Small IACT Arrays - Topological Triggers and AGN Observation

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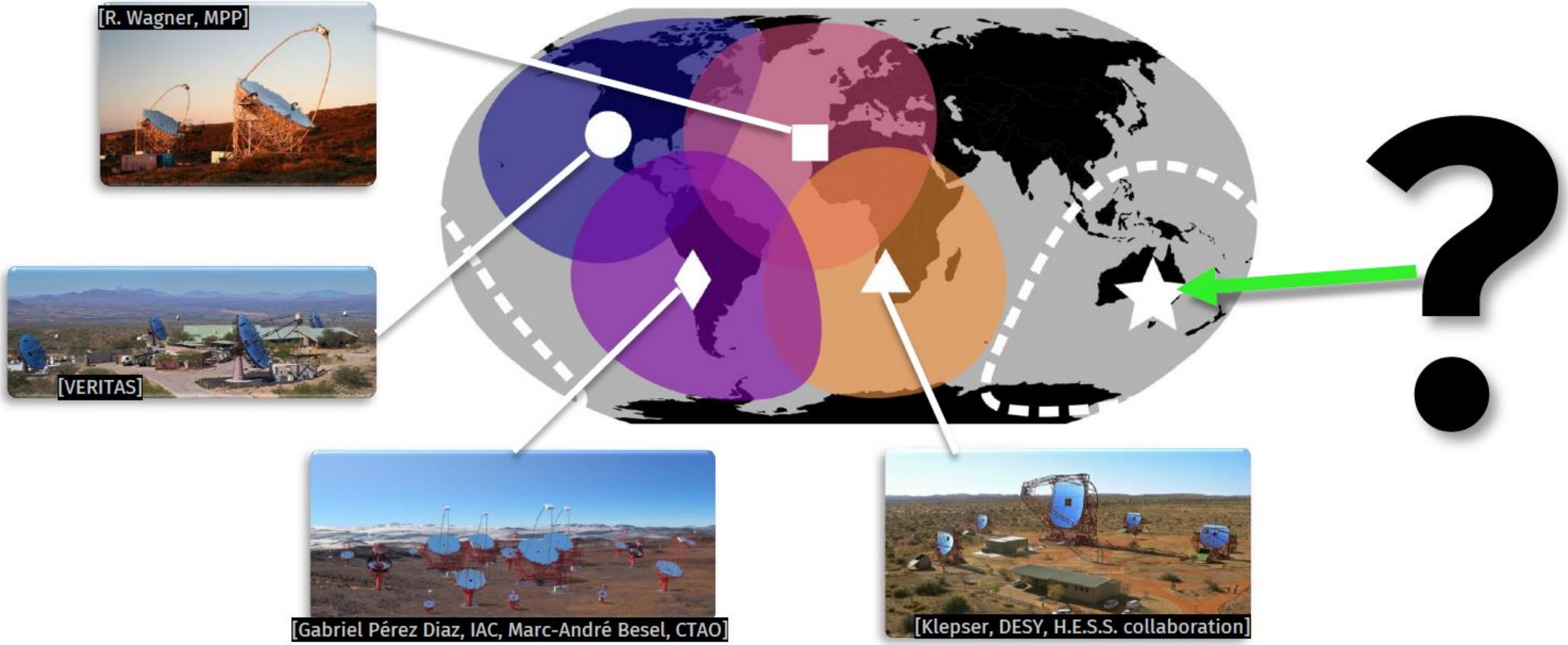
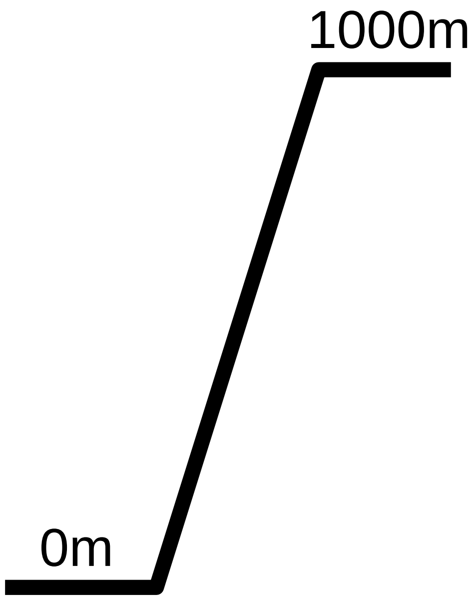
A γ-ray telescope network would be great for astronomy

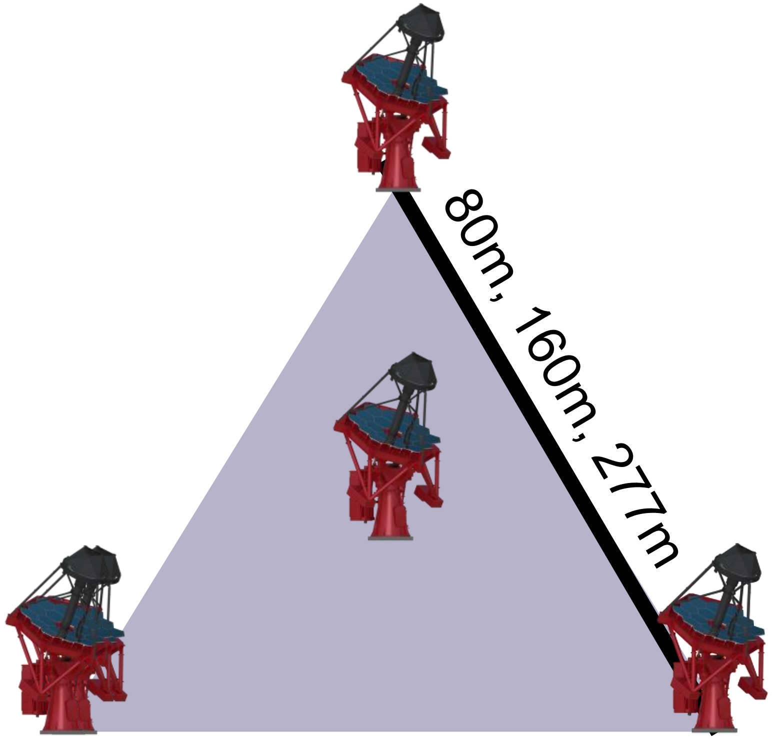


We ran simulations to compare some arrays

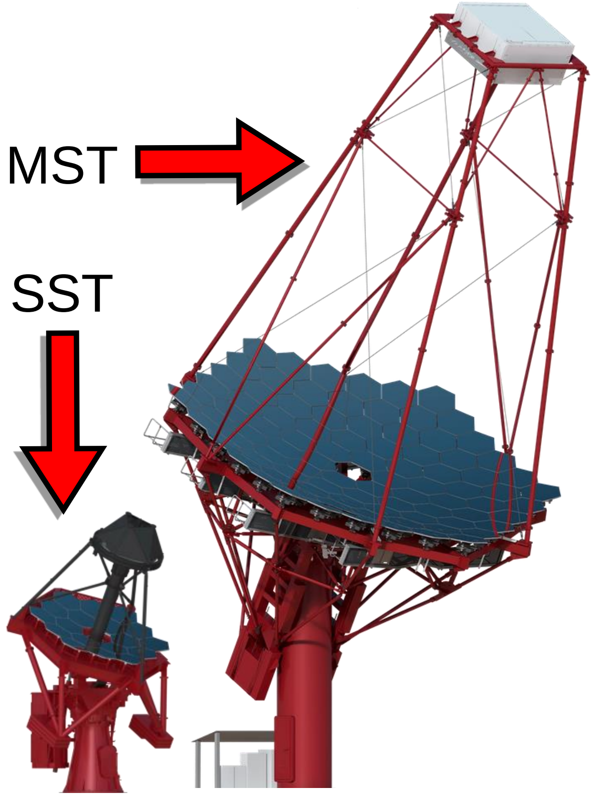
Different numbers of telescopes



Different altitudes



Different distances between telescopes



G. Pérez, IAC, SMM

Different telescope sizes (from CTA designs)

A small IACT array in Australia could give good performance

arXiv:2206.07945 **Performance of a Small Array of Imaging Air Cherenkov Telescopes sited in Australia**

S. Lee, S. Einecke, G. Rowell et al. Publications of the Astronomical Society of Australia **39**, 041 (2022)

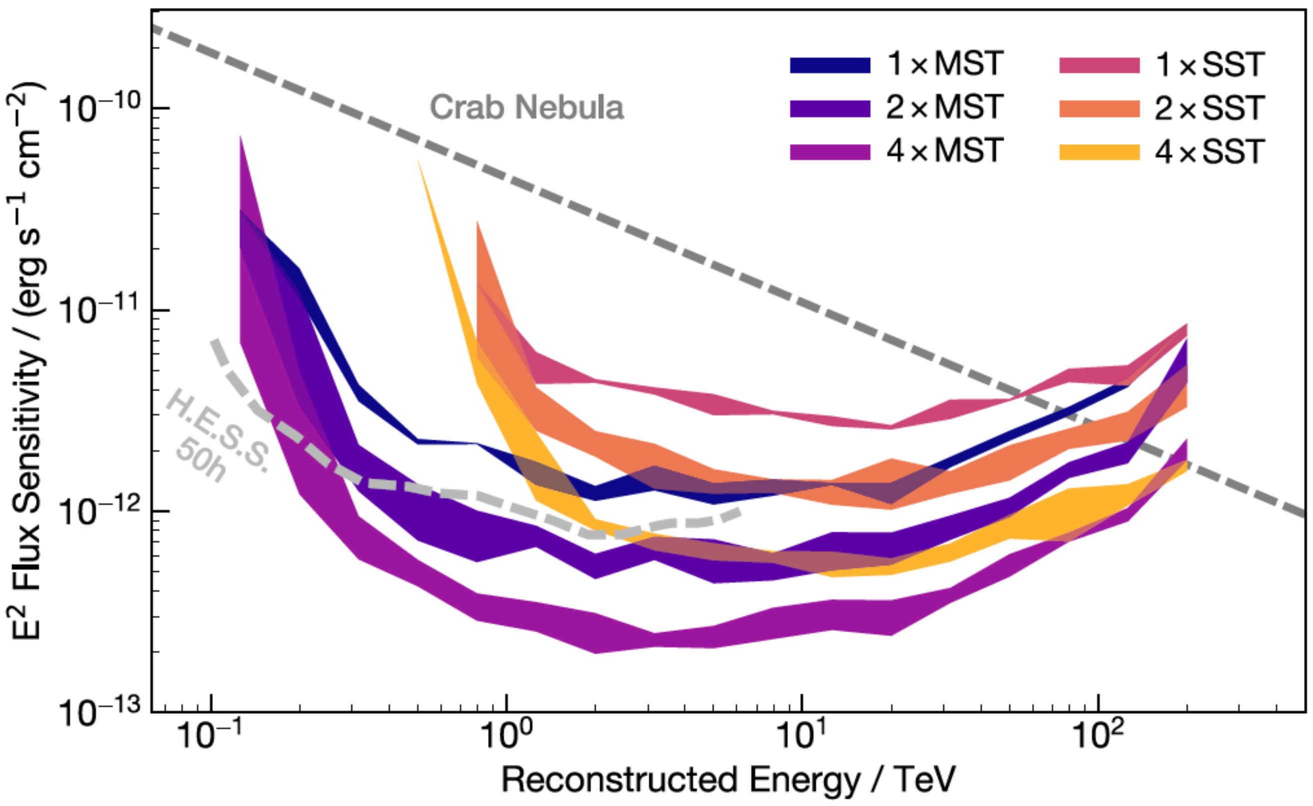


Figure 4. 50-hour differential point-source flux sensitivity for a 5σ detection as a function of reconstructed gamma-ray energy. Bands represent the range of sensitivities across the studied altitudes (0 m and 1000 m) and baseline distances (80 m to 277 m). Cuts on gamma score and θ^2 were applied for each energy bin to optimise sensitivity for each array setup. No cuts on the number of telescopes triggered were applied. The H.E.S.S. 50-hour sensitivity curve is shown for comparison (Holler et al., 2015).

For transients, we want to capture more low-energy γ rays

- Extragalactic sources are less visible at high energies due to Extragalactic Background Light (EBL) absorption

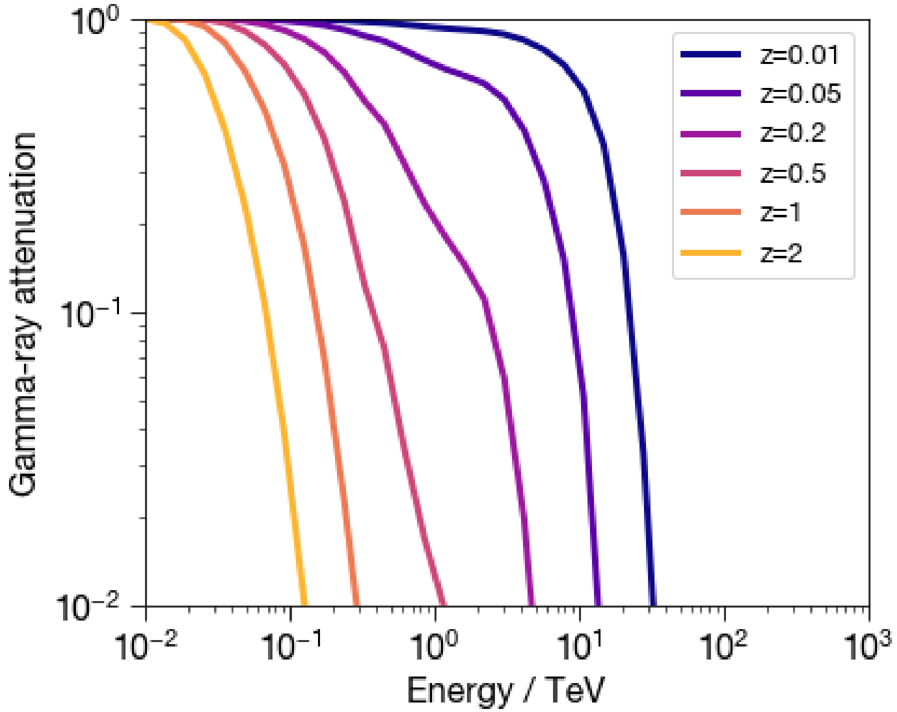


Figure 1: Gamma-ray attenuation at Earth of depending on redshift (z) due to EBL absorption

- To see lower-energy gamma rays, we want to reduce the telescope camera's trigger threshold (Discriminator Threshold, DT) without increasing triggers from the Night Sky Background (NSB)

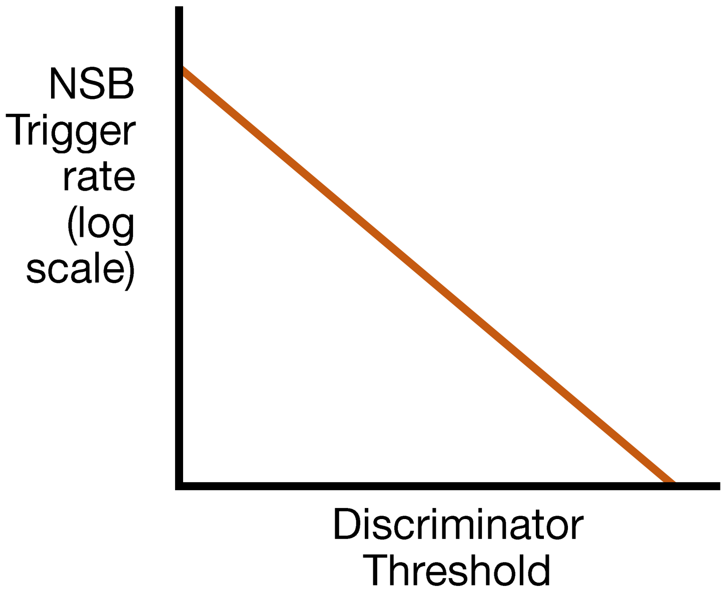


Figure 2: Relationship between DT and the rate of camera triggers due to NSB

A stereo trigger improved performance for most arrays

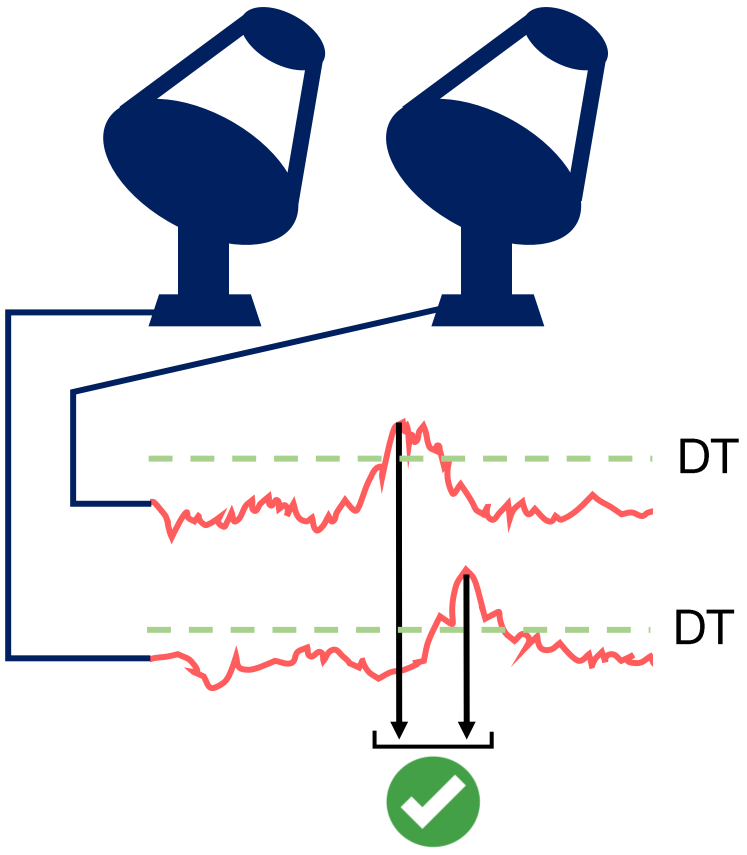


Figure 1: Diagram of how a stereoscopic array trigger works, requiring signals to cross a Discriminator Threshold in a time window

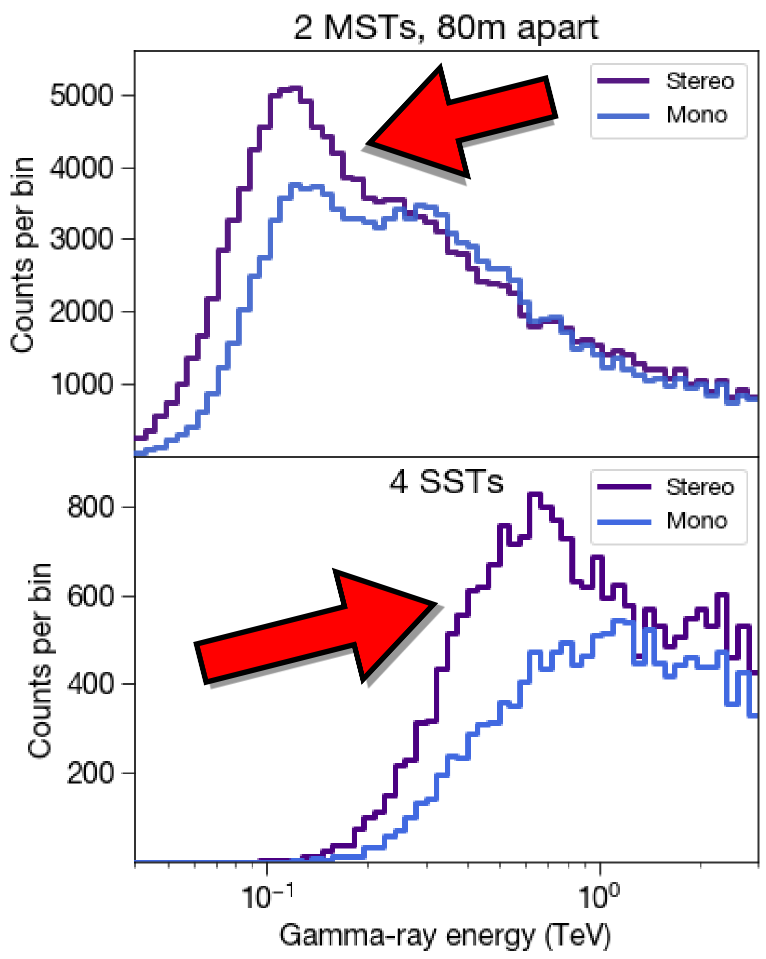


Figure 2: Distribution of gamma rays left after cleaning, quality cuts, and performance cuts, depending on trigger type

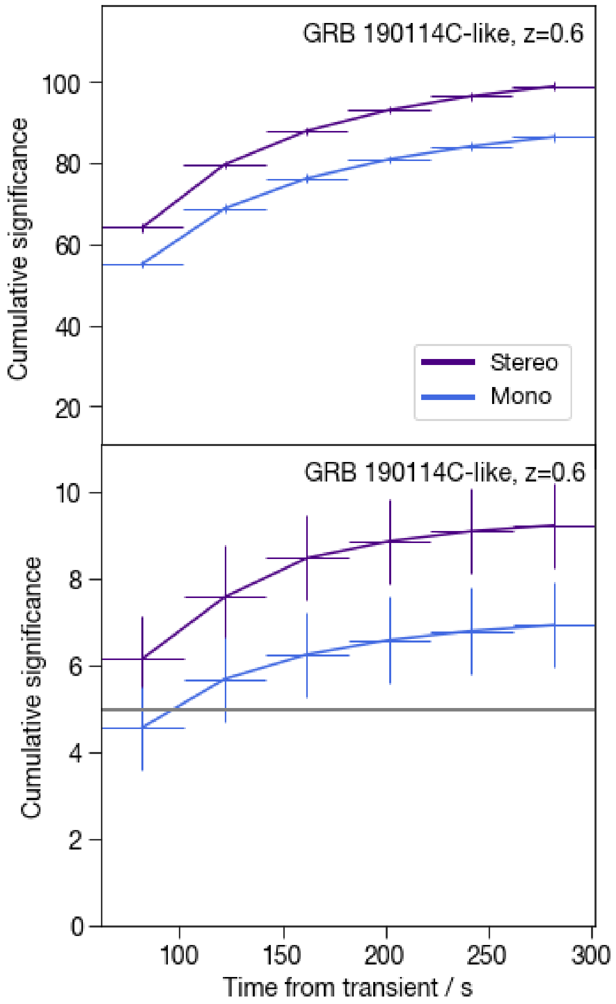
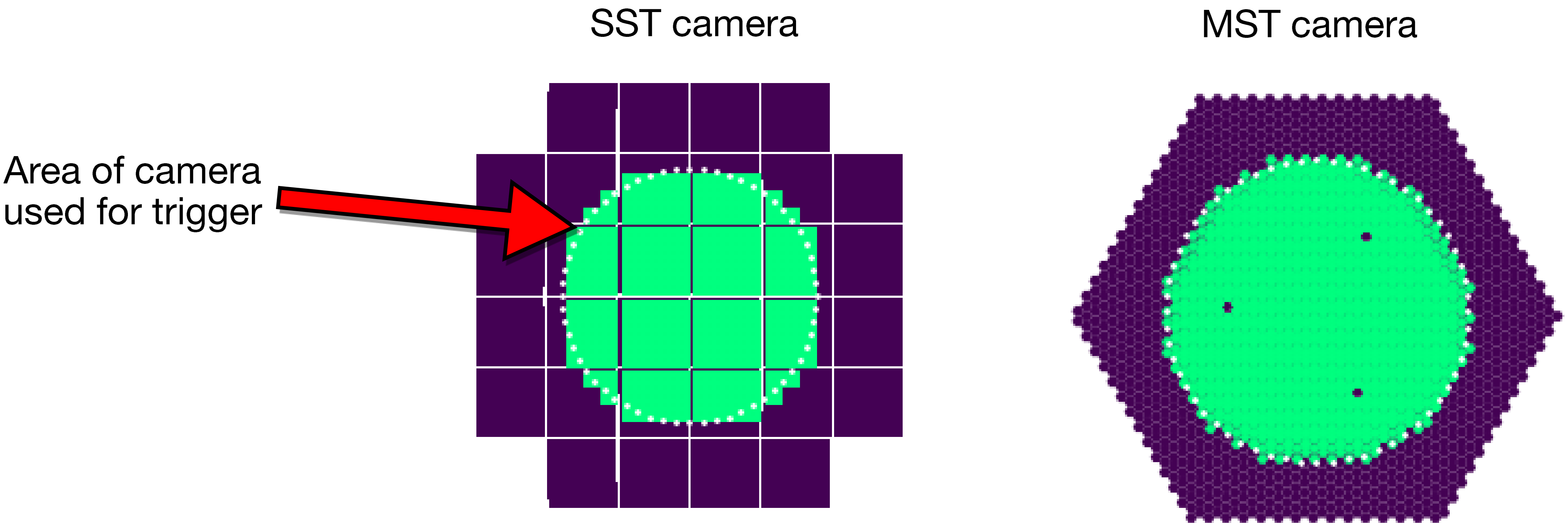


Figure 3: Cumulative significance plots for a GRB with a redshift of 0.6

We tried using only a small part of the camera for triggering



- “Topological” (topo) trigger
- Reduces NSB and protons triggers proportional to area of camera not used
- Keeps 100% of low-energy gamma rays

Trigger and cleaning thresholds were adjusted for equal NSB

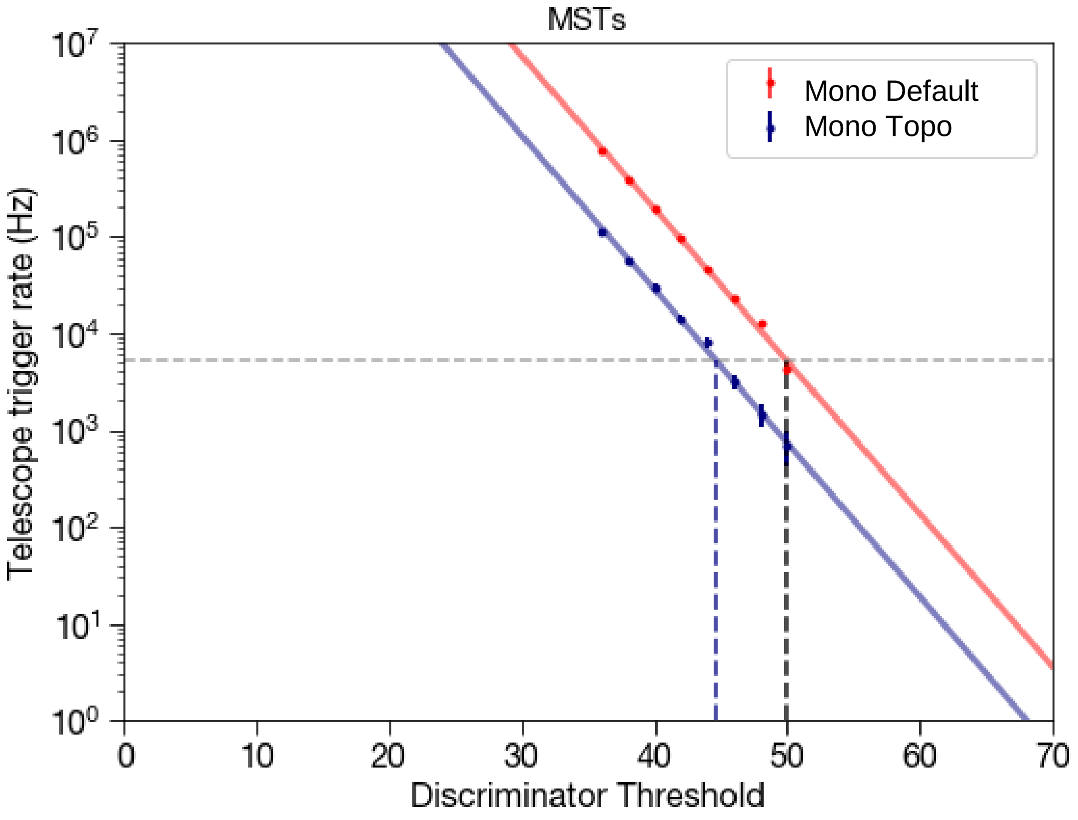


Figure 1: NSB trigger rate for both the default and the topological trigger for MSTs, showing the lower DT achievable with the topo trigger

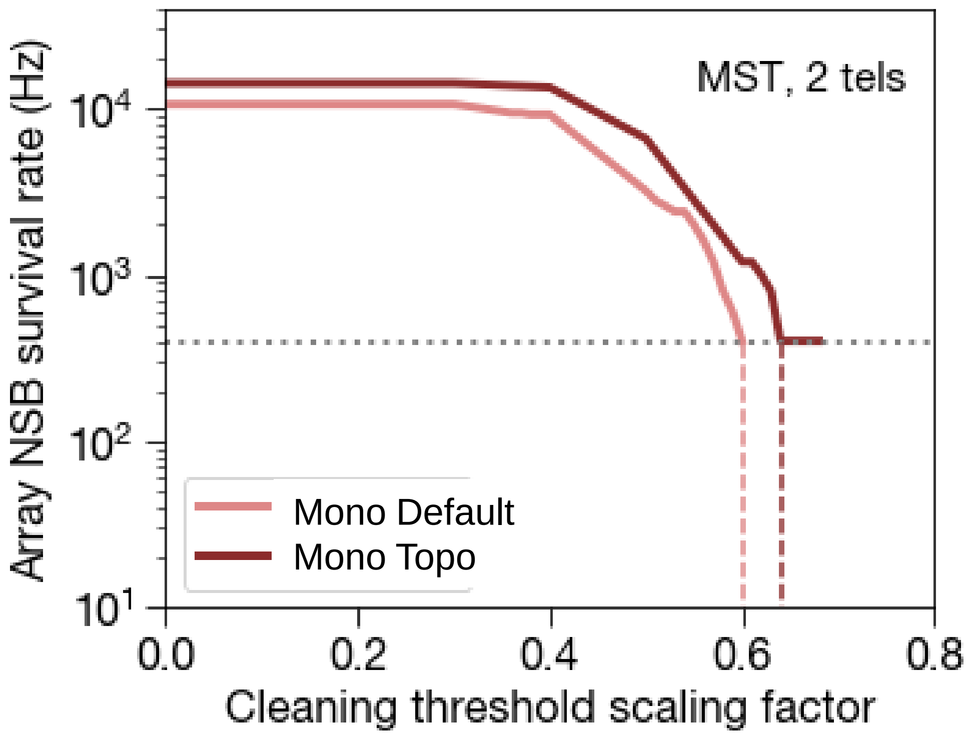
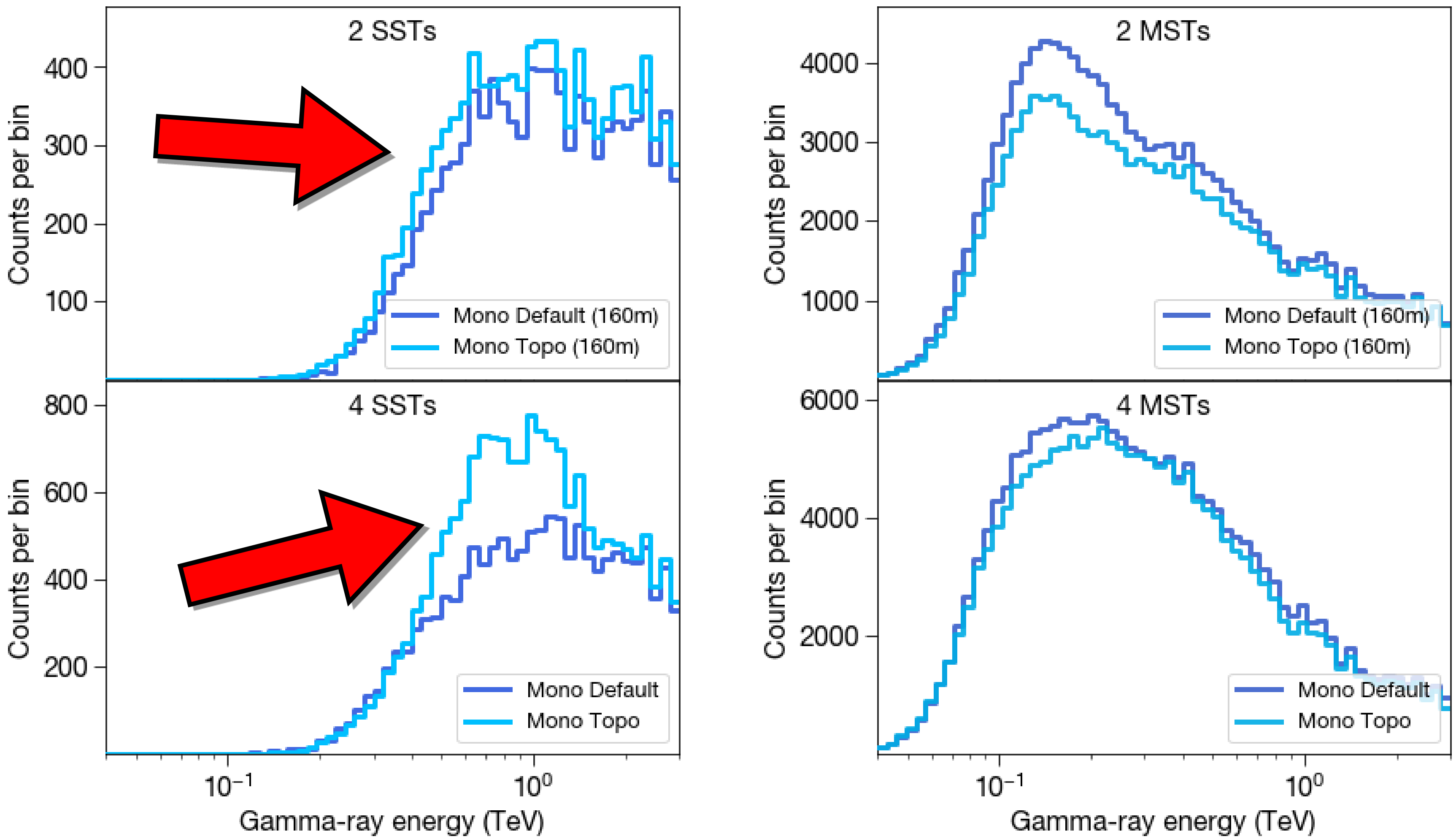
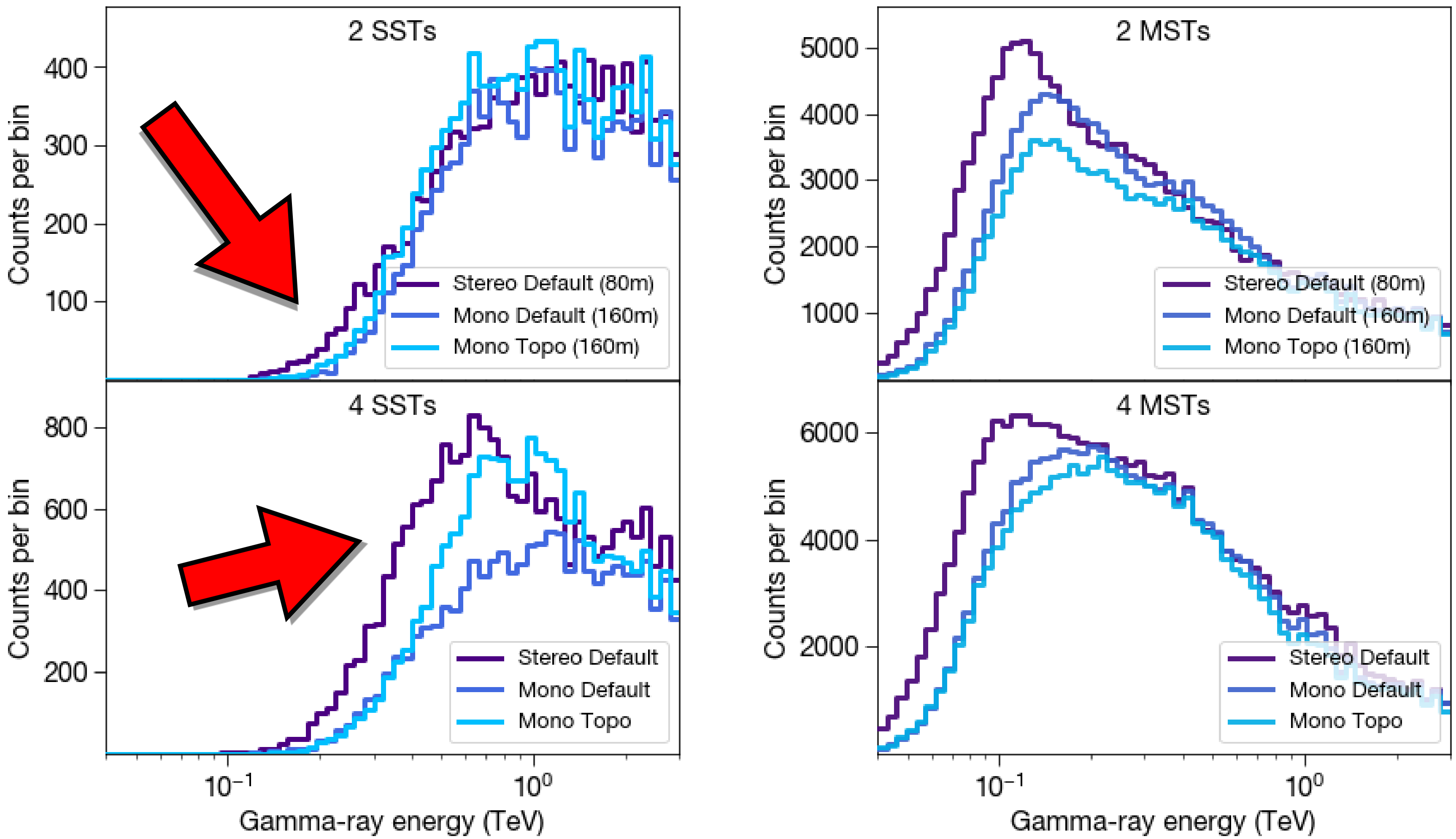


Figure 2: Adjusting the cleaning thresholds so and equal (low) number of NSB events survive

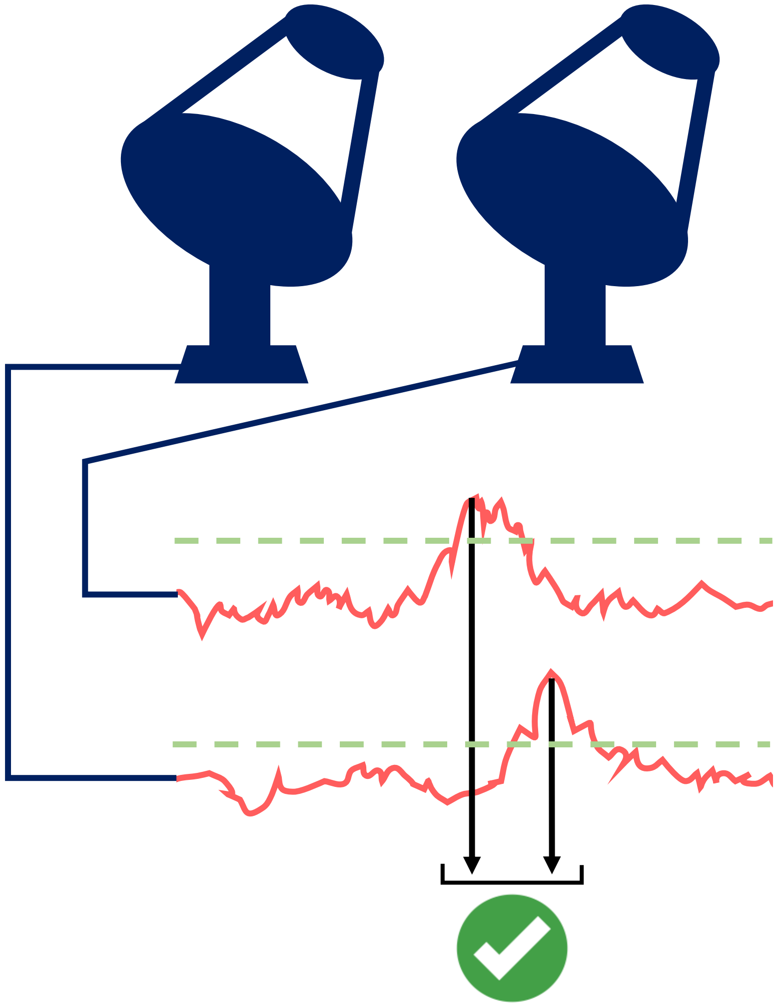
SSTs saw more γ rays with this topological trigger...



…but topo trigger on its own was not better than stereo



The stereoscopic and topological triggers can be combined



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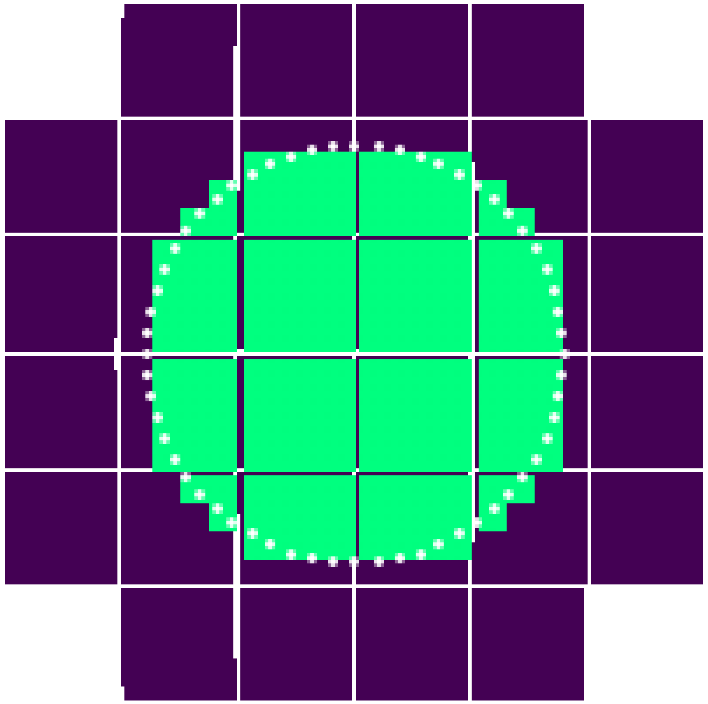


The stereo/topo trigger sometimes showed small benefits

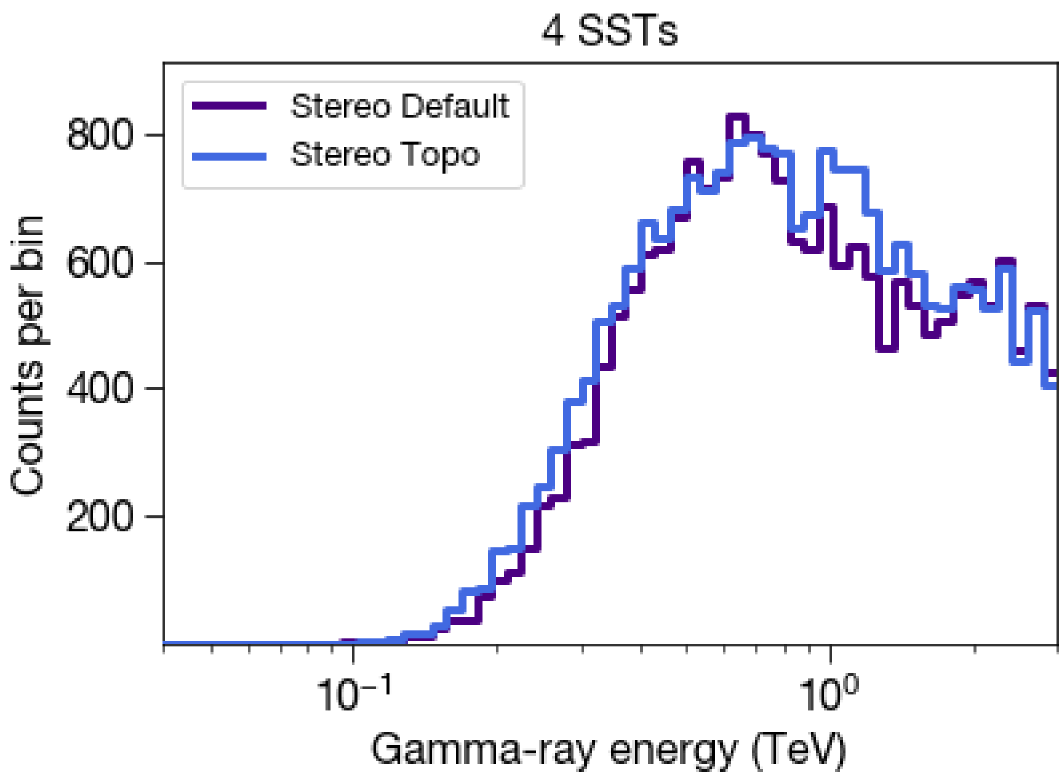
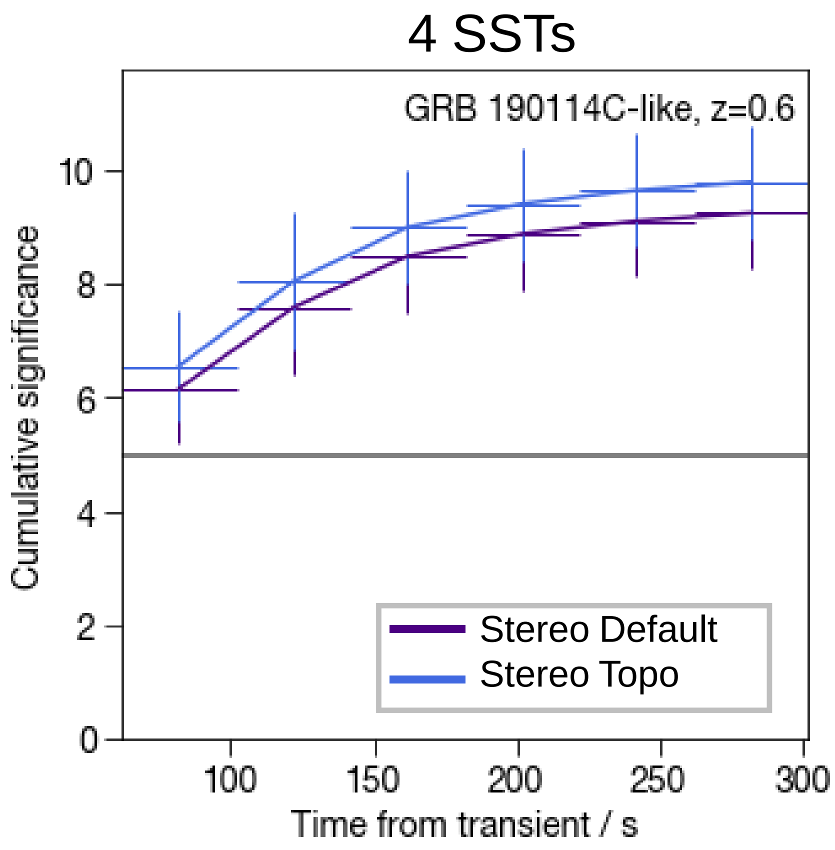


Figure 1: Distribution of gamma rays left after cleaning, quality cuts, and performance cuts, depending on trigger type



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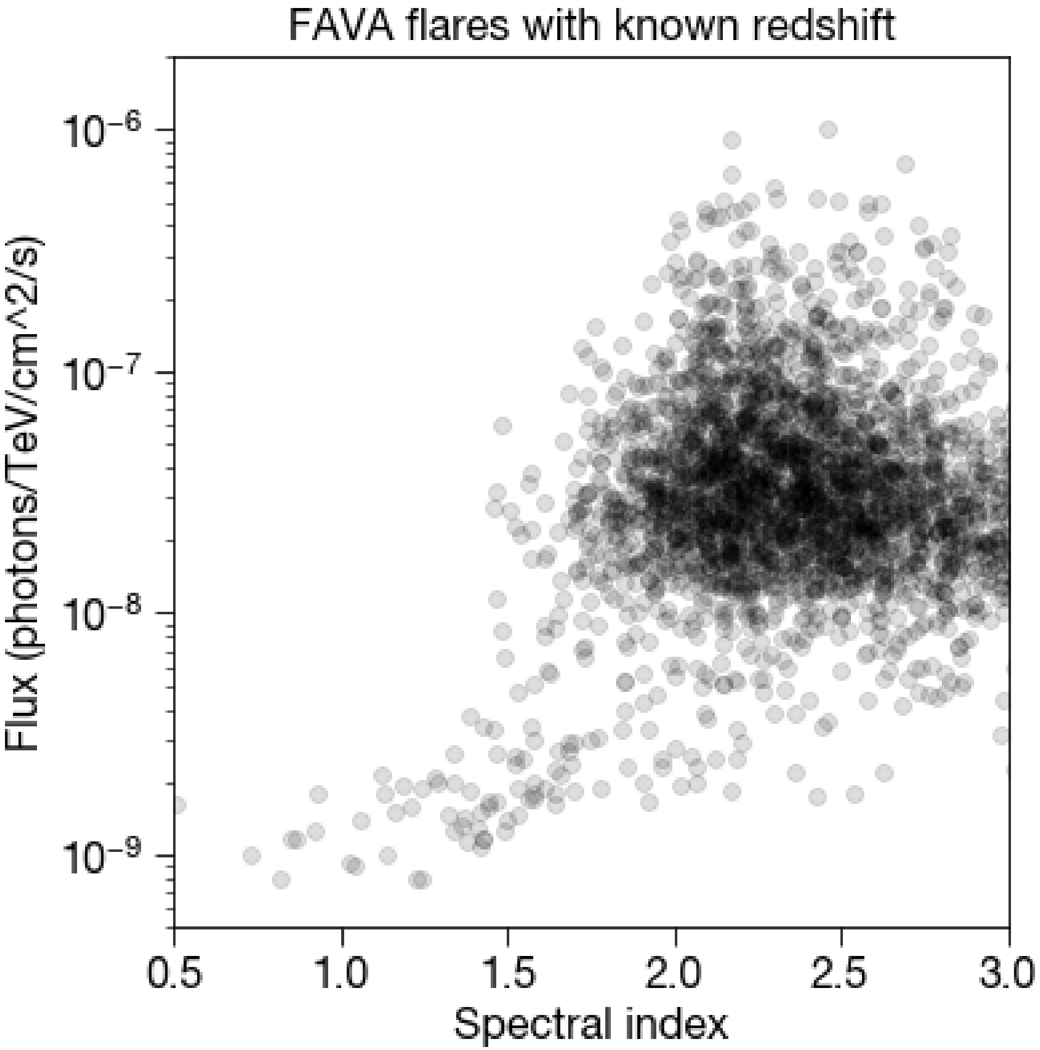
How well could these arrays observe AGN flares?



1. We obtained *Fermi*-LAT weekly-binned flare data for AGNs with known redshift (Abdollahi et al. 2017, Abdollahi et al, 2020 *ApJS* **247** 3)

~12 years, 505 AGNs, 3201 flares

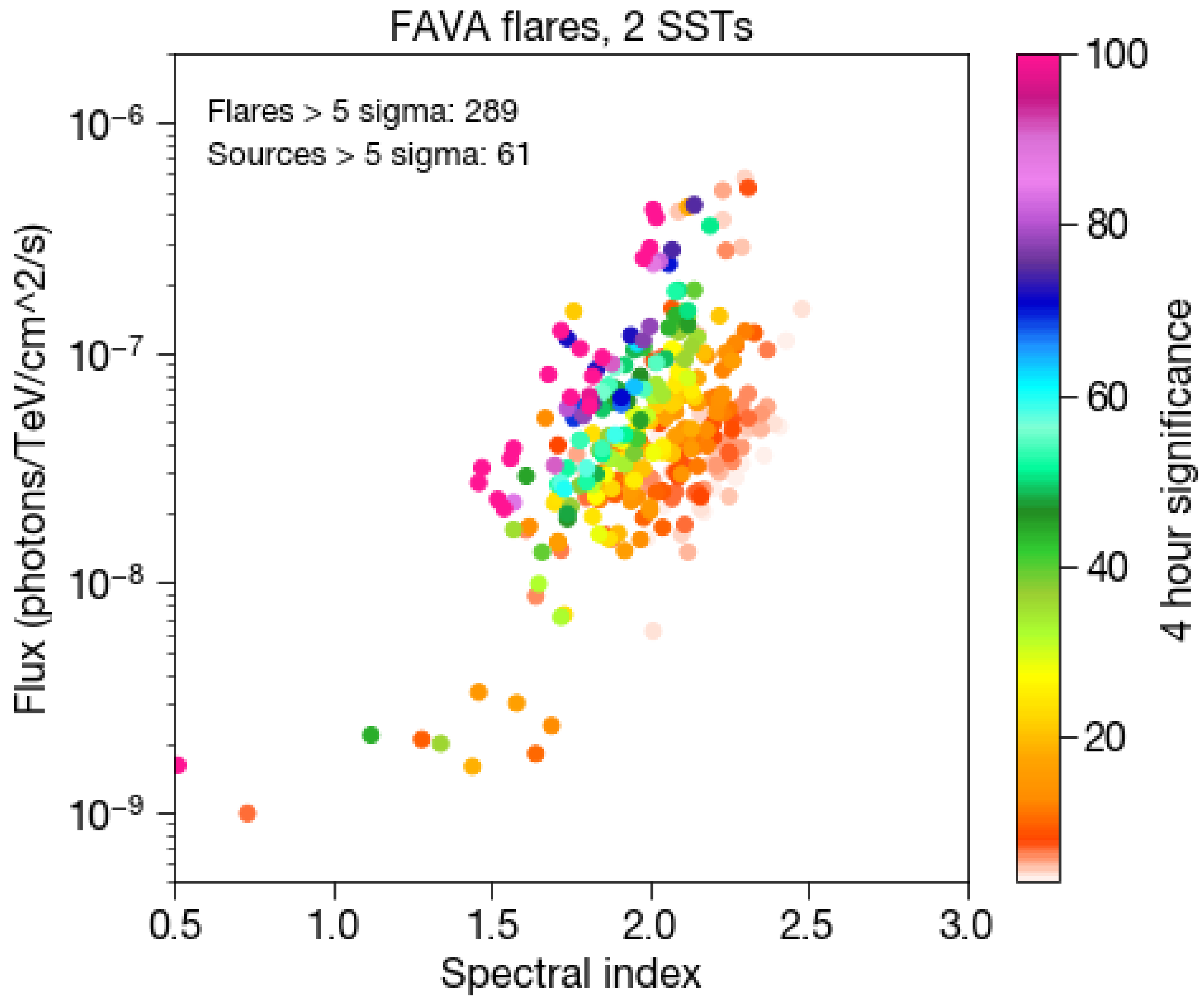
2. We modelled flares using the flux and spectral index in the Fermi-LAT high-energy bin (0.8 – 300 GeV)

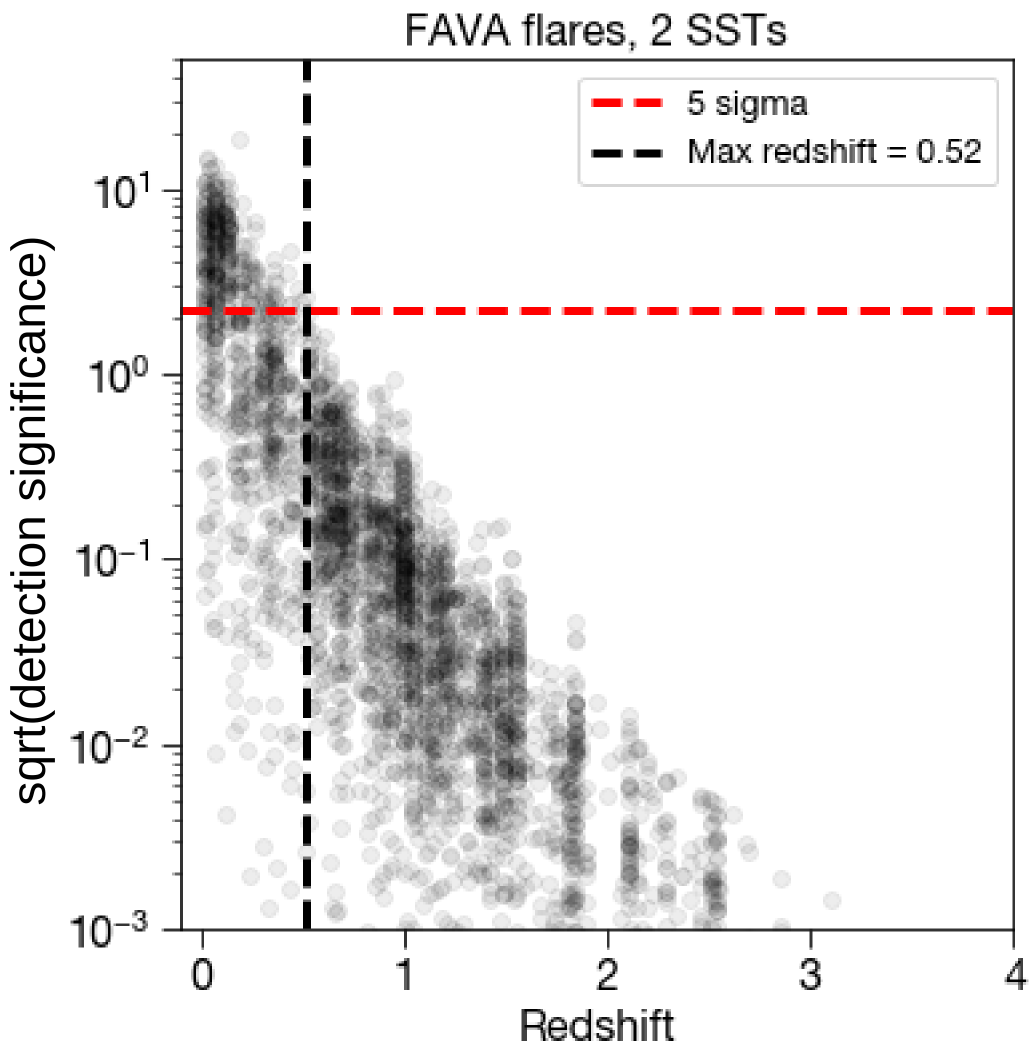
3. We assumed a temporal decay over the week Fermi-LAT observed the flare

4. We estimate IACT observation for **4 hours**, starting **24 hours** in to the Fermi week

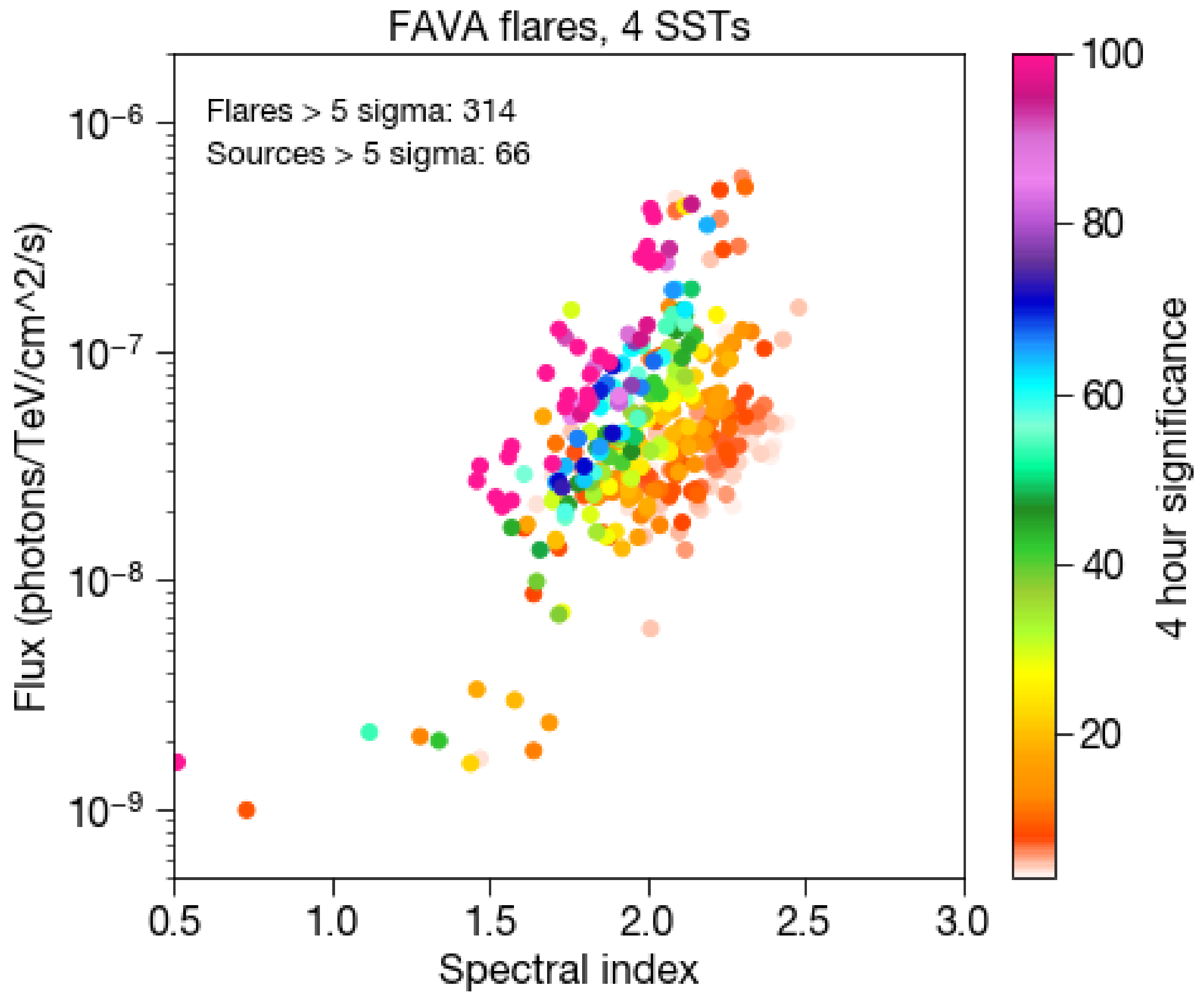
This is a rough model with many assumptions.
The forthcoming results are preliminary.

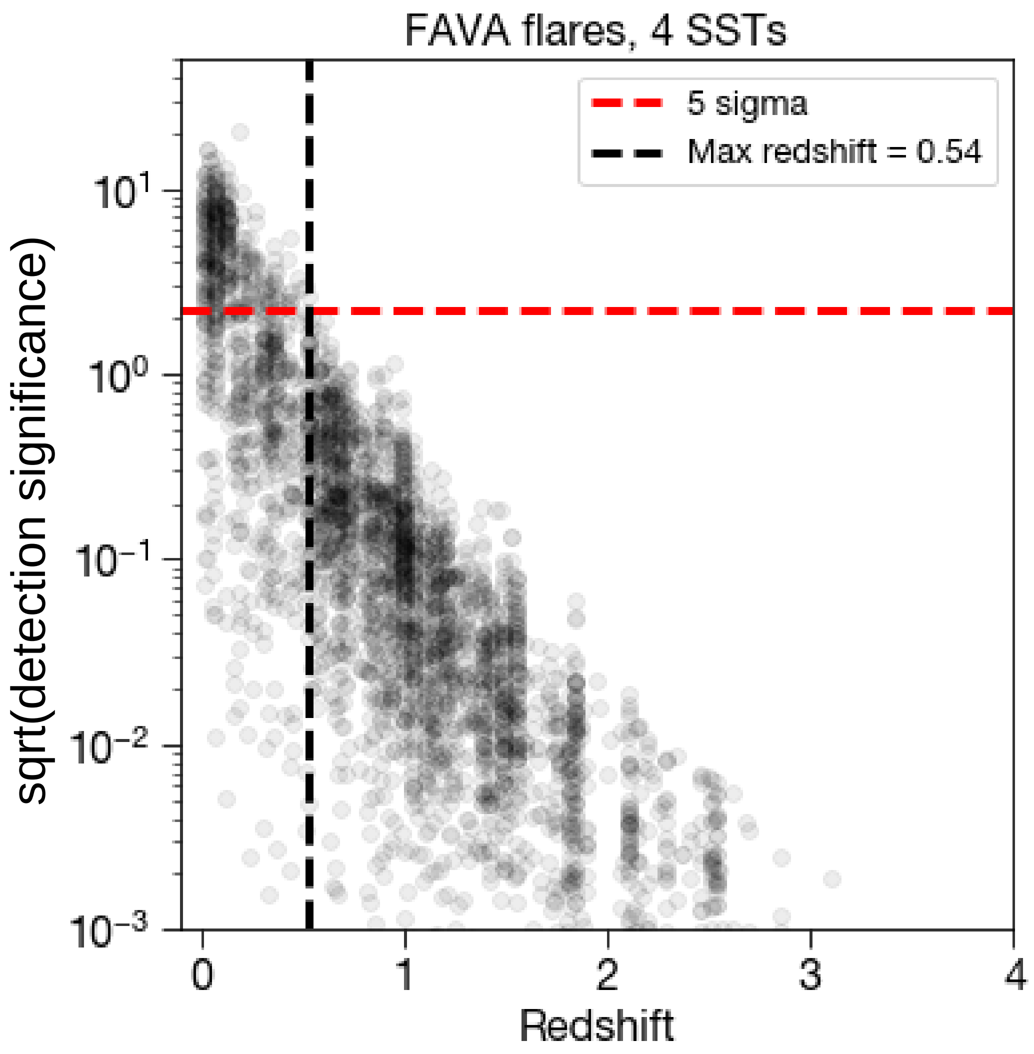
2 SSTs could see ~9% of AGN flares that *Fermi*-LAT sees



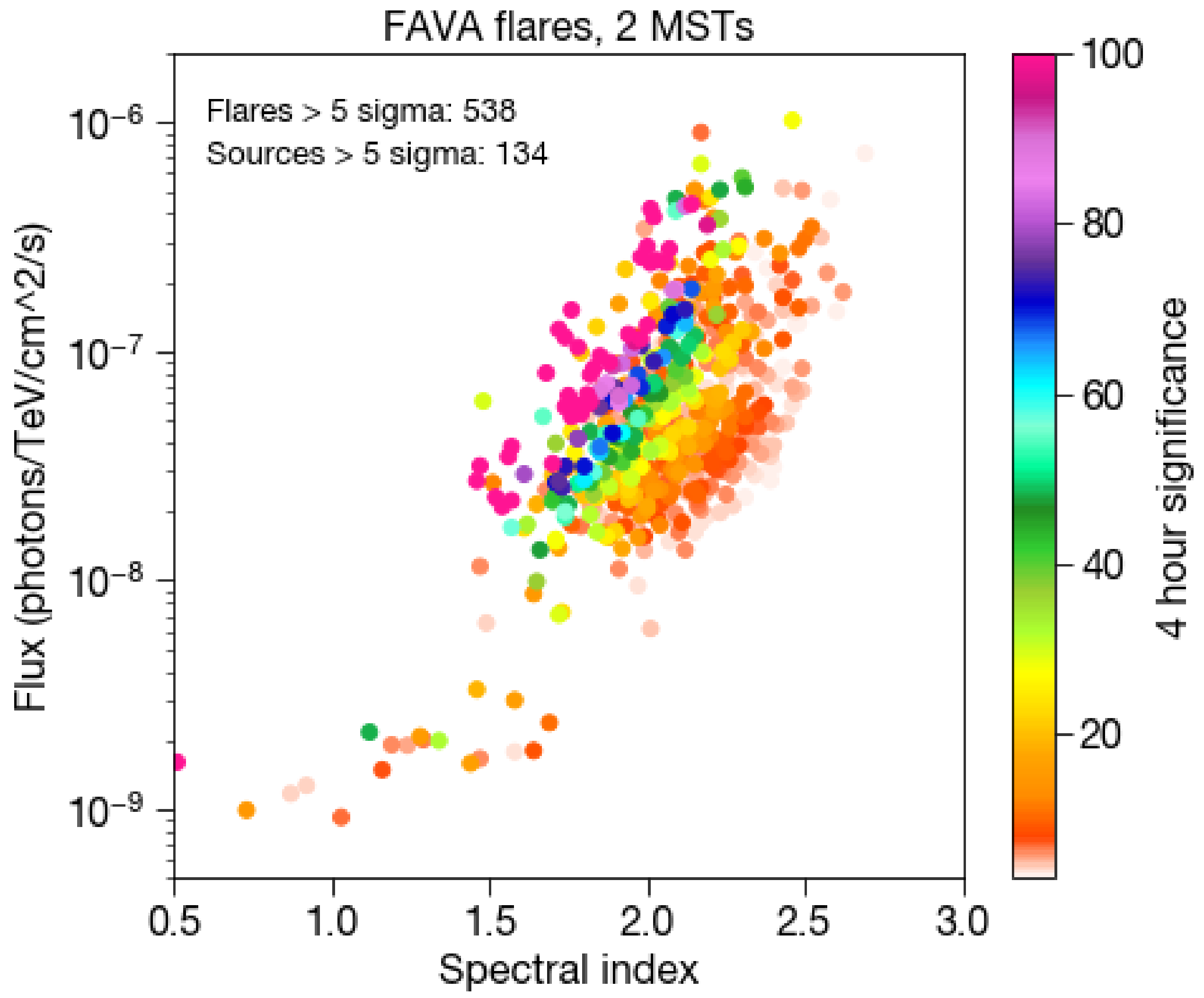


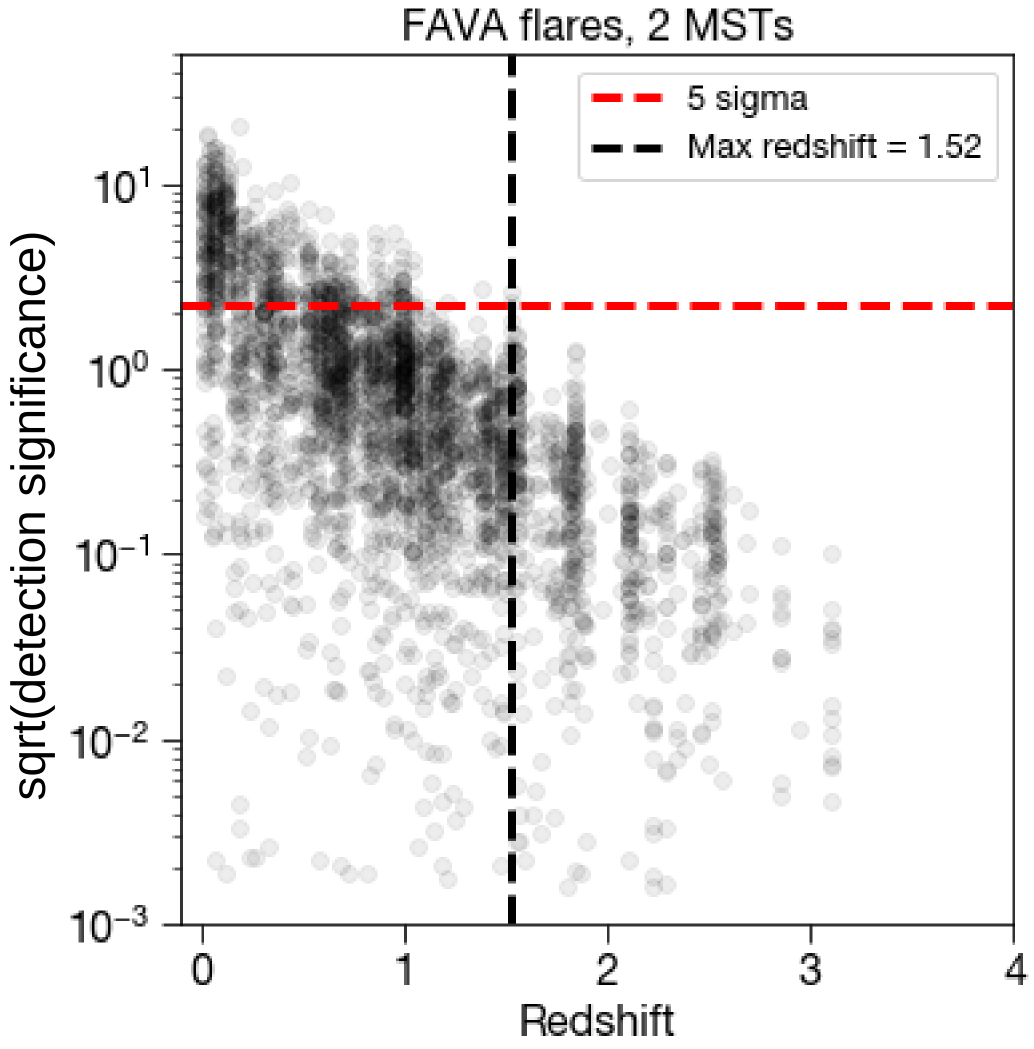
4 SSTs could see ~10% of AGN flares that *Fermi*-LAT sees



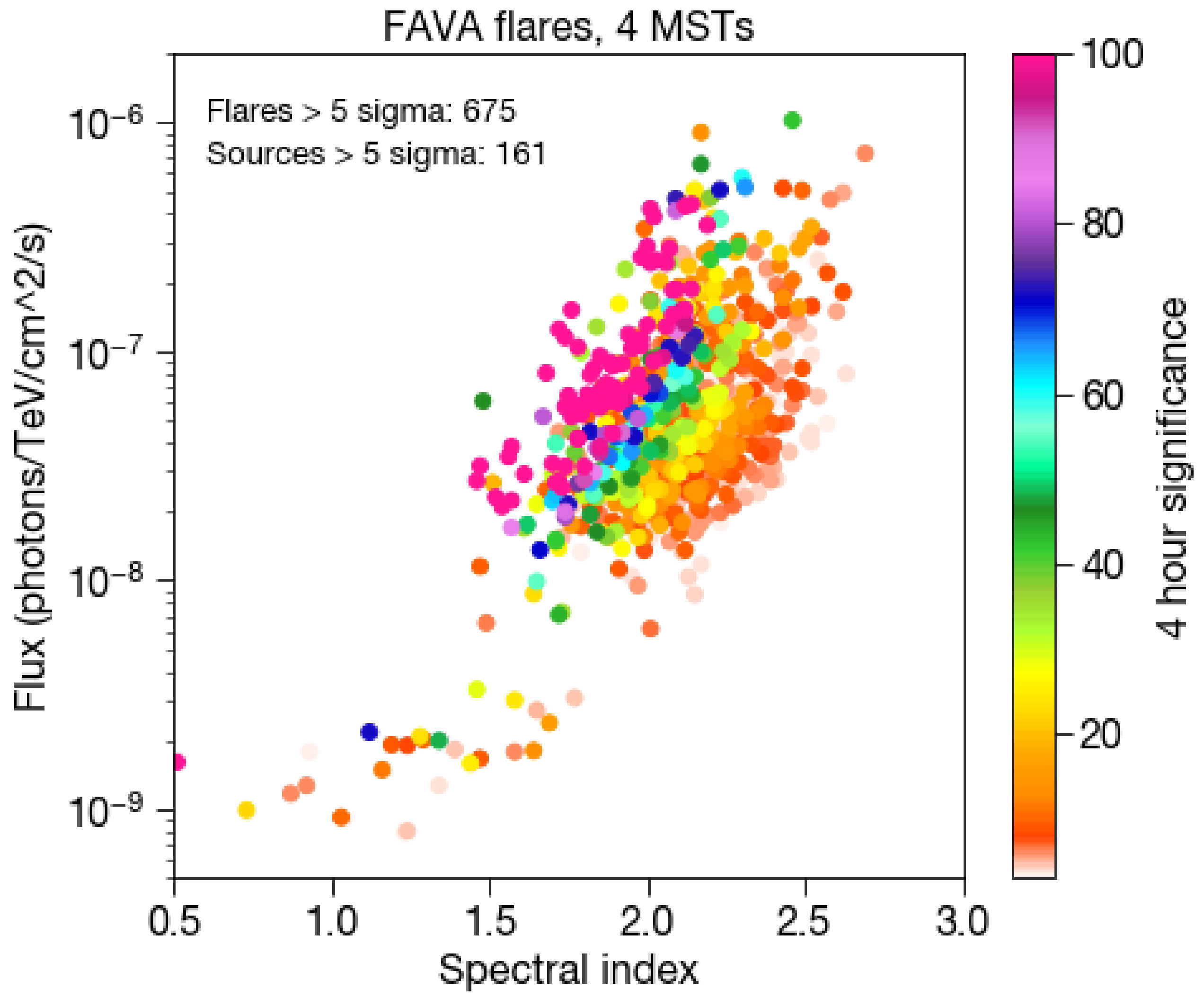


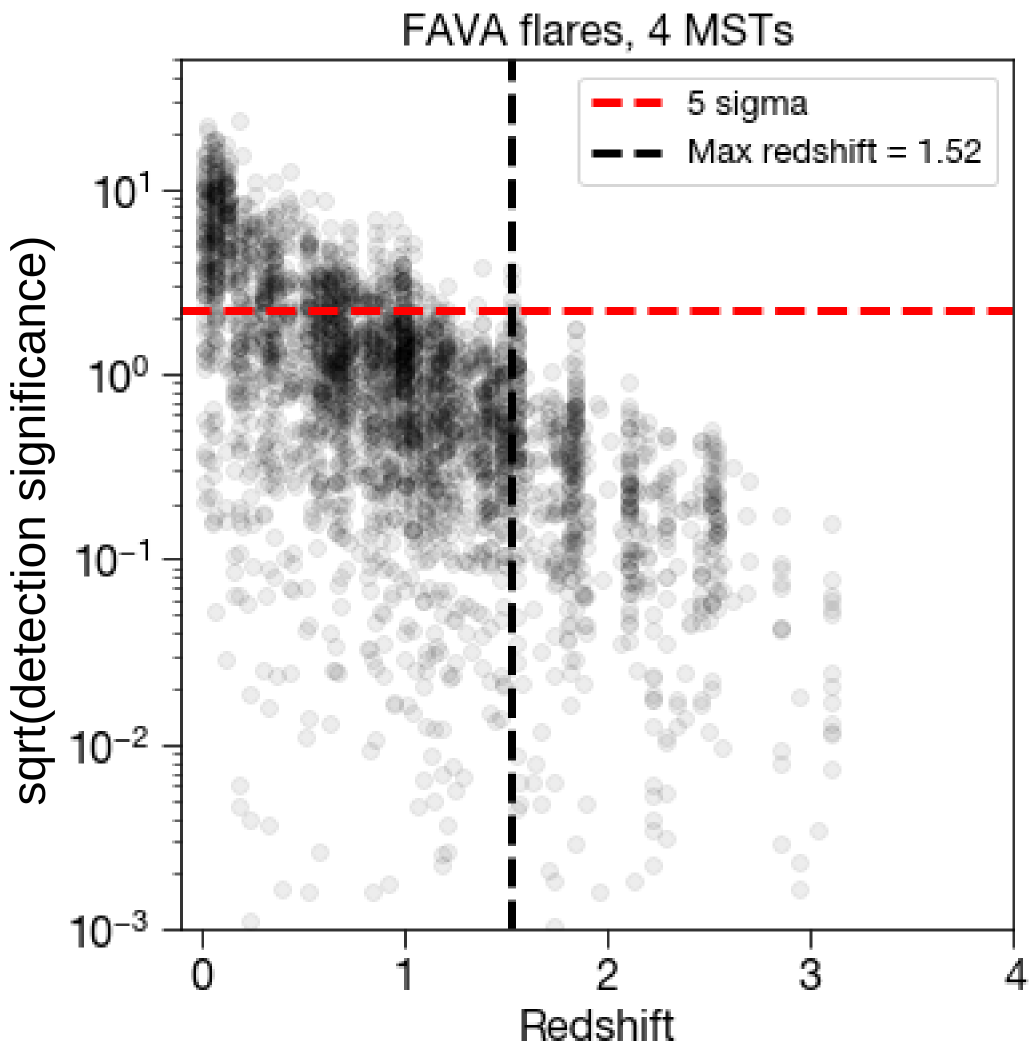
2 MSTs could see ~17% of AGN flares that *Fermi*-LAT sees



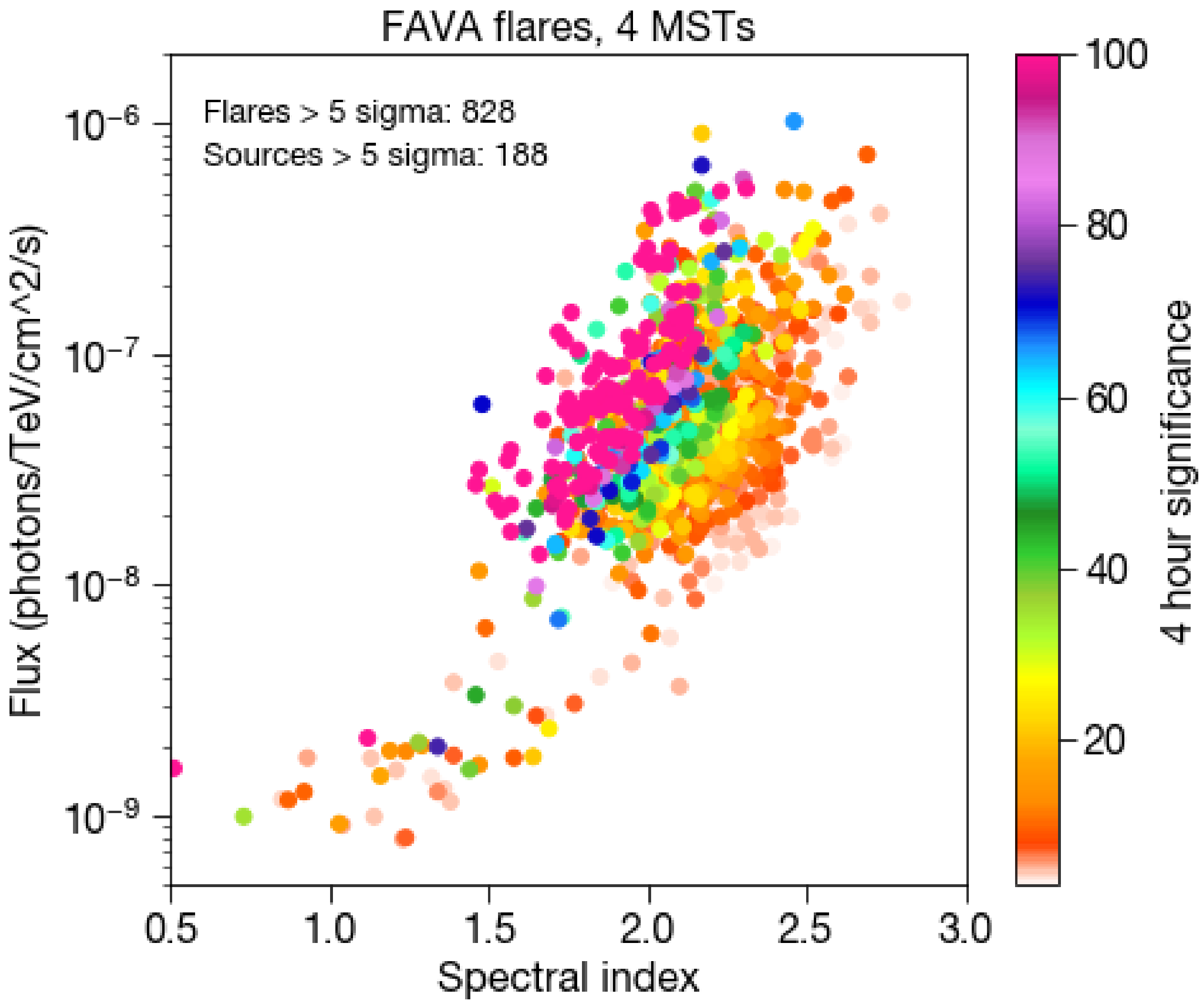


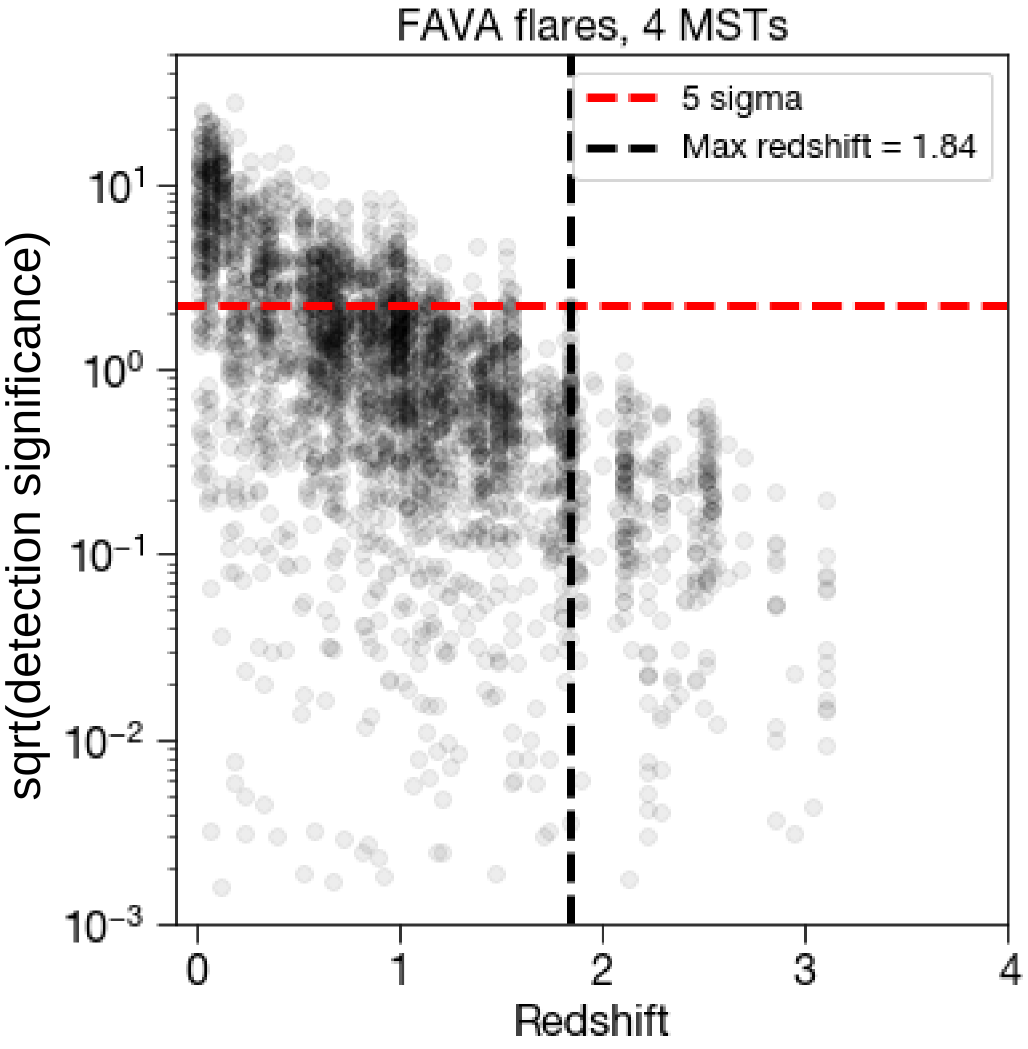
4 MSTs could see ~21% of AGN flares that *Fermi*-LAT sees





…or ~26% if it started observing 12 hours earlier





Conclusion

- A small IACT array in Australia would contribute well to a worldwide network of gamma-ray telescopes, including triggering and following up on CTA

- A simple topological trigger can improve performance over the default, but not over a stereo trigger

- Combining the stereo and topo triggers can give small performance benefits

- Such arrays could succesfully follow up on many flares seen by *Fermi*-LAT

Thankyou