GTC observations of GRB afterglows and their host galaxies

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Outline:

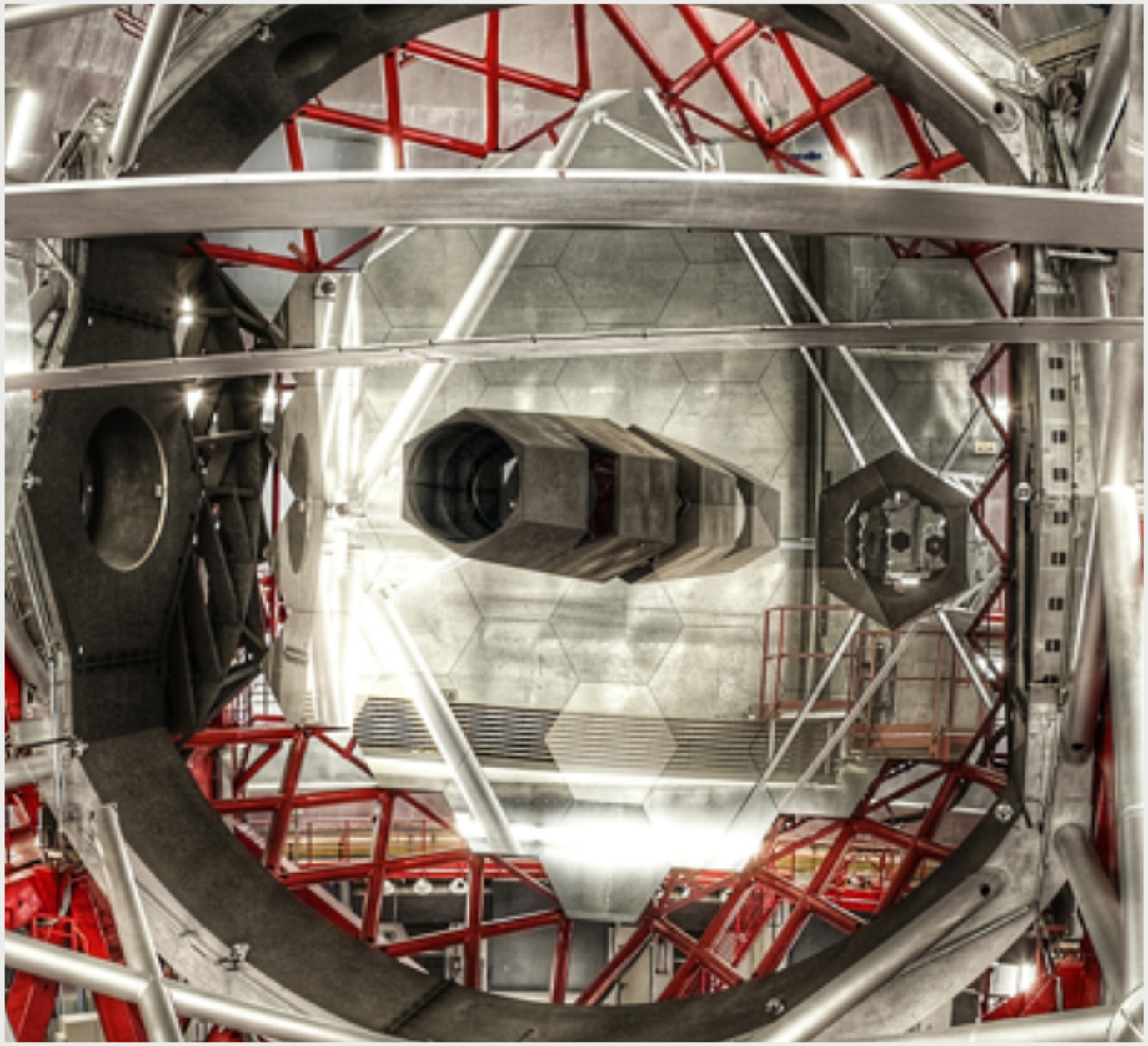
1.- Short Introduction to GTC.

2.- Main results (2009-2013).

- Imaging and spectroscopy of GRB afterglows.
  - Long GRBs
  - Short GRBs
- Study of SNe associated to Long GRBs.
- Host galaxies

GTC: SUITABLE FOR GRBs

- 10.4 m telescope on the observatory of Roque de los Muchachos, La Palma.
- The biggest optical photon collector.
- Privileged location.



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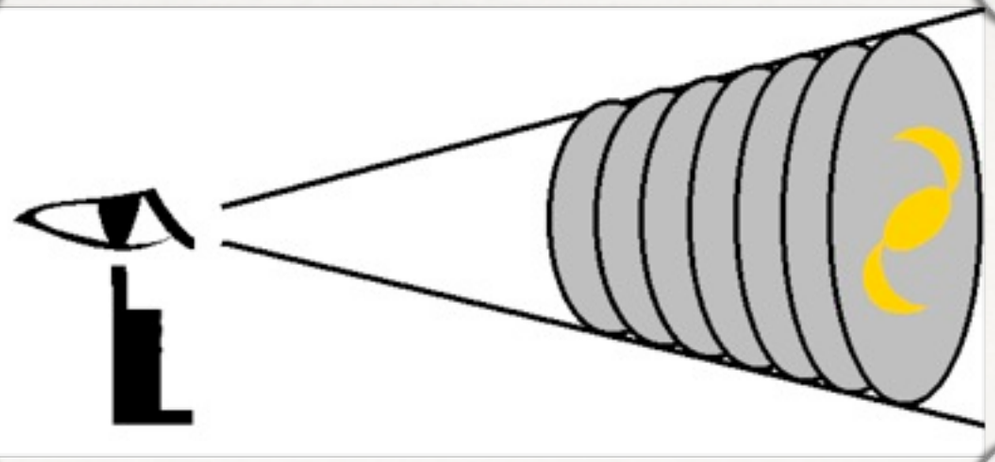
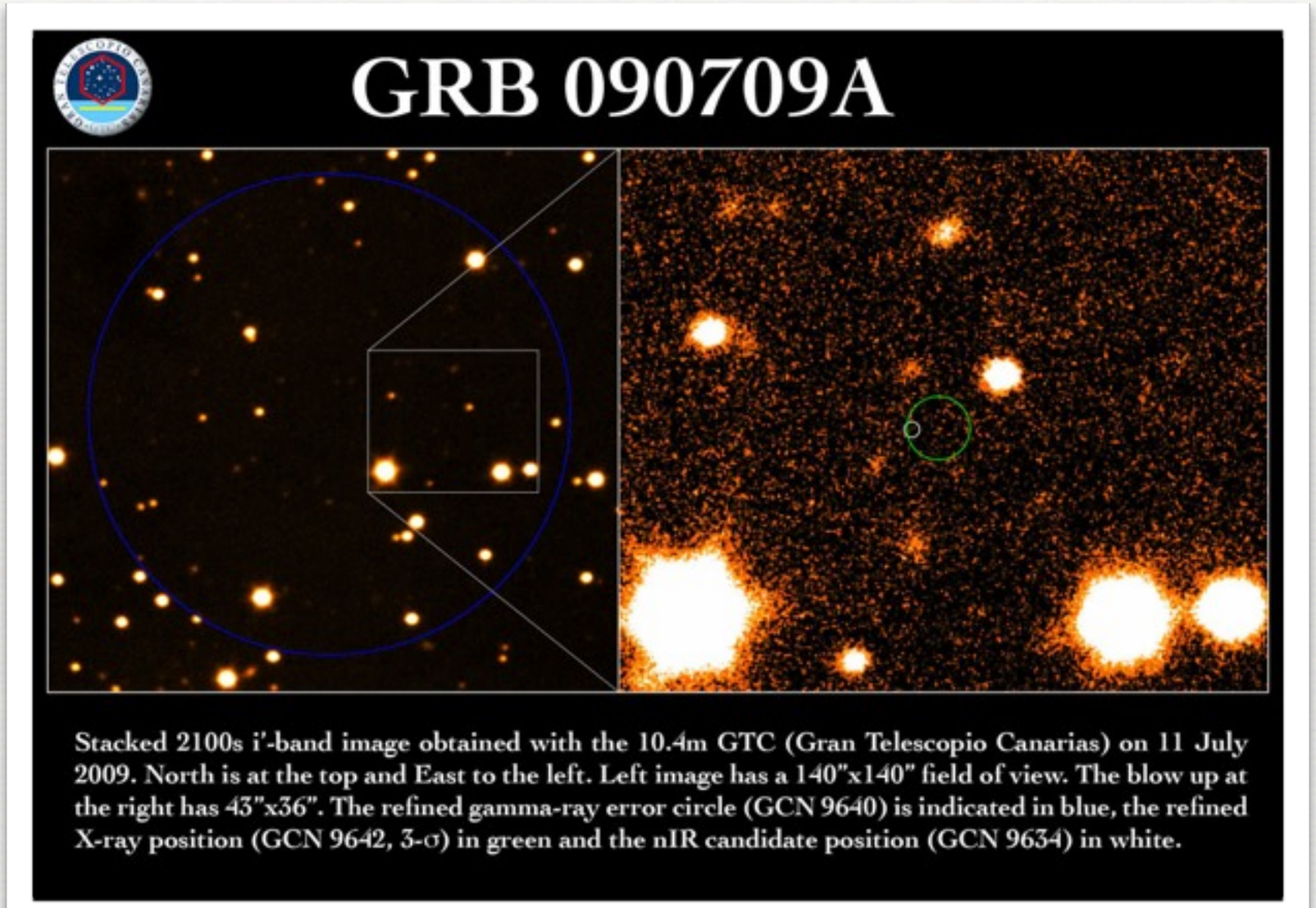
GTC INSTRUMENTATION

- OSIRIS
  - Optical camera & Low-resolution long-slit spectrosgraph.
  - FoV ~8′ x 8′. λ ~ 3500 – 9500 Å.
  - MOS, not fully operative yet.
  - 2 Tunable filters. 10 Å < $\Delta\lambda$ < 30 Å.



IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 090709A (first scientific result of GTC!!)
  - Proof that the primary mirror 36 segments were on phase.



Stacked 2100s i'-band image obtained with the 10.4m GTC (Gran Telescopio Canarias) on 11 July 2009. North is at the top and East to the left. Left image has a 140"x140" field of view. The blow up at the right has 43"x36". The refined gamma-ray error circle (GCN 9640) is indicated in blue, the refined X-ray position (GCN 9642, 3-σ) in green and the nIR candidate position (GCN 9634) in white.

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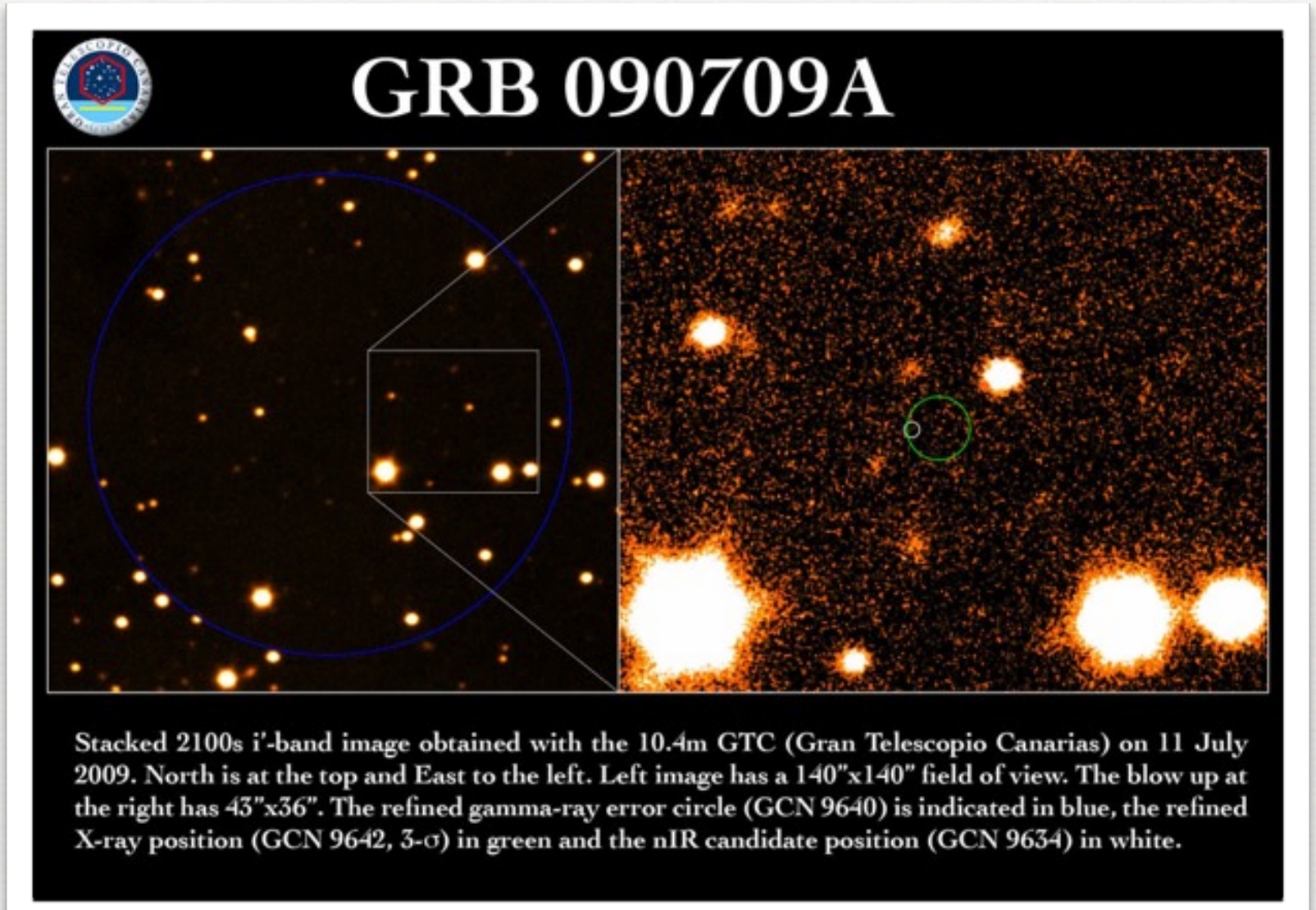

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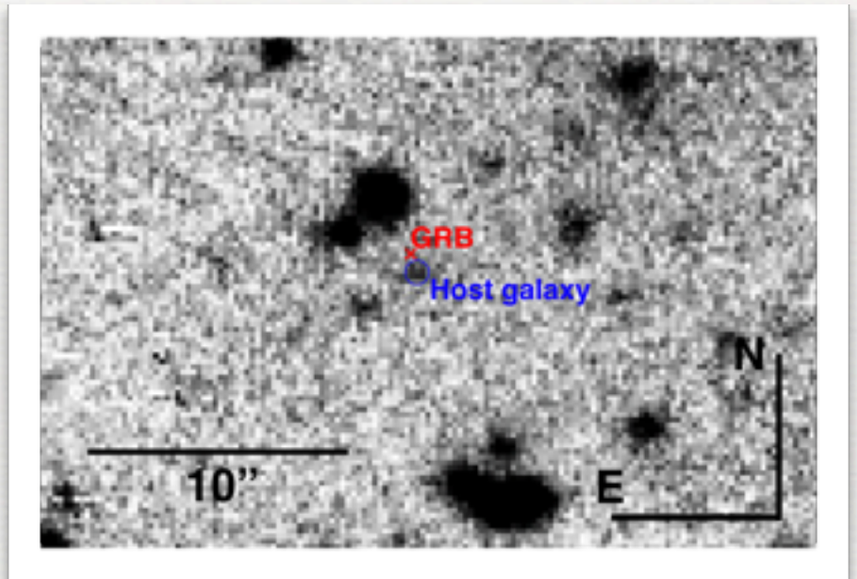
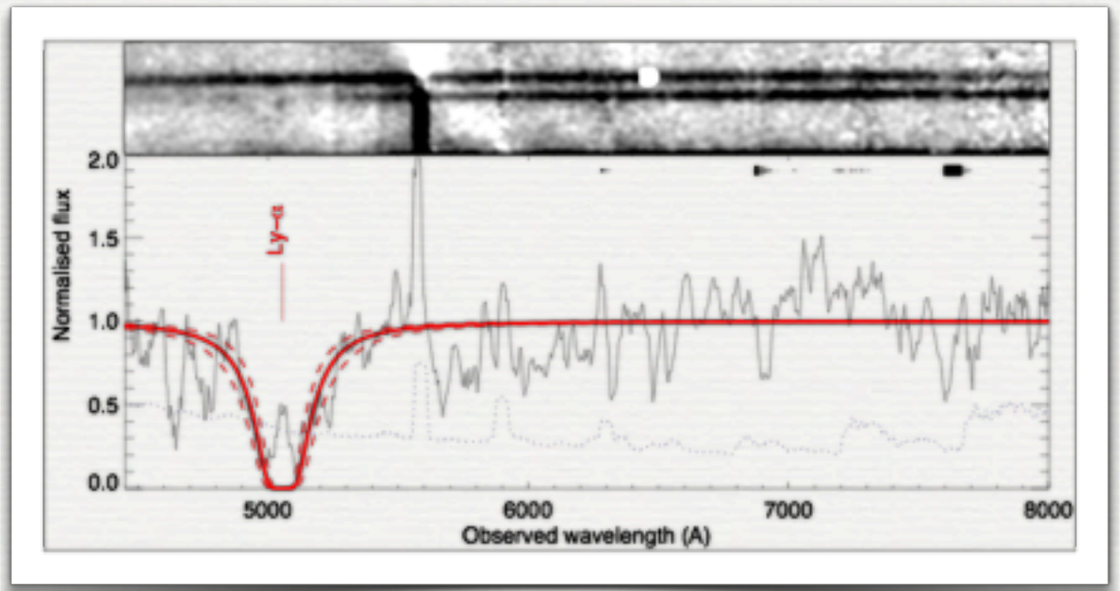
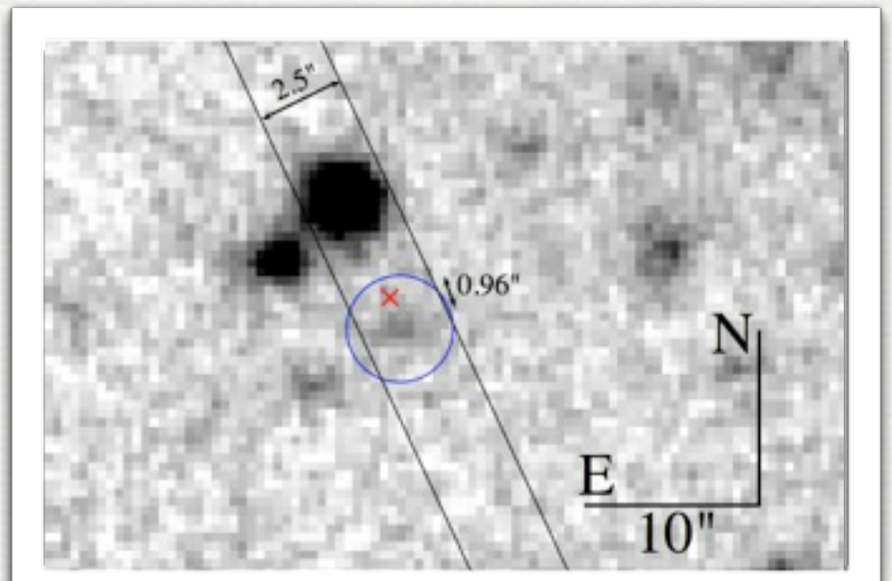
Castro-Tirado et al. 2009; GCNC 9655
Cenko et al. 2010, AJ 140, 224.

IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 100316A
  - DLA system at z=3.155.
  - Lyman-α emission shifted by ~2.5 kpc.
  - $N_H \sim 10^{22.5}$ cm^{-2}







IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

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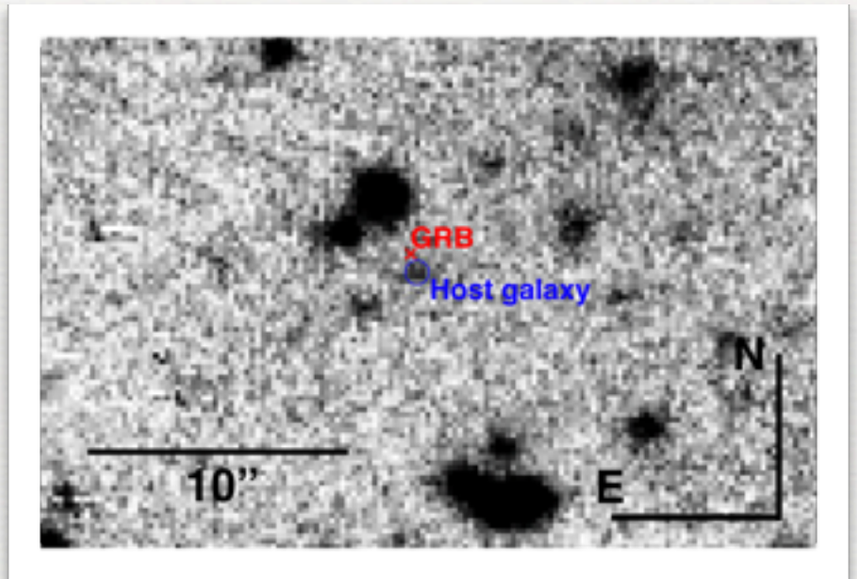
Sánchez Ramírez et al. in prep.



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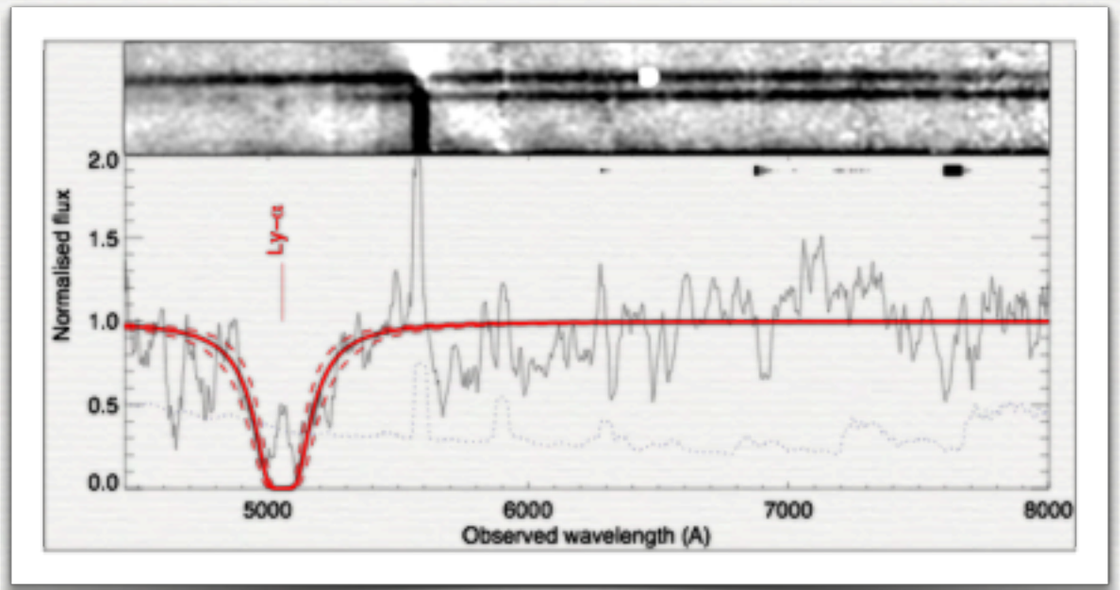
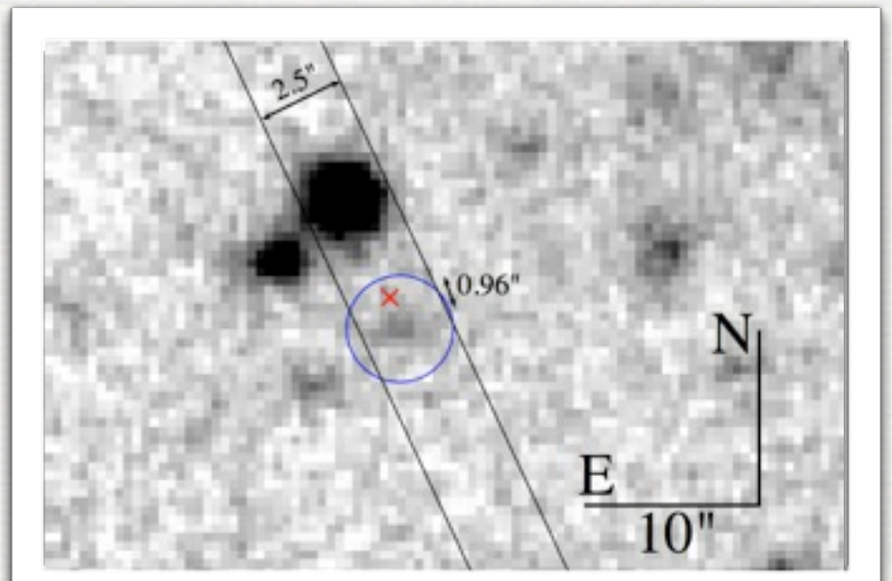
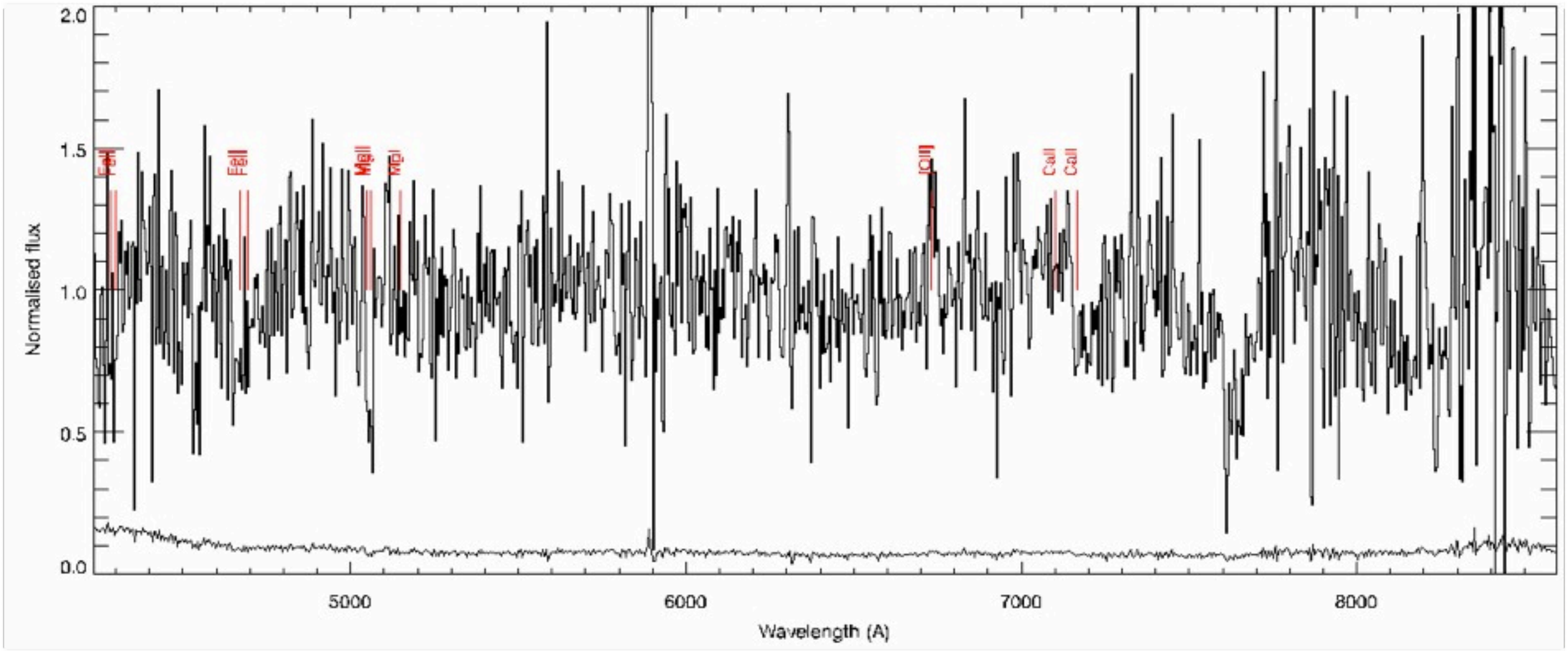




IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 100816A (z=0.805; Tanvir et al. GCN11123; Gorosabel et al. GCN11125)
- Pretty stable PSF all over the FoV. PSF-matching subtraction works fine.



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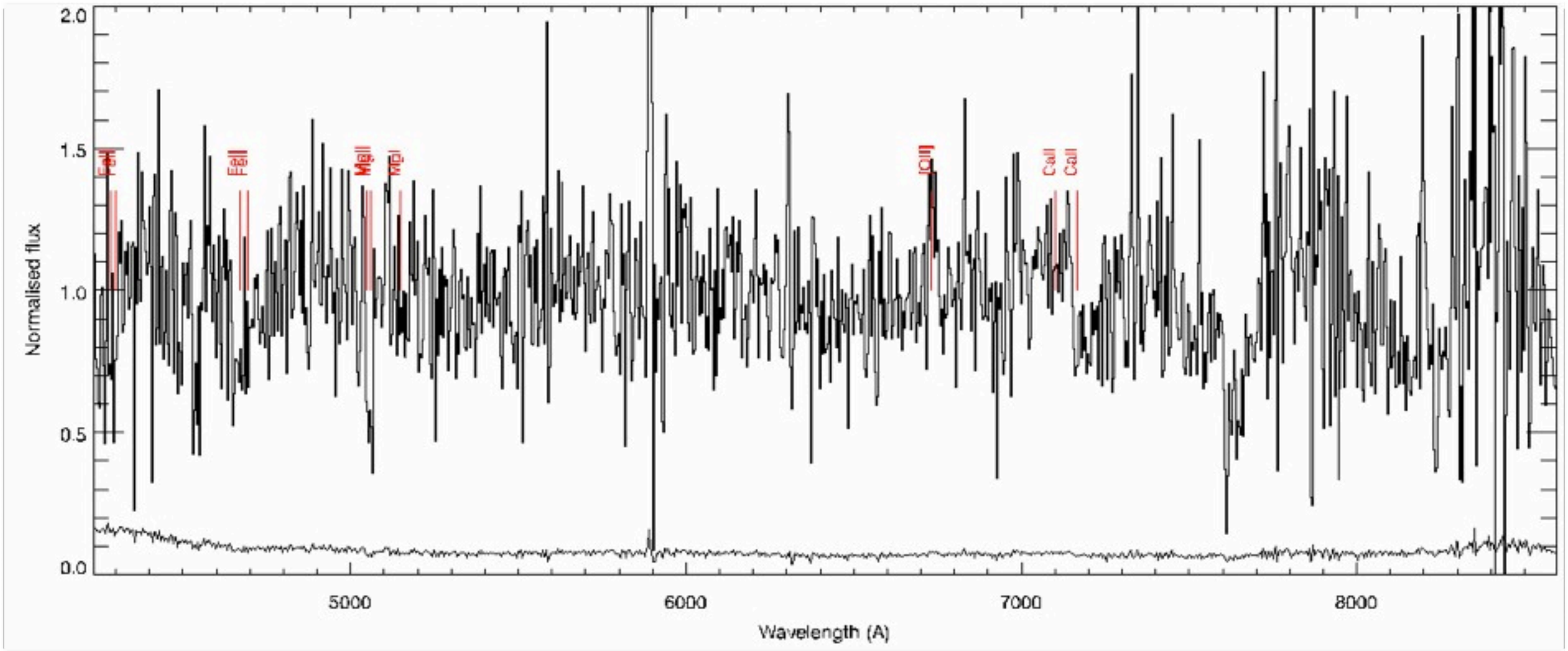

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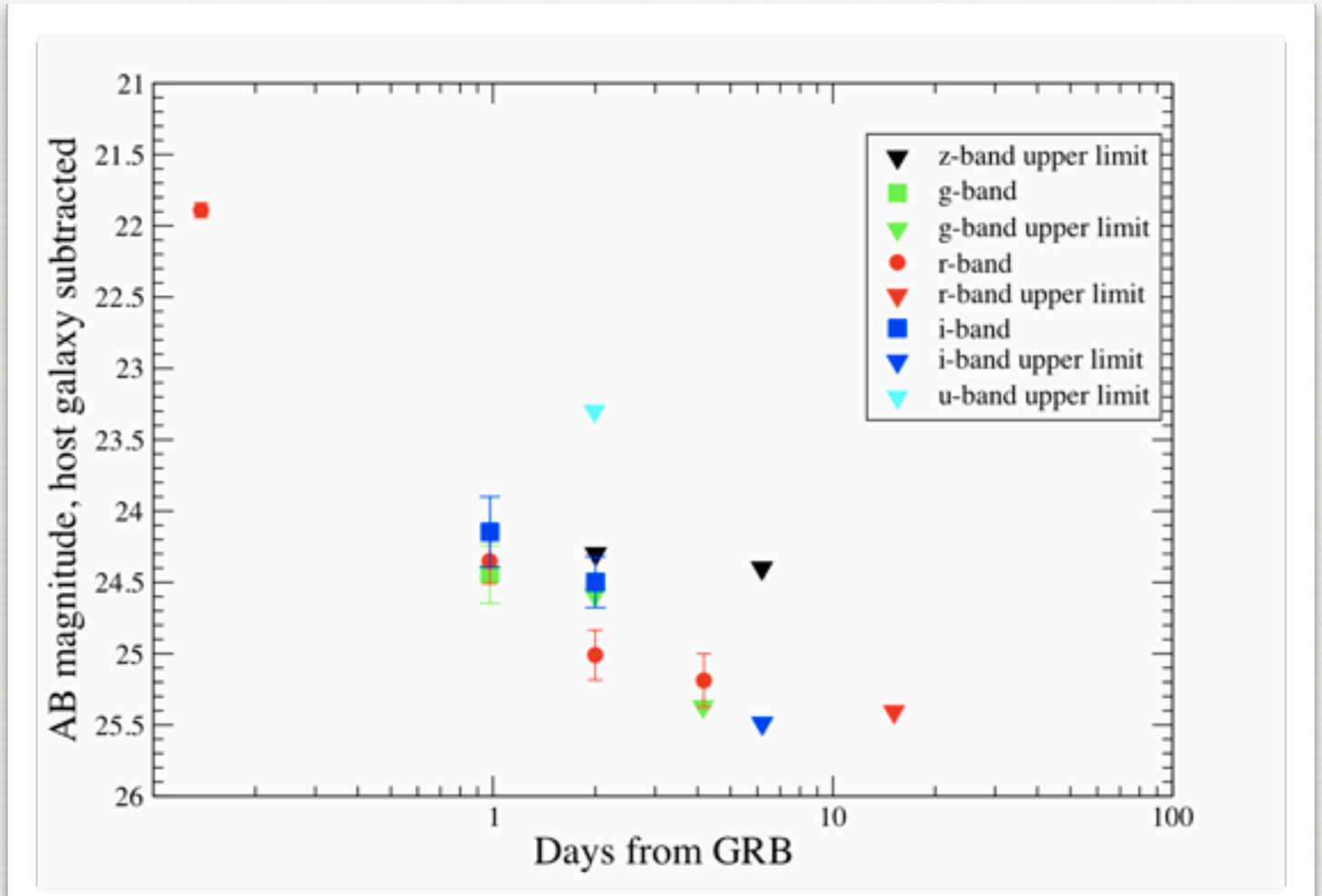

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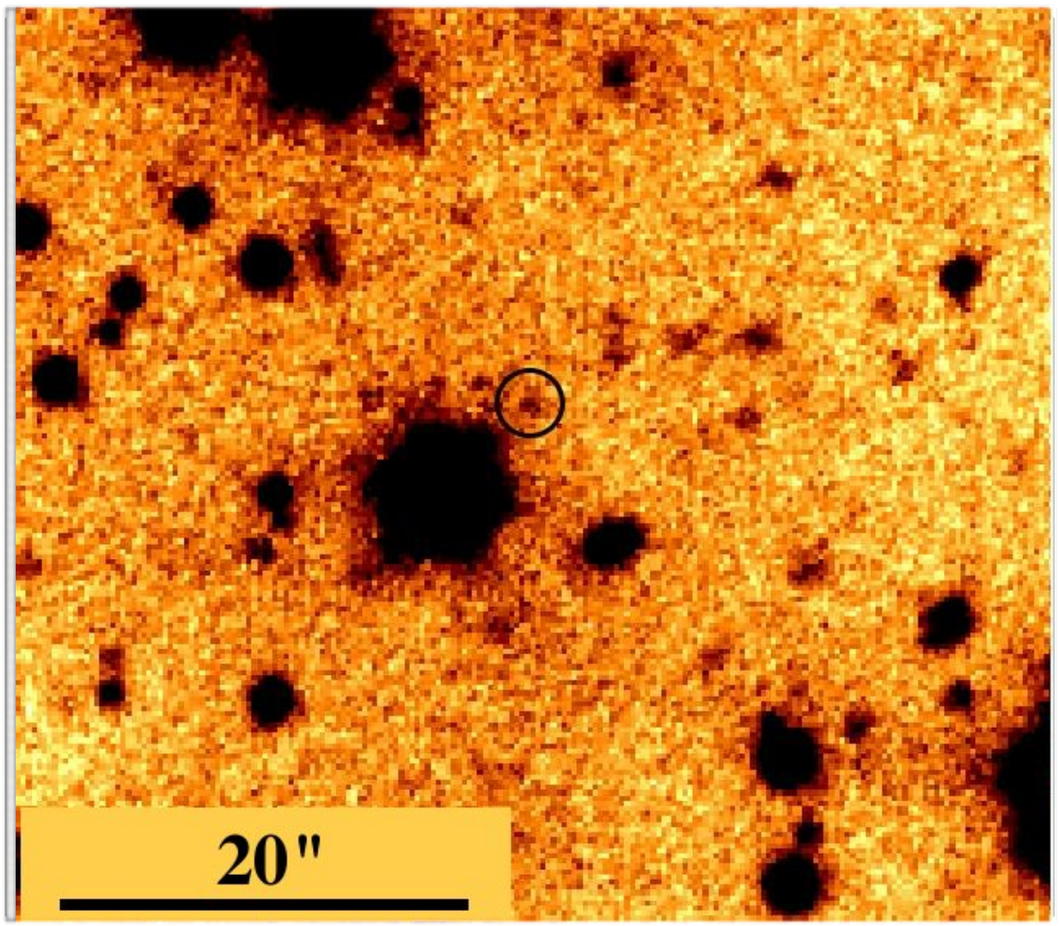
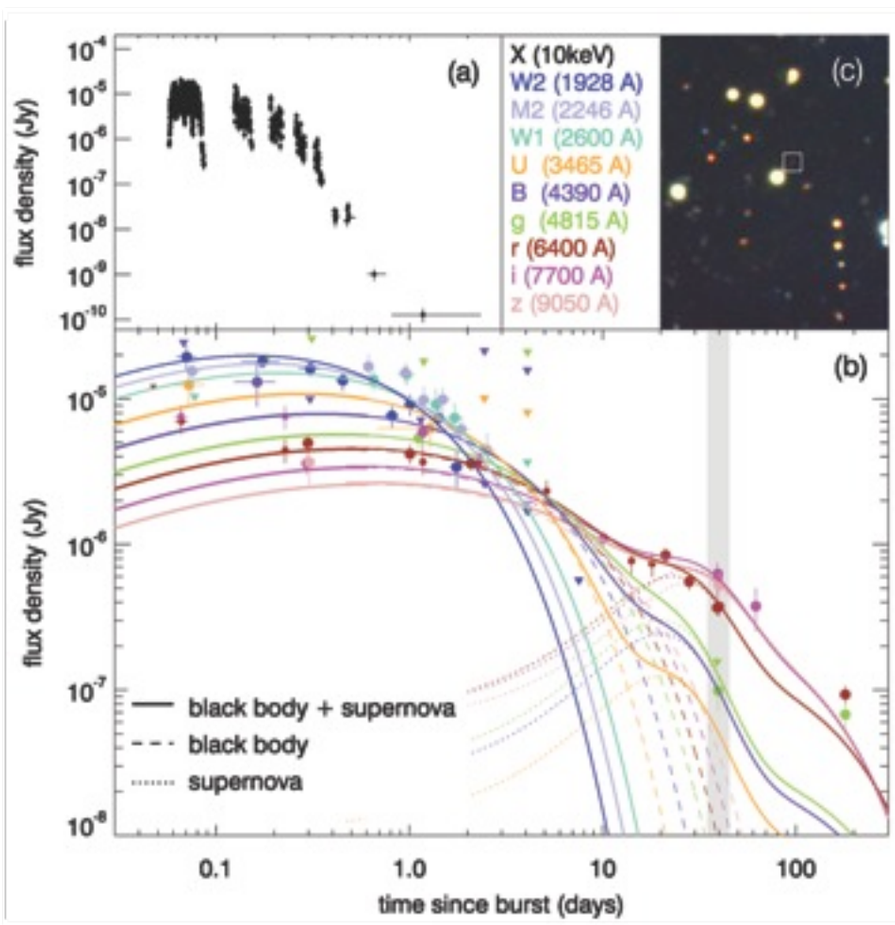
IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 101225A (*Christmas burst*):
  - Deep imaging key to detect the SN bump and the host galaxy at r=26.90±0.14





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Thöne et al. 2011, Nature 480, 72.

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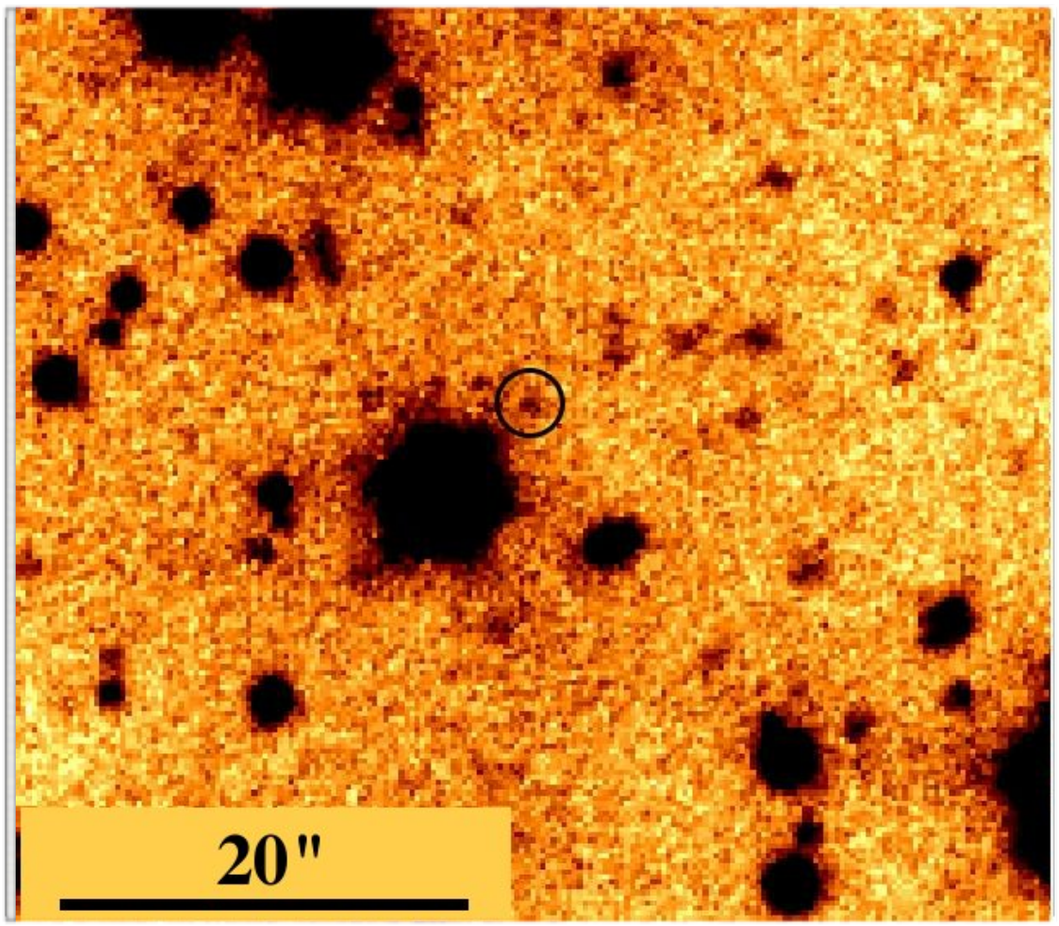

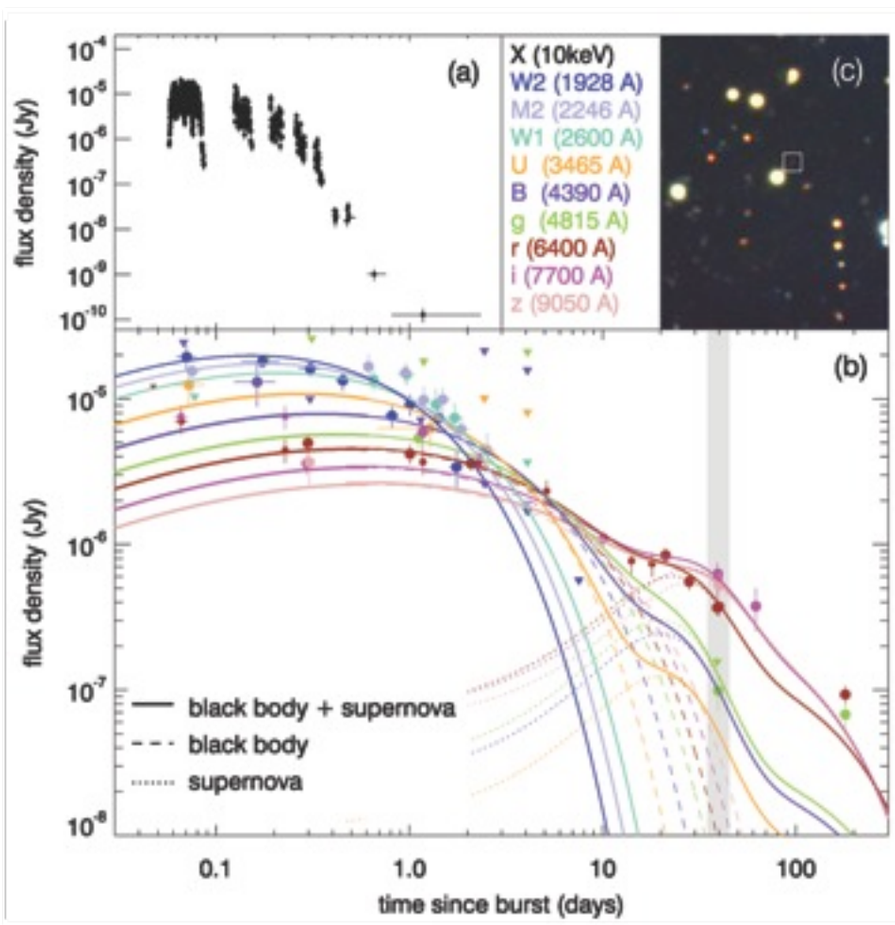

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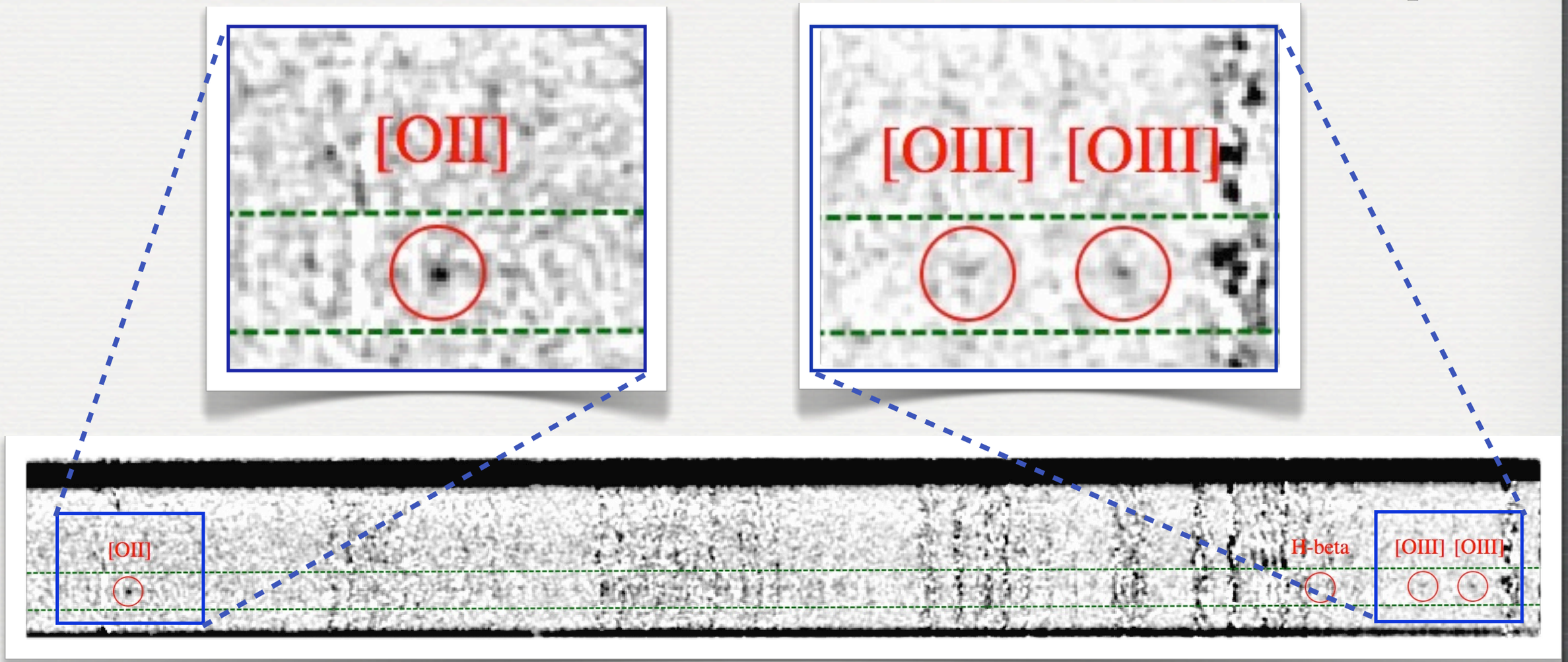

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Thöne et al. 2013, in prep.,
Levan et al. 2013, ApJ in press.

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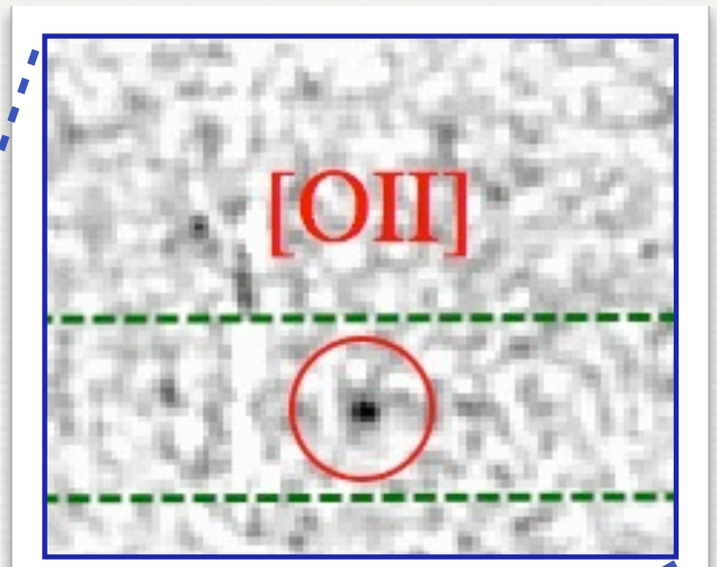
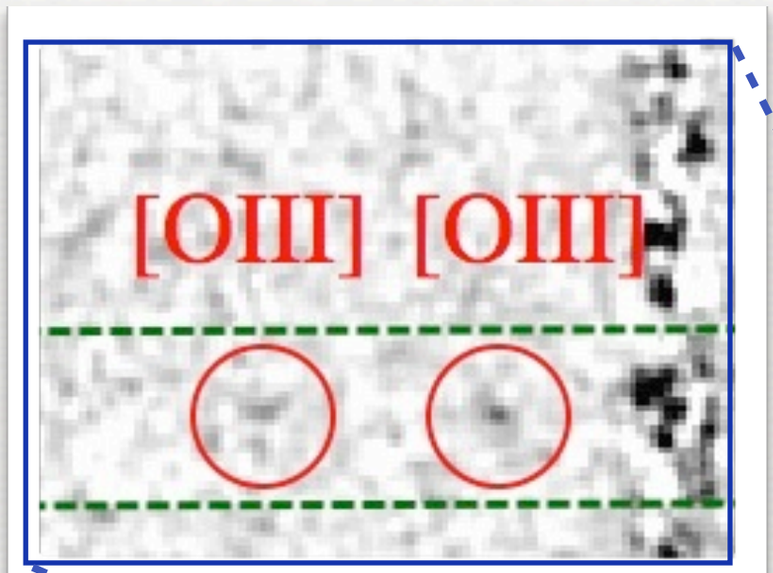
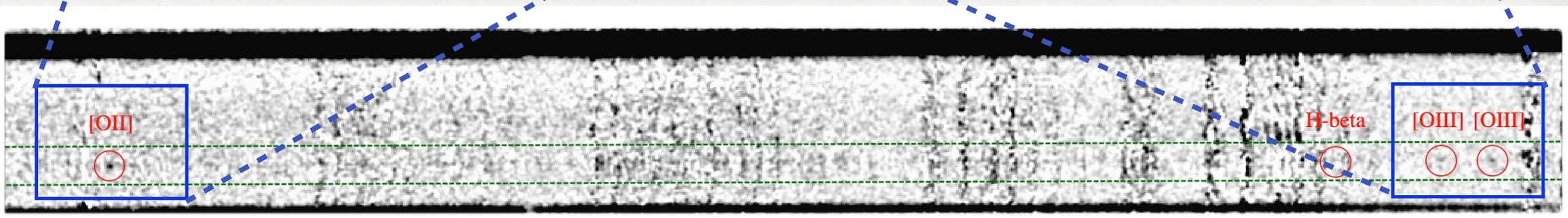
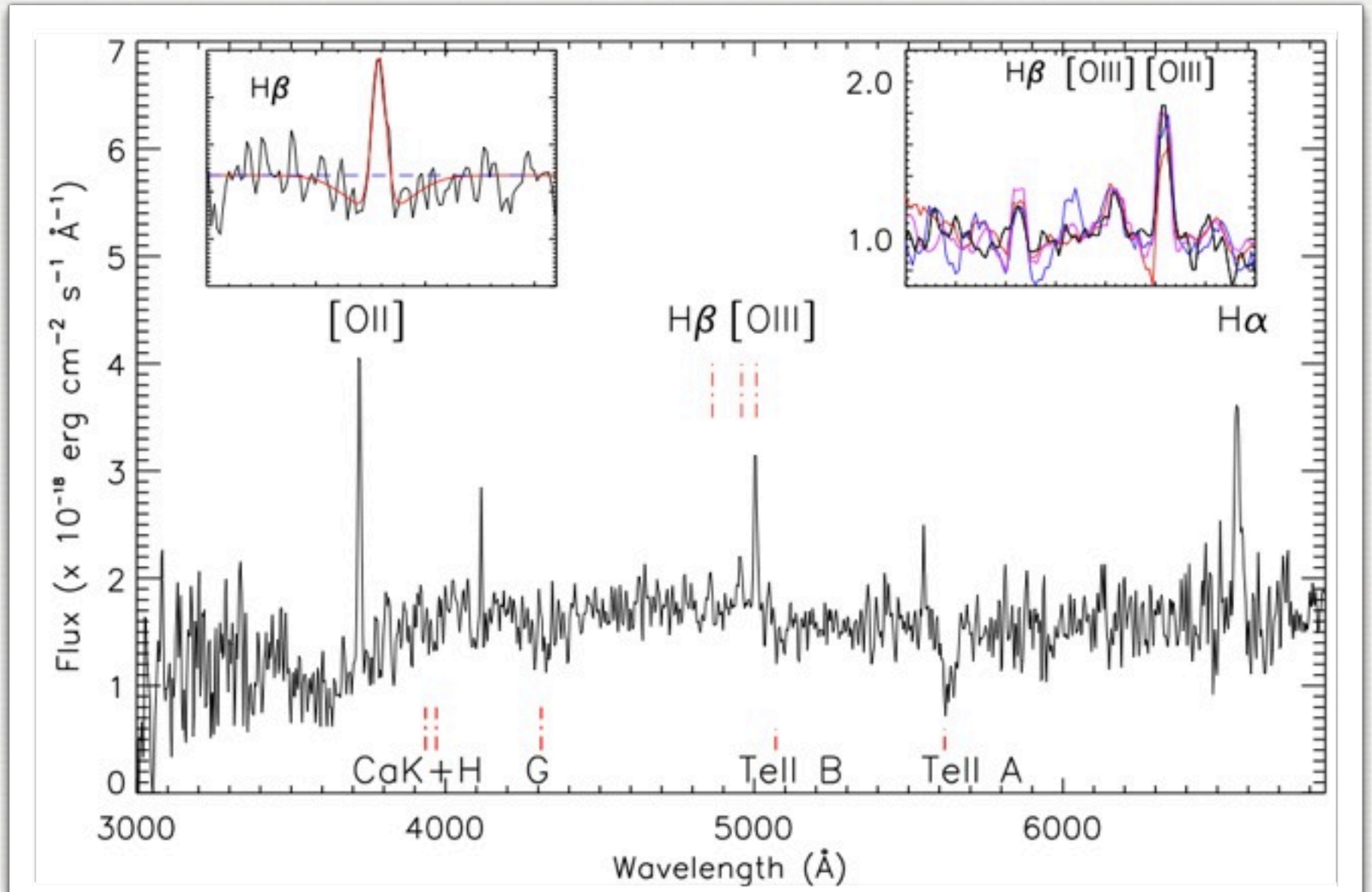






IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 110328 / Sw 1644+57
  - Photometric and spectroscopic follow up.



Levan et al. 2011, Science 333, 199.

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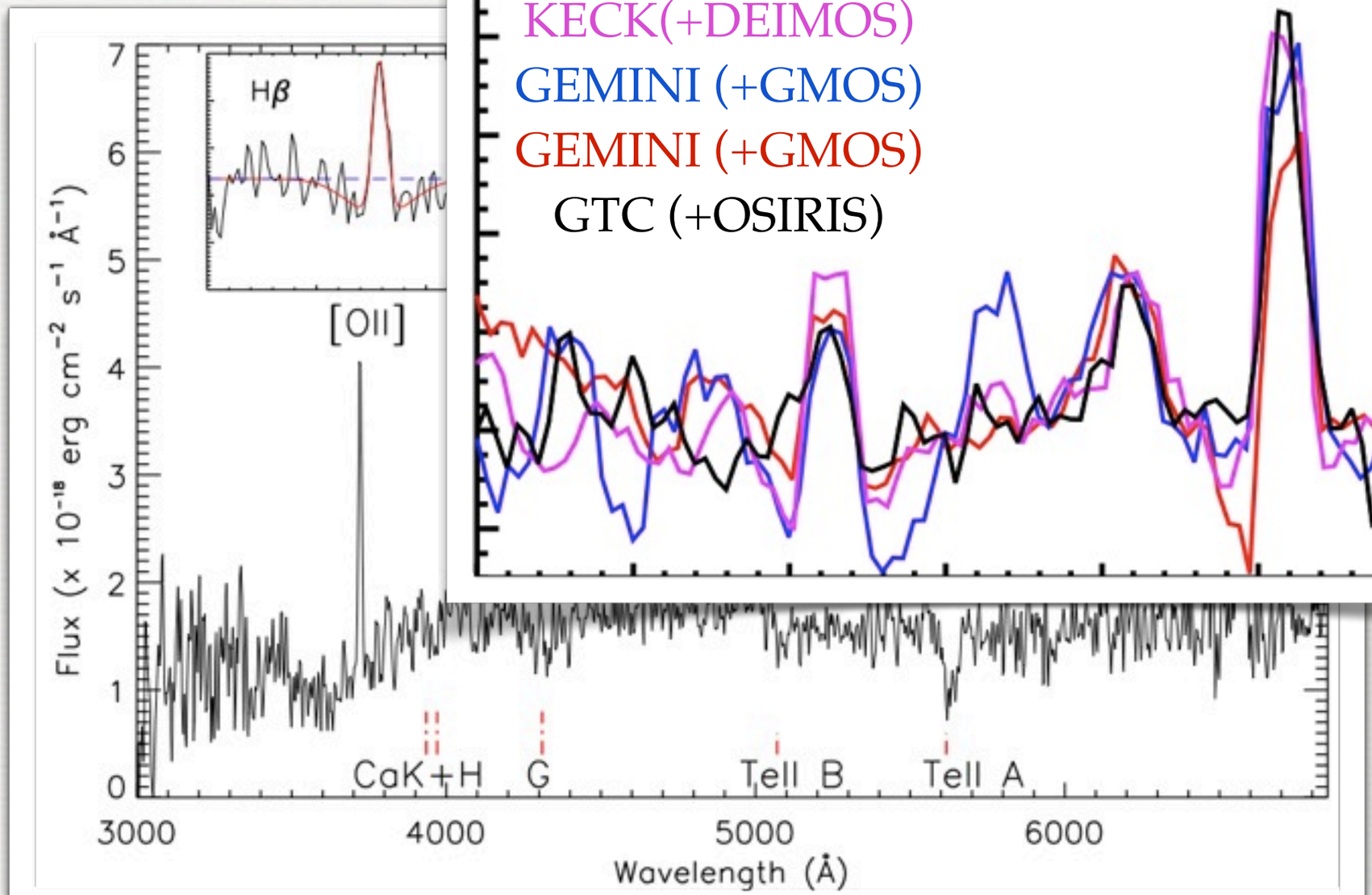
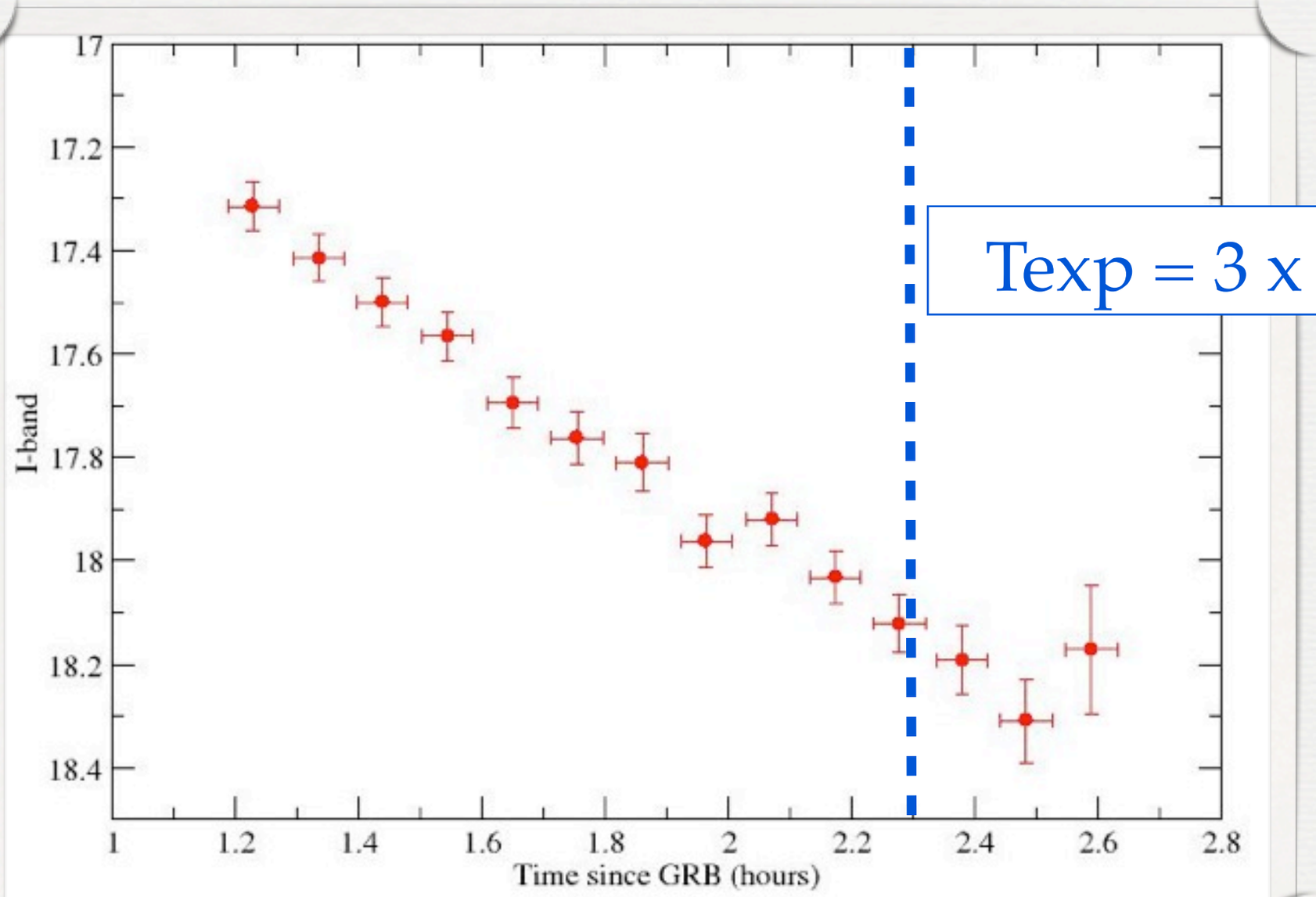


Levan et al. 2011, Science 333, 199.

IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 120327A
  - z=2.813 (Perley et al. GCN13133; Kruehler et al. GCN13134).



D'Elia et al. 2013, in prep.

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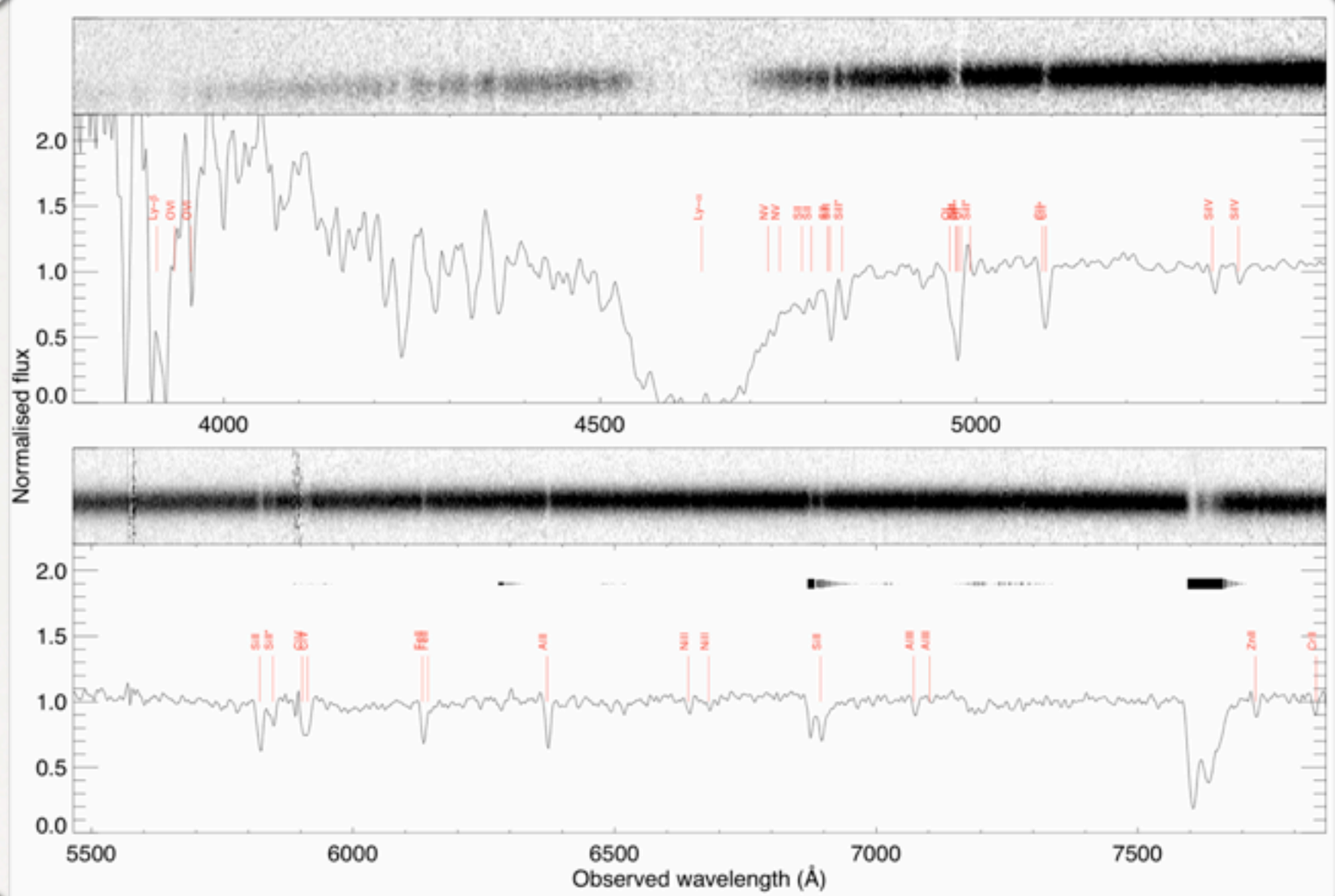
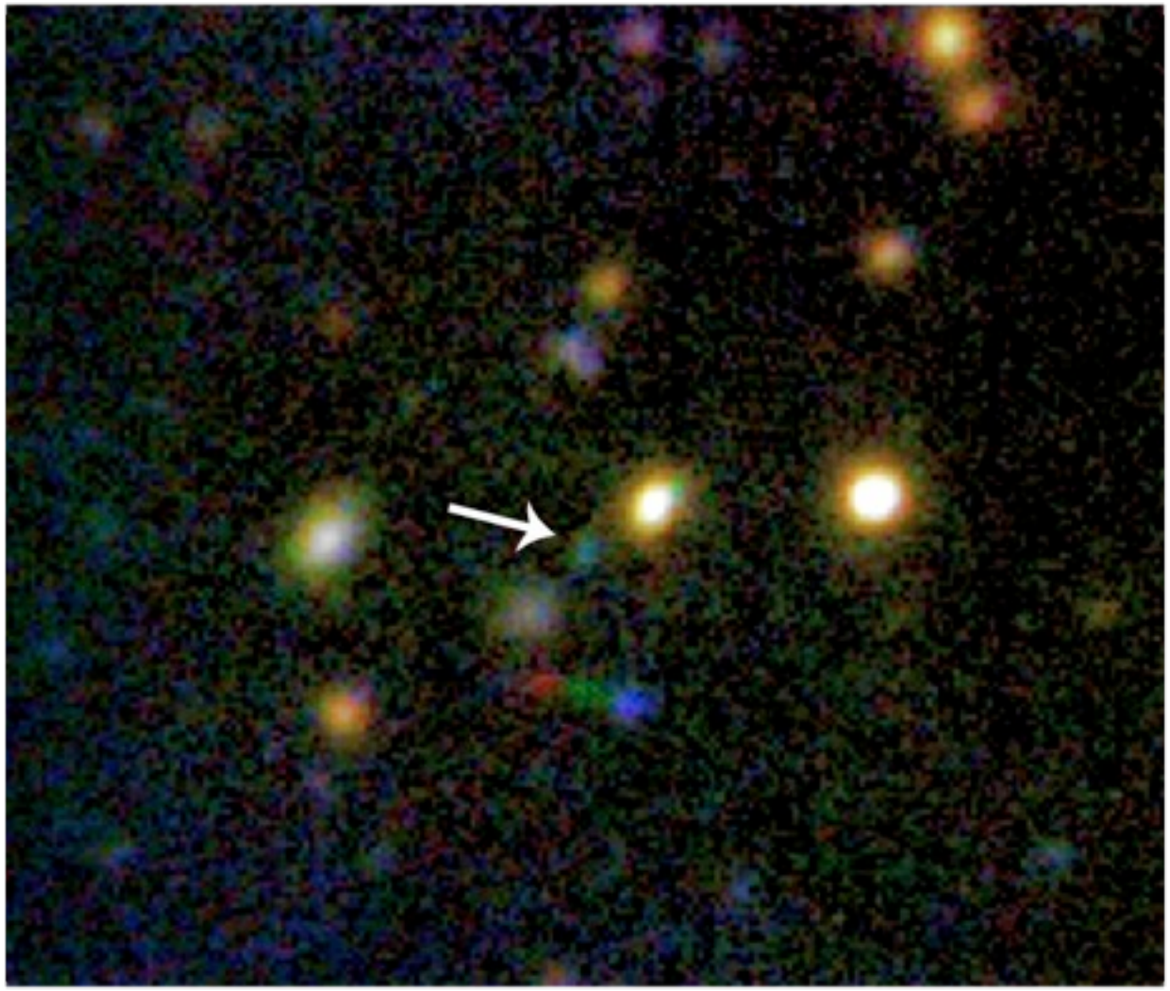


Texp=3x400s.

D'Elia et al. 2013, in prep.

IMAGING + SPECTROSCOPY OF GRB AFTERGLOWS

- GRB 120624B (z=2.20)
  - Hyper energetic and extinguised GRB hosted in luminous compact galaxy
  - One of the highest SFRs estimated for a GRB host ~91 M/yr



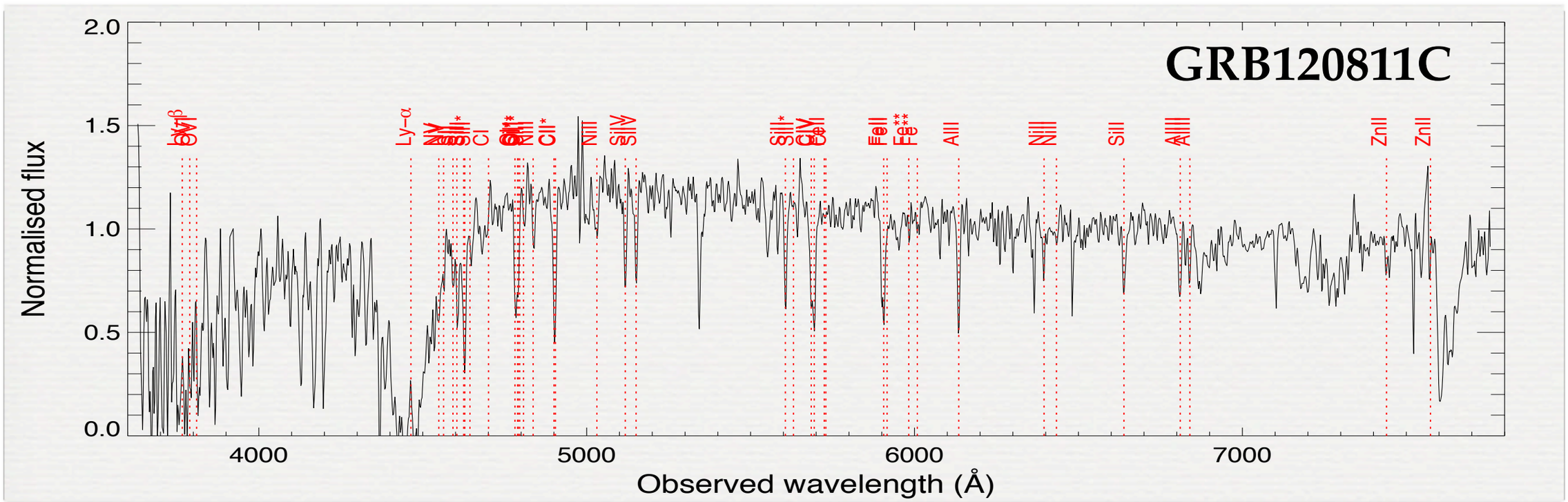
de Ugarte Postigo et al.
2013, A&A 557, L18

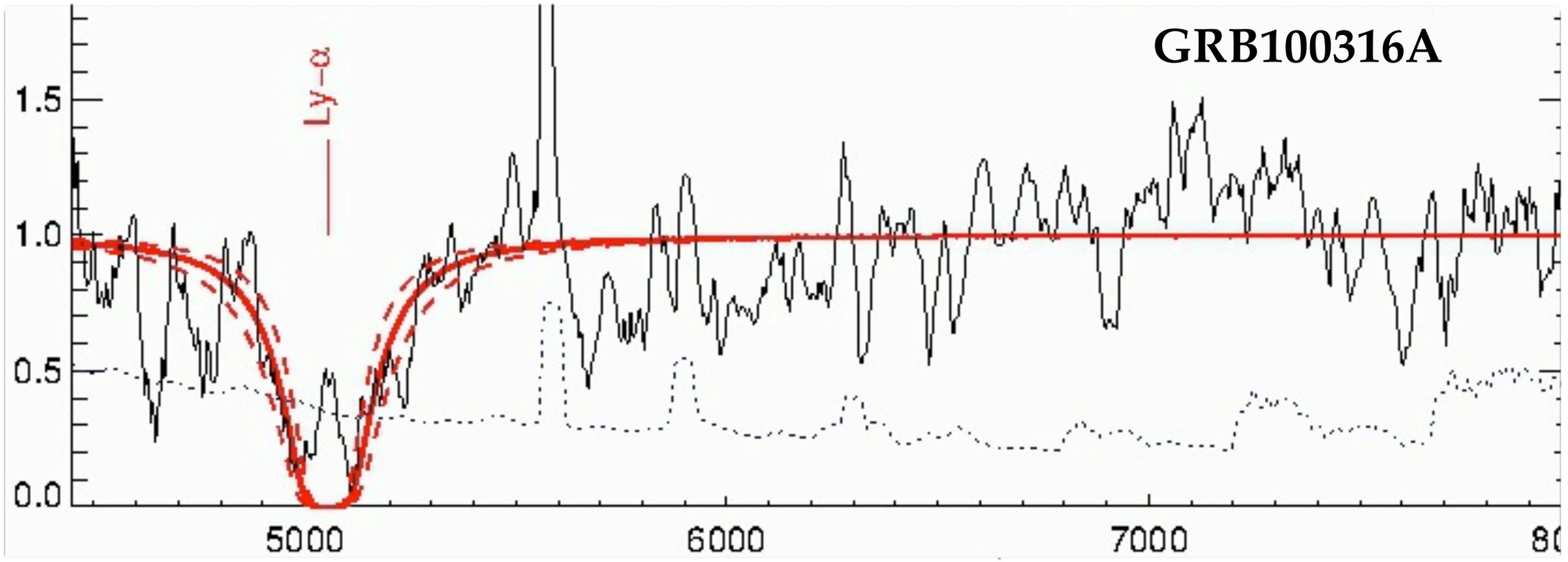
IMAGING + SPECTROSOCOPY OF GRB AFTERGLOWS

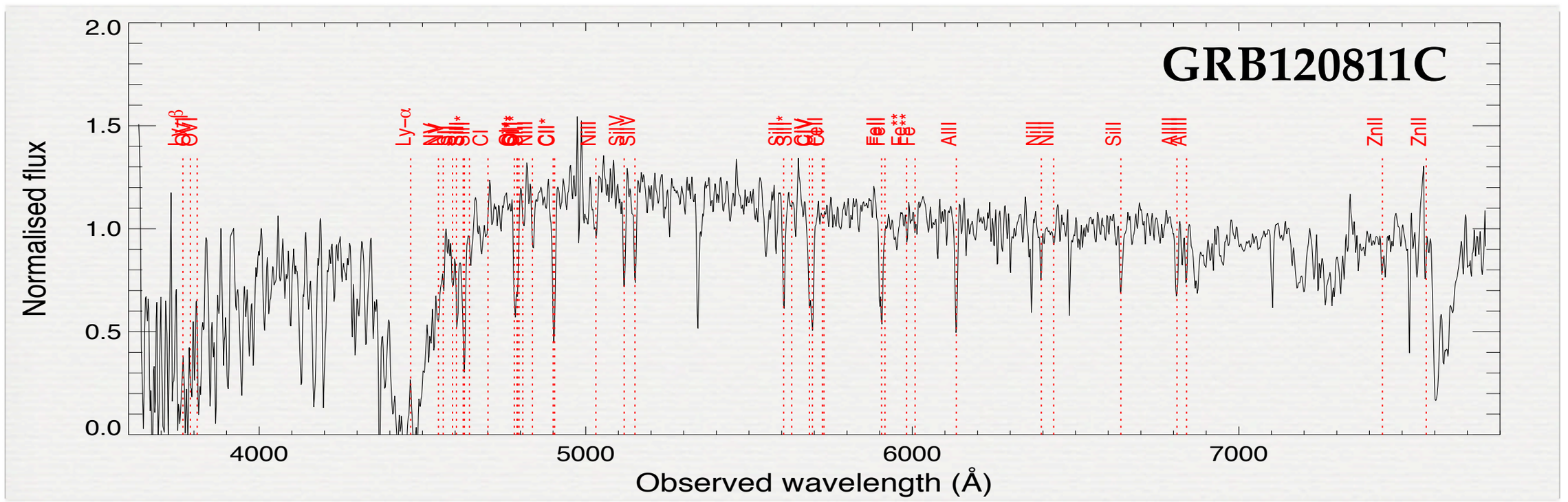
- GRB 120811C

Thöne et al. 2013, in prep.

  - z=2.671 (Thöne et al. 2011, GCN Circ. 13268, Texp=2400s).
  - Ly-α, Ly-β, SII, SiII, OI, CII, CIV, SiIV, AlII,AlIII, NiII, ZnII and SiII*
  - Log N_H ~10^{22} cm^{-2}

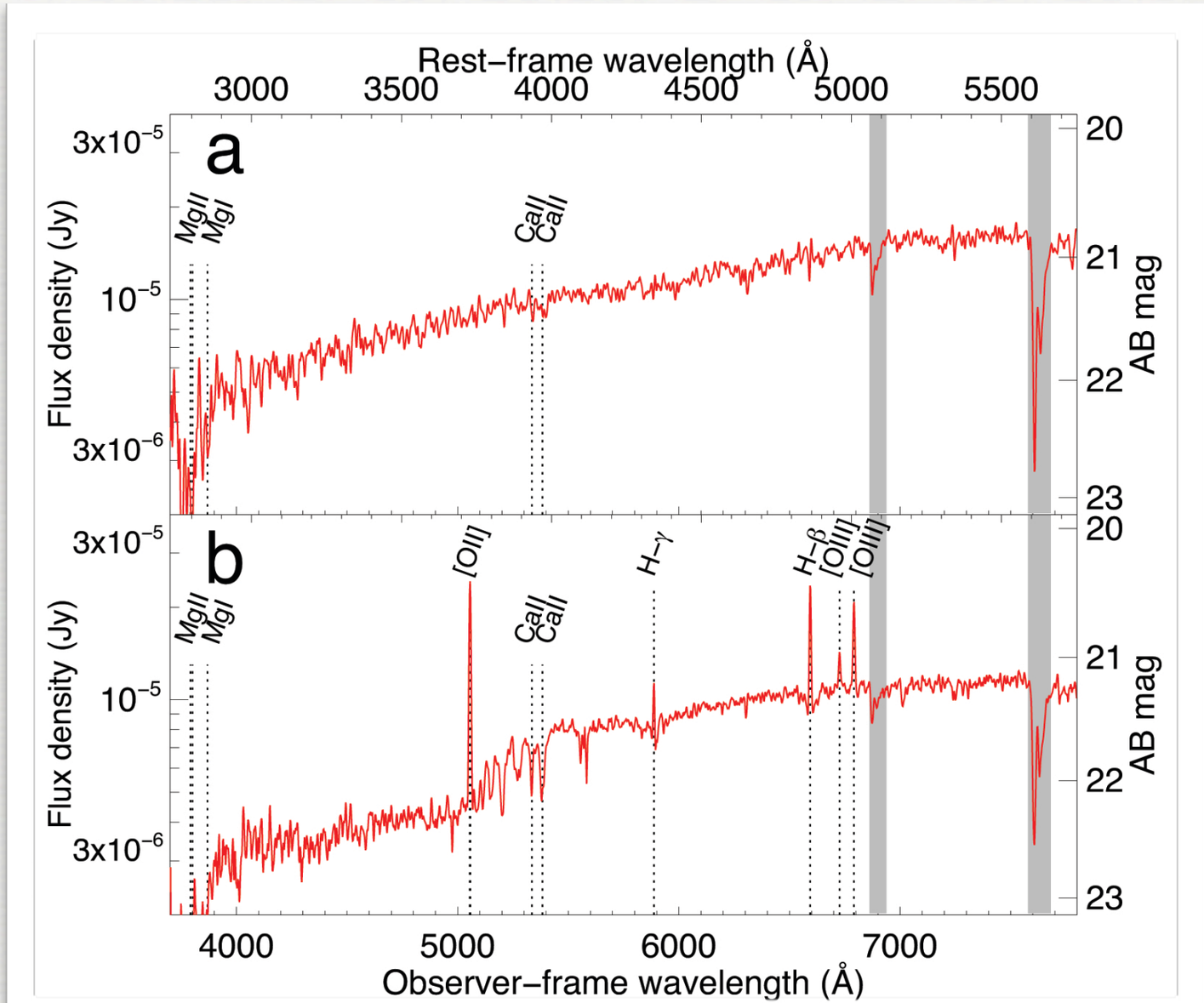



GRB100316A
Ly−α
1.5
1.0
0.5
0.0
5000
6000
7000


GRB120811C
Normalised flux
Observed wavelength (Å)
2.0
1.5
1.0
0.5
0.0
4000
5000
6000
7000
Ly−α
NiII
SiIV
SiII*
SiII
CaII
FeII
FeII**
AlII
NiII
SiII
AlIII
ZnII
ZnII

IMAGING + SPECTROSOCOPY OF GRB AFTERGLOWS

- GRB 130603B (z=0.356, Thöne et al. 2013, GCN Circ. 14744).
  - For the first time absorption lines detected for a short GRB afterglow.
  - Faint absorption lines of CaII, MgI, MgII.
  - 7.4 hours post GRB. Resolution ~1000. Texp=3x900s.
  - 126.0 hours post GRB. Resolution ~1000. Texp=3x1200s.

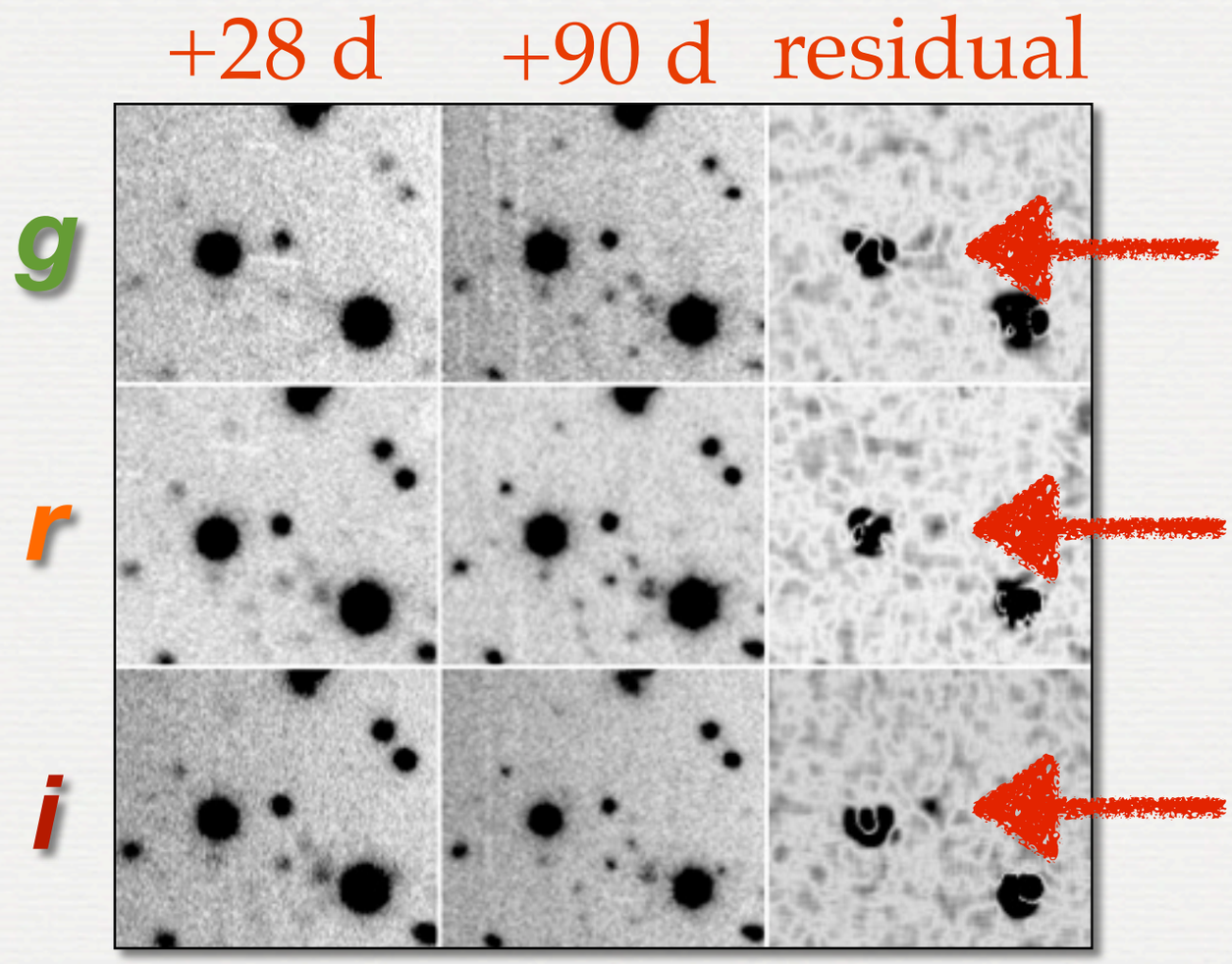


de Ugarte Postigo et al. 2013, submitted, arXiv1308.1984D

SN ⟷ GRB CONNECTION

- GRB 100418A
  - z=0.624 (Antonelli et al. GCN Circ 10620).
  - PSF matching subtraction revealed a likely SN.

de Ugarte Postigo et al. 2013, in prep.

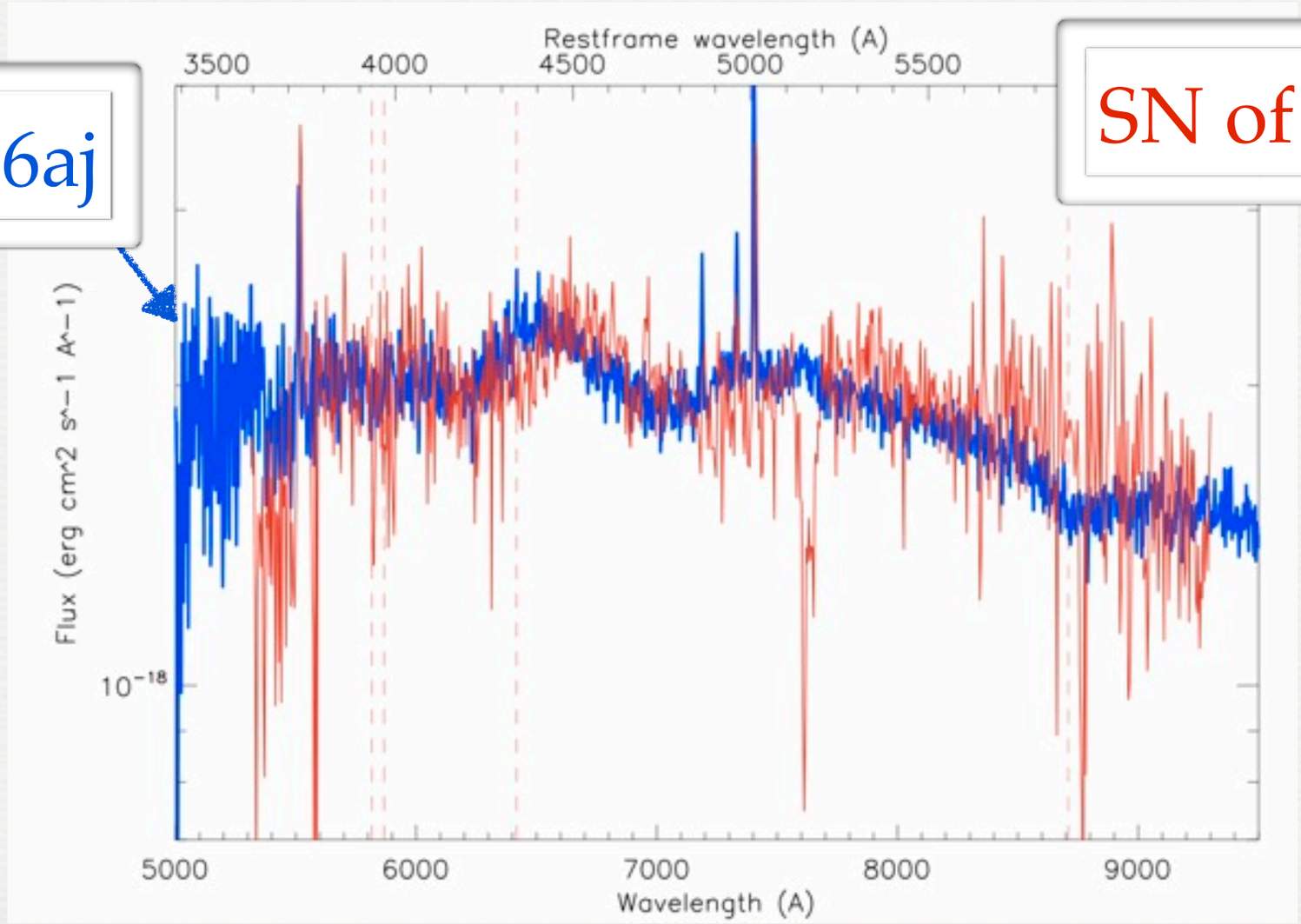


SN ⟷ GRB CONNECTION

- GRB 111211A
  - z=0.578 (Vergani et al. GCN 12677).
  - Late spectroscopy SED matches SN2006aj (de Ugarte Postigo et al. GCN 12802).

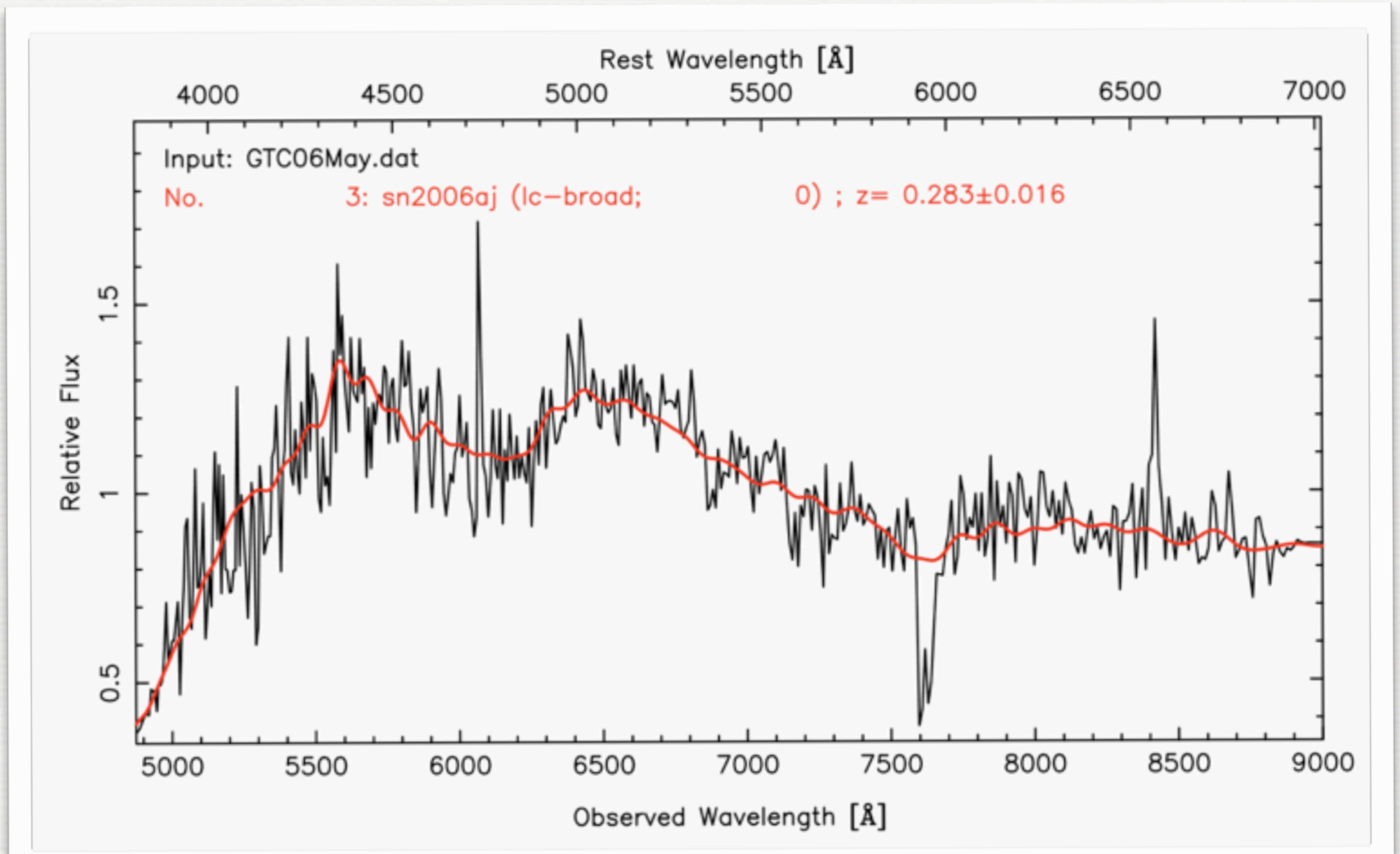
SN 2006aj

SN of GRB 111211A



SN ⟷ GRB CONNECTION

- GRB 120422A
  - SN identified @ z = 0.283 (Sánchez-Ramírez et al. GCNC 13281).



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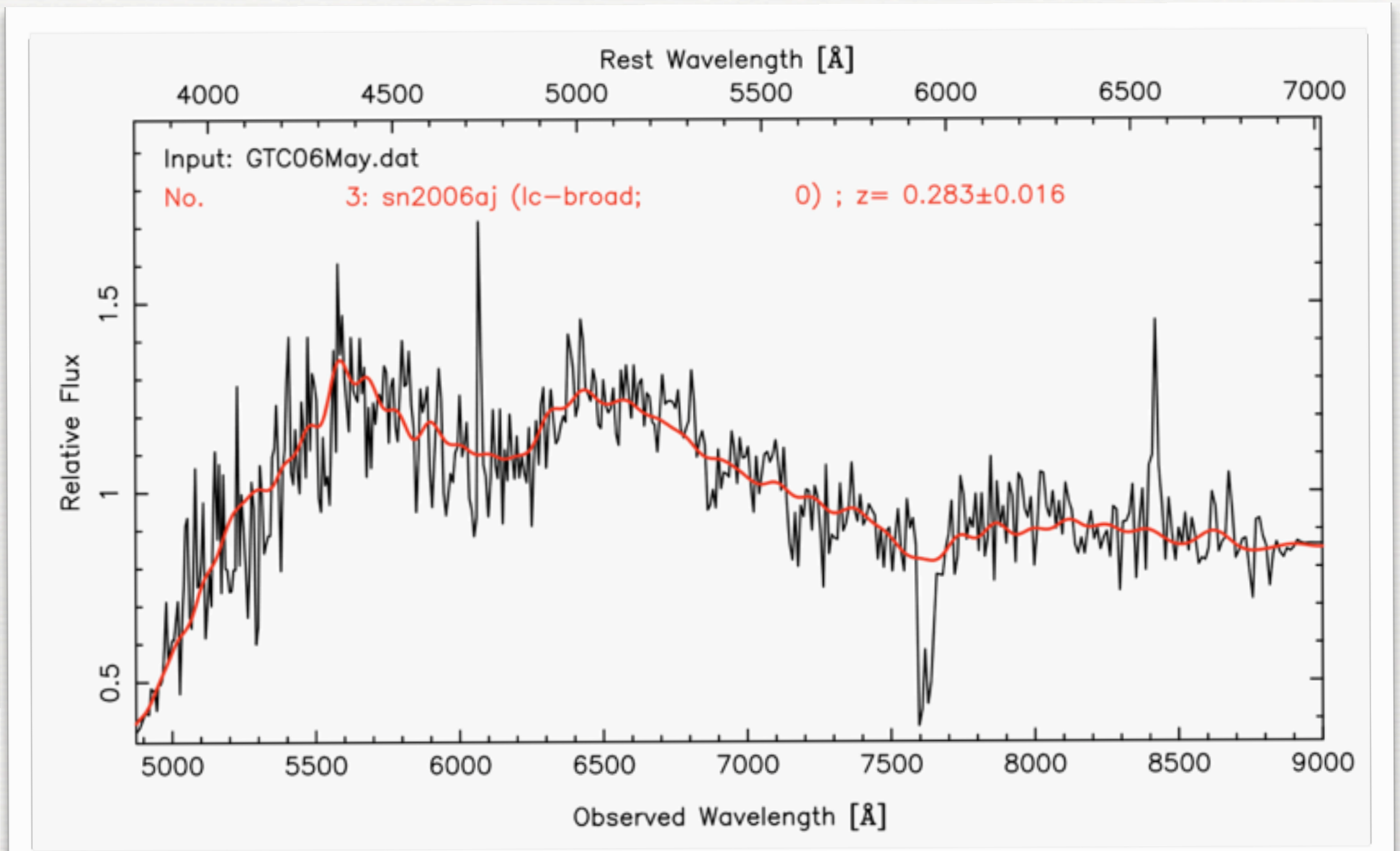
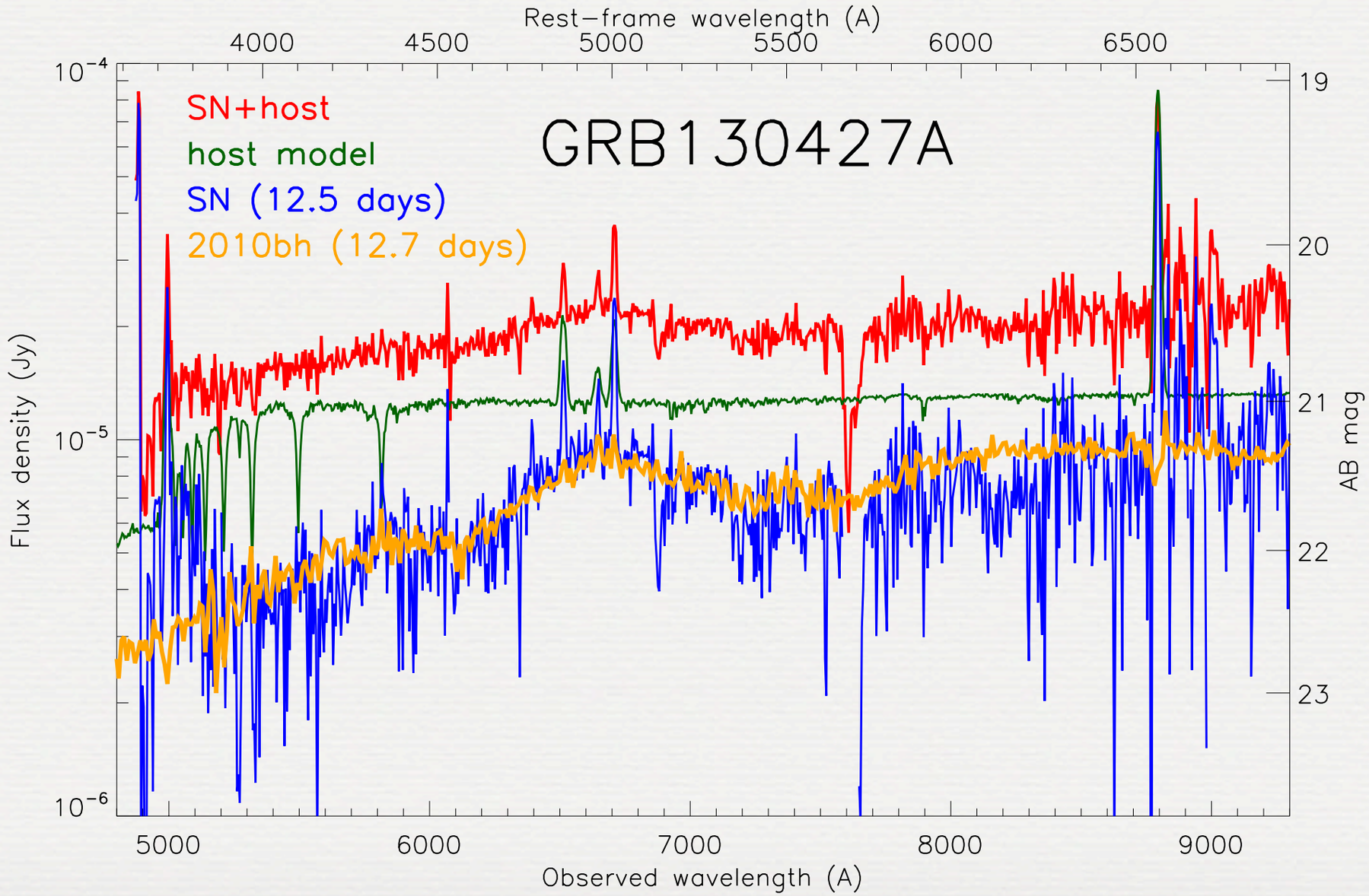


SN ⟷ GRB CONNECTION

- GRB 130427A
  - SN identified @ z = 0.34 (de Ugarte Postigo et al. GCNC 14646).



SN ⟷ GRB CONNECTION

Xu et al. 2013, arXiv1305.6832 in press.

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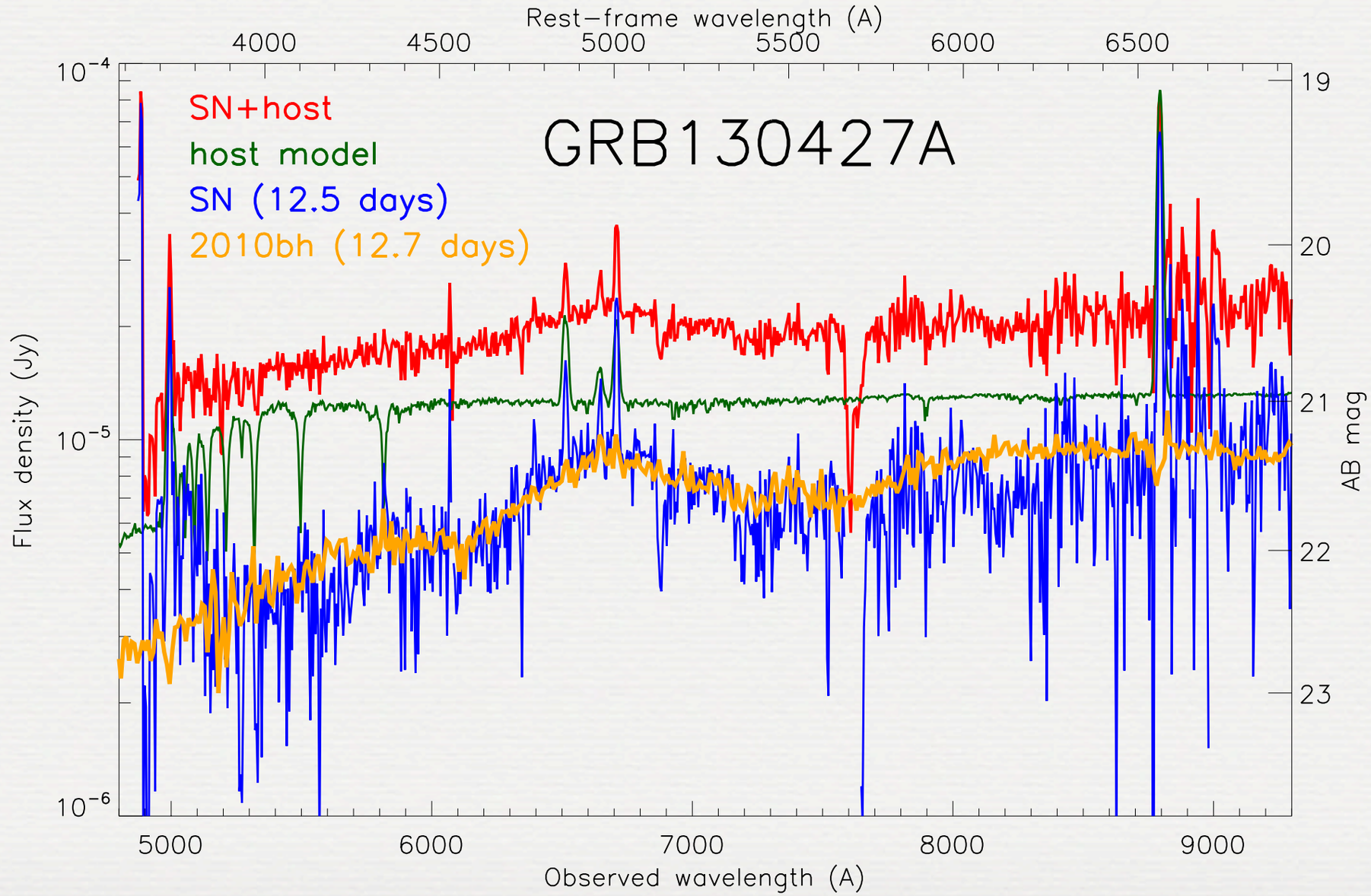
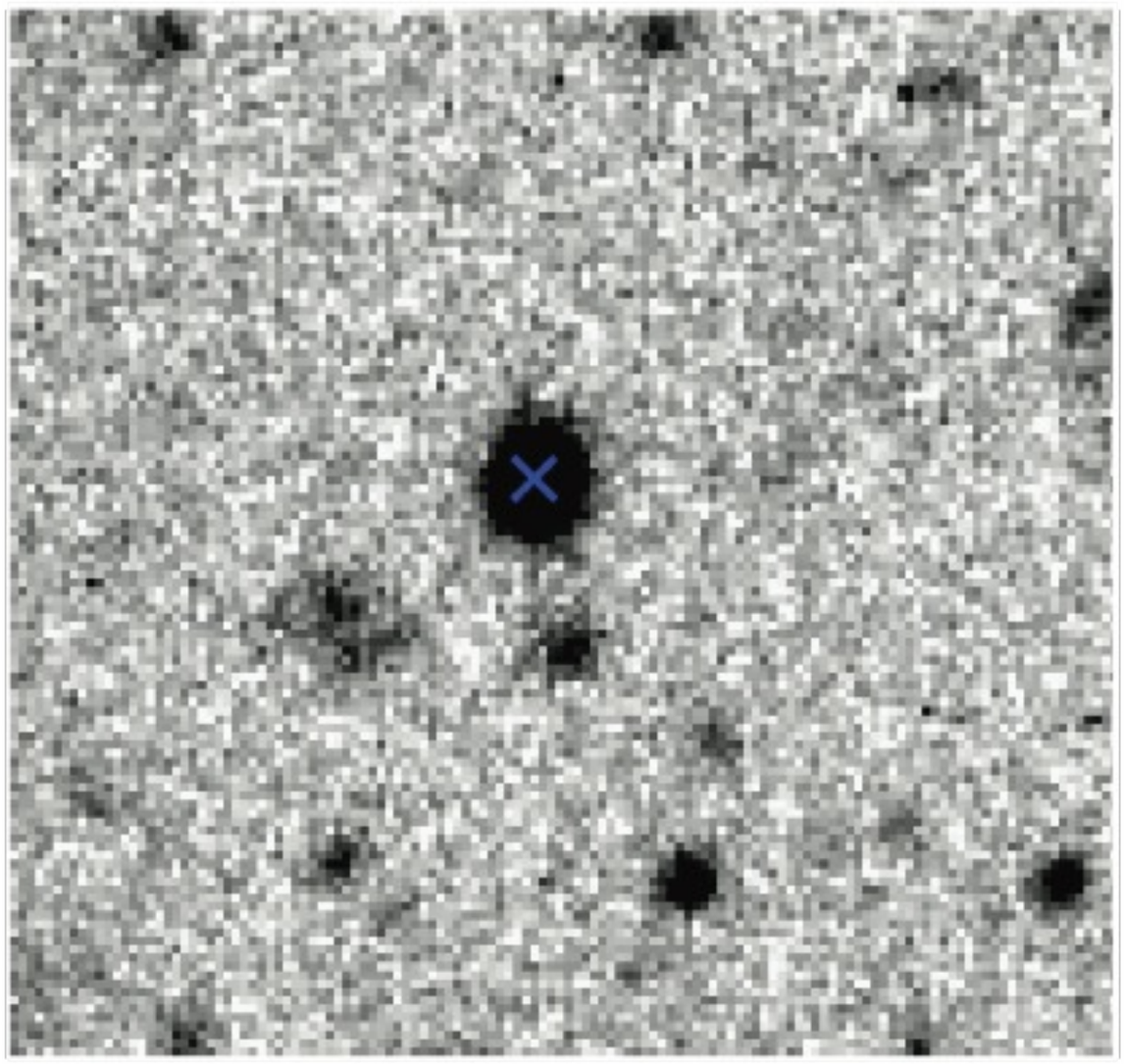
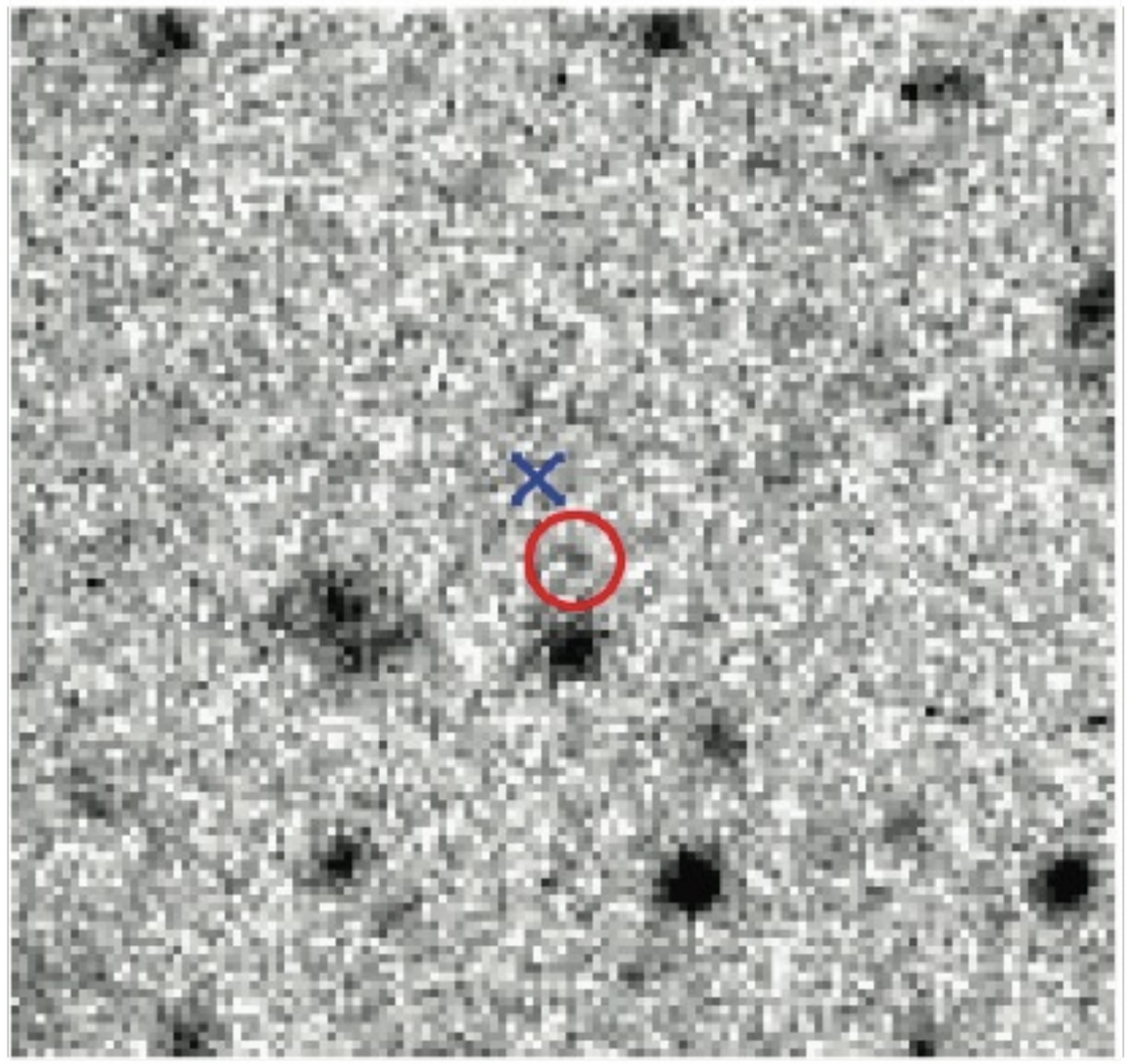


HOST GALAXIES

- Host of GRB 100219A (z=4.7) @ i ~ 26.7

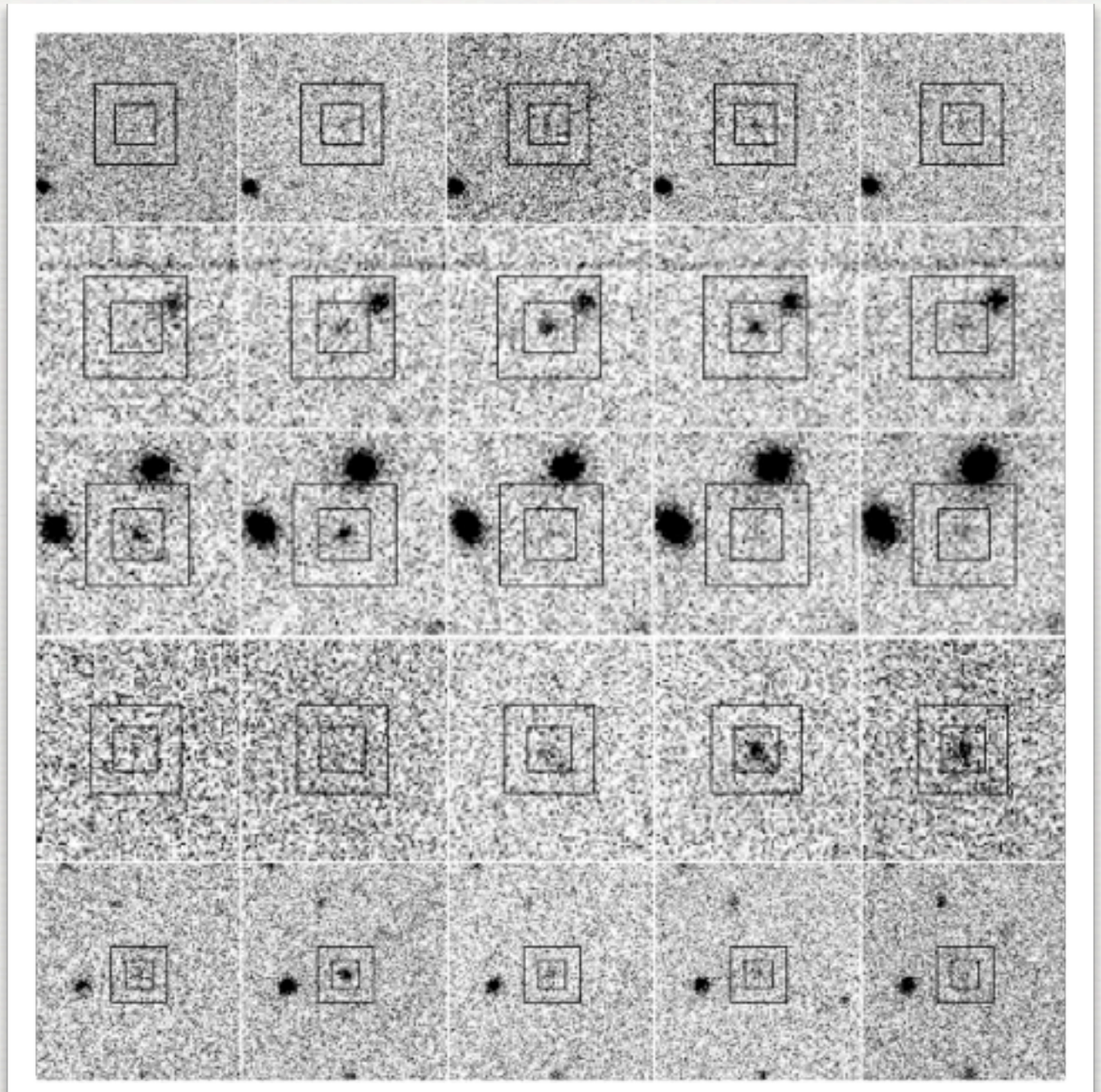




Thöne et al. 2013, MNRAS 428, 3590 .

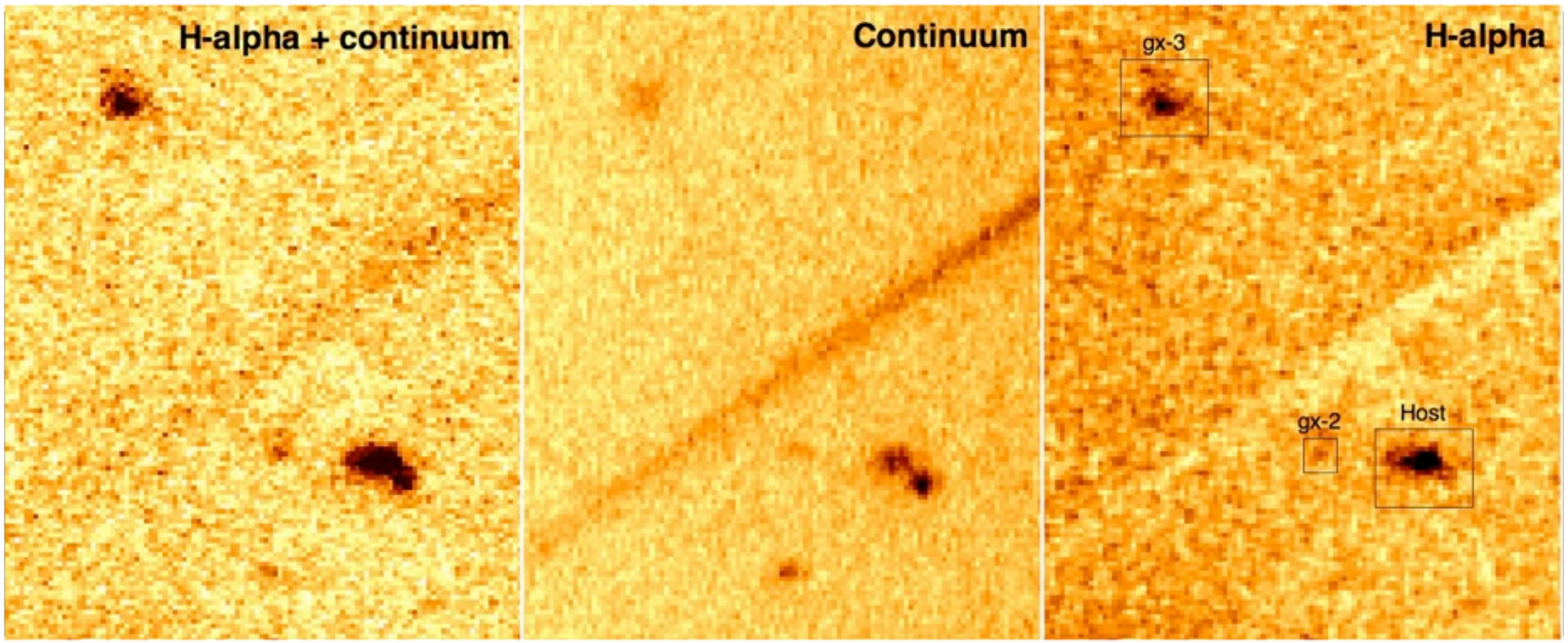
HOST GALAXIES (TF)

- GRB 111211A
  - [OIII] 5007Å imaging using the TF with 15 Å. Study of the host environment.



HOST GALAXIES (TF)

- GRB 120422A
  - TF imaging reveals several galaxies at the same redshift.



10″

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Schulze et al. 2013, in prep.

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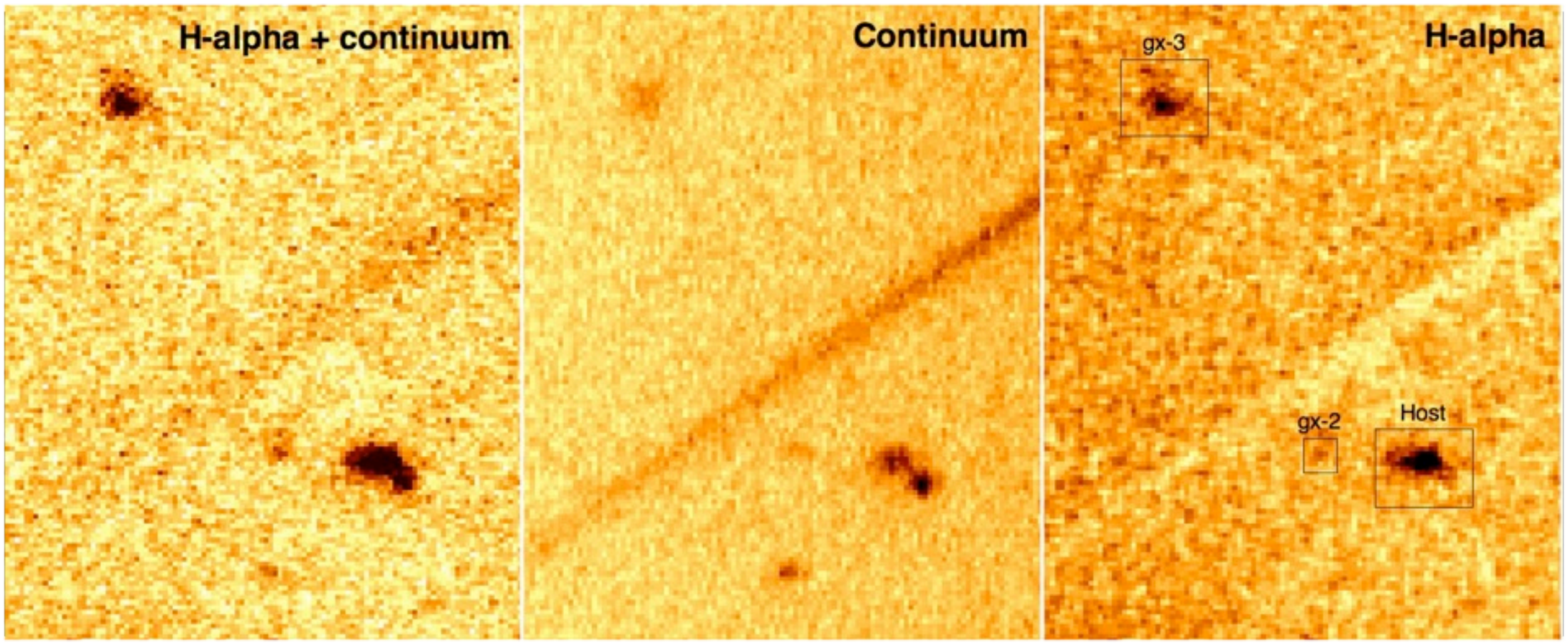
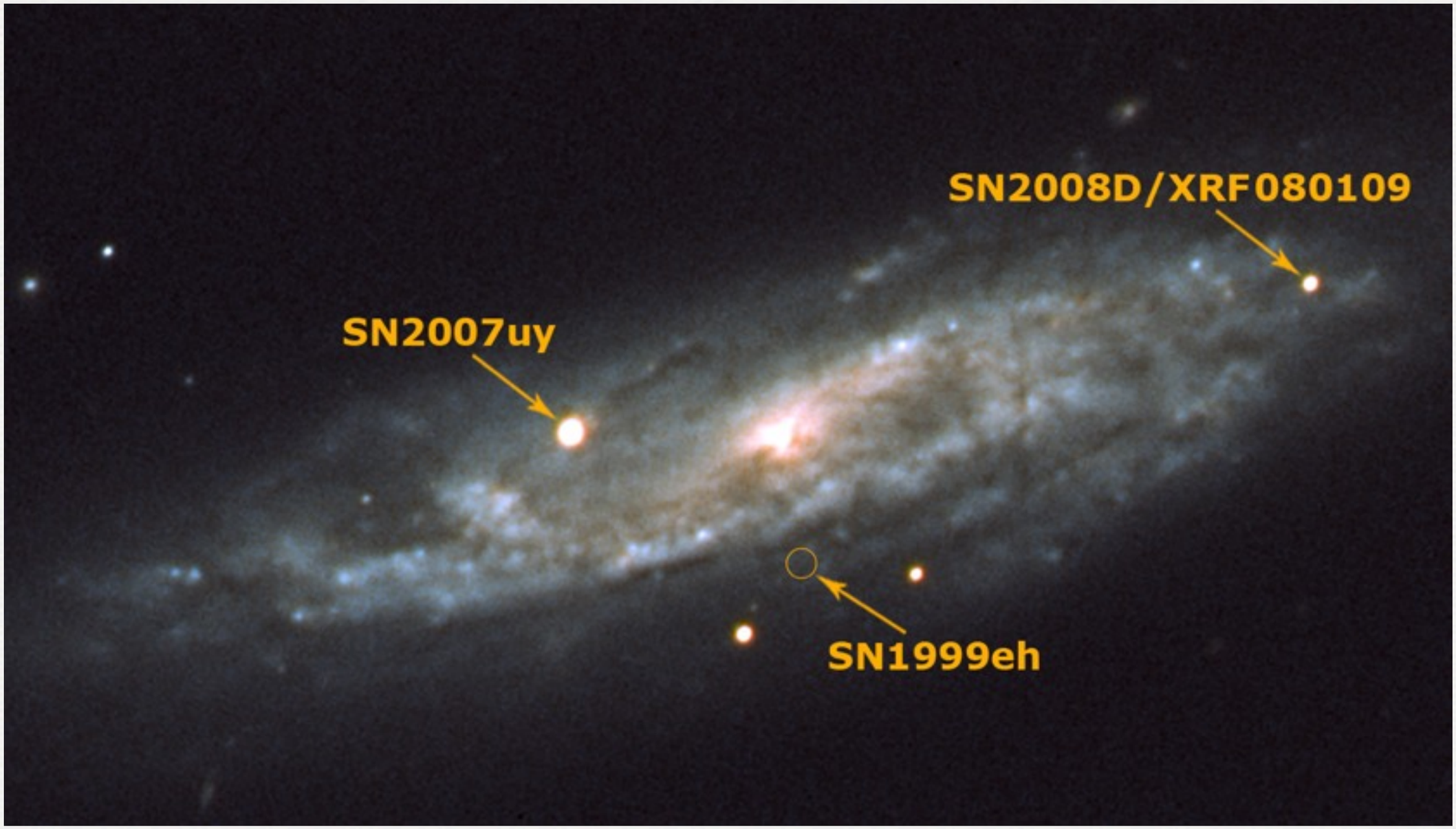


10″

HOST GALAXIES (TF)

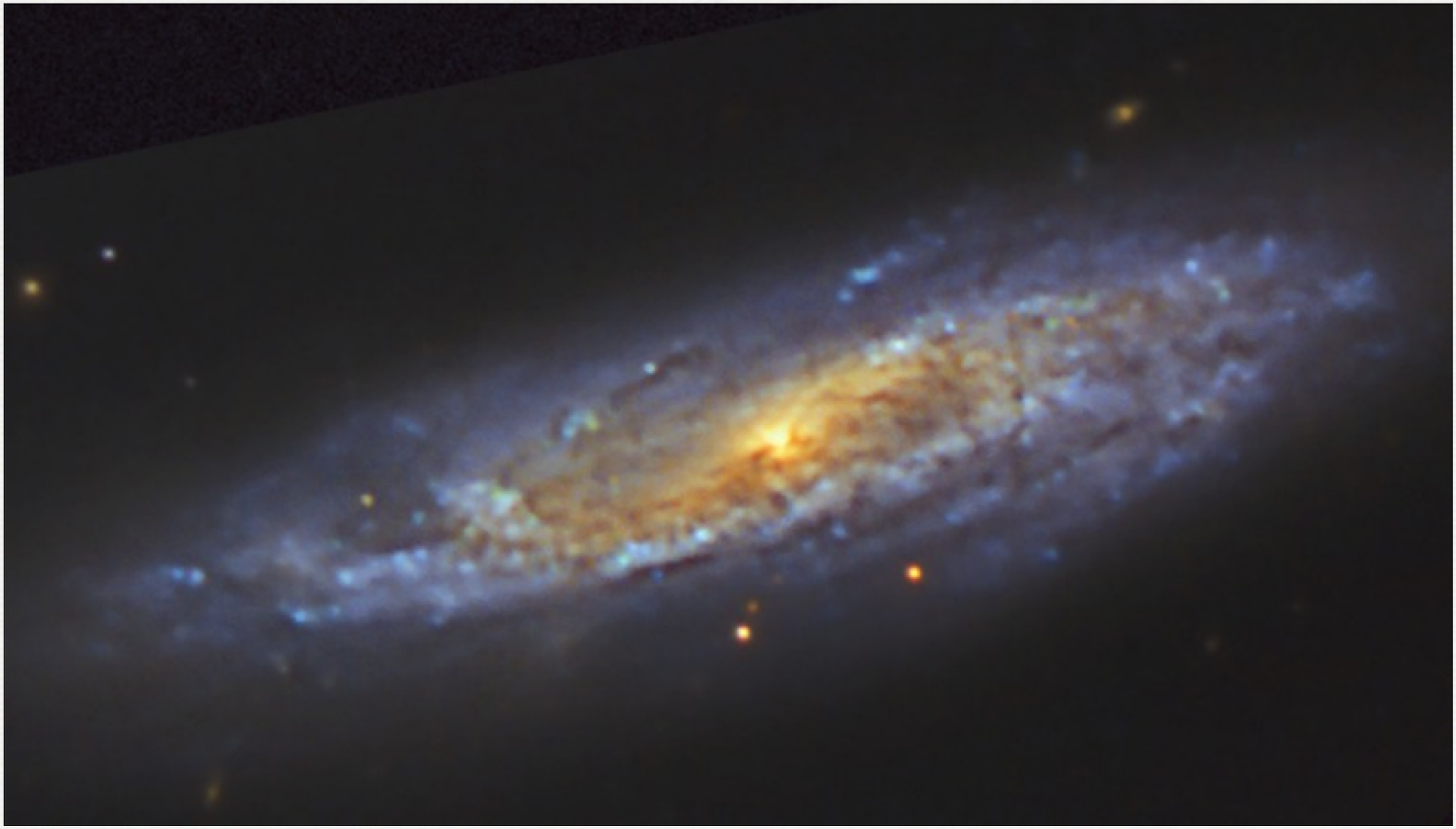
- TF scan of NGC2770 at H_α with a filter width of ~ 15 Å.



Gorosabel et al. 2011, AdSpR 47, 1421; Thöne et al. 2013 in prep.

HOST GALAXIES (TF)

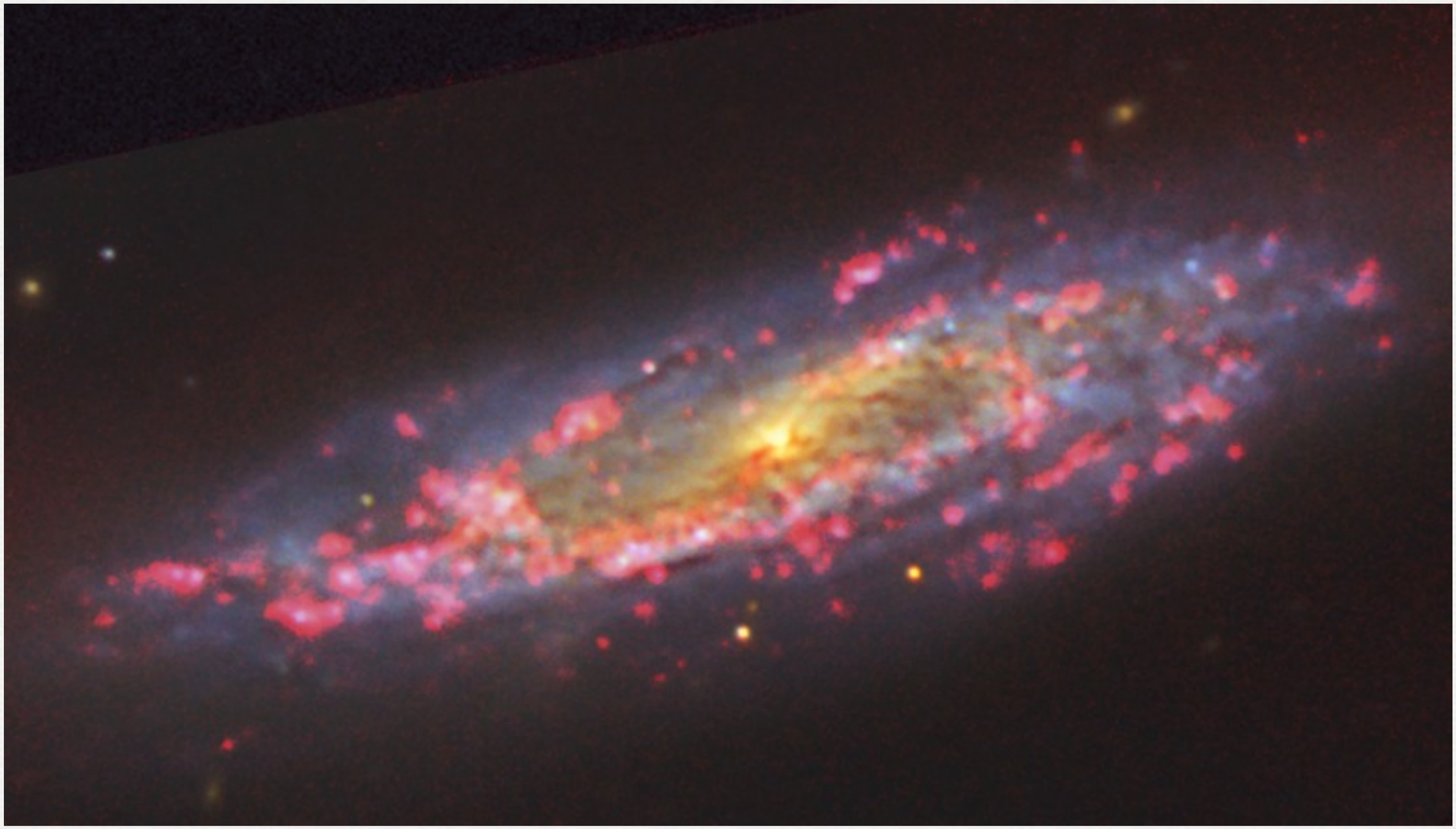
- TF scan of NGC2770 at H_α with a filter width of ~ 15 Å.



Gorosabel et al. 2011, AdSpR 47, 1421; Thöne et al. 2013 in prep.

HOST GALAXIES (TF)

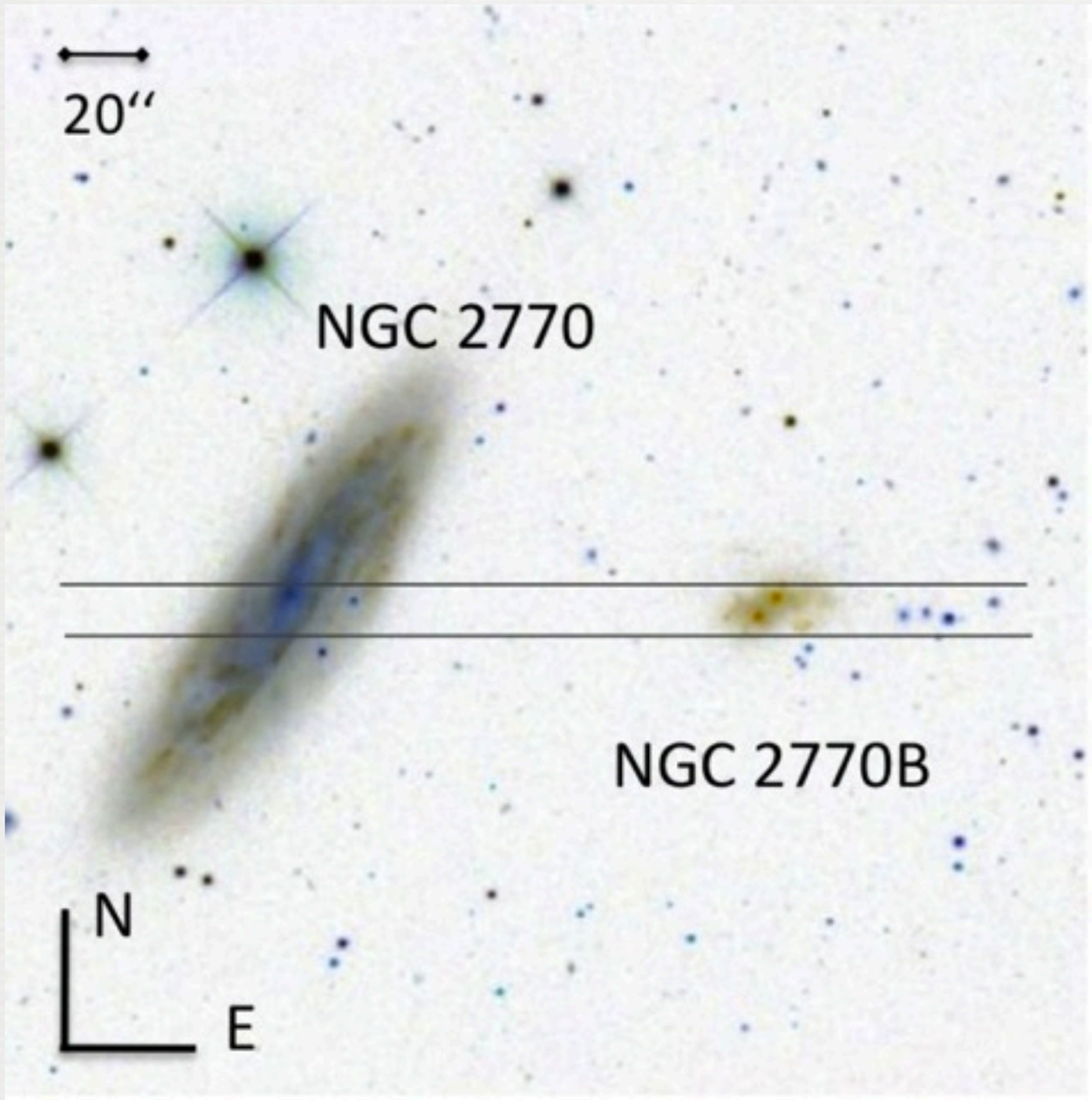
- TF scan of NGC2770 at H_α with a filter width of ~ 15 Å.

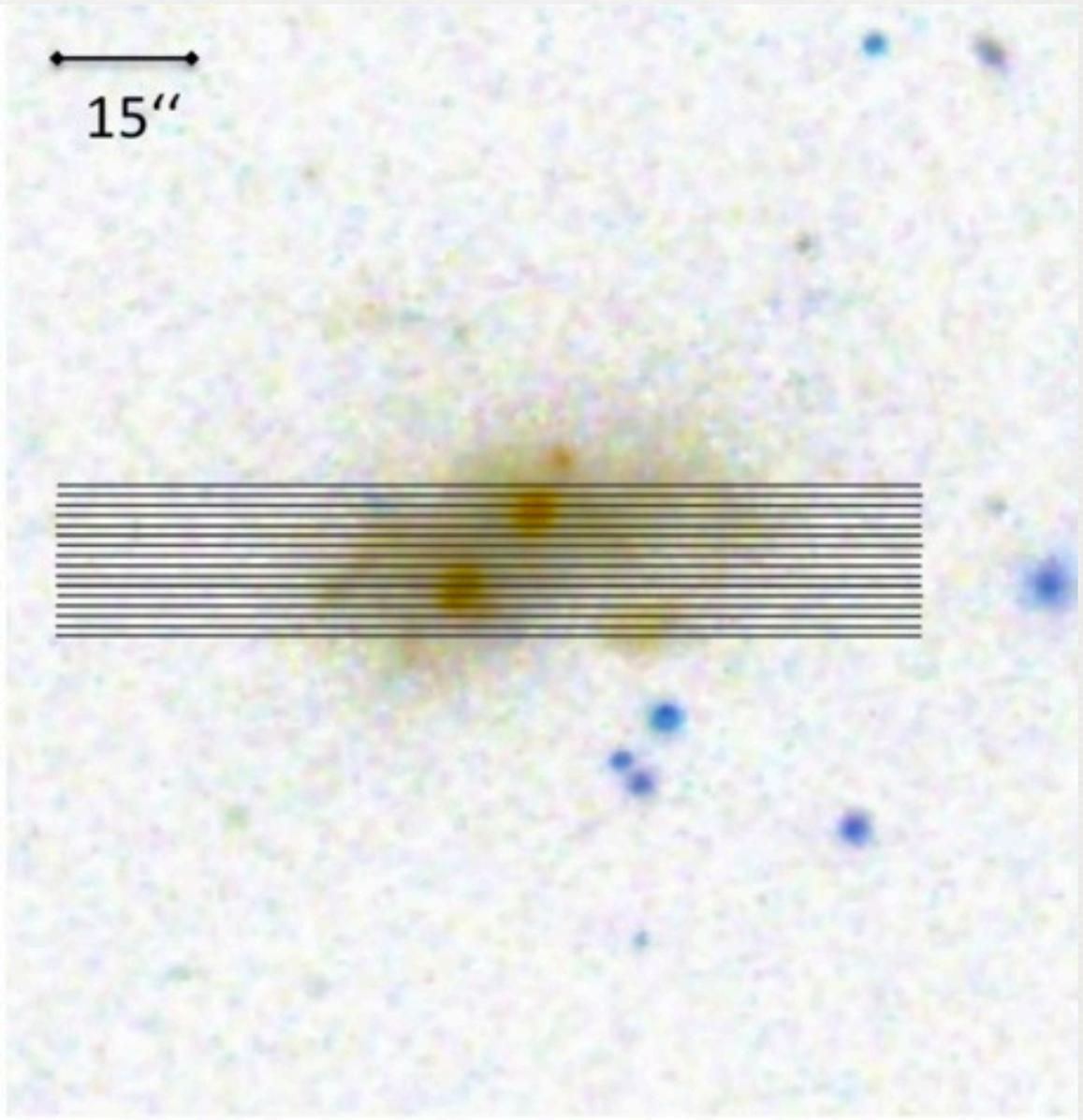


Gorosabel et al. 2011, AdSpR 47, 1421; Thöne et al. 2013 in prep.

HOST GALAXIES (TF)

- Long-slit scan of NGC2770 and NGC2770B.





Gorosabel et al. 2011, AdSpR 47, 1421; Thöne et al. 2013 in prep.

SUMMARY OF RESULTS

- Reaction times between ~1 and ~24 hrs.
- 35 GRBs followed up since July 2009 (phot + spec).

  GRB090404A, GRB090424A, GRB090709A, GRB091202, GRB100219A, GRB100316A, GRB100418A
  GRB100614A, GRB100816A, GRB101225A, GRB111022B, GRB110328A, GRB110422A, GRB110503
  GRB110801A, GRB110918A, GRB111117A, GRB111211A, GRB111228A, GRB120326A, GRB120327A
  GRB120422A, GRB120624B, GRB120729A, GRB120811C, GRB120907A, GRB121226A, GRB130215
  GRB130418A, GRB130420A, GRB130427A, GRB130502A, GRB130518A, GRB130603B, GRB13060
- 19 spectroscopic triggers, 18 redshifts measured. (94%
  (11 new + 7 confirmations).
- 4 new SNe identified. (GRB111211A, GRB120422, GRB130215A, GRB130427A).
- Emission lines of two host fields detected with the TF.
- 2 new host galaxies with $r_{AB} > 26.5$ (one of them through spectroscopy too).

Redshift records

1.-090424 confi
2.-100316A new
3.-100816A conf

101225 two tri
4- 101225A af
5.- 101215A ho

6-110328/swift
7-110422A conf
9.-110503A new
10.-110801A ne
11--110918A co
12.-120326A ne
13.-120327A co
14.-120907A ne
15.-130418A ne
16.-130420A ne
17.-130518A ne
18-130603B ne
19.-130606A ne

18 redshfits fro

THANKS !