

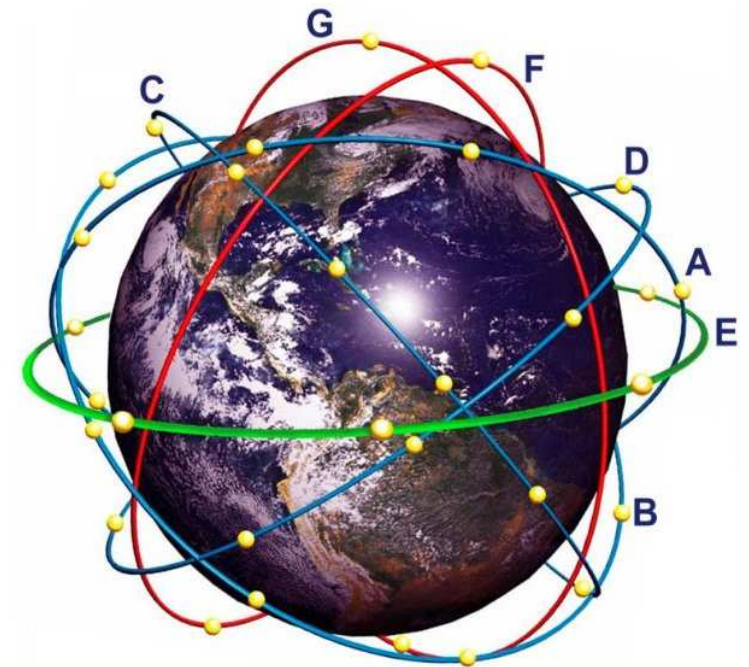
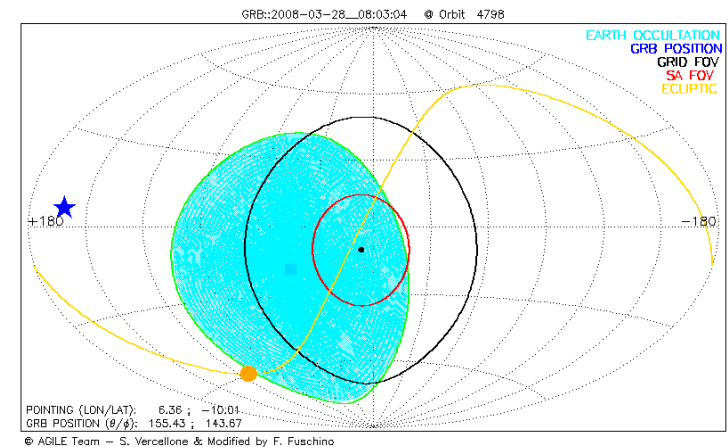
# One year of Gamma Ray Bursts observation with AGILE

E. Del Monte  
*on behalf of the AGILE team*

# Gamma Ray Bursts and AGILE

- Gamma Ray Bursts are among the most important scientific objectives of AGILE;
- The bursts can be triggered onboard by SuperAGILE and MCAL and can be localized onboard by SuperAGILE;
- The GRB position reconstructed by SuperAGILE is delivered by using the ORBCOMM alert system, independent on the telemetry downlink;
- Ground trigger software procedures are active on the SuperAGILE and MCAL telemetry data;
- SuperAGILE, MCAL, INTEGRAL as well as Swift-BAT GRBs are searched for in the GRID data;

Ettore Del Monte, INAF IASF Roma



Seminario ICRA, 24 July 2008

# AGILE instrumentation

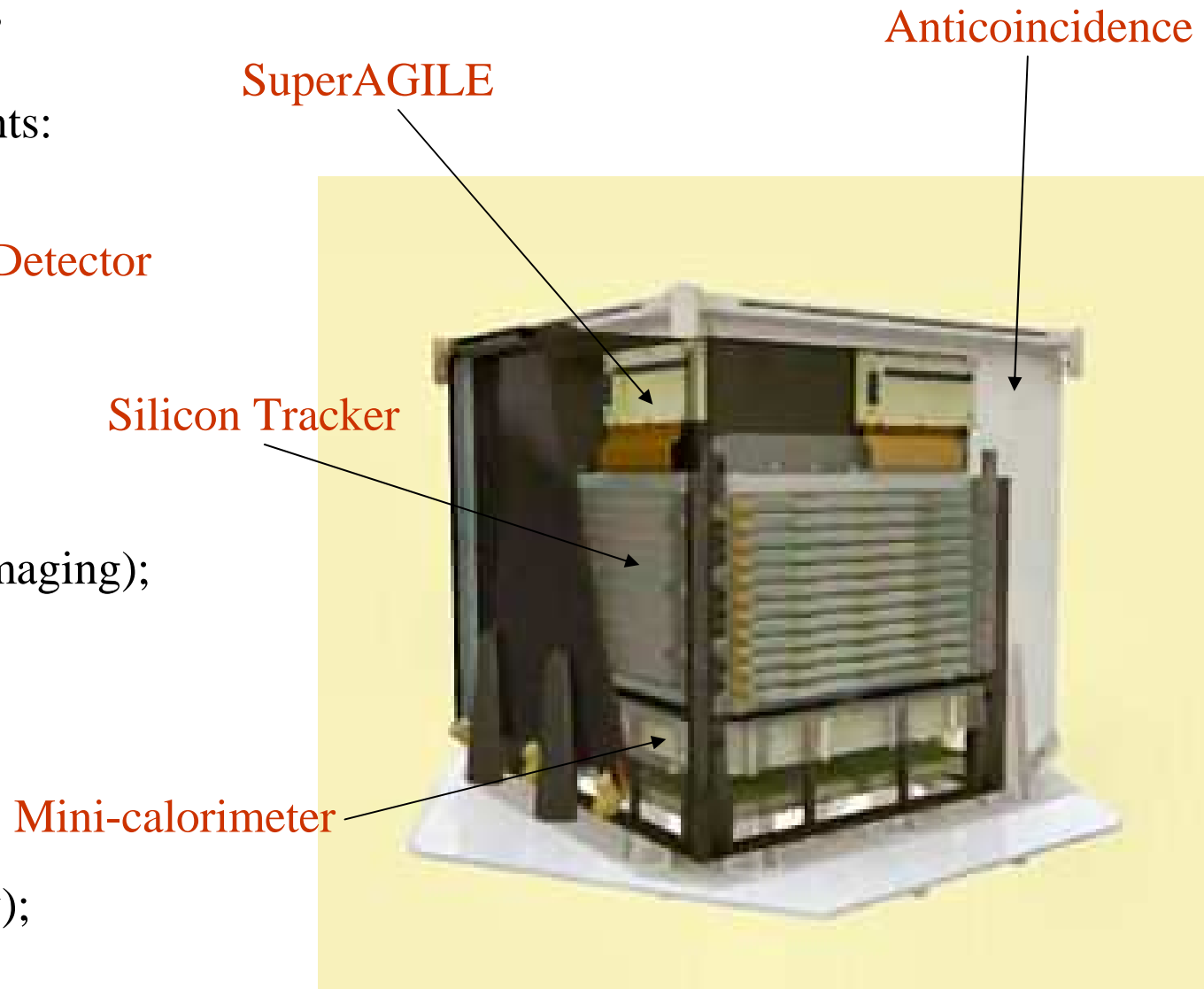
The AGILE payload is composed of two imaging instruments:

**Gamma Ray Imaging Detector (Silicon Tracker & Mini-calorimeter):**

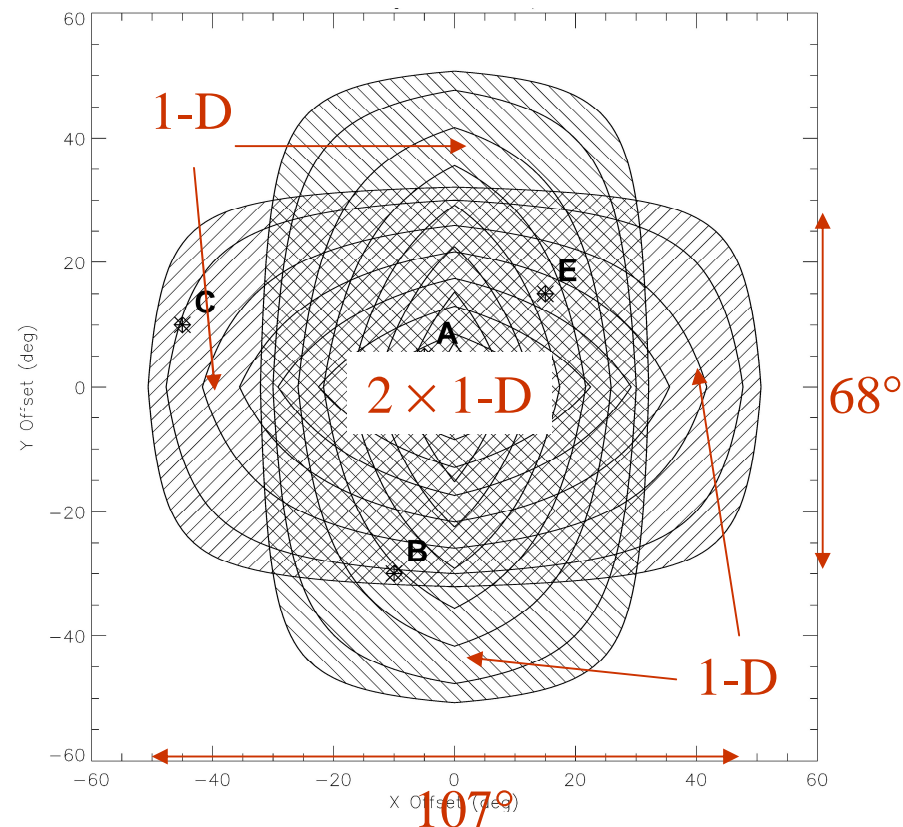
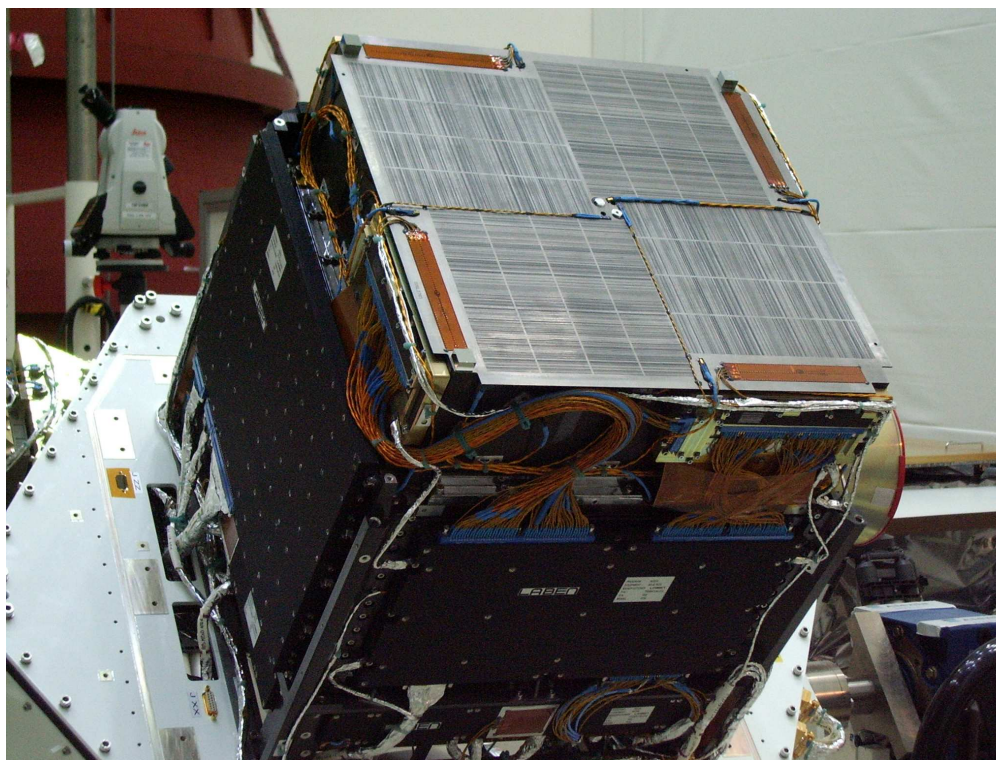
30 MeV – 50 GeV;  
~2.5 sr FoV;  
0.3 – 200 MeV (non imaging);

**SuperAGILE:**

18 – 60 keV;  
~0.8 sr FoV;  
10 mCrab ( $3\sigma$  in 1 day);  
1 Crab ( $3\sigma$  in 10 s);



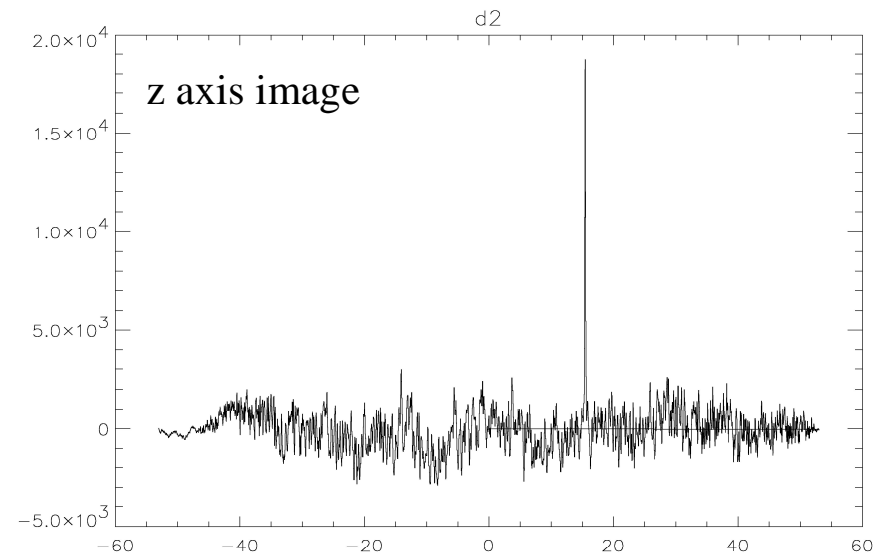
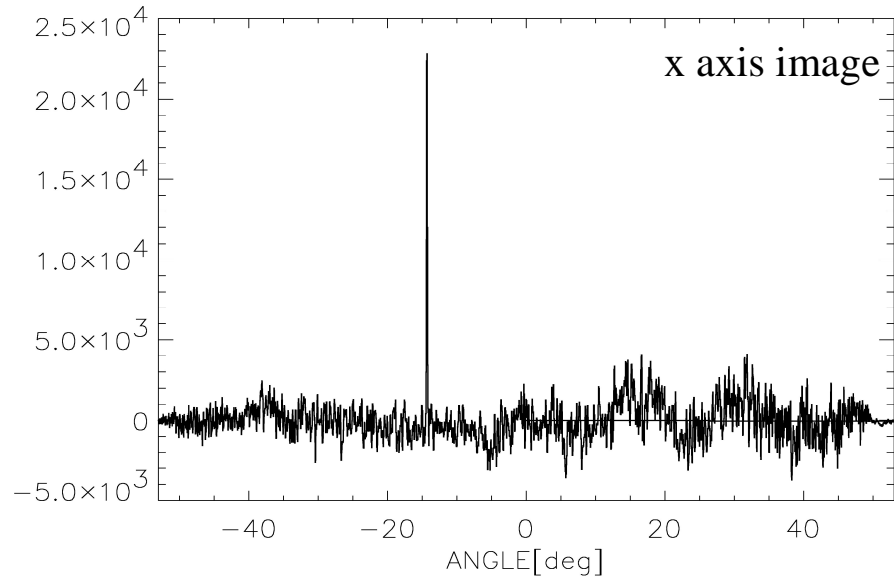
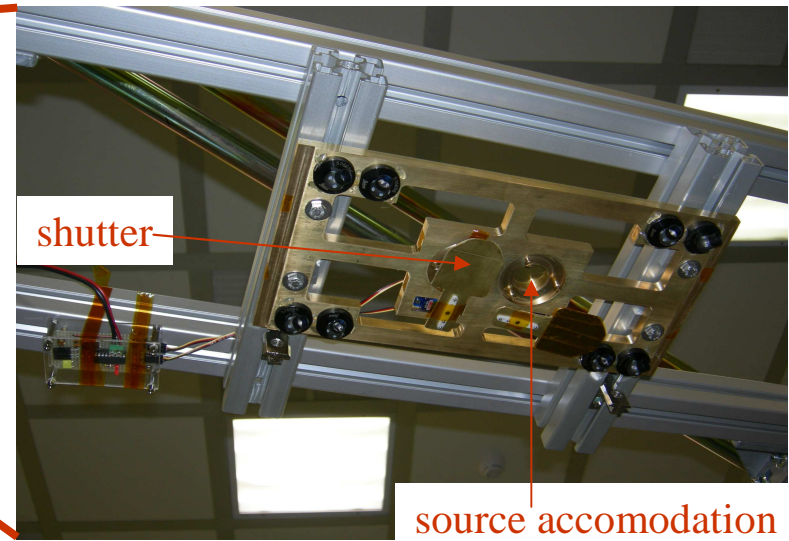
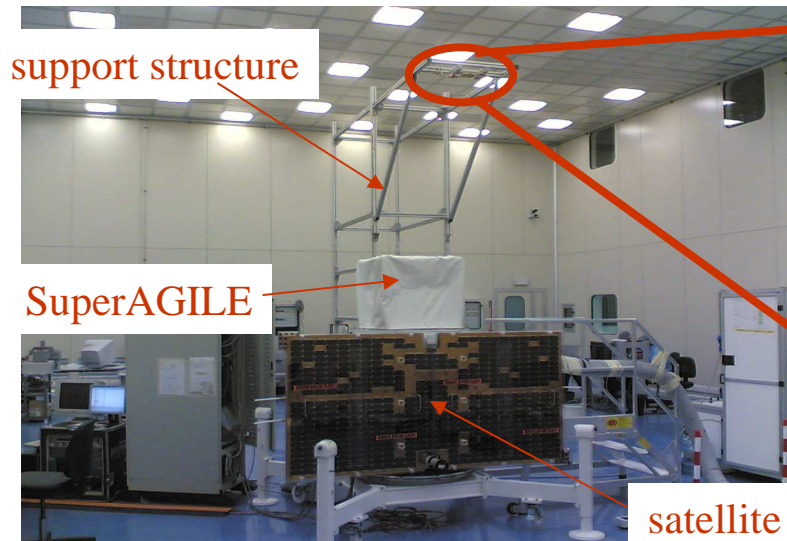
# SuperAGILE: imaging performances



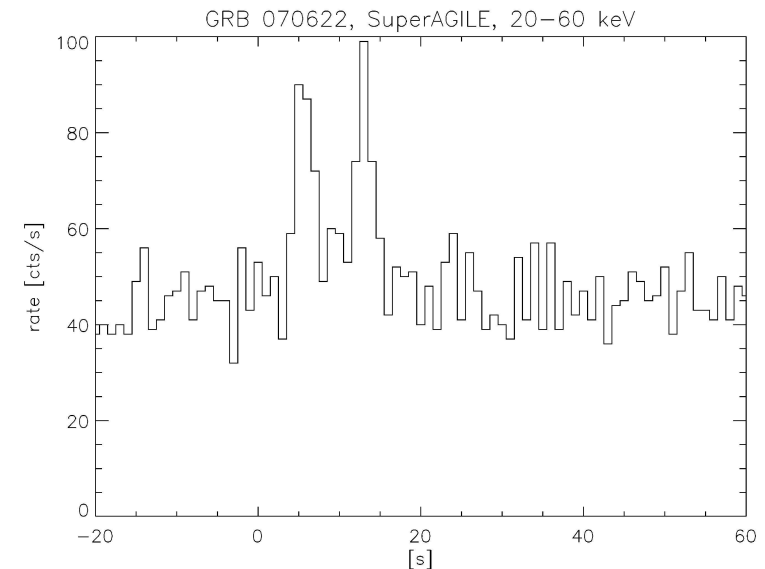
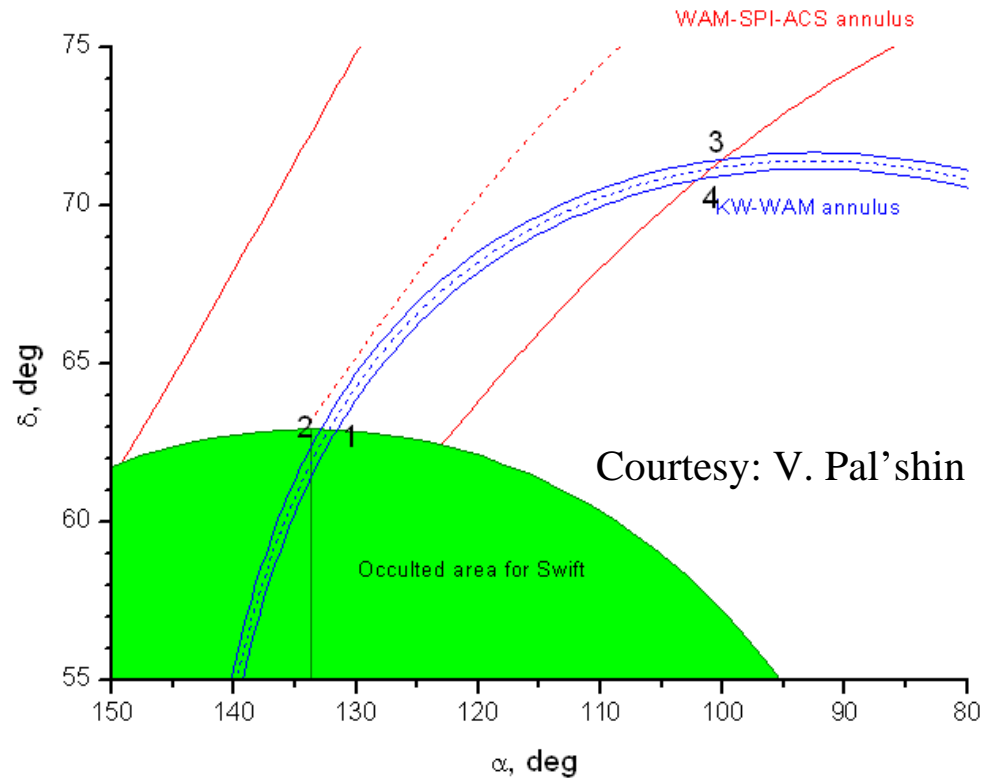
SuperAGILE is a twice **1-D** coded aperture imager. The field of view is composed of two crossing regions of **107° × 68°**. The source location accuracy is **1 arcmin** for intense sources and the error box is **3 arcmin**.



# Experimental tests of the on-board GRB detection system



# GRB 070622: an early detection during Commissioning

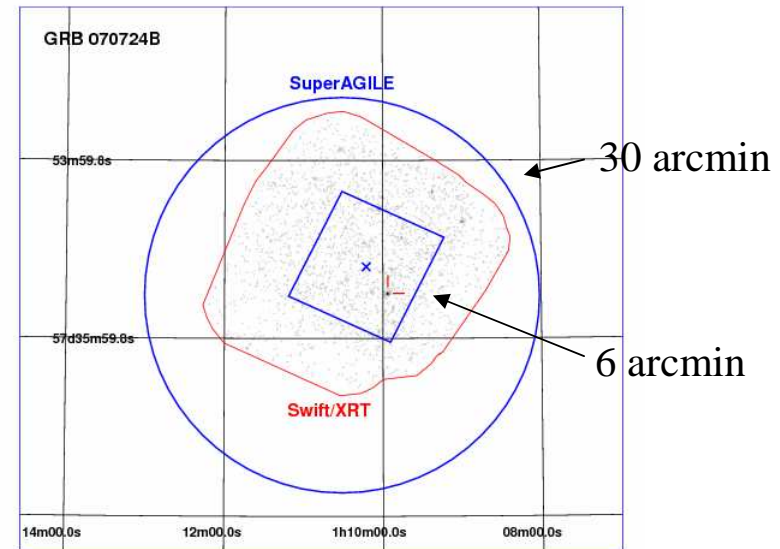
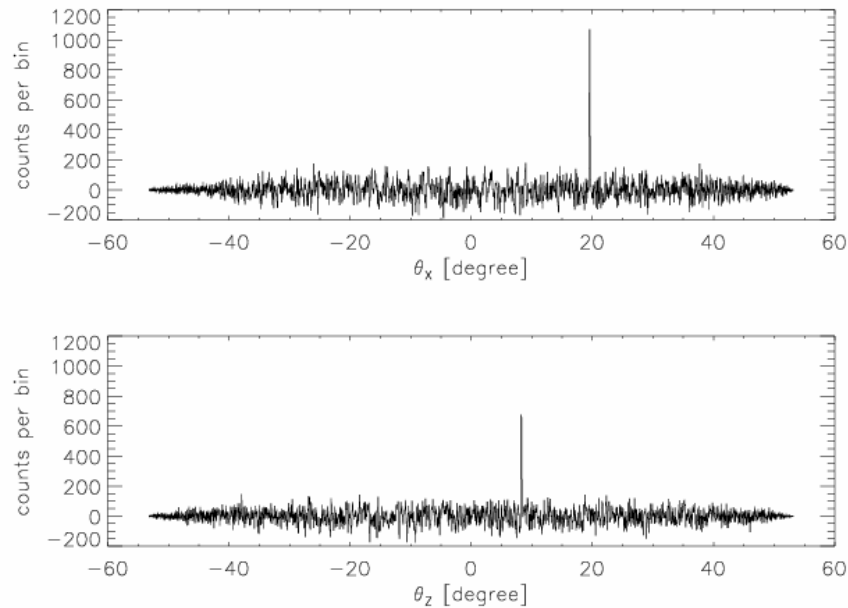


GRB 070622 has been detected **early** by SuperAGILE during the **Commissioning Phase**. This Gamma Ray Burst was **localized by the Interplanetary Network** (IPN) and was well outside the SuperAGILE FoV:  **$\sim 100^\circ$  off-axis**.

LETTER TO THE EDITOR

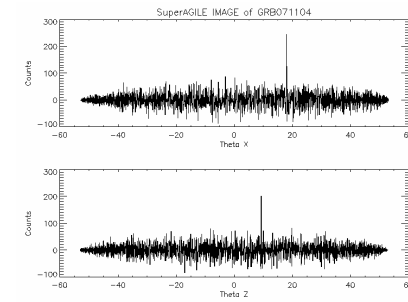
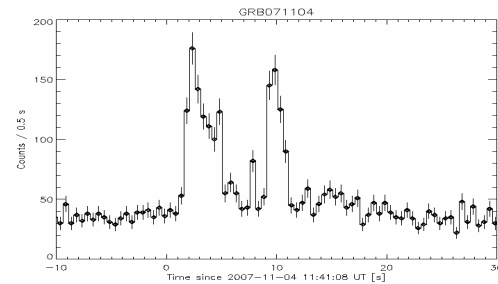
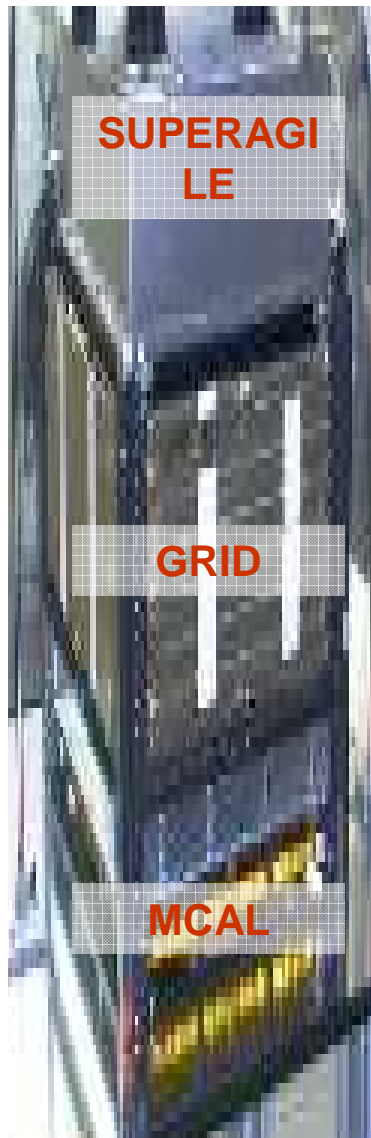
## GRB 070724B: the first gamma ray burst localized by SuperAGILE and its Swift X-ray afterglow★

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F. Lazzarotto<sup>1</sup>, M. Rapisarda<sup>3</sup>, A. Argan<sup>1</sup>, G. Barbiellini<sup>4,5</sup>, M. Basset<sup>4</sup>, A. Bulgarelli<sup>6</sup>, P. Caraveo<sup>7</sup>, A. Chen<sup>7</sup>,  
G. Di Cocco<sup>6</sup>, L. Foggetta<sup>4</sup>, F. Fuschino<sup>6</sup>, M. Galli<sup>8</sup>, F. Gianotti<sup>6</sup>, A. Giuliani<sup>7</sup>, C. Labanti<sup>6</sup>, P. Lipari<sup>2</sup>, F. Longo<sup>4,5</sup>,  
M. Marisaldi<sup>6</sup>, F. Mauri<sup>9</sup>, S. Mereghetti<sup>7</sup>, A. Morselli<sup>10</sup>, A. Pellizzoni<sup>7</sup>, F. Perotti<sup>7</sup>, P. Picozza<sup>10</sup>, M. Prest<sup>11</sup>,  
G. Pucella<sup>1</sup>, M. Tavani<sup>1,10</sup>, M. Trifoglio<sup>6</sup>, A. Trois<sup>1</sup>, E. Vallazza<sup>4</sup>, S. Vercellone<sup>7</sup>, V. Vittorini<sup>1</sup>, A. Zambra<sup>12</sup>,  
P. Romano<sup>13,14</sup>, D. N. Burrows<sup>15</sup>, G. Chincarini<sup>13,14</sup>, N. Gehrels<sup>16</sup>, V. La Parola<sup>17</sup>, P. T. O'Brien<sup>18</sup>, J. P. Osborne<sup>18</sup>,  
B. Preger<sup>19,20</sup>, C. Pittori<sup>19,20</sup>, L. A. Antonelli<sup>19,21</sup>, F. Verrecchia<sup>19,20</sup>, P. Giommi<sup>19,22</sup>, and L. Salotti<sup>22</sup>

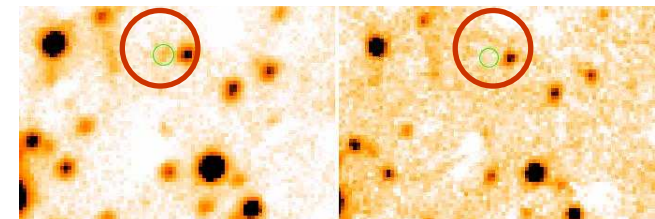
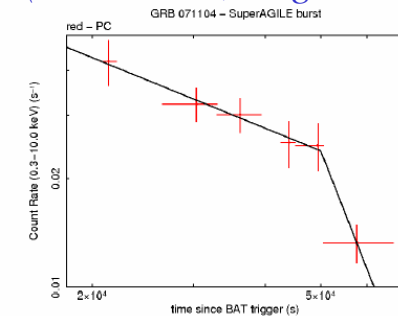


# GRB 071104: AGILE is Up and Running, waiting for the “big one”

*SA Position (GCN 7042, Donnarumma et al.)*



*X-ray Afterglow with Swift  
(GCN 7043, Page et al.)*



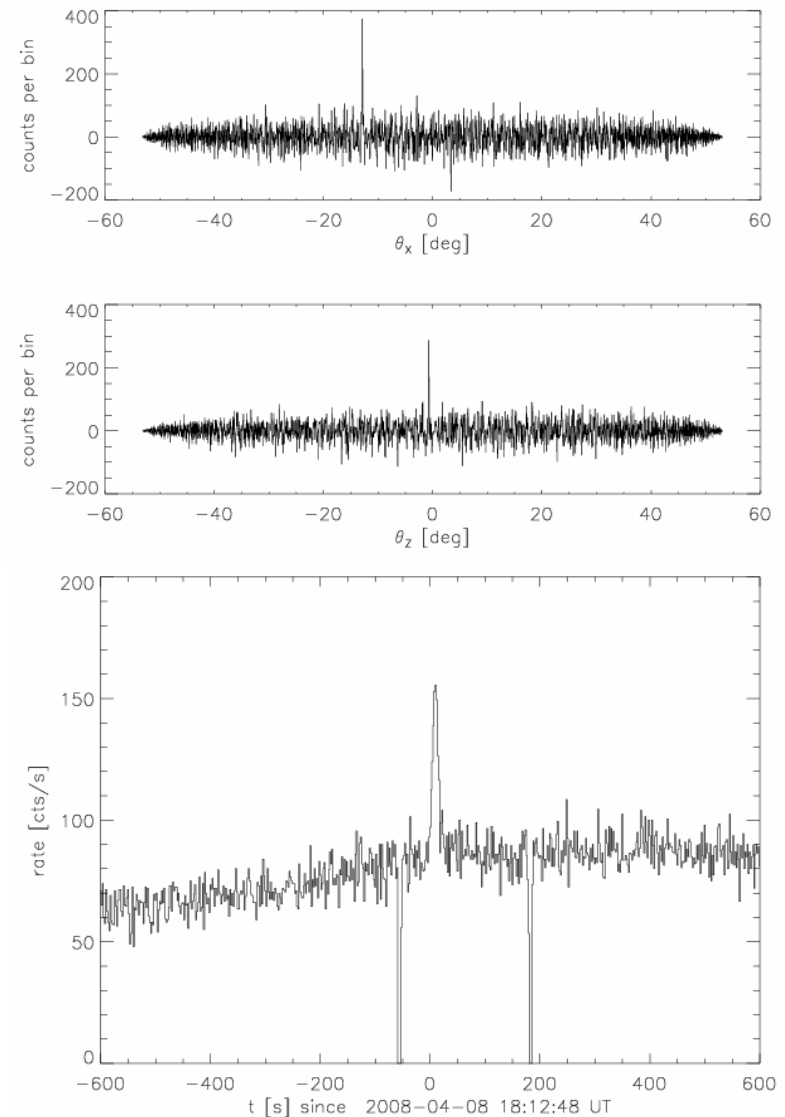
*NIR Afterglow: Jmag=20.5 @ hrs  
(GCN 7130, TNG, Antonelli et al.)*

Seminario ICRA, 24 July 2008

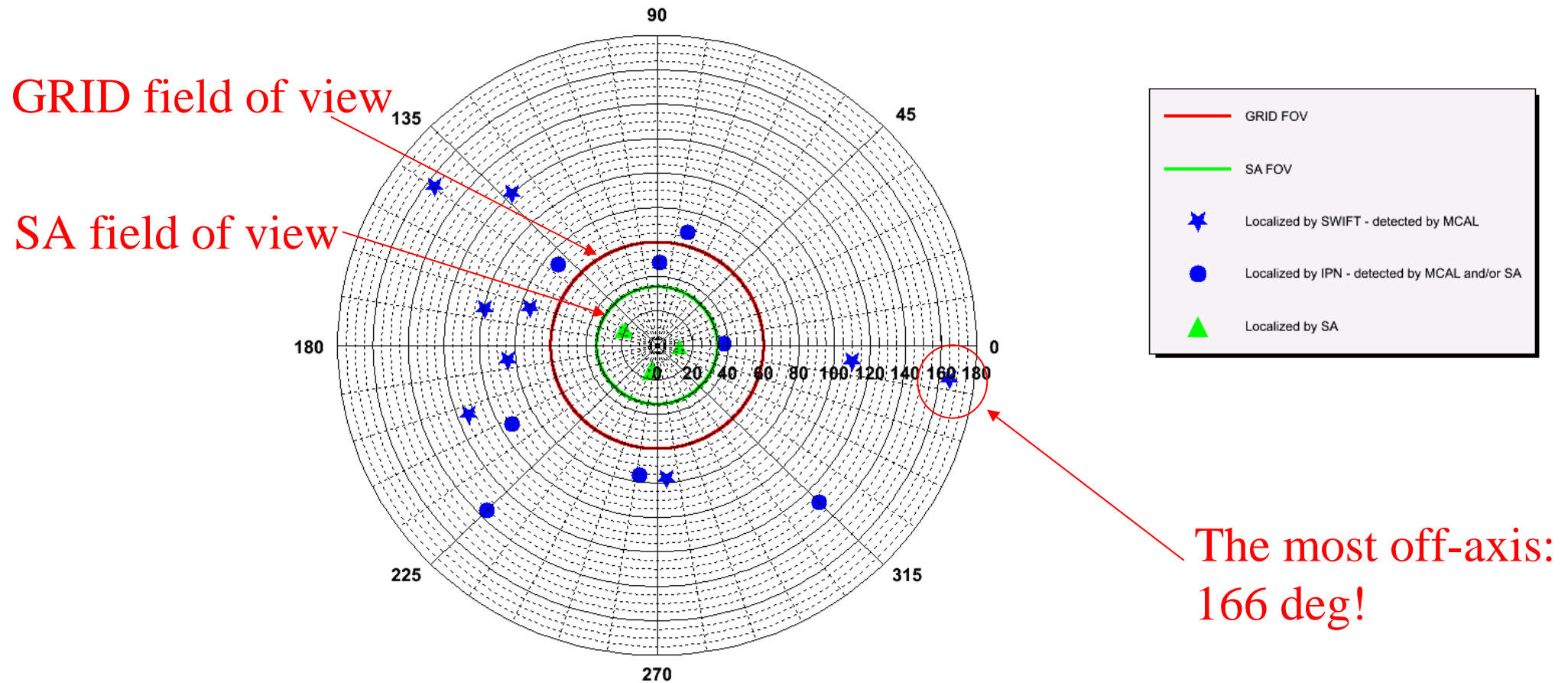


# Current performances: on-board localization of GRB 080408

- SuperAGILE and MCAL on-board triggers are currently running with timescale of 64 ms – 8 s;
- the uncertainty of the on-board position is  $\sim 20$  arcmin;
- the burst alert message is delivered with a typical delay of 10 – 30 minutes;
- the uncertainty of the refined (off-line) position is 3 arcmin;
- MCAL, SuperAGILE, Swift-BAT and INTEGRAL GRBs are automatically searched for in the GRID data;



# MCAL all-sky detection capabilities



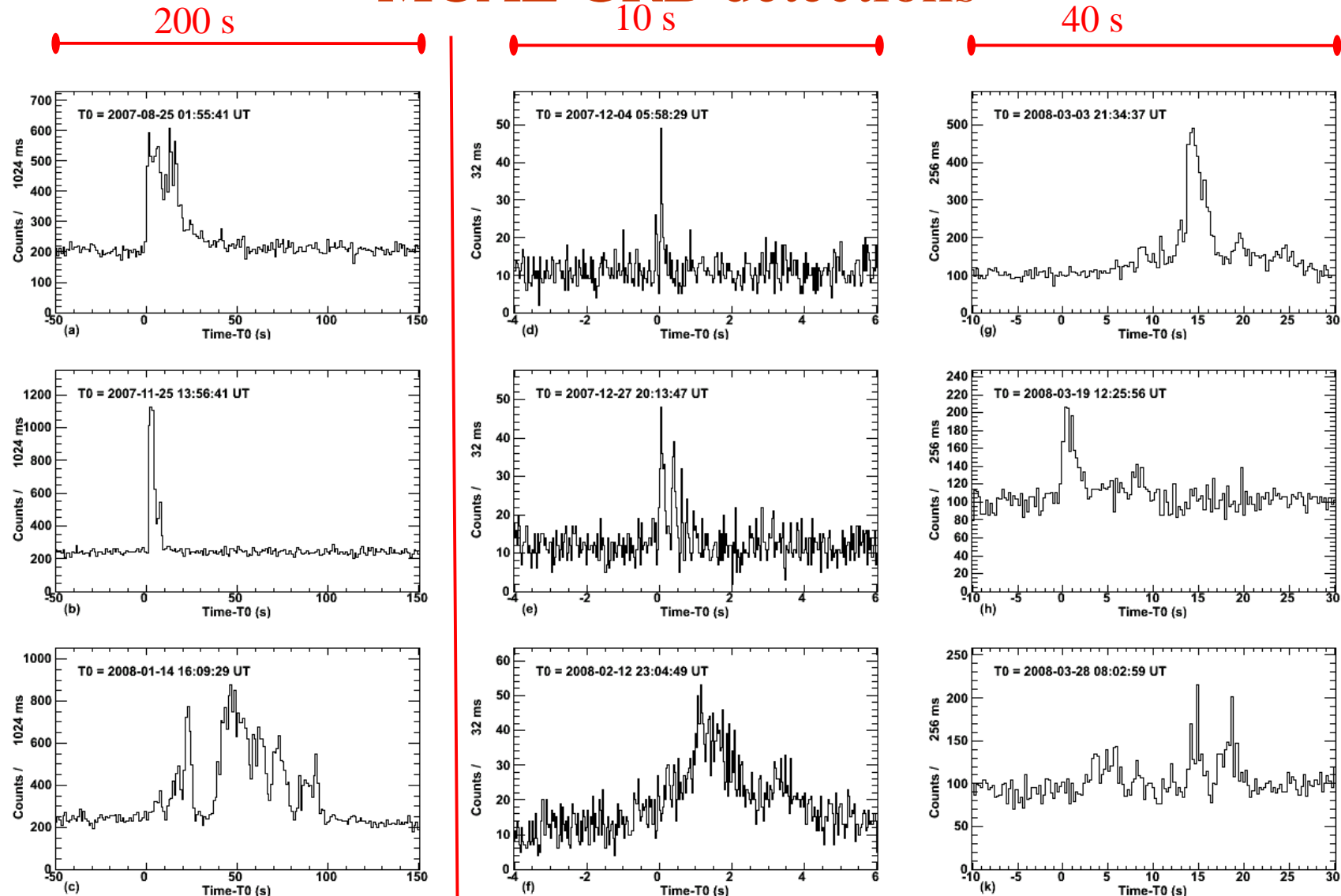
In the period July '07 – June '08: 49 GRBs detected (~1 GRB / week)

9 localized by SWIFT

8 localized by IPN (many more expected)

5 localized by SuperAGILE (other SuperAGILE localizations without MCAL detection)

# MCAL GRB detections

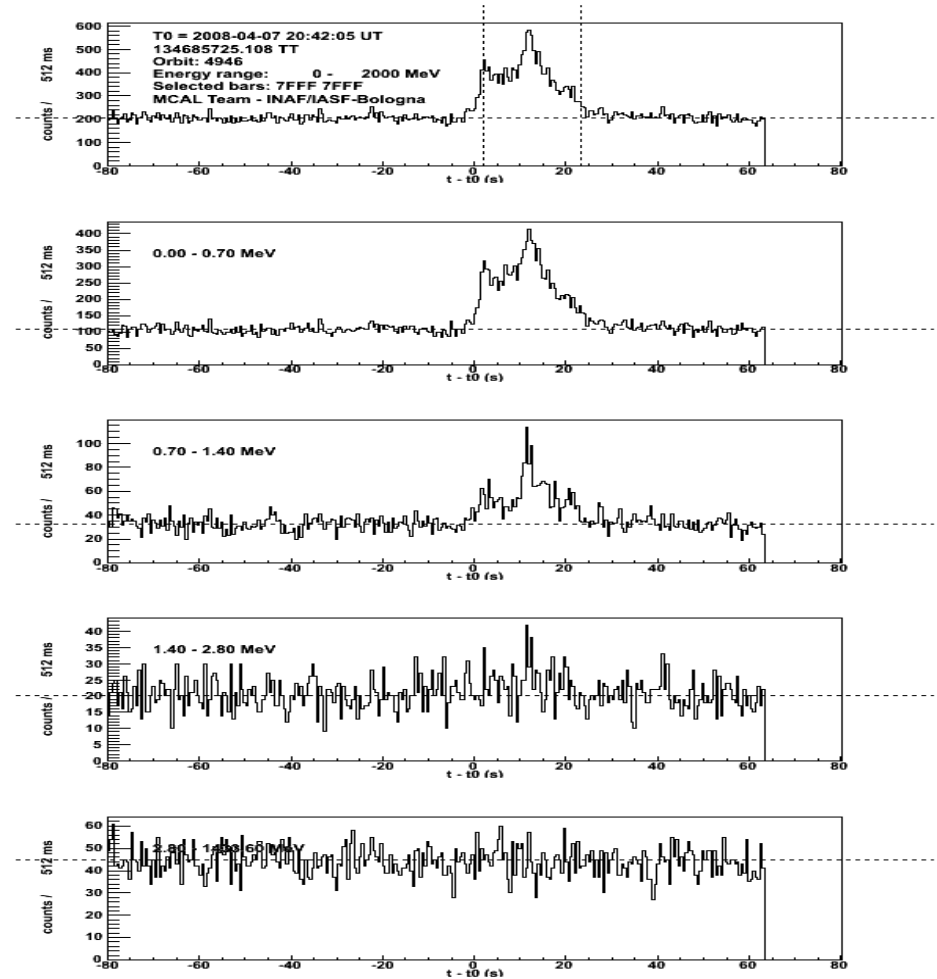
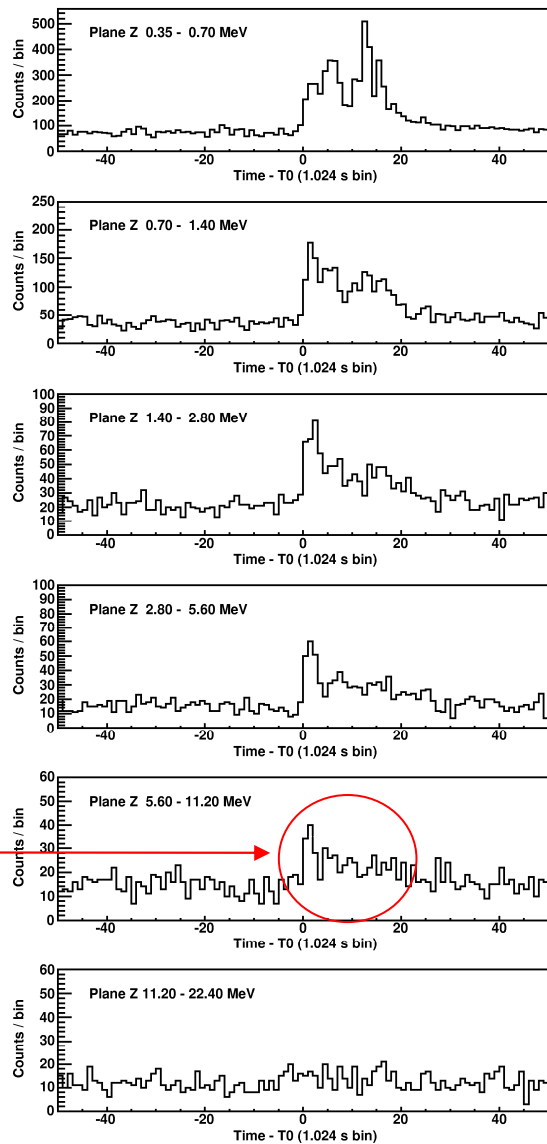


Detections with scientific ratemeters,  
1 s time resolution, 11 energy bands,  
before Feb. 2008

Detections with onboard trigger logic,  
any time and energy resolution,  
Dec. 2007 and since Feb. 2008

# MCAL & GRB: spectral coverage

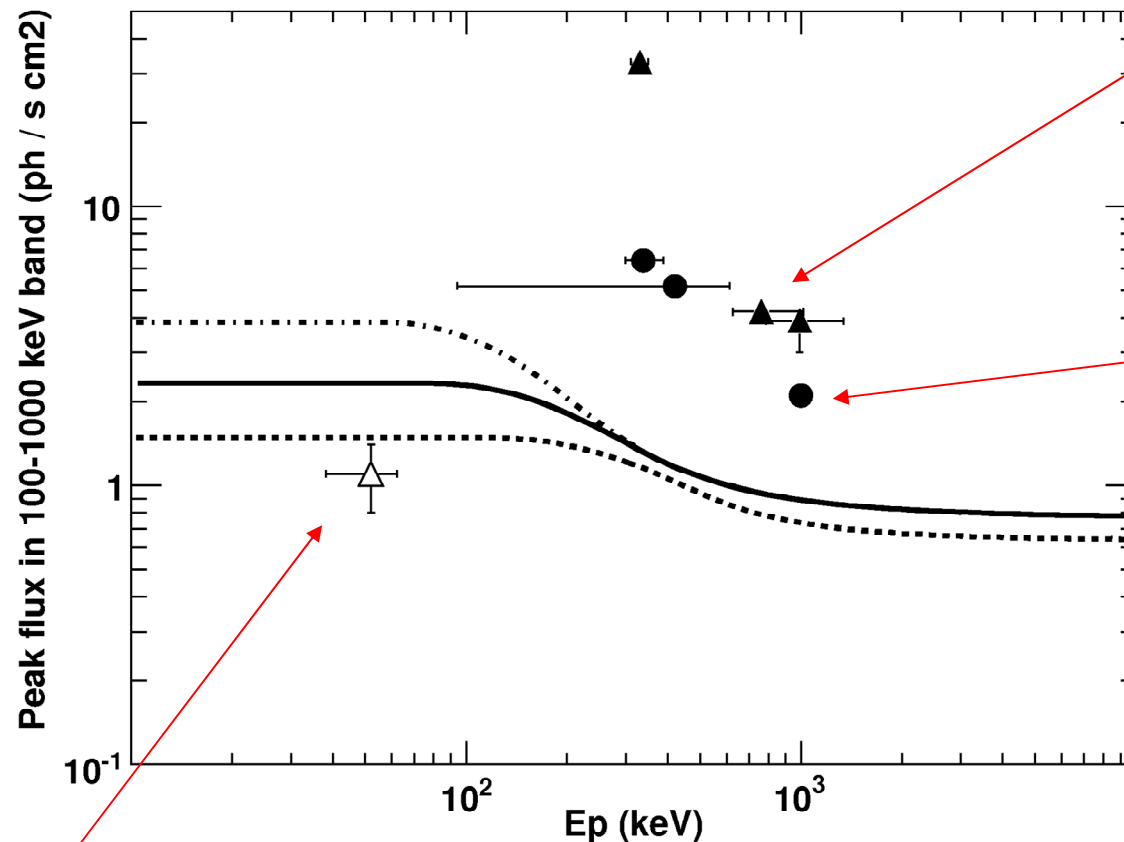
GRB070825: significant detection in  
the 5.6-11 MeV band



GRB080407B: the highest fluence  
GRB detected with onboard  
trigger logic



# MCAL GRB sensitivity



GRBs also  
detected by  
MCAL at  $\theta < 90^\circ$

GRBs also  
detected by  
MCAL at  $\theta > 90^\circ$

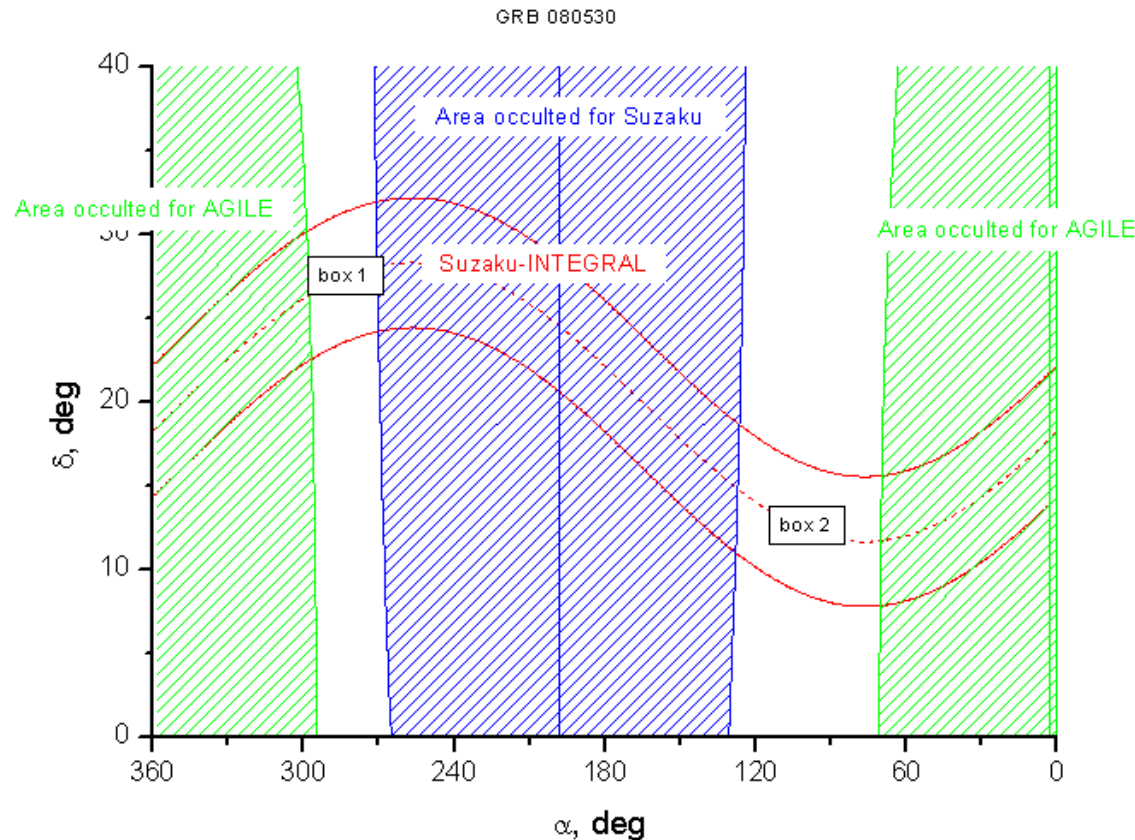
GRB at  $\theta < 90^\circ$   
NOT detected by  
MCAL

All spectral data point taken from  
Suzaku WAM GCN, sensitivity curves  
computed following Band (2003)

## GRID upper limits

GRB	localization	off-axis [deg]	upper limit [10 <sup>-4</sup> ph/cm <sup>2</sup> ]
080210	Swift/BAT	36.5	3.6
080413	Swift/BAT	48.5	1.4
080430	Swift/BAT	40.1	6.0
080506	Swift/BAT	50.0	2.0

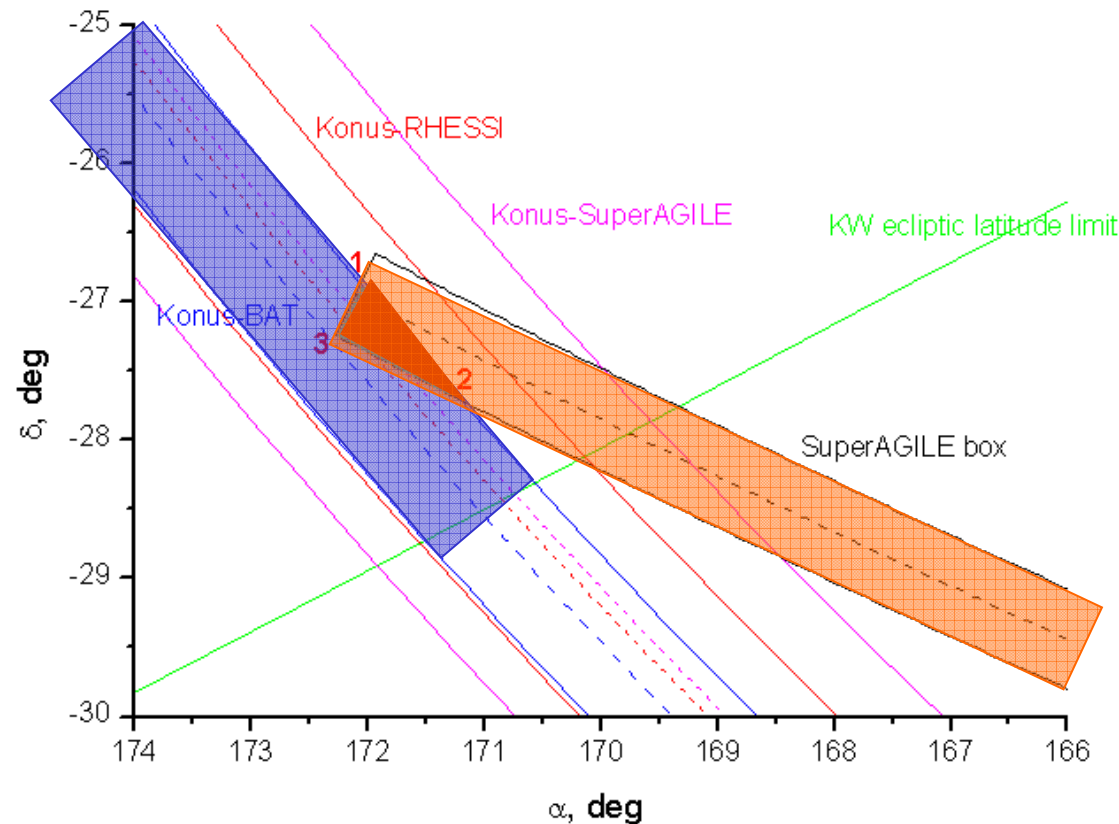
# AGILE and the Interplanetary Network



**SuperAGILE** and **MCAL** are active members of the **Interplanetary Network**, a collaboration of **Konus-Wind**, **Mars Odyssey**, **INTEGRAL**, **Suzaku**, **RHESSI**, **MESSENGER** and other satellites. GRB and other intense transients are localized by using the triangulation method, based on the delay of the arrival time of a burst to different and far experiments.

# Improving the IPN positions with SuperAGILE 1-D

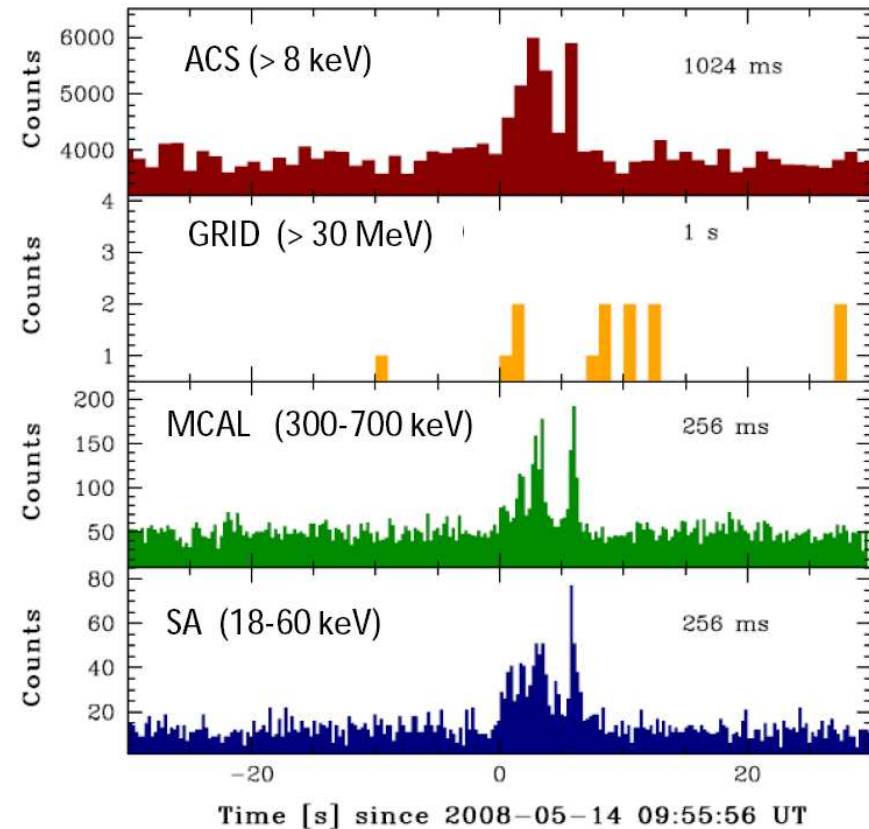
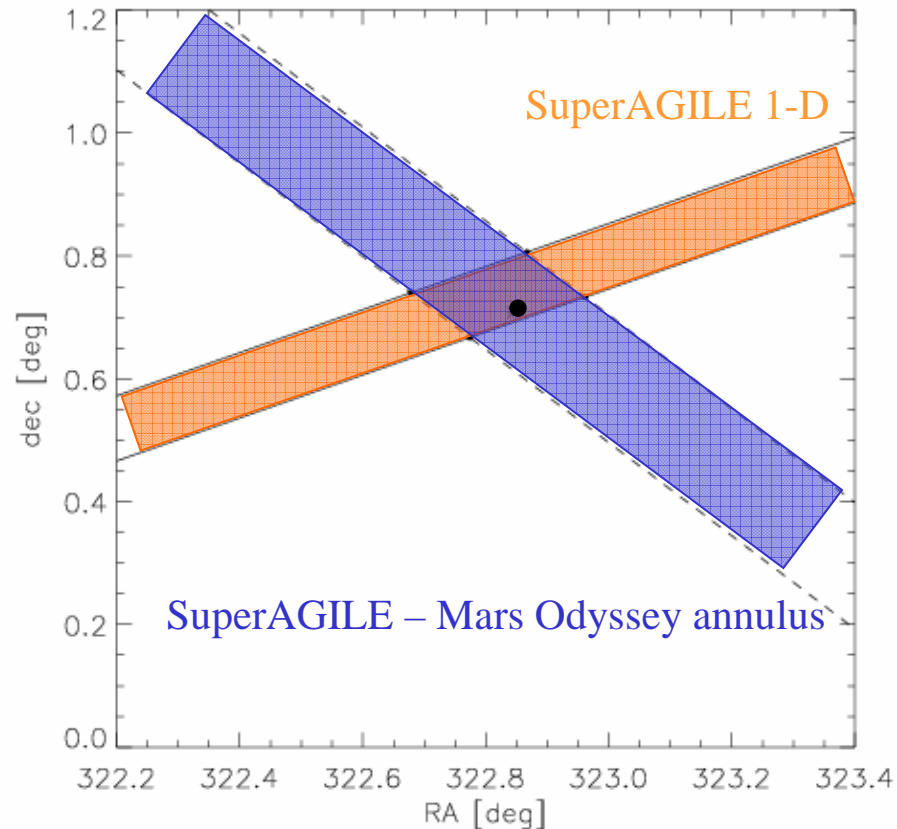
GRB 070824



GRB 070824 has been detected by SuperAGILE but it was at **48° off-axis** and could be imaged only in **1-D**. The combination of the annulus from the **Interplanetary Network** and the **SuperAGILE 1-D strip** gives a localization reducing the error box area from **~9 square degrees (without SuperAGILE)** down to **~1 square degree (with SuperAGILE, see GCN 6767)**.

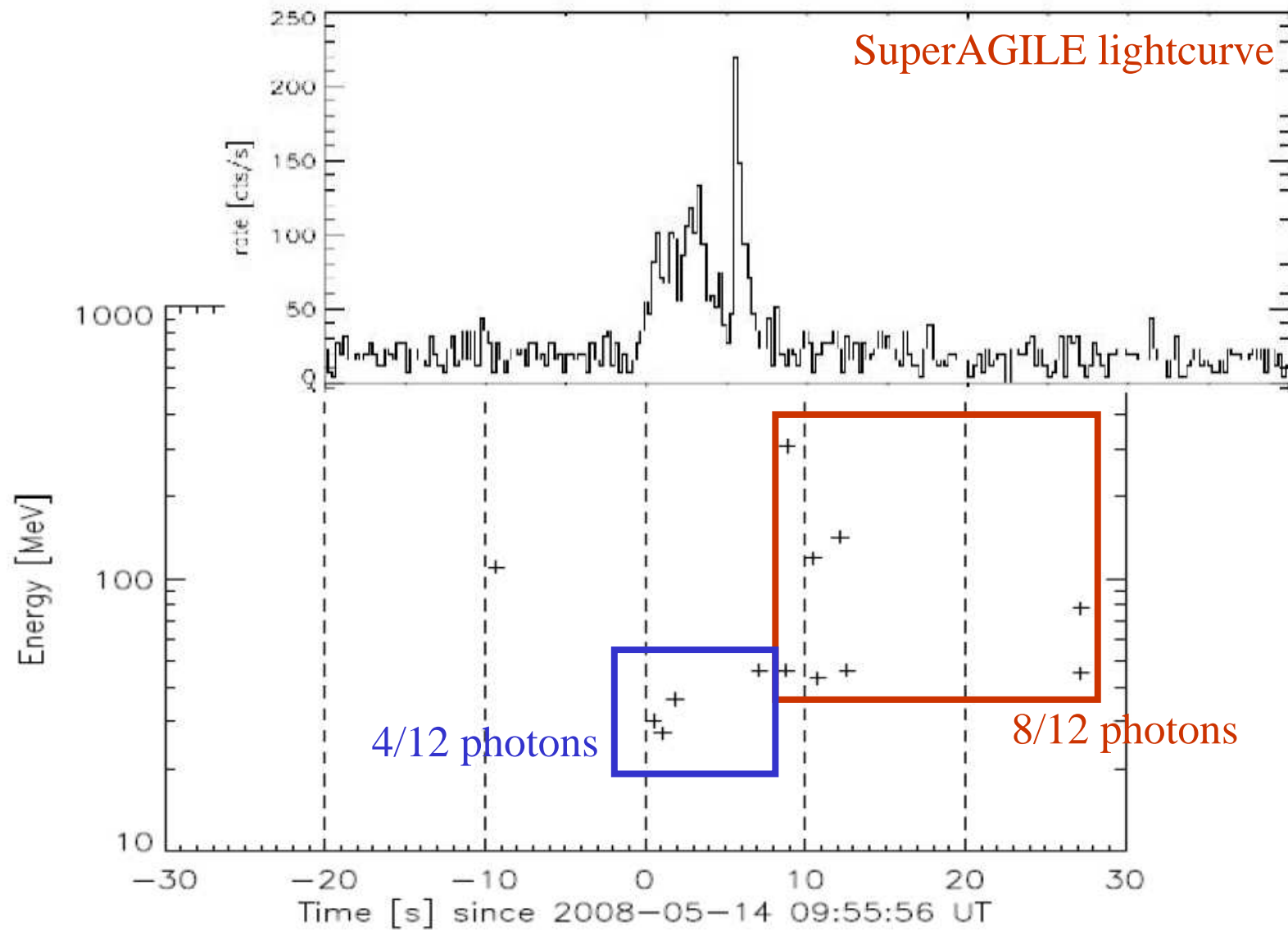


# AGILE detects the first gamma-ray emission from a GRB in the afterglow era: GRB 080514B



GRB 080514B has been localized jointly by SuperAGILE and IPN ([GCN 7715](#)) and shows a significant gamma ray emission ([GCN 7716](#)).

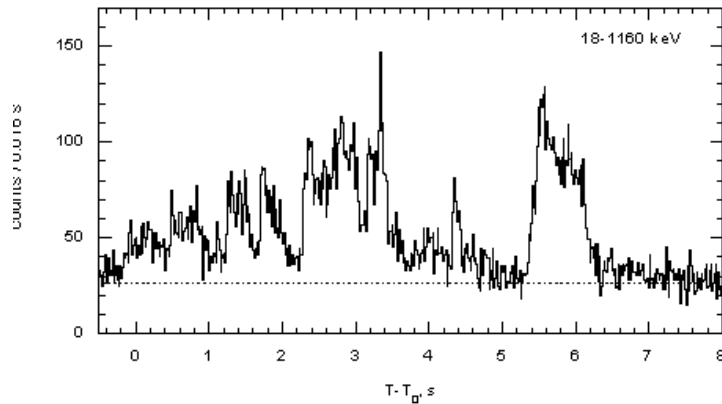
# Gamma-ray observation of GRB 080514B



# Flux and fluence of the prompt emission of GRB 080514B

KONUS-WIND GRB 080514  
 $T_0 = 35758.672$  s UT (09:55:58.672)

S2



fluence

$3.2 \times 10^{-5}$  erg/cm<sup>2</sup>

peak flux

$2.1 \times 10^{-5}$  erg/cm<sup>2</sup>/s

$E_{\text{peak}}$

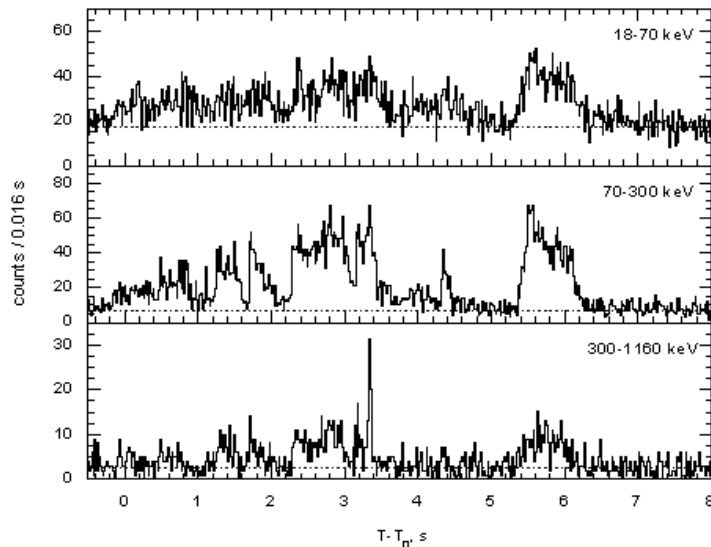
224 keV

All measured by Konus-Wind in 20 keV – 5 MeV  
(GCN 7751).

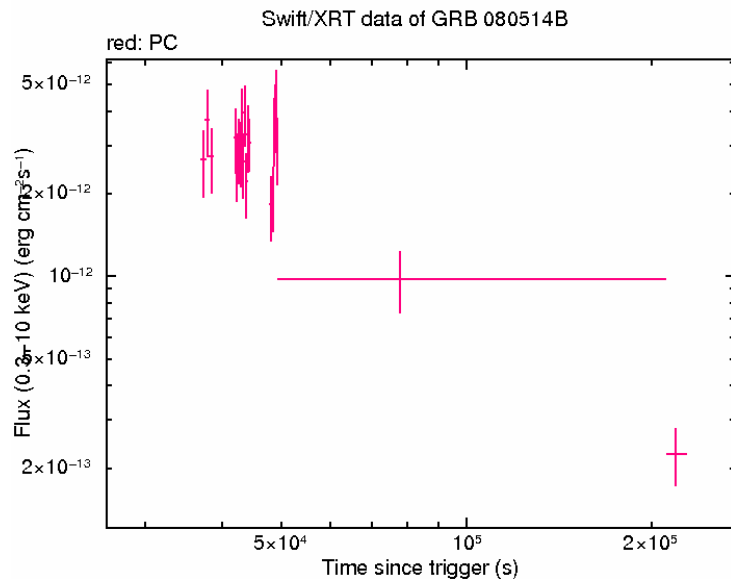
In the BATSE 50 – 300 keV band the peak flux belongs to the **top 1 %** of the Fourth BATSE Catalogue.

The flux measured by SuperAGILE (18 – 60 keV) is  $\sim 2 \times 10^{-7}$  erg/cm<sup>2</sup>/s.

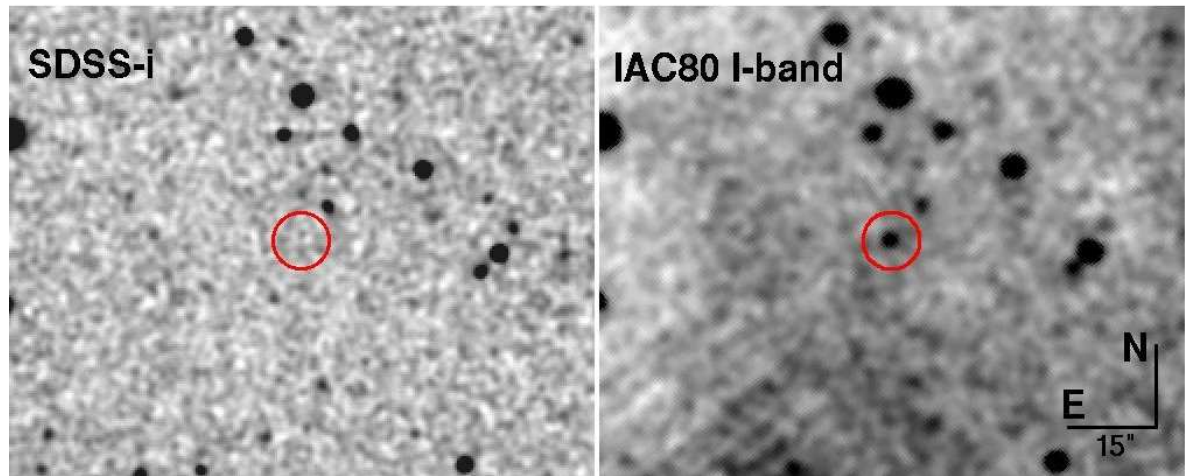
The fluence in 350 – 700 keV is  $\sim 7 \times 10^{-6}$  erg/cm<sup>2</sup>



# X-ray and optical follow-up of GRB 080514B



Evans et al., 2007



de Ugarte Postigo et al., GCN 7720

Follow-up by Swift ([GCN 7723](#) and [7750](#)) provided the afterglow in X-rays.

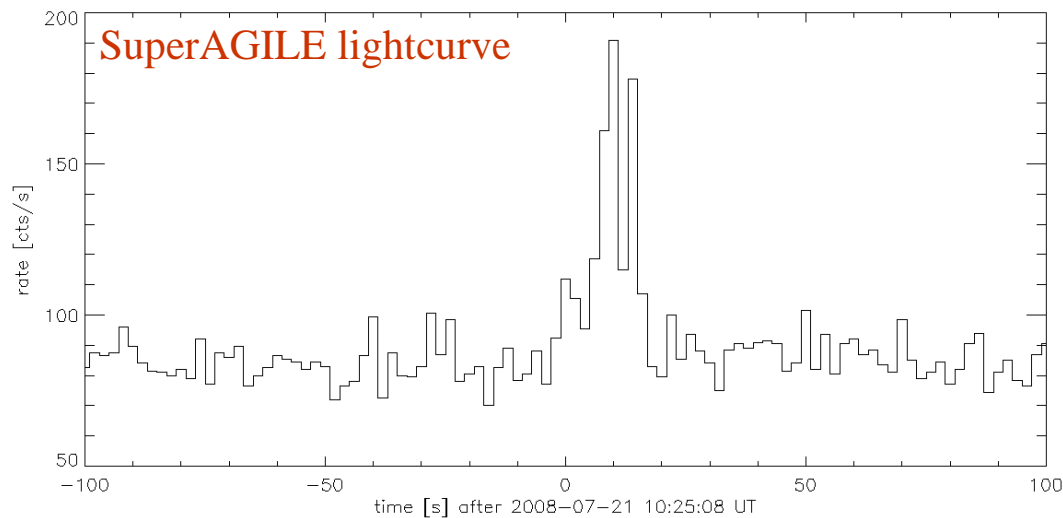
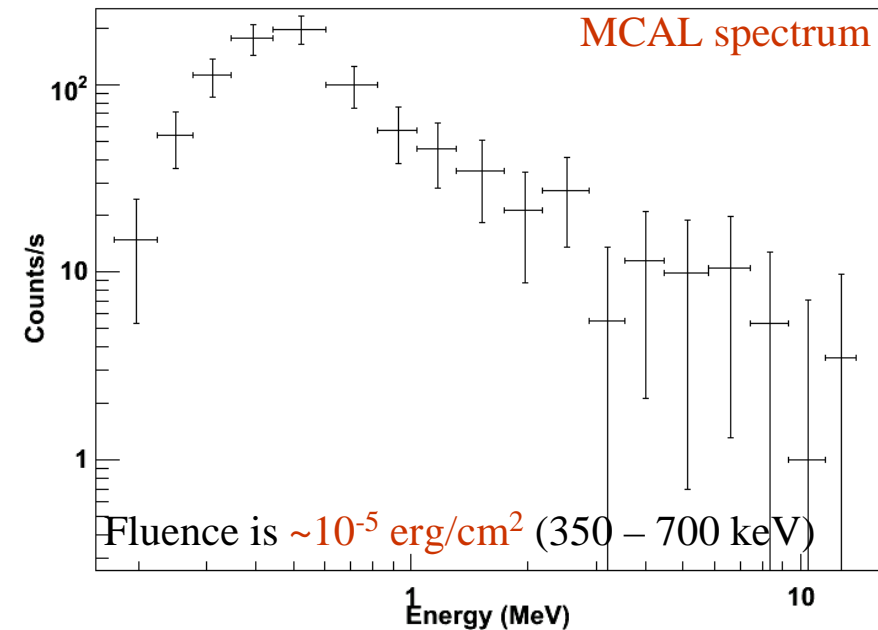
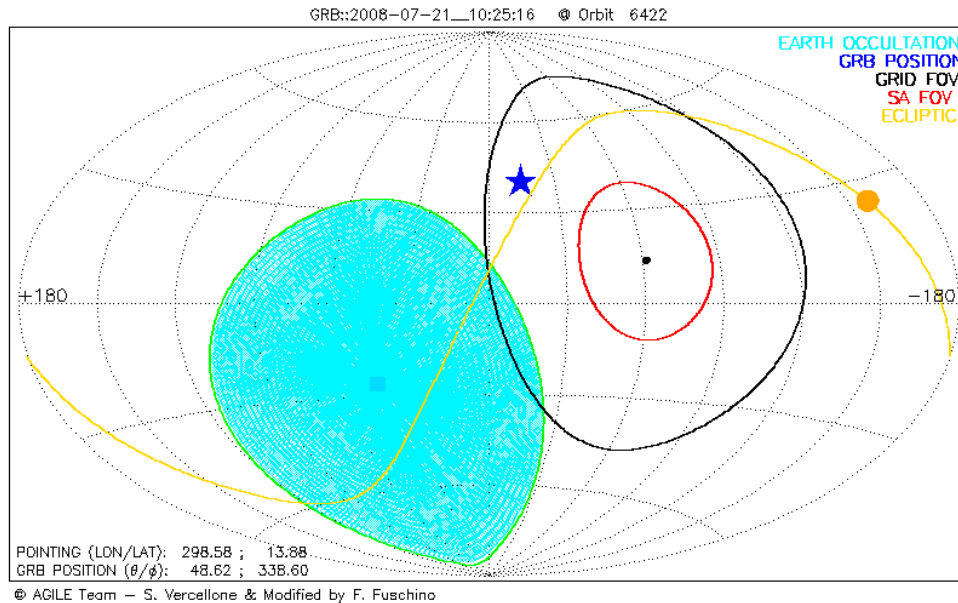
I=20.4 mag at 17.3 hours (IAC80, [GCN 7719](#)),  $g'=21.2$  mag at 21 hours with slow fading (GROND, [GCN 7722](#)),  $R = 22.5$  mag at 1.8 days (NOT, [GCN 7734](#)) and  $R = 23.9$  mag at 24.1 days (Keck, [GCN 7874](#)).

The photometric redshift from UVOT ([GCN 7759](#)) and NOT ([GCN 7734](#)) is in the range  $1.9 < z < 2.3$ .

The properties in X-rays and optical are typical for the GRB afterglows.



# Latest news: detection of the bright and hard GRB 080721



SuperAGILE and MCAL detected GRB 080721 ( $\sim 49^\circ$  off-axis), already localized by Swift/BAT (GCN 7988 and 7992). The GRB was inside the GRID FoV and the analysis is still in progress. The burst had a fluence of about  $8 \times 10^{-5}$  erg/cm<sup>2</sup> in 20 keV – 5 MeV with  $E_{\text{peak}}$  of 485 keV (Konus-Wind, GCN 7995) and it was at redshift 2.6 (GCN 7997).

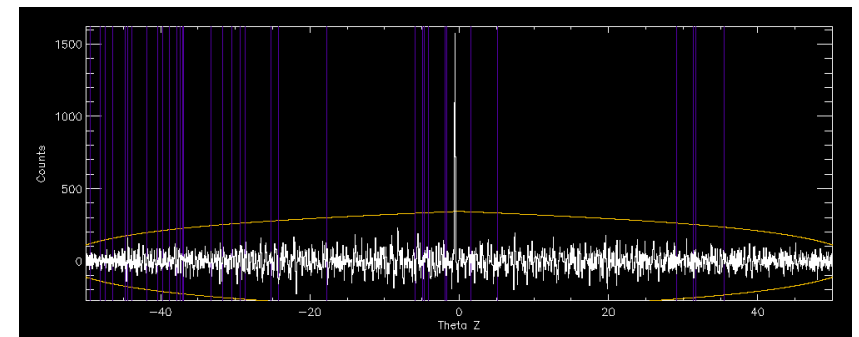
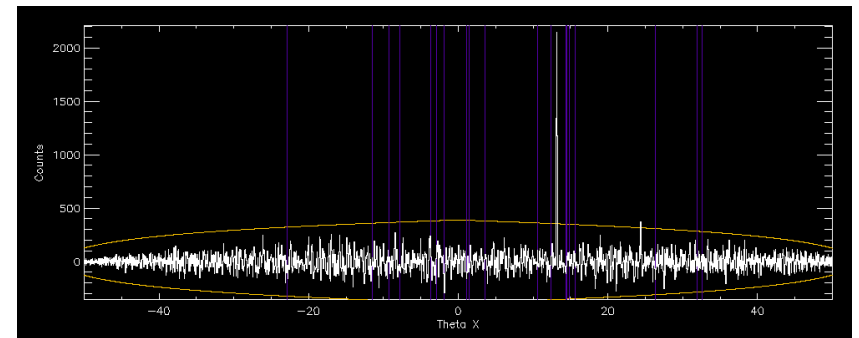
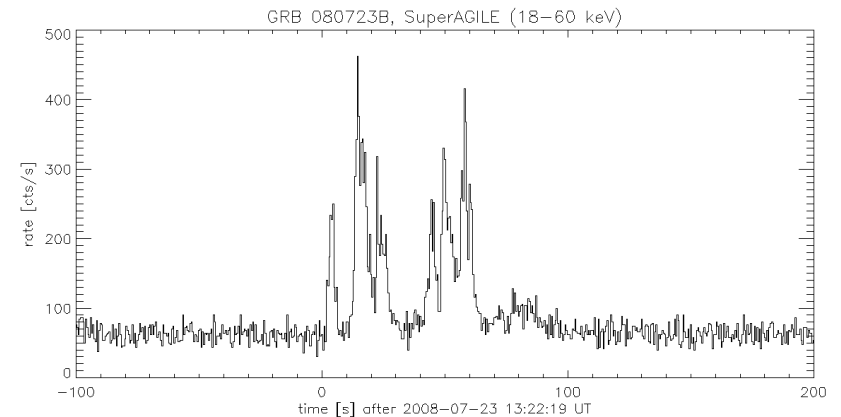
# Breaking news: localization of the bright 080723B

GRB 080723B was localized by INTEGRAL-IBIS and independently by SuperAGILE on 23 July 2008, at 13:22:19 UT (GCN 8003).

The GRB is at  $\sim 13^\circ$  off-axis. The average flux corresponds to  $\sim 10$  Crab in 18 – 60 keV ( $7.6 \times 10^{-8}$  erg/cm<sup>2</sup>/s).

No significant gamma-ray emission is detected, with a 99% c.l. upper limit of 0.03 photons/cm<sup>2</sup> for energy greater than 50 MeV (GCN 8006).

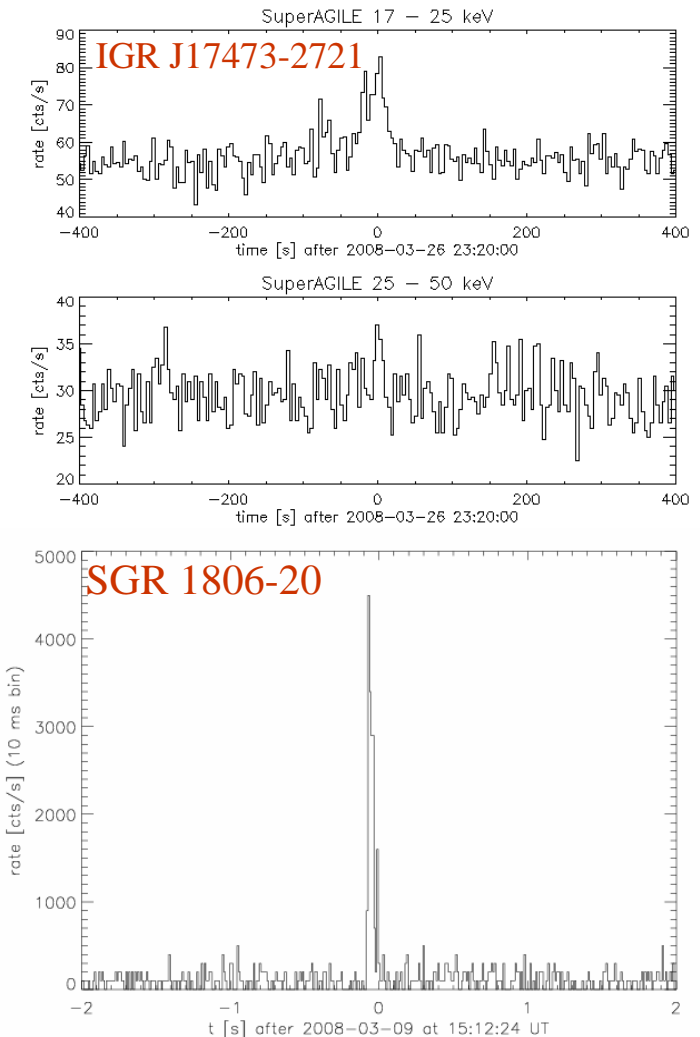
The fluence in the 350 – 700 keV range is  $(8 \pm 2) \times 10^{-6}$  erg/cm<sup>2</sup> (GCN 8006).



## ...not only GRBs: galactic X-ray bursts as well

On 26 March 2008 SuperAGILE detected and localized a **type I X-ray burst** from **IGR J17473-2721/XTE J1747-274 (Atel 1445)**. The source, still unidentified, can thus be classified as a **LMXB**. For more information see **Atel 1445, 1459, 1460, 1461 and 1468**;

SuperAGILE detected a bright burst from the Soft Gamma Repeater **SGR 1806-20** on 9 March 2008. The burst was so bright that it could be observed with **10 ms** resolution;



# Conclusions

SuperAGILE routinely localizes about 1 GRB every two months. About a factor of 2 more GRBs are detected outside the field of view.

MCAL detects about 1 GRB/week with on-board trigger and photon-by-photon data;

SuperAGILE and MCAL are active members of the Interplanetary Network (IPN), which localizes the GRBs by using the triangulation method. Among the IPN SuperAGILE cooperated in the localization of **GRB 080407B**, the Gamma Ray Burst with the **maximum duration ever detected**;

The reconstruction of the GRB positions by SuperAGILE has improved up to a **source location accuracy of 1 arcmin and an error box of 3 arcmin**;

**GRID detected a significant gamma ray counterpart of GRB 080514B, the first one after EGRET and in the afterglow era;**

The onboard trigger and imaging system of SuperAGILE has successfully detected and localized not only GRB but also **X-ray bursts from SGR and unidentified galactic sources**.