Relativistic explosions from the NOT

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On behalf of countless collaborators

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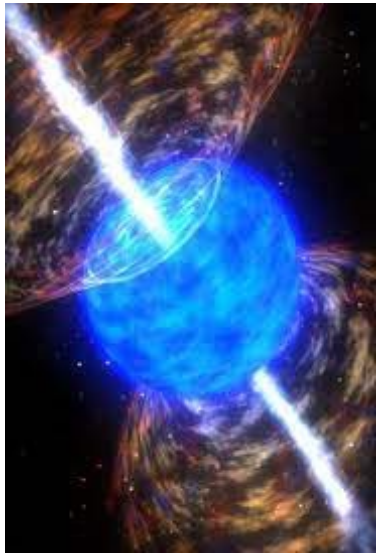
(Former past PIs highlighted in **purple**)

Connection between relativistic explosions

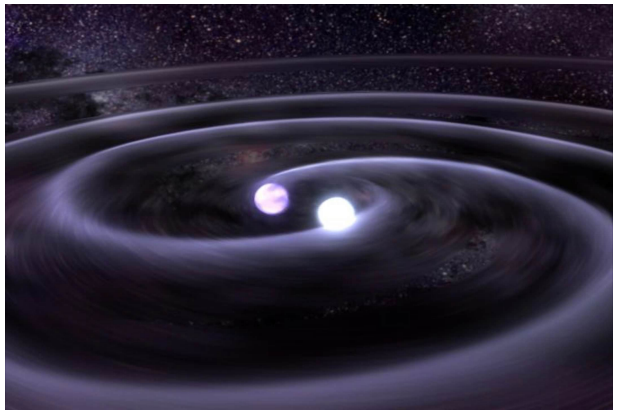


Gamma-ray bursts

Gravitational wave sources

Long GRB ("collapsar")

Short GRB ("merger")

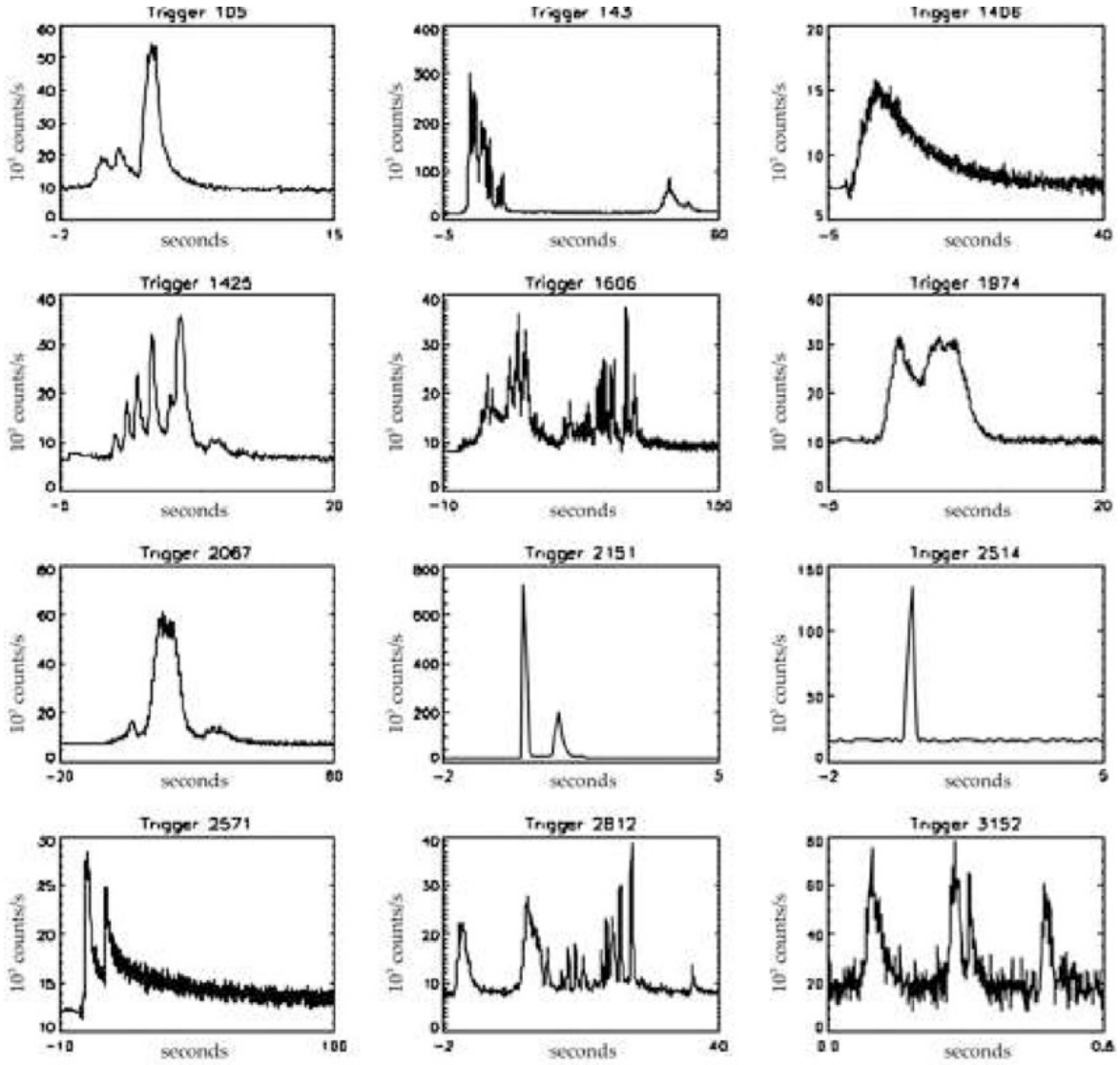


Supernova (optical)

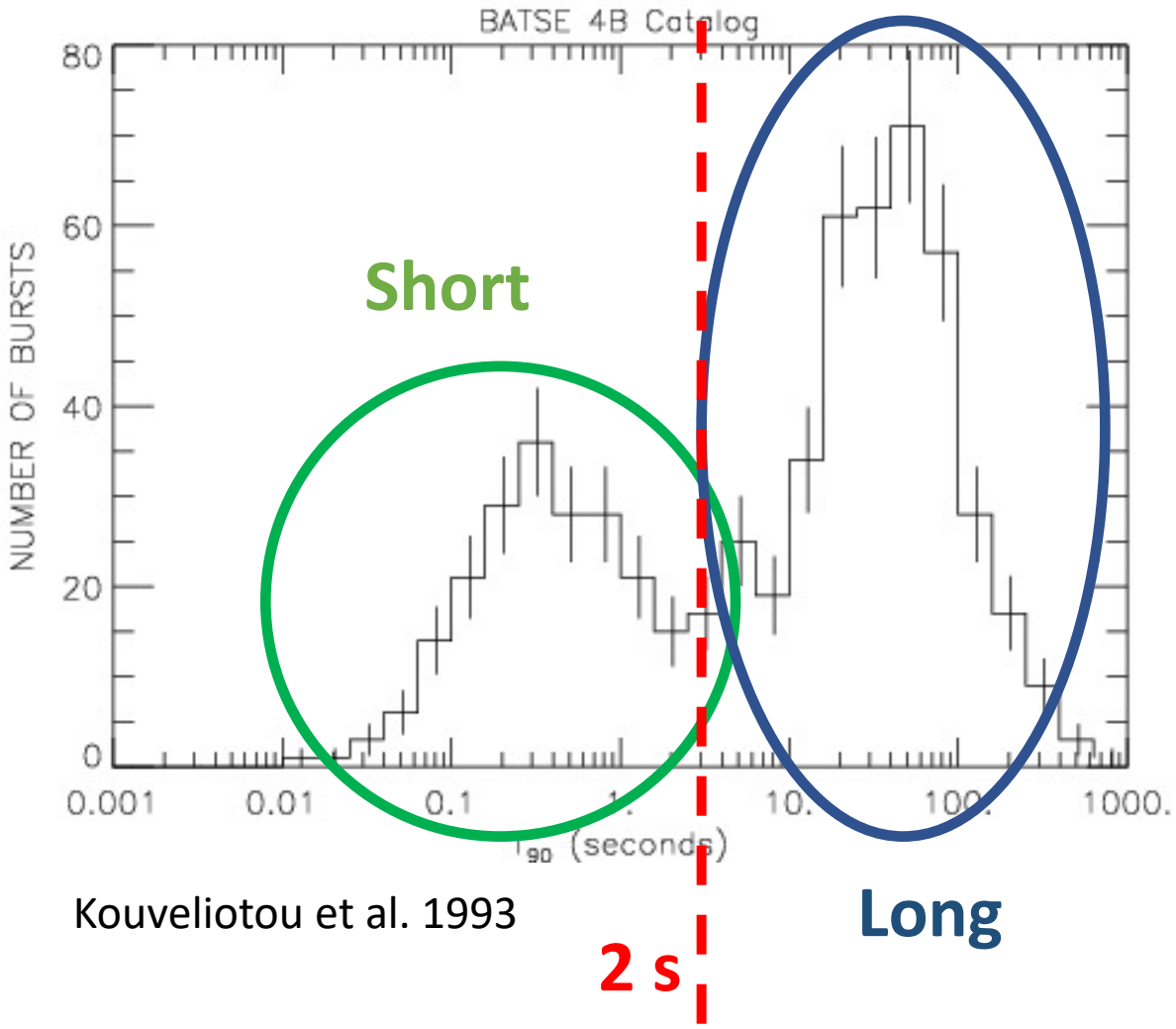
Afterglow (multiwavelngth)

Kilonova (NIR)

Long and short gamma-ray bursts



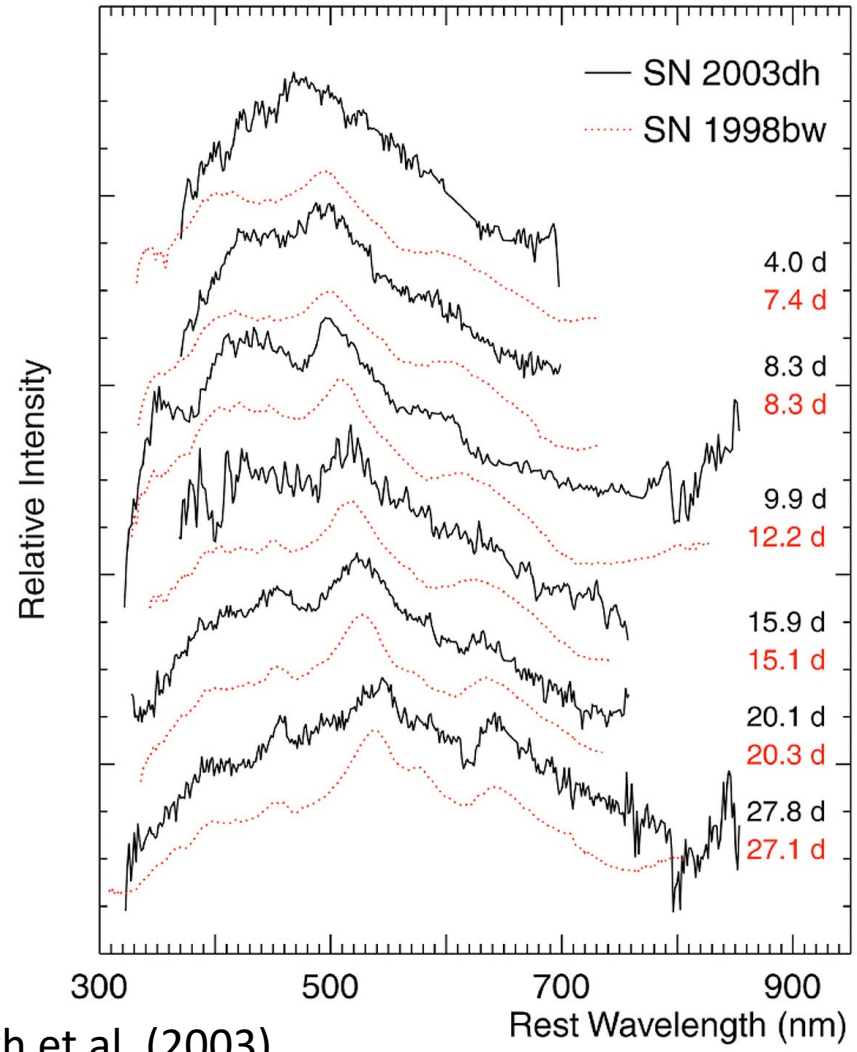
Variety of light curve profiles



Kouveliotou et al. 1993

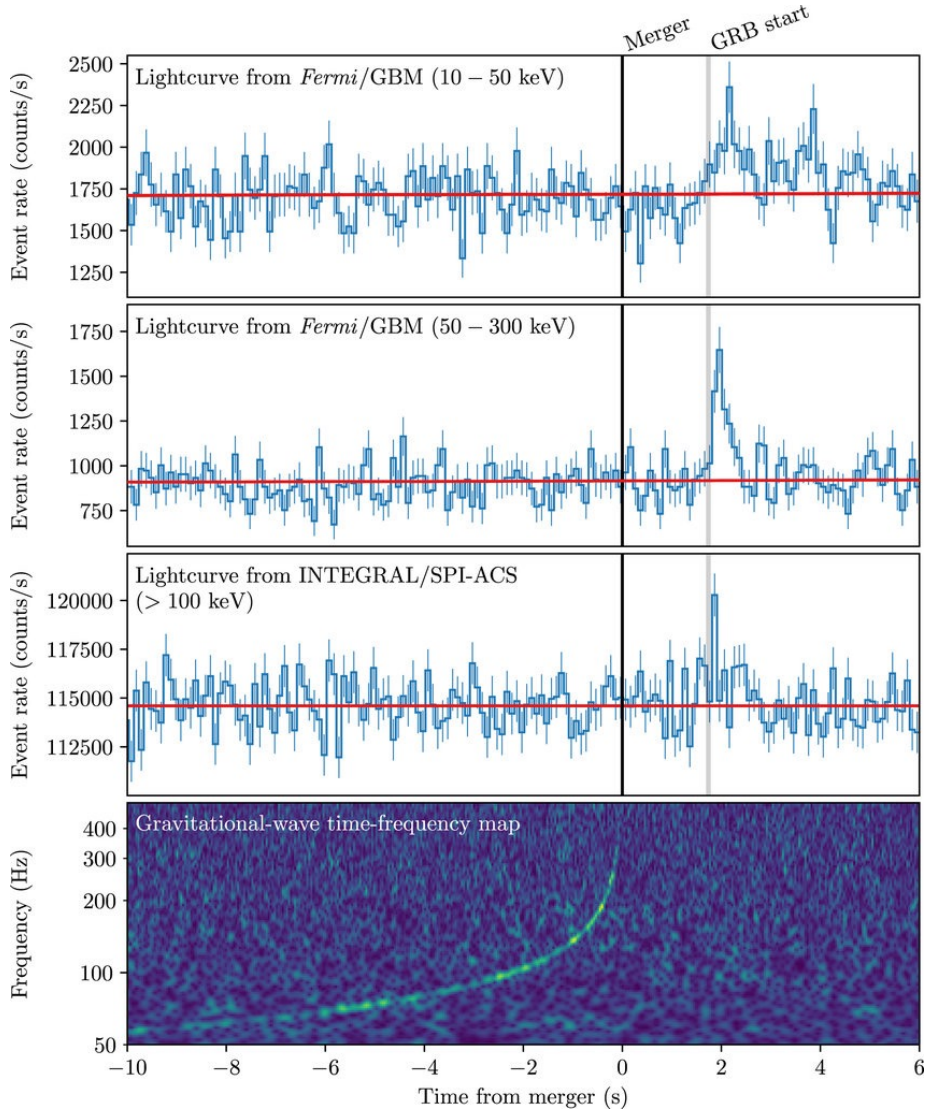
Progenitor systems

Long GRBs – massive stars exploding



Hjorth et al. (2003)

Short GRBs – NS/NS or NS/BH mergers

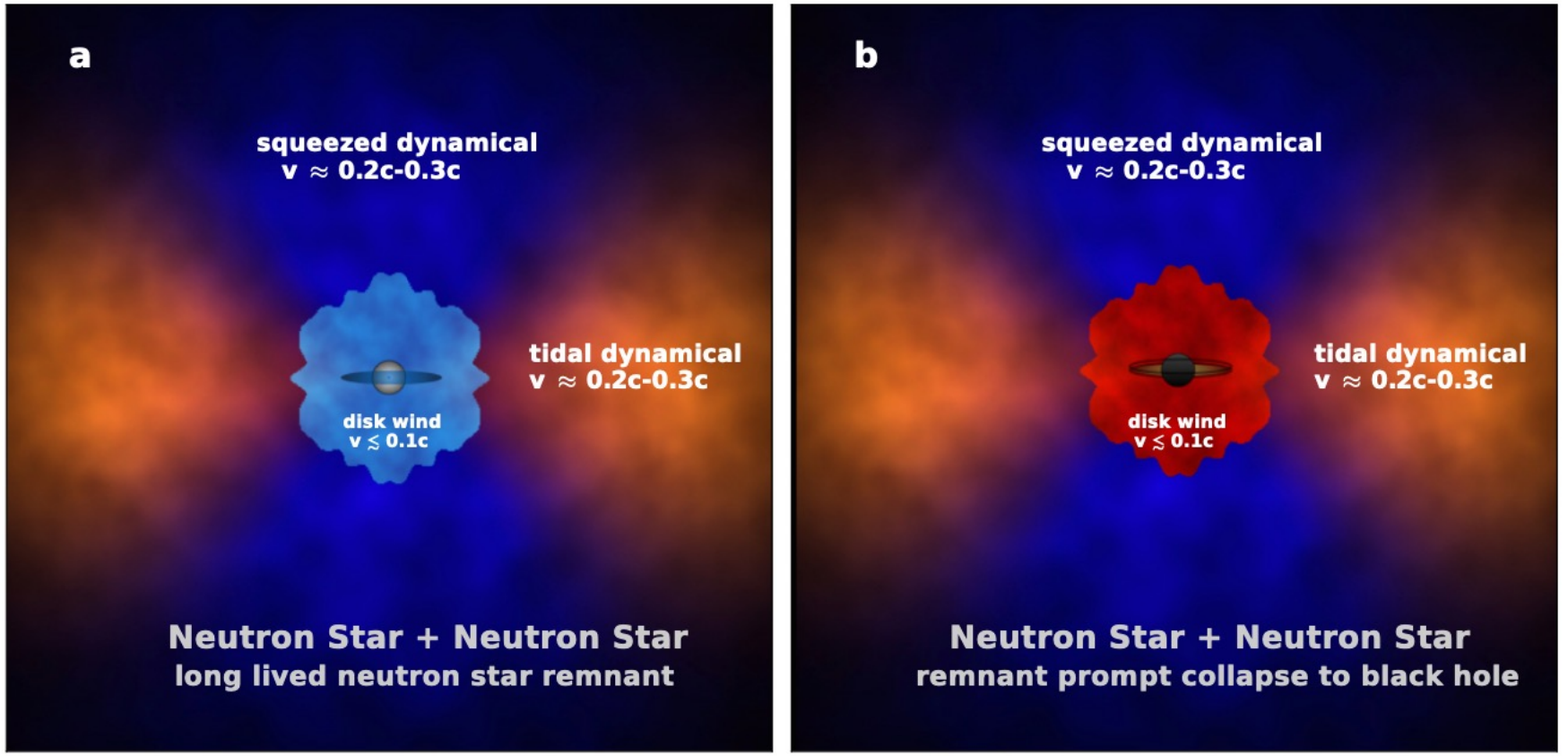


Abbot et al (2017), Goldstein et al. (2017), Savchenko et al. (2017)

Kilonovae

Neutron-rich ejecta from the merger

Candidate site of formation of **r-process (heavy) elements**



Kasen et al. (2017)

GRB follow-up from the NOT

The NOT participated in the follow-up of the very first GRB afterglow.

Published: 17 April 1997

Transient optical emission from the error box of the γ-ray burst of 28 February 1997

J. van Paradijs, P. J. Groot, T. Galama, C. Kouveliotou, R. G. Strom, J. Telting, R. G. M. Rutten, G. J. Fishman, C. A. Meegan, M. Pettini, N. Tanvir, J. Bloom, H. Pedersen, H. U. Nørdgaard-Nielsen, M. Linden-Vørnle, J. Melnick, G. van der Steene, M. Bremer, R. Naber, J. Heise, J. in't Zand, E. Costa, M. Feroci, L. Piro, F. Frontera, G. Zavattini, L. Nicastro, E. Palazzi, K. Bennet, L. Hanlon & A. Parmar

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Nature **386**, 686–689 (1997) | Cite this article

GRB follow-up from the NOT

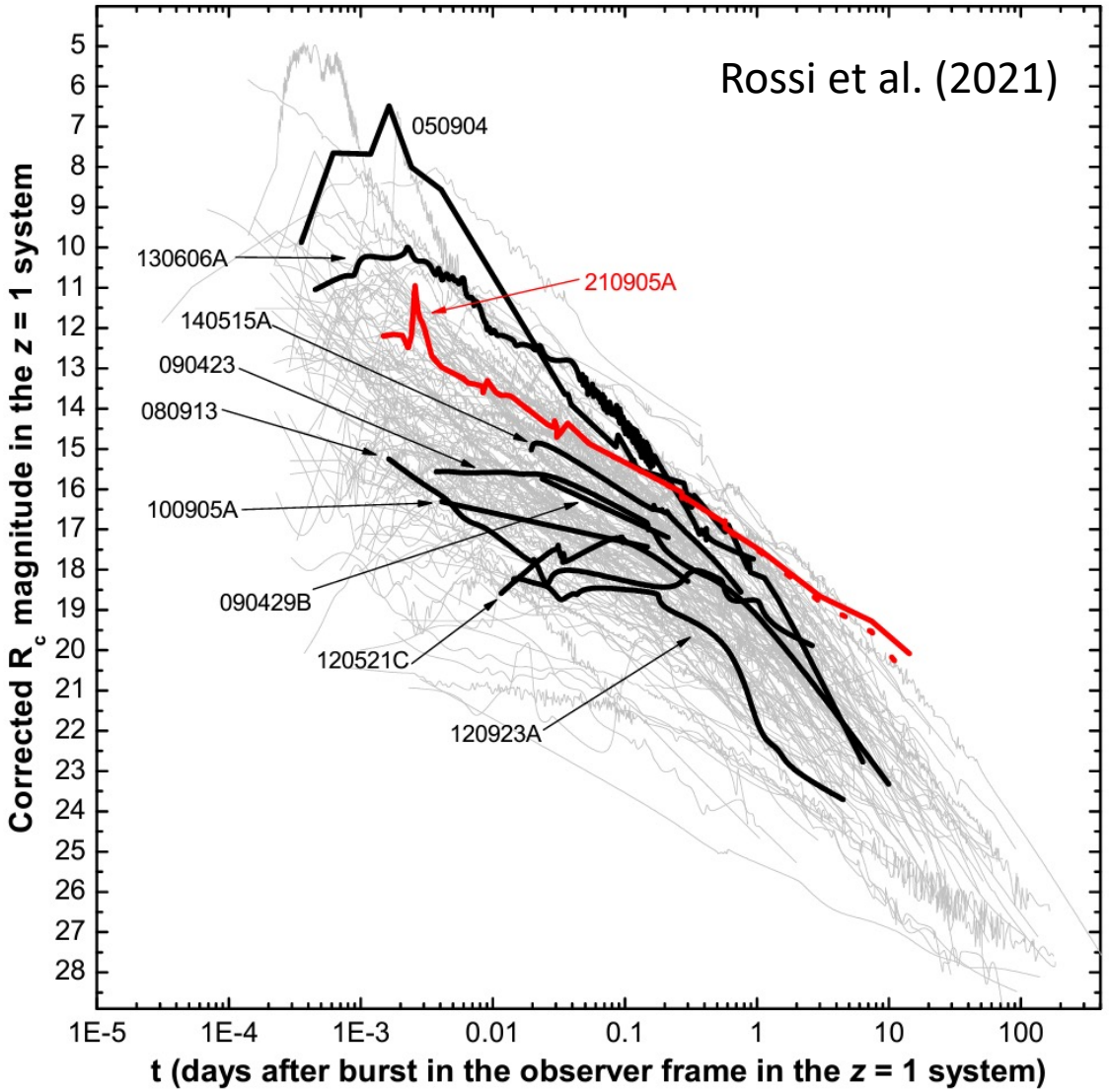
The NOT participated in the follow-up of the very first GRB afterglow.

It has been since then a major source of afterglow discovery and follow-up.

- Roughly 350 afterglows observed between 1997 and 2022.
- 30 spectroscopic redshifts.
- Nearby long GRB/SN follow-up.

- Important **enabling** facility to trigger dedicated campaign (VLT, HST, LBT, Gemini, …).
- World-wide recognition in the field: the NOT has quite a good reputation.

Observational challenges



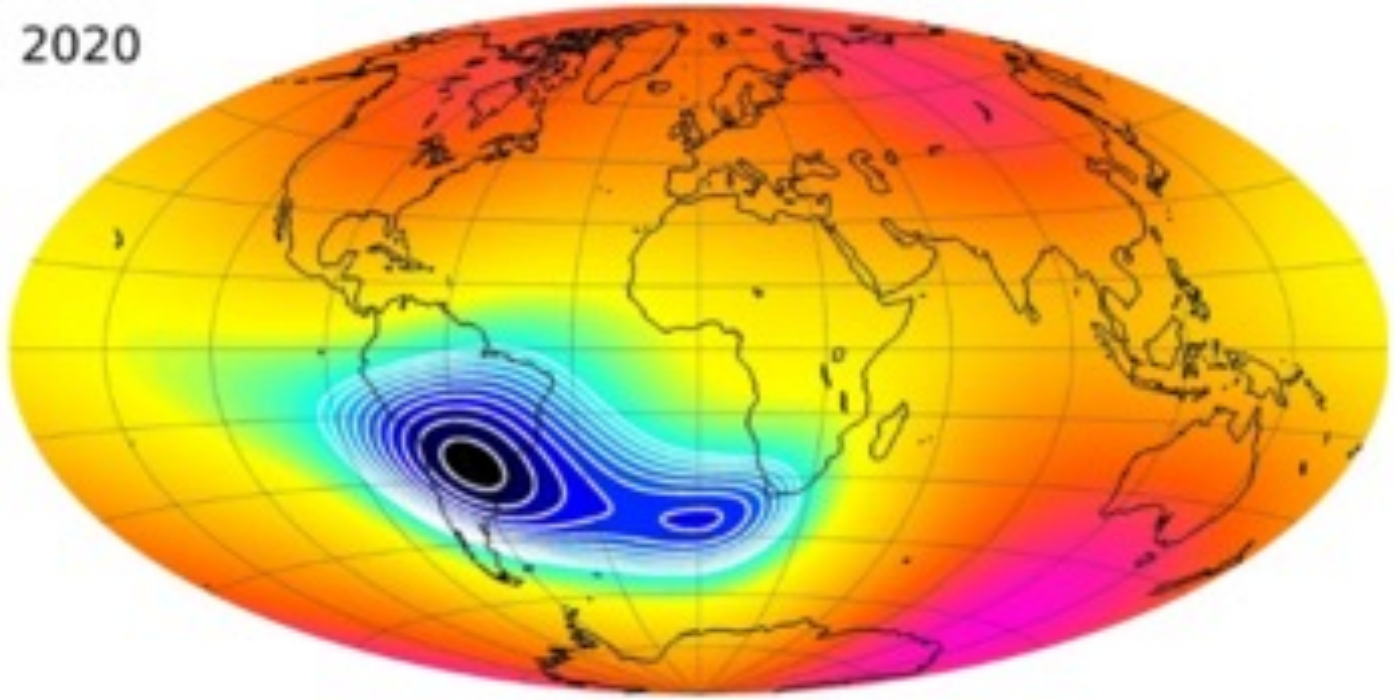
- GRB afterglows can be extremely bright, but fade very quickly.
- Rapid response can be as effective as a larger area.
- “Logarithmic” evolution: the same happens between 10 minutes and 20 minutes as between 1 day and 2 days

Rapid response mode

Hard to go under ~30 minutes reaction time for human response.

Robotic response has been implemented at several facilities, and is expected to be a major improvement with NTE.

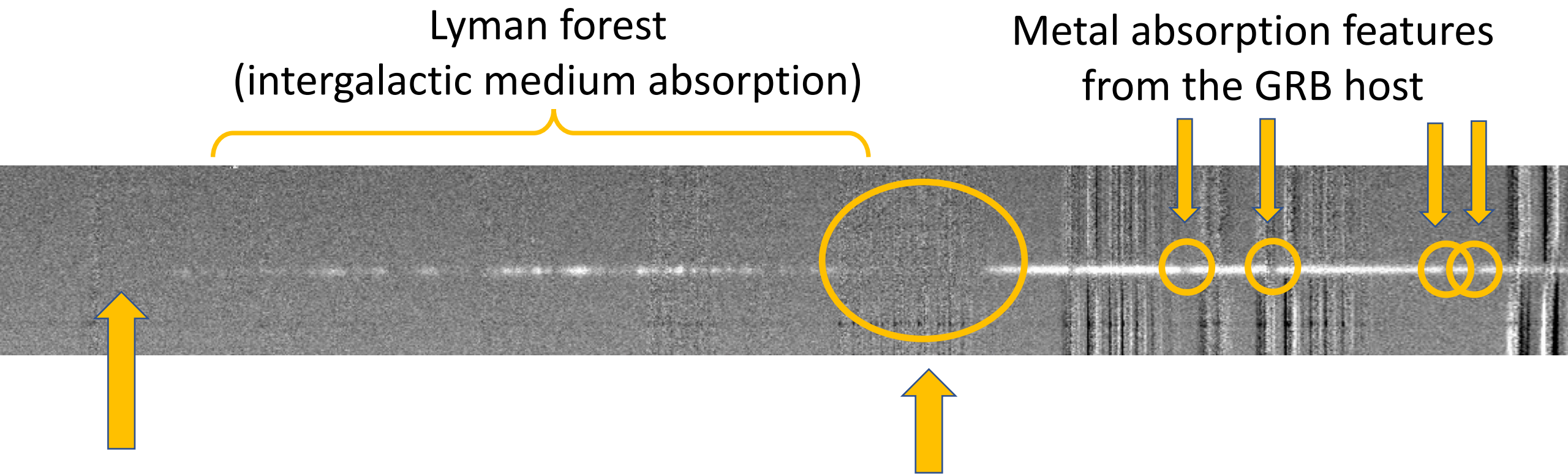
The Canary Islands are at a better location than Chile (ESO).



The South Atlantic Anomaly impairs GRB detection over South America

Example of afterglow spectroscopy

GRB 220521A – redshift $z = 5.57$



Example of afterglow spectroscopy

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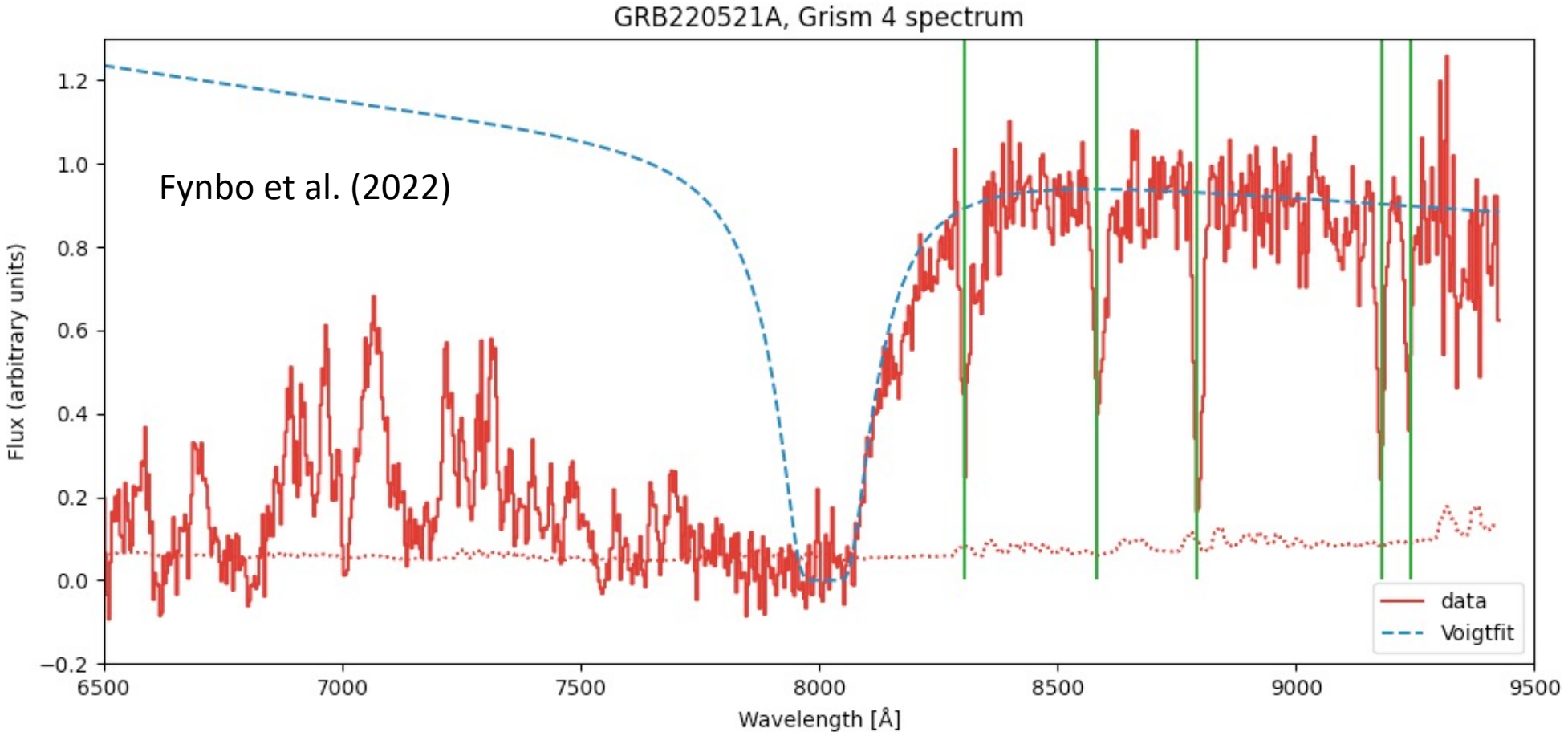
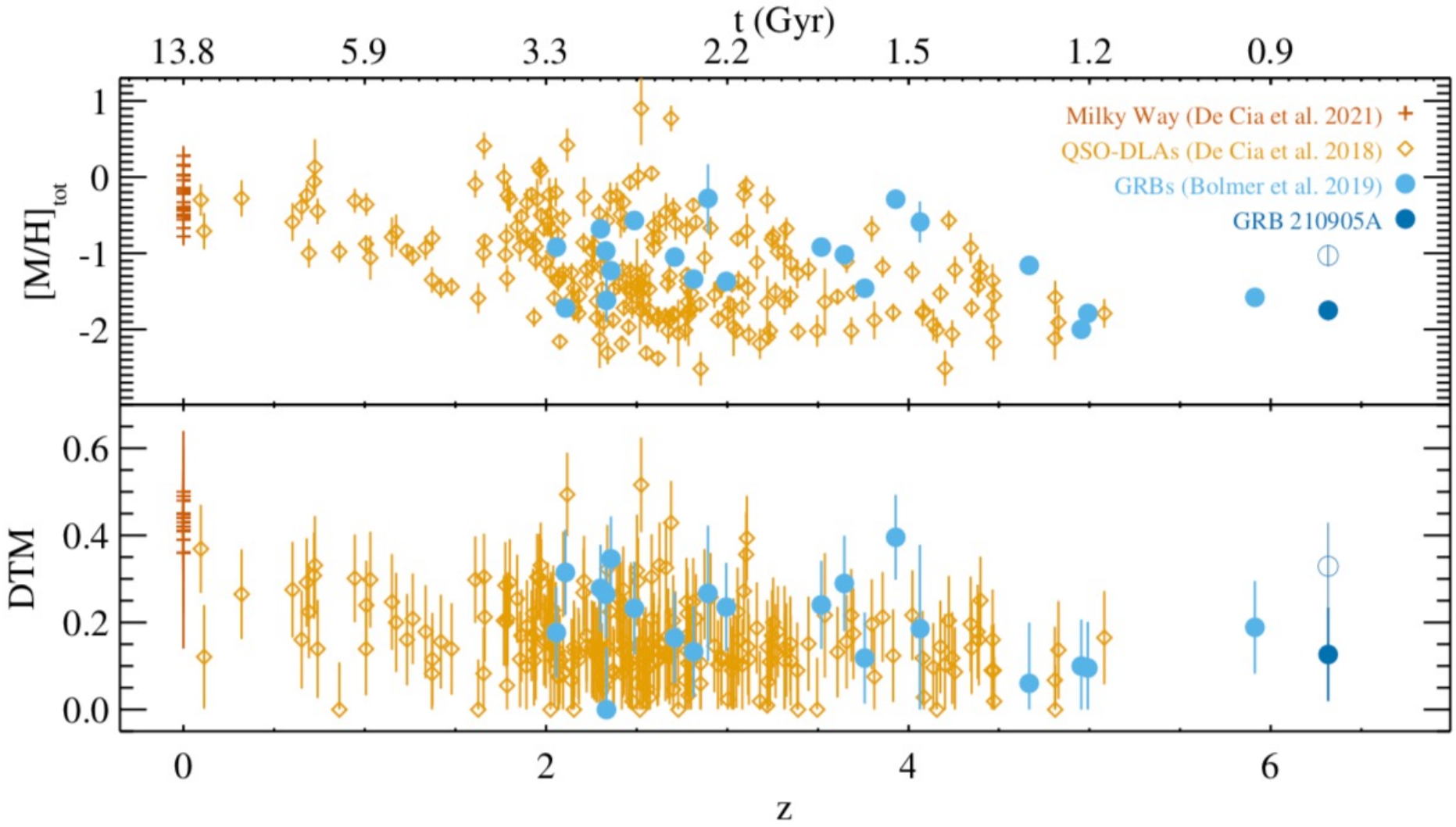


ALFOSC resolution **too low** to resolve line profiles – NTE significant improvement

GRBs as high-redshift probes



Covering the highest redshift range

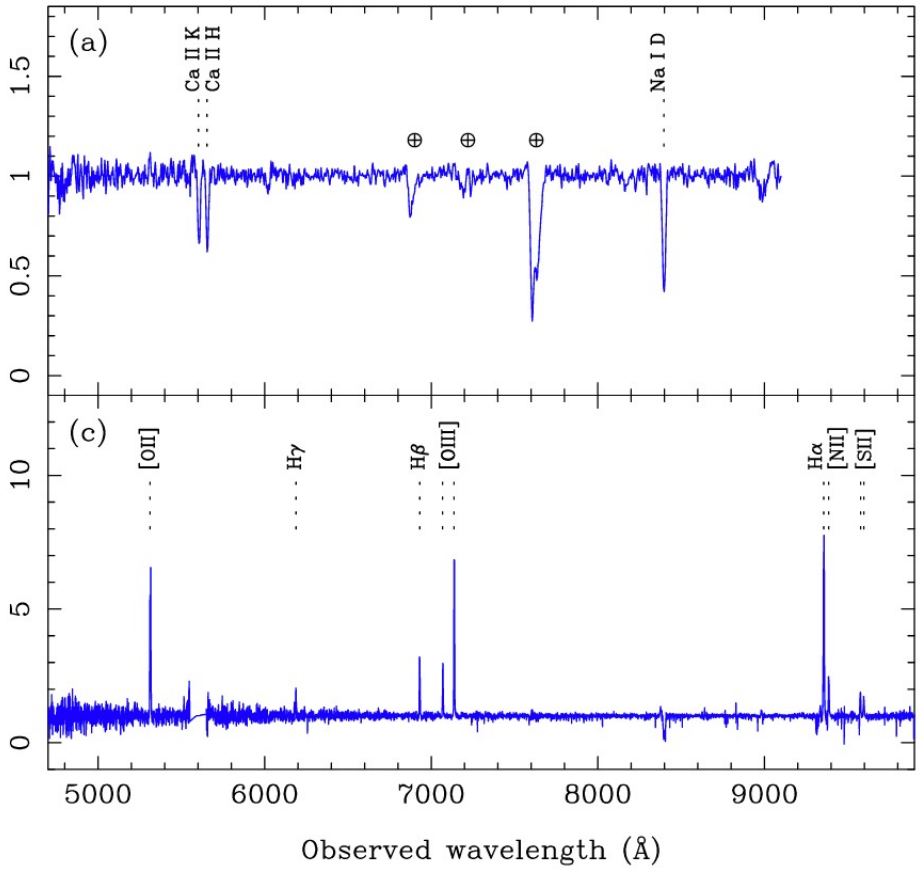
Study of metals, dust hydrogen, molecules

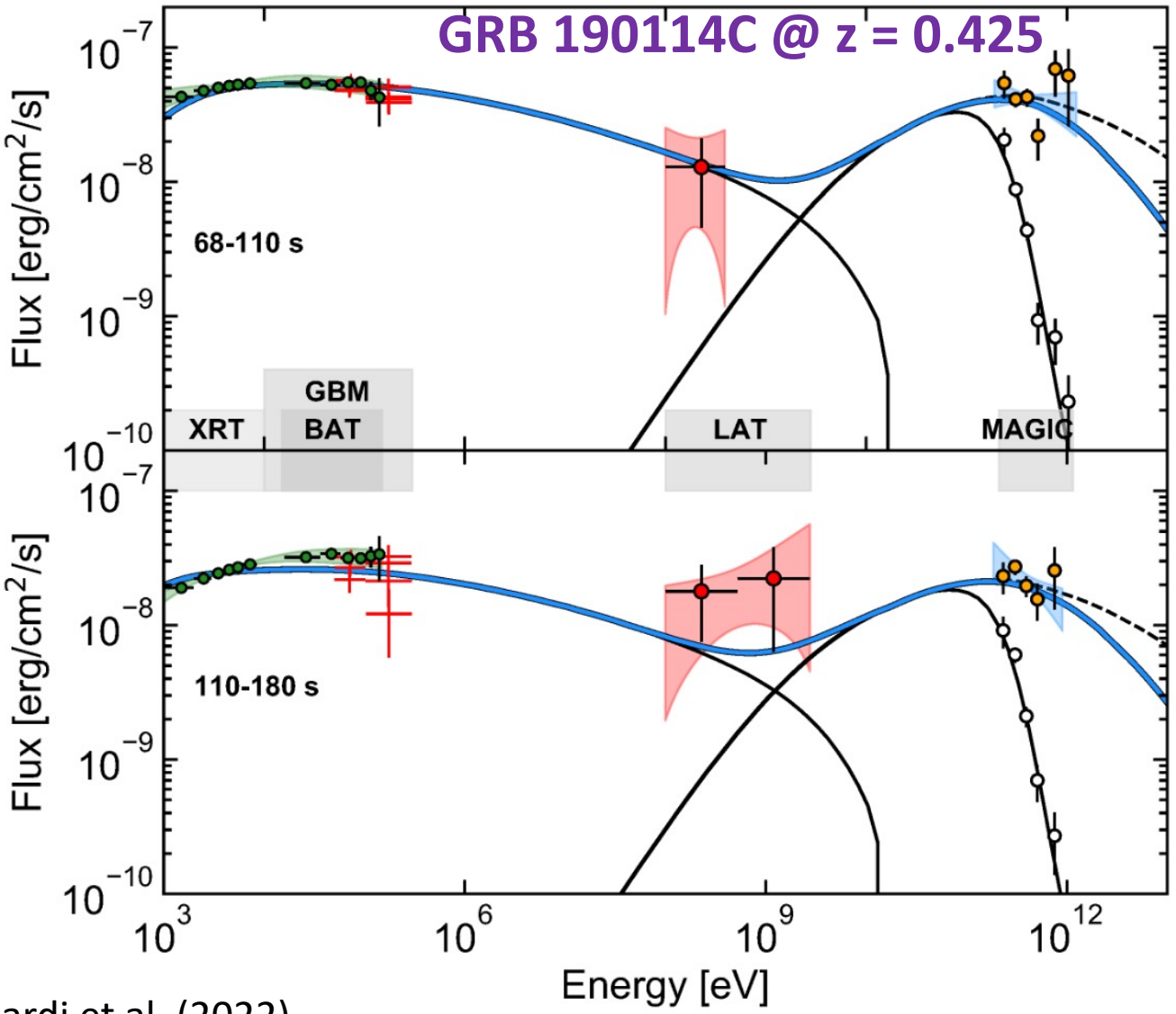
Saccardi et al. (2022)

Probing GRB physics – ultra-high energy emission

Coordination with Cherenkov telescopes

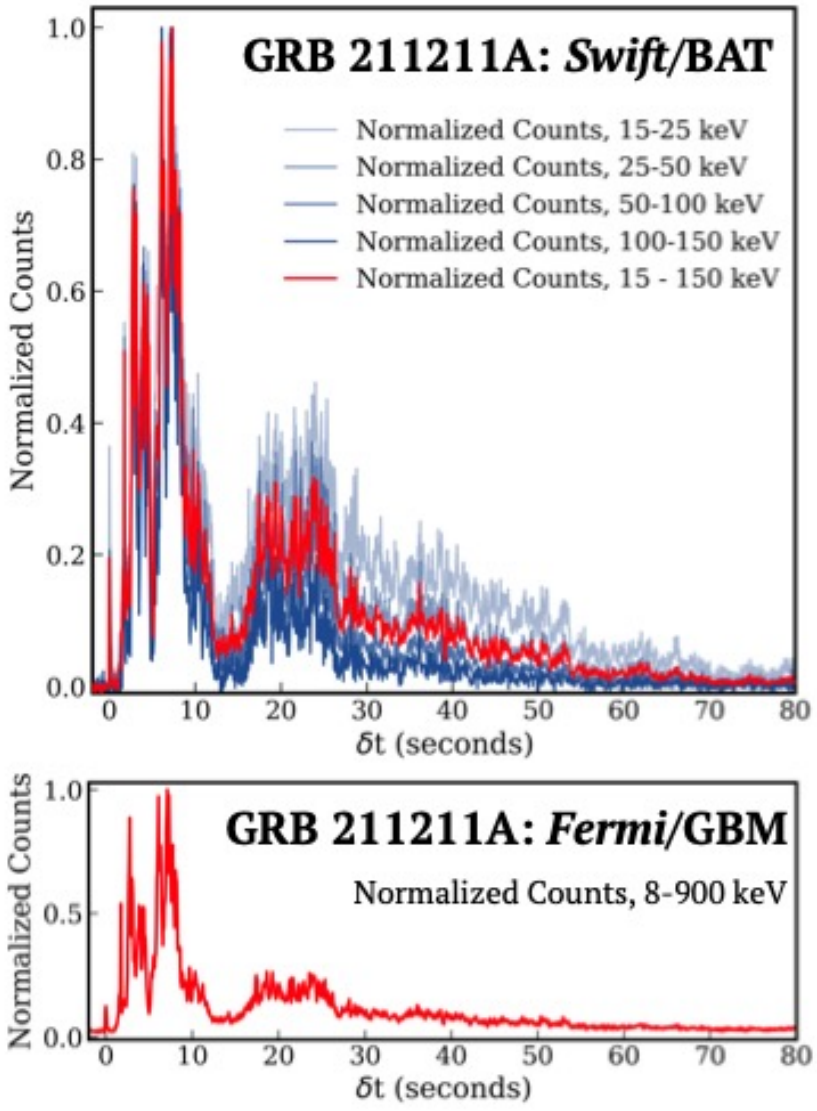
Role of environment?

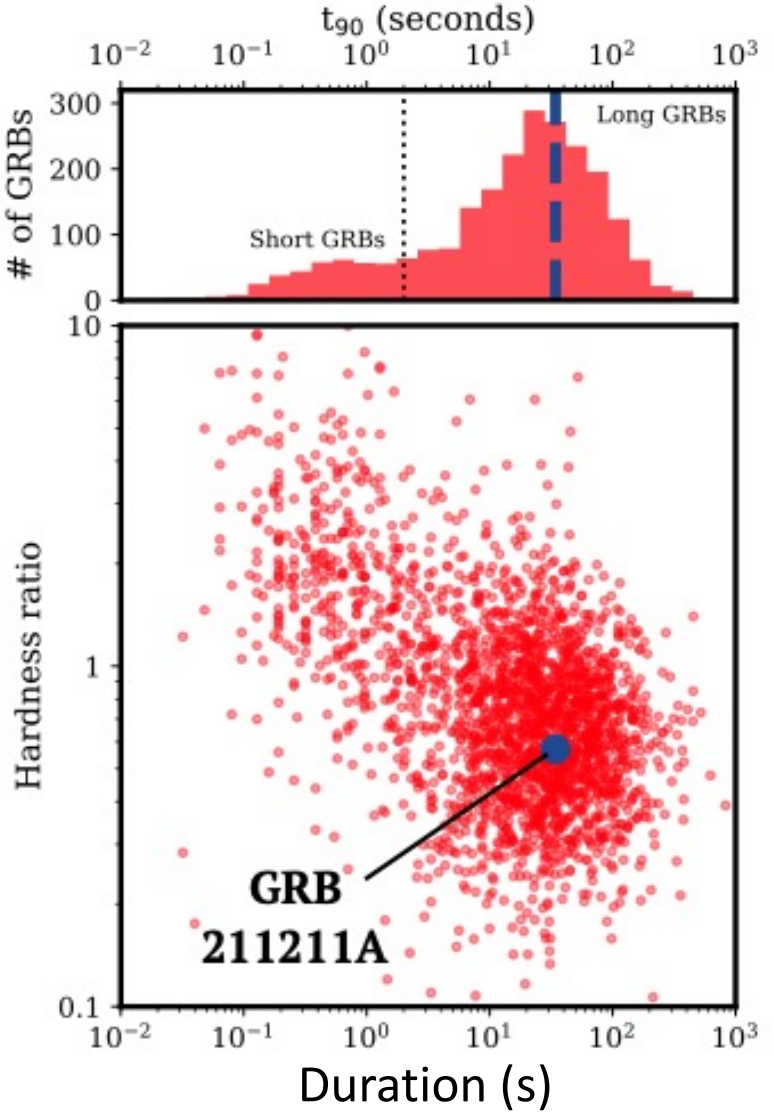




Acciardi et al. (2022)

GRB 211211A from *Gehrels* and *Fermi*





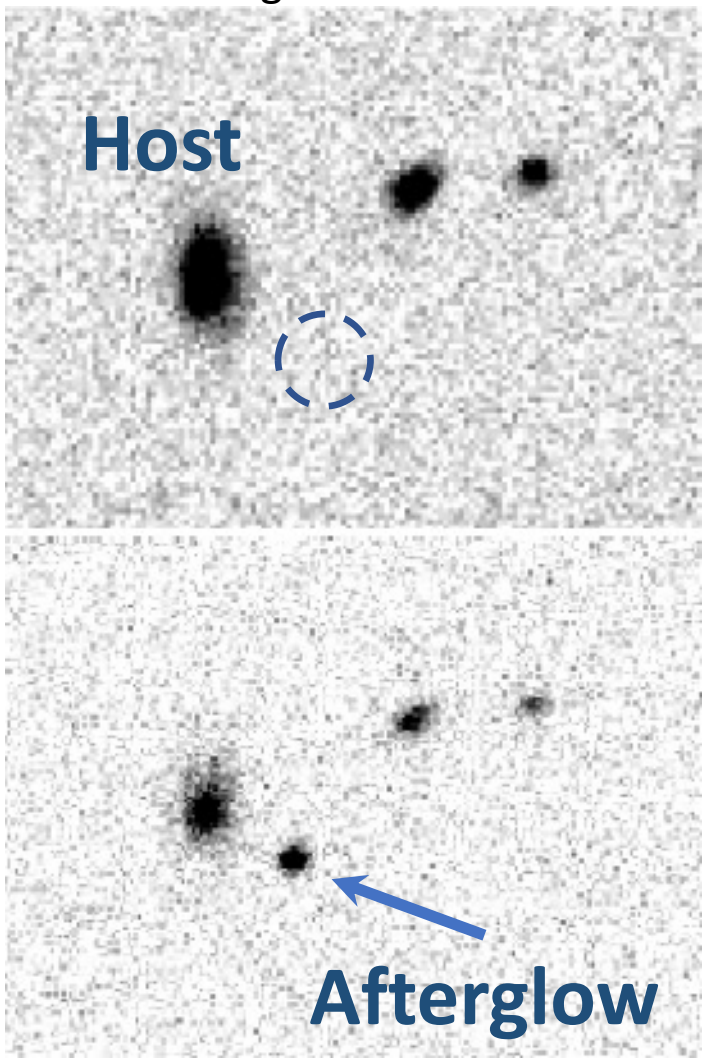
Duration ~50 s
Typical long GRB

But “initial spike” +
”extended emission”

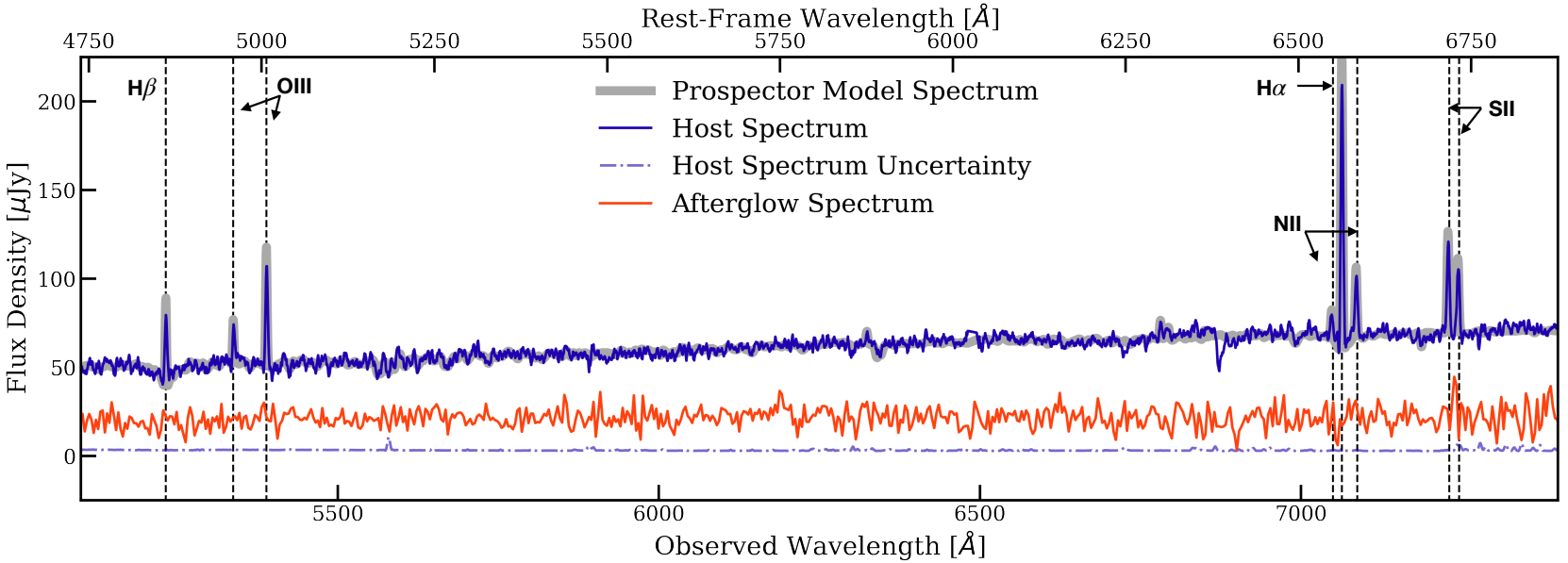
Based on:
Rastinejad et al. (2022),
Nature, 612,223

A new kind of cosmic explosion?

Archival image

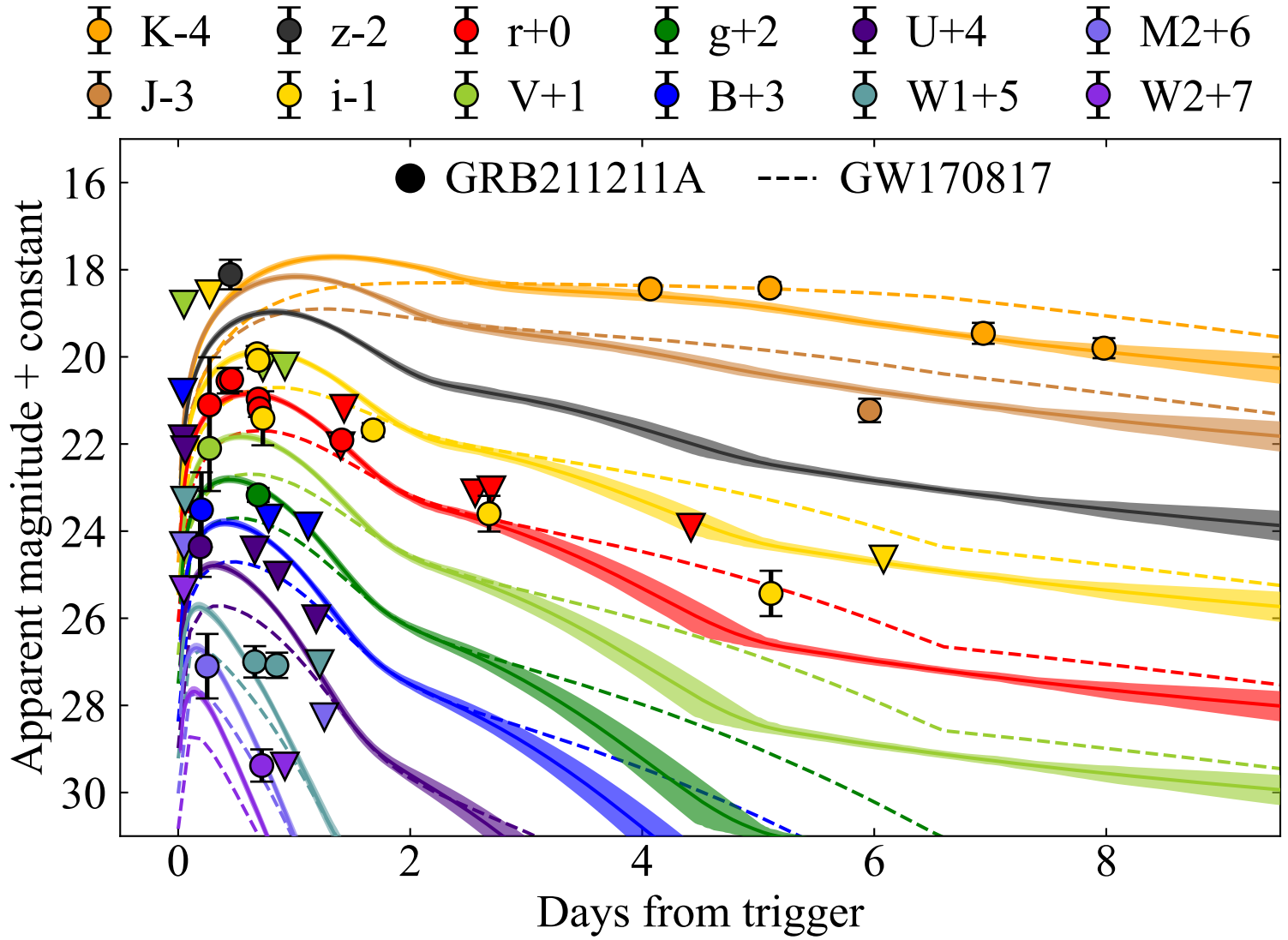


NOT image



NOT spectrum: z = 0.076 (350 Mpc).

The emerging kilonova



Data from Gemini, MMT, NOT, CAHA, …

Afterglow-subtracted light curve.

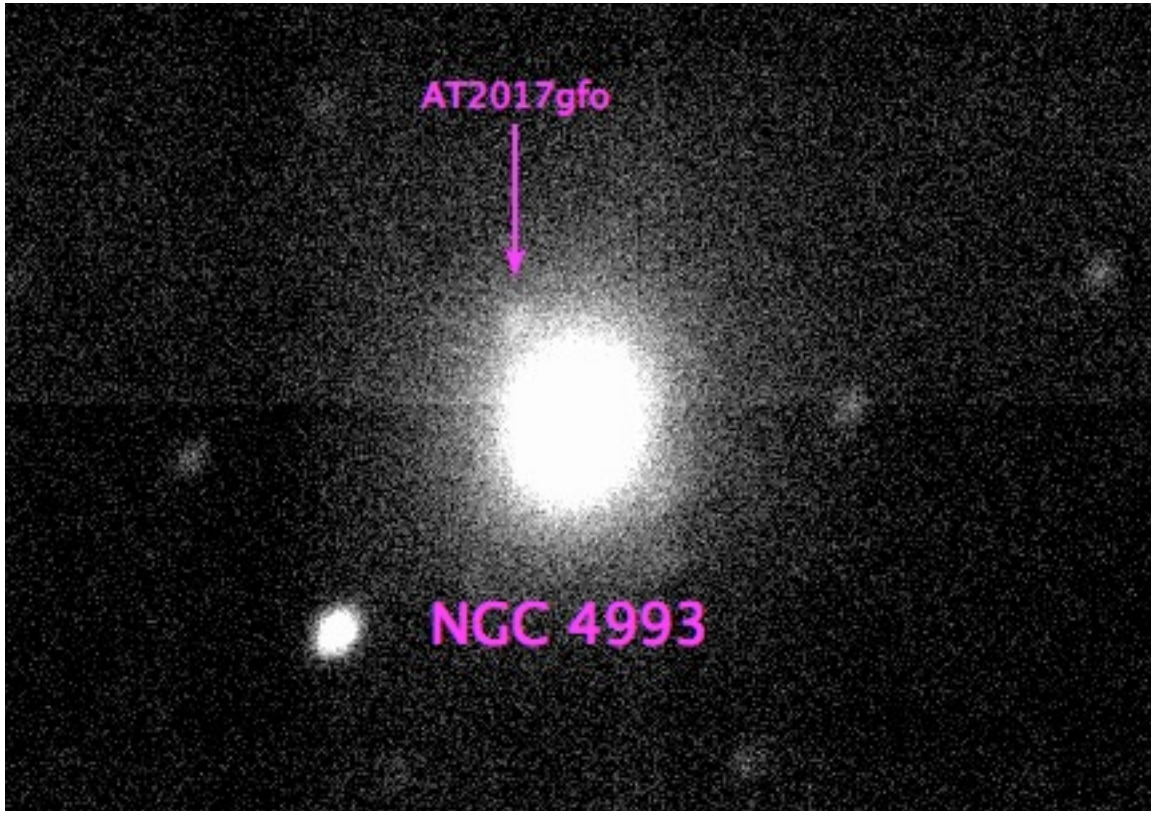
Good match with both models and AT 2017gfo template.

The kilonova following GW 170817

One kilonova was discovered following a GW detection (GW 170817 / AT 2017gfo).

Very badly observable from the NOT
Only one K-band observation secured.

The O3 observing run did not yield viable candidates
(but NOT follow-up of two promising events, GW 190814 and AT 2019wxt).



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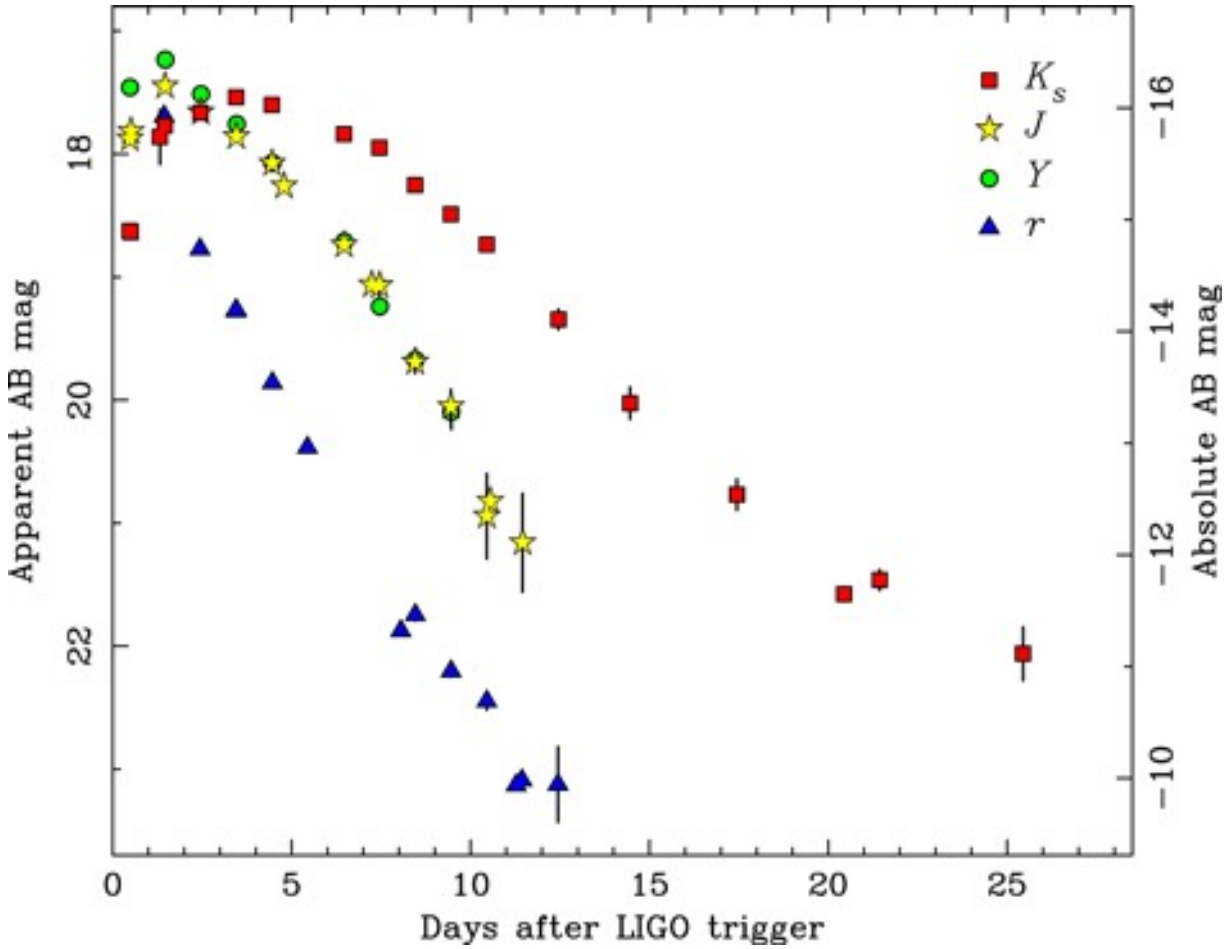
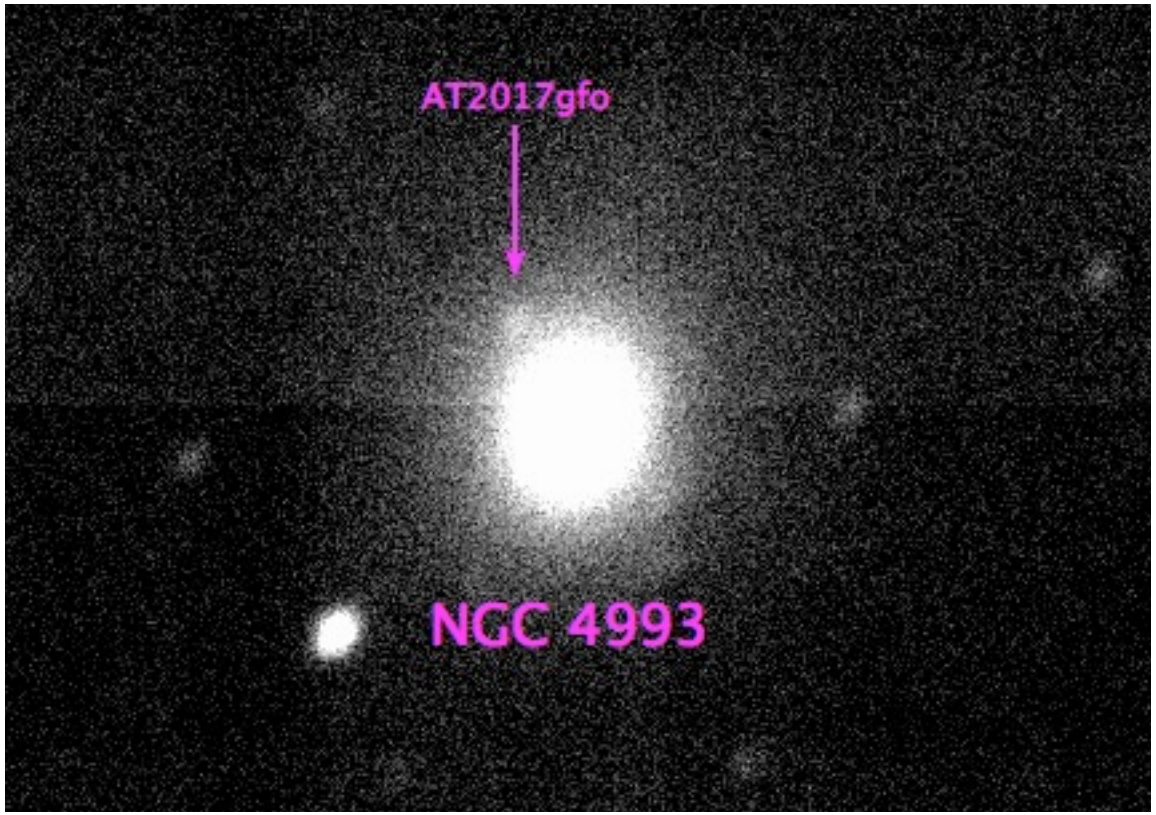
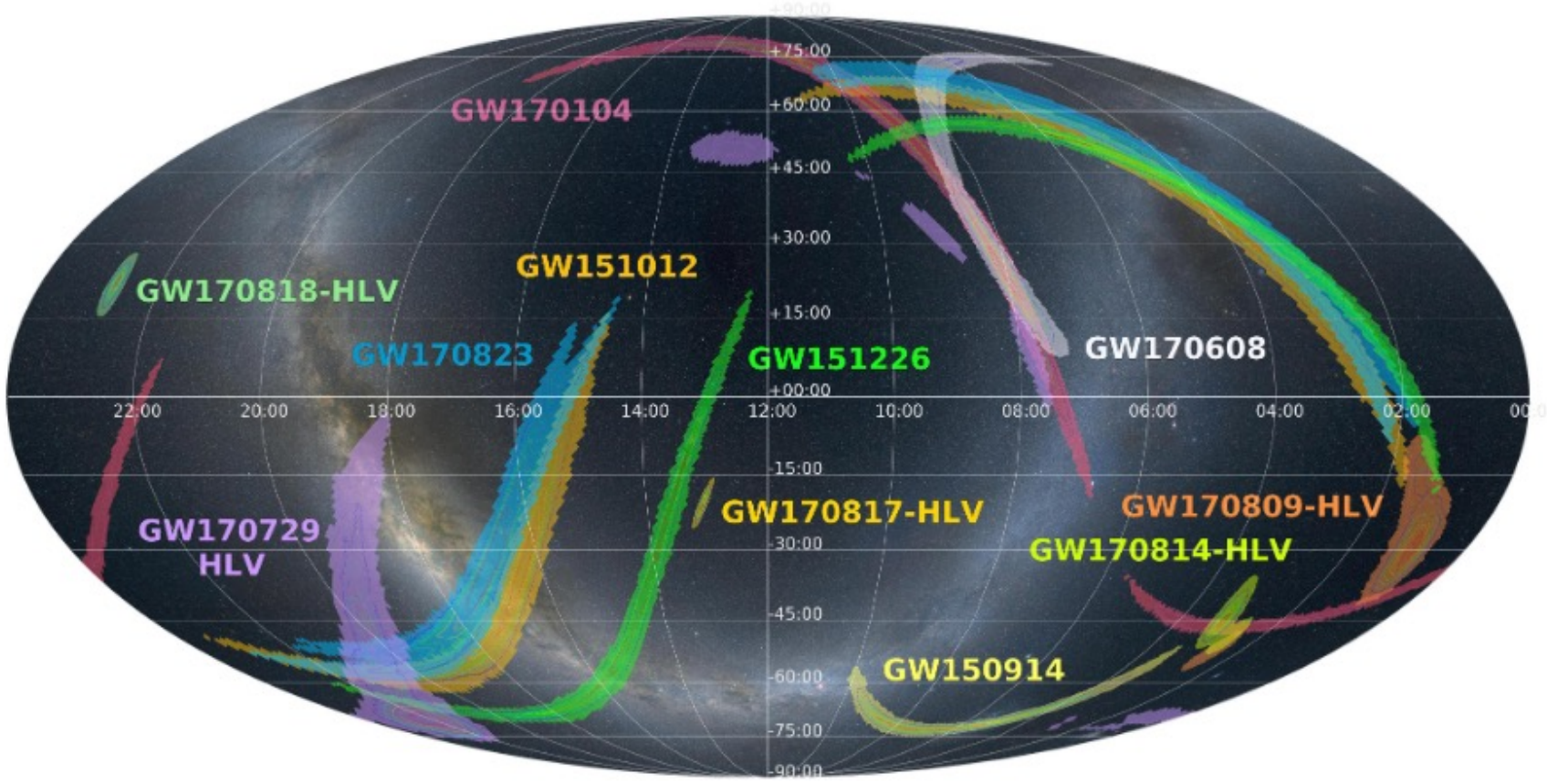




Tanvir et al. (2017)

Hunting for GW counterparts

Very large uncertainty regions
(S/N and number of detectors)



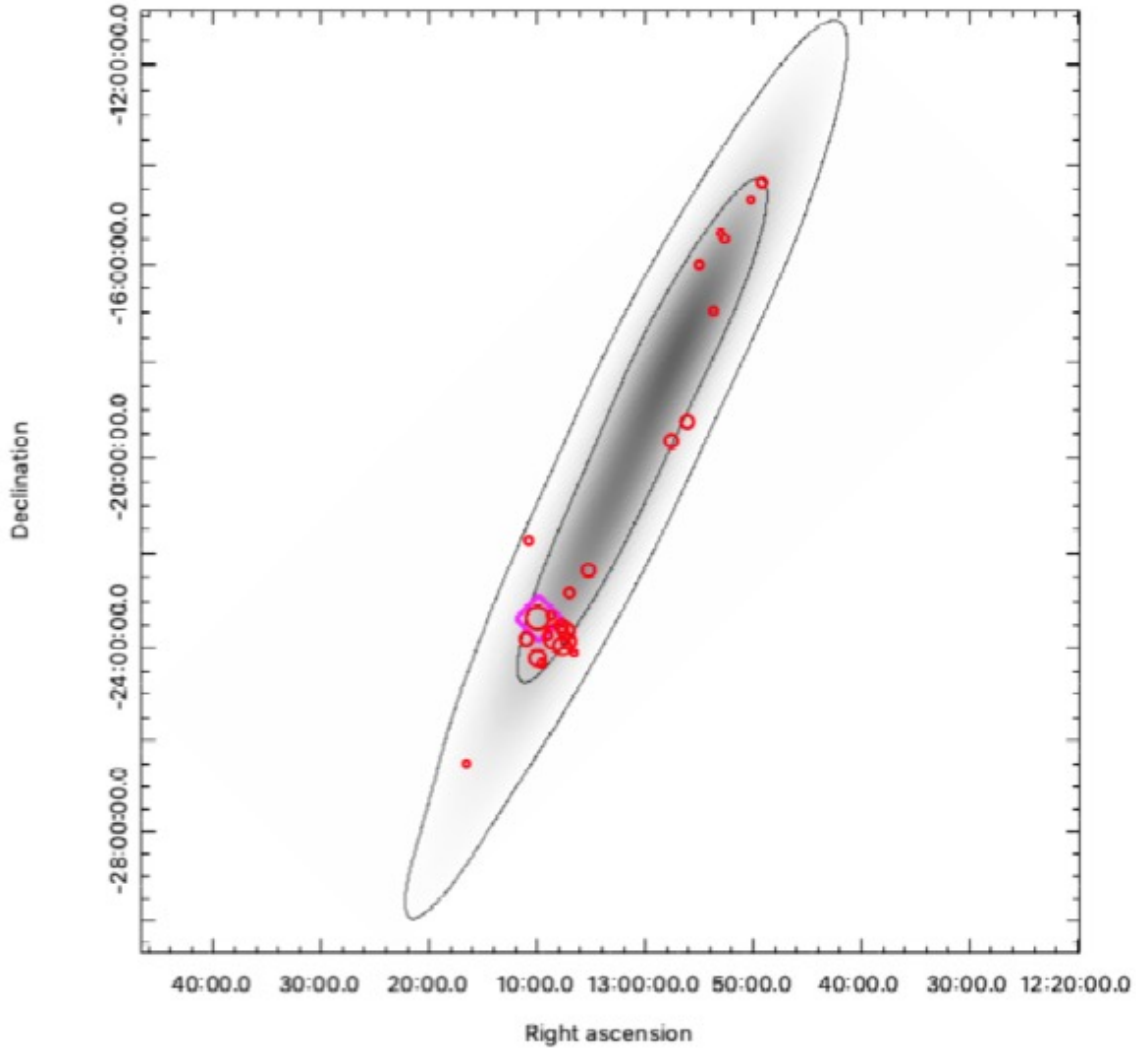
Hunting for GW counterparts

Very large uncertainty regions
(S/N and number of detectors)

Two strategies:

- Tiling with wide-field telescopes
- Target high-probability galaxies
- AT 2017gfo was 1st / 3rd ranked

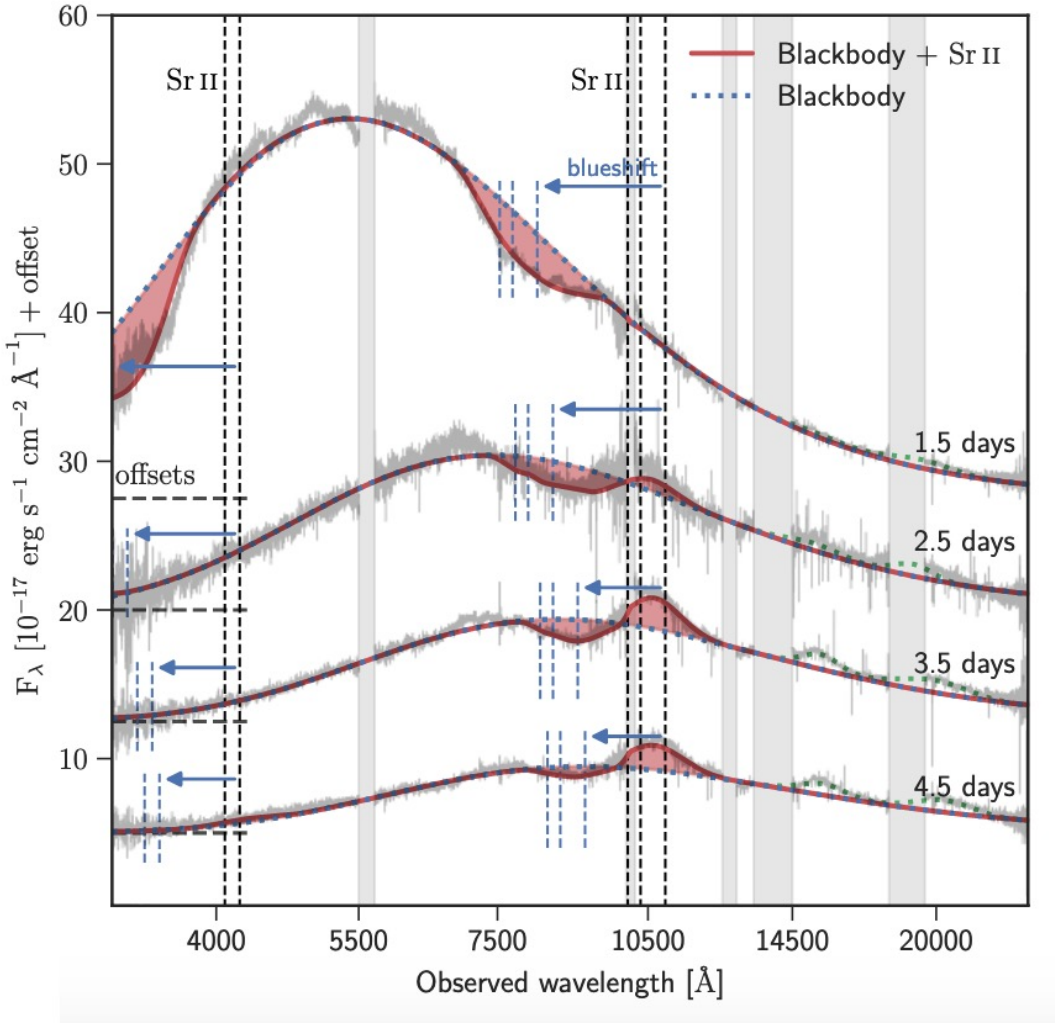
Approach followed at the NOT:
Ackley et al. (2020) for GW 190814.



NOT capabilities

- Automated follow-up of high-probability galaxies (auto selection of targets and OB generation).
- Classification of candidates identified by surveys (e.g. ZTF, Pan-STARRS, …)
- Optical and **NIR** follow-up of kilonova light curve.
- Spectroscopy and classification of kilonova features

Watson et al. (2019)



Enters NTE

- Spectroscopy at higher resolution: ability to infer detailed properties of the interstellar medium.
- Near-infrared coverage, important for high-redshift events, both for counterpart identification and spectroscopy (particularly relevant with the upcoming SVOM).
- Near infrared imaging: crucial for kilonova studies.
- All-time availability key for ToO studies.