
L'aurore de l'Univers
avec les sursauts-gamma
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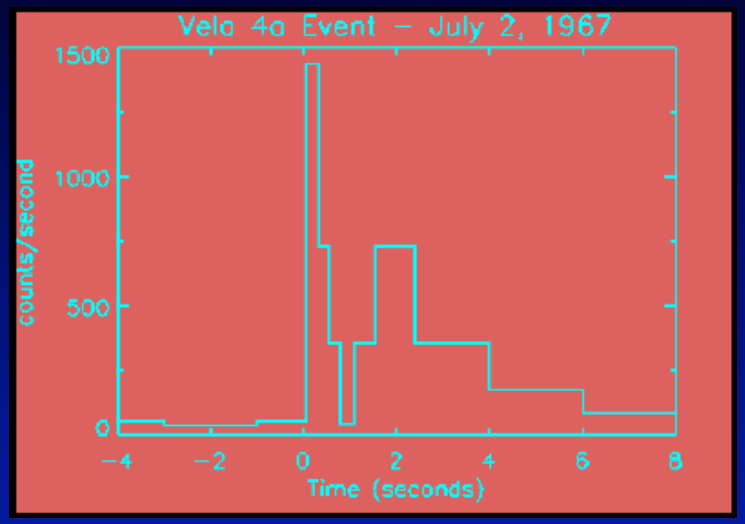
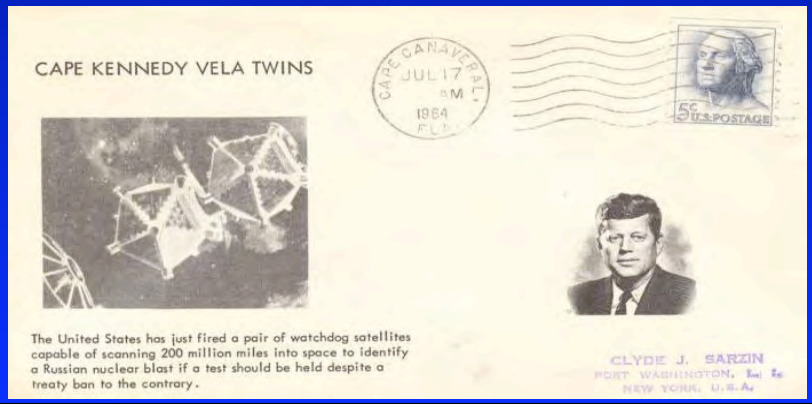
VELA: a very strange discovery

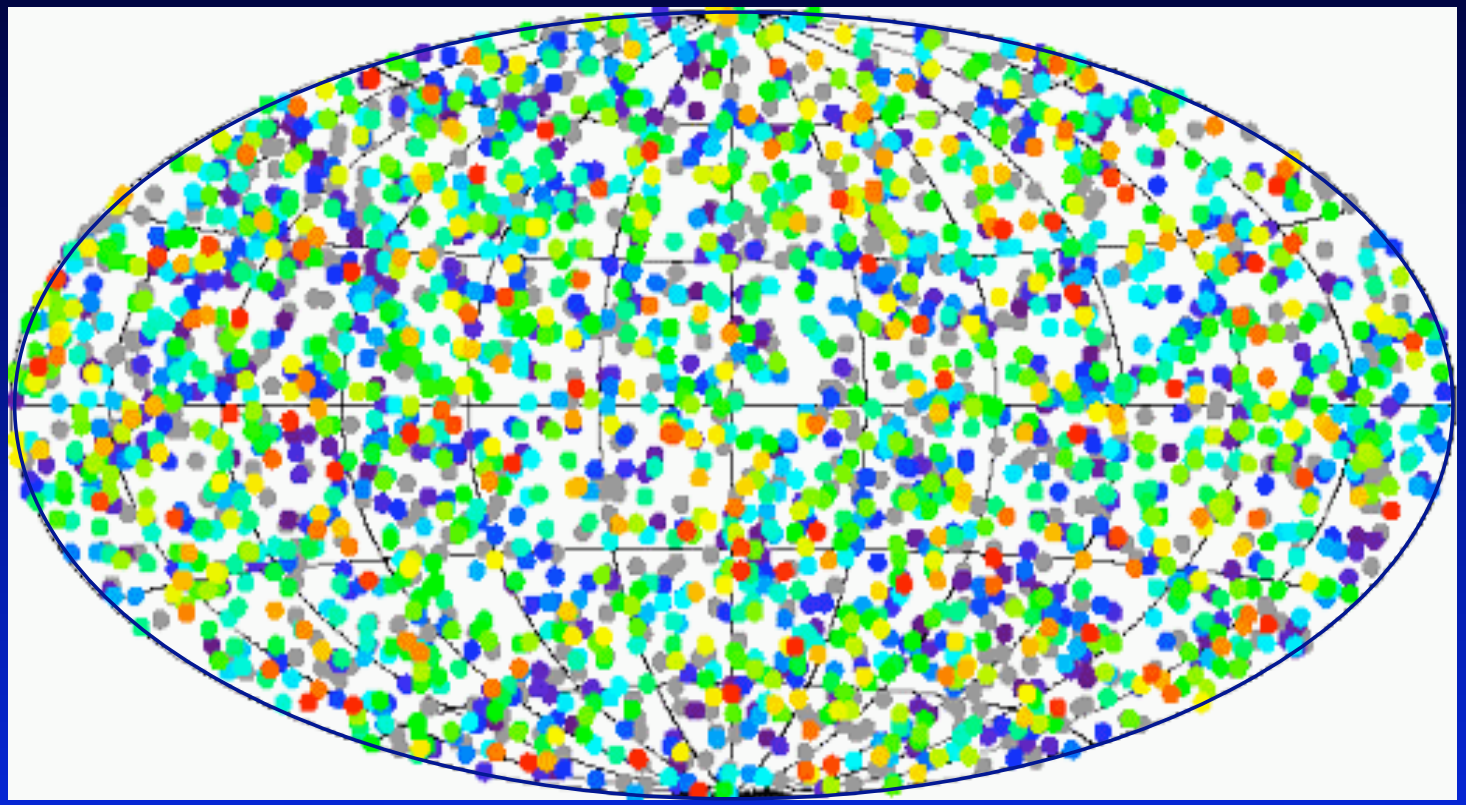


Klebesadel, Strong & Olson 1973

- Discover by US military satellites.
- Very short flash of gamma rays.
- Unpredictable location.

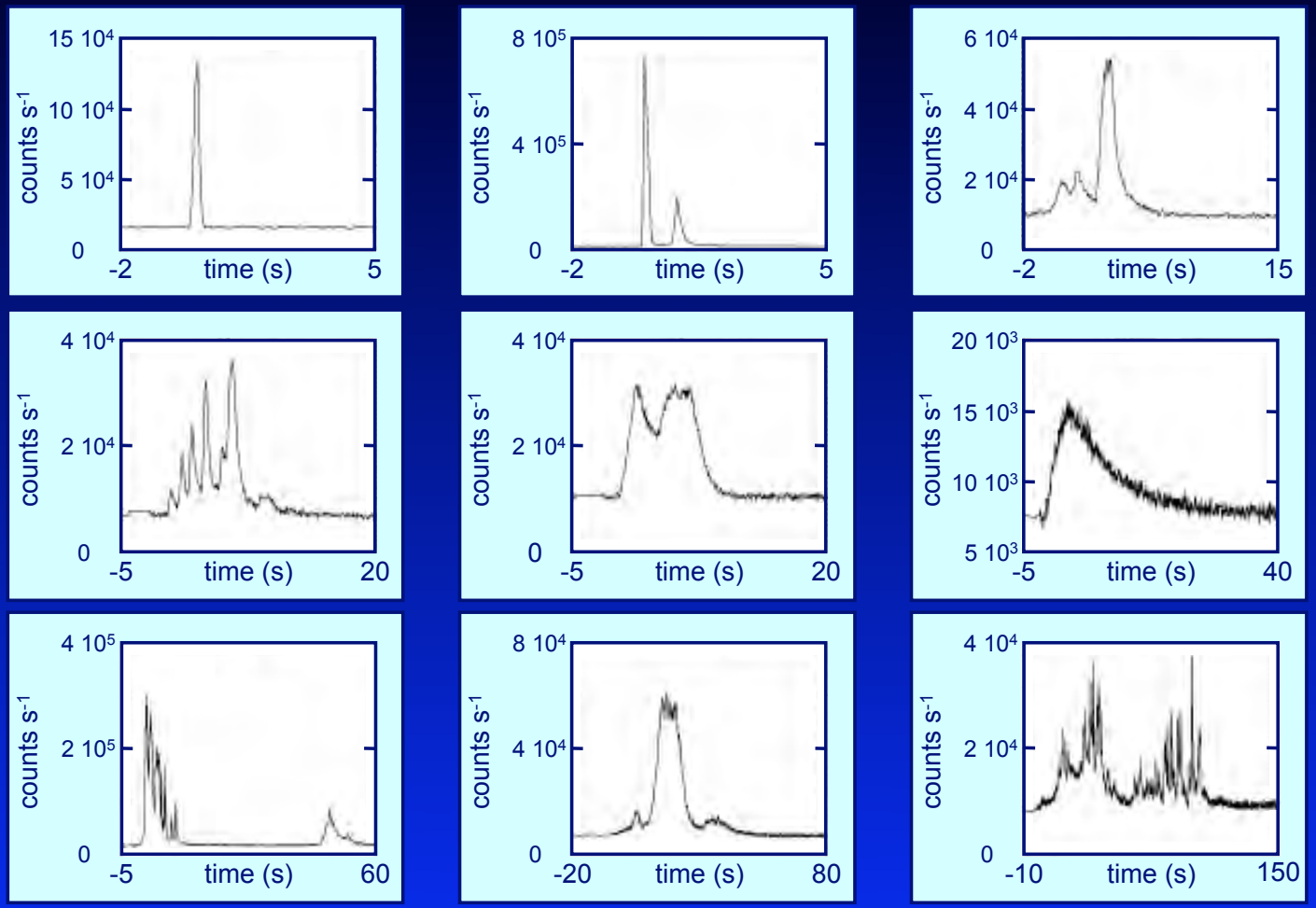


CGRO/BATSE: unprecedented statistics

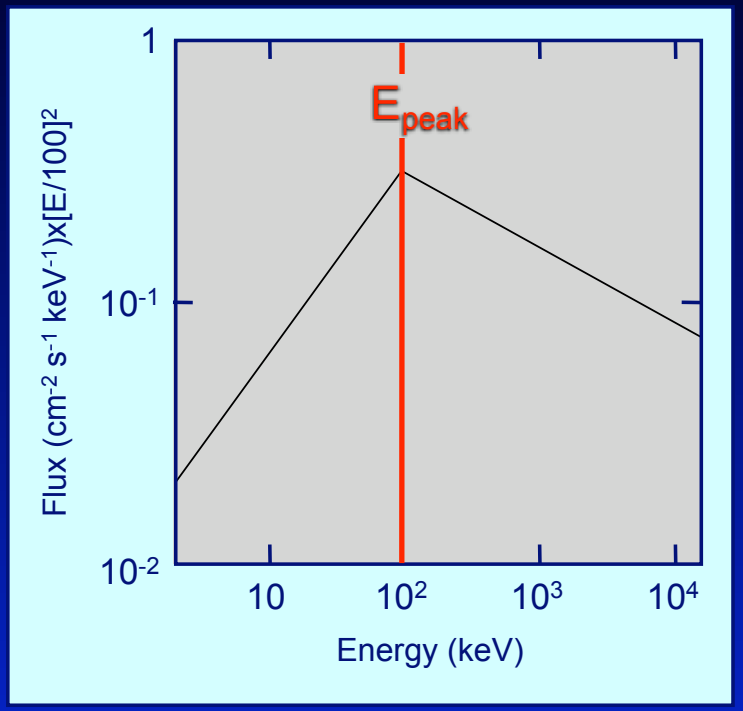


The 2704 GRBs detected by BATSE are uniformly distributed on the celestial sphere

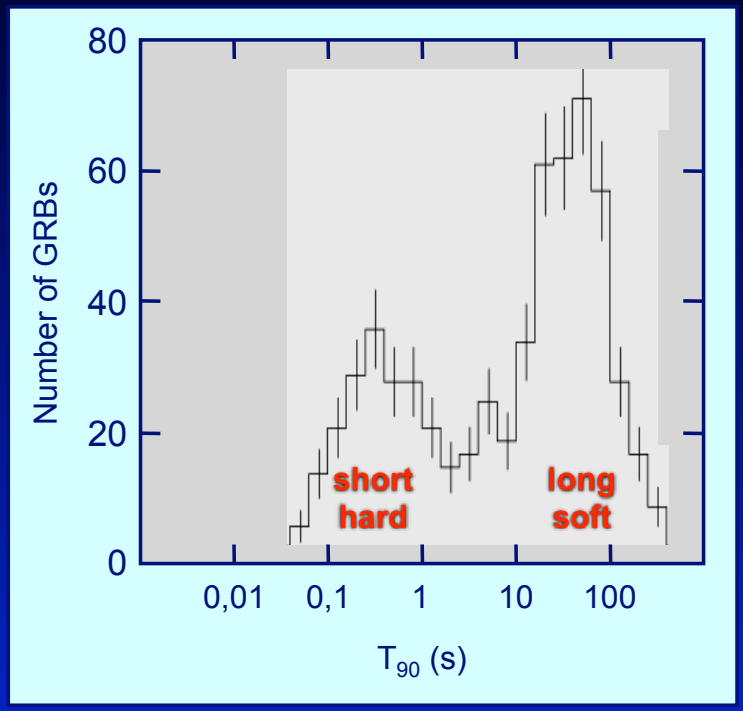
CGRO/BATSE: unprecedented statistics



CGRO/BATSE: unprecedented statistics



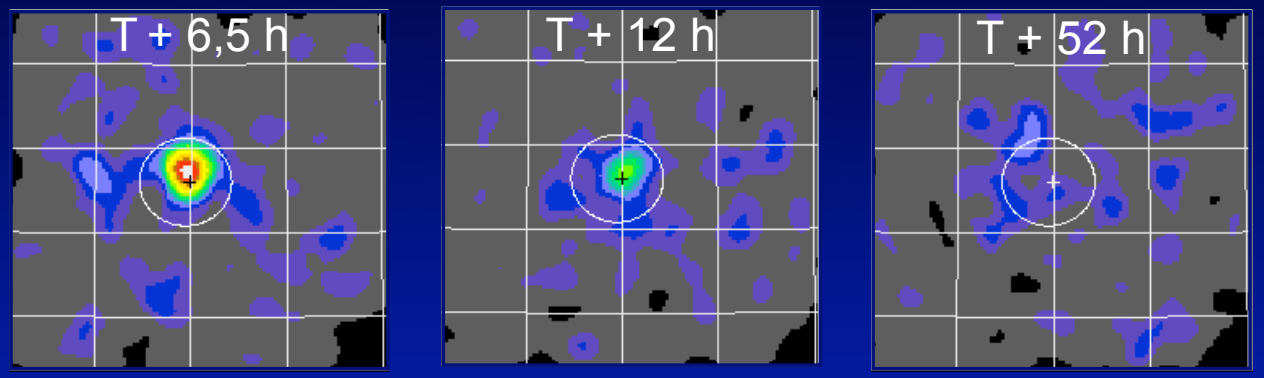
Energy radiated in the low energy gamma-ray band



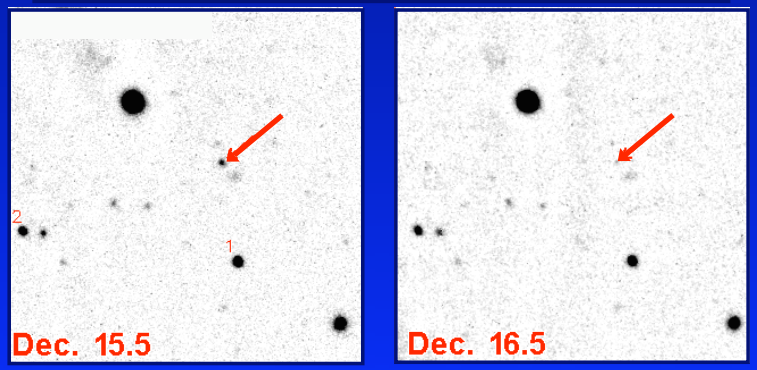
Bimodal distribution of GRB durations

BeppoSAX: long GRBs are cosmological

Afterglow of GRB 971214 detected by BeppoSAX in the X-ray band

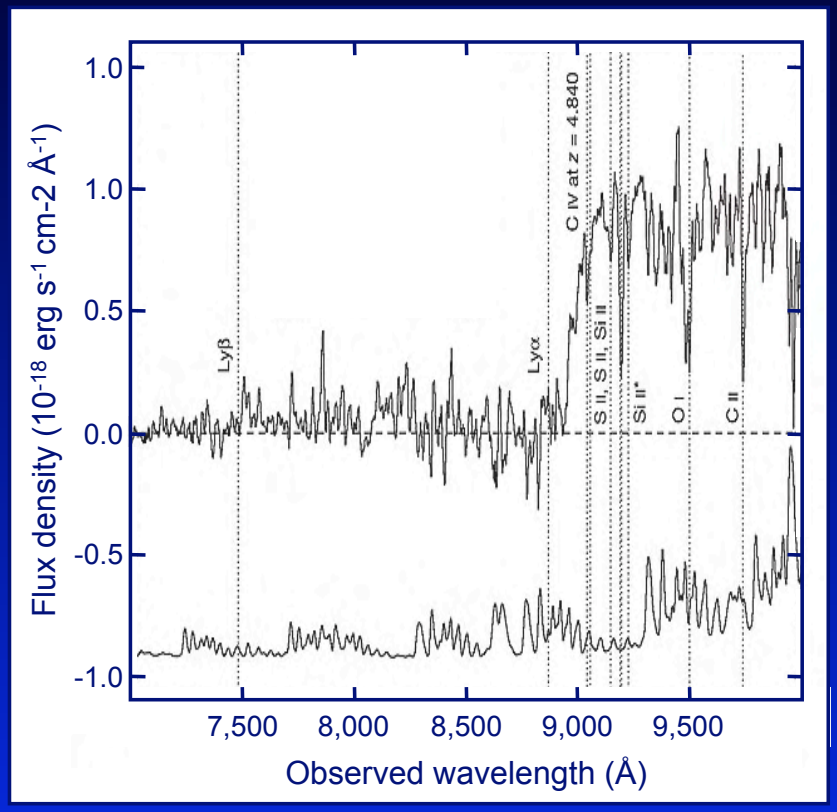


Afterglow in the visible band



- Detection of host galaxies
- Redshift measurements
- Cosmological distances
- Most energetic events
- 10^{44} J radiated in gamma rays

SWIFT: GRBs do exist at very high *z*



Cummings et al., GCN 3910, 2005

Kawai et al., Nature 440, 184, 2005

- On 05/09/04 at 01:51:44 Swift/BAT triggers on a long GRB (GRB 050904)
- T + 8 m: TAROT at CALERN observes the GRB field
- T + 27h: VLT measures the photometric redshift

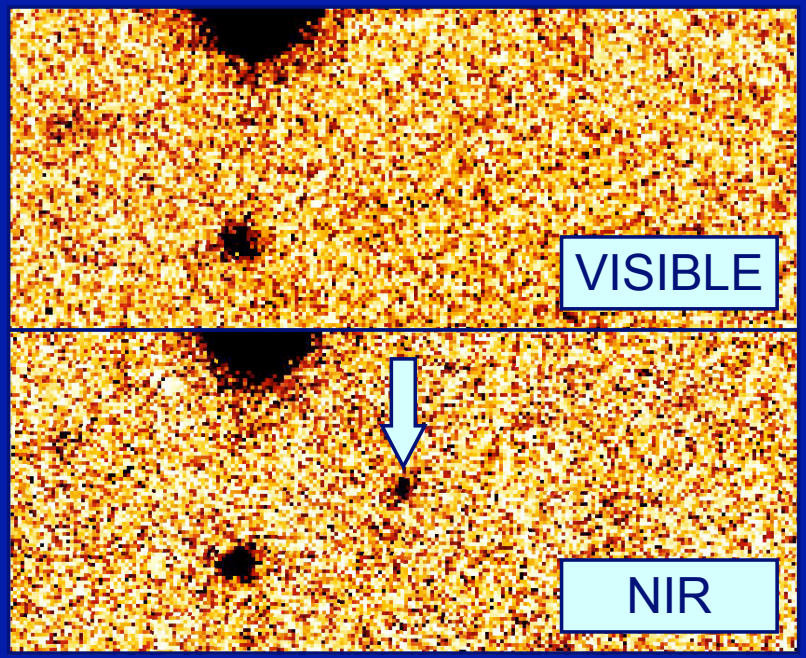
  z = 6.1 (+0.37 -0.12)
- T + 3.4 d: Subaru records a detailed NIR spectrum

  z = 6.295

The farthest ever GRB

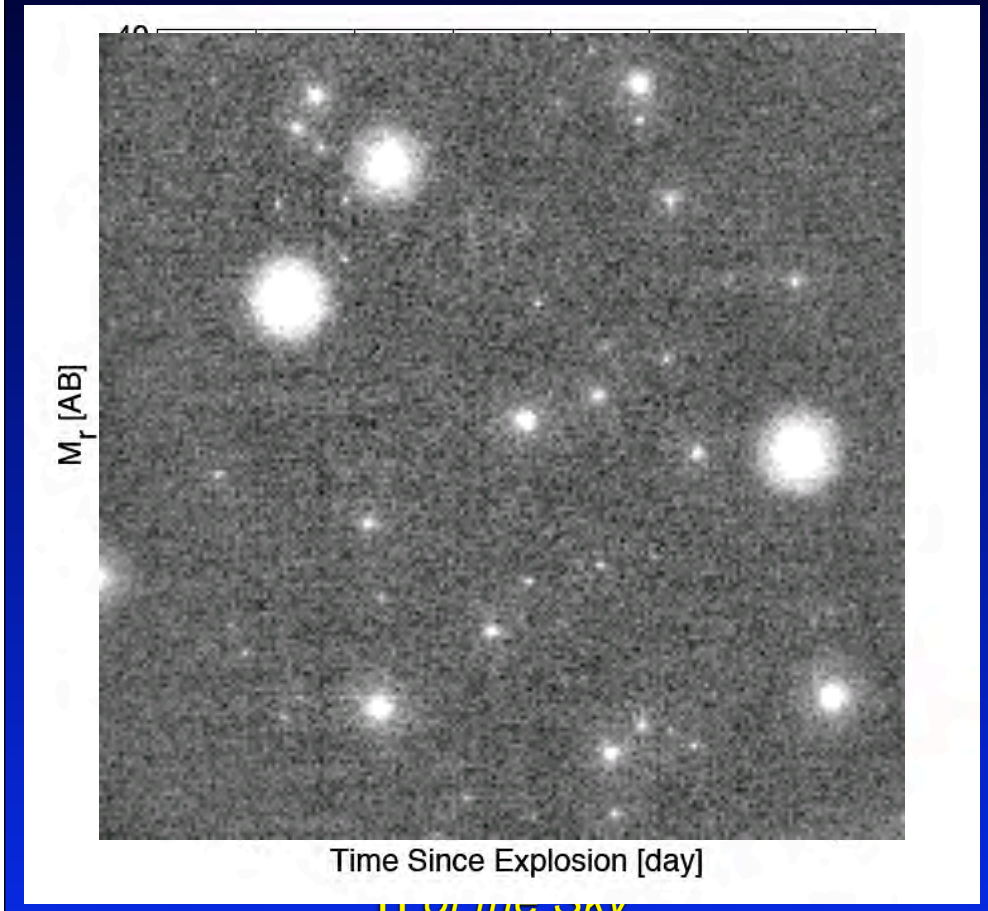
- On 13/09/08 at 06:46:54 Swift/BAT triggers on GRB 080913
- T + 2 h: VLT records a NIR spectrum **z = 6.7**

Shady et al., GCN 8217, 2008



Greiner et al., GCN 8223, 2008

SWIFT: GRBs are *VERY* bright!



- On 03/19/08 at 06:12:49 Swift/BAT triggers on a long GRB (GRB 080319b)
- Simultaneous observations by many telescopes:

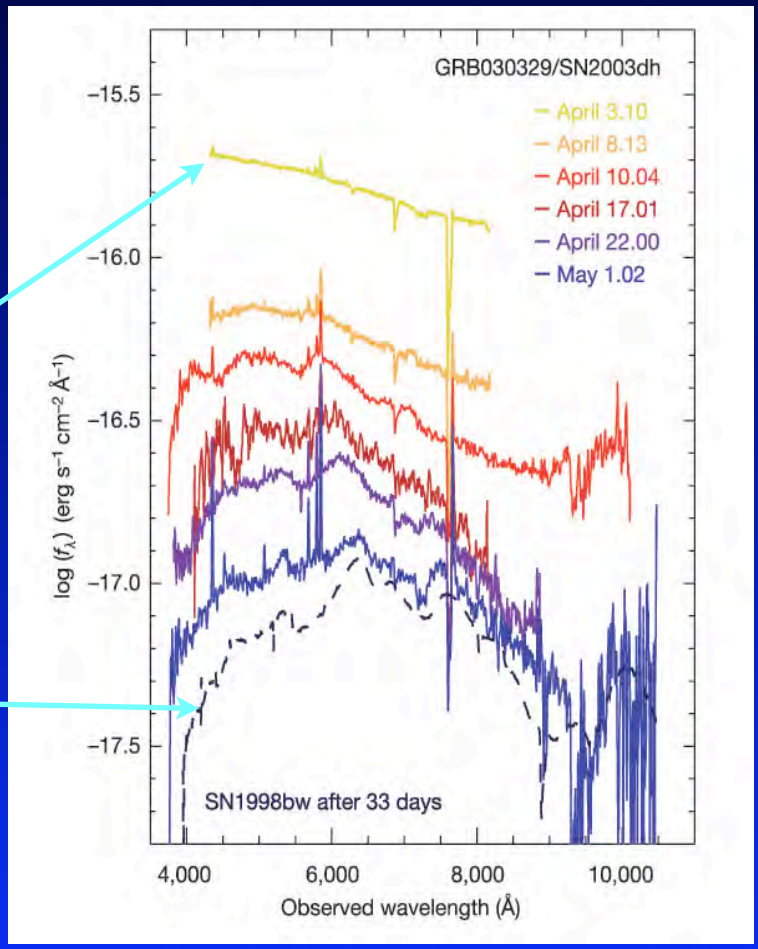
  $Mag_{Peak} = 5.8$
- T + 1h: VLT measures the redshift in Rapid Response Mode:

  $z = 0.937$

Hete-2: long GRB and Supernova connection

6 articles in Nature on GRB030329 and its associated supernova, SN2003dh:

- **Z = 0.1685**
- **E_{SN} = 2-5 10^{52} erg**



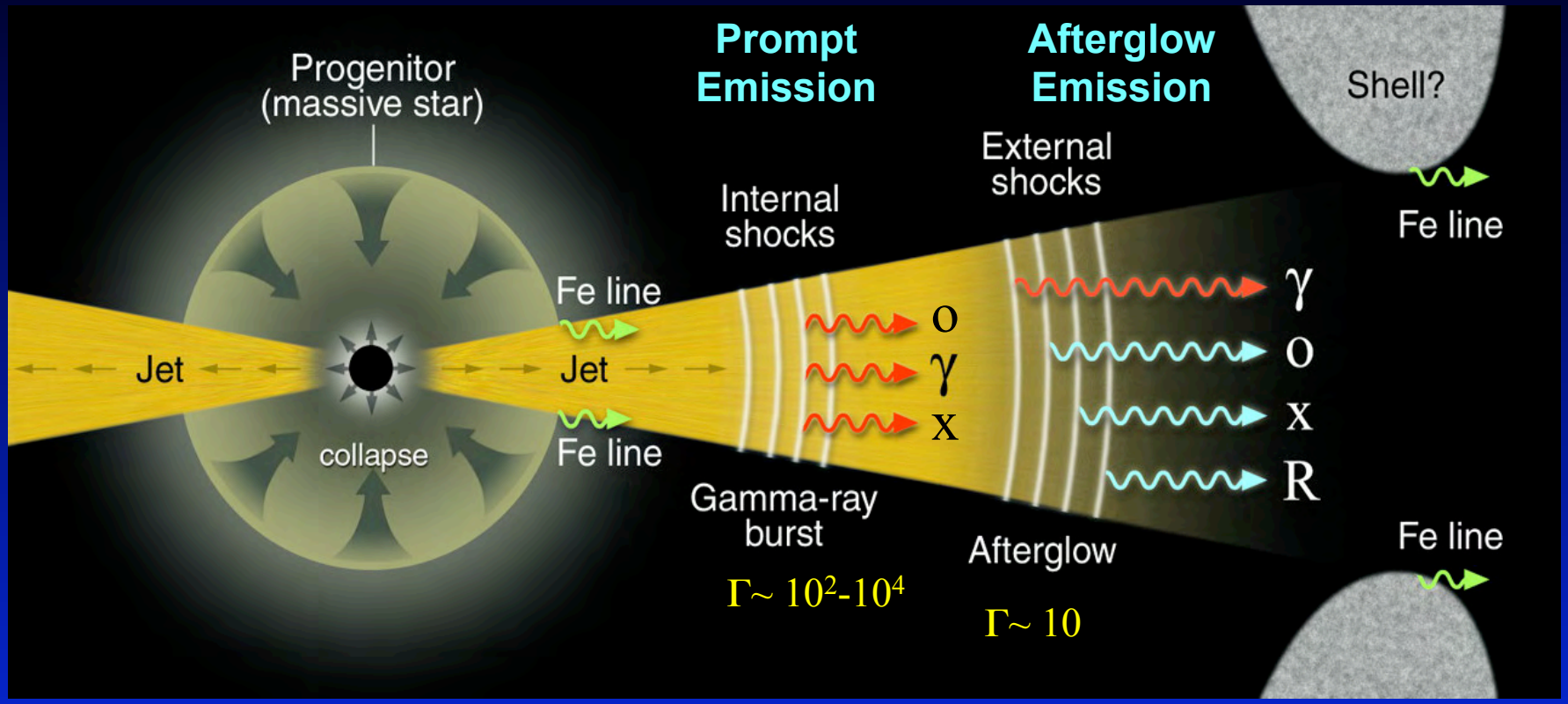
Hjorth et al., Nature, 2003

A small GRB primer

- GRBs are the most powerful phenomena in our Universe!
- GRBs are frequents: 1-2 event/day in the Sky.
- GRBs are one shot phenomena.
- GRBs emit over many decades in energy: from gamma-ray to visible and radio.


What do we believe
to be a GRB?

The Fireball model



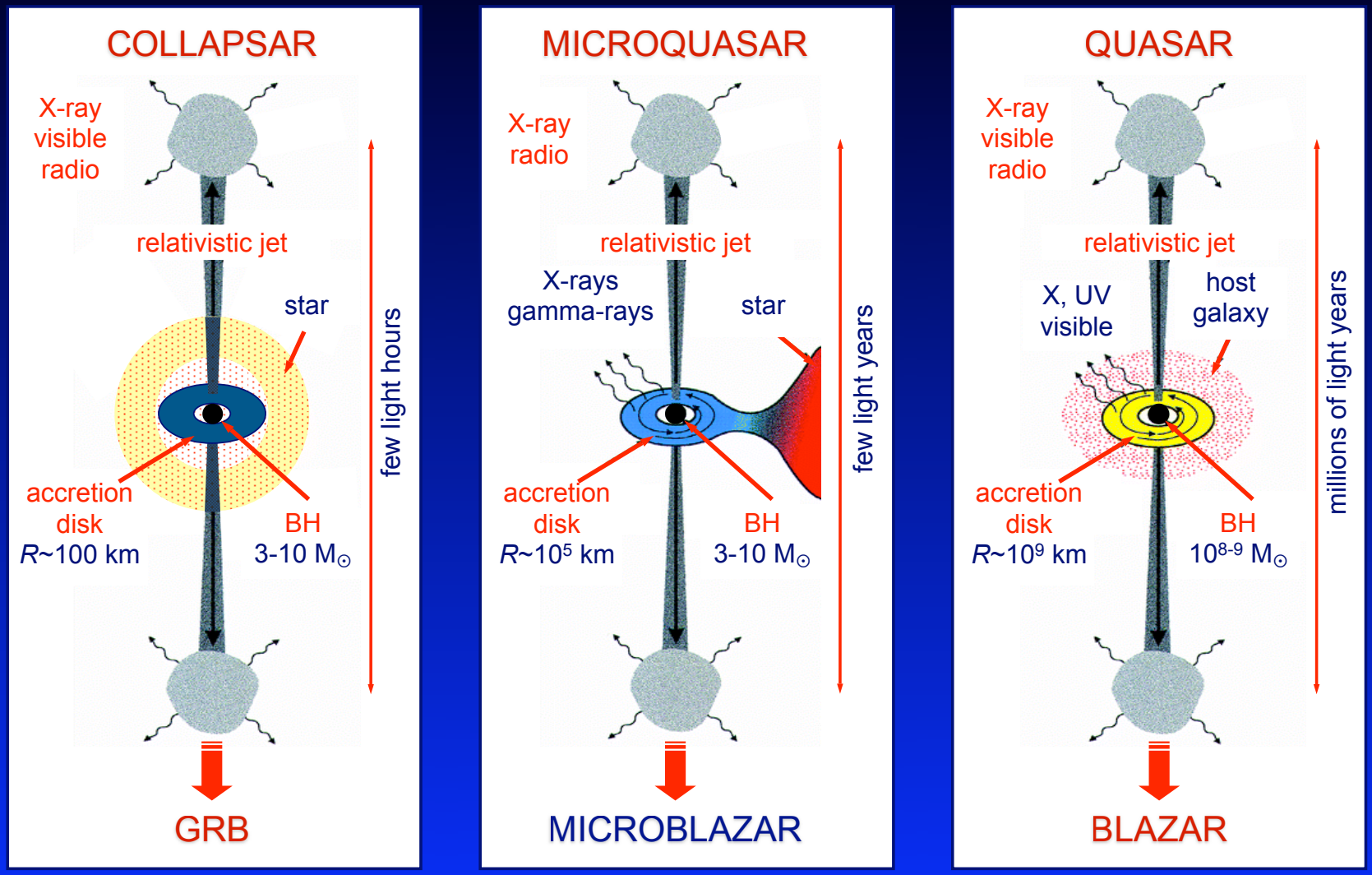
The Fireball model tells us how GRBs operate, but:

- Which processes generate the energetic ultra-relativistic flows?
- How is the shock-acceleration realized?

The Long GRBs

The Short GRBs

“Universality” of relativistic jets

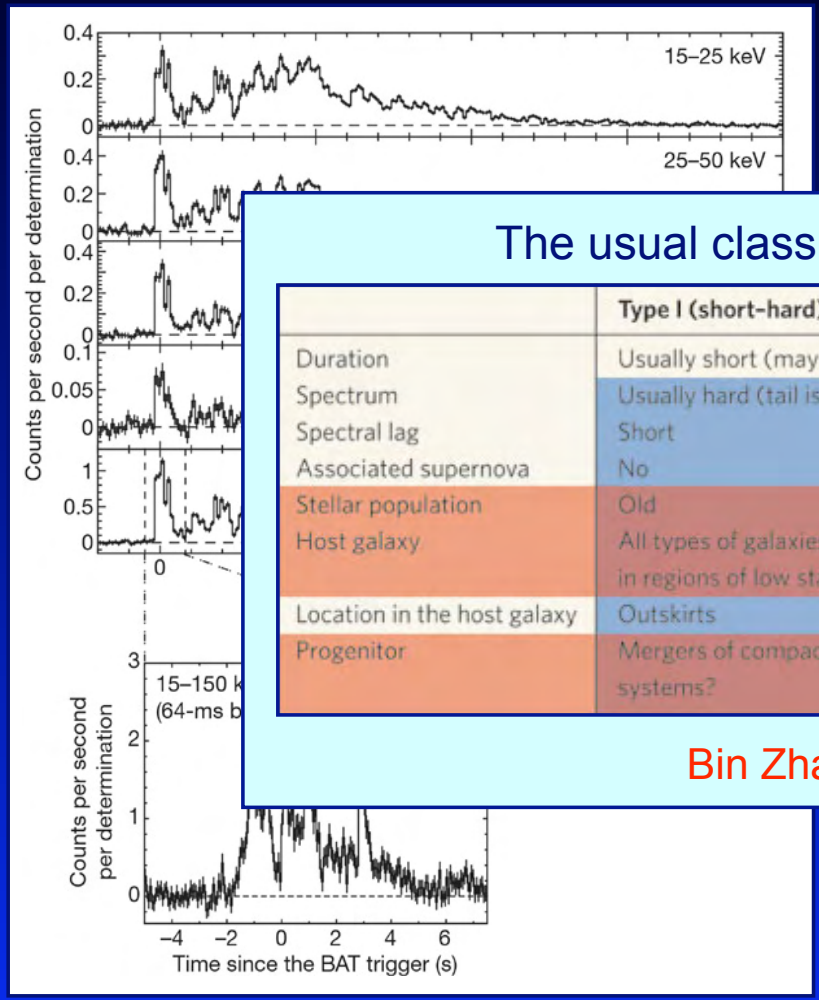



What can we learn
from the GRBs?

Questions for next decade

GRB phenomenon	• Diversity and unity of GRBs
GRB physics	• Acceleration and nature of the relativistic jet • Radiation processes • The early afterglow and the reverse shock
GRB progenitors	• The GRB-supernova connection • Short GRB progenitors
Cosmology	• Cosmological lighthouses (absorption systems) • Host galaxies • Tracing star formation • Re-ionization of the universe • Cosmological parameters
Fundamental physics	• Origin of high-energy cosmic rays • Probing Lorentz invariance • Short GRBs and gravitational waves

A burst of Nature papers ...



GRB 060614, a bright yet singular SWIFT GRB, subject of five papers in Nature (Vol 444, 20 Dec. 2006)

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weakest SN related to a GRB

Fynbo et al., p. 1048

Della Valle et al., p. 1050

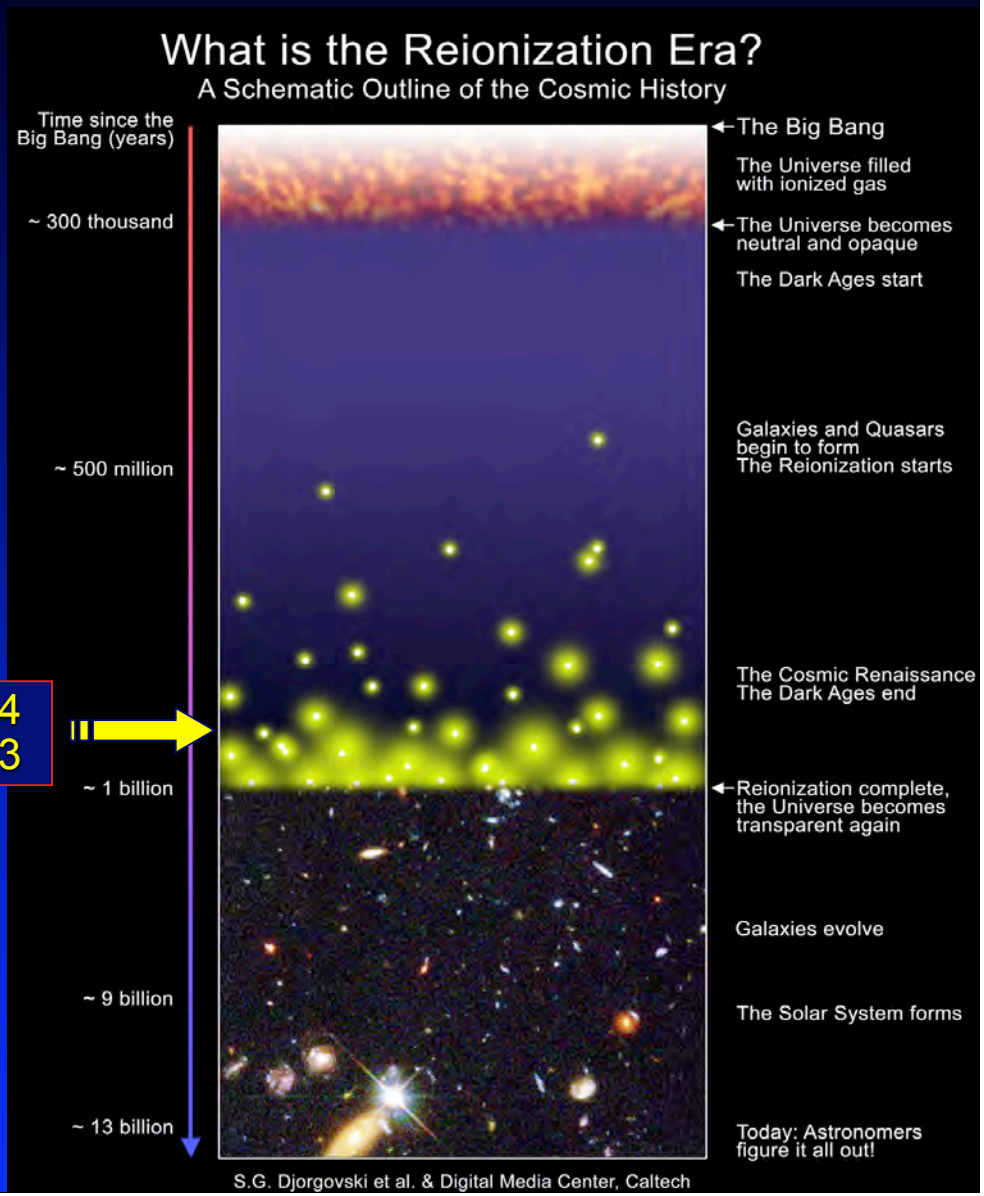
The usual classification in question?

	Type I (short-hard)	Type II (long-soft)
Duration	Usually short (may have a long tail?)	Usually long
Spectrum	Usually hard (tail is soft)	Usually soft
Spectral lag	Short	Long
Associated supernova	No	Yes
Stellar population	Old	Young
Host galaxy	All types of galaxies (predominantly in regions of low star formation rate)	Late-type galaxies (predominantly in irregular, dwarf galaxies)
Location in the host galaxy	Outskirts	Central
Progenitor	Mergers of compact objects in binary systems?	Single-star systems? (Core collapse of massive stars)

Bin Zhang, p. 1011

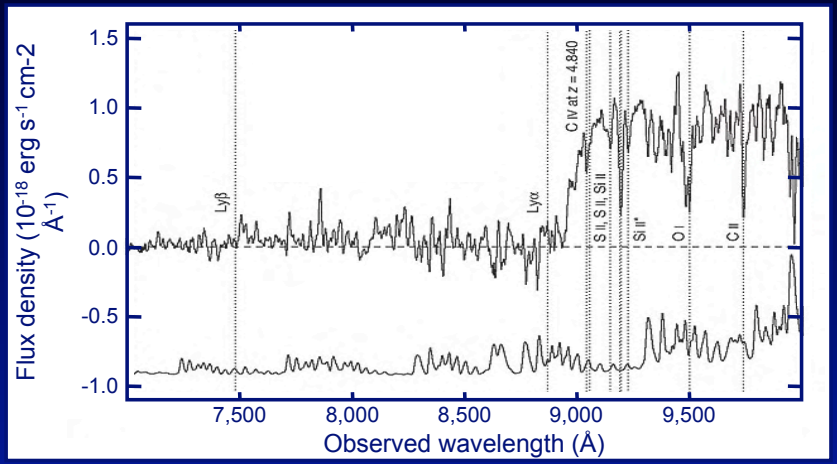
A brief history of the Universe

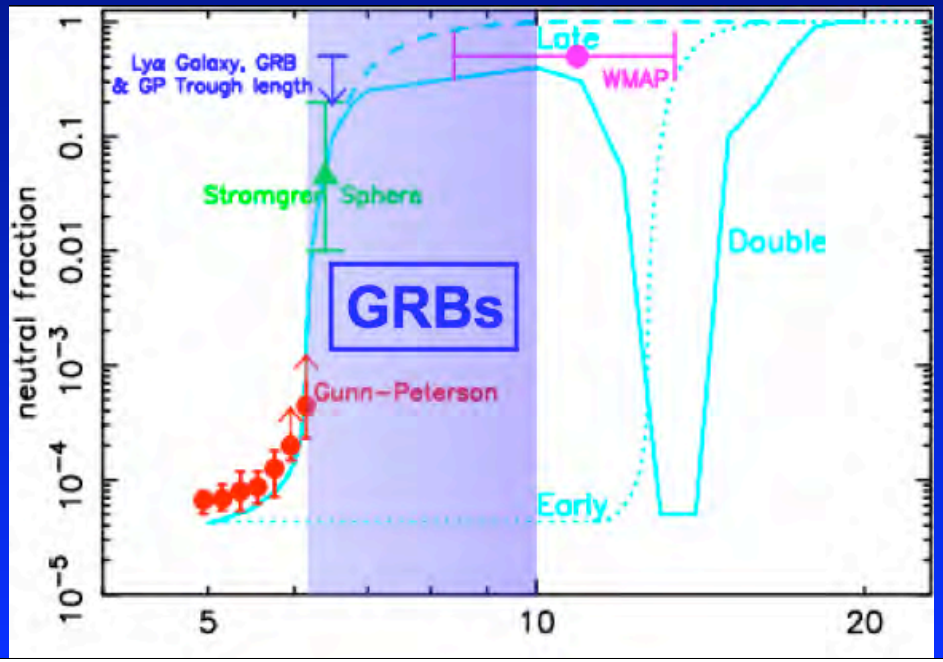
GRB 050904
GRB 080913



A powerful beacon

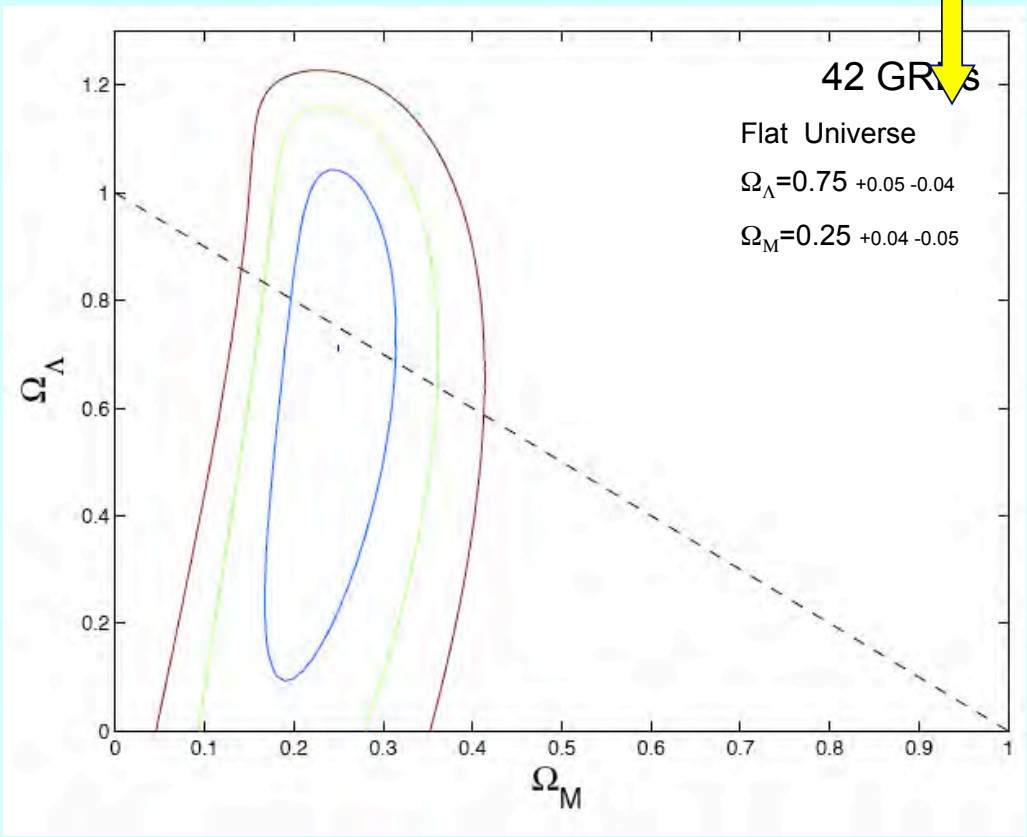
- GRB can be used as cosmological beacons for study of the IGM up to z > 6
- Study of the re-ionization epoch





GRBs on the SNe Ia tracks?

GRB 050904
GRB 080913



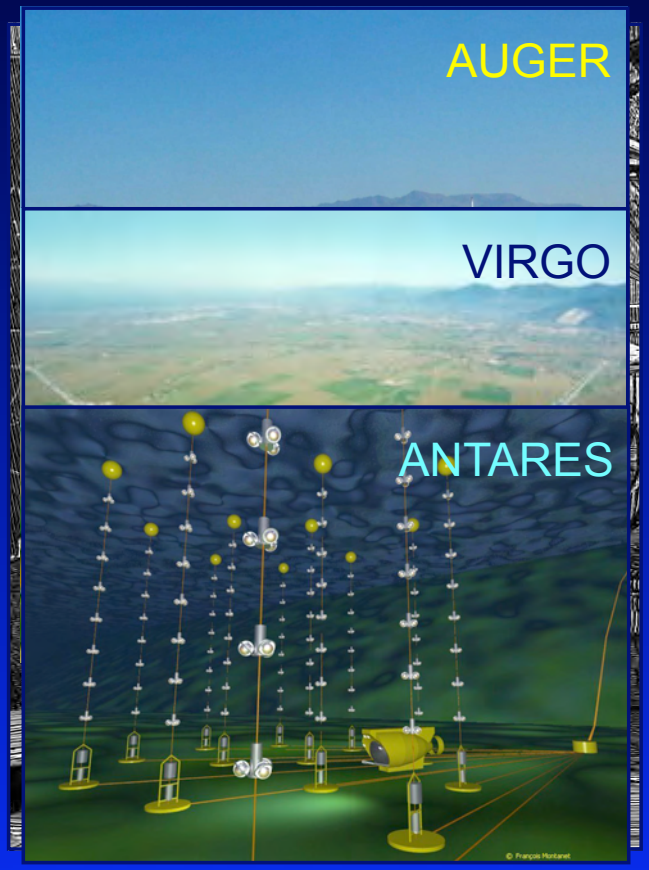
Ghirlanda et al., ApJ, 613, 2004

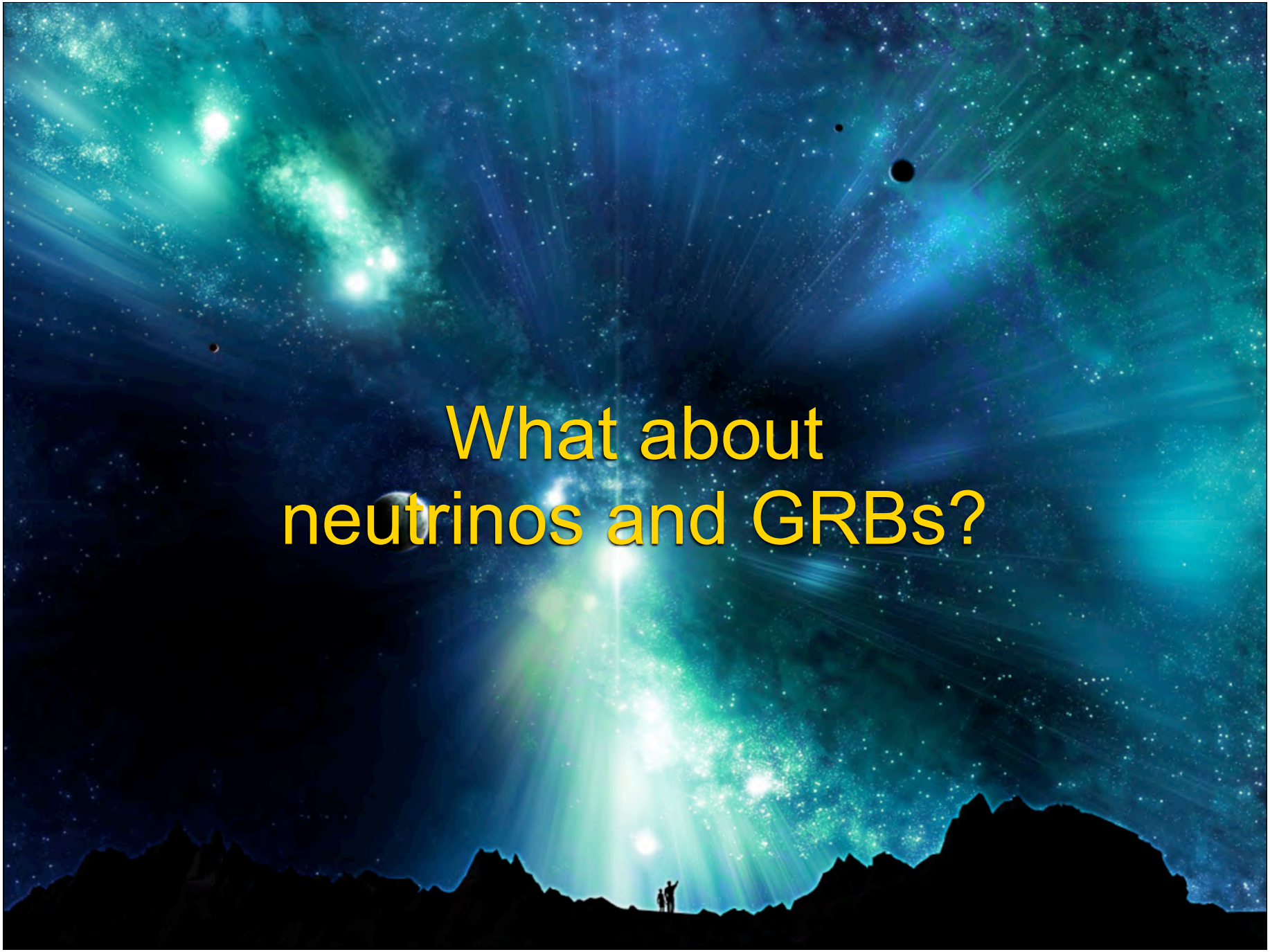
Liang et al., 2008

“Maids of all works” of particle astrophysics

In the framework of the “standard” model of GRBs, many theoreticians anticipate that GRBs could be sources of:

- Ultra high energy cosmic rays
- Gravitational waves
- High energy neutrinos




What about
neutrinos and GRBs?

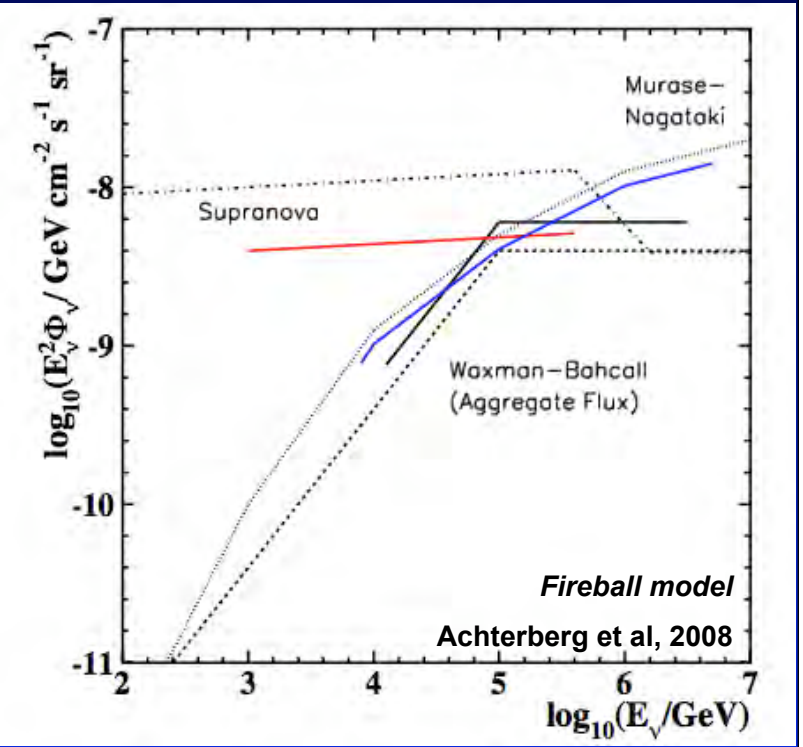
The neutrinos produced by a GRB

High energy neutrinos expected by photonuclear interactions of the observed gamma-rays with the protons accelerated by the internal shocks.

But neutrino flux very uncertain:

- Models: ratio proton/gamma, progenitor environment, ISM, ...
- Affected by neutrino oscillation.

Need to observe the production of high energy neutrinos to distinguish models!



Observing strategy

Detection in conjunction with accurate timing and positional information provided by an external source:

Triggered search

Searching for multiplets of neutrino events from the same direction and within a short time window:

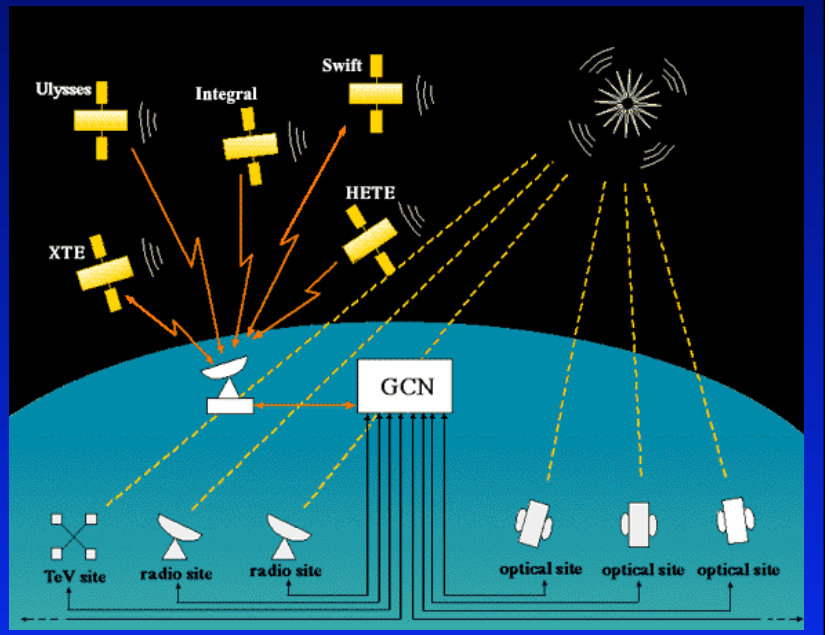
Rolling search

A very fast analysis of the data is mandatory !!!

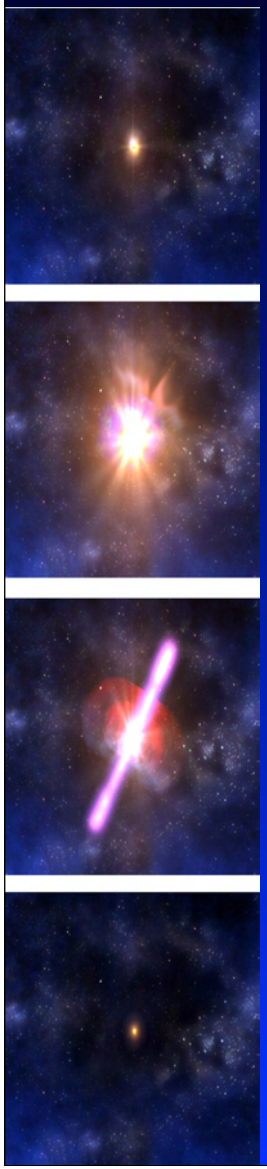
Triggered search

Possible to detect individual nearby bursts in conjunction with accurate timing and positional information provided by observations of the burst in the gamma-ray domain:

- Triggers delivered by a satellite.
- Information immediately available through the Gamma ray bursts Coordinates Network.
- Threshold reduced by using directional and temporal information.



Triggered search



Advantage: the nature of the source is known!

Inconvenient: depend on external sources!

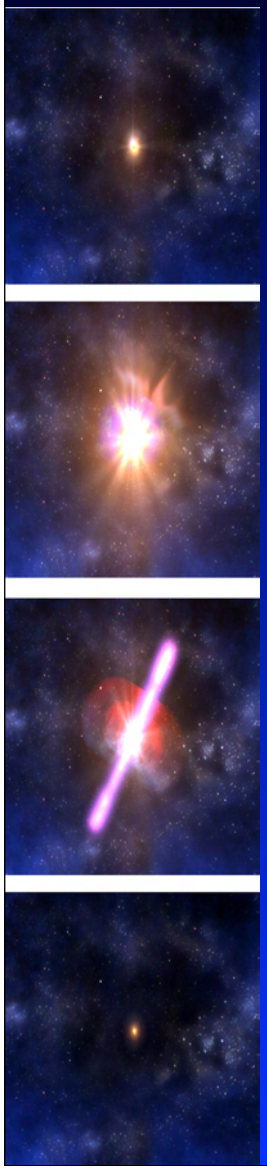
- SWIFT (1.4 sr fov): only ~1 / 9 GRB detected.
- No other observation for choked GRBs.

Rolling search

Possible to enhance the sensitivity of Neutrino Telescope by searching for neutrino-bursts:

- Trigger on multiplet of neutrino events (≥ 2) from the same direction and within a short time window, or very energy single event (>10 TeV).
- Sensitivity improved by a factor 2-3.
- Method sensitive to Choked GRBs!

But need a follow-up program to confirm detection.



Rolling search technique

Collaboration with the TAROT telescopes array

TAROT: two 25 cm telescopes located at Calern (South France) and La Silla (Chile)

- FoV: 1.86° x 1.86°
- Magnitude V<17 (10s)
  V<19 (100s)
- ~ 10s repositioning after the alert reception

Limit: no observation in the galactic plane

TAROT La Silla

IceCube plans to work with the 4 RAPTOR telescopes

On the importance of a multi wavelength follow-up

Whatever the method, observations of a transient phenomena has to organized:

A *great discovery* need a complete data set !!!

Fundamental to include it in a follow-up program:

- Prompt analysis mandatory: GRBs are short-lived phenomena (< 1 day).
- A good angular resolution is clearly an advantage!
- Important to report a “possible” neutrino observation to the GCN and/or to a follow-up network: trigger complementary observations.

SVOM,
the next GRB hunter!

Past milestones of the SVOM mission

2005 Sino-French discussions (CNES-CNSA) on a mini satellite mission

Scientific definition of the Space Variable Objects Monitor (SVOM)

CNES-CNSA decision to study the SVOM mission

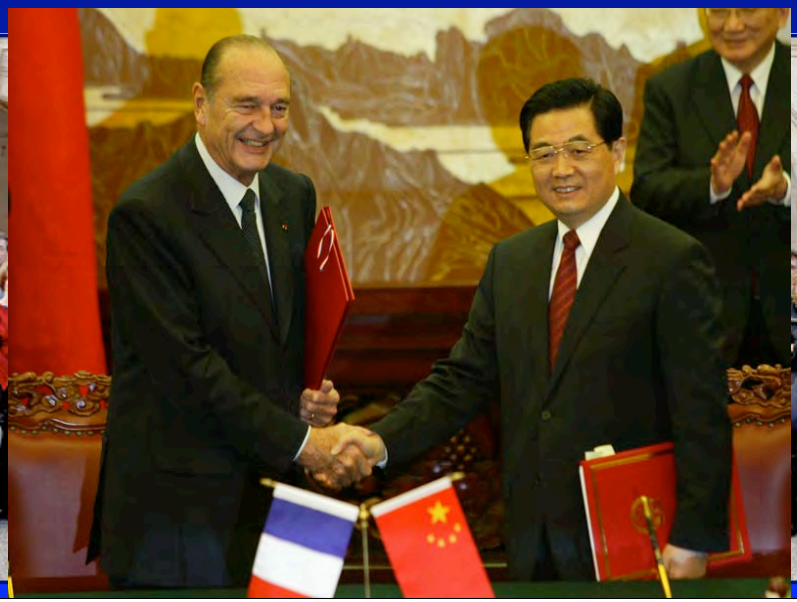
2006 SVOM Phase 0 kick-off meeting (March, Toulouse)

SVOM phase 0 review (Sept., Shanghai) – No critical issue

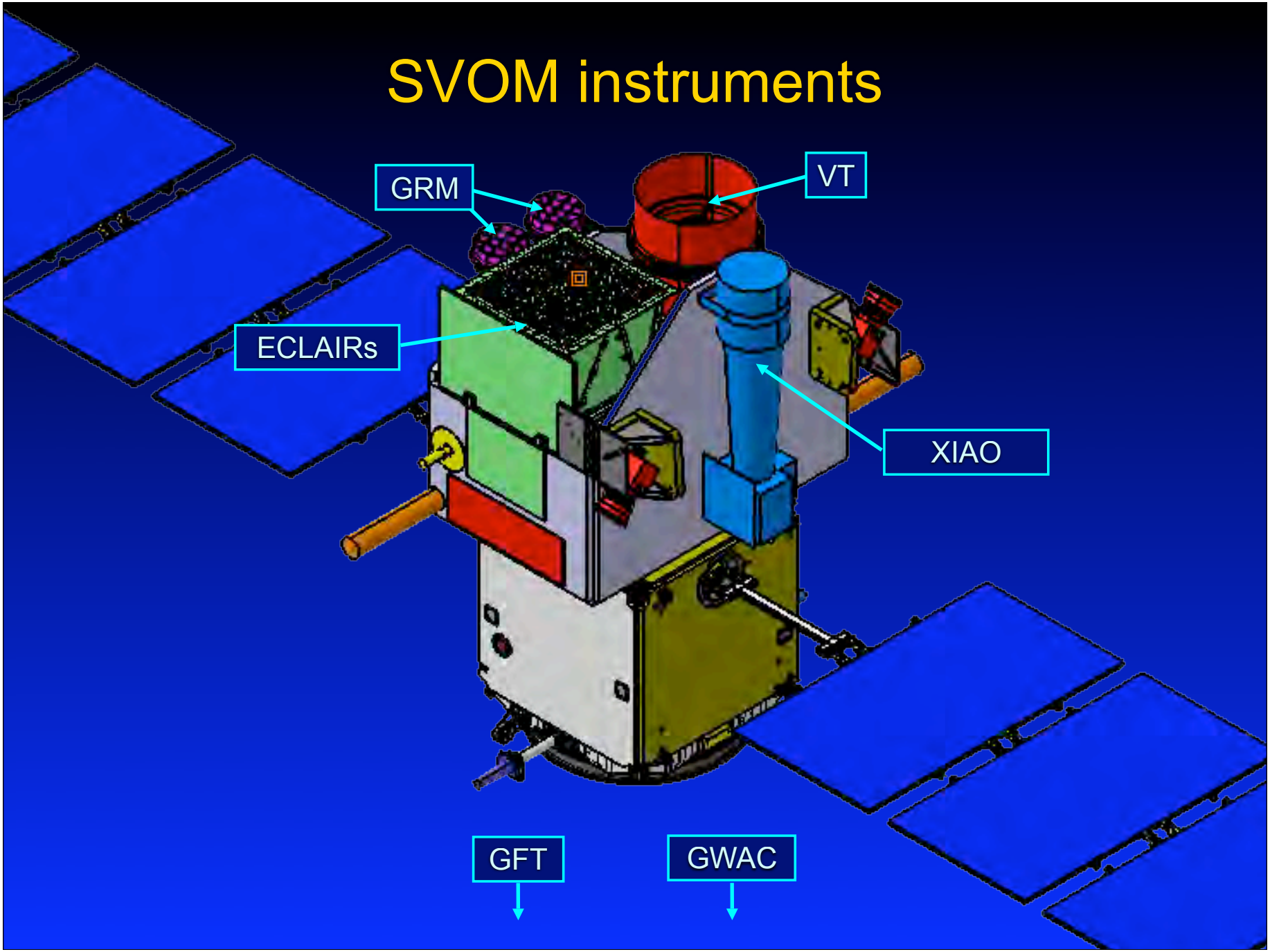
CNSA/CNES MoU signed during the President visit (Oct., Beijing)

2007

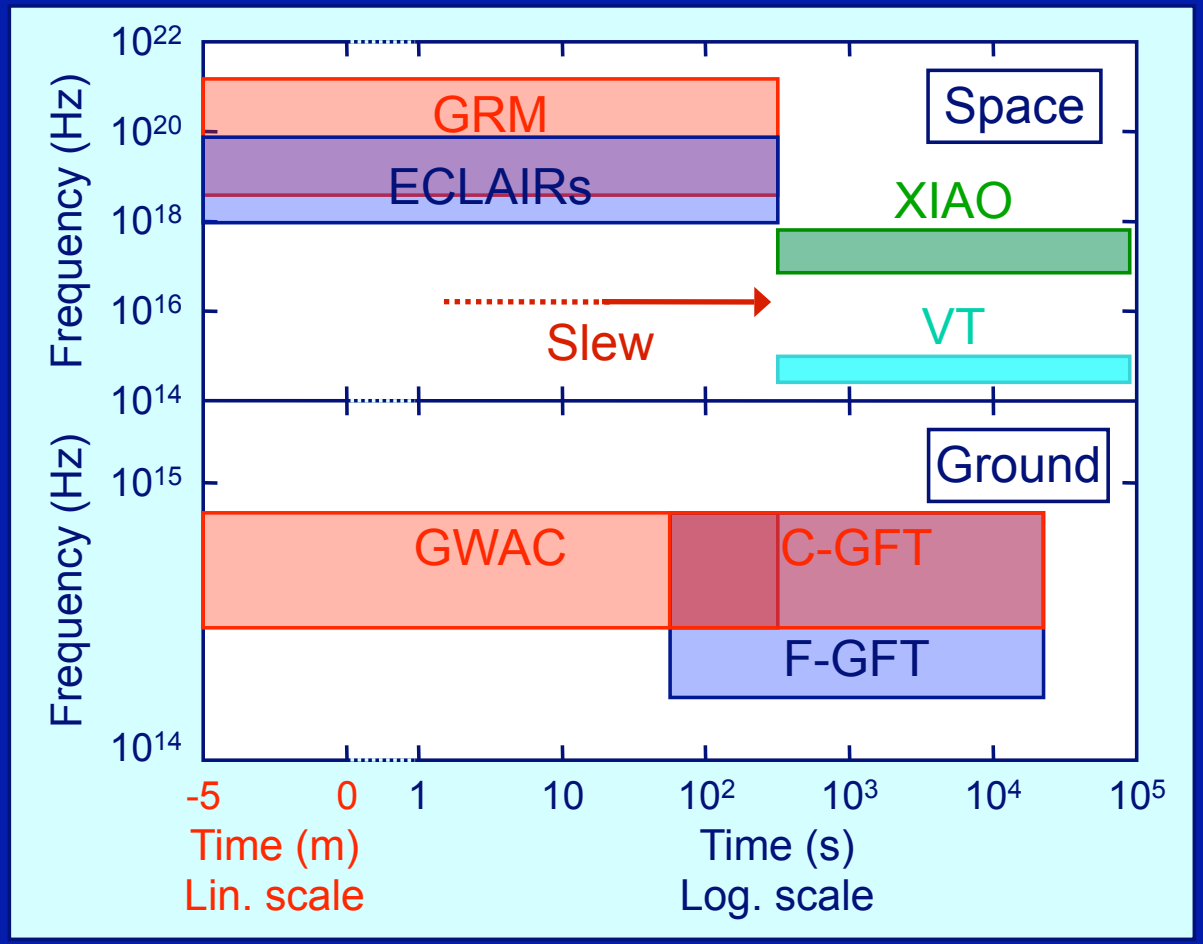
2008



SVOM instruments

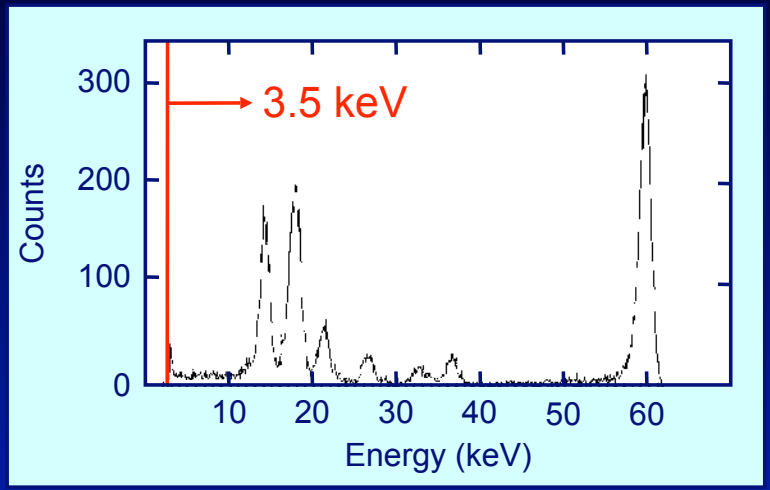


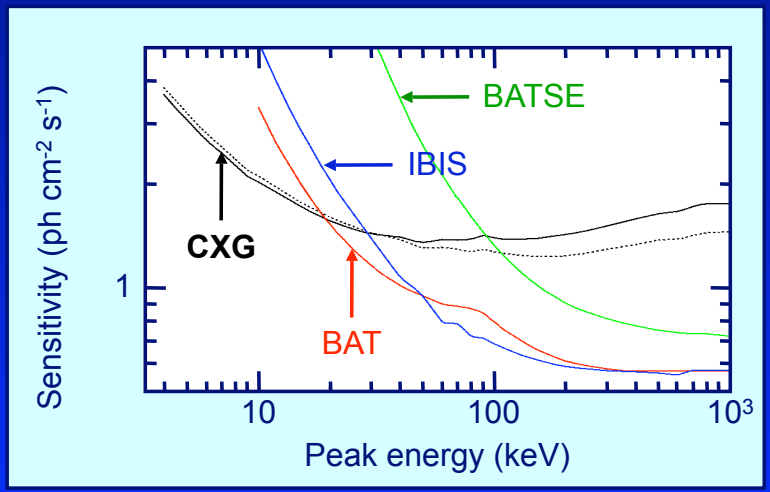
SVOM multi-wavelength capabilities



Space and ground instruments join to enable a unique coverage

Anticipated GRB trigger performances





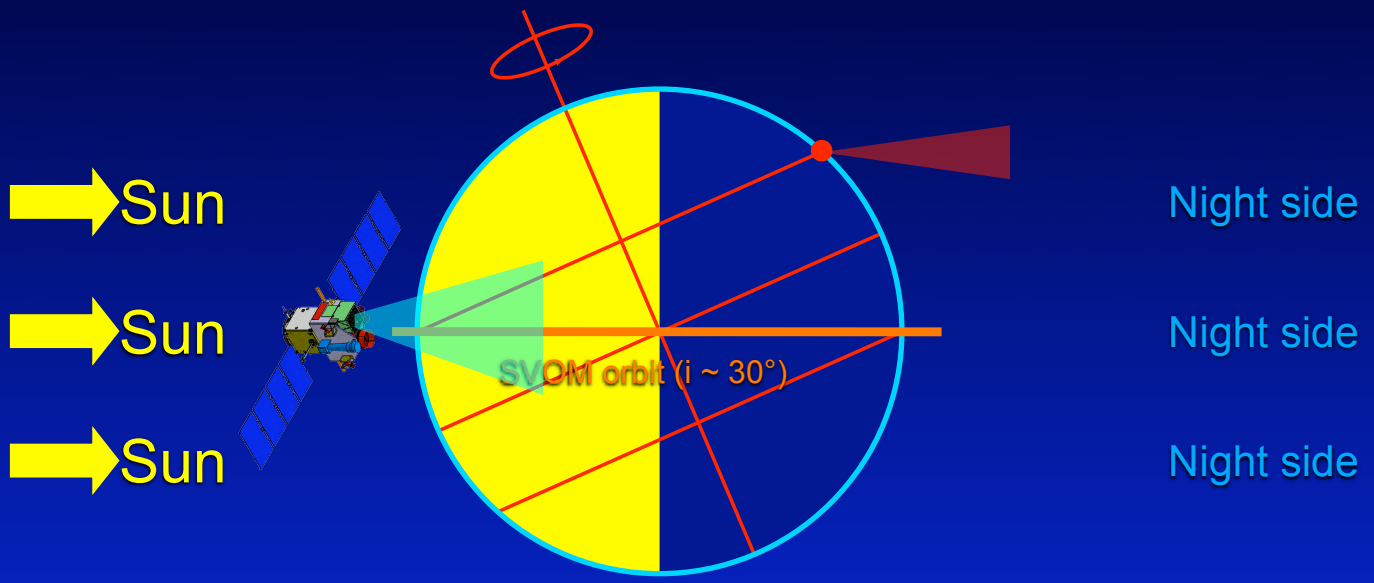
Instrument	Band (keV)	GRB/yr at z > 6
IBIS *INTEGRAL*	20-200	0.1-0.5
BAT *Swift*	15-150	1.3-4.0
CXG *SVOM*	4-50	2.0-4.0

CXG/SVOM

~ 80 GRB alerts/year

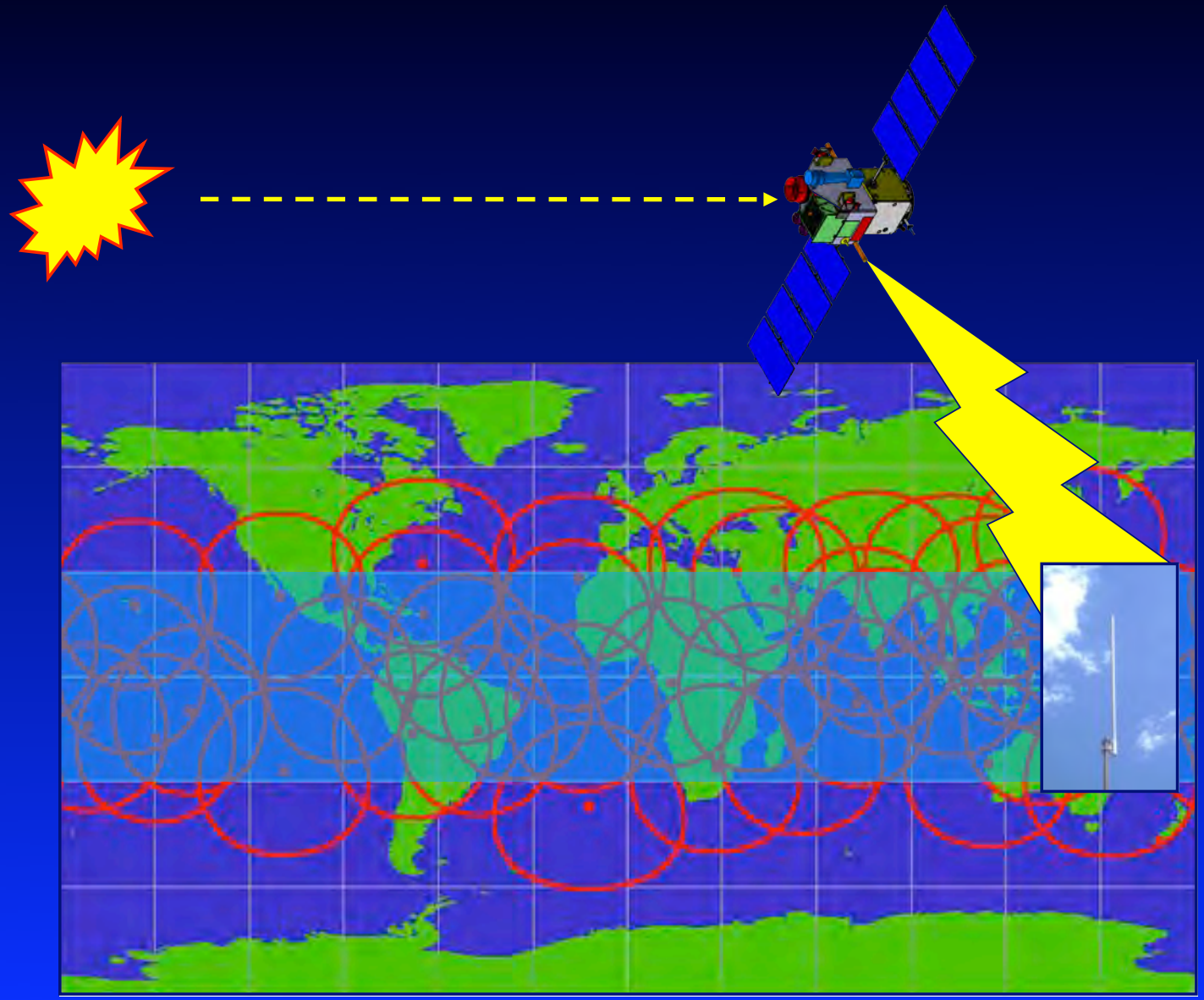
Salvatera et al. Astro-ph 2007

Pointing strategy: anti solar



Most of the GRBs detected by SVOM to be well above the horizon of large ground based telescopes all located at tropical latitudes

Prompt dissemination of the alerts



SVOM compared to SWIFT

Prompt emission measurement

- More sensitive below 20-30 keV
- E_{peak} measurement capability
- Multi-wavelength capabilities from visible band to MeV gamma rays

Afterglow emission measurement

- > 10 more sensitive in the visible
- Sensitive in the 650-950 nm band

Follow-up observations

- Dedicated follow-up robotic telescopes
- GRBs much easily scrutinized by the largest telescopes

SVOM: the successor of SWIFT

In summary

A strong scientific case

- Understand the most energetic events in the Universe.
- Study the Dawn of the Universe.

Participants

- China: *CAS, CNSA, NAOC, SECM, XIOPM.*
- France: *APC, CEA, CESR, CNES, IAP, INSU, LAM, LATT, OHP.*

Preparing a successful mission

- GDR European with France, Germany, Italy and United Kingdom: "Dawn of the GRBs"

Rendez-vous early 2013 for the very first events …

The cosmic distance ladder ?