
*Damien Turpin (CEA)*
*B. Cordier, T. Sadibekova, D. Götz (CEA), R. Le Montagner, J. Peloton, N. Leroy (IJCLab)*

**Ground-based multi-band astronomical Variable Objects Monitor**

UNOFFICIAL

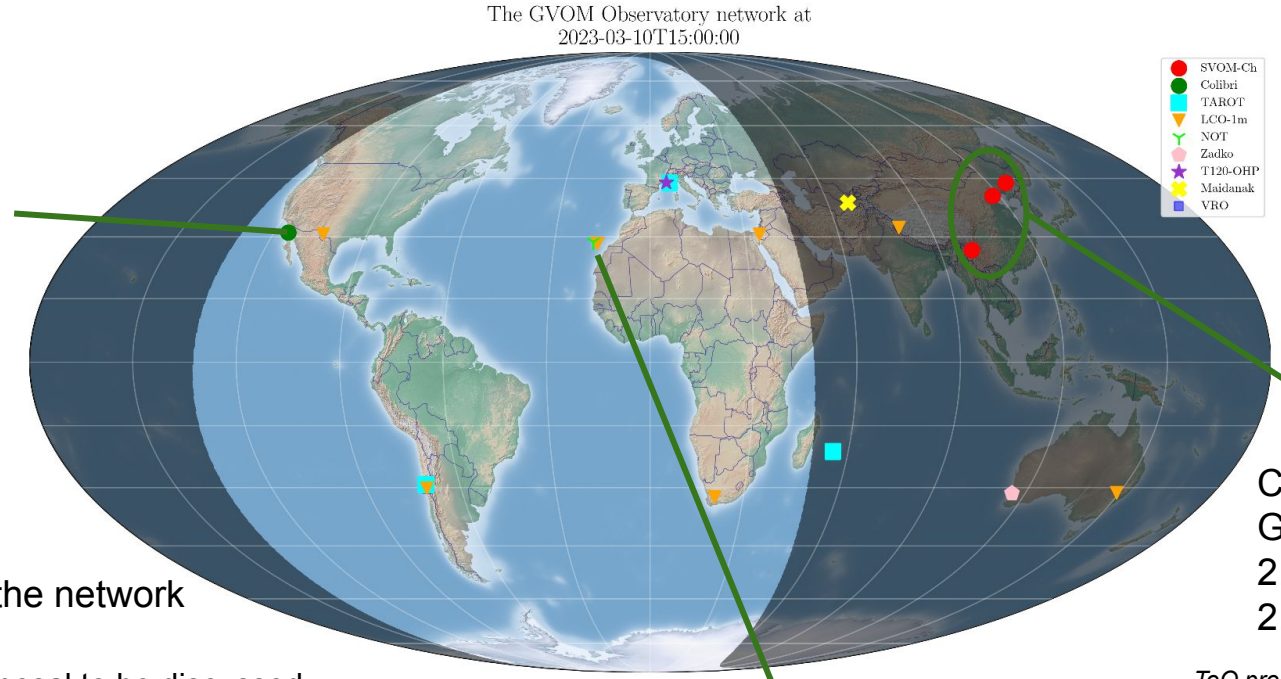
# Exploring the energetic transient sky of ZTF and VRO using the FINK broker

# Outlines

- What is the GVOM telescope network project ?
- What are the targeted science cases ?
- Simulation of the GVOM scientific operation using the FINK broker (with ZTF data)
- Conclusive words
- *on going work (some back-up slides) : Simulation of the GVOM scientific operation using the FINK broker with VRO data*

# What is the GVOM telescope network project ?

# A telescope network to build….




COLIBRI

***Colibri Science Proposal***

C-GFT
GWAC-F60
2.12m Xinglong
2.4m Lijiang

*ToO proposal with SVOM-CH team to be discussed*

Heart of the network

NOT

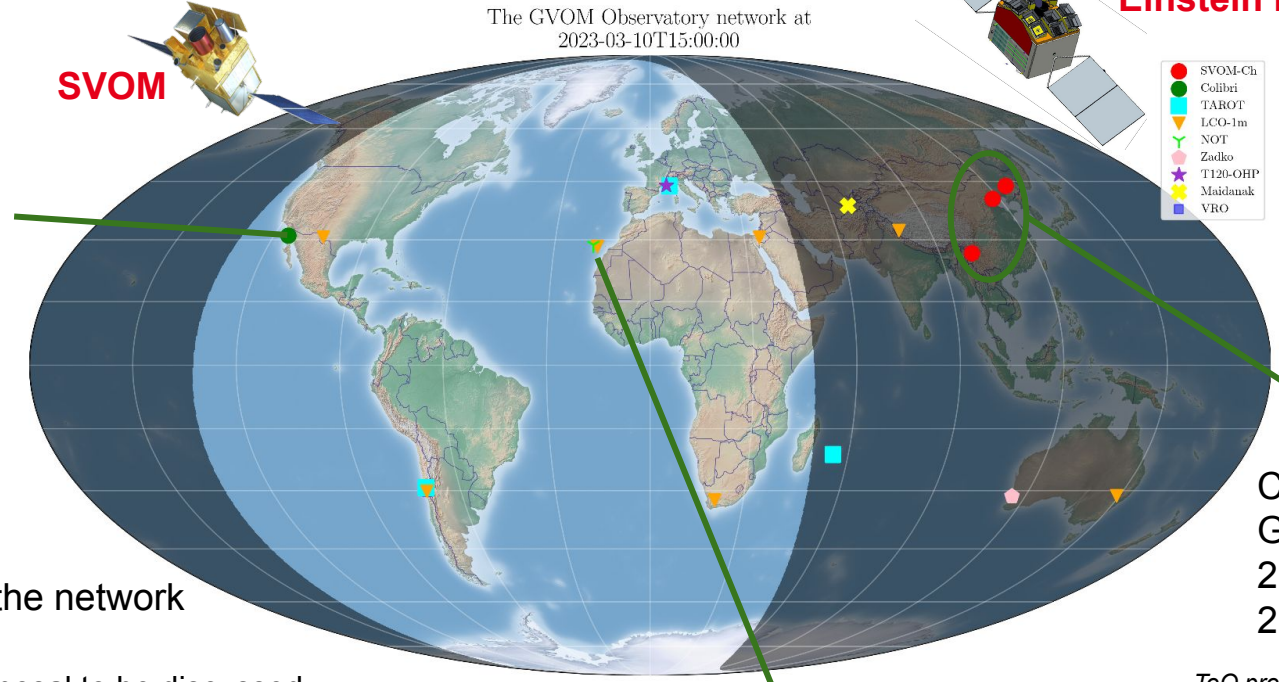
*ToO program to be discussed*

**Maidanak:** ToO proposal to be discussed
**TAROT + Les makes:** ToO proposal to be discussed
**Zadko:** ToO proposal to be discussed
**LCOGT:** Proposal or NAOC time ?
**OHP:** ToO proposal (193, 120cm) ?

# .... To be coordinated with high-energy space instruments

SVOM

Einstein Probe




COLIBRI

***Colibri Science Proposal***

C-GFT
GWAC-F60
2.12m Xinglong
2.4m Lijiang

*ToO proposal with SVOM-CH team to be discussed*

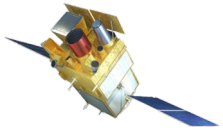
Heart of the network

NOT

*ToO program to be discussed*

**Maidanak:** ToO proposal to be discussed
**TAROT + Les makes:** ToO proposal to be discussed
**Zadko:** ToO proposal to be discussed
**LCOGT:** Proposal or NAOC time ?
**OHP:** ToO proposal (193, 120cm) ?

# The network management



*Dev.*
*J. Peloton*
*R. Le Montagner*

FINK

Alert provider

**FINK business**

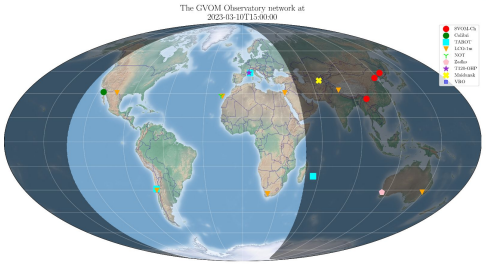
*Dev.*
*R. Le Montagner*
*(IJCLab)*

TOM TOOLKIT Las Cumbres Observatory LCO

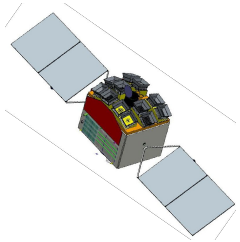
ToO manager
Telescope manager

**VOEvent alerts**

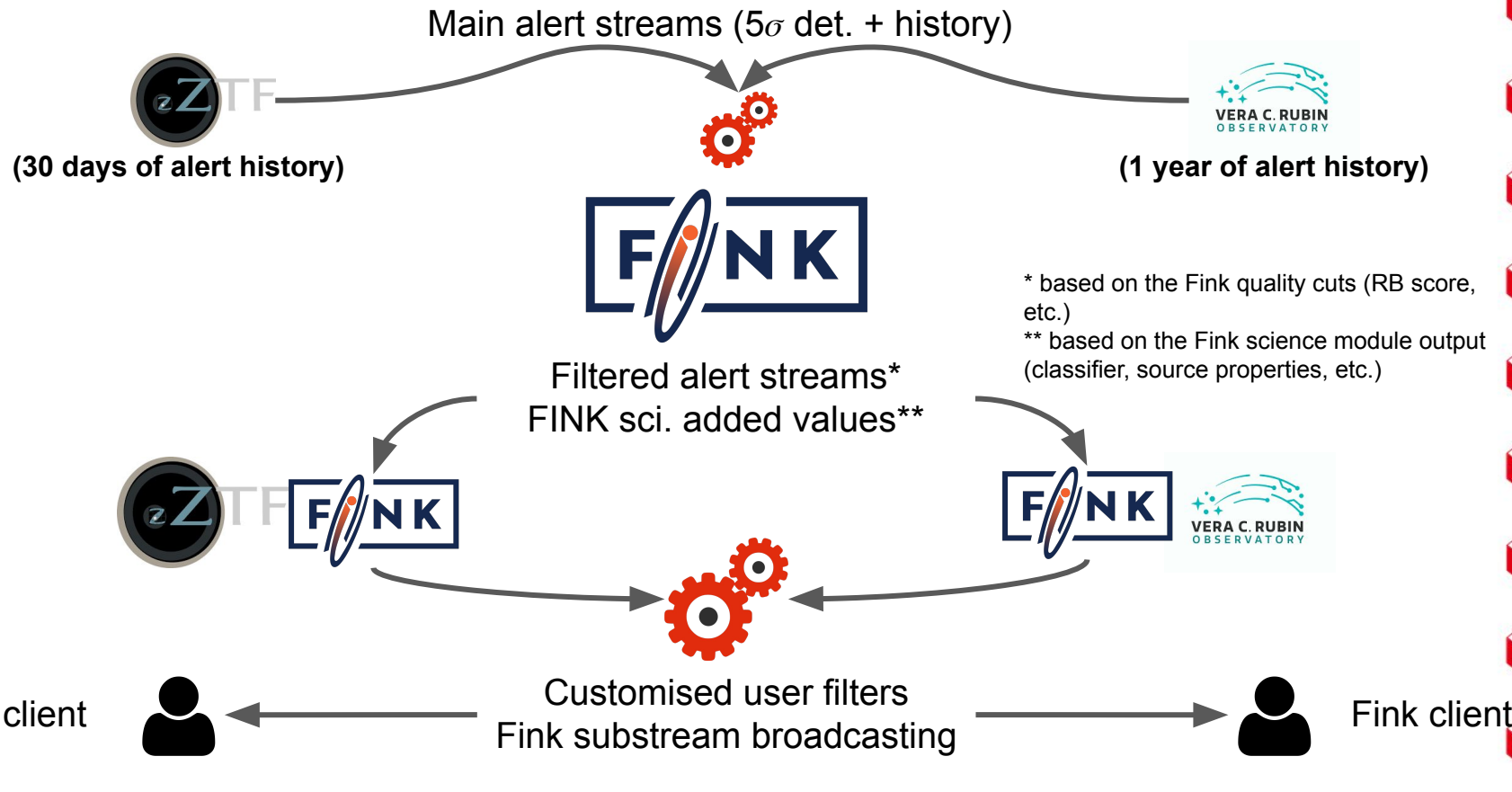
*Telescope teams*



data providers



# Exploring the optical transient sky with the FINK broker - Real-time ZTF/VRO alert streaming



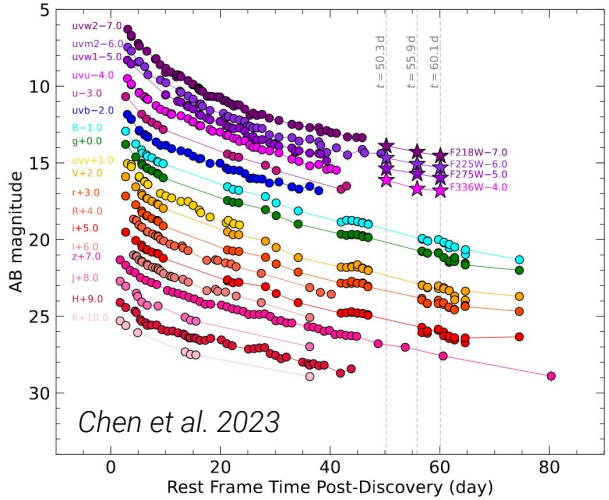
# The science cases
# FBOTS
## (& Kilonovae but not for today)

# The FBOTs : a mystery to solve!
# the missing link between SNe and classical Long GRBs ?

***5 confirmed detections with significant follow-up efforts***

1. ***AT2018cow*** *: Prentice et al. (2018), Perley et al. (2019), Ho et al. (2019) -> discovered by the ATLAS survey*
2. ***AT2018lug (ZTF18abvkwla)****: Ho et al. (2020) -> discovered by the ZTF survey*
3. ***CSS161010****: Coppejeans et al. (2020) -> discovered by CRTS and ASAS-SN*
4. ***AT2020xnd****: Perley et al. (2021), Ho et al. (2021), Bright et al. (2021) -> discovered by ZTF*
5. ***AT2020mrf****: Yao et al. (2022) -> discovered by ZTF and ATLAS*

*AT2018cow UVOIR emission*

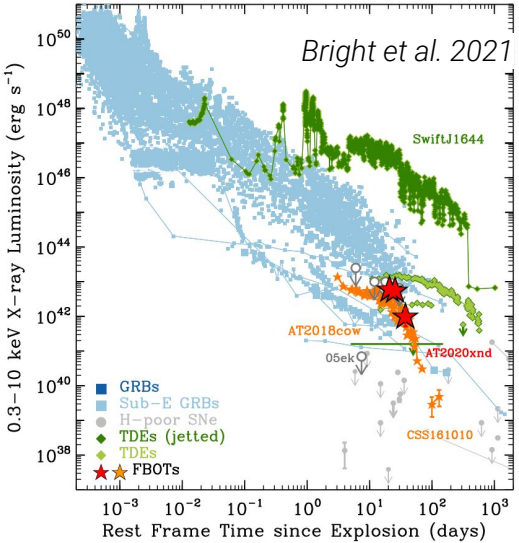



## *Observational facts*

- ***hot blue/UV and featureless optical spectrum in the first days/weeks***
- *Luminous in X-ray and radio*
- *X-ray excess compared to radio synchrotron cooling (non-thermal emission) : presence of a compact central engine? magnetar ?*
- *mildly relativistic outflow : 0.1-0.2c / 0.1M$_\odot$*
- *Shock wave ejecta/CSM*
- ***Located in SF galaxies***
- *FBOTs rate < 0.1% CCSNe rate*
- *-> Progenitors ?*

***multi-λ needed to study them!***

*FBOTs x-ray emission*



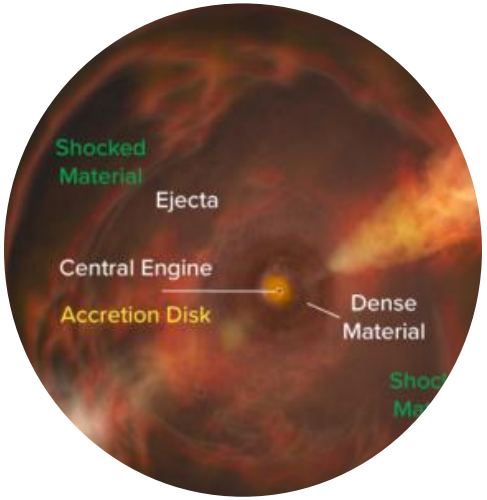
# The FBOTs: a mystery to solve!

***"LFBOTs are engine-powered explosions that generate highly aspherical ejecta spanning a wide range of velocities, propagating into a dense, radially extended preexisting CSM."*** *Metzger & Perley (2023)*

***low-mass ejecta mainly powered by a central engine (NS/magnetar)***
Drout et al. 2014; Yu et al. 2015; Pursiainen et al. 2018; Prentice et al. 2018; Fang et al. 2019; Margutti et al. 2019; Perley et al. 2019; Gottlieb et al. 2022

***IMBH-TDE***
Kuin et al. 2019; Perley et al. 2019;

***electron capture SNe***
*Moriya & Eldridge 2016; Mor et al. 2022; Leung et al. 2020*




Fast Blue Optical Transients

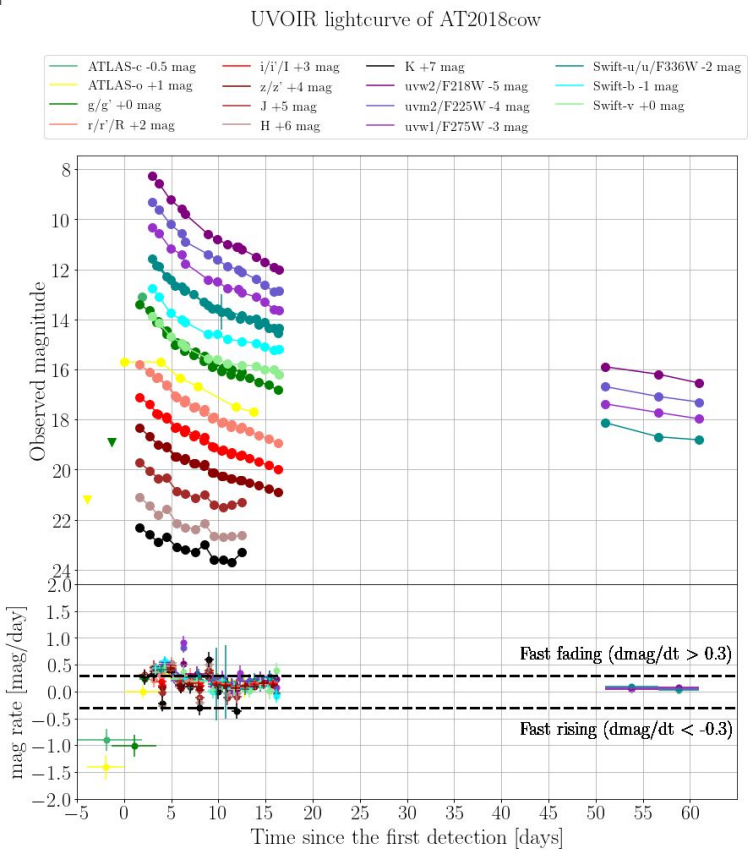
***accreting black hole and mass ejection***
Kashiyama & Quataert 2015; Margutti et al. 2019; Perley et al. 2019; Quataert et al. 2019; Antoni & Quataert 2022; Kremer et al. 2021

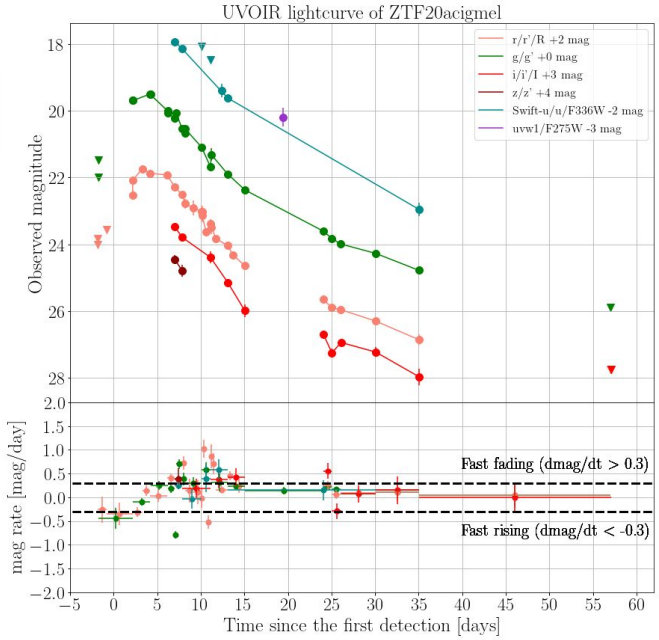
***SN explosions of ultra-stripped progenitor stars***
Tauris et al. 2013, 2015, 2017; Suwa et al. 2015; Hotokezaka et al. 2017; De et al. 2018; Sawada et al. 2022

***accretion-induced collapses (AICs) of white dwarfs***
*Kasliwal et al. 2010; Brooks et al. 2017; Yu et al. 2015, 2019; Lyutikov 2022*

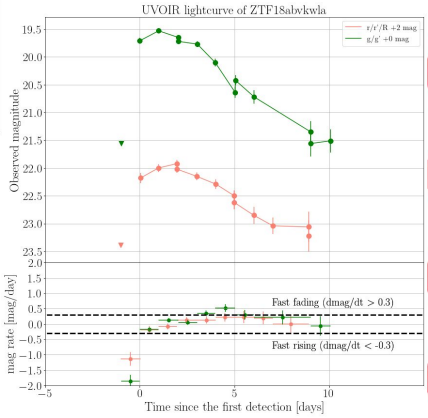
***Merger events***
*Yu et al. 2013, 2015, 2019b; Zenati et al. 2019; Soker et al. 2019; Schrøder et al. 2020; Uno & Maeda 2020; Metzger 2022; Soker 2022*

# The FBOTs : a mystery to solve!
# A look at their UVOIR light curves




1. Fast rising phase (> 1 mag/day)
2. moderately fast fading early phase (>0.3 mag/day)
3. color evolution ?
4. $t_{1/2}$ ?



# ZTF transients
# GVOM Obs. strategy
# & ToO rate

# Simulating the GVOM/ZTF ToO rate: observation strategy

## Telescope network filters

A target must satisfy the following criteria:

- Being observable by COLIBRI, NOT and the Chinese facilities (heart of the network) under the following conditions at each site:
  - Elevation > 30°
  - moon distance > 20°
  - airmass < 2
  - visible at least 2 hours
- gal. latitude |b| > 15°

## Science filters

### Not astro target dependent

- RB score > 0.9
- Allowed Fink class.: Unknown, SN candidate, Ambiguous

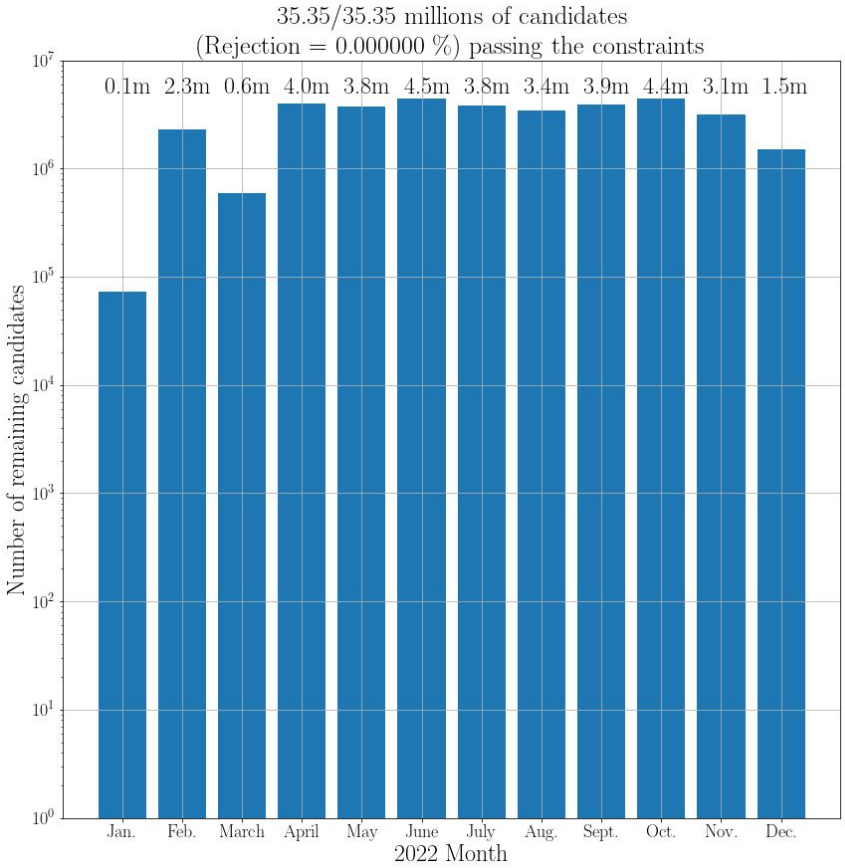
### FBOTs strategy

- Being bright enough r/g < 17 mag
- Have no historical detection more than 5 days prior to the alert time
- The rising/fading rate > 0.3 mag/day

### orphan Kilonovae strategy

- Being classified as KN by FINK
- more to come….

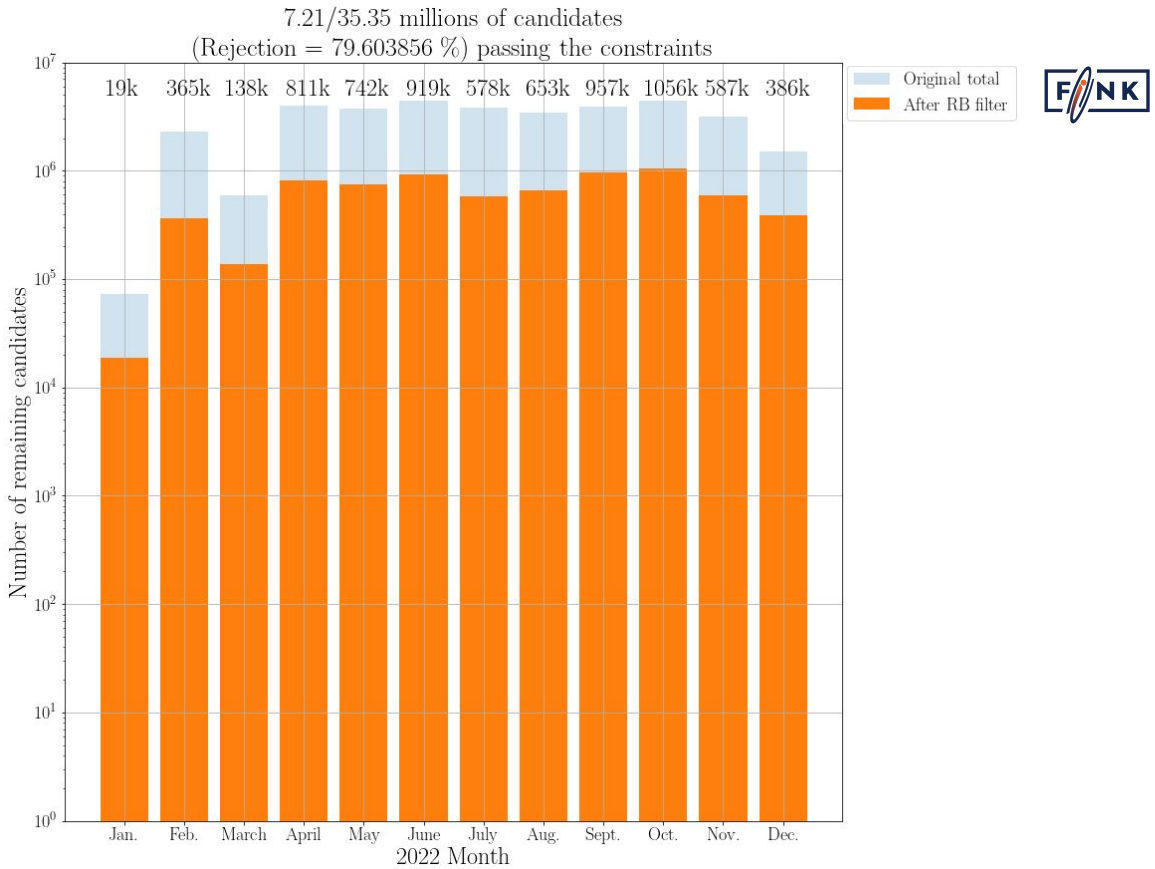
# Simulating the GVOM ToO/ZTF ToO rate : 2022 ZTF FINK alerts



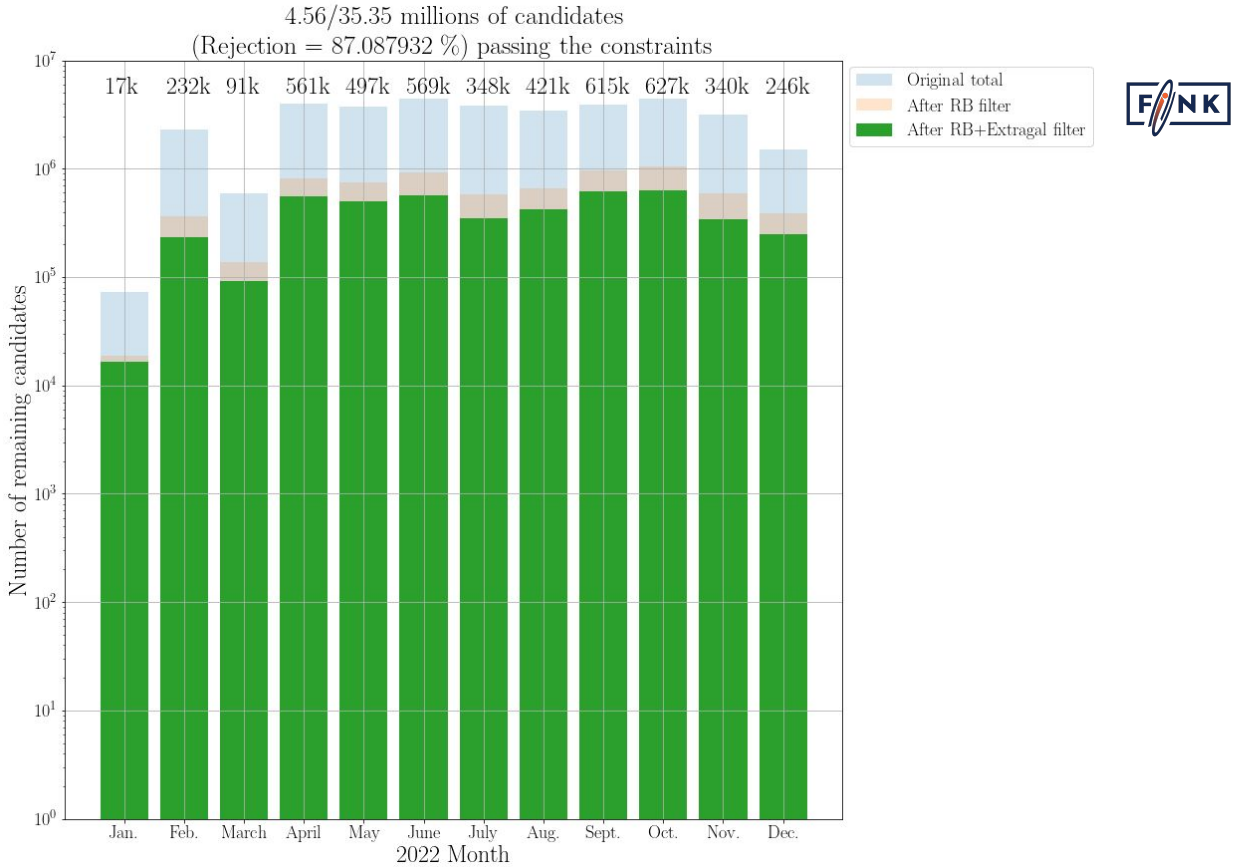

**Transient selection criteria by FINK**

1. All ZTF/Fink events in 2022
2. Fink quality cuts applied
3. All Fink classifications
4. All Real/Bogus scores [0-1]

# Simulating the GVOM/ZTF ToO rate: RB>0.9

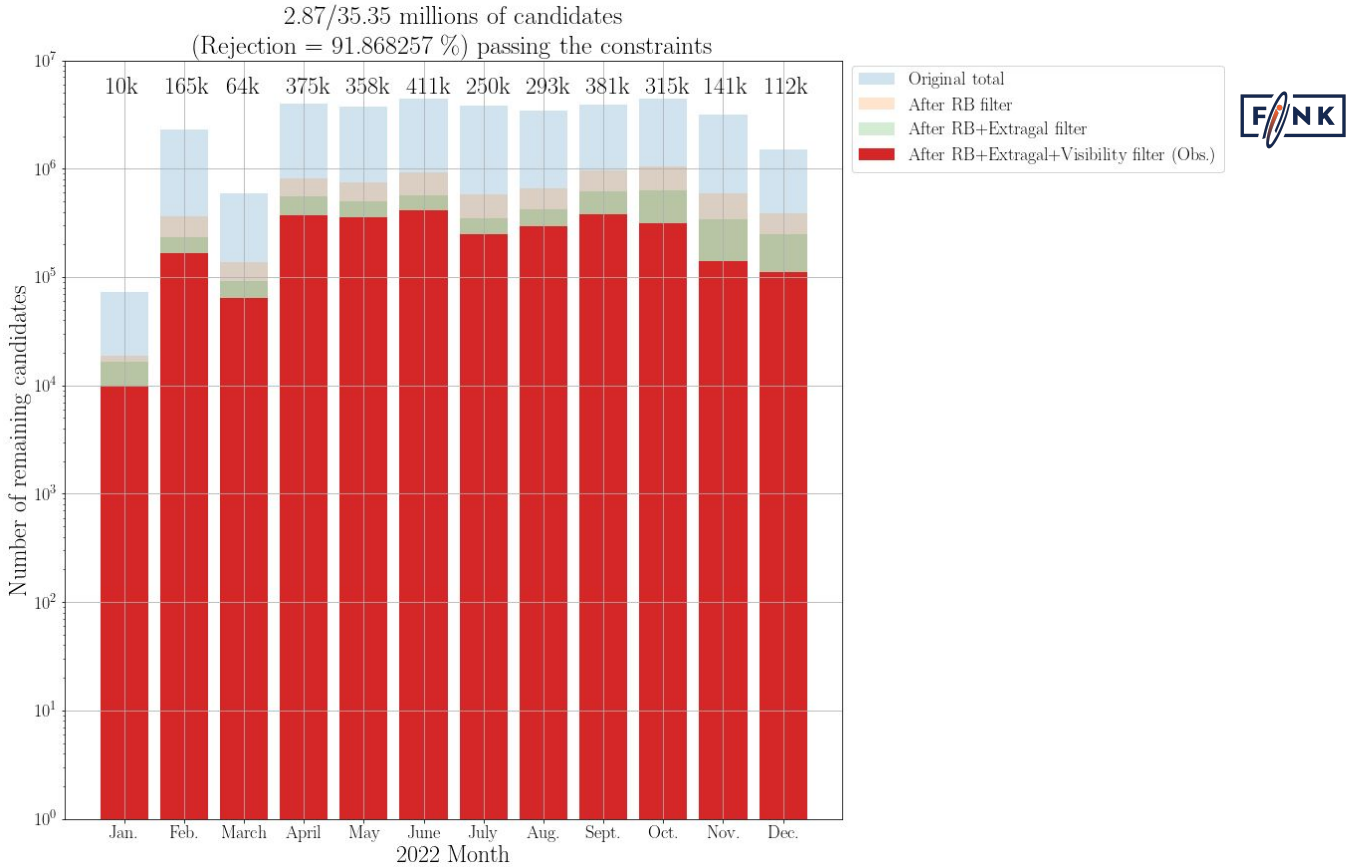


# Simulating the GVOM/ZTF ToO rate: RB>0.9 & |b|>15°



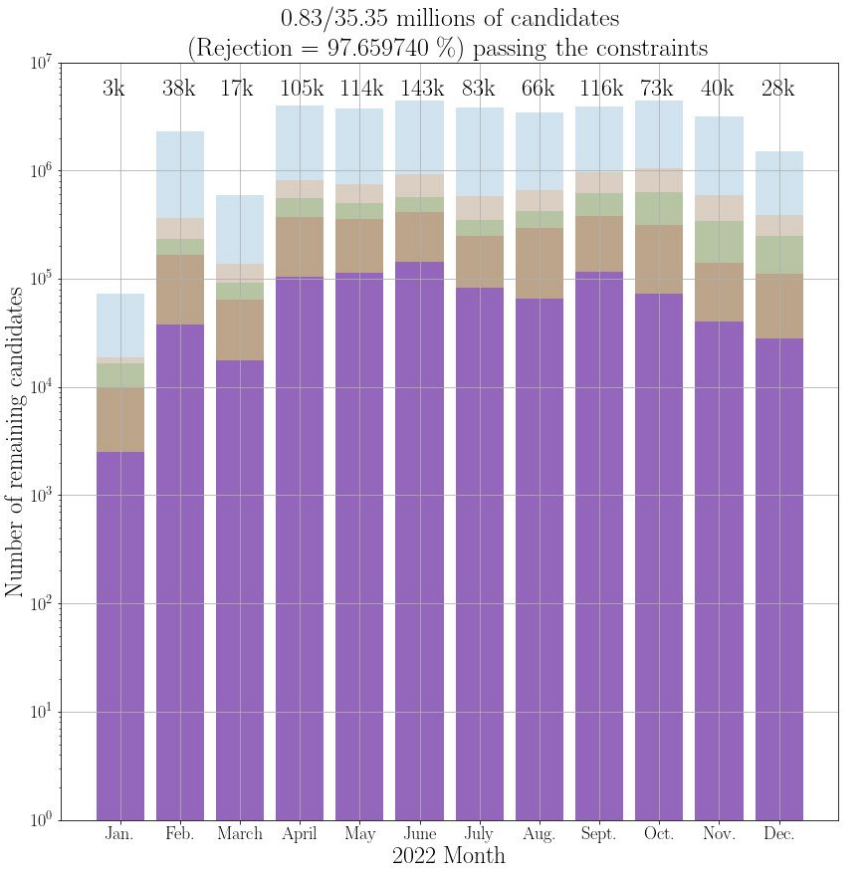
# Simulating the GVOM/ZTF ToO rate:

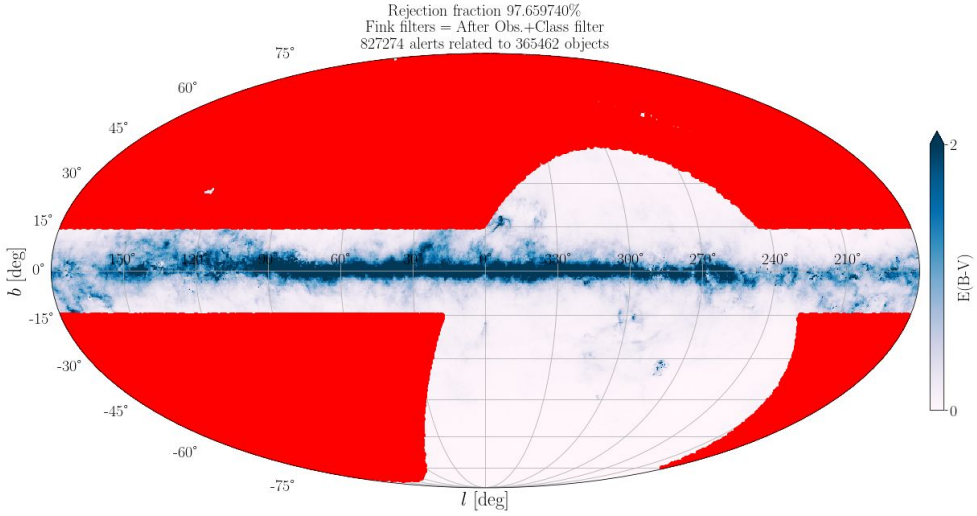
## RB>0.9 & |b|>15° & 2h visible by COLIBRI/C-GFT/NOT



# Simulating the GVOM/ZTF ToO rate:

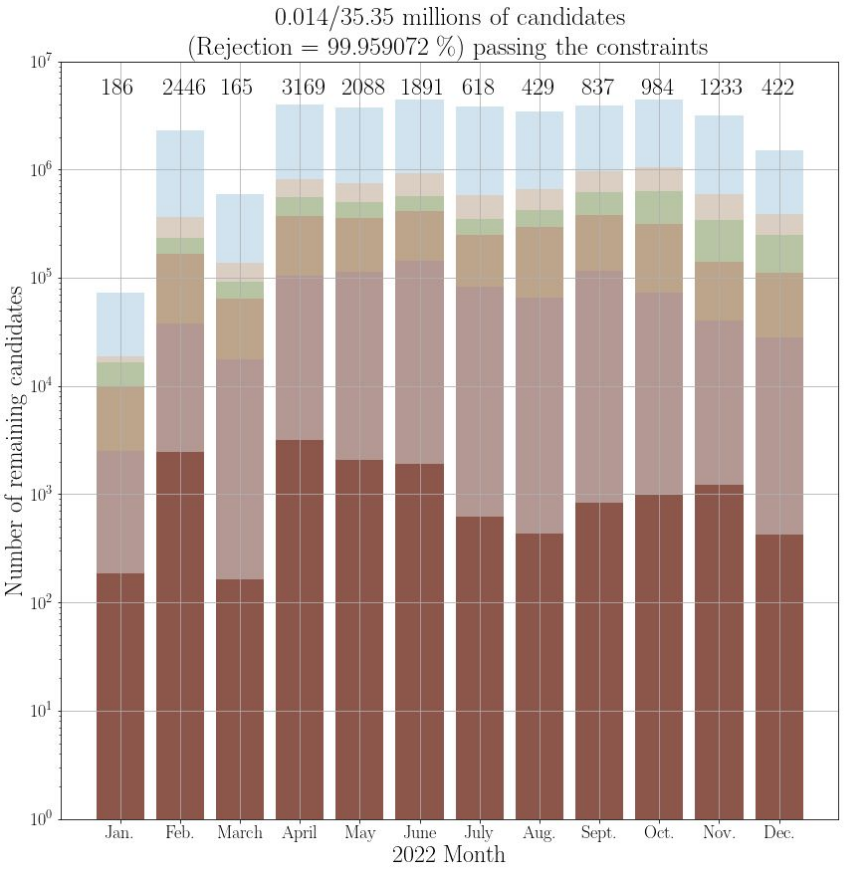
## Obs. filters & SN candidate/Unknown/Ambiguous

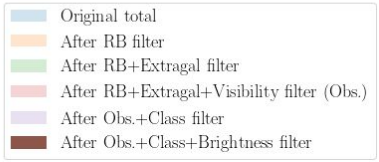


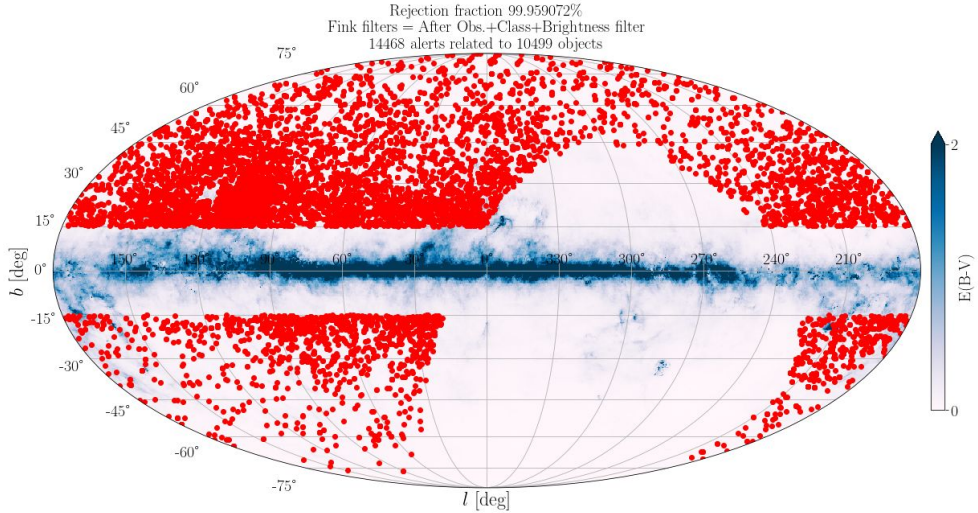



# Simulating the GVOM/ZTF ToO rate:

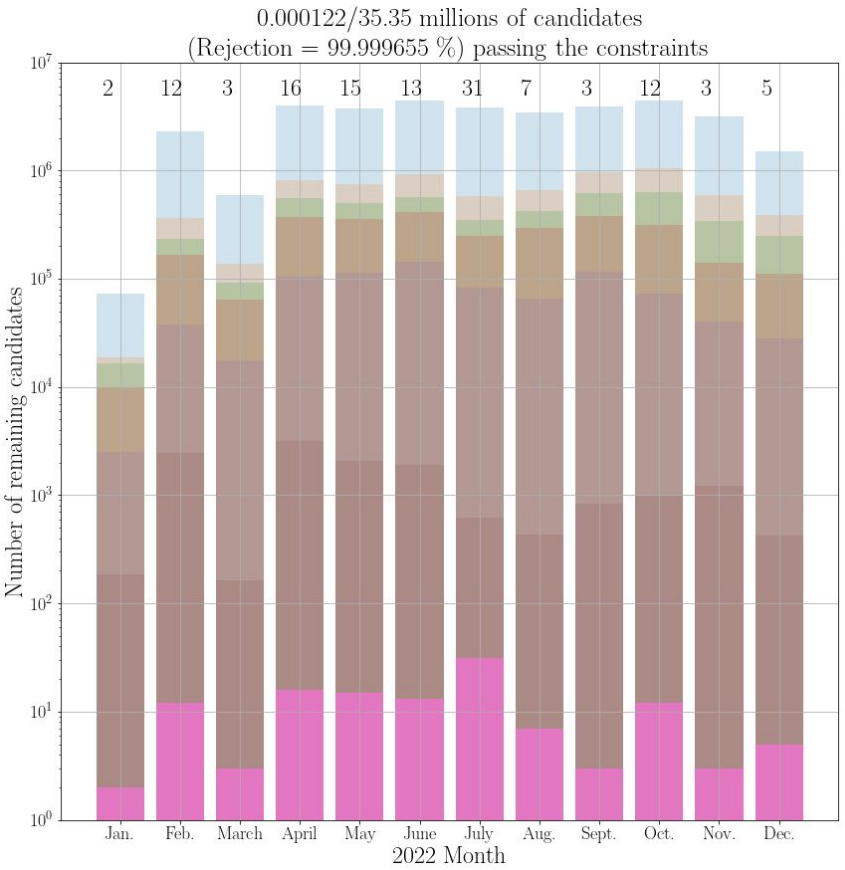
## Obs. filters & SN candidate/Unknown/Ambiguous & r or g < 17

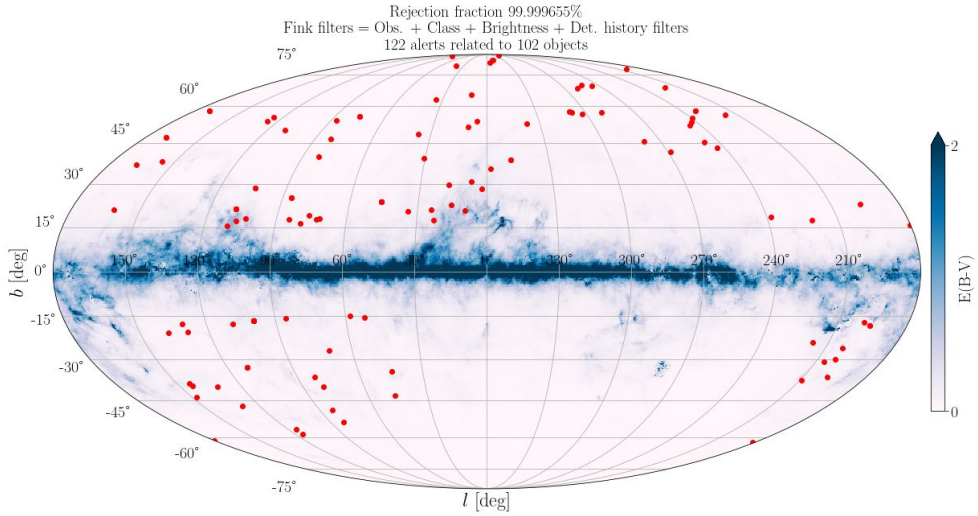


# Simulating the GVOM/ZTF ToO rate: All filters applied



# Conclusive words

# Synoptic surveys are great partners for the study of the transient sky

1. ZTF (and VRO then) is able to catch rare and bright extragalactic stellar explosions evolving at daily (weekly) timescales -> FBOTs, Kilonovae-like transients, untriggered GRB afterglows, etc.

2. FBOTs could be the missing link between typical CCSNe and classical long GRBs.

3. We need to have more statistics and continue to get well sampled multi-λ data to characterize the rich physics. Need to make joint space and ground-based ToO programs !

4. We are lucky, SVOM and Einstein Probe missions will both propose competitive ToO programs to get x-ray data!

5. We are double lucky, the FINK broker will ease a lot the selection process of the good candidates!

# Our working organization to make this proposal possible

1. Design a dedicated FINK science module to get specific outputs in the FINK alert objects that fit our scientific case

2. Design scientific filters to only get few ToO targets per night

3. Design a fink client to broadcast in real-time our OT candidates to a ToO manager (TOM) connected to a telescope net.

D. Turpin, R. Le Montagner, J. Peloton, E. Ishida, A. Möller

**Fast transient module (to be soonly implemented in FINK)**


D. Turpin, B. Cordier, T. Sadibekova, D. Götz + interested people

**Obs. strategy (work in progress at CEA)**

R. Le Montagner, J. Peloton, D. Turpin

**implementation of a TOM (work in progress at IJCLab)**

# Back-up

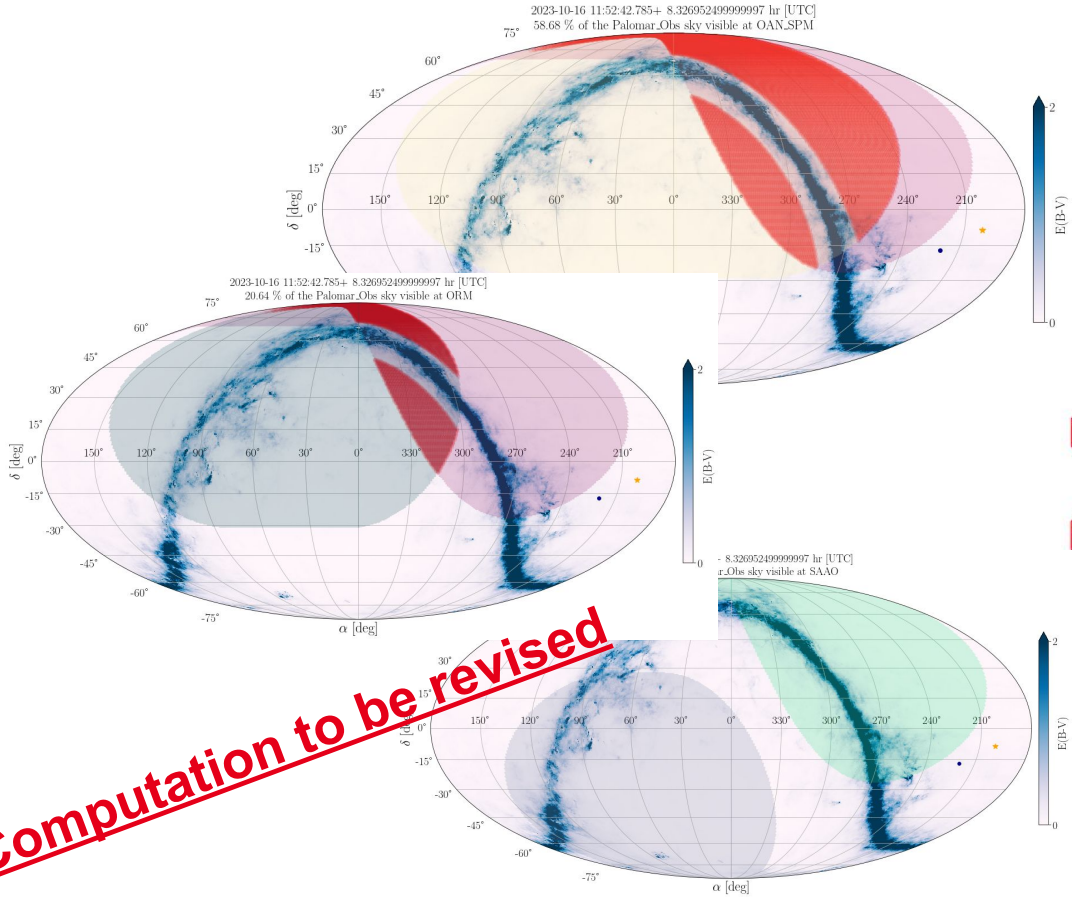
# About the ZTF sky visible by the GVOM telescopes

# The overlapping skies between GVOM and ZTF

**Scenario for every ZTF night**

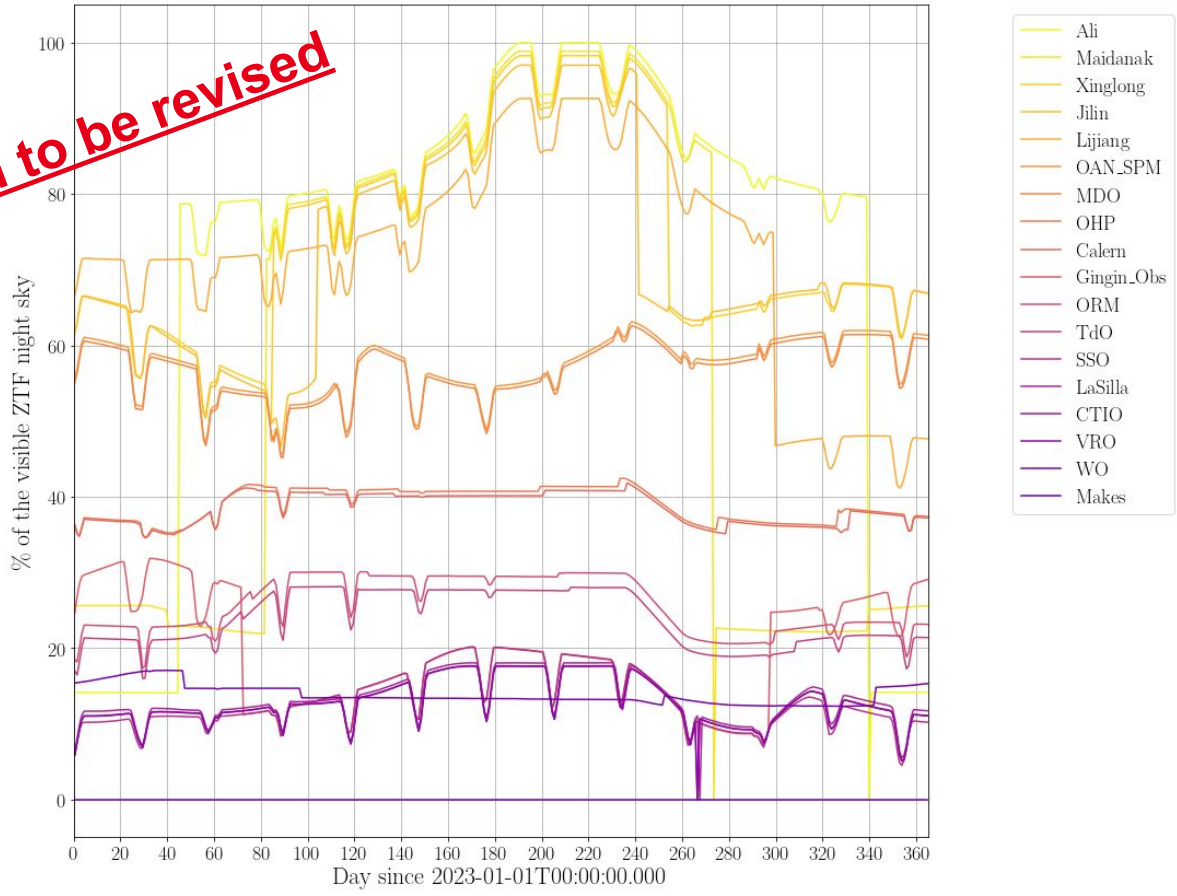
1. generate the instantaneous visible sky at Palomar Obs. at midnight
   - keep all sky sources with Elev > 30°
   - airmass < 2
   - moon dist > 20°

2. Loop over the GVOM observatories during their current or coming night
   - which fraction of the pre-computed Palomar sky is visible during the entire local night
   - deleting targets with 10°< $b_{gal}$<10°



# The overlapping skies between GVOM and ZTF

**Computation to be revised**



# VRO transients
# Obs. strategy & ToO rate

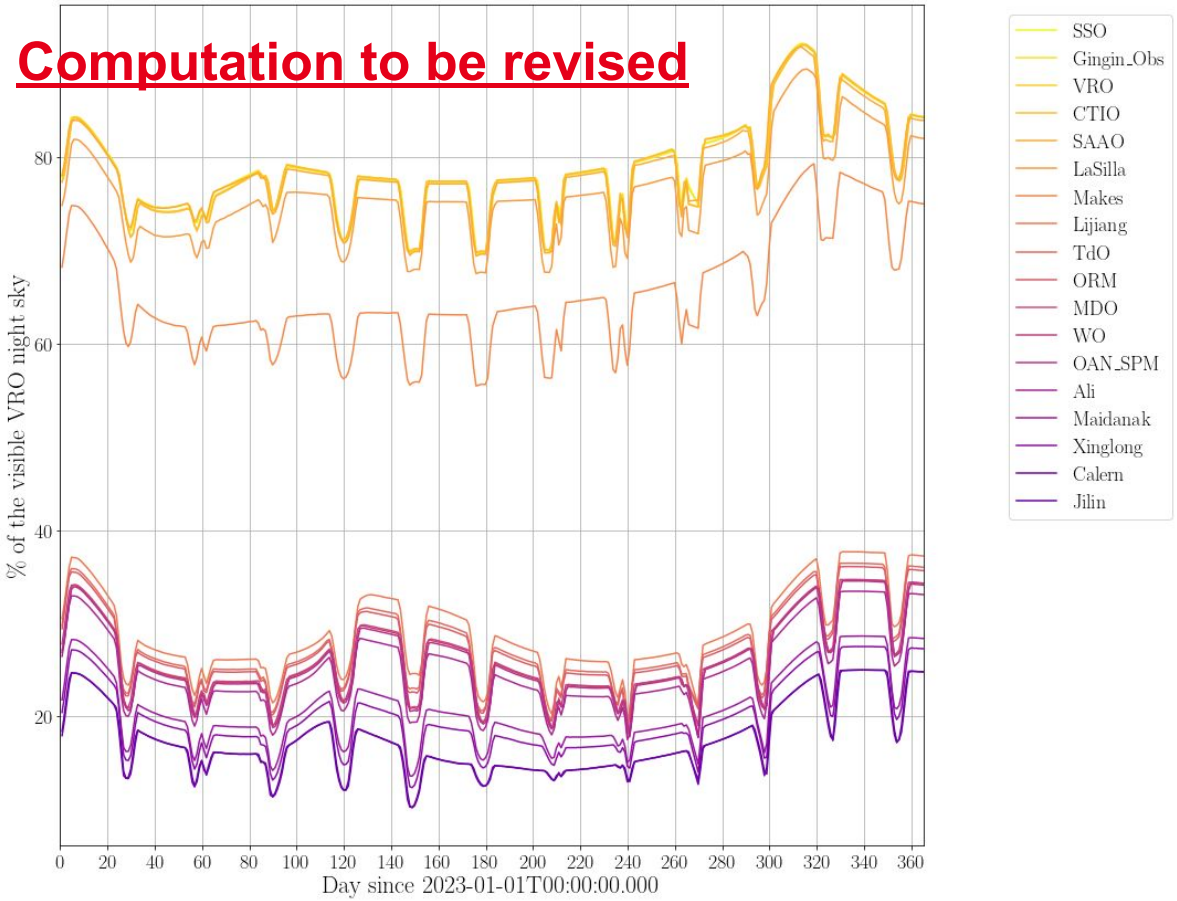
# The overlapping skies between GVOM and VRO

## Computation to be revised

**Scenario for every VRO night**

1. generate the instantaneous visible sky at VRO as soon as the night starts
   - keep all sky sources with Elev > 30°
   - airmass < 2
   - moon dist > 20°

2. Loop over the GVOM observatories during their current or coming night
   - which fraction of the pre-computed VRO sky is visible during the entire local night
   - deleting targets with $10° < b_{gal} < 10°$



# Simulating the GVOM/VRO ToO rate

## Working plan (May-July 2023)

1. Simulate XX years of VRO survey with rubinsim package
2. Inject AT2018cow randomly in the sky with the 0.1% CCSNe rate
3. Sample the AT2018cow light curves according to the VRO survey strategy
4. Generate alerts based on 5sigma detection by VRO (all classification including our fake FBOTs)
5. Apply the GVOM filters on those bunch of alerts and see what's the output ;)