Millimetre observations of gamma-ray bursts

(12 yrs of GRB observations at IRAM)

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Collaborators (over 12 yrs)

Collaborators nowadays:

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Former collaborators:

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Millimeter Observations

mm observations are essential. Why?

1. No absorption effects (like gamma-rays), i.e. dark or ultra-high z bursts can be detected !
2. The peak of the GRB synchrotron spectrum peaks in the mm range.
3. No self-absorption effects (as seen at lower-frecquencies)
4. No interstellar scintillation effects (as seen at lower-frequencies)
5. The peak of the *afterglow* emission takes hours-days to cross the mm band
6. PdB is the only observatory nowadays that has the sensitivity enough to detect the *afterglow* emission for a considerable number of events (and perhaps even for detecting the *forward* emission too in some cases)
7. A logistics advantage: the flexibility of PdB due to the fact that is a service observatory (with no observers present at the time of executing their programs) make easy to reschedule a ToO program.

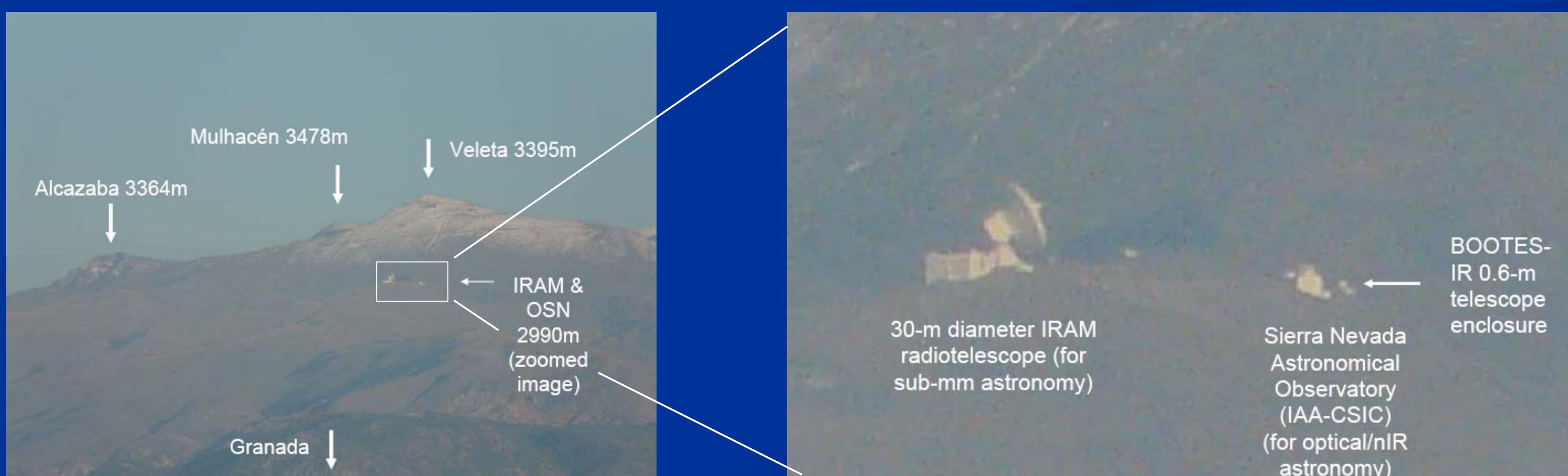
The PdBI

IRAM (the ‘Institut de Radioastronomie Millimétrique’ , IRAM) was founded in 1979 by the French CNRS (Centre National de la Recherche Scientifique), the German MPG (Max-Planck-Gesellschaft) and the Spanish IGN (Instituto Geográfico Nacional.

The interferometer on the Plateau de Bure in France, with its 6 antennas at 2550m in the Haute Alpes (France), is the most powerful observatory today operating at millimeter wavelengths (1 & 3 mm).

The 30m at Pico Veleta

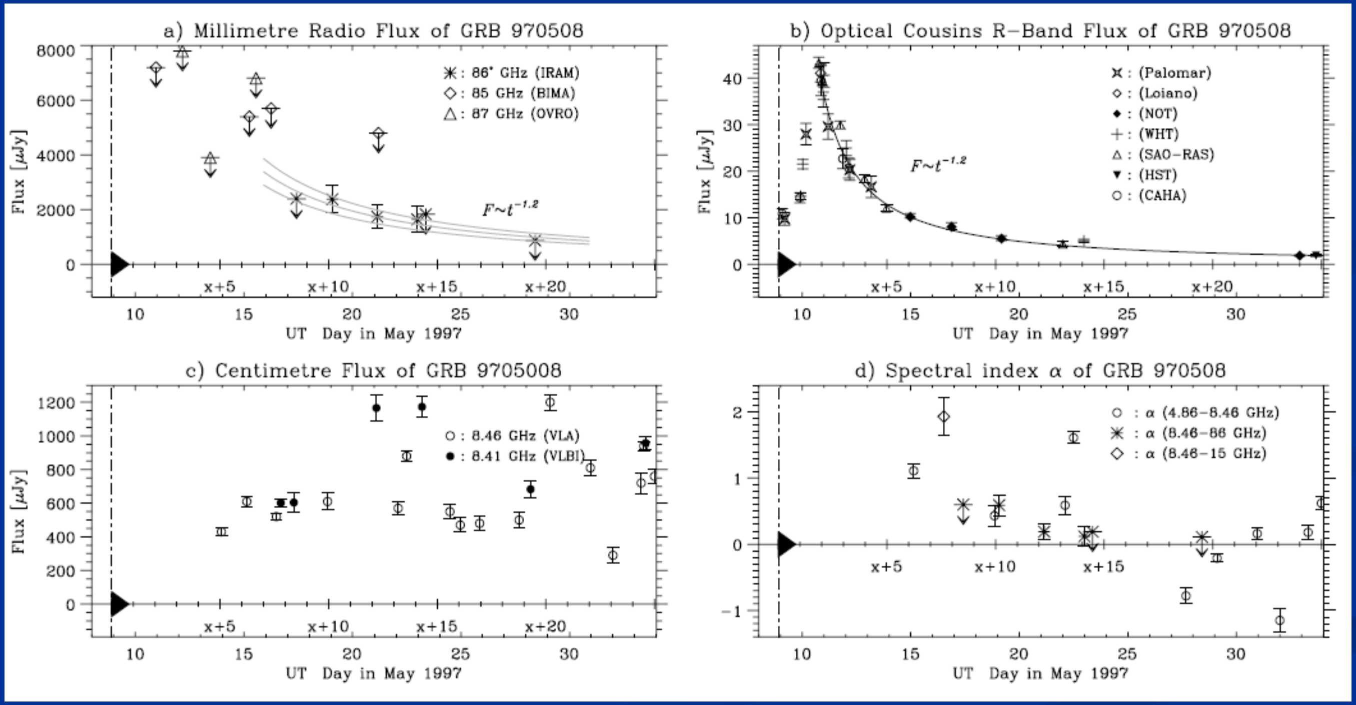
Sub-mm observations can be carried out at the 30m antenna at Pico Veleta, in Sierra Nevada, just 200 m from the IAA-CSIC's OSN observatory at 2850m in Granada (Spain).



Millimeter Observations (1)

1997: The first mm afterglow

As soon as the first X-ray afterglow was discovered by *BSAX* in Feb 1997, we attempted Bure observations for the second event (May 1997). They led to the first detection ever of an afterglow at mm wavelengths!



GRB 970508 at z = 0.805 (Bremer et al. 1998, A&A)

Millimeter Observations (2)

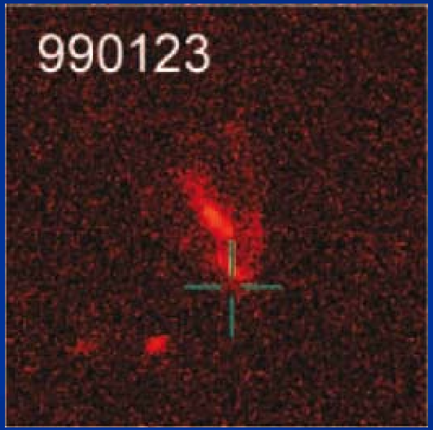
1999-2001: 3 limits and 1 detections

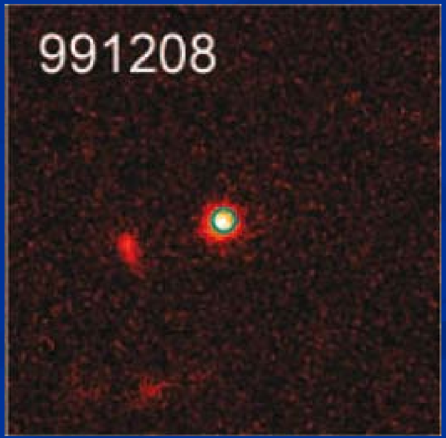
GRB 990123: < 1.5 mJy (Galama et al. 1999, Nature)

GRB 991208: 2.4 mJy @ 240 GHz with the 30m (Bremer et al. 1998, GCNC, Castro-Tirado et al. 1999, A&A)

GRB 001109: no detection with the 30m (Castro Cerón et al. 2004, A&A)

GRB 010222: < 1. 5 mJy @ 93 GHz (Bremer et al. 2001, GCNC and Sagar et al. 2001, BASI)





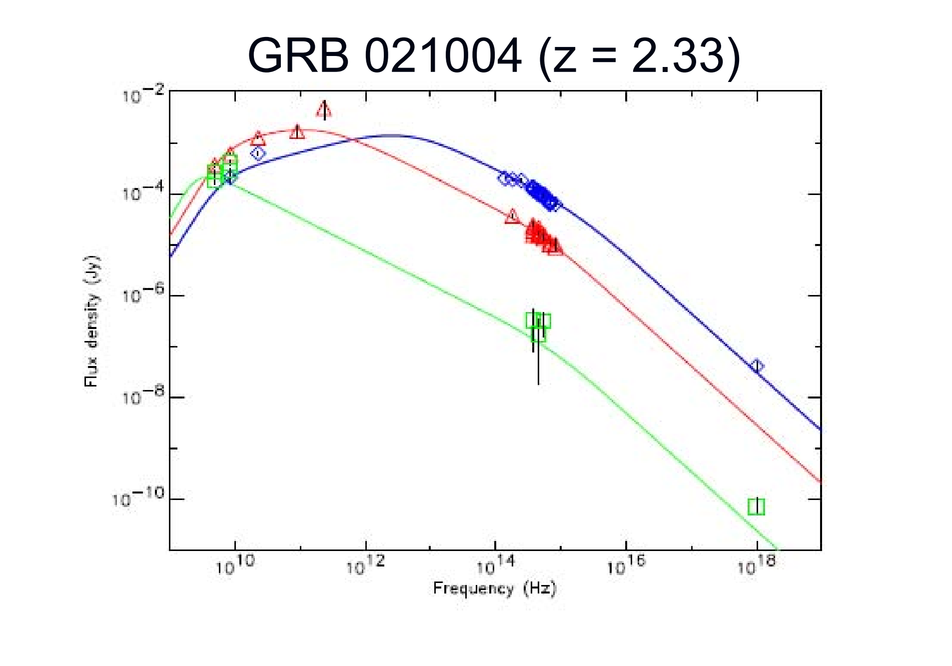
HST (Fruchter et al. 2008)

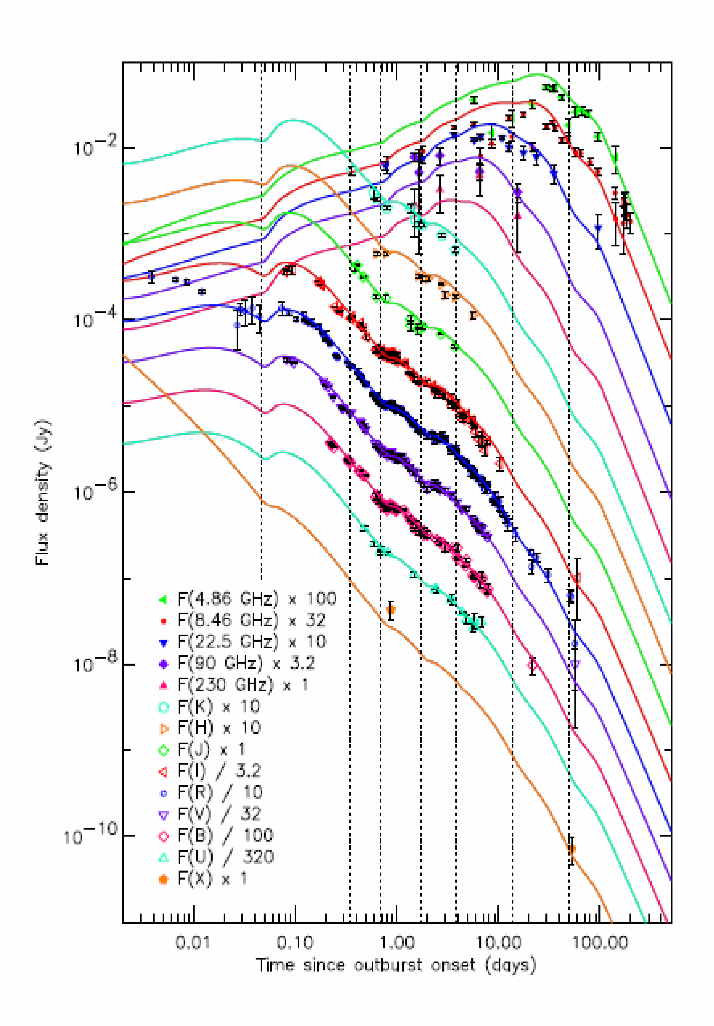
Millimeter Observations (3)

2002: 1 limit and 1 detection

GRB 020813: no (Bremer & Castro-Tirado 2002, GCNC)

GRB 021004: yes, @ 86 & 230 GHz (Bremer & Castro-Tirado 2002 GCN, de Ugarte Postigo et al. 2005, A&A)



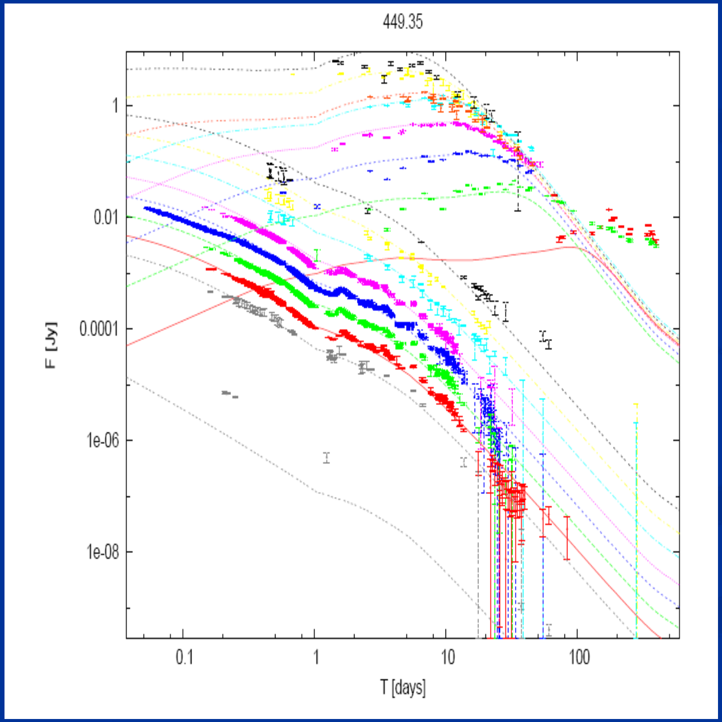


Millimeter Observations (4)

2003: the nearest "classical" GRB detected

GRB 030226: < 1.5mJy, Pandey et al. (2004, BASI)

GRB 030329: 58 mJy (!) @ 86 GHz. Also detected with SEST (Guziy et al. 2010)



Millimeter Observations (5)

2004-2005: The start of the *Swift* era: 2 detections and 3 limits

GRB 041219: 2 mJy detection

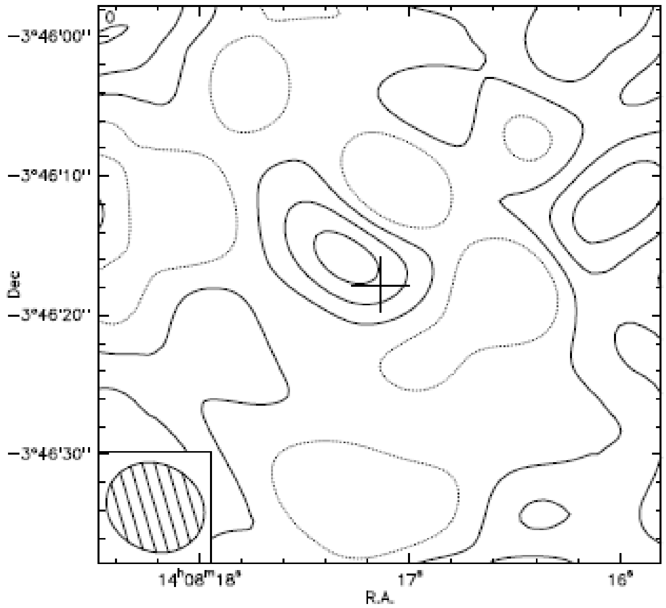
GRB 050408: < 1 mJy @ 86 GHz (de Ugarte Postigo et al. 2006, A&A)

GRB 050525: non detection

GRB 050509b (first mm follow-up of a short-duration GRB): non detection (Castro-Tirado et al. 2005, A&A)

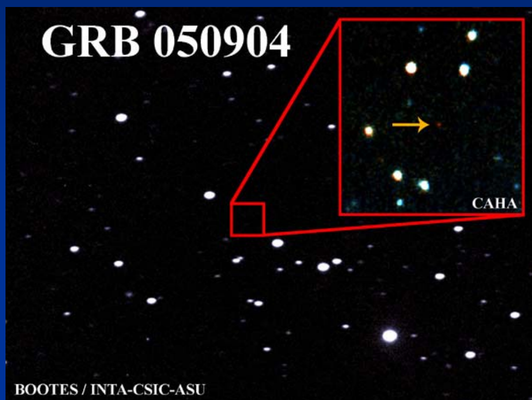
GRB 050730: detection, 1.7 +/- 0.5 mJy, z = 3.97 (Pandey et al. 2006, A&A)

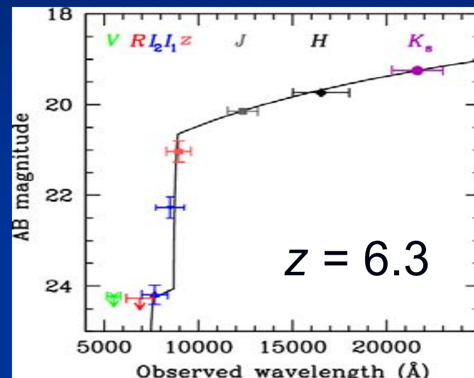
GRB 050730 (z = 3.97)



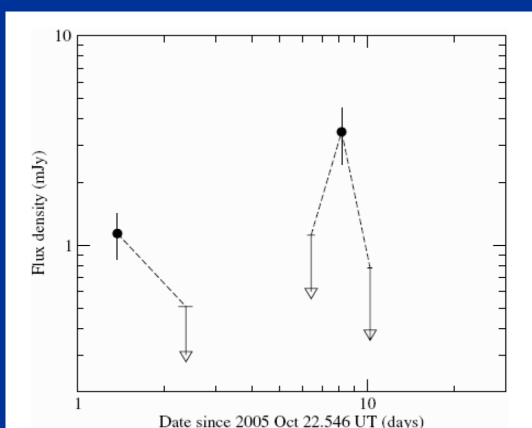
Millimeter observations (6)

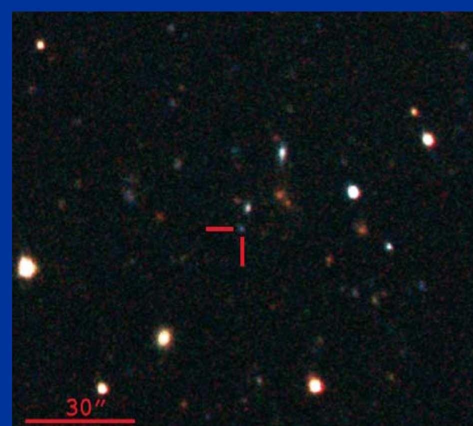
2005 (II): GRB 050904 and GRB 051022: detections !

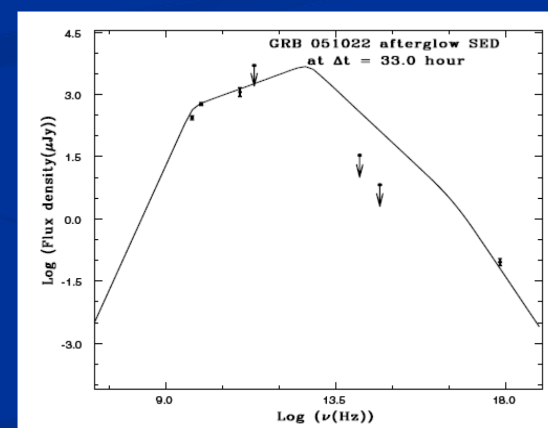




GRB 050904 (z = 6.3): ~1.3 mJy @ 90 GHz, the 2nd farthest away object detected by IRAM ! *(at that time)* (Castro-Tirado et al. 2010, in prep)







GRB 051022: A dark burst, with the host galaxy (z = 0.809) identified thanks to the mm flares and afterglow detected at Bure (Bremer et al. 2005, GCNC). A powerful sub-mm emitter galaxy?(Castro-Tirado et al. 2007, A&A)

Millimeter Observations (7)

2006-2007: 4 limits (in 2006) and 2 detections (in 2007)

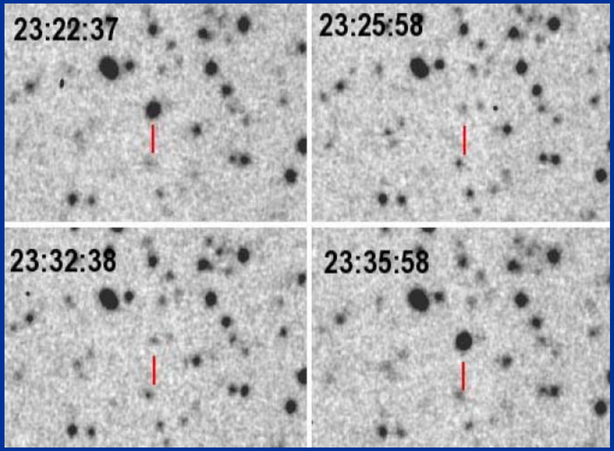
GRB 060111 & GRB 060515 (dark events): < 1 mJy @ 86 GHz

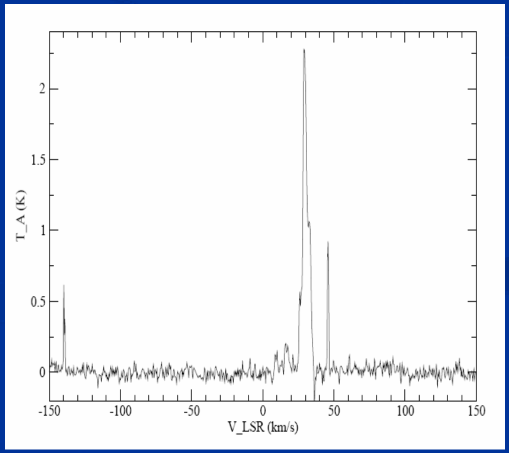
GRB 060218: the nearest GRB detected by Swift @ z = 0.03, associated with SN2006aj. No detection (Jelínek et al. 2010, in prep.)

GRB 060801 (the 2nd short GRB observed at Bure): < 1 mJy @ 86 GHz

GRB 070125: resembling GRB 030329 (Castro-Tirado et al. 2010, in prep.)

GRB 070610 / Swift J1955+255: < 0.6 mJy @ 82.5 GHz. CO (J = 1-0) spectrum at 30m. A new magnetar in the MW ? (Castro-Tirado et al. 2008, Nature)

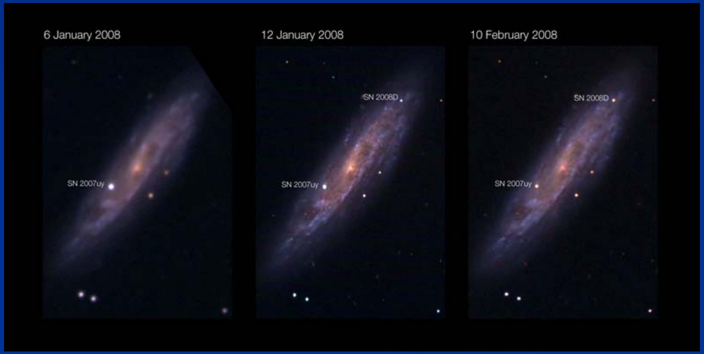




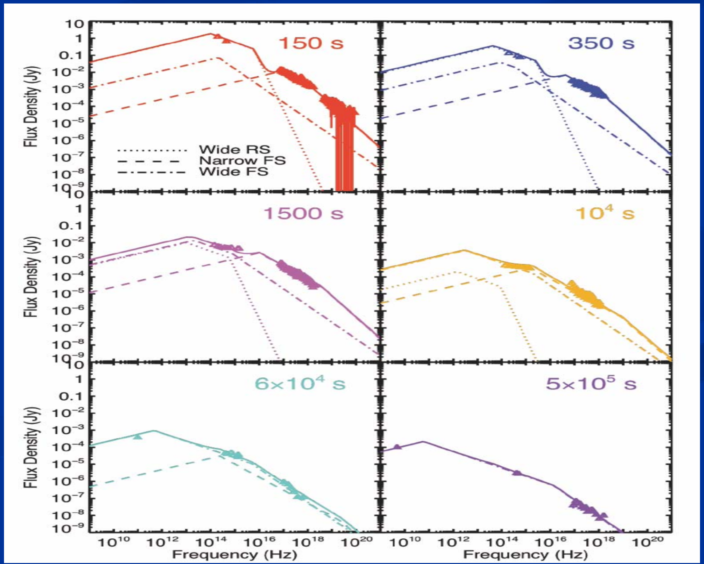
Millimeter Observations (8)

2008: The start of the *Fermi* era: 2 detections and 4 limits

GRB 080109, associated to SN2008D: 4.3σ detection at PdB (Gorosabel et al. 2010, A&A)



GRB 080319B: detection @ 86 GHz of prompt emission for this naked-eye burst at z = 0.937 (Racusin et al. 2008, Nature)



GRB 080426, 080430 (de Ugarte Postigo et al. 2009), 080514B (Rossi et al. 2008, A&A), 080913 (Pérez-Ramírez et al. 2009, A&A): upper limits in the range 0.4-0.6 mJy

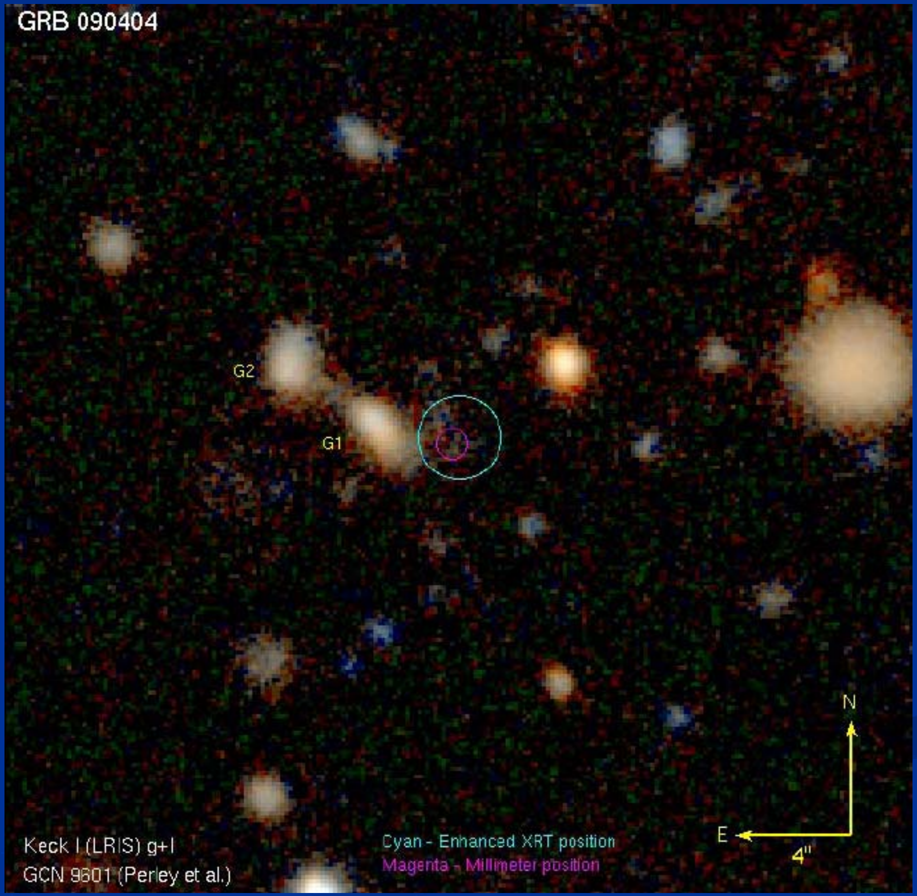
Millimeter Observations (9)

2009: 2 detections and 5 limits …

GRB 090313: 1 mJy detection (Melandri et al. 2009, A&A)

GRB 090323, 090407, 090709, 090726 and 091010: non detections

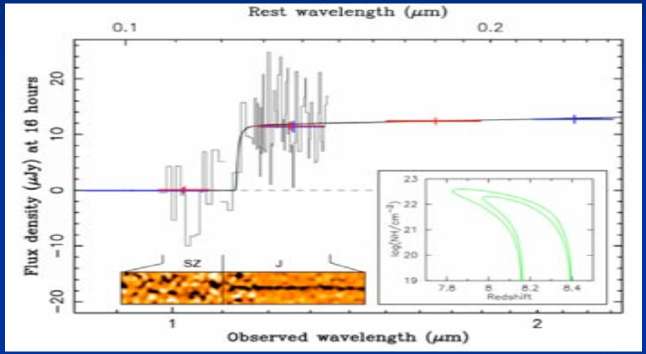
GRB 090404: detection of the afterglow for this dark GRB (Castro-Tirado et al. 2009, GCNC). No evident host galaxy, but lying close to two R = 23 mag systems. The Bure position was observed by the Spanish 10.4m GTC and by the 10.2m Keck telescopes.



Millimeter Observations (10)

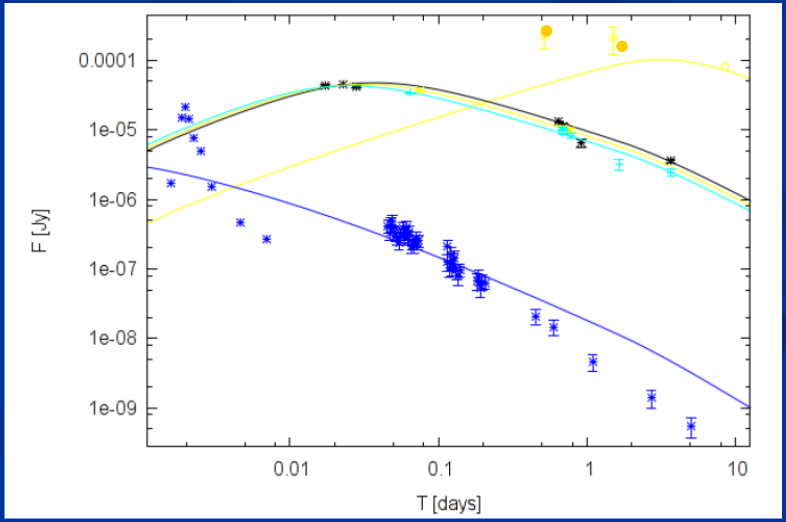
2009: …and one superb detection !

GRB 090423 at z = 8.3! (the most distant object in the Universe, for the time being). Tanvir et al. (2009, Nature)



PdB obs on Apr 23 (16 hr after !) & Apr 24: ~0.25 mJy (Castro-Tirado et al. 2010, in prep).

A Reverse shock ?
(see also Chandra et al. 2009, ApJ)

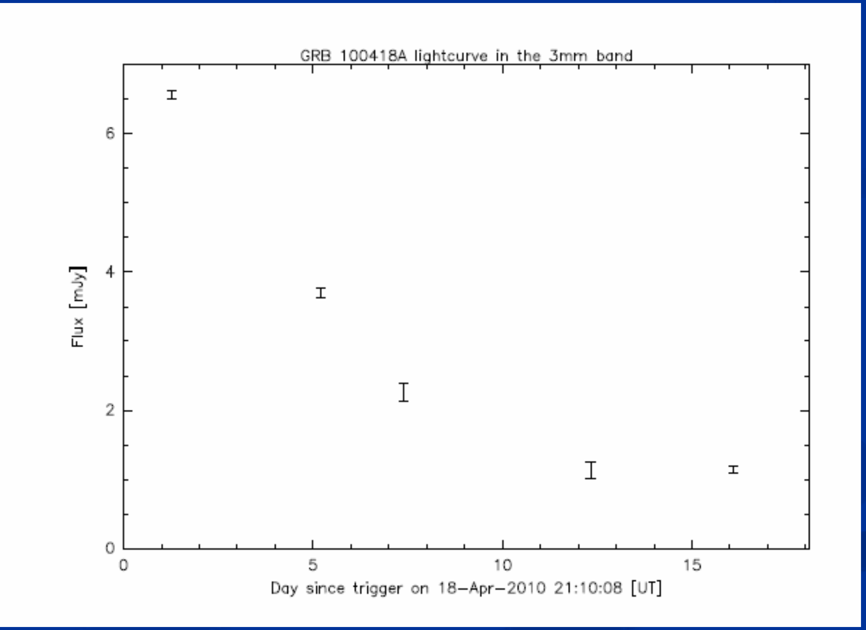


Millimeter Observations (11)

2010: 1 detection and 2 limits so far…

GRB 100205A and 100316A: non detections

GRB 100418A: detection of the afterglow with a flux density of ~6 mJy (100σ), followed up during 10 epochs (de Ugarte Postigo et al. 2010, in prep.)



Summary of 12 yrs of obs

(1997-2010) with the ToO program starting in 2001

Millimeter observations are not affected by high-z or extinction and usually can lead to sample the synchrotron peak in the spectrum as well as detecting the tail of the prompt emission and the forward shock.

Long-duration GRBs: 36 follow-ups, 14 detections of the *afterglow* emission and 1 detection of the possibly *forward shock* emission (for GRB 090423 at z = 8.3).

GRB afterglows detected in the range z = 0.03-8.3, and flux densities (3mm) of 0.25-60 mJy (but usually < 1.5 mJy) with first observations taking place around 1-2 days after the GRB

Detection of 2 (out of 3) GRBs at z > 6: GRB 050904 (z = 6.3) and 090423 (z = 8.3)

Detection of two "dark" GRBs: one associated with a z = 0.809 galaxy (GRB 051022) and the other one (GRB 090404) although the host galaxy is not properly identified

Detection of the low-z, faint GRB 090108 / SN 2008D (z = 0.03)

41.6% success rate

Short-duration GRBs: 2 follow-ups, all failed to detect either the afterglow or forward shock.

0 % success rate