Radboud University Nikhef

Enhancing Photon Detection in AugerPrime

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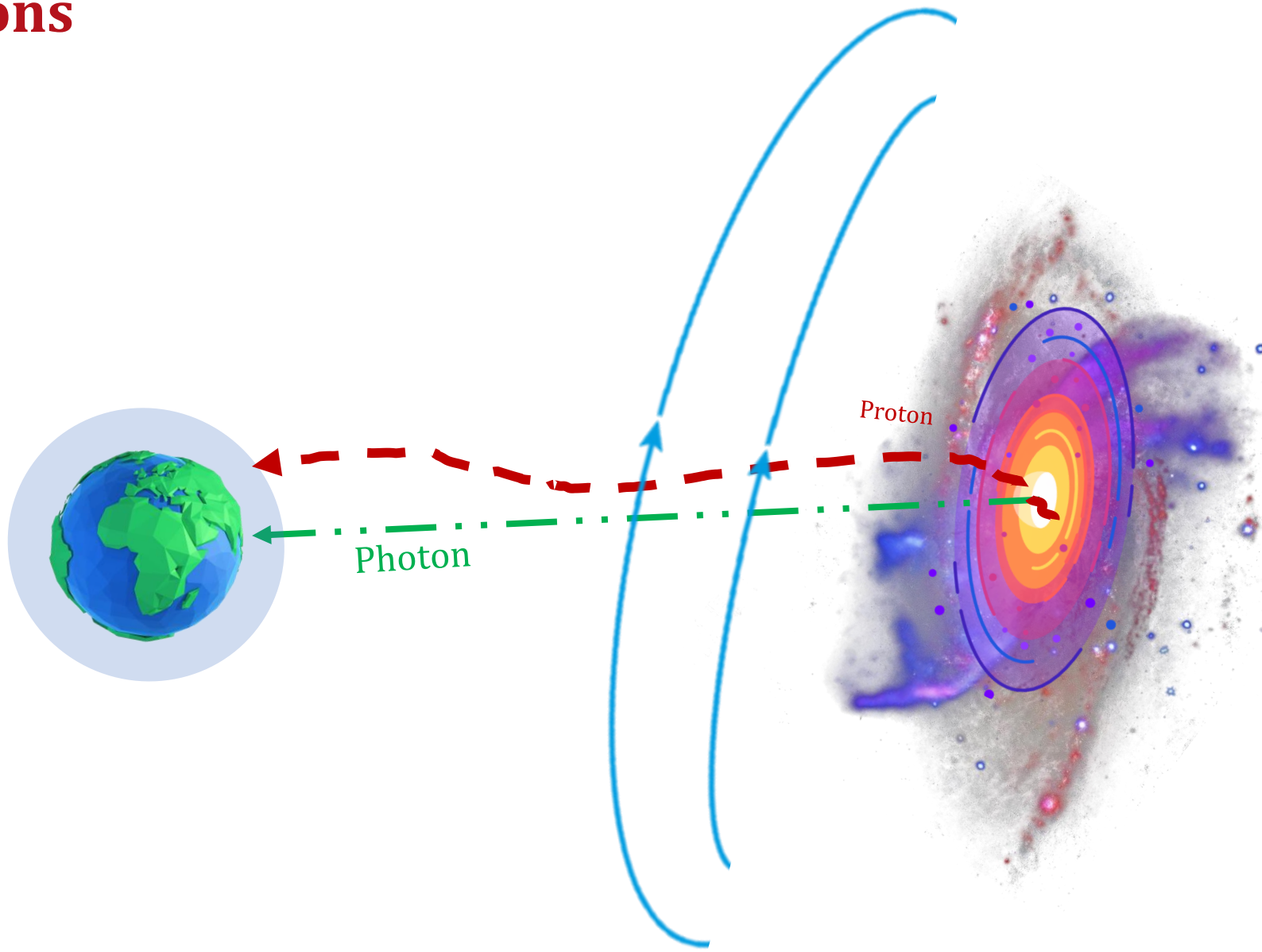
Ultra-High-Energy Photons



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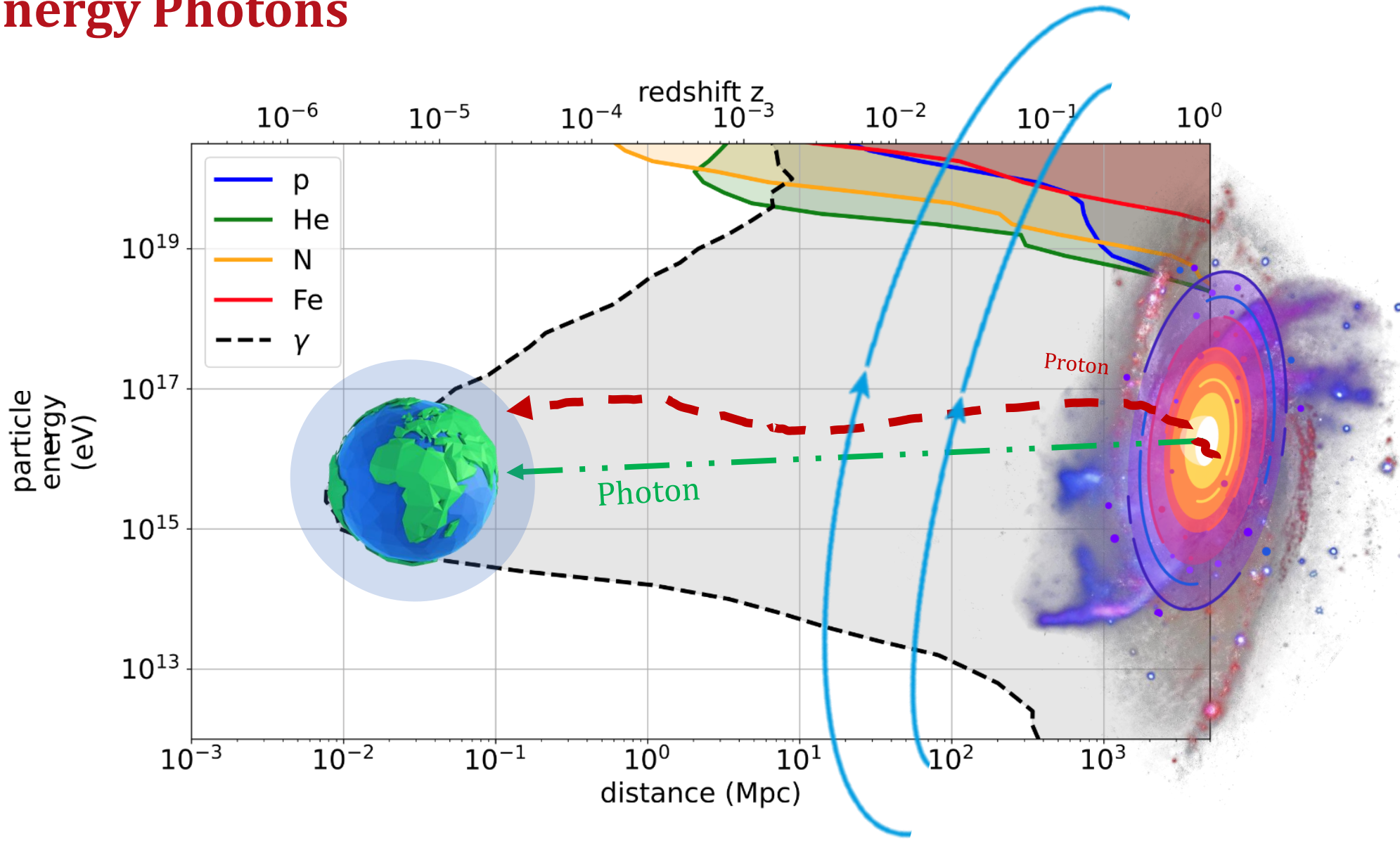

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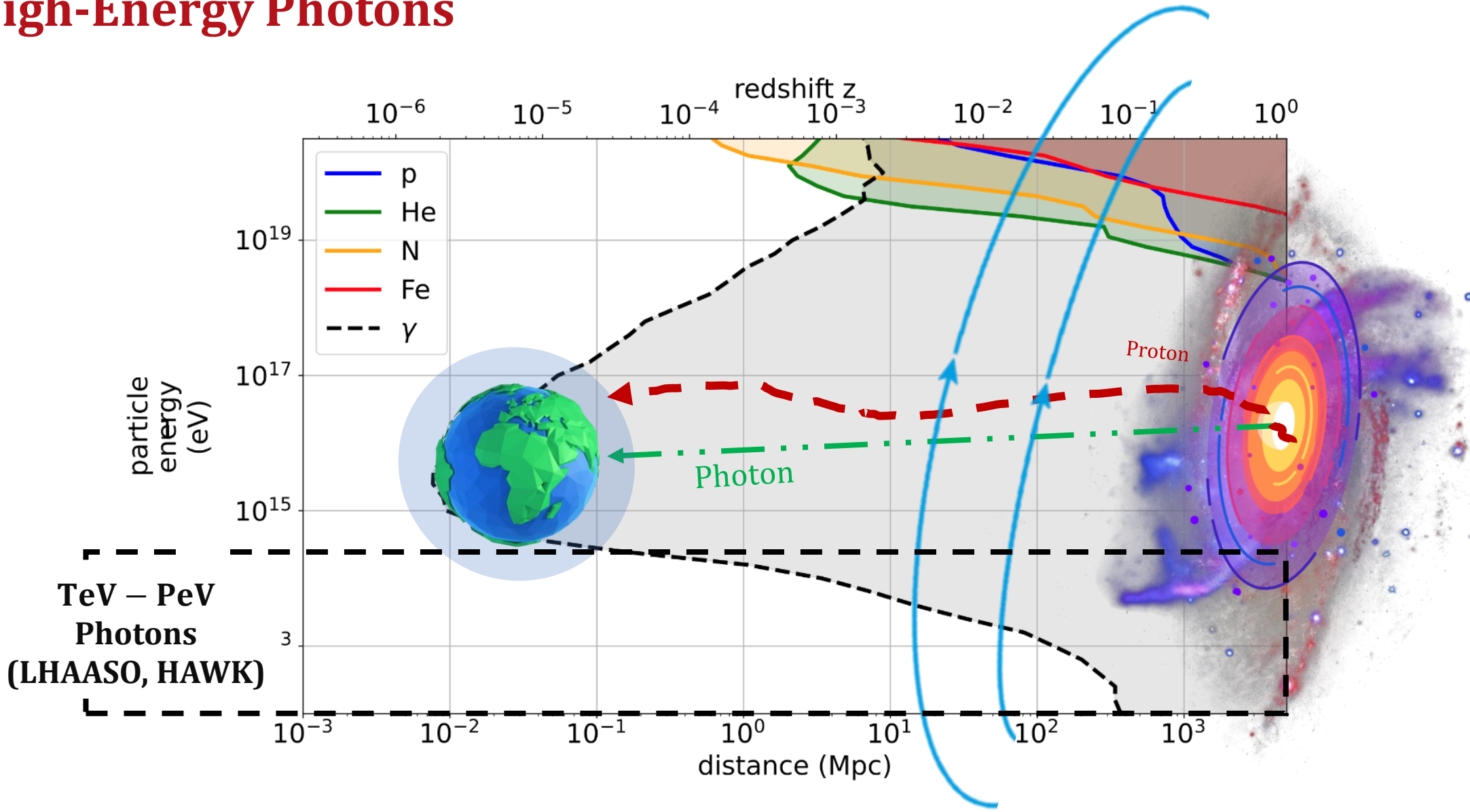

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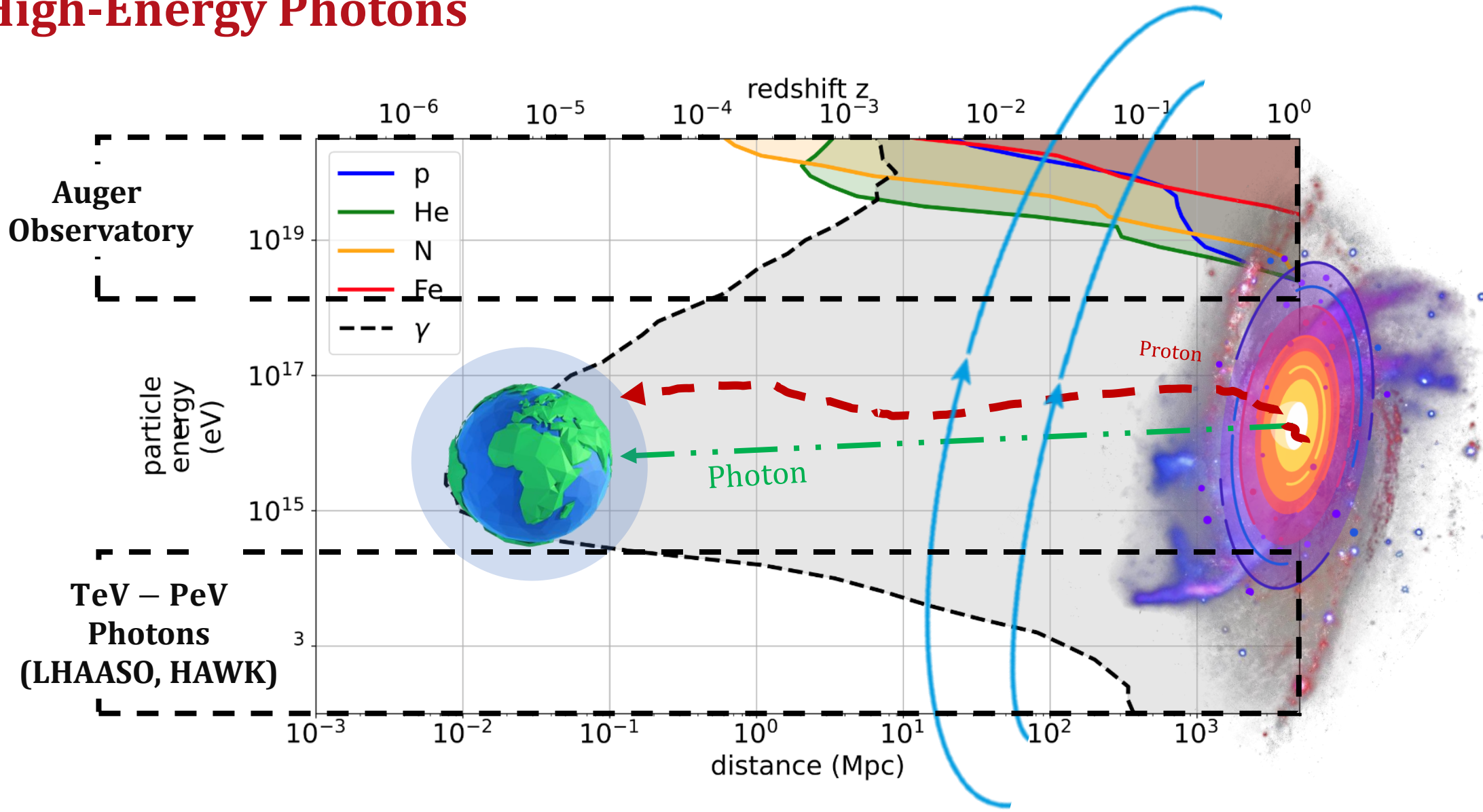
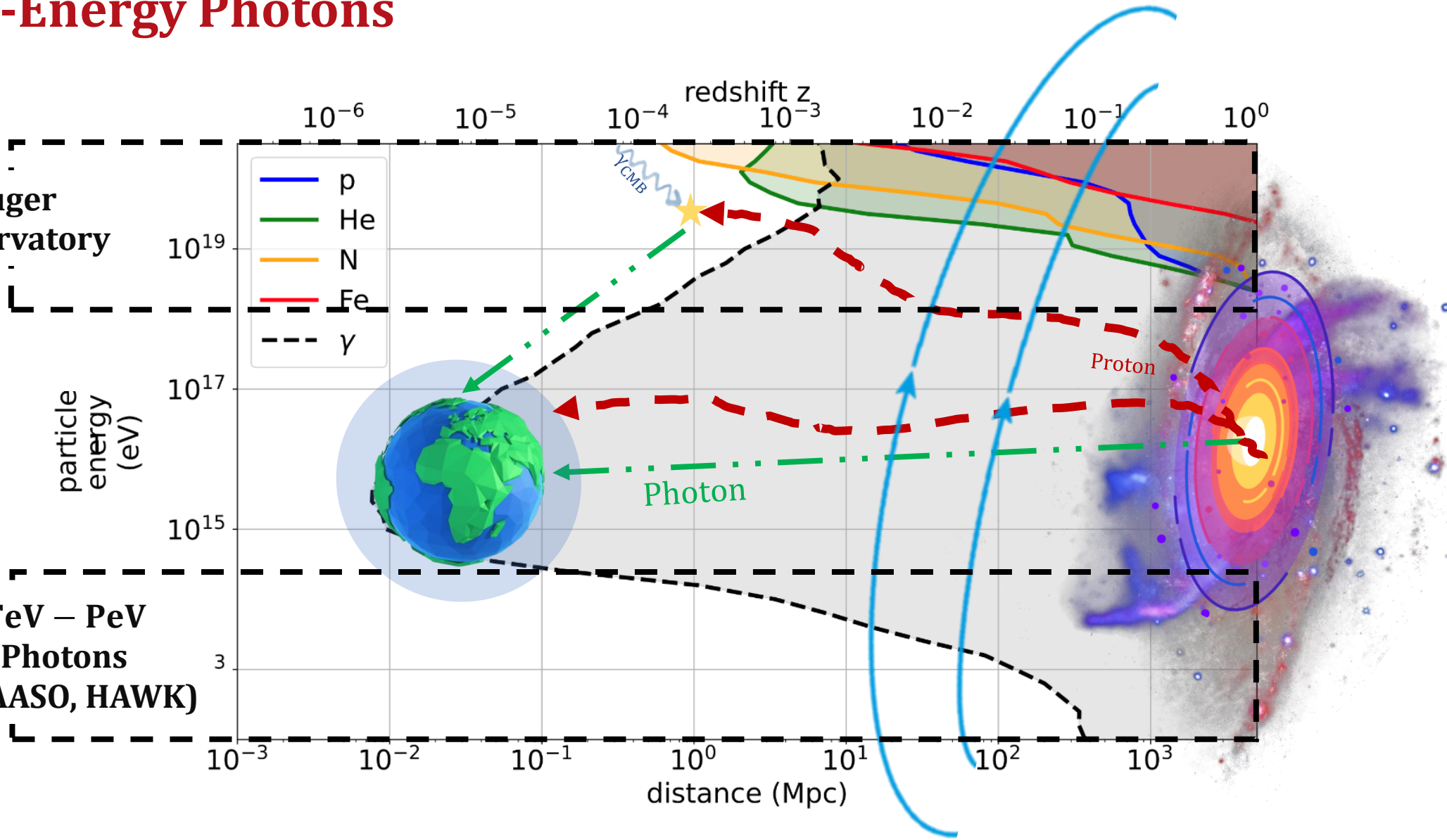


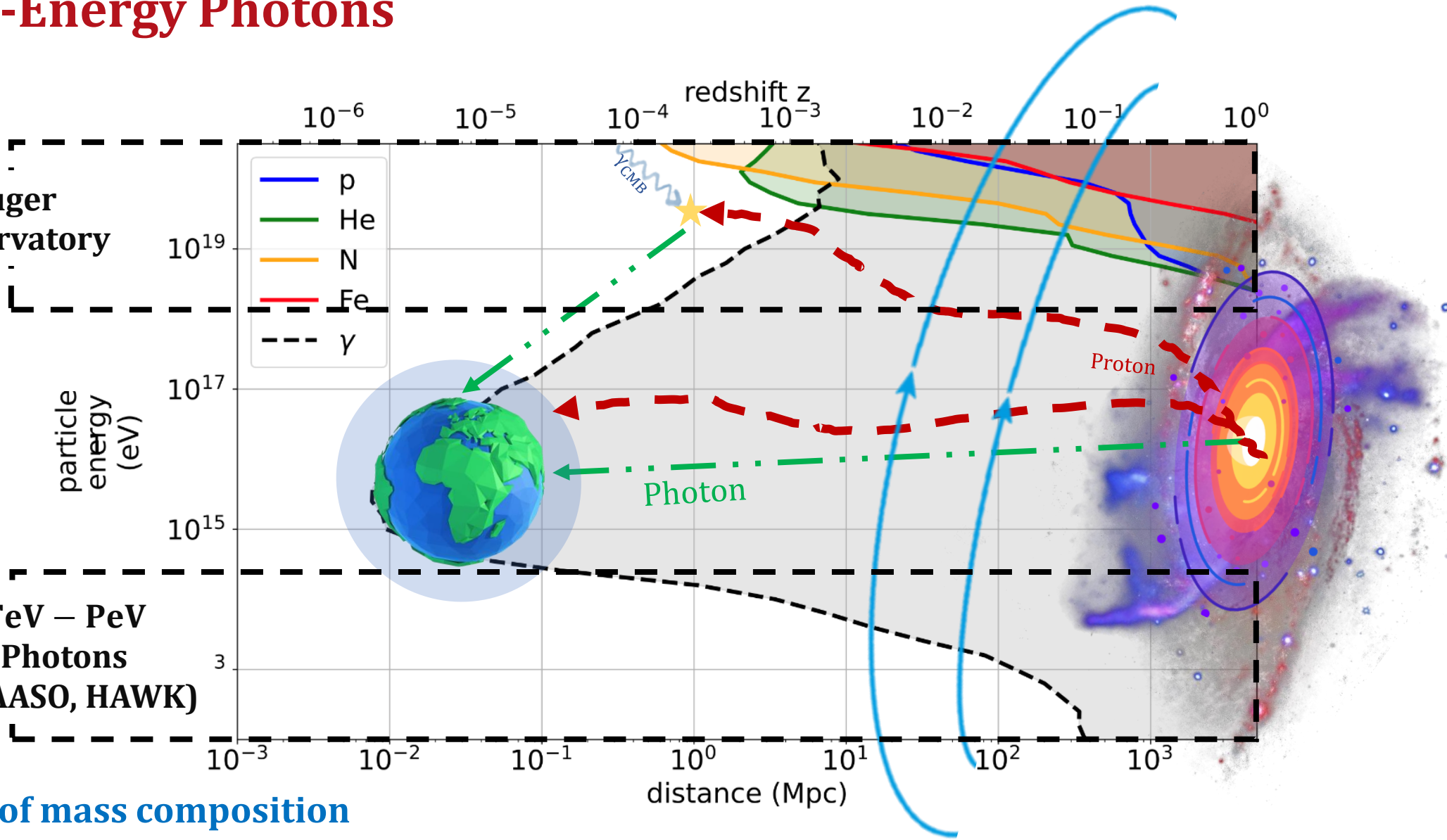
Ultra-High-Energy Photons

$\gamma_{CMB} + p$
$\rightarrow p + \pi^0$
$\rightarrow p + 2\gamma$
$(\sim EeV)$



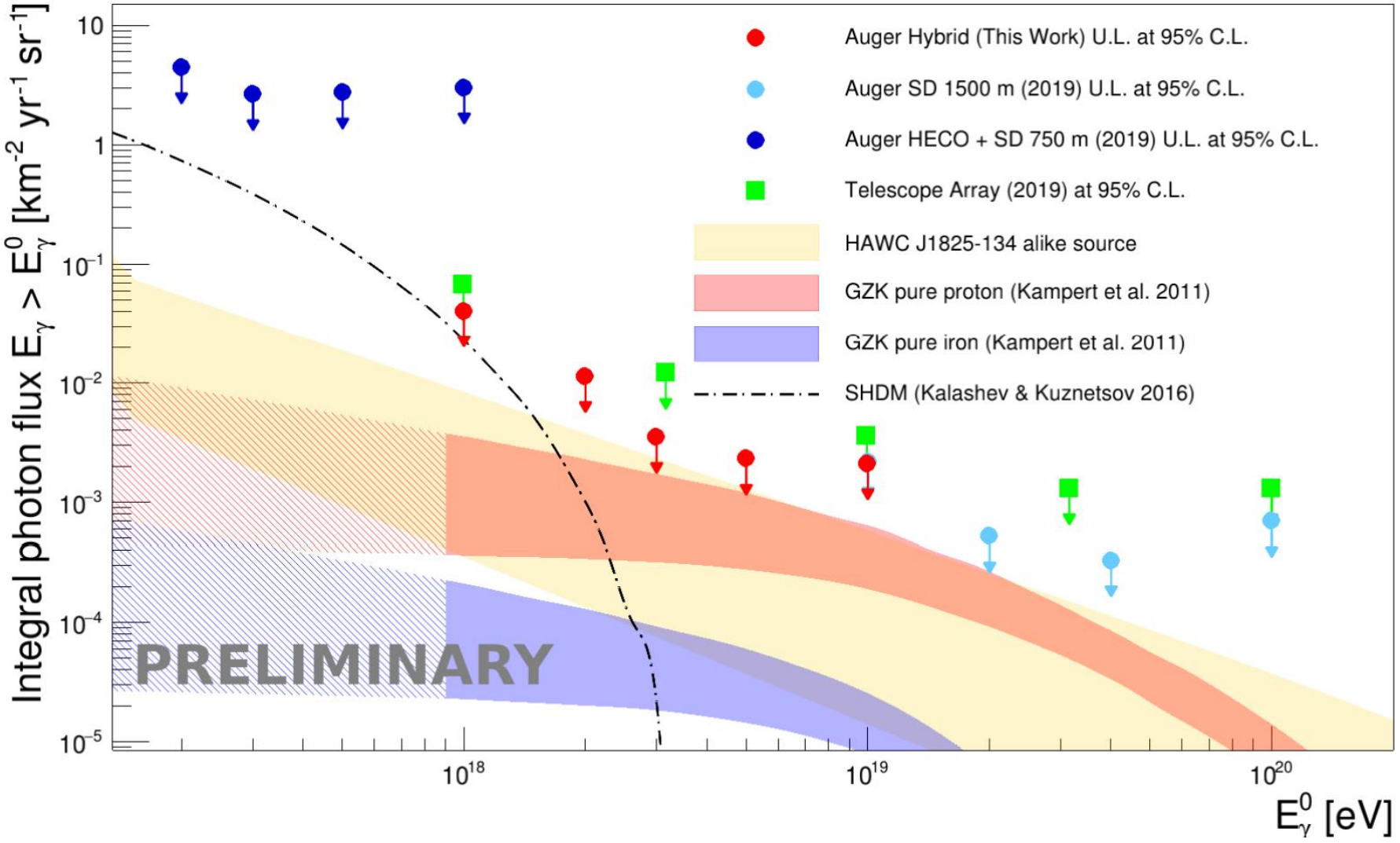
Ultra-High-Energy Photons

$\gamma_{CMB} + p \rightarrow p + \pi^0 \rightarrow p + 2\gamma$ (~EeV)



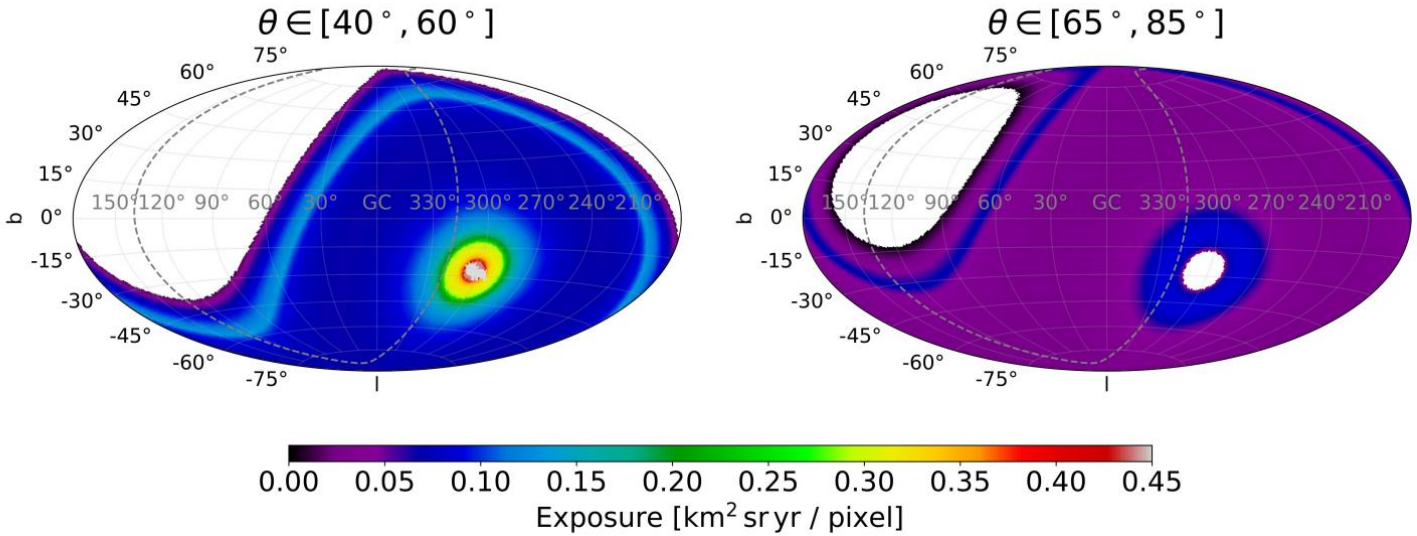
- Indirect test of mass composition
- Verify Cosmological Models or Astrophysical scenarios

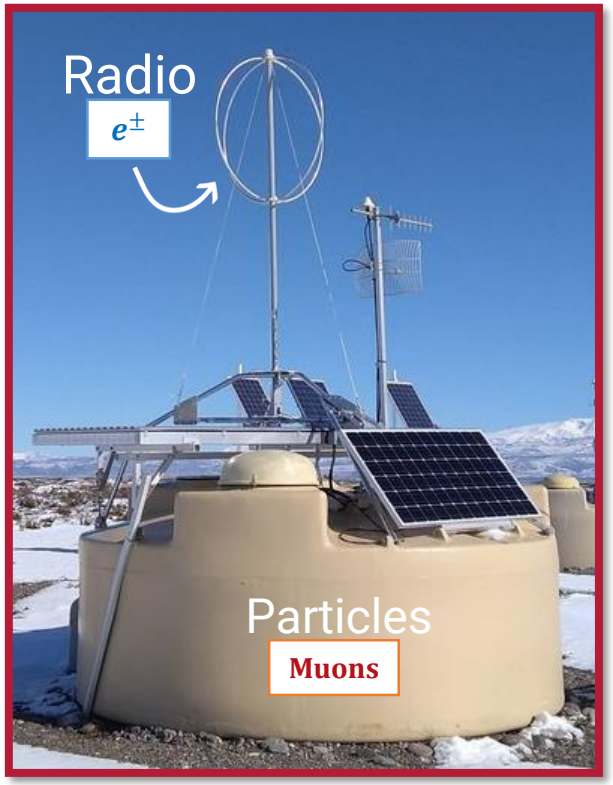
Photon Air shower In AugerPrime



AugerPrime Upgrade

- ~ 100% duty cycle → More Statistics
- Calorimetric energy of the primary particle
- Direct measurement for shower's electromagnetic content → Primary mass sensitive
- Efficient for inclined showers → Extends sky coverage





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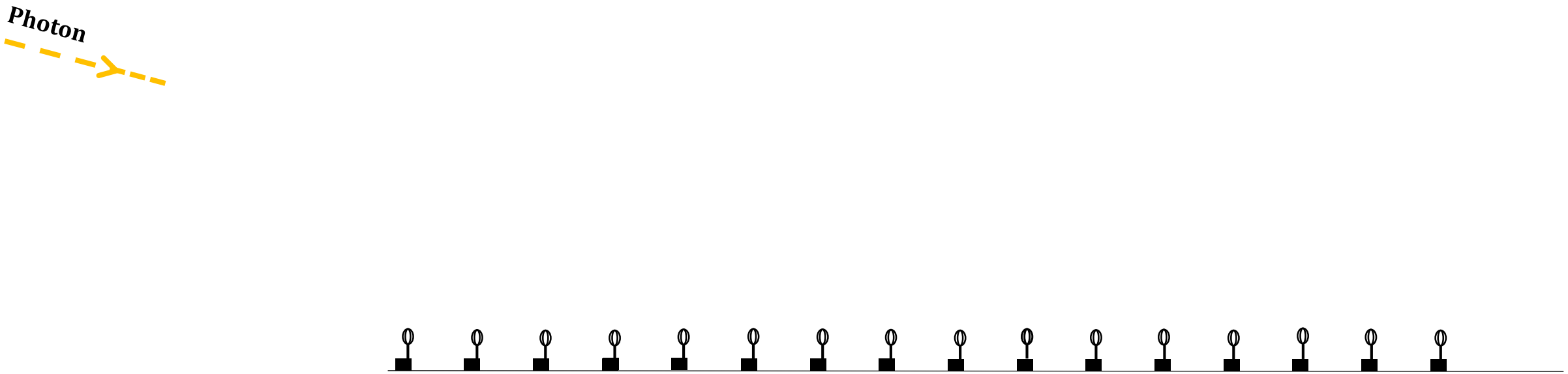

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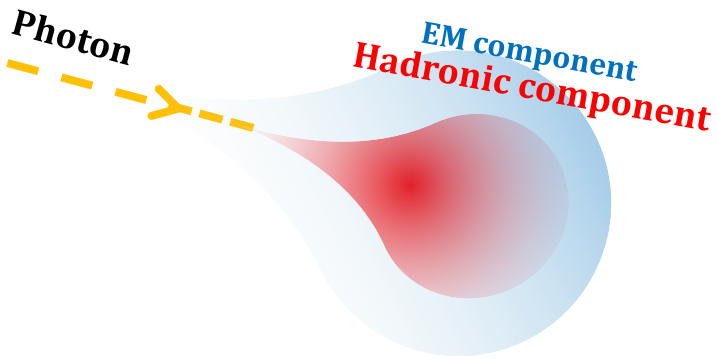

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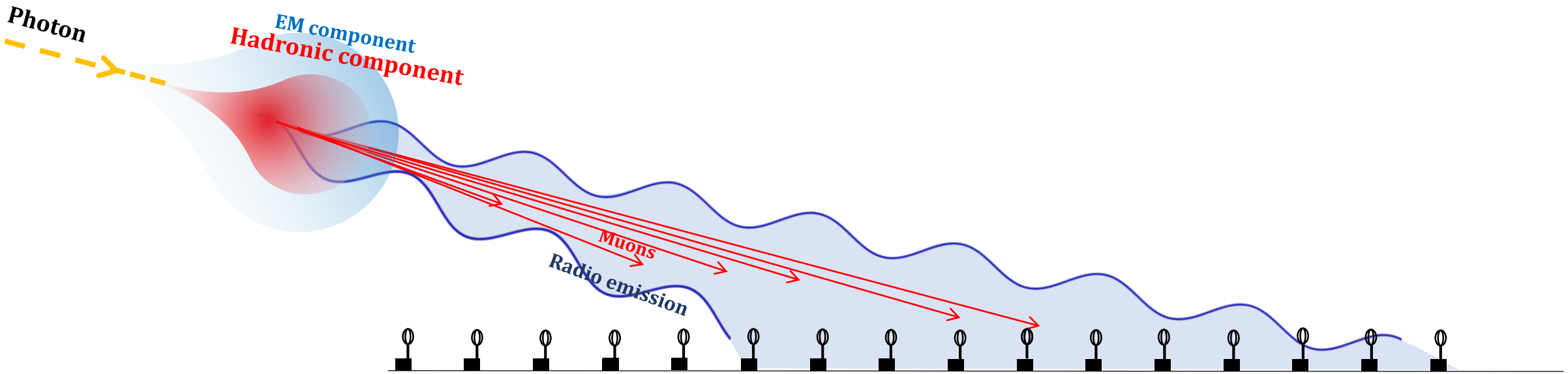

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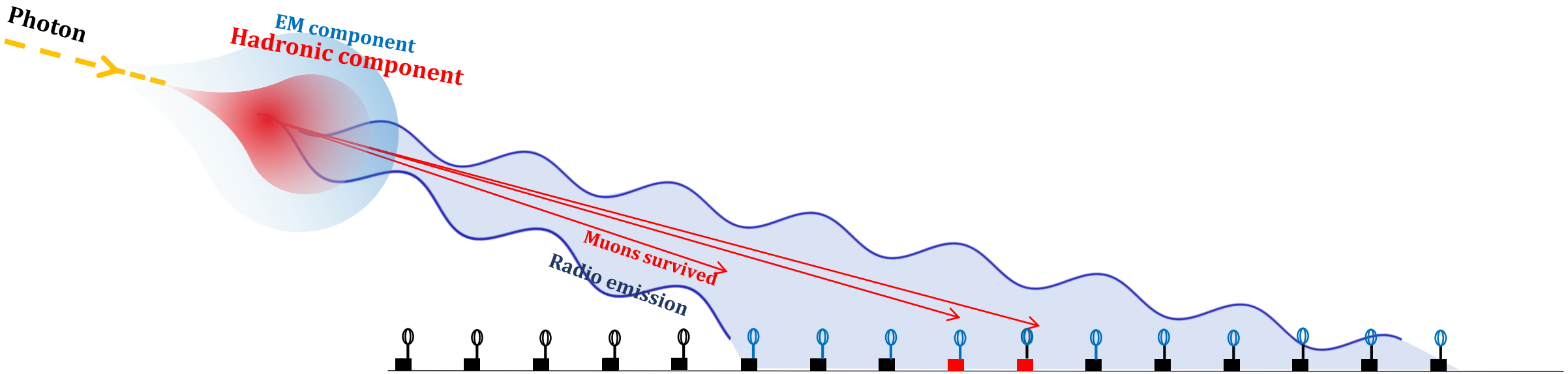
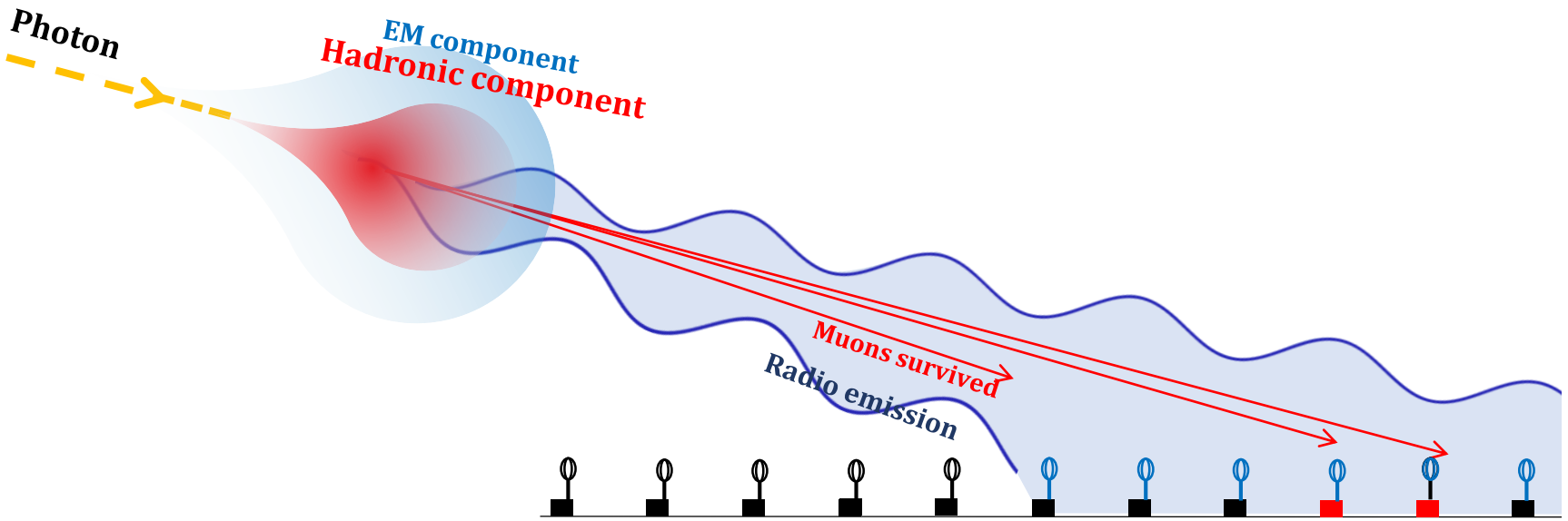
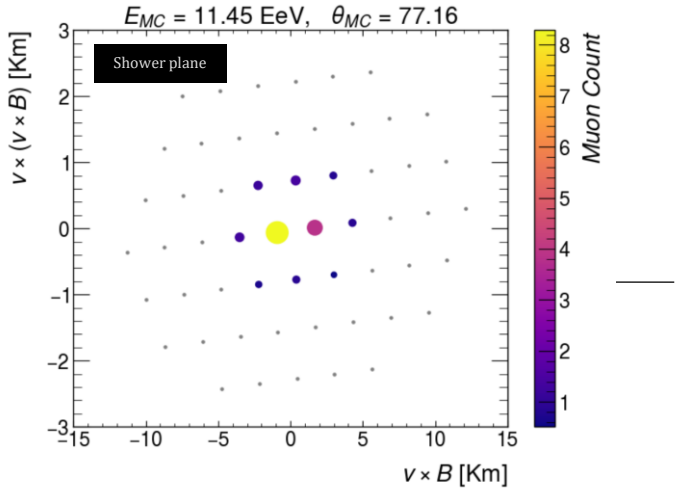


- The atmosphere is transparent to the radio frequencies. Inclined events have a large radio illuminated area, resulting in a higher number of stations capable of recording the radio emissions.

Photon Air shower In AugerPrime



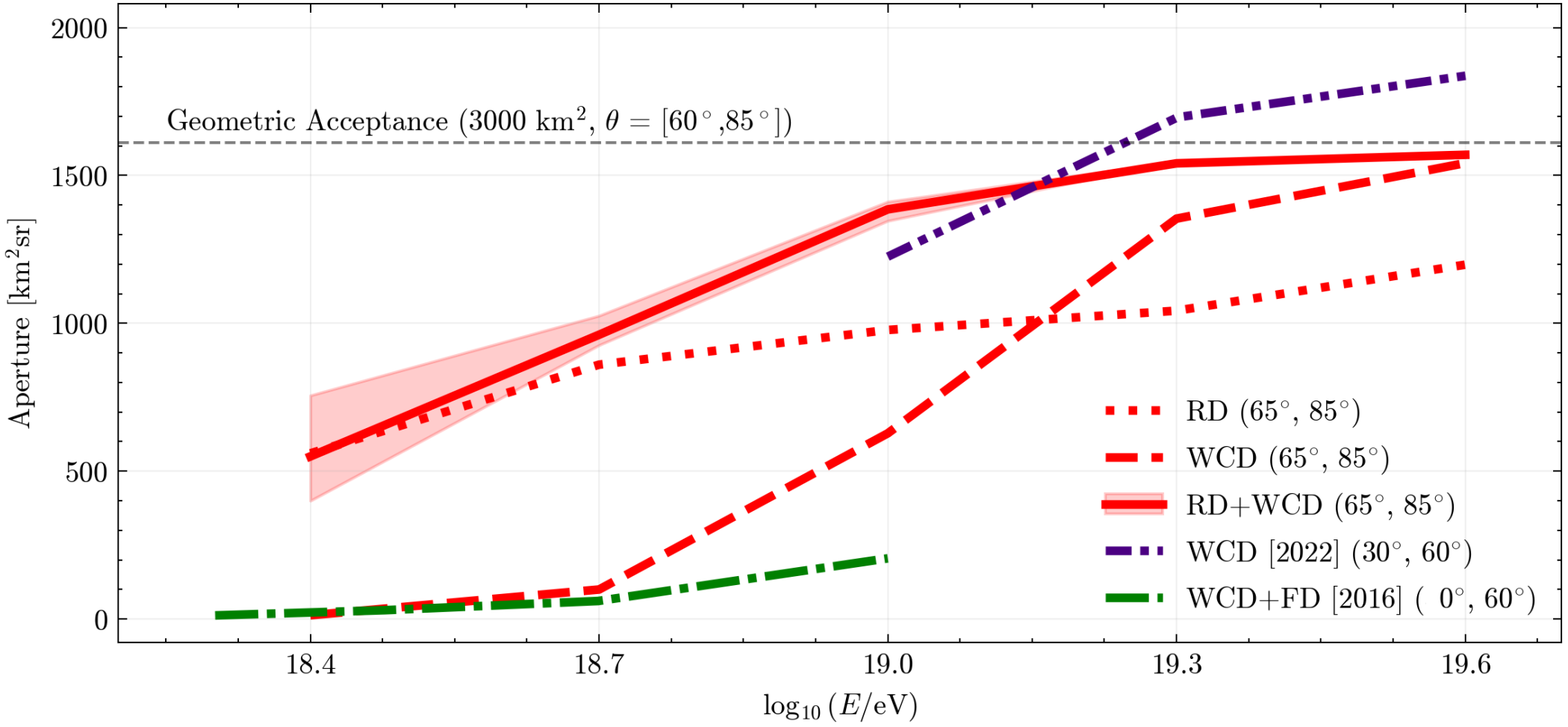


- The atmosphere is transparent to the radio frequencies. Inclined events have a large radio illuminated area, resulting in a higher number of stations capable of recording the radio emissions.
- Only a few Particle Detectors are triggered by the surviving muons that reach the observation level.

→ Trigger on Radio Signal is essential!

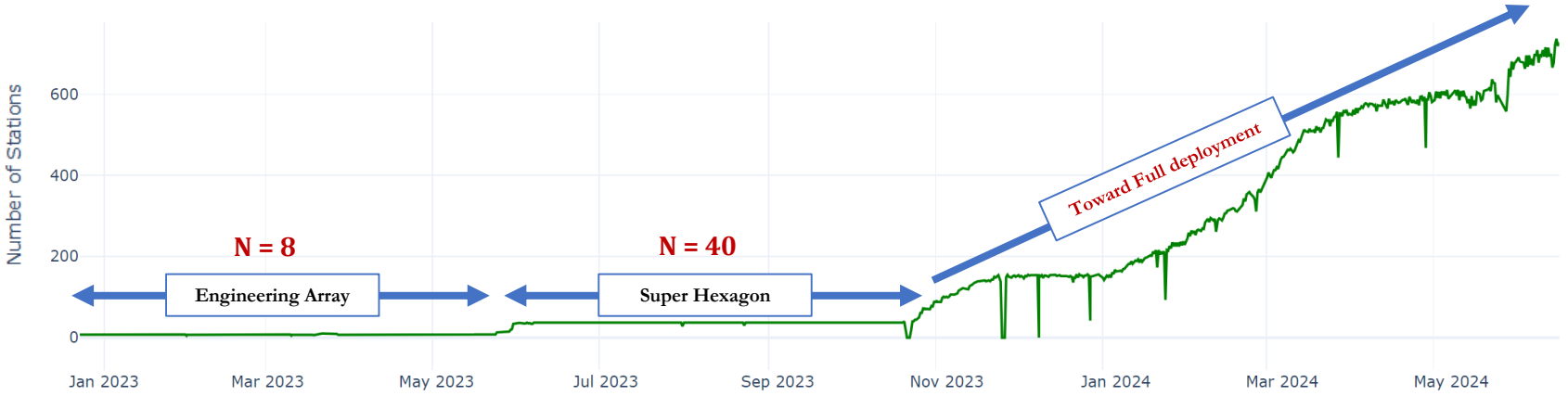
Photon Detection In AugerPrime

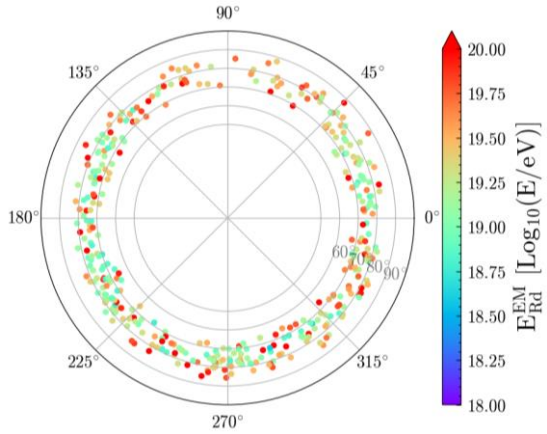
- The photon sensitivity will be at least × 10 better than what used to be.
- Enhance detection potential at lower energies compensating weak muon signal.



Radio Array Deployment

- +750 Stations fully operated → Trigger by Particle detector
- 2 Radio Self-trigger Test stations





- More than 700 Events reconstructed

Toward Self-Triggering Radio

Ingredients for Effective Radio Trigger:

Toward Self-Triggering Radio

Ingredients for Effective Radio Trigger:

- Hardware Realization → Limited bandwidth

  20 year old system ~1200 bits/s station bandwidth

Toward Self-Triggering Radio

Ingredients for Effective Radio Trigger:

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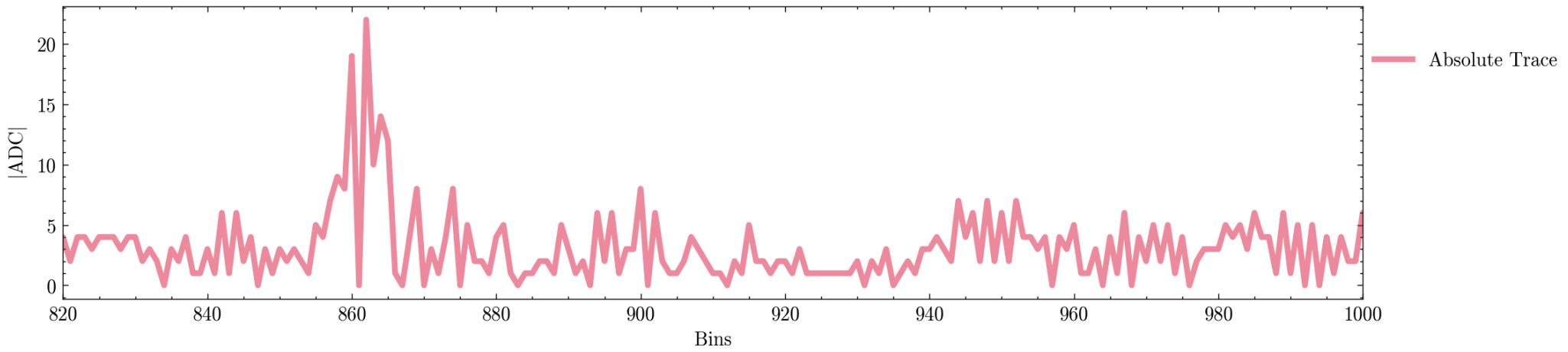
- A good Trigger Algorithm picking up signal and rejecting noise



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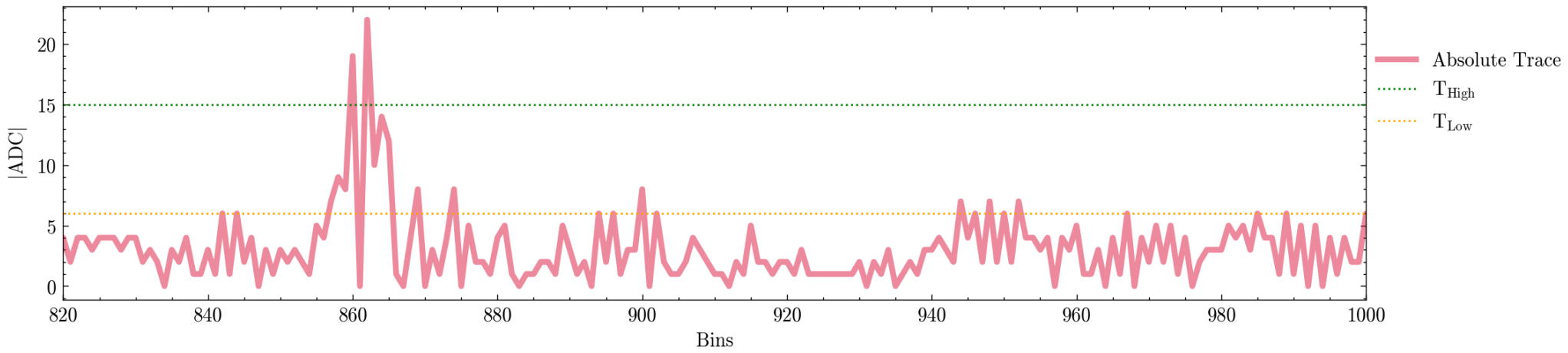

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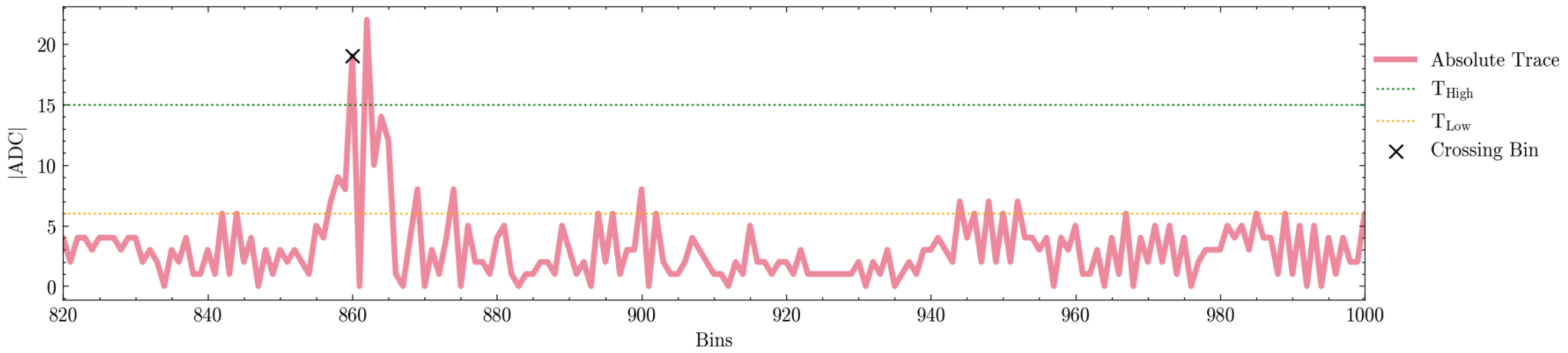

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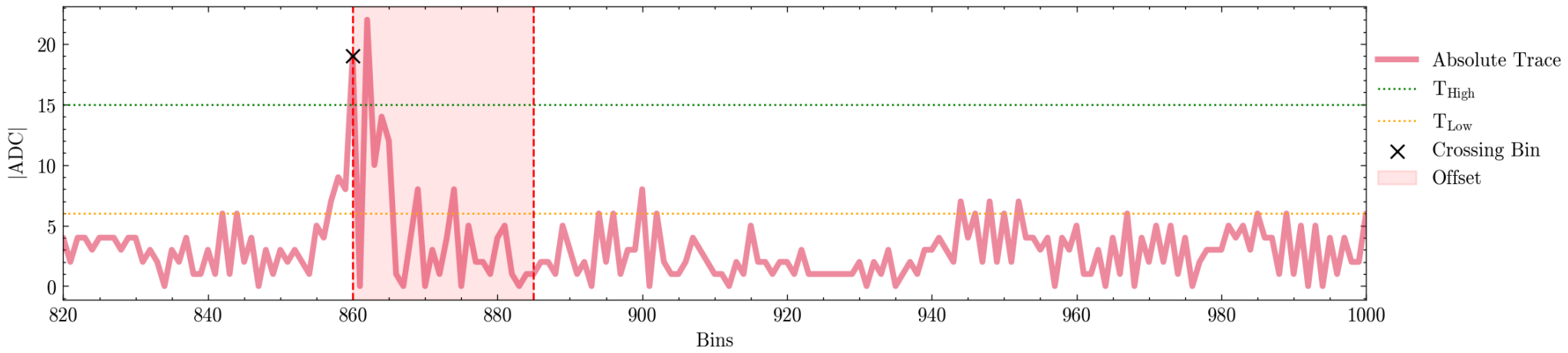

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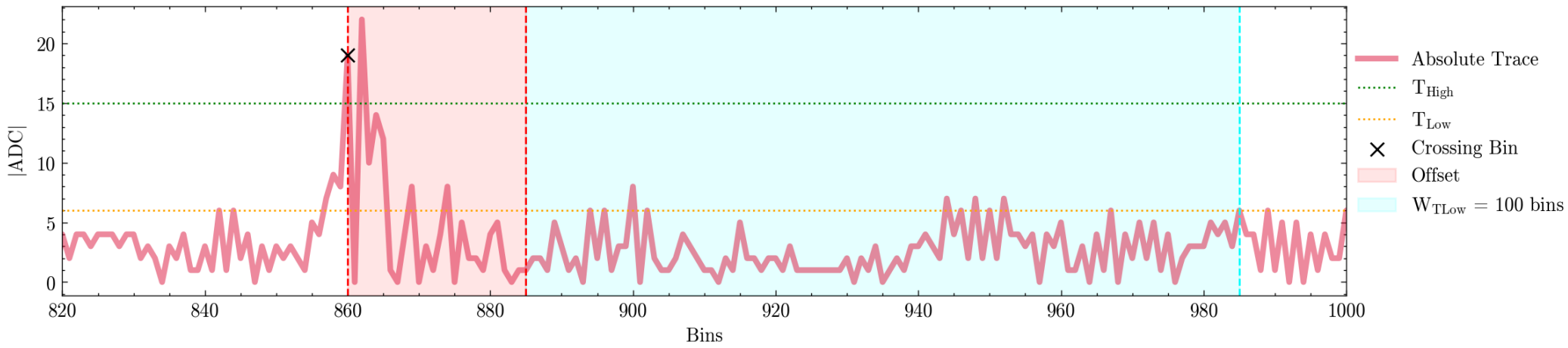

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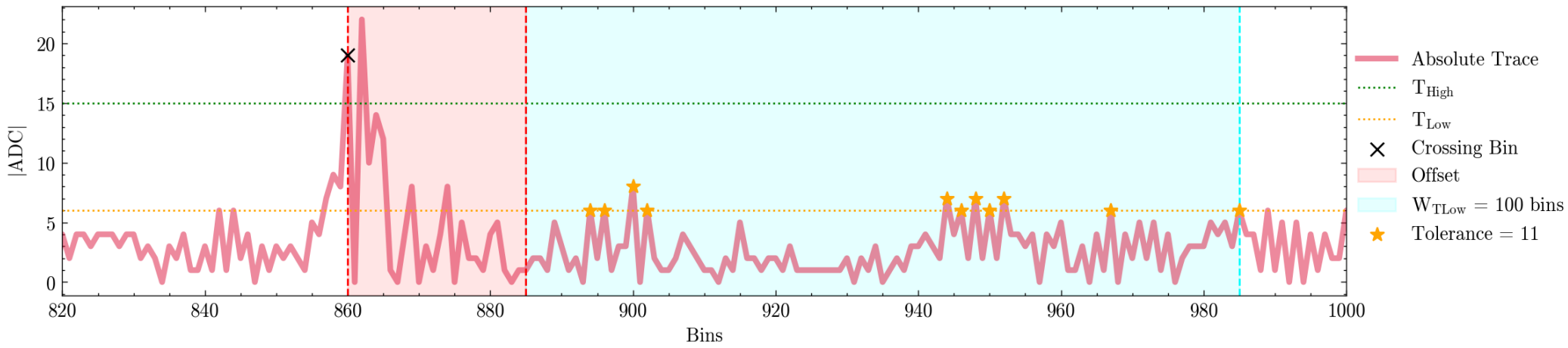

If tolerance less than 15 within this 100-bin have values exceeding T_{Low}

→ ***Trigger Accepted.***

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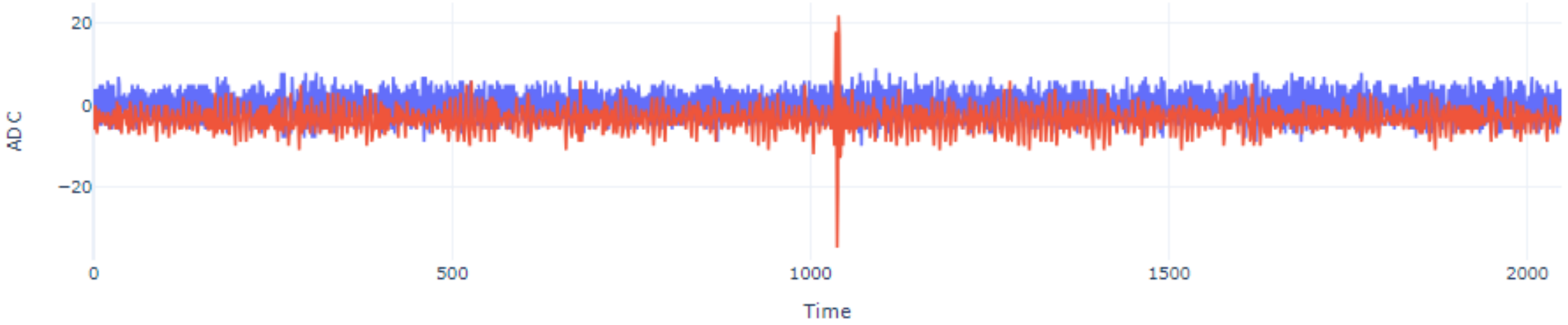
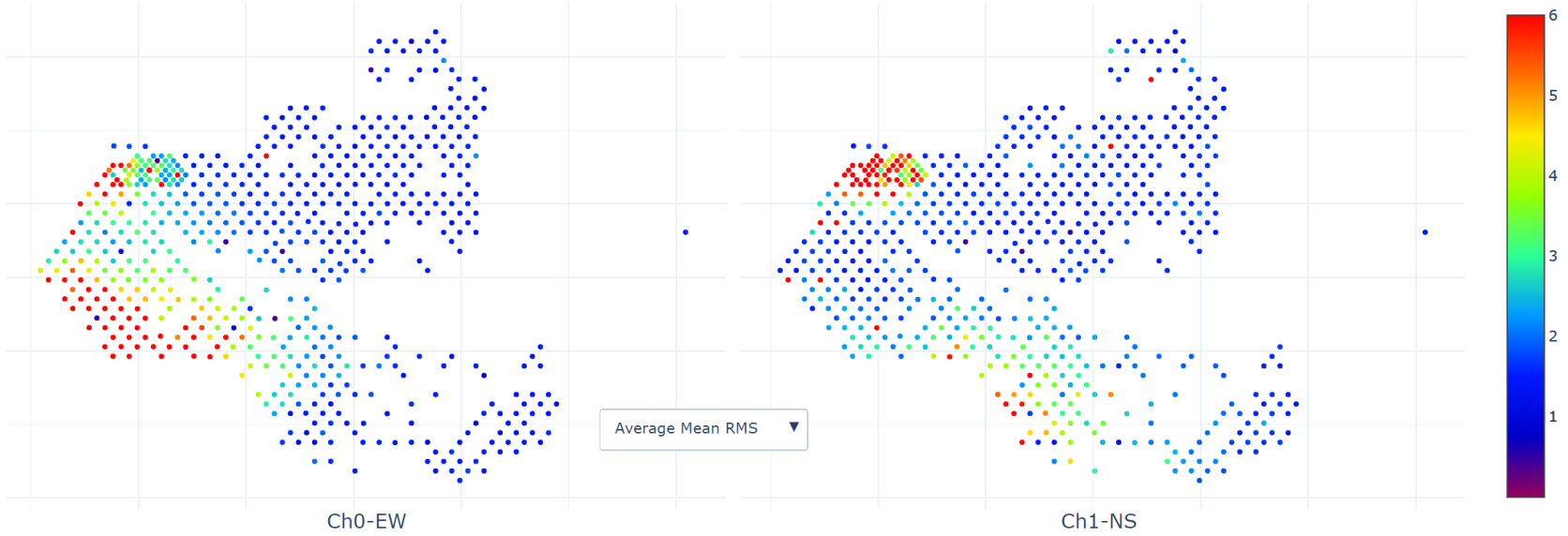


Toward Self-Triggering Radio

Ingredients for Effective Radio Trigger:

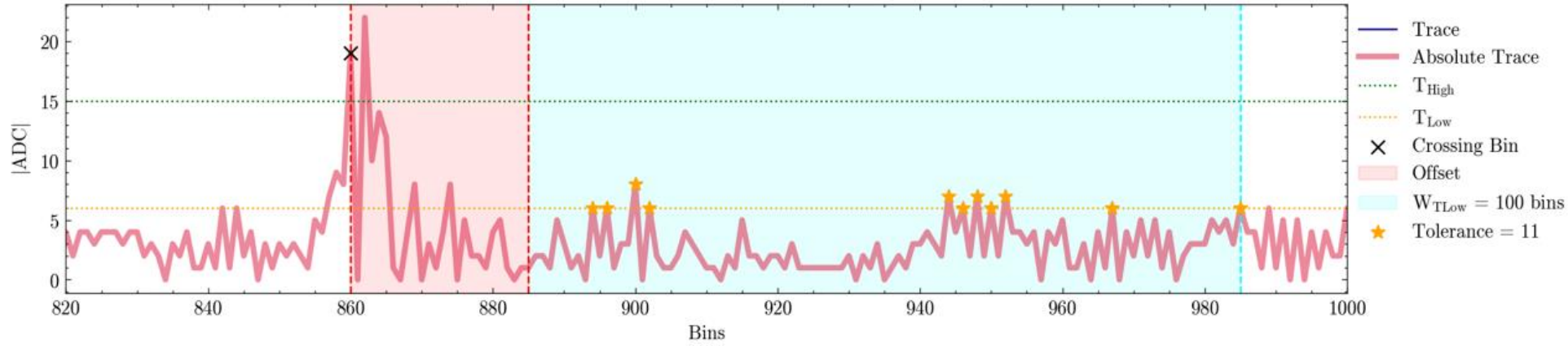
- Hardware Realization → Limited bandwidth
- A good Trigger Algorithm picking up signal and rejecting noise
- Understanding the noise over the array!

  → Monitoring a 3000 km^2 array



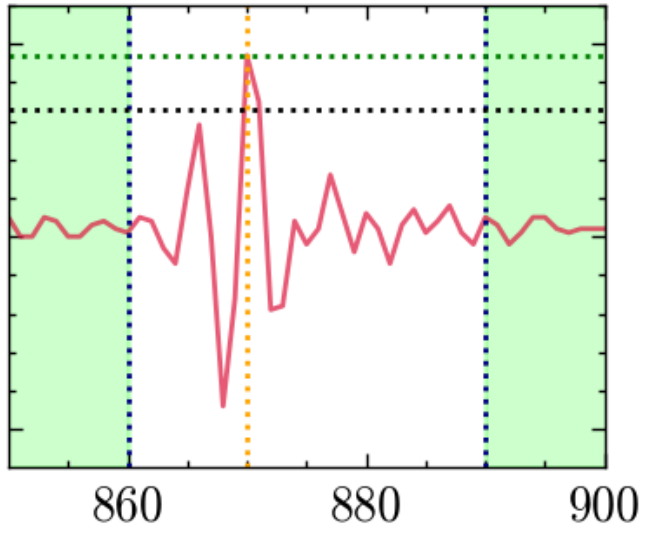
Outlook & Work In Progress

- Optimize the Radio Trigger algorithm Parameters on Real Data using the deployed stations (Real Onsite Noise)



- Develop Data-driven Radio Trigger

  → *The radio pulse has a definitive shape.*



Summary

The Pierre Auger Observatory is the project that is most sensitive to ultra-high energy photons

Promising increase in photon sensitivity using self-triggering radio.

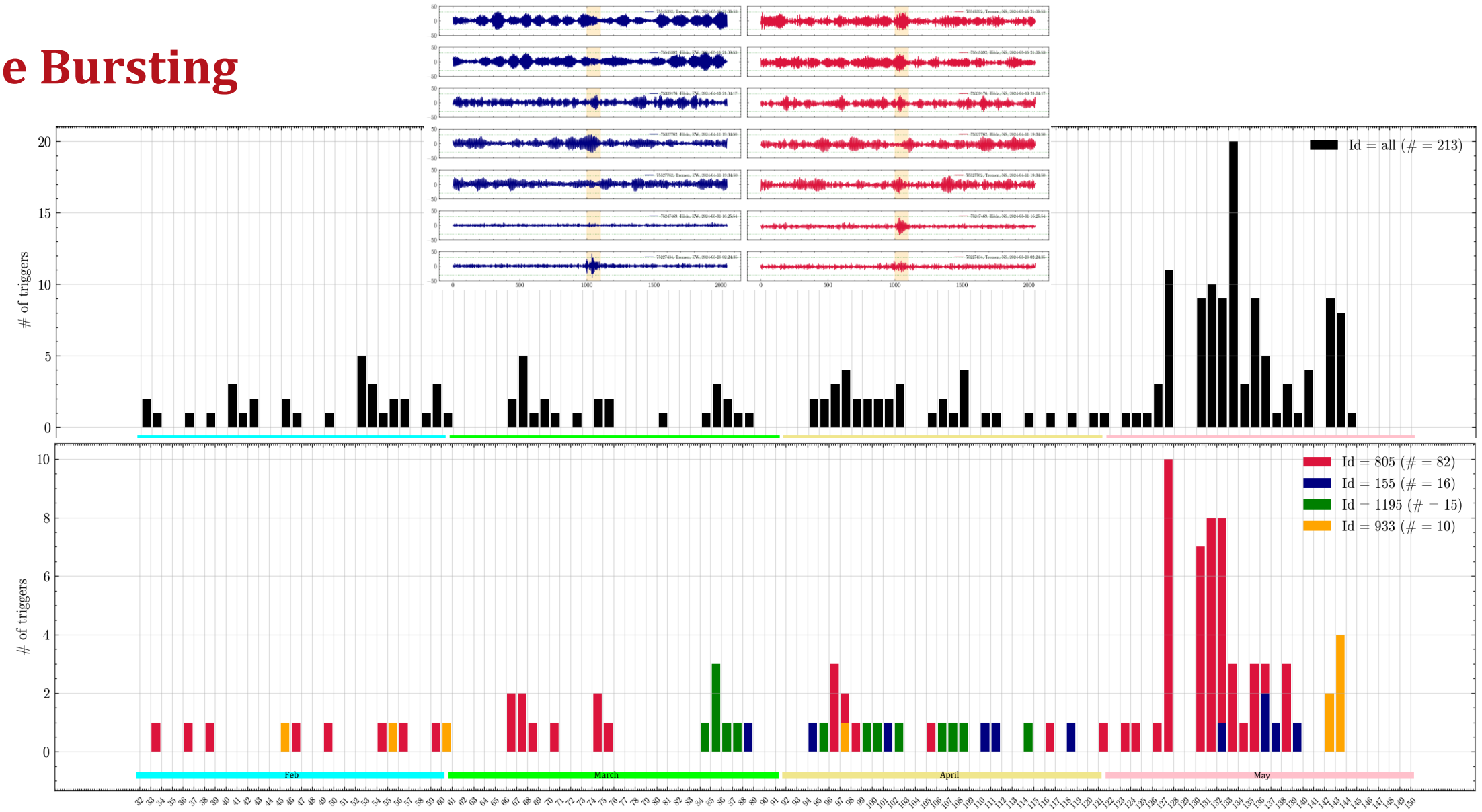
Deployment is going well. Continuous data collection helps radio self-trigger development

Operate a trigger algorithm over 3000 km^2 and +1600 stations is challenging!

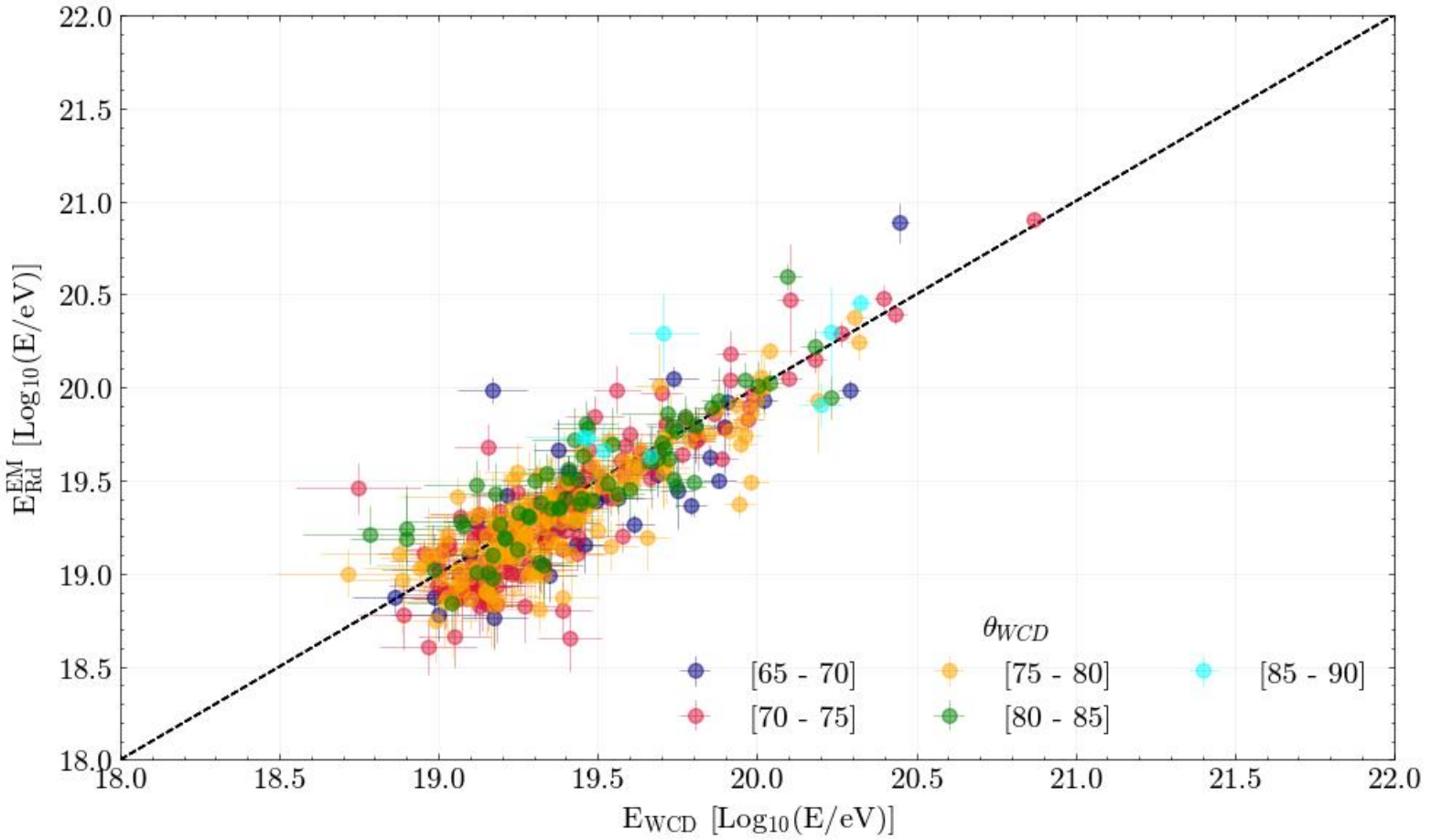
Backup

Backup
Backup
Backup
Backup
Backup
Backup
Backup
Backup

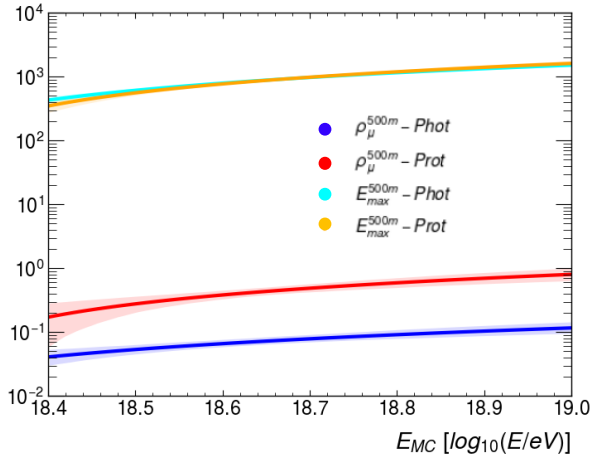
Noise Bursting



Reconstructed Radio Events



AugerPrime Observables



$$\epsilon = \frac{N_{Rd}}{N}$$

→ # of events triggered RD only

→ # of triggered events

→ ~ Low muon events