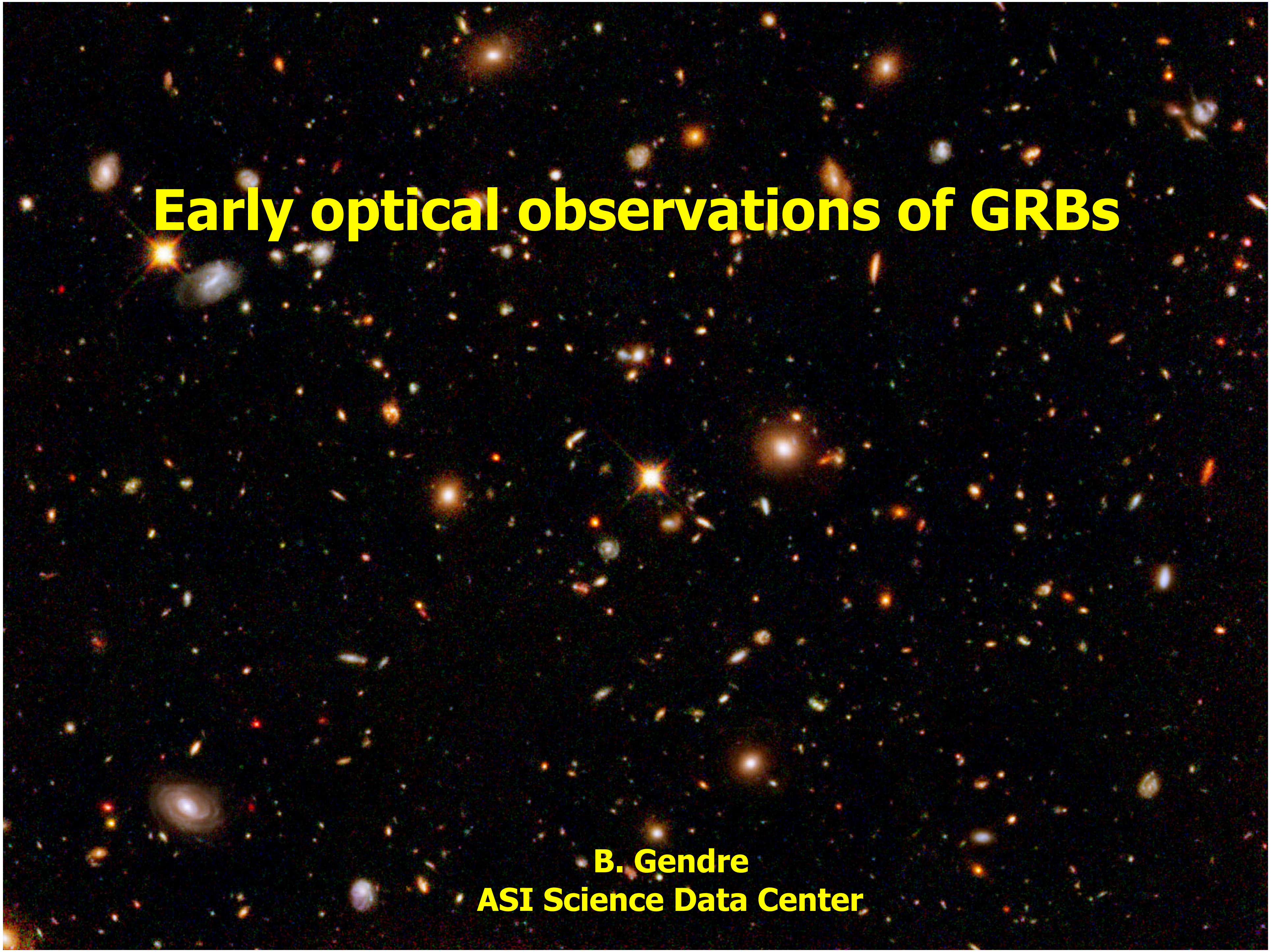


Early optical observations of GRBs

B. Gendre
ASI Science Data Center

Roadmap:

Observing facilities

Observations during prompt: to correlate or not to correlate ?

Rising afterglows

Plateau phase in optical

Panchromatic views with GROND

Polarization

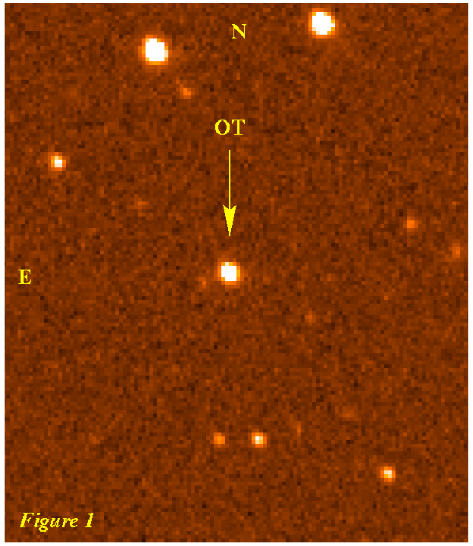


Figure 1

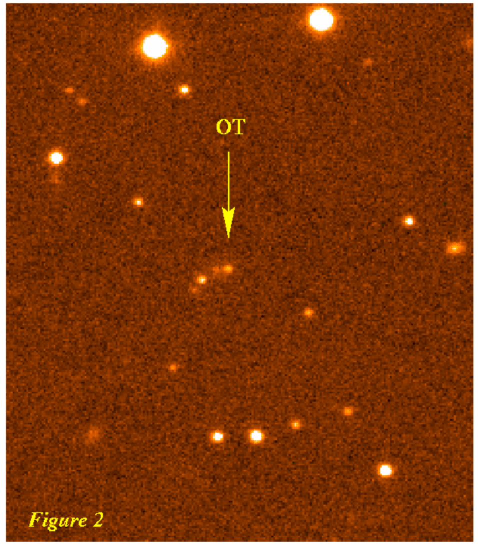


Figure 2

The GRB optical afterglow hunters

Robotic telescopes are in charge of observing GRB optical afterglows

- Located all around the world

Historical instruments

- ROTSE
- TAROT

Change of size

- Increase of the diameter towards 1m+ class
- Largest instrument so far : 8m

Change of instruments

- Polarization
- Near-infrared coverage

Change of observation strategy

- Reduce the dead-time readout
- Increase the spectral coverage

A definition of "early"

In this presentation several points need to be clarified

No discussion of alternative models

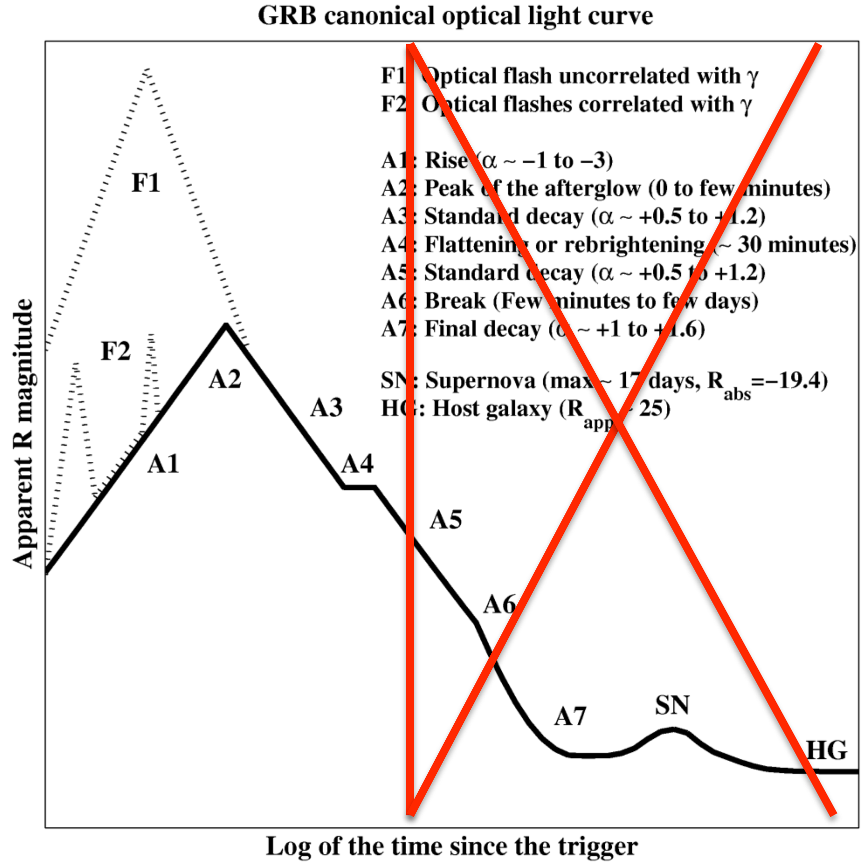
- I will present observations and use the fireball
- … but feel free to have a look to Gendre et al. 2010 to know my current feeling on this model…
- … and to follow talks by F. Daigne

No X-rays, gamma rays, radio observations alone

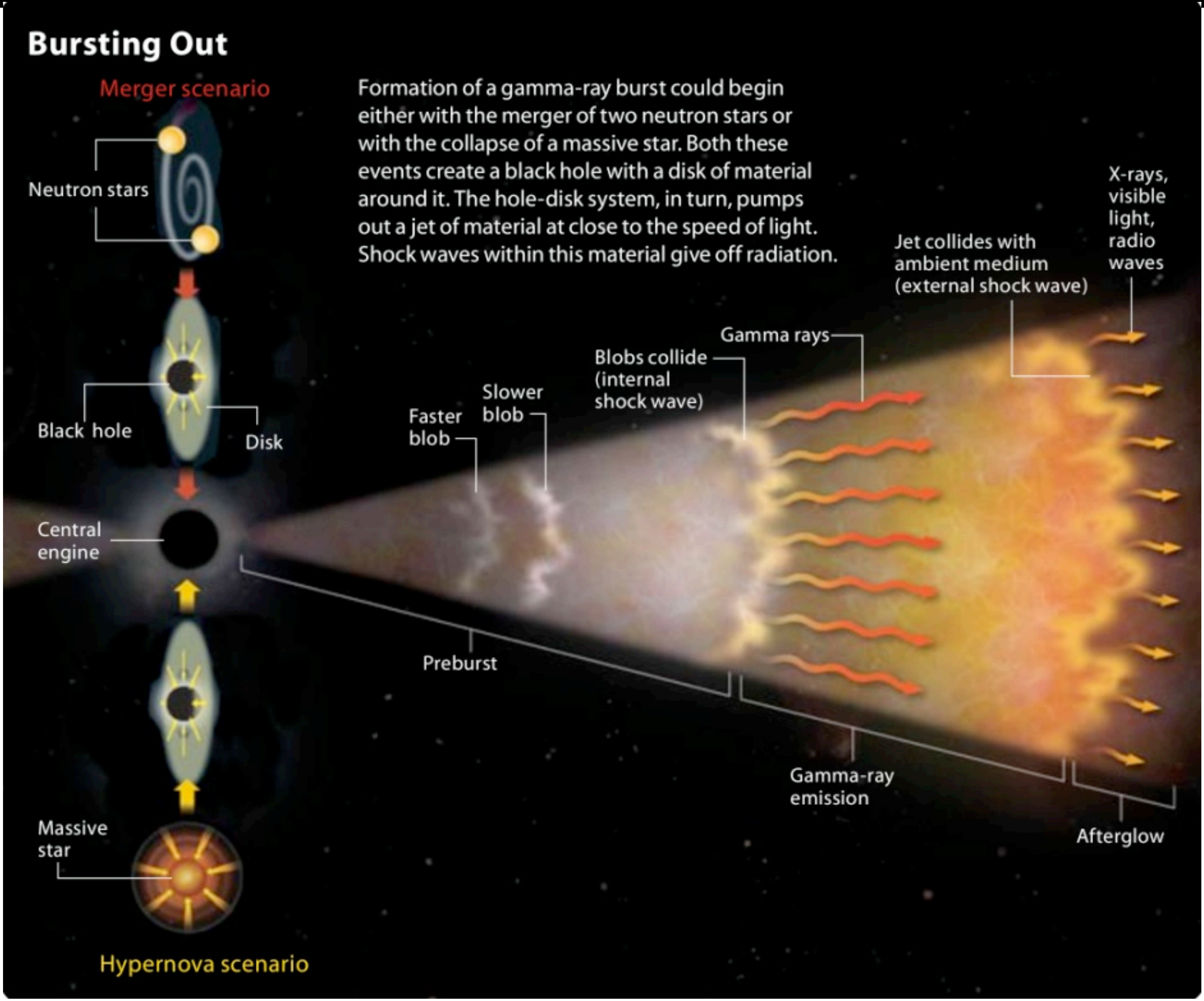
- …but I will compare optical with these when needed

No late observations alone

- I will focus on the first seconds, minutes and hours, not days



A definition of "standard model"

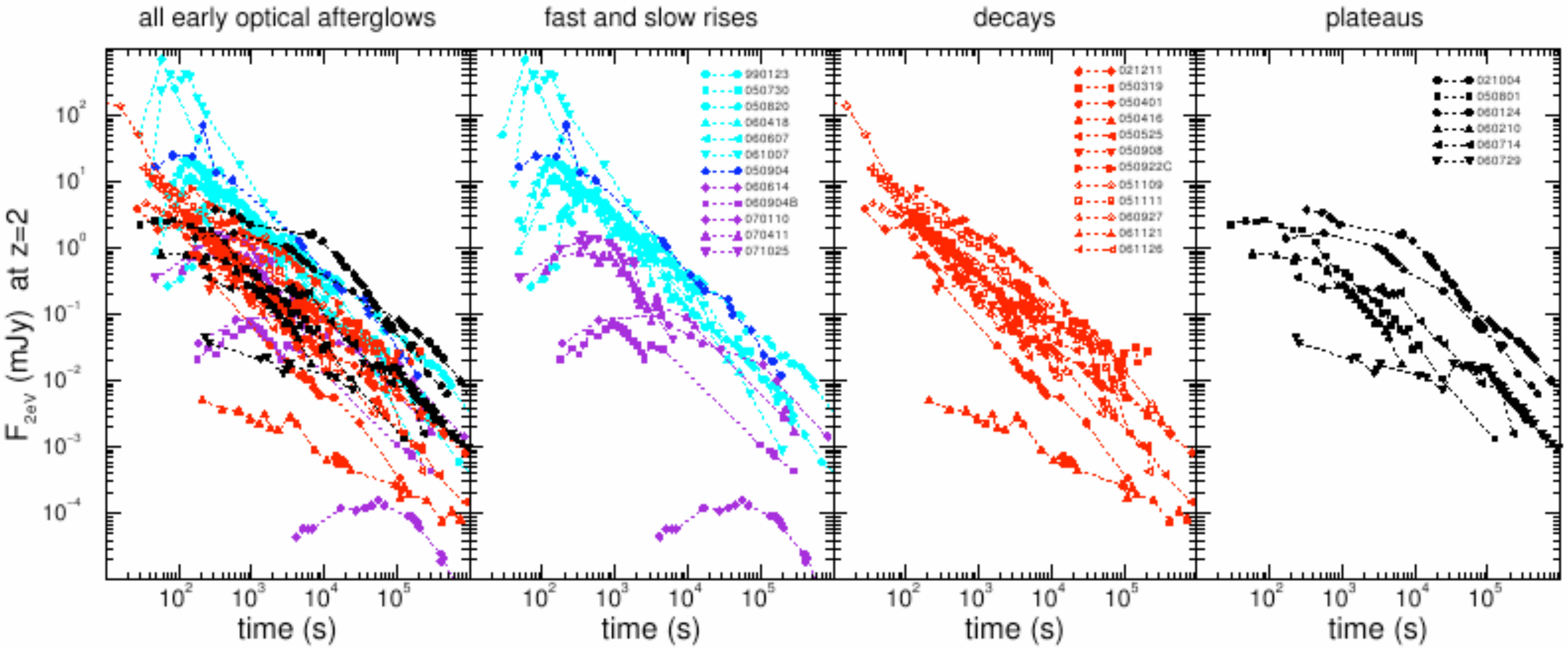


Global view of the observations

There are now several tens optical afterglows observed at early time

Several behaviors can be observed

- Initial plateaus, like X-rays
- Initial peak
- Monotonic decay



Panaitescu & Vestrand 2008

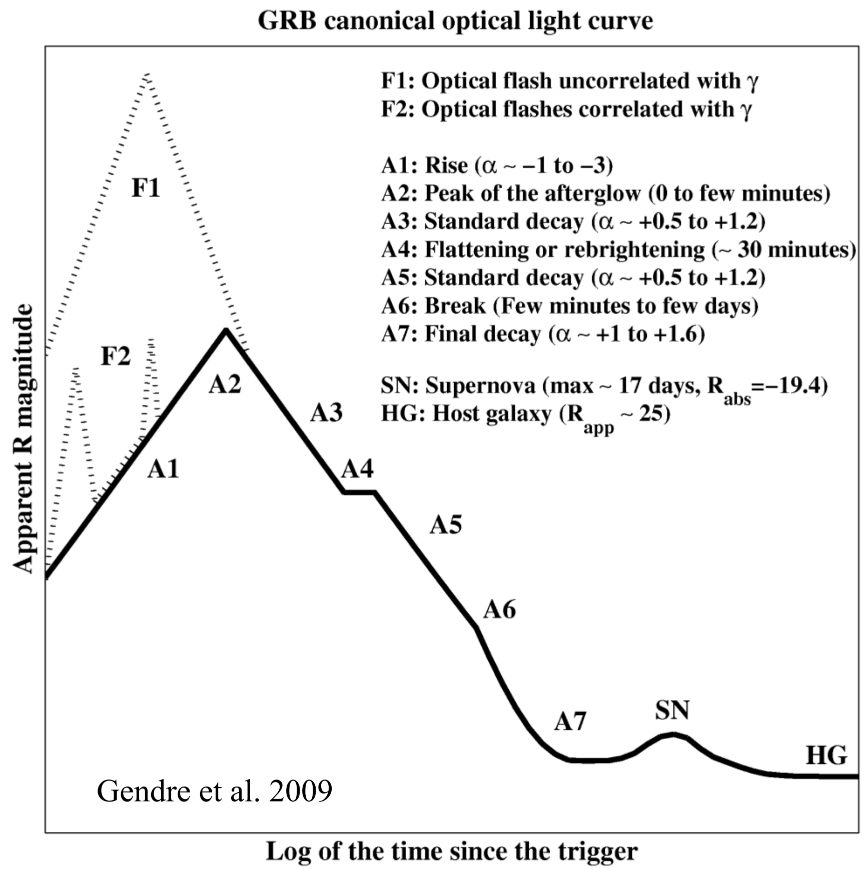
Global view of the observations

Optical template light curve (reconstructed from Klotz et al. 2008 and other works)

- Initial slow rise
- Peak time variable (can be null)
- Possible plateau (not always present), not correlated to X-ray

Two possible extra-components

- A large initial flare with fast rise, not correlating with HE prompt emission (prototype is GRB 990123)
- Several small flares, correlating with HE prompt emission (prototype is GRB 050820A)



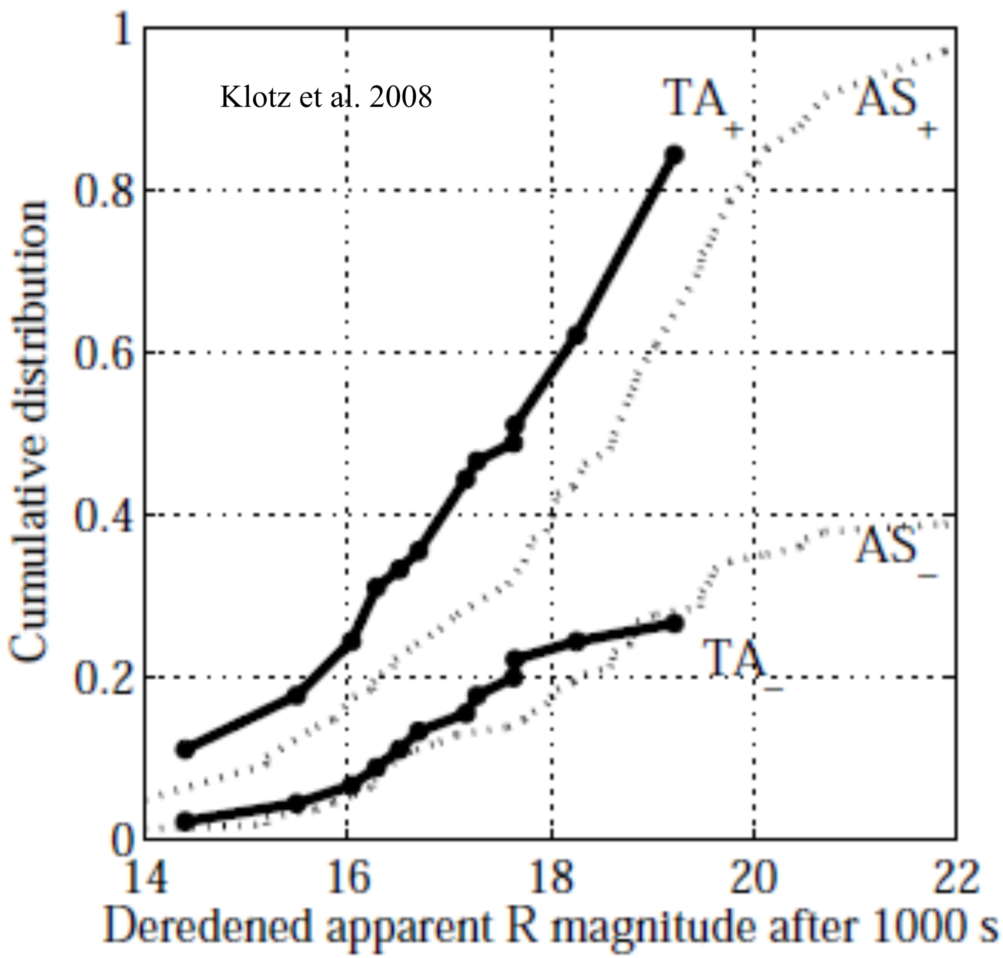
Brightness of the observations

Optical afterglows are bright

Mean observed magnitude (R) at 1000 s is ~18.2
Max observed magnitude is ~ 13.5
Obviously this are only detected afterglows: statistical bias present !

Mean magnitude at 1000s is below 18
10% brightest bursts are in rage 13.5-16.5

This does not solve the problem of dark bursts, but fix the telescope diameter to perform high precision optical studies



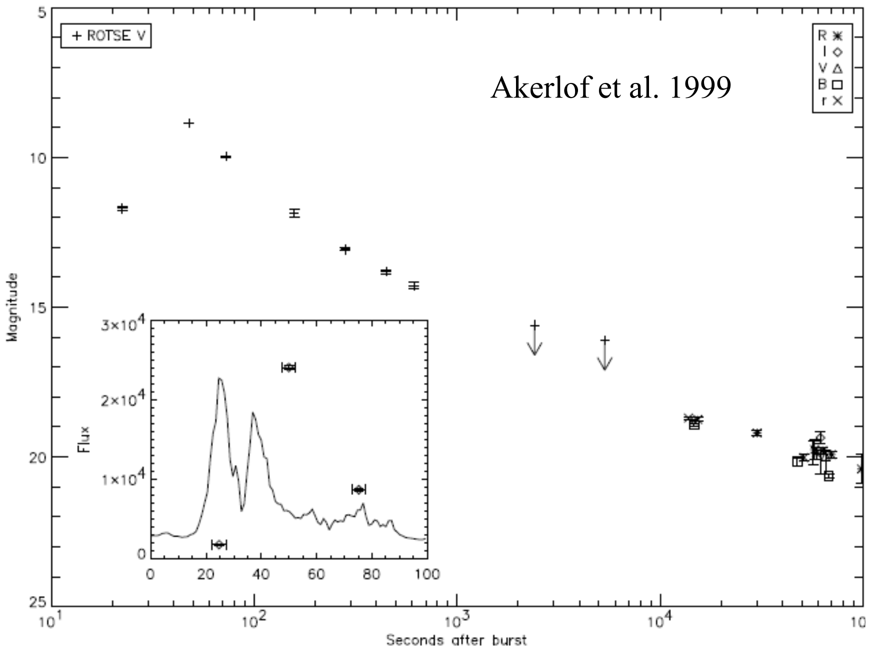
Observations during the prompt phase: optical/HE correlation

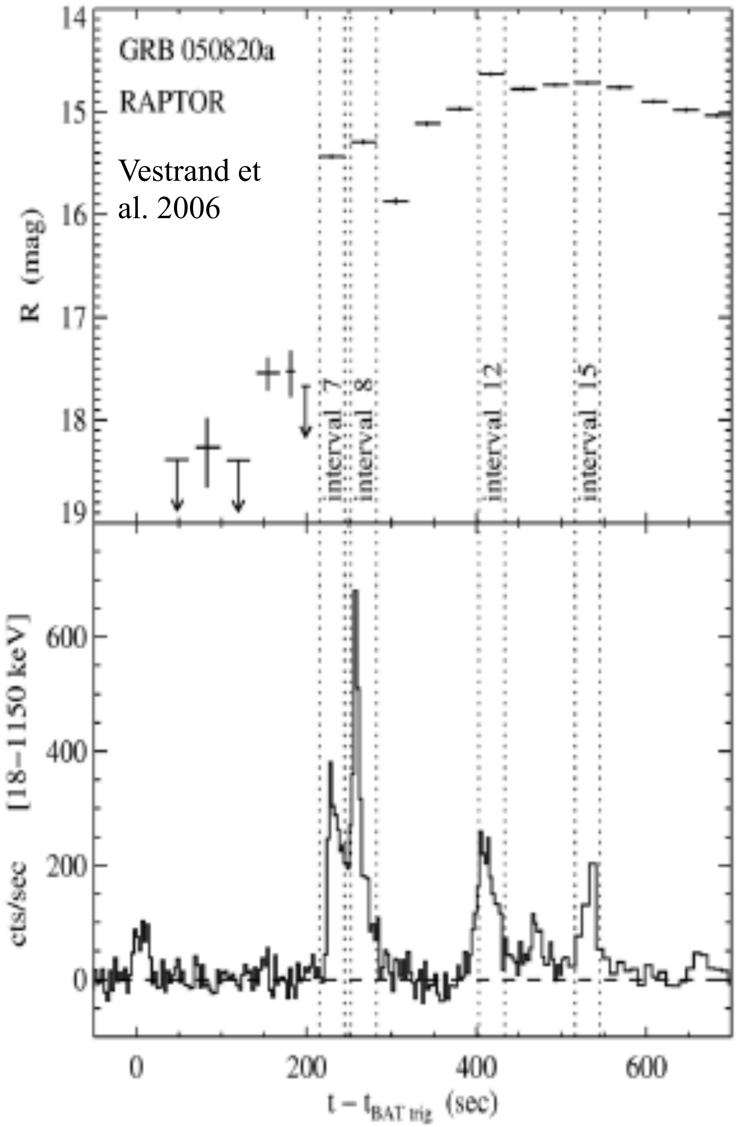
Several observations were done during the prompt phase
Two possible behaviors

1. Correlation between optical and HE
2. No correlation

In case of correlation, the optical emission is faint, and superimposed on another emission component

In case of no correlation, we can see a large flare or not

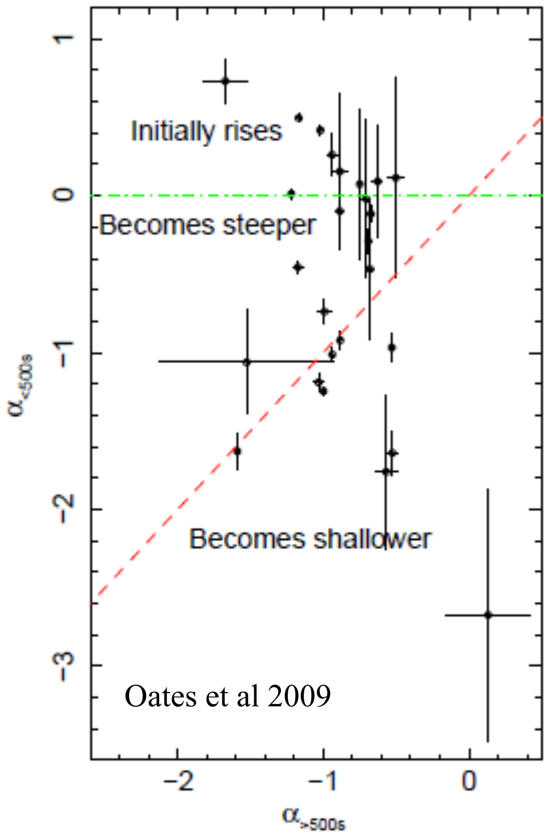


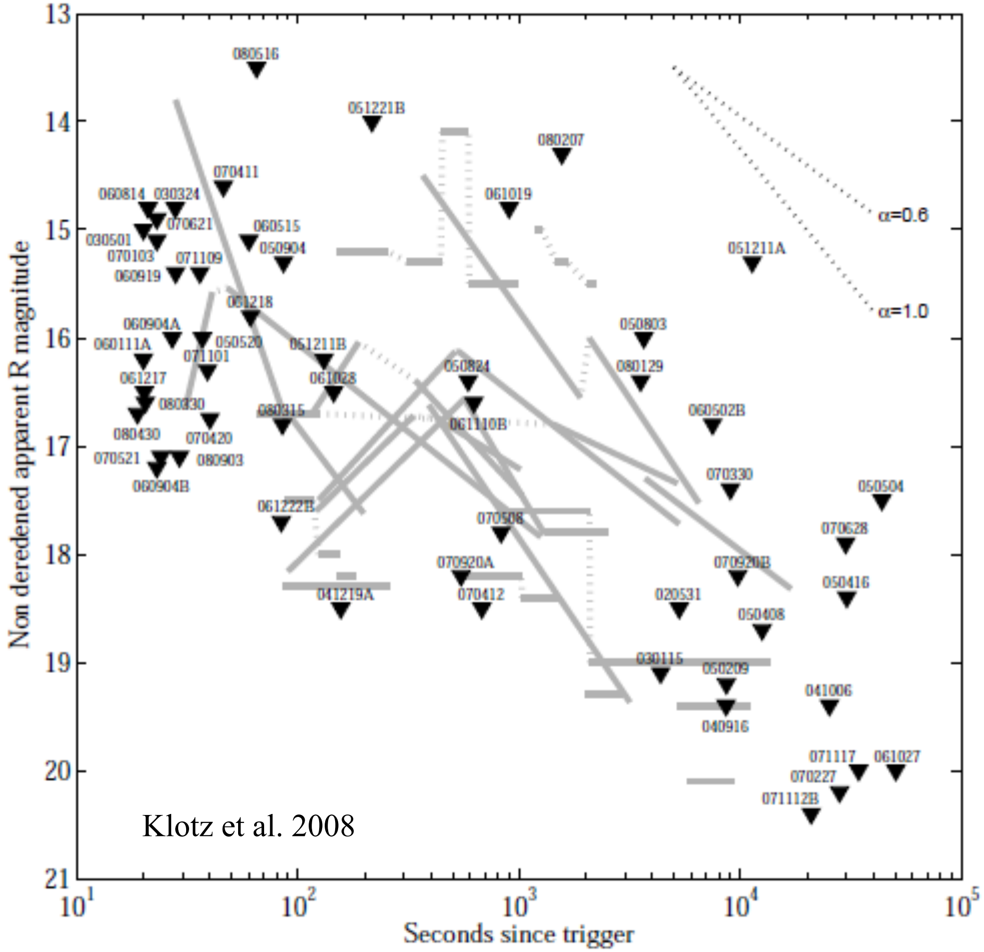


Rising afterglows

Optical light curves present a rising part

- About 1/3 of optical afterglows show this behavior
- Rise is generally smooth
- Rise index is typically ~ 1-3





Rising afterglows

Possible explanations:

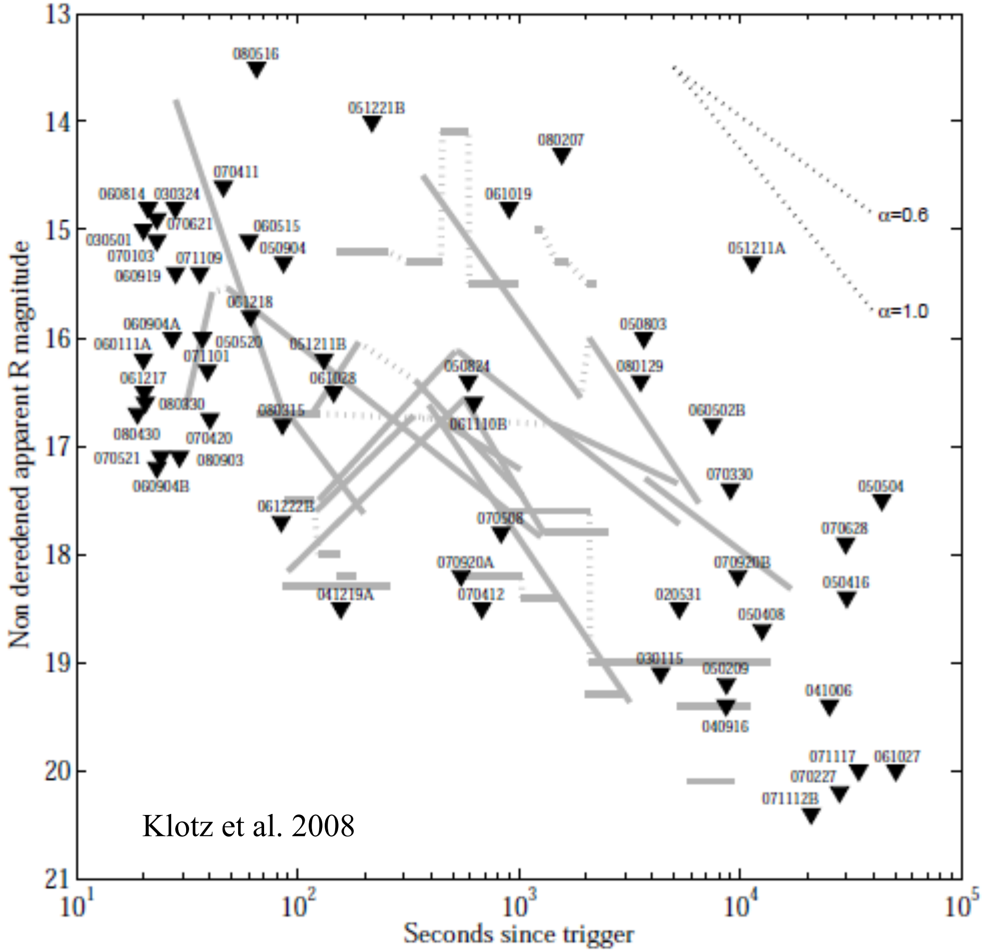
Internal shock, linked to prompt observations

No correlation between optical and HE, not possible

External shock, linked to the onset of the afterglow

Increase index not consistent with expected value, not possible

Reverse shock



The reverse shock hypothesis

A reverse shock can explain the observed properties

Hypothesis relativistic vs non-relativistic ejecta,

Both hypothesis are in agreement with the model

Hypothesis constant density profile vs variable density profile

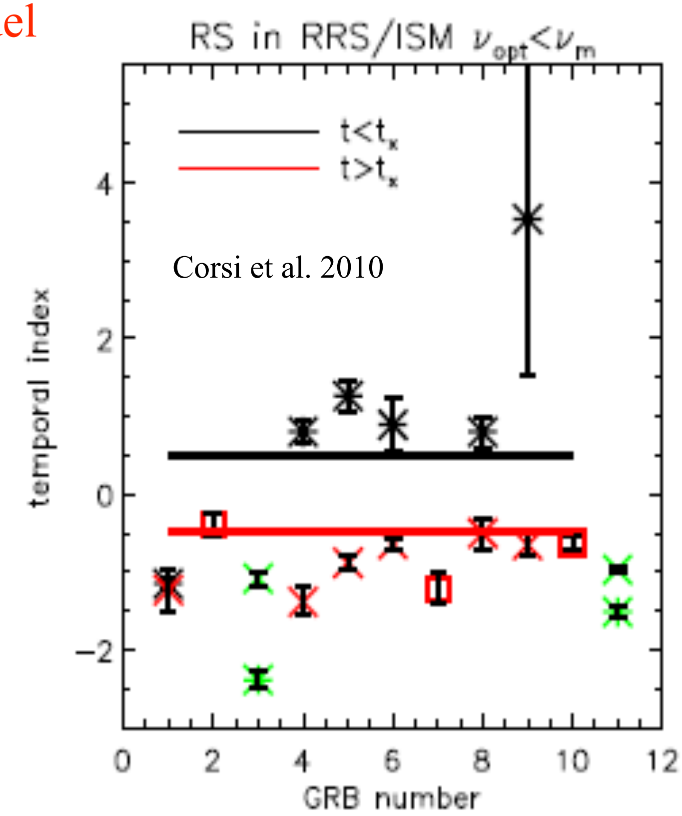
Data exclude wind density profile

Hypothesis and slow vs fast cooling mode

Data privilegiate slow cooling mode

A few plateaus have been seen in optical

- Observations started ~100 s post-burst
- No rising part
- No correlation with X-ray plateaus

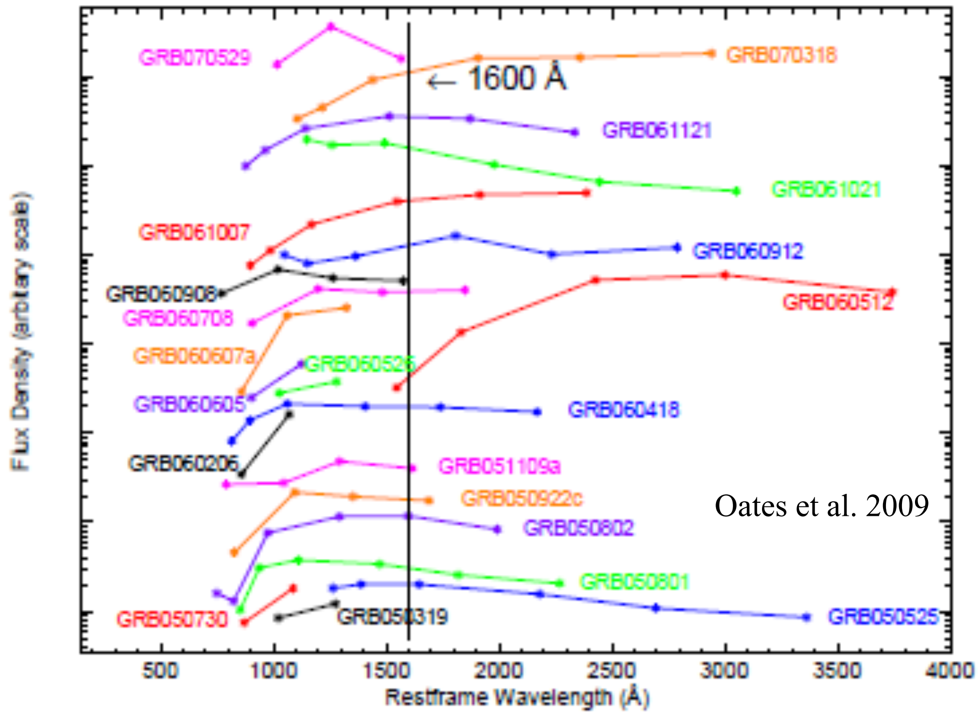


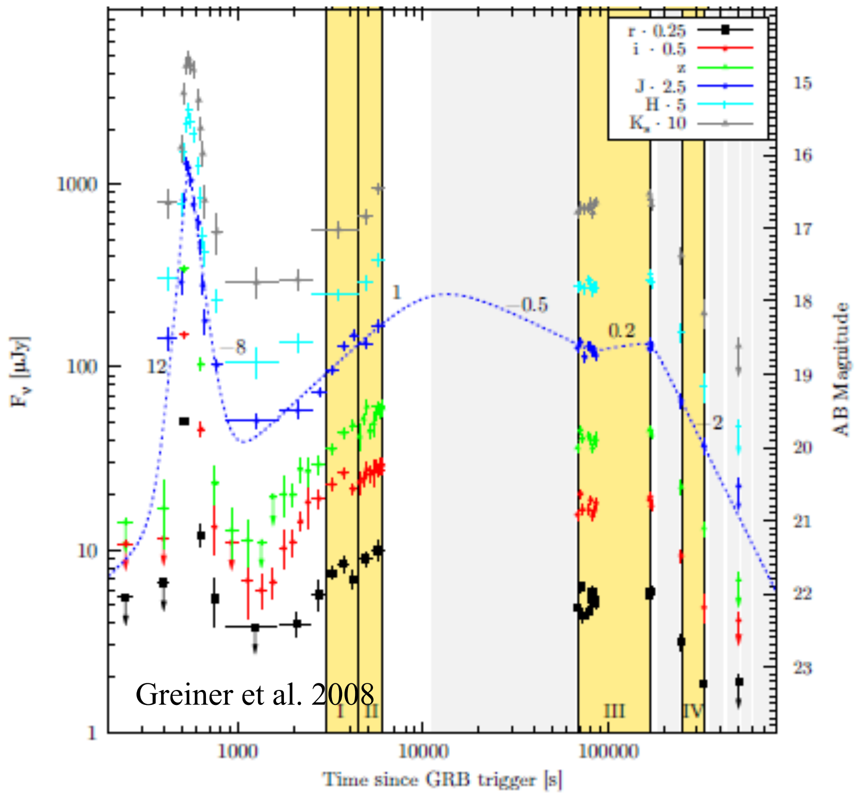
Can also be explained by a reverse shock if fine tuning of the parameters

Spectroscopy and SED

New experiments allow for simultaneous observation at several wavelength

- Possibility of SED extraction
- UVOT data in the blue part of the spectrum
- GROND data in the red part of the spectrum (IR to g')





Early (minute scale) spectrum is yet a dream
see however talks by P. Petijean and S. Vergani

Spectroscopy and SED

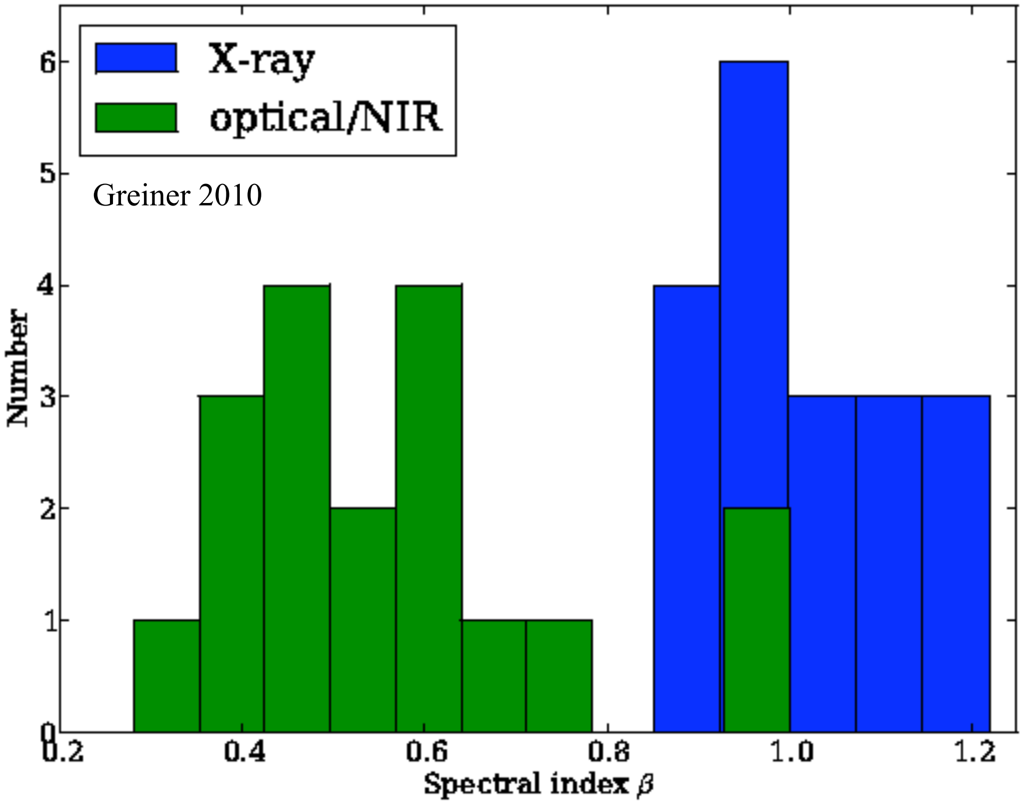
First information: the continuum

Fireball implies some relations between optical and X-ray spectral indices

1. Equality
2. Difference of 0.25 if cooling frequency between them
3. Difference of ~ 1 if injection frequency between them

Statistically, a specific frequency should lie between the optical and X-ray bands

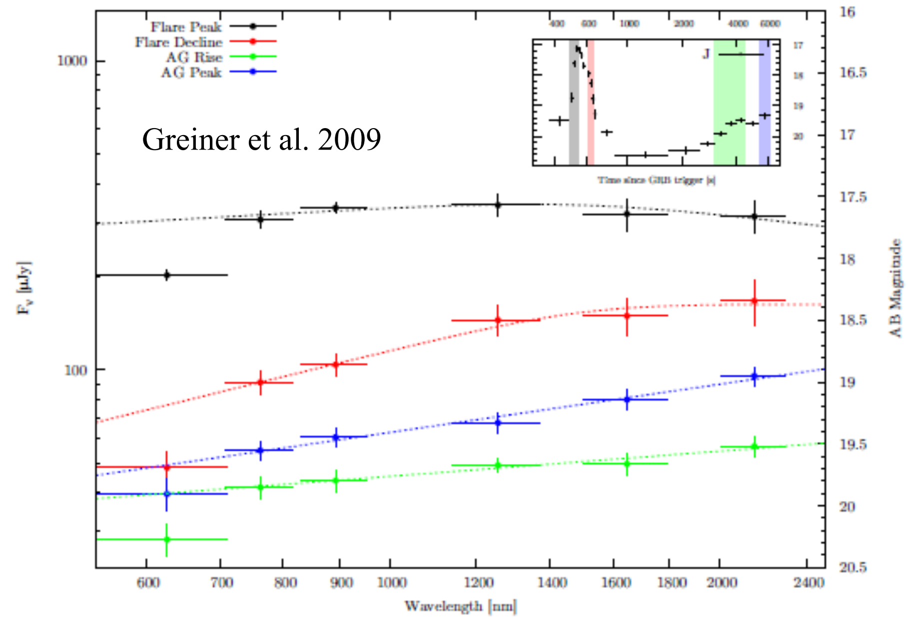
However, difficult to conclude because the dust modifies the continuum properties



Spectroscopy and SED

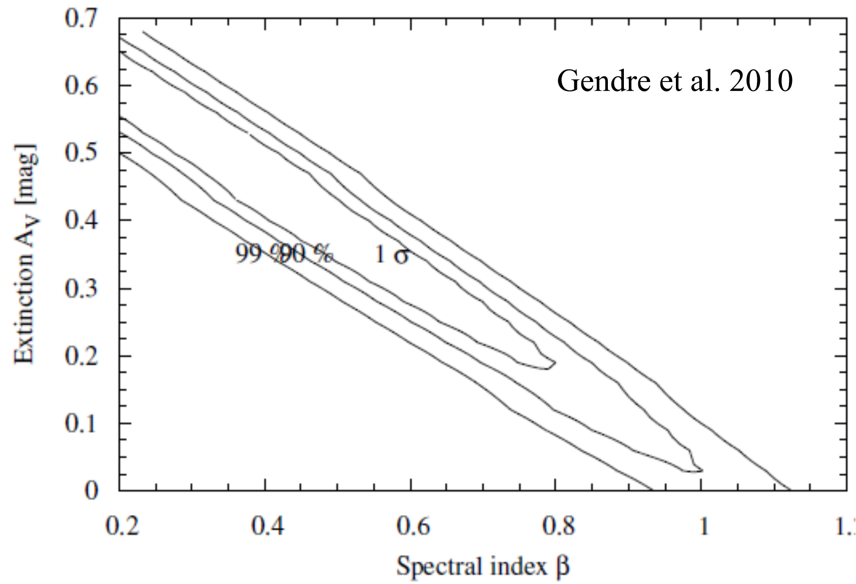
Second information: the spectral variation

- There are spectral variations observed (e.g. during the optical flares)
- Modification of dust properties
- Modification of emission regime



Last information: the durst properties ?

- Wrong idea! It supposes continuum model to apply to the data
- Only in case of galactic extinction law (with strong 2100 A feature) the dust content can be estimated from the SED alone



Polarization

It is now possible to measure the early polarization

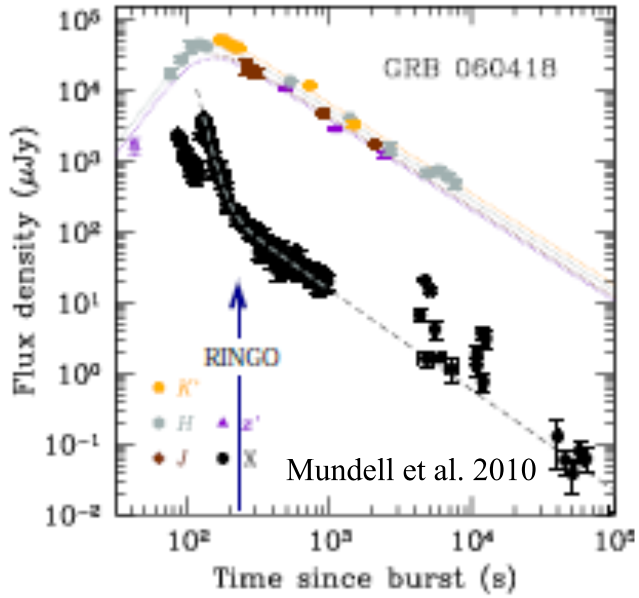
- •RINGO instrument (Faulkes & Liverpool telescopes)
- •Measures around 200s post-burst

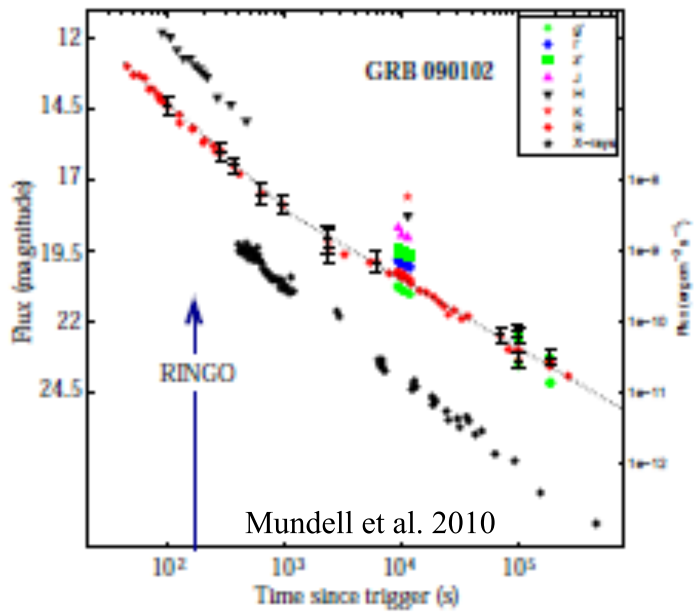
One stringent upper limit

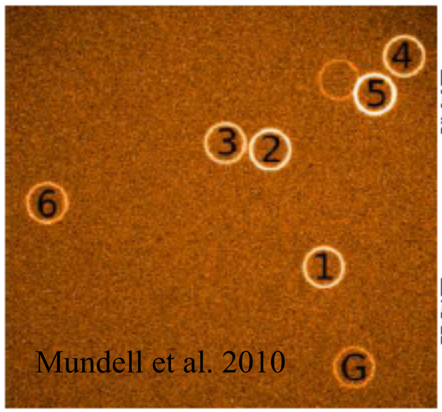
GRB 060418 P < 8 %

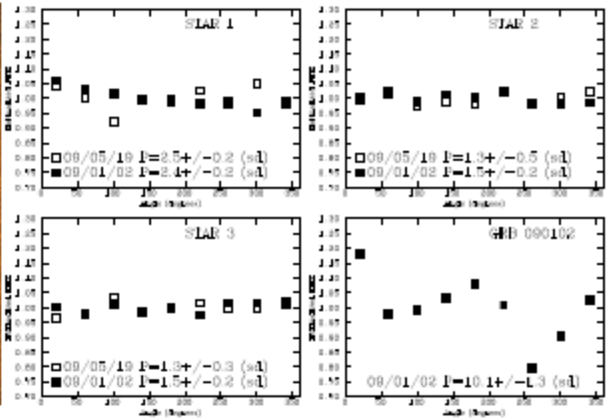
One confirmed measurement

GRB 090102 P – 10.2 +/- 1.3 %





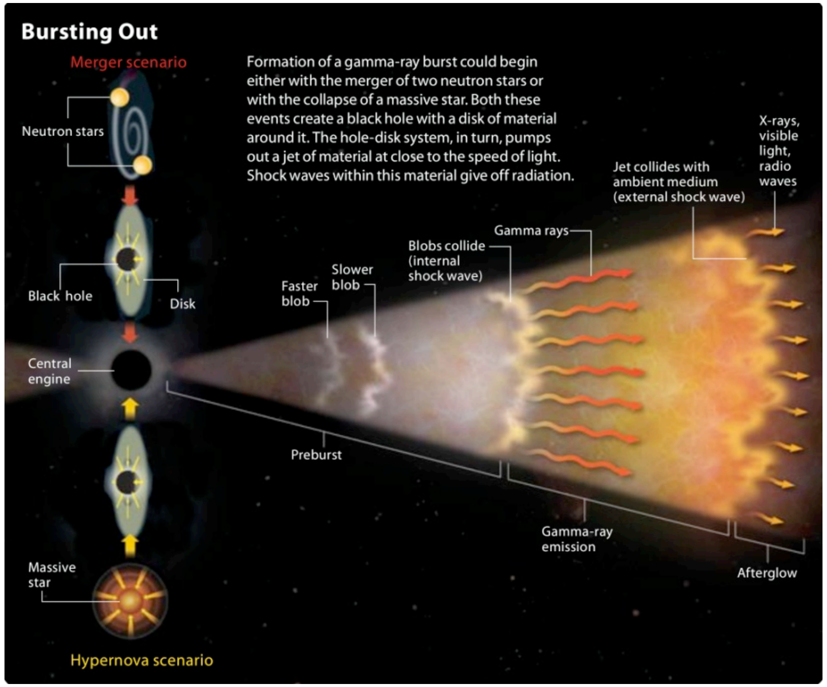




What about the orphans ?

The fireball model propose a strong dependence on the geometry of the ejecta of the phenomenon visibility

- •Jet seen on-axis: normal GRB
- •Jet seen off-axis: XRF
- •Observation seen out of the jet edge: no prompt, but a possible late afterglow



Several programs can look at orphans

- •CFHT
- •PI of the sky

To date

No claimed orphan detection

??

Conclusions

A change on the observation strategy

We went from "the optical detection" to "the optical study" of the afterglow

… that triggered several discoveries

Shape of the light curve, physic at play during the afterglow

A change on the information obtained

We went from the temporal behavior to spectral behavior

… that allows several studies not related to the GRB itself

Dust properties of the medium, density profile

Conclusions

So, what is next ?

Still no precise information about the prompt spectral properties in optical

we are lacking an instrument which can perform spectroscopy, mounted on a fast-slewing robotic telescope, on an object with unknown position

Still no information about fast variability

we are lacking an instrument which can perform photometry at the millisecond scale

Still very few information in the (far) infrared

we are lacking instruments like GROND and REM

Still some work to do in early polarization

we are lacking instruments which can perform this study