ESO GW workshop 2018

ESO contributions to GRB science
- lessons learned -

Nial Tanvir
University of Leicester

GRBs @ ESO

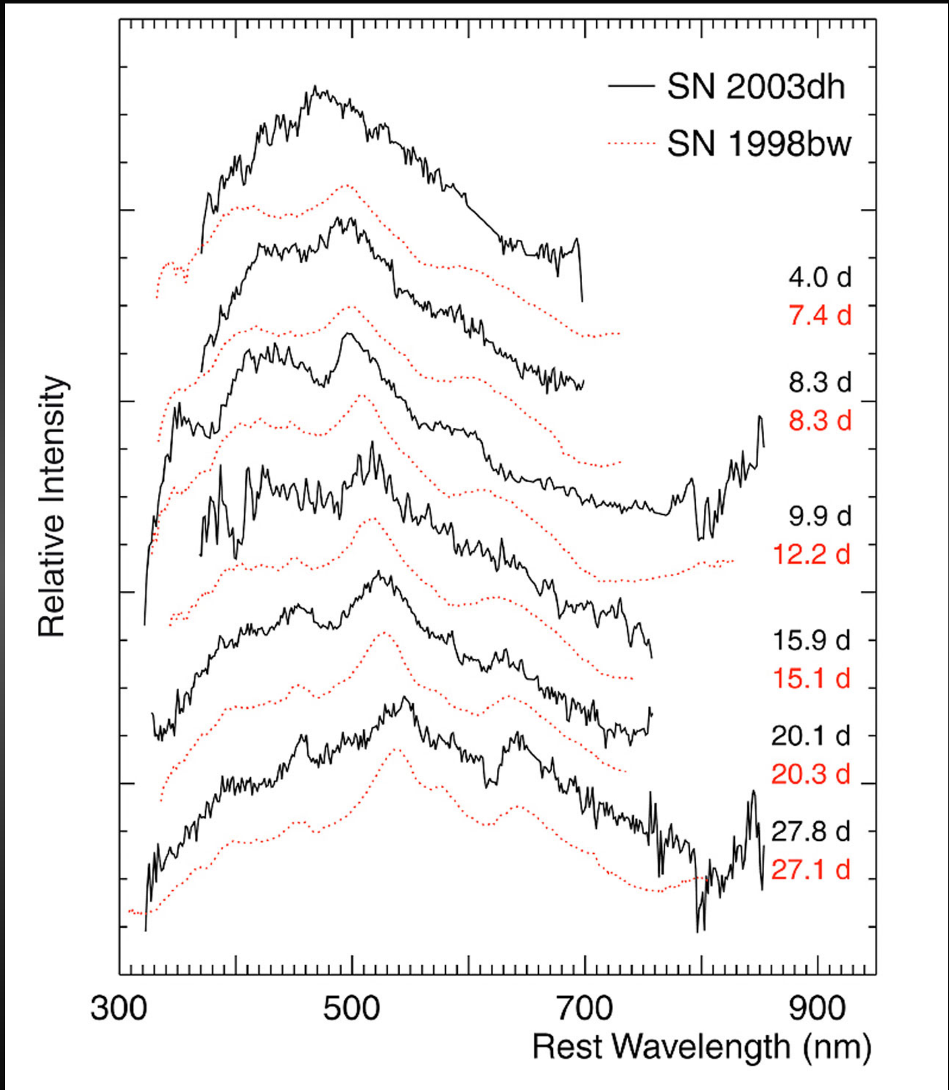
Follow-up for most of past 20 years.

Large fraction of all redshifts (both afterglows and hosts) and very large fraction of the high-quality spectra -> major contributor to the statistical samples.

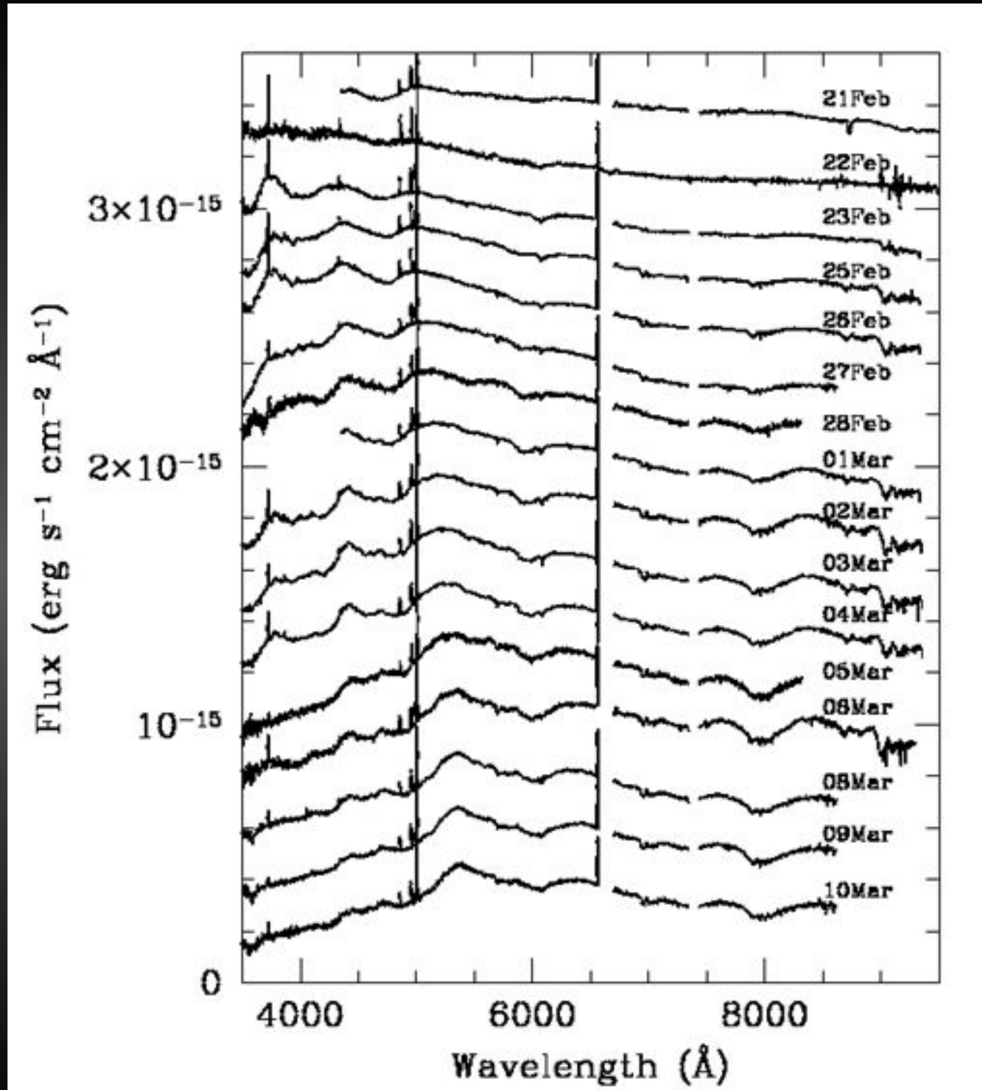
A few particular highlights:

- GRB980425/SN98bw – remarkable low luminosity GRB + bright SN
- GRB030329 – first cosmological LGRB + SN connection
- GRB060218 – nearest Swift LGRB
- GRB080319B – "naked eye" burst – UVES spectroscopy
- GRB090423 – z=8.2 record spectroscopic redshift
- GRB120923A – z=7.9 redshift
- 2012: TOUGH survey - nearly redshift complete sample, based on ESO LP
- GRB130603B – first evidence of KN with SGRB (ESO providing early obs)
- GRB130606A – highest S/N z~6 GRB spectrum
- GRB170817A – coincident with GW170817

GRBs + SN



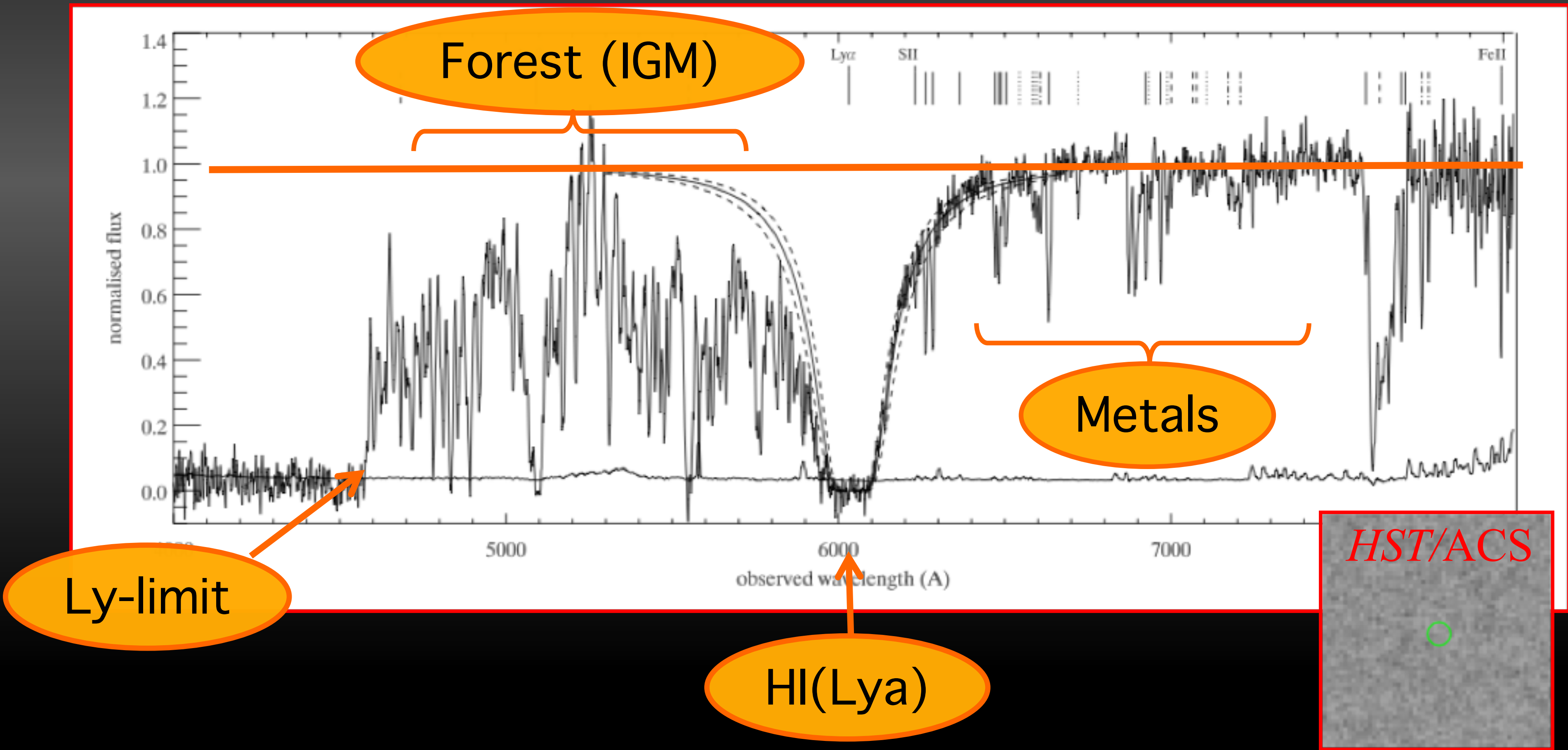
GRB030329



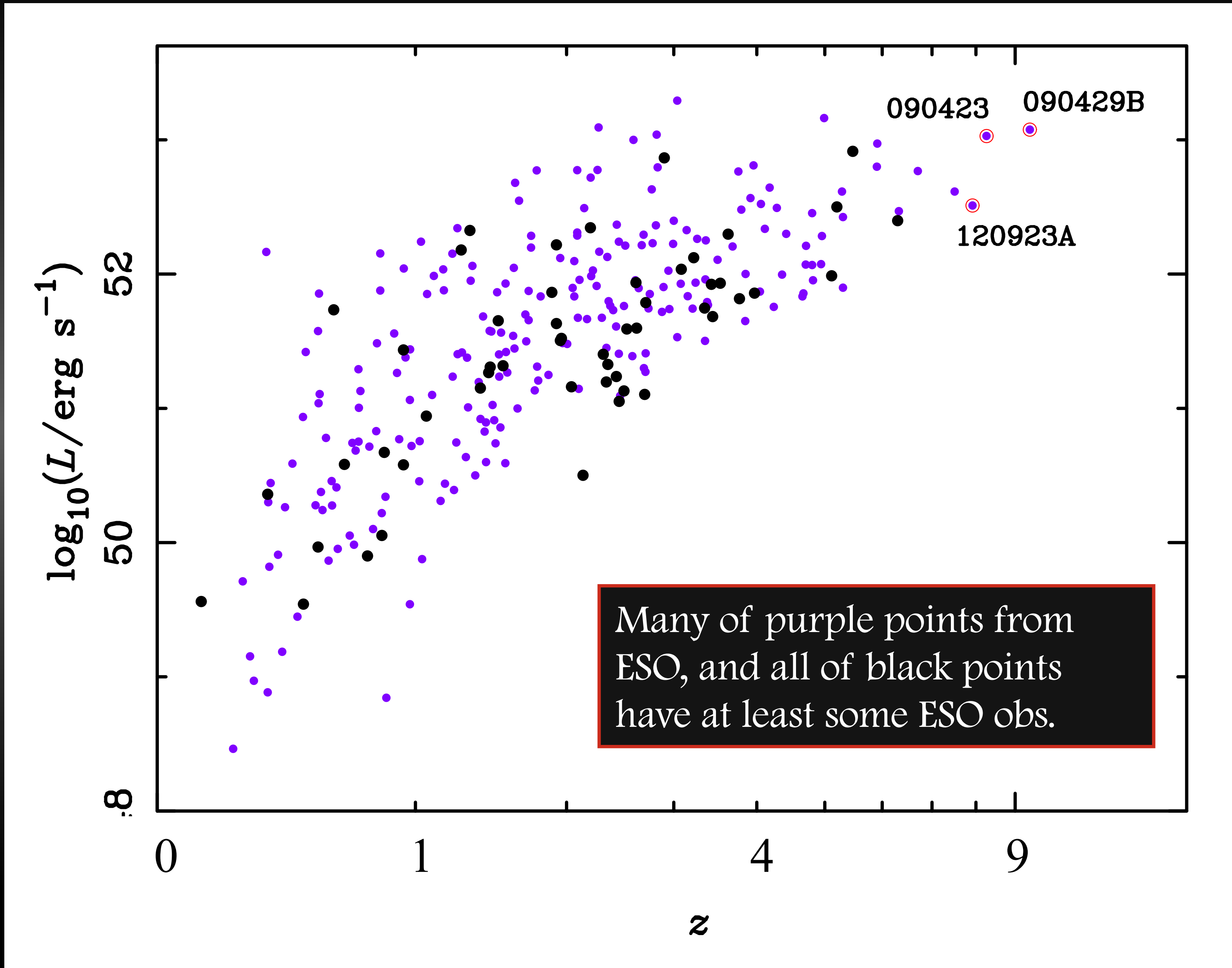
GRB060218

Afterglow spectra contain much information

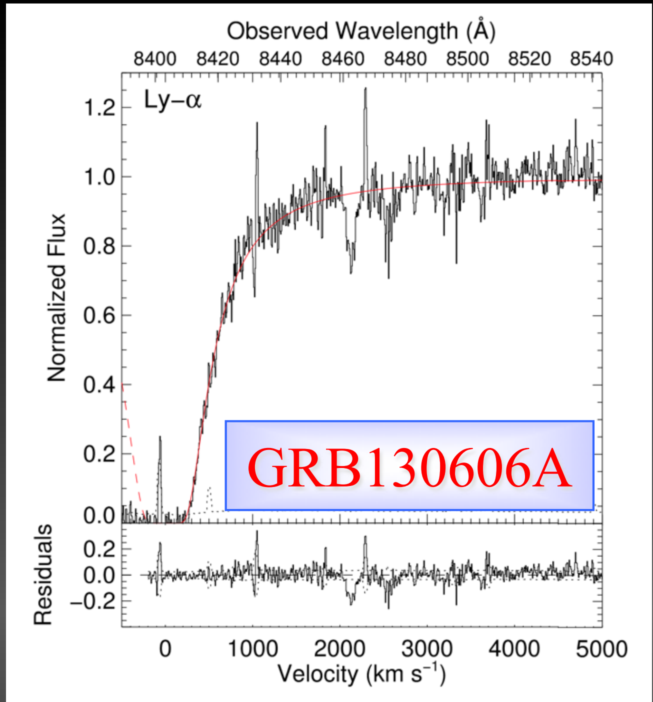
Abundances, HI, dust, dynamics etc. even for very faint hosts. E.g. GRB 050730: faint host (R>28.5), but z=3.97, [Fe/H]=~2 and low dust, from afterglow spectrum (Chen et al. 2005; Starling et al. 2005).

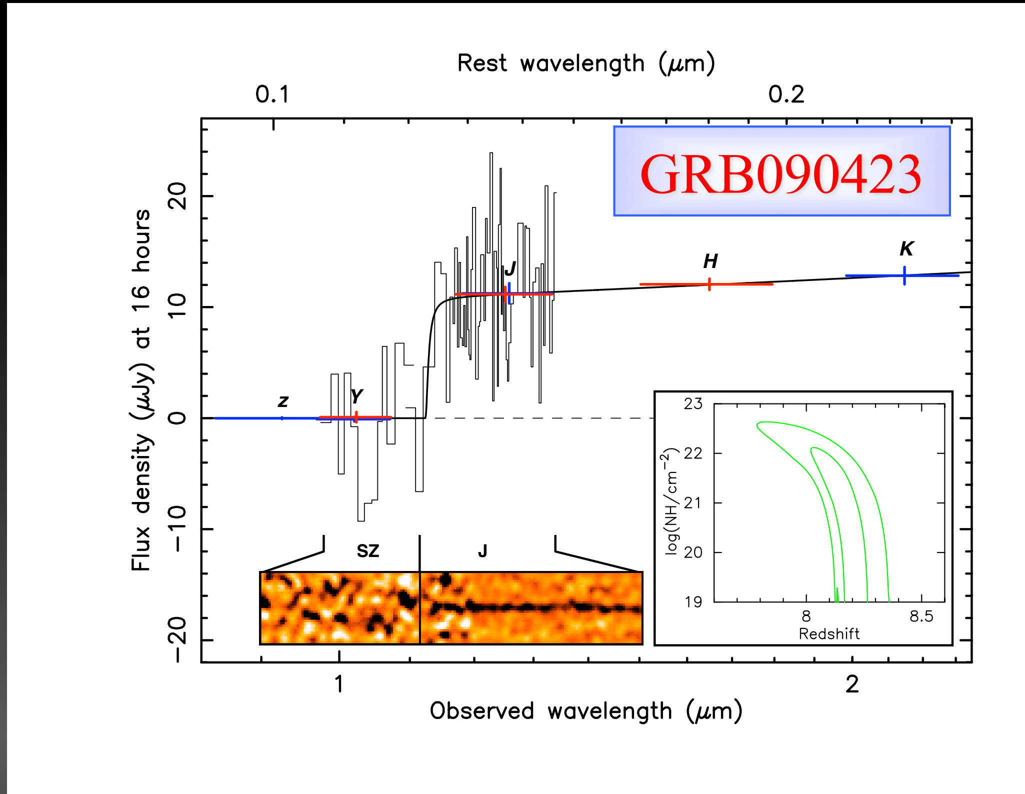


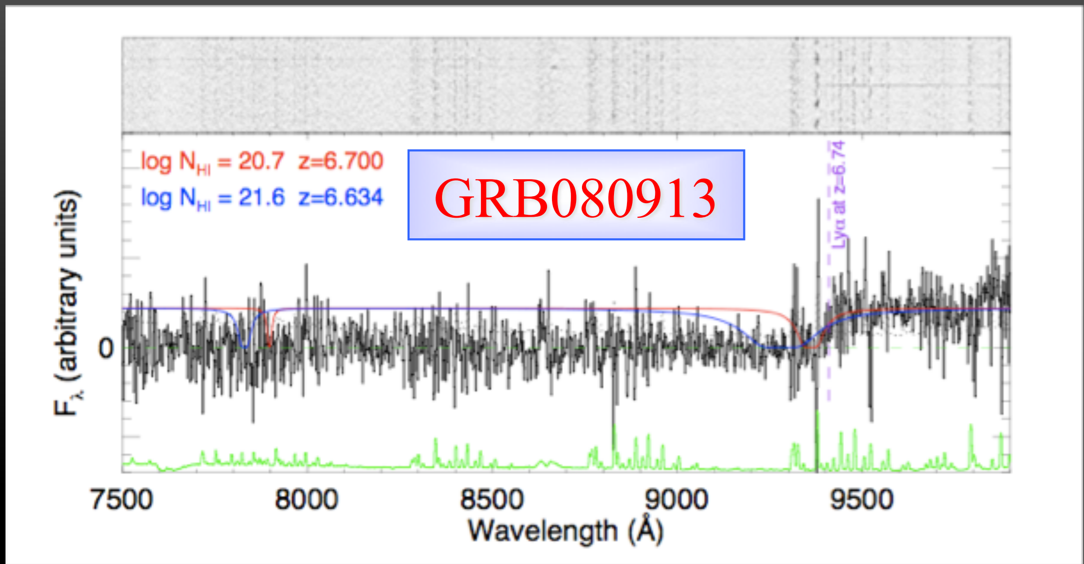
Swift GRBs span most of cosmic history

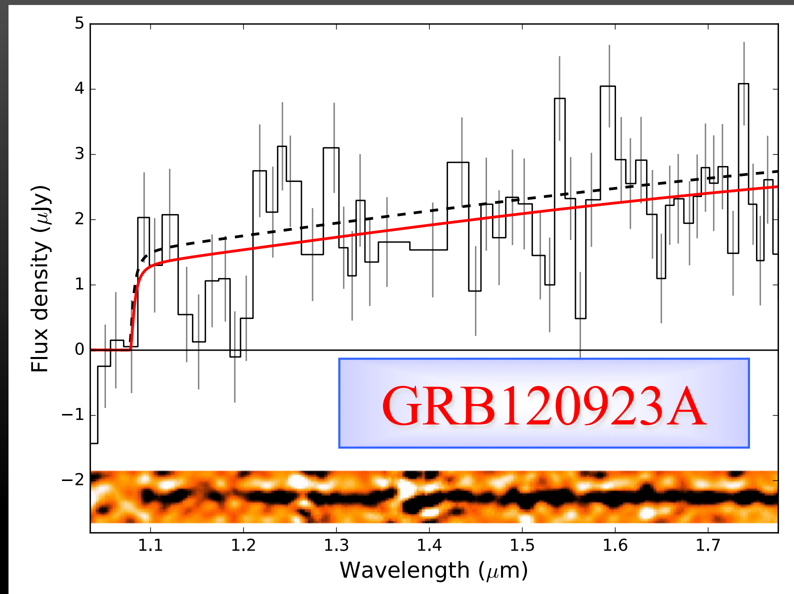


High-z GRBs


Observed Wavelength (Å)
8400 8420 8440 8460 8480 8500 8520 8540
Ly−α
Normalized Flux
Residuals
Velocity (km s⁻¹)
GRB130606A

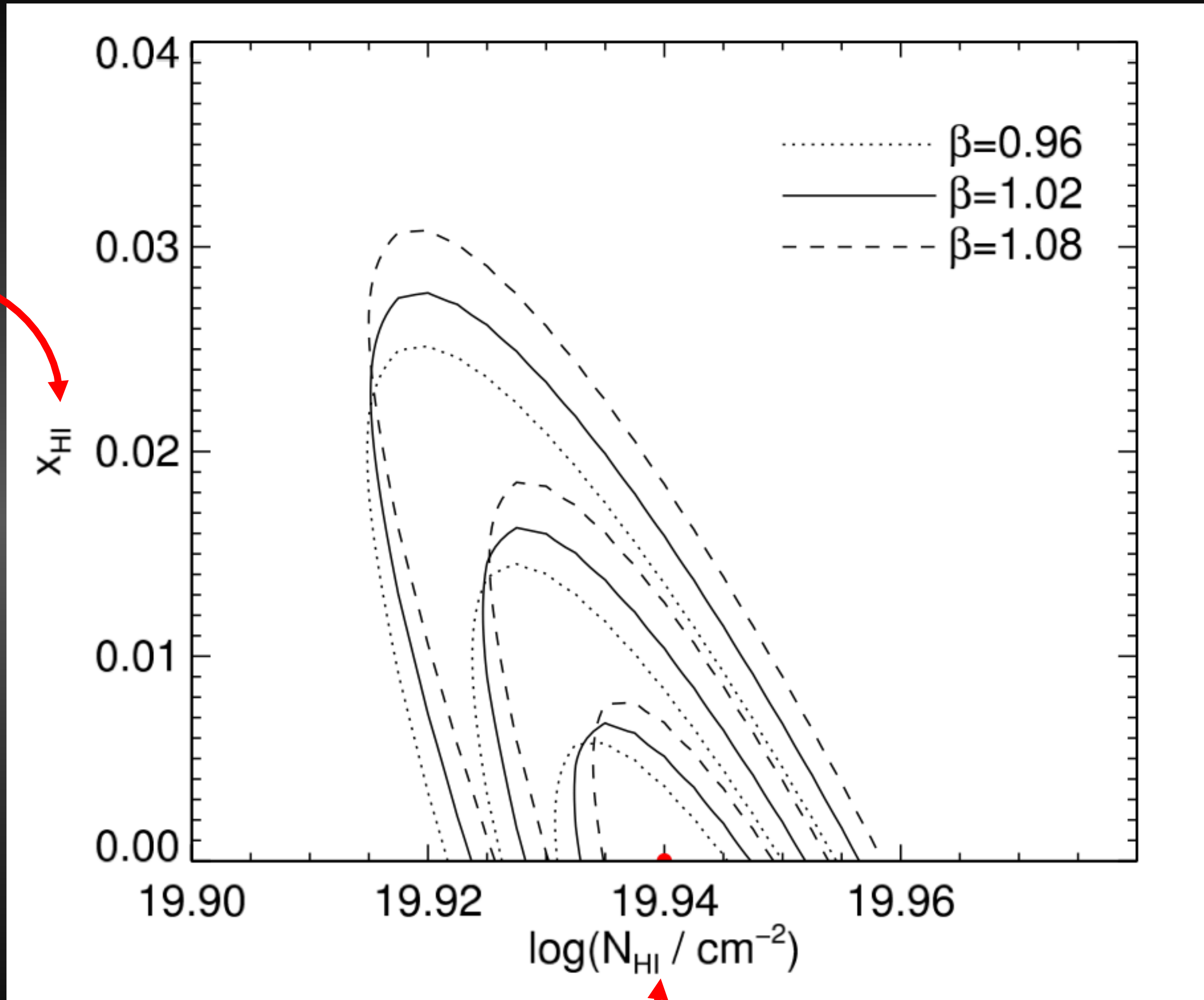

Rest wavelength (μm)
0.1 0.2
GRB090423
Flux density (μJy) at 16 hours
Observed wavelength (μm)
z Y J H K
SZ J
log(NH/cm⁻²)
Redshift


log N_HI = 20.7 z=6.700
log N_HI = 21.6 z=6.634
GRB080913
Lyα at z=6.74
F_λ (arbitrary units)
7500 8000 8500 9000 9500
Wavelength (Å)


Flux density (μJy)
GRB120923A
Wavelength (μm)

e.g. GRB 130606A at z=5.91

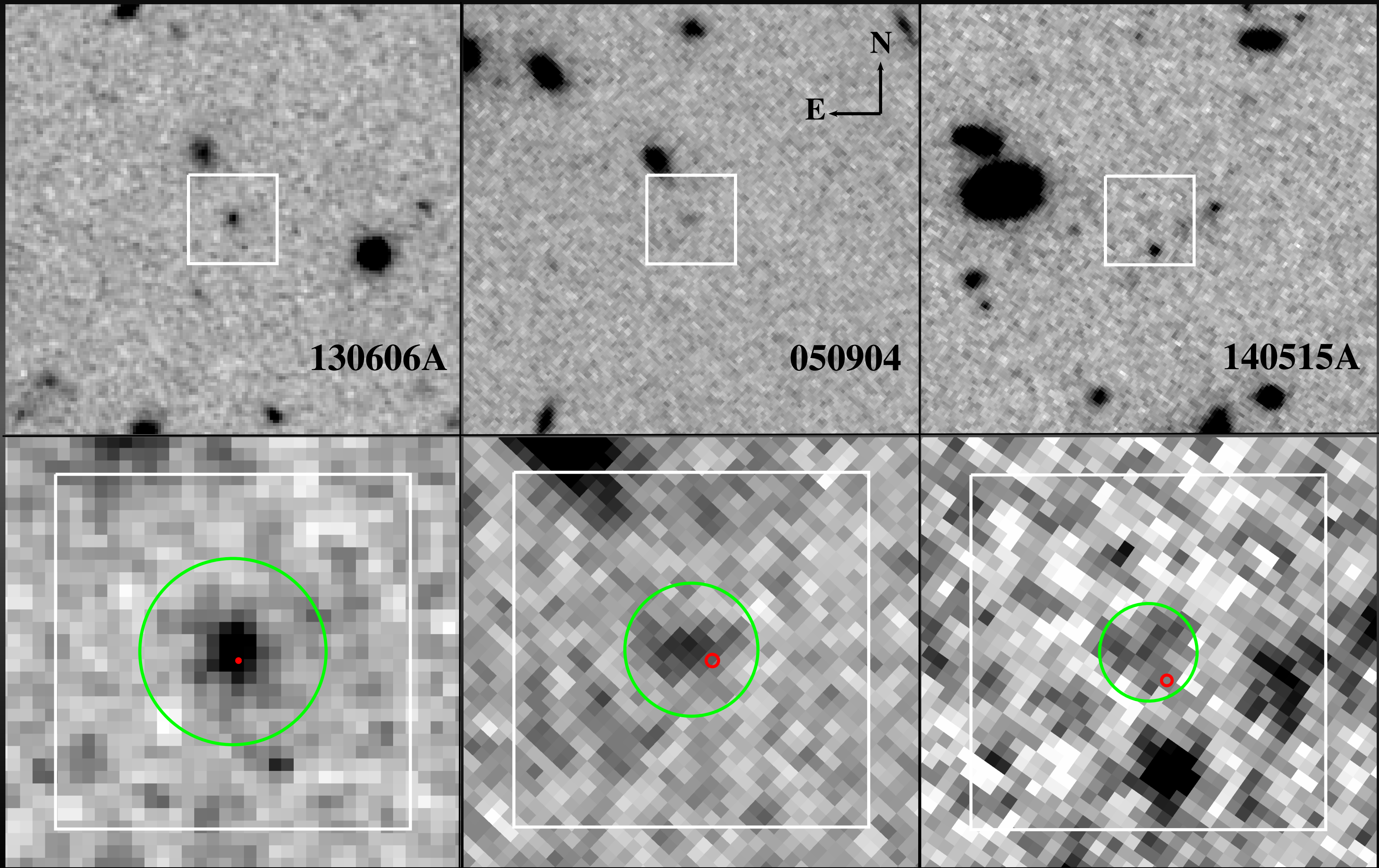
IGM predominantly ionized by z~6



Host NH relatively low, but still opaque to ionizing photons.

Science enabling

HST

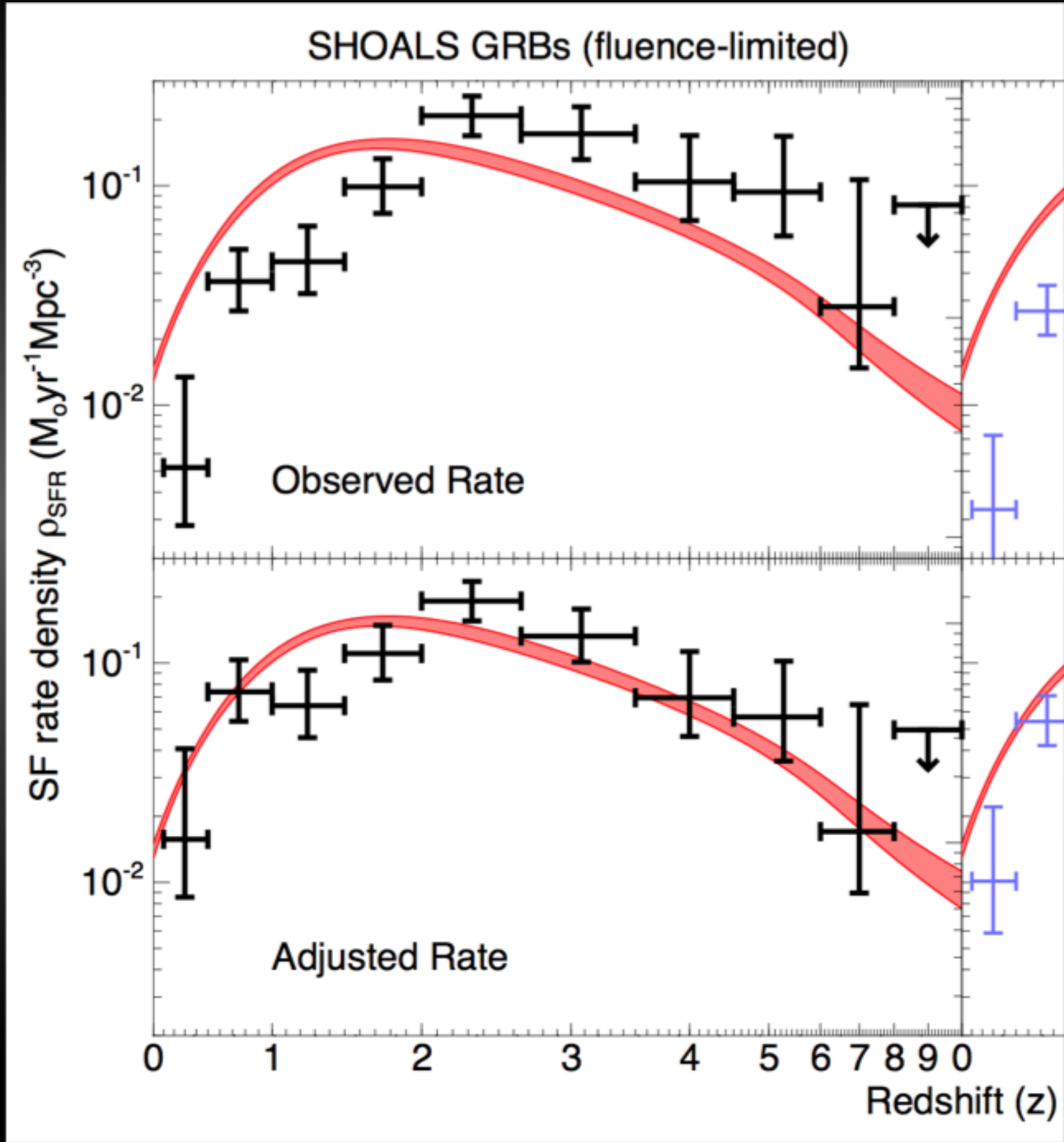


Star formation history from GRBs

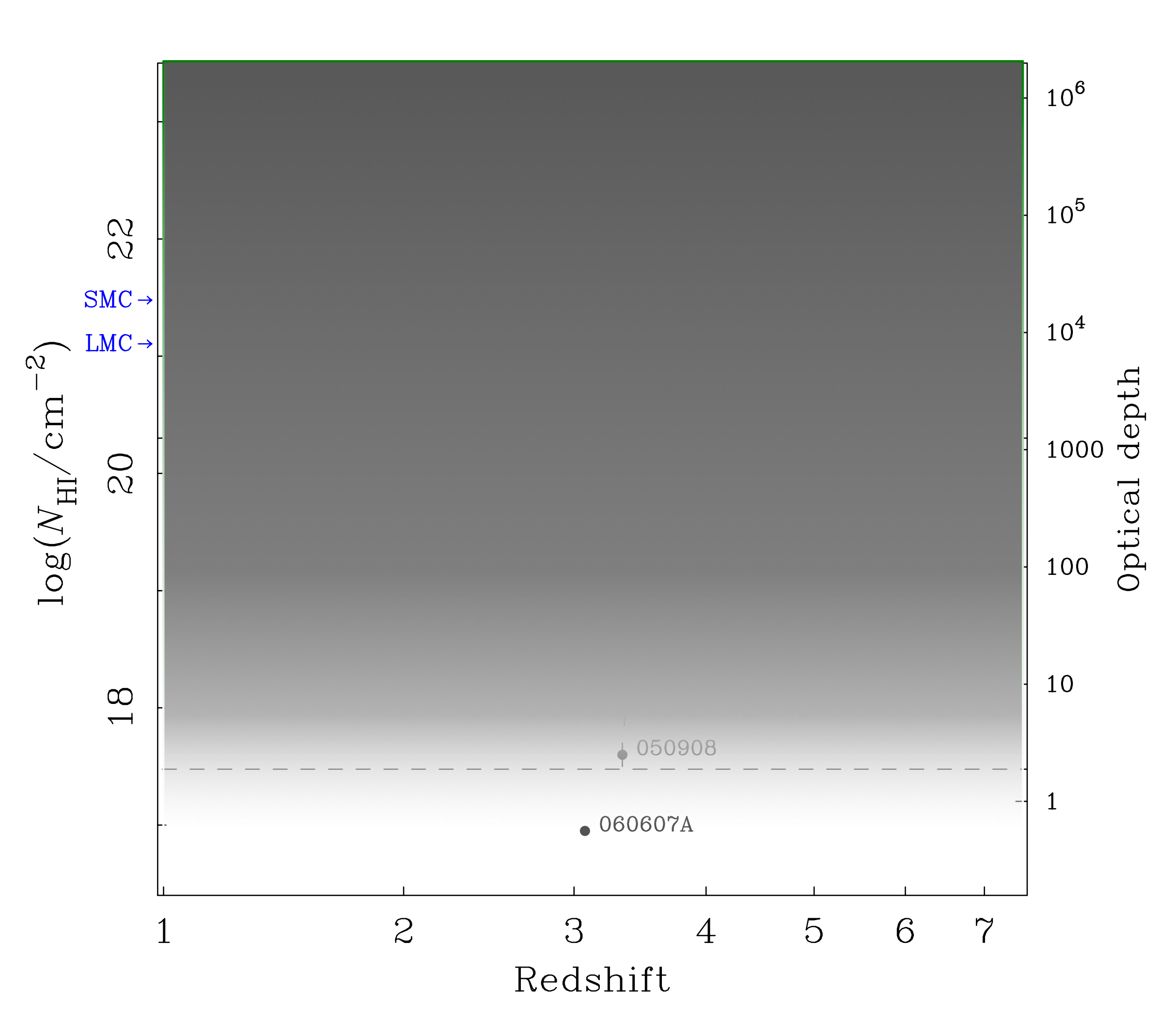
Perley et al. 2016

Long-standing problem – "too many GRBs at high-z" compared to naïve predictions based on galaxy SFR estimates.

Better accounting for evolving GRB:SFR (i.e. metallicity effects) and faint end of galaxy LF - tension reduced.



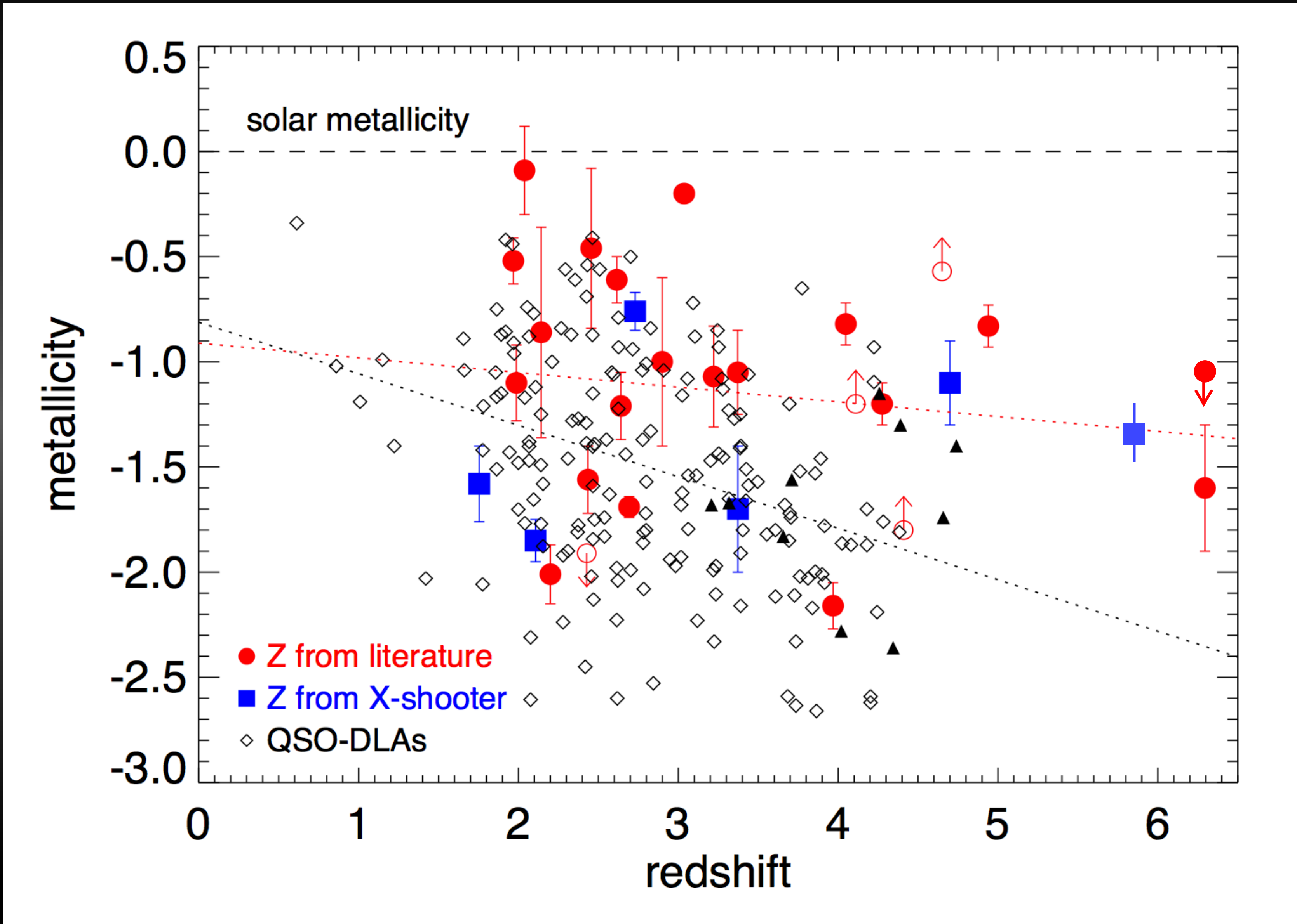
HI column density evolution



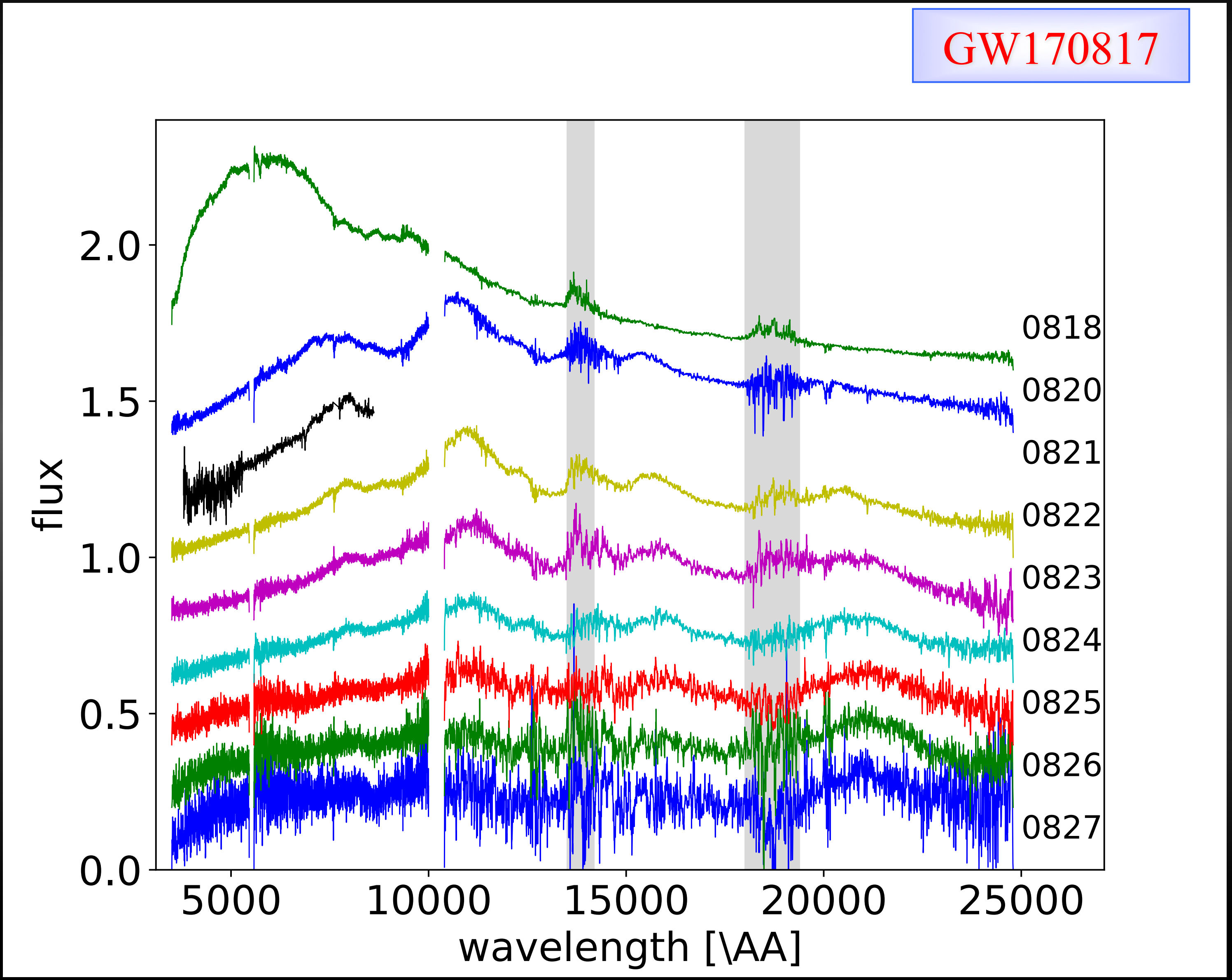
High column densities seen in optical spectra of most 2<z<4 GRBs suggest escape fractions for these stellar pops of <~1 %.

Chemical evolution

From hosts and afterglow spectroscopy, mostly low (at least ~sub-solar) metallicity.



Short bursts and GW



GRBs @ ESO

Pros:

- Powerful and broad range of instrumentation (esp. XS!) – often usable in parallel.
- Much time in service mode on VLTs.
- Experienced staff, e.g. helping to make decisions on the fly.
- RRM

Cons:

- Lack of "long-term" ToO programmes on VLT has made it hit-and-miss for rare events (and building up samples can look "incremental" in one period).
- Constraints of strictly defined OBs can sometimes reduce flexibility.
- Data return to archive sometimes a bottle-neck. Ie. high level of quick-look helpful.
- Visitor mode (and VLTI etc.) can throw spanners in the works.
- X-shooter would benefit from IR acquisition option.
- Only one hemisphere!

Thought: competition between ToO groups at ESO for very similar goals always makes life complicated, with little tangible benefit scientifically.