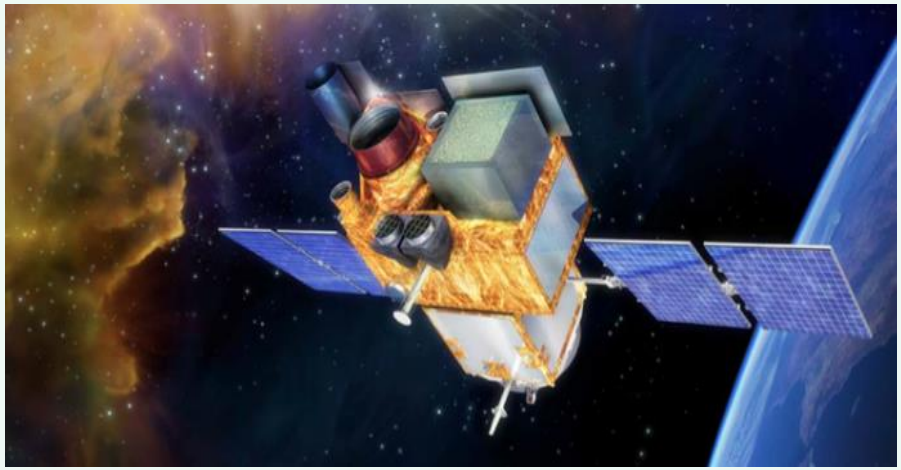
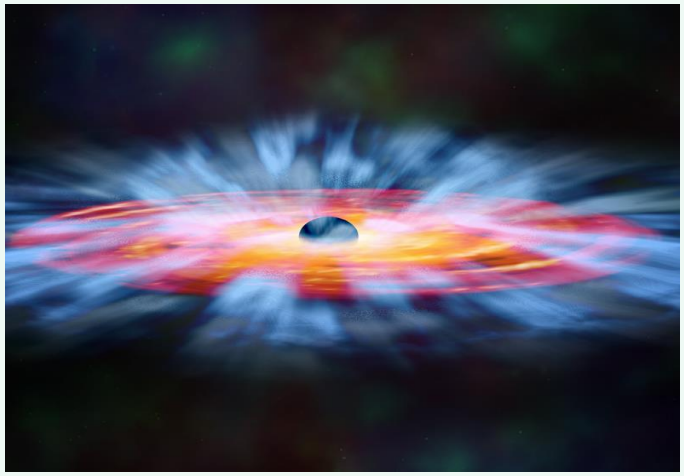
SVOM MISSION REQUIREMENTS



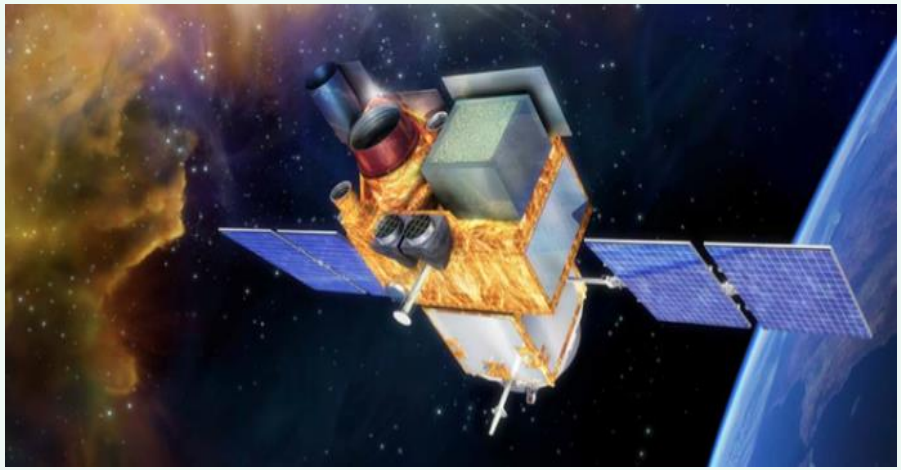


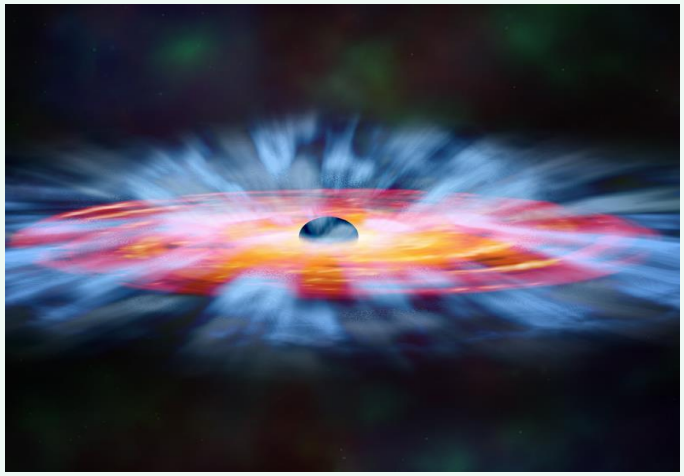
for SOS !

Andrea Goldwurm

(APC – Paris, SAp/CEA – Saclay)

SVOM MISSION REQUIREMENTS





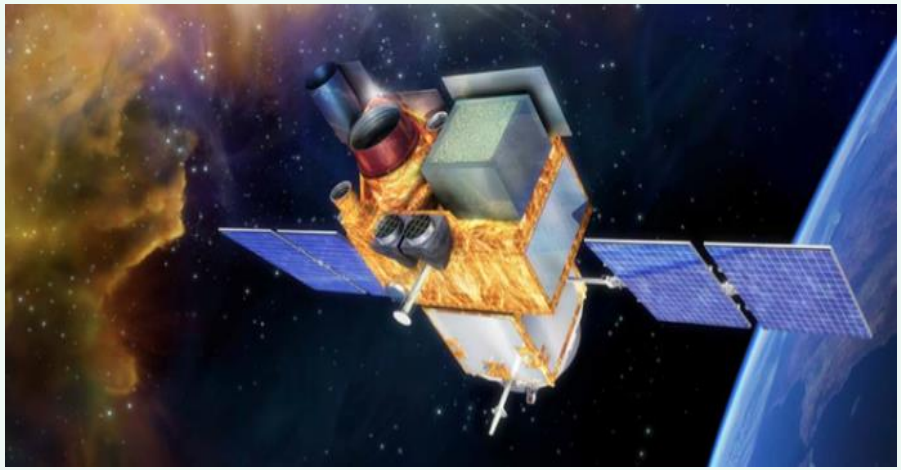
SVOM OBSERVATORY SCIENCE

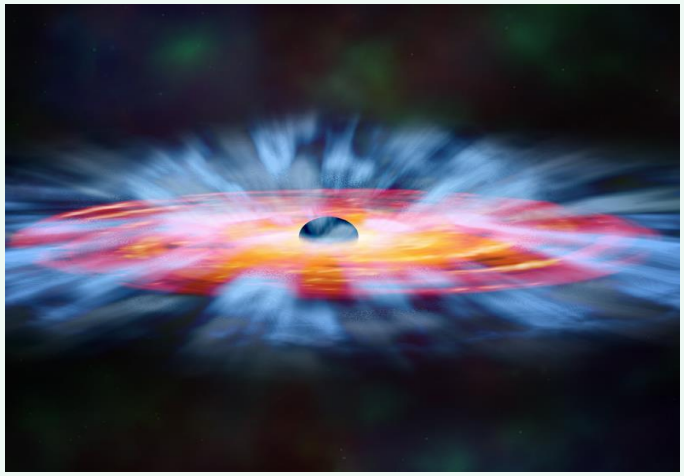
Andrea Goldwurm

(APC – Paris, SAp/CEA – Saclay)

AS PRESENTED TO THE SVOM SRR – June 2015

SVOM MISSION SRR





SVOM OBSERVATORY SCIENCE

Andrea Goldwurm
SVOM Mission Scientist
(APC – Paris & SAp/CEA – Saclay)

On behalf of SVOM Team, contribution from the SVOM Obs. Sc. Working Group

Outline

- SVOM Observatory Science: definition and general considerations
- Sky visibility for the Observatory Science
- Some of the (X-ray biased) objectives of the SVOM Observatory Science
- The Mission Requirements: MRR-GP MRR-TO

Contribution from a Working Group on Observatory Science:

C. Adami (LAM), V. Beckmann (APC), L. Bouchet (IRAP), M. Clavel (SAp), M. Coriat (IRAP), O. Godet (IRAP), A. Goldwurm (APC/CEA), R. Goosmann (OAS), D. Götz (SAp), C. Gouiffes (SAp), D. Horan (LLR), M. Lemoine (CENBG), C. Motch (OAS), P. O. Petrucci (IPAG), J. Rodriguez (SAp), N. Webb (IRAP)

+ others

SVOM Observatory Science

- The **SVOM Observatory Science**, as opposed to the Core Science dedicated to GRBs, indicates the **SVOM Non-GRB science**
- It includes all science topics that are not connected directly to Gamma-Ray Bursts
- Operationally will cover the **General Program (GP)** and the **Target of Opportunity (ToO)** Observations, i.e. respectively planned and unplanned obs. of objects other than GRBs
- MRR document: Section 6 (+ Section 5 on the multi-wavelength and multi-messanger time domain, TBW), and requirements named **MRR-GP# and MRR-TO#**

SVOM Strengths as an Observatory

SVOM strengths for the Observatory Science:

- Rapid and flexible High-Energy Observatory: catching transient and variable events of the violent universe
- Broad-Band Multi-wavelength Observatory
- Dedicated and flexible optical/IR ground based follow-up facilities
- Provides THE after-Swift-era high-energy sky monitoring, during operation of CTA, JWST, Euclid, LSST, SKA photon experiments, and advanced multi-messanger observatories (GW, ν)

General Comments

- SVOM is a GRB mission but Observatory Science will also likely contribute to the success of the mission, if prepared for that !
- SVOM Core Program (GRB science Obs.) will totally amount to < 25 % of the mission observation time => More than 70 % of the SVOM Observing time will be used for sources that are not GRBs.

- Observatory science planned observations will be performed within the General Program, unplanned ones in Target of Opportunity Obs.
- They shall not impact on the Core Program => GP, ToOs are subject to a several constraints (B1 attitude law, interruption by GRB detections).

- However Swift shows that science other than GRB becomes important for a GRB mission in the extension phase and in the long run (> few years) => need to prepare the mission to relax constraints for a fraction of the observing program and particularly in the extension phase.

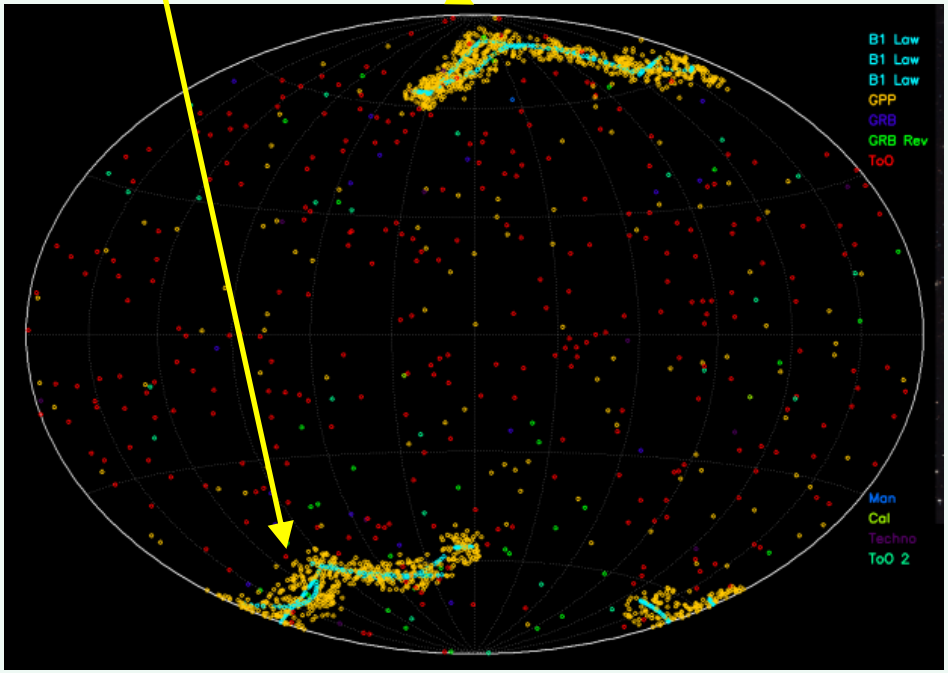
Expected ECLAIRs 1-yr Exposure

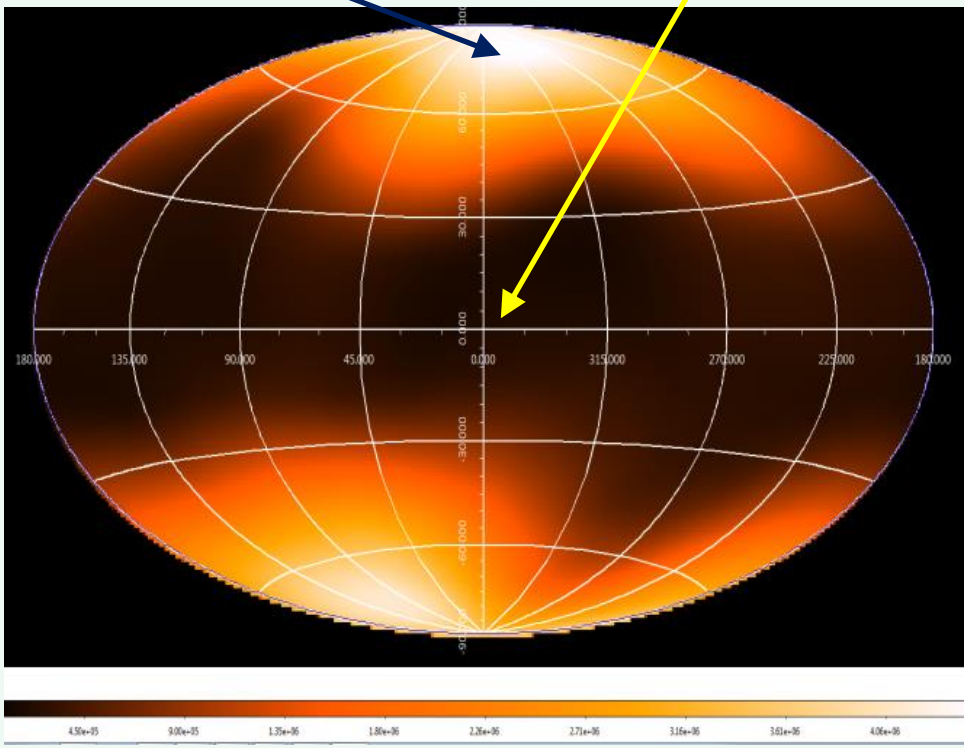
Simulation of 1 year SVOM Observing Program
(GP fully within 5° B1 law, GRB follow-up/rev. and ToOs randomly distr.)

B1 Attitude law

Max Expo: 4.5 Ms

Galactic Center: 2 ks





Aitoff proj., Gal. coo., 18% SAA 30% Earth Occ. loss

SVOM Sky Visibility

Simulation of 1 yr SVOM Observing Program

- About 1200 sources of the RASS/BSC catalog (18000 sources, F > 0.2 mC) are within the 5° from the B1 law
- Many of these have counterparts in the optical 2MASS and USNO catalogs => SVOM multi-wave studies
- Considering ECLAIRs 1-yr Exposure: 600 Swift/BAT sources detected at > 3 sig (~ 50 contaminated because separations < 0.75°)
- Obviously the largest exposures are obtained for high latitude sources: extragalactic (AGN, ULX) or close-by (CVs, stars) objects

Some (X-ray biased) Objectives

Extragalactic Compact Objects:

- AGN and Blazars
- Tidal Disruption Events
- Ultra Luminous X-ray Sources

Galactic (or LMC/SMC) Compact Objects:

- BH/NS X-ray Binaries and transients
- Magnetars, SGRs, isolated NS and their plerions
- CVs (White Dwarf binaries) and Active Stars

Some diffuse components:

- Cosmic X-Ray Background
- Galactic Ridge and some bright SuperNova Remnants

Peculiar objects and exceptional events:

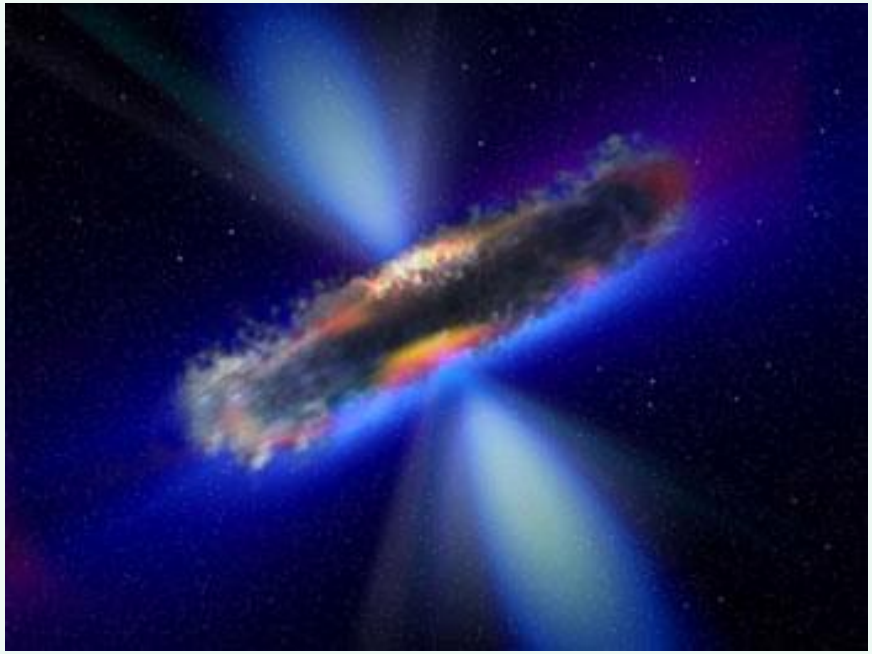
- Terrestrial Gamma-Ray Flashes (TGF)
- Galactic SN, Sgr A* outburst, Magnetar Superbursts ….

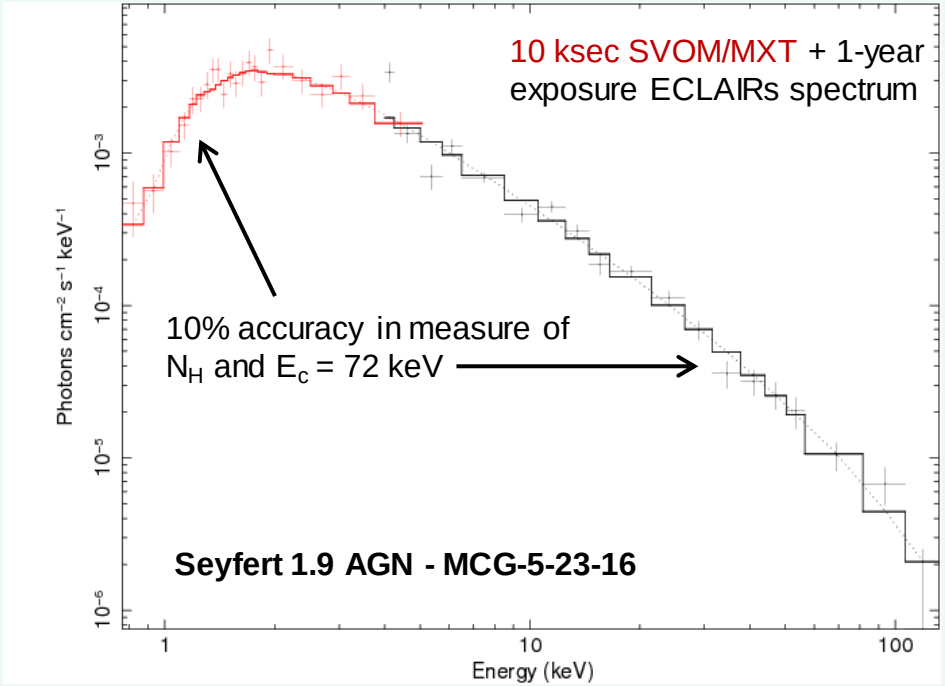
Accretion / Ejection Physics

Matter in Extreme Conditions of Gravitation & Magnetic Fields and densities

Particle acceleration

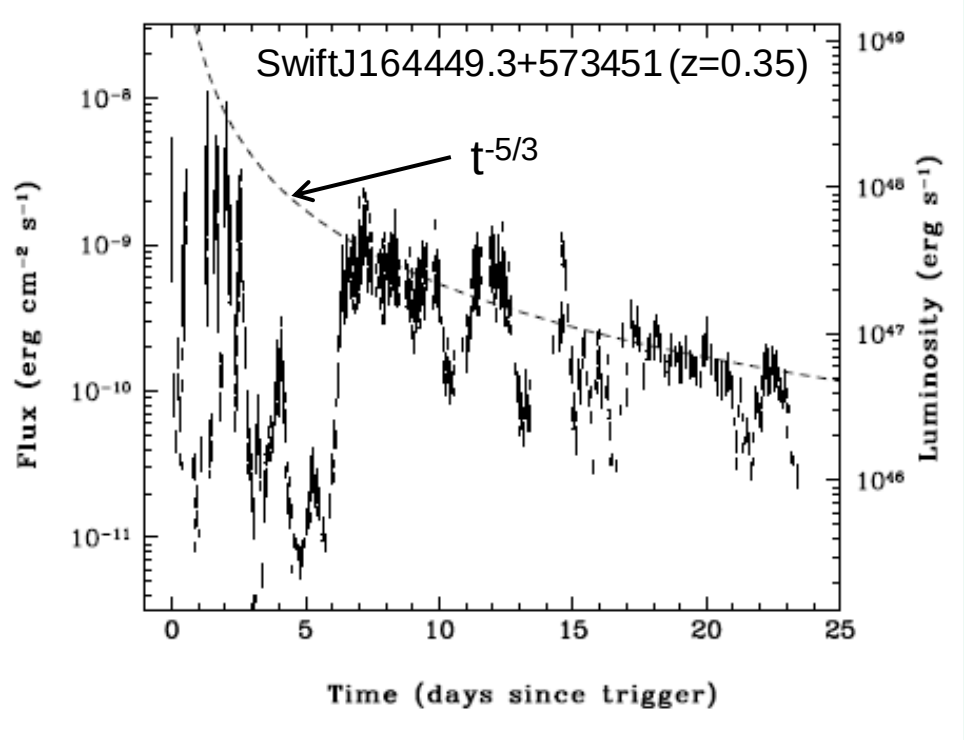
Seyfert type AGN





- AGN are powered by supermassive Black Holes at the center of Galaxies: priority targets for the GP since easily compliant with CP constraints ***[MRR-GP1, GP2]***
- 10 mCrab AGNs: measure of reflection, Compton hump, absorption in MXT (10 ks)
- 1 mCrab AGNs: measure of photon index, abs. in MXT in 10 ks
- > 250 AGN with ECLAIRs in the first year ~700 at end of mission (for ~ 4 Ms /yr)

Tidal Disruption Events



Capture by a SMBH of a Star

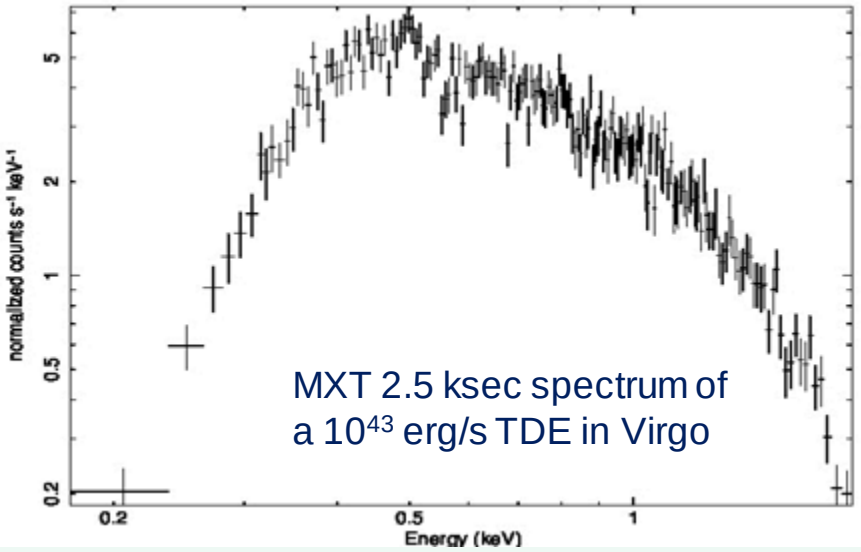
Times: 10 sec rise – 2 yr decay

B1 compliant Search *[MRR-GP2,TO1]*

Swift Super Eddington TDE:

Jet pointing towards us

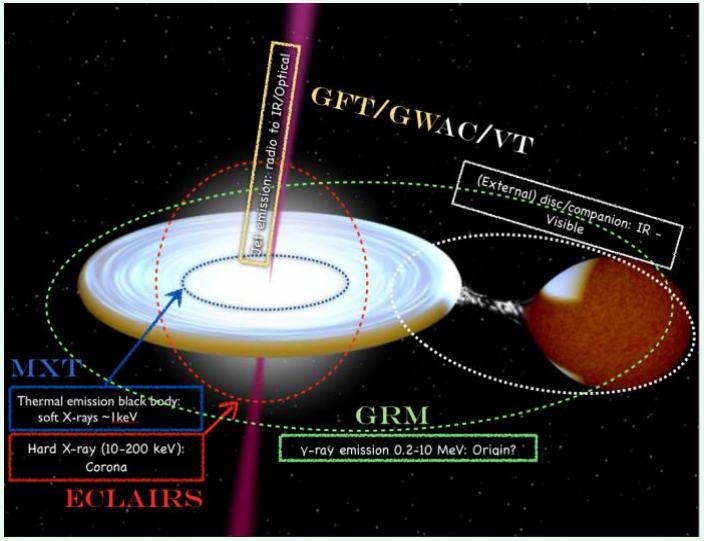
- Rare: 1 event in 7 yrs but visible by Swift even at z = 0.8
- Other detected (e.g. Integral)
- Simulation of detection of less powerful TDE in Virgo

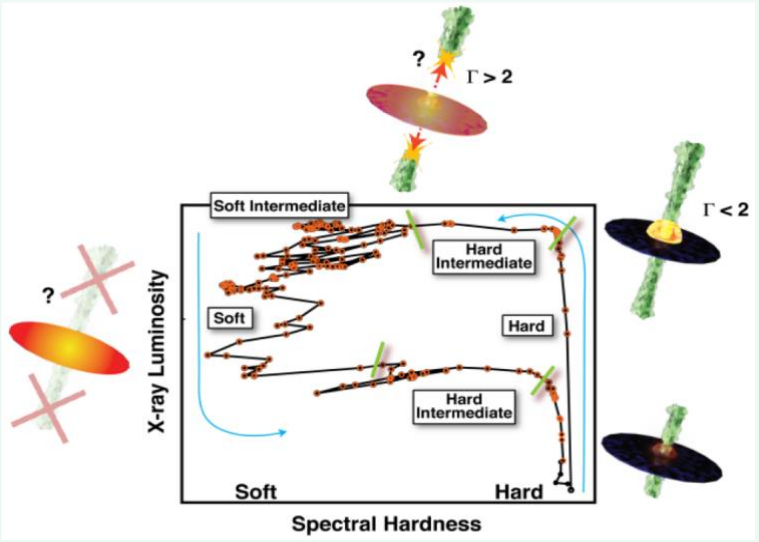


X-Ray Binaries

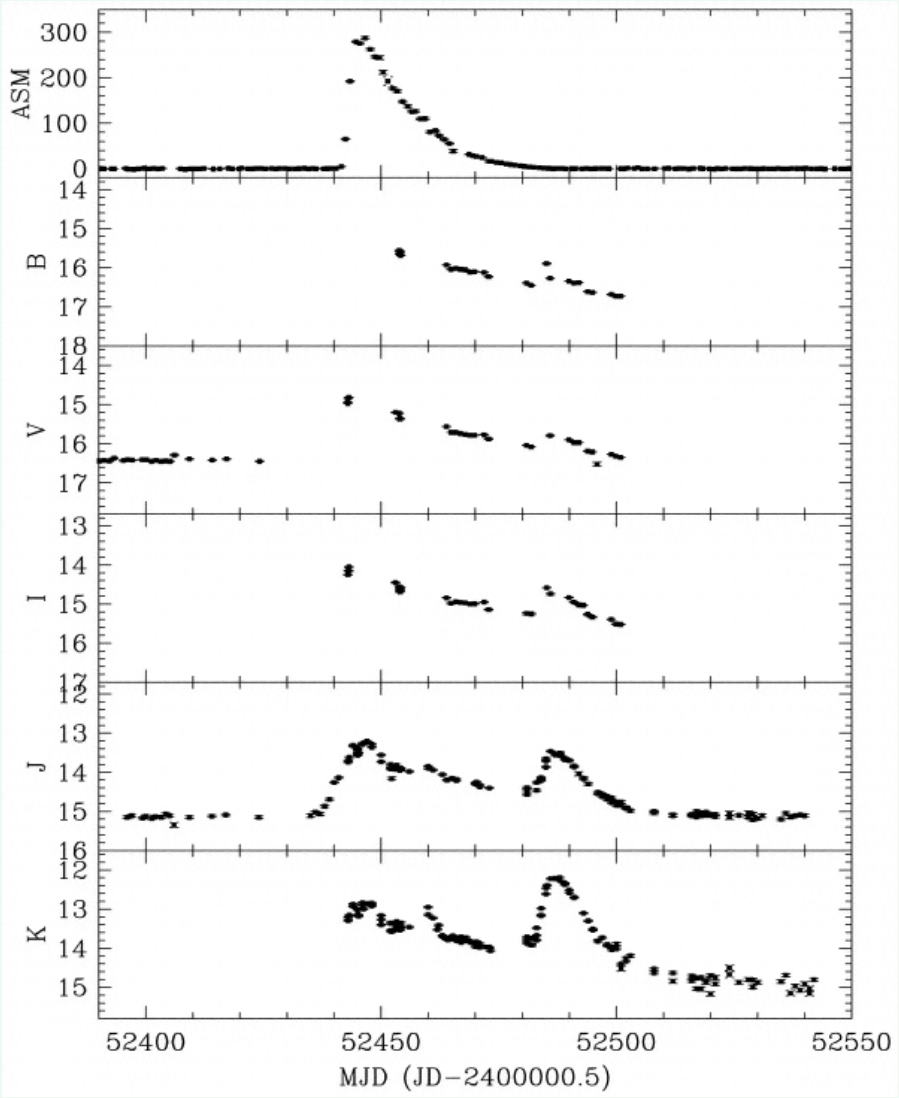
SVOM strengths:

- ECLAIRs FoV long term monitoring (state changes, variability)
- Discovery of new transients: fast alerts and automatic slews
- Triggering of multi-wavelength observations
- Perform multi-wave obs. with MXT and VT from automatic slews and fast ToO from external triggers (e.g. LSST and SKA)
- Studies of early stages of the Transient Outbursts (hard X-ray first !)

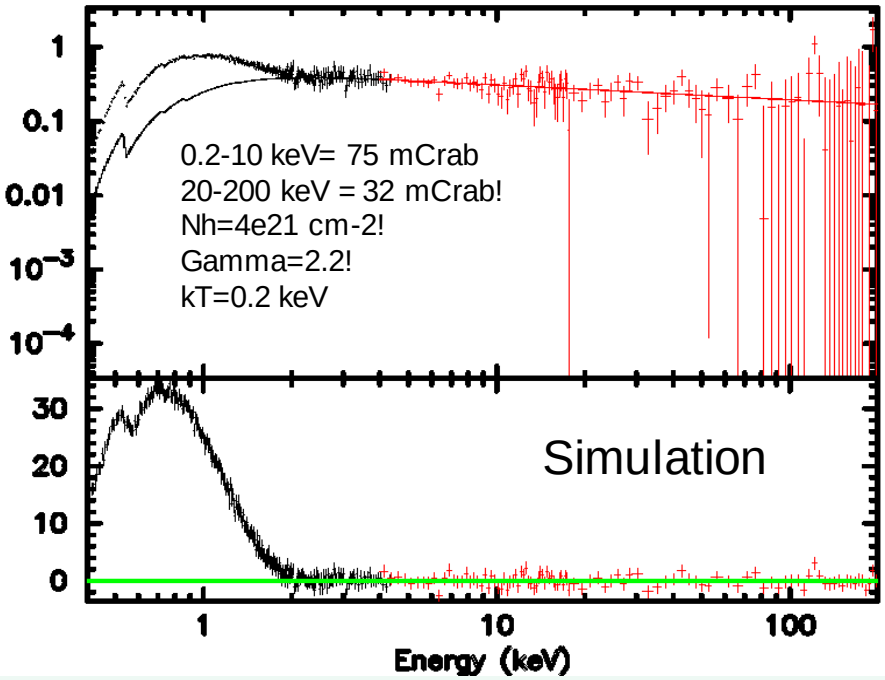




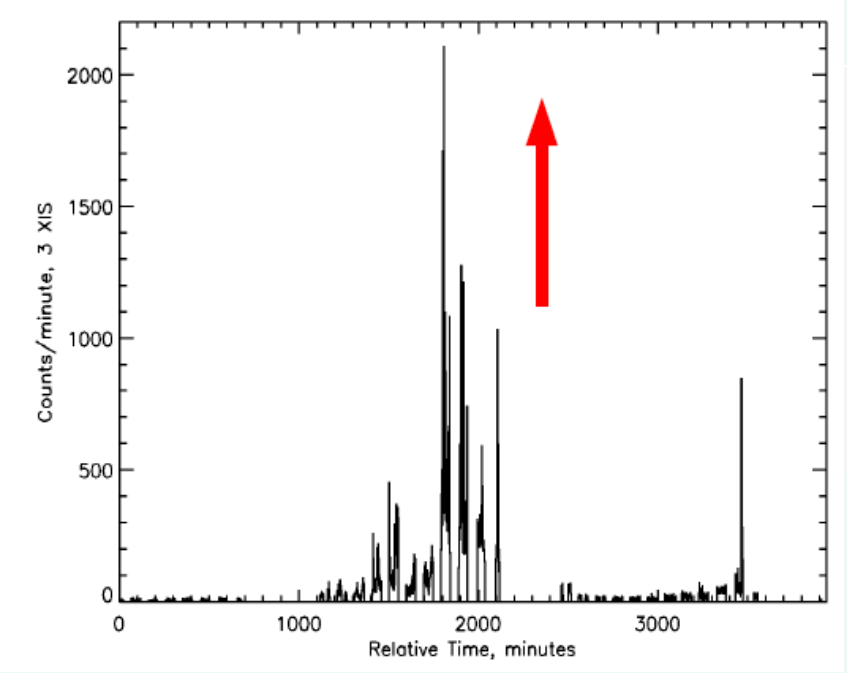
BH X-Ray Transients

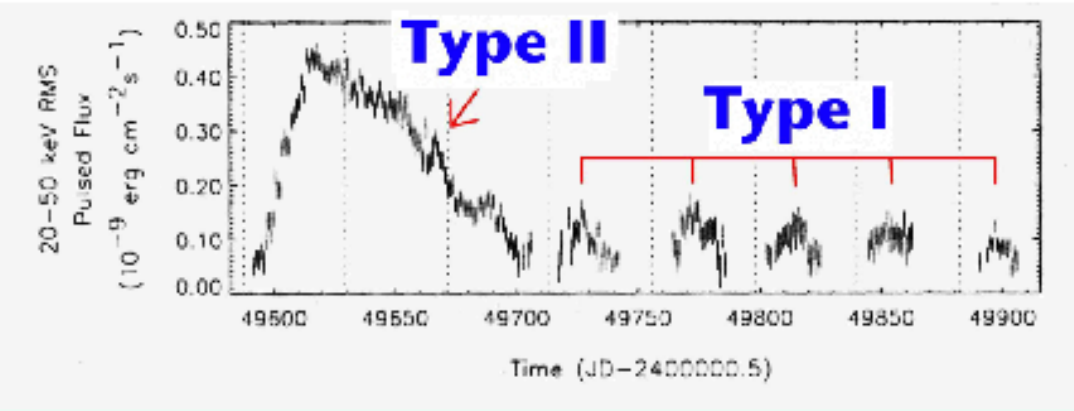


- Bright Multi-λ systems in outburst *[MRR-TO1, 3, 4]*
- Outbursts on weeks/months
- Study of Accretion/Ejection



SFXT and Be/XRB





Why some are SFXT others (Vel X-1) no ?

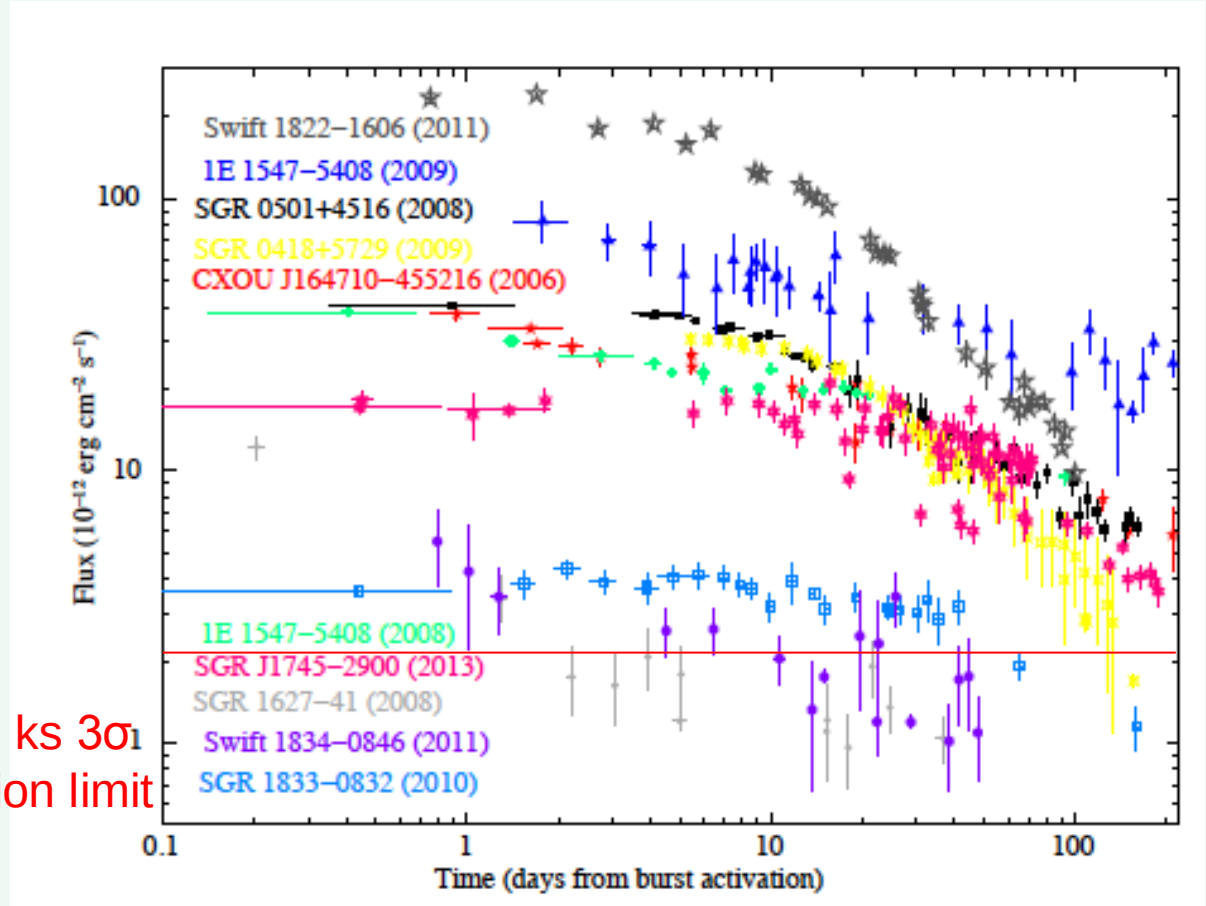
- XRB wt weak persistent emission, Supergiant companion, fast transients
- SFXT bursts duration < 1 day (few hr), too short for ToO but rapid alert useful and fast slew repointing crucial => ***MRR-GP10***
- Be/X bursts ~ several days. Important interplay X-Optical.
- **Alerts and possibly slews on these events as for GRBs =>** ***MRR-TO5***

Magnetars

Isolated NS powered by a huge Magnetic Field

Variability time scales

- X-ray pulsars (AXP)
- Short bursts(ms-100s)
- Giant outbursts
- Persistent emission
- Transient Magnet. =>



MXT 1 ks $3\sigma_1$ detection limit

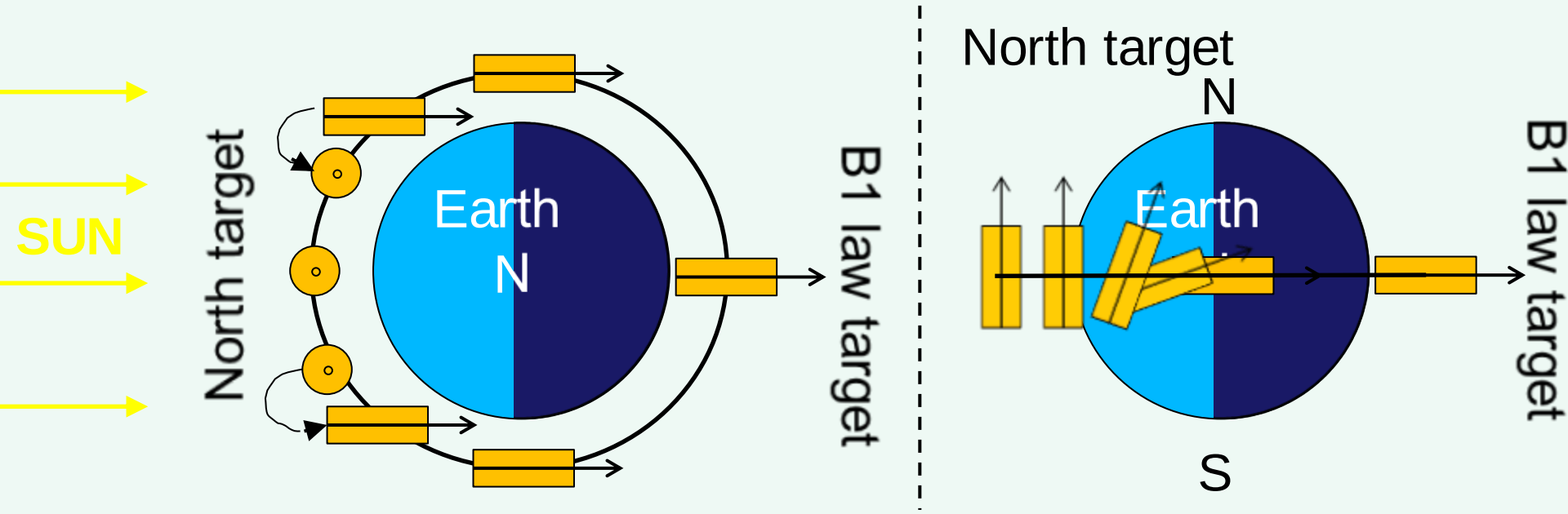
- ECLAIRs detection, MXT follow-up of transient magnetars
- Galactic - Plane sources => ***MRR-GP1, GP3, GP5, TO1, TO5***

SVOM GP/ToO Req.: rational of GP5

GP5 - Number of targets per orbit: It shall be possible to plan 1 target per orbit with a goal of 3 (TBC) targets per orbit.

GP11- Observation duration: For a given target, the observation duration shall range from 45 min (goal of 10) to 2 consecutive days (goal of 5). …

Rational: Two pointings per orbit allow to observe another target when the B1 target is occulted by the Earth. Three (goal) would give more flexibility. Trade off shall be studied for the PDR considering overhead for slew and stabilization.



SVOM Observatory Science

		Observ. Science Topics	ECLAIRs	GRM	MXT	VT	GWAC	GFT	VHF	FSC	Pointing / Mission repartition
MRR-GP1	Perform GP and ToO obs.	All topics									X
MRR-GP2	Reference law	from Core Science									X
MRR-GP3	Minimum fraction out of B1	Gal. Sources									X
MRR-GP4	Key program	L/SMC, M1, GC									X
MRR-GP5	**Number of targets per orbit**	**All but CXB**									X
MRR-GP6	GRB/ToO priority	Rare BH Novae									X
MRR-GP7	GP A targets	priorities of All									X
MRR-GP8	Standard analysis	All								X	
MRR-GP9	Observations in X-rays	Bright XRBs			X						
MRR-GP10	Ground-based observations	Gal. Sou., SFXT						X			
MRR-GP11	Observation duration	Improve GP/ToO									X
MRR-TO1	ToO propositions	Blaz, XRB, Mag,TDE									X
MRR-TO2	New messenger ToO	GW or ν Alerts, TDE									X
MRR-TO3	ToO analysis	All ToO								X	
MRR-TO4	Quick Look Analysis (&GP)	Blaz, XRT, Mag								X	
MRR-TO5	Transient events non-GRB	Mag, SFXT, SuperB	X						X	X	

MRR 19/06/2015 - GP

[MRR-GP1]

Perform GP and ToO Observations: outside GRB observations, calibration observations, operational maneuvers and SAA passages, ECLAIRs, GRM, VT and MXT shall be available to perform science observations of non-GRB source targets with the maximum efficiency allowed by the constraints of the core program. Non-GRB target observations will be of two different types: preplanned observations of known sources or regions of the sky and unplanned observations of newly discovered sources or transient/variable events of known sources. The ensemble of the first kind of observations will constitute the SVOM General Program (GP) while the second type the Target of Opportunity observations (ToO).

[MRR-GP2]

Reference law: the general program observations shall usually point targets within 5° (TBC) from the satellite reference attitude law which optimizes GRB search (the so called "B1 attitude law"), when the Earth does not occult the narrow field instruments. The goal is to devote at least 60% (TBC) of the useful lifetime of the nominal mission to the general program observations and at least 35% in case of the extended mission.

[MRR-GP3]

Minimum fraction out of B1: As a way to introduce flexibility, an increasing fraction of observing time away from the reference pointing law should be made available to the General Program along the mission lifetime from a minimum of 10 % (TBC) in the beginning of the nominal mission lifetime gradually up to 50 % (TBC) for the extended mission lifetime.

[MRR-GP4]

Key program: the system should allow scheduling large key programs that can be defined by the SVOM Co-Is. These key programs will represent 20% (TBC) of the GP.

[MRR-GP5]

Number of targets per orbit: It shall be possible to plan 1 target per orbit with a goal of 3 (TBC) targets per orbit.

MRR GP 2

[MRR-GP6]

GRB/ToO priority: GRB pointing or TOO observations erase the general program observations. After slewing back from a GRB/TOO pointing, the general program observing plan shall resume where it would have been at that moment in the absence of a GRB/TOO pointing.

[MRR-GP7]

GP A targets: at least 50% of the useful lifetime of the nominal mission shall be allocated to high priority observations, the so called A-target observations. These observations should resume or be rescheduled after being interrupted by GRB or ToO observations, till fulfill as much as possible the planned exposure, as long as operational constraints are met. If operational constraints prevent rescheduling of the A-target interrupted observations these observations shall be rescheduled in the GP of the following year (TBC). At least 30% of the useful lifetime of the extended mission shall be allocated to high priority observations.

[MRR-GP8]

Standard analysis: consolidated science data products of the general program from ECLAIRs, MXT, VT and GRM shall be available and shall be delivered to the observation PI within 30 (TBC) days after data reception at the science data center for at least 90% (TBD) of the observations performed.

[MRR-GP9]

Observations in X-rays: MXT shall be able to observe a target with a source in the field of view that is optically brighter than V = XX mag.

[MRR-GP10]

Ground-based observations: A fraction of 5-10% of the effective observing time of the GFTs shall be spent on targets of the general program for performing pre-planned or ToO simultaneous observations.

[MRR- GP11]

Observation duration: For a given target, the observation duration shall range from 45 minutes (goal of 10 minutes) to 2 consecutive days (goal of 5). If a target is planned to (and can) be observed for a longer time, another observation shall be scheduled.

MRR TO

[MRR-TO1]

ToO propositions: ToO can be proposed and defined in the same process of GP definition (and then triggered when criteria are met) or requested directly to SVOM PI – NOT DECIDED, IMPACT ON SMP). ToO shall be performed within 48 hr (TBC) from ToO acceptance/trigger. They are not subject to reference attitude law, but only to normal operational constraints. ToO are interrupted by GRB observations.

The goal is to devote at least 15% (1 ToO/day) of the useful lifetime of the nominal mission to the ToO observations and at least 40% (5 ToO/day) in case of the extended mission.

There is however a class of ToO that are considered exceptional and that shall be performed within 12 hr (goal) from acceptance and shall not be interrupted by GRB observations. The expected rate of the Exceptional ToO is one per month (TBC).

[MRR-TO2]

New messenger ToO: In case of a new-messenger ToO (a subset of the exceptional ToO), the system should permit to cover the error box of the source by performing multiple, between 4 – 25, tiling pointing with a duration of 10 minutes (TBC) for each of them.

[MRR-TO3]

ToO analysis: Preliminary science data products of the ToO from ECLAIRs, MXT, VT and GRM shall be available to the observation PI within 24 hours (TBC) after data collection on board for at least 90% (TBD) of the observations performed, and in less than 30 days for the consolidated data.

[MRR-TO4]

Dissemination of ToO observations: The scientific community shall be informed about new sources and transient events detected in ECLAIRs observations (position and flux in predefined energy bands) within 72 (TBC) hours after reception of the data by the science center.

[MRR-TO5]

Transient events from non-GRB sources: The SVOM community should be informed in less than 1 hour about transient events detected on board by ECLAIRs and related to a defined list of non GRB sources (position, flux, and time). In case of the detected flux is greater than a defined threshold the SVOM platform shall point autonomously the transient source and shall permit to observe it continuously for 2 orbits (TBC). The content of the list (sources and associated threshold) shall be updated along the mission life time.

MRR CAL

[MRR-CAL1]

ECLAIRs calibration: ECLAIRs flux calibration shall be precise to 10% (TBC) throughout the mission. Energy calibration should be better than XX @ XX keV

[MRR-CAL2]

MXT calibration: MXT flux calibration shall be precise to 10% (TBC) throughout the mission. Energy calibration should be better than XX @ XX keV.

[MRR-CAL3]

VT calibration: VT flux calibration shall be precise to 1% (TBC) throughout the mission. Differential photometry accuracy shall be better than 0.1%.

[MRR-CAL4]

GRM calibration: to be written

[MRR-CAL5]

MXT and ECLAIRs cross-calibration: MXT and ECLAIRs should be calibrated in a way for a persistent source with > XX mCrab, that the flux at 5 keV derived from both instruments lies within +/- XX %, and the 4-10 keV spectral slope should agree within XX %.

[MRR-CAL6]

ECLAIRs and GRM cross-calibration: to be written

SVOM Observatory Science

Thank You