# THE SVOM MISSION

Bertrand Cordier & Wei Jianyan

on behalf on the Svom collaboration

2019 Nanjing GRB conference

# THE SVOM CONSORTIUM

- **China (PI J. Wei)**
  - SECM Shanghai
  - Beijing Normal University
  - Central China University Wuhan
  - Guangxi University Nanning
  - IHEP Beijing
  - KIAA Peking University
  - Nanjing University
  - NAOC Beijing
  - National Astronomical Observatories
  - Purple Mountain Observatory Nanjing
  - Shanghai Astronomical Observatory
  - Tsinghua University Beijing

- **France (PI B. Cordier)**
  - CNES Toulouse
  - APC Paris
  - CEA Saclay
  - CPPM Marseille
  - GEPI Meudon
  - IAP Paris
  - IRAP Toulouse
  - LAL Orsay
  - LAM Marseille
  - LUPM Montpellier
  - OAS Strasbourg

Taking into account the feedback from

***Neil Gehrels Swift obs. & Fermi***
*for space observations*

***TAROT***
*for ground observations*

- **Mexico** UNAM Mexico

- **UK** University of Leicester

- **Germany**
  - MPE Garching
  - IAAT Tübingen

Frédéric Daigne and Bing Zhang are the mission scientists in charge of the core program

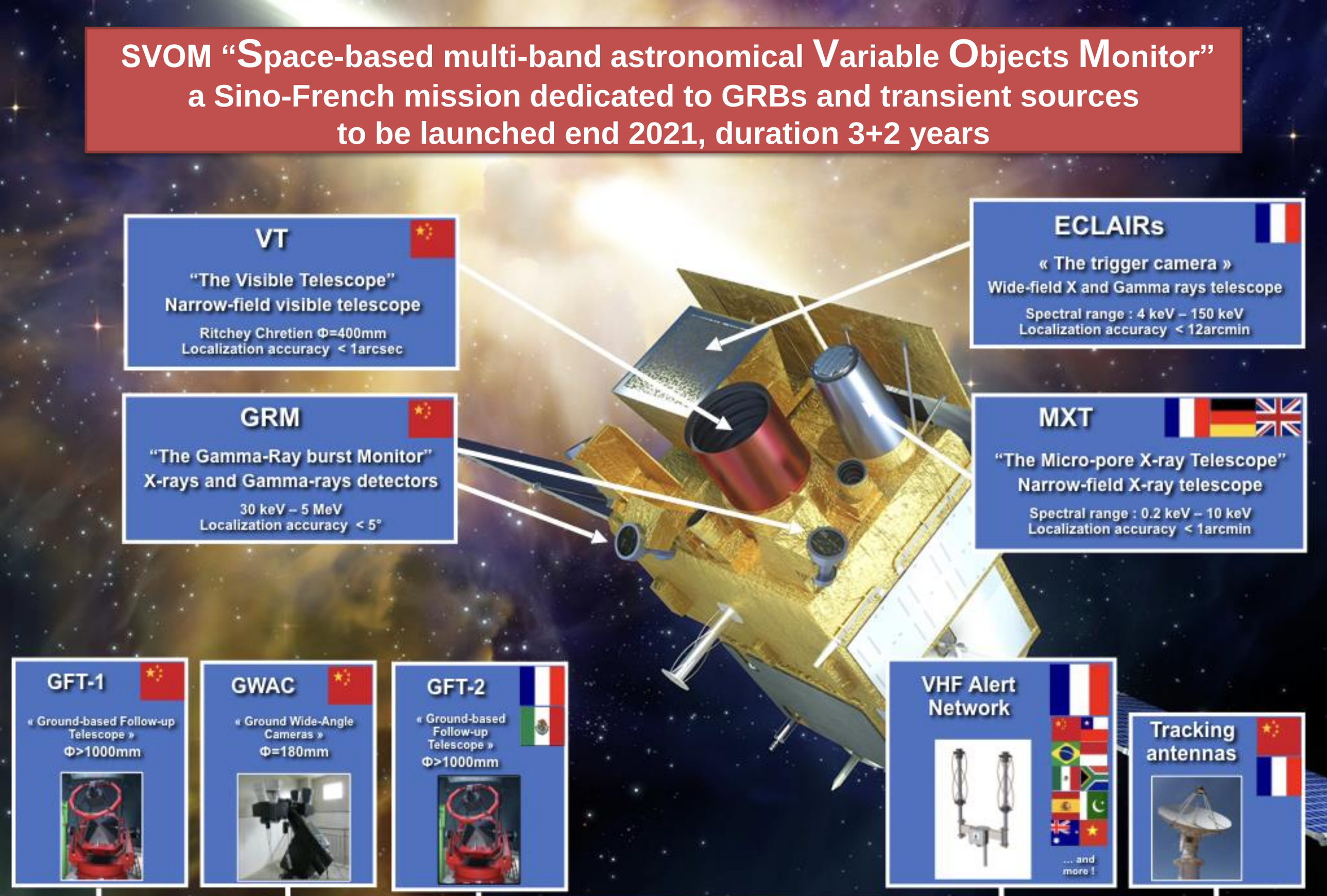
# SVOM "Space-based multi-band astronomical Variable Objects Monitor"
## a Sino-French mission dedicated to GRBs and transient sources
## to be launched end 2021, duration 3+2 years

### VT
"The Visible Telescope"
Narrow-field visible telescope
Ritchey Chretien Φ=400mm
Localization accuracy < 1arcsec

### GRM
"The Gamma-Ray burst Monitor"
X-rays and Gamma-rays detectors
30 keV – 5 MeV
Localization accuracy < 5°

### ECLAIRs
« The trigger camera »
Wide-field X and Gamma rays telescope
Spectral range : 4 keV – 150 keV
Localization accuracy < 12arcmin

### MXT
"The Micro-pore X-ray Telescope"
Narrow-field X-ray telescope
Spectral range : 0.2 keV – 10 keV
Localization accuracy < 1arcmin



### GFT-1
« Ground-based Follow-up Telescope »
Φ>1000mm



### GWAC
« Ground Wide-Angle Cameras »
Φ=180mm



### GFT-2
« Ground-based Follow-up Telescope »
Φ>1000mm



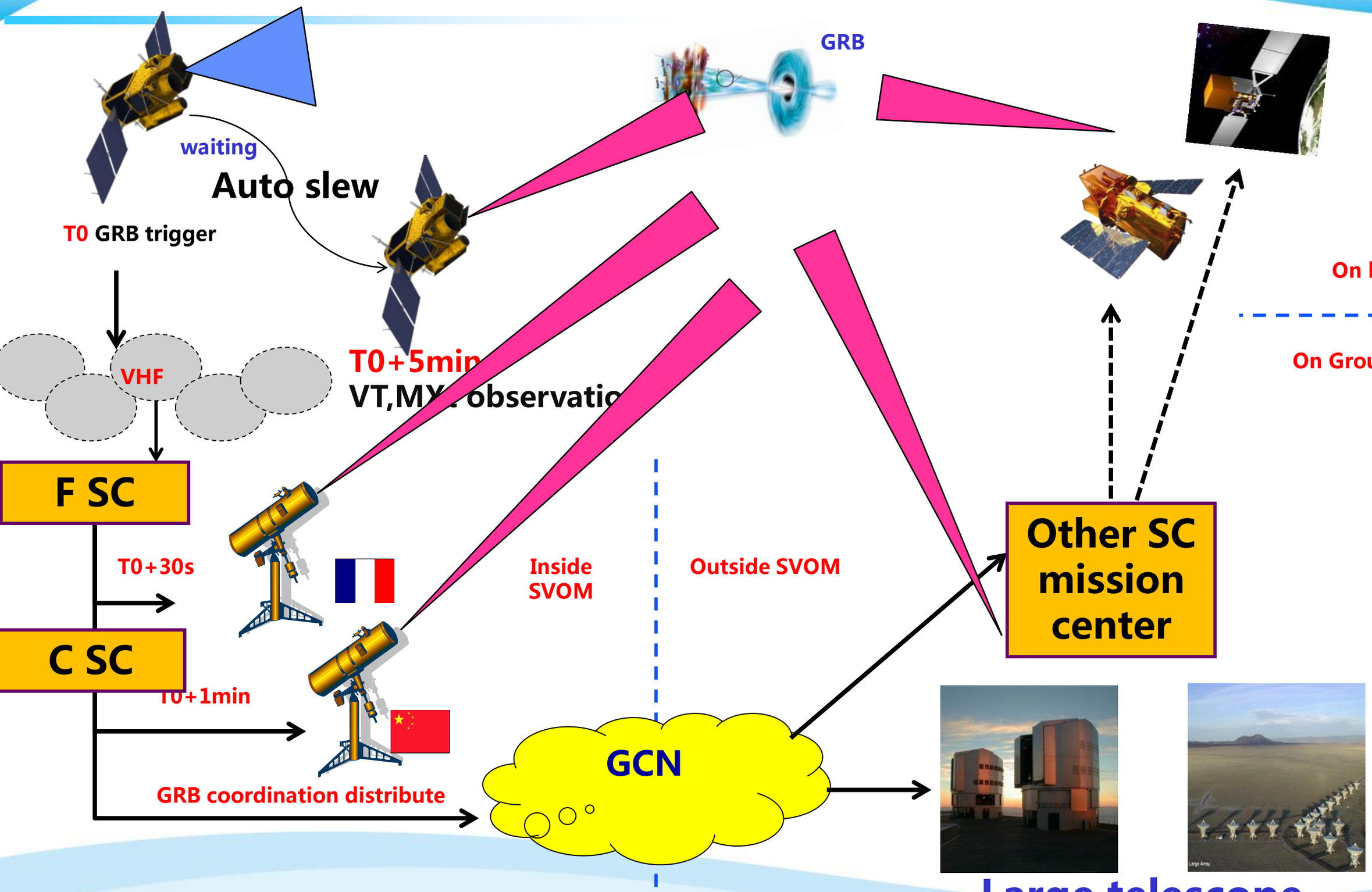
### VHF Alert Network



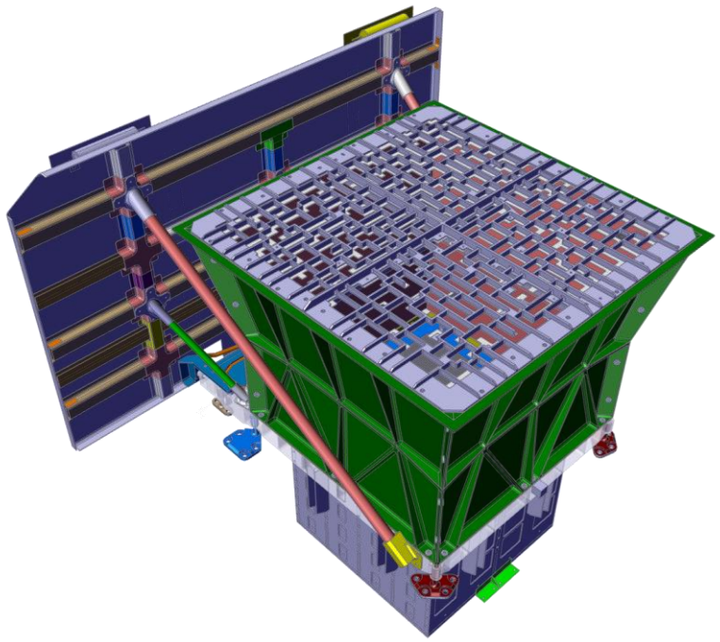
... and more !

### Tracking antennas

# GRB Observation scenario



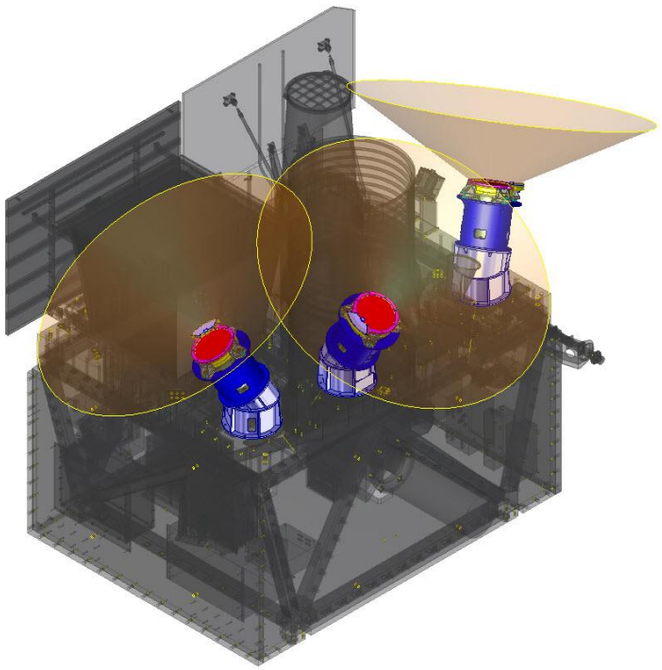
# INSTRUMENTS (with LARGE FIELD OF VIEW)



## ECLAIRs (CNES, IRAP, CEA, APC)

- 40% open fraction
- Detection plane: **1024 cm²**
- 6400 CdTe pixels (4x4x1 $mm^3$)
- FoV**: 2 sr** (zero sensitivity)
- Energy range: **4** - 150 keV
- Localization accuracy **<12 arcmin** for 90% of sources at detection limit
- Onboard trigger and localization: **~65 GRBs/year**

Well adapted for the detection of lGRB with low $E_{PEAK}$
-> See Nicolas Dagoneau talk

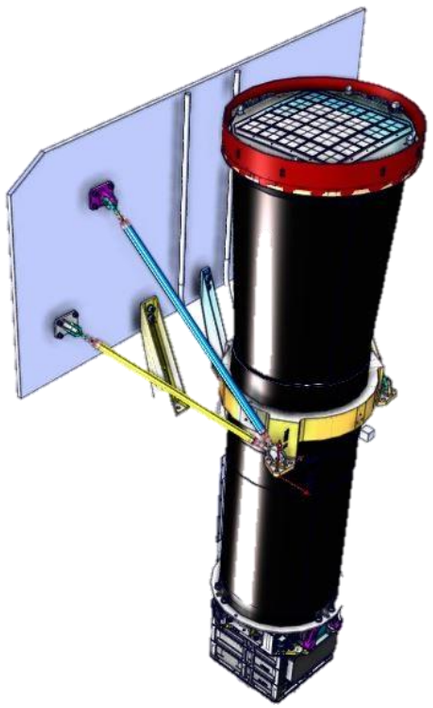


## GRM Gamma-Ray Monitor (IHEP)

- **3 Gamma-Ray Detectors** (GRDs)
- NaI(Tl) (16 cm Ø, 1.5 cm thick)
- Plastic scintillator (6 mm) to monitor particle flux and reject particle events
- FOV: **5,6 sr** 3 GRDs, **1,0** intersection of 3 GRDs
- Energy range : 30-**5000** keV
- Aeff = **190 cm²** at peak
- Rough localization accuracy
- Expected rate: **~90 GRBs / year**

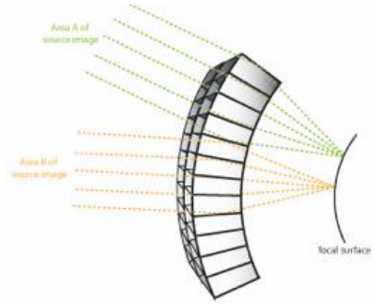
Will provide $E_{PEAK}$ measurements for most ECLAIRs GRBs
Will detect short GRBs in & out of the ECLAIRs FOV

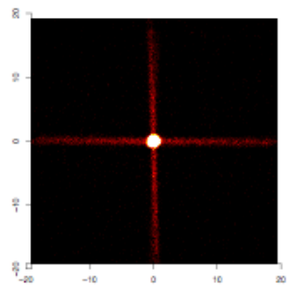
# INSTRUMENTS (with NARROW FIELD OF VIEW)



## MXT Micro-channel X-ray Telescope (CNES, CEA, UL, MPE)

- **Micro-pores optics** (Photonis) with **40 µm square pores** in a “Lobster Eye” conf. (UL design)
- pnCCD (MPE) based camera (CEA)
- FoV : **64x64 arcmin²**
- Focal length: 1 m
- Energy range : 0.2 – 10 keV
- Aeff = **27 cm² @ 1 keV** (central spot)
- Energy resolution: ~80 eV @ 1.5 keV
- Localization accuracy **<13 arcsec** within 5 min from trigger for 50% of GRBs (statistical error only)



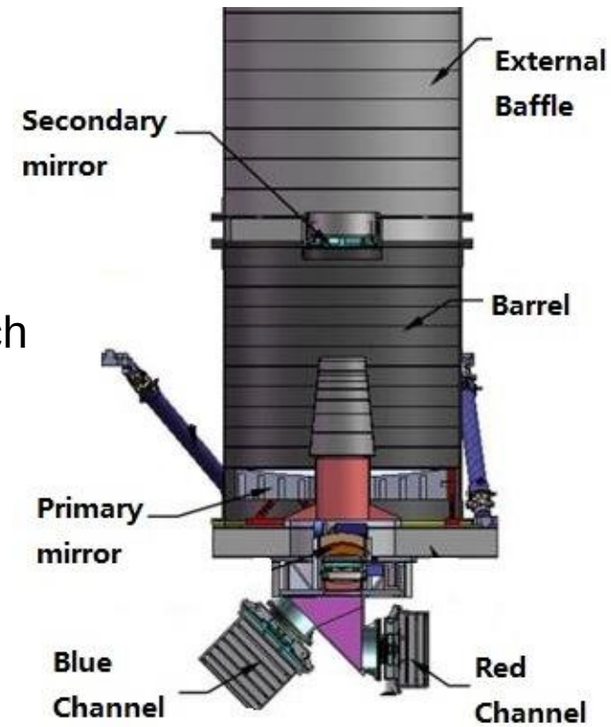



Implements innovative focussing X-ray optics based on « Lobster-Eye » design
Will reduce the ECLAIRs error box
Will be able to promptly observe the X-ray afterglow

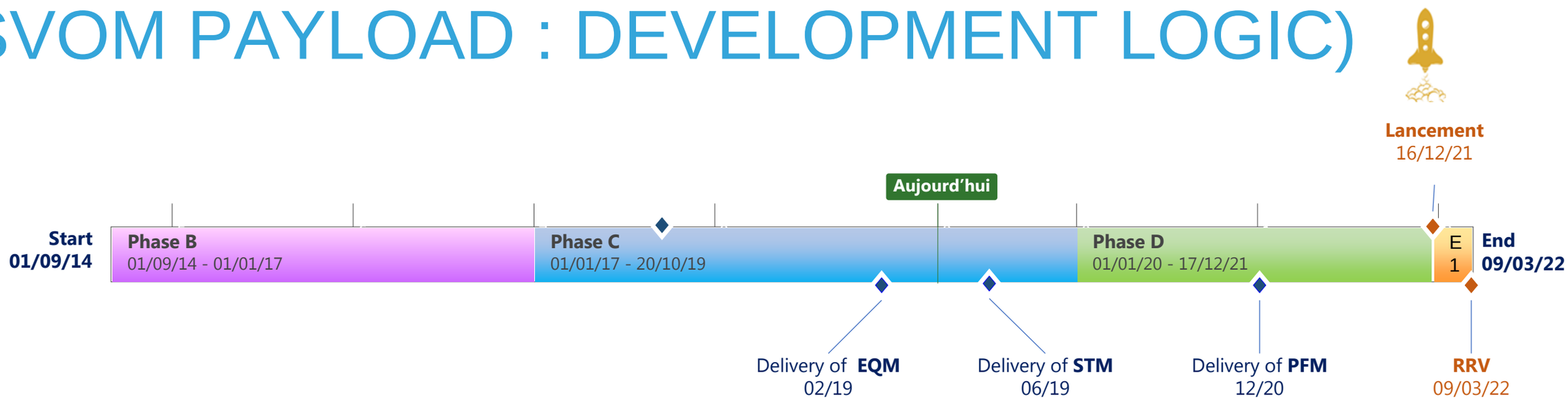
## VT Visible Telescope (XIOMP, NAOC)

- Ritchey-Chretien telescope, 40 cm Ø, f=9
- FoV: **26x26 arcmin²**, covering ECLAIRs error box in most cases
- **2 channels: blue (400-650 nm) and red (650-1000 nm),** 2k * 2k CCD detector each
- **Sensitivity MV=23 in 300 s**
- Will detect ~80% of ECLAIRs GRBs
- Localization accuracy **<1 arcsec**

Able to detect high-redshift GRBs up to z~6.5 (sensitivity cutoff around 950 nm)
Can quickly provide redshift indicators due to the presence of two channels



# SVOM PAYLOAD : DEVELOPMENT LOGIC)




## Proto Flight Model-oriented development logic

### Engineering and Qualification Model (electronic units): Delivered

- Objective: Mechanical, thermal and EMC qualification
- Participation in Flat Sat (Electrical + Functional) and QM Sat (Functional + Environmental Qualification) tests

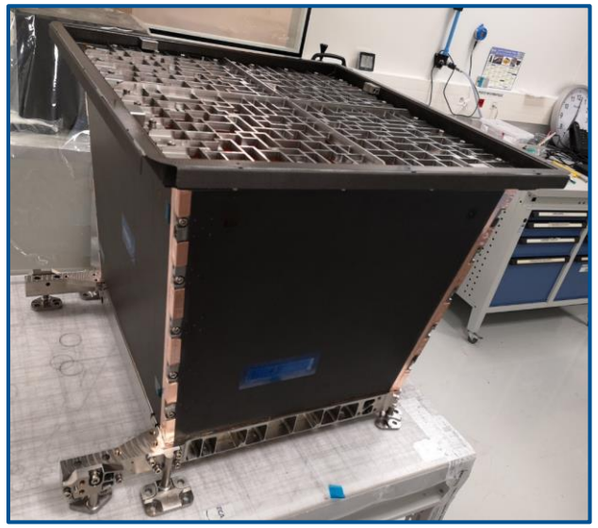
### Structural and Thermal Model : Integration in progress, Delivery summer 2019

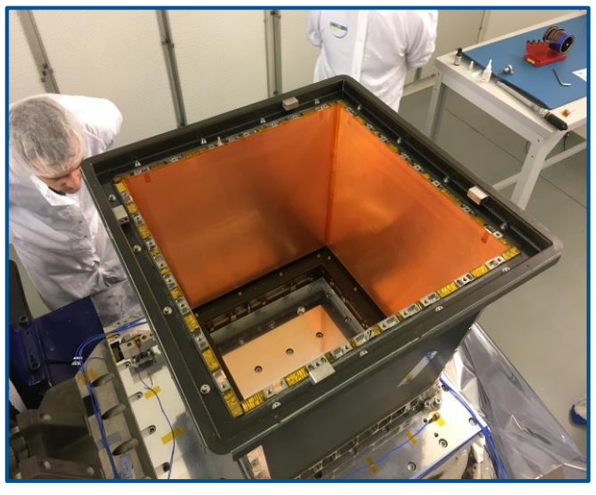
- Objective: Mechanical and thermal qualification of instrument level
- Validation of the integration sequence, Validation of the levels seen at the interfaces and in some critical points
- Participation in  Environmental Qualification tests of the satellite

### Proto Flight Model : Delivery at the end of 2020

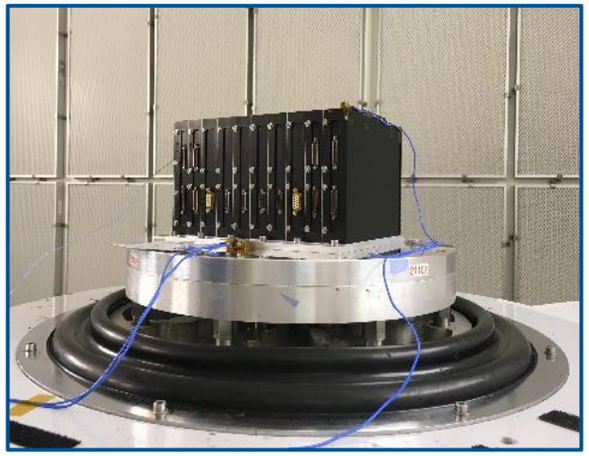
- Performance characterization
- Integration of the Proto Flight Model of the  satellite

## STM





## EQM

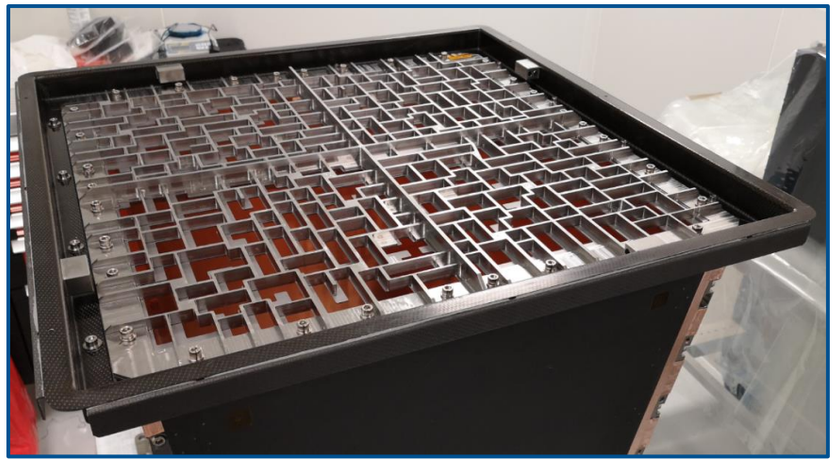


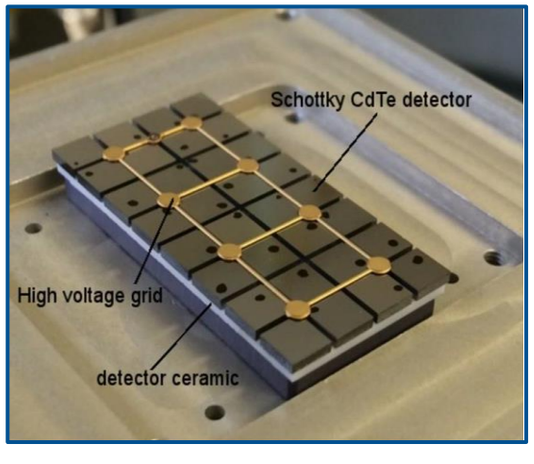
1. **ECLAIRs STM**
   - Shielding ready
   - Mask already qualified !
   - Thermal bus and DPIX ready
   - Integration at CNES

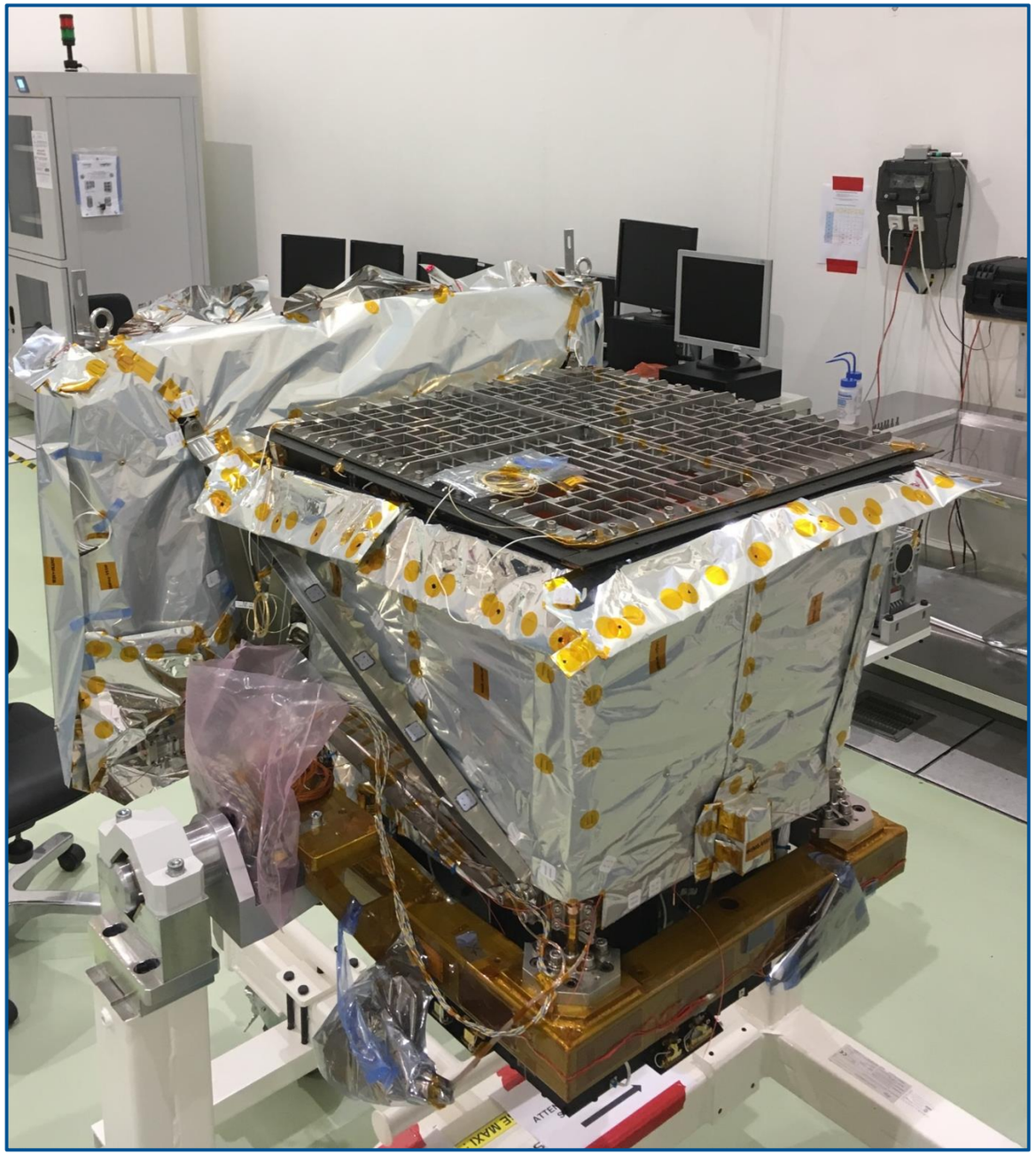
2. **ECLAIRs EQM**
   - Qualification tests (vibration, electrical) performed
   - Hardware / Software integration at CNES
   - Integration to the flat satellite model at SECM

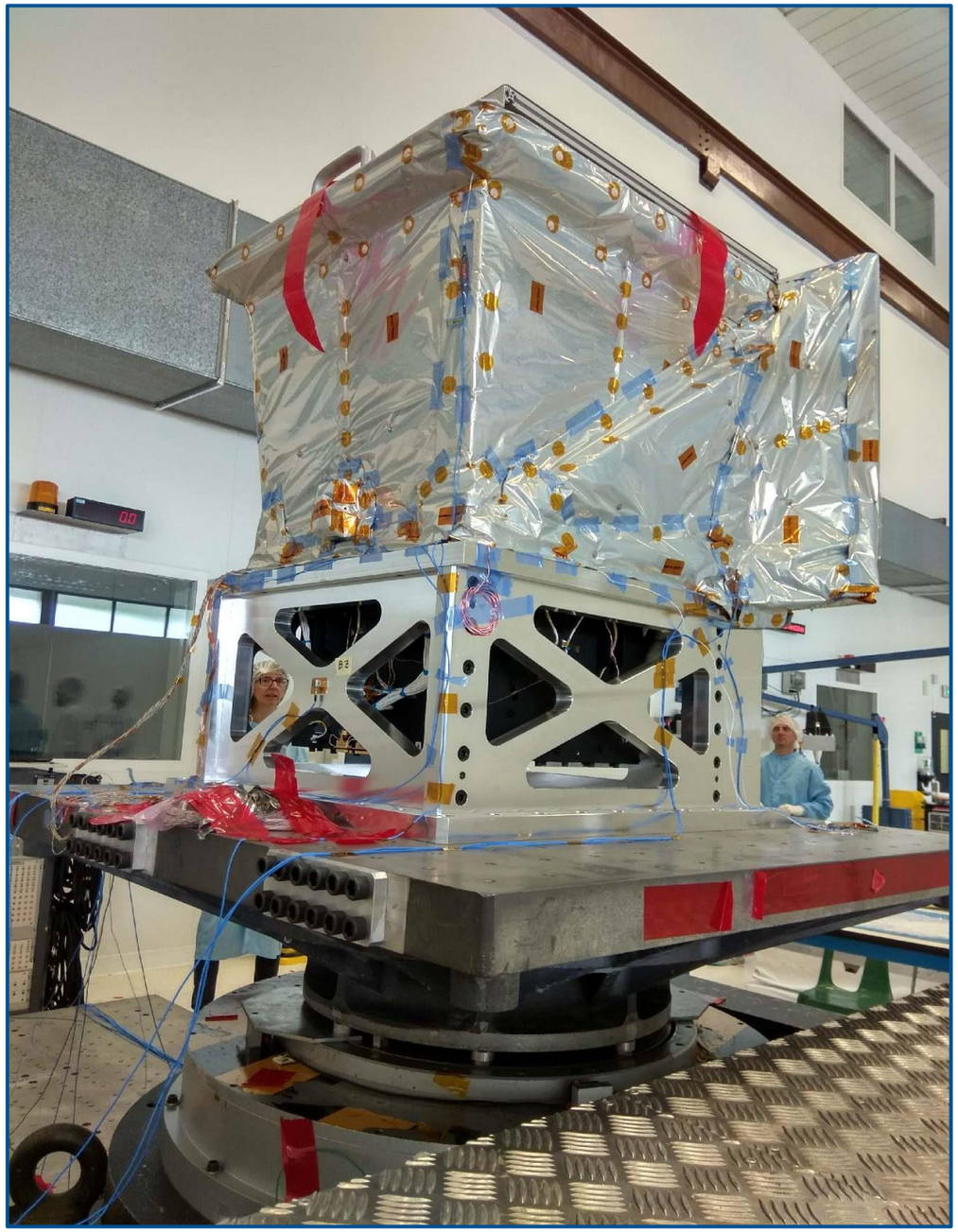
3. **ECLAIRs PFM fabrication**
   - All parts are procured (EEE components, detectors, MLI, connectors, …)
   - Waiting for sub-system qualification tests before going ahead in PFM fabrication

## PFM





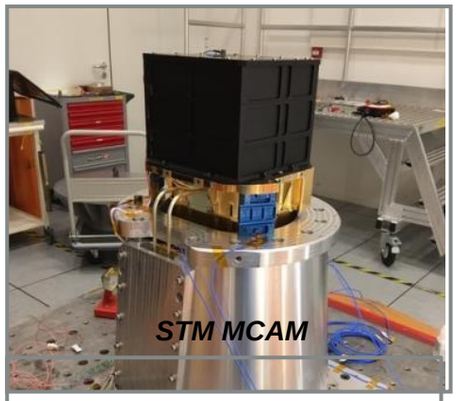



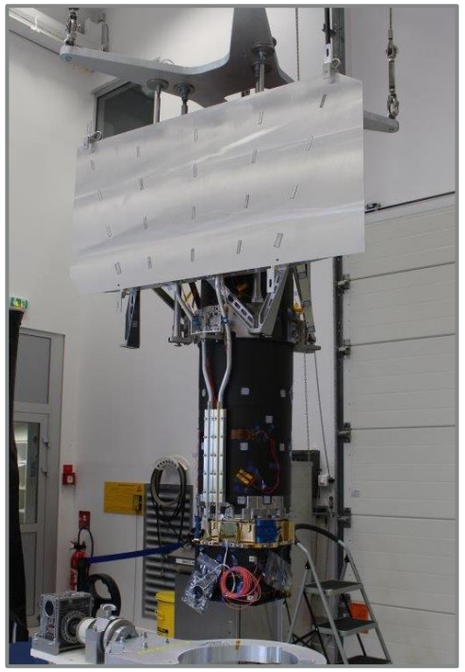


**ECLAIRs Structural and Thermal model ready for vibration tests**

**For a detailed description of ECLAIRs see the poster: ECLAIRs: the hard X-ray imager and trigger of SVOM**

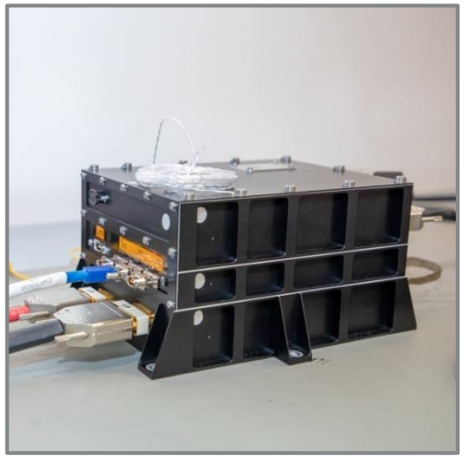
## STM

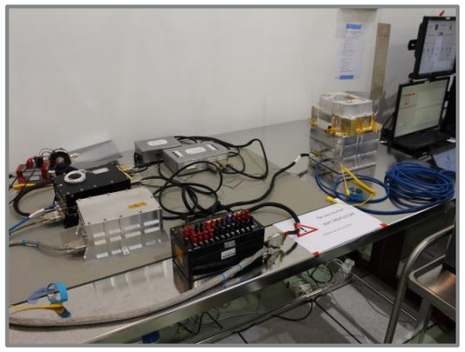


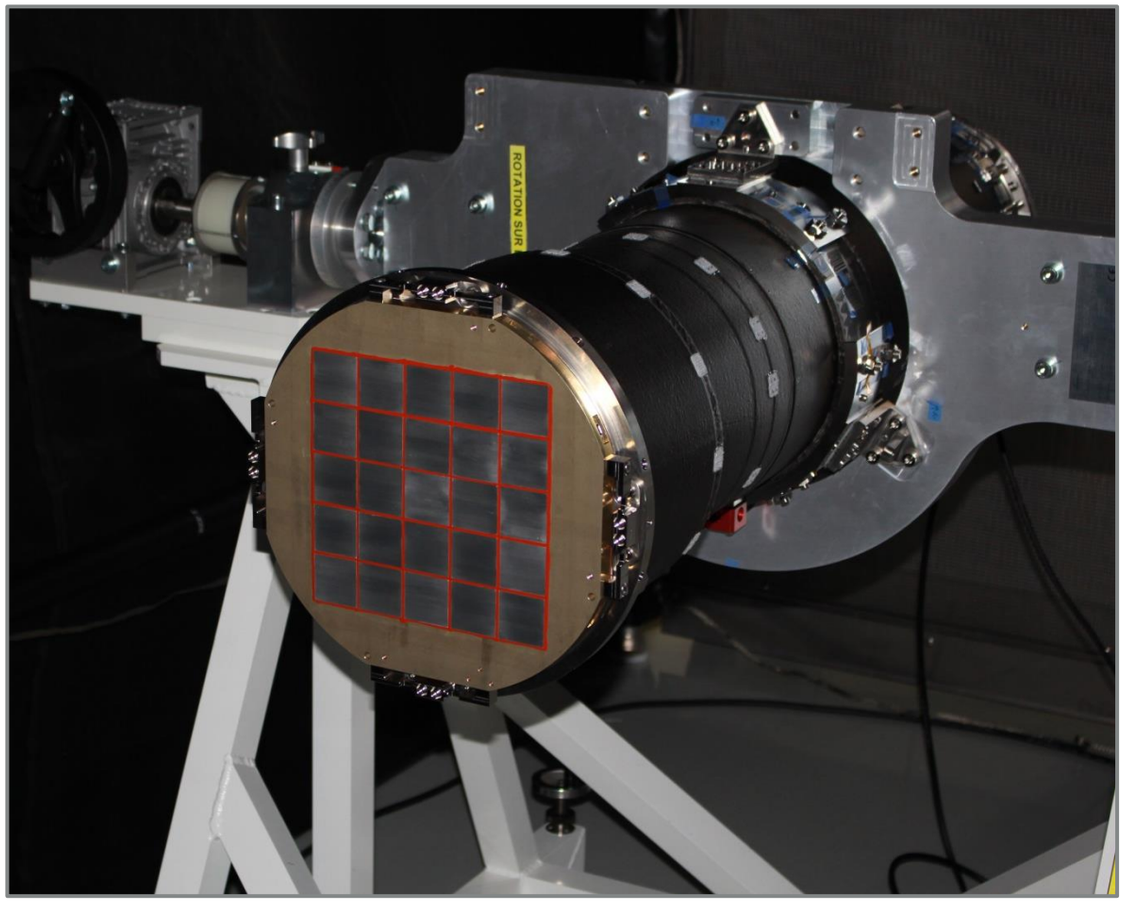

1. **MXT Structural Thermal Model**
   - Camera ready
   - Tube readdy
   - Optics dummy ready
   - Thermal bus ready
   - Integration at CNES
2. **MXT EQM**
   - Qualification tests (vibration, electrical) at sub-contractor level
   - Hardware / Software integration at CNES
   - Integration to the flat satellite model at SECM
3. **MXT Proto Flight Model fabrication**
   - All parts are procured (MPO Plates, EEE components, detectors, MLI, connectors, …)
   - Waiting for sub-system qualification tests before going ahead in PFM fabrication

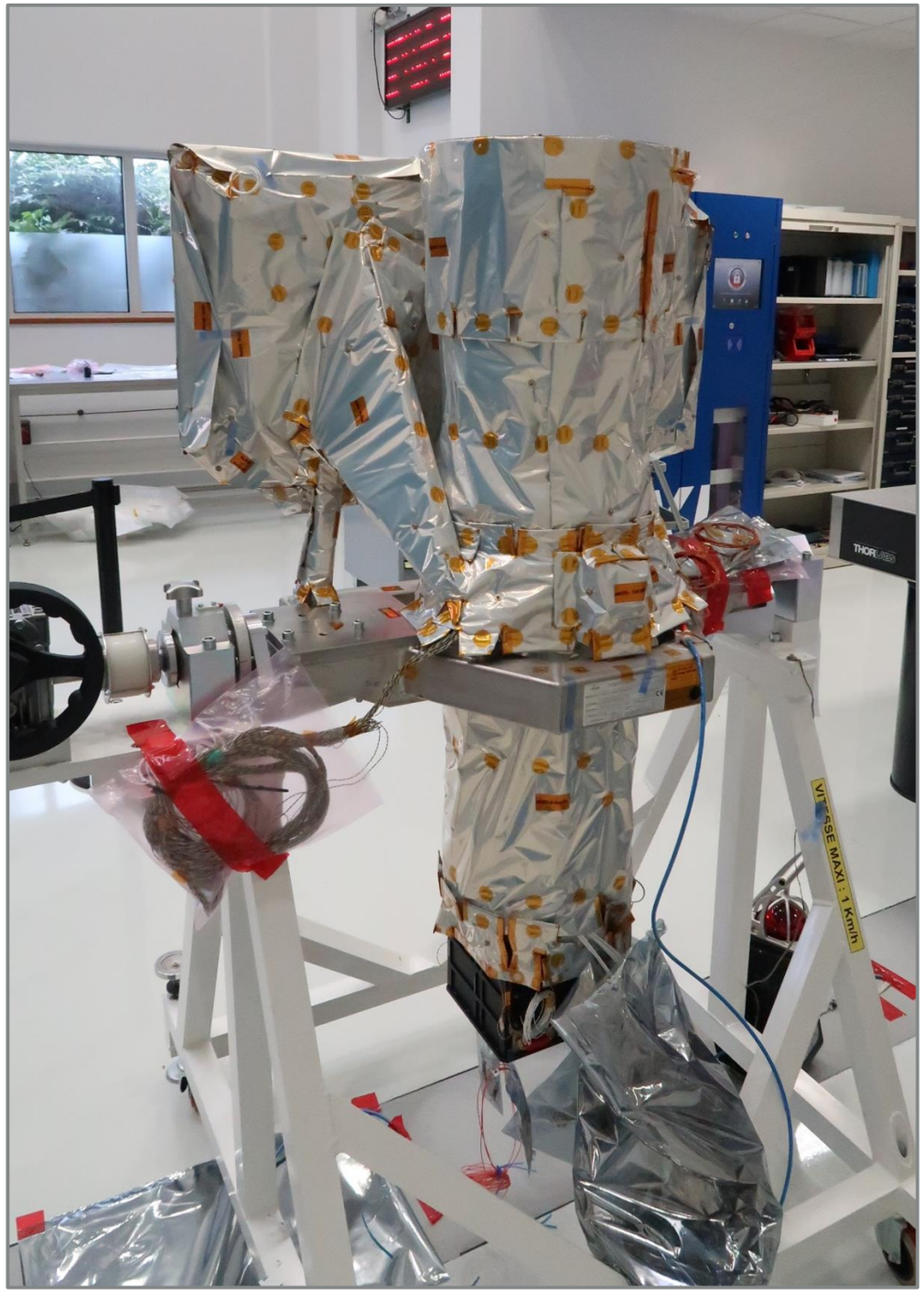
## EQM





## PFM

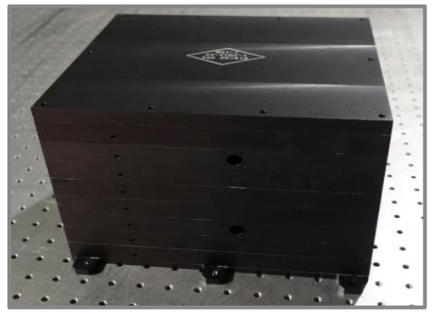


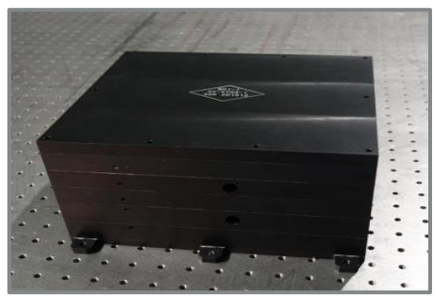



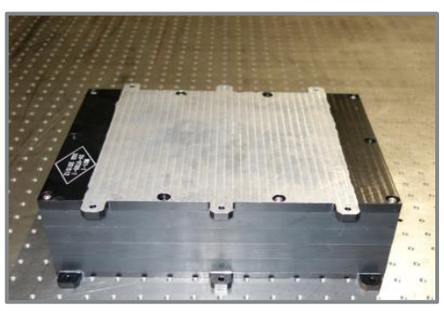

## MXT Structural and Thermal model ready for vibration tests

**For a detailed description of MXT see the poster: The MXT X-ray telescope on board the SVOM mission**

## STM

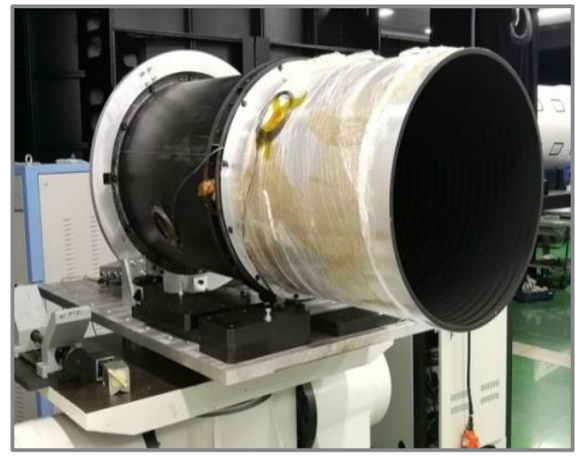


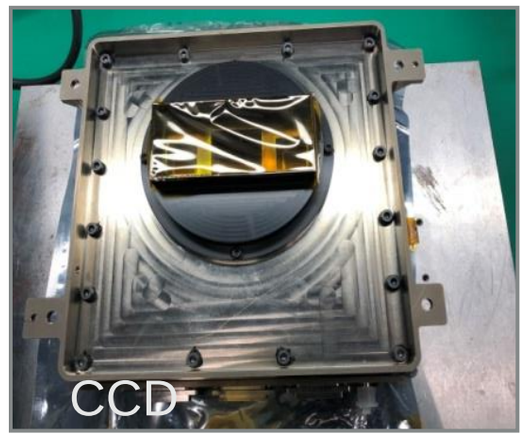


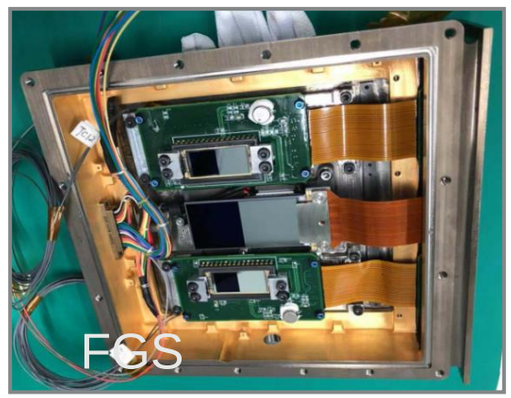


1. **VT STM fabrication**
   - Telescope ready
   - Thermal bus ready
   - Integration at SECM
2. **VT QM fabrication**
   - Hardware / Software integration at XIOPM
   - Qualification tests (vibration, shockl) performed
   - Thermal cycle on going
   - Calibration campaign at NAOC
3. **VT Flight Model fabrication**
   - All parts are procured (EEE components, detectors, MLI, connectors, …)
   - Waiting for sub-system qualification tests before going ahead in PFM fabrication

## QM



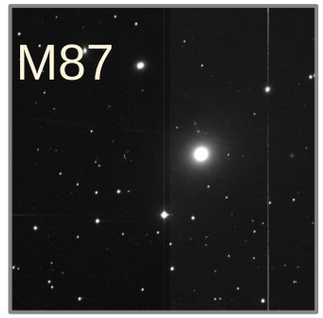


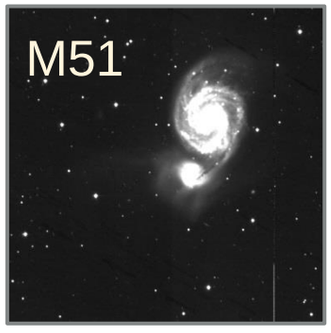



# QM performance campaign



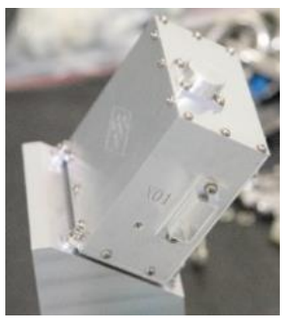

Blue Channel



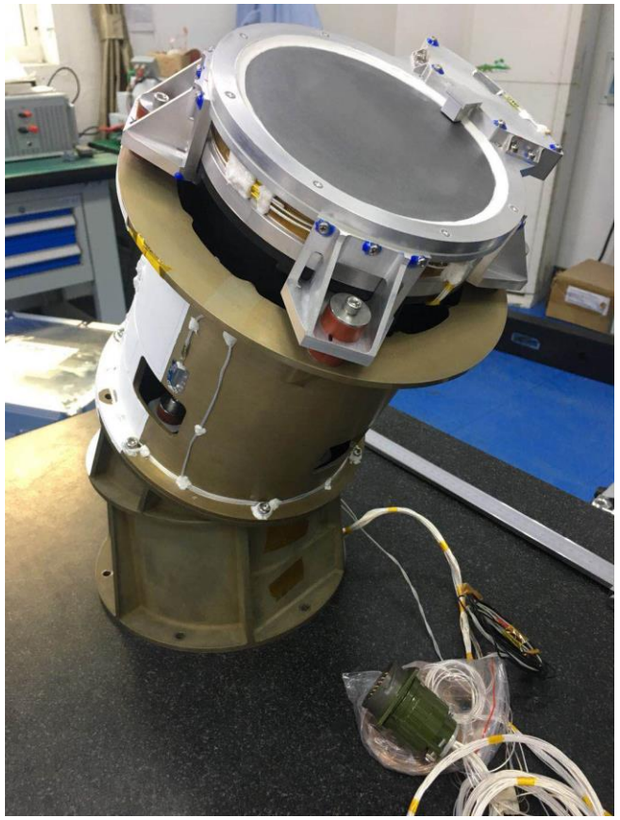

QM of VT achieves the required sensitivity

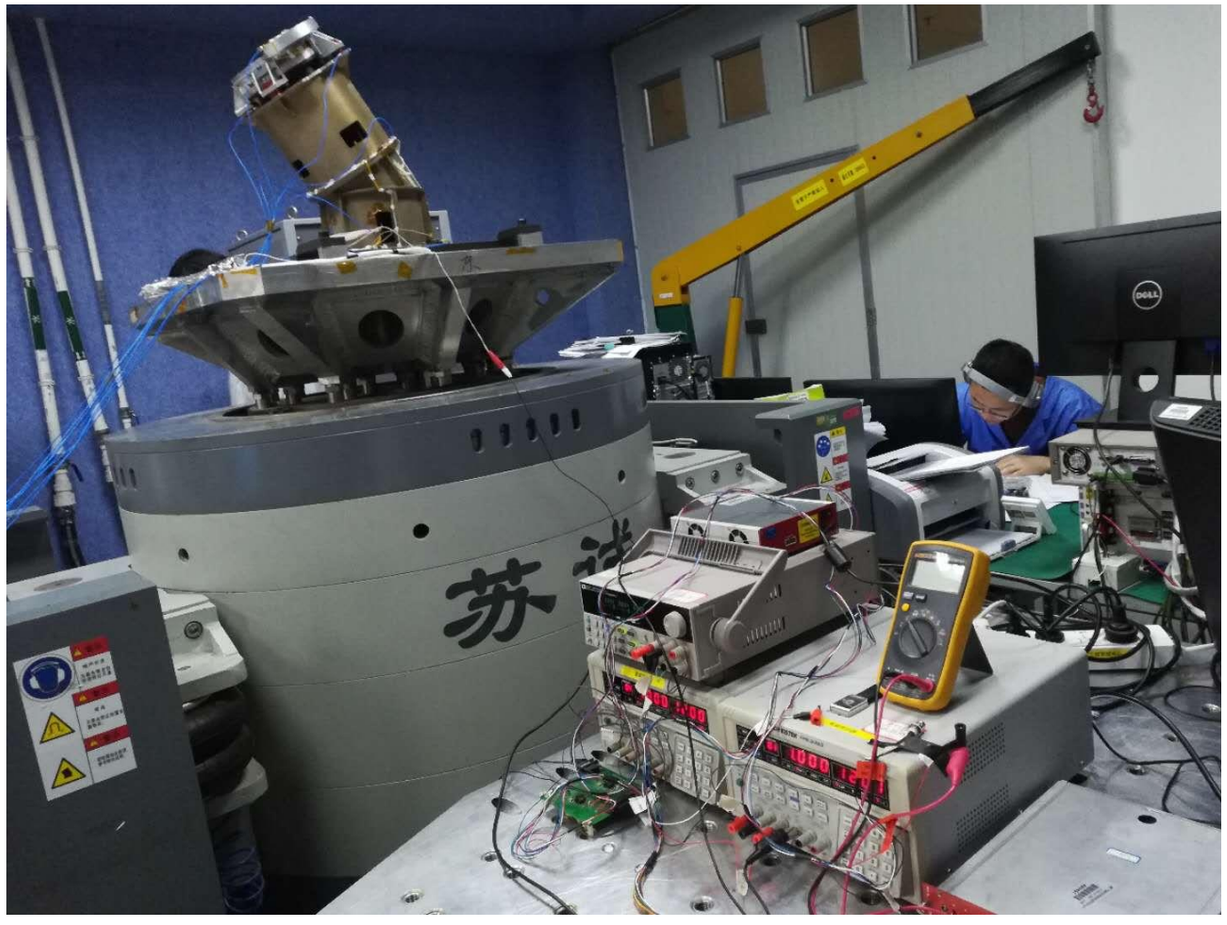
## STM



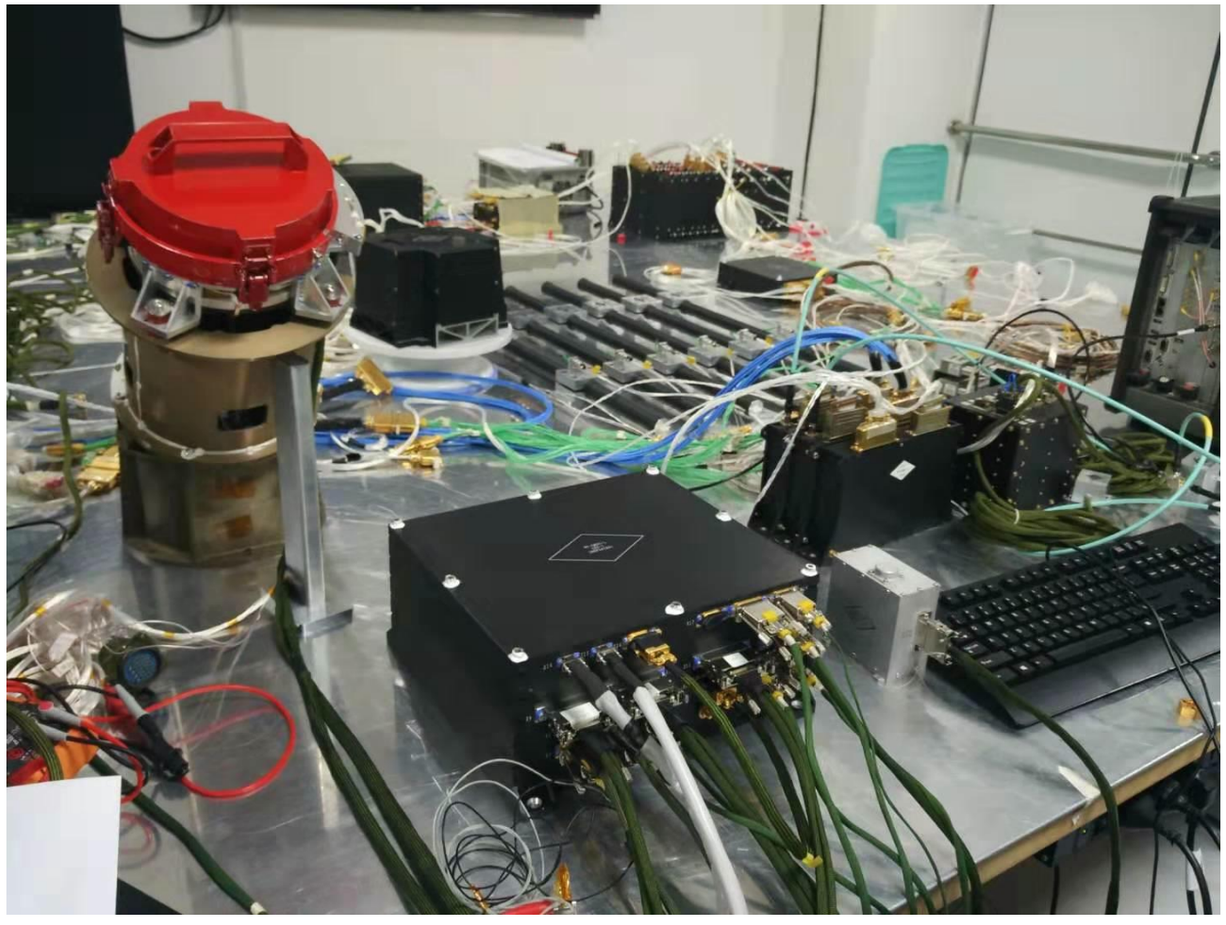
1. **GRM STM fabrication**
   - Developed
   - Integration at IHEP
   - Delivered
2. **GRM QM fabrication**
   - Hardware / Software integration at IHEP
   - Vibration and shock tests performed
   - Calibration campaign at IHEP
3. **GRM Flight Model fabrication**
   - All parts are procured (EEE components, detectors, MLI, connectors, …)
   - Waiting for sub-system qualification tests before going ahead in PFM fabrication

## QM

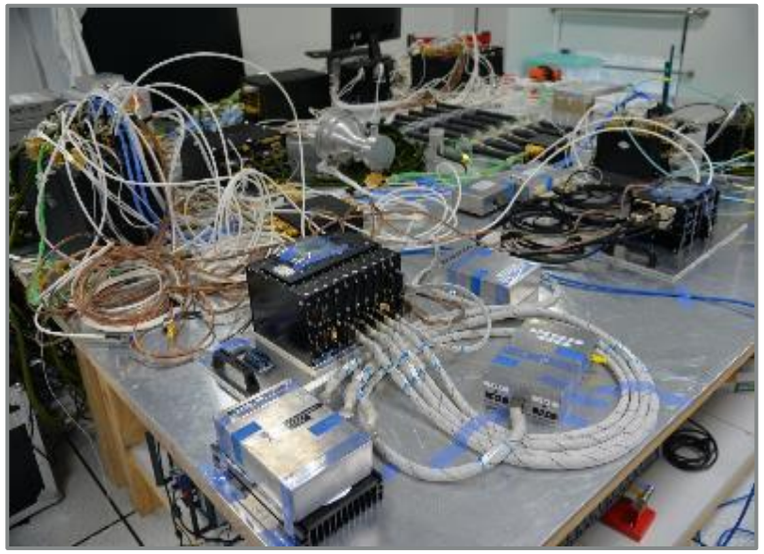


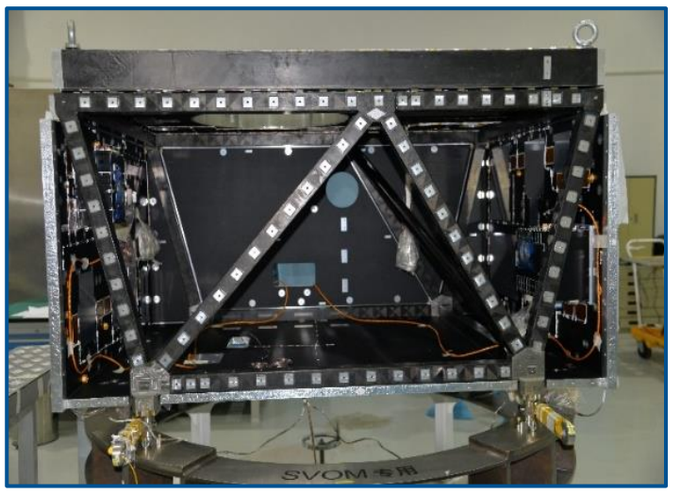


QM mechanical  tests



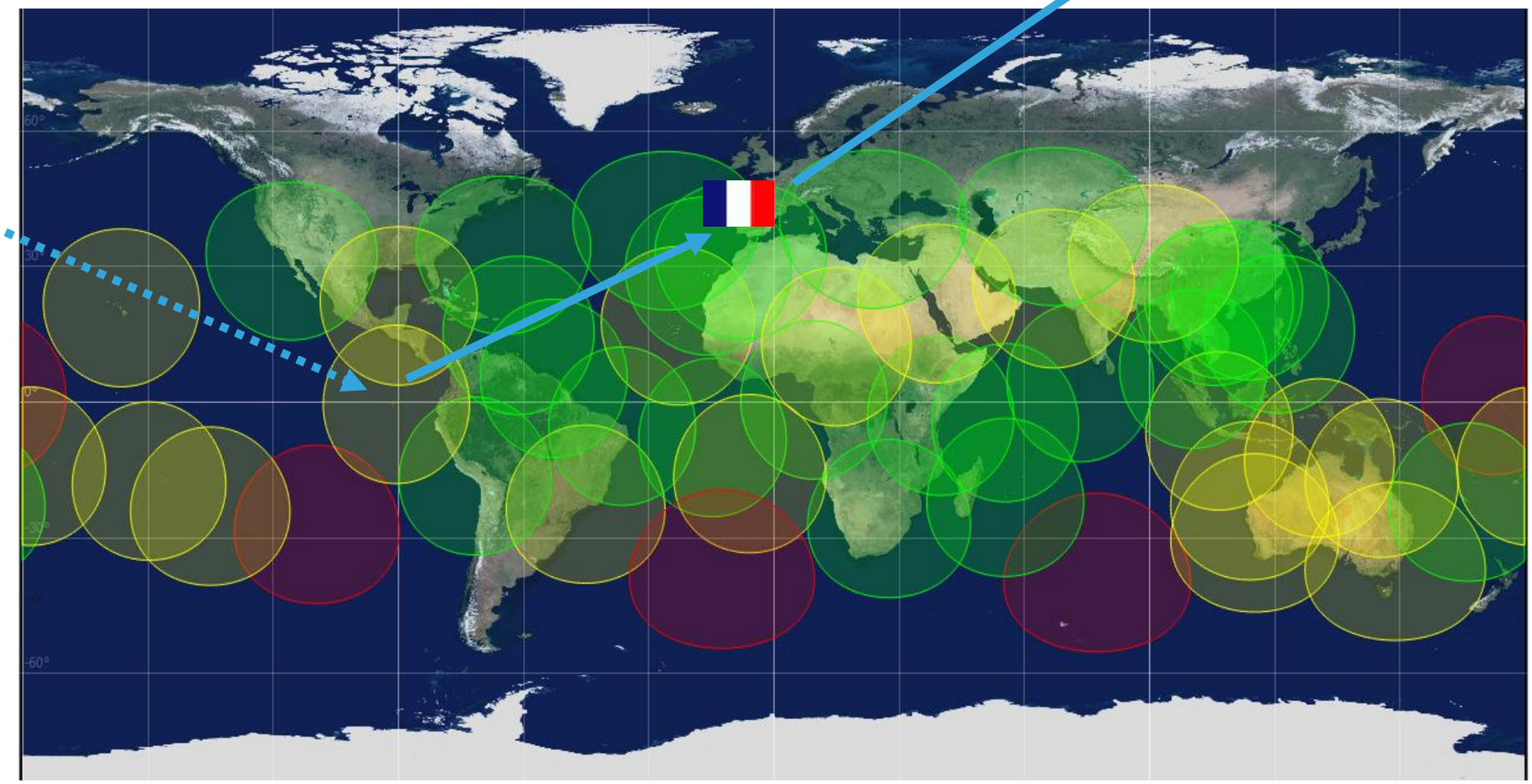
QM electrical tests





EQM’s tested in SECM premises
from February 18th to March 13th 2019

# SVOM ALERT SYSTEM

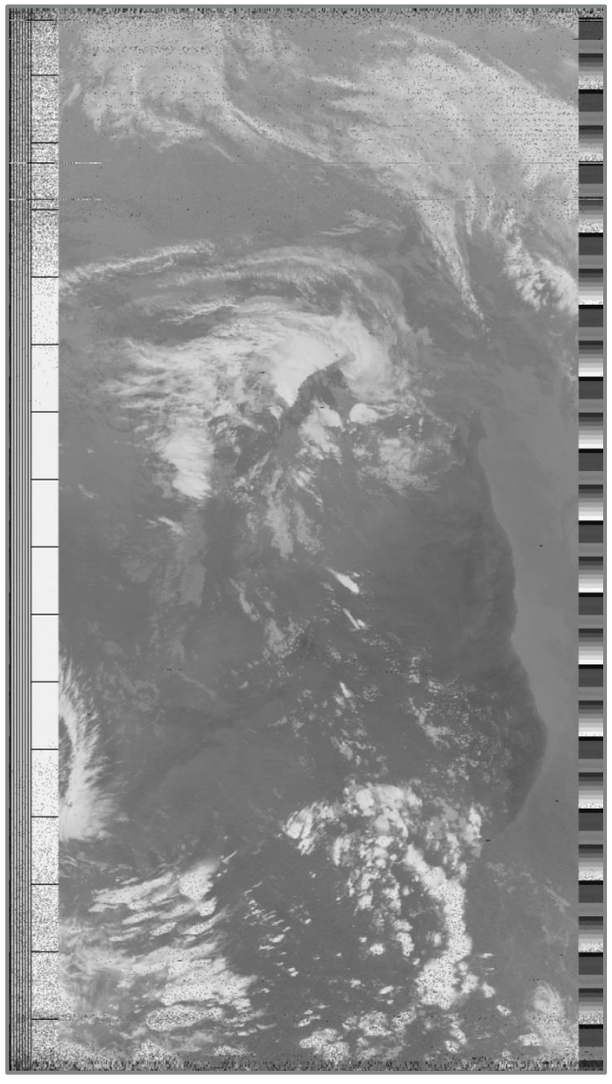



Alerts are transmitted to a network of ~40 VHF receivers on Earth

Goal: 65% of the alerts received within 30 s at the French Science Center

First Tests of the VHF Ground Station Prototypee

First installation in South Africa



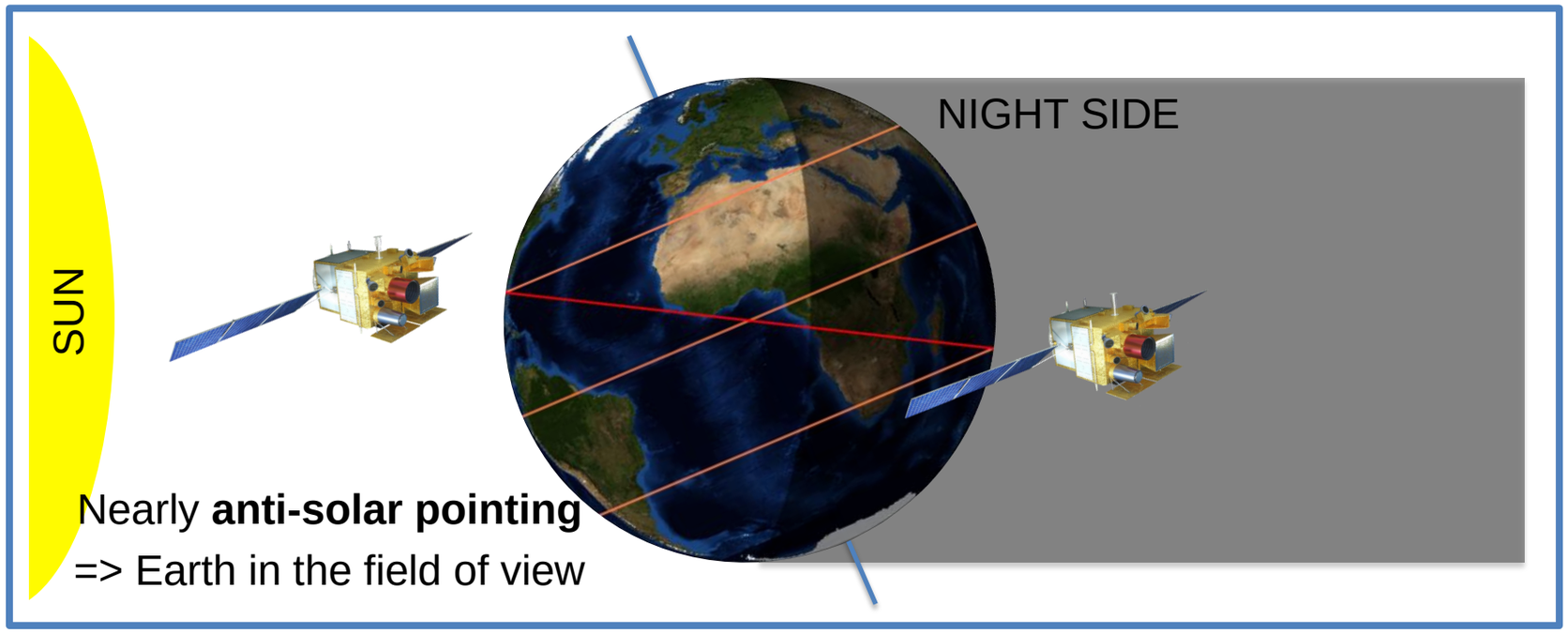
First reception on the NOA19 satellites

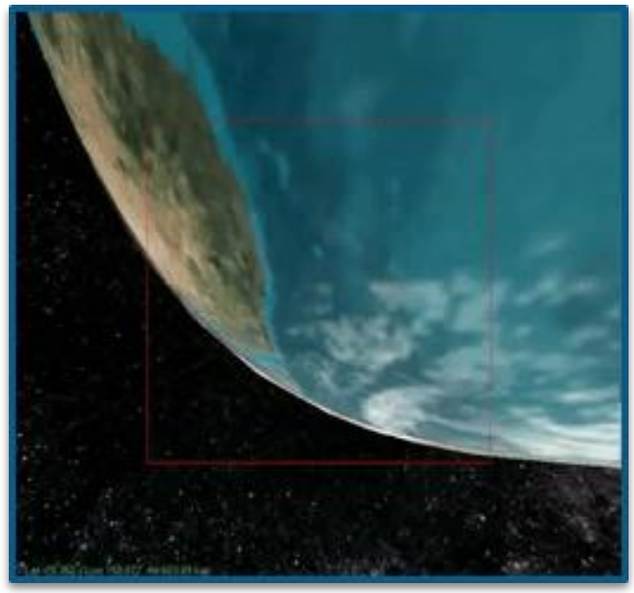
# KOUROU, FRENCH GUYANA


Next station  will be installed at GuanXI University on Spetember 19

# ORBIT AND POINTING STRATEGY

*Optimizing the ground follow-up of GRB candidates (should increase  the success of the ground redshift measurement)*



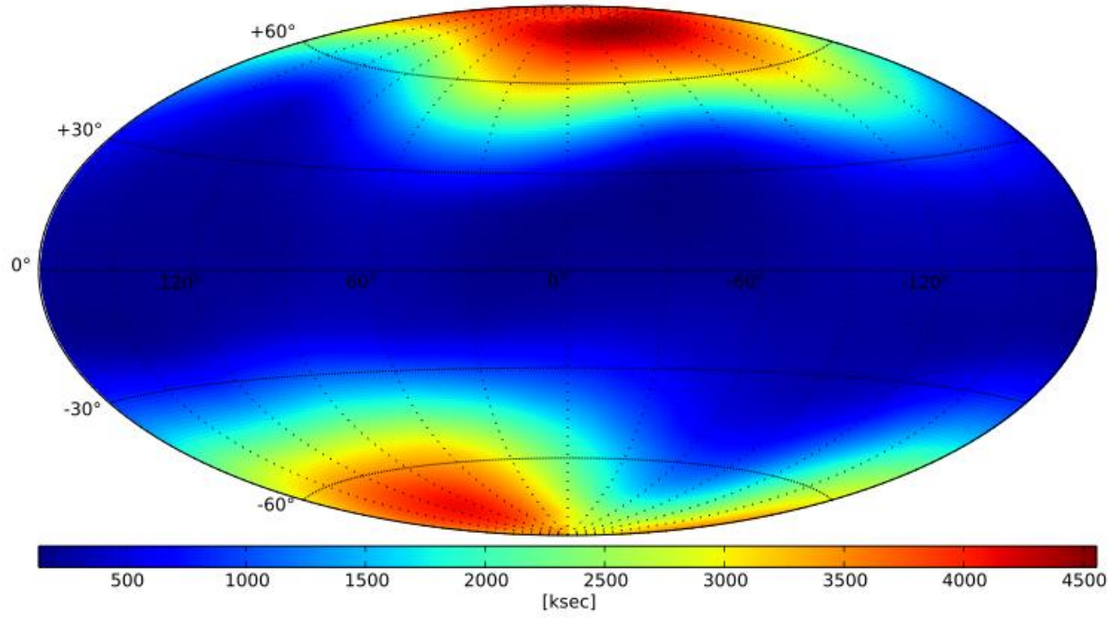



65% of duty cycle for ECLAIRs
about 50% for MXT and VT

*Waiting between the detection of two GRB candidates…*

**Avoidance of the galactic plane** (most of the time)
and also intense sources such as  **Sco X-1**

**ECLAIRs exposure map**
(65 GRBs/year, 1 ToO per day)
- 4 Ms in the direction of the galactic poles
- 500 ks on the galactic plane

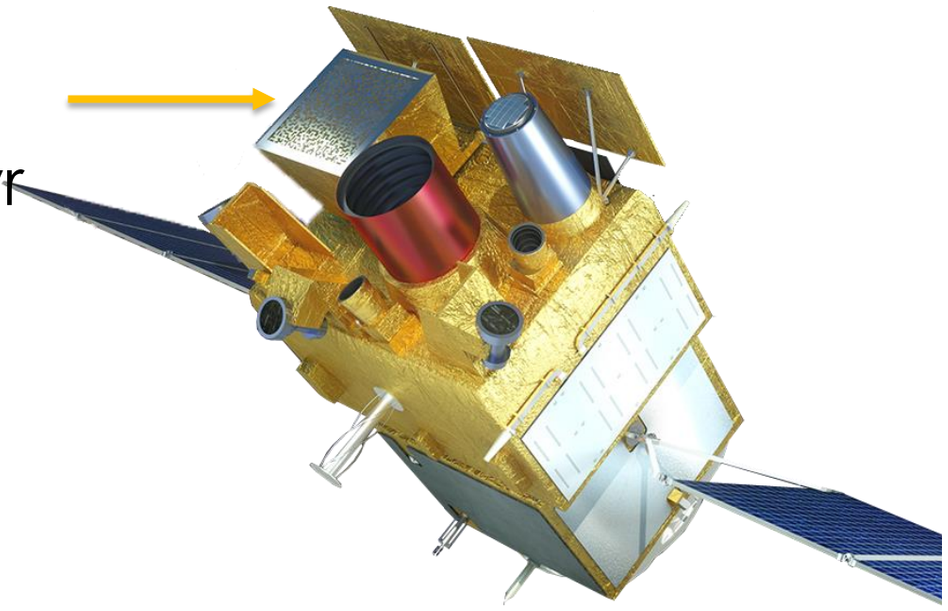


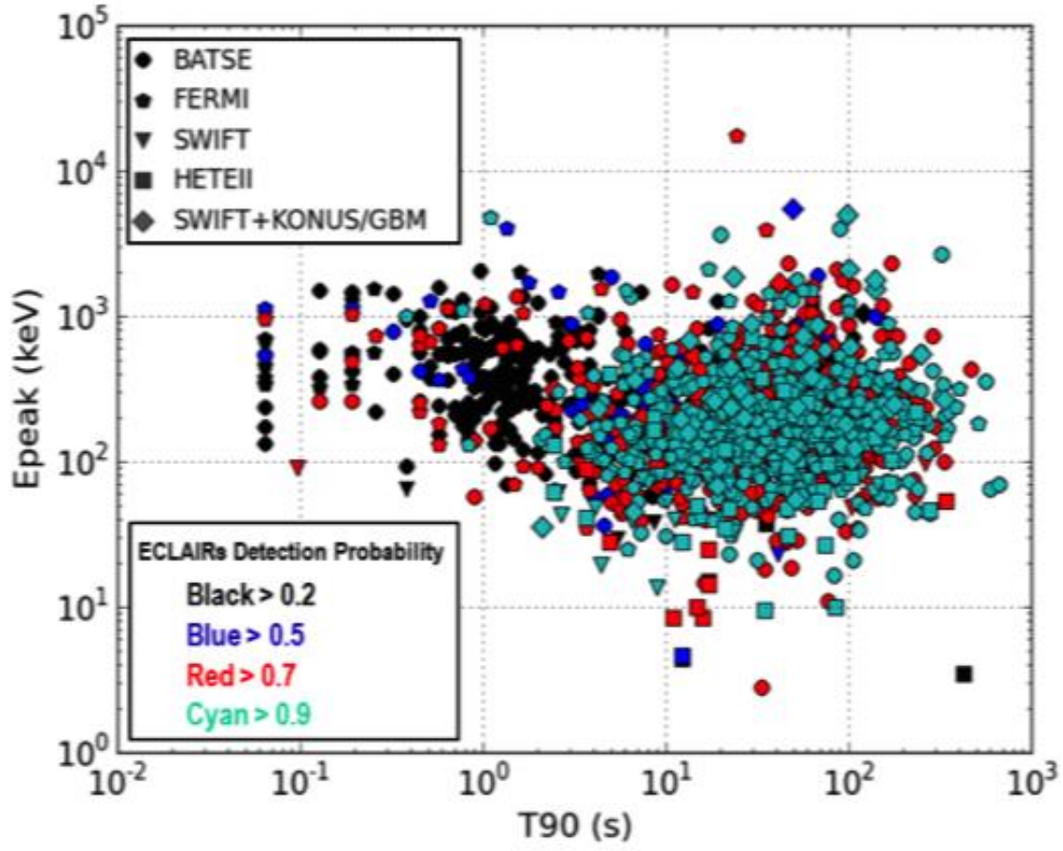
# Core Program : a complete GRB sample

GRB trigger

**ECLAIRs**

42-80 GRBs/yr





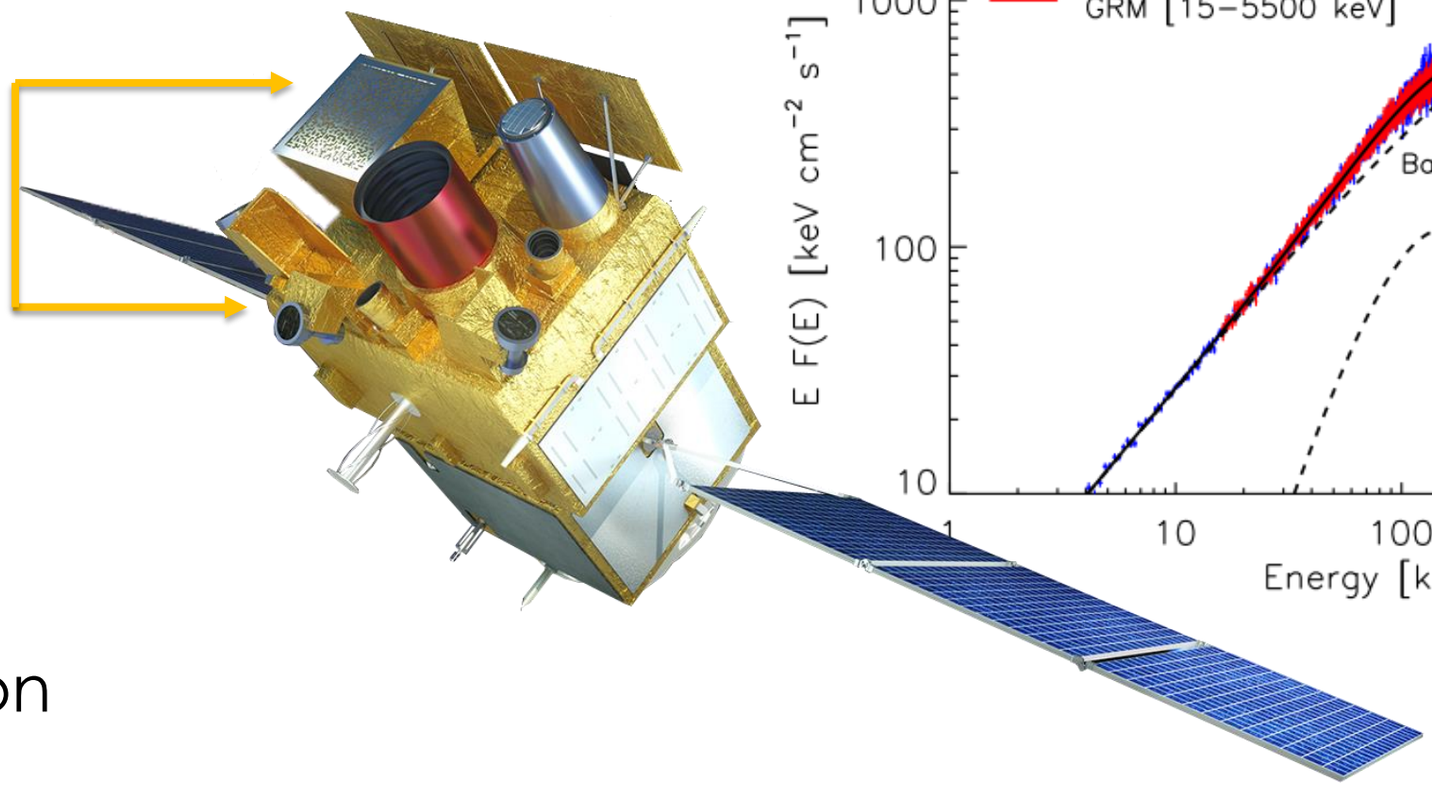

*SVOM is sensitive to all classes of GRB (long/short/soft/…)*

# Core Program : a complete GRB sample

## Prompt emission

**ECLAIRs+GRM**

Prompt GRB emission over 3 decades (4 keV-5.5 MeV)






*The multi-component spectrum of the Fermi/GBM burst GRB 100724B simulated in ECLAIRs+GRM.*

**GWAC**

prompt visible emission in ~16% of cases

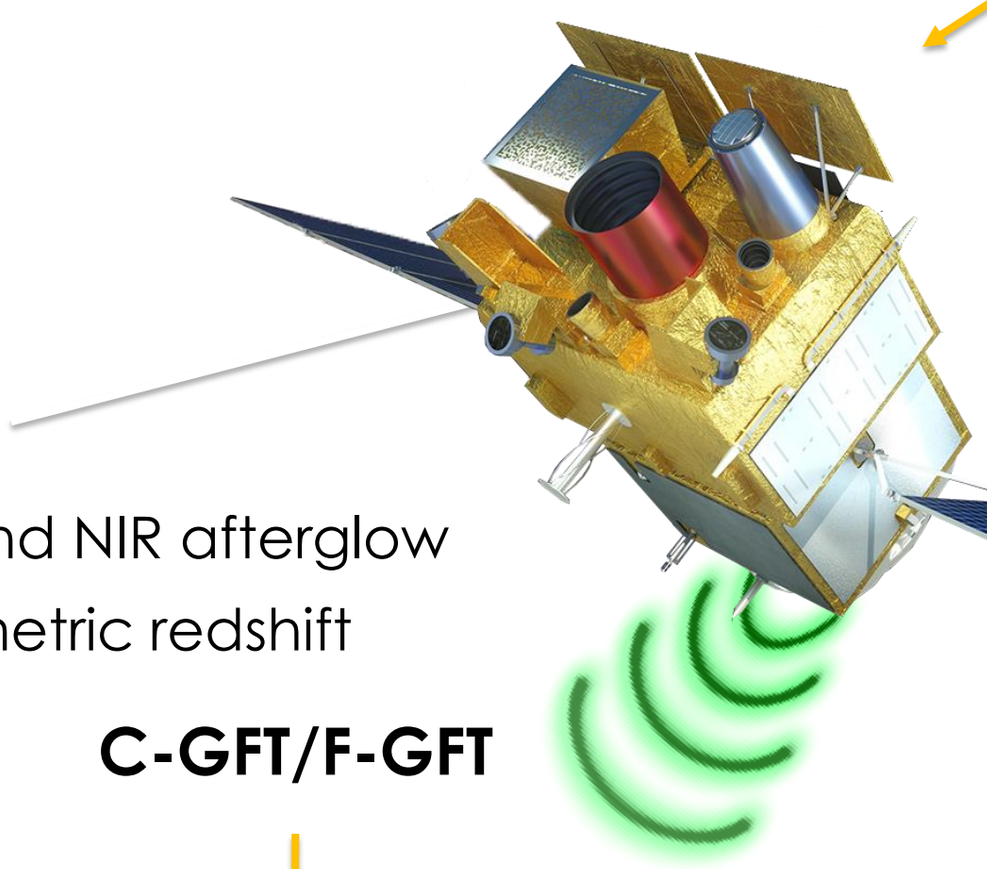
# Core Program : a complete GRB sample

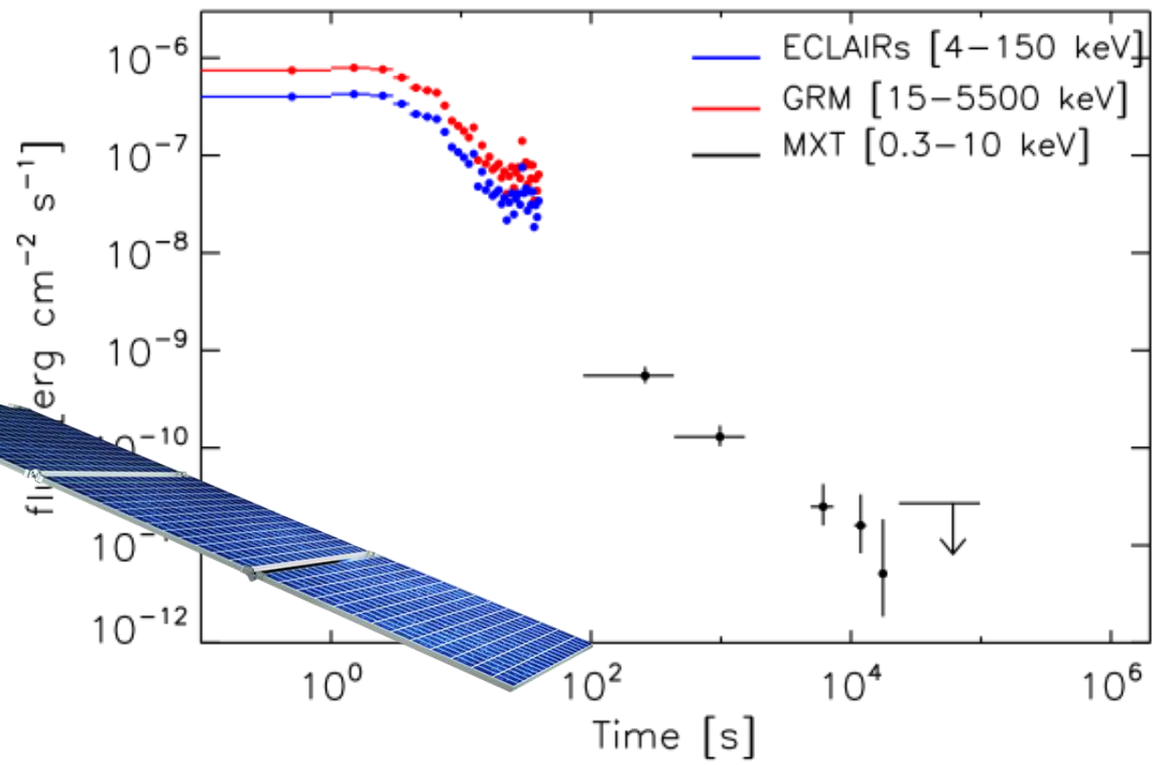
## Afterglow & distance

slew request: 36-72 GRB/yr

**MXT**

X-ray afterglow
(>90% of GRBs after a slew)






*The X-ray afterglow of the Swift burst GRB 091020 simulated in MXT.*

**VT**

Visible and NIR afterglow
+photometric redshift

**GWAC** **C-GFT/F-GFT**

**Very large telescopes**

Redshift in ~2/3 of cases

-> See Frederic Daigne presentation

# BESIDES GRBs …SVOM AS AN OPEN OBSERVATORY

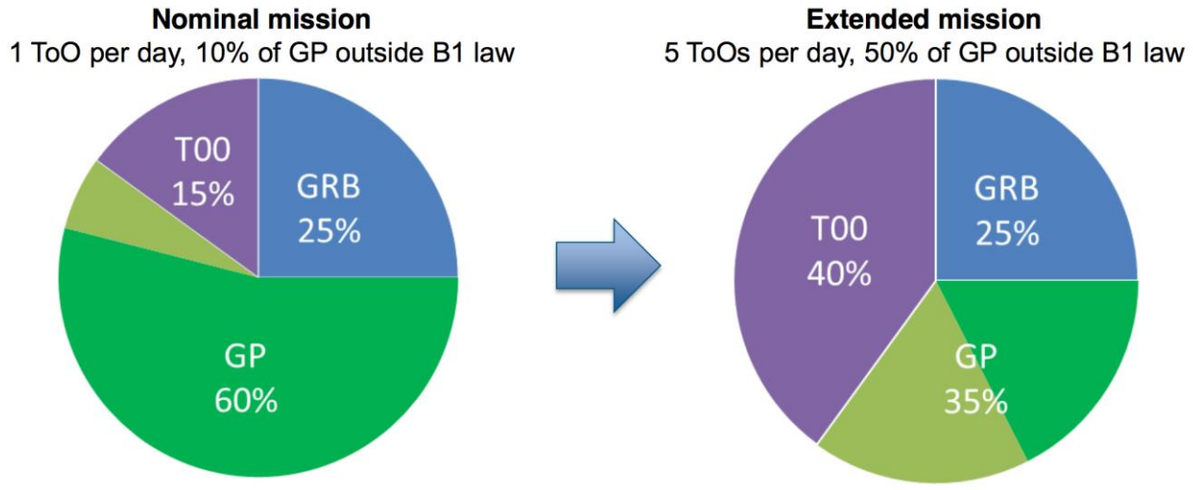
**The general program (GP)**

- Observation proposals being awarded by a TAC (a SVOM co-I needs to be part of your proposal) for astrophysical **t**argets of interest mostly compliant with the satellite attitude law
- Only 10% of the time can be spent on low Galactic latitude sources during the nominal mission, up to 50% during the extended mission

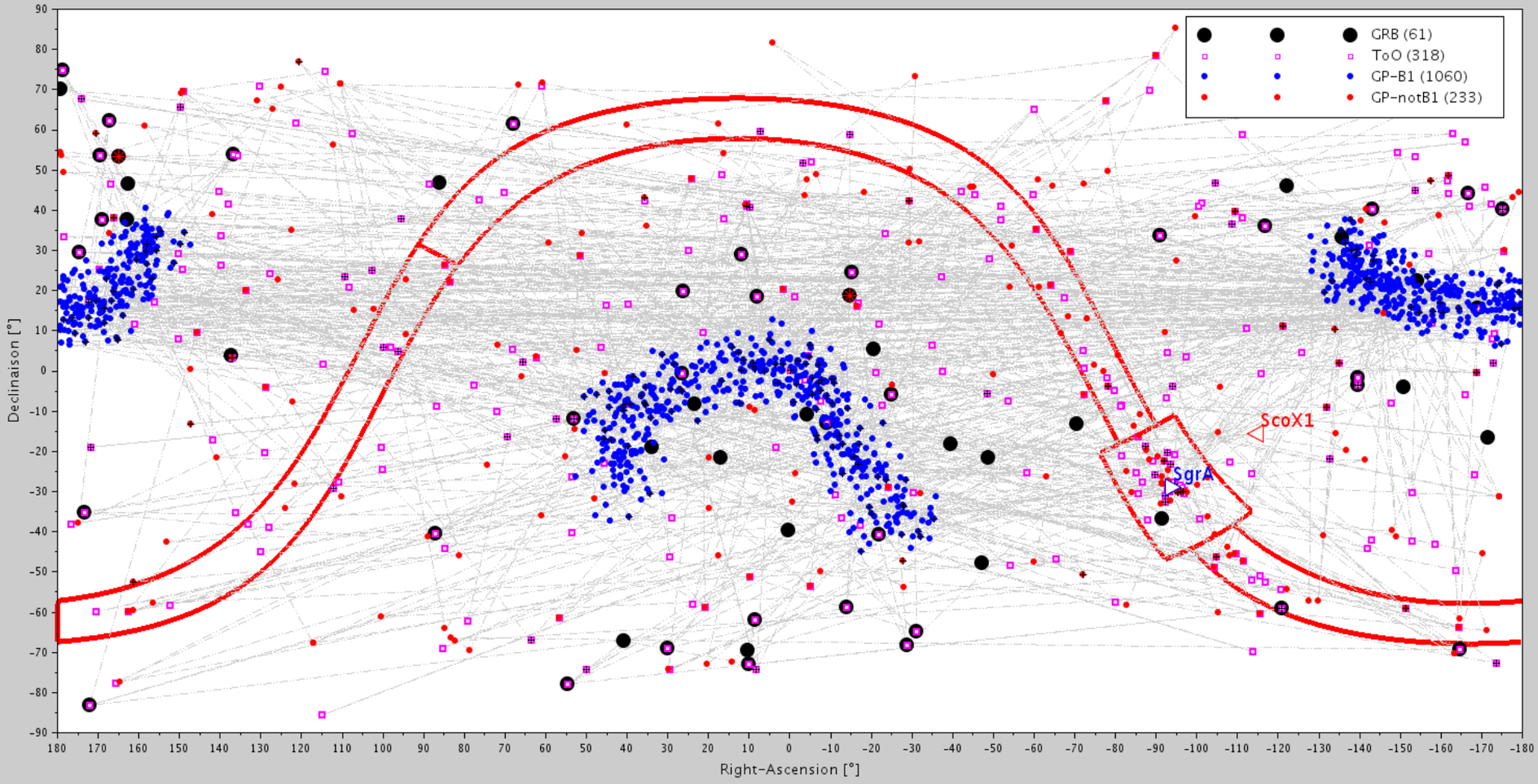
**Target of Opportunity (ToO) programs**

- **ToO-NOM** is the nominal ToO which covers the basic needs for efficient transient follow-up alerts sent from the ground to the satellite (GRB revisit, known source flaring, new transient)
- **ToO-EX** is the exceptional ToO which covers the needs for a fast ToO-NOM in case of an exceptional astrophysical event we want to observe rapidly.
- **ToO-MM** is the ToO-EX dedicated to EM counterpart search in response to a multi-messenger alert. What differs from the ToO-NOM and ToO-EX is the unknown position of the source within a large error box…

- Initially 1 ToO/day focussed on time domain astrophysics, will increase during the extended mission



# One year of SVOM Observation




Core Program GRBs  61 pointings,

ToOs  Program 318 pointings

General Program 1293 pointings

# THE SVOM MISSION PART 2