Theoretical models of γ-ray emission by RS Oph: comparison with SWIFT/BAT observations

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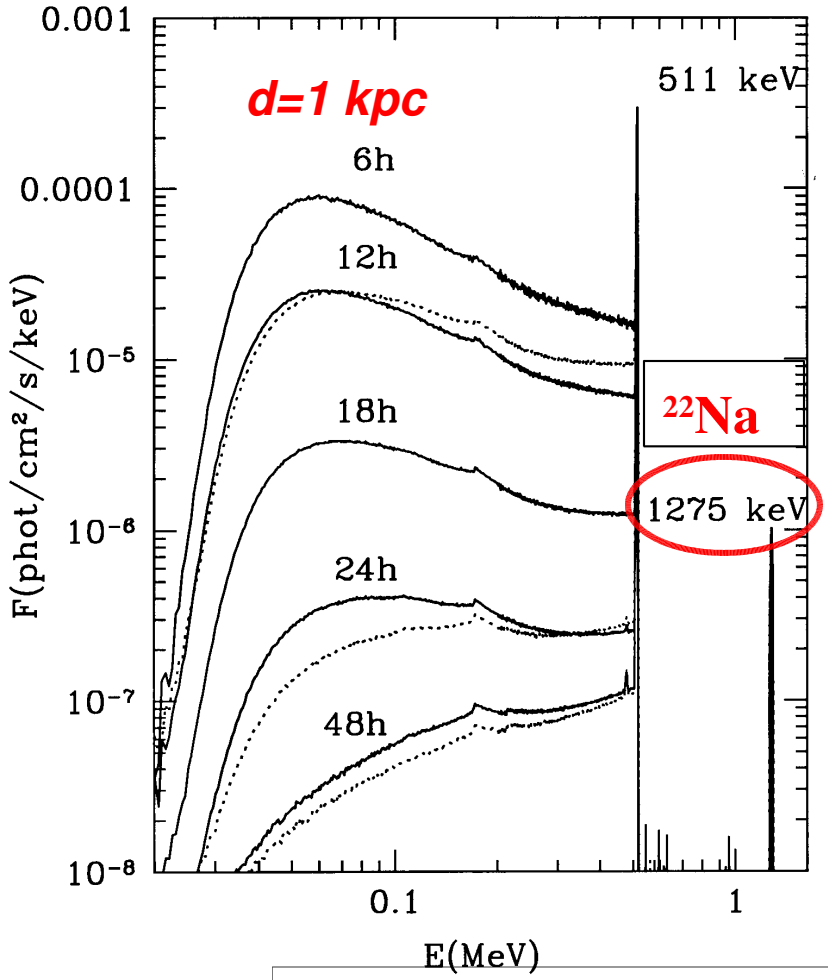
- Realistic models of RS Oph outburst based on thermonuclear runaway (TNR) on a massive ONe white dwarf
- Swift/BAT observations of RS Oph in the (14-200) keV range not related with radioactivity, i.e. NOT due to degradation of γ-rays

Radioactive isotopes synthesized in classical novae relevant for their γ-ray emission

Nucleus	τ	Type of emission	Nova type
^{13}N (β^+)	862 s	511 keV line continuum (E<511 keV)	CO and ONe
^{18}F (β^+)	158 min	511 keV line continuum (E<511 keV)	CO and ONe
^{7}Be (ec)	77 days	478 keV line	CO mainly
^{22}Na (β^+)	3.75 yr	1275 keV line	ONe
^{26}Al (β^+)	1.0X10^6 yr	1809 keV line	ONe

Spectra of ONe novae

M_{WD}=1.15 M (solid), 1.25 M (dotted)



- e^--e^+ annihilation and Comptonization: continuum and 511 keV line; e^+ from ^{13}N and ^{18}F
  - ➡ Leising & Clayton 1987
- photoelectric absorption
  - ➡ cutoff at 30 keV
- 1275 keV line from ^{22}Na decay
  - ➡ Clayton & Hoyle 1974
- similar behaviour for the 2 models, because of similar KE and yields

Gómez-Gomar, Hernanz, José, Isern,1998, MNRAS
Hernanz et al 1999, ApJL, 2002...NewAR

Models for the RS Oph outburst

M_{wd} ($M_\odot$) - ONe	1.35	1.38
$T_{peak}(10^8 K)$	2.8	3.1
M_{acc} ($M_\odot$)	$4.7\ 10^{-6}$	$2.0\ 10^{-6}$
M_{ejec} ($M_\odot$)	*$3.0\ 10^{-6}$*	*$1.3\ 10^{-6}$*
t_{acc}	23.3 yr	10.0 yr
t_{rise} ($3\ 10^7$-10^8 K)	0.7 yr	0.4 yr
t_{peak} (10^8K-T_{peak})	$4.7\ 10^3$ s	$4.4\ 10^3$s
t_{TOT}	*24 yr*	*10.4 yr*
KE_{ejec} (erg)	$3\ 10^{44}$	$2\ 10^{44}$
$<v_{ejec}>$ (km/s)	$3\ 10^3$	$4\ 10^3$

dM/dt=$2\ 10^{-7}$ $M_\odot$ /yr

No mixing (solar accretion)

M_{wd} increases

M_{acc}-M_{ej} > 0 (35% of M_{acc})

$3\ 10^4$ yr to reach $M_{Chandra}$

BUT ONe WDs do not explode as SNIa

Nucleosynthesis in RS Oph outburst: ejecta composition

H	0.61 - 0.58
He	0.37 - 0.40
C	$(4.4 - 3.6)10^{-3}$
N	$(8.3 - 9.4)10^{-3}$
O	$(1.2 - 0.8)10^{-5}$
Ne	$(9.2 - 3.3)10^{-5}$
Si	$(1.7 - 0.6)10^{-4}$
S	$(2.7 - 1.7)10^{-3}$
Ar	$(2.5 – 2.1)10^{-4}$

no large enhancements

Radioactive nuclei

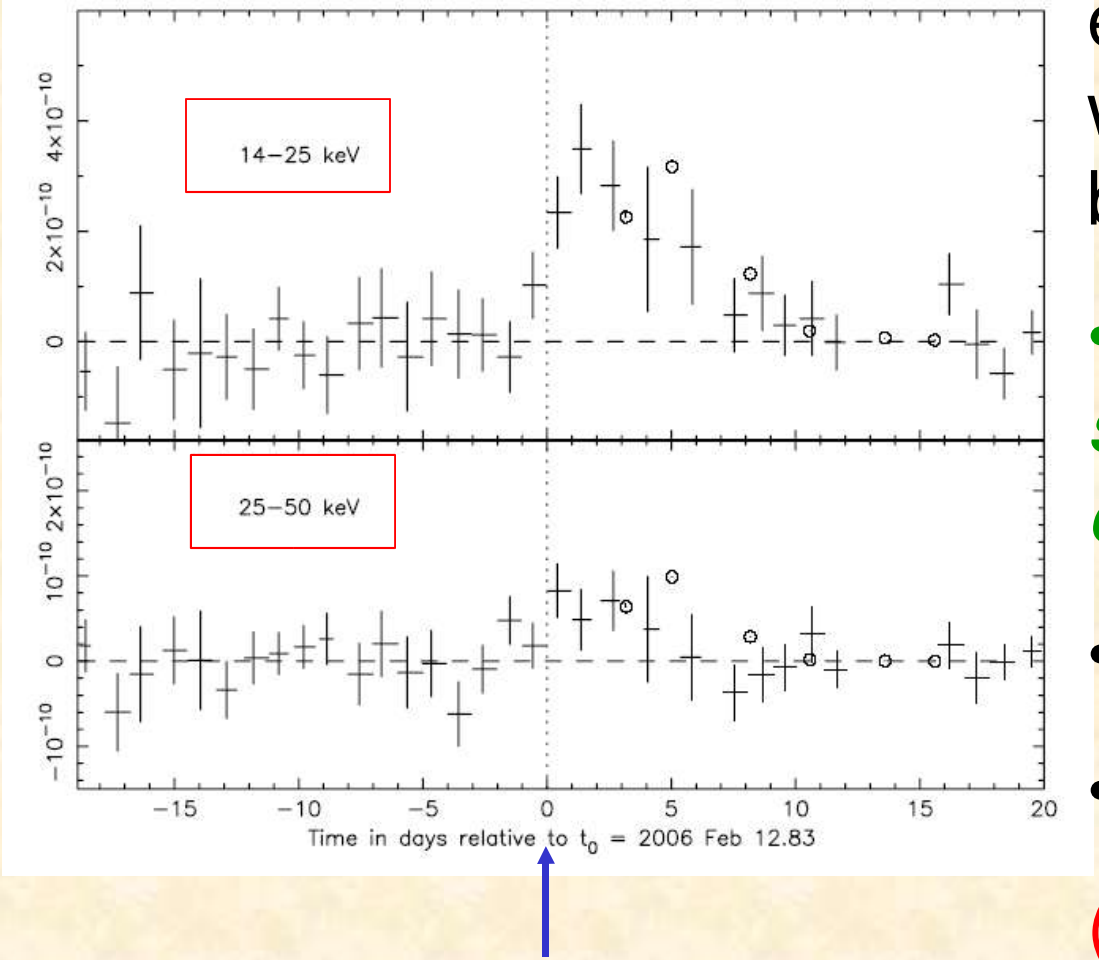
^{13}N	$3\ 10^{-4}$ (~ 3h after T_{peak})
^{18}F	$8\ 10^{-9}$ (idem)
^{7}Be	$5\ 10^{-11}$
^{22}Na	10^{-7}

much smaller yields and M_{ejec} than in "normal" novae and transparency occurs later

=> smaller γ-ray fluxes

Swift/BAT light curves of the 2006 outburst of RS Oph

Bode et al. 2006

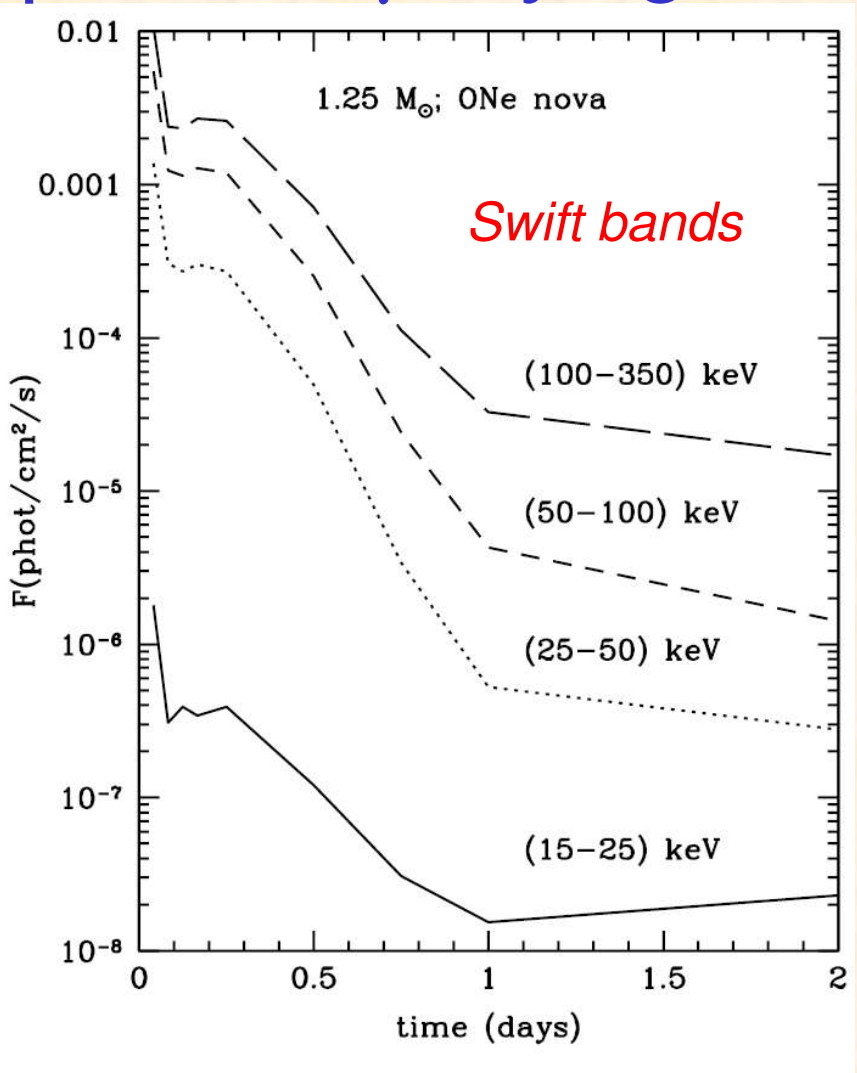


Hard X-ray (soft γ-ray) emission not related with radioactivity because of:

- ***expected flux smaller than observed***
- spectral shape
- time of detection

(G. Skinner's talk)

Spectral: γ-ray light curves of ONe novae



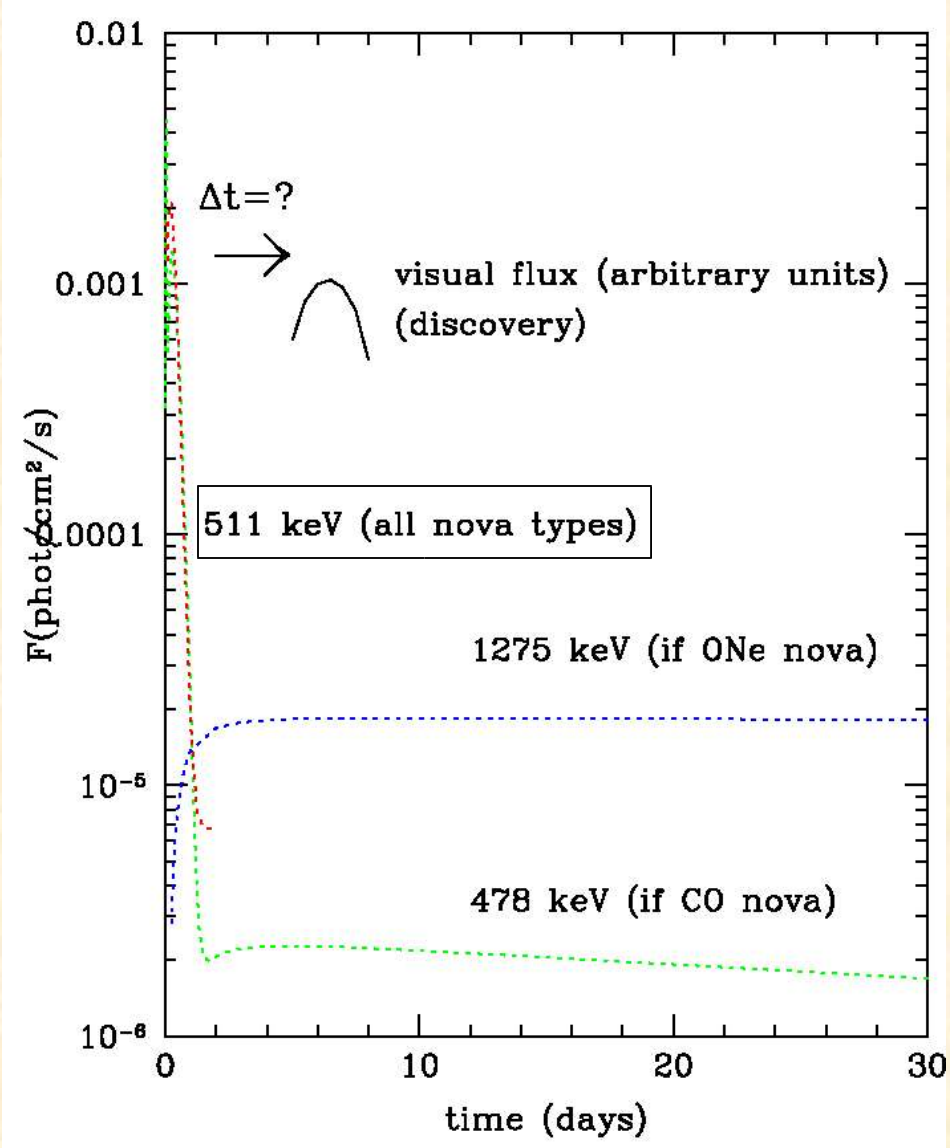
Flux (25-50) keV

larger than

Flux (15-25) keV

contrary to what was observed with Swift/BAT

Temporal: γ-ray and visual light curves



Continuum & 511 keV line, (e^--e^+ annihilation), are intense, but very short and before visual discovery

➡ detection requires “a posteriori” analyses with wide FOV instruments

Models for the RS Oph outburst: summary

- Main properties reproduced with TNR model; no mixing between accreted matter and ONe WD core assumed
  - M(ONe WD) ~ 1.35 – 1.38 M

- Not much H burned. No enrichments above solar in the ejecta. Overproduction of S and Ar (coronal lines in the IR), underproduction of O and Ne

- M_{wd} increases and will reach $M_{Chandra}$ in ~30000 yrs, but ONe WDs do not explode (collapse).

- No γ-rays at a detectable level expected: Swift/BAT observations cannot be explained with radioactivity