The SVOM GRB mission

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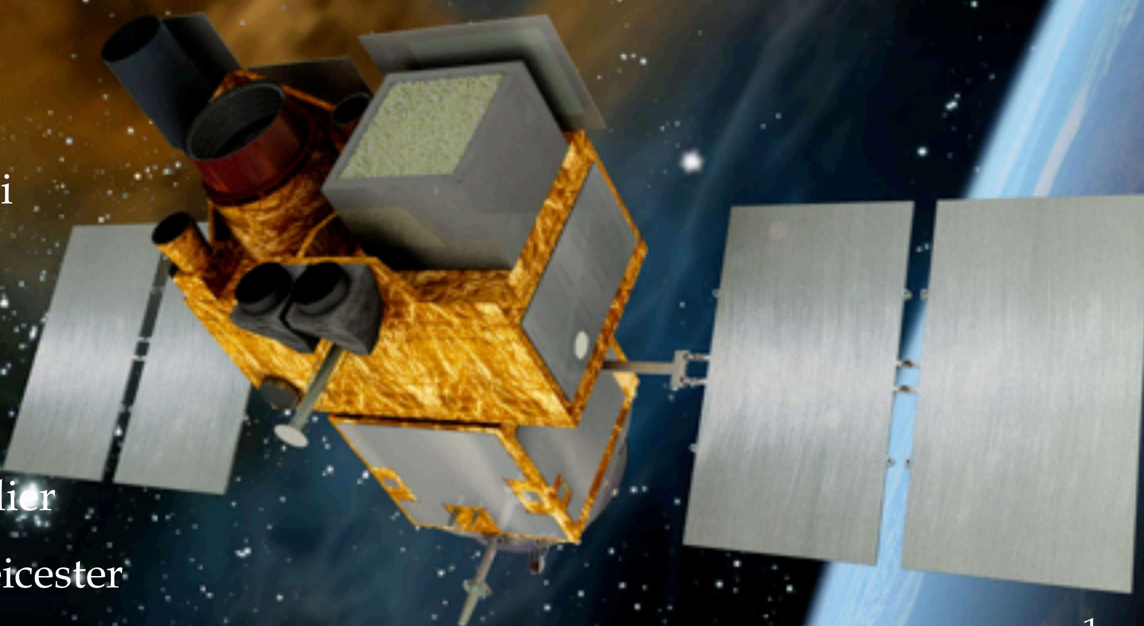
on behalf of the SVOM consortium



NAOC, Beijing
XIOPM, Xi'an
CEA-Irfu, Saclay
APC, Paris
LAM, Marseille
CPPM Marseille
GEPI Meudon
MPE, Garching

IHEP, Beijing
SECM, Shanghai
IRAP, Toulouse
IAP, Paris
LAL Orsay
LUPM Montpellier
University of Leicester
CNES, Toulouse

SVOM in context

- **SVOM** = **S**pace-based multiband astronomical **V**ariable **O**bjects **M**onitor

- SVOM is a ***Chinese-French space mission*** dedicated to the detection and study of GRBs and their use for astrophysics & cosmology. The PIs of the mission are ***J. Wei*** from NAOC and ***B. Cordier*** from IRFU (CEA-Saclay).

- SVOM is presently under construction and planned to be ***launched early in the next decade (2021)***, for a 3 year nominal mission.

- SVOM will operate in the era of ***advanced GW detectors***, providing the opportunity to search correlations between GW and GRBs

- SVOM GRBs will benefit from follow-up with a new generation of astronomical instruments: JWST, SKA precursors, CTA, LSST, etc.

SVOM in context

- SVOM will provide ~80 GRB/yr. It will explore the realm of ***soft GRBs and X-ray Flashes*** (above 4 keV), and the ***prompt optical emission*** with a good sensitivity.

- We aim at ***>50% of SVOM GRBs with a redshift*** thanks to:
  - A pointing strategy optimized for ground follow-up
  - The good sensitivity of the on-board visible telescope
  - Dedicated NIR follow-up on the ground.

Scientific rationale of the SVOM mission

GRB phenomenon
- Diversity and unity of GRBs

GRB physics
- Acceleration and nature of the relativistic jet
- Radiation processes
- The early afterglow and the reverse shock

GRB progenitors
- The GRB-supernova connection
- Short GRB progenitors

Cosmology
- Cosmological lighthouses (absorption systems)
- Host galaxies
- Tracing star formation
- Re-ionization of the universe
- Cosmological parameters

Fundamental Physics
- Origin of High-Energy Cosmic Rays
- Probing Lorentz invariance
- Short GRBs and gravitational waves

Short GRBs and gravity waves

- Coordinated searches of GW and short GRBs may confirm or dismiss the favorite scenario for short GRBs: the coalescence of two compact objects.

  A key ingredient: GRB beaming ?

- **Coincident events:** within the horizon of GW detectors (~400 Mpc), we expect ~1 event in ECLAIRs FOV and ~2 events in GRM FOV, in 5 years of operation.

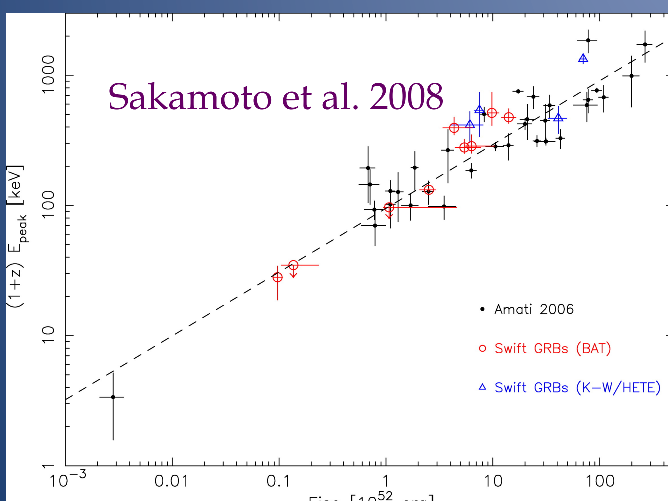
- **Follow-up:** within the horizon of GW detectors, we expect ~15 events in 5 years of operation that can be followed quickly (6 hours) with SVOM narrow-field instruments.

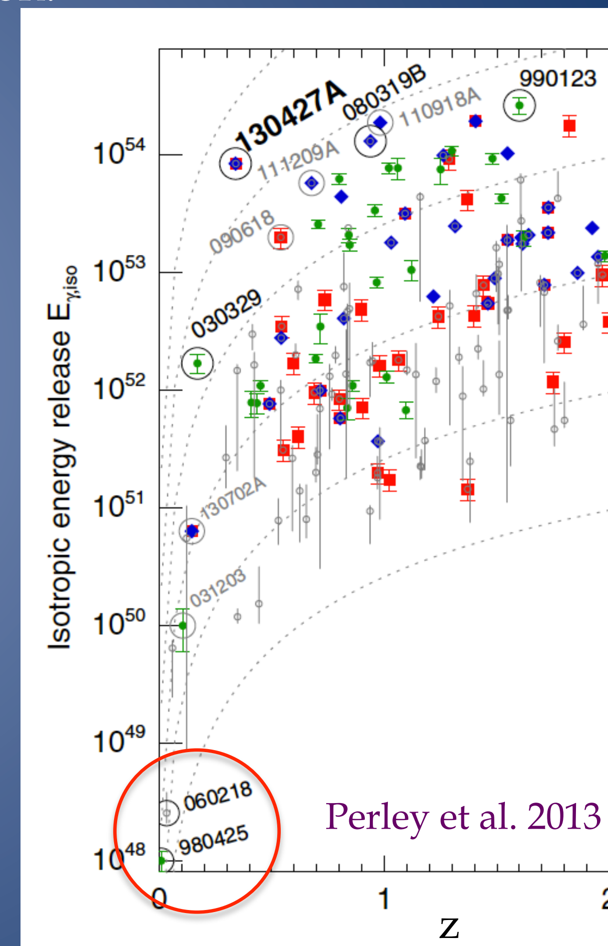
Highly redshifted GRBs

- We expect to detect ~5 GRBs/yr at redshift z>5 with ECLAIRs.
- We aim to quickly identify high-z GRBs, thanks to the pointing strategy of SVOM, the sensitivity of VT, and fast NIR follow-up on the ground (see next slides). This will permit optical spectroscopy of most of highly redshifted afterglows, allowing crucial scientific studies.
- Highly redshifted GRBs allow studying the young universe:
  - Gas and dust in young galaxies
  - Reionization of the IGM
  - Star formation rate
  - Search for GRBs from Population III stars (challenging)
    (rare, energetic, possibly very long like GRB111209A, with no detectable host)

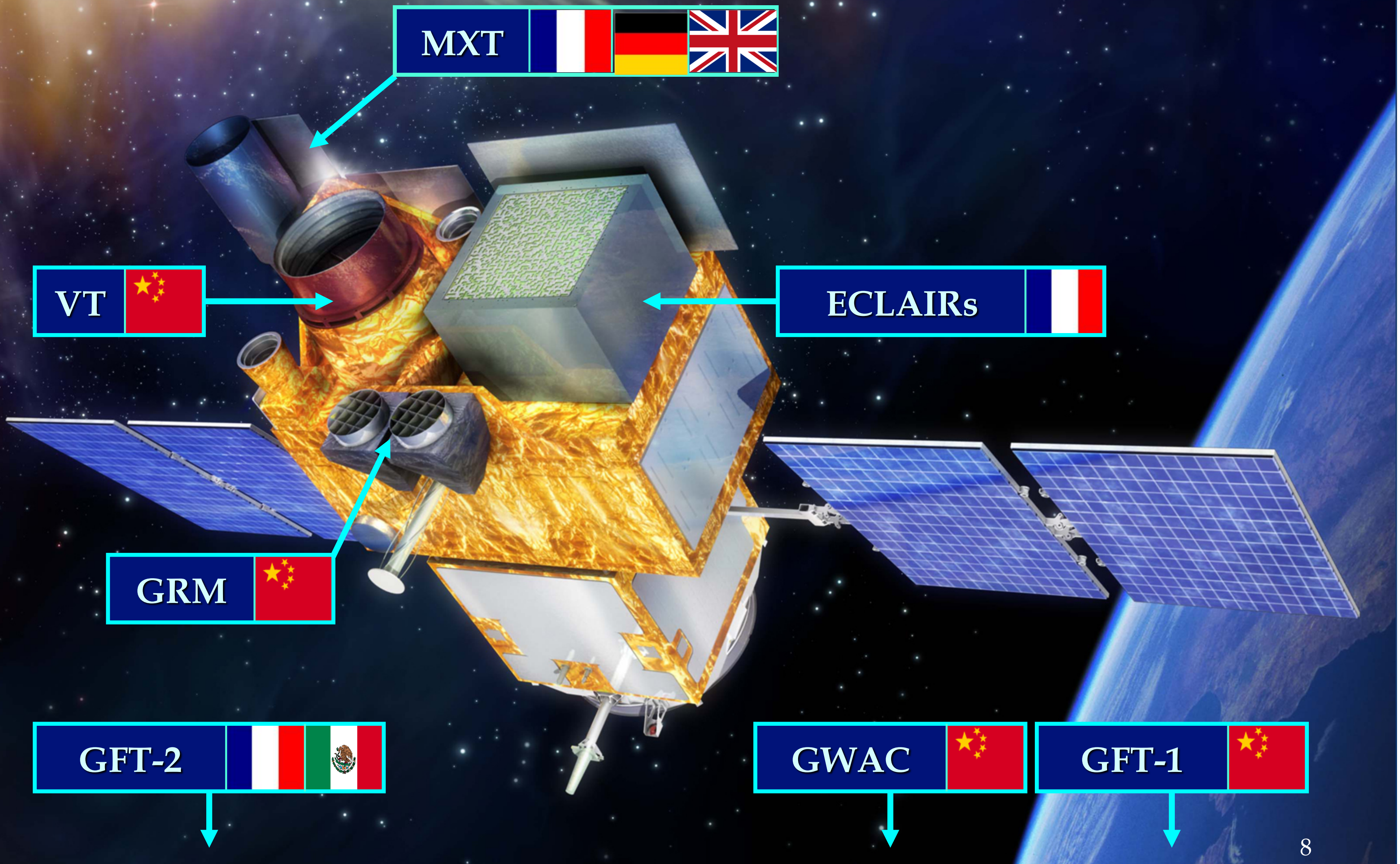
Low-luminosity GRBs and the SN-GRB connection

- The low-luminosity end of the GRB luminosity function is not well known, but we know that low-luminosity GRBs exist, and they may dominate the GRB population.
- Low-luminosity GRBs are more easily detected if they have low Epeak (since they have more photons).
- The detection of low-luminosity GRBs in the local universe (z≤0.1)would provide crucial clues to understand the SN-GRB connection

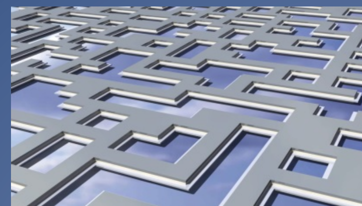


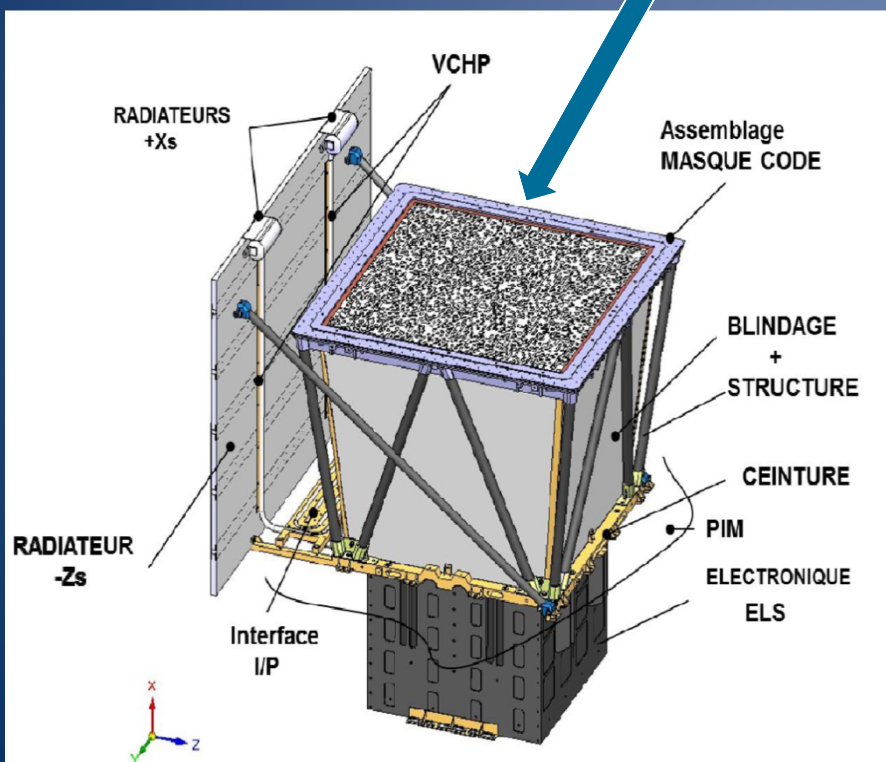


SVOM scientific instrument arrangement



ECLAIRs – The trigger camera





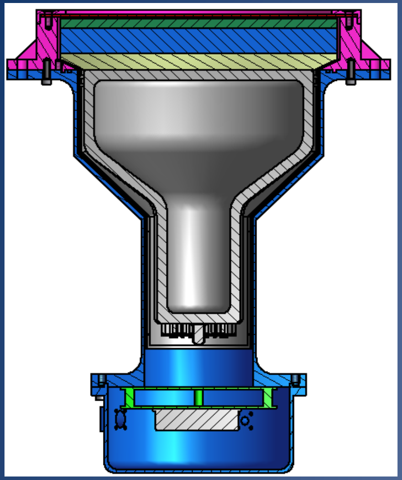
Main characteristics

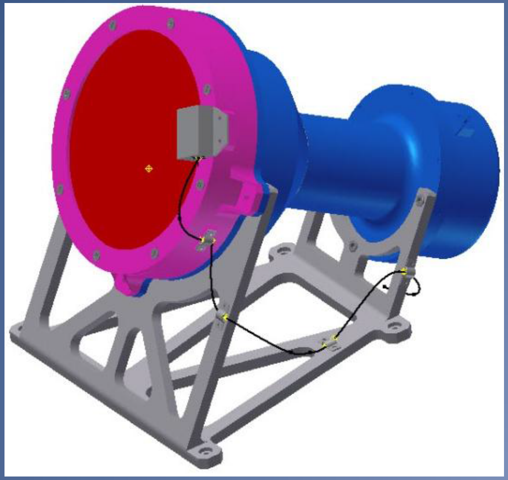
Coded mask telescope
Wide FOV : 2 Sr
6400 CdTe - 1024 cm^2
4 keV – 150 keV

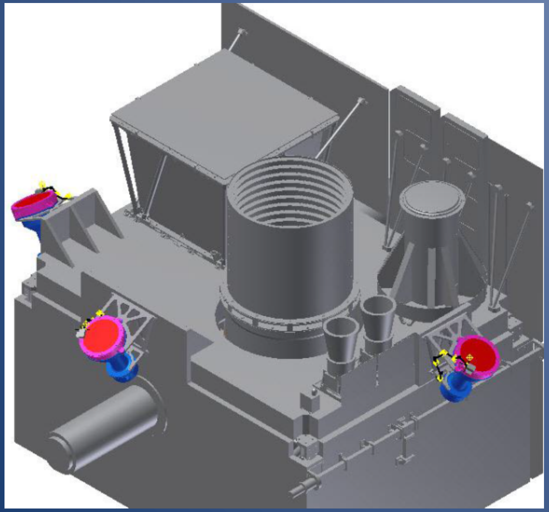
Anticipated performance

Loc. accuracy < 10arcmin
3 arcmin for bright burst
80 GRBs / year

GRM – The Gamma Ray Monitor







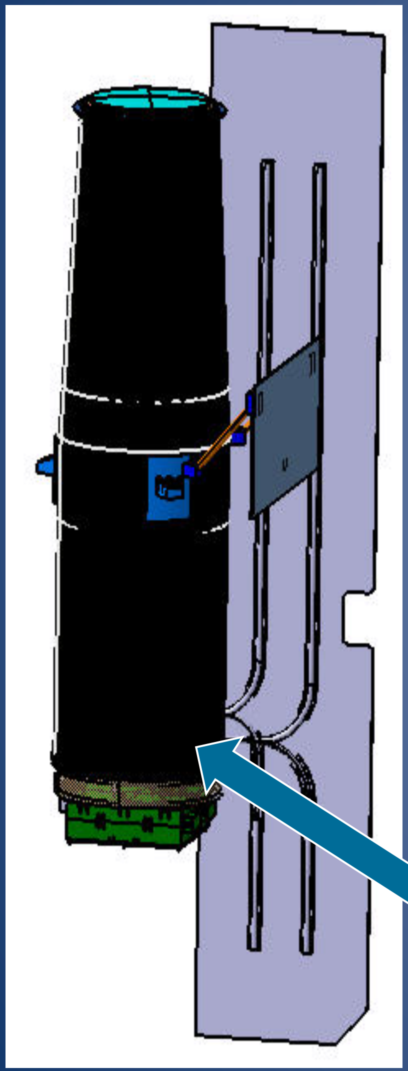
Main characteristics

3 NaI detectors, 280 cm² each
Thickness: 1,5 cm
FOV : 3x2 Sr
50 keV – 5 MeV

Anticipated performances

Loc. accuracy ~ 2°(in 2.6 sr)
110 GRBs / year

MXT – The Multi-channel X-ray Telescope

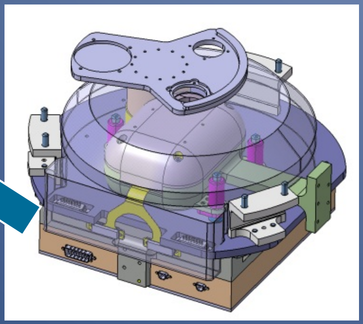


Main characteristics

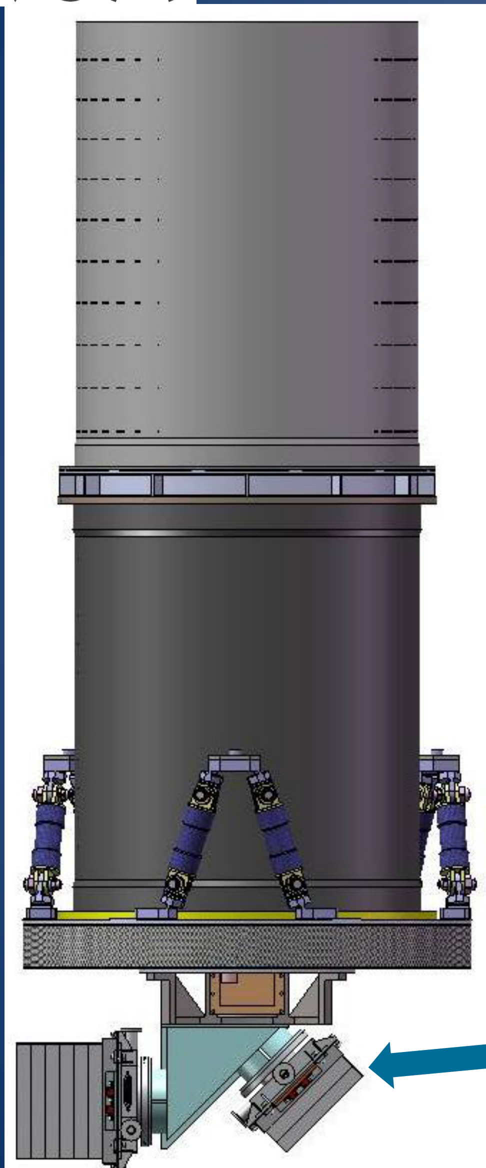
MCP X-ray optic
FOV ~ 1 deg^2
256 x256 PN CCD
0.3 keV – 10 keV

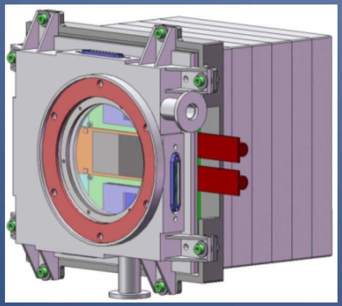
Anticipated performances

Loc. accuracy < 1 arcmin
20 arcsec for bright GRB
5×10^{-12} erg cm^{-2} s^{-1} in 1000s



VT – The visible telescope





Main characteristics

Ritchey Chretien Φ=40cm
FOV : 26 x 26 arcmin^2
2 X 2048x2048 CCD
400 nm – 950 nm

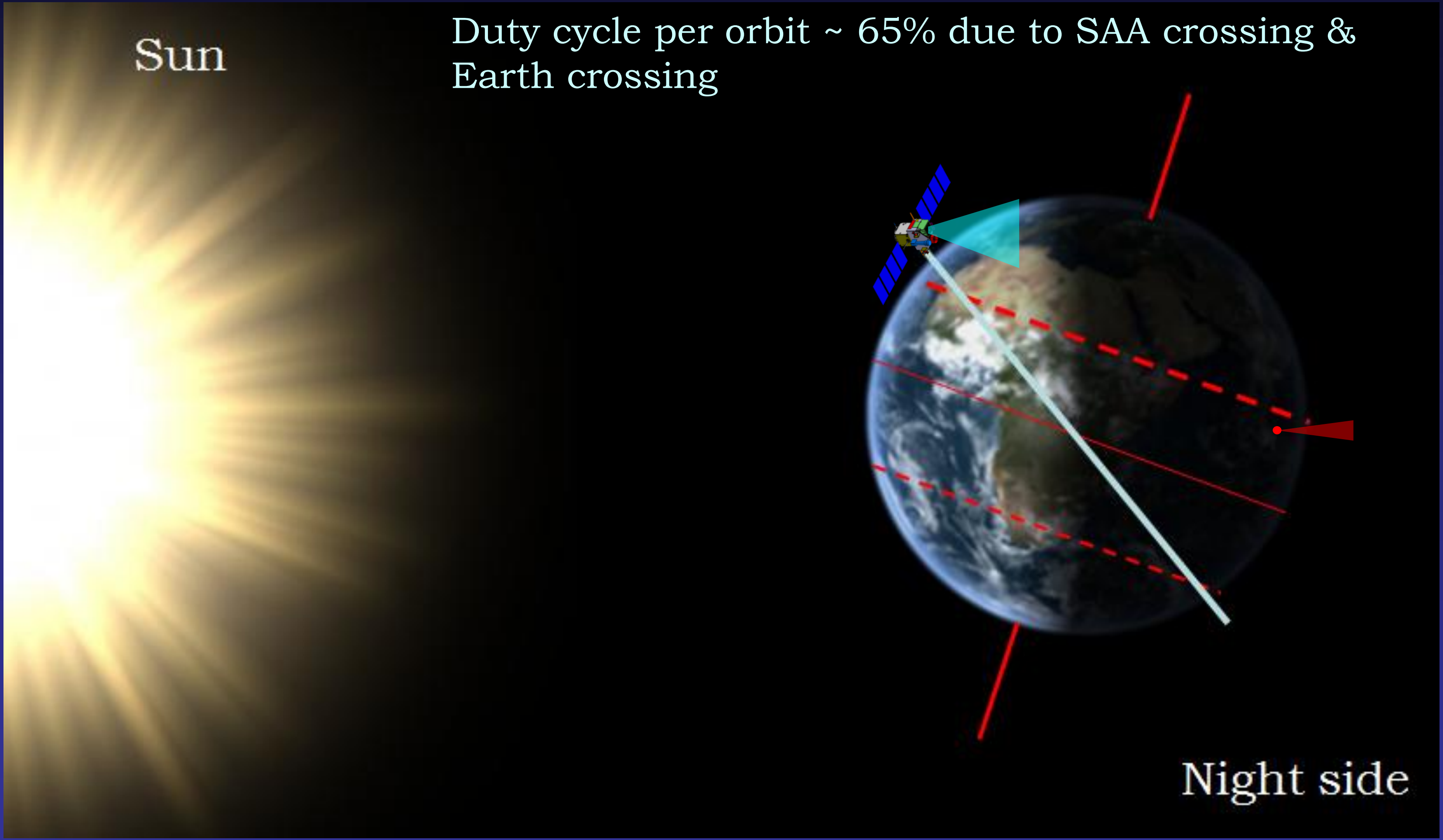
Anticipated performances

Loc. accuracy < 2 arcsec
Mv = 22.5 in 300s

SVOM orbit

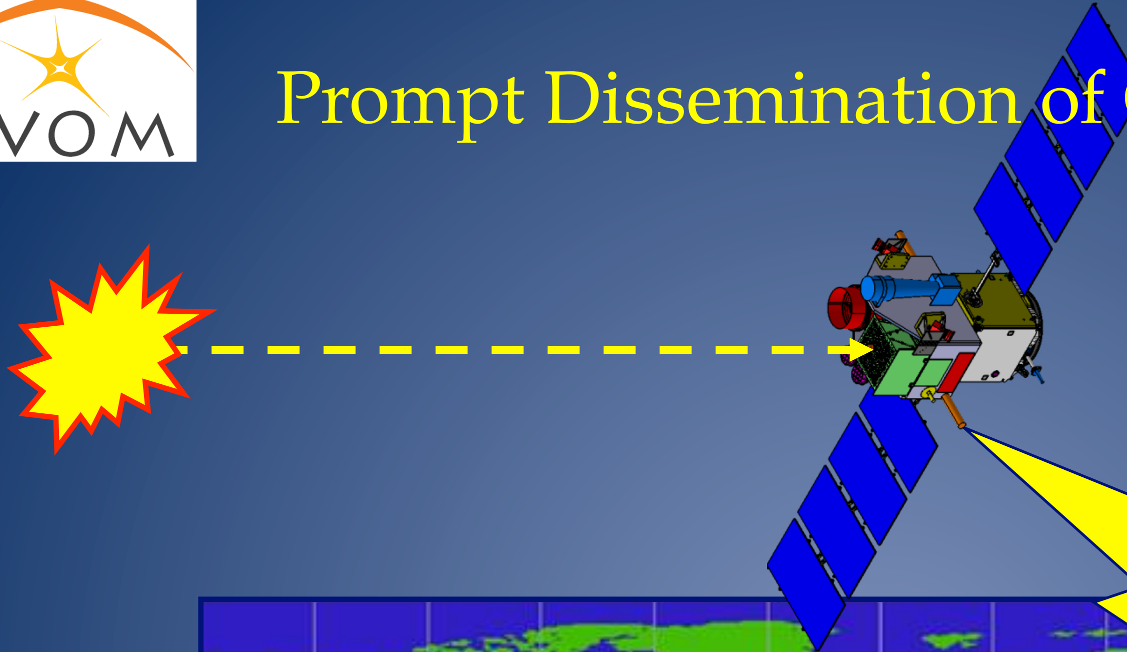
Orbit: LEO (625-650 km) with an inclination of ~30° & Anti-Sun pointing

Avoidance of the Galactic Centre as well as the brightest X-ray sources

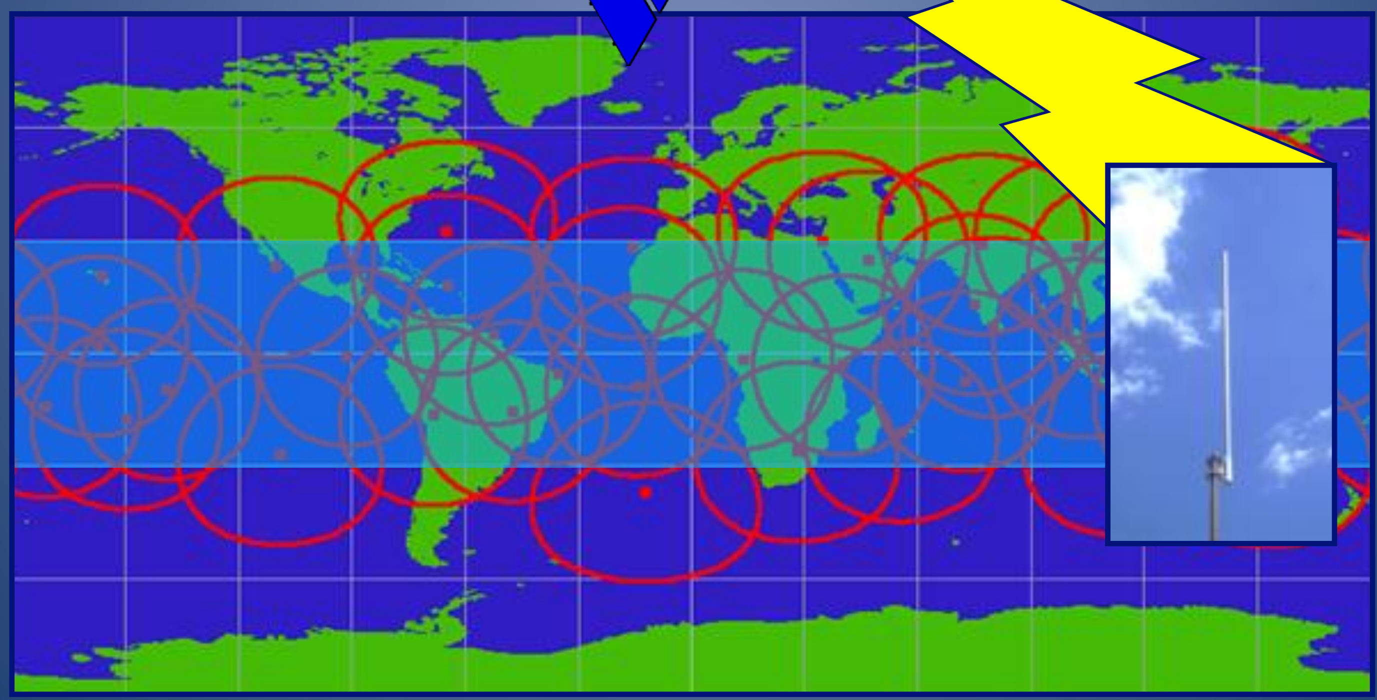


Most of the GRBs (up to 75-80%) detected by SVOM to be well above the horizon of large ground based telescopes all located at tropical latitudes

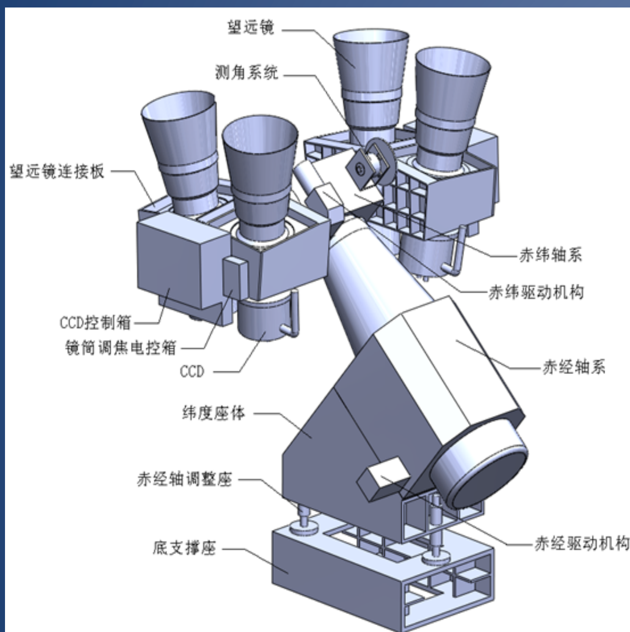
Prompt Dissemination of GRB Parameters



Alerts are transmitted to a network of 30-40 VHF receivers on Earth by the on-board VHF emitter.
Goal: 65% of the alerts received within 30 sec



GWAC – The Ground Wide Angle Cameras



- **Cameras: 36**
- **Diameter: 180mm**
- **Focal Length: 213mm**
- **Wavelength: 450—900nm**
- **Total FoV: 5000Sq.deg**
- **Limiting Mag: 16.0V（5σ，10sec）**
- **Self Trigger: <15sec**

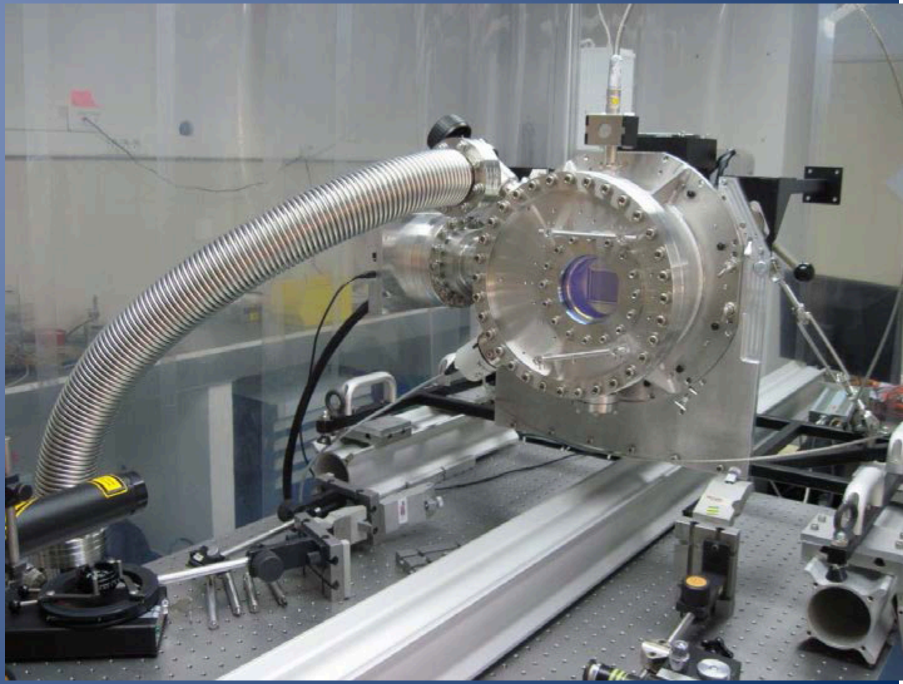
Prompt optical emission detection down to $M_V \sim 16.0$ (10 s exposure)

GFT: Two Ground-based Follow-up Telescopes

- GFTs are two 1-meter robotic telescopes, with imaging cameras
  - GFT-1 is a Chinese telescope at Xinglong observatory (TNT / EST)
  - GFT-2 is a French-led project, discussions are undergoing with the San Pedro Mártir Observatory in Mexico and LCOGT to host the telescope.

    GFT-2 will have two cameras: 1 visible and 1 NIR (below)

GFTs permit the fast identification and measure of early optical/NIR afterglows (light-curve, SED) from the ECLAIRs positions, while the spacecraft is slewing to the source



SVOM unique capabilities for GRB studies

- Low energy threshold at 4 keV to detect soft GRBs
- Measure of GRB prompt emission over 6 decades in energy, from 1 to ~10^6 eV.
- Good sensitivity to short GRBs with GRM and ECLAIRs (soft bump)
- Many consecutive orbits with the same pointing allowing the detection of hour long transients, like the 15000 sec long GRB 111209A at z=0.677
- Good sensitivity of VT, providing accurate GRB positions for >70% of the bursts. Dedicated NIR & vis. ground follow-up telescopes increase this fraction to >80%
- Large fraction of the afterglows seen by both MXT and VT.
- GRBs well located for ground based follow-up

SVOM: getting GRBs with redshifts

- SVOM has been designed to provide a larger fraction of GRBs with a redshift (>50%), as compared to Swift (~33%):
  - The pointing strategy provides a high fraction of GRBs suitable for fast follow-up with large telescopes on Earth
  - The good sensitivity of the VT will result in ≥70% of SVOM GRBs having a well localized optical counterpart. VT positions will allow rapid but also delayed spectroscopic follow-up.
  - Dark bursts not seen by VT will be rare and they will be quickly observed by the GFTs and by other ground-based NIR imagers. NIR follow-up will increase the fraction of well localized GRBs to above 80%

- With its observing strategy optimized for the follow-up from the ground, SVOM is expected to provide each year as many GRBs with a redshift as Swift

Conclusions

- SVOM, like Swift, will be a highly versatile astronomy satellite, with built-in multi wave-length capabilities, autonomous repointing and dedicated ground follow-up.
- SVOM will have a broad science return thanks to its unique instrumental combination of 3 wide-field instruments: ECLAIRs, GRM, GWAC, and 3 narrow-field instruments: MXT, VT, GFTs.
- SVOM has the possibility to detect and localize short GRBs associated to GW events, even if it is challenging. Such a detection would represent the "holy grail" of GW astronomy.
- A Memorandum of Understanding was signed on August 2, 2014 in Beijing between ***Jean-Yves Le Gall*** (CNES) and ***Xu Dazhe*** (CNSA), for a launch of SVOM in 2021.

NAOC, Beijing
IHEP, Beijing
XIOPM, Xi'an
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APC, Paris
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LAM, Marseille
Obs Strasbourg
LPAG Grenoble
LUPM Montpellier
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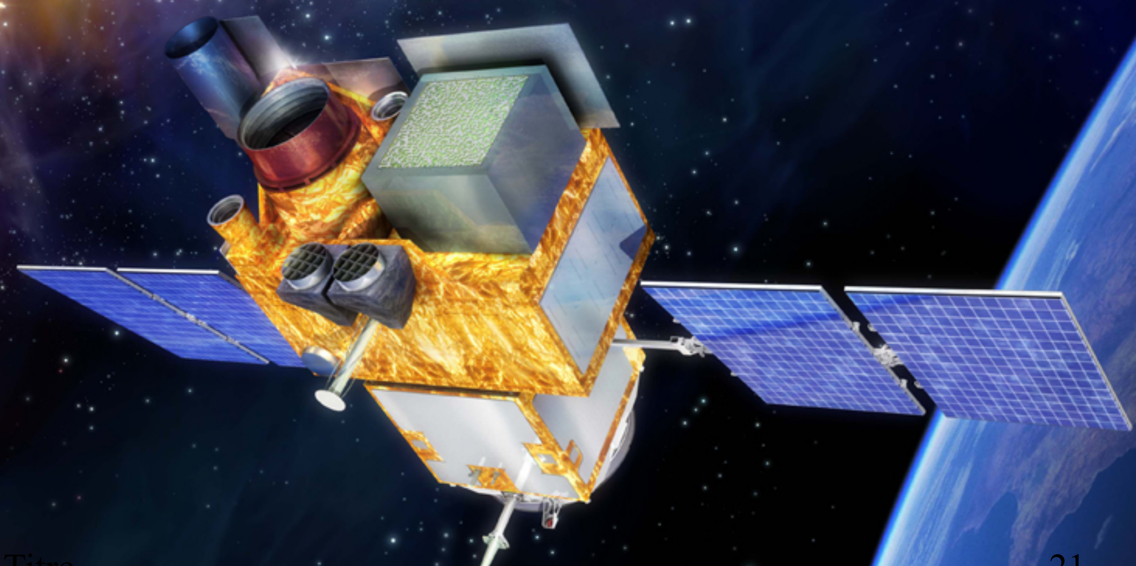
GEPI Meudon
LPC2E Orléans
University of Leicester
MPE, Garching
CNES, Toulouse

GO SVOM !

去 SVOM !



launch 2021

Phase B kick-off 2014