Hunting for the w’s

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Milestones in SN/GRB connection

- **GRB 980425 & SN 1998bw:** an odd GRB and a strange SN

- **GRB 030329 & SN 2003dh:** somewhat less anomalous
  
  - Galama et al.
  - Patat et al.
  - Matheson et al.
  - Stanek et al.
  - Kawabata et al.

- **GRB 021211 & SN 2002lt:** spectroscopic confirmation
  
  - Bloom et al.
  - Garnavich et al.
  - Zeh et al.
  - Stanek et al.
  - Hjorth et al.
  - Roth et al.
  - Della Valle et al.

**SN bumps** in GRB afterglows:
all long GRBs?

See talks by Bloom, Fruchter, Levan
Observations of GRB 031203

• Trigger from INTEGRAL
  Götz et al. 2003
  (talk by S. Sazonov)

• Afterglow:
  X-ray (XMM) & radio (VLA)
  Watson et al. 2004, Soderberg et al. 2004

• Our observations:
  ESO NTT & VLT

• Low redshift host galaxy ($z = 0.1$)
  Very faint: $E \sim 10^{49} ÷ 10^{50}$ erg
  Large extinction: $E(B-V) \approx 1$

Prochaska et al. 2004
Watson et al. 2004
The X-ray ring

Bright impulsive source + Large dust column \[\Downarrow\] Expanding X-ray ring

Measurement of prompt X-ray!

Vaughan et al. 2004 (talk by M. Ward)
A near-infrared afterglow

X-ray data from Watson et al. 2004

Extinction: $E(B-V) = 1.1$

GRB 031203
has a NIR afterglow

* Very faint
* Very red
* Double-peak SED
* Slow X-ray decay

Nice opportunity for robotic telescopes
Searching for the SN

Brightening source inside the host galaxy

See also
* Thomsen et al.
* Cobb et al.
* Gal-Yam et al.
* Bersier et al.
* Free register:
The very bright supernova 2003lw

SN 2003lw

vs

SN 1998bw

Overall similar

With $E(B-V) = 1.1$:

* 0.5 mag brighter
* Same colors
* Slower evolution
* Small SN/GRB delay
The host galaxy

Bright star-forming host galaxy

- SFR $\sim 10 \, M_\odot/\text{y}$
- $Z \sim 0.1 Z_\odot$
- $E(B-V) \sim 1.1$
- $R \sim 200 \, \text{pc}$

Broad undulations in the continuum

See also Prochaska et al.
Host galaxy subtracted

Expansion velocity:
15000 km/s
(1998bw: 18000 km/s)

Hypernova?
Spectra of SN 2003lw (2)

“New” red spectrum
(just for the host!)
Hints for larger extinction

Mazzali et al. in prep.

EB-V
1.1
1.0
0.9
0.8

Flux (erg cm^{-2} s^{-1} Å^{-1})

Wavelength (Å)
## GRB 031203 vs GRB 980425

<table>
<thead>
<tr>
<th></th>
<th>GRB 980425</th>
<th>GRB 031203</th>
<th>Cosmic GRBs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light curve</td>
<td>Single peak</td>
<td>Single peak</td>
<td>Diverse</td>
</tr>
<tr>
<td>GRB energy</td>
<td>$\sim 10^{48}$ erg</td>
<td>$\sim 10^{50}$ erg</td>
<td>$5 \times 10^{51}$ erg</td>
</tr>
<tr>
<td>Peak energy</td>
<td>120 keV</td>
<td>$&gt; 200$ keV</td>
<td>10 keV - 1 MeV</td>
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<tr>
<td>Opt. afterglow</td>
<td>no/undetected</td>
<td>faint</td>
<td>bright</td>
</tr>
<tr>
<td>X-ray afterglow</td>
<td>faint &amp; slow</td>
<td>faint &amp; slow</td>
<td>bright &amp; fast</td>
</tr>
<tr>
<td>Radio afterglow</td>
<td>faint</td>
<td>faint</td>
<td>bright</td>
</tr>
<tr>
<td>Supernova</td>
<td>SN 1998bw</td>
<td>SN 2003lw</td>
<td>SN 2003dh</td>
</tr>
</tbody>
</table>
Summary & conclusions

- **The w’s**: GRB 031203 & GRB 980425
- All (long) GRBs seem associated with SNe
- Next step: identify SNe in *afterglow bumps*
- Do weak bursts have powerful SNe?
The w’s have more powerful SNe than the cosmological GRBs.

SN luminosities: Zeh et al.
A troubled story

GRB 031203 was an unlucky burst:
• Heavy extinction on the Galactic plane...
• Crowded field...
• No early-reported optical afterglow...
• Weak burst...

BUT

• supernova
• dust echo
• 10 published papers + 2 in prep.
• 5 dedicated talks here

The revenge of the poor!
That's All Folks