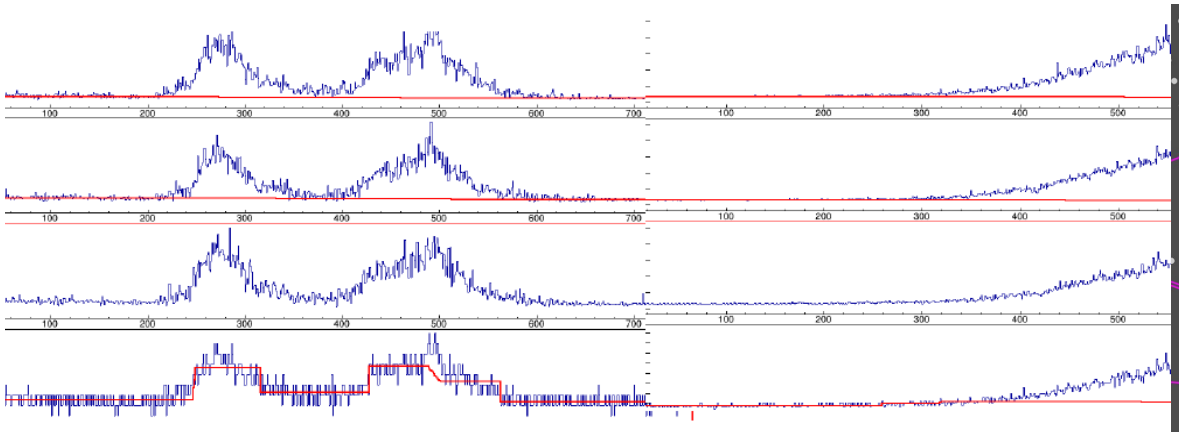
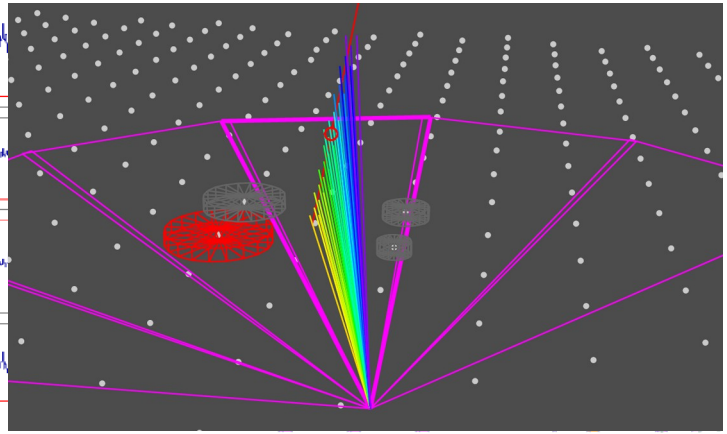
Low-Energy GZ-events at the Pierre Auger Observatory?

Martin Schimassek

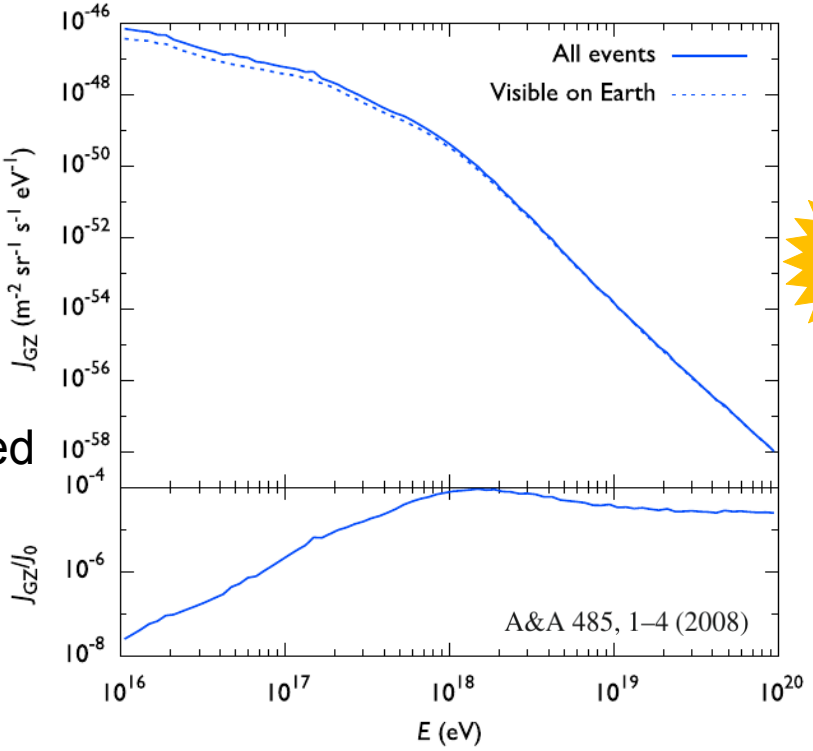


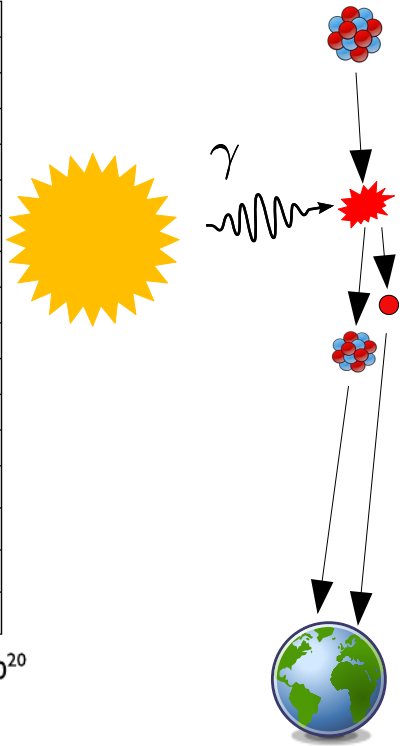


AstroParticle Symposium 2022

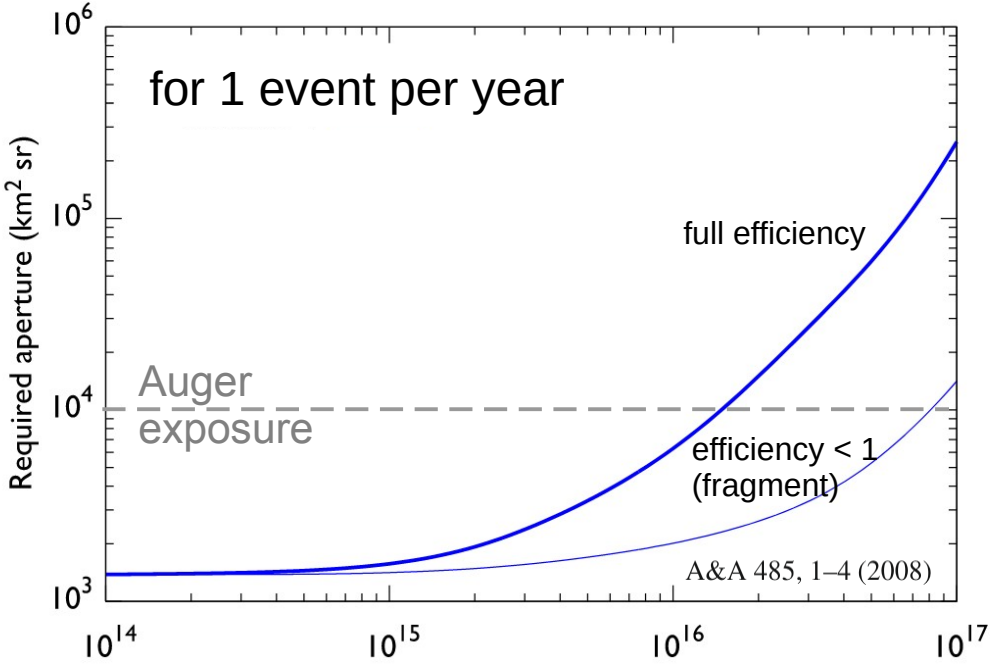
The Gerasimova-Zatsepin (GZ) Effect

- nuclear disintegration in solar photon field predicted 1960 by G&Z
- separation of fragments in solar magnetic field
- very small rates, not observed
- direct proof A > 1
- direct A measurement

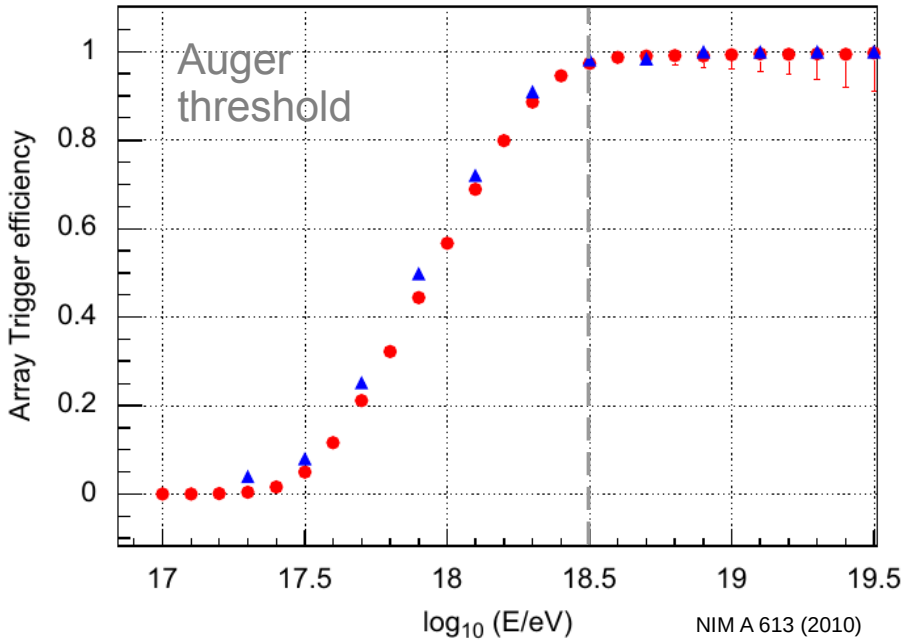




Need for Lower Energies

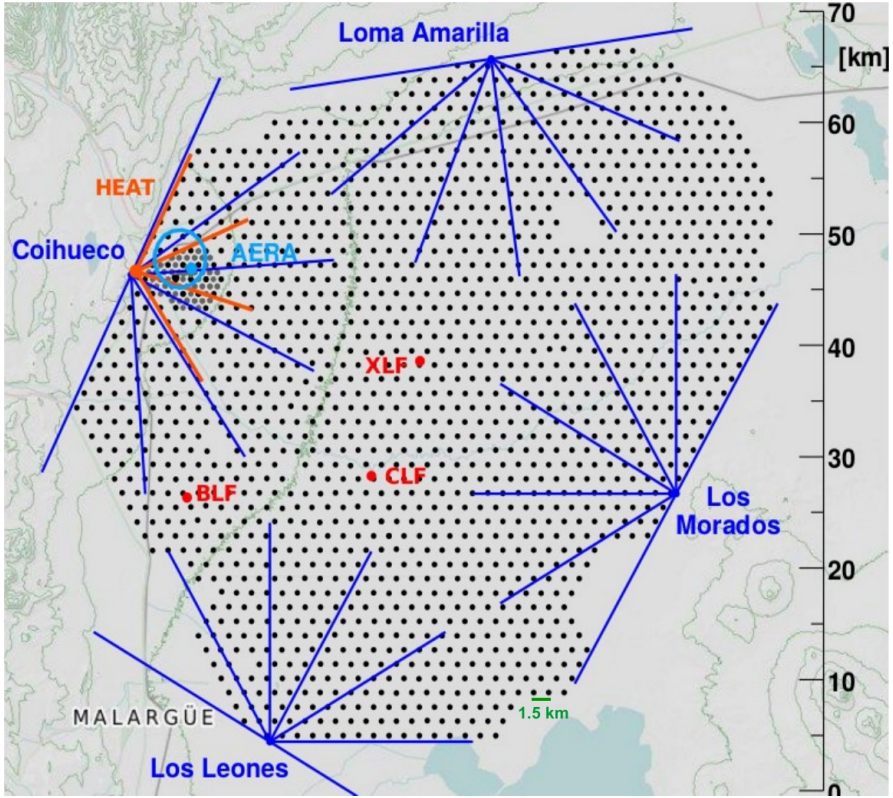


required $E_{\mathrm{threshold}}(\mathrm{eV})$



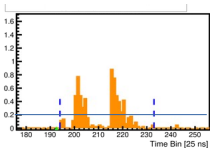
$A\,\Omega \approx 10^4\,\mathrm{km}^2\,\mathrm{sr}$

The Pierre Auger Observatory



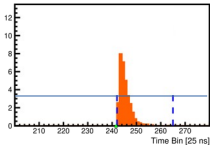
covering 3000 km²
built for the highest energies

Station Triggers



~2 Hz

signal trigger → promote / select → station trigger



~100 Hz

station trigger → ~20 Hz → array trigger

geometry → array trigger

timing → array trigger

since January 2016:
trigger data stored for offline analysis

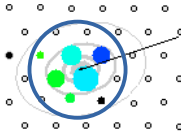
(about 360 GB per month,
normal data ~30GB / month)

only trigger data

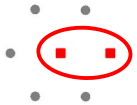
station id
trigger time
trigger type

Search for GZ-Events

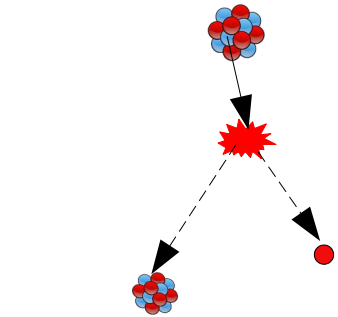
- lower threshold by using nn-trigger pairs
- several combinations possible
- implicitly select different energies and backgrounds

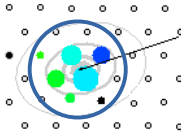


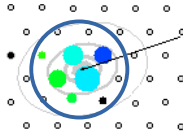
reconstr. event (event data)

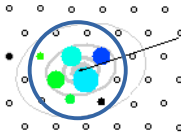


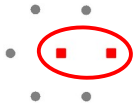
nn-pair from station triggers

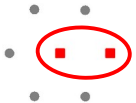


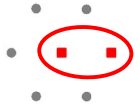




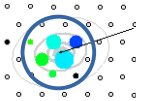




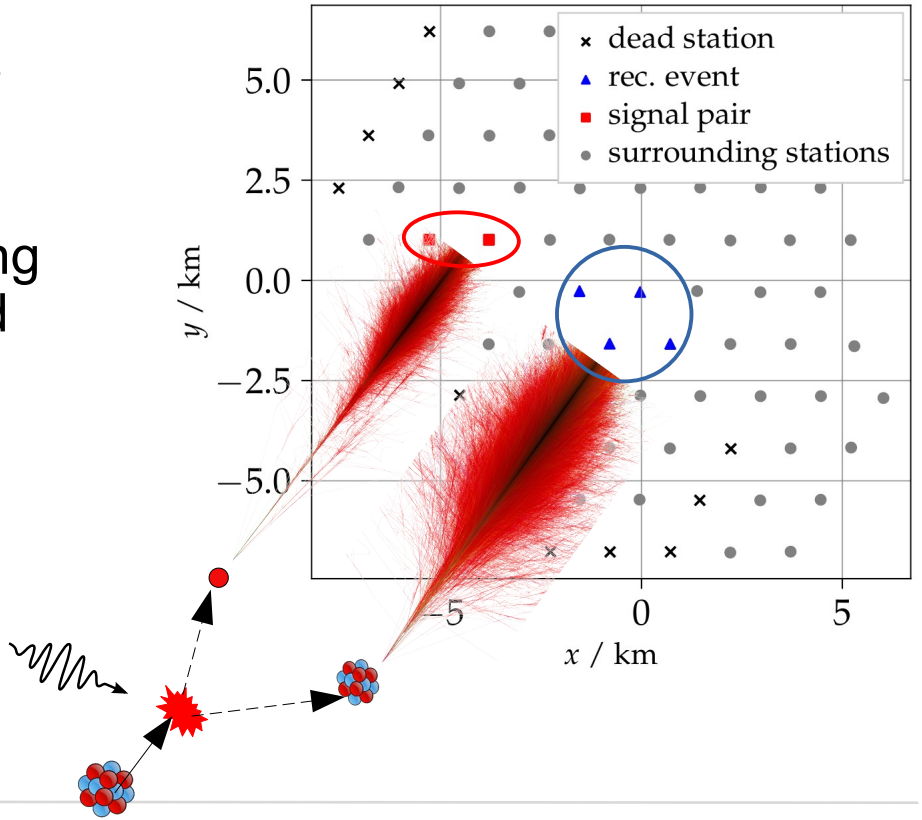




Example: Event + Pair



- lower threshold by using trigger pairs for the lower energetic shower
- the reconstructed direction fixes timing precisely → less random background
- extension to two trigger pairs: even lower threshold but more background

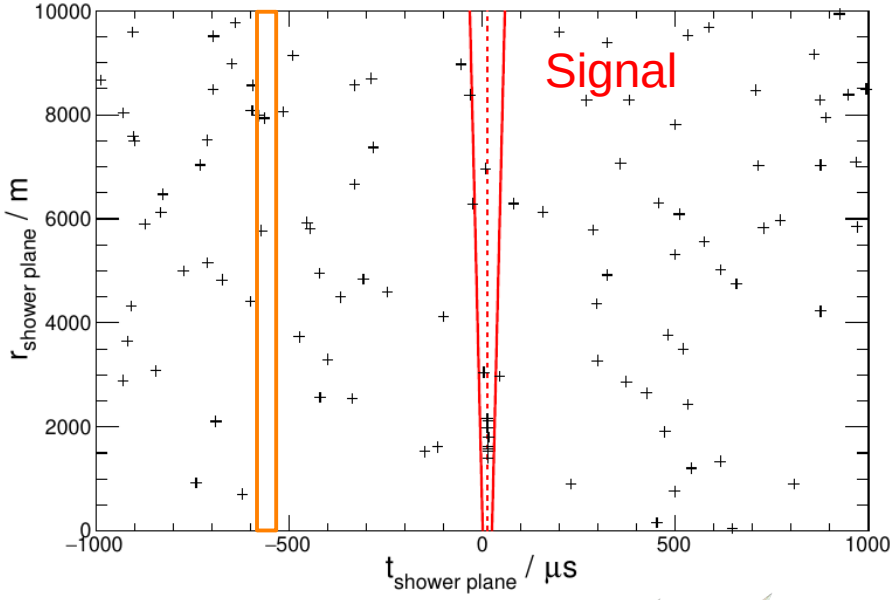


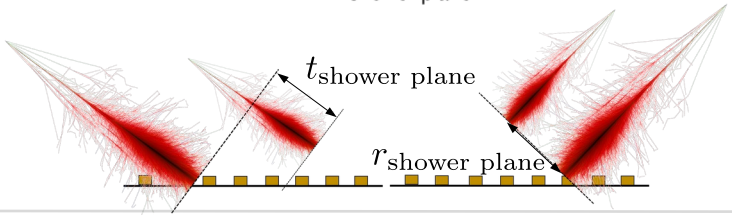
Background Estimation

- search window at time t ~ 0, limited to < 5 km (background)
- get background from random t
- from shuffled data:

$$\Gamma_{\mathrm{Bg}} = 5.3 \times 10^{-9}\,\mathrm{Hz} = 0.17\,\mathrm{yr}^{-1}$$

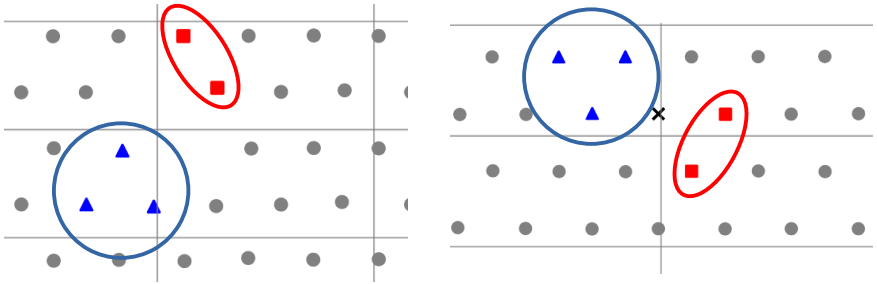
Background

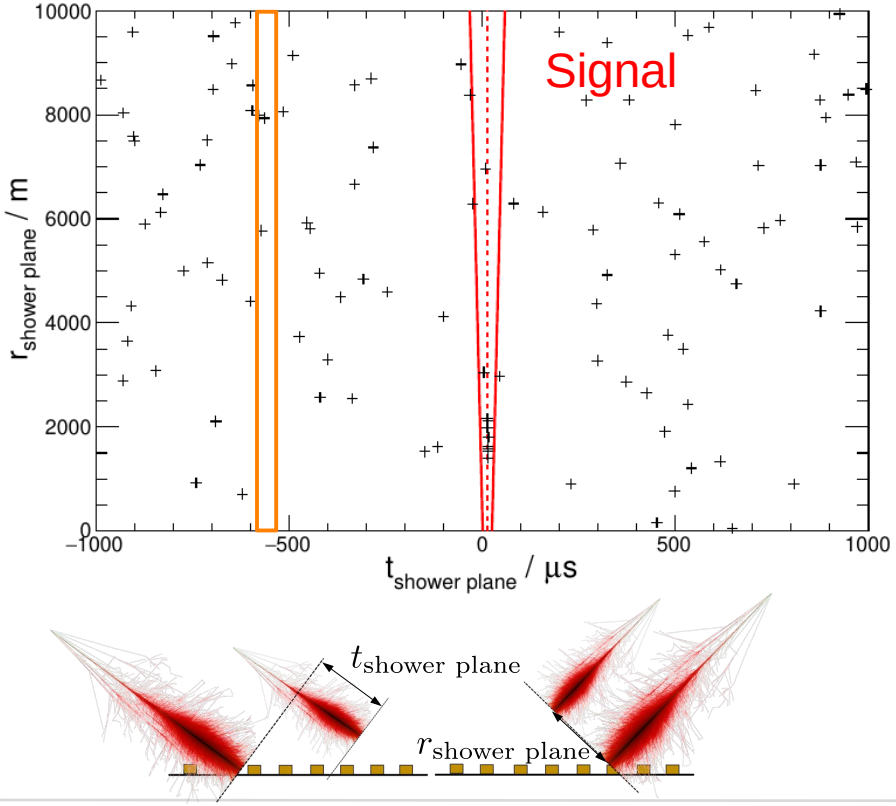




Background Estimation

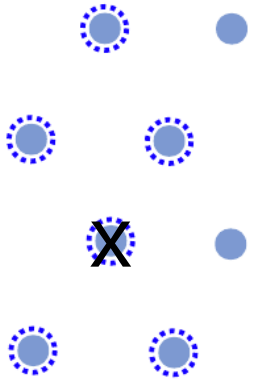
- expect non-random contributions:
  - missing stations
  - dead-stations
- Information available: remove for final analysis





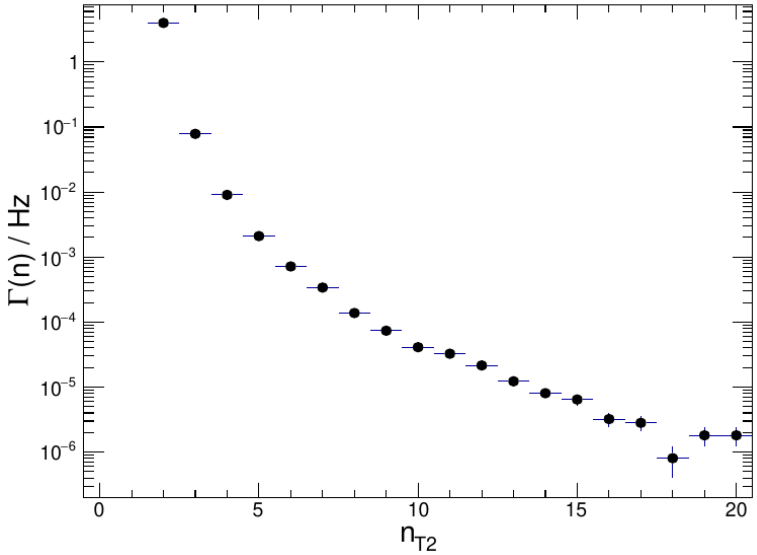
Background: Dead-time and split events

- split events due to dead-time of stations



- calculate as

$$\Gamma_{\mathrm{dead}} \approx \Gamma(n \geq 6)\gamma_{\mathrm{geo}} p(\mathrm{dead})$$



- result:

$$\Gamma_{\mathrm{dead}} = 6.8\times10^{-9}\,\mathrm{Hz} = 0.21\,\mathrm{yr}^{-1}$$

from dead-time:

$$p(\mathrm{dead}) = p(n \geq 2|\lambda) \approx \lambda^2/2 = (\Gamma\Delta t)^2/2 \approx 2.4\times10^{-4}$$

Summary

- rich data set from station triggers available at the Pierre Auger Observatory
- useful to calculate background expectations for Gerasimova-Zatsepin events
- we obtain background of less than 1 event per year for small separations