cherenkov telescope array

UNIVERSITÉ DE GENÈVE

First follow-up of transient events with the CTA Large Size Telescope prototype

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for the **CTA LST project**

The Cherenkov Telescope Array

A facility for Very High Energy gamma-ray astrophysics in the next decades

extragalactic science, transients...

alpha configuration:

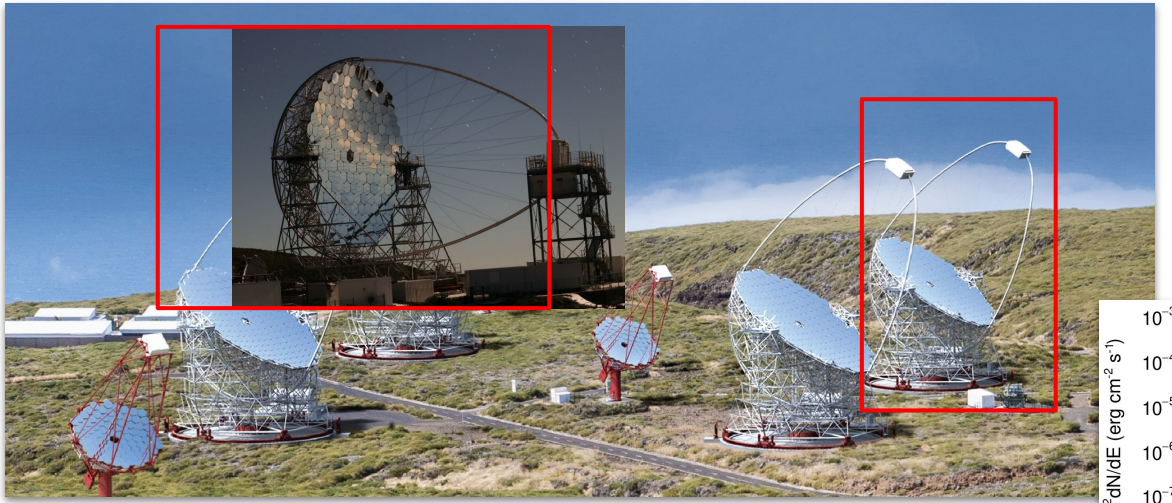
North: 4 LST + 9 MST
South: 14 MST + 37 SST

galactic, > 100 TeV

- ❑ 2 arrays (north & south)
- ❑ 3 telescope size classes
- ❑ large n. of telescopes

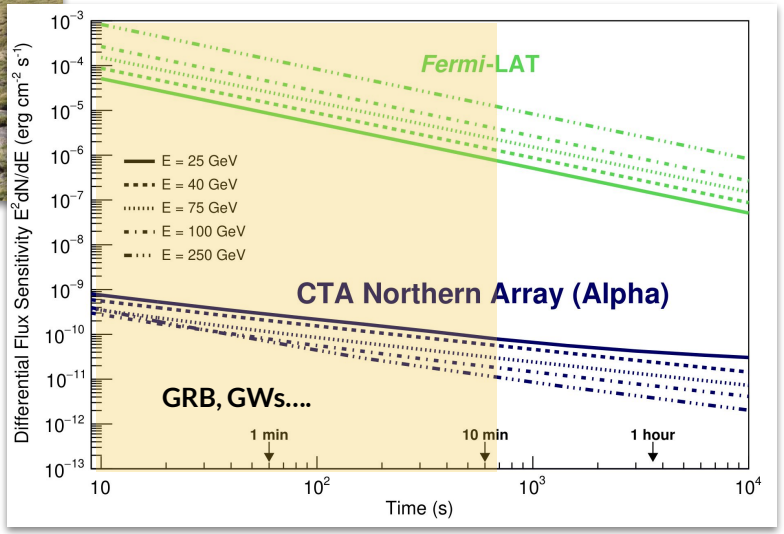
- near full sky coverage
- wider energy range (~20 GeV - 300 TeV)
- higher sensitivity: ~5-10x current IACT
- better angular resolution: ~5x current IACT
- larger FoV: 2.5x current IACT

The LST-1 prototype



The LST-1 prototype, the first 23-m class telescope for the CTA, is finalizing its commissioning phase and gradually entering regular scientific operations

- Low energy threshold (down to ~20 GeV)
- Large effective area at multi-GeV range
  (~ 10^4 x Fermi-LAT @ ~ some mins. timescale)
- Fast slewing capabilities (~20 s/180^0 in azimuth)



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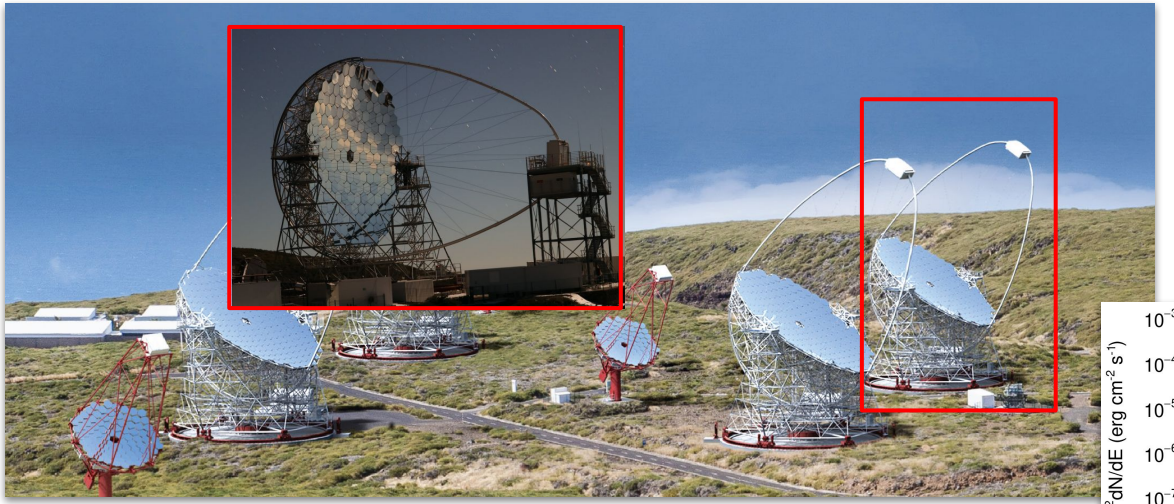

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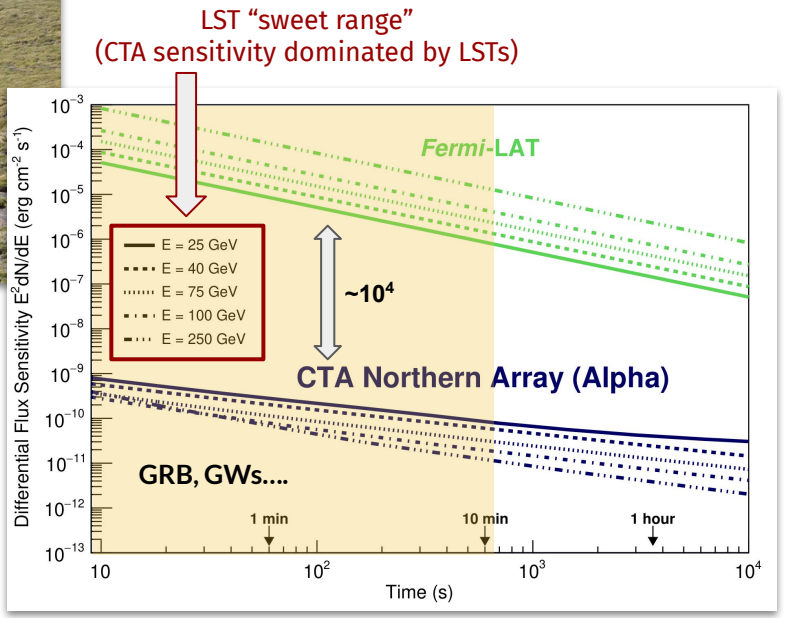
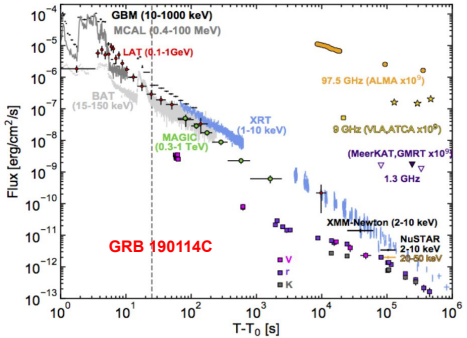
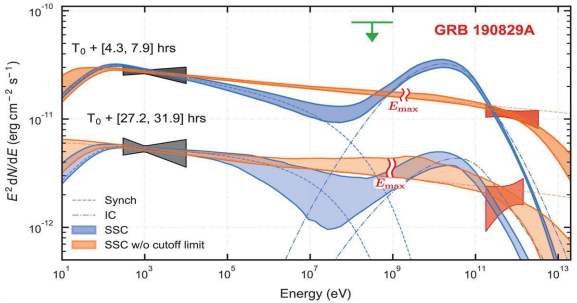


VHE Transient Astrophysics

VHE Transient Astrophysics is “warming up” in the last years:

- **GRB detection at VHE: a long-awaited result!**





MAGIC GRB 190114C… (2019, Nature, 575, 455/459)
H.E.S.S. GRB 190829A… (2021, Science , 372, 6546)

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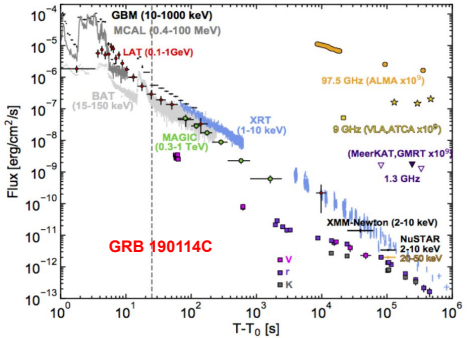

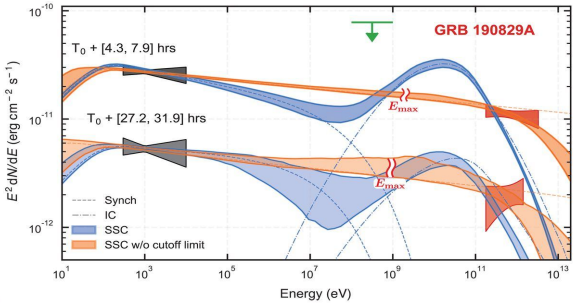

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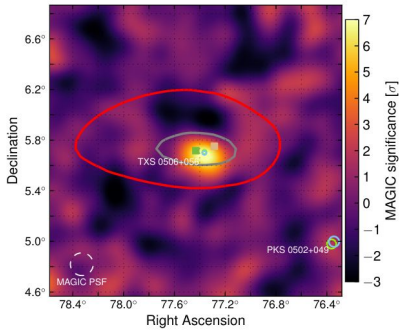
❑ Neutrino/VHE connections for TXS 0506+056



IceCube/MAGIC....
(2018, Science, 361, 6398)

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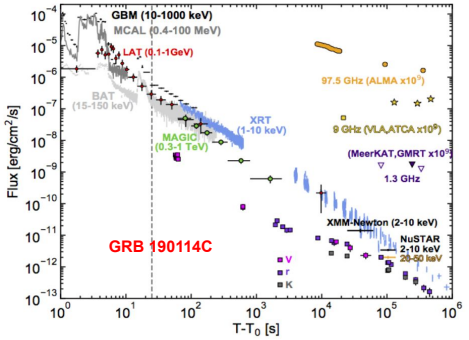

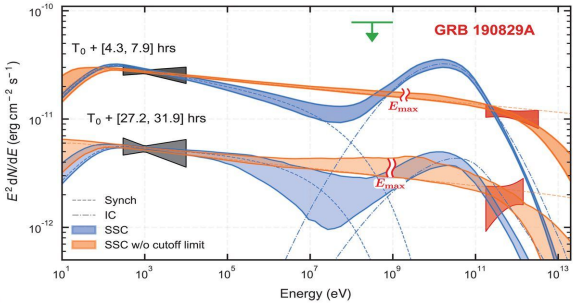

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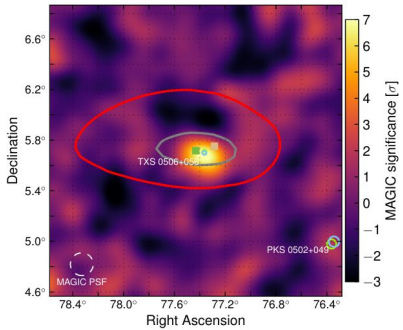

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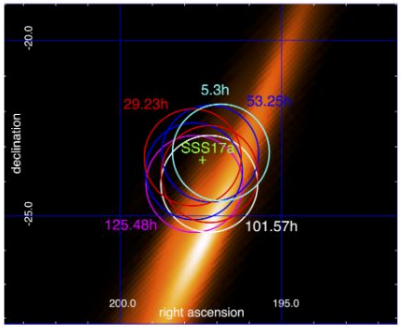
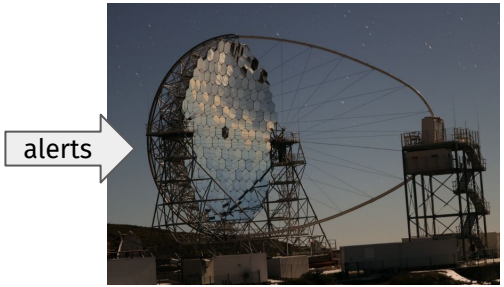
❑ GW-astrophysics with IACT



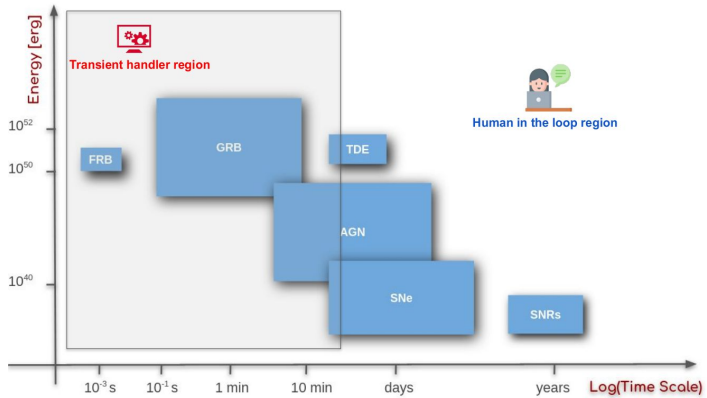
H.E.S.S. GW 170817
(2017, ApJL, 850, L22)

MWL & multi-messenger synergies

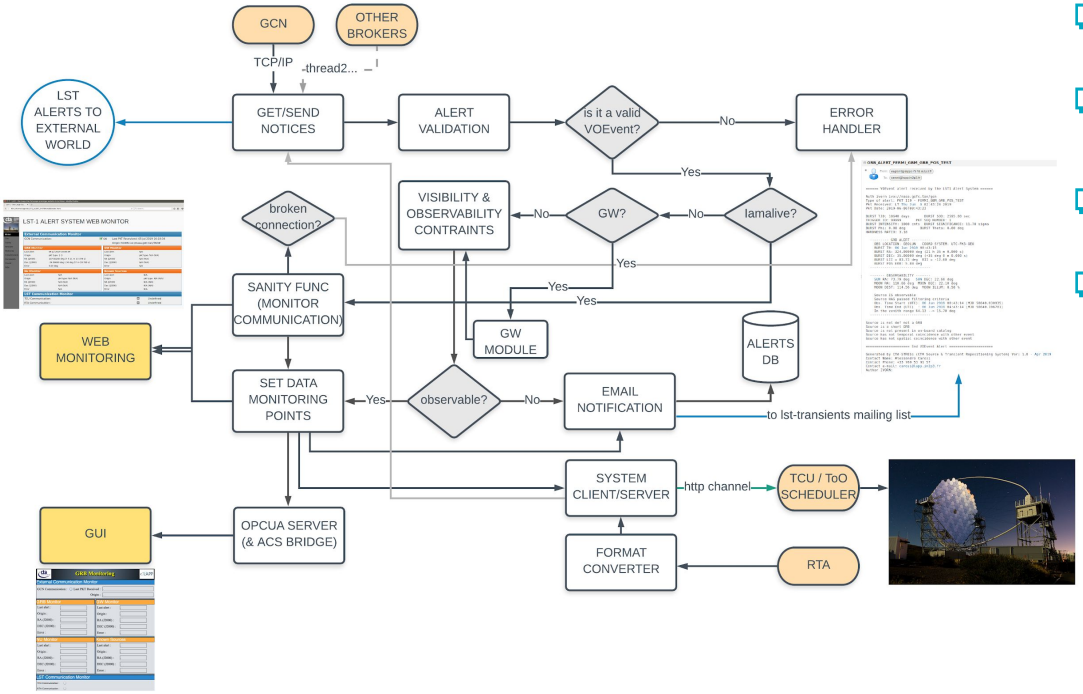
Image credit: R. Zanin @TeVPA 2019



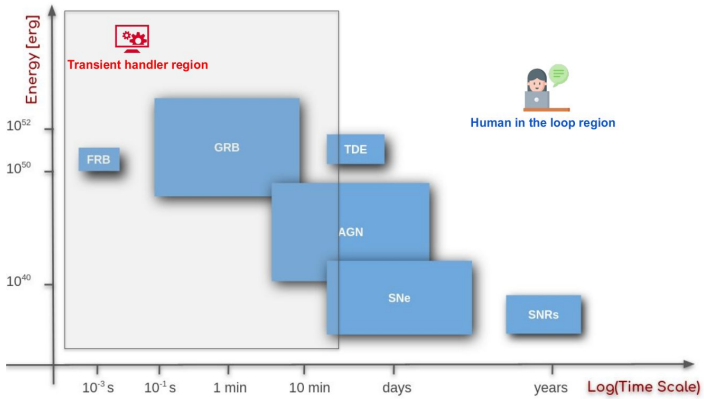
- **Multi-messenger era will require large synergies between facilities operating at different bands and with different 'signals'**
  - LST-1 will be able to receive alerts from many different sources thanks to dedicated '*transient handler*'
  - In the future, the system will be also able to deliver alerts in almost real-time to the external astrophysical community



Transient handler



- **External communication handling**
  → comm. protocols, connection(s) with brokers...
- **Alerts handling**
  → receiving, parsing, archiving...
- **Visibility/filtering**
  → visibility evaluation, obs constrains...
- **Internal interfaces handling**
  → communication with TCU/CC/scheduler, RTA...



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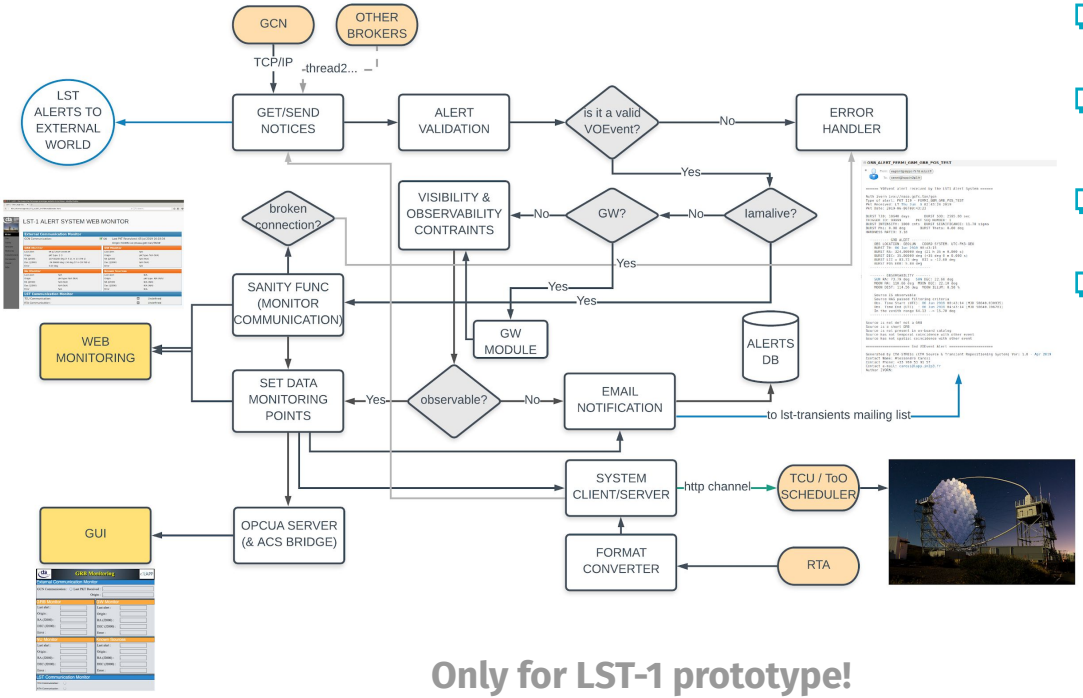

Only for LST-1 prototype!
To be updated with the full *transient handler* of CTA

- **External communication handling**
  → comm. protocols, connection(s) with brokers...
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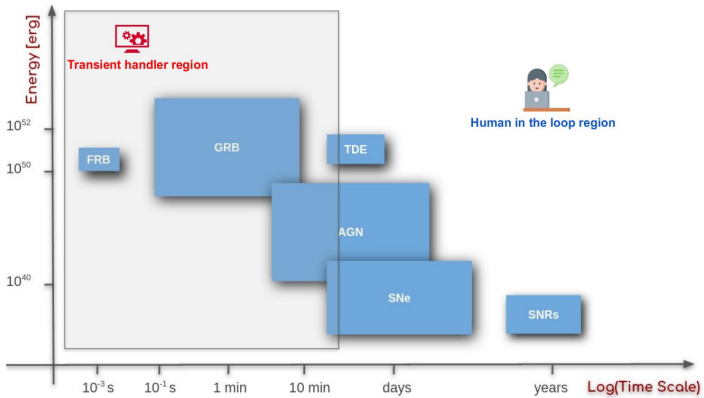
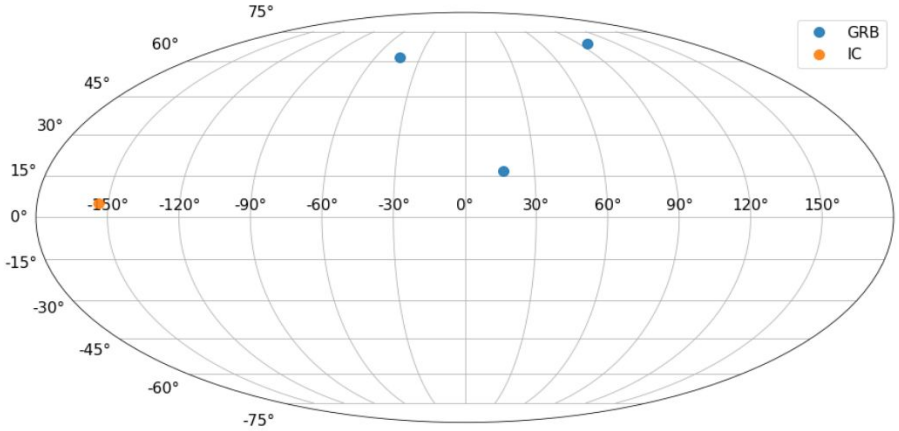


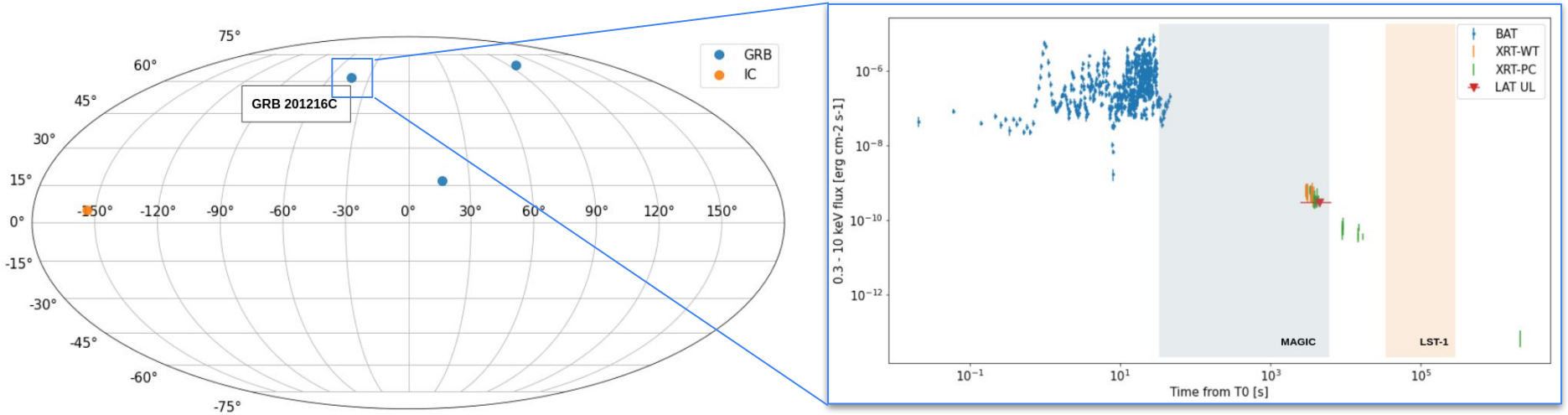
First follow-up events with LST-1



- **First regular follow-up started at the beginning of 2021 :**
  - a bunch of events observed so far (swift malfunctioning)
  - still human-in-the-loop follow-up but implementation of dedicated automatic procedure ongoing
  - initial science already possible:
    - preliminary analysis did not reveal VHE emission

	T_0 [UTC]	T_{90} [s]	z	Start time [UTC]	Zenith [deg.]	Delay [s]	Trigger	VHE
GRB 201216C	23:07:31	48.0	1.1	20:57:03	40	79200	*Swift*	Y^{α}
GRB 210217A	23:25:42	4.2	-	23:40:22	44	880	*Swift*	N
GRB 210511B	11:26:39	6	-	03:37:54	45	58200	*Fermi*-GBM	N
IC 210210A	11:53:55	-	-	05:41:54	25	64134	IceCube	N

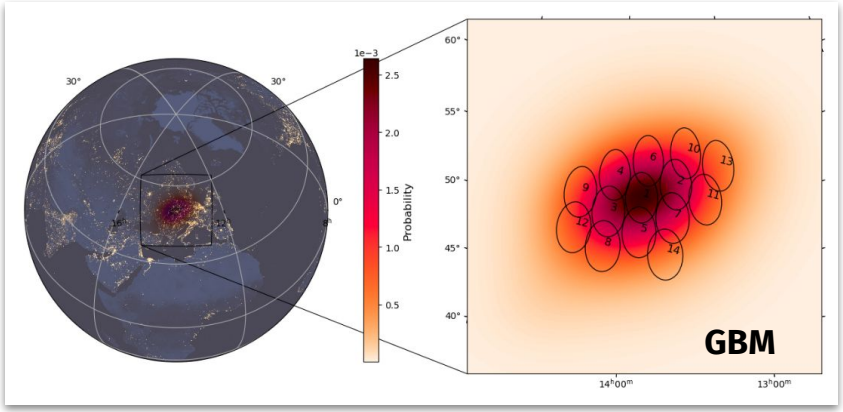
GRB 201216C

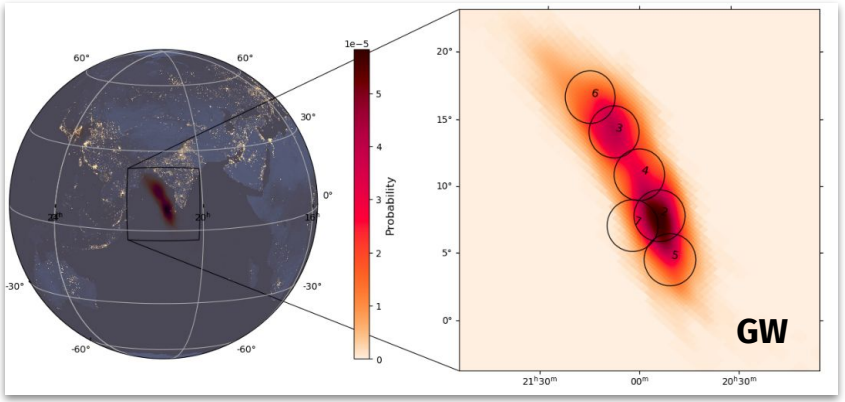


- **Triggered and located at 23:07:31 UT by Swift-BAT**
  - T_{90} ~ 48 s
  - Relatively low (for GRB) redshift (z = 1.1)
  - E_{iso} ~ 6.2 × 10^{53} erg
  - Detected by MAGIC

observed by LST-1 only the night after (transient handler not yet operational). No detection achieved but promising test-bench for MAGIC-LST combined observations on GRBs

Future Improvements





- **Major challenge: large localization alerts → GBM-like GRBs & GW**
  - localization uncertainty ranging from 10-1000 deg^2
  - optimizing pointing strategy for tiling observations
- **Fully automatic follow-up procedure**
  - To take advantages of fast repointing speed of LST-1
  - First tests already this summer

Conclusions

- The LST-1 prototype, the first 23-m class telescope foreseen for the Cherenkov Telescope Array, is finalizing its commissioning phase and gradually entering regular scientific operations
- Starting from the beginning of 2021, transient alerts are regularly received by means of a dedicated transient handler allowing follow-up observations in a multi-messenger context
- No detection has been achieved so far, although the number of observed alerts is still rather limited and observation procedures are not yet optimized
- A fully automatic follow-up procedure is currently under development allowing in the near future the rapid repositioning of the telescope and the exploitation of its full scientific capabilities. At the same time, improvements in the tiling observation strategy will allow the extensive follow-up of large localization alerts such as GBM GRBs and GW
- The synergies with MAGIC will represent a key role in the forthcoming years and an important test-bench for the full CTA