Toward a Unified Model for GRB Prompt Emission;

Are GRB Standard Candles?

Sylvain Guiriec

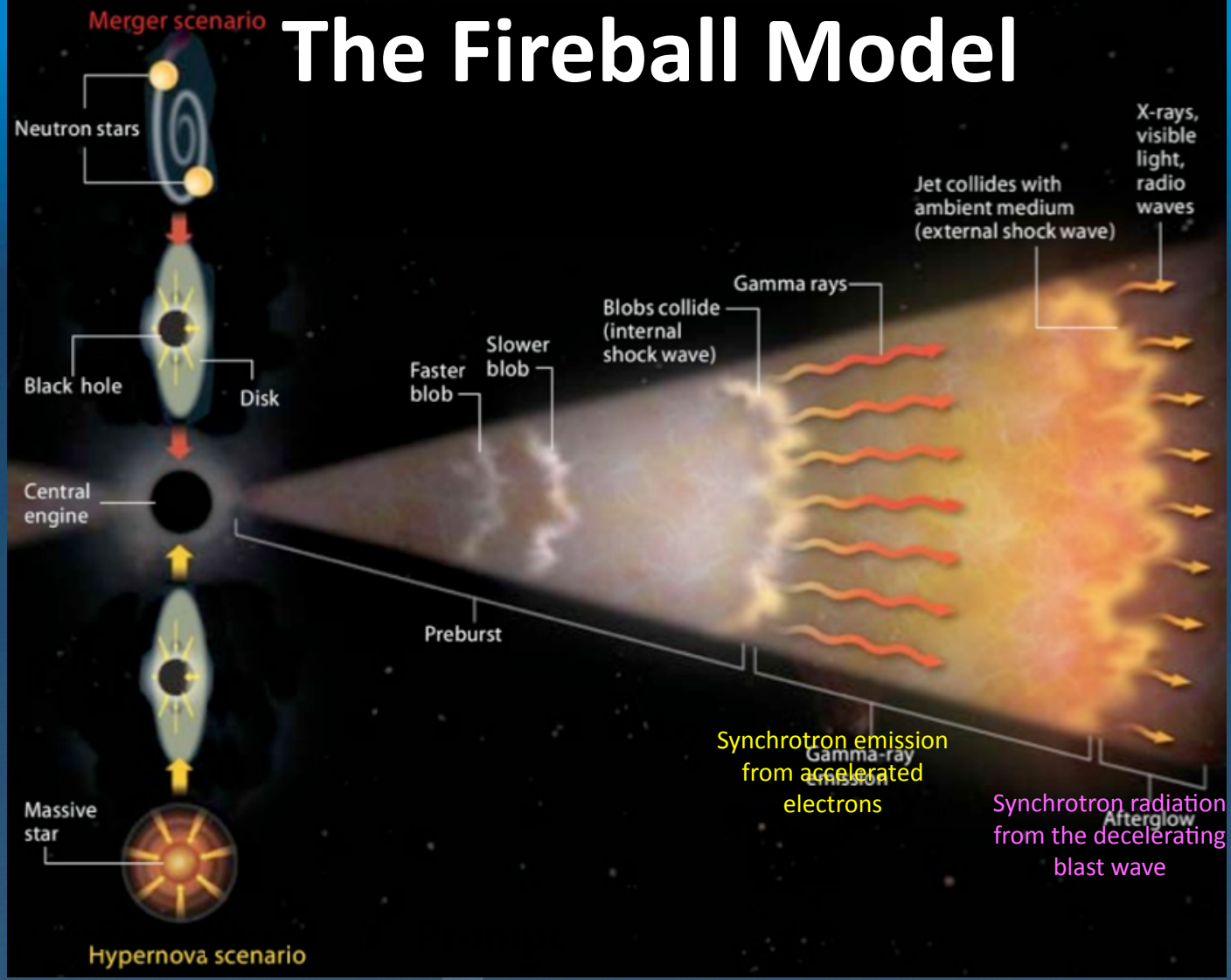
(NASA GSFC/UMD/CRESST)

on behalf of

C. Kouveliotou, D. Hartmann, J. Granot, K. Asano, P. Meszaros, R. Mochkovitch, F. Daigne, T. Piran, N. Gehrels & J. McEnery, …

28th Texas Symposium, Geneva, Switzerland – December 17th, 2015

The Fireball Model



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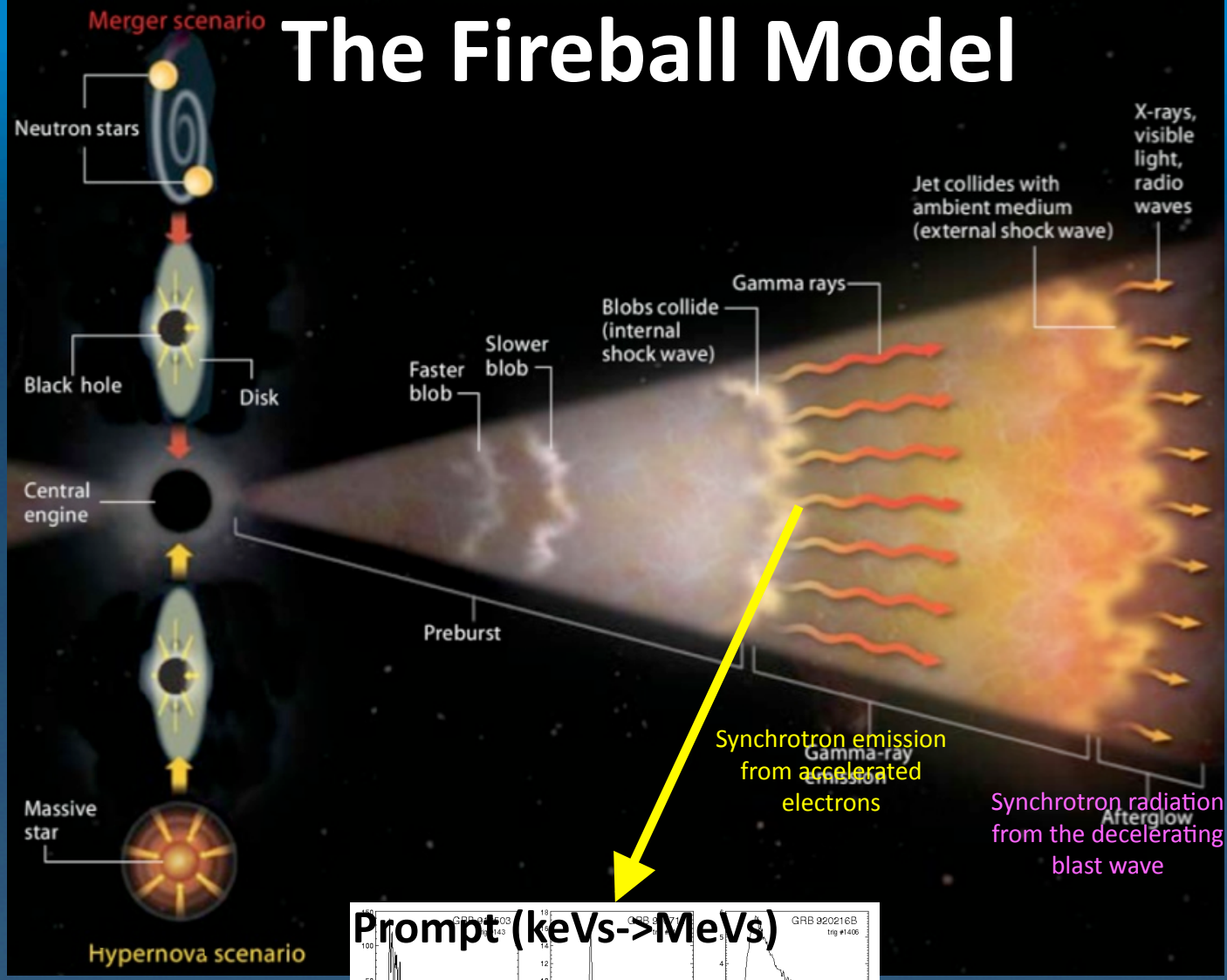
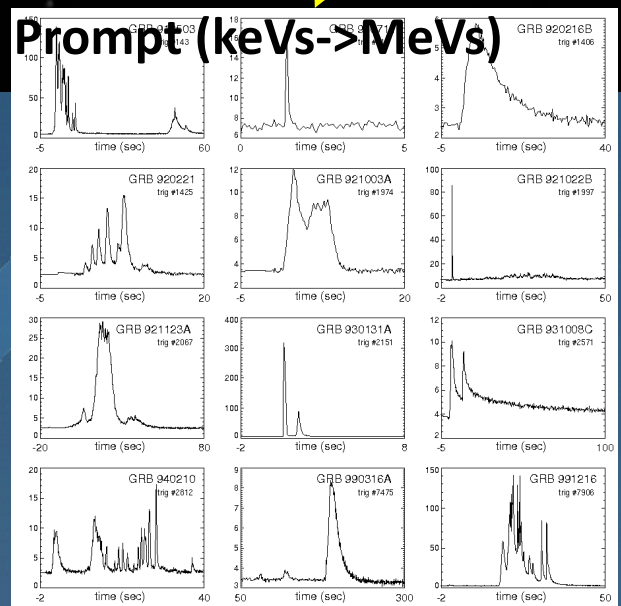


Prompt (keVs->MeVs)



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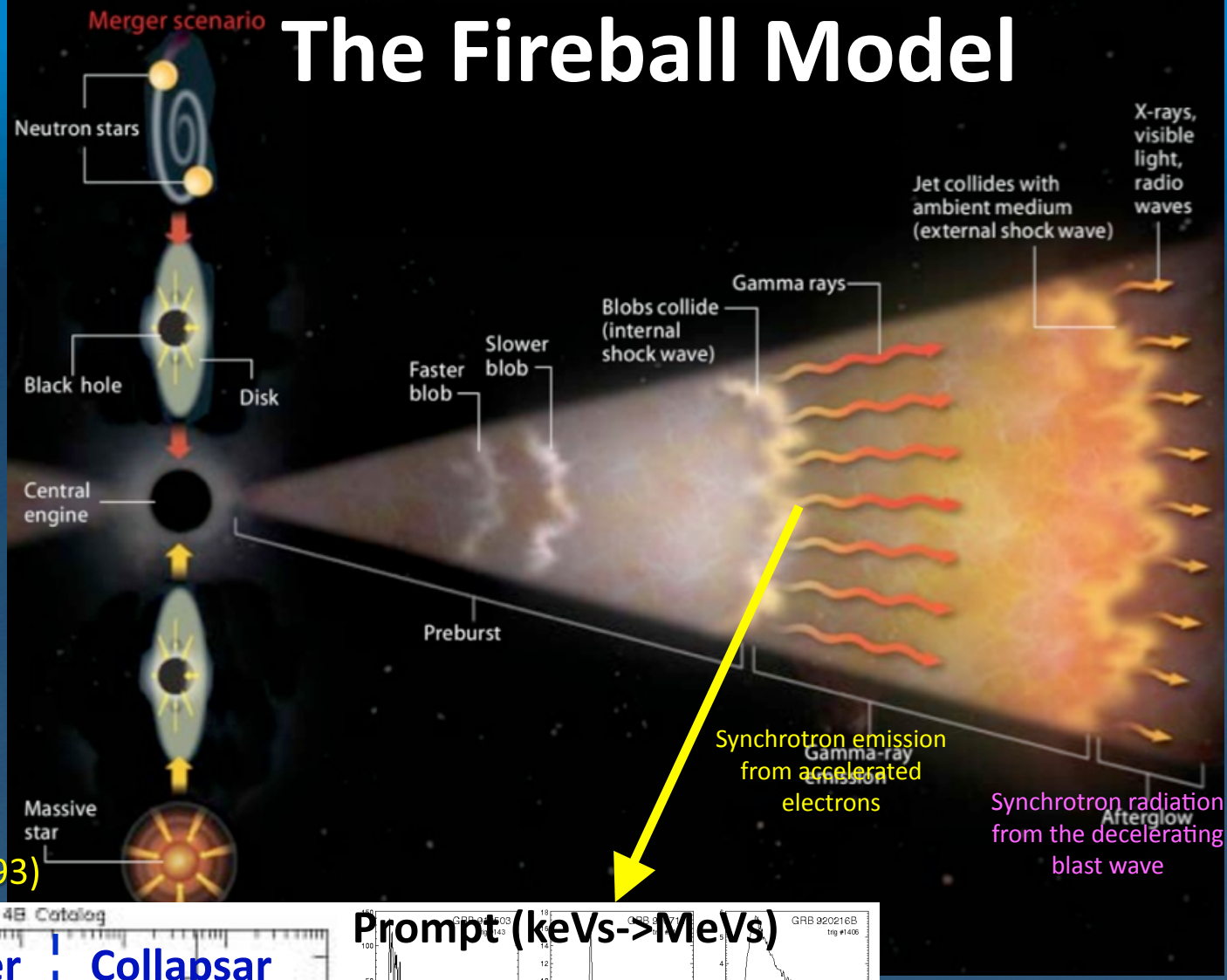
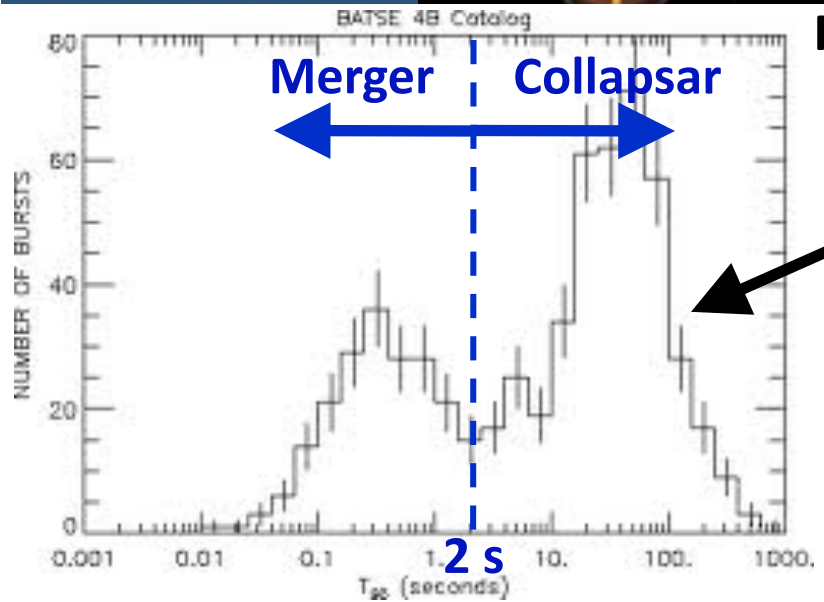


(Kouveliotou et al. 1993)



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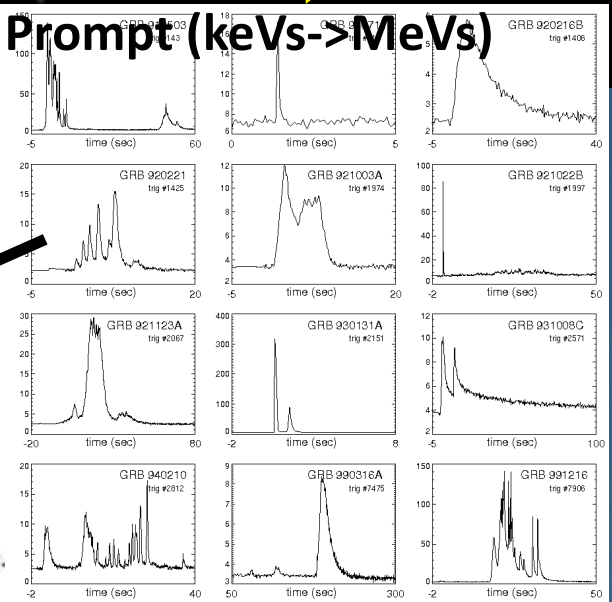

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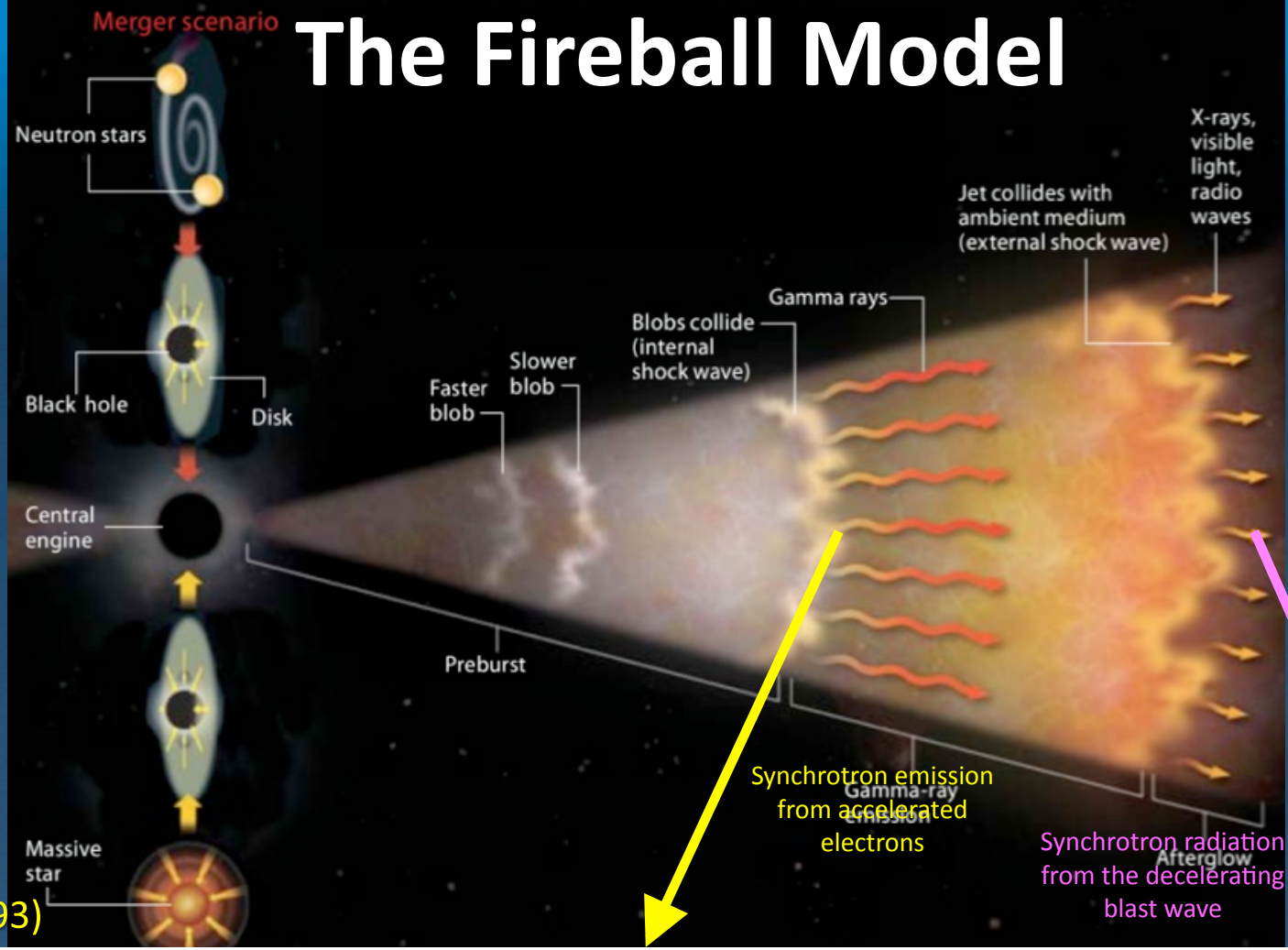

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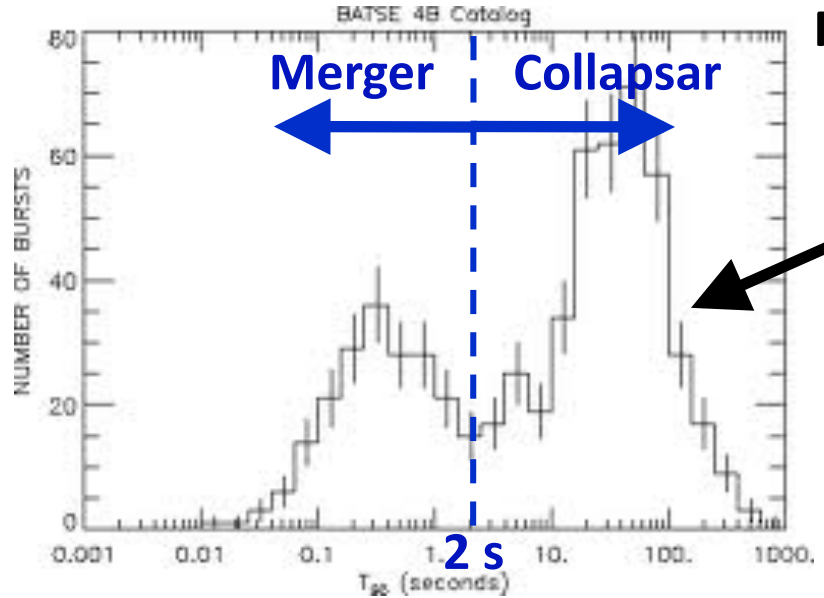

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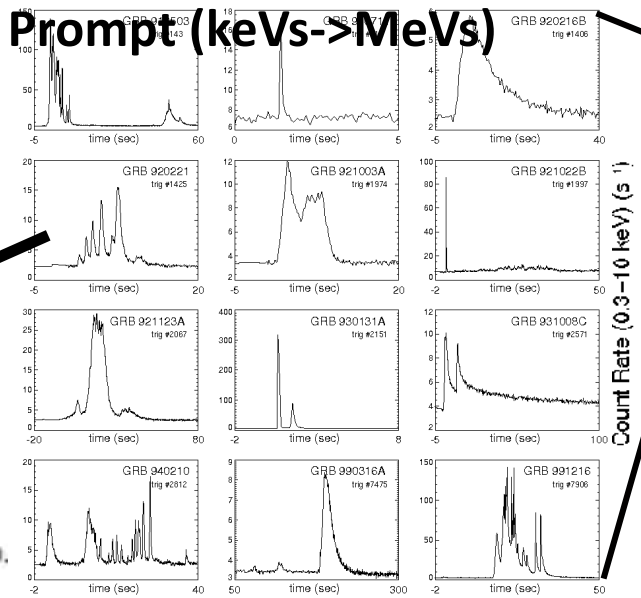

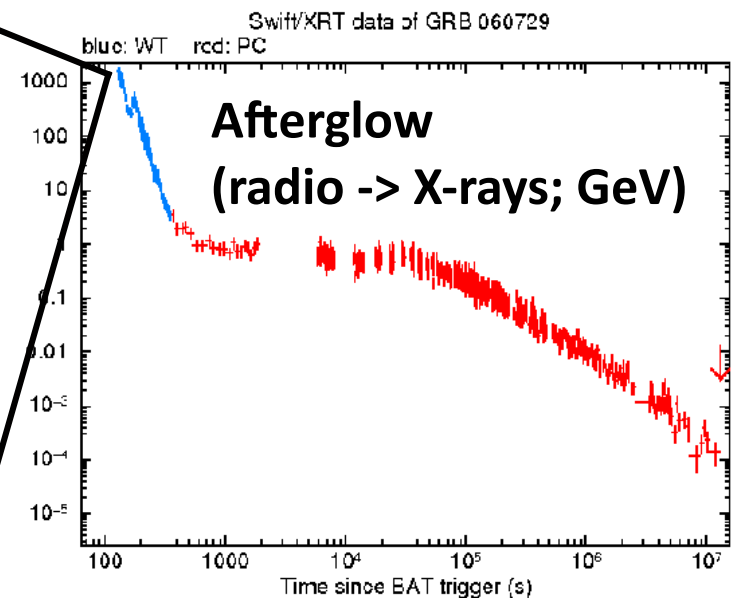

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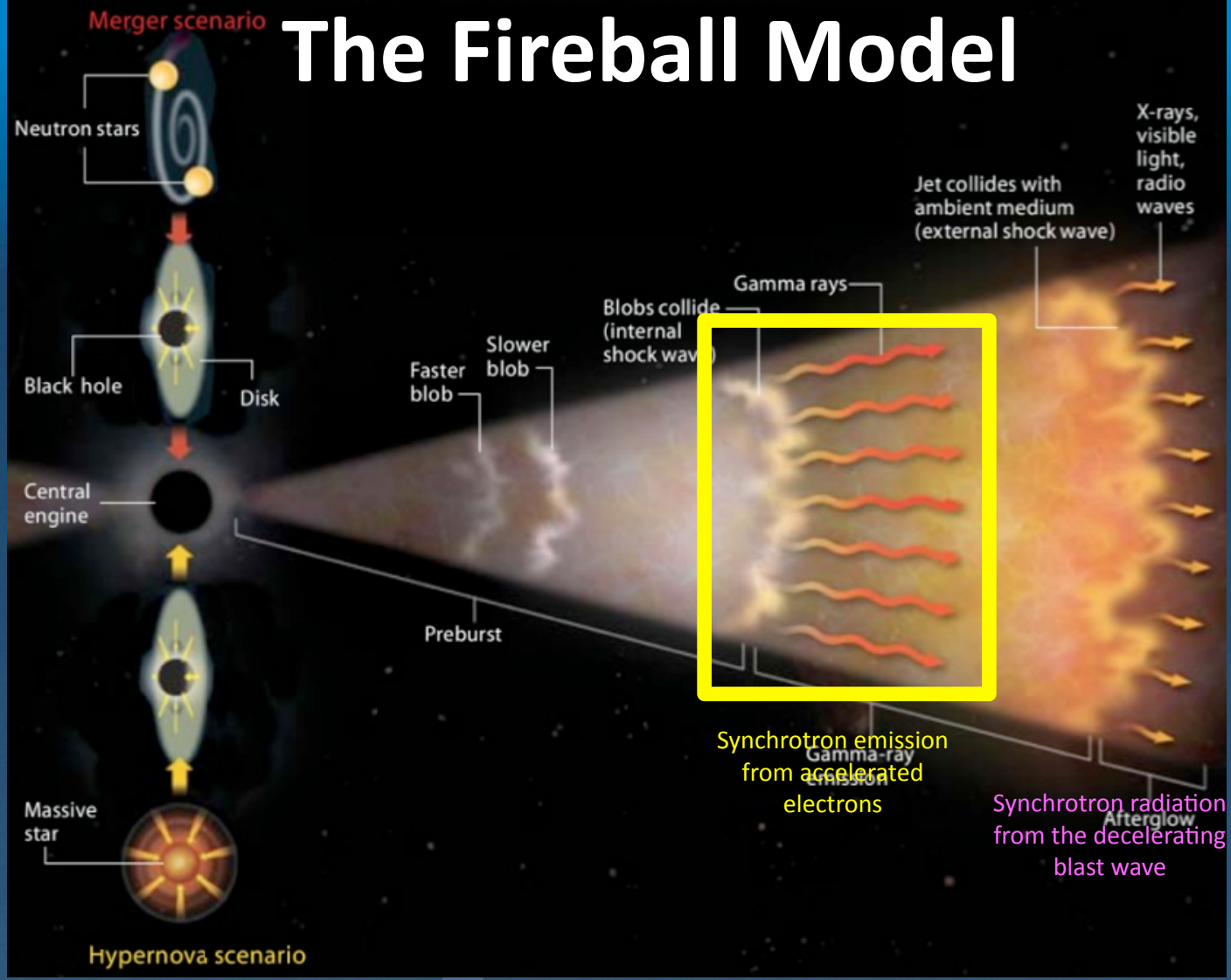

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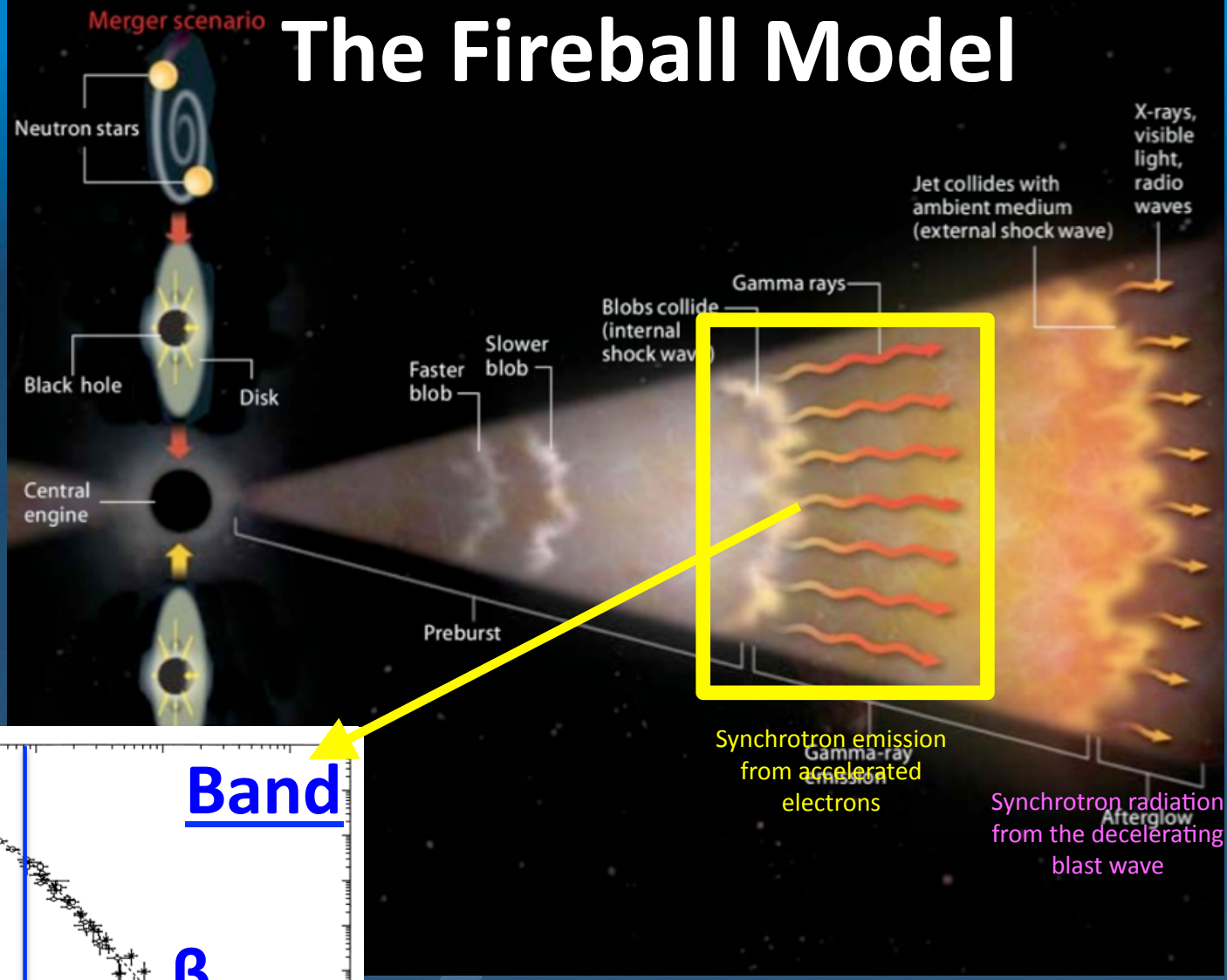

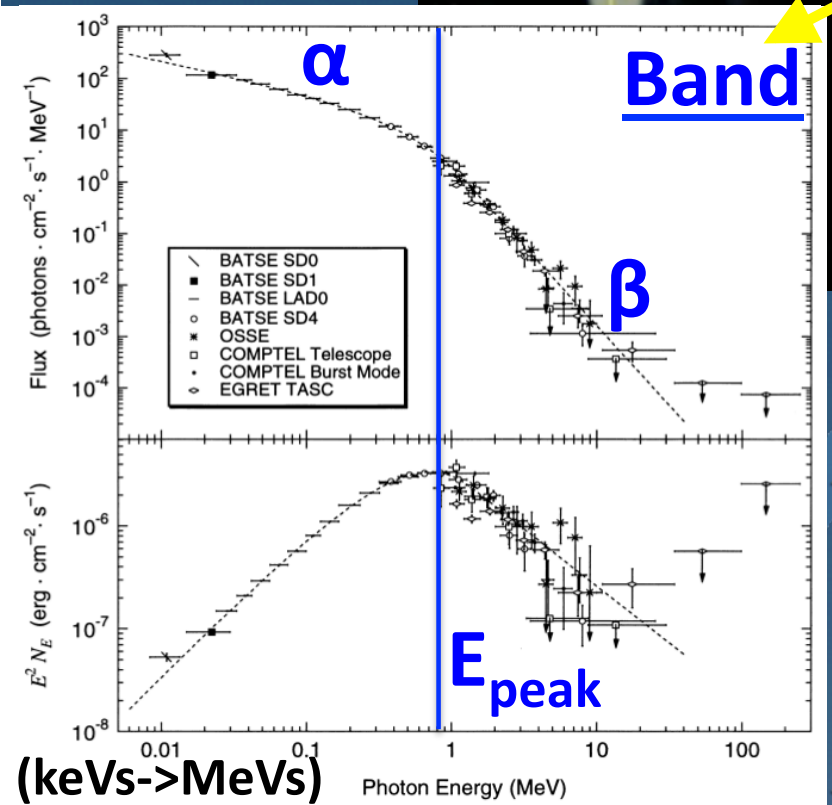

(keVs->MeVs)

(Band et al. 1993)

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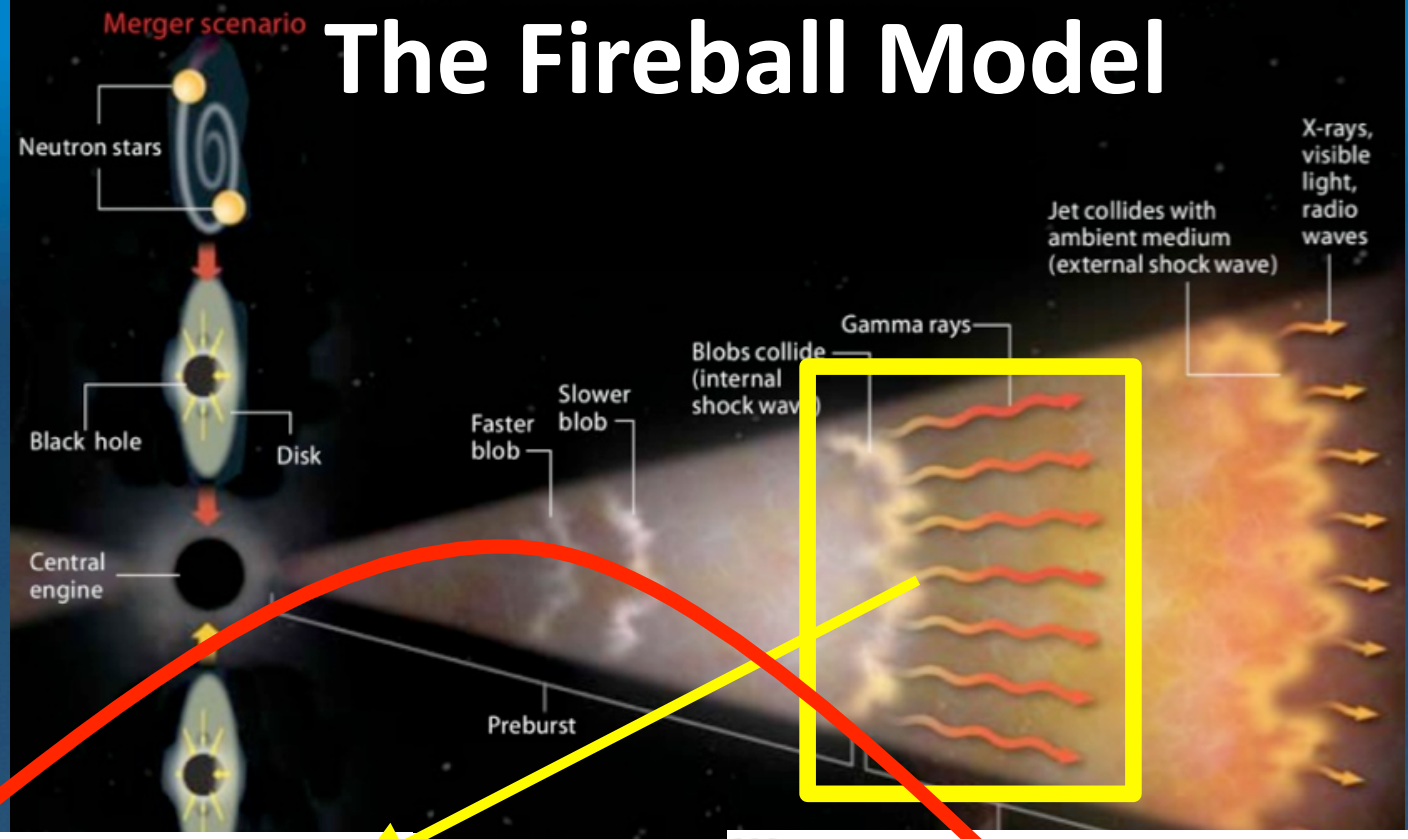
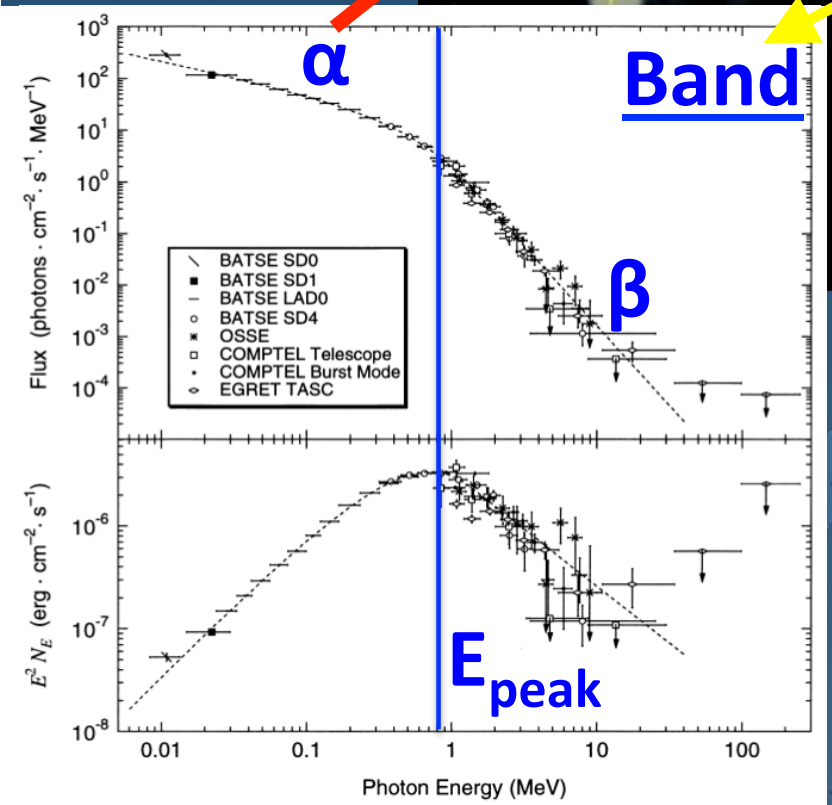
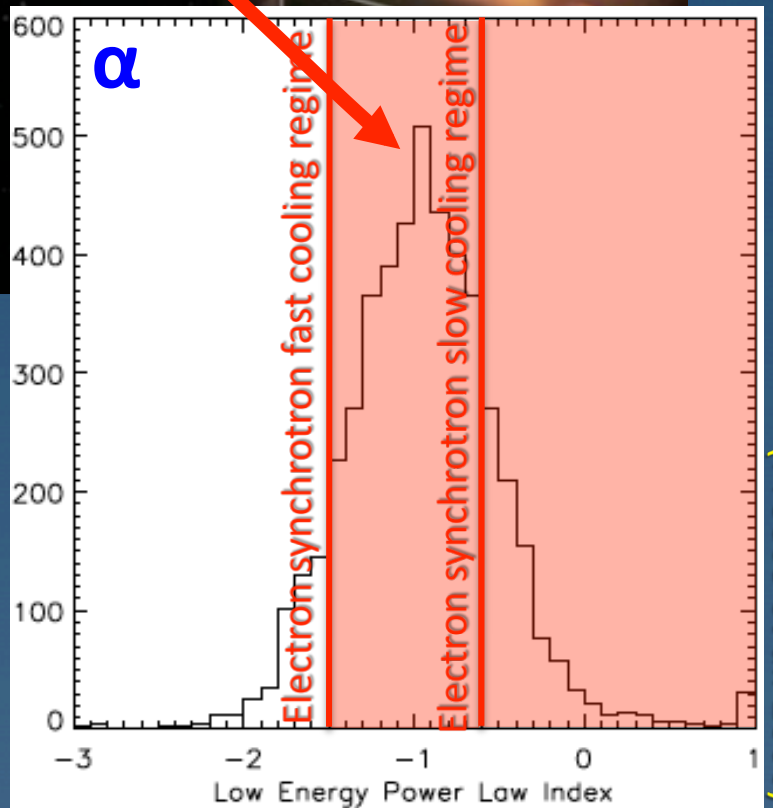
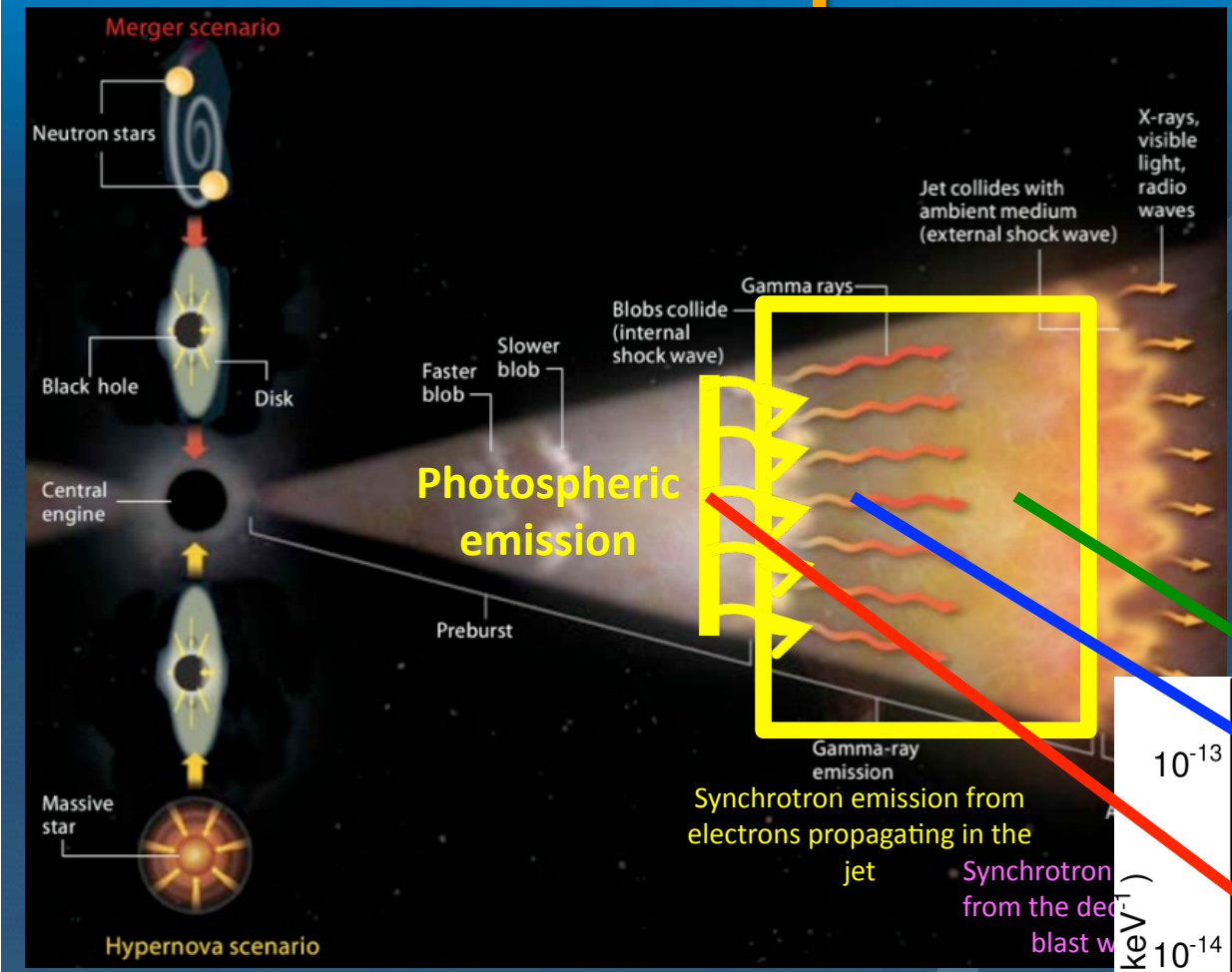
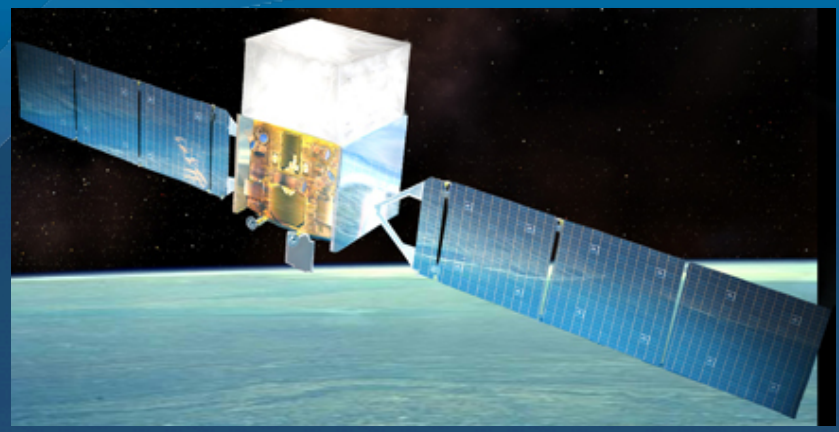






A New GRB Prompt Emission Model with Fermi



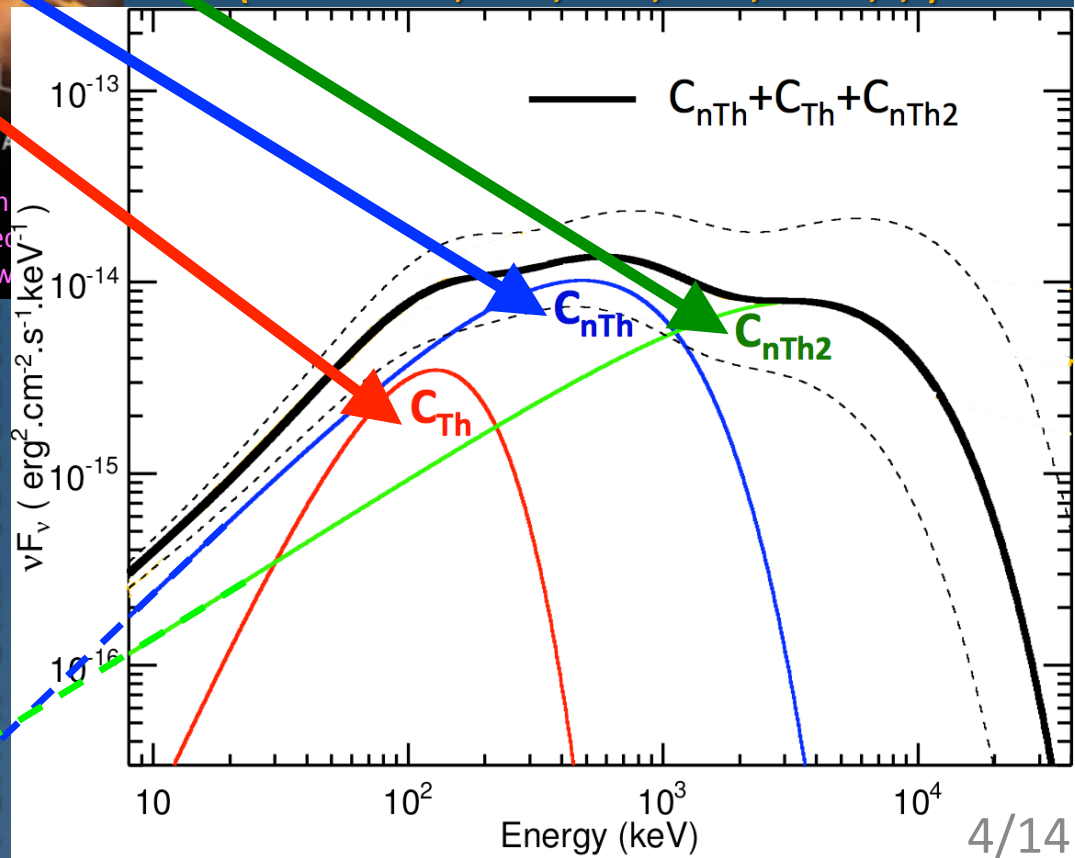


(Guiriec et al., 2010, 2011, 2013, 2015a,b,c)

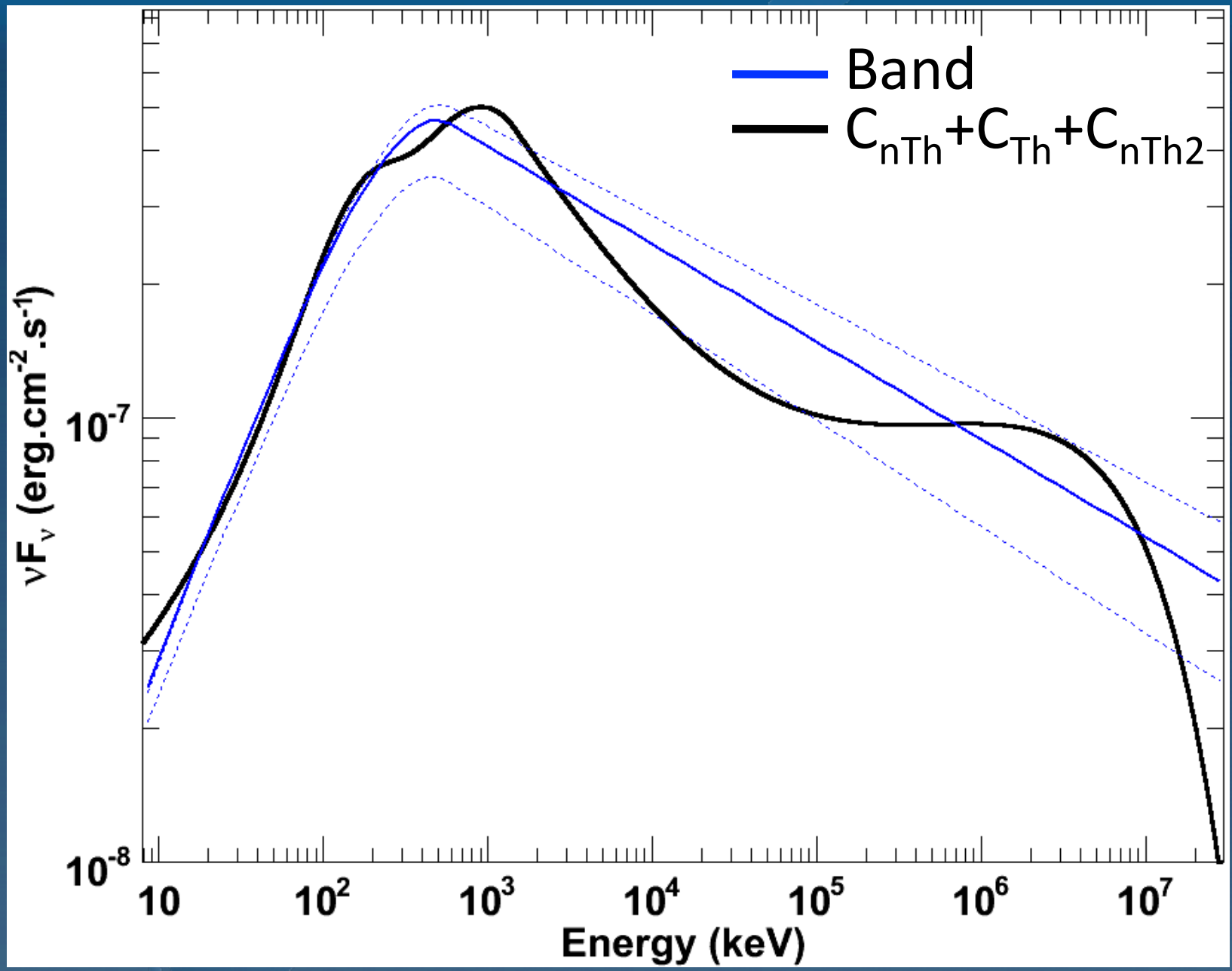
C_{Th}: thermal-like emission from the jet photosphere.

C_{nTh}: non-thermal emission from internal shocks or strongly reprocessed photosphere.

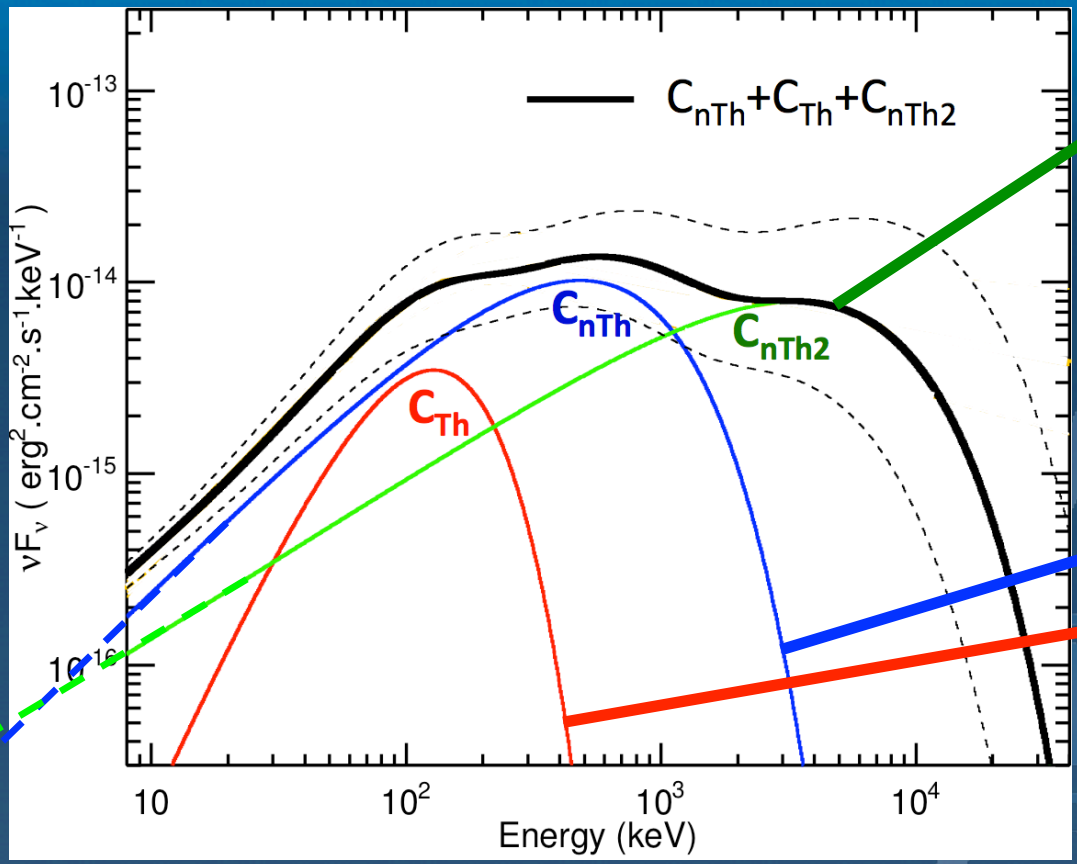
C_{nTh2}: non-thermal emission from magnetic reconnections.

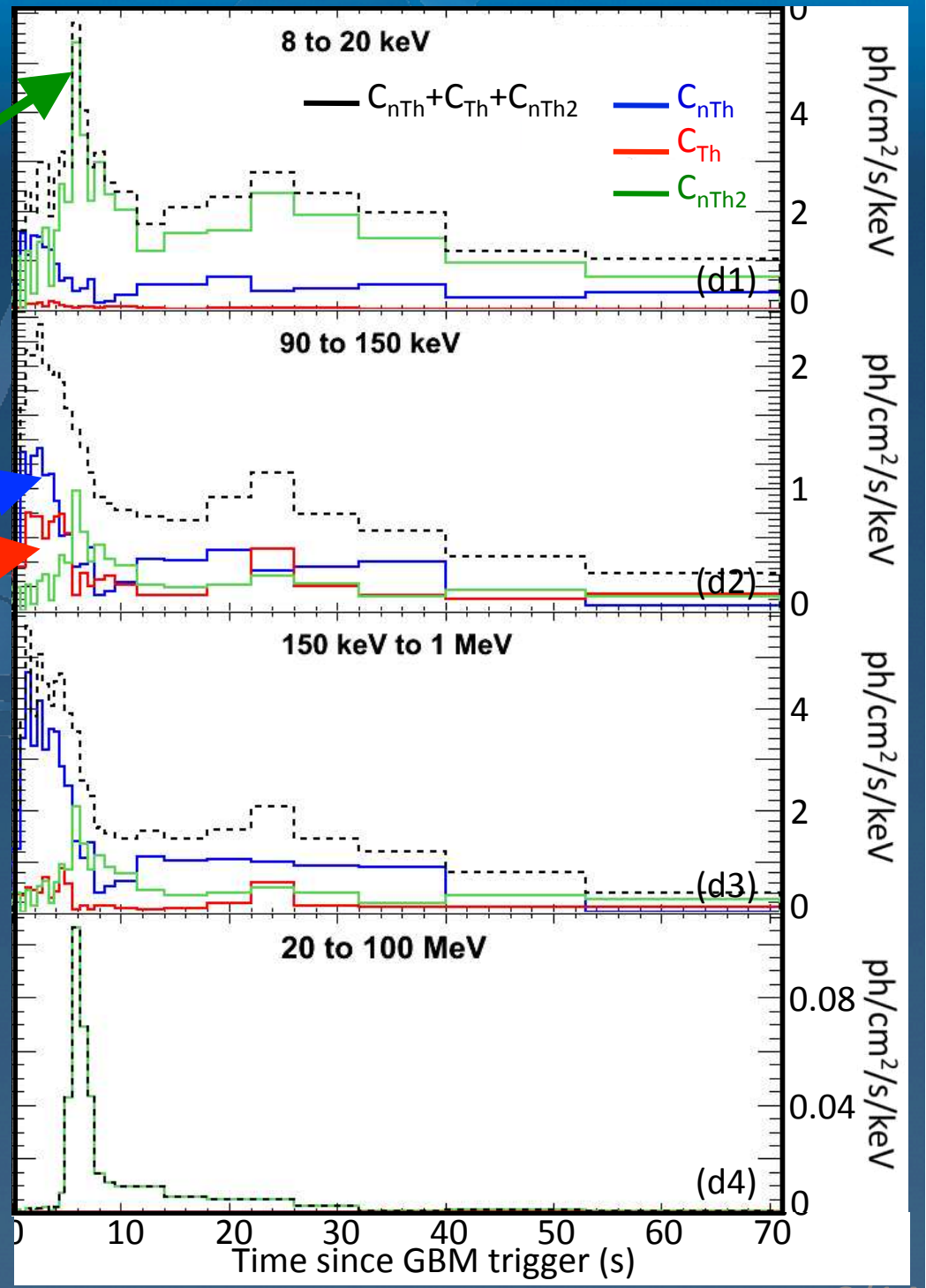


Band vs $C_{nTh}+C_{Th}+C_{nTh2}$



Spectro-Temporal Evolution with $C_{nTh}+C_{Th}+C_{nTh2}$





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(Guiriec et al., 2015a)

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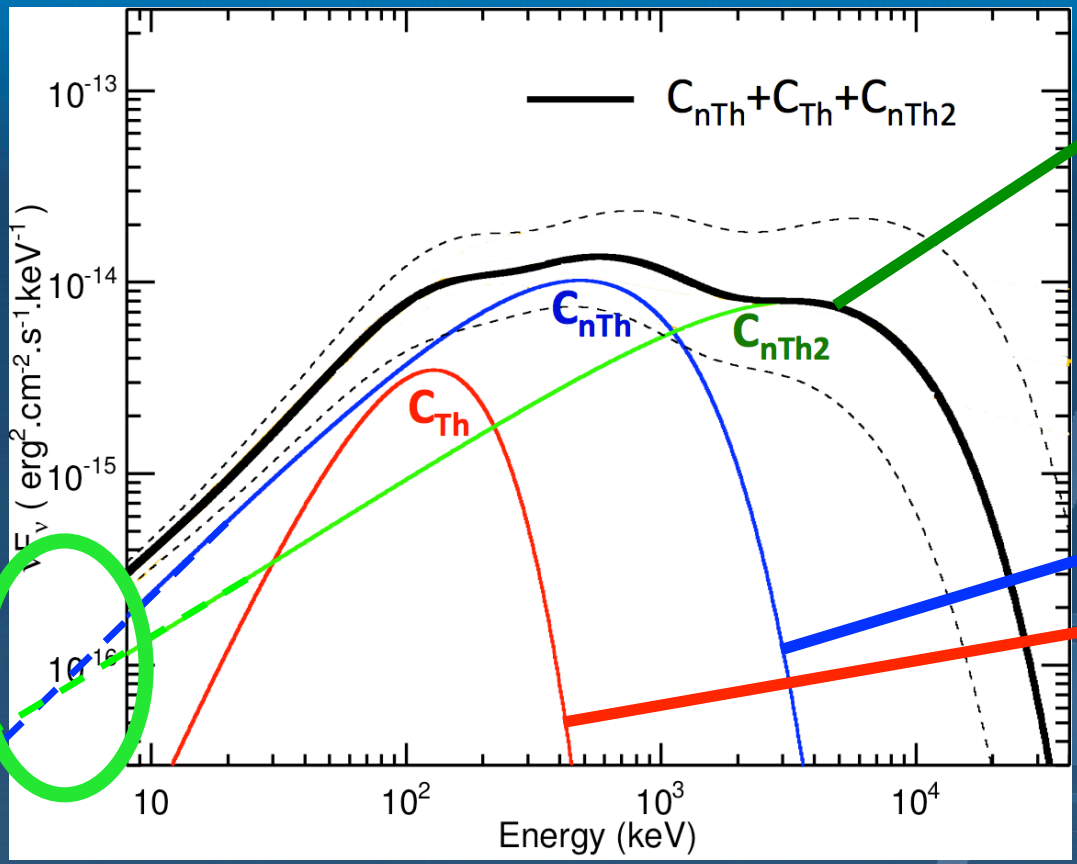

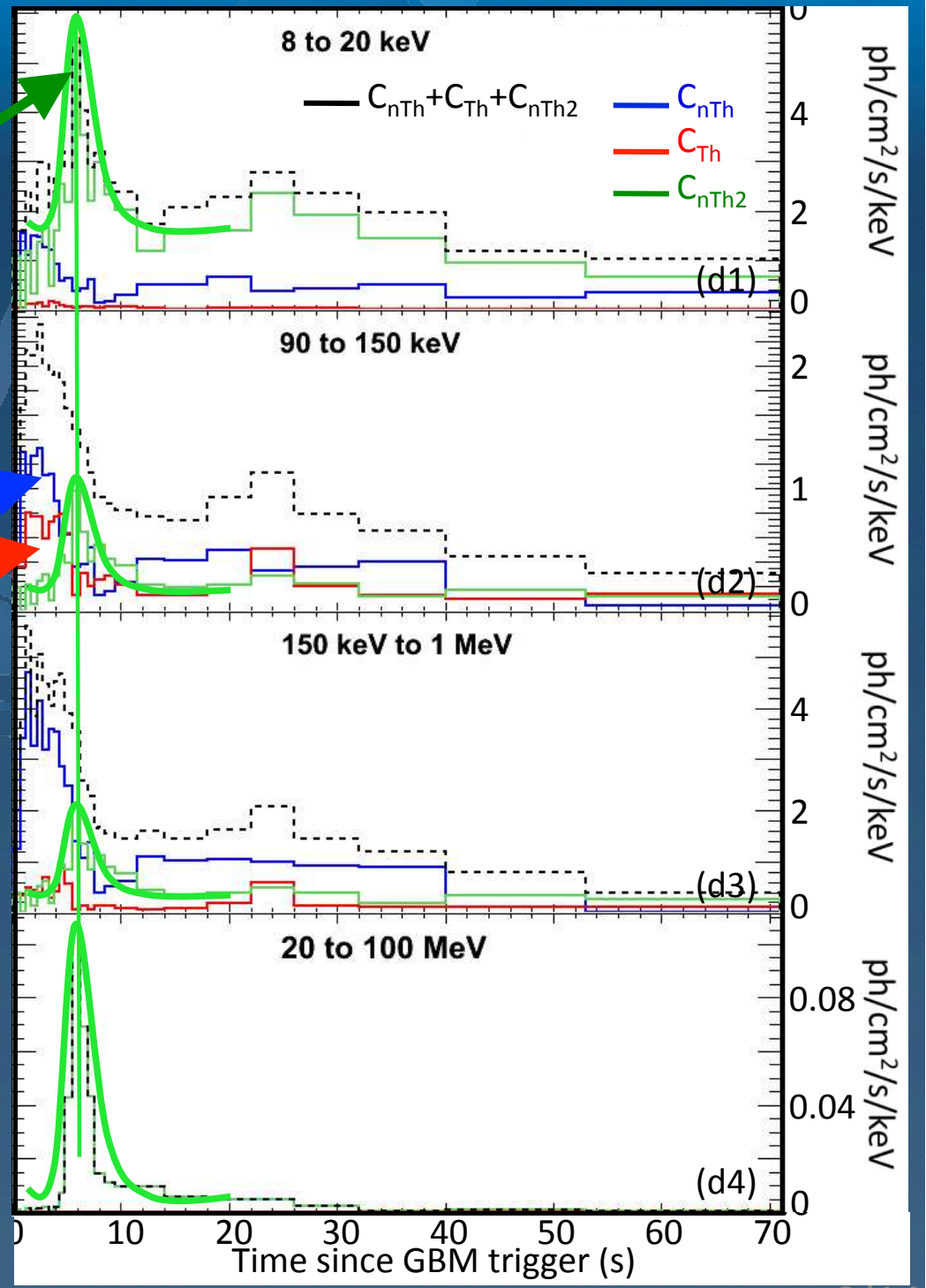

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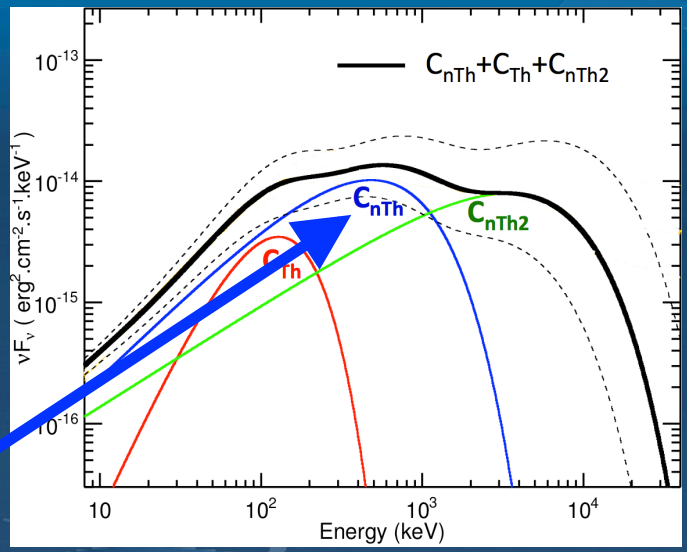
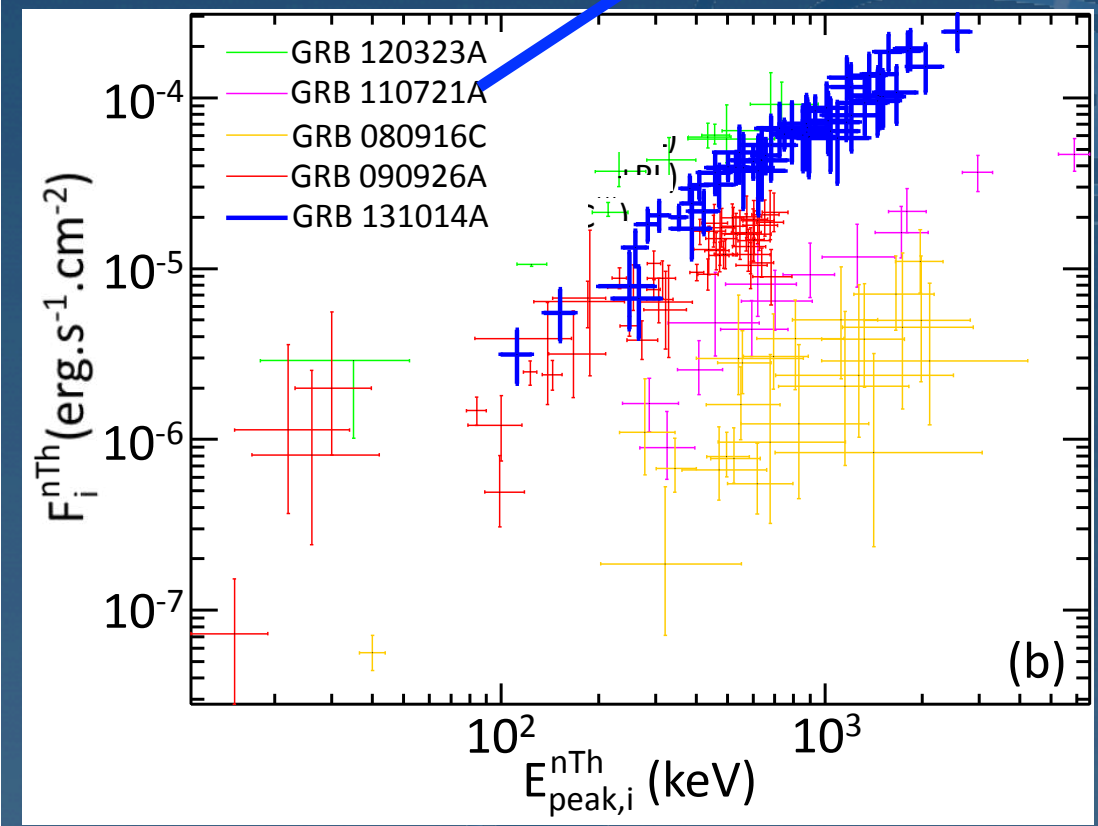
A Strong Correlation: the L_i^{nTh}-$E_{peak,i}^{nTh,rest}$ Relation





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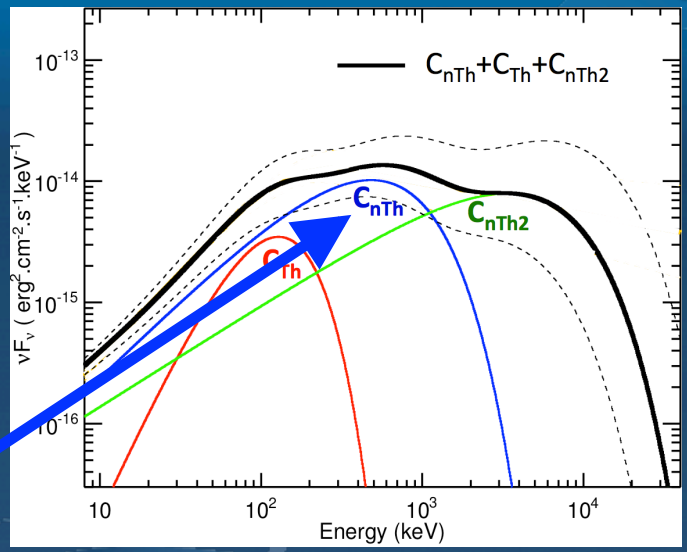

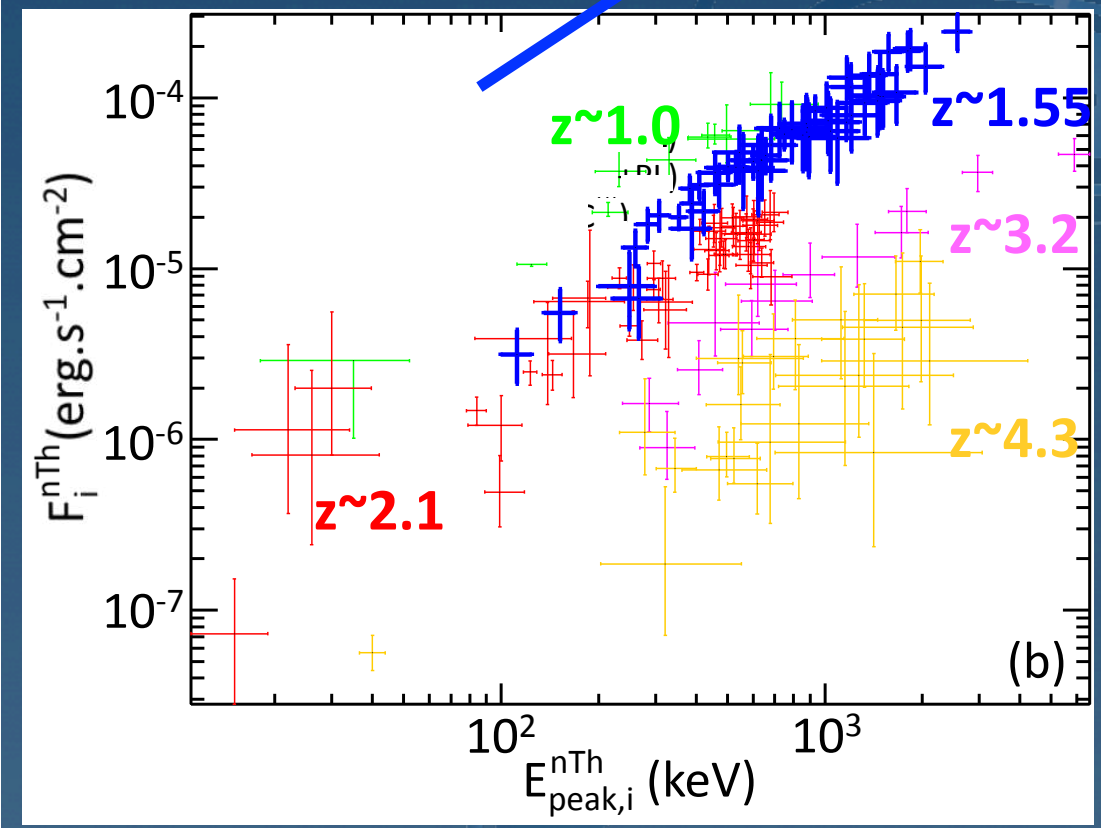

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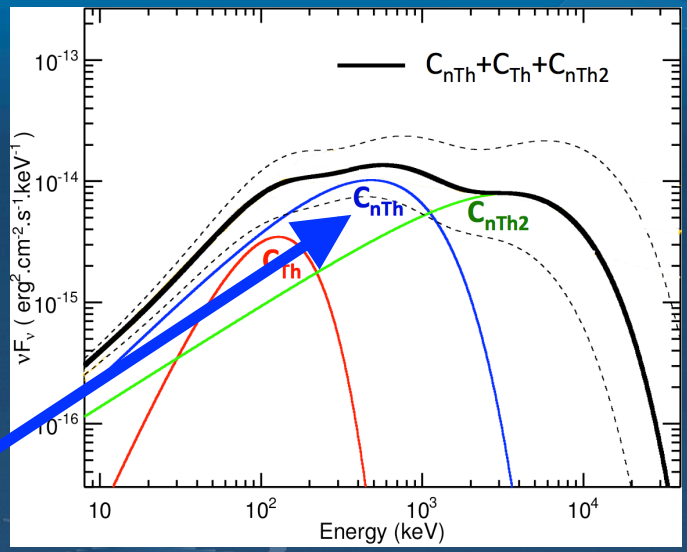
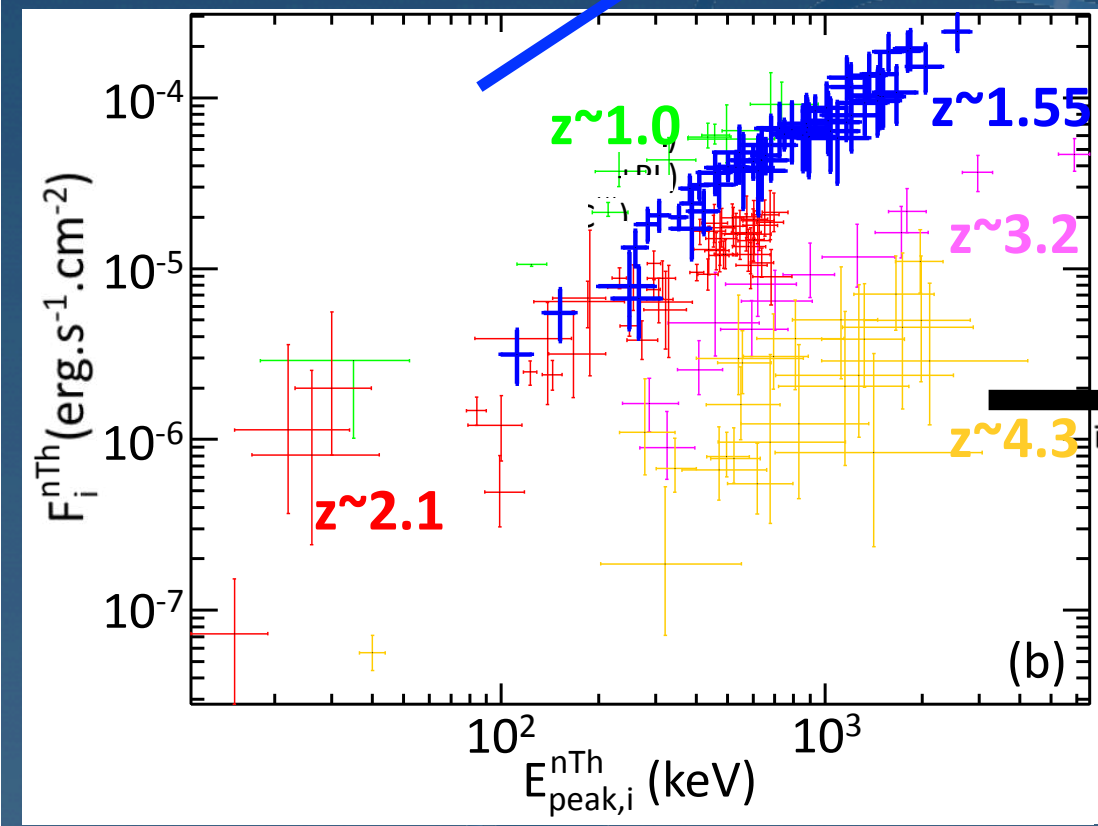
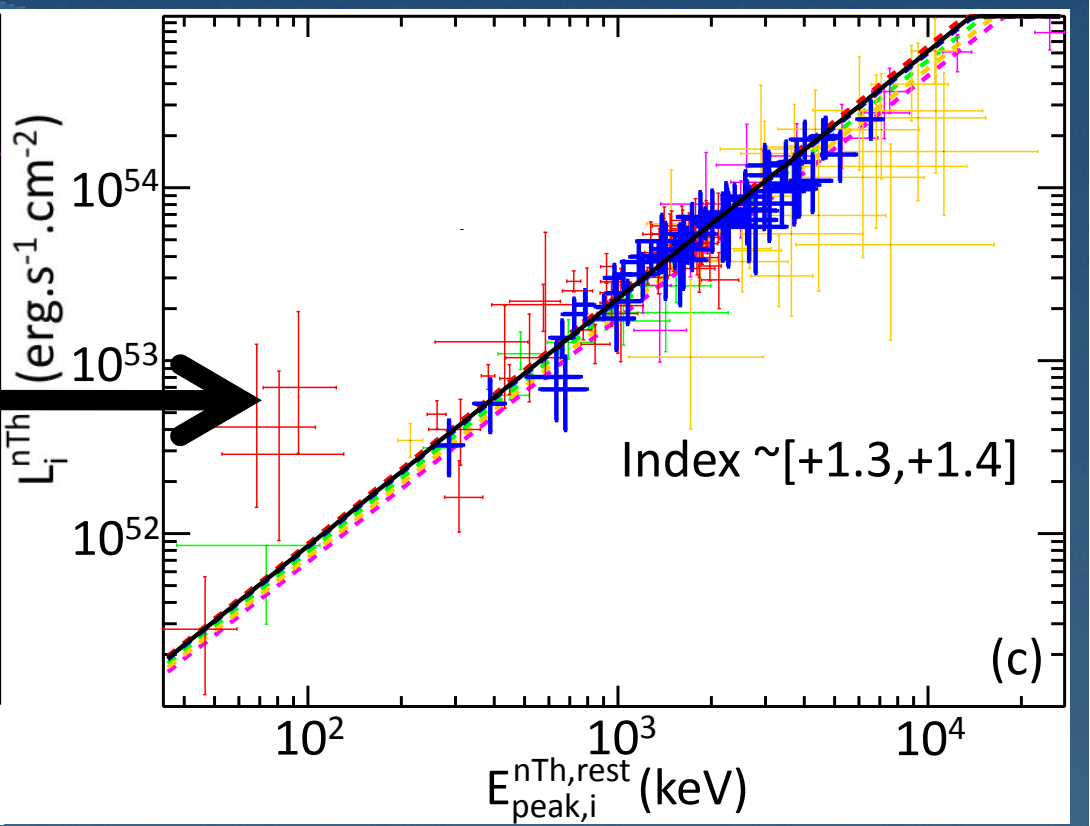


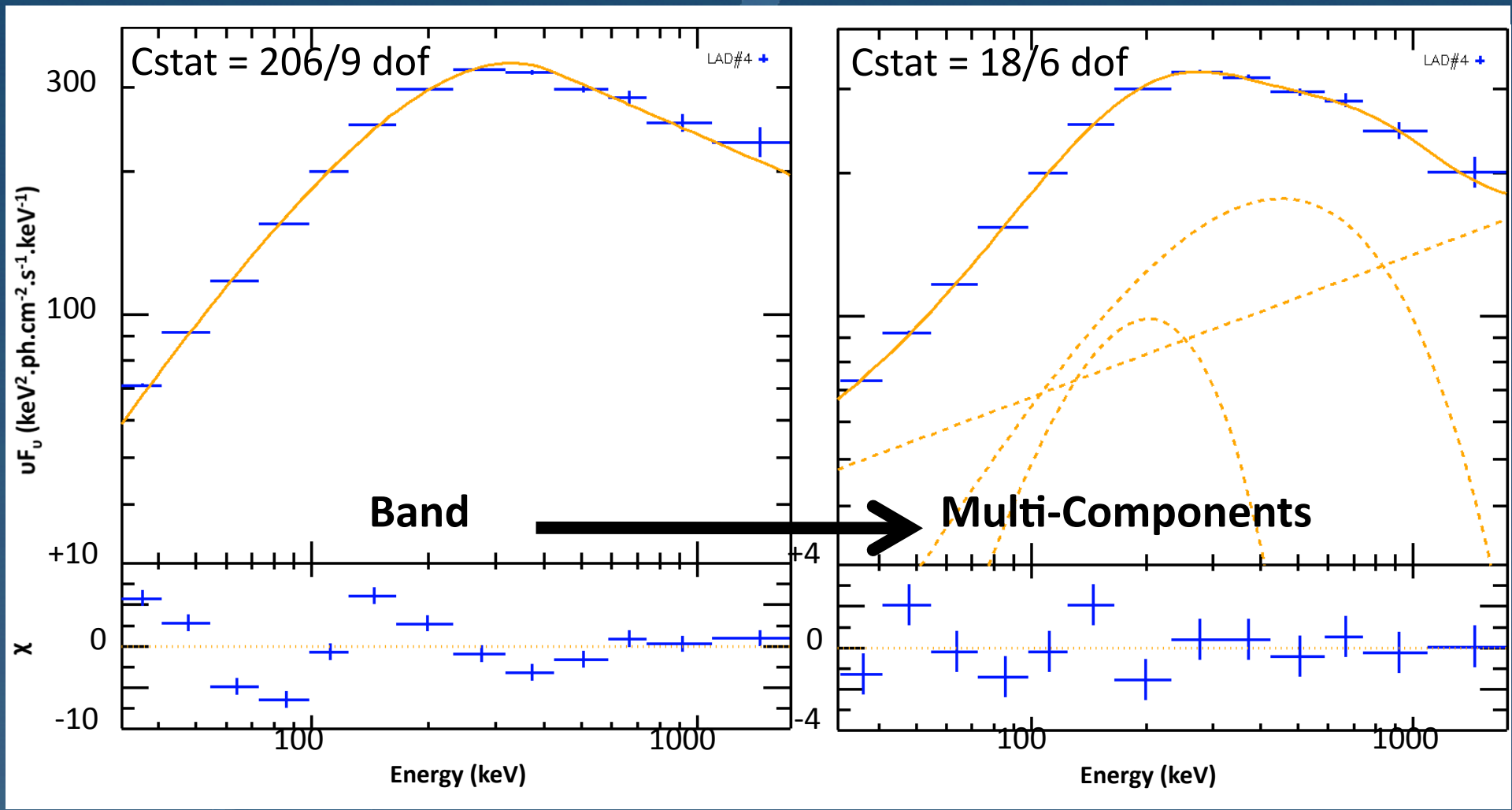




(Guiriec et al., 2013, 2015a,b,c)

Does Only Fermi Capture Those Components ?

BATSE GRB 941017



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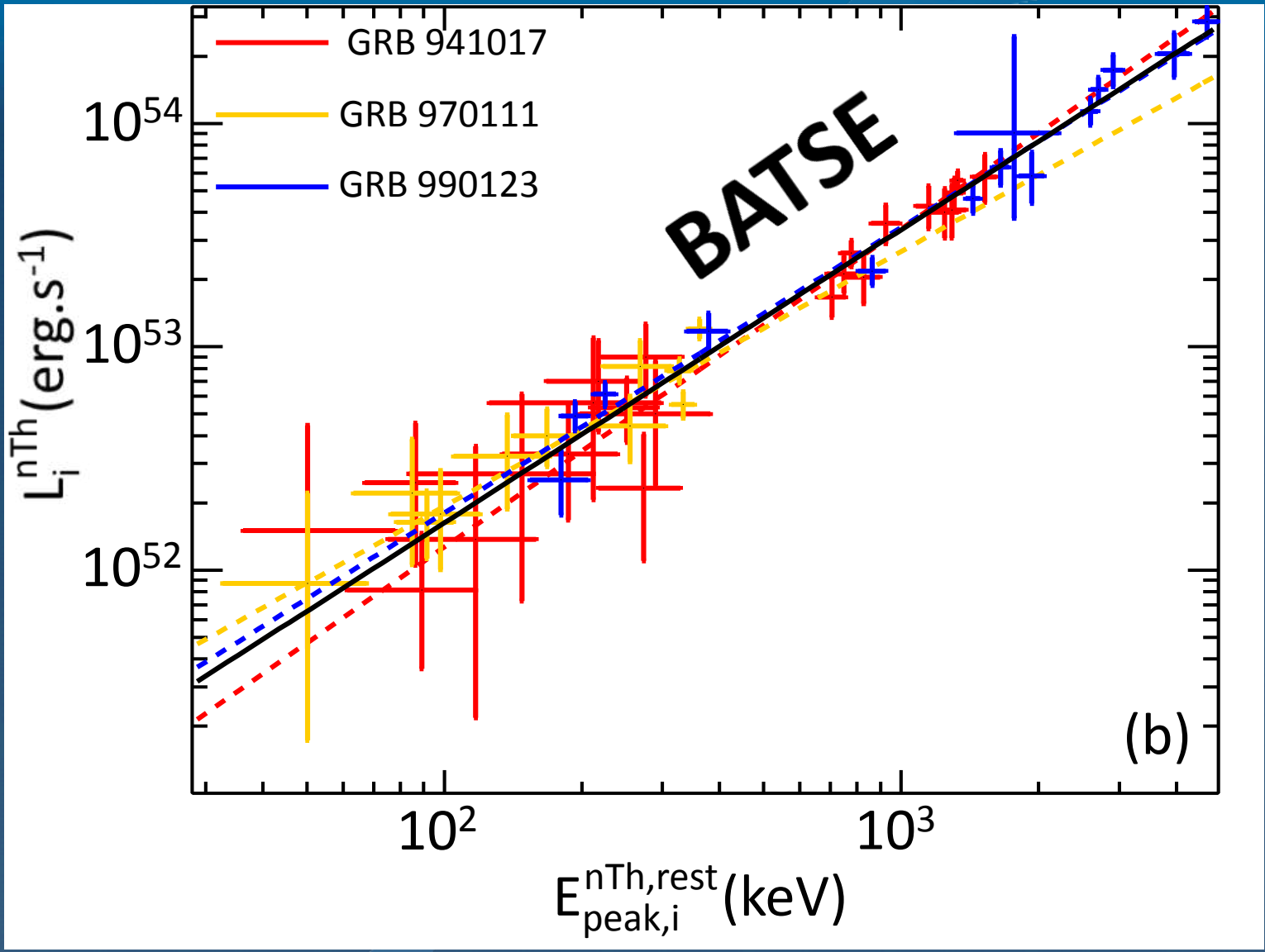

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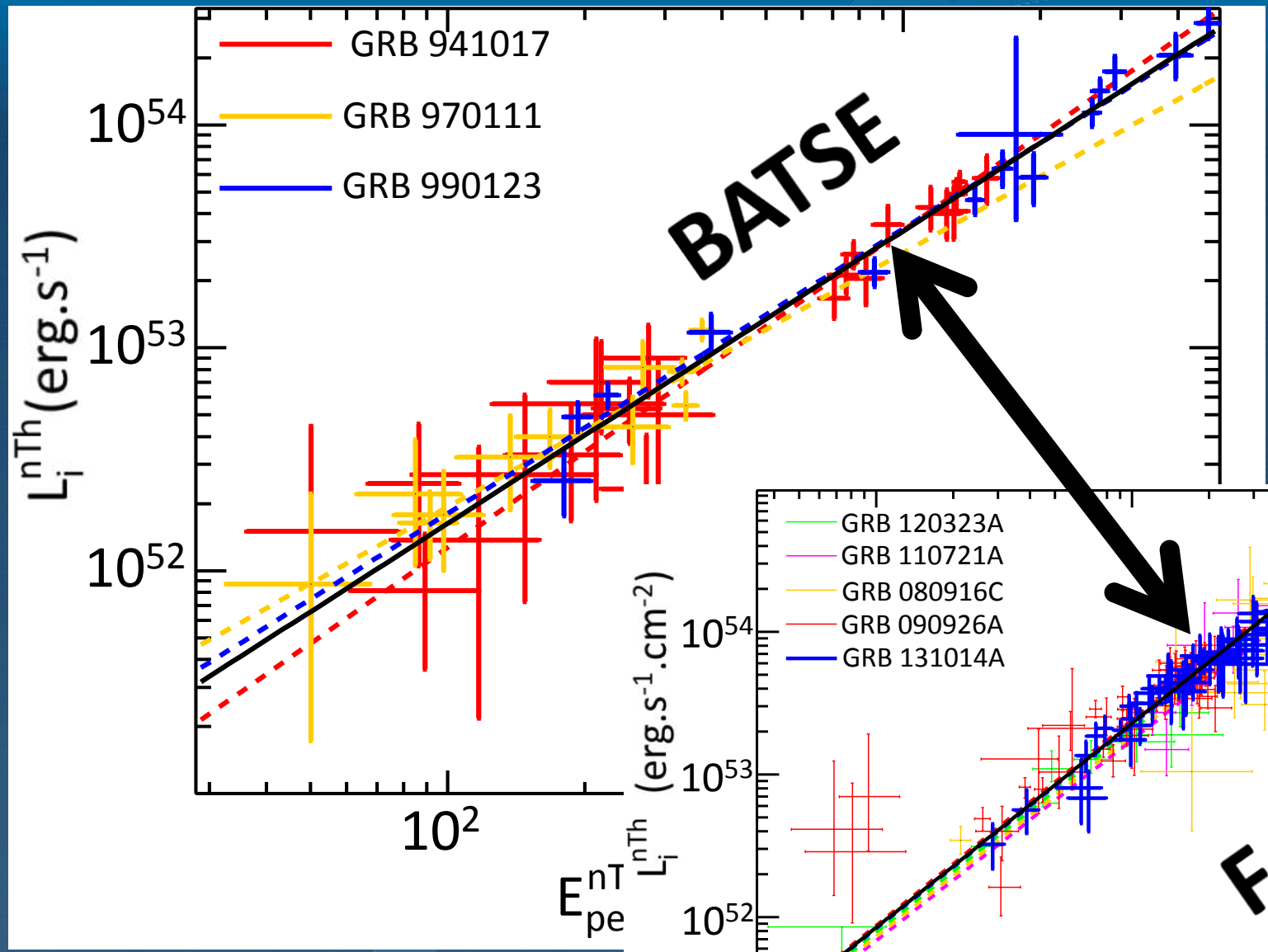

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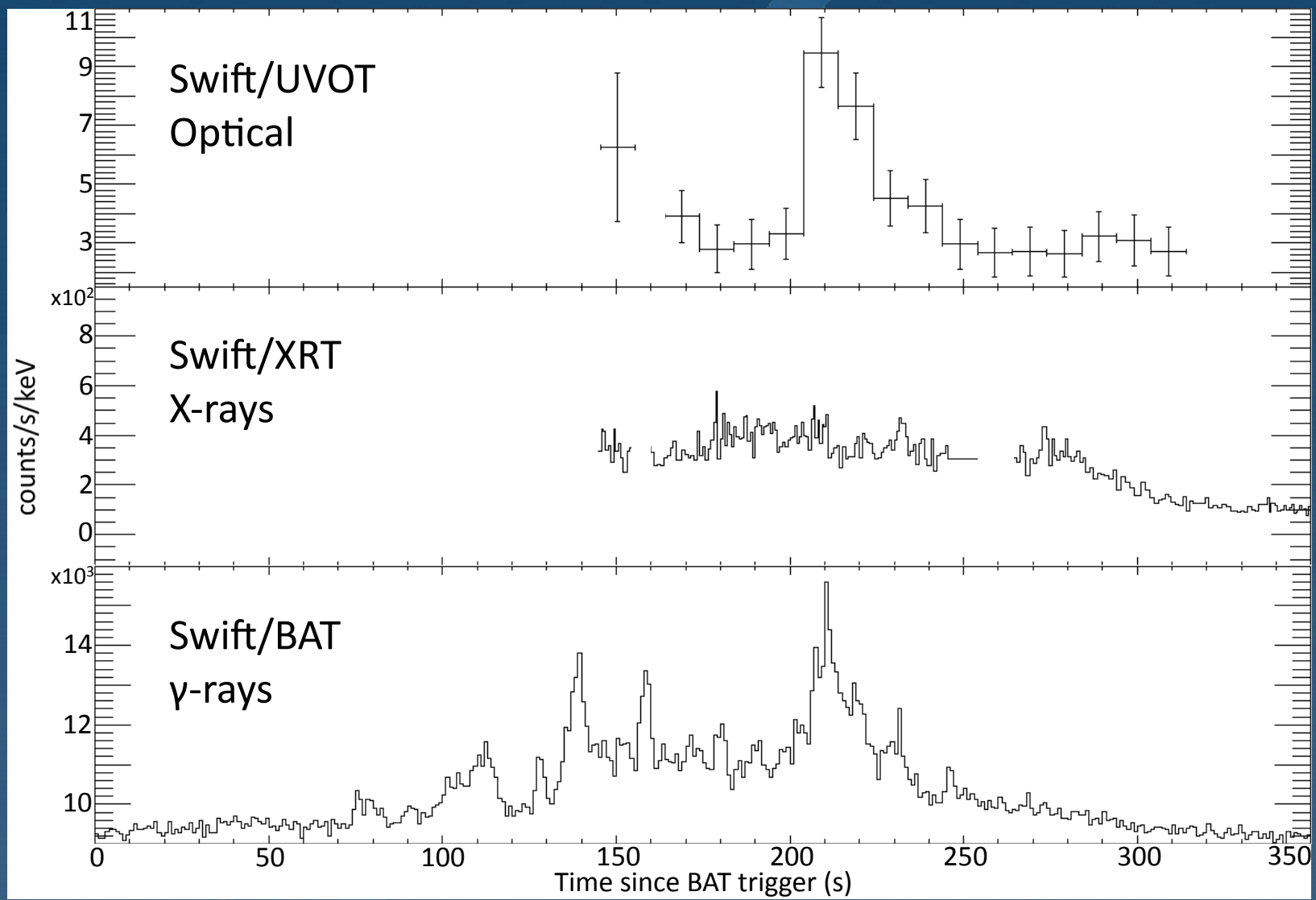
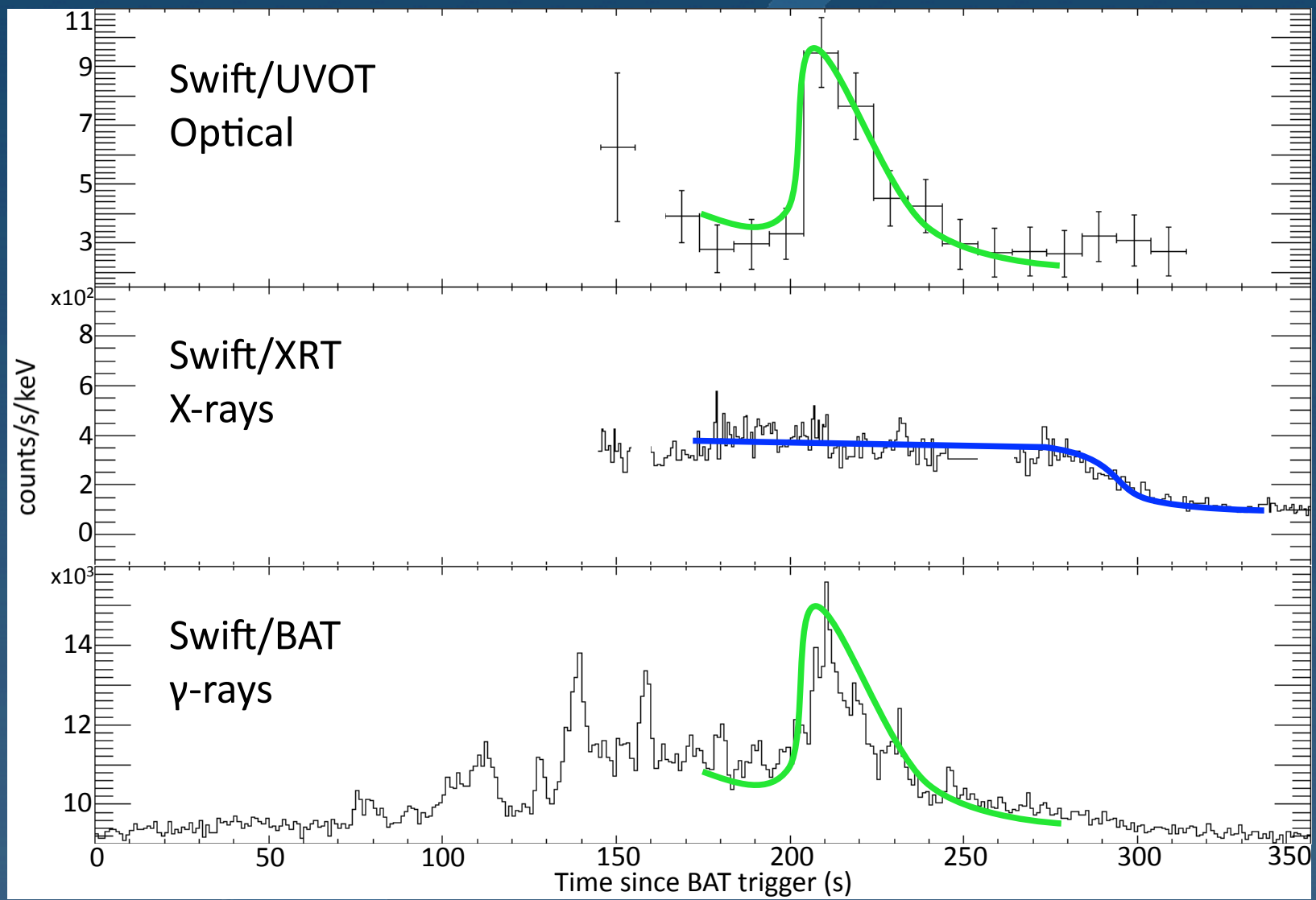
Swift/Suzaku GRB 110205A: What About Optical Prompt Emission?



(Guiriec et al., in Preparation)

Swift/Suzaku GRB 110205A: What About Optical Prompt Emission?



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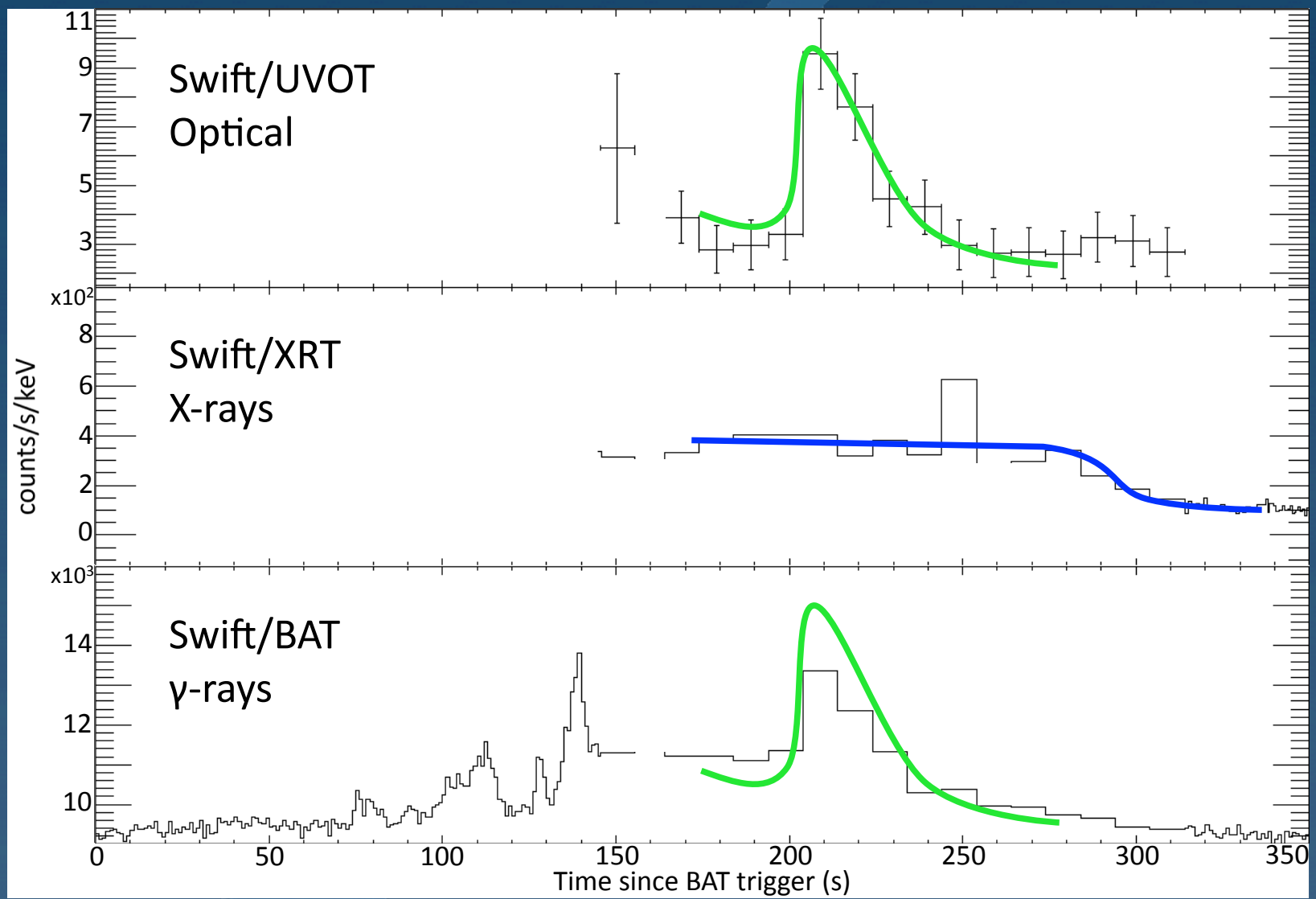
Swift/Suzaku GRB 110205A: What About Optical Prompt Emission?



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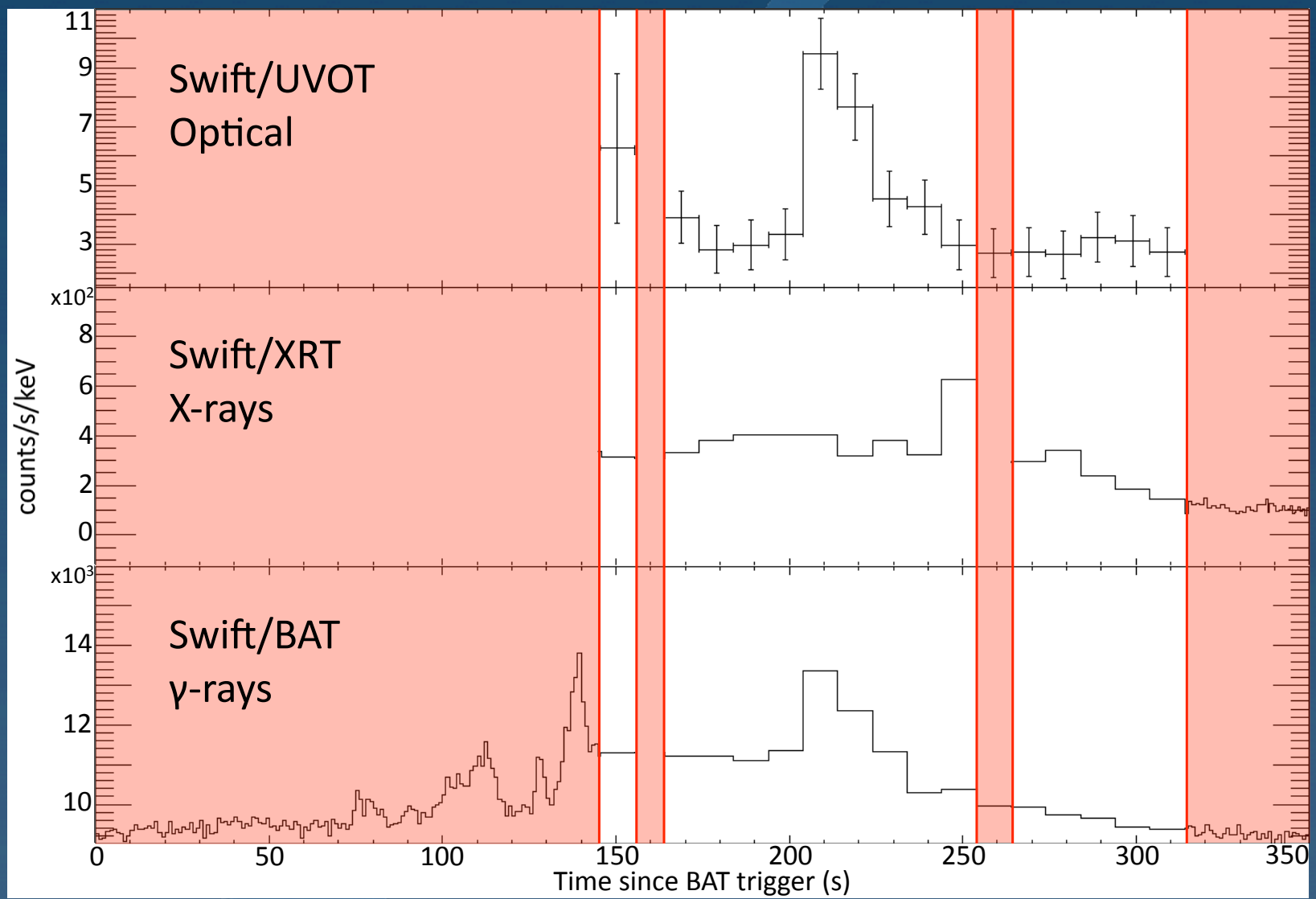

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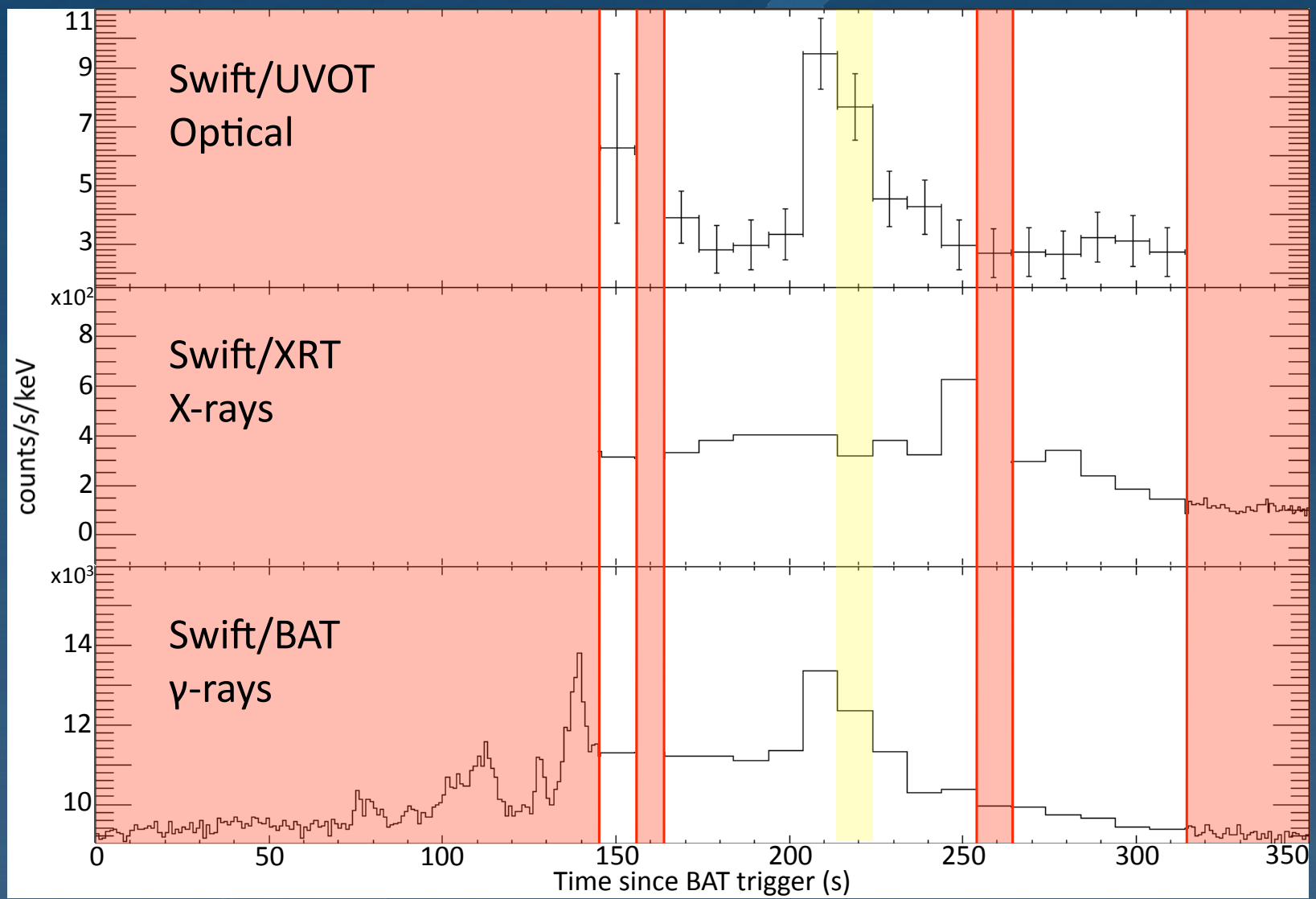
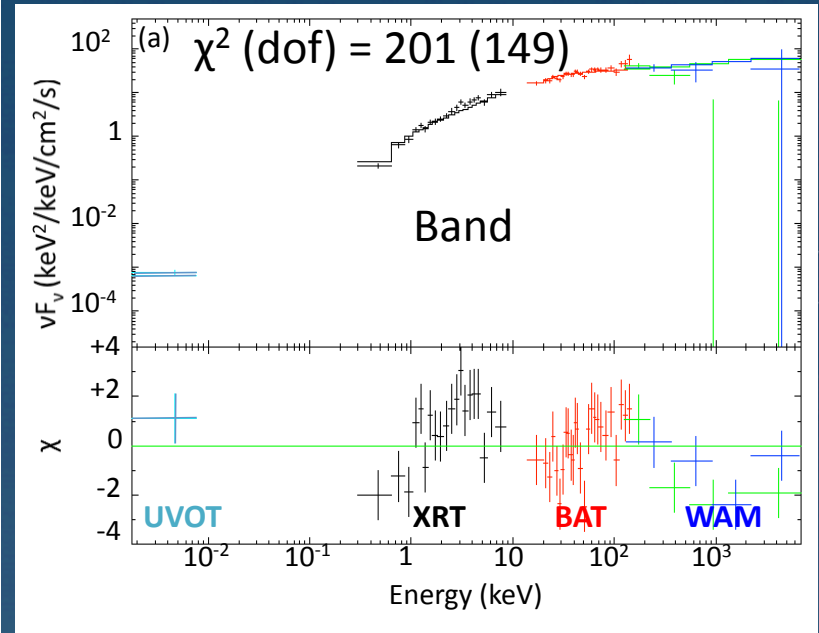


(Guiriec et al., in Preparation)

Broadband Prompt Emission



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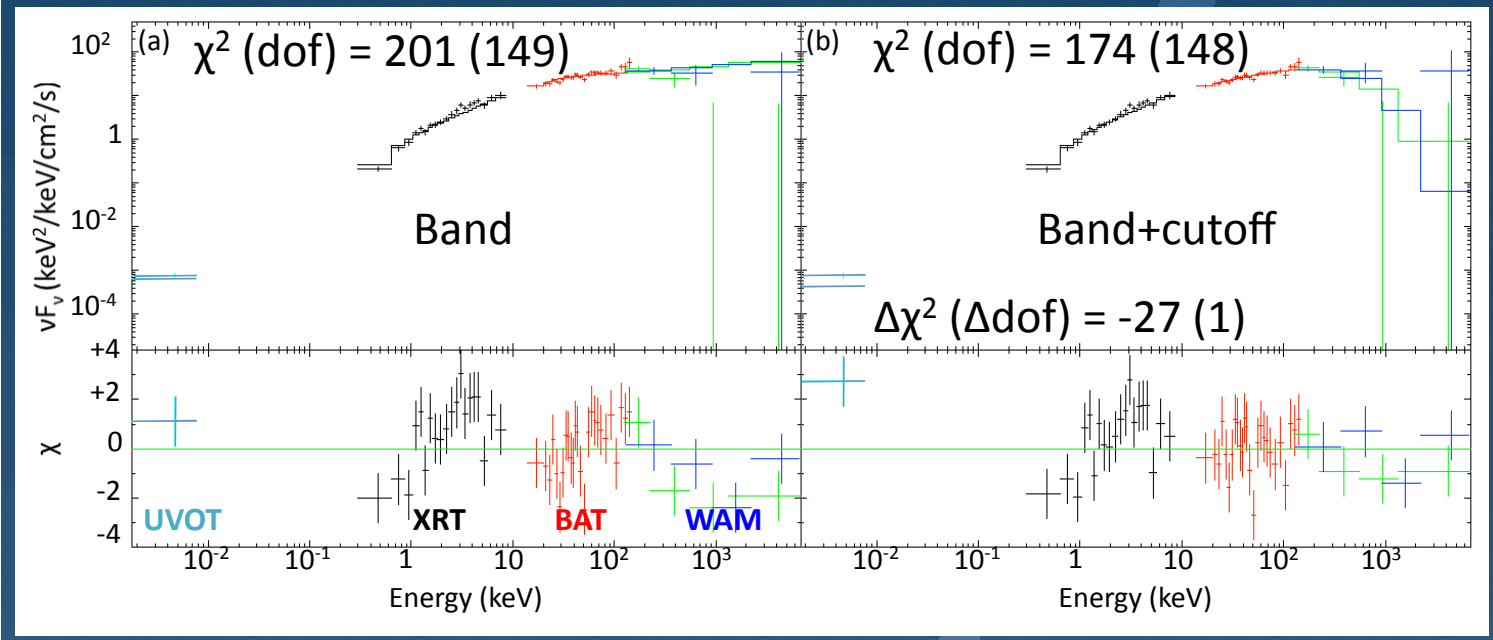

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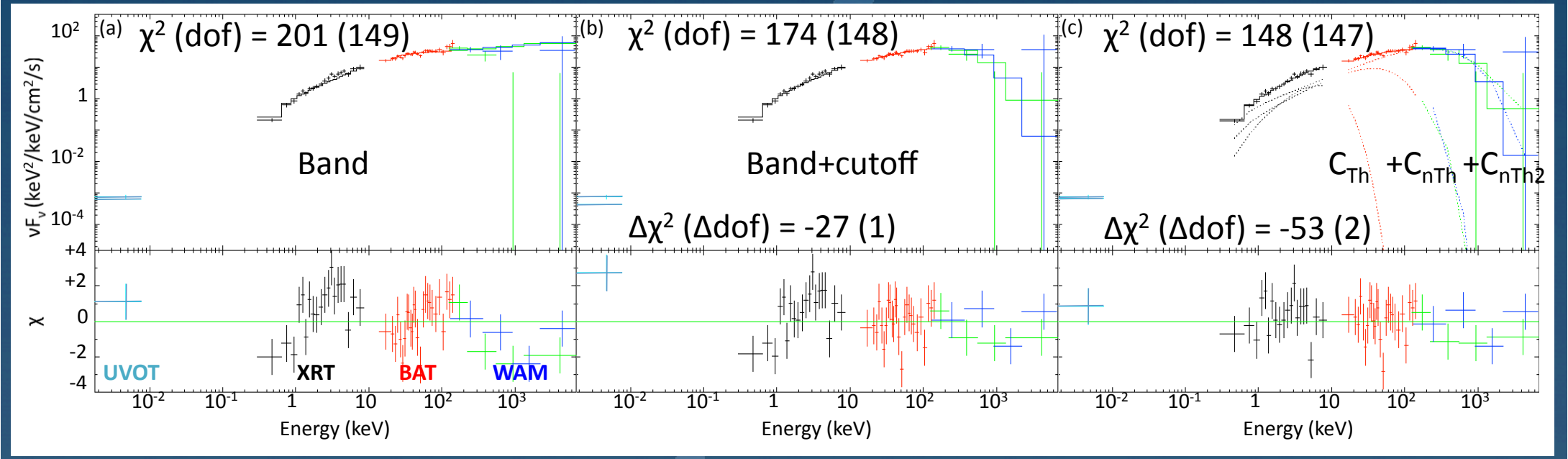

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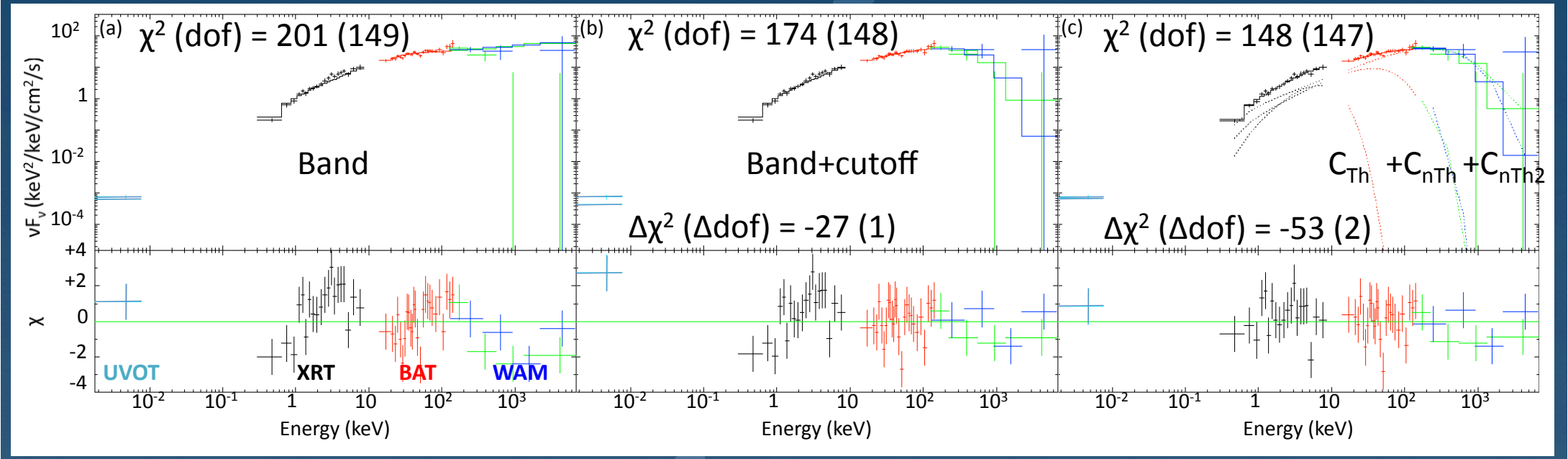

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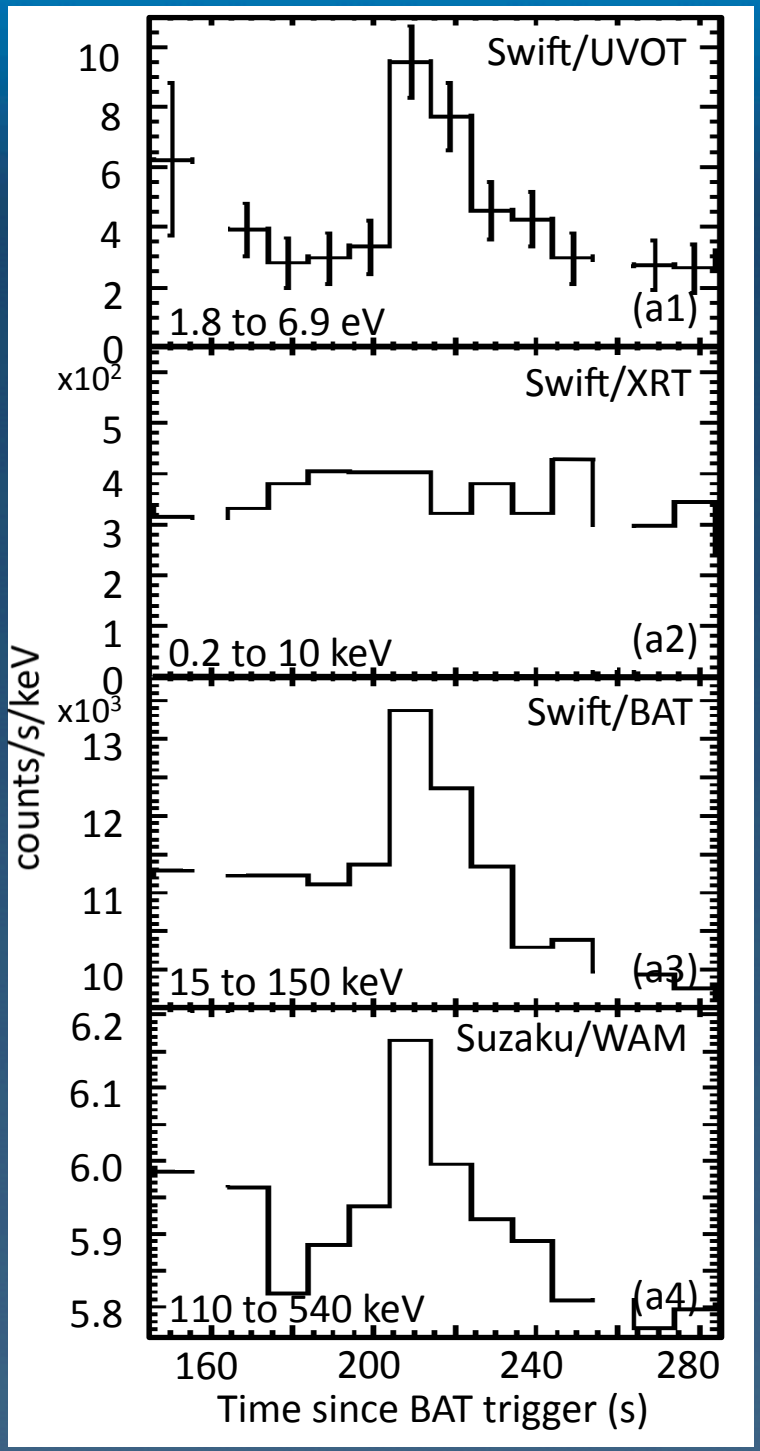
4 free parameters **5 free parameters** **5 free parameters**

How Predictive is the New Model?



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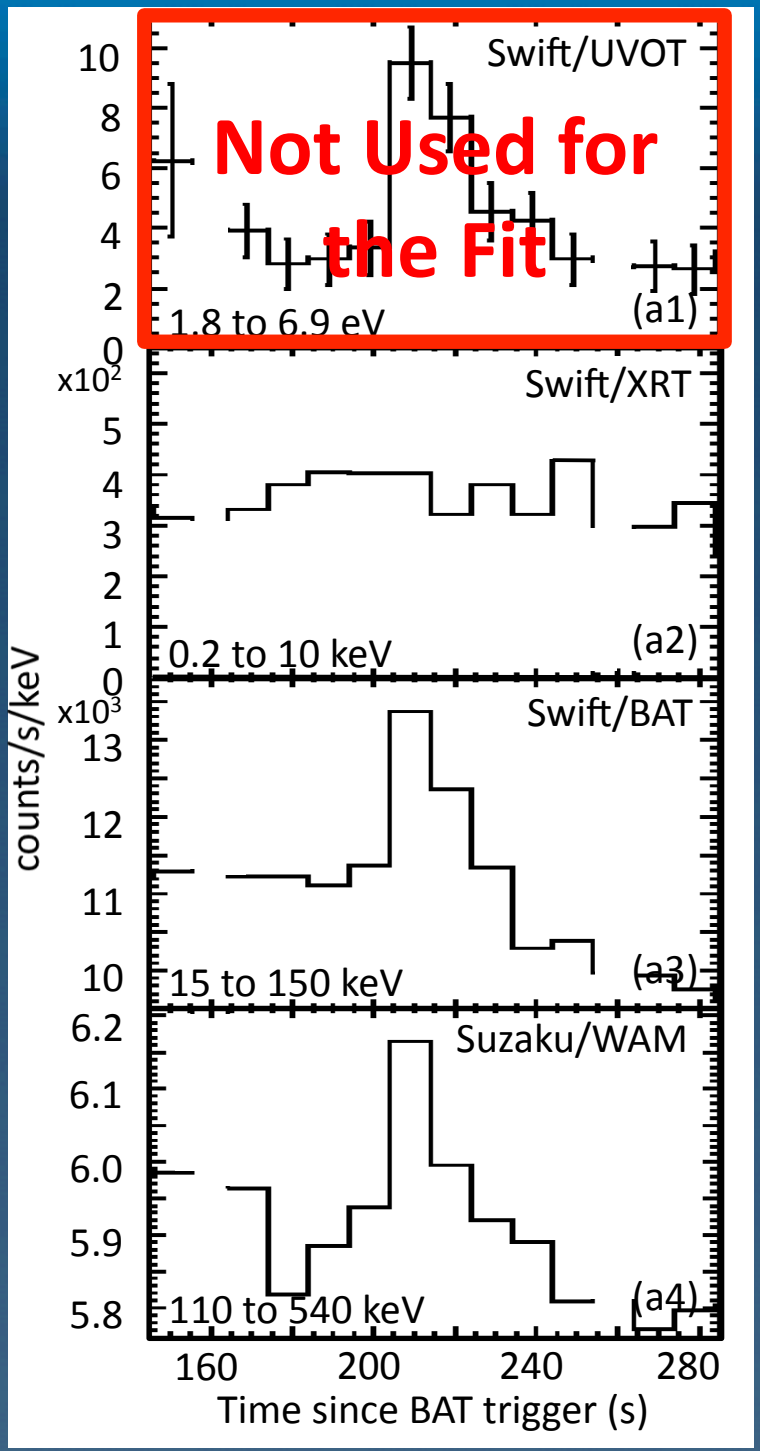

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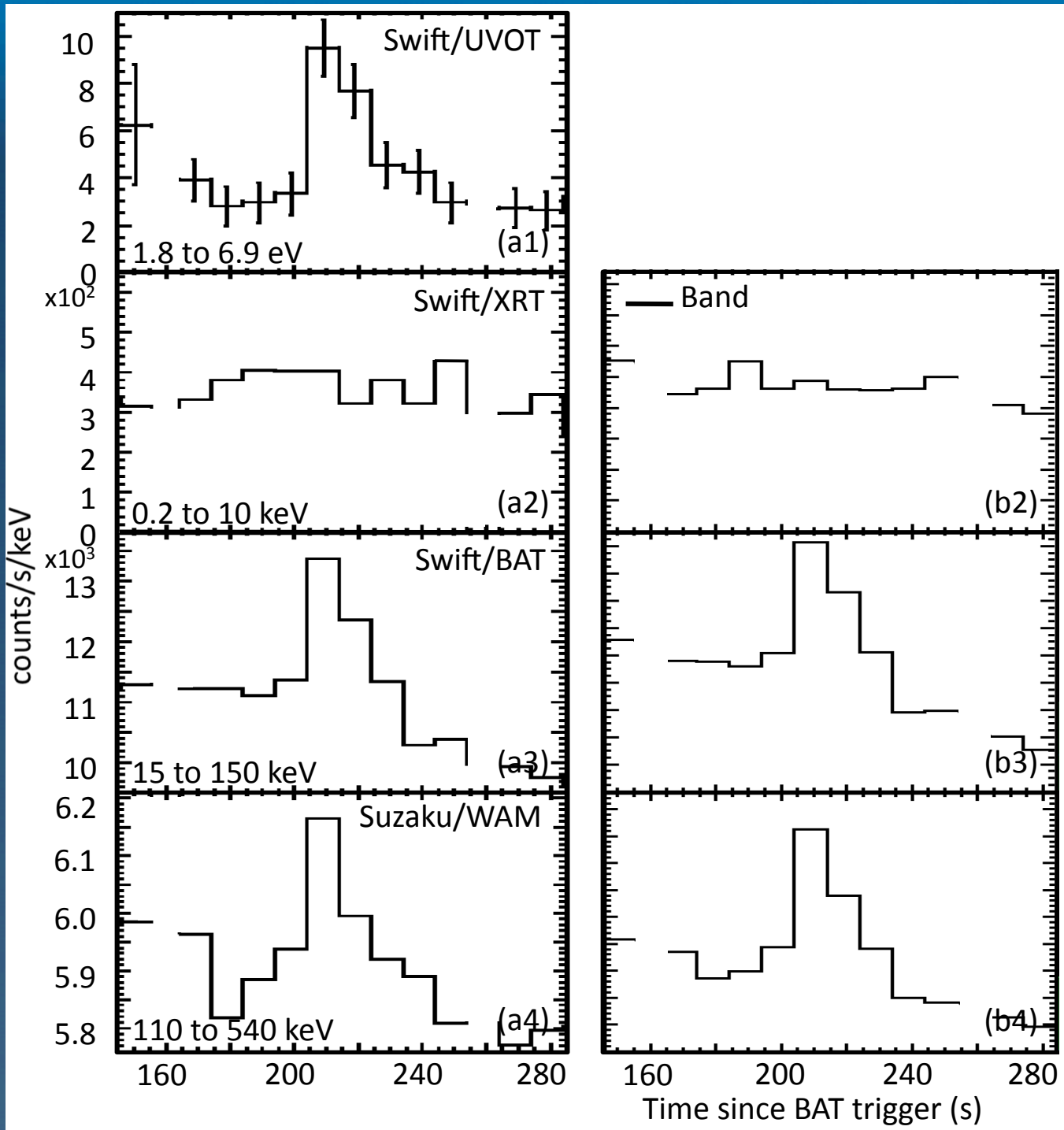

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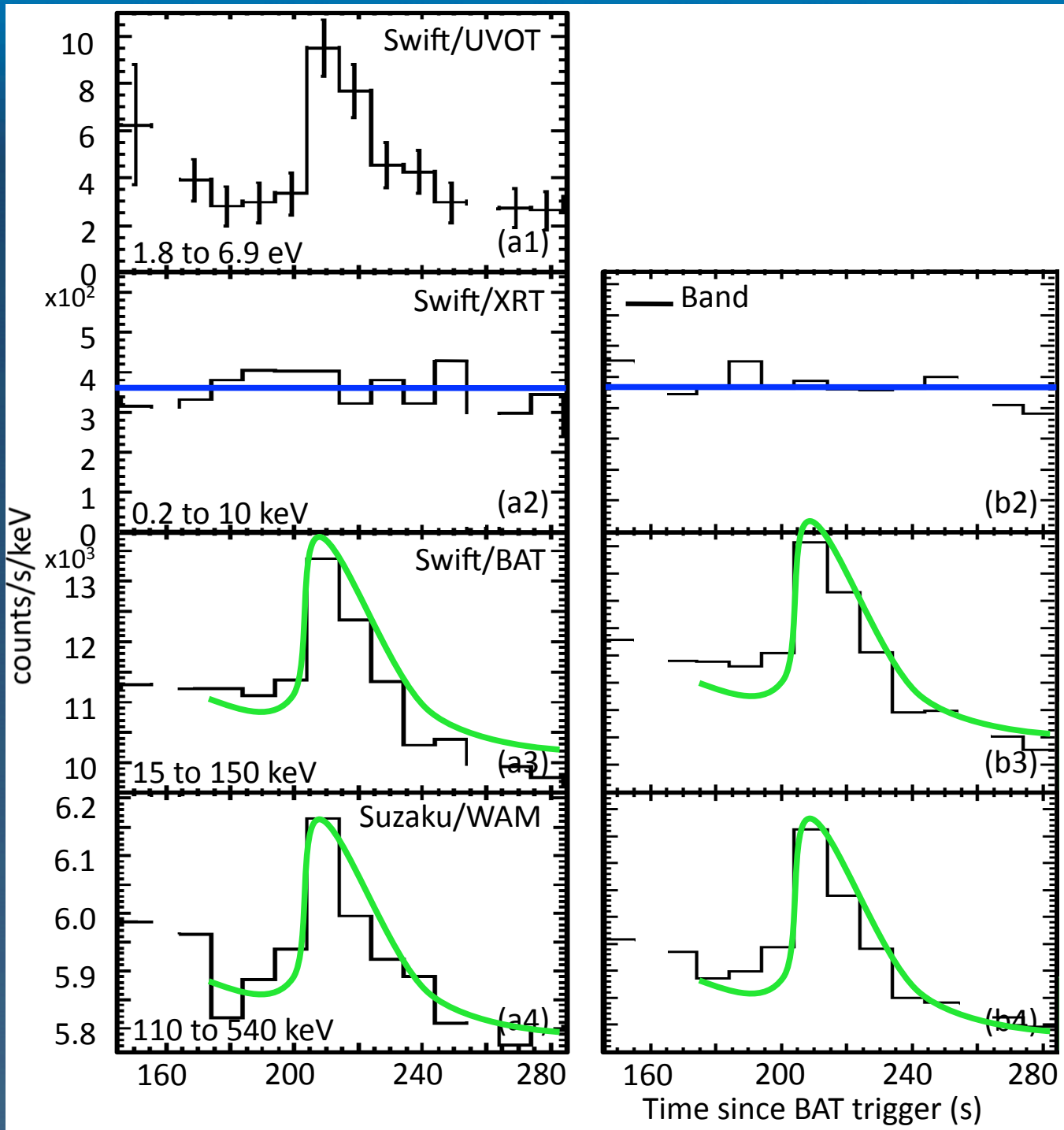

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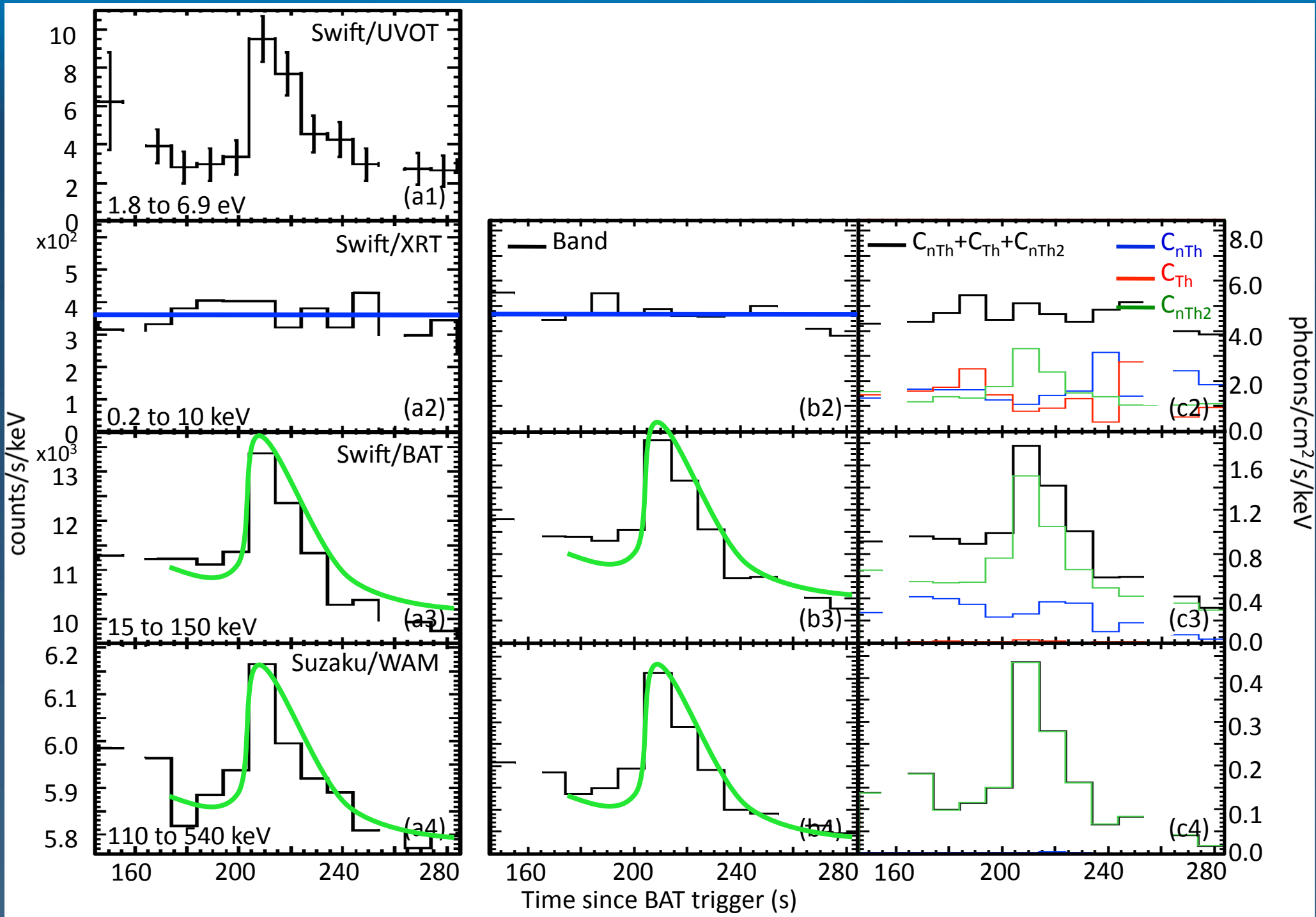

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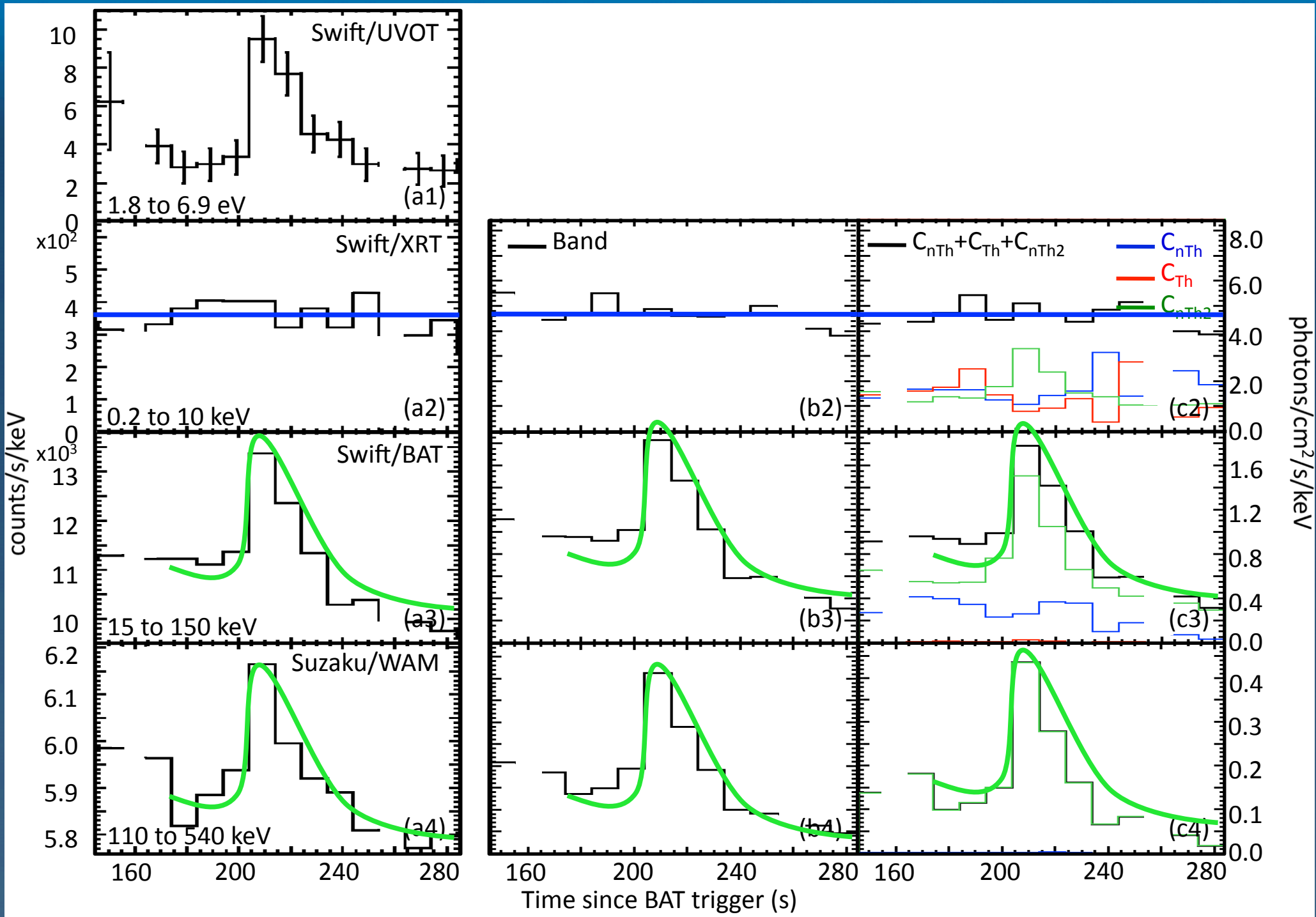
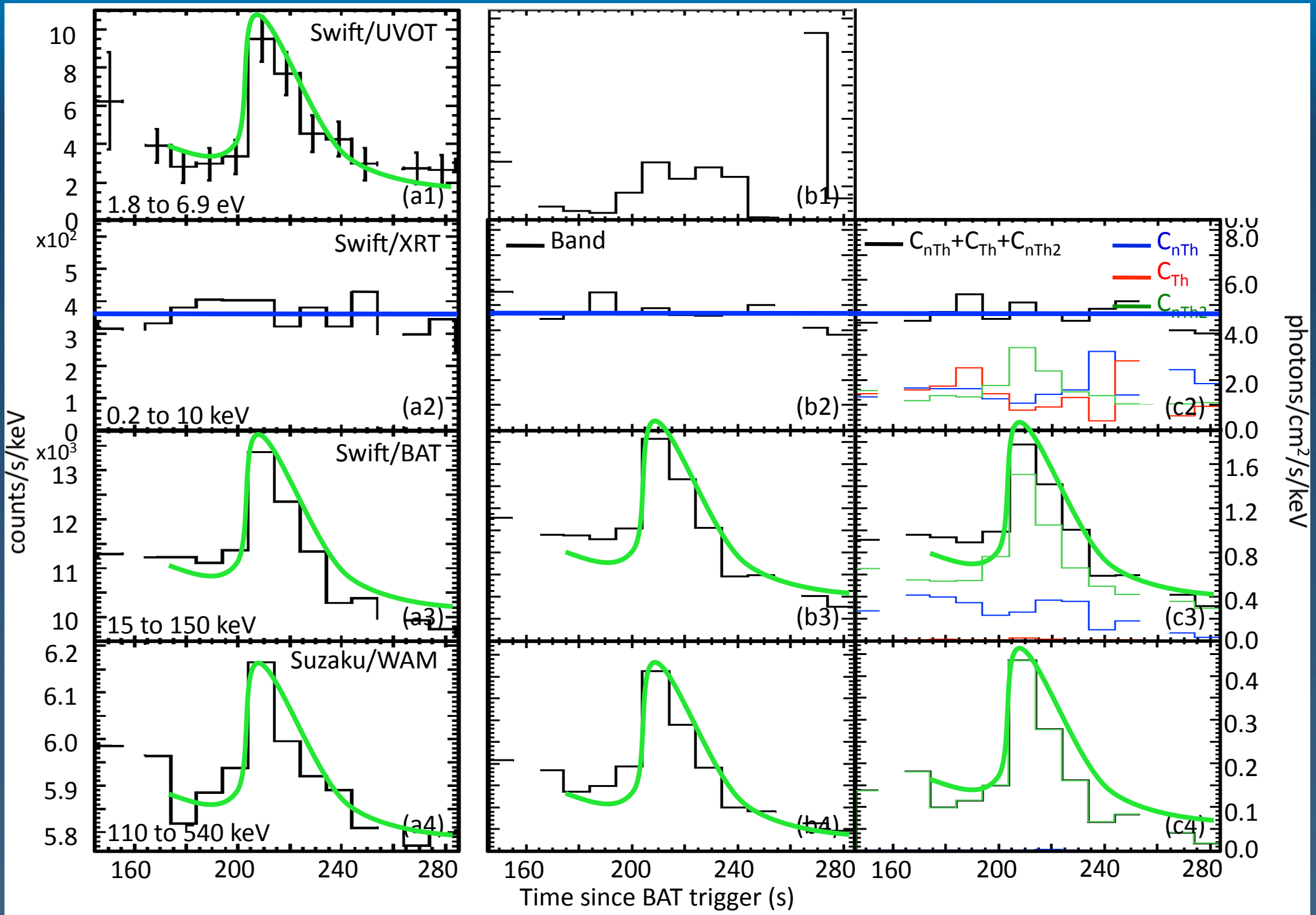


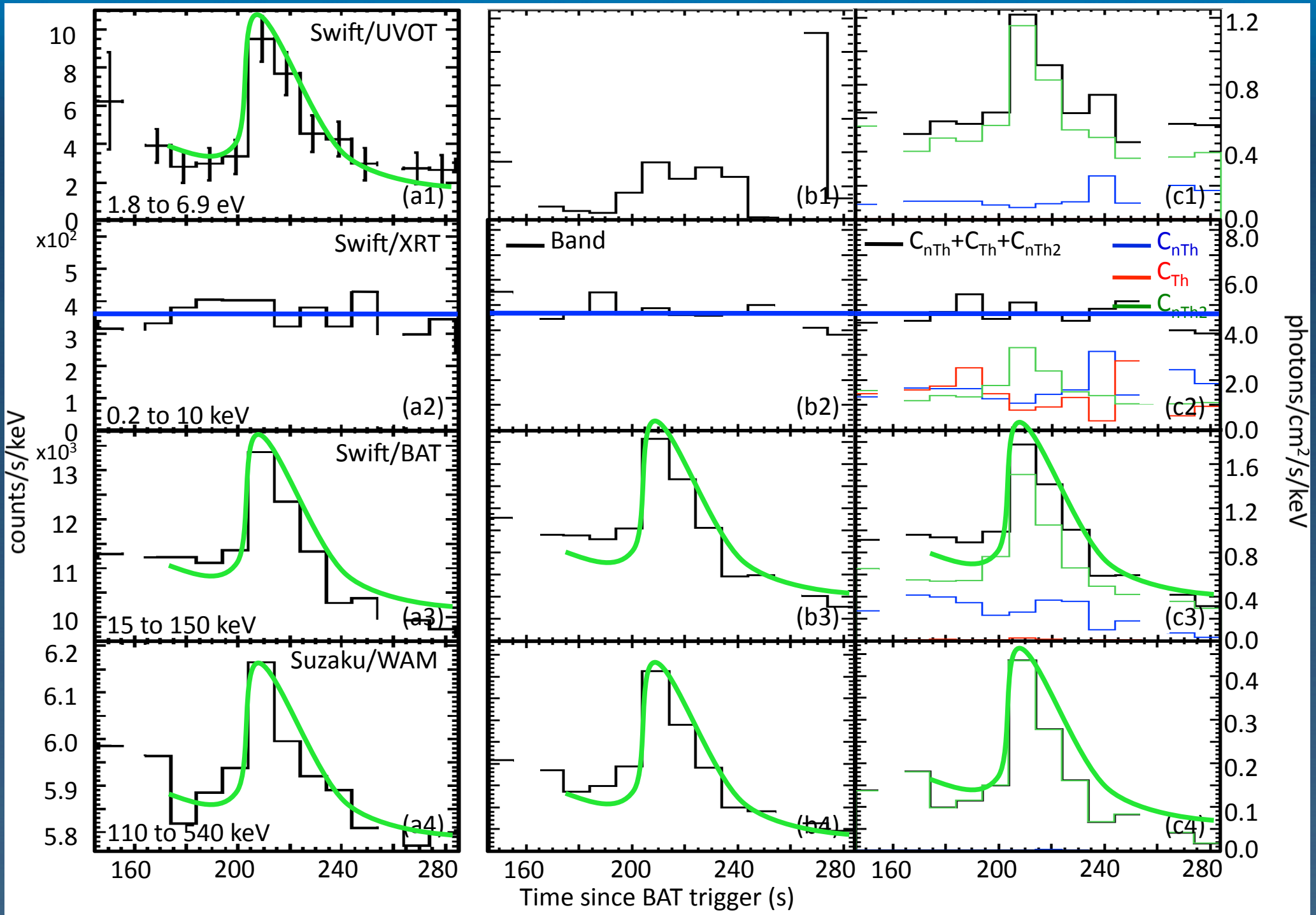
(Guiriec et al., in Preparation)

How Predictive is the New Model?



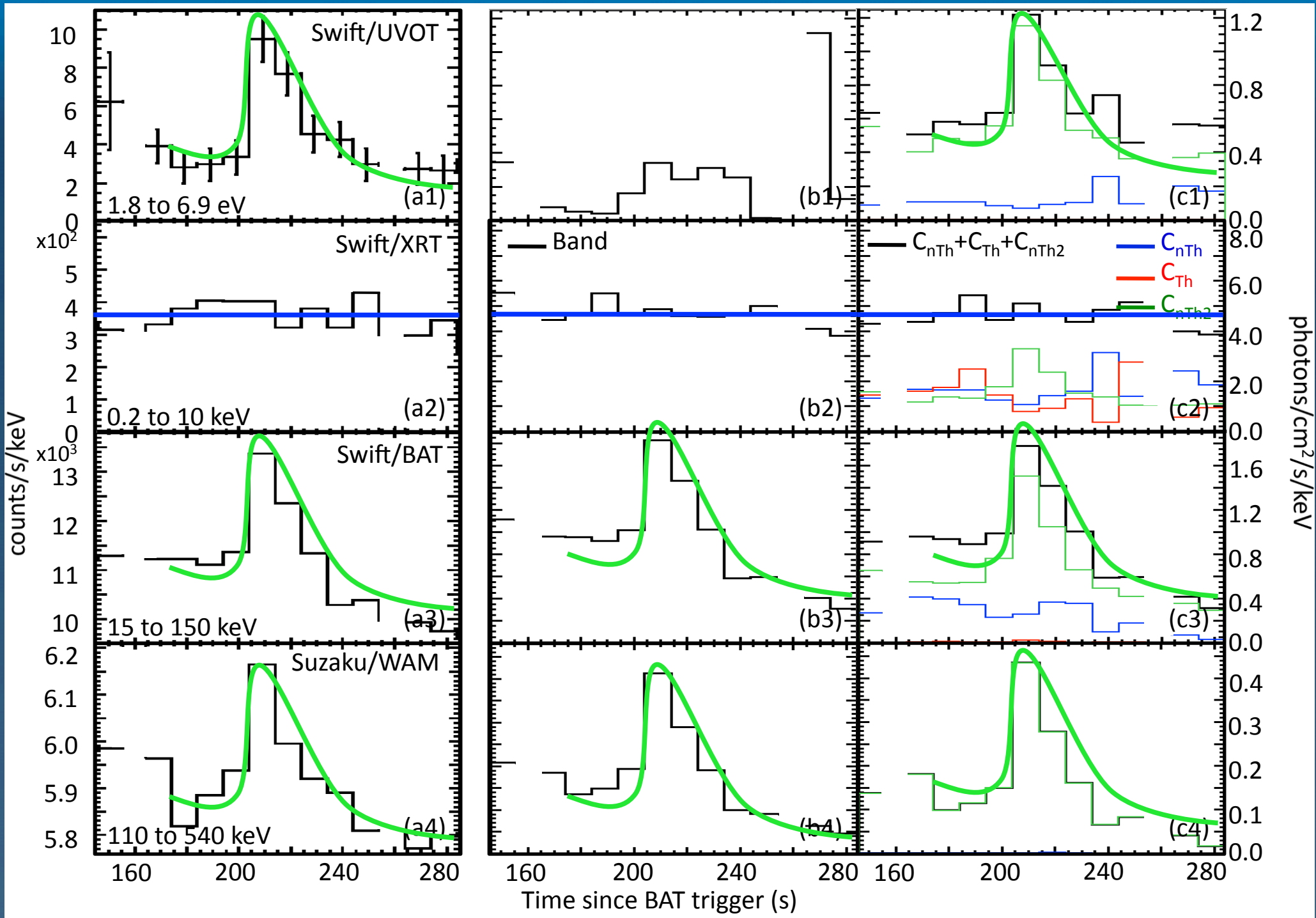
(Guiriec et al., in Preparation)

How Predictive is the New Model?



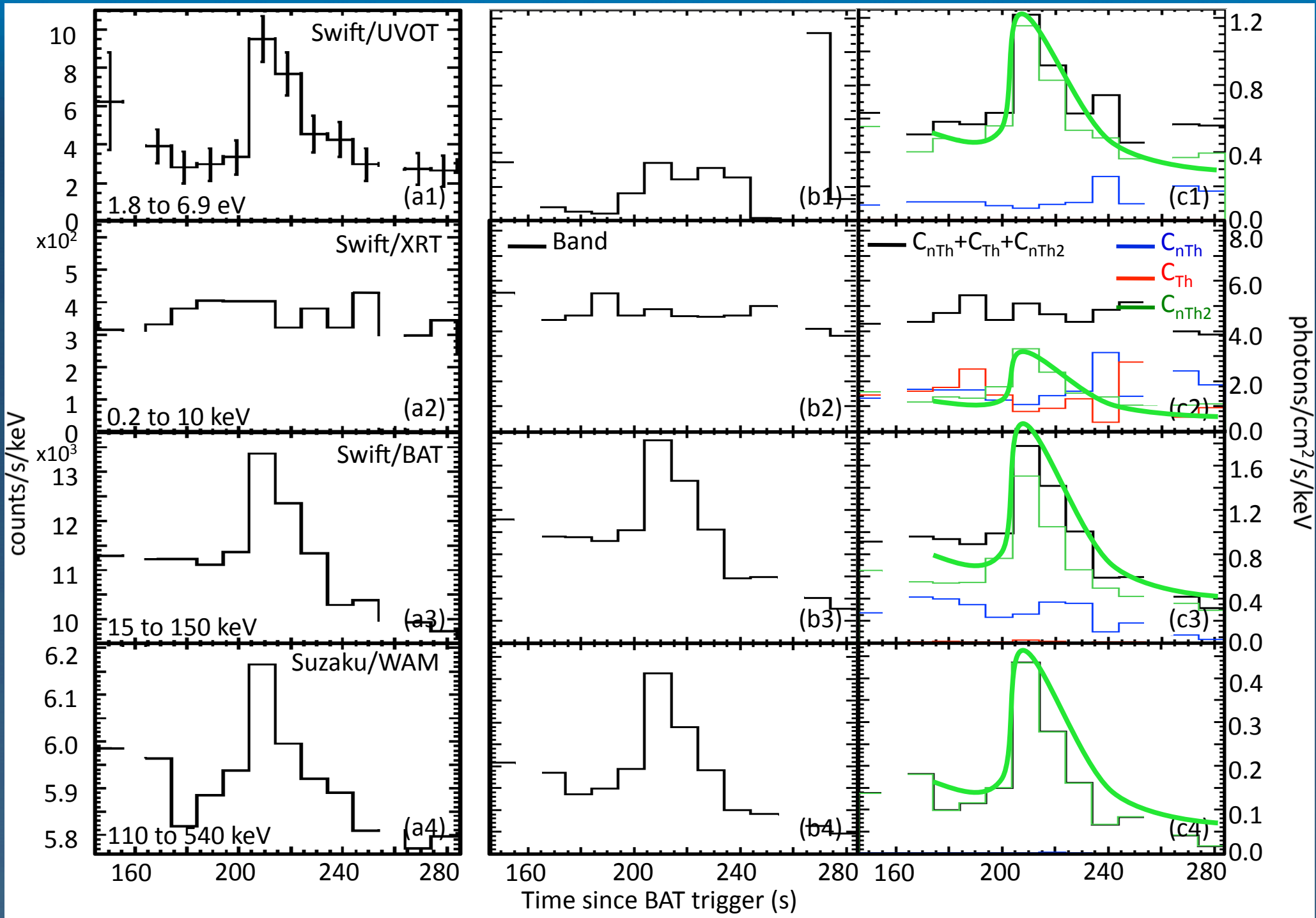
(Guiriec et al., in Preparation)

How Predictive is the New Model?



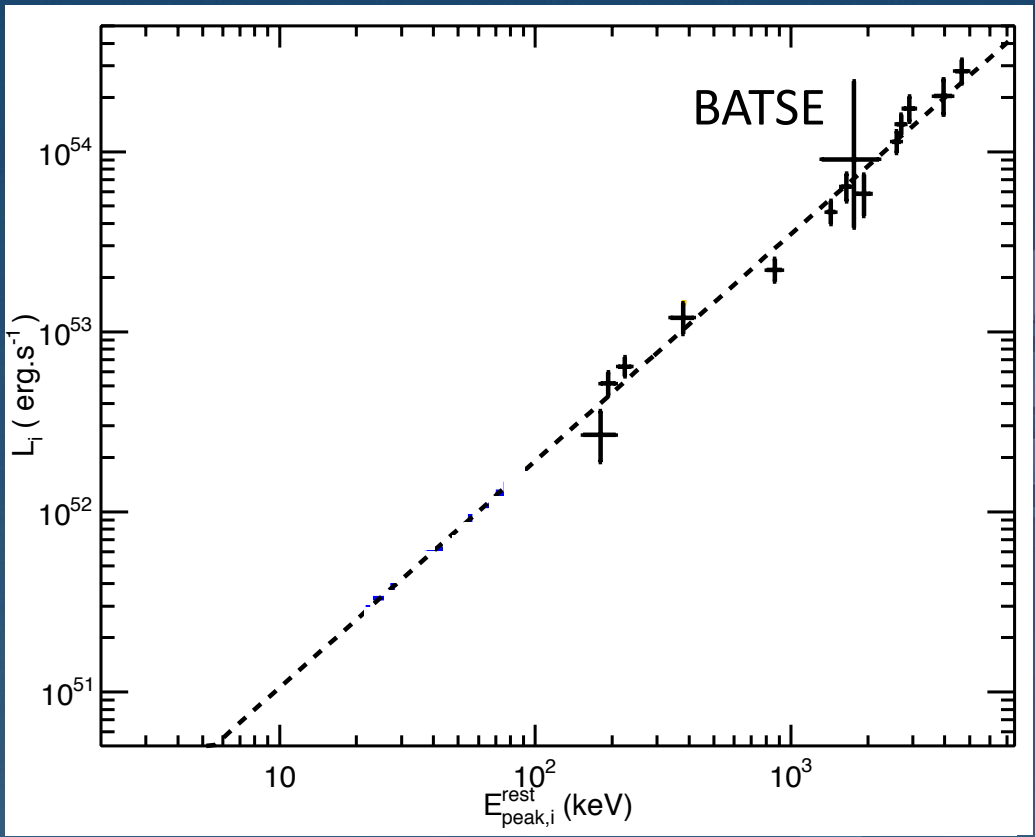
(Guiriec et al., in Preparation)

How Predictive is the New Model?



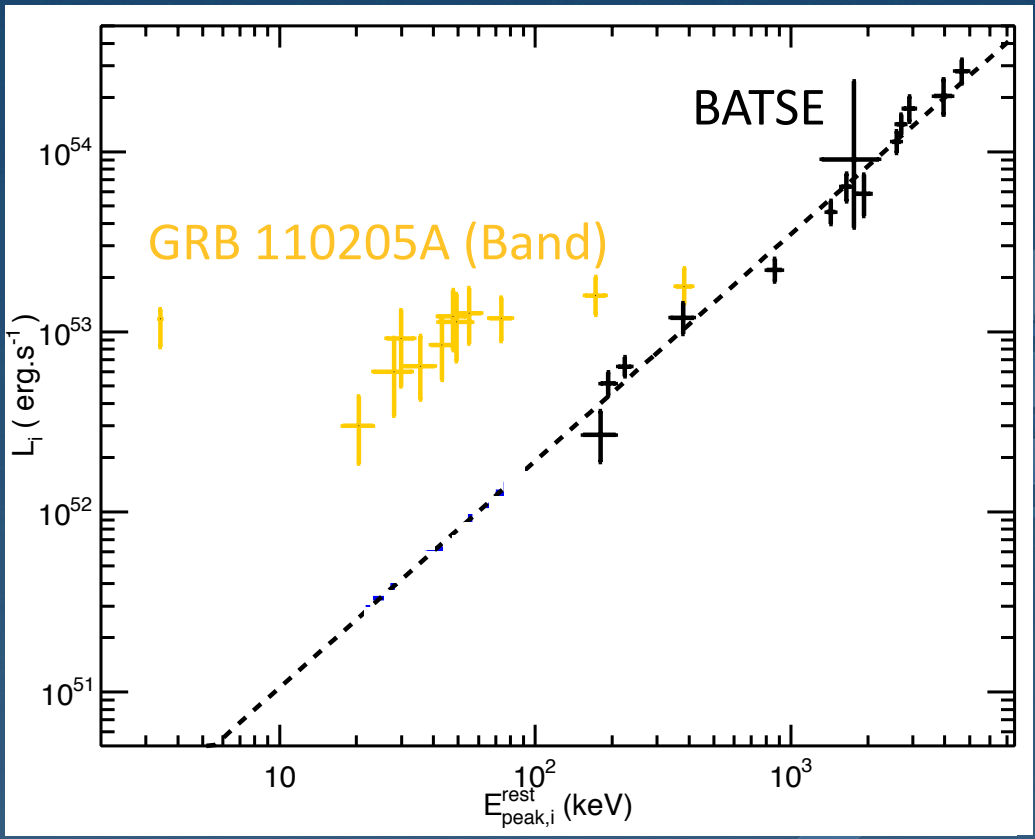
(Guiriec et al., in Preparation)

L_i^{nTh}-$E_{peak,i}^{nTh,rest}$ Relation and Redshift Estimation



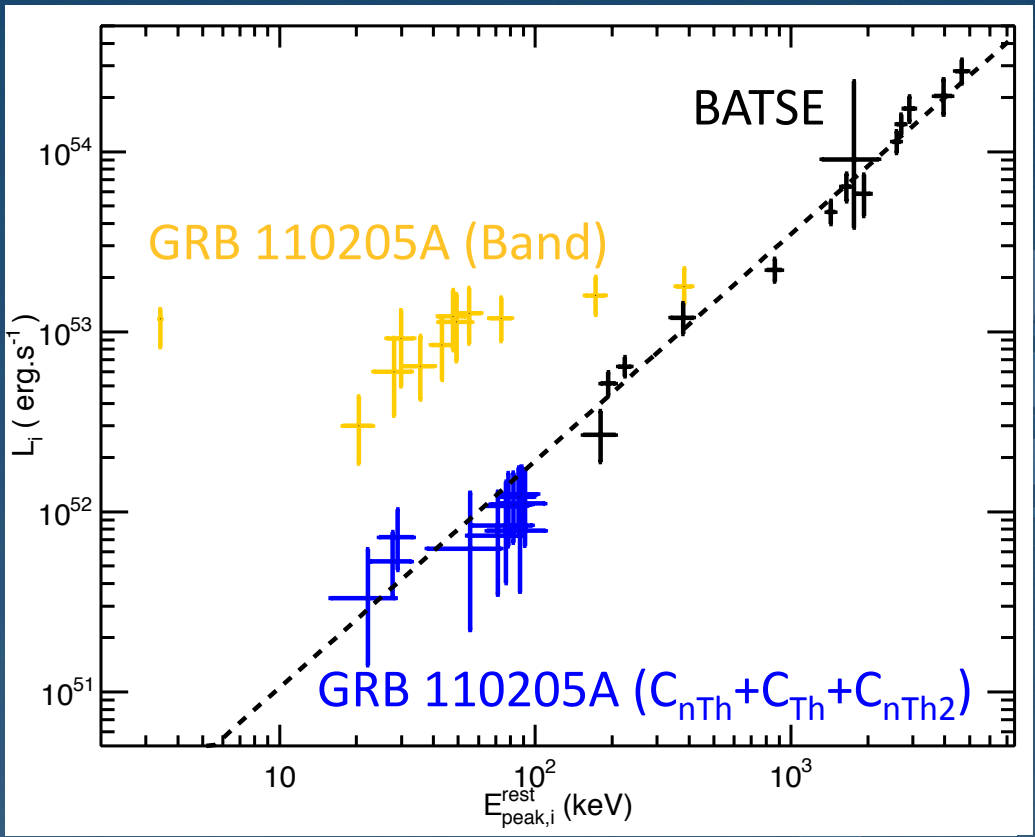
(Guiriec et al., in Preparation)

L_i^{nTh}-$E_{peak,i}^{nTh,rest}$ Relation and Redshift Estimation



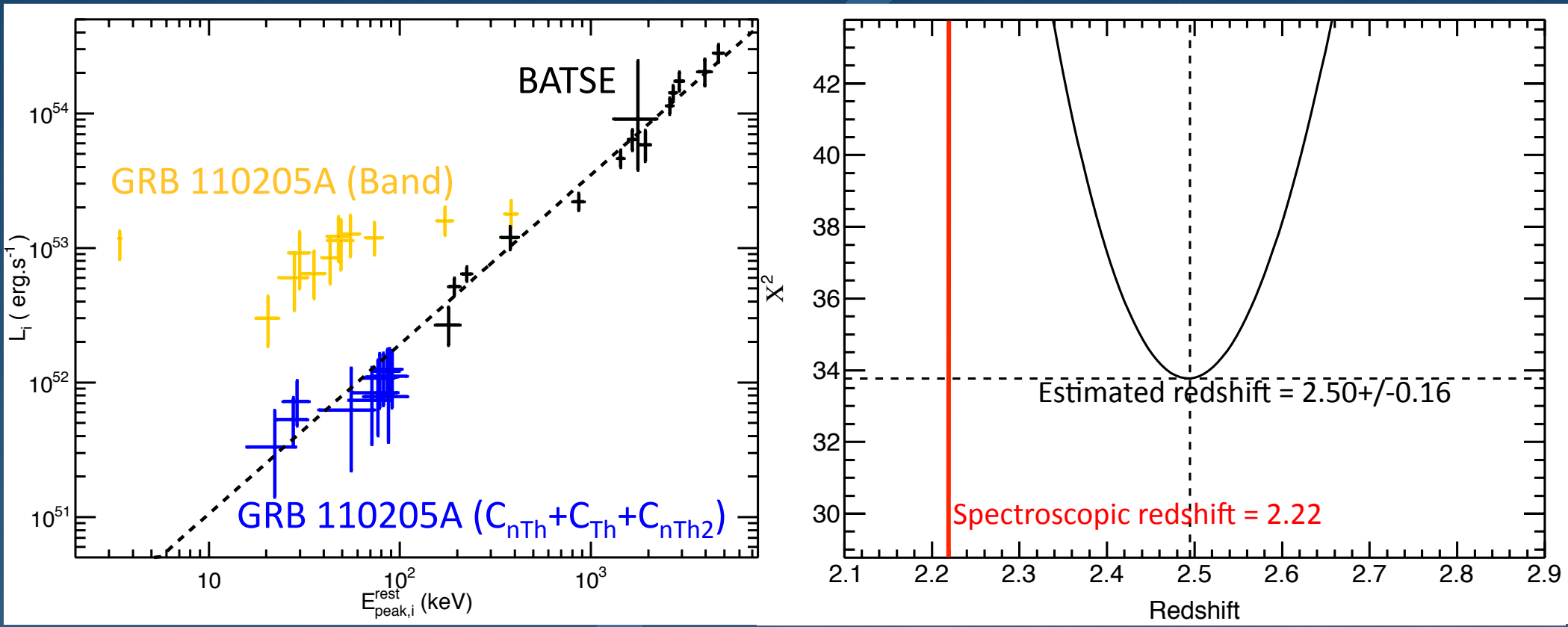
(Guiriec et al., in Preparation)

L_i^{nTh}-$E_{peak,i}^{nTh,rest}$ Relation and Redshift Estimation



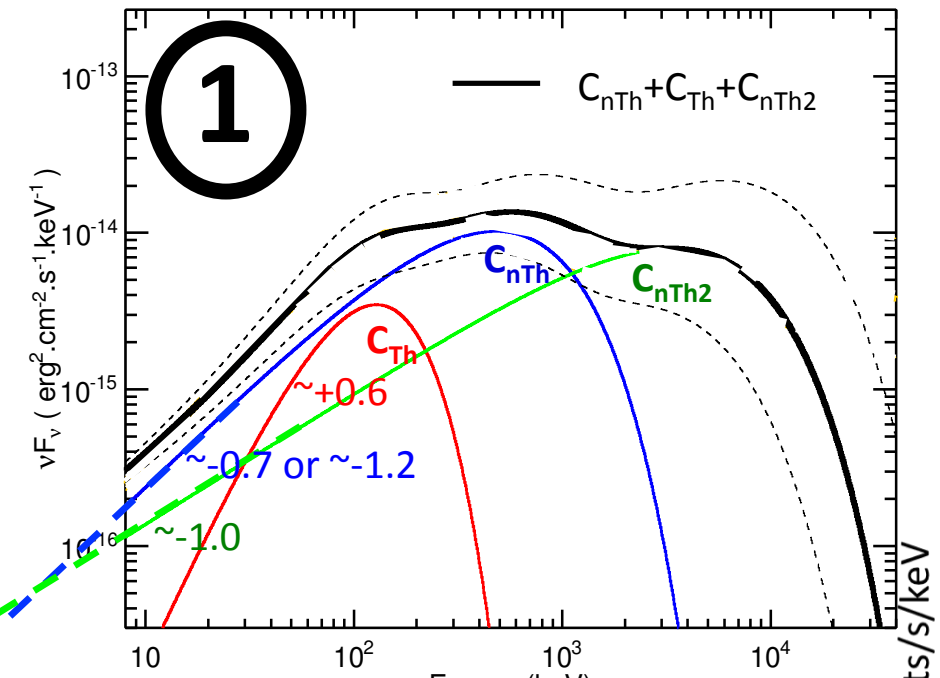
(Guiriec et al., in Preparation)

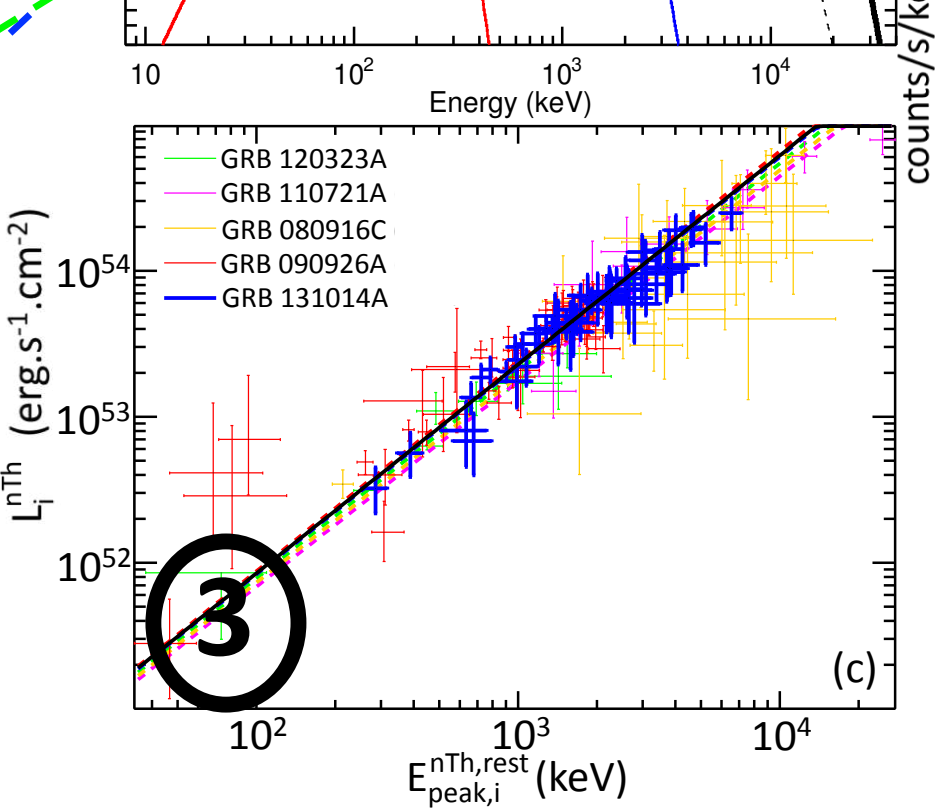
L_i^{nTh}-$E_{peak,i}^{nTh,rest}$ Relation and Redshift Estimation

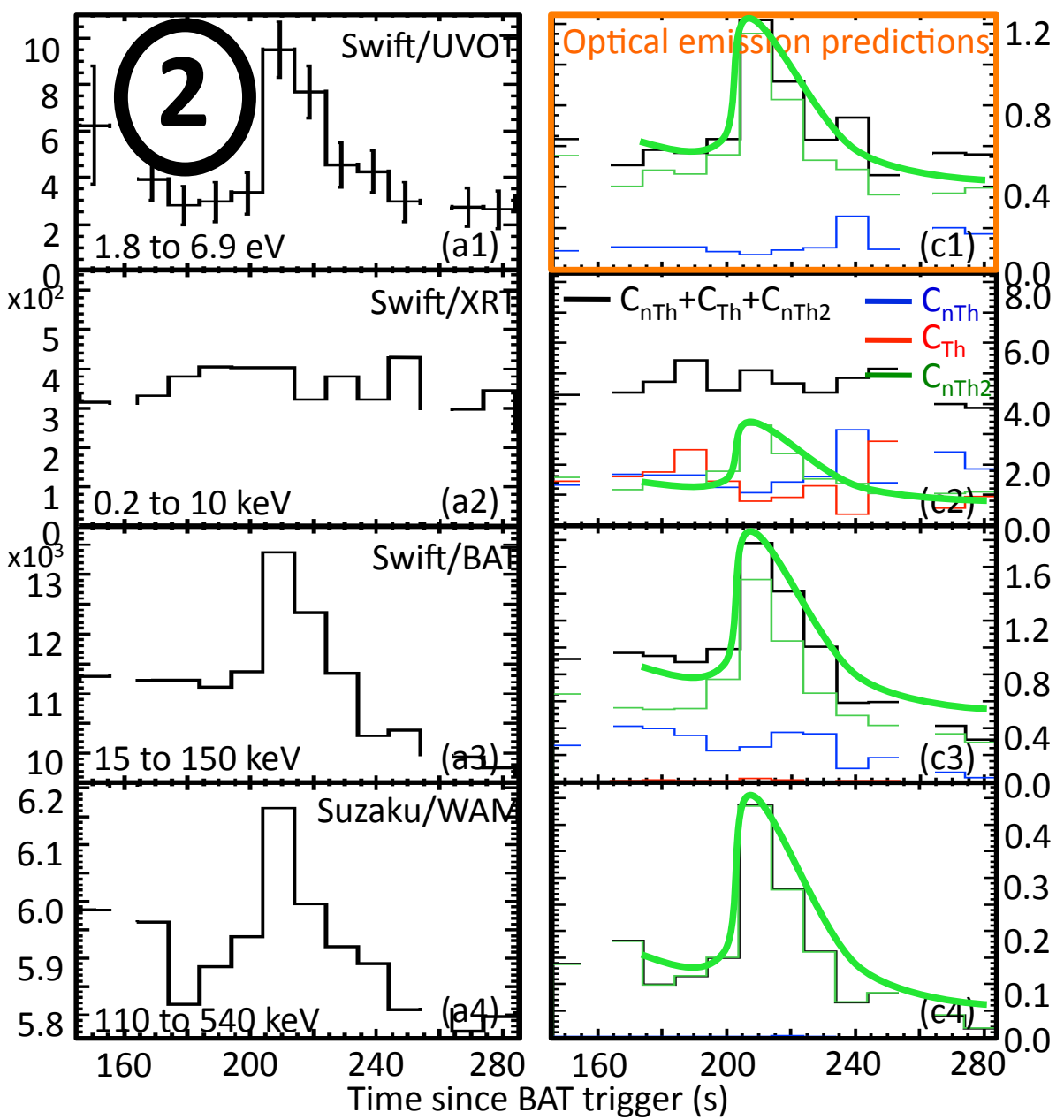


(Guiriec et al., in Preparation)

Summary in a Few Figures

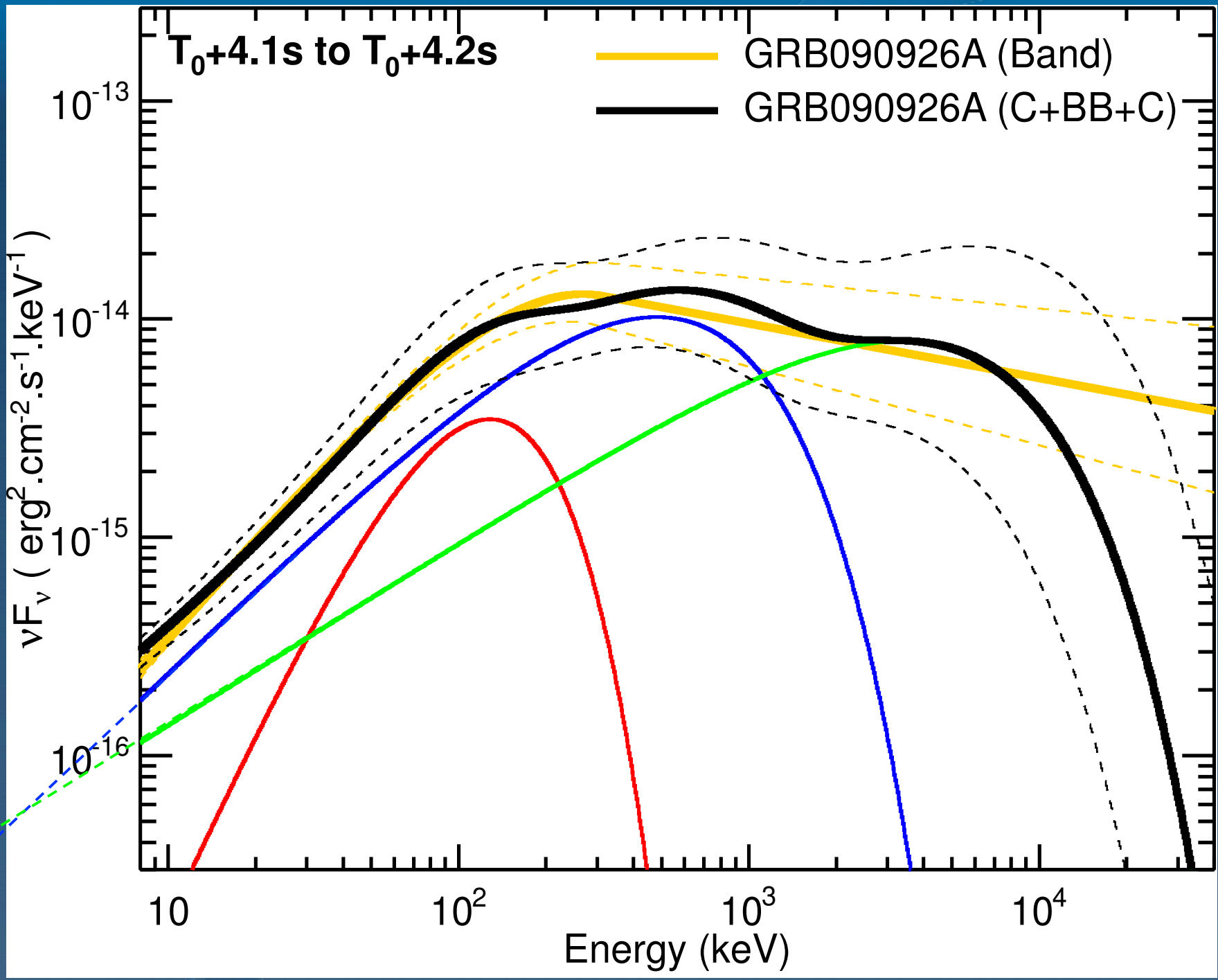




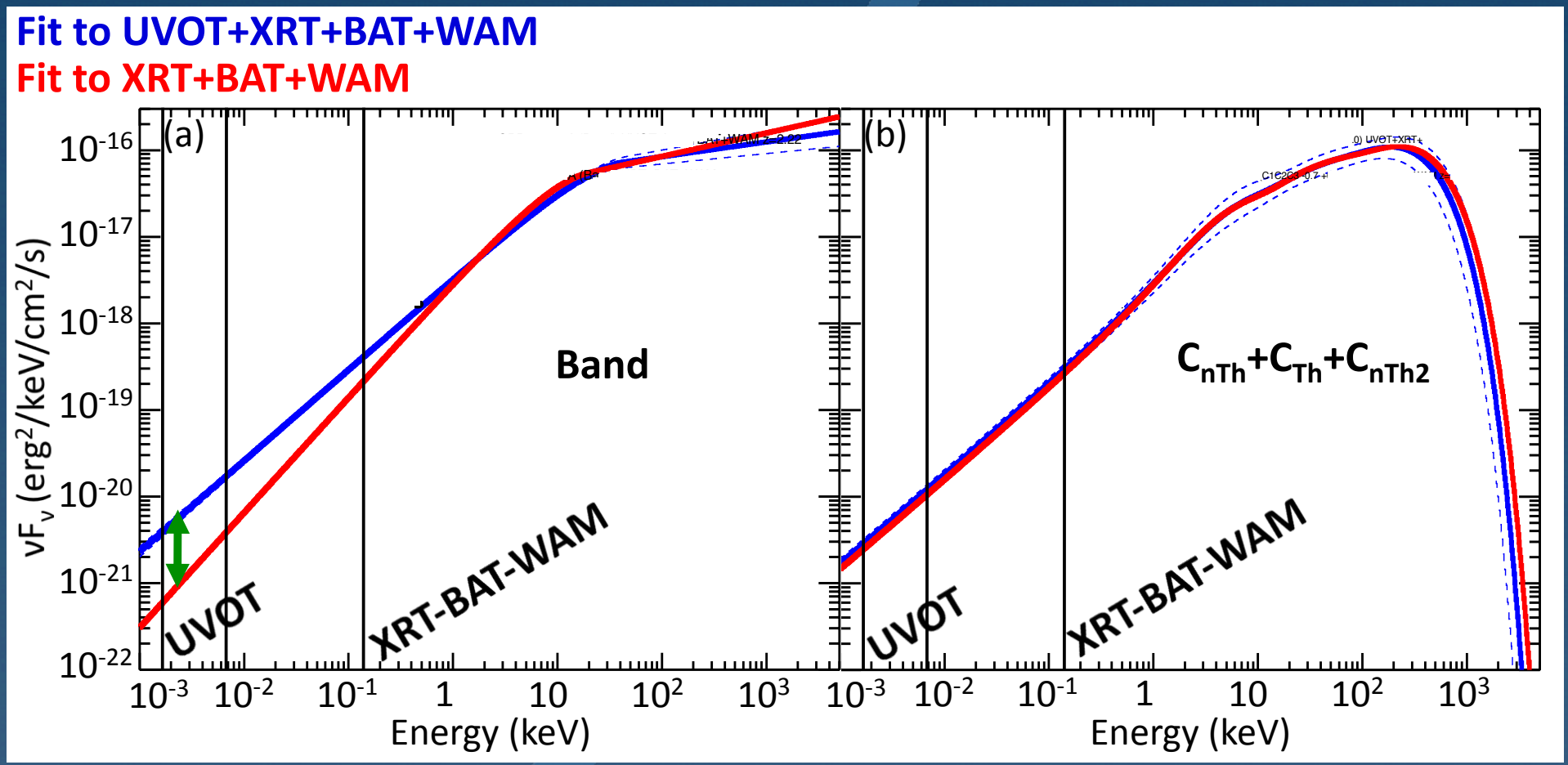


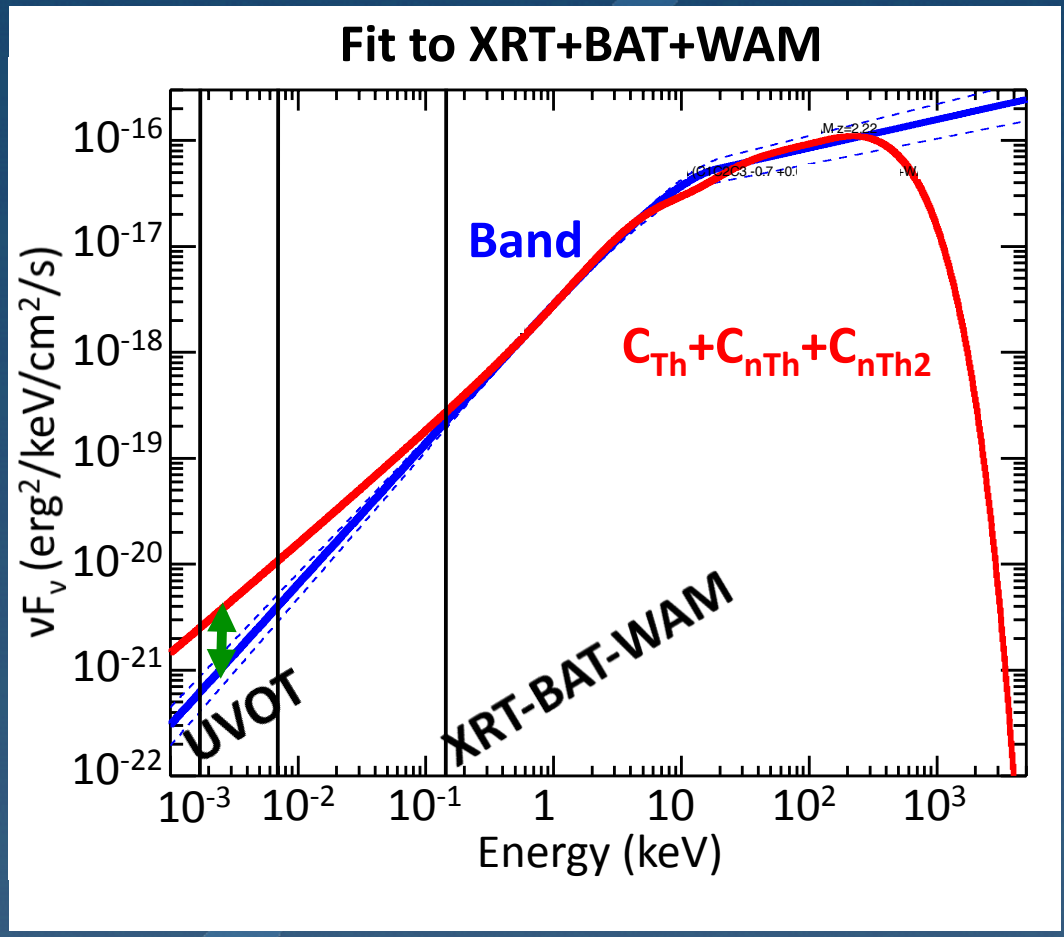
We are starting to probe the grey area between prompt and afterglow emission.

Backup Slides

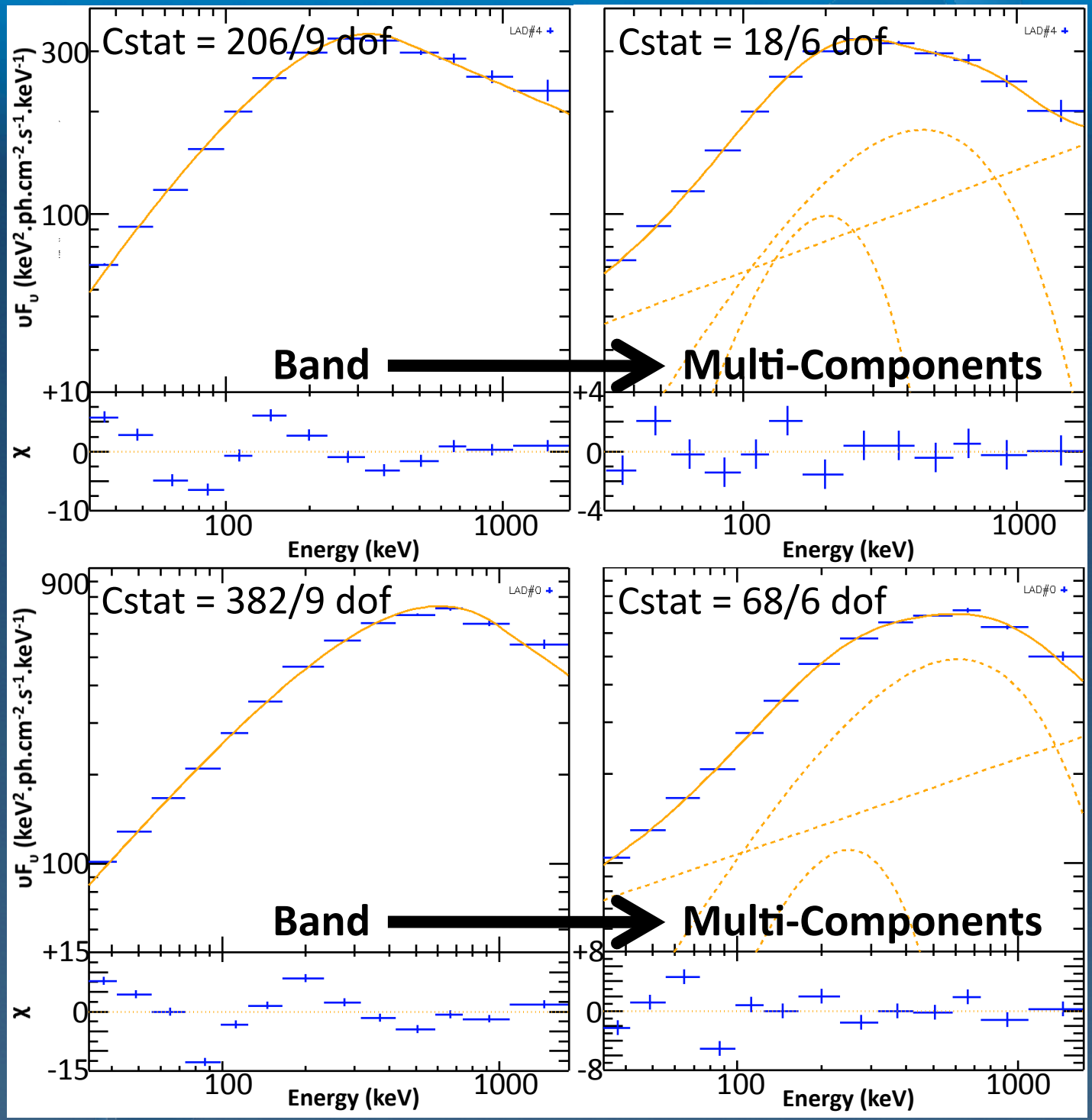

T0+4.1s to T0+4.2s
GRB090926A (Band)
GRB090926A (C+BB+C)
10-13
10-14
10-15
10-16
νFν (erg2.cm-2.s-1.keV-1)
10
10^2
10^3
10^4
Energy (keV)

Broadband Prompt Emission Spectrum from Optical to γ-Rays

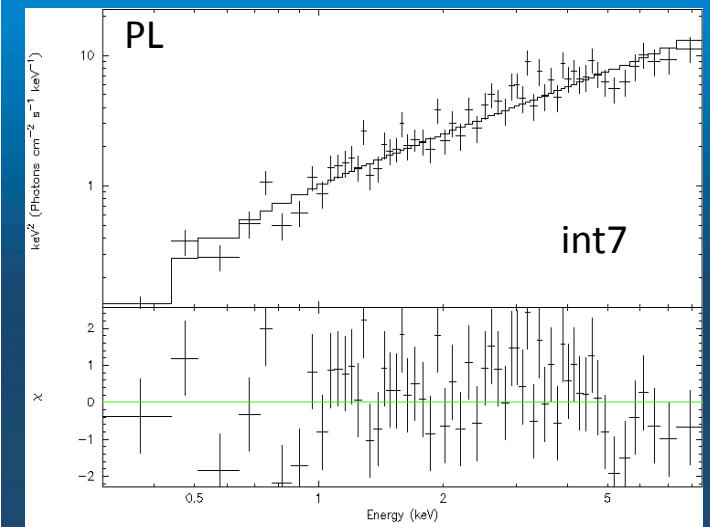


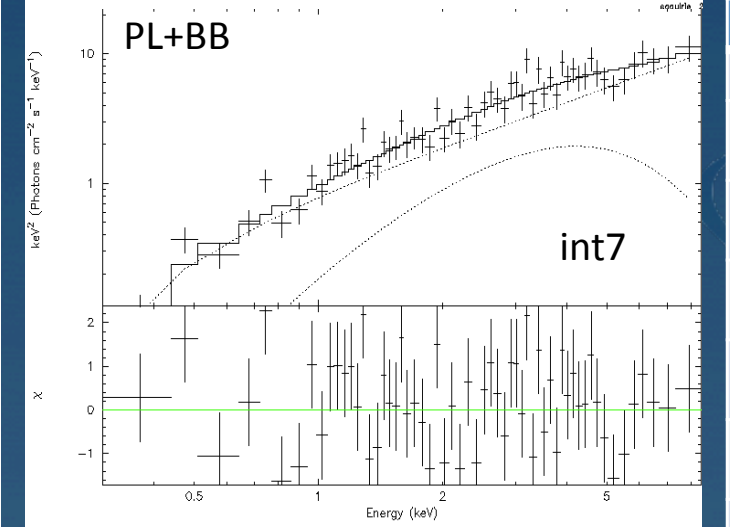

Fit to XRT+BAT+WAM
Band
$C_{Th}+C_{nTh}+C_{nTh2}$
UVOT
XRT-BAT-WAM
vF_v (erg^2/keV/cm^2/s)
Energy (keV)
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3

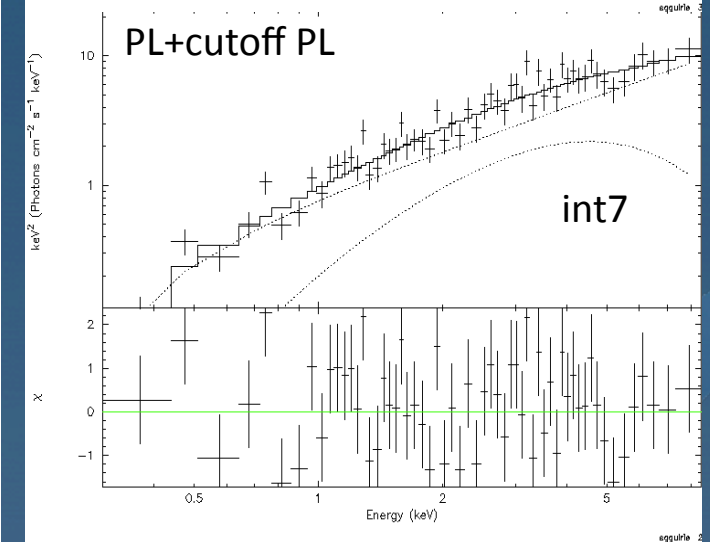
Does Only Fermi Capture Those Components ?

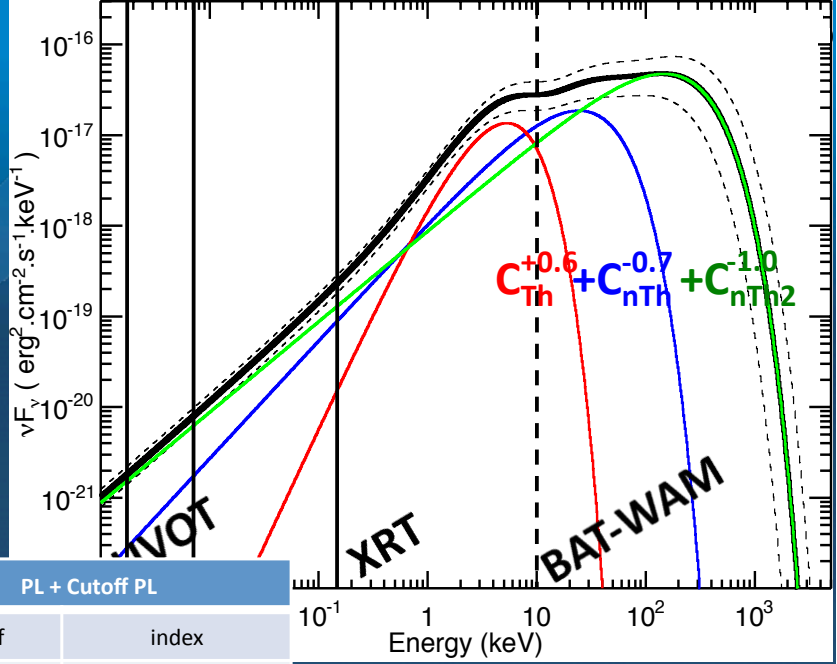


(Guiriec et al., 2015c)

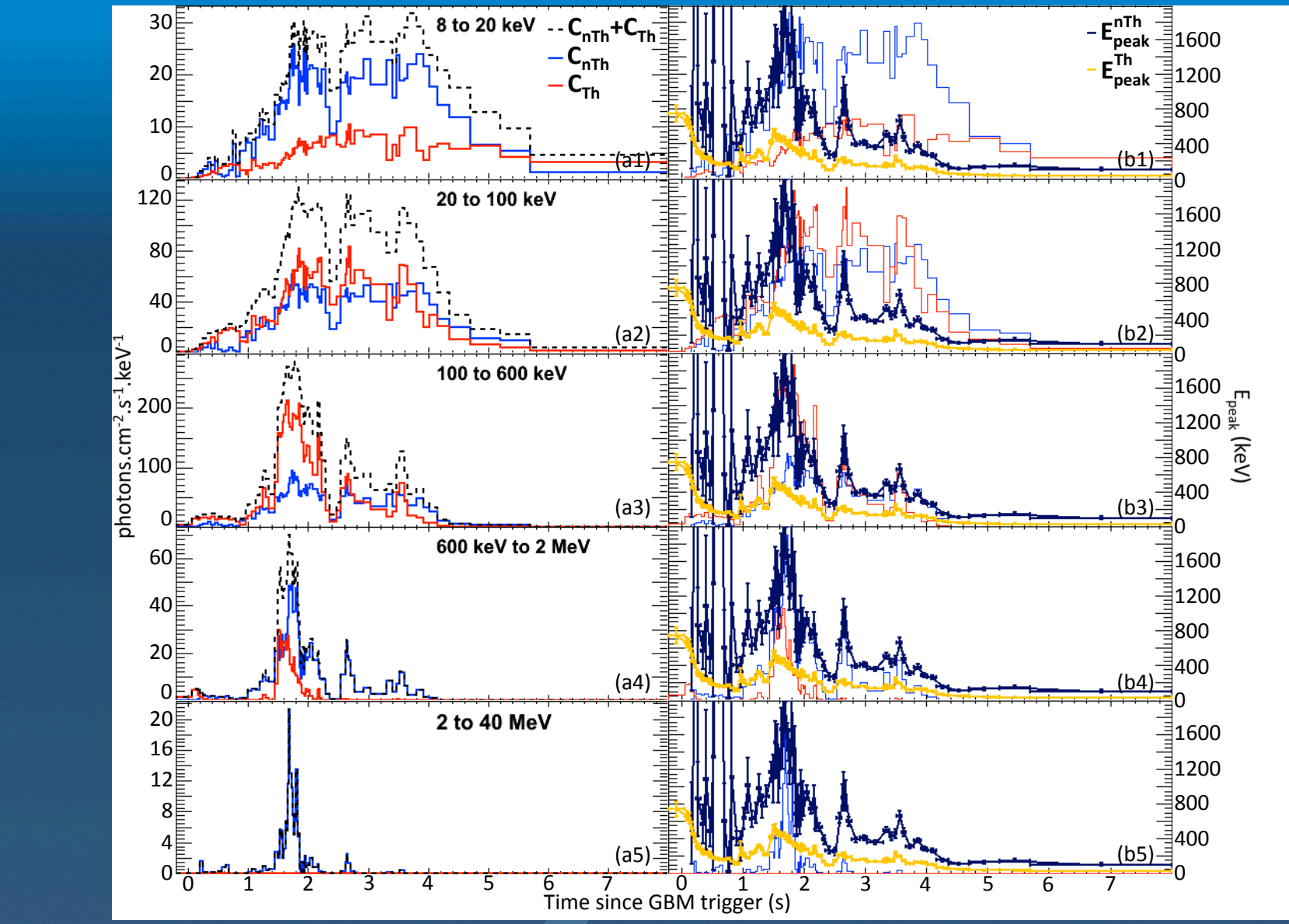


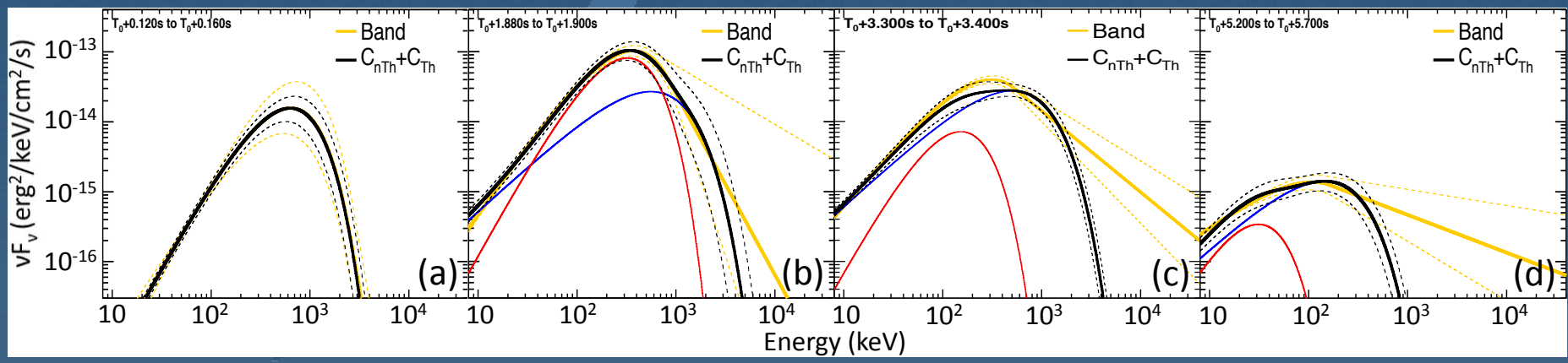


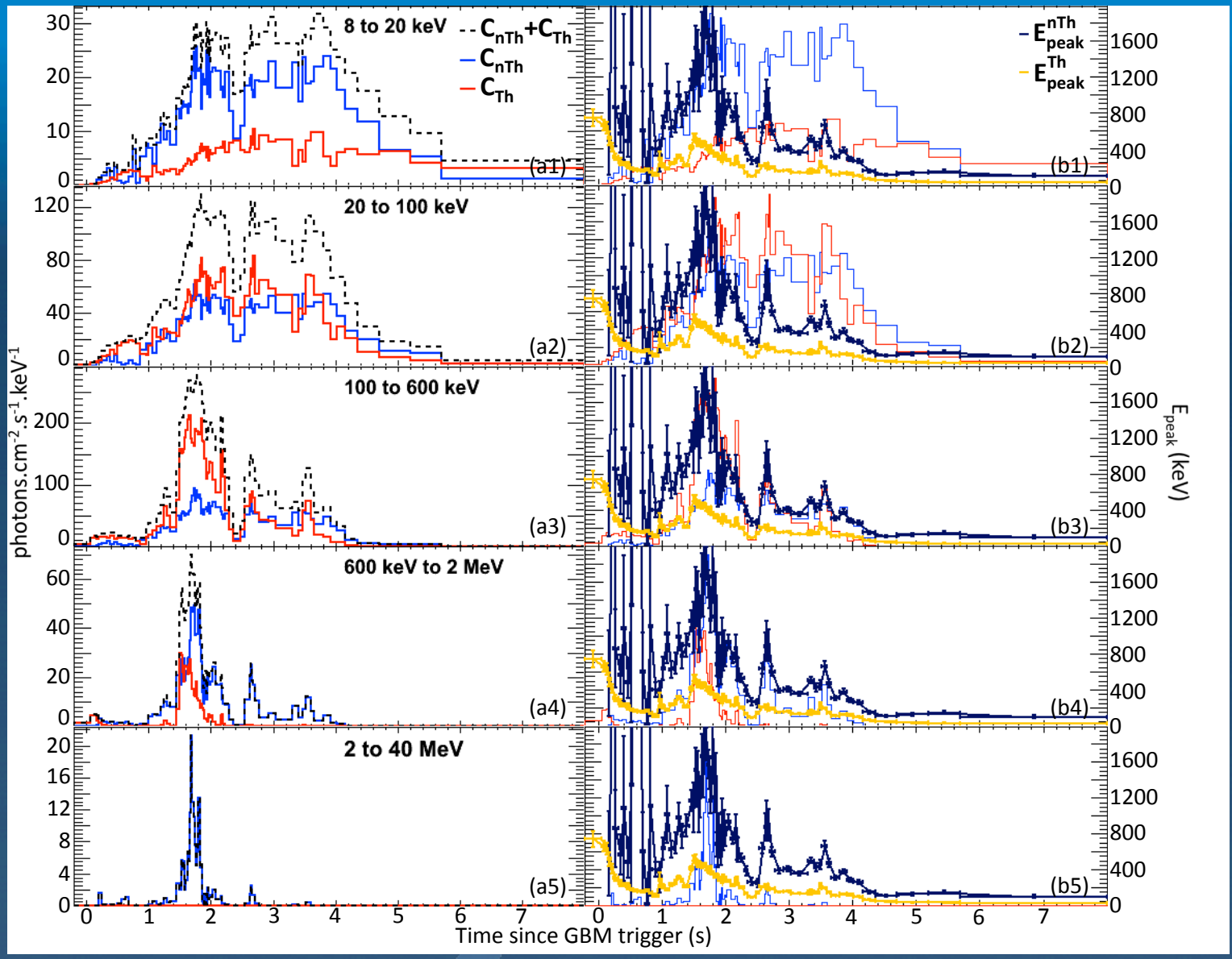


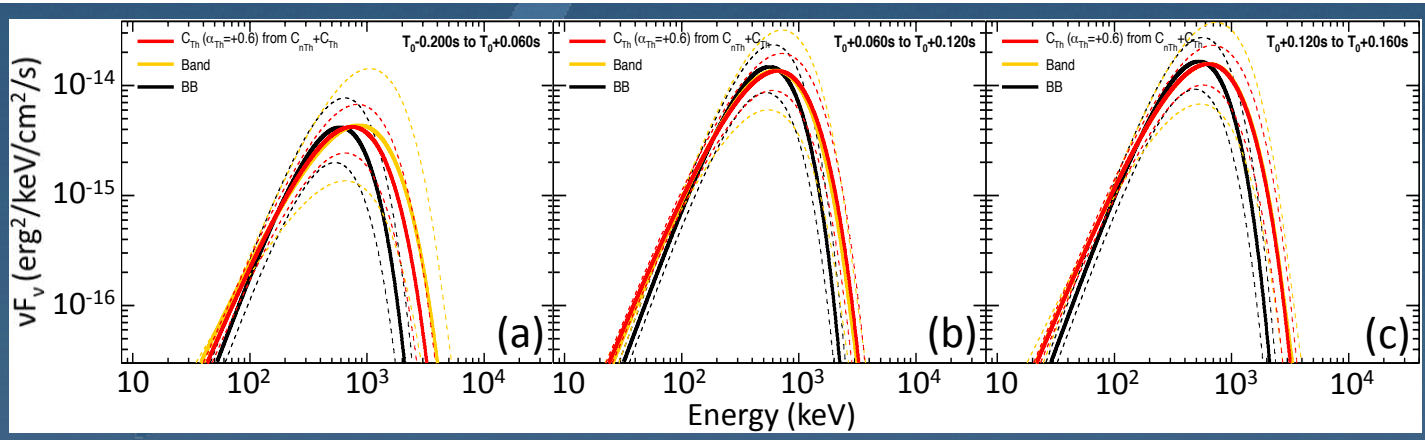


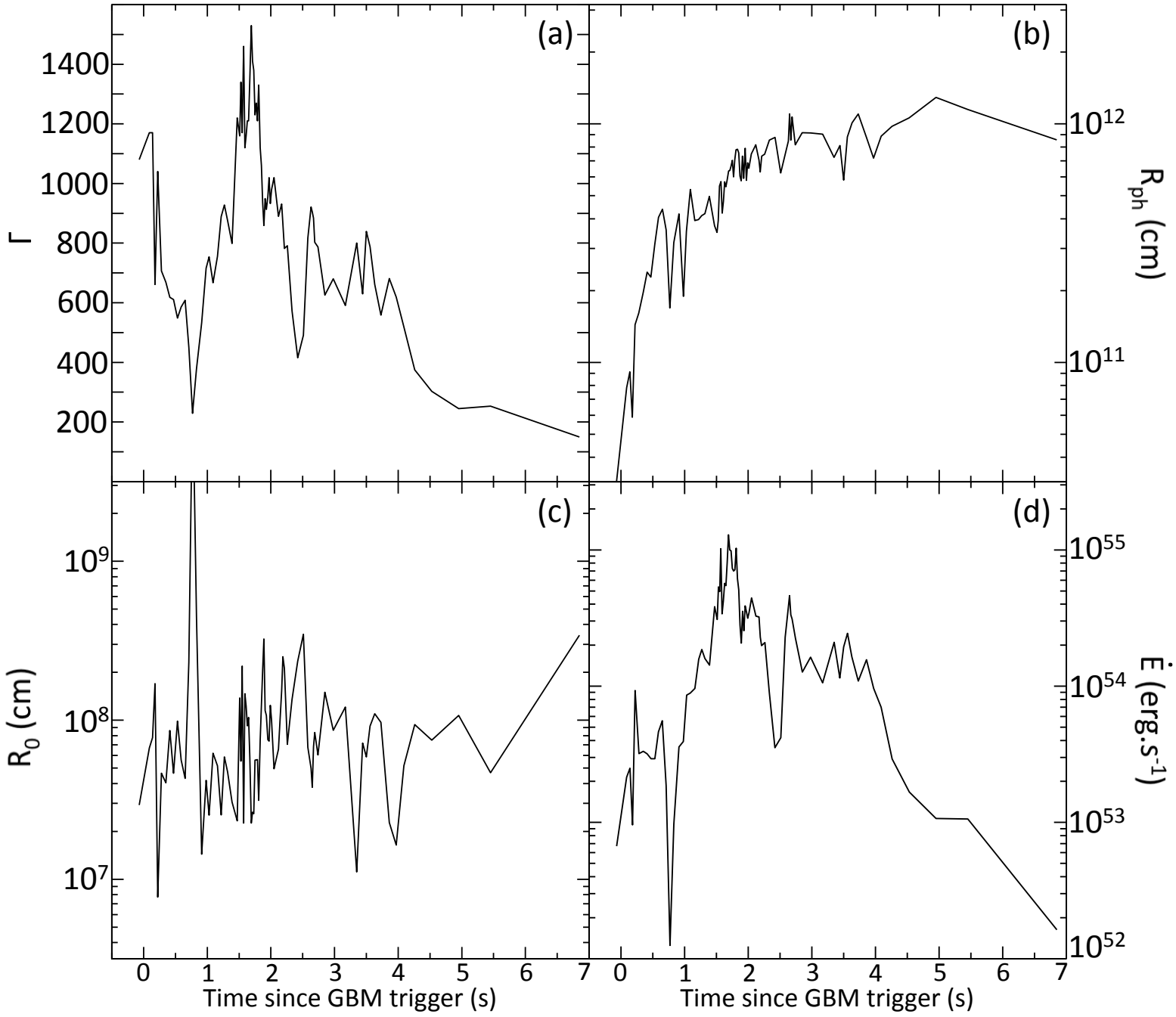
	PL	PL+BB	PL + Cutoff PL	
	χ^2/dof	χ^2/dof	χ^2/dof	index
Int1: 146-155	48/50 (0.96)	35/48 (0.74)	35/47 (0.74)	+0.69 [+0.19,+1.13]
Int2: 164-174	79/57 (1.39)	56/55 (1.02)	55/54 (1.02)	+0.58 [+0.23,+0.91]
Int3: 174-184	83/63 (1.32)	62/61 (1.01)	60/60 (1.00)	+0.51 [+0.15,+0.87]
Int4: 184-194	81/62 (1.31)	61/60 (1.02)	61/59 (1.03)	+0.52 [+0.15,+0.93]
Int5: 194-204	58/58 (1.00)	46/56 (0.83)	45/55 (0.83)	+0.54 [-0.03,+0.97]
Int6: 204-214	53/59 (0.90)	41/57 (0.72)	41/56 (0.74)	+0.56 [+0.07,+0.95]
Int7: 214-224	72/57 (1.26)	61/55 (1.10)	61/54 (1.12)	+1.14 [+0.56,+1.23]
Int8: 224-234	65/55 (1.18)	43/53 (0.81)	43/52 (0.83)	+1.10 [+0.70,+1.14]
Int9: 234-244	43/50 (0.87)	38/48 (0.80)	38/47 (0.82)	+0.80 [-0.11,+1.22]
Int10: 244-254	7/11 (0.68)	2/9 (0.20)	2/8 (0.20)	+0.51 [-0.14,+0.89]
Int12: 264-274	63/47 (1.33)	53/45 (1.19)	54/44 (1.22)	+0.74 [+0.09,+0.81]
Int13: 274-284	91/48 (1.90)	63/46 (1.37)	57/45 (1.26)	-0.31 [-0.48,-0.13]


8 to 20 keV
20 to 100 keV
100 to 600 keV
600 keV to 2 MeV
2 to 40 MeV
$C_{nTh}+C_{Th}$
C_{nTh}
C_{Th}
E^{nTh}_{peak}
E^{Th}_{peak}
(a1)
(a2)
(a3)
(a4)
(a5)
(b1)
(b2)
(b3)
(b4)
(b5)
photons.cm^{-2}.s^{-1}.keV^{-1}
E_{peak} (keV)
Time since GBM trigger (s)


T_0+0.120s to T_0+0.160s
T_0+1.880s to T_0+1.900s
T_0+3.300s to T_0+3.400s
T_0+5.200s to T_0+5.700s
Band
$C_{nTh}+C_{Th}$
(a)
(b)
(c)
(d)
vF_v (erg^2/keV/cm^2/s)
Energy (keV)

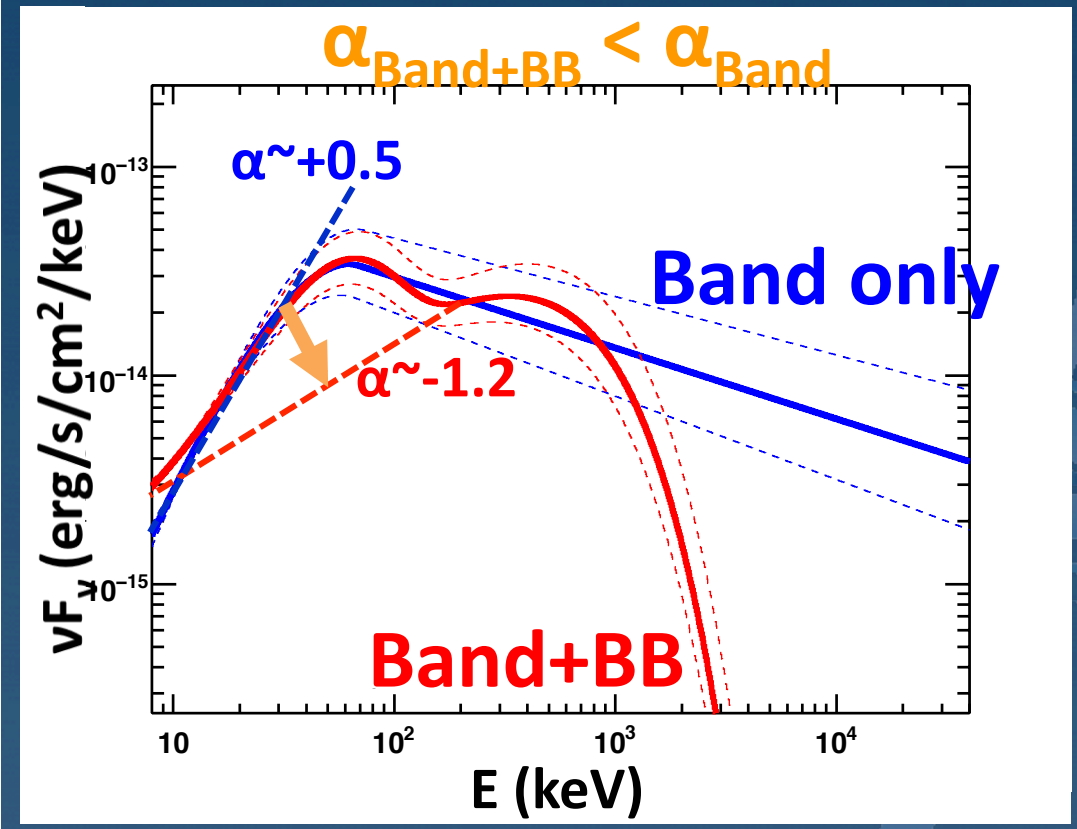

8 to 20 keV
20 to 100 keV
100 to 600 keV
600 keV to 2 MeV
2 to 40 MeV
$C_{nTh}+C_{Th}$
C_{nTh}
C_{Th}
E^{nTh}_{peak}
E^{Th}_{peak}
(a1)
(a2)
(a3)
(a4)
(a5)
(b1)
(b2)
(b3)
(b4)
(b5)
photons.cm^{-2}.s^{-1}.keV^{-1}
E_{peak} (keV)
Time since GBM trigger (s)

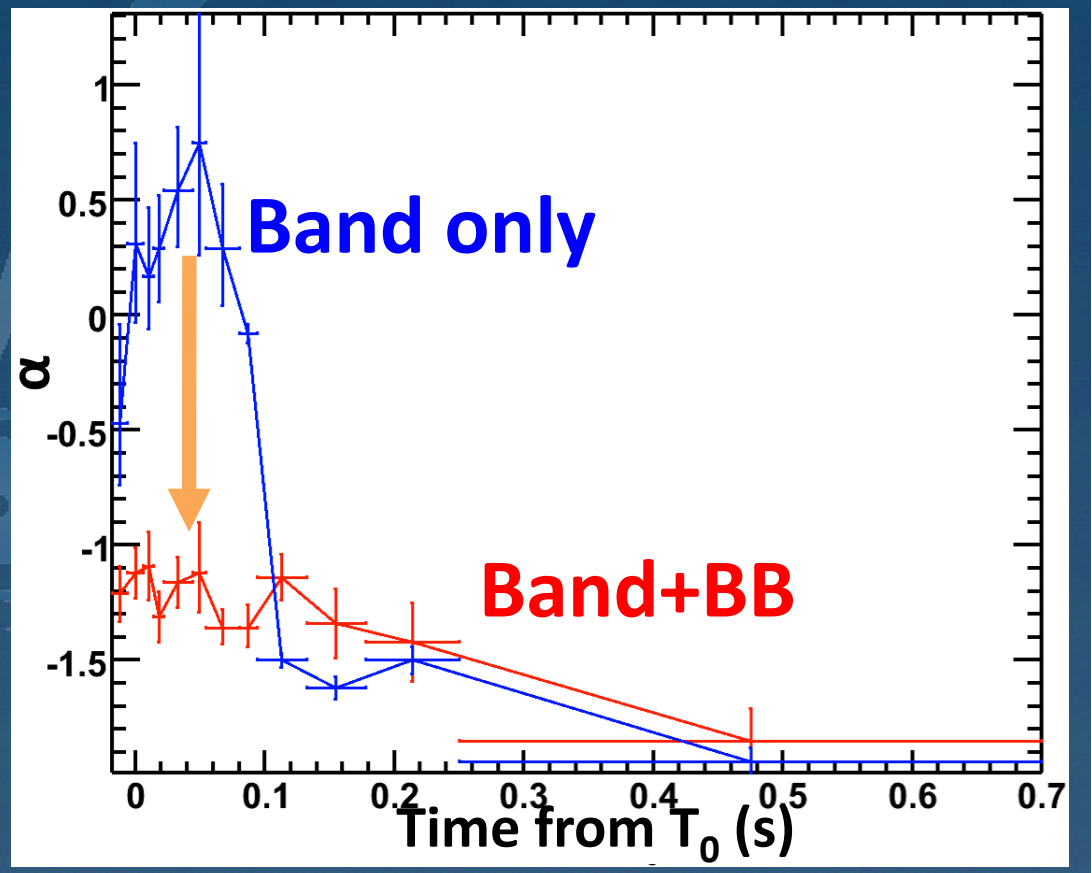

C_{Th} (α_{Th}=+0.6) from $C_{nTh}+C_{Th}$
Band
BB
T_0-0.200s to T_0+0.060s
T_0+0.060s to T_0+0.120s
T_0+0.120s to T_0+0.160s
(a)
(b)
(c)
vF_v (erg^2/keV/cm^2/s)
Energy (keV)


(a)
(b)
(c)
(d)
Γ
1400
1200
1000
800
600
400
200
R_{ph} (cm)
10^{12}
10^{11}
R_0 (cm)
10^9
10^8
10^7
$\dot{E}$ (erg.s^{-1})
10^{55}
10^{54}
10^{53}
10^{52}
0 1 2 3 4 5 6 7
Time since GBM trigger (s)
0 1 2 3 4 5 6 7
Time since GBM trigger (s)

Black Body + Band

GRB 120323A



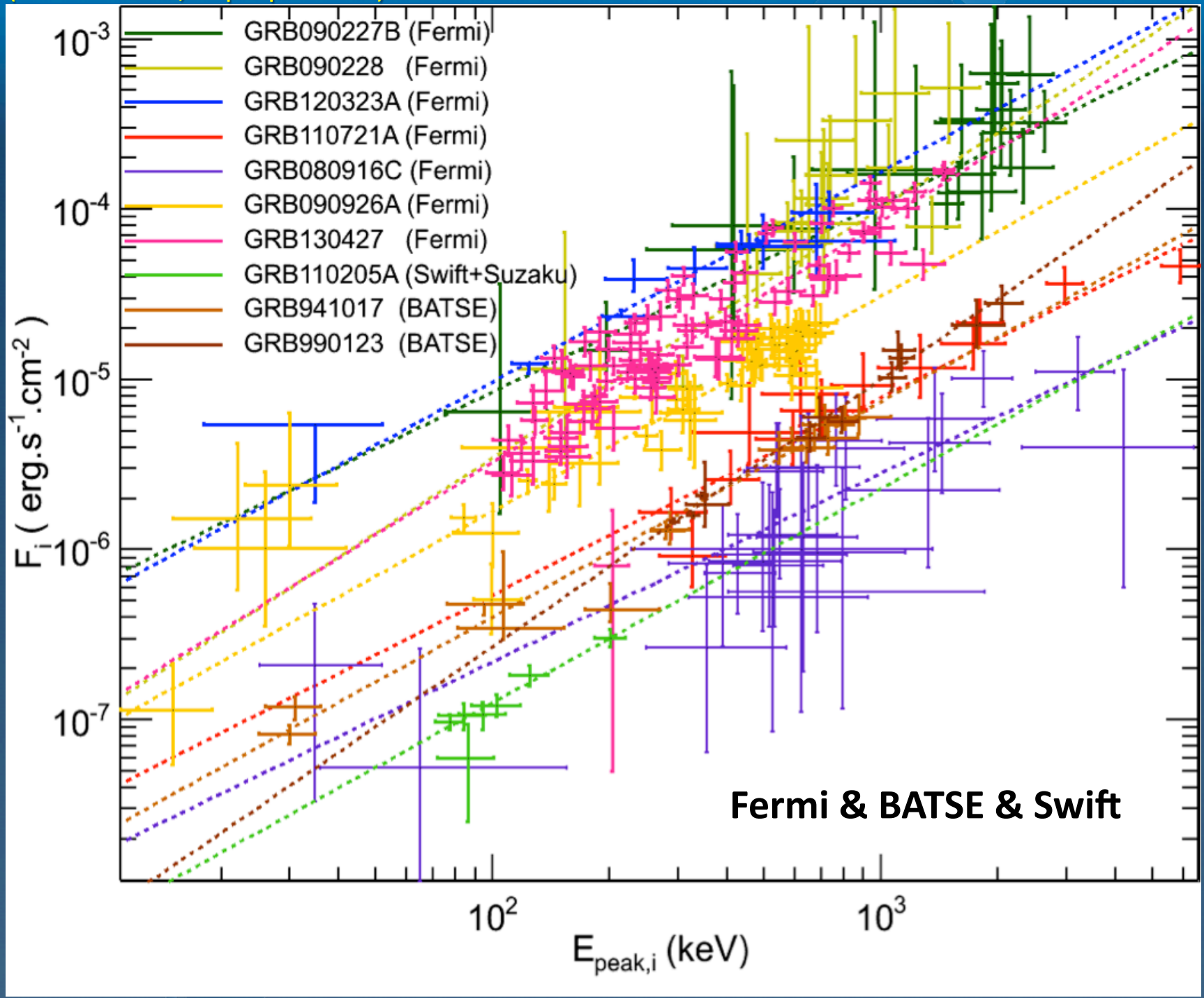


(Guiriec et al. 2013)

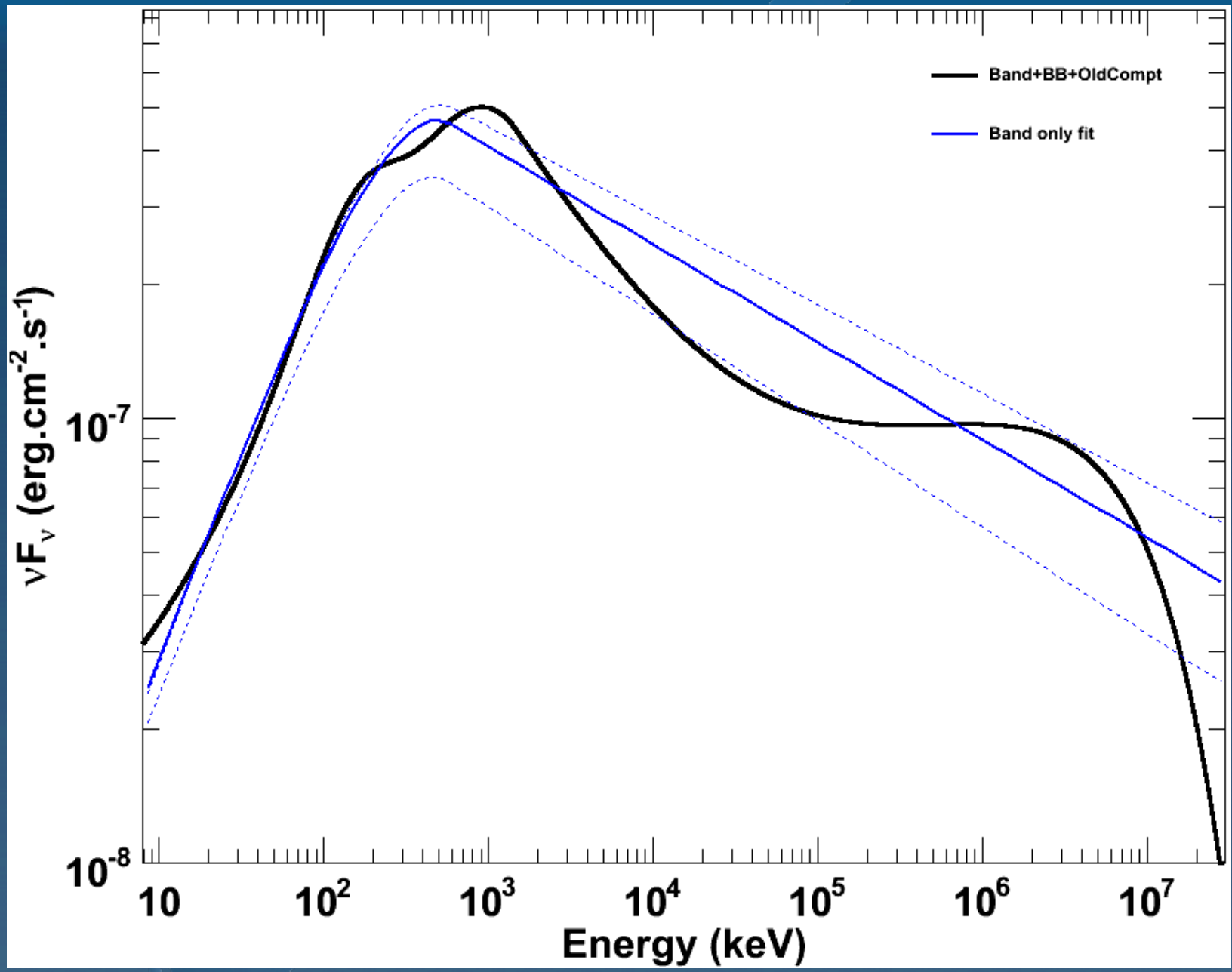
With BB, the Band function is more compatible with synchrotron emission scenarios !

The L_{Band}-E_{peak} Relation

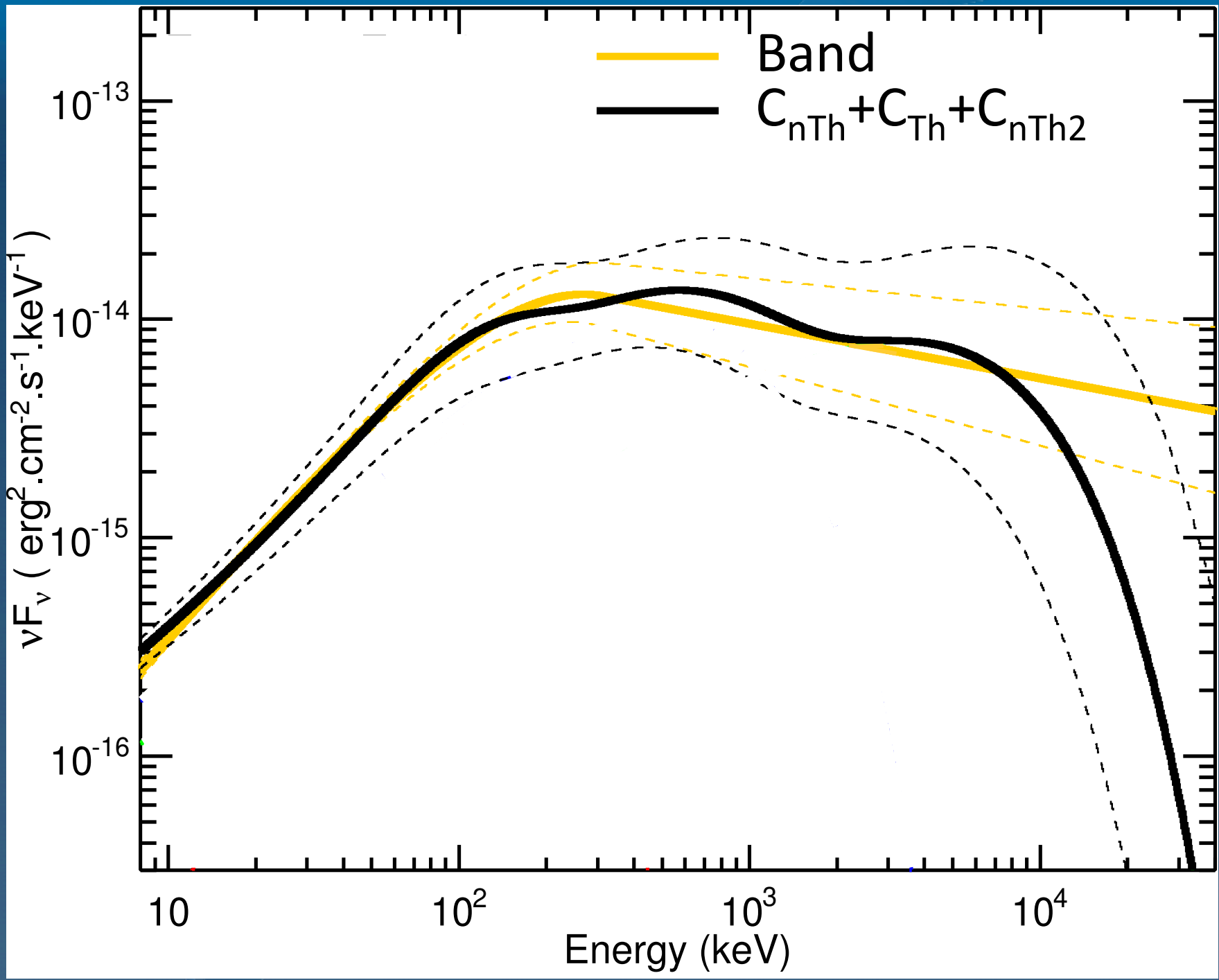
(Guiriec et al., in preparation)



GRB080916C : Band vs Band+BB+Compt



Band vs $C_{nTh}+C_{Th}+C_{nTh2}$



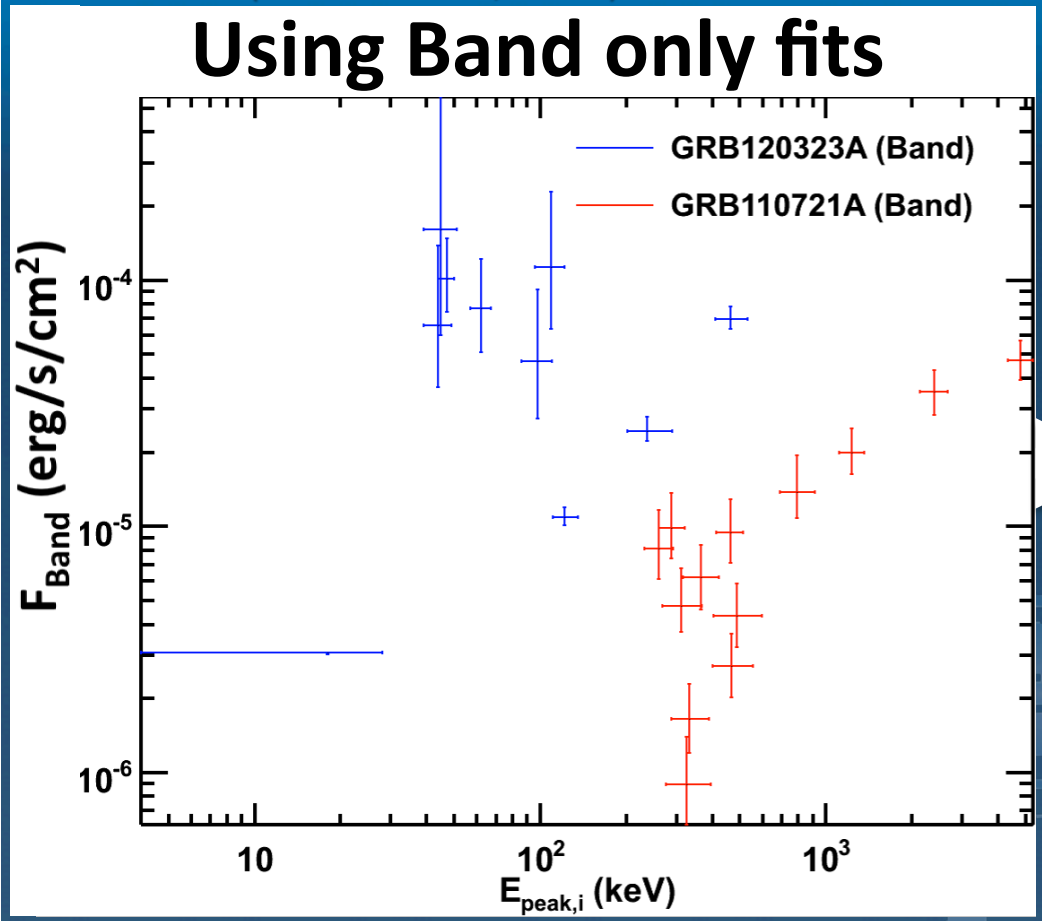
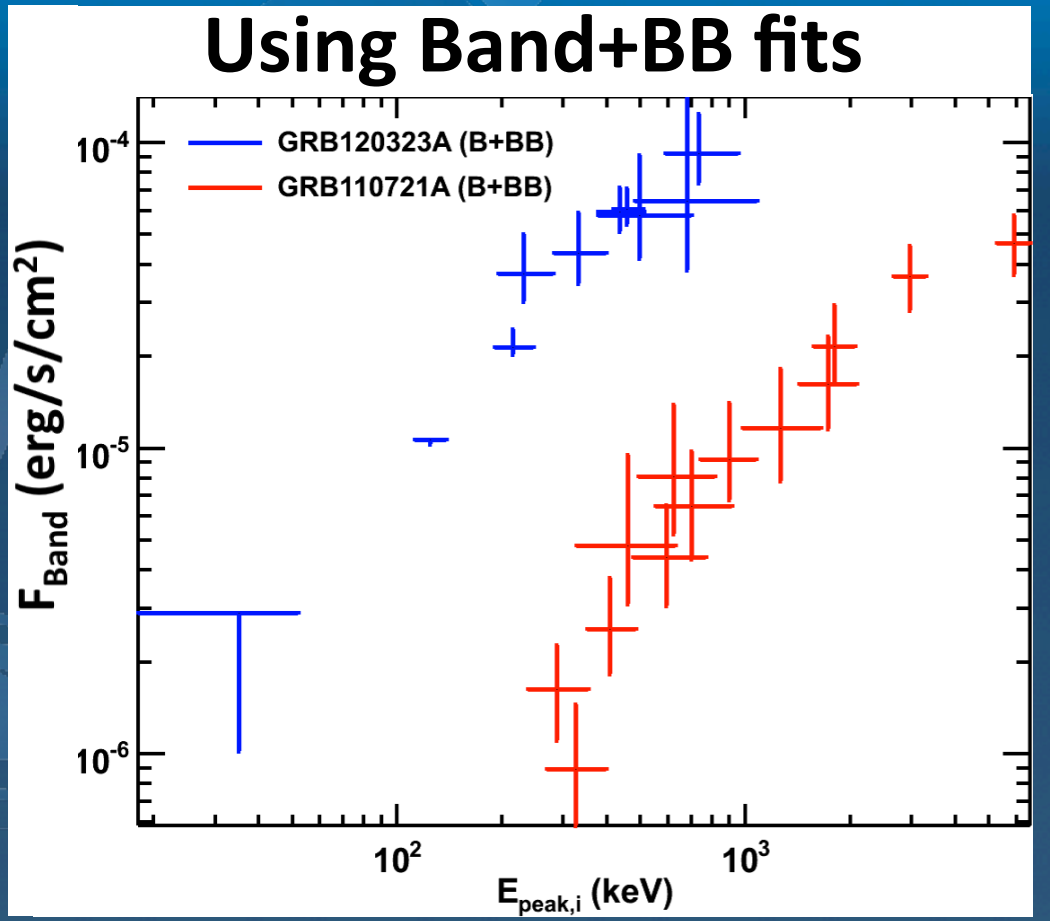
Fermi GRB 090926A

(Guiriec et al., 2010, 2011, 2013, 2015a,b,c)

The F_{Band}-E_{peak} Relation

(Guiriec et al., 2013)

Using Band only fits



Using Band+BB fits