# Transient Handler for the LST-1 prototype

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## Abstract

In 2019, the first firm detection of a very high energy (VHE, E>100 GeV) emission component from Gamma-ray Bursts (GRBs) has definitely opened a new observational window for the study of those enigmatic transient events.These discoveries did not arrive unexpectedly but they represent the result of a 20-year-long hunt by the major Cherenkov telescope collaborations. Furthermore, the recently discovered high-energy neutrinos and gravitational waves from astrophysical sources have opened the era of multi-messenger astrophysics. The proven connection between gravitational waves and short GRBs has shown the importance of coordinated follow-up observations triggered by different cosmic signals. However, the unpredictable nature of the transient sky makes it difficult for the large ground-based Imaging Atmospheric Cherenkov Telescopes (IACTs) to point and start follow-up of these sources rapidly enough to catch their early emission phase(s). The instrument response to external triggers (GRB and multi-messenger transients) relies on a dedicated automatic *transient handler.* In this contribution, I will report about the first implementation of transient handler within the LST-1 framework.
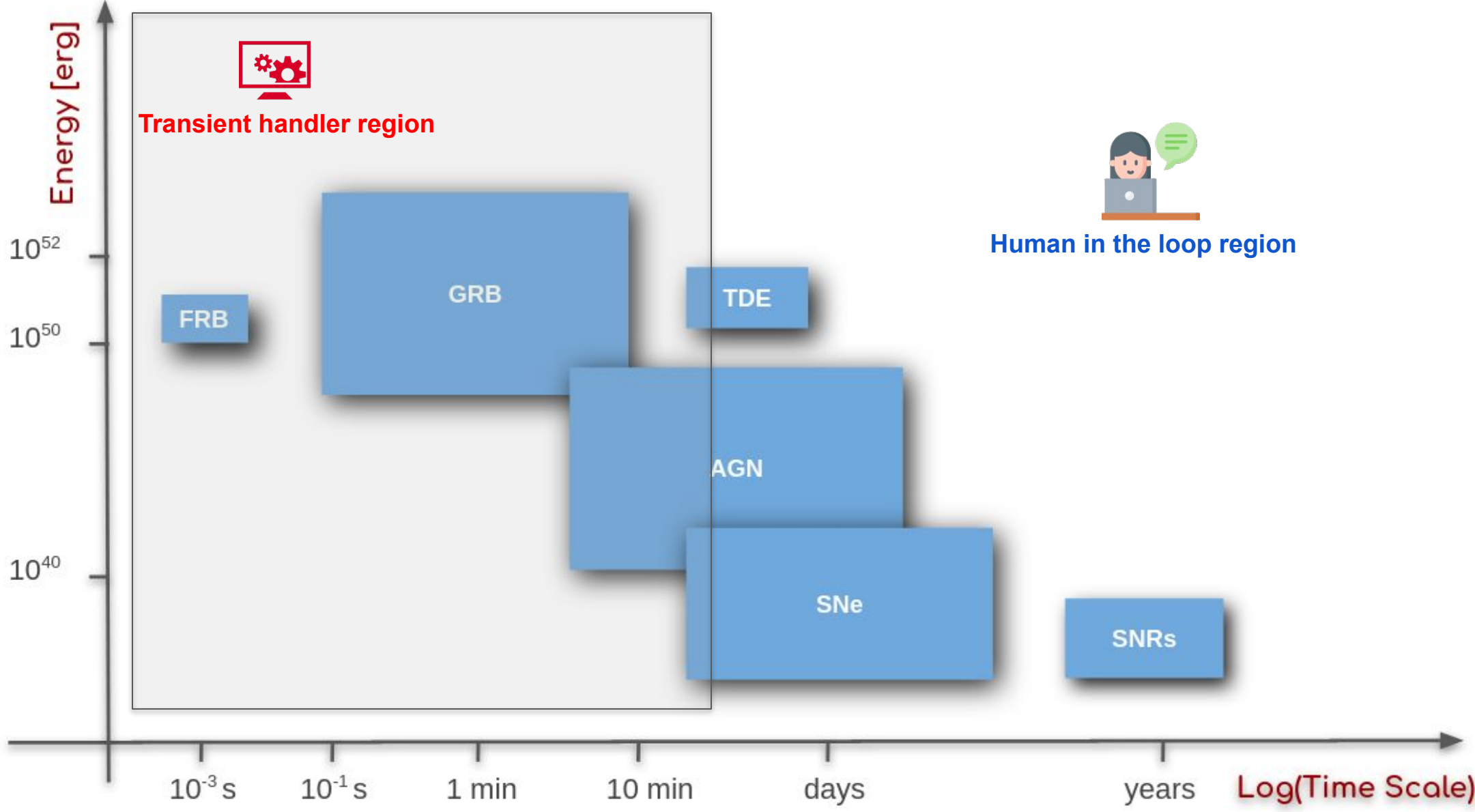
## Why a Transient Handler is needed



**Fig 1:** *Energetics and characteristic time scales for different transient sources of interest for Cherenkov telescope. Reaction time for this kind of sources is often critical and cannot rely on human in the loop intervention. An automatic transient handler is thus needed to correctly schedule follow up*

| Source | Duration | Energy Release | Energy Source |
|---|---|---|---|
| | | [erg] | |
| Fast Radio Burst (FRB) | <~msec | ~$10^{50}$ | B field (?) |
| Gamma-ray Burst (GRB) | msec - min | ~ $10^{49}$ - $10^{53}$ | Gravity |
| Tidal Disruption Event (TDE) | min - months | ~$10^{52}$ | Gravity |
| Supernovae (SNe) | min - years | ~$10^{44}$ | Gravity |
| Active Galactic Nuclei (AGN) | min -days | ~$10^{43}$ erg/s | Gravity |

**Tab 1:** *Time scale and energetics for some of the transient events of interest for IACT. In addition, we should include also multi-messenger signals such as gravitational waves (GW) and neutrinos that need a fast reaction and are received by transient handler. Adapted from [1]*

Short time-scale transients represent a still marginally explored science case although they are key science targets for both current IACT collaborations and for CTA. Short time-scale follow-ups often differ from normal observations:

- interruption of nominal operations, fast repointing, special setup, custom data analysis
- They cover all areas of the experiment: instrument, analysis & physics

## The LST-1 Transient Handler

### Main functionalities

- ❏ ***External communication handling***
  → comm. protocols, connection(s) with brokers…
- ❏ ***Alerts handling***
  → receiving, parsing, archiving…
- ❏ ***Visibility/filtering***
  → visibility evaluation, observing constraints…
- ❏ ***Internal interfaces handling***
  → communication with TCU/scheduler, Real Time Analysis (RTA)

### Technical Specification

- ❏ 1 broker until now (GCN) through VOEvent protocol V2 (xml)
- ❏ MOS (Multi-purpose OPCUA Server) plugin with multi-thread modular design:
  - "low-level" code, C/C++ (communication, parsers, interpreters...)
  - "high-level" code, python (visibility & observability) + GW module
- ❏ OPCUA (Open Platform Communications Unified Architecture)
- ❏ Dedicated communication channel with Telescope Control Unit (TCU) to avoid possible latency in alert propagation to the telescope
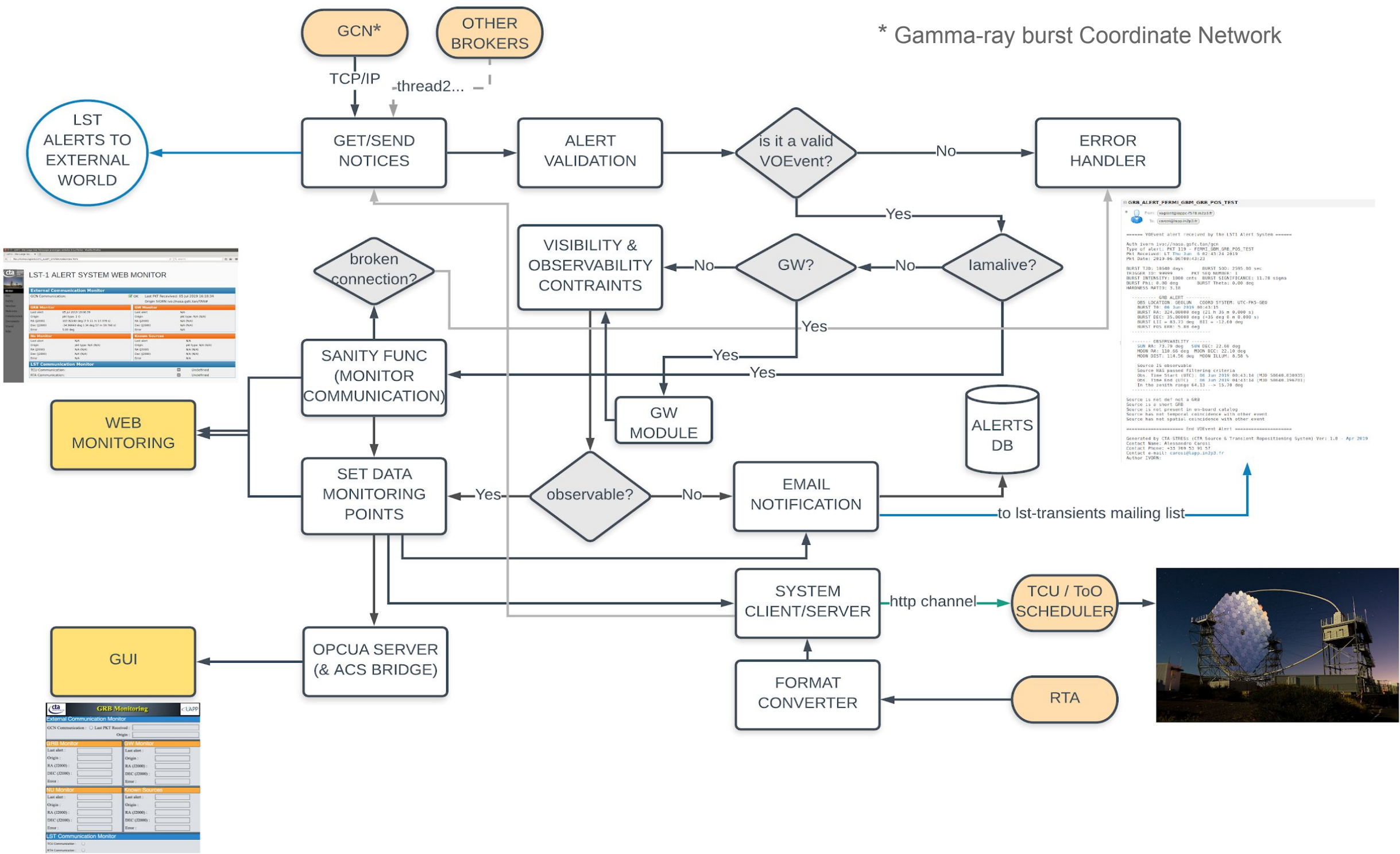- ❏ Connection to RTA to deliver alerts produced by the telescope to outside world



**Fig 1:** *The flowchart of the currently under development transient handler for the LST-1 prototype. At present, only communication with GCN has been installed and extensively tested. Connection with other (current and future) brokers or single facilities is planned.*

## Conclusion and future developments

As demonstrated by recent detection of GRBs by current IACT, the field of VHE transient astronomy is rapidly evolving toward the observations of new sources also in the context of a multi-messenger approach. It is hoped that such observations will become routine in the future, especially when CTA will be fully deployed. Thus, the synergies between instruments operating at different energy bands has to be considered as one of the priority for any new observatories and will play a crucial role for achieving the maximum scientific reward. Within this framework, a dedicated transient handler is going to be deployed within the LST-1 prototype allowing the telescope to receive alerts from external facilities/satellites. In the first months of 2021, the proposed system will allow the first follow-ups of transient events, exploring the unique characteristics of LST-1 prototype (fast repointing and low energy threshold) until the full CTA transient handling system will be available within the Array Control and Data Acquisition System (ACADA).

[1] J. Hinton & R.L.C. Starling (2013) *High Energy Emission from Transients,* https://doi.org/10.1098/rsta.2012.0279