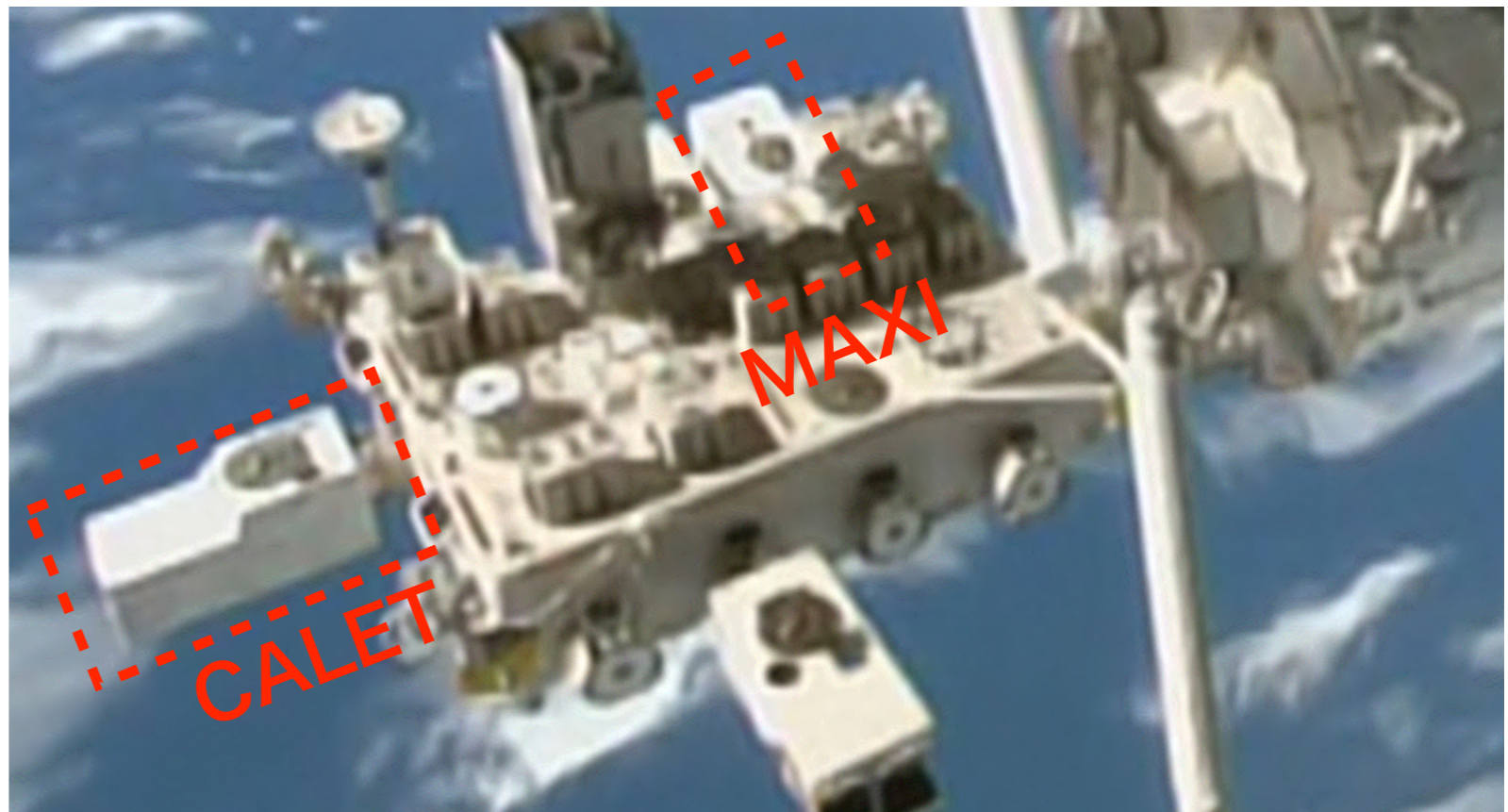
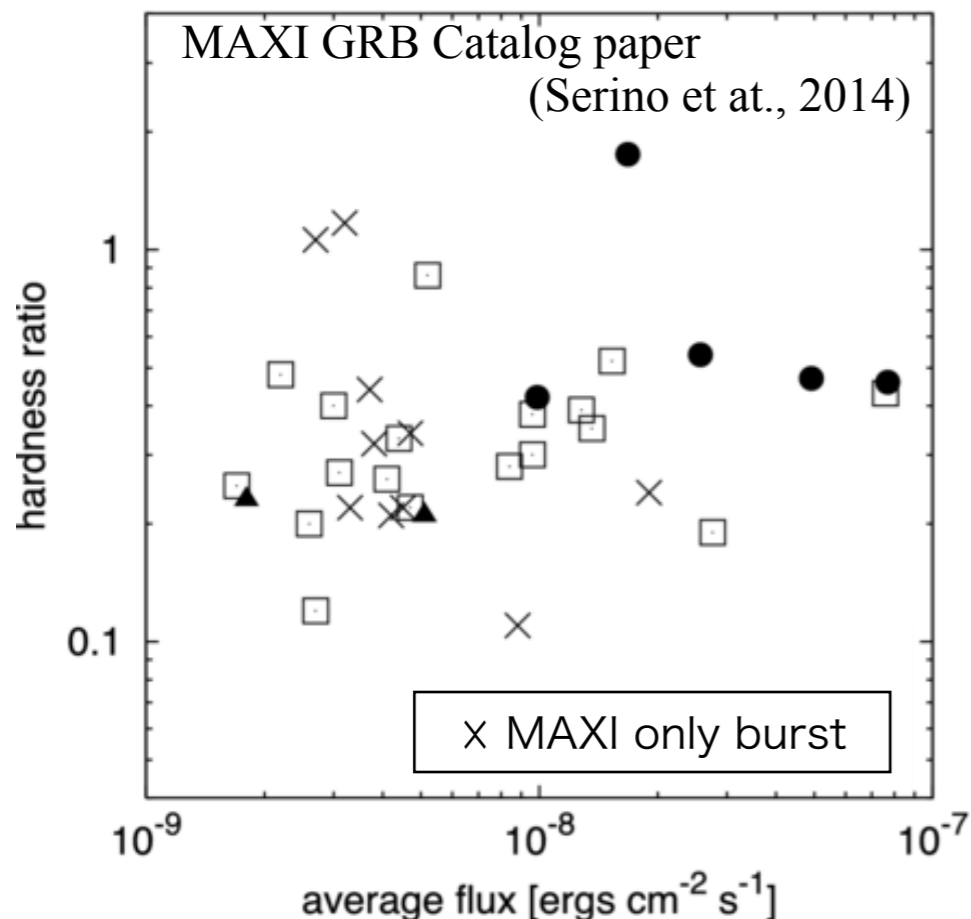


# GRBs with MAXI and CALET (on ISS/Kibo-EF)

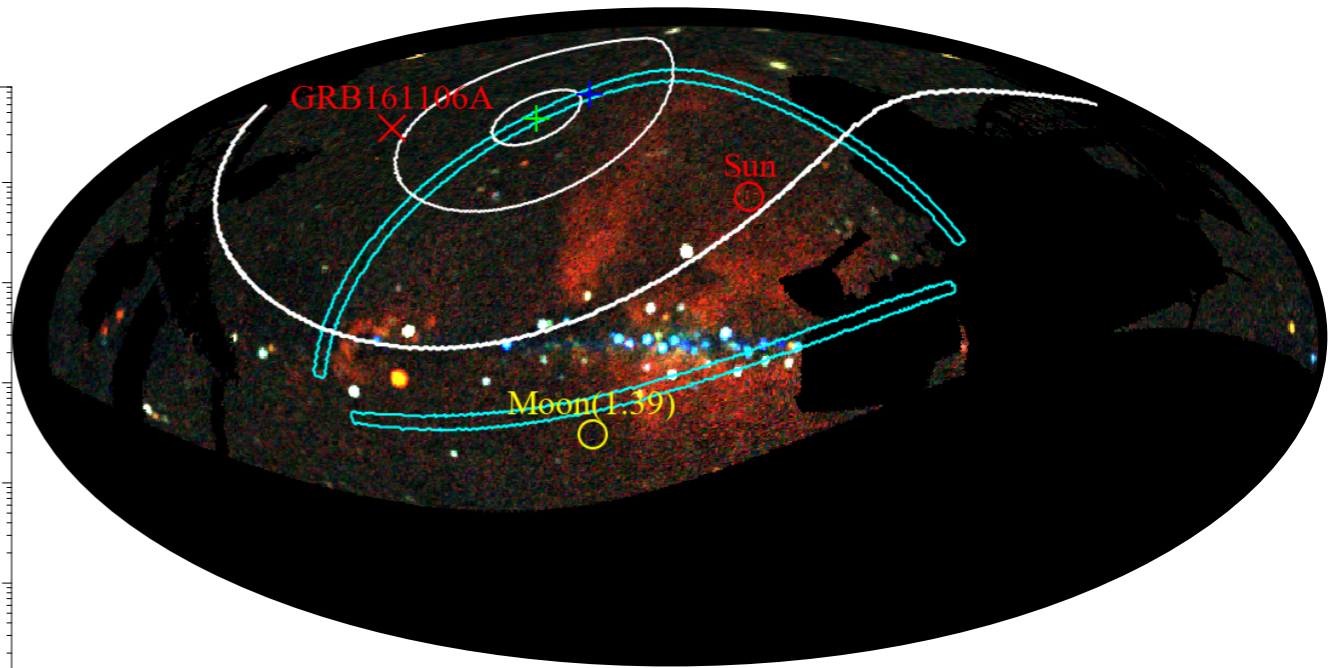
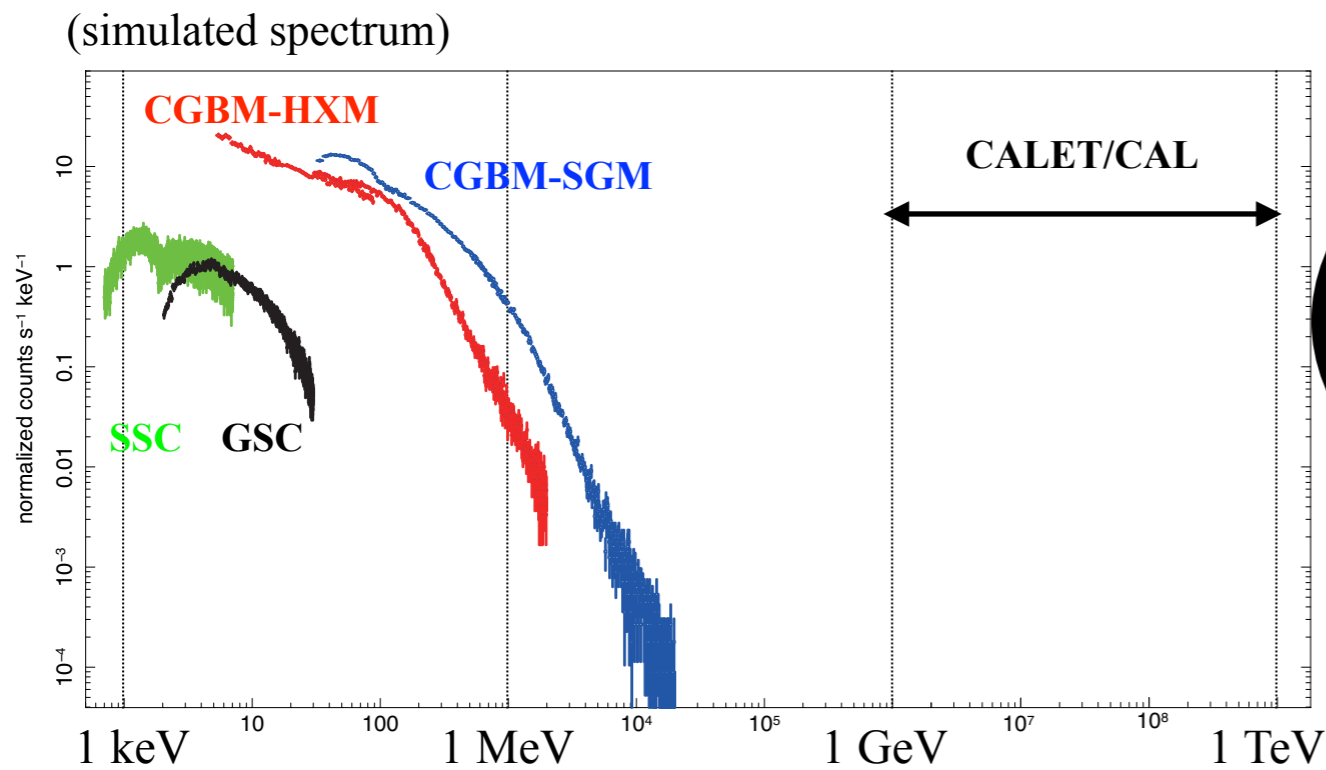
Satoshi Nakahira (JAXA) for the CALET collaboration

- Since 2009 August, **MAXI/GSC** detected ~90 GRBs
- MAXI is a unique GRB instrument with its soft X-ray sensitivity
  - 1/2 of MAXI GRBs are "Only MAXI" burst. Only MAXI GRBs tend to **Soft and Dim**
- 2015 October, gamma-ray burst monitor for **CALET (CGBM)** started observation in the same platform with MAXI.
- CGBM always observe the same direction with MAXI.

flux and of MAXI-detected GRBs



# Energy bands and Field of view



## MAXI

## CALET

**energy bands**

0.7-7 keV (SSC)  
2-30 keV (GSC)

7-1000 keV (HXM)  
100 keV-20 MeV (SGM)  
1 GeV-10 TeV (CAL)

**instantaneous  
field of view**

2%(GSC)  
1%(SSC)

20%(HXM, CAL)  
60%(SGM)

1/3 of GSC FoV is overlapped with SSC, HXM, SGM and CAL

→ **Ultra wide energy observation is possible in one platform (JEM/EF)**

# Contents

Introduction of CALET and CGBM

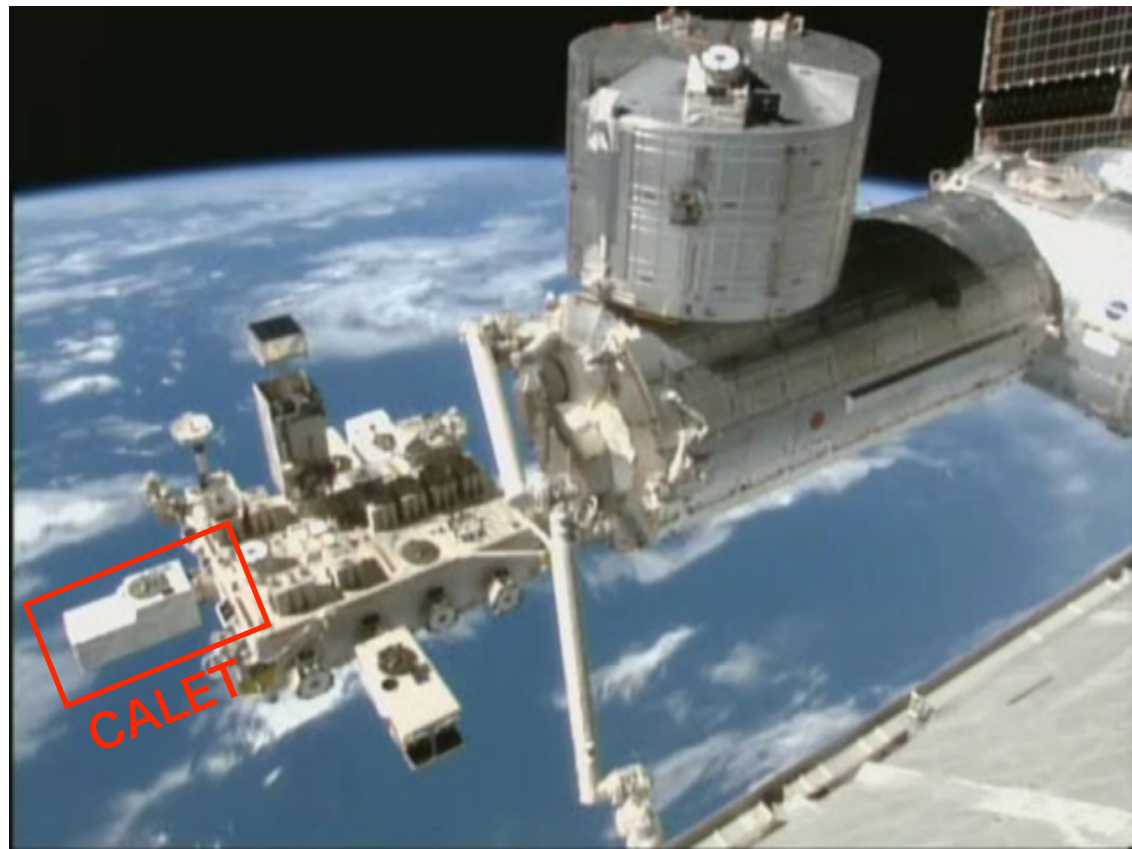
Status of CGBM  
performance  
operation

Summary of detected GRBs with MAXI and CALET

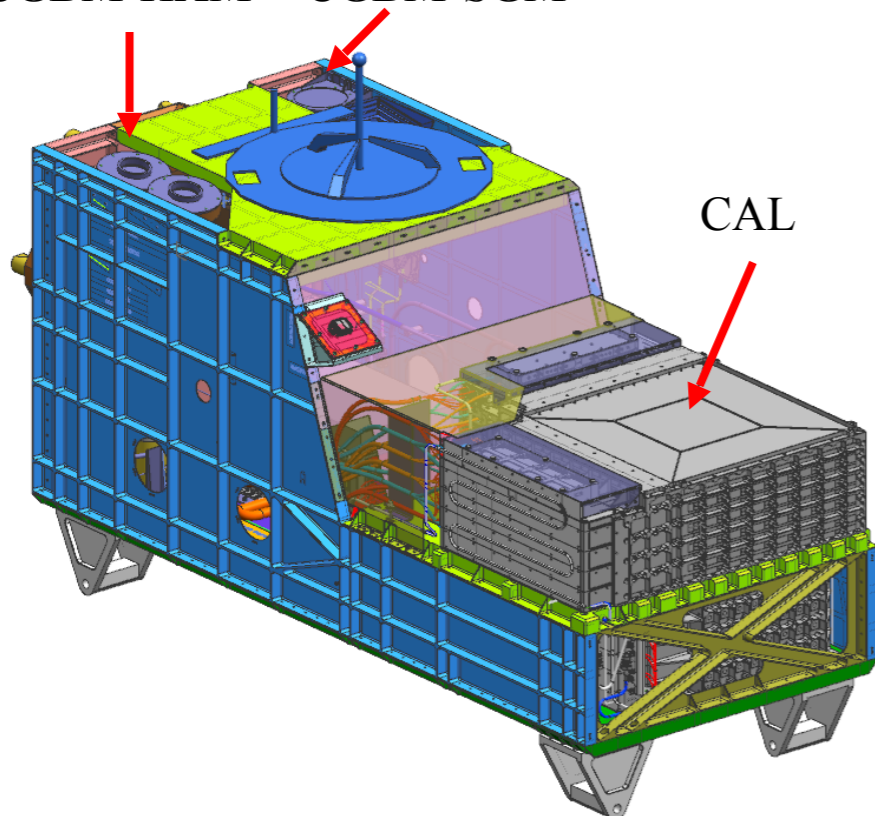
Details of simultaneously detected GRBs



# CALorimetric Electron Telescope(CALET)



CGBM-HXM CGBM-SGM



## Scientific targets of CALET

- [primary]High energy cosmic ray spectrum
- All-Sky Gamma-ray survey
- High Energy transients (GRBs, SGRs)

## Scientific instruments:

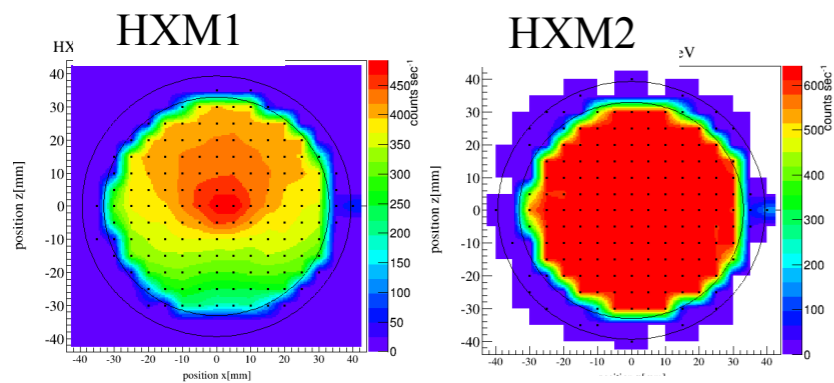
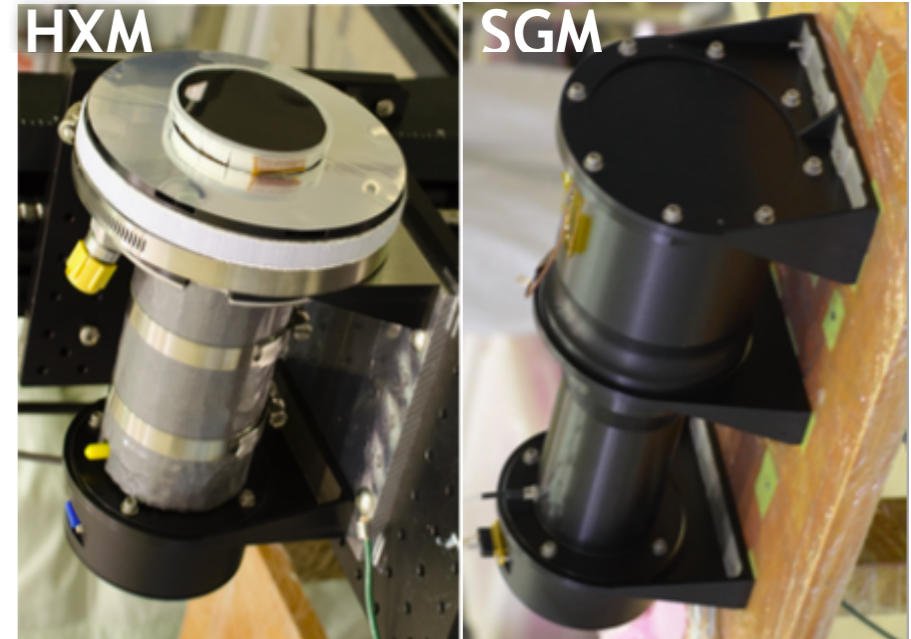
- CALorimeter(CAL)
  - Electrons: 1 GeV– 20 TeV
  - Gamma-rays : 1 GeV – 10 TeV
  - Protons and heavy ions: ~10 GeV– 1 PeV
- CALET Gamma-ray Burst Monitor (CGBM)
  - Hard X-ray Monitor (HXM) × 2 :  
LaBr<sub>3</sub>(Ce)+PMT 7 keV – 1 MeV
  - Soft Gamma-ray Monitor (SGM):  
BGO+PMT 100 keV – 20 MeV

# Status of CGBM detectors

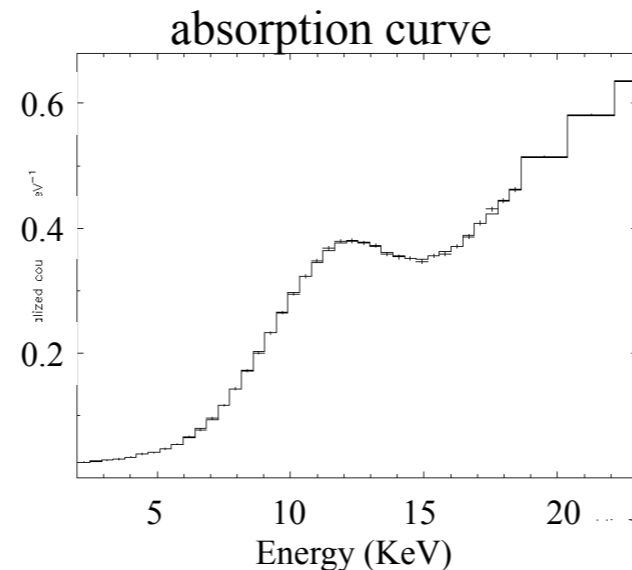
First use of  $\text{LaBr}_3(\text{Ce})$  crystal in space observation

- Low transparency problem in HXM1 window

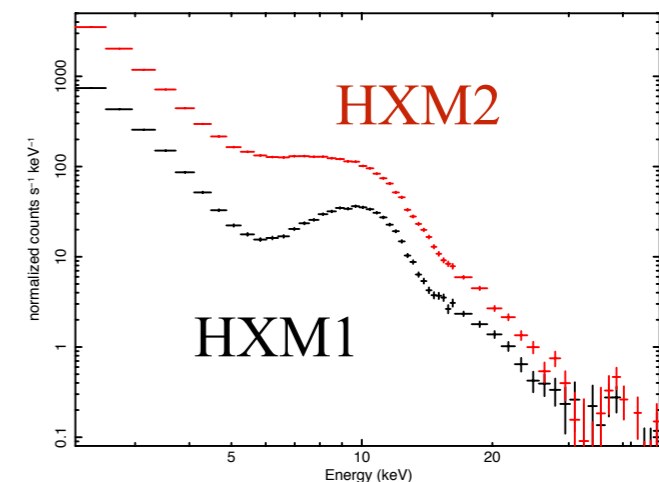
Probably due to a degradation of  $\text{LaBr}_3(\text{Ce})$  Surface  
(in production or integration phase; not in space)



count rate map for 14 keV beam  
taken in ground test on 2014 Jan.



solar flare spectrum (flight data)  
at 2016/04/15 14:20



HXM1 has low sensitivity in low energy.

Inside of the HXM1 crystal is ok (higher energy).

HXM2, SGM performance is good

- Response function still needs more improvement

We have difficulties in reconstructing low energy absorption feature and backscatter,  
by ISS structure in the FoV including RMS, Solar Panels (movable)

see also: poster P-14

# Status of CGBM operation

~60% of HV-on time  
to avoid local particle event at high latitude

when MAXI (~42%) is on → CGBM is on

## Periodic histogram data

8 ch, 1/8 sec intervals for light curve  
512 ch, 4 sec intervals for spectrum  
(per detector)

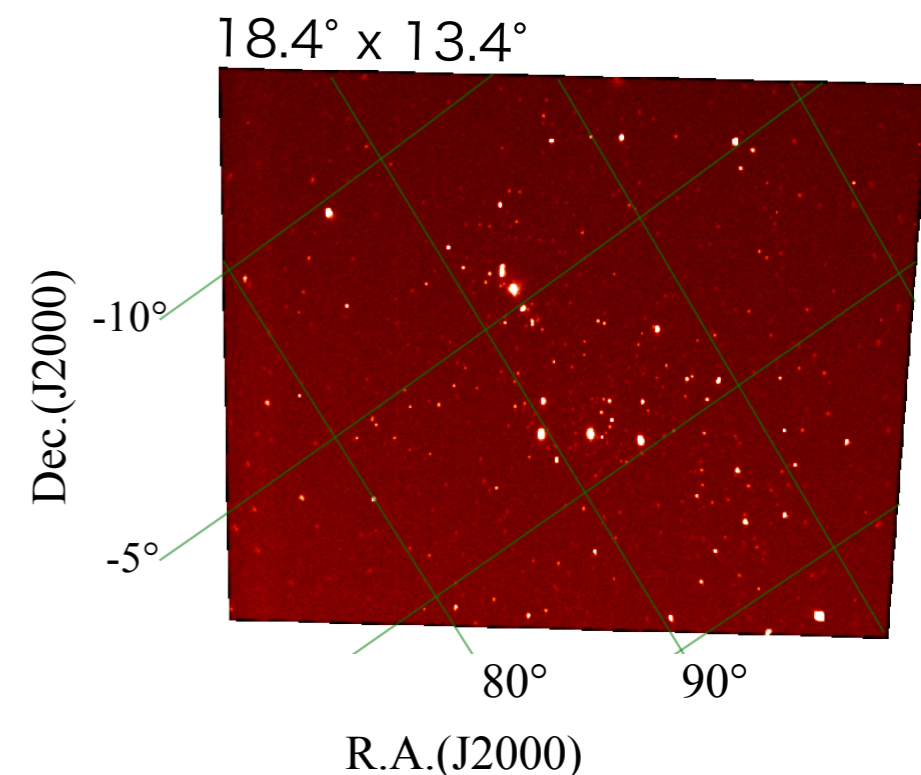
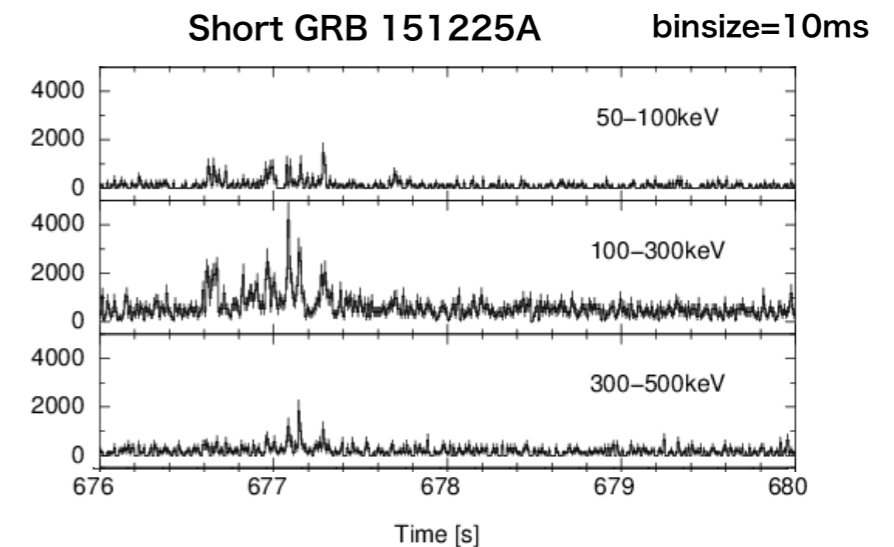
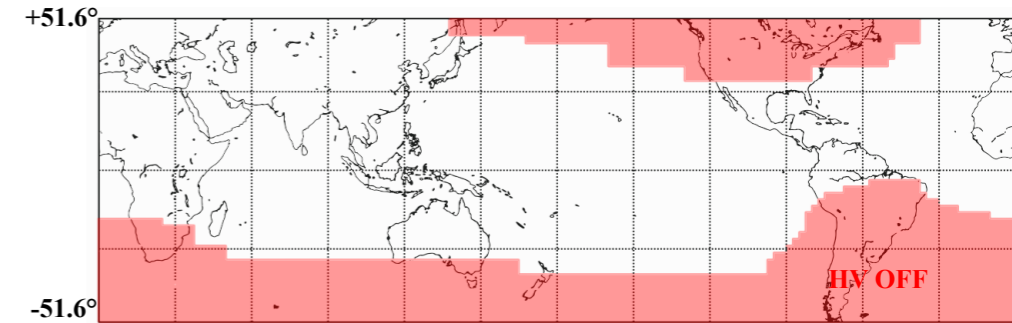
## Trigger mode

- capture event by event data  
(8092ch, 62.5  $\mu$ s time accuracy)
- ASC Image dump (~8.6 mag)
- change CAL LD from HE mode (10 GeV) to LE mode (1 GeV)

## Alert

- GCN Notice(Automatic), Circular(Manual)
- publicly available light curve (~ 10min delay )  
[http://cgbm.calet.jp/cgbm\\_trigger/flight/](http://cgbm.calet.jp/cgbm_trigger/flight/)

(inclination angle=51.6°)



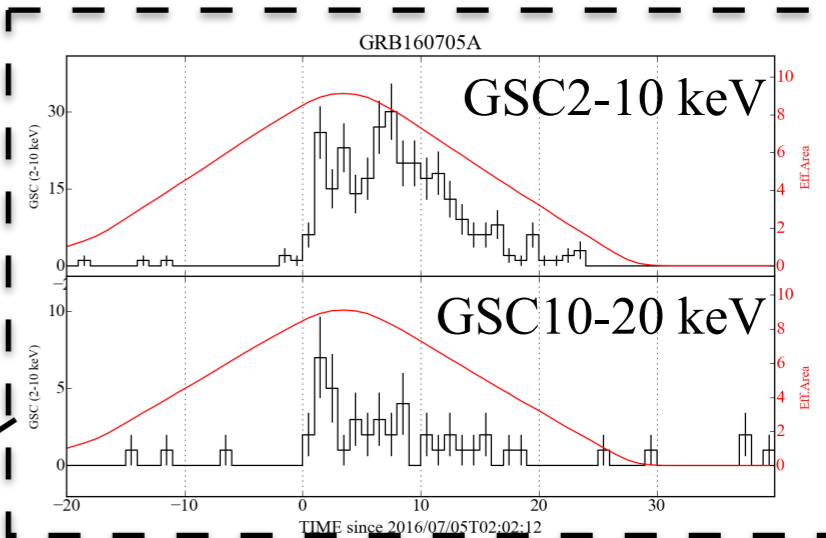
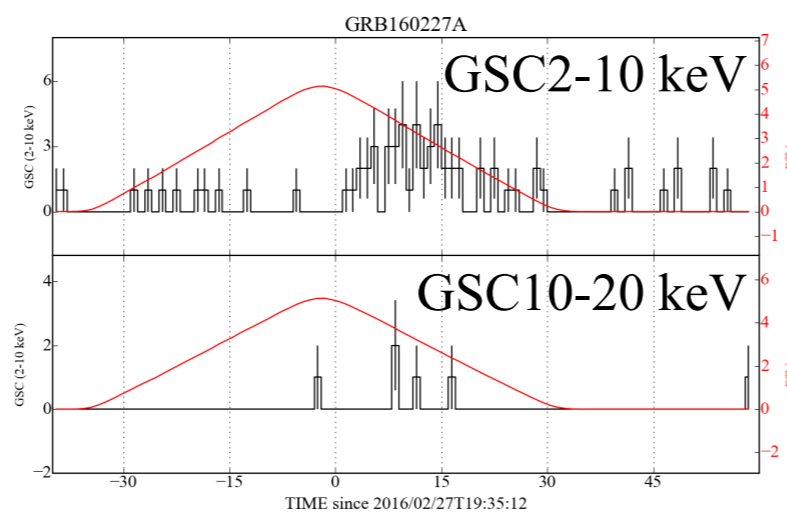
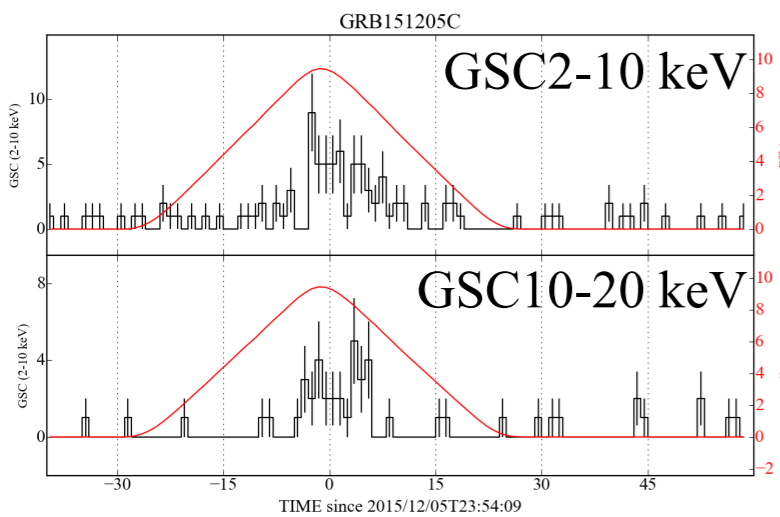
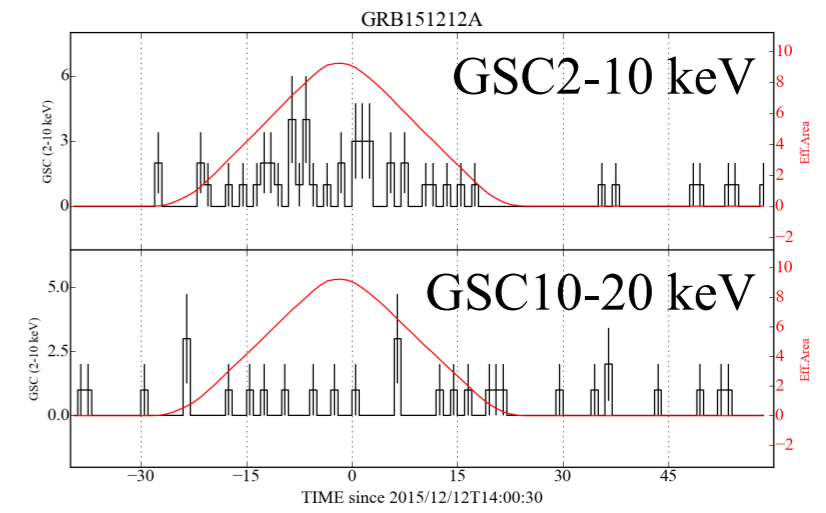
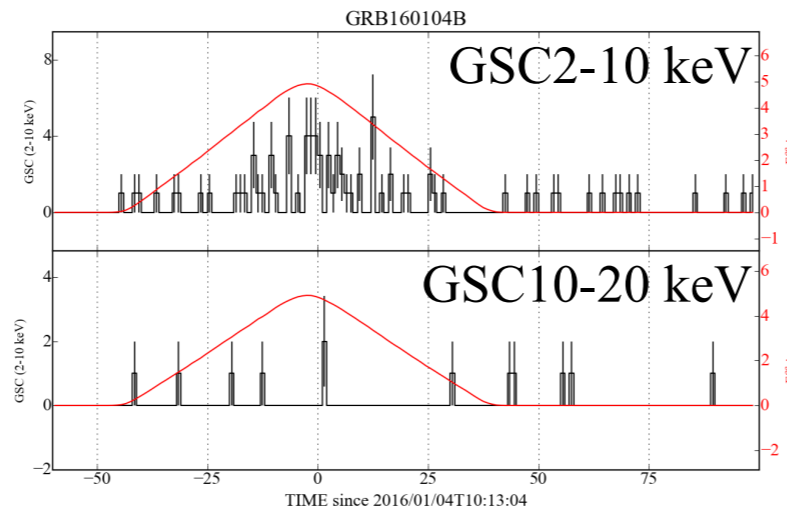
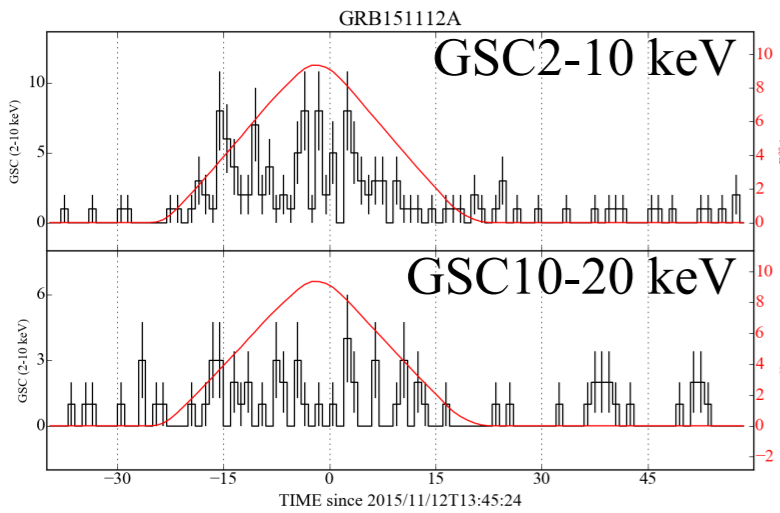




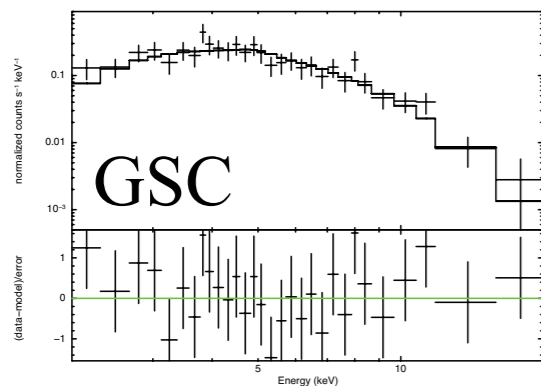
# CGBM undetected MAXI bursts

**H**

**Z**



**GRB160705A(MAXI J0748-149 ): bright / soft**

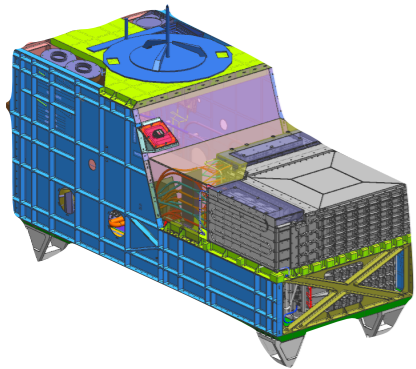


*power law*: Index  $1.83 \pm 0.15$  ( $\chi^2/\text{dof}=44.48/27$ )  
*blackbody*: kT  $1.62 \pm 0.14$  keV ( $\chi^2/\text{dof}=16.89/27$ )

(L,B)=(232.64, 5.08)

likely to be a Galactic transient





# Summary of GRB detections

(since 2015 Oct.)

**CGBM: 49**

**MAXI:15**

Long 40, Short 9  
localized 37



**10: not detected with CGBM**

**6: horizontal (SGM only)**

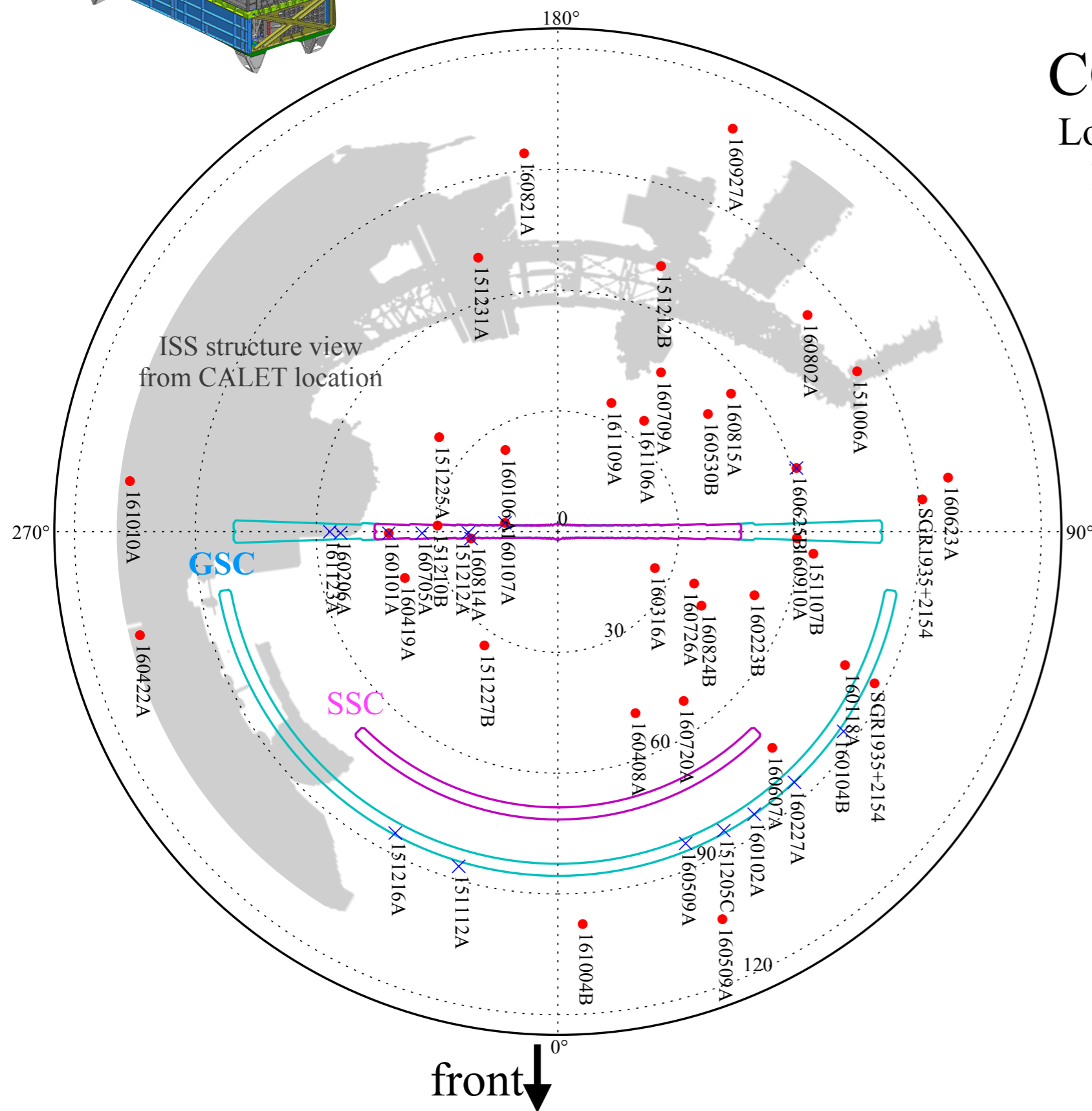
2: CGBM operation stop

**4: zenithal (HXM+SGM)**

2: blocked by JEM structure

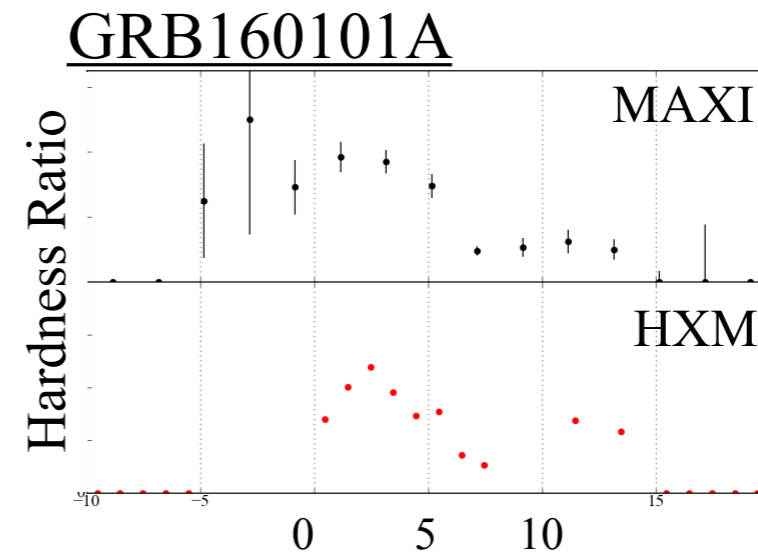
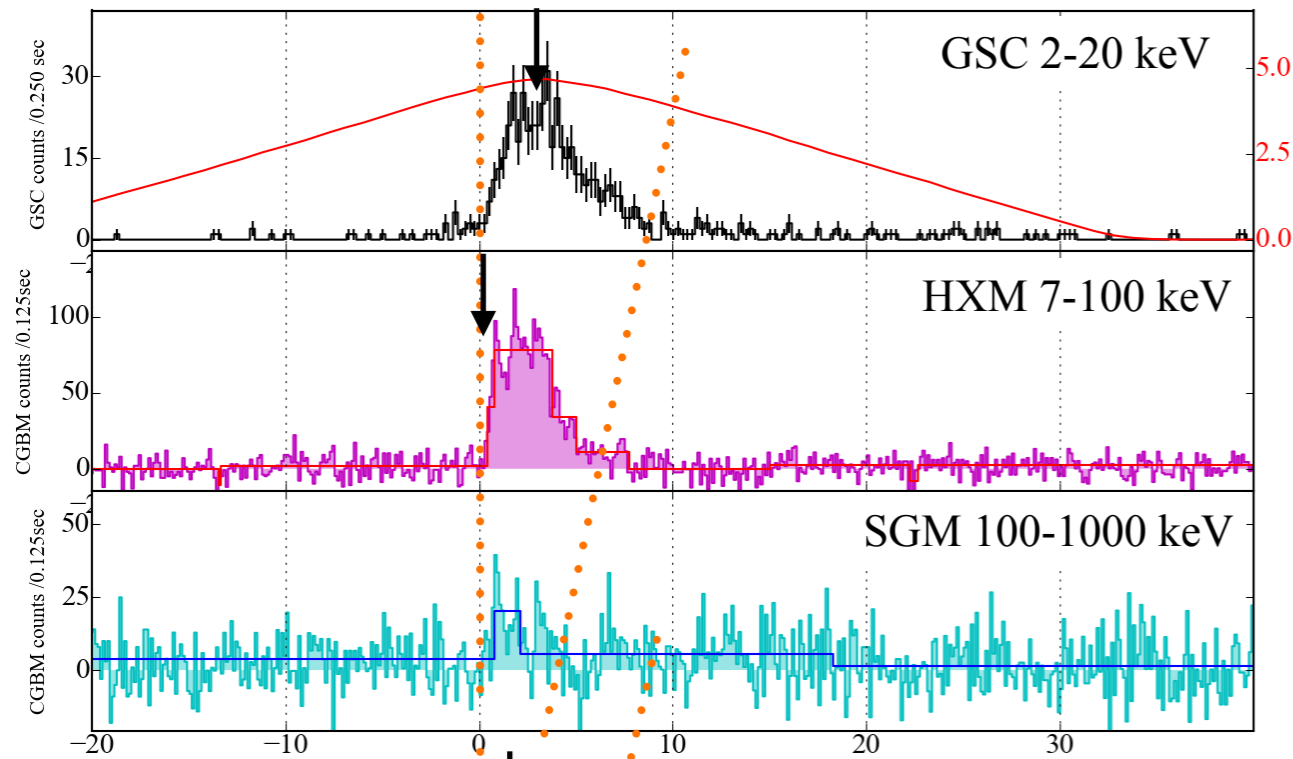
**5: detected with CGBM**

- GRB160101A
- GRB160107A
- GRB160509A
- GRB160814A
- GRB160625B

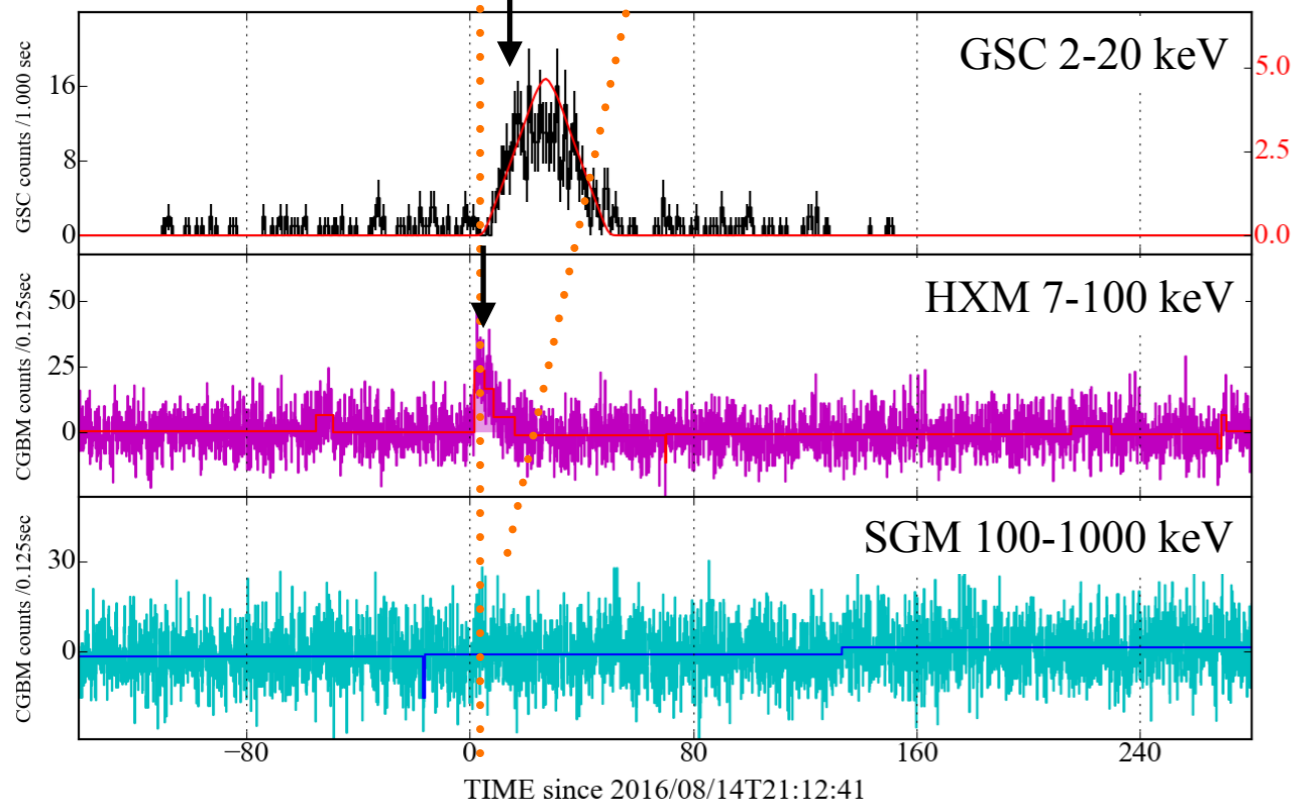


# GRB160101A, GRB160814A

almost simultaneously triggered  
low energy pulse has broader shape



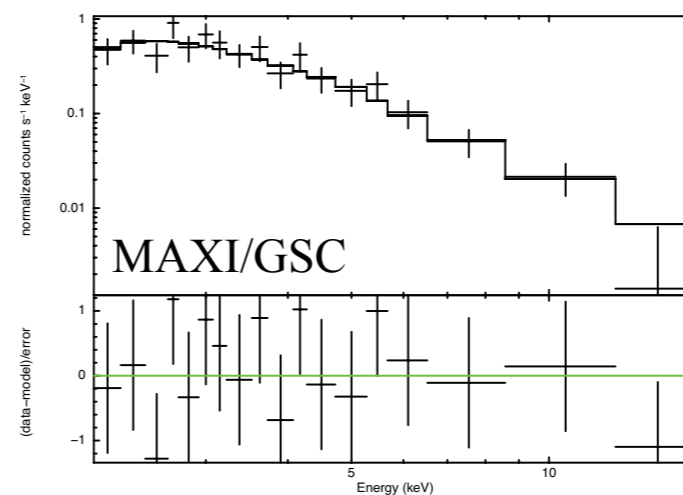
Also detected:  
Fermi/GBM  
Swift/XRT, UVOT



## GRB160814A

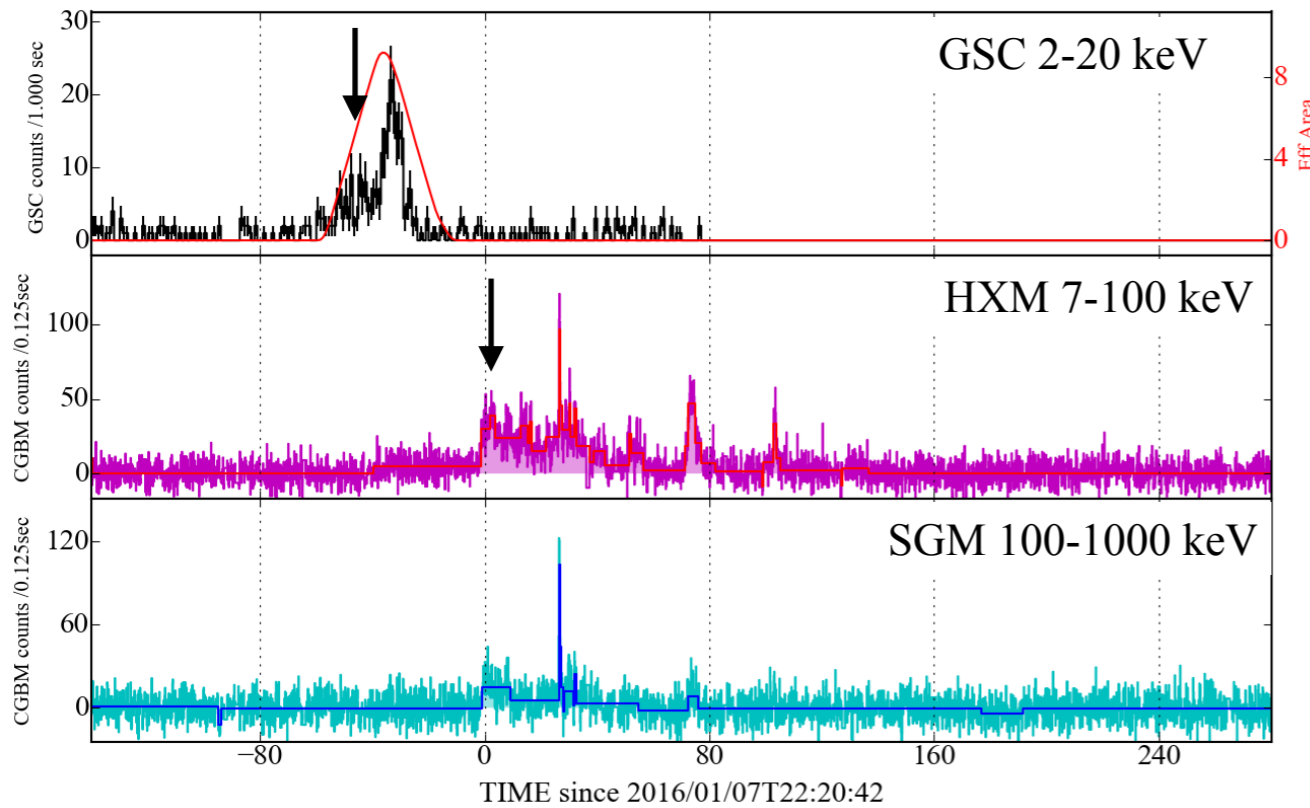
Also detected:  
Konus

$T_{90} =$  HXM: 10 sec  
MAXI/GSC: >45 sec (longer than a transit time)



*power law:*  
 $\Gamma = 2.83(-0.27/+0.30)$

# GRB160107A, GRB160509A



separated pulse was triggered  
 positions are consistent

## GRB160107A

Pre burst emission at T0-45 s

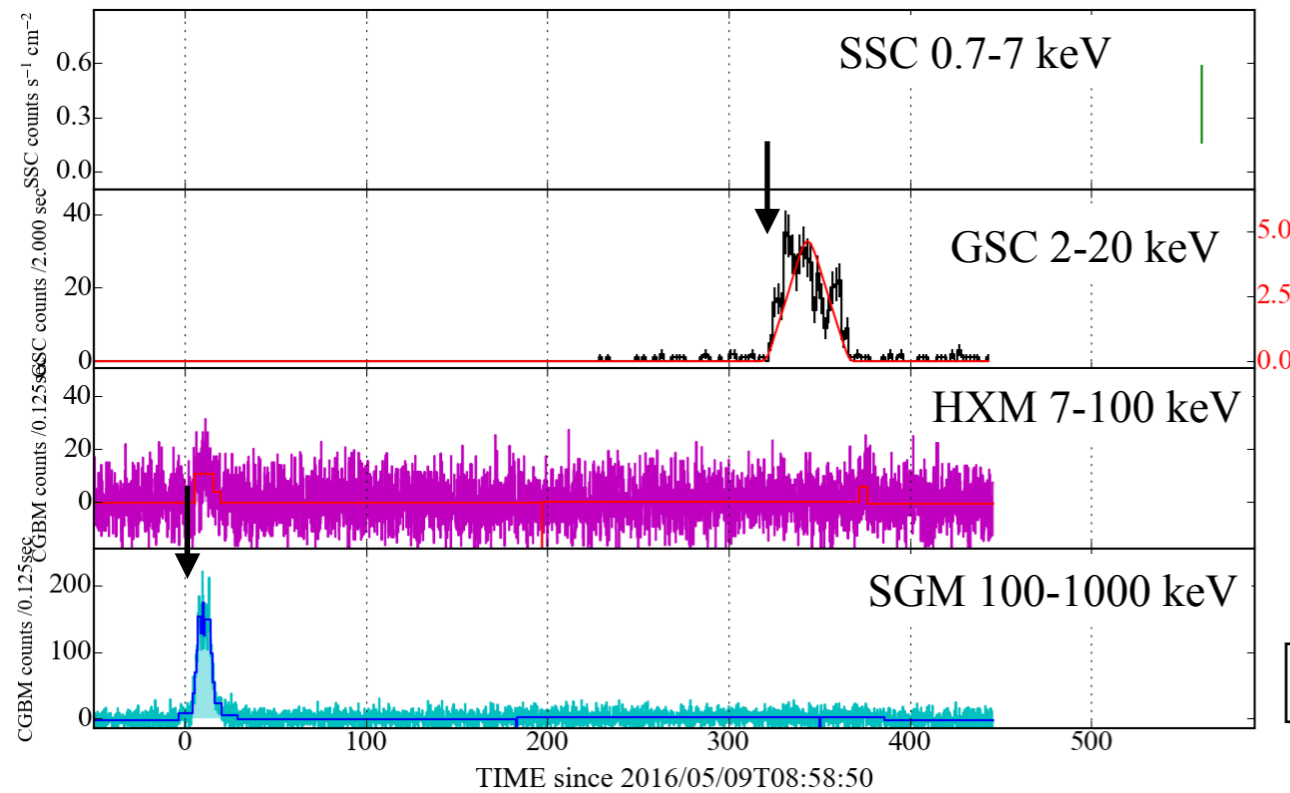
T0-45

*absorbed power law*  
 $NH=5.35 -2.87/+3.64$   
 $\Gamma=2.72 -0.53/+0.65$   
 or  
 black body  
 $kTe=1.35 -0.15/+0.17$

T0~T0+110

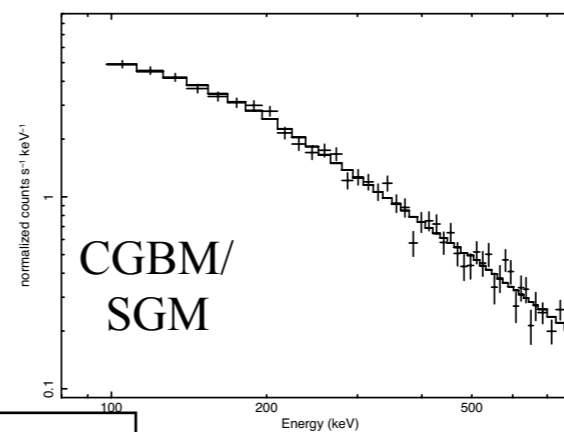
$\alpha = -1.75 \pm 0.03$   
 $\beta = -2.47 \pm 0.14$   
 $E_p = 50.8 \pm 3.1$  keV,  
 (Fermi result)

Also detected:  
 Fermi/GBM  
 Swift/XRT, UVOT



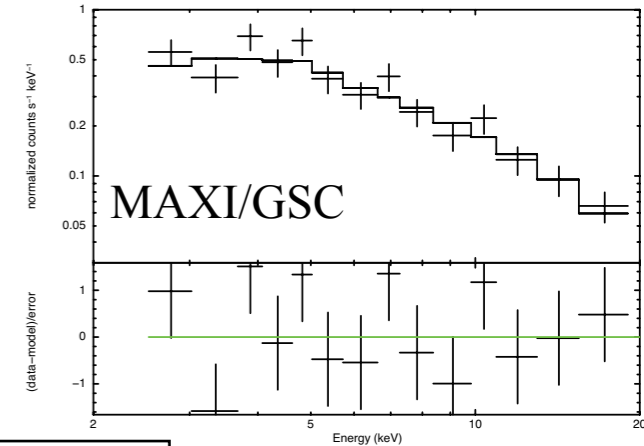
## GRB160509A

X-ray flares in early afterglow T0+320 s



T0 peak

*band function*  
 $\alpha = -0.37 (-0.42/+0.80)$   
 $\beta = -1.99 (-0.07/+0.06)$   
 $E_p = 201.7 (-121.3/+286.0)$



T0+320

*power law*  
 $\Gamma = 1.33 (-0.16/+0.16)$

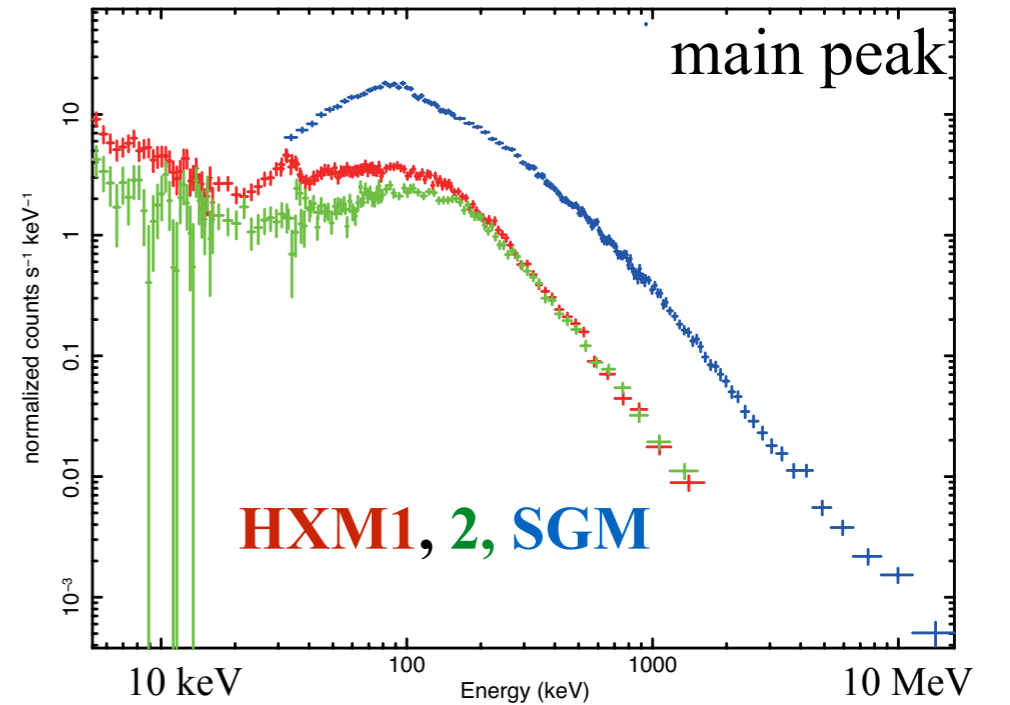
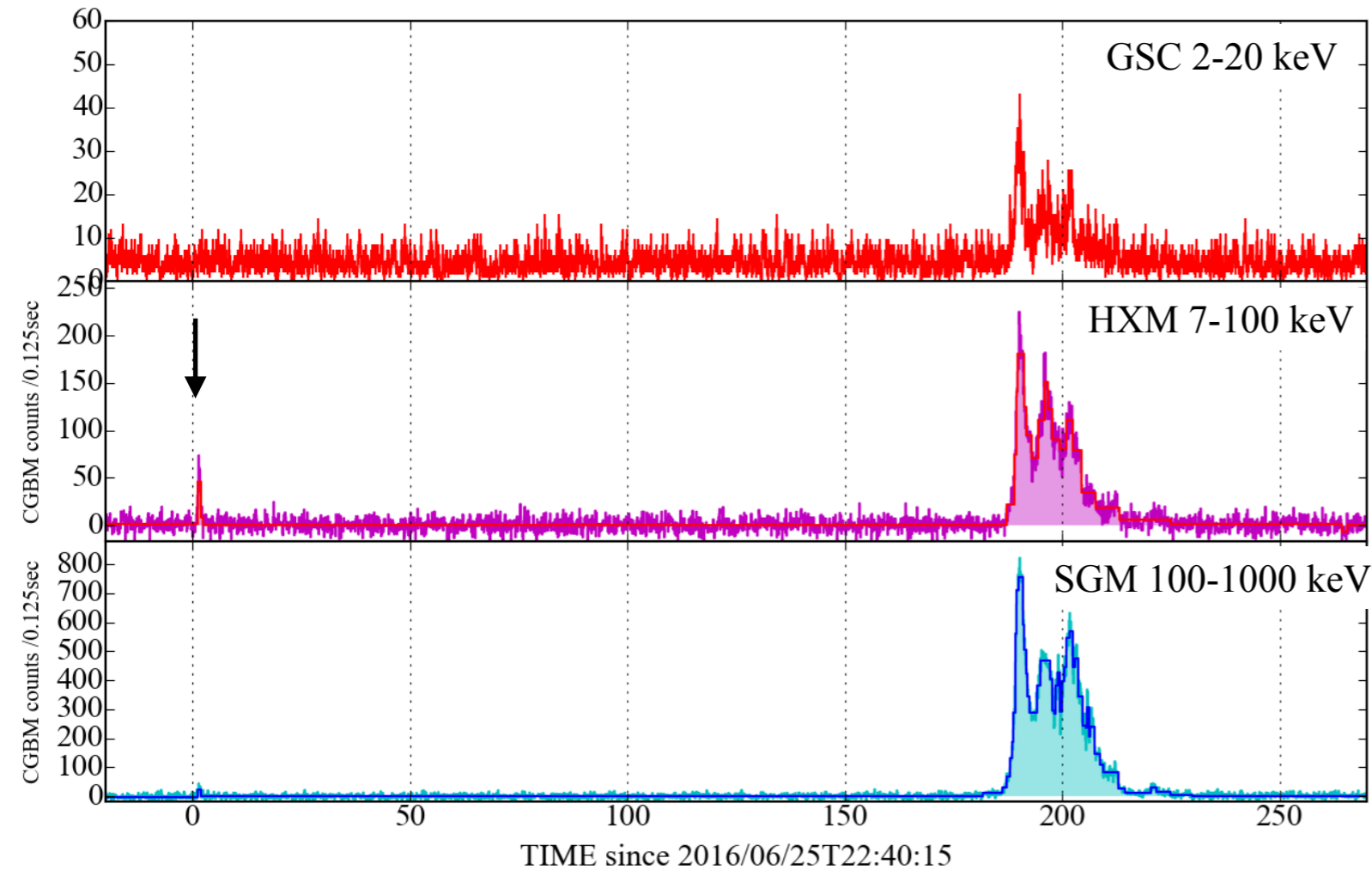
Also detected:  
 Konus



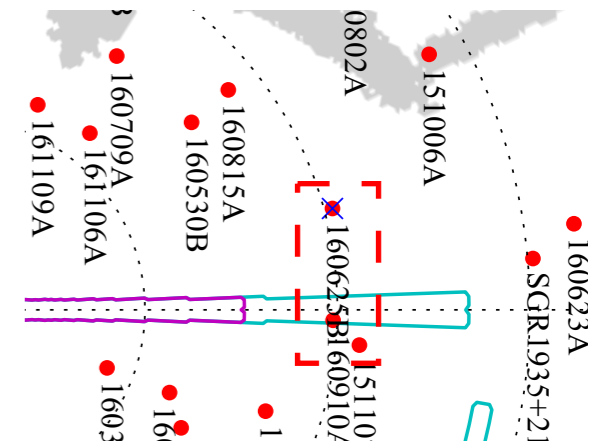
# GRB 160625B

Also detected:

Fermi/GBM, LAT  
Swift/XRT, UVOT  
optical  
radio



CGBM Triggered the precursor at 2016/06/25T22:40:15  
 T0+180~ main pulse  
 Detected up to 20 MeV by SGM  
 Out of FoV event of MAXI (detected by entire the GSC)



## summary

CALET and MAXI continue observation on ISS/Kibo-EF

CGBM detected 49 GRBs (40 Long, 9 Short)

MAXI detected 15 GRBs

10 burst was not detected with CGBM

5 burst simultaneously detected by CGBM

Simultaneous observation with MAXI and CGBM  
will reveal different aspect of GRB

GSC, CGBM+ SSC and CAL detection did not occur on the first-year.  
Hope it will happen in the next year.