# SVOM ground follow-up performance with F-GFT

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## Abstract

**Context:** the french chinese space mission SVOM (Space Variable Object Monitor) will be launched in 2021 with the aim of observing gamma-ray bursts (GRB). A few seconds after the trigger the French-Ground Follow-up Telescope (F-FGT) will be dedicated to perform optical and Near Infra-Red (NIR) observations to localise the GRB within 1" accuracy and infer a photometric redshift indication 5 minutes after the ECLAIRs trigger.

**Objectives:** development of a telescope simulator and photo-redshift algorithm to estimate the F-GFT performance and provide data to the reduction pipeline.

## What is a Gamma Ray Burst?

- Manifestation of a gigantic explosion, these flashes of light are considered to be the brightest and most energy-rich events since the Big Bang. This makes them visible at very large distances.
- 2 types of progenitor:
  - Long GRB (>2s): collapse of very massive stars ($> 20\ M_\odot$).
  - Short GRB (<2s): coalescence or fusion of compact objects (neutron star or black hole).
- Random event in time and space.
- Emission from gamma rays to radio through a relativistic jet.

- Scientific interests:
  - distant GRBs → explore first generation of stars.
  - a natural laboratory of extreme physics.

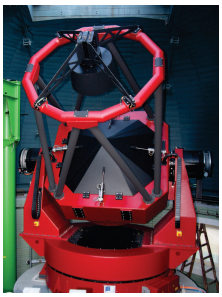
## What is SVOM?

SVOM is a space and ground based multi-wavelength observatory:

- Instruments onboard the satellite:
  - **ECLAIRs**: X and soft $\gamma$ ray telescope (4-250 keV)
  - GRM: $\gamma$-ray telescope (15kev - 5MeV)
  - MXT: soft X-ray telescope (0.2-10 keV)
  - VT: optical/NIR telescope (400-1000nm)
- Ground follow-up:
  - **F-GFT: 1.3m robotic optical/NIR telescope (in Mexico).**
  - C-GFT: 1m robotic optical telescope (in China).
  - GWAC: Ground Wide Angle Camera, 5000 deg$^2$ in optical (in China).
- It will detect about 70 GRBs per year.

## F-GFT characteristics

- Primary diameter of 1.3 meters.
- Field of View of 26 arcmin.
- 3 arms covering:
  - Optical domain.
  - NIR domain (up to H band).
- Delay between alert reception and start of an observation $<$ 20s.
- Dedicated telescope: observe all the GRB alerts (even low thresholds from SVOM).



- 23% of the GRBs are observable immediately.
- GRBs occuring during daytime are observable within 17h after the trigger.

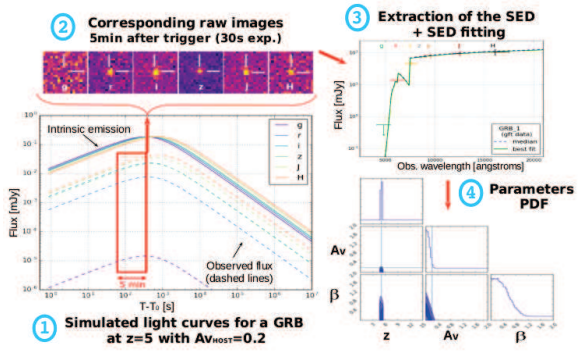
F-GFT location: San Pedro de Martyr, Mexico

## F-GFT simulator

A whole F-GFT simulator has been developed in Python and contains:

- GRB afterglow light curves simulator.
- Extinction processes in the host Galaxy and Inter Galactic Medium.
- Exposure Time Calculator (ETC) and Image Simulator (IS) taking into account the telescope characteristics (PSF, CCD, Sky background,...).
- Photometric redshift code using MCMC.

This simulator is not F-GFT specific and can be used for any optical/NIR imaging telescope.




## Observational strategy

**Problem:** The emission from a GRB fades quickly with time.
⇒ the response time is of key importance.
⇒ efficient observational strategy required.

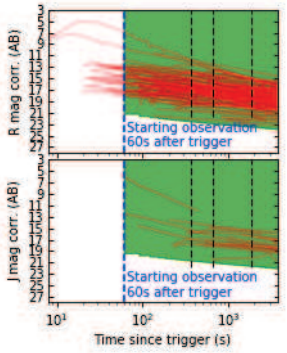
**Strategy:**

- 1. ECLAIRs detects a new source within 20' accuracy.
- 2. F-GFT starts observing 1 min after ECLAIRs trigger.
  ⇒ 1" localisation accuracy for a few candidates.
  ⇒ photometric redshift estimation of candidates.

**Objective:**
Optimise the observational strategy between detection efficiency using wide filter bands and a more resolved wavelength coverage for the photo-z.
⇒ Starts with wide filter bands (*gri*, *zy* and *J*).
⇒ Once detected, switch to narrower filter bands. (*g,r,i,z,y,J,H*) alternatively used.

## Detection performance

- *red lines:* real GRB light curves.
- *green area:* 5$\sigma$ F-GFT sensitivity.
- 100% detection 1 min after the trigger.
- $\sim$ 2 magnitudes deeper in NIR at early times.
- $\sim$ 70% of detection 17h after the trigger (not shown here).



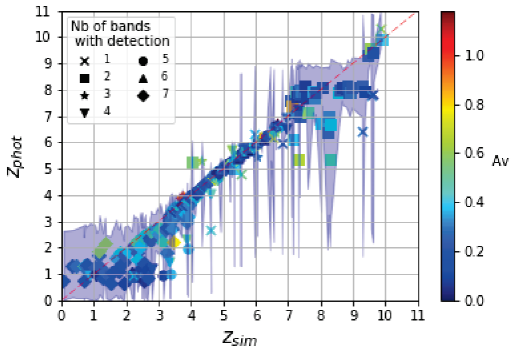

## Photometric redshift accuracy estimation

**Objective:** Test photo-z estimation accuracy on a realistic mock sample.

- Mock sample of 300 GRBs based on real observations.
- Simulating 5 first minutes after trigger.
- Using observational strategy defined above.
- Redshift range (z): 0-10.
- Host extinction ($A_V$) range: 0-1.2.

**Results:**

- 87% of detection (262/300).
- z $<$ 3: upper limits only.
- 3 $<$ z $<$ 7.5: $<$10% accuracy .
- z $>$ 7.5: larger uncertainty due to the degeneracy between highly extinguished and high redhift GRB. Can only be broken with good SNR.




## Conclusions

- Development of a universal ETC-IS for optical/NIR imaging telescope and a reliable photo-z algorithm.
- F-GFT would have detected 100% of the GRB detected so far 5 min after the trigger and $\sim$ 70% 17h after the trigger.
- 2 mag deeper at early times in NIR.
- F-GFT will deliver a reliable photometric redshift for 3<z<7.5 .

## Acknowledgements

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