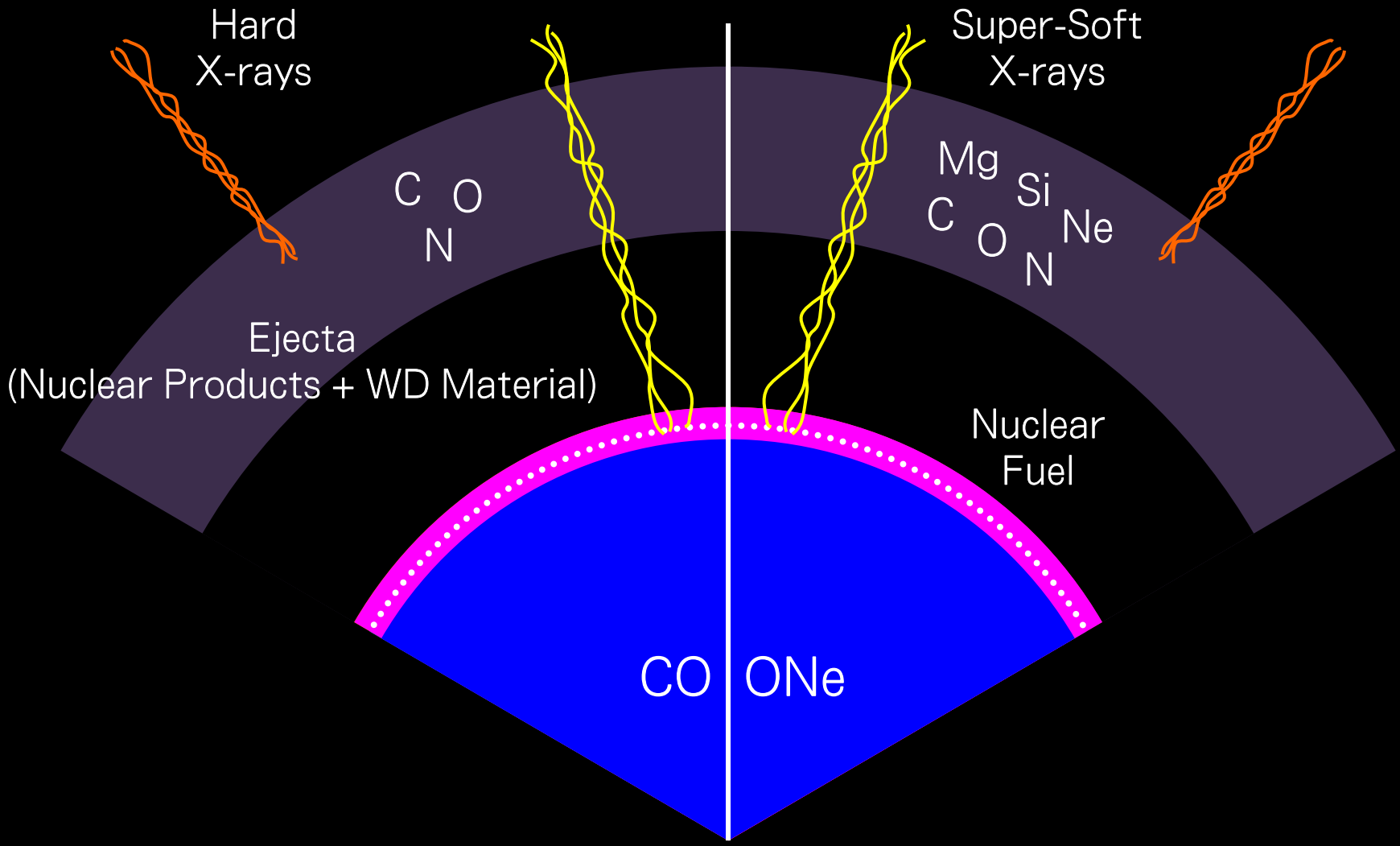
Suzaku Observations of a Super Soft Source and Classical Novae

Dai Takei[1], Masahiro Tsujimoto[2,3*], Shunji Kitamoto[1], Jan-Uwe Ness[4,5*], Jeremy Drake[6], Hiromitsu Takahashi[7], and Koji Mukai[8,9]

[1]Rikkyo University, [2]ISAS/JAXA, [3]PSU, [4]ESA/ESAC, [5]ASU, [6]SAO, [7]Hiroshima University, [8]NASA/GSFC, [9]University of Maryland, *Chandra Fellow

X-ray Sources from Novae



X-ray Satellite Suzaku (すざく)

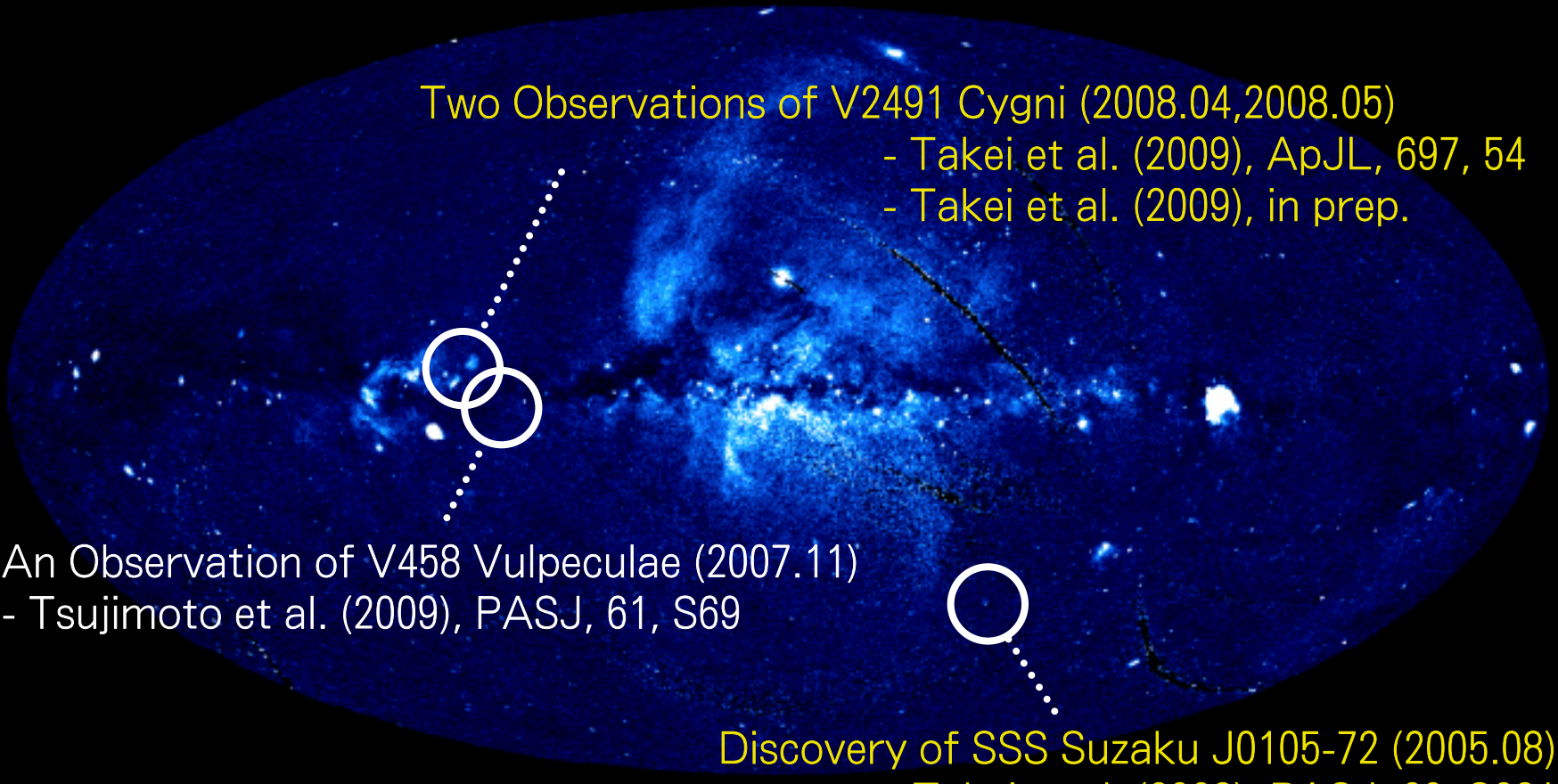
http://www.isas.jaxa.jp/j/enterp/missions/asca/image/pct_main_asuka.jpg
http://eda.plain.isas.jaxa.jp/suzaku_xoops/modules/newbb/download.php?url=/Bamba_Bamba_Aya.ppt.1149042392000

Suzaku Detectors of Suzaku

XRS	XIS (0,1,2,3)	HXD (PIN,GSO)
Bandpass	0.2 ～ 12 keV	10 ～ 600 keV
Spatial Resolution Not-Working...	～2 arcm. (HPD)	Non-Imaging...
Energy Resolution	～130 eV @ 6 keV	～4.0 keV (PIN)
Time Resolution	8 sec	61 μ sec

http://www.astro.isas.jaxa.jp/suzaku/overview/
http://eda.plain.isas.jaxa.jp/suzaku_xoops/modules/newbb/download.php?url=/Bamba_Bamba_Aya.ppt.1149042392000

Suzaku View : SSS and Novae



http://skyview.gsfc.nasa.gov/cgi-bin/query.pl
ROSAT ALL-Sky X-ray Background Survey (0.73-1.56 keV)

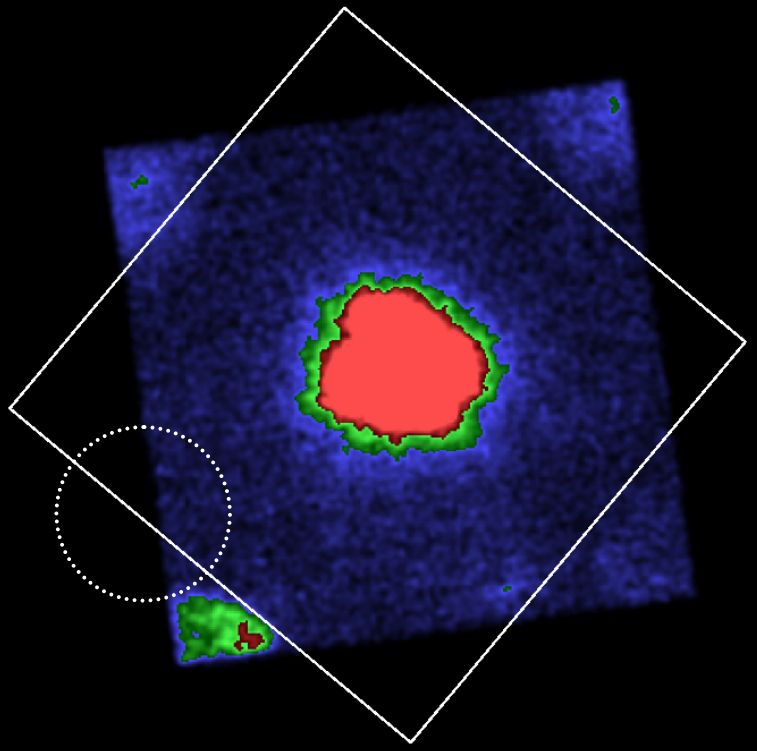
Discovery of Suzaku J0105-72

Serendipitous discovery of a transient source during a series of routine calibration observations of 1E0102.2-7219.

Table 1. Suzaku observation log

Sequence number	Start date	t_{exp}* (ks)
100001020	2005-08-13	4
100014010†	2005-08-31	24
100044010	2005-12-16	111
100044020	2006-01-17	42
100044030	2006-02-02	21
101005010	2006-04-16	22
101005020	2006-05-21	19
101005030	2006-06-26	22
101005040	2006-07-17	22
101005050	2006-08-25	49
101005060	2006-09-19	11
101005070	2006-10-21	37
101005090	2006-12-13	28
101005100	2007-01-15	24

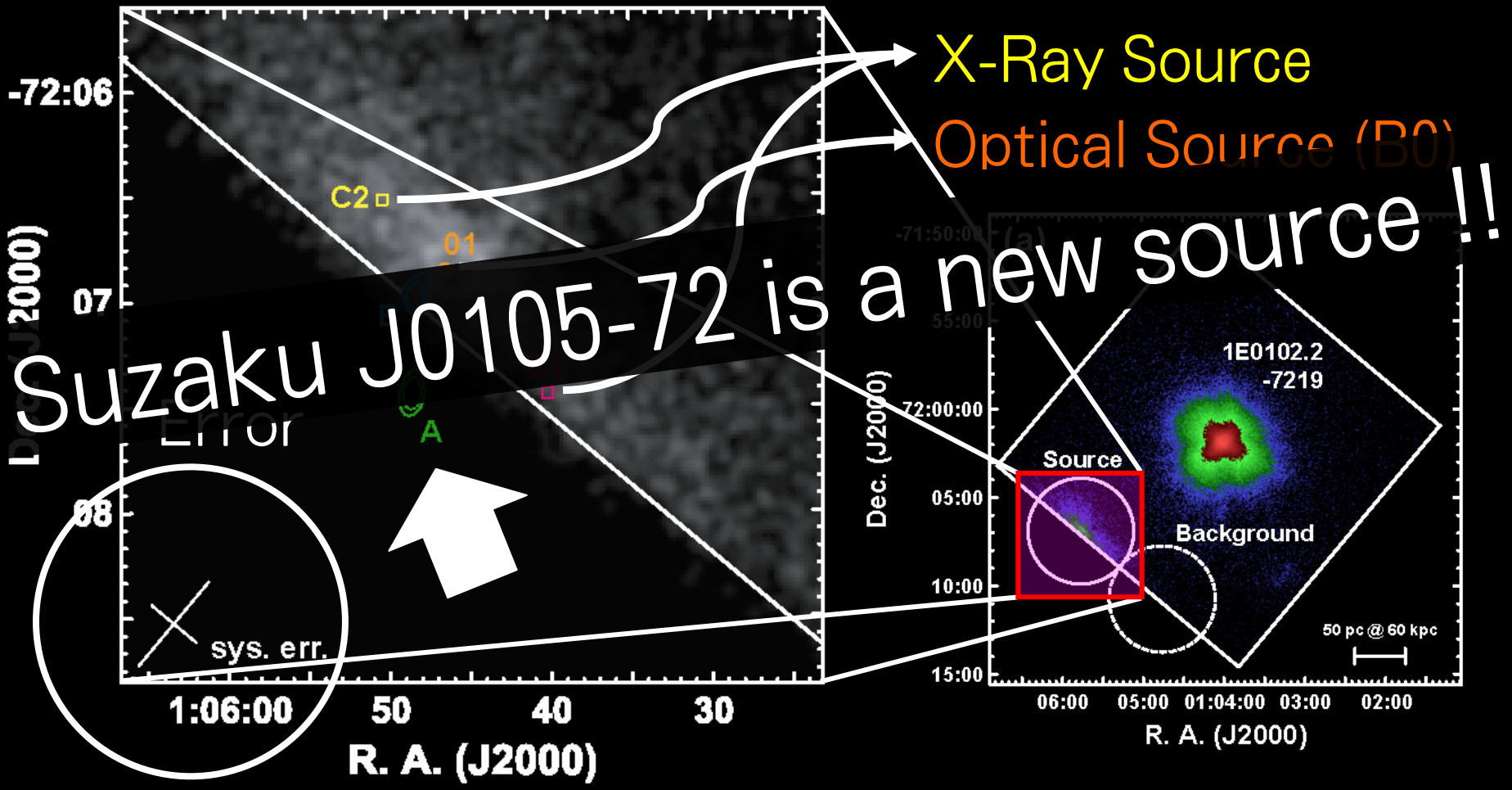
* Averaged exposure time of operating CCDs.
† The transient source was detected during this observation.



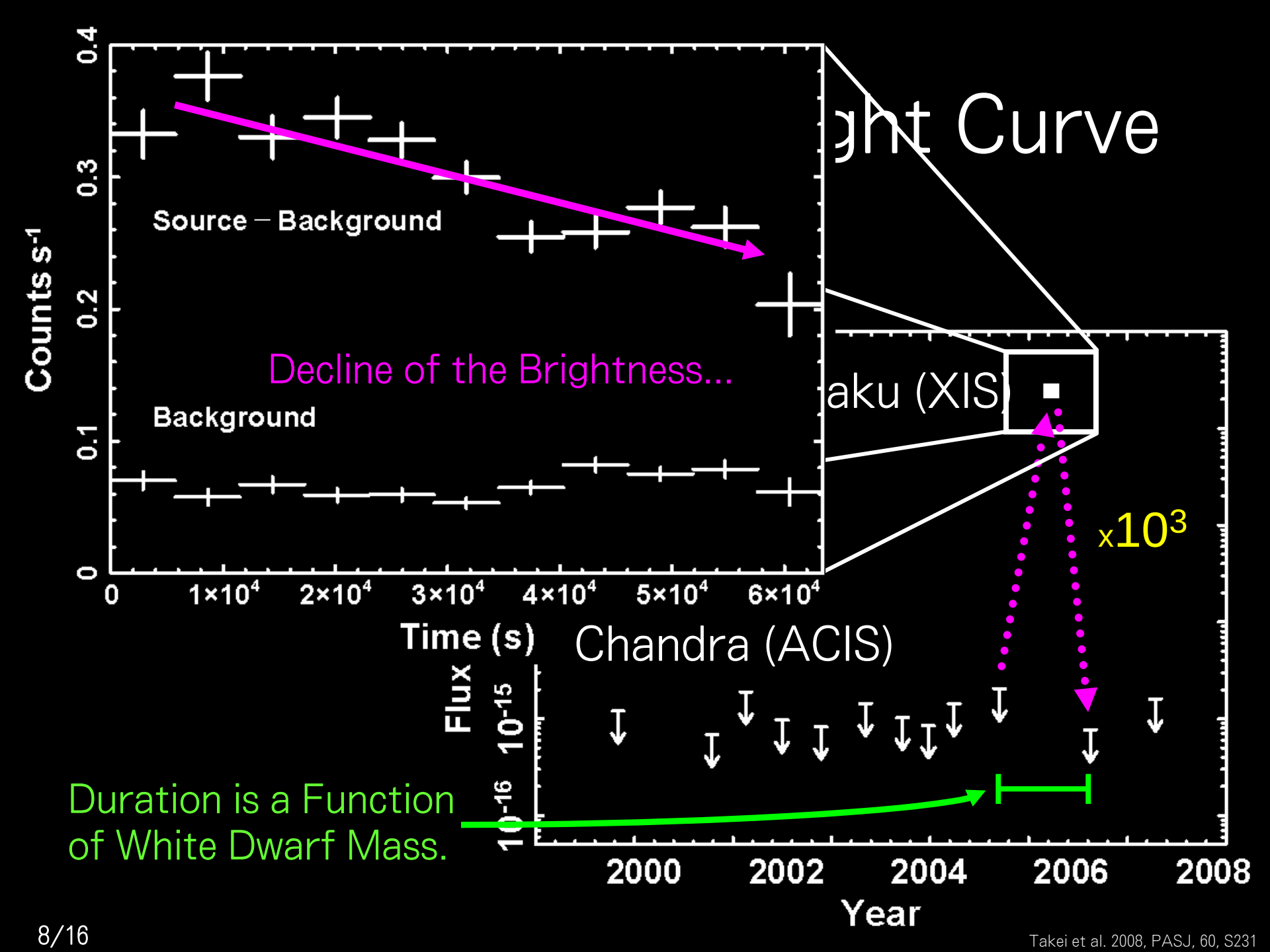
Position reconstructed; Outside of the XIS FoV.

Takei et al. 2008, PASJ, 60, S231

Suzaku J0105-72 : Position

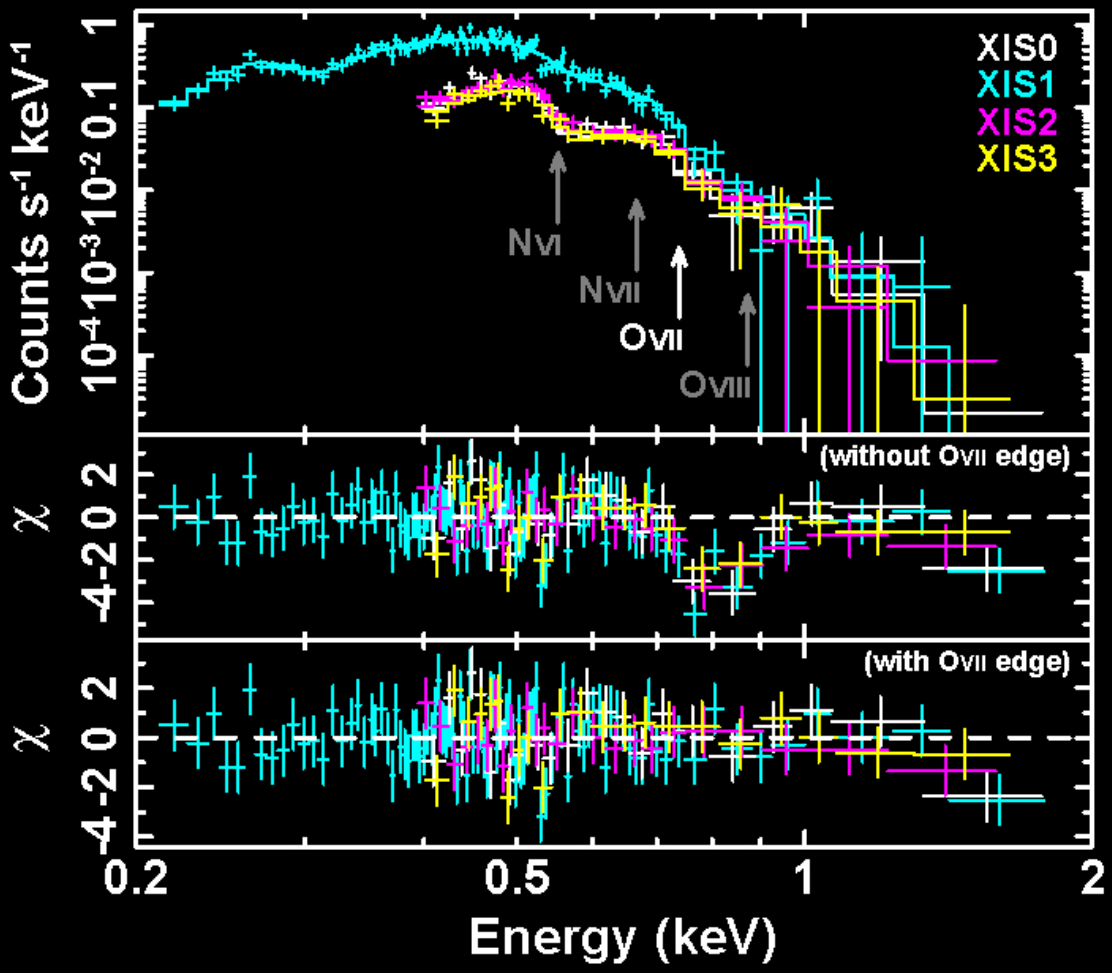


Takei et al. 2008, PASJ, 60, S231



Takei et al. 2008, PASJ, 60, S231

Suzaku J0105-72 : Spectrum



Continuum

- Blackbody (kT ～ 72±2 eV)

WD Atmosphere

- O_{VII} Absorption Edge (τ ～ 1.2)

We assume the distance of 60 kpc to the Small Magellanic Cloud...

- L_{bol} ～ 10^{37} erg s^{-1}
- R_{WD} ～ 10^{8} cm

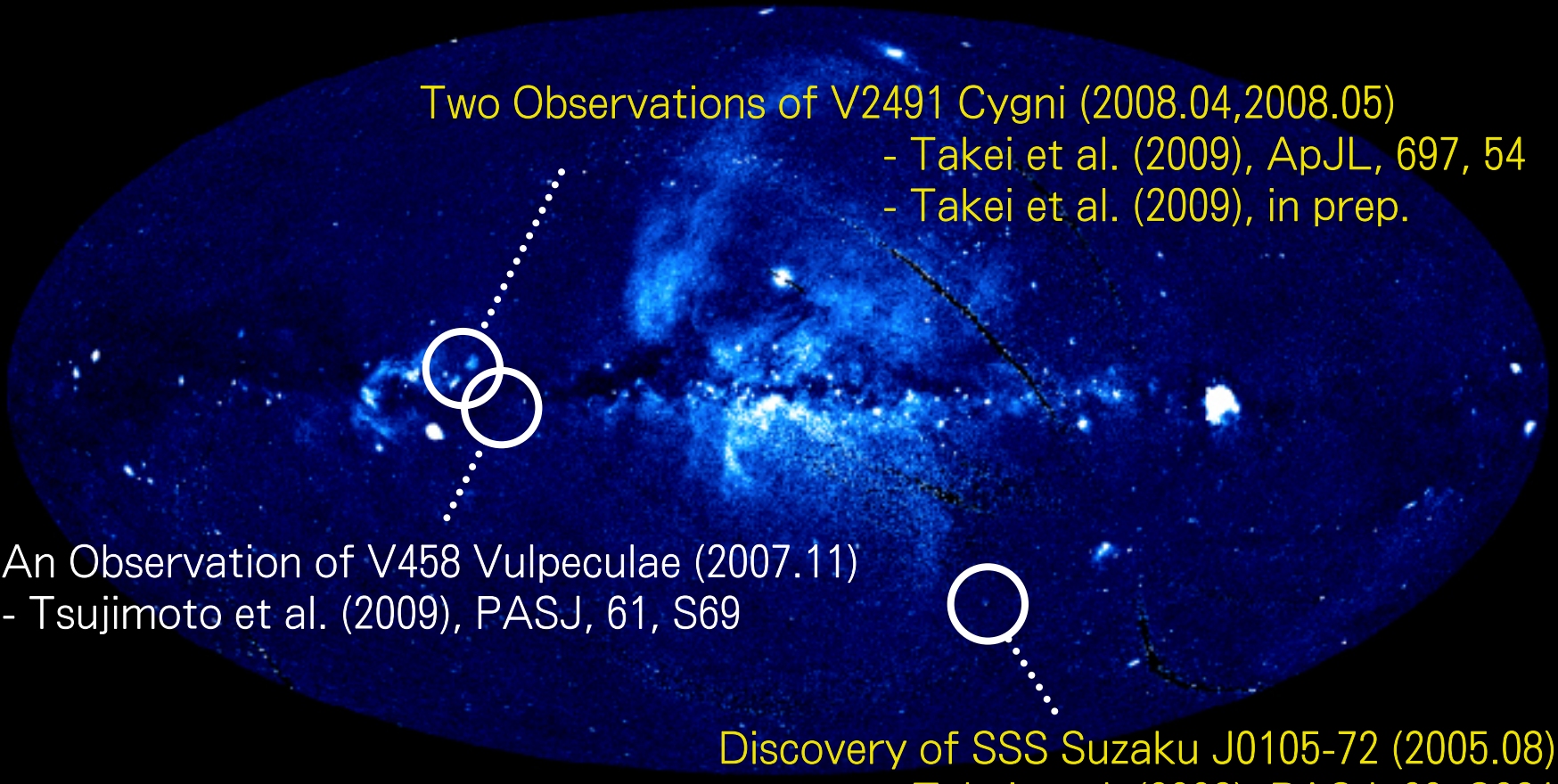
All these properties were indicate that this is a super-soft source.

The temperature and duration are function of the WD mass.

- WD Mass ～ 1.2 $M_{\odot}$

Takei et al. 2008, PASJ, 60, S231

Suzaku View : SSS and Novae



http://skyview.gsfc.nasa.gov/cgi-bin/query.pl
ROSAT ALL-Sky X-ray Background Survey (0.73-1.56 keV)

Classical Nova V2491 Cygni

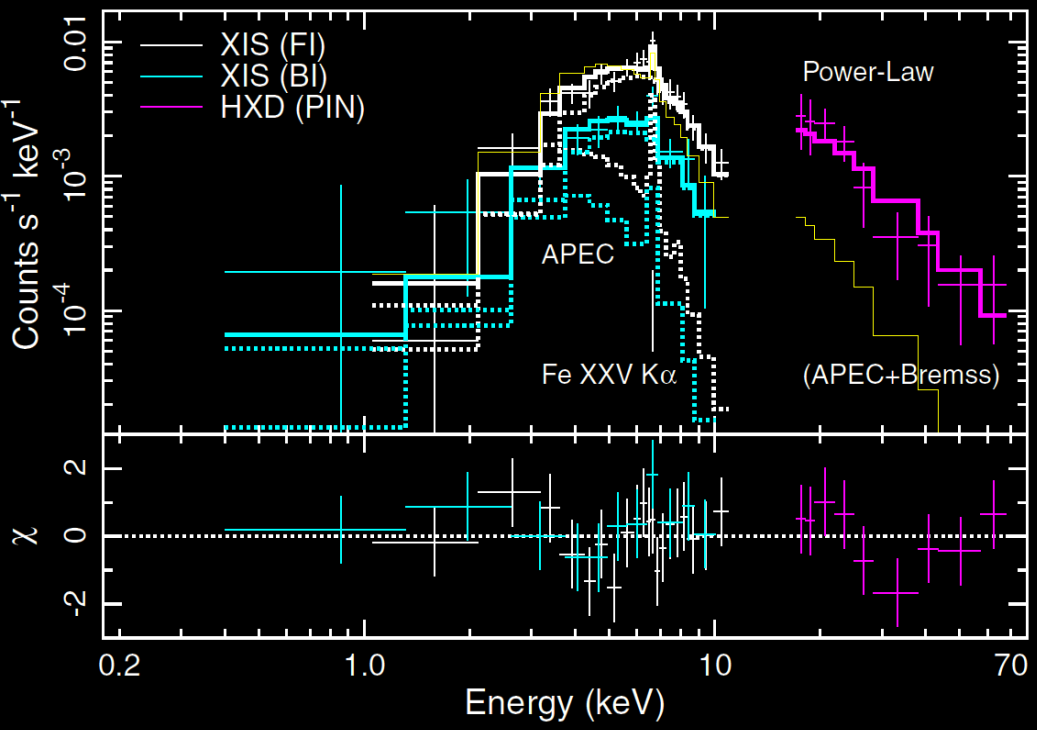
- Discovery at 2008 April 10.728 (UT).
  (Nakano et al. 2008, IAUC, 8934, 1)
- Swift detected X-rays 5 days after the outburst.
  (Page et al. 2009, MNRAS, submitted.; Presentation by Julian Osborne)
- XMM-Newton observed on days 39 and 43.
  (Ness et al. 2009, in prep.; Presentation by Jan-Uwe Ness)
- X-rays were detected in the pre-nova phase.
  (Ibarra et al. 2009, A&A, 497, L5)

http://www.ztv.ne.jp/web/K.Nakajima/image/Nova%20Cyg%202008-2(08.04.11).jpg

V2491 Cygni : Light Curve

The optical data were provided by the variable star observations from the AAVSO International Database and the VSOLJ Observation Database contributed by observers worldwide and used in this research.

V2491 Cygni : Spectrum (Day 9)



The highest energy photons up to 70 keV ever detected from novae !!

(Takei et al. 2009, ApJL, 697, 54)

Super-hard and flat emission

- Power-Law ($\Gamma \sim 0.1$)
- The spectrum can not explain by a simple thermal-bremss model.

Fe line from thin-thermal plasma

- APEC (kT $\sim$ 3 keV)

We obtained the X-ray spectrum in the early stage of the outburst.

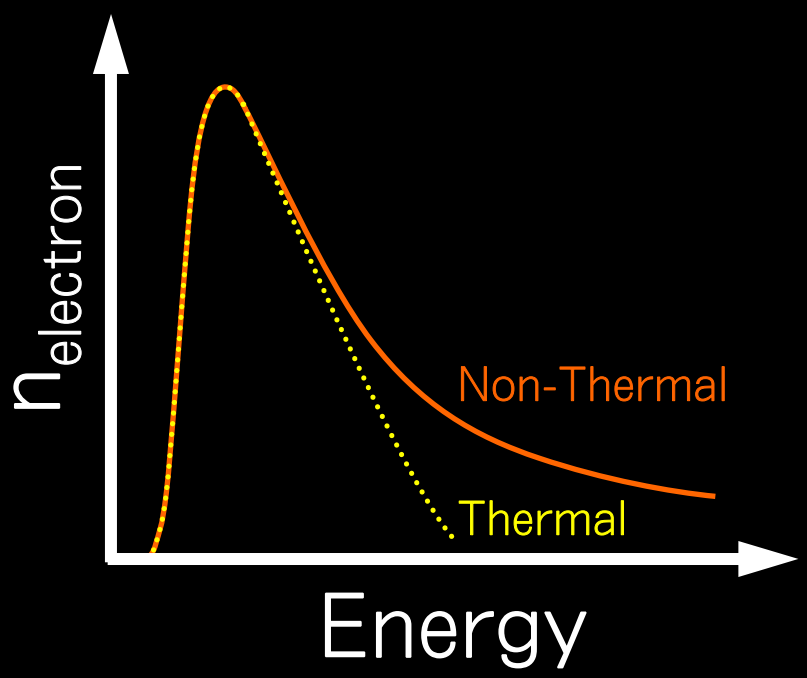
Were these X-rays emitted from the shocks of the ejecta ... ?

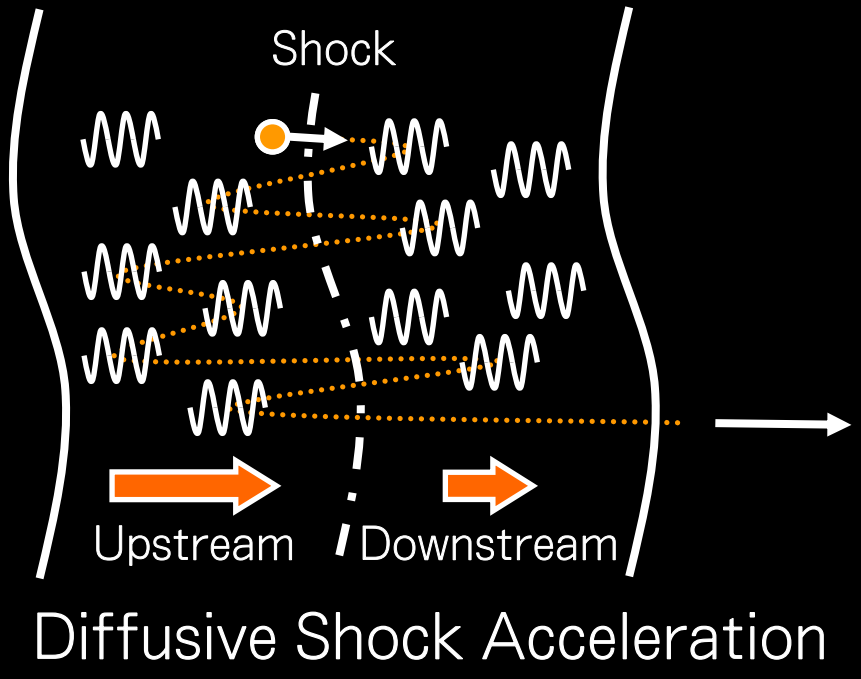
What is the radiation mechanism of the power-law emission ... ?
-> generally, non-thermal origin.

Takei et al. ,2009, ApJL, 697, 54

Non-Thermal Emission

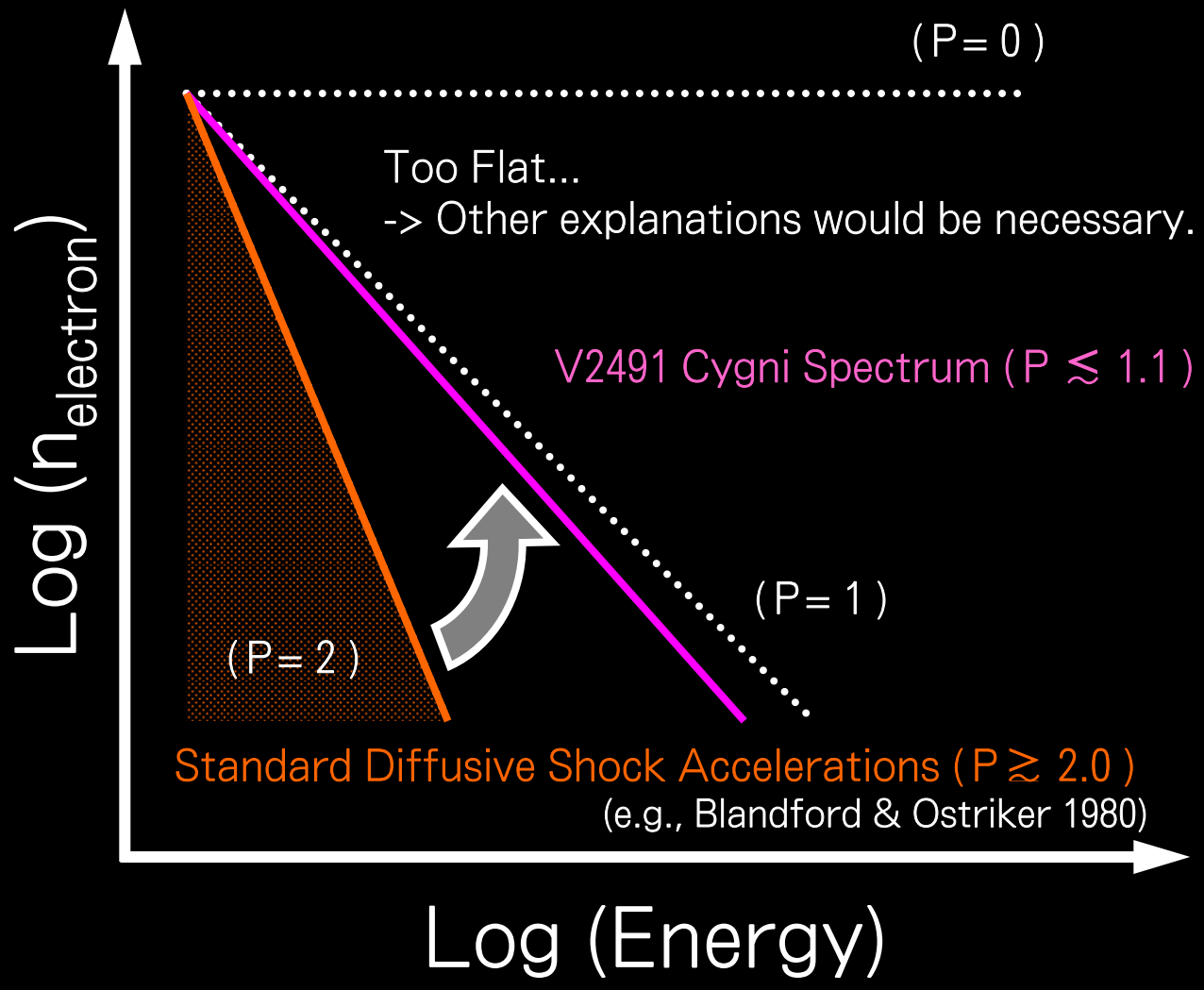
We considered Diffusive Shock Accelerations similar to SNRs.
Non-thermal particles in classical novae are suggested
in some radio observations and theoretical studies of RS Oph.
(e.g., Tatischeff & Hernanz et al. 2007; Rupen et al. 2008)





http://www.astro.isas.ac.jp/xjapan/news/article/2004/1209/
http://vega.ess.sci.osaka-u.ac.jp/info/HE08/HE08/hoshino.ppt

Number Index of Electron



Conclusions

- Suzaku detected X-rays from Novae and SSS.
- We discovered SSS Suzaku J0105-72 in the SMC.
- Super-Hard X-ray emission was detected up to ～70 keV from the classical nova V2491 Cygni.
- The flat power-law spectrum suggests that the presence of non-thermal emission from Novae.

http://eda.plain.isas.jaxa.jp/suzaku_xoops/modules/newbb/download.php?url=/Bamba_Bamba_Aya.ppt.1149042392000