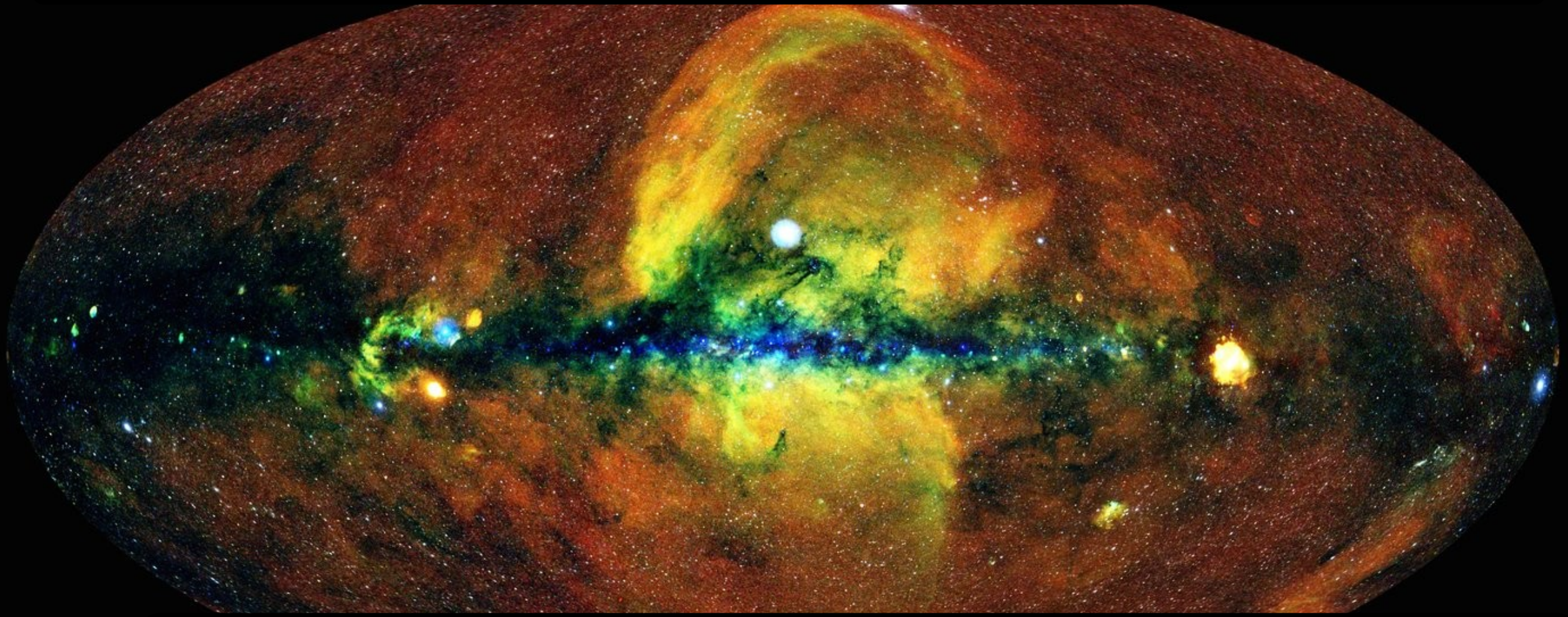
Old novae in the eROSITA All Sky Survey (eRASS)

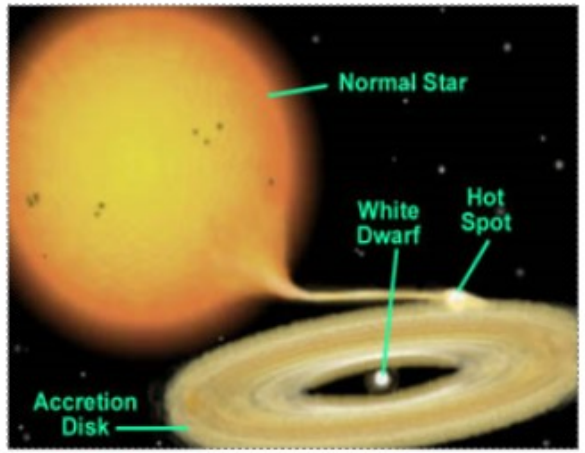


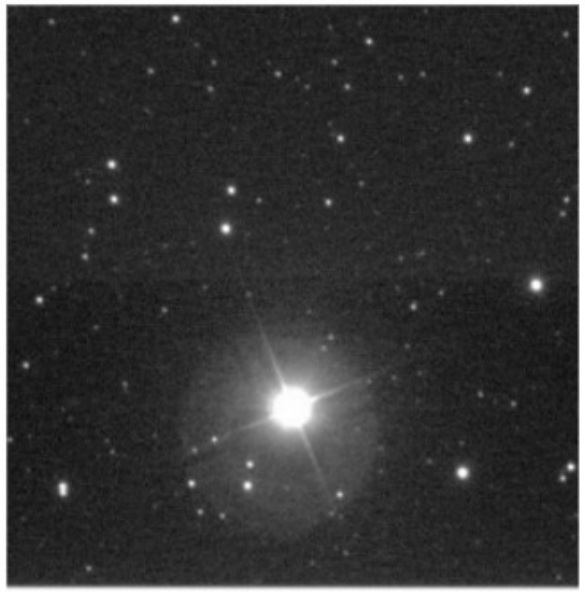
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Glòria Sala (UPC, Barcelona)
Frank Haberl(MPE), Axel Schwope (AIP),
Chandreyee Maitra(MPE), Elif Safak (UPC), Jochen Greiner (MPE)

eROSITA

NOVAE: What? Thermonuclear events on white dwarfs





accretion of H onto white dwarf

↓

after ~10^{-5}-10^{-4} $M_{\odot}$ accreted slow enough and enriched via mixing with core

↓

H-ignition in degenerate conditions

↓

NOVA OUTBURST

↓

optical luminosity increases up to 10^5 L_{sun}

EJECTION of enriched envelope into interstellar medium

HOW MANY?

Theoretically 30-60 novae/yr in the Galaxy

..... But OBSERVED?

~10 novae/yr *observed*

HOW OFTEN?

In most cases **ONE UNIQUE EVENT** observed per System

(10000 years recurrence time!)

EXCEPT..... **recurrent novae**

down to **< 12 months recurrence time**

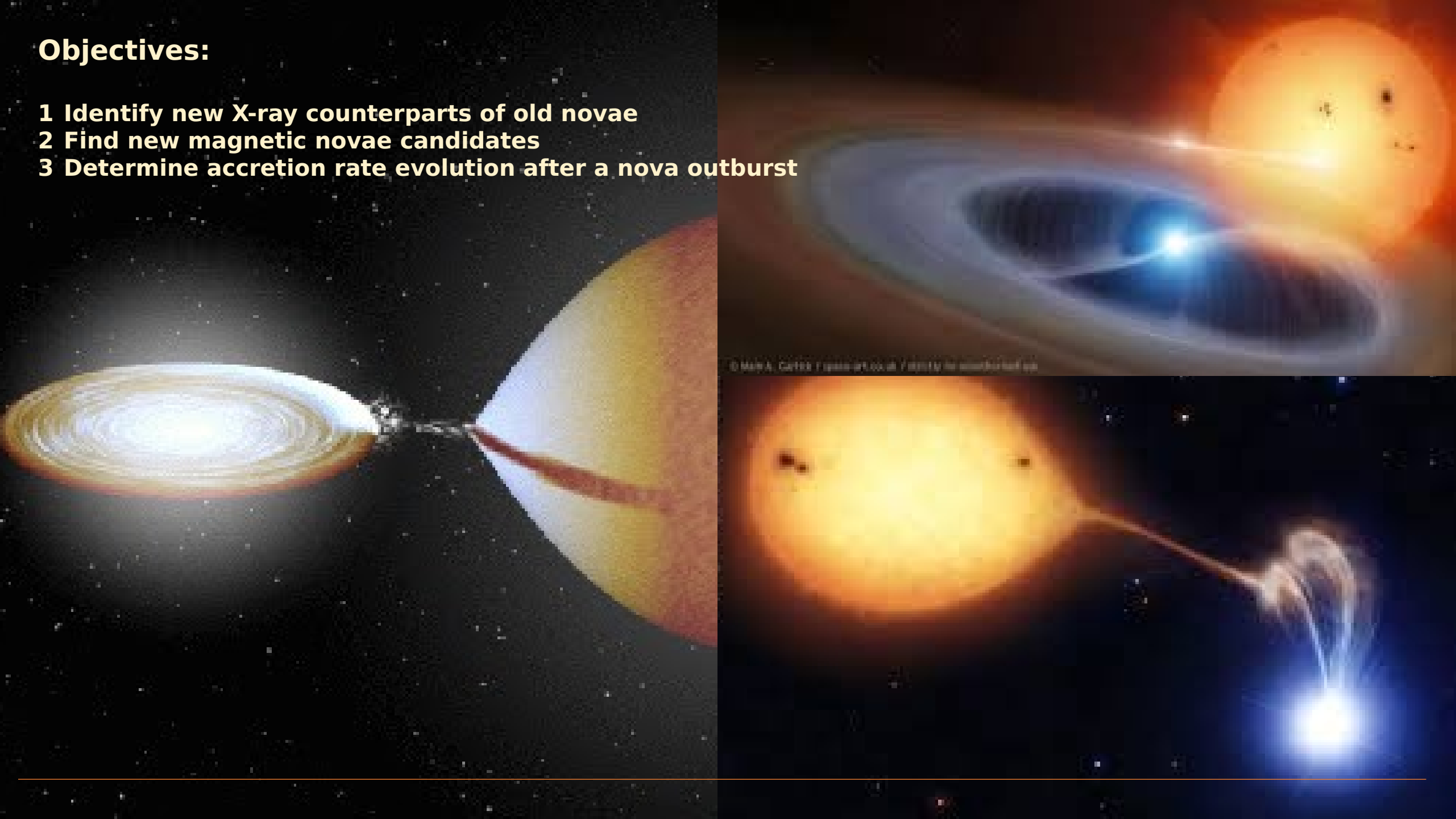
(M31N 2008-12a; Henze et al. 2015…2018, Darnley et al 2015..2019)

IN WHICH ACCRETION STATE?

host systems are often too distant and faint before or after outburst

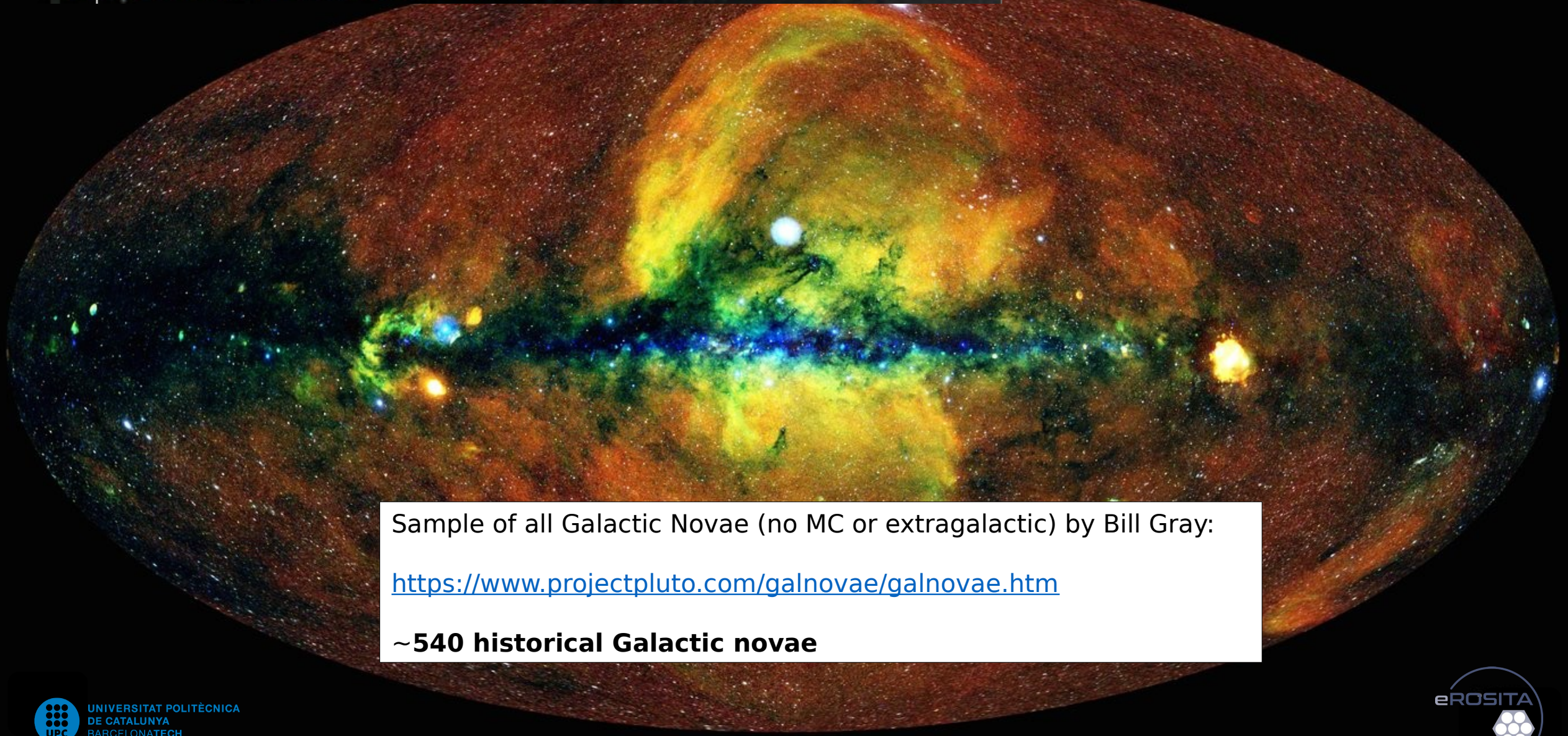
Objectives:

1 Identify new X-ray counterparts of old novae
2 Find new magnetic novae candidates
3 Determine accretion rate evolution after a nova outburst



1 Identify new X-ray counterparts of old novae

0.3-2.3 keV - RGB

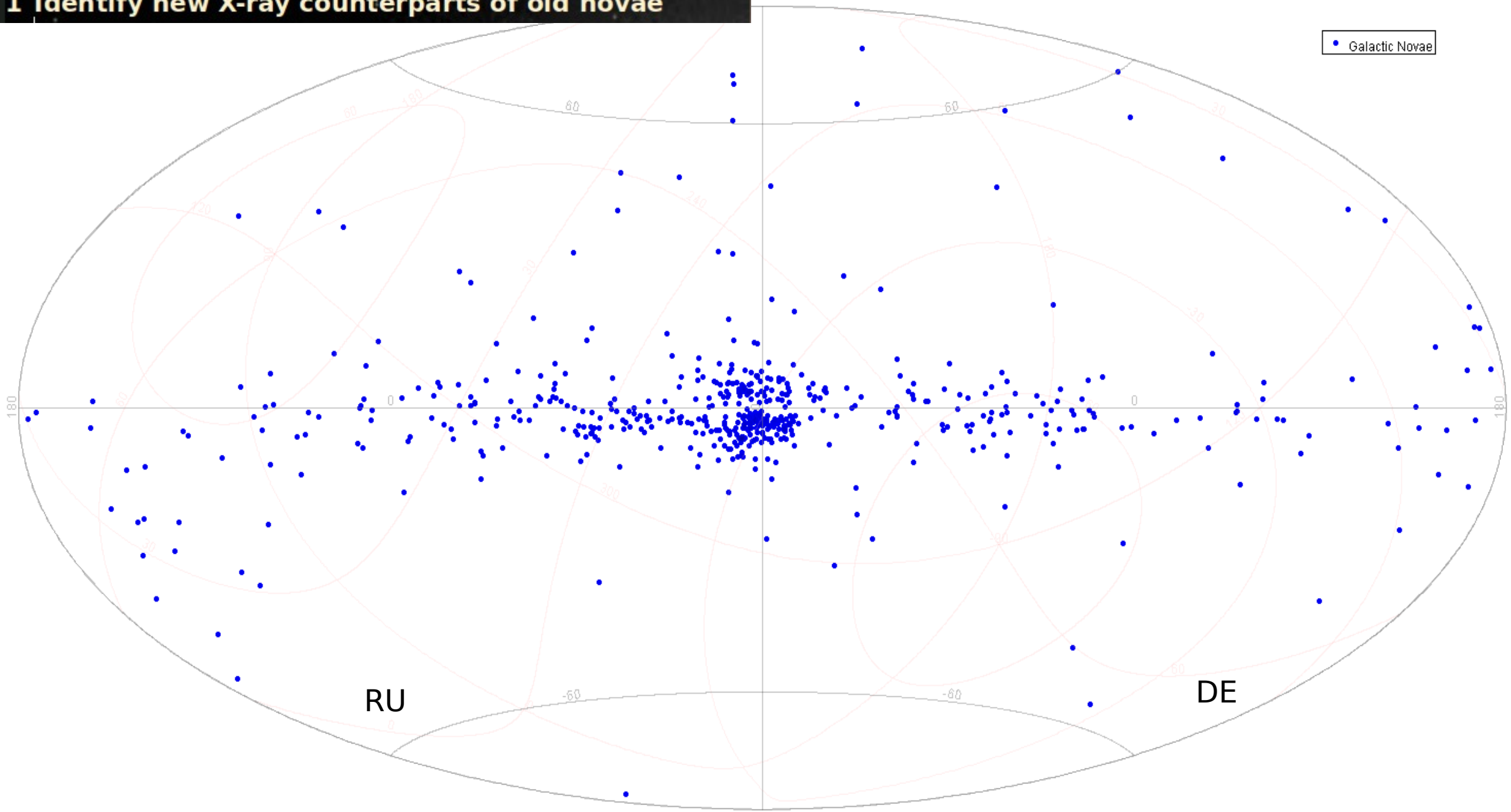


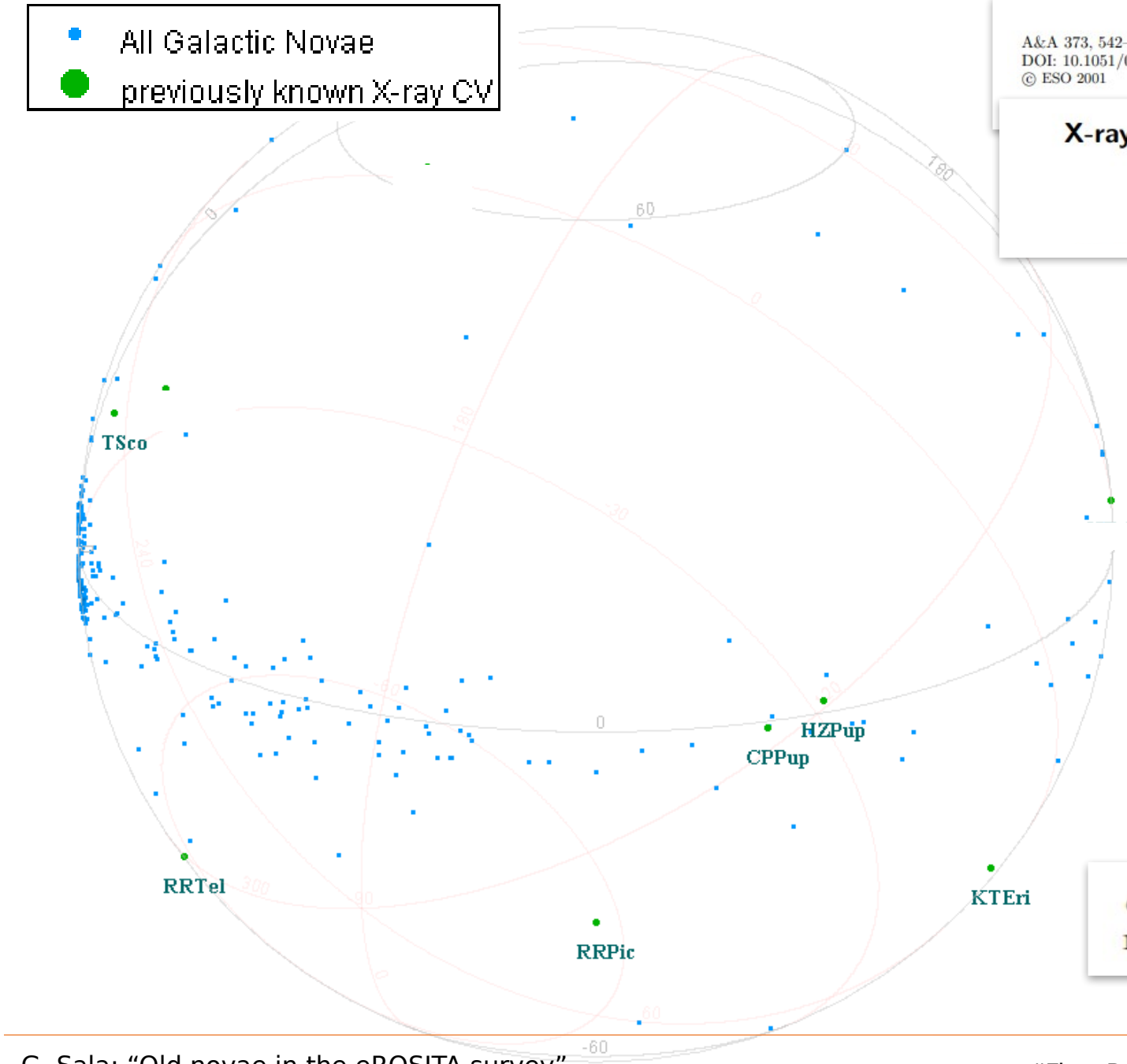
Sample of all Galactic Novae (no MC or extragalactic) by Bill Gray:

https://www.projectpluto.com/galnovae/galnovae.htm

~540 historical Galactic novae

1 Identify new X-ray counterparts of old novae





A&A 373, 542–554 (2001)
DOI: 10.1051/0004-6361:20010537
© ESO 2001

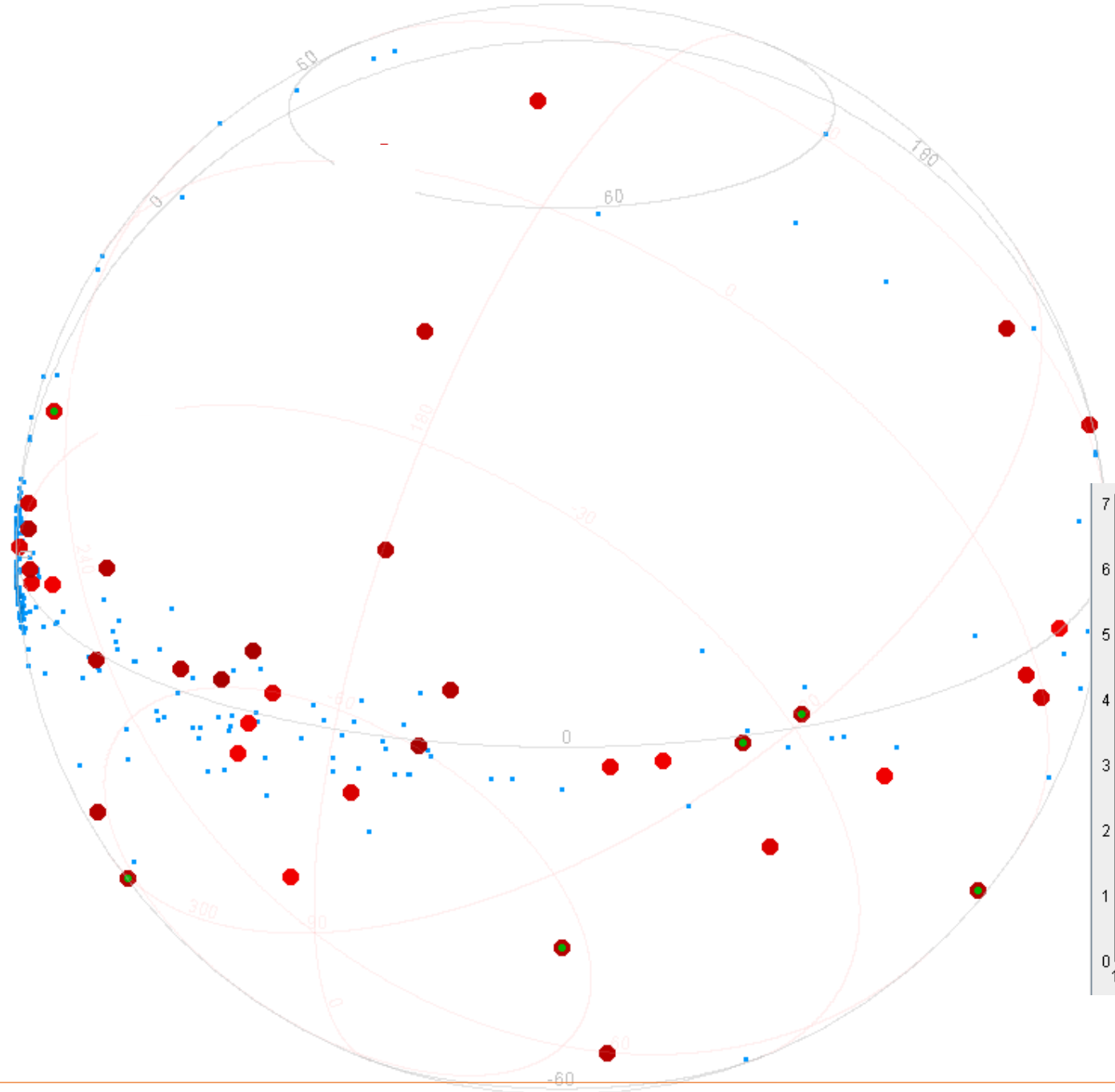
Astronomy & Astrophysics

X-ray emission from classical and recurrent novae observed with ROSAT

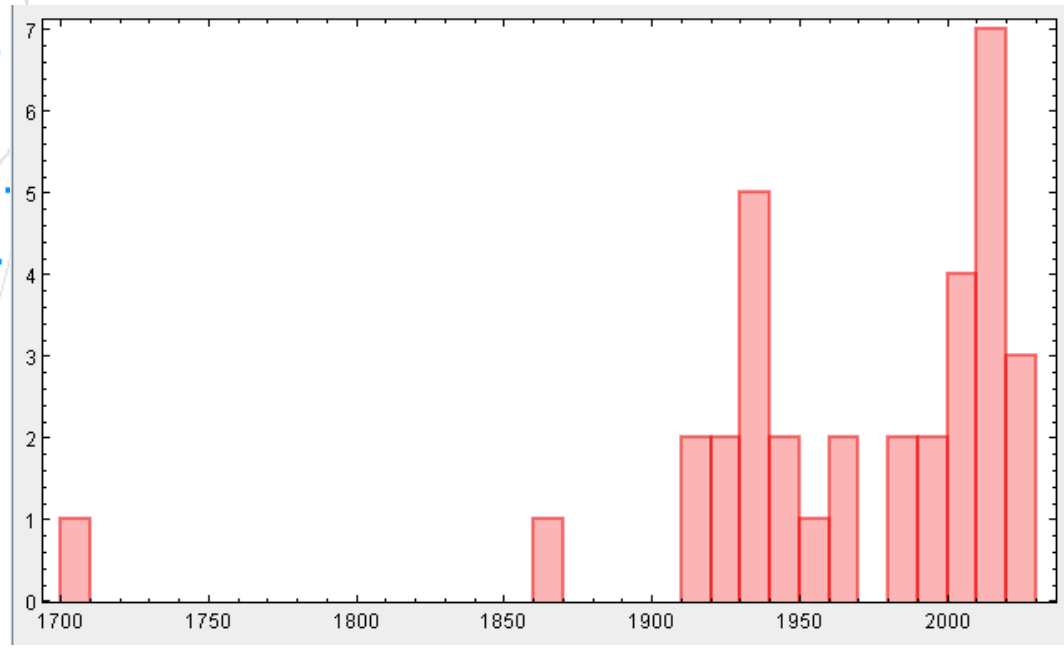
M. Orio[1,2], J. Covington[3], and H. Ögelman[3]

Nova	d (kpc)	$L_x \times 10^{32}$ erg s^{-1}	V	L_x/L_{opt} $\times 10^{-2}$	l.t.	orb.
V603 Aql	0.43	2	11.7	1.4	x	n
GK Per	0.6	3.5	13.0	2.8	x	
CP Pup	0.7	0.59–5.9	15.0	4.8		?
V841 Oph	1.0	0.3	13.4	1.6	?	
CP Lac	1.15	3.8	16.6	1.1	?	
T Sco	9.1	33	22.2	4.8		
DQ Her	0.33	0.03	14.5	0.005		
RS Oph	1.2	0.28–1.64	12.5	0.2	x	
RR Pic	0.26	0.02	12.2	0.06	x	n
V446 Her	1	0.72	18.0	3.3	x	
QU Vul	2.6	0.18	19.0	1.7		

accretion. However, only 11 out of 81 quiescent Galactic novae observed in the pointed observations were detected.



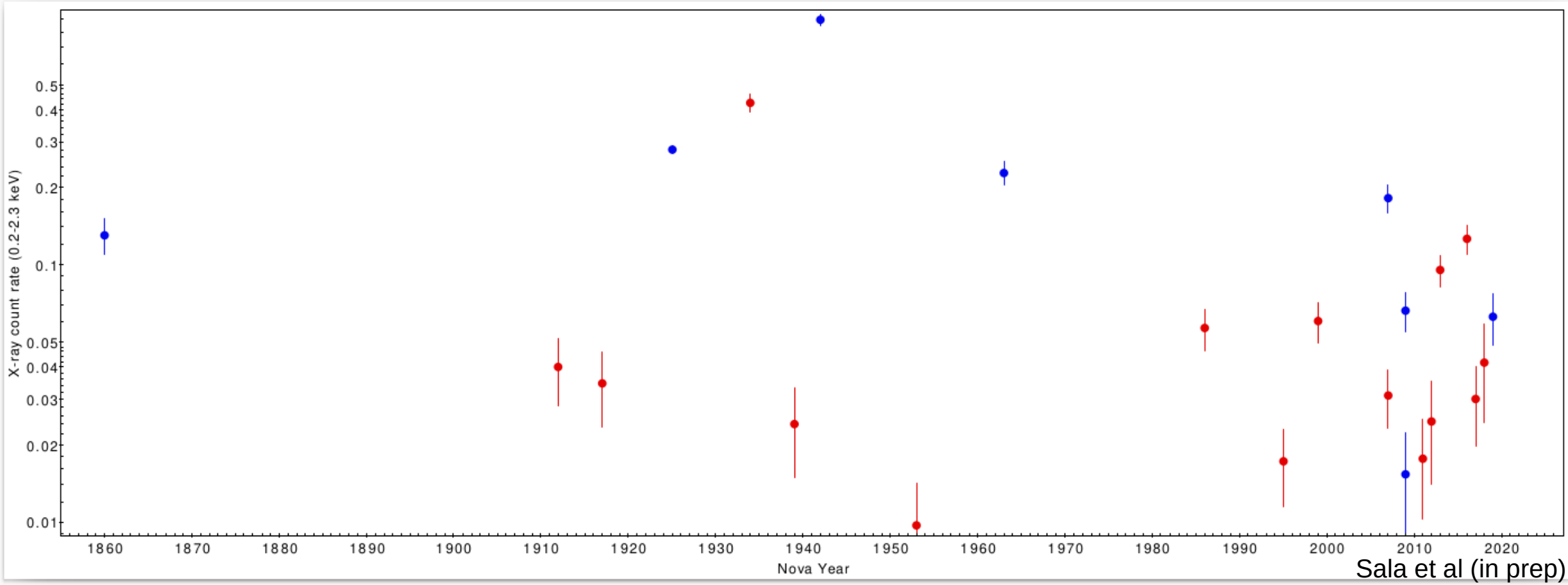
Galactic Novae
Detected in eRASS1:5
Previously known in X-ray



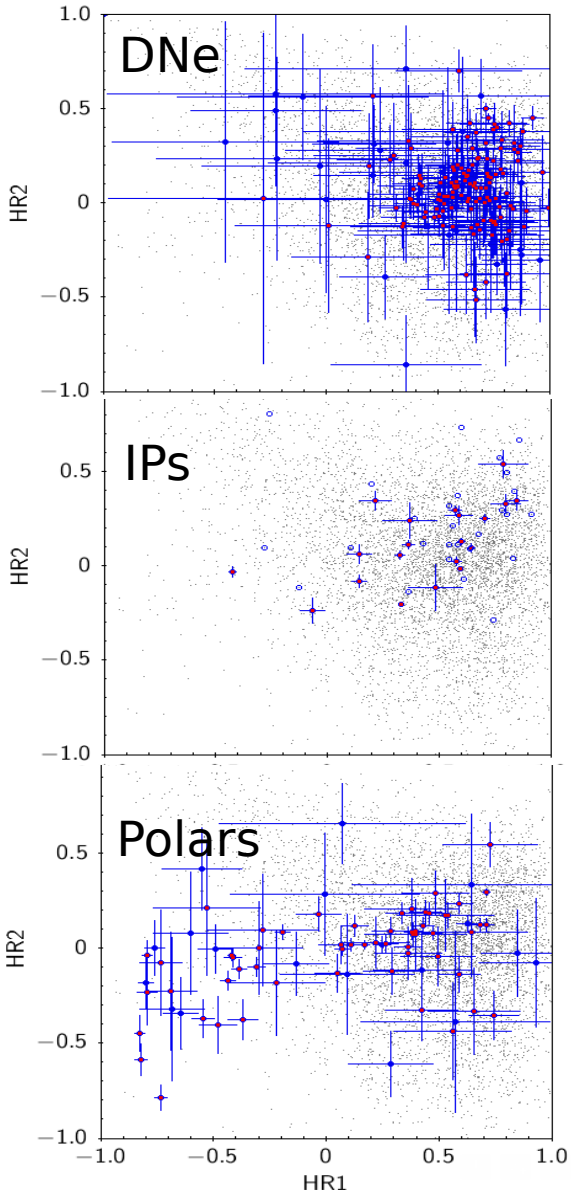
Sala et al (in prep)

Galactic novae detected in eRASS:

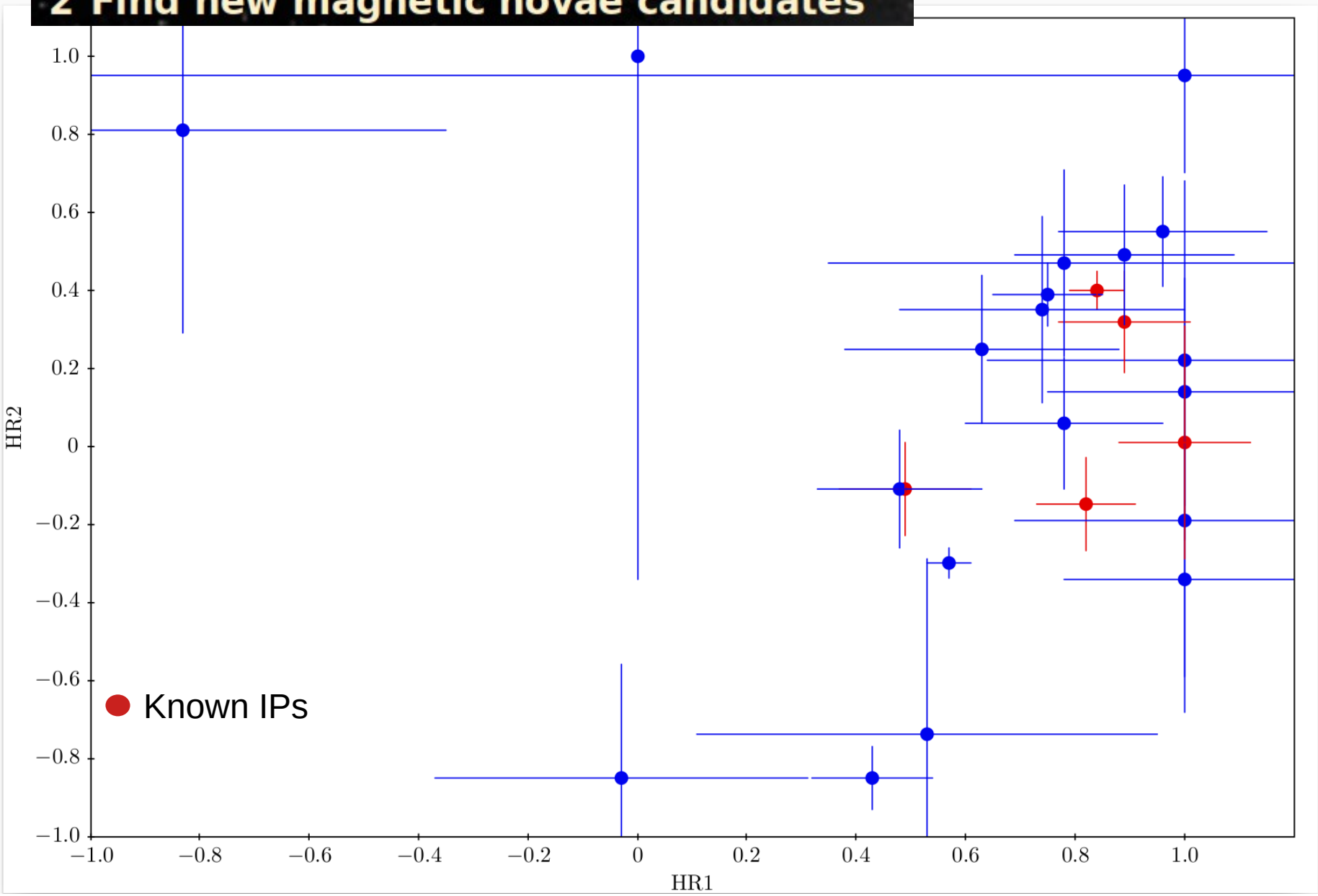
- First detected fireball (YZ Ret, König et al. *Nature* 2022)
- Three novae in outburst, two of them in SSS phase (V1706 Sco, V1708 Sco, V1710 Sco; *ATel #14075*, *ATel #14927*)
- **8 old novae already known in X-rays**
- **16 new X-ray counterparts to old novae**



2 Find new magnetic novae candidates

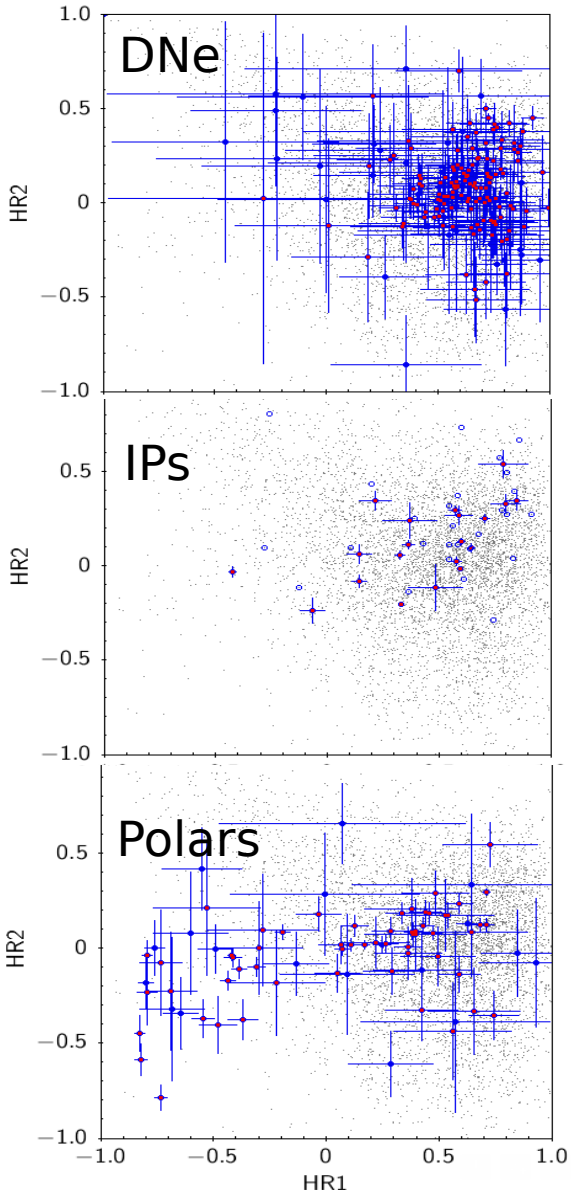


All CVs in eRASS
(Schwope+24)

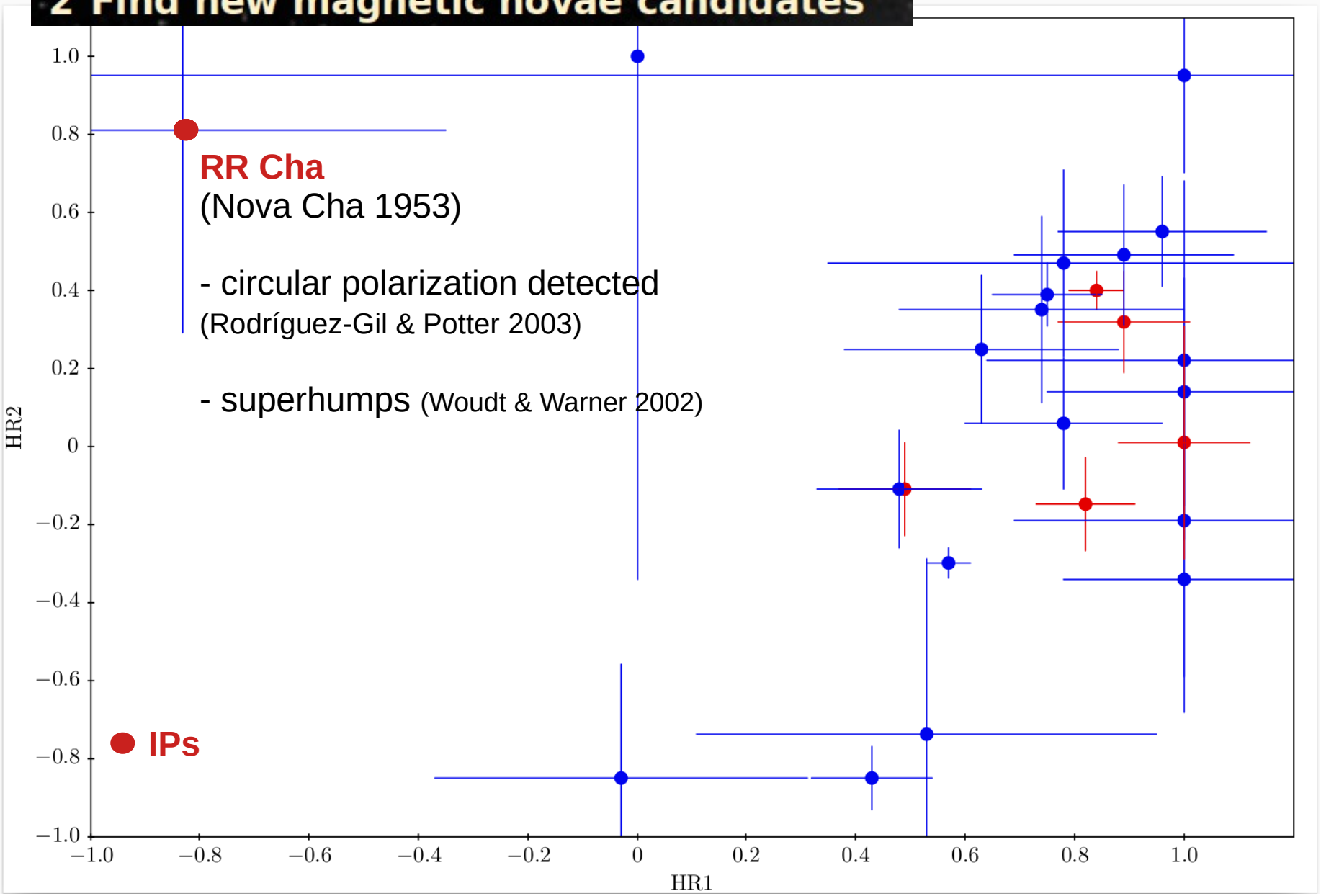


Sala et al (in prep)

2 Find new magnetic novae candidates



All CVs in eRASS
(Schwope+24)



Sala et al (in prep)

2 Find new magnetic novae candidates

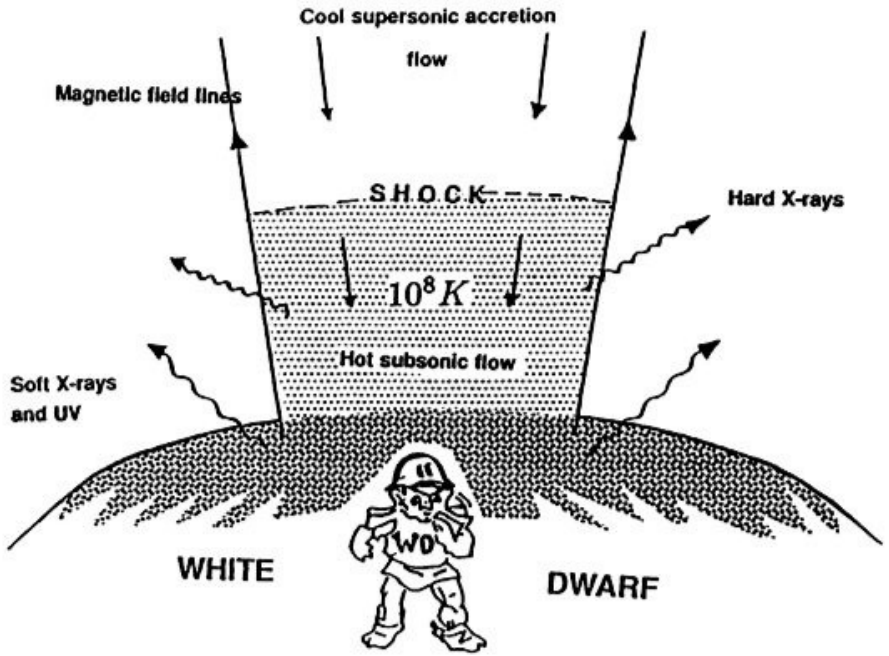
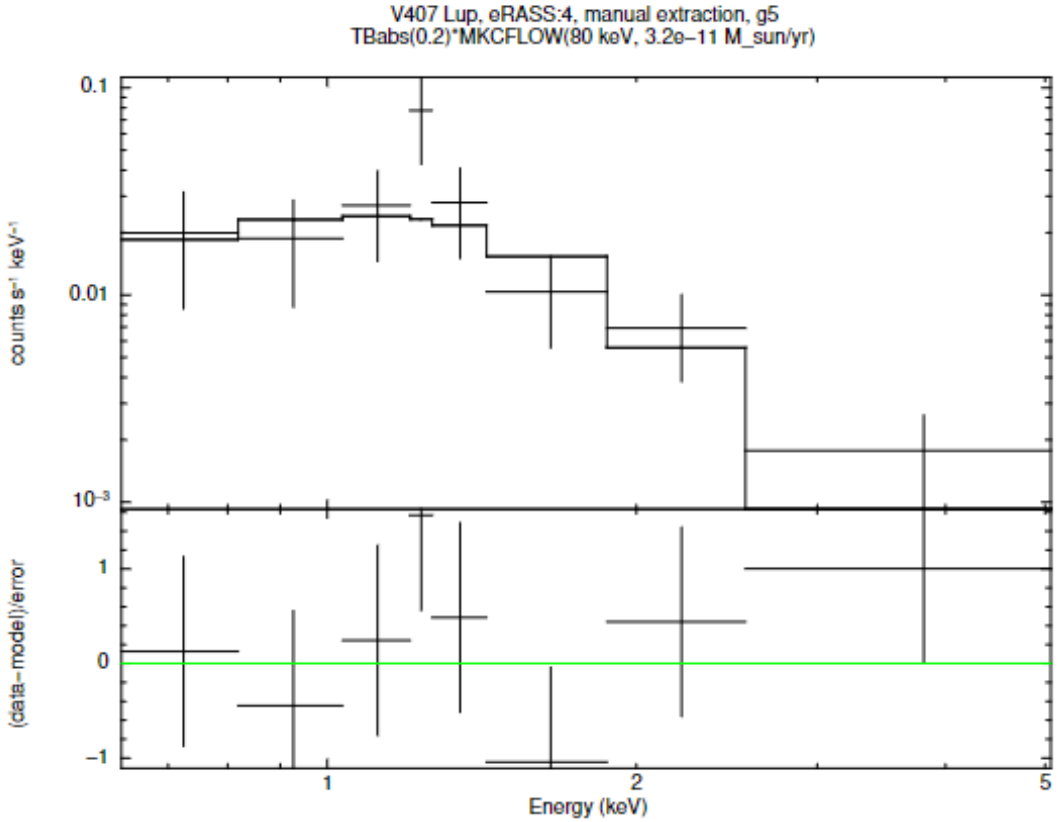


Diagram of intermediate polar emission
(Patterson 1994)

Non-magnetic example: V407 Lup (N Lup 2016)



Sala et al (in prep)

2 Find new magnetic novae candidates

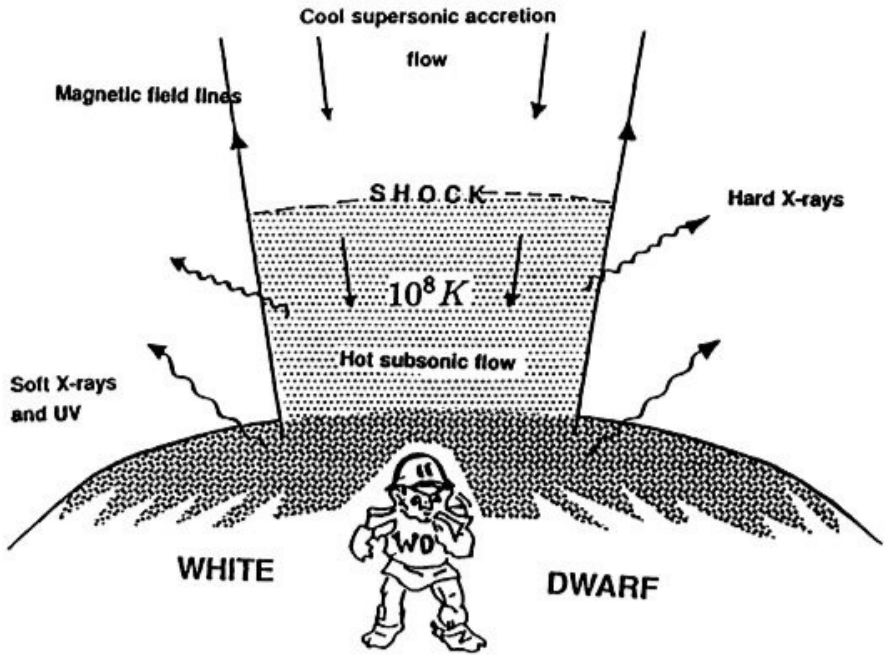
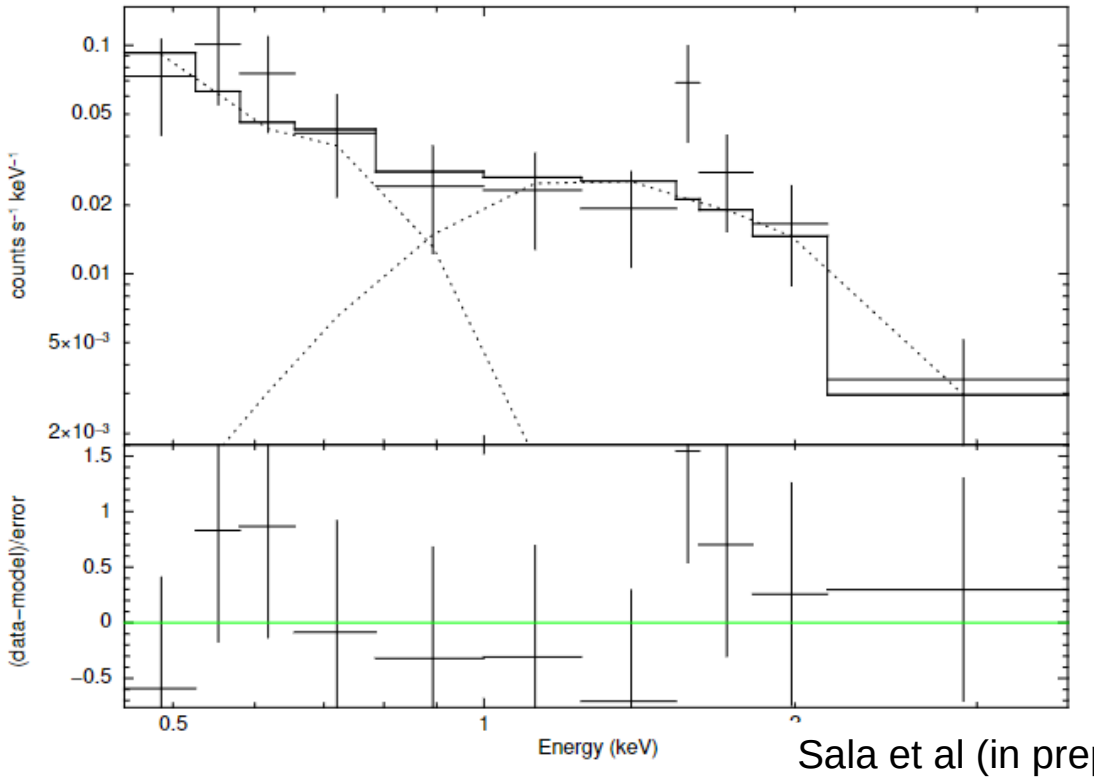


Diagram of intermediate polar emission
(Patterson 1994)

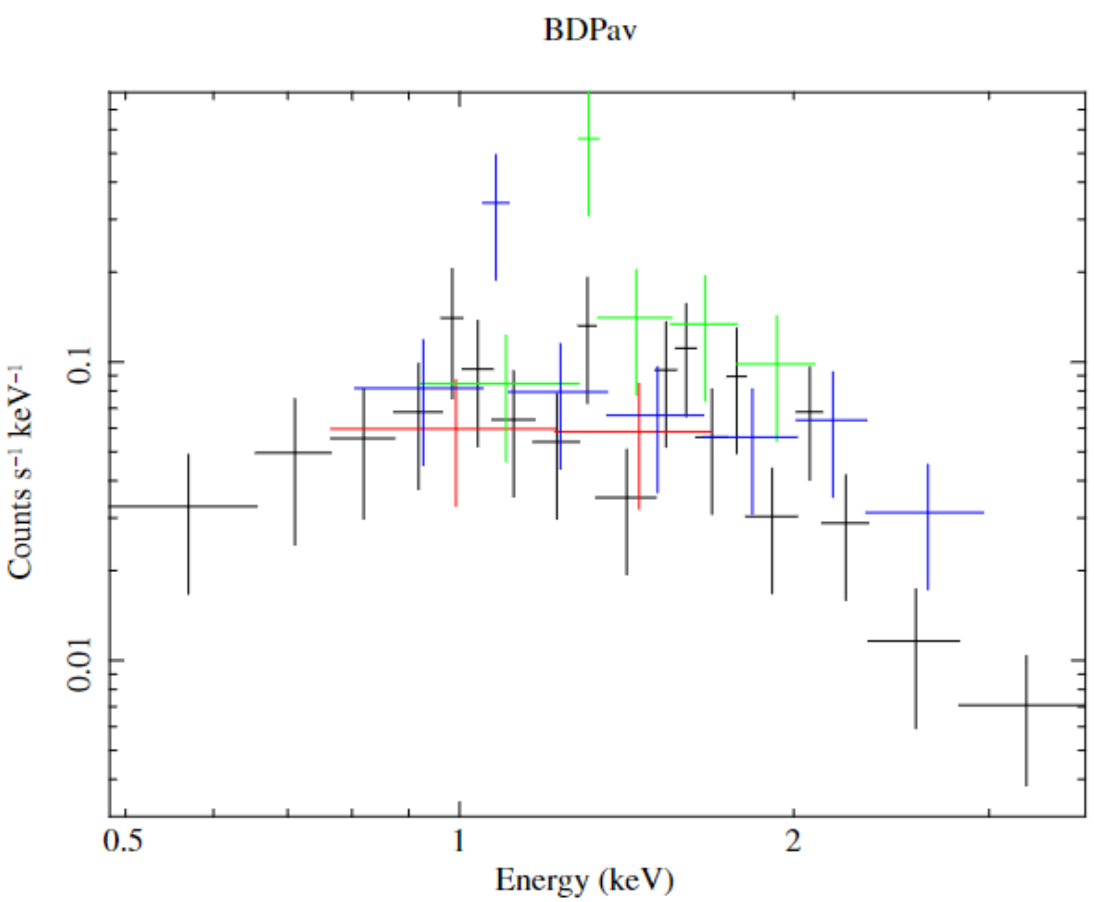
Magnetic test case, known IP: HZ Pup (Nova Pup 1963)

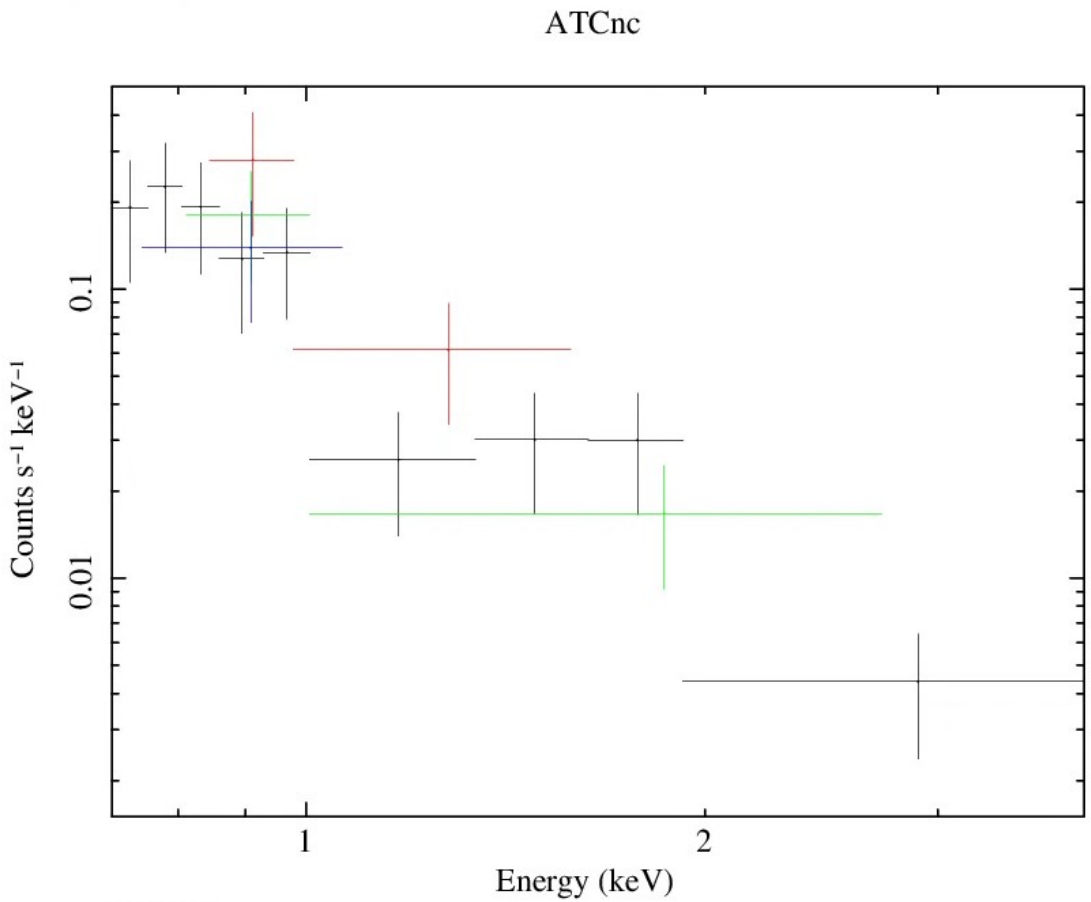


Sala et al (in prep)

- IP candidate: P_{orb}~5h, P_{spin}~20 min (Abbott & Shafter 1997)
- eROSITA spectrum compatible with results found with XMM-Newton (Wörpel et al. 2020)

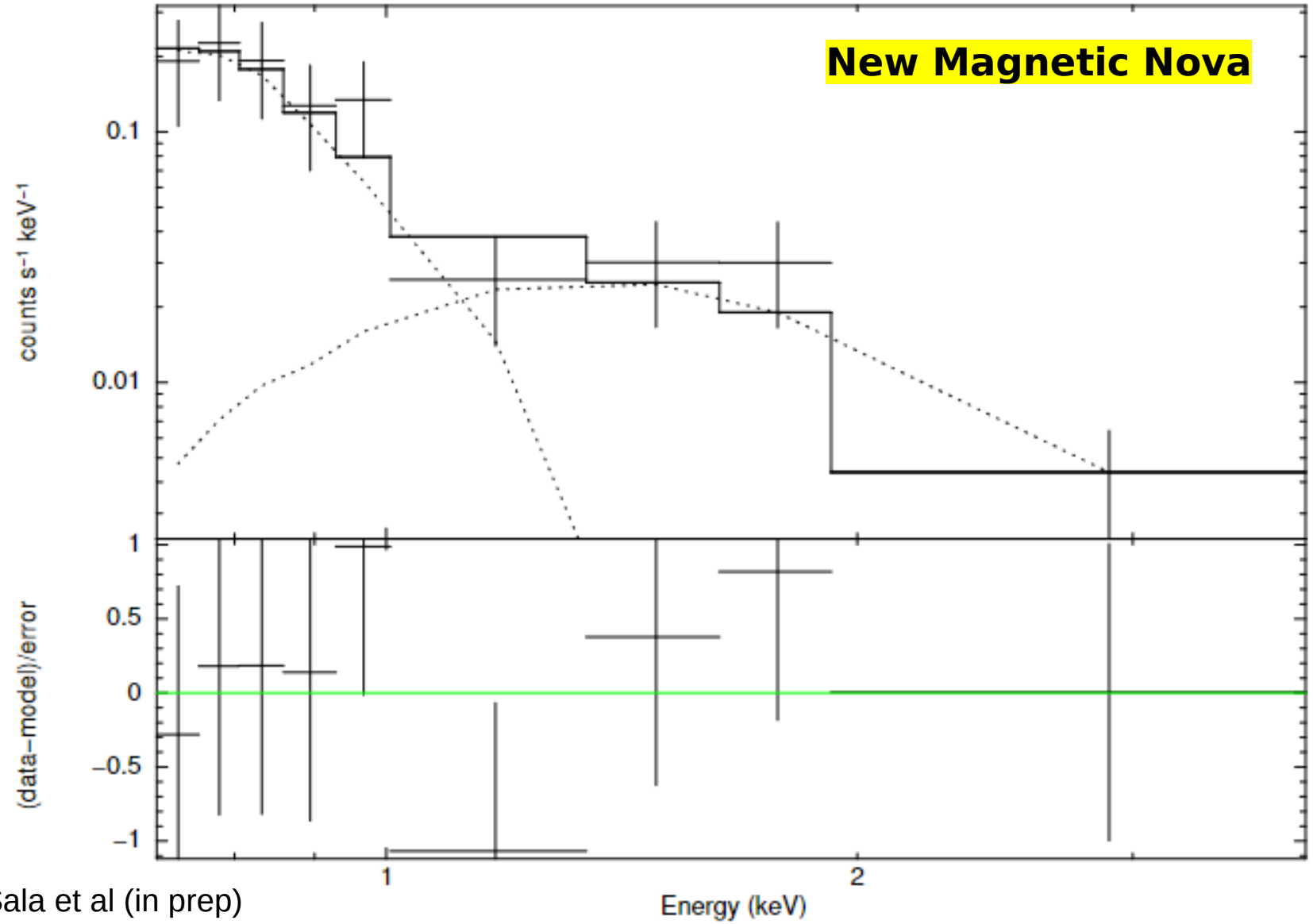
Spectra of X-ray counterparts of old novae in quiescence: BD Pav and AT Cnc





CV Name	Nova	CV type	orb.(h)	SpType
AT Cnc	1700	DN, ZC	4.8	K7-M0/5
BD Pav	1934	DN, UG	4.32	M5-8/5

AT Cnc



Sala et al (in prep)

Nova shell from 1700
(Shara et al 2012)

Two periodicities:

- Orbital: 4.8 h = 290 min
- Spin: 26 minutes

(Bruch et al. 2019)

mkcflow model:

Low kT: 200 eV
High kT: >2.5 keV
Acc. Rate : $1.4 \times 10^{-12} \mathrm{M}_{\odot}/\mathrm{yr}$

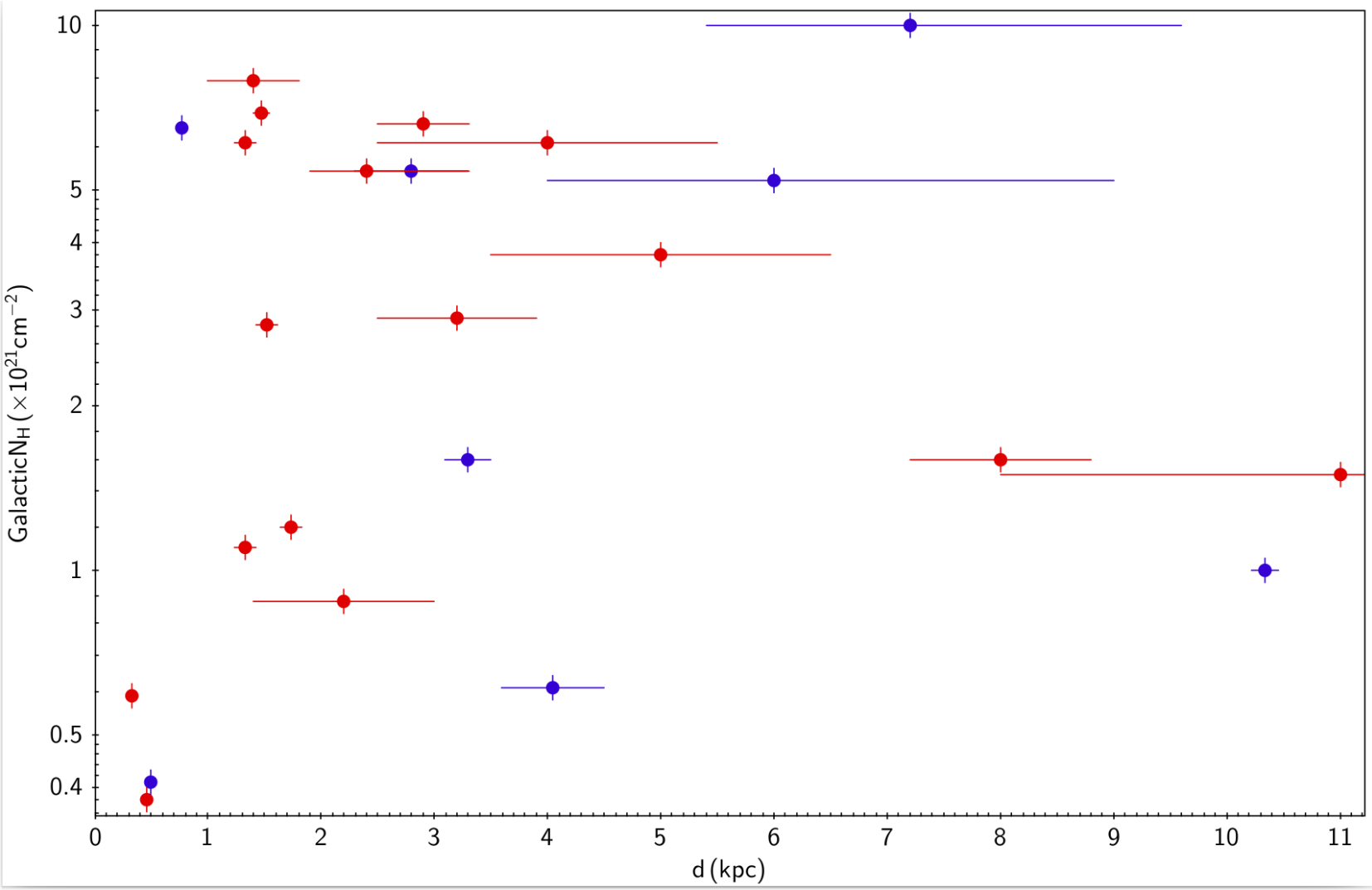
Soft excess bbody model:

kT_{eff}: 70 eV
L_{bol}: 4×10^{33} erg/s

0.2-2.3 keV luminosity:

$7 \times 10^{30} \mathrm{erg/s}.$

3 Determine accretion rate evolution

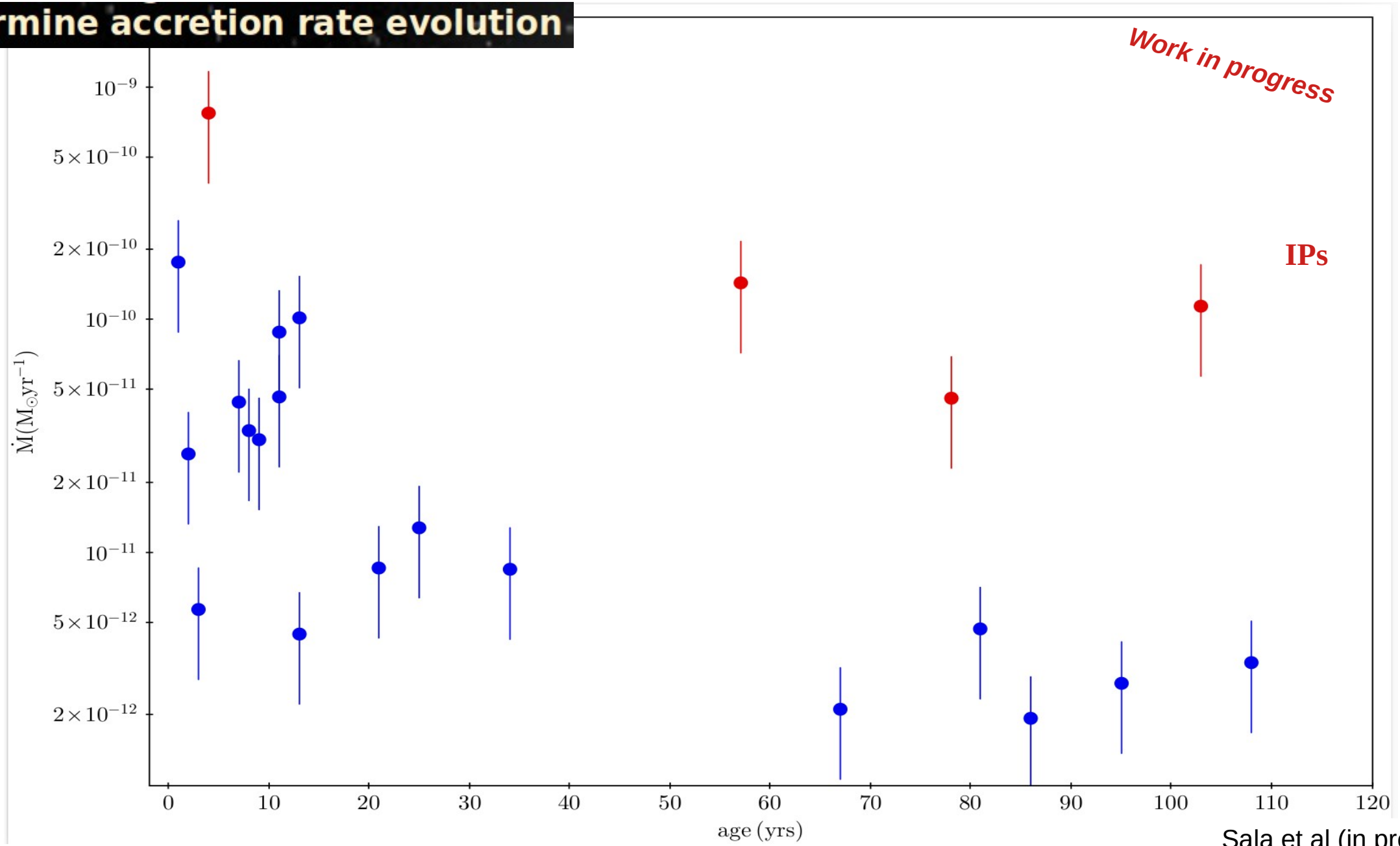


Distance and interstellar N_H known for each source.

Determine accretion rate from luminosity, assuming multi-temperature thermal emission, cooling flow *(mkcflow)*.

Unconstrained higher temperature leads to 50% uncertainty in the bolometric corretion.

3 Determine accretion rate evolution



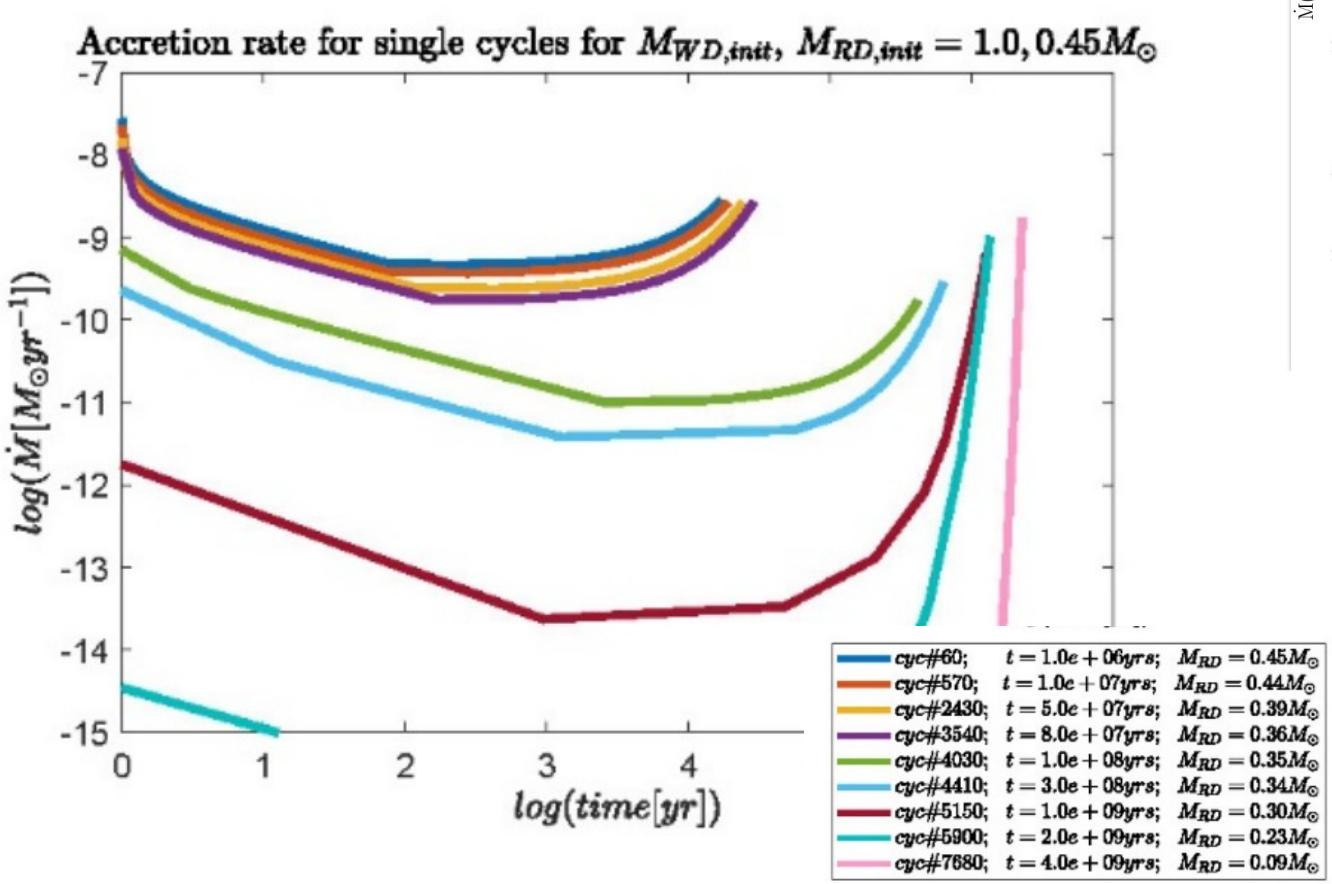
Sala et al (in prep)

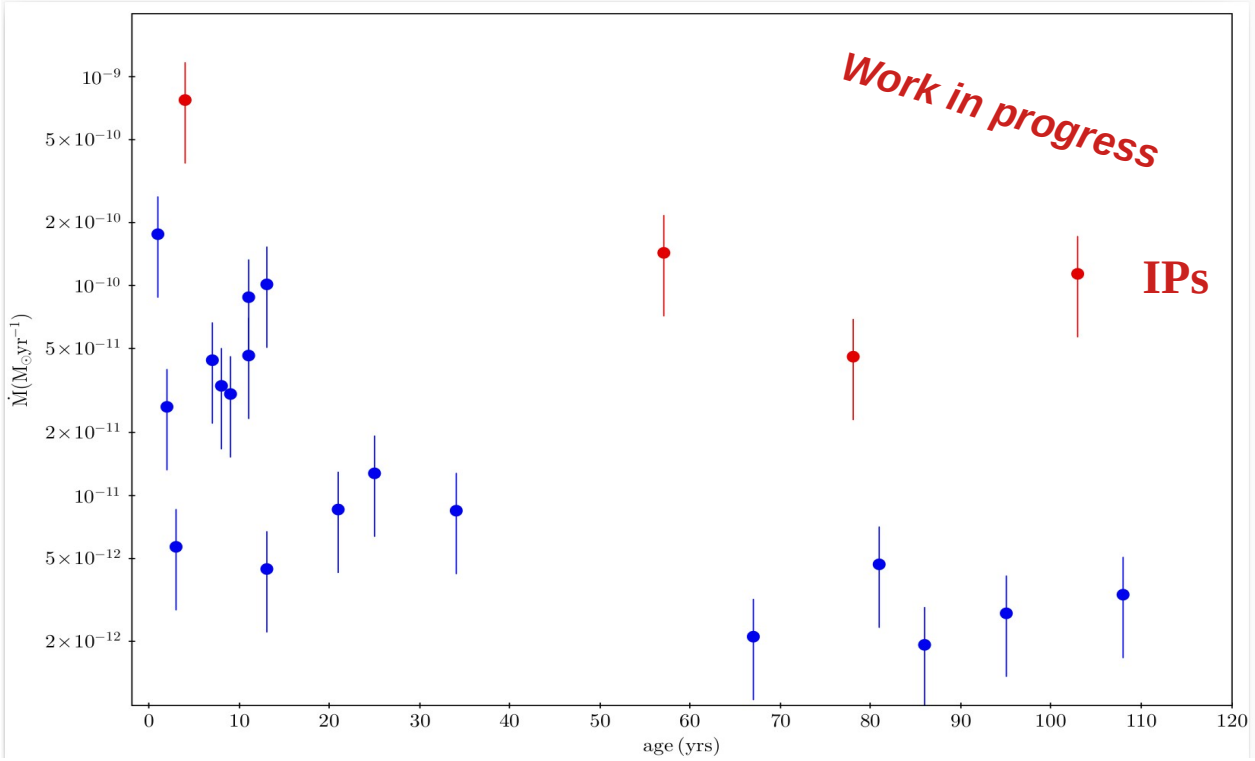
Letter | Published: 23 March 2020

A unified theory of cataclysmic variable evolution from feedback-dominated numerical simulations

Yael Hillman ✉, Michael M. Shara ✉, Dina Prialnik & Attay Kovetz

Nature Astronomy **4**, 886–892 (2020) | Cite this article





Sala et al (in prep)

Irradiation of donor star during the nova outburst increases radius and mass transfer

Summary:

1 Identify old novae in X-rays: 16 new counterparts identified

2 New magnetic novae candidates:
AT Cnc and RR Cha (dedicated X-ray observations needed for characterization)

3 Accretion rate evolution after a nova outburst:
Confirmation of enhanced mass accretion rate in the first decades post-outburst