



Fermi  
Gamma-ray Space Telescope



# Osservazioni ad alte energie con *Fermi*

Niccolò Di Lalla  
[niccolo.dilalla@pi.infn.it](mailto:niccolo.dilalla@pi.infn.it)

*Fermi* collaboration

Pisa, 18 Ottobre 2017  
Polo Fibonacci

# Fermi observatory

- Launched by NASA on June 11<sup>th</sup> 2008

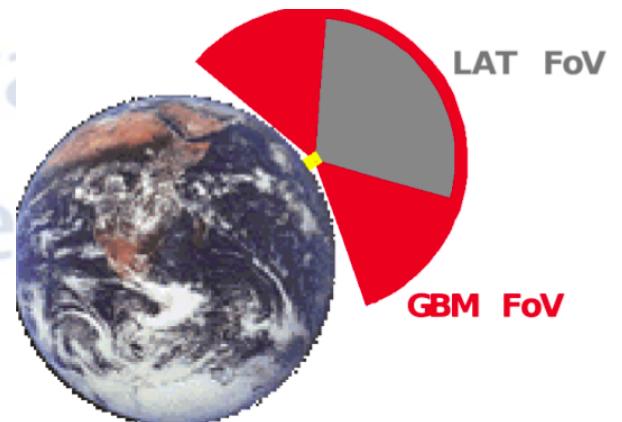
- Large Area Telescope (LAT)

- Pair-conversion telescope
- Energy range: 20 MeV - >300 GeV
- Large field of view (~20% of the sky)
- Complete sky survey every ~ 3 hours
- Angular resolution ~ 1–10 arcmin
- 15 GRBs/yr (1–2 short GRBs/yr)
  - The only instrument that has detected high-energy emission from short GRBs!



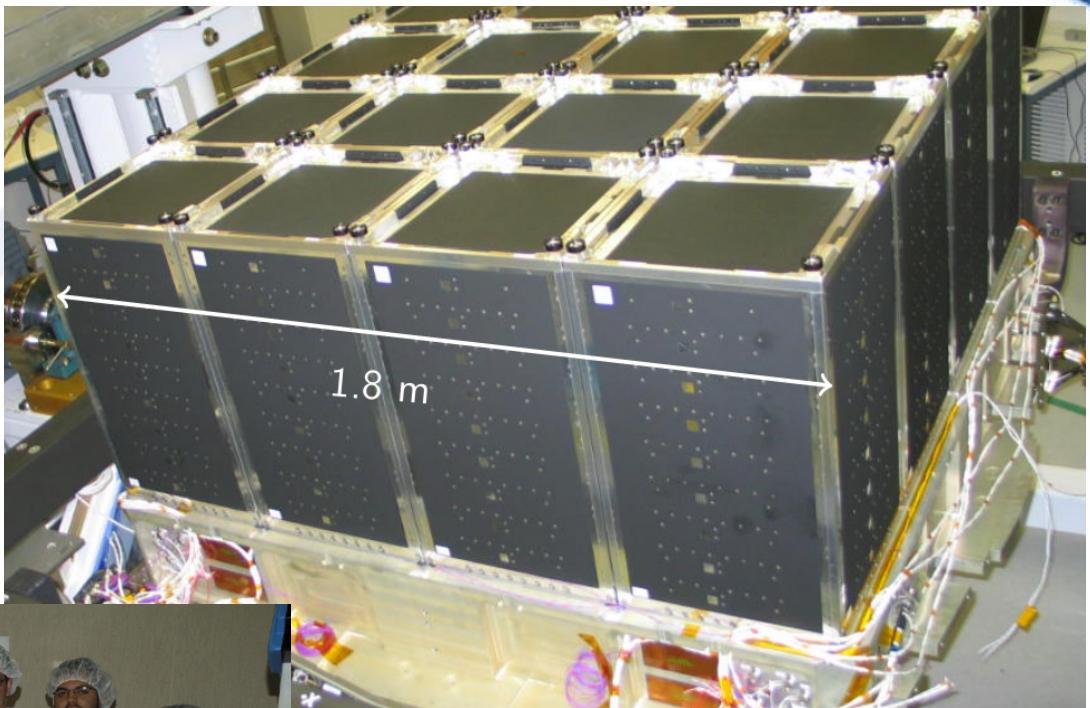
- Gamma-ray Burst Monitor (GBM)

- 12 NaI and 2 BGO detectors
- Energy range: 8 KeV–40 MeV
- Views the entire sky unocculted by the Earth (~65% of the sky)
- Angular resolution ~ 3°
- More than 2000 GRBs detected (~17% short GRBs)



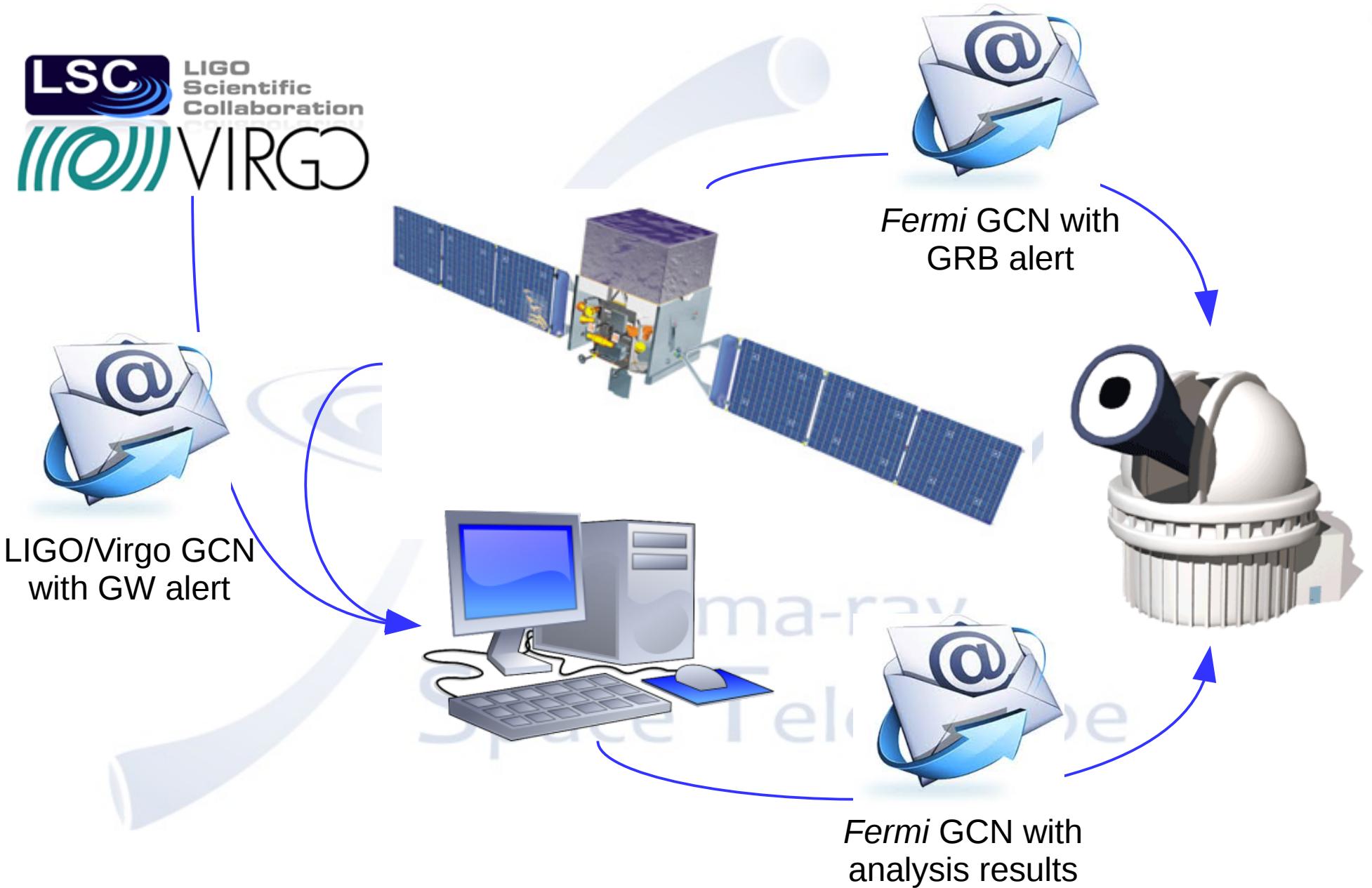
# INFN/Unipi contribution to *Fermi*

- LAT silicon tracker design, construction, testing and operation
- Multi-year effort led by Ronaldo Bellazzini (started in near 2000)

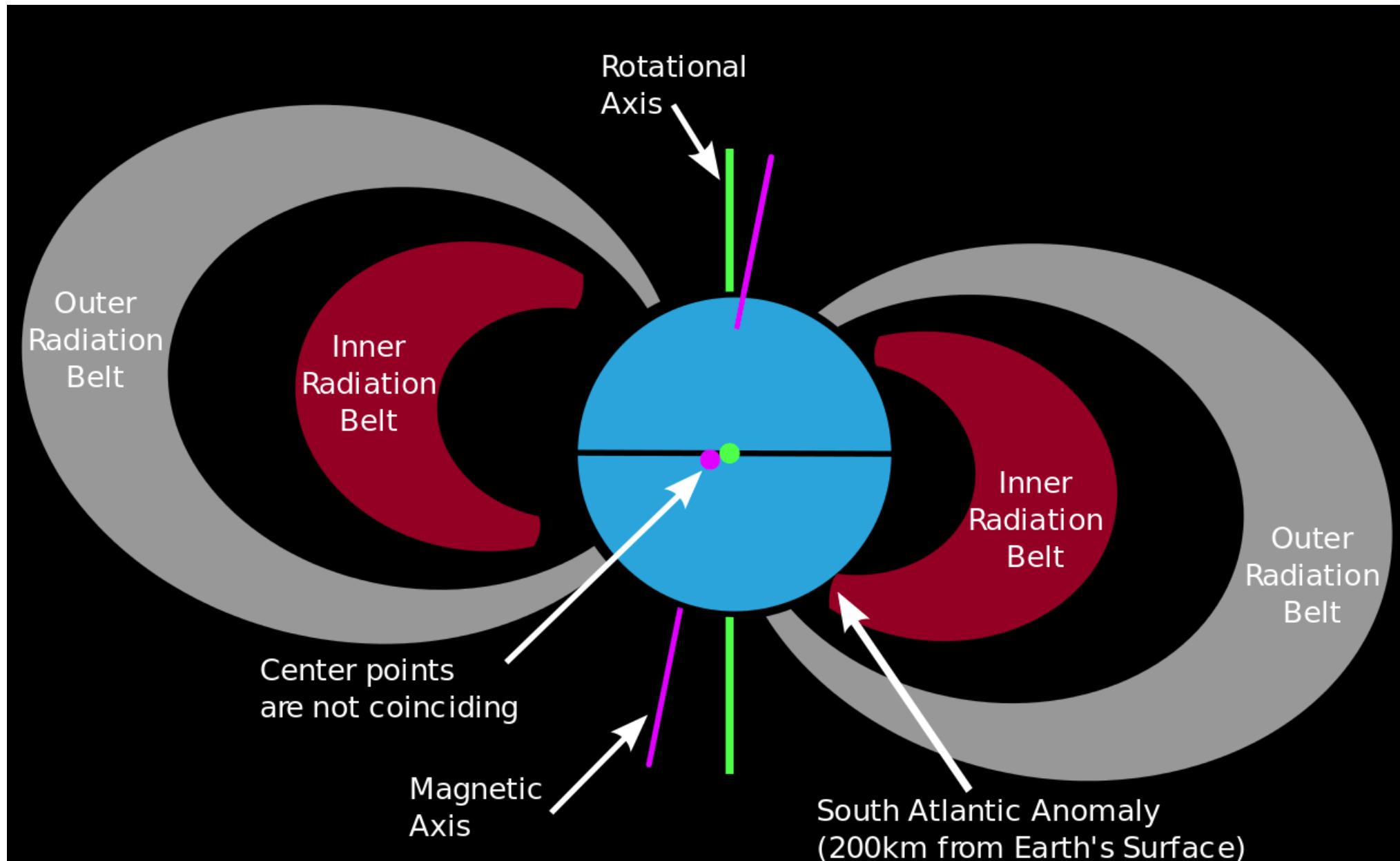


- $1.8 \times 1.8 \text{ m}^2$  footprint
- $80 \text{ m}^2$  silicon-strip detectors
- 1 M readout channels
- 160 W power budget
- > 99.5% hit efficiency within the effective area, ~ 3000 defective channels (after 9 years in orbit)

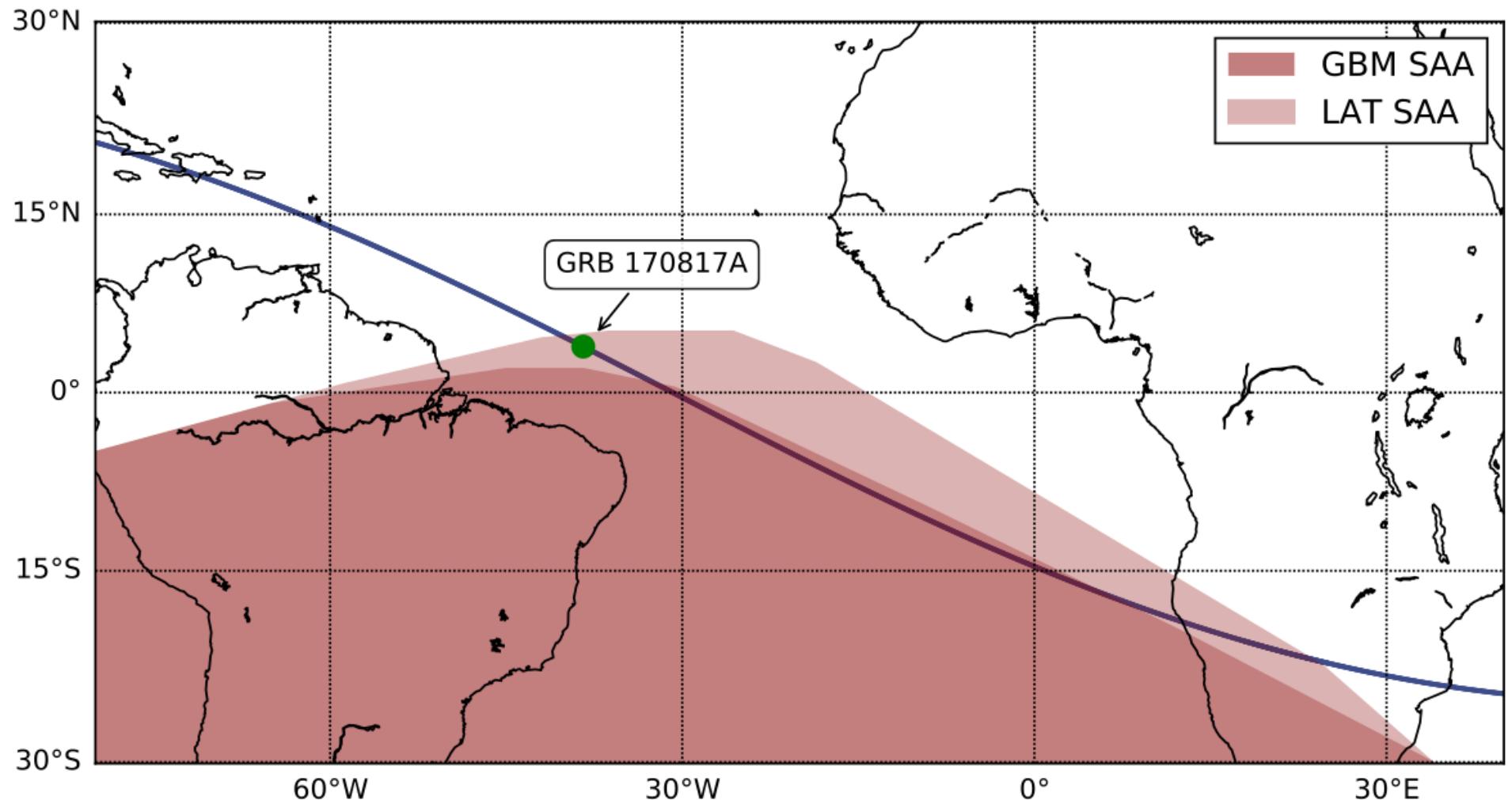
# The GW follow-up activity



# South Atlantic Anomaly

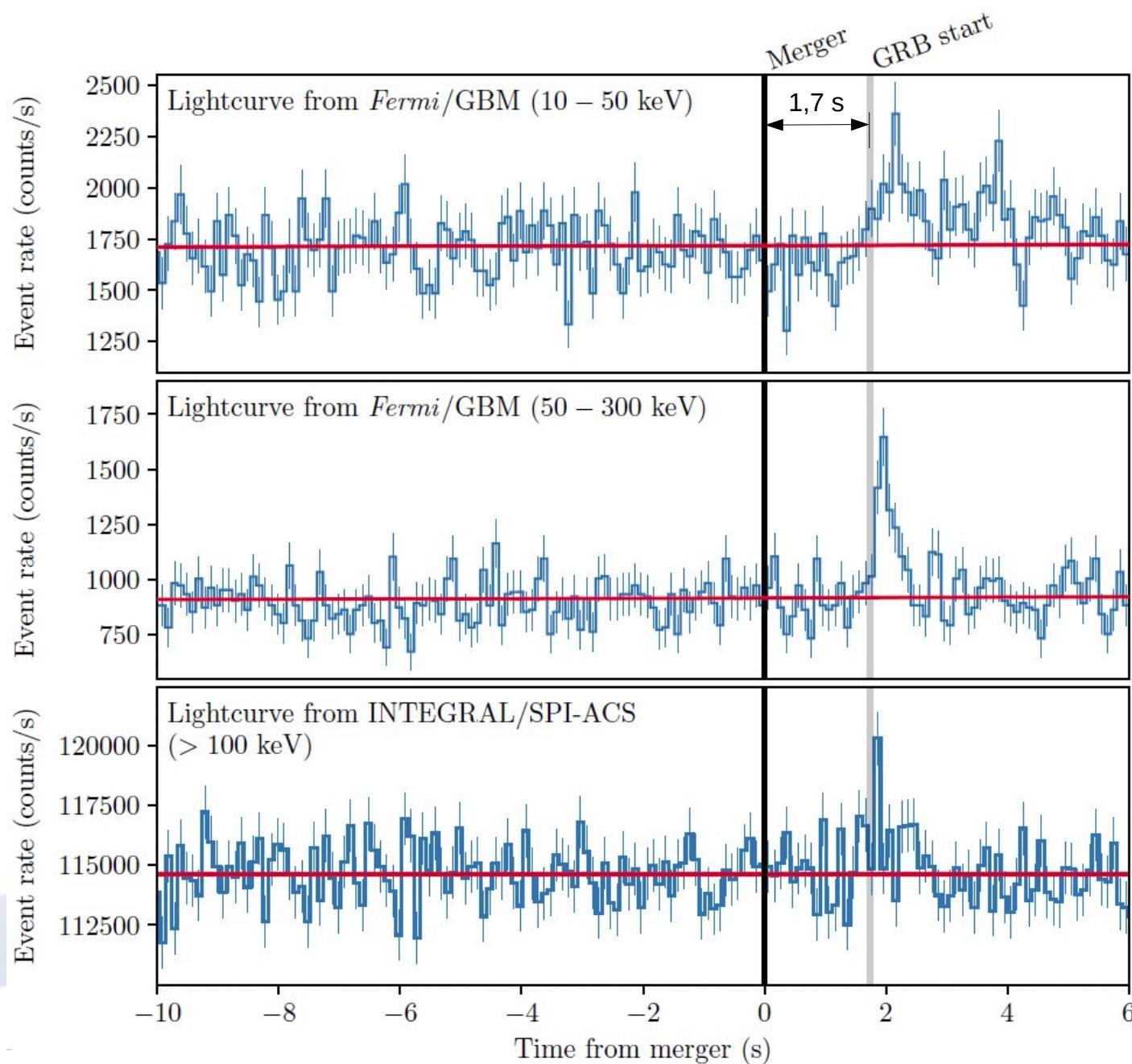


# The situation at the GW time



The LAT entered the SAA just **one minute before** the trigger!  
LAT SAA entering time: 12:40:02 – Trigger time: 12:41:06

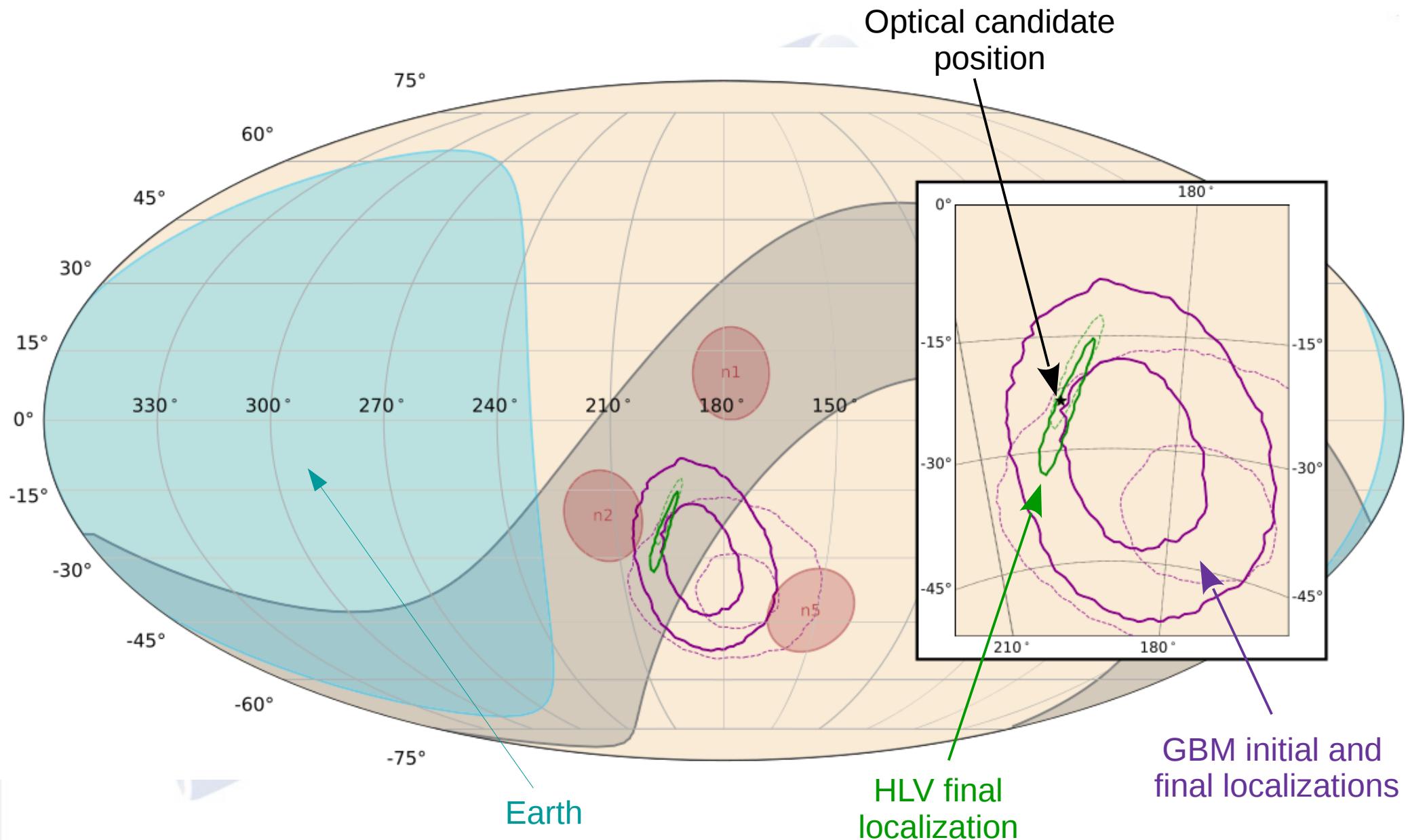
# GRB 170817A



# The GW/GRB detection timeline

Time (UTC)	Relative	Comment
12:41:06.474598	0	Trigger Time: End of 0.256 s interval containing statistically significant rate increase
12:41:06.477006	+2.4 ms	Triggered: Autonomously detected in-orbit by the <i>Fermi</i> -GBM flight software
12:41:20	+14 s	<i>Fermi</i> -GBM Alert Notice sent by the GCN system at NASA/GSFC
12:41:31	+25 s	Automatic location from GBM flight software sent by the GCN: R.A. = 172.0, Decl. = -34.8, err = 32.6 deg
12:41:44	+38 s	More accurate automatic location by ground software sent by GCN: R.A. = 186.6, Decl. = -48.8, err = 17.4 deg
13:26:36	+44.9 min	More accurate human-guided localization sent by GCN: R.A. = 176.8, Decl. = -39.8, err = 11.6 deg
13:47:37	+66.5 min	LVC GCN Circular reporting localization and consistency of signal with a weak short GRB (Connaughton et al. 2017)
20:00:07	+7.3 hr	Public GCN Circular establishing GRB name and standard GBM analysis (von Kienlin et al. 2017)
00:36:12 (next day)	+11.9 hr	LVC GCN Circular reporting updated spectral analysis, energetics, and association significance (Goldstein 2017)

# HLV-GBM localization map



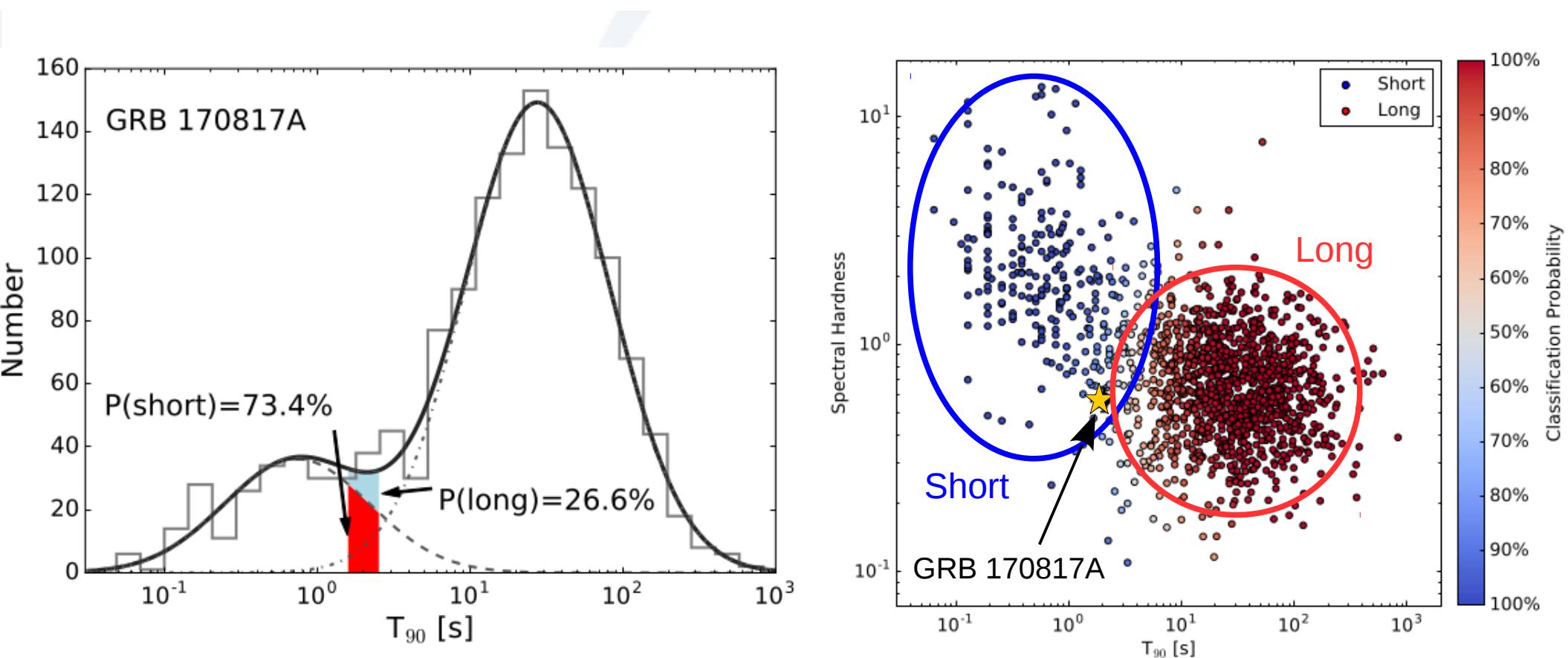
# An ordinary short GRB

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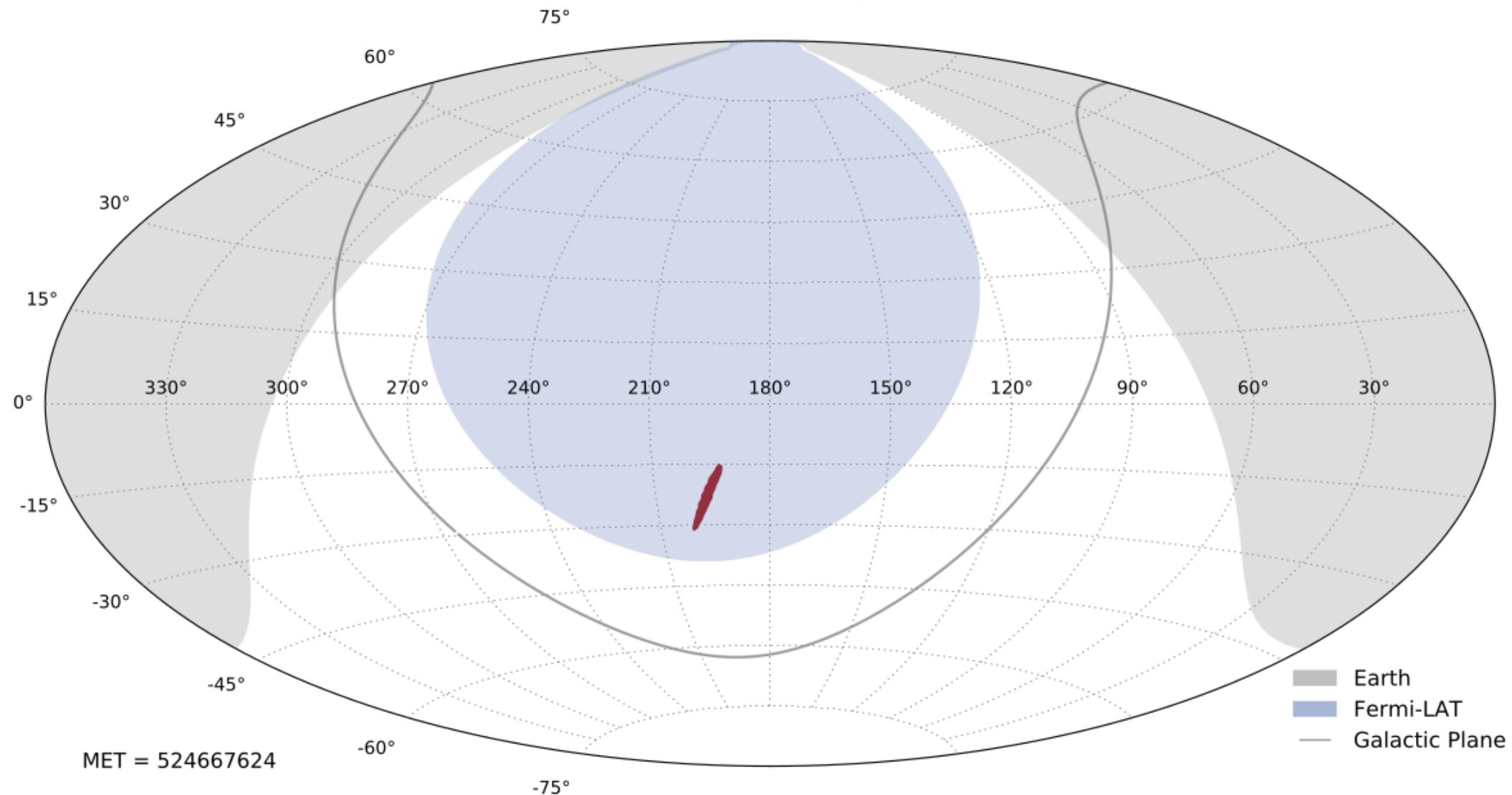
<https://doi.org/10.3847/2041-8213/aa8f41>



## An Ordinary Short Gamma-Ray Burst with Extraordinary Implications: *Fermi*-GBM Detection of GRB 170817A

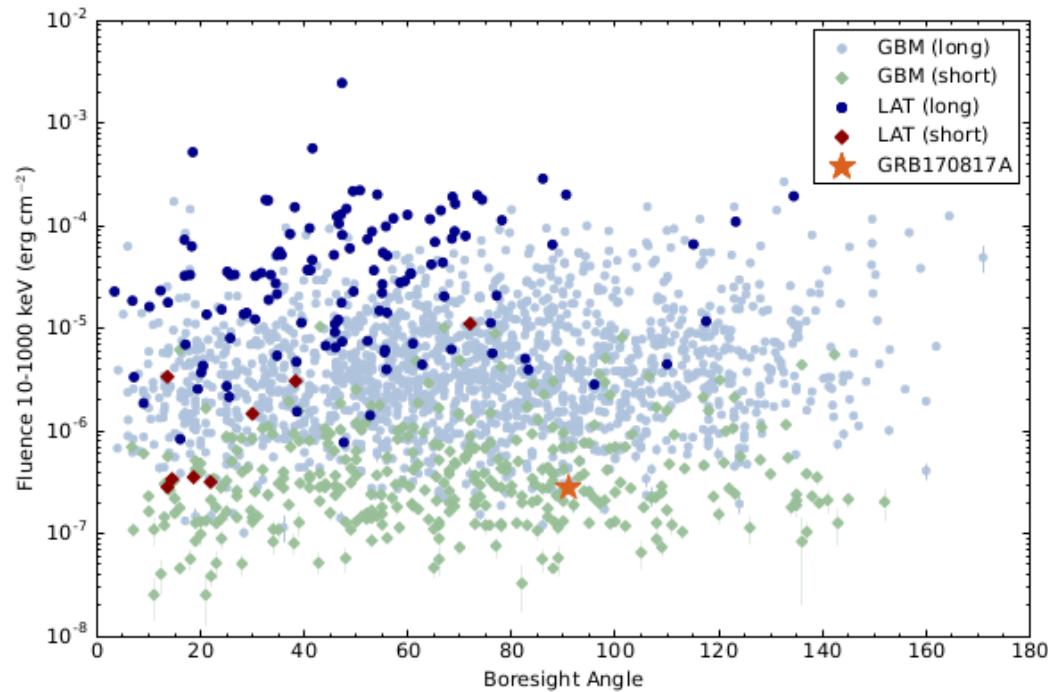
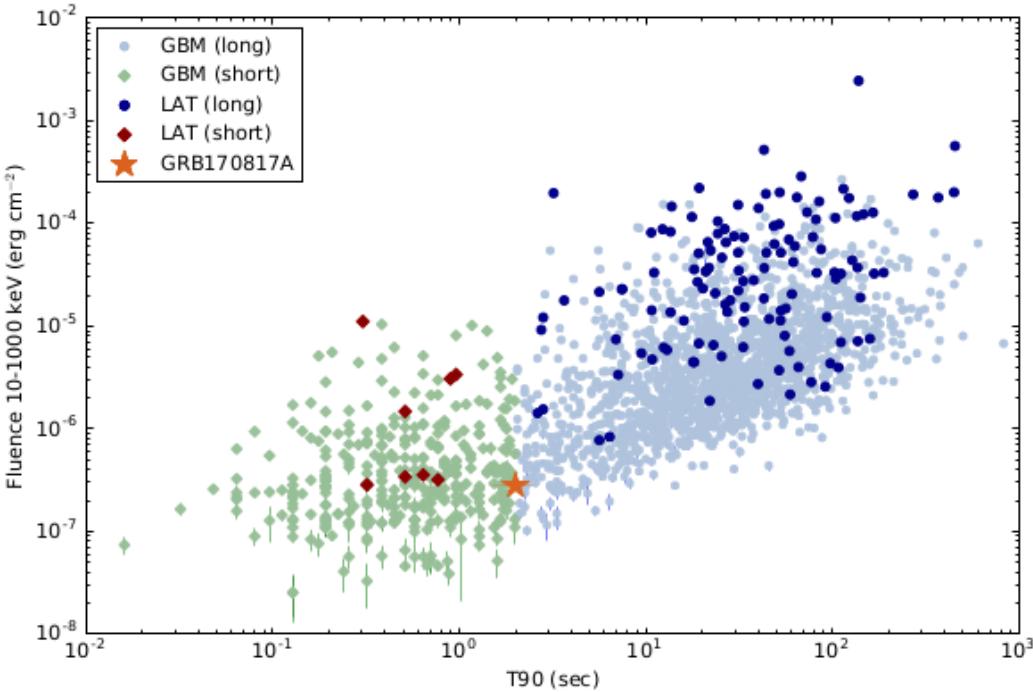


# Fermi-LAT FOV



After exiting the SAA (+1153 s)

# Could the LAT detect GRB/GW?



- The LAT detects ~ 8% of the GBM-detected GRBs (~ 5% of the SGRBs)
- The LAT observed ~ 35% of the SGRBs detected by the GBM within ~ 100 seconds of the trigger
- It is likely that LAT could detect one or more GRB/GW within few years (especially with a modification of the repointing strategy)

# Conclusions

- On August 17 at 12:41:04 UTC LIGO/Virgo interferometers triggered on a binary compact merger candidate
- After 1.7 seconds the *Fermi*-GBM detected and autonomously triggered on the short GRB 170817A
- The *Fermi*-LAT had just entered the SAA and the following monitoring resulted in no significant new sources
- *Fermi* after 9 years of mission will continue to monitor the high-energy sky and play a primary role in the new era of gravitational-wave multi-messenger astronomy!



**SPARE SLIDES**

Gamma-ray  
Space Telescope

# Large Area Telescope

Struttura modulare: matrice di  $4 \times 4$  moduli (torri)

Dimensioni:  $1.8 \text{ m} \times 1.8 \text{ m} \times 0.72 \text{ m}$

## Modulo del tracciatore

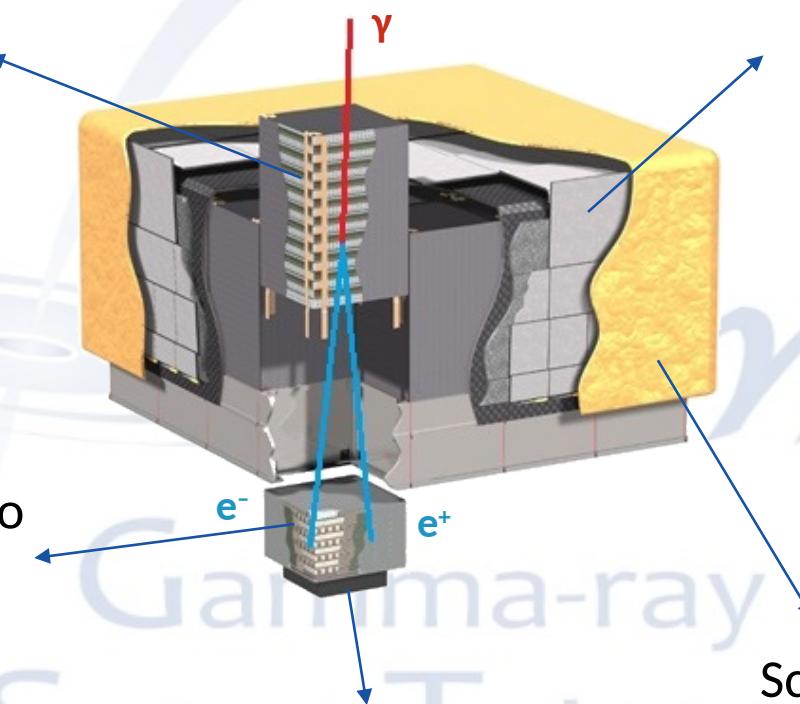
### - convertitore:

- 18 piani x-y traccianti di rivelatori a strisce al silicio
- 16 piani di tungsteno per favorire la conversione (1.6 R.L. on axis)

## Modulo del calorimetro

### di CsI(Tl):

- 96 cristalli disposti in 8 piani (8.6. R.L. on axis)
- Misura dell'energia
- Immagine 3D dello sciamo
- Reiezione del fondo

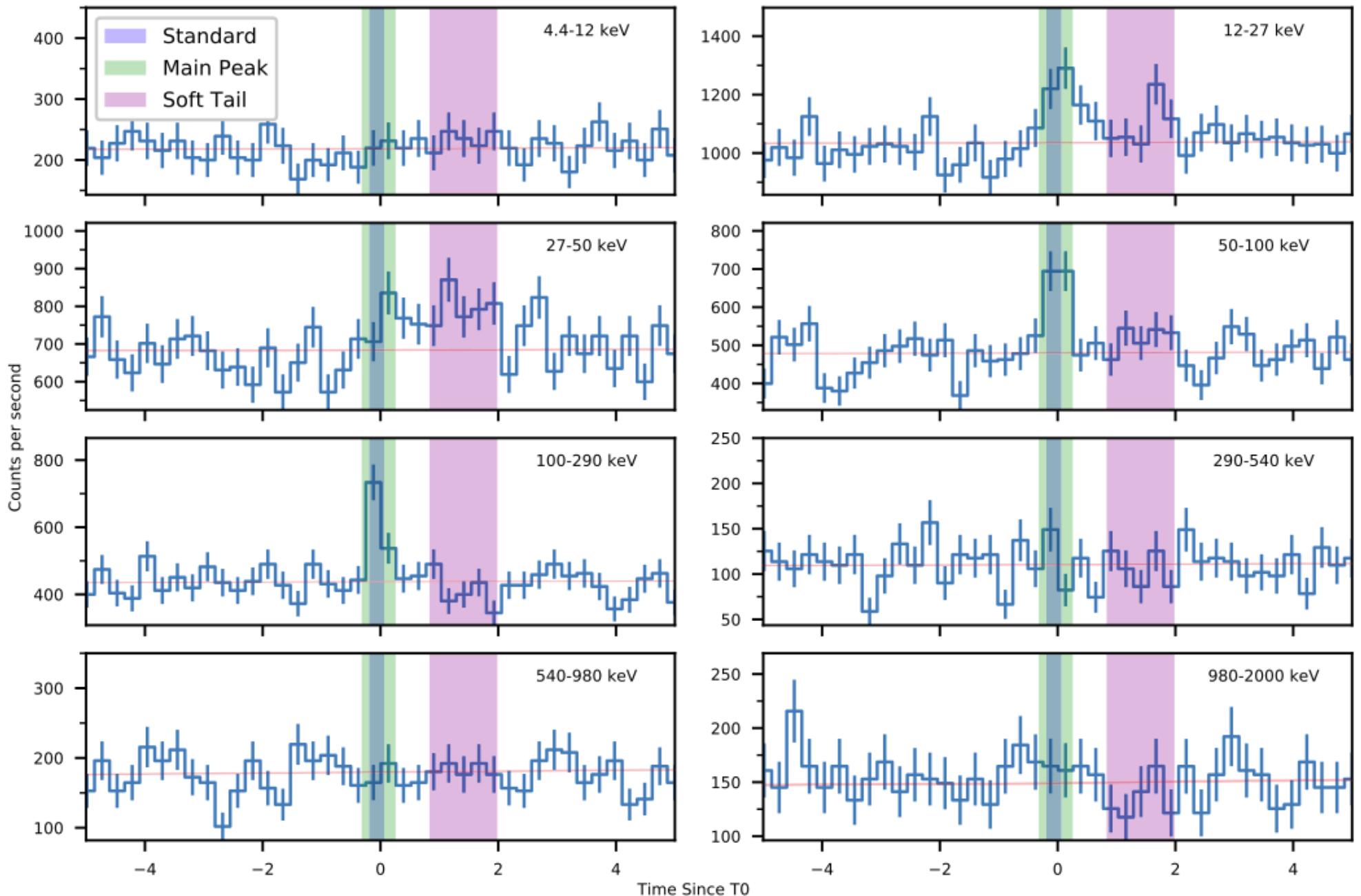


## Rivelatore di anticoincidenza:

- 89 mattonelle di scintillatore plastico
- Efficienza media maggiore del 99.97% per MIP
- Separazione dei fotoni dalle particelle cariche

## Scudo protettivo

# GRB 170817A



# Fermi-LAT monitoring

