Dark Cosmology Centre

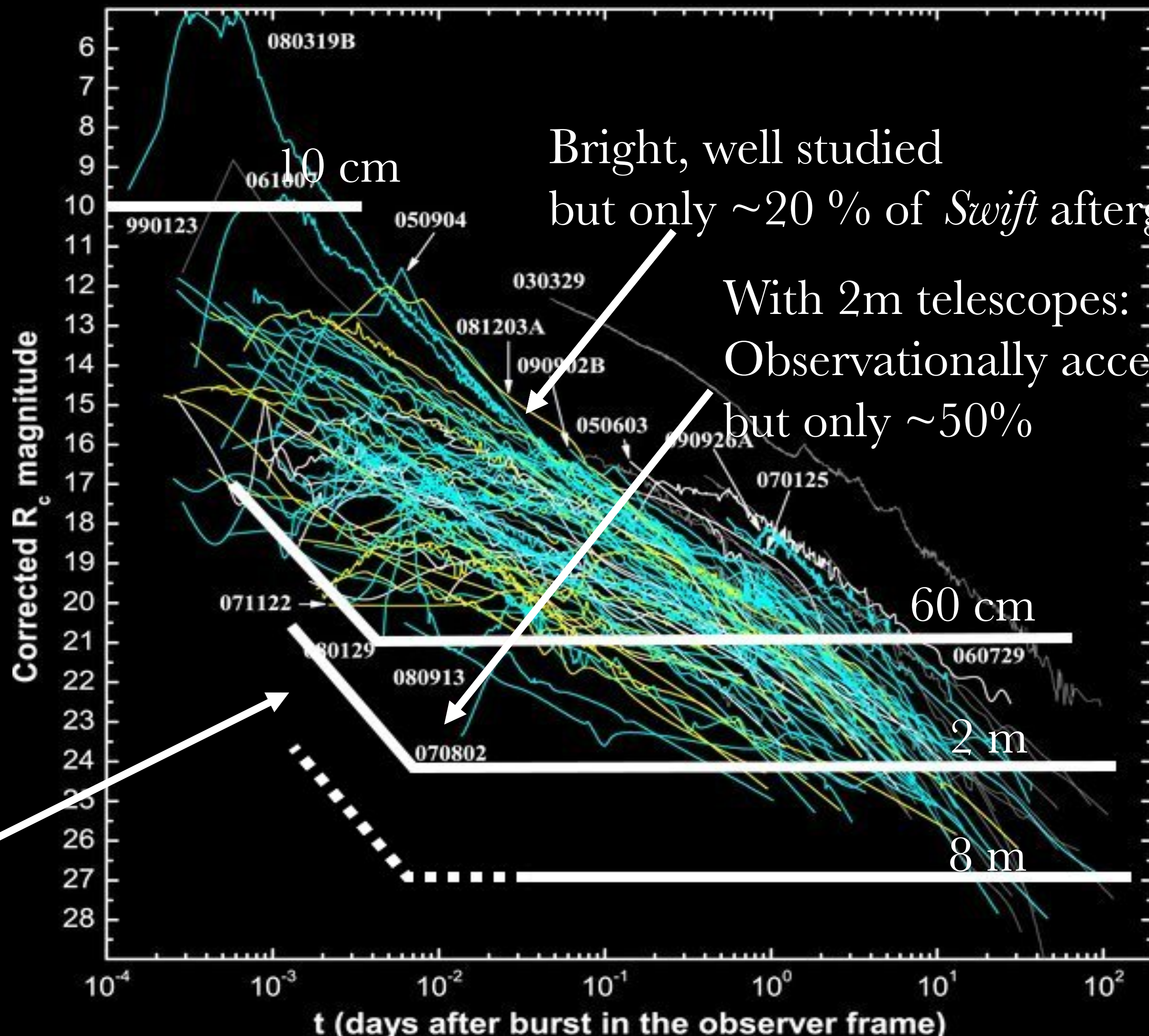
Observational Aspects of Gamma-ray Burst Afterglows

Thomas Krühler (DARK)

Thanks to J. Greiner, J. Fynbo, D. Malesani, R. Filgas, A. Kann and many others

Gamma-Ray Bursts 2012 @ Munich 08/05/2012

Afterglows



Bright, well studied
but only ~20 % of *Swift* afterglows

With 2m telescopes:
Observationally accessible
but only ~50%

Afterglows, that
we typically miss:

Intrinsically faint ?
dust extinguished ?
high-z ?

Kann+ 10

Afterglows and redshifts

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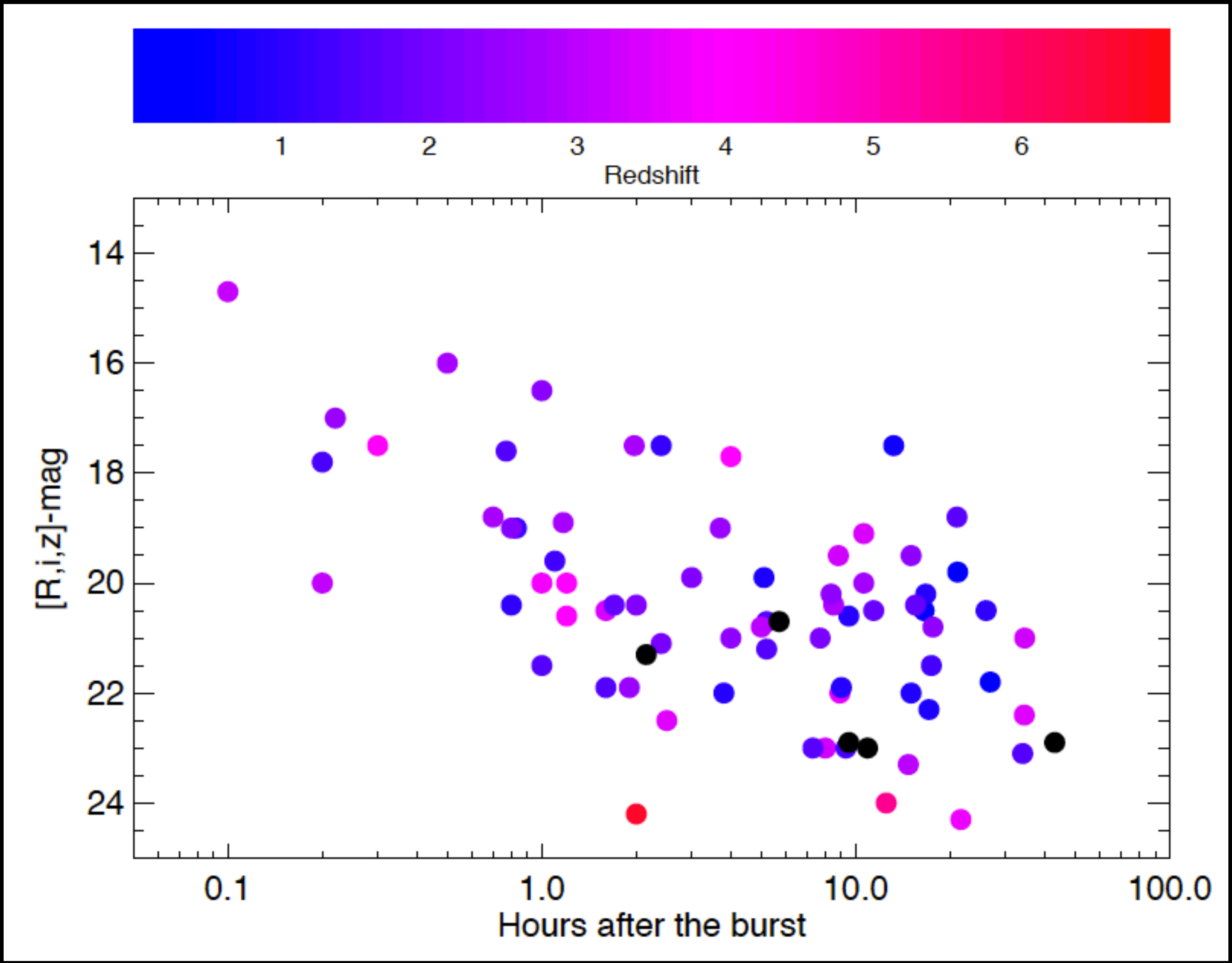

Fynbo+ 09

Afterglows and redshifts

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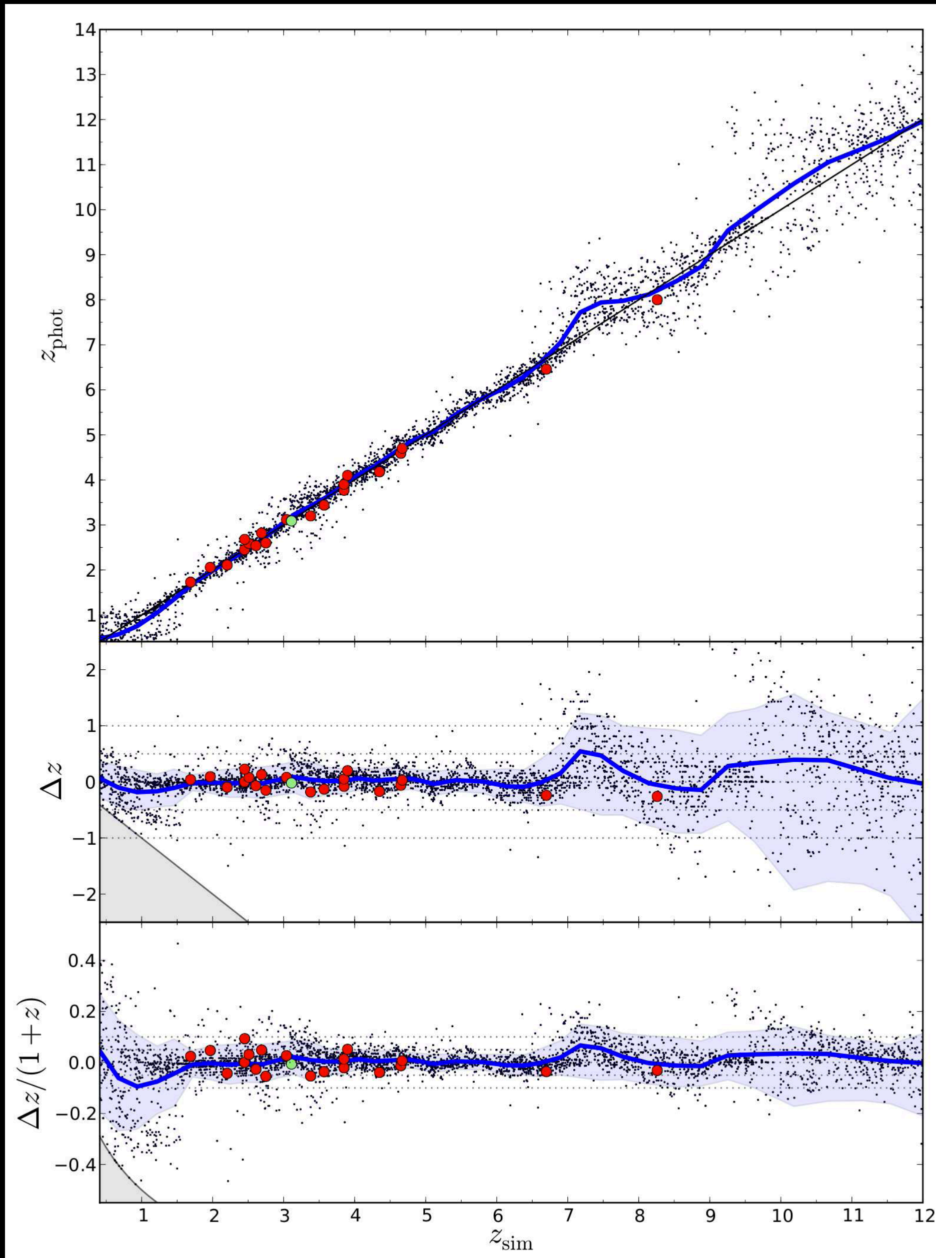
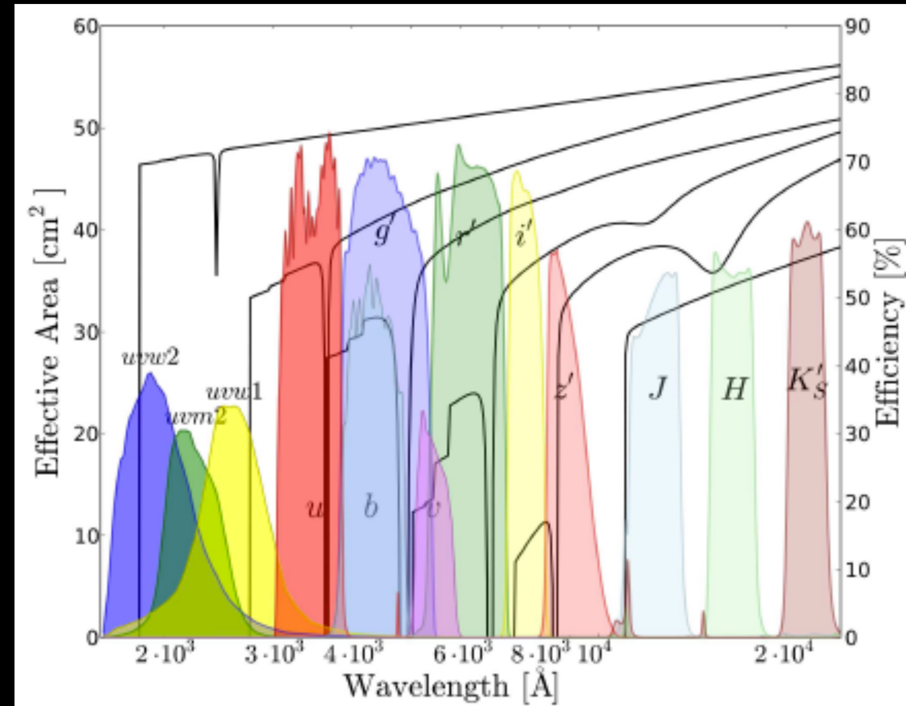
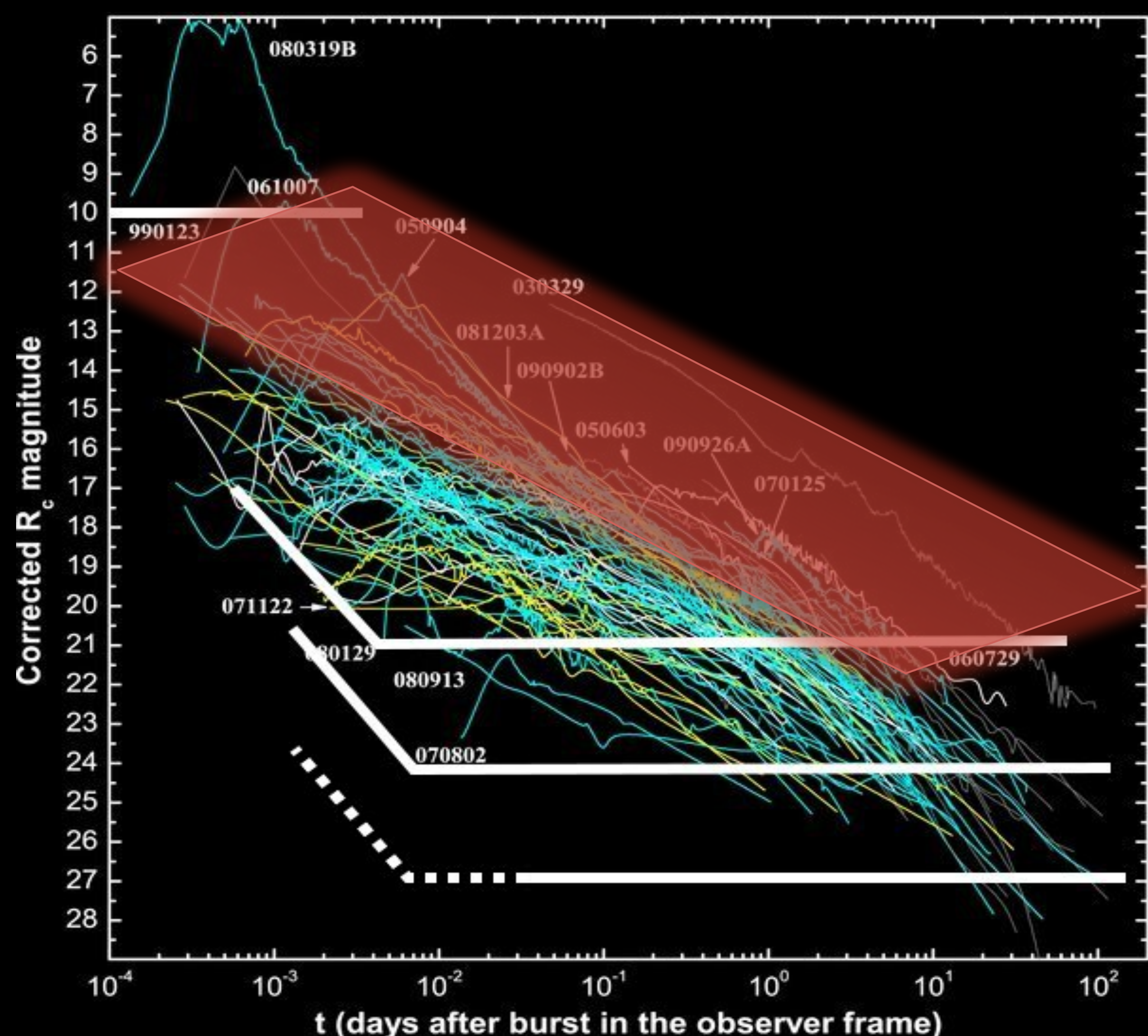




- Very good and robust photo-z's up to z ~ 10
- Simple spectrum
- Unique identification

TK+ 11

Afterglows



Kann+ 10

The afterglows of LAT bursts

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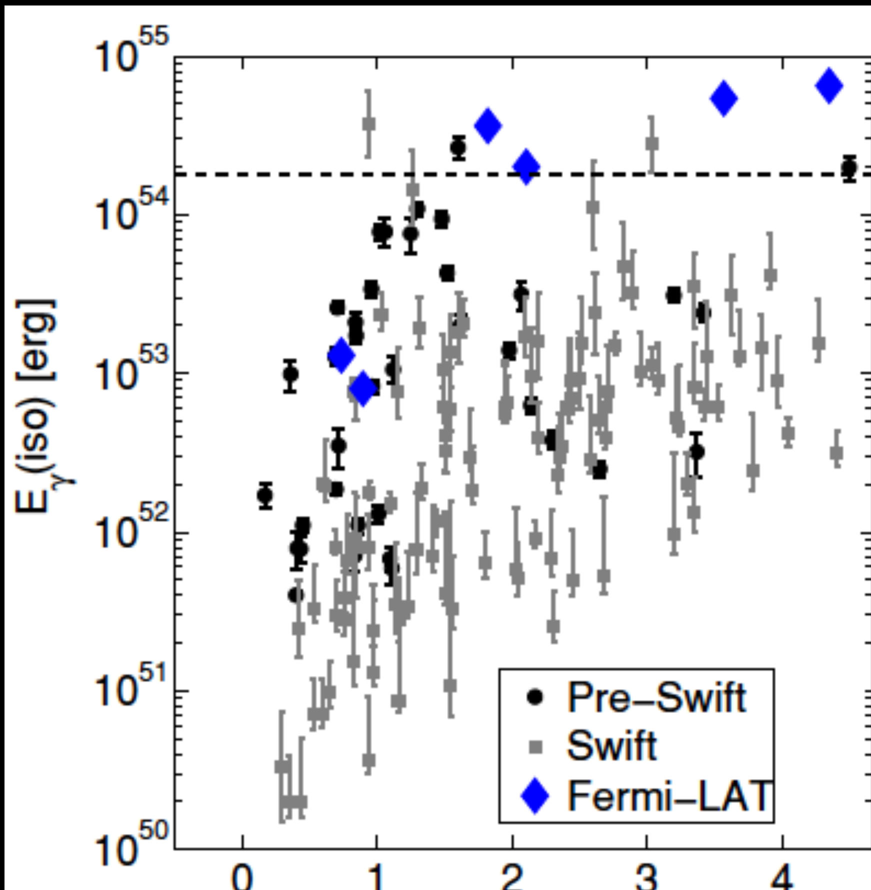
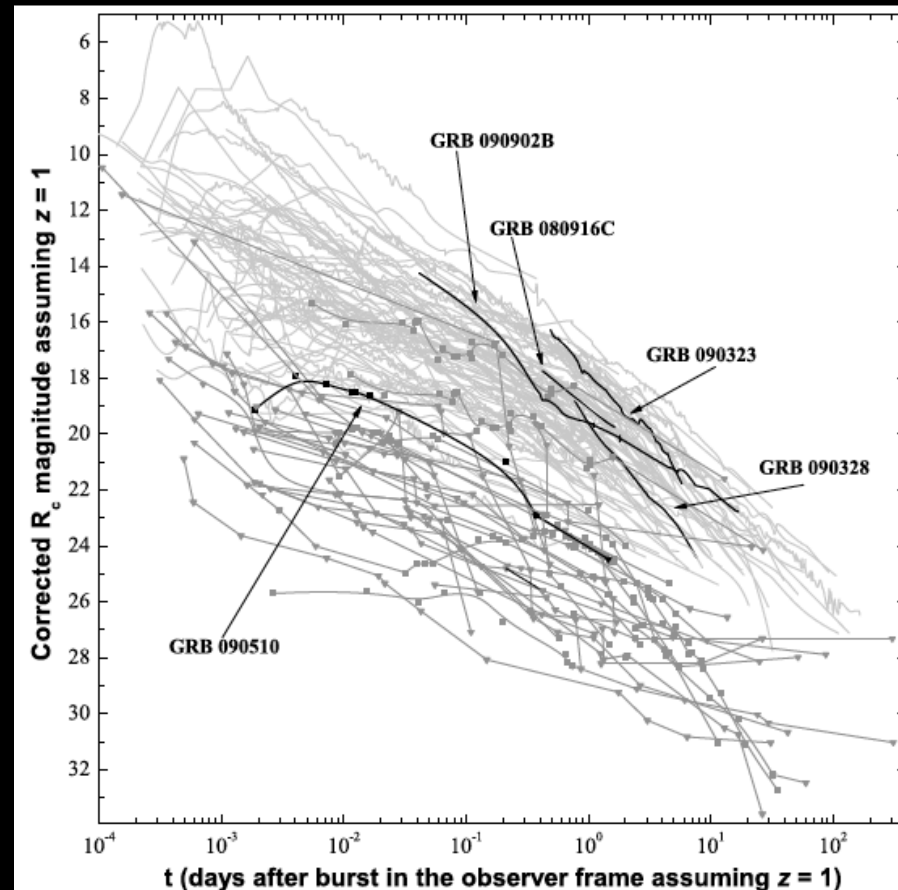


Cenko+ 11



McBreen+ 10

See also Greiner+ 09, Amati+ 09, Pandey+ 10, Rau+ 10, de Pasquale+ 10, Swenson+ 10, Racusin+11, Panaitescu 11, Nicuesa+ 12, Urata+ 12 ….

Afterglows

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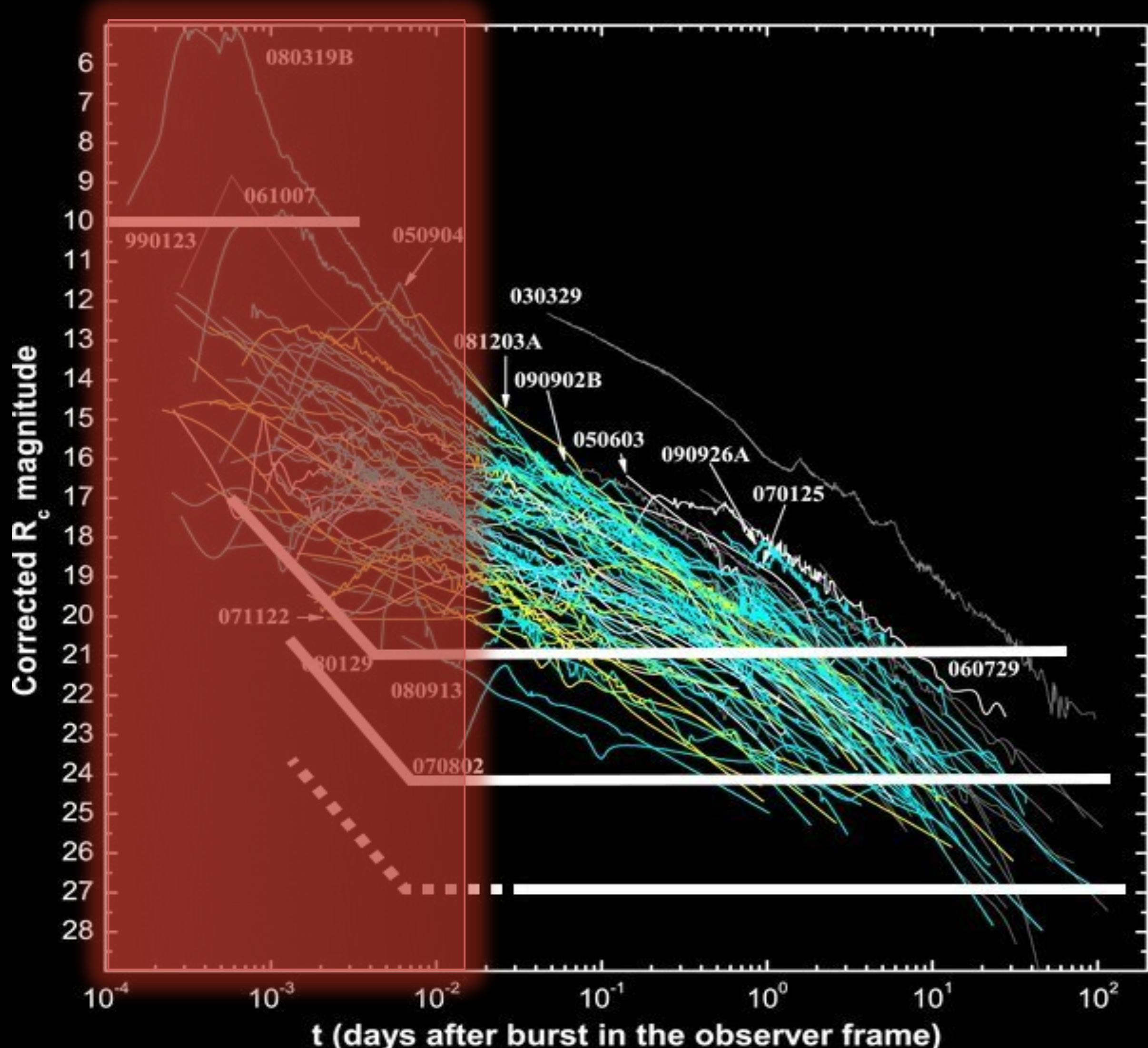

Kann+ 10

The onset of the afterglow

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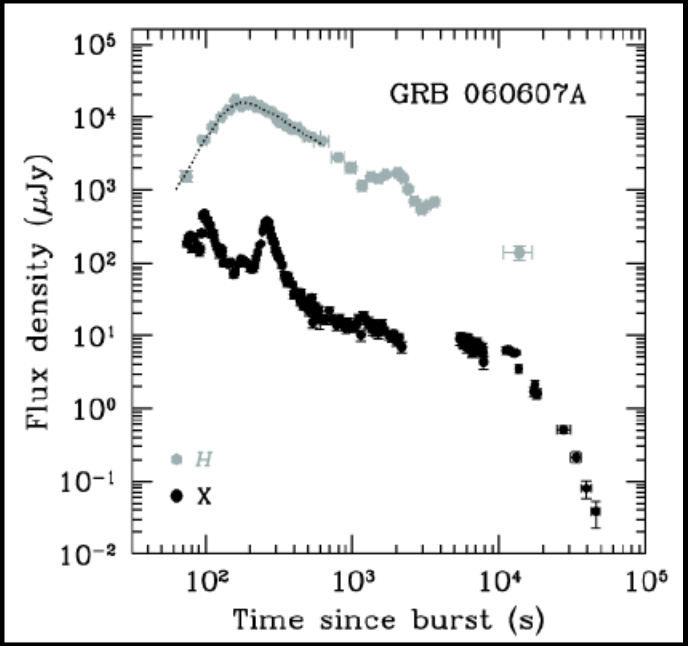
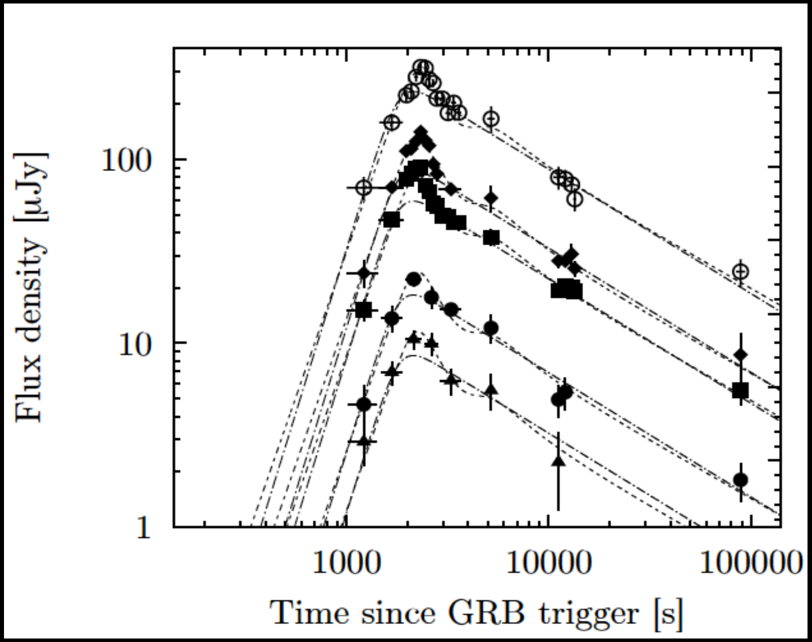
- Early rise ($t^{0.5\text{-}4}$)
- Peaking at < 100 … 1000 s
- Smooth turnover to decay
- Achromatic



Molinari+ 07



e.g., Molinari+ 07, Krühler+ 08,09, Greiner+ 09, Perley+ 10, Melandri+ 10, Liang+ 10, Oates+ 10, Cucchiara+ 11

The onset of the afterglow

Forward shock is dominating the optical emission most of the time:

* Lorentz-factor Γ = 100-500

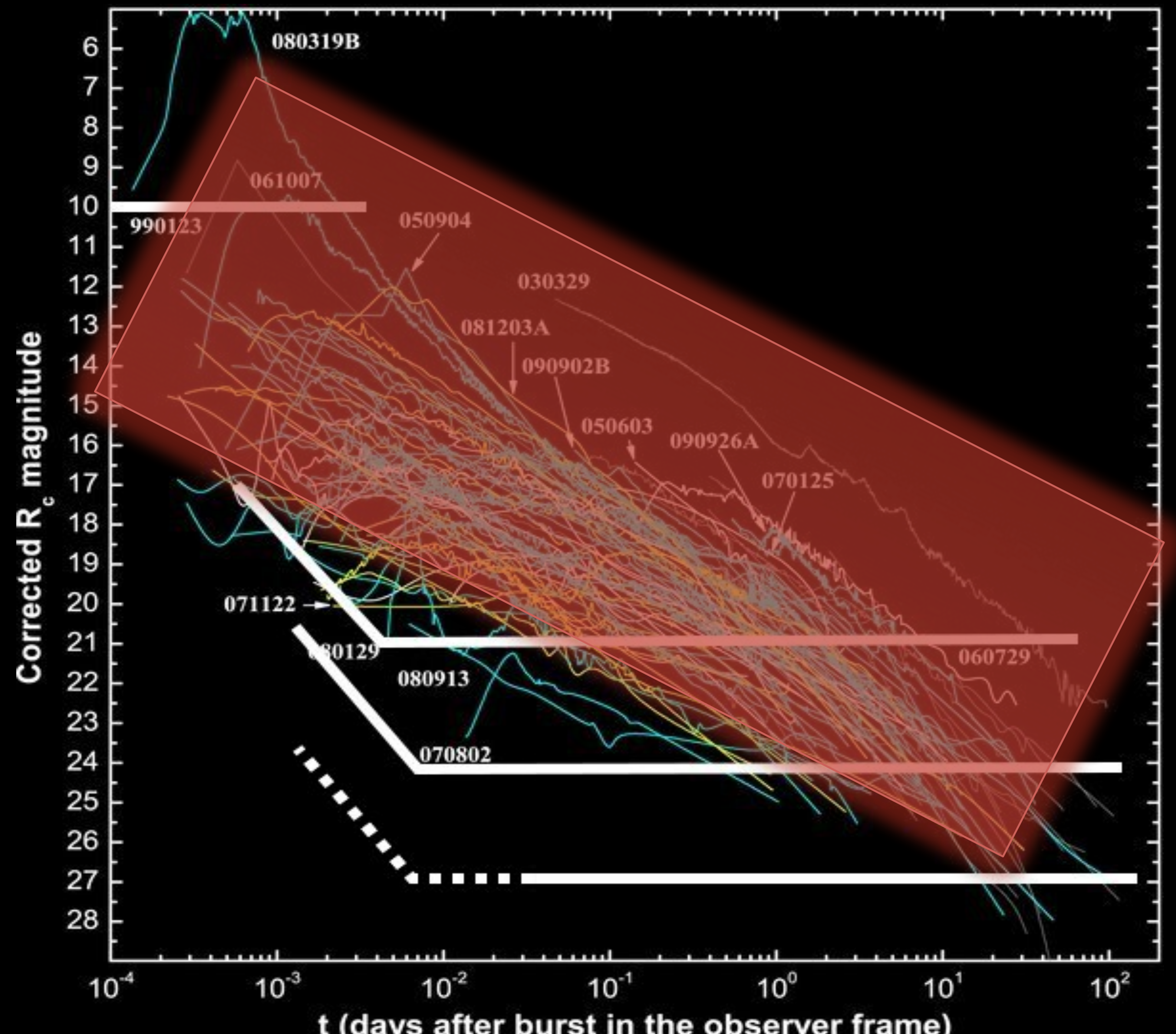
  -> Direct measurement of ultra-relativistic nature

* Deceleration radius $R_{dec} \sim 10^{17}$-10^{18} cm

  -> Direct measurement of emission region

* Correlation between Γ and $E_{\gamma,iso}$ (Liang+ 10)

Afterglows


080319B
061007
990123
050904
030329
081203A
090902B
050603
090926A
070125
071122
080129
080913
070802
060729
Corrected R_c magnitude
t (days after burst in the observer frame)

Broad-band lightcurves

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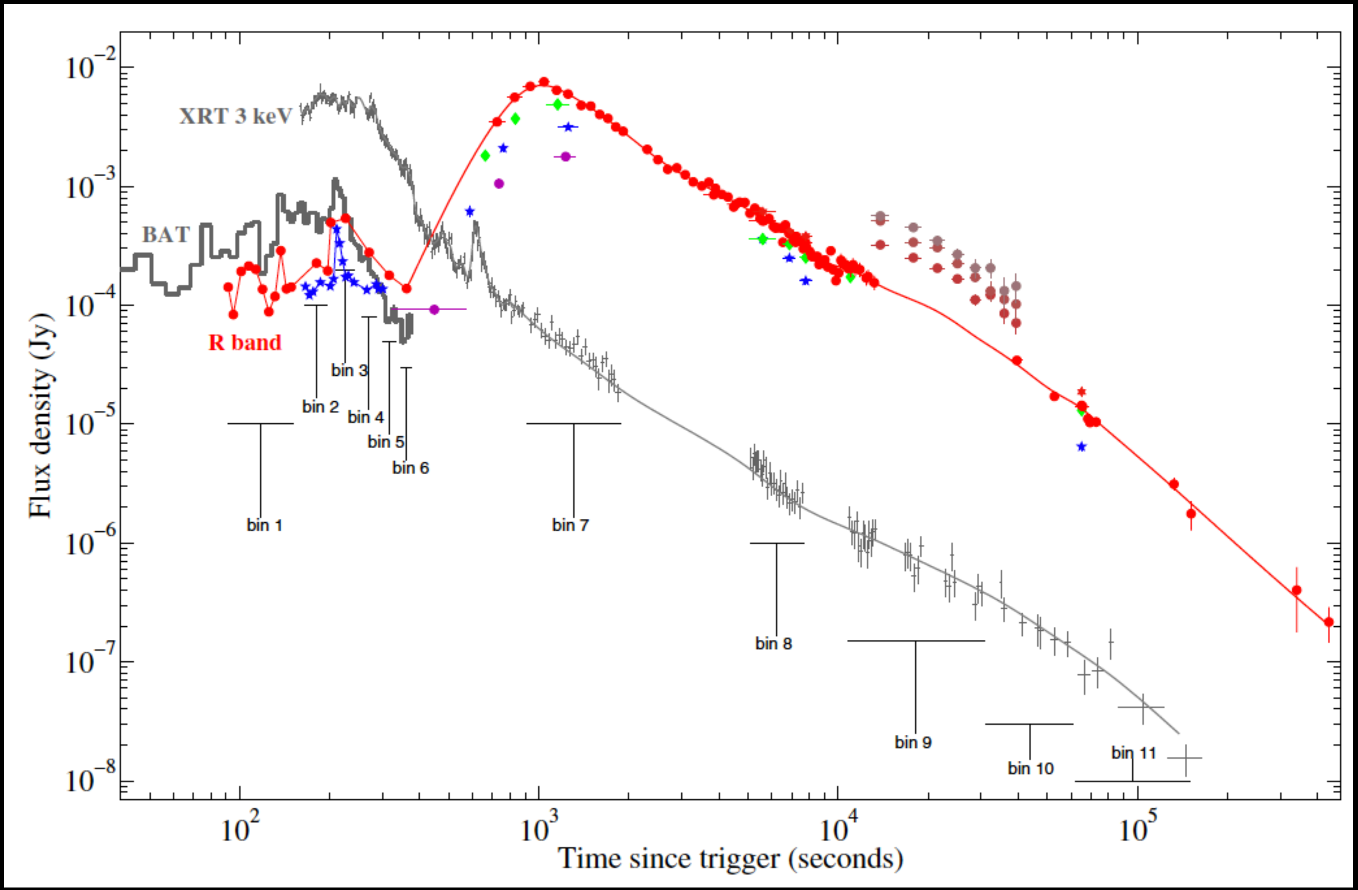
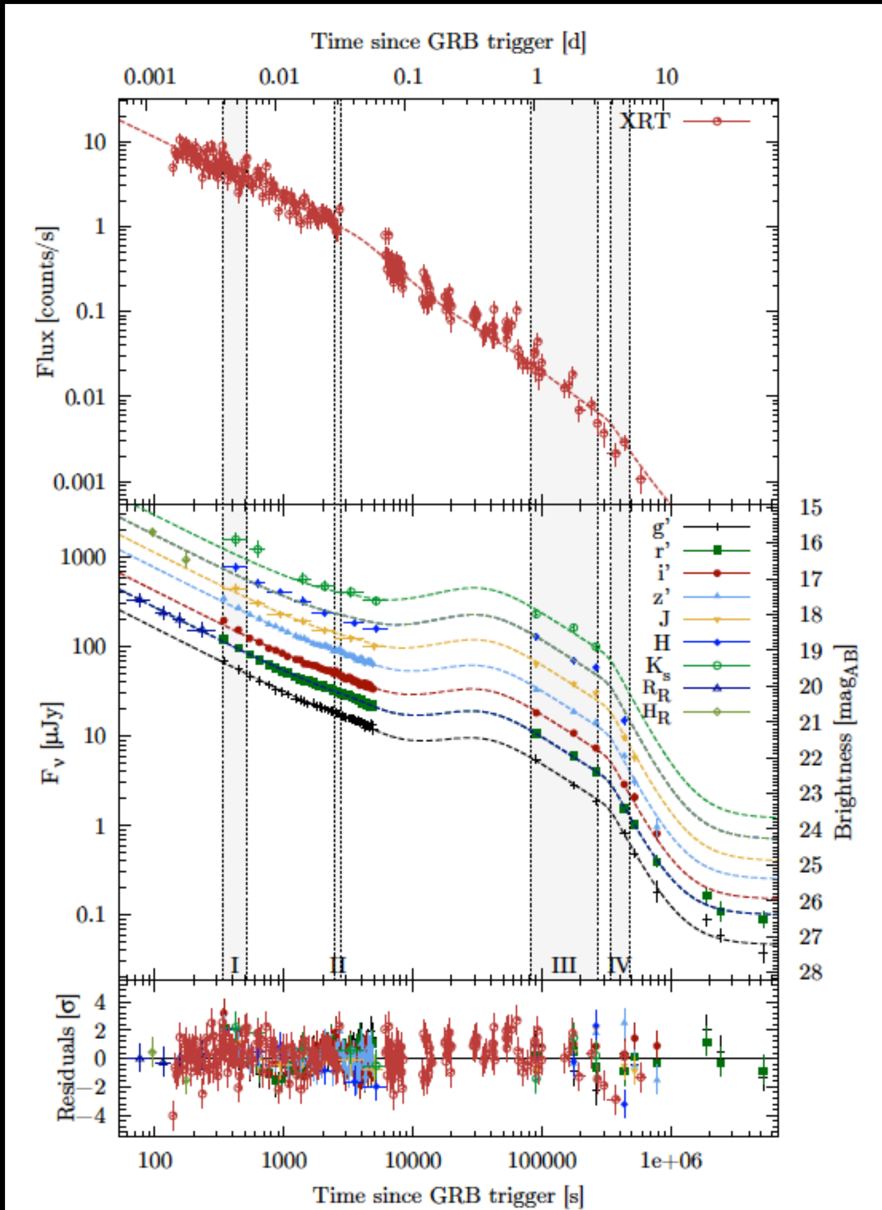


Gendre+ 12
(see also Cucchiara+ 11,
Zheng+ 11,
Gao+ 11)

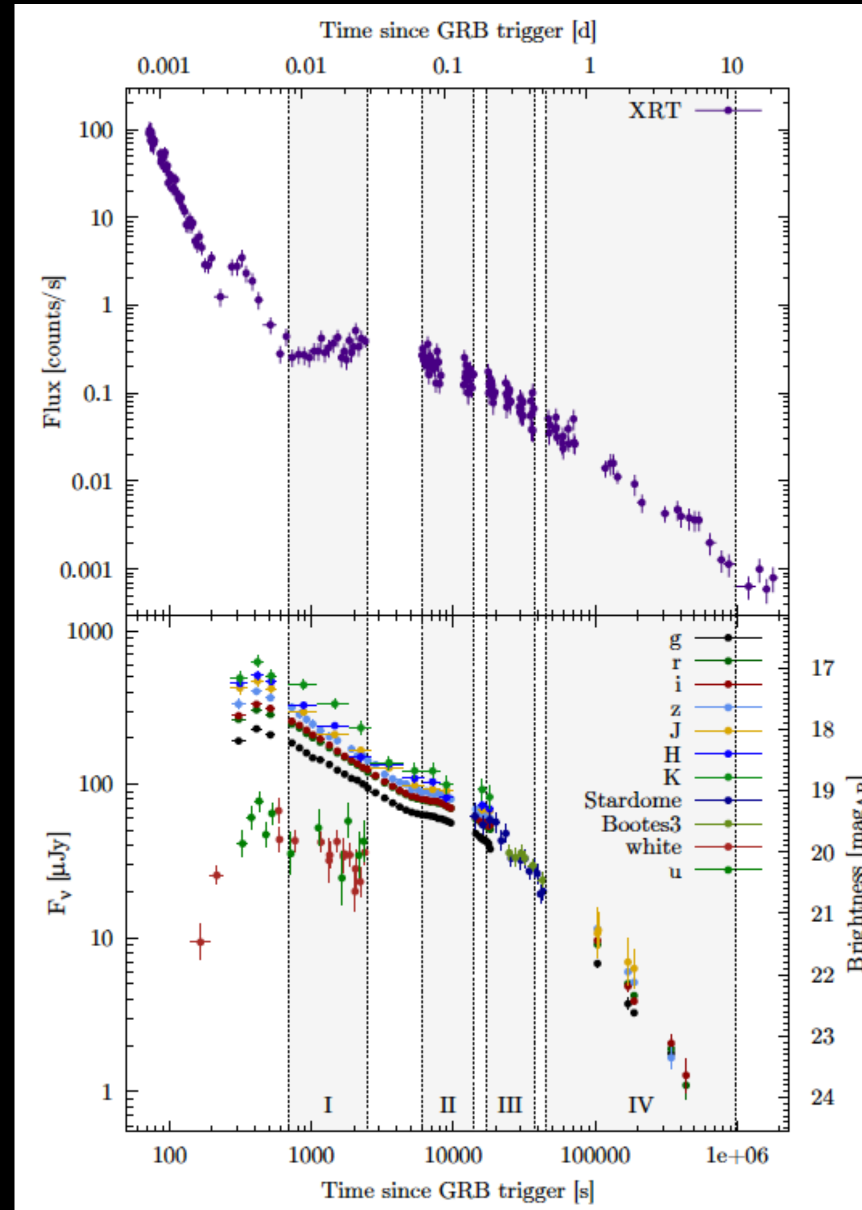
- Prompt phase (Gamma-, X-ray and optical)
- Reverse Shock & Forward shock afterglow
- RS optical only
- Jet break and post jet break light-curve evolution

Broad-band lightcurves

Dark Cosmology Centre



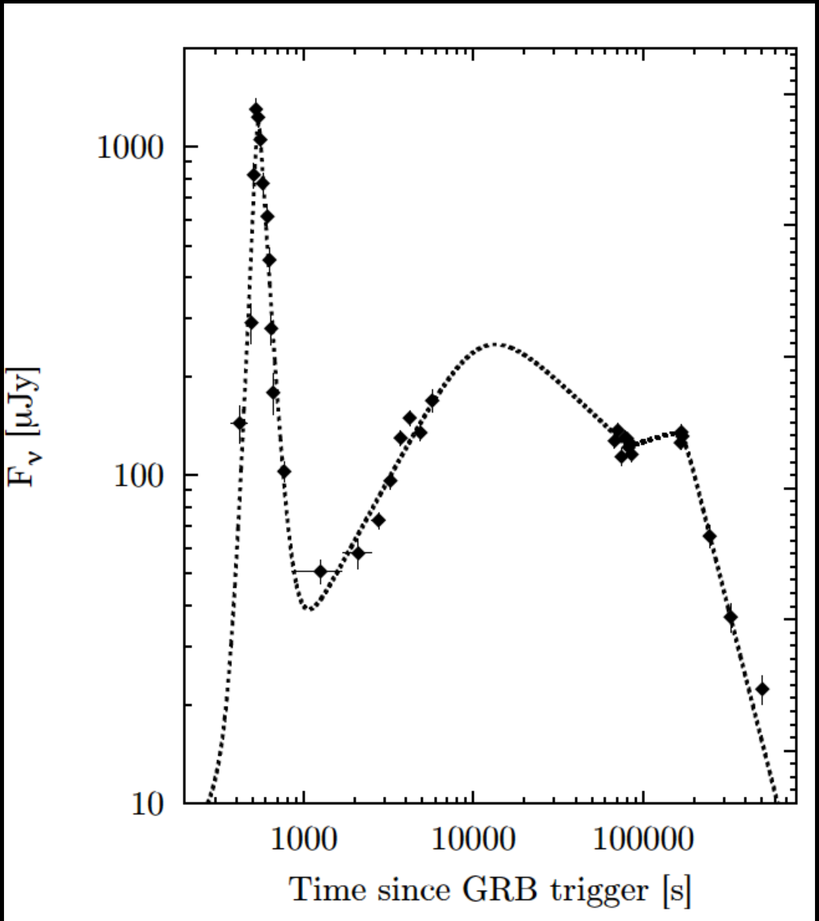
Filgas+ 11



Filgas+ 12

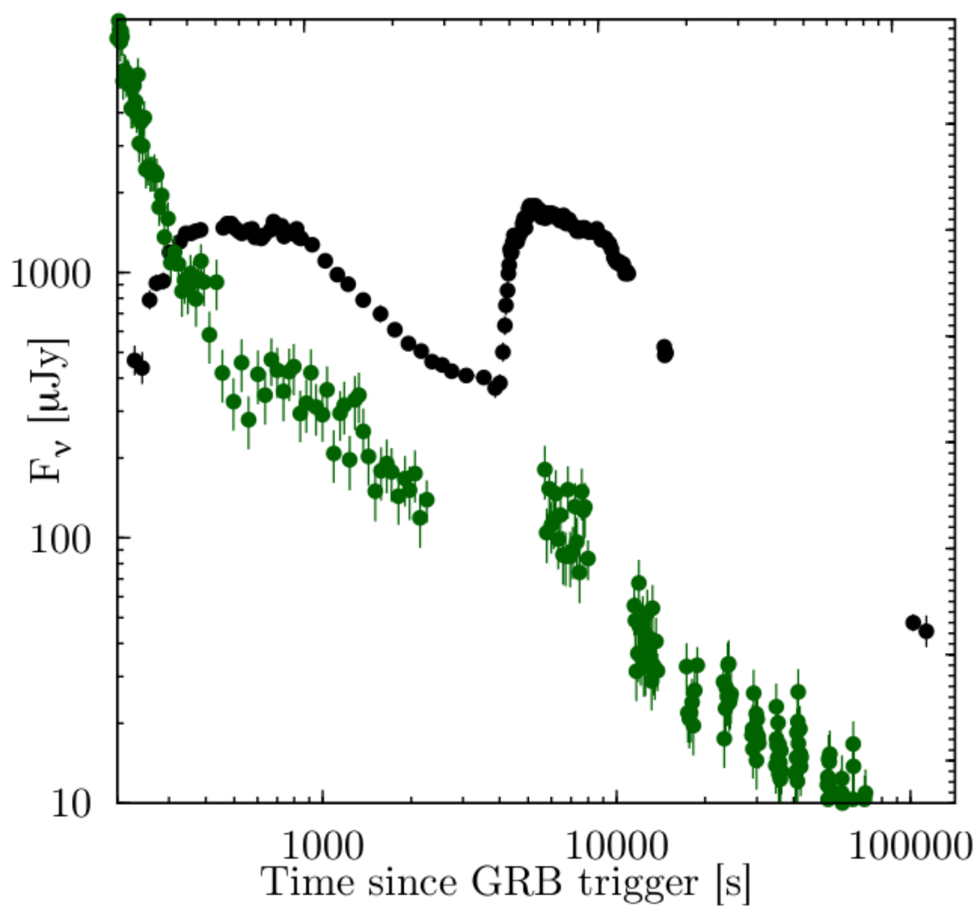
Variability

Flares



Greiner+ 09

Jumps



TK+ 11

Talk by M. Nardini

Conclusions I

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- The brightest (well-studied) afterglows continue to give important insights into GRB physics
- LAT GRBs are energetic and have luminous afterglows
- Some events are well reproducible with simple fireball scenarios
- Most of the well studies events pose challenges:

-> Decoupling between optical and X-ray light-curves

-> Variability and morphology of the optical light-curve

Conclusions I

- Open questions:

  -> Role of magnetic fields (Reverse shock, polarimetry …) (-> Talk by K. Wiersema)

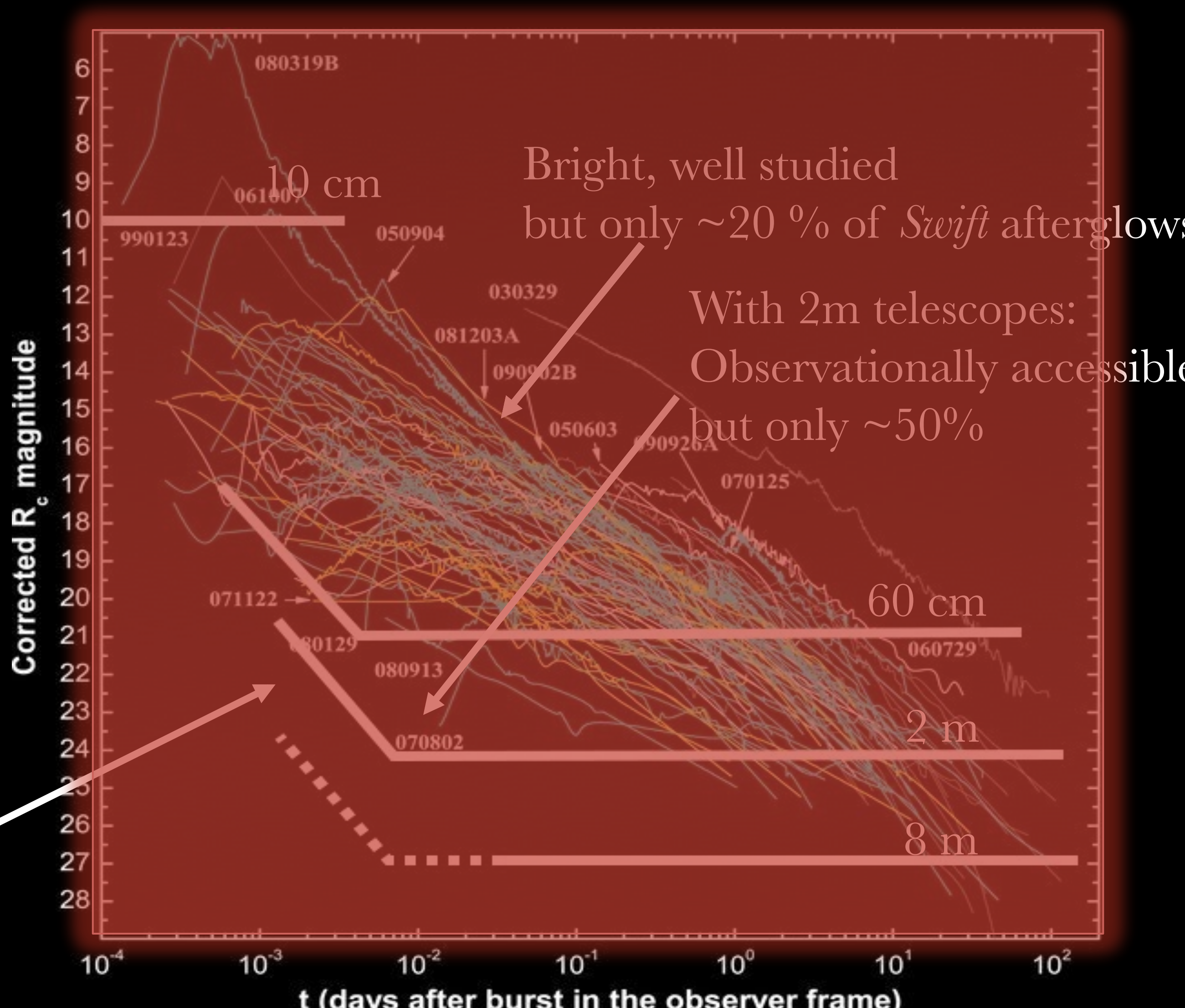
  -> Mechanism to decouple optical from X-ray light curve

  -> Long-term activity of the central engine

  -> Temporal evolution of the microphysical parameters

Afterglows

Dark Cosmology Centre



Afterglows, that
we typically miss:

Intrinsically faint ?
dust extinguished ?
high-z ?

Kann+ 10

Optically selected GRB samples

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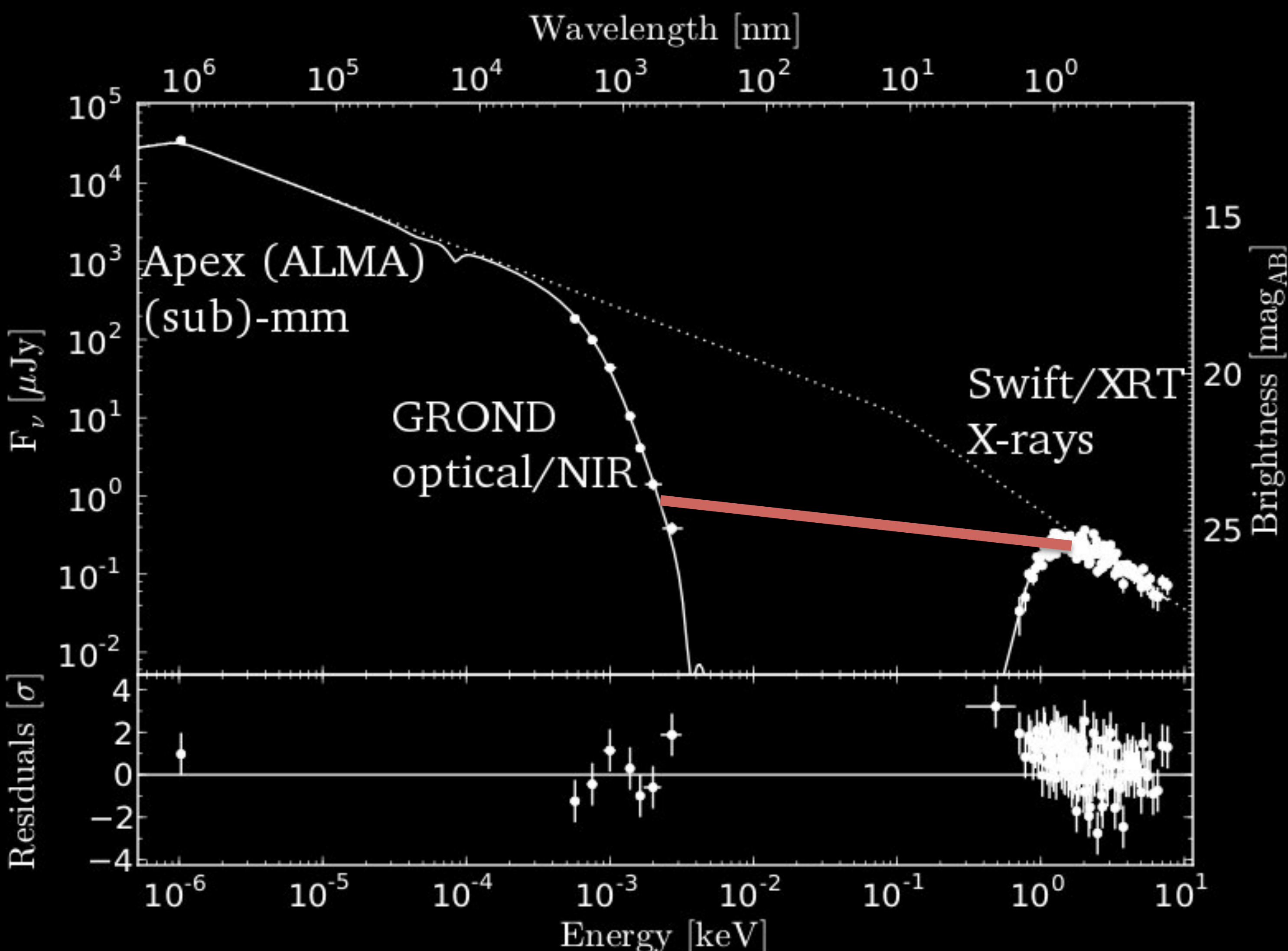
- P60 (Cenko+ 09, Perley+ 09)
- UVOT (Roming+ 09, Oates+ 09)
- GROND (Greiner+ 10)
- Liverpool & FTS/N (Melandri+ 08)
- VLT (Fynbo+ 10, Zafar+ 11)
- ROTSE (Rykoff+ 09)
- Dark hosts (Perley+ 09, 12) -> Talk by D. Perley
- VLT hosts (Hjorth+ 12, Malesani+ 12, Jakobsson+12, Milvang-Jensen+ 12, TK+ 12) -> Talk by J. Hjorth
- VLT dark hosts (Rossi+ 12) -> Poster by S. Klose
- Bright Swift events (Salvaterra+ 12, Melandri+ 12, Campana + 12, Nava+ 12) <- Talk by L. Nava

1. The nature of dark GRBs



Optically selected GRB samples

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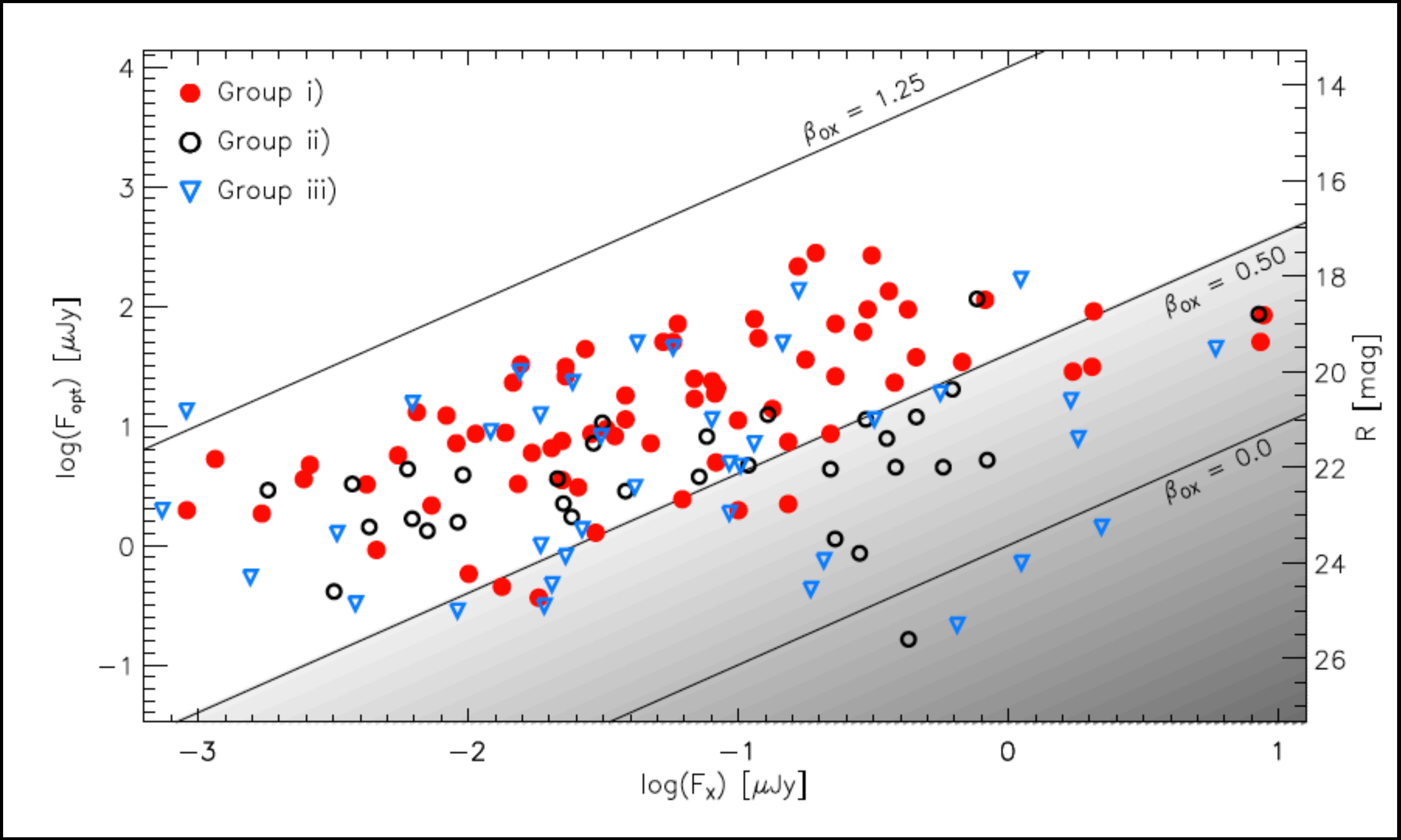
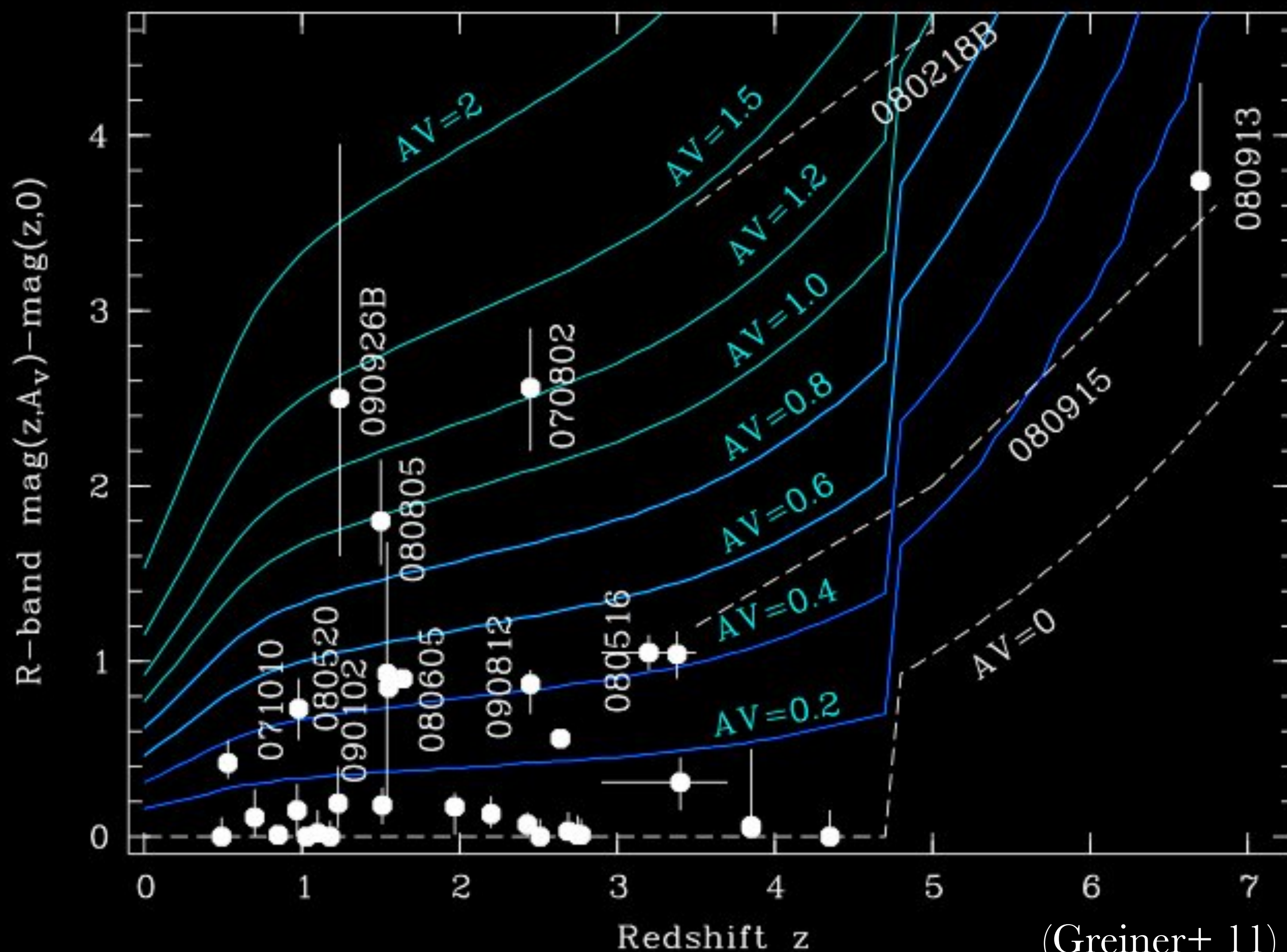
1. The nature of dark GRBs



Jakobsson+04, Fynbo+ 09

1. The nature of dark GRBs



(Greiner+ 11)

1. The nature of dark GRBs

Dust Abundance:

* Previously: Little dust extinction in previous studies (optically selected)

* Due to GROND NIR capabilities:
- Increased detection rate
- Higher dust columns

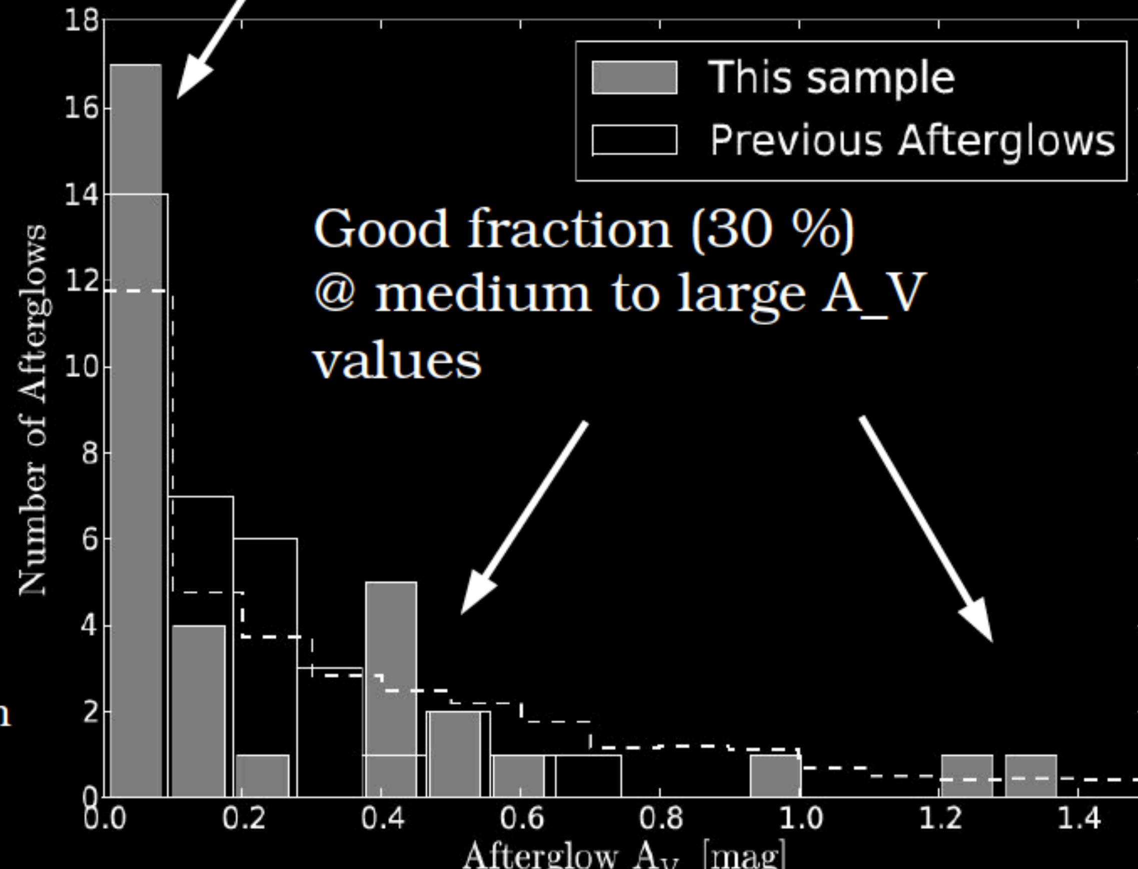
* Up to $A_V \sim 4$

* Never directly measured in previous GRB afterglows

-> Dominant cause of 'dark' GRBs

Large fraction (50 %) @ low A_V values

Good fraction (30 %) @ medium to large A_V values

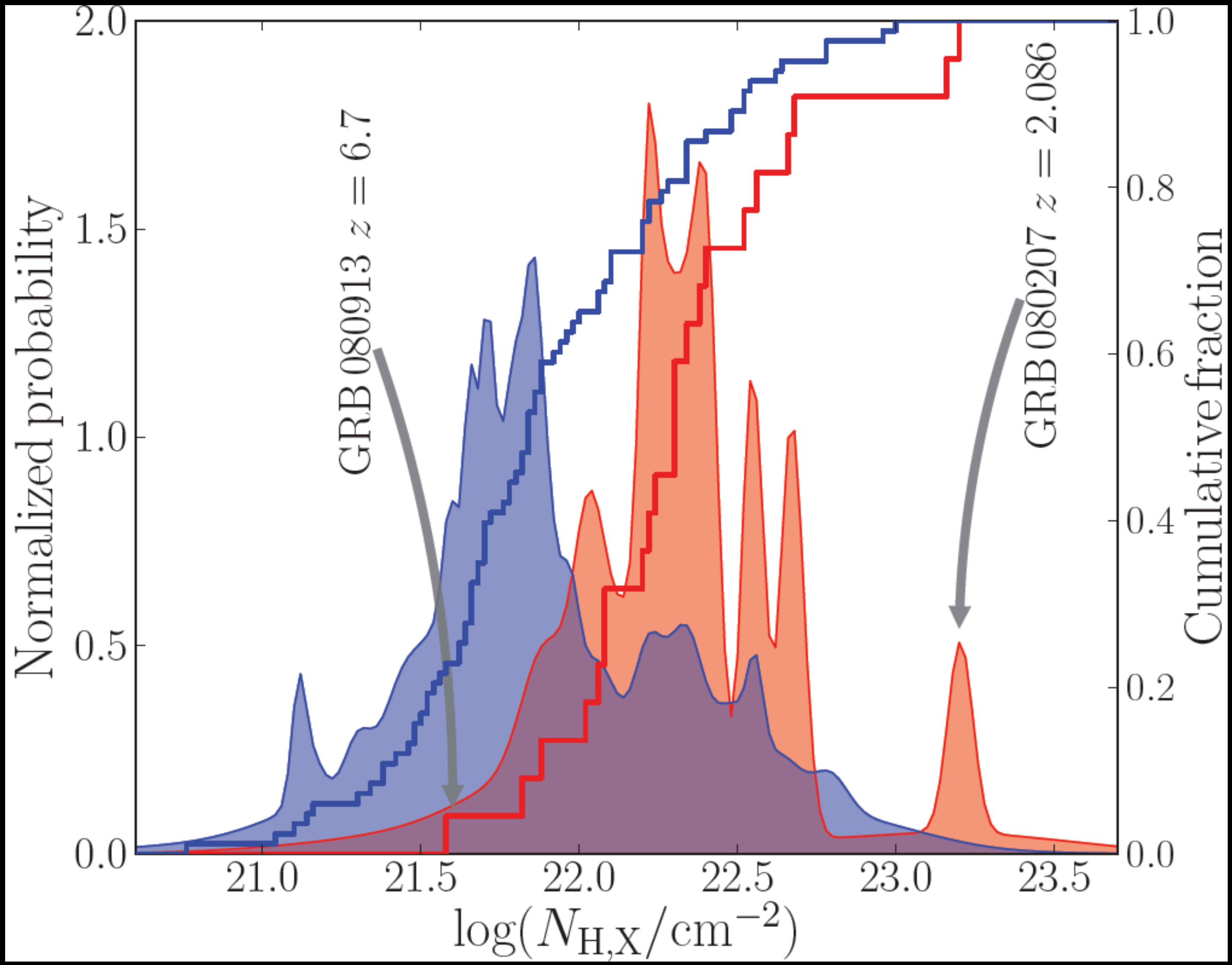


-> Talk by P. Schady

JG, TK + 10

Optically selected GRB samples

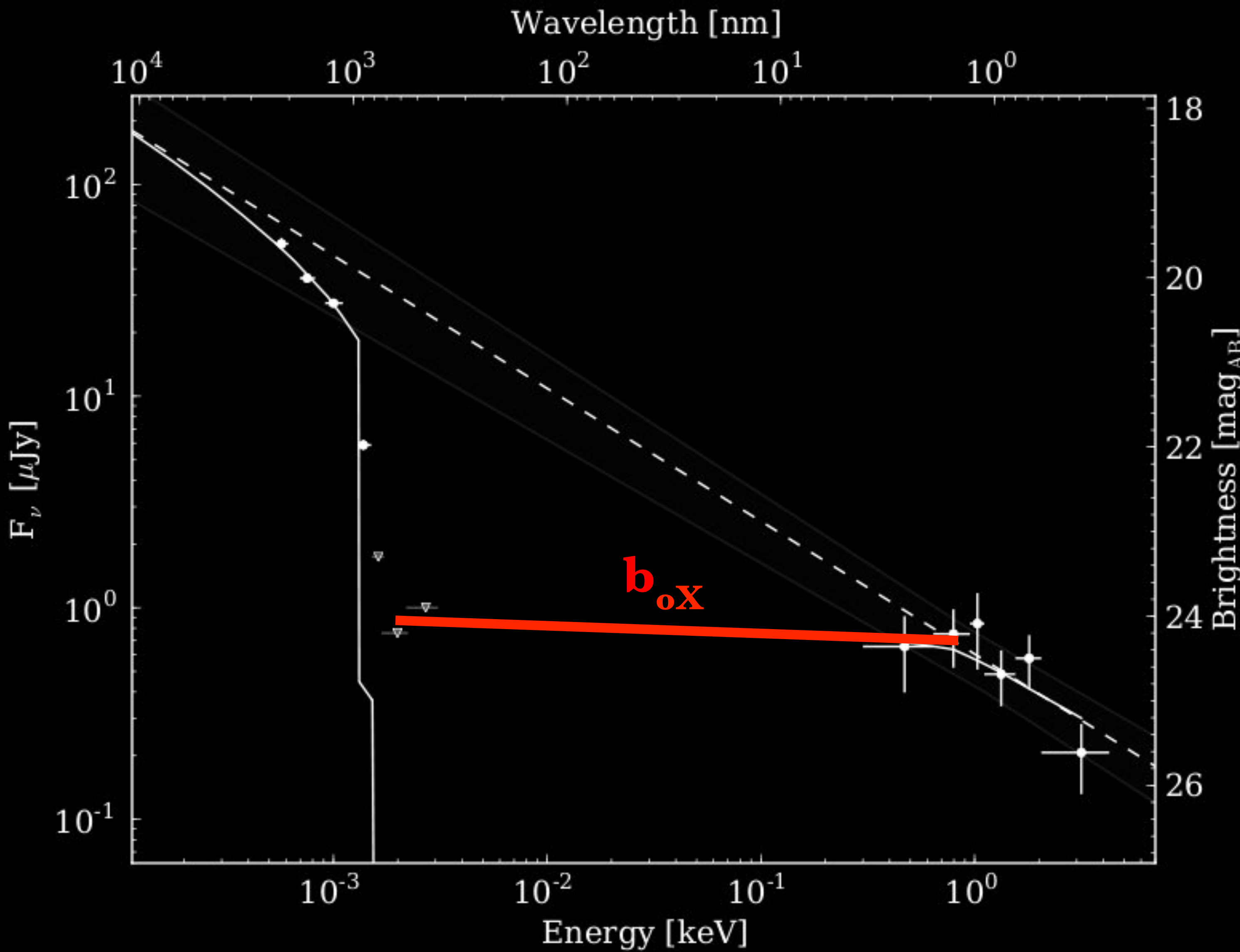
Dark Cosmology Centre



-> Talk by D. Watson

(TK+ 12, see also Fynbo+09, Campana+12)

2. The fraction of high-z GRBs



Optically selected GRB samples

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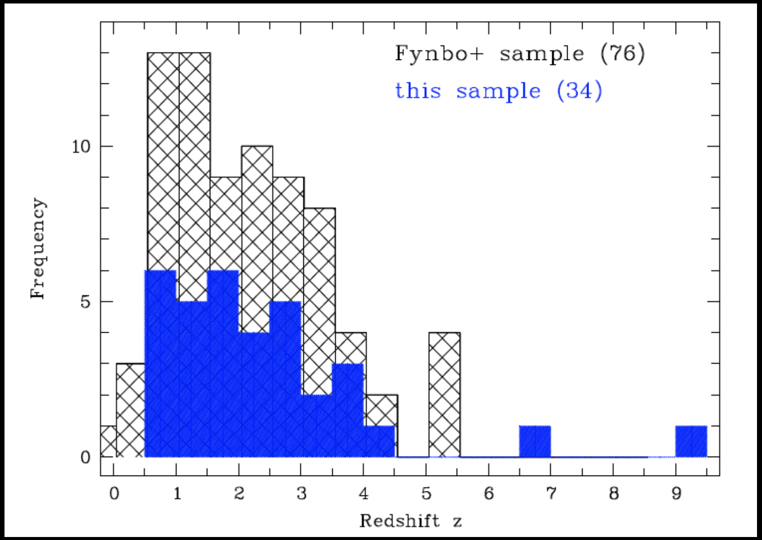
2. The fraction of high-z GRBs

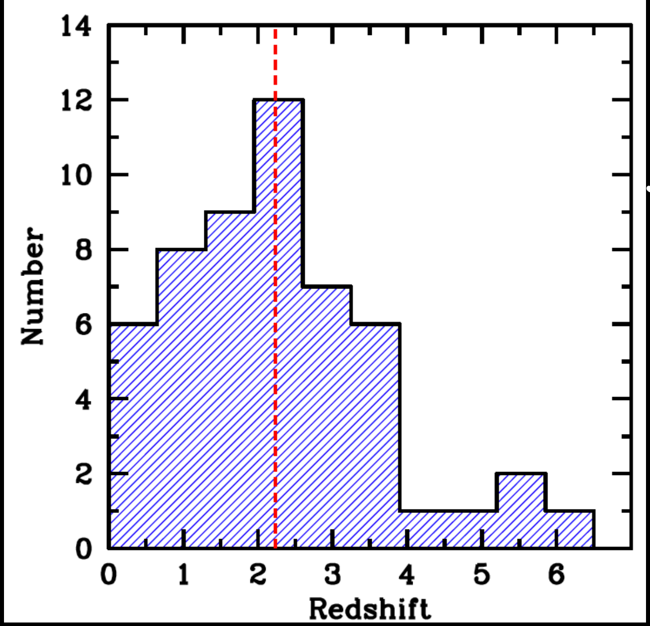
- 5.5 +/- 2.8 %
  $z > 5$ (Greiner+ 10)
- < 14 %, < 7 %
  $z > 5$, $z > 7$ (Perley+ 09)
- 3-5 %, 0.2-0.7 %
  $z > 5$, $z > 8$ (Salvaterra+ 12)
- < 14 %, < 5 %
  $z > 6$, $z > 7$ (Jakobsson+ 12)

- cp. SDSS/CFHT QSO:
(~0.05 %) $z > 5.7$ (Willott+ 10)

-> Talk by N. Tanvir

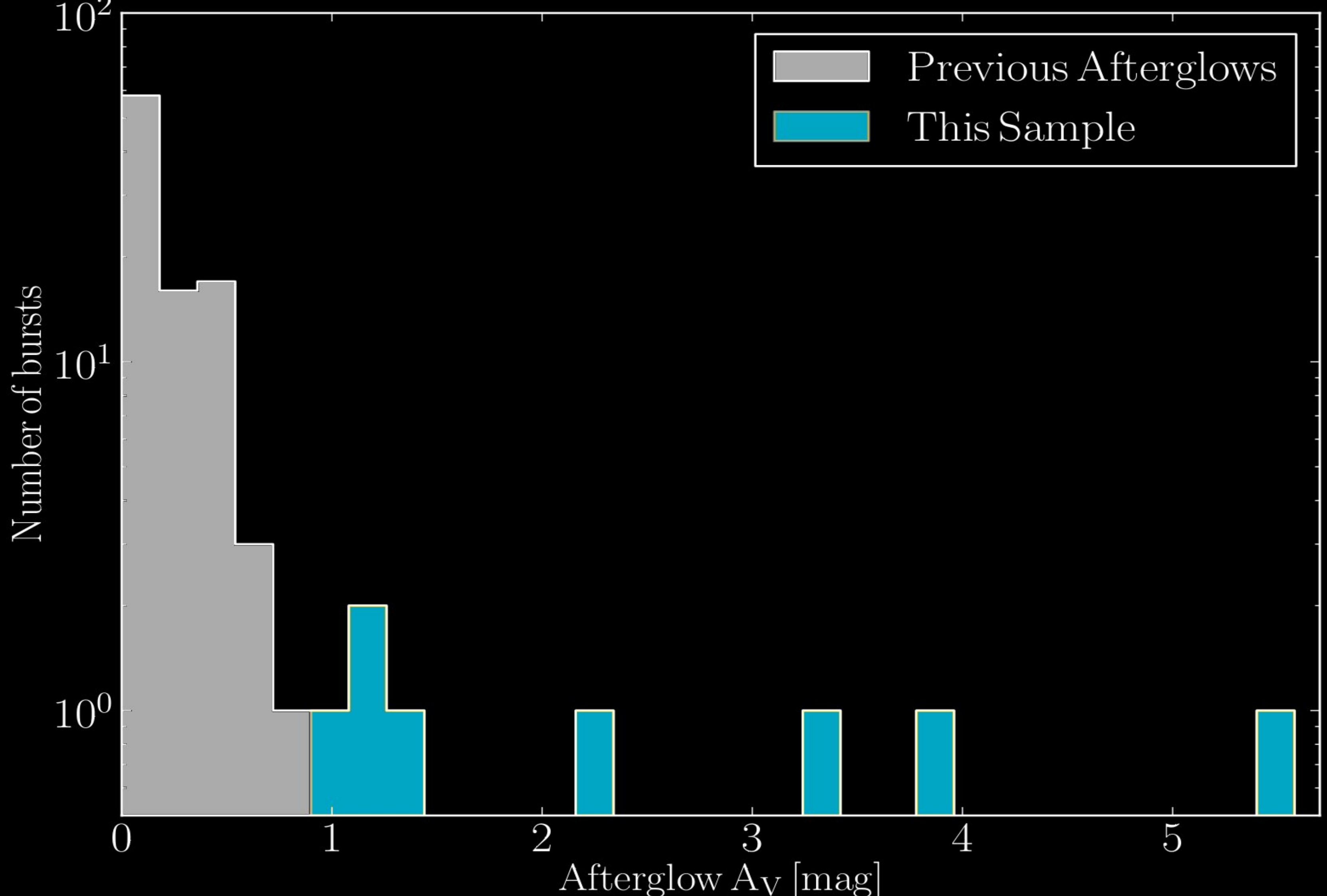


(Greiner+ 10)



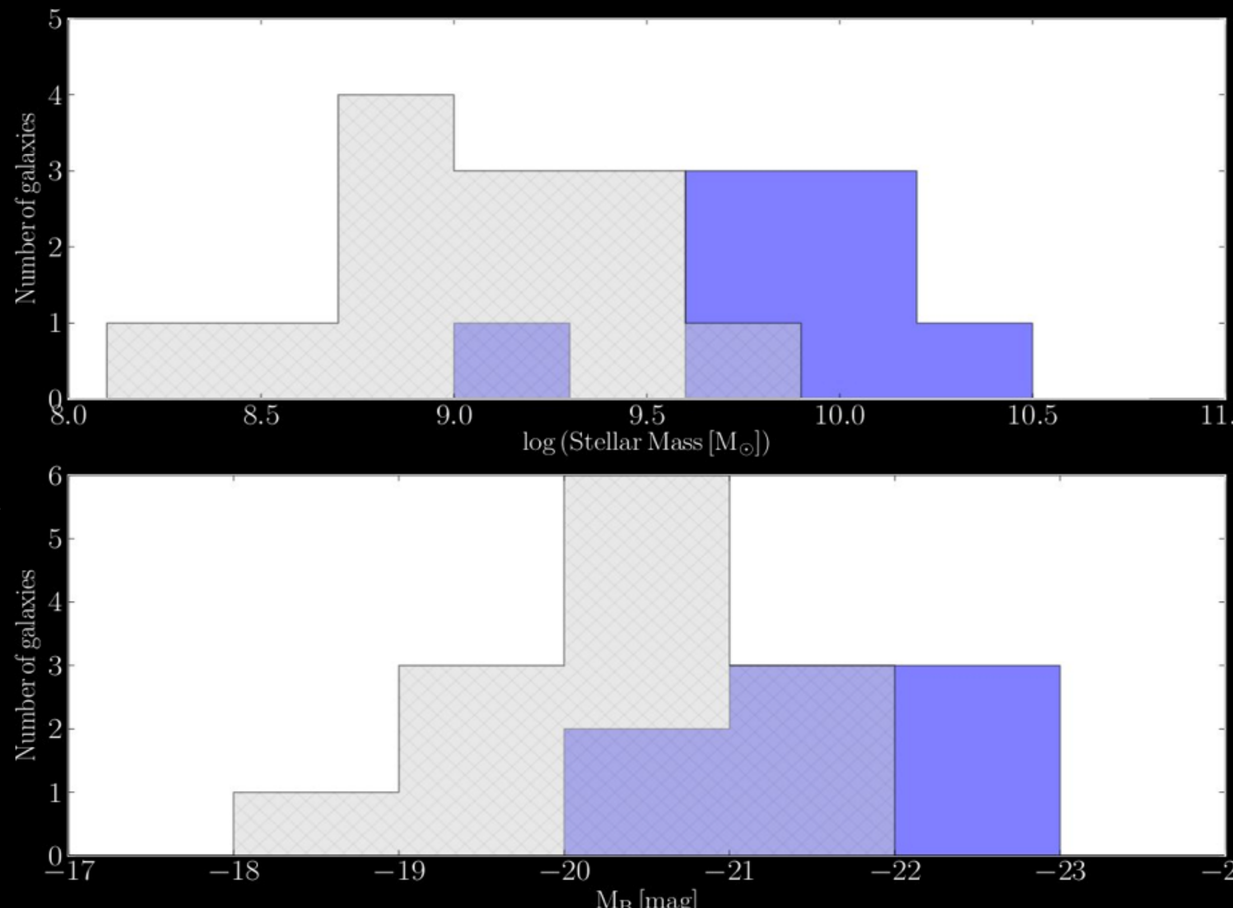
(Hjorth+ 12, Malesani+ 12, Jakobsson+ 12)

3. The hosts of long GRBs



3. The hosts of long GRBs

- Dark GRBs have
  redder,
  more luminous,
  higher mass and
  higher metallicity hosts
  than the hosts of
  optically bright GRBs



-> Talk by D. Perley

TK+ 11

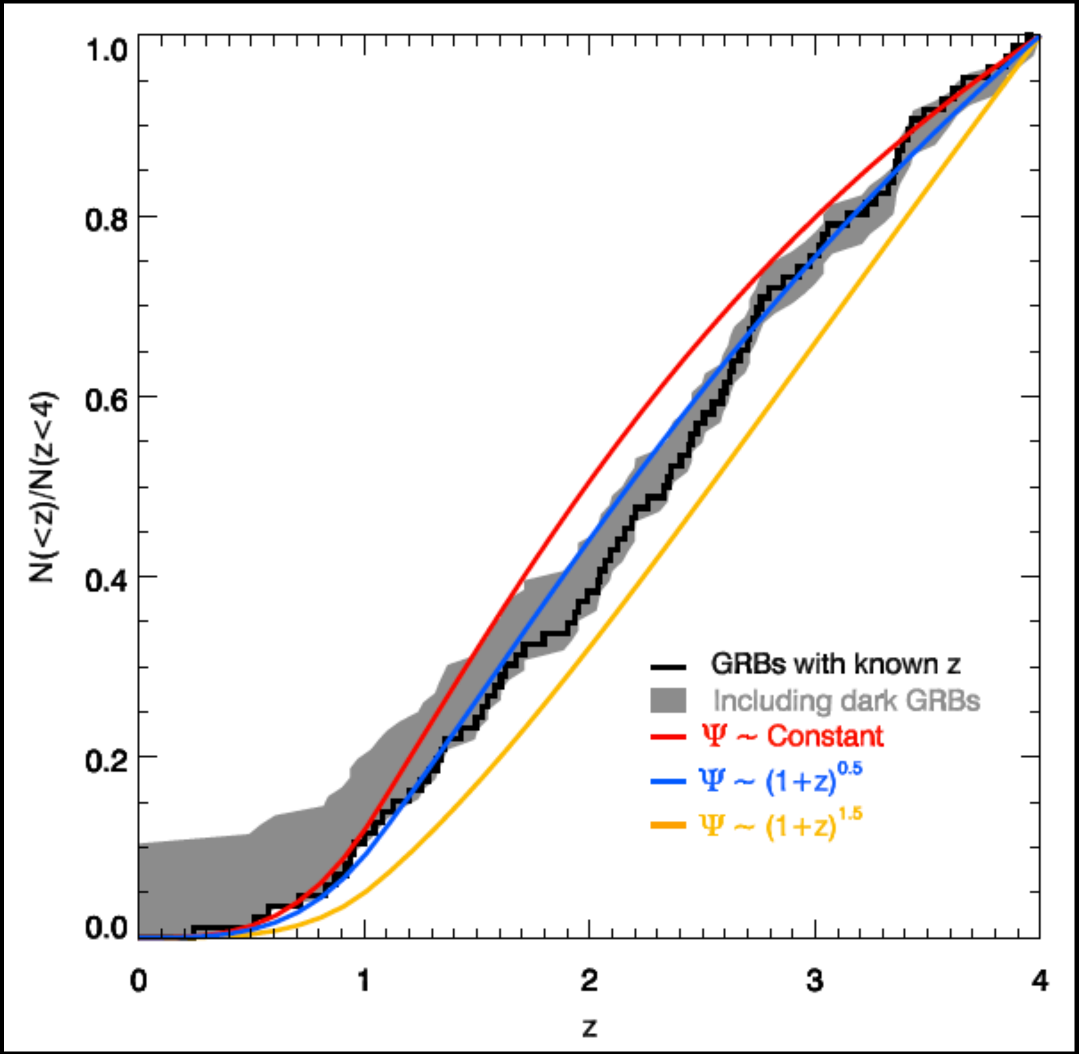
4. The fraction of SFR traced by GRBs

- Connect SFR w. GRB rate:

None to strong evolution:

-> a ~ 0 … 2

(Virgili+11, Wang & Dai 11, Elliott+ 11, Jakobsson+12, Robertson & Ellis 12, Salvaterra+ 12)



(Robertson & Ellis 12)

-> Talk by J. Elliott

Conclusions II

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- Well defined, statistically significant, and highly complete samples of GRBs are now available
- Give new insights into the nature of genuine dark GRBs (80% dusty, 20% high-z (z > 5))
- Provide good constraints on the high-z rate (~5% z > 5, factor 100 higher than QSOs
- Indicate substantial selection biases in the distribution of DLA metallicities, dust and host properties
- Connect SFR vs. GRB rate including selection biases

Afterglows

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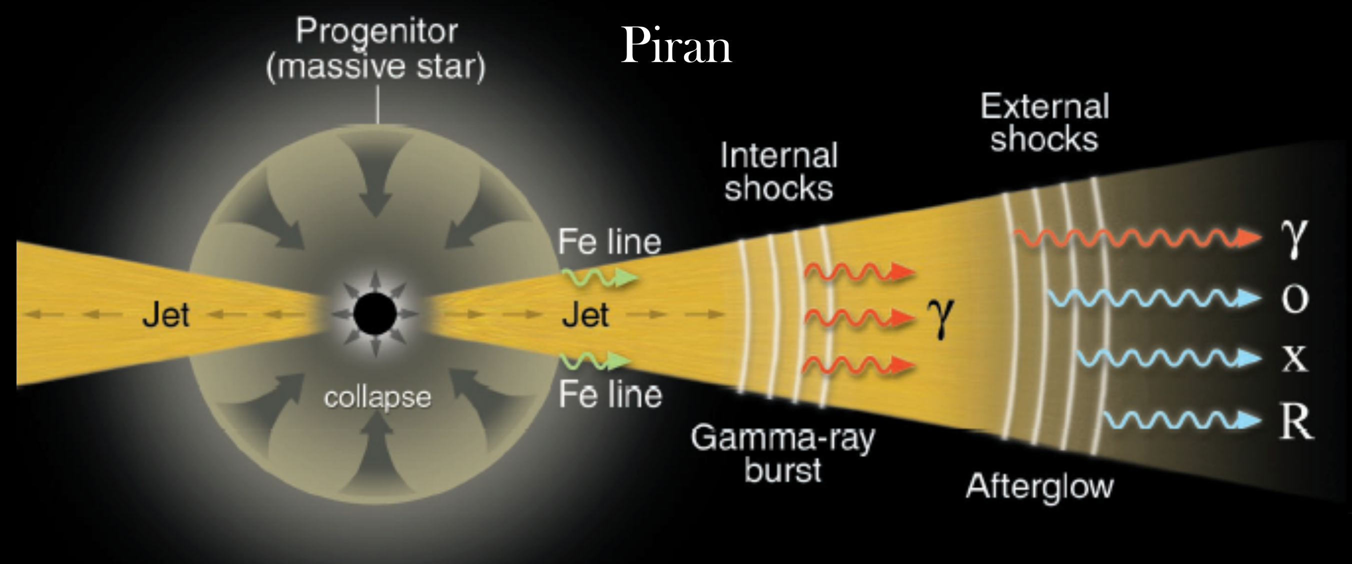
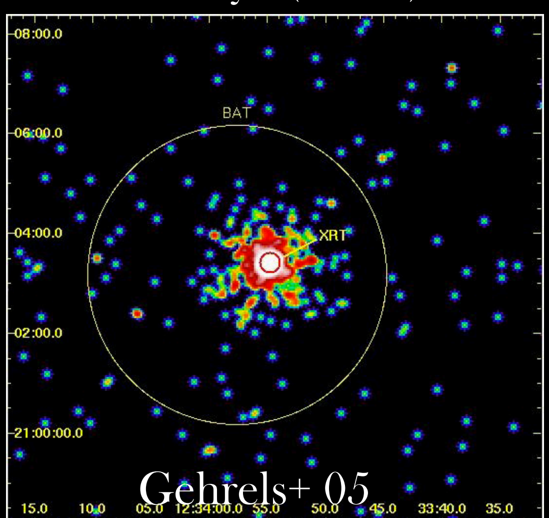
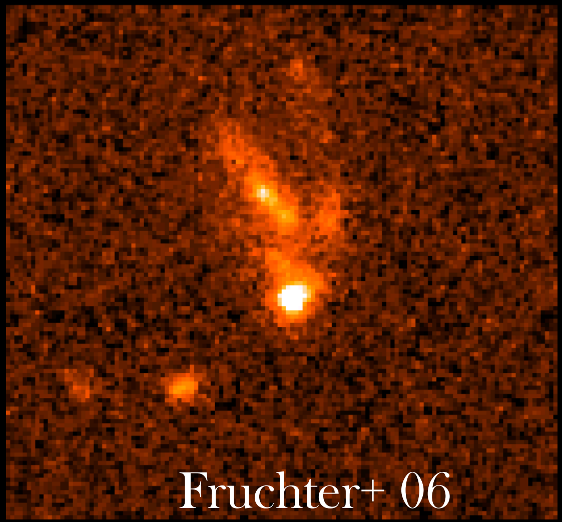


Piran

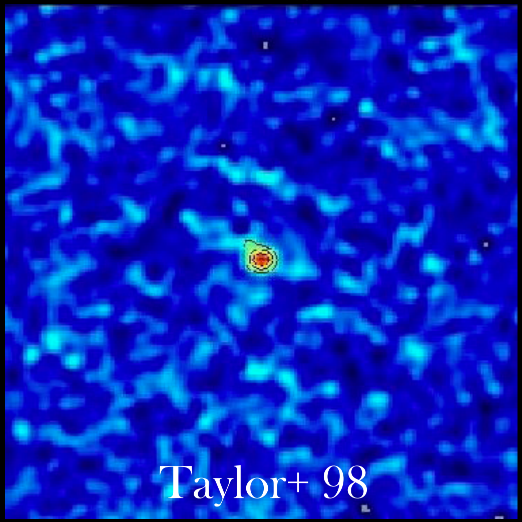
X-rays (XRT)



Optical (HST)



Radio (VLA)



Broad-band lightcurves

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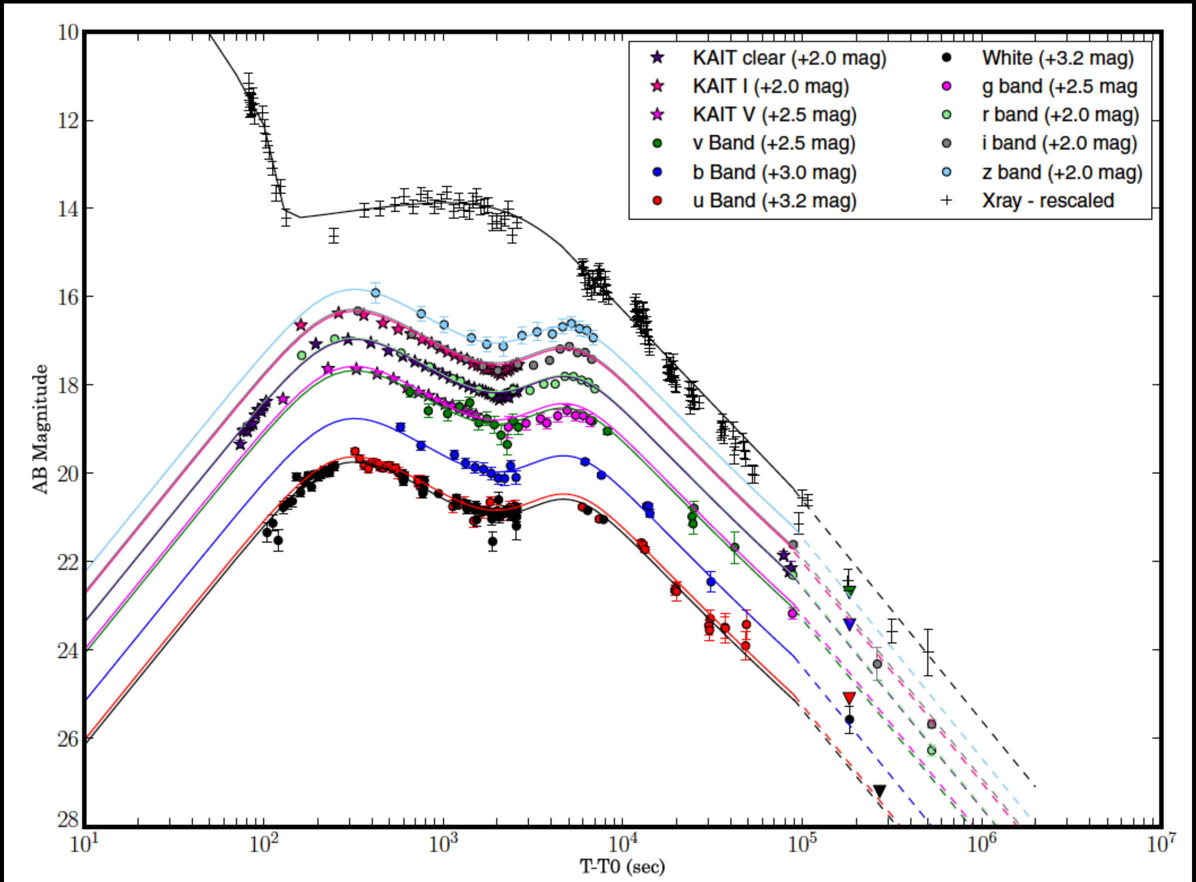

Cucchiara+ 11

- Double peaked optical/NIR afterglow w/o X-ray counterpart
- FS onset & energy injection
- Decouple X-ray and optical

Jumps

Broad-band behavior:

- No/weak signature in the X-rays
- Late afterglow seem to track each connect well