Highlights from the H.E.S.S. GRB program

And a few notes on synergies between THESEUS and the Cherenkov Telescope Array

Irfu - CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

Fabian Schüssler

université PARIS-SACLAY

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The H.E.S.S. Transient program

Flaring stars

CVs / Novae

Supernovae

Gamma-ray Bursts

Gravitational Waves

Gamma-ray Binaries

Microquasars

Unknowns

Active Galactic nuclei

Tidal Disruption Events

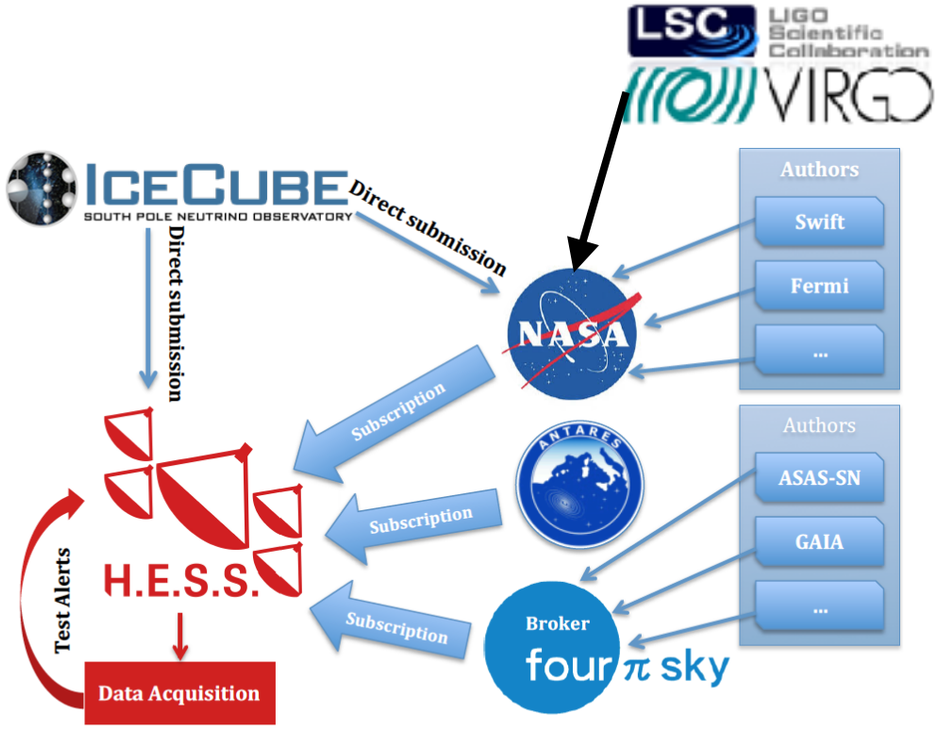
Neutrinos

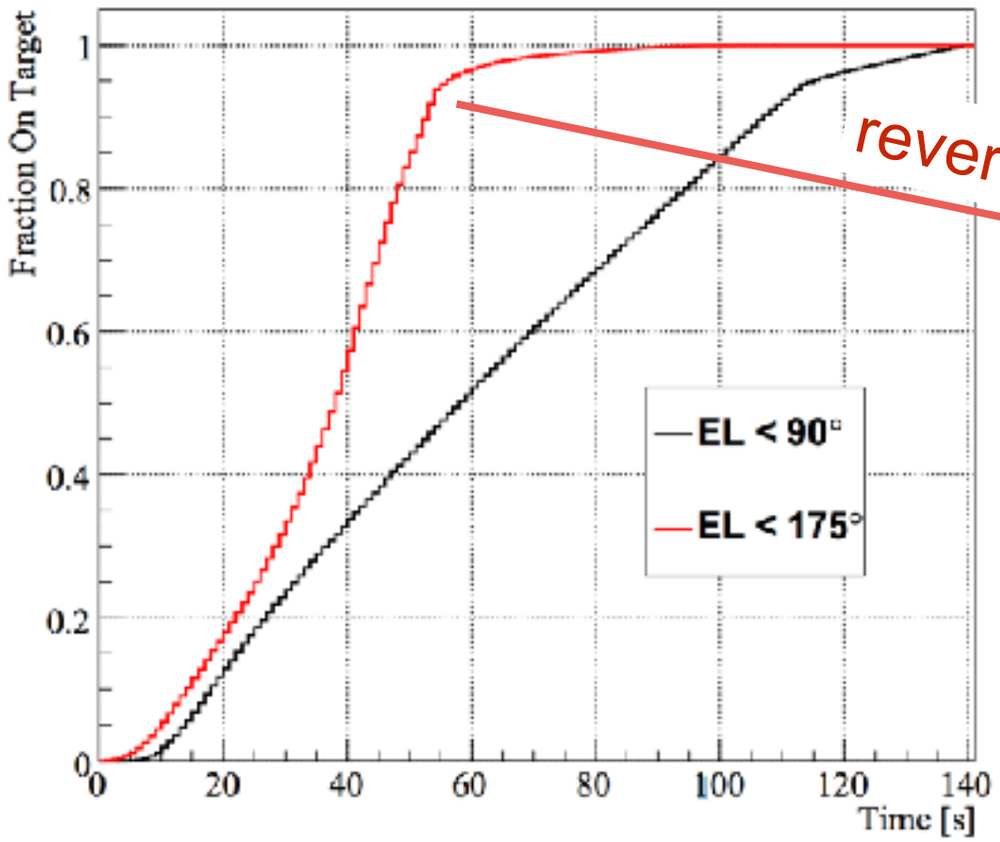
Fast Radio Bursts

Soft Gamma-ray Repeaters

The H.E.S.S.-II response to ToOs

- main design principles of the H.E.S.S. 28m telescope
  - large photon collection area (614 m² mirror area; largest IACT worldwide)
  - **rapid response time**
  - **flexible + fully automatized alert system**
  - **real-time data analysis**

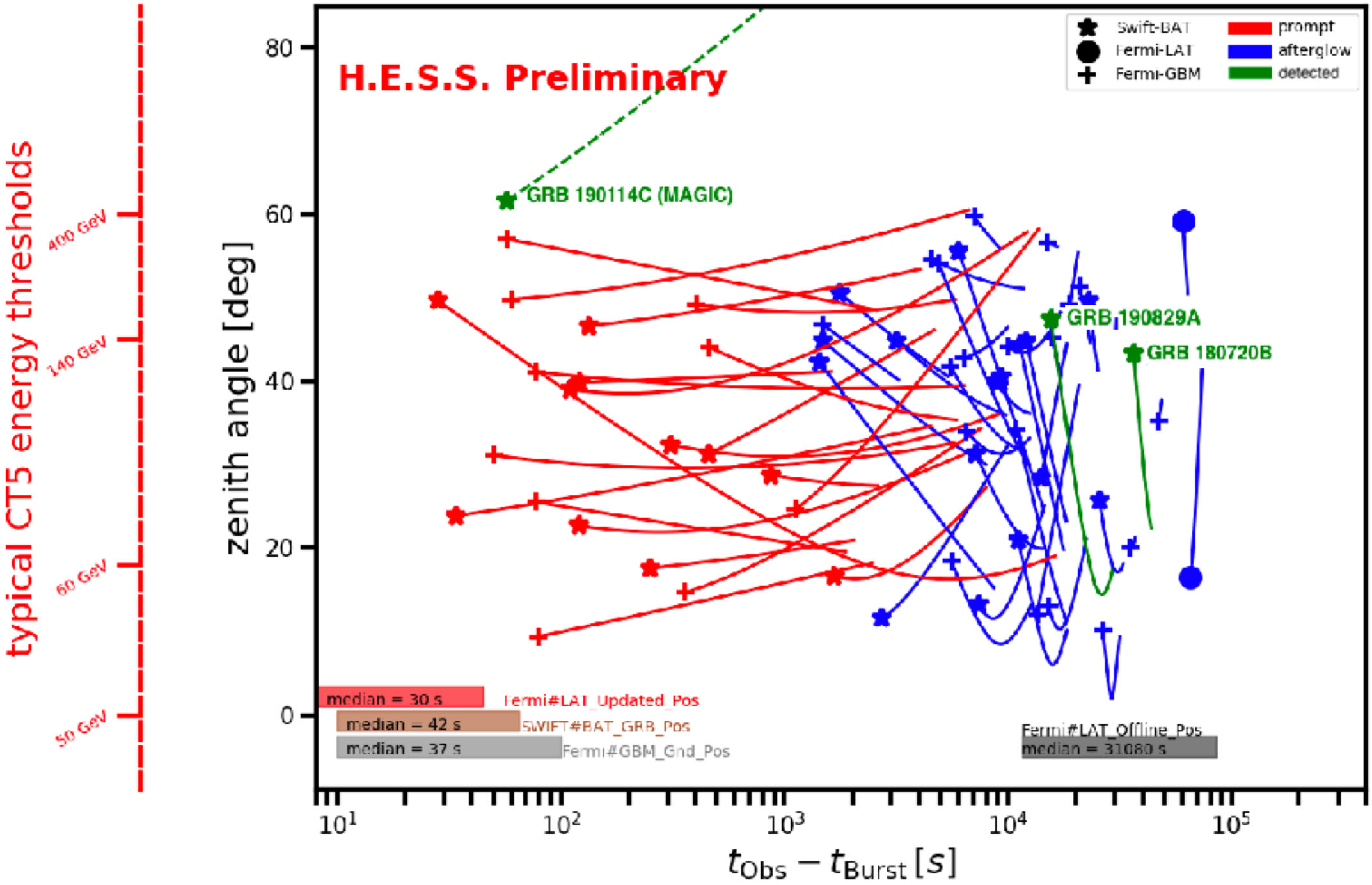




reverse tracking

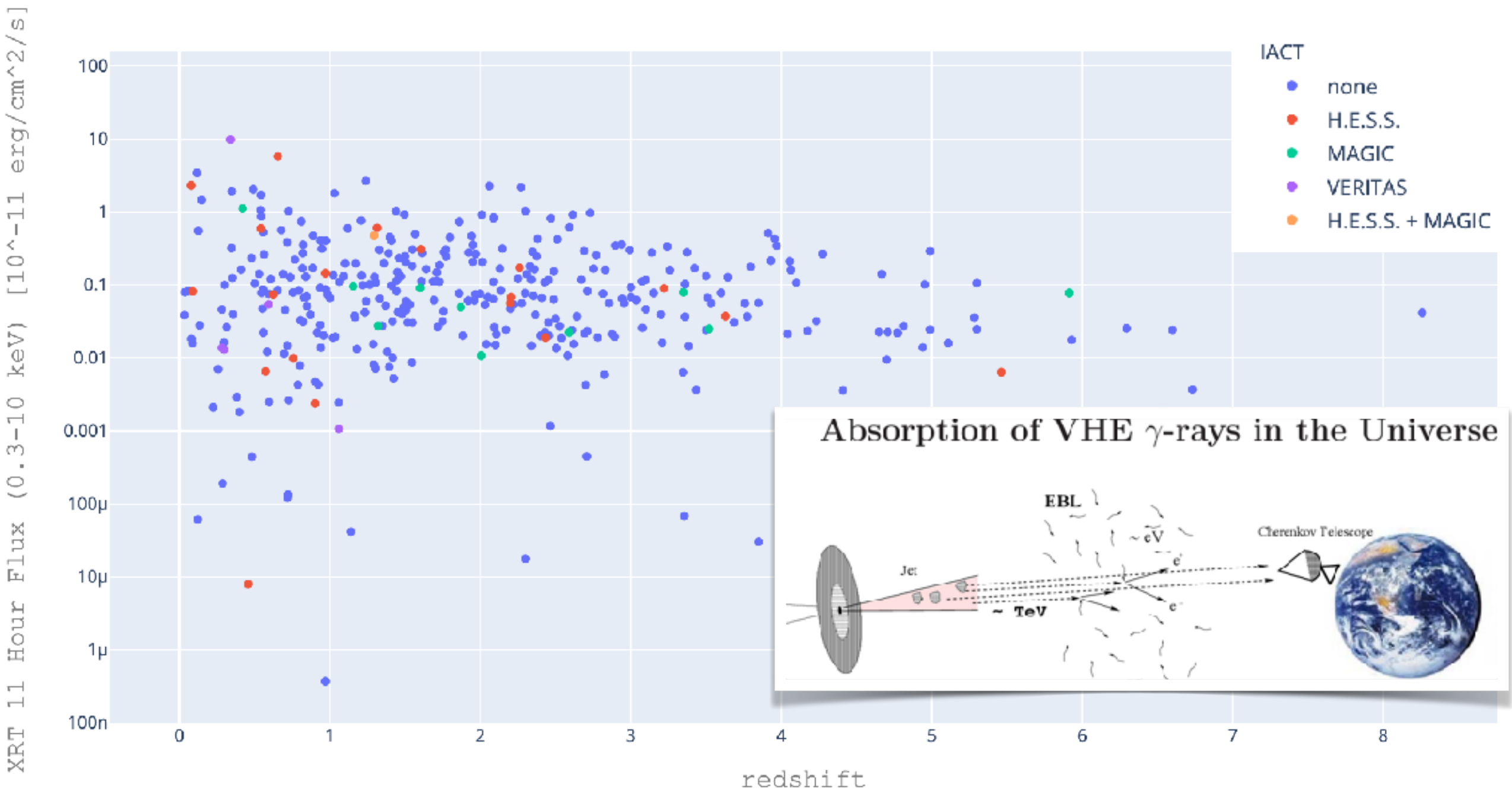
Hofverberg et al., ICRC 2013

Hunting VHE emission of GRBs with H.E.S.S.



Updated from C. Hoischen et al., PoS(ICRC2017)636

GRB observations with IACTs

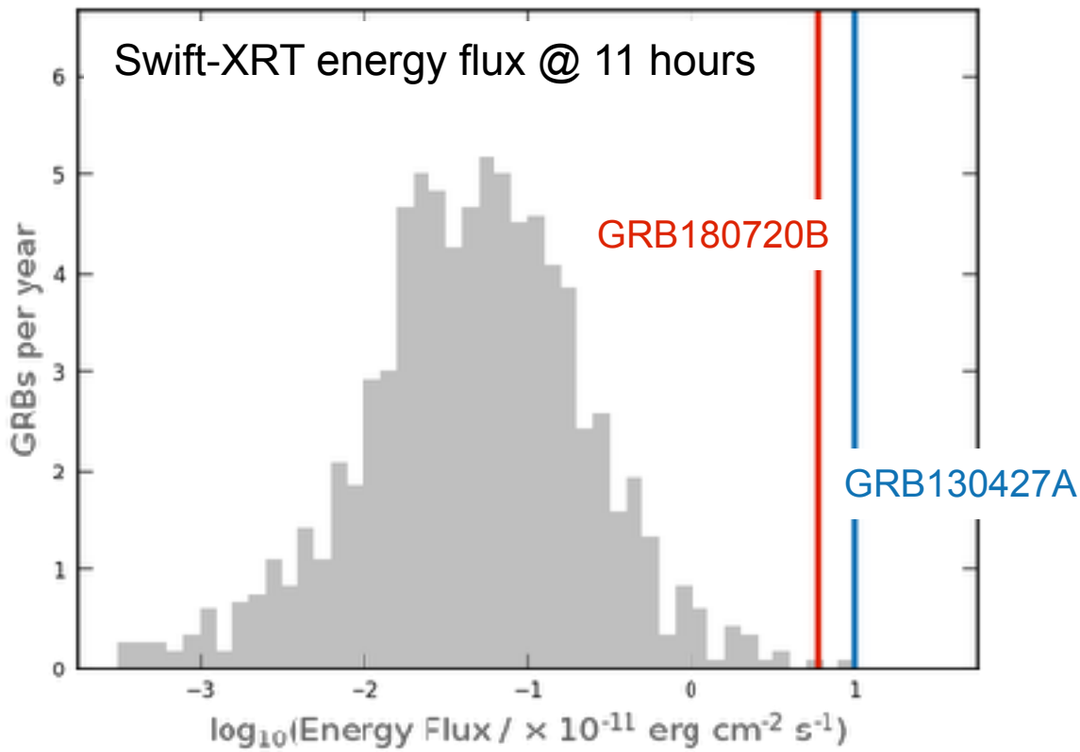


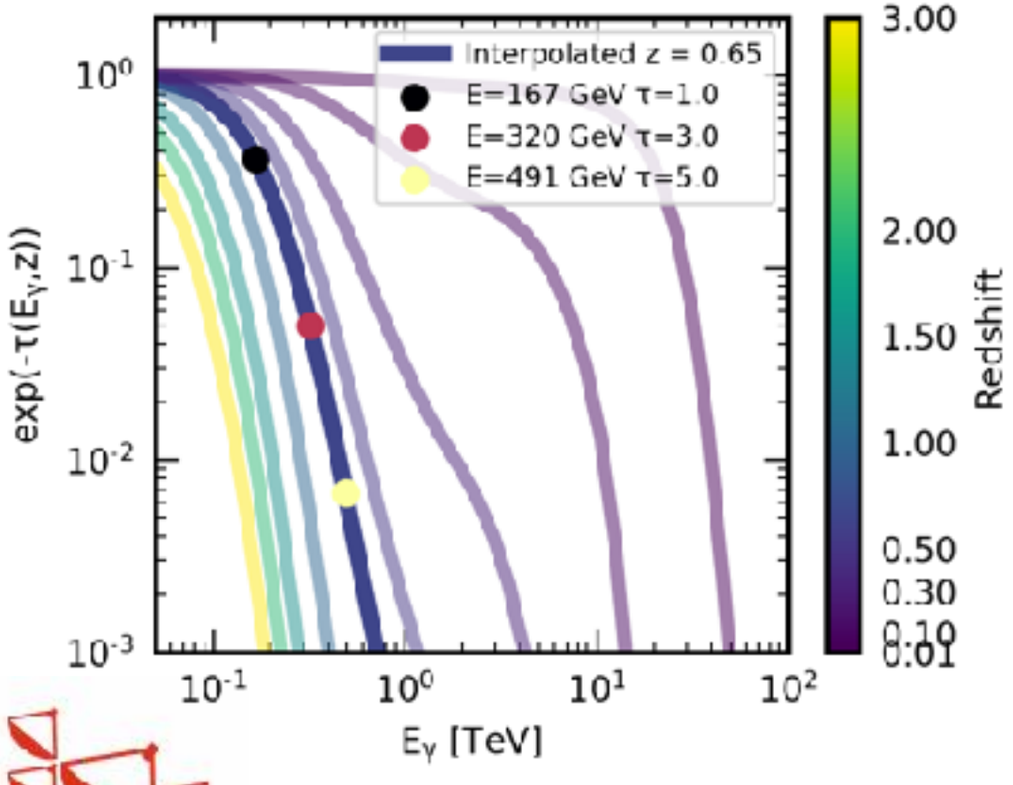
Recent news on Gamma Ray Bursts @ IACTs

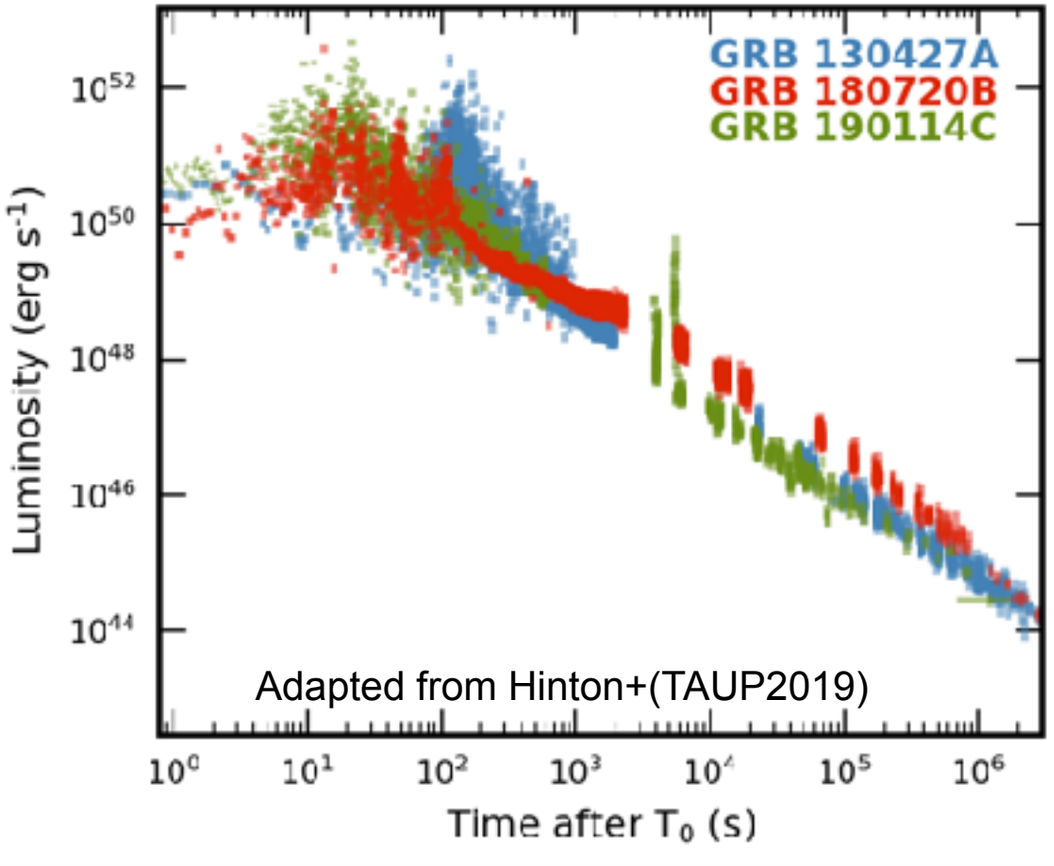
- short-GRB 160821B @ MAGIC: hint for detection (arXiv:2012.07193), later associated with a kilonova (Lamb et al. 2019 arXiV:1905.02159)
- GRB 180720B @ H.E.S.S.: >100GeV emission 10h after the burst (*Nature* **575,** 464–467 (2019))
- GRB 190114C @ MAGIC: >300GeV emission 50s after the burst (*Nature* **575,** 459 (2019))
- GRB 190829A @ H.E.S.S.: >5sigma; observations > 4h20 (ATEL #13052)
- GRB 201216C @ MAGIC: >5sigma, observations > 57s (ATEL #14275)
- …

H.E.S.S.: GRB180720B

- Triggered by Fermi-GBM and Swift-BAT
- Fermi-LAT detection until T_0+700s (E_{max} ≈5 GeV)
- Extremely bright burst (e.g. 2nd brightest XRT afterglow)
- Redshift: z = 0.653 (>99% absorption at ~500 GeV)

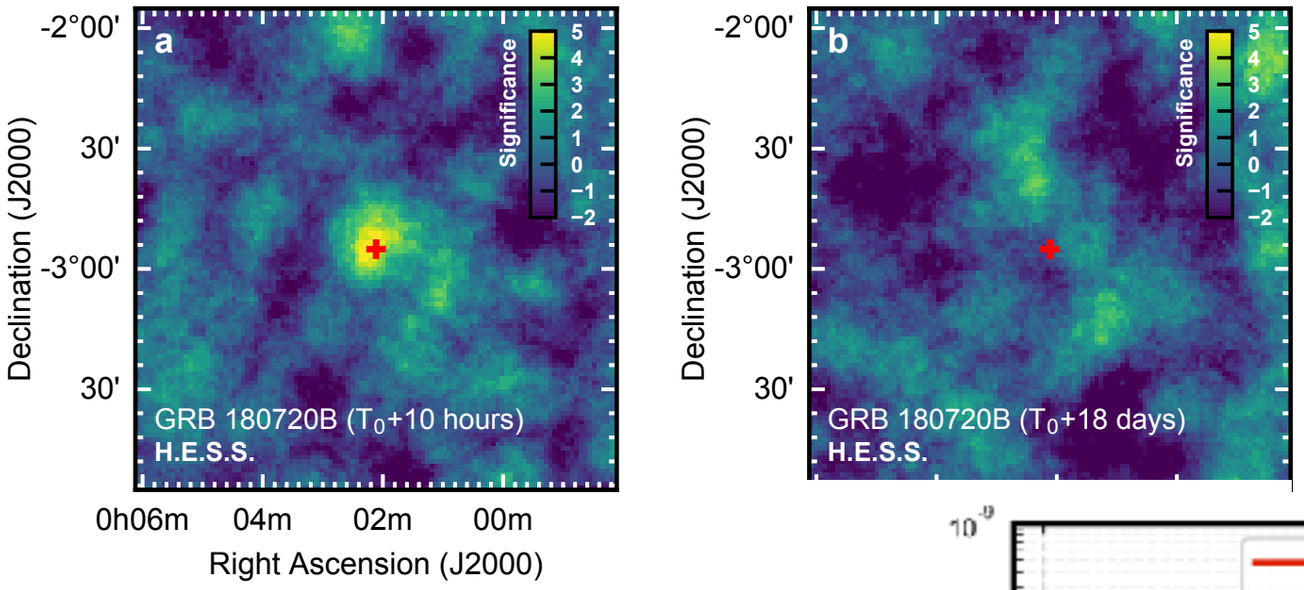


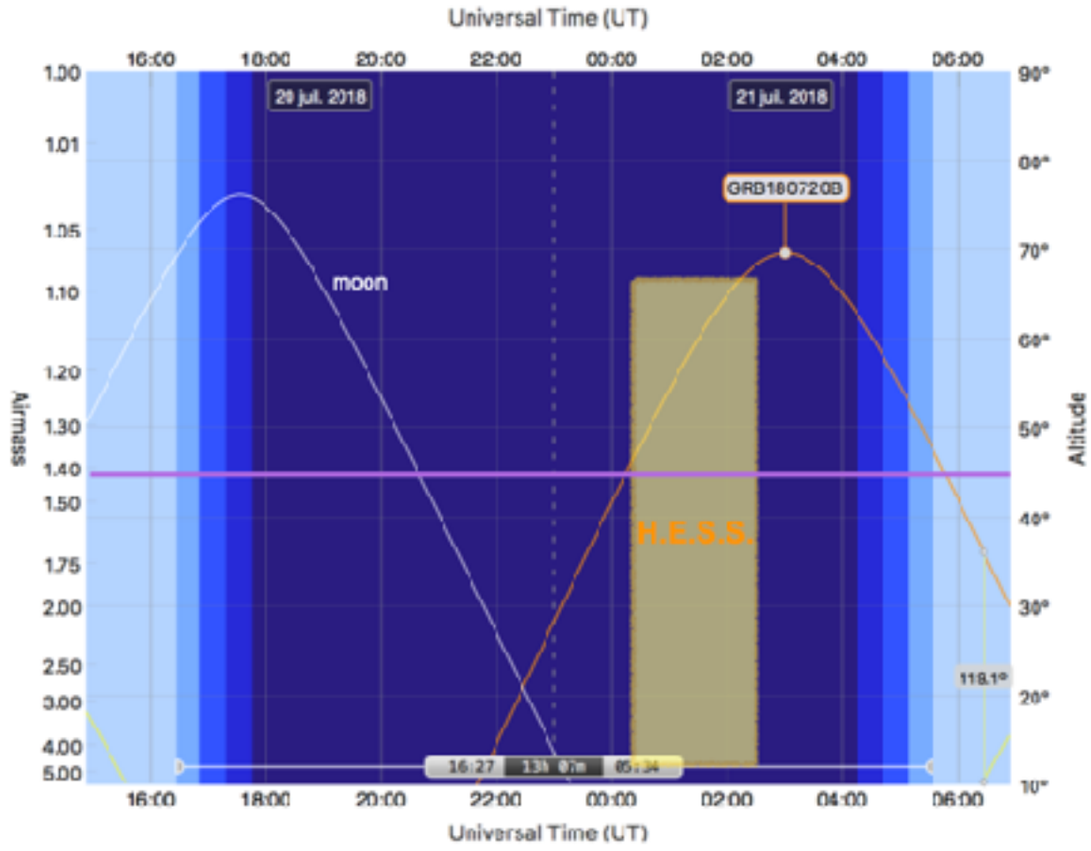


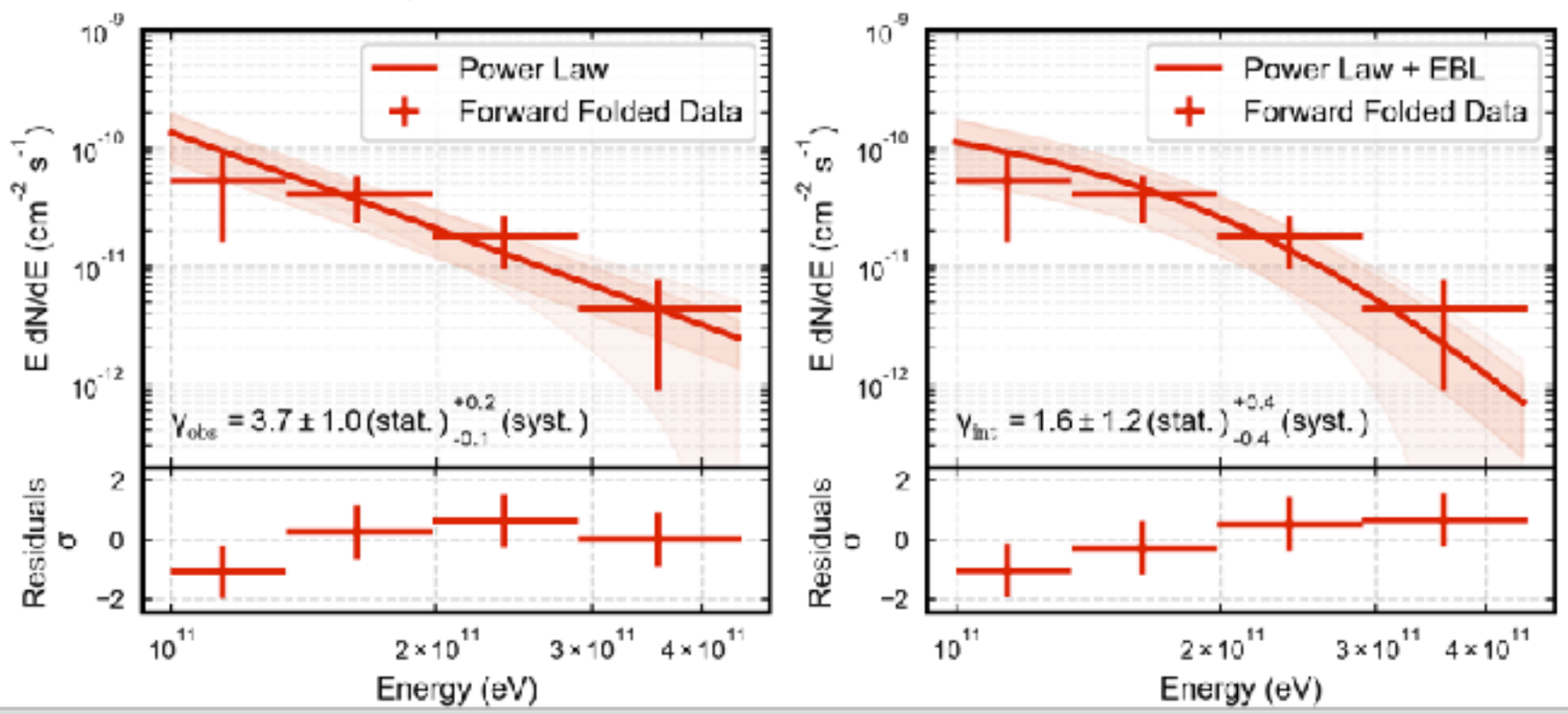


H.E.S.S.: GRB180720B

- Visibility constrains: observations starting ~10h after the burst !!
- 2h of data (zenith >45deg)

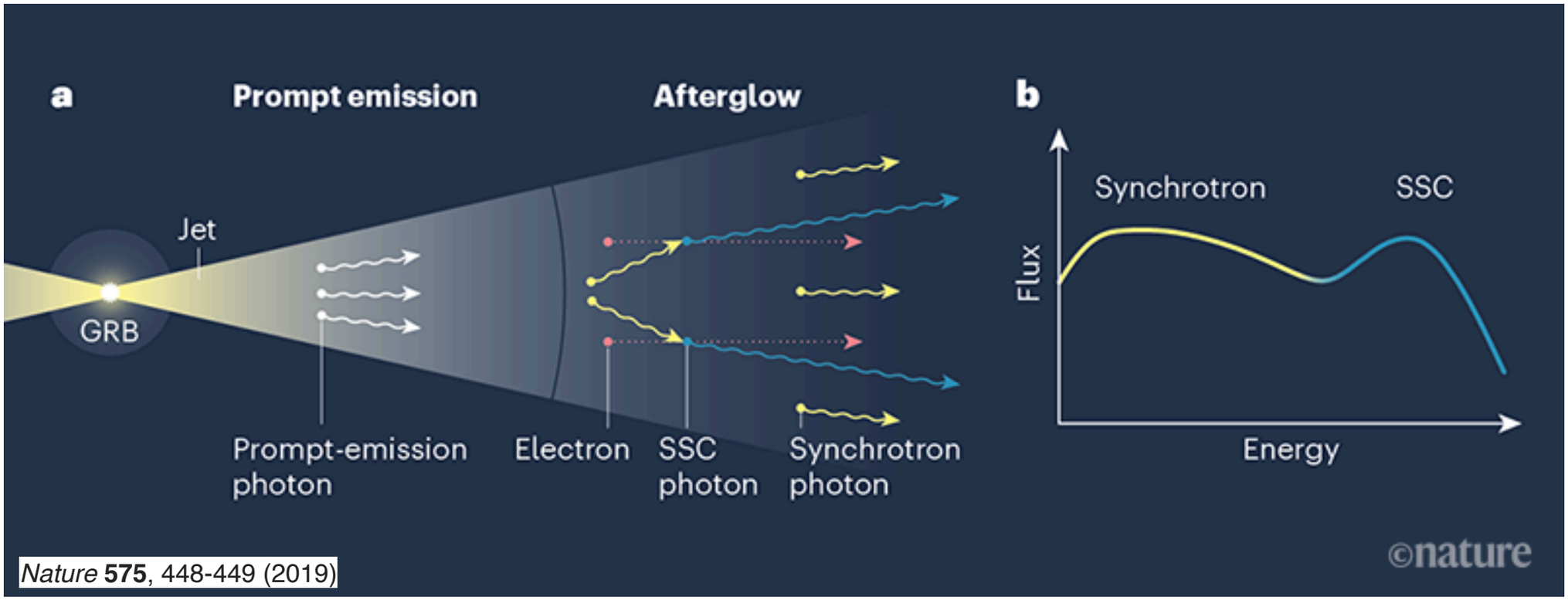






HESS Collaboration
Nature **575,** 464–467 (2019)

A second high-energy component

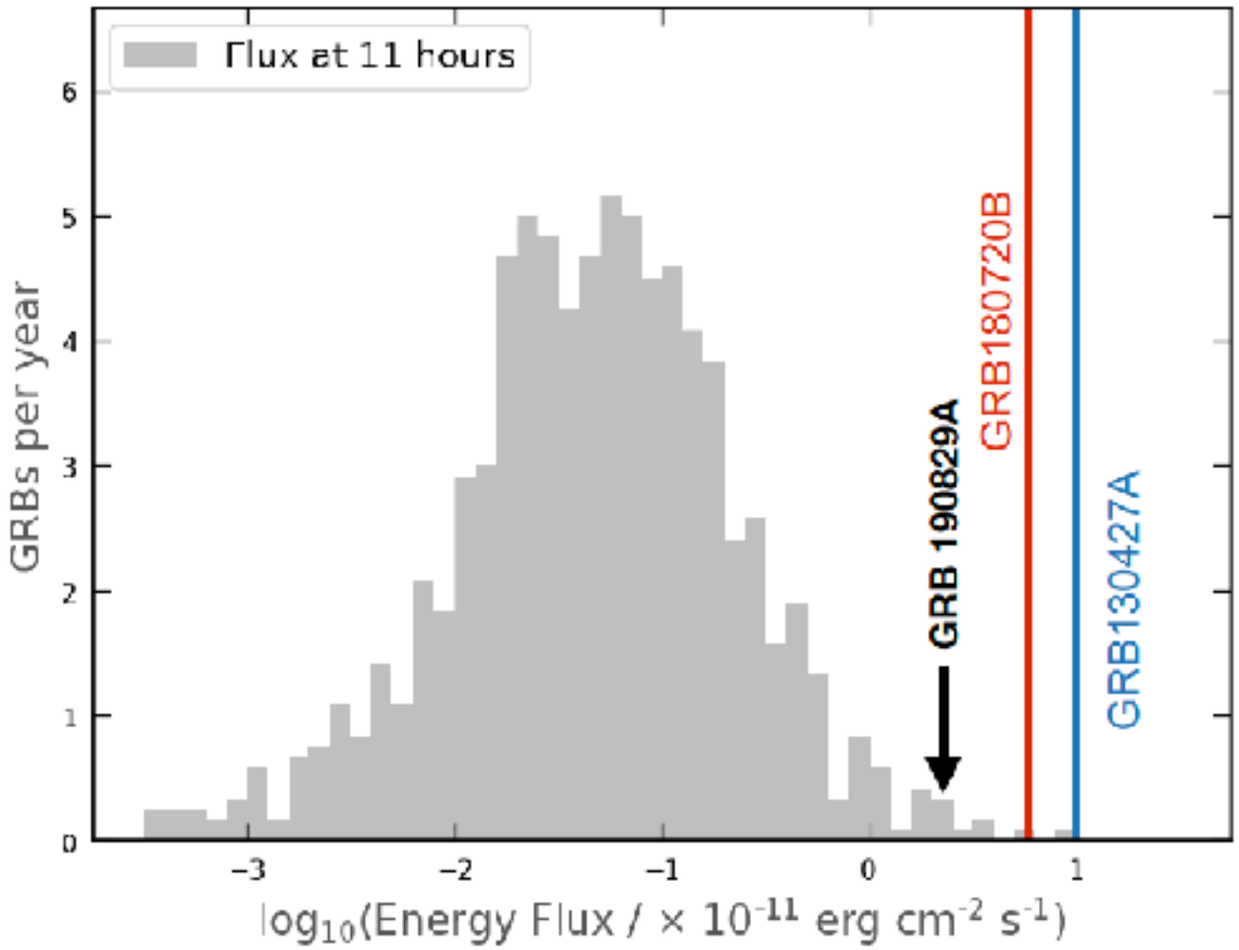


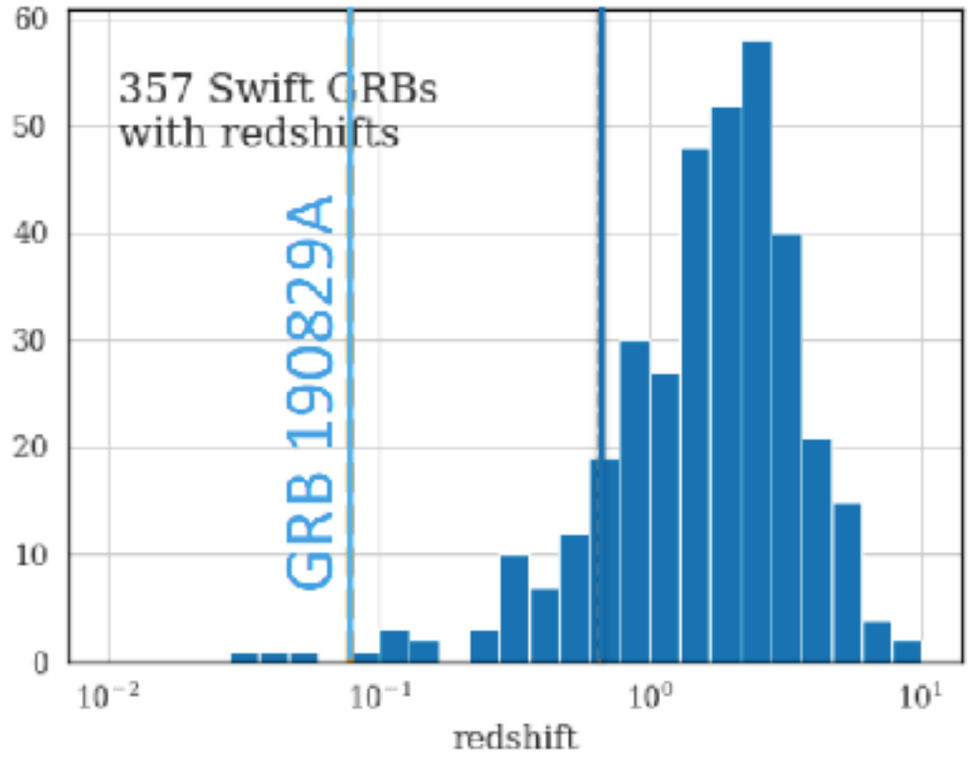
Nature **575**, 448-449 (2019)

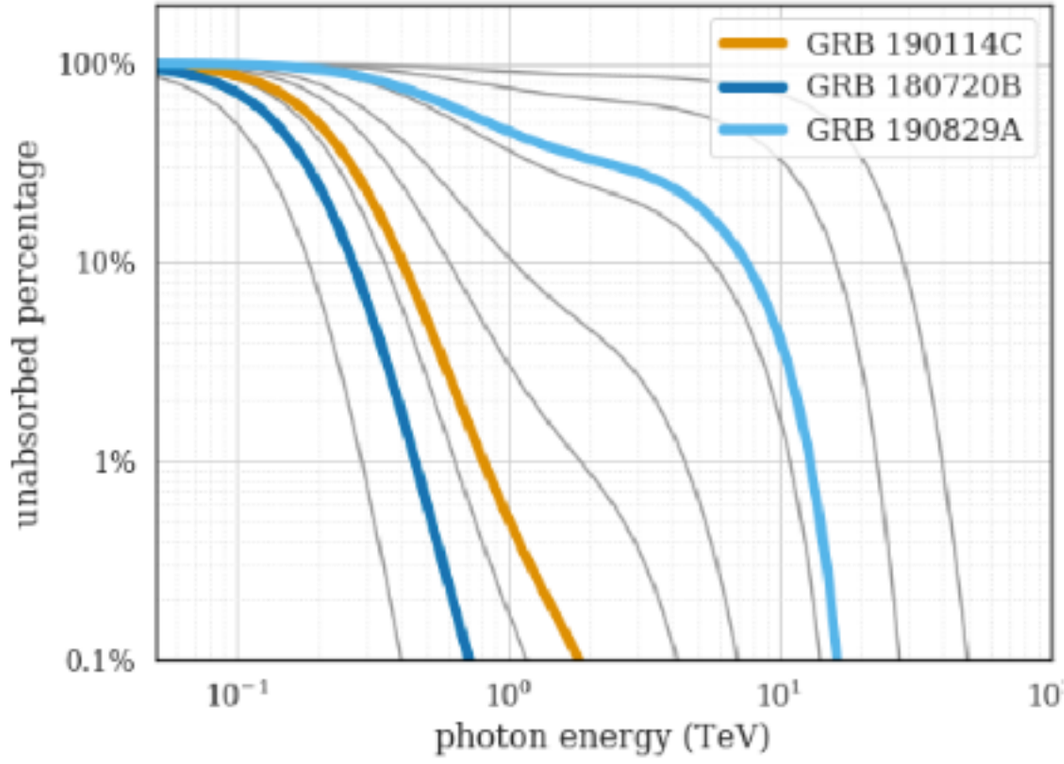
- Observation of the SSC component in GRBs
- X-rays and gamma-ray fluxes are of the same level
  - We were missing ~half of the emission in most previous GRB observations
- New questions
  - Is this true for all GRBs? What are the necessary conditions? …
  - How long does the VHE emission last? What is the maximum energy, efficiency,… ?
- Can we verify this with further observations (?)

H.E.S.S.: GRB190829A

- Extremely close burst: redshifts z = 0.0785
- Another very X-ray bright burst







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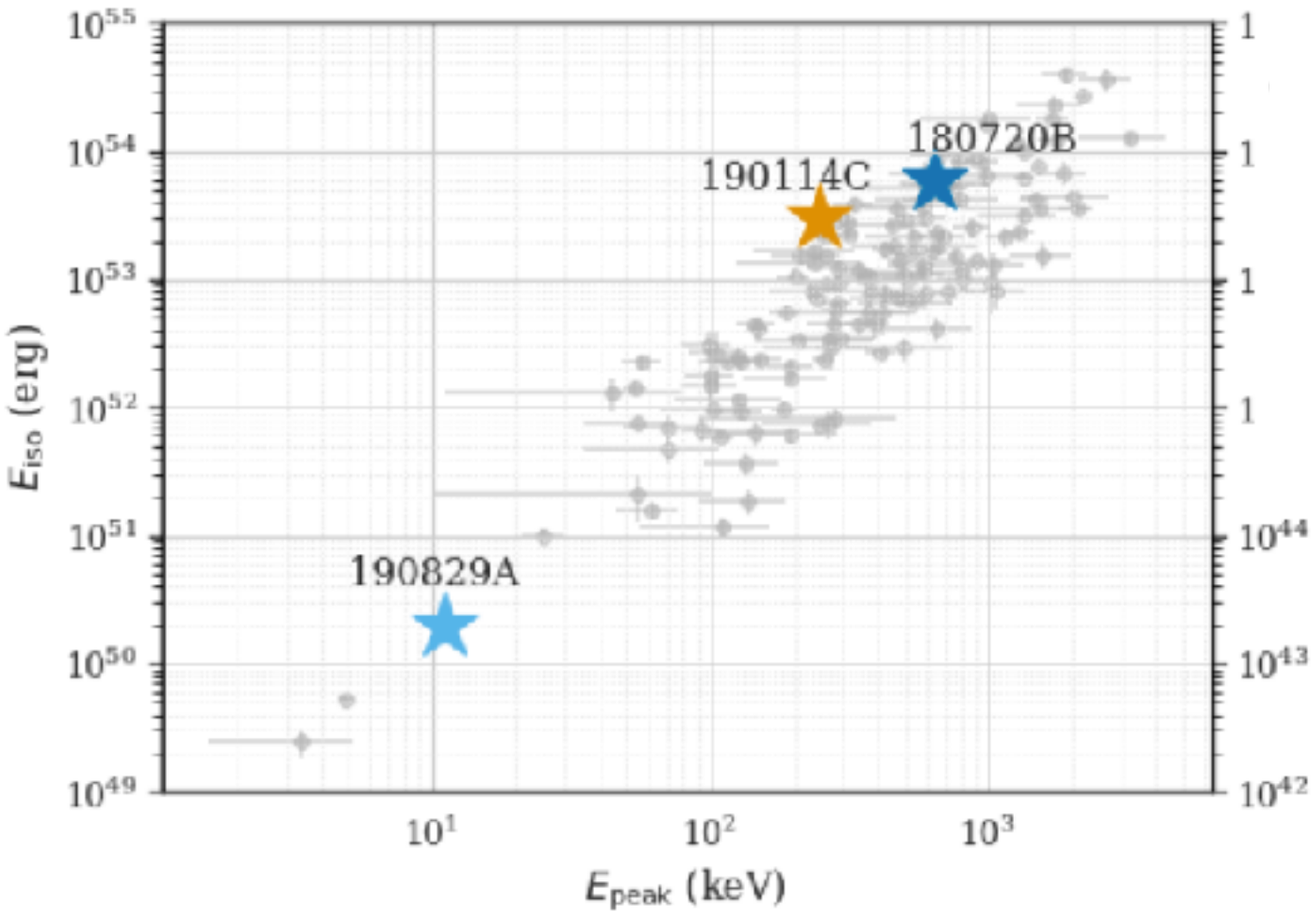
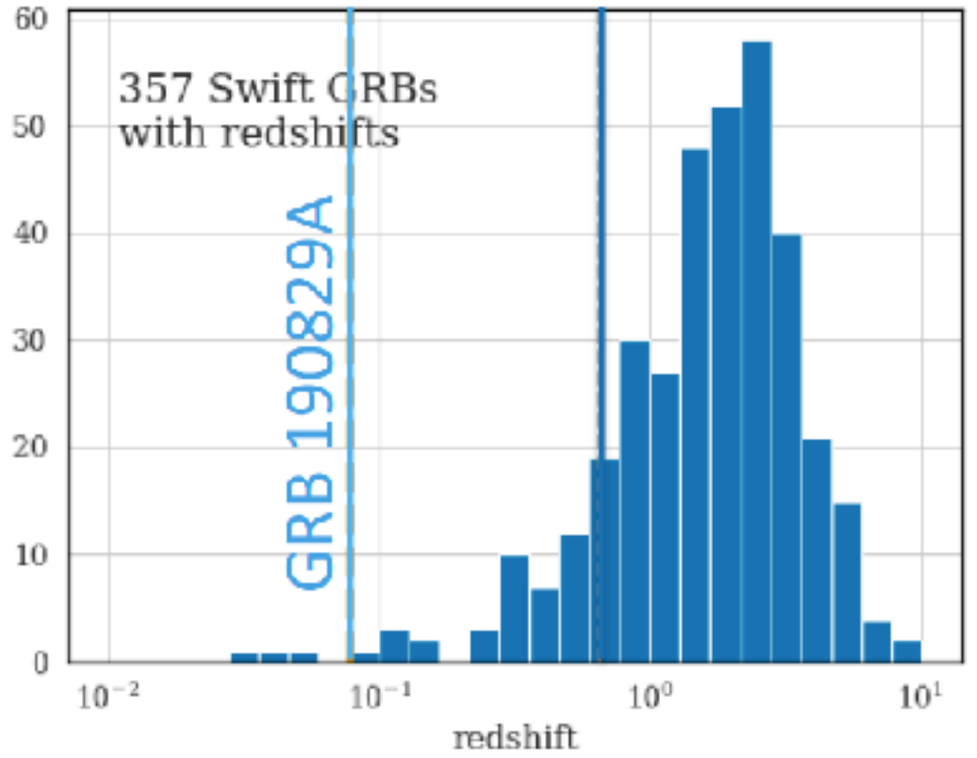
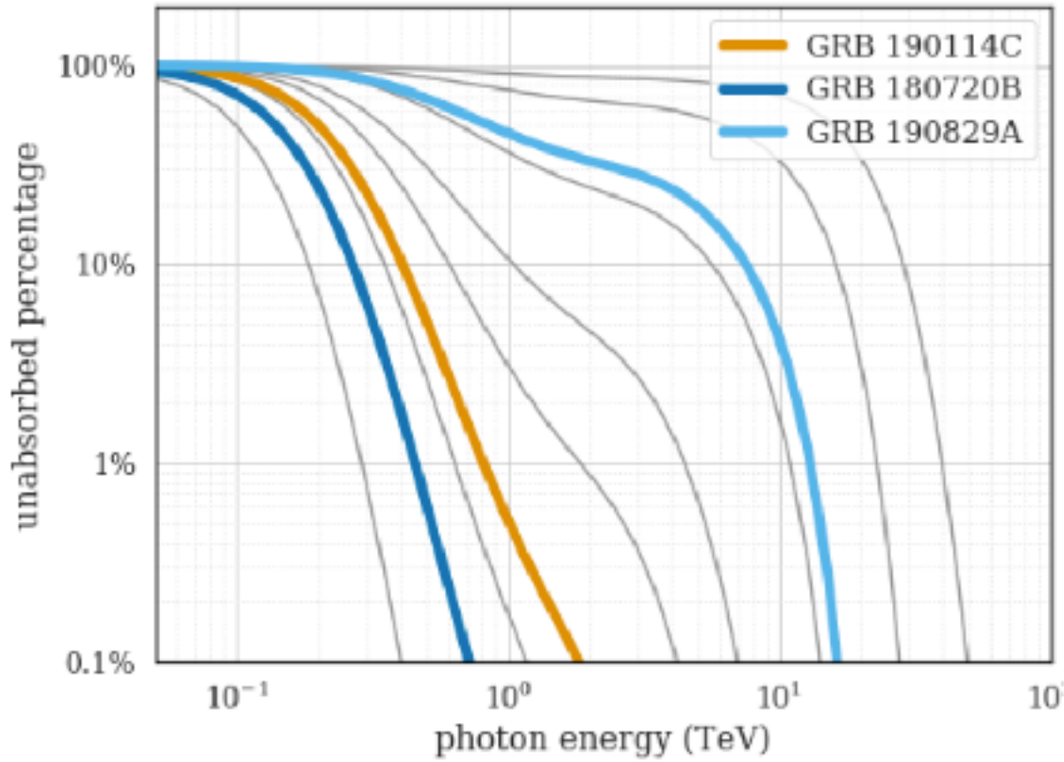
- A special burst: low E_{iso} + low E_{peak}







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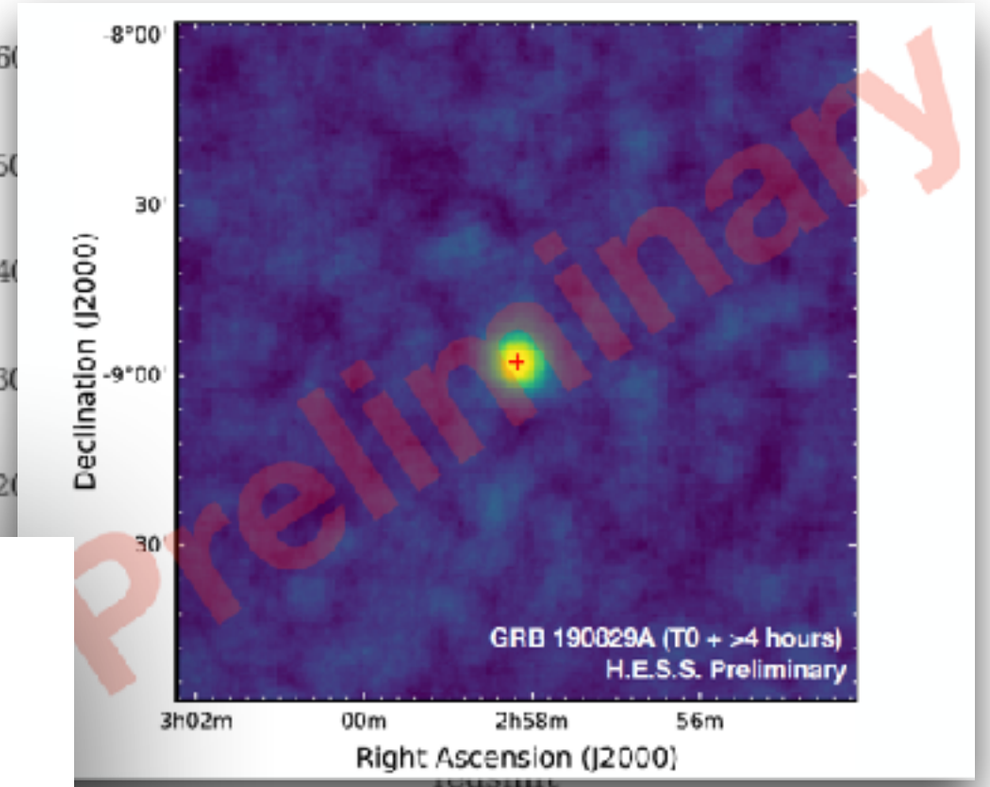

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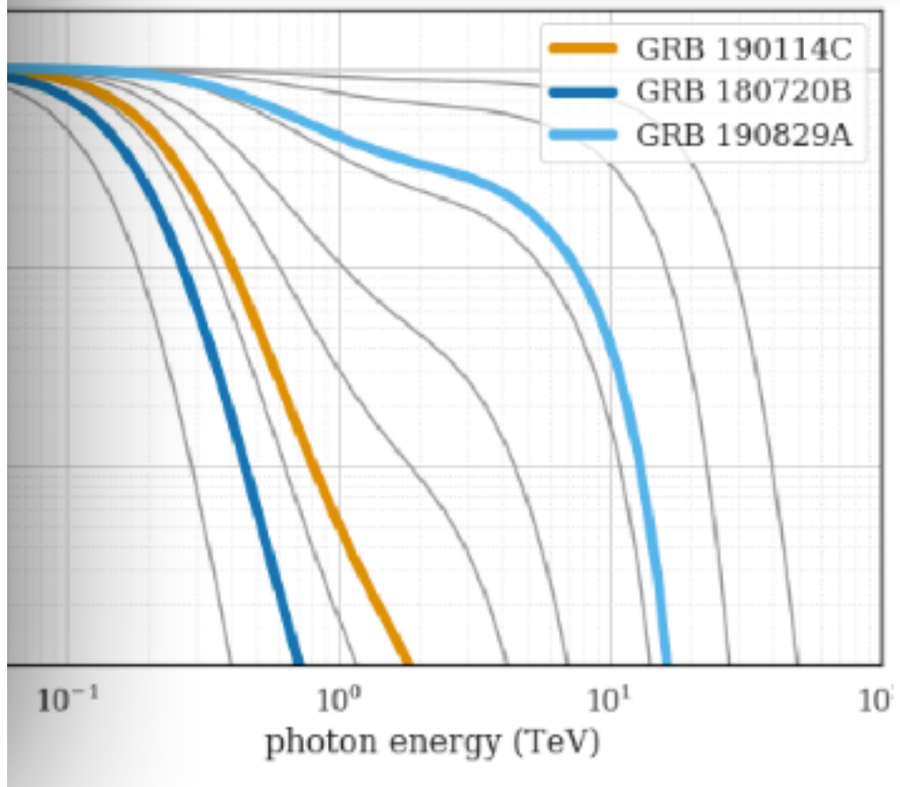
GRB190829A: Detection of VHE gamma-ray emission with H.E.S.S.

ATel #13052; *M. de Naurois (H. E.S. S. Collaboration)*
on 30 Aug 2019; 07:12 UT
Credential Certification: Fabian SchÃ fÂ¼ssler (fabian.schussler@cea.fr)

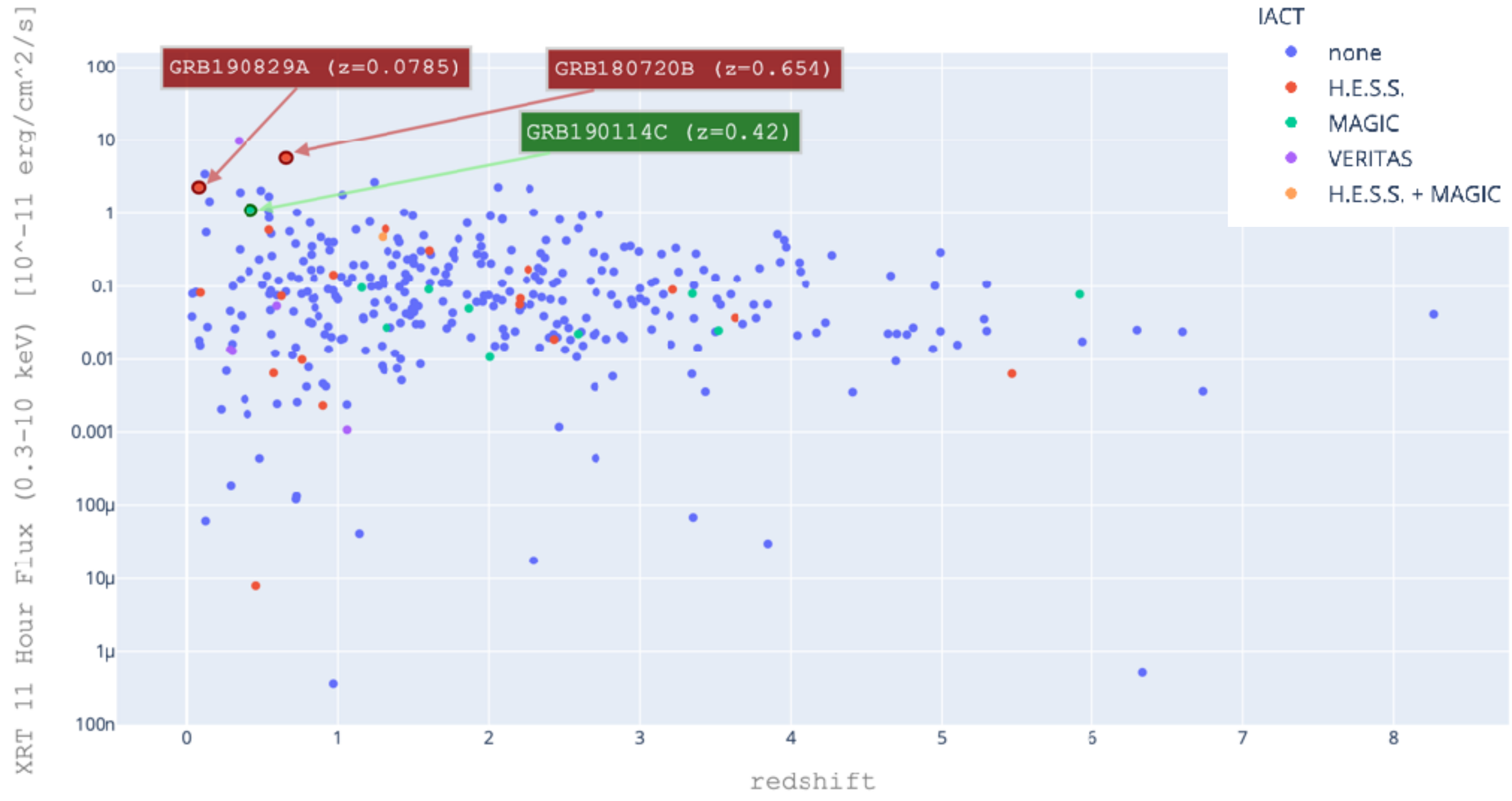
Subjects: Gamma Ray, >GeV, TeV, VHE, Gamma-Ray Burst

Tweet

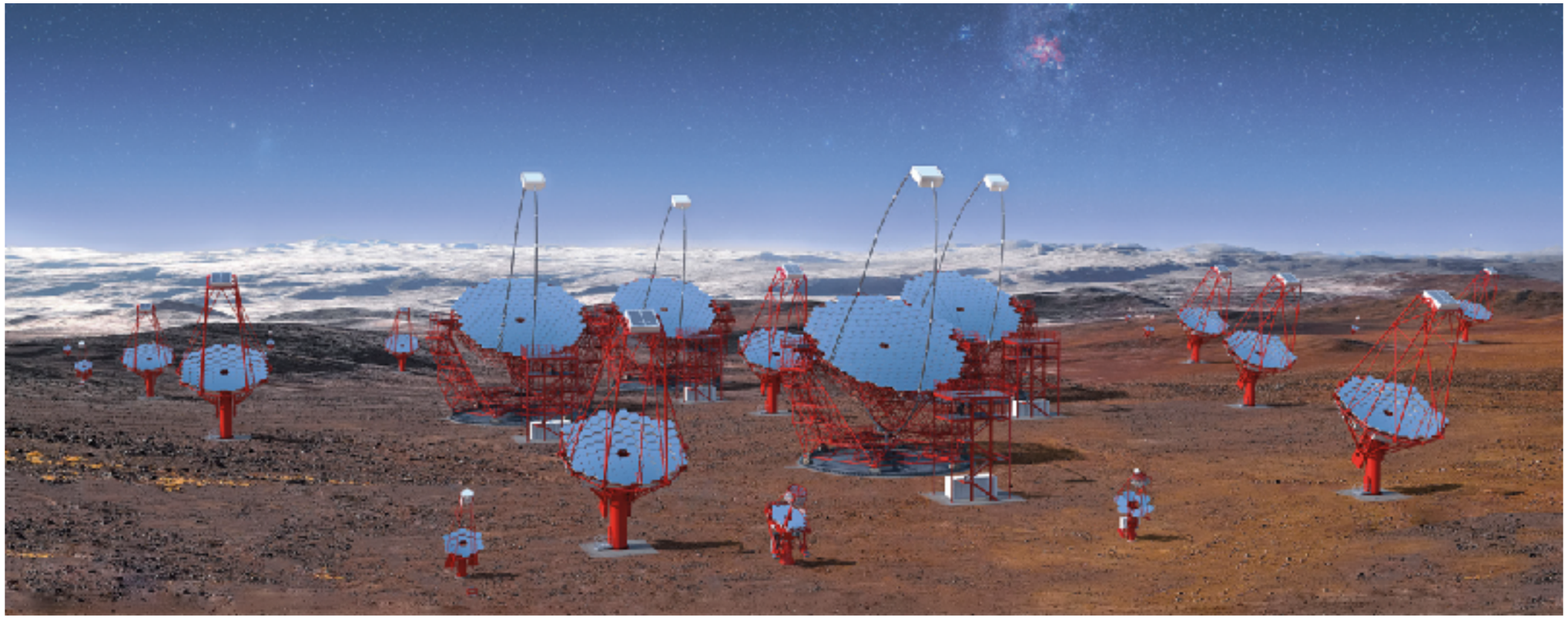
The H.E.S.S. array of imaging atmospheric Cherenkov telescopes was used to carry out follow-up observations of the afterglow of GRB 190829A (Dichiara et al., GCN 25552). At a redshift of z = 0.0785 +/- 0.005 (A.F. Valeev et al., GCN 25565) this is one of the nearest GRBs detected to date. H.E.S.S. Observations started July 30 at 00:16 UTC (i.e. T0 + 4h20), lasted until 3h50 UTC and were taken under good conditions. A preliminary onsite analysis of the obtained data shows a >5sigma gamma-ray excess compatible with the direction of GRB190829A. Further analyses of the data are on-going and further H.E.S.S. observations are planned. We strongly encourage follow-up at all wavelengths. H.E.S.S. is an array of five imaging atmospheric Cherenkov telescopes for the detection of very-high-energy gamma-ray sources and is located in the Khomas Highlands in Namibia. It was constructed and is operated by researchers from Armenia, Australia, Austria, France, Germany, Ireland, Japan, the Netherlands, Poland, South Africa, Sweden, UK, and the host country, Namibia. For more details see https://www.mpi-hd.mpg.de/hfm/HESS/

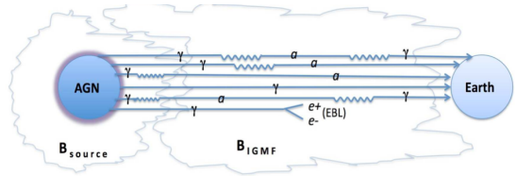


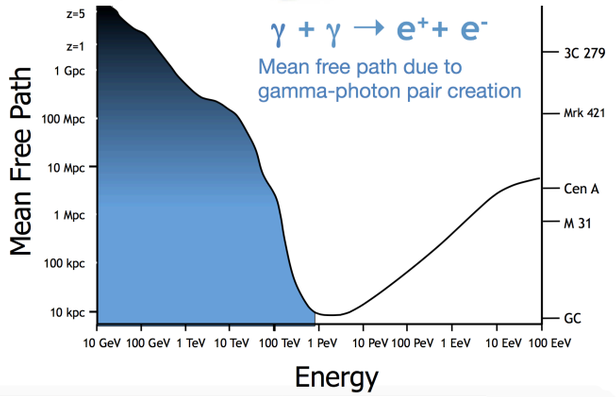
GRB observations with IACTs

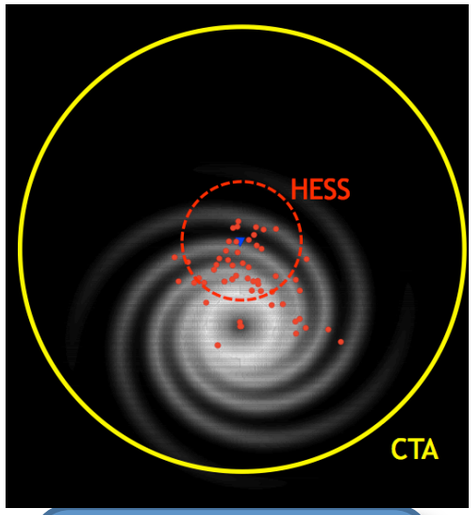


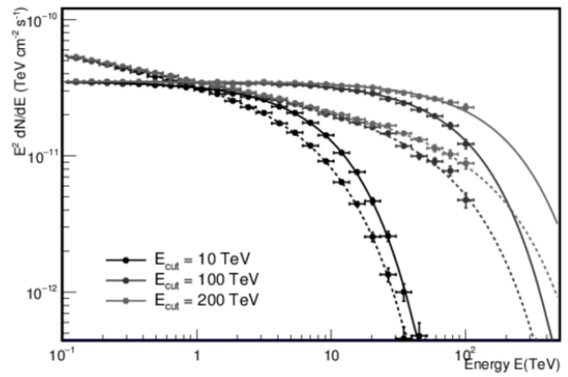
The Cherenkov Telescope Array

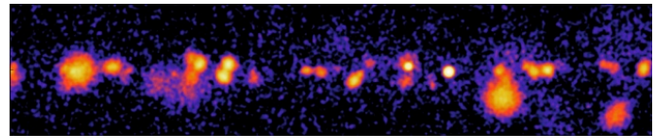


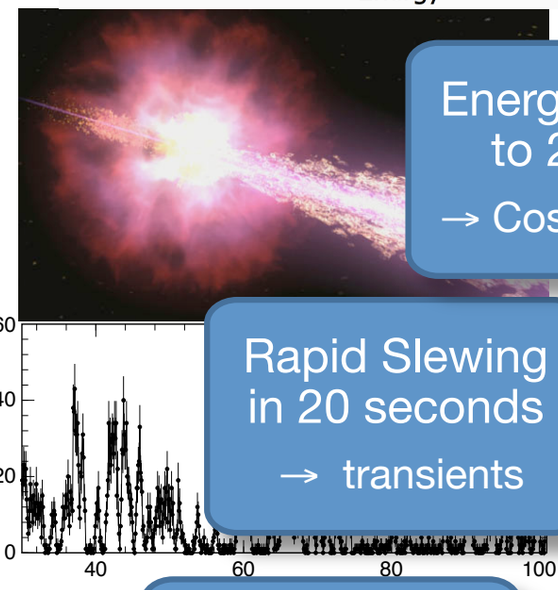


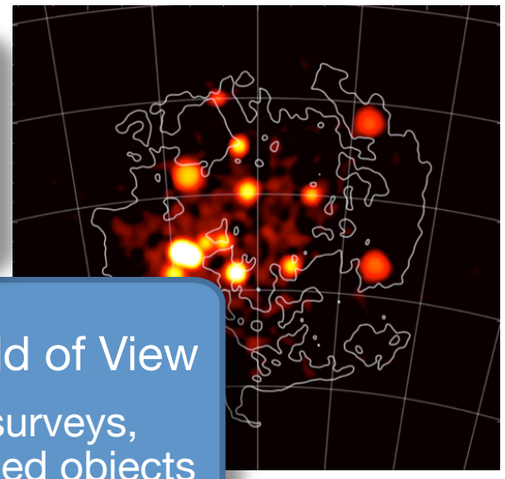


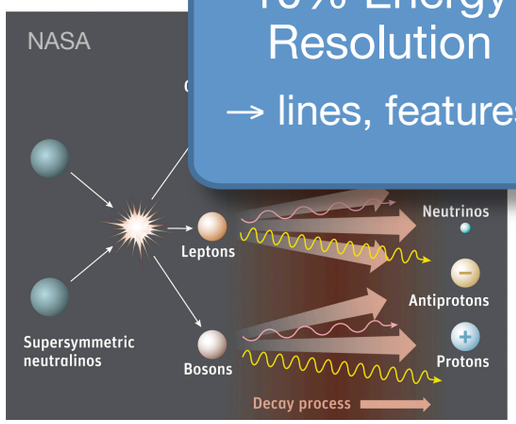


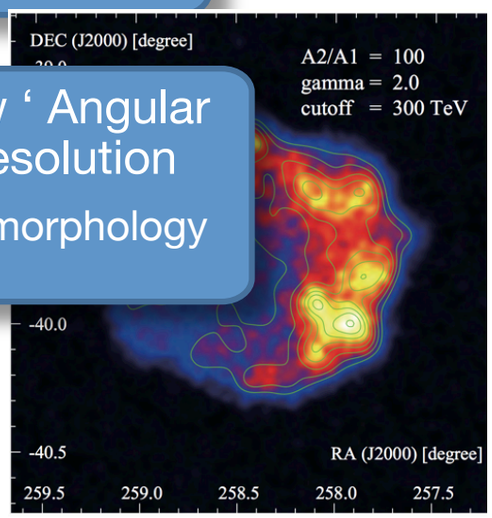












10 x Sensitivity, Large Collection Area
→ all topics

Energies down to 20 GeV
→ Cosmology++

Energies up to 300 TeV
→ Pevatrons

Rapid Slewing in 20 seconds
→ transients

8° Field of View
→ surveys, extended objects

10% Energy Resolution
→ lines, features

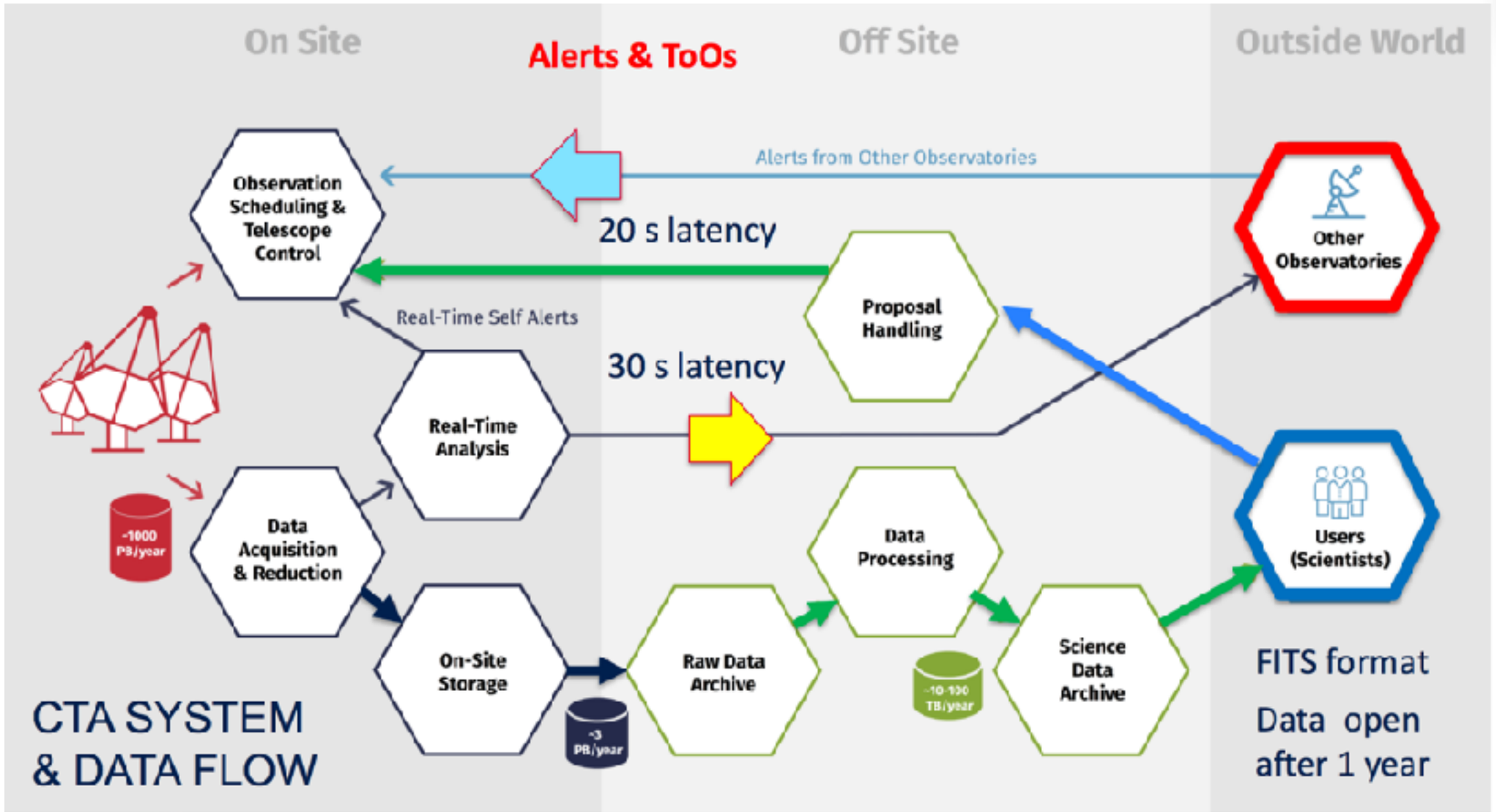
Few ‘ Angular Resolution
→ morphology

cta
cherenkov telescope array

H.E.S.S.

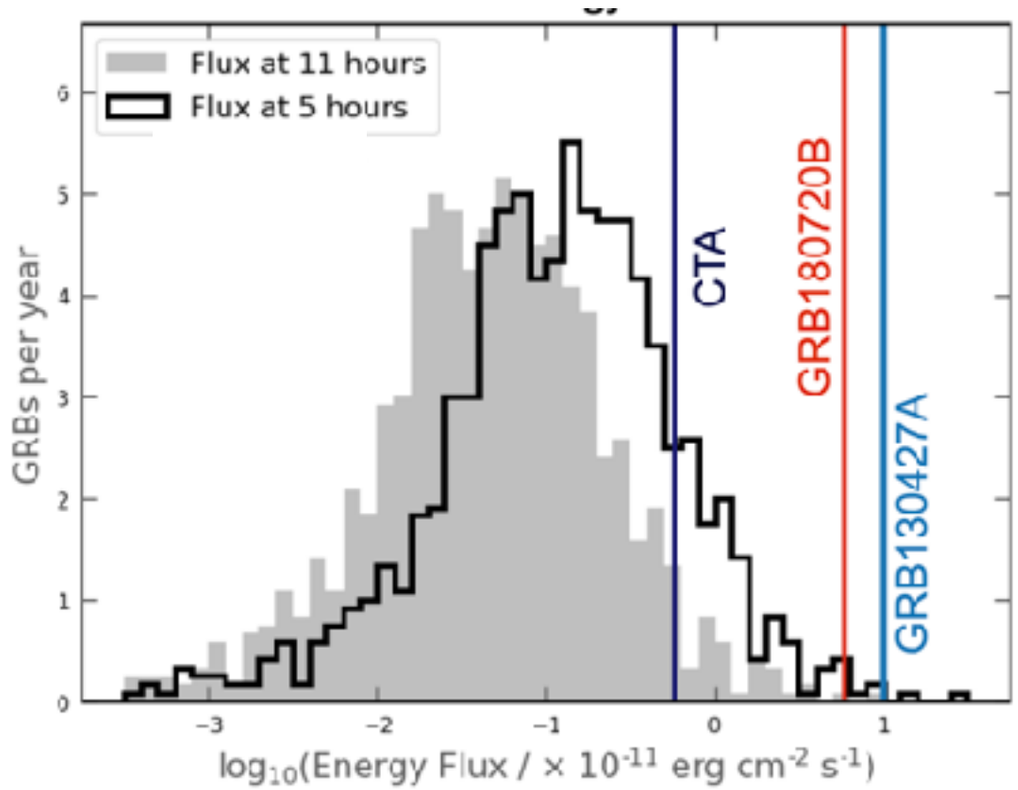
The CTA Transient program

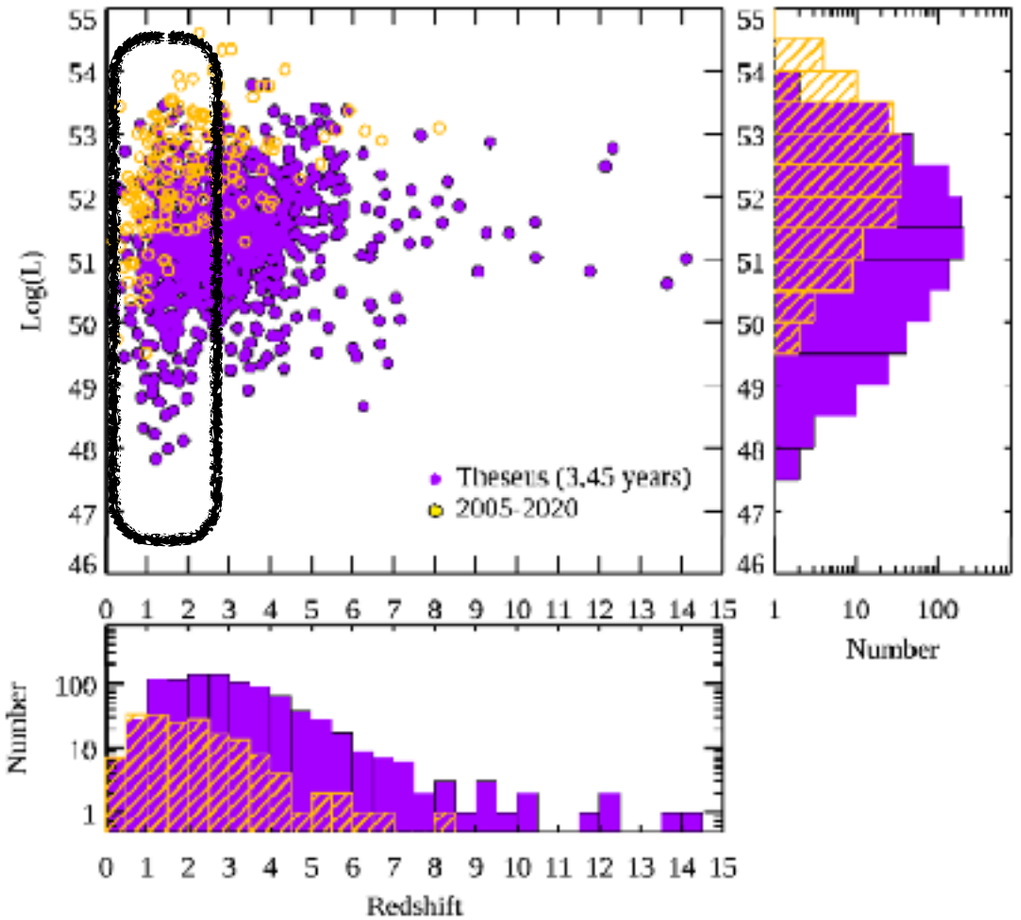
- Transients are integral part of the CTA ”Key Science Projects”
  - Observation time allocated to the CTA consortium
- THESEUS timescale: transfer to open observatory time



Outlook: GRB detections with CTA

- ~10 times better sensitivity => increase detections + probe deeper into the afterglow
- Rapid slewing of the LSTs => catch parts of the prompt phase (?)
- Synergies with THESEUS:
  - Increased parameter space (low luminosities, etc.)
  - Localisation of short GRBs associated to GWs
  - …

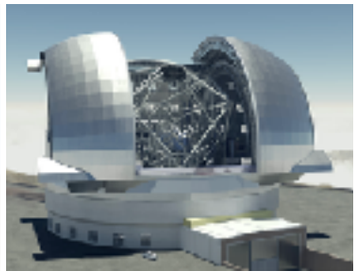


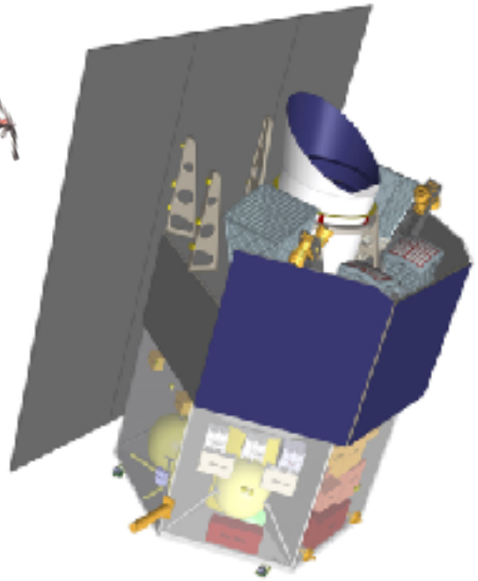


Highlights of the H.E.S.S. GRB program

- **Several years of preparation coming to fruition**
  - automatic alert systems + dedicated data analysis tools + motivated BAs + …
- **Gamma Ray Bursts**
  - major breakthroughs over the last years (GRB180720B, GRB190929A)
  - Answering many questions
    - Are GRB emitting at TeV energies? In the afterglow phase?
  - But also raising new ones
    - Are all GRBs emitting at TeV energies? What are the necessary conditions? What is the maximum energy? How does the emission scale with jet opening and/or observation angle (cf. GRB170817)? etc. etc.
  - H.E.S.S. aims at answering some of them in the next years

- **Great prospects for CTA!**
- **Great synergies between THESEUS and CTA!**



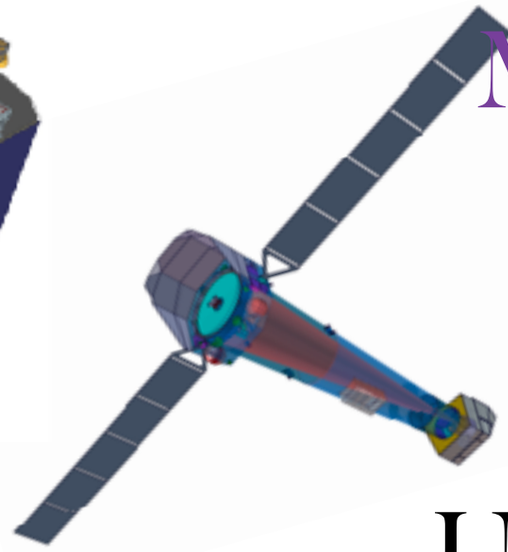
Gamma-ray Binaries

Microquasars

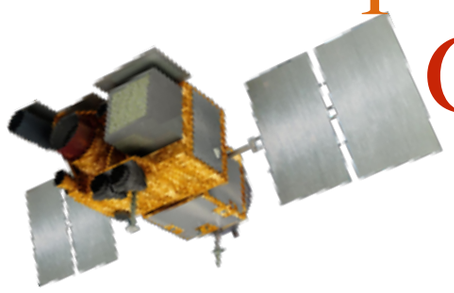
Flaring stars

CVs / Novae

Supernovae



Gamma-ray Bursts



Unknowns

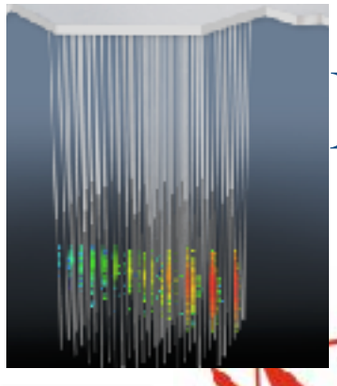
Gravitational Waves


Active Galactic nuclei

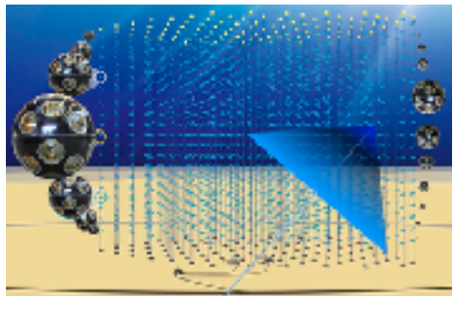
Tidal Disruption Events

Fast Radio Bursts

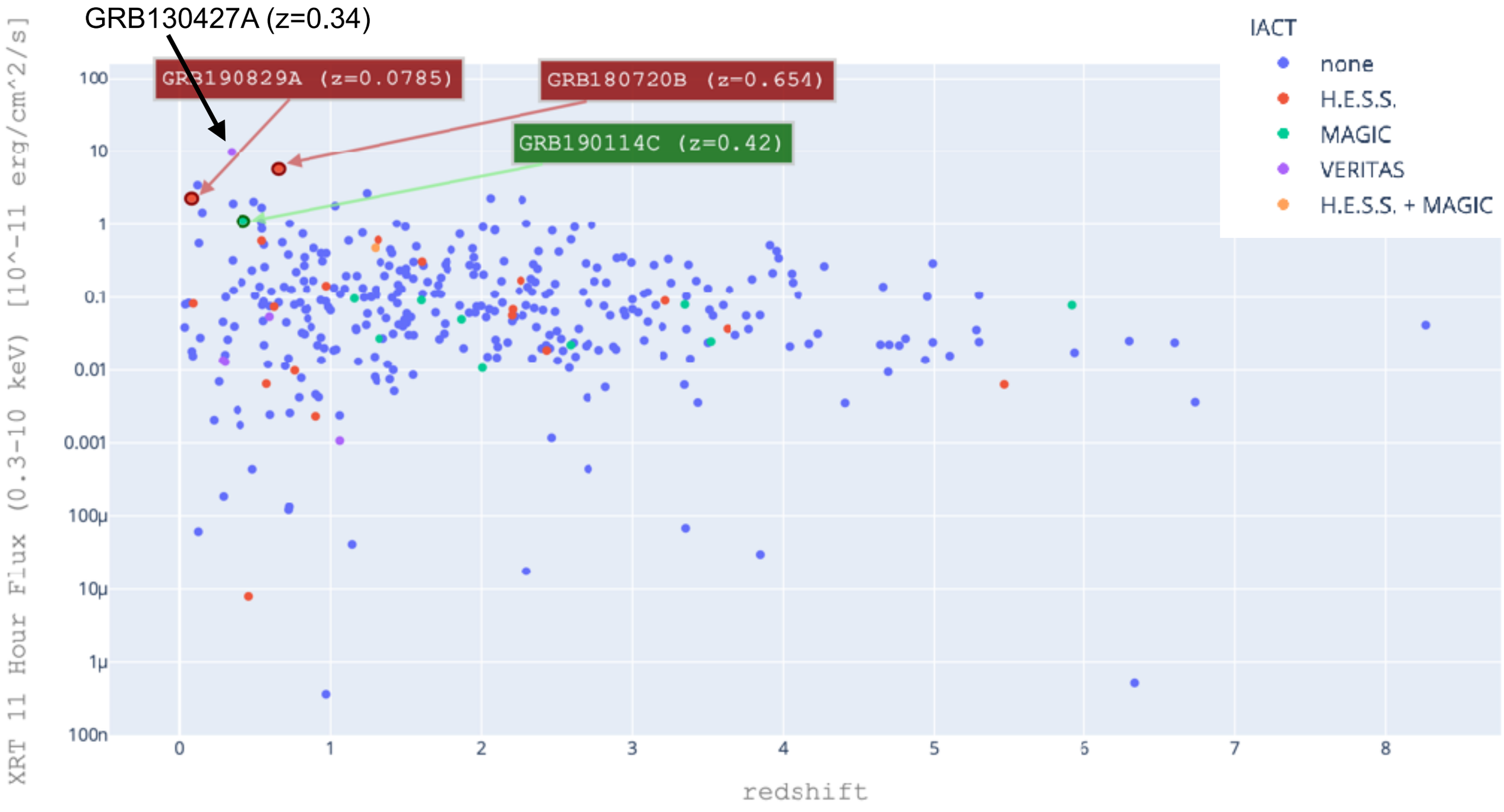
Soft Gamma-ray Repeaters



Neutrinos



GRB observations with IACTs



The H.E.S.S. observatory

- four 12m telescopes + one 28m telescope
- low energy threshold ~30GeV
- large FoV (~3.5deg)
- fast slewing

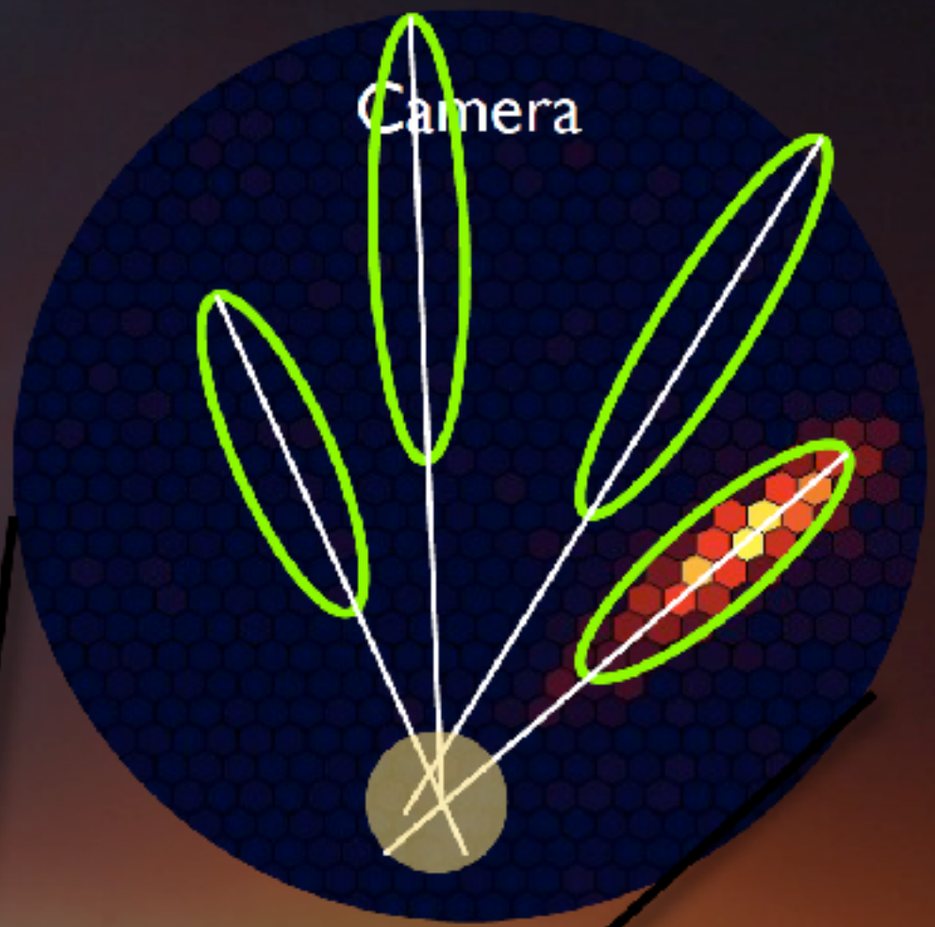
VHE Gamma-ray

Interaction in atmosphere
generates an *Air Shower*
(e+ , e-)

$$\theta_c = \cos^{-1}\left(\frac{1}{\beta n}\right)$$

Cherenkov
Radiation

≈ 10km



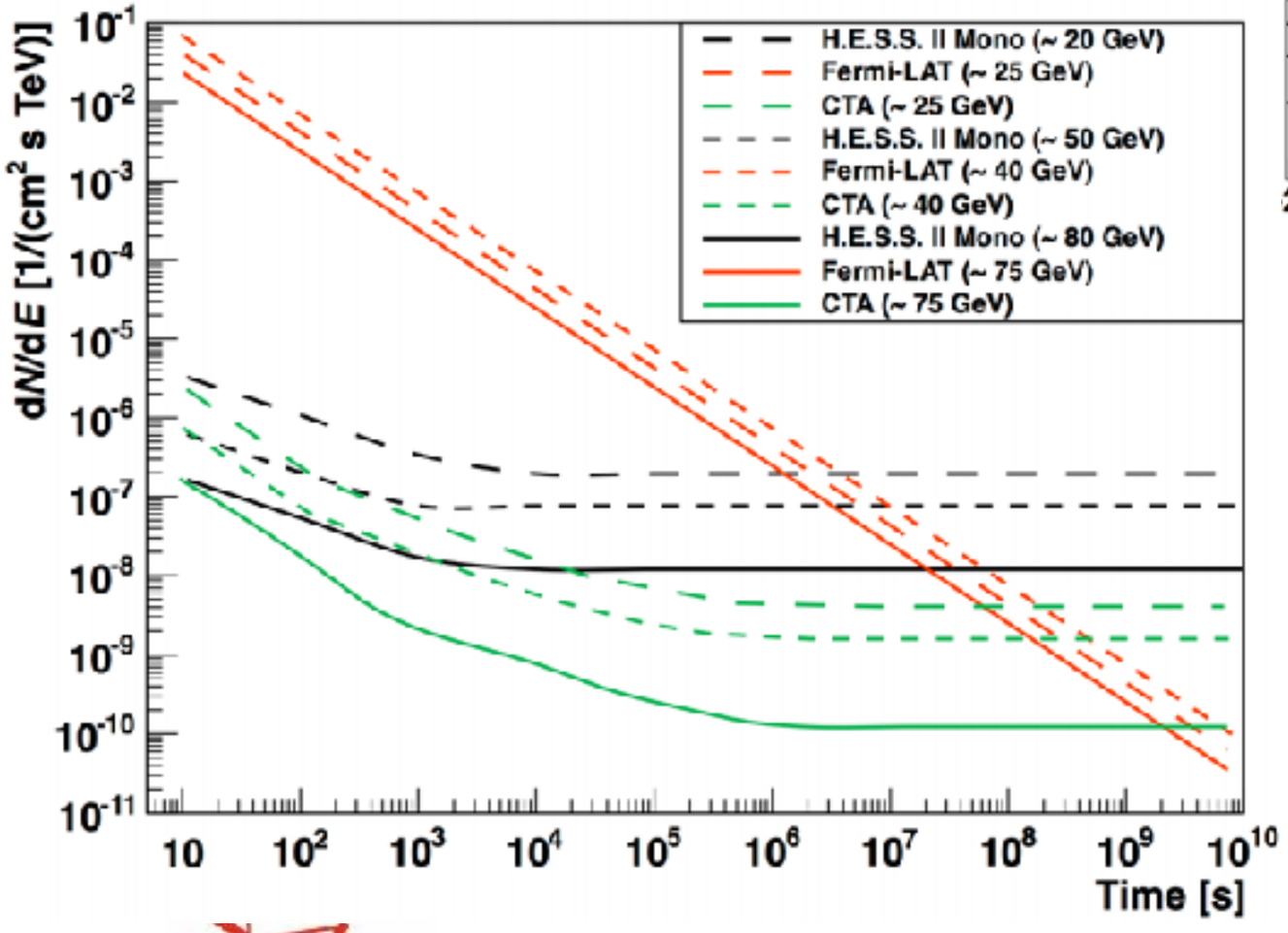
Energy ∝ total signal
(Calorimeter)

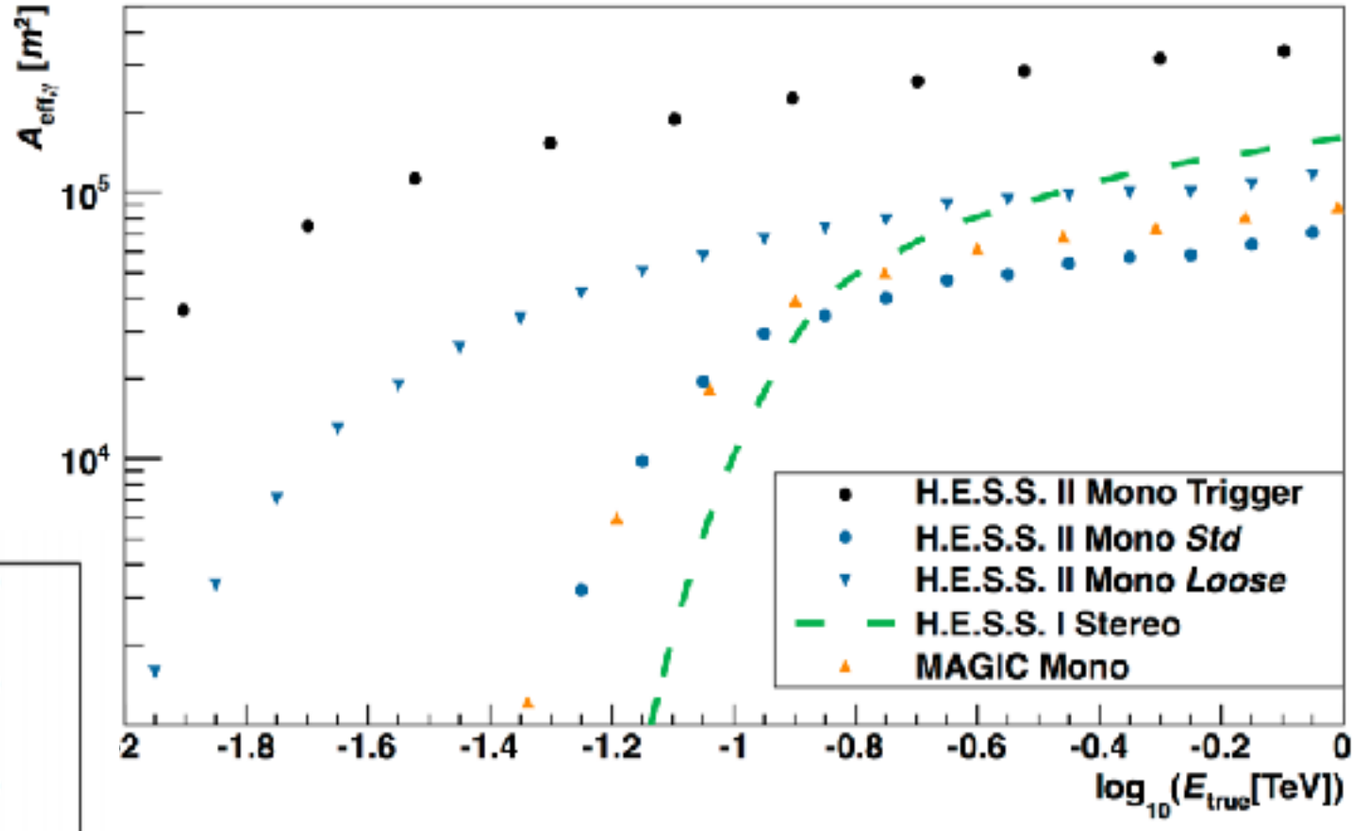
~ 100 m

Karl Kosack, ISAPP 2012

GRB follow-up: sensitivity

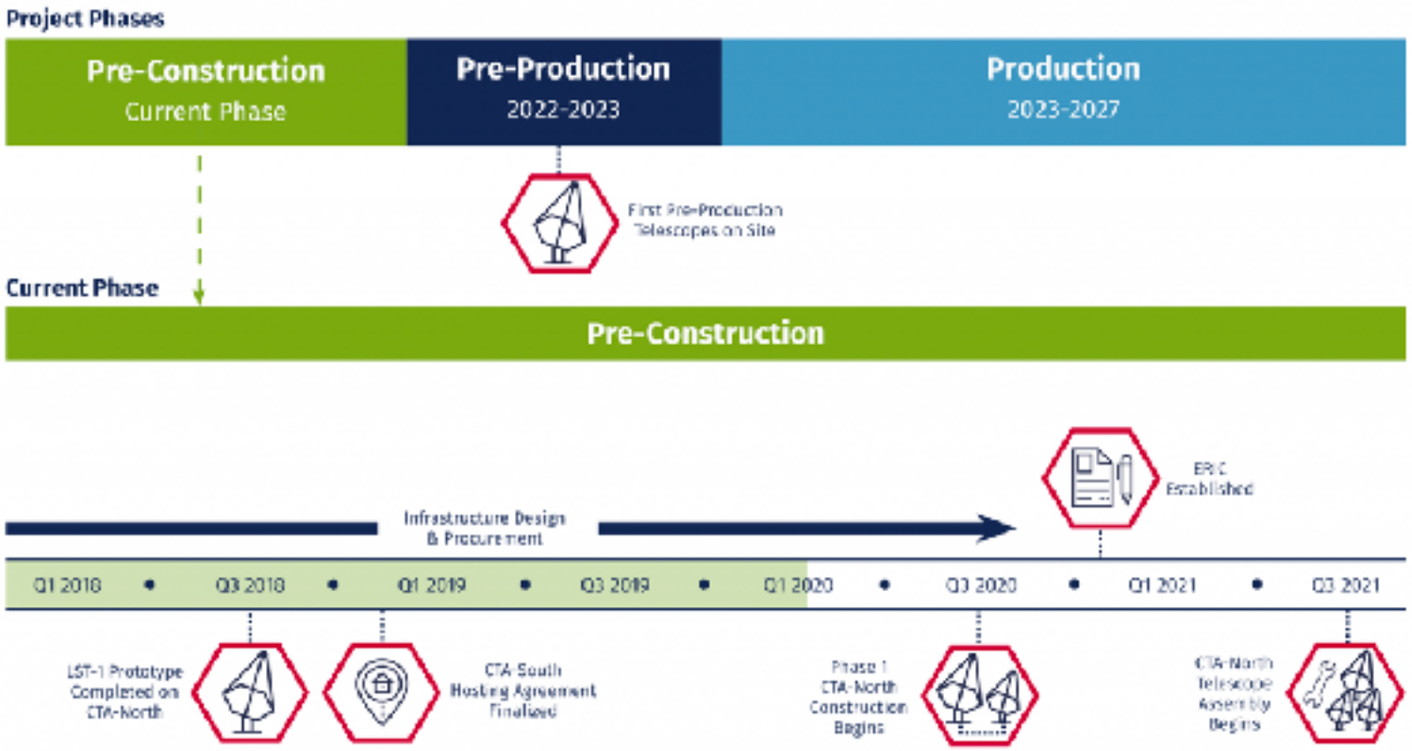
- rapid response + best sensitivity





D. Parsons et al., ICRC 2015, arXiv: 1509.05191

CTA timeline



CTA: Gamma-ray burst prospects