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Study and optimization of the scientific performance of the micro channel X-ray telescope MXT on board the SVOM space mission

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Abstract

SVOM is a French-Chinese space mission to be launched in 2021. Its goal is the study of Gamma-Ray Bursts, the most powerful stellar explosions in the Universe. The Micro-channel X-ray Telescope (MXT) is an X-ray focusing telescope, on board SVOM, with a field of view of 1° working in the 0.2-10 keV energy band. It is dedicated to the rapid follow-up of the Gamma-Ray Bursts counterparts and to their precise localization. In order to reduce the optics mass and to have an angular resolution of few arc minutes, a "Lobster-Eye" optical configuration has been chosen. Using a numerical model of the MXT point spread function (PSF) we simulated MXT observations of point sources in order to develop and test different localization algorithms to be implemented on board SVOM. These algorithms have to be a combination of speed and precision. We present the preliminary results of the different methods.

Gamma-Ray Bursts

Definition

- Powerful explosions
- Brief gamma-ray phenomena
  - Few ms – hundreds seconds
- Random events in time and space
- Accretion disk + 2 sided jets

Formation

- *Long* (>2s) = Collapse of a massive star (>50 Msun)
- *Short* = Merging of 2 compact objects (neutron stars)

Scientific goals

- Distant GRBs = cosmological goal : investigate the early Universe (firsts stars)
- Understand physical processes associated with GRBs

Characteristics

- Emission from radio to gamma rays

SVOM

- Space based multi-band astronomical Variable Object Monitor

Collaboration

- The French Space Agency (CNES)
- The Chinese Academy of Sciences (CAS) and the Chinese Space Agency (CNSA)

Aim of the mission

- Study Gamma-Ray Bursts and other high-energy sources

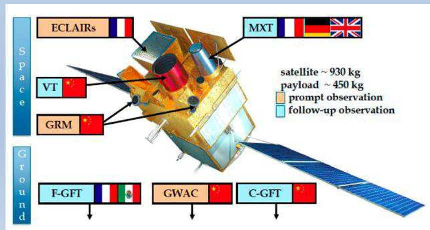
Instruments on board

- 2 wide field of view : ECLAIRs and GRM
- 2 narrow field of view : MXT and VT

⇒ Operates from near-infrared to gamma rays

What happens when there is a GRB ?

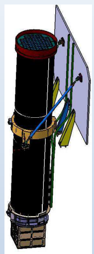
- ECLAIRs will detect and localize the GRB
- SVOM will reorient itself thanks to ECLAIRs indication
- MXT and VT will observe the GRB with a better precision and transmit the information to ground based telescopes



MXT

Goal

- Observe GRBs in X-rays (0.2-10 keV)
- Localize GRB afterglows in real time
- Transmit their positions to ground based telescopes



Localization of GRBs

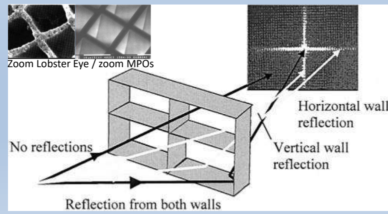
- Field of view 57 x 57 arcmin
- Smaller Point Spread Function (PSF) than ECLAIRs : 6.5' vs 1°

Localization error

- Less than 1' vs less than 10' for ECLAIRs

Composition

- Detector of 256 x 256 pixels, 75µm side
- Optics in Lobster Eye configuration = focus X-rays thanks to reflections in micropores



MXT Simulator

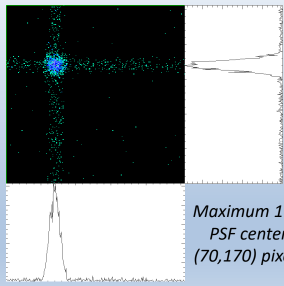
Goals

- Simulate realistic MXT observations
- Develop and optimize the on board localization algorithms

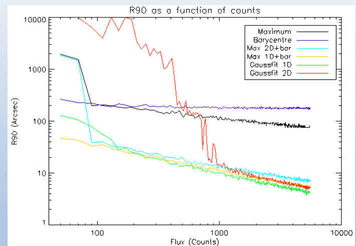
IN		OUT
GRB characteristics	**Simulator** ⇒	Photon characteristics
❖ Duration ❖ Flux ❖ Spectral model ❖ Temporal model		❖ Position ❖ Energy ❖ Arrival time ❖ Origin (source / background) ❖ CCD impact pattern

⇒ **Configurable PSF + event file**

Localization Methods



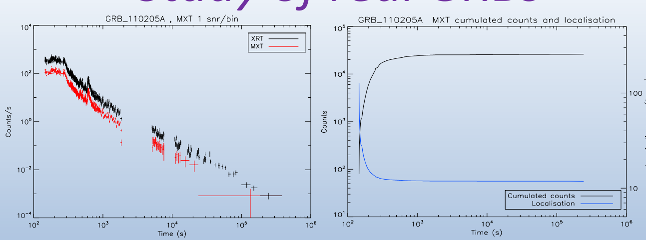
Maximum 1D : PSF center (70,170) pixels



⇒ **1D methods are better at high and low fluxes**

⇒ **Good compromise between precision and calculation time**

Study of real GRBs



Localization < 15 arcsec for few hundred seconds

Statistical error

⇒ **Good precision of the localisation error**

SVOM Follow-up Strategy

Gravitational waves

Formation

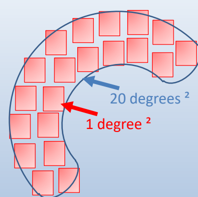
Possible counterparts of short Gamma Ray Bursts

Particularities

- Fast decrease of the counterparts
- Confirmation of a GW detection = few hours
- Large error boxes (tens of degrees in the best cases)

Simulations

- Observations 4h/6h/12h + 4 orbits
- Calculation of the cumulated counts
- Analysis of the localization



Svom tiling strategy

5 observations of 500 sec/orbit

4 orbits (~6h)

= 20 tiles

References

L. Gosset et al., SPIE, 99051L (2016)

D. Götz et al., SPIE, 99054L (2016)

B. Cordier et al, ArXiv e-prints (2015)

Conclusions

We have developed a simulator to assess the scientific capabilities of MXT. It is highly configurable and it demonstrates the gain in scientific performance of starting the localization algorithms before reaching the complete stabilization of SVOM. MXT is also able to search for gravitational wave sources counterparts in the X-rays thanks to the SVOM follow-up strategy.