# The SVOM GRB mission

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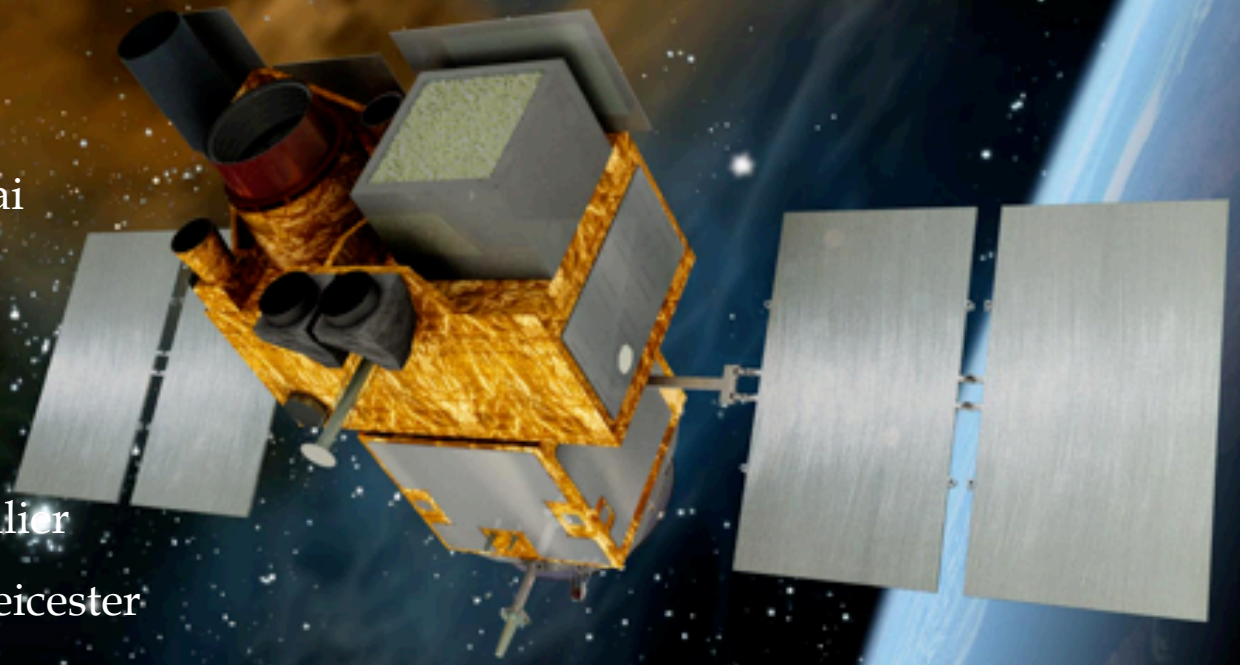
On behalf of the SVOM consortium



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 is a ***Chinese-French space mission*** dedicated to the detection and study of GRBs and their use for astrophysics and 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.

  **But 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.

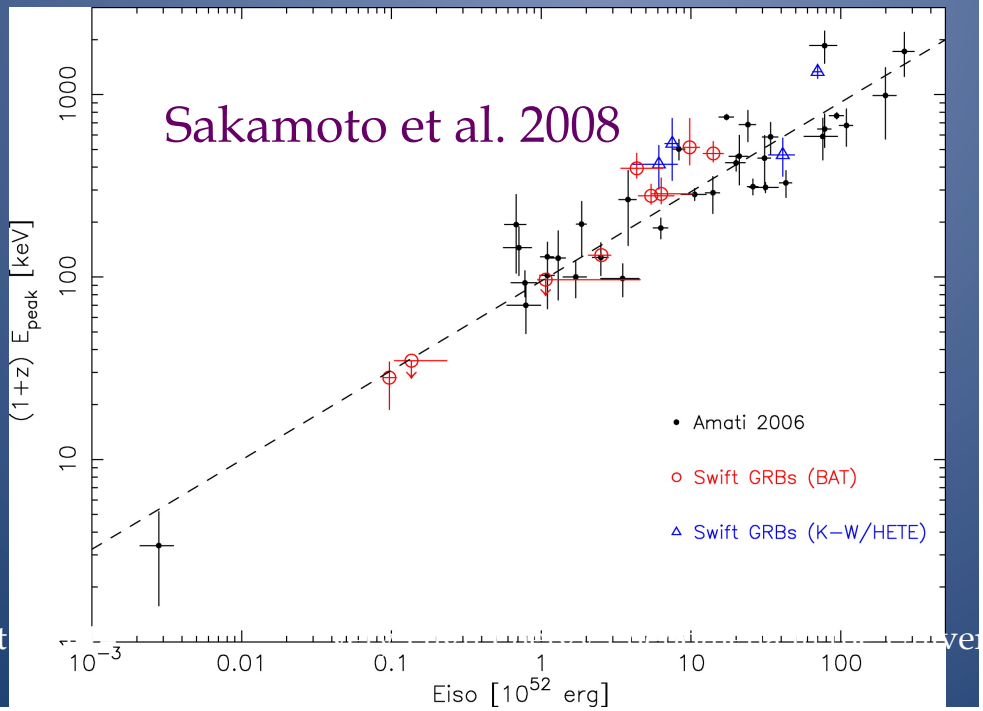
# Highly redshifted GRBs

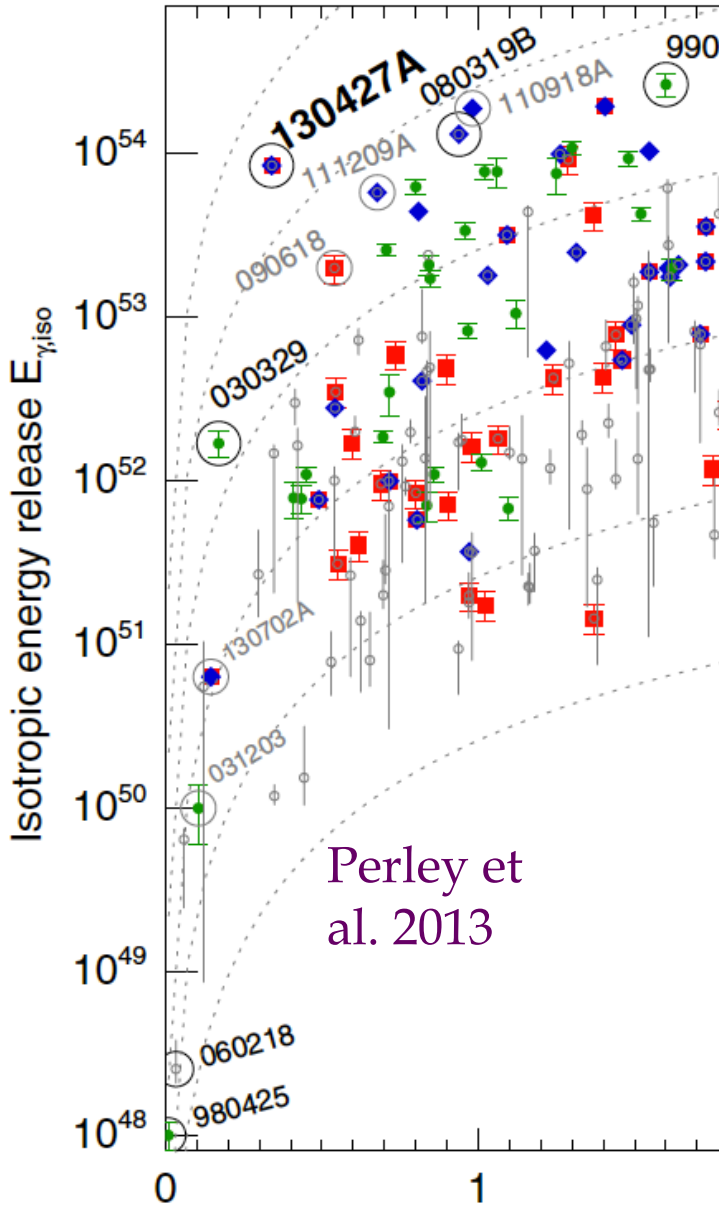
- We expect to detect ~5 GRBs/yr at redshift z>5 with ECLAIRs.
- We aim to quickly identify high-z GRBs, thanks to the pointing strategy of SVOM, the sensitivity of VT, and fast NIR follow-up on the ground (see next slides). This will permit optical spectroscopy of most of highly redshifted afterglows, 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)

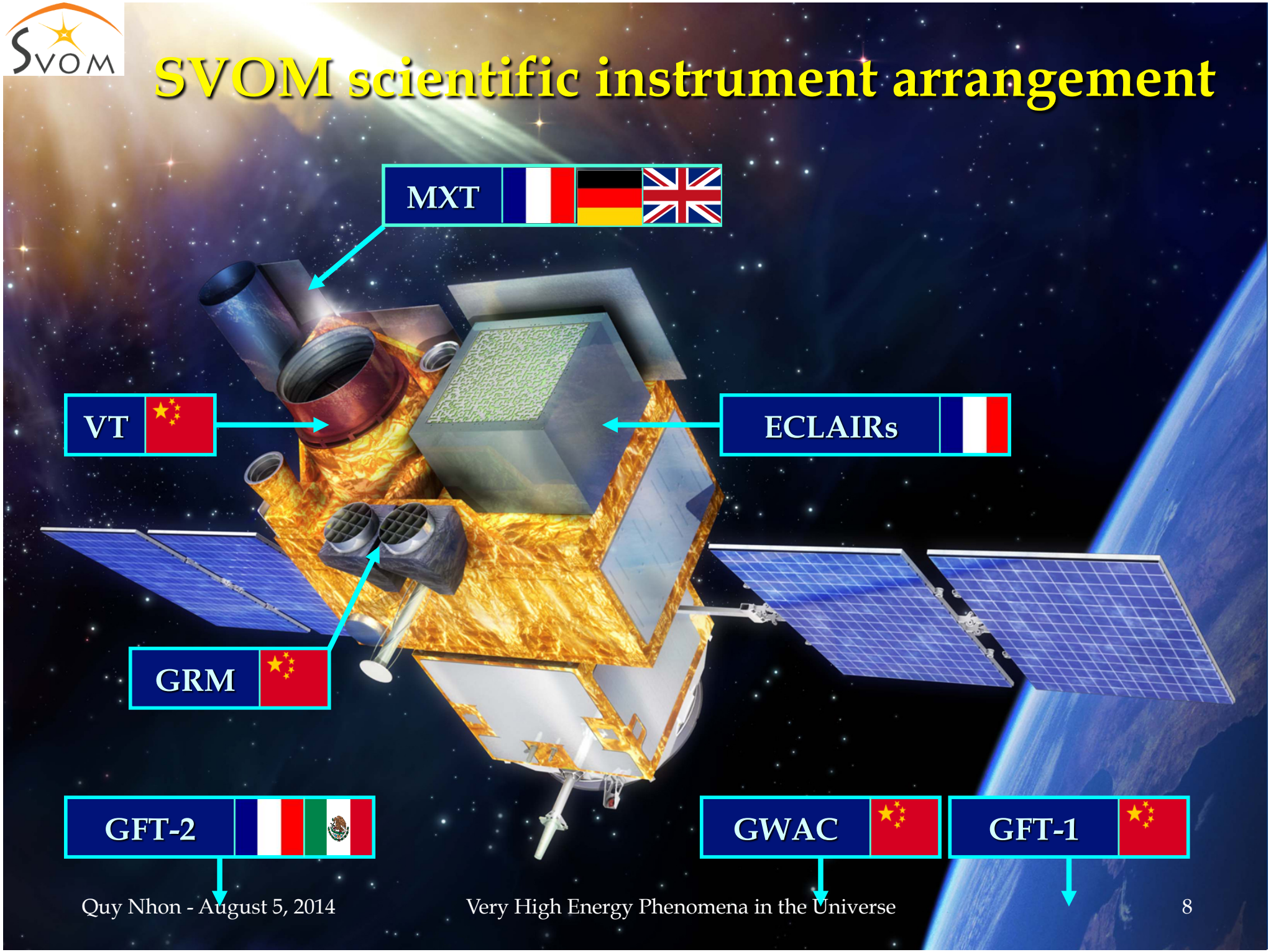
# Low-luminosity GRBs and the SN-GRB connection

- 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

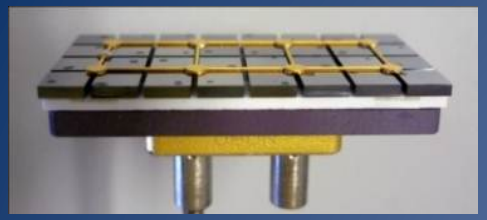


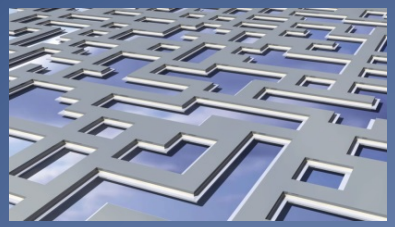



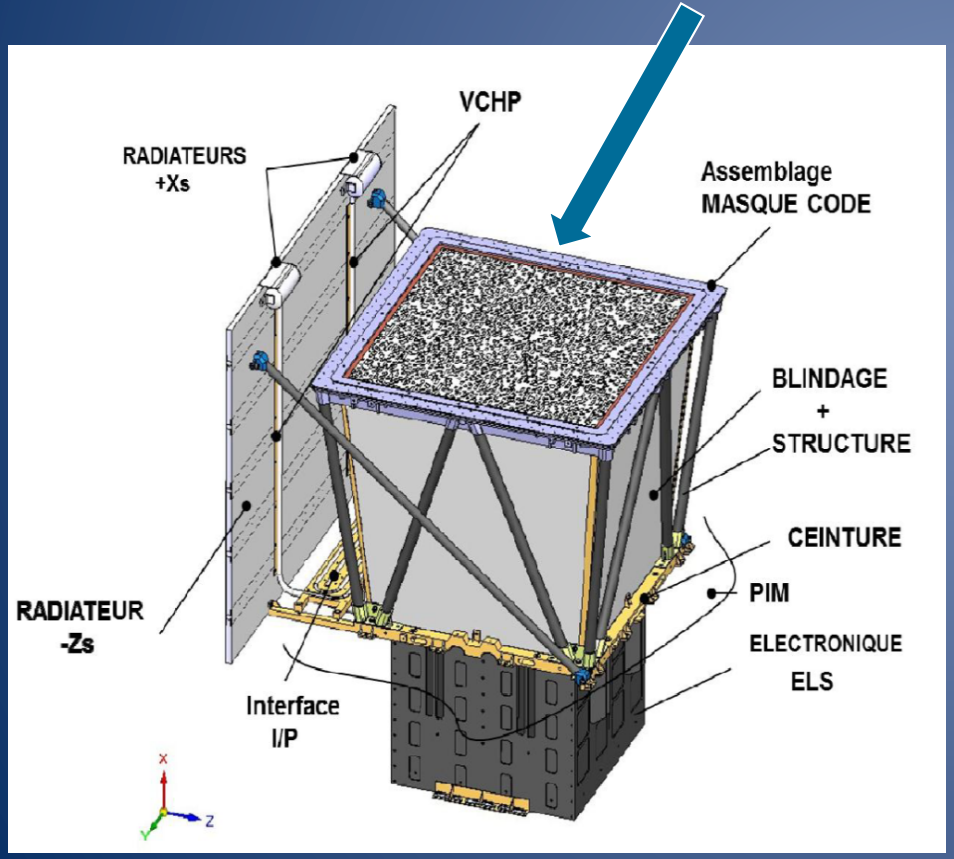
# SVOM scientific instrument arrangement



# ECLAIRs – The trigger camera







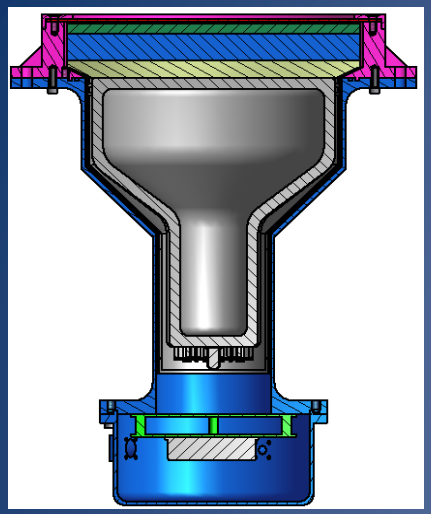

## Main characteristics

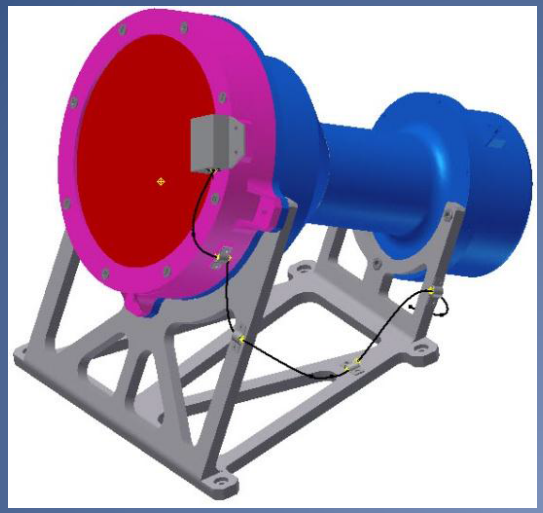
Coded mask telescope
Wide FOV : 2 Sr
6400 CdTe - 1024 $cm^2$
4 keV – 150 keV

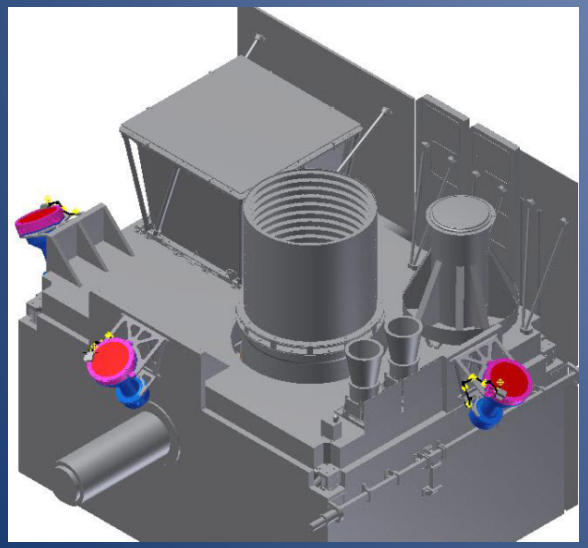
## Anticipated performance

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

# GRM – The Gamma Ray Monitor







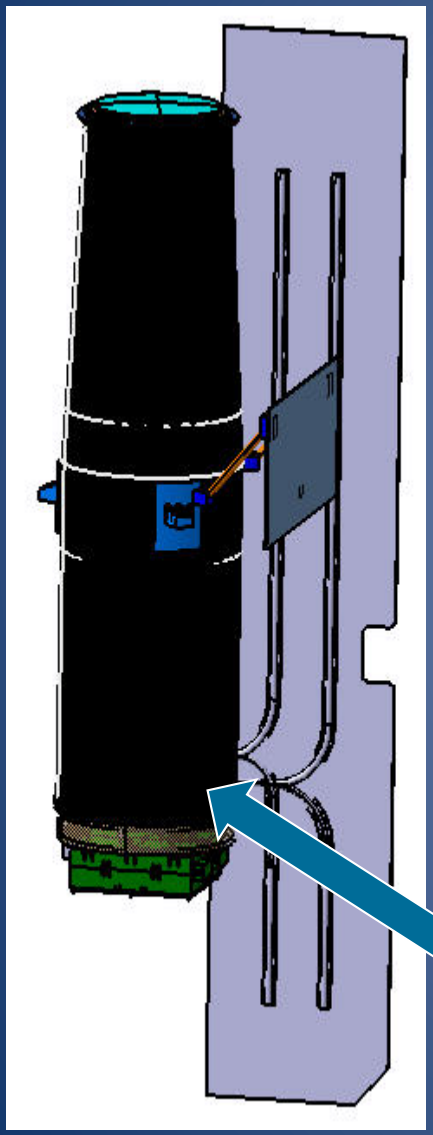
## Main characteristics

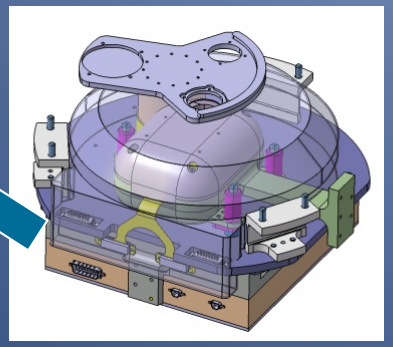
3 NaI detectors, 280 $cm^2$ each
FOV : 3x2 Sr
50 keV – 5 MeV

## Anticipated performances

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

# MXT – The Multi-channel X-ray Telescope





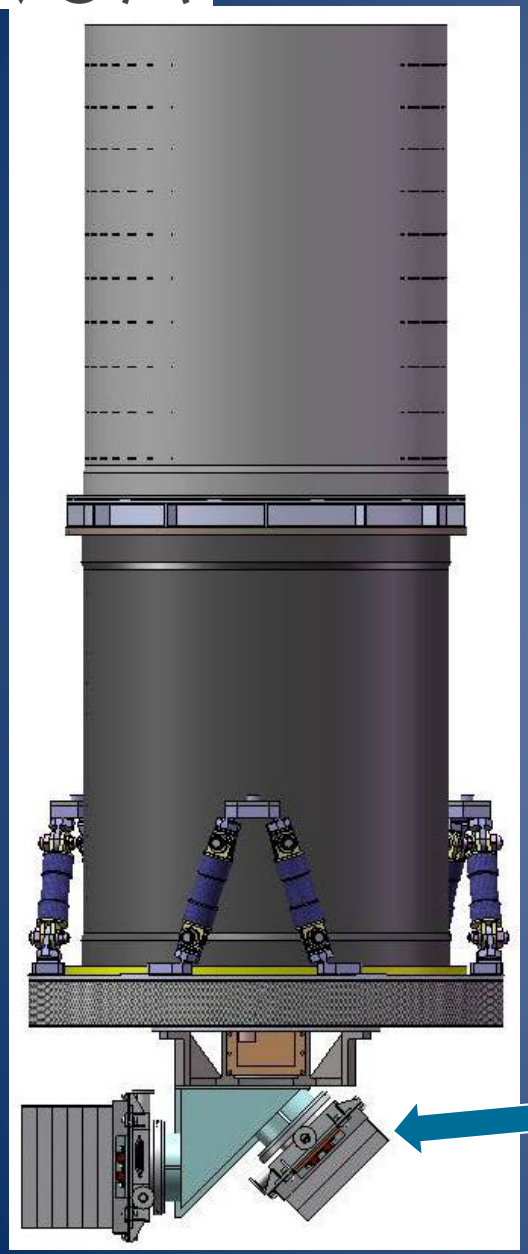
**Main characteristics**

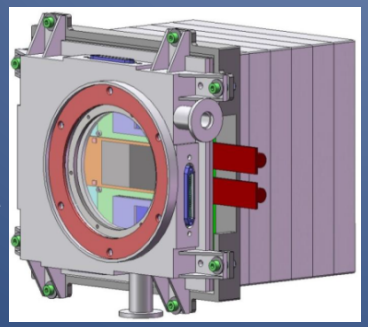
MCP X-ray optic
FOV ~ 1 deg$^2$
256 x256 PN CCD
0.3 keV – 10 keV

**Anticipated performances**

Loc. accuracy < 1 arcmin
20 arcsec for bright GRB
5x10$^{-12}$ erg cm$^{-2}$ s$^{-1}$ in 1000s

# VT – The visible telescope





## Main characteristics

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

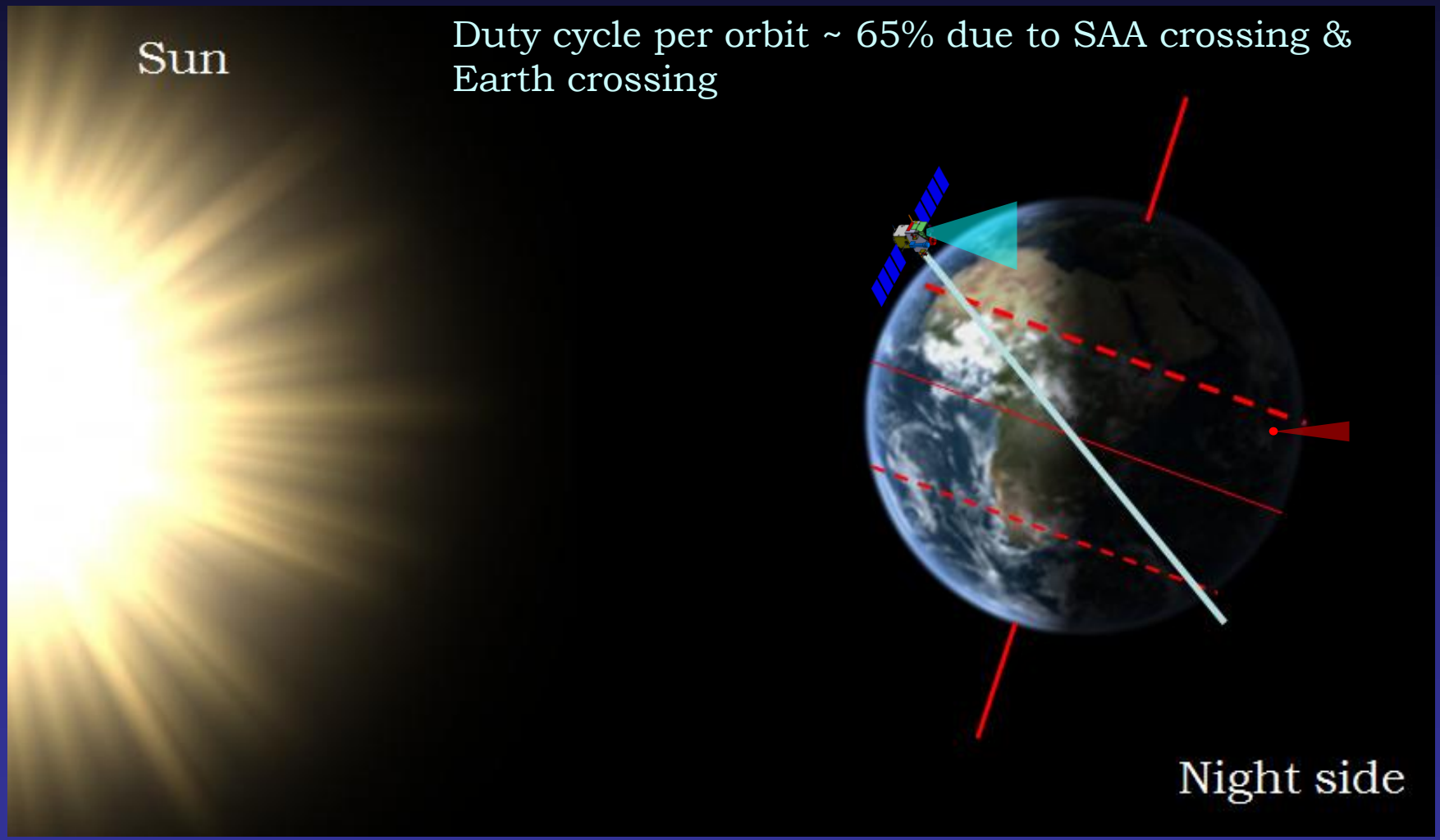
## Anticipated performances

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

# SVOM orbit

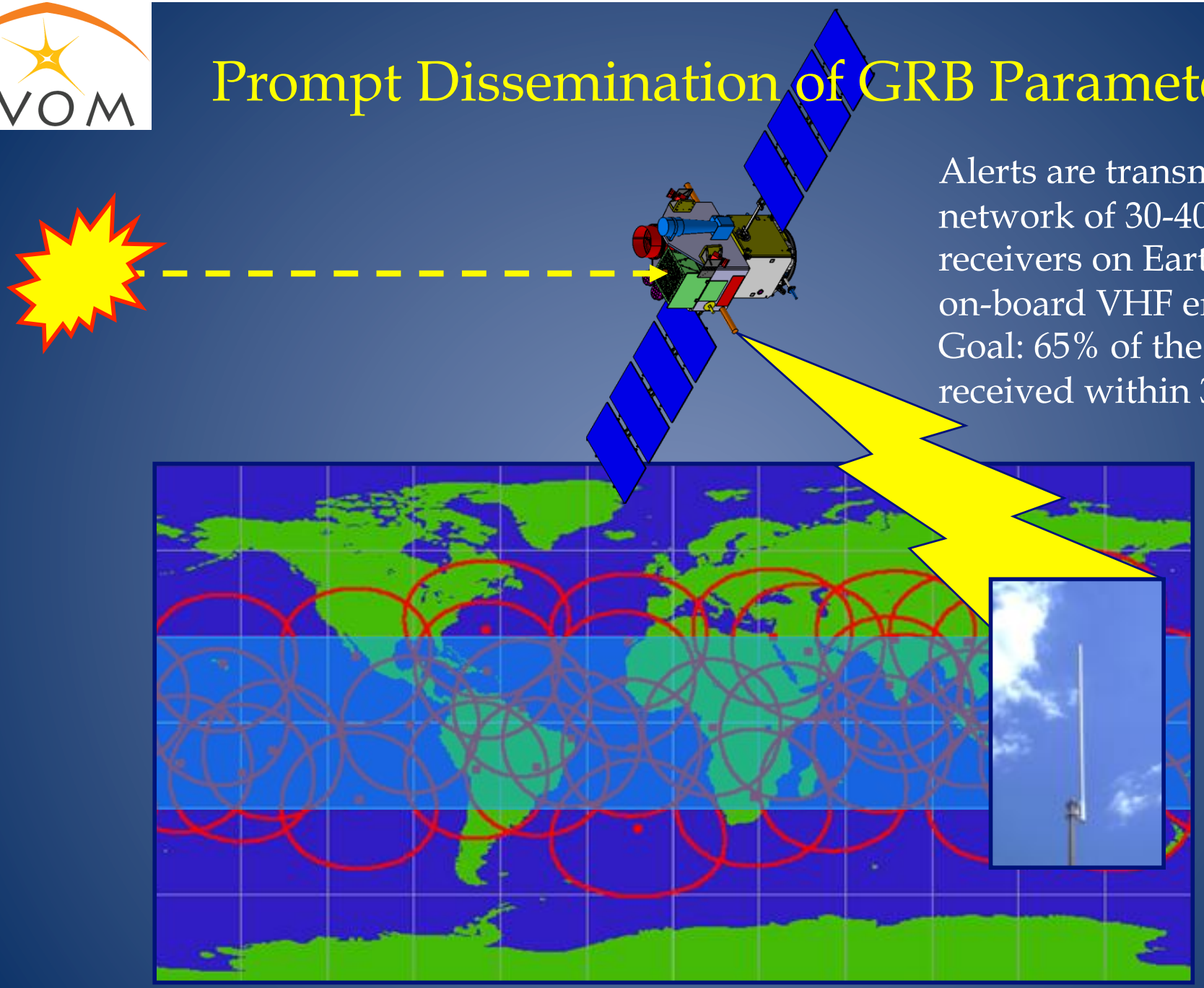
Orbit: LEO (625-650 km) with an inclination of ~30° & Anti-Sun pointing

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



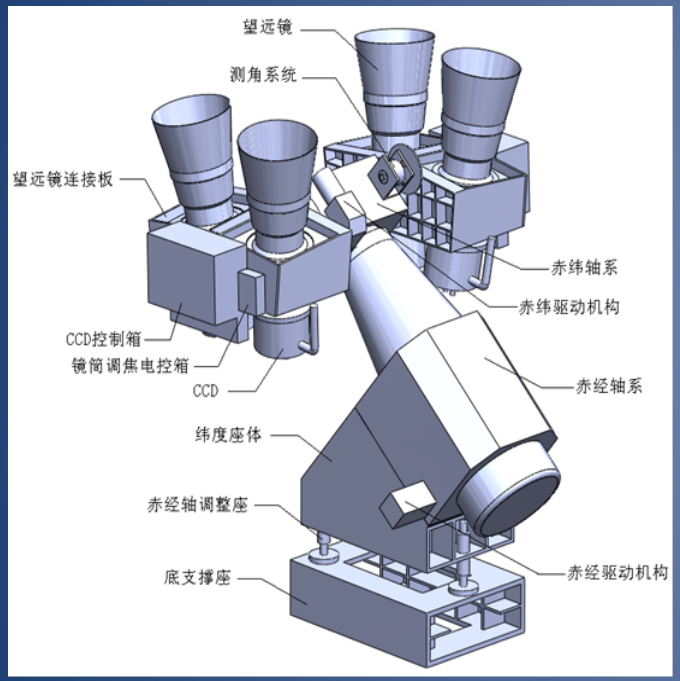

Most of the GRBs (up to 75-80%) detected by SVOM to be well above the horizon of large ground based telescopes all located at tropical latitudes

# 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



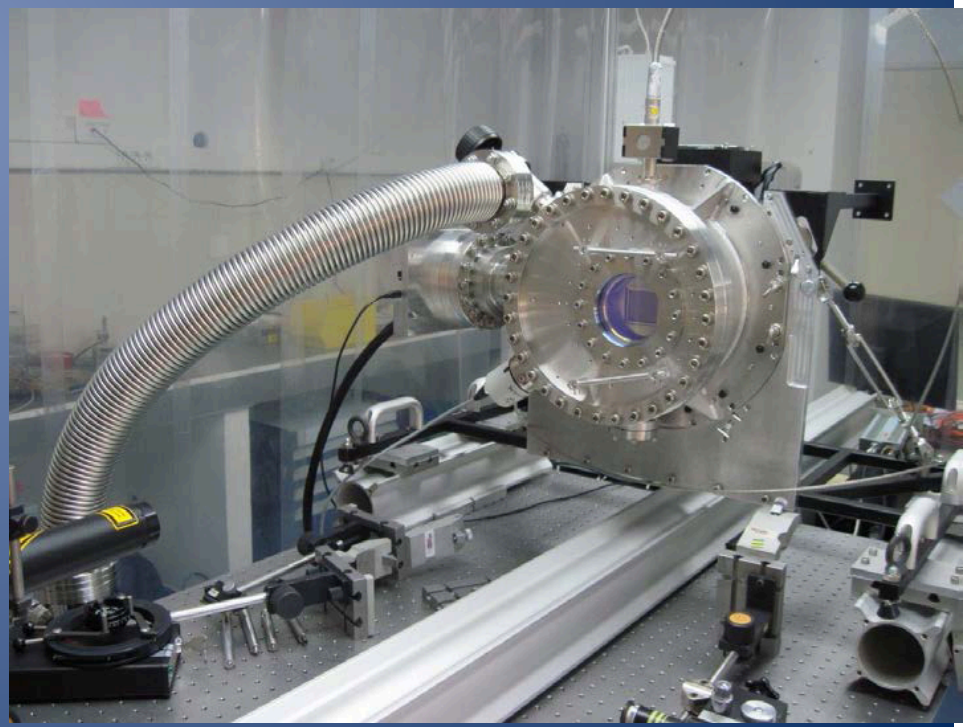

- Cameras: 36
- Diameter: 180mm
- Focal Length: 213mm
- Wavelength: 450—900nm
- Total FoV: 5000Sq.deg
- Limiting Mag: 16.0V（5σ，10sec）
- Self Trigger: <15sec

**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

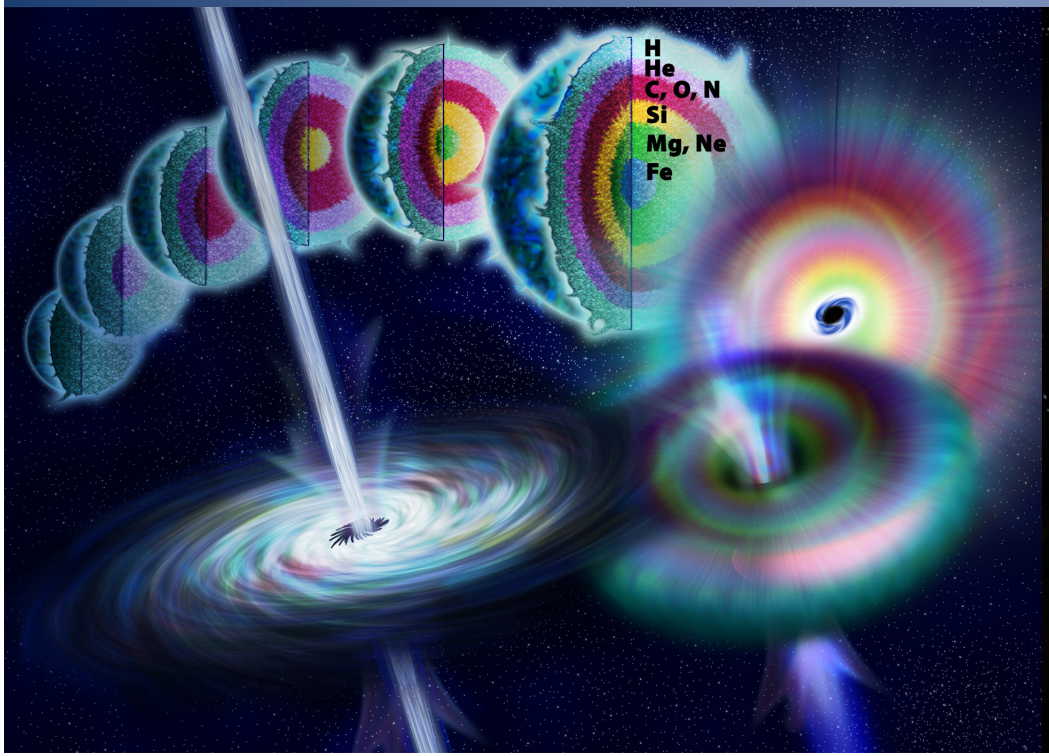
- SVOM has been designed to provide a larger fraction of GRBs with a redshift (>50%), as compared to Swift (~33%):
  - The pointing strategy provides a high fraction of GRBs suitable for fast follow-up with large telescopes on Earth
  - The good sensitivity of the VT will result in ≥70% of SVOM GRBs 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%

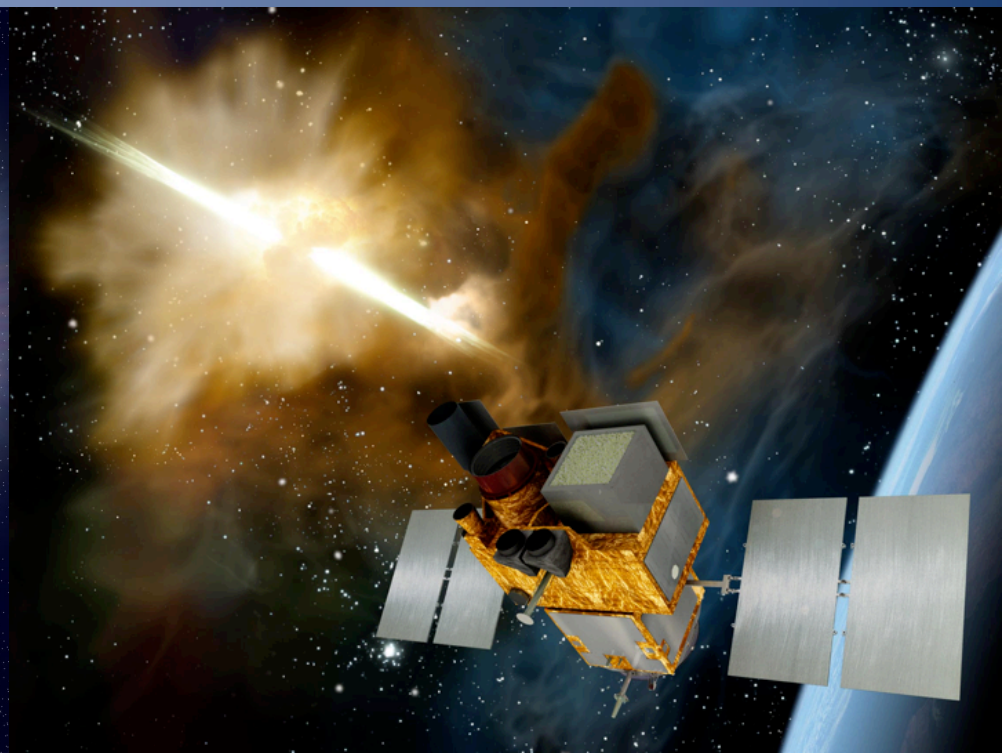
- With its observing strategy optimized for the follow-up from the ground, SVOM is expected to provide each year as many GRBs with a redshift as Swift

# 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 last week between ***Jean-Yves Le Gall*** (CNES) and ***Xu Dazhe*** (CNSA), for a launch of SVOM in 2021.

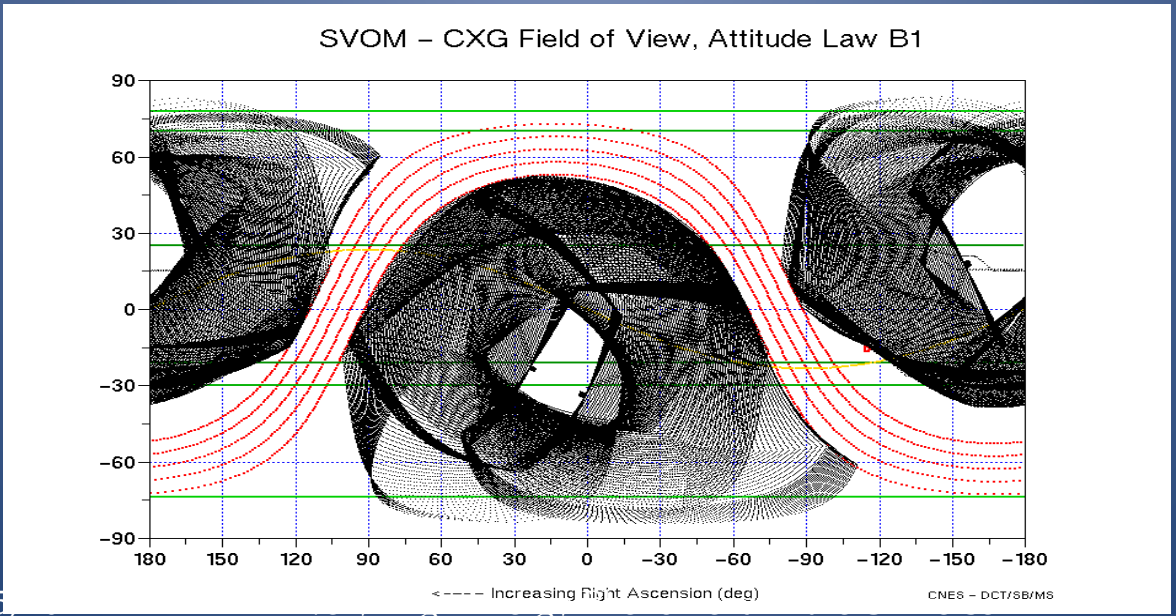
# The end



# SVOM attitude law

Objective: to favor the redshift measurement by the large telescopes on ground

Solution: the attitude law (optimization at system level)

- Offset of 45° with respect to the antisolar direction
- Avoidance of the Galactic Plane (+/- 10° for the ECLAIRs FOV )
- avoidance of the the Sco X1source ( outsite of the ECLAIRs FOV)
- If possible, edge of the ECLAIRs FOV at low latitudes
- Tolerance of 5° with respect to the nominal pointing