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IAU 279 - DEATHS OF MASSIVE STARS:
SUPERNOVAE AND GRBS

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GRB 101225A -
A NEW CLASS OF GRBS?

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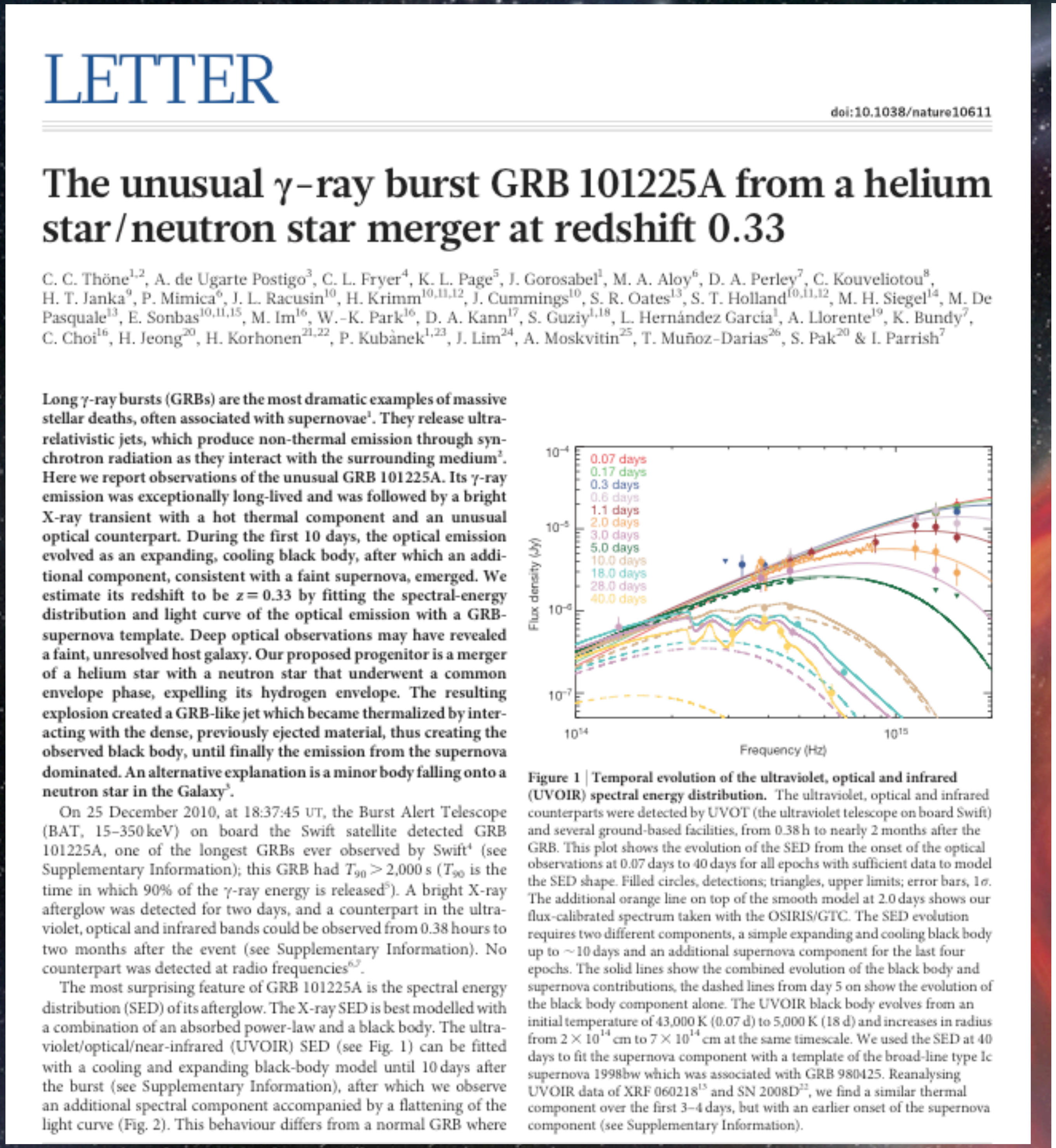
TWO LETTERS PUBLISHED IN NATURE
2 DIFFERENT EXPLANATIONS



LETTER

doi:10.1038/nature10611

The unusual γ-ray burst GRB 101225A from a helium star/neutron star merger at redshift 0.33

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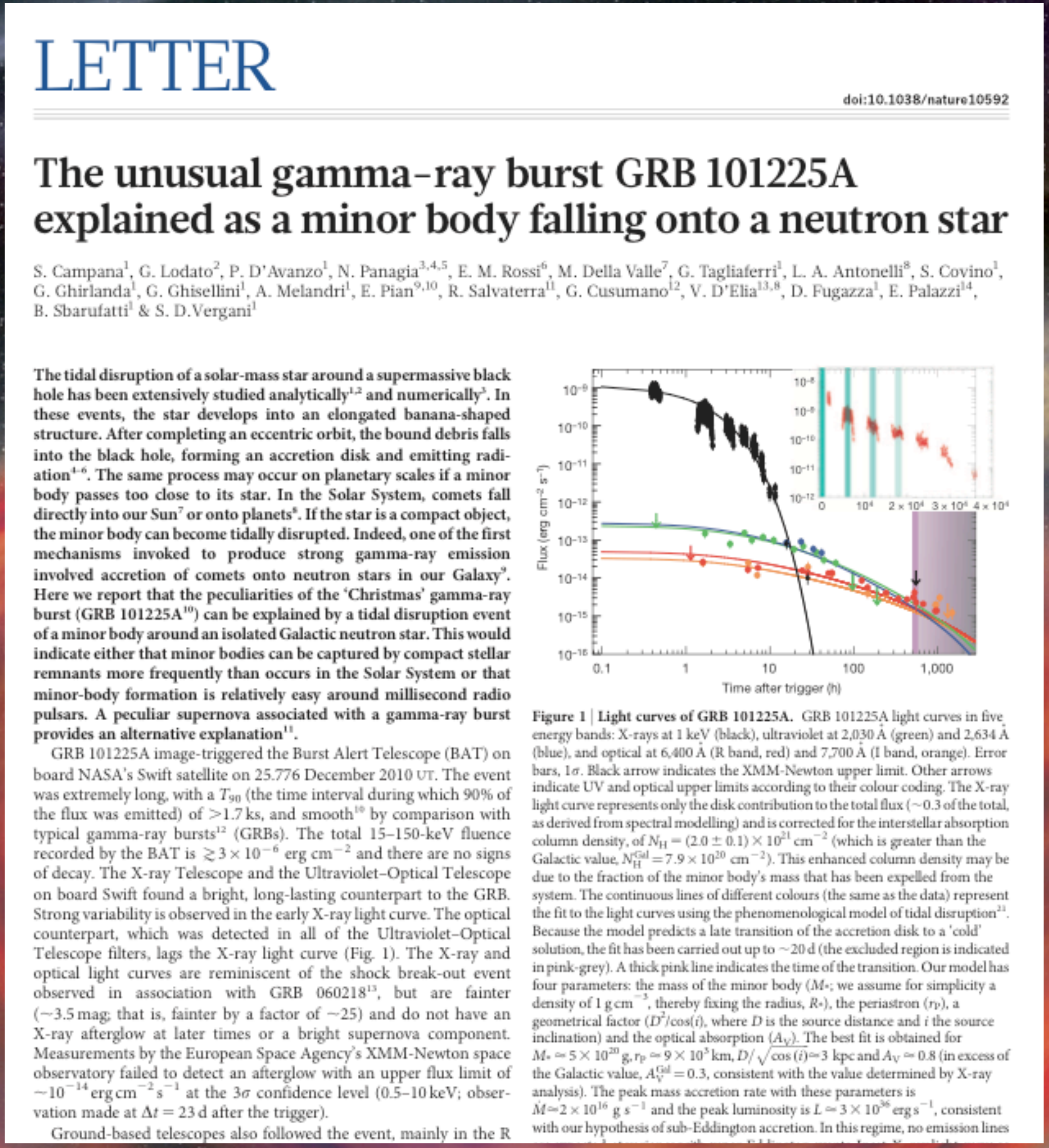
Long γ-ray bursts (GRBs) are the most dramatic examples of massive stellar deaths, often associated with supernovae[1]. They release ultra-relativistic jets, which produce non-thermal emission through synchrotron radiation as they interact with the surrounding medium[2]. Here we report observations of the unusual GRB 101225A. Its γ-ray emission was exceptionally long-lived and was followed by a bright X-ray transient with a hot thermal component and an unusual optical counterpart. During the first 10 days, the optical emission evolved as an expanding, cooling black body, after which an additional component, consistent with a faint supernova, emerged. We estimate its redshift to be $z = 0.33$ by fitting the spectral-energy distribution and light curve of the optical emission with a GRB-supernova template. Deep optical observations may have revealed a faint, unresolved host galaxy. Our proposed progenitor is a merger of a helium star with a neutron star that underwent a common envelope phase, expelling its hydrogen envelope. The resulting explosion created a GRB-like jet which became thermalized by interacting with the dense, previously ejected material, thus creating the observed black body, until finally the emission from the supernova dominated. An alternative explanation is a minor body falling onto a neutron star in the Galaxy[3].

On 25 December 2010, at 18:37:45 UT, the Burst Alert Telescope (BAT, 15–350 keV) on board the Swift satellite detected GRB 101225A, one of the longest GRBs ever observed by Swift[4] (see Supplementary Information); this GRB had $T_{90} > 2{,}000$ s (T_{90} is the time in which 90% of the γ-ray energy is released[5]). A bright X-ray afterglow was detected for two days, and a counterpart in the ultraviolet, optical and infrared bands could be observed from 0.38 hours to two months after the event (see Supplementary Information). No counterpart was detected at radio frequencies[6,7].

The most surprising feature of GRB 101225A is the spectral energy distribution (SED) of its afterglow. The X-ray SED is best modelled with a combination of an absorbed power-law and a black body. The ultraviolet/optical/near-infrared (UVOIR) SED (see Fig. 1) can be fitted with a cooling and expanding black-body model until 10 days after the burst (see Supplementary Information), after which we observe an additional spectral component accompanied by a flattening of the light curve (Fig. 2). This behaviour differs from a normal GRB where

Figure 1 | Temporal evolution of the ultraviolet, optical and infrared (UVOIR) spectral energy distribution. The ultraviolet, optical and infrared counterparts were detected by UVOT (the ultraviolet telescope on board Swift) and several ground-based facilities, from 0.38 h to nearly 2 months after the GRB. This plot shows the evolution of the SED from the onset of the optical observations at 0.07 days to 40 days for all epochs with sufficient data to model the SED shape. Filled circles, detections; triangles, upper limits; error bars, 1σ. The additional orange line on top of the smooth model at 2.0 days shows our flux-calibrated spectrum taken with the OSIRIS/GTC. The SED evolution requires two different components, a simple expanding and cooling black body up to ~10 days and an additional supernova component for the last four epochs. The solid lines show the combined evolution of the black body and supernova contributions, the dashed lines from day 5 on show the evolution of the black body component alone. The UVOIR black body evolves from an initial temperature of 43,000 K (0.07 d) to 5,000 K (18 d) and increases in radius from 2×10^{14} cm to 7×10^{14} cm at the same timescale. We used the SED at 40 days to fit the supernova component with a template of the broad-line type Ic supernova 1998bw which was associated with GRB 980425. Reanalysing UVOIR data of XRF 060218[13] and SN 2008D[22], we find a similar thermal component over the first 3–4 days, but with an earlier onset of the supernova component (see Supplementary Information).



LETTER

doi:10.1038/nature10592

The unusual gamma-ray burst GRB 101225A explained as a minor body falling onto a neutron star

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The tidal disruption of a solar-mass star around a supermassive black hole has been extensively studied analytically[1,2] and numerically[3]. In these events, the star develops into an elongated banana-shaped structure. After completing an eccentric orbit, the bound debris falls into the black hole, forming an accretion disk and emitting radiation[4–6]. The same process may occur on planetary scales if a minor body passes too close to its star. In the Solar System, comets fall directly into our Sun[7] or onto planets[8]. If the star is a compact object, the minor body can become tidally disrupted. Indeed, one of the first mechanisms invoked to produce strong gamma-ray emission involved accretion of comets onto neutron stars in our Galaxy[9]. Here we report that the peculiarities of the 'Christmas' gamma-ray burst (GRB 101225A[10]) can be explained by a tidal disruption event of a minor body around an isolated Galactic neutron star. This would indicate either that minor bodies can be captured by compact stellar remnants more frequently than occurs in the Solar System or that minor-body formation is relatively easy around millisecond radio pulsars. A peculiar supernova associated with a gamma-ray burst provides an alternative explanation[11].

GRB 101225A image-triggered the Burst Alert Telescope (BAT) on board NASA's Swift satellite on 25.776 December 2010 UT. The event was extremely long, with a T_{90} (the time interval during which 90% of the flux was emitted) of >1.7 ks, and smooth[10] by comparison with typical gamma-ray bursts[12] (GRBs). The total 15–150-keV fluence recorded by the BAT is $\gtrsim 3 \times 10^{-6}$ erg cm^{-2} and there are no signs of decay. The X-ray Telescope and the Ultraviolet–Optical Telescope on board Swift found a bright, long-lasting counterpart to the GRB. Strong variability is observed in the early X-ray light curve. The optical counterpart, which was detected in all of the Ultraviolet–Optical Telescope filters, lags the X-ray light curve (Fig. 1). The X-ray and optical light curves are reminiscent of the shock break-out event observed in association with GRB 060218[13], but are fainter (~3.5 mag; that is, fainter by a factor of ~25) and do not have an X-ray afterglow at later times or a bright supernova component. Measurements by the European Space Agency's XMM-Newton space observatory failed to detect an afterglow with an upper flux limit of ~10^{-14} erg cm^{-2} s^{-1} at the 3σ confidence level (0.5–10 keV; observation made at $\Delta t = 23$ d after the trigger).

Ground-based telescopes also followed the event, mainly in the R

Figure 1 | Light curves of GRB 101225A. GRB 101225A light curves in five energy bands: X-rays at 1 keV (black), ultraviolet at 2,030 Å (green) and 2,634 Å (blue), and optical at 6,400 Å (R band, red) and 7,700 Å (I band, orange). Error bars, 1σ. Black arrow indicates the XMM-Newton upper limit. Other arrows indicate UV and optical upper limits according to their colour coding. The X-ray light curve represents only the disk contribution to the total flux (~0.3 of the total, as derived from spectral modelling) and is corrected for the interstellar absorption column density, of $N_H = (2.0 \pm 0.1) \times 10^{21}$ cm^{-2} (which is greater than the Galactic value, $N_H^{Gal} = 7.9 \times 10^{20}$ cm^{-2}). This enhanced column density may be due to the fraction of the minor body's mass that has been expelled from the system. The continuous lines of different colours (the same as the data) represent the fit to the light curves using the phenomenological model of tidal disruption[21]. Because the model predicts a late transition of the accretion disk to a 'cold' solution, the fit has been carried out up to ~20 d (the excluded region is indicated in pink-grey). A thick pink line indicates the time of the transition. Our model has four parameters: the mass of the minor body (M_*; we assume for simplicity a density of 1 g cm^{-3}, thereby fixing the radius, R_*), the periastron (r_p), a geometrical factor ($D^2/\cos(i)$, where D is the source distance and i the source inclination) and the optical absorption (A_V). The best fit is obtained for $M_* \simeq 5 \times 10^{20}$ g, $r_p \simeq 9 \times 10^3$ km, $D/\sqrt{\cos(i)} \simeq 3$ kpc and $A_V \simeq 0.8$ (in excess of the Galactic value, $A_V^{Gal} = 0.3$, consistent with the value determined by X-ray analysis). The peak mass accretion rate with these parameters is $\dot{M} \simeq 2 \times 10^{16}$ g s^{-1} and the peak luminosity is $L \simeq 3 \times 10^{36}$ erg s^{-1}, consistent with our hypothesis of sub-Eddington accretion. In this regime, no emission lines

30 LA GACETA

Jueves, 1 de diciembre de 2011

Sociedad_Ciencia

Científicos españoles descubren una novedosa muerte estelar

“Es una de las imágenes más profundas hechas desde la Tierra”

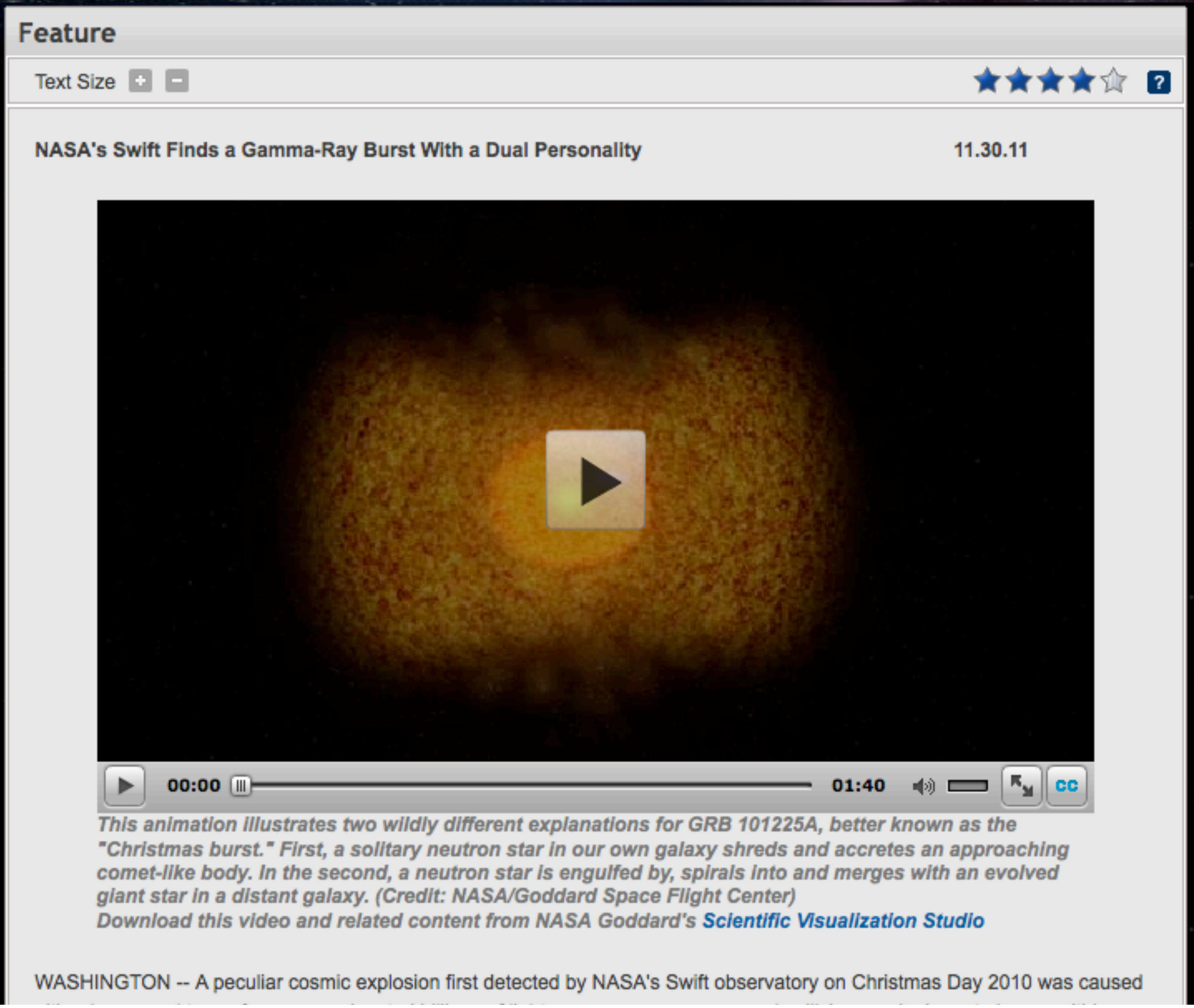
Fusión de la estrella gigante y la de neutrones. / 'Nature'

Amparo Ledo. Madrid

El día de Navidad de 2010 se produjo un estallido de rayos gamma que rompía los patrones existentes. Además de una duración muy superior a la media, la explosión mostró un resplandor posterior de origen térmico inédito hasta el momento. Las estrellas habían encontrado una nueva forma de morir o, al menos, hasta ese día nunca se había observado.

El fenómeno, que obliga a añadir un nuevo escenario a los dos existentes para explicar las explosiones de rayos gamma –el tipo de luz más energético conocido–, se publica hoy en *Nature* en un artículo liderado por Cristina Thöne y Antonio de Ugarte, del Instituto de Astrofísica de Andalucía. El primer estudio basado en datos del Gran Telescopio de Canarias (La Palma) del que se hace eco la prestigiosa revista.

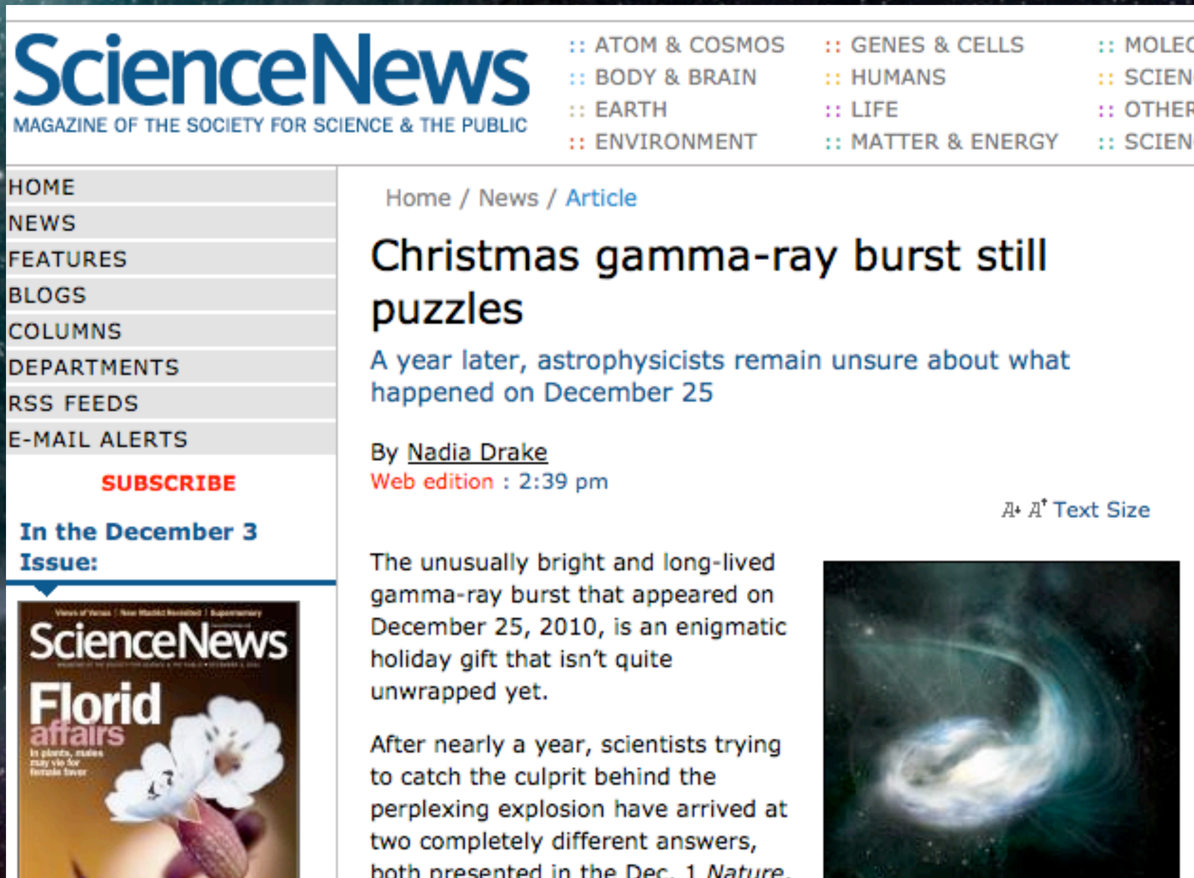
Ambos investigadores, que estudian las muertes estelares más violentas que se producen en el Universo, apuntan que “este descubrimiento presenta un tipo de evento predicho pero nunca observado con anterioridad. Revela cómo los grandes telescopios actuales son capaces de mostrar fenómenos en el Universo que antes sólo



NASA's Swift Finds a Gamma-Ray Burst With a Dual Personality 11.30.11

This animation illustrates two wildly different explanations for GRB 101225A, better known as the "Christmas burst." First, a solitary neutron star in our own galaxy shreds and accretes an approaching comet-like body. In the second, a neutron star is engulfed by, spirals into and merges with an evolved giant star in a distant galaxy. (Credit: NASA/Goddard Space Flight Center)
Download this video and related content from NASA Goddard's Scientific Visualization Studio

WASHINGTON -- A peculiar cosmic explosion first detected by NASA's Swift observatory on Christmas Day 2010 was caused



Christmas gamma-ray burst still puzzles

A year later, astrophysicists remain unsure about what happened on December 25

By Nadia Drake
Web edition : 2:39 pm

The unusually bright and long-lived gamma-ray burst that appeared on December 25, 2010, is an enigmatic holiday gift that isn't quite unwrapped yet.

After nearly a year, scientists trying to catch the culprit behind the perplexing explosion have arrived at two completely different answers, both presented in the Dec. 1 *Nature*

ASTROnews | 01.12.2011

HOCHENERGIE-ASTROPHYSIK

"Weihnachts-Gammablitz" noch längst nicht enträtselt

Weihnachten 2010 entdeckten Astronomen am Nachthimmel einen ungewöhnlichen Lichtblitz. Zwar erinnerte dieser an einen Gammastrahlenausbruch, doch seine Eigenschaften passen zu keiner gängigen Theorie für solche Explosionen. Nun versuchen sich gleich zwei Forschergruppen darin, die Beobachtungen mit alternativen Modellen zu erklären. Demnach könnte die Ursache in einer Kombination aus Gammablitz und Supernova liegen oder aber in einem kleinen Himmelskörper, der auf einen Neutronenstern stürzte.

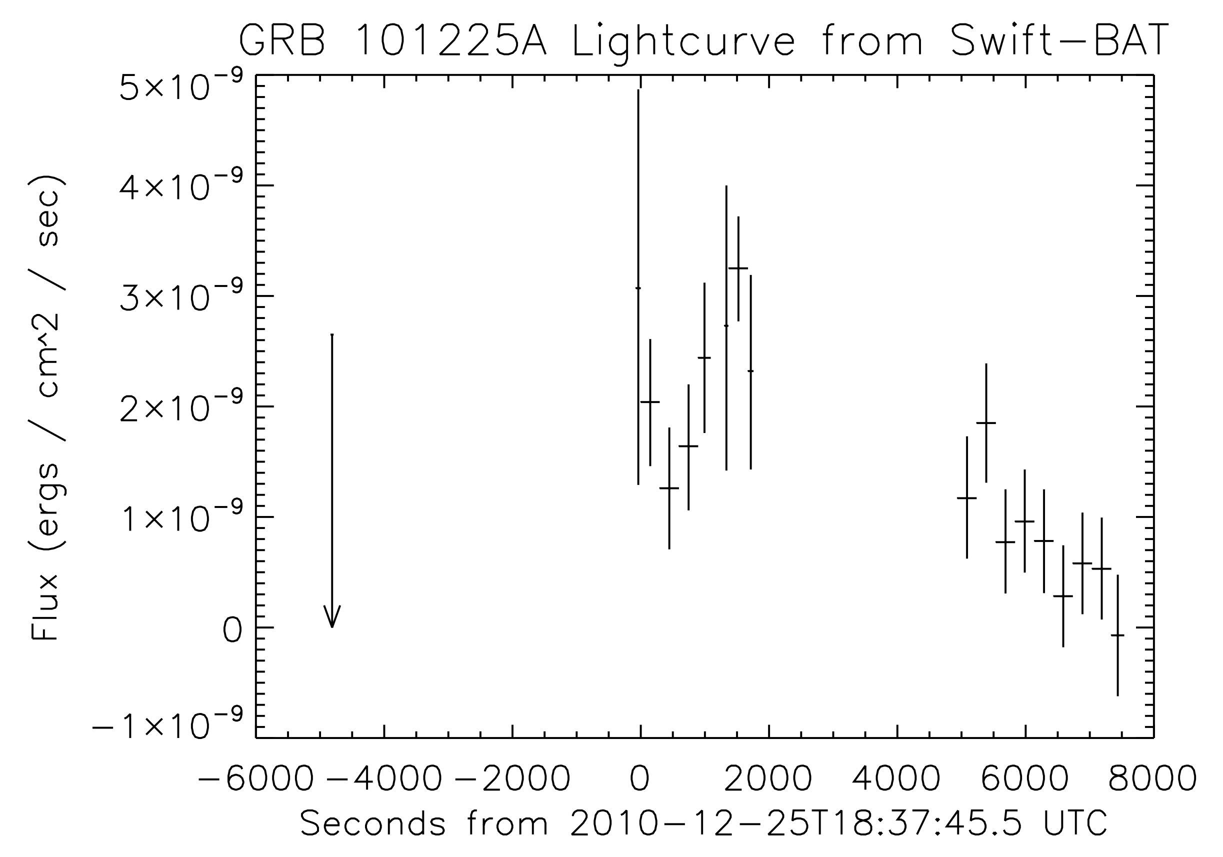
Neutronenstern zerreißt kleinen

Der Gammastrahlenausbruch GRB 101225A dauerte mindestens eine halbe Stunde, während bei gewöhnlichen Ereignissen maximal wenige Minuten vergehen. Zudem verblasste das Nachglühen viel schneller als bei anderen Gammablitzen und wies überdies ein von der Norm abweichendes Energiespektrum auf. Um diese Eigenarten zu erklären, wärmten Sergio Campana vom Osservatorio Astronomico di Brera in Merate, Italien, und Kollegen ein bereits im Jahr 1973 vorgeschlagenes Szenario auf.

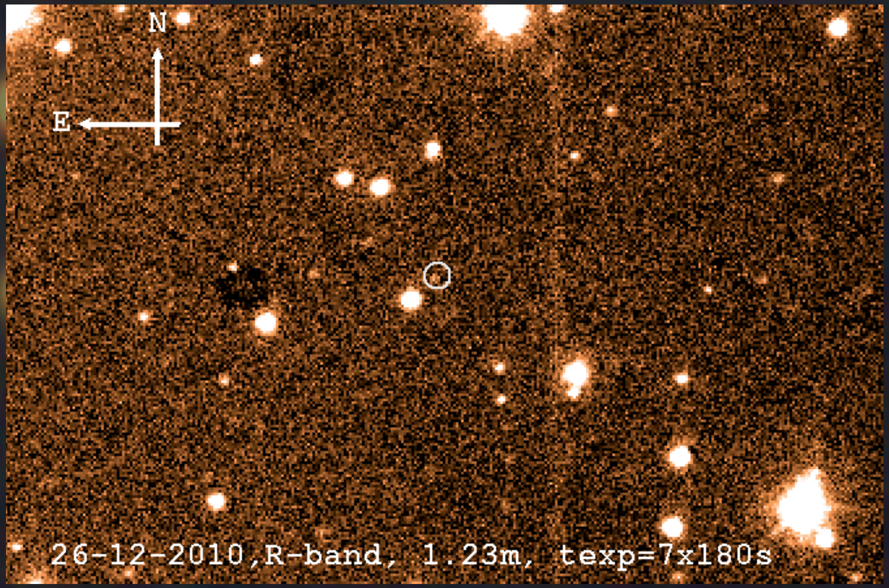
Ein Komet oder Asteroid nähert sich darin einem alleinstehenden Neutronenstern auf weniger als 5000 Kilometer, worauf ihn die auftretenden Gezeitenkräfte zerrissen. Ein Teil der Trümmer fiel auf die Oberfläche des Sterns, was zu dem beobachteten

2010, DEC. 25
18:37 UT

- Swift image trigger
- very long $T_{90} > 2000$s (probably emission up to 9d)
- XRT observations at 1400s brightest X-ray counterpart of any Swift GRB at several 1000 s
- optical counterpart at 1.5h from the NOT (Xu et al.)
- no radio afterglow (Zauderer et al, Frail et al.)



First OT image from CAHA



A STRANGE AFTERGLOW

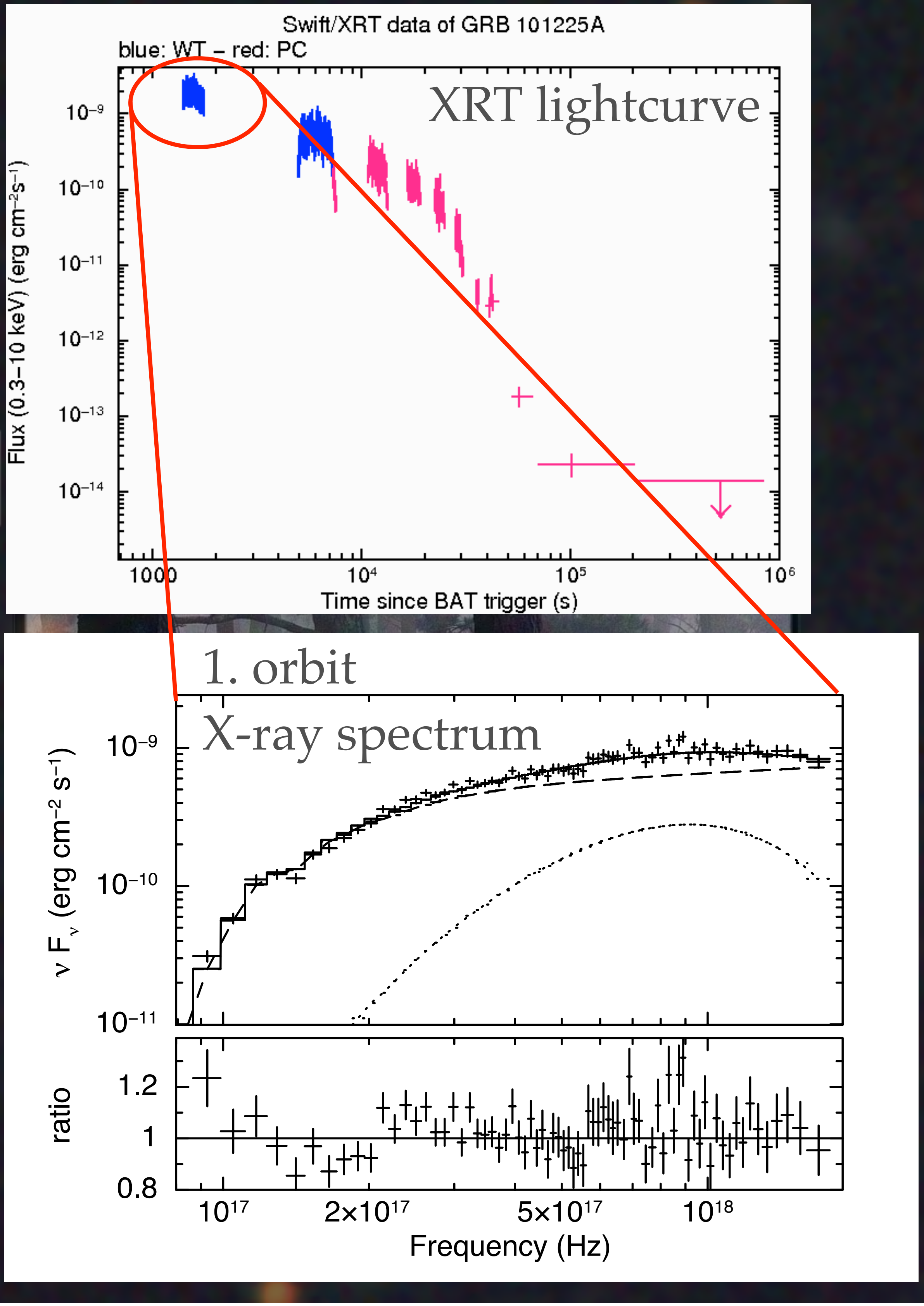
- **X-rays:**
  - PL + BB best fit

    20% BB - contribution

    T ~1 keV

    (other models possible though...)
  - steep decline: $t^{-5.95}$

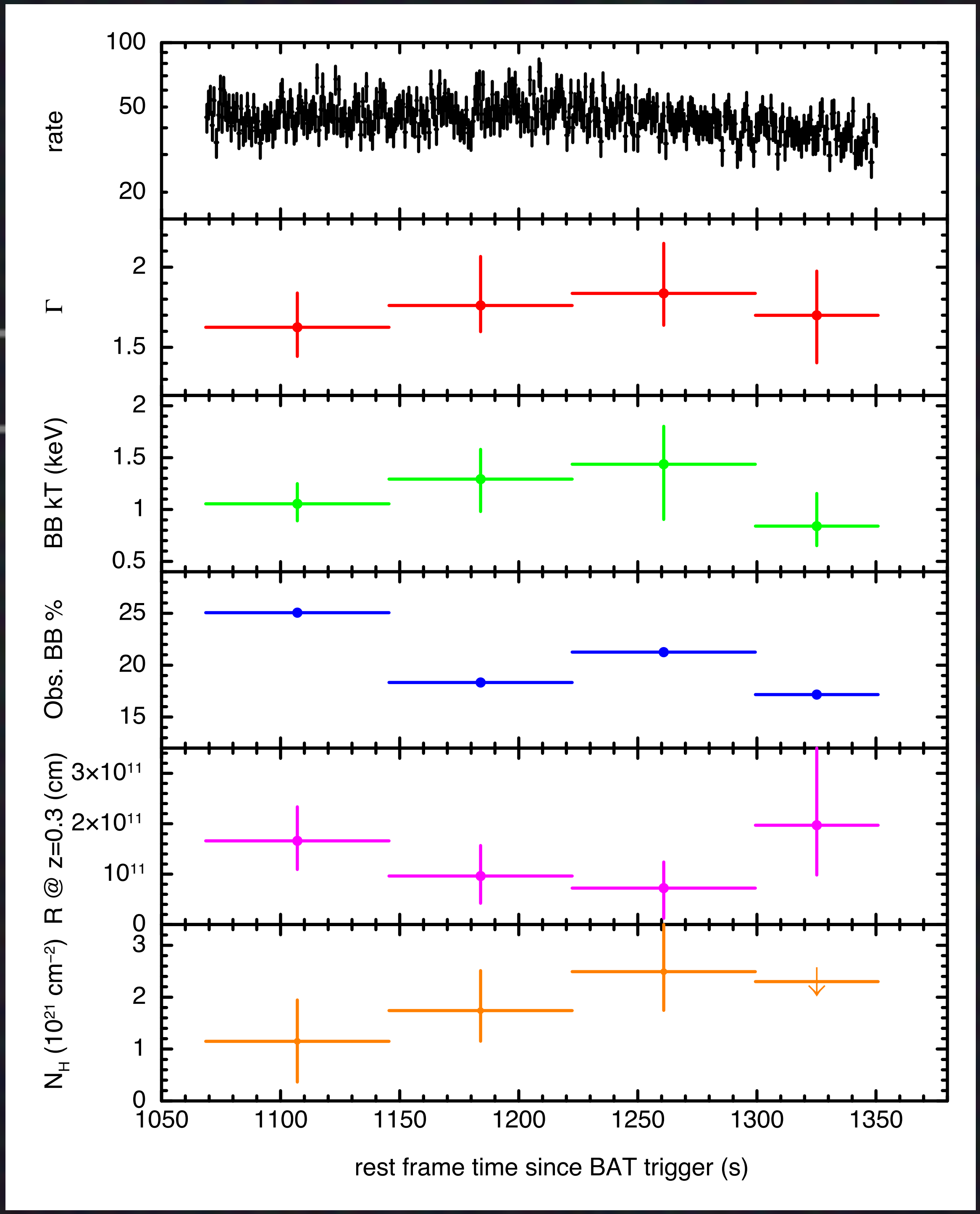
    --> no synchrotron
  - no periodicity (?)

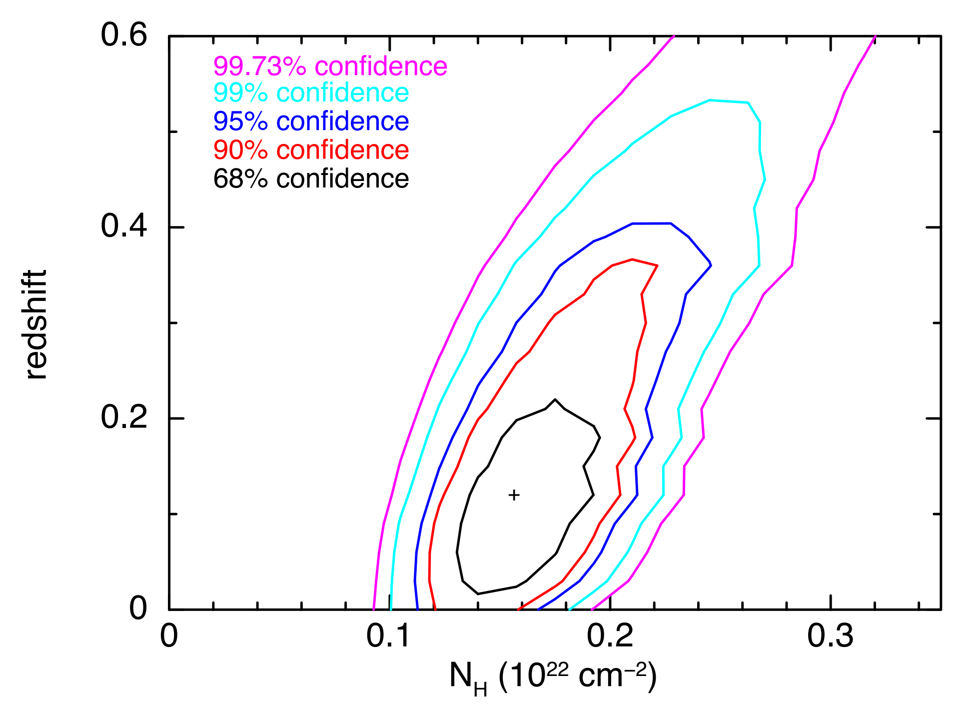


A STRANGE AFTERGLOW

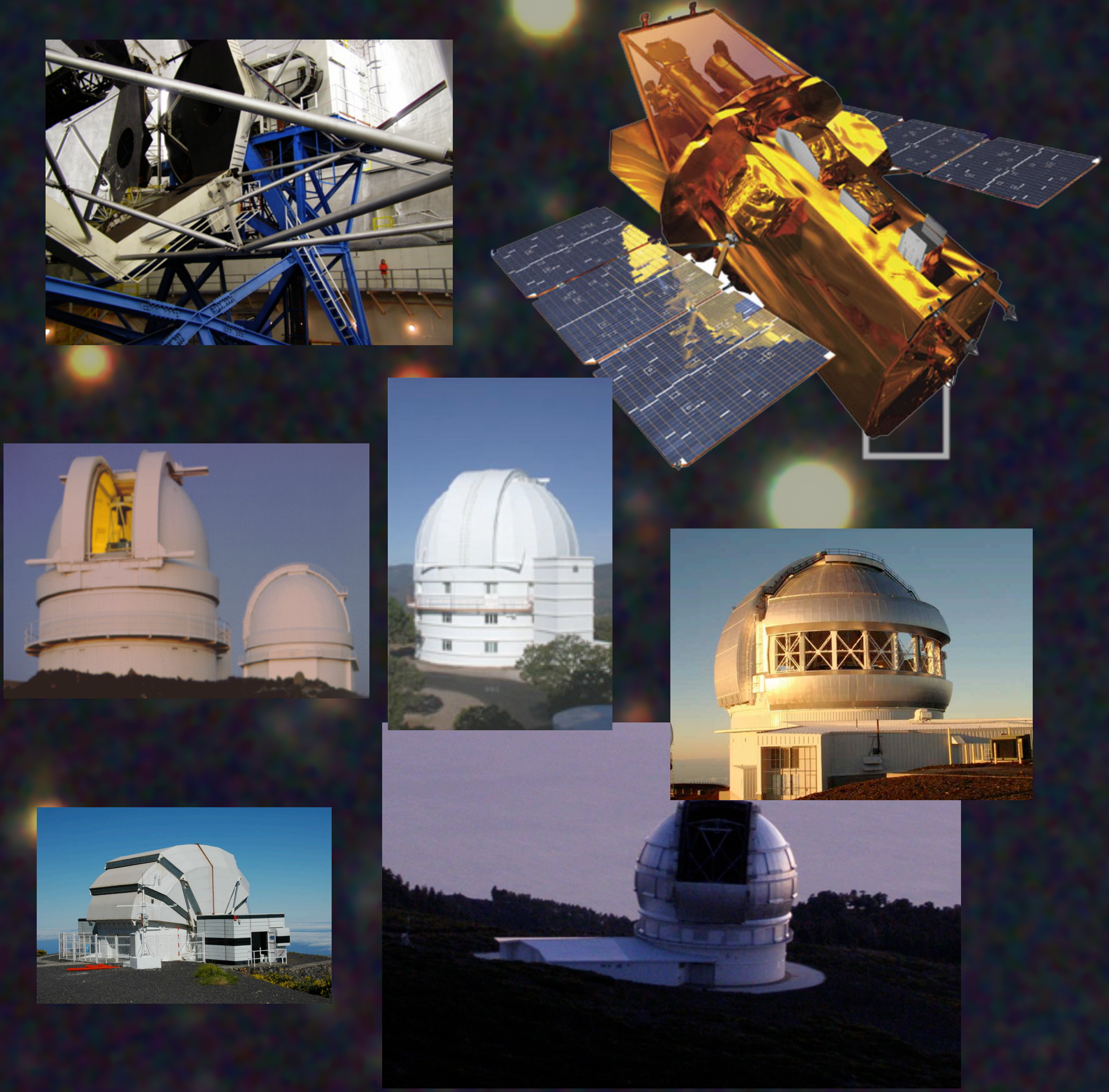
- **X-rays:**
  - PL + BB best fit
    T ~1 keV
  - steep decline: $t^{-5.95}$
    --> no synchrotron
  - no periodicity (?)
  - redshift <0.5

1. orbit analysis





LARGE OBSERVING CAMPAIGN IN UV, OPTICAL, IR



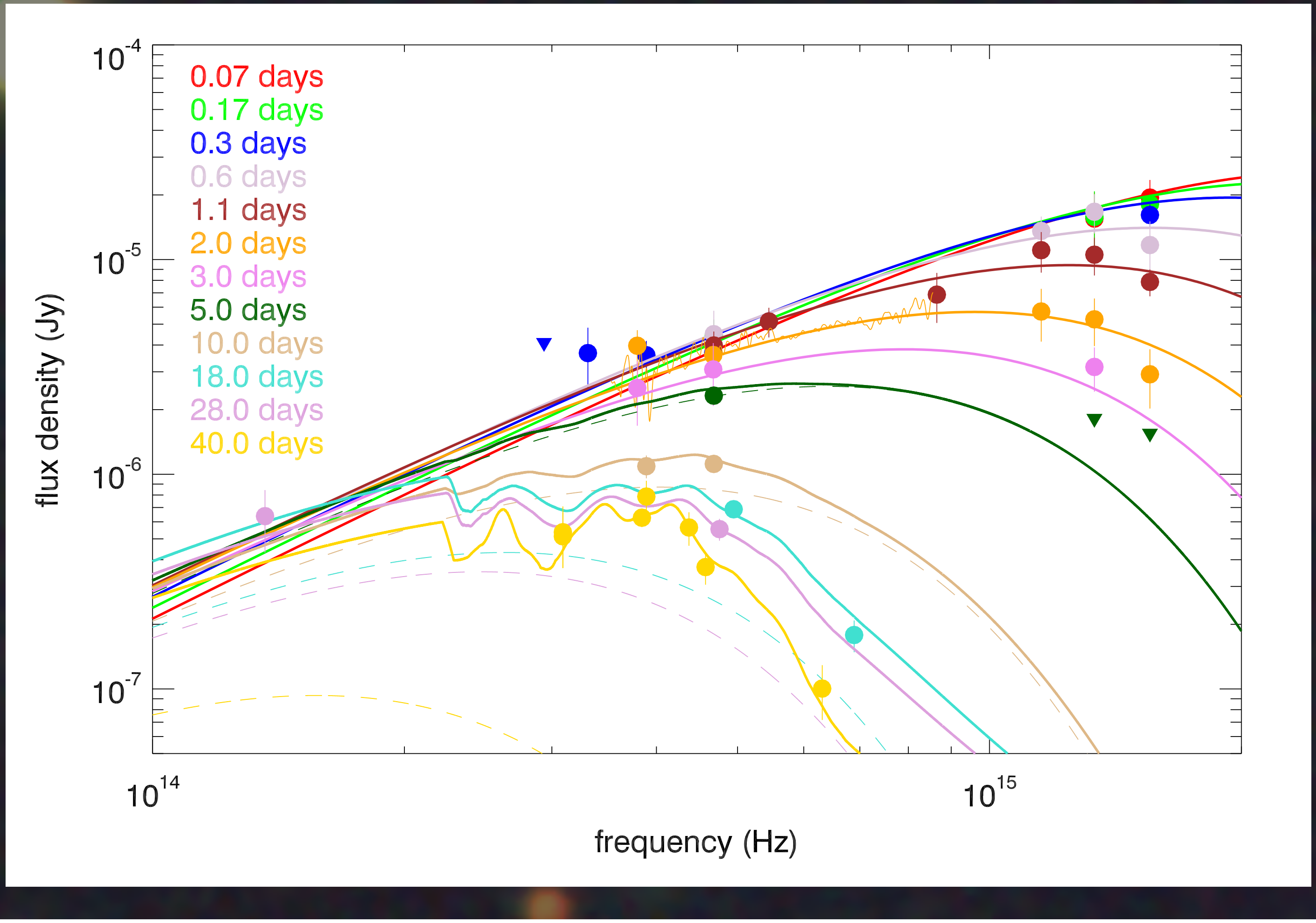
Mid t-t$_0$ (days)	Exposure (s)	Filter	Telescope	Mag$_{AB}$	Flux (μJy)
Premaging	3×500	g'	3.5mCFHT	>26.9 (27.2±0.5)	<0.06 (0.048±0.22)
Premaging	3×500	i'	3.5mCFHT	>25.5	<0.22
0.01848	168	$w2$	UVOT	>21.36	< 10.38
0.07041	1431	$w2$	UVOT	21.56± 0.20	8.65± 1.80
0.17373	6719	$w2$	UVOT	21.63± 0.11	8.06± 0.88
0.30739	6679	$w2$	UVOT	21.76± 0.12	7.19± 0.85
0.45280	5805	$w2$	UVOT	21.96± 0.15	5.96± 0.91
0.81302	12039	$w2$	UVOT	22.57± 0.17	3.42± 0.58
1.00869	11753	$w2$	UVOT	22.37± 0.16	4.08± 0.67
1.41736	23440	$w2$	UVOT	22.61± 0.20	3.27± 0.66
1.75211	23368	$w2$	UVOT	23.45± 0.30	1.51± 0.49
2.44862	74516	$w2$	UVOT	>23.73	< 1.17
4.07964	138747	$w2$	UVOT	>24.20	< 0.76
7.52954	377712	$w2$	UVOT	>25.39	< 0.25
0.01818	319	$m2$	UVOT	>20.81	< 17.14
0.07515	1431	$m2$	UVOT	21.97± 0.31	5.89± 1.94
0.61452	899	$m2$	UVOT	21.90± 0.21	6.34± 1.33
0.95369	12104	$m2$	UVOT	22.00± 0.15	5.74± 0.83
1.18487	18396	$m2$	UVOT	22.47± 0.23	3.74± 0.87
1.48860	23468	$m2$	UVOT	22.46± 0.19	3.76± 0.73
1.85629	29528	$m2$	UVOT	22.97± 0.22	2.35± 0.53
2.51507	40973	$m2$	UVOT	23.34± 0.30	1.68± 0.53
4.08285	138701	$m2$	UVOT	>24.25	< 0.73
0.01846	318	$w1$	UVOT	>21.15	< 12.64
0.07752	1431	$w1$	UVOT	>22.10	< 5.26
0.65205	5571	$w1$	UVOT	21.81± 0.17	6.88± 1.15
0.96984	16520	$w1$	UVOT	21.72± 0.16	7.46± 1.19
1.37145	18904	$w1$	UVOT	22.23± 0.26	4.65± 1.25
1.71425	29052	$w1$	UVOT	22.46± 0.25	3.76± 0.97
2.44380	74329	$w1$	UVOT	>22.97	< 2.36
4.07673	138760	$w1$	UVOT	>23.22	< 1.86
0.01789	169	u	UVOT	>20.46	< 23.68
0.07228	2579	u	UVOT	21.59± 0.28	8.42± 2.47
1.28374	103571	u	UVOT	22.33± 0.26	4.24± 1.14
2.44533	74215	u	UVOT	>21.82	< 6.80
4.07781	138647	u	UVOT	>22.06	< 5.46
0.01817	169	b	UVOT	>19.94	< 38.37
0.06802	1430	b	UVOT	>20.86	< 16.51
0.16319	6726	b	UVOT	21.53± 0.30	8.83± 2.86
0.30647	8349	b	UVOT	>21.83	< 6.76
1.14624	127458	b	UVOT	>22.19	< 4.85
2.44615	74224	b	UVOT	>21.00	< 14.47
4.07834	138632	b	UVOT	>21.33	< 10.64
0.01789	318	v	UVOT	>19.35	< 66.30
0.07278	1431	v	UVOT	>20.36	< 26.12
0.18317	6538	v	UVOT	>21.04	< 13.96
0.31290	5819	v	UVOT	>20.69	< 19.20
1.11739	21×180	V	1.23mCAHA	22.47±0.19	3.73±0.65
1.18728	121098	v	UVOT	>21.08	< 13.39
2.45087	74279	v	UVOT	>20.50	< 22.93
4.08128	138537	v	UVOT	>20.92	< 15.56
39.11207	6×180	g'	OSIRIS/10.4mGTC	> 26.3	< 0.11
39.49403	5×180	g'	GMOS/8mGemini	26.80±0.35	0.07±0.03
∼180	42×200	g'	OSIRIS/10.4mGTC	27.21±0.27	0.047±0.010
1.04545	19×180	R	1.23mCAHA	22.61±0.16	3.28±0.48
0.29887	3×300	r'	CQUEAN/2.1mMcD	22.43±0.14	3.87±0.50
2.08833	1×30	r'	OSIRIS/10.4mGTC	23.39±0.12	1.60±0.18
21.15017	10×60	r'	OSIRIS/10.4mGTC	24.21±0.14	0.75±0.10
28.49818	5×180	r'	GMOS/8mGemini	24.81±0.13	0.43±0.05
39.10159	4×120	r'	OSIRIS/10.4mGTC	24.77±0.13	0.45±0.05
39.47981	5×180	r'	GMOS/8mGemini	25.24±0.15	0.29±0.04
44.08258	4×180	r'	OSIRIS/10.4mGTC	> 24.7	< 0.48
∼180	32×200	r'	OSIRIS/10.4mGTC	26.90±0.14	0.063±0.008
1.17359	17×180	I	1.23mCAHA	22.18±0.35	4.88±1.57
61.96267	20×120	I	SCORPIO/6mBTA	25.17±0.35	0.31±0.10
0.29516	3×300	i'	CQUEAN/2.1mMcD	22.72±0.18	2.96±0.49
10.09449	9×900	i'	RAT/2.0mLT	24.01±0.13	0.90±0.11
39.12164	5×60	i'	OSIRIS/10.4mGTC	24.36±0.17	0.65±0.11
39.46336	5×180	i'	GMOS/8mGemini	24.61±0.09	0.52±0.04
0.30384	3×300	z'	CQUEAN/2.1mMcD	22.65±0.34	3.16±1.00
39.09432	6×60	z'	OSIRIS/10.4mGTC	24.73±0.42	0.47±0.18
39.44619	7×180	z'	GMOS/8mGemini	24.77±0.25	0.45±0.10
0.30745	3×300	Y	CQUEAN/2.1mMcD	> 22.5	< 3.63
37.45092	32×60	J	NIRI/8mGemini	> 23.4	< 1.58
28.46873	44×60	K_S	NIRI/8mGemini	24.48±0.35	0.59±0.19

Thanks to A. de Ugarte Postigo!

A STRANGE AFTERGLOW

- **X-rays:** PL + BB, steep decline
  redshift <0.5

- **UVOIR afterglow SED:**
  - very blue color in the beginning
  - color changes (sign of PL-slope changed the first days)
    uuh?!?
  - modelled with expanding+cooling BB
  (not a GRB??)

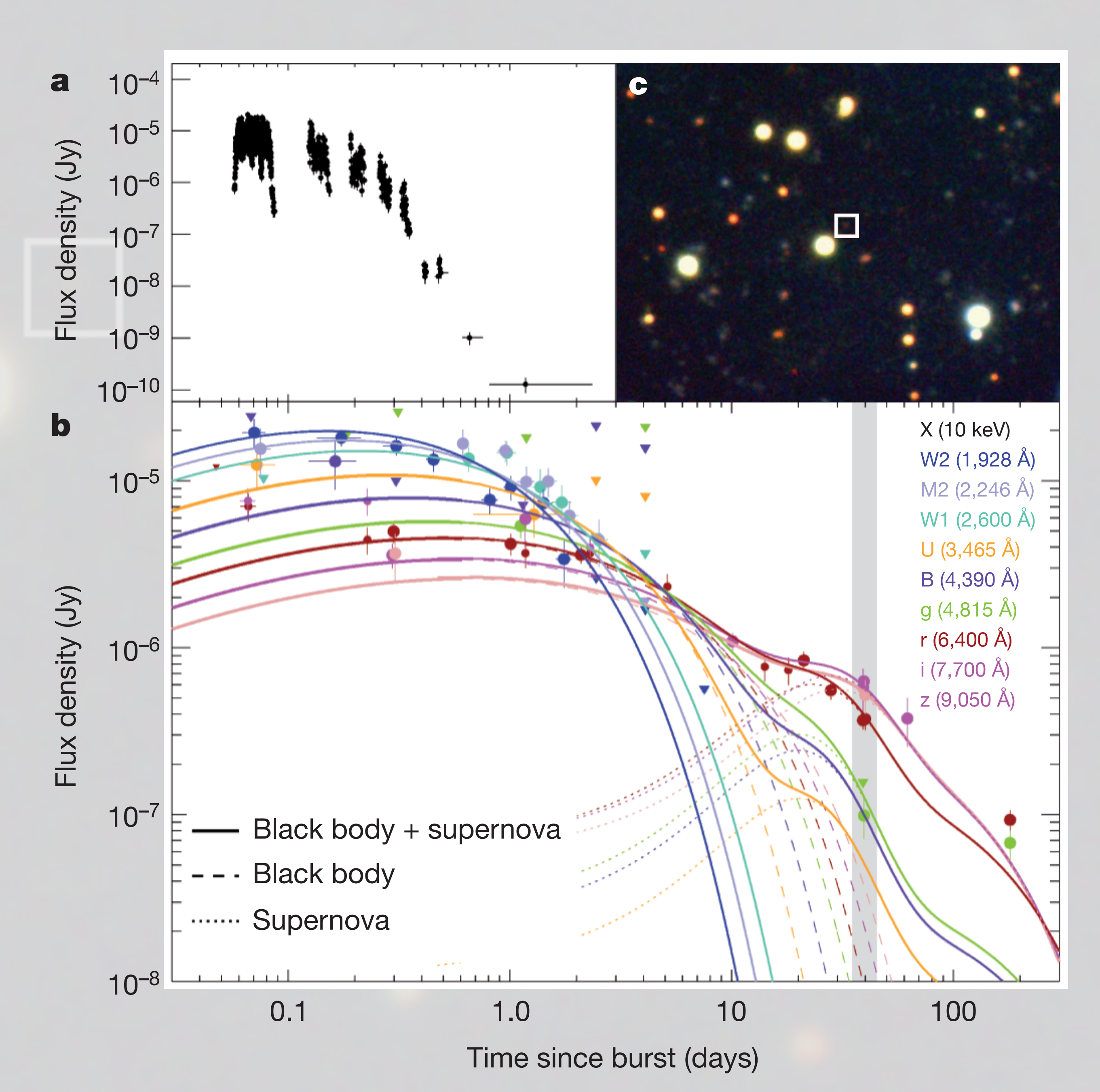


A STRANGE AFTERGLOW

- X-rays: TC, steep decline
  redshift < 0.5

- UVOIR „afterglow“ SED:
  - very blue color, color changes!
  - modelled with
    expanding+cooling BB

- **UVOIR Lightcurve:**
  flat for ~2 days, decay, stable at 30d, new decay (SN??)



A STRANGE AFTERGLOW

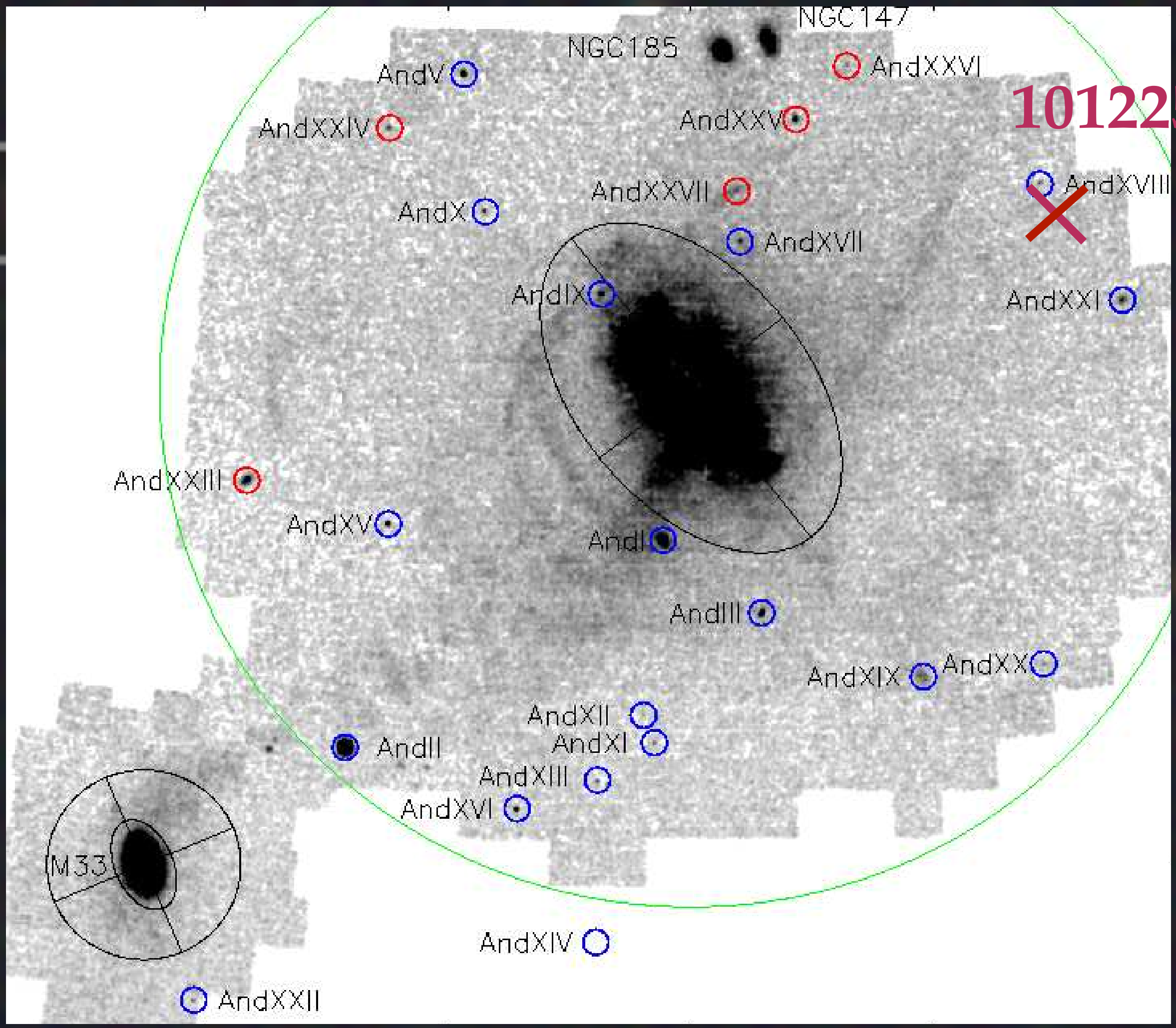
- X-rays: TC, steep decline
  redshift < 0.5

- UVOIR „afterglow“ SED:
  expanding+cooling BB

- **UVOIR Lightcurve:**
  flat for ~2 days, decay, stable at 30d, new decay (SN??)

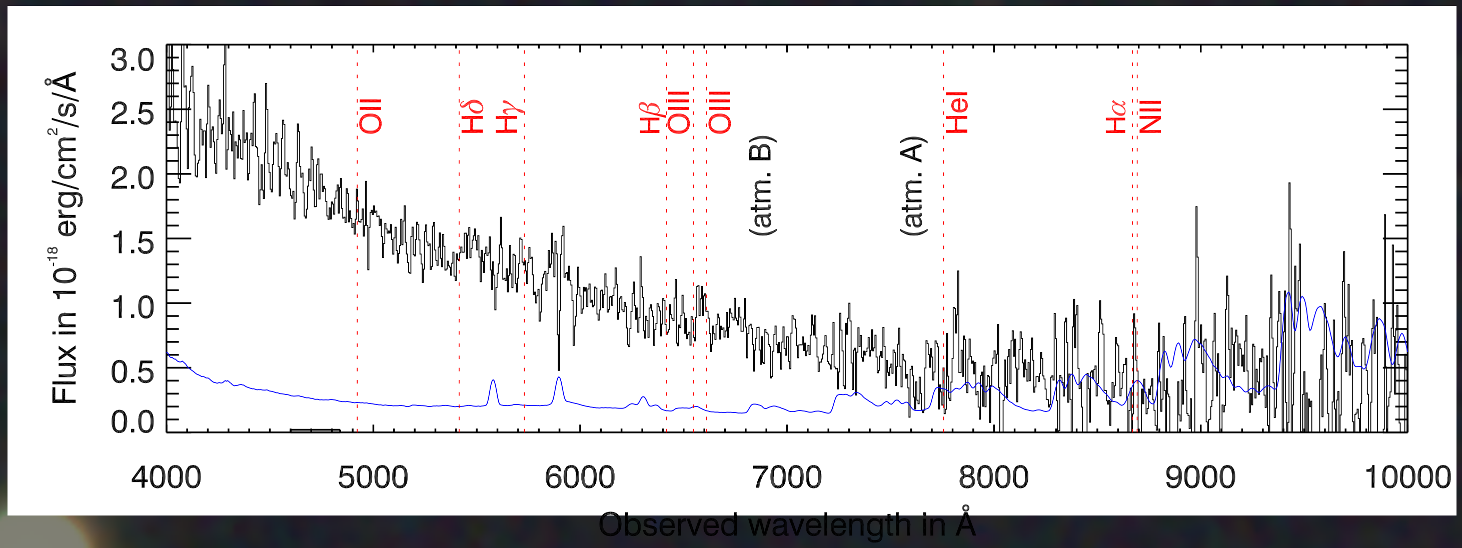
- ~~optical redshift ~0.4~~
  ~~Hα at z~0 in narrowband~~
  ~~-> in M31??~~

PAndAS - survey: CFHT



A STRANGE AFTERGLOW

- X-rays: TC, steep decline
  redshift < 0.5
- UVOIR „afterglow“ SED:
  expanding+cooling BB
- **UVOIR Lightcurve:**
  flat for ~2 days, decay, stable at 30d, new decay (SN??)
- featureless spectra at several epochs



GTC spectrum at 2 d

Thanks to AdUP + J. Gorosabel!

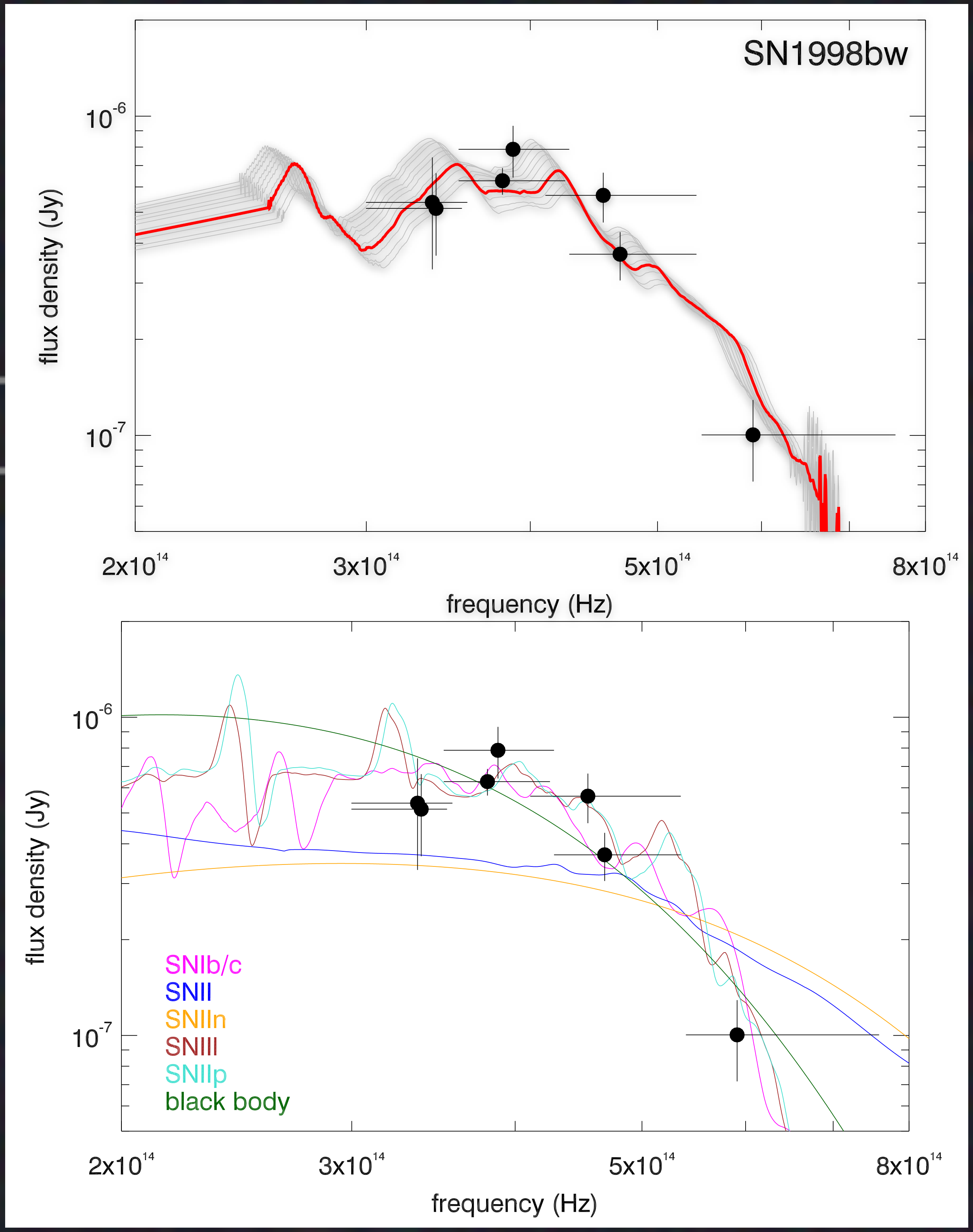
SUPERNOVA FITTING

- No spectroscopic confirmation
  Keck spectrum at 40d
  had low S/N

- SN + redshift by fitting templates
  of different SN types:
  best fit with SN 1998bw

- z=0.33 $^{+0.07}_{-0.04}$

- M$_{abs}$=-16.7 mag
  faintest GRB-SN!



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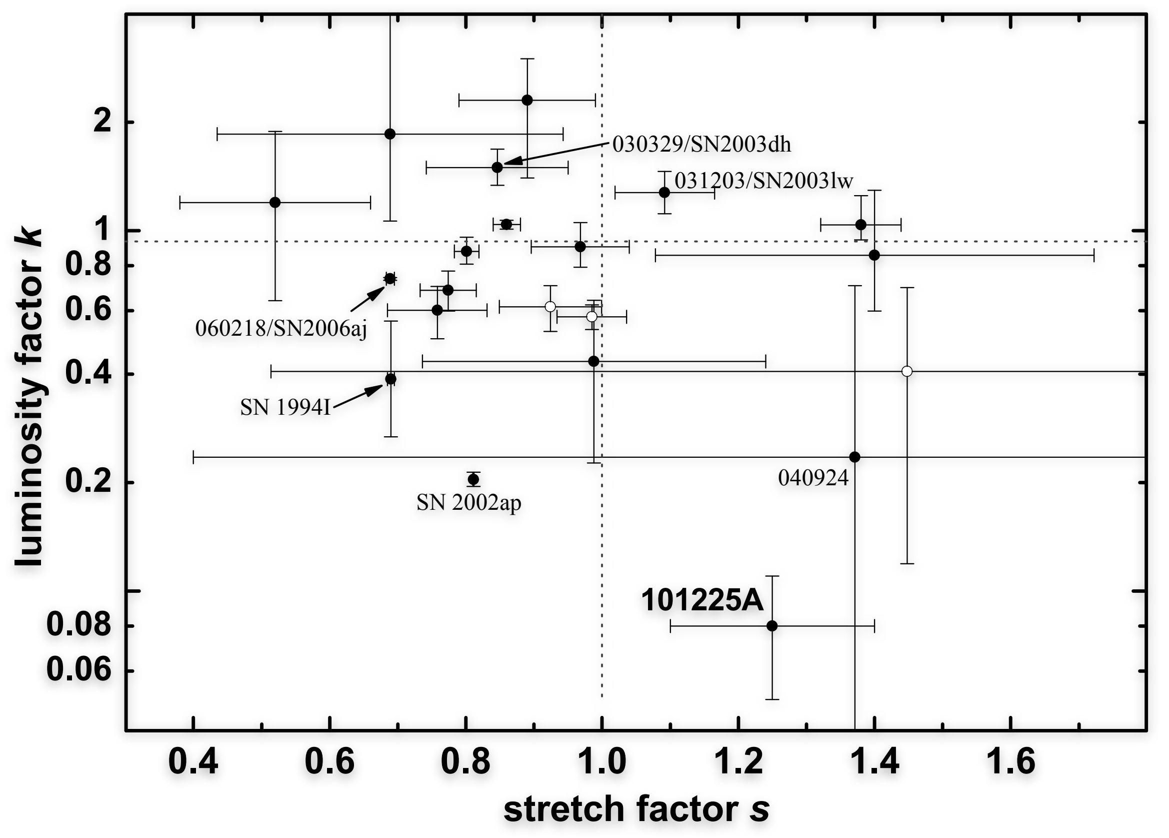
- 1/12th of luminosity
  S=1.25 compared to SN1998bw



adopted from Ferrero et al. (thanks to A. Kann)

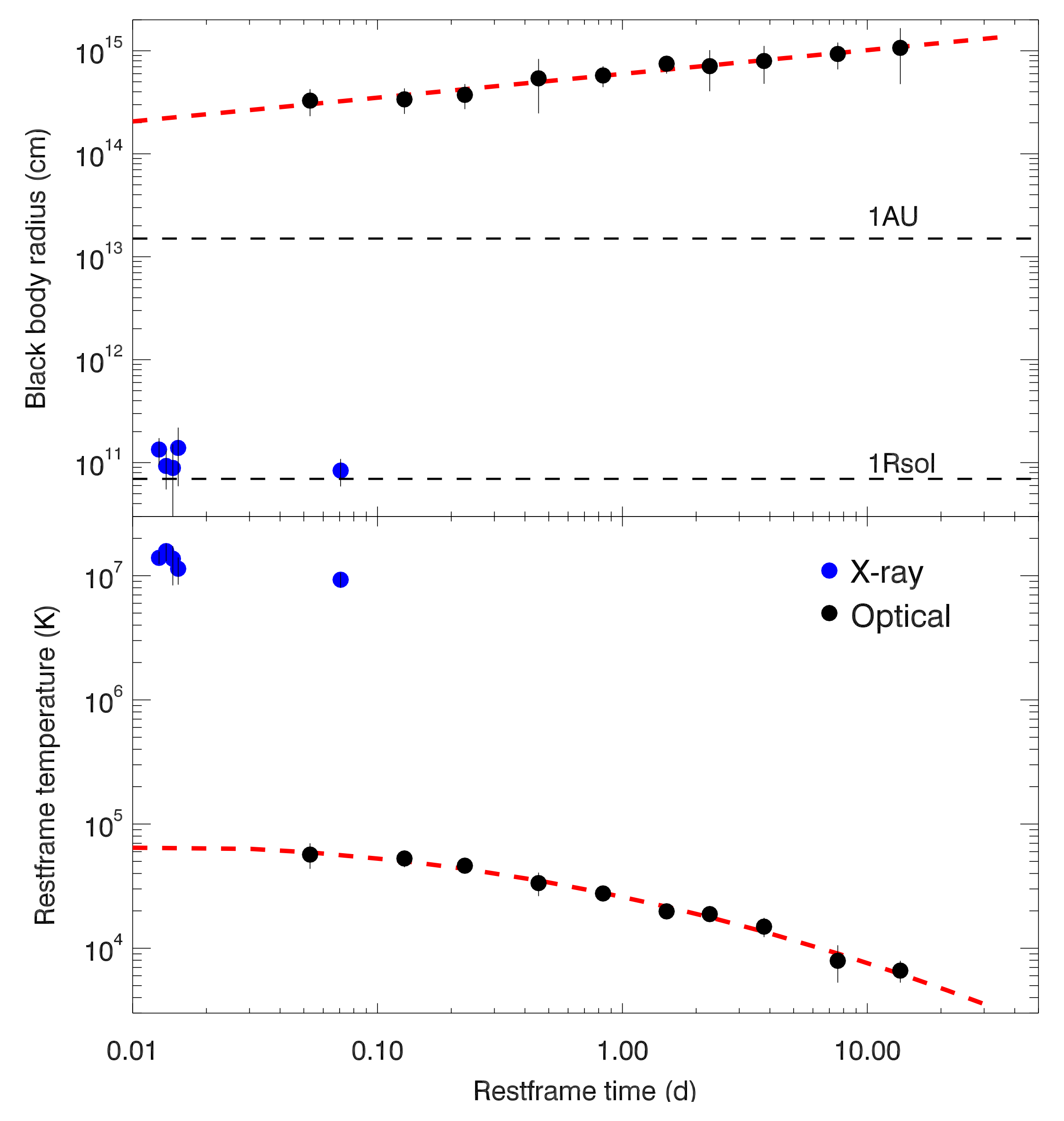
PHYSICAL DISTANCES/RADIUS

- $E_{\text{iso}} > 1.4$ x 10^{51} erg
  (higher than for most nearby GRB-SNe)

- X-rays: radius (~3 solar R) and temperature constant!

- optical:
  - R starting from ~13 AU, simple powerlaw
  - T cooling from 80,000 to 5000 K, more complicated evolution
  - v_{ini}~70,000 km/s

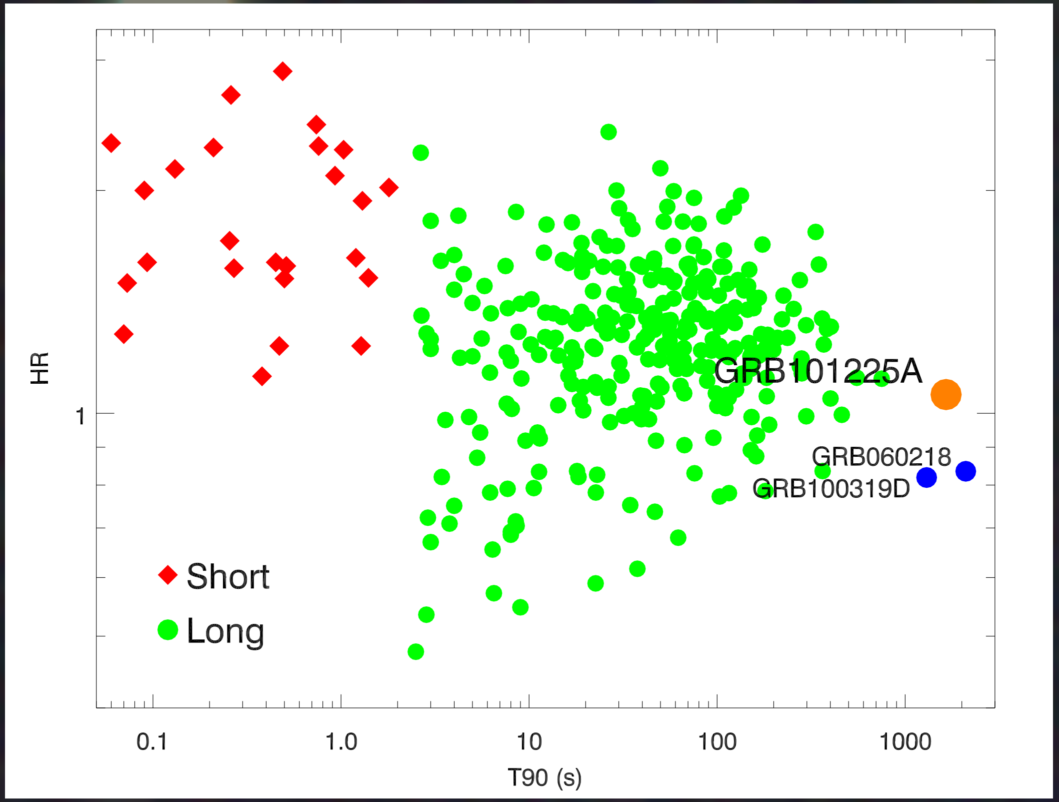
- optical/X-ray BB cannot come from same process

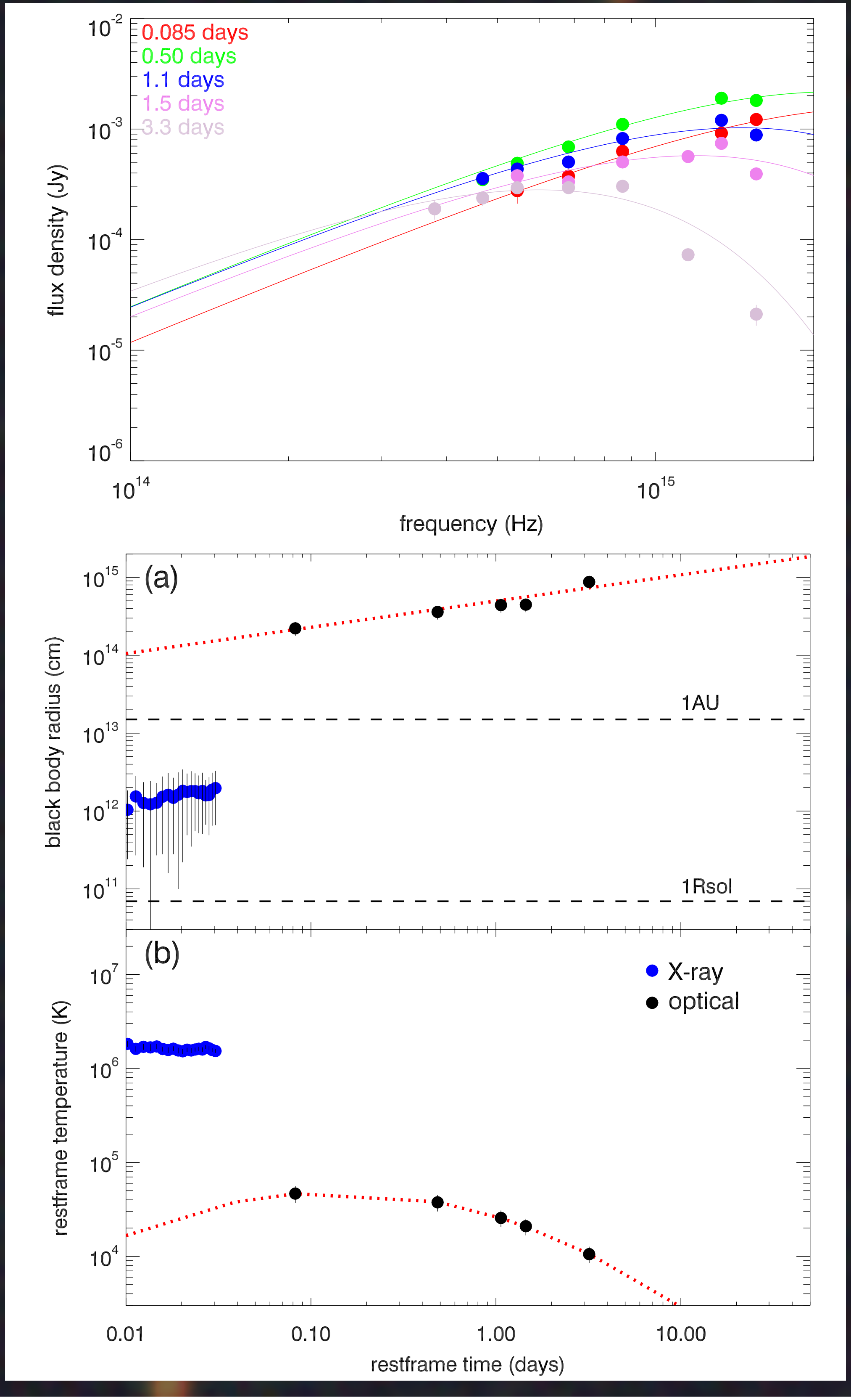


SIMILAR SN-GRBS IN THE PAST??

- X-ray TC in 3 other GRBs:
  060218, 090618, 100316D
  (Campana 06, Page 11, Starling 11)
  2 very long GRBs

- optical TC in 2 other GRBs/SN:
  060218, 080109 (SN 2008D)





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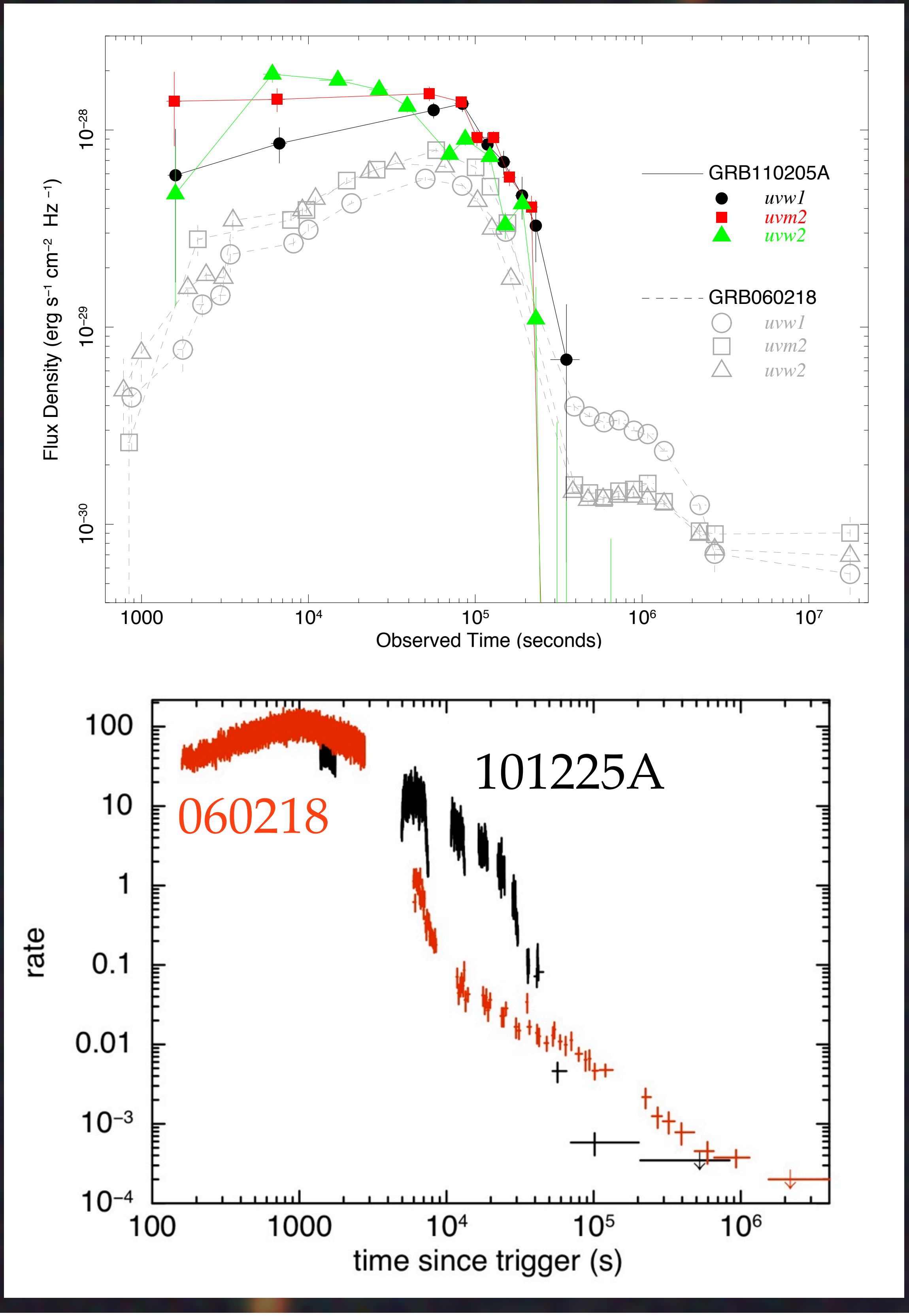
- GRB 060218: optical BB with similar evolution, X-ray BB radius larger



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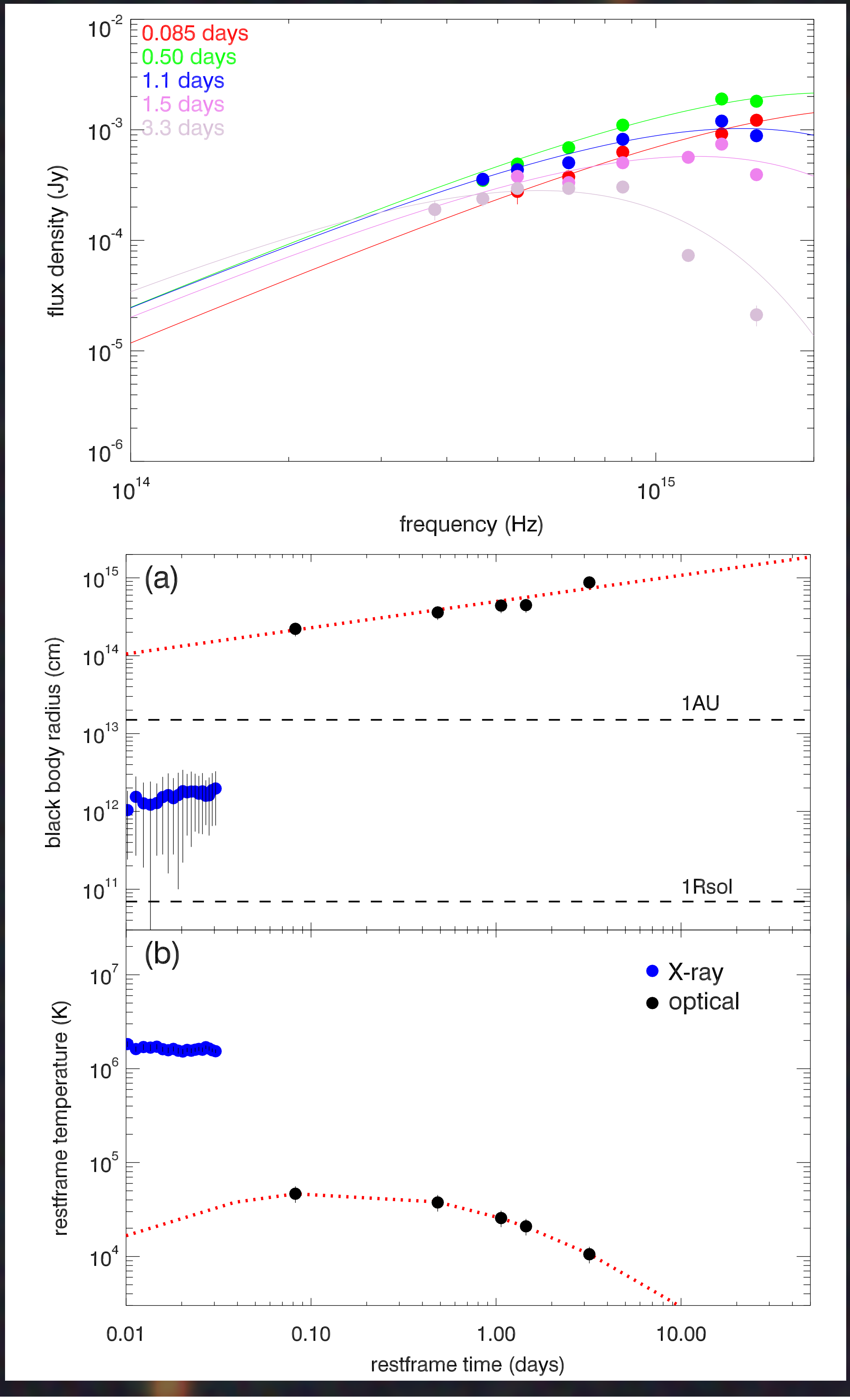
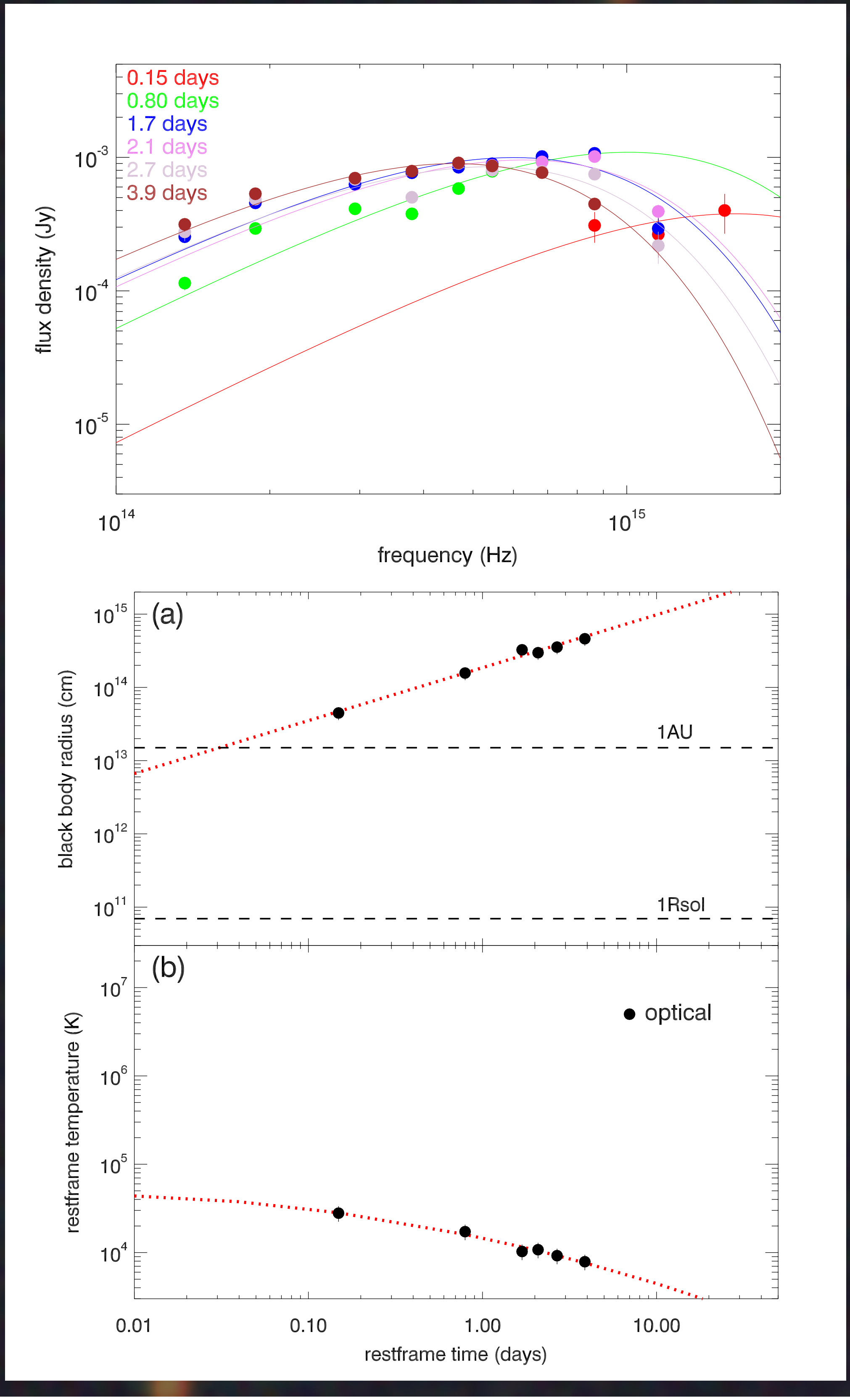


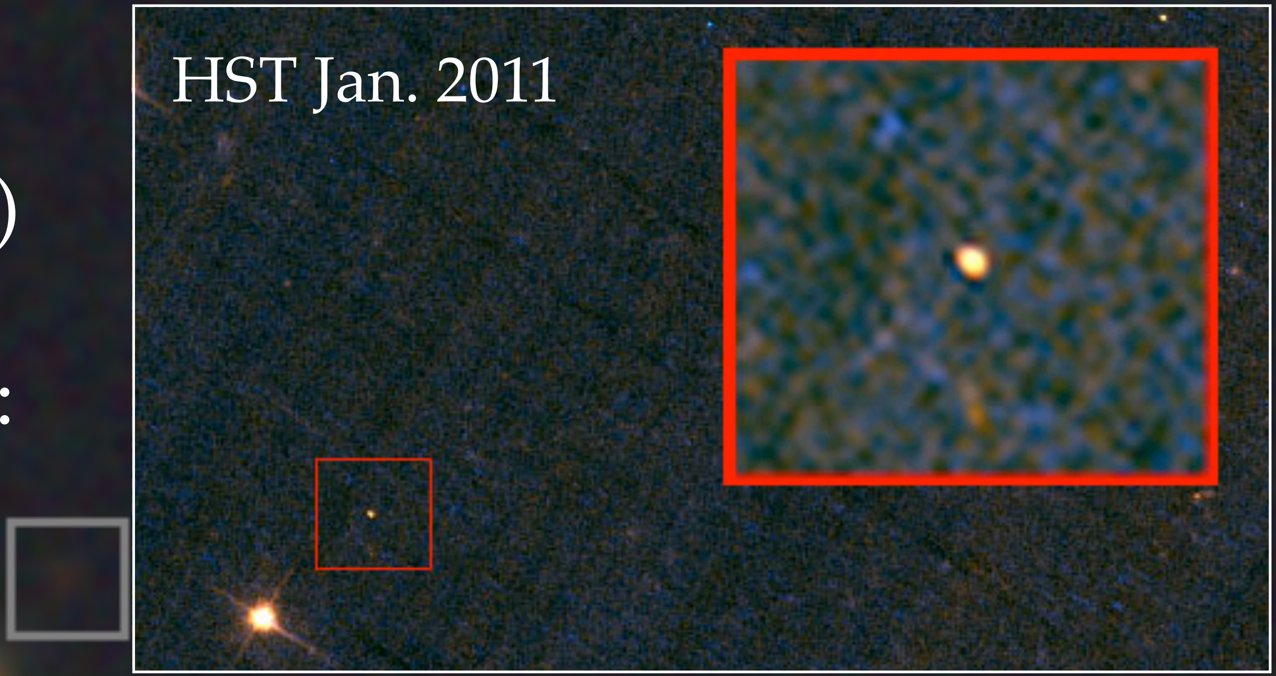
SIMILAR SN-GRBS IN THE PAST??

- X-ray TC in 3 other GRBs:
  060218, 090618, 100316D
- optical TC in 2 other GRBs/SN:
  060218, 080109 (SN 2008D)
- GRB 060218: optical + X-ray BB
  -> a twin with different progenitor??
- XRO 080109: no X-ray TC,
  optical BB consistent with extension of the shock breakout
- GRB 100316D: X-ray BB
  optical not enough data :(
- GRB 090618: X-ray BB, PL afterglow!

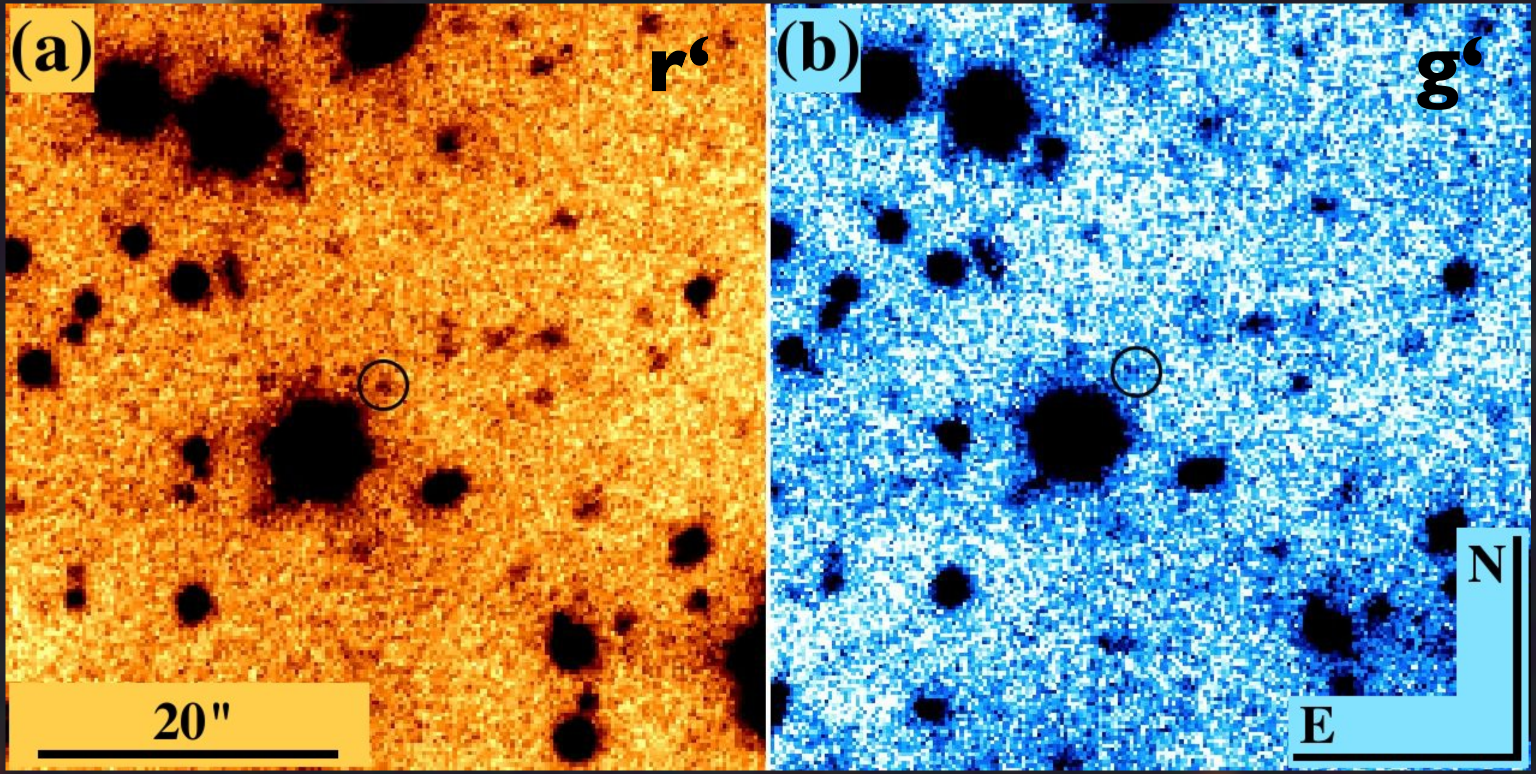


THE HOST (?)

- preimaging from CFHT:
  candidate at g~27.2 mag (2 sigma)
- deep observations from GTC (4h):
  g‘=27.2 +/- 0.27 (
  r‘= 26.9 +/- 0.14
- blue colors (?)
- at z=0.33
  M_{abs}=-13.7 or 0.0001 L*
  (GRB 060218: -15.9 mag)
- not resolved

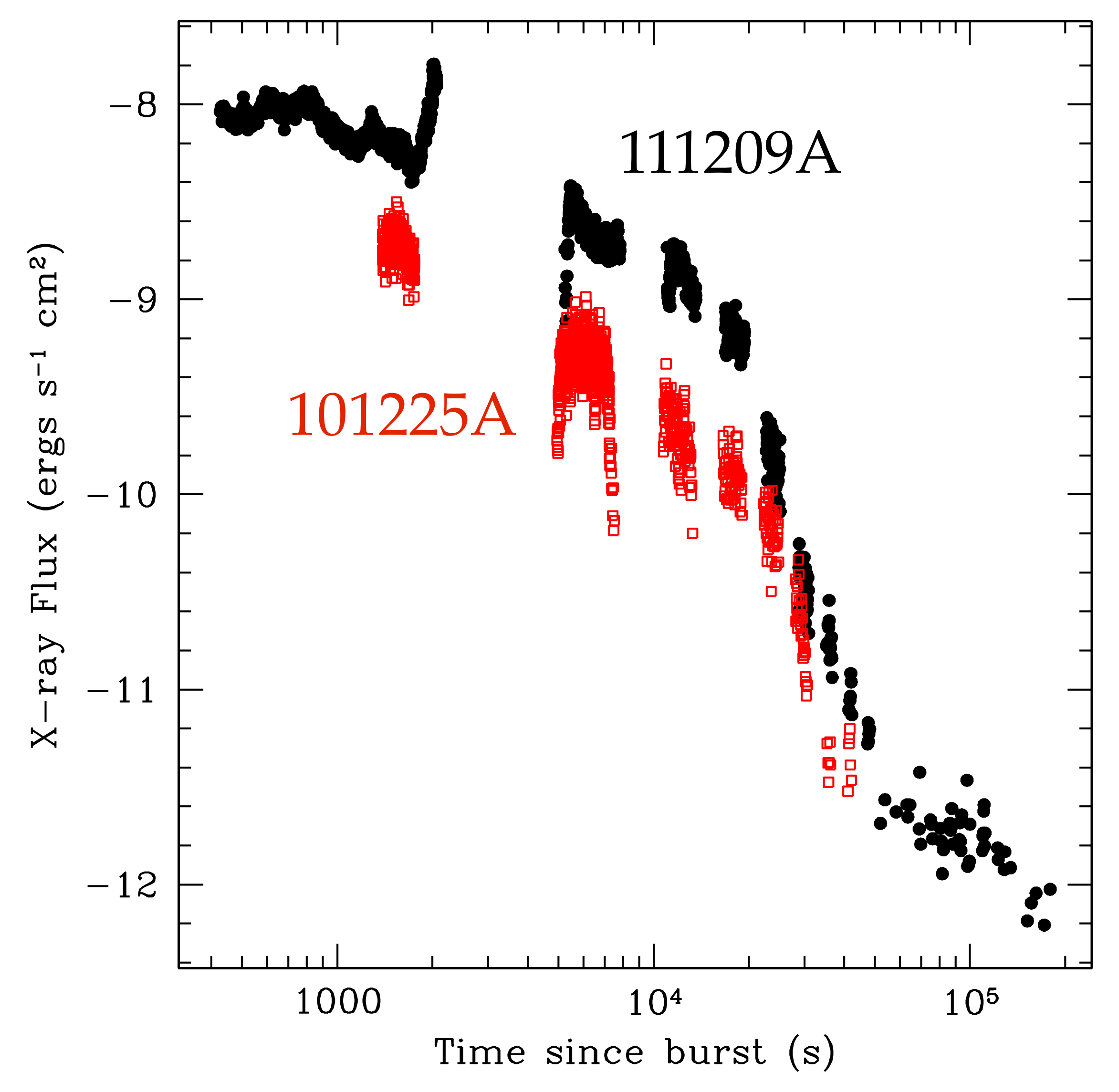


GTC



GRB 111209A - A COUSIN??

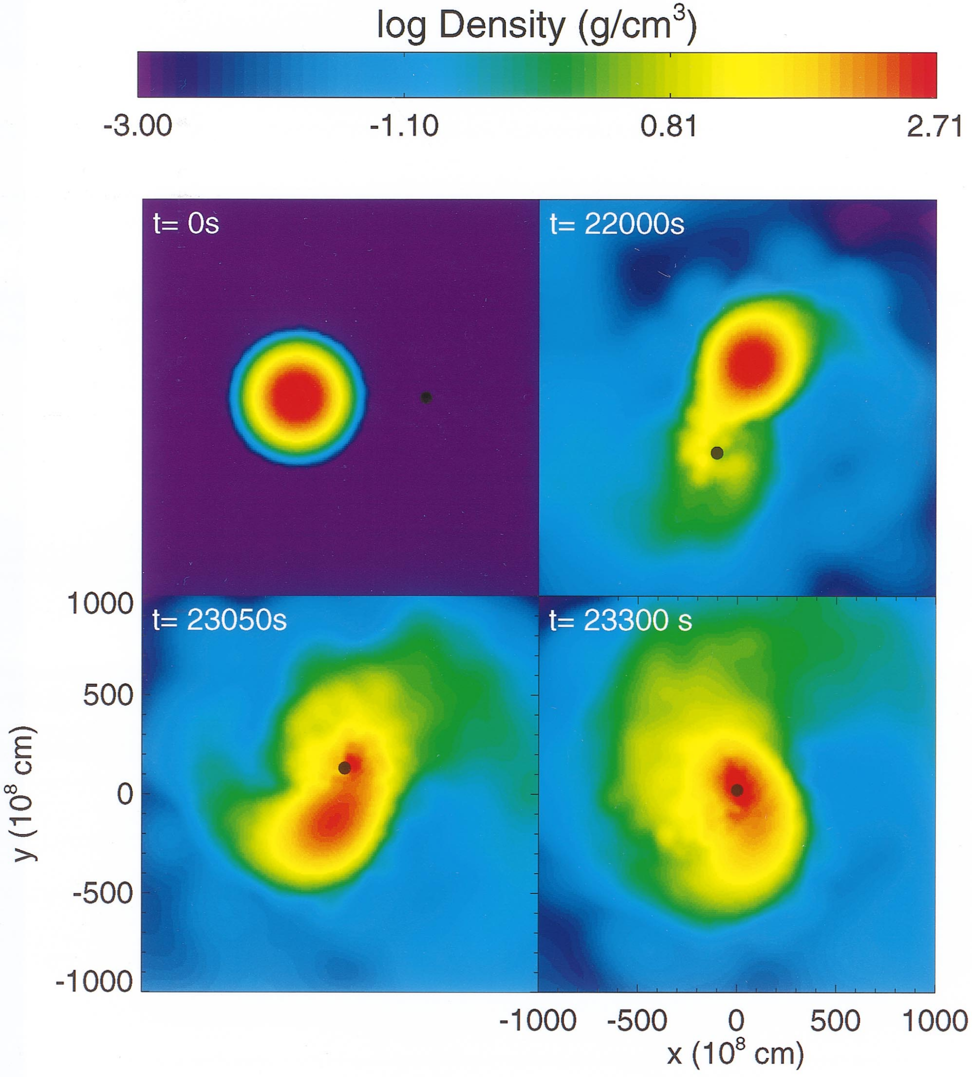
- **Very** long duration (> 10ks?)
- X-ray lightcurve:
  similar shape
  sharp drop
  strange „dips“
- **But:**
  lightcurve + SED powerlaw
  some very early color changes
  (could be prompt emission)
- z=0.67
  emission lines from host detected
  (host itself not yet detected with
  HST, must be compact)



The Model

AN OLD MODEL

- Fryer &Woosley 1999/ Zhang&Fryer 2001: He-star - BH merger with common envelope phase
- CE phase leads to mass ejection: suggested as a way to remove H-envelope in GRB progenitors
- transfer of angular momentum: spin up of core -> GRB
- weak SN produced (if any)

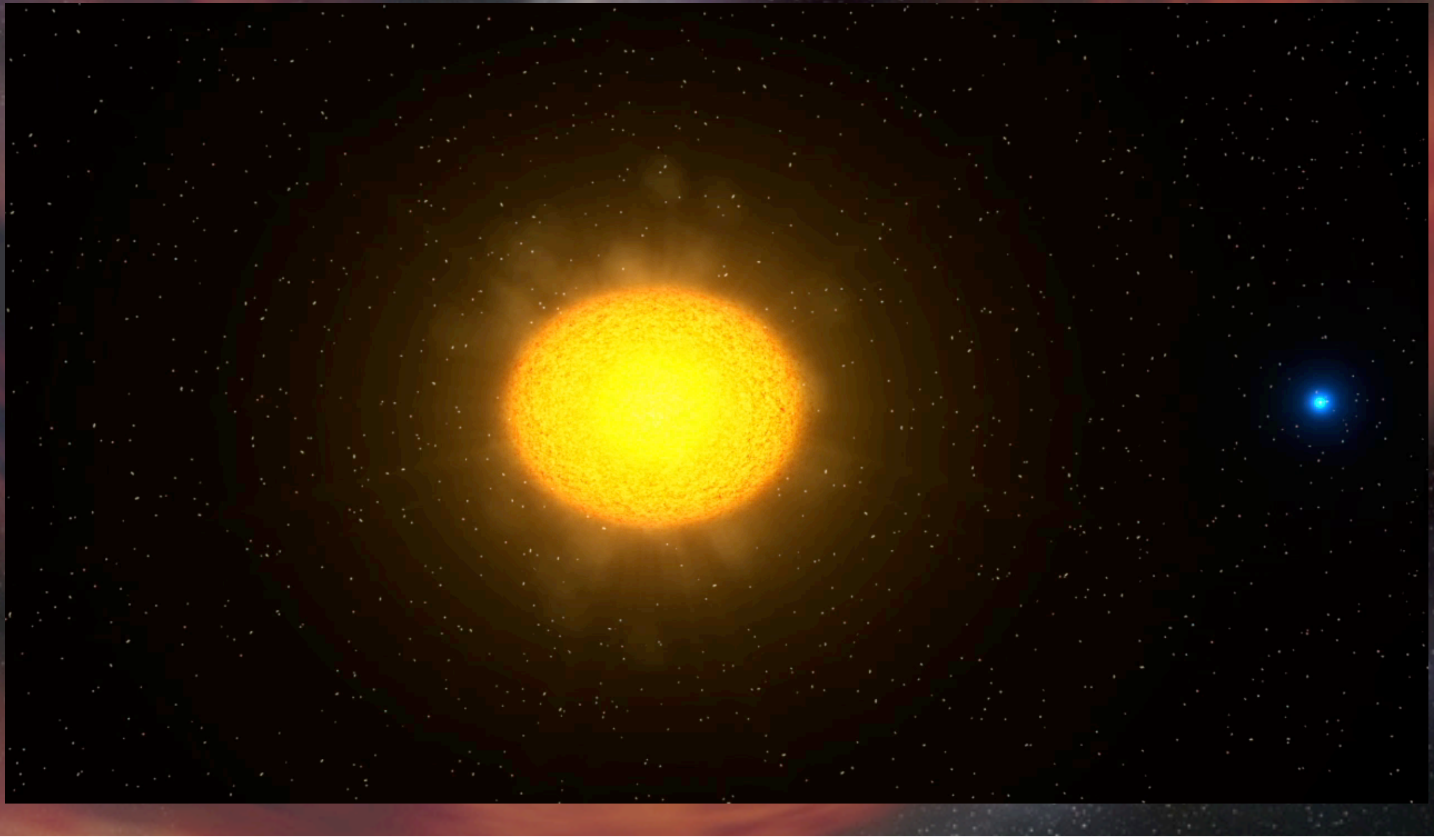


W. Zhang&Fryer 01

Thanks to C. Fryer!

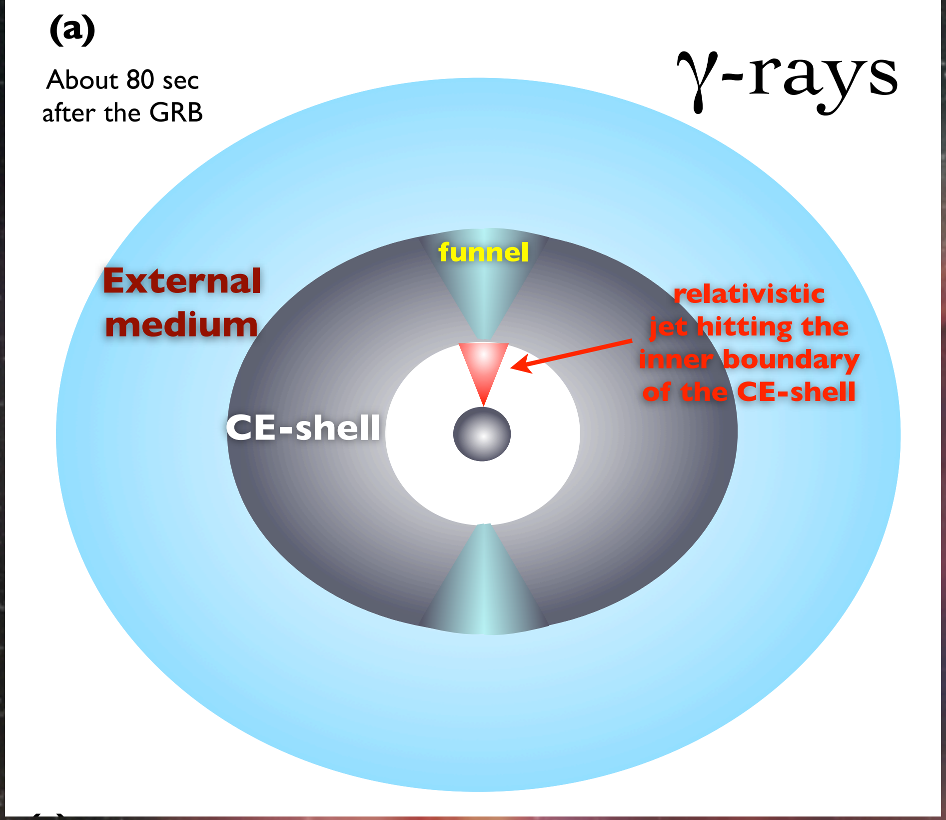
THEORETICAL MODEL OF THE EVENT

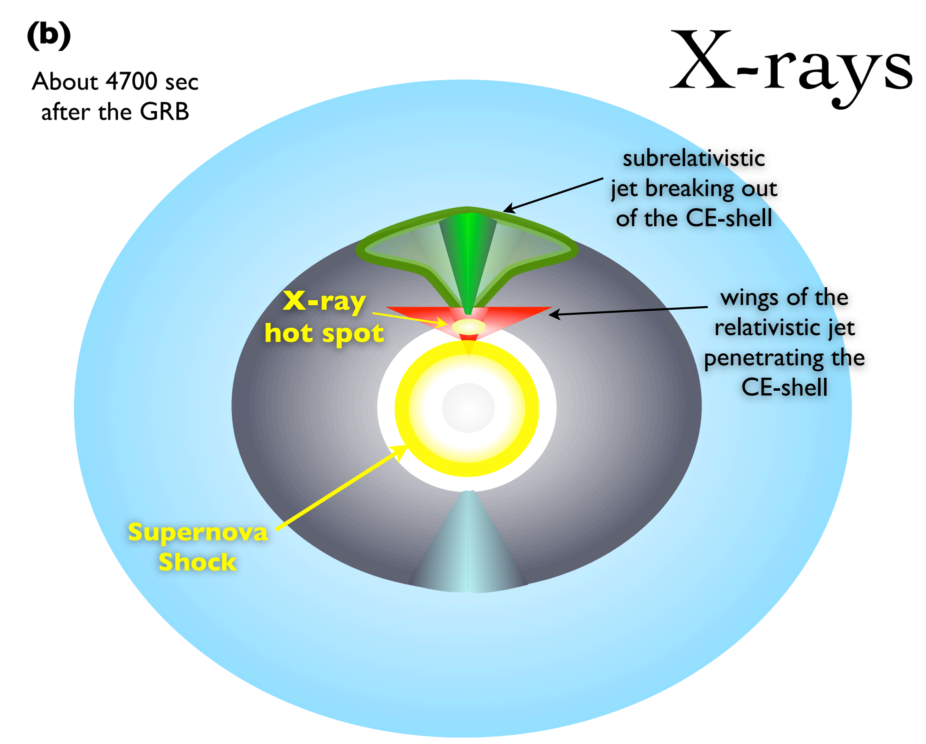
- Progenitor system:
  Close binary system of evolved He-star and NS
- Common envelope phase -> ejection of torus-like shell (~1.5y before explosion)
- Final merger: accretion disk + jet, magnetar for long activity?
- Part of the jet gets thermalized when interacting with the CE shell:
  no synchrotron emission
  no traditional afterglow
- Several days later:
  SN shell overtakes CE-shell

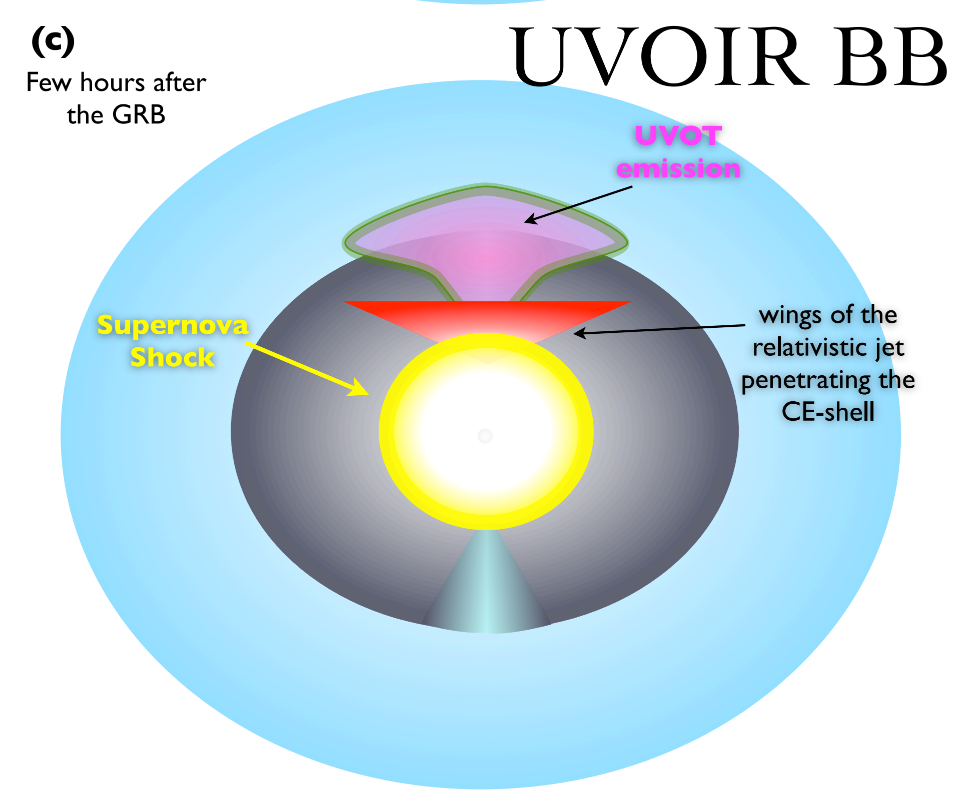


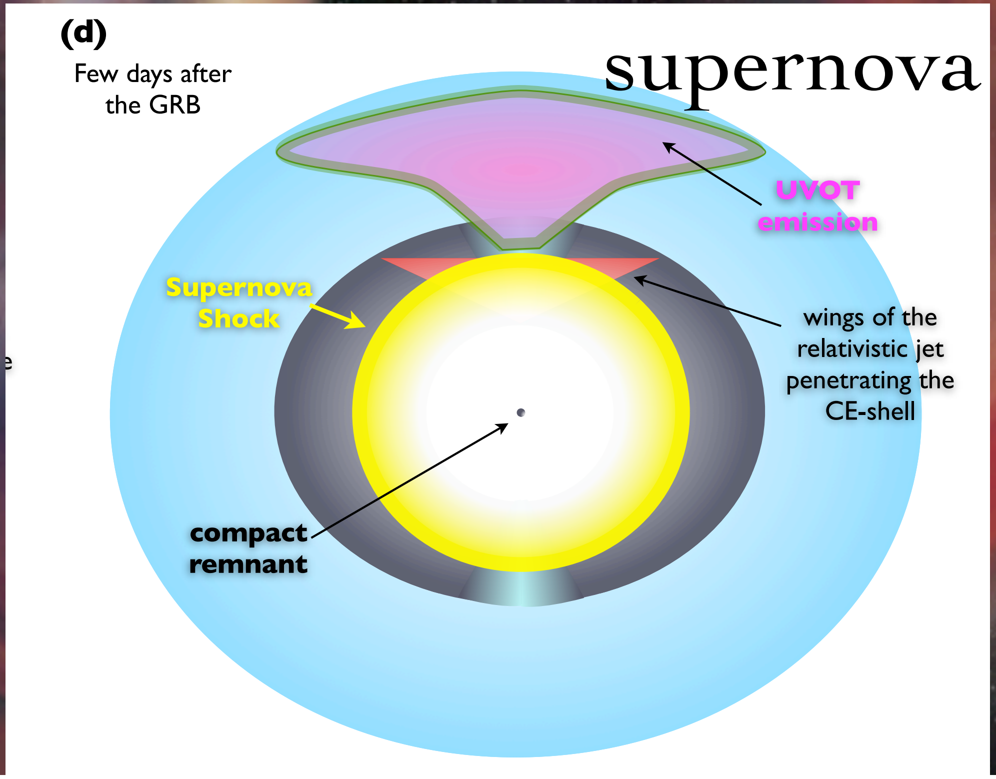
Thanks to M. Aloy!

Emission Mechanisms

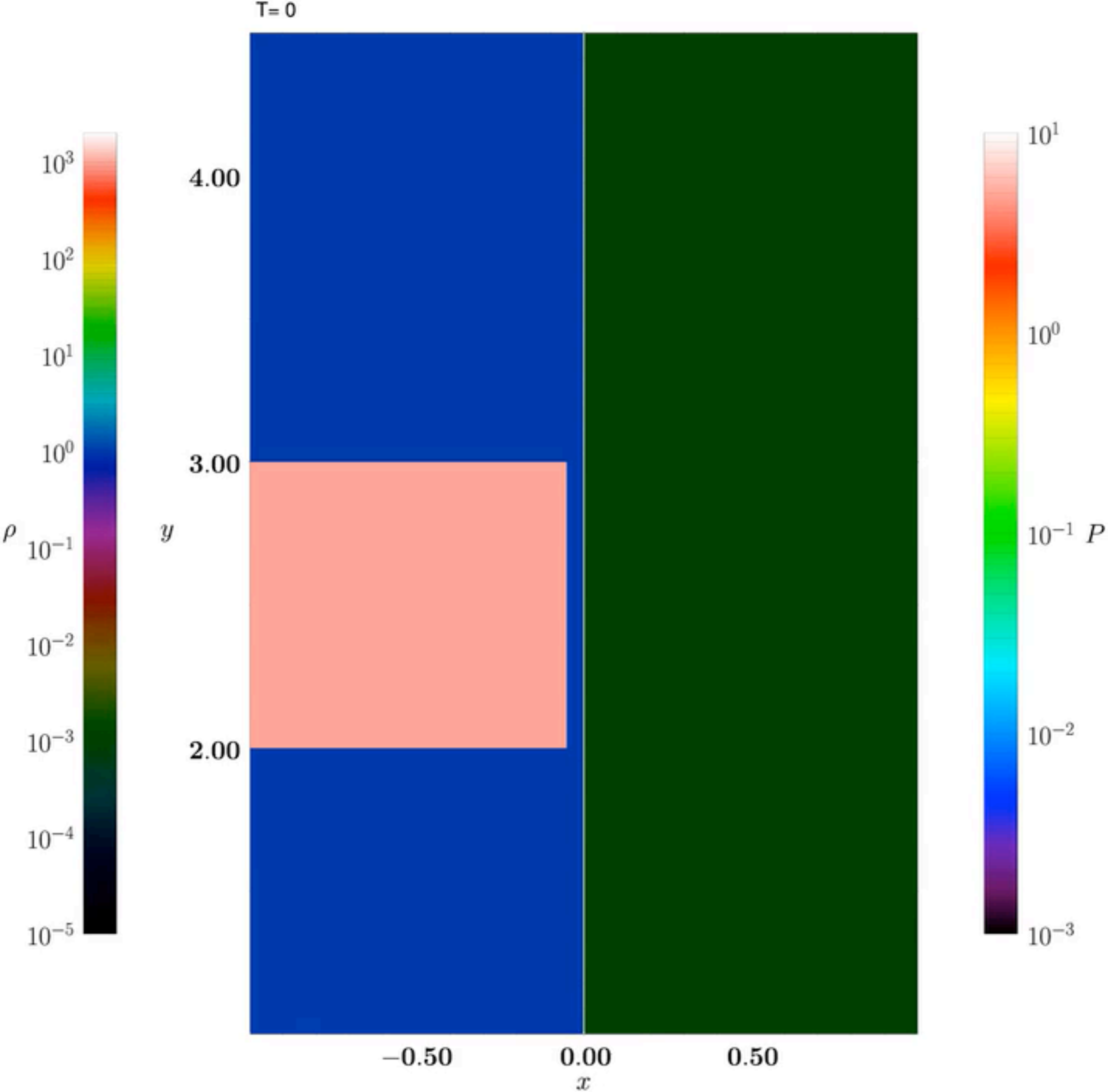




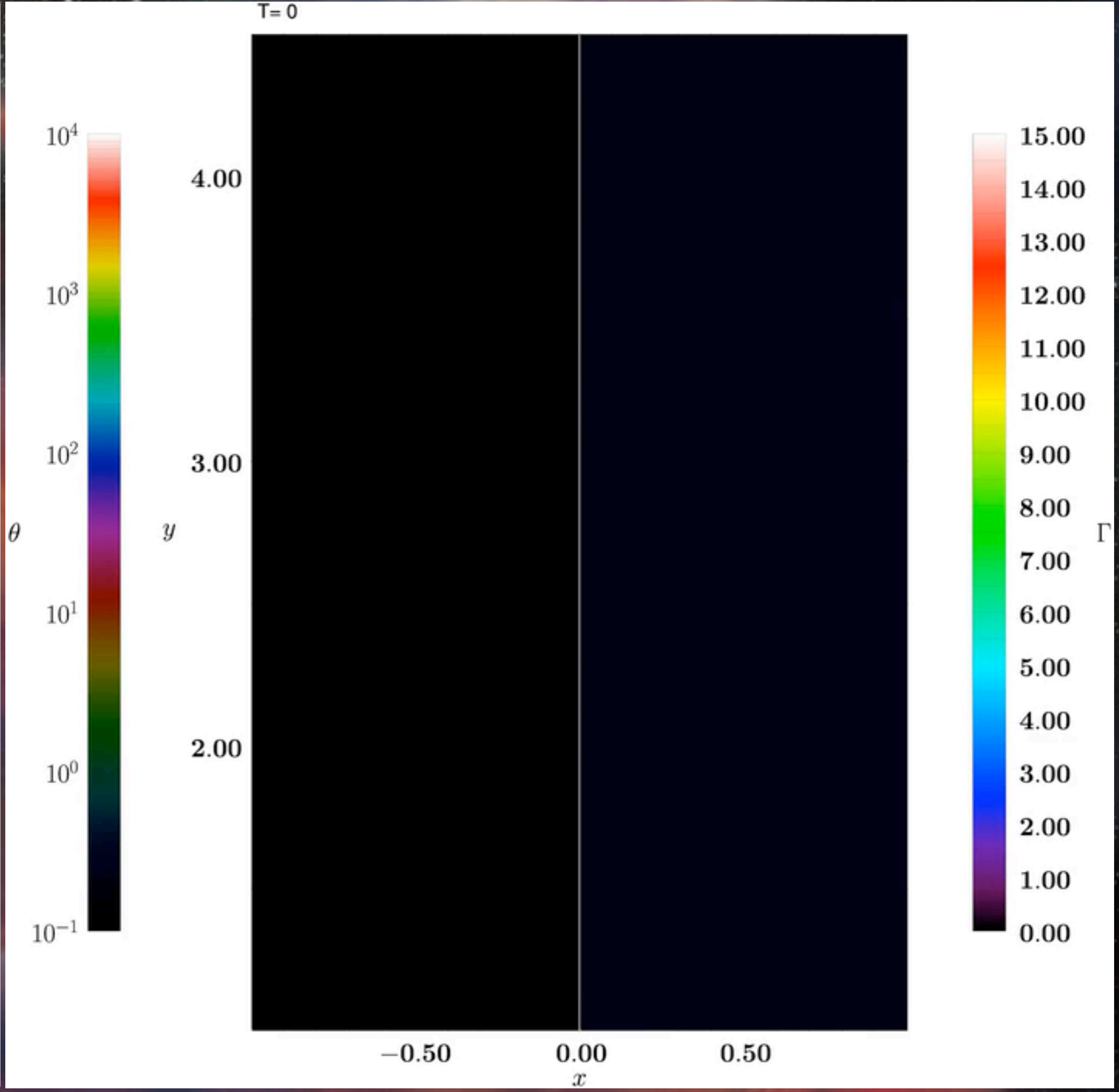




Jet Thermalization - Model



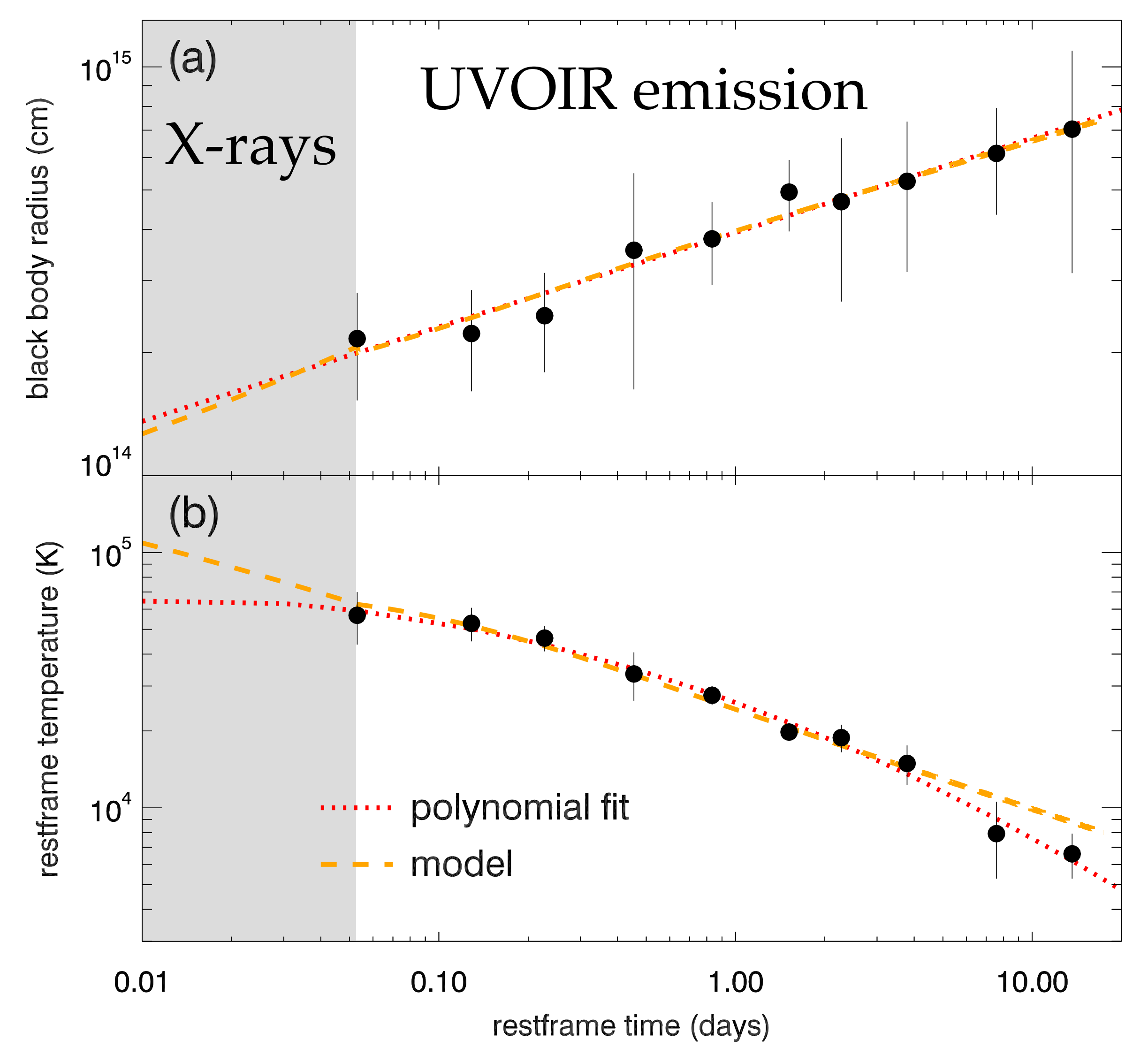
density pressure



Lorentz-factor

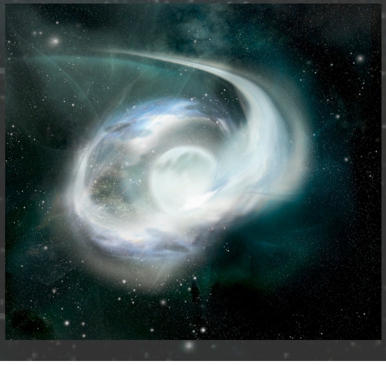
JET THERMALIZATION - MODEL

- Model by Huang et al. 2000
- Modeling interaction of jet with the funnel
- $\Gamma_{\text{in}} = 100$, $\theta_{\text{in}} = 2$deg initially v ~0.25c, θ ~ 70 deg after breakout
- model deviates only mildly from powerlaw evolution for radius T-evolution no powerlaw

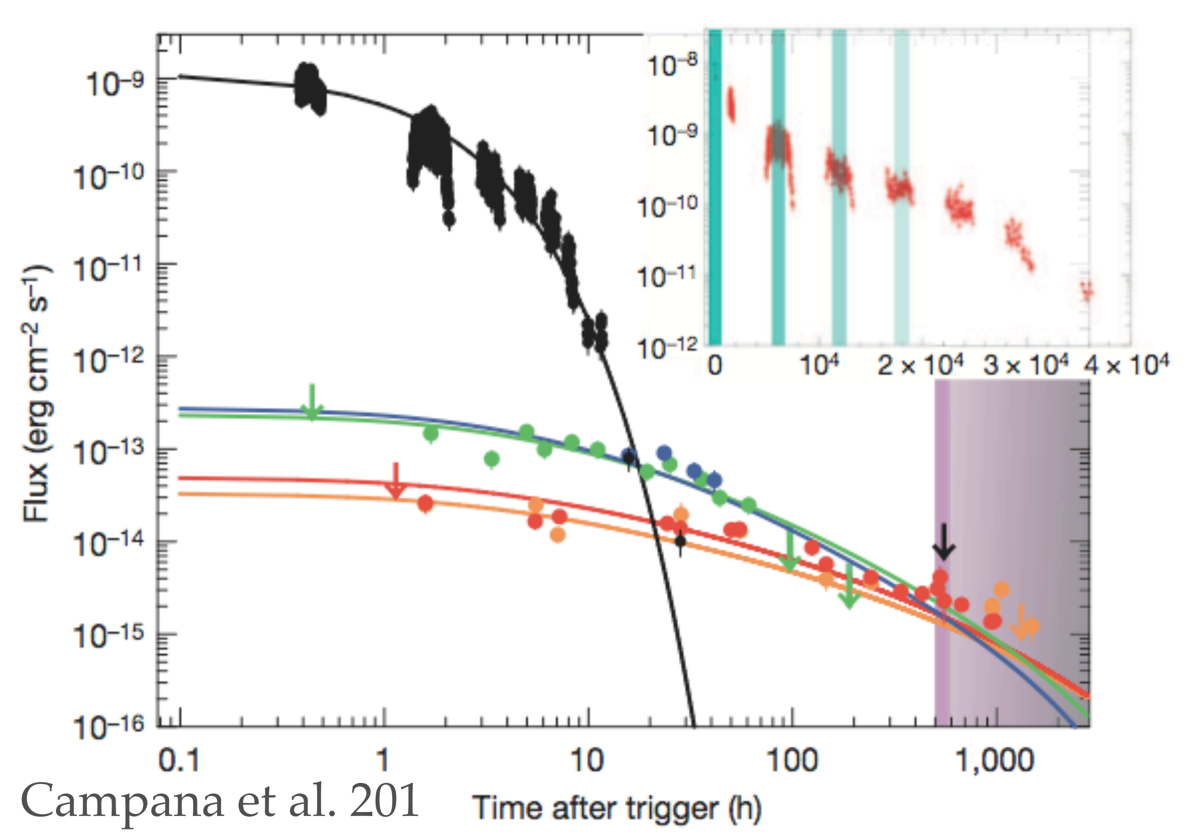


Alternatives?

ALTERNATIVE MODEL(S)?

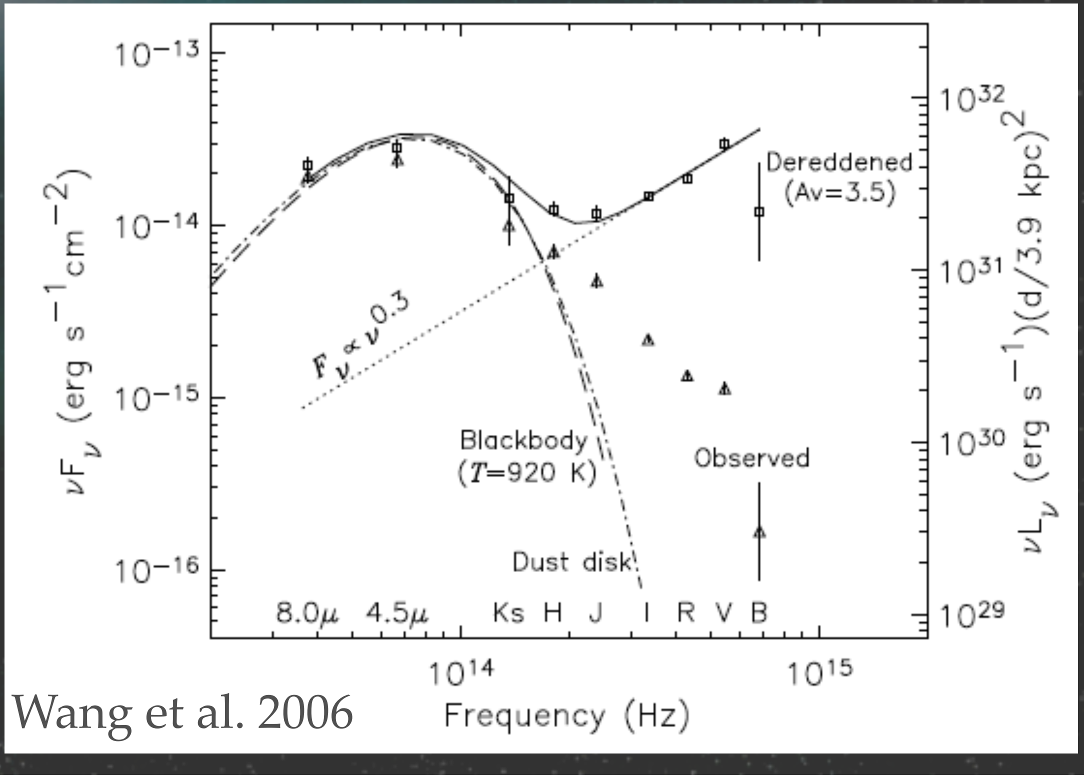


Campana et al., the other Nature:
Tidal disruption of a minor body (e.g. a comet) near a neutron star in the MW
distance ~3 kpc
optical emission explained by disk-BBs
(very old model for GRBs...!)



Campana et al. 201

Problems:
- place in the MW: high above the disk
  -> expelled from SF region in the disk??
- no explanation for the full SED
- neglect SN bump in LC and SN-SED
- persistent source (=our host):
  isolated NS with emission from magnetosphere?
  (cold isolated NS would have mag~33)
  emission from protoplanetary disk
  (e.g. Wang et al. 2006)?



Wang et al. 2006

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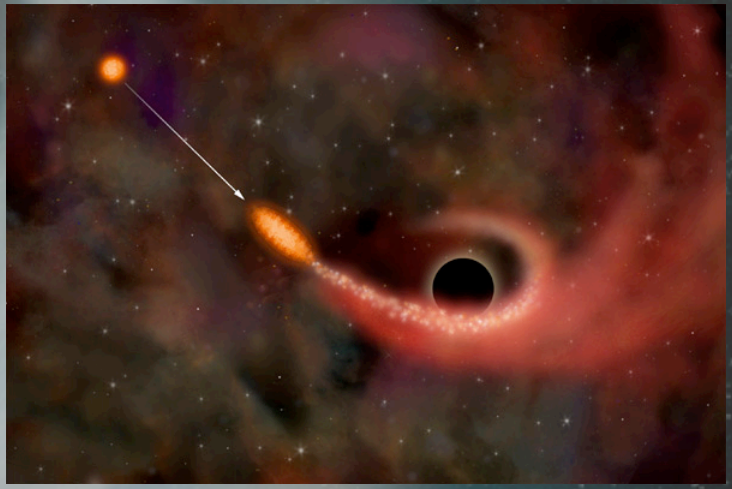
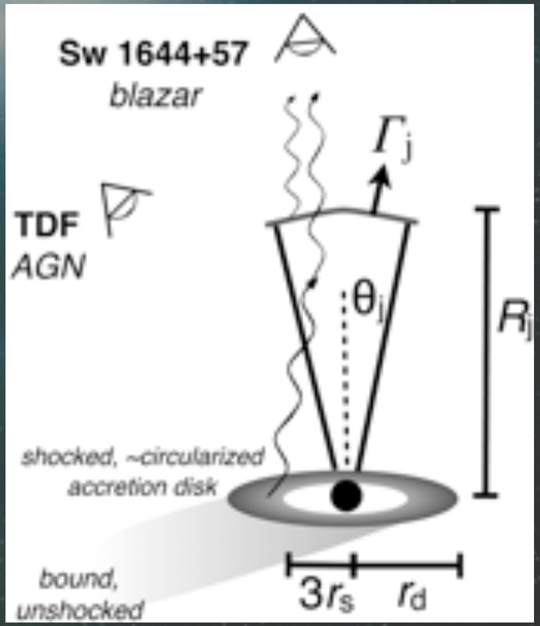


Tidal disruption event ala 110328A in a distant galaxy (Levan, Tanvir etc.)



Explains: dips in the X-ray lightcurve
Problems:
- rather short duration for a TDE in gamma-rays
- has to be coincident with center of the galaxy (we will see...)

HOW DO WE RESOLVE THE ISSUE?

New observations:
- HST (??)
- Chandra (??)
- Effelsberg (radio)
- ground based imaging (??)

- HST: extended source -> ~~NS~~, GRB-like event ✔, TDE ✔
  point source -> NS ✔, ~~GRB~~?, ~~TDE~~?
- X-ray detection -> NS ✔, ~~GRB~~, ~~TDE~~?
  nondetection -> NS ?, GRB ✔ , TDE ✔
- radio detection -> NS ✔, ~~GRB~~, TDE ?
  nondetection -> NS ?, GRB ✔ , TDE ✔

ありがとう ございます!