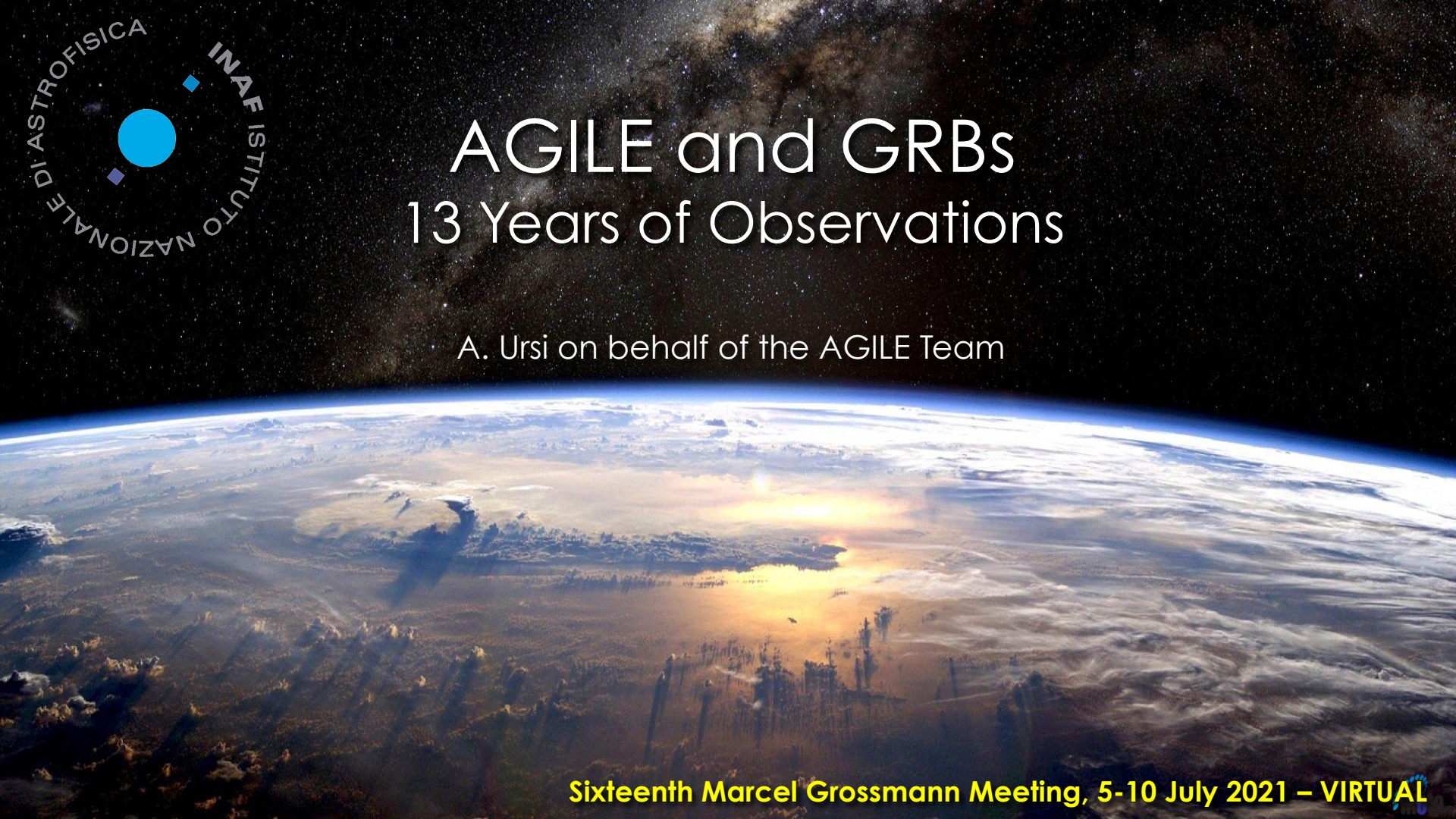
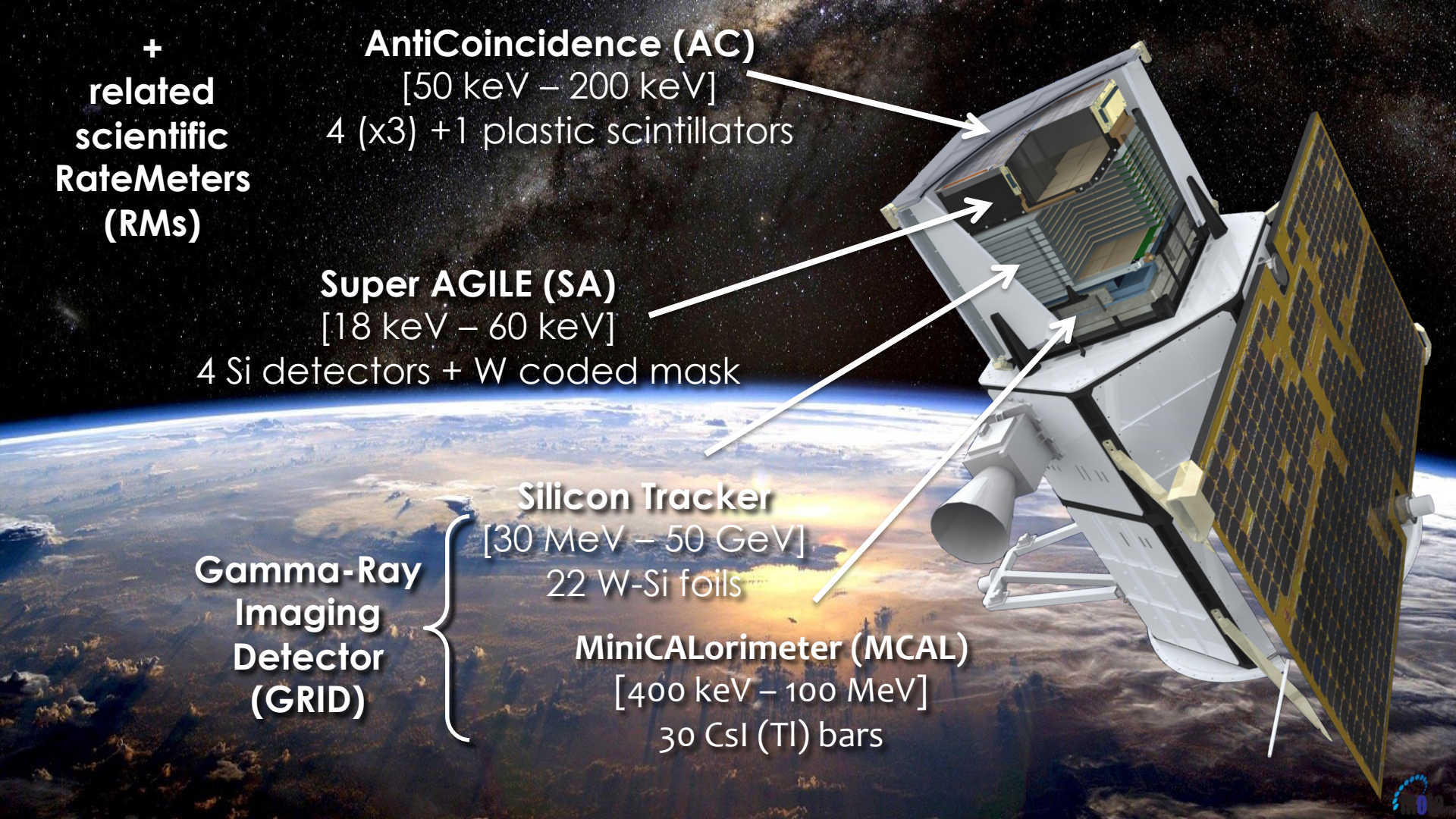


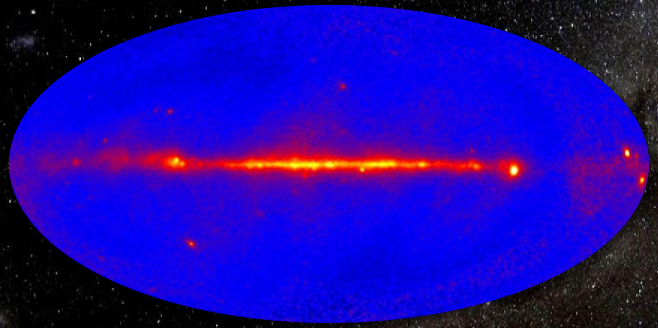
AGILE and GRBs
13 Years of Observations

A. Ursi on behalf of the AGILE Team

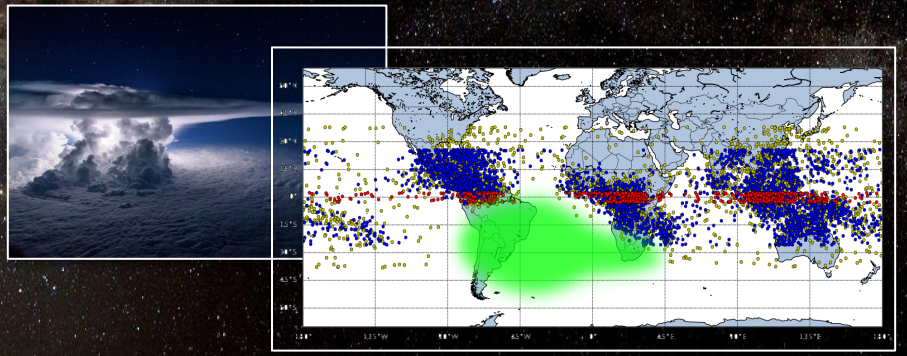
Sixteenth Marcel Grossmann Meeting, 5-10 July 2021 – VIRTUAL

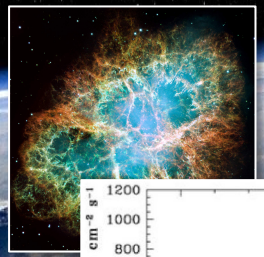

+
related
scientific
RateMeters
(RMs)
AntiCoincidence (AC)
[50 keV – 200 keV]
4 (x3) +1 plastic scintillators
Super AGILE (SA)
[18 keV – 60 keV]
4 Si detectors + W coded mask
Gamma-Ray
Imaging
Detector
(GRID)
Silicon Tracker
[30 MeV – 50 GeV]
22 W-Si foils
MiniCALorimeter (MCAL)
[400 keV – 100 MeV]
30 CsI (Tl) bars

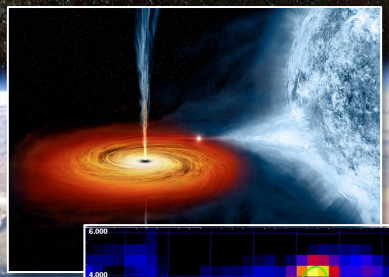
gamma-ray sky

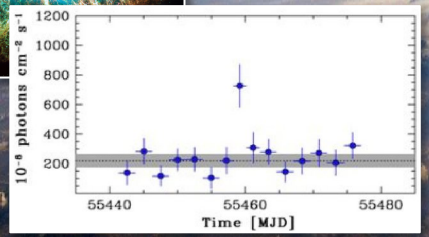


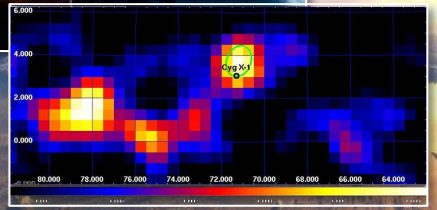
Terrestrial Gamma-ray Flashes (TGFs)

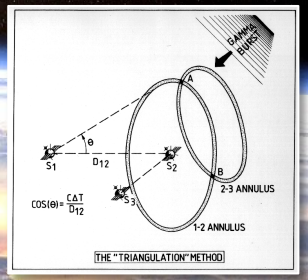


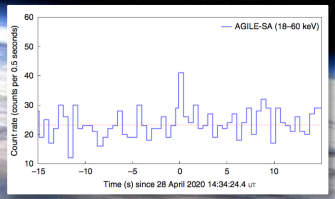












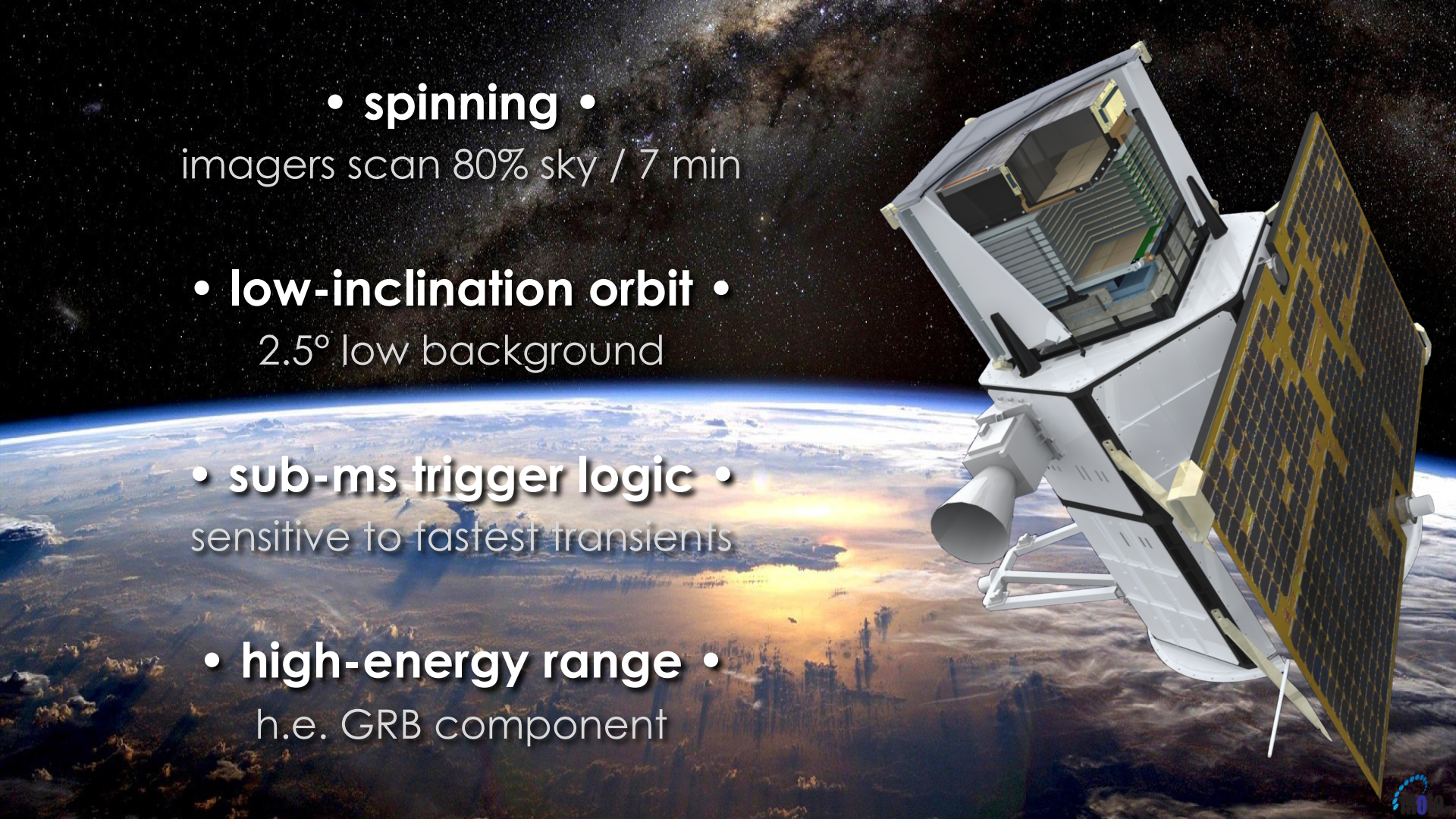
IPN partner

FRBs

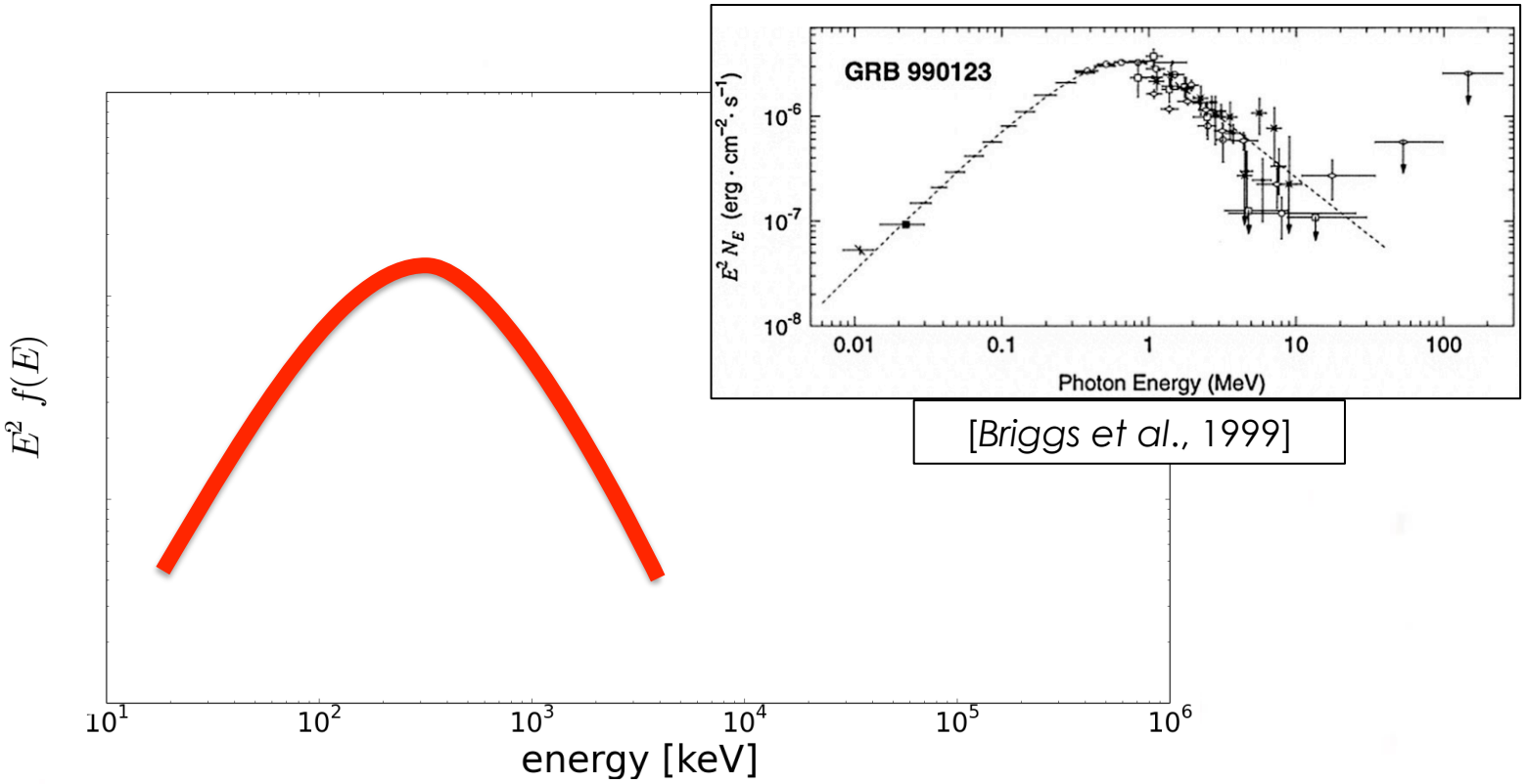
Crab nebula

microquasars

GW follow-up partner

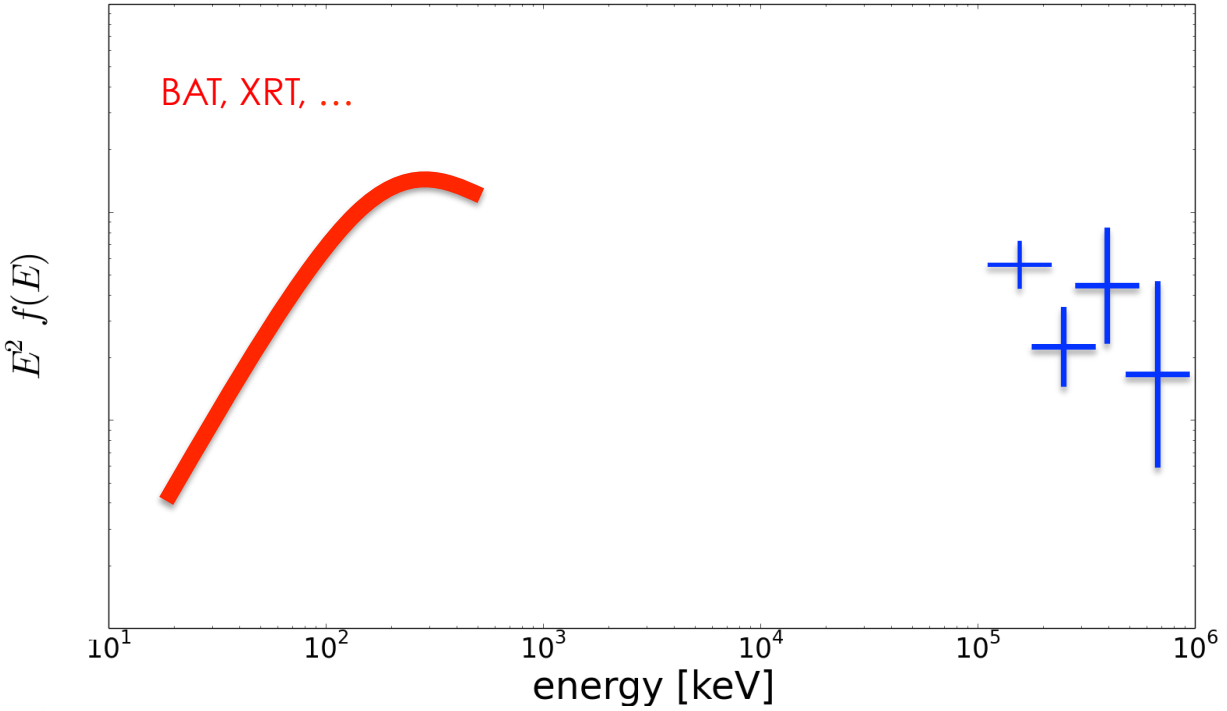

• spinning •
imagers scan 80% sky / 7 min
• low-inclination orbit •
2.5° low background
• sub-ms trigger logic •
sensitive to fastest transients
• high-energy range •
h.e. GRB component

High-Energy GRBs



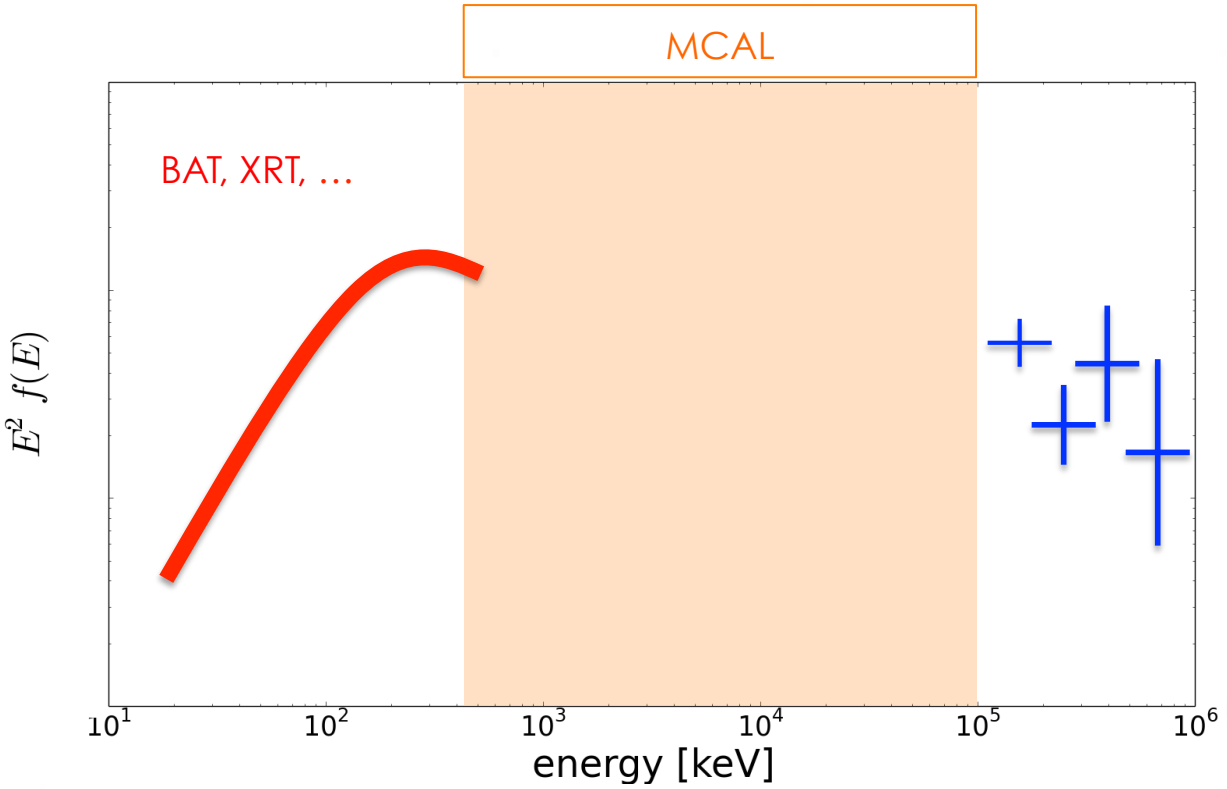
[*Briggs et al.*, 1999]

High-Energy GRBs



high-energy detections (GRID, LAT, …)

High-Energy GRBs



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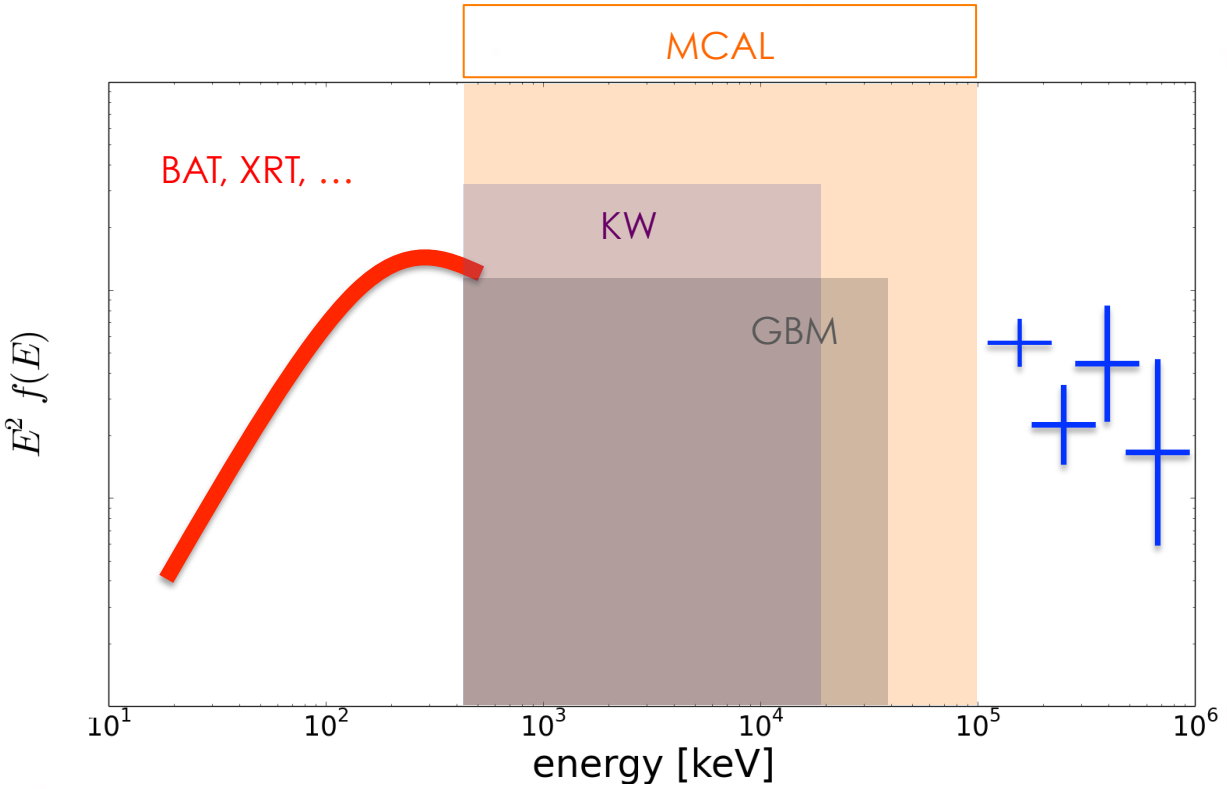
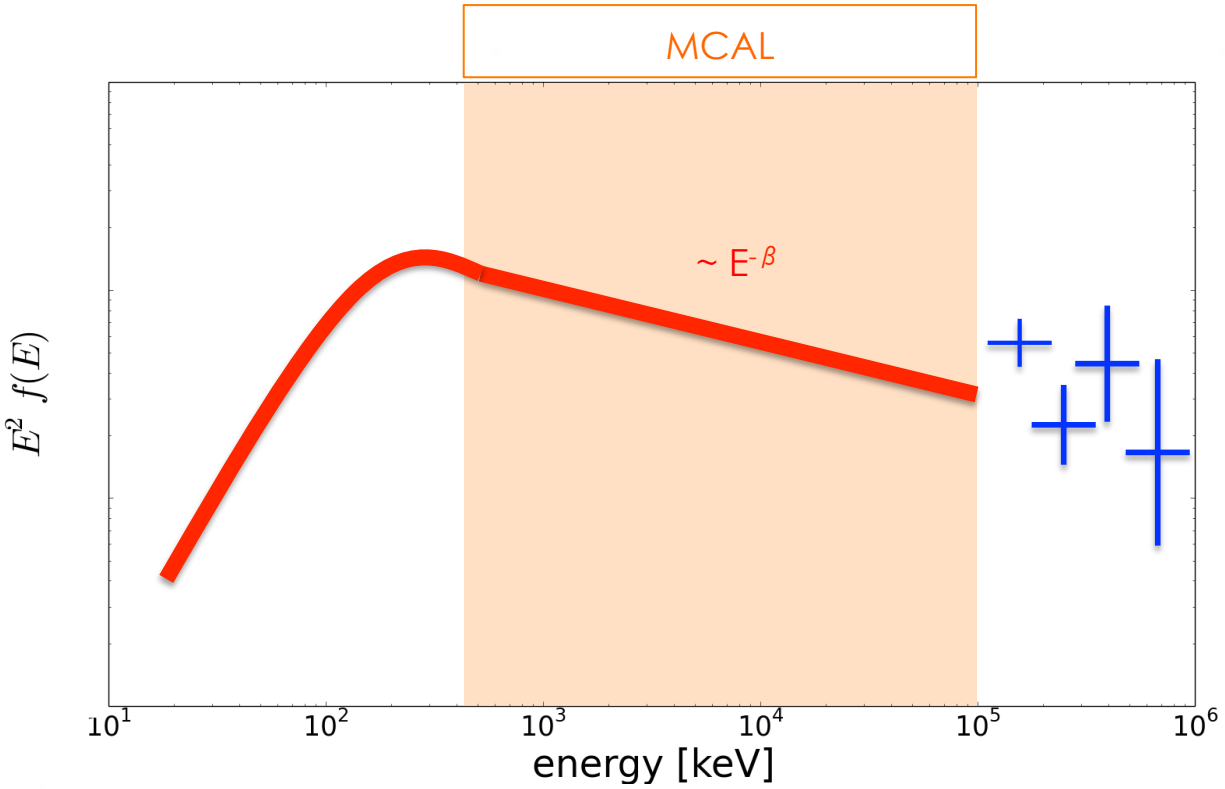
High-Energy GRBs

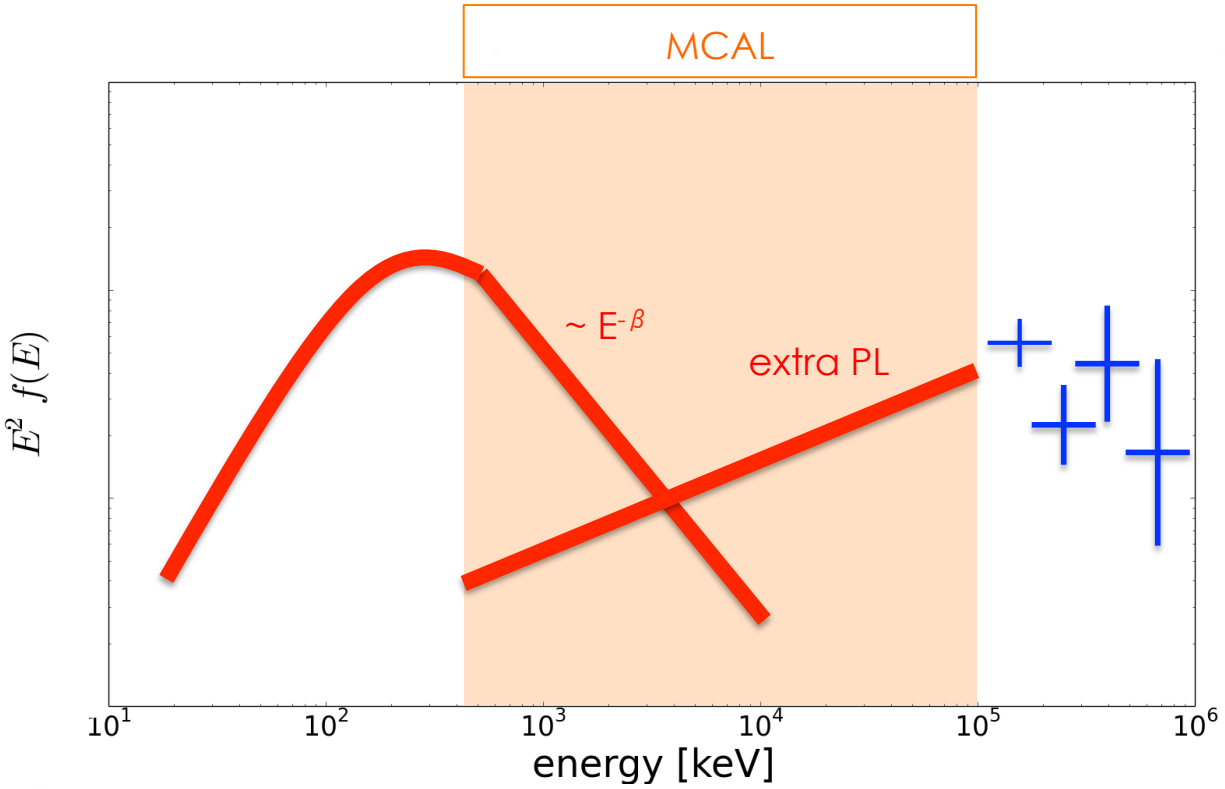


high-energy detections (GRID, LAT, …)

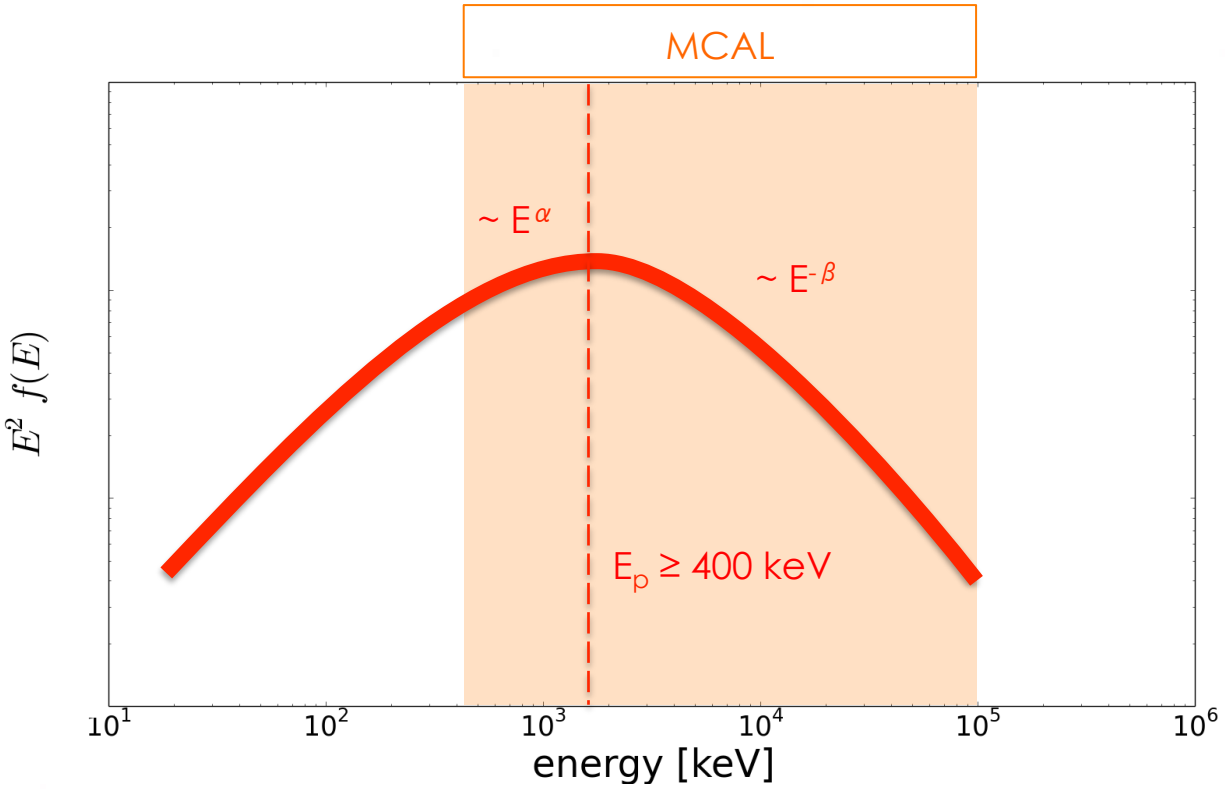
High-Energy GRBs



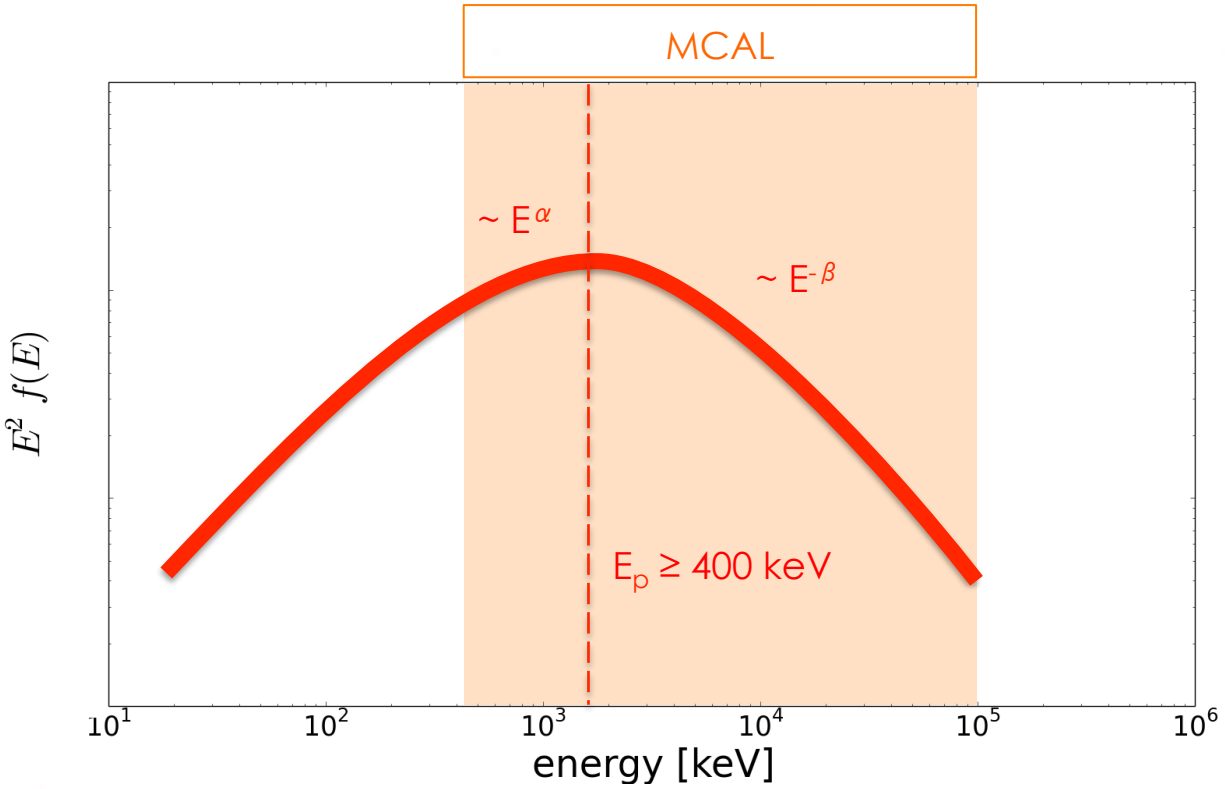
High-Energy GRBs



High-Energy GRBs

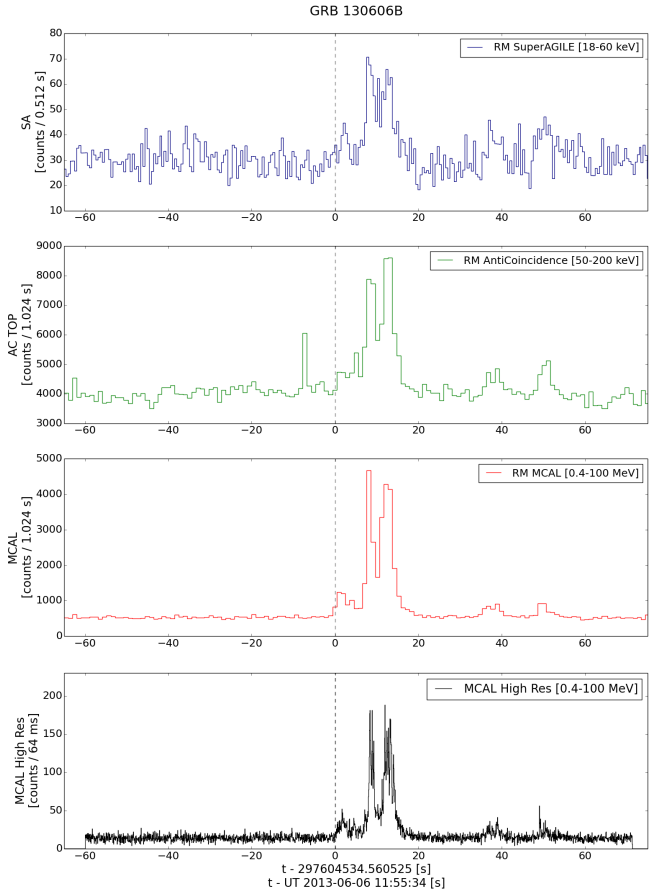


High-Energy GRBs



simultaneous/prompt or delayed/extended

AGILE & GRBs



continuous

continuous data stream with 0.5 s – 1 s time resolution

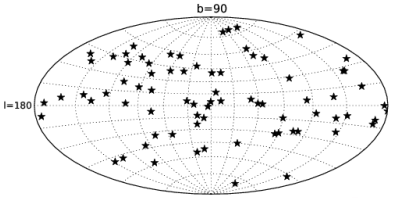
triggered

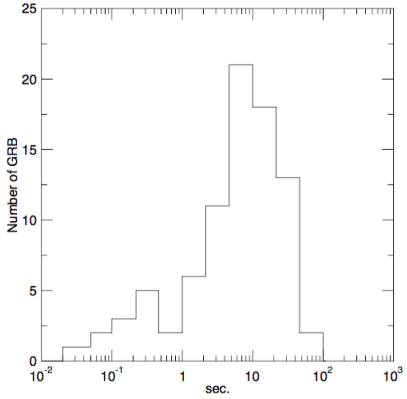
limited data acquisition ph-by-ph with 4 μs time resolution
(not always covering the whole event…)

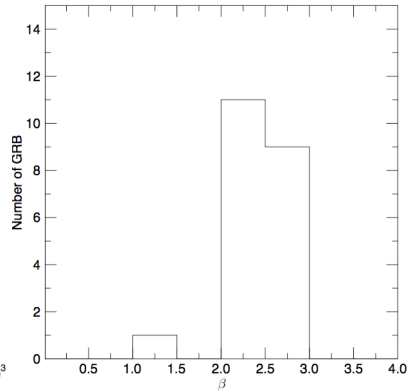
AGILE & GRBs

MCAL 1st GRB catalog
[*Galli et al.*, 2013]

84 GRBs







AGILE & GRBs

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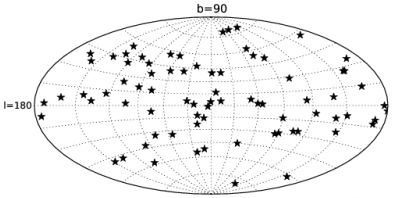
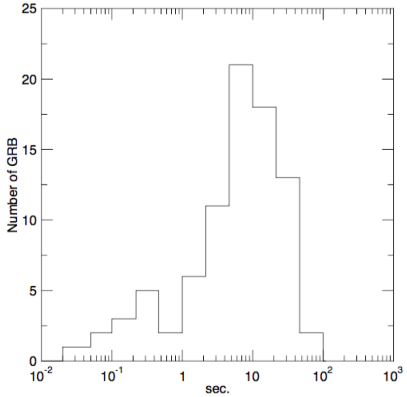
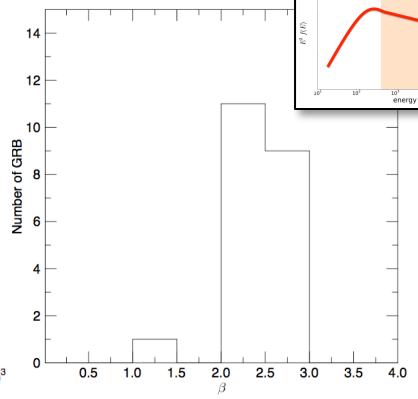
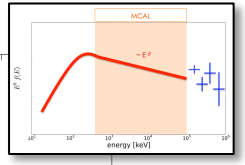
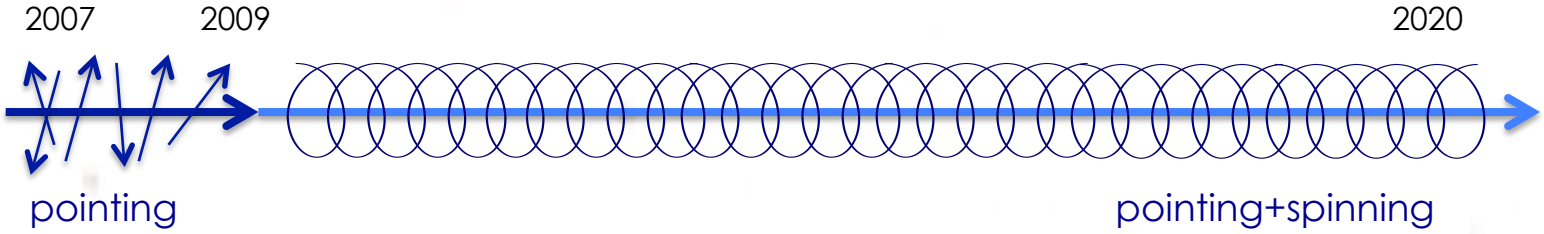








AGILE & GRBs



MCAL 1st GRB catalog
[*Galli et al.*, 2013]

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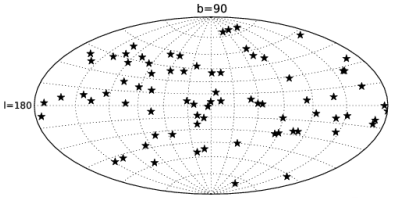
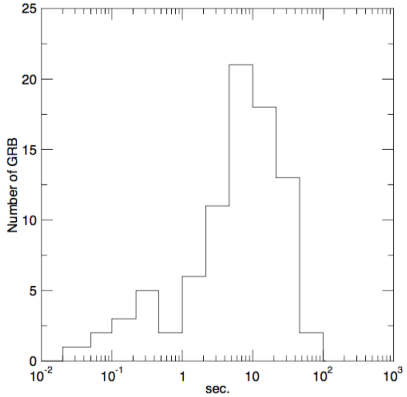
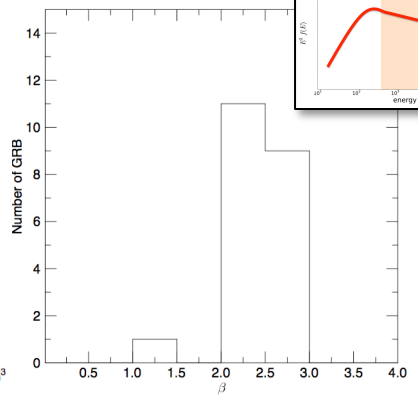
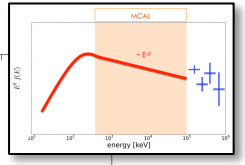


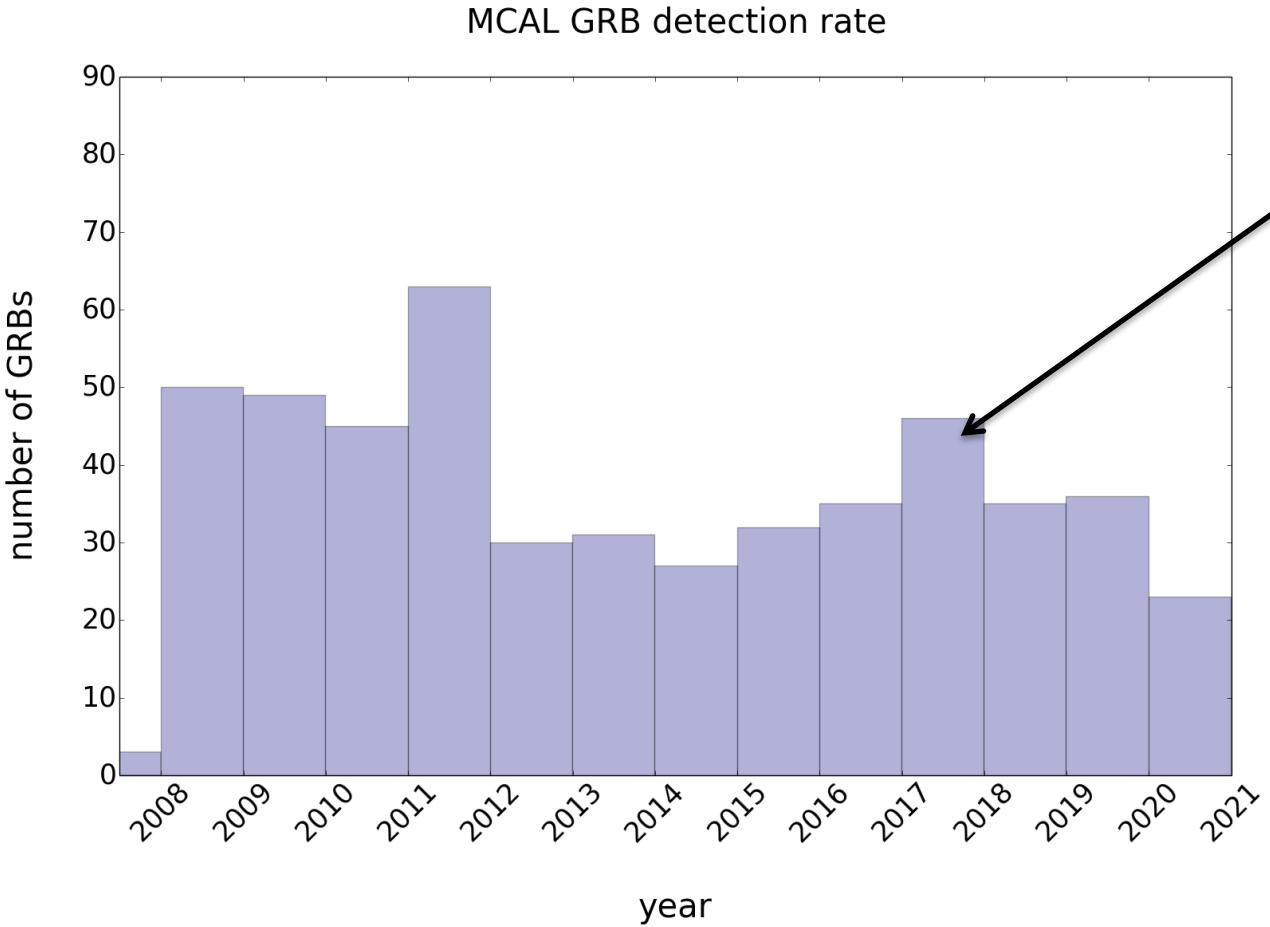






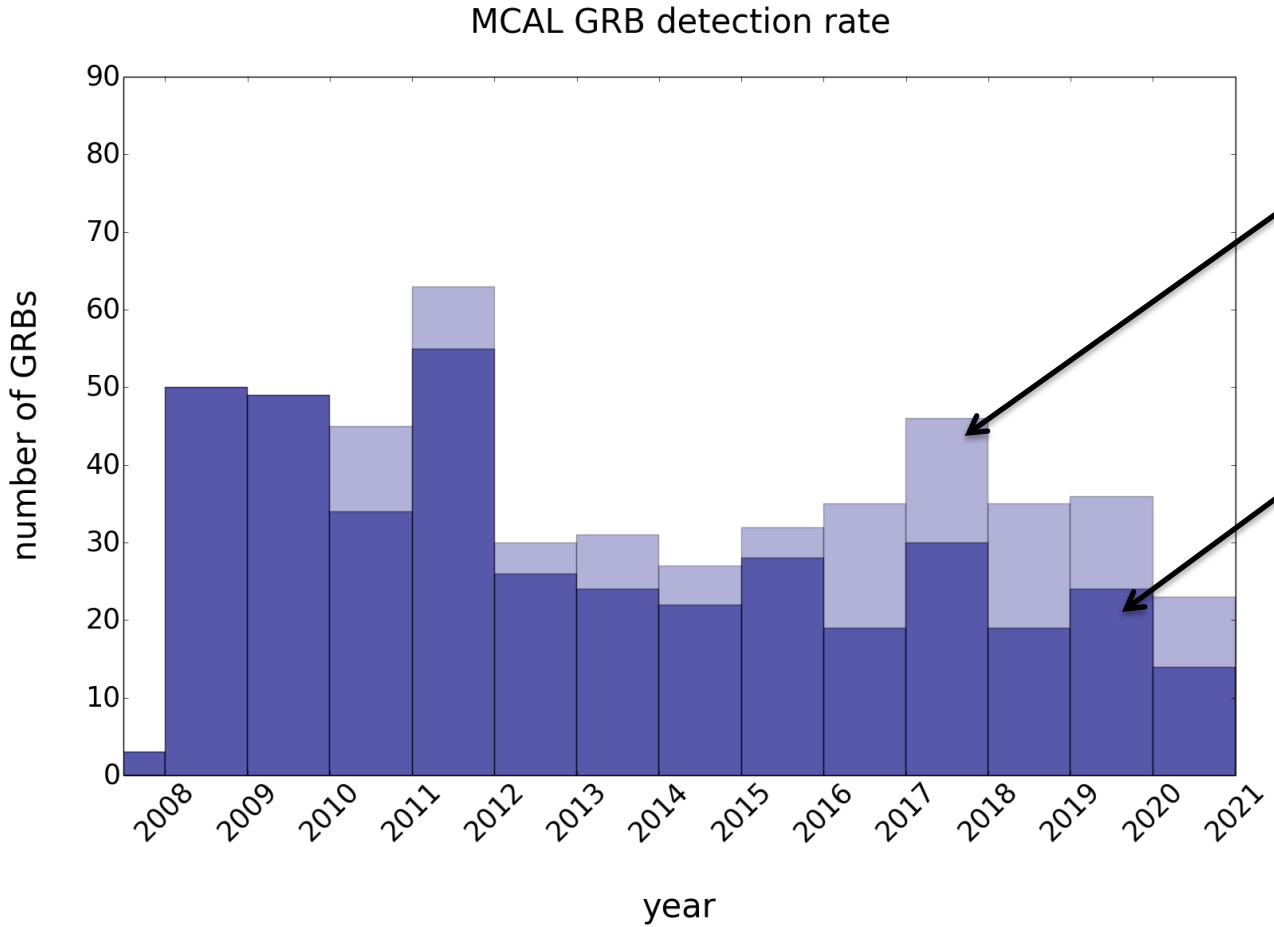
?

AGILE & GRBs



503 GRBs triggered by AGILE/MCAL

AGILE & GRBs

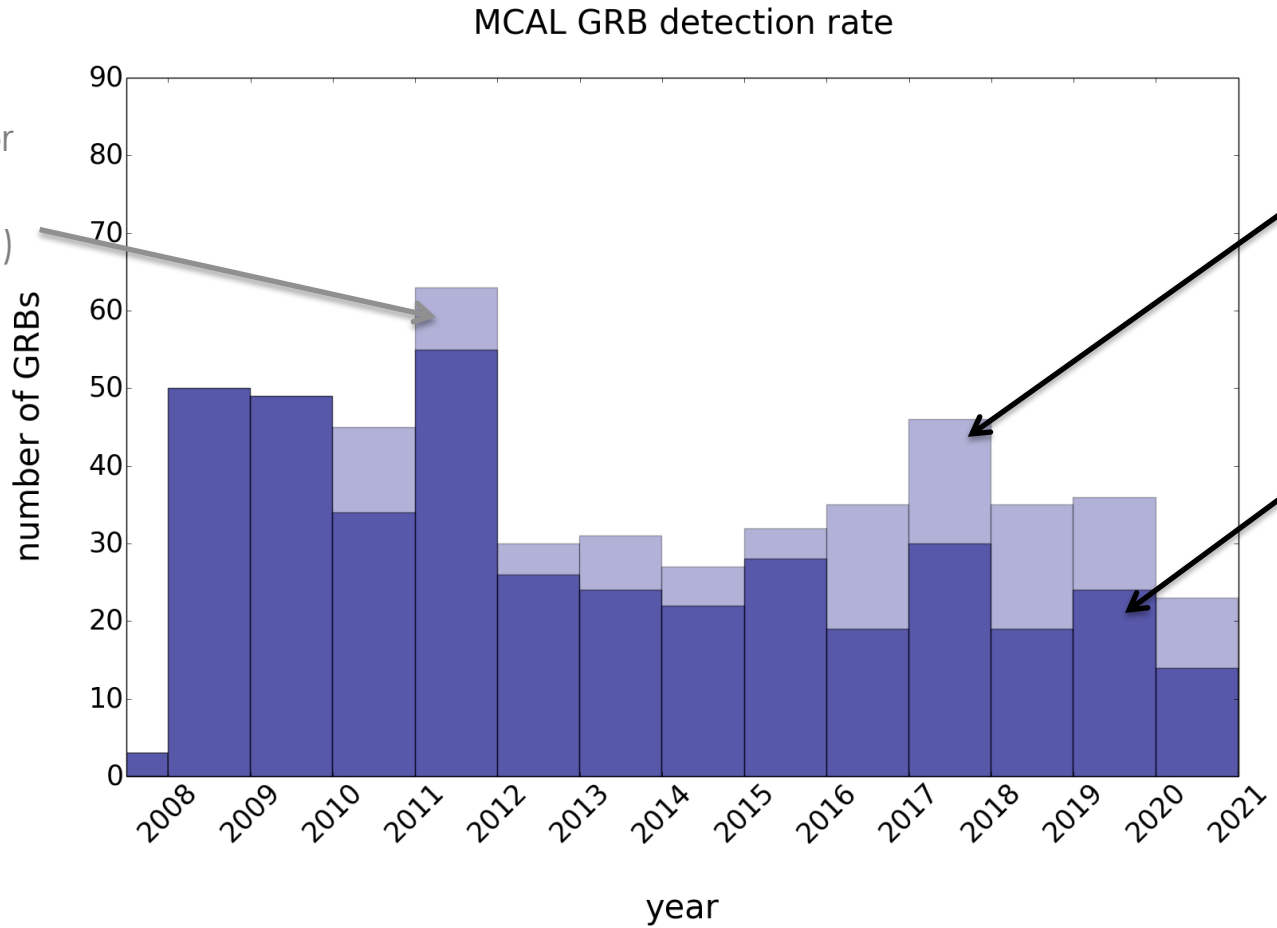


503 GRBs triggered by AGILE/MCAL

393 GRBs completely detected by AGILE/MCAL

AGILE & GRBs

110 GRBs incomplete or fragmented (**useful for IPN**)



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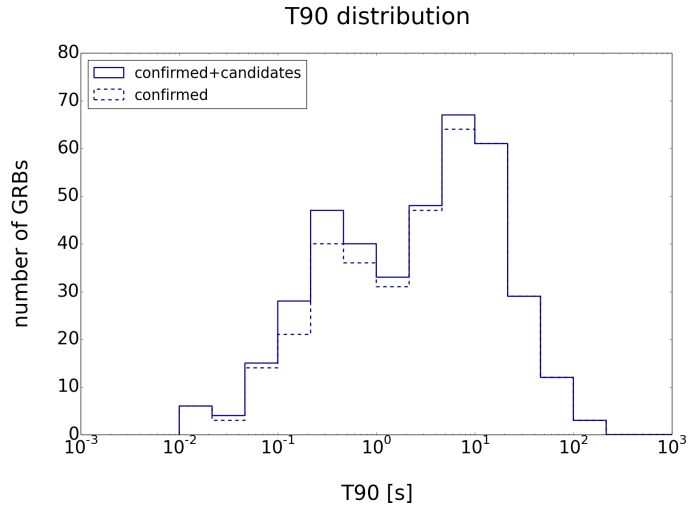
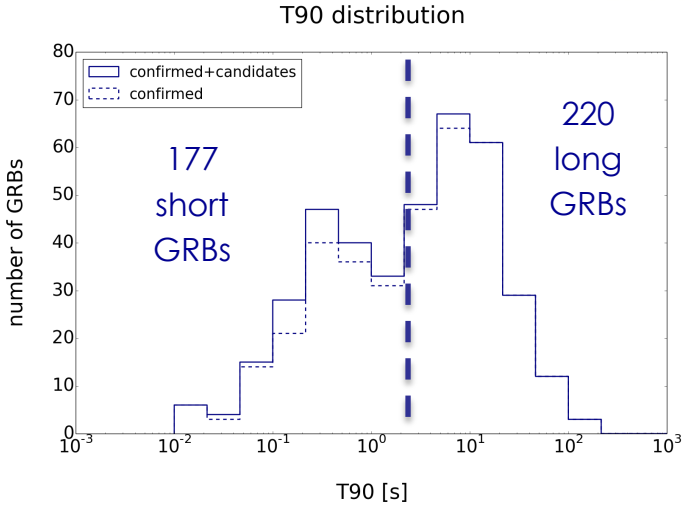
AGILE & GRBs



393 GRBs
fully detected
by MCAL

27 candidates
not in IPN list

AGILE & GRBs



~ 44% short GRBs

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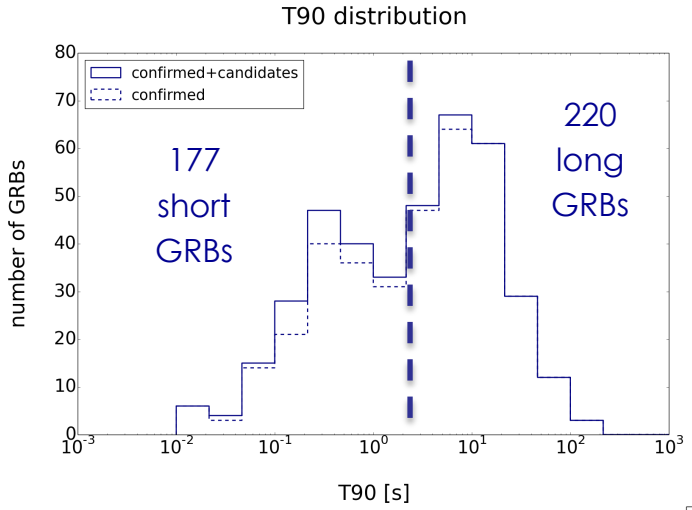
AGILE & GRBs

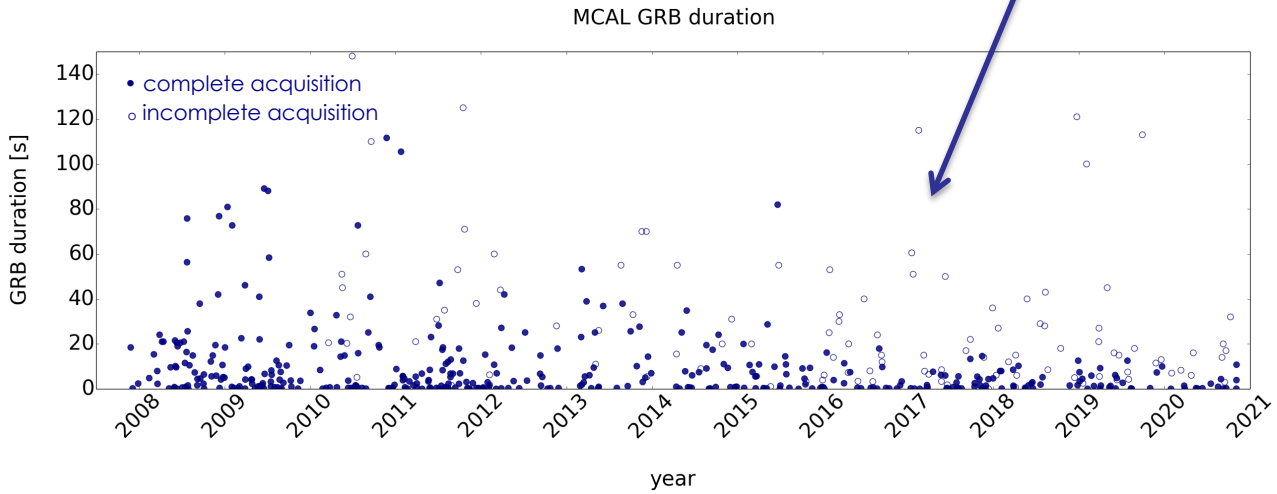


393 GRBs
fully detected
by MCAL

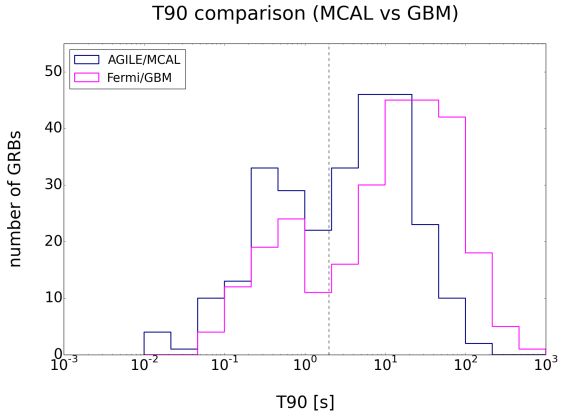
27 candidates
not in IPN list

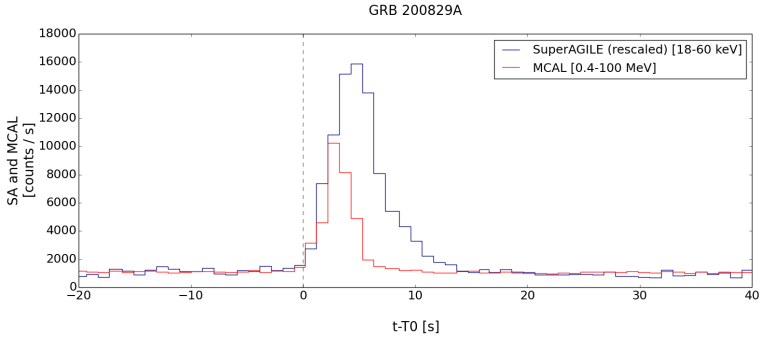
- telemetry restrictions
- MCAL-GW configuration
- not bad for spinning issue
- limited energy range

~ 44% short GRBs



AGILE & GRBs





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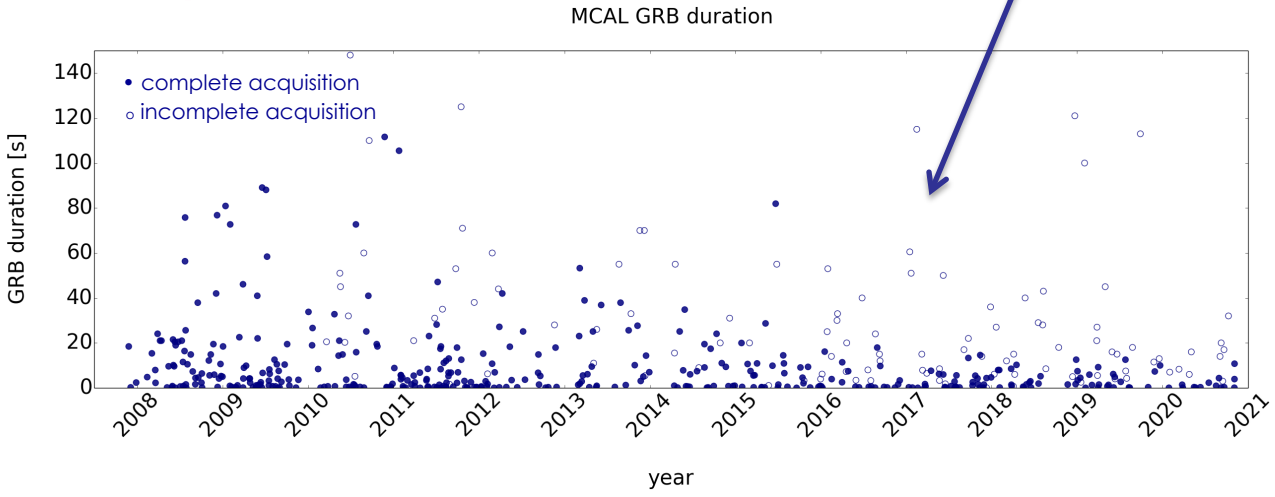
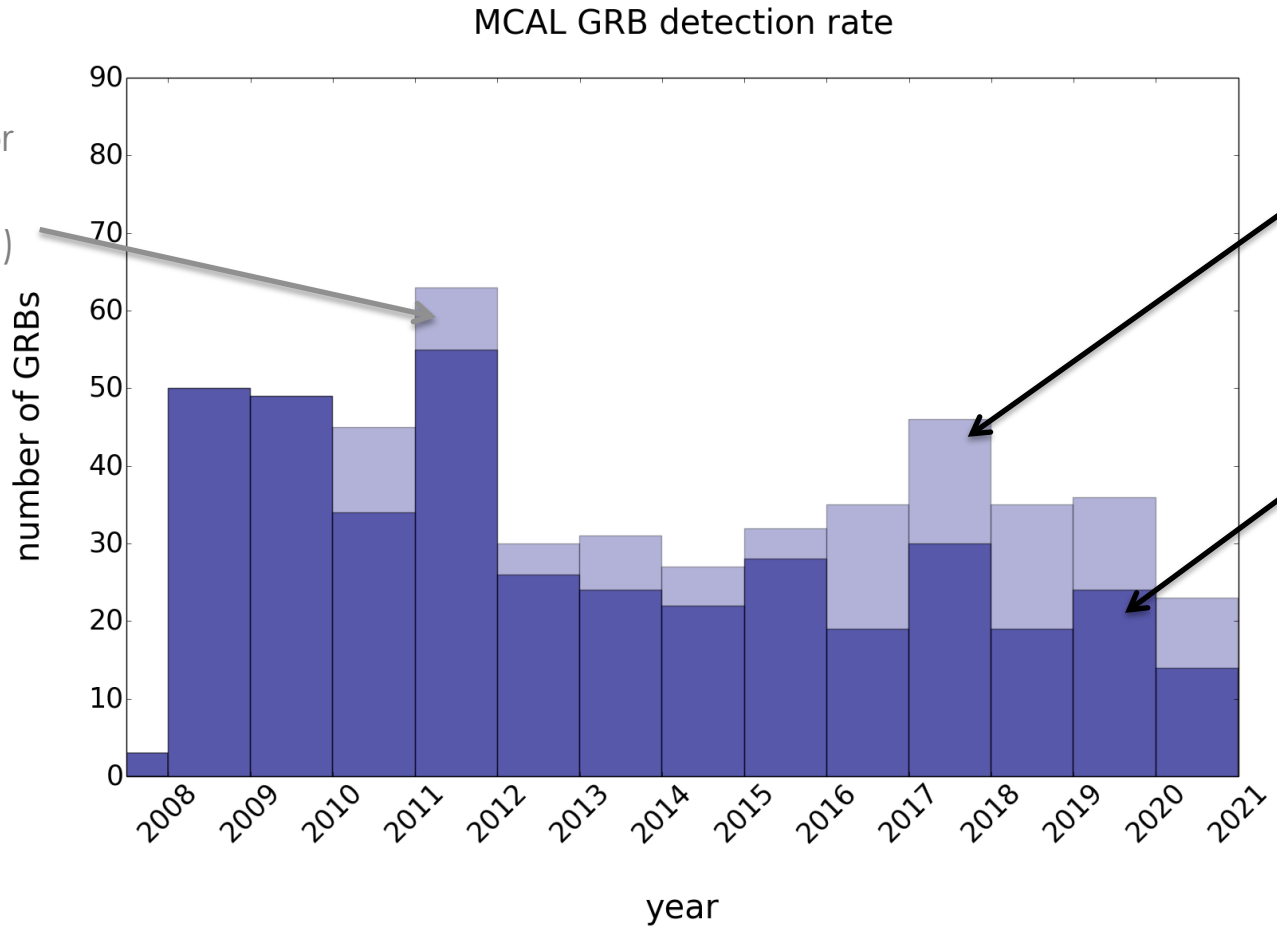


AGILE & GRBs

110 GRBs incomplete or fragmented (**useful for IPN**)



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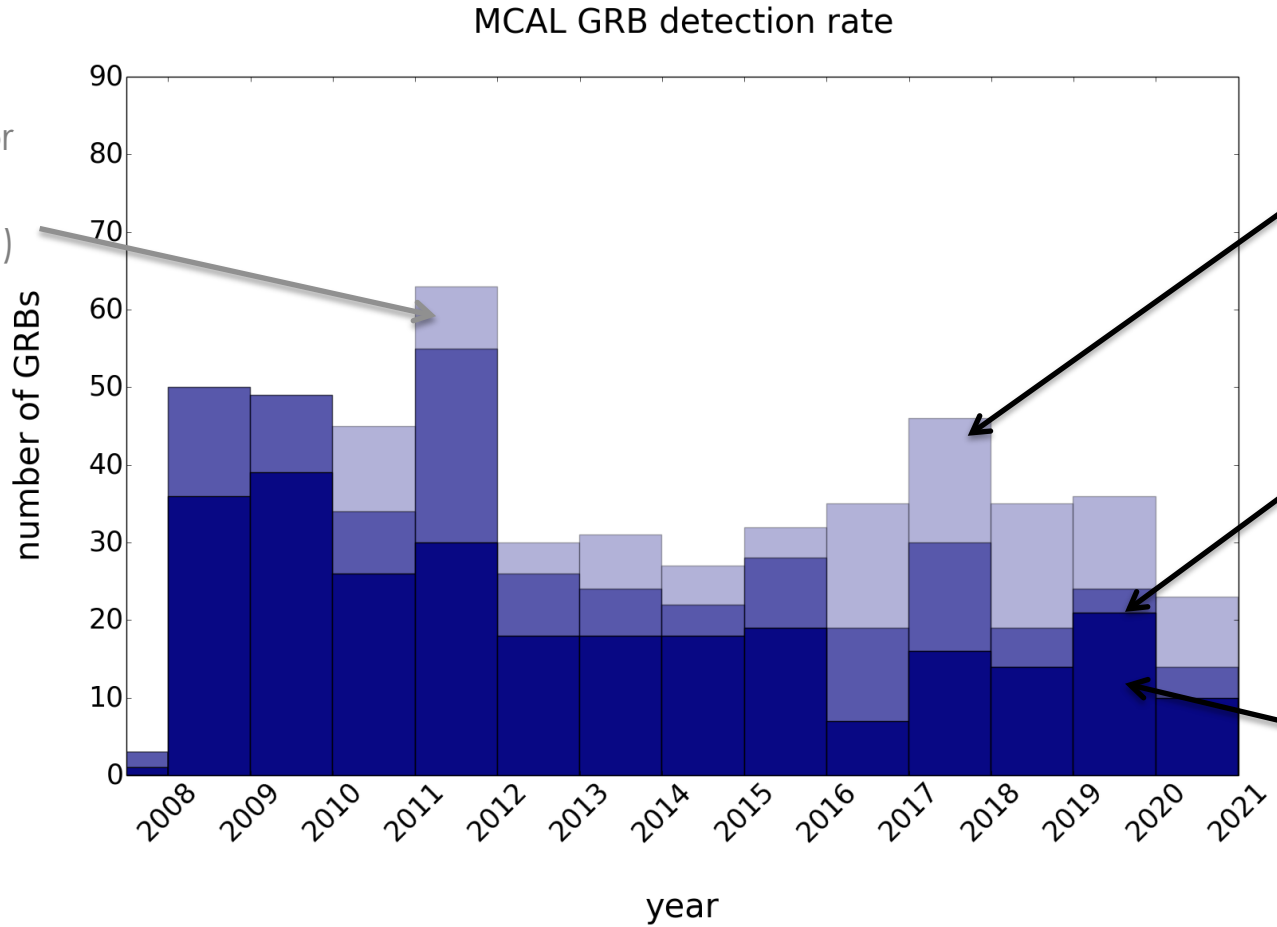
393 GRBs completely detected by AGILE/MCAL

AGILE & GRBs



110 GRBs incomplete or fragmented (**useful for IPN**)

503 GRBs triggered by AGILE/MCAL

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276 GRBs localized by space missions or IPN, available for spectral analysis

AGILE & GRBs

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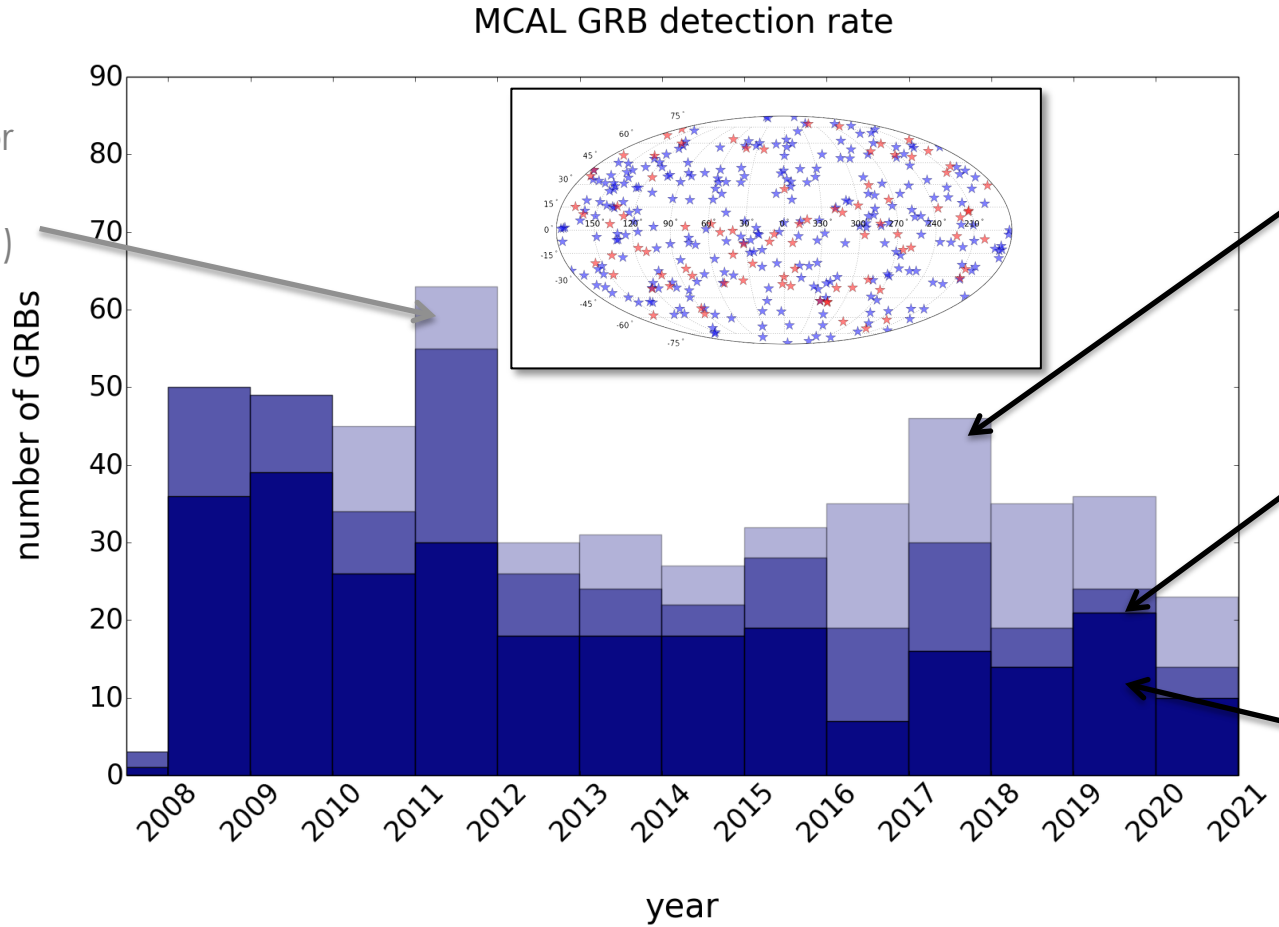

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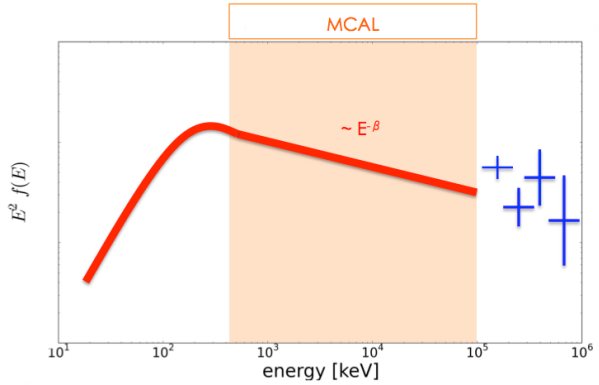
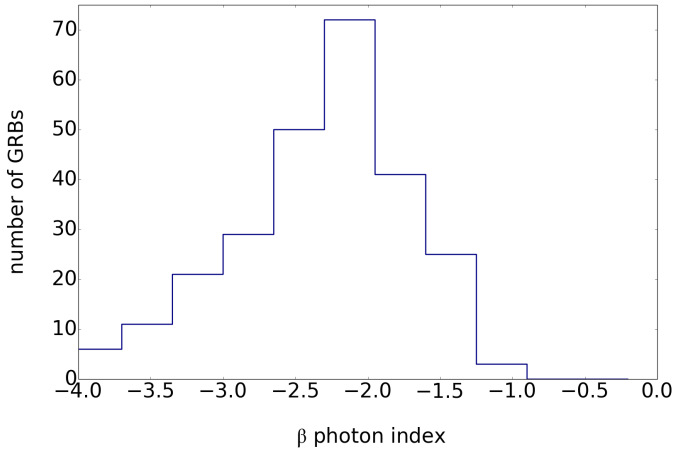
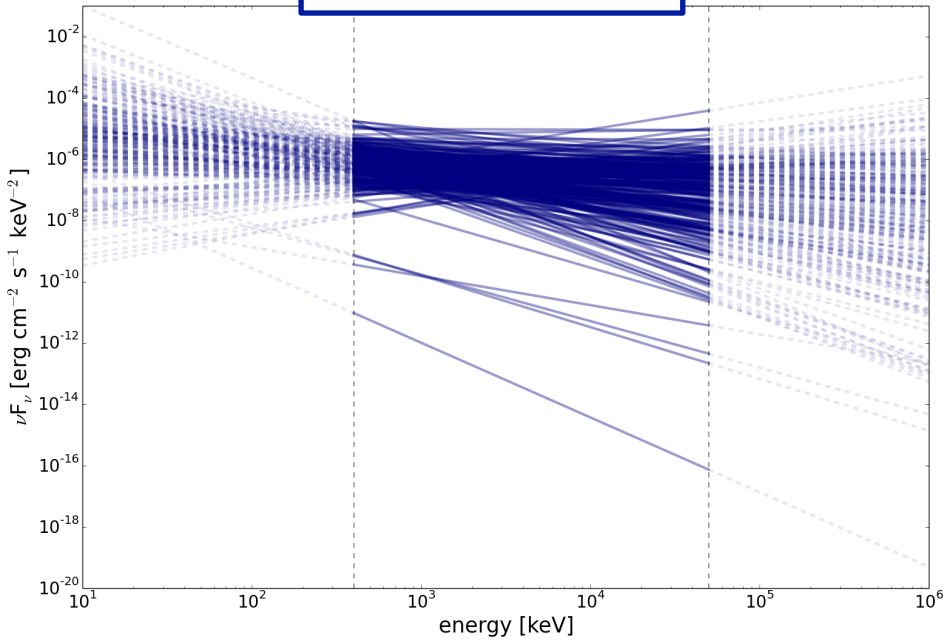
AGILE & GRBs



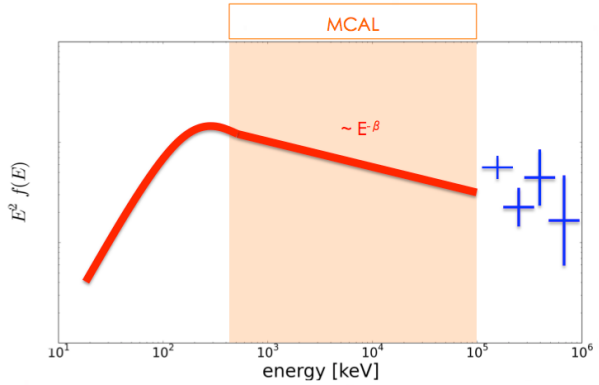
power law photon index distribution



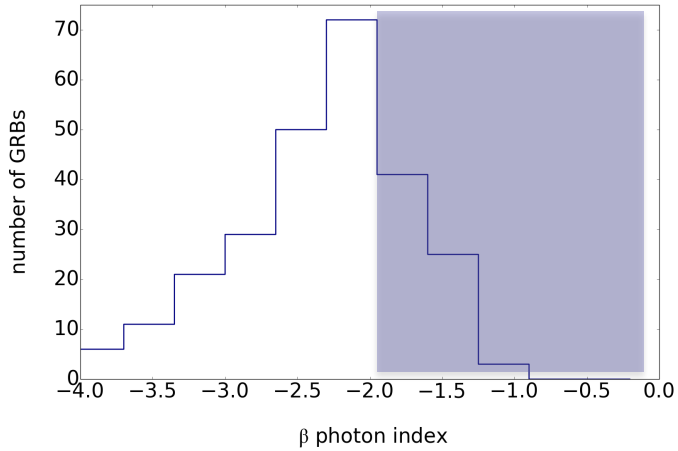
spectral fit
400 keV – 10/50 MeV



AGILE & GRBs



power law photon index distribution



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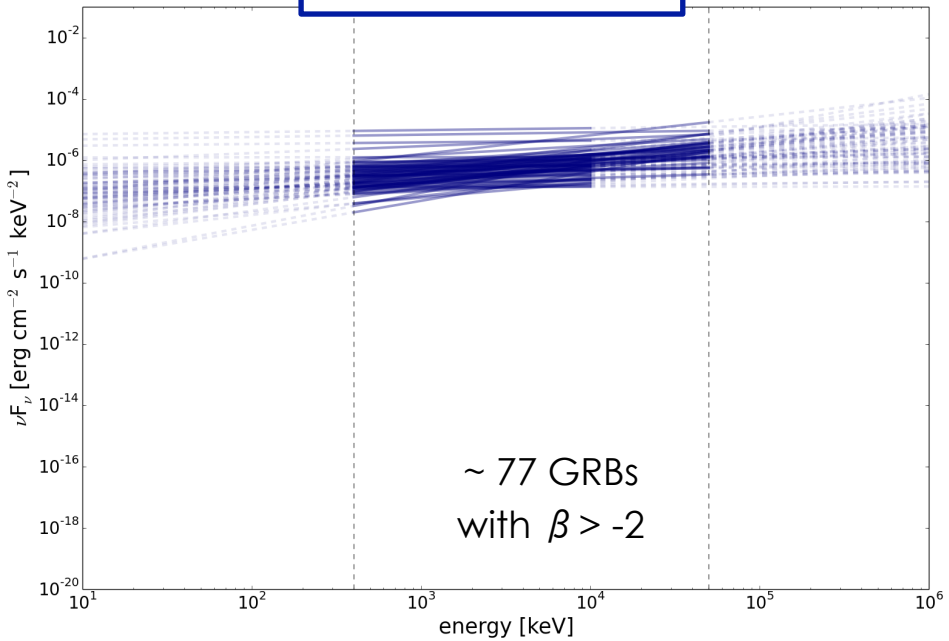
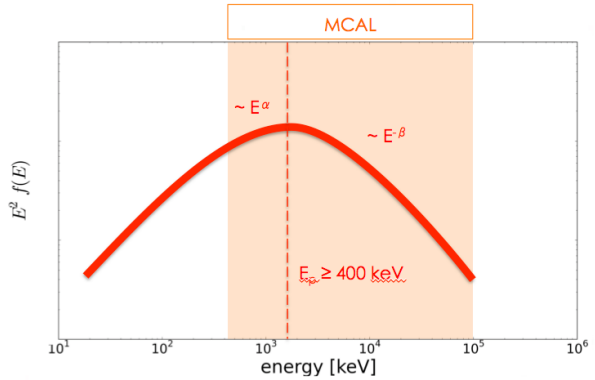
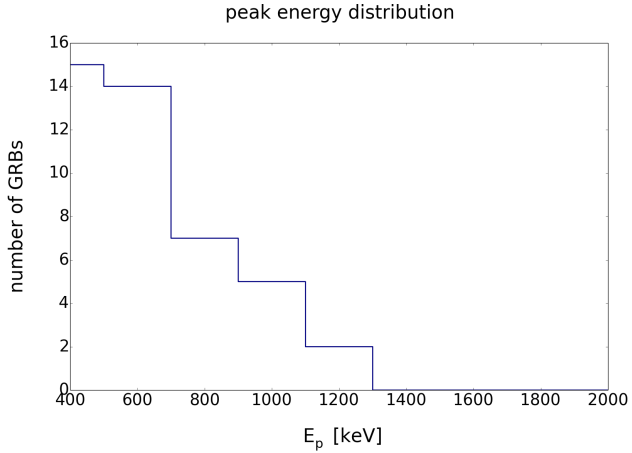


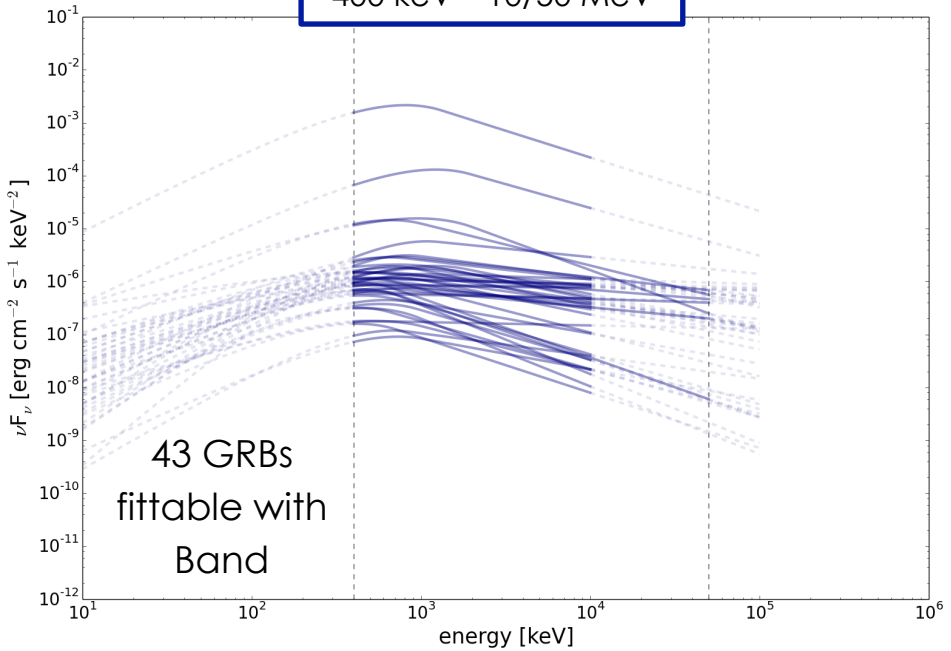
~ 77 GRBs
with $\beta > -2$

AGILE & GRBs

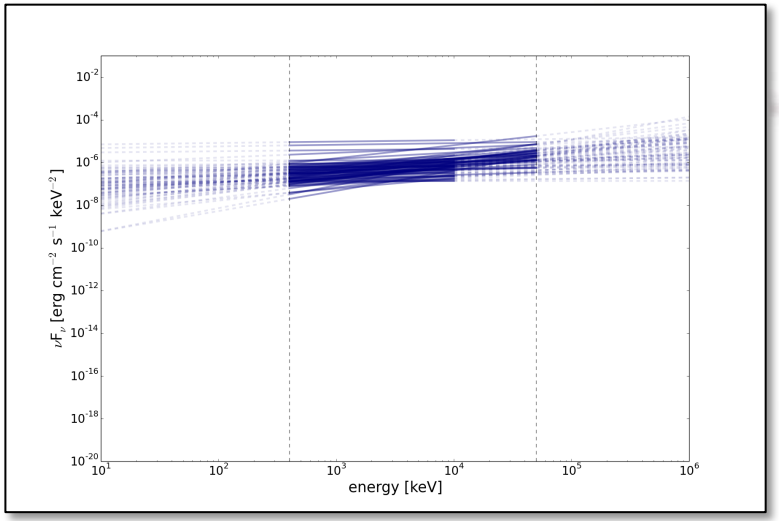


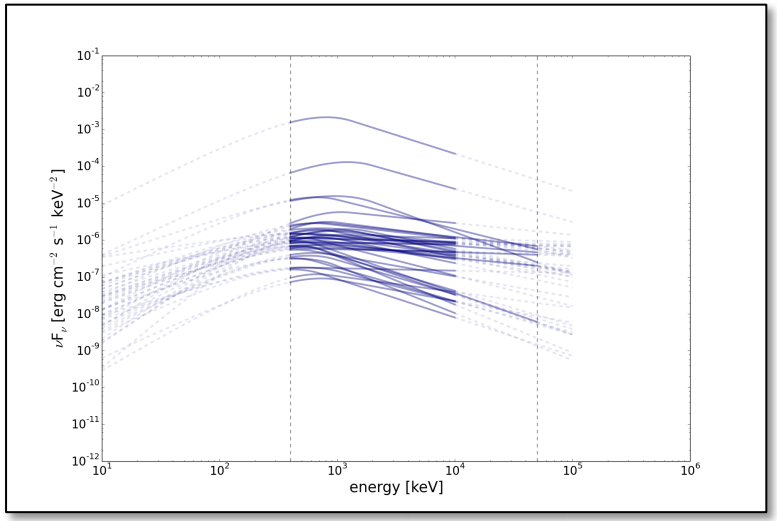


spectral fit
400 keV – 10/50 MeV



AGILE & GRBs



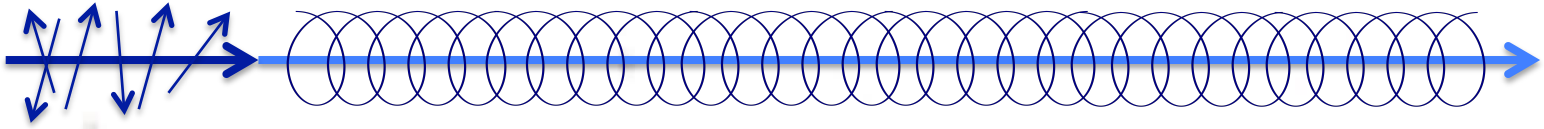


extra components?
temporal behavior?
GRID association?
[next work]

34 of which with LAT detection

AGILE & GRBs

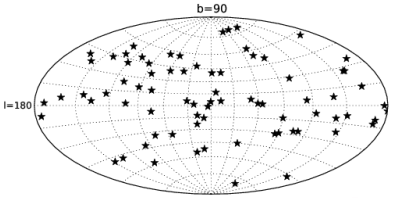
2007 2009 2020

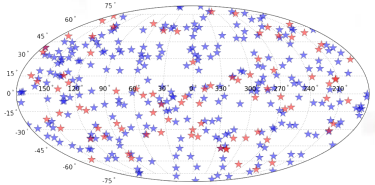


pointing pointing+spinning

MCAL 1st GRB catalog
[*Galli et al.*, 2013]

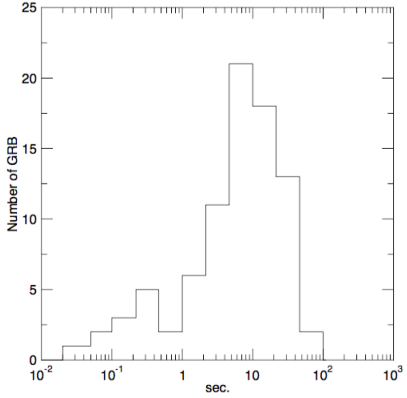
84 GRBs

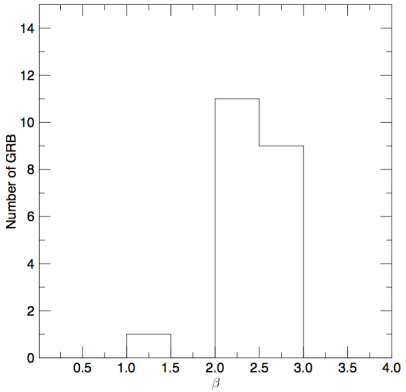


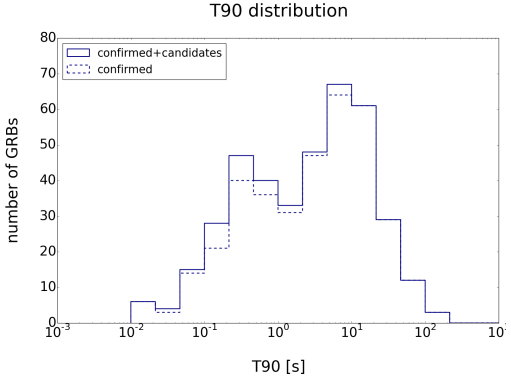


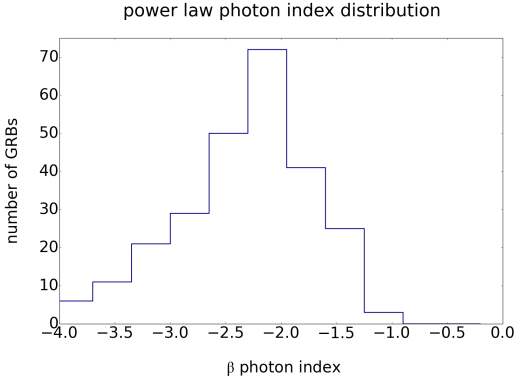
MCAL 2nd GRB catalog
[*Ursi et al.*, submitt.]

503 GRBs

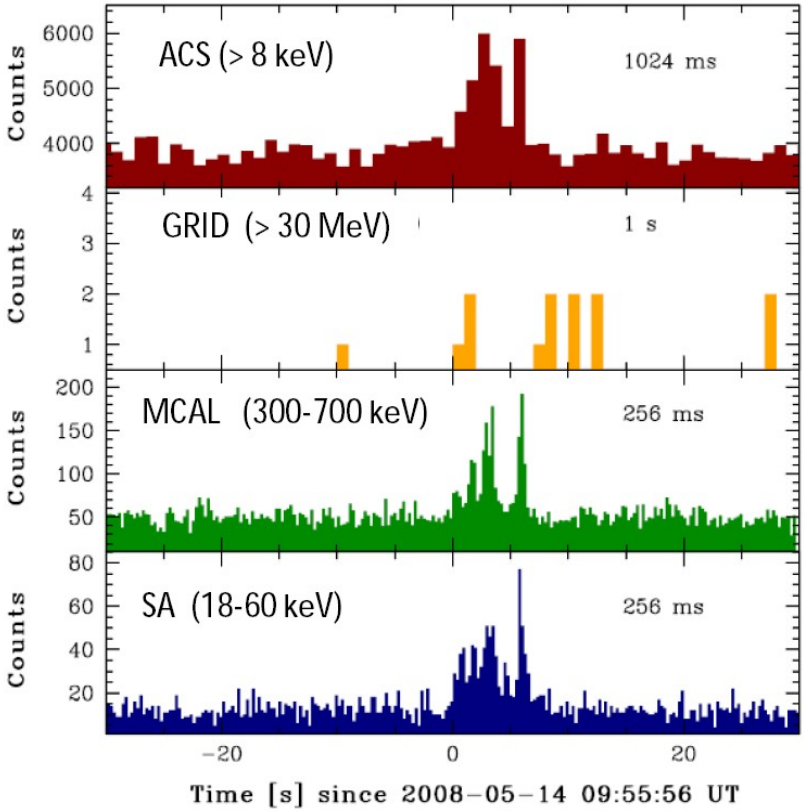








AGILE & GRBs

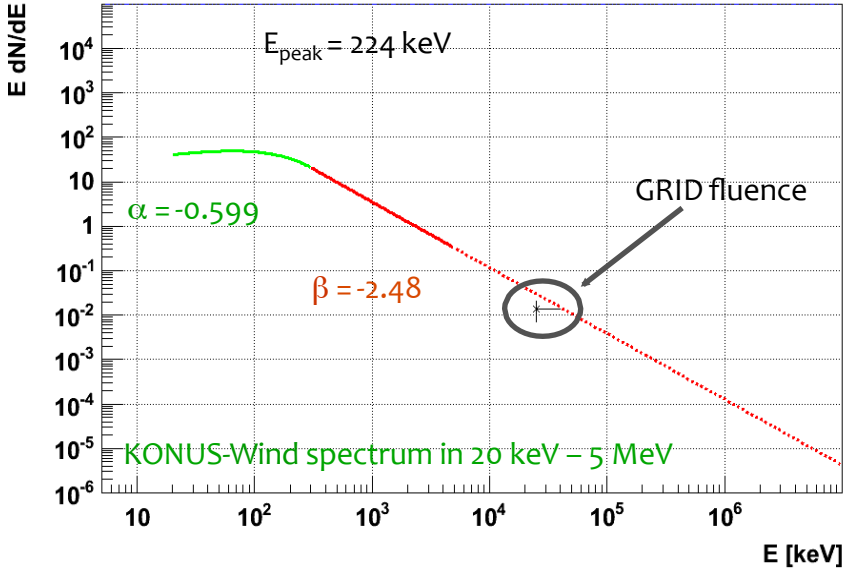


GRB 080514B [*Giuliani et al.*, 2008]

- first GeV-bright GRB after EGRET
- afterglow with photometric redshift of 1.8

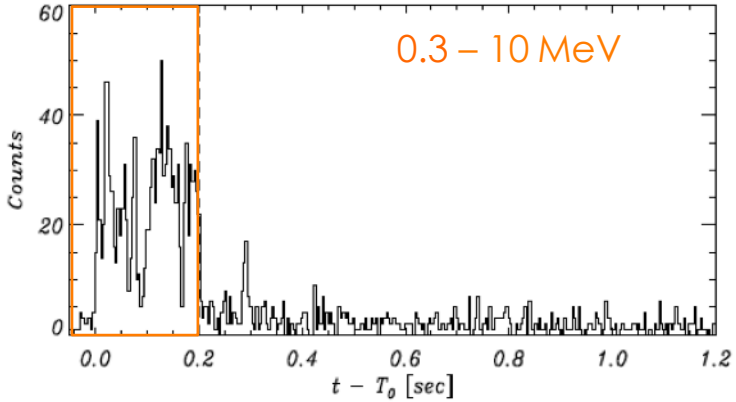
extended emission

same model

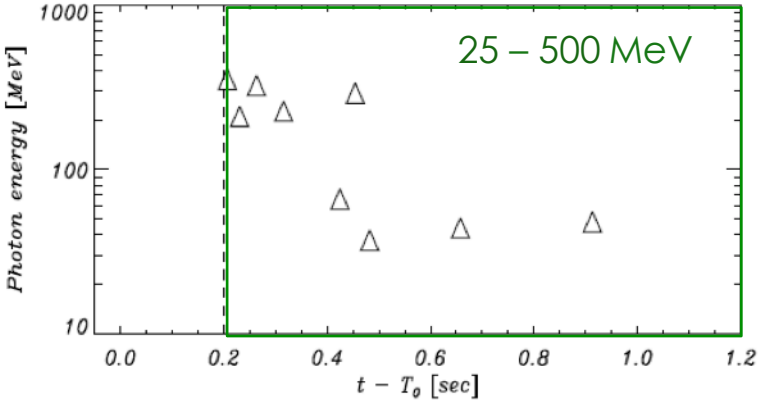


AGILE & GRBs

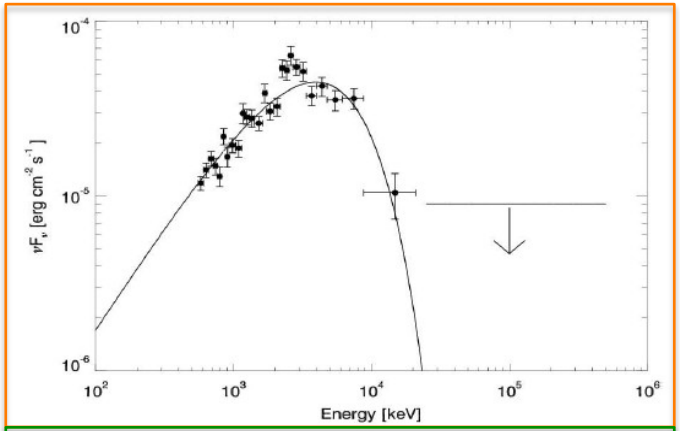
MCAL



GRID



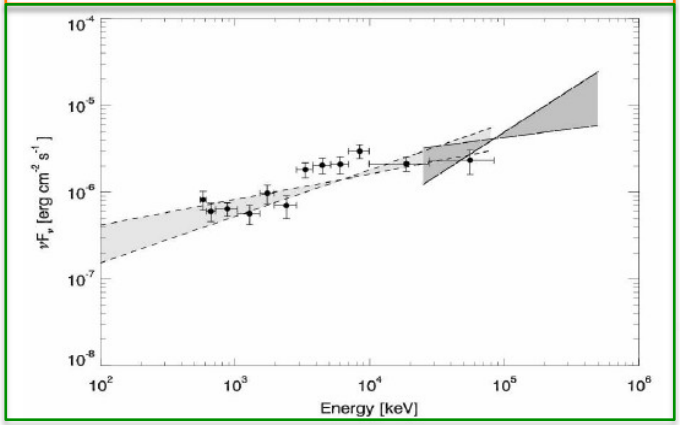
GRB 090510 [*Giuliani et al.*, 2010]



Powerlaw + cutoff

$F = 1.8 \times 10^{-5}$ erg/cm^2

(0.5 – 10 MeV)



Powerlaw

$F = 3.1 \times 10^{-6}$ erg/cm^2

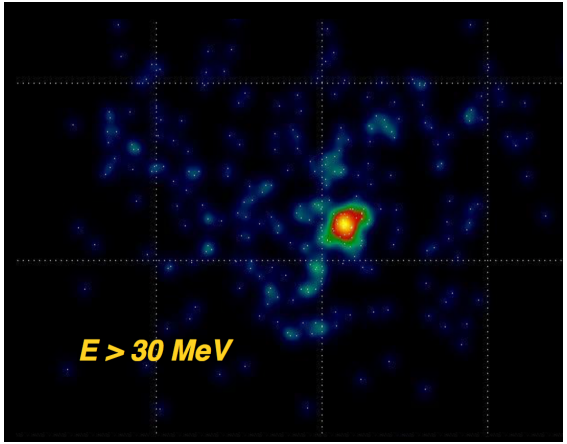
(0.5 – 10 MeV)

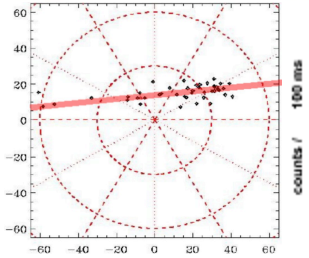
$F = 2.9 \times 10^{-5}$ erg/cm^2

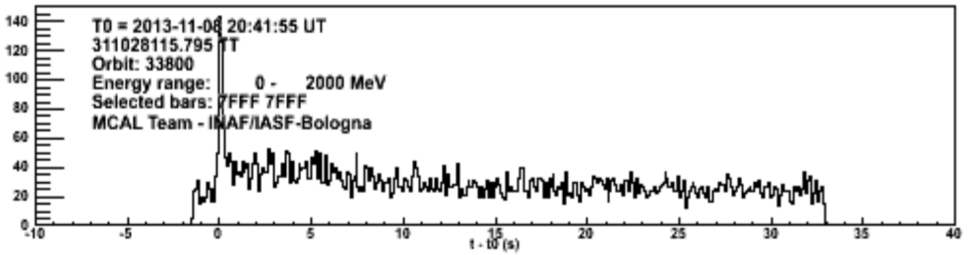
(25 – 500 MeV)

extended/delayed emission

AGILE & GRBs

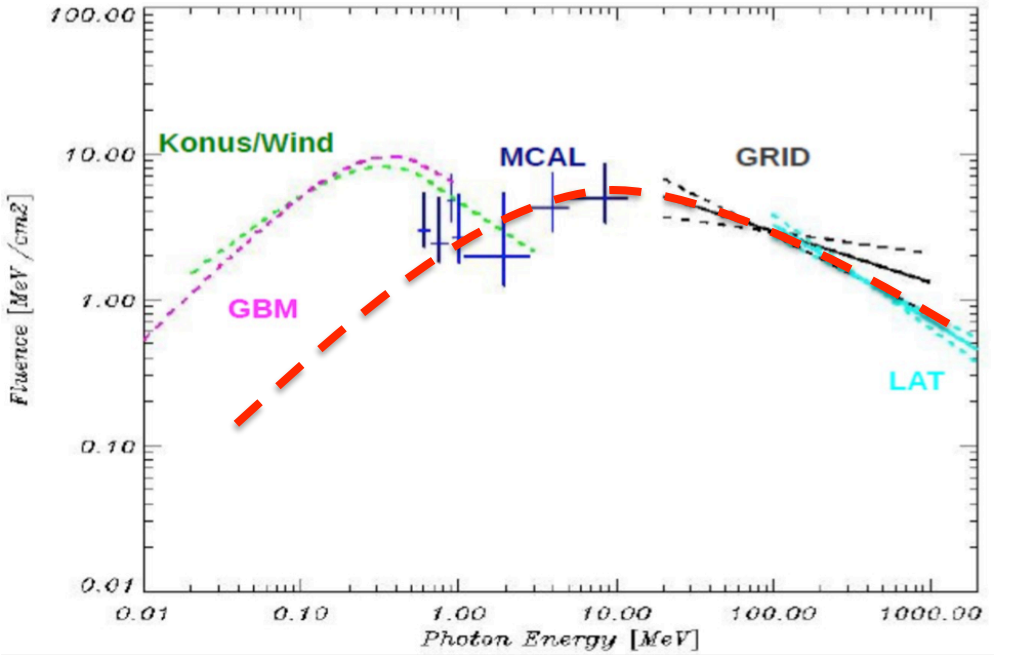






GRB 131108A [*Giuliani et al.*, 2014]

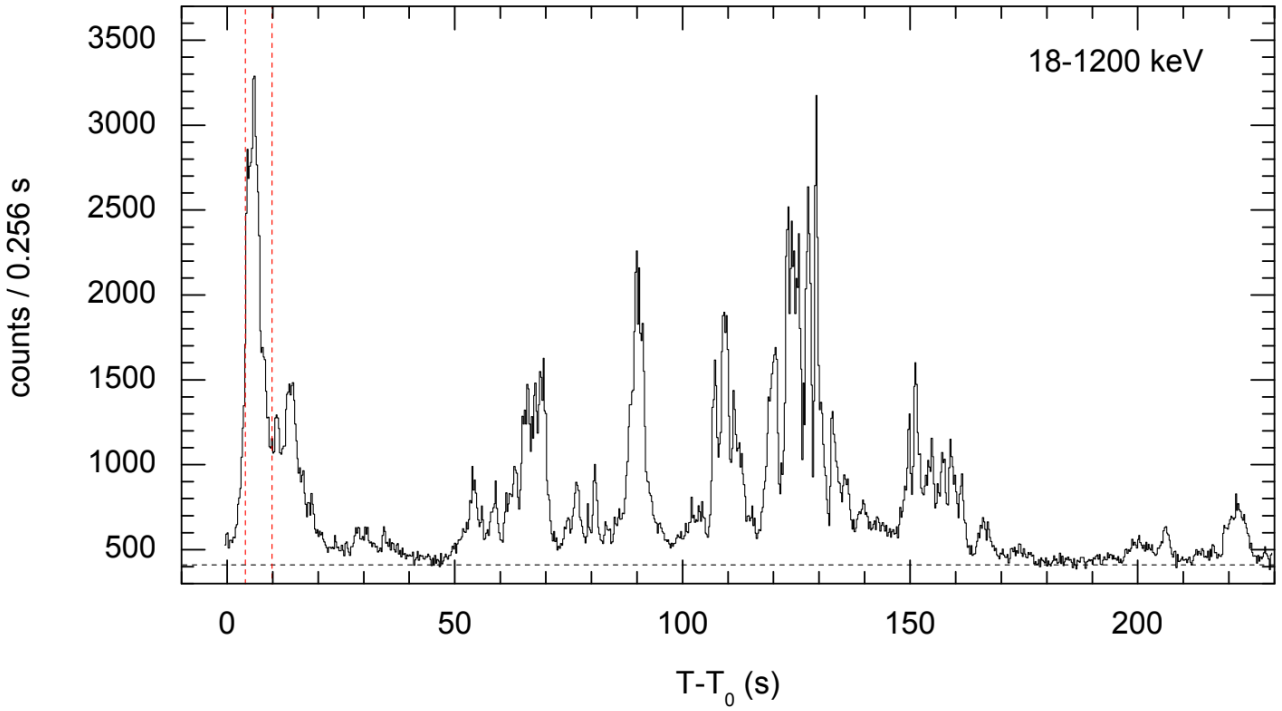
- 66 photons in first 80 s
- F (30 MeV - 1 GeV) = $2.56 \cdot 10^{-5}$ erg cm^{-2}
- z = 2.4



additive component

AGILE & GRBs

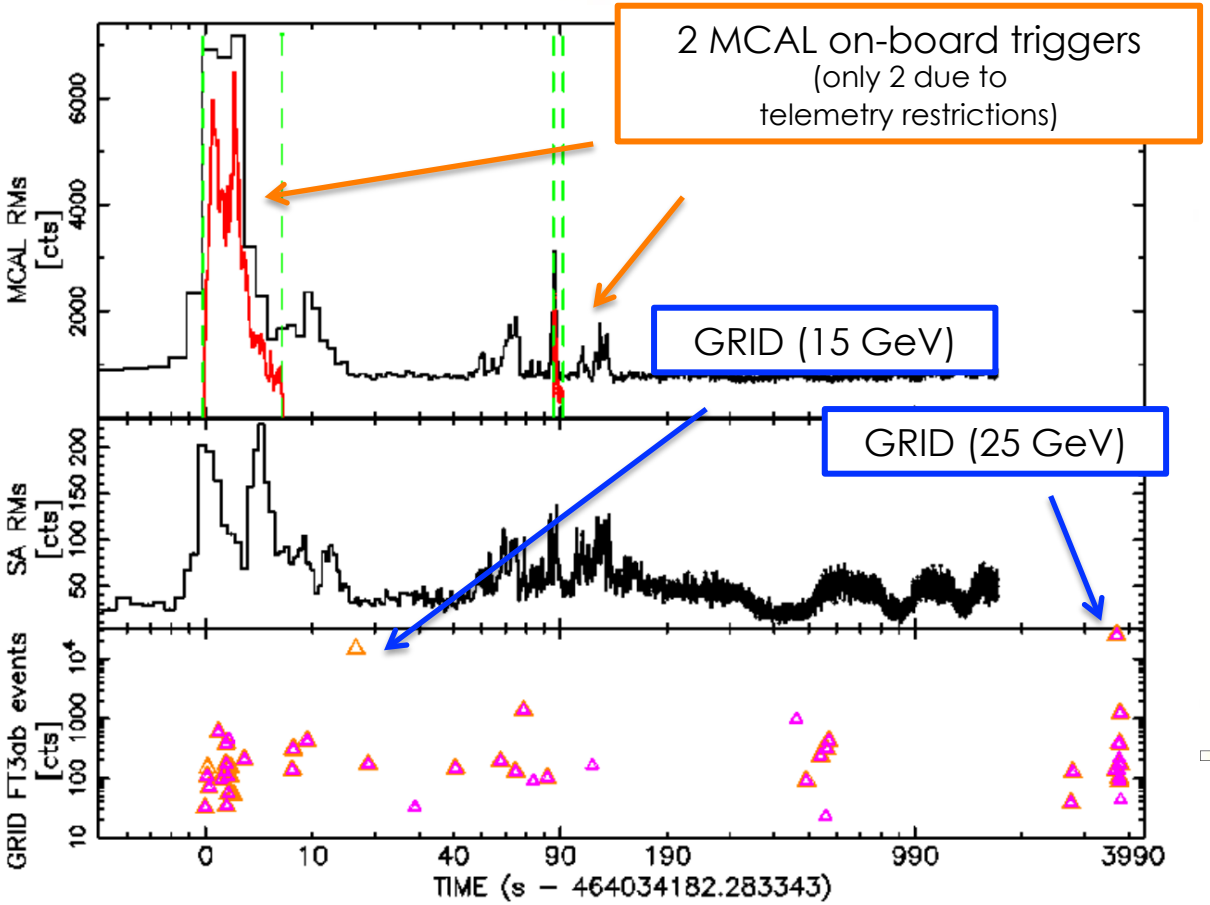
KONUS-Wind light curve



[*courtesy of D. Frederiks*]

GRB 180914B

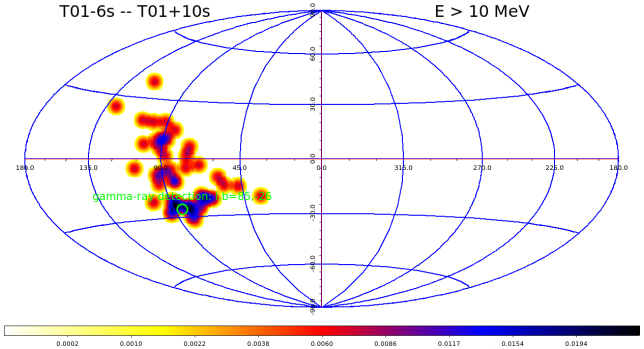
AGILE & GRBs



prompt emission

extended/delayed emission

first AGILE/GRID localization as first!
(confirmed by Fermi/LAT)



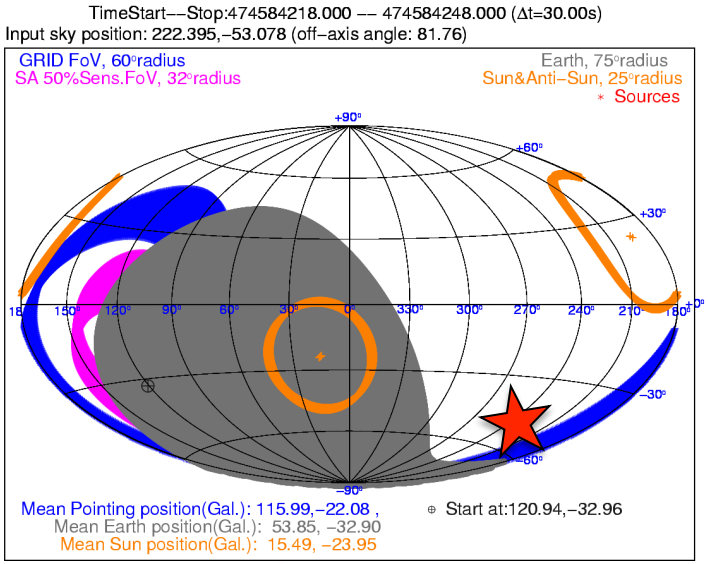
z ~ 1.1

AGILE & GRBs

extended/delayed emission

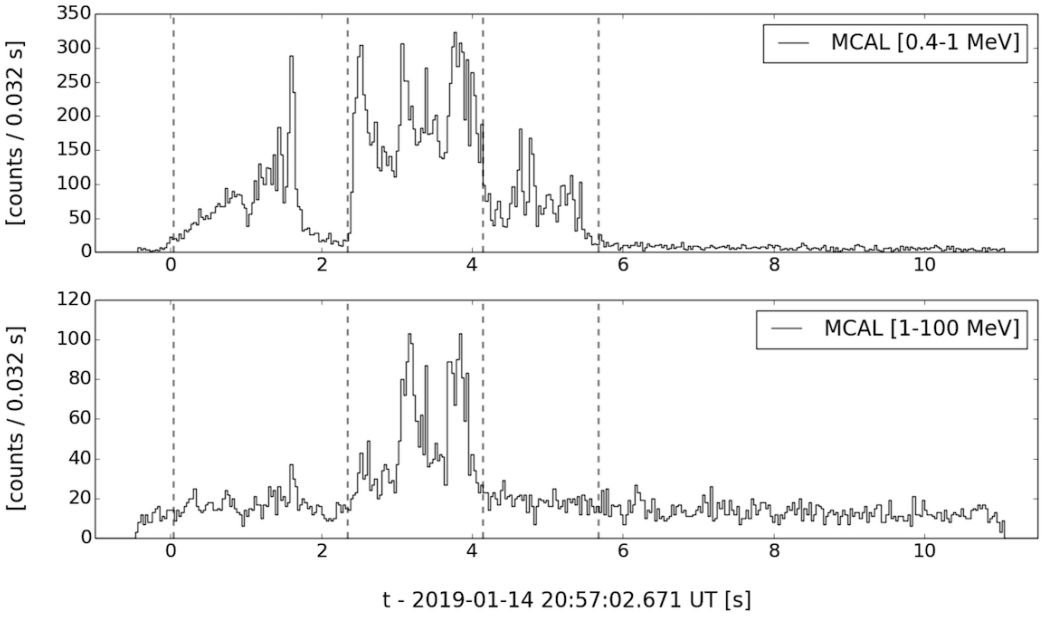
detected by MAGIC at E > 300 GeV

[*Nat., 2019*]



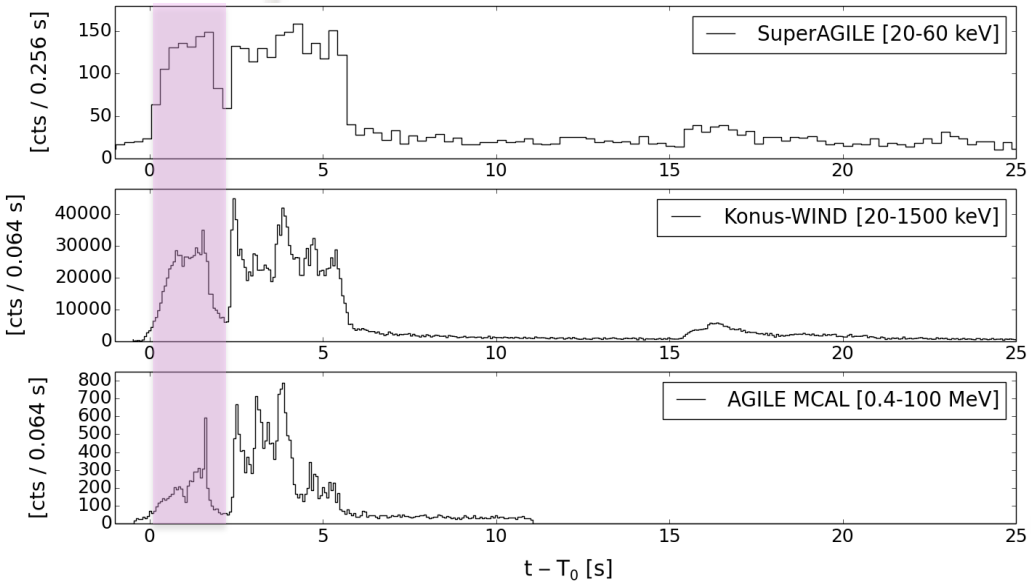
at T0 just outside GRID FoV!

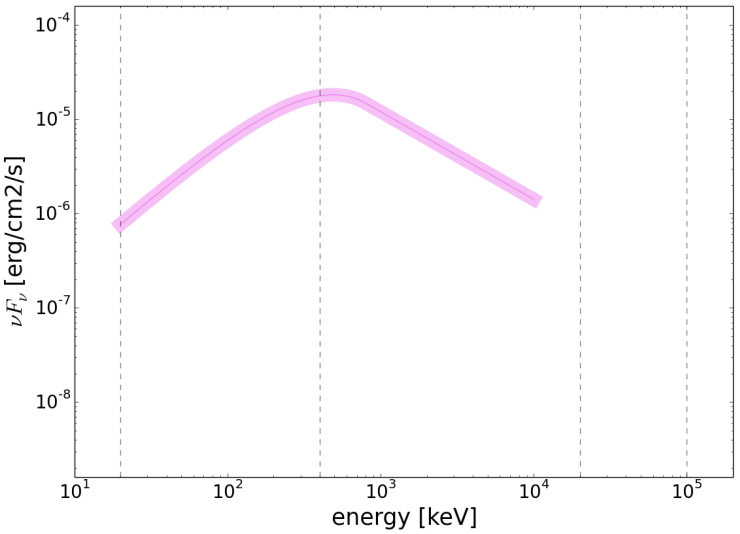
but interesting MCAL…



[*Ursi et al.*, 2020]

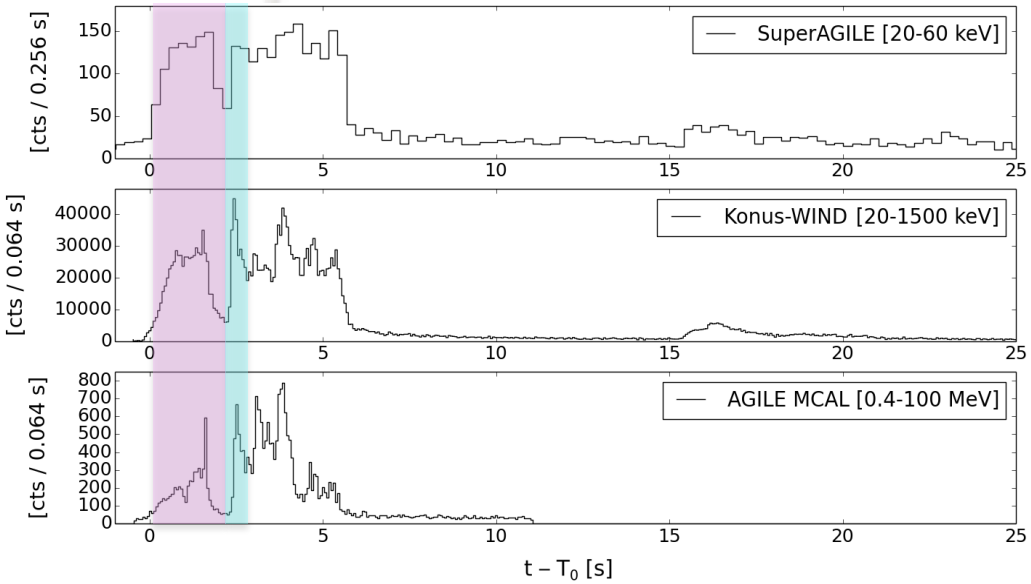
AGILE & GRBs

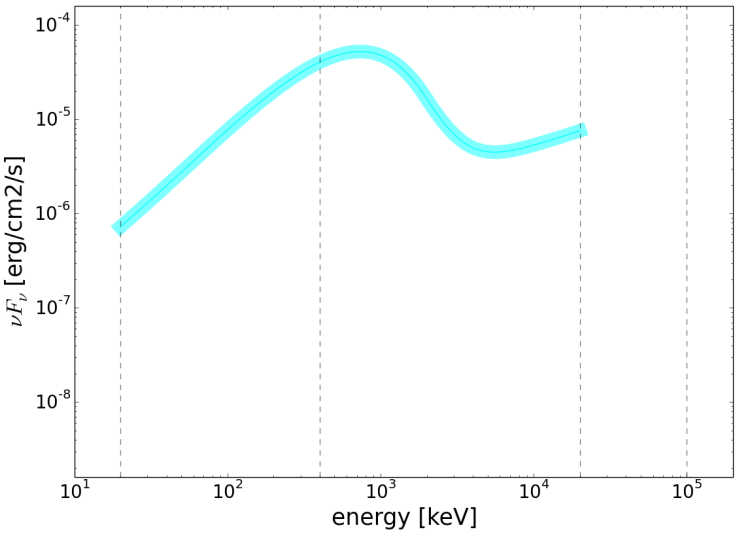




Band

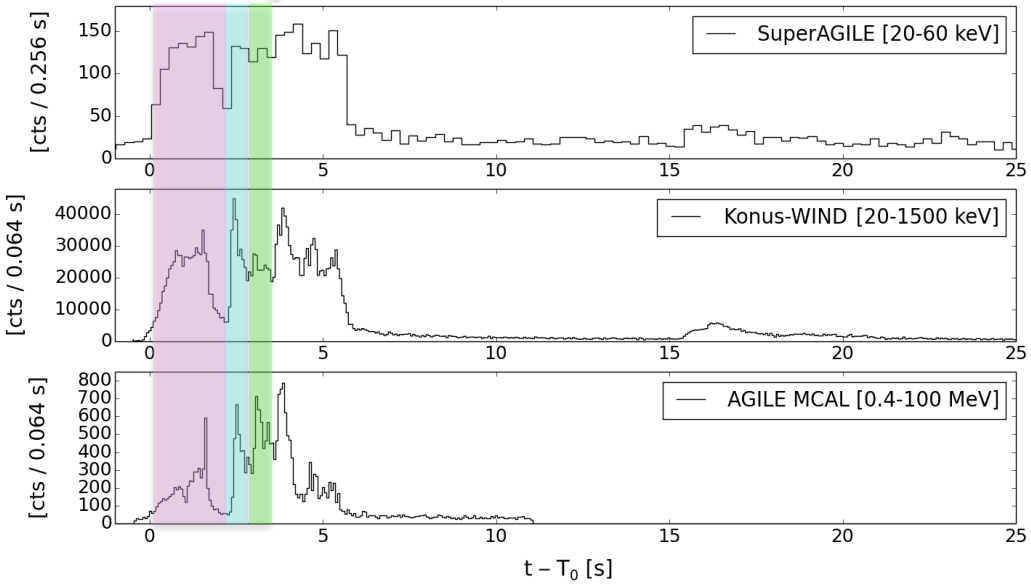
AGILE & GRBs

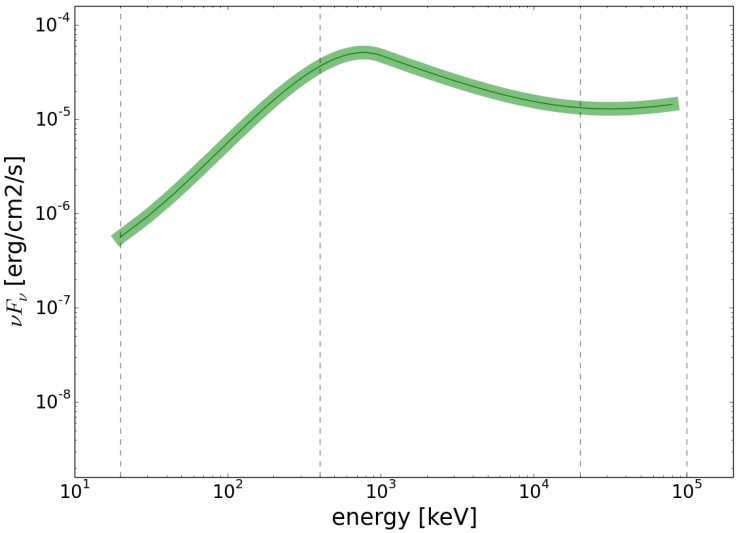




Band + he spectral component → hard-flat component

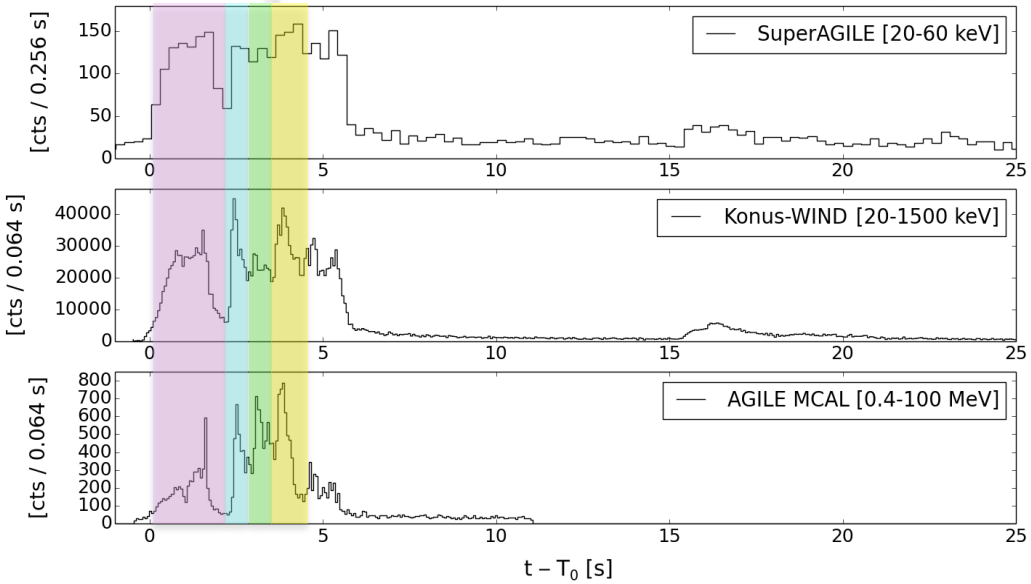
AGILE & GRBs

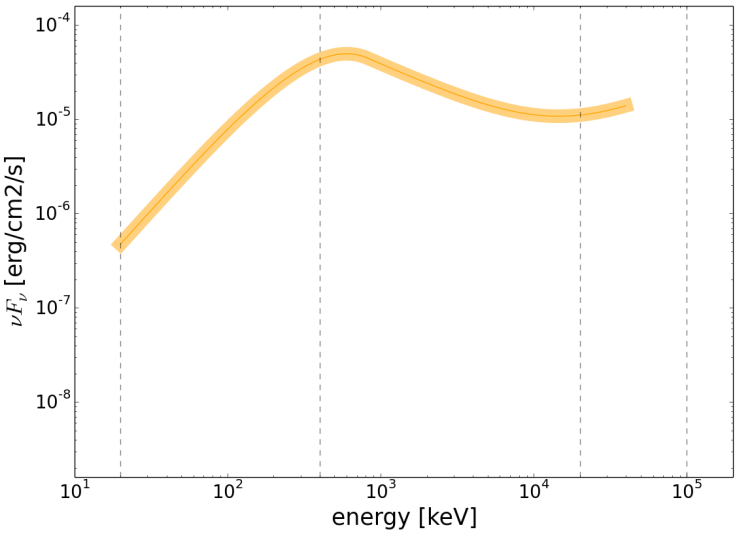




Band + he spectral component → hard-flat component

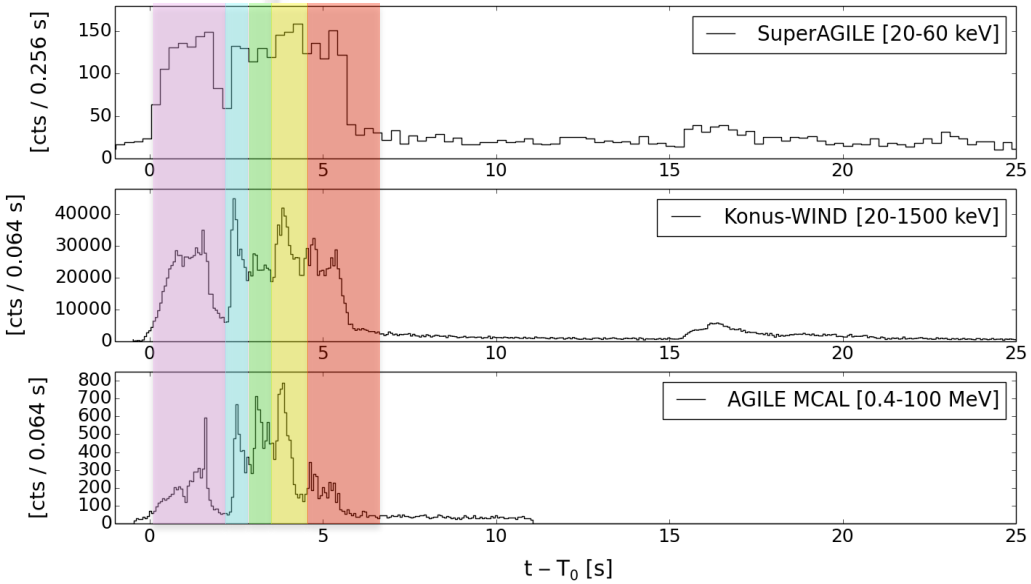
AGILE & GRBs

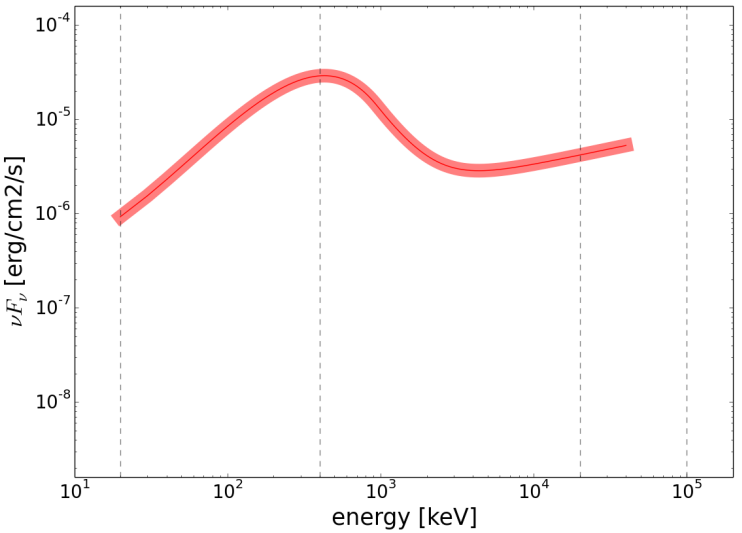




Band + he spectral component → hard-flat component

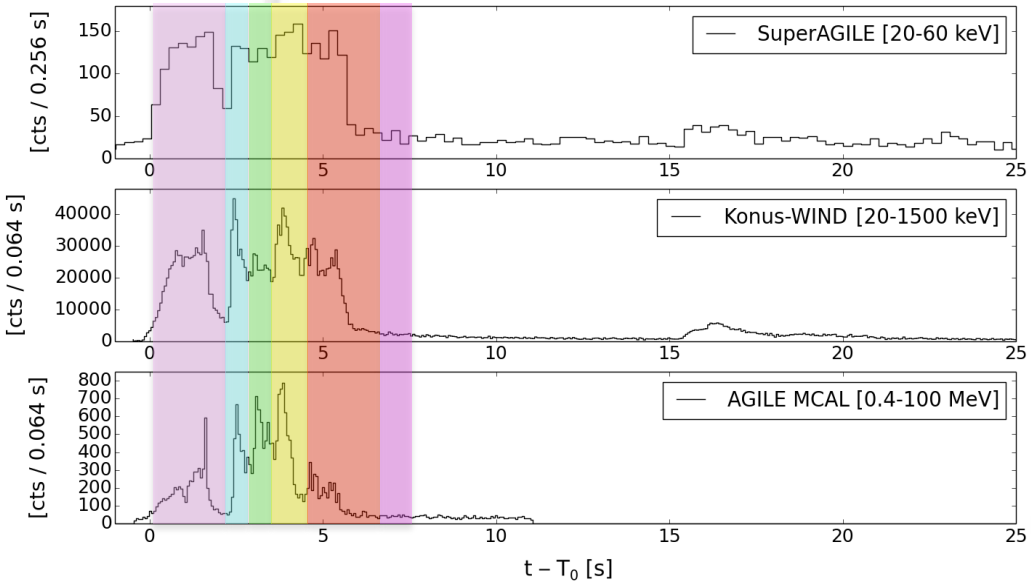
AGILE & GRBs

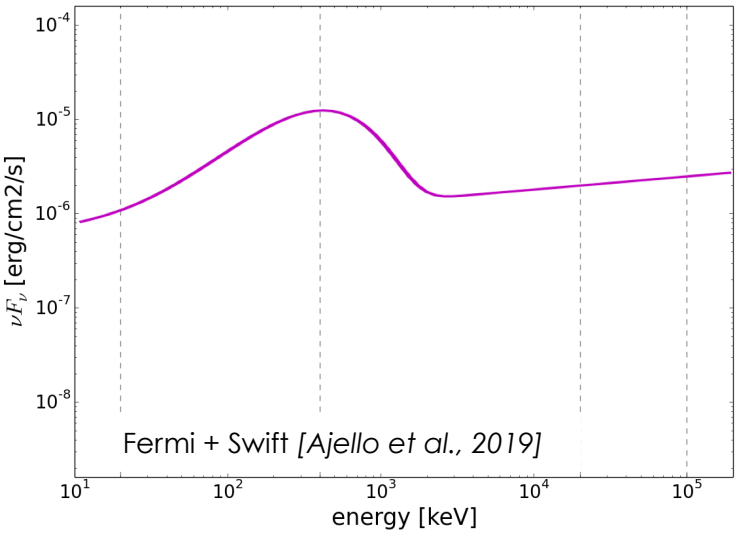




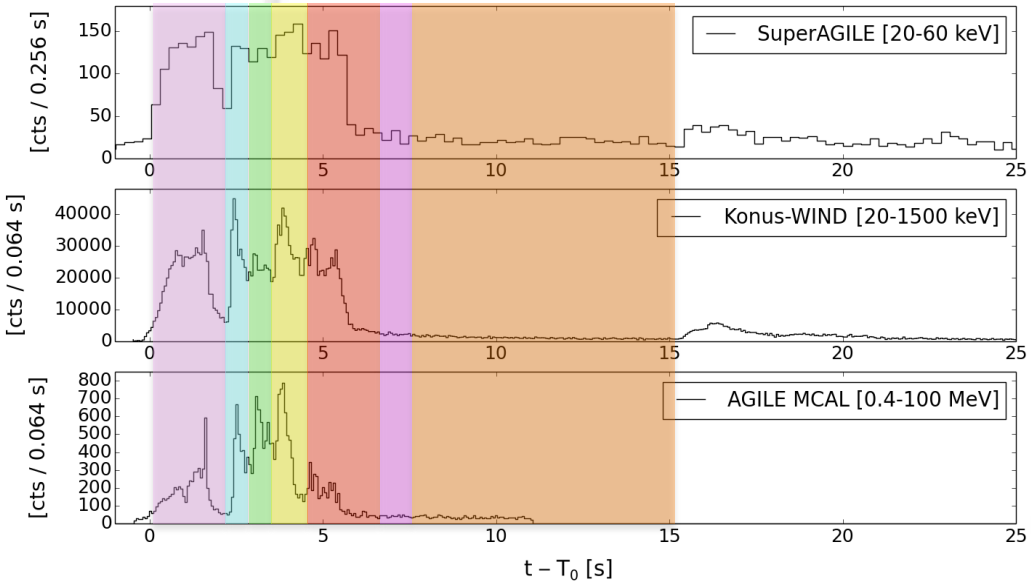
Band + he spectral component → "V-shape" hardening

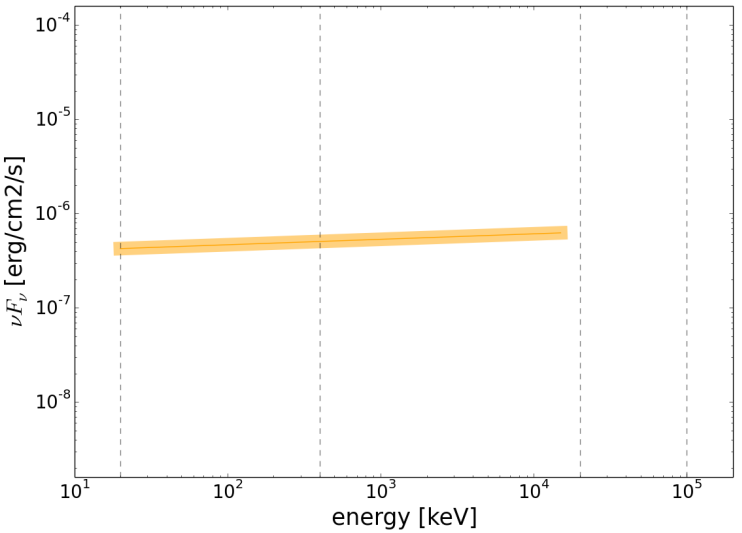
AGILE & GRBs


SuperAGILE [20-60 keV]
Konus-WIND [20-1500 keV]
AGILE MCAL [0.4-100 MeV]
[cts / 0.256 s]
[cts / 0.064 s]
[cts / 0.064 s]
t – T0 [s]

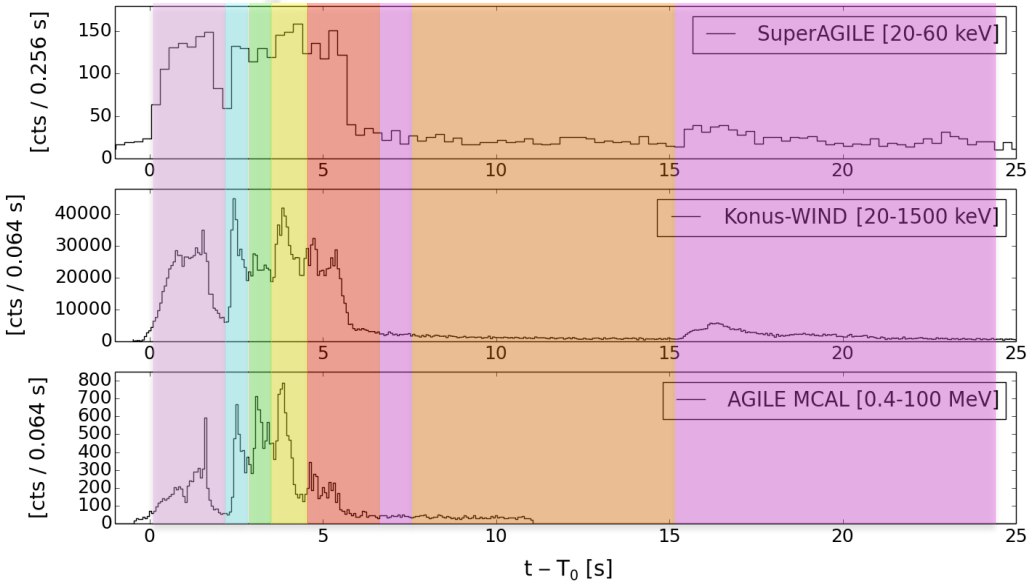

Fermi + Swift [Ajello et al., 2019]
energy [keV]

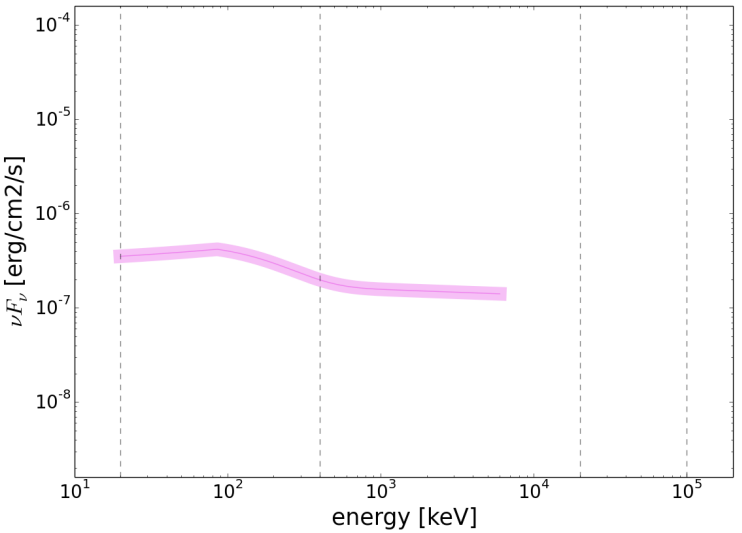
AGILE & GRBs


SuperAGILE [20-60 keV]
Konus-WIND [20-1500 keV]
AGILE MCAL [0.4-100 MeV]
[cts / 0.256 s]
[cts / 0.064 s]
[cts / 0.064 s]
t – T0 [s]

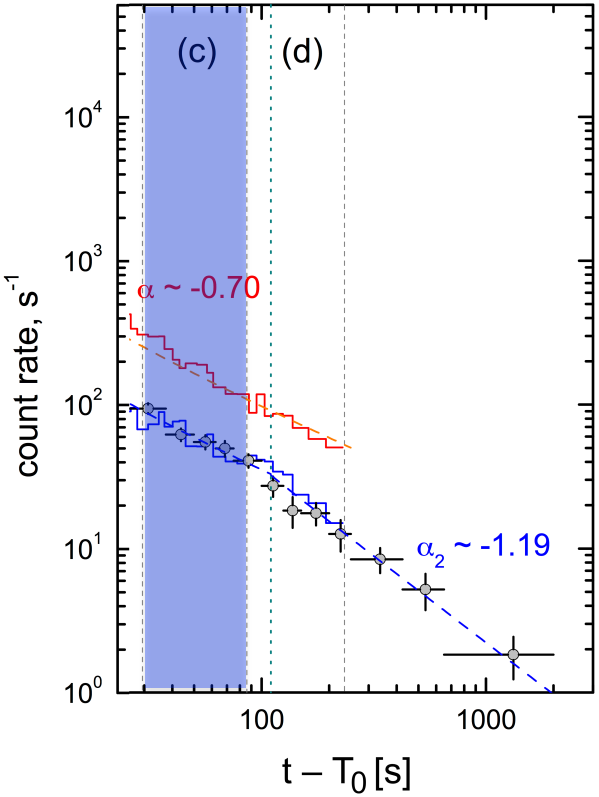

νFν [erg/cm2/s]
energy [keV]

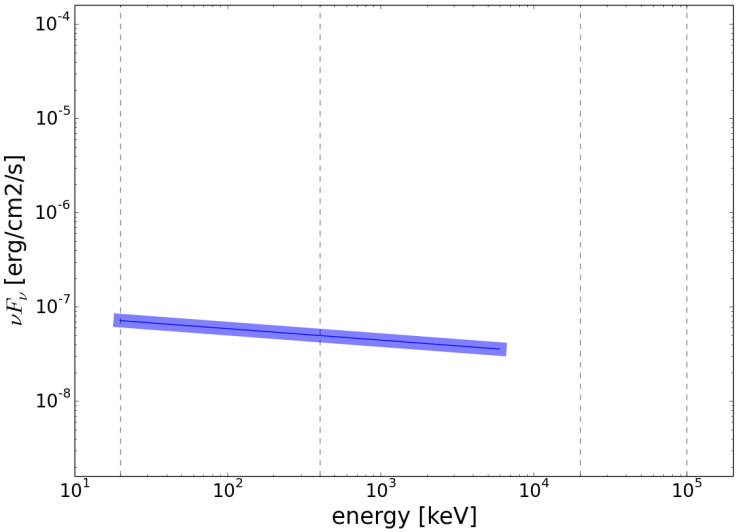
AGILE & GRBs


SuperAGILE [20-60 keV]
Konus-WIND [20-1500 keV]
AGILE MCAL [0.4-100 MeV]
[cts / 0.256 s]
[cts / 0.064 s]
[cts / 0.064 s]
t – T0 [s]

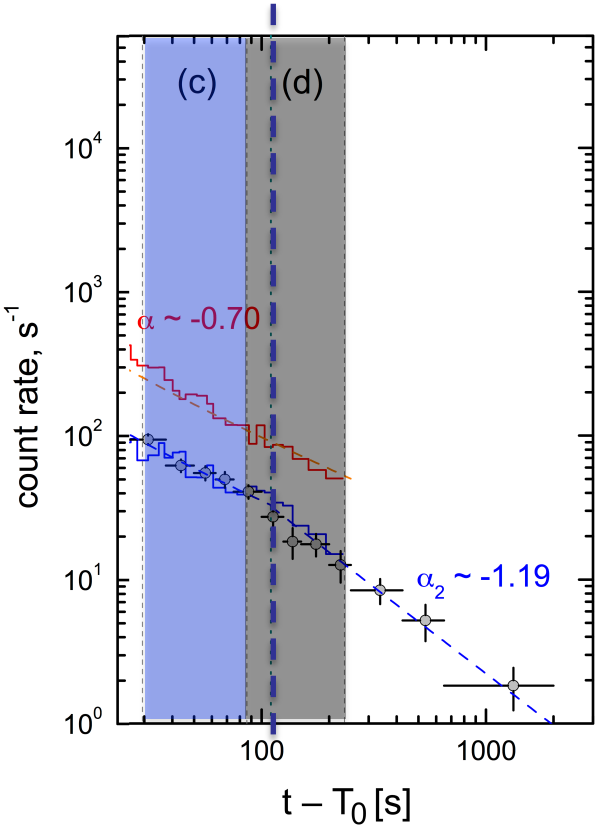

νFν [erg/cm2/s]
energy [keV]

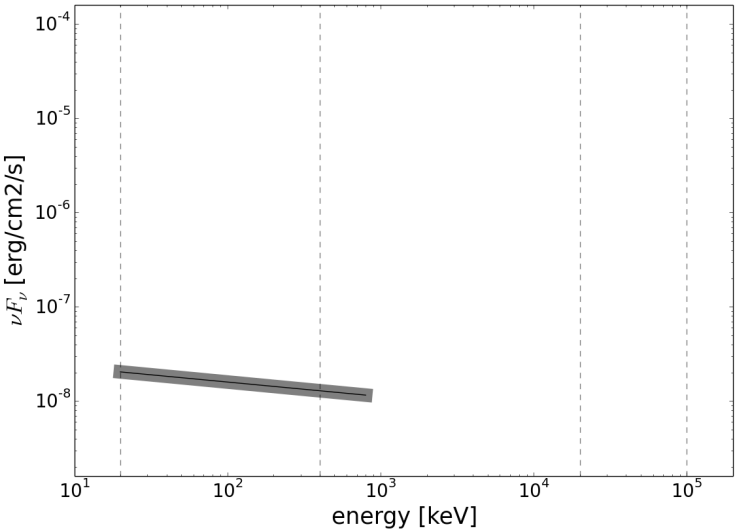
AGILE & GRBs


(c)
(d)
count rate, s^{-1}
10^4
10^3
10^2
10^1
10^0
α ~ -0.70
α$_2$ ~ -1.19
100
1000
t – T$_0$ [s]


10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
νF_ν [erg/cm2/s]
10^1
10^2
10^3
10^4
10^5
energy [keV]

AGILE & GRBs





flux break at T0+100 s (KW, INTEGRAL)

radiative evolution of the early afterglow from a fireball expanding in a wind-like circumburst medium

Conclusions

- new MCAL GRB Catalog:

  - 503 triggered (393 fully acquired, 27 new)

  - mostly short-duration hard-spectrum GRBs

  - ~100 GRBs with high-energy spectra (PL+ or Band) and LAT detections

  - simultaneous RMs detections (20 keV – 100 MeV)

  - possible GRID associations?

Thank you