The SVOM mission for the study of the transient sky

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on behalf of the SVOM collaboration

THESEUS Conference

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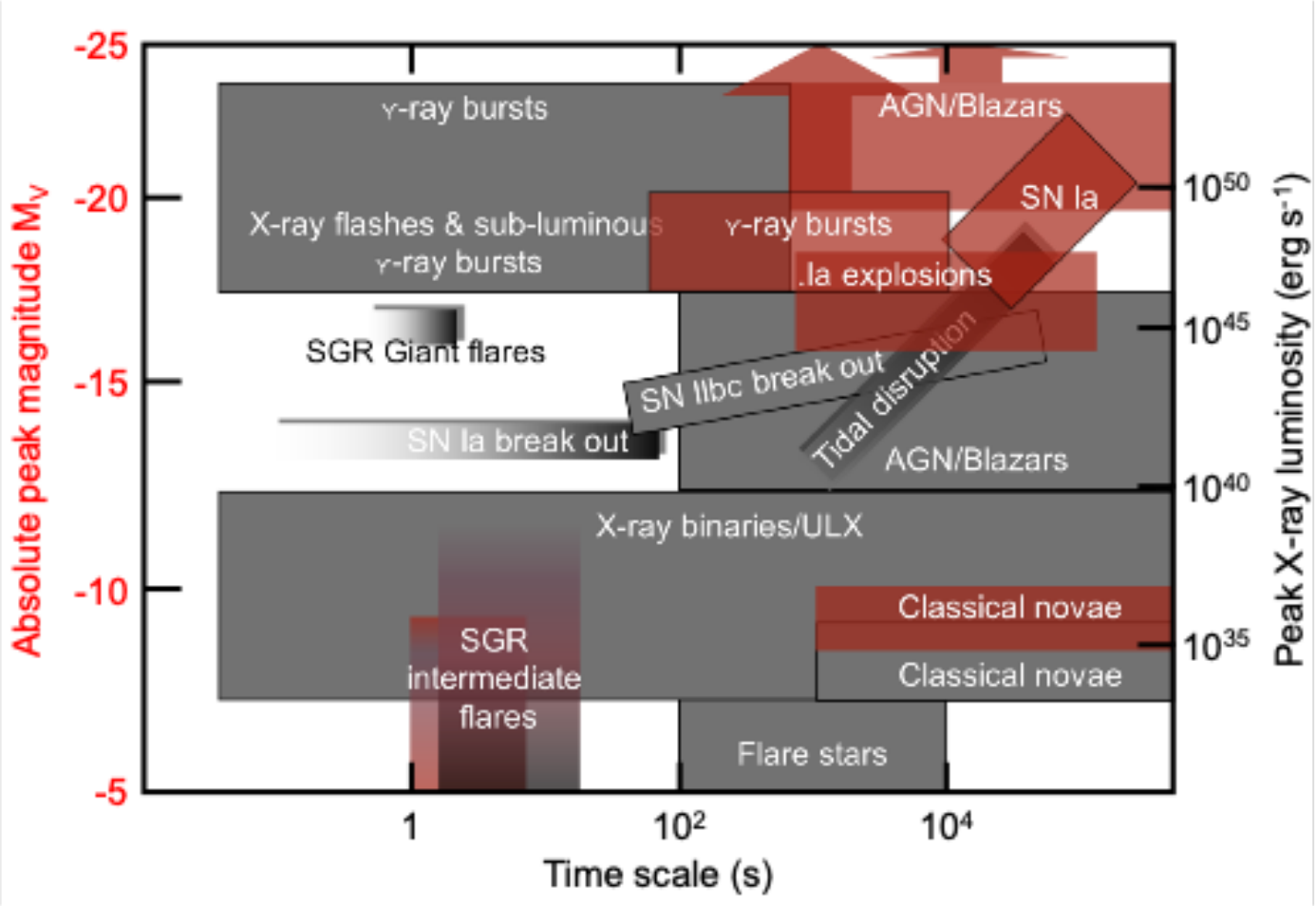
Time-domain astronomy



- 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)

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

- **Mexico** UNAM Mexico 

- **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

- **UK** University of Leicester 

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

SVOM "Space-based multi-band astronomical Variable Objects Monitor"

a Sino-French mission dedicated to GRBs and transient sources to be launched in September 2022, 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

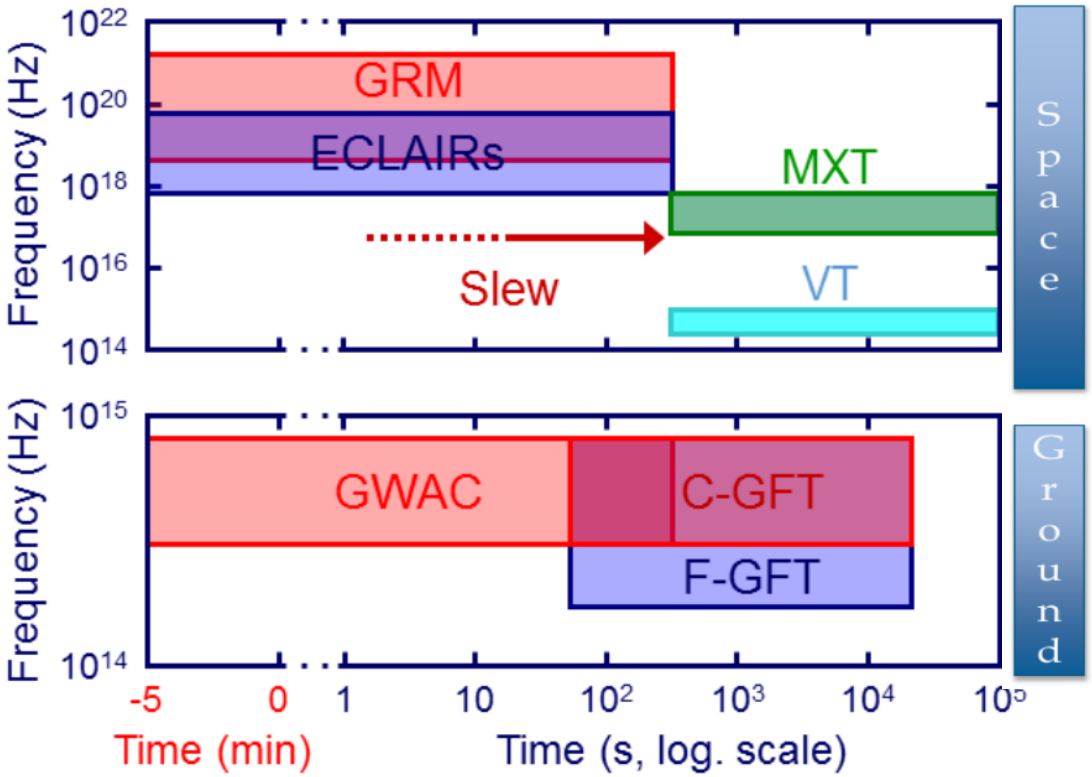
The GRB “core" program

- Trigger and locate GRBs, alerts and localization distributed in real-time
- Optimized pointing strategy for ground-based follow-up

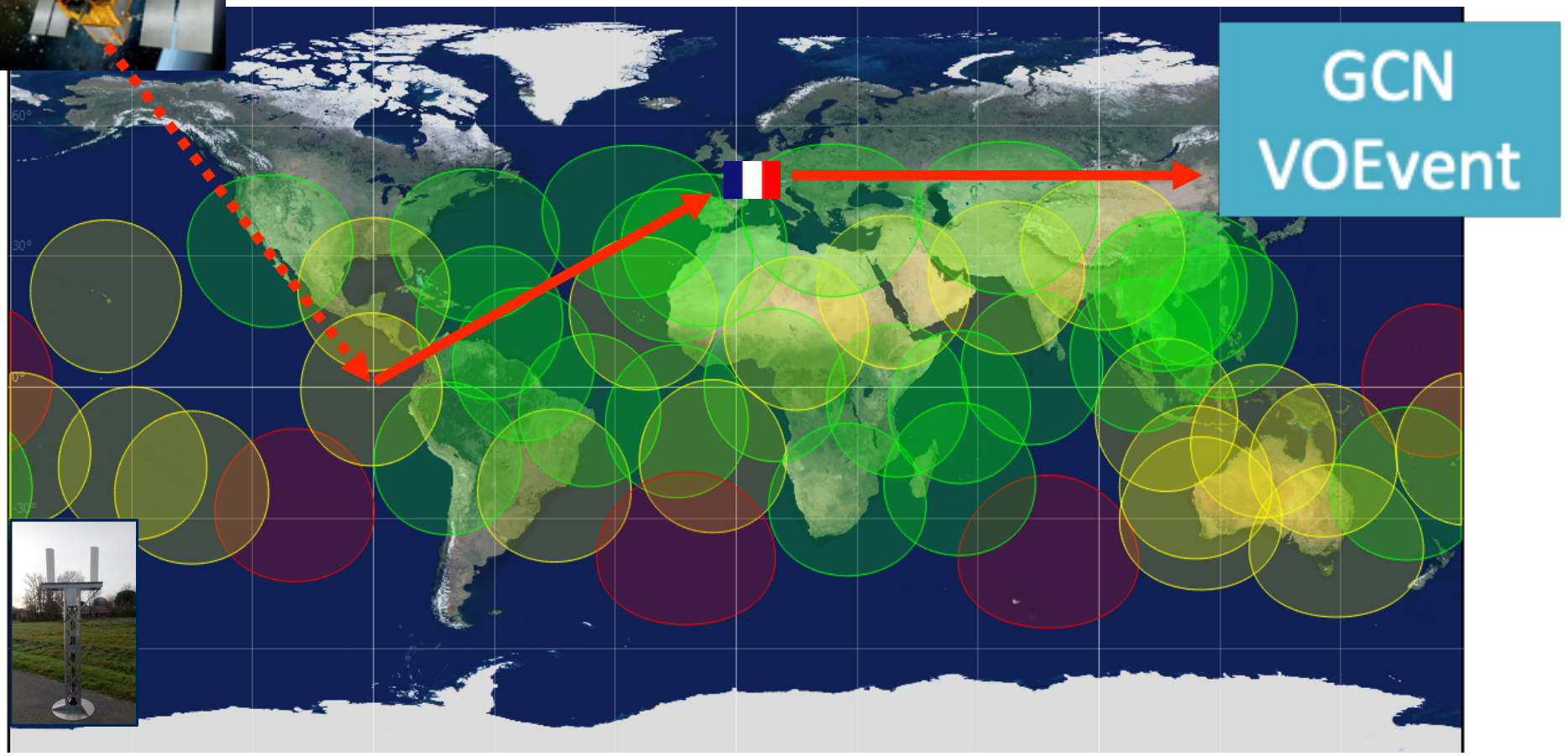
➡ Synergy with other space and ground based facilities
➡ Larger fraction of GRBs with Redshift

- Synergy btw 7 instruments in space and on ground for a multiwavelength follow-up

➡ Complete coverage of the GRB emission over 7 decades in energy from the trigger up to the late afterglow phase



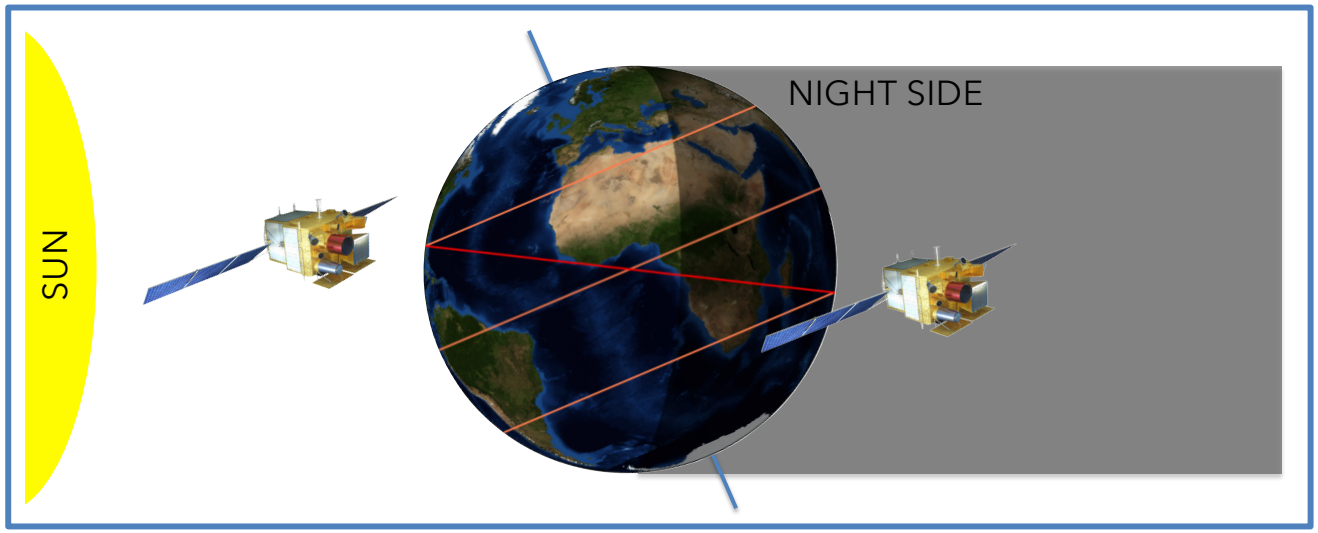
SVOM alert system



- 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

Orbit and pointing strategy

Aim: optimizing the ground follow-up of GRB candidates (increase the redshift measurement)



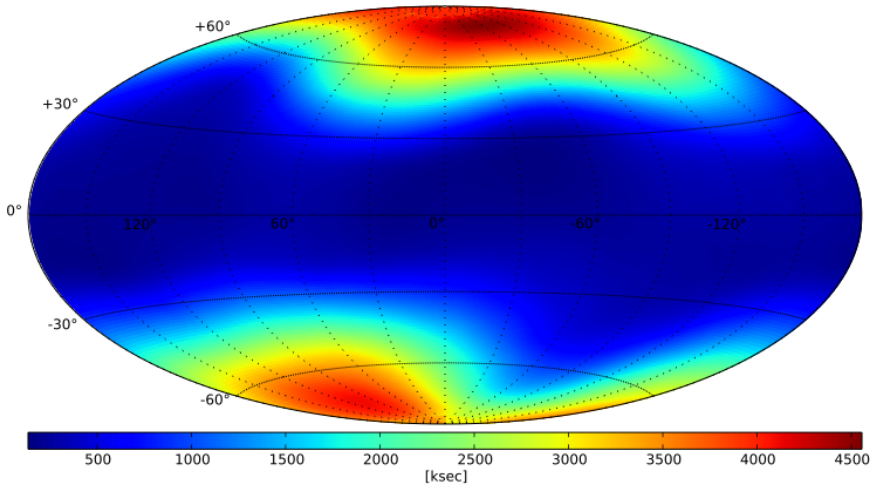
Nearly **anti-solar pointing**

Earth in the field of view

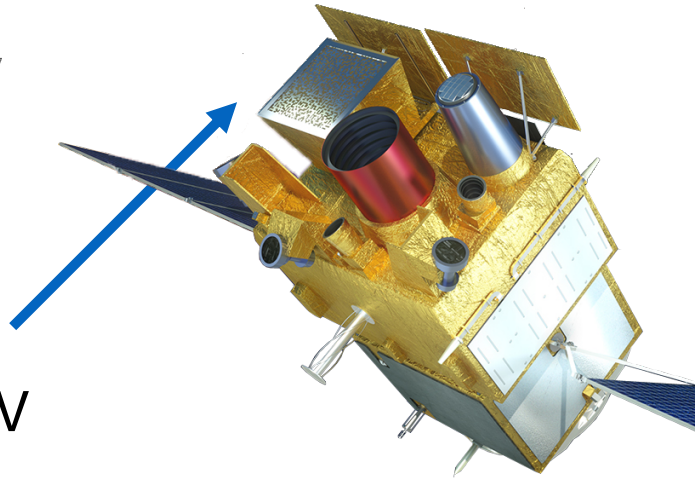
Avoidance of the galactic plane and bright sources as Sco X-1

ECLAIRs 1 yr exposure map:

- 4 Ms in the direction of the galactic poles
- 500 ks on the galactic plane

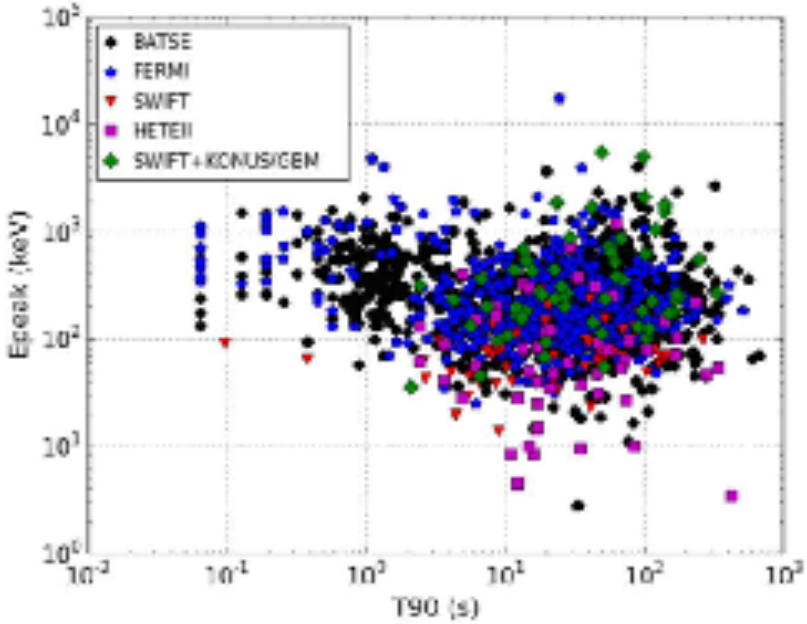


The GRB detection



ECLAIRs
- 4-150 keV
- ~ 2 sr
- Loc. < 12’
- 42-80 GRBs/yr

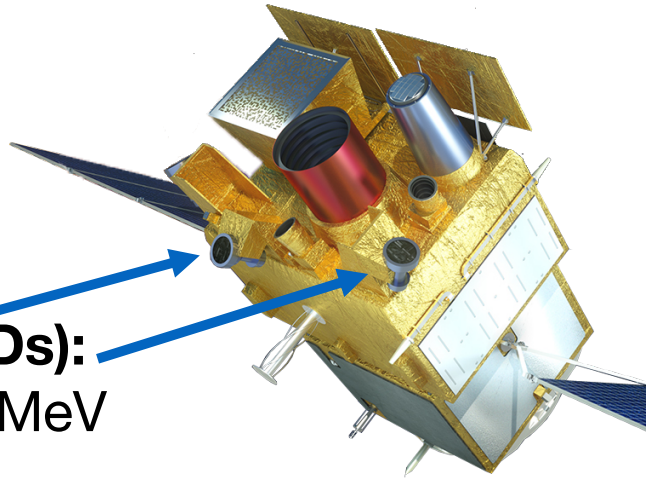
Detection probability by ECLAIRs



(simulations by S. Antier; Wei, Cordier et al., arXiv:1610.06892)

ECLAIRs is sensitive to all classes of GRBs:
- Classical long GRBs
- **Soft GRBs (XRR, XRF)**
- Short GRBs (but with a moderate efficiency)

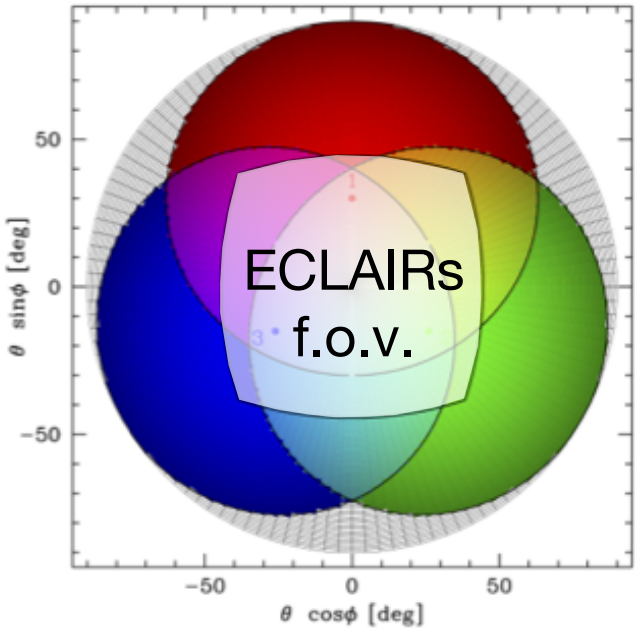
The GRB detection



GRM (3 GRDs):

- 15 keV - 5 MeV
- ~ 5.6 sr
- Loc. ~5-10 deg
- ~90 GRBs/yr

GRM field of view

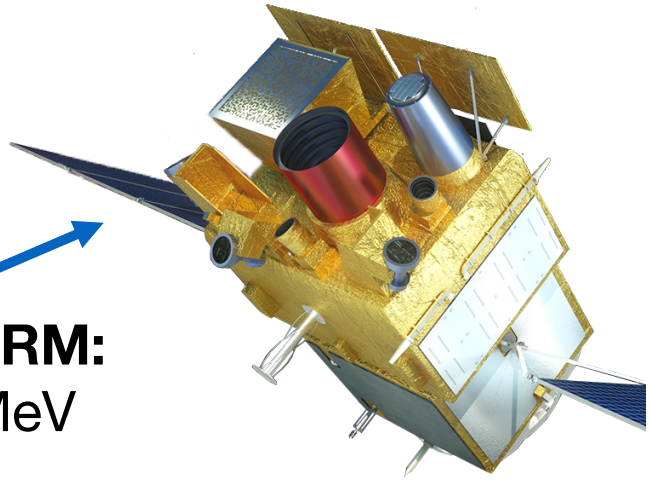


GRM has a larger field of view than ECLAIRs

GRM will have a slightly higher sensitivity to short GRBs than Fermi/GBM

ECLAIRs sensitivity to short GRBs can be improved by combining ECLAIRs+GRM

The GRB prompt emission

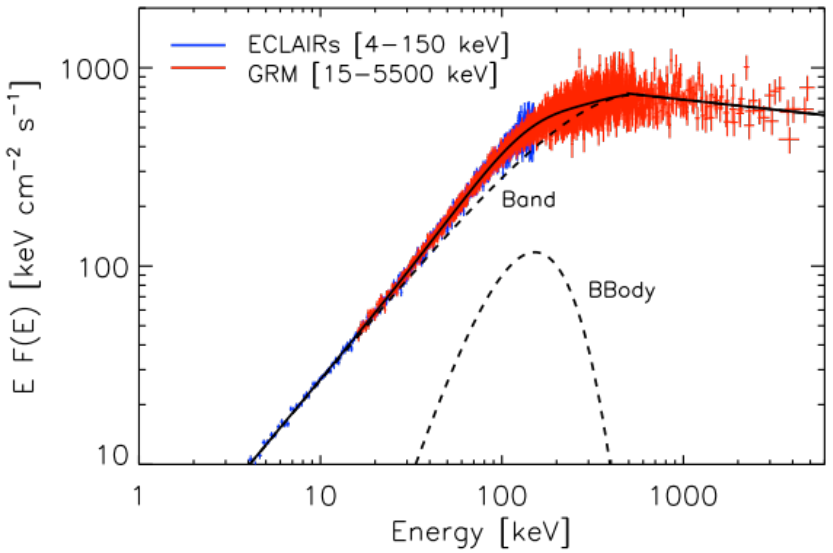


ECLAIRs+GRM:
- 4 keV - 5 MeV

+

GWAC:
- 2x5000 deg^2
- 500-800 nm
- m_{lim} ~ 16-17 (10s exposure)
- Prompt visible emission in ~16% cases

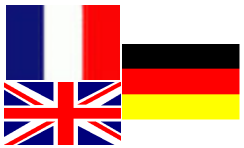
Multi-component spectrum of the Fermi burst GRB 100724B simulated in ECLAIRs+GRM.

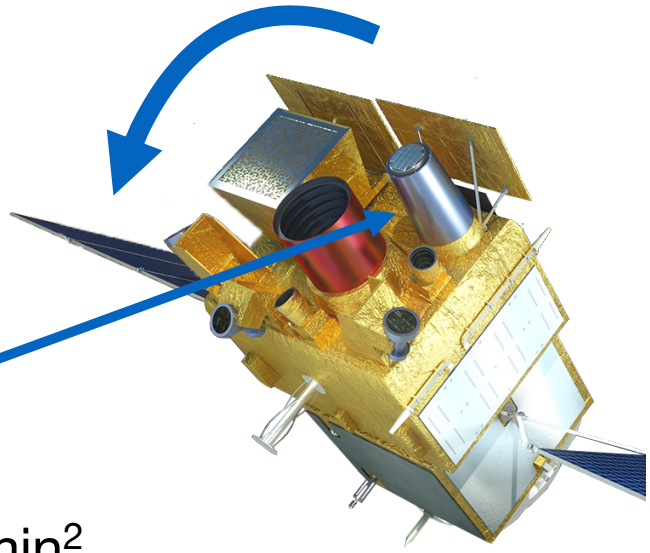


(Bernardini et al., 2017)

- ECLAIRs+GRM can measure the prompt spectrum over 3 decades in energy
- GWAC will add a constraint on the associated prompt optical emission in a good fraction of cases.

The GRB follow-up



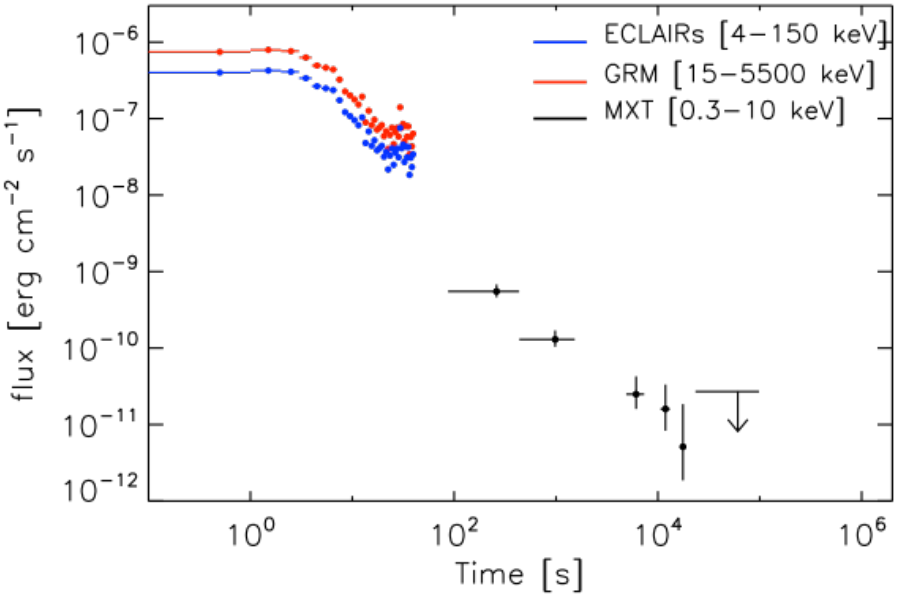


MXT:

- 0.2-10 keV
- 64x64 arcmin^2
- Loc. <13”

slew request: 36-72 GRB/yr

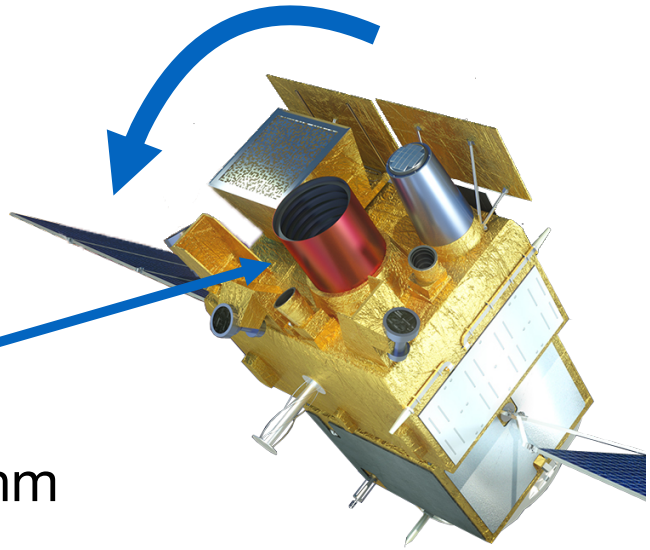
The X-ray afterglow of the Swift GRB 091020 simulated in MXT



(Wei, Cordier et al., arXiv:1610.06892)

- MXT can detect and localize the X-ray afterglow in >90% of GRBs after a slew

The GRB follow-up



VT:
- 400-1000 nm
- Loc. <1”

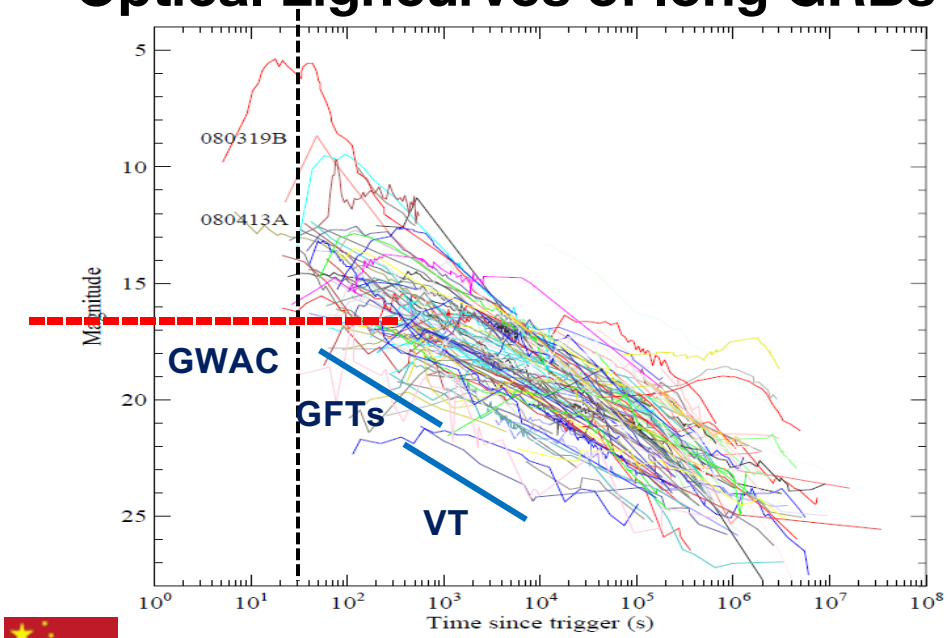
+

GWAC:
- 2x5000 deg^2
- 500-800 nm

F-GFT:
- 1.3 m
- 400-1700 nm

C-GFT:
- 1.2 m
- 400-950 nm

Optical Lighcurves of long GRBs



(Wang et al., 2013)

- VT + ground segment will detect, localize and characterize the V-NIR afterglows (lightcurve+photo-z)
- Early observations by large telescopes are favored by pointing strategy
- Redshift measurement is expected in ~2/3 of cases

The SVOM GRB sample

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

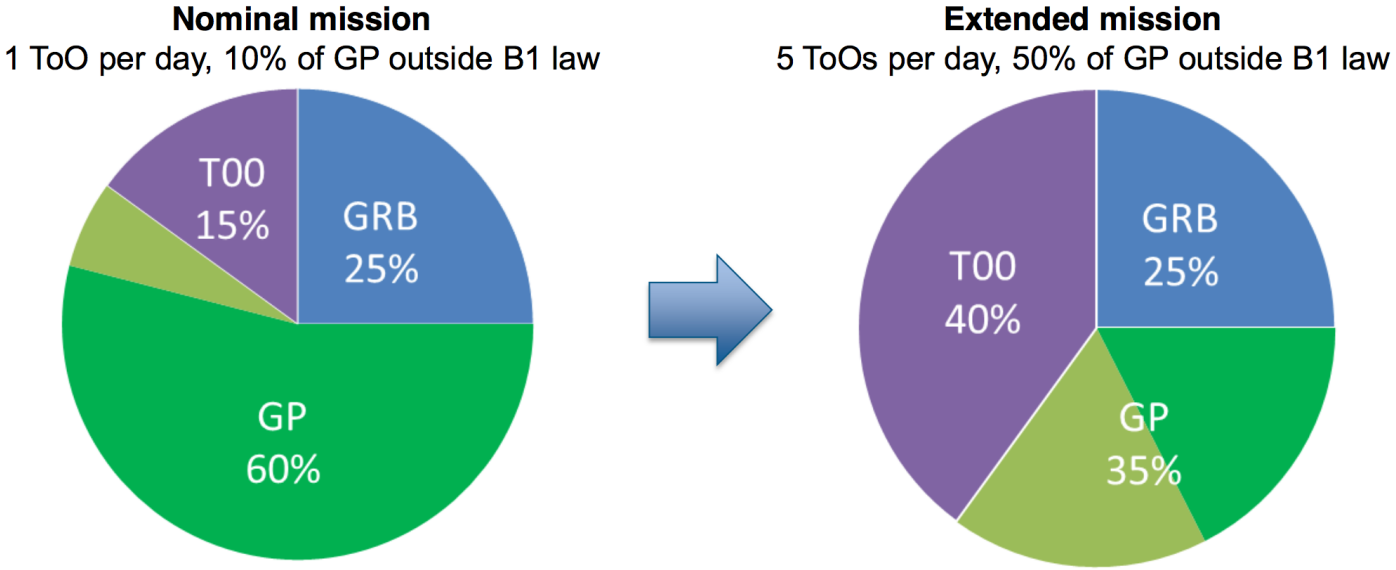
- **prompt emission** over 3 decades (+ optical flux/limit: 16%)
- X-ray and V/NIR **afterglow**
- **redshift**

	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

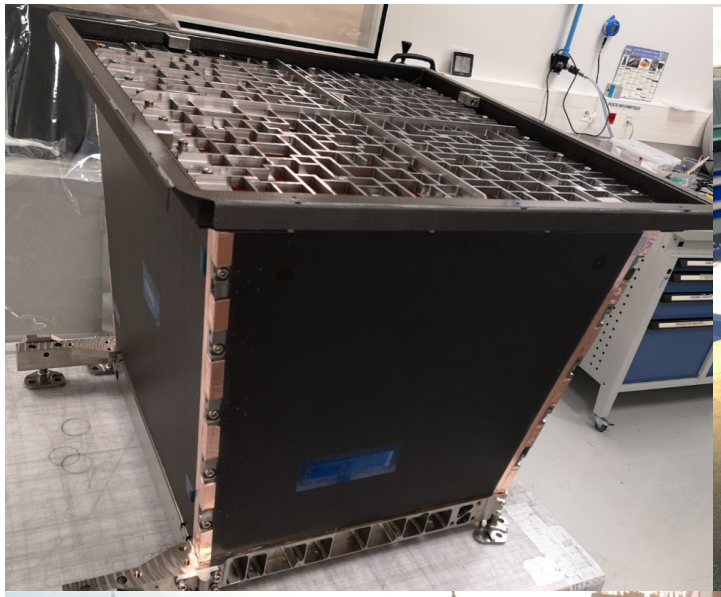
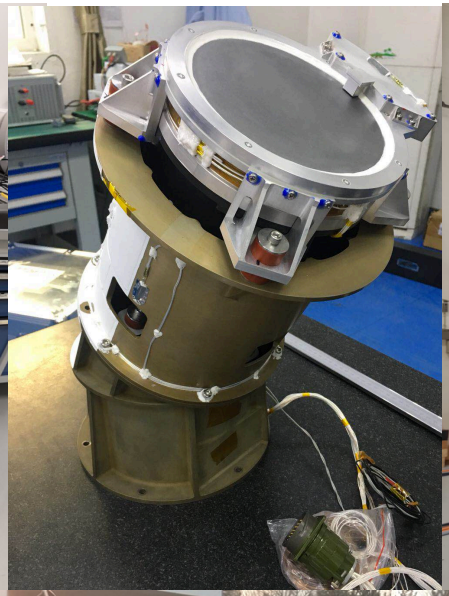
SVOM as an open observatory

- **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…

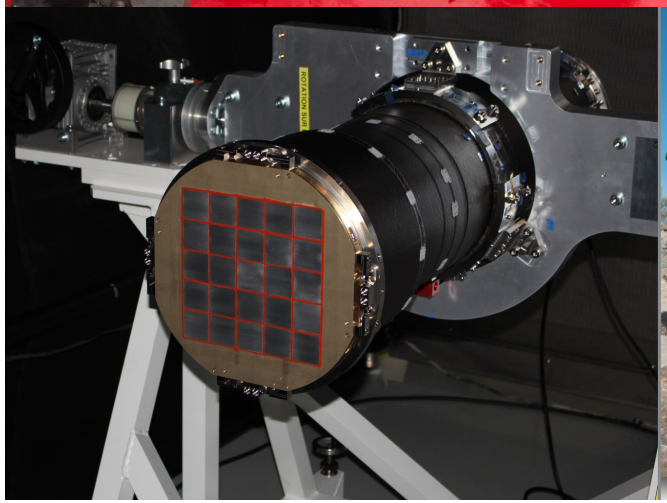


Data policy

- **Core Program:**
  - Scientific products generated under the supervision of the Burst Advocate are public **as soon as they are available**
  - All the scientific products are public **six month** after the data production
- **General Program:**
  - All the SVOM data products will be distributed to the Responsible Co-I
  - After **one year of proprietary period**, the data products will be public
- **ToOs:**
  - **ToO-MM**: the policy same as Core Program
  - **ToO-Nom and ToO-Ex**: the data are immediately public




Everything will be ready for the end of 2022
Stay tuned!!