Bariloche, 8 November 2018

AT2018cow

A fast luminous relativistic transient

Antonio de Ugarte Postigo
(HETH/IAA-CSIC, Granada; DARK/NBI, Copenhagen)

Cow, what cow?

- Discovered by **ATLAS** as a likely foreground CV spatially coincident with a galaxy at 60 Mpc
- 59 ATels followed
- 6 papers already out:

1. **Prentice et al. 2018**, ApJL 865, 3
   The cow: Discovery of a luminous, hot, and rapidly evolving transient
2. **Rivera Sandoval et al. 2018**, arXiv:1807.06369
   X-ray Swift observations of SN 2018cow
3. **Perley et al. 2018**, arXiv:1808.00969
   The fast, luminous ultraviolet transient AT2018cow: Extreme supernova, or disruption of a star by an intermediate-mass black hole?
4. **Kuin et al. 2018**, arXiv:1808.08492
   Swift spectra of AT2018cow: A white dwarf tidal disruption event?
5. **Margutti et al. 2018**, arXiv: 1810.10720
   An embedded X-ray source shines through the aspherical AT2018cow: Revealing the inner workings of the most luminous fast-evolving optical transients
6. **Ho et al. 2018**, arXiv: 1810.10880
   AT2018cow: A luminous millimeter transient

   …

?. **Kann et al.** *in preparation*

ATLAS18qqn (AT2018cow) - a bright transient spatially coincident with CGCG 137-068 (60 Mpc)

ATel #11727; *S. J. Smartt, P. Clark K. W. Smith, O. McBrien, K. Maguire, D. O'Neil, M. Fulton, M. Magee, S. Prentice, C. Colin (Queen's University Belfast), J. Tonry, L. Denneau, B. Stalder, A. Heinze, H. Weiland, H. Flewelling (IfA, University of Hawaii), A. Rest (STScI),*
on 17 Jun 2018; 22:22 UT
Distributed as an Instant Email Notice Supernovae
Credential Certification: Stephen Smartt (s.smartt@qub.ac.uk)

Subjects: Optical, Cataclysmic Variable, Nova, Supernovae, Transient

Referred to by ATel #: 11729, 11732, 11734, 11736, 11737, 11738, 11740, 11741, 11742, 11743, 11744, 11748, 11749, 11750, 11751, 11752, 11753, 11757, 11758, 11759, 11760, 11761, 11766, 11767, 11772, 11773, 11774, 11775, 11776, 11781, 11782, 11785, 11788, 11789, 11792, 11793, 11794, 11795, 11796, 11799, 11801, 11808, 11809, 11810, 11813, 11818, 11819, 11822, 11836, 11843, 11862, 11868, 11891, 11921, 11950, 11956, 12030, 12067

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ATLAS is a twin 0.5m telescope system on Haleakala and Mauna Loa. Each unit has a single camera covering 28.9 square degree field of view and is robotically surveying the sky every night. Two filters are used, cyan and orange (denoted c and o, all mags in AB system), more information is on http://www.fallingstar.com. While carrying out the primary mission for NEOs, we search for and publicly report stationary transients (see Tonry et al. ATel #8680, Tonry et al. 2018, PASP, 130, 4505).

We report a bright new transient source, which is spatially coincident with the galaxy CGCG 137-068 (z=0.014145, 60 Mpc). We discovered ATLAS18qqn (AT2018cow) on MJD 58285.441 == 2018-06-16 10:35:02 UTC at o = 14.76 +/- 0.10. ATLAS18qqn is offset by 3.46 arsec south, 4.86 arcsec west of the core of CGCG 137-068. If it were in the galaxy it would be M_o = -19.2.

It has a very fast rise time, with no detection on MJD=58281.5 to o~19.5. Most likely it is a foreground CV in chance alignment with the galaxy. There are a number of blue knots (possible foreground stars or host galaxy features) visible in the Pan-STARRS and SDSS images. The transient is close to but not coincident with any of these sources. There are no previous outbursts in ATLAS or any other survey that we are aware of.

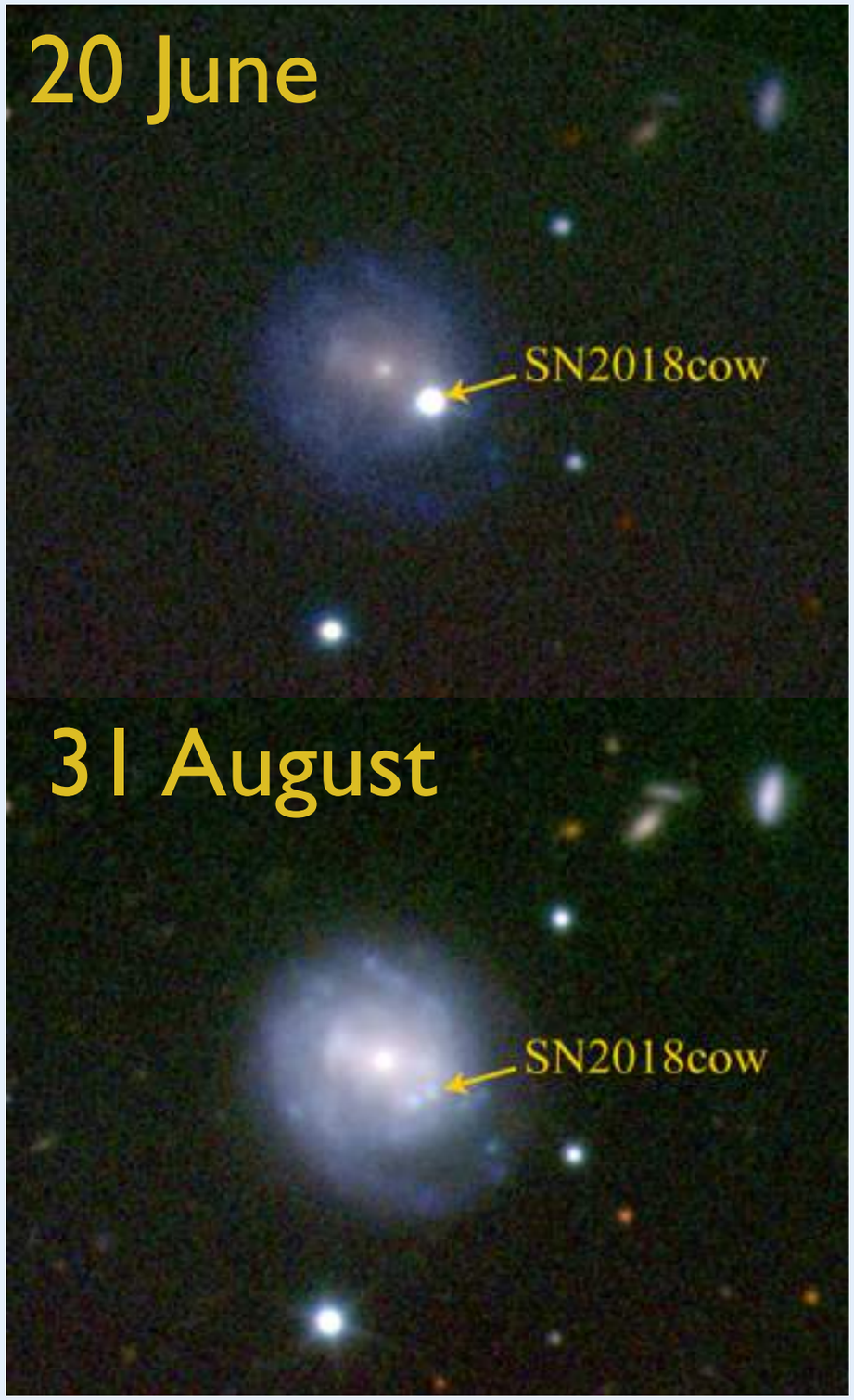
To rule this out being a very unusual transient in this galaxy CGCG 137-068, or (more likely) confirm it as a foreground CV, a spectrum is required.

The object details and pointer to the PS1 finder are available on the TNS: https://wis-tns.weizmann.ac.il/object/2018cow

Name	ATLAS Name	RA (J2000)	Dec (J2000)	Disc. Date	Disc Mag
AT2018cow	ATLAS18qqn	16:16:00.22	+22:16:04.8	58285.441	14.76 o

Discovery

- Discovered by ATLAS on June16.44 UT (Smartt et al. 2018)
- Coincident with a galaxy at $z = 0.014$ (61 Mpc)
- Last non detection on June 15.13
- Estimated explosion on June 15.34 (Prentice et al. 2018)
- Rise to peak in ~3.5 days
- Peak at g'=13.40
- Peak luminosity 4×10^{44} erg (Perley et al. 2018)



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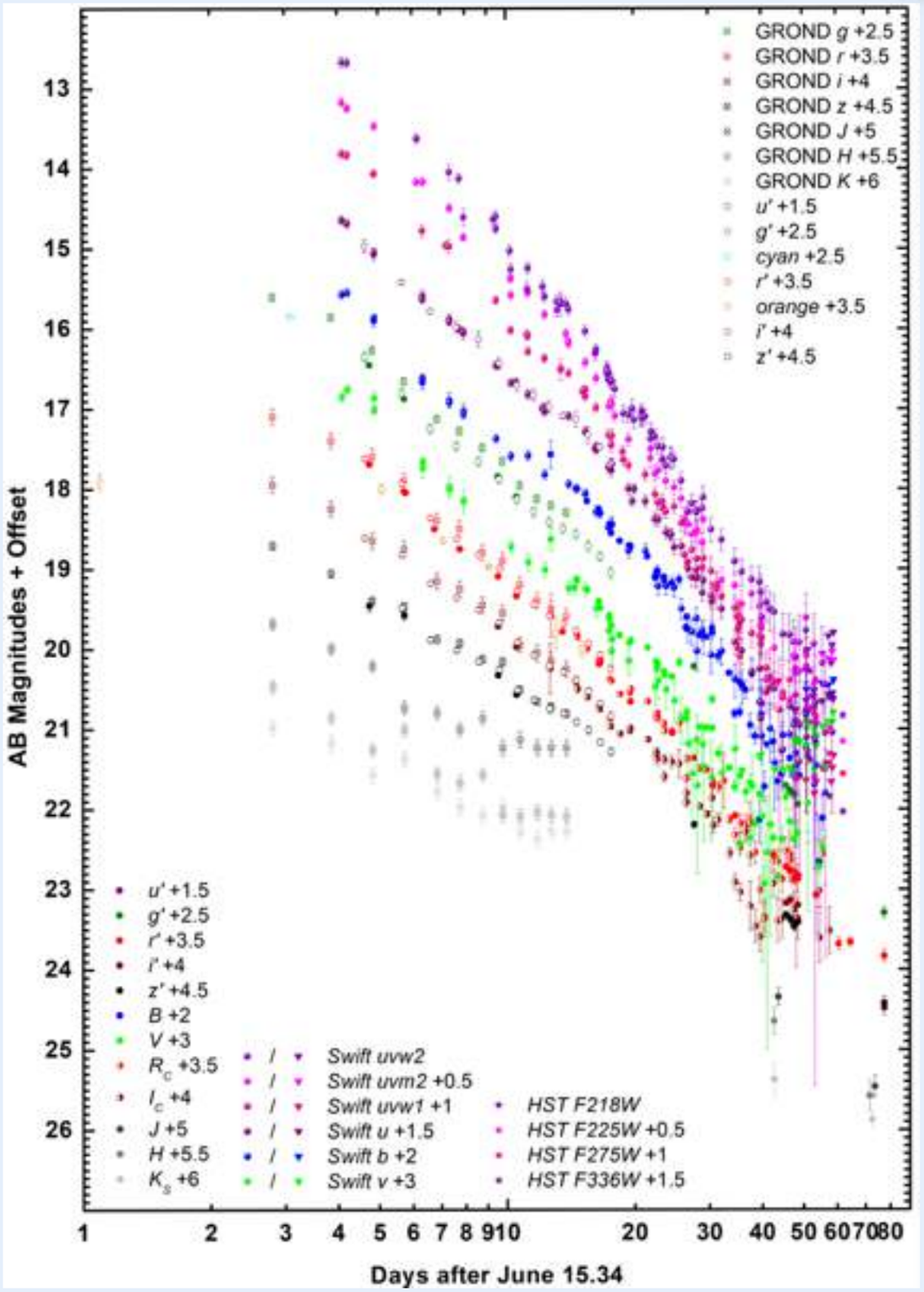

Our data

- **Spectroscopy**: GTC (15), X-shooter (3), Calar Alto (6) and NOT (5)

- **Photometry**: UVOT, GTC, VLT, HST, OSN, CAHA, WHT, Ondrejov

- **Millimeter**: NOEMA (9), ALMA (5)

Black body emission

- UV/Optical/NIR well described with a hot black body

- Temperature decreasing from 30 000 K to 12 000 K

- Radius decreased from 10^{15} to 10^{14} cm (70 to 7 AU)

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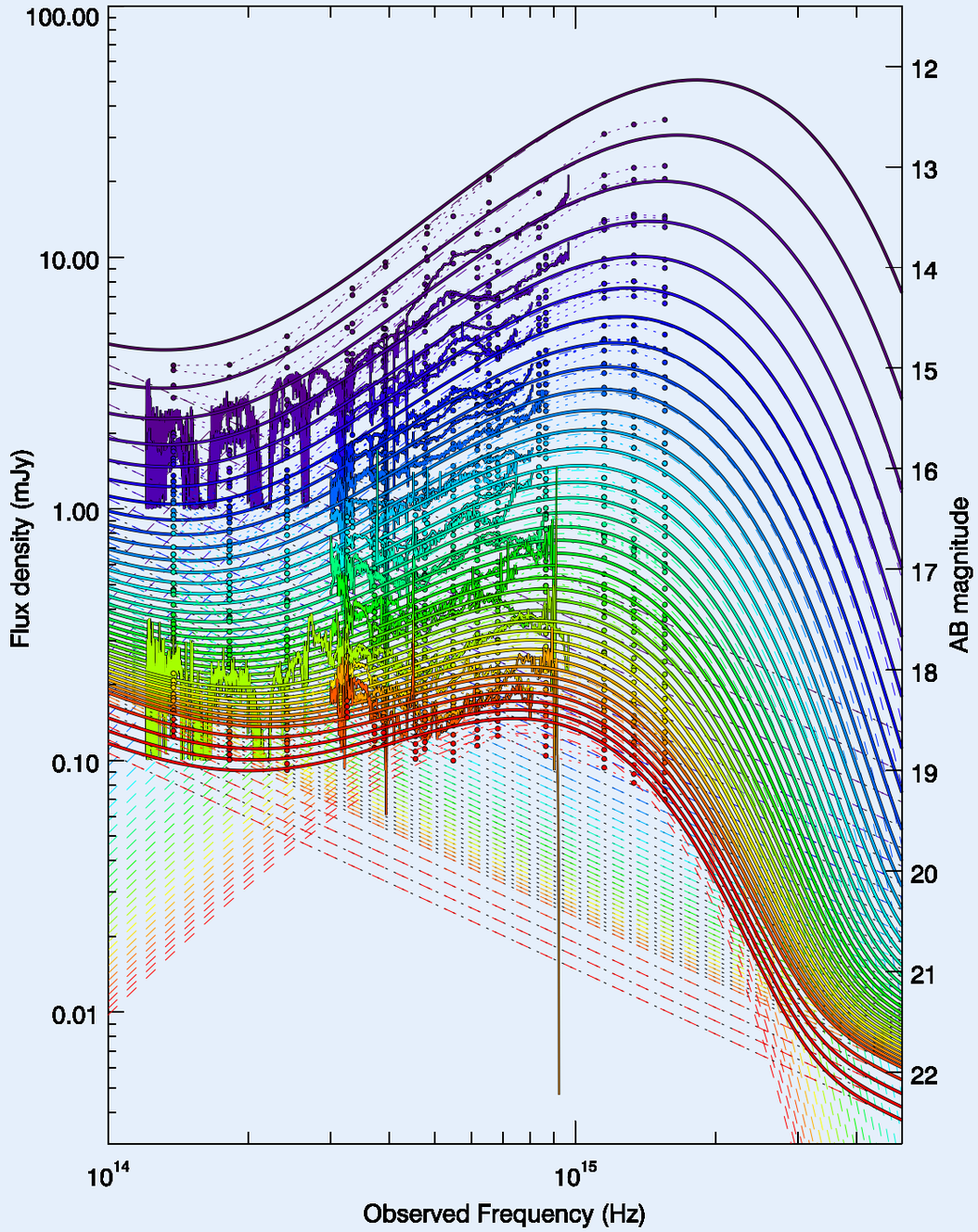

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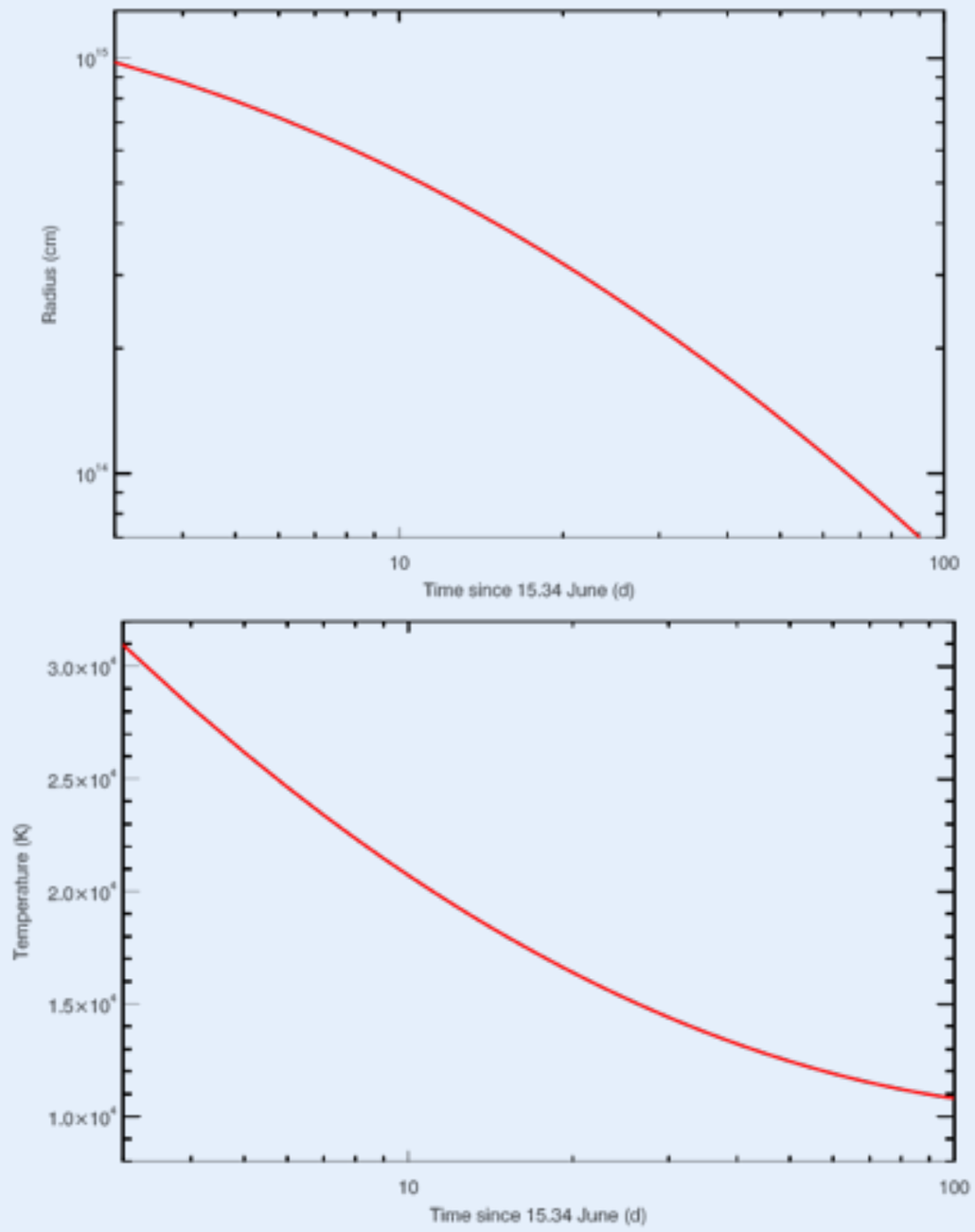
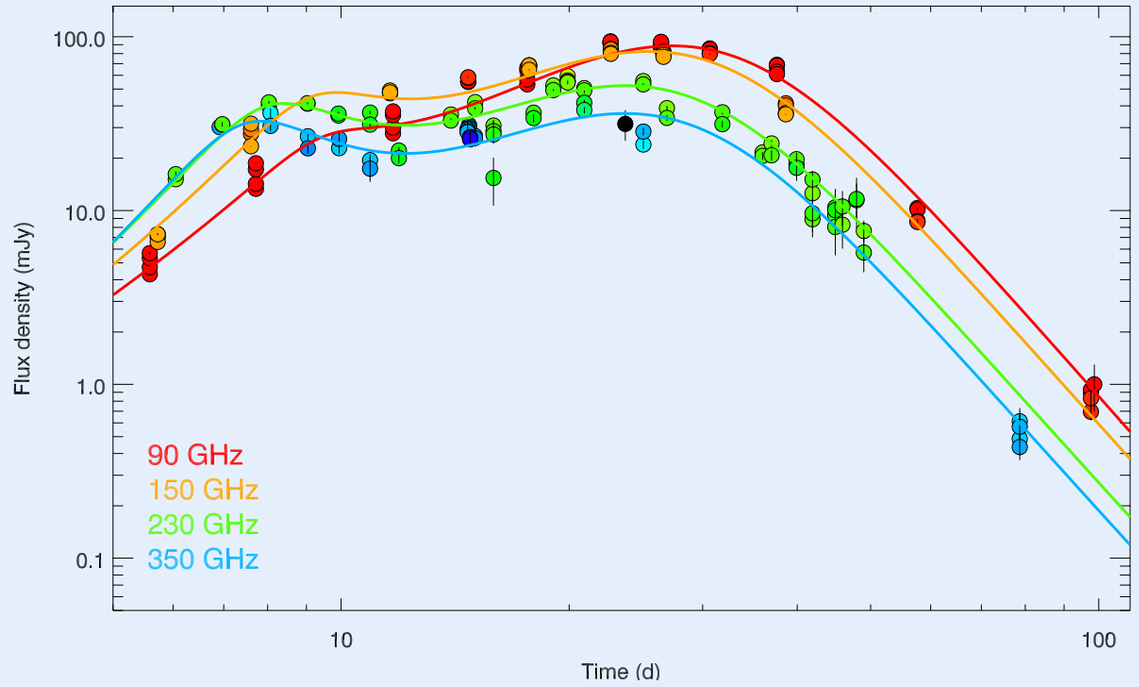
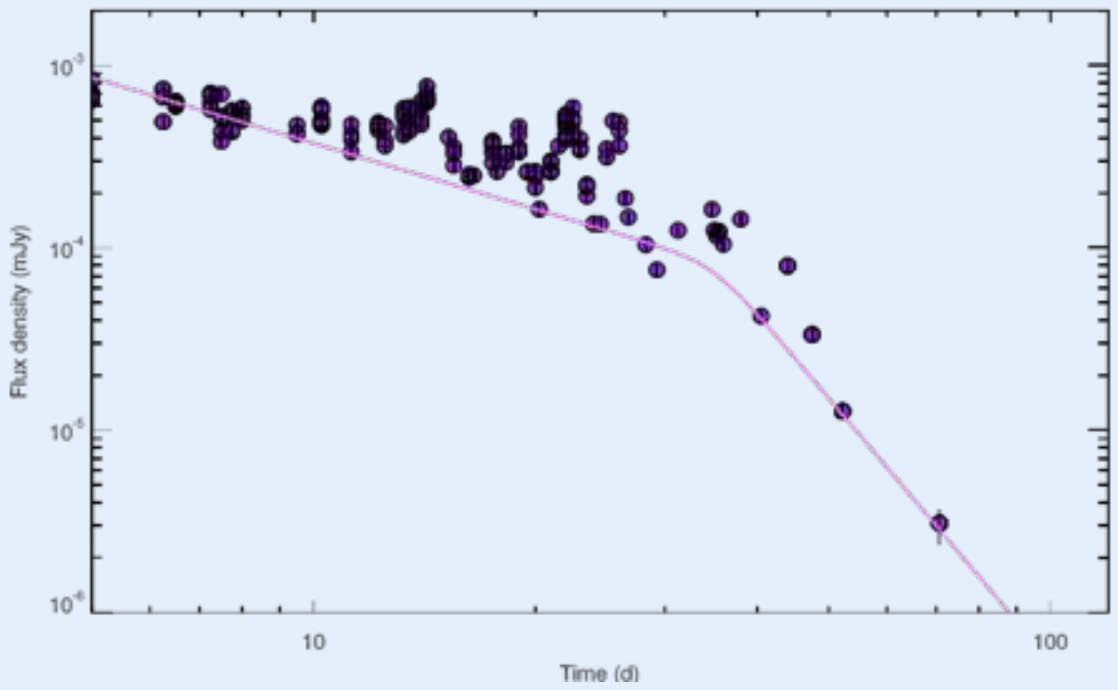


Broad-band component

- Detection of X-ray emission (Rivera Sandoval, ATel#11737) with flaring episodes
- Detection of a bright mm counterpart (de Ugarte Postigo et al., ATel#11749)
- Are they linked?
- Spectral slopes don't seem to match
- At late time, both decay in a similar way





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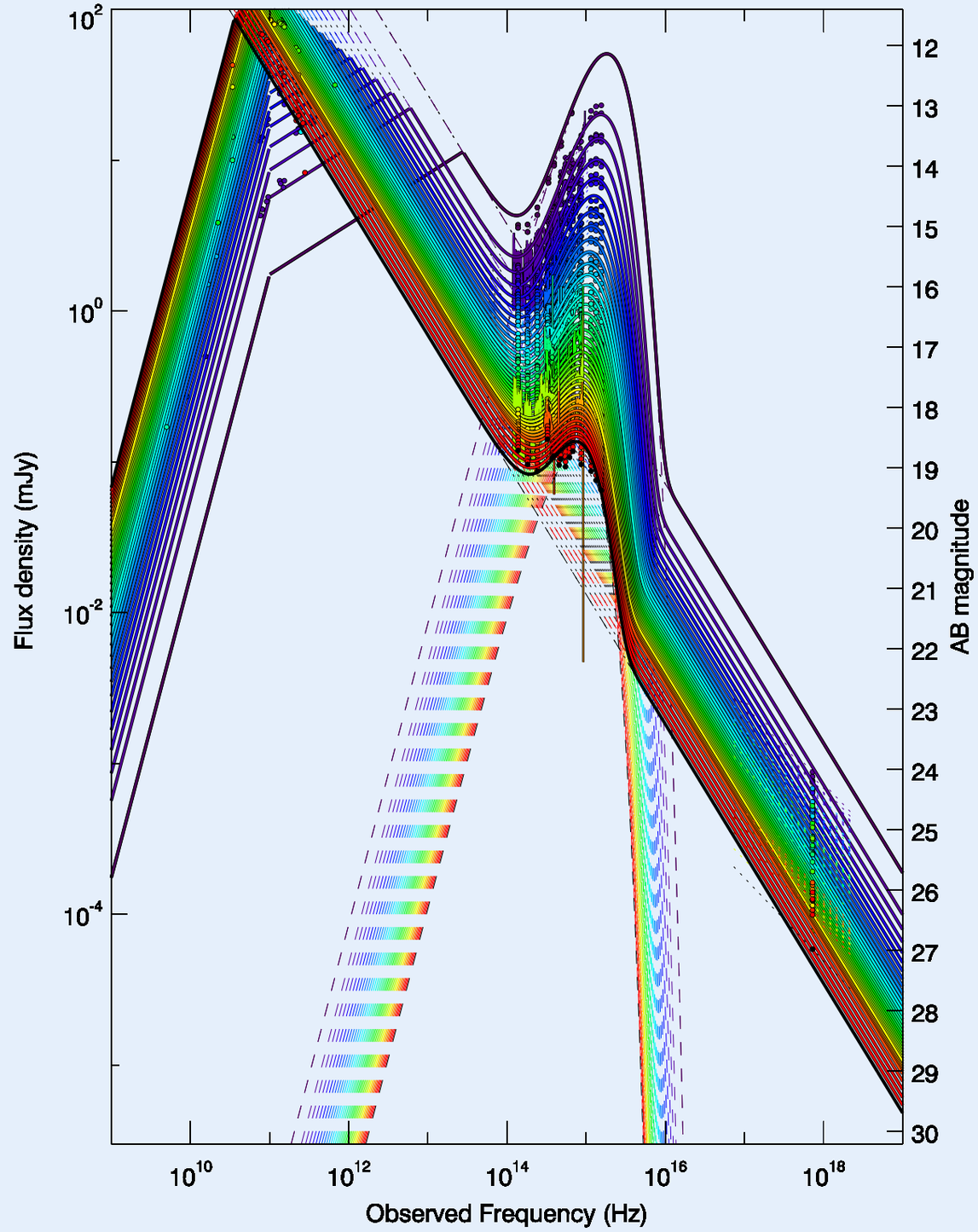
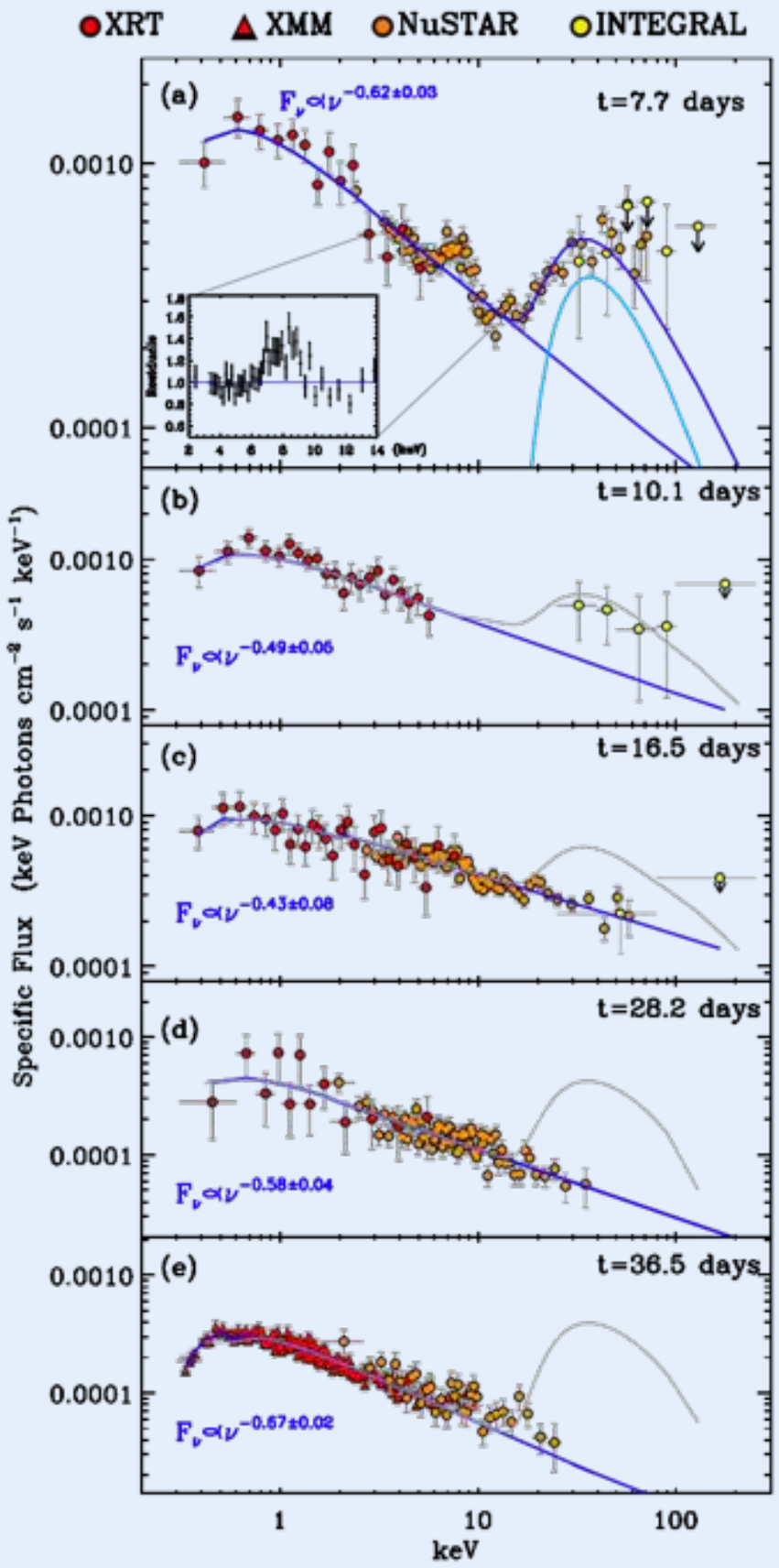


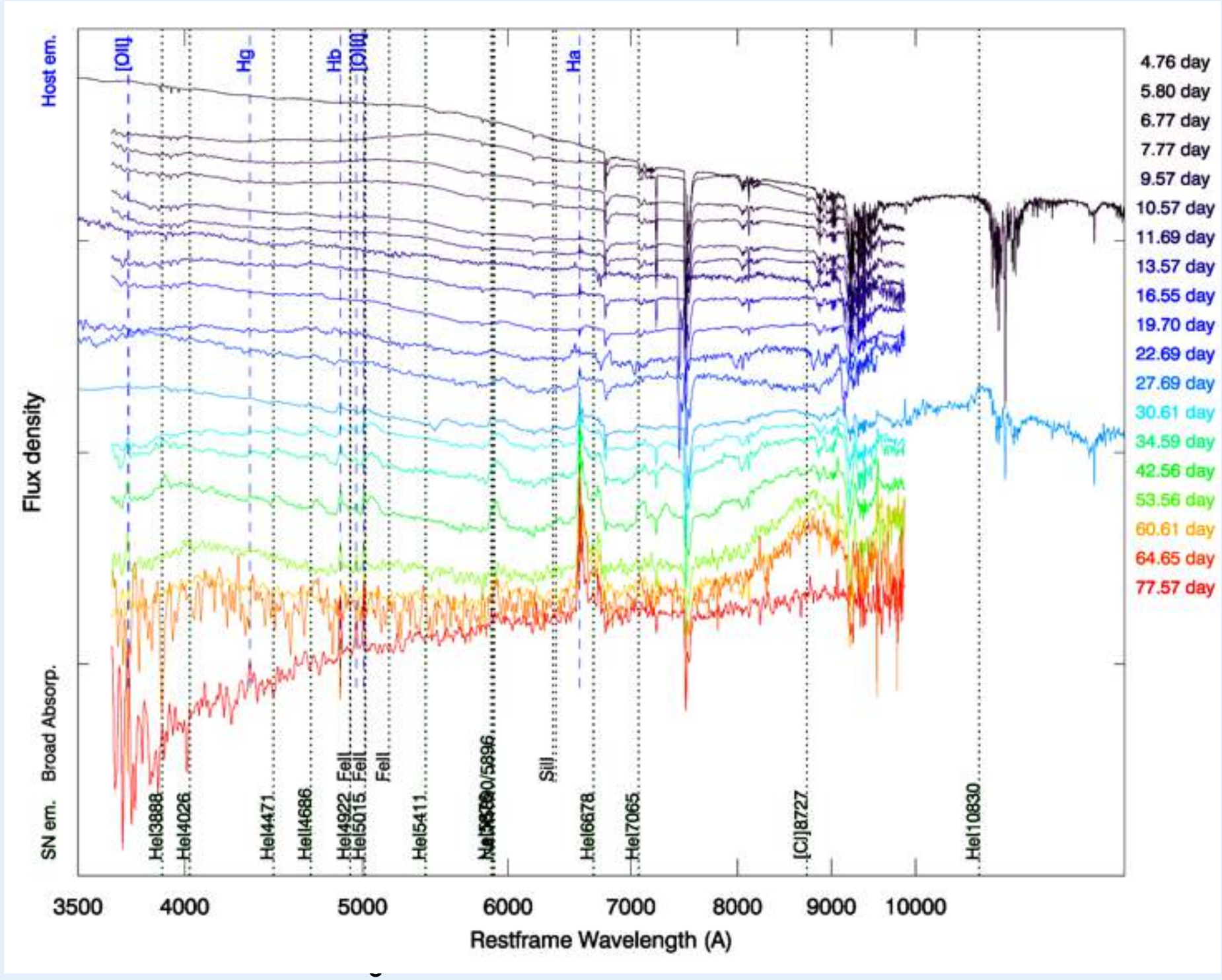


Hard X-ray component

- A hard X-ray component was detected using NuSTAR and INTEGRAL (Margutti et al.)
- Observations covering between 0.3 and 100 keV (also XRT + XMM)
- Significant only during the first days.
- Possible Fe K-alpha emission (typical in accretion disks and interacting SNe)
- Excess at E >10 keV (Compton hump?)

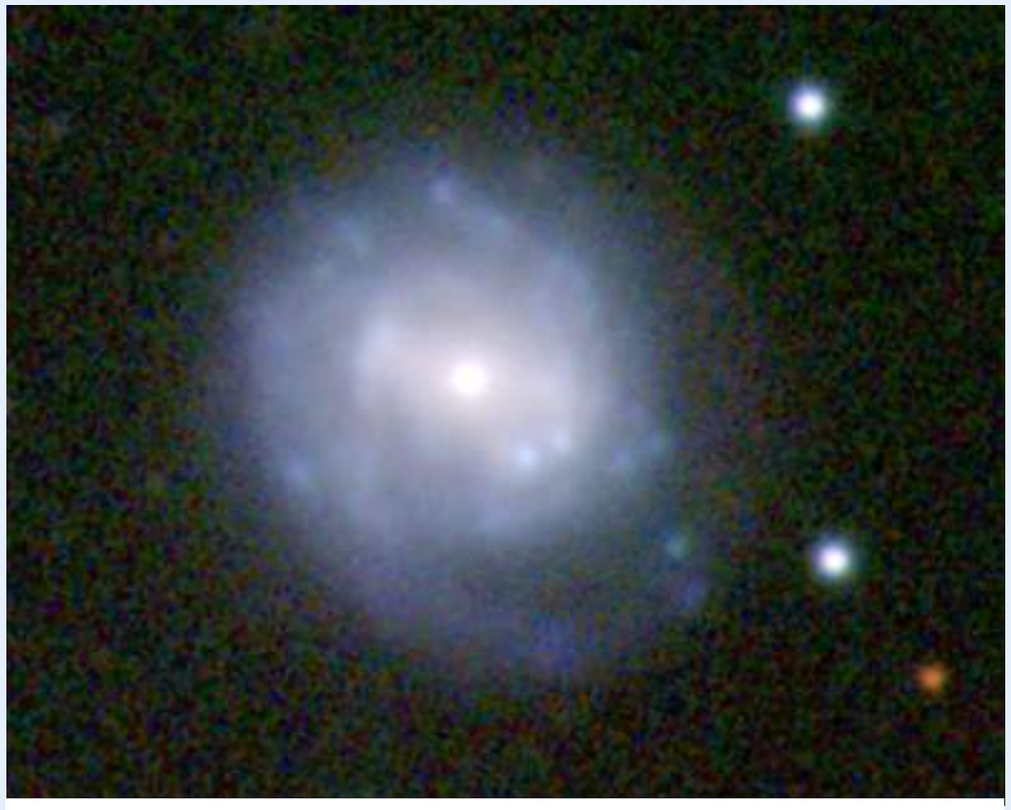
Spectral evolution

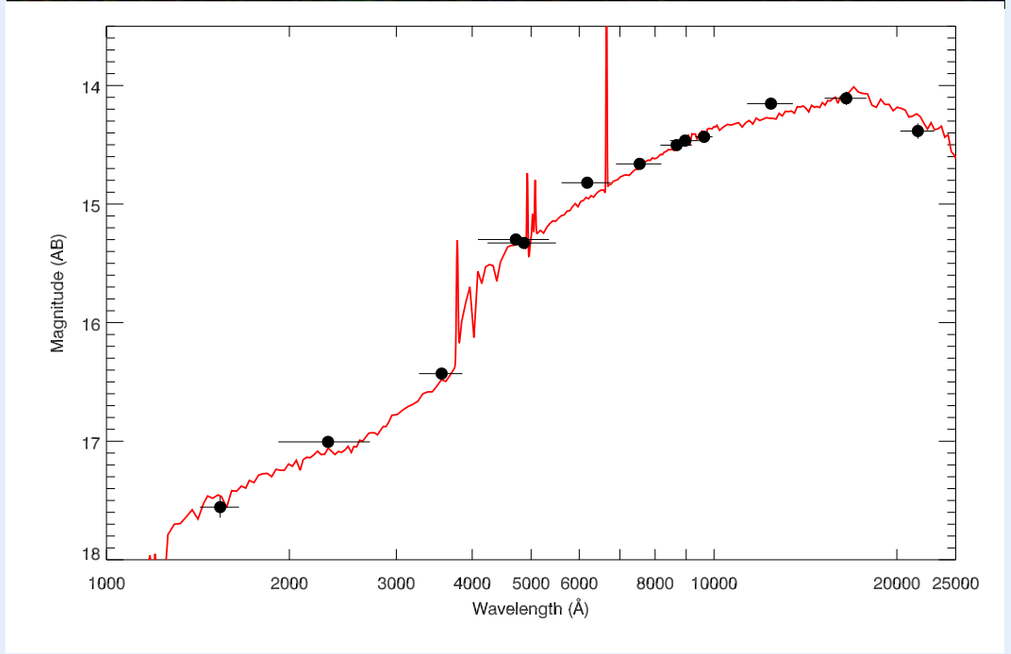
- Very broad features at early times (first 10 days)
- Emission features appear at day 13, strengthen until day 42, disappear at day 50
- Broad [CI] feature developing at 8800 Å between 40 and 70 days



Host galaxy

- Star forming barred spiral:
  - Mag = -18.66
  - Age = $2.00_{-0.36}^{+0.07}$ Gyr
  - Mass = $1.51_{-0.16}^{+0.15} \times 10^9$ $M_\odot$
  - SFR = $1.19_{-0.11}^{+0.29}$ $M_\odot$/yr
  - Z ~ 70% Solar (shallow gradient)
- HST UV observation
- CO detection





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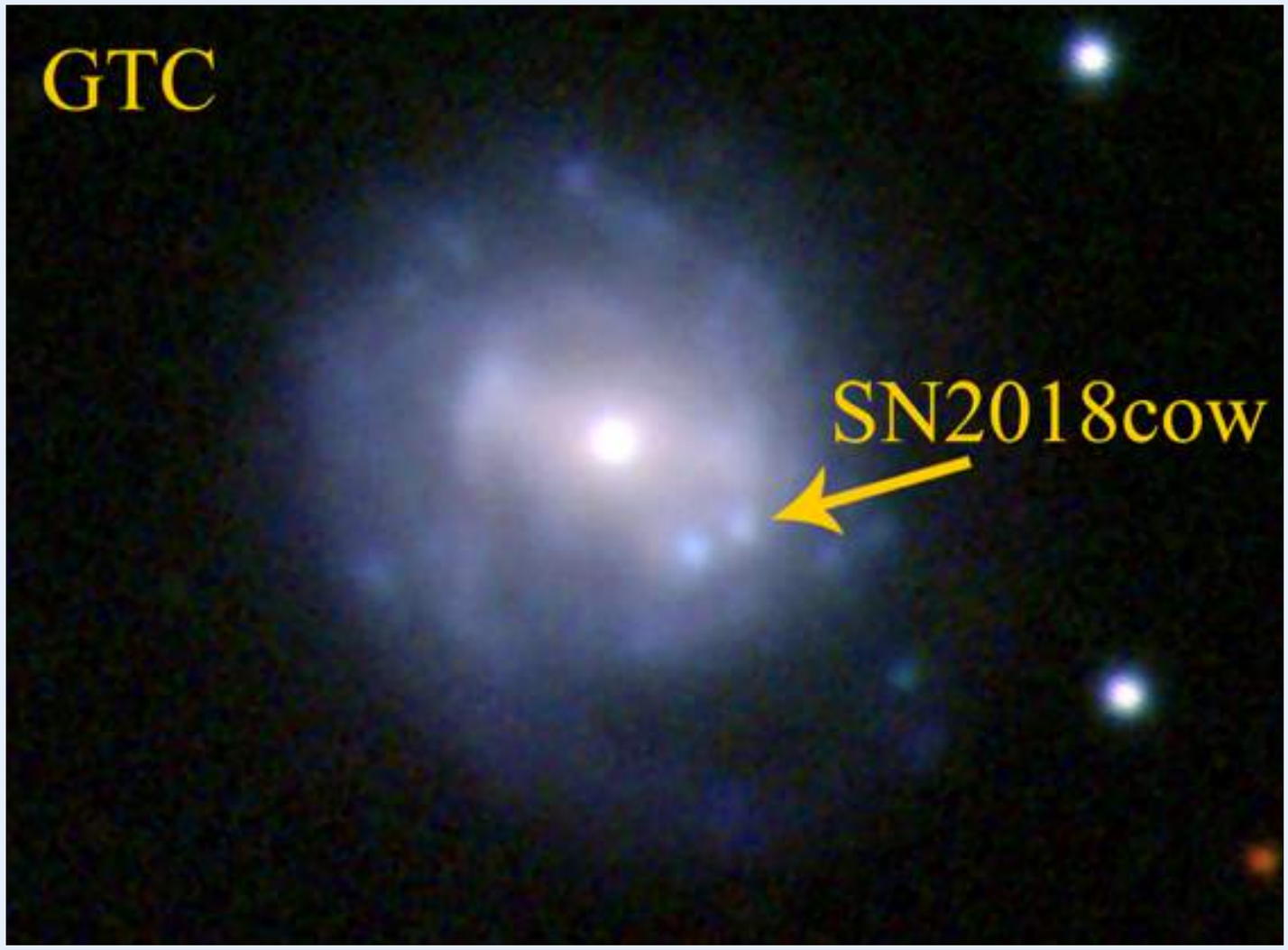

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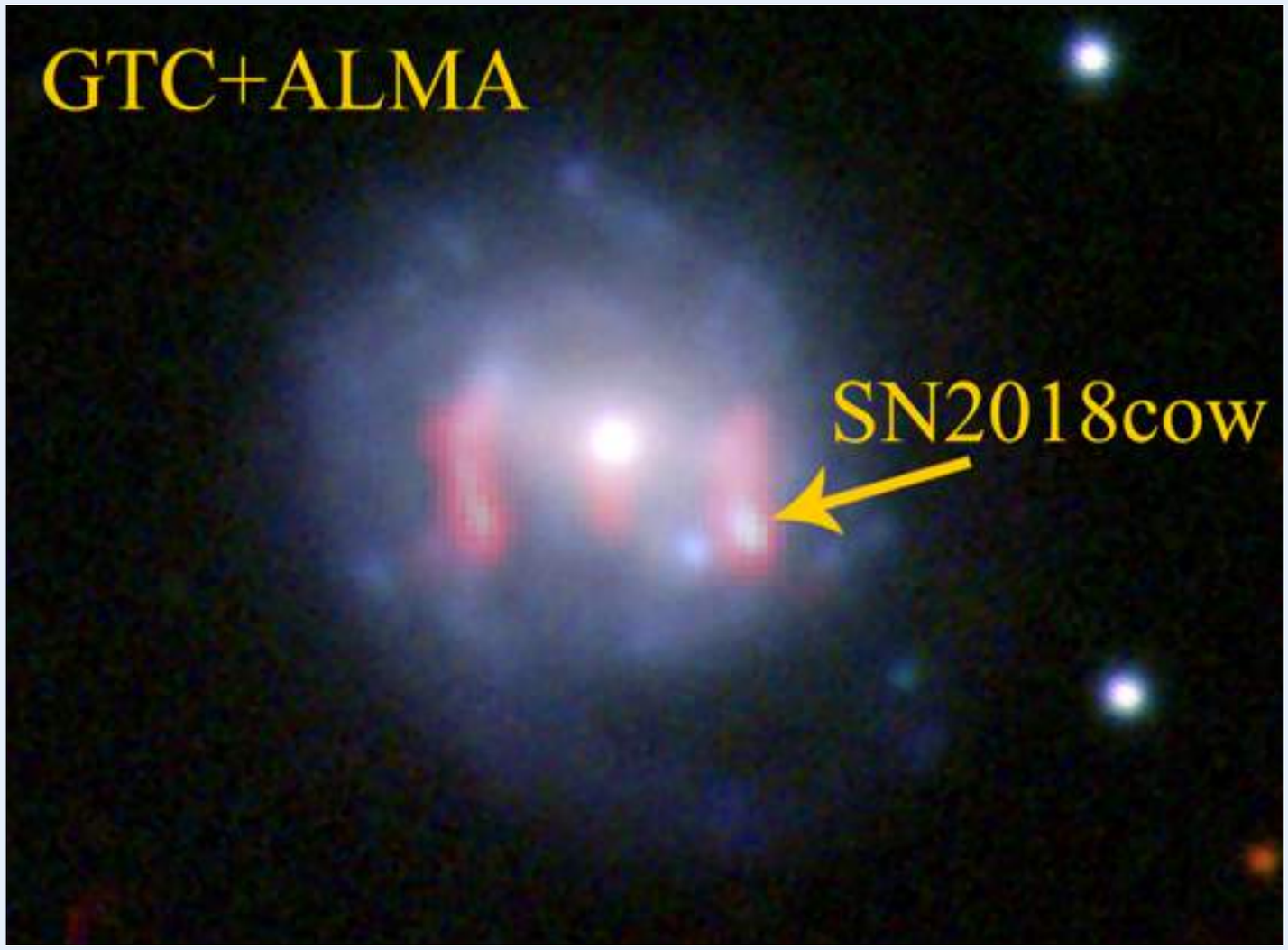

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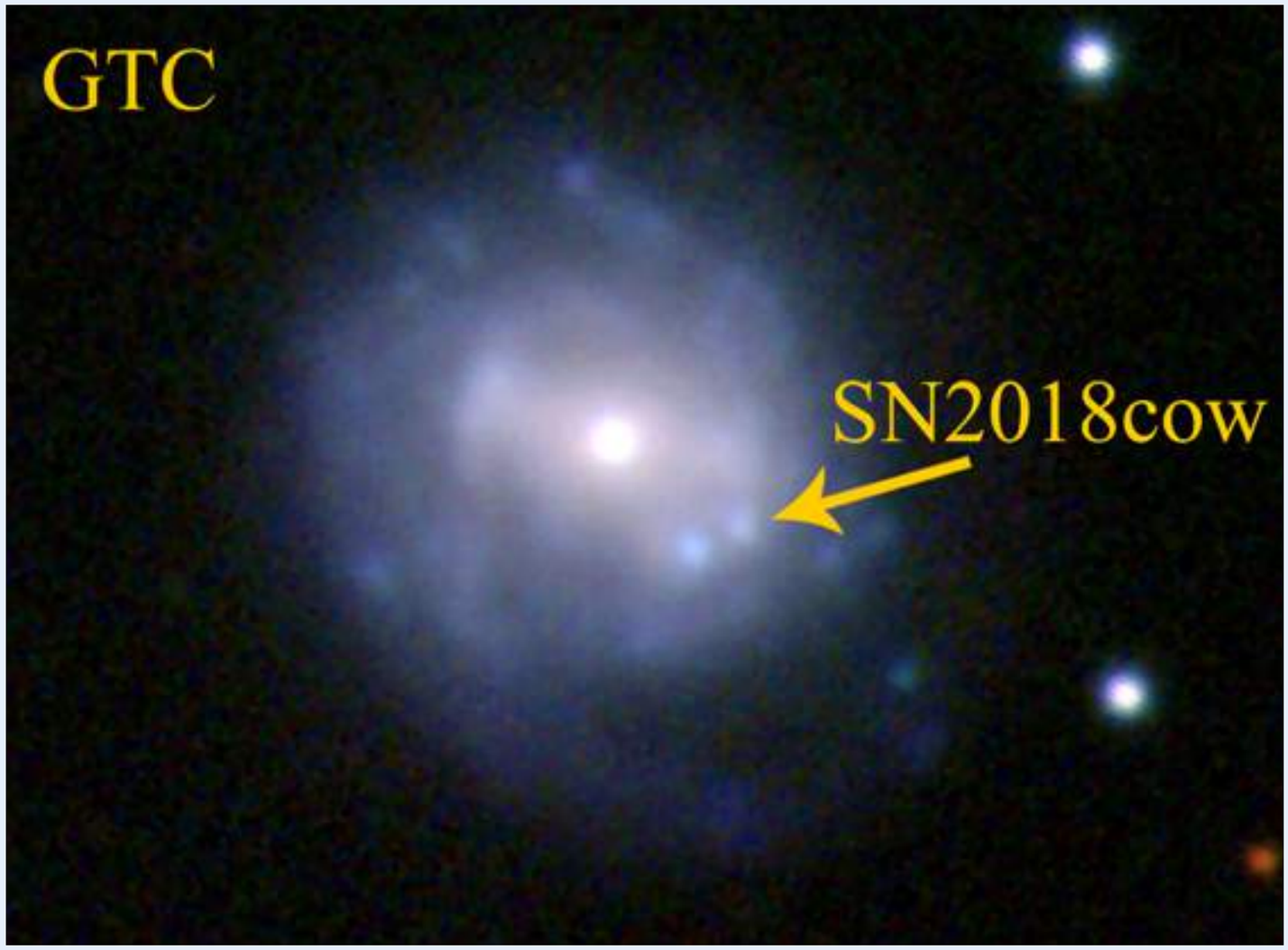

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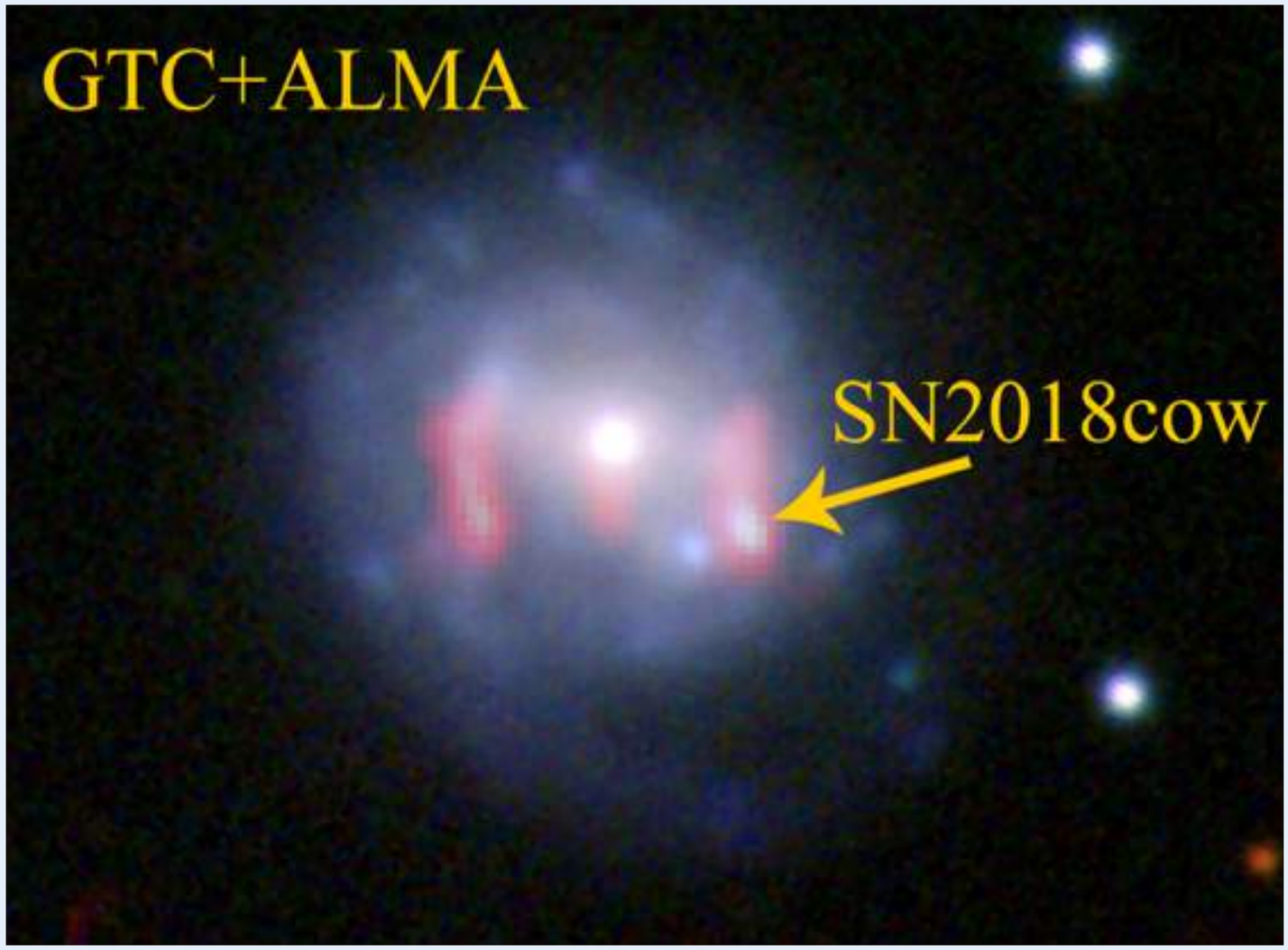
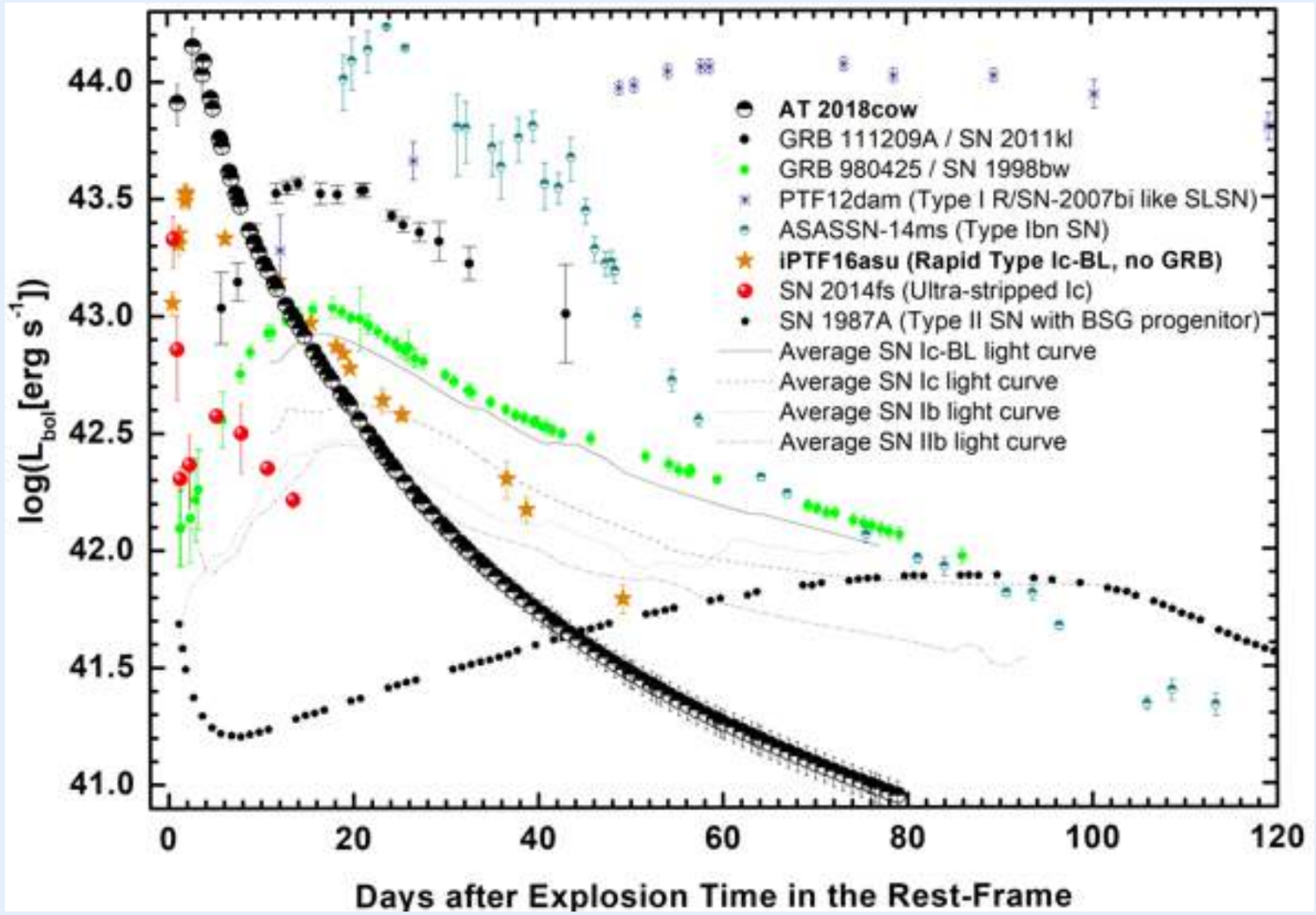


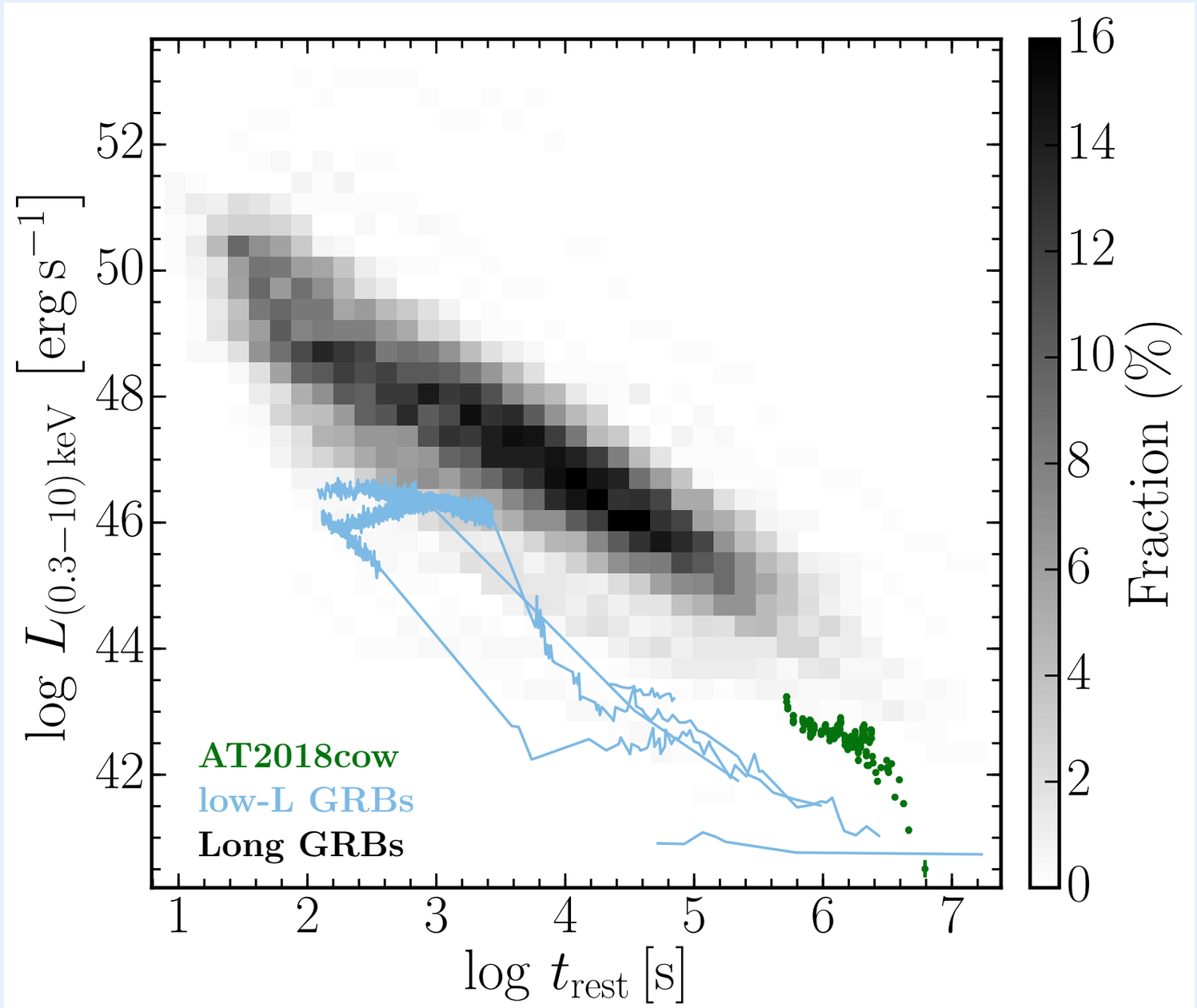
Comparisons: Optical

- Extreme peak luminosity (like SLSNe)
- Very fast rise time
- Very fast decay (not compatible with ^{56}Ni powered emission)
- Observed emission dominated by black body



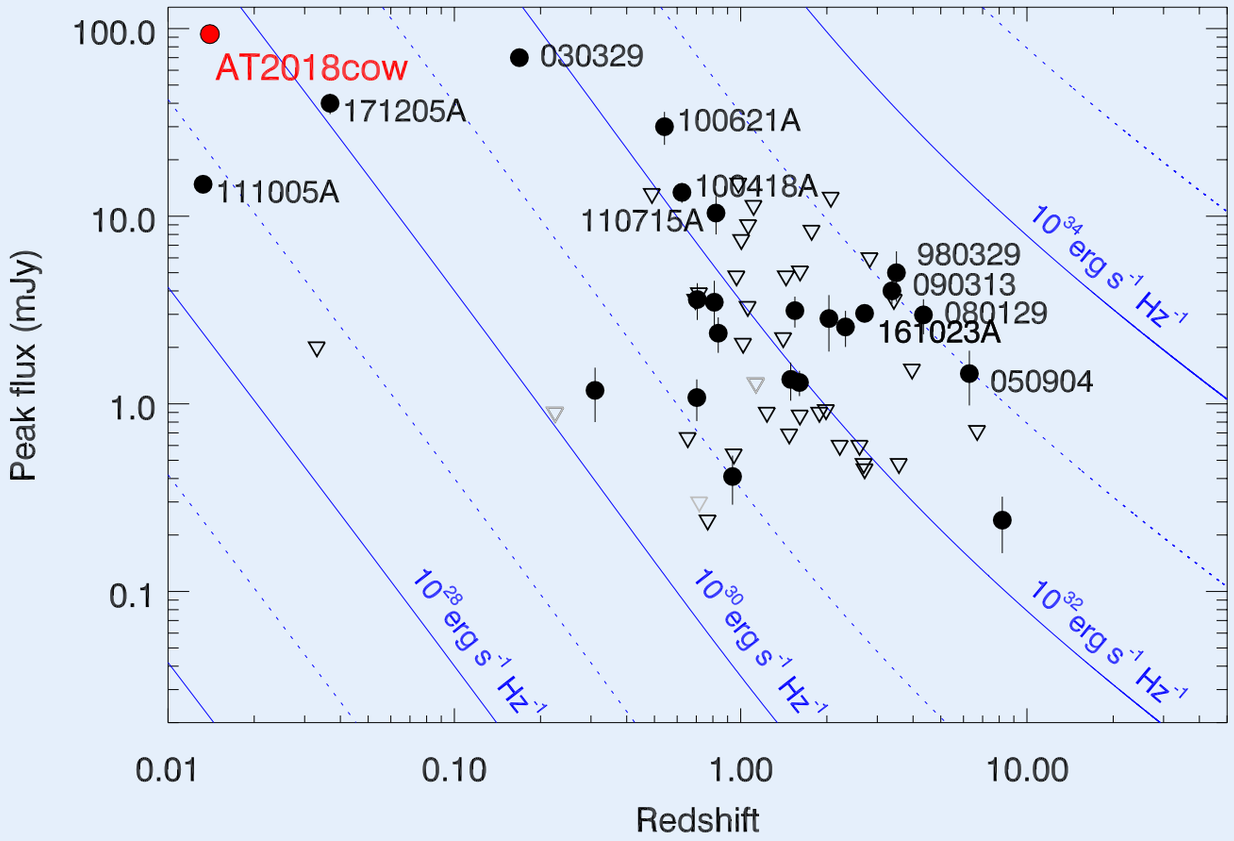
Comparisons: X-ray

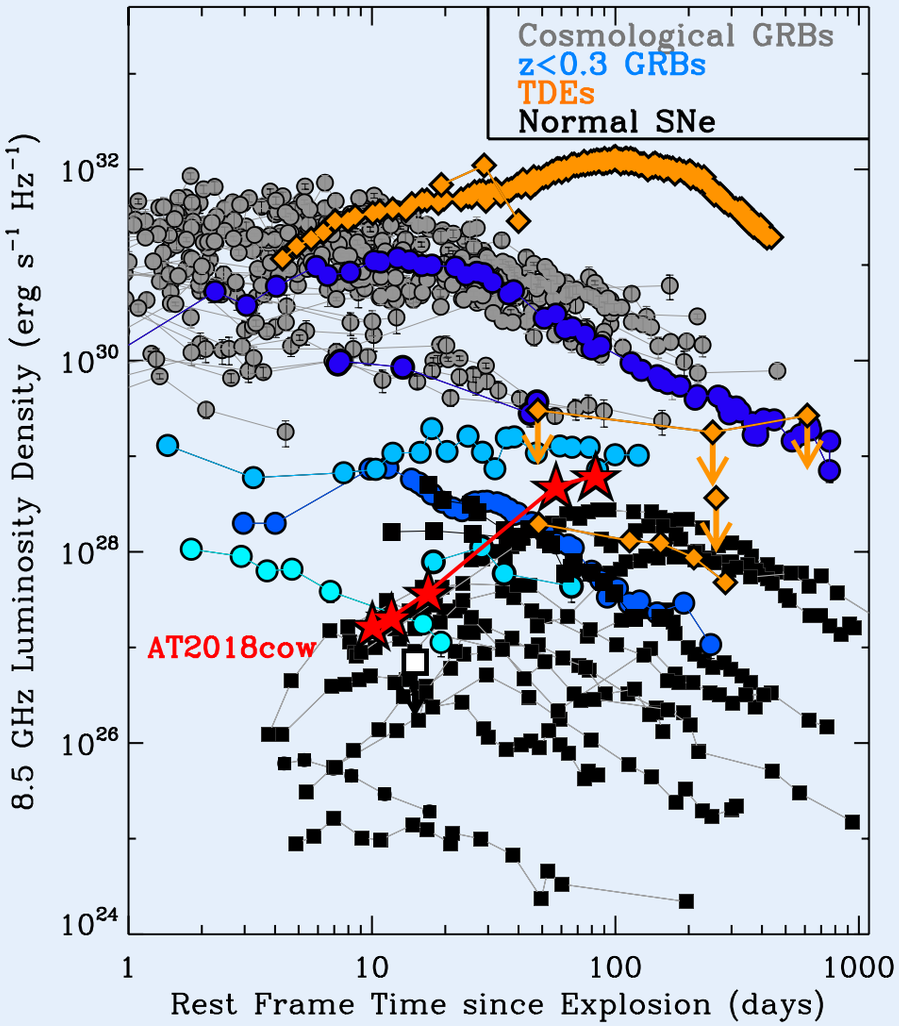
- Consistent in luminosity with GRB afterglows
- But late decay is faster than any GRB
- Brighter than SNe



Comparisons: Radio

- Similar to low luminosity GRBs, both in radio and millimetre wavelengths.
- More luminous than SNe (especially in millimetre)





Margutti et al. 2018

Progenitor models

- *Prentice et al.:*
  - **Magnetar** in a **binary neutron star merger**
- *Rivera Sandoval et al.:*
  - Some type of SNe **ejecta interacting with an LBV-like ejecta**
- *Perley et al.:*
  - **Relativistic jet** within a **fallback supernova**
  - **Disruption** or a star by an **intermediate-mass black hole**
- *Kuin et al.:*
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Summary

- Rise time ~3.5 d
- Very fast ejecta (~0.1c)
- Black body that cools from 30 000 to 10 000 K and shrinks from 10^{15} to 10^{14} cm
- Spectral features: Early broad features, He/H emission lines, 8800 Å feature.
- Radio and millimetre emission
- X-ray emission, including flaring
- Hard X-ray component
- In a star forming galaxy, within a star forming region, with abundant CO