SVOM

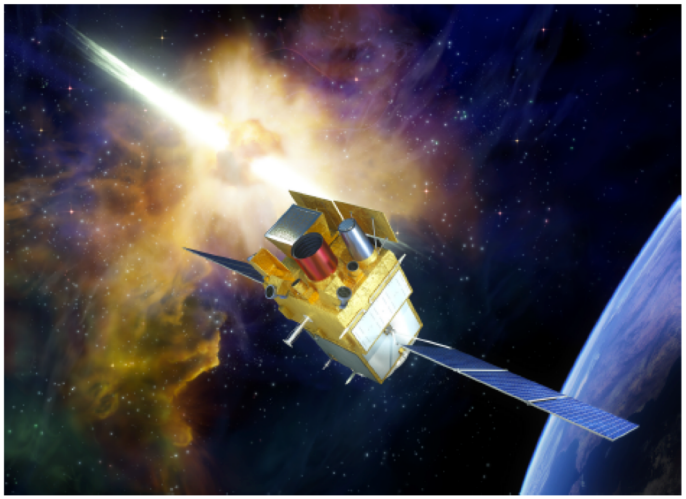
Scientific prospects

(JLA on behalf of the *SVOM* collaboration)

The Deep and Transient Universe: New Challenges and Opportunities

Scientific prospects of the *SVOM* mission

J. Wei, B. Cordier, et al.
(Version of 05-10-2016, for full list of contributors see overleaf)



- *High-Energy Astronomy*
- *Transient Sky Astronomy*
- *Multi-Messenger Astronomy*

High-Energy Astrophysics

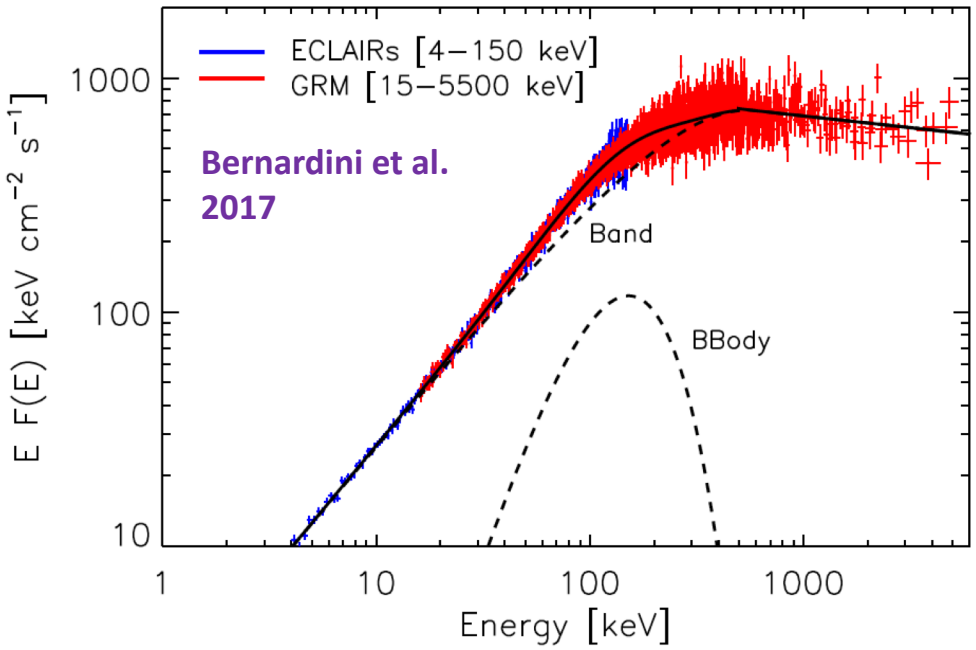
- **Observations:**
  - Gamma-ray bursts (from *SVOM*, but not only)
  - Soft Gamma Repeaters
  - Relativistic tidal disruption events: disruption of a star in the vicinity of a supermassive BH
  - Active Galactic Nuclei
  - Galactic HE transients (accreting binaries)
- ***SVOM* features:**
  - Long exposures in the same direction allowing the detection of long transients
  - MWL coverage of the prompt emission (ECLAIRs, GRM, GWAC) (Bernardini et al. 2017)
  - ECLAIRs low energy threshold
  - Good coverage of the prompt-afterglow transition
  - Good sensitivity balance between VT & MXT for GRBs
  - Pointing strategy: expected large fraction of GRBs with a redshift (>50%)
  - Quick identification of high-z GRBs as “dark GRBs” (VT & GFTs)
- **Instrumental environment:**
  - VHE γ-rays: CTA, HAWC
  - γ-rays: *INTEGRAL* – *Swift* – *Fermi* – *GECAM* – Polarimeter?
  - X-rays: eROSITA

High-Energy Astrophysics

- **Phenomenology:**
  - Transition prompt – afterglow in GRBs
- **Physics:**
  - Relativistic jets in GRBs and AGNs: composition, acceleration and dissipation processes, geometry, impact of the central engine (for GRBs)…
  - Physics of accretion / ejection around compact objects
  - Origin of magnetar activity
  - Role of jets in VHE cosmic rays production
  - Test of Lorentz Invariance
- **Astrophysics:**
  - Explore the GRB-SN connection globally, with faint, local X-Ray flashes
  - Origin of ultra-long GRBs (Dagoneau et al. 2020)
  - BH astrophysics: demography, birth places, masses & spins?
  - Hosts of BNS mergers and r-process elements
  - Pop III & star formation at high-z, Pop III & first BHs
  - Spectroscopy of high-z GRBs (z>6):
    - Host galaxy physical state: abundances, ionization…
    - Ionization of the IGM, escape of ionizing radiation from high-z galaxies

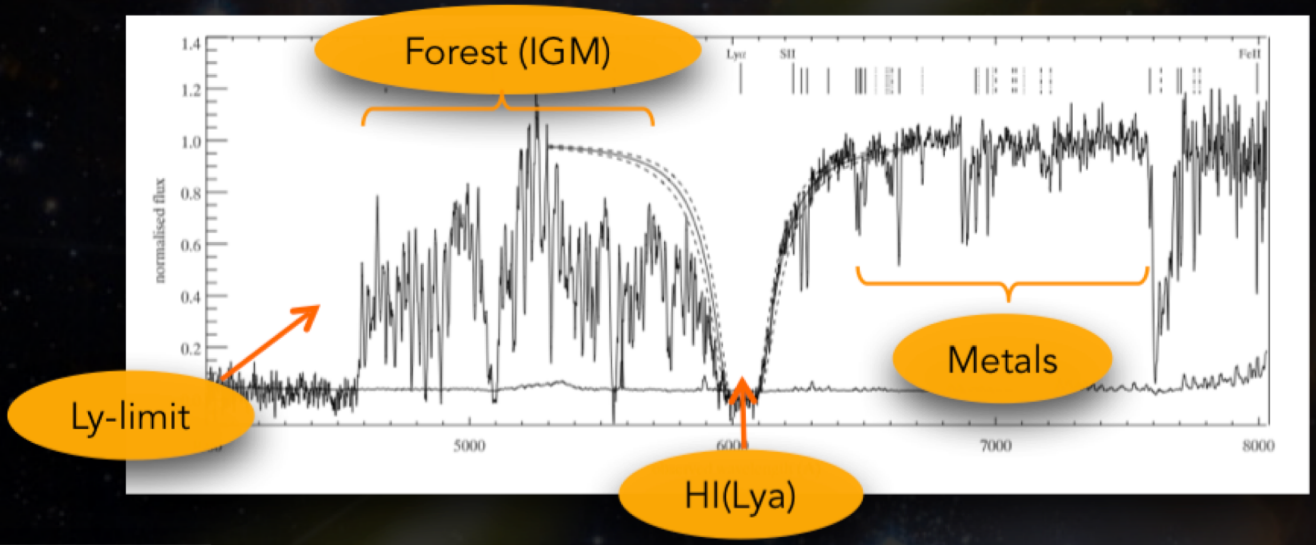
GRB physics

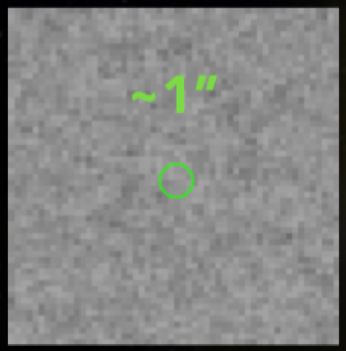
- Broadband time-resolved spectroscopy of the prompt GRB emission with ECLAIRs+GRM (and eventually GWAC), will offer a renewed view of this phase, allowing to disentangle the role of the photosphere from internal shocks and other dissipation processes (Bernardini et al. 2017).
- For some GRBs, the prompt coverage may be extended to VHE gamma-rays with Fermi/LAT and CTA.



High-z Galaxies

Motivation: Study of the bulk of the high-redshift galaxy population
BUT they are extremely faint
BUT GRB afterglows are bright background sources!





z=4
[Fe/H]=-2
R>28.5
Chen+ 2005; Starling+2005

Thanks to GRBs
we can determine the properties
of faint galaxies at high-z

Transient Sky Astronomy

- **Observations:**
  - HE *survey*: GRBs, SGRs, TDEs, AGNs, galactic X-ray binaries
  - Optical *survey* with GWAC
  - *Follow-up* of selected transient sources:

    GRBs, SGRs, TDEs, AGNs, galactic X-ray binaries

    SNe, KNe, ULXs, FRBs, GWs, neutrinos, etc.

- ***SVOM* features:**
  - Strong ToO program
  - Unique combination of space & ground instruments for MWL observations in survey mode (GRM, ECLAIRs, GWAC) and follow-up (VT, MXT, GFTs)
  - Long exposure times in the same direction

- **Instrumental environment:**
  - X-rays: eROSITA
  - Optical: pan-STARRS, ZTF, Vera Rubin Observatory (LSST)
  - Radio: SKA & precursors ; FRB detectors

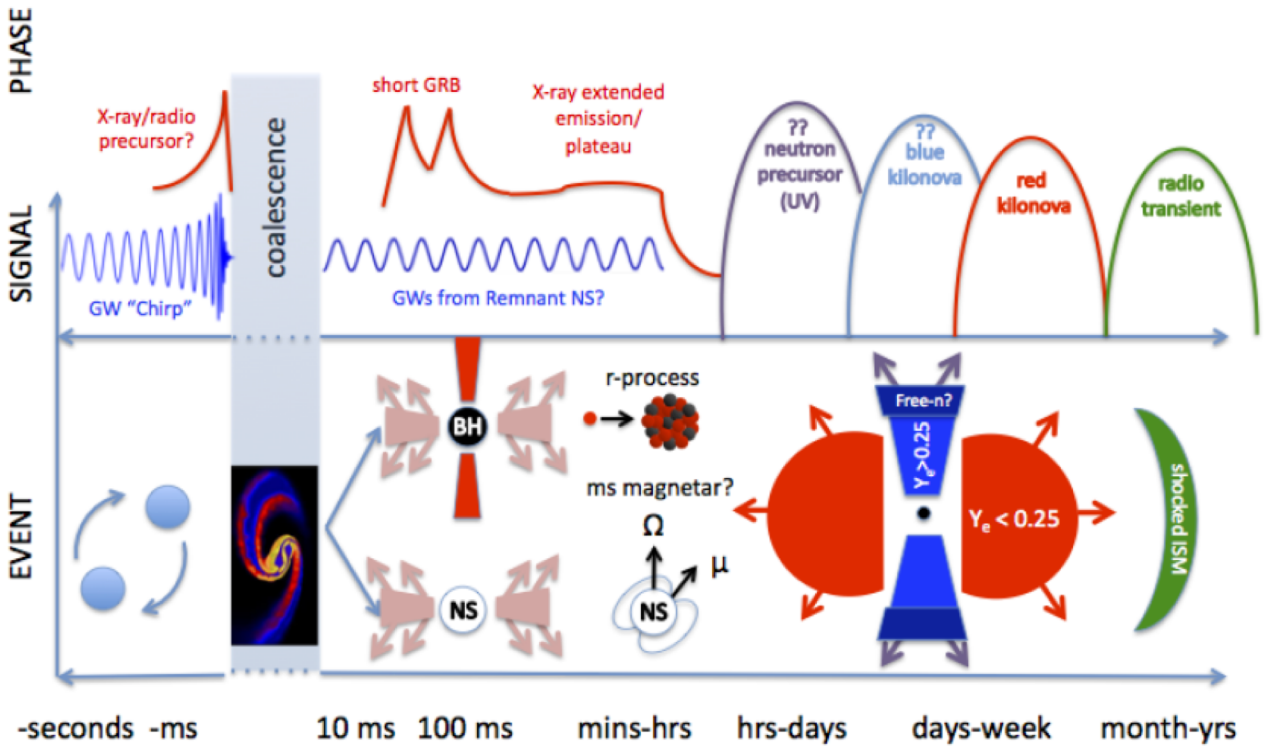
  (multi-messenger)

Transient Sky Astronomy

- **Phenomenology:**
  - Orphan GRBs : statistics of optical/radio GRB afterglows and beaming angle
  - HE counterparts of explosive phenomena (e.g. SNe, FRBs)
  - Optical counterparts of *SVOM* and non-*SVOM* HE transients with GWAC
  - Simultaneous X-Ray & optical follow-up of selected transients
  - Monitor the activity of galactic transients: X-ray binaries & microquasars, X-ray novae, magnetars
  - Discover / follow-up galactic gravitational micro-lensing events
- **Physics:**
  - Nuclear burning on NSs and WDs
  - Spectral Energy Distribution of AGNs in outburst
  - Scale invariant behavior of black holes
- **Astrophysics:**
  - MWL modelling of exploding stars: novae, kilonovae, supernovae

The rich phenomenology of mergers

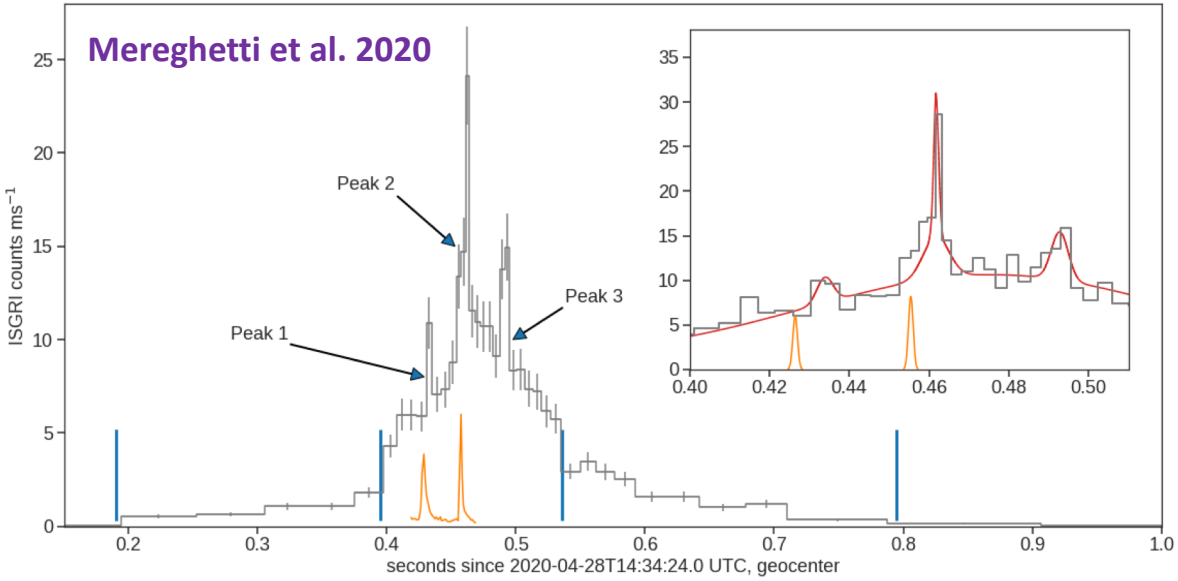
- The only merger observed during its full “life” has shown a rich and unexpected phenomenology. It is crucial to observe many more events to understand the physics at work and the astrophysical role of mergers.
- We expect *SVOM* to be a major contributor of these observations.

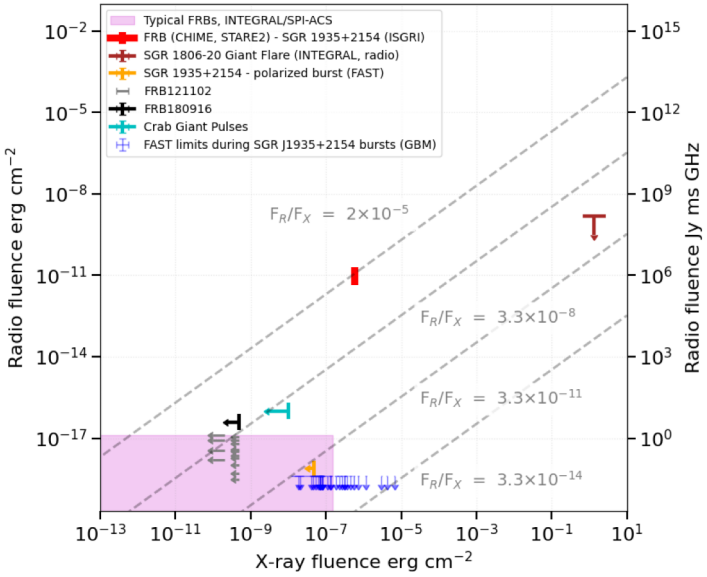


Fernandez & Metzger 2015

A Fast Radio Burst from an SGR?

- SGR 1935+2154 became very active in april 2020, and 1 bright X-ray burst (INTEGRAL, HXMT) was associated with a fast radio burst (CHIME, STARE2), very similar to cosmological FRBs.
- SVOM will systematically look for short optical (GWAC) and X-ray flares (ECLAIRs, GRM) from FRBs in its FoV.





Multi-Messenger Astrophysics

- **Observations:**
  - Mergers of compact stars: BHs and Ns
  - Explosive phenomena as possible sources of neutrino bursts.

- ***SVOM* features:**
  - Good sensitivity to short GRBs over a wide FoV (GRM)
  - Good localization accuracy for sGRBs in the ECLAIRs FoV
  - Strong ToO program and MWL capabilities, for follow-up

- **Instrumental environment:**
  - GWs: LIGO – VIRGO – KAGRA
  - Neutrinos: KM3NeT – ICECUBE

Multi-Messenger Astrophysics

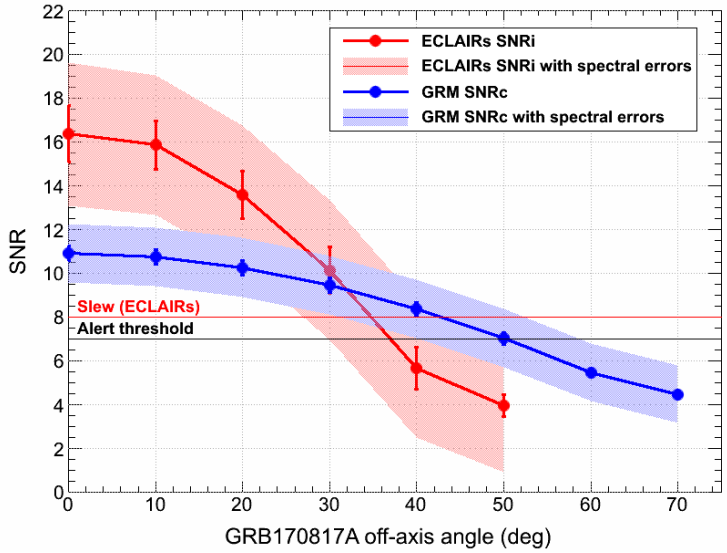
- **Phenomenology:**
  - Search and characterize the EM counterparts of transient GW signals
  - Search and characterize the EM counterparts of neutrino signals
  - Check if gamma-ray emission is associated with some BBH mergers
  - Clarify the origin (merger or not) of nearby GRBs without SN

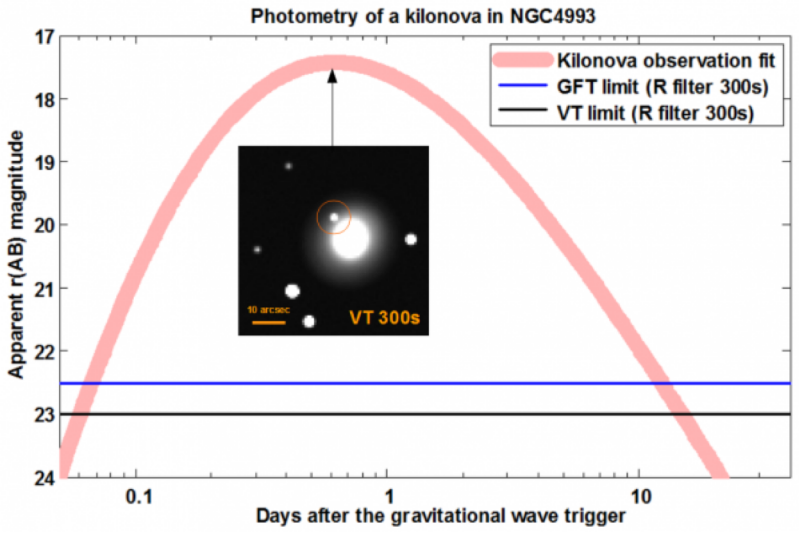
- **Physics:**
  - Origin of heavy elements: role of BNS, study at the production site, galaxy enrichment
  - Jets of short GRBs (GRB 170817A)
  - Physics of mergers

- **Astrophysics:**
  - BBH demography & merger rates at distances comparable with long GRBs
  - BH+NS binaries: demography, origin, merger remnant
  - BH masses: Why BHs seen by LVC in binaries are so massive, compared with accreting BHs in our galaxy? What are the masses of the BHs in GRBs?

GRB 170817A

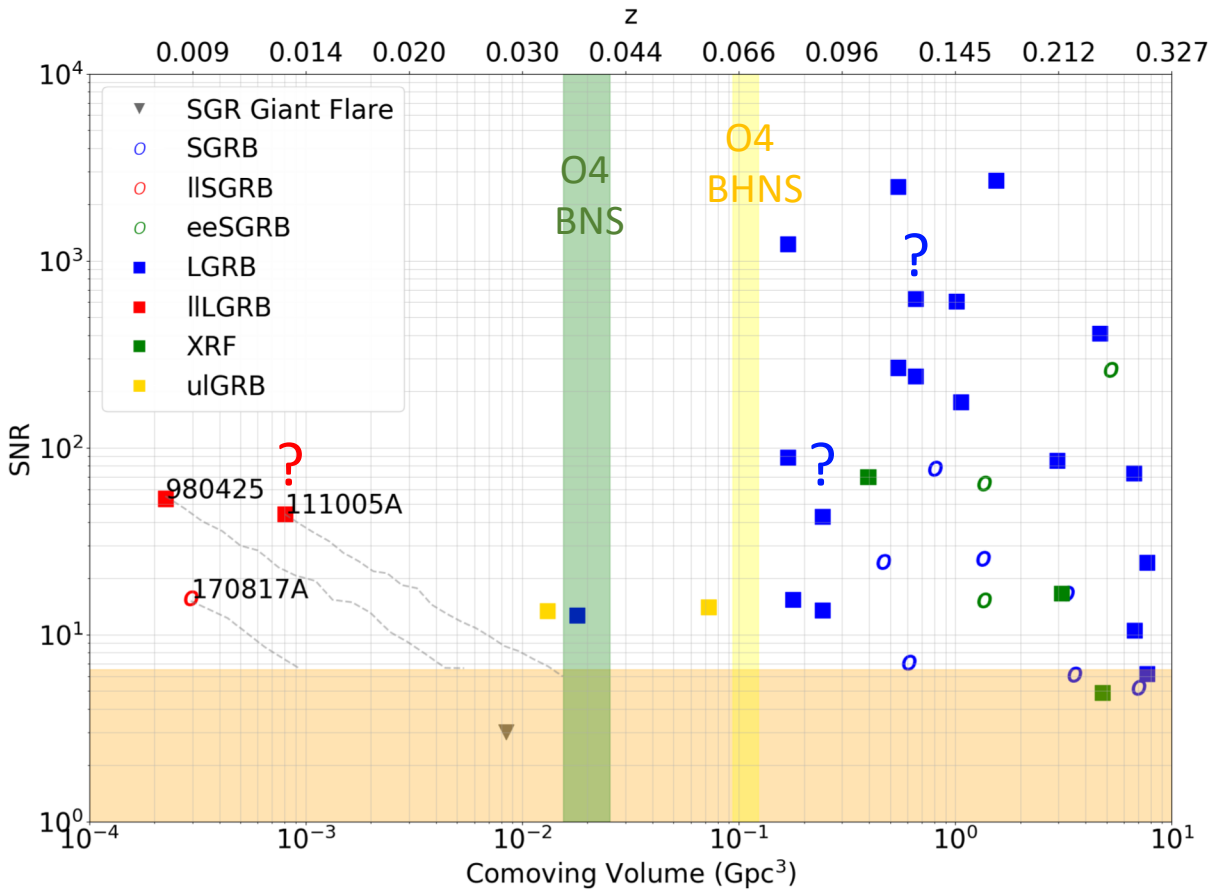
- Simulations of the observation of GRB 170817A (BNS merger) and its kilonova with *SVOM*.
- SVOM has the sensitivity to detect the prompt short GRB and the kilonova, from the first hour.
  - Delay GW → GRB
  - Orientation of the jet
  - Kilonova & its host





GRBs in the local universe

- Long GRBs without a SN have been observed in the local universe, before the operation of GW detectors.
- The joint operation of *SVOM* and GW interferometers will clarify whether they are collapsars or a new kind of mergers (e.g. BHNS or BH + He star)!



Conclusions

- Observing GRBs, AGNs, TDEs and GW transient sources, *SVOM* will be a major observatory for the study of Black Holes and their astrophysical impact.
- With its unique combination of space and ground facilities, it is expected to become a key player in the fields of High-Energy Astrophysics, Time Domain Astronomy and Multi-Messenger Astrophysics. These domains are expected to develop very rapidly thanks to a new generation of powerful observatories:
  - Vera Rubin Observatory – Pan-STARRS – ZTF
  - GW detectors
  - SKA precursors & FRB detectors
  - Large neutrino observatories
  - CTA
- *SVOM* will crucially contribute to strengthen the role of France in these quickly evolving fields. The French community must prepare for the scientific exploitation of the *SVOM* mission.