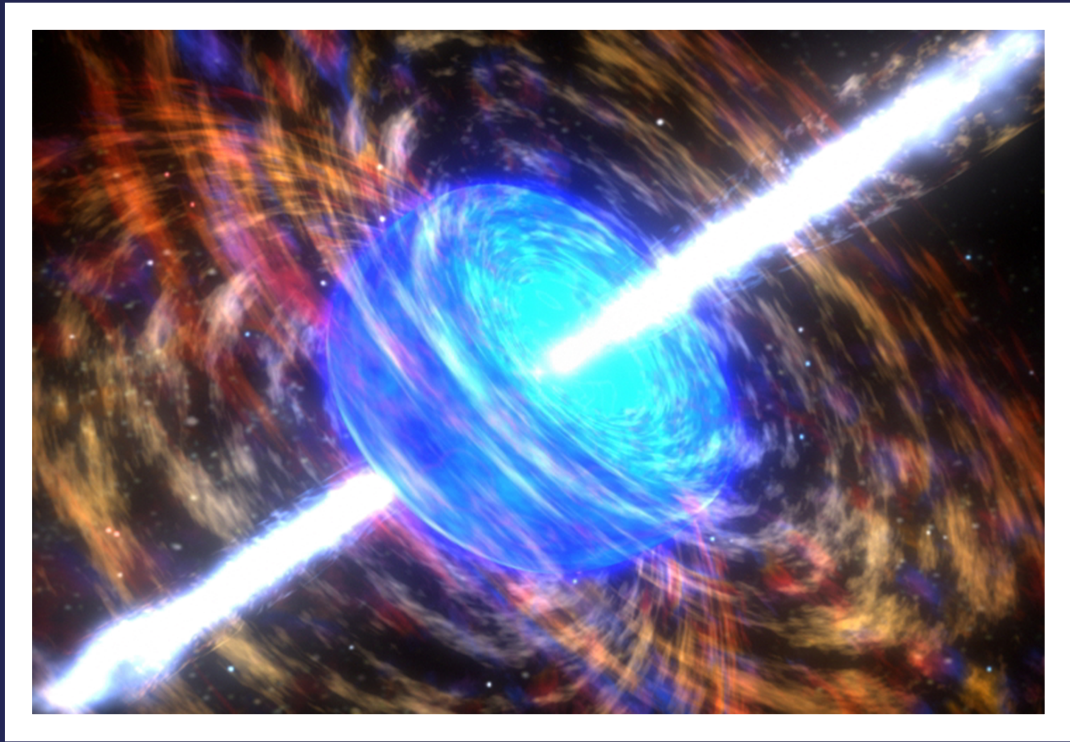
Statistical Study of the ISM of GRB hosts



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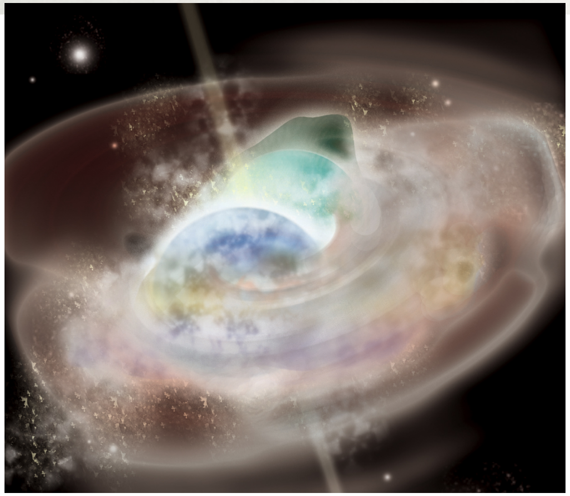
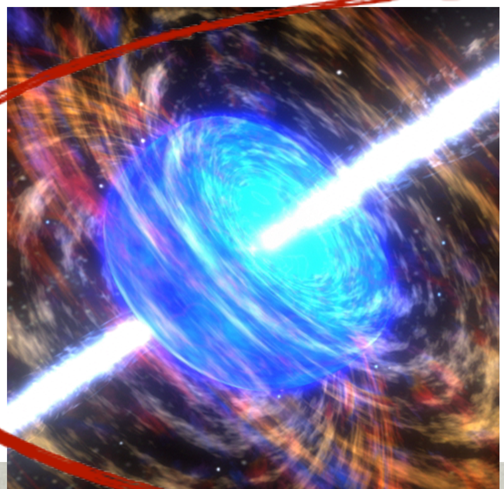
Based on: de Ugarte Postigo et al. A&A Submitted

Gamma-ray bursts



Short bursts < 2s



Long bursts > 2s

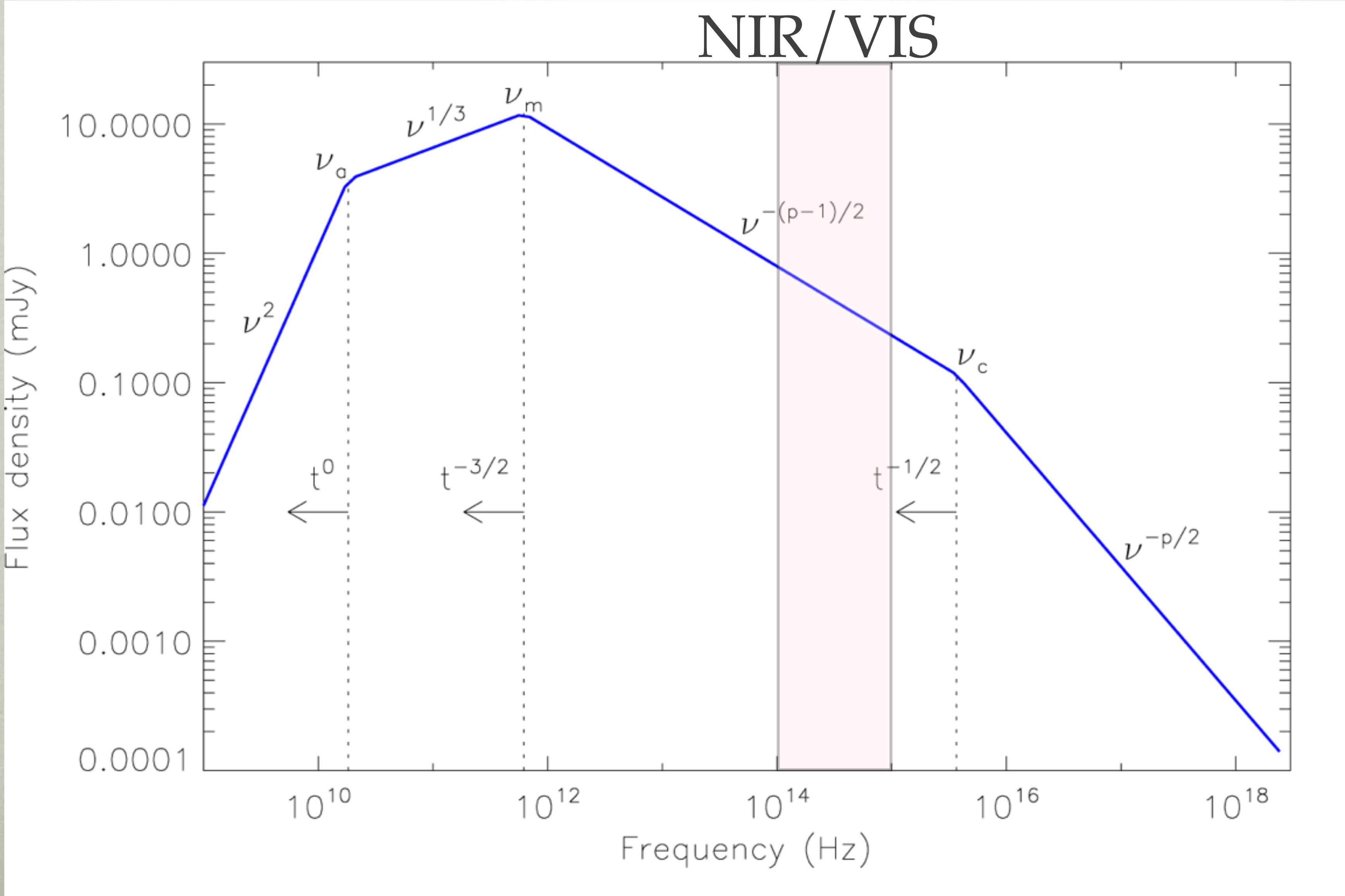
Fermi gamma-ray sky

GRBs are great beacons to study their hosts

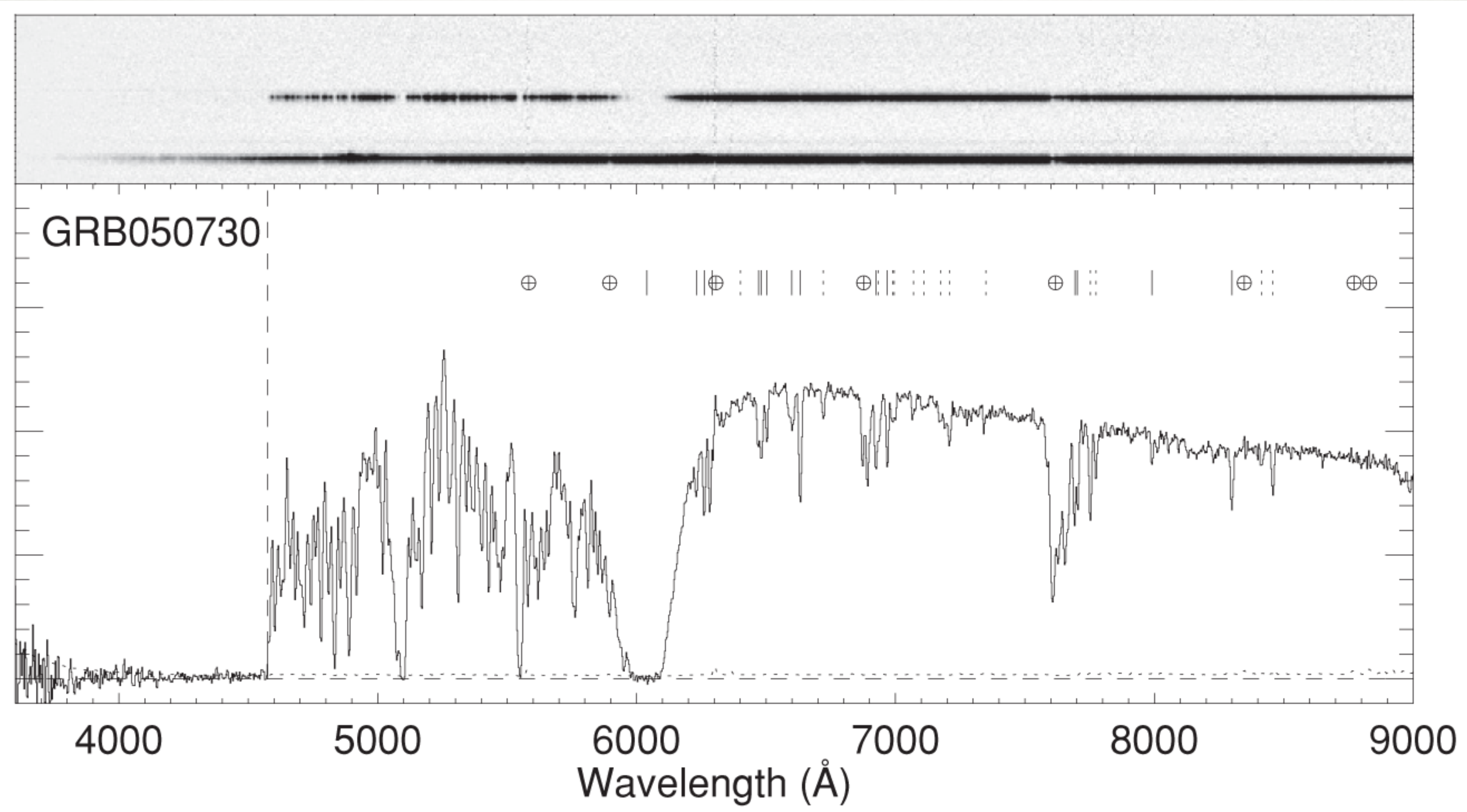
Starburst dwarf galaxies

GRBs can trace STAR FORMATION

GRBs have clean powerlaw spectra



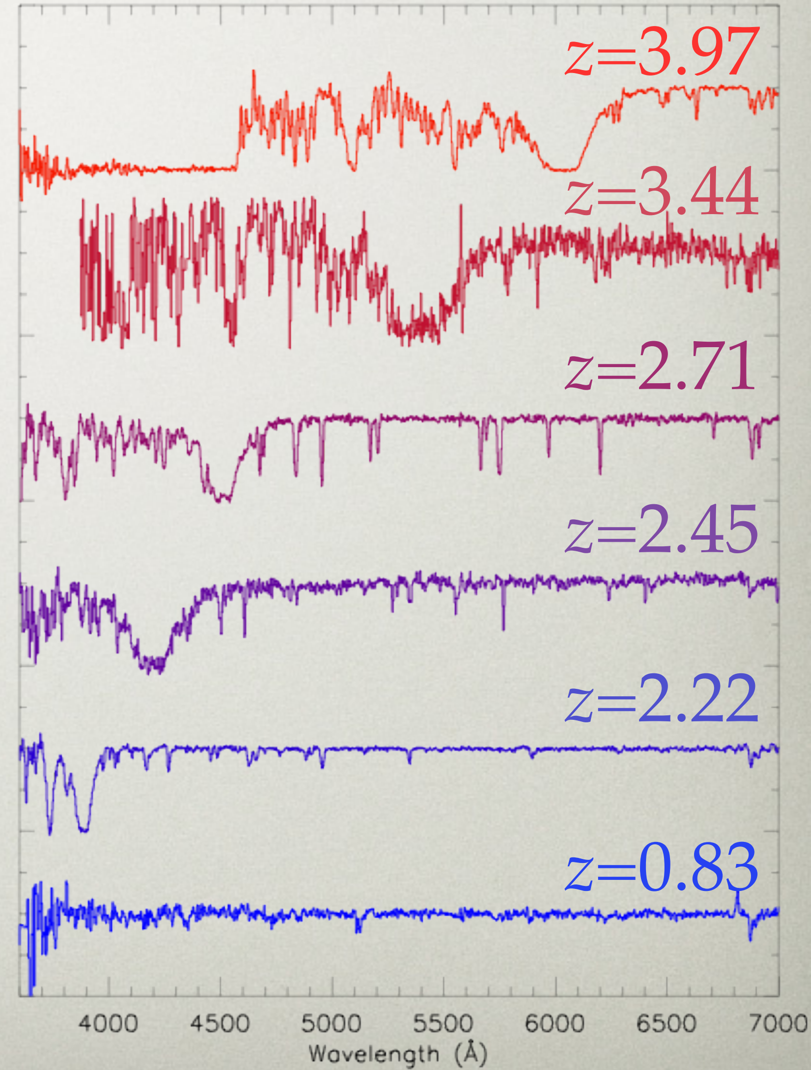
GRBs have a clean powerlaw spectra



We are interested in the host galaxy features

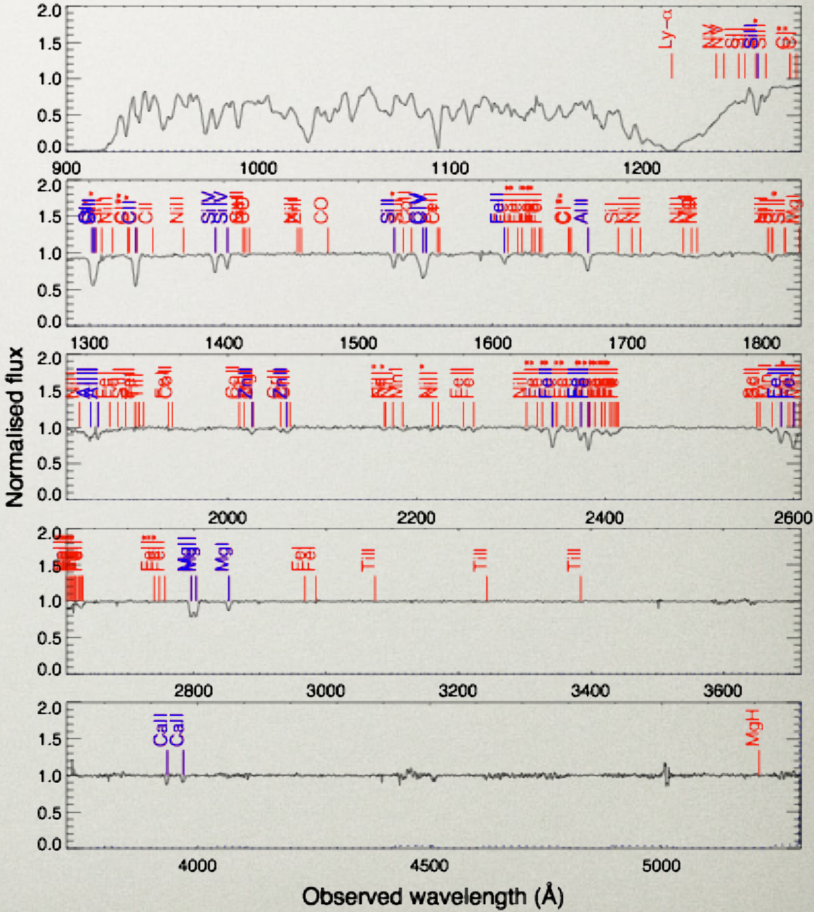
The Spectra Sample

- **69 GRB low resolution spectra** total observing time over 100 hr.
  - 2005-2009 (Fynbo et al. 2009)
  - 8 new spectra obtained with FORS/VLT
- **Redshifts** from 0.12 to 6.70



Spectral Feature Selection

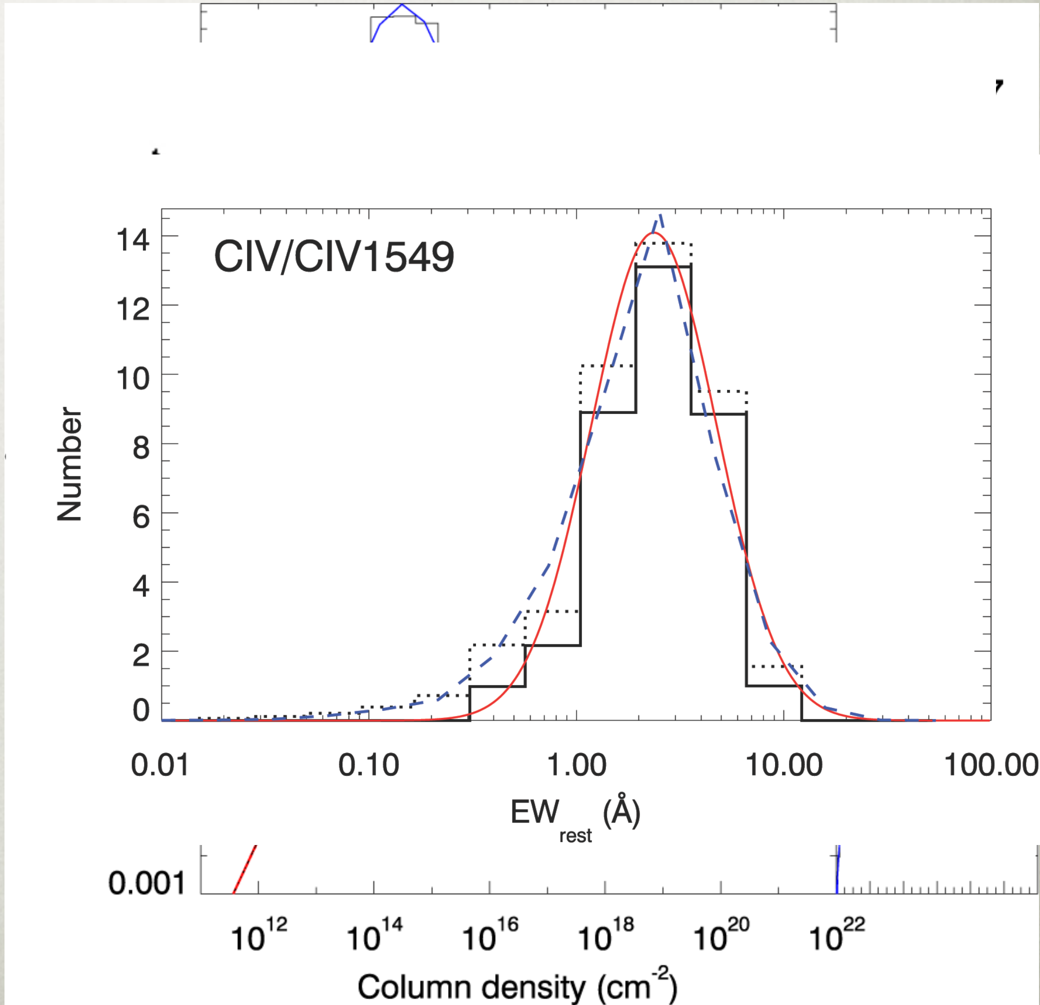
- We select only strong features, EW > 0.5A
- **22 spectral features**



Christensen et al. (2011)

Method

- Equivalent width histograms:
  - Rest frame
  - Detected lines
  - 3-sigma limits
  - Logarithmic scale
- Log-normal fit as 1st approximation



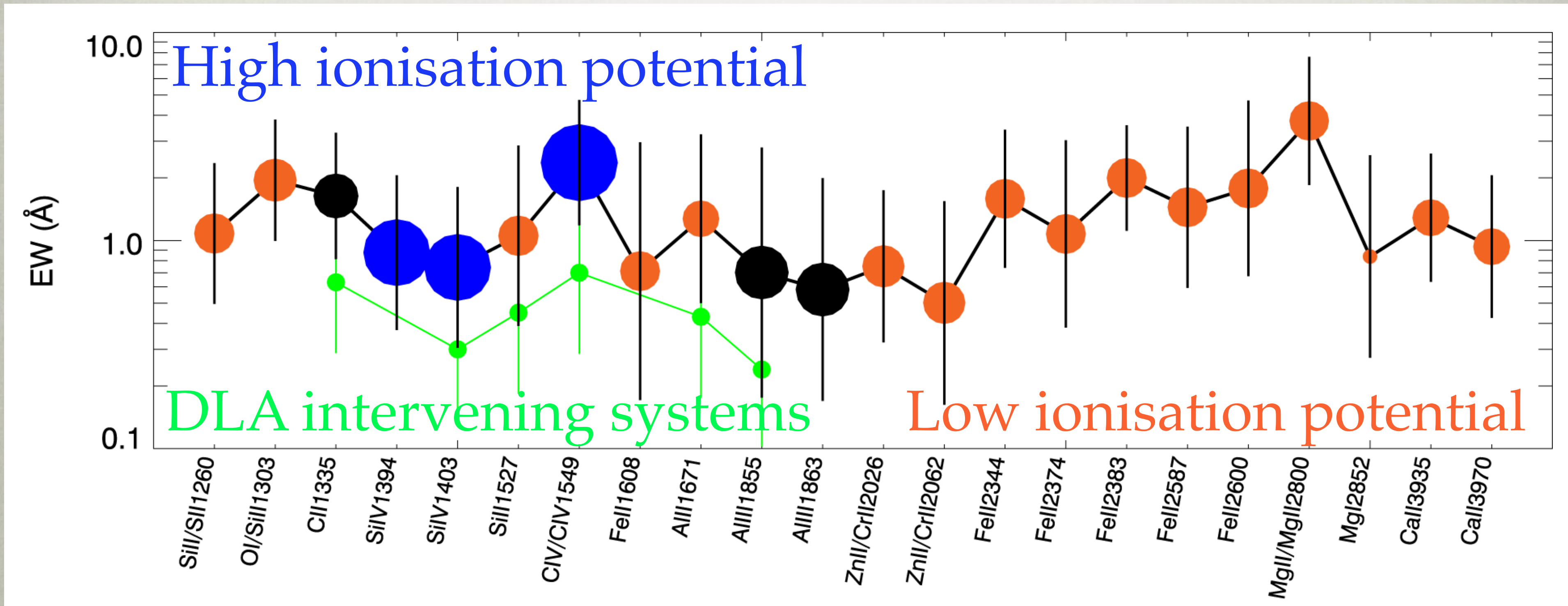
Distribution of EWs

- 69 spectra
- Average of 36 spectra per line
- 52% detection rate (30-87%)

Feature	Det.	Lim.	$10^{\langle \log \mathrm{EW} \rangle}$ (Å)	$\sigma_{\log(\mathrm{EW/Å})}$
Si II/S II λλ1260,1260	15	20	1.08	0.34
O I/Si II λλ1302,1304[a]	22	15	1.95	0.29
C II λ1335[a]	23	16	1.64	0.30
Si IV λ1394	19	19	0.88	0.37
Si IV λ1403	19	19	0.74	0.39
Si II λ1527	27	16	1.05	0.43
C IV λλ1548,1551	35	7	2.37	0.30
Fe II λ1608	19	24	0.71	0.61
Al II λ1671	26	13	1.27	0.41
Al III λ1855	15	27	0.70	0.60
Al III λ1863	14	29	0.58	0.53
Zn II/Cr II λλ2026,2026	16	27	0.75	0.37
Zn II/Cr II λλ2063,2062	11	26	0.50	0.49
Fe II λ2344[a]	23	14	1.59	0.33
Fe II λ2374	17	20	1.08	0.45
Fe II λ2382[a]	23	15	2.00	0.25
Fe II λ2587	20	16	1.45	0.39
Fe II λ2600[a]	18	16	1.78	0.42
Mg II λλ2796,2803	27	4	3.76	0.30
Mg I λ2852	12	18	0.84	0.49
Ca II λ3935	7	8	1.29	0.31
Ca II λ3970	7	8	0.93	0.34

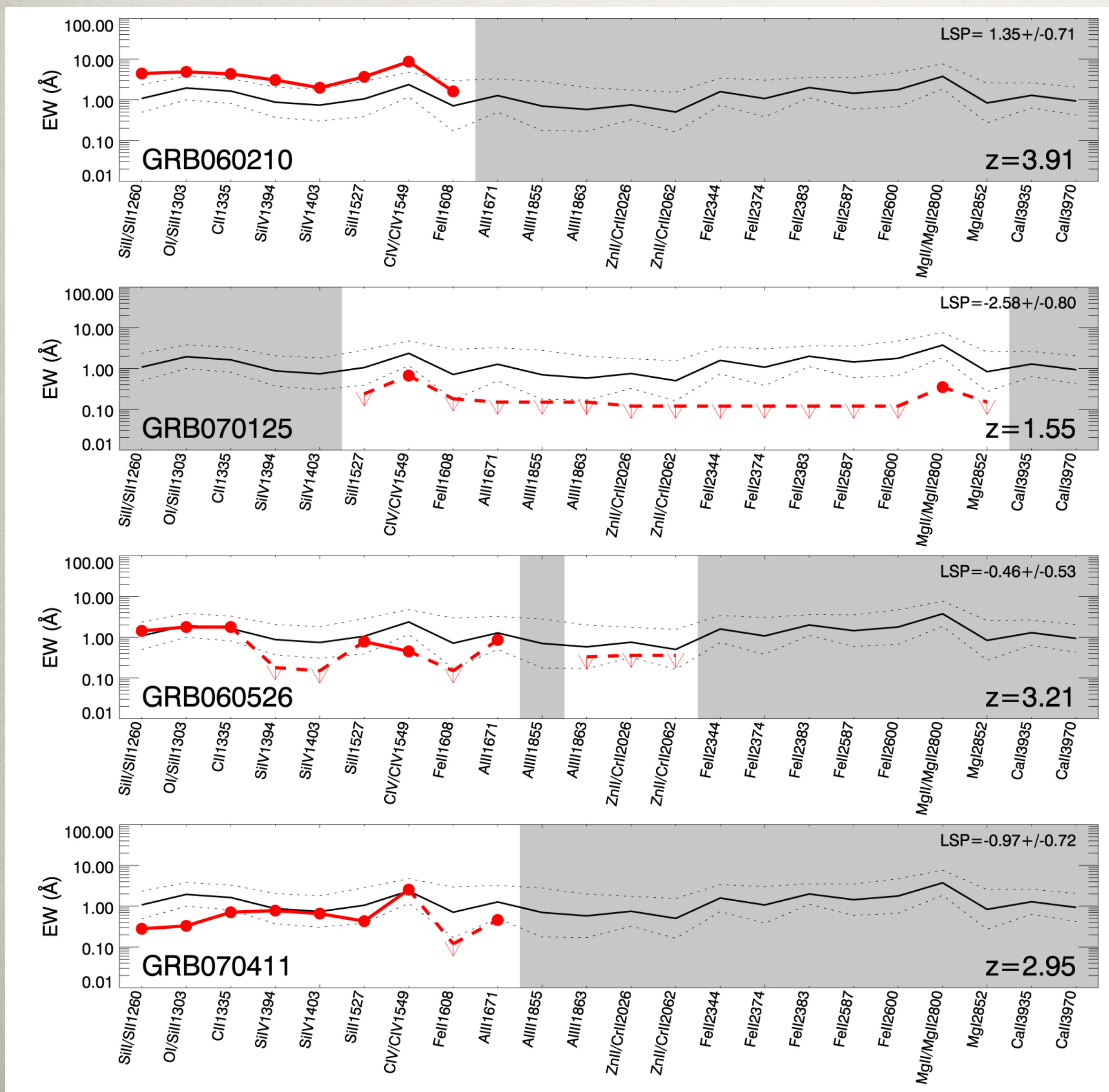
NOT INTUITIVE

EW Diagram



Easy tool to compare bursts

Some Examples of EW Diagrams



← Strong features

← Weak features

← Low ionisation

← High ionisation

The Line Strength Parameter

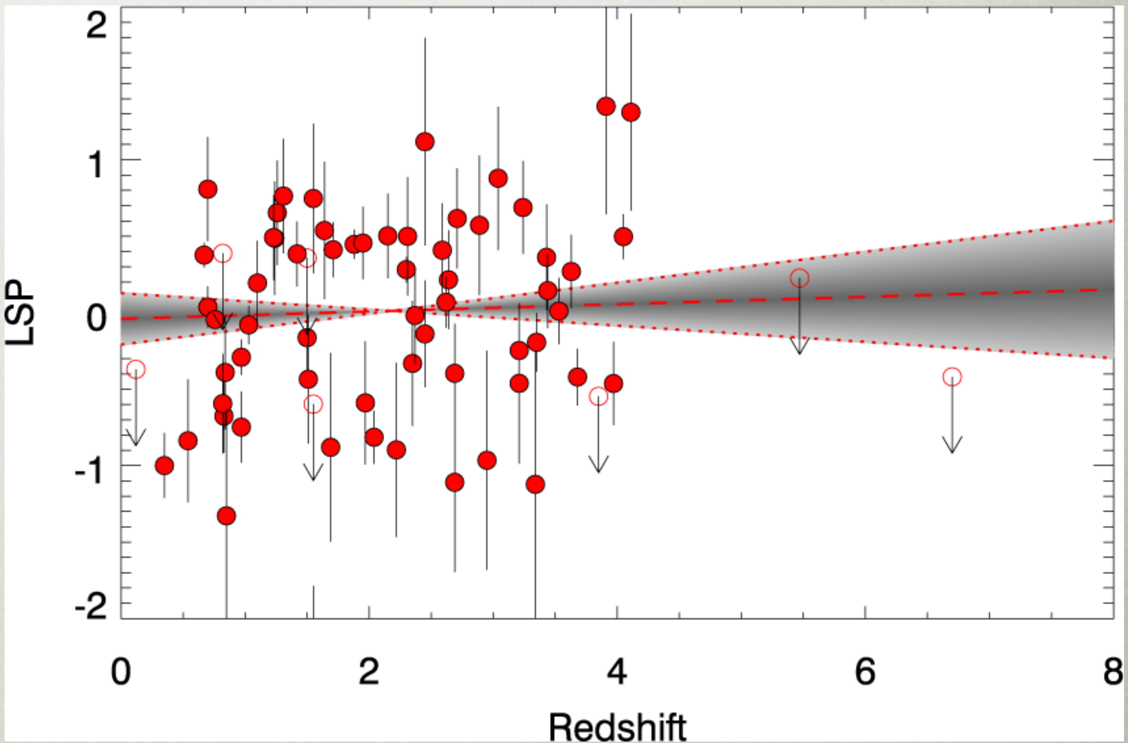
- Single parameter to evaluate line strength
- Independent of the observed range
- Can be used at any redshift
- Less information than comparing specific lines

$$LSP = \frac{1}{N} \sum_{i=1}^{N} \frac{\log EW_i - \langle \log EW \rangle_i}{\sigma_{\log EW, i}}$$

0 - Typical EWs
> 0 - Strong EWs
< 0 - Weak EWs

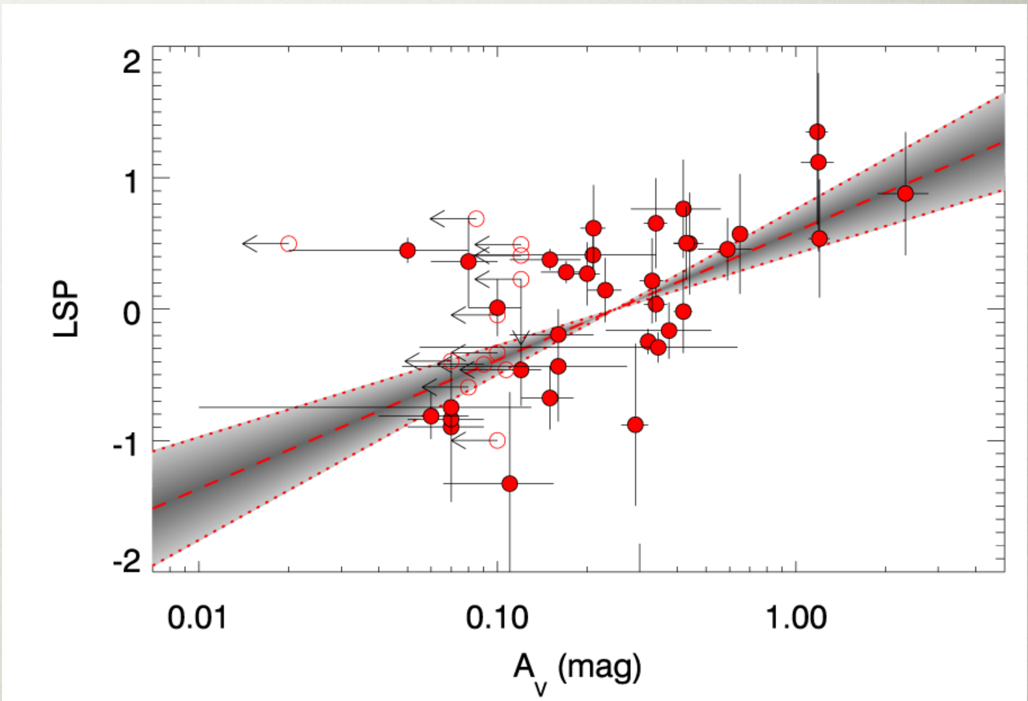
LSP and redshift

- No evolution
- High-z sample is still small



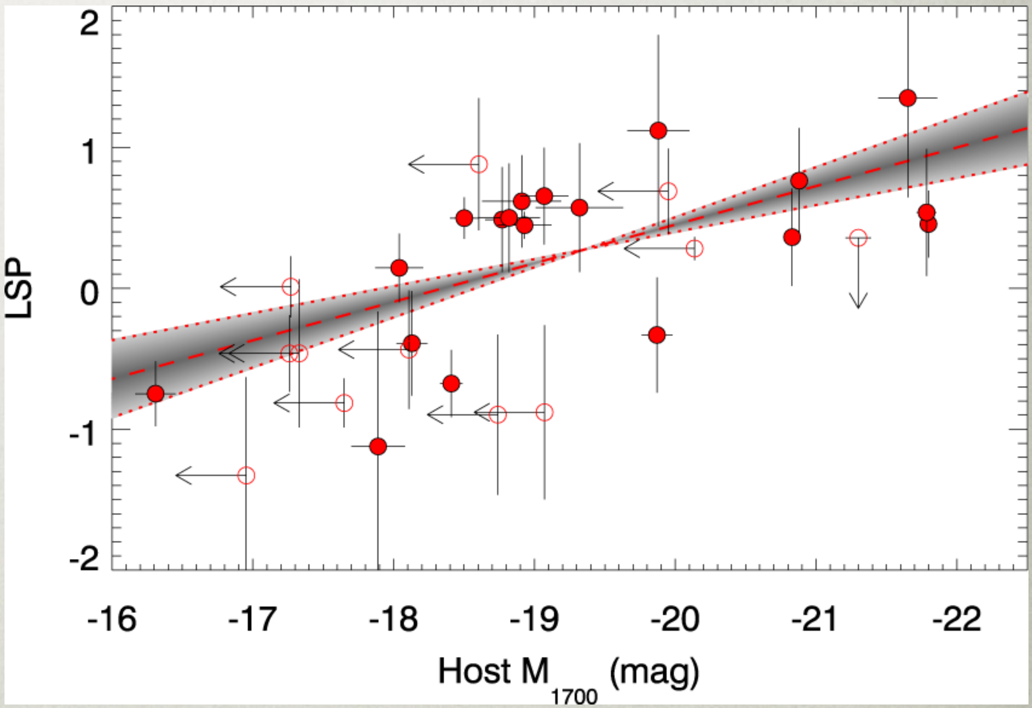
LSP and Extinction

- Stronger features imply more material and result in more extinction
- Where there is more metals there is also more dust



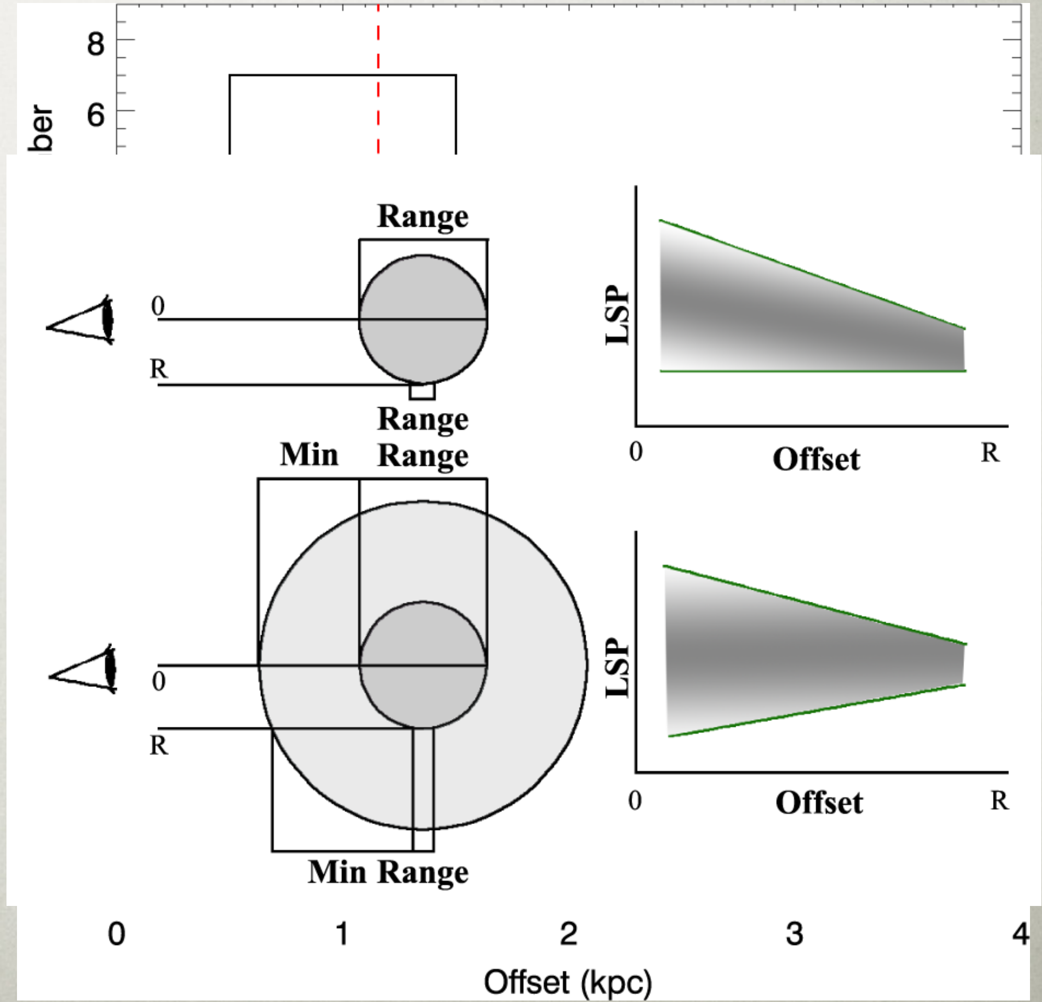
LSP and host galaxies

- Brighter / bigger hosts have stronger spectral features
- Absorption is related with the host and not with the GRB



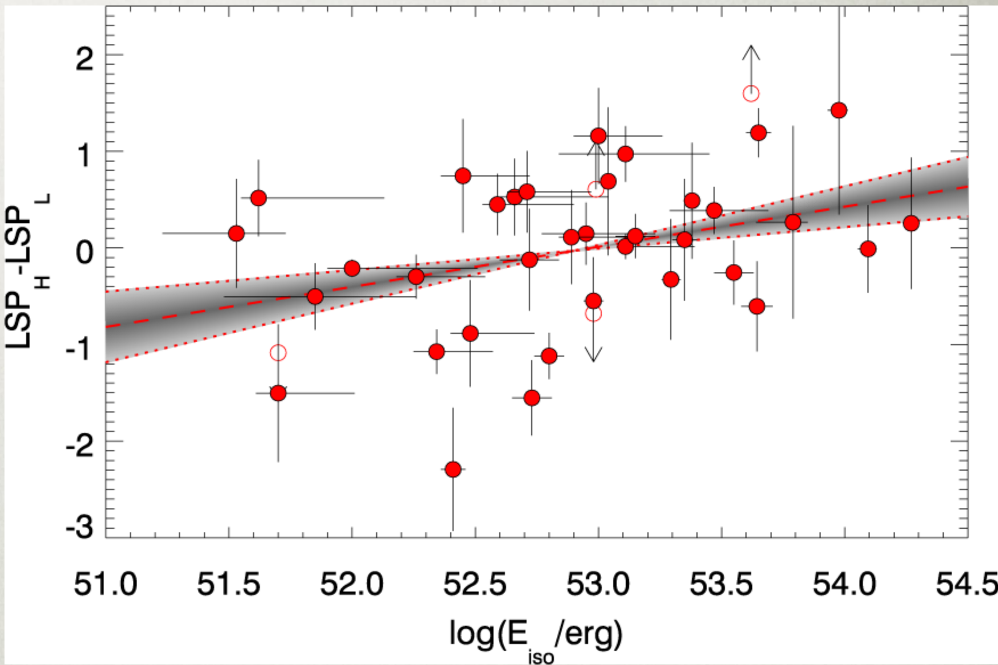
LSP and host offsets

- Decay in the maximum as offset increases
- Increase in the minimum!
- Geometric effect? GRBs are only in star forming regions

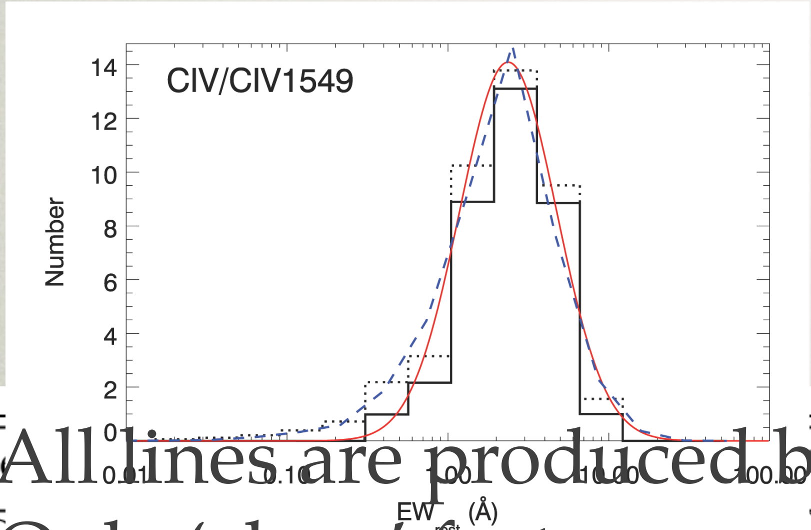


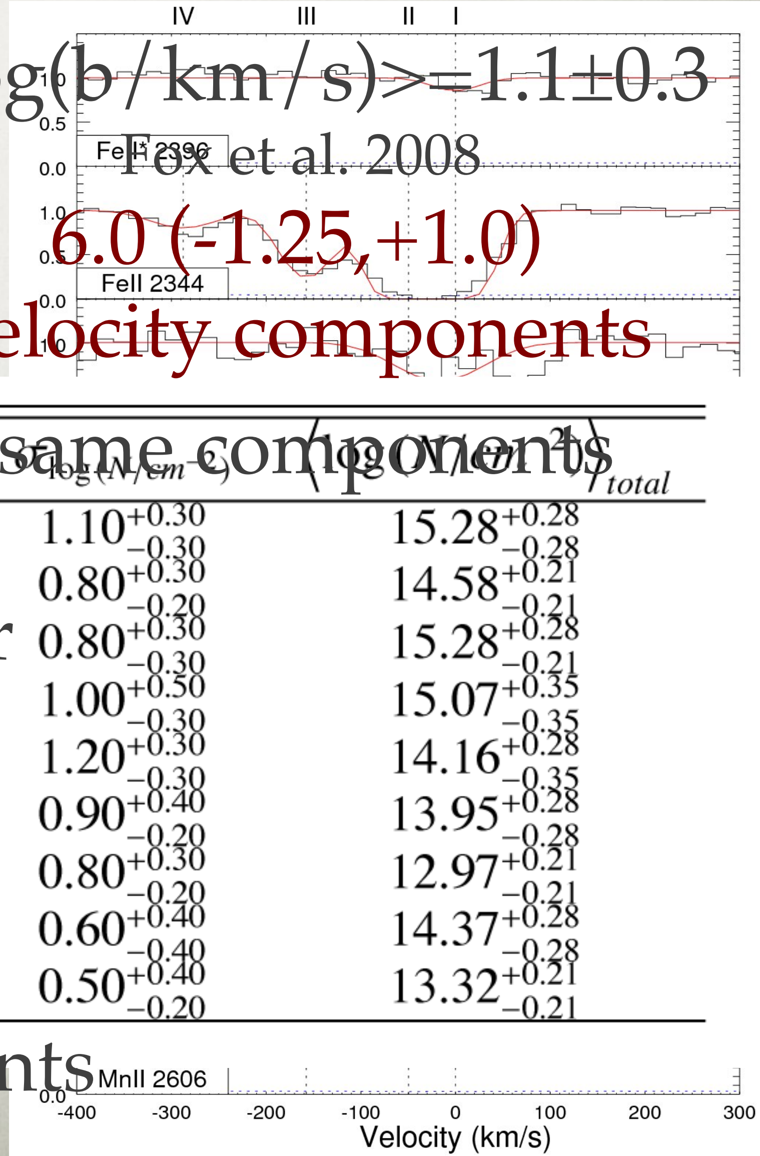
Ionisation vs. Energy

- More energetic bursts show higher ionisation
- Galaxies with higher star formation produce brighter bursts



Distribution of column densities





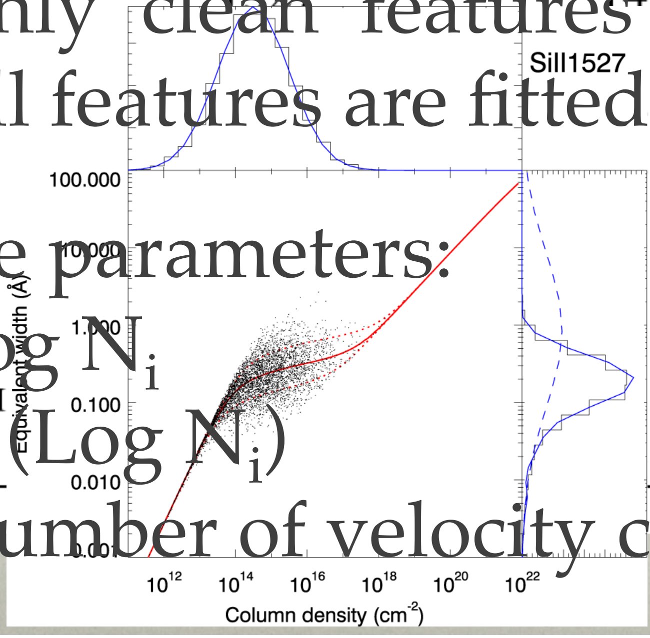
<log(b/km/s)>=1.1±0.3

Fox et al. 2008

6.0 (-1.25,+1.0)

velocity components

Sp[illegible]	[illegible] comp	$\sigma_{\log(N/cm^{-2})}$	$\langle \log(N/cm^{-2}) \rangle_{total}$
Si II	[illegible]$^{-0.28}$	$1.10^{+0.30}_{-0.30}$	$15.28^{+0.28}_{-0.28}$
Si IV	$.80^{+0.21}_{-0.21}$	$0.80^{+0.30}_{-0.20}$	$14.58^{+0.21}_{-0.21}$
C IV	[illegible]	$0.80^{+0.30}_{-0.30}$	$15.28^{+0.28}_{-0.21}$
Fe II	$.29^{+0.35}_{-0.35}$	$1.00^{+0.50}_{-0.30}$	$15.07^{+0.35}_{-0.35}$
Al II	$.38^{+0.28}_{-0.35}$	$1.20^{+0.30}_{-0.30}$	$14.16^{+0.28}_{-0.35}$
Al III	$.17^{+0.28}_{-0.28}$	$0.90^{+0.40}_{-0.20}$	$13.95^{+0.28}_{-0.28}$
Mg I	$.19^{+0.21}_{-0.21}$	$0.80^{+0.30}_{-0.20}$	$12.97^{+0.21}_{-0.21}$
Mg II	$.59^{+0.28}_{-0.28}$	$0.60^{+0.40}_{-0.40}$	$14.37^{+0.28}_{-0.28}$
Ca II	$.54^{+0.21}_{-0.21}$	$0.50^{+0.40}_{-0.20}$	$13.32^{+0.21}_{-0.21}$



- All lines are produced by the same component
- Only 'clean' features
- All features are fitted together

Free parameters:

- Log N_i
- σ (Log N_i)
- Number of velocity components

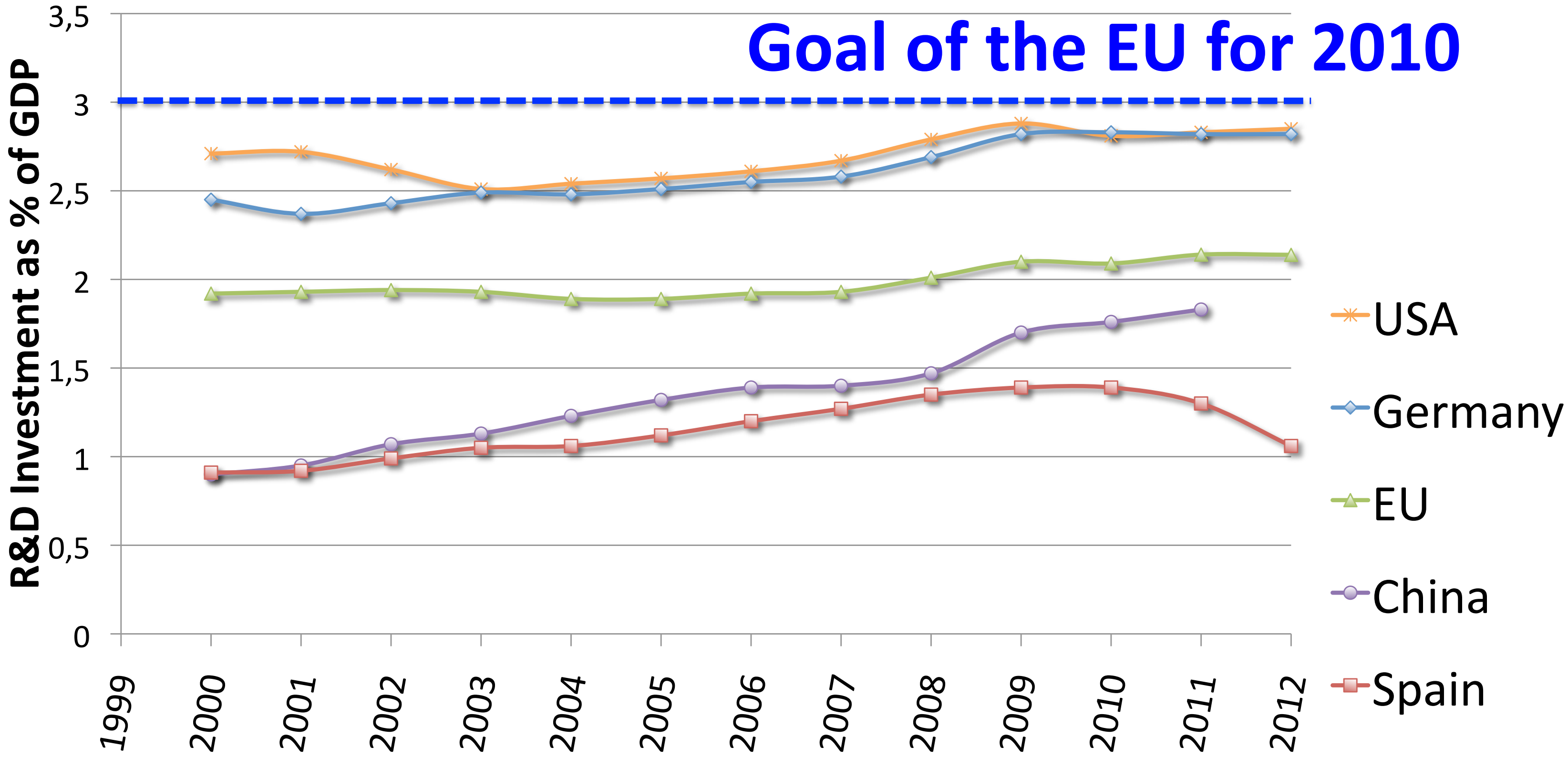
Conclusions

- Sample of 22 lines in 69 spectra, 0.12<z<6.70
- ***EW diagrams*** to compare with the sample
- ***LSP*** characterises the strength of the lines:
  - Does not depend on *z*
  - Correlates with extinction and galaxy size
- The energy of the burst correlates with the ionisation (→ Related to star formation)
- Physical fit of histograms to derive the distribution of column densities

Future?

…

SCIENCE AND ASTRONOMY IN SPAIN: WORRIES



- 33% cut of science budget since 2009
- 50% cuts in Grants (all research activities apart from staff salaries)
- 10% of replacements of retirements
- Funds gained in open competition (eg FP7 EC) retained: Severe delays of travel reimbursement and equipment payments


THANKS!