GROND view of the "dark burst" mystery

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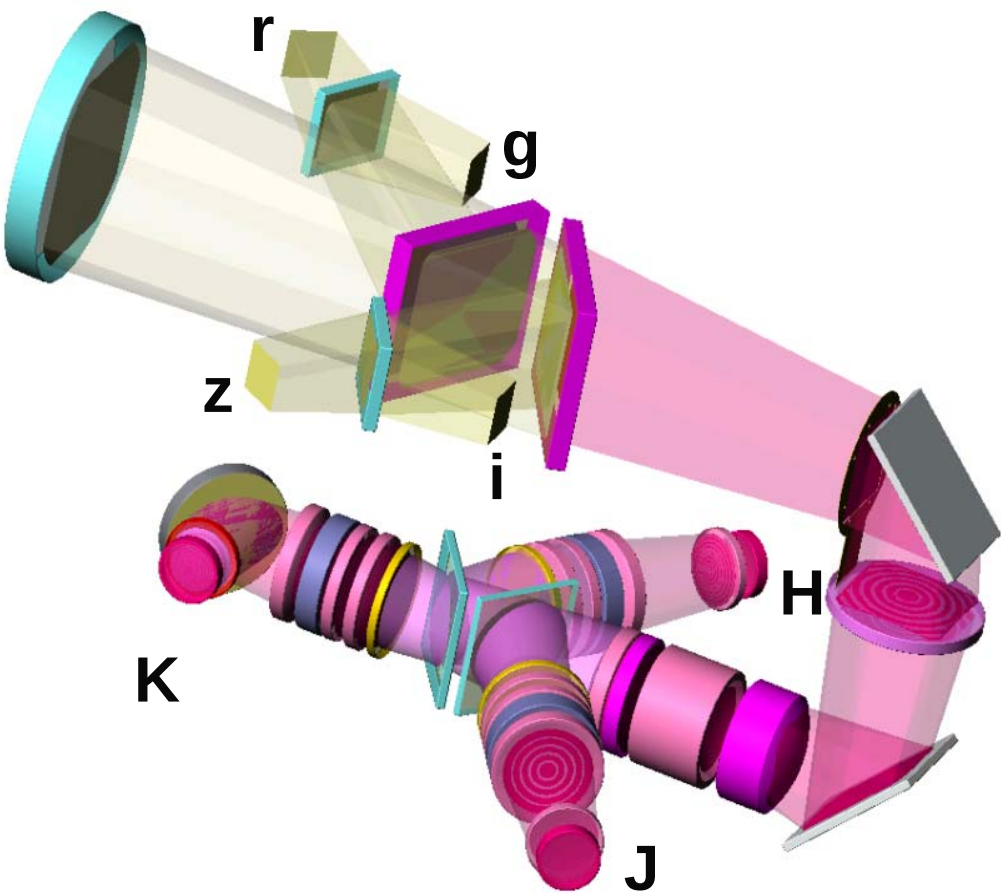
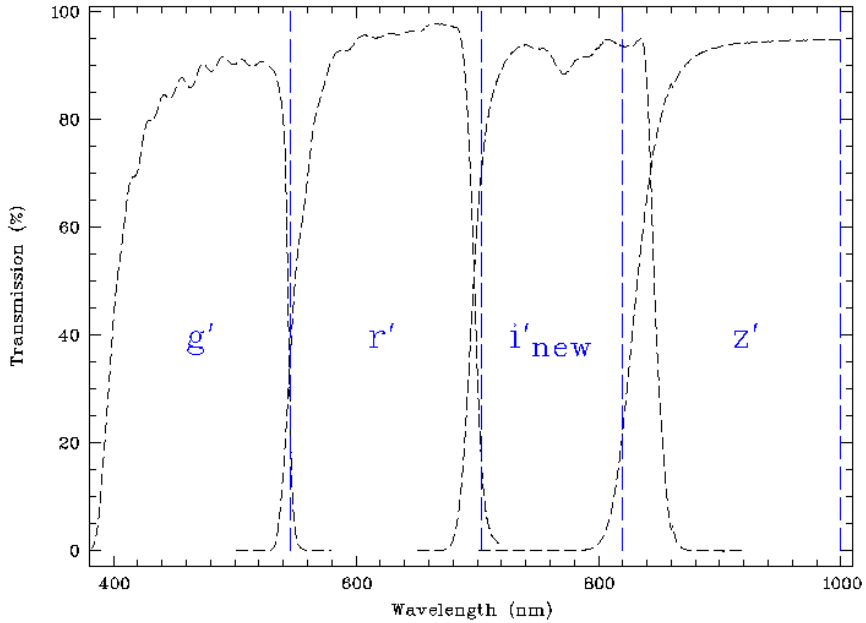
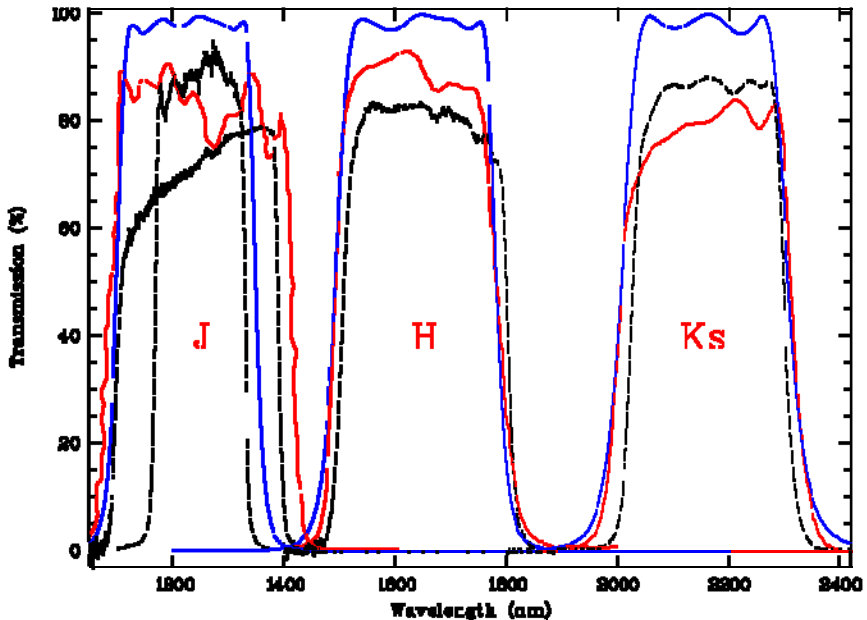
GROND=GRB Optical/NIR Detector

Imaging in 7 channels simultaneously







GROND: General Design

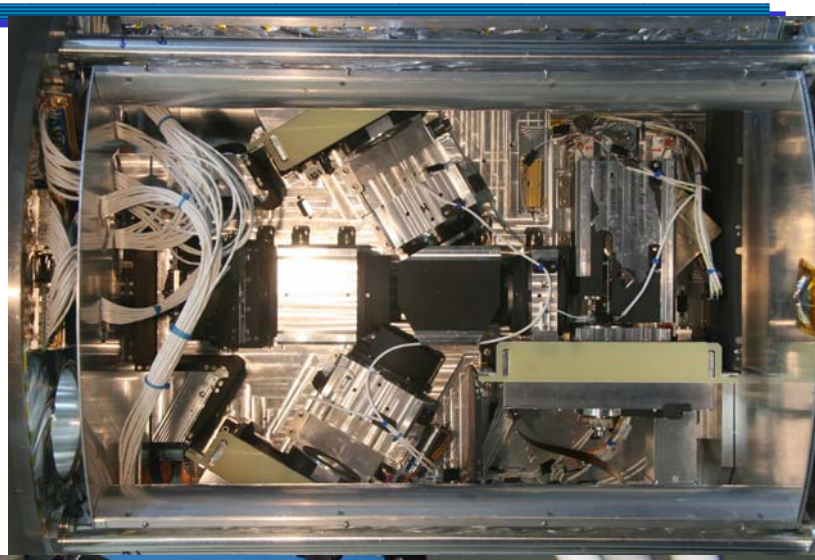
- **7 bands: Sloan g', r', i', z' and J, H, K**
  One detector for one filter band (no movable filters!)
  3 HAWAII 1K*1K Arrays + 4 E2V 2K*2K CCDs
- **Field-of-view: Visual: 5.4´x5.4´ (0.16´´/pixel)**
  NIR: 10´x10´ (0.59´´/pixel)
- **Dichroics tuned to minimize intrinsic polarization effects**
- **2 shutters, i.e. g'r' and i'z' pairs of CCDs have same exposure**
- **Combined telescope and intrinsic mirror (K-band) dithering**
- **Sensitivity:**

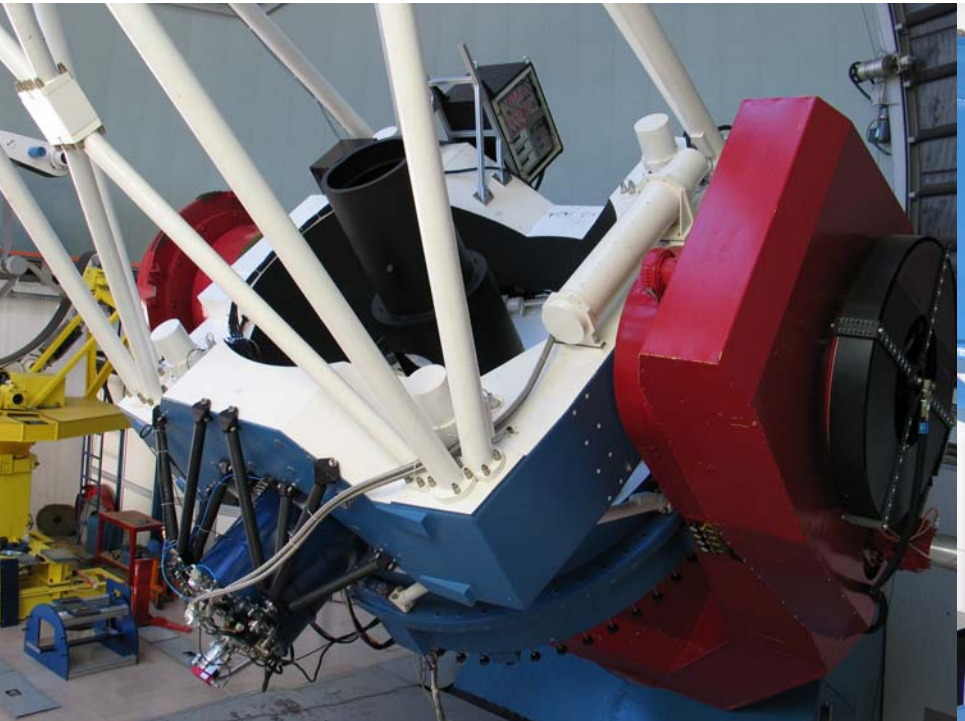
	4 min	1 hr
gr	21.5 mag	24.5 mag
iz	20.5 mag	23.5 mag
J/H/K (AB)	18.5/17.5/16.5 mag	21.5/20.5/19.5 mag

GROND @ 2.2m MPI/ESO telescope

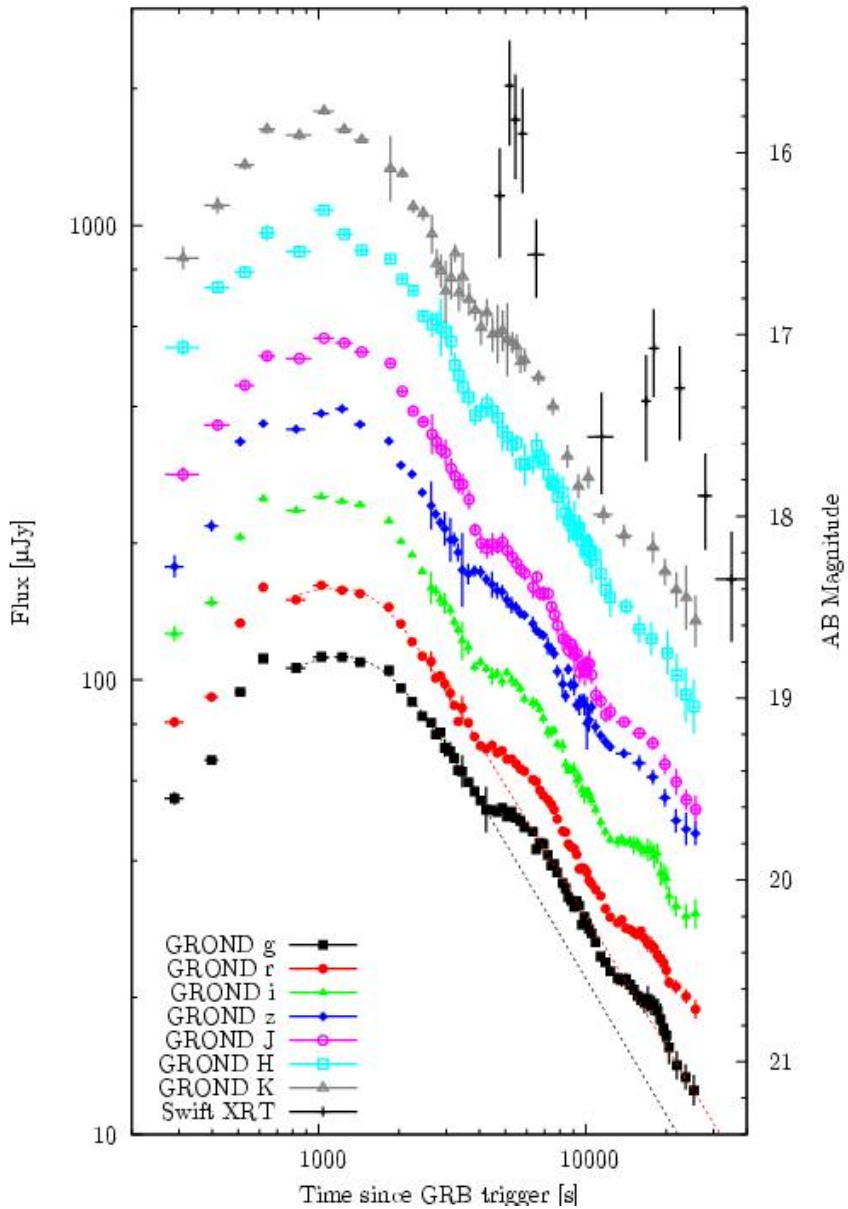
History:

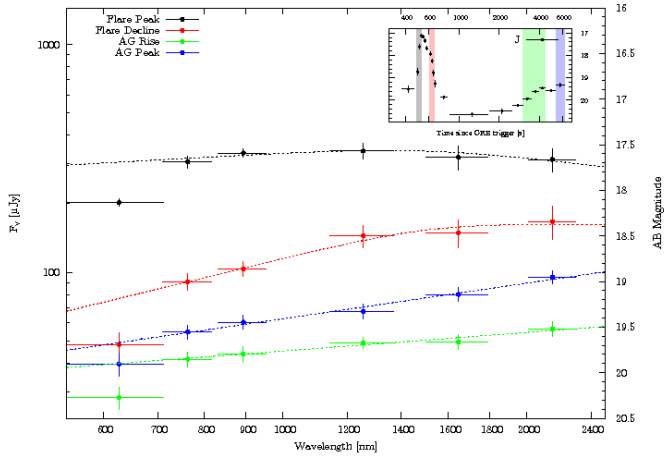
First light: Apr 30, 2007
First GRB: May 21, 2007
Photometric calibration: Jul 2007
Routine observations: since Sep 2007
fastest response time: 2 min

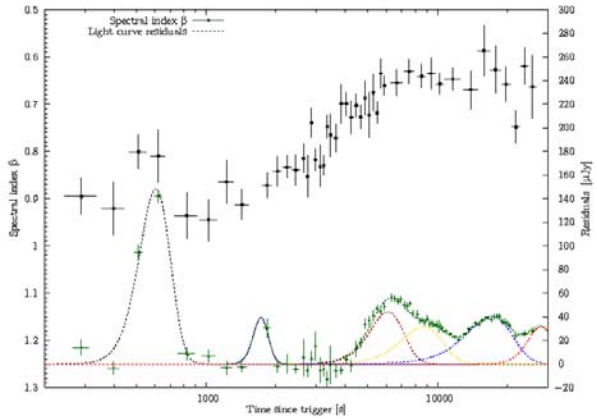


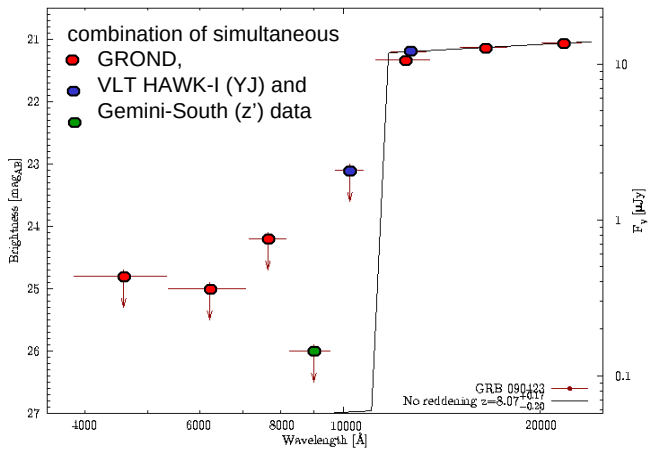


What we measure







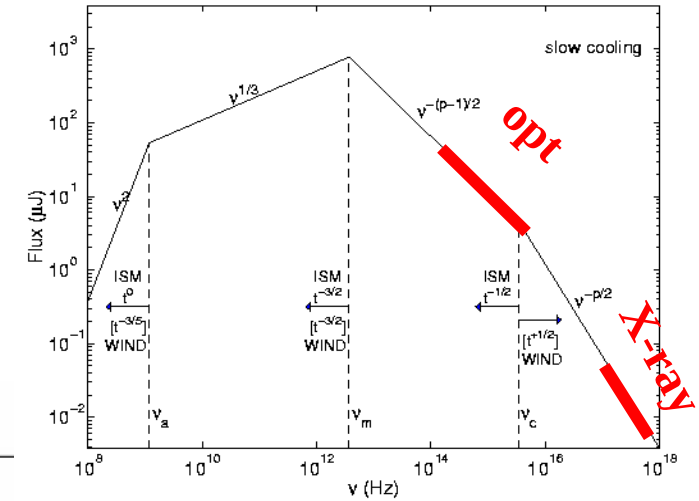


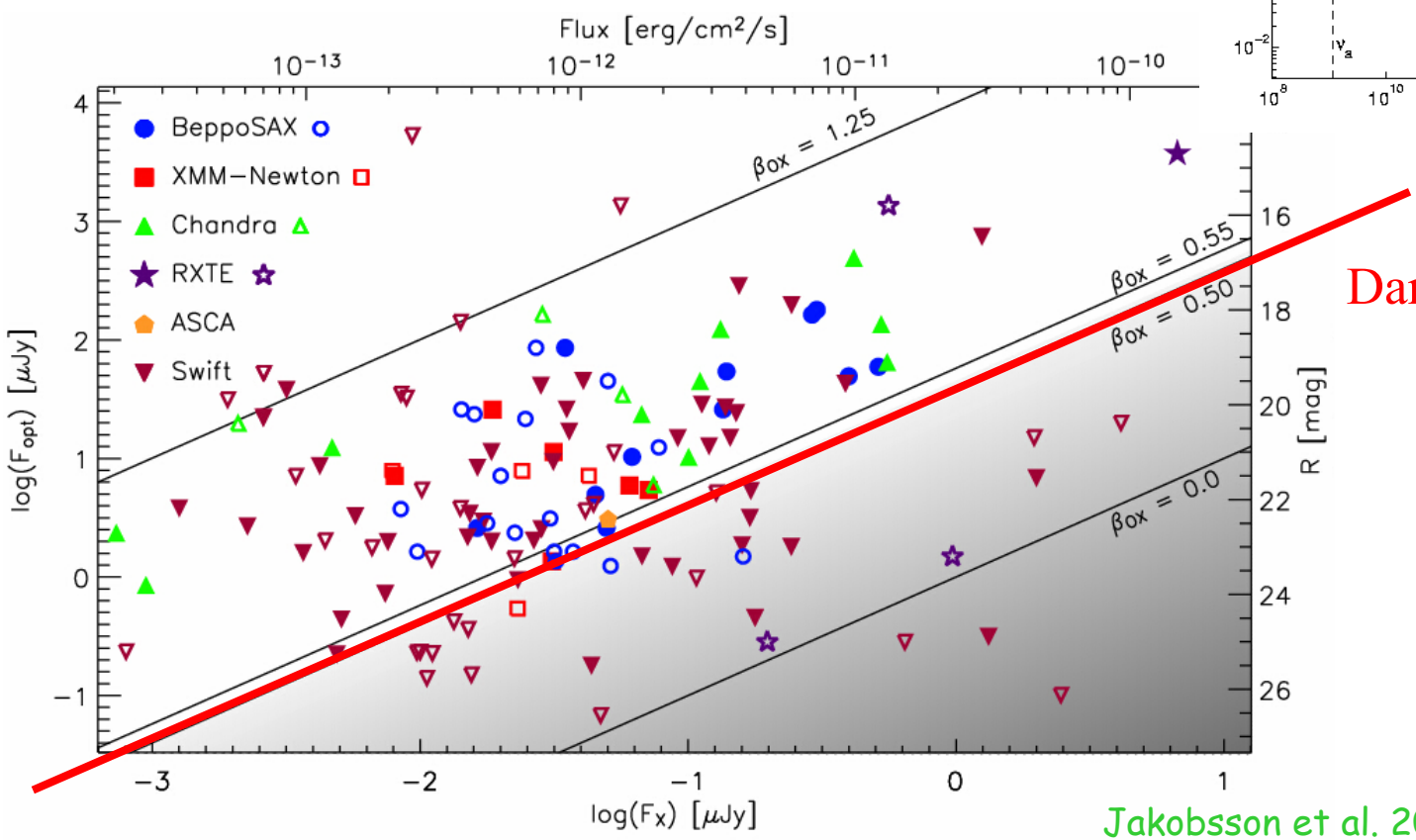
CC

2. The "dark burst" issue

Potential causes for optical darkness:

- Intrinsically faint (e.g. Fynbo et al. 2001)
- High redshift (e.g. Lamb & Reichart 2000)
- Large extinction (e.g. Rhoads 1999, Fynbo et al. 2001)

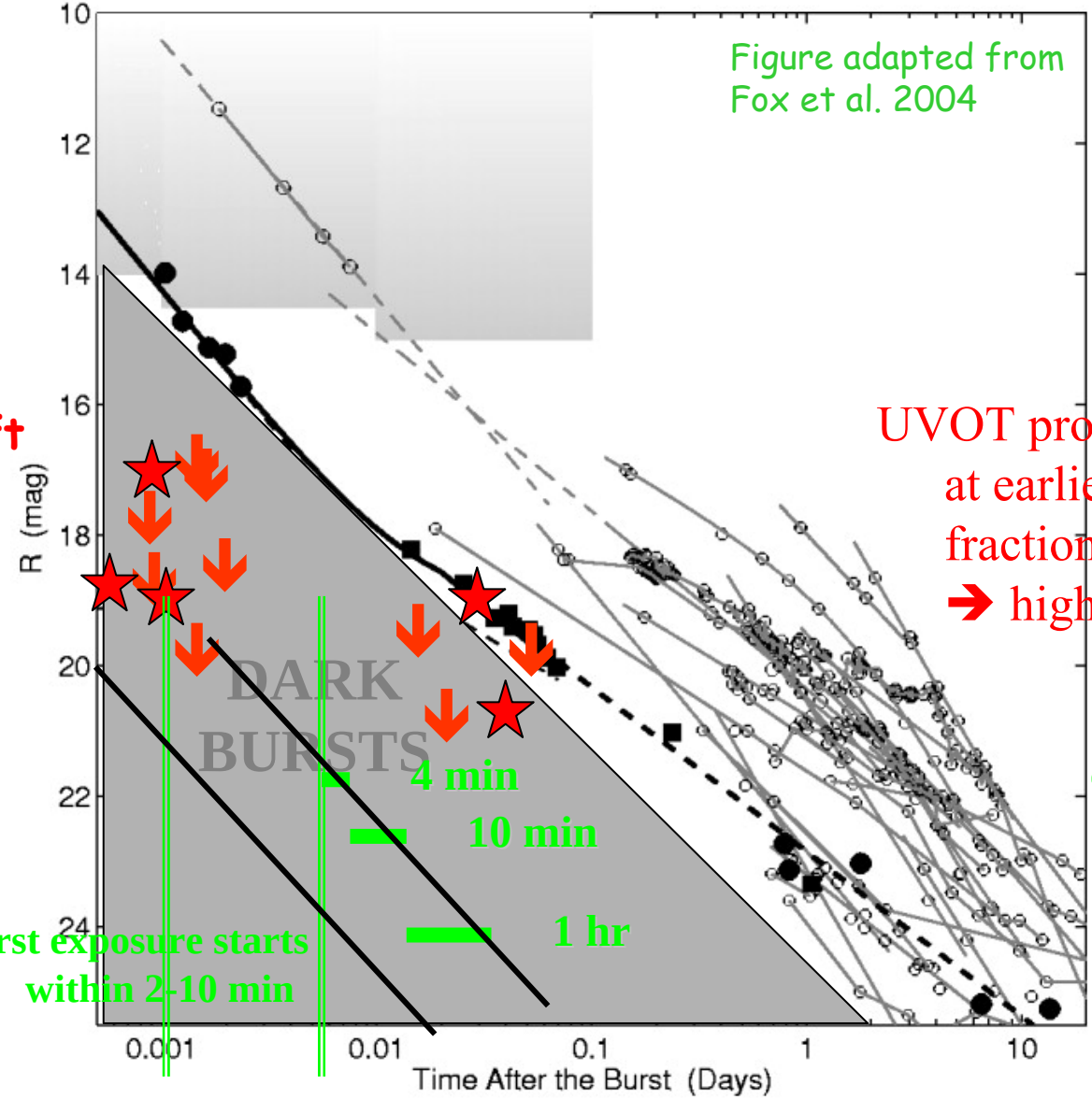




Dark bursts: $\beta_{ox} < 0.5$

Jakobsson et al. 2004…2009

pre-Swift "dark" GRBs vs. UVOT vs. GROND



UVOT/Swift

UVOT probes ~5 mag deeper at earlier times; yet large fraction of "dark" bursts ➔ high-z, extinction

GROND at the 2.2m MPI/ESO telescope

GROND probes another ~2 mag deeper, +NIR

First exposure starts within 2-10 min

The GROND "dark burst" sample

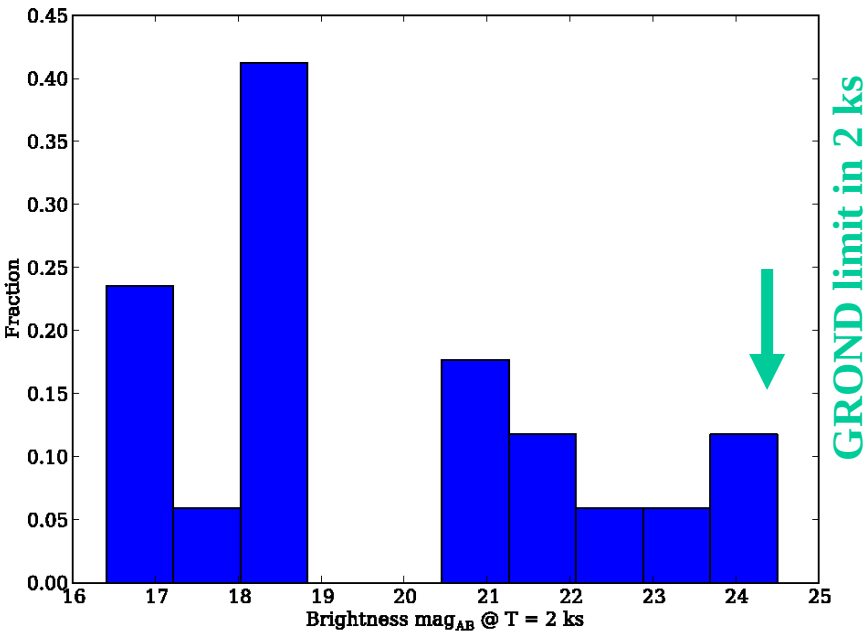
Selection criteria:

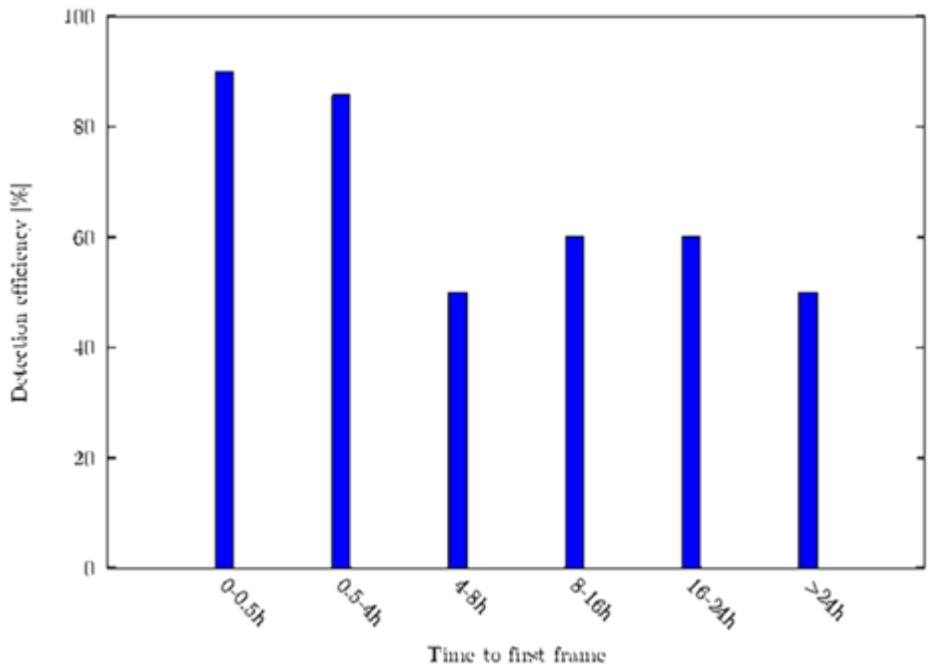
- Swift/XRT detection (at any time)
- GROND start-of-observation within 30 min of Swift trigger

➔ 20 GRBs: only 2 not detected with GROND:

GRB 090429B (but Gemini detection; z~9.3 candidate (Cucchiara et al))

GRB 080915 (very faint X-ray afterglow, but consistent with picture as described in the following)



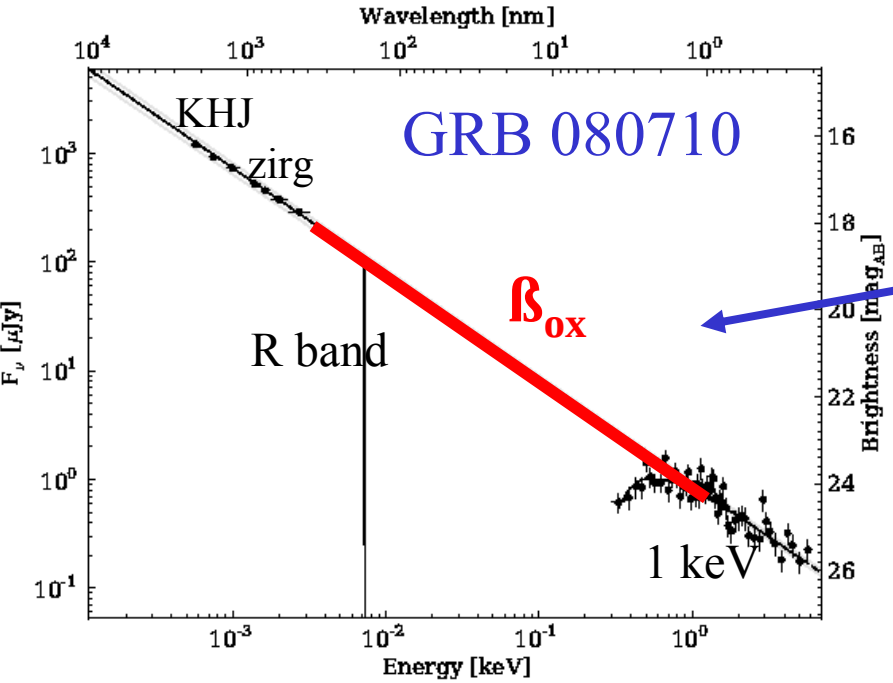


Data handling

- All 18 bursts: fit simultaneous Swift/XRT and GROND SED
  ➔ determine $ß_o$, $ß_x$, A_V, N_H and break energy
- z-distribution (all 18 have z)
- A_V-distribution

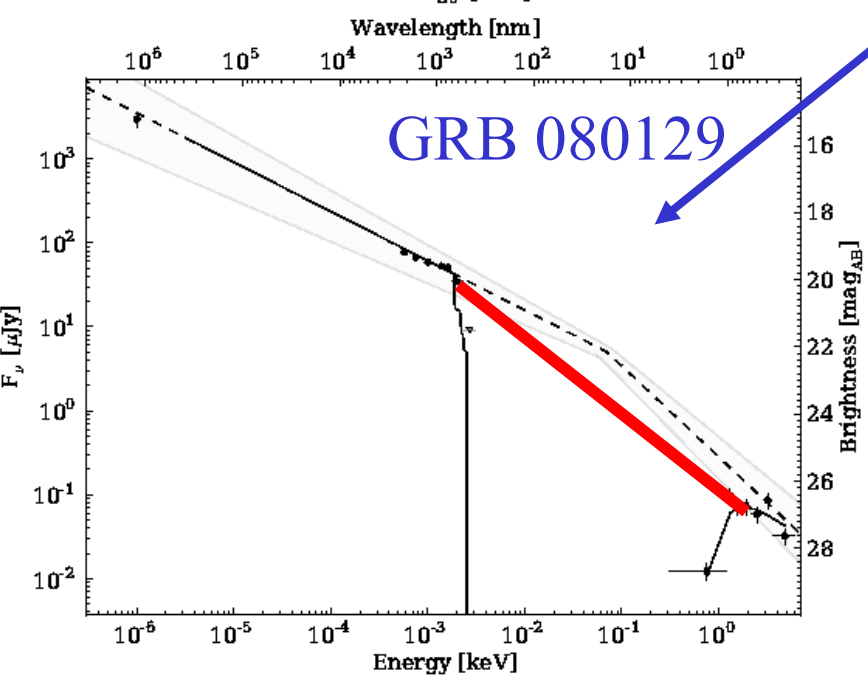
Completeness level: 18/20 ≡ 90%

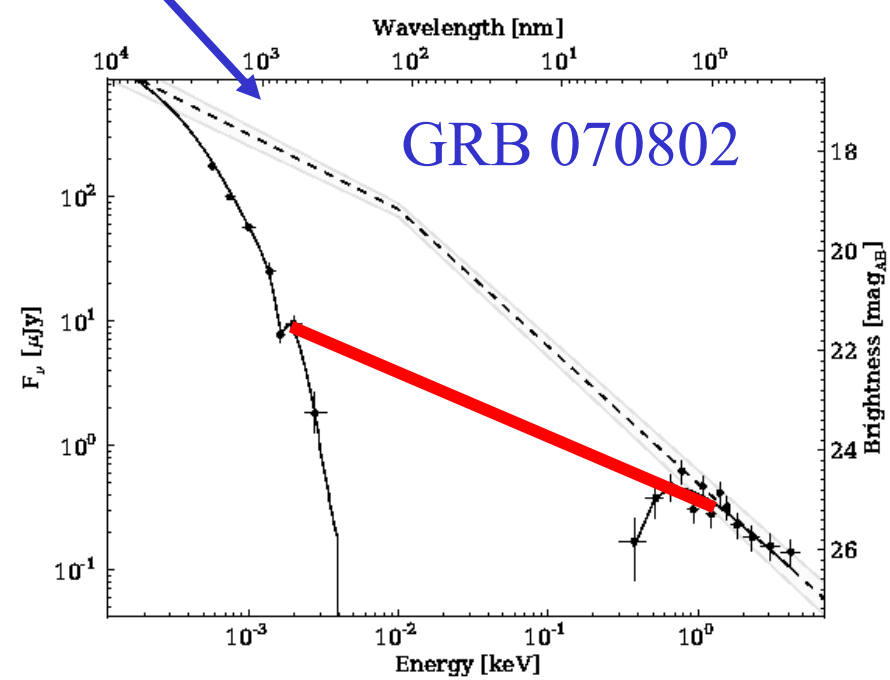
XRT-GROND SEDs



Only 1 GRB with X-ray and optical/NIR on same powl

ß$_{ox}$ sensitive to extinction A_V AND SED shape

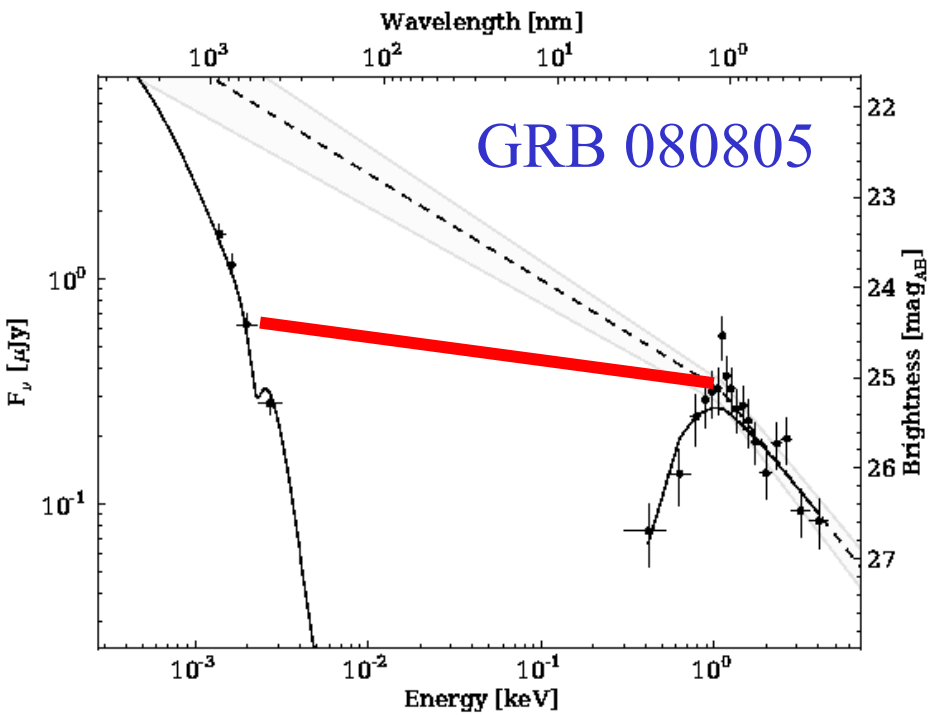




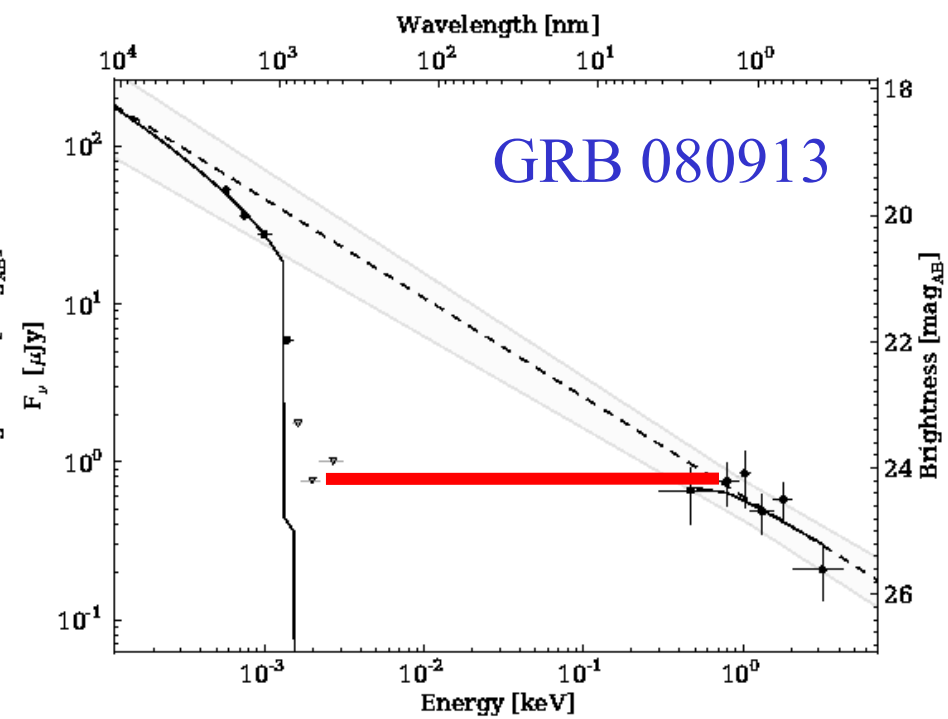
2 examples with flat SEDs

… both have nearly $\beta_{ox} \sim 0$:

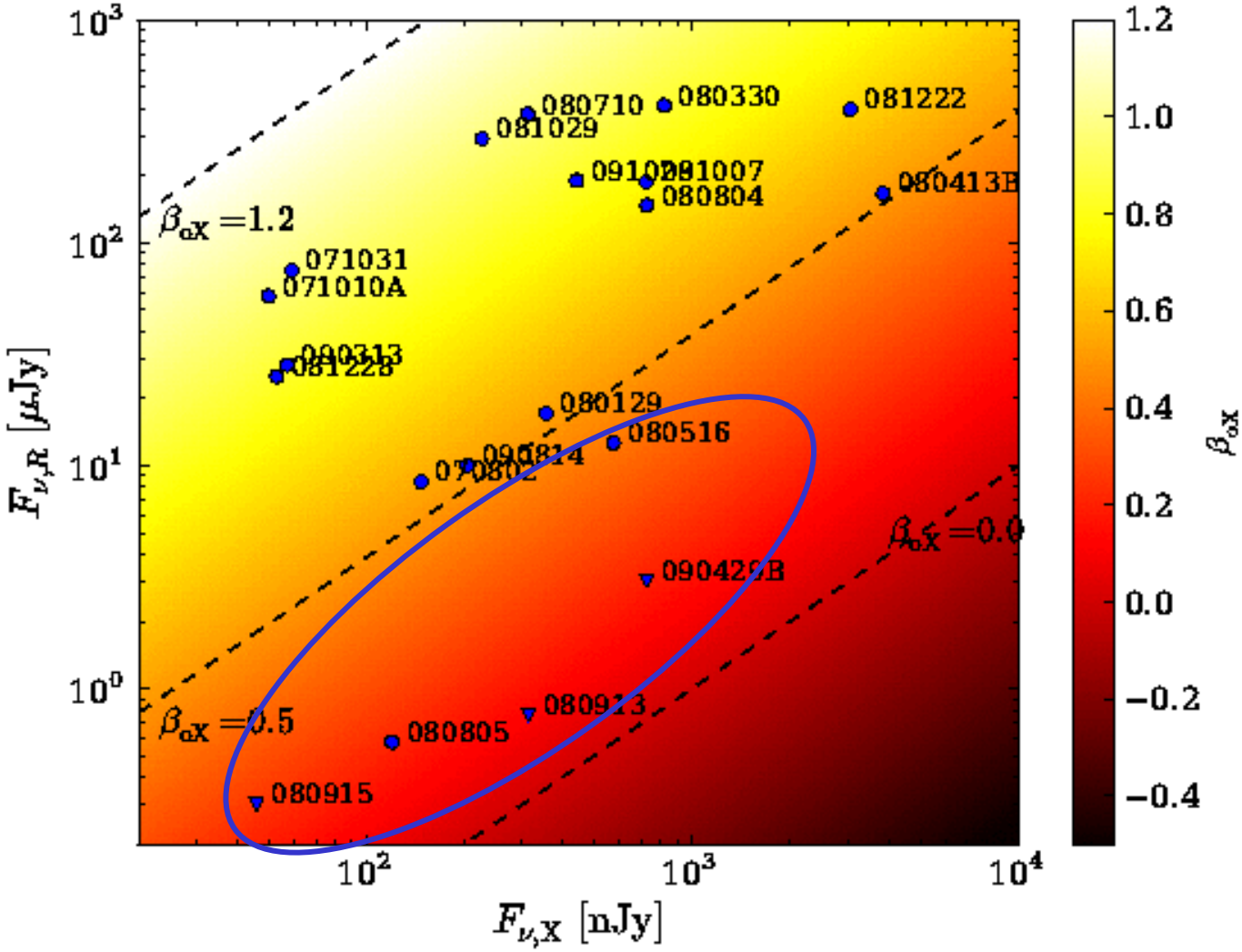
$A_V \sim 1.2$



z=6.7



Dark bursts in our sample



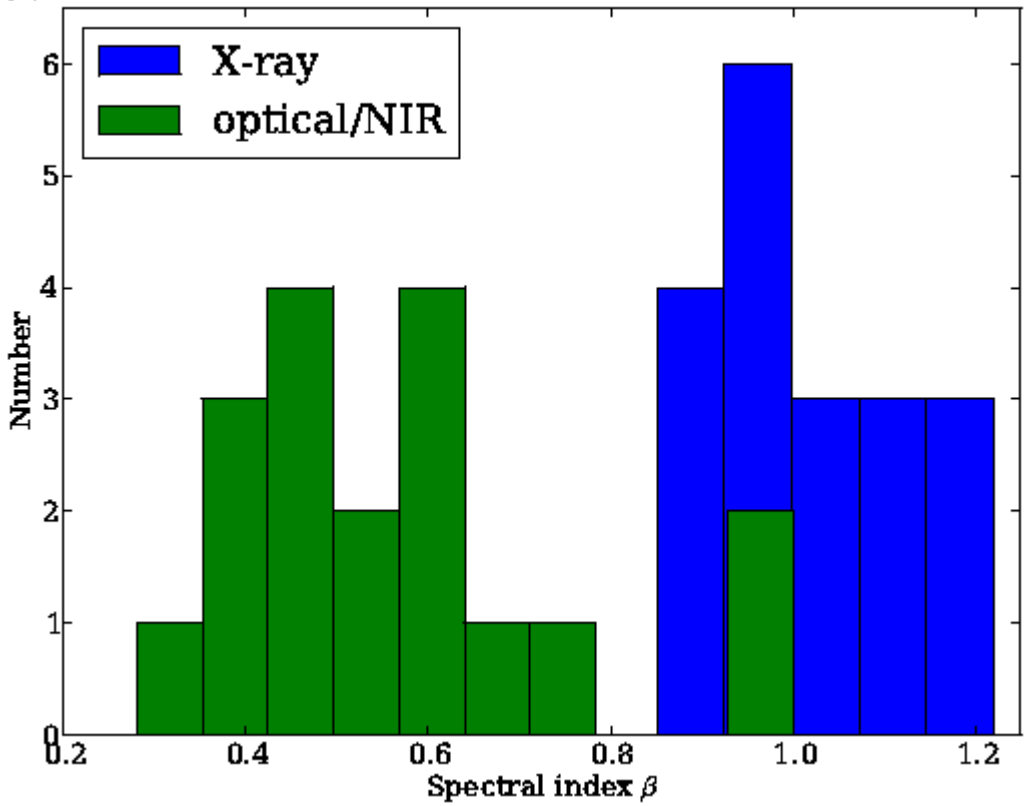
5 dark bursts
≡ 25%
(with another 4 just at borderline)

↓

Consistent with earlier numbers

SED slope distribution

- Majority has break, but break energy not well defined
- Break is consistent with 0.5 in all but 1 case
- Implies optical brightness up to ~4 mag fainter than without break, if break energy near 0.1 keV

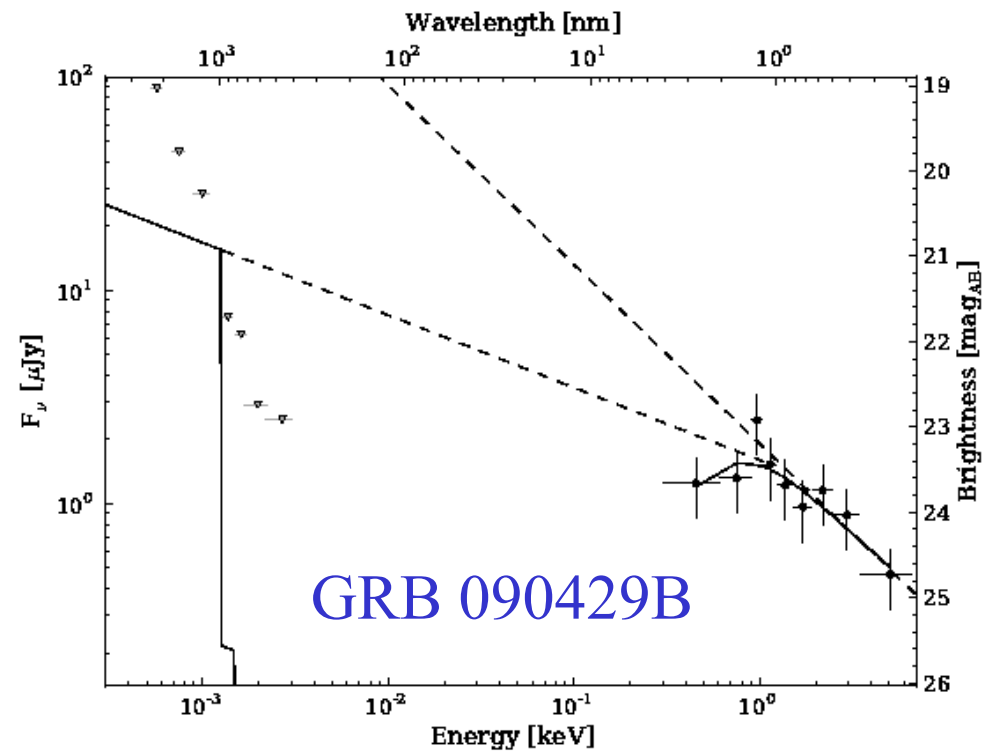


The 2 non-detected GRBs

Extrapolating X-ray spectrum with Δß=0.5, and comparing with GROND upper limits:

- GRB 080915 ➔ faint X-rays: consistent with even low z and A_V=0
- GRB 090429B ➔ consistent with z>6 & A_V=0, or z~5 & A_V~1

Effectively not only 18 detected, but all 20 GRBs consistent with above picture

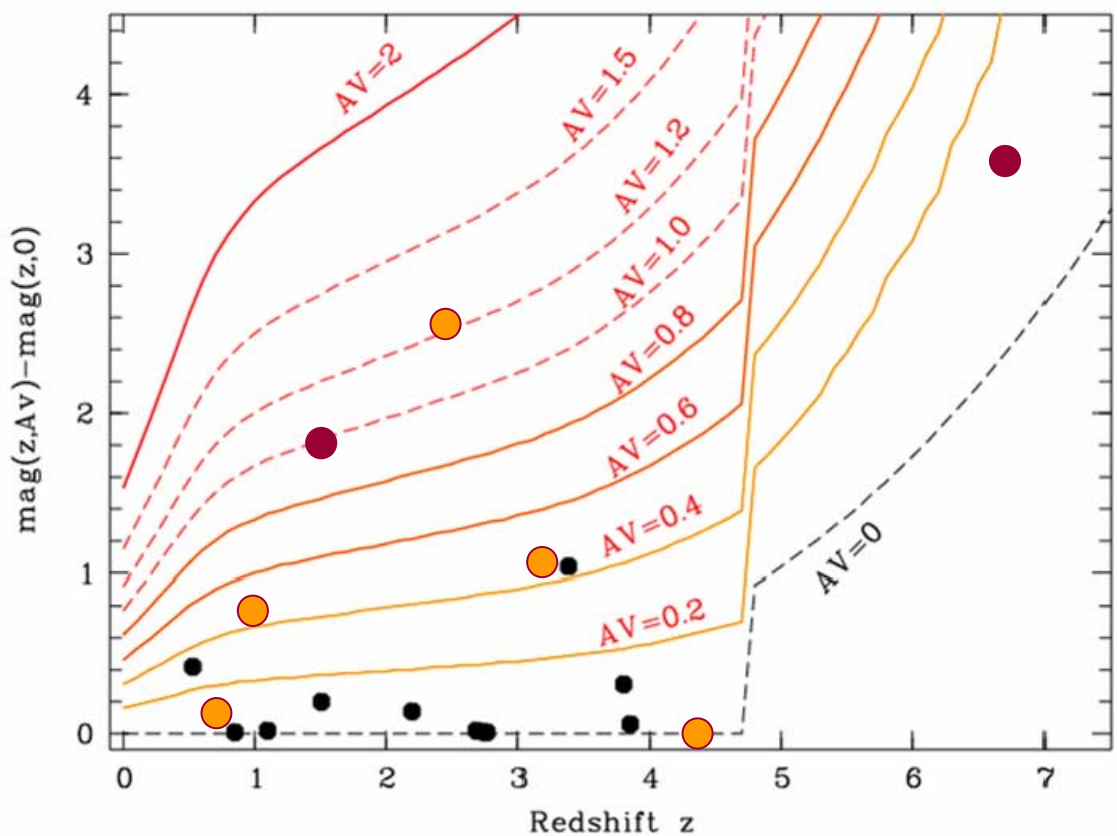


Dark bursts revealed

Optical darkness well explained by

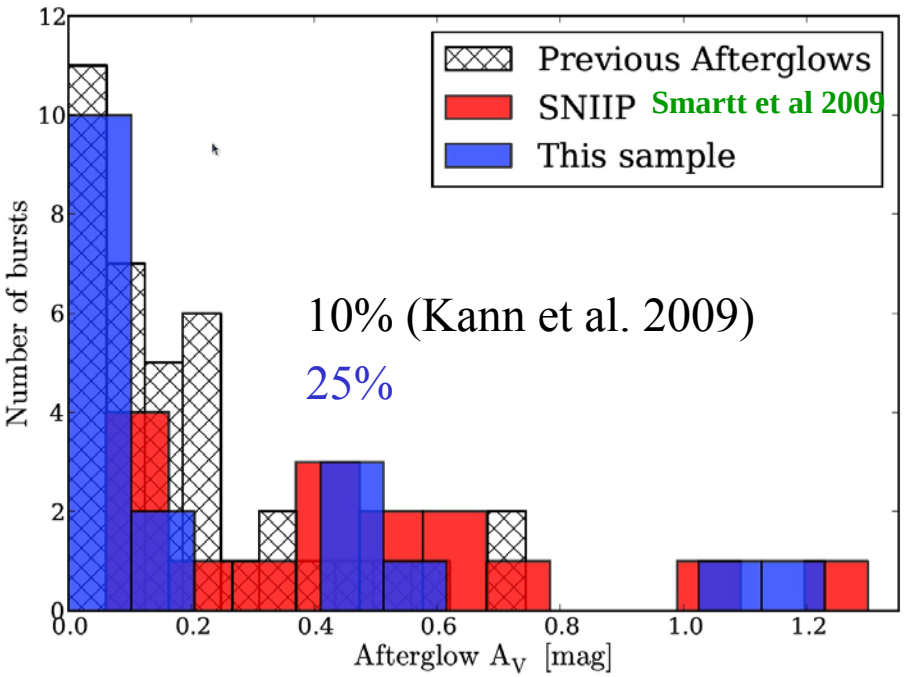
- combination of moderate redshift and moderate extinction A_V
- ~25% fraction of high-z bursts

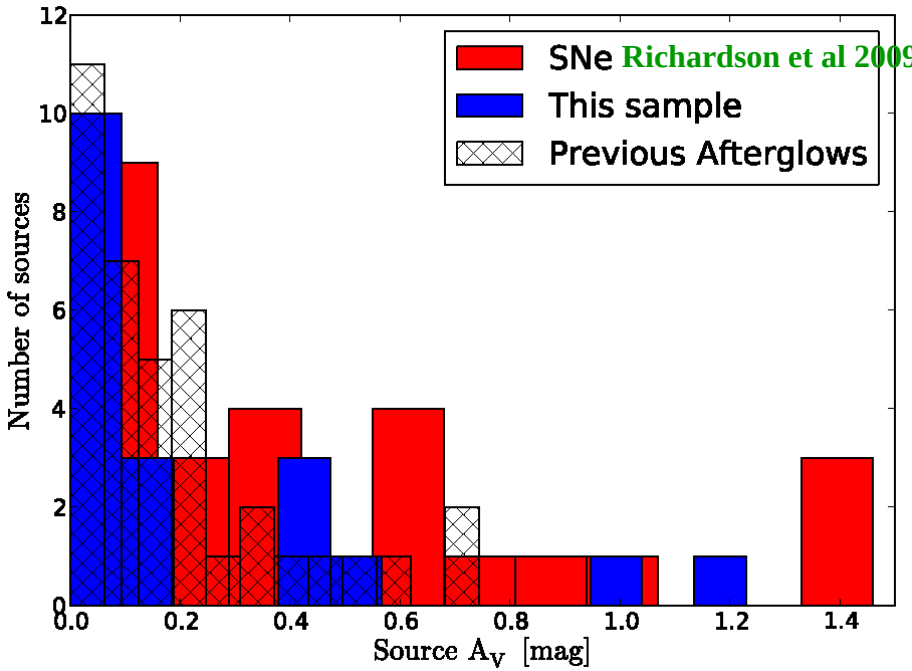
"Dark" bursts are not a reservoir of many high-z bursts



Intrinsic A_V distribution in GRBs

- We see substantially more afterglows with solid A_V detection
  ➔ 25% of GRBs have A_V~0.5 mag; ~10% have $A_V > 1$ mag
- Within statistics similar to A_V distribution of core-collapse SN-IIP (Smartt et al. 2009) or SN Ib/c (Richardson et al. 2009)
  Warning: cannot properly distinguish between host vs. source A_V



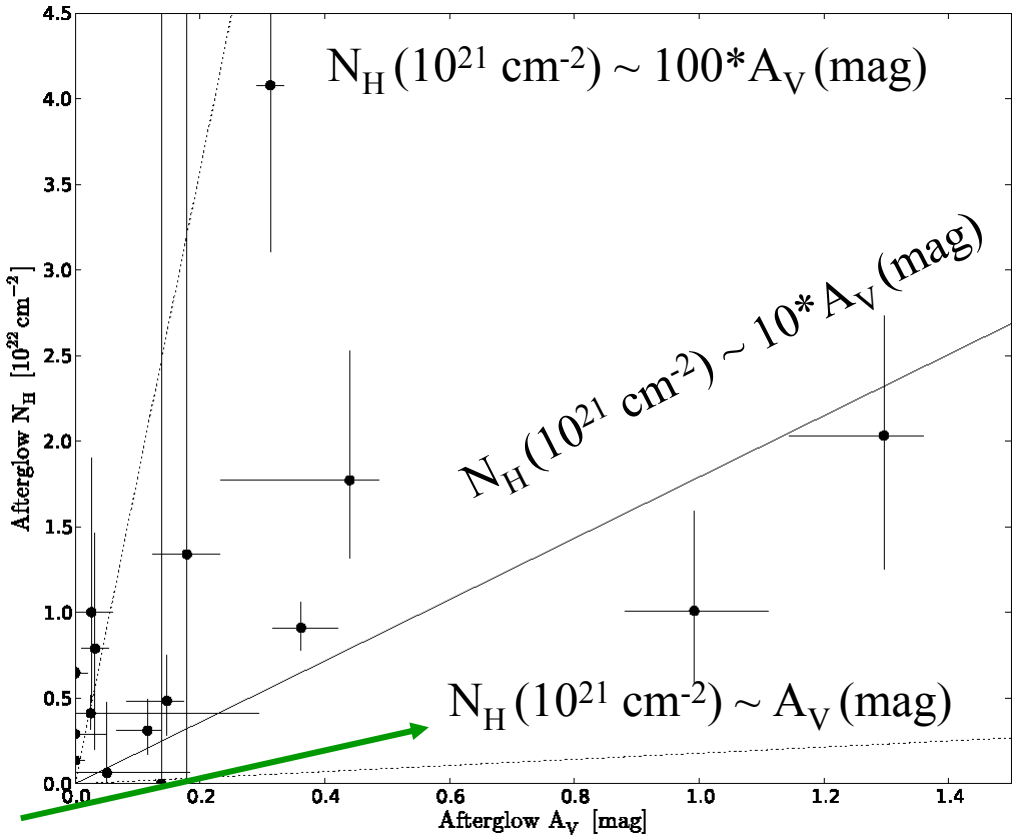


A_V-N_H correlation?

- No obvious correlation, but

  ➔ N_H error large or N_H even unconstrained for higher redshifts: X-rays not sensitive anymore

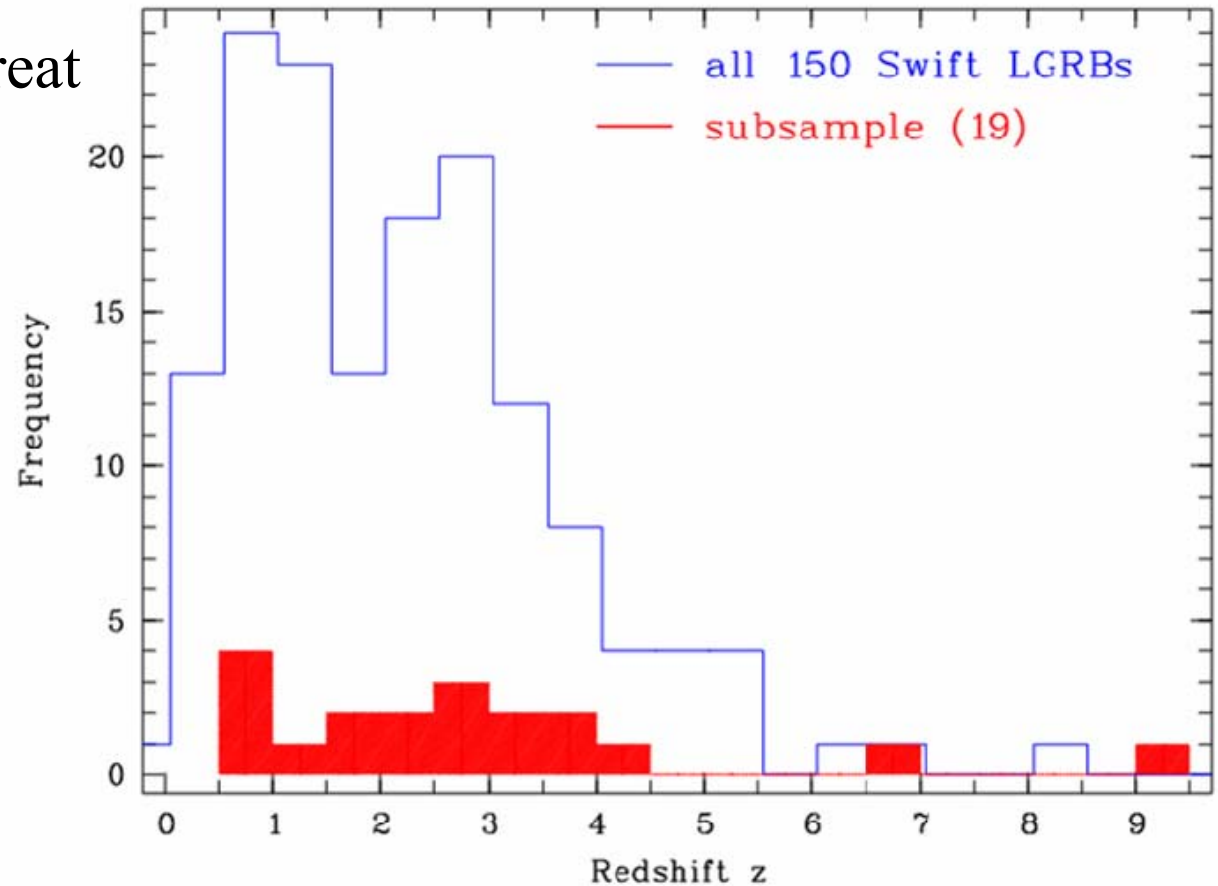
  ➔ possible bias (too large N_H) due to XRT response, though very unlikely to explain large deviations from Predehl&Schmitt relation



Predehl & Schmitt (1995)

A (nearly) complete redshift distribution

- Has completeness level of 95%
- Is flatter than previous distributions (which had smaller completeness levels)
- Statistics not yet great



Summary

- Dark bursts well explained by
  ➔ combination of moderate A_V and moderate z (1-5 mag)
  ➔ ~25% fraction of high-z bursts
- Detection of substantial (fraction & amount of) dust in GRBs
- Amount of neutral gas vs. dust seemingly not correlated; could be due to
  ➔ ionisation near GRB
  ➔ different locations of dust and gas along the line of sight