Gamma ray burst afterglows with GROND

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Gamma Ray Bursts with GROND

- The Gamma Ray Burst Optical Near Infrared Detector
  GROND – Hard- and Software
  see – Poster Clemens et.al.,
  or Greiner, et.al, PASP, submitted,
  or ESO Messenger (December)
  or Yoldas, et.al, in prep.

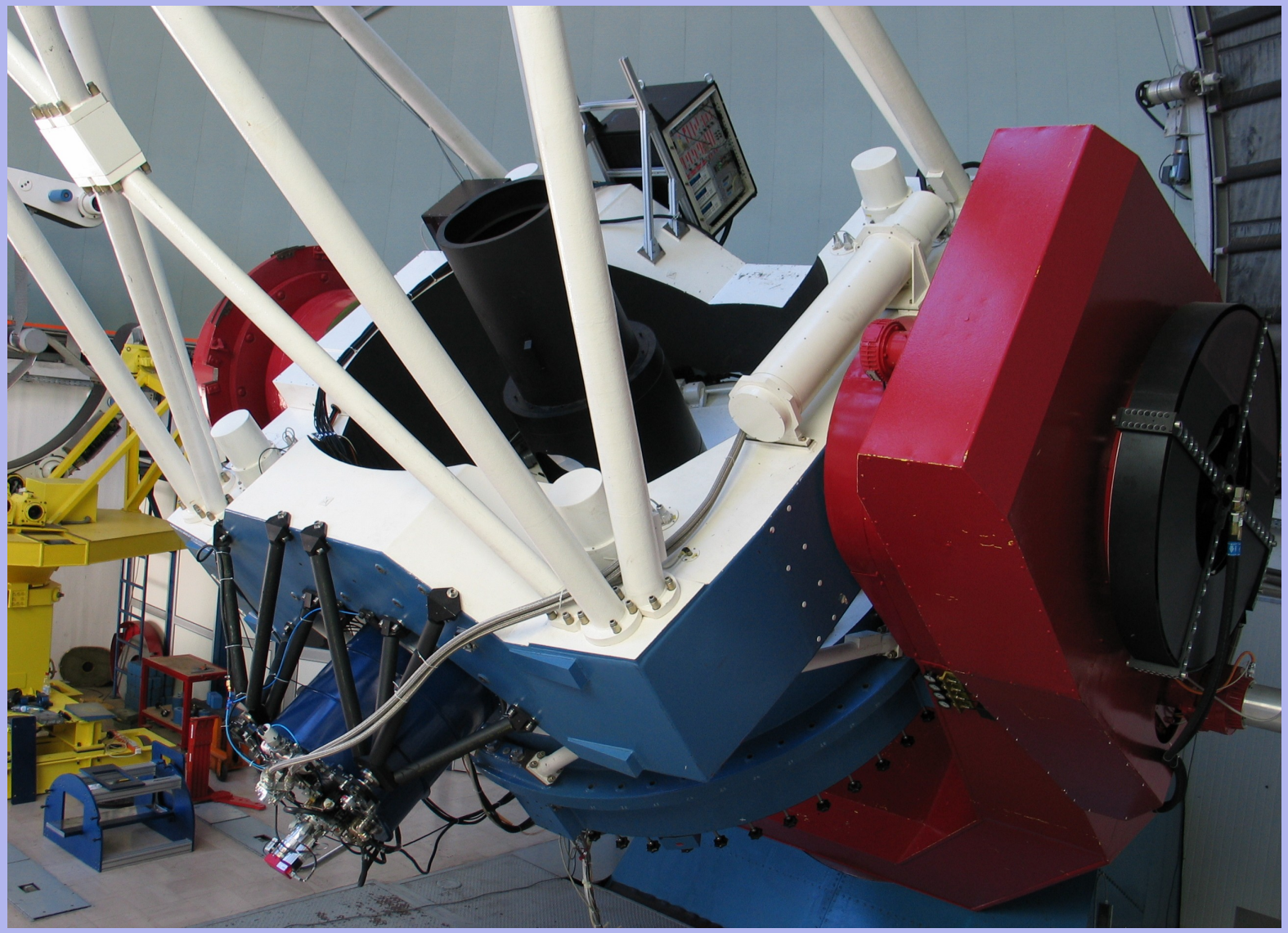
- Gamma Ray Burst Afterglows

  see Standard Literature

- First GROND Results
  the afterglow of GRB 070802 (Kruehler et.al, in prep)
  and 071031 (Kruehler et.al, in prep)

  the host of GRB 070729 and 070508
  Kuepcue-Yoldas et. Al (Kuepcue-Yoldas et.al, in prep)

Gamma Ray Bursts with GROND



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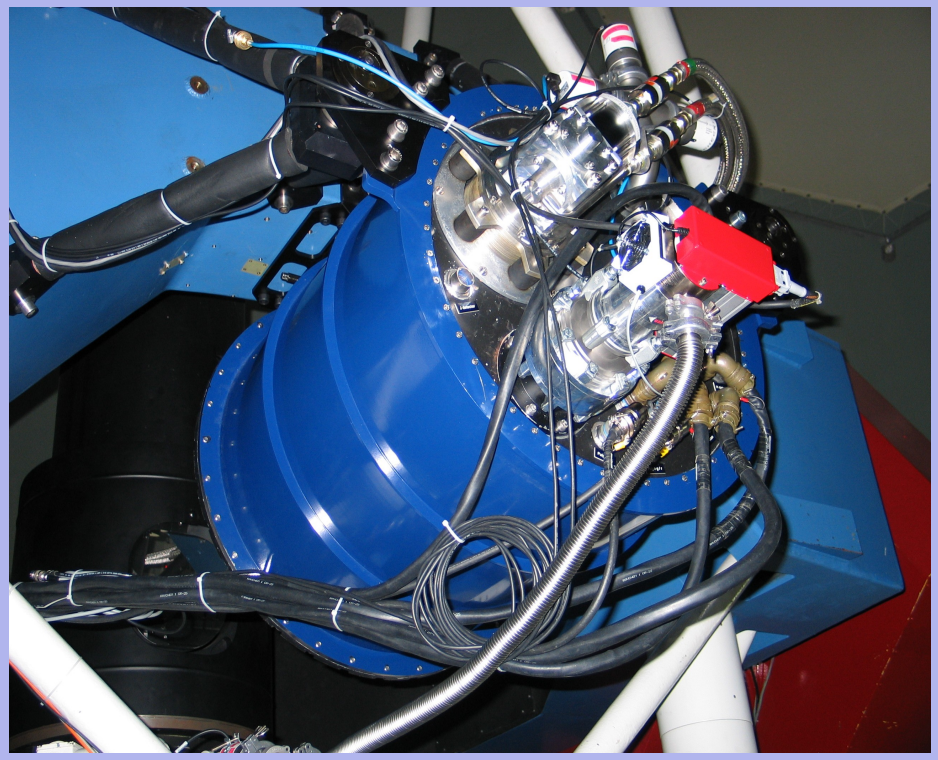
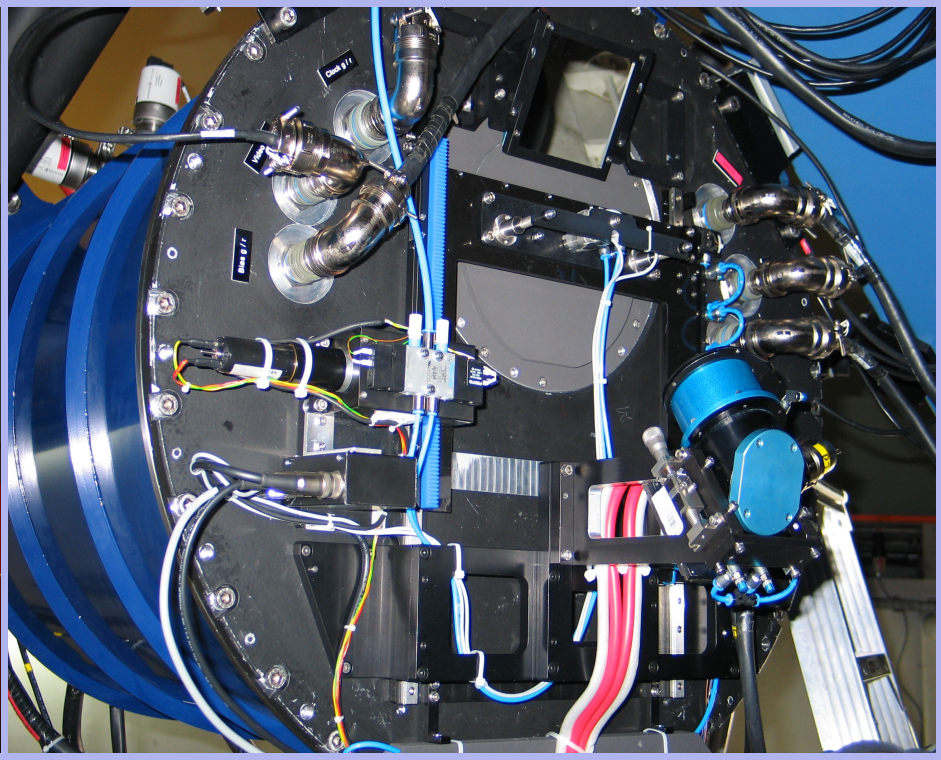
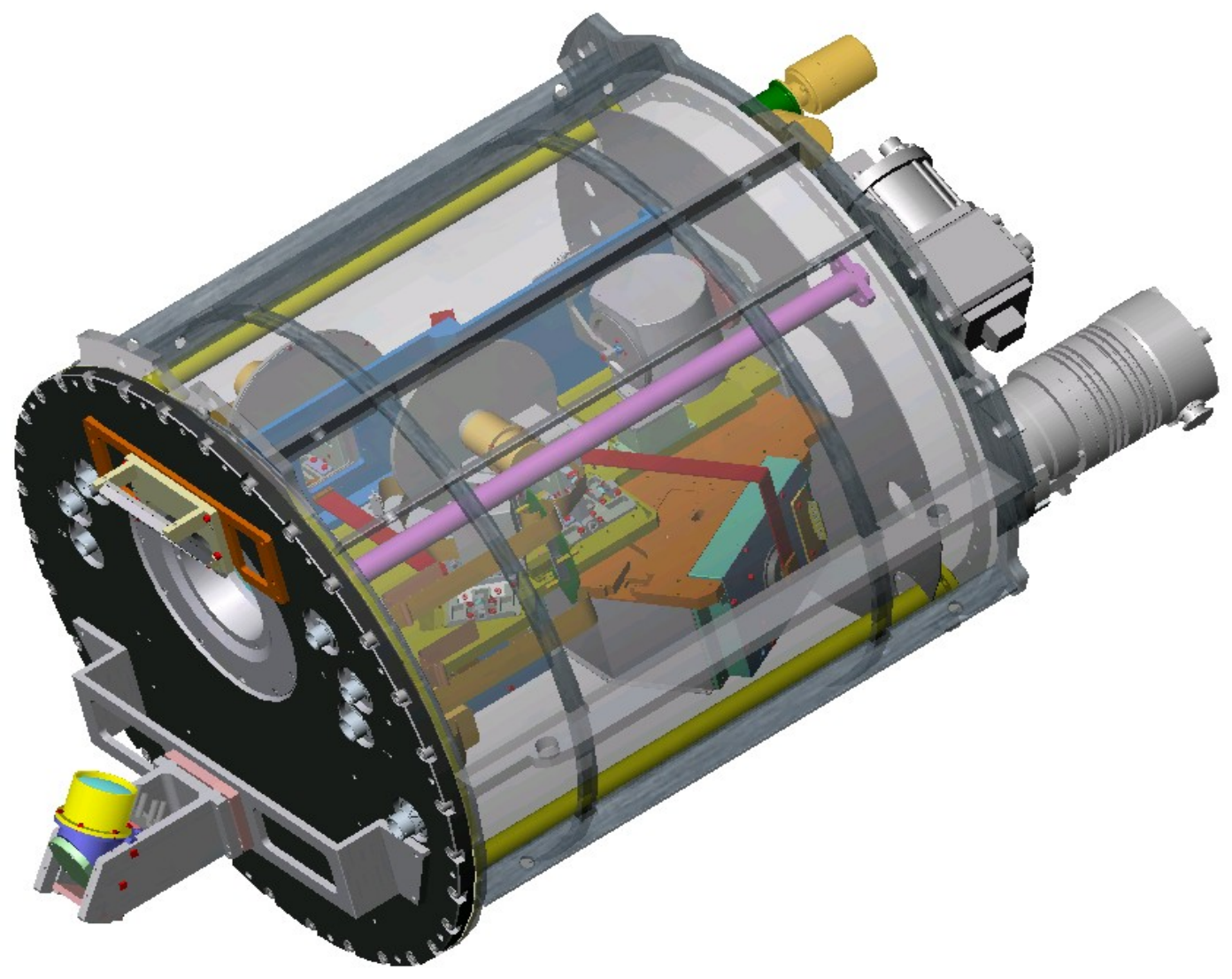




Gamma Ray Bursts with GROND



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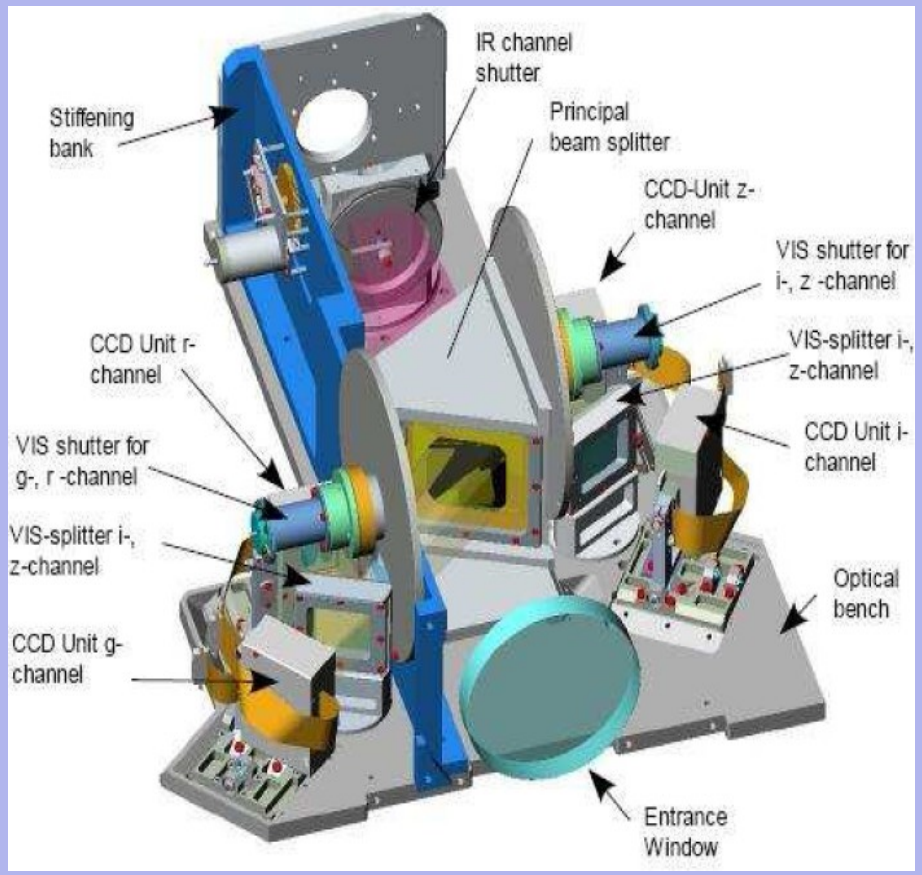

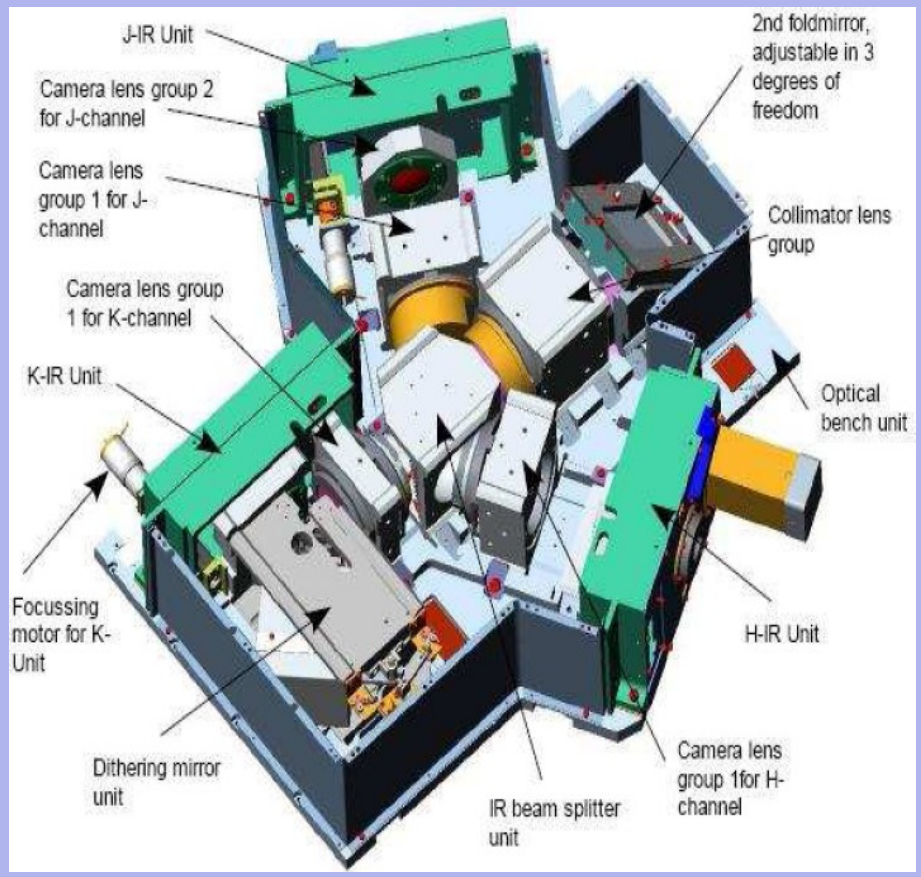

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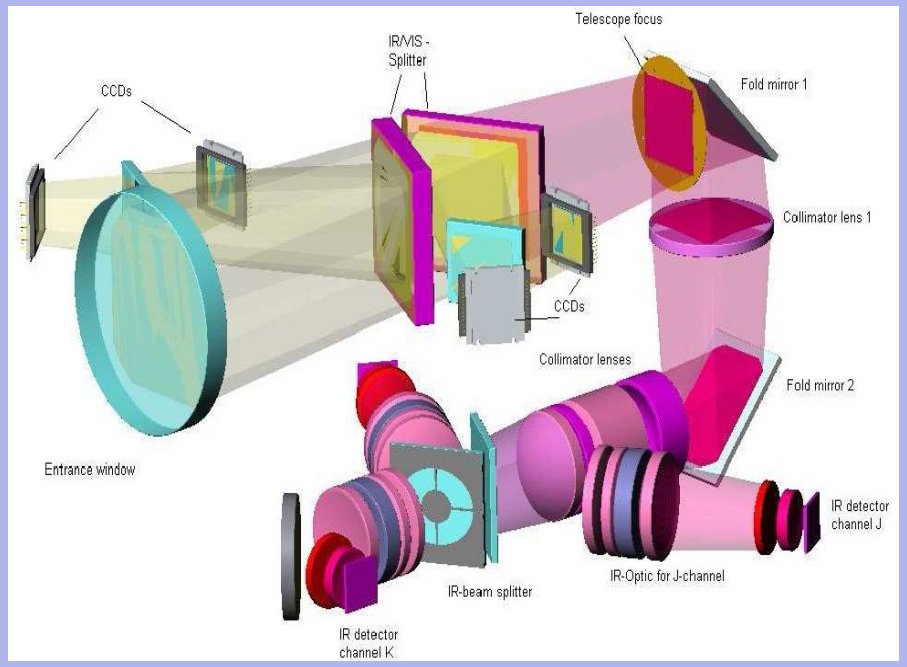
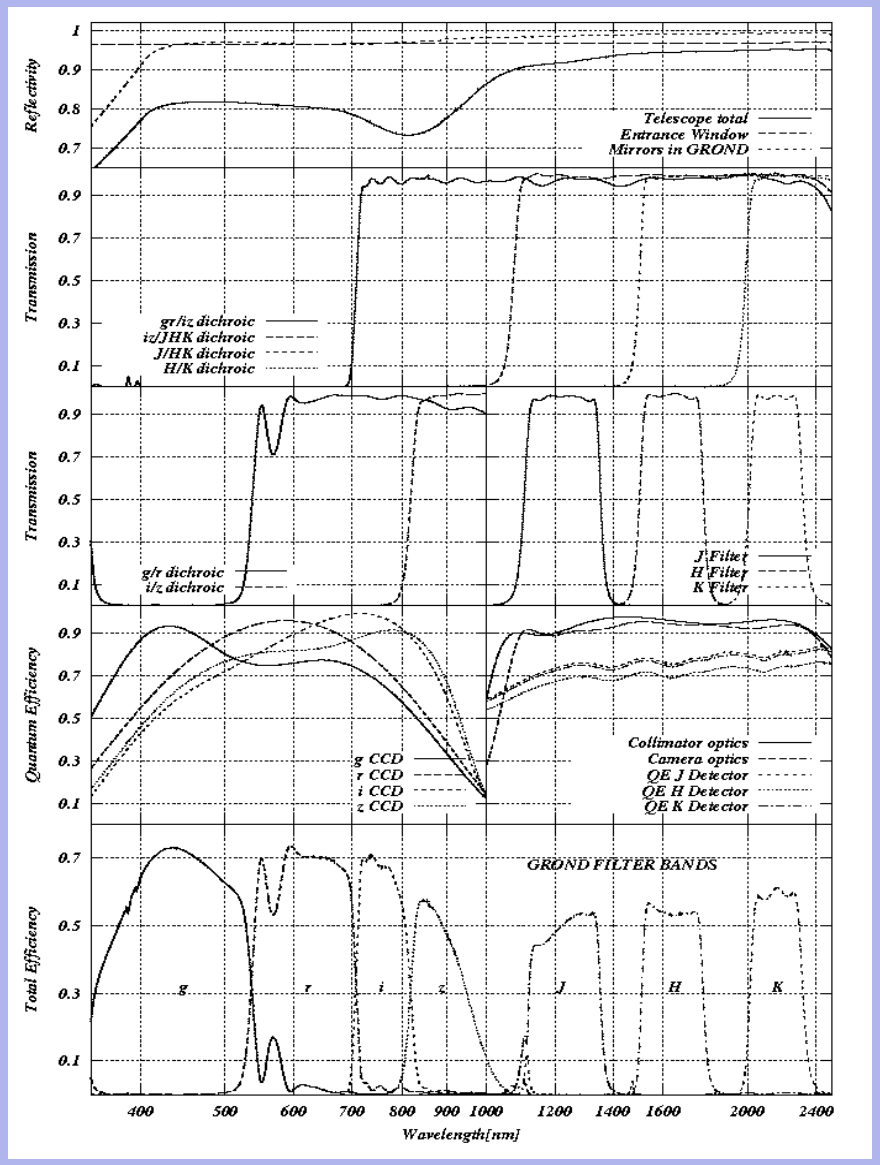


GROND-Band	50%	5%
g	402–546 nm	387–553 nm
r	546–696 nm	539–709 nm
i	696–843 nm	683–869 nm
z	843–1000 nm	817–1050 nm
J	1170–1331 nm	1154–1340 nm
H	1492–1781 nm	1466–1831 nm
K	2005–2310 nm	1963–2355 nm



Gamma Ray Bursts with GROND

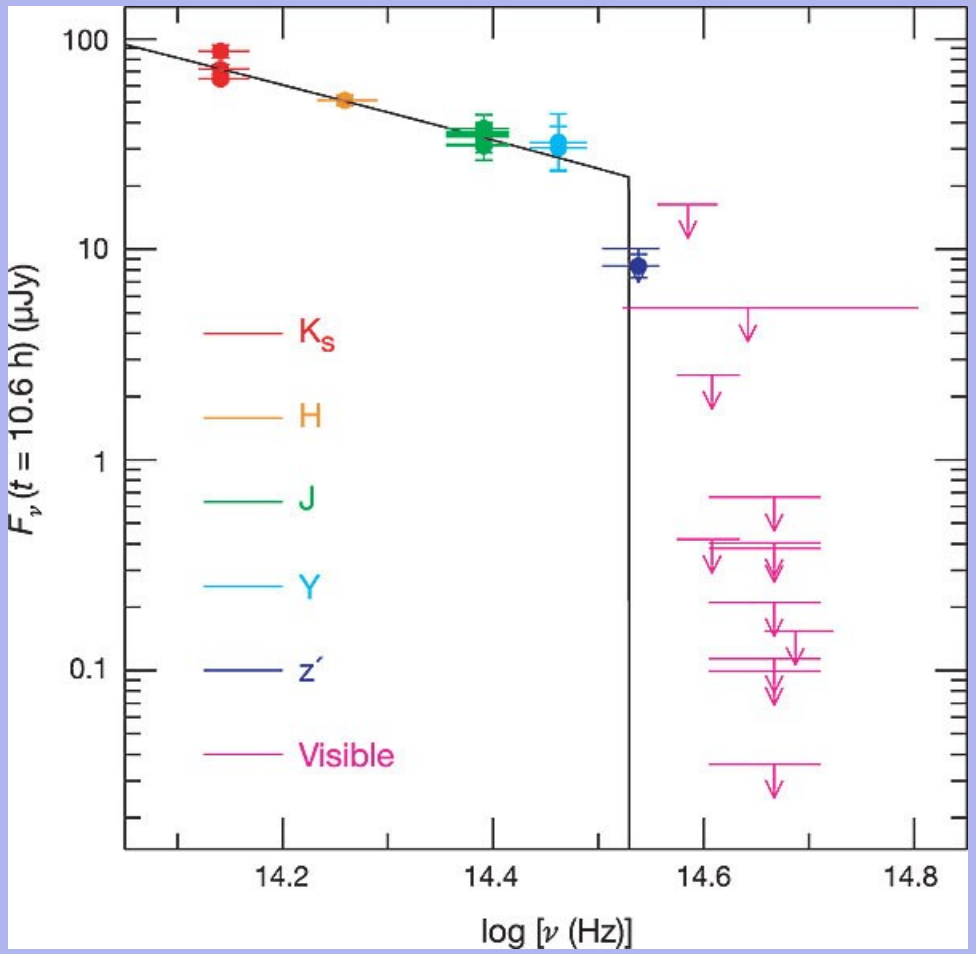
Use of custom made dichroics, filters, high-QE IR chips, specific coatings for the CCDs (each CCD is sensitivity enhanced for its wavelength regime), high throuput optics, Ag coated mirrors -> Overall max. throuput of 55 to 75 %

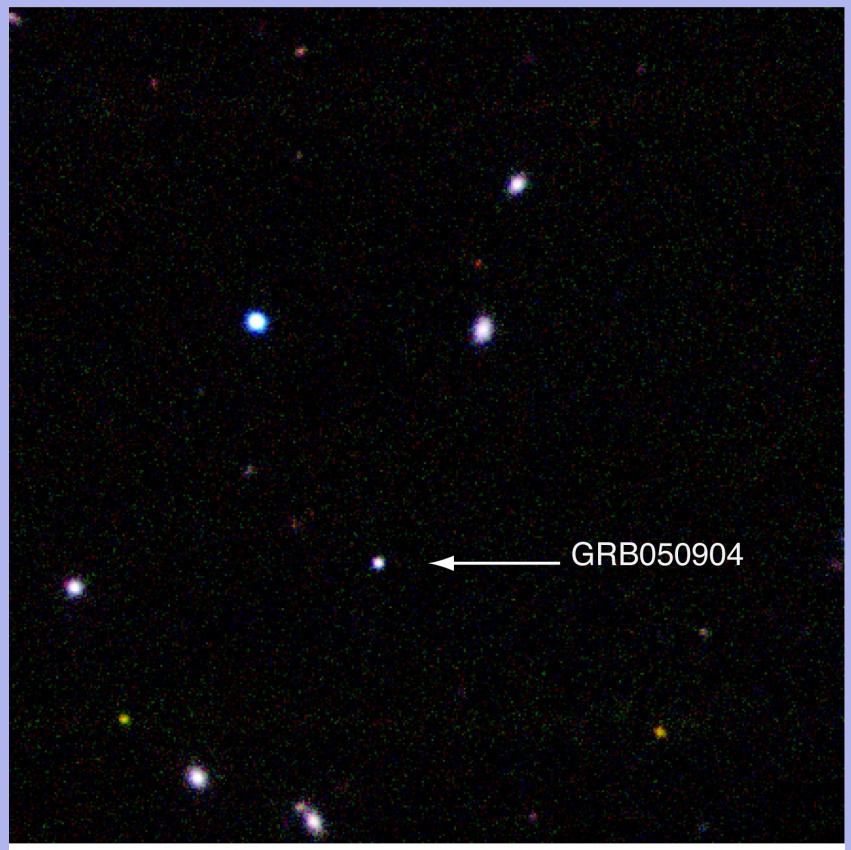
3 sigma limiting Magnitudes (5000s exp, ~1.5 h, Airmass 1, Seeing 1" VEGA Magnitudes):

g' = 24.5
r' = 24.3
i' = 23.8
z' = 23.5
J = 22.2
H = 21.3
K_s = 20.7

NIR sensitivity is comparable to SOFI at the NTT (3.54 m) (~21 in K_s in 1.5 h)

Gamma Ray Bursts with GROND

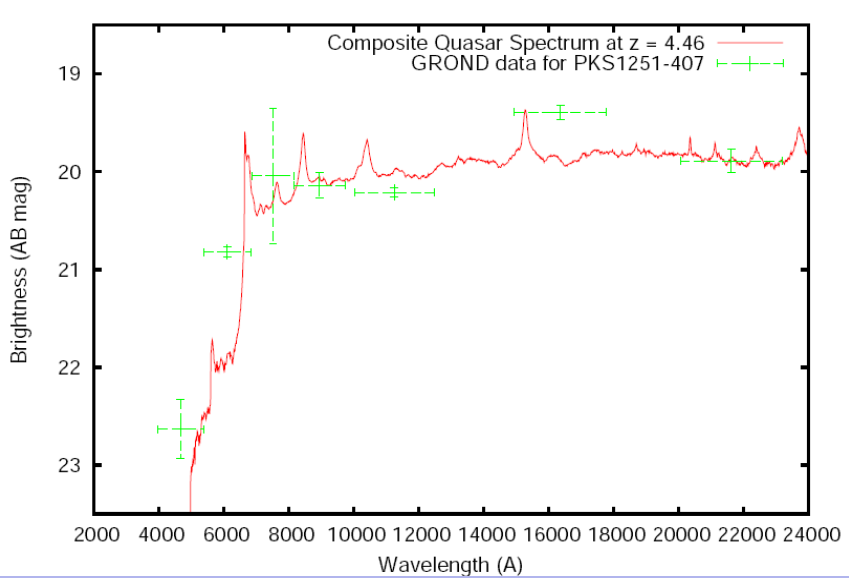




The Distant Gamma-Ray Burst GRB050904
(ISAAC/VLT)

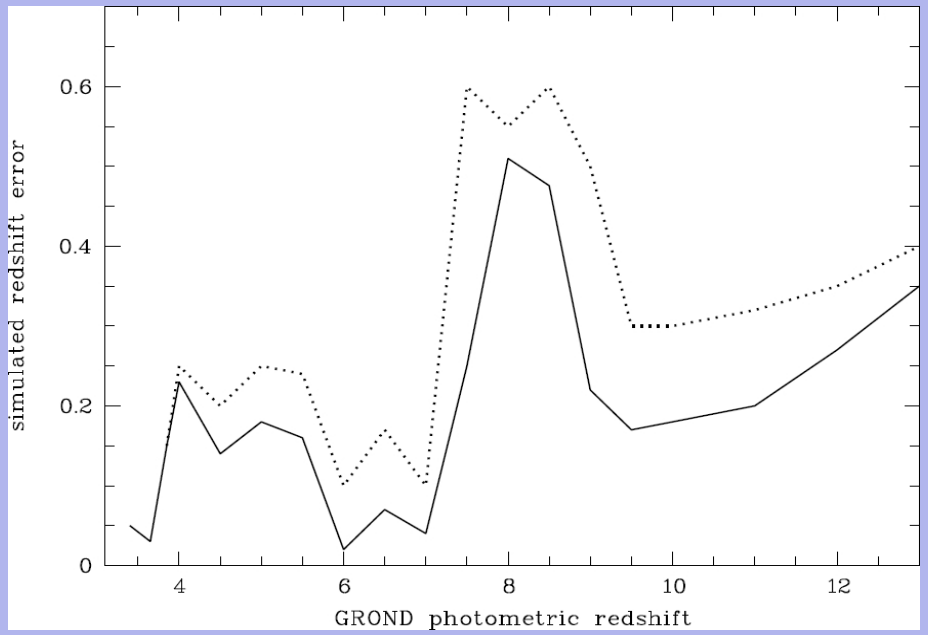
ESO PR Photo 27a/05 (September 12, 2005)

Gamma Ray Bursts with GROND



First science demonstration with Quasar PLS1251-407 (redshift 4.46) taken during first light

Simulations about the accuracy of the GROND photometric redshift estimate for GRB afterglows



Gamma Ray Bursts with GROND

- Retrieves Alerts from NASA via Socket Connection
- Schedules according to visibility, moon/major planet distance, 2nd or 3rd or ... GRB
- Initiates automatic Observations (~2s)
- Aborts ongoing observation with WFI/FEROS via RRM (30s)
- Sets up and moves the telescope/2p2 dome/M3 (30s to several minutes)

- Stars predefined sequence of OBs (Integration times according to the brightness of afterglow candidate)
- Automatically retrieves images and starts data analysis

- Will eventually find the transient and estimate the photometric redshift

=> Only user interaction needed: Guiding !!

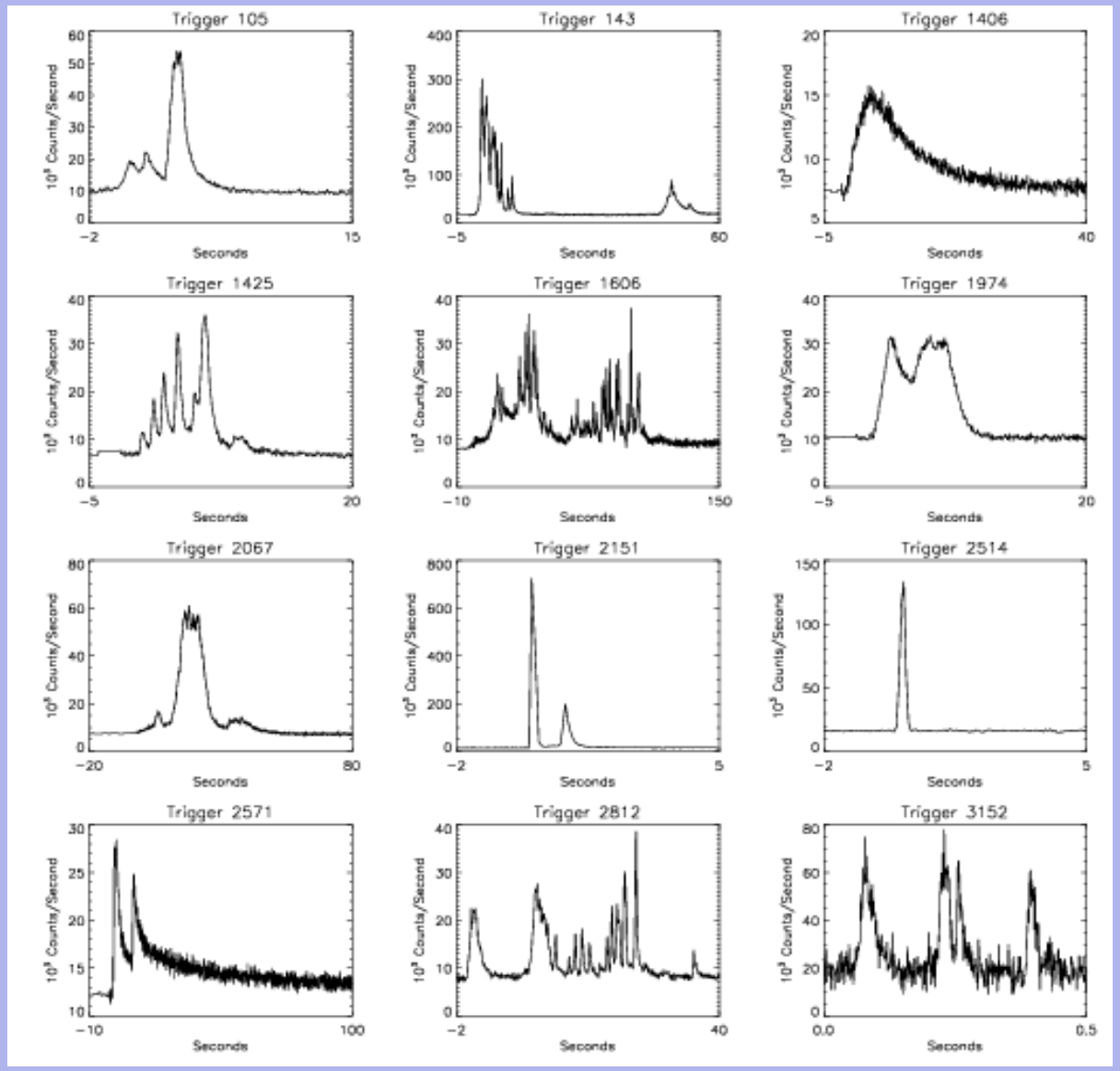
Gamma Ray Bursts with GROND

Performance up to now:

- Running for 6 month maintenance free
- Producing 2.5 TB of data (raw + calib)
  -> ~ 14 TB of reduced data
- In total around 140.000 raw frames were taken in 420 h of Observations

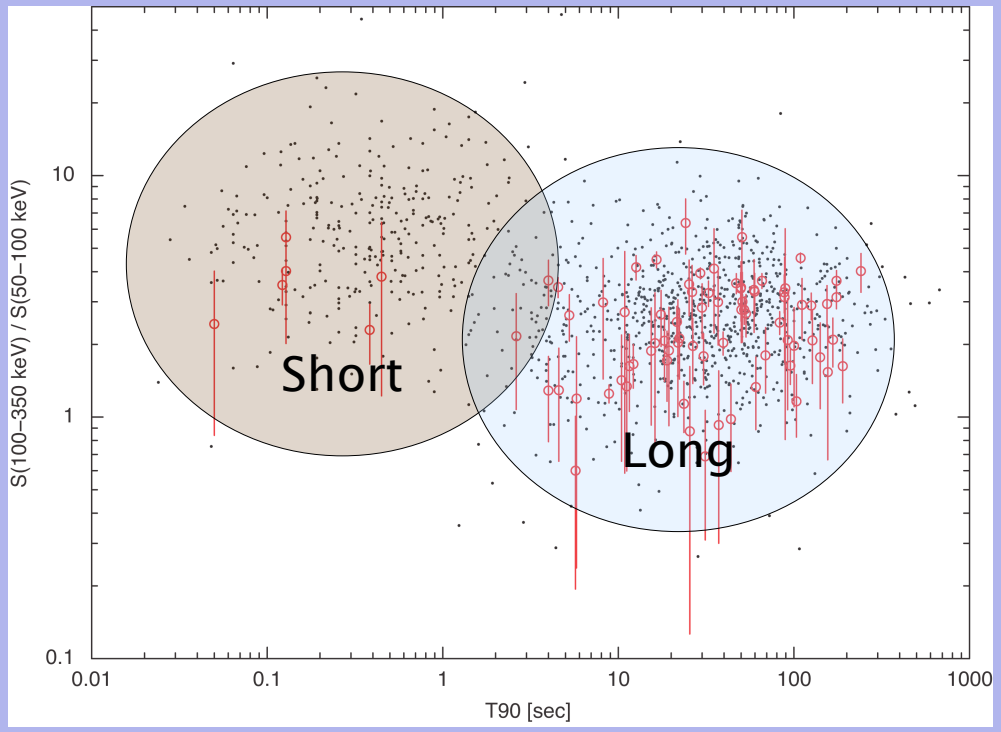
- 59 Bursts up to today, 40 visible from LaSilla
- GROND observed 15, thus 32 % including 2 prompt triggers
  -> 10 bad weather (25 %, LaSilla mean 15 %)
  -> 10 no override of WFI or FEROS
  -> 5 due to various reasons (Telescope/GROND techical, nearby bright stars, near sun ...)

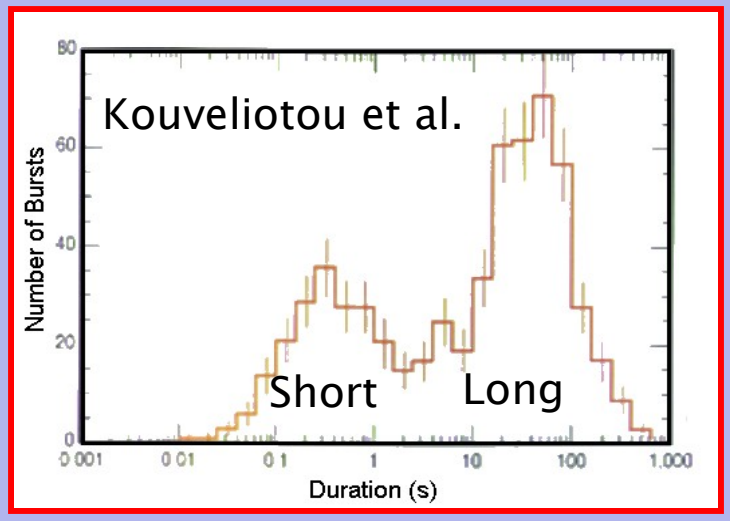
- Science observations also include:
  - High-z Quasar search
  - Inclination of X-ray binaries
  - Search for (dark) GRB hosts
  - Transiting planets
  - Galaxy clusters



The energy release of GRBs is about 10^{52} ergs on very short (0.1 to ~100 sec) timscales. Variablity of the brightness in gamma rays implies a compact source < 100 km and therefore requires ultrarelativistic outflow $\Gamma > 50$.

Gamma Ray Bursts with GROND

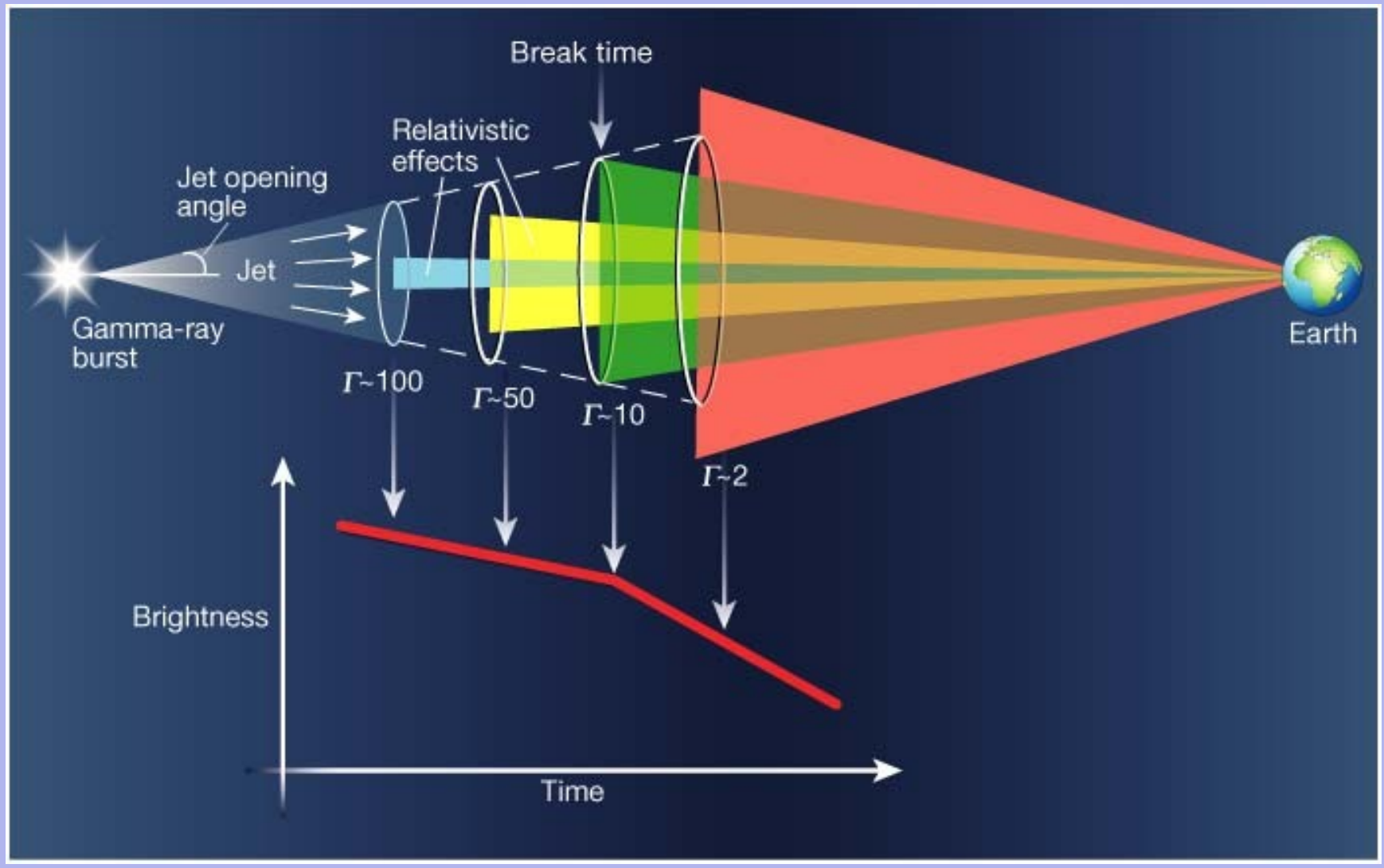




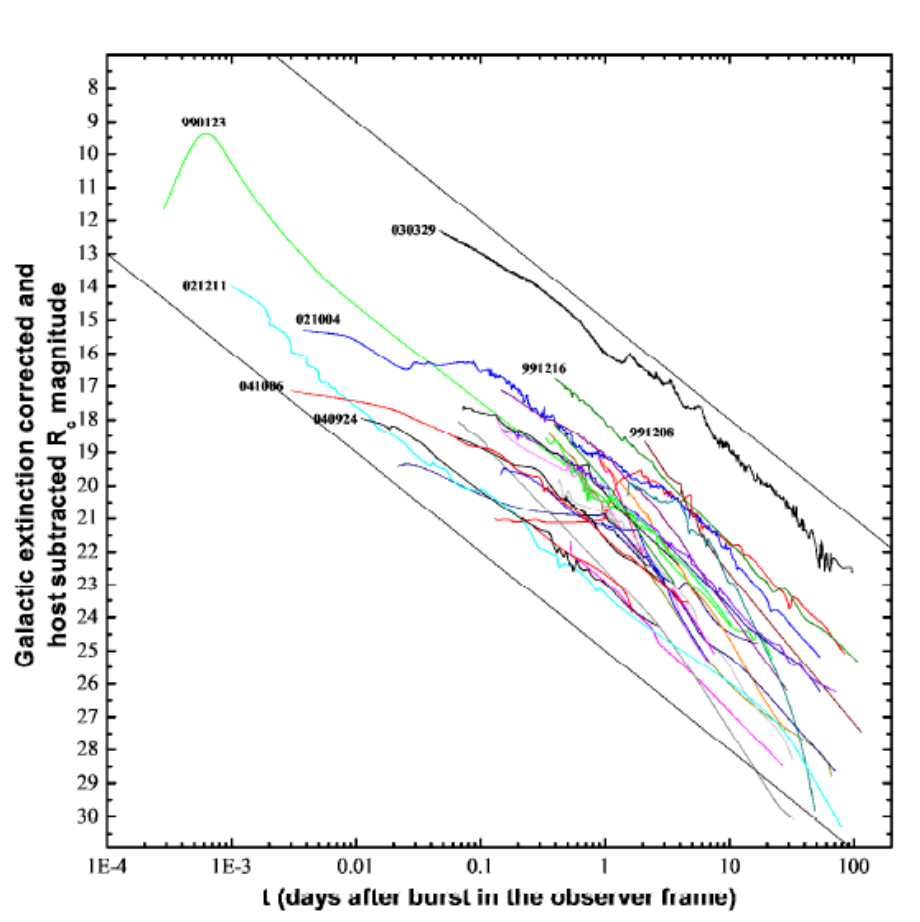
GRBs cluster in two different categories, short-hard versus long-soft.

They differ in duration, spectral properties, energy release, progenitor and host galaxy
-> Collapse of a very massive, fast rotating WR star -> Long GRB
-> Merger of two compact objects -> Short GRB
-> Both models produce a black hole with an accretion disk

Gamma Ray Bursts with GROND



Gamma Ray Bursts with GROND



Compilation of pre-Swift afterglow lightcurves corrected for extinction host contribution.

GROND will starts observing at 0.005 days with R~21 mag

Brightest GRB is 030329 (10^{4-5} times brighter than a Quasar)

Gamma Ray Bursts with GROND

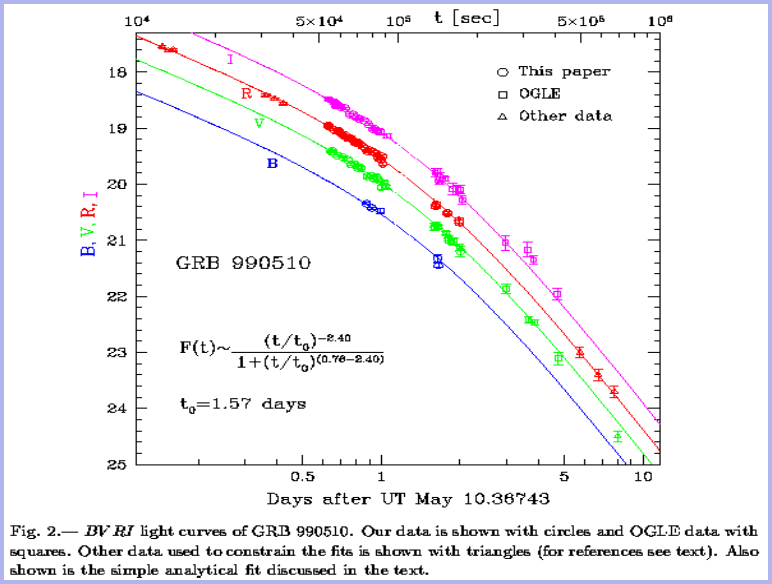
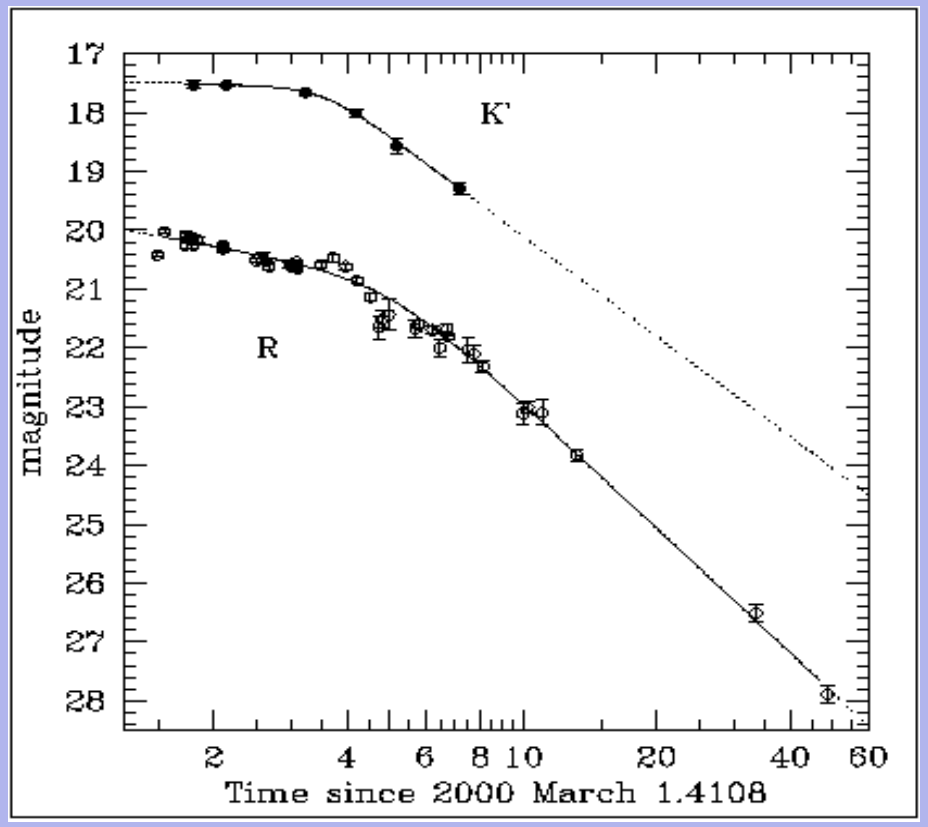


Fig. 2.— *BVRI* light curves of GRB 990510. Our data is shown with circles and OGLE data with squares. Other data used to constrain the fits is shown with triangles (for references see text). Also shown is the simple analytical fit discussed in the text.

GRB000301C

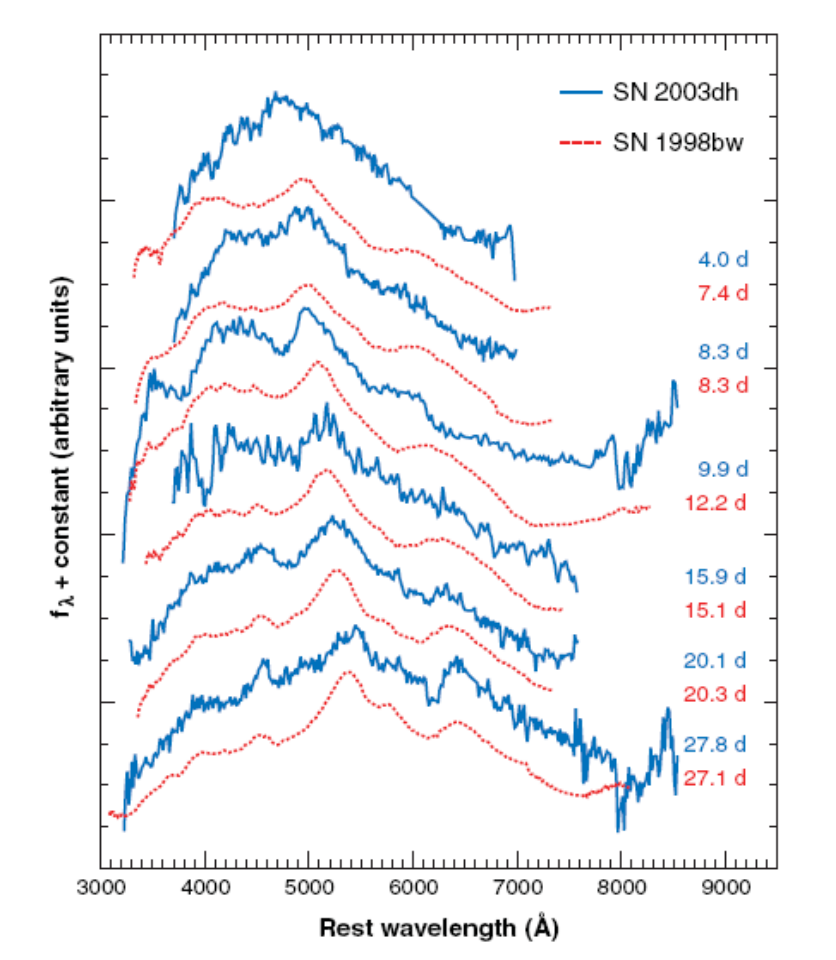


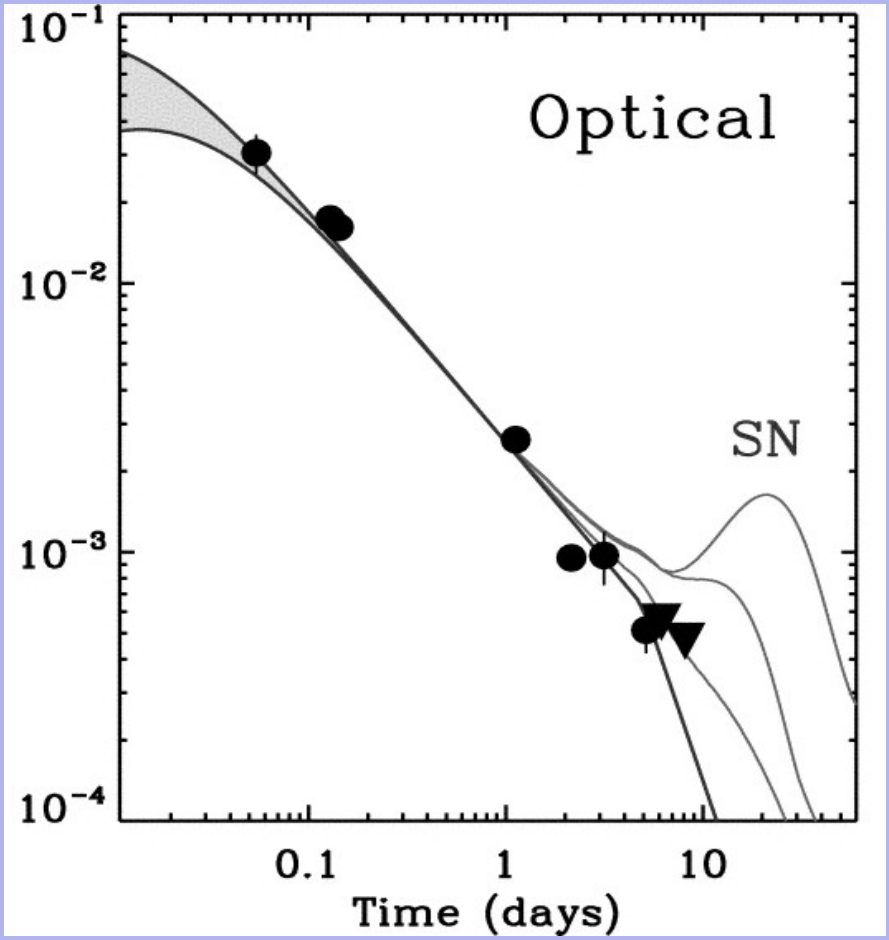
Jet break has been claimed for several bursts. But none could be robustly fitted in all bands (radio, optical, X-rays) ....

Gamma Ray Bursts with GROND

SN underlying (some) long GRBs

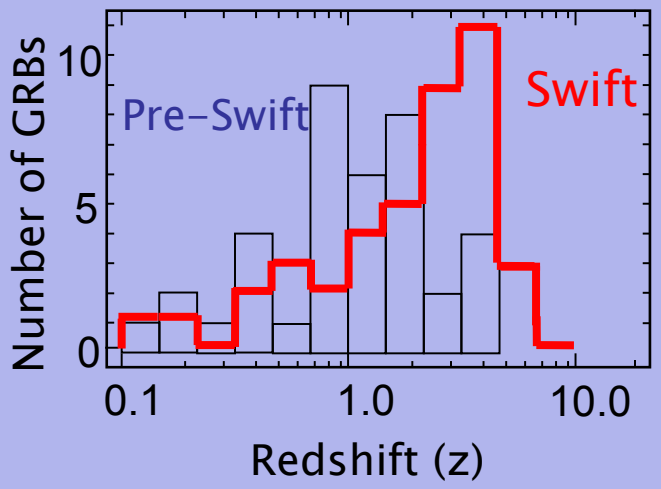
But not short GRBs





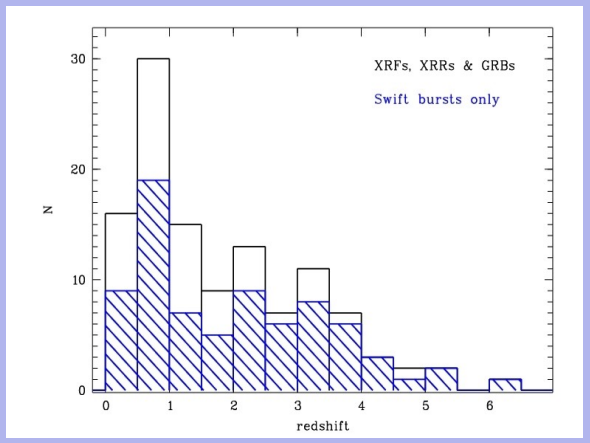
Gamma Ray Bursts with GROND

Long GRBs

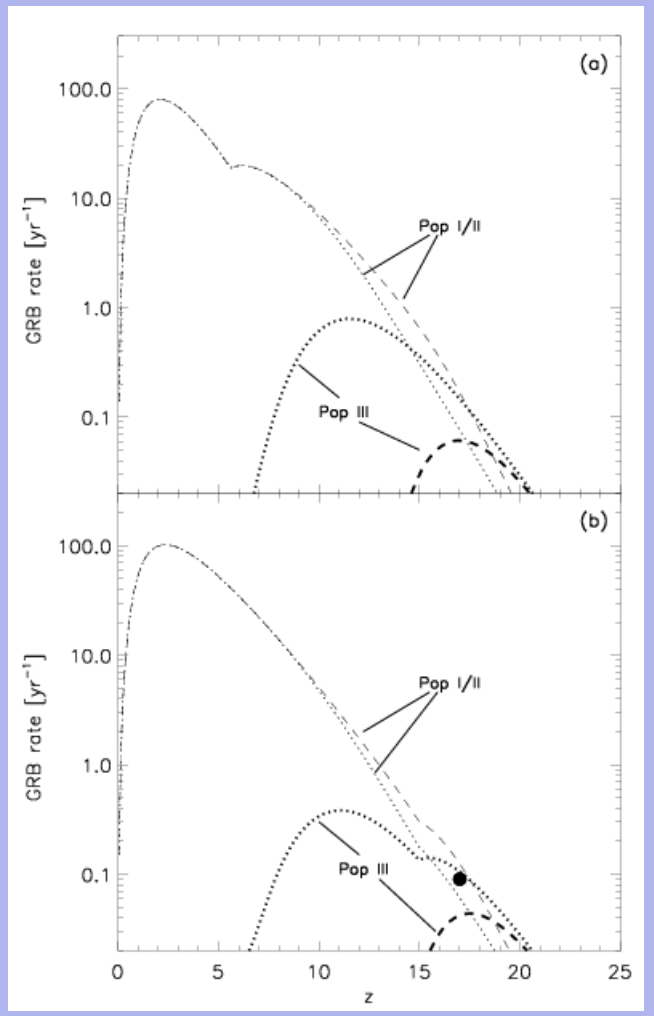


Redshift range up to ~6.3

$\langle z \rangle_{short} = 0.6 \quad \langle z \rangle_{long} = 2.3$



GRBs occur at cosmological distances

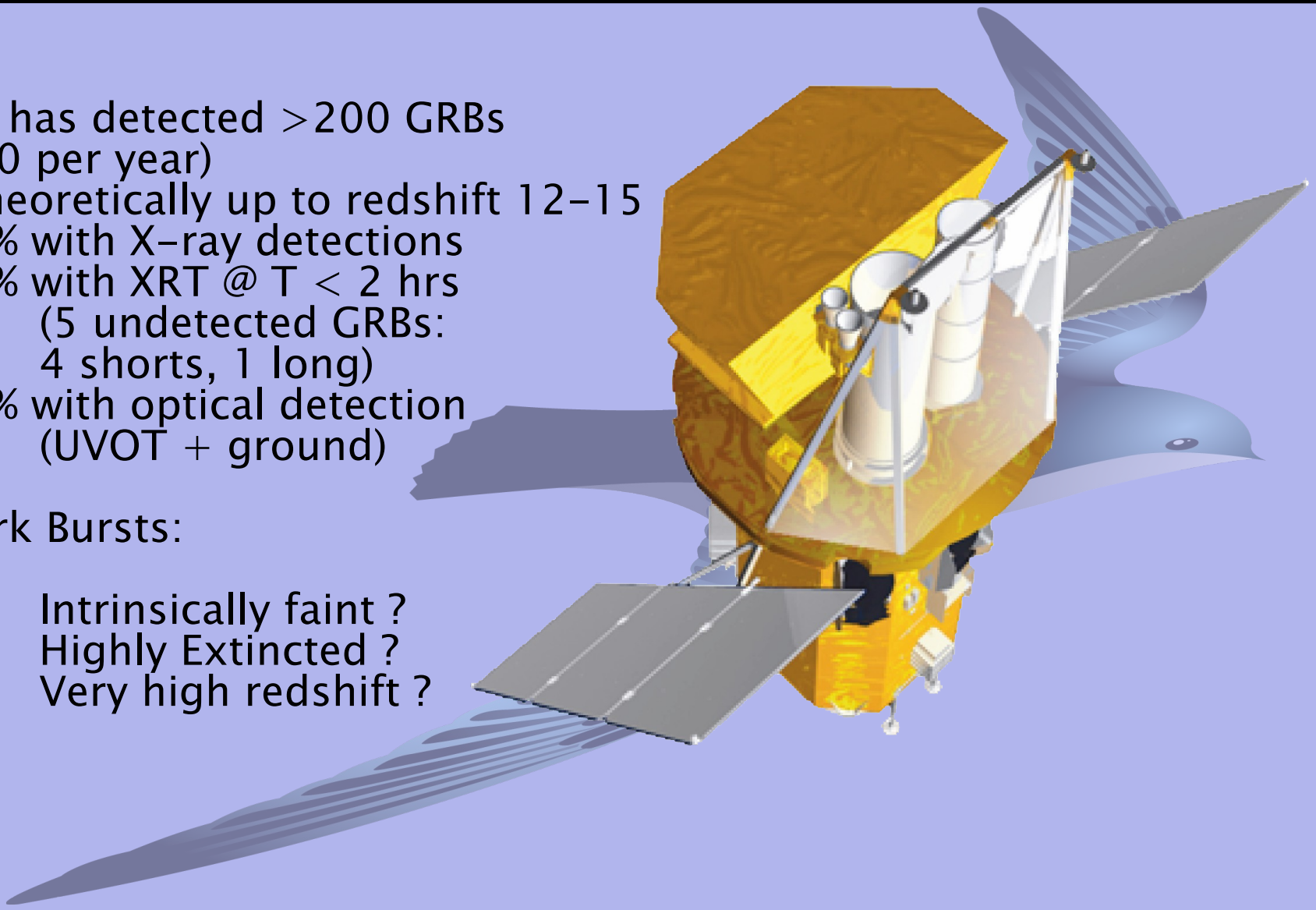


Gamma Ray Bursts with GROND

BAT has detected >200 GRBs
(~100 per year)
theoretically up to redshift 12-15
85% with X-ray detections
97% with XRT @ T < 2 hrs
(5 undetected GRBs:
4 shorts, 1 long)
50% with optical detection
(UVOT + ground)

Dark Bursts:

Intrinsically faint ?
Highly Extincted ?
Very high redshift ?



Gamma Ray Bursts with GROND

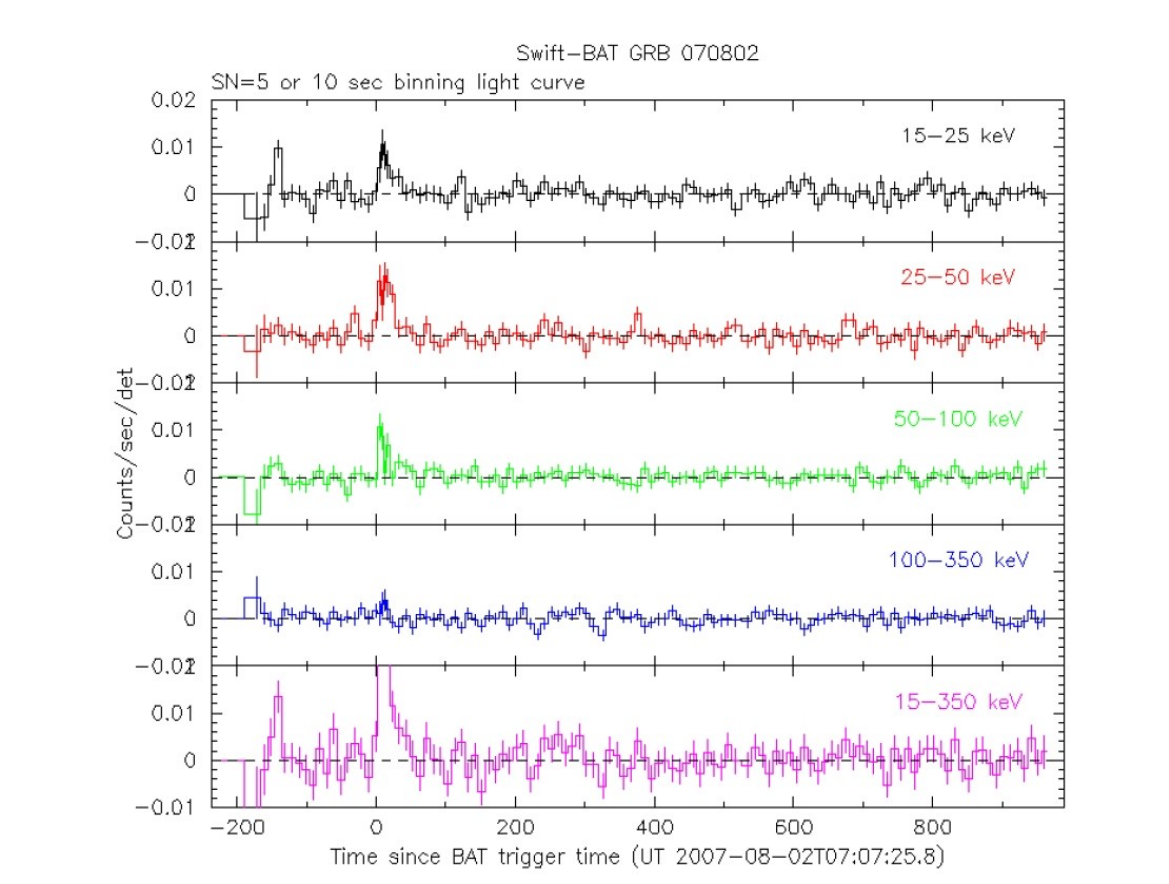
BAT trigger 286809

- T90 = 16.4 s
- Fast XRT observations
  -> 138 s post burst
- z = 2.45

- No UVOT source detected

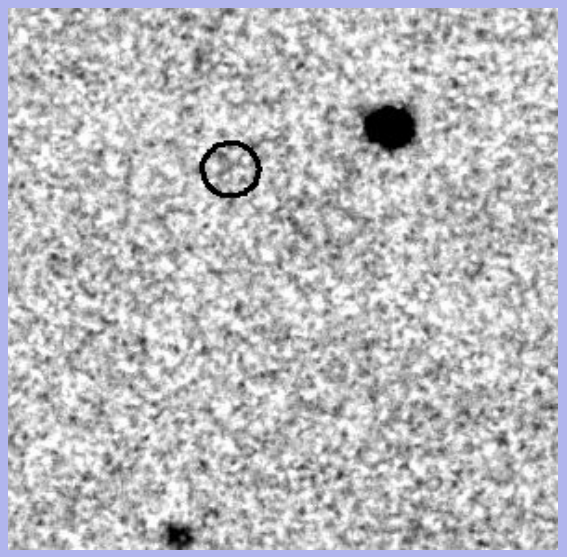
GROND initiated automatic observations, first frame taken 7 min after trigger

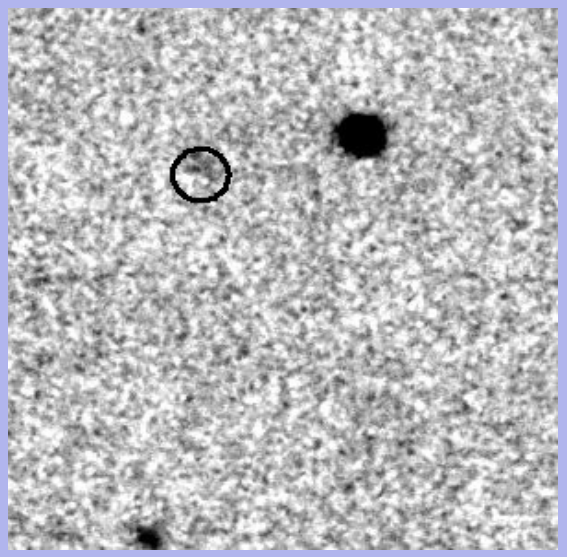
First OB + analysis complete @ 20 min after trigger



Gamma Ray Bursts with GROND

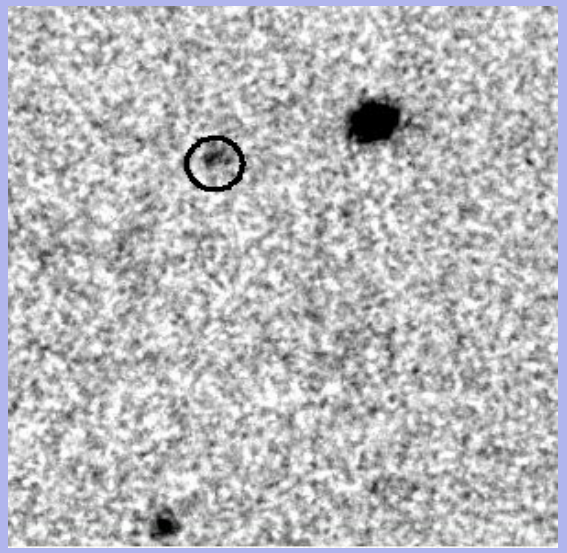
~1000s

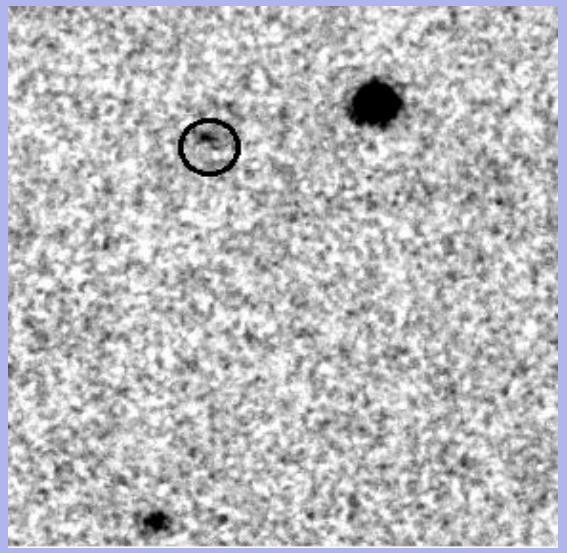




~1500 s

~2000 s

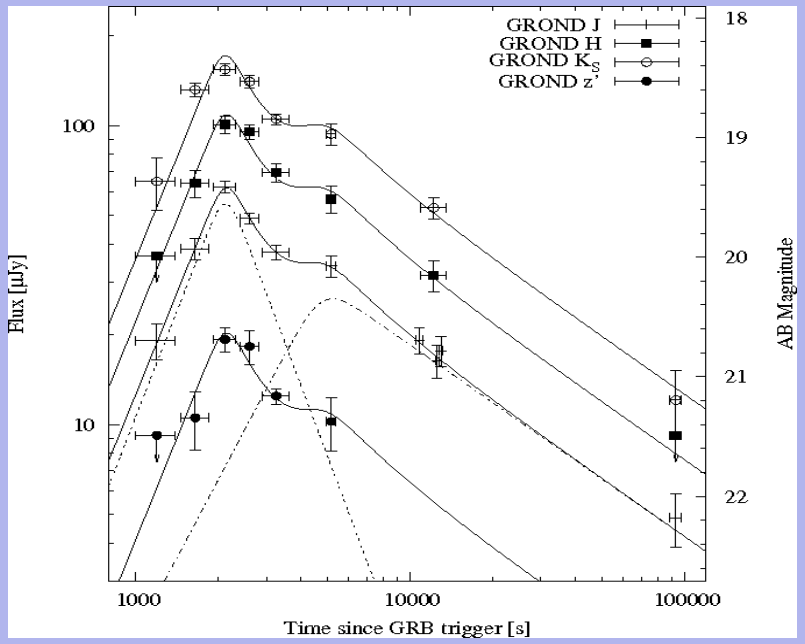




~3000 s

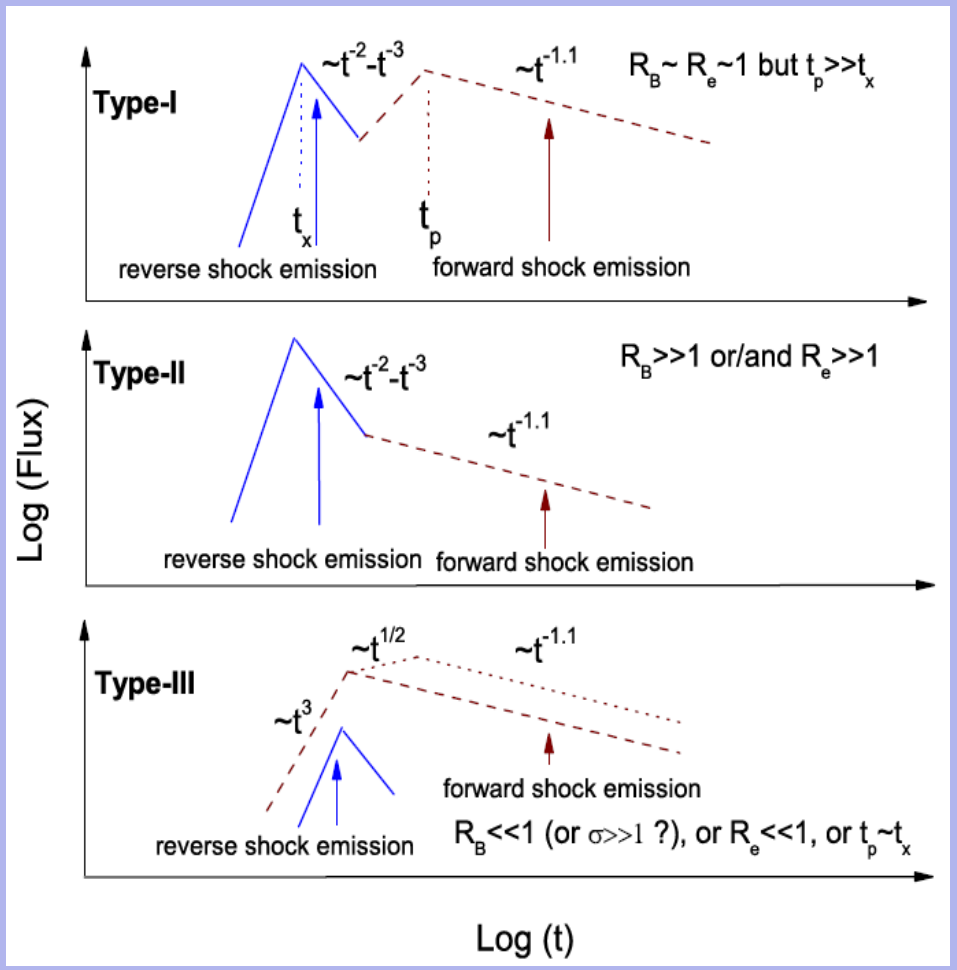
GROND K Band

Gamma Ray Bursts with GROND



$$F_\nu^r(t) = F_0^r \left[\left(\frac{t}{t_1}\right)^{-s^r\alpha_1^r} + \left(\frac{t}{t_1}\right)^{-s^r\alpha_2^r} \right]^{-1/s^r}$$

$$F_\nu^f(t) = F_0^f \left[\left(\frac{t}{t_2}\right)^{-s^f\alpha_1^f} + \left(\frac{t}{t_2}\right)^{-s^f\alpha_2^f} \right]^{-1/s^f}$$



Gamma Ray Bursts with GROND

GRB070802 is just the second burst where theoretically expected peaks of both, reverse and forward shock could be observationally identified.
(The other GRB041209, Blake, et.al. 05, Nature)

Interpretation of the initial rise of the Light curve helps understanding the energy production and the composition of the ultra relativistic outflow:

i) Diagnose the composition of the fireball ejecta

ii) Constraining the environment of the GRB

iii) Give Hints on the central engine activity

Gamma Ray Bursts with GROND

Using the RS emission as a diagnostic :

Analyzing the Lightcurve of GRB070802 in detail yields:

- The inital Lorentzfactor of the ejecta using

$$\Gamma_c \cong 125 E_{52}^{1/8} T_2^{-3/8} \left(\frac{1+z}{2}\right)^{3/8}$$ and $$\Gamma_x = \Gamma_c (T/t_x)^{3/8}$$

- The circumburst medium
  ISM like

- Emission mechanism
  Fireball dominated by baryons

Gamma Ray Bursts with GROND

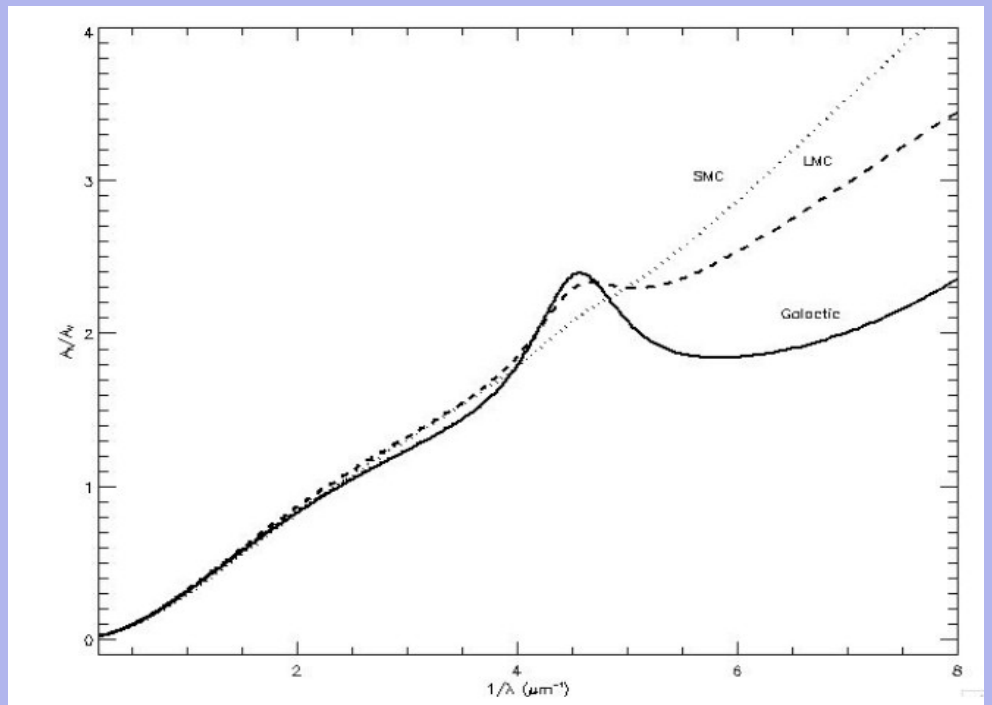
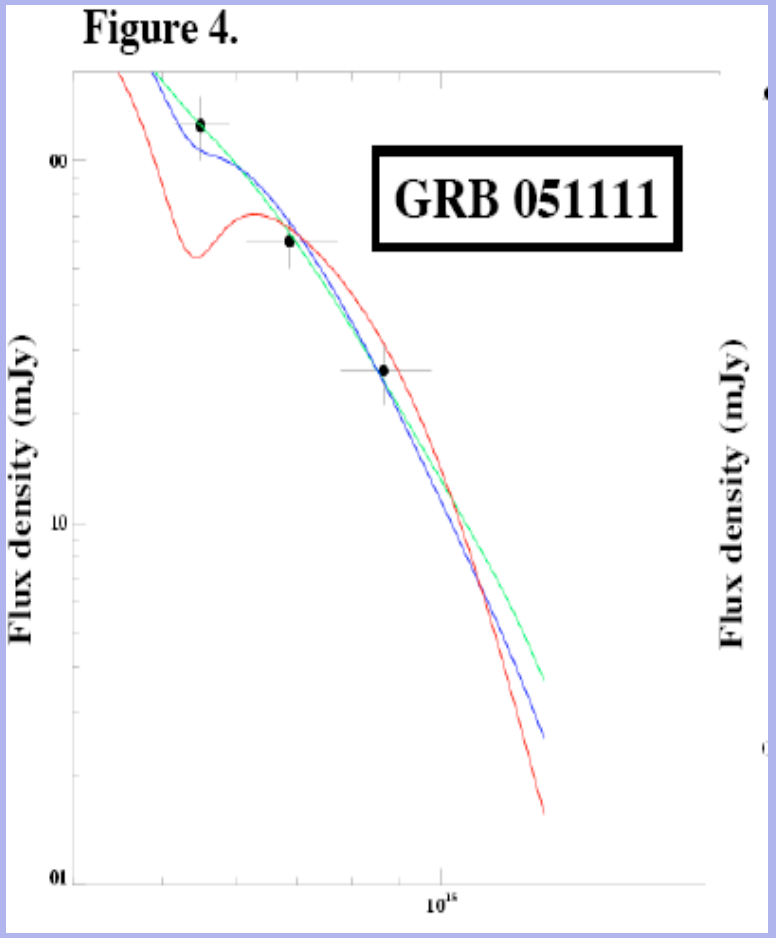
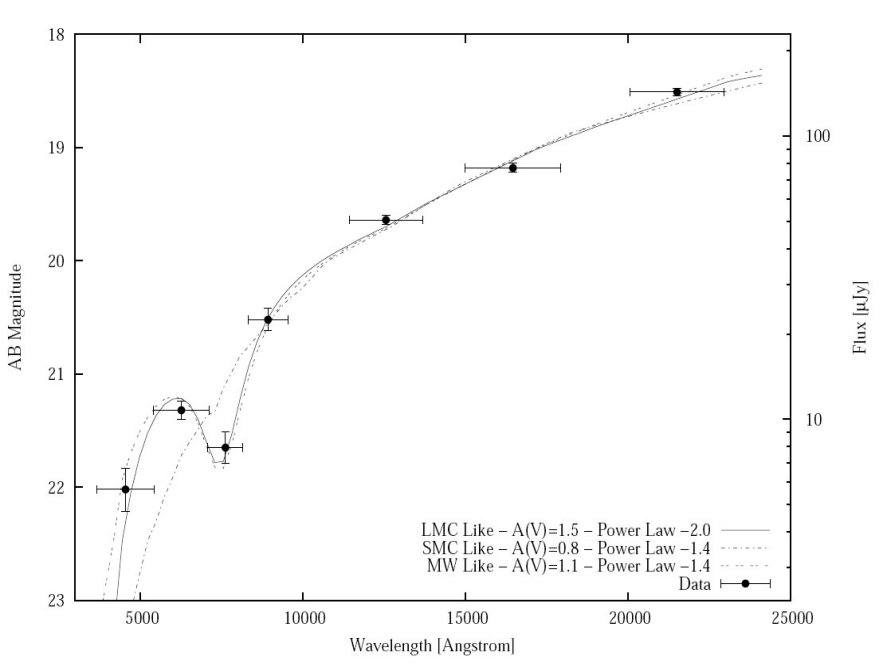
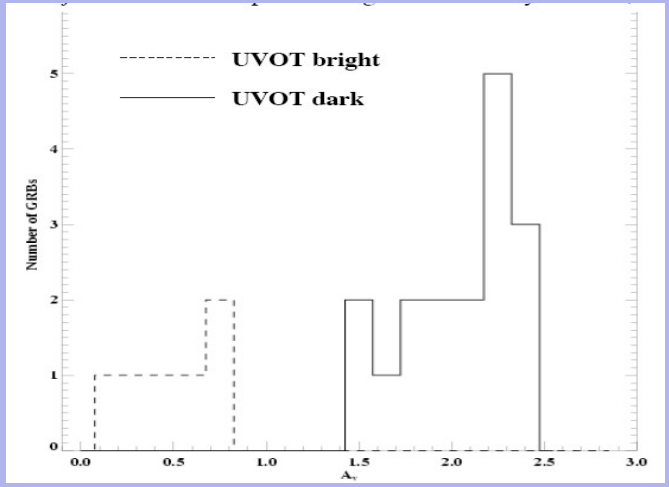


Figure 1. Galactic (sold), LMC (dashed) and SMC (dotted) extinction curves. Curve parameterisations are taken from Pei (1992)

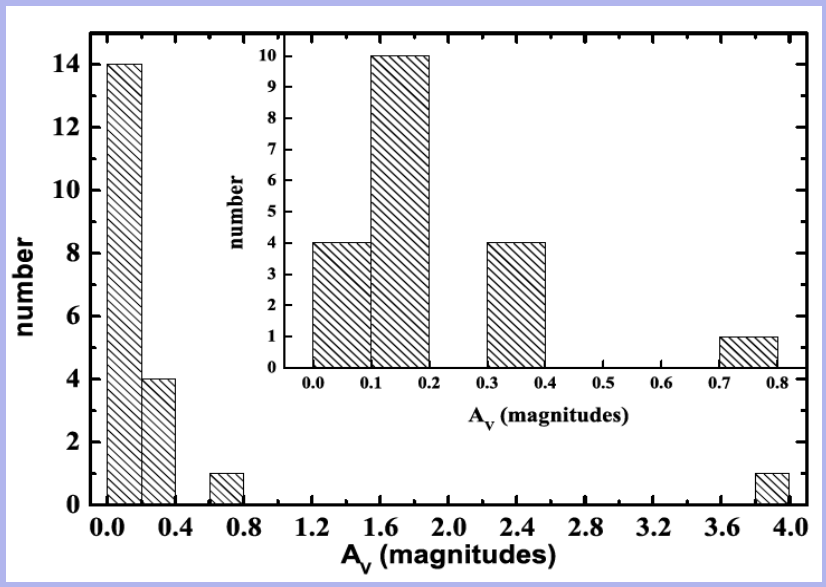


Gamma Ray Bursts with GROND





GRB 070802 is the first burst to be put in the 'dark burst desert'. GROND might break the observational bias of dark bursts



Gamma Ray Bursts with GROND

The SED of GRB070802 shows for the very first time:

i) High extinction in the host (UVOT selected A_V range only up to 0.6, observational bias)

ii) Dominant C2175 A feature in the host as seen in MW and LMC extinction models at redshift 2.45, implying the environment of GRB070802 is carbon richer than for previous bursts

iv) May dust destruction by the burst not play as an important role as previously thought ?

-> Utilizing the GROND NIR+optical capabilities for the dust properties in future burst may result in constraints in the cosmic dust formation up to very high redshifts.

-> Clarify the origin of dark bursts: Extincted or high z ?

Gamma Ray Bursts with GROND

Putting everything together yields an explosion scenario for GRB 070802:

- Long burst at redshift 2.45

- Mildly relativistic outflow from a compact source (most preferentially a collapsing WR star)

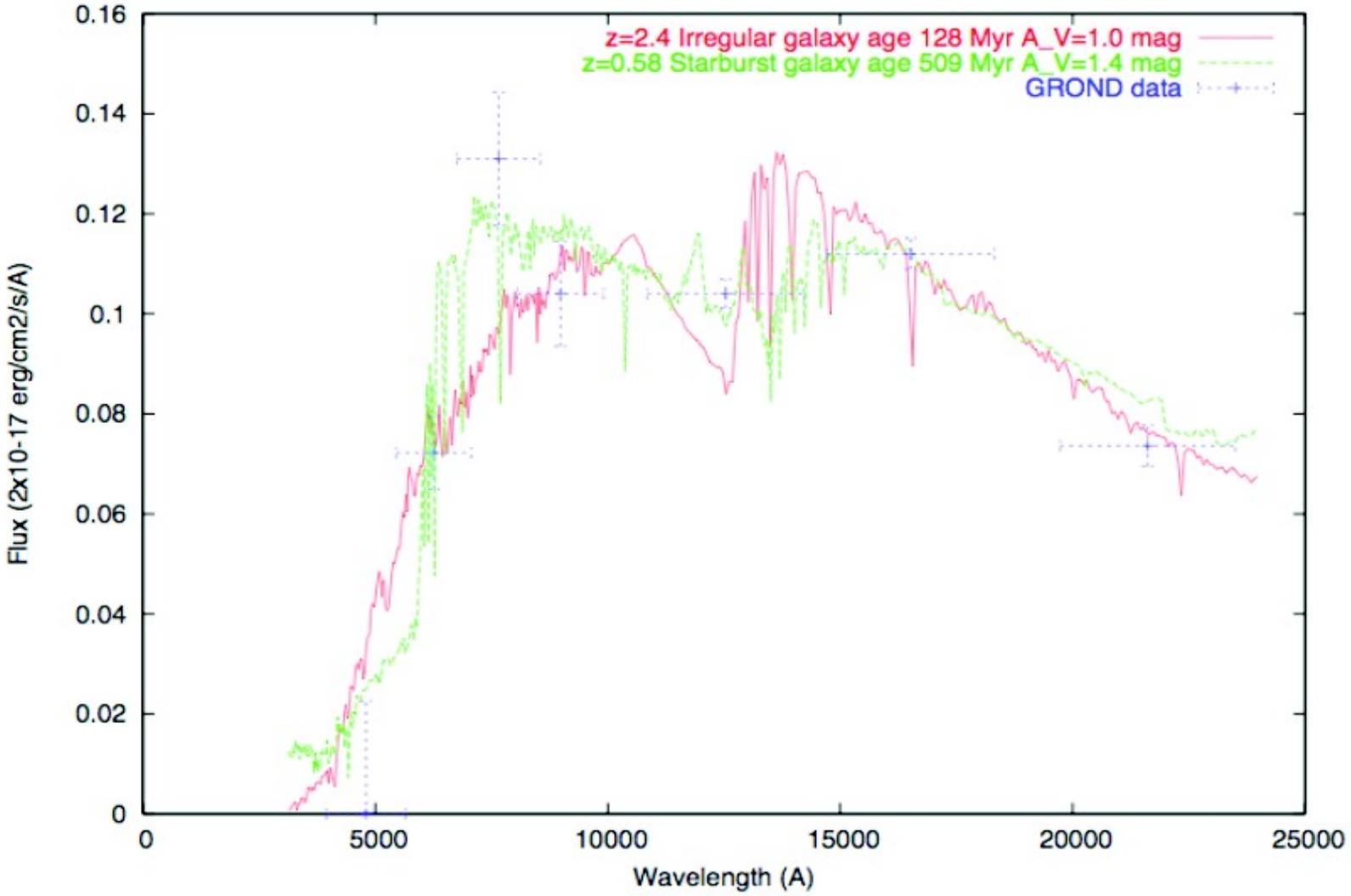
- The emission and energy production are dominated by baryons

- The circumburst medium is ISM like

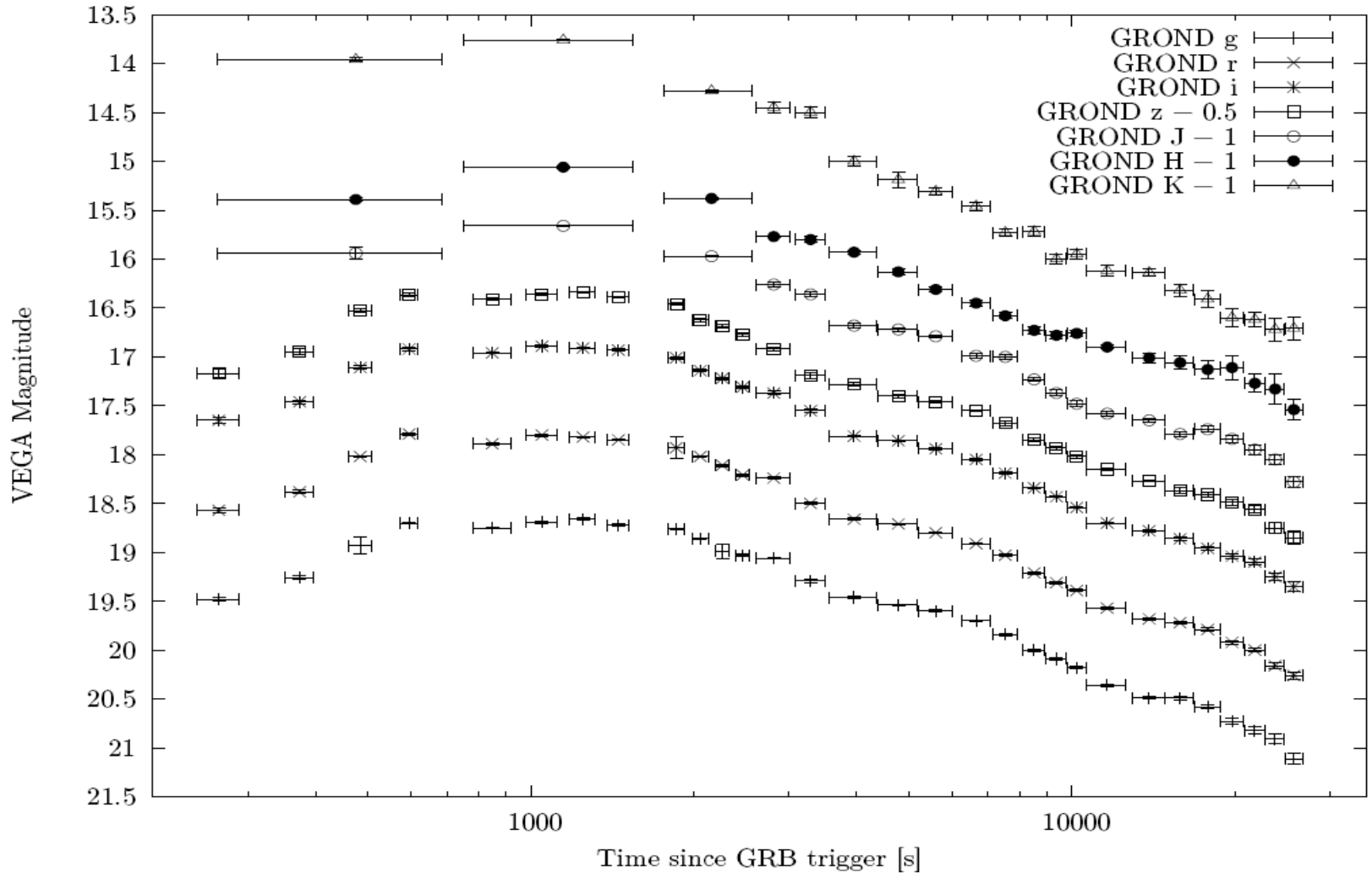
- The extinction in the host is MW-Like

- The host is Carbon rich

Gamma Ray Bursts with GROND



Gamma Ray Bursts with GROND



Gamma Ray Bursts with GROND

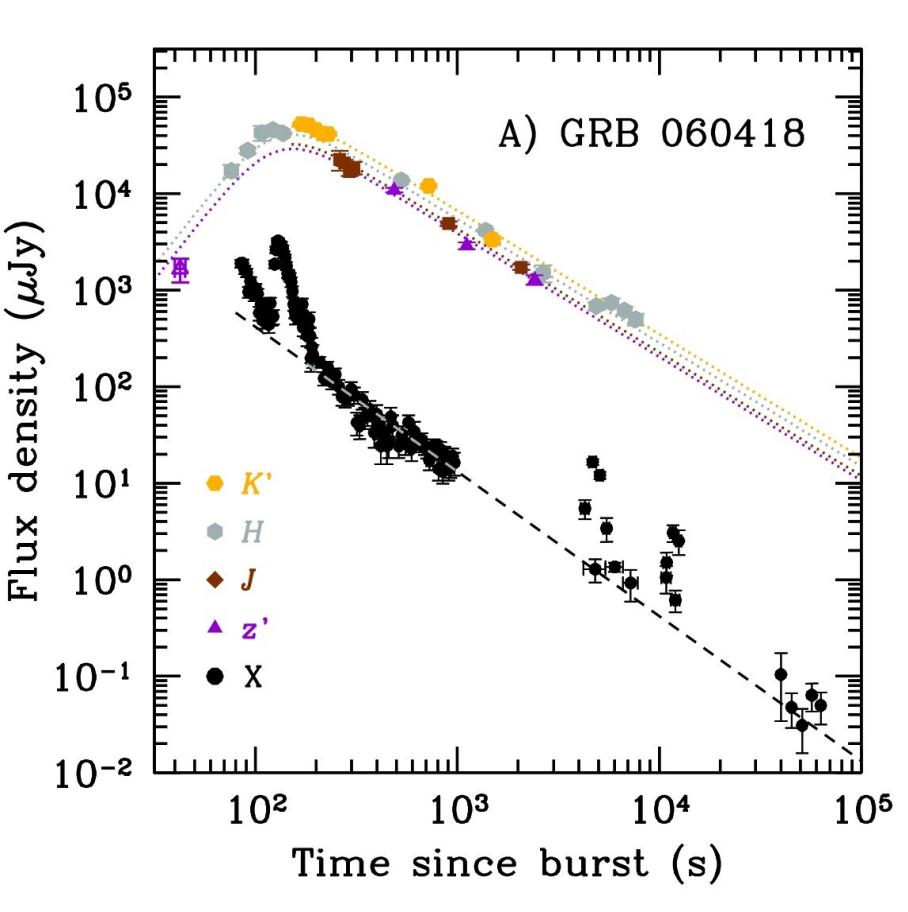
- With GROND beeing operational, there is now a unique tool combining medium sized telescope aperture, rapid response, NIR capabilities and a (rather) large FoV for the investigation of GRB afterglows (primarily, but not only)

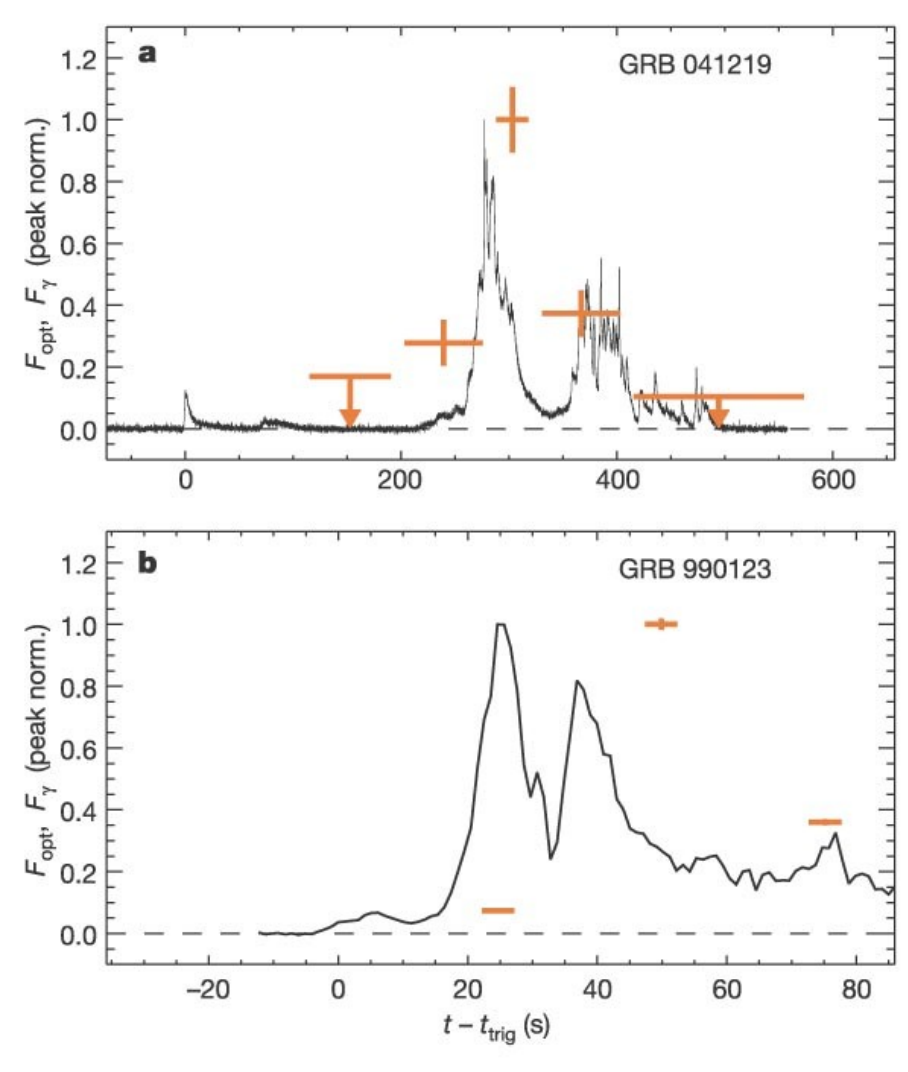
- Within 4 months operation, GROND imaged the Afterglow of ~10 GRBs, 2 prompt triggers (reaction time 70 s and 7min) and found ~4 host galaxies with first results waiting to be published (soon ...)

- Still waiting for the high-z GRB !

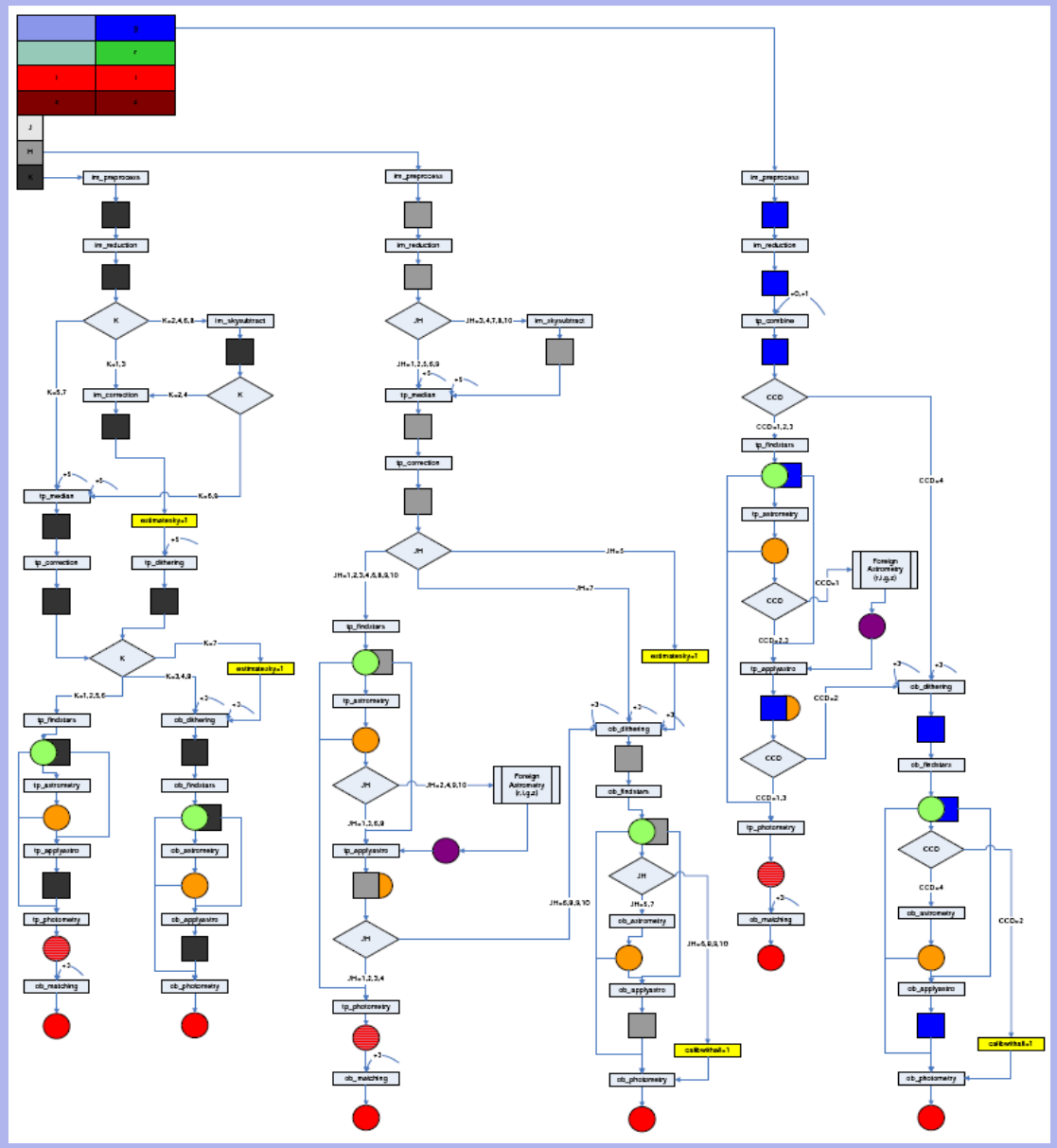
Gamma Ray Bursts – GROND

Gamma Ray Bursts - GRBs

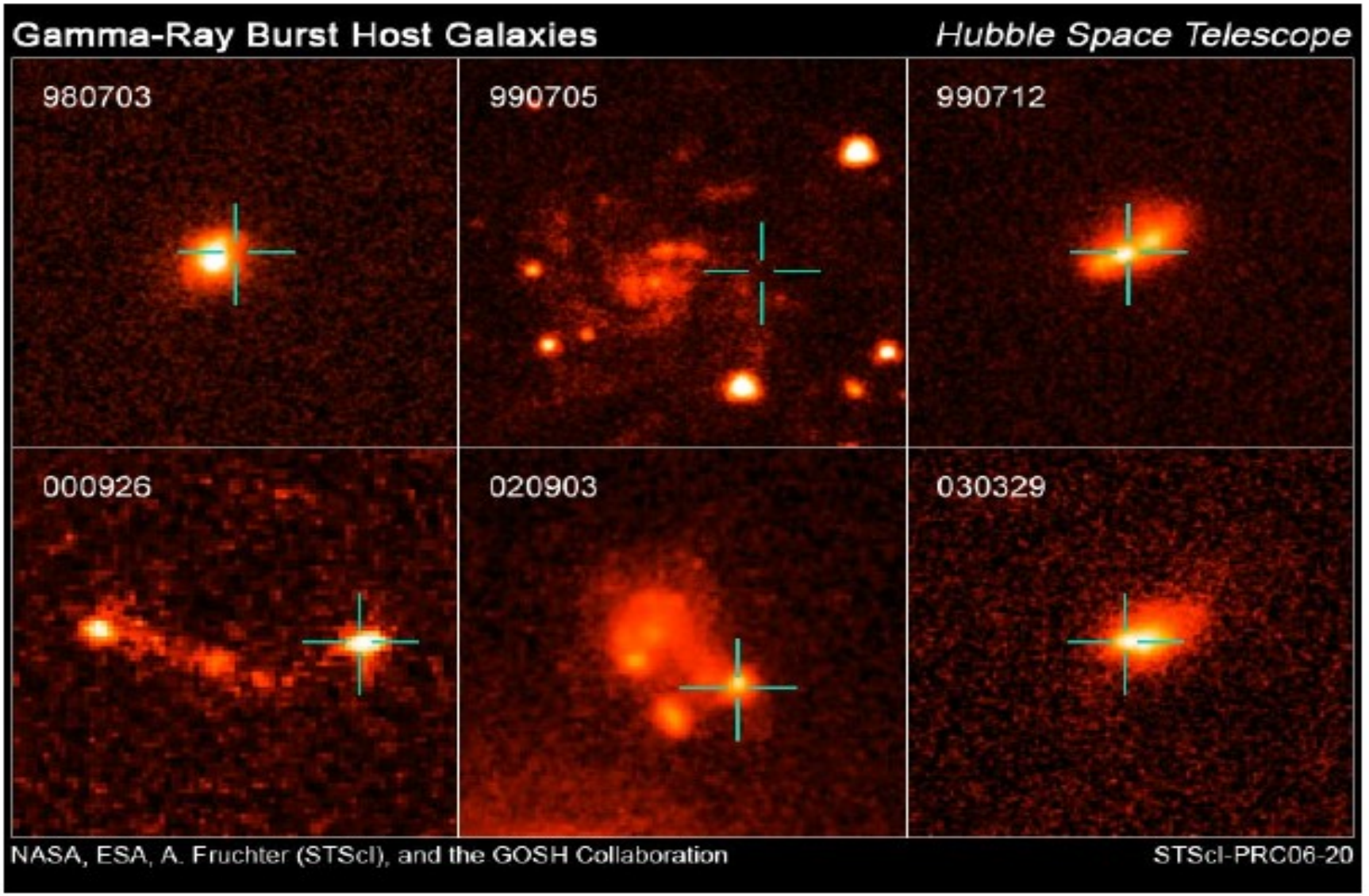




Gamma Ray Bursts - GROND Pipeline

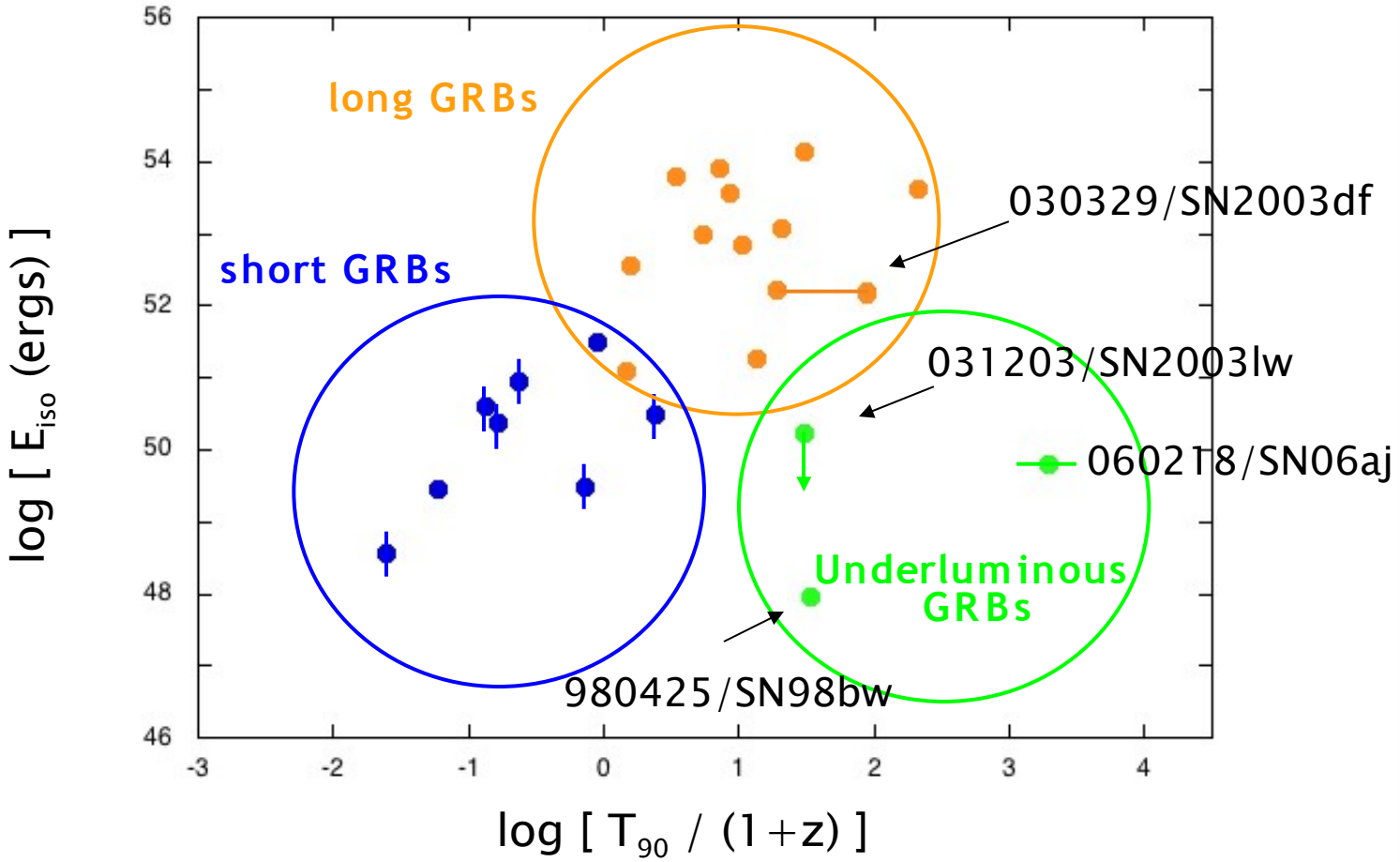


Gamma Ray Bursts – Host galaxies



Gamma Ray Bursts - GRBs

A THIRD CATEGORY ???

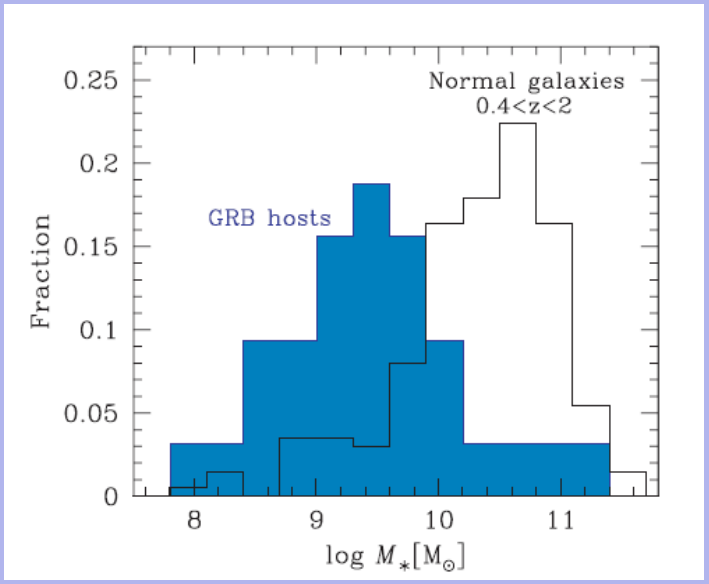


Gamma Ray Bursts - GRBs

- Morphologies of GRB Hosts are normal for their redshift
- Position of GRBs within their hosts trace the (young) starlight
- GRB Hosts have low metallicities, low masses
- Host spectra are consistent with actively star forming galaxies

-> Select Star Forming Galaxies
at high redshift

-> Probe the Star Formation History



Gamma Ray Bursts - GRBs