Daniele Bjørn Malesani

DAWN/NBI (HEAVYMETAL) and Radboud Univ.

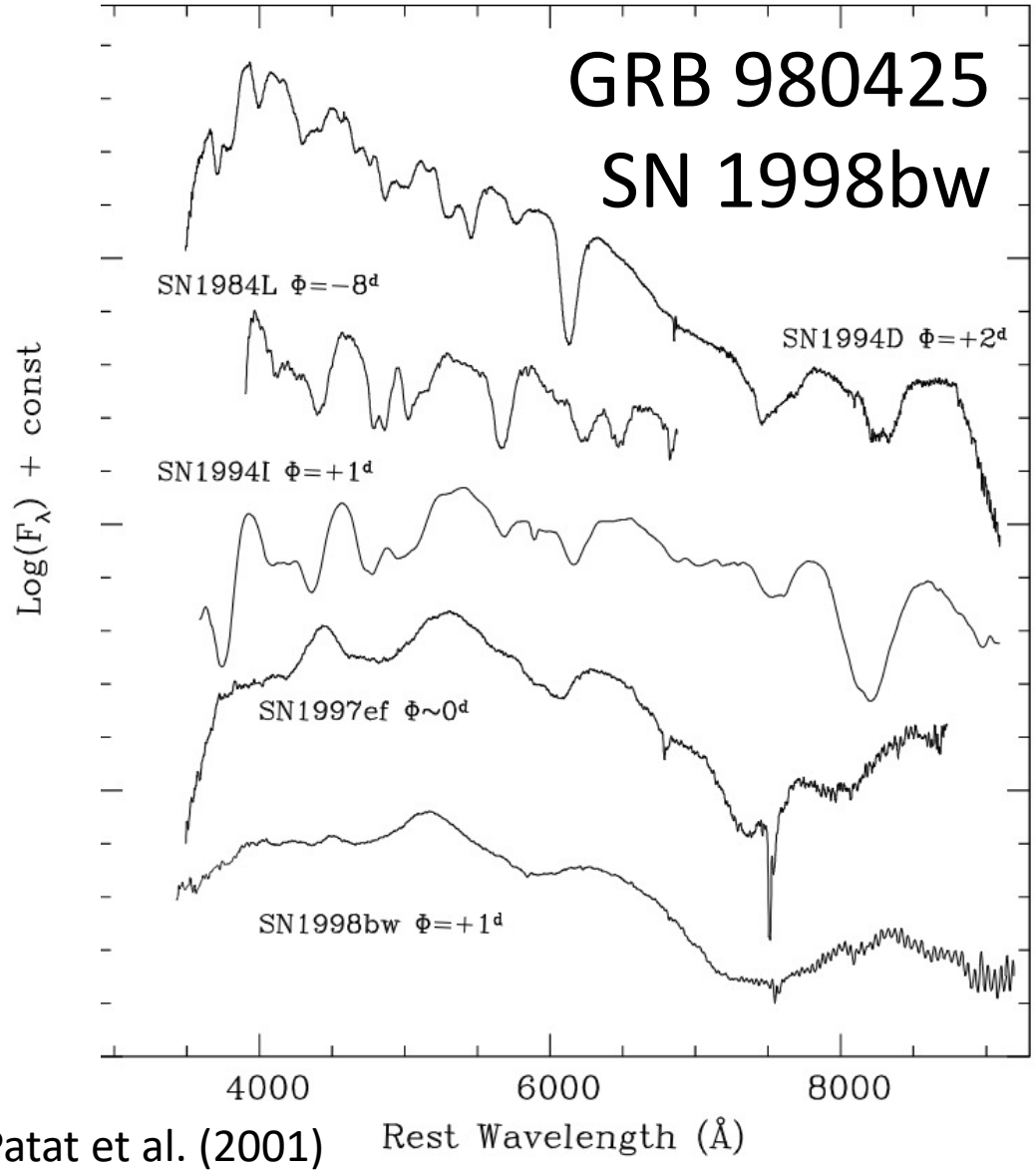
A JWST survey of gamma-ray bursts supernova progenitors

Andrew Levan
Antonio Martin-Carrillo
Benjamin Gompertz
Benjamin Schneider
Luca Izzo

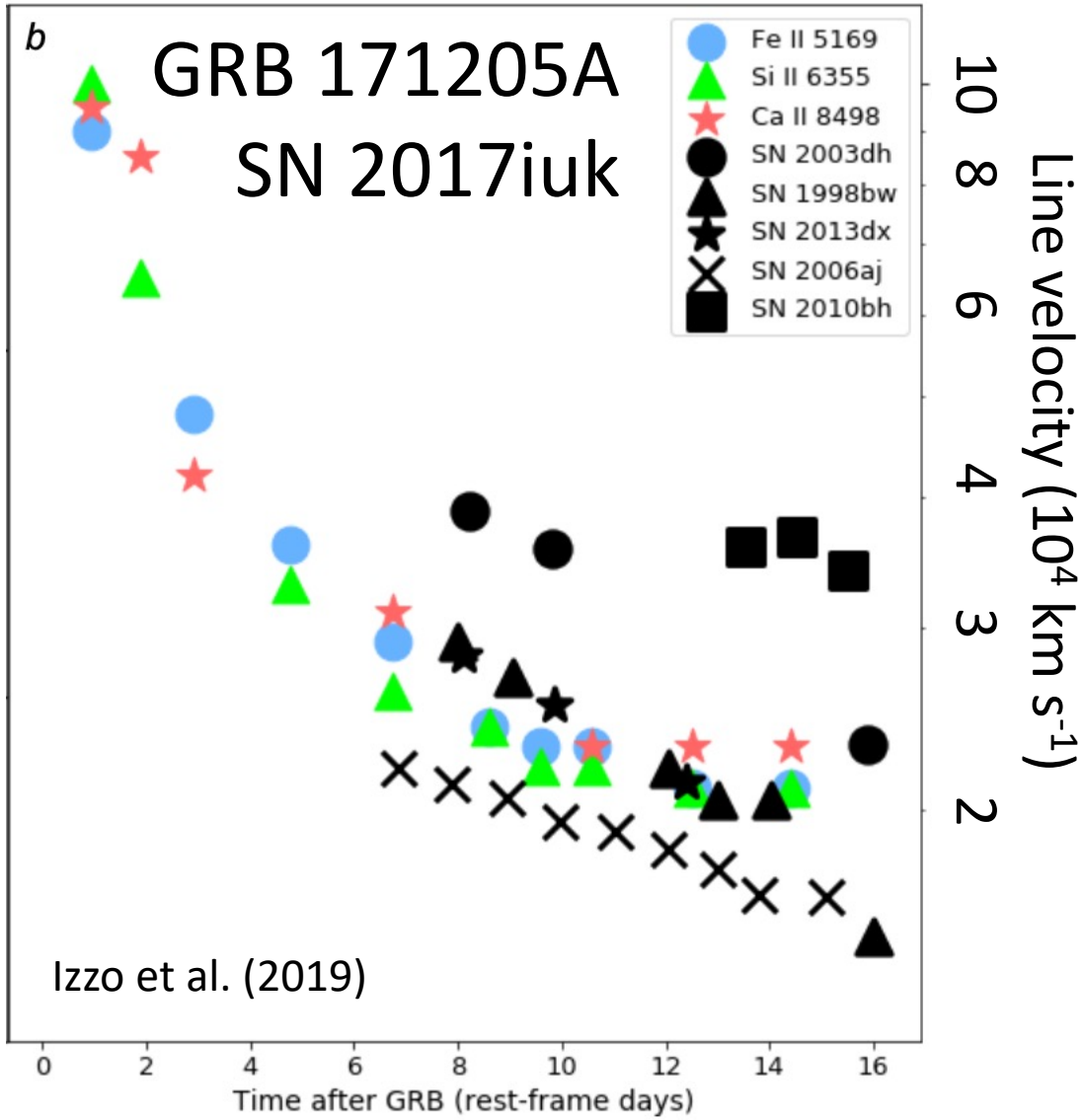
K. Ackley, E. Burns, V. D'Elia, M. De Pasquale, A. de Ugarte Postigo, Dimple, A. S. Fruchter, J. Hjorth, L. Izzo, P. Jakobsson, P. G. Jonker, G. Lamb, T. Laskar, E. Le Floch, I. Mandel, M. Nicholl, S. Oates, J. T. Palmerio, G. Pugliese, M. E. Ravasio, A. Rossi, A. Rouco Escorial, A. Roychowdhury, R. Salvaterra, N. Sarin, N. R. Tanvir, C. C. Thöne, J. van Dalen, A. van Hoof, D. Watson

Credit: Facebook, Maria Teresa & Avet (?)

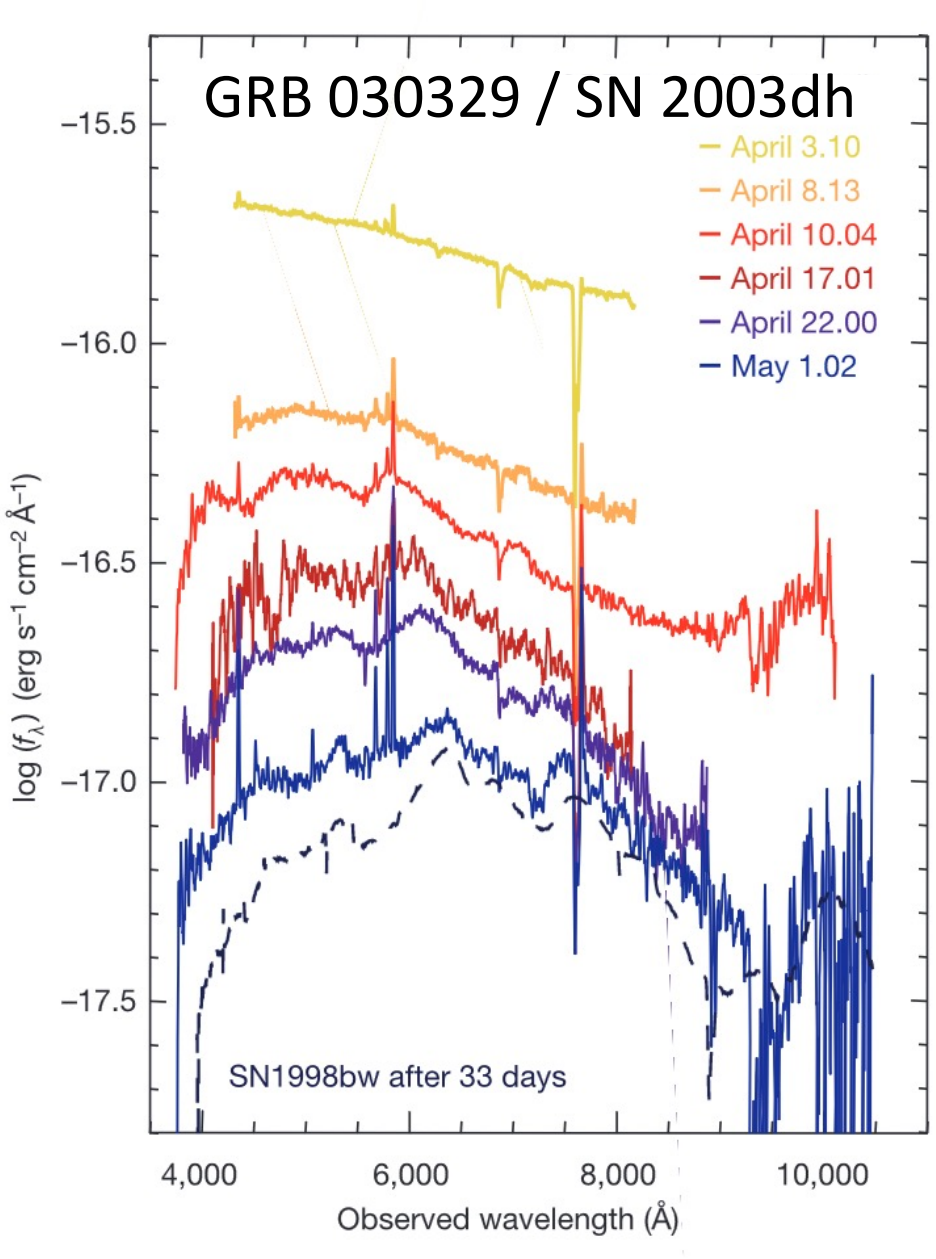
The “long” GRB – SN connection



Patat et al. (2001)

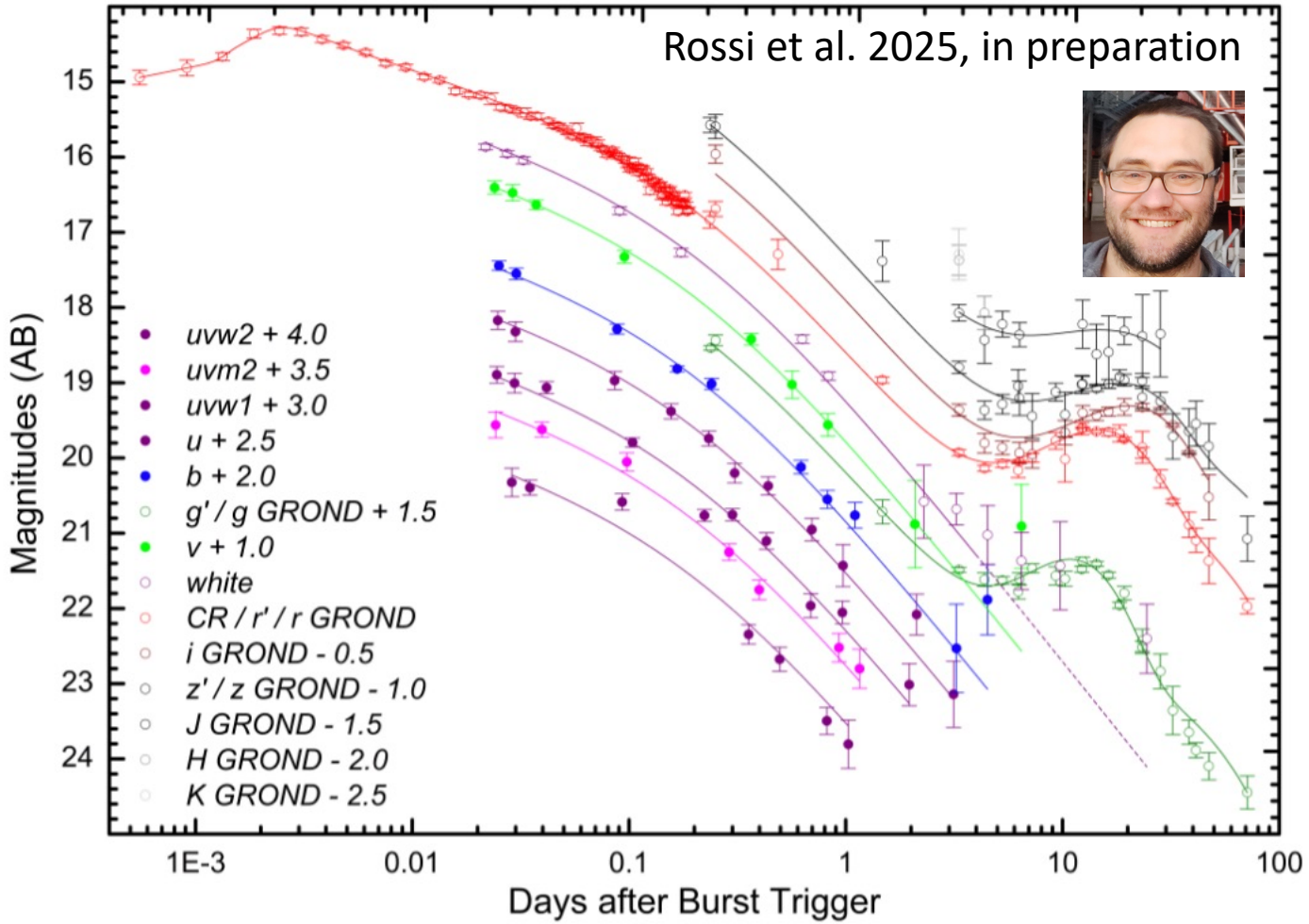


The “long” GRB – SN connection

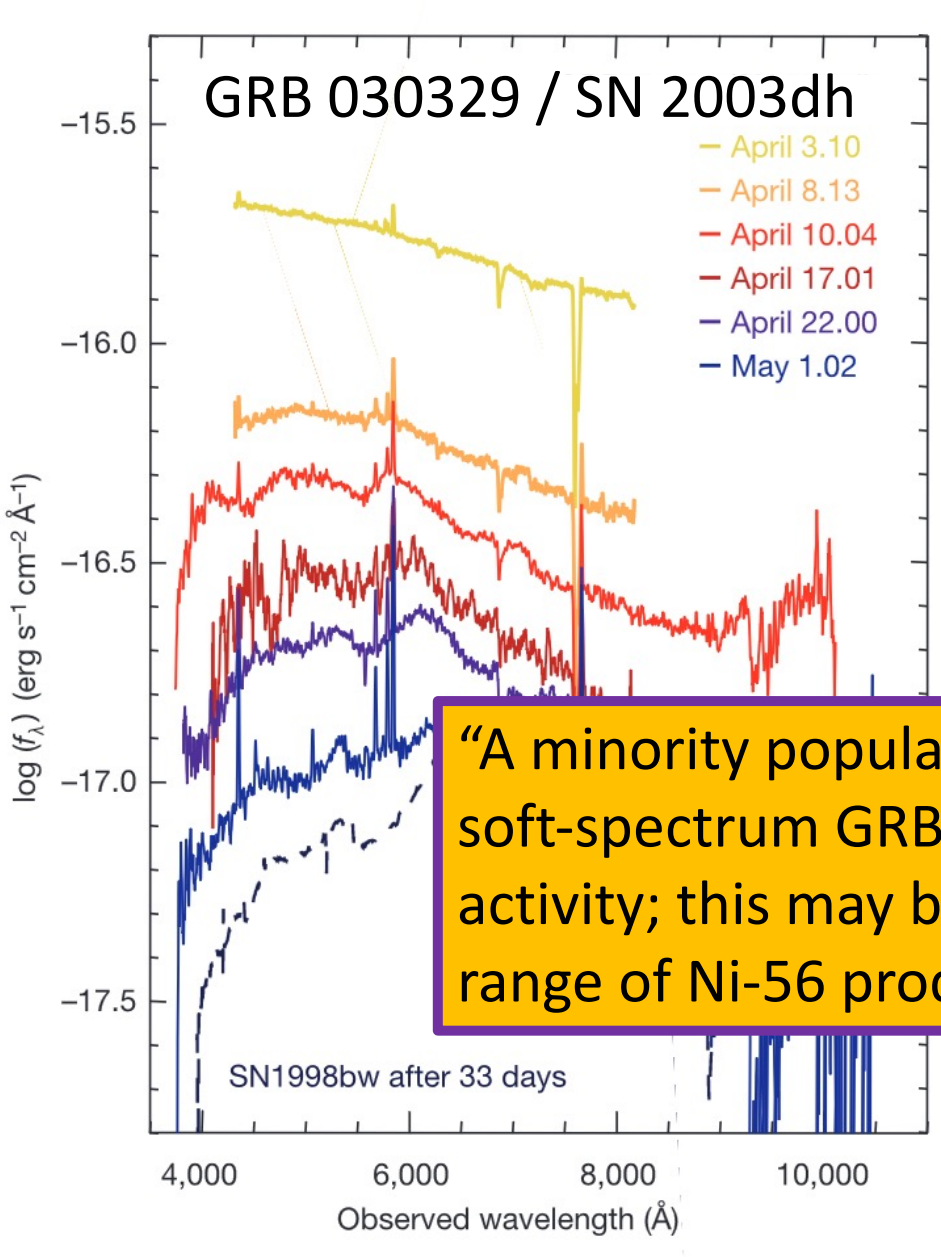


Hjorth et al. (2003), see also Stanek et al. (2003)

GRB 180728A / SN 2018fip

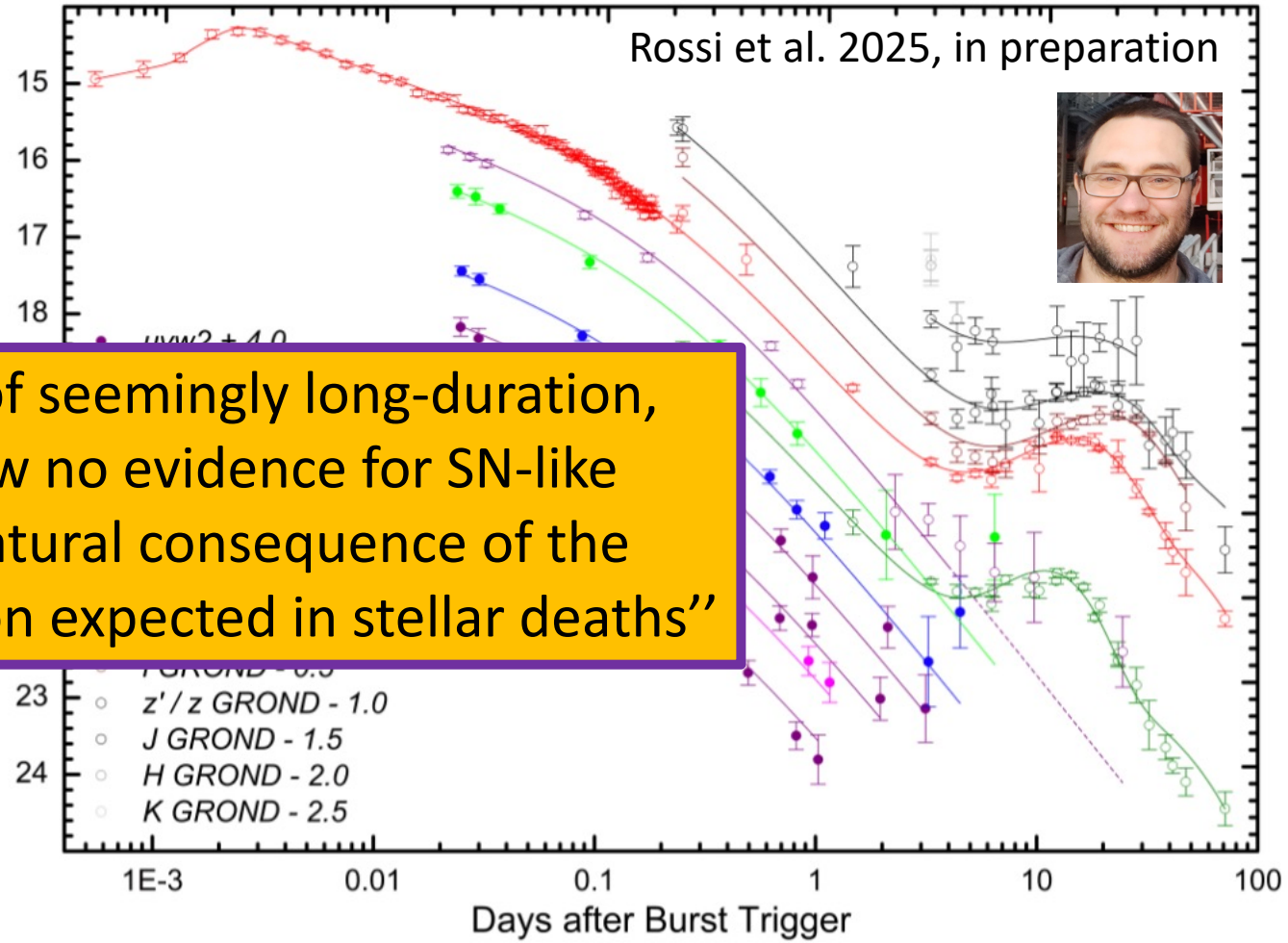


The “long” GRB – SN connection



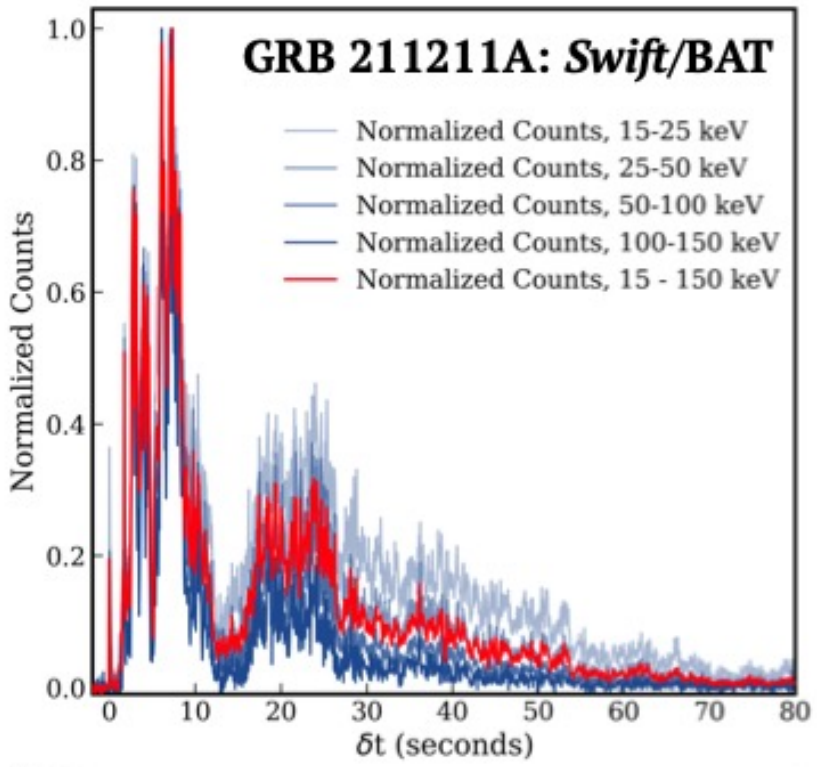
Hjorth et al. (2003), see also Stanek et al. (2003)

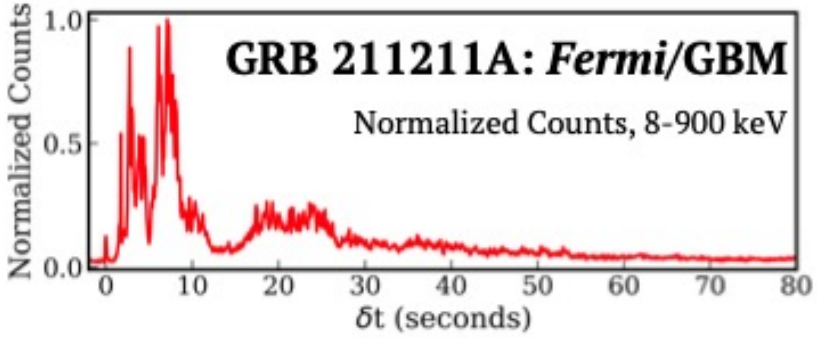
GRB 180728A / SN 2018fip

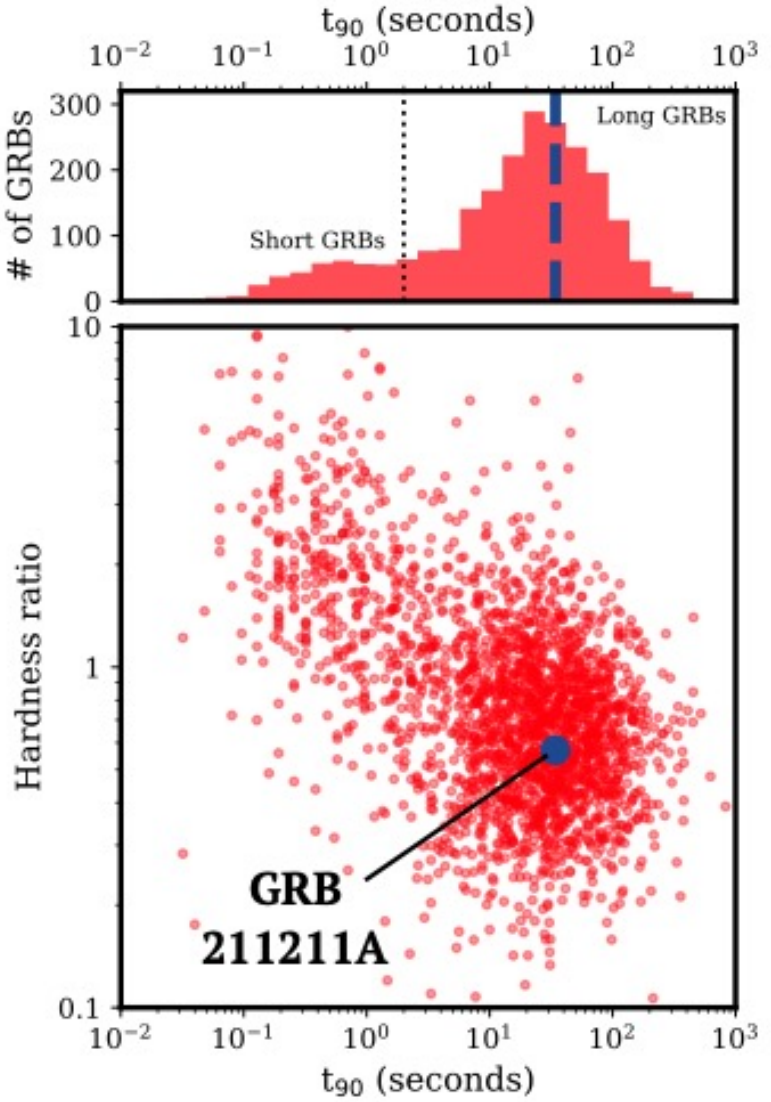


“A minority population of seemingly long-duration, soft-spectrum GRBs show no evidence for SN-like activity; this may be a natural consequence of the range of Ni-56 production expected in stellar deaths”

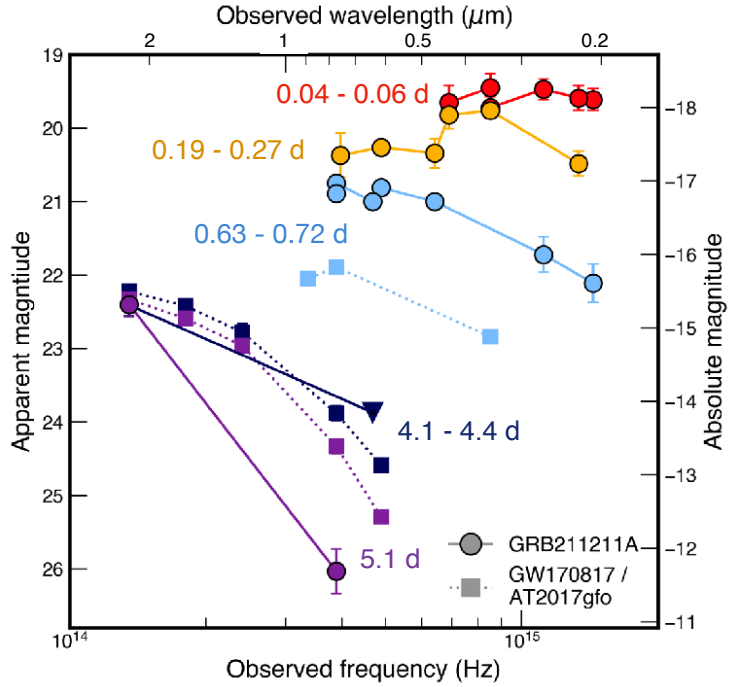
A broken paradigm (1)







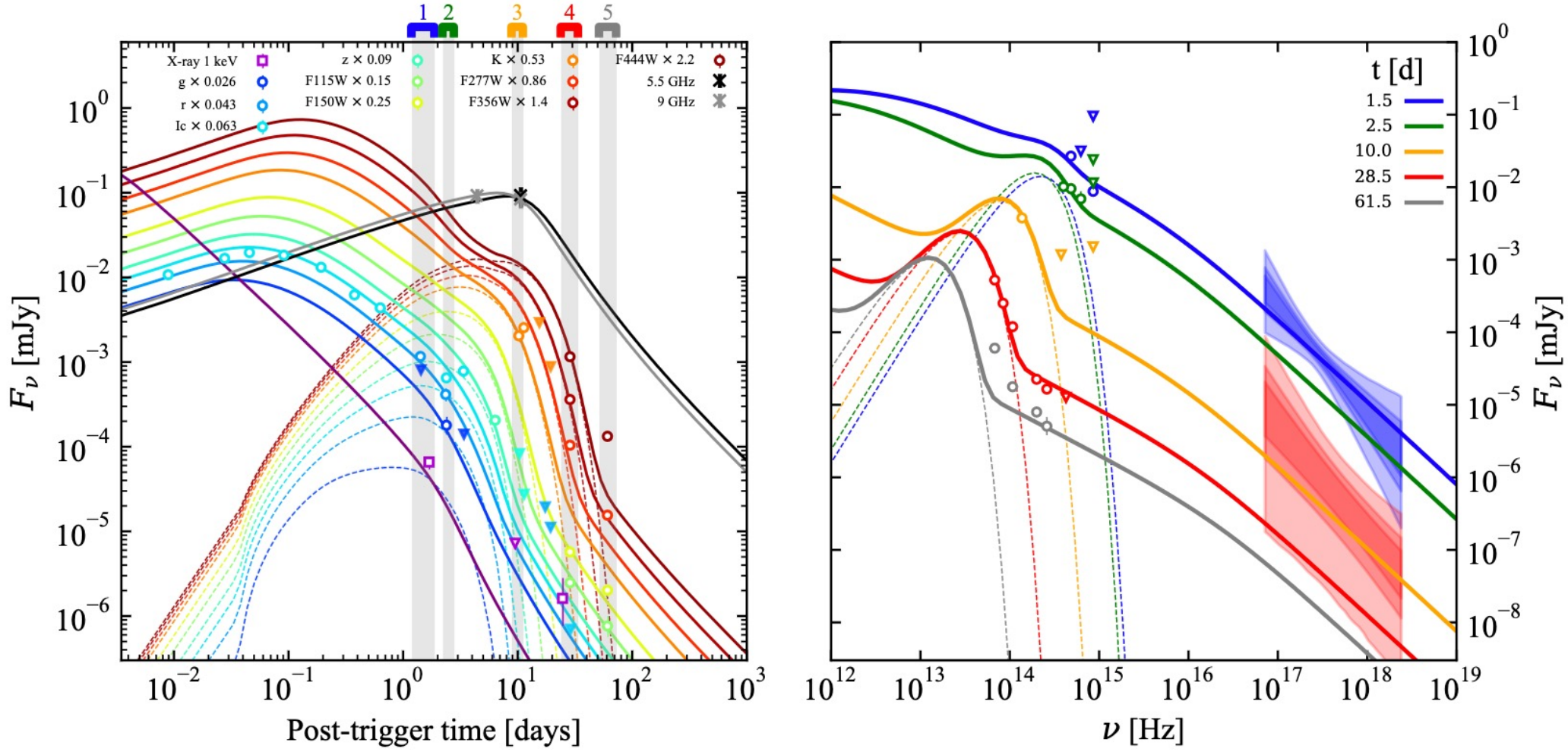
A long GRB (50 s) with no SN and KN evidence



Rastinejad et al. (2022), Troja et al. (2022), Yang et al. (2022), Mei et al. (2022), Gompertz et al. (2022)

A broken paradigm (2)

Long GRB 230307A at z = 0.065 with associated kilonova (photometric and spectral evidence)



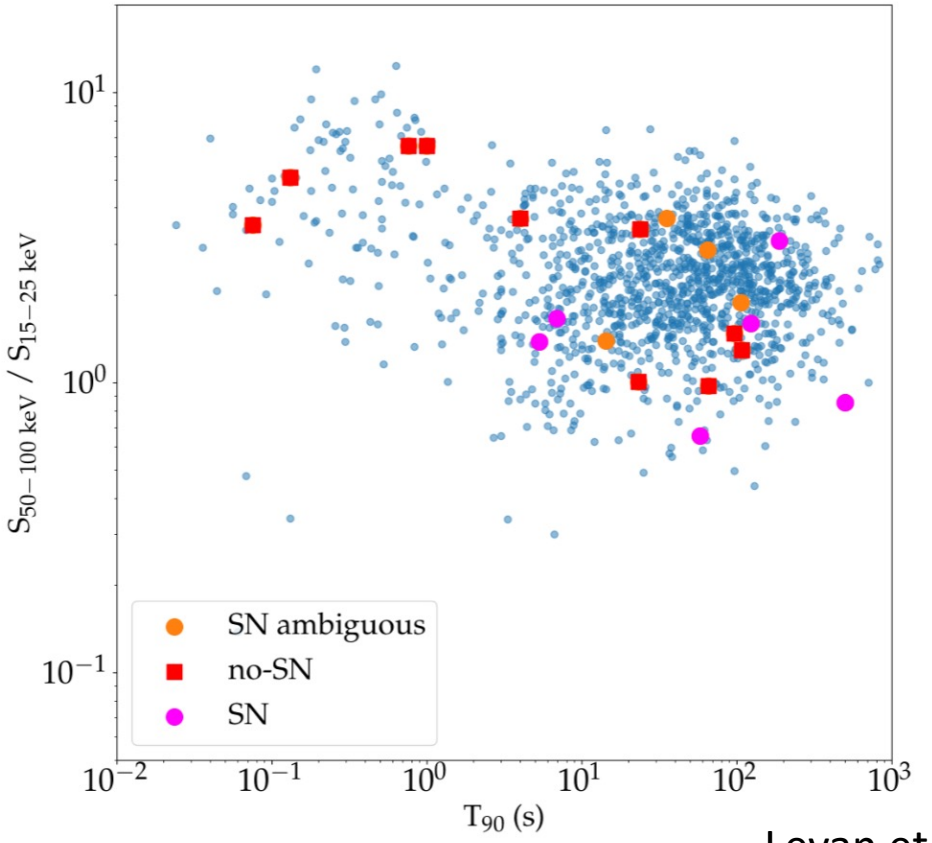
Levan et al. (2024), Yang et al. (2024), Gillanders & Smartt (2025)

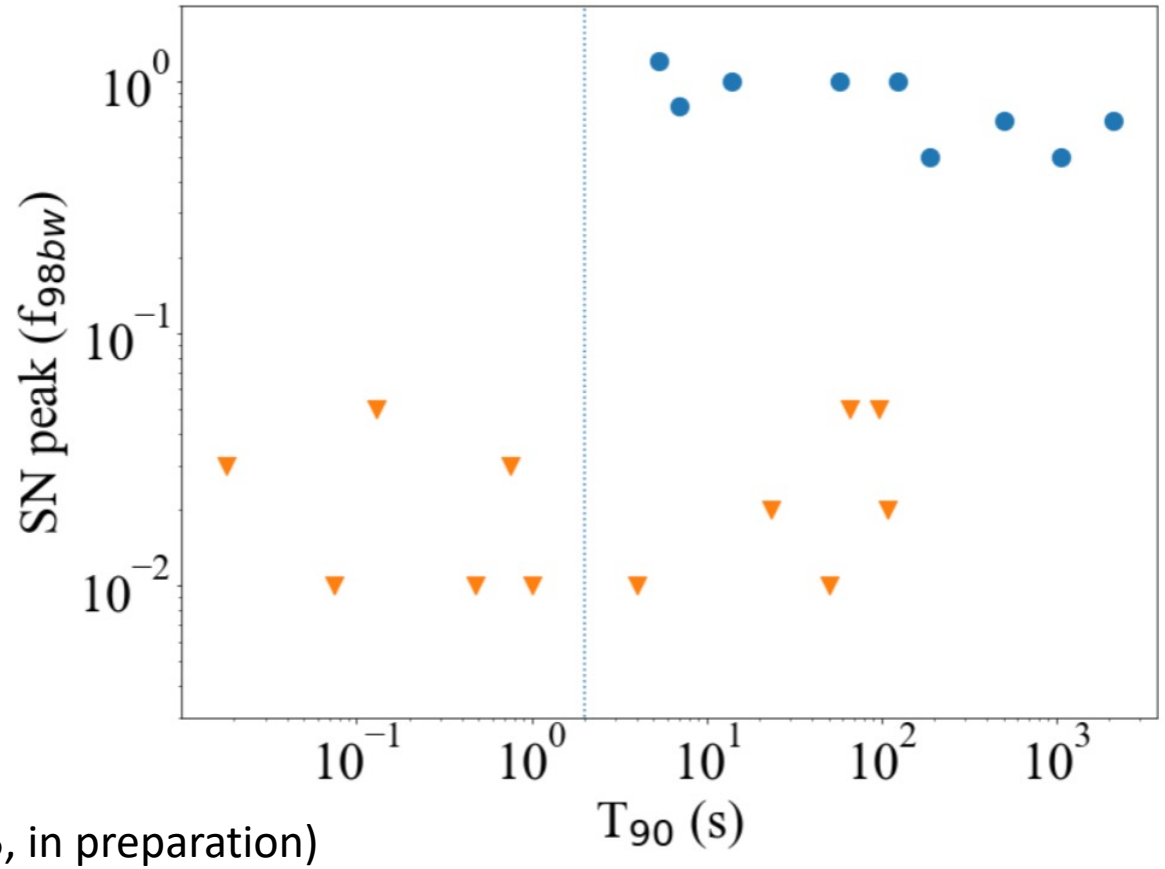
The incidence of mergers in nearby GRBs

Swift GRB sample: 20 long events at **z < 0.3**.

- 9 with SN confirmation;
- 7 with SN exclusion or ancient host;
- 4 inconclusive cases.

Fraction of mergers can be up to ~50%!





Levan et al. (2025, in preparation)

A systematic search of SNe (and KNe)

Renewed interest in the search of GRB-SNe (also: r-process):

- at high redshift $1.5 < z < 2$: PI Levan, 4 events;

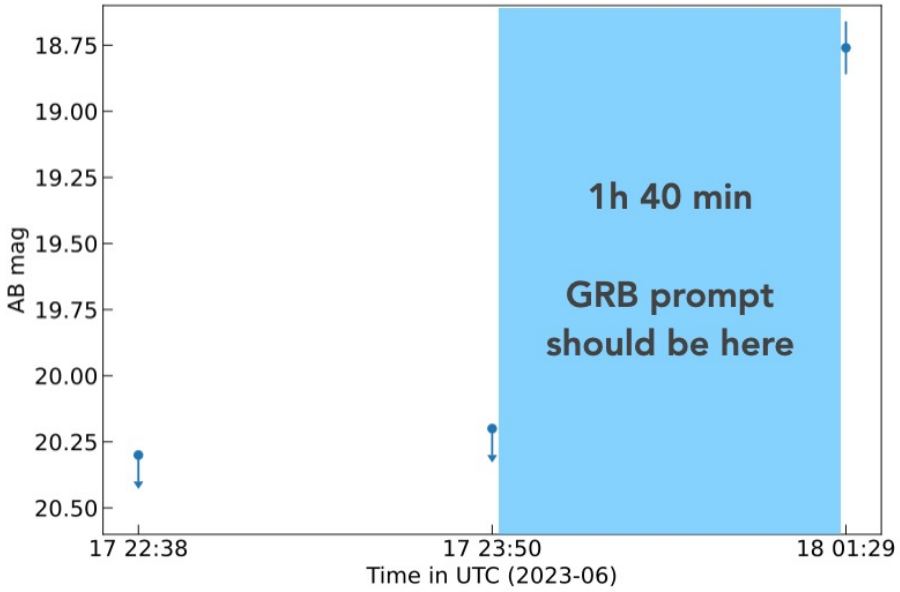
  GRB 230818A @ z = 2.42
  GRB 240414A @ z = 1.833
  EP240801A @ z = 1.673
  GRB 241026A @ z = 2.791

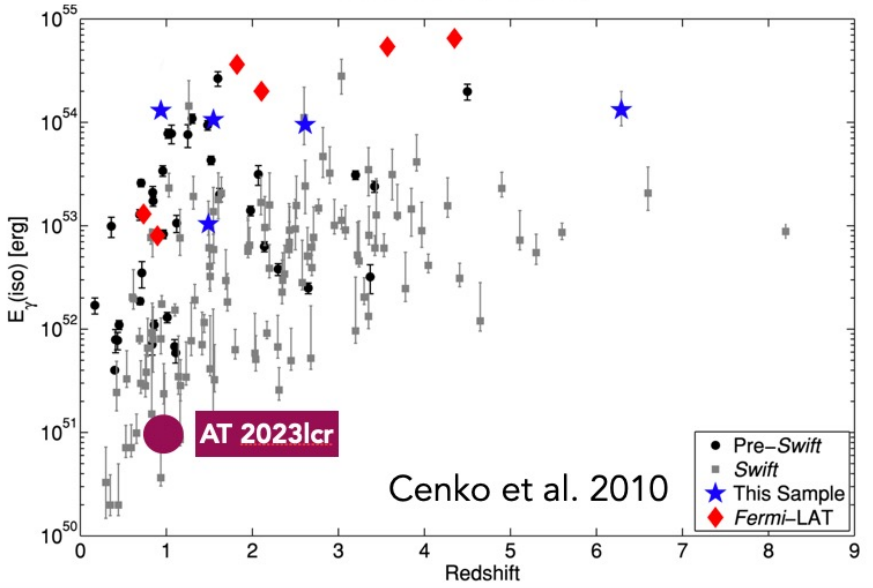
- at $z < 1$: PI Gompertz, 3-cycles, 15 events complete mini-sample;

  GRB 240825A @ z = 0.659
  GRB 241001A @ z = 0.573
  GRB 241010A @ z = 0.977
  EP250108A @ z = 0.200

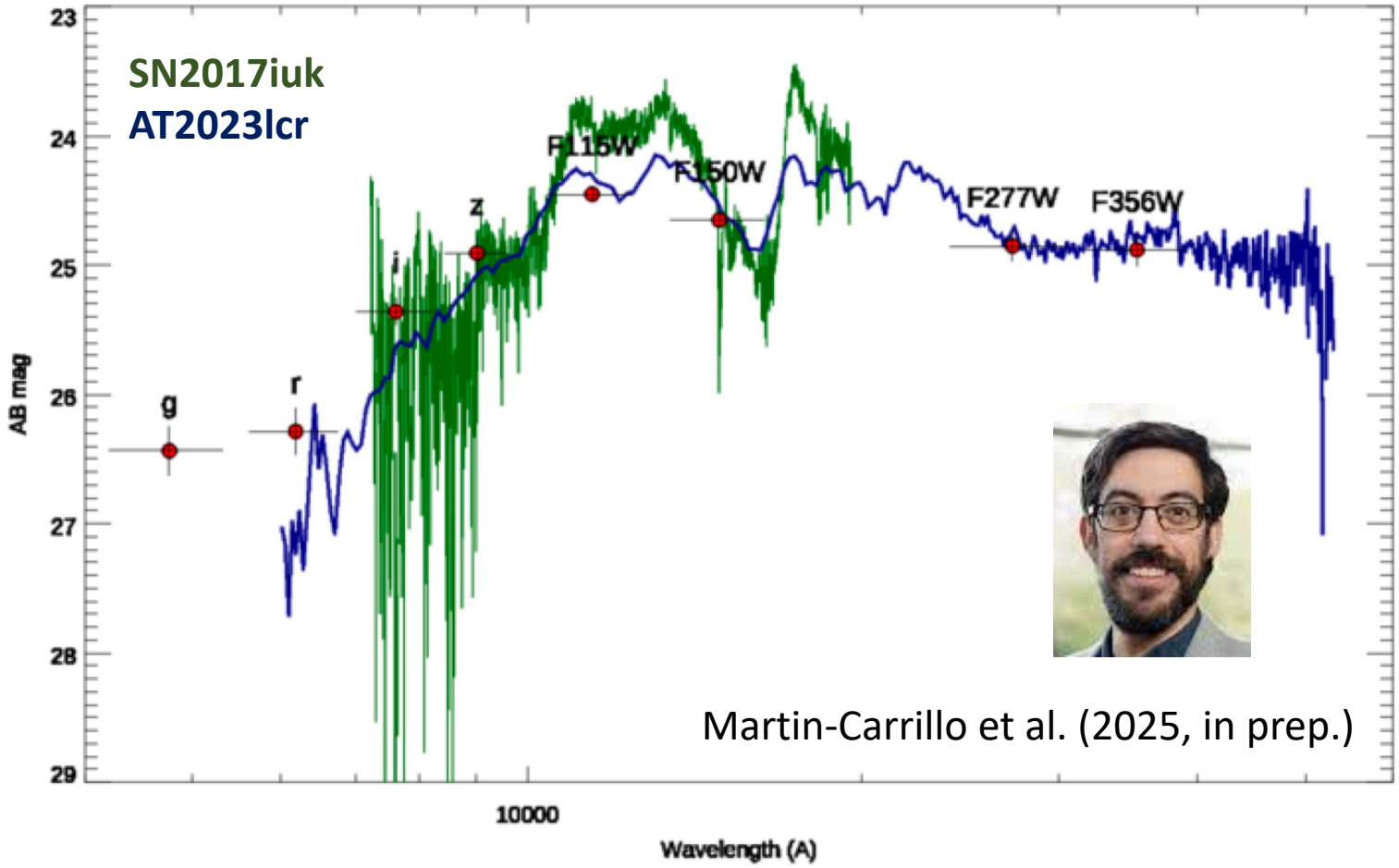
- 2 miscellaneous events: AT 2023lcr at z = 1.027 and GRB 221009A at z = 0.151

The “orphan” AT2023lcr (no GRB)



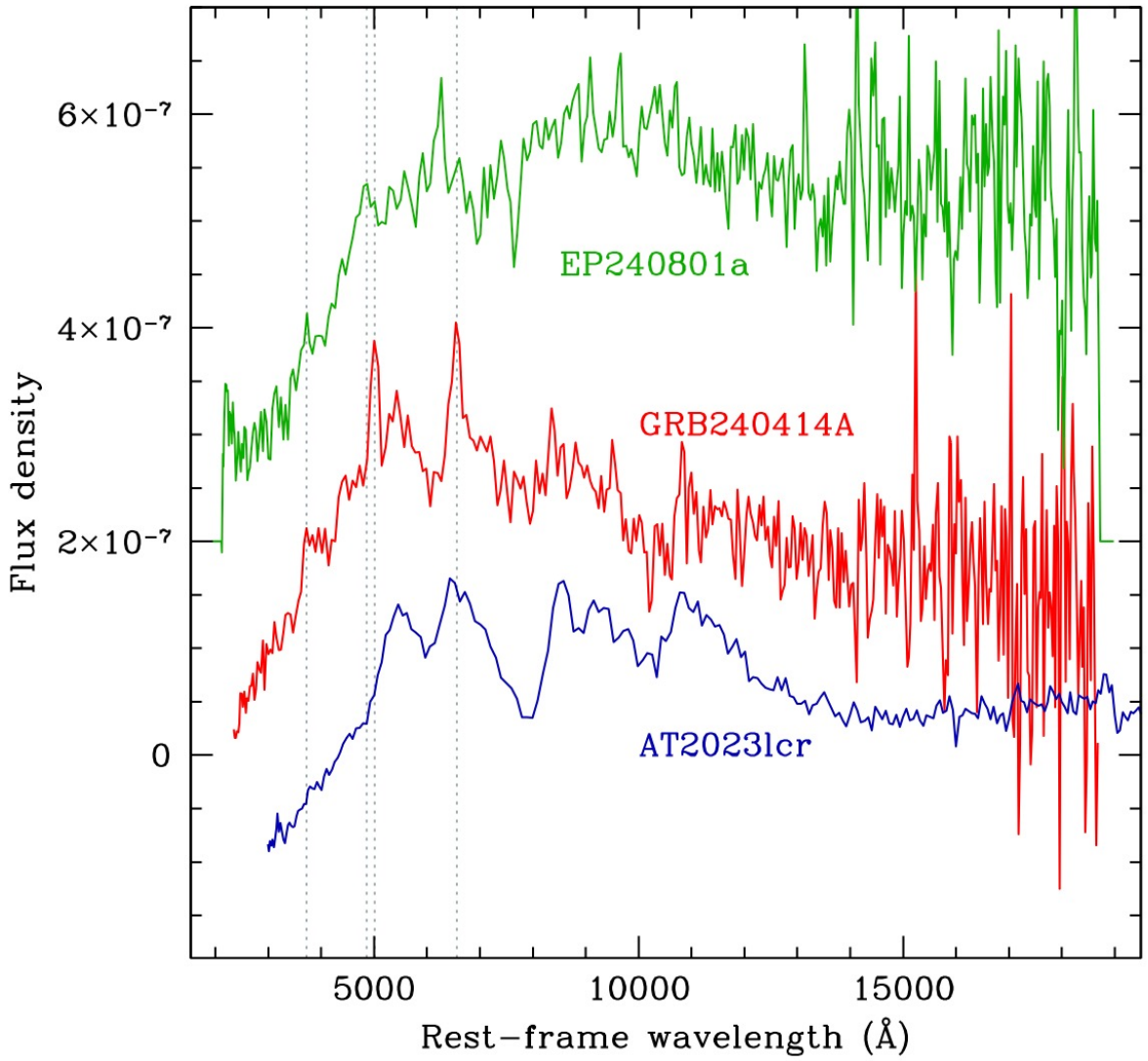


No GRB detected, afterglow discovered by ZTF.
Strong limits on the timing



Martin-Carrillo et al. (2025, in prep.)

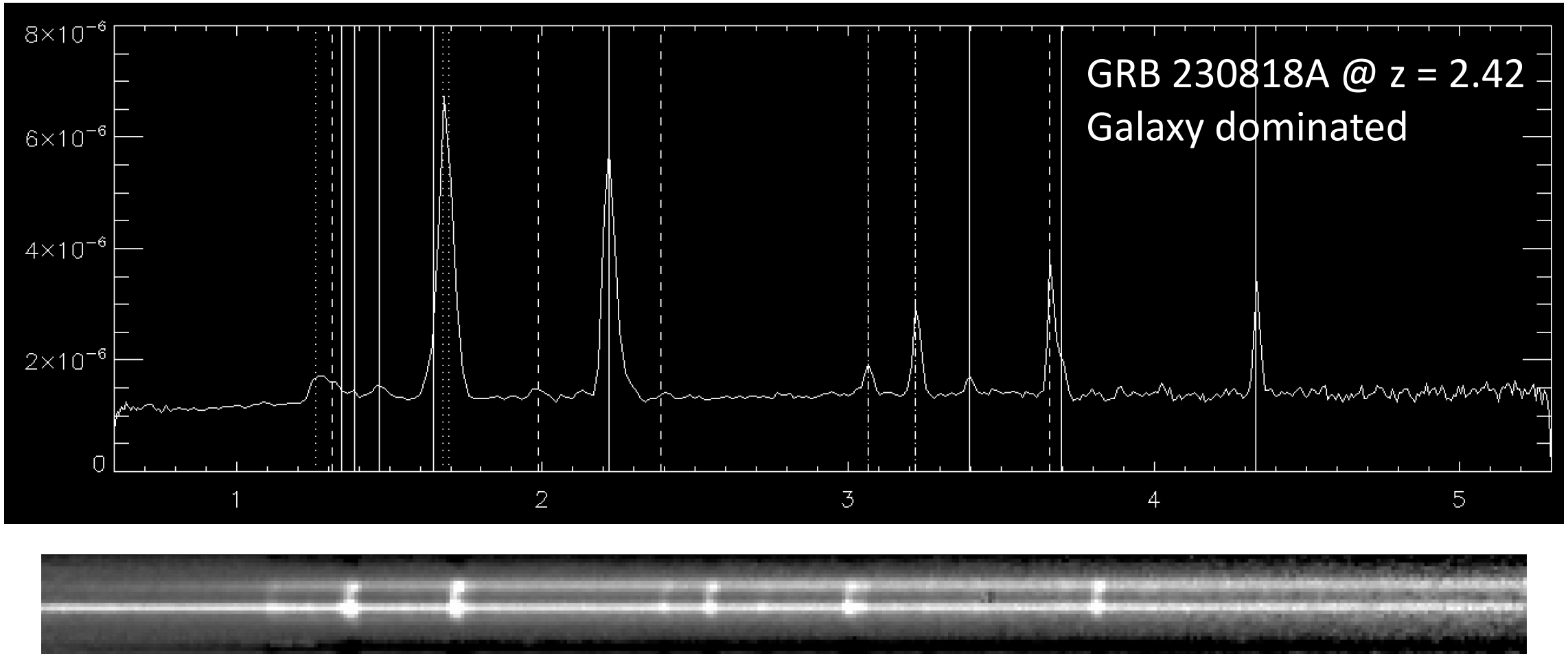
High-redshift success stories



One good SN detection and one with overall good shape agreement.

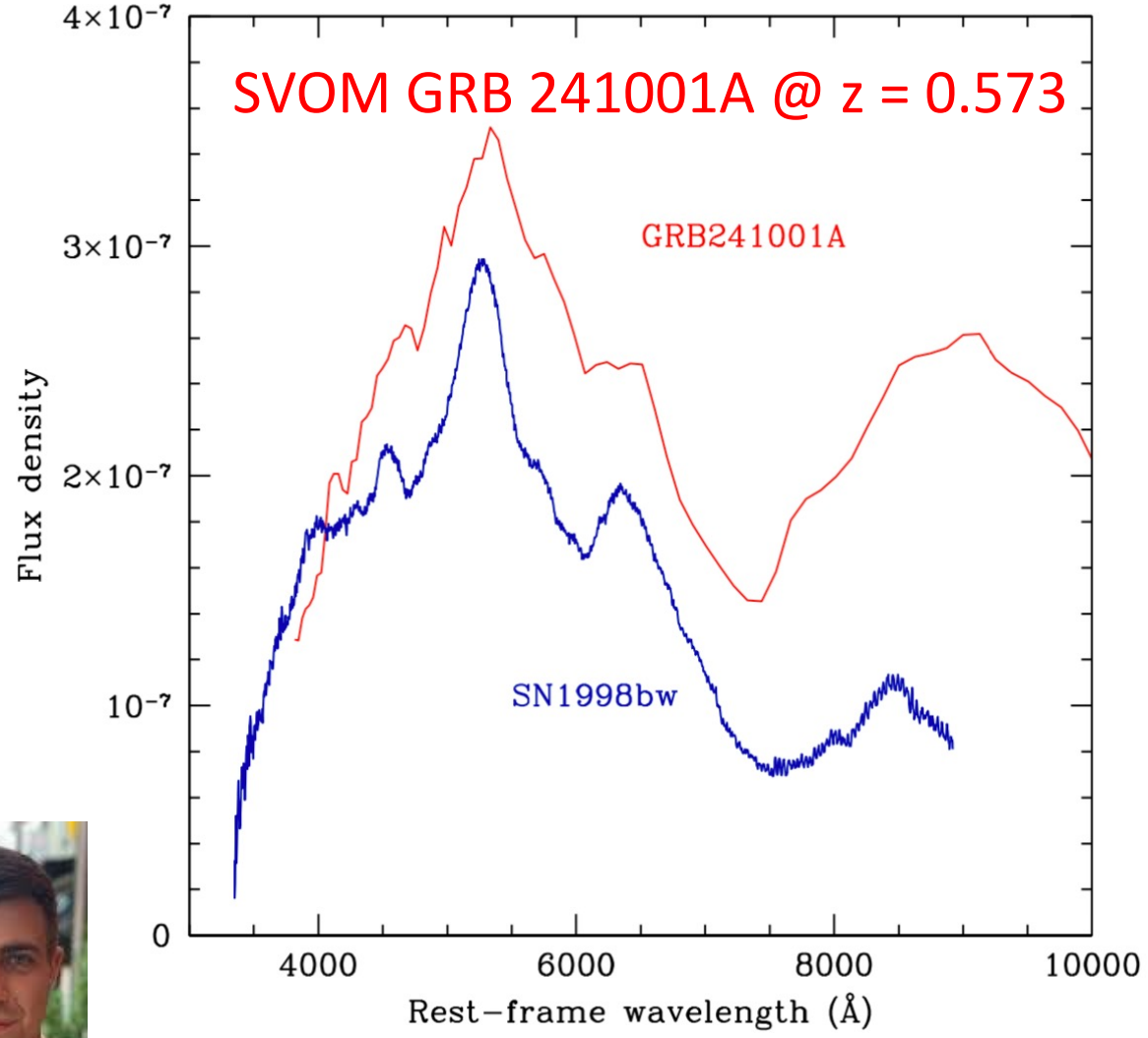
Host not subtracted.

High-redshift different kinds of success story



Solid lines: H – dashed lines: He – dotted lines: O – dashed-dotted: Si.

Low-redshift results



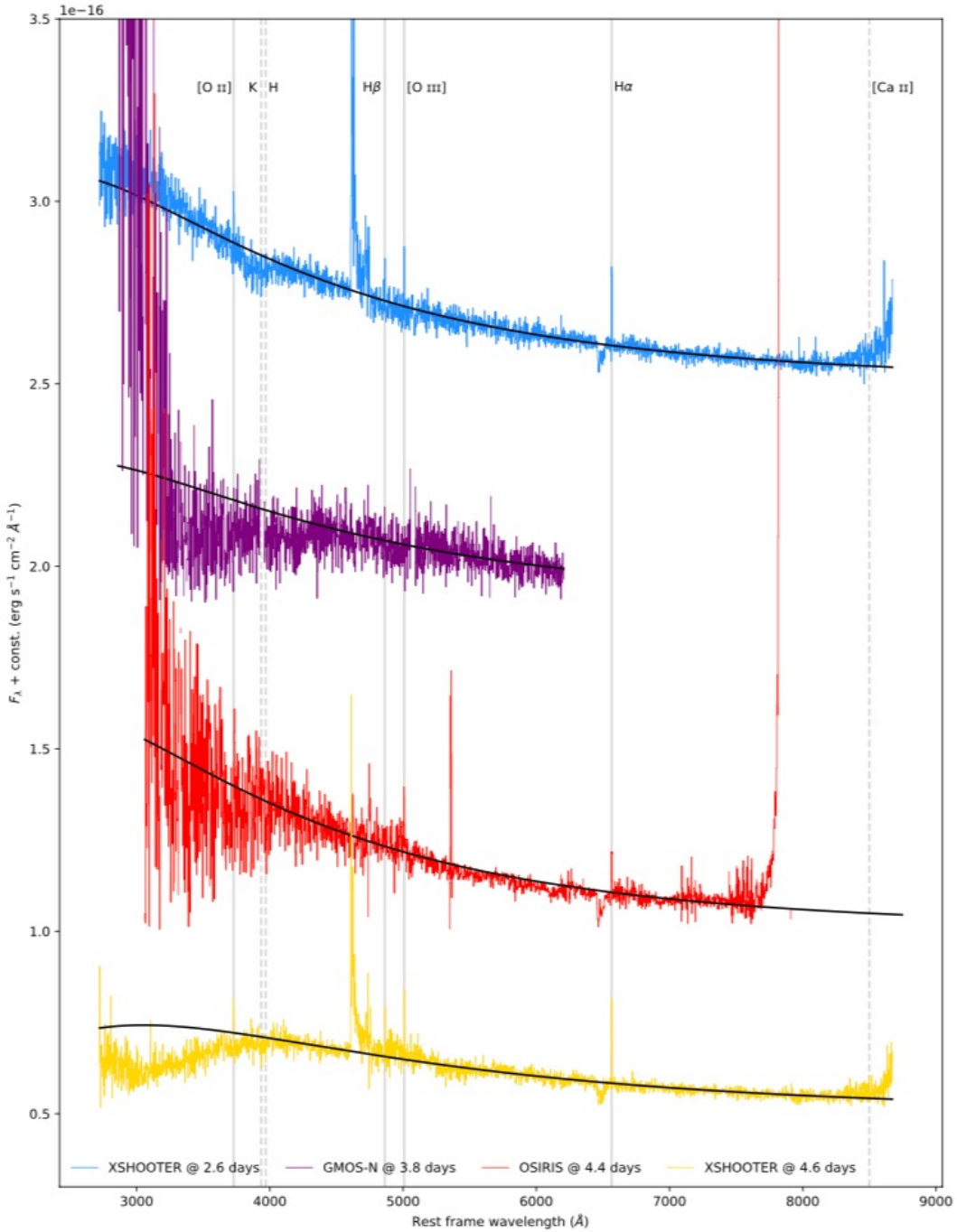
Schneider et al. (2025a, 2025b, in prep.)

- Two good SN detections.
- Two host-dominated cases.

We are at ∼25% of the program.
Work very much in progress.

Mitigation of host galaxy effect:

- smaller extraction aperture;
- late-time template subtraction;
- better afterglow centroid accuracy.

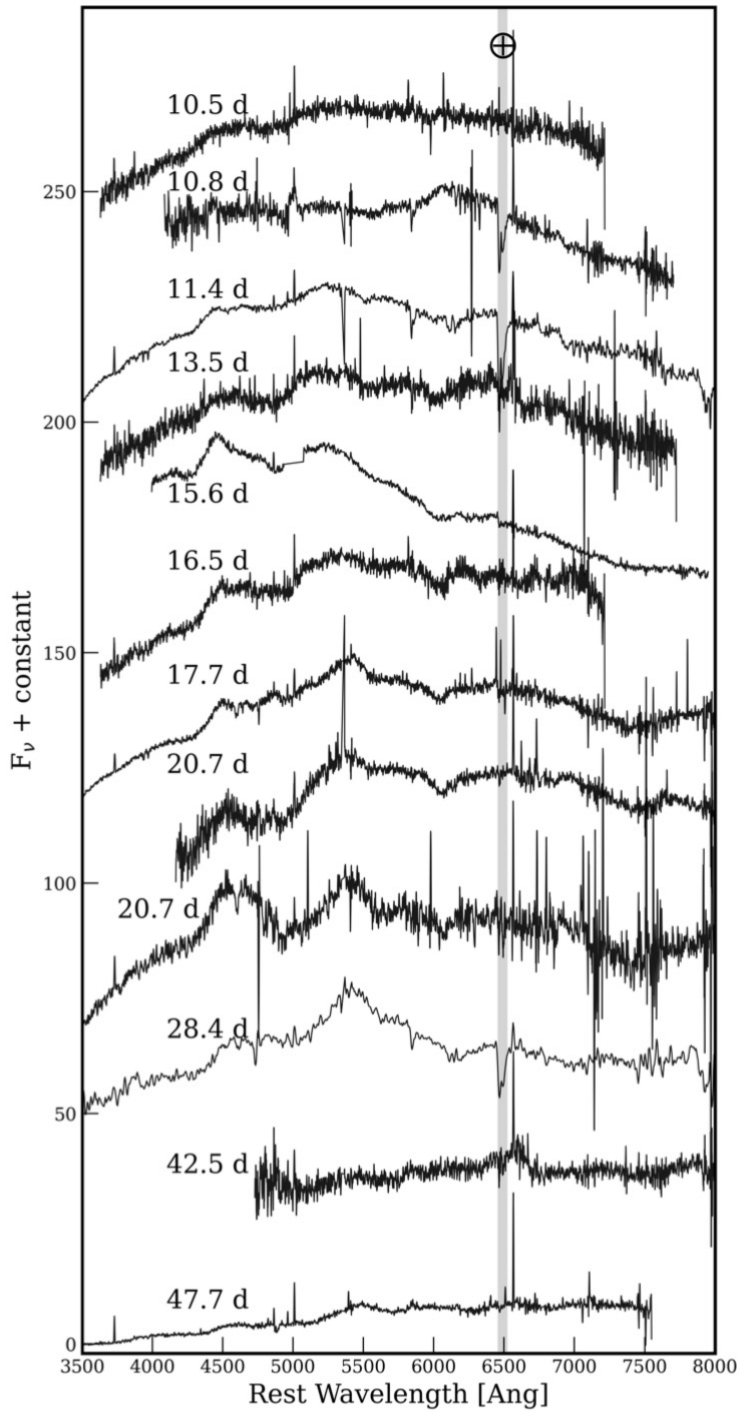


Enter Einstein Probe and SVOM

New GRB missions launched in 2024, sensitive to X-rays ("fast X-ray transients"). Different population of events? Shock breakout? Different stellar progenitors?

SN 2025kg ("the kangaroo"). Early spectra: thermal, blue, hot. Not afterglow synchrotron. Technically… an FBOT.

Eyles-Ferris et al. (2025, in prep.); Rastinejad et al. (2025, in prep.)



Enter Einstein Probe and SVOM

New GRB missions launched in 2024, sensitive to X-rays ("fast X-ray transients"). Different population of events? Shock breakout? Different stellar progenitors?

SN 2025kg ("the kangaroo"). Early spectra: thermal, blue, hot. Not afterglow synchrotron. Technically… an FBOT.

Evolution into a "classic" broad-lined type Ic SN.

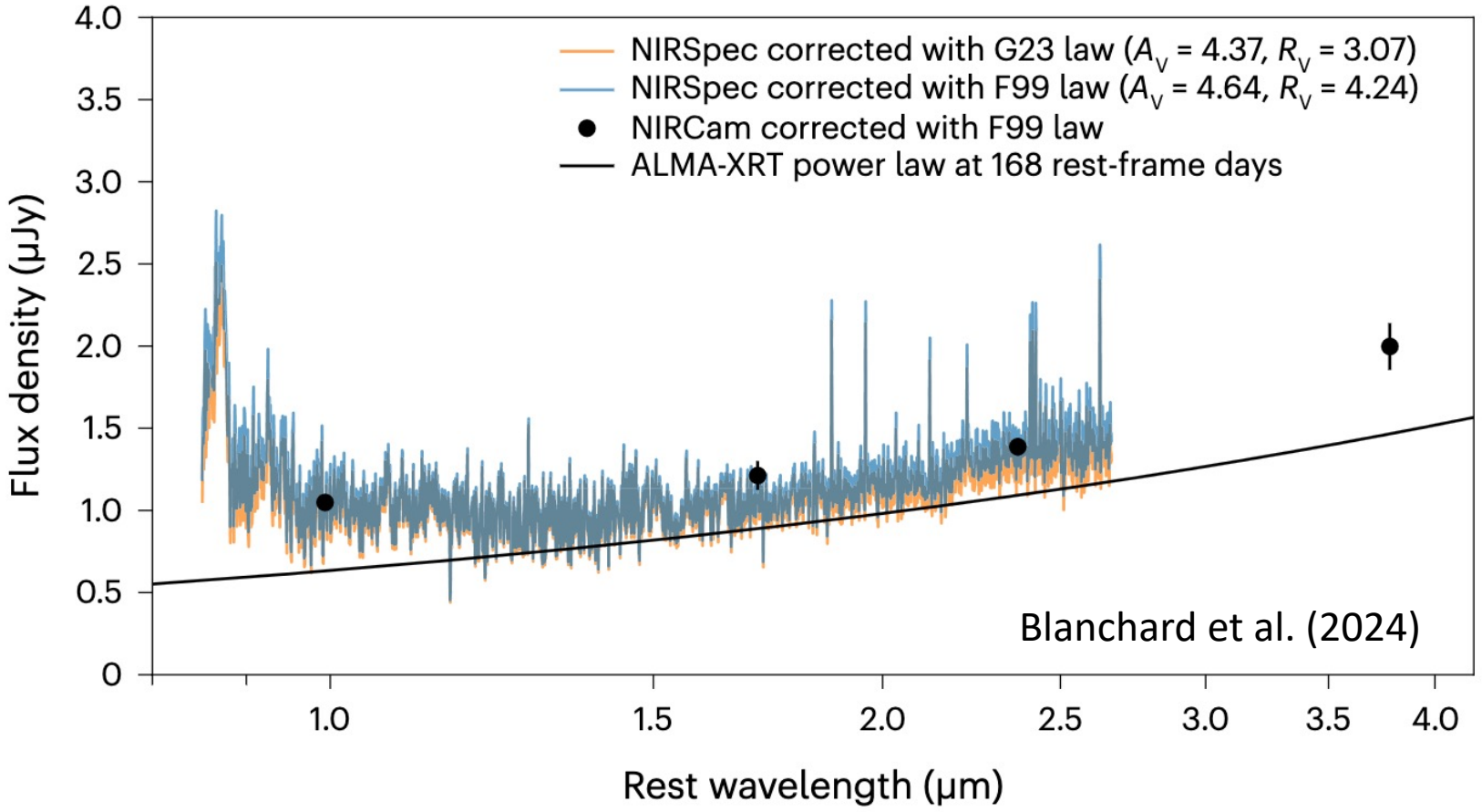
Eyles-Ferris et al. (2025, in prep.); Rastinejad et al. (2025, in prep.)

The brightest of all times

JWST detected a SN associated to GRB 221009A, the “BOAT”, at z = 0.151.

Hard from ground because of $A_V > 4$ mag.

SN slightly fainter than other GRB-associated supernovae (but extinction trouble).



Summary and ongoing activities

- JWST is a good instrument to study GRB-associated SNe: who could have told.
- Ongoing survey progressing for 2 more years (but faster pace is possible).
- Einstein Probe events have a variety of behaviours at high energies, but the SNe seem overall homogeneous – key insights on progenitors.
- Keep on looking for SNe – it seemed a done thing, it ain't.
- Thank you Massimo (DV) and this whole community for intriguing me with GRB/SNe

«Truth is round. If it had edges, it would depend on the viewpoint» – MdV, 2007 Feb 28
«S/N is like clay. In my hands, it can be moulded» – MdV, 2011/10/24