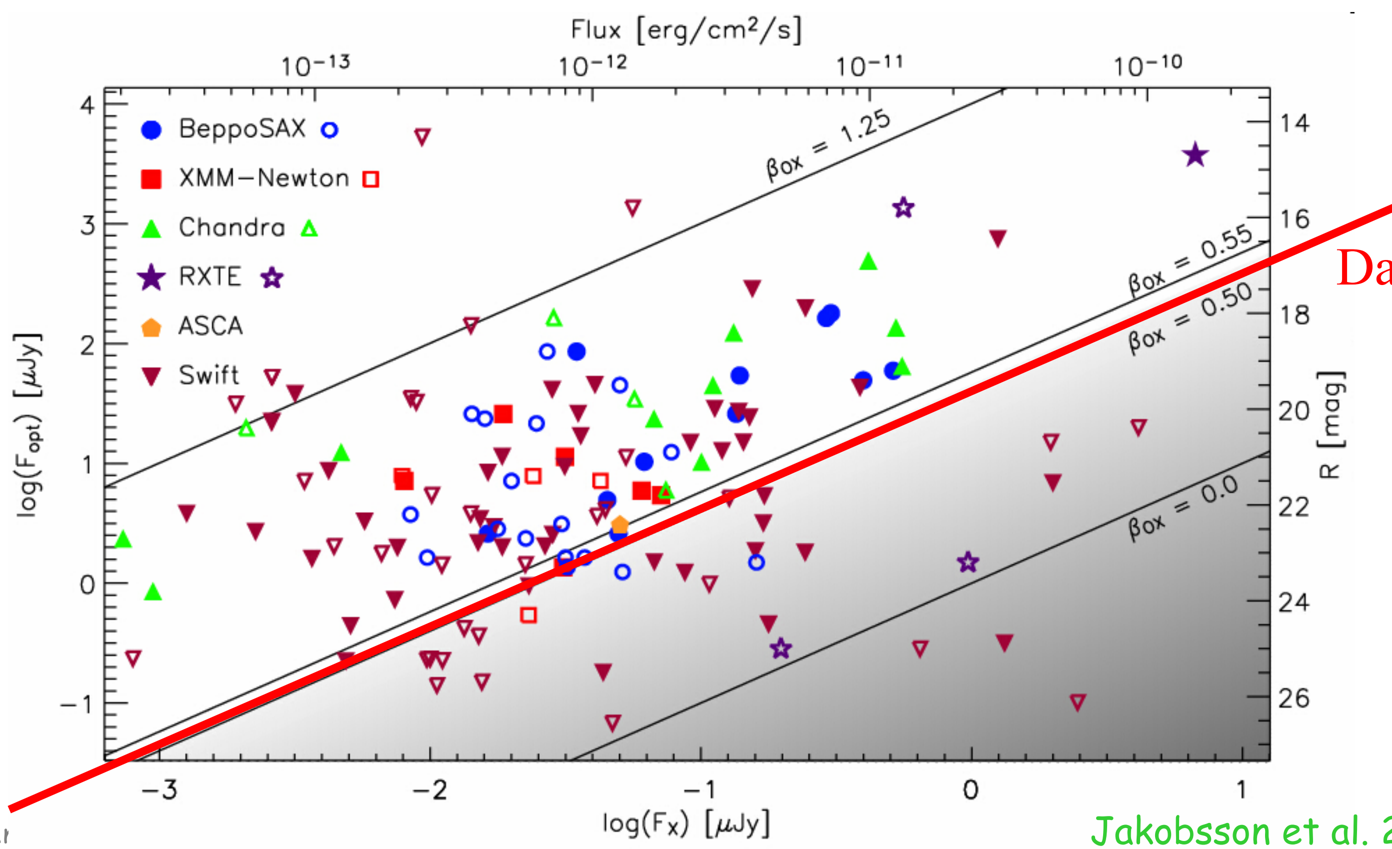
GROND observations of GRB Afterglows: Implications for “dark GRBs”

(Jochen Greiner) - Marco Nardini
Max-Planck-Institute for extraterrestrial Physics
Garching, Germany

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)

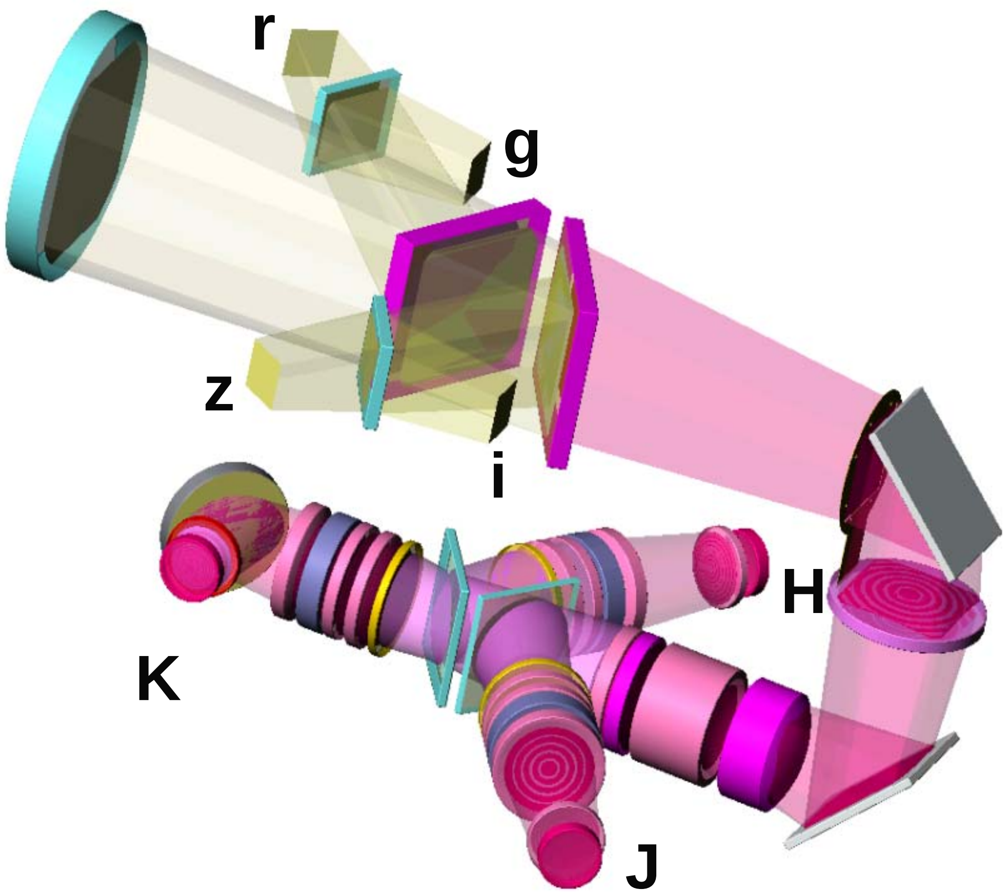


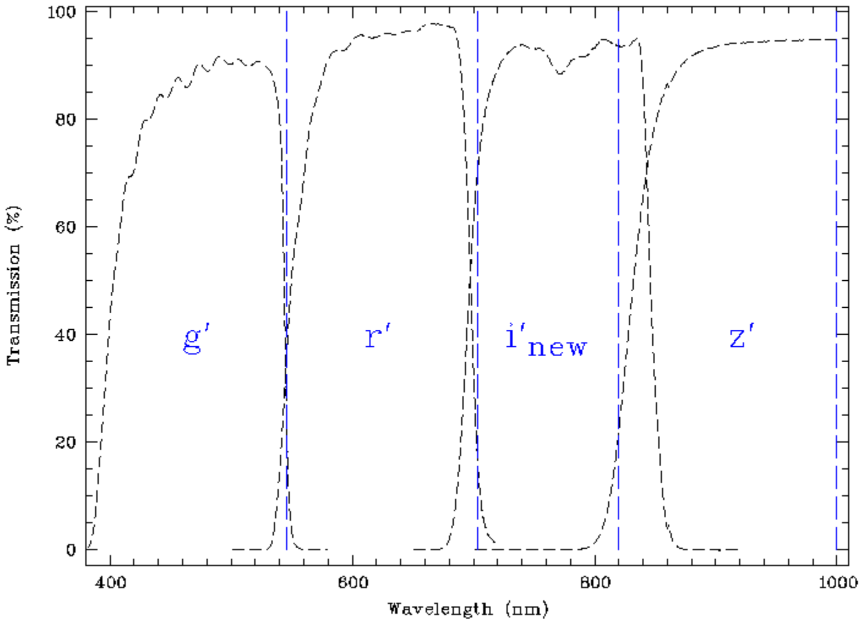
Dark bursts: $\beta_{ox} < 0.5$

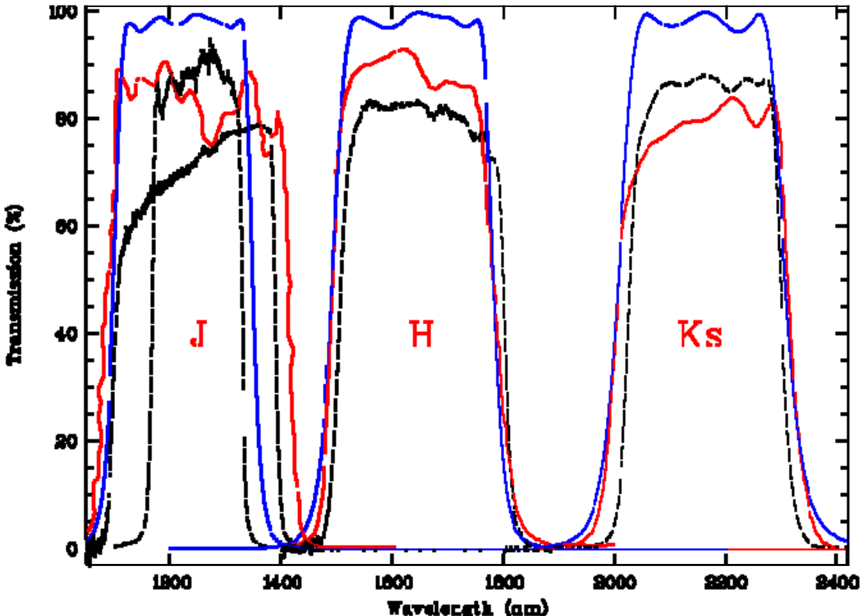
Jakobsson et al. 2004…2009

GROND=GRB Optical/NIR Detector

Imaging in 7 channels simultaneously



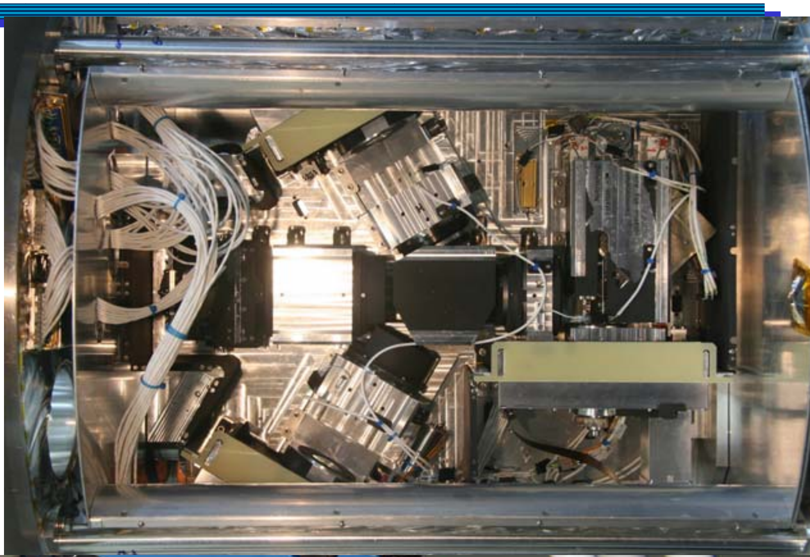


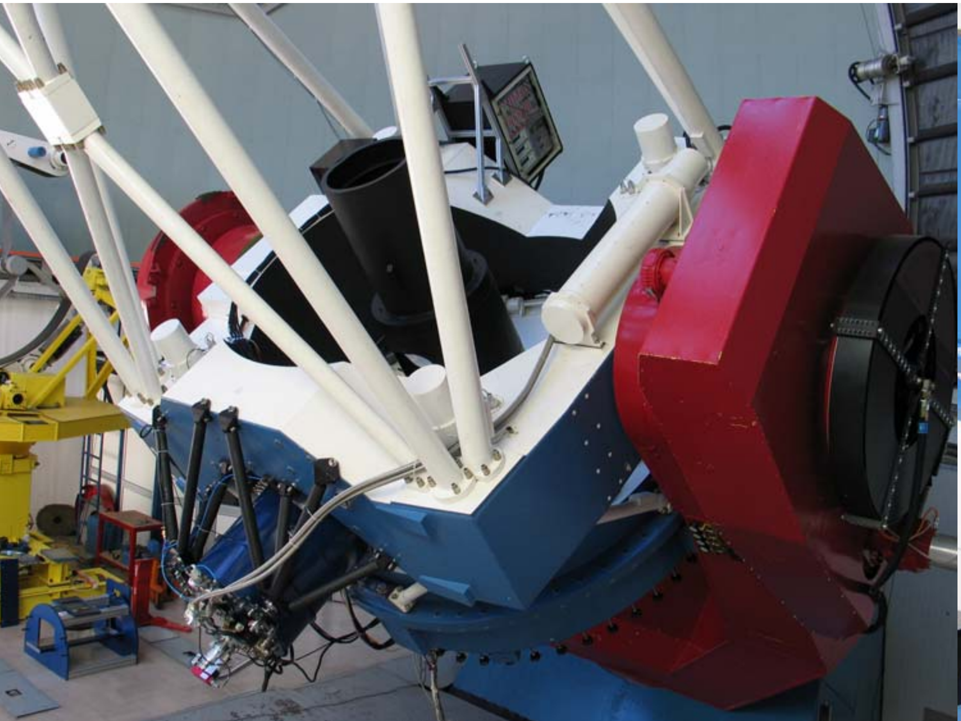


GROND @ 2.2m MPI/ESO telescope

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

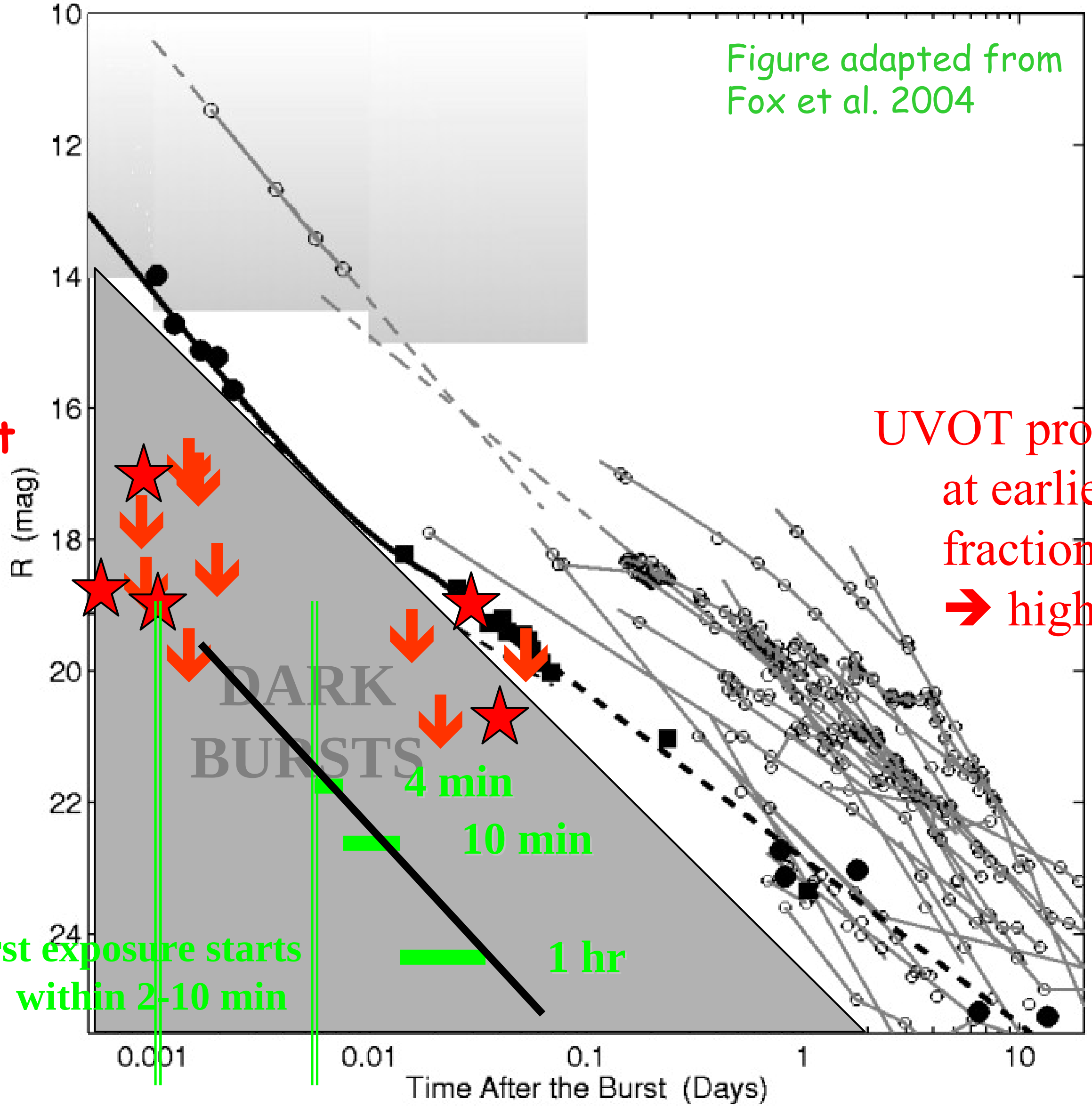




pre-Swift “dark” GRBs vs. UVOT vs. GROND

UVOT/Swift

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



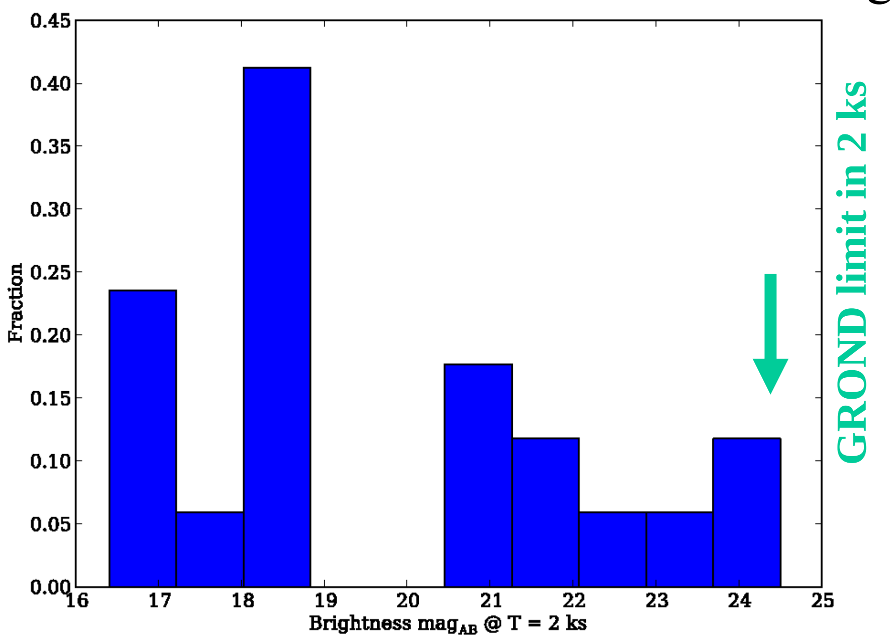
GROND at the 2.2m MPI/ESO telescope

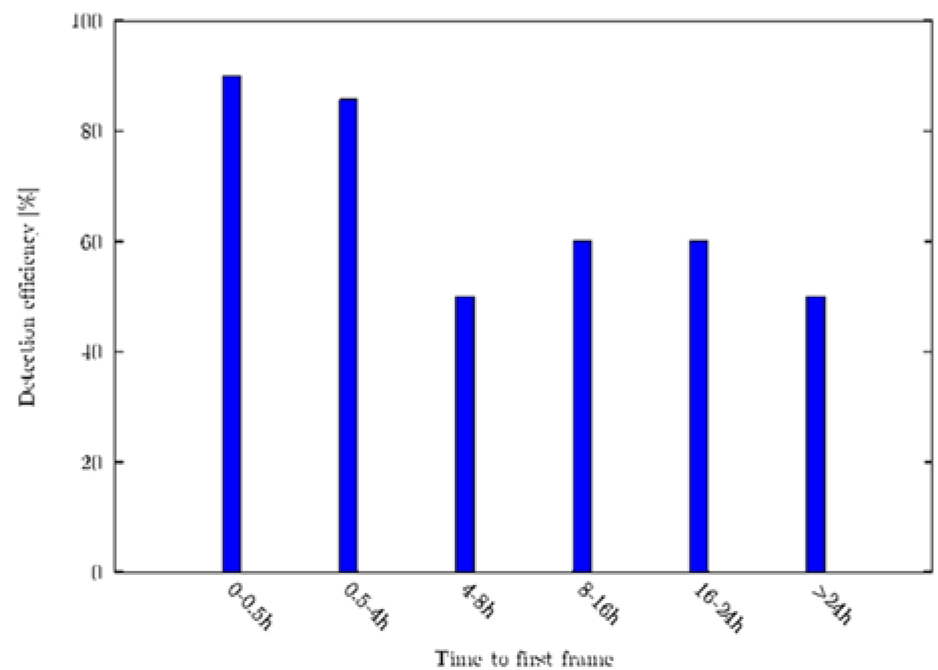
GROND probes another ~2-3mag deeper, +NIR

The GROND sample:

Selection criterion: Swift/XRT detection (any time)

- **39** GRBs with GROND start-of-observation within 240 min
- **4** not detected with GROND:
  090429B (but Gemini; z~9.2 candidate (Cucchiara+10))
  080218B/080915 (very faint X-ray afterglow, but consistent with picture as described in the following)
  100205A: due to cirrus 2 mag worse sensitivity; Gemini-OT

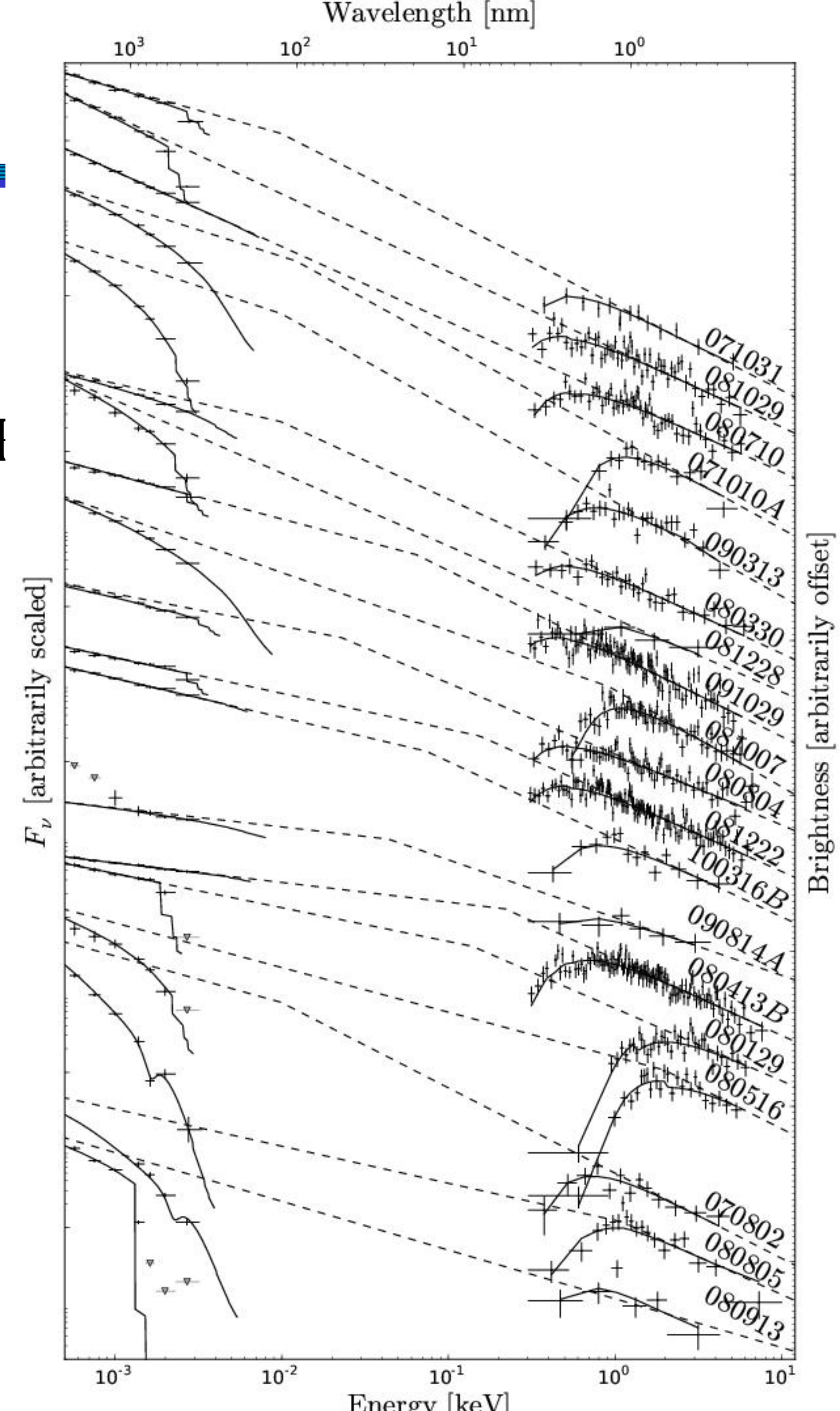




Data handling

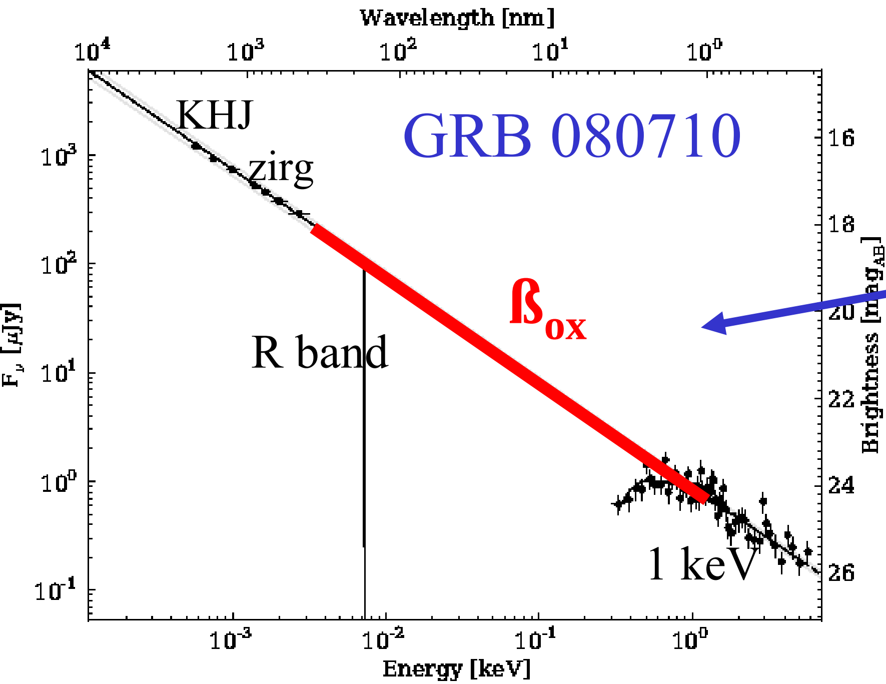
- All bursts: fit simultaneous Swift/XI and GROND opt-NIR SED
  ➔ determine β_o, β_x, A_V
- z-distribution (35 have z)
- A_V-distribution (33)

Completeness level: 35/39 ≡ 92%

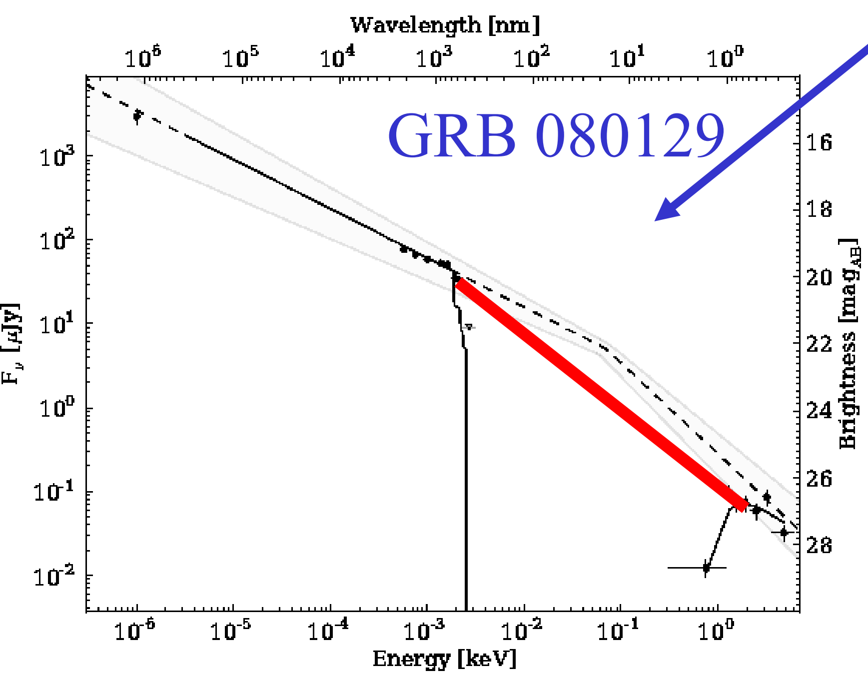


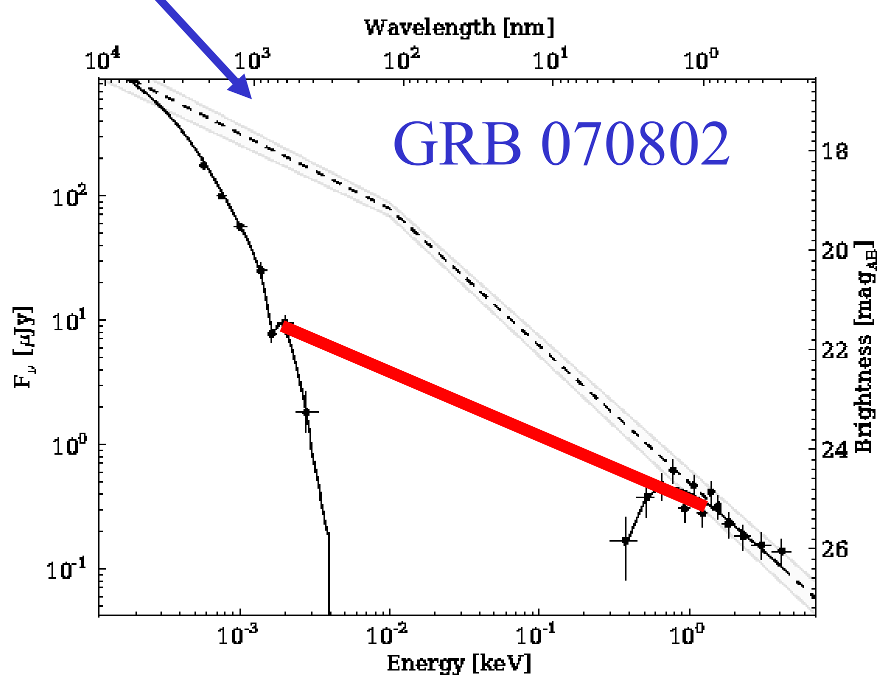
XRT-GROND SEDs

Only 7 GRBs with X-ray and optical/NIR on same powl



$ß_{ox}$ sensitive to extinction A_V AND SED shape

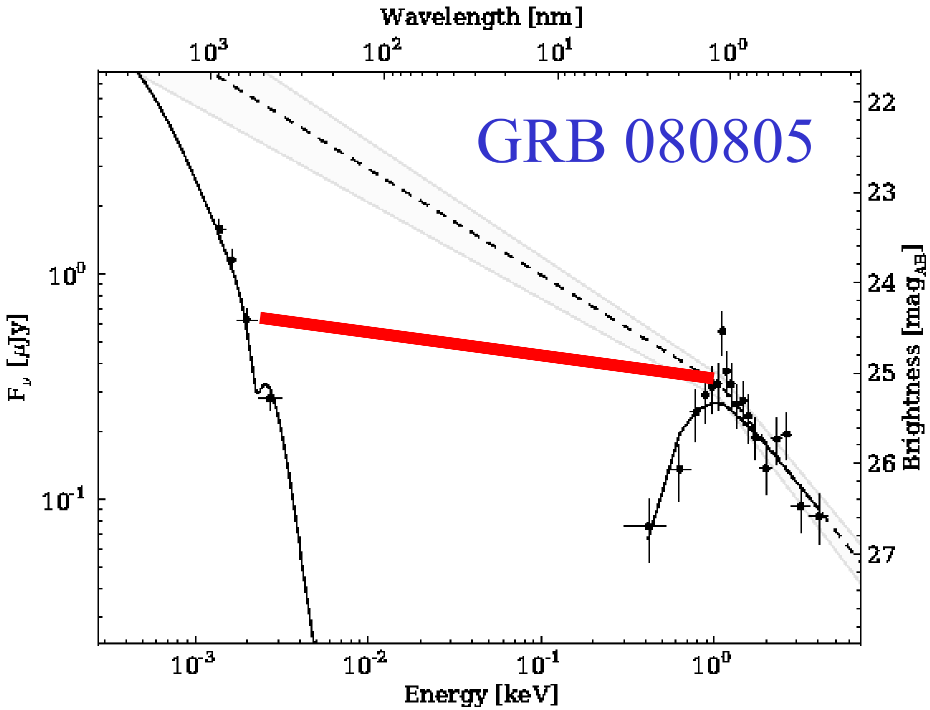




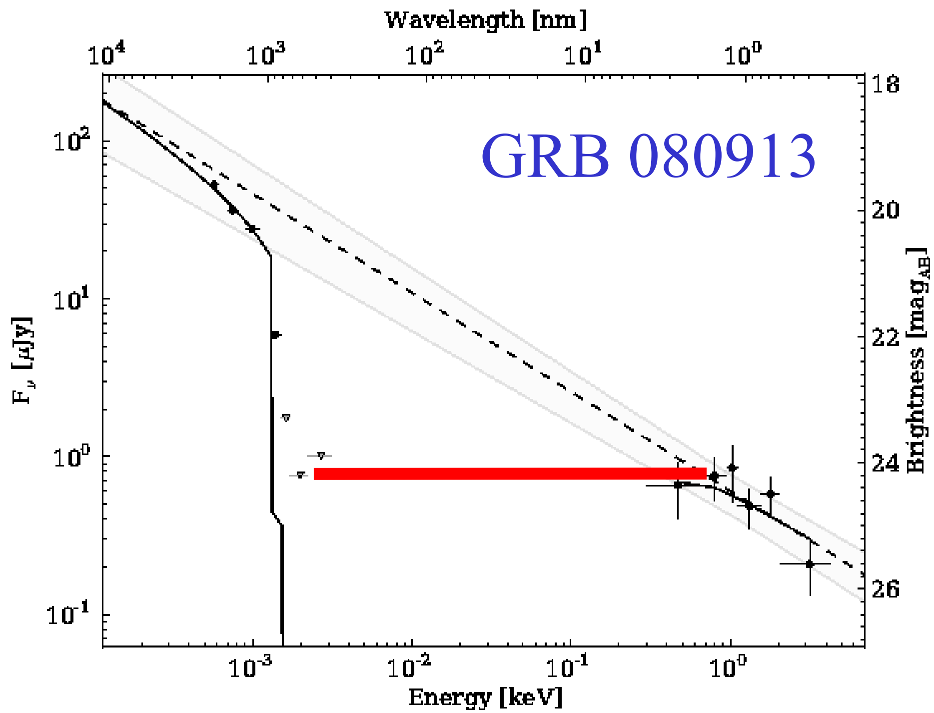
2 examples with flat SEDs

… both have nearly $ß_{ox} \sim 0$:

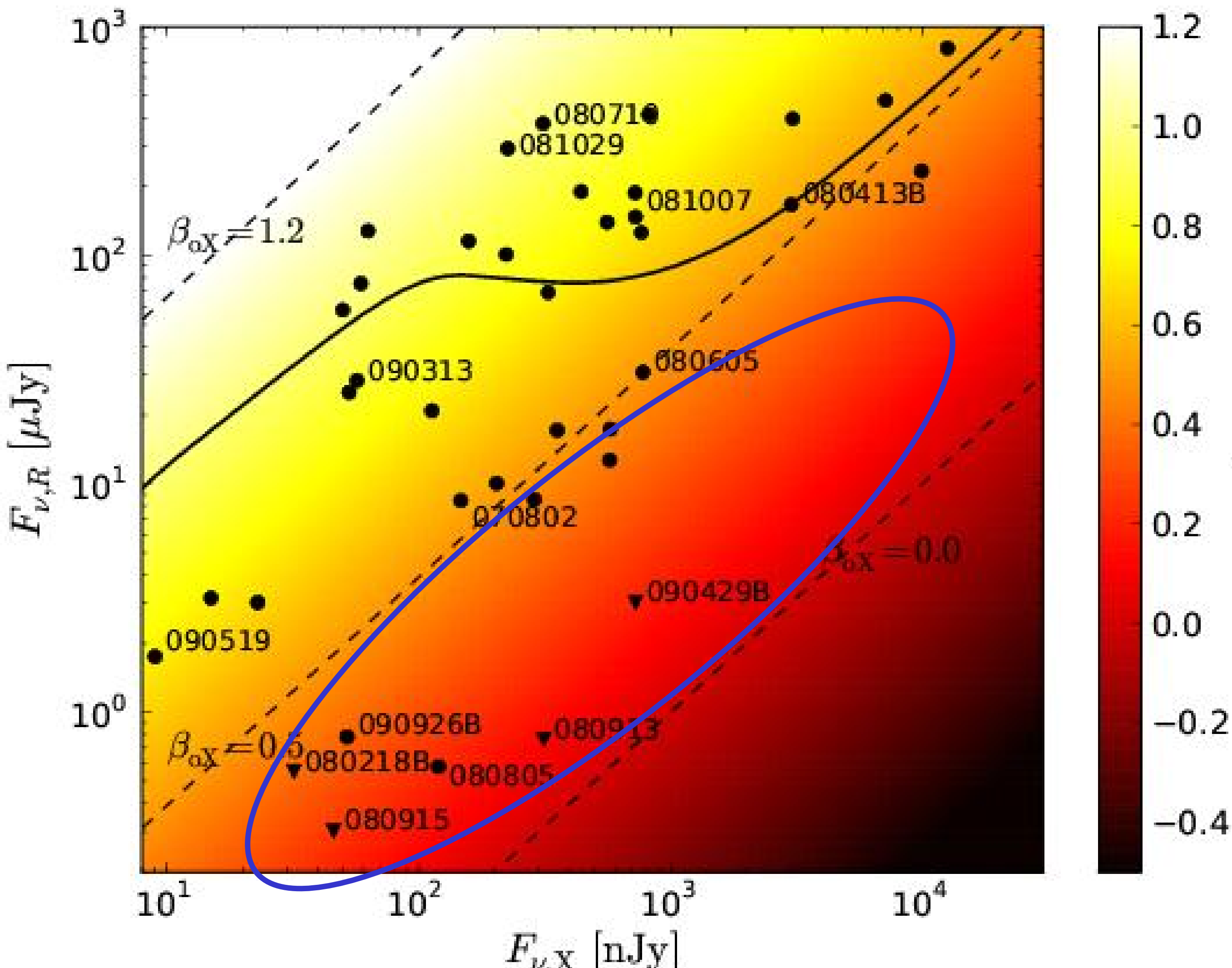
$A_V \sim 1.2$



z=6.7



Dark bursts in our sample



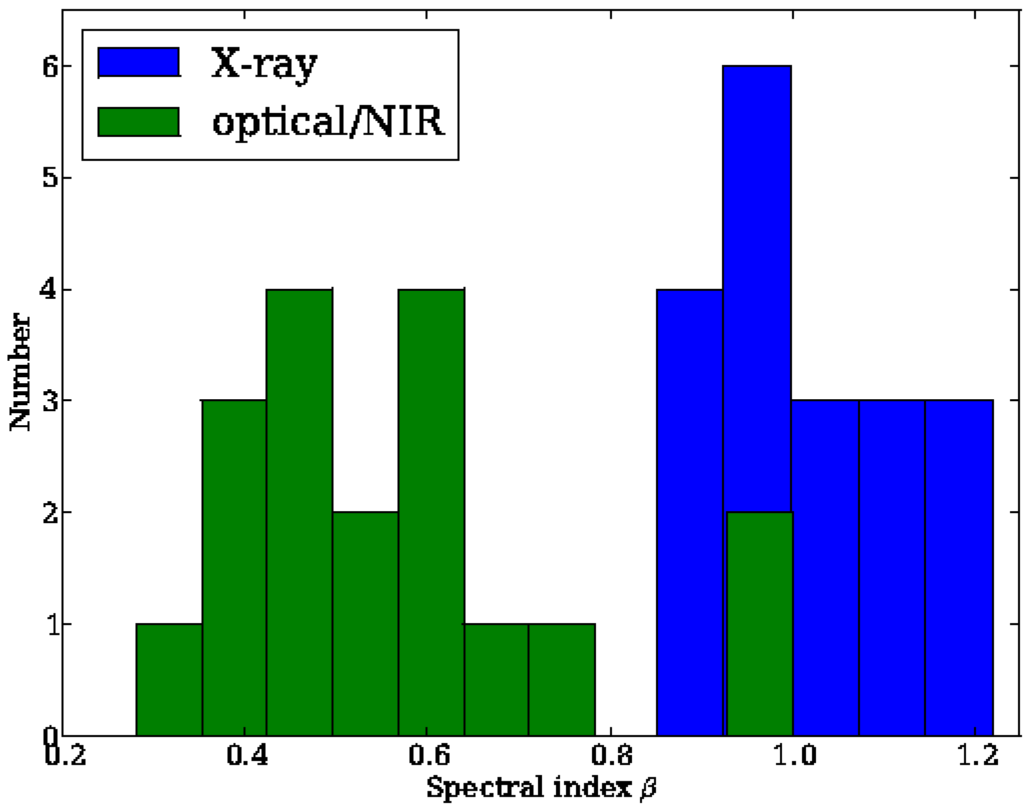
9 dark bursts
≡ 25%
(with another 7
just at borderline)

Consistent with earlier numbers

Noteworthy:
there is nothing like a single $ß_{ox}$ per burst: $ß_{ox}$ evolves through afterglow phase

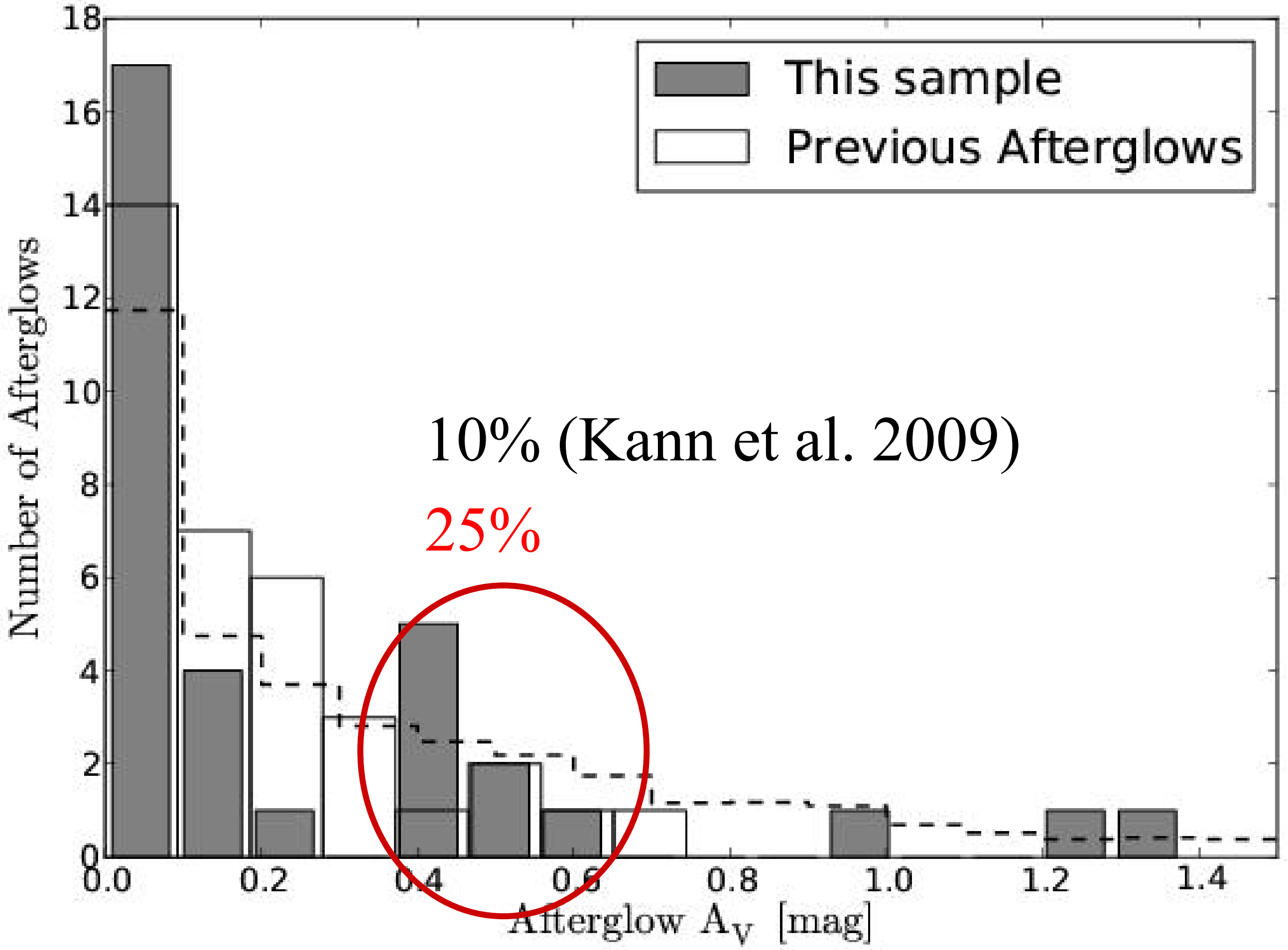
SED slope distribution

- Majority has break between O-X, but break energy not well defined
- Break is consistent with 0.5 in all but 1 case (080413B – Filgas+10)
- Implies optical brightness up to ~4 mag fainter than without break, if break energy near 0.1 keV



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

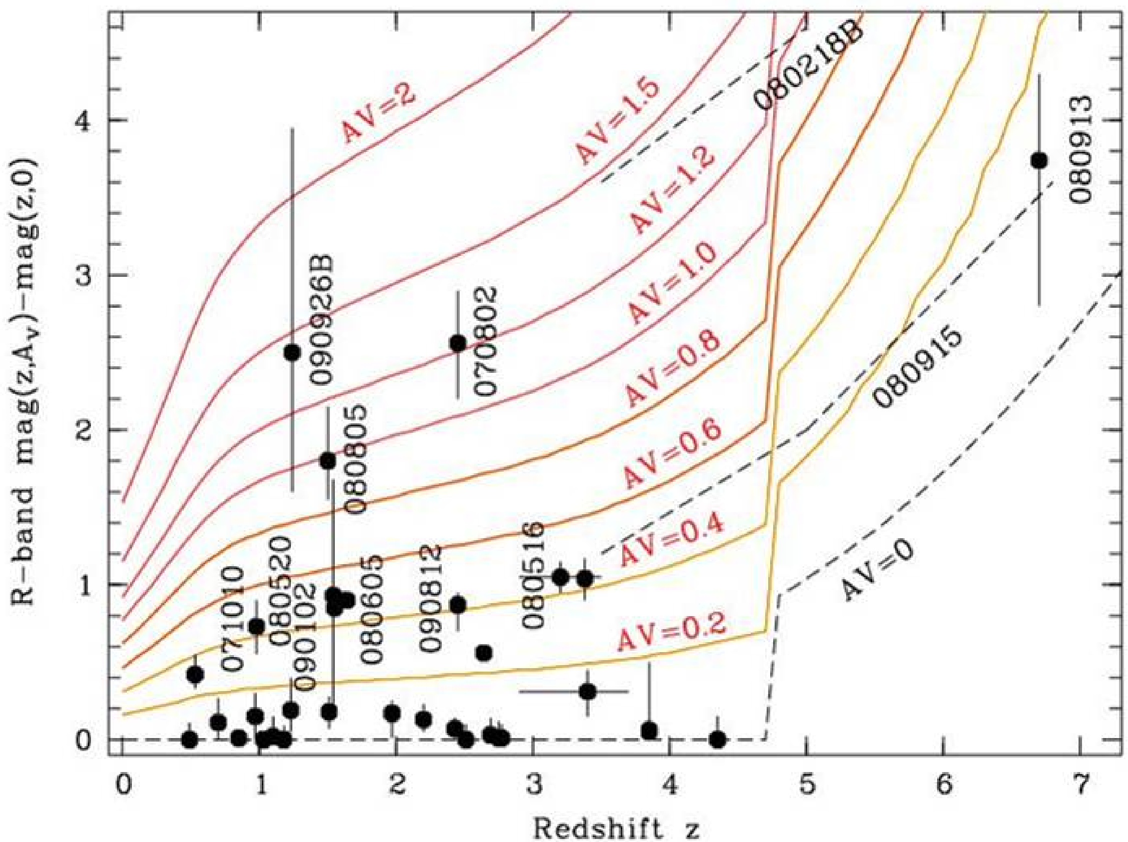


Dark bursts revealed

Optical darkness well explained by combination of

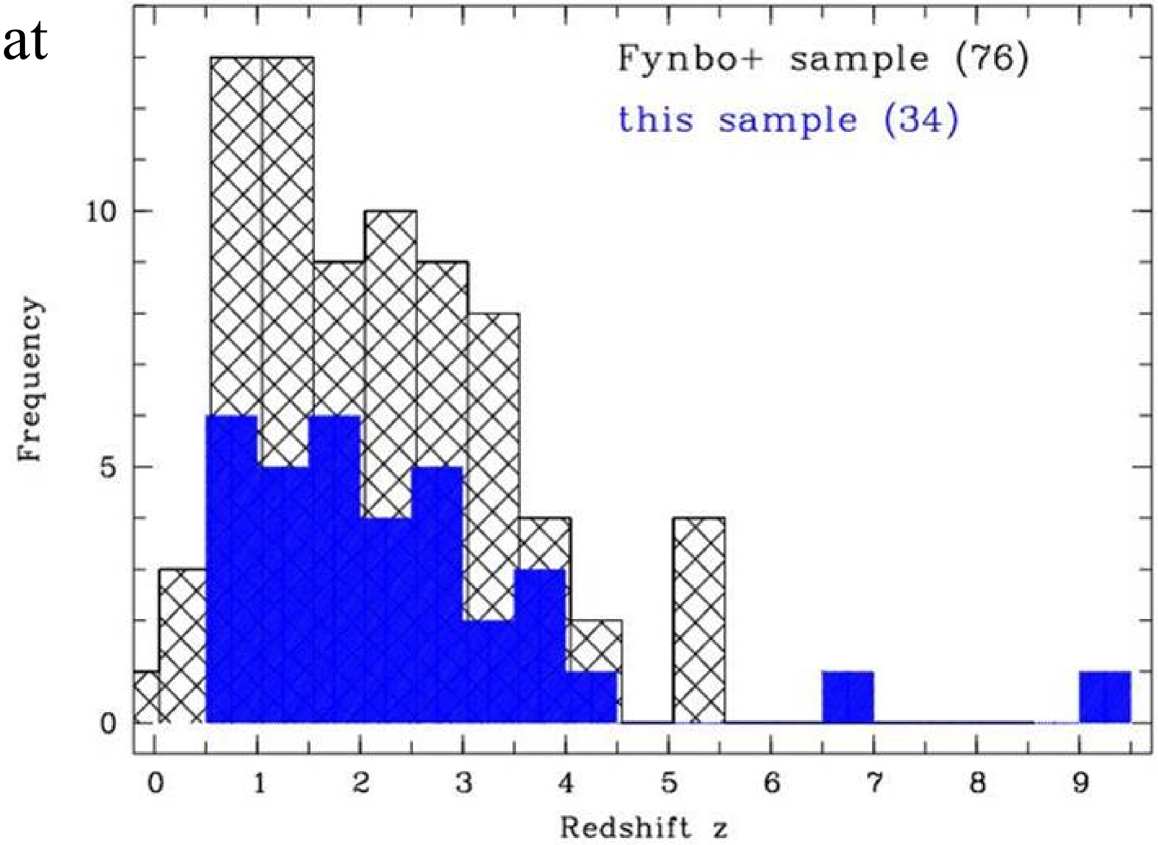
- combination of moderate redshift and moderate A_V
- ~22% high-z events among dark bursts

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



Redshift distribution

- Has completeness of 92%
- Is somewhat flatter than previous distribution of Fynbo+09 (50% completeness level; z-upper limits omitted)
- Statistics not yet great

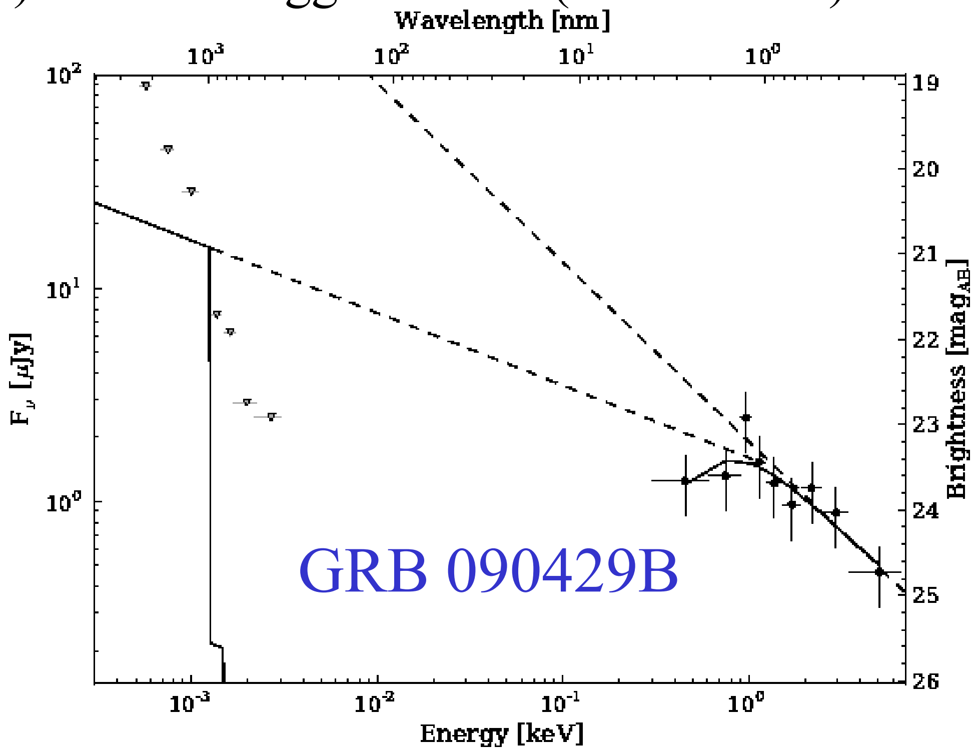


The 4 non-detected GRBs

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

- 080218B ➔ consistent with [z~10;A_V=0.5], or [z~7; A_V~0.7] or [z~3.5; A_V~1.5]
- 080915 ➔ consistent with even low z and A_V=0
- 090429B ➔ consistent with z>6 & A_V=0, or z~5 & A_V~1
- 100205A ➔ Gemini: H-K(AB)=1.6±0.5 suggests z>11 (Cucchiara+10)

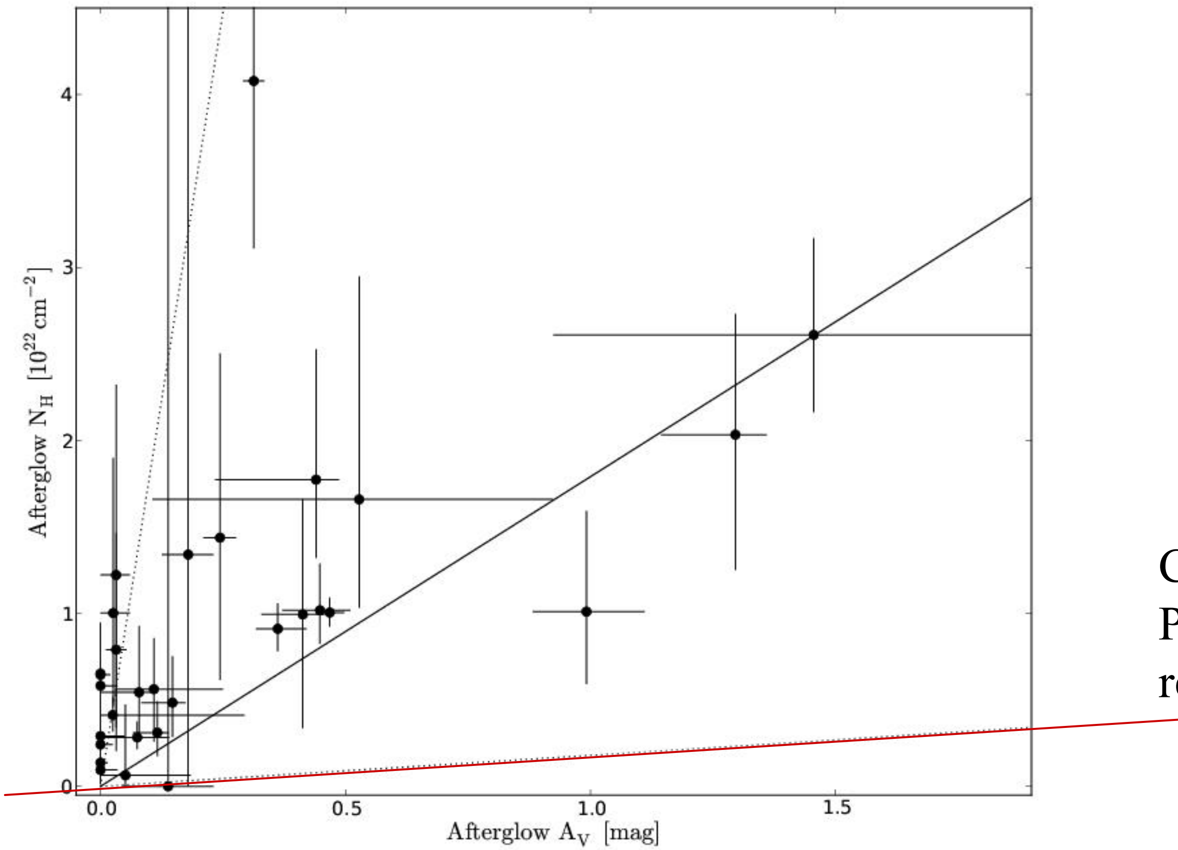
Effectively not only 35 GROND-detected, but all 39 GRBs consistent with above picture



A_V-N_H relation

Substantially more dust than neutral hydrogen, by factor ~10-100!

➔ Effect of ionization of nearby surrounding? Then dust would be local to GRB environment



Canonical Schmitt & Predehl (1993) relation

Summary

- 39 GROND-detected GRBs within 240 min form 90-92% complete sample for detection, redshift and A_V-distribution
- substantially more afterglows with solid A_V detection seen: ~25% of GRBs have A_V~0.5 mag; ~10% have A_V > 1 mag
- Dark bursts are due to moderate dust, enhanced for the observer due to redshift-effect, plus moderate high-z fraction
- High-z burst fraction among "dark" bursts is ~22% (z>5 fraction on total GRB sample is 5.5±2.8%)