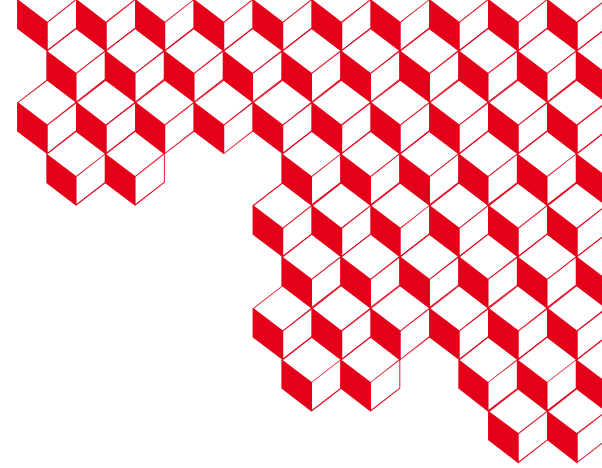




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Probing Gamma-Ray Burst at Very High Energy : Results from 15 Years of H.E.S.S. Observations

Mathieu de Bony de Lavergne, Cornelia Arcaro,
Zhiqiu Hang, Brian Reville, Edna Ruiz-Velasco,
David Sanchez, Mohanraj Sennippan,
for the H.E.S.S. collaboration



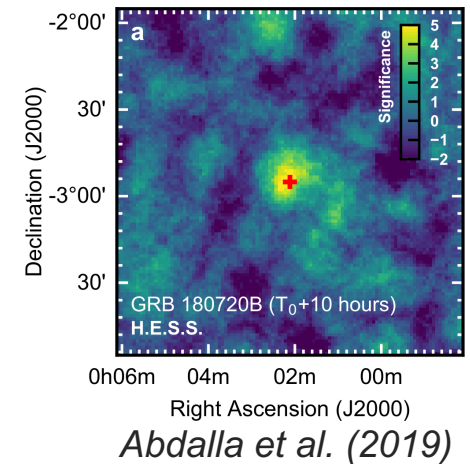
The long quest for the detection of GRBs at VHE



- During more than 20 years, numerous attempts to detect GRBs at VHE have been performed
 - Hint of signal for GRB 970417A in Milagro (*Atkins et al. 2000*)
 - 95 GeV photon detected by Fermi/LAT from GRB 130427A (*Ackermann et al. 2013*)

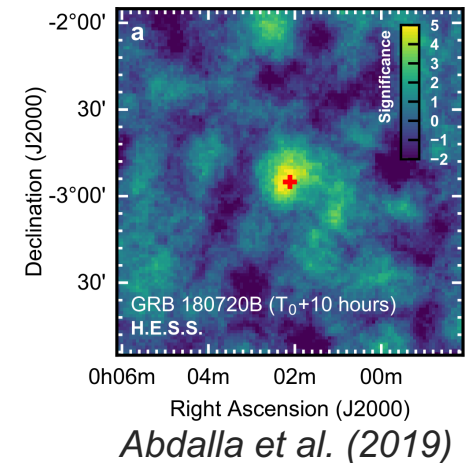
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 - Quickly followed by detections by H.E.S.S. and MAGIC of GRB 190114C, GRB 190829A and GRB 201216C (*MAGIC Collaboration 2019, H.E.S.S. Collaboration 2021, MAGIC Collaboration 2021*)
 - More recently, detection by LHAASO of the BOAT, GRB 221009A (*LHAASO Collaboration 2023*)



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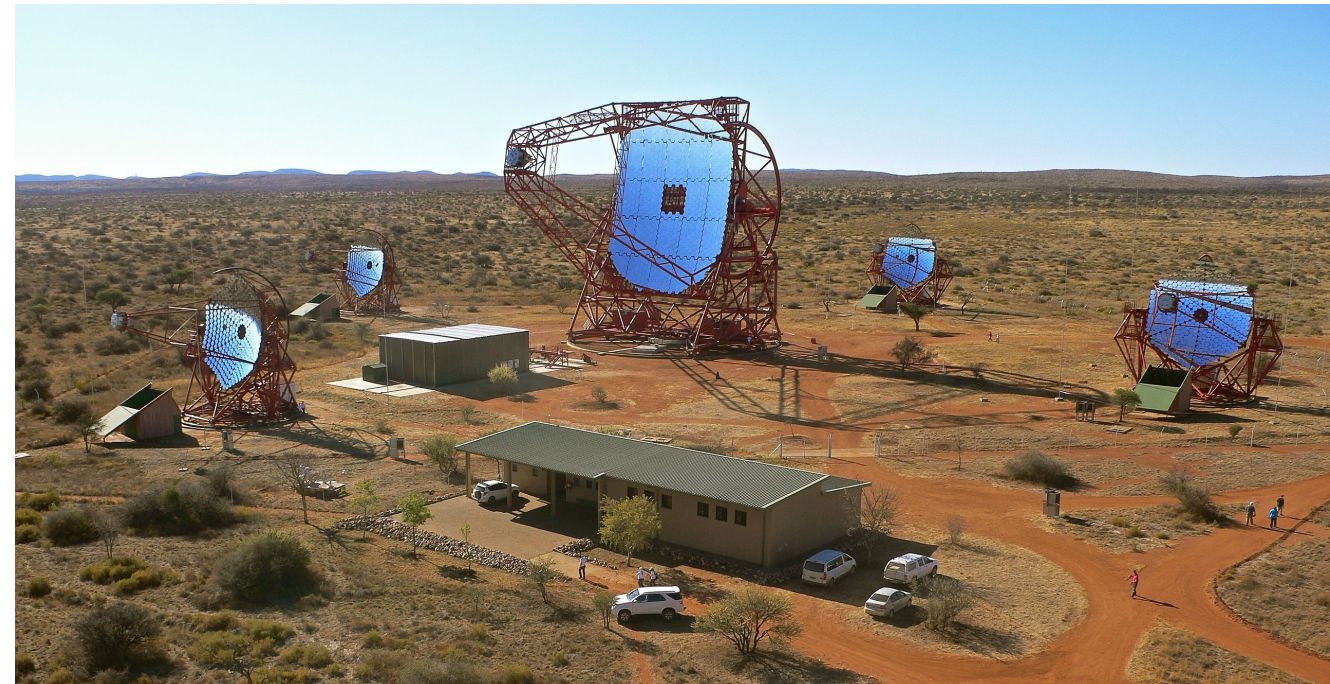
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Why so many detections in the recent years and none before ?

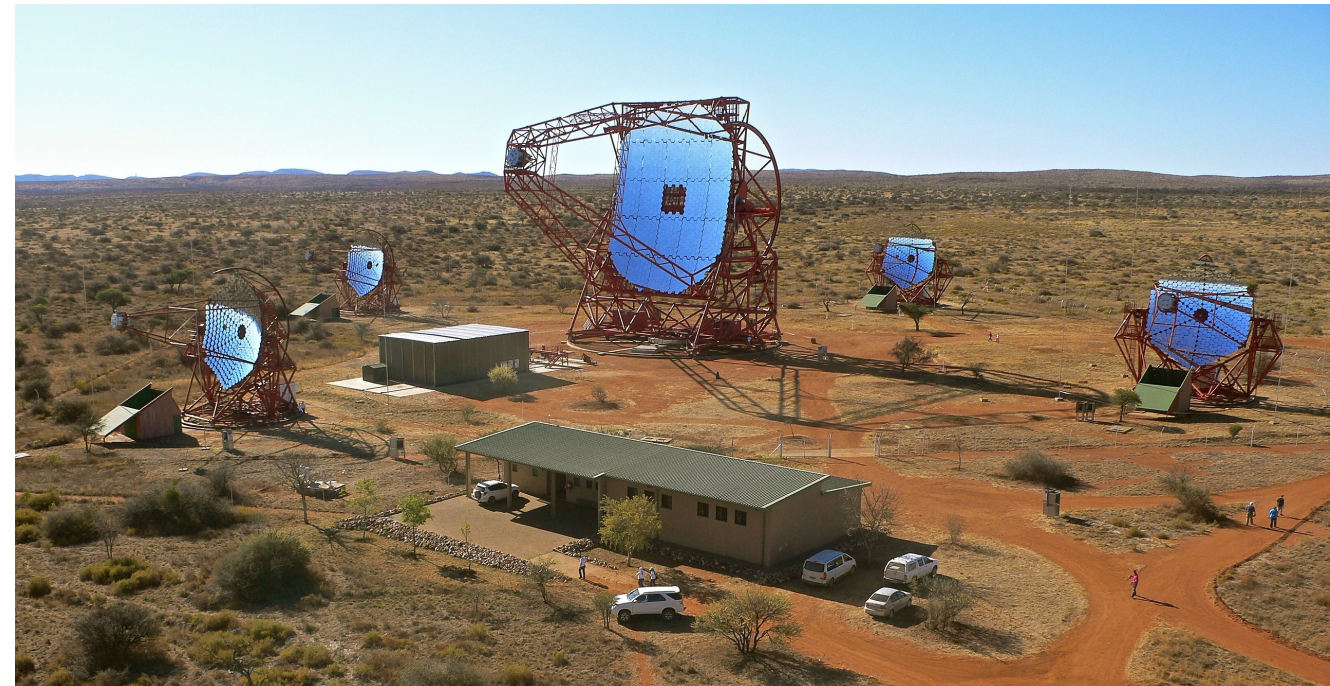
H.E.S.S. GRB program

- H.E.S.S. is performing follow-up observations of GRBs since the start of the operation in 2004
 - Trigger conditions for follow-up has evolved across time
 - Follow-up of alerts from various instrument :
 - HETE 2
 - Swift/BAT
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- Construction in 2012 of CT5, the central 28m telescope, allowing for a much lower energy threshold



Analysis of archival data

- **Cross-match GRBs catalogue and H.E.S.S. observation database**
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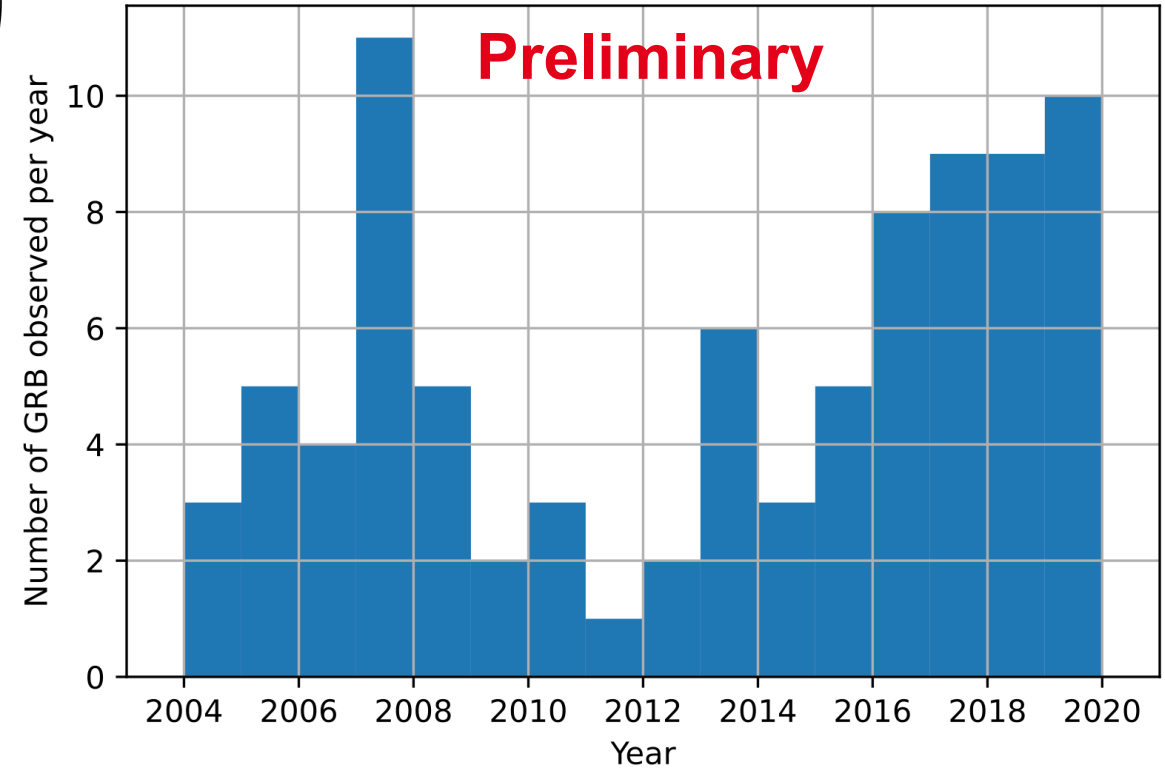
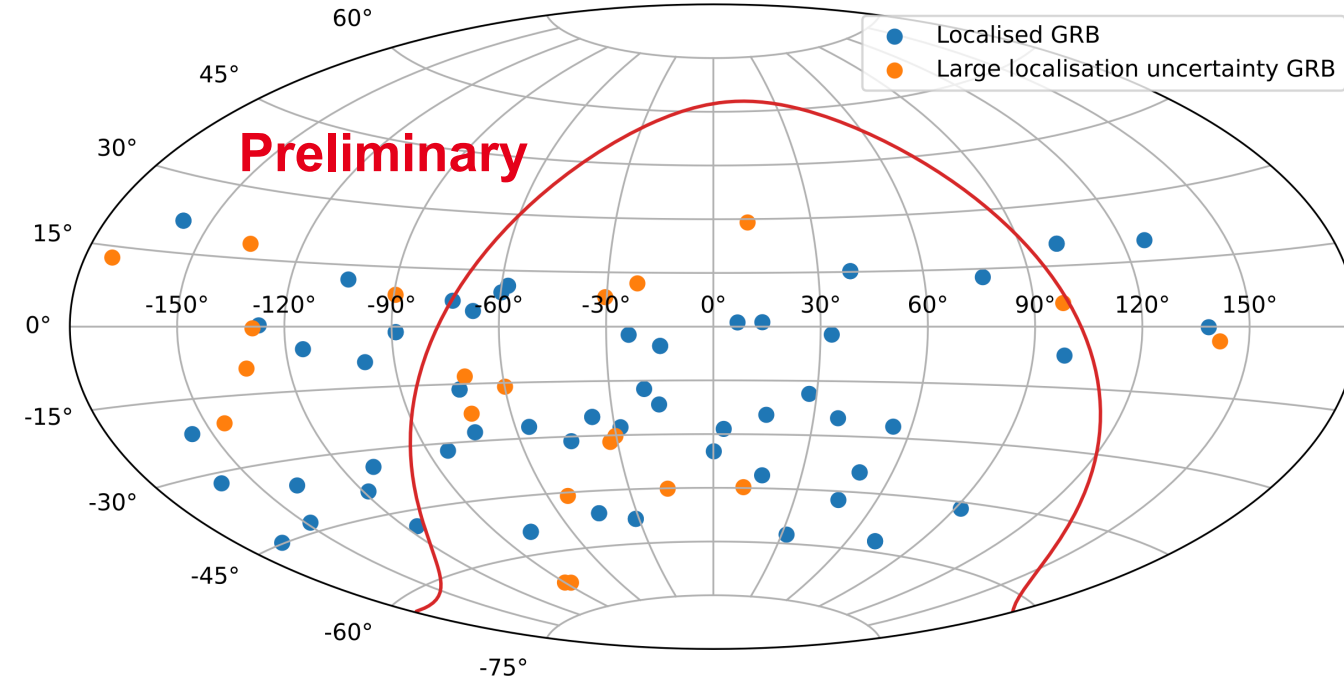
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- **Analysis of observations of 63 GRBs**
- Separated in two groups :
 - GRB with poor localisations (mainly Fermi/GBM), **10 GRBs, 19.0 h of observations**
 - GRB with precise localisations, **53 GRBs, 81.3 h of observation**

A large number of observed GRBs



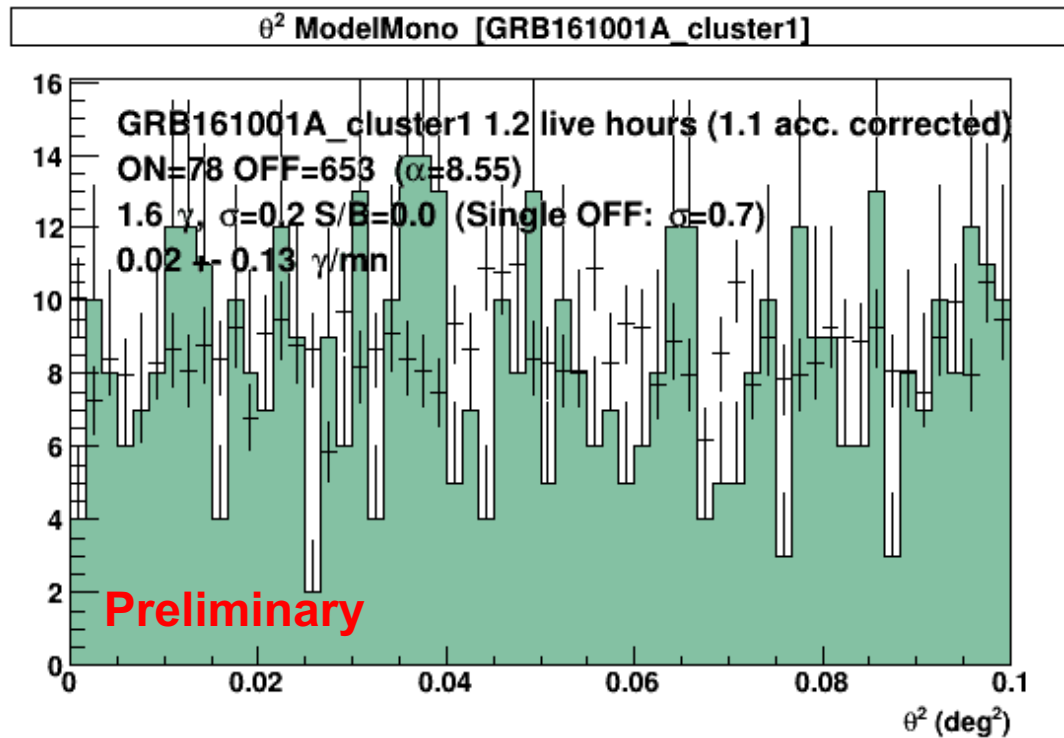
75° GRBs observed by HESS



Analysis of each GRB

- An individual analysis is performed for each GRB

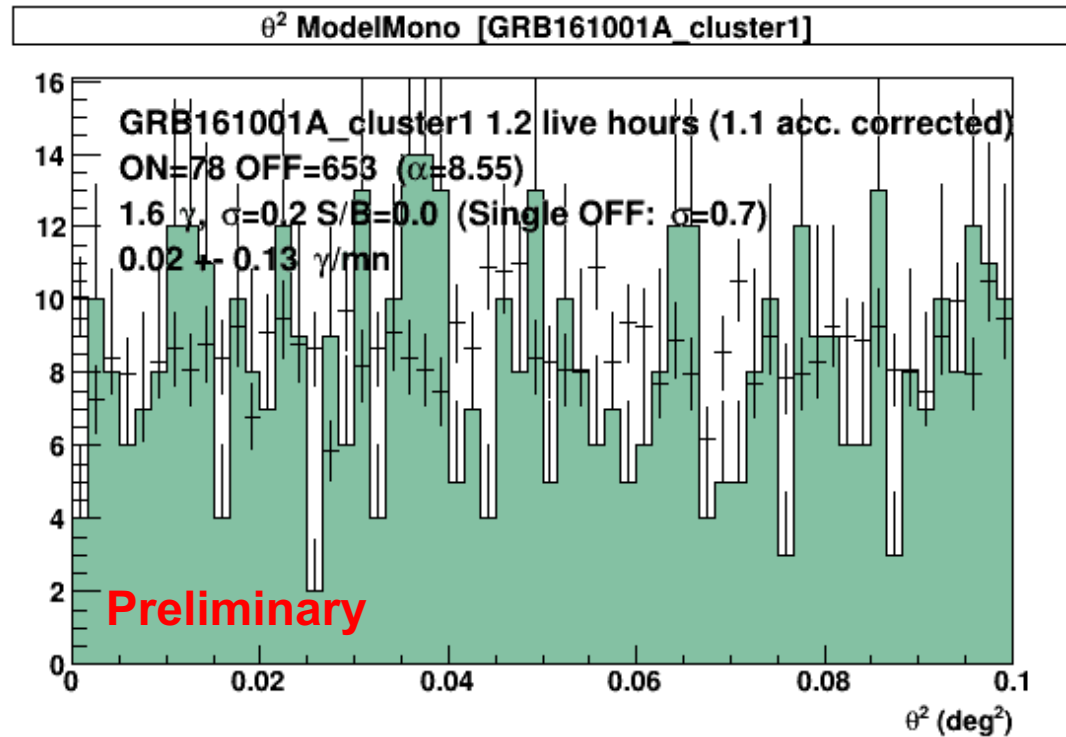
GRBs without precise localisation :
Theta2 and integral upper limit



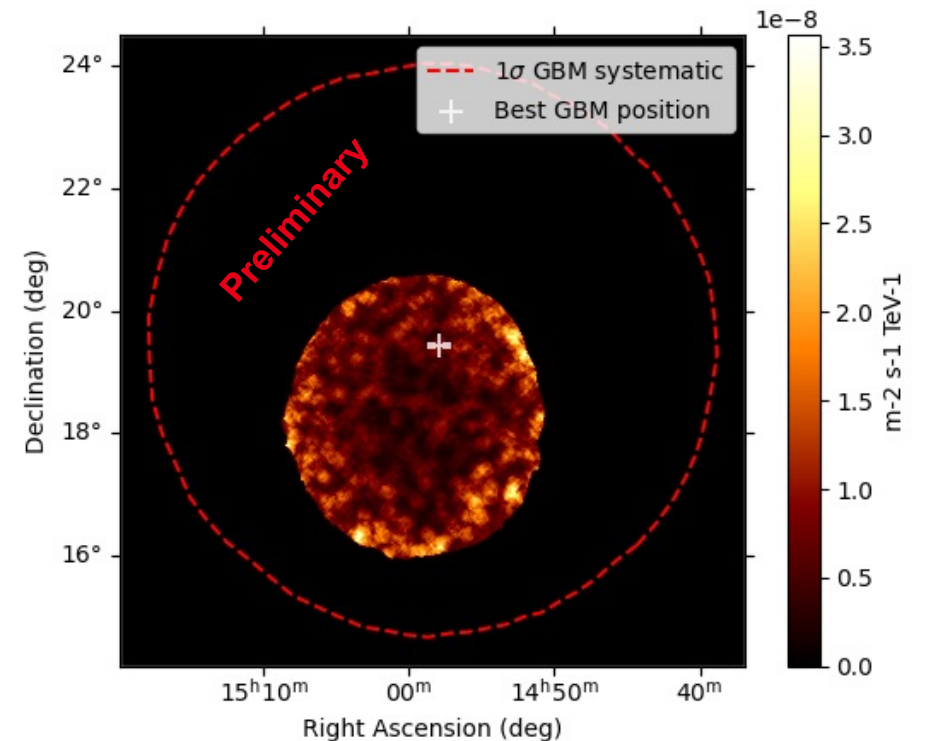
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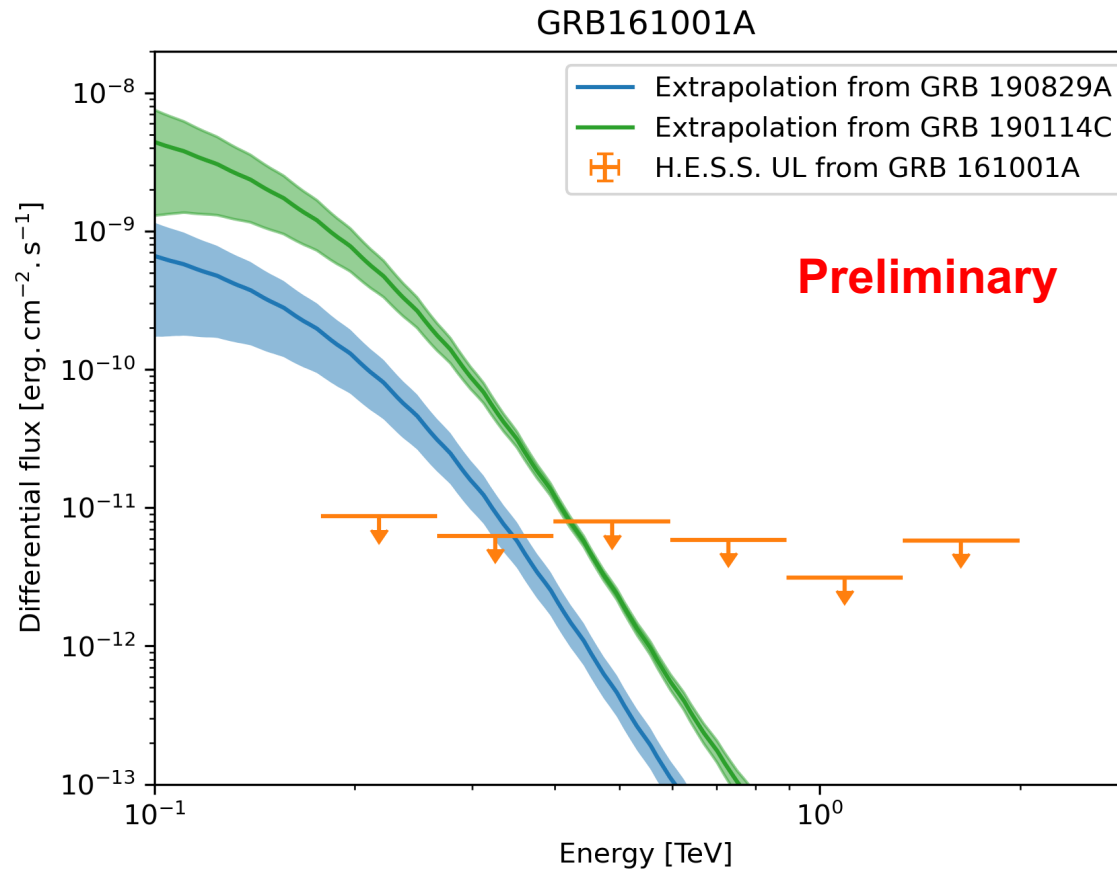


GRBs without precise localisation :
significance map and integral upper limit map

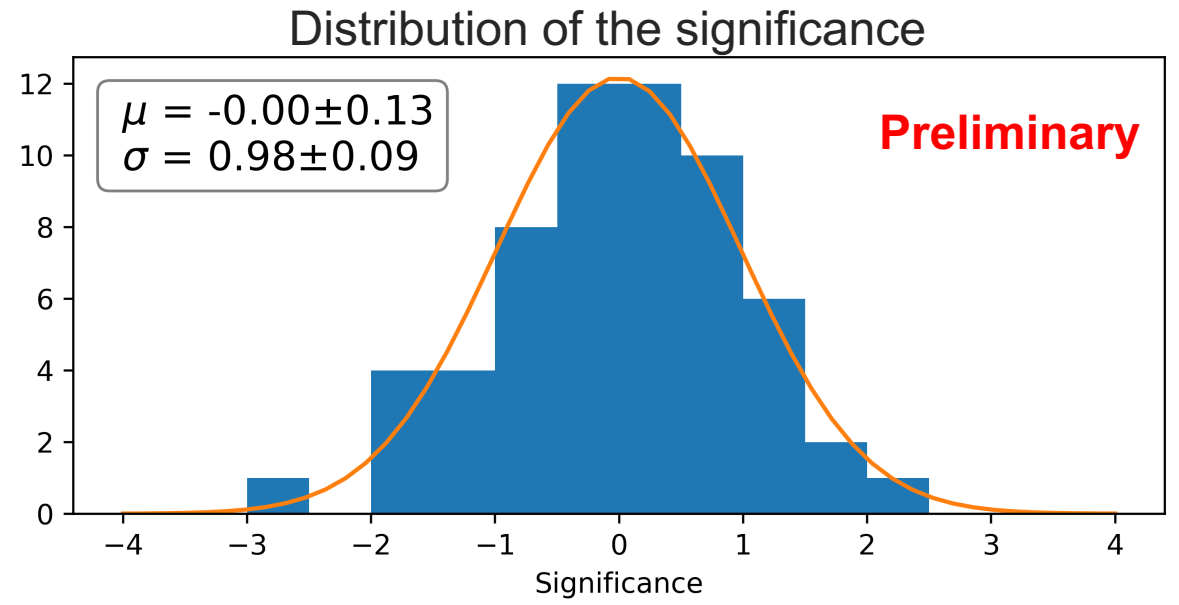
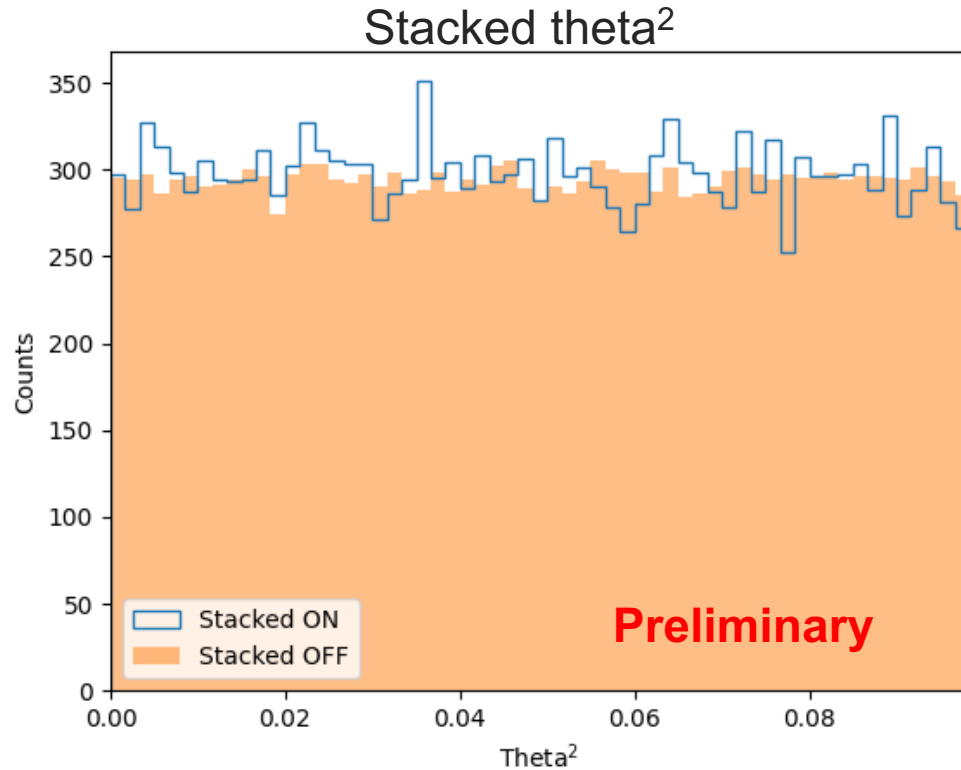


Possible to reject emission as bright as VHE detected GRBs

- Extrapolation of the spectra of GRB 190829A and GRB 190114C to observation of GRB 161001A
 - Correction for difference of EBL absorption due difference of redshift
 - Correction for difference of delay and observation window



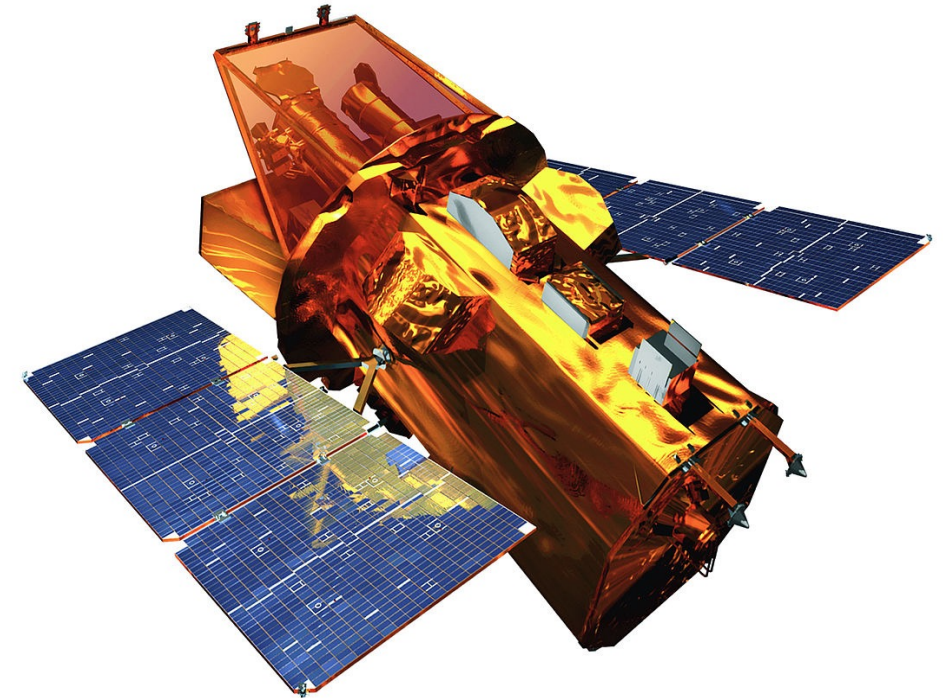
Analysis results of all localized GRBs



No hint of signal

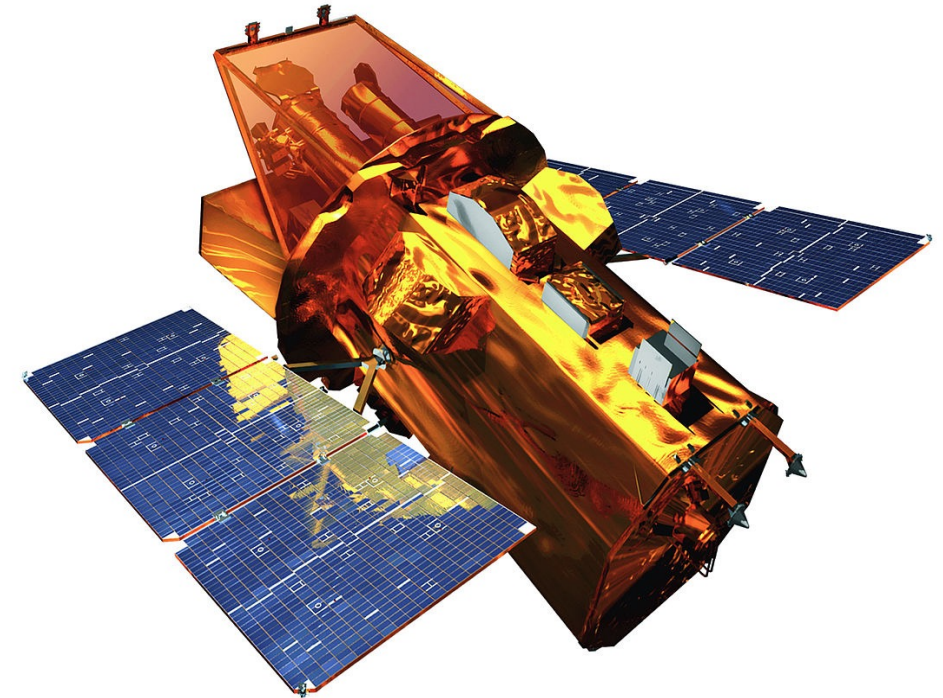
Population studies : Swift/BAT and XRT GRBs

- Most GRBs detected by Swift/BAT and Swift XRT
 - Large sample of GRBs, properties of the prompt and afterglow phase



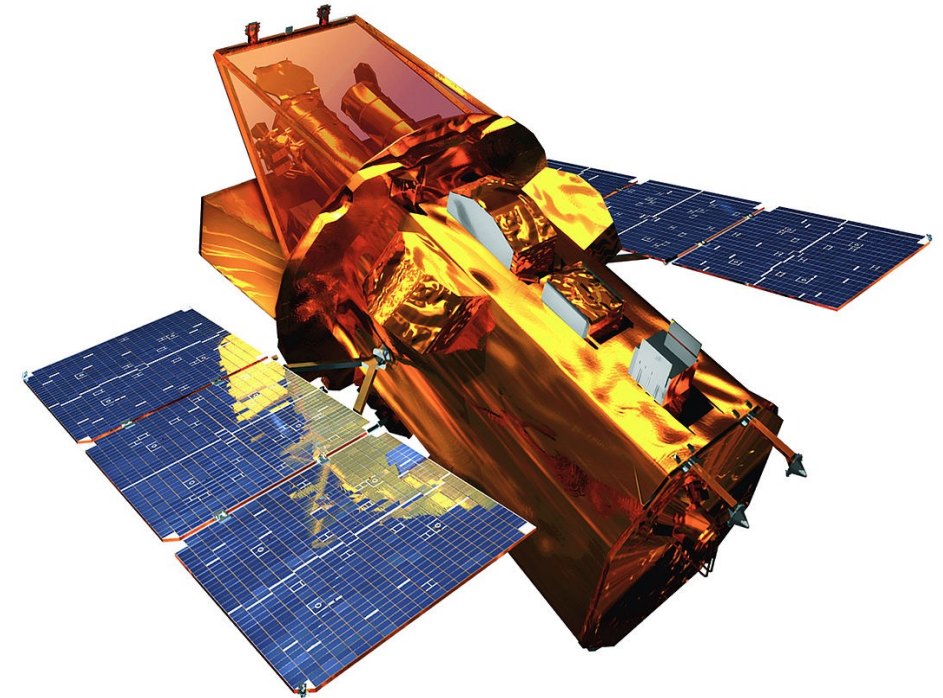
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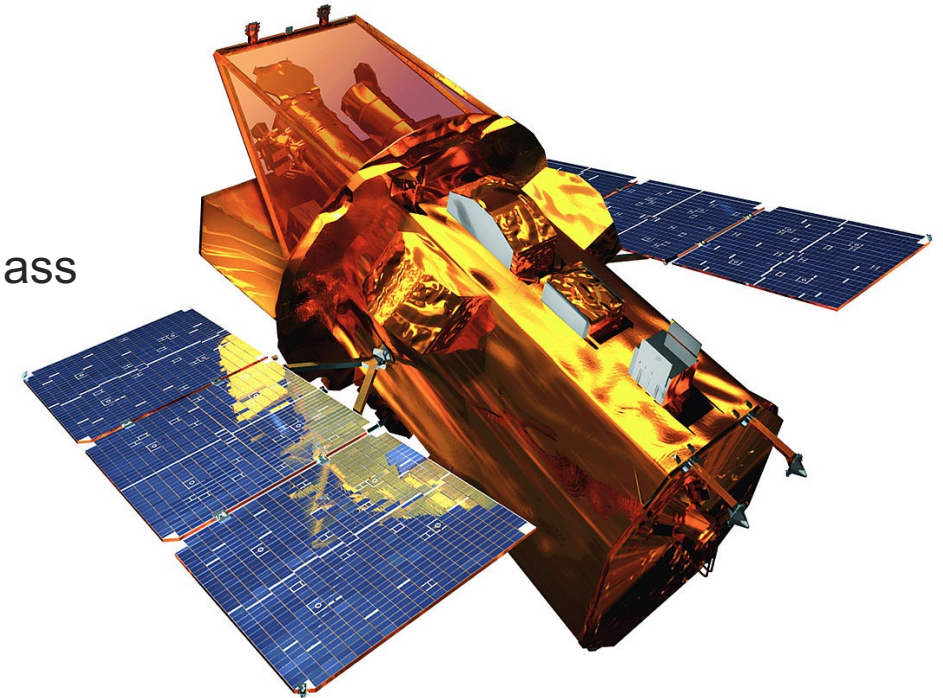
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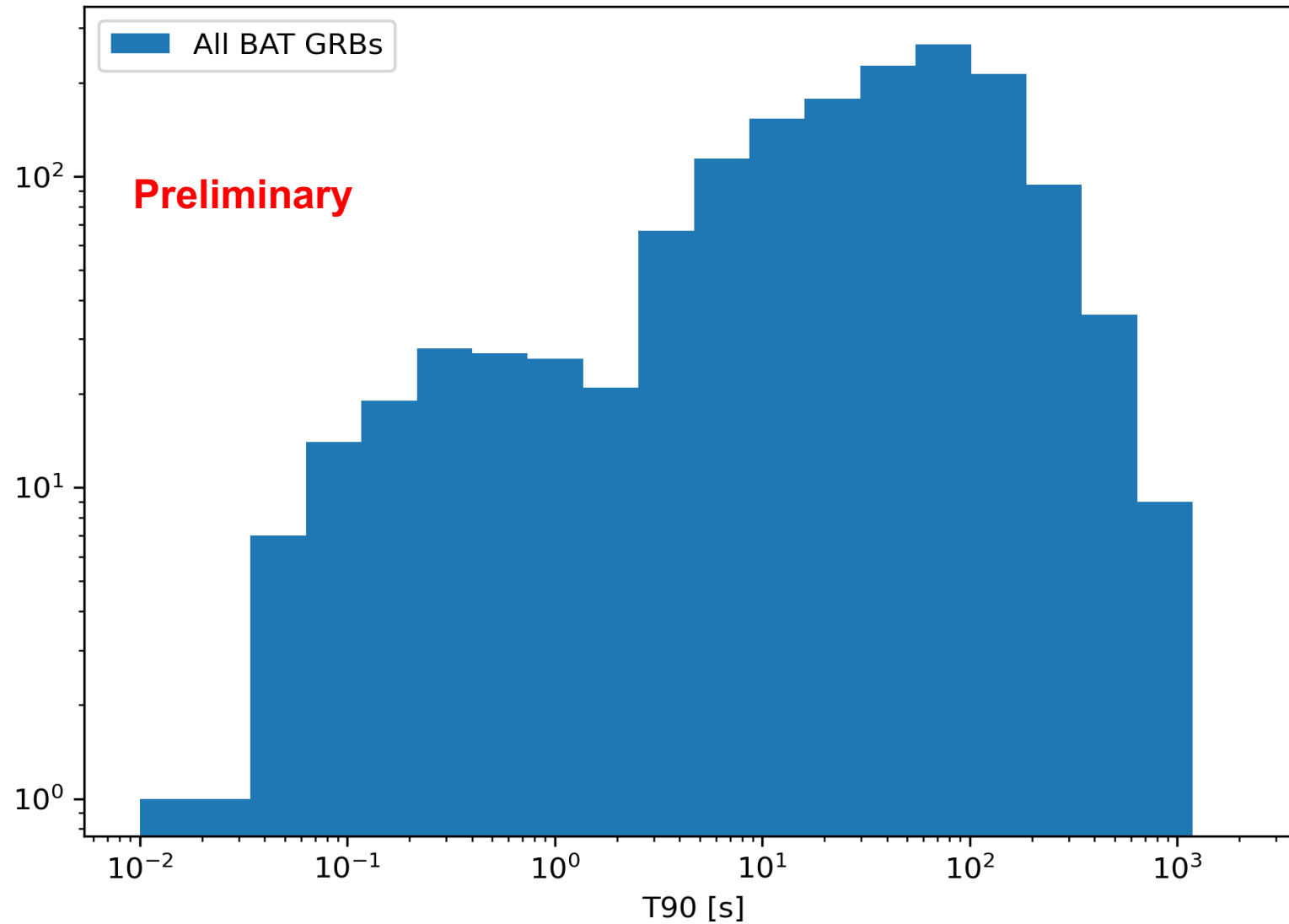


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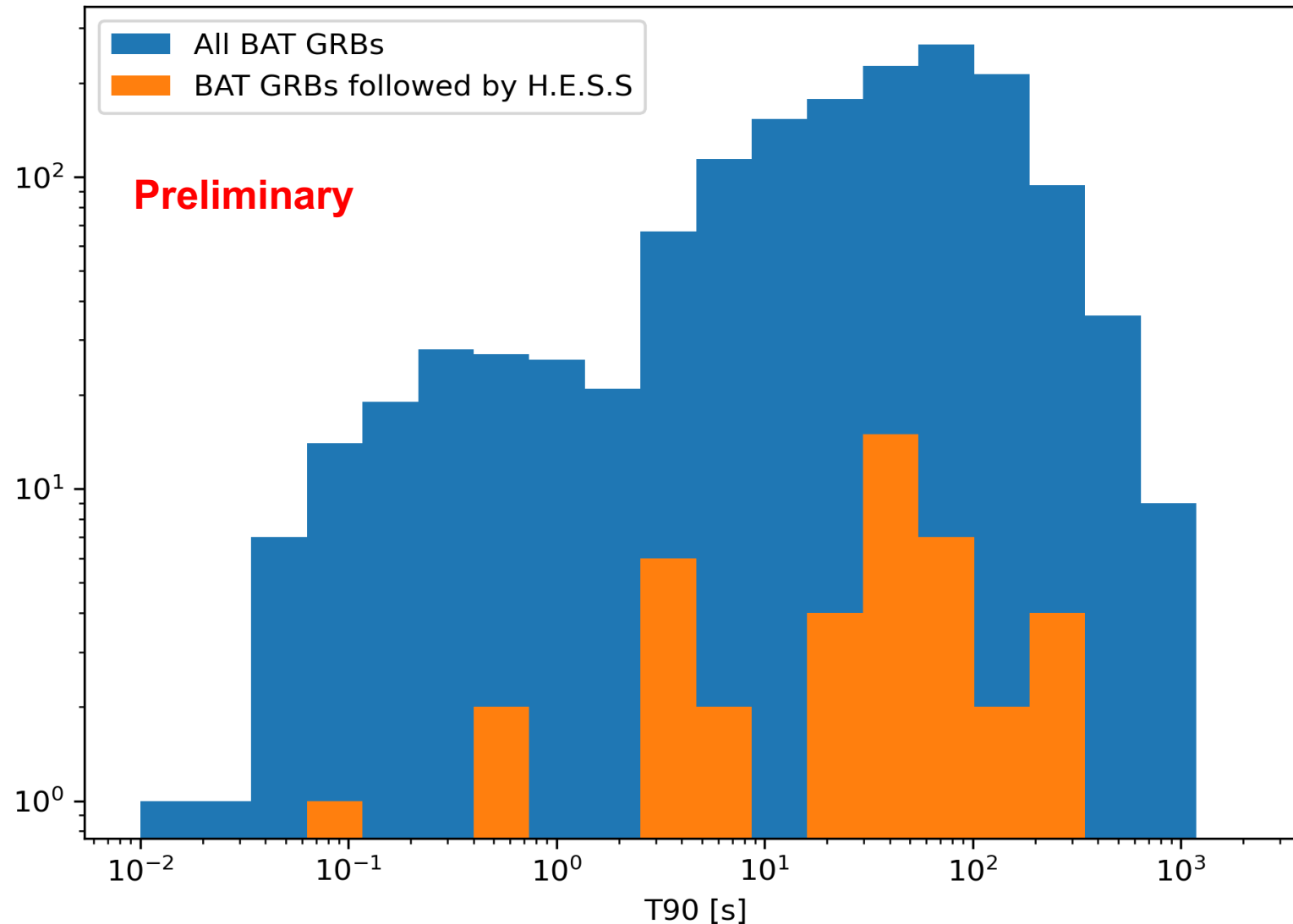
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 - Comparing properties of our sample to all Swift/BAT GRBs
 - Using official Swift/BAT catalog (*Lien et al. 2016*)
 - GRB 190829A is a candidate for the low luminosity GRB class
 - Will look at comparison with and without GRB 190829A



Prompt : T90 distributions

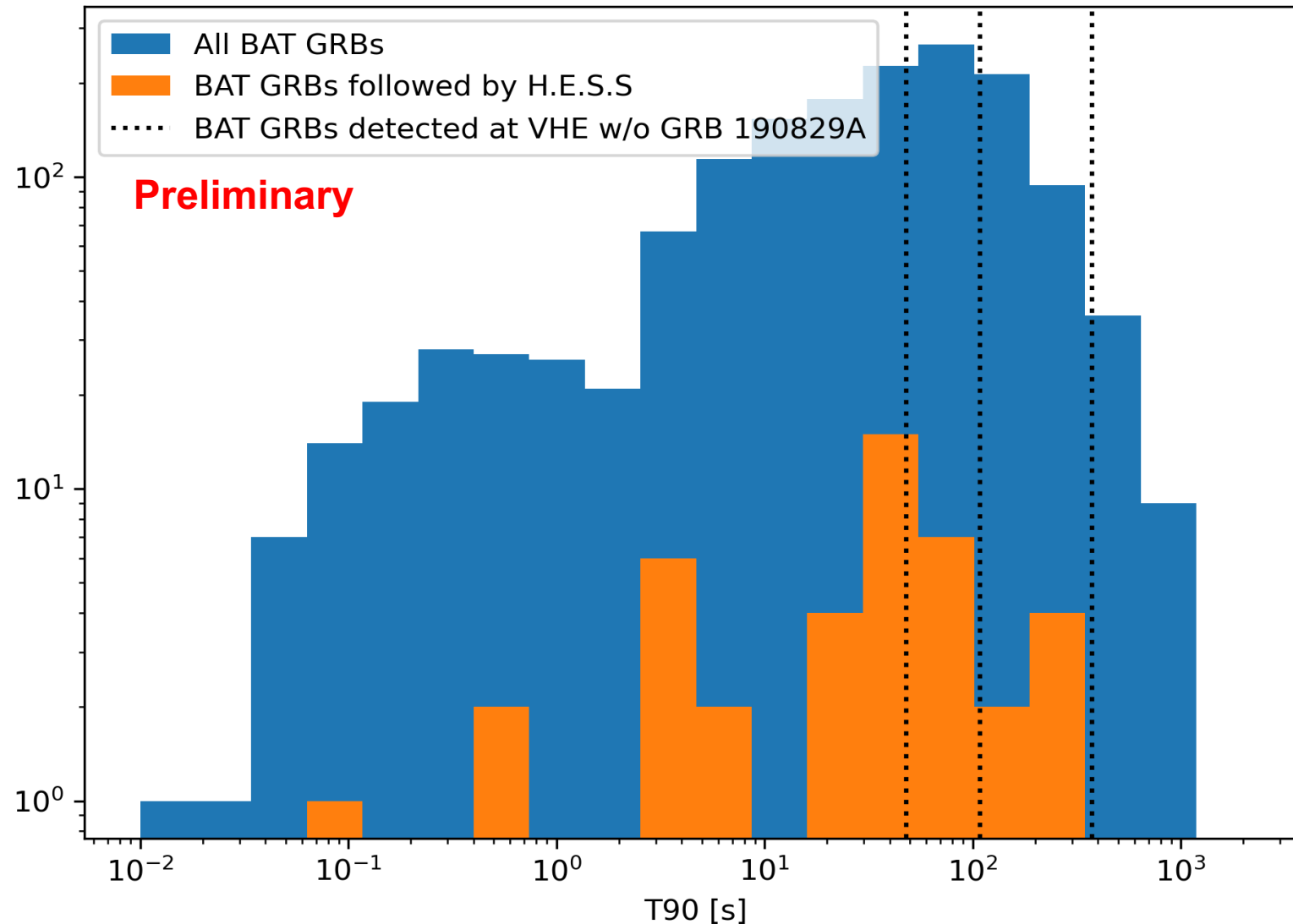


Prompt : T90 distributions



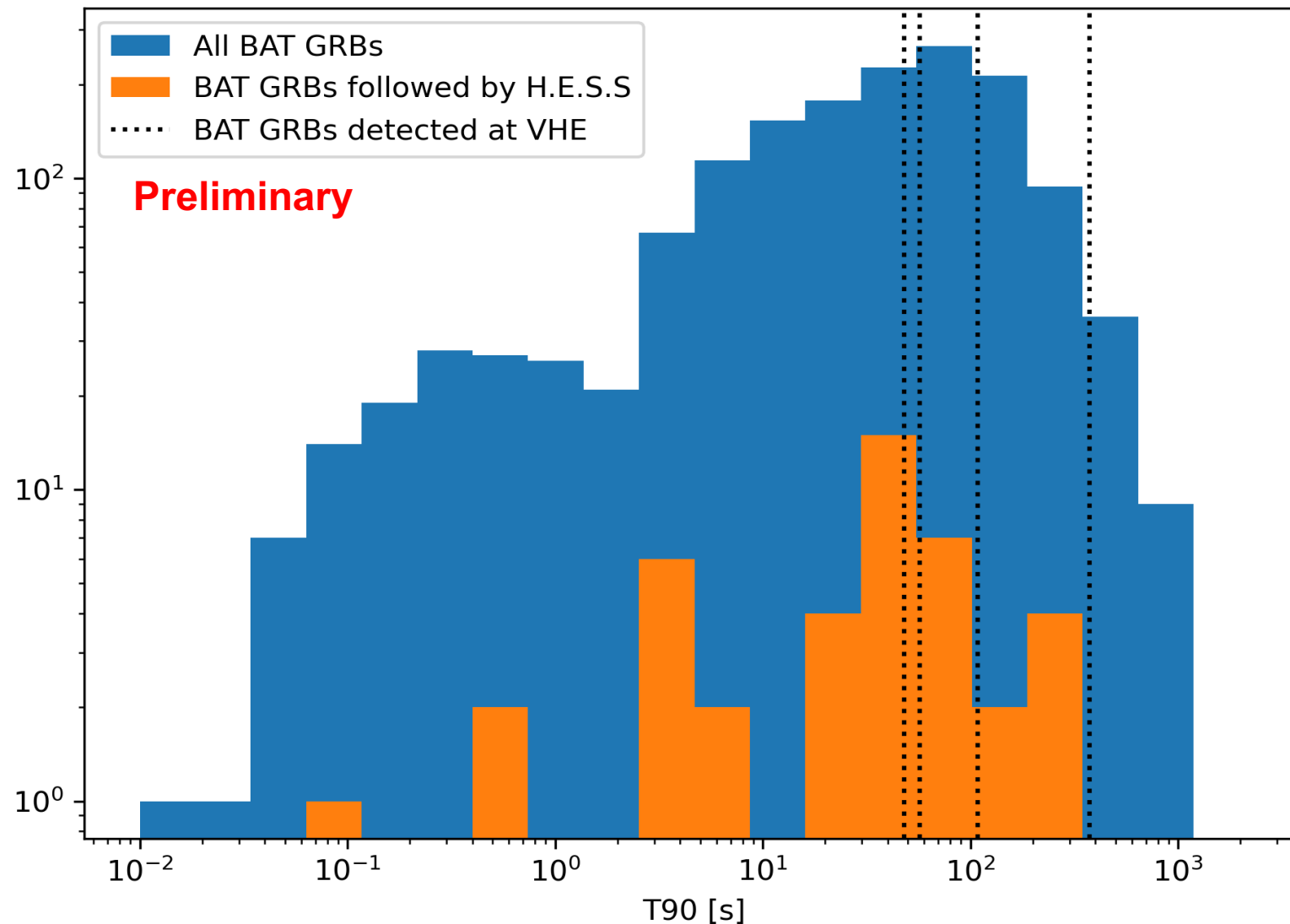
Distributions are compatible
(Deviation at 1.4σ)

Prompt : T90 distributions



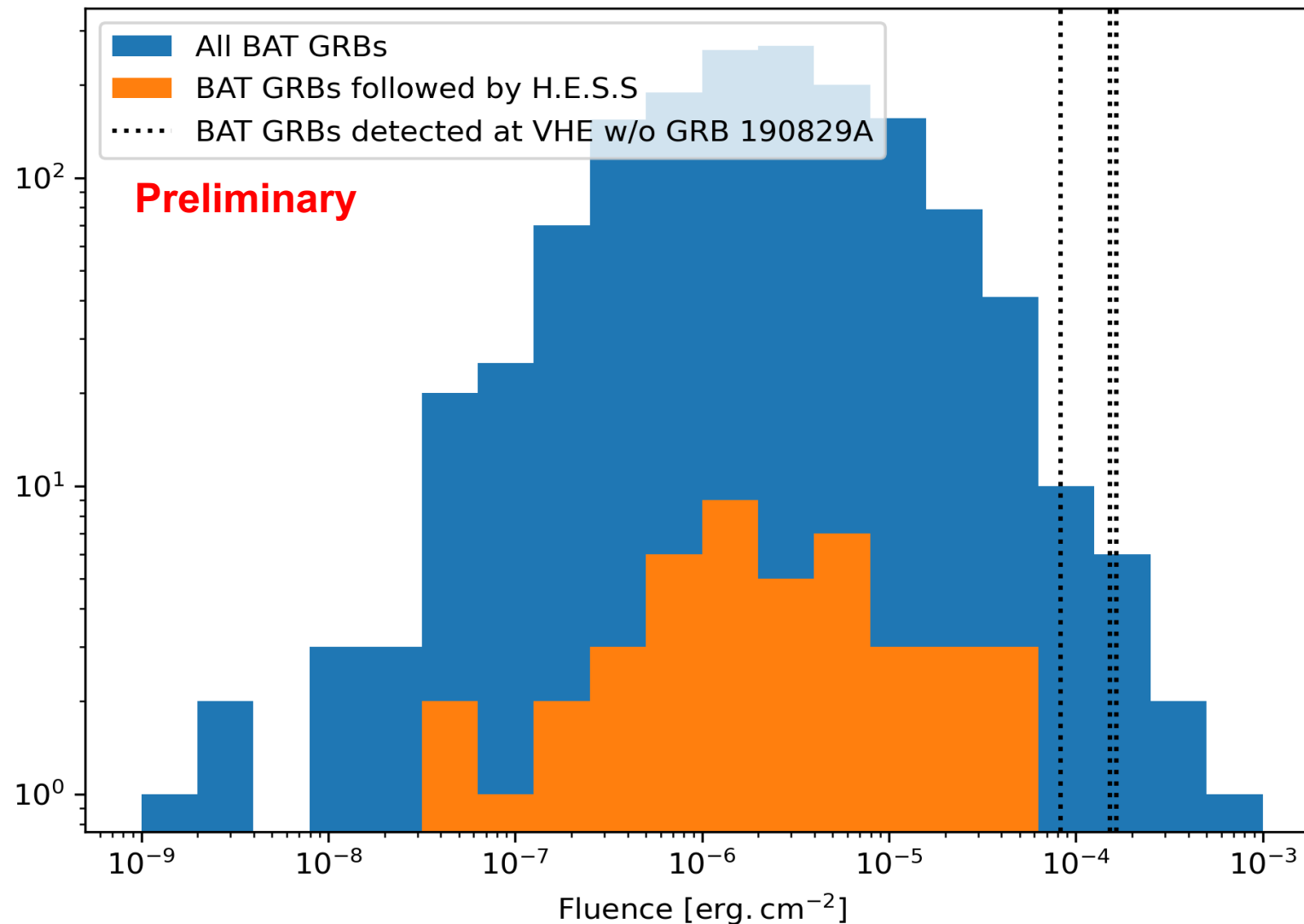
Only detected long GRBs
Statistical significance 2.1 σ

Prompt : T90 distributions



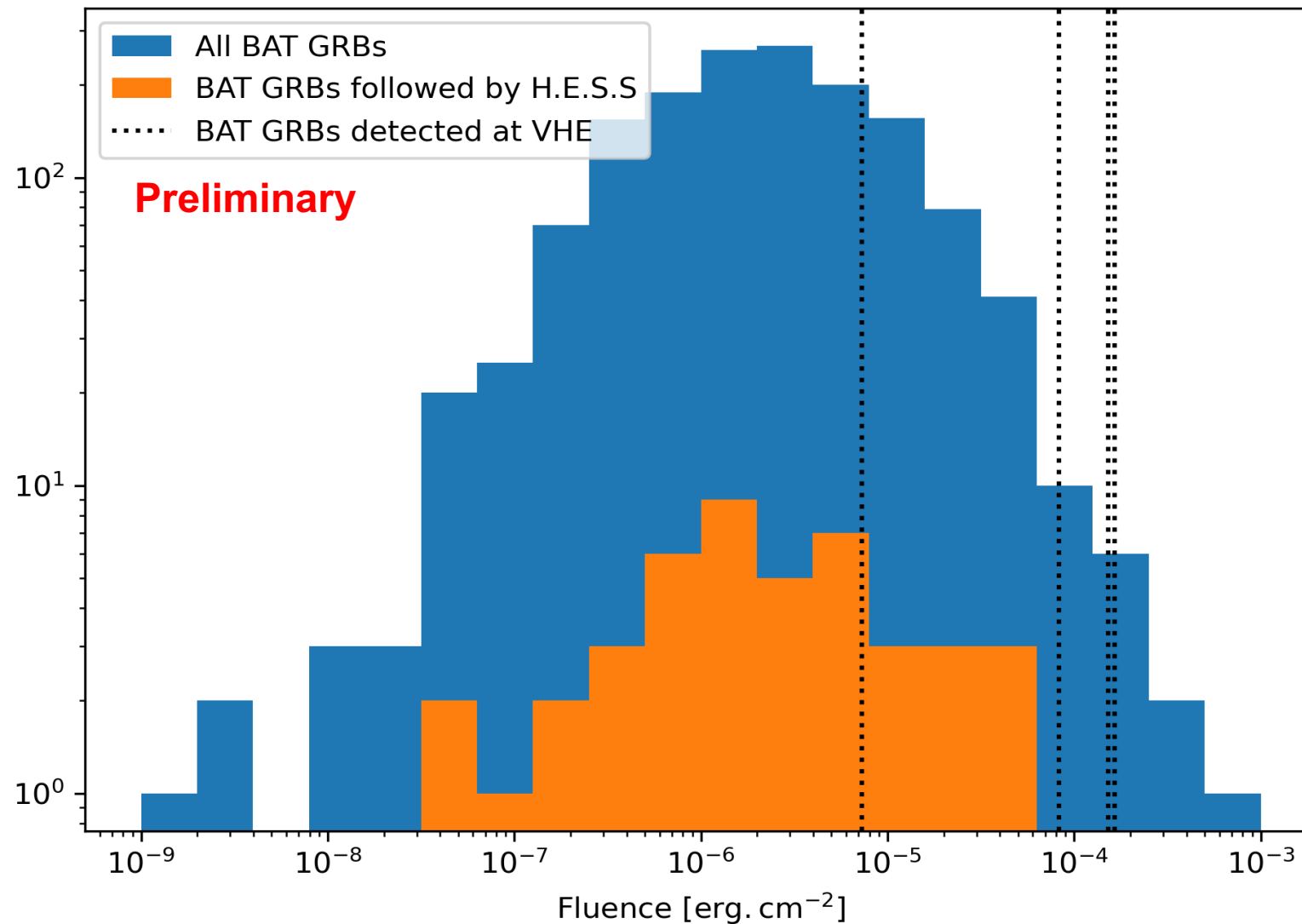
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Prompt : Fluence distributions



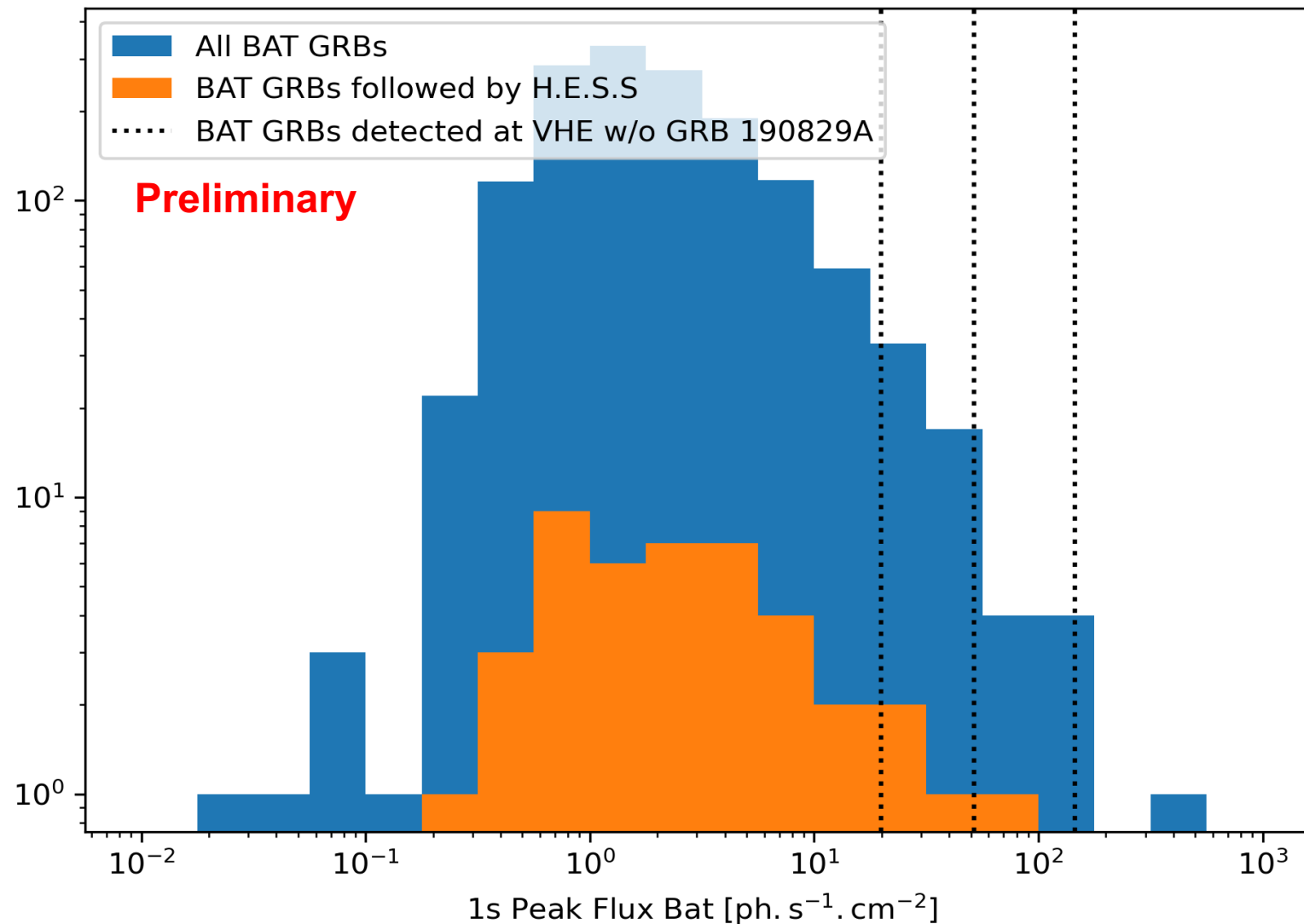
Detected only the brightest GRBs
Statistical significance 5.0 σ

Prompt : Fluence distributions



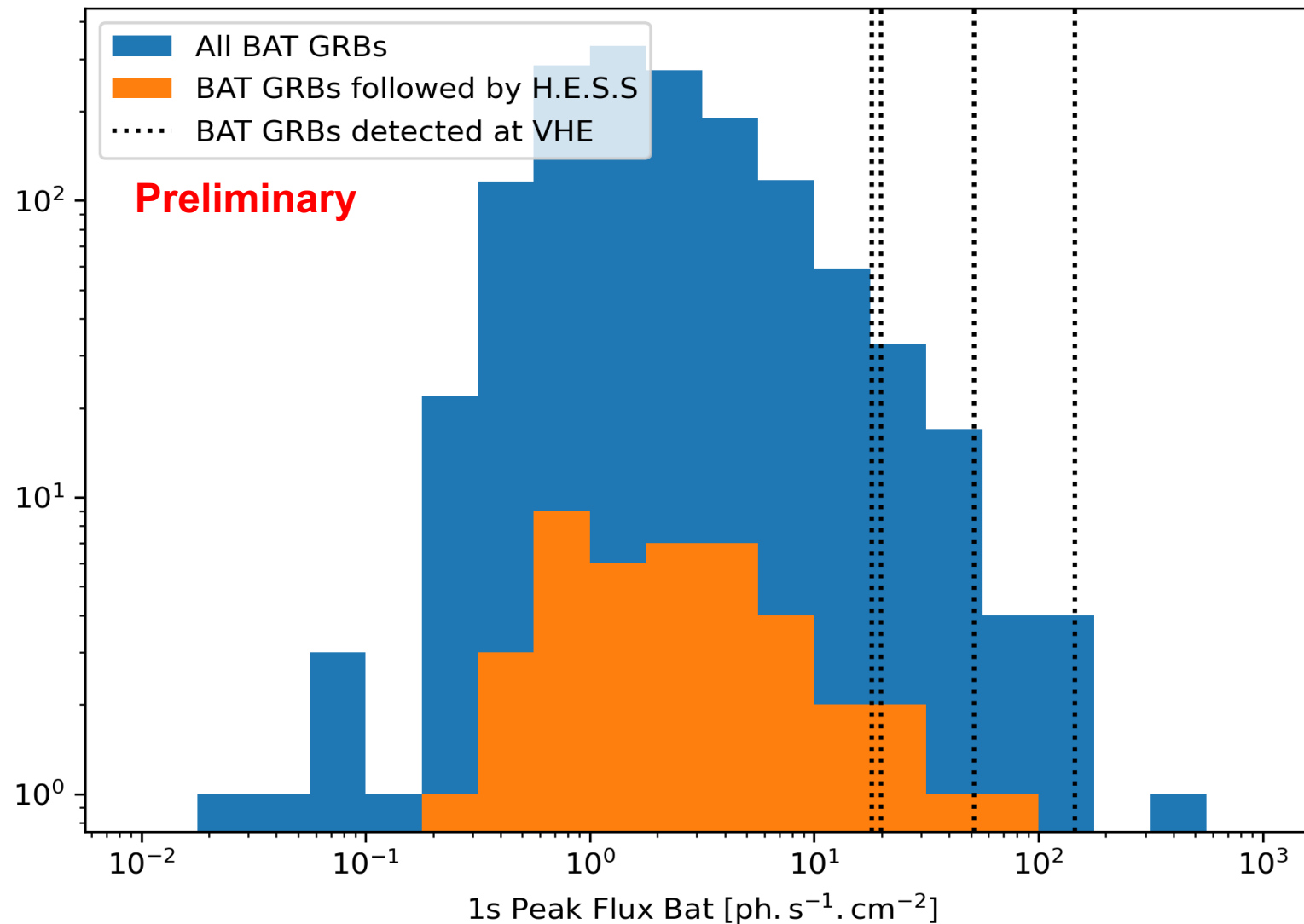
Detected only the brightest GRBs
Statistical significance 3.1 σ

Prompt : Peak flux distributions



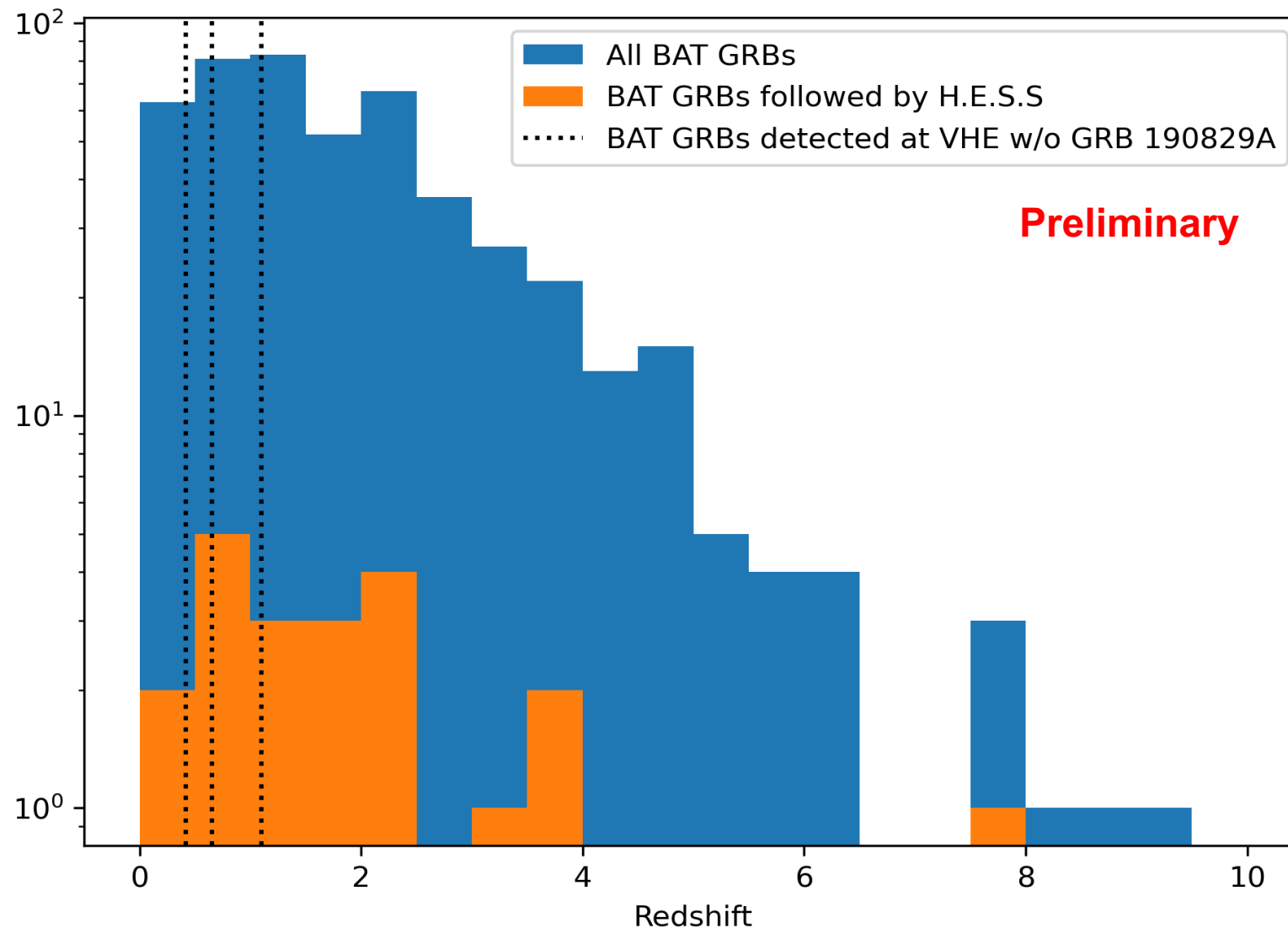
Detected only the brightest
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Statistical significance 4.1 σ

Prompt : Peak flux distributions



Detected only the brightest GRBs
Statistical significance 4.7 σ

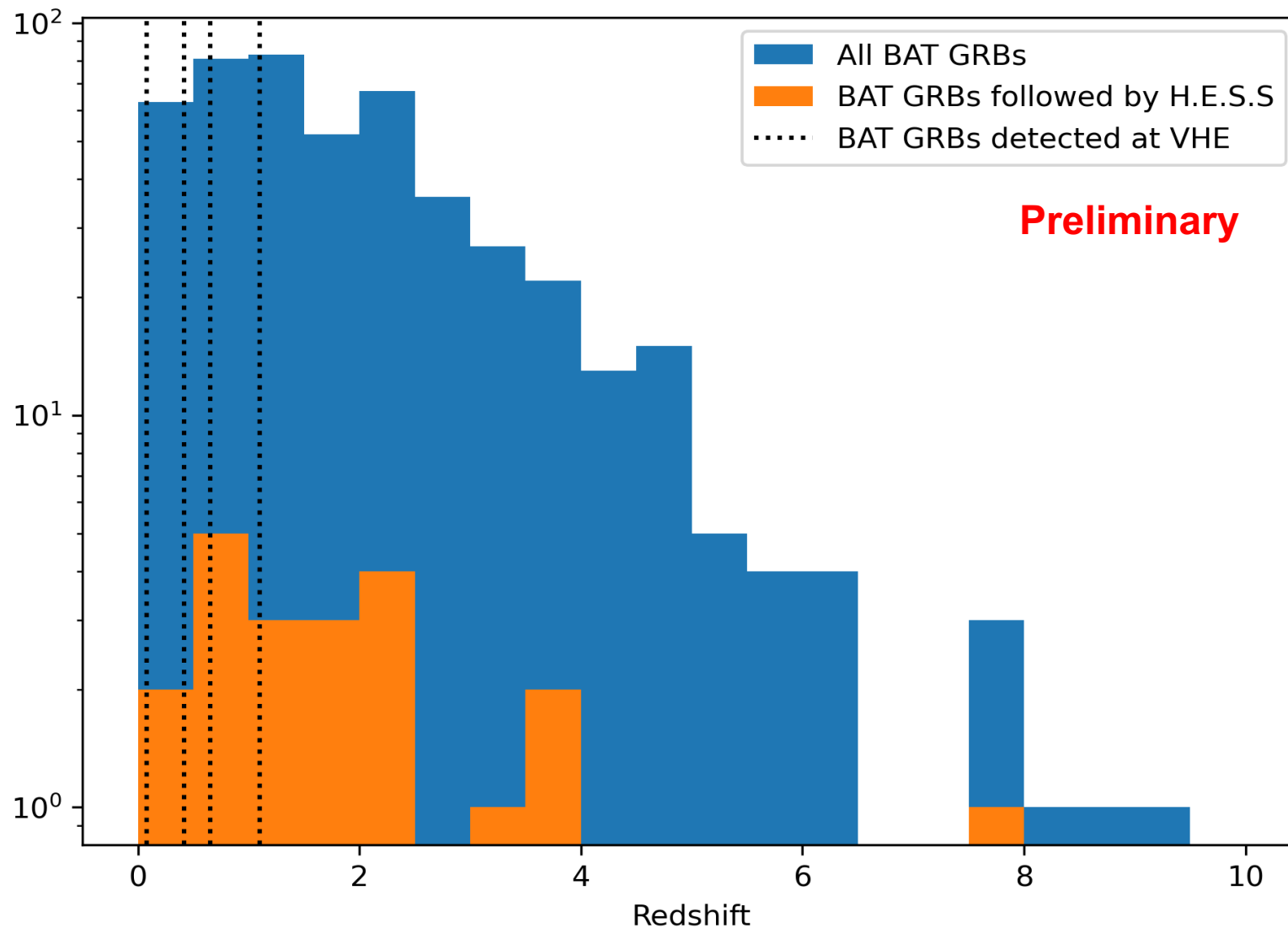
Prompt : Redshift



GRBs observed deviate from the BAT distribution at 2.2σ

GRBs detected deviate from the BAT distribution at 1.9σ

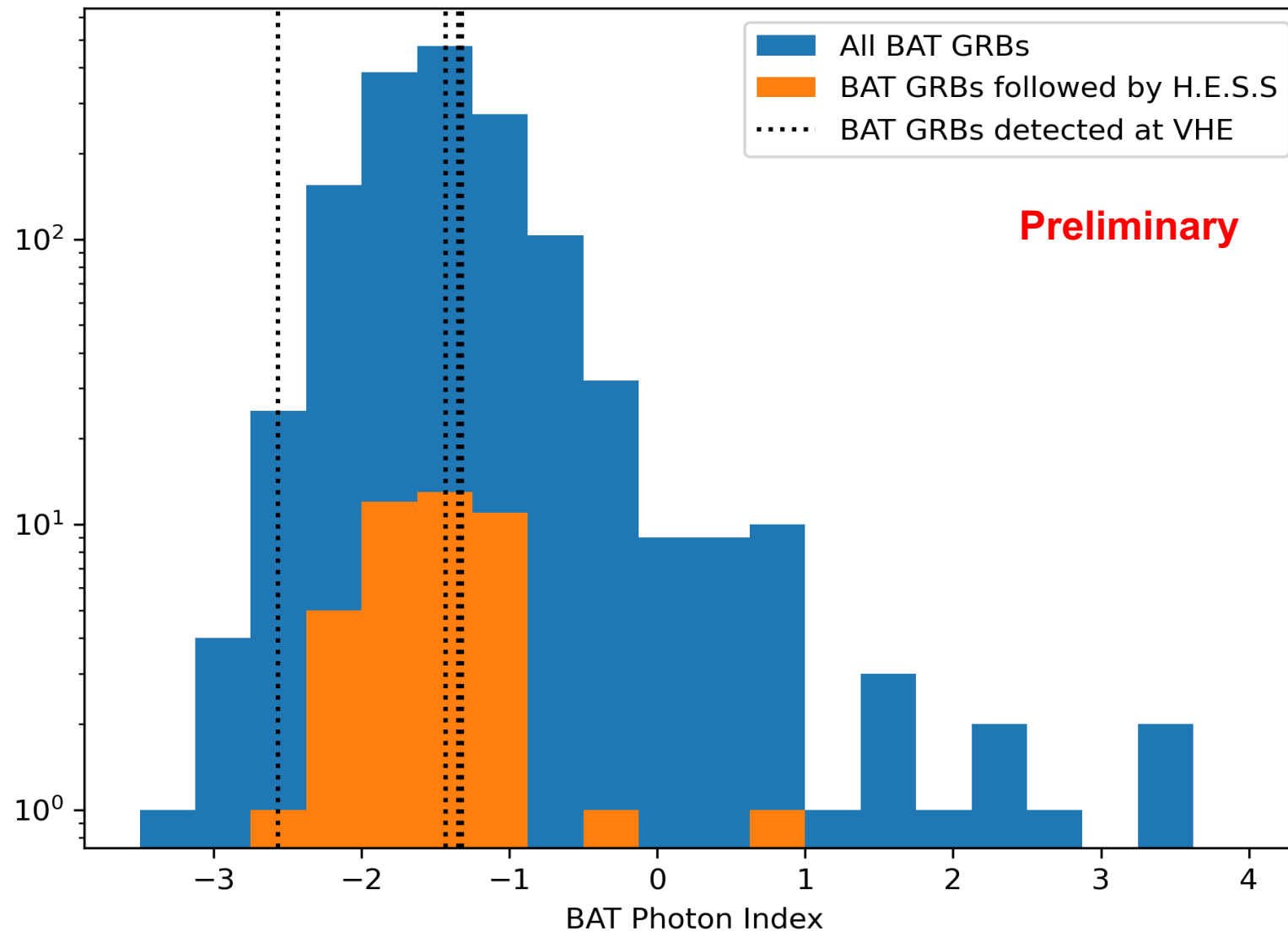
Prompt : Redshift



GRBs observed deviate from the BAT distribution at 2.2σ

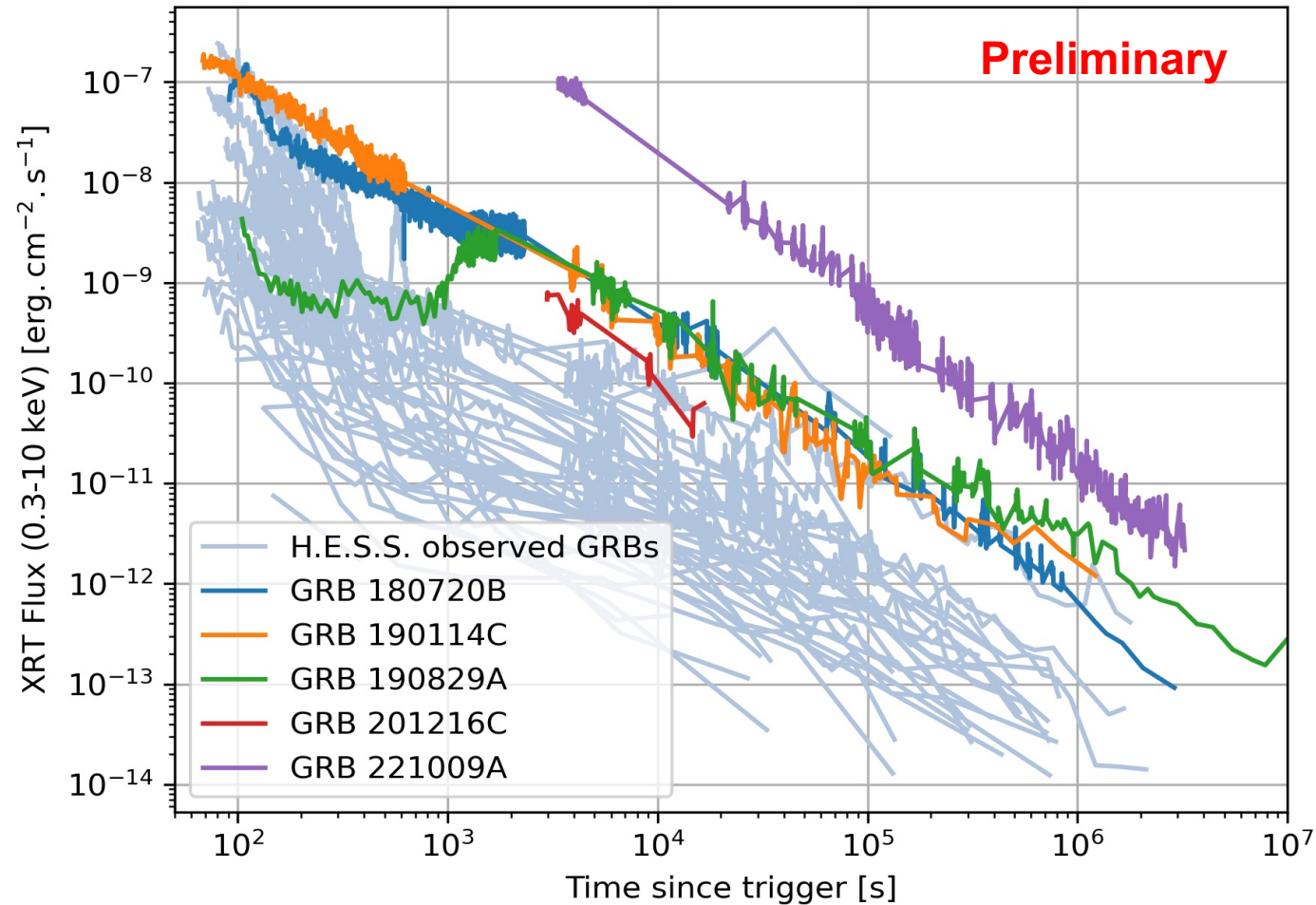
GRBs detected deviate from the BAT distribution at 2.1σ

Prompt : Photon index

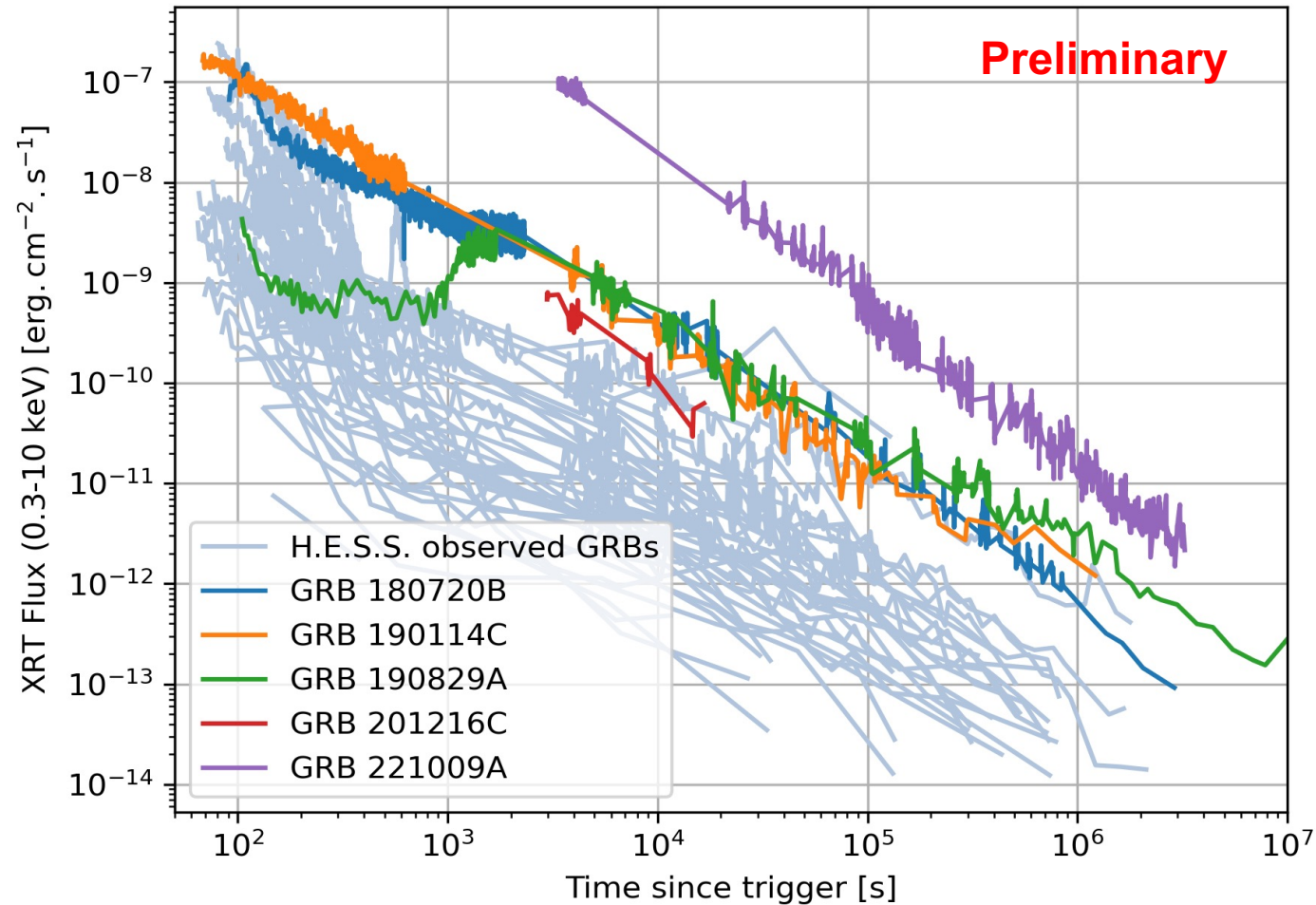


No significant effect

Afterglow : X-Ray Light Curve



Afterglow : X-Ray Light Curve



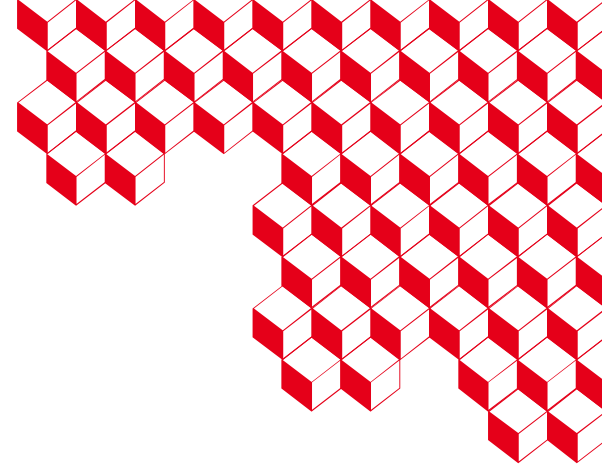
Detected only the brightest GRBs

Conclusion

- Analysis of **15 years of GRBs observations** by H.E.S.S.
- **No hint of signal** from any GRBs
- Population of GRBs detected by Swift :
 - **Unbiased sample of GRBs**
 - **GRBs detected at VHE are :**
 - **Long GRBs**
 - **Close-by GRBs**
 - **Extremely bright (Prompt and Afterglow)**
- Publication in preparation



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Thanks for your attention

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