Unfolding the title

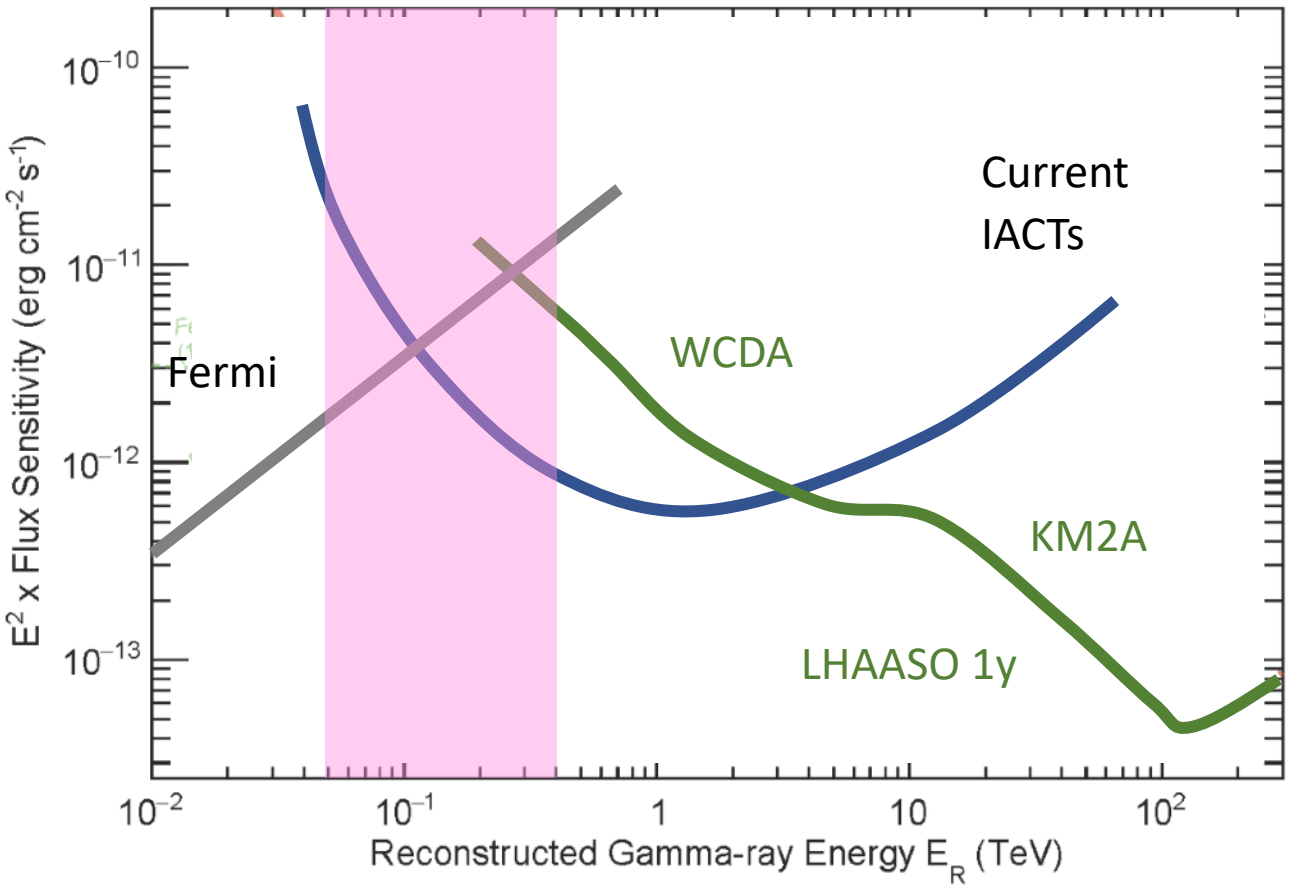
Line-of-Sight Trigger

LOST Updates

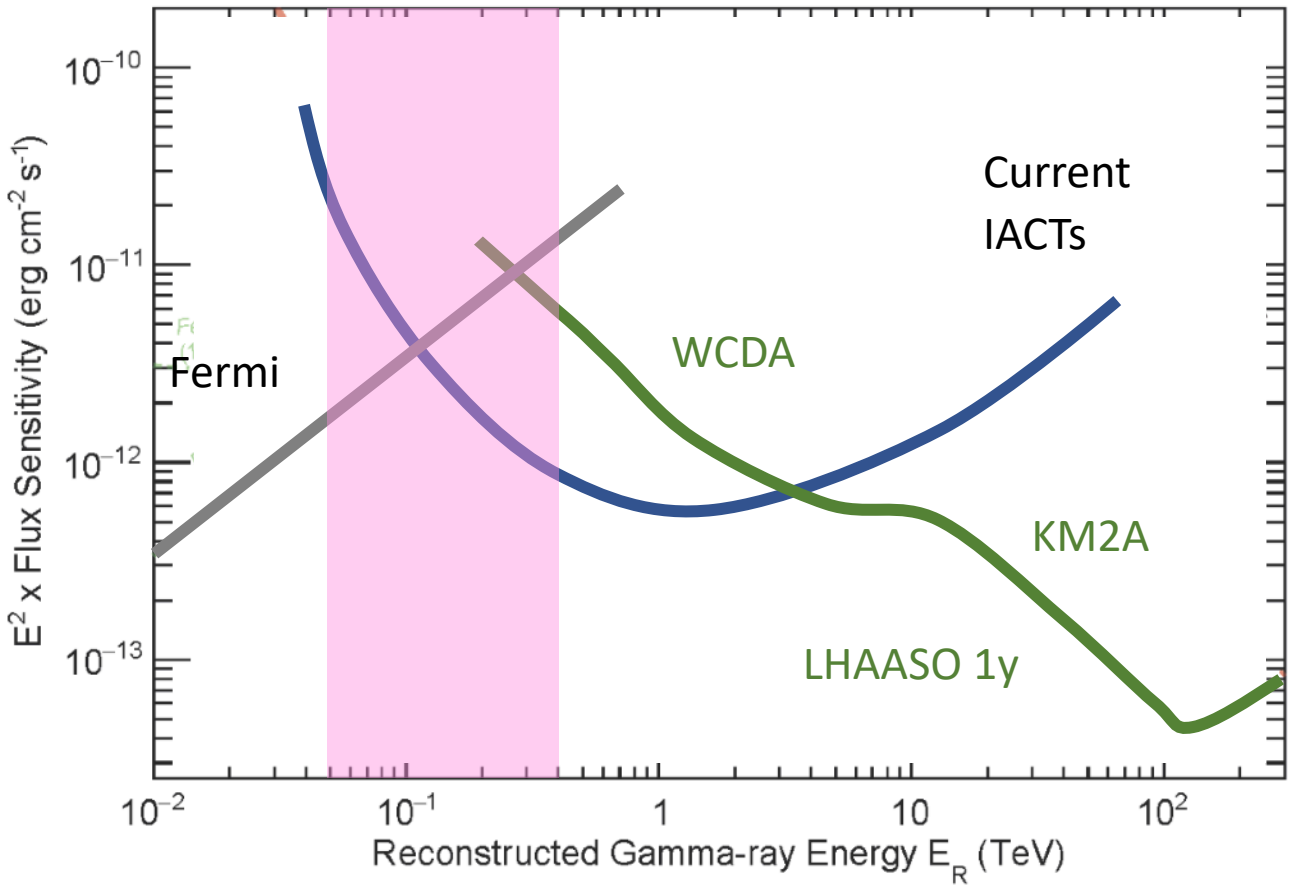
Hao Zhou, Minhao Gu, Ruiyi Tang

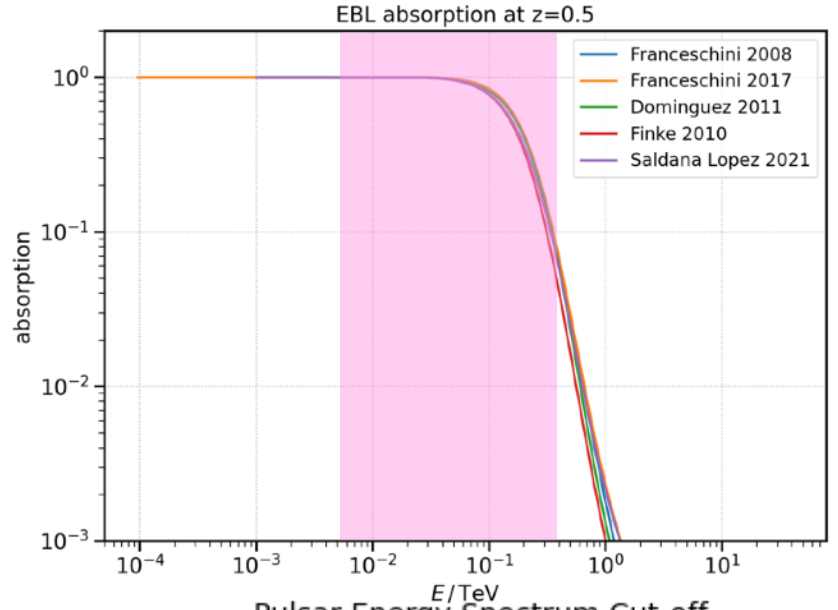
For the low energy end of WCDA,
Using the particle detector array as a pointing telescope,
Trading the large FoV for low energy sensitivity to certain directions

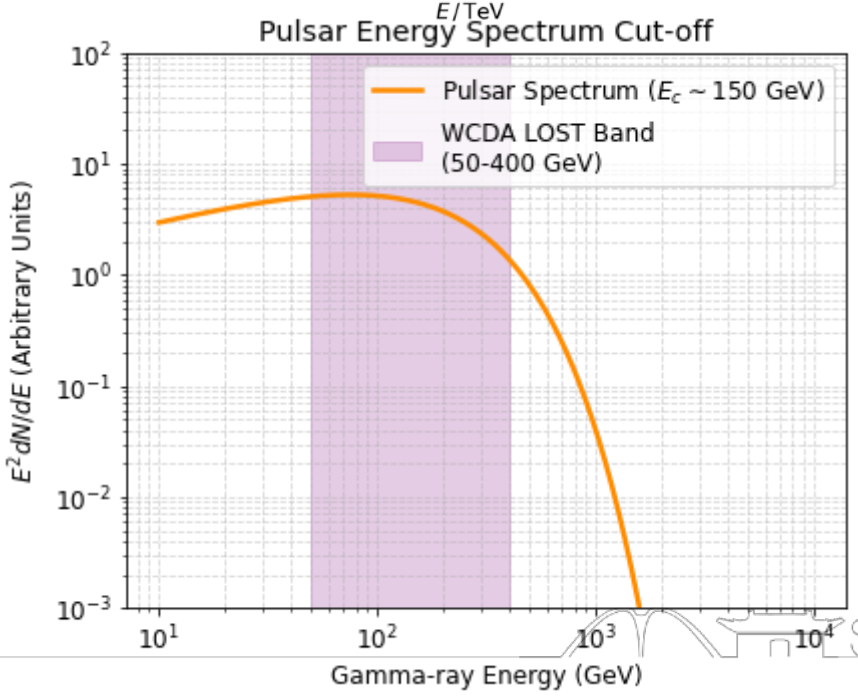
Motivation: Sensitivity Gap



Motivation: Sensitivity Gap

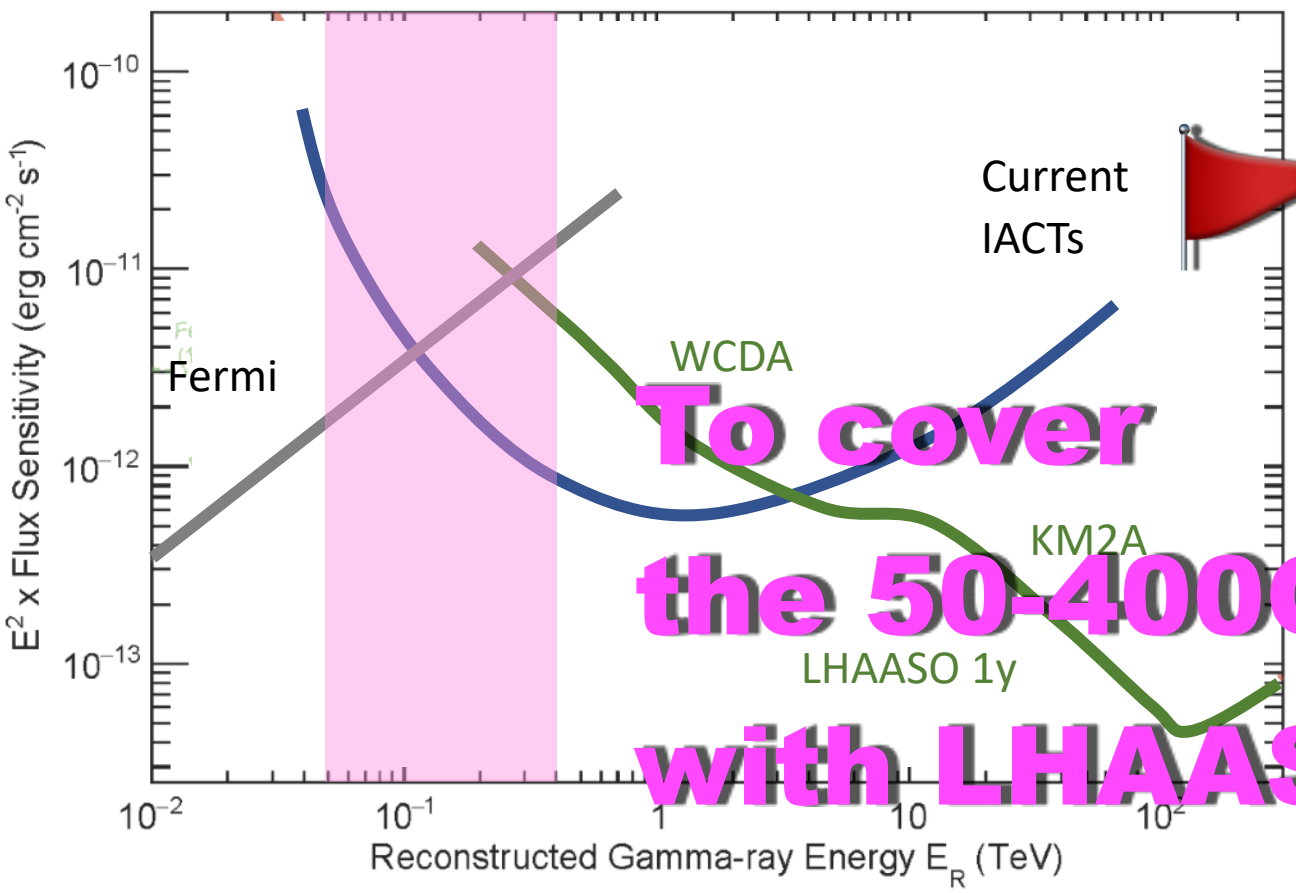




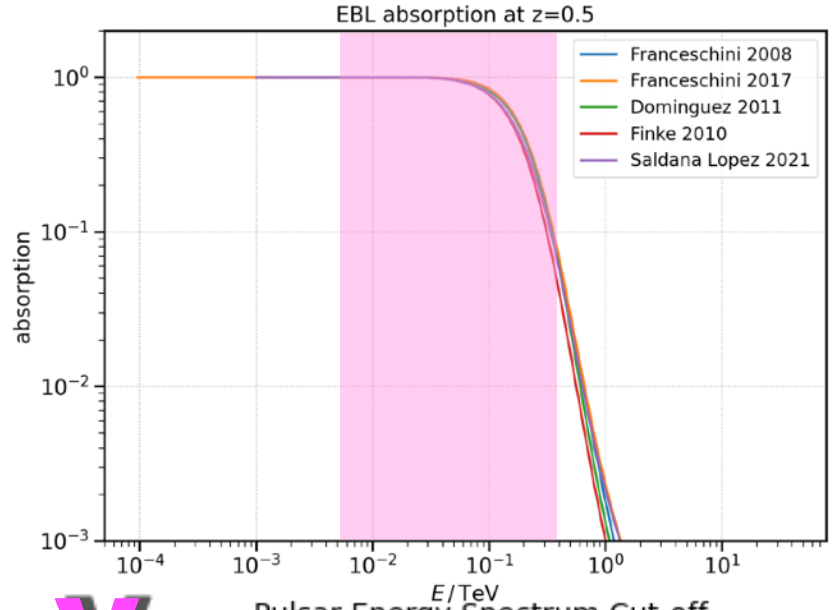


The highest energy photons from distant or dense astrophysical objects falls in the gap

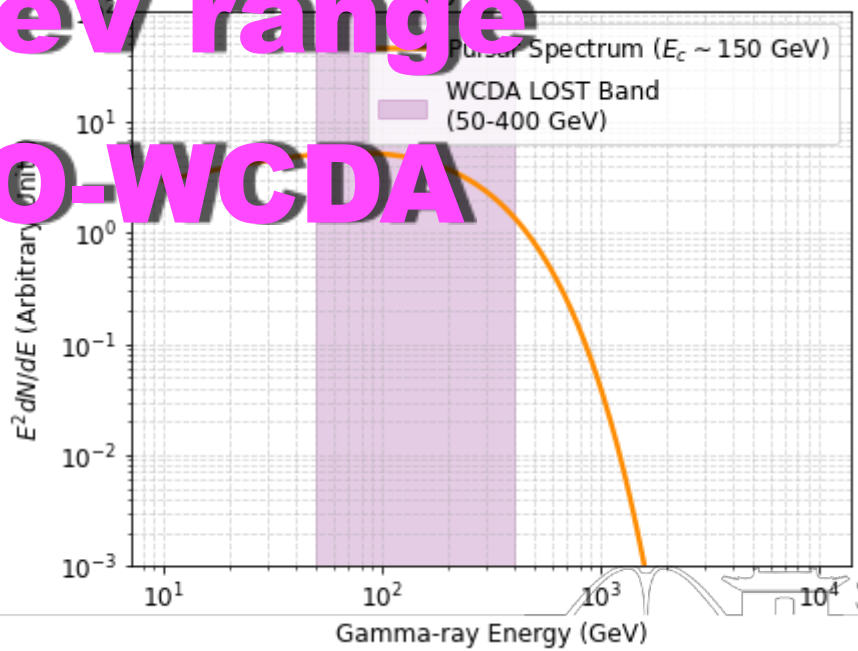
Motivation: Sensitivity Gap



To cover the 50-400GeV range with LHAASO-WCDA

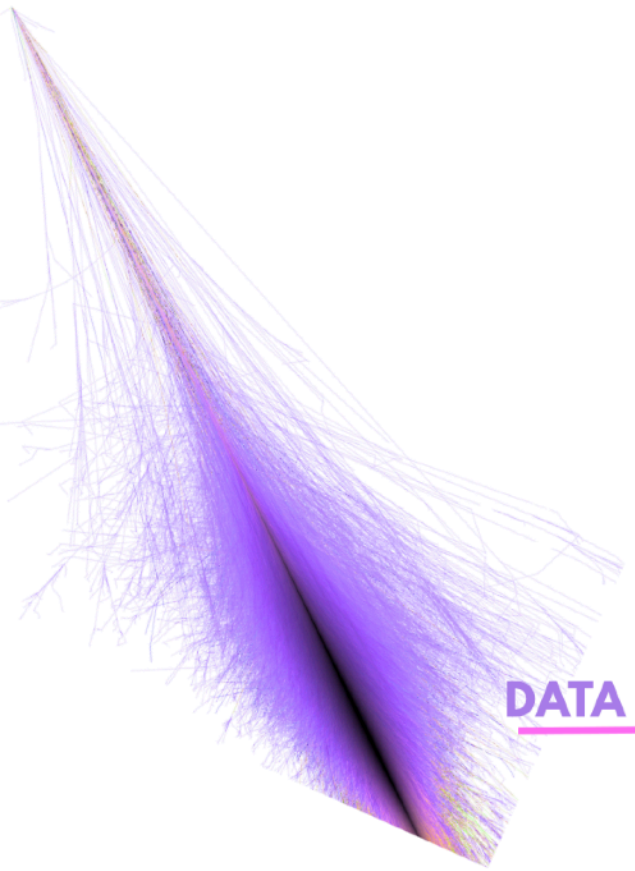


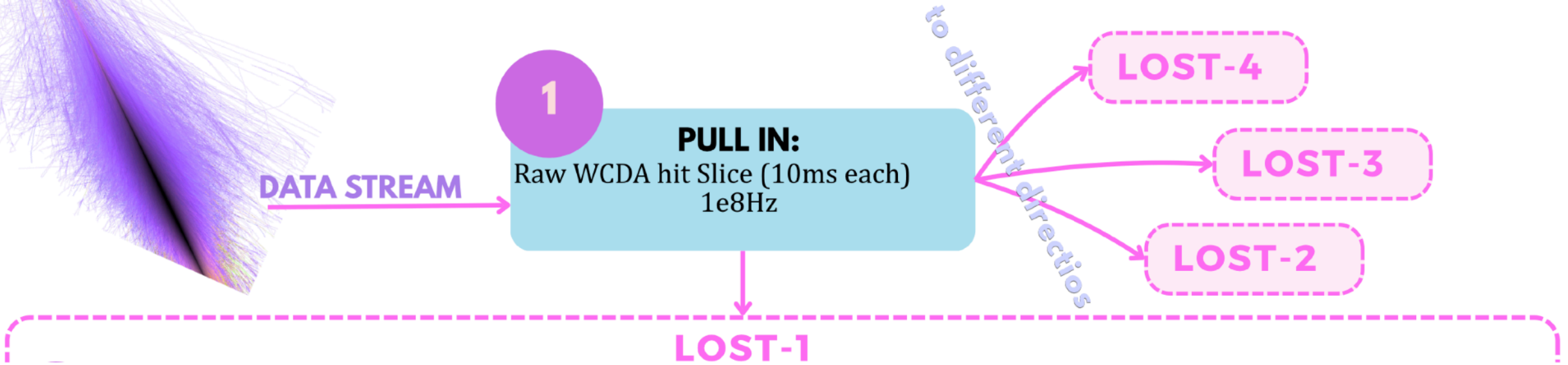
Pulsar Energy Spectrum Cut-off



The highest energy photons from distant or dense astrophysical objects falls in the gap

Step1. DAQ plugin



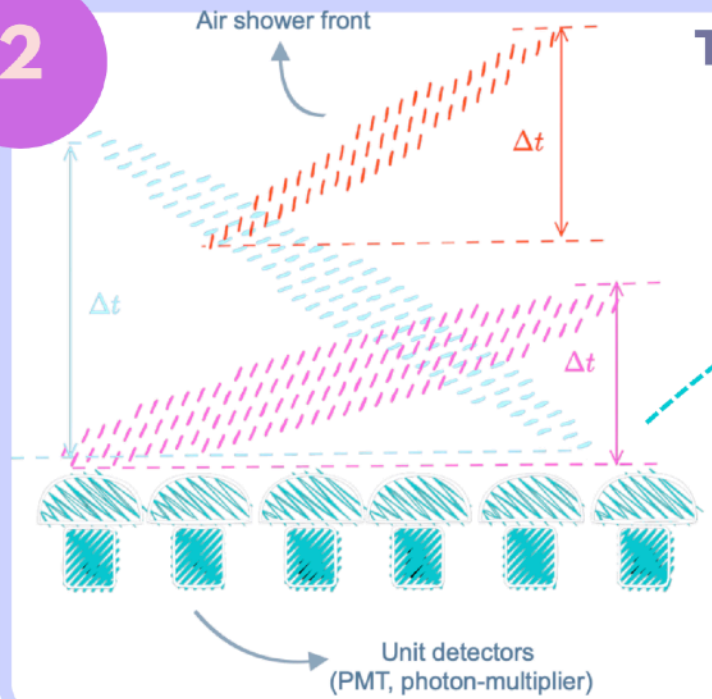


Step2. Pointing

LOST-1

2

Time Transformation Loop



TRANSFORM HITS()

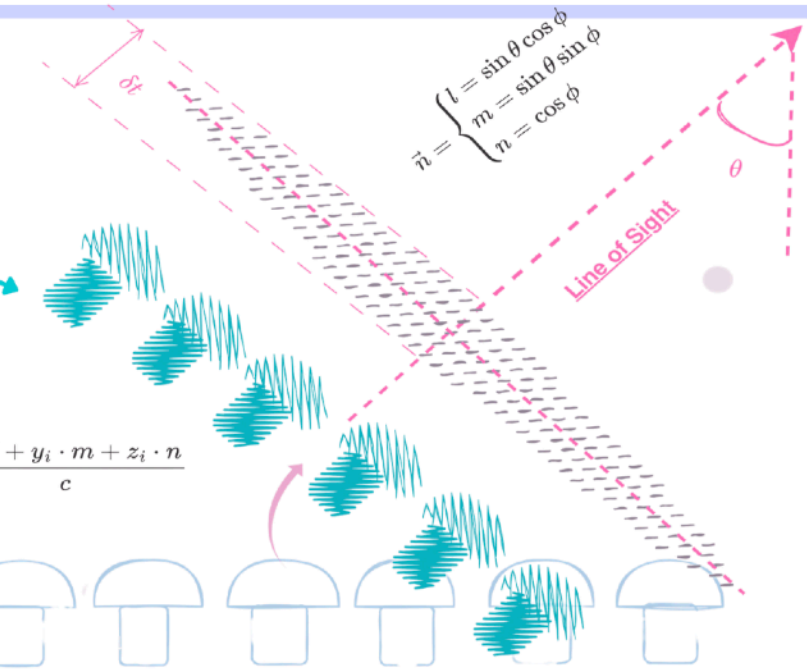
From Standard trigger(left) to LOST(right)

1. Get Line-of-sight vector
2. Calculate dt for each hit
3. Apply time offset

HISTOGRAMMING SORT()

Bottleneck: Traditional sorting is O(NlogN)
Solution: LOST uses 1ns resolution histogramming (O(N) complexity)
Result: >1 order of magnitude speedup, enabling low-latency triggering.

$$t_{\text{exp}} = \frac{x_i \cdot l + y_i \cdot m + z_i \cdot n}{c}$$

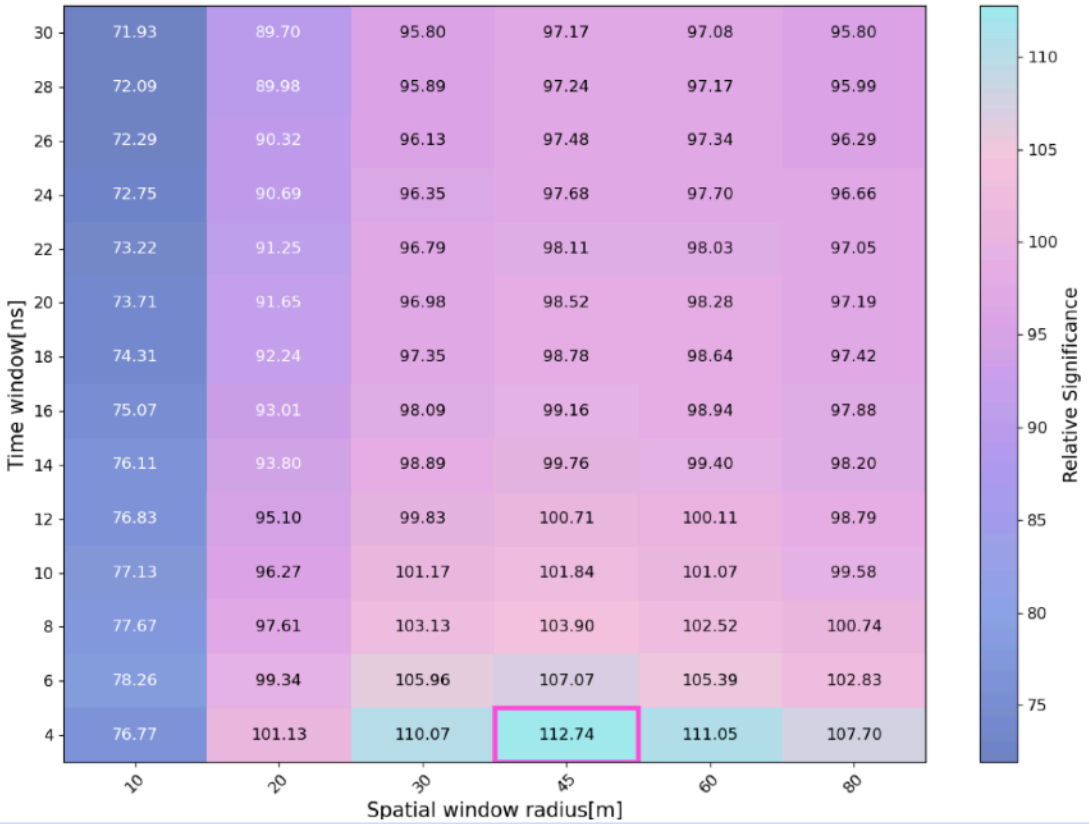


Step3. Trigger

3

Trigger Loop

Manipulate nhit threshold=4 to reach lowest energy, and search for tw&rm for max significance



Temporal Window (4ns):
Aligns hits relative to the shower front, effectively suppressing random PMT thermal noise

Spatial Filter (45m):
Restricts the search area; covers secondary particles falling within the core for a 100 GeV shower

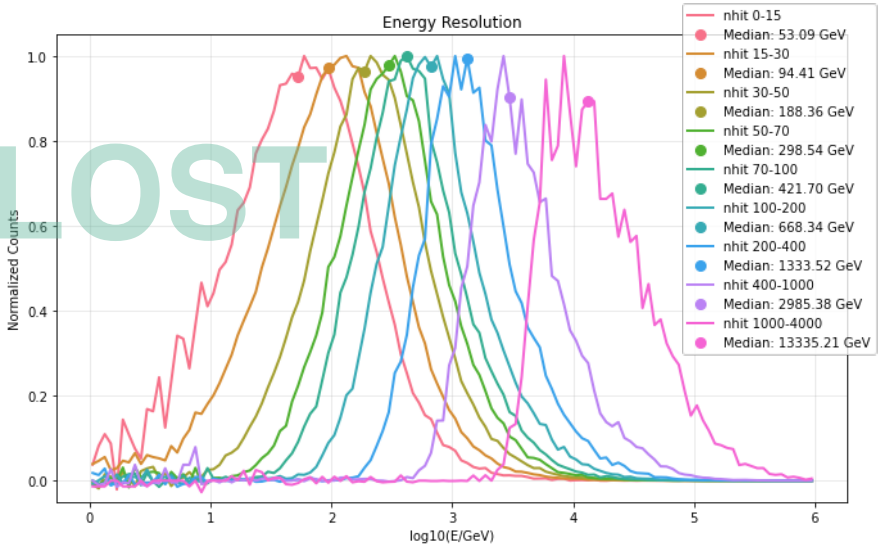
Step4. Output events

BuildEvent():
Iterative expansion using 10ns steps to reconstruct the shower.
PackEvent() & Buffer:
Prepare validated hit clusters for the output file.

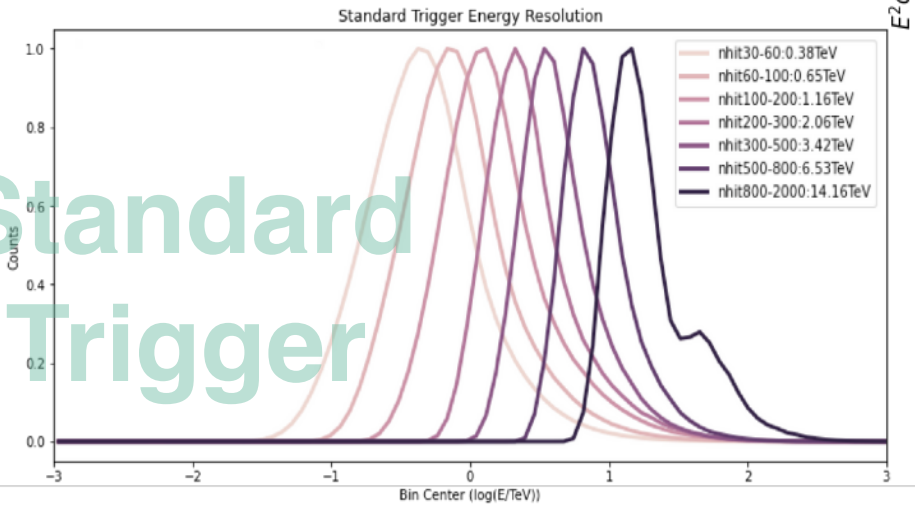
4

3s later...

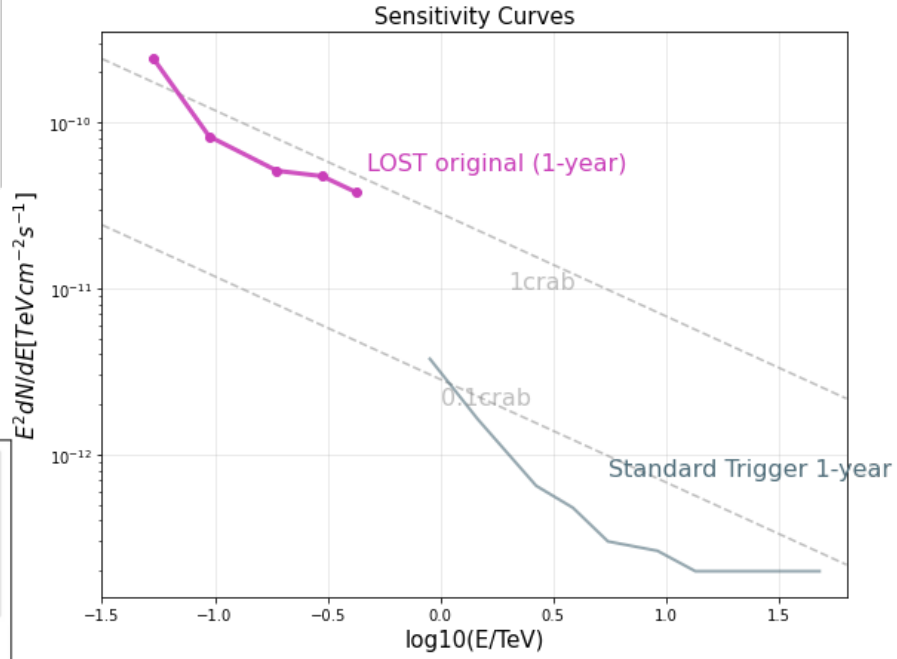
OUTPUT FILE:
WCDA LOST events
100kHz 😱



LOST



Standard Trigger

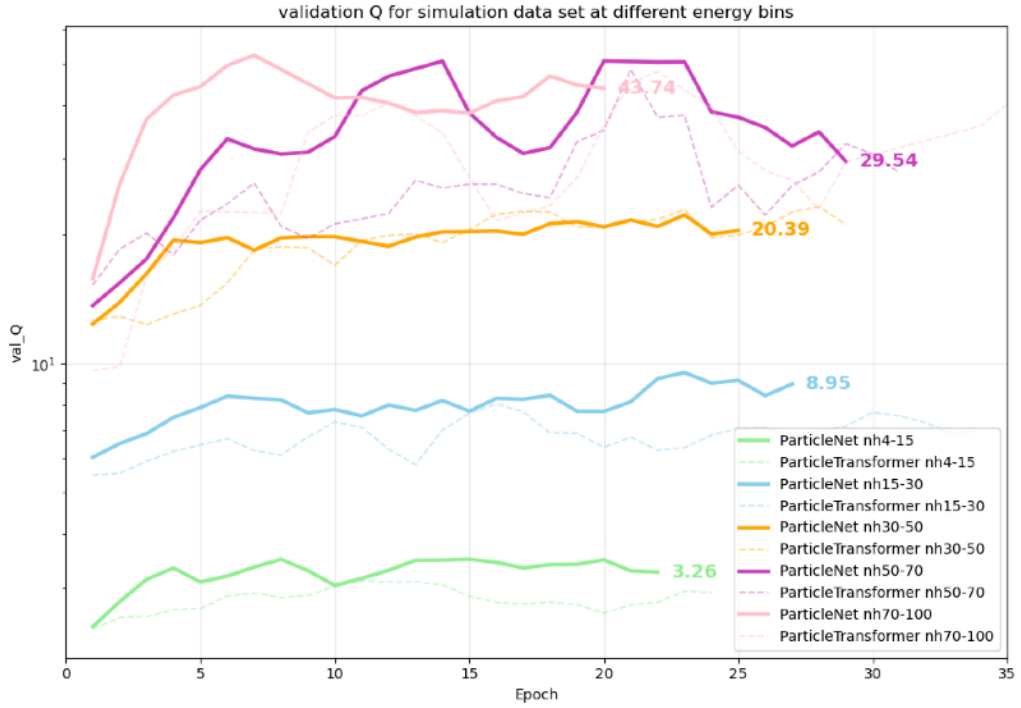


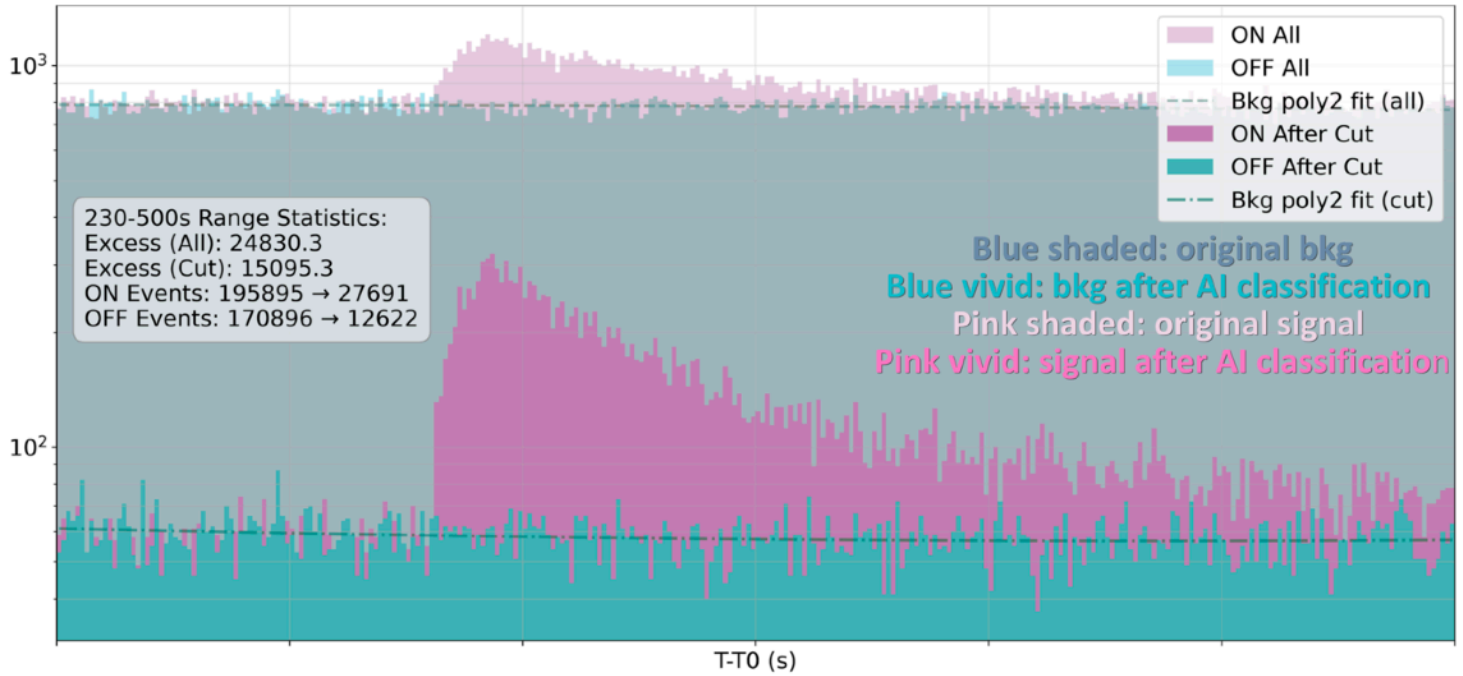
G/P separation with AI

- **Task:** signal/bkg classification
- **models:**
  ParticleNet, ParticleTransformer
- **features:** shower footprints
- (x, y, time, charge)

The Brightest of all time(BOAT)
GRB221009A

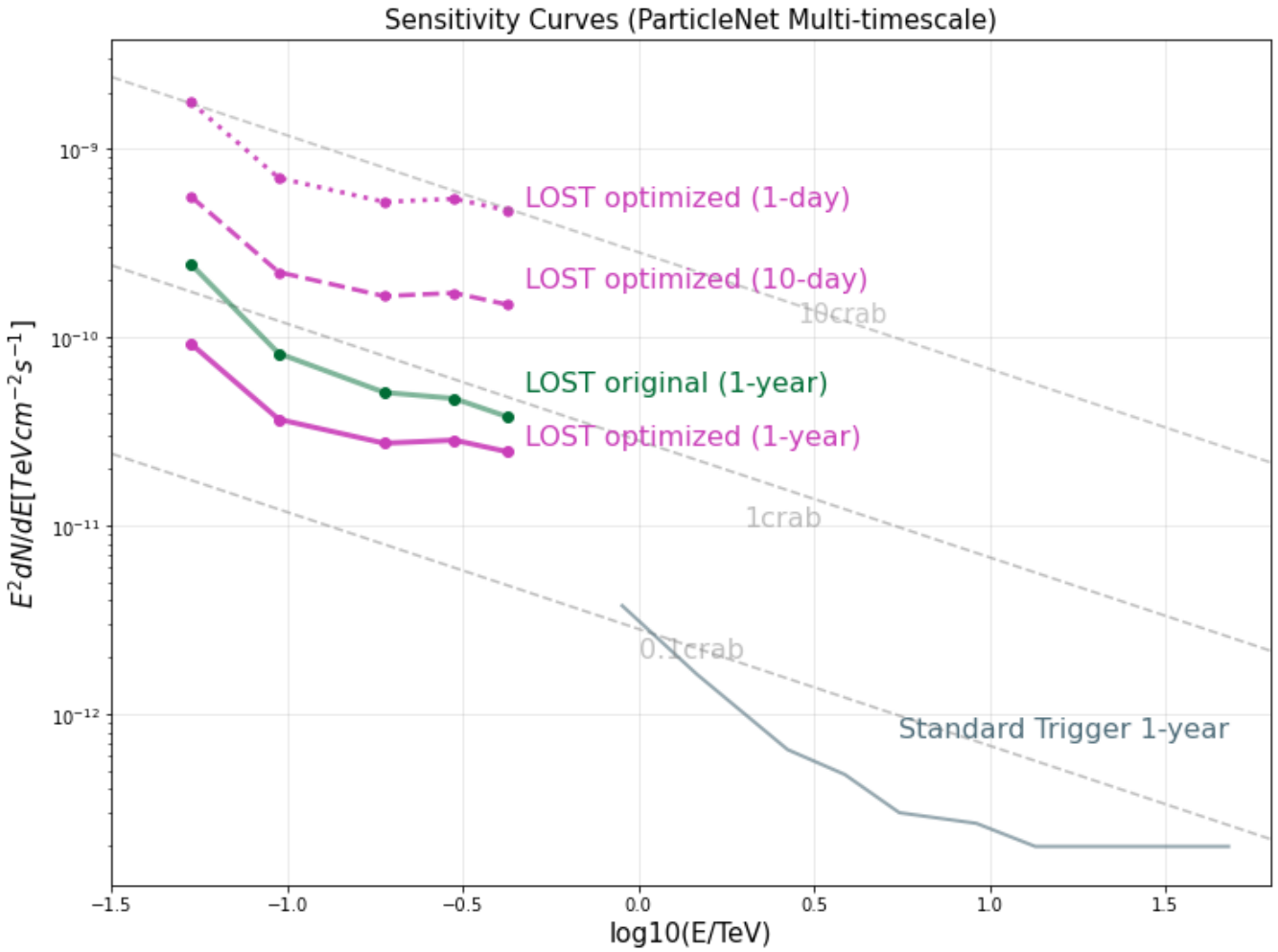
- >15k photons in the first 270s
- **Signal efficiency:** > 60%,
- **Bkg rate**: suppressed ~633 → 47 /s
- **Significance:** enhanced by 2.3 times





Results

LOST has WCDA mimic a pointing telescope



Good news:

- Energy threshold is effectively extended below 100GeV
- AI separates bkg from signal and achieved promising sensitivity
- Integrated LOST pipeline to LHAASO DAQ

Challenges:

- Mismatch between simulation and experiment

Future:

- Use LOST data in scientific analysis(on-going)
- Check simulation and keep tuning the model

THANKS!!!