SVOM et Einstein Probe à l'affût du ciel transitoire

SVOM and Einstein Probe on the lookout for the transient sky

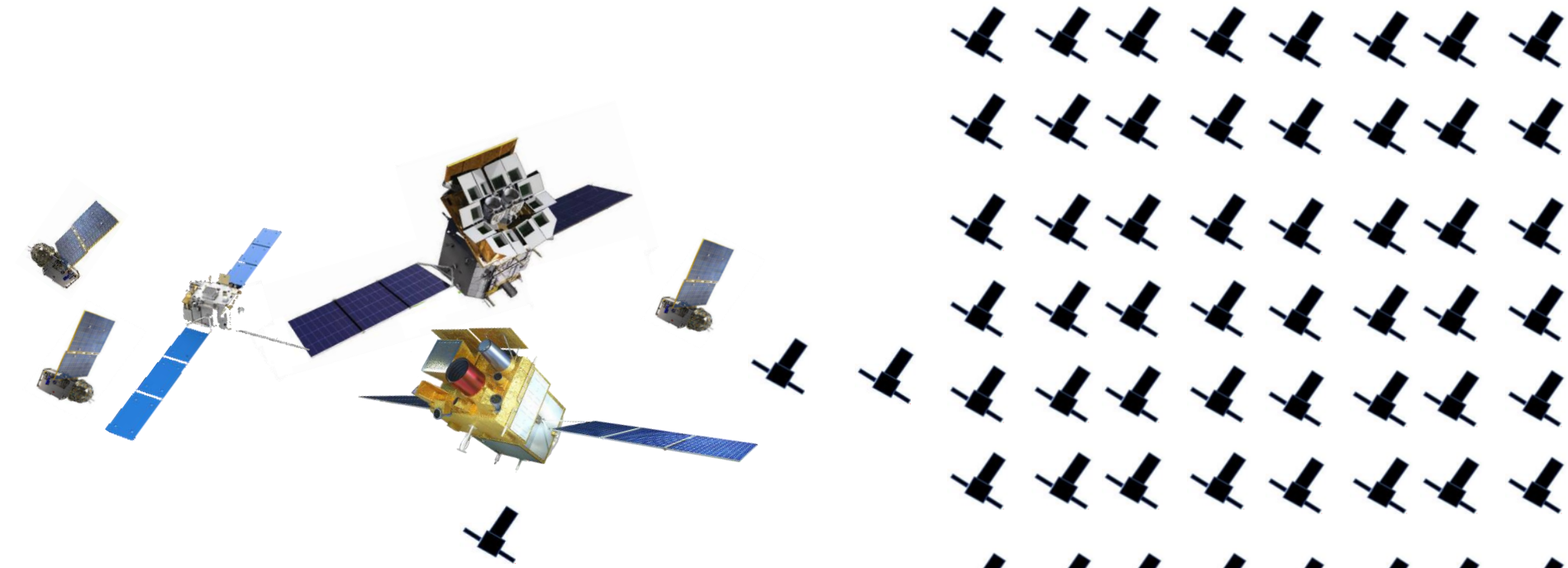
Bertrand Cordier

on behalf of the SVOM Collaboration

SVOM white paper: arxiv1610.06892
SVOM site : https://www.svom.eu/en

PNHE
2023 September 7

The Chinese fleet in the next decade



GECAM A B

GECAM C
EP Pathfinder

EP
SVOM
CATCH A Pathfinder

GECAM D

CATCH B C Pathfinders

CATCH

2020

2023

2030

All these projects are being developed by the same CAS institutes: NAOC, IHEP and SECM and operated by the same centre: NSSC.

What is SVOM ?

The SVOM Collaboration

China (PI J. Wei) 

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

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 

SVOM "Space-based multi-band astronomical Variable Objects Monitor"
a Sino-French mission dedicated to GRBs and transient sources to be launched in spring 2024, 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

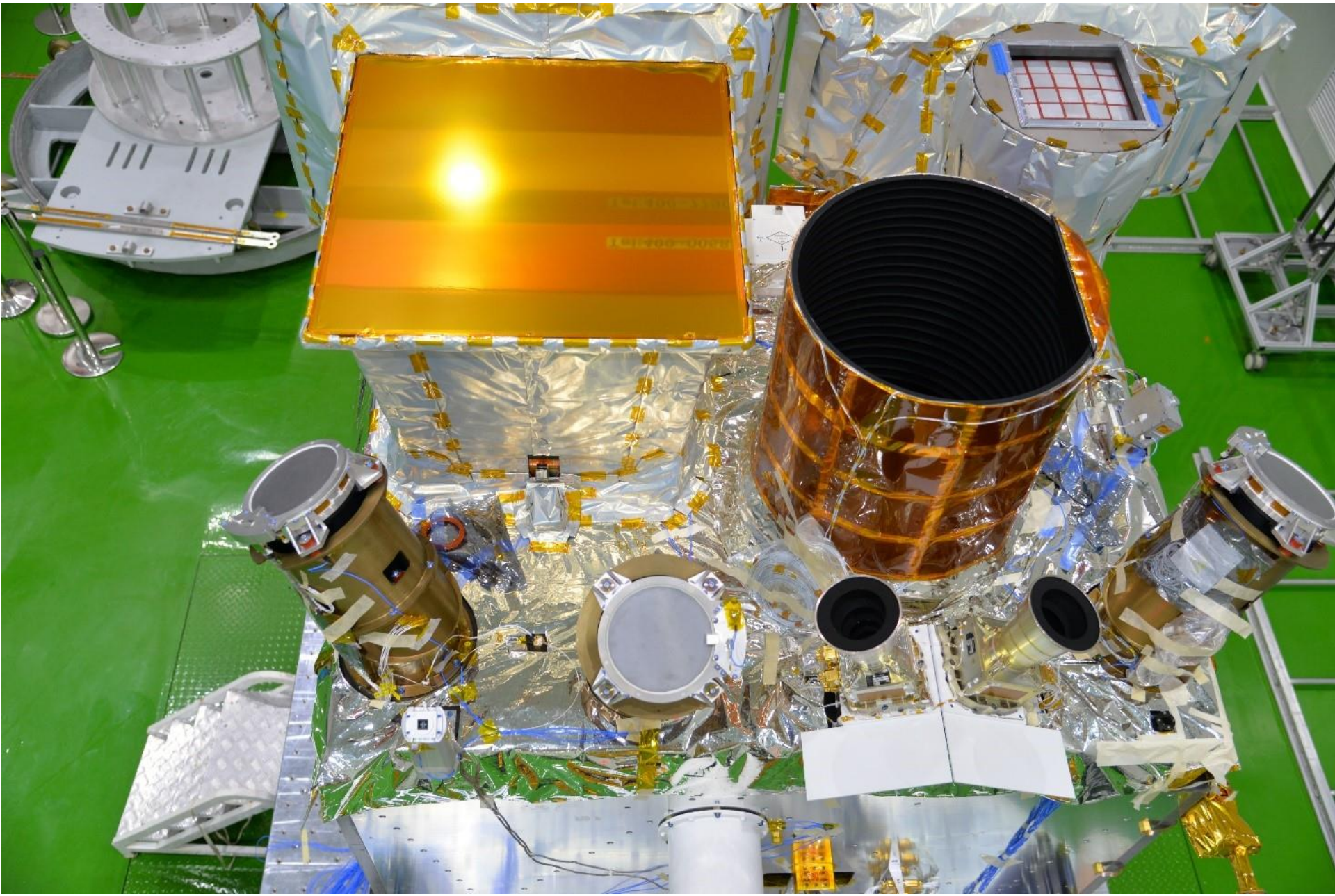
GFT-1
« Ground-based Follow-up Telescope »
Φ>1000mm

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

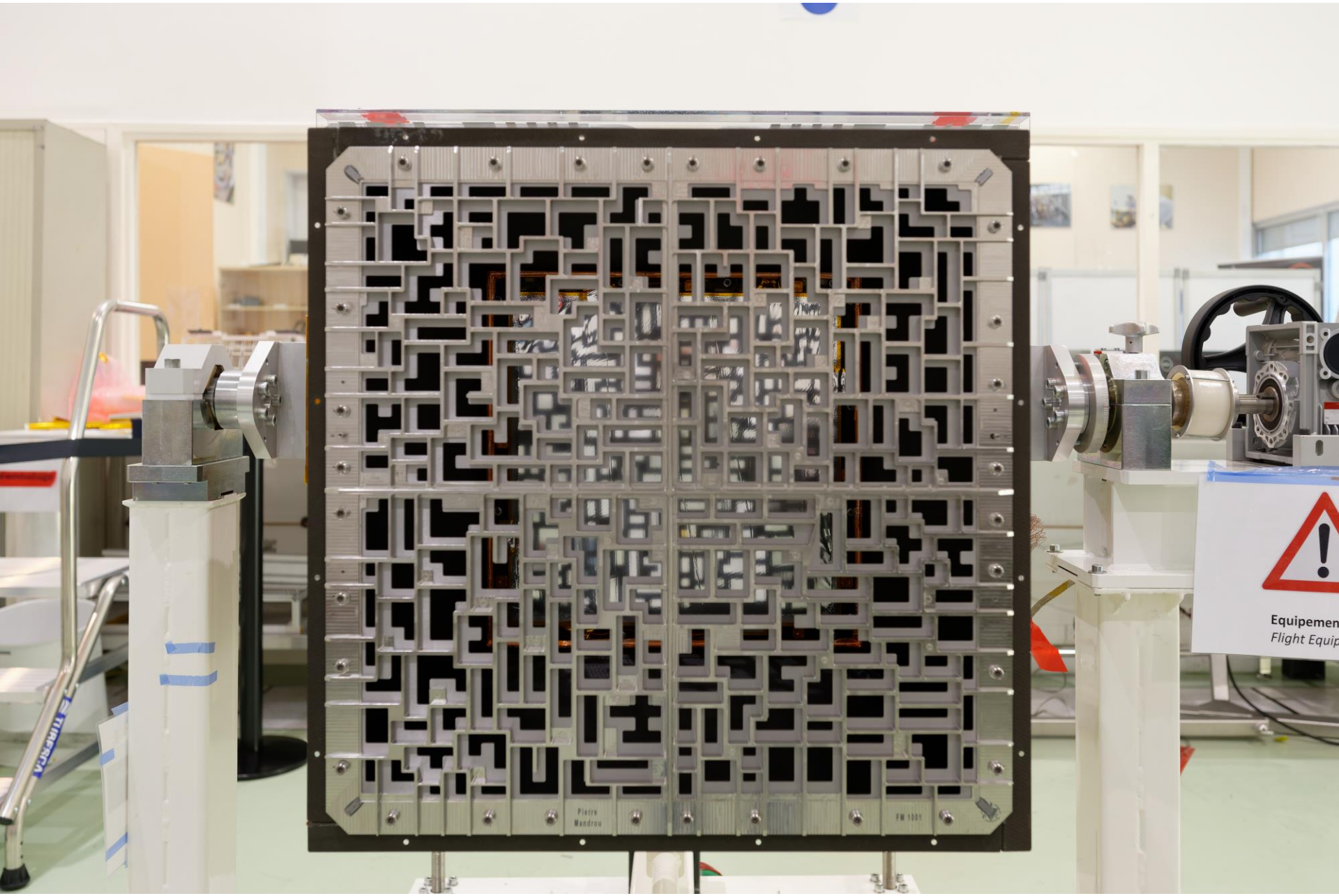
GFT-2
« Ground-based Follow-up Telescope »
Φ>1000mm

VHF Alert Network
... and more !

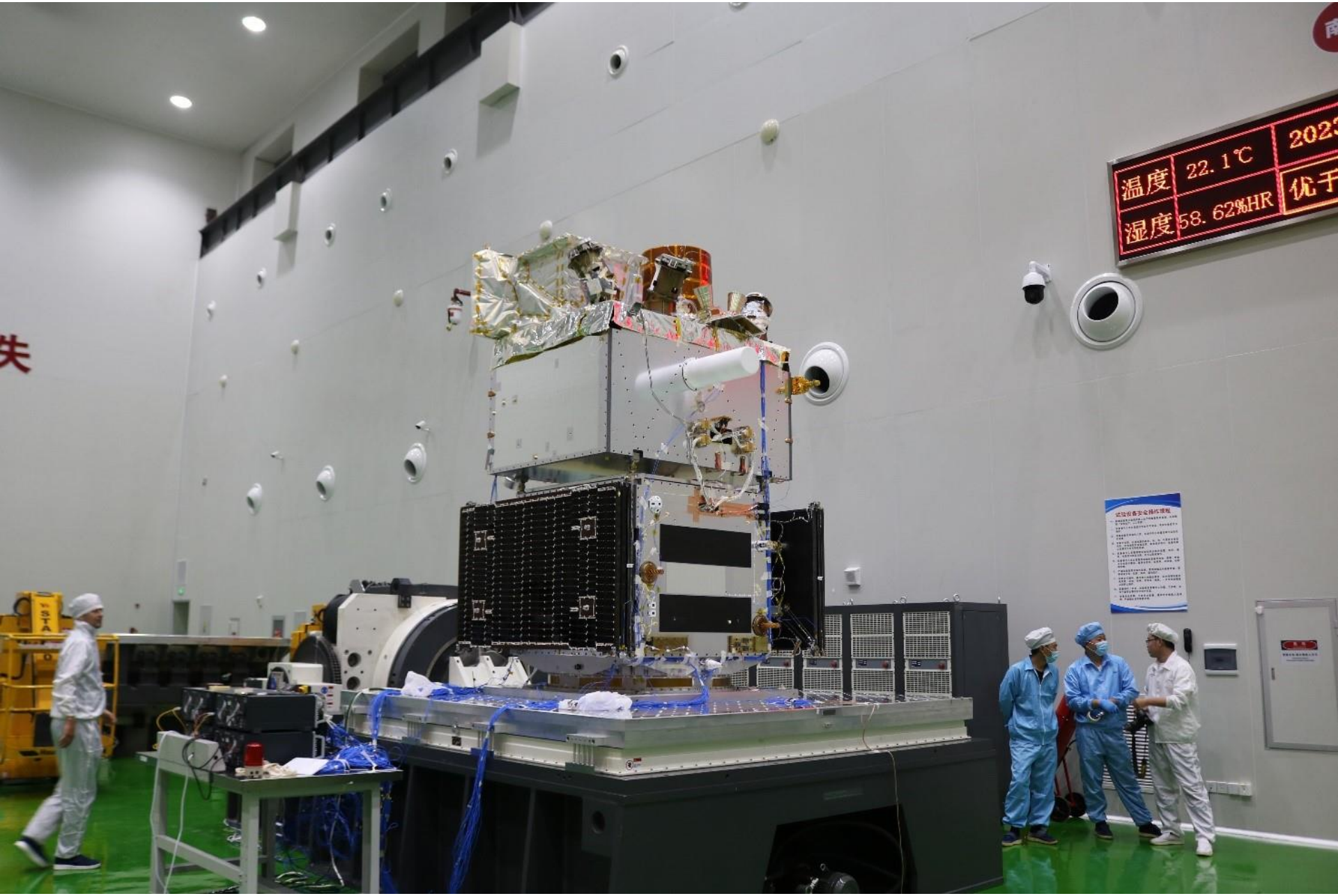
Tracking antennas



Shanghai, 2023 July



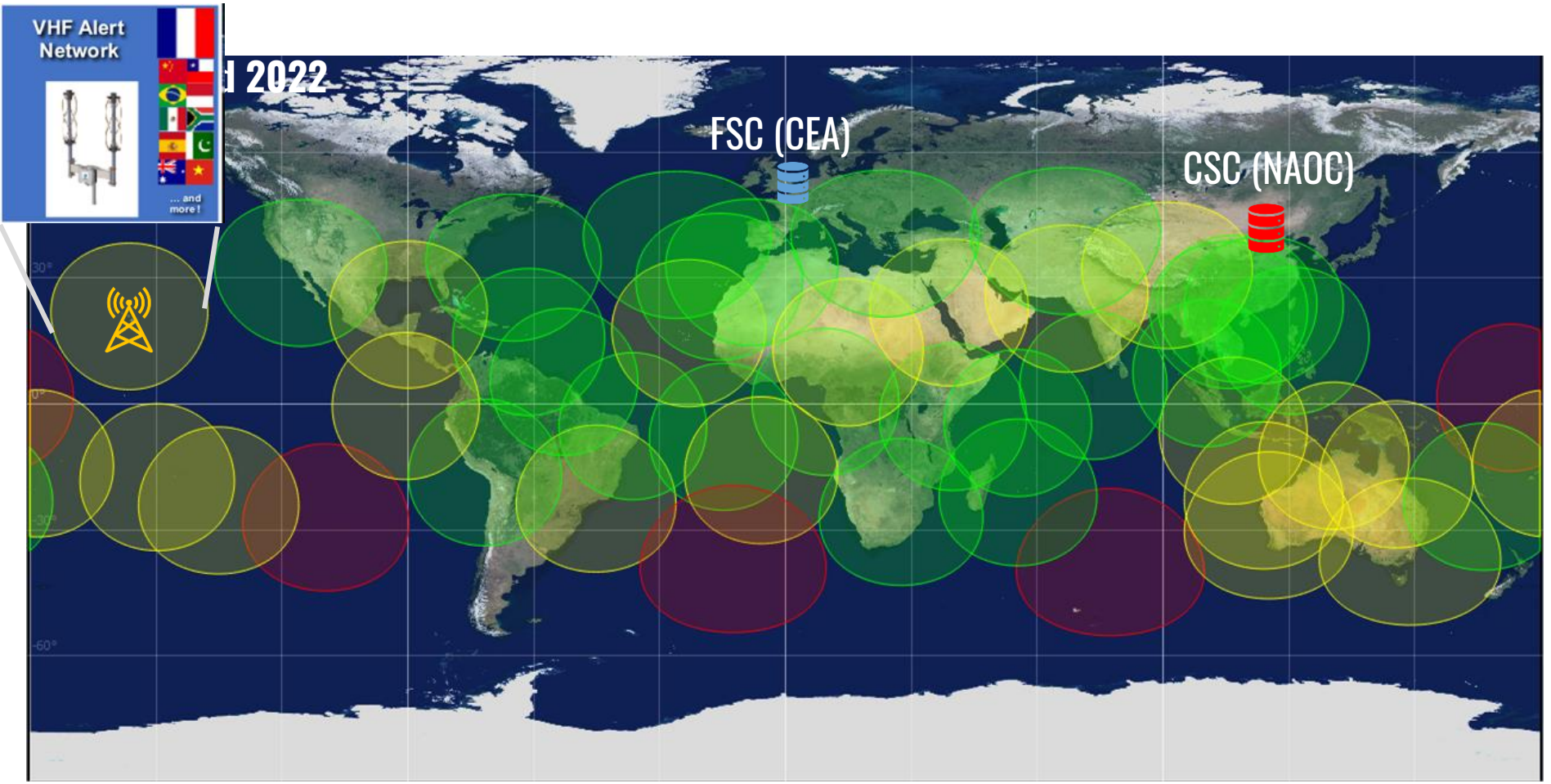
Toulouse, March 2022



Shanghai, 2023 July

The SVOM ground segment

1. An alert network: ~40 VHF receivers on Earth / 65% of the alerts received within 30s at the French Science Center (FSC) / We are also planning to be connected to the chinese Beidou network.



The VHF network

UPF
Papeete
French Polynesia

METEO FRANCE
Rikitea
French Polynesia

IRD
Ouagadougou
Burkina Faso

BSC
Malindi
Kenya

OUKAIMEDEN
OBSERVATORY
Morocco

CARNARVON S&T
MUSEUM
Australia

SURE
Diego Garcia

AST. OBSERVATORY
Maidenak
Uzbekistan

TRISTAN DA CUNHA
UK

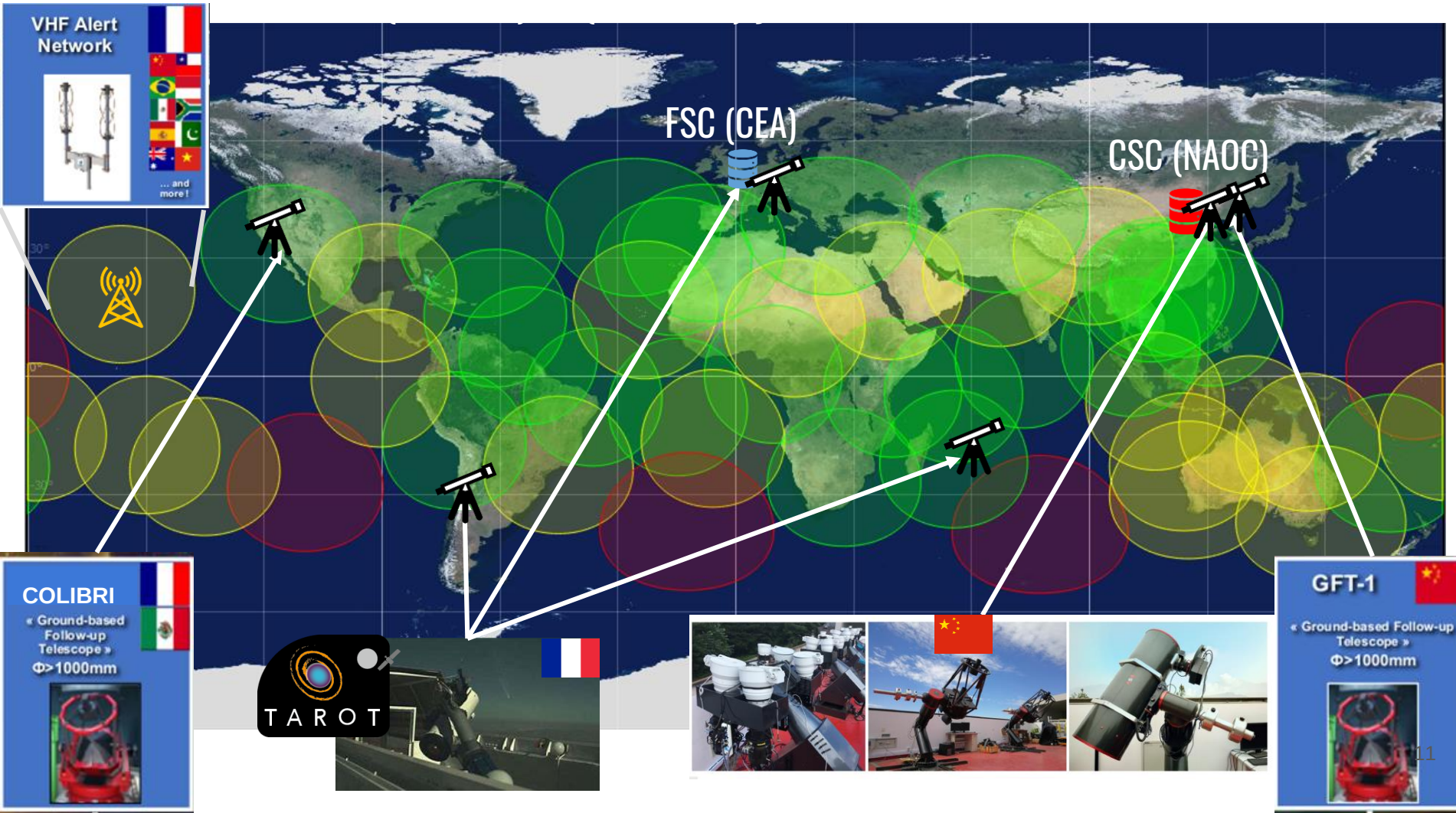
NSSTC
Al Ain
UAE

SMA
Mahe
Seychelles

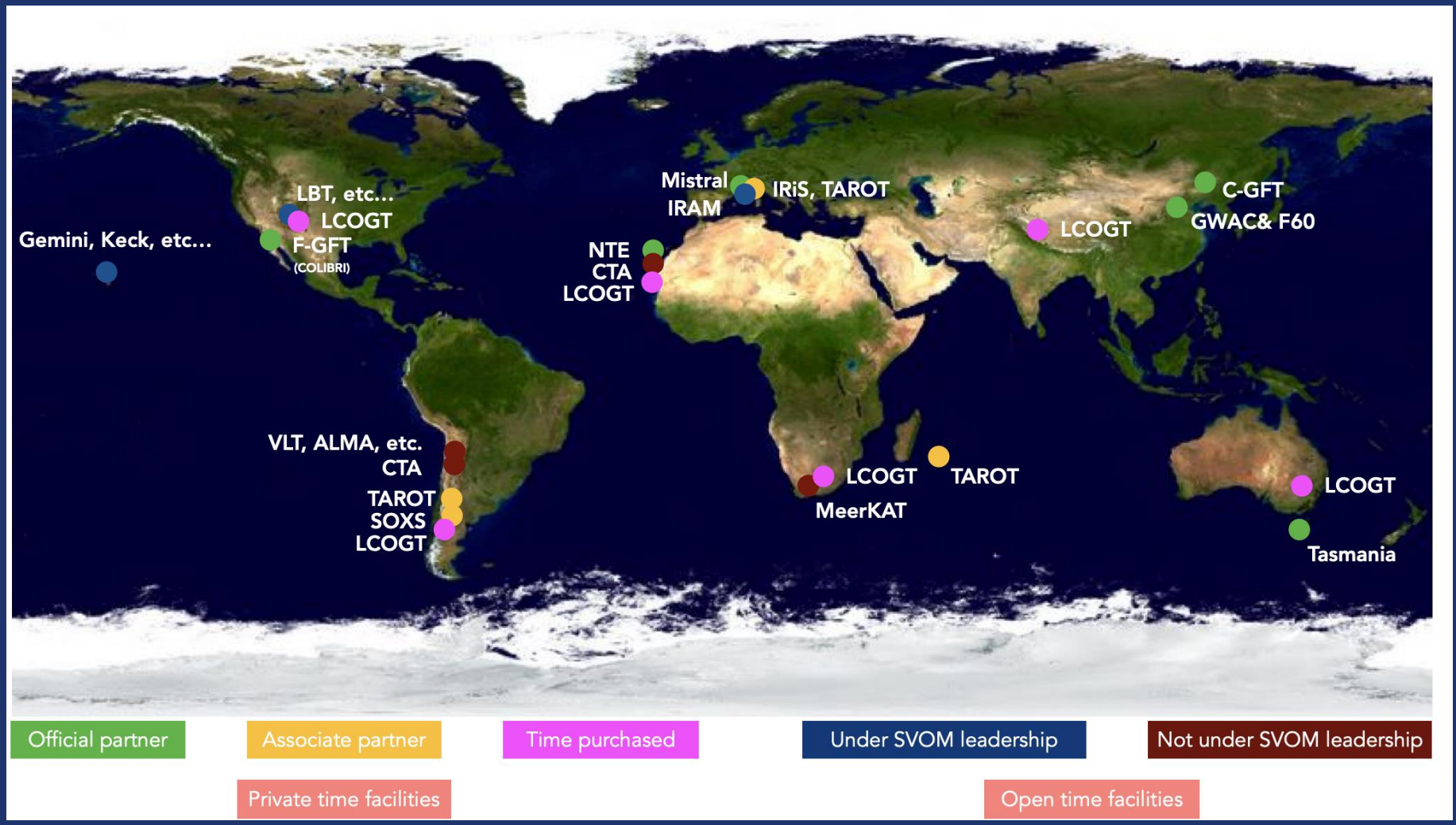
GUANGXI UNIVERSITY
Nanning
China

The SVOM ground segment

1. An alert network: ~40 VHF receivers on Earth / 65% of the alerts received within 30s at the French Science Center (FSC) / We are also planning to be connected to the chinese Beidou network.
2. A telescope network for the SVOM follow-up activities



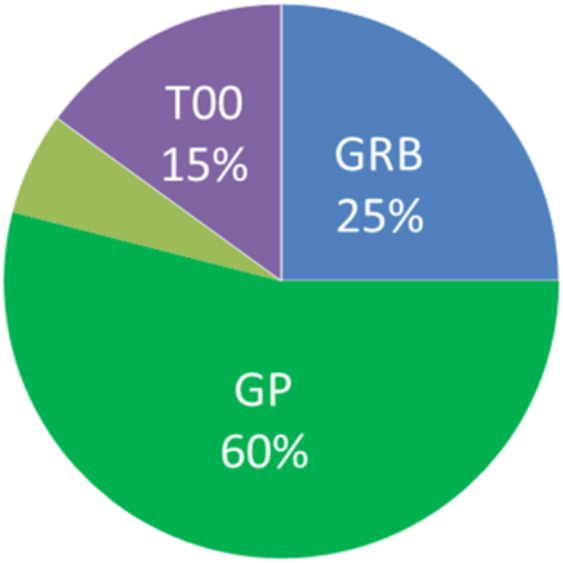
SVOM Follow-Up preparation



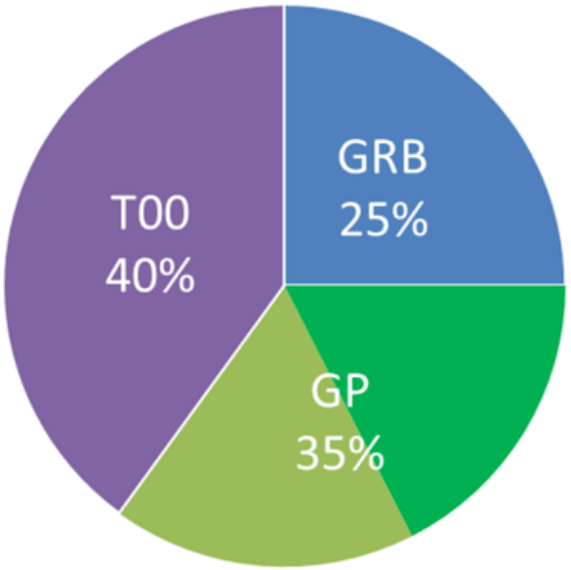
Work in progres, coordinated by Stéphane Basa and Susanna Vergani (on the french side)

SVOM scientific programs

Nominal mission
1 ToO per day, 10% of GP outside B1 law



Extended mission
5 ToOs per day, 50% of GP outside B1 law



SVOM data policy

Core Program

- The scientific products generated under the supervision of the Burst Advocate are public **as soon as they are available** (similar to Fermi or Swift).
- All the scientific products are public **six month** after the data production.
- For a given GRB, the publication of SVOM observations is the responsibility of the Burst Advocate.
- **Transverse Programs** will be set up by the SWG **within the CoIs** to
  - develop the catalogue of GRBs
  - study the population of X –ray rich GRBs
  - study the population of ultra-long GRBs
  - …

SVOM data policy

General Program

- Program normally open to the scientific community through a call for observation.
- It consists of observation proposals being awarded by a TAC (?) for astrophysical targets, mostly compliant with the satellite nominal attitude law (outside the galactic plane).
- At least one SVOM co-I needs to be part of the proposal. All the SVOM data will be processed by the SVOM Co-I.

- But, **the first year of operation the GP is restricted to the SVOM Co-Is. No call for observation.**

- The first year, the General Program will consist of observations of targets proposed by the Co-Is, selected by the General Program Manager and approved by the SVOM Science Working Group.

- The General Program Manager prepares a provisional one-year General Program so that (if possible) 60% of the observing time is granted to proposals submitted by Chinese Co-Is and 40% to proposal submitted by French Co-Is.

- **One year of proprietary period** before the scientific products become public.

SVOM data policy

Target of Opportunity (ToO) program

ToO	Latency	Frequency	Duration
ToO-NOM	<48hrs	1-5/day	1 orbit or more
ToO-EX	<3hrs *	1/month	7-14 orbits
ToO-MM	<3hrs *	1/week	~14 orbits

* Contribution of Beidou

- **ToO-NOM** - nominal ToO which covers the basic needs for efficient transient follow-up alerts (GRB revisit, known source flaring, new transient). **Open to the scientific community**.

- **ToO-EX** - exceptional ToO which covers the needs for a fast ToO-NOM in case of an exceptional astrophysical event we want to observe rapidly. **Restricted to the SVOM Co-Is.**

- **ToO-MM** - ToO-EX dedicated to EM counterpart search in response to a multi-messenger alert (unknown position, tiling of large portion of the sky). **Restricted to the SVOM Co-Is.**

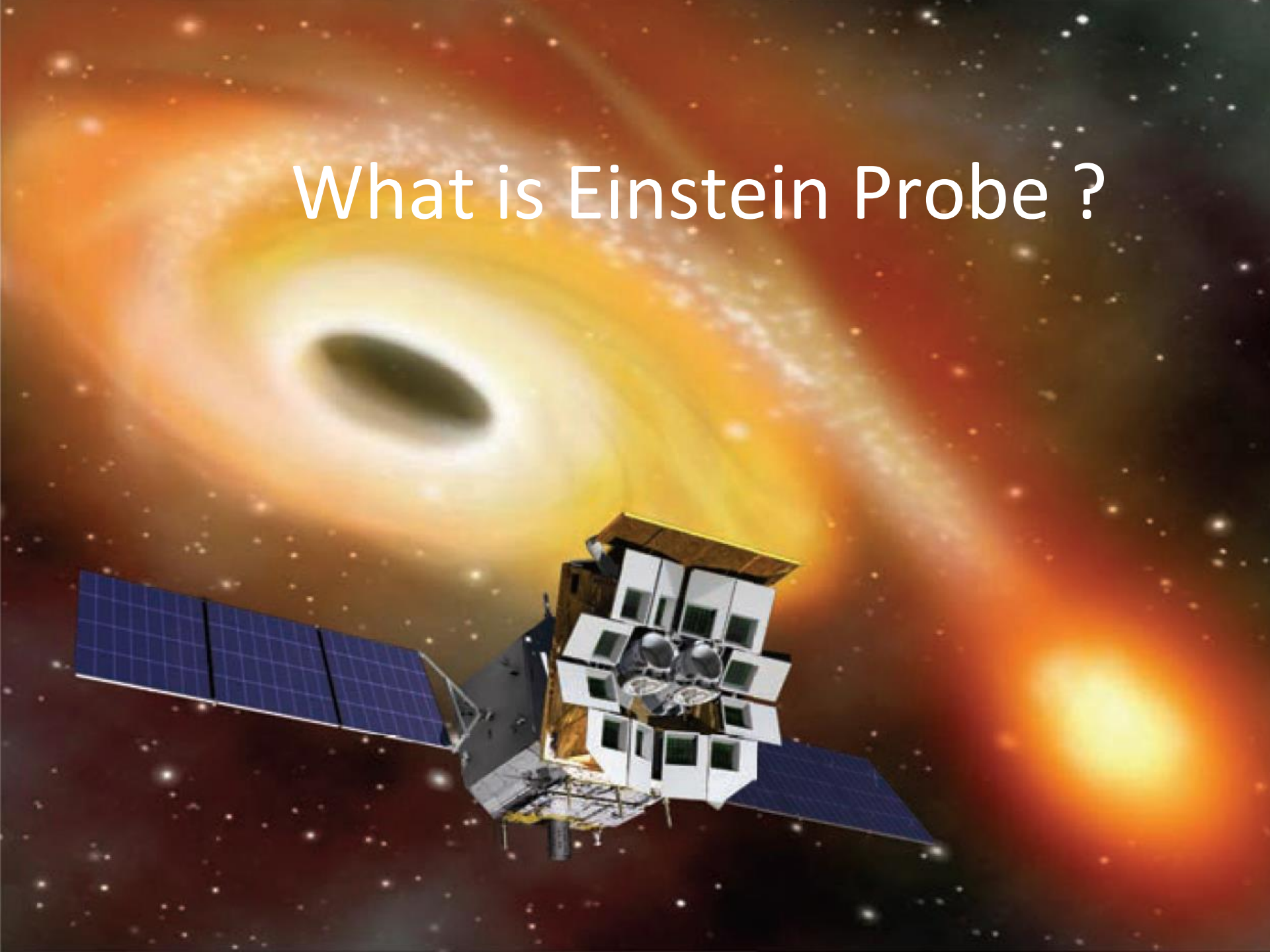
SVOM data policy

Target of Opportunity (ToO) program

- **ToO-Ex, ToO-MM and ToO-NOM triggered by SVOM Co-Is**: scientific products relevant to perform follow-up observations will be public as soon as possible. Other scientific products to be released will be decided case by case.

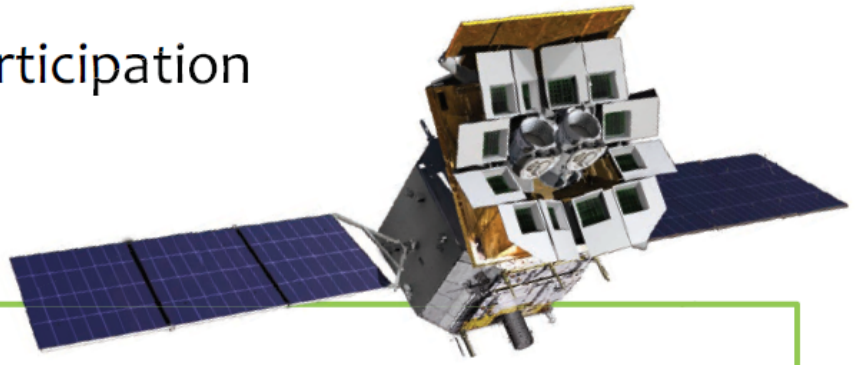
- **ToO-NOM triggered by non SVOM Co-Is**: all the scientific products will be public as soon as they are available.

What is Einstein Probe ?



The Einstein Probe (EP) mission

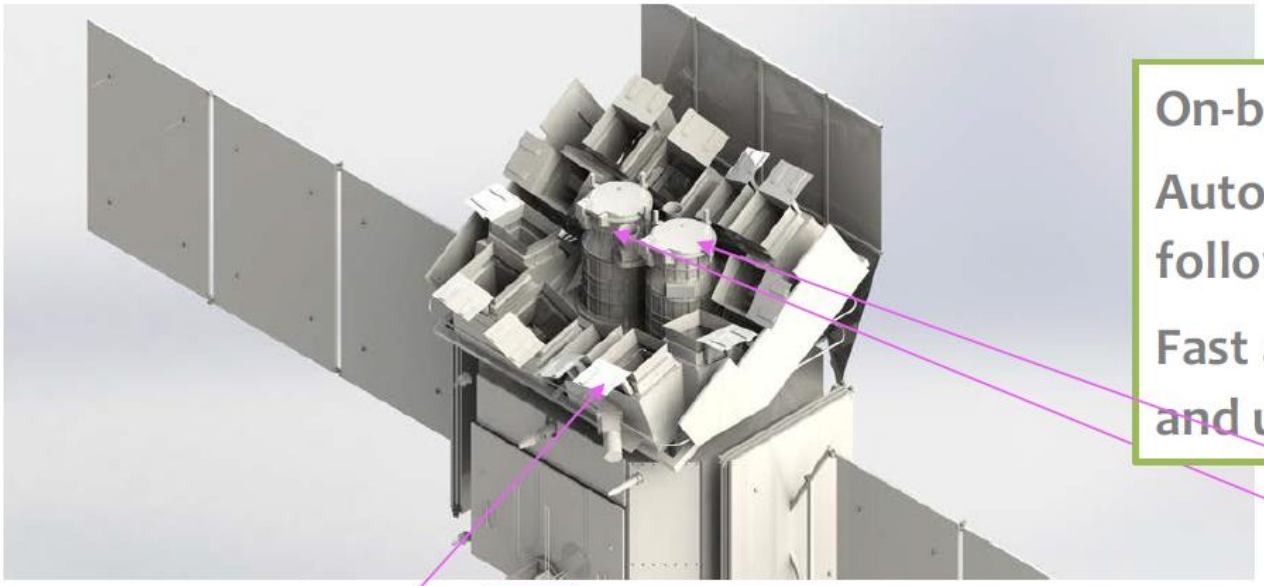
- A space observatory for all-sky monitoring to discover & study high-energy transients and variability in X-rays
- CAS's mission with international participation



- Large Field of View 3600 sq. deg.
- Monitoring: soft X-ray band: 0.5-4 keV
- Sensitivity: > 1 order of magnitude higher than those in orbit
- Good angular resolution (~5' fwhm) and positioning accuracy (<1')
- Autonomous X-ray follow-up (<10 arcsec localisation; 0.3-10keV)
- Fast alert data downlink and (possible) fast uplink (ToO)

Launch 31/12/2023

Einstein Probe (EP) mission



On-board data processing

Autonomous slew & follow-up in 3-5 min

Fast alert data downlink and uplink (ToO)

WXT (12 modules) esa

lobster-eye MPO + CMOS

FoV: 3600 sq deg (1.1 sr)

band: 0.5 – 5 keV soft X-ray

eff. area: ~3 cm^2 @1keV

FWHM: ~ 5', positioning <1'

Sensitivity: 10-100 x increase

FXT(2 modules) esa

Wolter-1 type + CCD

FoV: 38'

band: 0.3-10keV

eff. area: 2x 300cm^2 @1keV

angular FWHM: 30"

positioning accuracy: <10"

Mission Management

- Mission management: EP is one of the CAS's missions in its Space Science Program (2nd phase).
- The project is managed by the CAS's National Space Science Center (NSSC) on behalf of CAS.
- The mission will be operated at the EP Mission Operation Center (EPMOC) hosted at NSSC.
- The science operation will be carried out at the EP Science Center (EPSC), which is the responsibility of and hosted mainly at National Astronomical Observatories of China (NAOC), CAS

Status of international collaboration

- ESA -- mission of Opportunity (signed 2019)
  - FXT mirror assembly, WXT device/module testing/calibration, ground stations

- Max-Placnk-Instit. for extraterrestrial Physics, Germany (signed 2019)
  - FXT CCD modules, mirror design and mandrels, one eROSITA MA DM and Flight Spare, ...

- France – SVOM scientific consortium
  - SVOM VHF alert Network
    -> In return, scientific rights on 5% of EP data for SVOM cols

EP Science Team

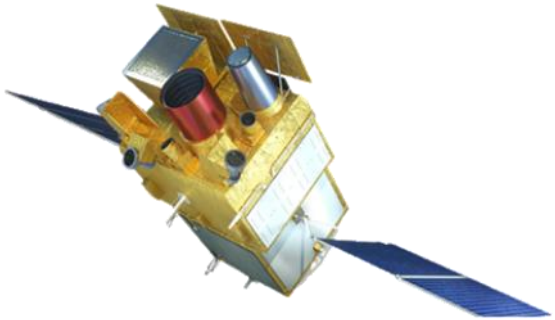
1. **Tidal Disruption Events & AGNs**
2. **Fast extragalactic transients**
3. **Multi-messenger astronomy**
4. **Compact stellar objects**
5. **Observatory Science**
6. **Follow-up observation activities (Open to all co_Is)**

French participation to the EP Science Team

			1rst STP	2nd STP	Contribution
Sébastien	Guillot	IRAP - Toulouse	3	4	CNES-SVOM
Nicolas	Leroy	IJCLab - Orsay	3	2	CNES-SVOM
Pierre	Maggi	ObAS – Strasbourg	4	5	CNES-SVOM
Damien	Turpin	CEA - Saclay	2	3	CNES-SVOM
Bertrand	Cordier	CEA - Saclay	2	3	CNES-SVOM
Alexis	Colero	APC-Paris	2	1	ESA

Associated Scientists : Stéphane Basa LAM- Marseille, panel 6
Susanna Vergani GEPI- Meudon, panel 6

SVOM / EP common points

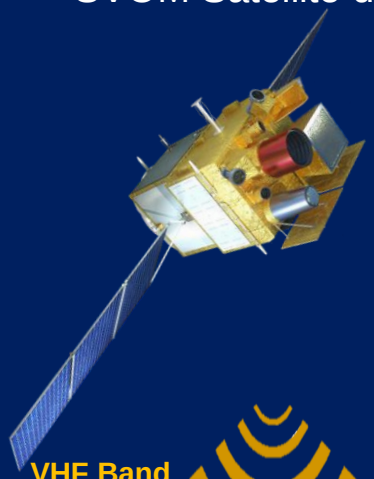


- Same Chinese laboratories involved:
  Scientific: NAOC, IHEP
  Satellite developed by SECM, same project manager for both satellite
- Same orbit: low earth orbit inclined at 30°.
- Almost the same platform: many common elements (on-board computer, inertial wheels, VHF transmitters, etc.)
- Very similar system and same VHF communications networks
- Shared ground segment on the Chinese side, operations at the NSSC, science at the NAOC and the same contacts as on SVOM.
- Follow-up?

How can the French SVOM community, and behind it the French community interested in the transient sky, could benefit from the synergy between the two missions?

Operational Scenario for GRB detection by SVOM

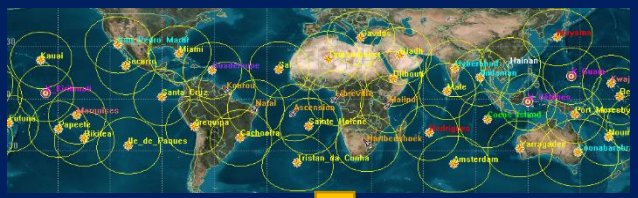
SVOM Satellite detects a GRB



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

Object detected by other observatories Space or Ground

LSST

LIGO VIRGO

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

Preparation of satellite TC plan by Mission Center

Chinese Control Center

Telecommands

Beidou and S Band

Tracking antennas

Science data

X Band

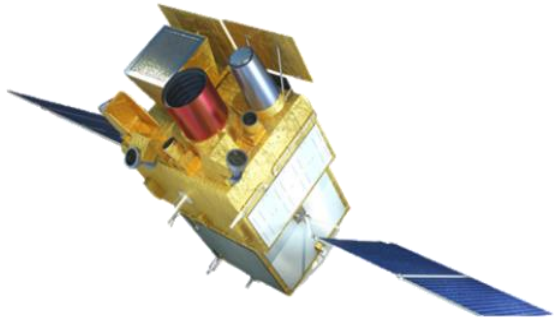
Tracking antennas

Science data processing by French and Chinese Science Centers

SVOM robotic telescopes

LCOGT

Others…



Thank you !

Questions, discussions and suggestions are welcome !

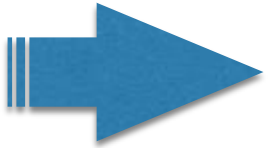
Back-up slides

SVOM Science Working Group (SWG)

The scientific exploitation of the SVOM mission will be coordinated by the SVOM Science Working Group (SWG) :

- The PIs (one Chinese, one French).
- The Co-PIs (one Chinese, one French).
- The Instrument PIs (six Chinese, four French).
- The ToO scientists (one Chinese, one French).
- The Mission Scientists (Three Chinese, two French).
- The General Program Manager (One Chinese).

22 scientists, 13 Chinese, 9 French



PI: B.Cordier
CoPI: S. Basa
IPI ECLAIRs: J-L. Atteia
IPI MXT: D. Götz
IPI FSC: A. Claret
IPI Follow-up: S. Vergani
MS CP: F. Daigne
MS GP: A. Goldwurm
ToO SC: C. Lachaud

This group will be responsible for :

- Organizing the scientific exploitation
- Appointing the Co-Is responsible for the transverse programs
- Resolving potential conflicts
- Organize the publication of results
- …

SVOM Science Community

The SVOM Science Community is the assembly of the scientists that will have access to all SVOM proprietary data (Physical Data and Data products).

The SVOM Science Community is composed of the members of the SVOM Science Working Group plus SVOM Co-Investigators (Co-Is).

The list of SVOM Co-Is, which should not include more than 100 persons, should include roughly 60% of scientists from the Chinese scientific community and 40% from the French scientific community.
Each Co-I may have a PhD student or a postdoc
A party can select Co-I from a foreign country.

The French side can therefore count on 40 CoIs including our foreign collaborators (UK, Germany, Mexico, Danmark).

The exact list of CoIs has not yet been established, (target mid 2023).