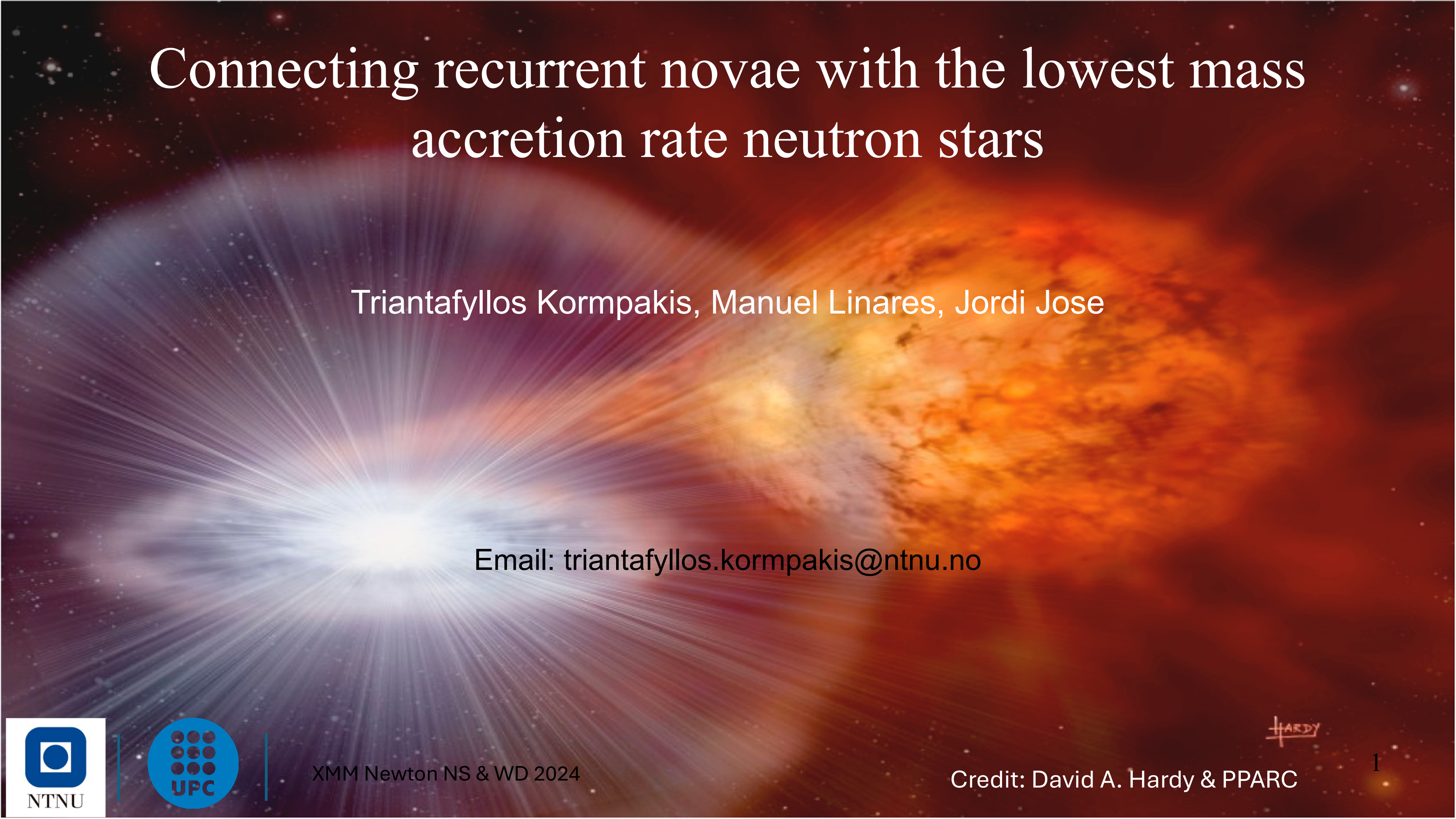

Connecting recurrent novae with the lowest mass accretion rate neutron stars

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Credit: David A. Hardy & PPARC

Accreting WD and NS: General motivation

Thermonuclear bursts (or Thermonuclear runaways) on WD and NS:

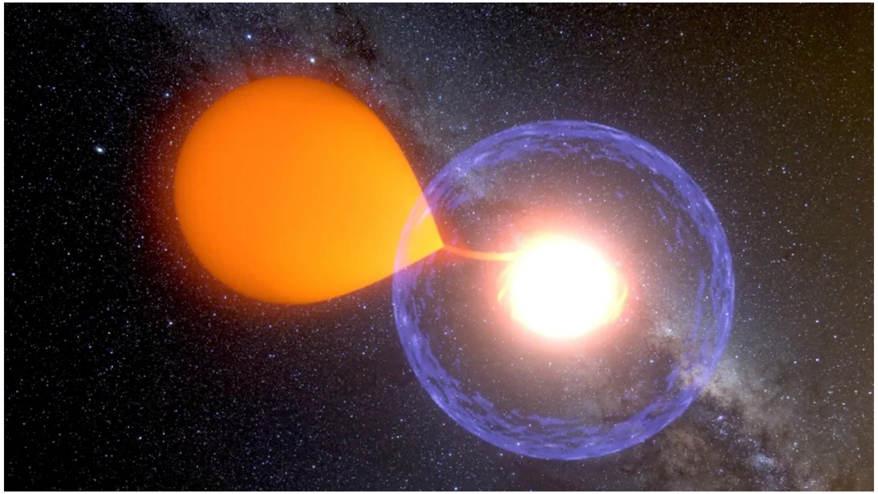
- Recurrent Novae (burst recurrence $t_{rec} \leq 100\ yrs$): possible type Ia supernovae progenitors
- NS Photospheric Radius Expansion: NS mass and radius constraints

Stable fuel burning vs unstable burning (type I X-ray bursts):

- How often and at what accretion rate?

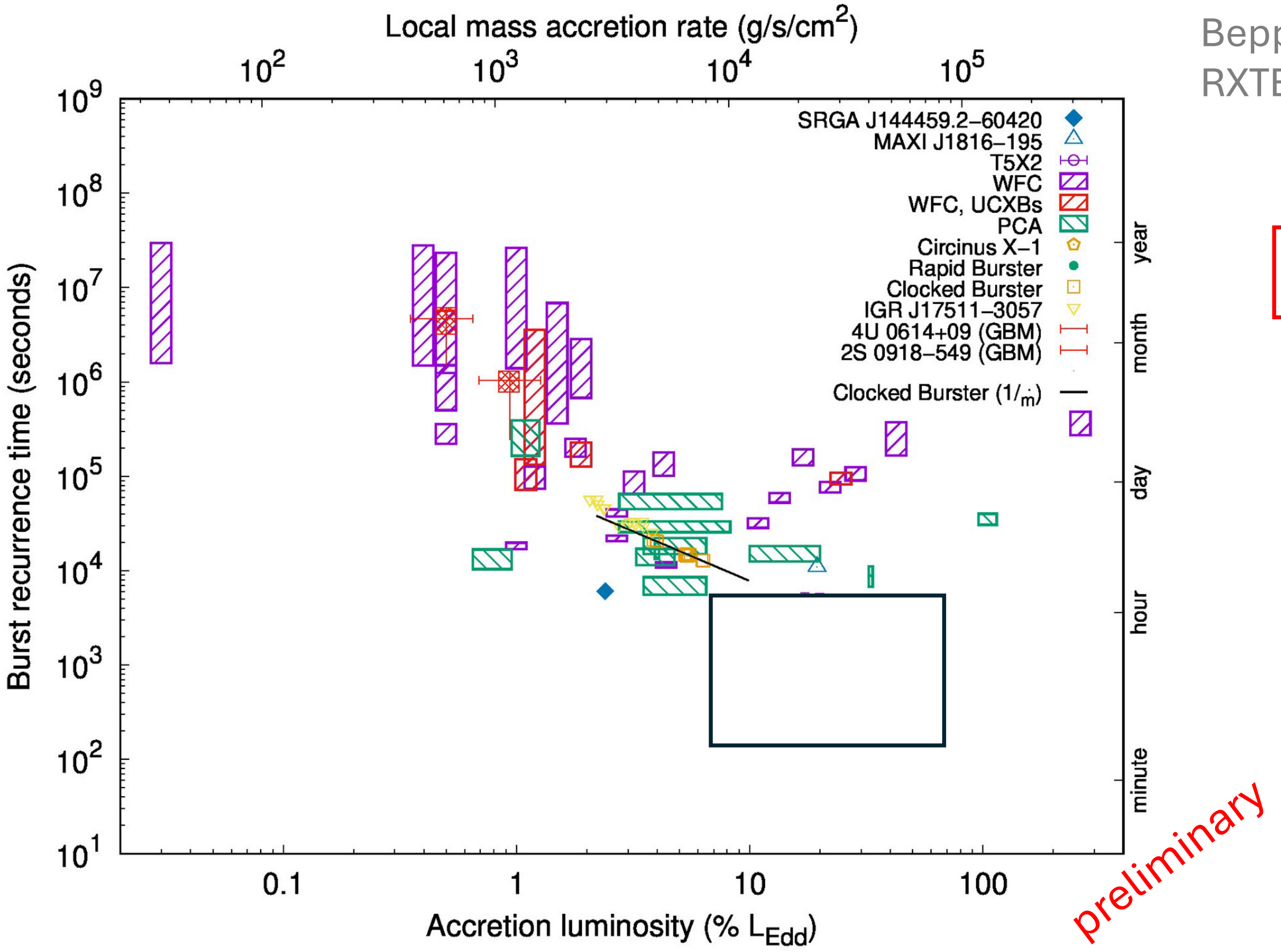
milliHerz quasi-periodic oscillations (mHz QPO's): marginally stable burning, i.e stable He burning tracer.

models of H and/or H/He ignition (NS). Do they agree with observations?



Artist's portrayal of a classical nova explosion.
K. Ulaczyk/Warsaw University Observatory

NS - ‘bursters’ recurrence time vs mass accretion rate



Bepposax /WFC - in ’t Zand et al 2007
RXTE /PCA – Galloway et al 2008

Local mass accretion rate

$$\dot{m} = 3 - 2.6\times10^{5}(g\ s^{-1}cm^{-2})$$

Global mass accretion rate

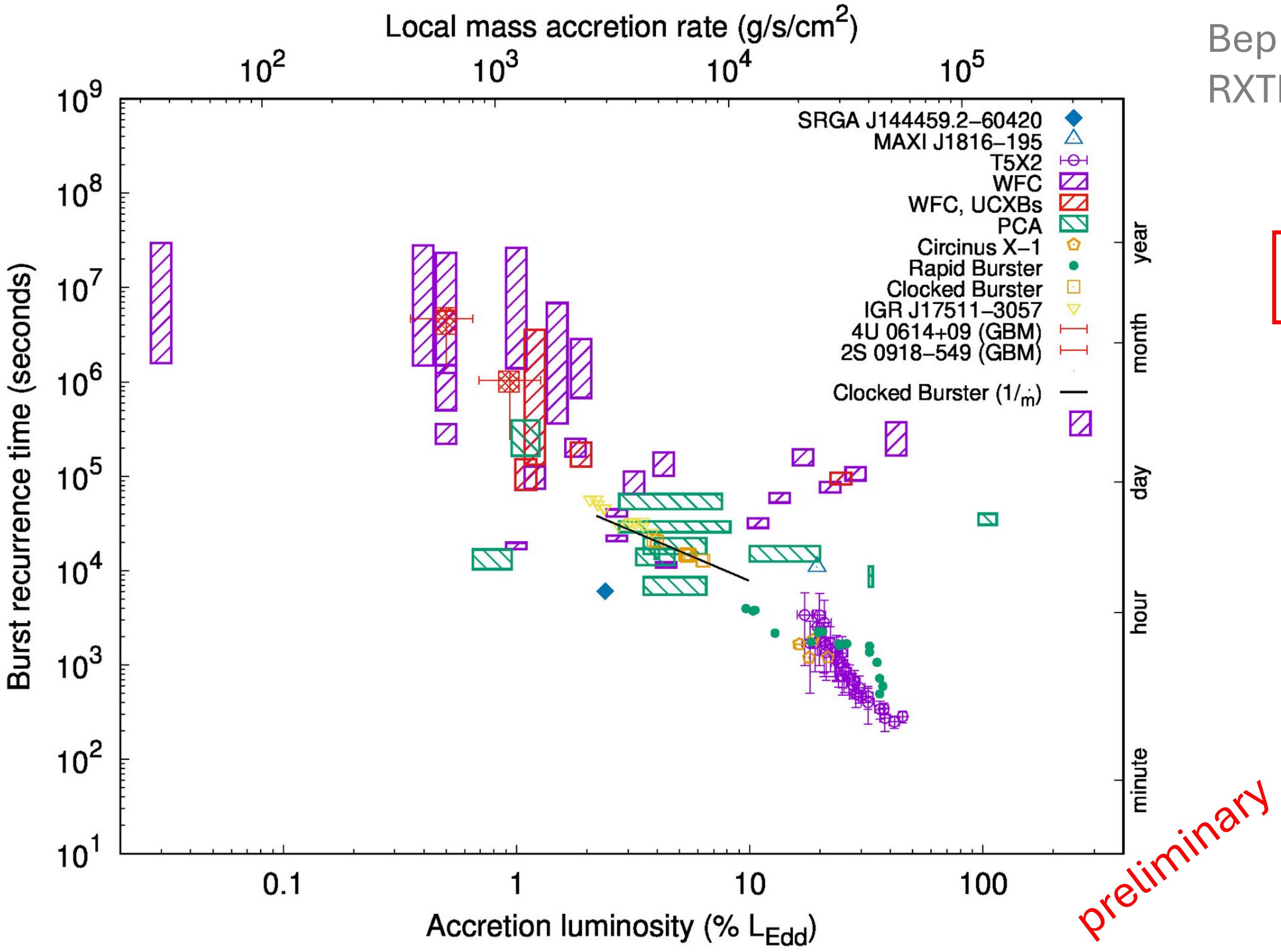
$$\dot{M} = 10^{-13} - 10^{-8}\ M_{\odot}/yr$$

Accretion luminosity (% Eddington)

$$L_{acc} = 0.03 - 263\%\ L_{Edd}$$

Burst recurrence times (t_{rec}):
Until 2012: down to 1 hour

NS - ‘bursters’ recurrence time vs mass accretion rate



Bepposax /WFC - in ’t Zand et al 2007

RXTE /PCA – Galloway et al 2008

Local mass accretion rate

$$\dot{m} = 3 - 2.6{\times}10^{5} (g\ s^{-1} cm^{-2})$$

Global mass accretion rate

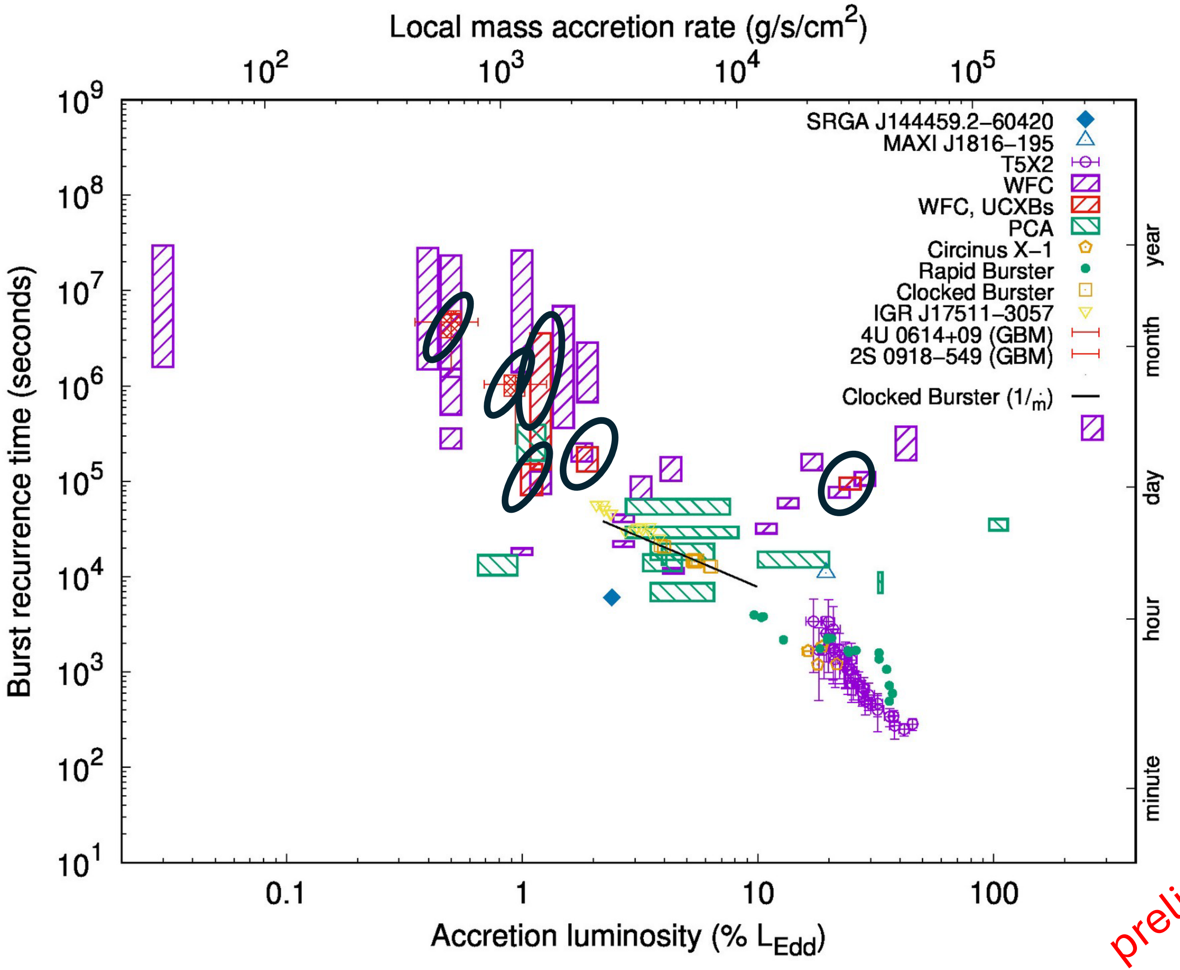
$$\dot{M} = 10^{-13} - 10^{-8}\ M_{\odot}/yr$$

Accretion luminosity (% Eddington)

$$L_{acc} = 0.03 - 263\%\ L_{Edd}$$

Burst recurrence times now (t_{rec}):
From several minutes, up to a year

NS - 'bursters' recurrence time vs mass accretion rate



Bepposax /WFC - in 't Zand et al 2007
RXTE /PCA – Galloway et al 2008

Local mass accretion rate

$$\dot{m} = 3 - 2.6\times10^5 (g\ s^{-1} cm^{-2})$$

Ultracompact X-ray binaries (UCXBs)

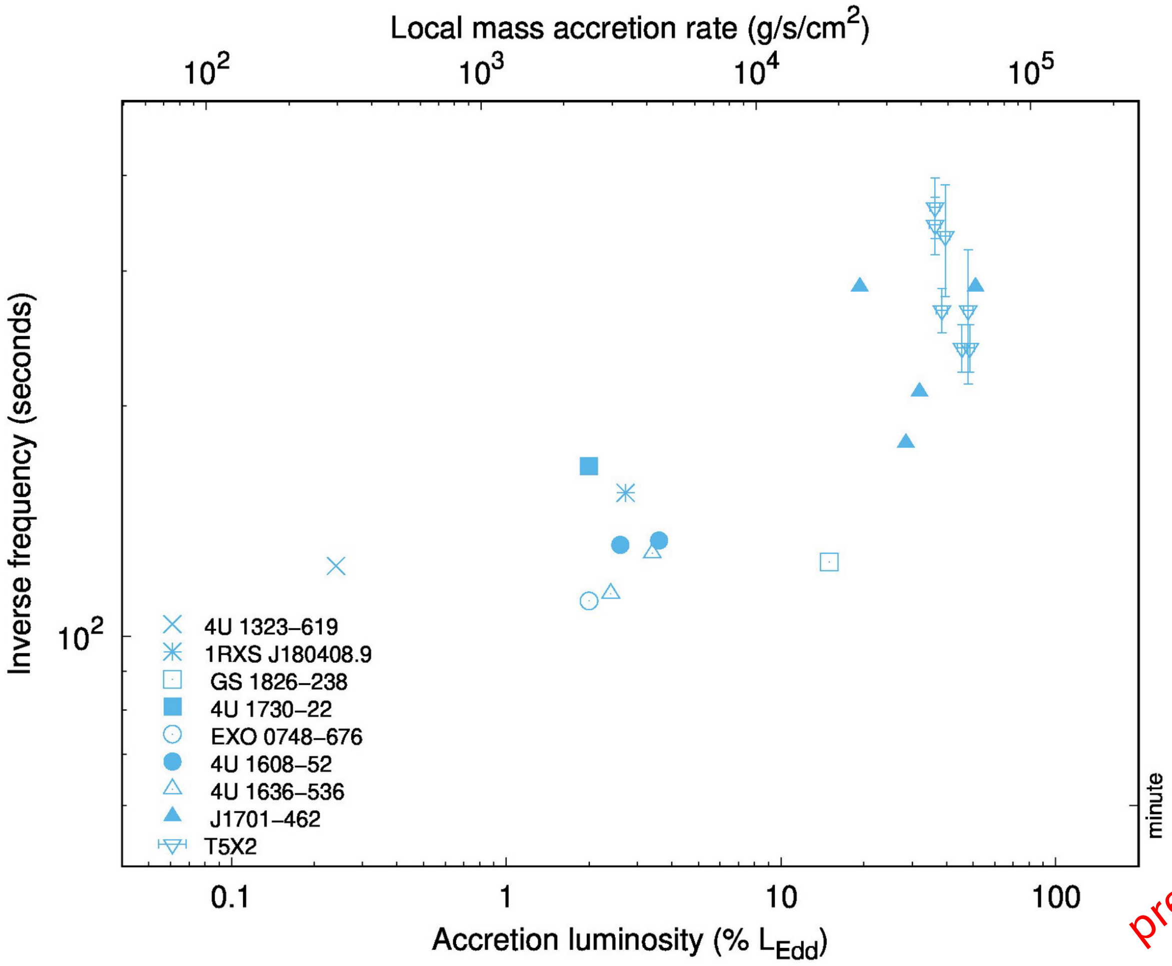
$$(P_{orb} < 1\ hr)$$

- Poor H systems, He rich accretion

T5X2 (Linares et al 2012):
Slow rotator (11 Hz), more frequent bursts

preliminary

NS – mHz QPOs



T5X2: and mHz QPOS!

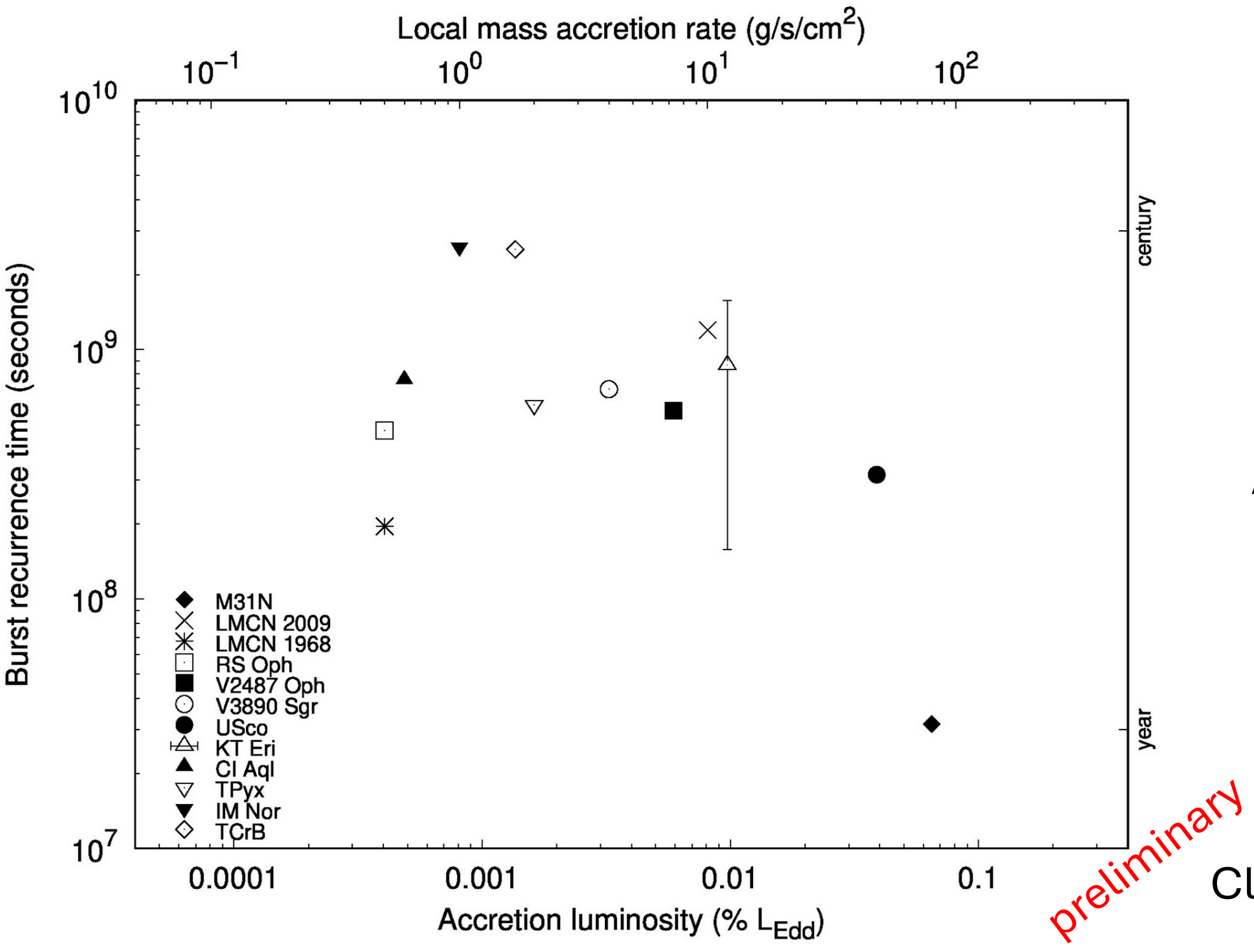
-Frequencies: 2.8 – 8.8 mHz

-Accretion rates: $L_{acc} = 0.2 - 50\% \, L_{Edd}$

Revnivtsev et al. (2001), Strohmayer & Smith (2011), Linares et al. (2012a), Ferrigno et al. (2017), Strohmayer et al (2018), Mancuso et al. (2019), Tse et al. (2021) Mancuso et al. (2023), Tse et al. (2023)

preliminary

WD – RNe recurrence time vs mass accretion rate



Local mass accretion rate

$$\dot{m} = 0.5 - 80(g\ s^{-1} cm^{-2})$$

Global mass accretion rate

$$\dot{M} = 10^{-8} - 10^{-6}\ M_{\odot}/yr$$

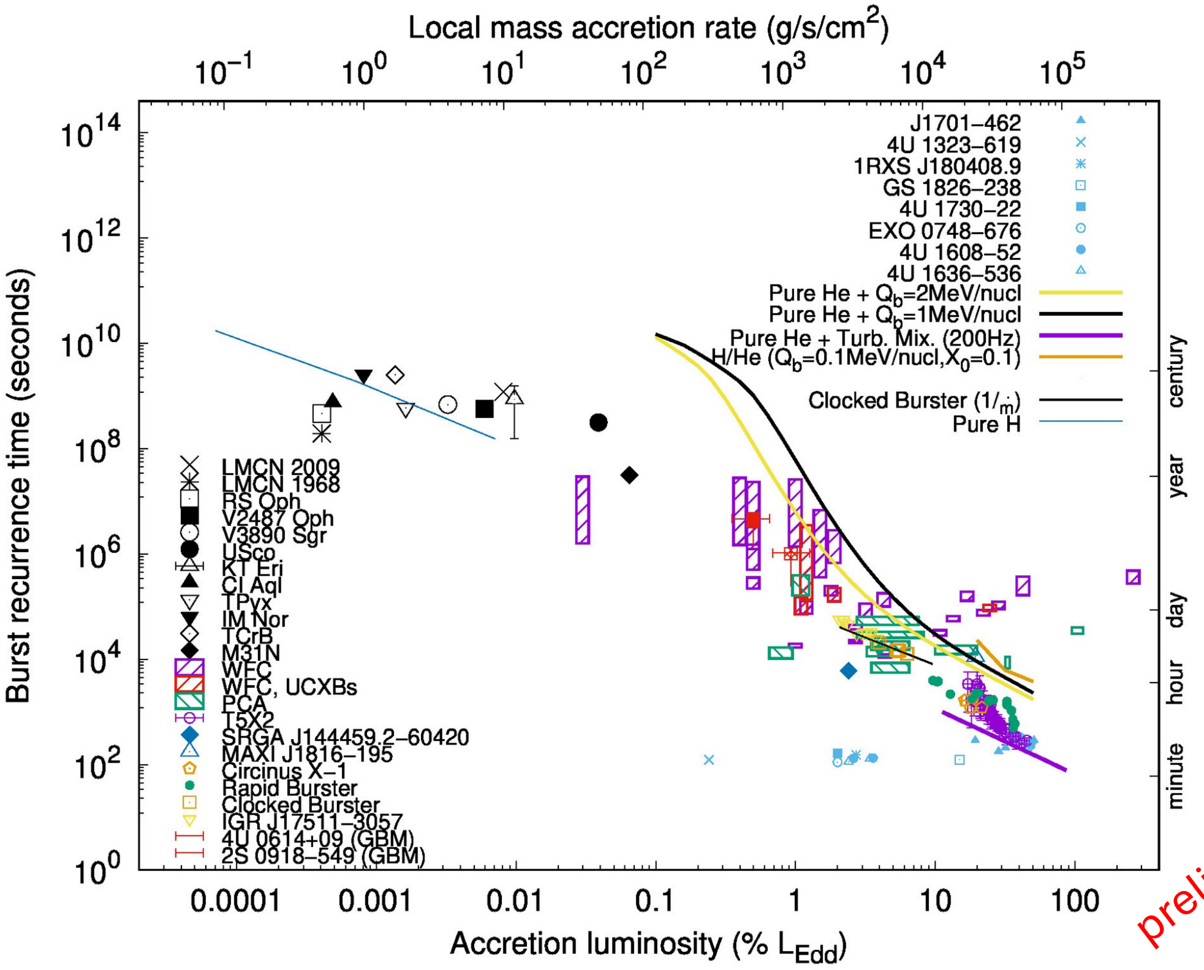
Accretion luminosity (% Eddington)

$$L_{acc} = 10^{-3} - 0.1\ \%\ L_{Edd}$$

Burst recurrence times (t_{rec}):
1 year to a 100 years

Classical Novae: extend t_{rec} to 10^5 yrs

WD & NS – Ignition Models



preliminary

H ignition on RNe:

$$M_{WD} = 1.38\, M_{\odot}, L = L_{\odot}, Z = 1$$

- t_{rec} (RNe): ~ 5 years

Pure He and H/He ignition on NS:
(Cumming & Bildsten 2000)

Rotation and turbulent mixing:
(Piro & Bildsten 2007)

More frequent bursts!

Conclusions

- RNe and NS ‘bursters’ together, cover 6 orders of magnitude in t_{rec}, and 5 in $\dot{m}$ and L_{acc}
- slower rotating accreting NS – more frequent bursts?
- highest mass accreting RNe bridge the gap with NS ‘bursters’
- mHz QPOs: marginally stable burning, observed at $L_{acc} = 2 - 50\%\ L_{Edd}$
- fuel composition and rotational dynamics can influence burst frequency
- more observations – better probing of burning regimes (hopefully!)