

The high-energy transient sky observed by SVOM and GRANDMA

Damien Turpin (CEA)



1st Astro-Colibri workshop
26-30, Sept. 2022



The SVOM mission

Exploring the high-energy transient sky



<https://arxiv.org/pdf/1610.06892.pdf>

<https://www.svom.eu/>

Damien TURPIN (CEA)
on behalf of the SVOM collaboration
damien.turpin@cea.fr



1st Astro-Colibri workshop
26-30, Sept. 2022

Launch in fall 2023



A satellite



ECLAIRs

(γ -rays: 4-150 keV)

Trigger instr.

(loc. radius <10 arcmin)



MXT

(X-rays: 0.2-10 keV)

Follow-up instr. (FoV = 1°x1°)



Gamma-ray Monitor

(γ -rays: 15keV-5MeV)

Trigger instr.

(loc. radius < few degrees)



(\varnothing = 40cm / *Blue* & *Red* channels)

Follow-up instr. (FoV = 26'x26')

Visible Telescope

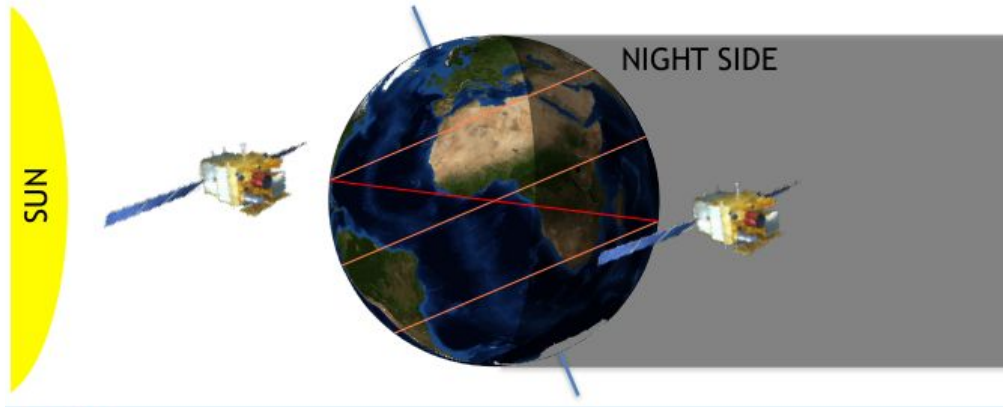
- Satellite equipped with 4 multi-wavelength instruments (ECLAIRs, GRM, MXT, VT)
- Trigger on gamma-ray events (4-150keV & 15keV-5MeV)
- Real-time ECLAIRs and GRM trigger alerts broadcasted on ground via a VHF antenna network
- Automatic follow-up sequence on board (slew & fast x-ray/opt follow-up with MXT and VT)
- Capability to perform quick ToO via VHF and BeiDou systems with MXT and VT instr.

A satellite

- On Low Earth orbit : ~625km of altitude
- 1 Orbit ~ 90 min (24h~14 orbits)
- Nearly anti-solar pointing

-> Earth occultation ~50% of an orbit
 -> alerts mostly detected in night side to favor fast follow-up on ground
 -> Avoidance of the galactic plane and Sco X-1

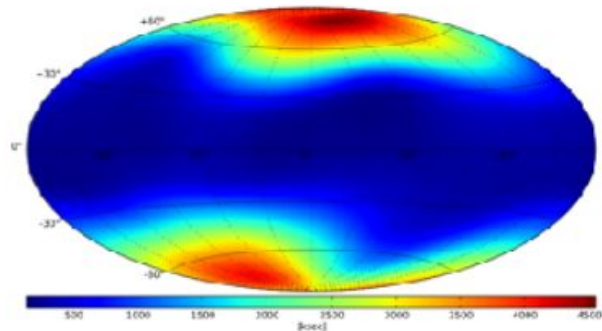
- Slew capability : 9°/min (including arcsec stabilization)



ECLAIRs exposure map

(65 GRBs/year, 1 ToO per day)

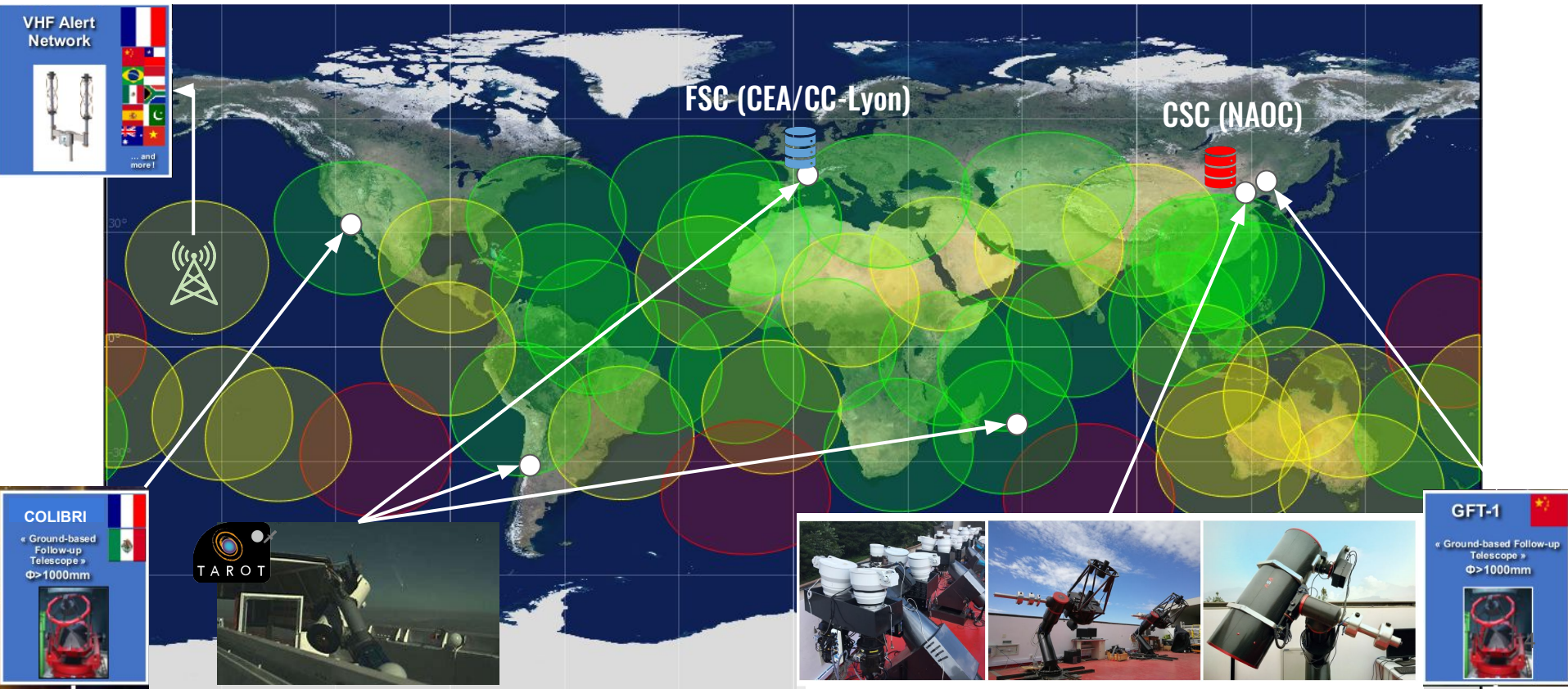
- 4 Ms in the direction of the galactic poles
- 500 ks on the galactic plane





.... associated with a ground segment

- A Very High Frequency (VHF) antenna network to communicate (downlink only) in real-time with the satellite
- optical/IR dedicated robotic follow-up telescopes + partnership with (TAROT, LCOGT, NOT2.5m, Xinglong2.12m, Lijiang 2.4m + ...)

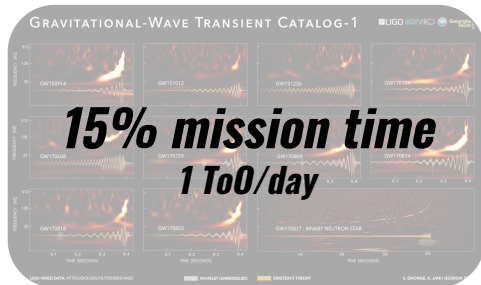




SVOM timeline and mission programs

Nominal mission (3 years / expected launch date : fall 2023)

Target-of-Opportunity Program (ToO)



Mission Core Program (CP)

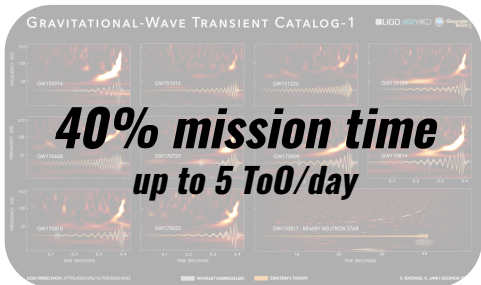


General Program (GP)



Extended mission (2 years / End of mission : 2028)

Target-of-Opportunity Program (ToO)



Mission Core Program (CP)



General Program (GP)





SVOM alert system related to the Core Program (GRBs)



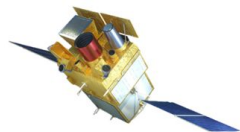
Goals

(All VHF scientific products will be publicly available)

- Provide **the ECLAIRs/GRM triggers within 30s** to the scientific community (with loc. < 10 arcmin for about $\frac{2}{3}$ of the γ -ray triggers)
- Provide localization updates (MXT < 1 arcmin & VT ~ arcsec) in **real-time as soon as the information is available** (typically few minutes after the GRB trigger time)
- Provide **Burst Advocate** trigger retraction or confirmation **reports within half an hour for every on-board detected triggers**



SVOM alert system related to the Core Program (GRBs): Real-time!



space to ground



VHF antenna location to SVOM/FSC

- 30s to reach the subscribers
- All VHF scientific products are public!
- The content of the SVOM alert notices is now under construction (VOEvent)

SVOM Real-time alerts system

at the French Science Center (CC Lyon/IN2P3)

broadcast

broadcast

we are going to follow the GCN notices system to quickly broadcast our alerts

we also have our own SVOM alert broker (Comet broker sending VOEvent messages) at the SVOM/FSC

<p>For legacy applications GCN Classic</p> <p>Three formats, three protocols.</p> <p>Get Started (Old Web Site)</p>	<p>Recommended GCN Classic over Kafka</p> <p>Three formats, one protocol.</p> <p>Get Started</p>	<p>Coming soon GCN Kafka</p> <p>One format, one protocol.</p>
--	---	--



Alert subscribers





SVOM Burst Advocate system
at the French Science and Chinese
Science Centers

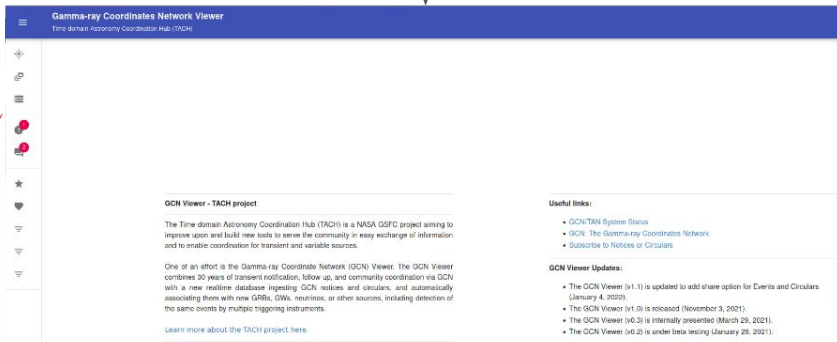


- First SVOM BA GCN Circulars should arrive within 30 minutes after the trigger time

**- We will probably not send any ATEL or other kind of manual messages (any concern about that ?)
“except for known sources in flaring state (GP)”**

**Human
validated report**

we are going to follow the GCN Circular system to quickly
broadcast our BA report



The screenshot shows the 'Gamma-ray Coordinates Network Viewer' interface. The header includes the NASA logo and the text 'Gamma-ray Coordinates Network Viewer' and 'Time domain Astronomy Coordinator Hub (TACH)'. The main content area is divided into sections: 'GCN Viewer - TACH project' with a description of the TACH project, 'Useful links' with a list of links, and 'GCN Viewer Updates' with a list of recent updates. A NASA logo is also visible on the left side of the interface.

GCN Circular subscribers



ToO nominal

- 1/day
- Allocated time : 1 orbit (~45min)
- Max latency : 24-48h
- Instr: MXT and VT

Open-access

100% of the scientific products will be delivered to the scientific community as soon as they are available

ToO MM

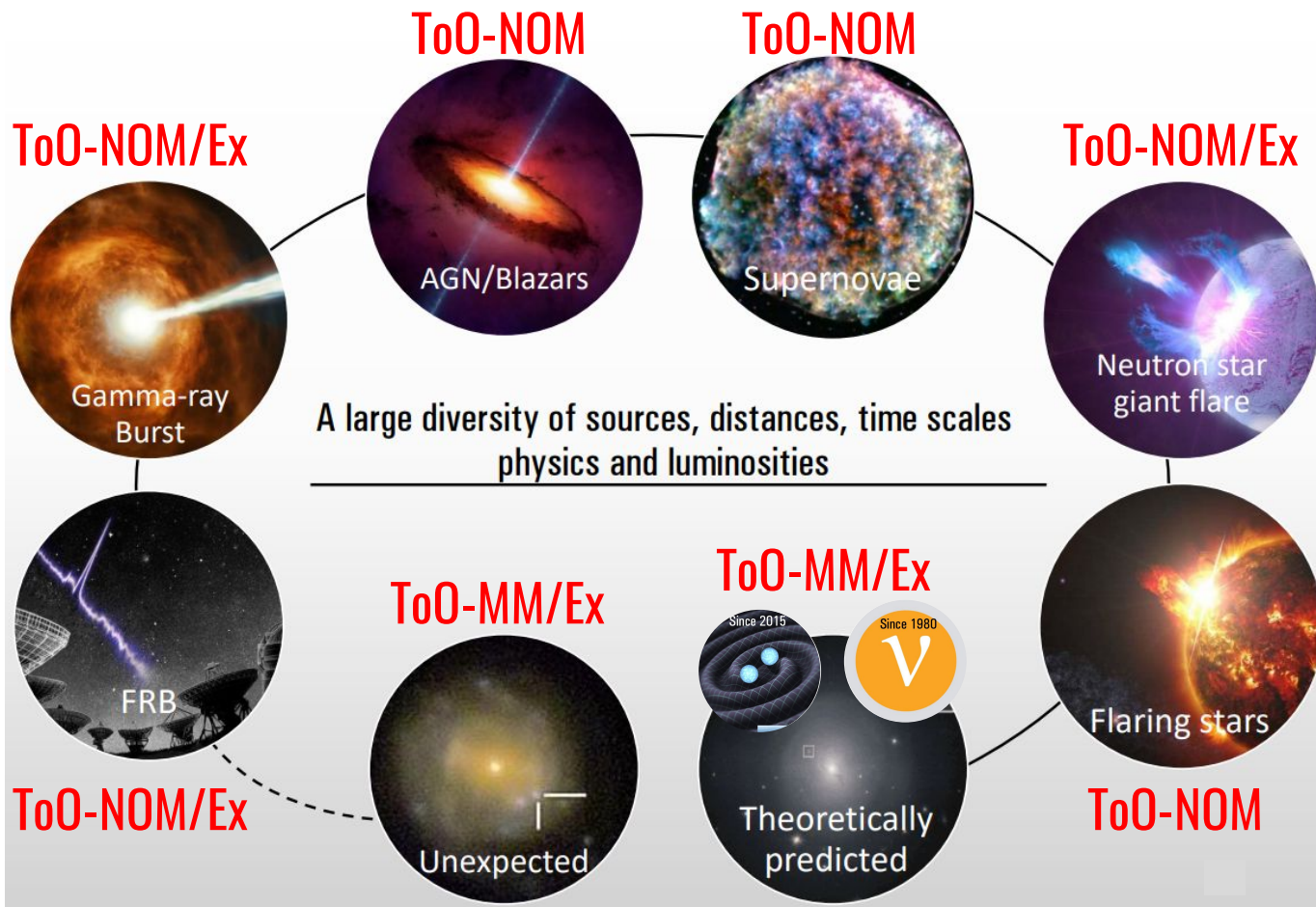
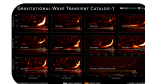
- 1/week
- Allocated time : 1-14 orbits (24h max)
- Max latency : 12h (S-band) / <4h (BeiDou)
- Instr: MXT and VT

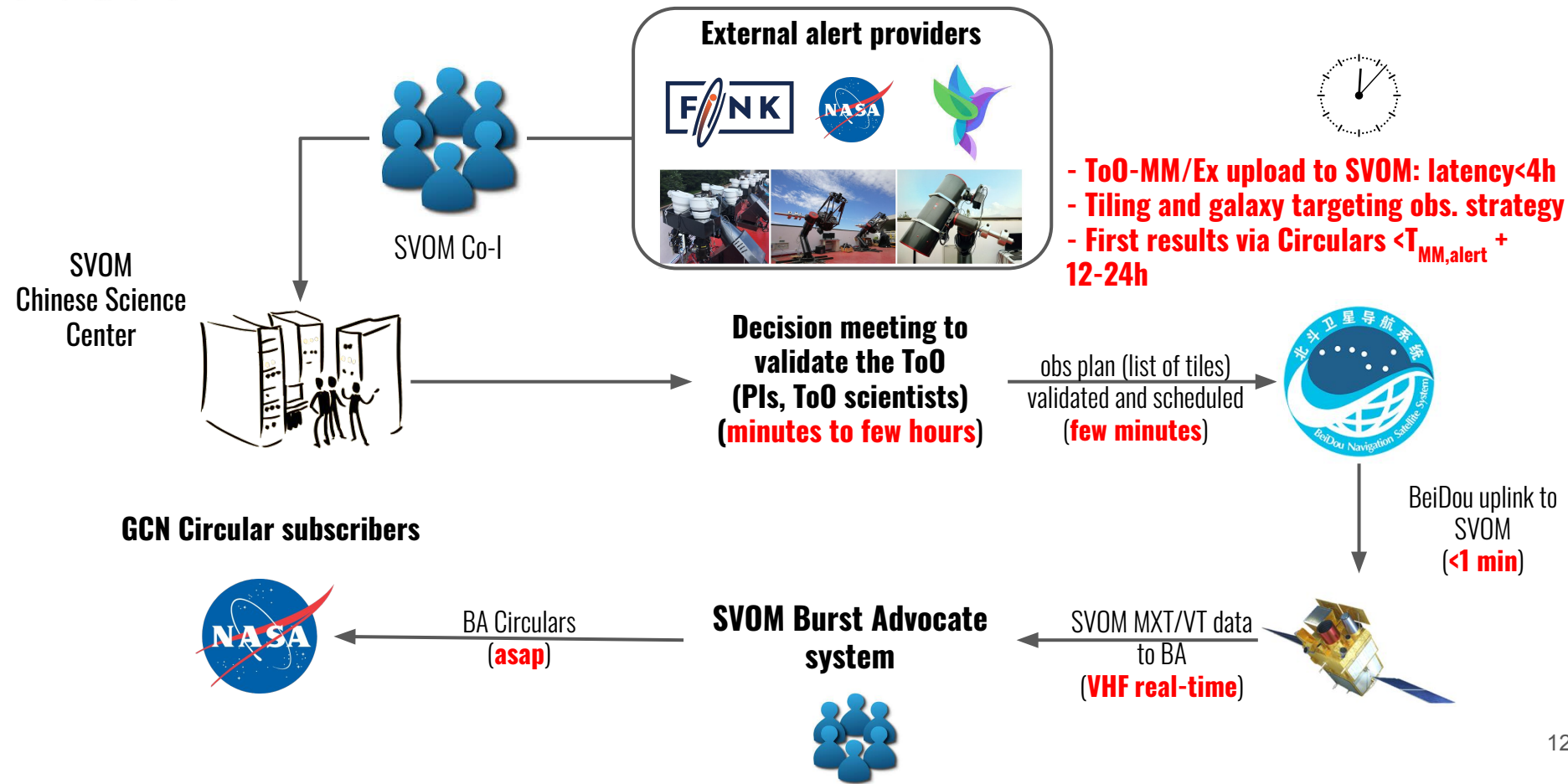
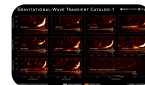
ToO Exceptional

- 1/month
- Allocated time : 7-14 orbits (24h max)
- Max latency : 12h (S-band) / <4h (BeiDou)
- Instr: MXT and VT

Can ONLY be triggered by a SVOM CO-I

100% of the informations that are needed to trigger external follow-ups will be publicly available as soon as possible (within few minutes)







SVOM take-away messages

About the SVOM Core Program (GRBs) alert system:

- **60-90 GRB/year** (not a huge alert flow) -> SVOM strategy : **24h continuous follow-up** in x-rays and in optical (space & ground).
- **All the informations** relevant for follow-up activities will be **publicly** released in **real-time** to the scientific community to maximise the science returns
- SVOM GCN notices are under construction now. The schema of the SVOM notices sequence will be provided via the (new) GCN system
- SVOM GCN Circulars are under discussion in regular internal meetings (delay, content, how many Circulars per GRBs etc.)
- The SVOM broker is alive (but the SVOM VOEvents currently delivered are not the last version) ! Anybody interested in connecting to it (for test) can contact us (damien.turpin@cea.fr).
- As for Swift, SVOM Burst Advocates will be your main contact person for any question about a given trigger

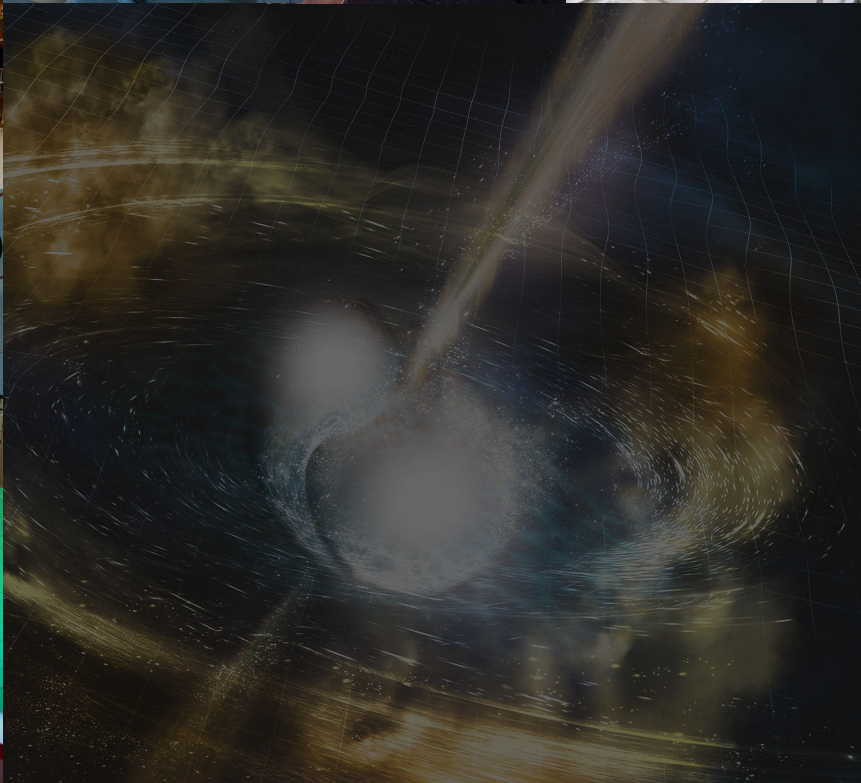
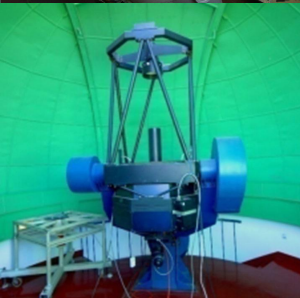
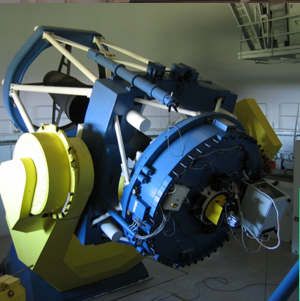
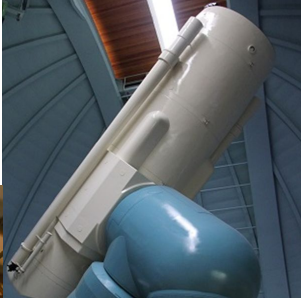
*The SVOM collaboration is willing to have partnership with all types of MW/MM facilities interested in transient science.
This is the right time to reach us!*



SVOM take-away messages

For the future of the MM astronomy what we foresee:

- Importance of having clear and well defined science cases to extract “THE ONES” from the different alert streams (especially during VR/LSST era -> SVOM is actively working with the FINK broker for example).
- You need to have a dedicated strategy for every types of (fast) transients (model dependent...).
- (real-time) Coordinated efforts are mandatory (alert communication and follow-up scheduling) in our research field
- New visualisation tools must be developed to deal with multiple instrument/messenger data.
- We may need an infrastructure that will standardise the scientific products coming from different projects (alert communication channel, localisation, light curves, spectra, etc.)



<https://grandma.iijclab.in2p3.fr/>

Damien TURPIN (CEA)

*on behalf of the GRANDMA
collaboration*

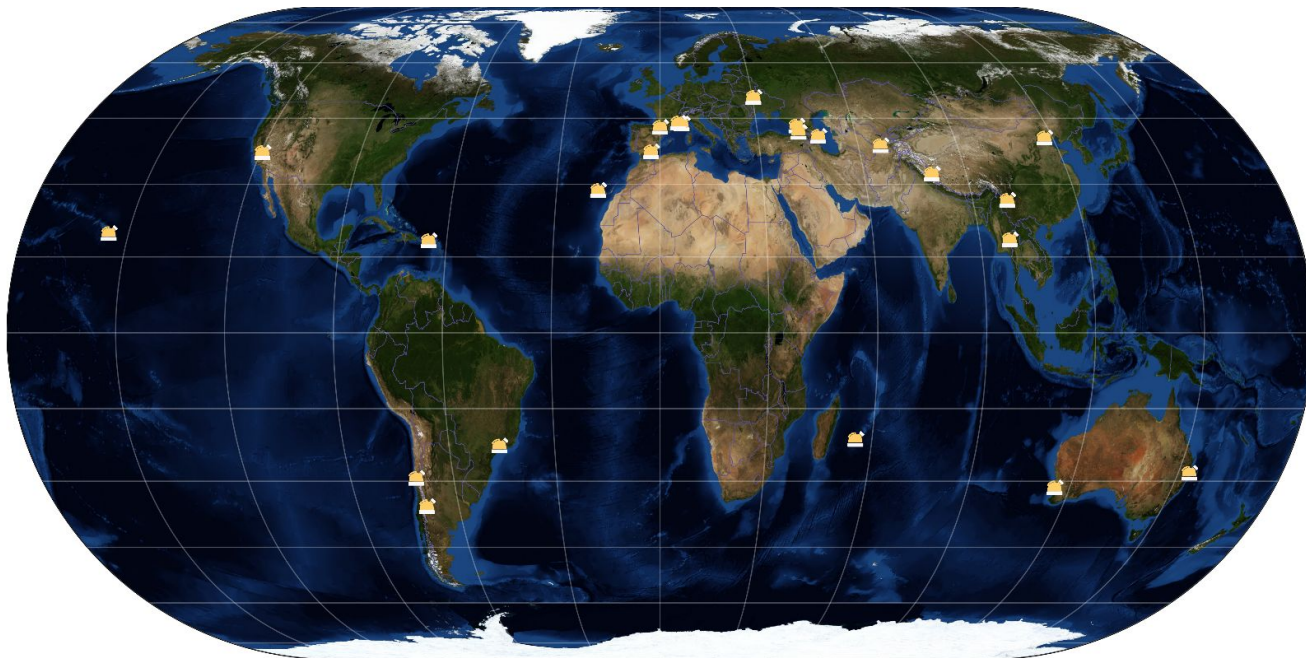
damien.turpin@cea.fr



**1st Astro-Colibri workshop
26-30, Sept. 2022**



A network of optical/IR telescopes....



- Operated since 2018
- 23 Observatories / 30 telescopes
- 42 Institutes / 18 countries
- photometric and spectro telescopes [18cm - 3.6m]
- Filters (UBVRIJH, u',g',r',i')
- Capability to perform quick follow-up observations within a minute latency with our robotics
- global scheduler (ToO manager) to efficiently schedule follow-ups of poorly localized MM transients





dedicated to the multi-messenger astronomy

- Identification and characterization of the optical/IR counterparts associated with GW sources
- Physical constraints on kilonova model and mass ejection fraction post-merger
- follow-up of post-merger GRB afterglow emission
- Short GRB host galaxies studies in the nearby Universe

GRANDMA references

<https://arxiv.org/abs/1910.11261>

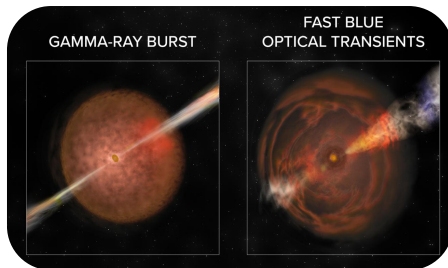
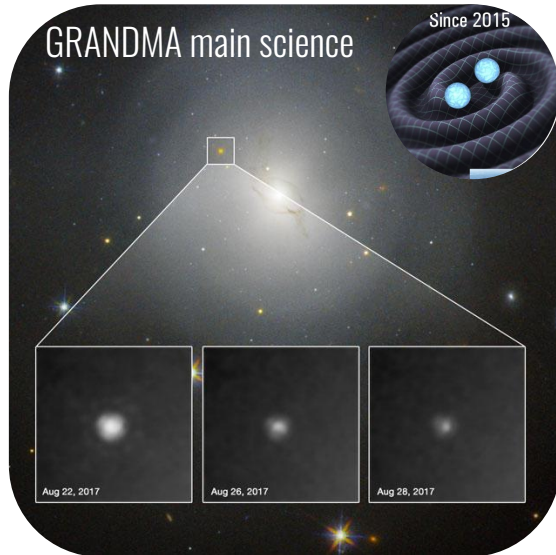
<https://arxiv.org/abs/2004.04277>

<https://arxiv.org/pdf/2207.10178.pdf>

- Follow-up of peculiar fast transients
- Identification of orphan GRB afterglow/kilonovae in optical synoptic surveys (ZTF-II, VR/LSST)

GRANDMA references

<https://arxiv.org/abs/2202.09766>



GRANDMA internal ToO program



The GRANDMA machinery

Layer 1 : external alert streams



GCN notices, Fink broker, etc.

Layer 2 : the heart of GRANDMA
(the orchestrator)

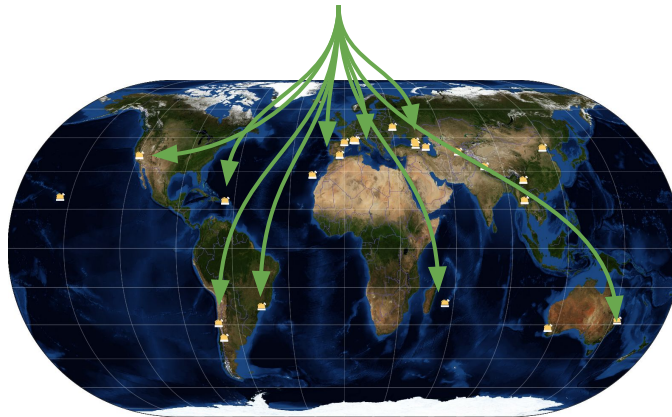


**Interface and Communication for Addicts of the
Rapid follow-up in multi-messenger Era**

- Digest and reformat alerts
- Produce and update custom obs. plans (dynamic scheduling)
- Store obs. results in DB
- Launch quick scientific analysis
- Visualization of alert and follow-ups data
- Trigger additional follow-ups to robotics
- Manage Follow-up Advocate shifts

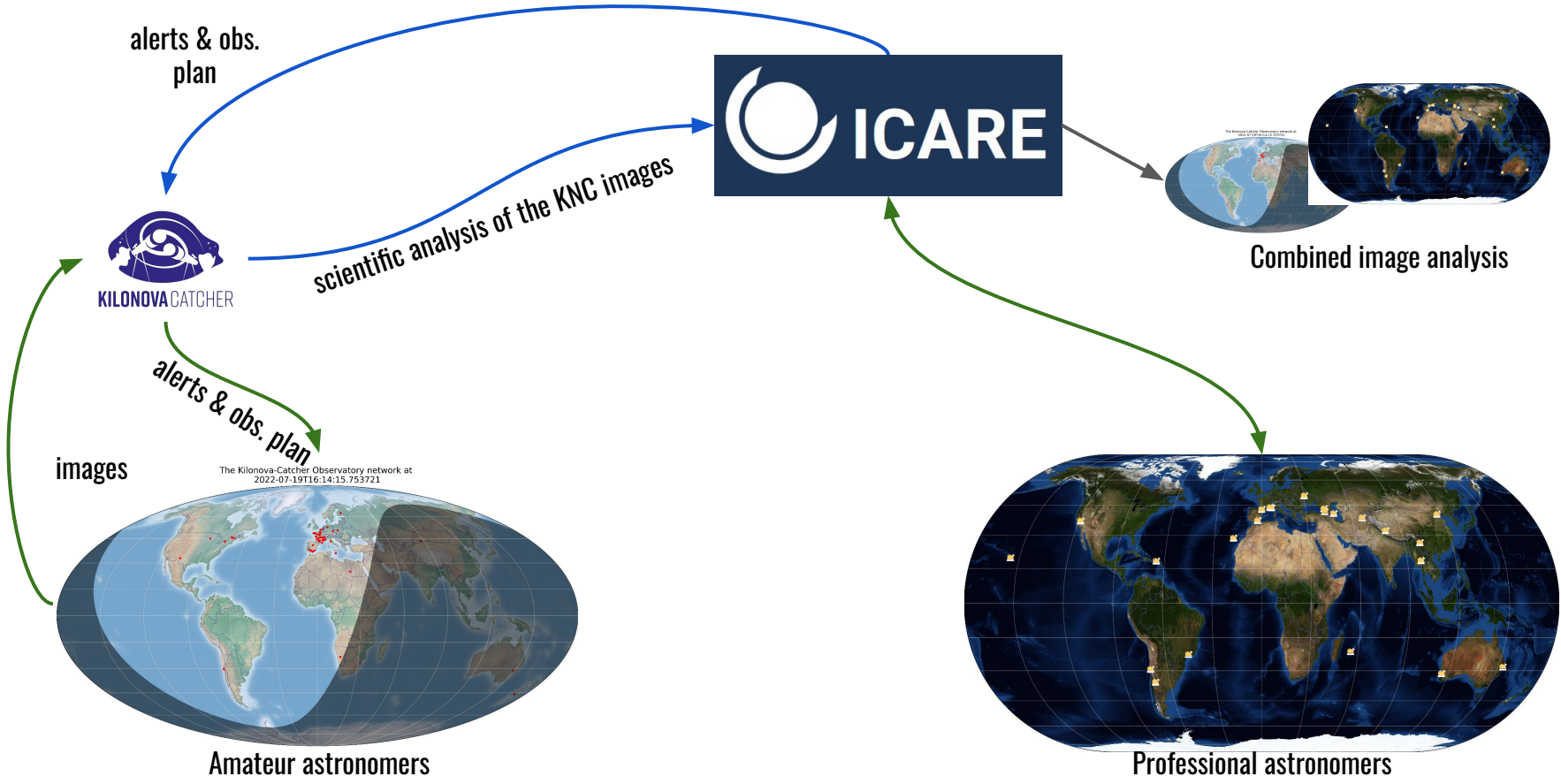
we rely on <https://skyportal.io/>

Layer 3 : the eyes of GRANDMA



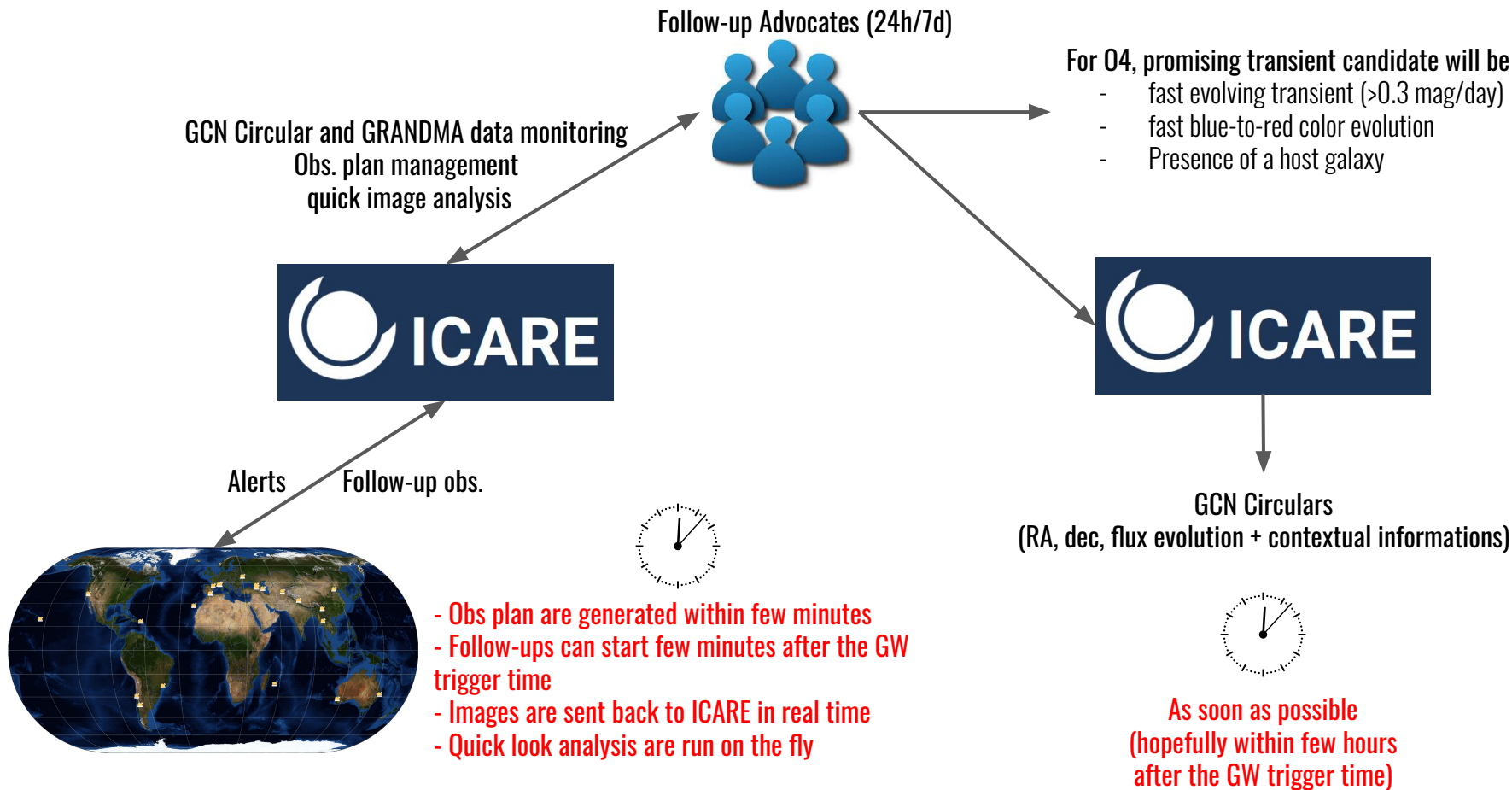
- Photometric multi-band follow-ups
- Spectroscopic follow-up (bright sources)
- Real-time access to the obs. results

The GRANDMA citizen science program : Kilonova-Catcher





The GRANDMA alert system towards the outside world (For the O4 campaign)





The GRANDMA take-away messages

For the future of the MM astronomy what we foresee:

- A **configurable** tool that allows quick cross-matches in space and time between several multi-messenger triggers and send automatic alert notifications to subscribers. We should avoid multiplying the alert streams to listen to.
- Importance of science portals like **Skyportal** to efficiently manage the global scheduler of its own network (**a must have nowadays**)
- Have efficient visualization tools to combine data coming from different instruments (across wavelengths) -> again tools like Skyportal are here to do this job
- Real-time communication must be a standard in our field of research
- In case of complicated follow-ups as for GW or poorly localised high-energy transients, key statistics about the follow-up status (%of skymap covered, number of revisits/tile, number of transients found with their crude classifications, etc.) is truly needed to help the FA/astronomer for taking the right decisions
- Maximum of automatization !