The SVOM mission and the collaboration with the Maidanak observatory

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on behalf of the SVOM collaboration

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The SVOM Collaboration

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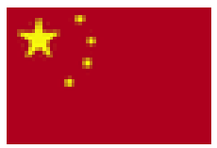
China (PI J. Wei) 

- SECM Shanghai
- NAOC Beijing
- IHEP Beijing
- GuangXi University Nanning

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France (PI B. Cordier) 

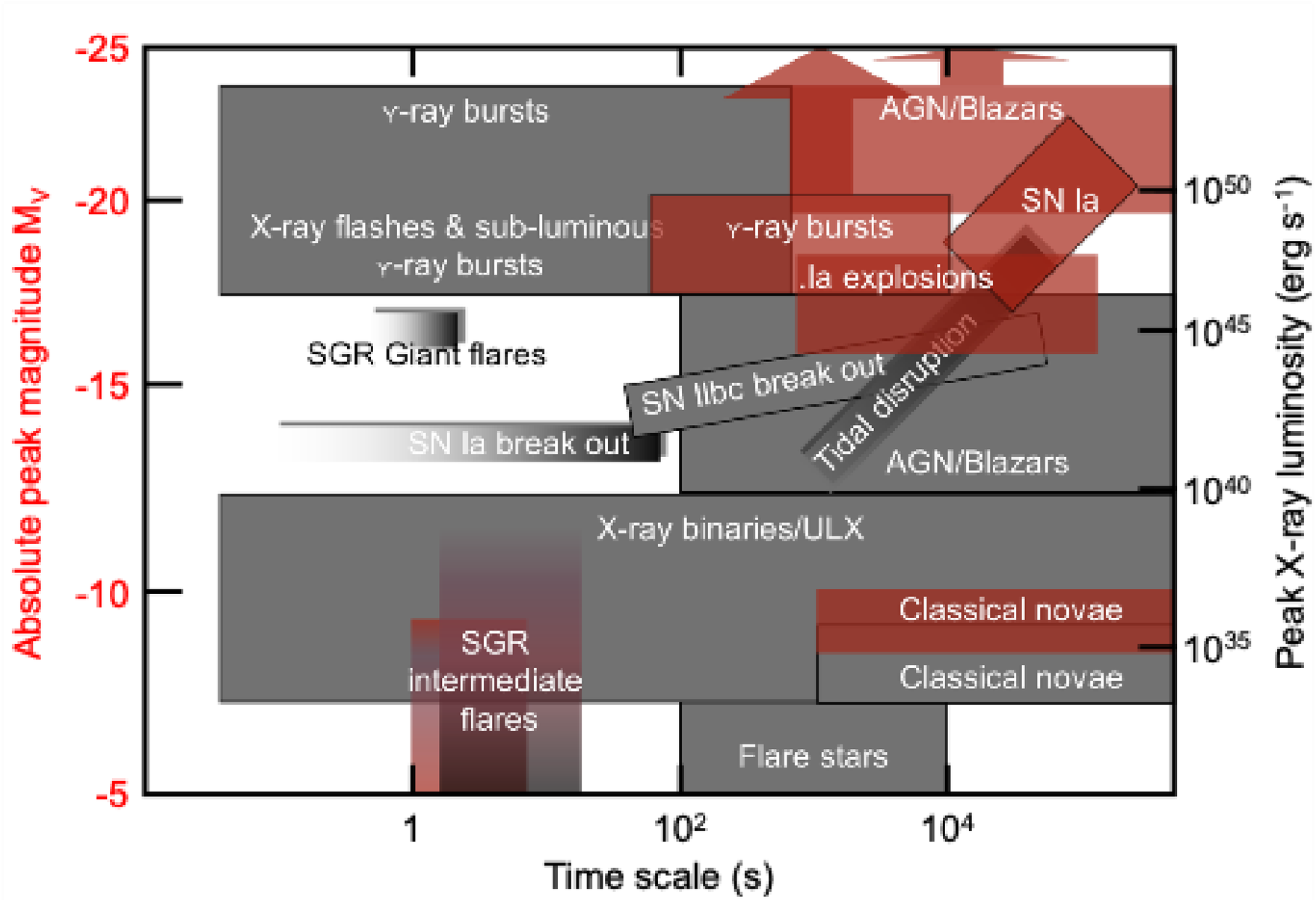
- CNES Toulouse
- CEA Saclay
- APC paris
- CPPM Marseille
- GEPI Meudon
- IAP Paris
- IJC Lab Orsay
- IRAP Toulouse
- LAM Merseille
- LUPM Montpellier
- OAS Strasbourg
- OCA Nice

Mexico UNAM Mexico 

UK University of Leicester 

Germany MPE Garching 

Time-domain astronomy



- Time-domain astronomy is a priority area of research in the next decade
- Hot topics: explosive transients (GRBs, SN shock breakouts, TDE, FRB), multi-messenger astronomy (GWs, neutrinos)

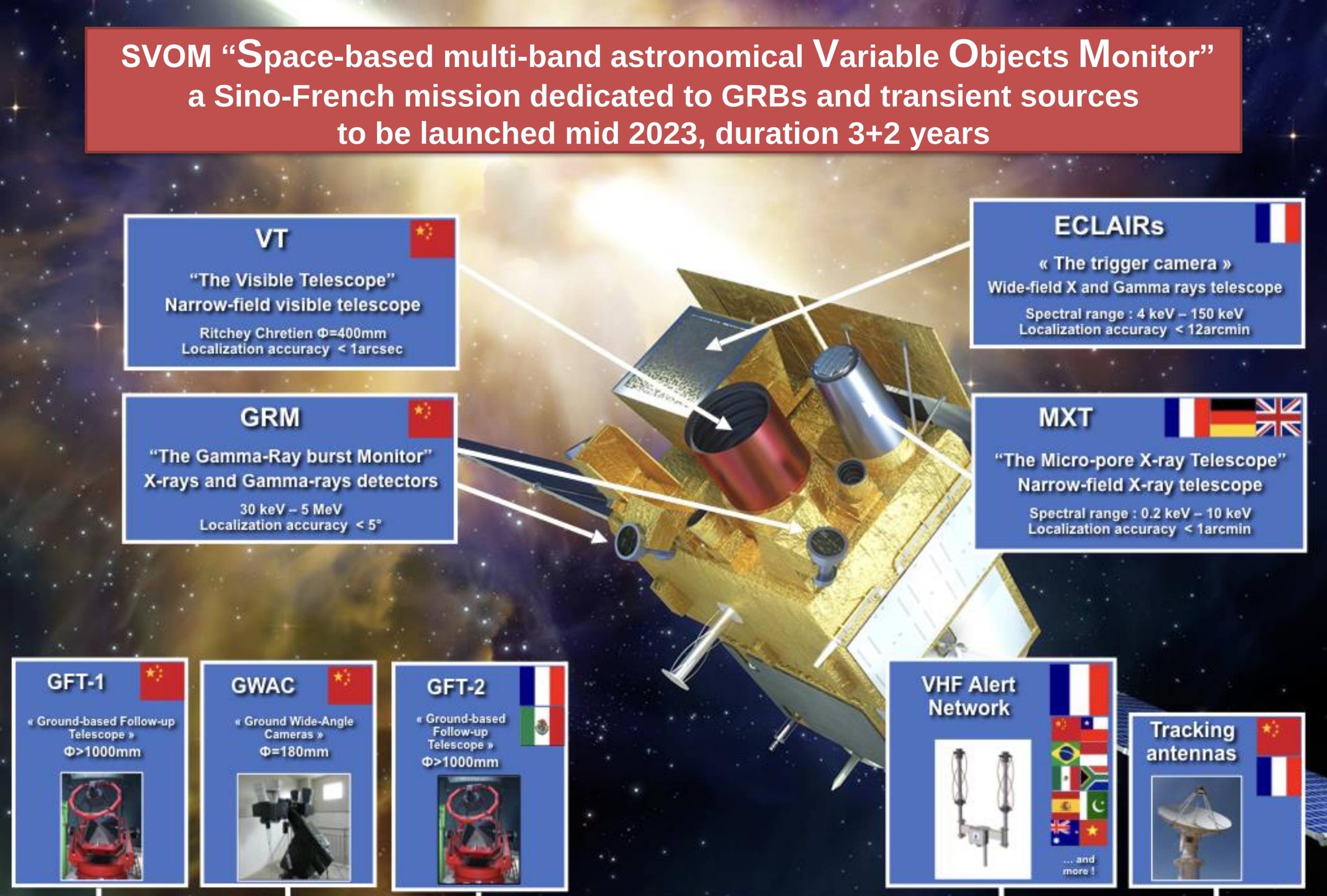
SVOM "Space-based multi-band astronomical Variable Objects Monitor"
a Sino-French mission dedicated to GRBs and transient sources
to be launched mid 2023, duration 3+2 years

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

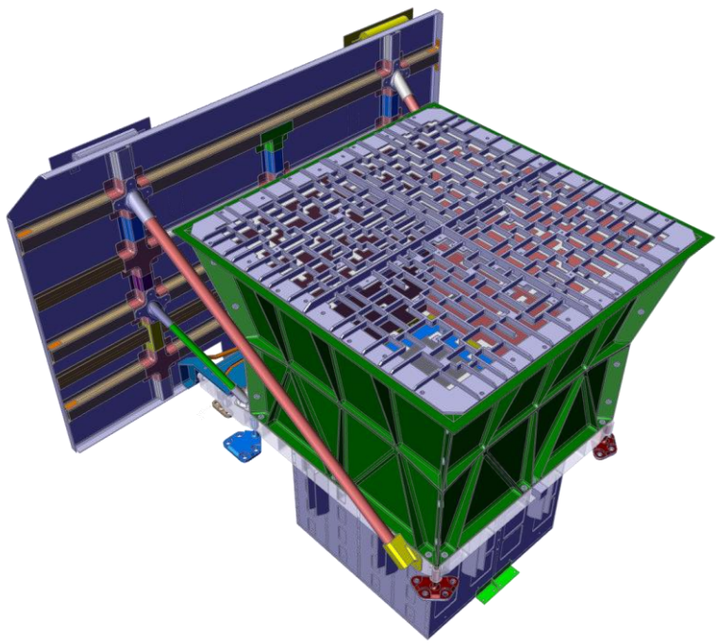
GFT-2
« Ground-based Follow-up Telescope »
Φ>1000mm

VHF Alert Network

... and more !

Tracking antennas

INSTRUMENTS with LARGE FIELD OF VIEW IN SPACE

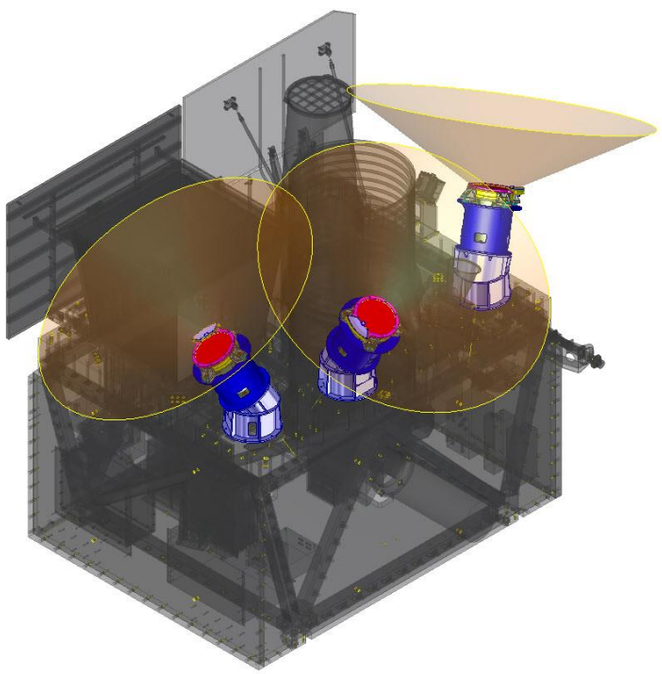


ECLAIRs (CNES, IRAP, CEA, APC)

- 40% open fraction
- Detection plane: **1024 cm²**
- 6400 CdTe pixels (4x4x1 mm³)
- 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**

Will detects, localizes and characterizes HE transients. It generates alerts and slew requests:

Well adapted for the detection of lGRB with low E_{PEAK}



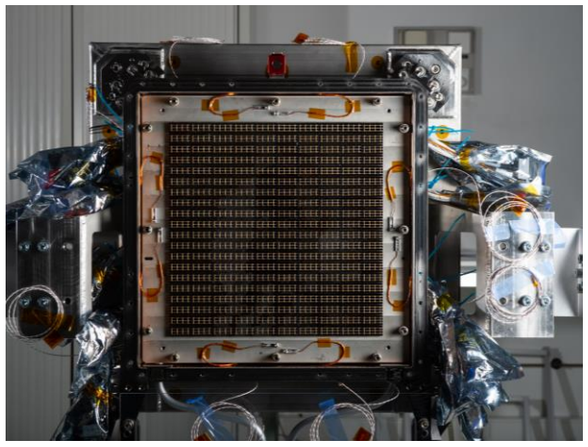
GRM Gamma-Ray Monitor (IHEP)

- **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

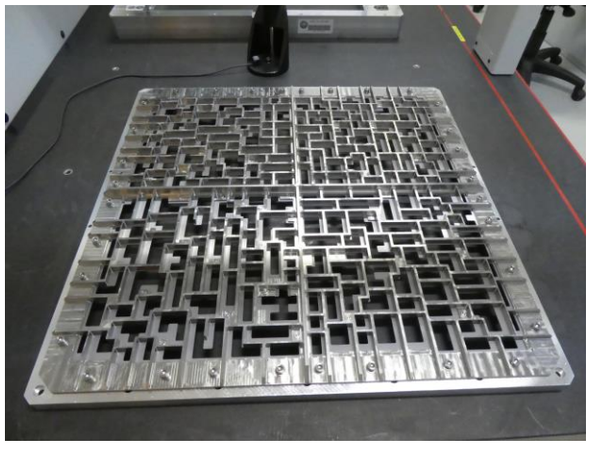
Will detect short GRBs in & out of the ECLAIRs FOV

ECLAIRS FM STATUS

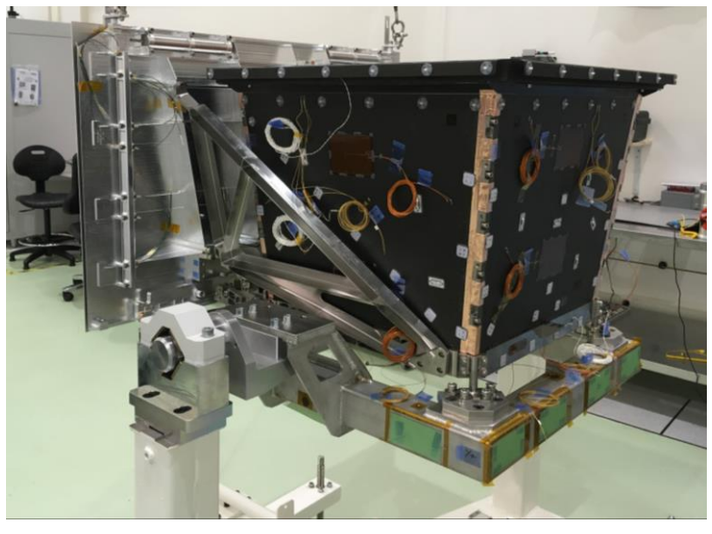


Detection plane

Onboard computer

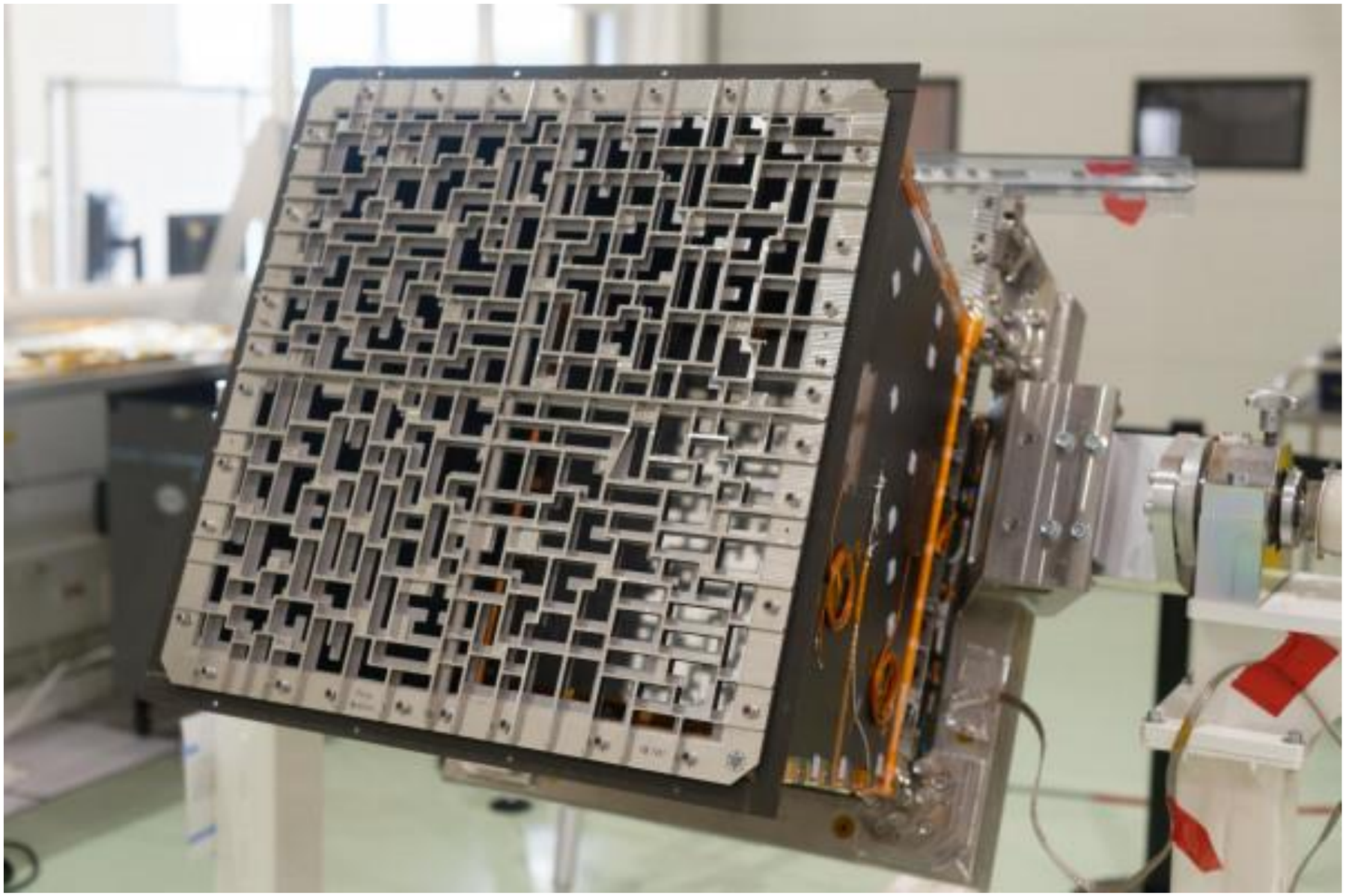


Coded mask



Structure, mechanical & thermal

December 20, the flight models of all subsystems have been manufactured



July 21, instrument fully integrated

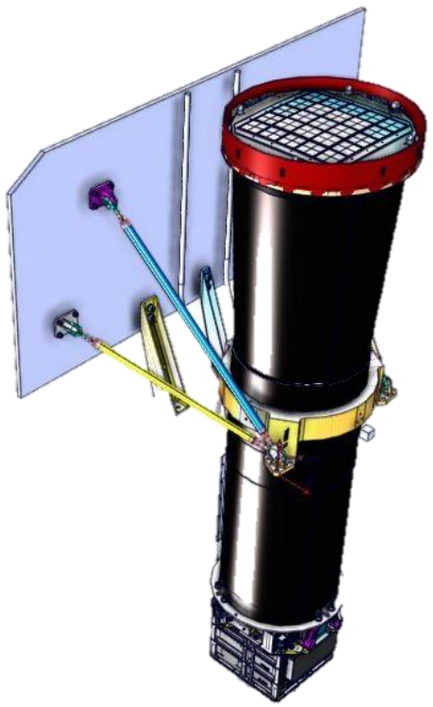
INSTRUMENTS with LARGE FIELDS of VIEW: on GROUND

Ground Wide Angle Cameras (NAOC)

cameras: 40
wavelength : 500-800nm
5000 deg2, mV= 16 (10s)
Self Trigger

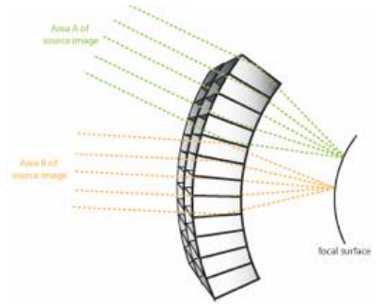
- Search for prompt visible counterparts of GRB
- Of course this instrument can be used to search for electromagnetic counterpart in the large error boxes of gravitational wave detectors

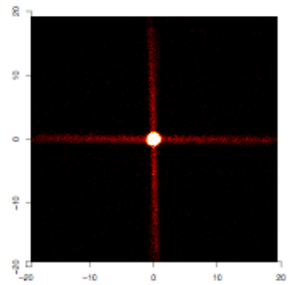
INSTRUMENTS with SMALL FIELD OF VIEW IN SPACE



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)



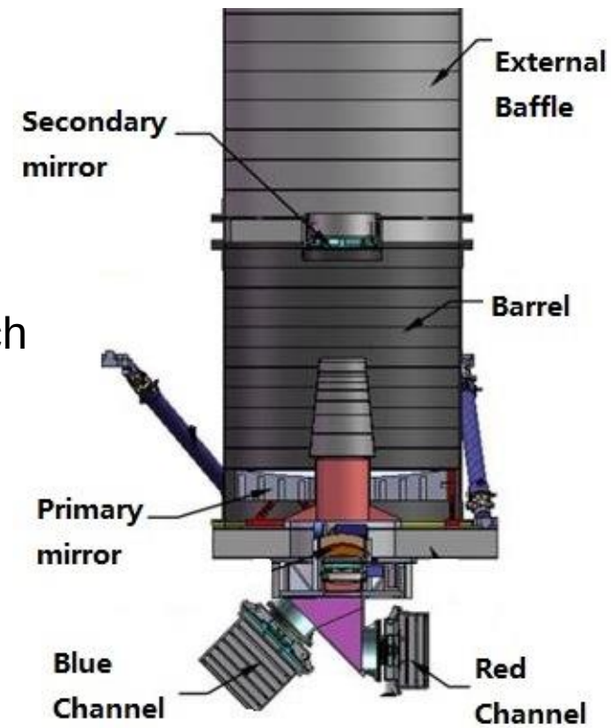


Implements innovative focussing X-ray optics based on « Lobster-Eye » design
Will reduce the ECLAIRs error box
Will be able to promptly observe the X-ray afterglow

VT Visible Telescope (XIOMP, NAOC)

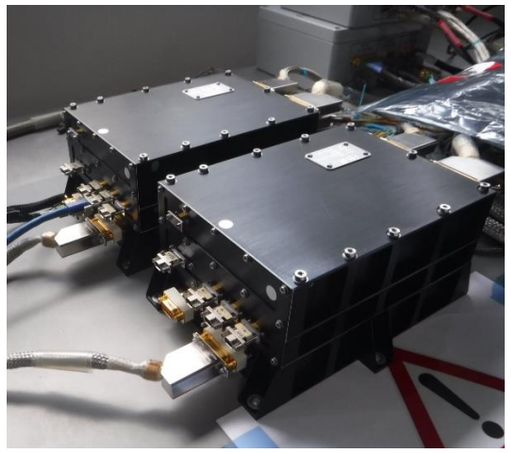
- Ritchey-Chretien telescope, 40 cm Ø, f=9
- FoV: **26x26 arcmin²**, covering ECLAIRs error box in most cases
- **2 channels: blue (400-650 nm) and red (650-1000 nm),** 2k * 2k CCD detector each
- **Sensitivity MV=23 in 300 s**
- Will detect ~80% of ECLAIRs GRBs
- Localization accuracy **<1 arcsec**

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

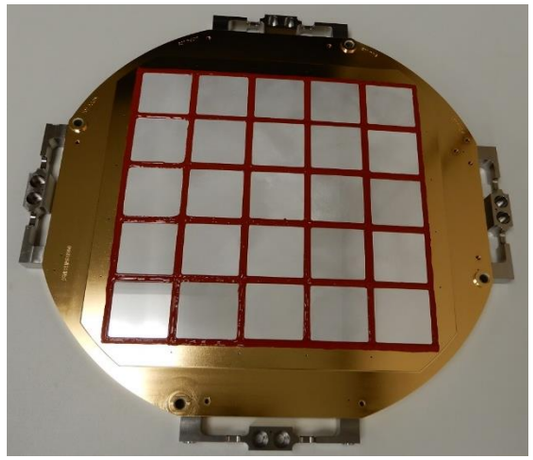


MXT FM STATUS

Detector and camera

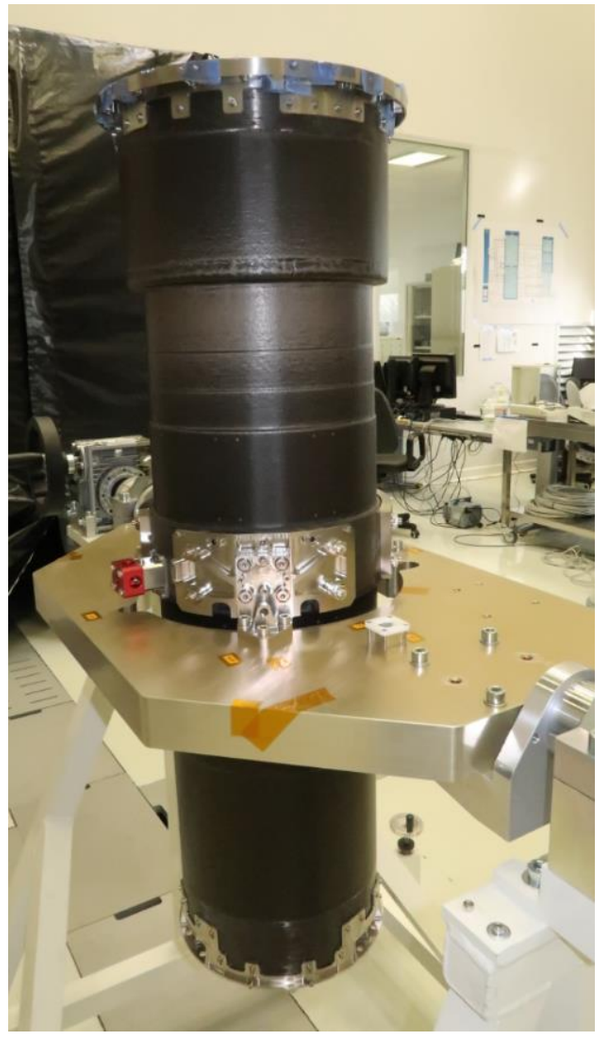


Onboard computer



Optics

Structural tube



December 20, the flight models of all subsystems have been manufactured

July 21, instrument fully integrated

INSTRUMENTS with SMALL FIELDS of VIEW: on GROUND

Grounf Follow-up Telescopes permit the fast identification and measure of early optical/NIR afterglows using the ECLAIRs positions, while the spacecraft is slewing to the source.

- C-GFTs is located at Weihai observatory (Jilin province)
- F-GFT will be located at San Pedro Martir (Mexico)

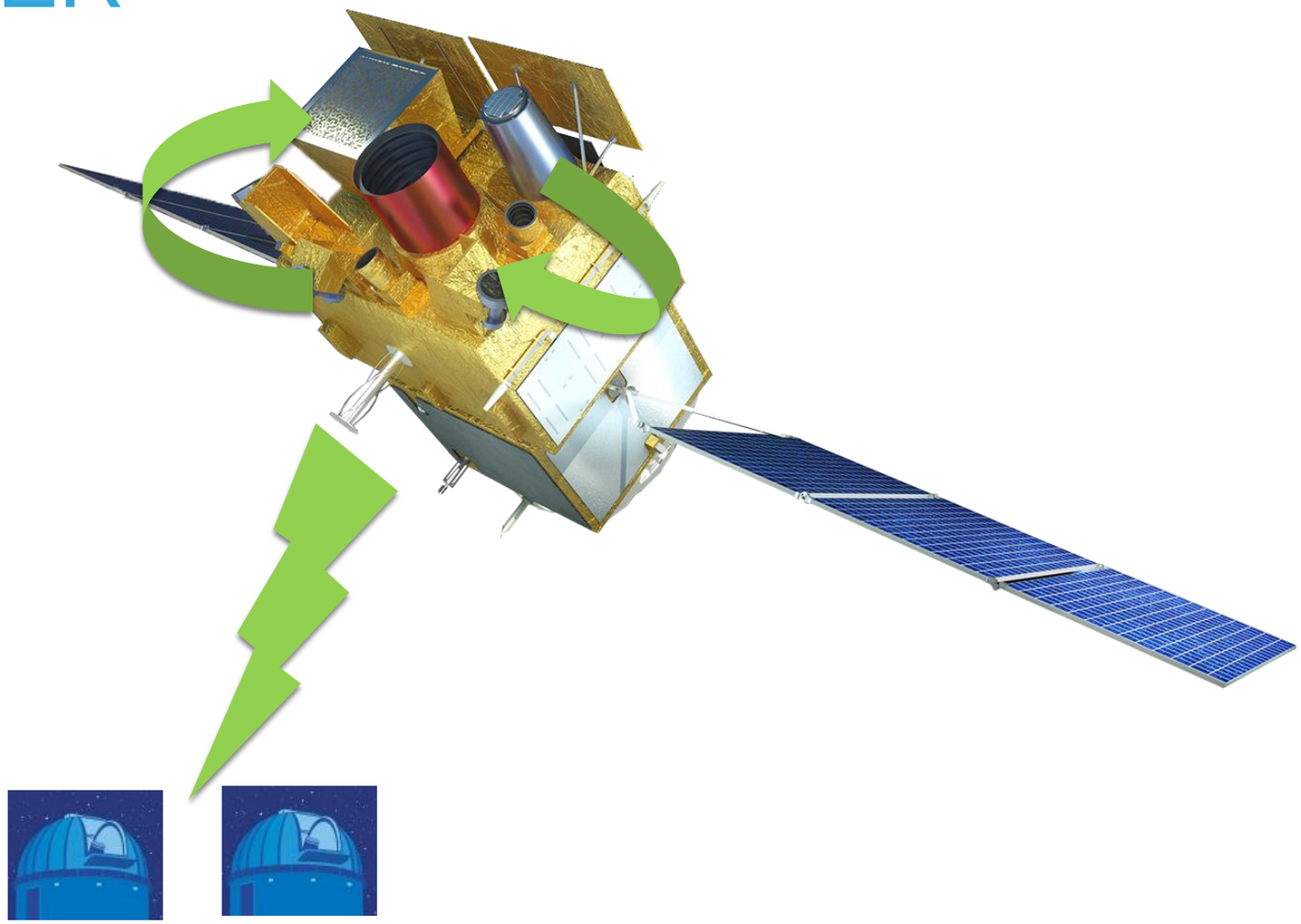
Diameter : 130 cm
FOV : 26 x 26 arcmin
400 – 1700 nm

Diameter : 120cm
FOV : 90 x 90 arcmin
400 – 900nm

Guaranteed access to the LCOGT network through NAOC (2000hr/year)

>75% of ECLAIRs-detected GRBs immediately visible by one ground telescope (GFTs+LCOGT)

SVOM INSTRUMENTS COMMUNICATE WITH EACH OTHER



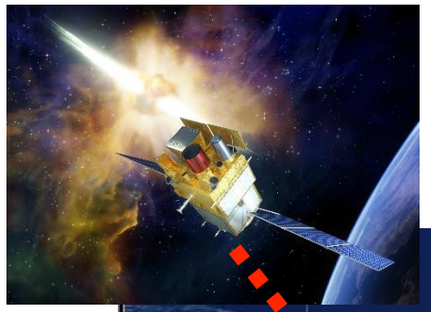
GRM -> ECLAIRs to help the detection of short GRB

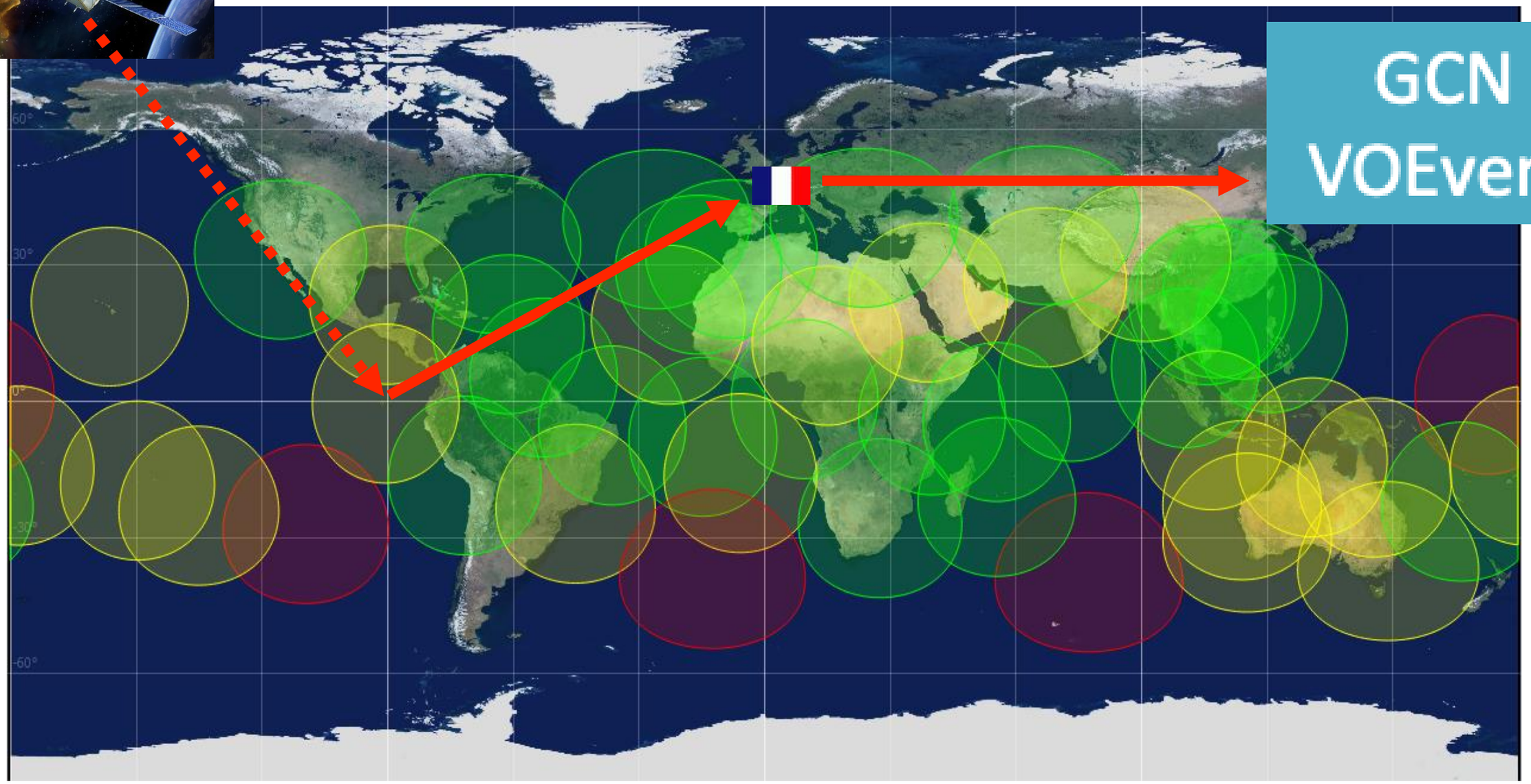
MXT-> VT to search for sources in the VT image inside the MXT error

ECLAIRs , MXT and VT -> GWAC and GFTs to indicate the coordinates of te GRB

GRM-> GWAC to indicate the time slice of the trigger

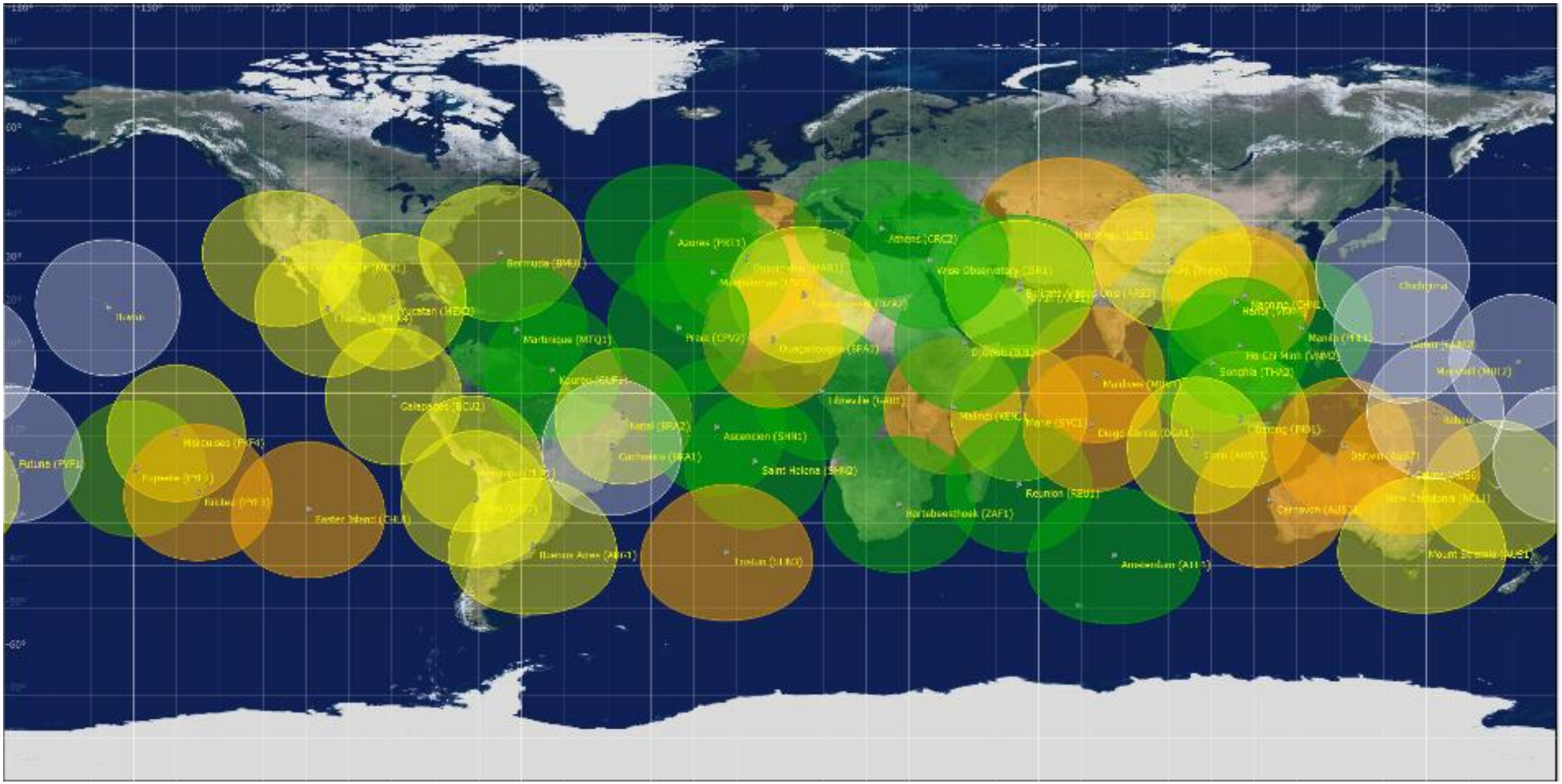
SVOM alert system





- 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

Le déploiement - suite



Station Installée

Station sur place/en transit

Accords de principes

Discussions engagées

NB : cercles de visibilité théoriques à EL=10°

Florilèges des stations installées









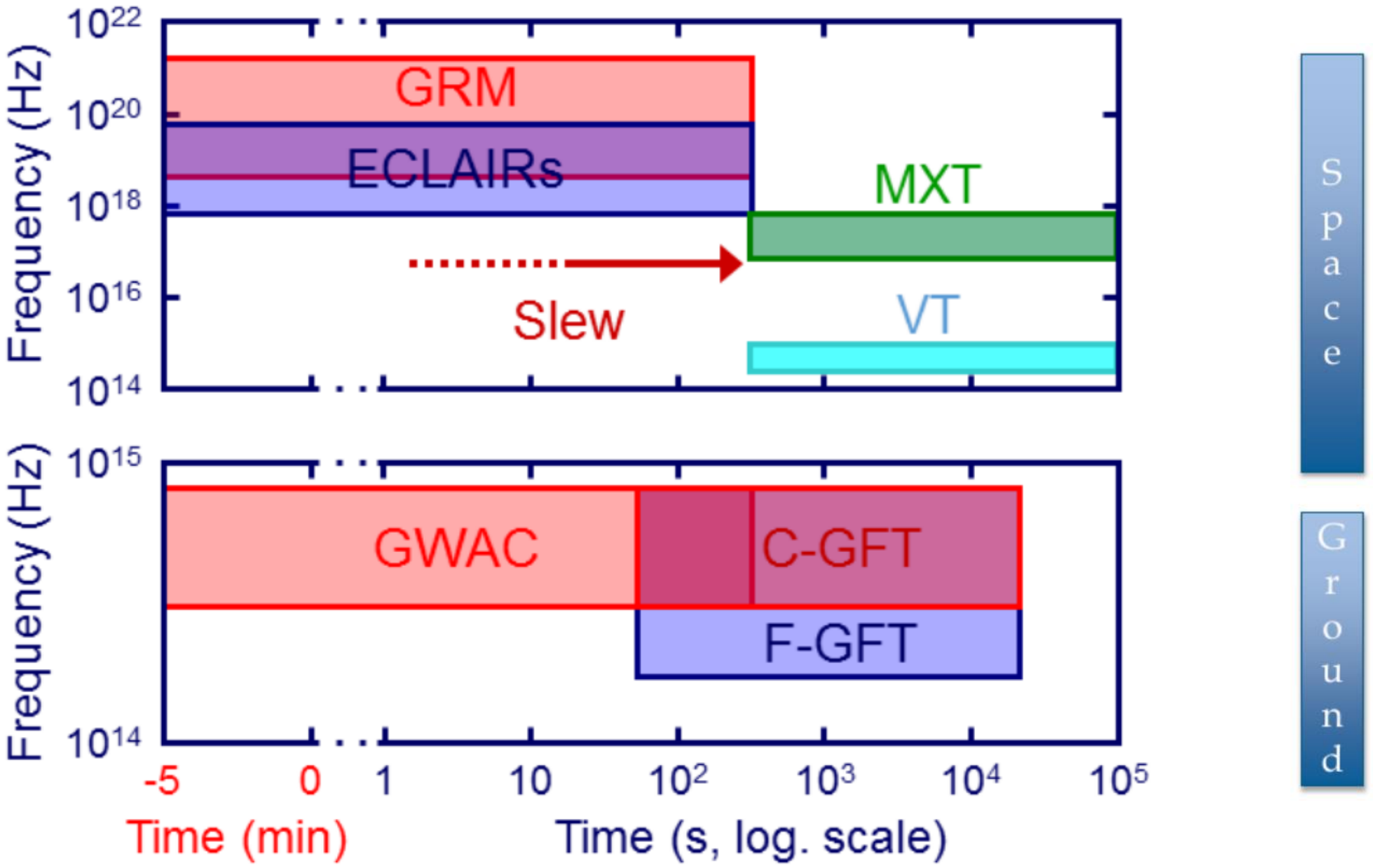






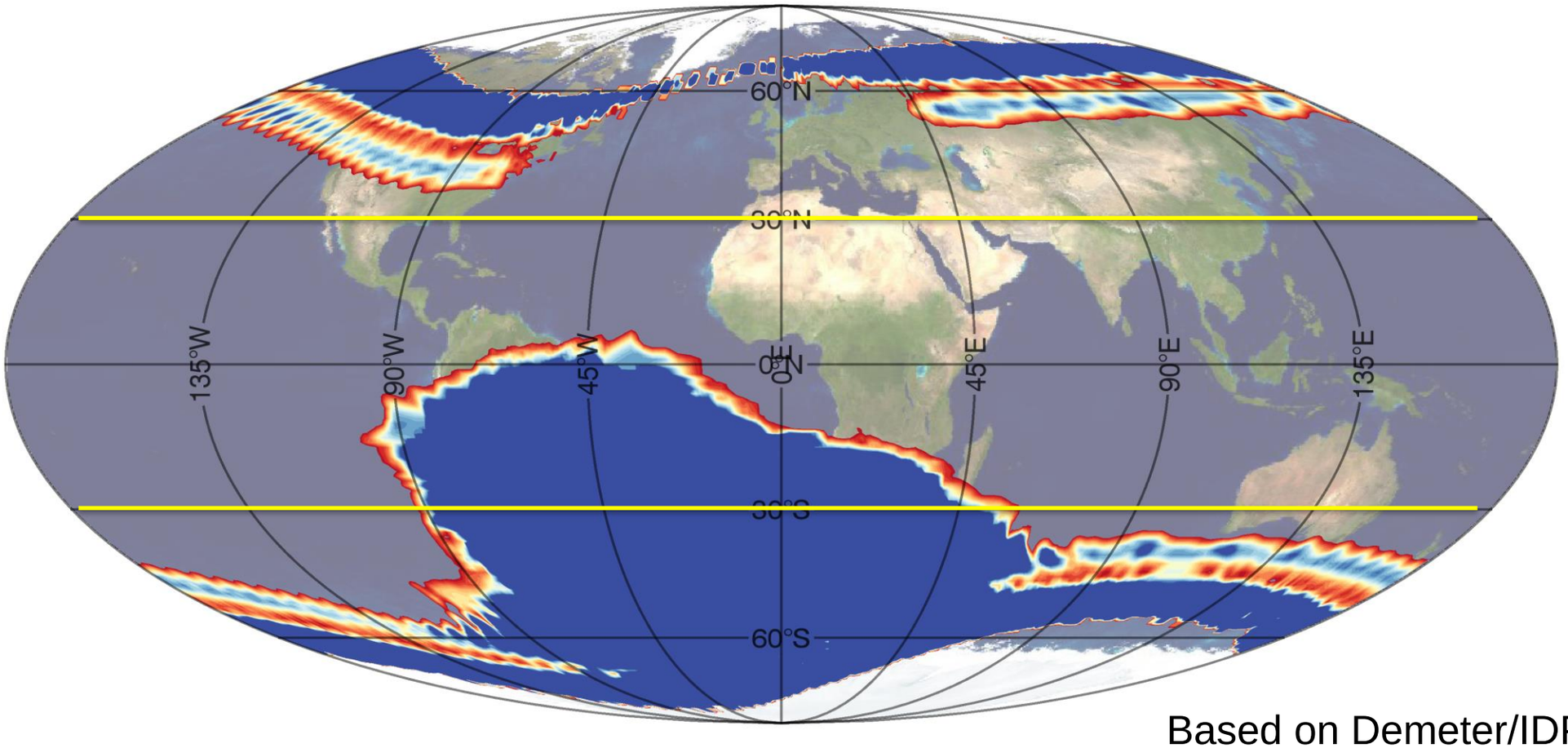


A powerful time domain machine



- Trigger and locate (hard) X-ray transients
- Multi-wavelength follow-up
- Alerts and localization distributed in real-time => **follow-up from other facilities**

The SVOM orbit

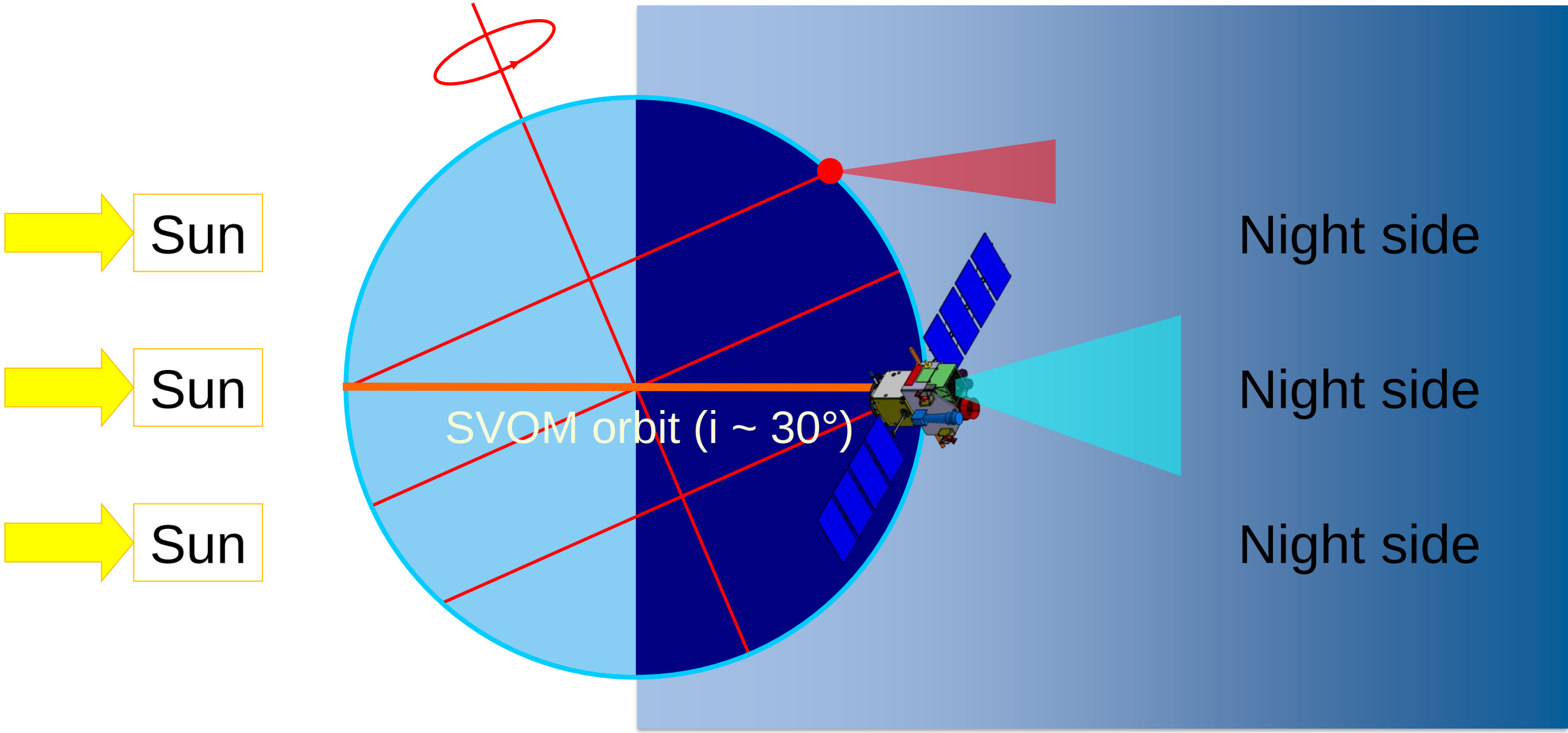


Based on Demeter/IDP electron flux

LEO altitude 625 km, with an inclination of 30°, launched by a LM-2C from Xichang

→ the satellite passes though the South Atlantic Anomaly
→ induces a dead time of (13-17)%

The SVOM attitude law



To detect GRB on the night side → attitude law : roughly antisolar

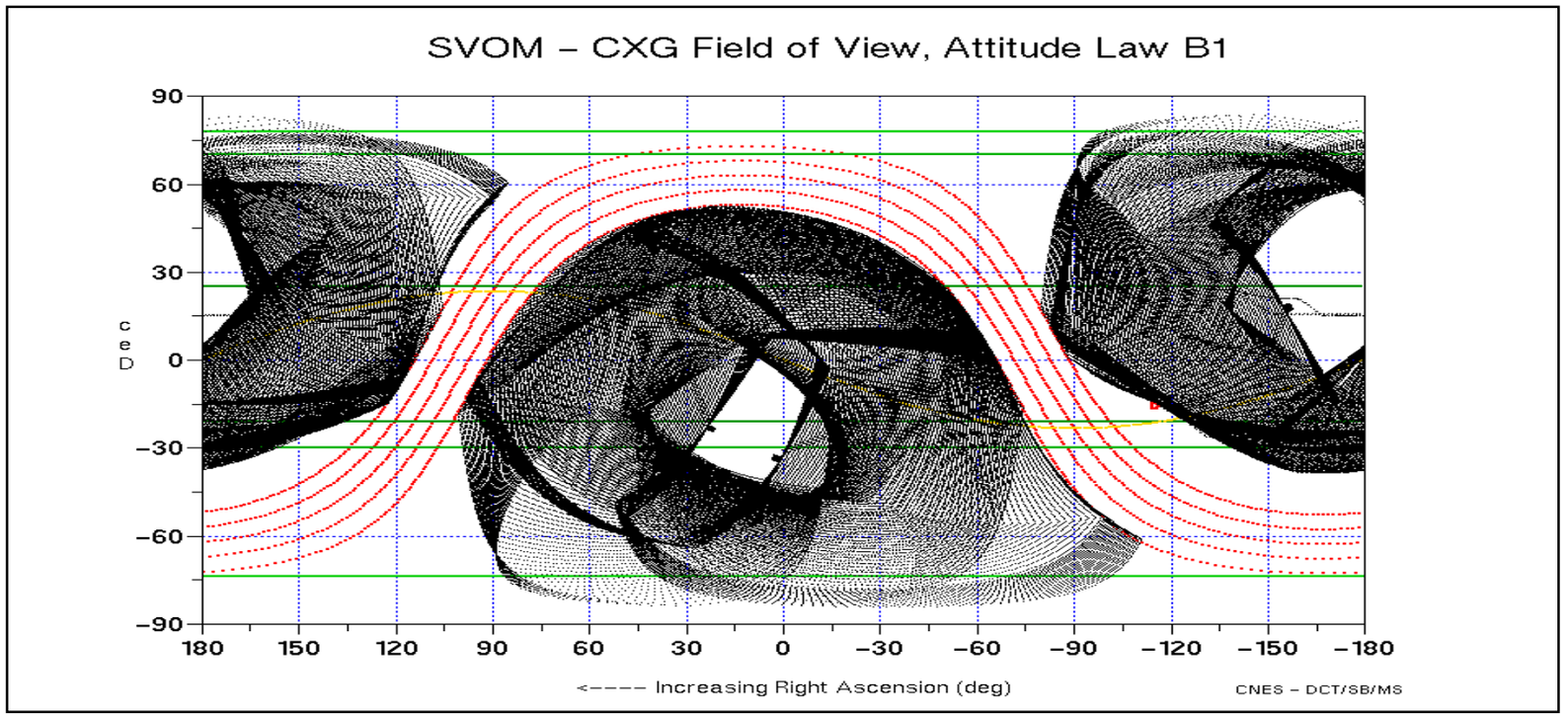
Optimization of the SVOM attitude law

To favor the GRB detection by ECLAIRs
- avoidance of the the Sco X1source (outsite of the ECLAIRs FOV)
- avoidance of the Galactic Plane (+/- 10° for the ECLAIRs FOV)

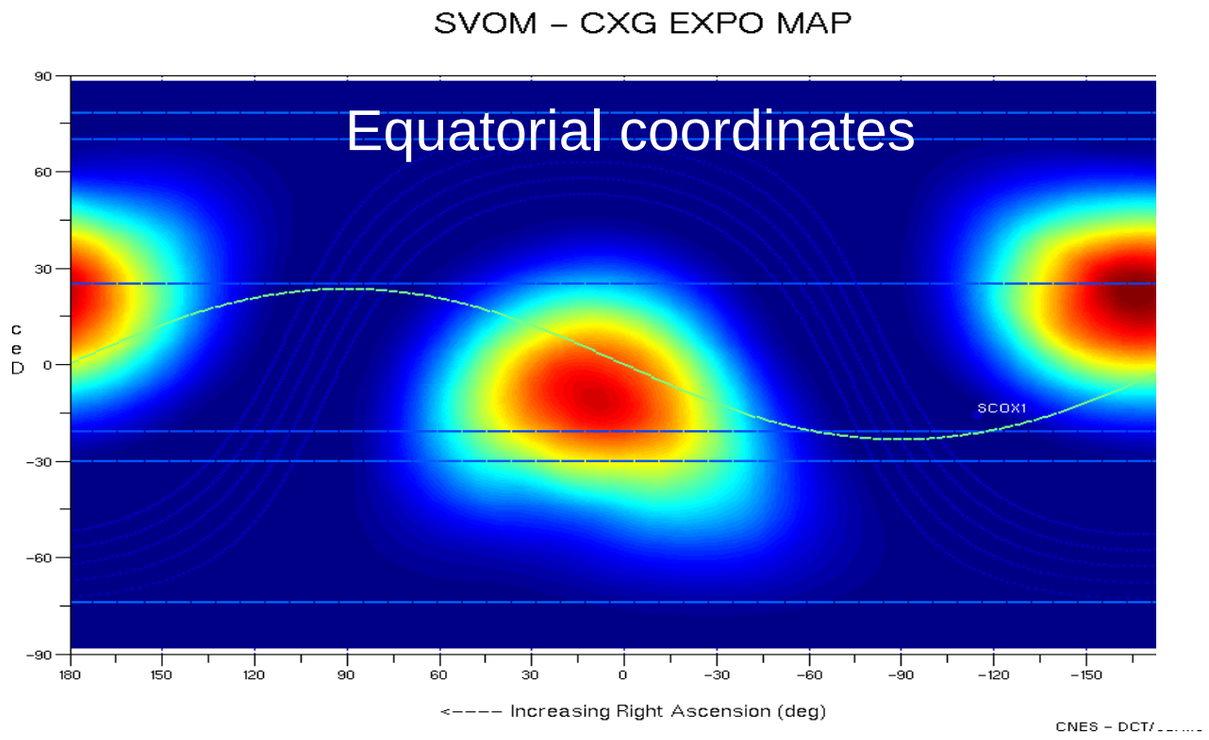
To favor the redshift measurement on ground.
- avoidance of the Galactic Plane (+/- 10° for the ECLAIRs FOV)
- → to favor the sky area observable from both Hawaii, Chile and the Canary
- → SVOM points to areas near the equator (declination $\delta=0$)

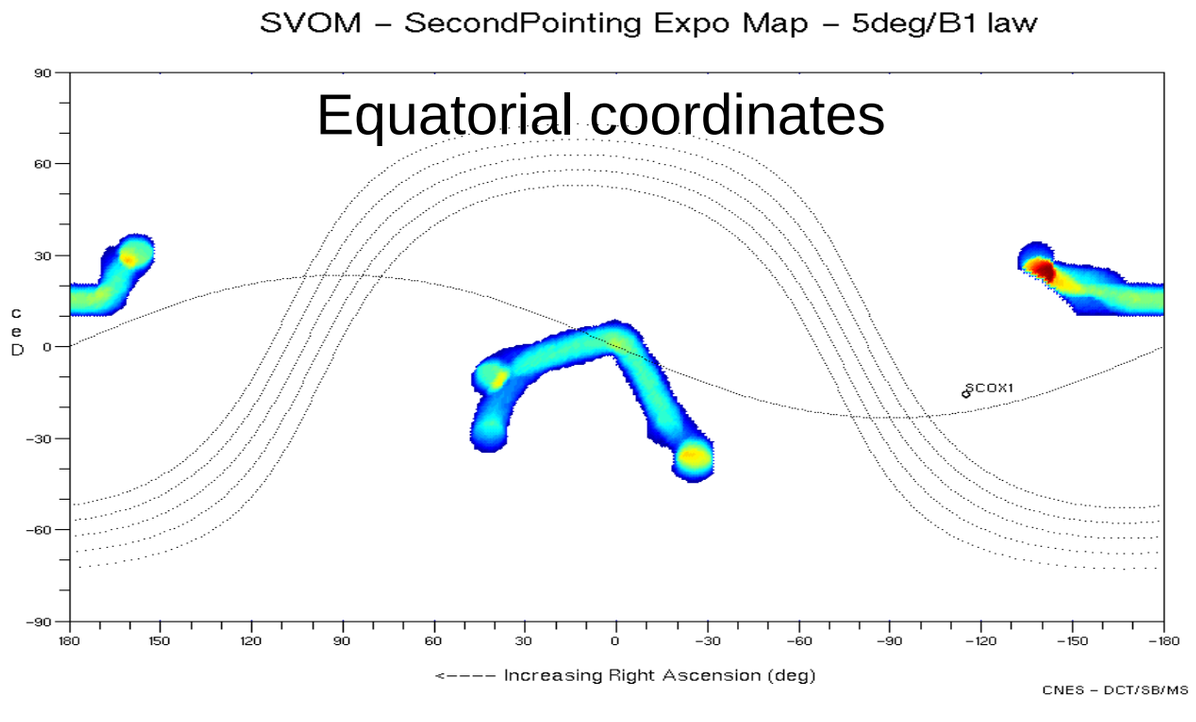
To maintain a cold face for the satellite
Offset of 45° with respect to the antisolar direction

Tolerance of 5° with respect to the nominal pointing

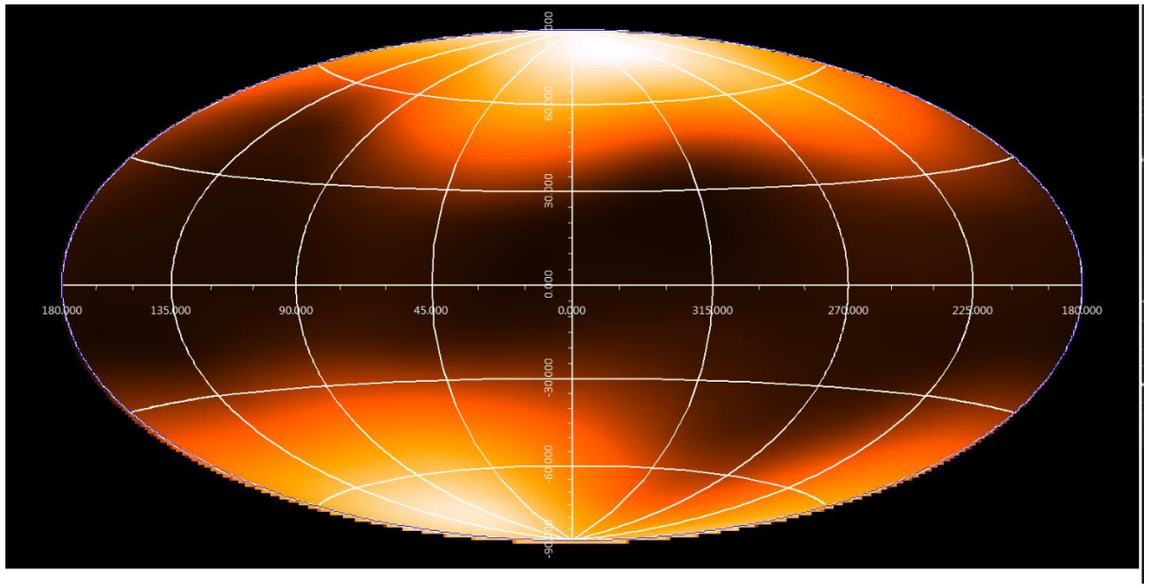


The SVOM attitude law: consequences on the exposure map
1 year scenario

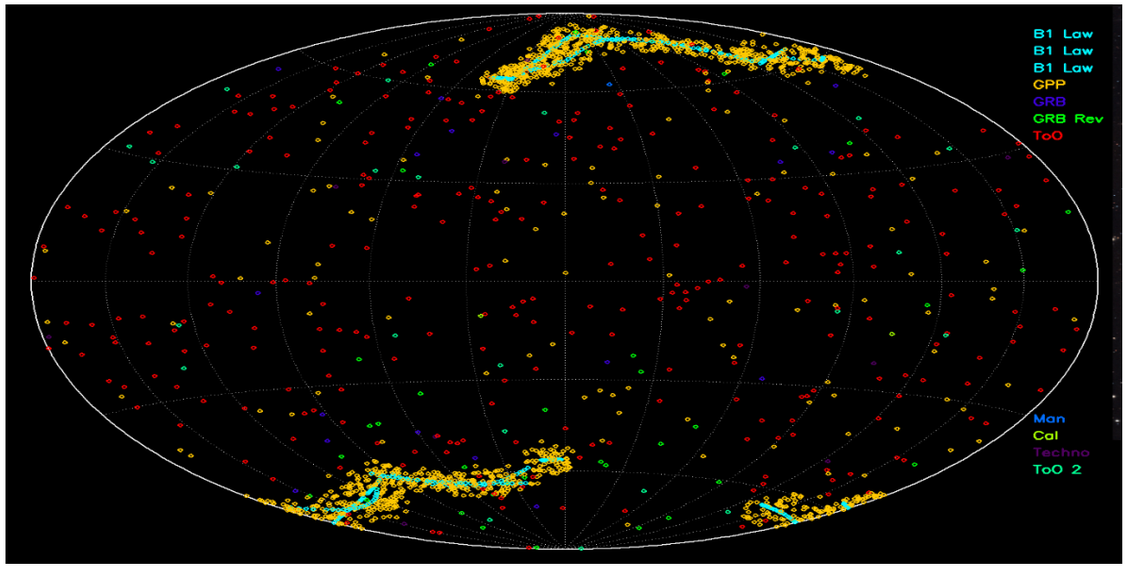




Galactic coordinates



Galactic coordinates



Wide field instruments : ECLAIRS, GRM,

Narrow field instruments : MXT, VT

The SVOM GRB sample

A unique sample of **30-40 GRB/yr** with:

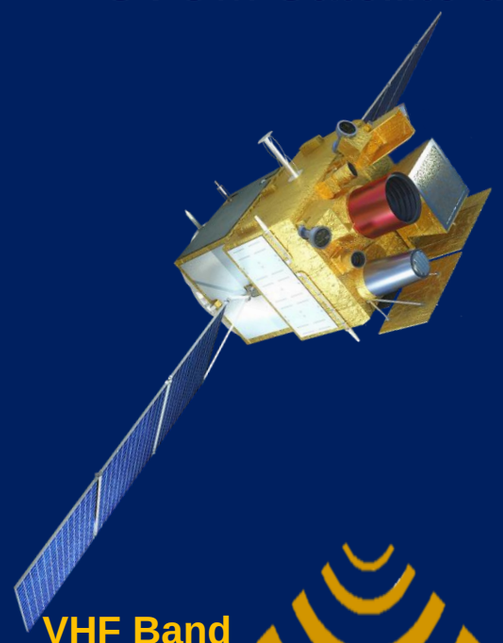
- **prompt emission** over 3 decades (+ optical flux/limit: 16%)
- X-ray and V/NIR **afterglow**
- **redshift**

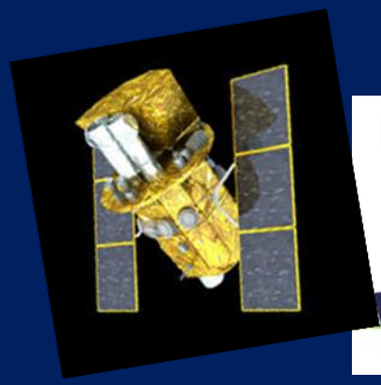
	Swift	**Fermi**	**SVOM**
Prompt	Poor	Excellent 8 keV -100 GeV	**Very Good** **4 keV - 5 MeV**
Afterglow	Excellent	> 100 MeV for LAT GRBs	**Excellent**
Redshift	~1/3	Low fraction	**~2/3**

- **Physical mechanisms at work in GRBs**
  - Nature of GRB progenitors and central engines
  - Acceleration & composition of the relativistic ejecta
- **Diversity of GRBs: event continuum following the collapse of a massive star**
  - Low-luminosity GRBs / X-ray rich GRBs / X-ray Flashes and their afterglow
  - GRB/SN connection
- **Short GRBs and the merger model**
  - GW association

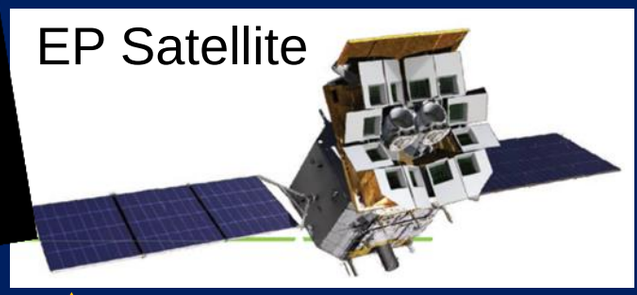
Operational Scenario for GRB detection by SVOM

SVOM Satellite detects a GRB



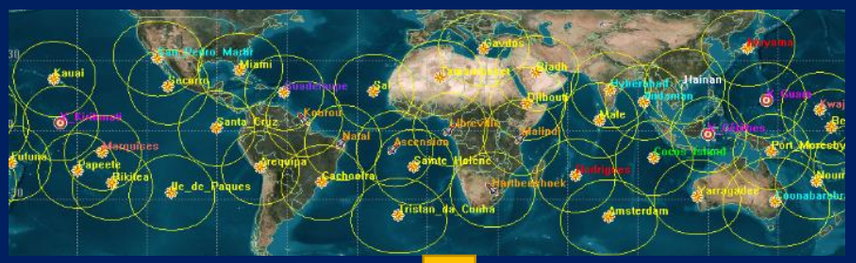


EP Satellite



VHF Band

X & S Band



Tracking antennas

VHF alert data

Science and HK data

Alert data processing by French Science Center + SVOM BA system

Science data processing by French and Chinese Science Centers

SVOM robotic telescopes

LCOGT

Others…

Large Ground Telescopes

... Now that this whole system is in place, SVOM is a powerful time domaine machine that can work in both direction

SVOM Satellite slews and observes a Target of Opportunity

X Band

Tracking antennas

Science data

Beidou and S Band

Tracking antennas

Telecommands

Object detected by other observatories Space or Ground

Observation requests (ToO) analysed at French and Chinese Science Centers

Preparation of satellite TC plan by Mission Center

Chinese Control Center

Science data processing by French and Chinese Science Centers

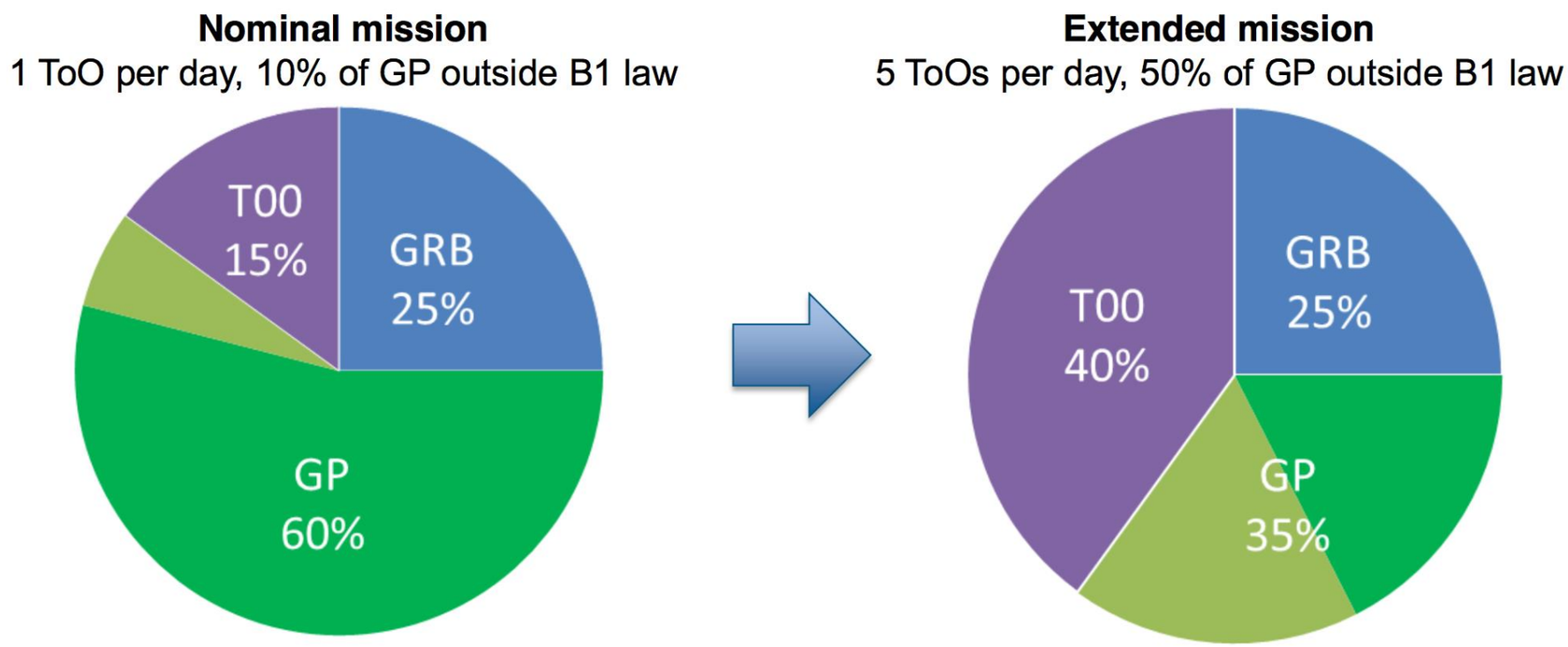
SVOM robotic telescopes

LCOGT

Others…

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 targets of interest mostly compliant with the satellite attitude law
- **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…



The SVOM ToO programs

WORLD

Only accessible by the SVOM CO-Is

ToO-Multi-Messenger

- 1/week
- Allocated time: 1-14 orbits (1 day)
- Max latency: 12h (S-Band) / <4h (Beidou)
- Instruments: MXT, VT + grd seg.

ToO-EXceptional

- 1/month
- Allocated time: 7-14 orbits (1 day)
- Max latency: 12h (S-band) / <4h (Beidou)
- Instruments: MXT, VT + grd seg.

+

Accessible to everybody

ToO-NOMinal

- 1/day
- Allocated time: 1 orbit (~45 min)
- Typical latency: 24-48h
- Instruments: MXT, VT + grd seg.

a % of sci. products public

all sci. products public

Maidanak participation to SVOM project

SVOM and Maidanak

- The Maidanak observatory hosts a VHF SVOM station, as such the Maidanak observatory will be in a position to request 3 nominal ToO per year

- The SVOM team will help the Maidanak scientist to process their SVOM data.

- SVOM consortium wants Maidanak to become an associate partner. Such a partner is a voluntary facility, which responds at its convenience to the SVOM alerts.

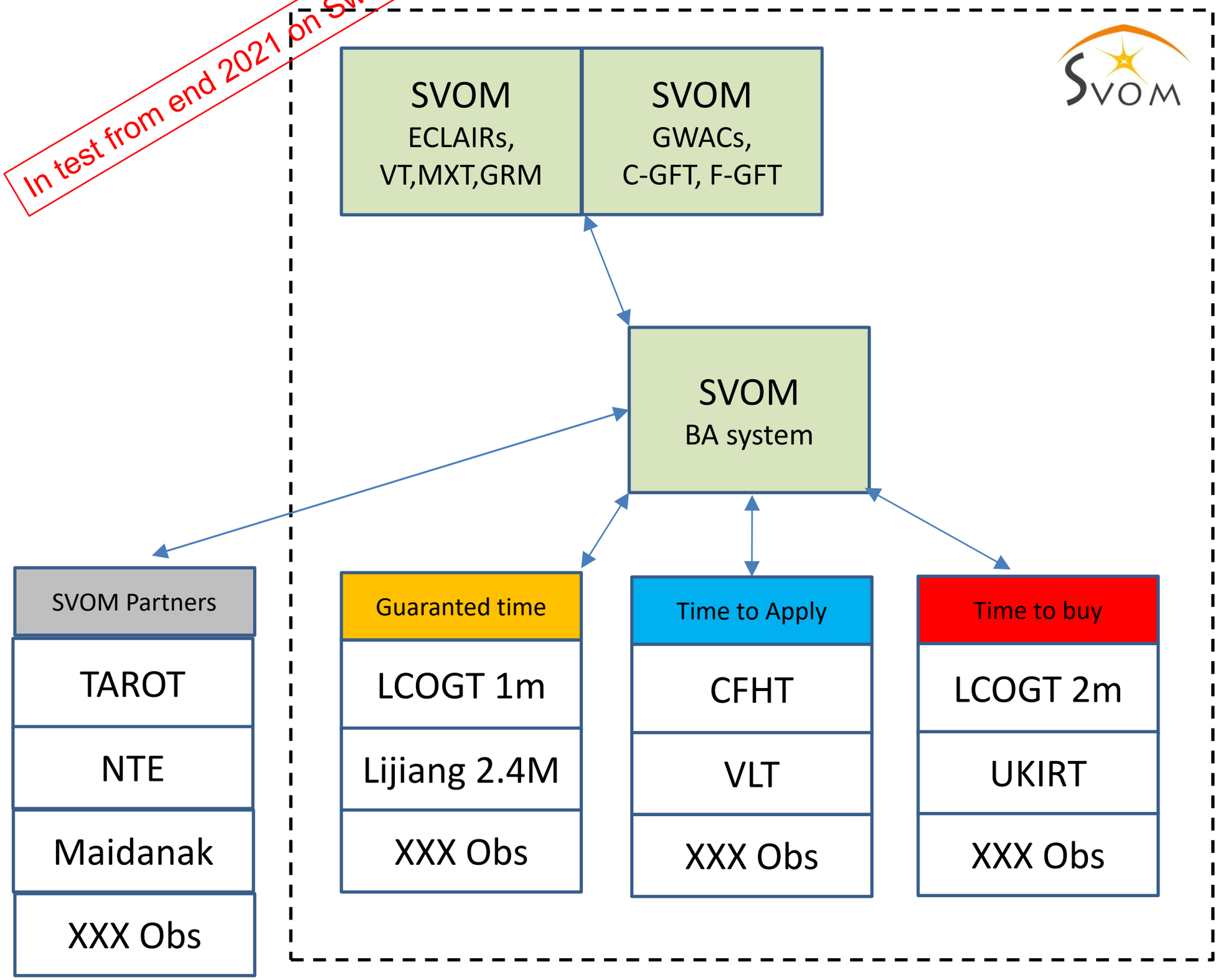
- The partner commits itself on the basis of a best effort. The acquired data are not automatically considered as SVOM data.

- The management of the data sharing (from the partner to SVOM and vice-versa) and of the resulting publications is then done on a case by case basis, following specific agreements (if any).

- To be discussed in the near future

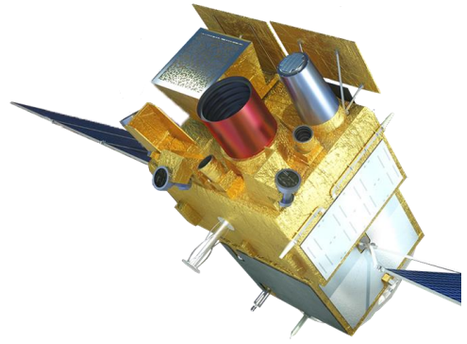
SVOM Follow-up System 2023

In test from end 2021 on Swift alerts



Organization of the SVOM Follow-up system, operational end 2022 and based on the attractiveness of SVOM
The exchanges between SVOM and its various partners are defined in the updated SVOM Science Management Plan

CONCLUSION, in the next decade



- SVOM is mini-satellite class mision (< 1000kg)
- SVOM will provide ~80 GRB/yr.
- SVOM will study the GRBs in a wide spectral band (from Gamma-ray to IR)
- We aim to measure the redshift for >50% of the SVOM GRBs, thanks to the attitude law of he spacecraft and the follow-up netwok
- The Maidanak Observatory will have the possibility to apply for 3 ToO/year, which concerns the observation of a source with all the instruments of the mission.
- By becoming a partner of SVOM, the Maidanak observatory will be able to contribute to the monitoring of alerts and enrich the spectro-temporal coverage of the SVOM sample.

GO SVOM !

NAOC, Beijing

IHEP, Beijing

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SECM, Shanghai

CEA-Irfu, Saclay

IRAP, Toulouse

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LPAG Grenoble

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launch mid 2023