THE SVOM MISSION

Jean-Luc Atteia (IRAP)

on behalf on the Svom collaboration

SVOM "Space-based multi-band astronomical Variable Objects Monitor"
a Sino-French mission dedicated to GRBs and HE transients
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

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

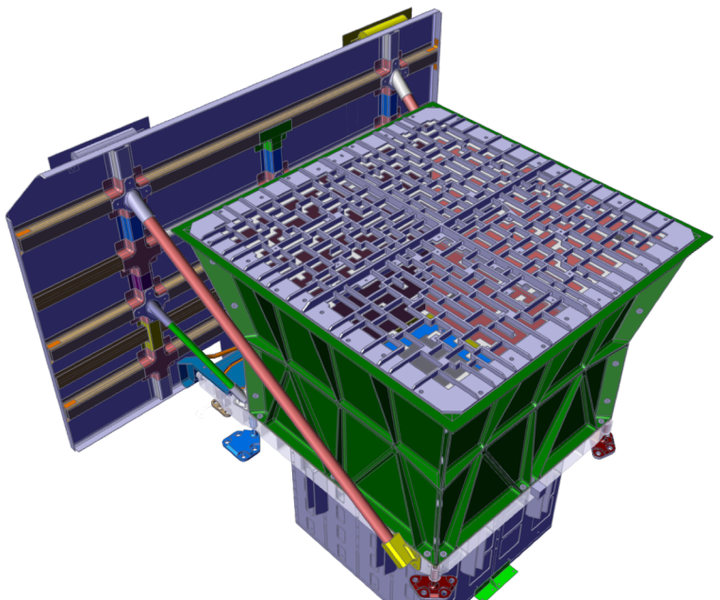
Neil Gehrels Swift obs. & Fermi
for space observations

TAROT
for ground observations

- **Mexico** UNAM Mexico
- **UK** University of Leicester
- **Germany**
  - MPE Garching
  - IAAT Tübingen

Frédéric Daigne is the french mission scientist in charge of the core program

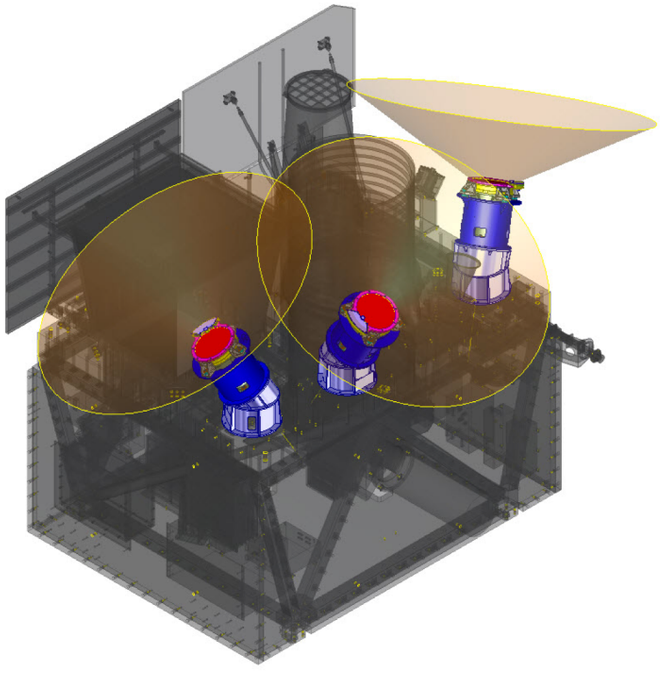
INSTRUMENTS (with LARGE FIELD OF VIEW)



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 arcsin** for 90% of sources at detection limit
- Onboard trigger and localization: **~65 GRBs/year**

Well adapted for the detection of lGRB with low EPEAK

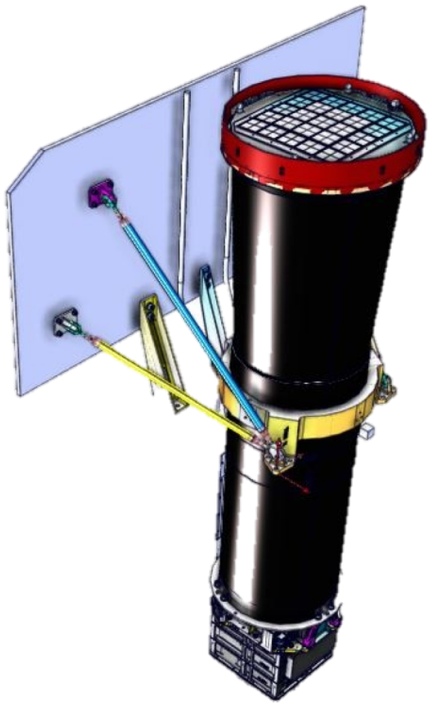


GRM Gamma-Ray Monitor (IHEP)

- **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:2 sr per GRD**
- **Energy range: 15-5000 keV**
- Aeff = 190 cm^2 at peak
- Rough localization accuracy
- Expected rate: **~90 GRBs / year**

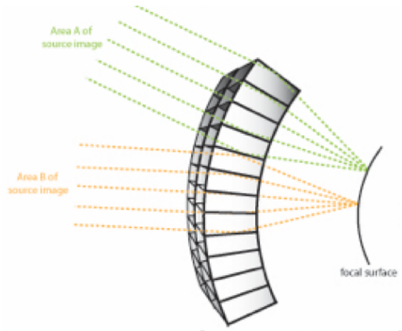
Will provide EPEAK measurements for most ECLAIRs GRBs
Will detect GRBs and transients out of the ECLAIRs FOV (with poor localization)

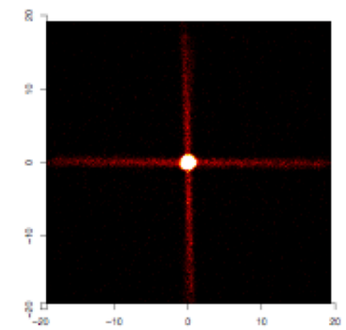
INSTRUMENTS (with NARROW FIELD OF VIEW)



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

- **Micro-pores optics** (Photonis) with **square 40 µm 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)



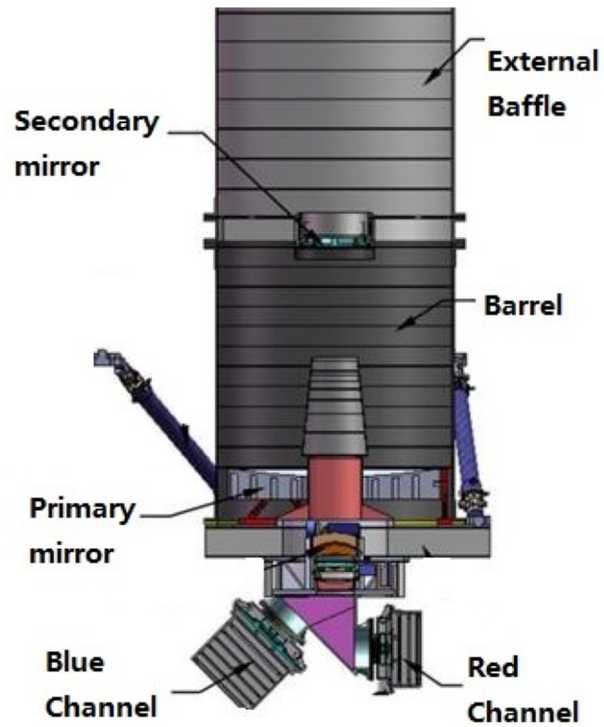


Implements innovative focussing X-ray optics based on « Lobster-Eye » design
Will be able to promptly observe the X-ray afterglow

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



GROUND BASED INSTRUMENTS (1)

GWAC Ground-based Wide Angle Camera (2018)

- Partly installed in China (near Muztagh Ata) and partly in Chile to optimize the observation of prompt GRB optical emission

- **In China**: 40 cameras of 180 mm diameter
  - **total FOV ~6000 deg²** ; limiting magnitude 16 (V, 10s)

- **In Chile**: 50 cameras of 250 mm diameter
  - **total FOV ~5000 deg²** ; limiting magnitude 17 (V, 10s)

Each set will cover instantaneously about 12% of the ECLAIRs FOV
Will scan the entire accessible sky each night

Self triggering capabilities: will be able to catch autonomously optical transients

The Chinese GWACs are in commissioning phase, will participate to O3 LIGO/VIRGO run

GROUND BASED INSTRUMENTS (2)

GFTs permit the fast identification and measure of early optical/NIR afterglows (light-curve, SED) 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 de Martir (Mexico)

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

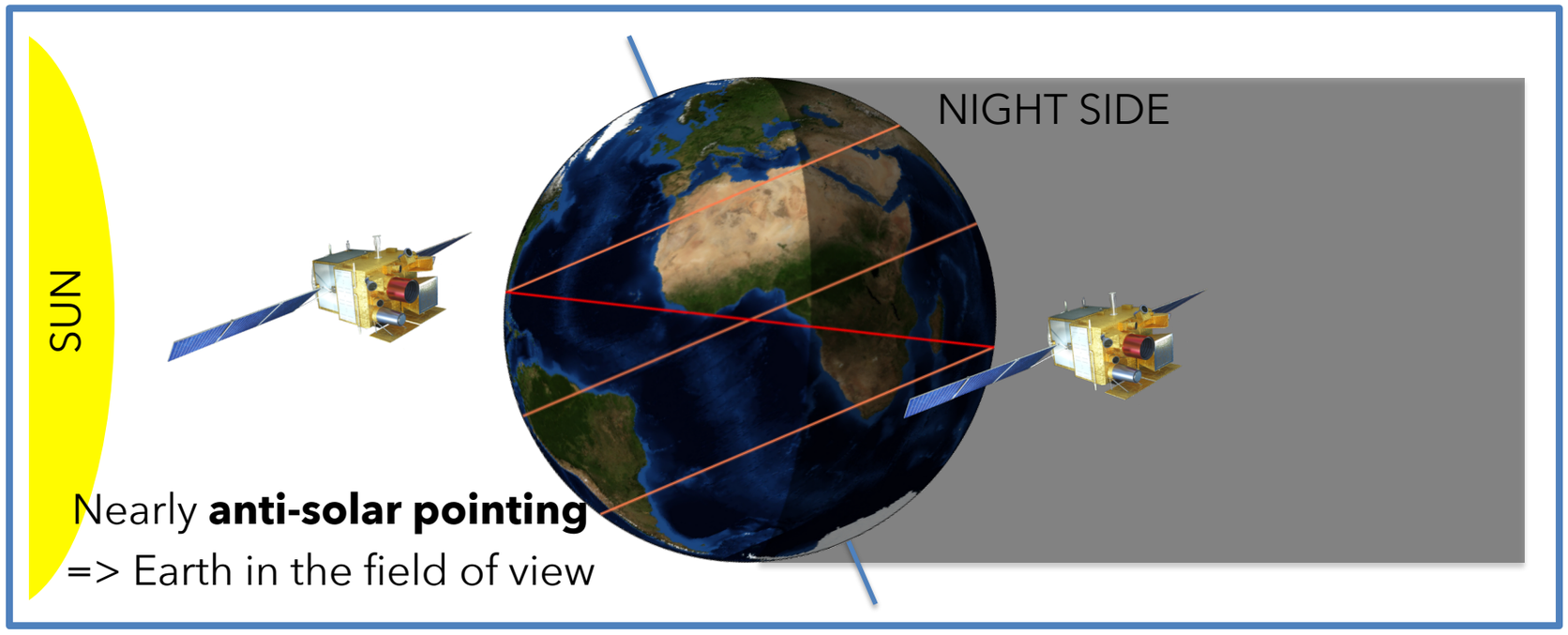
Diameter : 120cm
FOV : 90 x 90 arcmin
400 – 900nm

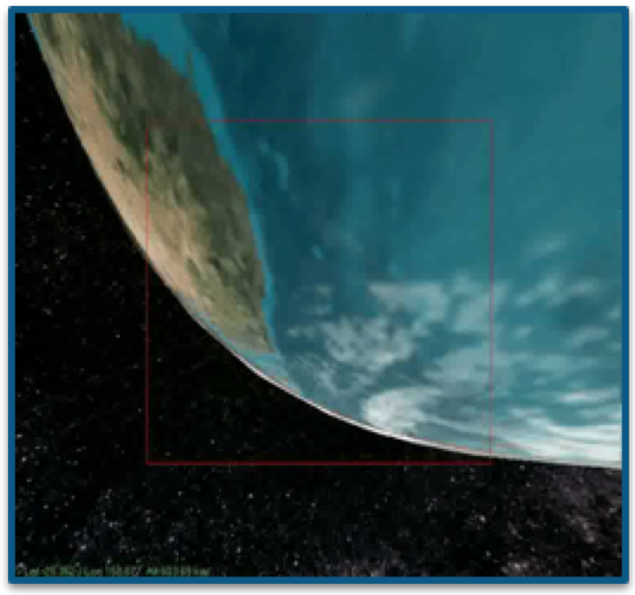
Contribution to the LCOGT network (12x1m+2x2m tel.)

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

ORBIT AND POINTING STRATEGY

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



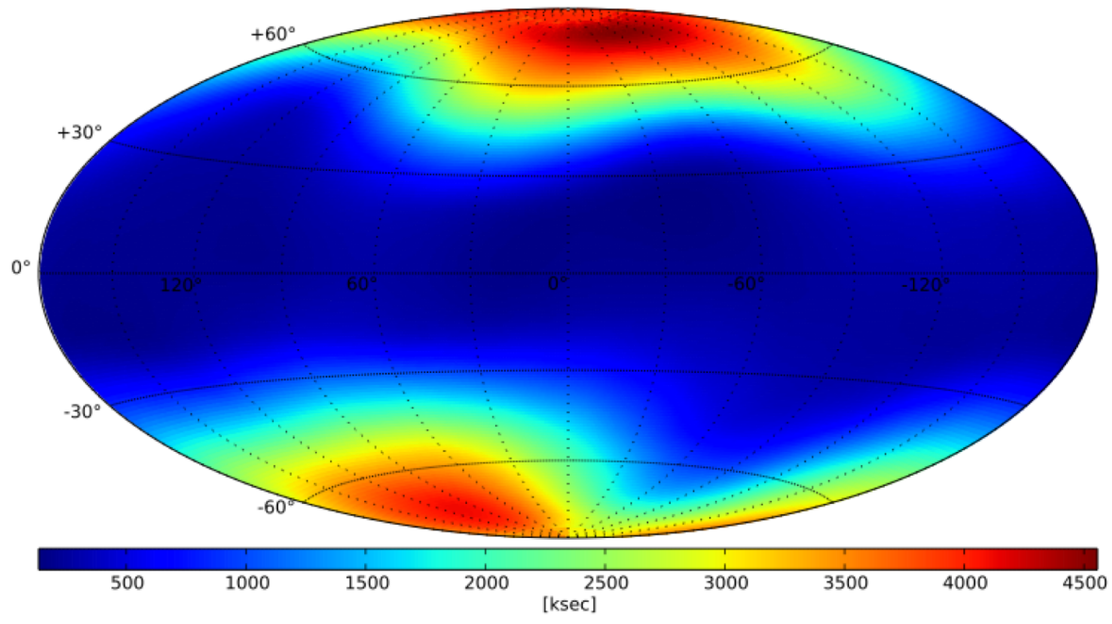


65% of duty cycle for ECLAIRs
about 50% for MXT and VT

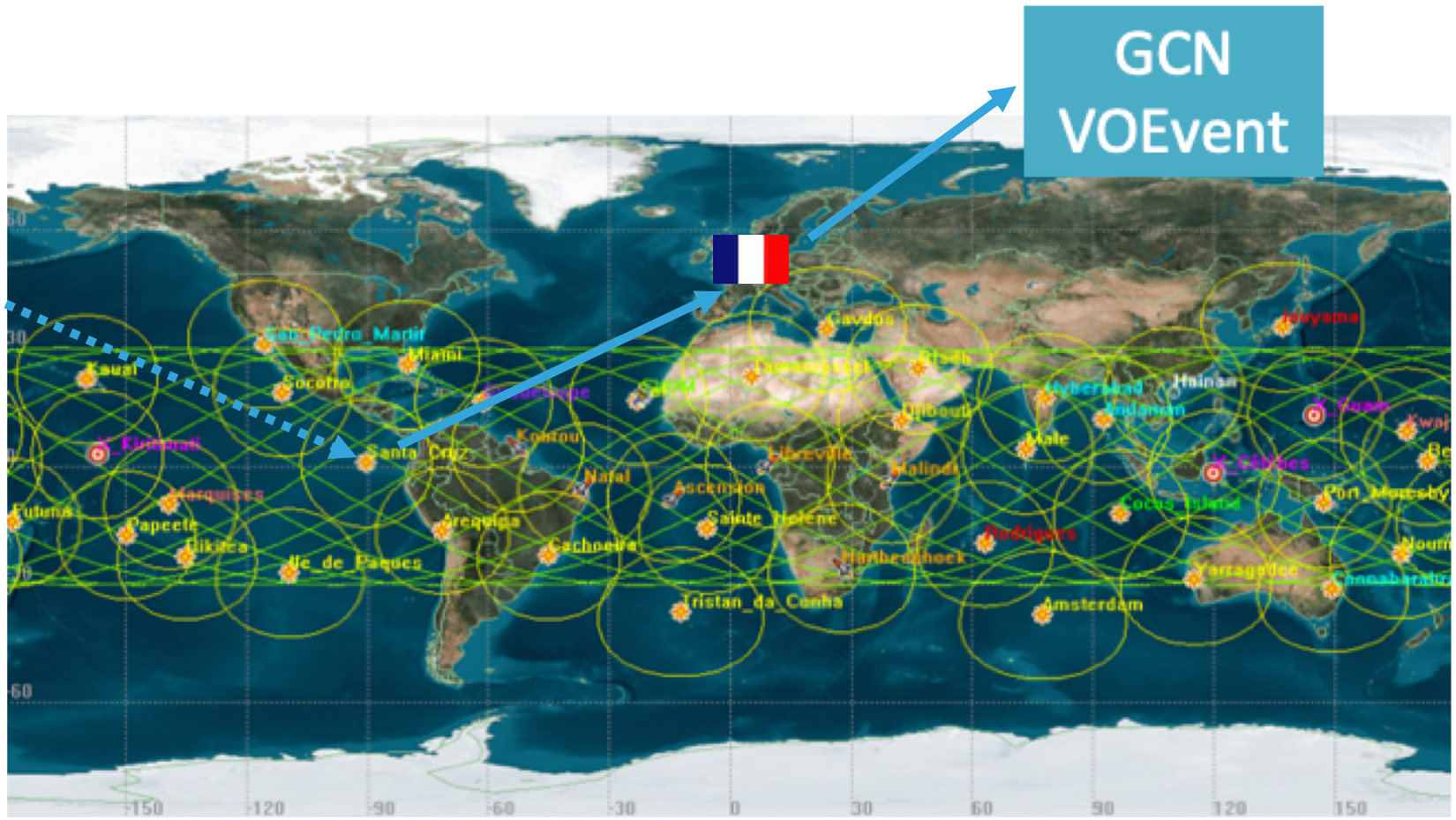
Waiting between the detection of two GRB candidates…

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



SVOM ALERT SYSTEM

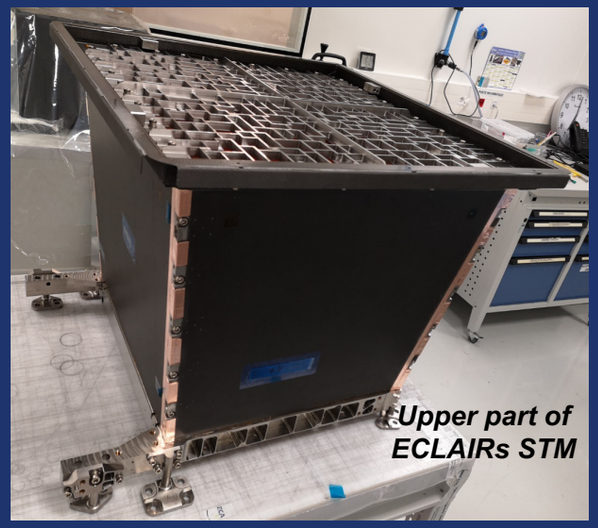


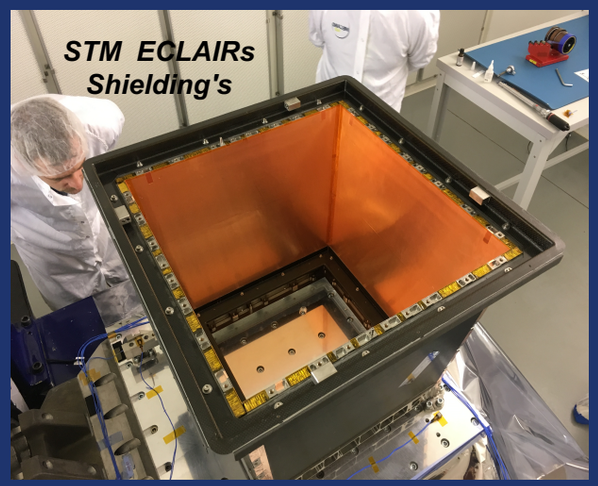
Alerts are transmitted to a network of 40 VHF receivers on Earth

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

ECLAIRs + post-slew X-ray and Visible information is also sent through the VHF link

ECLAIRs Status





1. ECLAIRs EQM fabrication

- Qualification tests (vibration, electrical) at sub-contractor level
- Hardware / Software integration at CNES

2. ECLAIRs STM fabrication

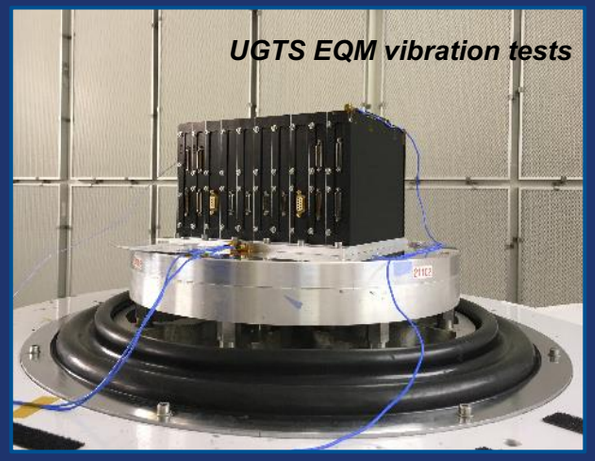
- Shielding and belt ready for qualification tests (mechanical and thermal)
- Mask already qualified !
- Thermal bus and DPIX mock-up on-going…

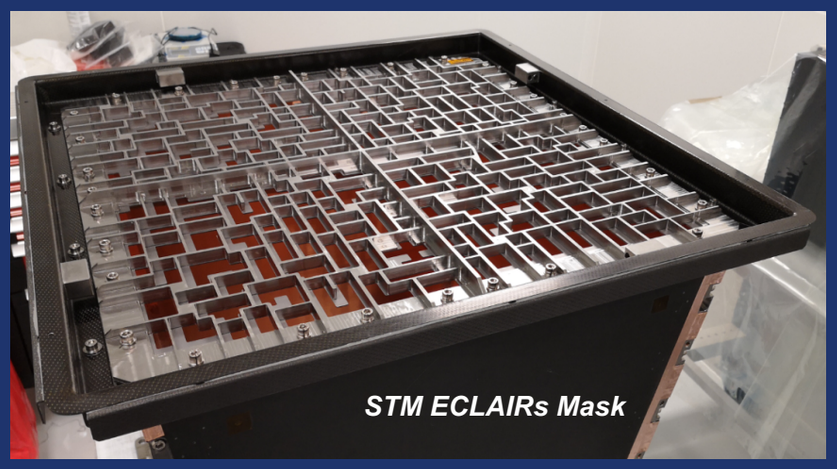
3. ECLAIRs PFM fabrication

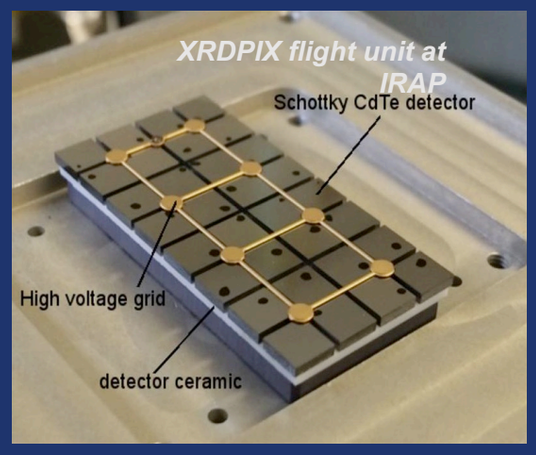
- All parts are procured (EEE components, detectors, MLI, connectors, …)
- Waiting for sub-system qualification tests before going ahead in PFM fabrication

4. AIT at CNES & SEC

- Flat Sat campaign preparation (test plan, organization)

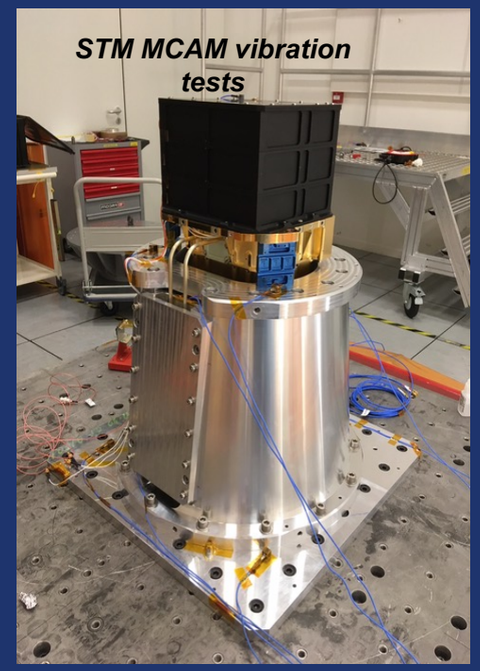


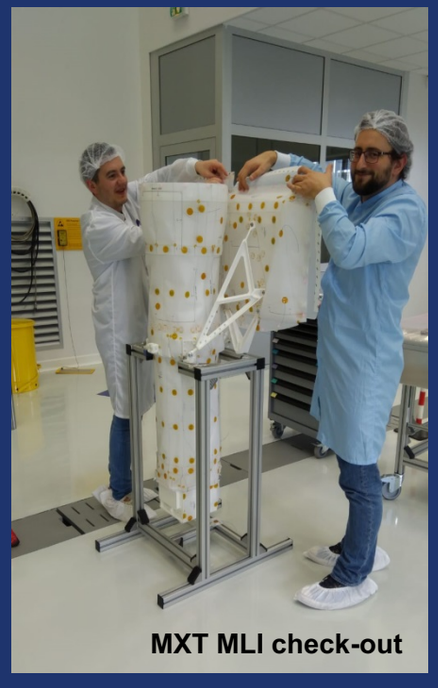


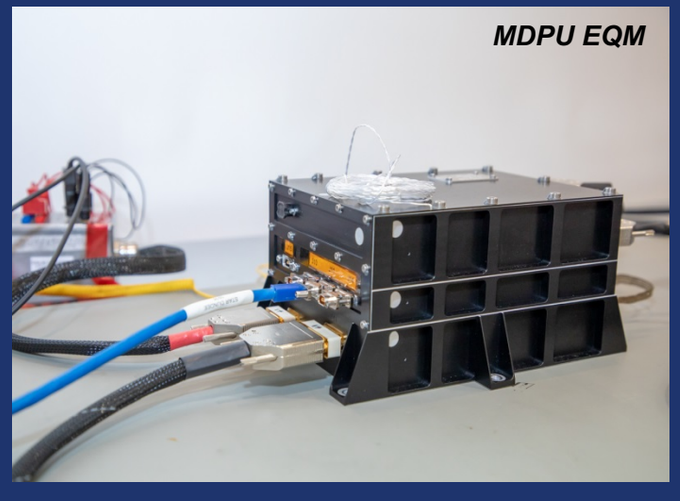


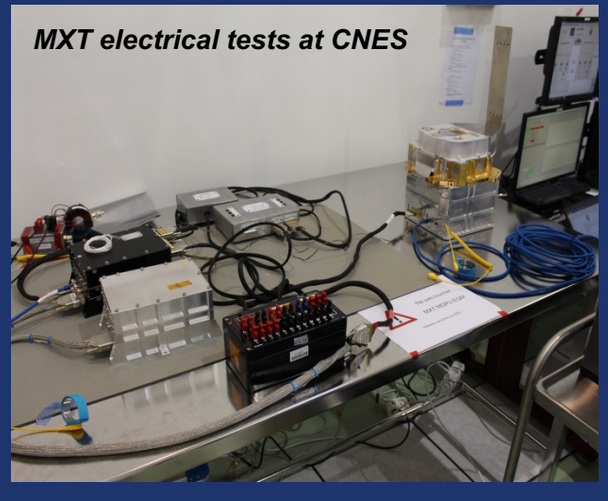
MXT Status

1. **MXT EQM fabrication**
   - Qualification tests (vibration, electrical) at sub-contractor level
   - Hardware / Software integration at CNES
2. **MXT STM fabrication**
   - Tube for qualification tests (mechanical and thermal)
   - Optics dummy ready
   - Thermal bus and DPIX mock-up on-going…
3. **MXT PFM fabrication**
   - All parts are procured (MPO Plates, EEE components, detectors, MLI, connectors, …)
   - Waiting for sub-system qualification tests before going ahead in PFM fabrication
4. **AIT at CNES & SECM**
   - Flat Sat campaign preparation (test plan, organization)



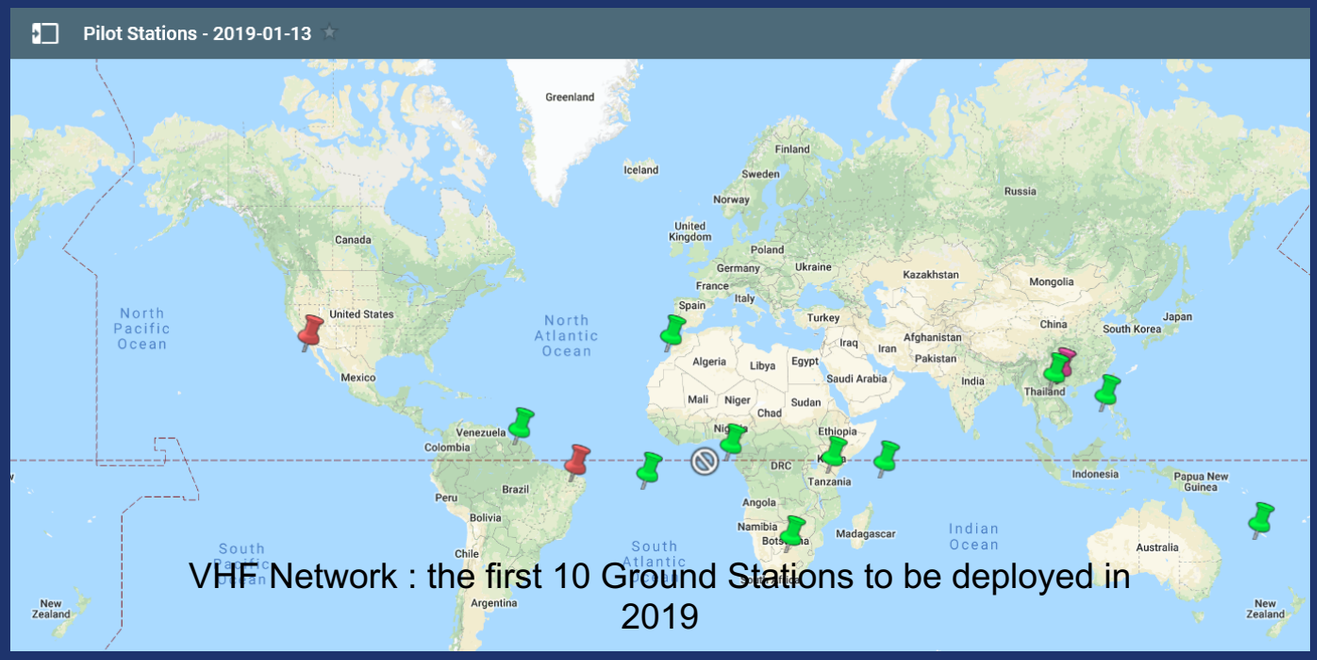






VHF Ground Station

First Tests of the VHF Ground Station Prototype
Excellent Results !



VHF Network : the first 10 Ground Stations to be deployed in 2019

Core Program : a complete GRB sample

	Swift	Fermi	SVOM
Prompt	Limited	Excellent 8 keV -100 GeV	Very Good 4 keV - 5 MeV
Afterglow	Excellent	/	Excellent
Redshift	~1/3	/	~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

X-ray rich GRBs/X-ray Flashes and their afterglow

GRB/SN connection

Short GRBs and the merger model

GW emission from the final stages of orbital decay and merger

BESIDES GRBs . . .SVOM AS AN OPEN OBSERVATORY

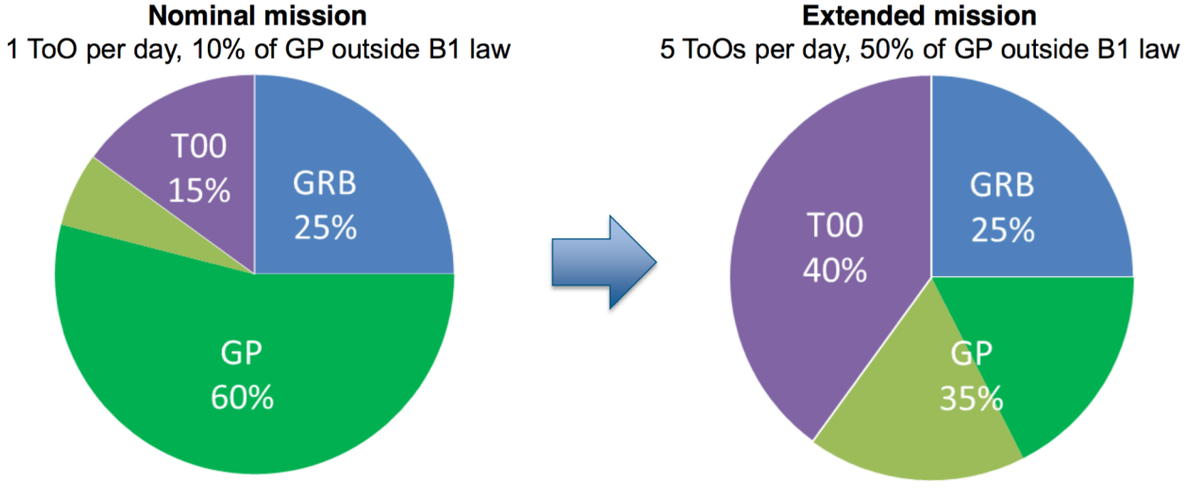
The general program (GP)

- 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 including multi-messengers, will increase during the extended mission

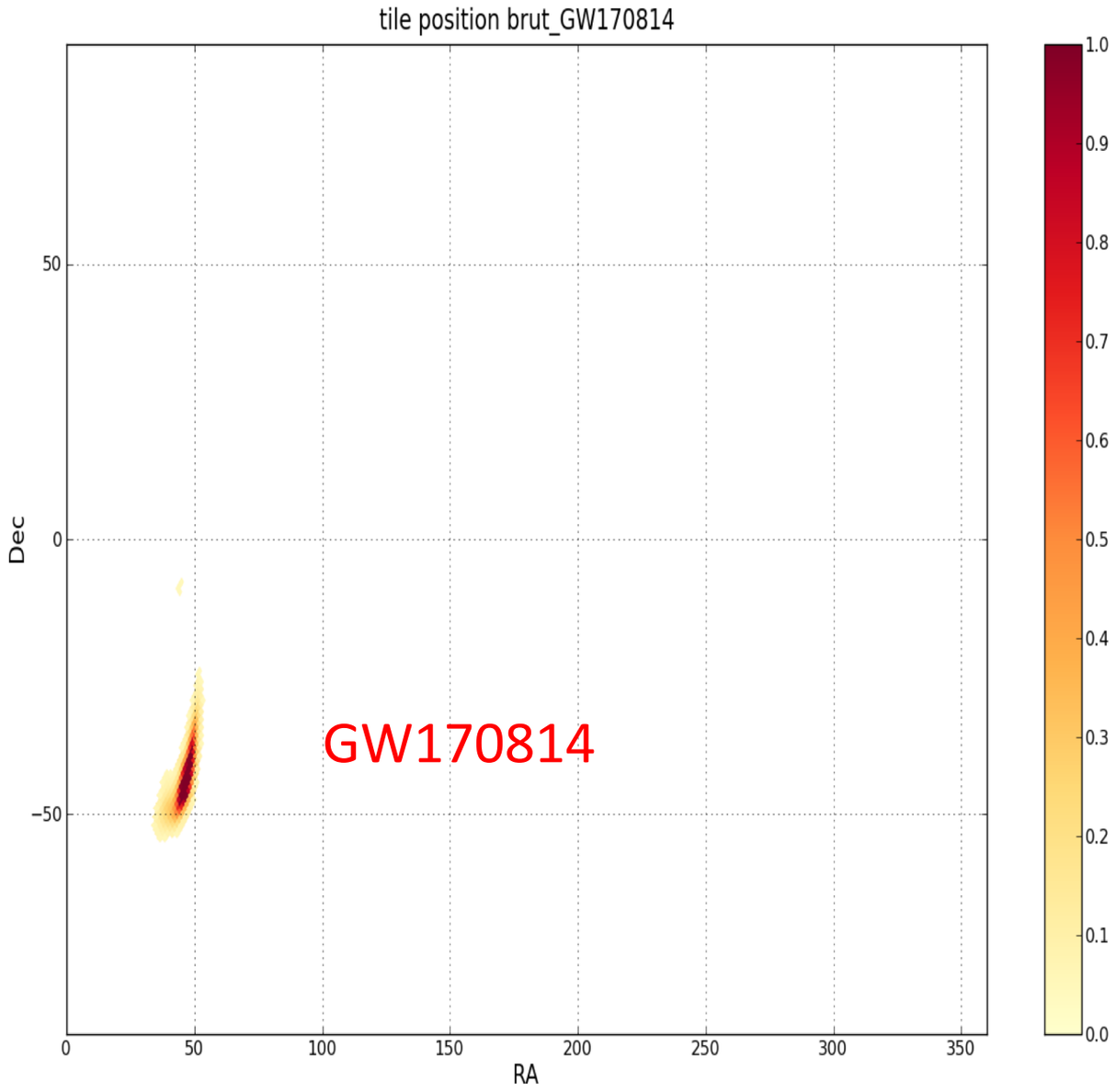


ToO	Approval	From accep-tance/ trigger	GRB inter-ruption	Frequency	Duration
ToO-NOM	PI	<48h	Yes	MAX 1/day => 5/day	1 orbit
ToO-EX	PI	<12h	No	MAX 1/month	1-14 orbits

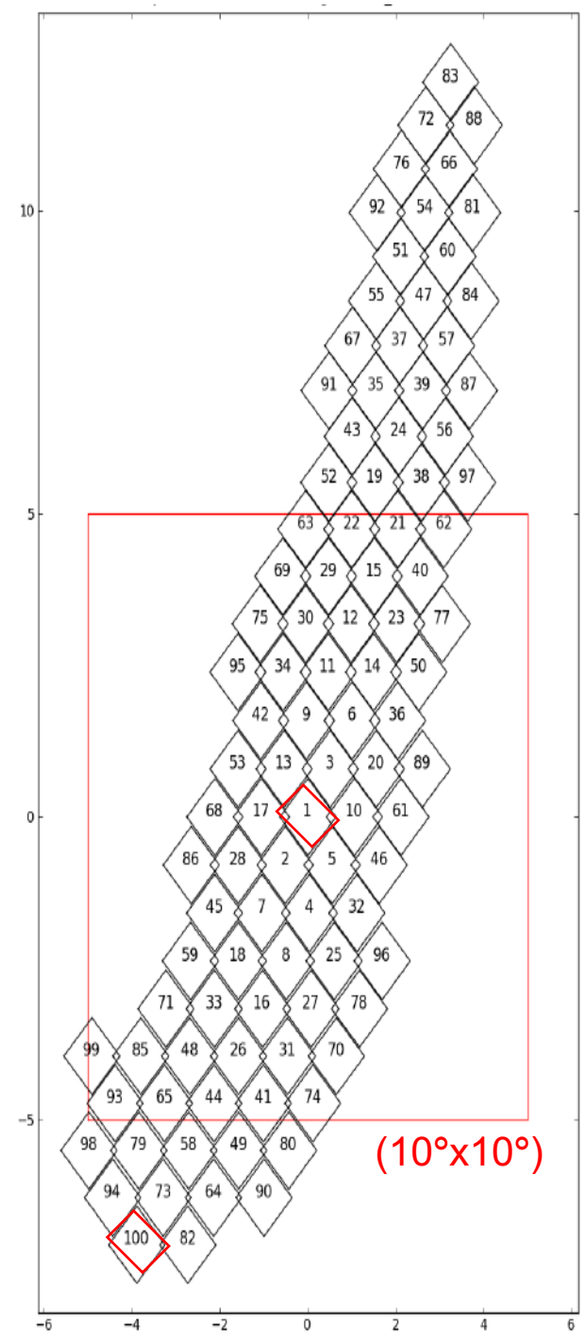
ToO Multi-Messenger : Tiles sequencing simulations

- **First example of ToO-MM request : scenario « focused »**

GW170814



Scenario	170814 GW
Nb. tiles	230
RA min (°)	34.4
RA max (°)	53.4
Dec min (°)	-54.3
Dec max (°)	-7.8
LH total (%)	90.0
LH 75 (%)	66.0

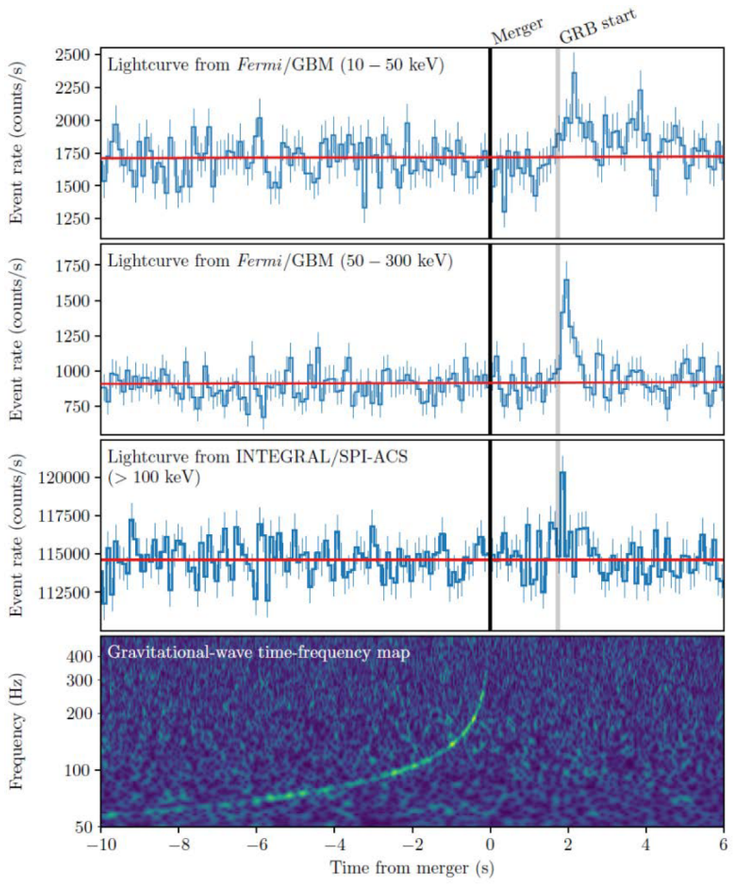


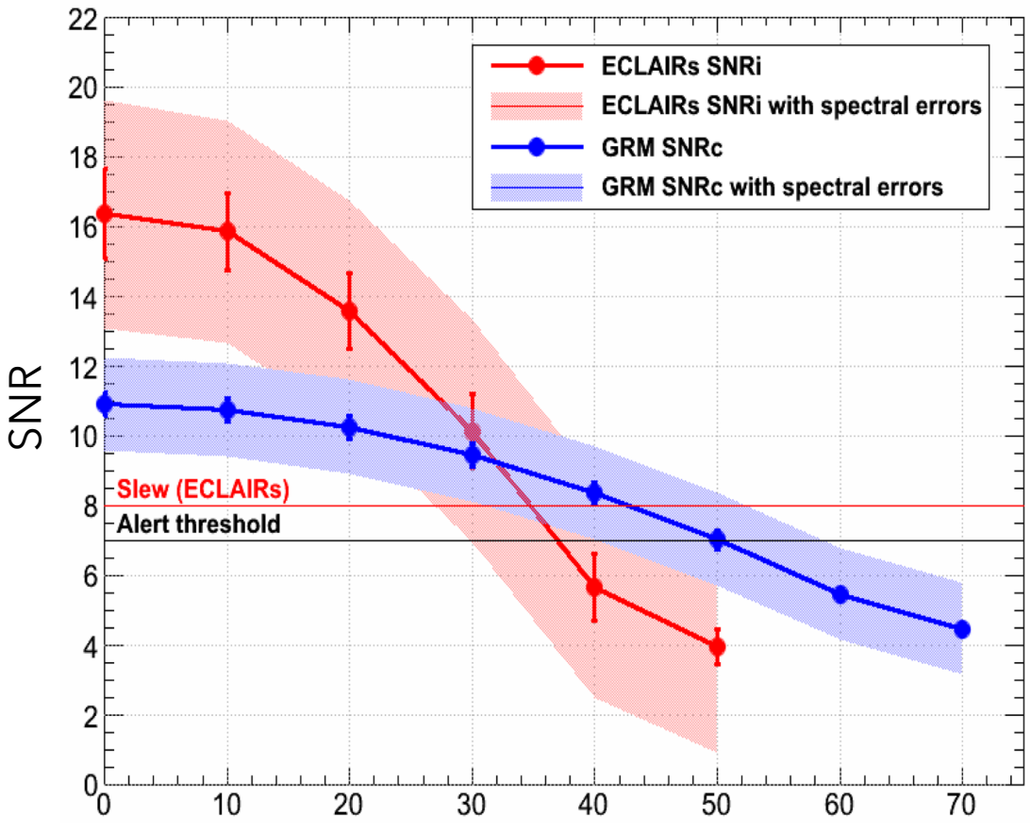
First 100 tiles

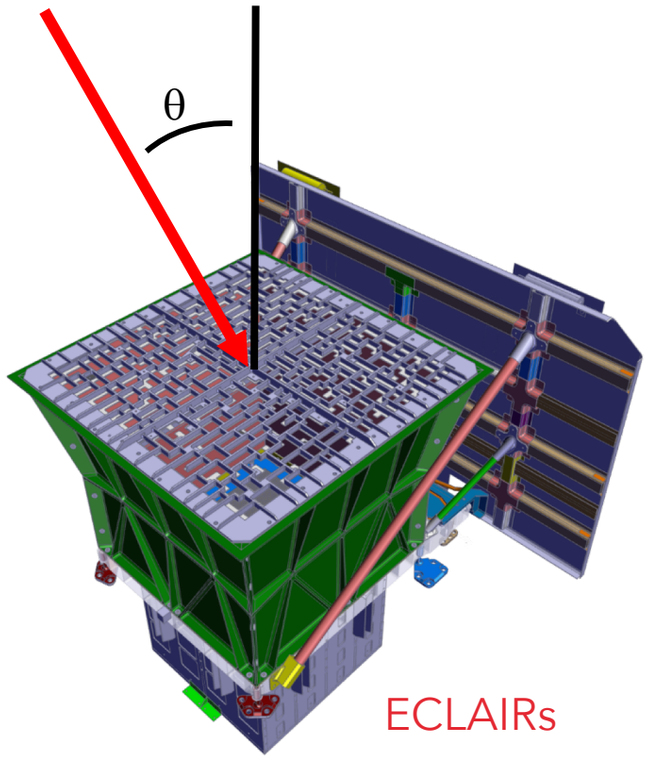
GW 170817 / GRB 170817A

ECLAIRS & GRM DETECTION OF THE GRB ?

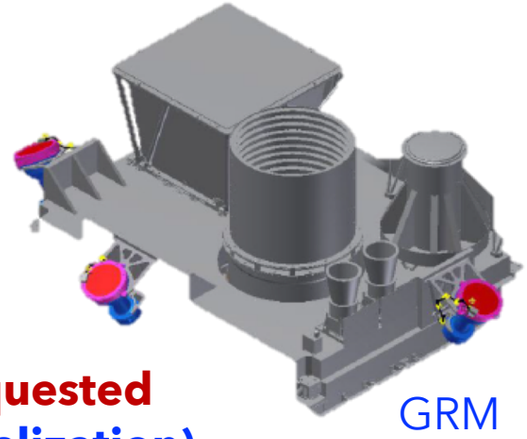
Simulation of the event GRB170817A + CXB
with parameters from Fermi-GBM (public GCN 2017/8/17 20:00 TU)







ECLAIRs

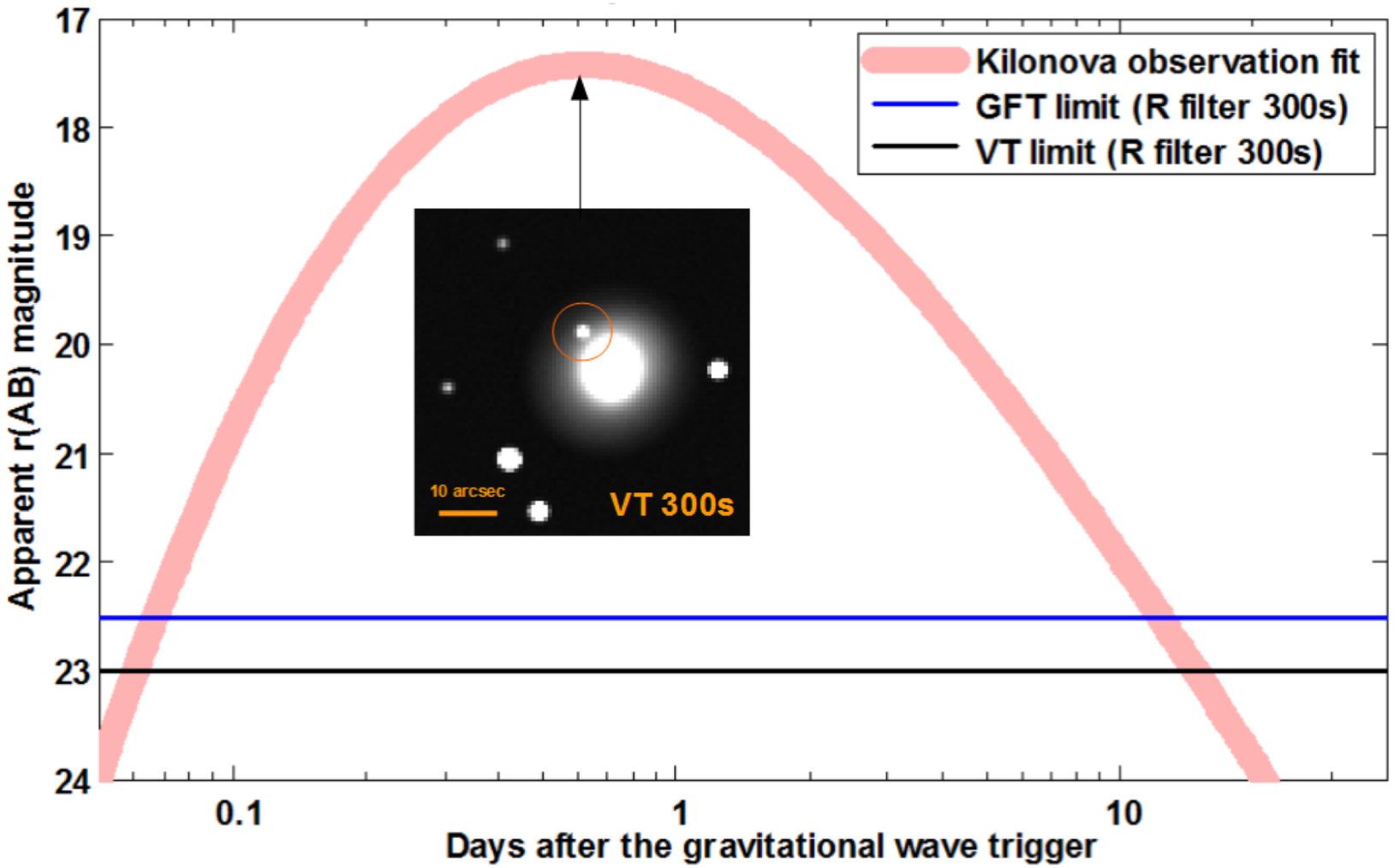


GRM

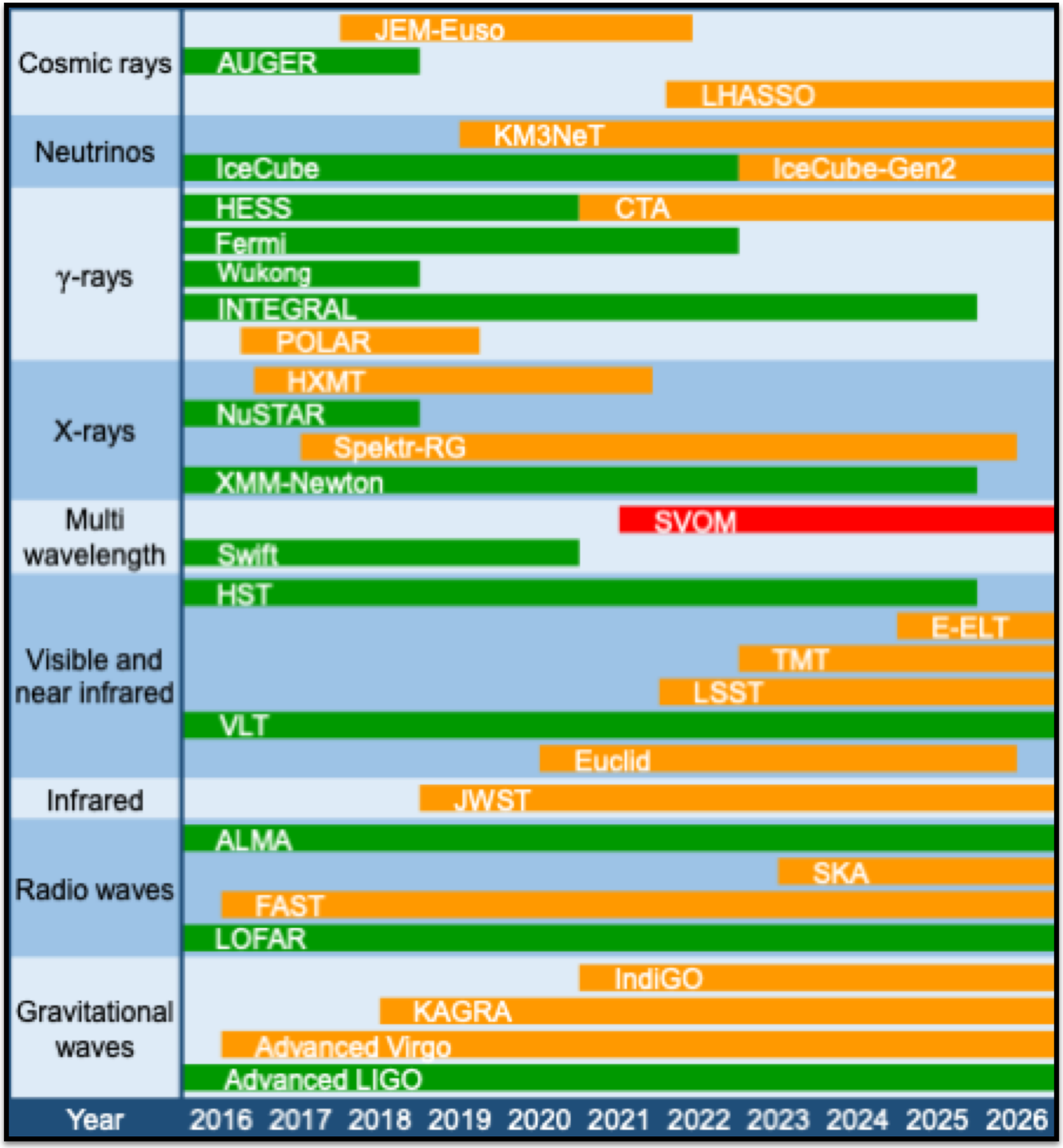
➔ **Up to 35° off axis: ECLAIRs triggers + alert is sent to the ground + slew is requested**
➔ **Up to 50° off-axis: GRM triggers + alert is sent to the ground (with rough localization)**

VT & GFT DETECTION OF THE KILONOVA ?

Simulation of the kilonova in NGC 4993 as seen by VT in 300 s at peak magnitude

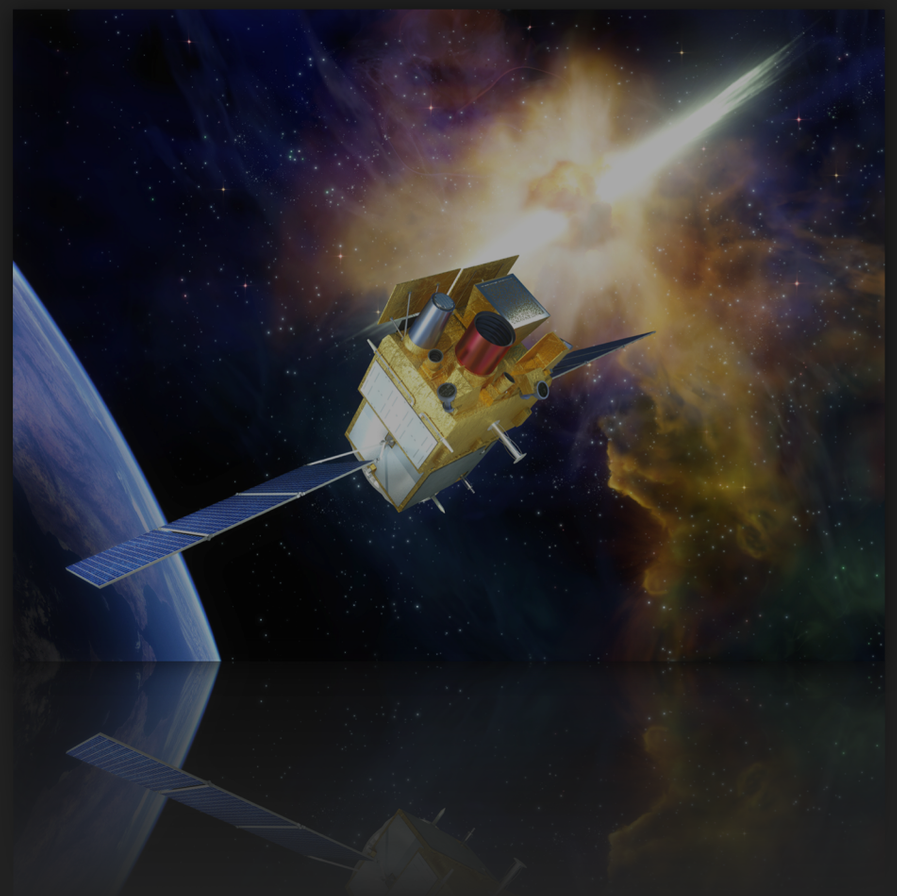


→ **VT and GFTs have the capacity to detect the kilonova since T0+2h**
→ **and can follow it during 10 days**


Cosmic rays
JEM-Euso
AUGER
LHASSO
Neutrinos
KM3NeT
IceCube
IceCube-Gen2
γ-rays
HESS
CTA
Fermi
Wukong
INTEGRAL
POLAR
X-rays
HXMT
NuSTAR
Spektr-RG
XMM-Newton
Multi wavelength
SVOM
Swift
Visible and near infrared
HST
E-ELT
TMT
LSST
VLT
Euclid
Infrared
JWST
Radio waves
ALMA
SKA
FAST
LOFAR
Gravitational waves
IndiGO
KAGRA
Advanced Virgo
Advanced LIGO
Year
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

CONCLUSION

- SVOM is a set of instruments distributed on the ground and in space, interconnected with each other
- SVOM is designed to study the physics of the GRB phenomenon in all its diversity with good spectral (from infrared to MeV) and temporal coverage for both the prompt and afterglow emission
- Optimized observation and follow-up strategy is aiming at redshift determination for a large fraction of SVOM GRBs (>60%)
- SVOM is prepared to play an important role in the time domain astrophysics and in the multi-messenger era
- Launch 2021



MORE INFORMATIONS

SVOM white paper: arXiv:1610.06892

SVOM Website: http://www.svom.fr/en/

THANK YOU FOR YOUR ATTENTION!