γπ workshop

3-4 December 2024

Armelle Jardin-Blicq - FCLA, Cerro Calán - armelle.jardin-blicq@lp2ib.in2p3.fr

γπ workshop

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Welcome and thank you for your interest !

Timetable and material available on the **indico page** - Please register !

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What is gammapy : a python package to analyse gamma-ray data (**Documentation**)

How to install it : **Quickstart Setup (v 1.2)**

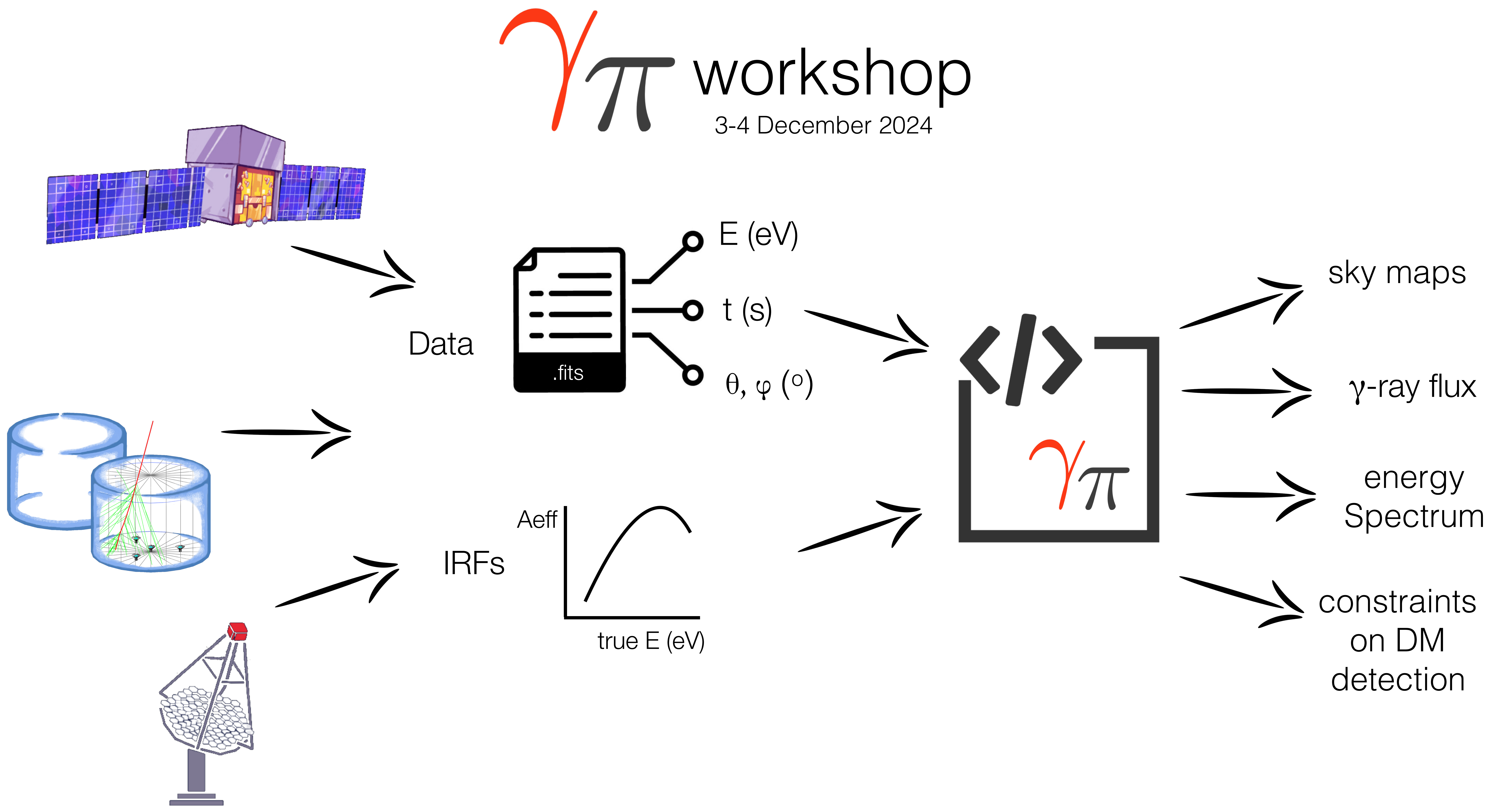
Latest version : 1.2 -> 1.3 !

Please install it for tomorrow to do the tutorial.

If you have problems -> contact me or come to the help-desk sessions.

How to use it : purpose of the workshop

Feel free to join the slack workspace : **gammapy.slack.com**


γπ workshop
3-4 December 2024
Data
.fits
E (eV)
t (s)
θ, φ (°)
IRFs
Aeff
true E (eV)
γπ
sky maps
γ-ray flux
energy
Spectrum
constraints
on DM
detection


γπ workshop
3-4 December 2024
1 - Instrumentation and detection techniques
Data
.fits
E (eV)
t (s)
θ, φ (°)
IRFs
Aeff
true E (eV)
2 - γ-ray data
3 - Data analysis
γπ
sky maps
γ-ray flux
energy Spectrum
constraints on DM detection
4 - Physics output

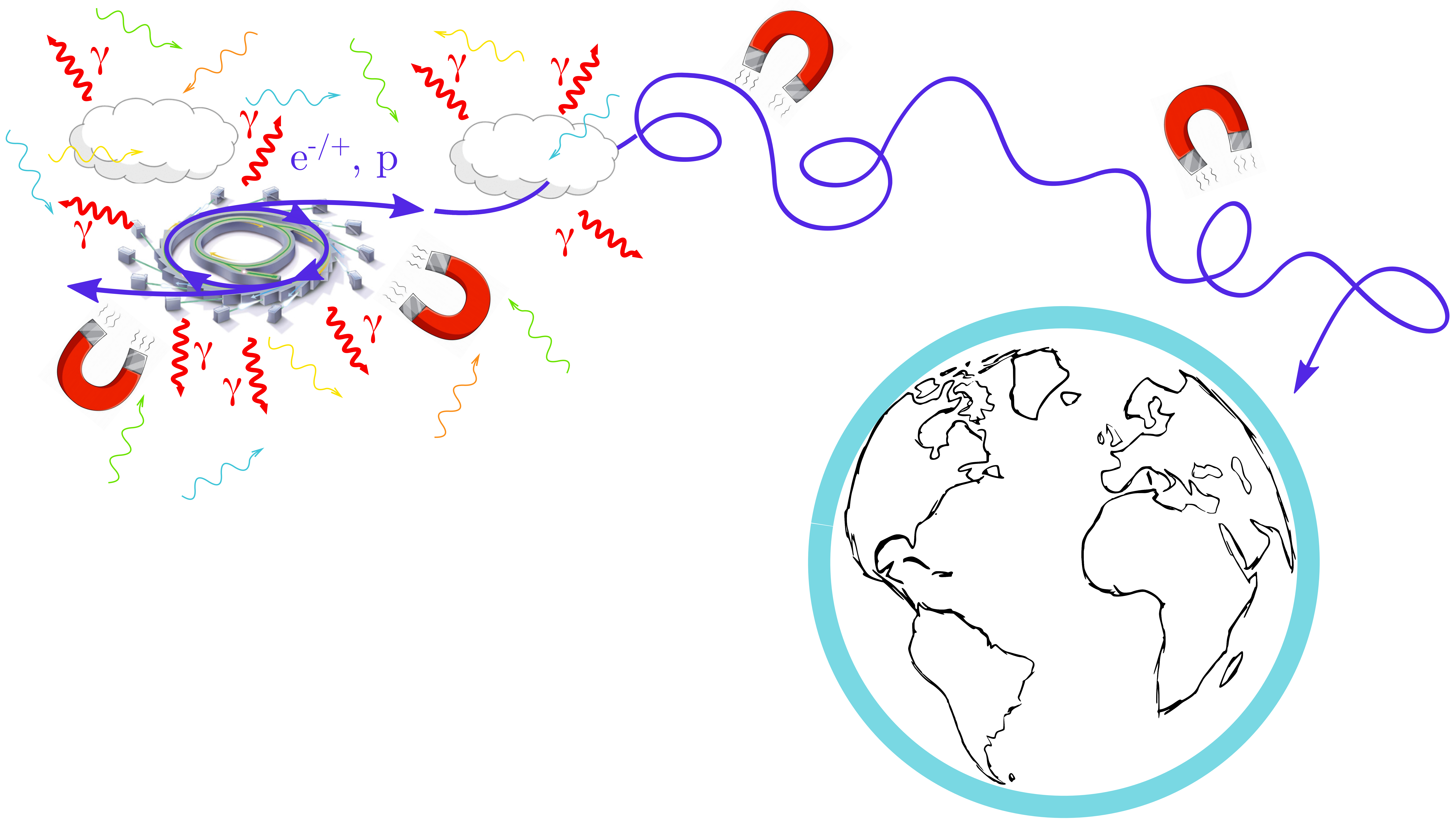
γπ workshop

3-4 December 2024

1 - Instrumentation for gamma-ray astronomy and detection techniques

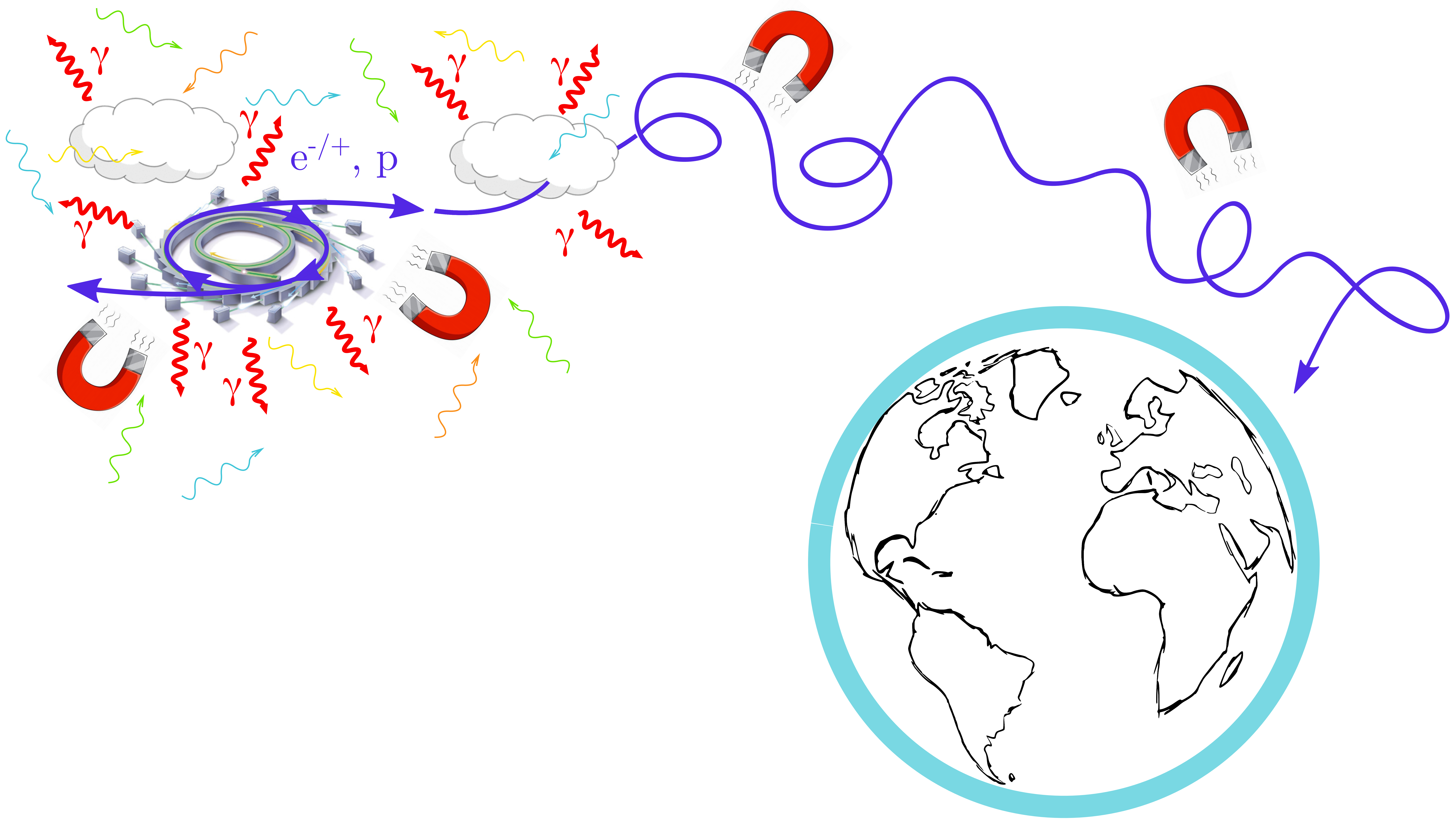
Armelle Jardin-Blicq - FCLA, Cerro Calán - armelle.jardin-blicq@lp2ib.in2p3.fr

Instrumentation for γ-ray astronomy



Instrumentation for γ-ray astronomy

Instrumentation for γ-ray astronomy



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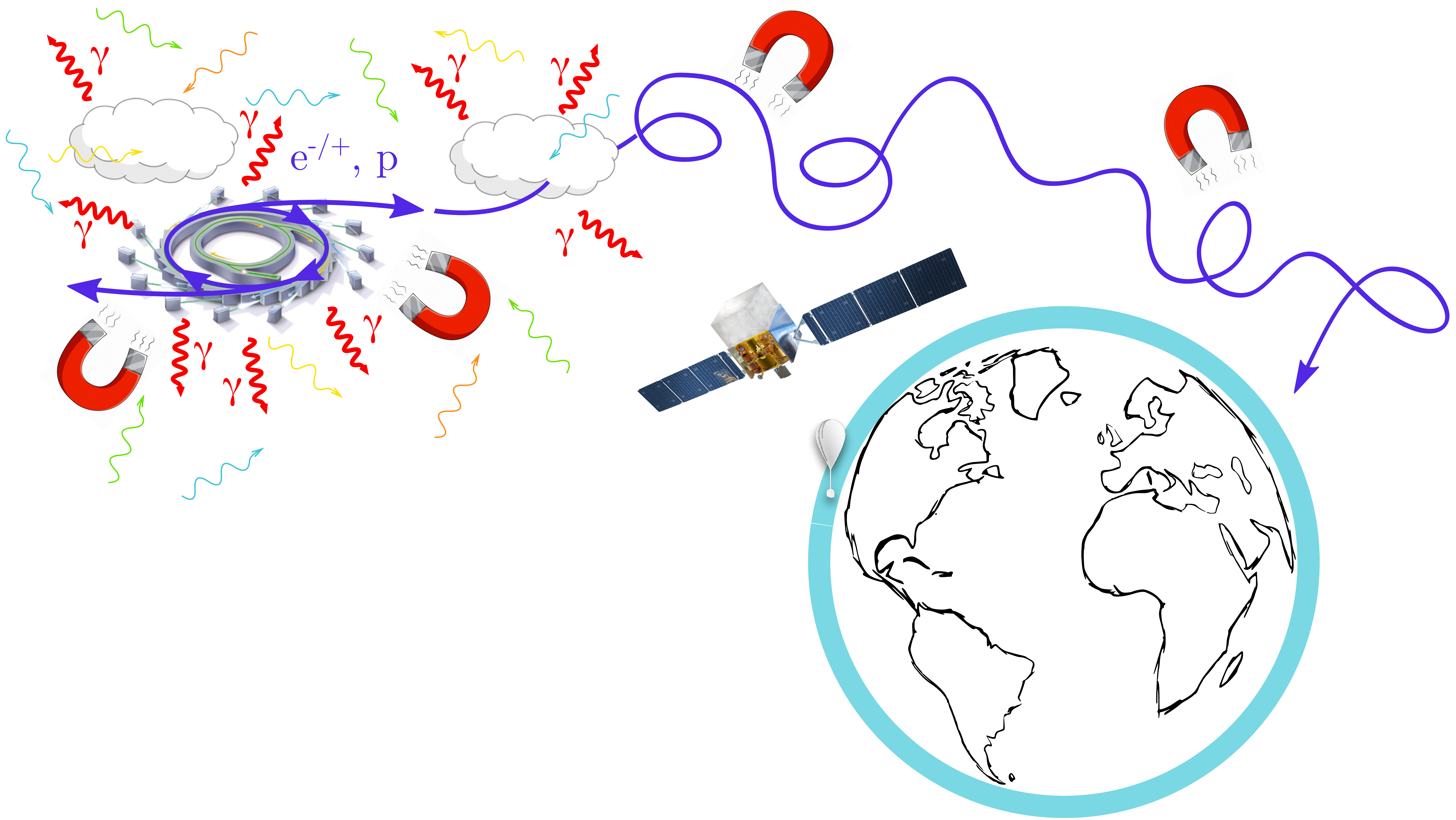
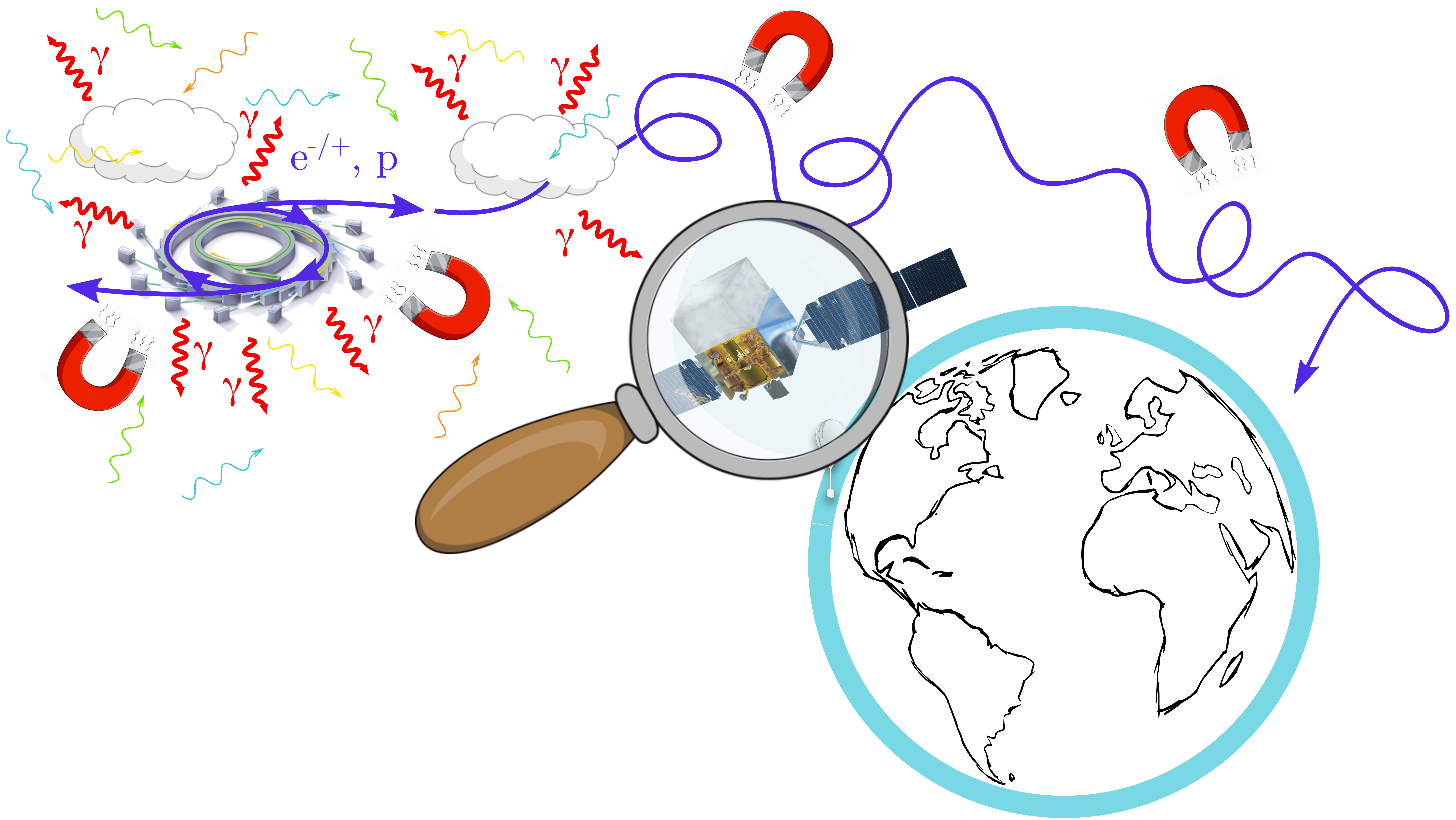
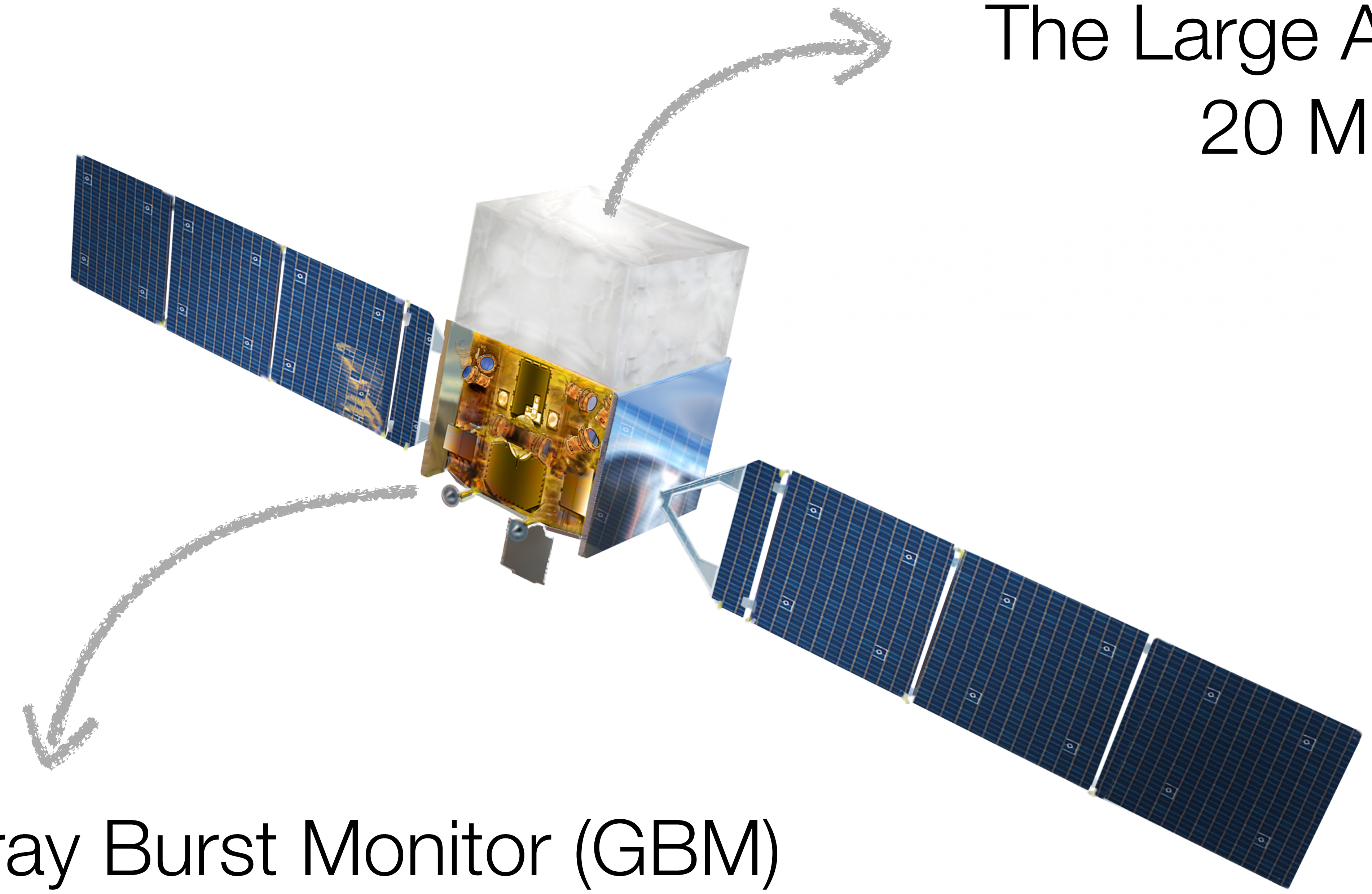


Instrumentation for γ-ray astronomy

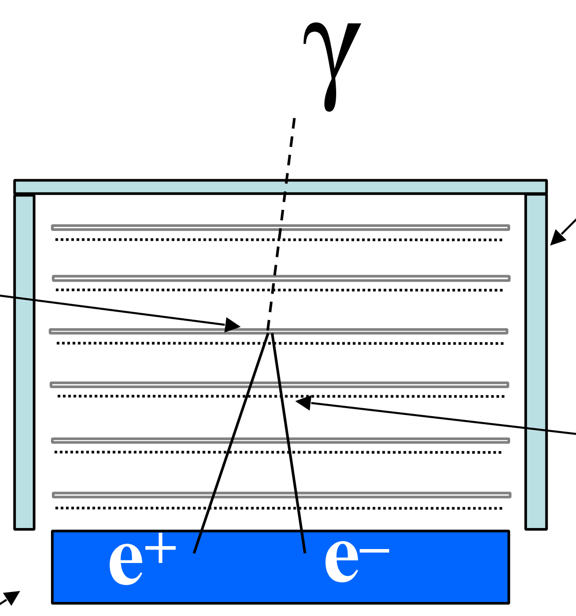


Instrumentation for γ-ray astronomy



The Large Area Telescope (LAT)
20 MeV - 400 GeV

Gamma ray **converts** to an e^+ e^- pair in a high density foil layer.

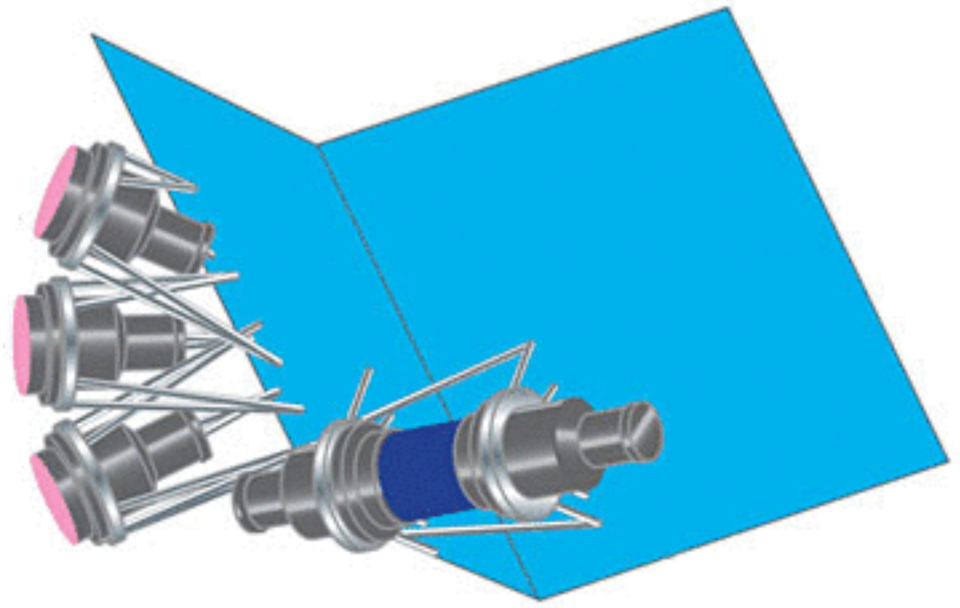


An **anti-coincidence detector** identifies and rejects incoming charged particles.

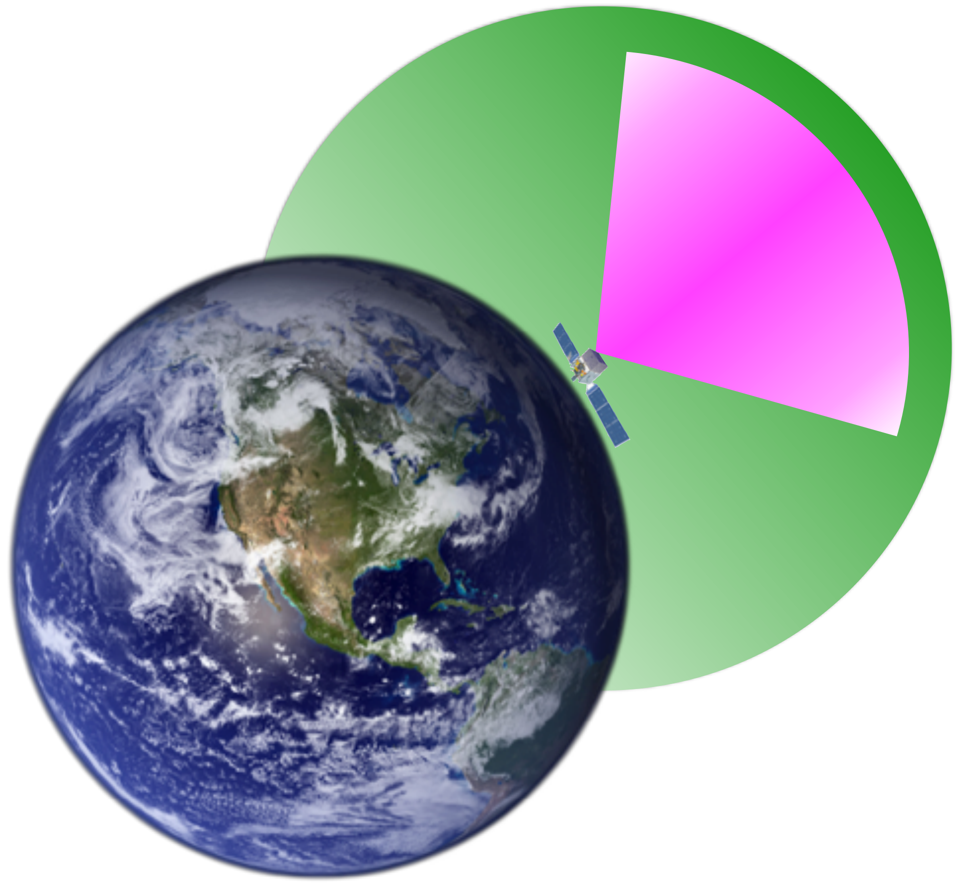
The **tracks** of charged particles in the instrument are recorded by sensors. They are used to determine the direction of the gamma-ray source.

The photon energy is determined from measured energy deposited in the **calorimeter**.

The Gamma ray Burst Monitor (GBM)
8 keV - 30 MeV



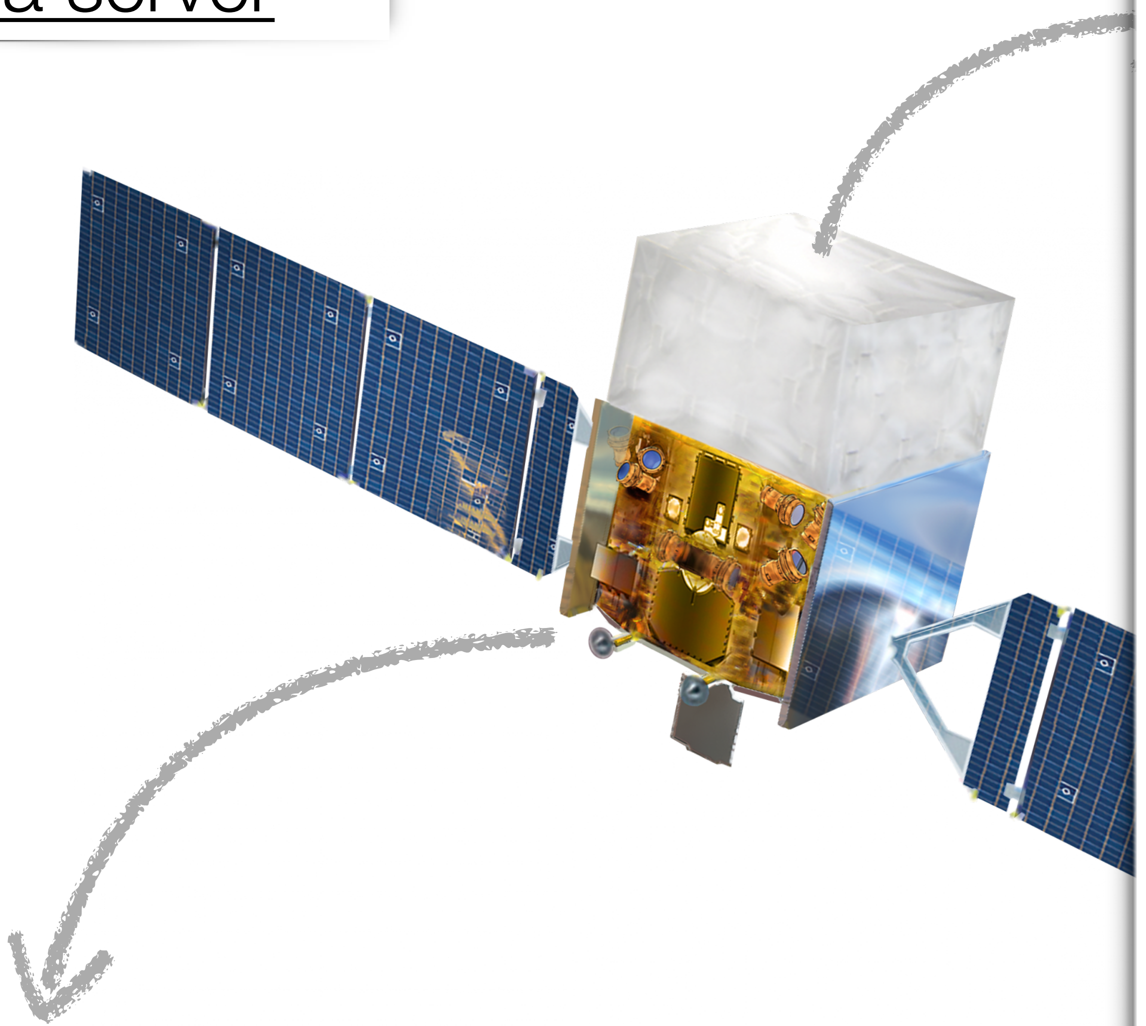
Scintillation detectors are distributed around the spacecraft with different viewing angles in order to determine the direction of a burst by comparing the count rates of different detectors



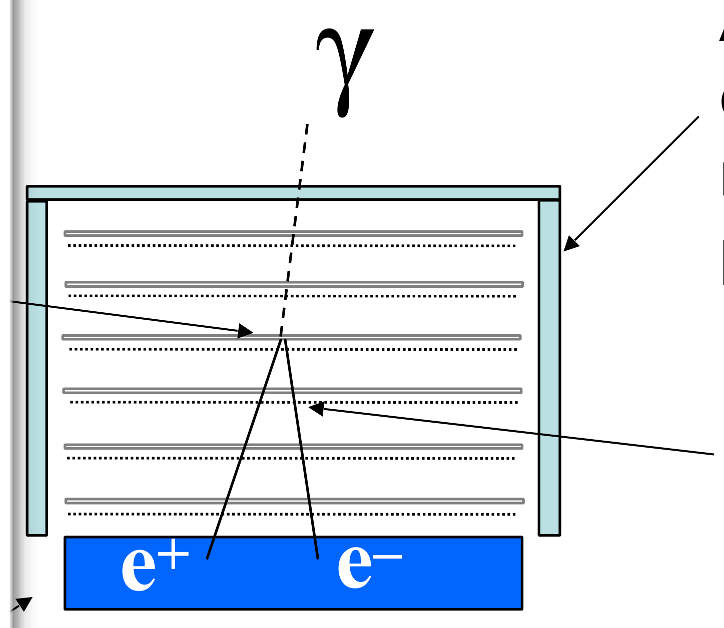
Credit : Liz Hays and Judy Racusin (Fermi school 2021)

Instrumentation for γ-ray astronomy

Fermi data are public !
-> LAT data server



Credits: NASA/General Dynamics Advanced Information Systems

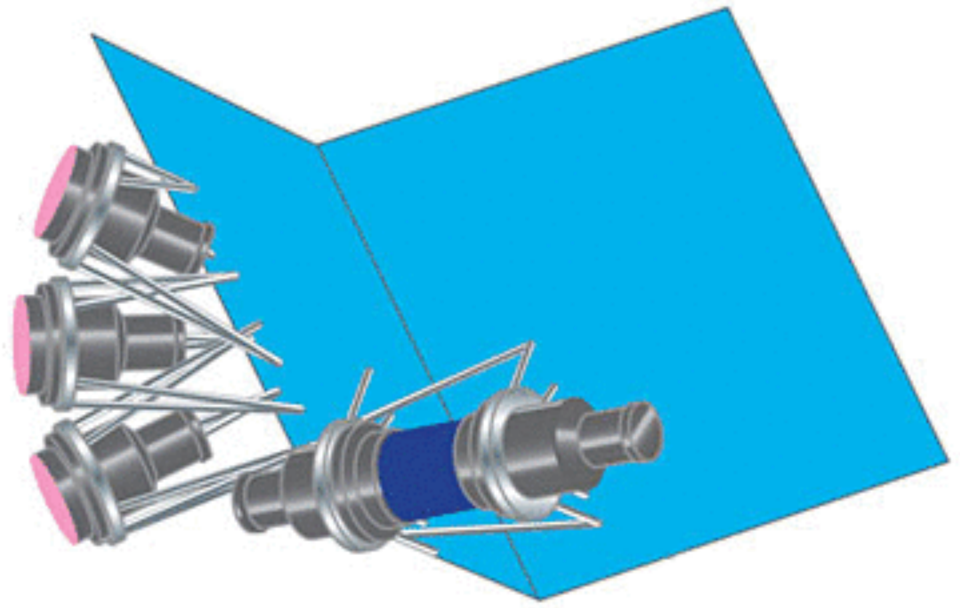


An **anti-coincidence detector** identifies and rejects incoming charged particles.

The **tracks** of charged particles in the instrument are recorded by sensors. They are used to determine the direction of the gamma-ray source.

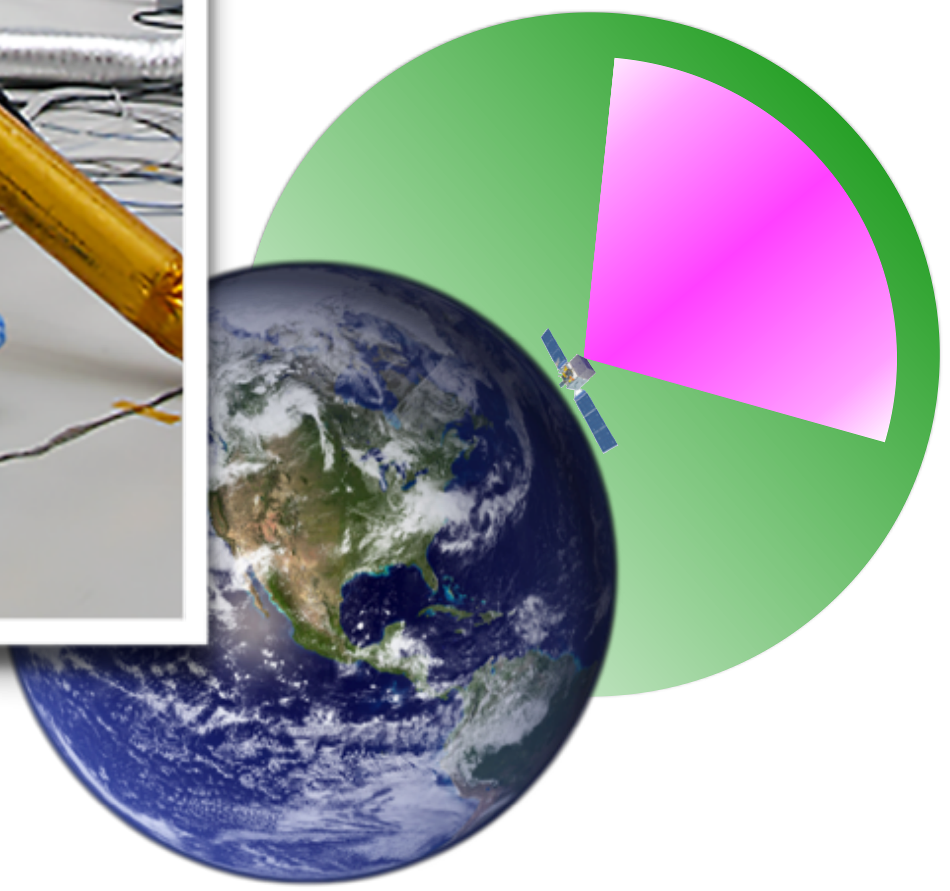
…etermined
…deposited

The Gamma ray Burst Monitor (GBM)
8 keV - 30 MeV



Scintillation det…
around the spa…
viewing angles …
the direction of …
the count rates …

GBM Field of View

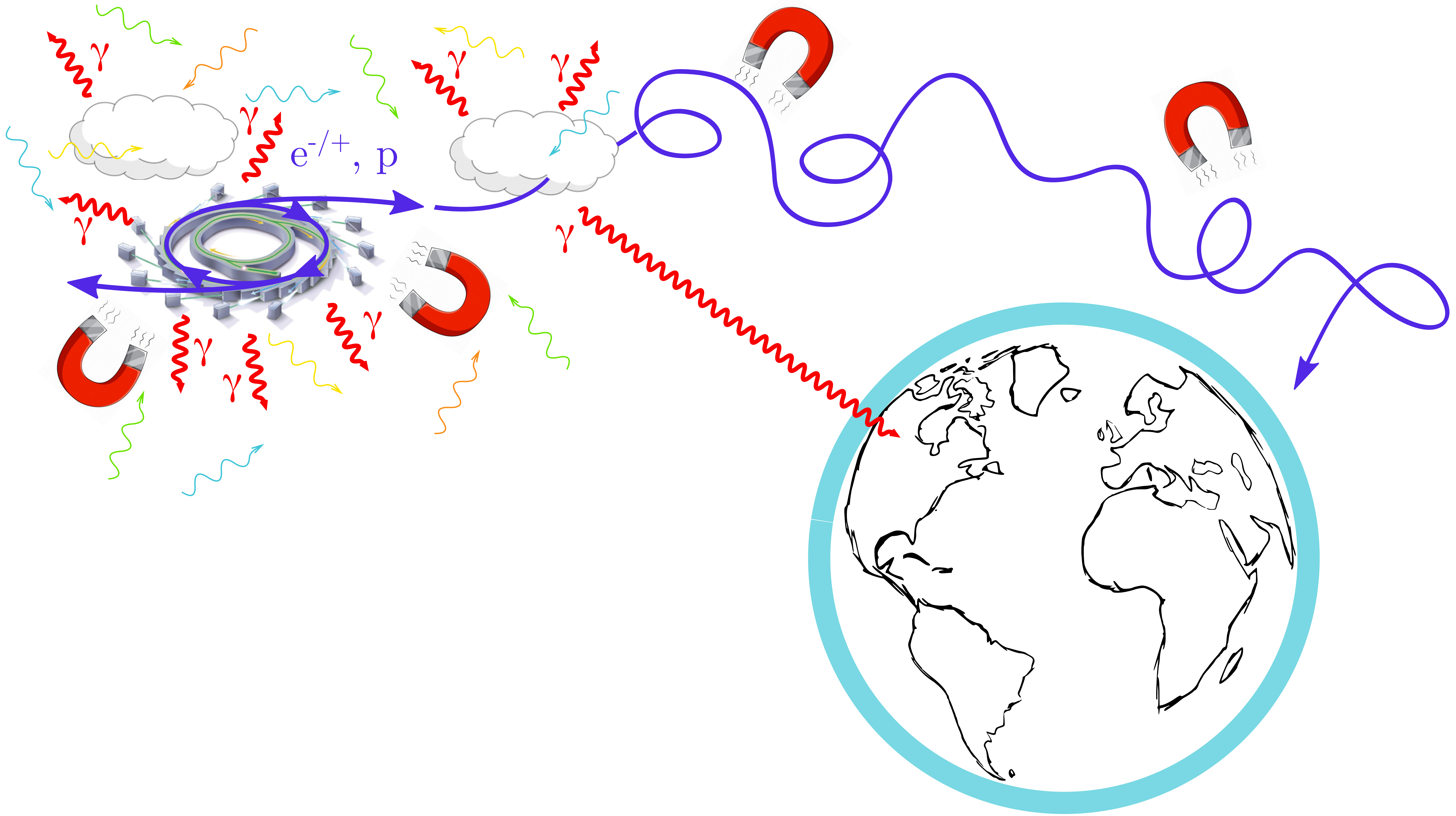


LAT Field of View

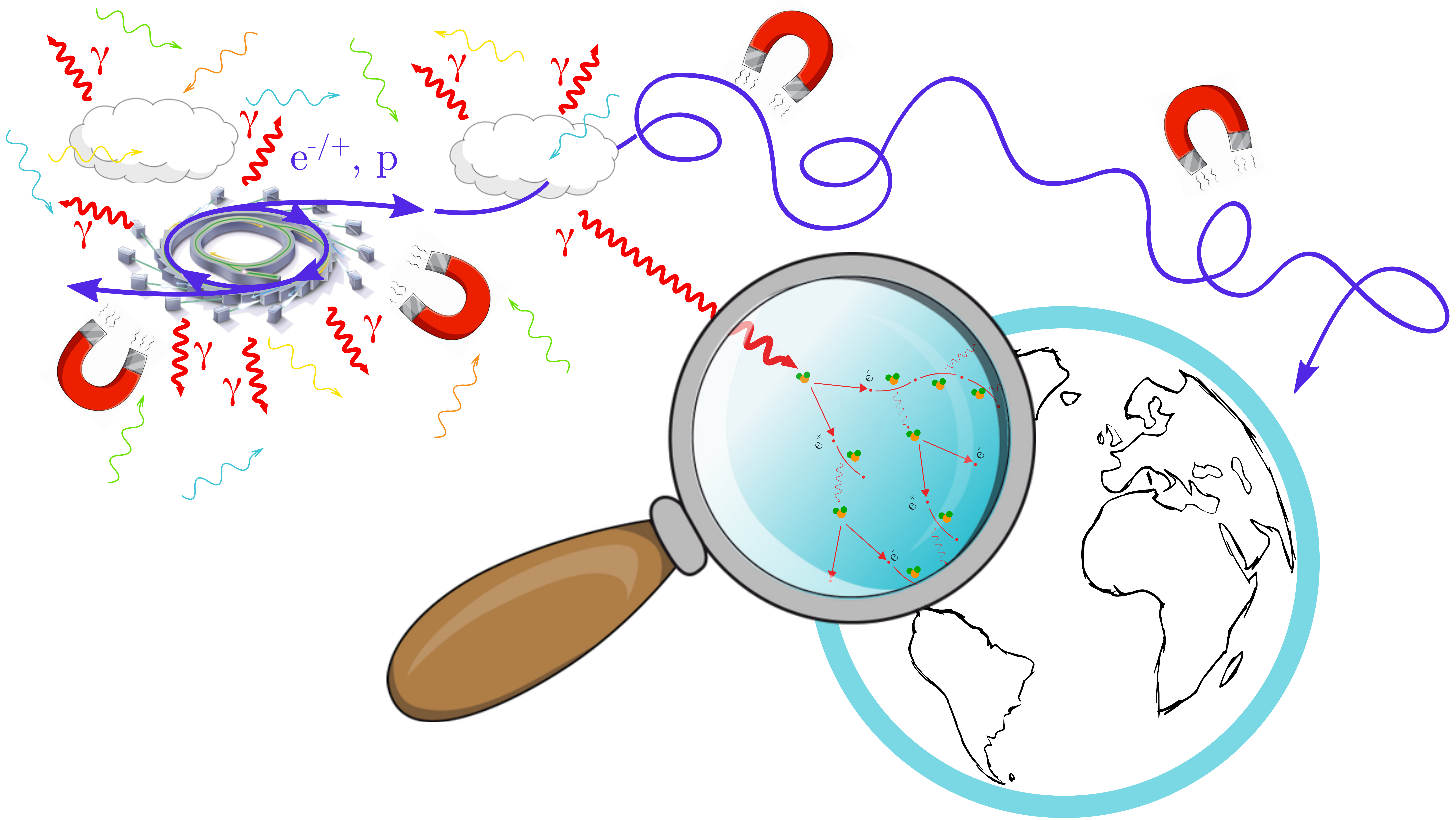
Credit : Liz Hays and Judy Racusin (Fermi school 2021)

More about Fermi spacecraft and instruments

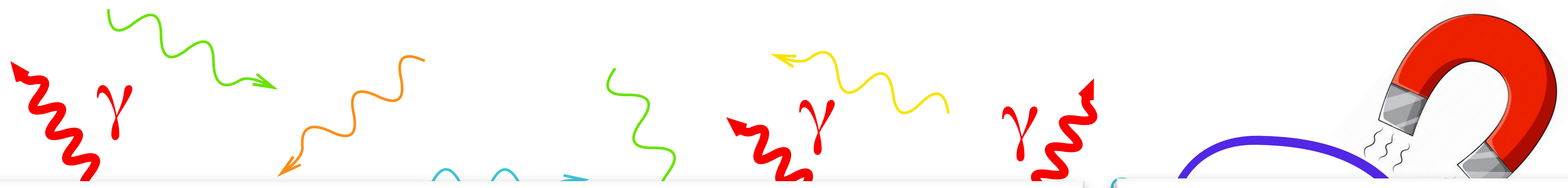
Instrumentation for γ-ray astronomy



Instrumentation for γ-ray astronomy

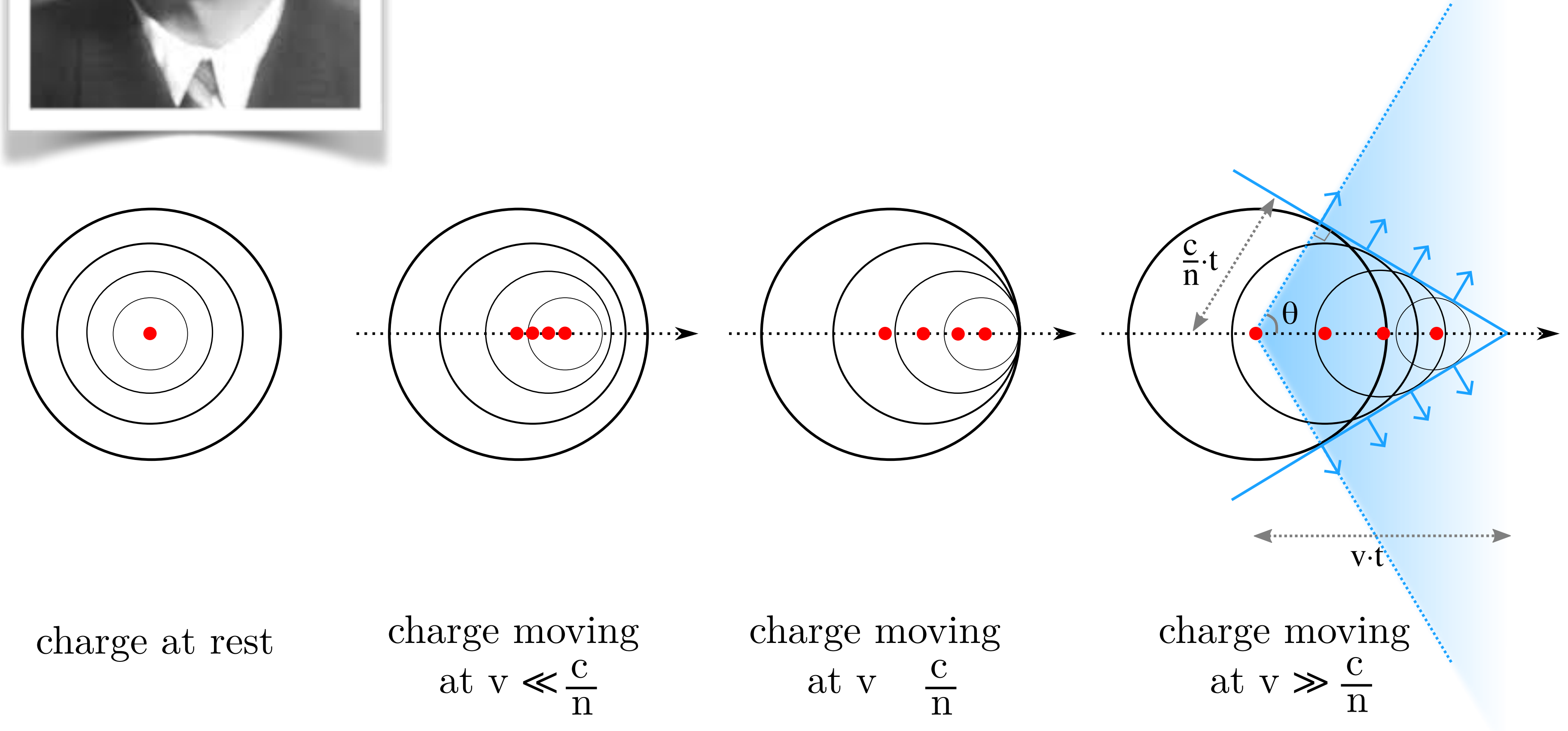


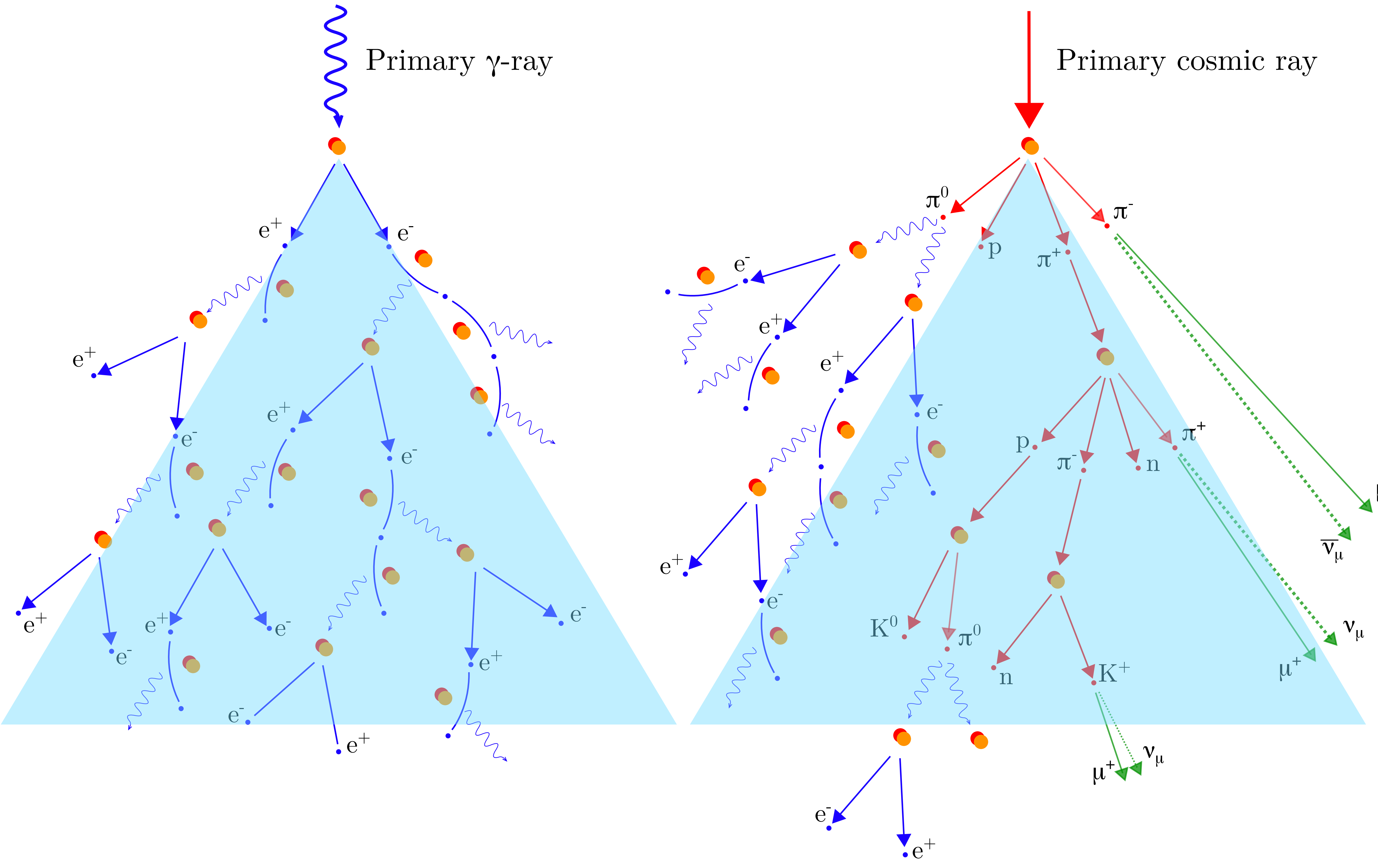
Instrumentation for γ-ray astronomy



Cherenkov light !

Nobel prize in Physics 1958
"for the discovery and the interpretation of the Cherenkov effect"

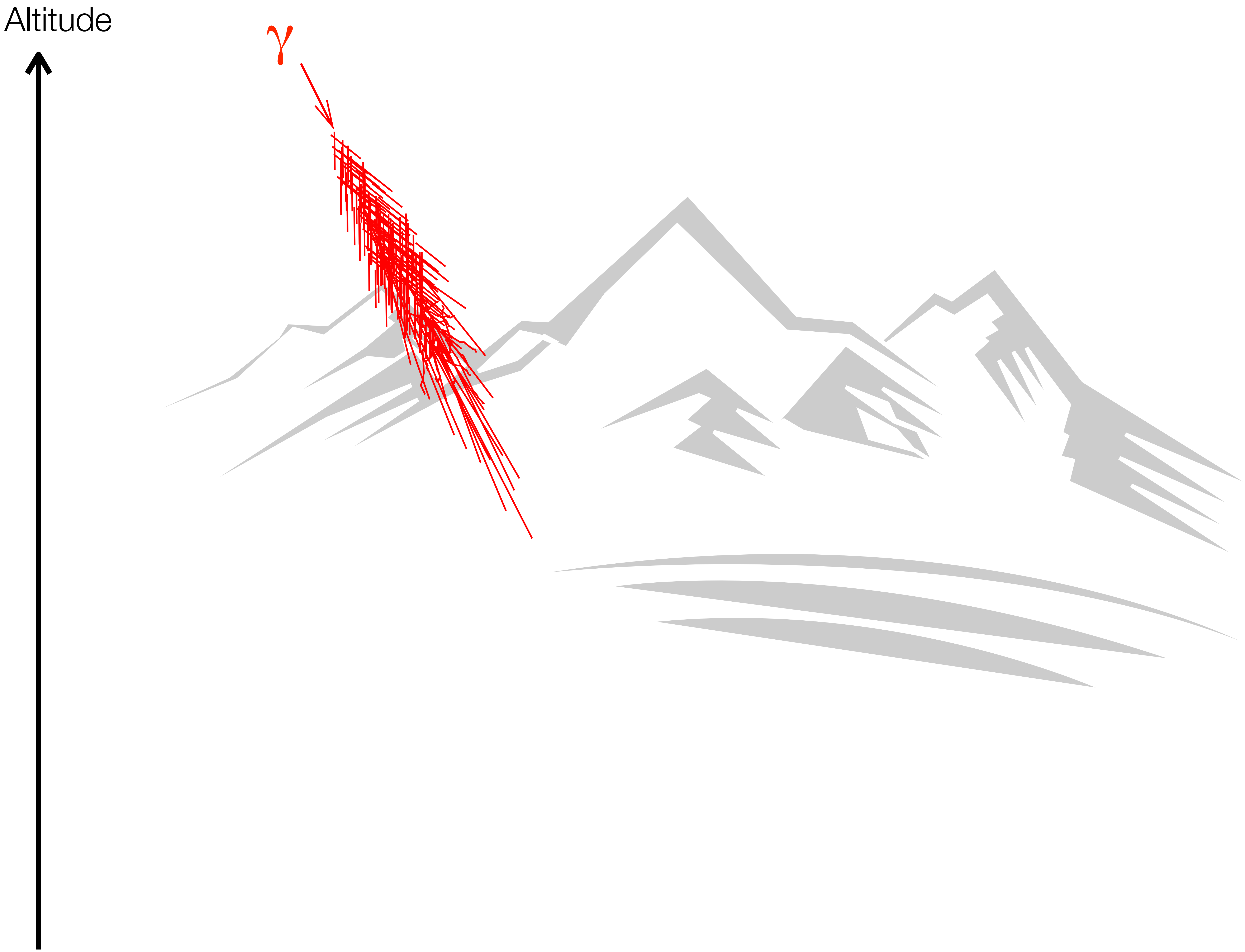


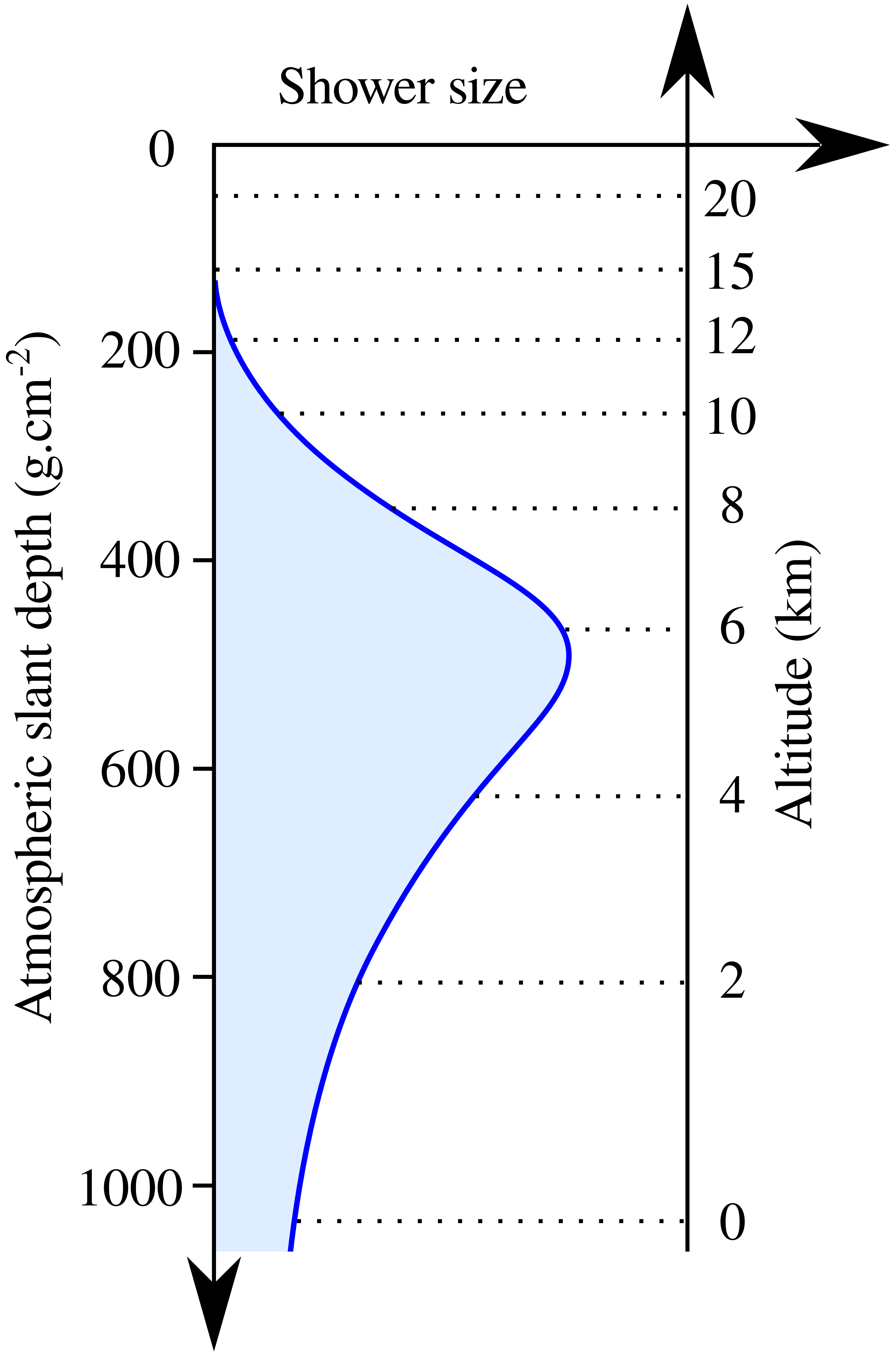


2 ways to indirectly detect γ rays and cosmic rays :

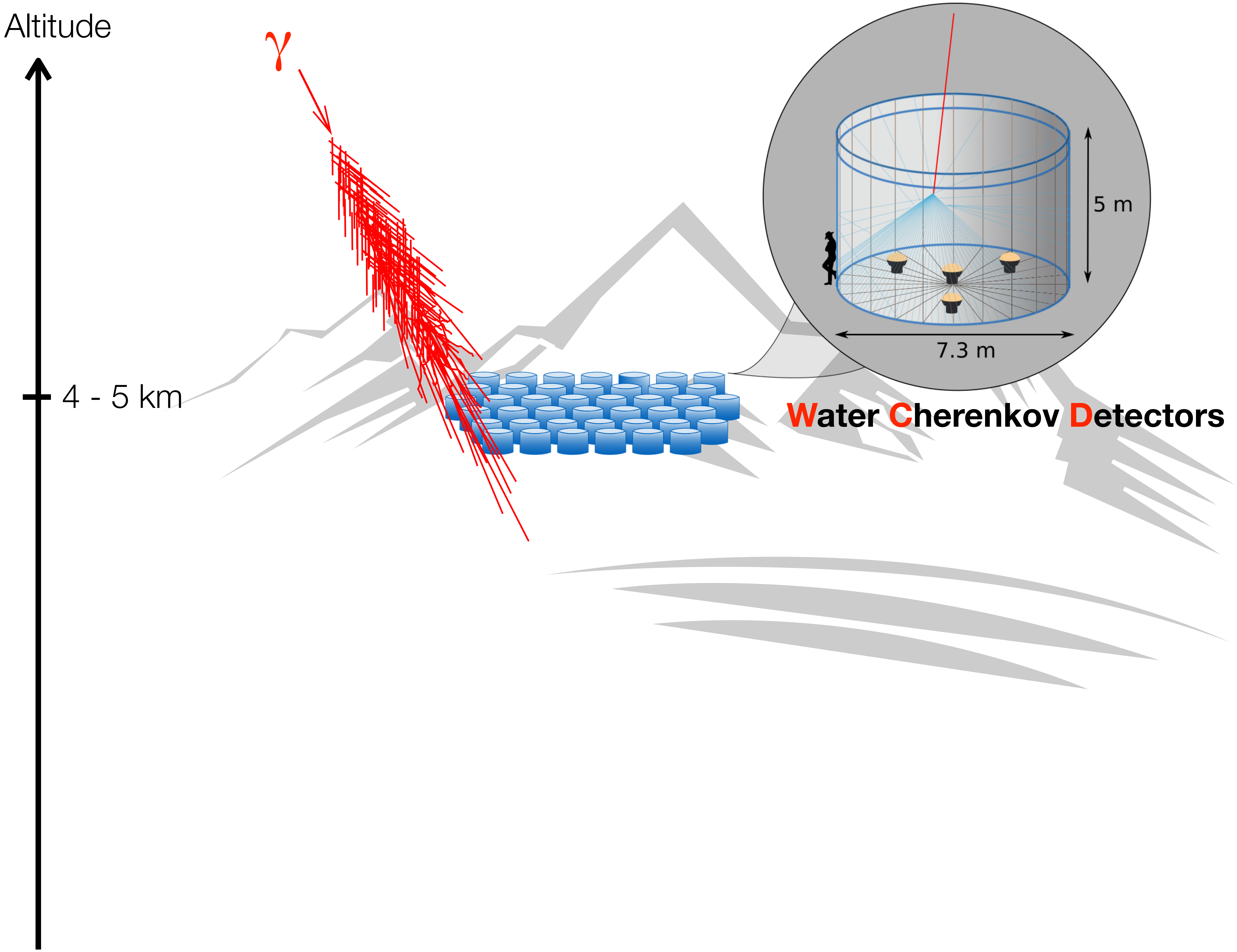
- detect the secondary particles
- detect the Cherenkov light

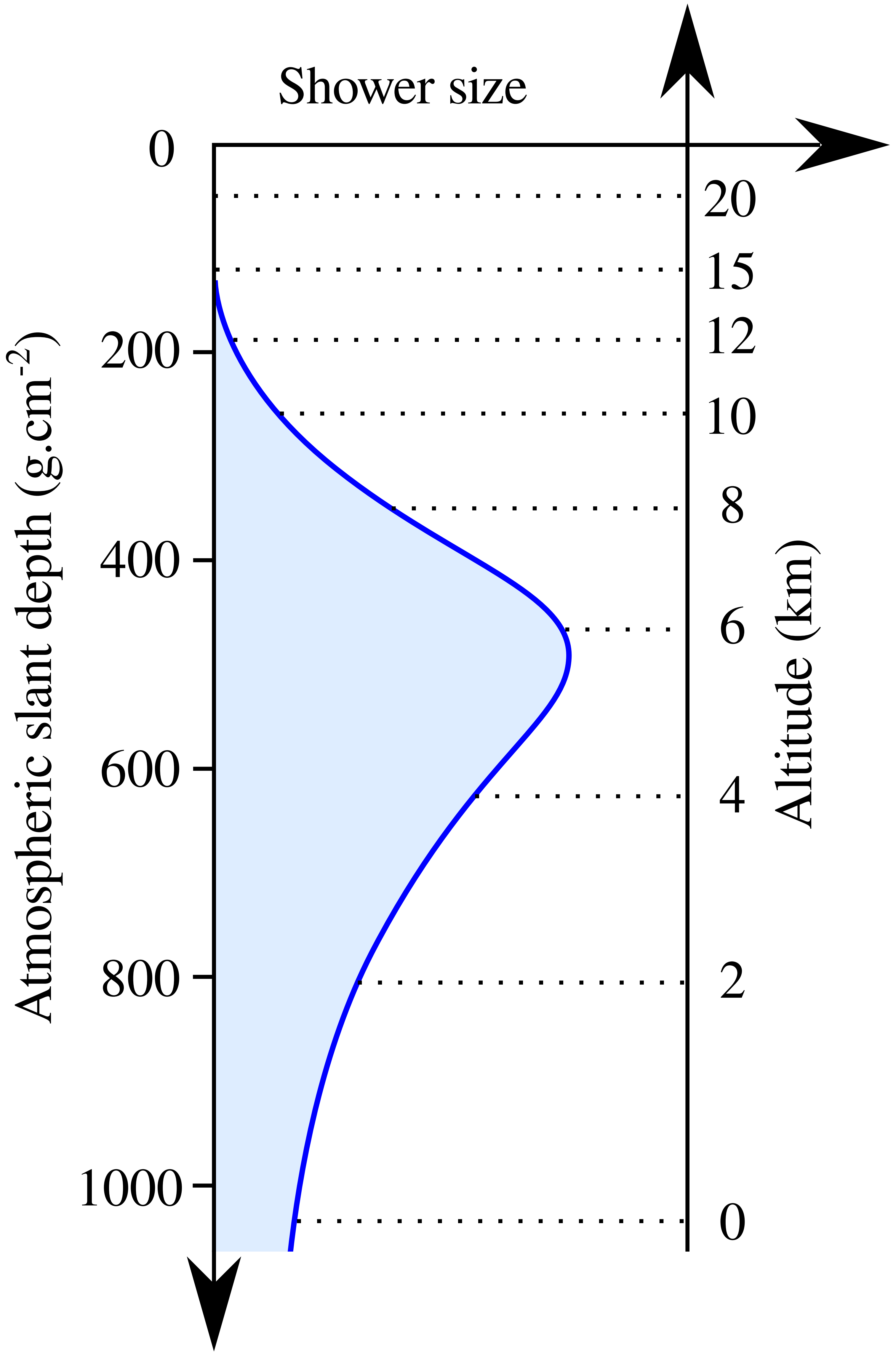
Instrumentation for γ-ray astronomy



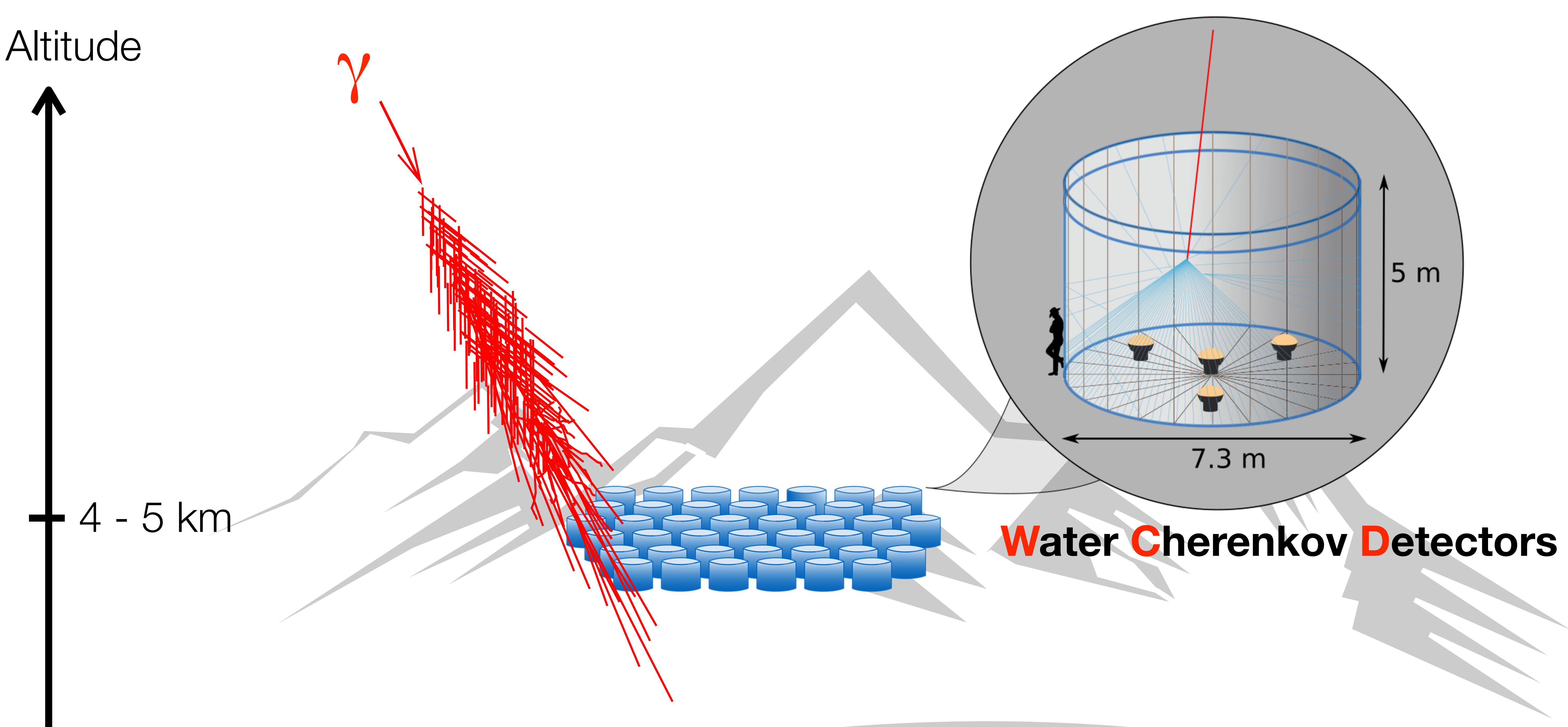


Instrumentation for γ-ray astronomy



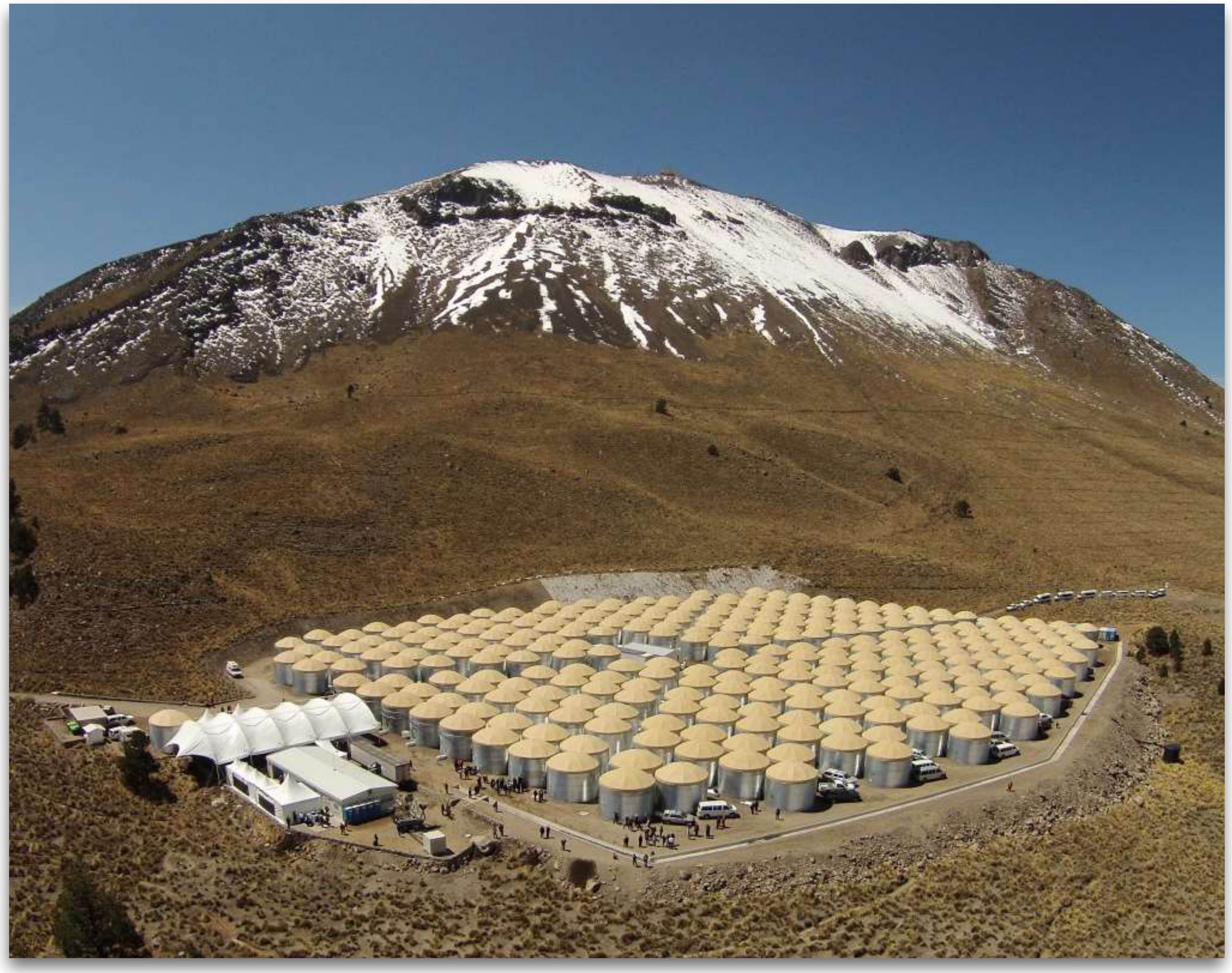


Instrumentation for γ-ray astronomy



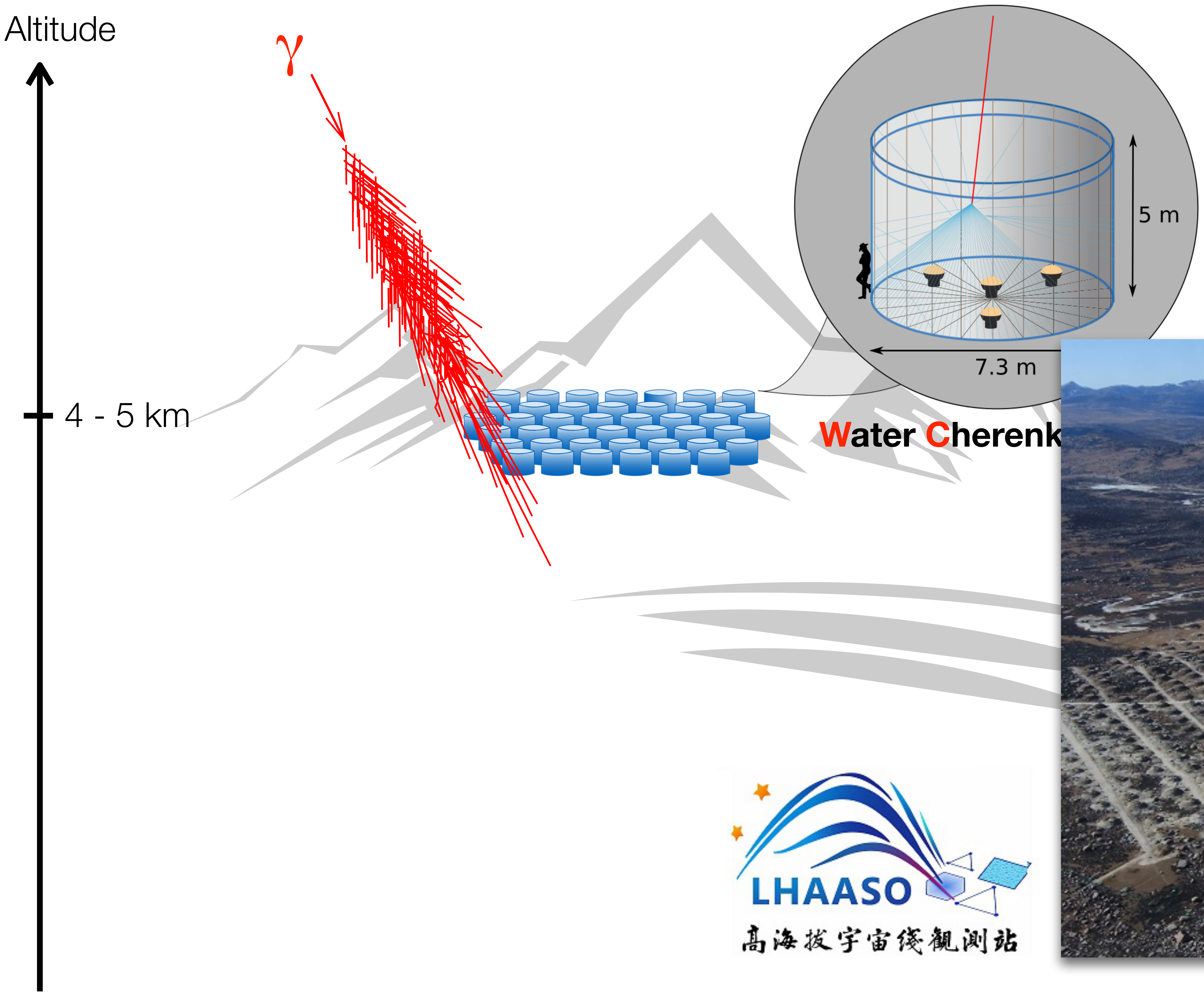
Altitude : 4100 m, latitude : 19N
300 light tight tanks with 4 PMTs
Area : 22000 m^2, 60% coverage
Trigger rate : ~25KHz
Energy range : ~100 GeV - ~100 TeV

HAWC
High Altitude Water Cherenkov
Gamma-Ray Observatory



Credits: HAWC collaboration

Instrumentation for γ-ray astronomy

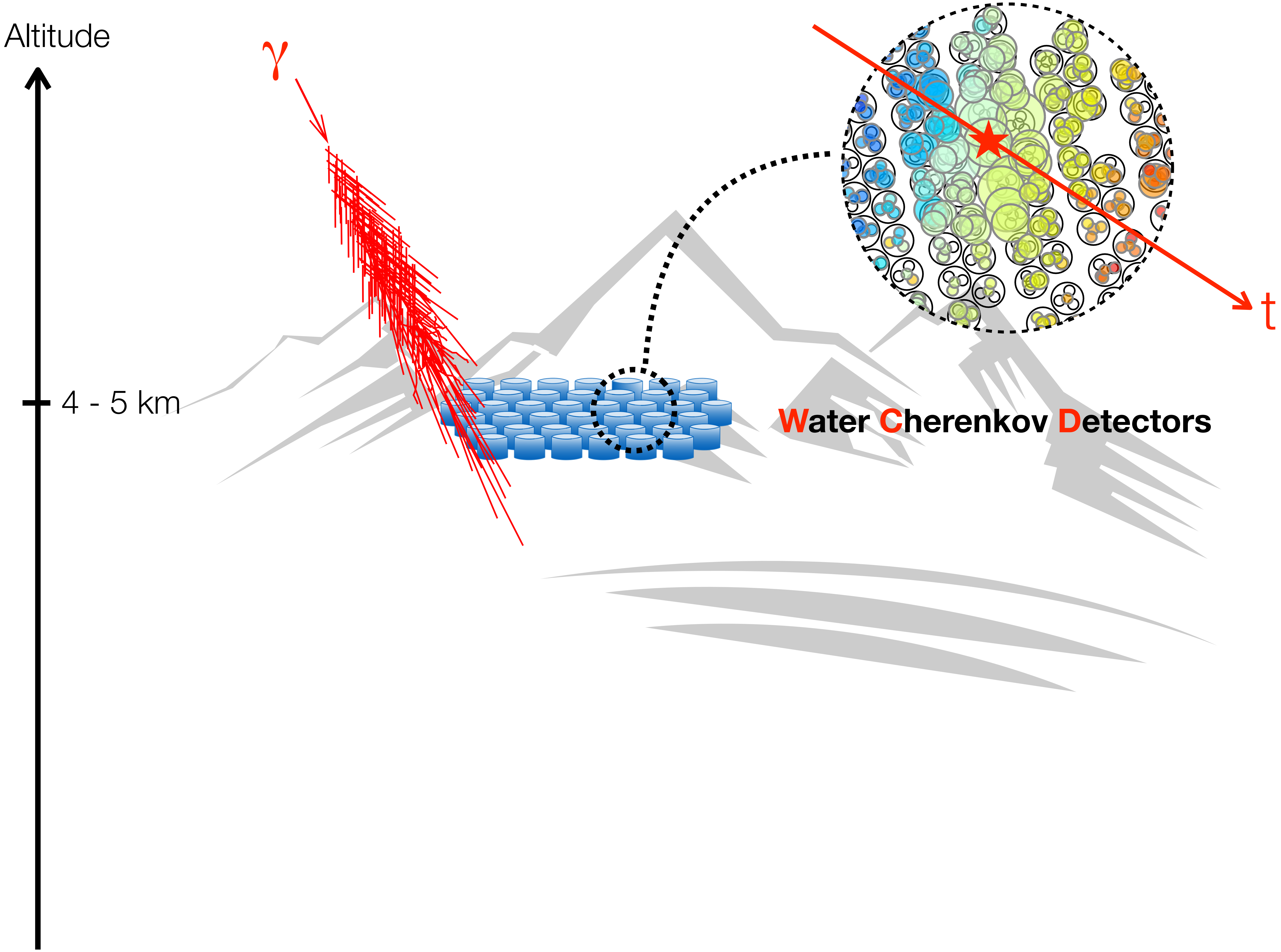


Altitude : 4400 m, Latitude : 29N
WCDA : Area : 78 000 m^2, 100% coverage
Energy range : ~100 GeV - ~20 TeV
Trigger rate : ~45 kHz
KM2A : scintillators + WCD
Area : 1 km^2
Energy range : ~20 TeV - a few PeV
Trigger rate : ~900 Hz

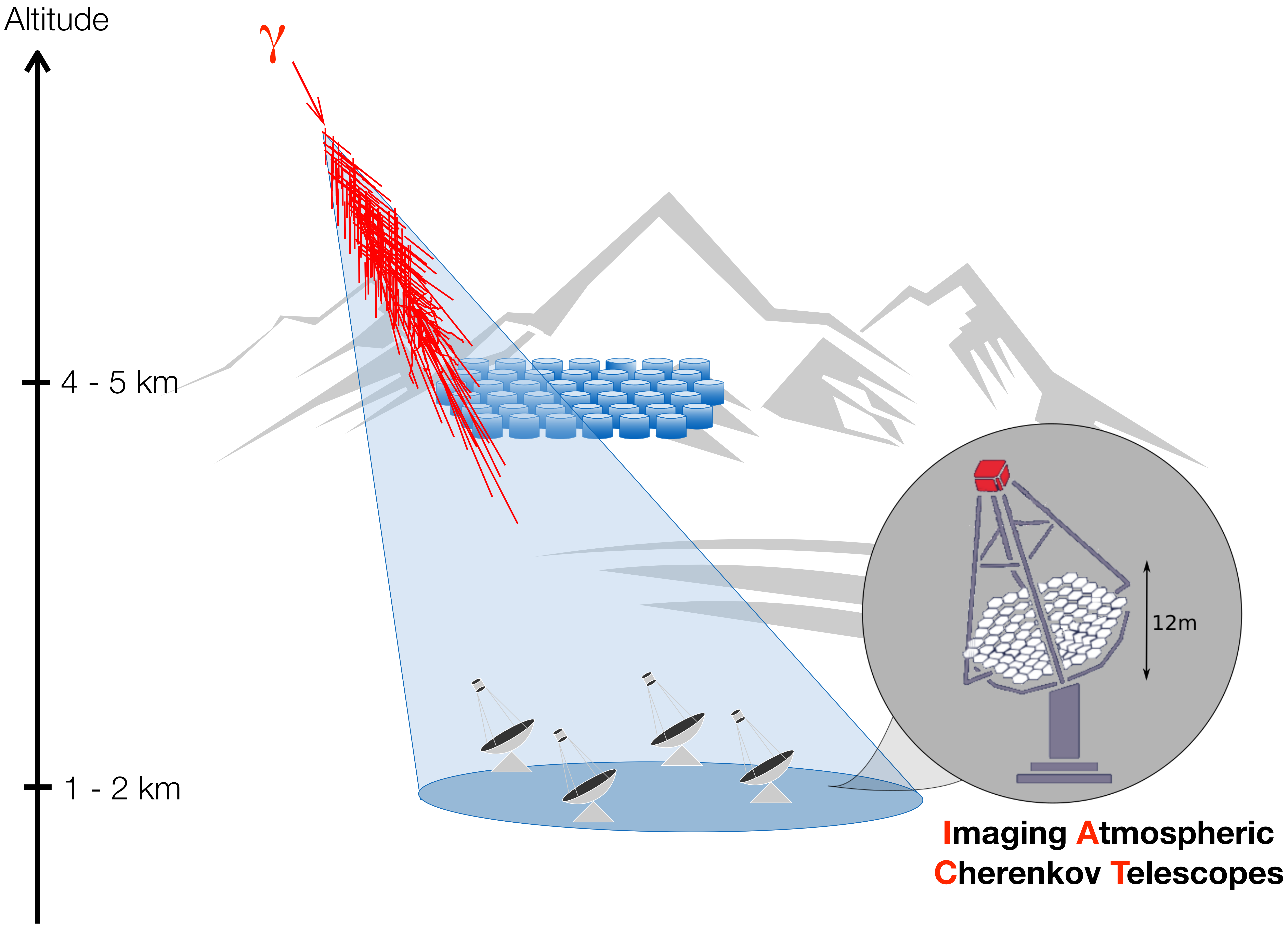
LHAASO
高海拔宇宙线观测站

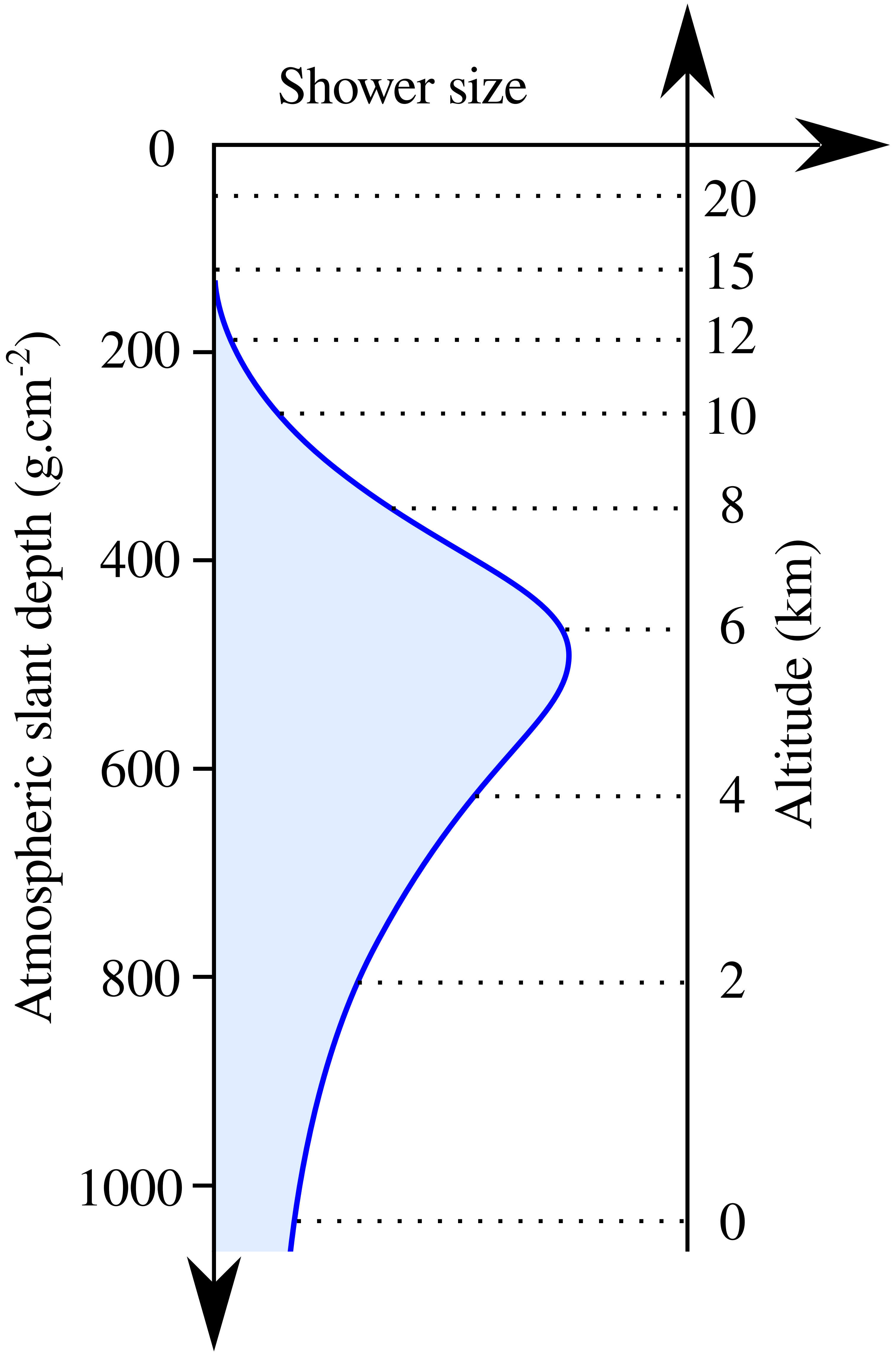
The LHAASO collaboration

Instrumentation for γ-ray astronomy

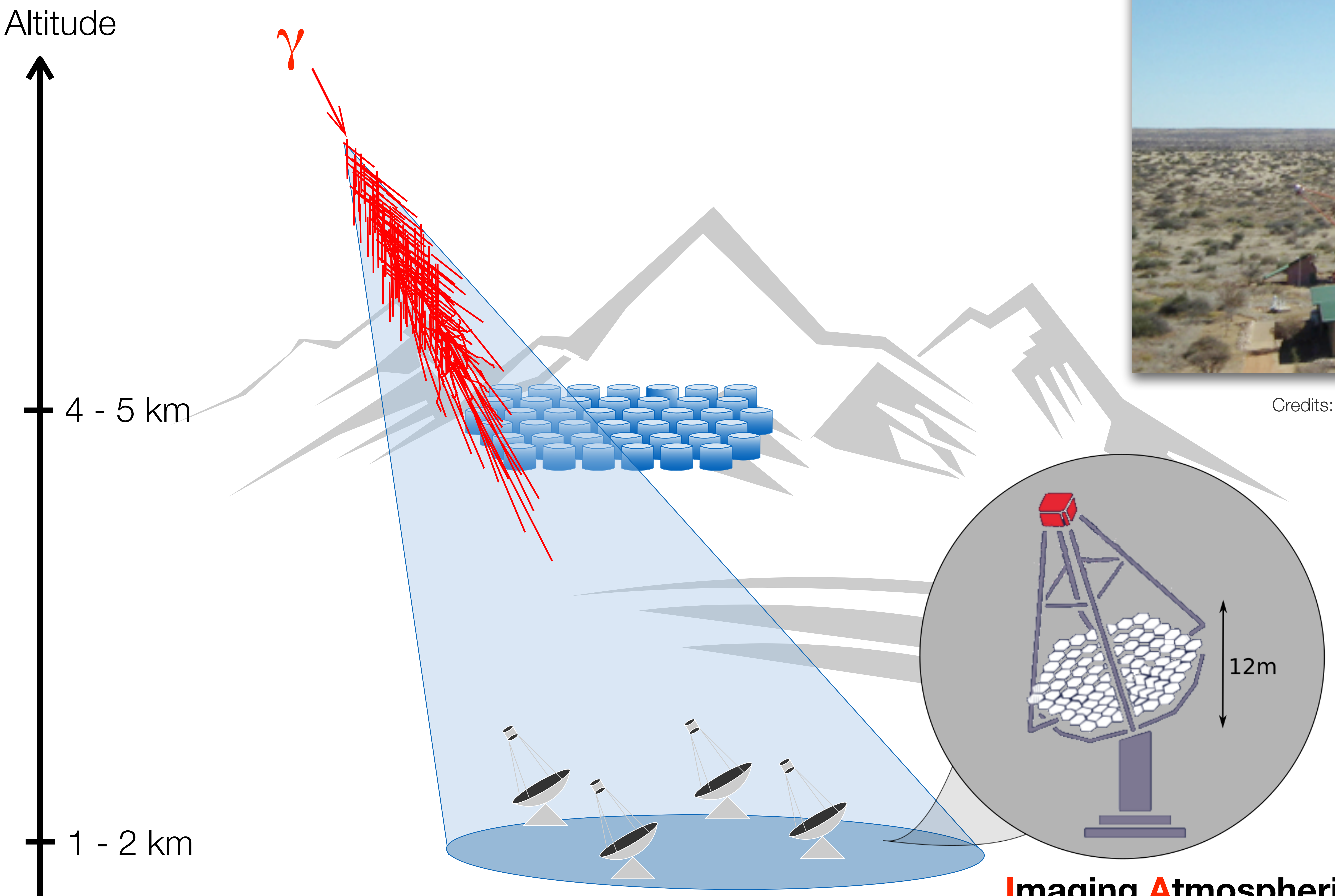


Instrumentation for γ-ray astronomy





Instrumentation for γ-ray astronomy



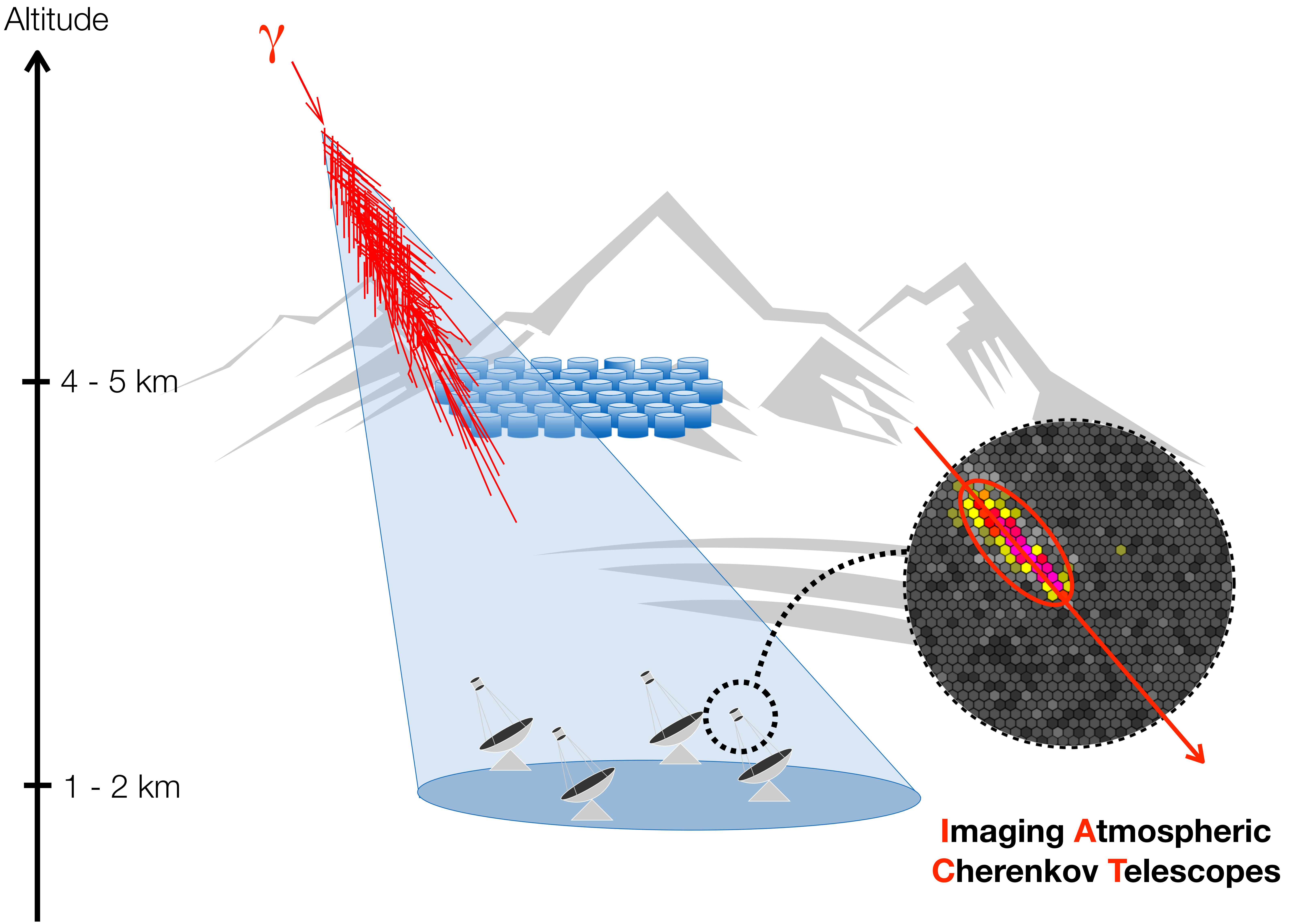
Imaging Atmospheric Cherenkov Telescopes

Credits: HESS collaboration

Credits: CERN Courrier, 2005

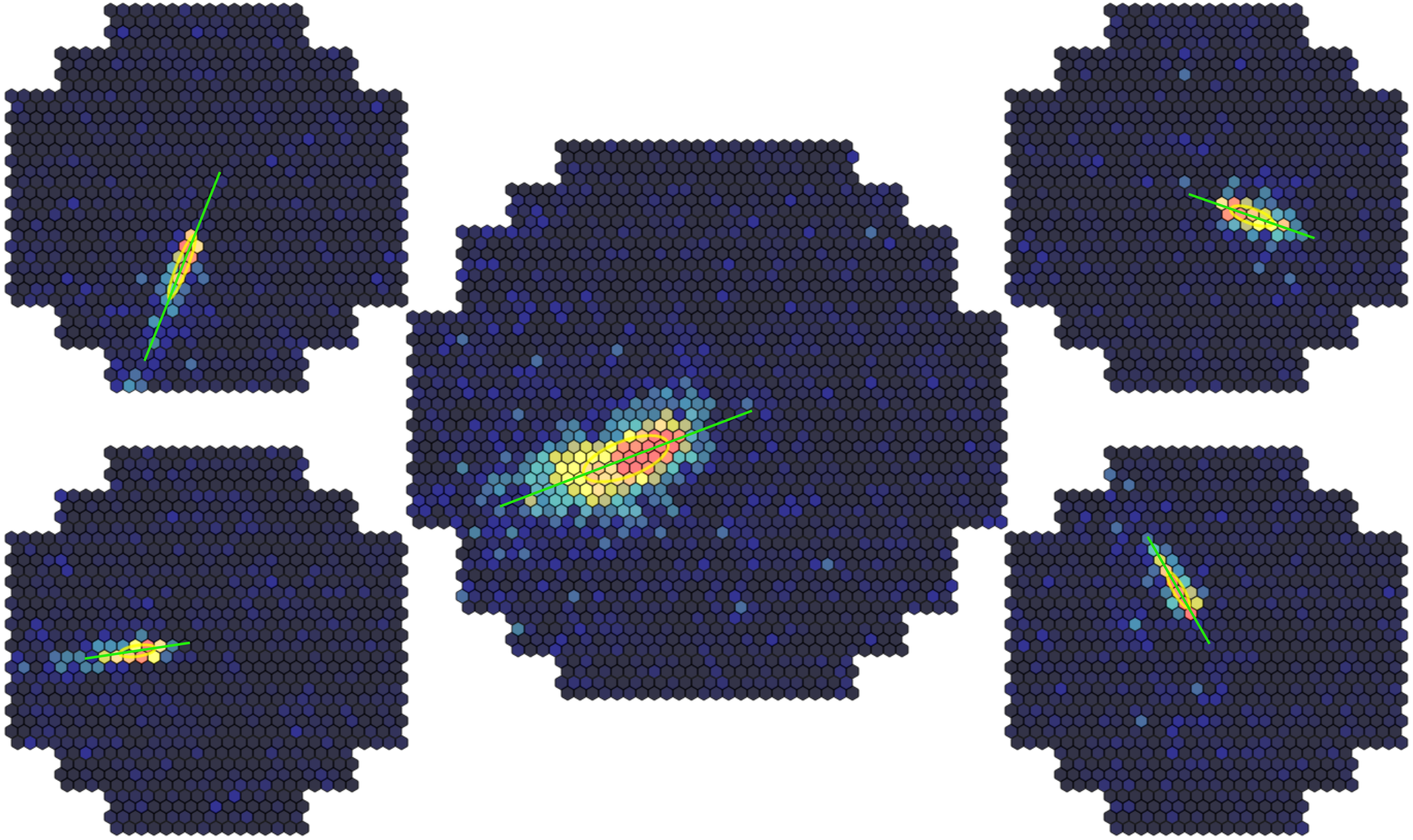
Altitude : 1800 m, Latitude : 23S
Area : 120 x 120 m
Trigger rate : ~400 Hz (CT1-4) / 1 kHz (CT5)
Energy range : ~30 GeV - ~100 TeV

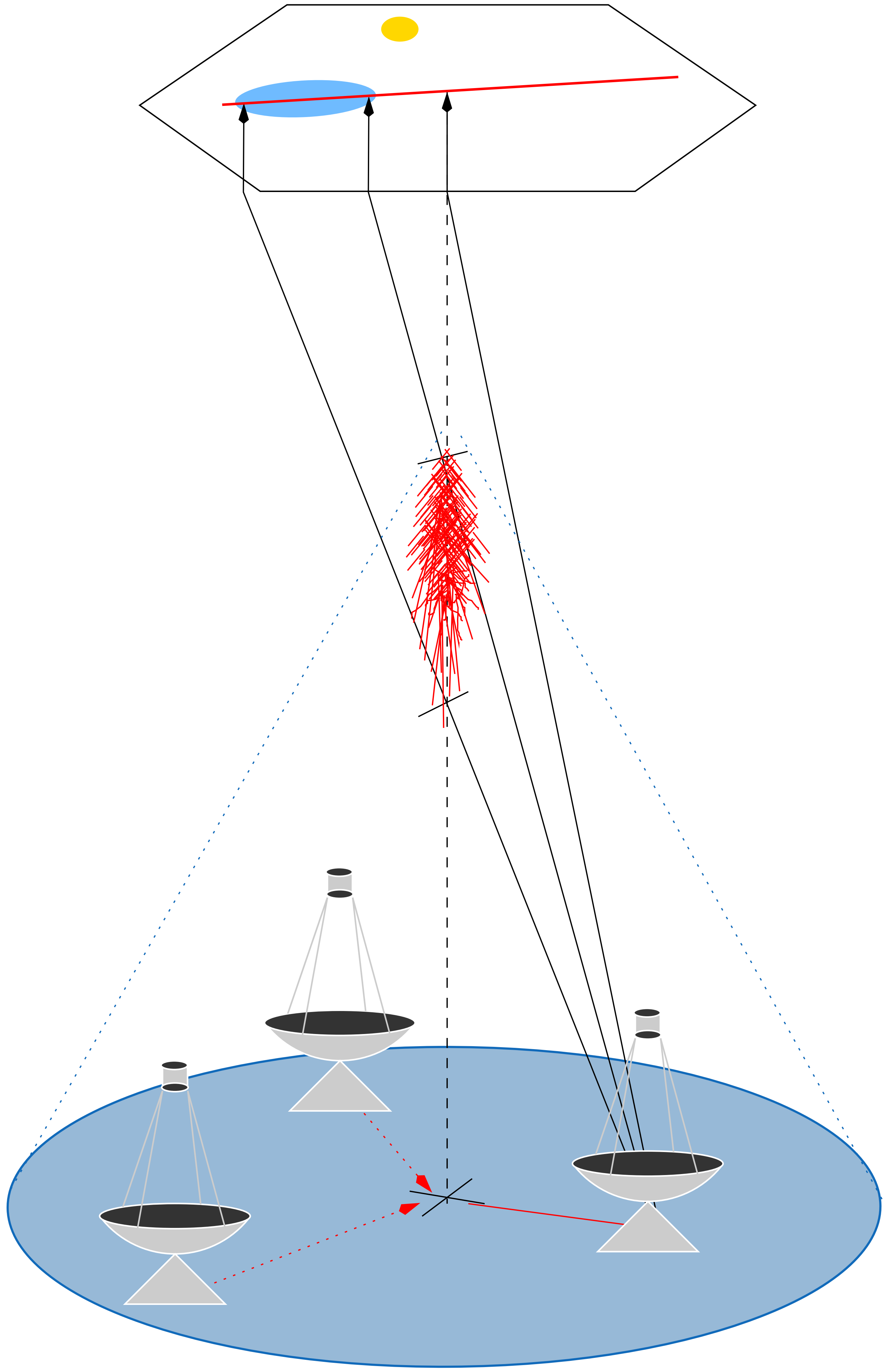
Instrumentation for γ-ray astronomy



Instrumentation for γ-ray astronomy

Simulated 700 GeV γ ray

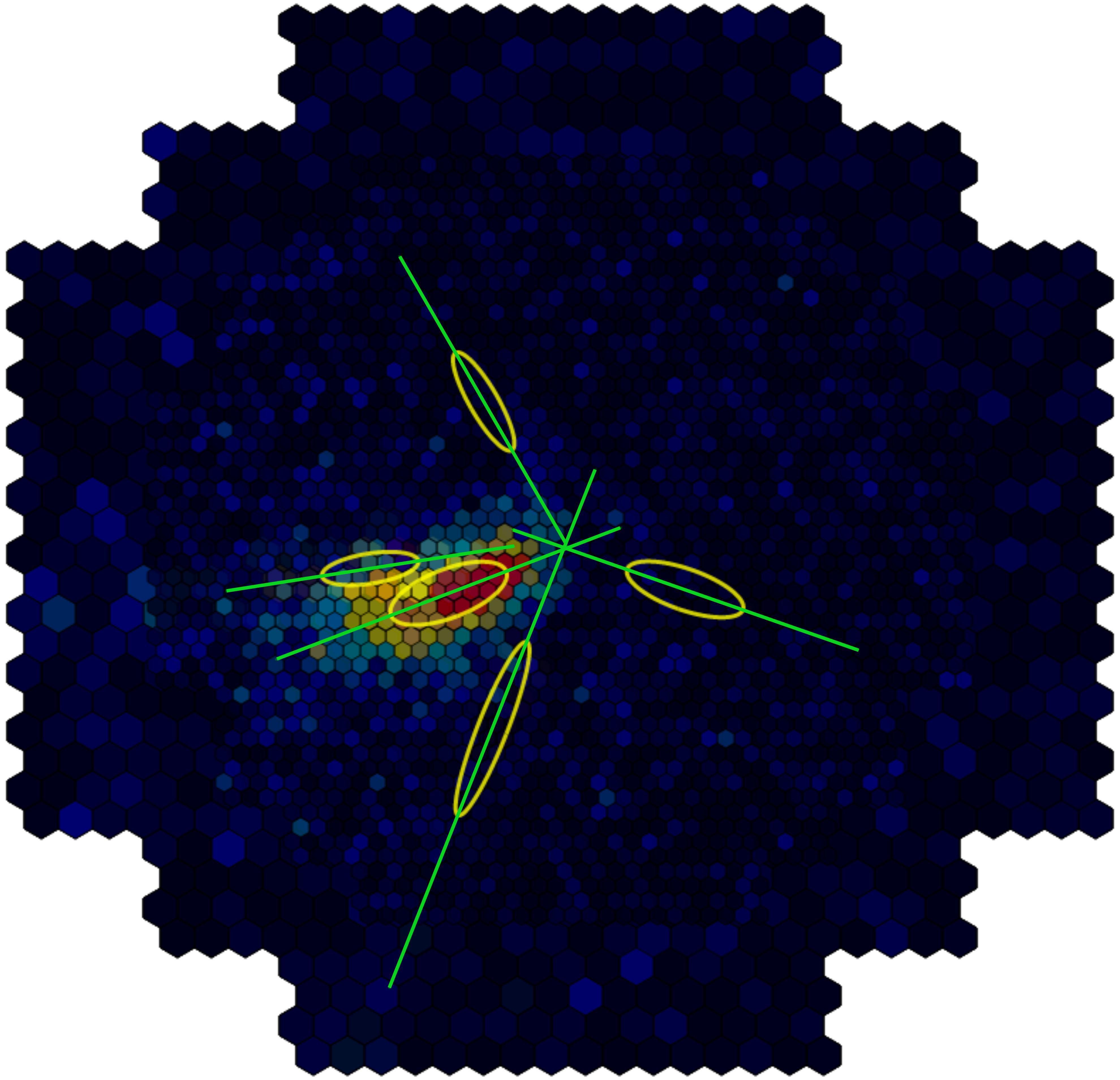


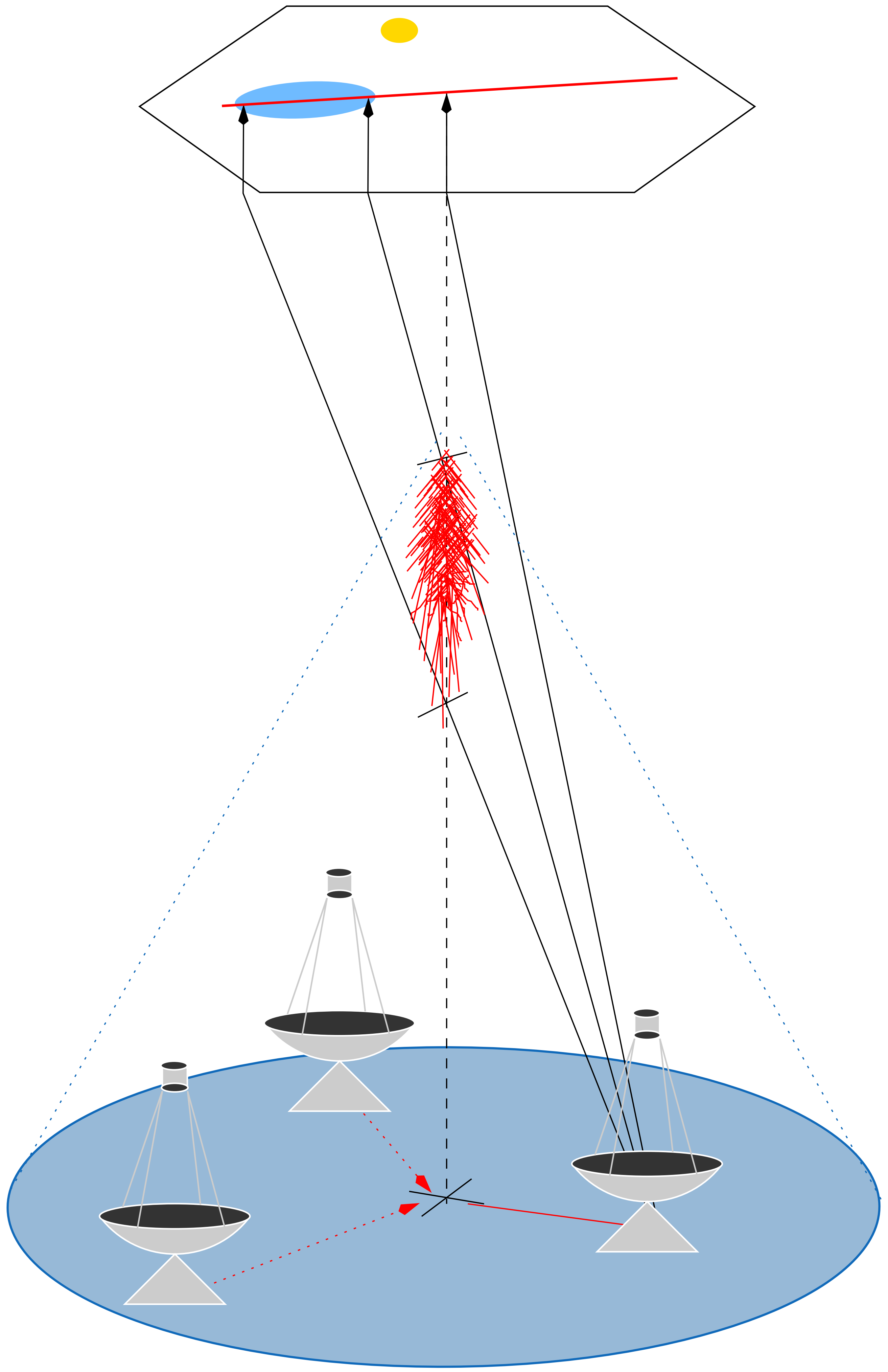


Credits: Ramin Marx and the HESS collaboration

Instrumentation for γ-ray astronomy

Simulated 700 GeV γ ray





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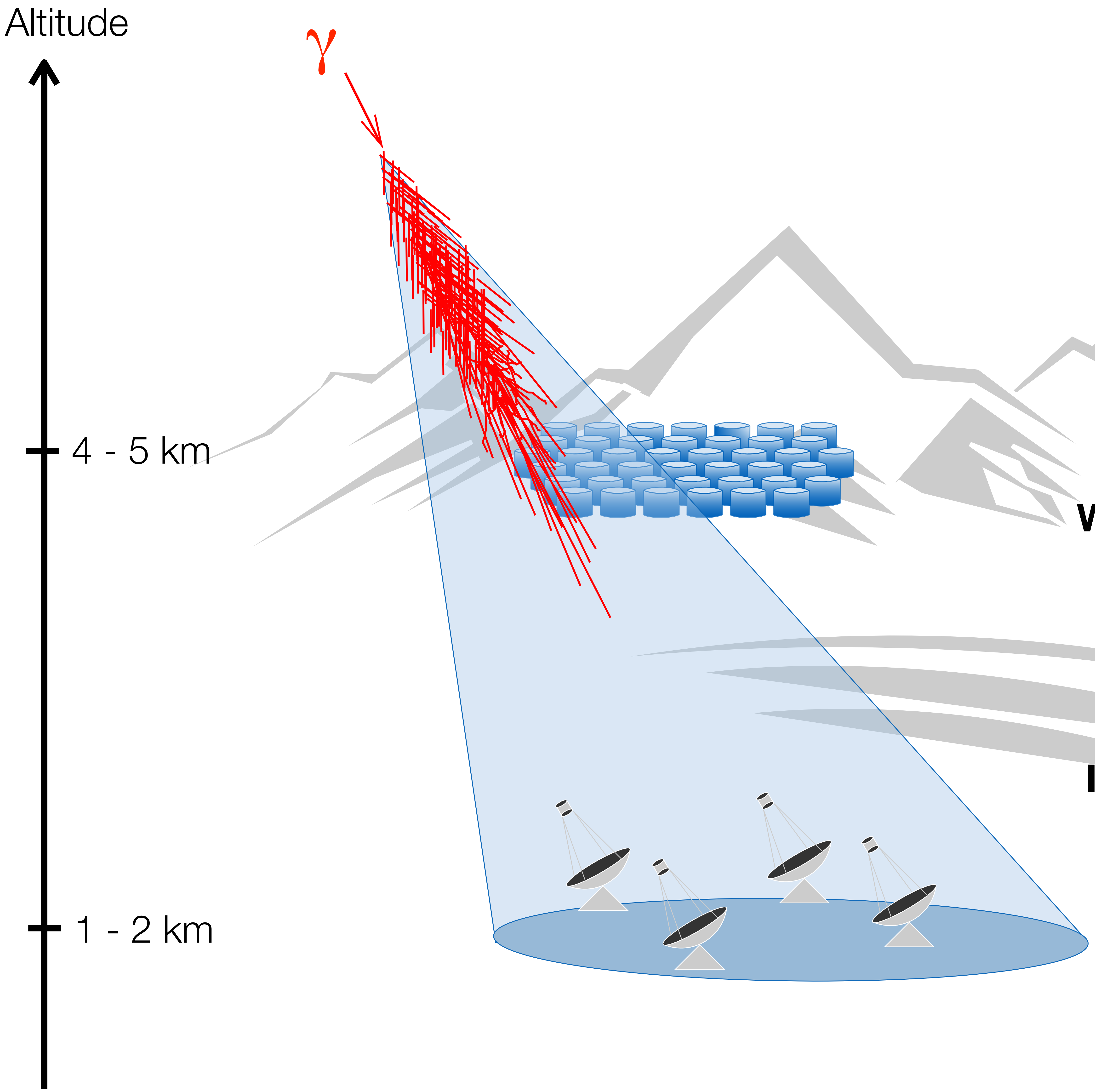
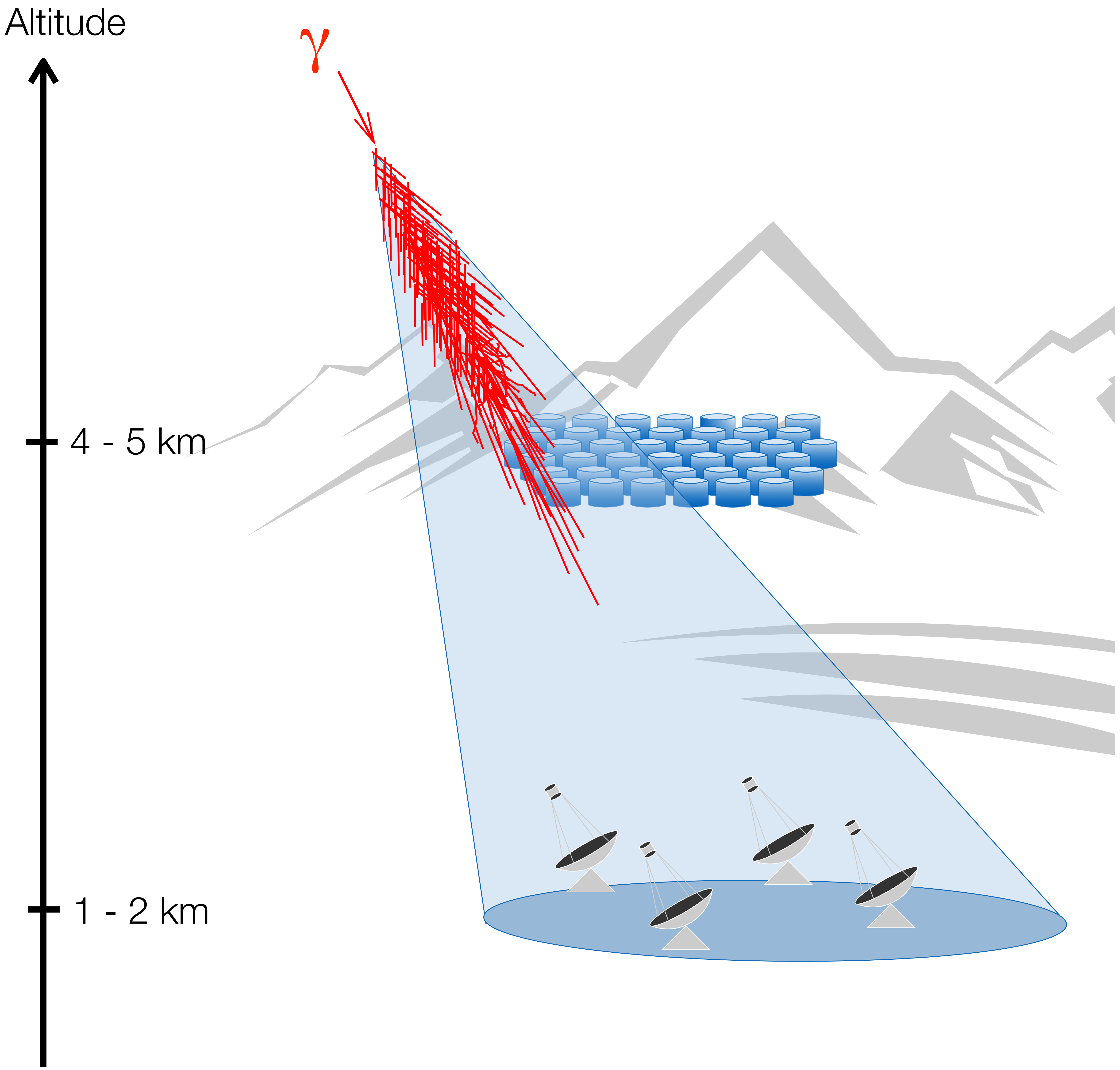
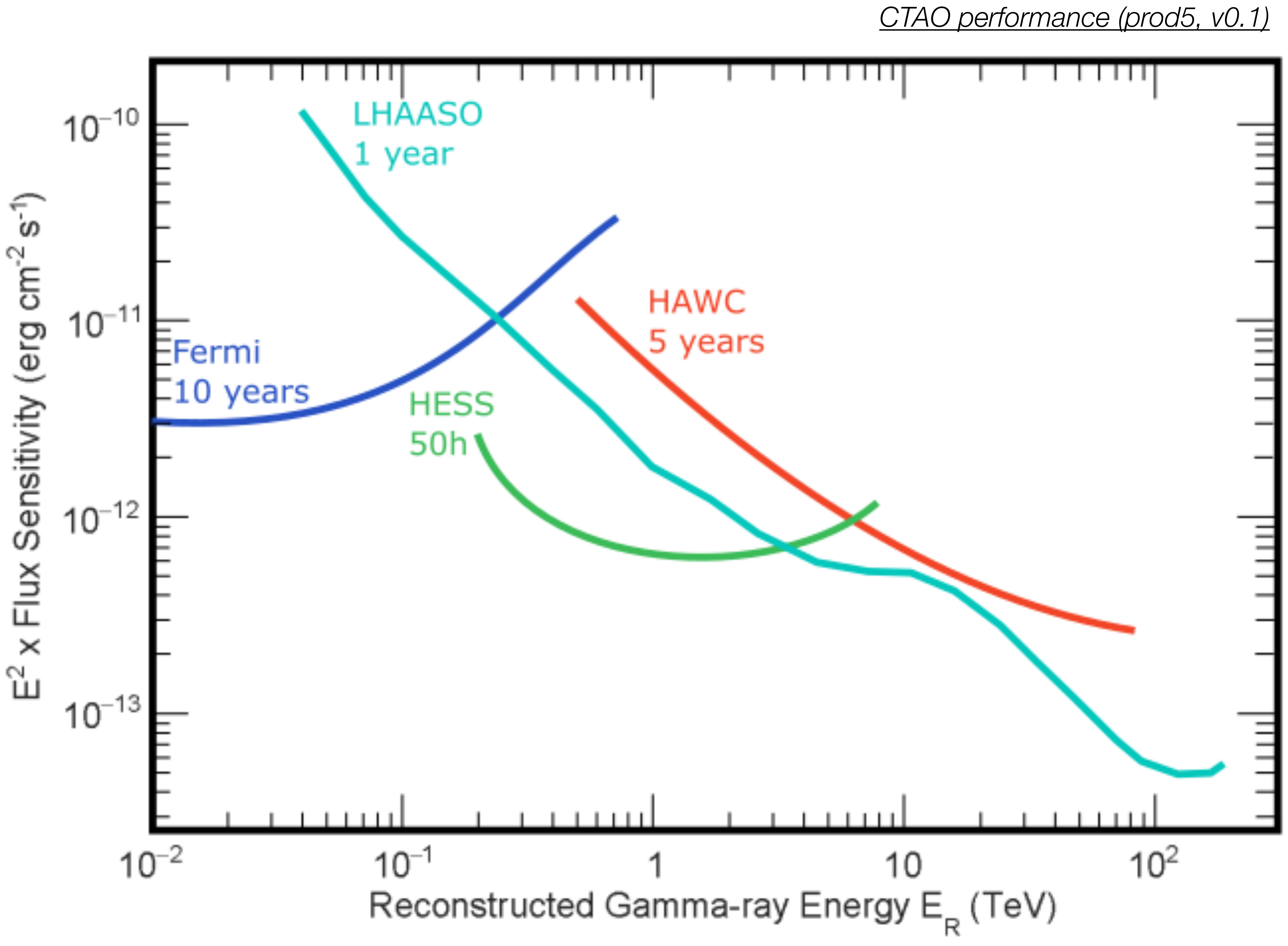
Instrumentation for γ-ray astronomy



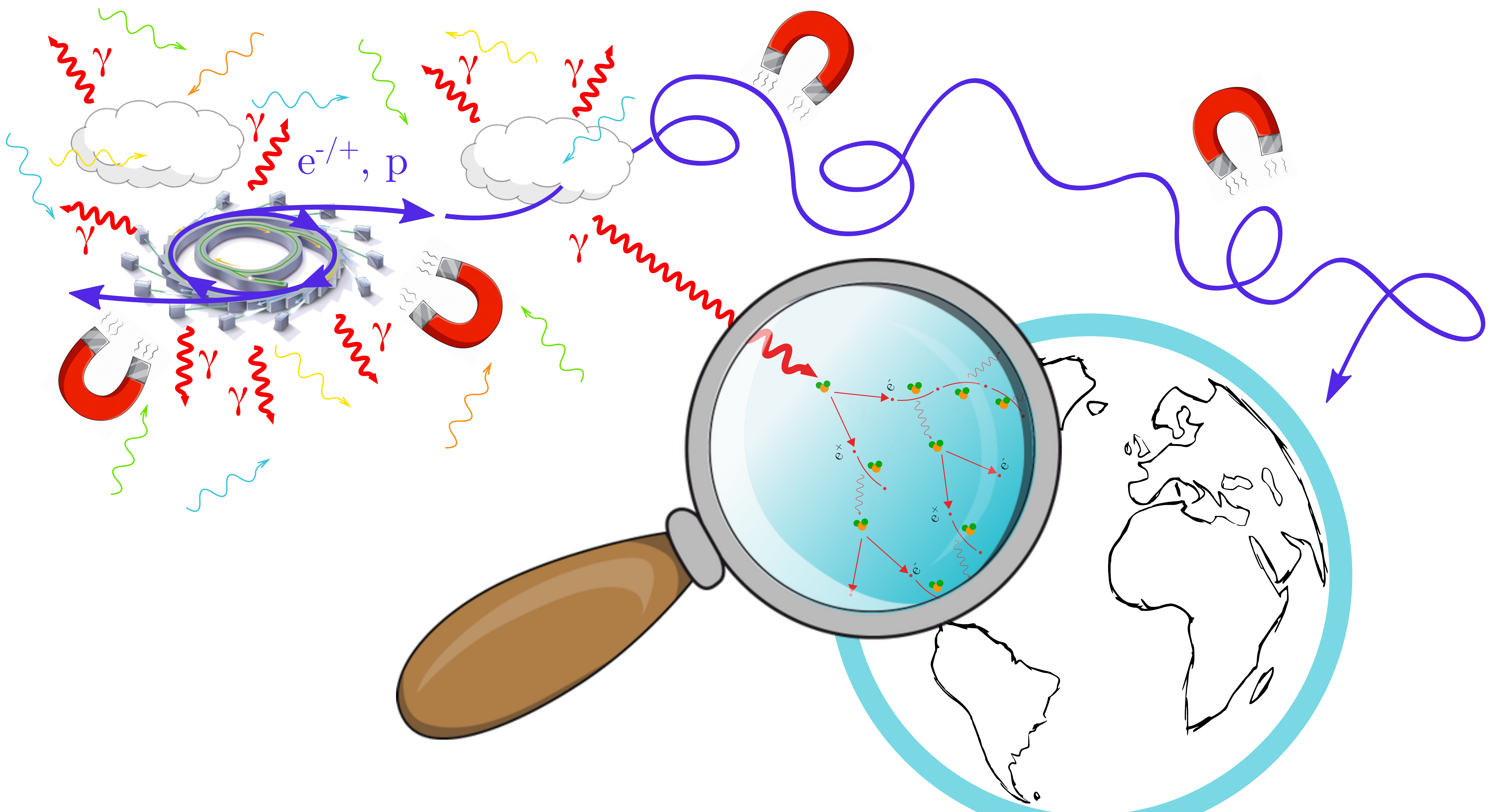
	Duty cycle	Field of view	Energy range	Energy resolution	Angular resolution
WCD (HAWC)	✓ ~95%	✓ 90°	✓ 0.5 - 100 TeV	✗ 20% at 1 TeV 10% at 100 TeV (on-array events)	✗ 0.8 - 0.1°
IACT (HESS)	✗ ~10% ~1000 h/y	✗ 5°	✓ 0.03 - 100 TeV	✓ < 10% for E > 1 TeV	✓ 0.1 - 0.05°

Instrumentation for γ-ray astronomy





γ-hadron separation



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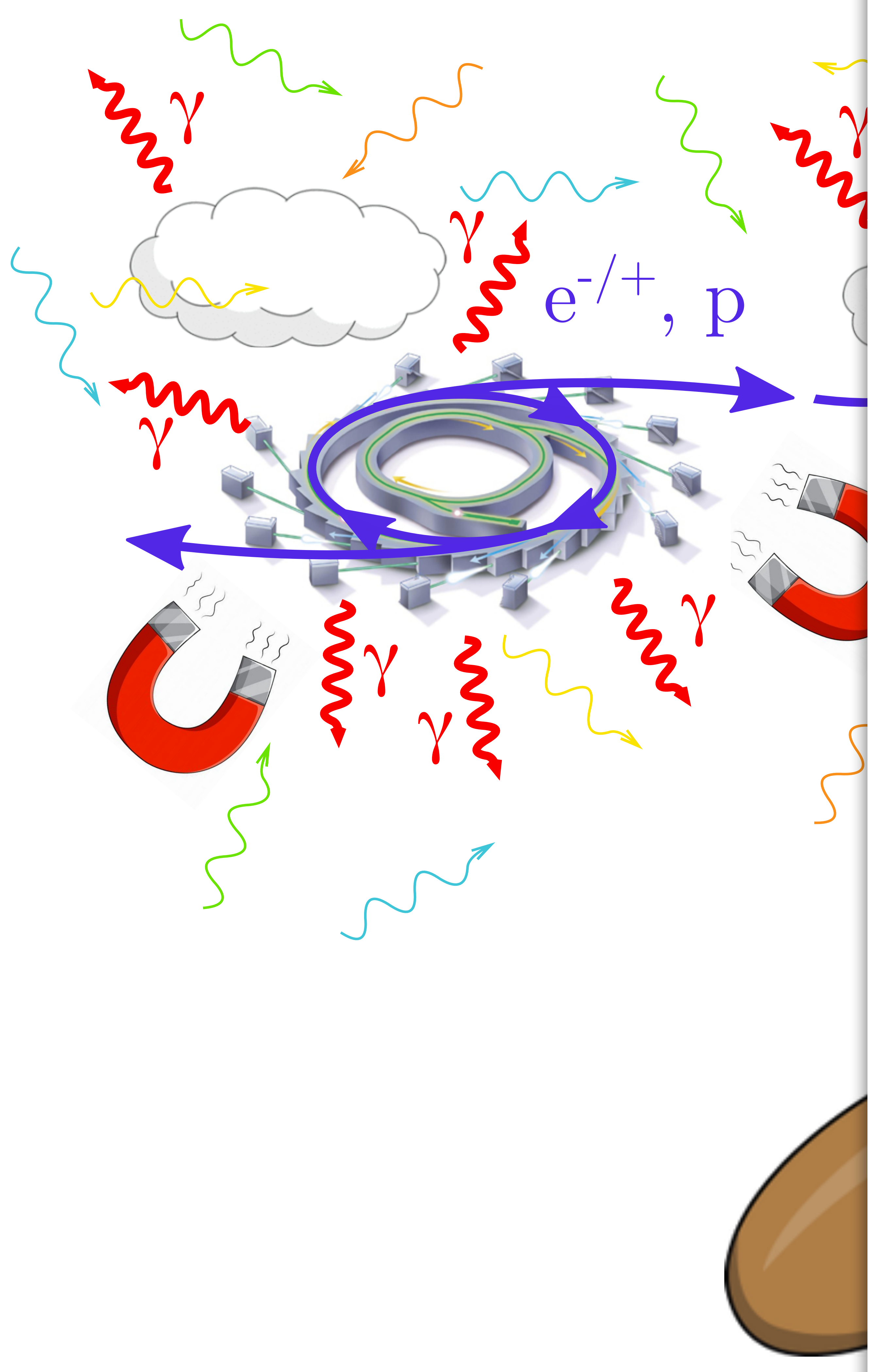

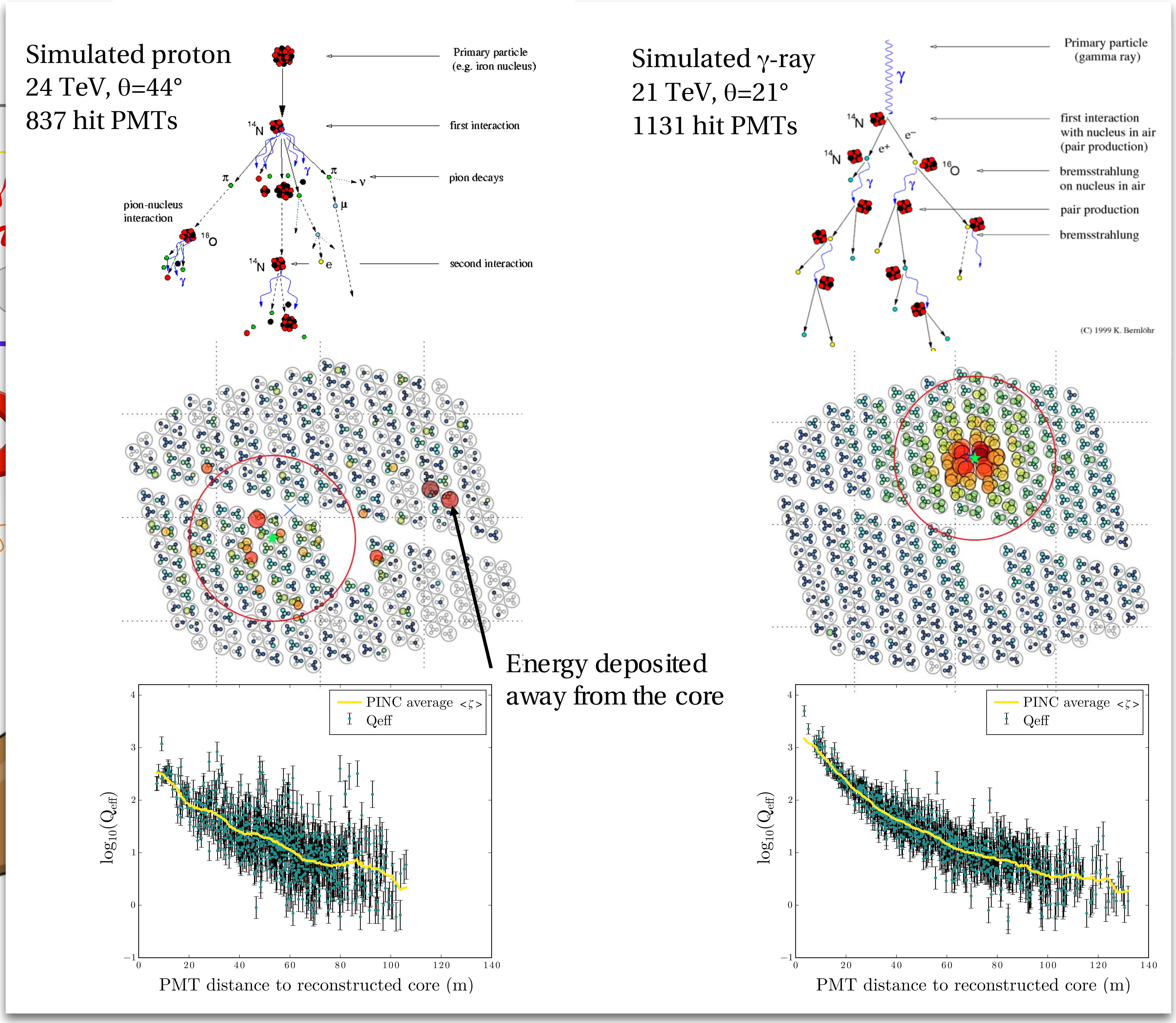

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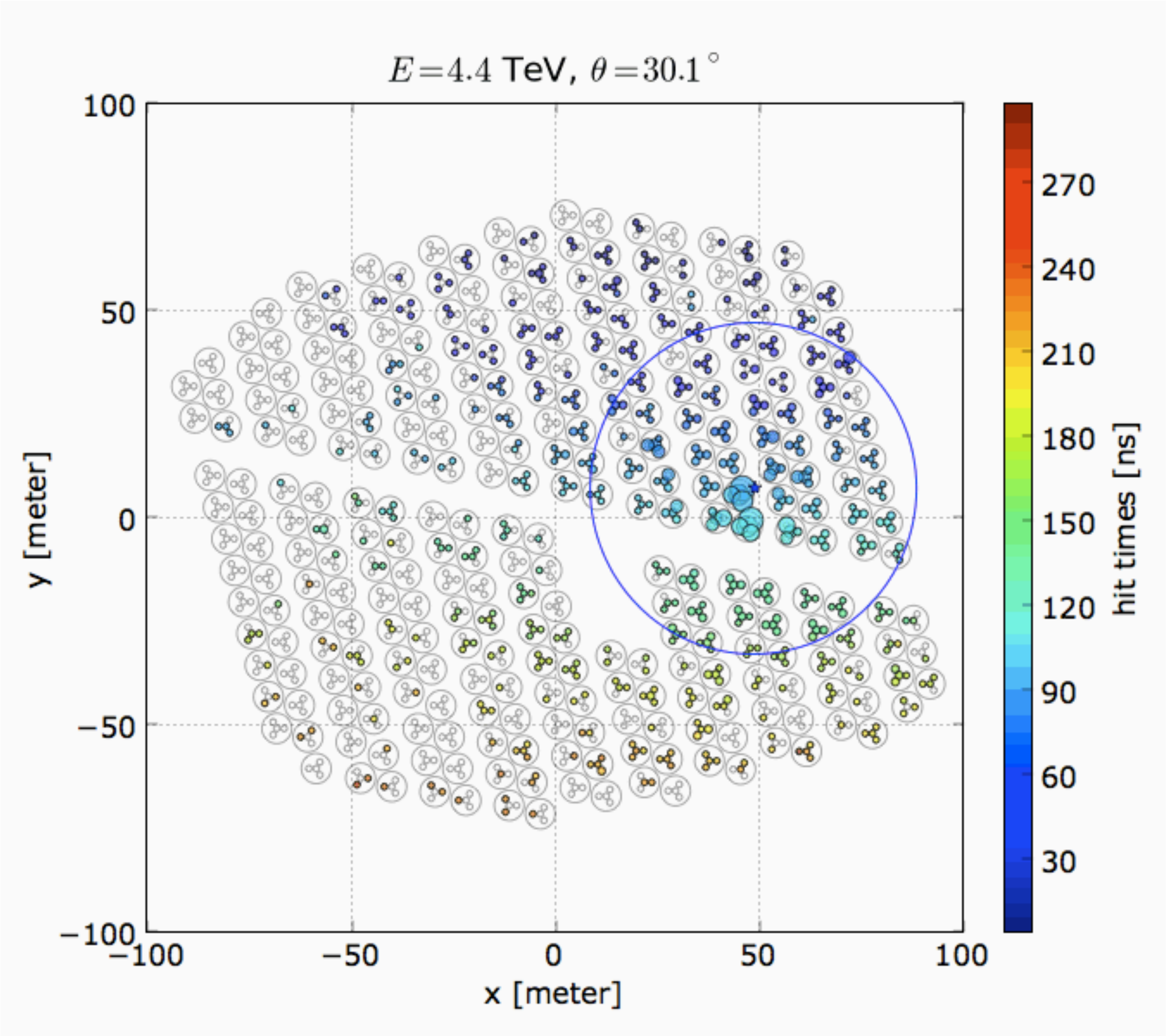

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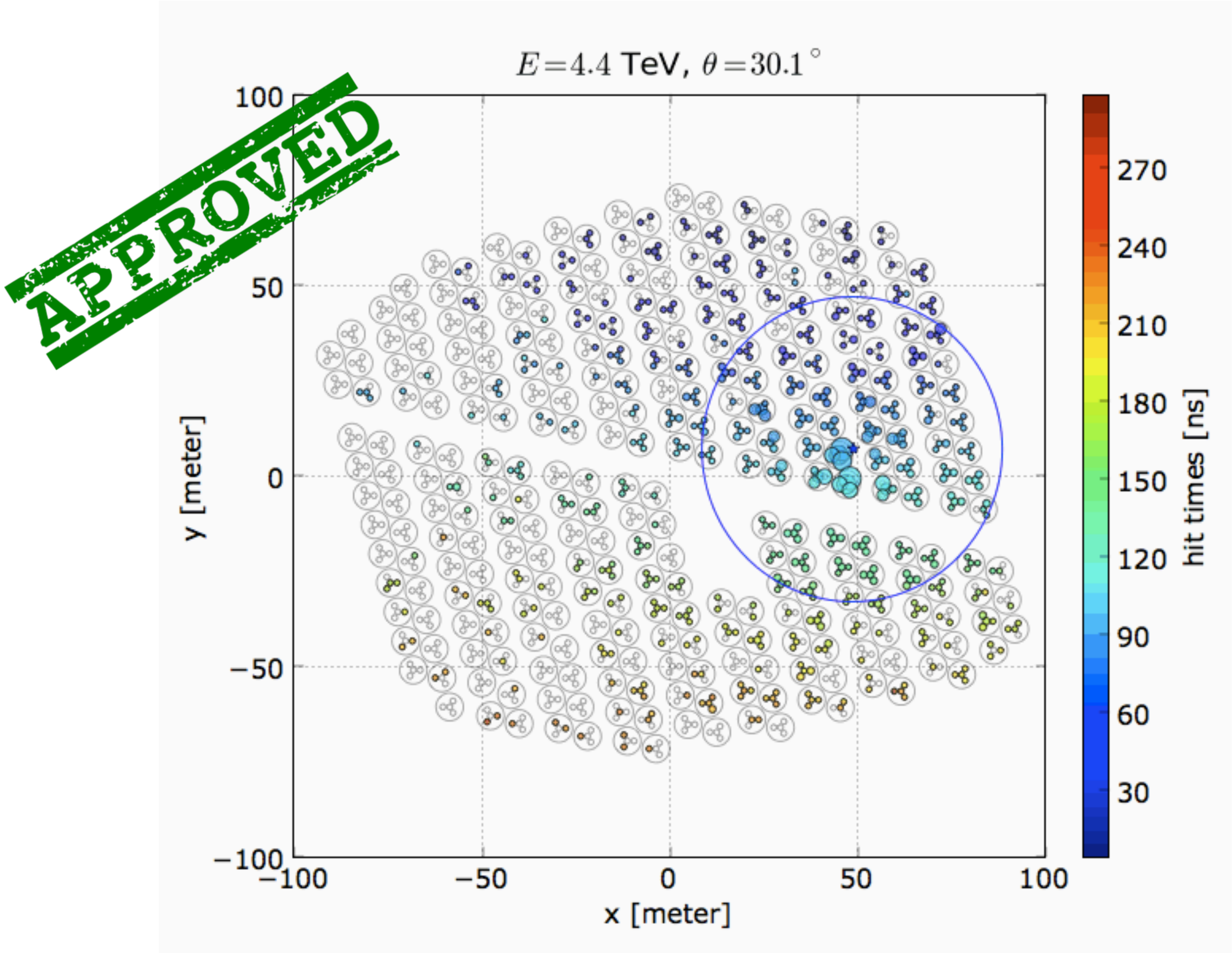

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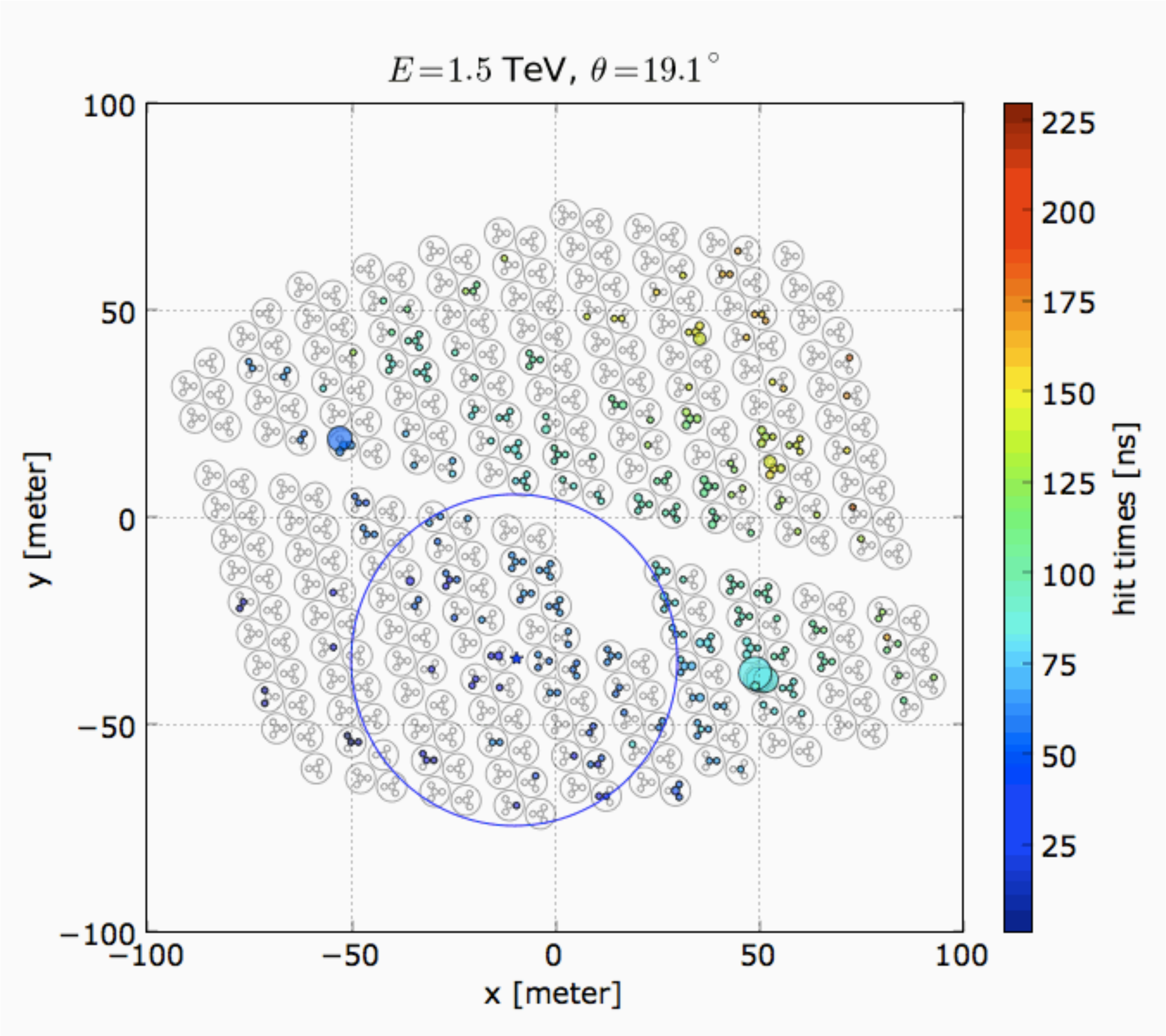

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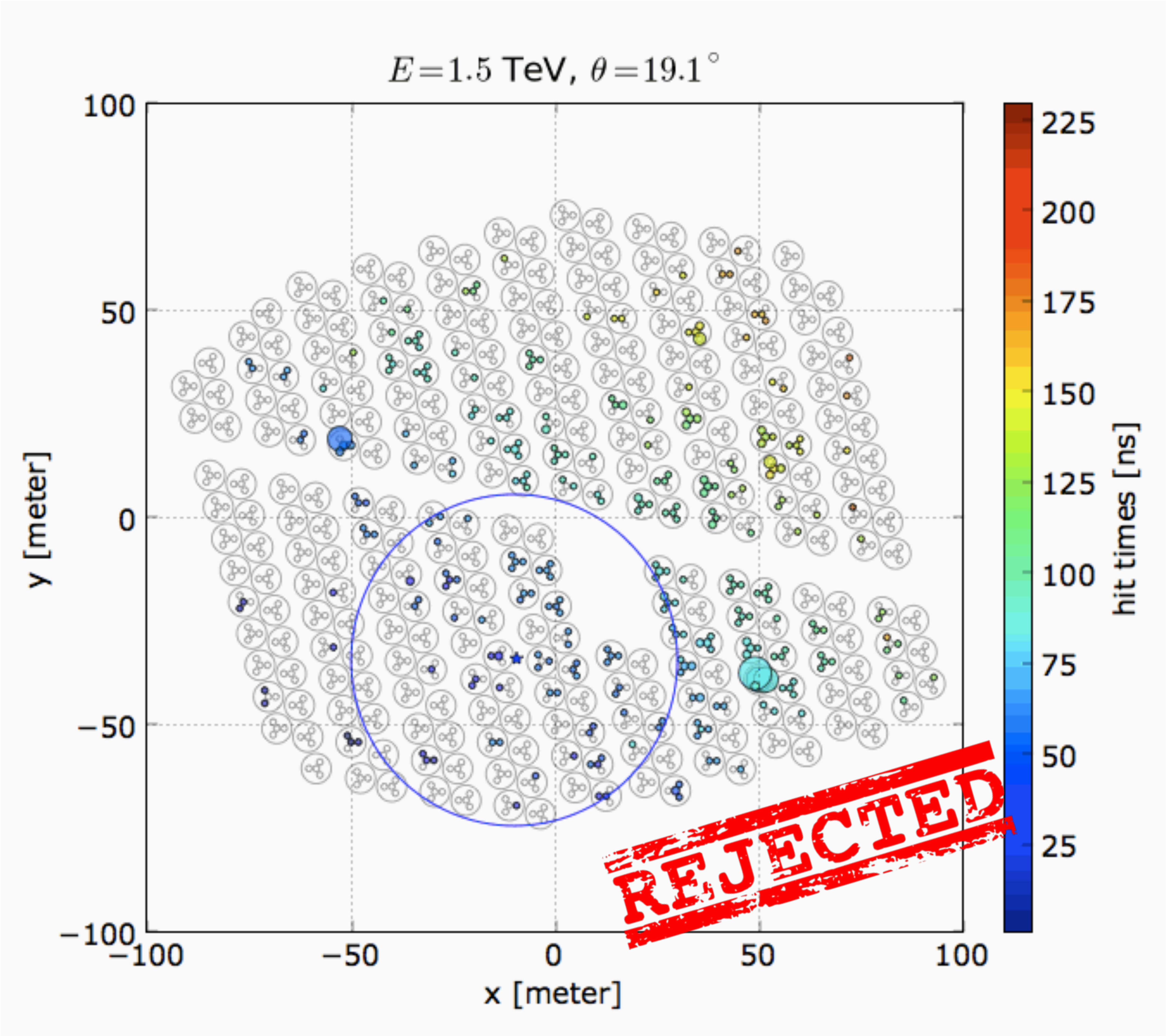

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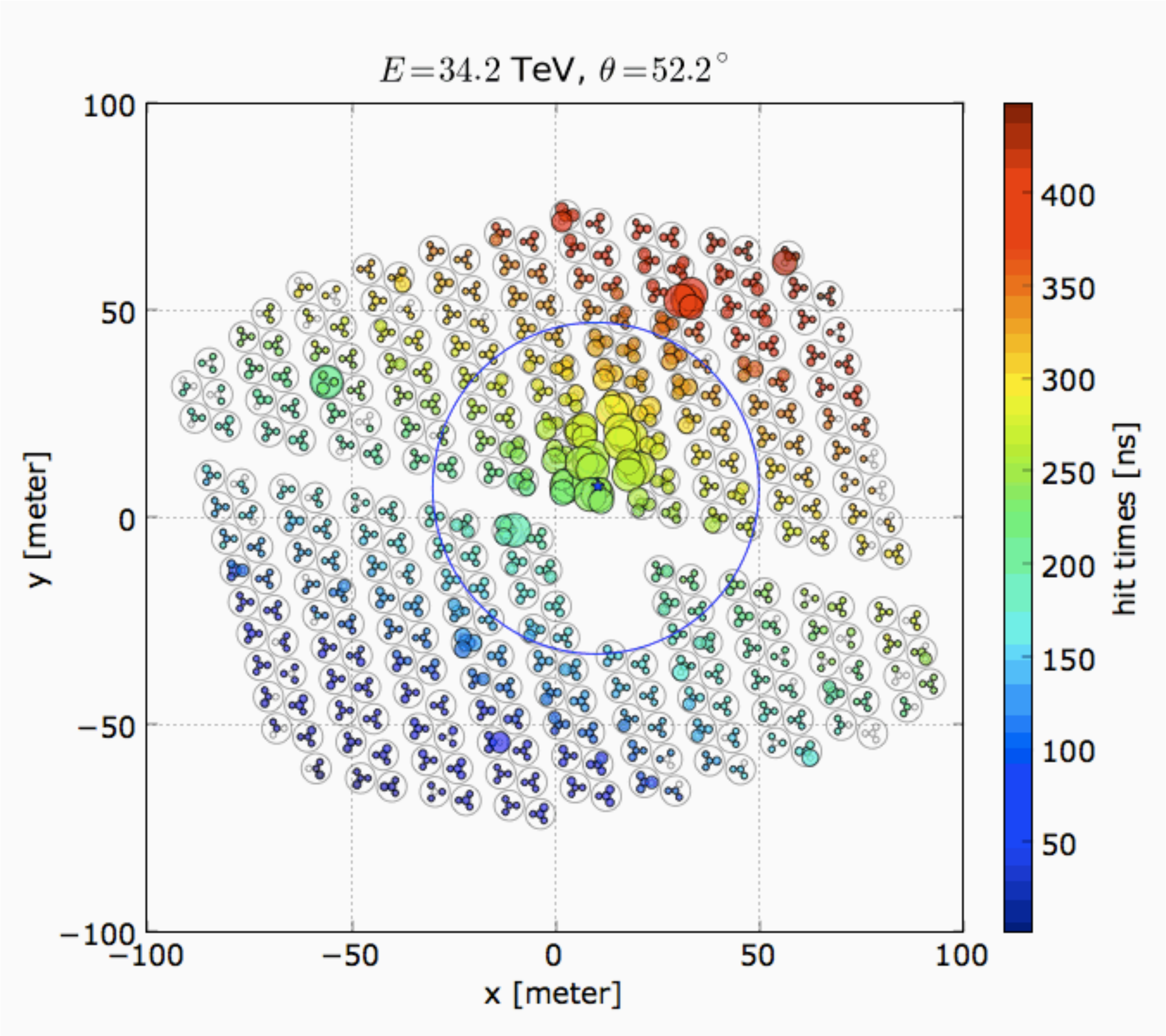

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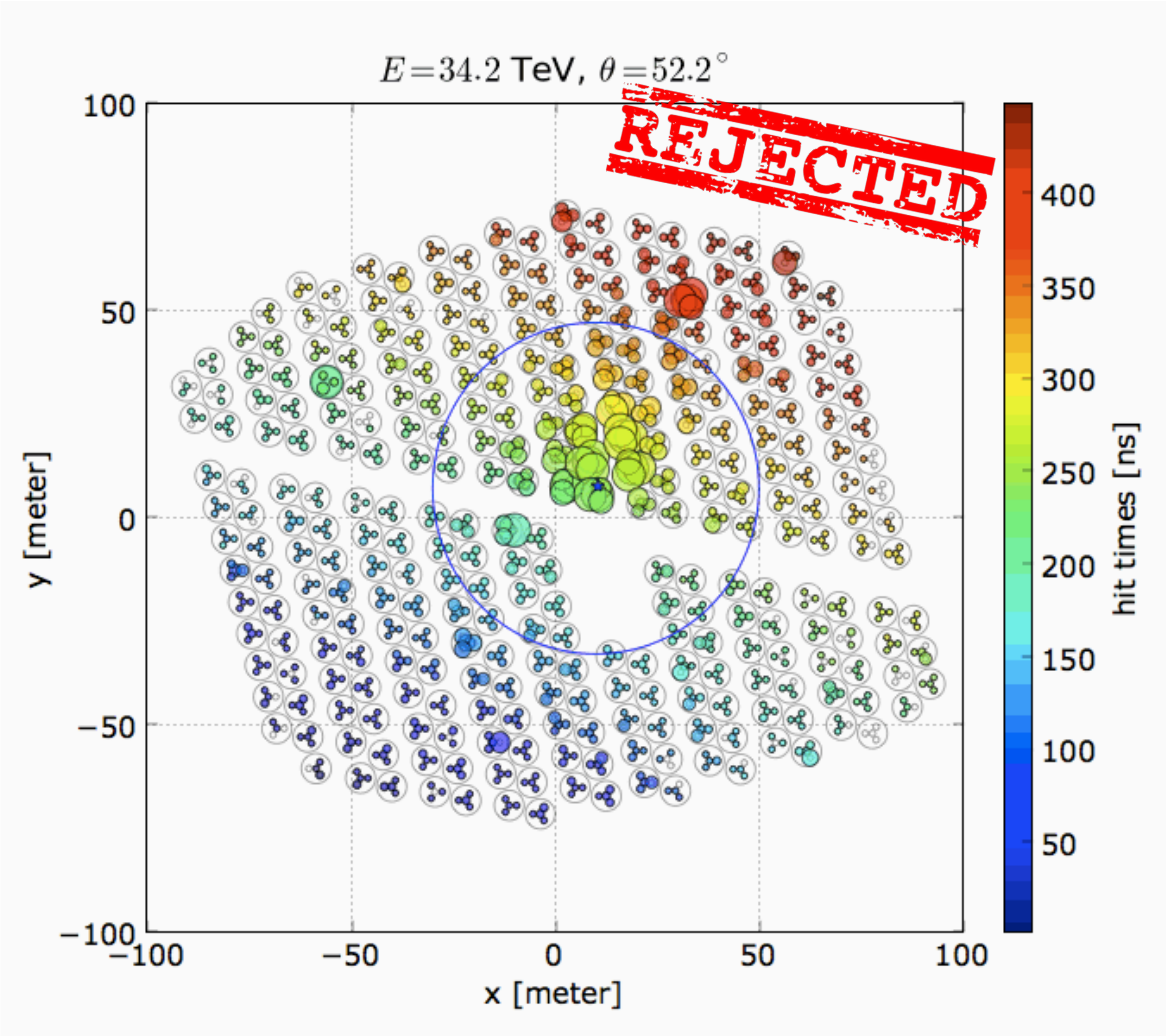

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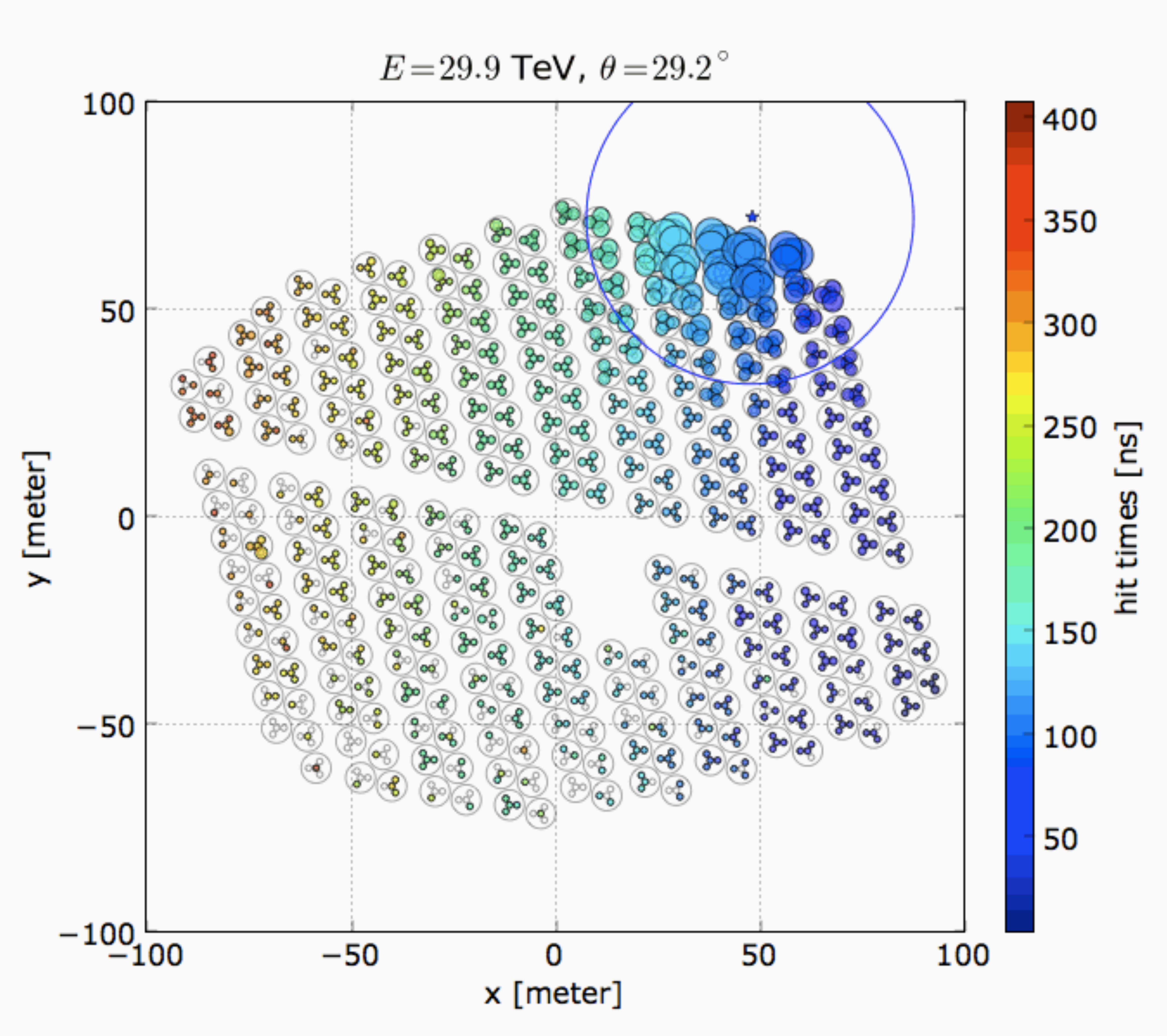

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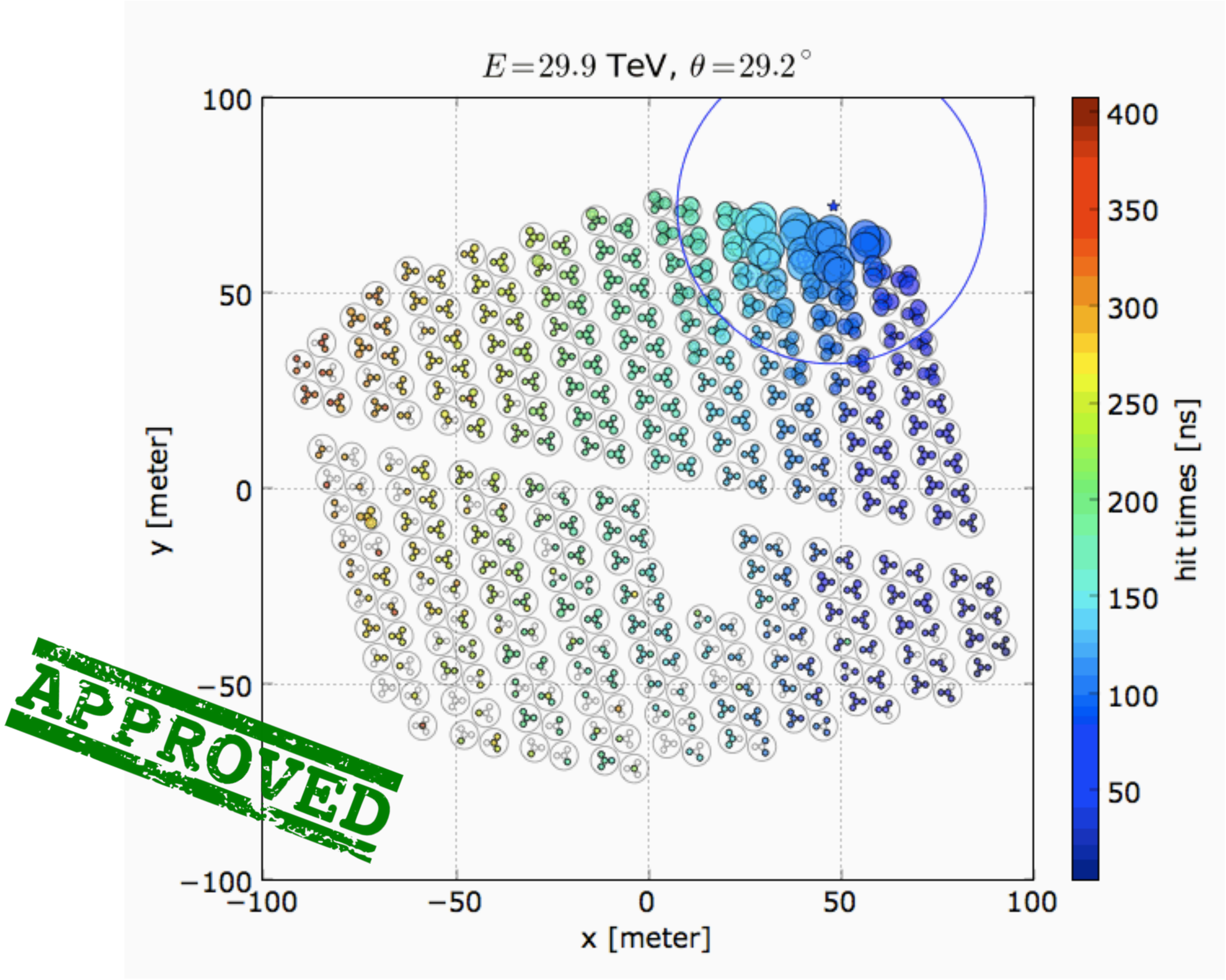

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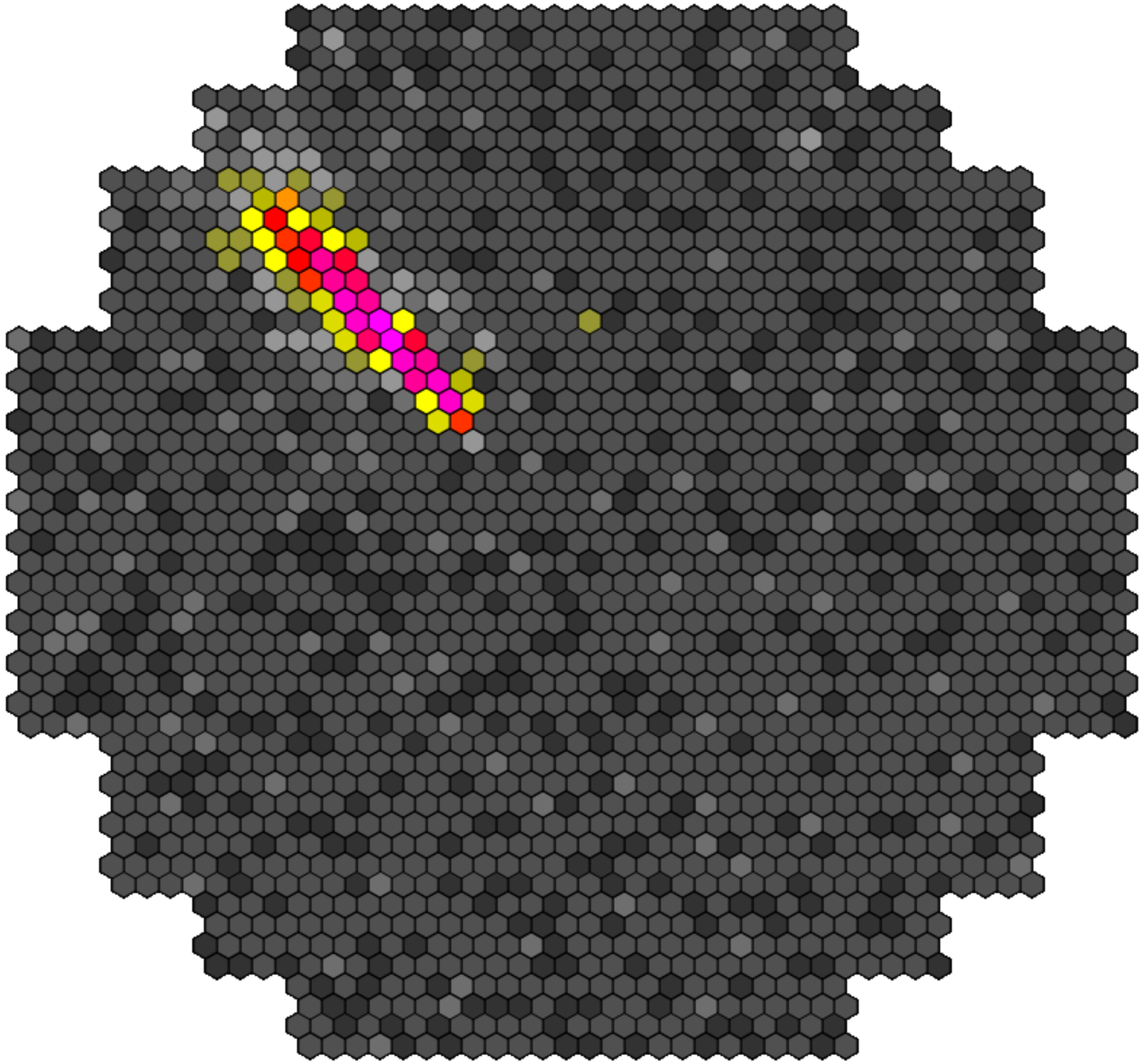
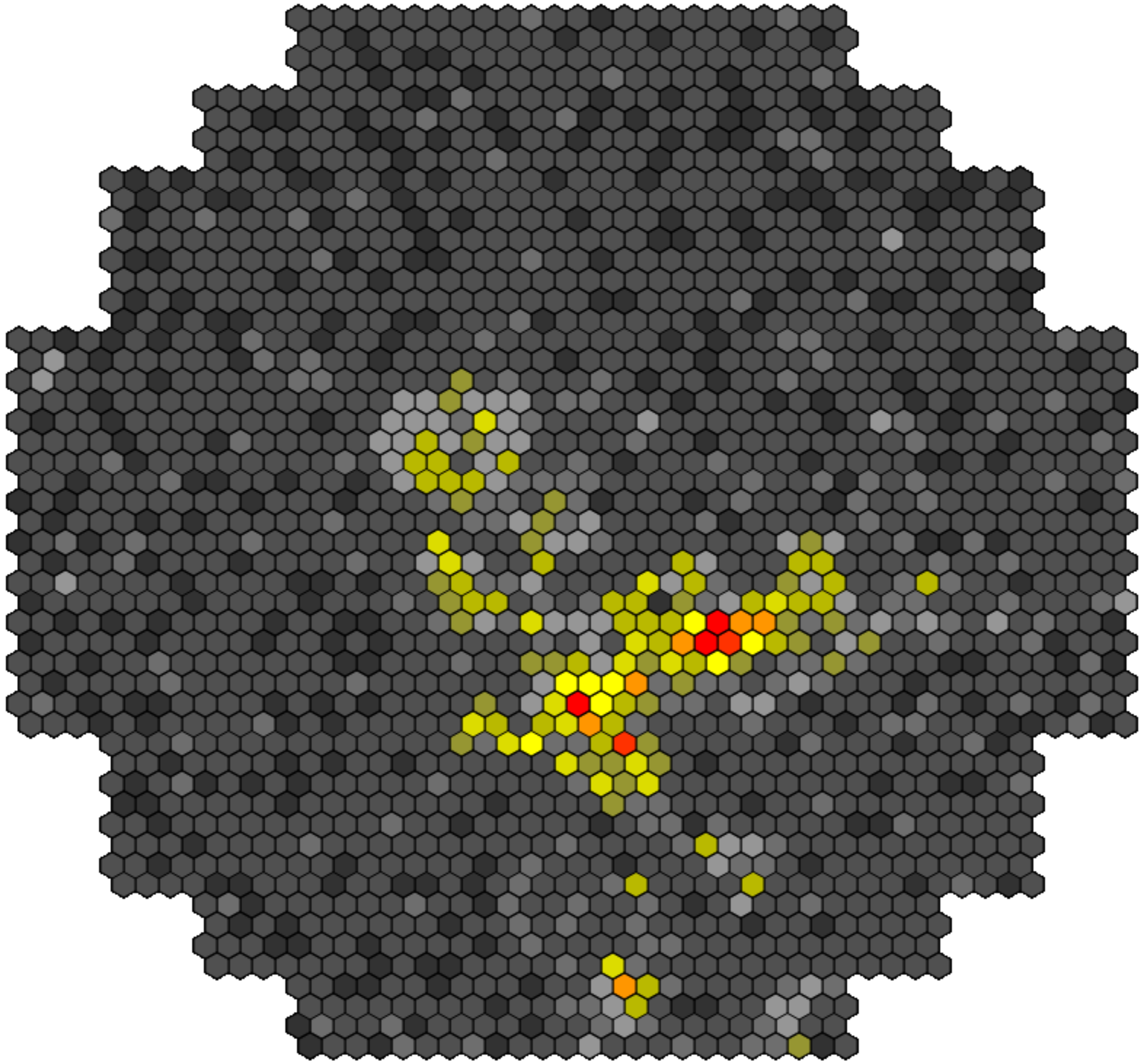
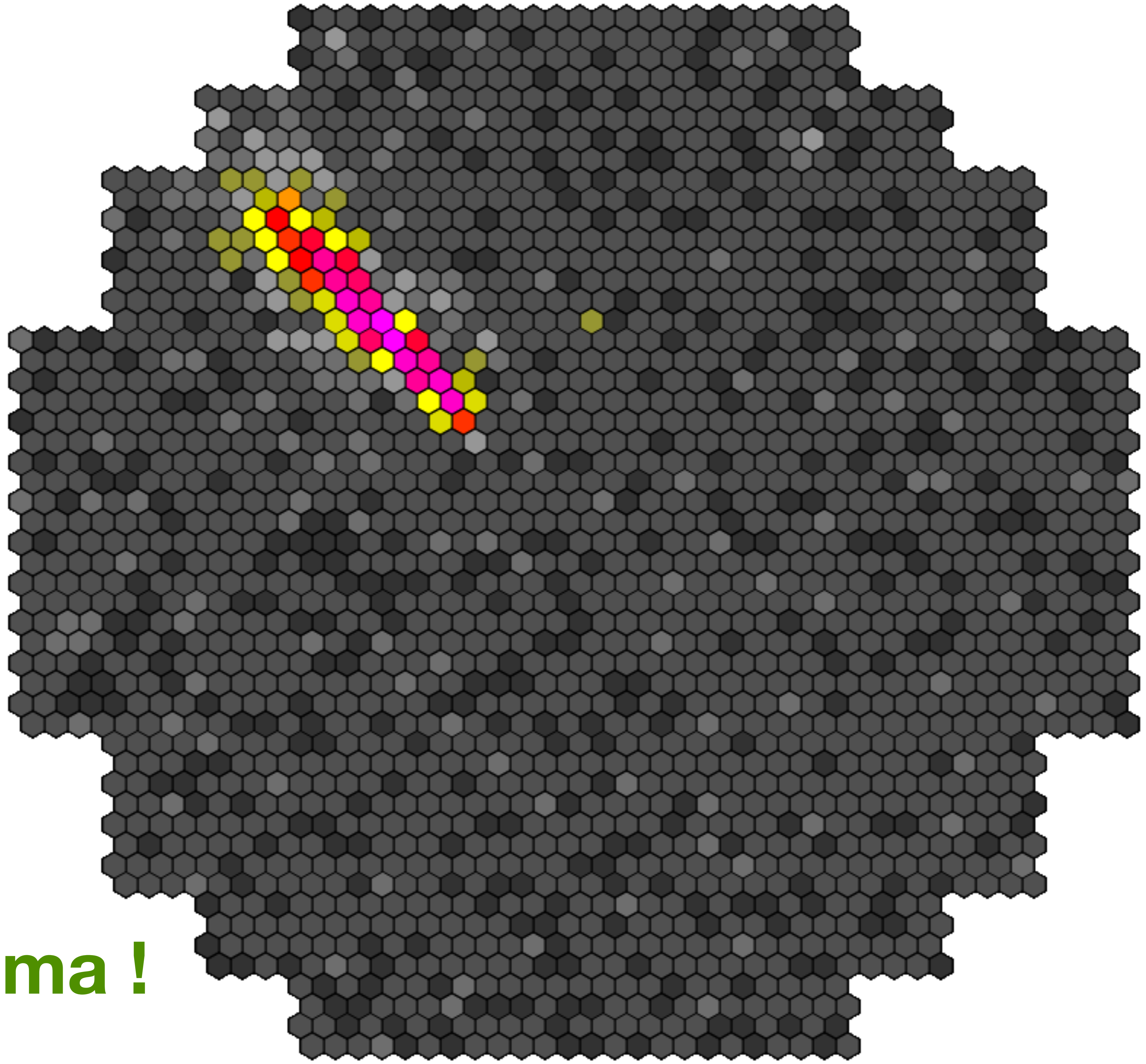


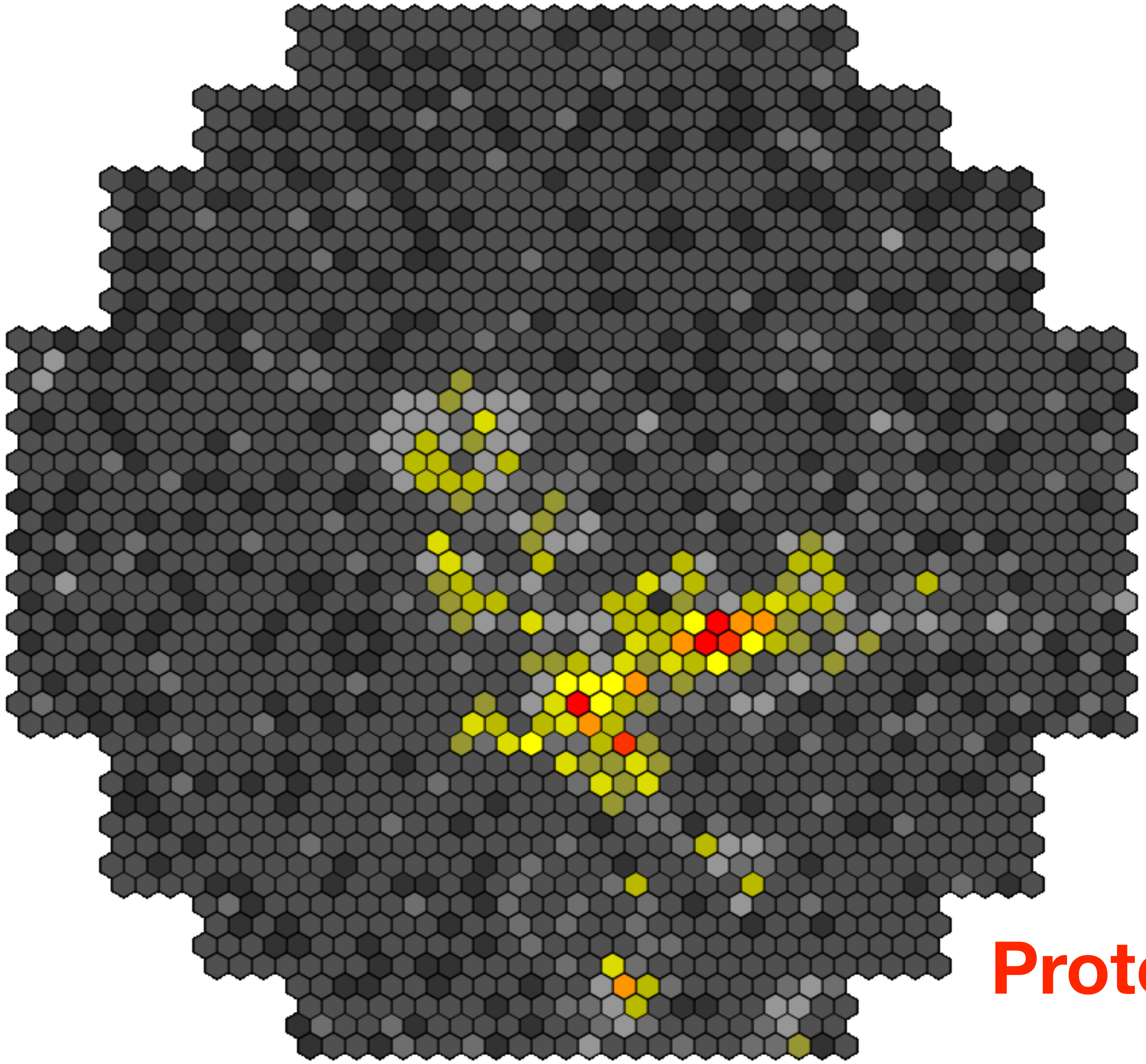


Credits: Ramin Marx and the HESS collaboration

γ-hadron separation



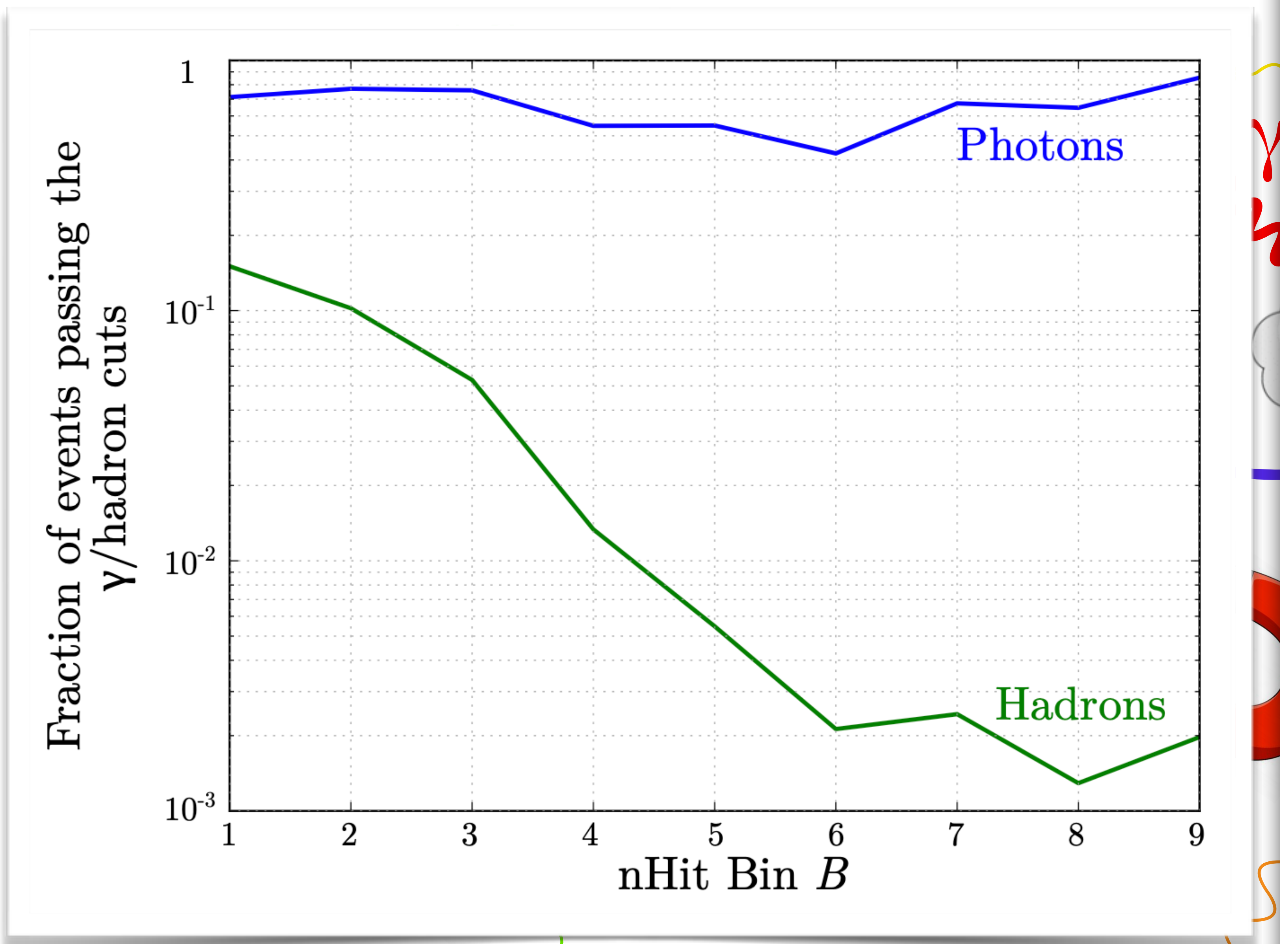
Gamma !



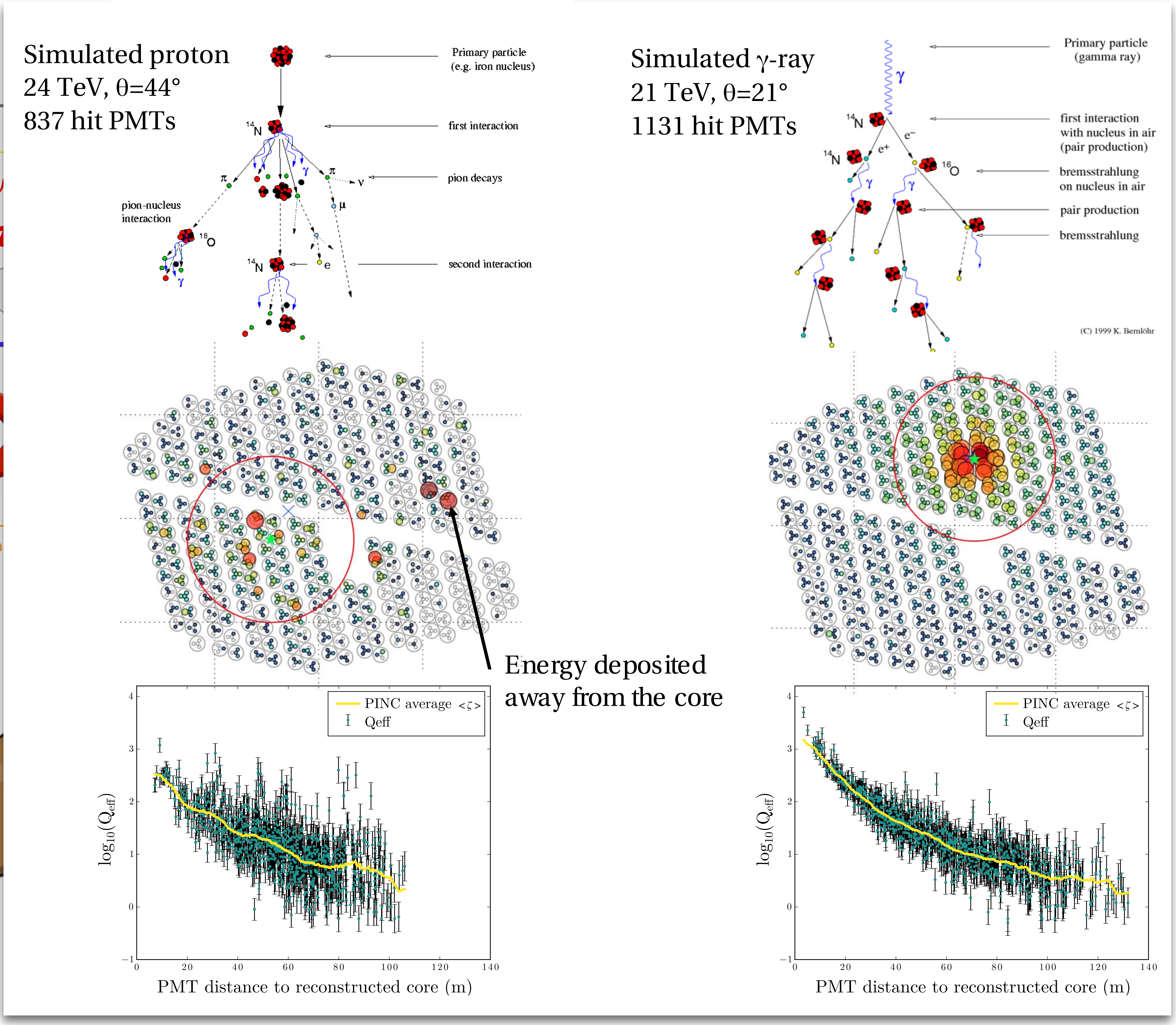
Proton !

Credits: Ramin Marx and the HESS collaboration

γ-hadron separation



From Abeysekara et al, 2017



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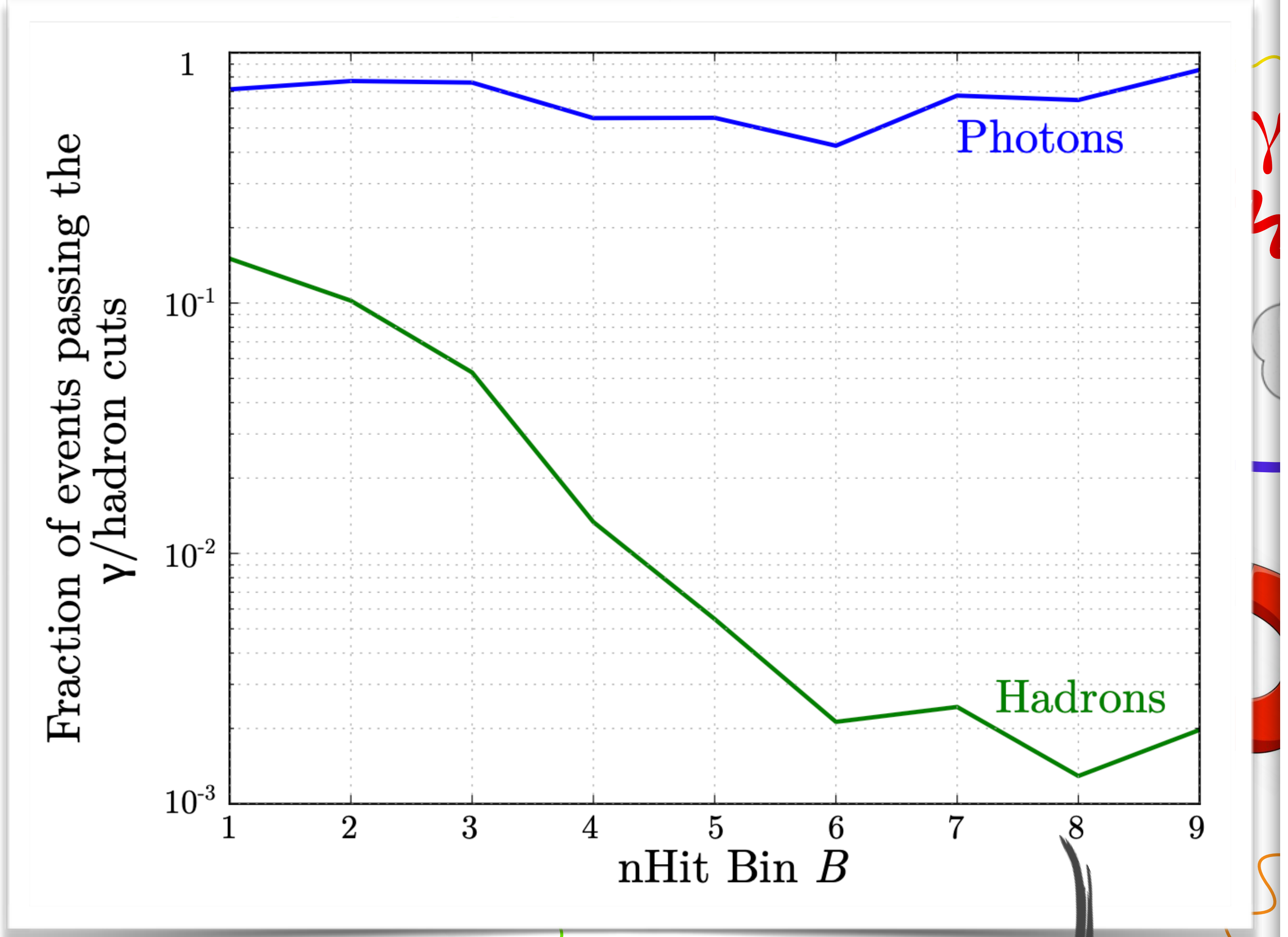
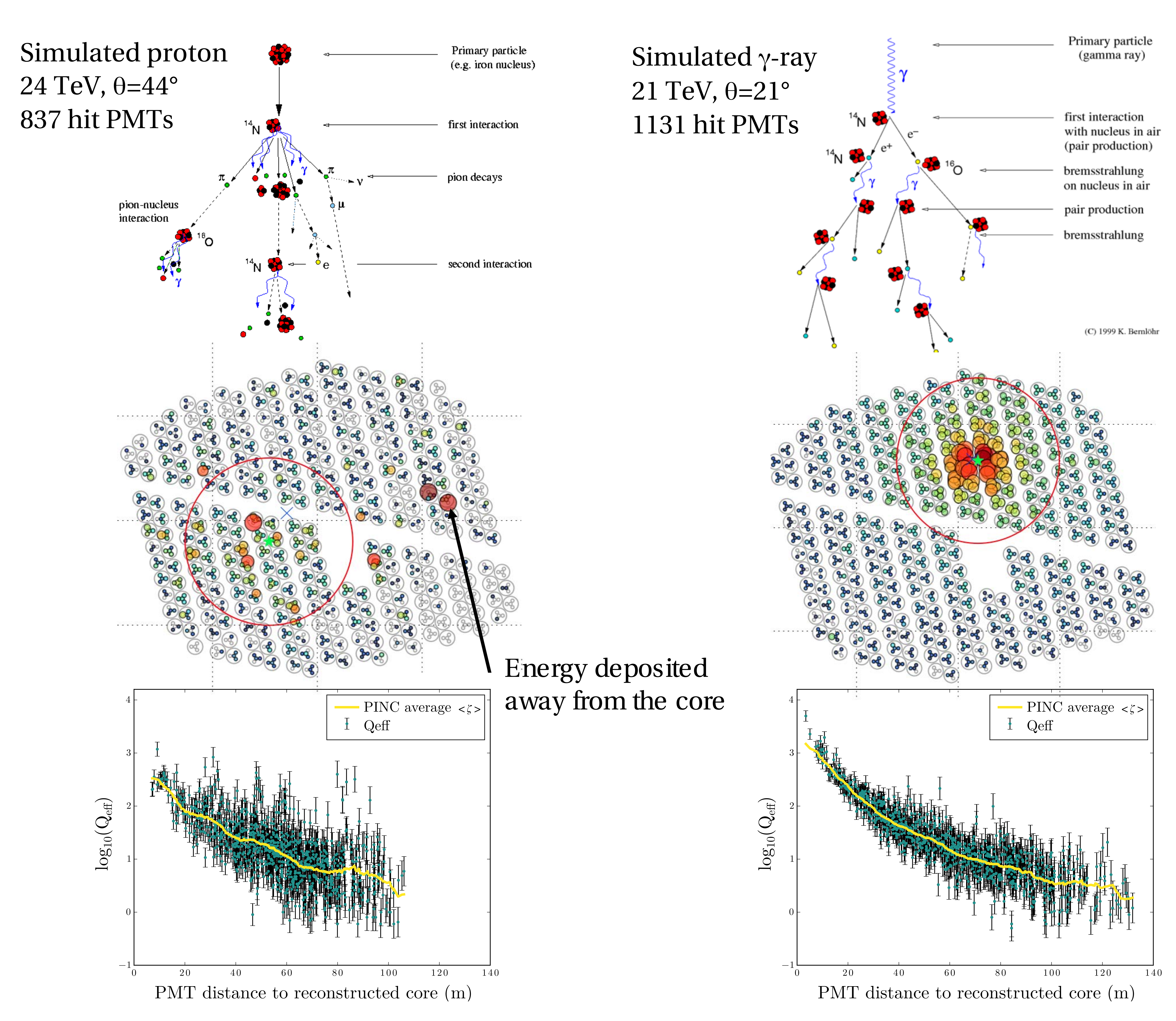


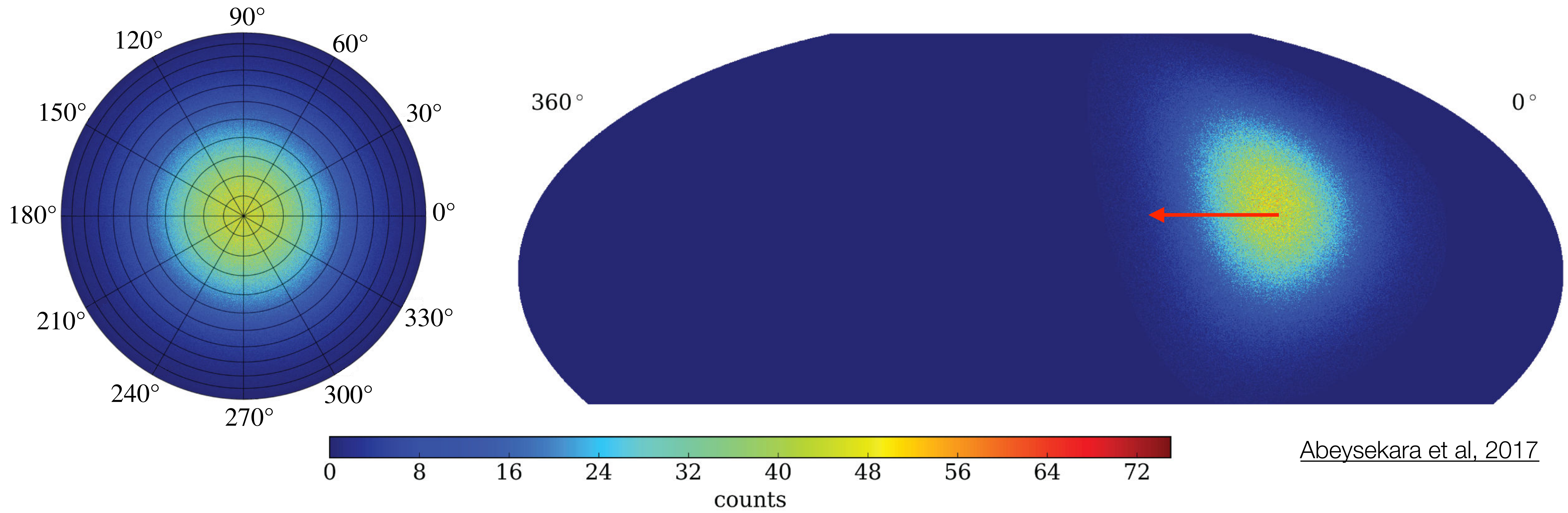
From Abeysekara et al, 2017

Background estimation !



Background estimation

Direct integration method



Local map (Az/zenith)

Local map binned in (HA/Dec)

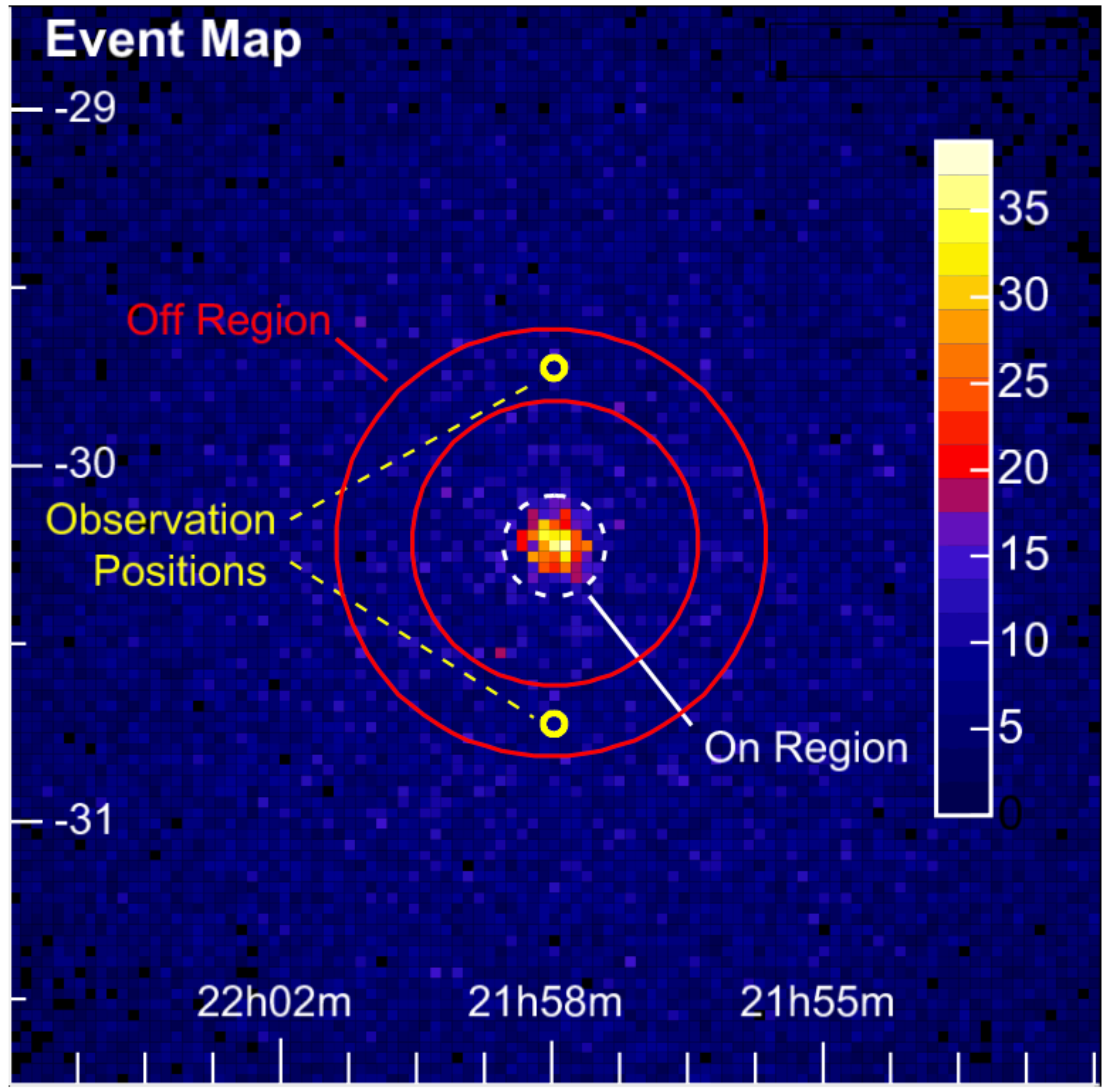
Detector efficiency times event rate integrated over 2 hours

- ✔ Background estimated on the data themselves and constantly updated
- ✔ Assuming stable detector during 2h
- ✔ Mask the galactic plane and bright known sources

Background estimation

Ring background

Berge et al. 2006

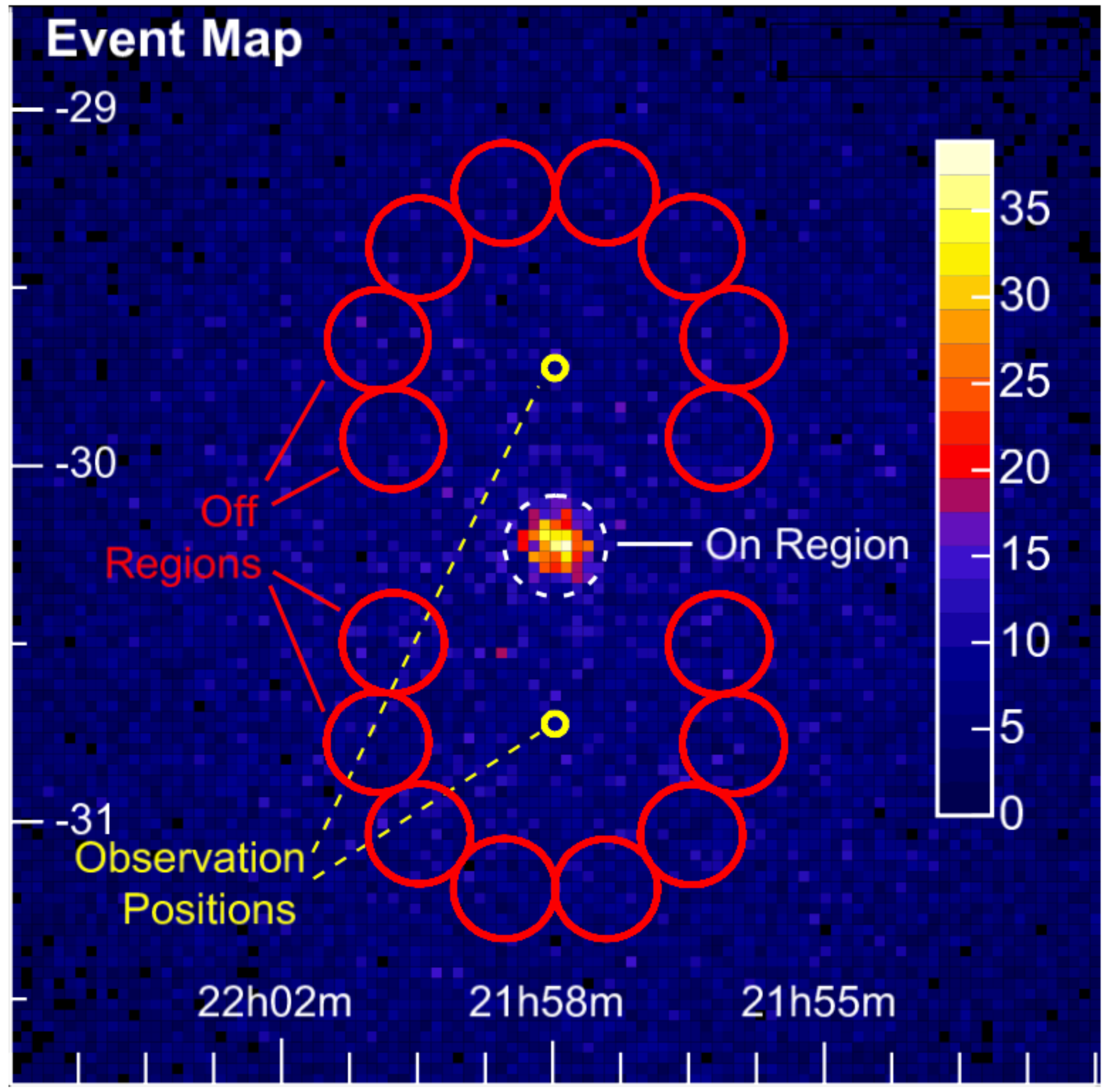


Background estimated on the data

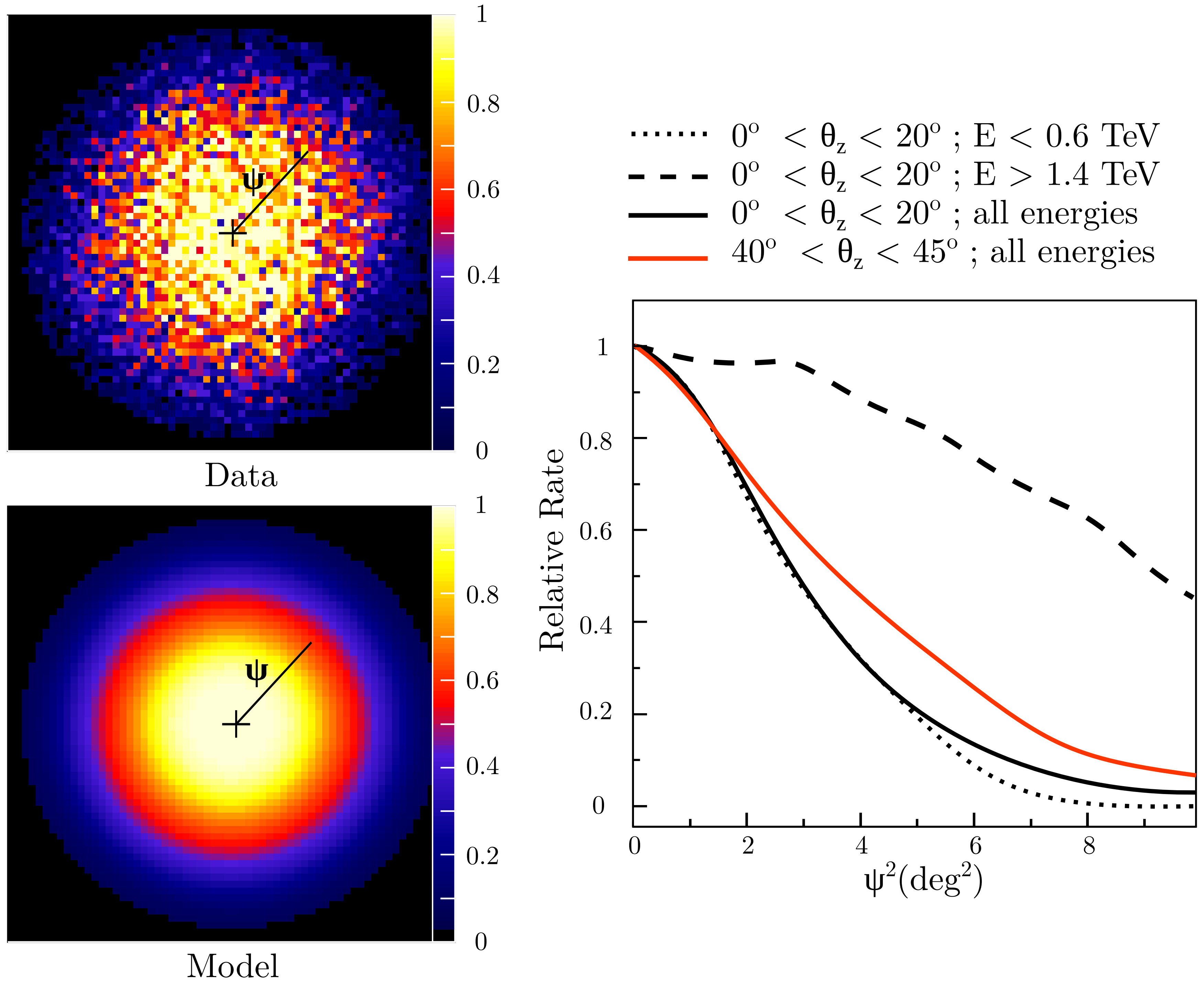
Limited by the size of the FoV

Adapt the ring and mask known sources

Reflected background



Field-of-view background



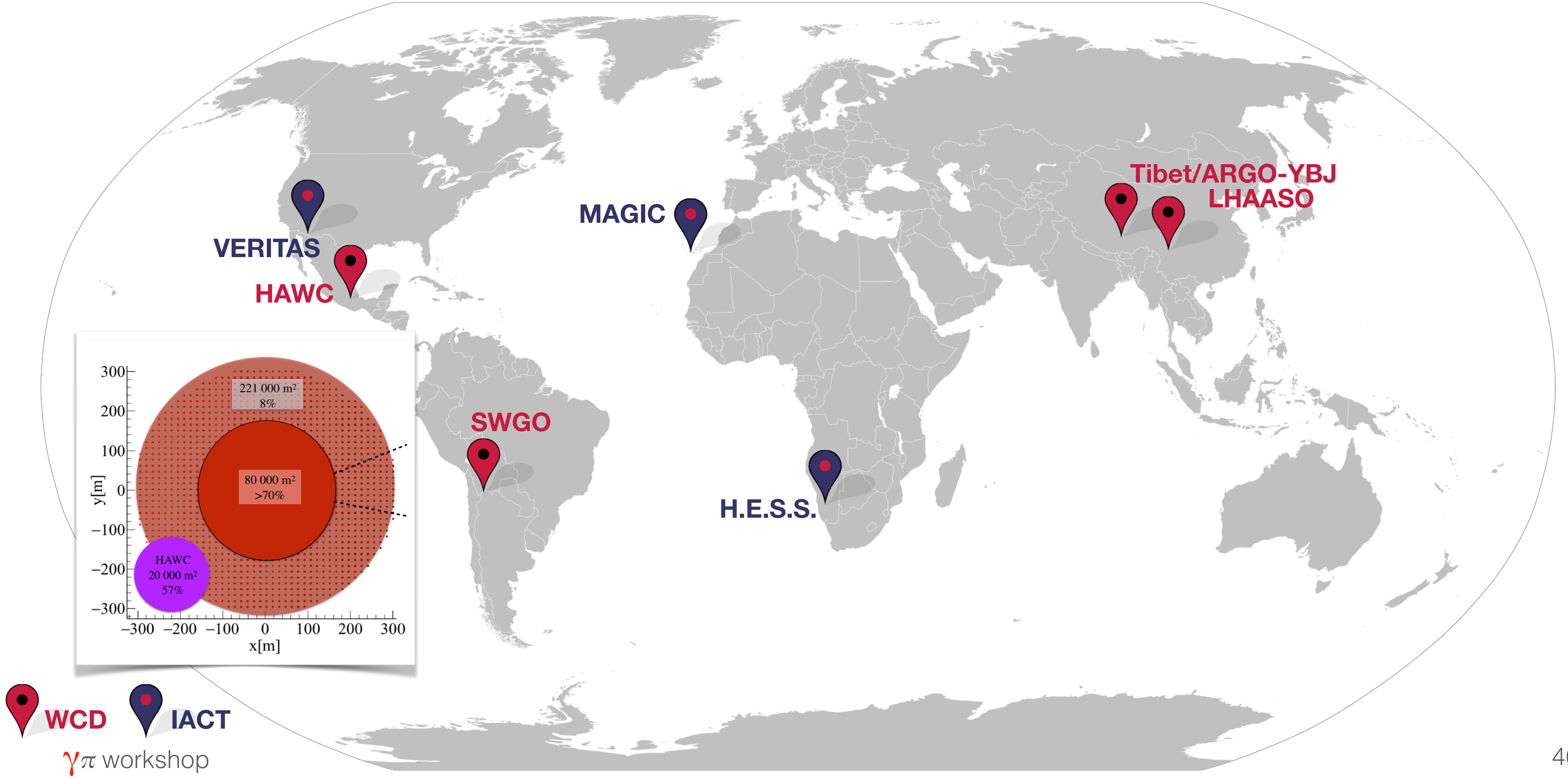
Background estimated using other observations

Suitable for extended sources

Higher systematic uncertainties

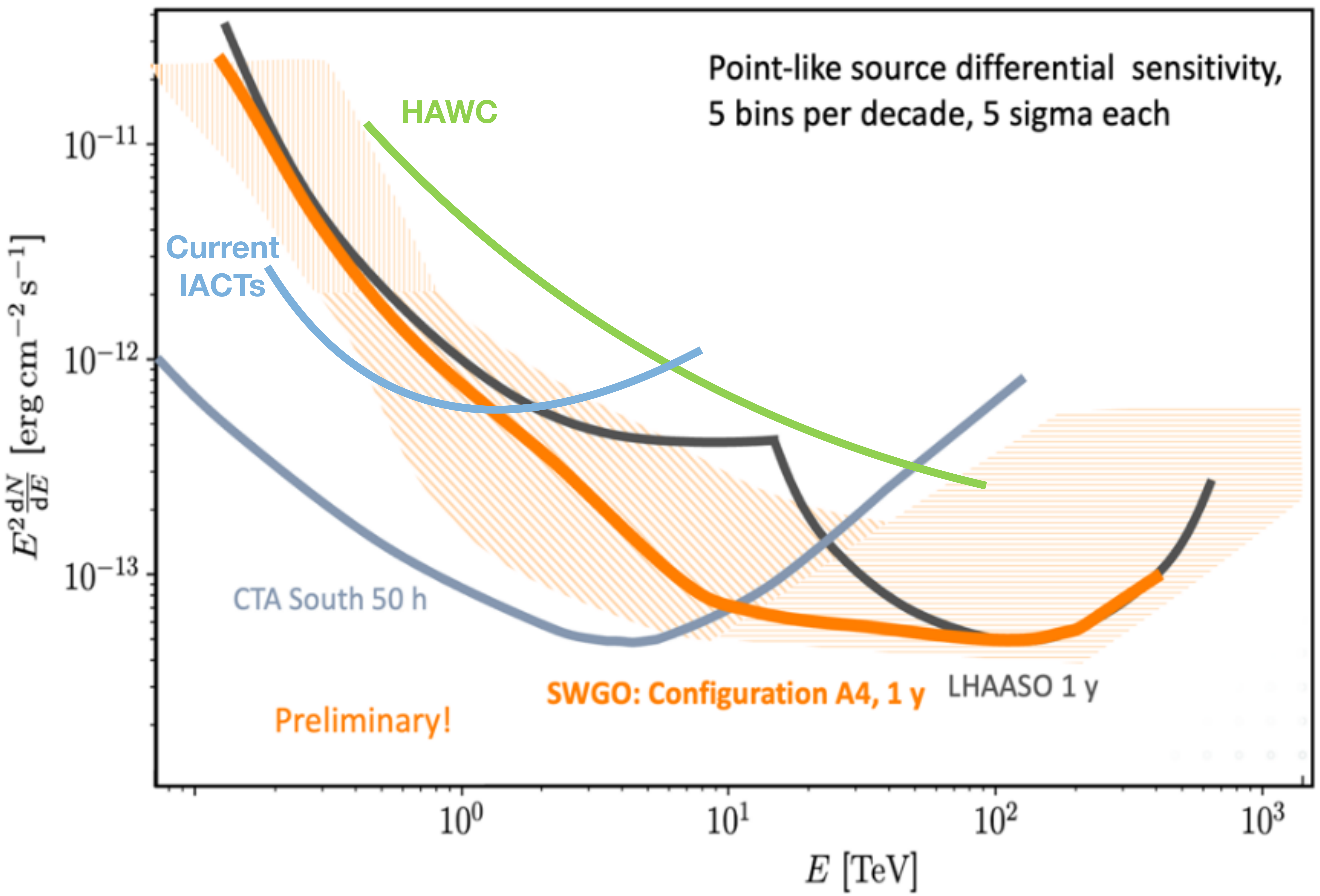
γ-ray instruments around the world

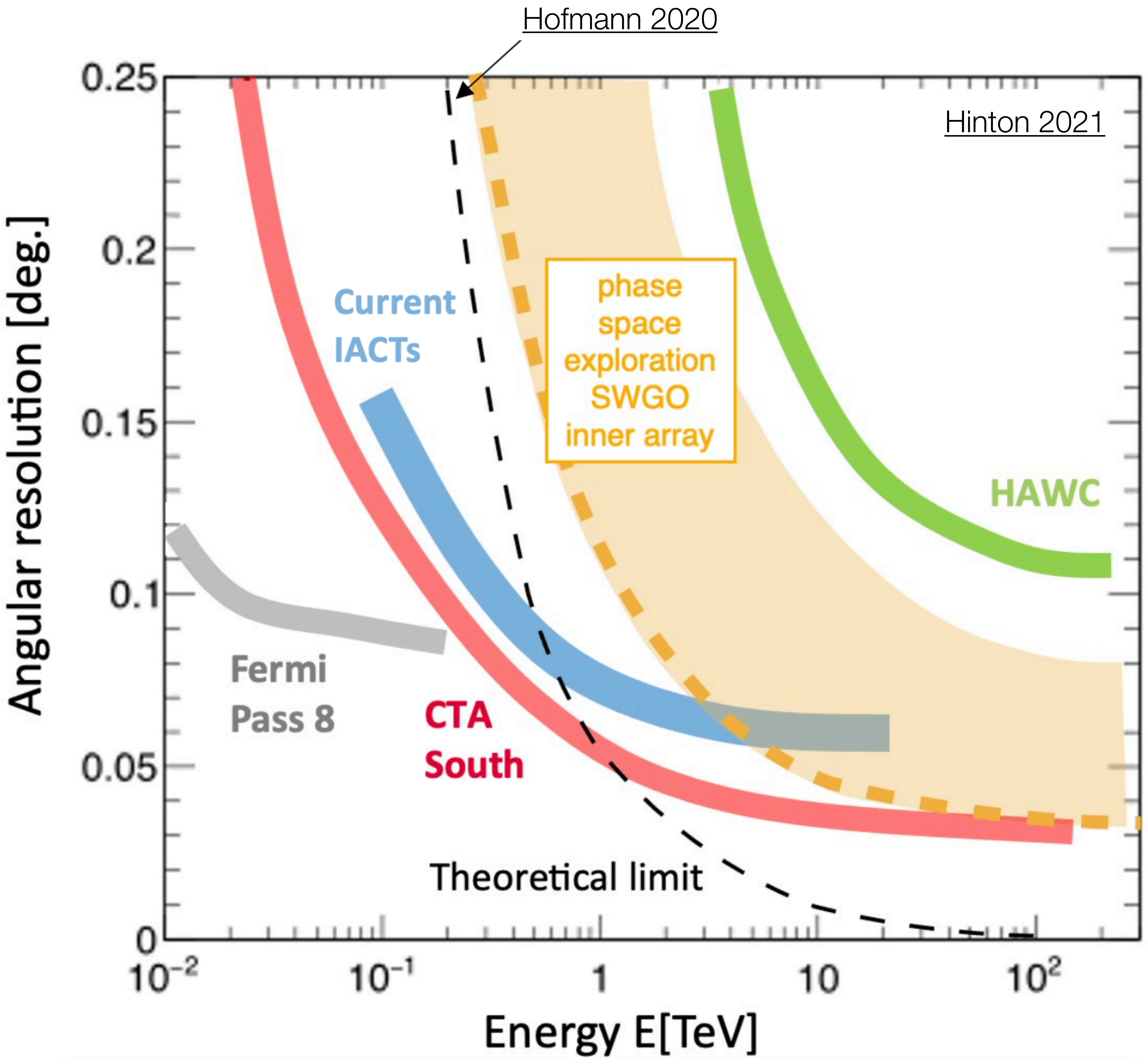
γ-ray instruments around the world



γ-ray instruments around the w

CTA and SWGO performance





Questions ?