



X-ray Studies of Classical Novae

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AN X-RAY STUDY OF CLASSICAL NOVAE

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- Jan-Uwe Ness (ESA/ESAC)
- Jeremy J. Drake (Harvard CfA)

and all concerned ...

X-rays : Suzaku, XMM-Newton, and Swift operation teams
Chandra, Beppo-SAX, ASCA, ROSAT, and Einstein

Infrared : Kanata TRISPEC team in Hiroshima University

Optical : Variable star databases (AAVSO, VSNET, VSOLJ)
Worldwide amateur astronomers

Summary of the Ph.D. thesis

Scope : Classical novae are important in astrophysics
X-ray studies are necessary for understanding
But, it was difficult by their transient nature ...

Method : 1. Data archive search
2. Target-of-Opportunity (ToO) observations
Point : Collaboration with amateurs and multi-satellites
Agenda : Five important challenges in astrophysics

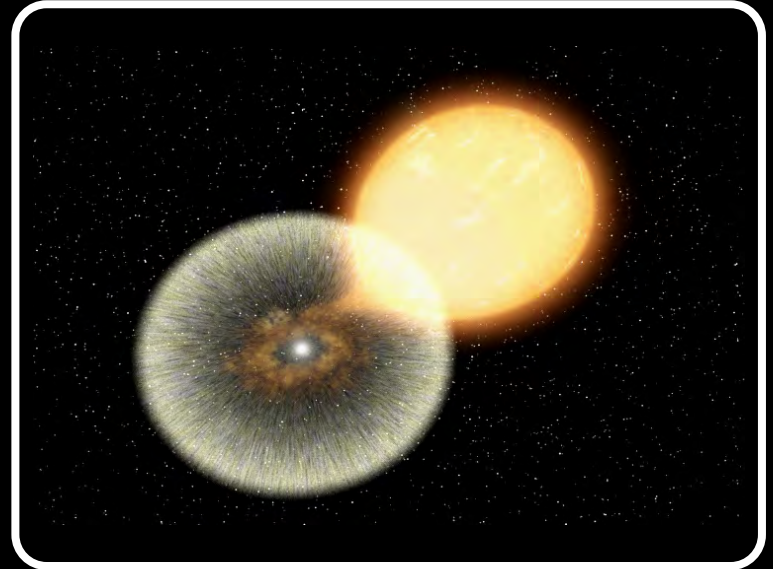
Result : X-ray studies of five novae ($\sim 20\%$ of the total)
Both expected and unexpected scientific results

Goal : Understanding the nature of classical novae !!

Classical Novae and X-rays

- Classical Novae (CNe)

- Binary (WD and Late-Type)
- Sudden hydrogen fusion
- Energy : $10^{45} \sim 10^{46}$ erg
- Mejecta : $10^{-4} \sim 10^{-6} M_{\odot}$
- V_{ejecta} : $10^2 \sim 10^4$ km/s
- Rate : 10/yr (discovered)



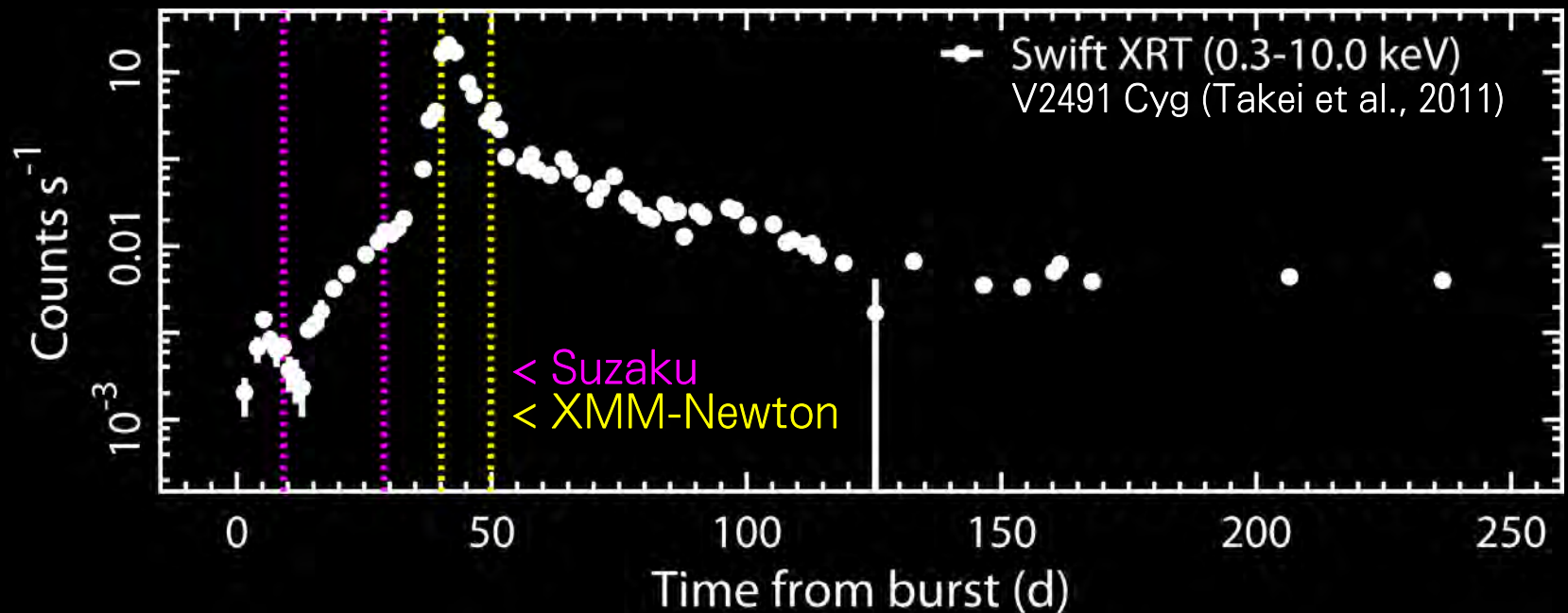
- X-rays from CNe

- Soft X-rays (< 1 keV) from WD surface (a.k.a. SSS)
- Hard X-rays (> 1 keV) from shocks in the ejecta
- The system returns to a quiescent phase over time

Advent of Swift era

- X-ray studies of CNe were quite difficult
 - Rare event in post CNe explosions
 - Faint, variable, and transient behaviors
 - ToO observations were risky
- Swift changed the game, completely !!
 - X-ray snapshots for discovered CNe
 - Monitoring campaigns at a high cadence
 - Risk reduction for other observatories

Road to X-ray spectroscopy has opened
The golden age of CNe has arrived



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Suzaku View : Classical Novae

③ V2491 Cyg (2008.04)

- Takei et al. (2009), *ApJL*, 697, 54
- Takei et al. (2010), *AN*, 331, 183
- Takei et al., (2011), *PASJ*, in press.

⑤ U Sco (2010.01)

- Takei et al., in prep.

⑥ V1280 Sco (2007.02)

- Observed in AO-5

⑦ RS Oph (2006.02)

- Planned in AO-6

④ V2672 Oph (2009.08)

- Takei et al., in prep.

② V458 Vul (2007.08)

- Tsujimoto et al. (2009), *PASJ*, 61, S69

① Suzaku J0105-72 (2005.08)

- Takei et al. (2008), *PASJ*, 60, S231

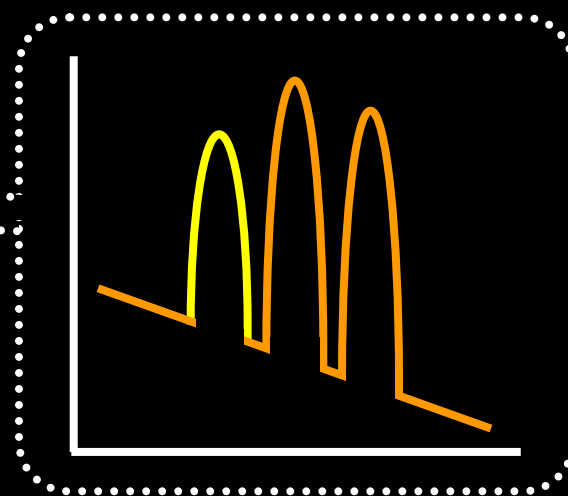
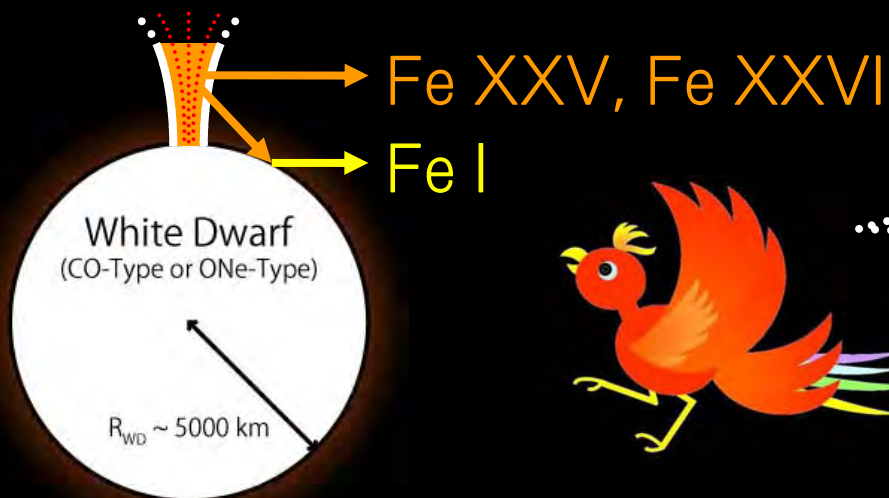
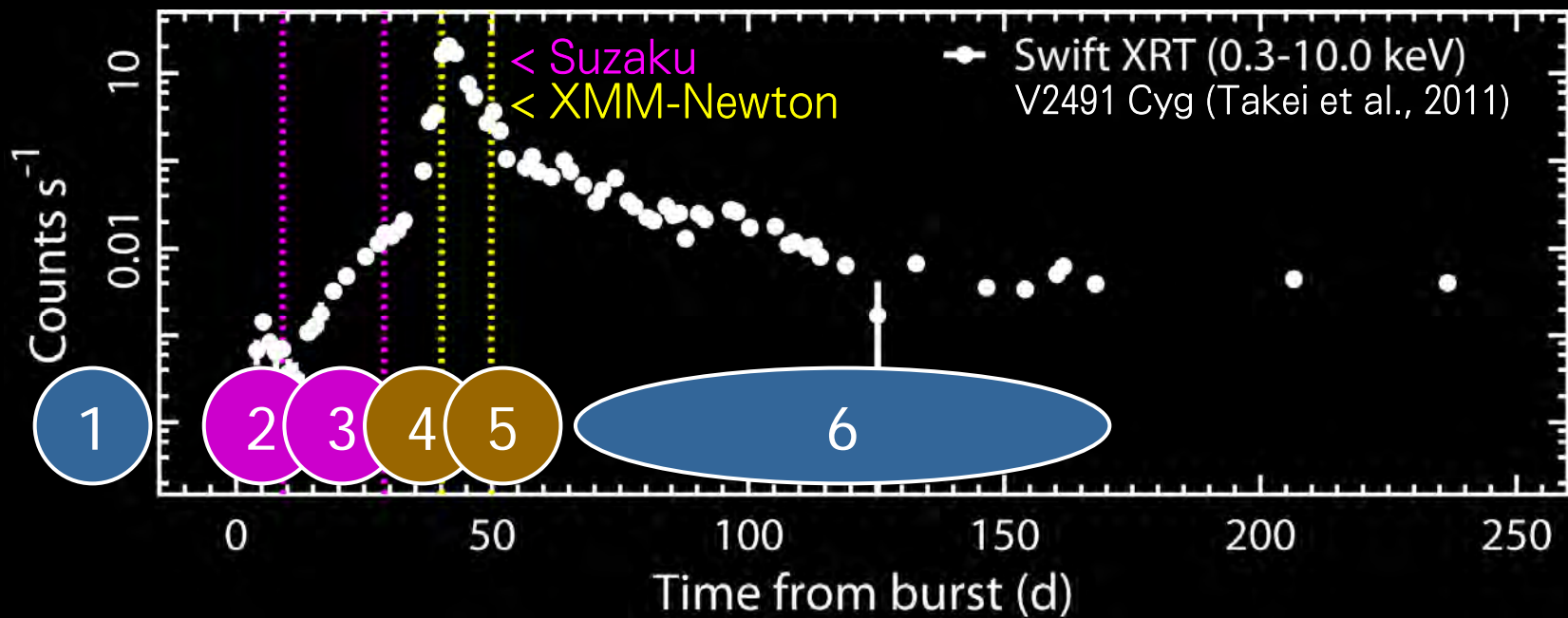
Objectives of Research

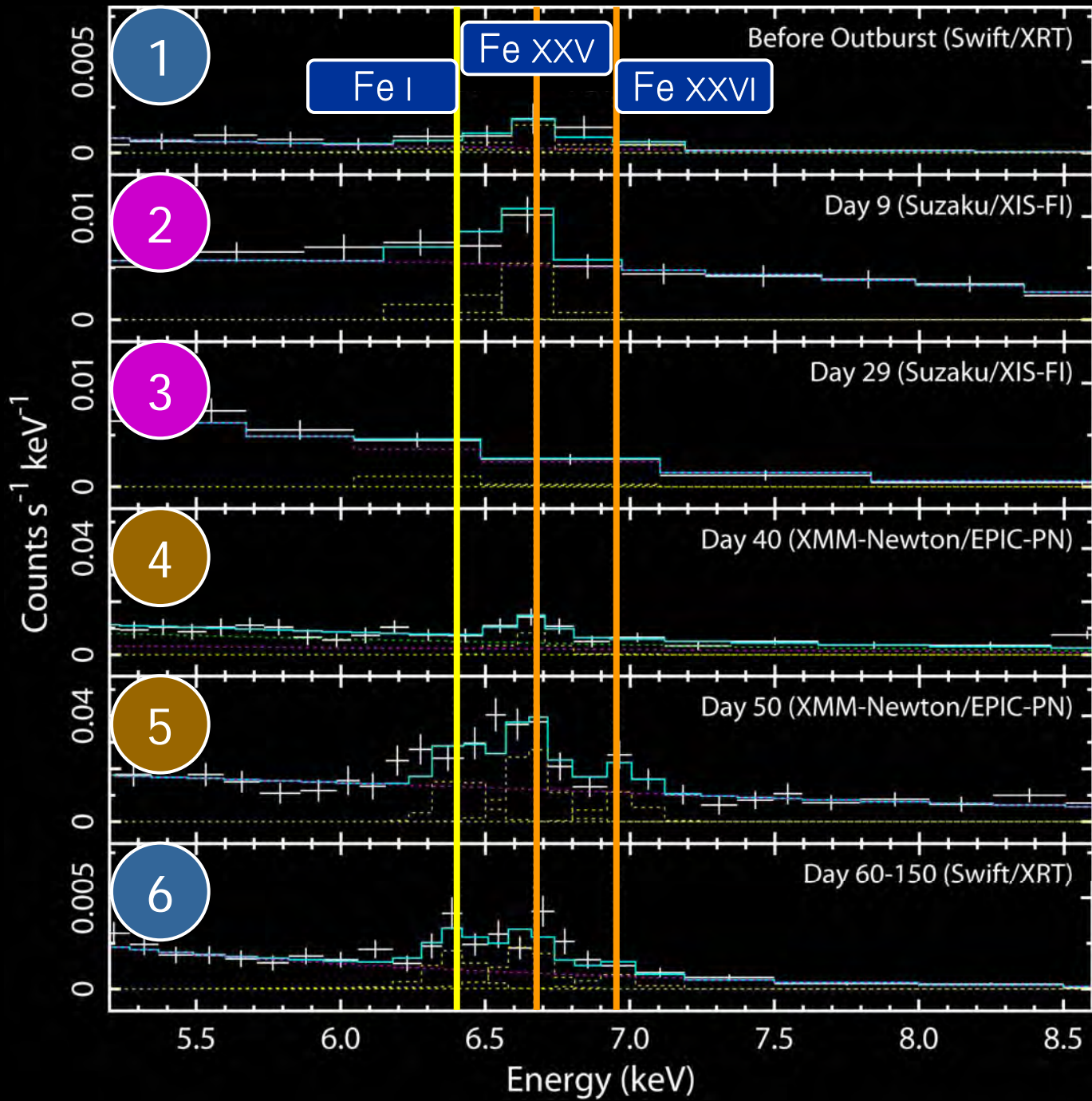
1. Classification of X-ray Emission
2. WD Atmosphere
3. Ejecta Chemistry
4. Reestablished Accretion
5. Discovery of Non-thermal Process

Reestablished Accretion

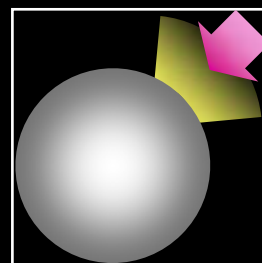
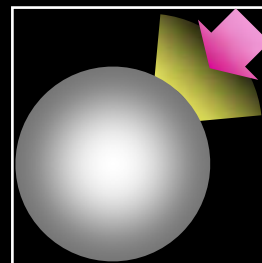
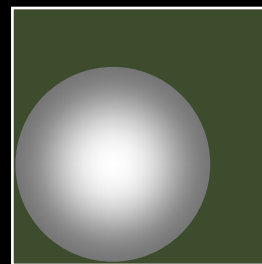
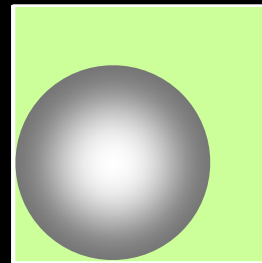
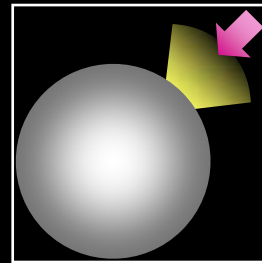
- How early does an accretion proc. resume ?
 - An accretion process stops after a nova outburst
 - But, it is reestablished in the binary evolution
- Get the evidence of an accretion proc.
 - Some CNe occur in magnetized WDs (i.e., Polar, IP)
 - IPs are strong emitters of Fe lines (talk by T. Yuasa)

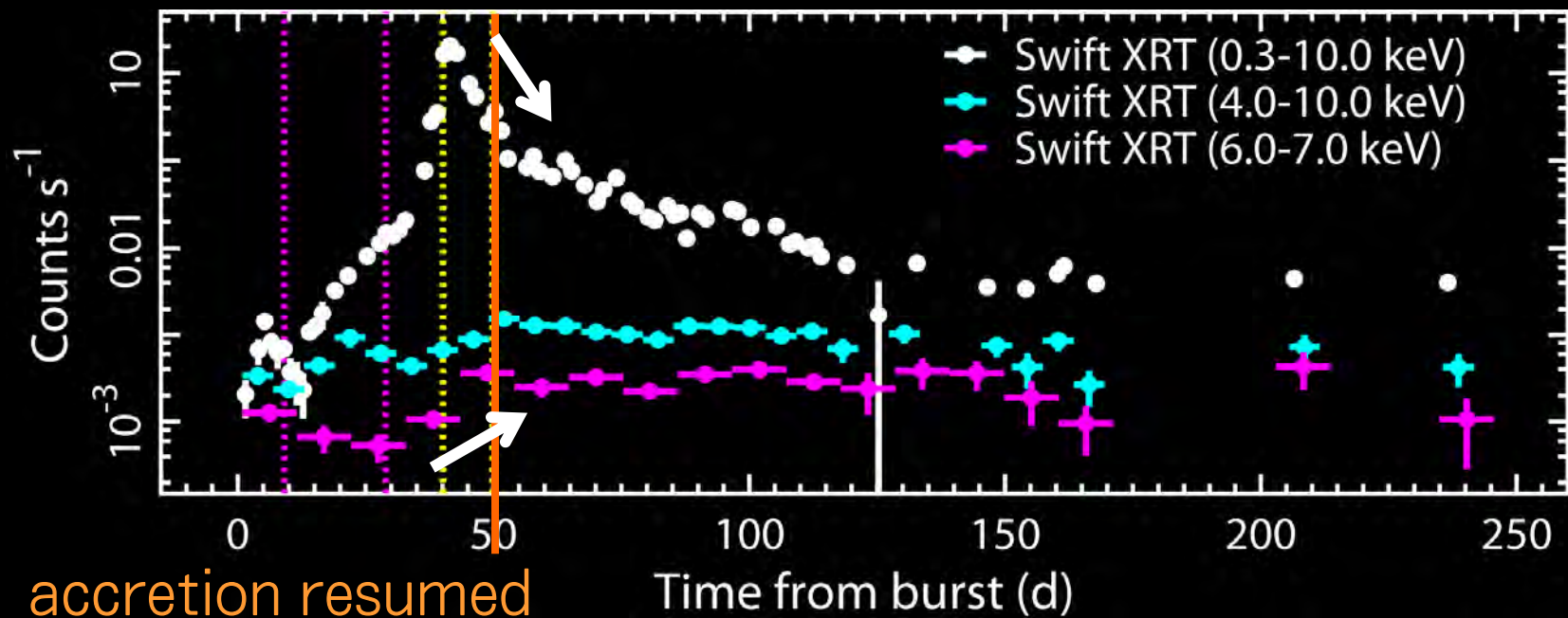






Takei et al. (PASJ, 2011, in press.)





Result and Discussion :

- Radiation pressure inhibits an accretion proc.
 - Bright soft X-rays from the WD surface
- Accretion resumes when the fuels consumed
 - Inverse correlation between soft and Fe light curve
 - We confirmed the time-line of the binary evolution

Summary

1. Dawn of a golden age of classical novae
2. Recent studies impact on astrophysics
3. Suzaku brought me the Ph.D. degree !!

Please let me know if you are interested
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