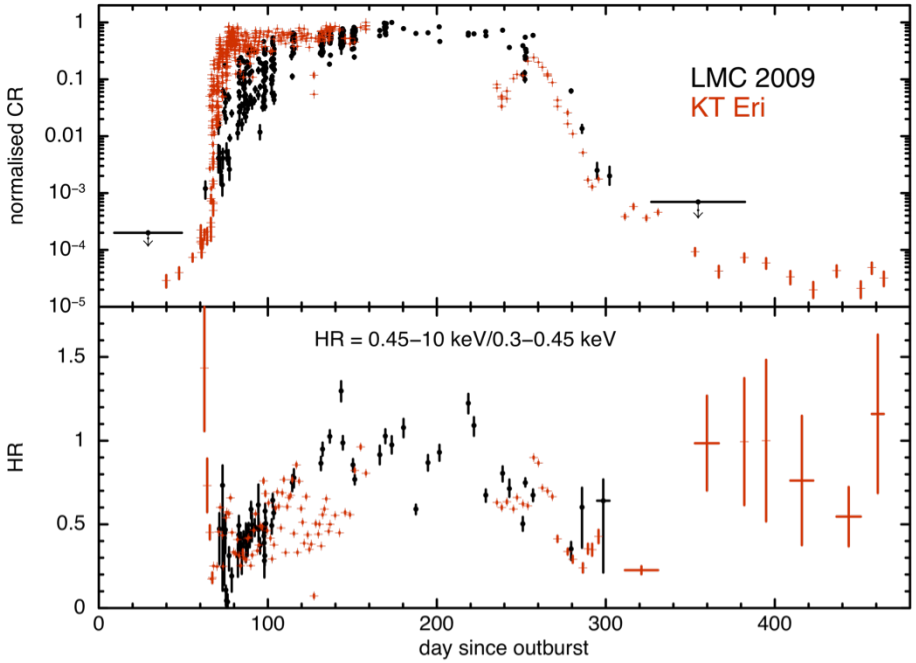
- Nova LMC 2009a was the second recorded outburst of Nova LMC 1971b
- Nova exhibited a fast decline and He/N spectrum
- 1.2 day periodic X-ray and UV emission (associated with orbital period? - Bode et al., 2009 ATel)
- Progenitor system was recovered from archival data
- Indications that the outburst is very similar to KT Eri



LMC Recurrent Nova Progenitor

Bode et al., in prep

- Nova LMC 2009a was the second recorded outburst of Nova LMC 1971b
- Nova exhibited a fast decline and He/N spectrum
- 1.2 day periodic X-ray and UV emission (associated with orbital period? - Bode et al., 2009 ATel)
- Progenitor system was recovered from archival data
- Indications that the outburst is very similar to KT Eri

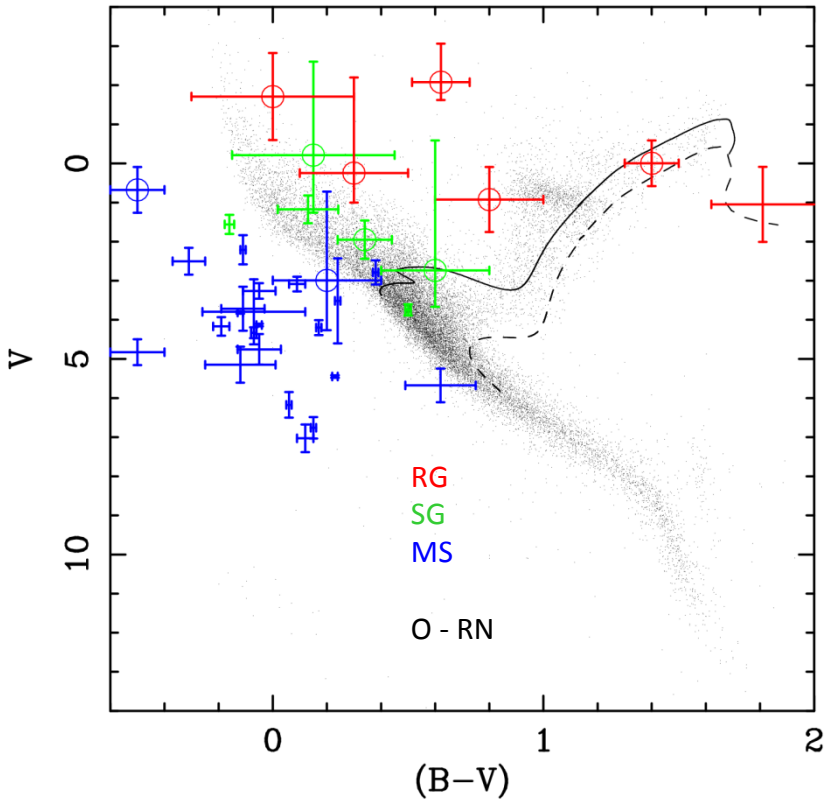


- Similar A, $[M_v]_{max}$ (~-8.5) and optical devel.
- XRT cps scale by distance within factor 2
- Remarkably similar SSS phases

Galactic Progenitors – Optical

Darnley et al., 2012

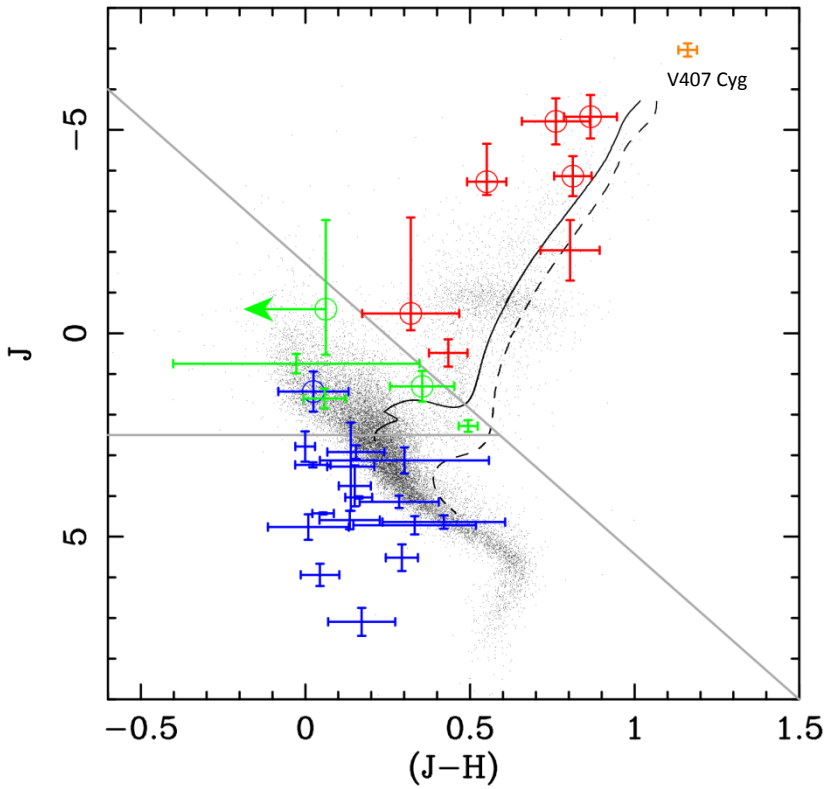
- Assumption that the colour & mag of a quiescent nova can be used to determine secondary type
- Colour-mag position is determined by the secondary – accretion disk shifts emission blue-wards and luminosity upwards
- Used a catalogue of 38 novae with known distances, extinctions and inferred secondary type
- Proposed nova classification based solely on evolutionary state of the secondary



Galactic Progenitors – Near IR

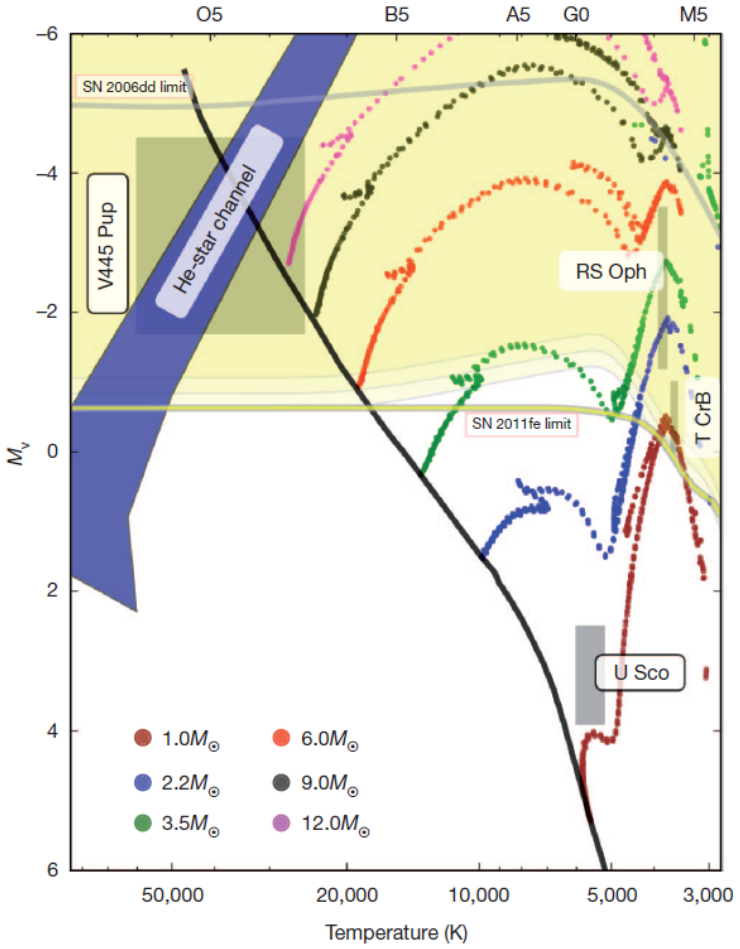
Darnley et al., 2012

- Assumption that the colour & mag of a quiescent nova can be used to determine secondary type
- Colour-mag position is determined by the secondary – accretion disk shifts emission blue-wards and luminosity upwards
- Used a catalogue of 38 novae with known distances, extinctions and inferred secondary type
- Proposed nova classification based solely on evolutionary state of the secondary



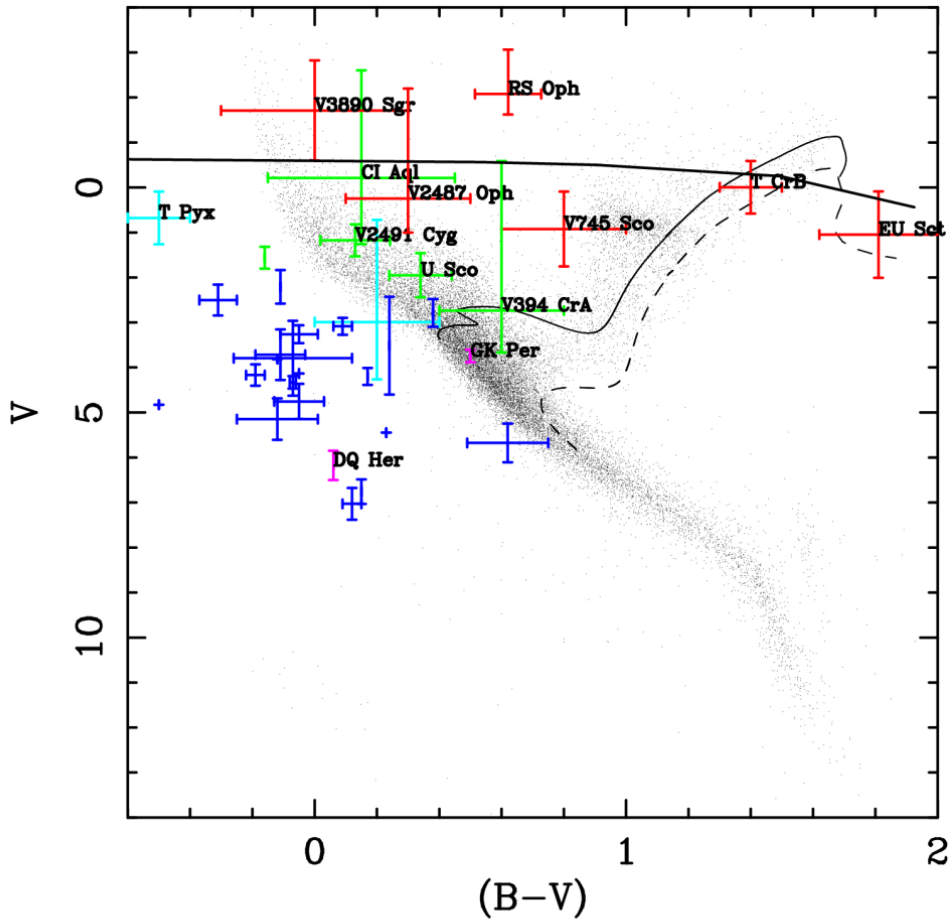
Link to Type Ia Progenitors

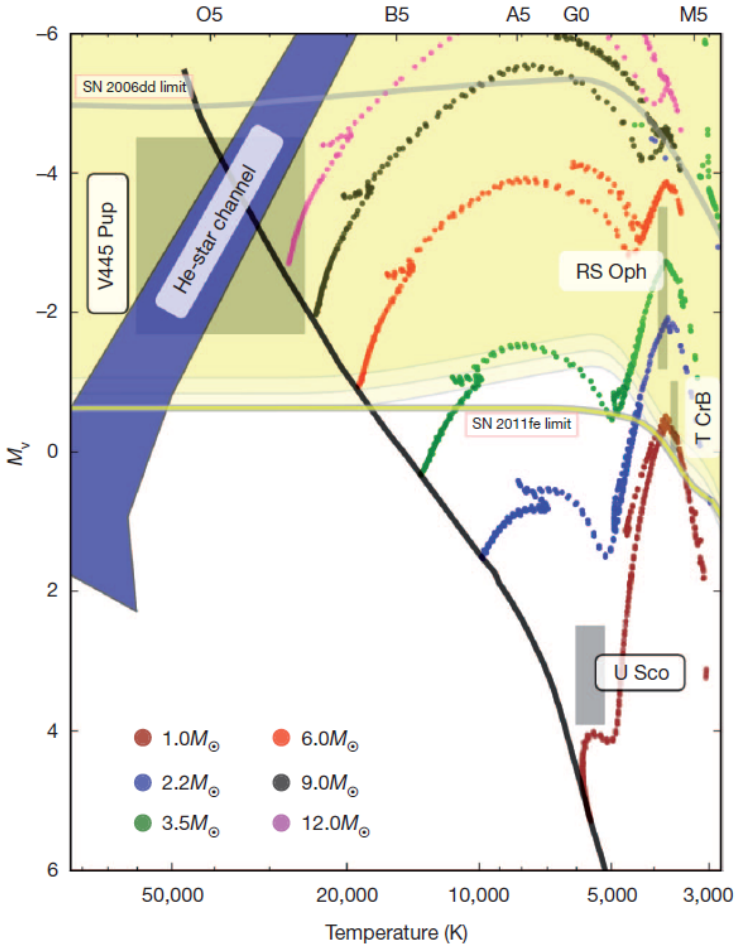
- Novae (specifically "recurrents") are a Type Ia SN single-degenerate progenitor candidate
- A few recent papers have cast some doubt
  - Schaefer & Pagnotta (2012) failed to find surviving secondary within SNR 0509-67.5
  - Li et al. (2011) excluded a luminous red giant as the progenitor of SN 2011fe (M101)



Li et al., 2012

Link to Type Ia Progenitors





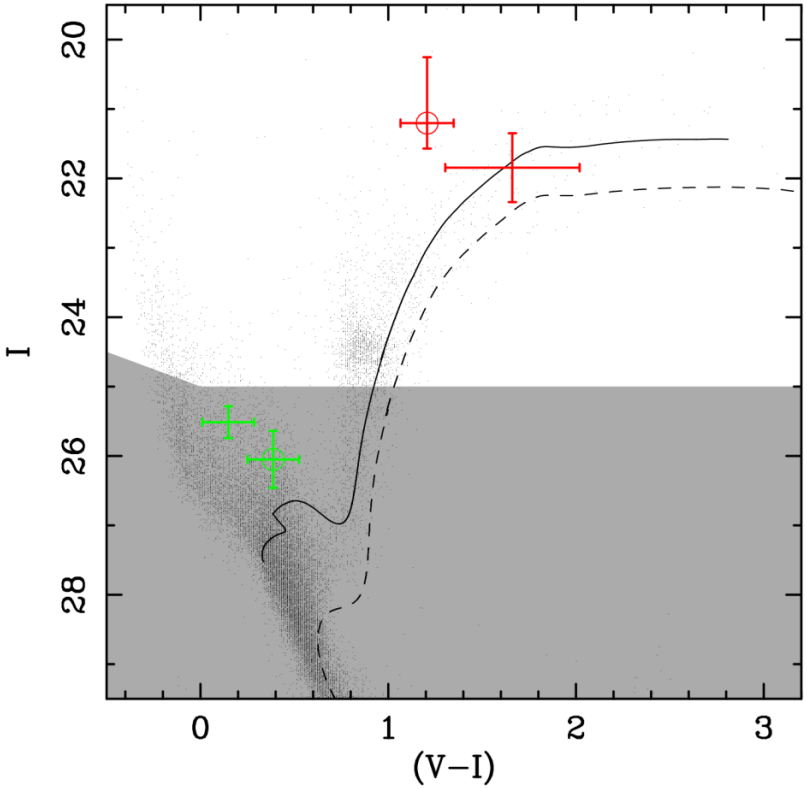
Li et al., 2012

liverpool JMU

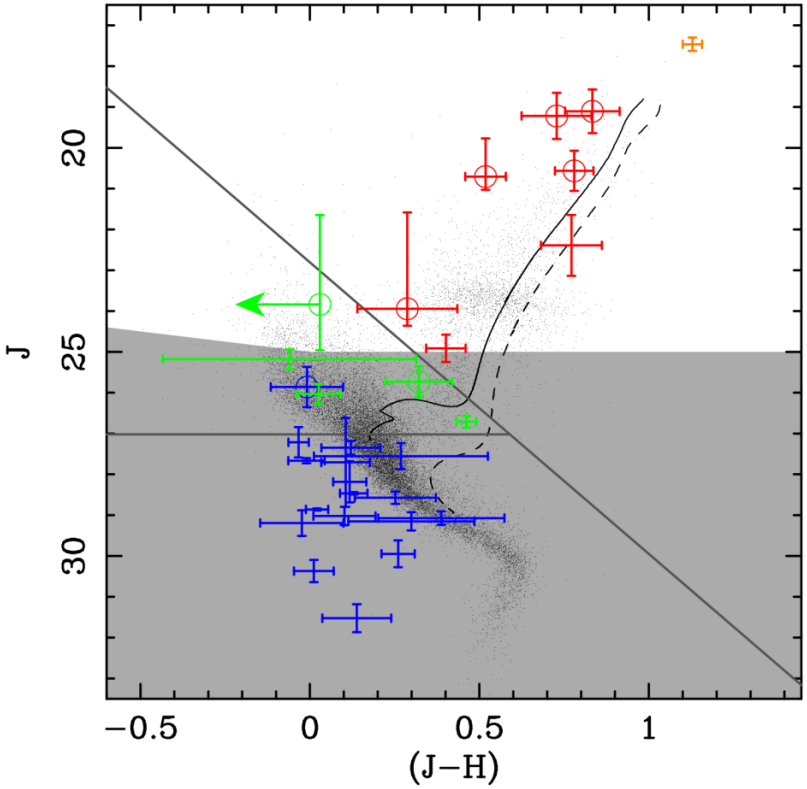
Extragalactic (M31/32/33) Progenitors

S. C. Williams et al., in prep

***HST* WFC3/UVIS**



***HST* WFC3/IR**



liverpool JMU

Summary

- SMEI
  - Bright nearby nova outbursts are still missed
  - Pre-maximum halt present in most light curves
- M31N 2007-12b
  - First recovery of progenitor in M31
  - System contains a red giant secondary
- Galactic Systems
  - Identification of evolved secondaries in “non-recurrent” nova systems
- Nova LMC 2009a
  - Recovery of a LMC nova progenitor
  - System contains sub giant secondary
  - Similarities to KT Eri, U Sco
- Galactic Progenitor Population
  - The evolutionary state of the secondary can be determined from near IR quiescent photometry
  - Proposal of new classification based on secondary state (MS/SG/RG-nova)
  - Identified possible sub-class of low(er) luminosity RG-novae
  - Indications that novae with evolved secondaries may be more numerous than thought
  - Follow-up observations underway to confirm predictions
- Link to SN Ia bolstered by low luminosity RG-novae
- RG-novae at quiescence can be readily recovered in the Local Group