Discussion on gamma-ray astronomy (alerts and ToOs)

TS2020, LAL, June 21 2017

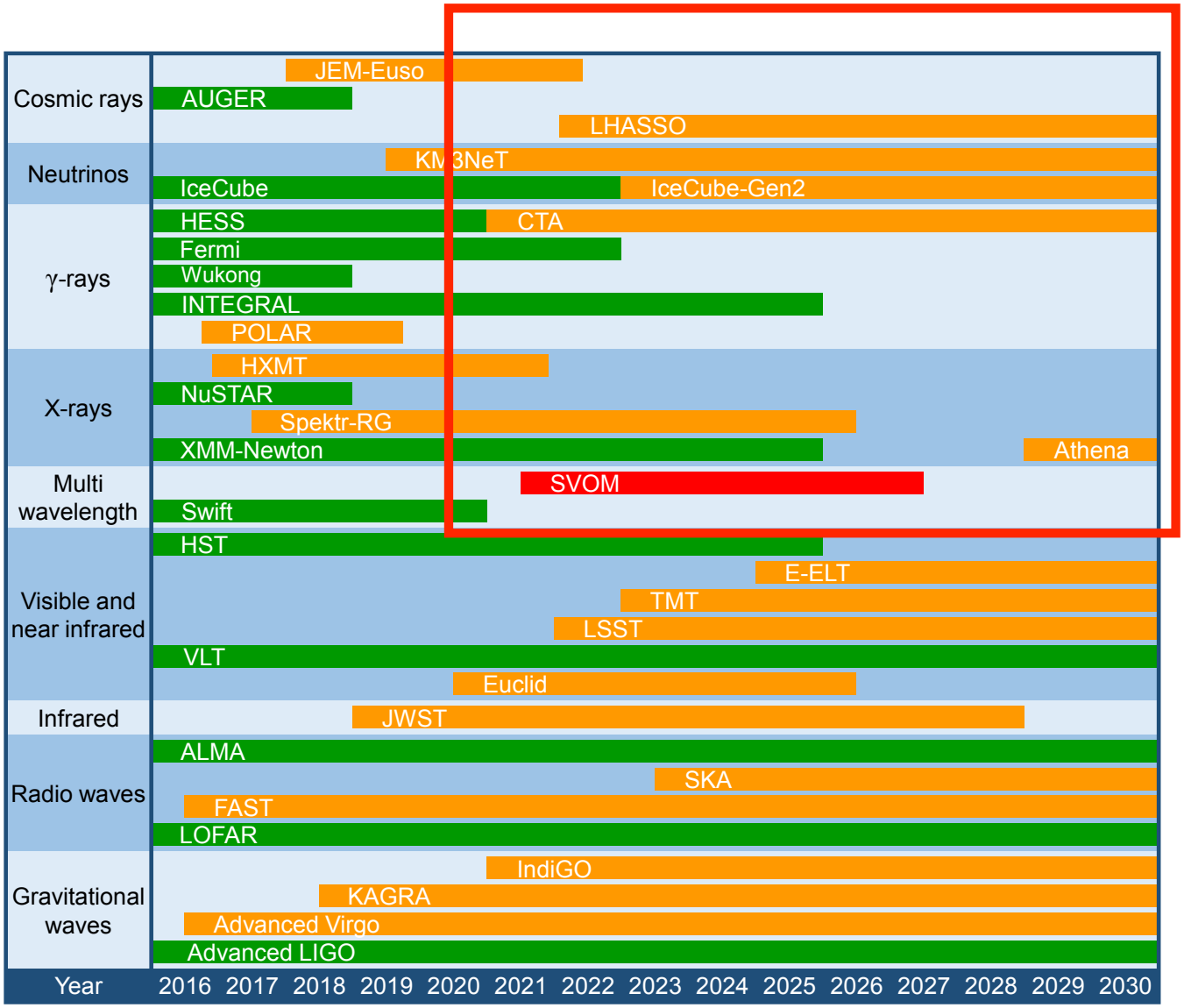
The transient sky in gamma-rays

- **HE transients:**
  - gamma-ray bursts
  - PWNe (es. Crab flares)
  - magnetar giant flares
  - AGN/blazars
  - microquasars and X-ray binaries
  - novae
- **HE counterparts of X-ray, optical or radio transients:**
  - TDEs and SN shock breakouts
  - FRBs
- **HE counterparts of multimessenger emitters:**
  - neutrino transients, GW transients

+ new discoveries

Triggering facilities in 2020

- High-energy:
  - CTA
  - HAWK
  - LHAASO
- Gamma/X-rays:
  - SVOM
  - Swift, Fermi (??)



Wei, Cordier et al., 2016, “The deep and transient Universe: new challenges and opportunities”

Alerts dissemination: status of the art

Well organised for GRBs:

- Triggered events:
  - automatic analysis + manual validation
  - quick (~ mins) distribution of tigger information

  \+ offline automatic search of untriggered events
- **Gamma-ray burst Coordinate Network (GCN)**: since 1993, maintained by NASA:
  - notices (localisation, real time, capable to trigger automatic sequences)
  - circulars (human readable, free format, contain information about the GRB)+ reports (summary for a single GRB)
  - common repository for most of the obs. and follow-up

Not well organised for other HE sources:

- mainly **Astronomer's Telegram (ATel)**, significant delay

Alerts from gamma-ray telescopes in 2020

Alerts processing and diffusion to be more effective:

- full automatic processing or manual intervention? organisation of people involved (es. BAs)

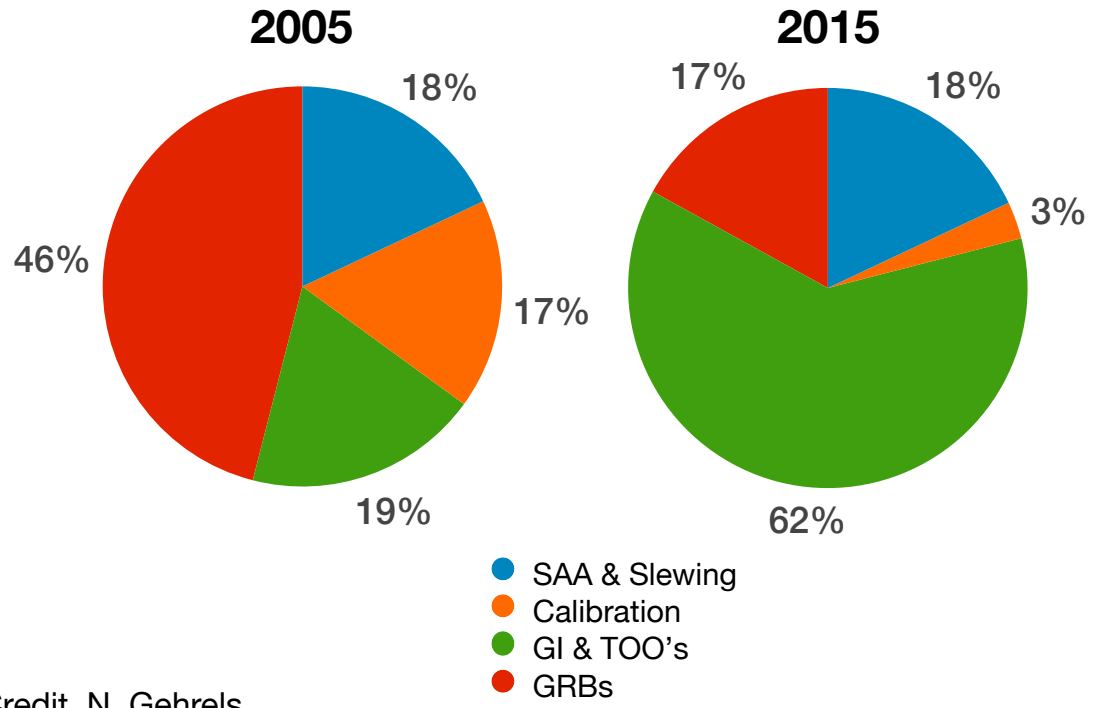
Multiwavelength/multimessenger observations crucial for the identification/characterisation of transients:

- how to improve the alert dissemination? GCN, VOEvents, Atel, email systems?
- uniform system for all transients?
- sharing is the keyword, but requires distribution policies (MoUs)

ToOs: the lesson from Swift

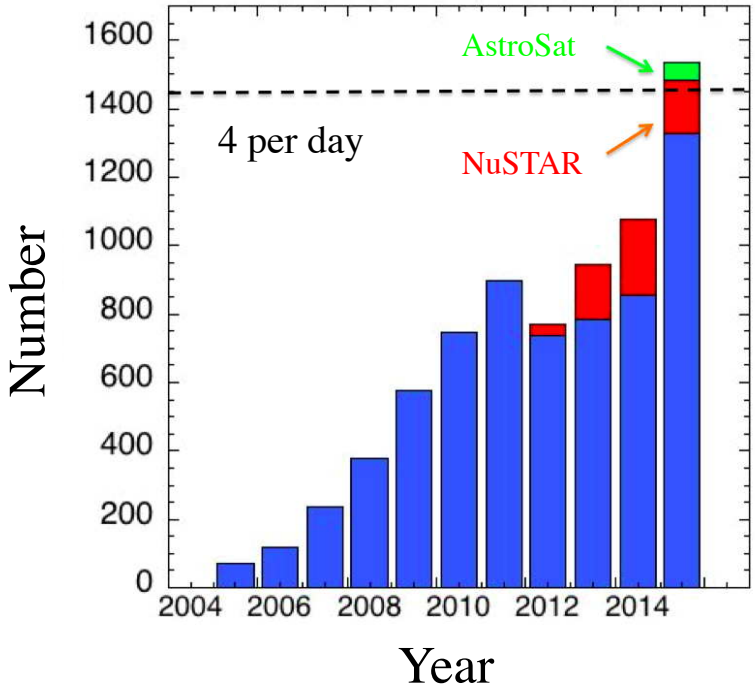
- time allocated for ToOs increased with time
- possibility to perform tilings on large portion of the sky
- synergy with other missions (es. NuSTAR, Fermi)
- the science return from ToOs is increasing

EVOLVING OBSERVING TIME



Credit, N. Gehrels

APPROVED ToOs/yr



ToOs in 2020

A burst of external triggers is expected in the future, hard to handle them:

- how to choose what is interesting? choice made case by case, for science themes, agreements with each community?
- who has to make this choice? Should external facilities select a certain number of “good” trigger to be followed?

Instrument	CTA North (2019 - ??)	CTA South (2020 - ??)	HAWC (2015 - ??)	LHAASO (2019 - ??)
Location	Chile (near Paranal)	Roque de los Muchachos (La Palma)	Mexico (19° 01′ 47″ nord, 97° 16′ 13″ west)	Sichuan Daocheng (China)
FOV	up to 4deg radius	up to 4deg radius	2sr instantaneous (2/3 sky during 24h)	2sr instantaneous (2/3 sky during 24h)
Energy bands	~50GeV - 100 TeV	~20GeV - 50TeV	currently ~1TeV - 100TeV (expectation: ~250GeV - 100TeV)	~250GeV - 1PeV
Time integration	<min - hours	<min - hours	min - years	min - years
Others caractéristiques				
Observation plan	GP survey + pointed obs.	EGAL survey + pointed obs.	survey of the accessible sky	survey of the accessible sky
Alert types	various (short transients, AGN flares, etc.)	various (short transients, AGN flares, etc.)	various (short transients, AGN flares, etc.)	various (short transients, AGN flares, etc.)
Trigger Characteristics	min delay: 30s	min delay: 30s	min delay: ~min	min delay: ~min
Min Rate (/year)	unknown	unknown	unknown	unknown
Max (/year)	unknown	unknown	unknown	unknown
Confidence Level	adjustable, typically 3sigma	adjustable, typically 3sigma	various, dependent on the transient	various, dependent on the transient
Actions	internal self-triggers (prolonged observation) + public alert emission	internal self-triggers (prolonged observation) + public alert emission	alert emission to partner observatories + public alerts via ATELs/GCN	public alerts
External ToO	various (HE/VHE flares, gal. transients, high-E neutrinos, GW, etc.	various (HE/VHE flares, high-E neutrinos, GW, GRBs, etc.	various (HE and VHE flares, GRBs, high-E neutrinos, GWs, etc.)	various (HE and VHE flares, GRBs, etc.)
Frequency + Delay	depending on alert type (~12 gal. transients/yr, ~10 high-E neutrinos/year)	depending on alert type (~12GRBs/year, ~10 high-E neutrinos/year)	dedicated data analysis delay <15min	
Duration	typically 2h (extended after detections)	typically 2h (extended after detections)	dependent on the ToO, data can be analysed on various timescales	dependent on the ToO, data can be analysed on various timescales
Specific features			1-2 months of data available for online analyses, all data available for offline searches	combination of various instruments possible
Alert distribution policy			public + MoU partners	public
Alert distribution System			various (manual email/ATEL + automatic flare searches)	
Standard Delay	>min	> min	~min - days	~hours
Localisation Error Box	<0.1deg	<0.1deg	<1deg, source localisation dependent on flux	
Type Alert			various (manual email/ATEL/GCN + automatic email for flare searches)	
Informations of the Alert	position, flux (?)	position, flux (?)	position, flux	
Data policy			data private, release of alerts and catalogs	data private
Delay of public Data Release	1 year	1 year		
Data Access				

Instrument	SVOM/ECLAIRs (2022 ? -)	SVOM/MXT (2022 ? -)	SVOM/GRM (2022 ? -)
Location	Space (LEO)	Space (LEO)	Space (LEO)
FOV	2.04 sr (ZCFOV)	1 deg2	3 detectors, 2 sr each / 2sr comon FOV
Energy bands	4- 150 keV	0.2 - 10 keV	15 keV - 5 MeV
Time integration	Photon by photon	Photon by photon	Photon by photon
Others characteristics	80x80 CdTe pixels Aeff=1000 cm2 (add mask open fraction: 0.4)	Focal length: 1 m S=27 cm2 at 1 keV	NaI S = 3 x 200 cm2
Observation plan	Mostly away from Galactic plane 1 orbit : 90 min (56 min usefull time)	Away from Galactic plane 1 orbit : 90 min/45 min usefull time	Common FOV away from Galactic Plane
Alert types	New transient (short and long GRB, XRF) Known transient sources flaring { Quicklook Analysis (<48h delay) }		High energy transient sources
Trigger Characteristics	Onboard, delay ~30 s		Onboard, delay ~30 s
Min GRB rate (/year)	46 GRBs		90 GRBs
Max GRB rate (/year)	82 GRBs		90 GRBs
Confidence Level	High		Crude position
Actions	Autonomous slew of the satellite Alert sent to the ground		Alert sent to the ground immediately
External ToO	search "a posteriori" transient source in images	ToO-NOM; ToO-EX; ToO-MM	Search "a posteriori" a temporal coincidence in the data
Frequency + Delay	no delay if the transient source is within the ECLAIRs observable field	ToO-NOM : 1/day - < 48h ToO-EX : 1/month - < 12h ToO-MM : 1/month - < 12h	
Duration	all the time the source is within the ECLAIRS FOV	ToO-NOM : Typ. 1 orbit (45 min us.time) ToO-EX : < 14 orbits (1 day/630 min us. time) ToO-MM : < 14 orbits (1 day/630 min us. time)	
Specific features		ToO-MM : Tiles : up to 3 tiles/orbit (max : 42 sq.deg./ToO-MM) MXT photons sent through VHF for immediate analysis	
Alert distribution policy	Public	Public	Public
Alert Distribution System	SVOM VHF + FSC	SVOM VHF + FSC	SVOM VHF + FSC
Standard Delay	~10 min	~ 10 mins	30s - 1min
Localisation Error Box	< 12 arcmin	< 30"	> 5°
Type of Alert	VO + GCN	VO + GCN	VO + GCN
Informations of the Alert	Finding charts + subimages	Position, Lightcurve, Spectrum	Lightcurve, Spectrum, Position ?
DATA policy	PI	PI	PI
Delay of public Data Release	> 6 months	> 6 months	> 6 months
Data Access	Via co-I	Via co-I	Via co-I