

Astroteilchenphysik II: Gamma-Astronomie Vorlesung 5

Ralph Engel und Markus Roth
Institut für Kernphysik
Markus.Roth@kit.edu

Vergleich der Erzeugungsprozesse von Gamma-Strahlung

- Synchrotron-, inverse Compton- und Bremsstrahlung:
Zusammenfassung
- hadronische Photonerzeugung

Messmethoden für den Nachweis von Gamma-Strahlung

- Ausbreitung/Absorption von Gamma-Strahlen
- direkte Messung mit Satellitenexperimenten
- indirekte Messung mit Cherenkov-Teleskopen
- indirekte Messung mit Luftschauerdetektoren

Dienstag		Donnerstag	
		23.04.2020	Vorlesung
		30.04.2020	Vorlesung
		07.05.2020	Vorlesung
12.05.2020	Übung	14.05.2020	Vorlesung
		-	Feiertag
		28.05.2020	Vorlesung
		04.06.2020	Vorlesung
09.06.2020	Übung	-	Feiertag
		18.06.2020	Vorlesung
23.06.2020	Übung	25.06.2020	Vorlesung
		02.07.2020	Vorlesung
07.07.2020	Übung	09.07.2020	Vorlesung
		16.07.2020	Vorlesung
21.07.2020	Übung	23.07.2020	Vorlesung

Photonen aus leptonischen und hadronischen Wechselwirkungen

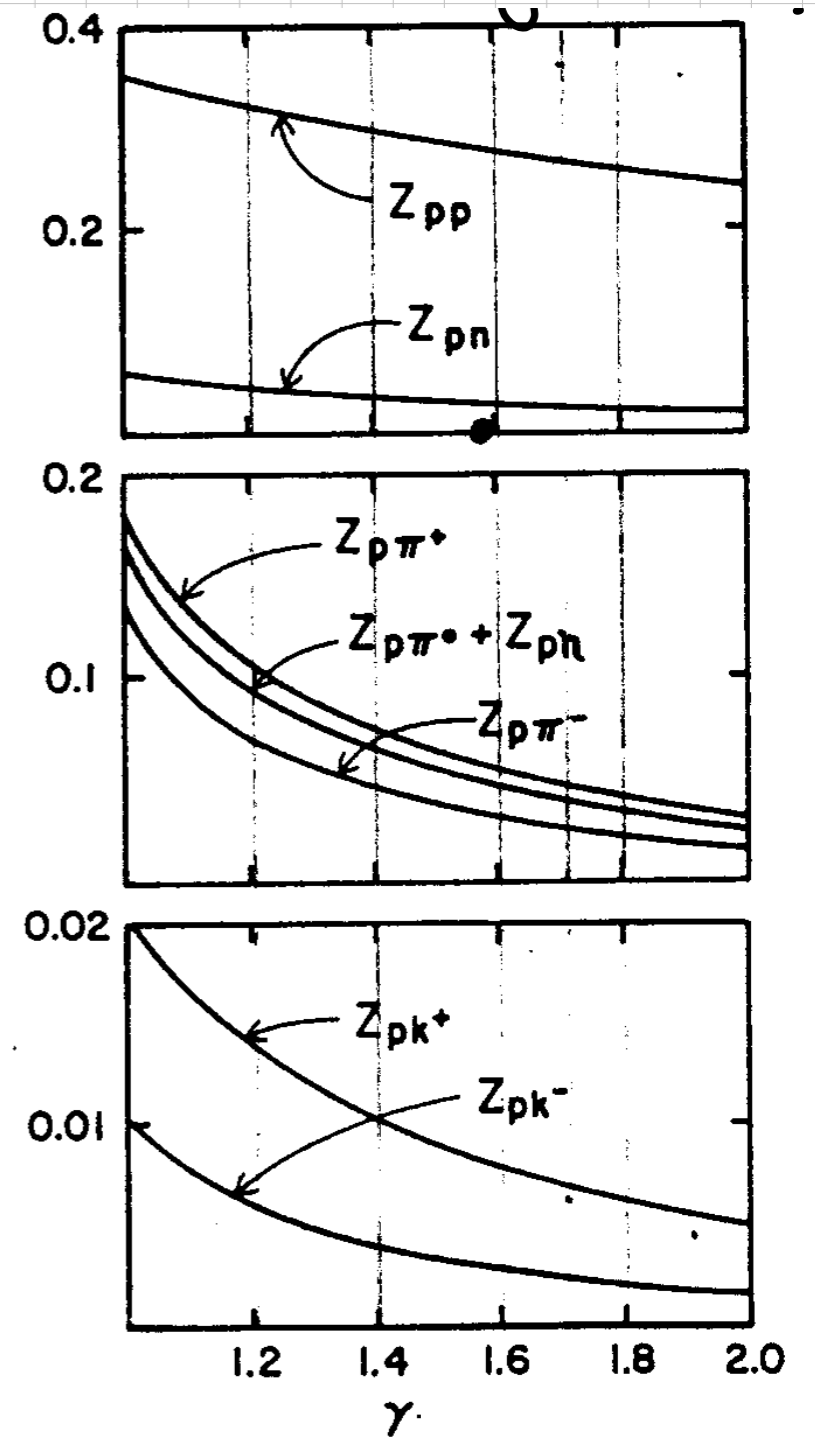
Zusammenfassung: leptonische Erzeugungsprozesse

Bremsstrahlung

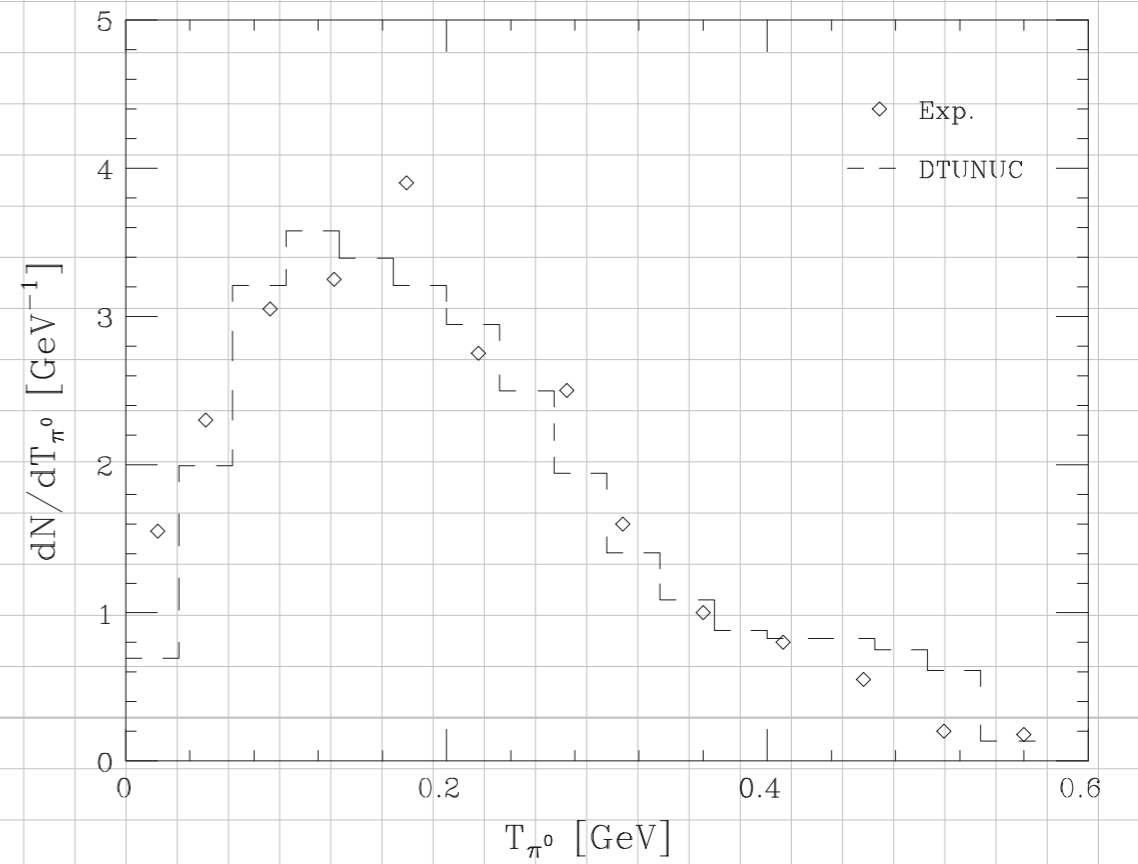
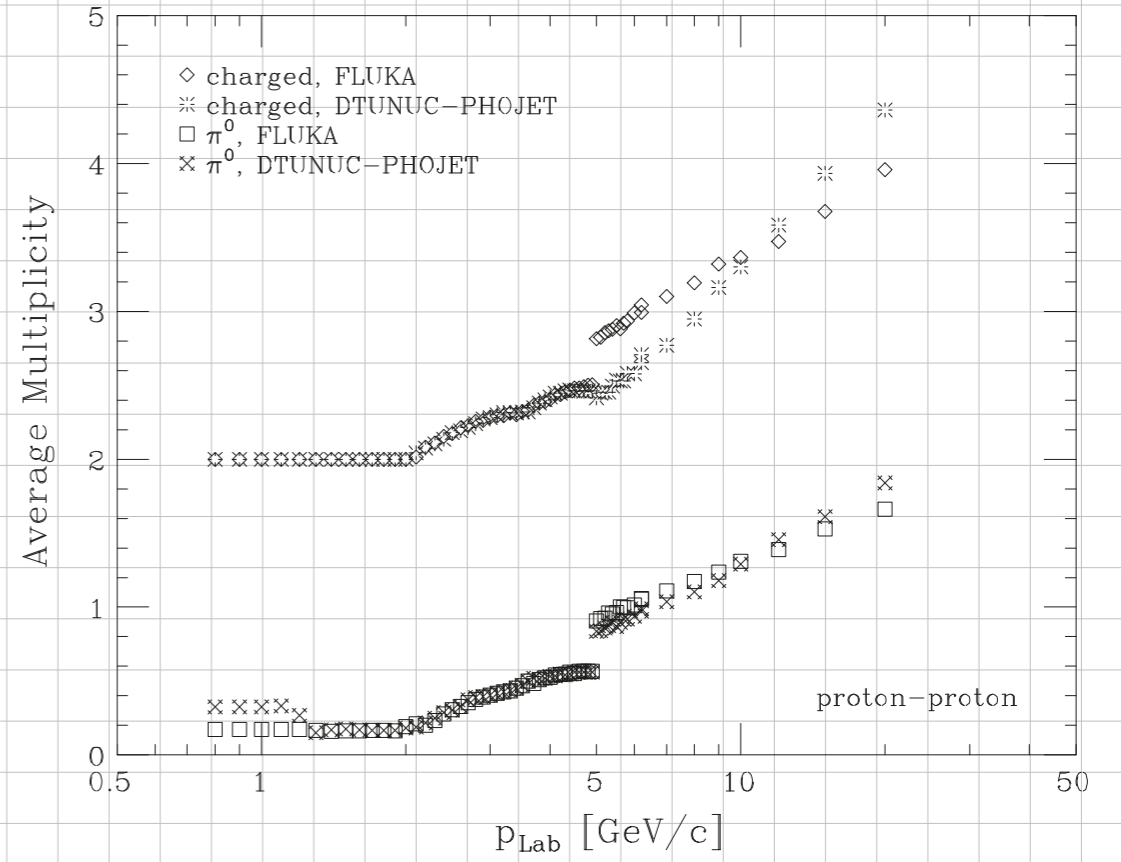
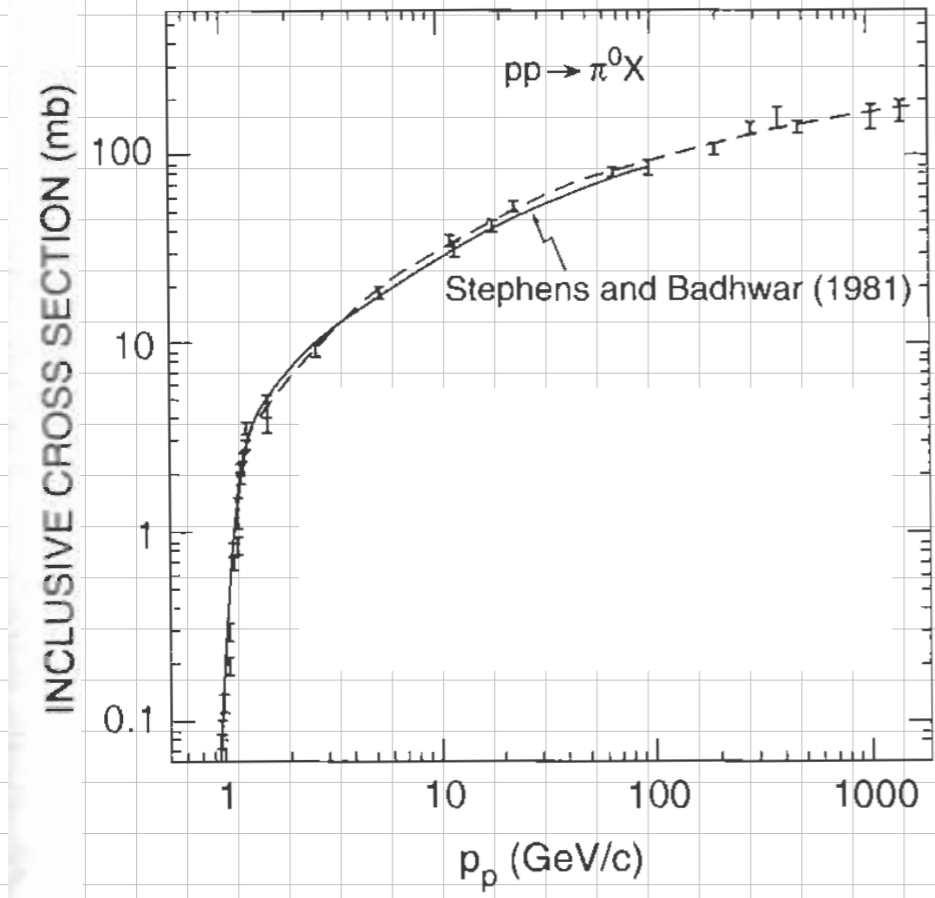
Inverse Comptonstreuung

Synchrotronstrahlung

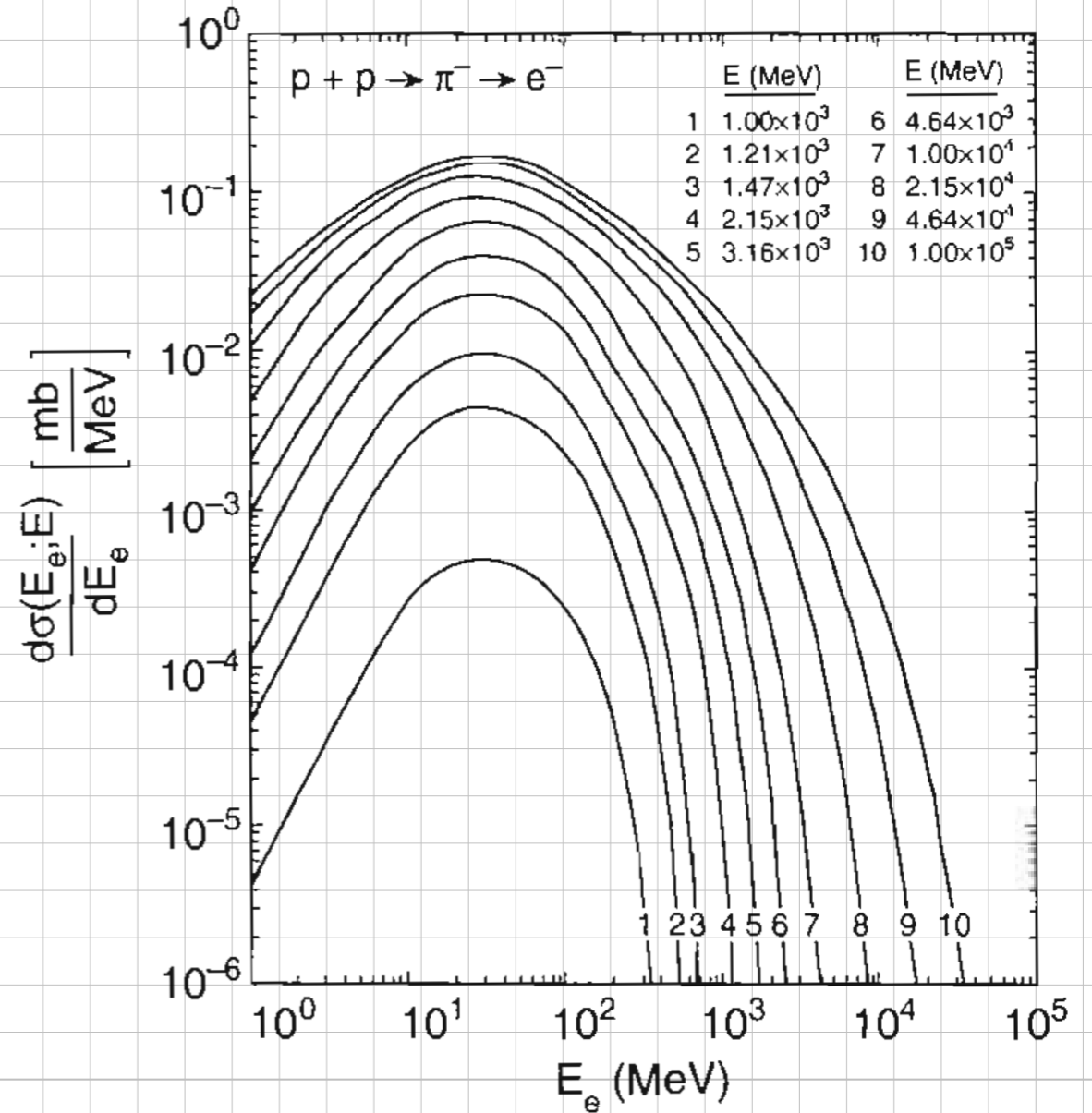
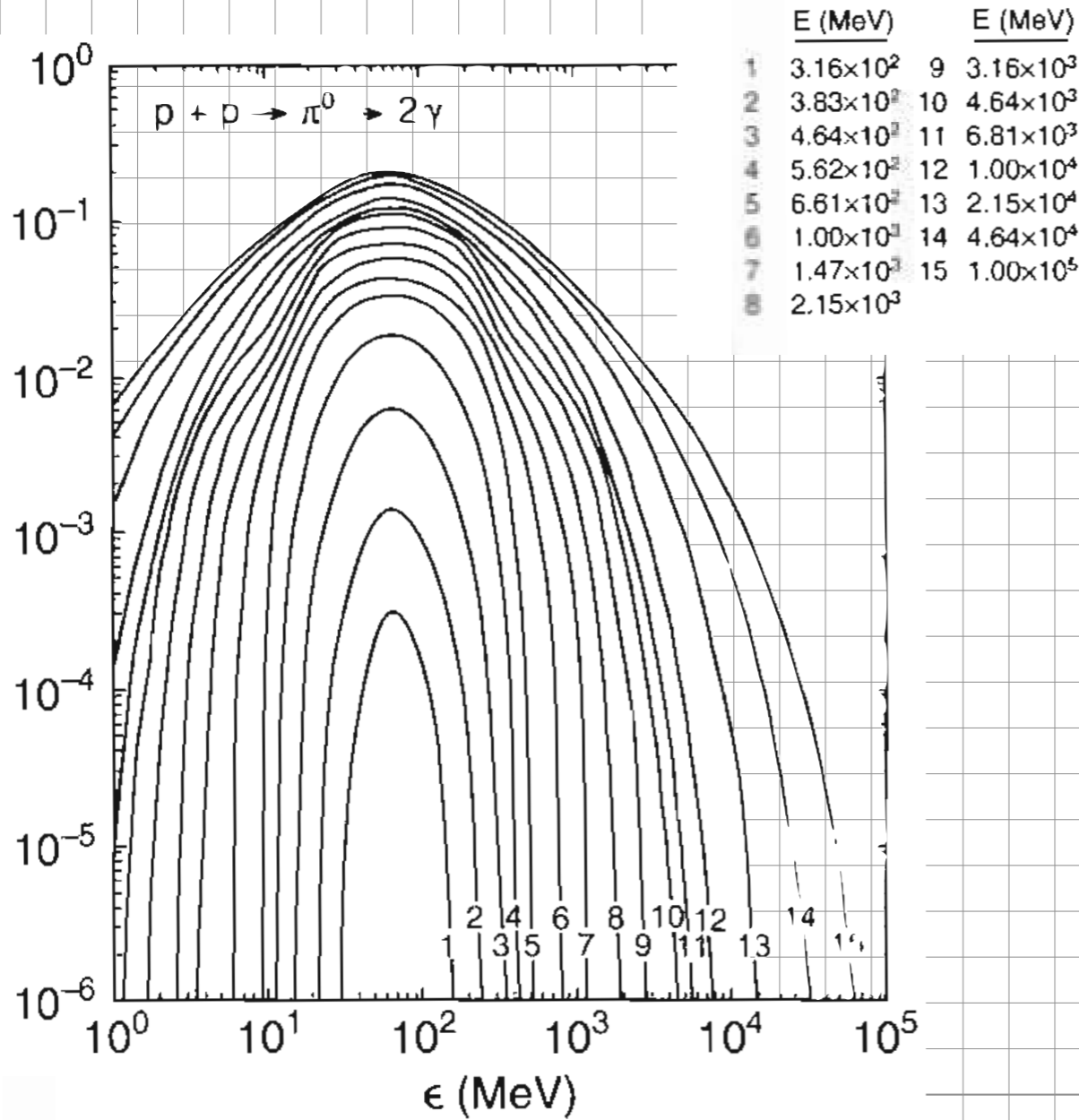
Z-Faktor, spektrumgewichtete Momente



Hadronische Erzeugung von Gamma-Strahlen



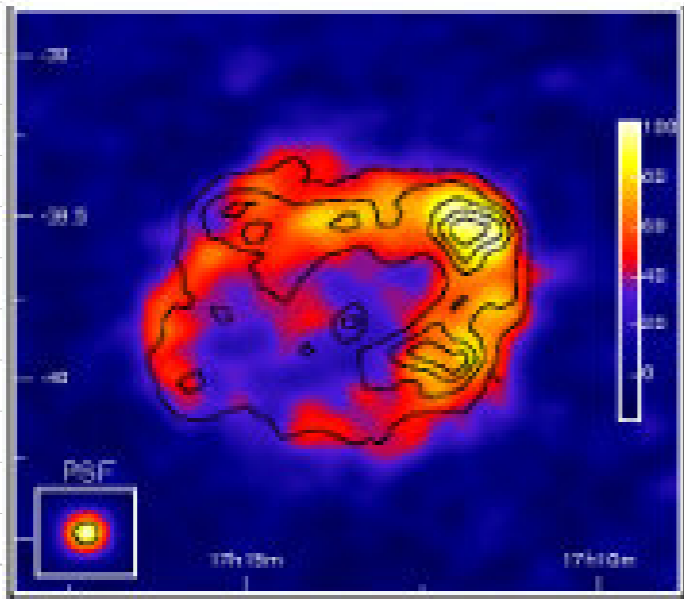
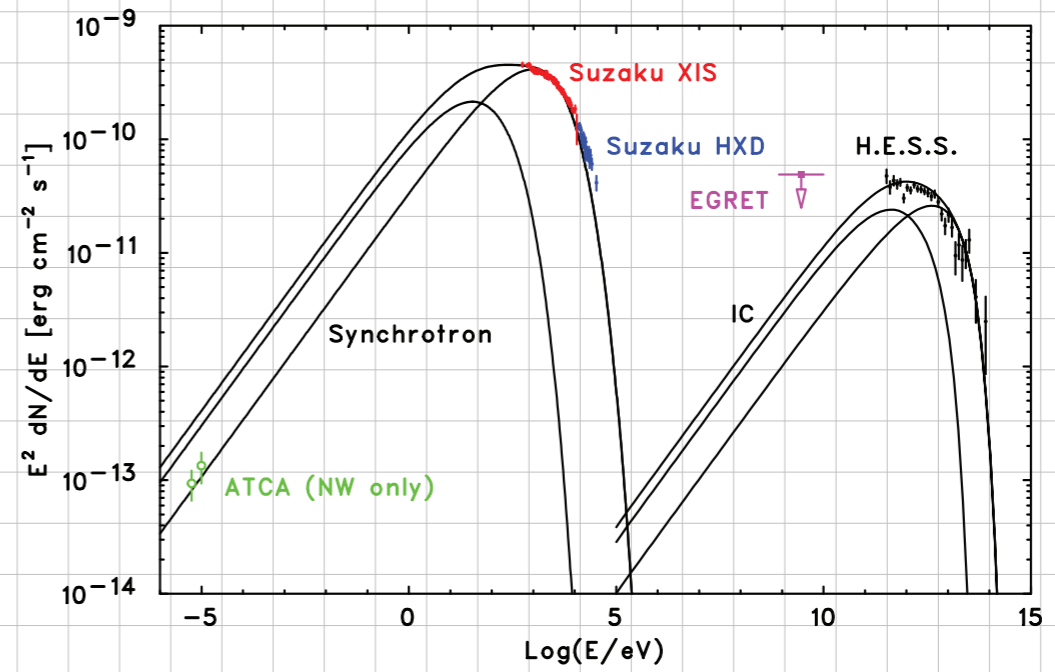
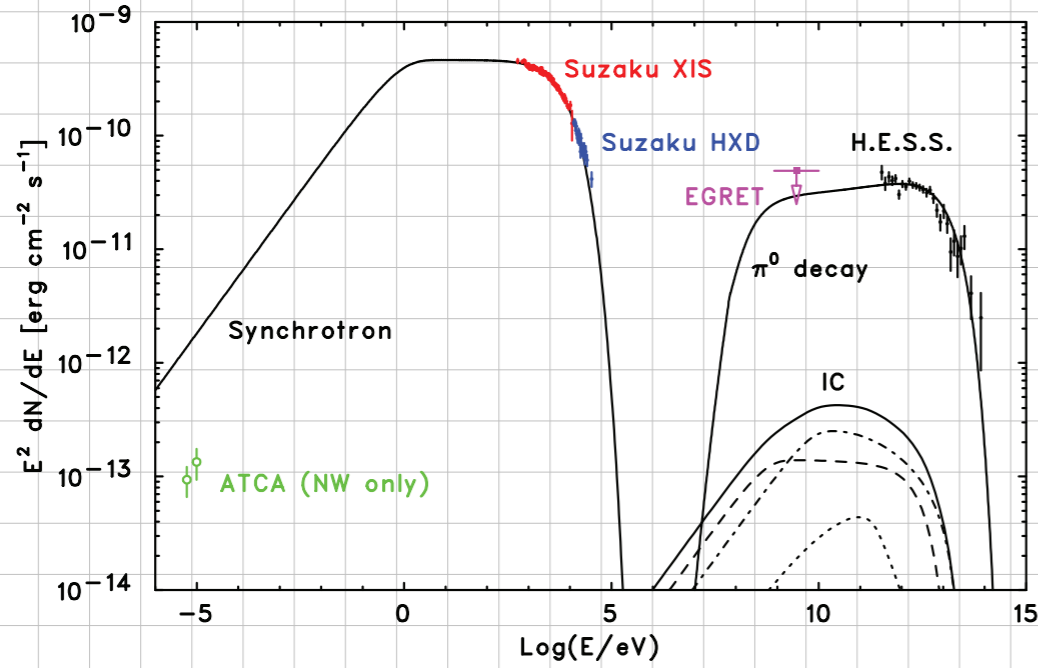
Hadronische Erzeugungsspektren



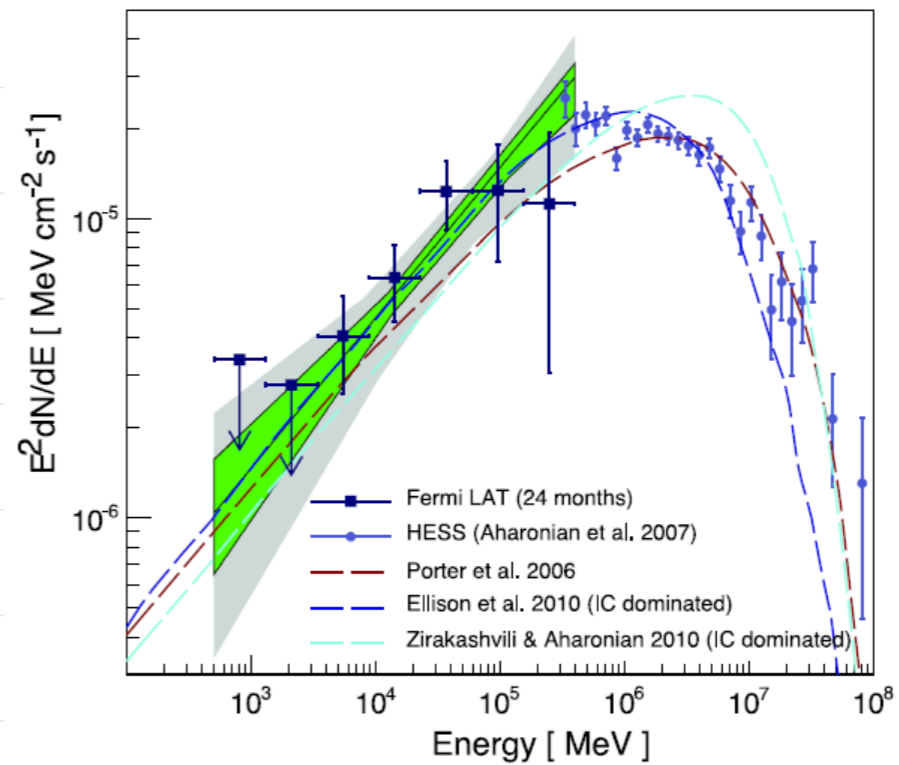
Photonspektrum

Leptonisch vs. hadronisch RX J1713.73946

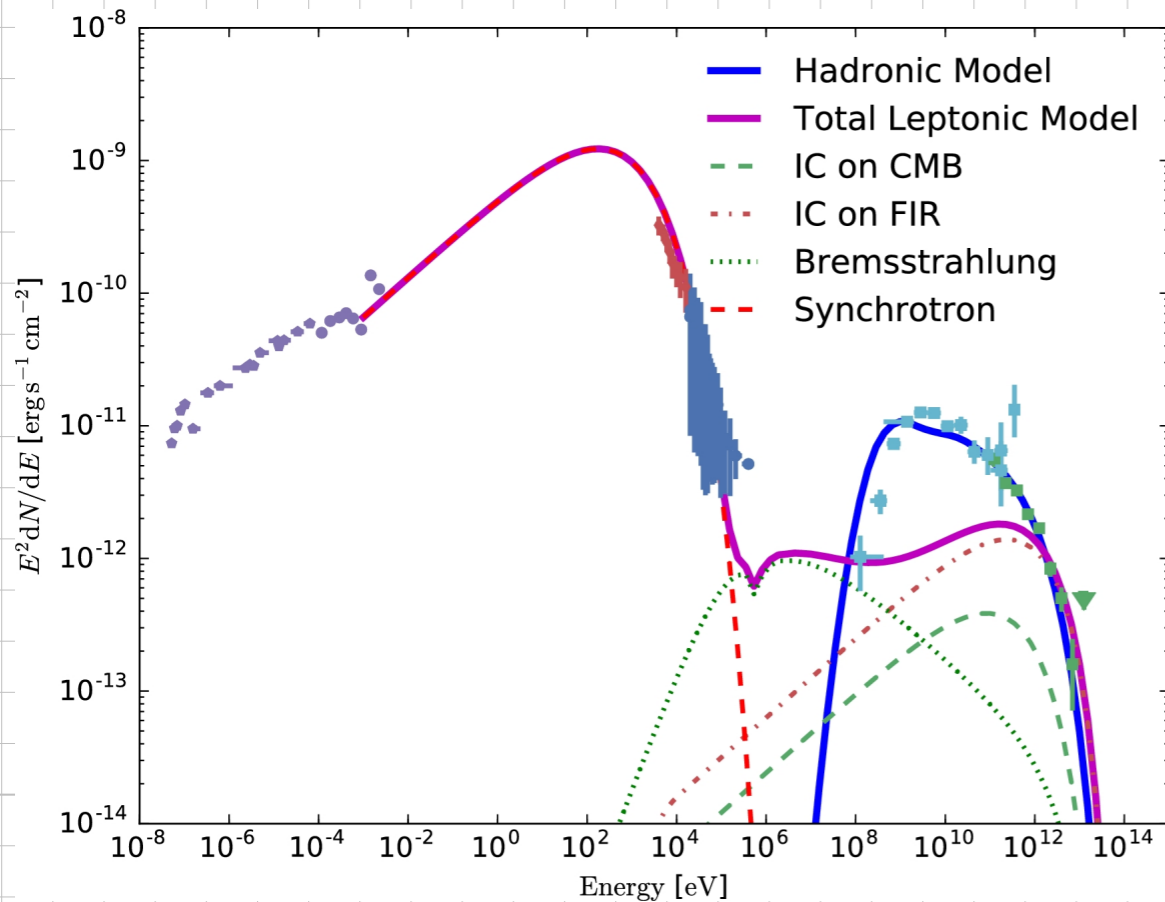
Tanaka et al, *Astrophys.J.* 685 (2008) 988



H.E.S.S.

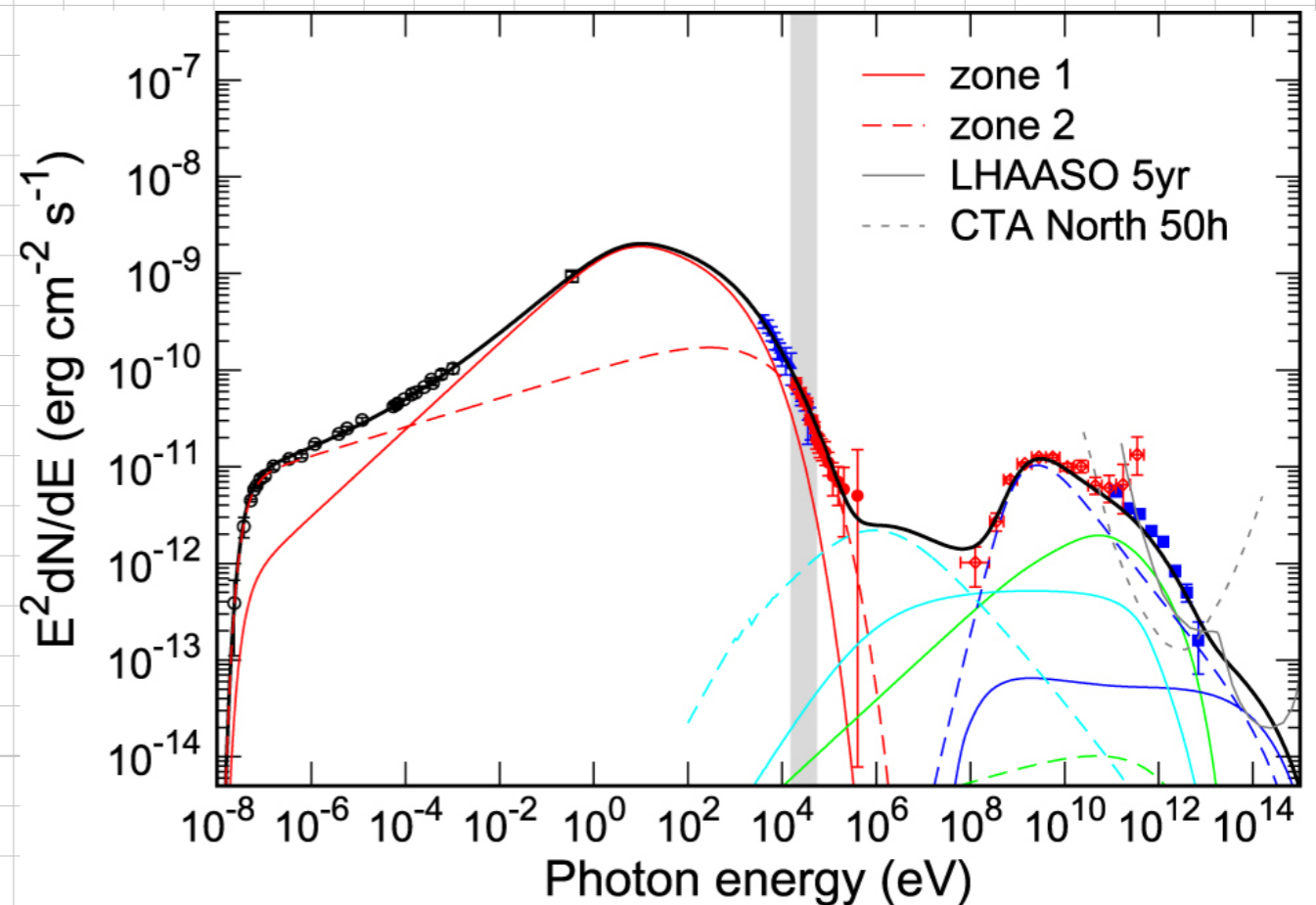


Leptonisch vs. hadronisch – Cassiopeia A



The black solid line represents the total emission from zones 1 (solid) and 2 (dashed) with various components considered in this work: synchrotron (red), inverse Compton (green), bremsstrahlung (cyan), and p–p collision (blue).

We treat the outer "thin rim" (the forward shocks) and the diffuse region immediately behind the forward shock as zone 1. Zone 2 then includes the rest of the emission regions (mainly the bright radio ring, knots, and interior, in particular regions containing inward-moving shocks).

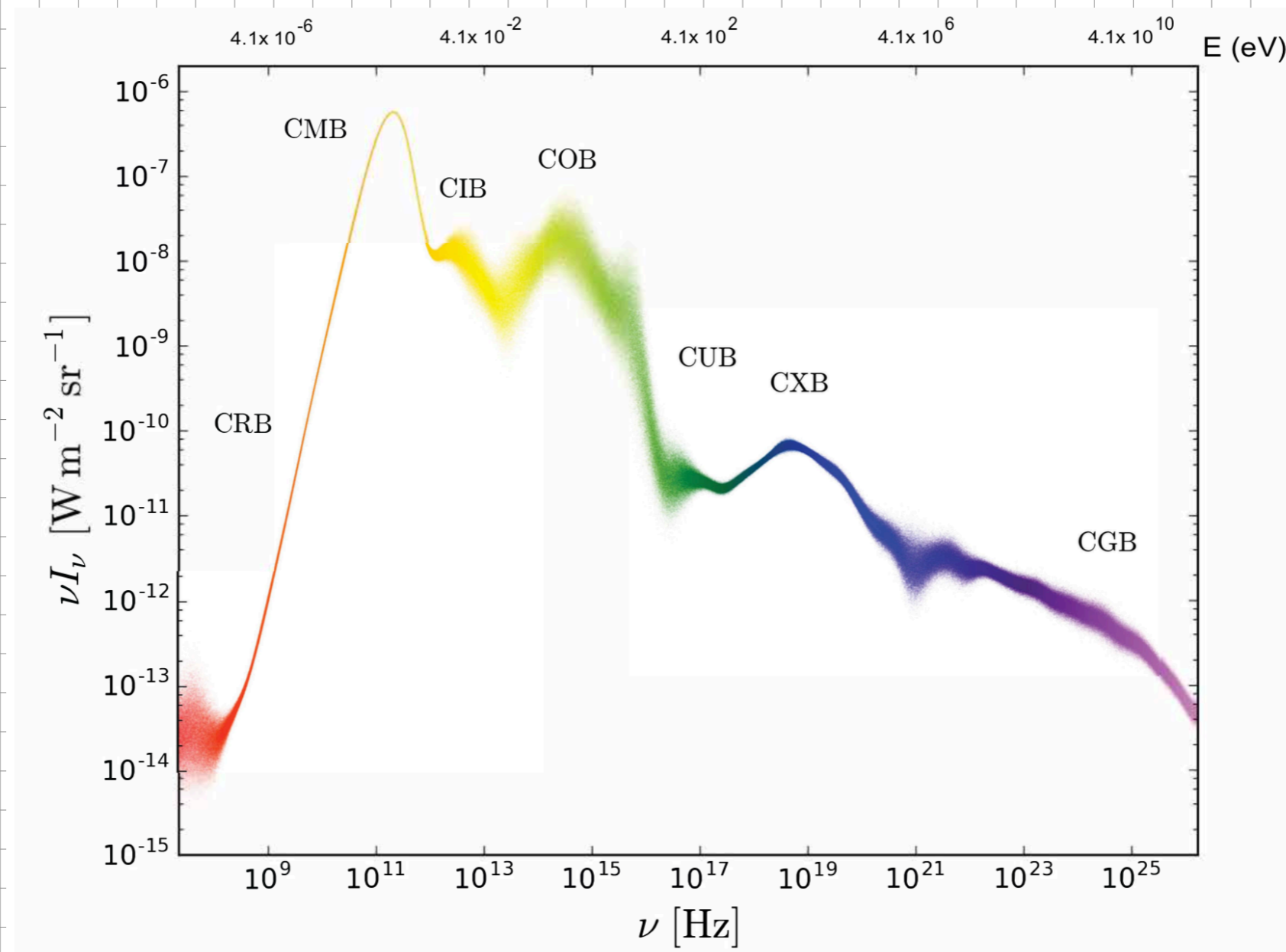


Nachweis von Gammastrahlung

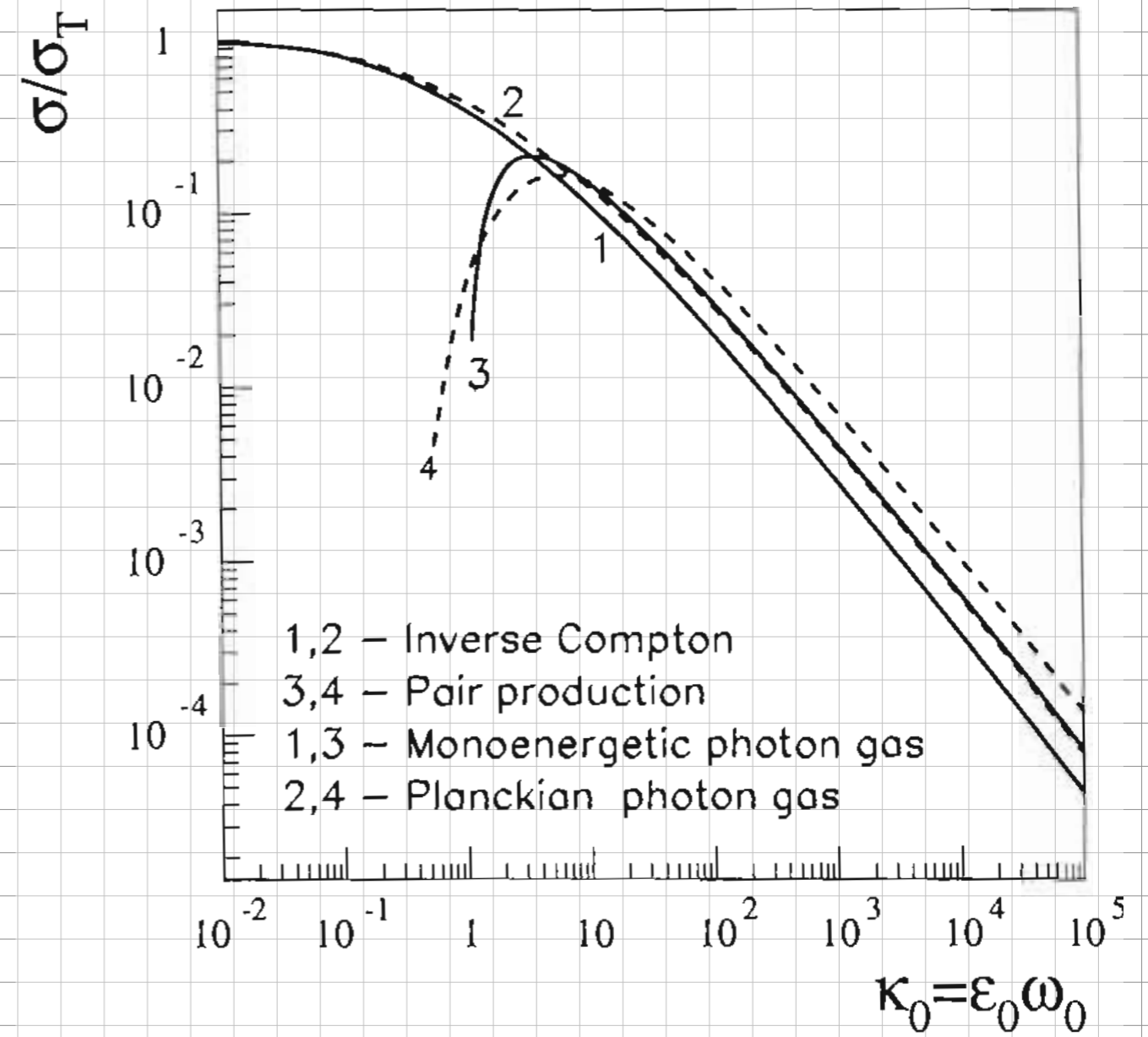
Messmethoden für den Nachweis von Gammastrahlung

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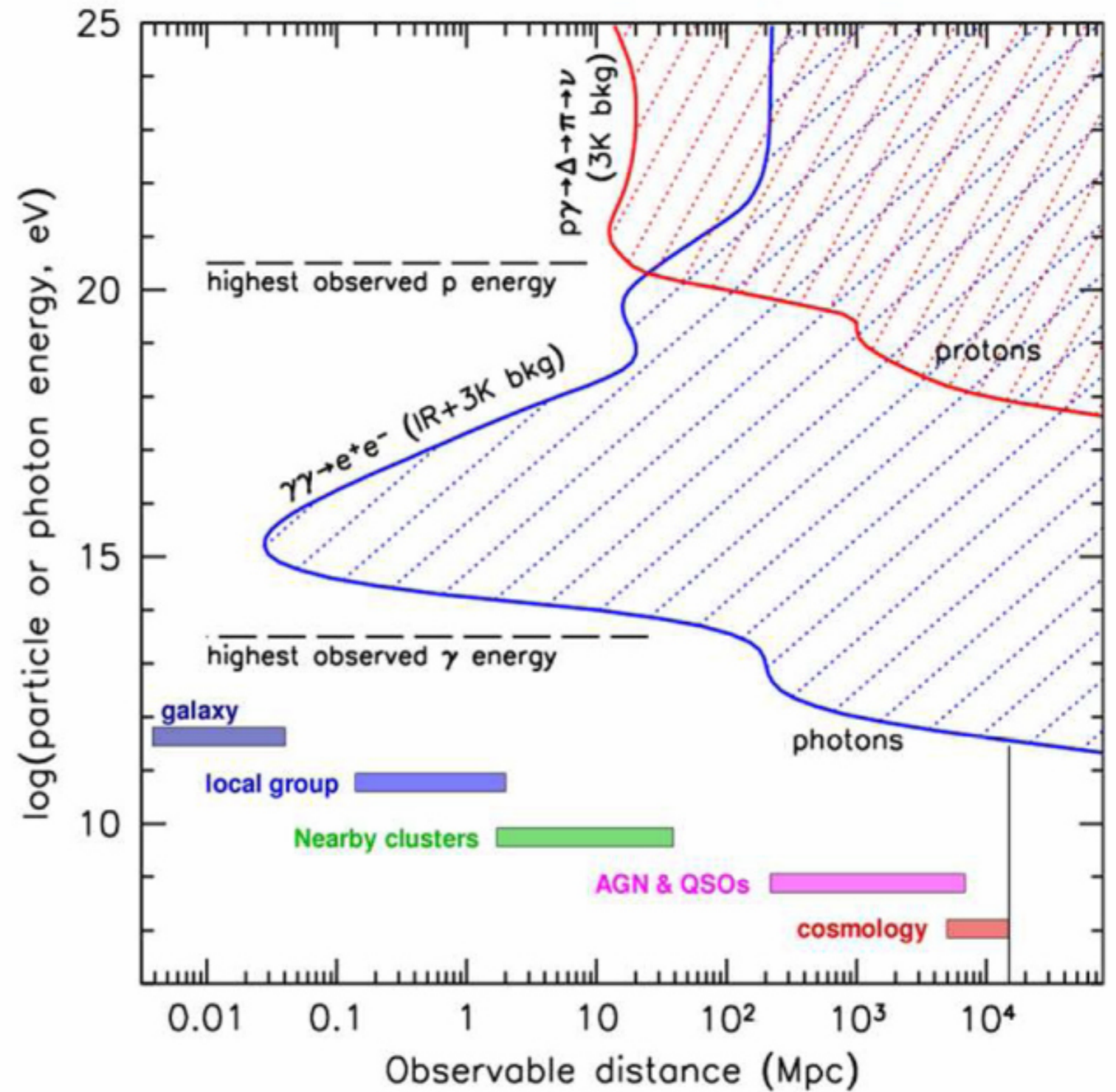
Ausbreitung von Gamma-Strahlen: Hintergrundstrahlungsfelder



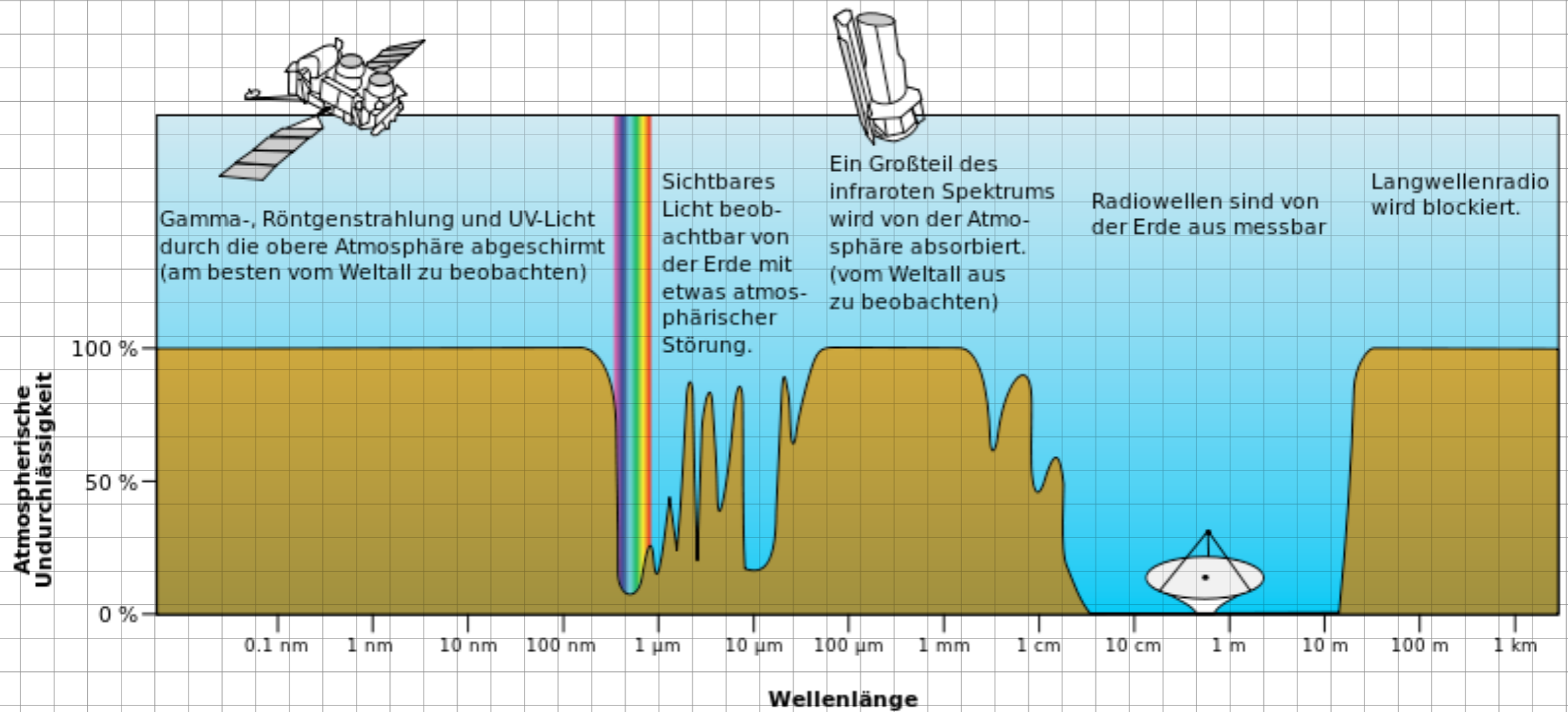
Paarerzeugung



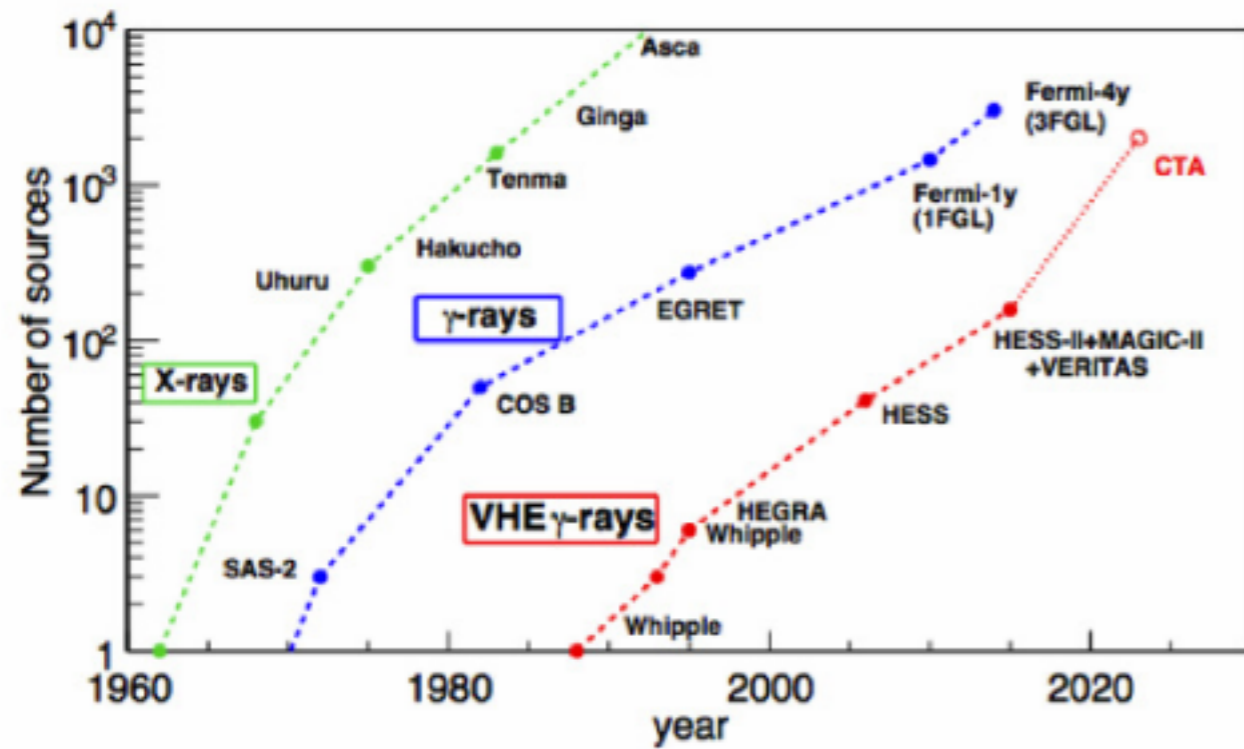
Absorption von Gamma-Strahlung: Ausbreitungsentfernungen



Absorption von Gamma-Strahlung: Atmosphäre



Historische Entwicklung



Vierter Fermi-LAT-Katalog (2020)
5064 Quellen

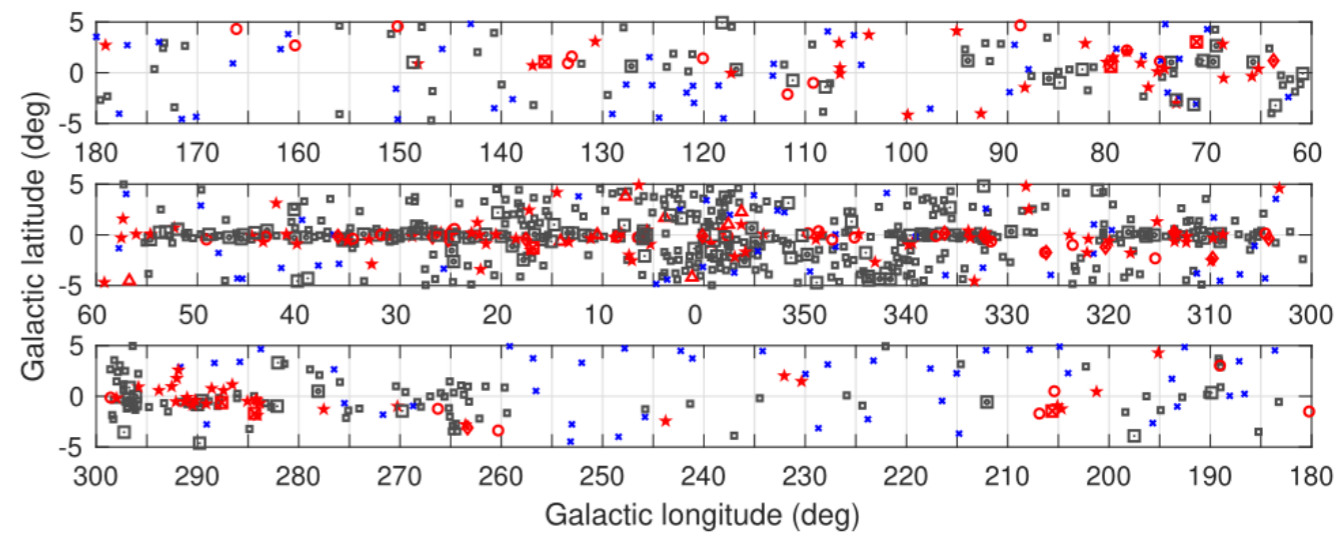
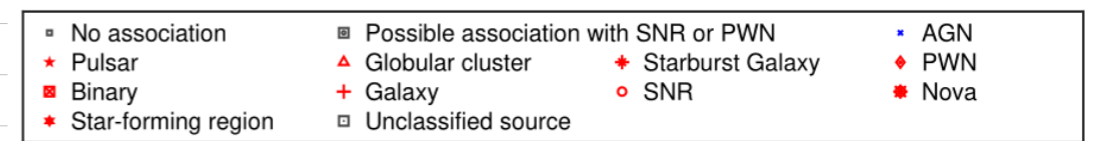
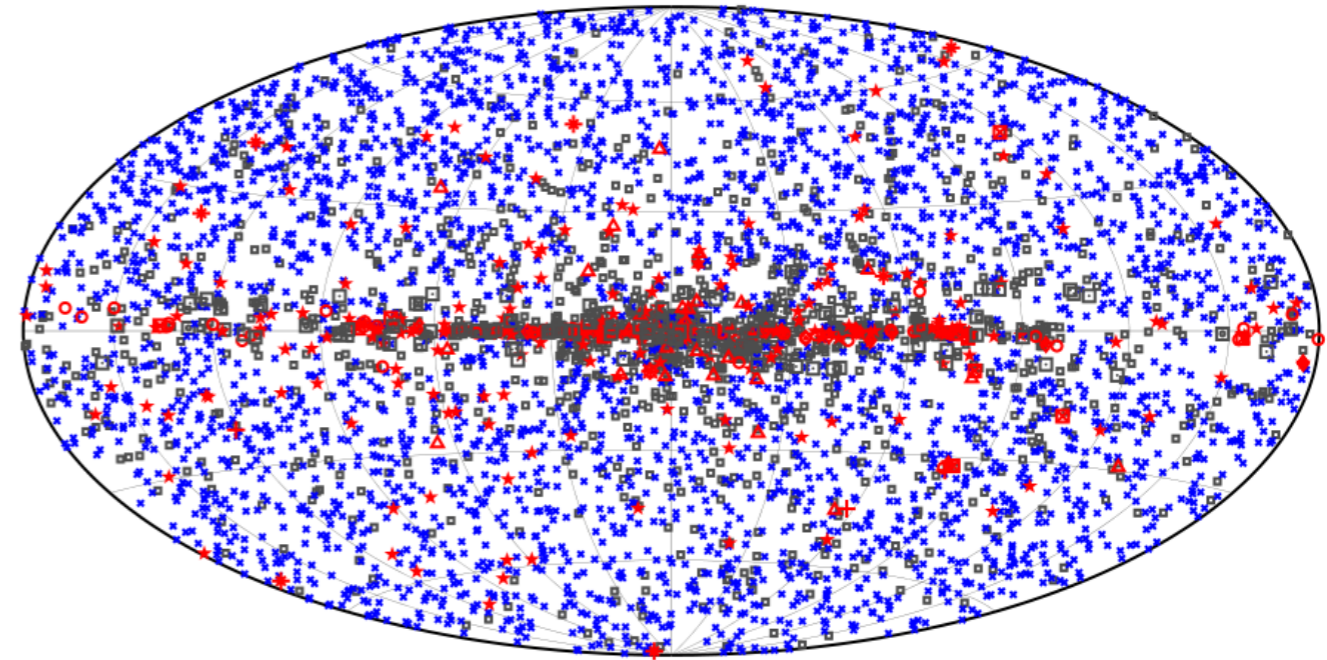
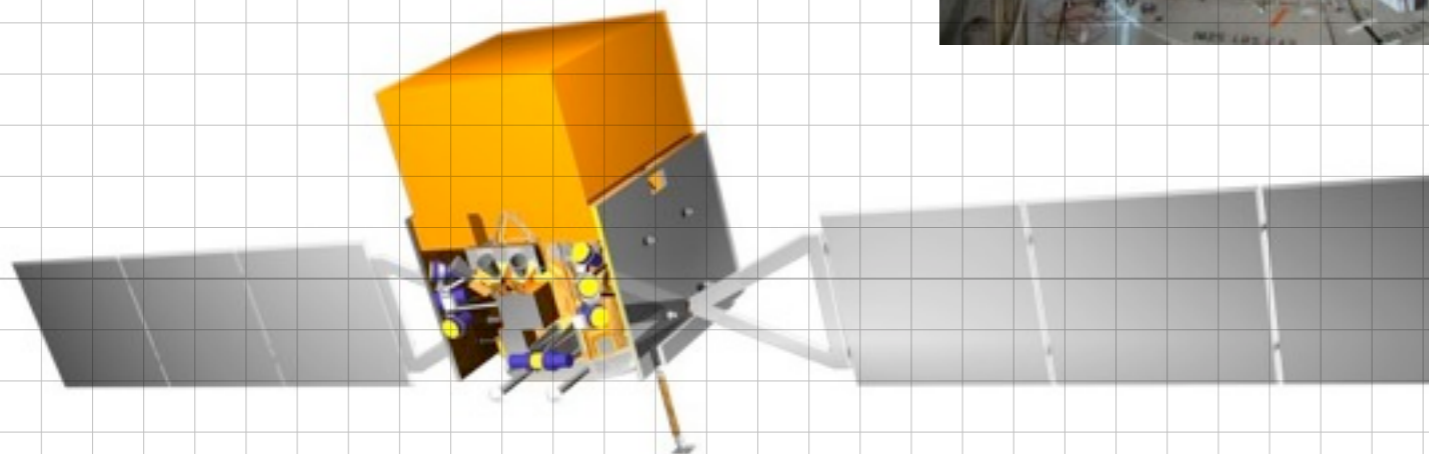
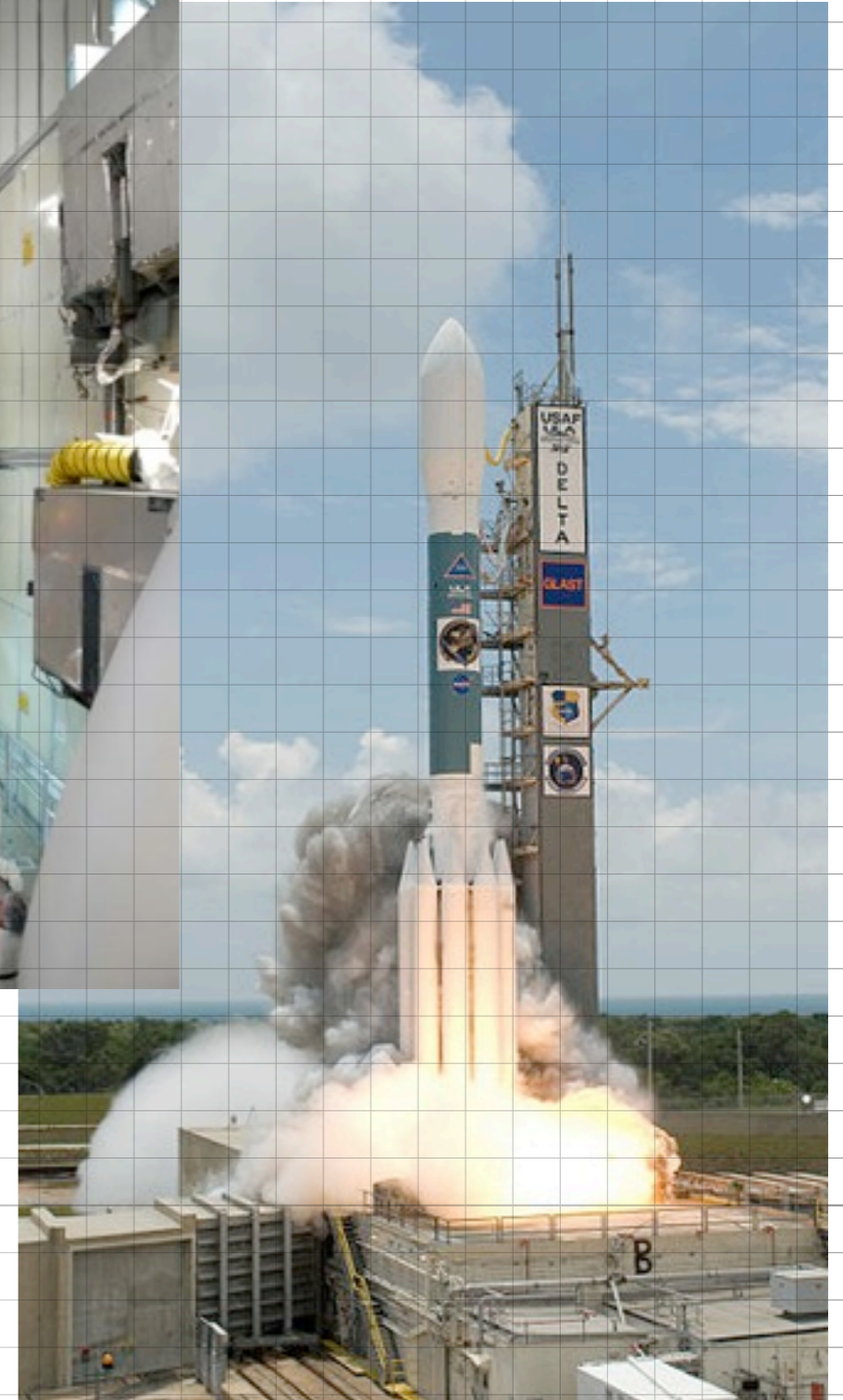
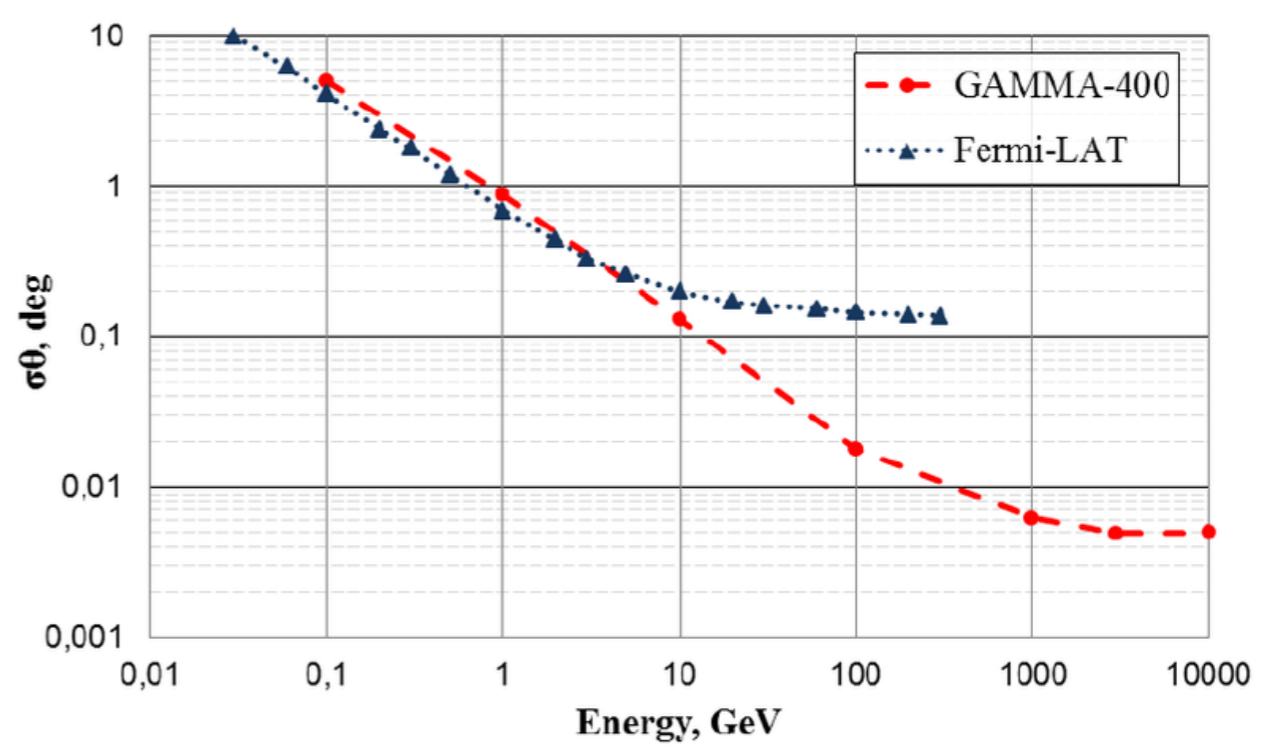
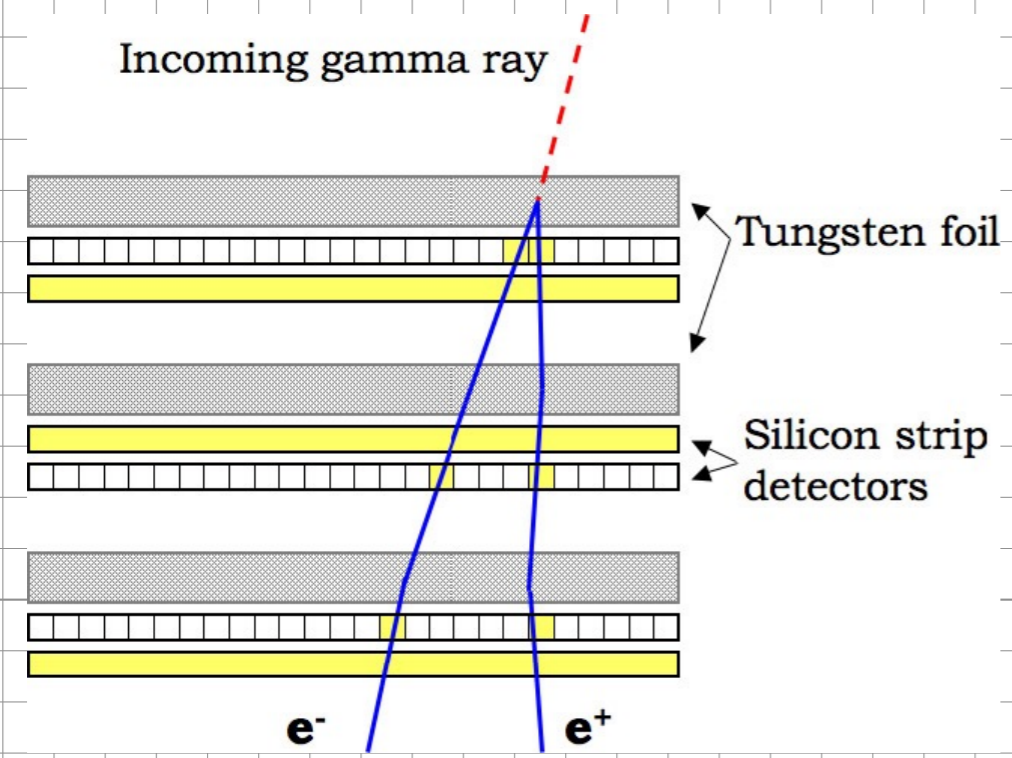
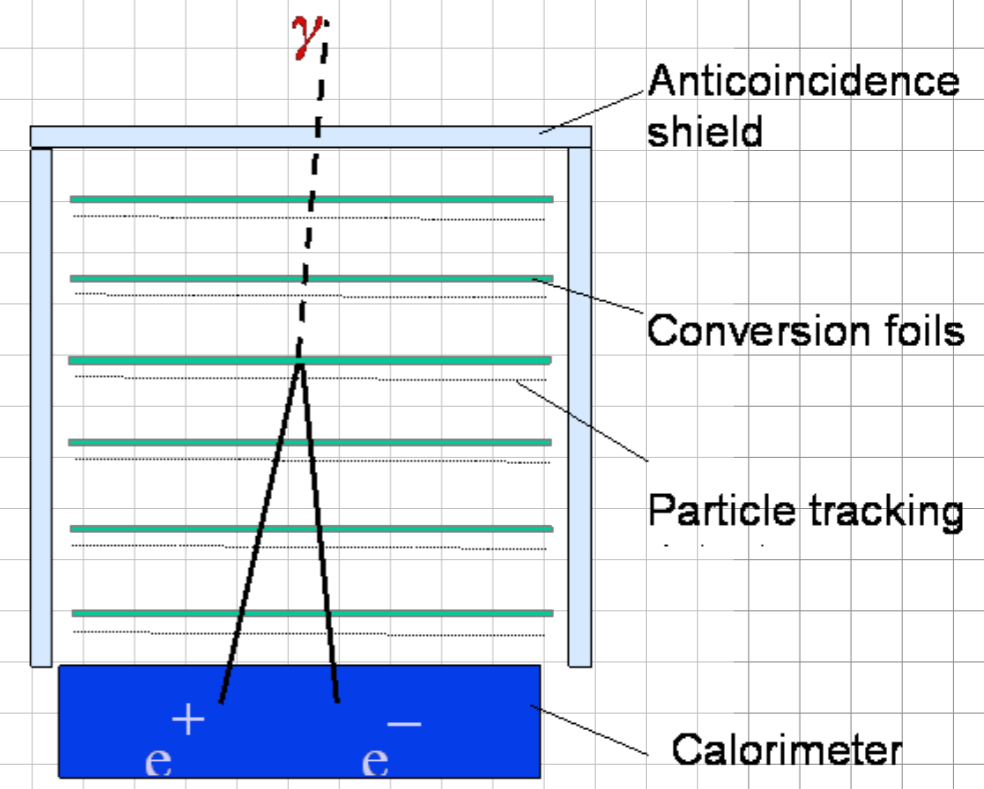
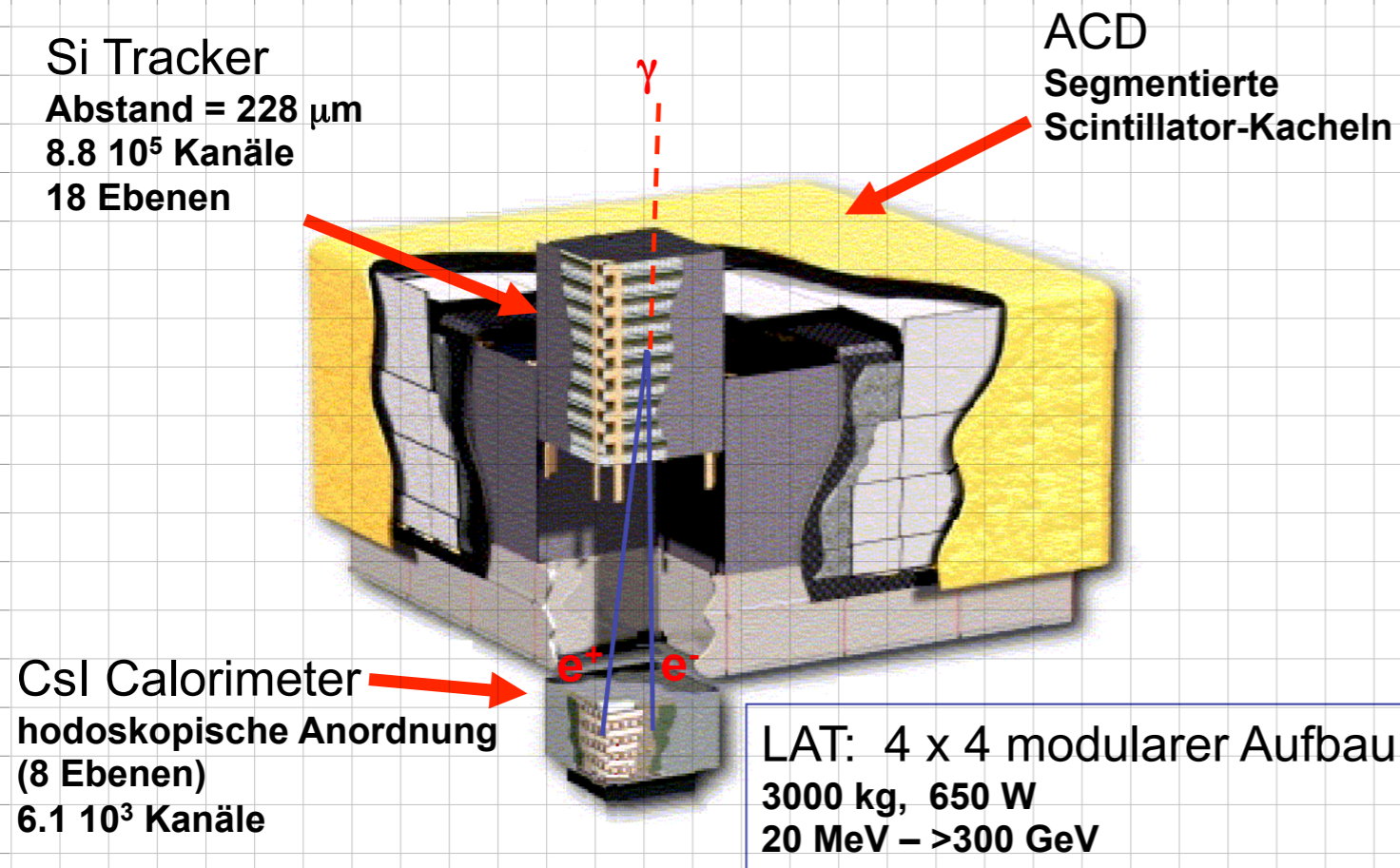


Figure 14. Full sky map (top) and blow-up of the Galactic plane split into three longitude bands (bottom) showing sources by source class (see § 6, no distinction is made between associations and identifications). All AGN classes are plotted with the same blue symbol for simplicity. Other associations to a well-defined class are plotted in red. Unassociated sources and sources associated to counterparts of unknown nature are plotted in black.

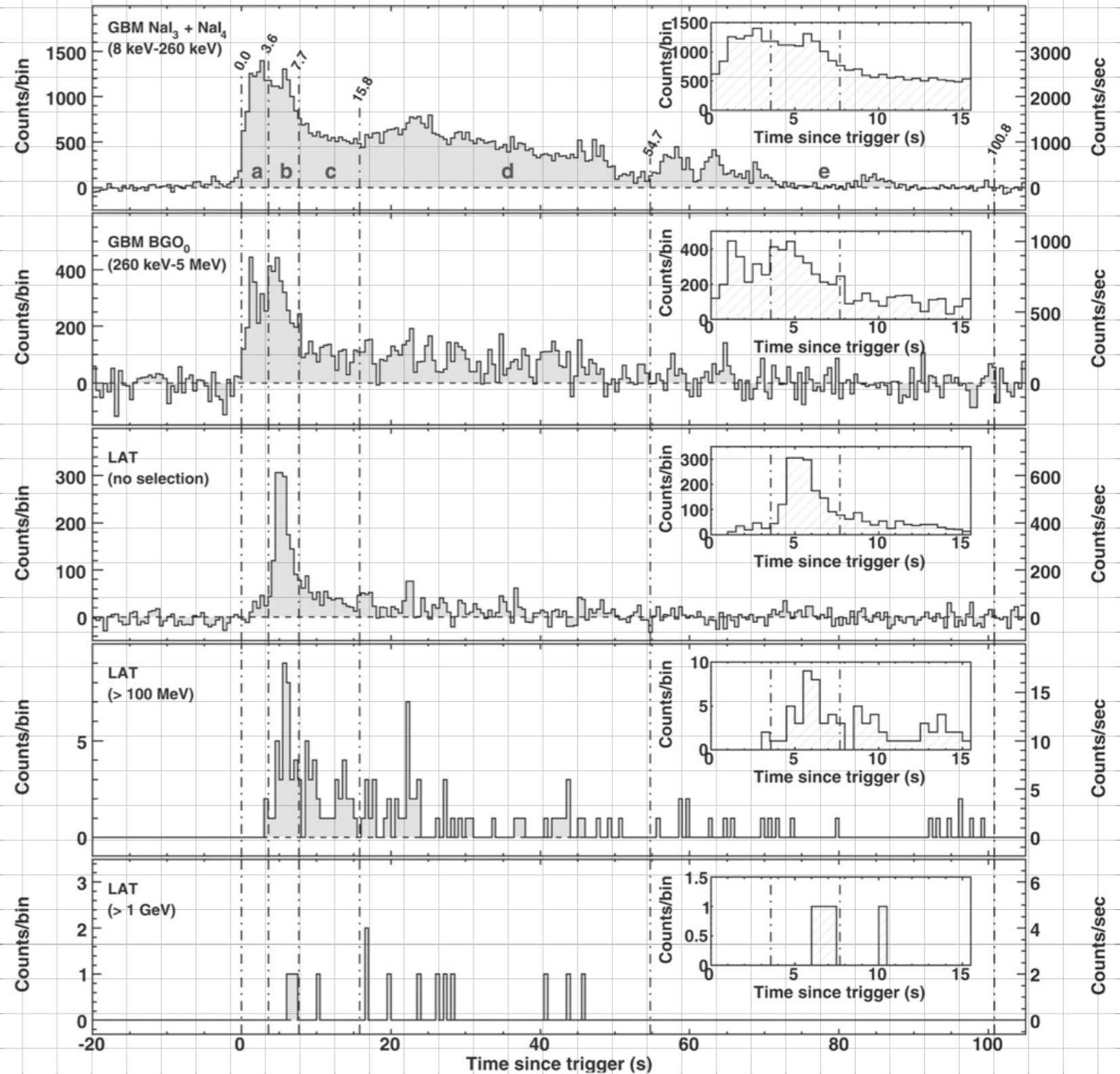
Direkte Messung hochenergetischer Photonen



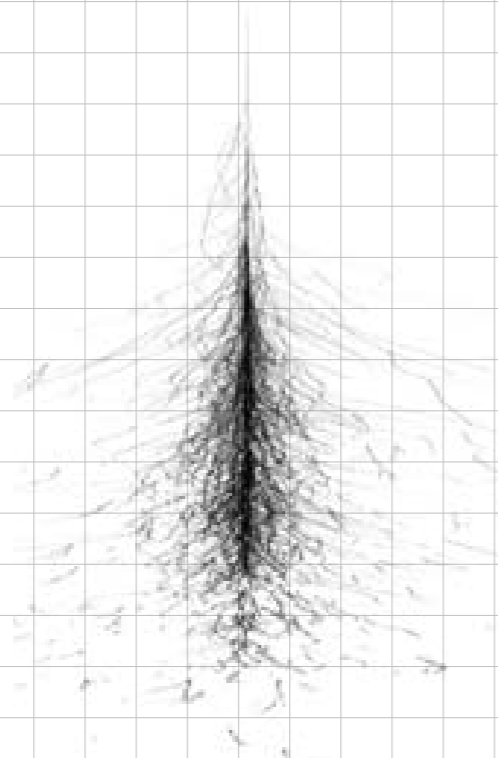


Beispiel: Beobachtung eines Gamma-Strahlen-Blitzes

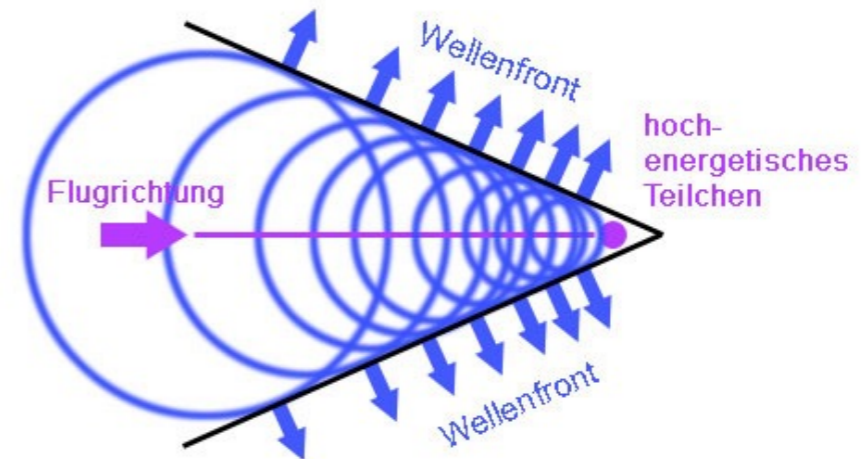
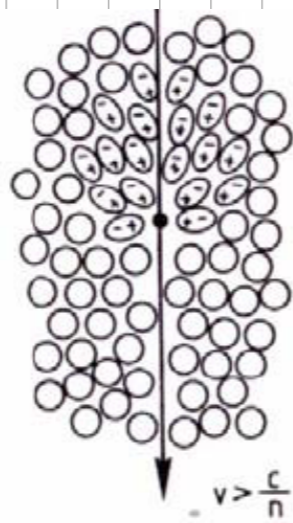
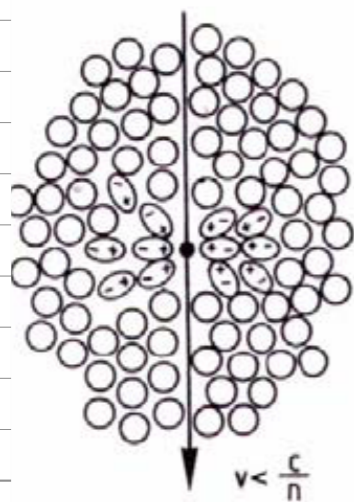
GRB 080916C



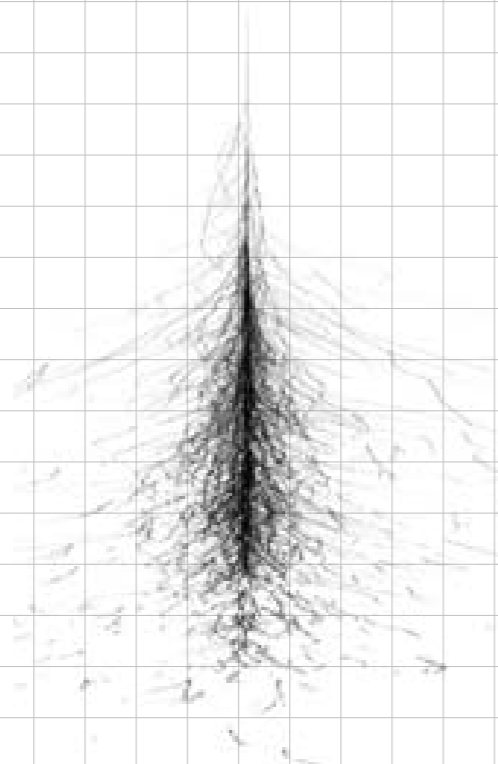
Indirekte Messung: Cherenkov-Teleskope



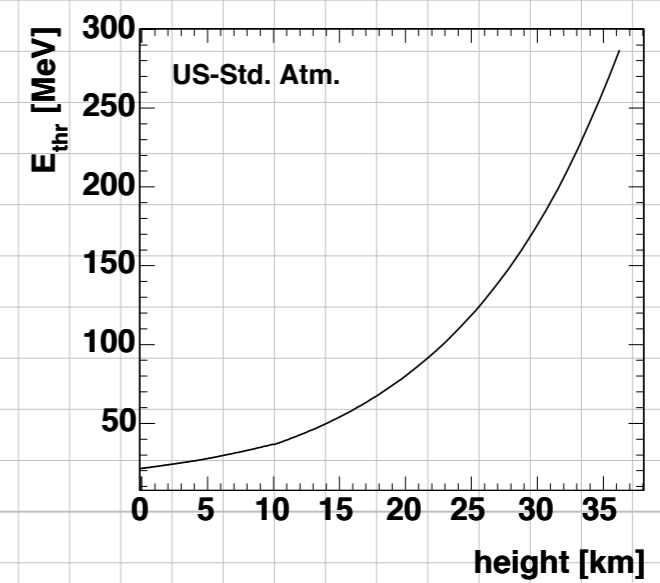
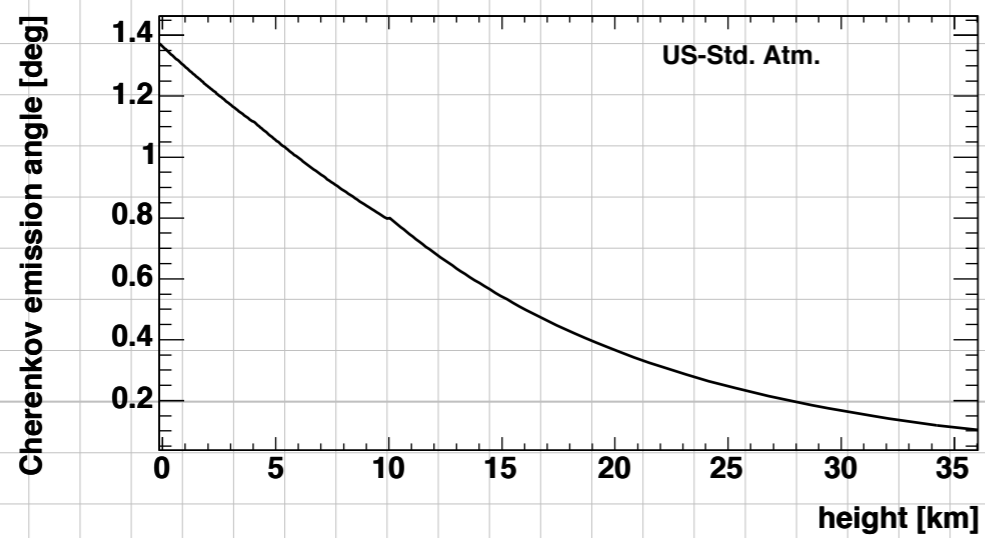
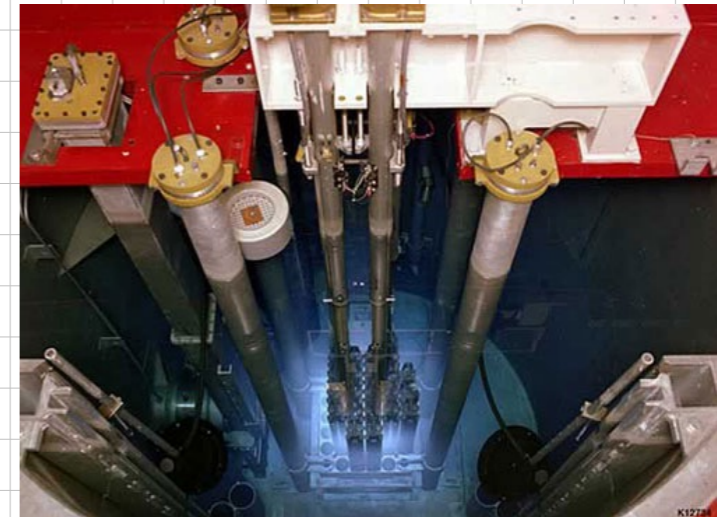
Gamma shower

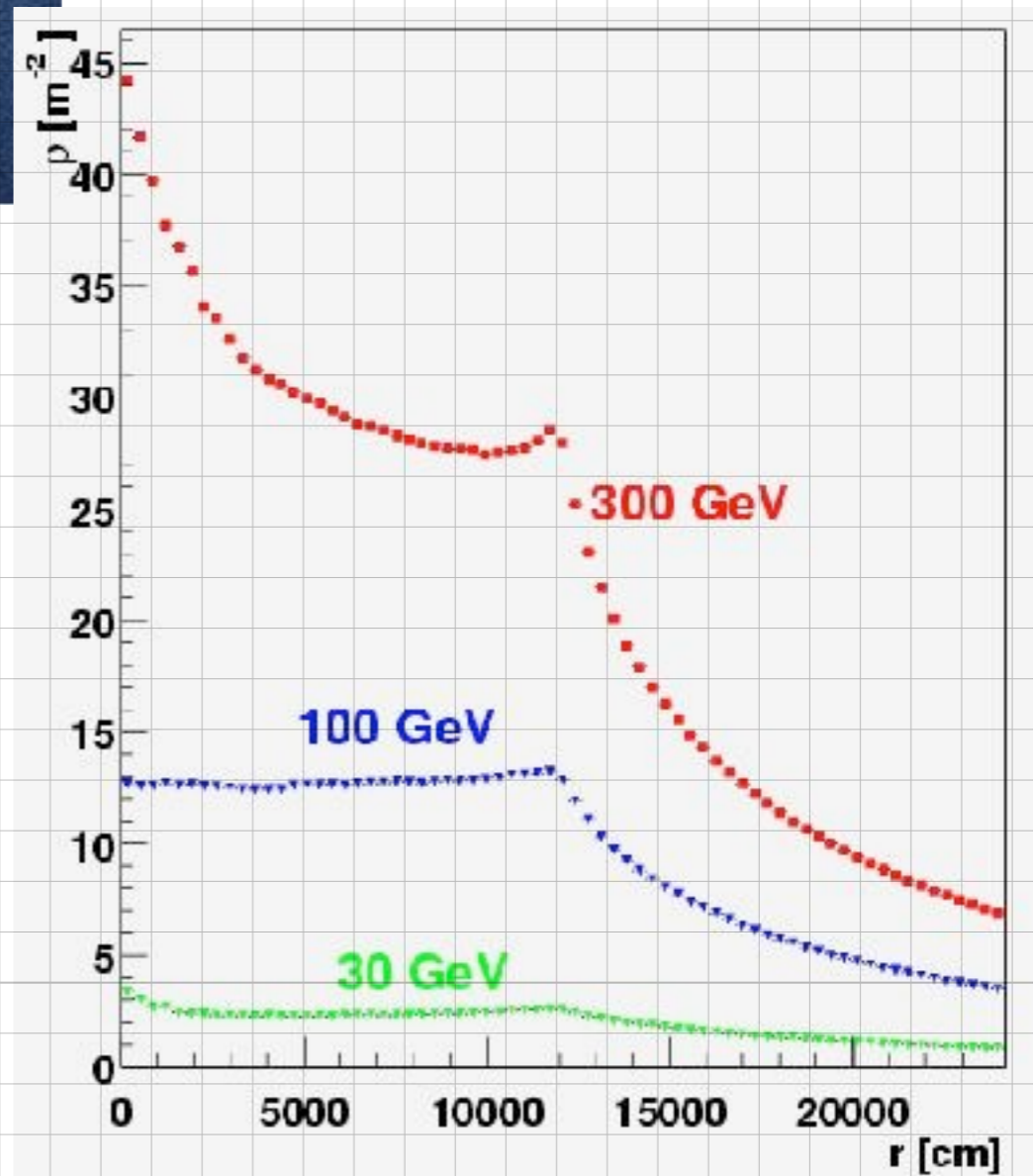
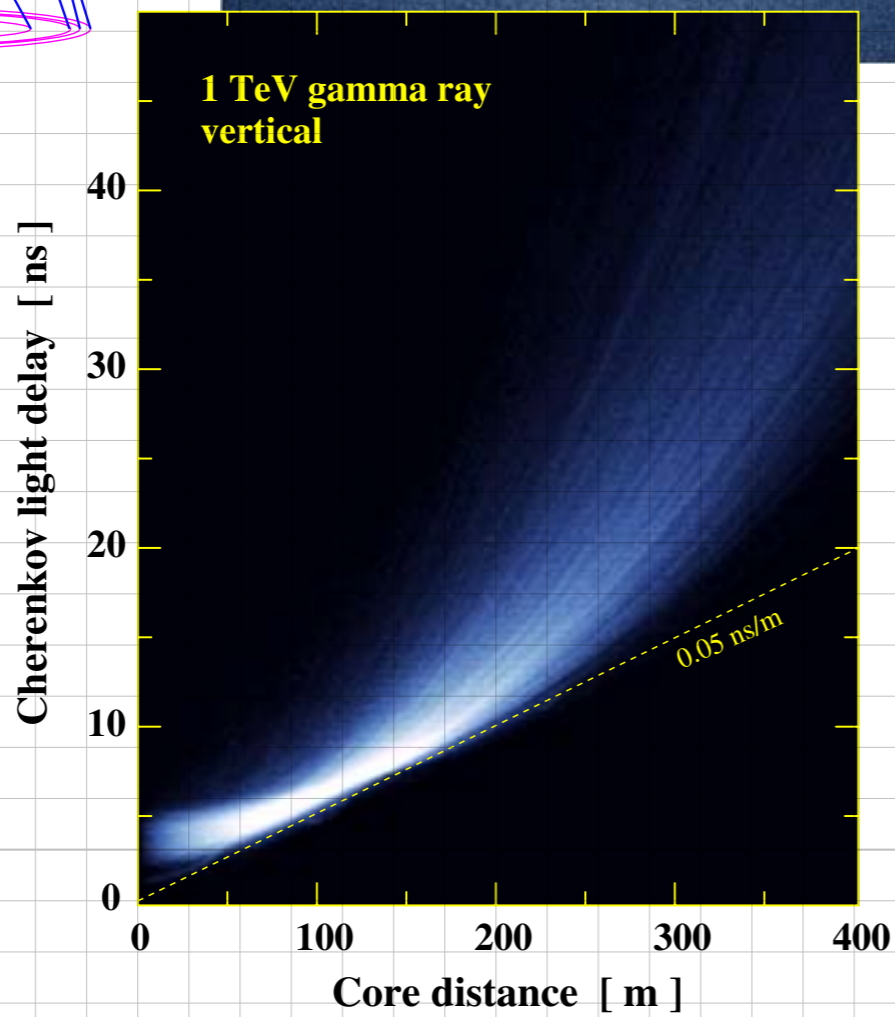
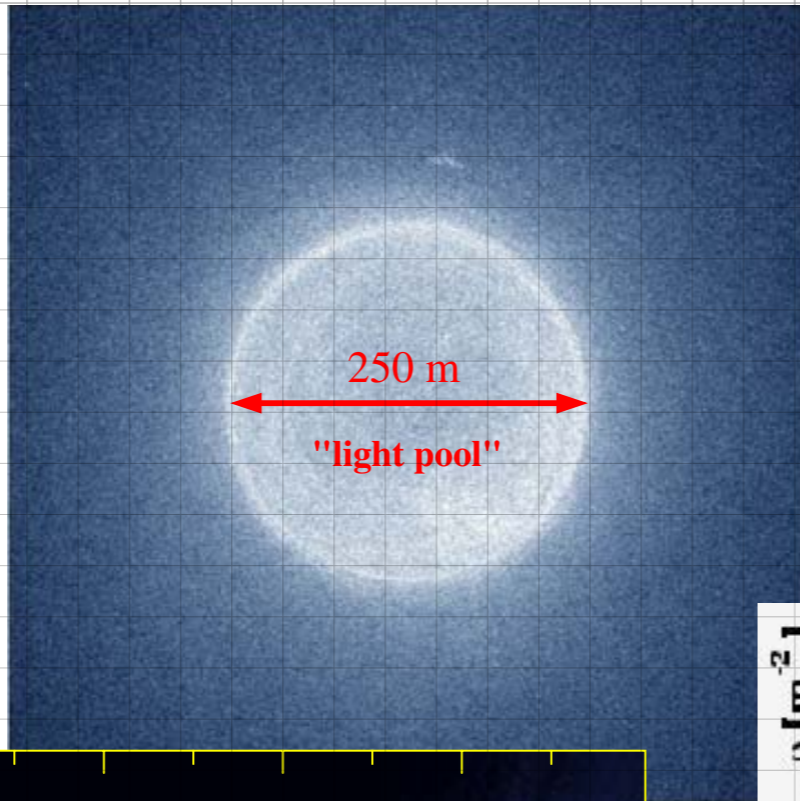
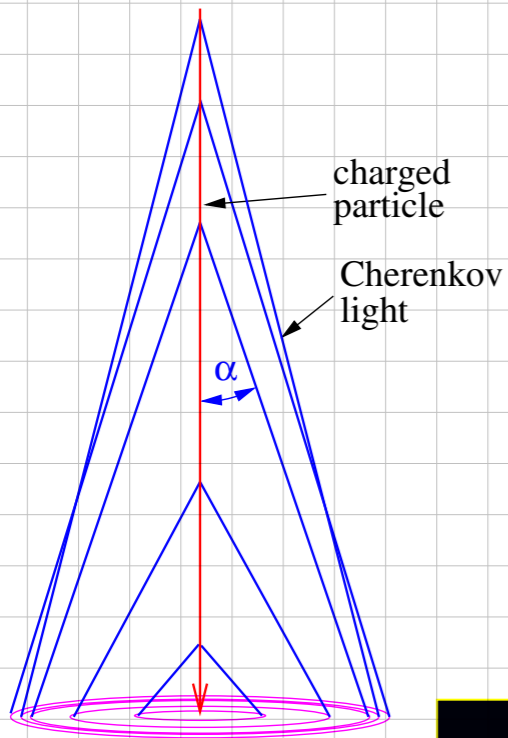


Indirekte Messung: Cherenkov-Teleskope

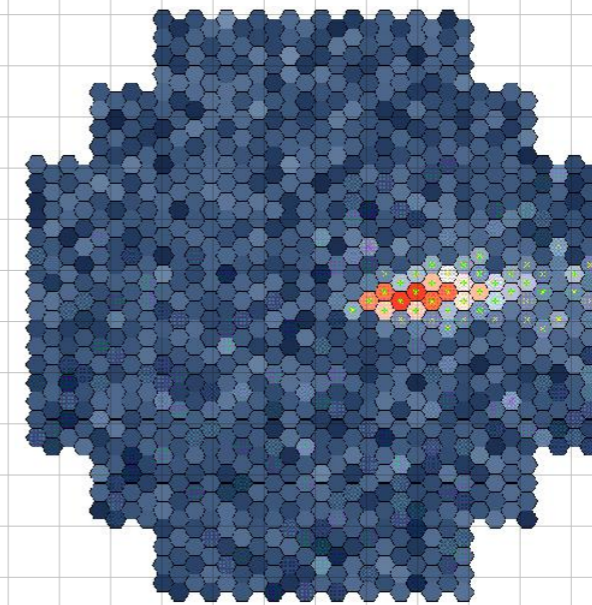
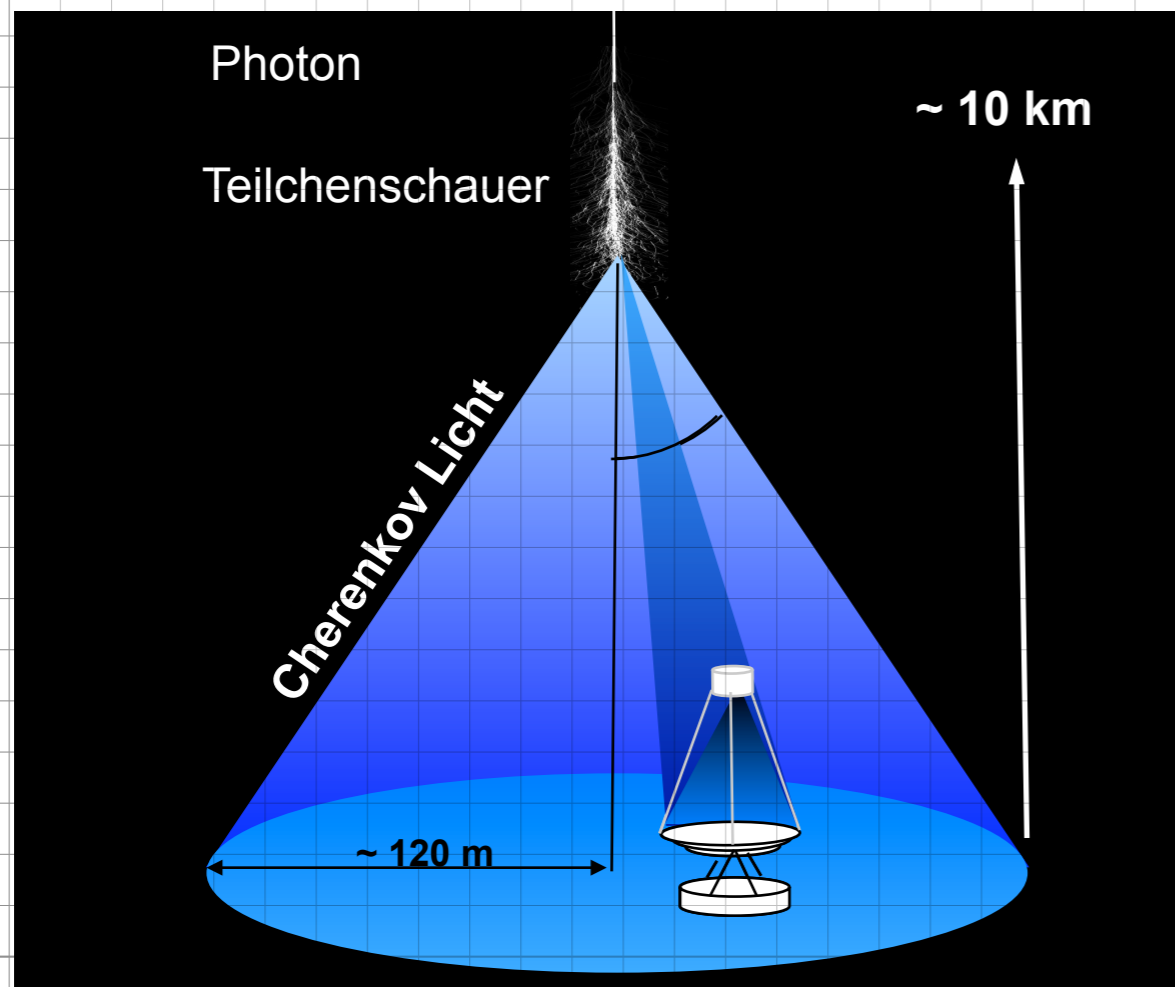


Gamma shower





Primärteilchenrekonstruktion

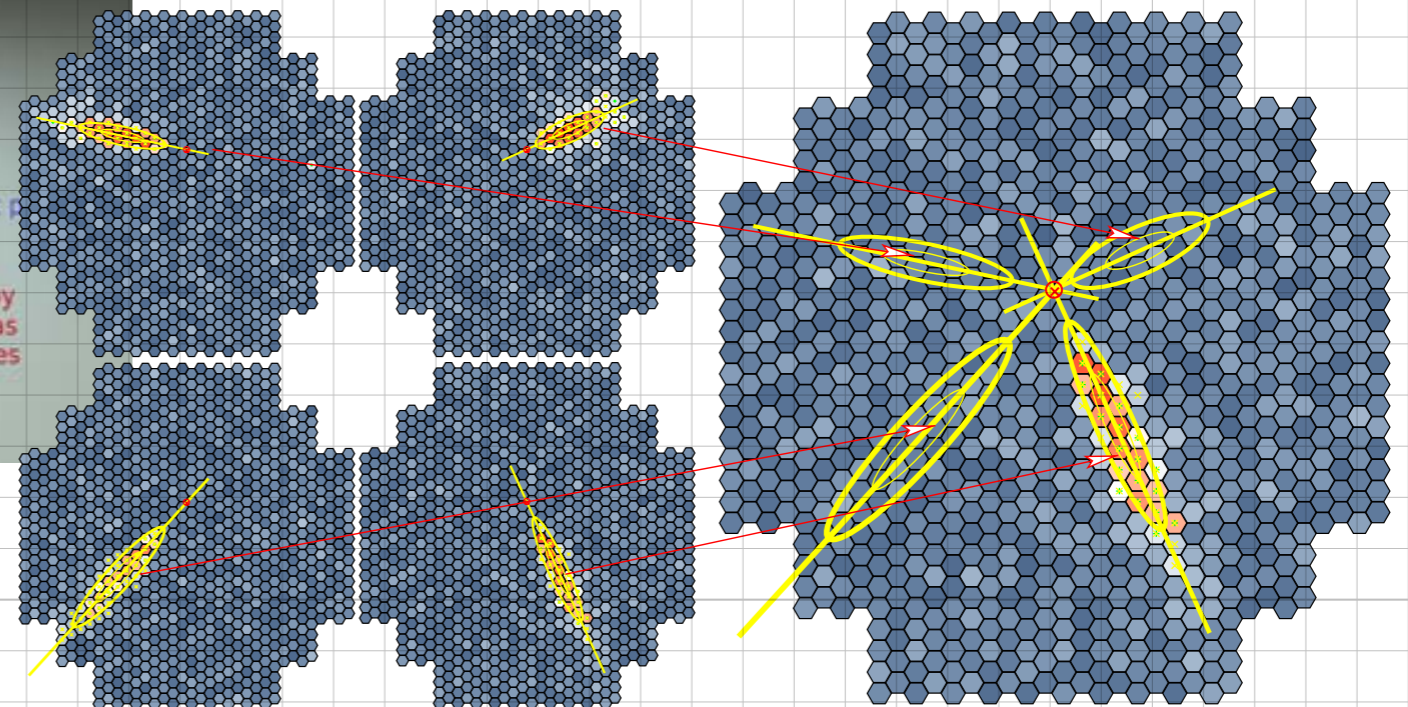
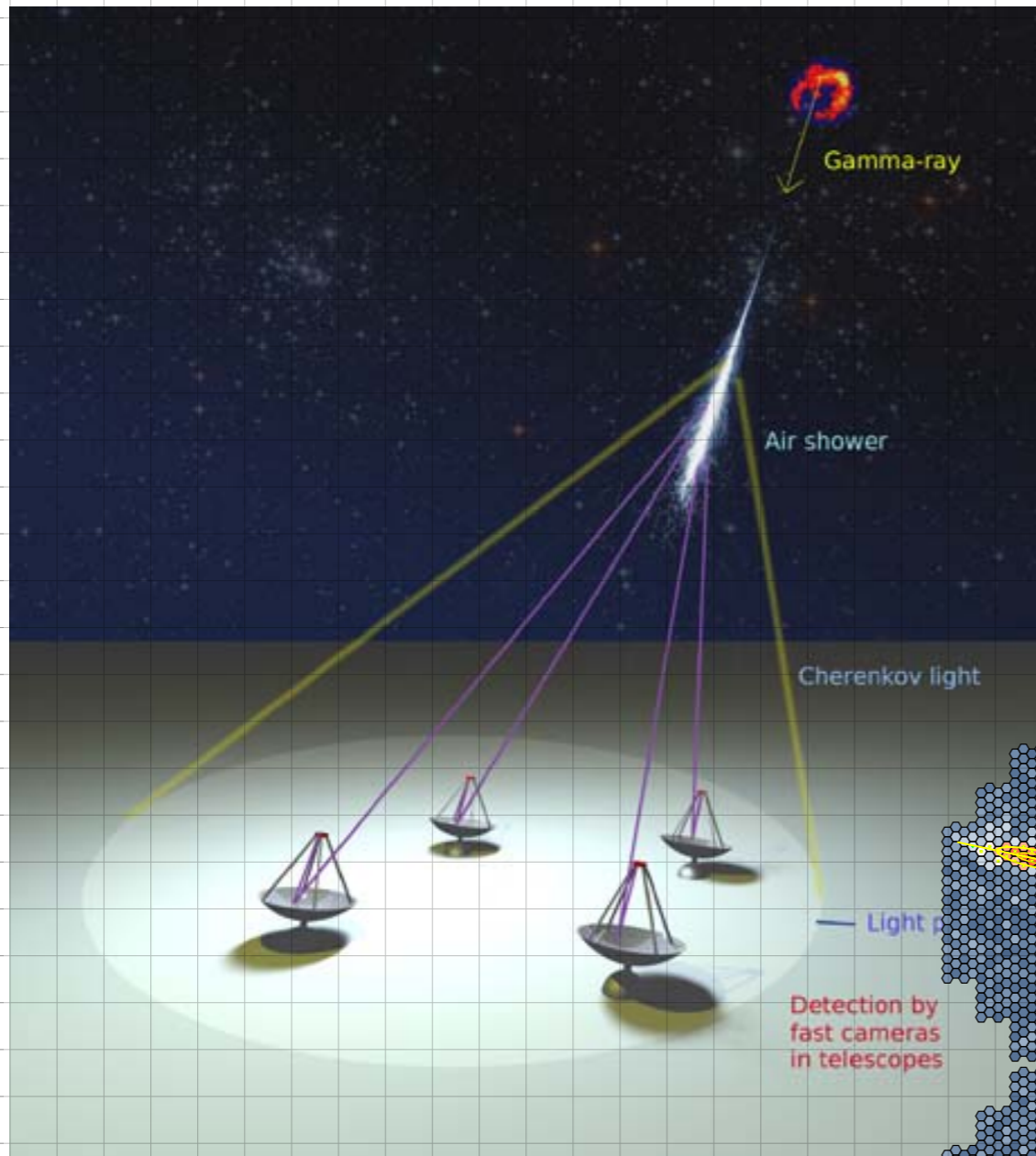


Bildintensität: Energie

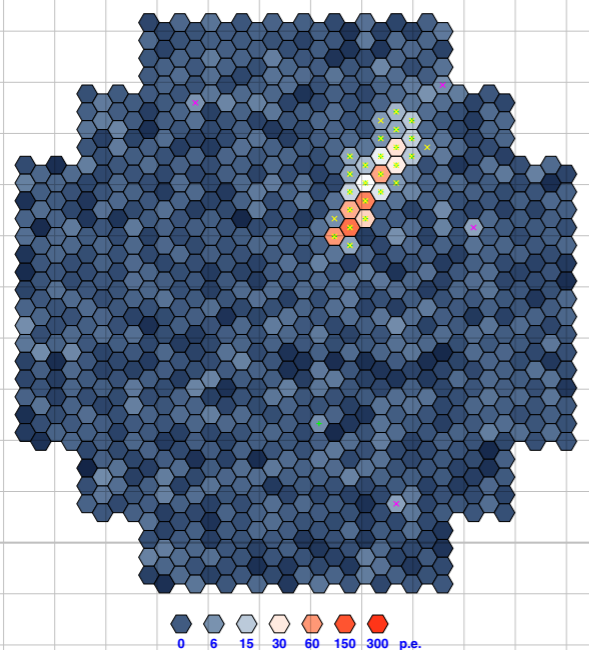
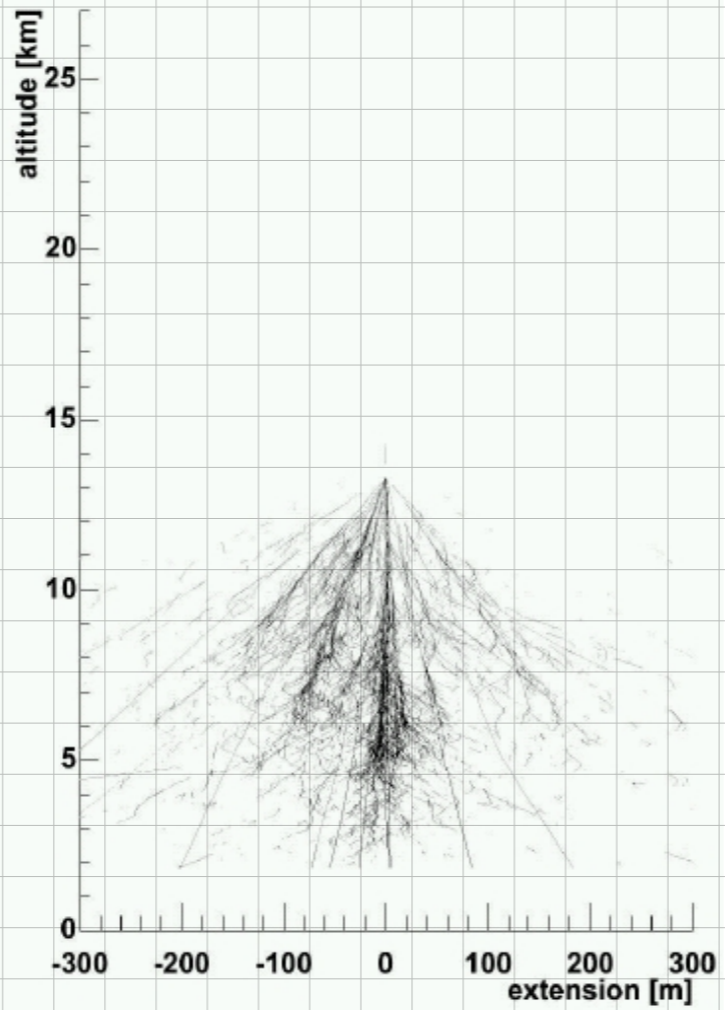
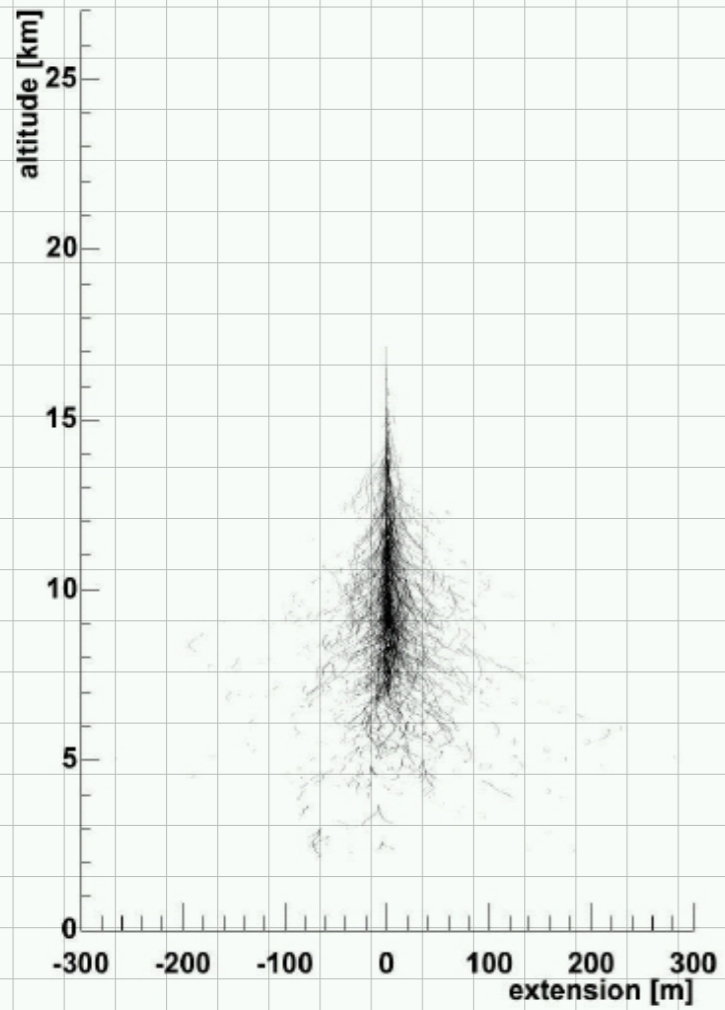
Schnittpunkt: Richtung

Bildform: Primärteilchen

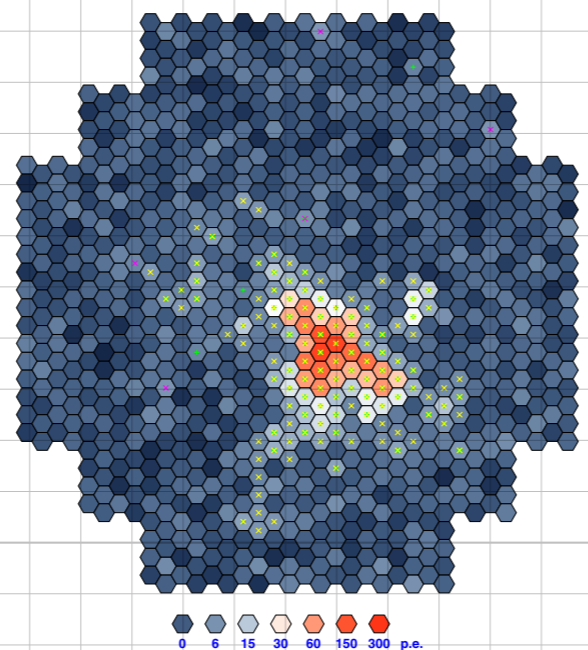
Cherenkov-Teleskope:Ankunftsrichtung



Photon-Hadron-Separation

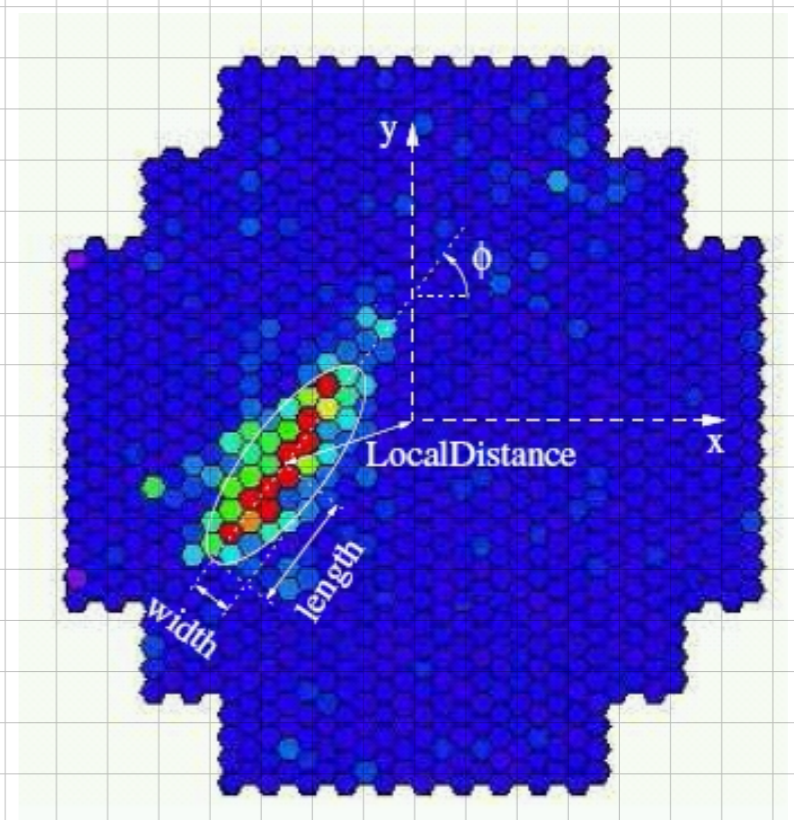


1.0 TeV gamma shower

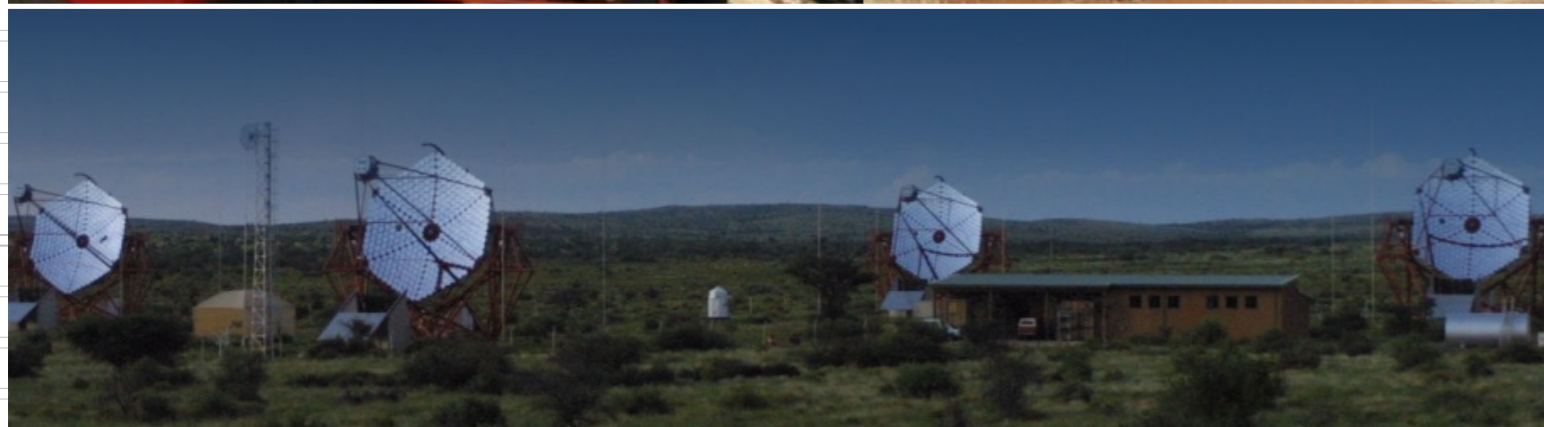
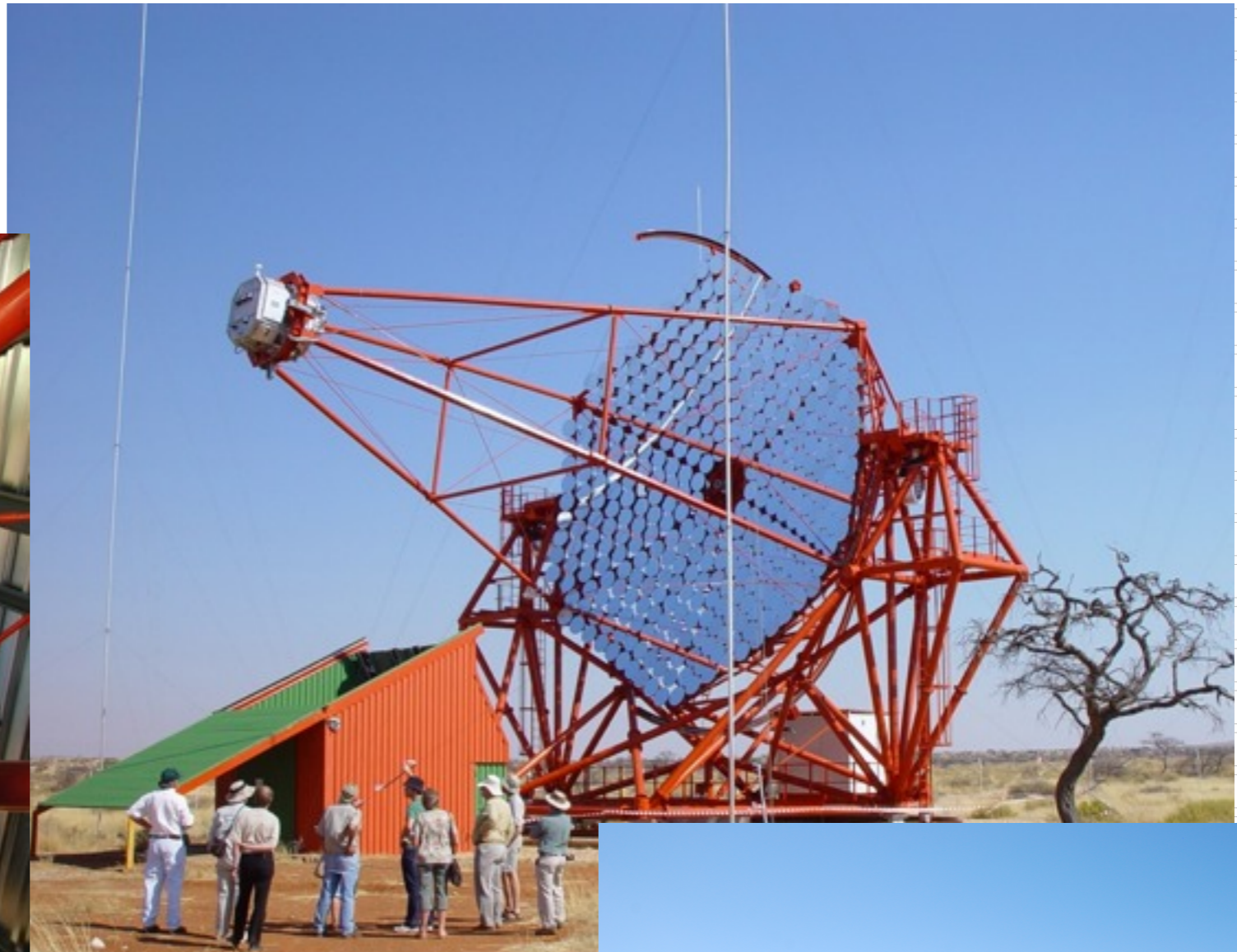


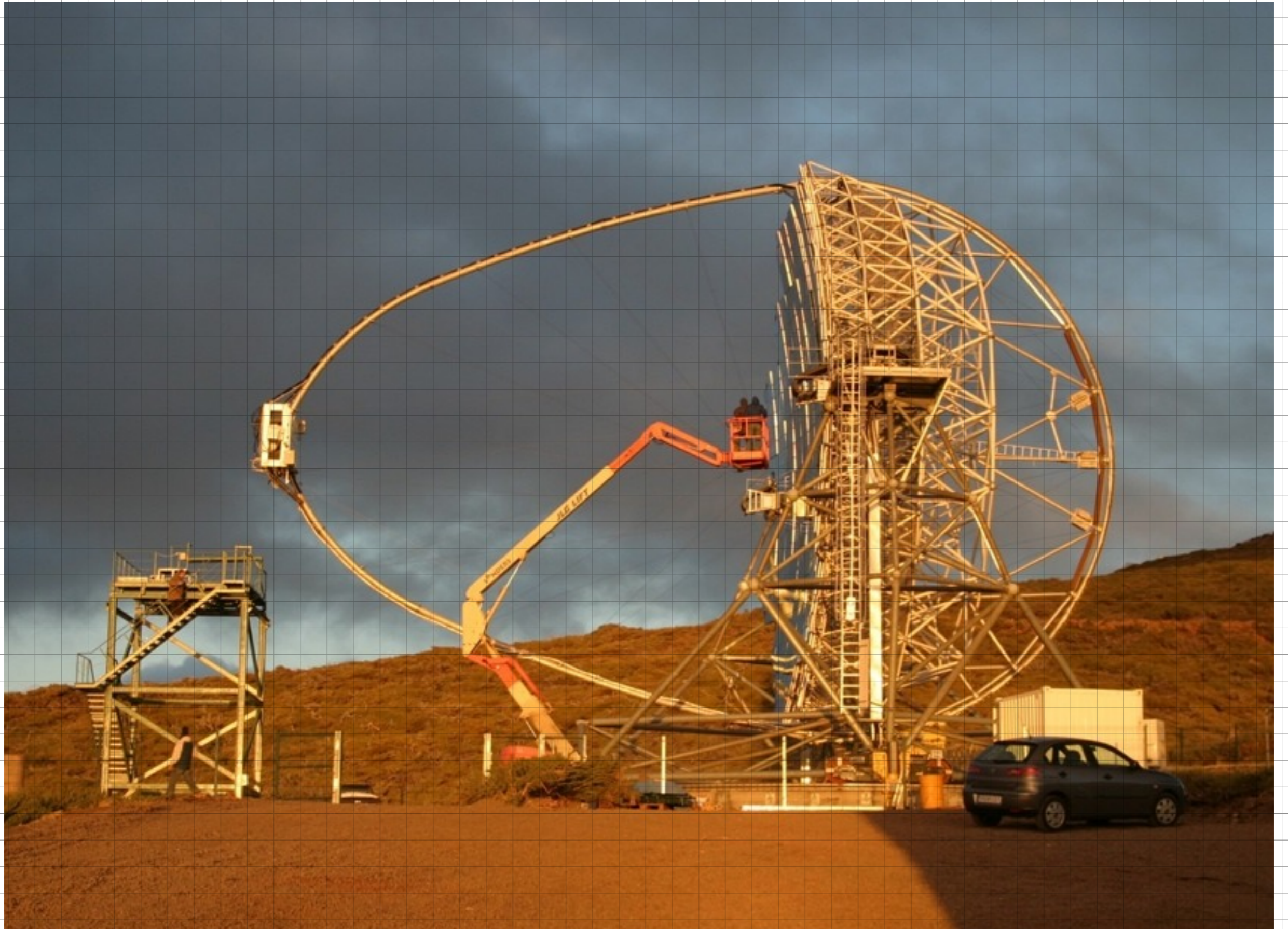
2.6 TeV proton shower

Hillas-Parameter

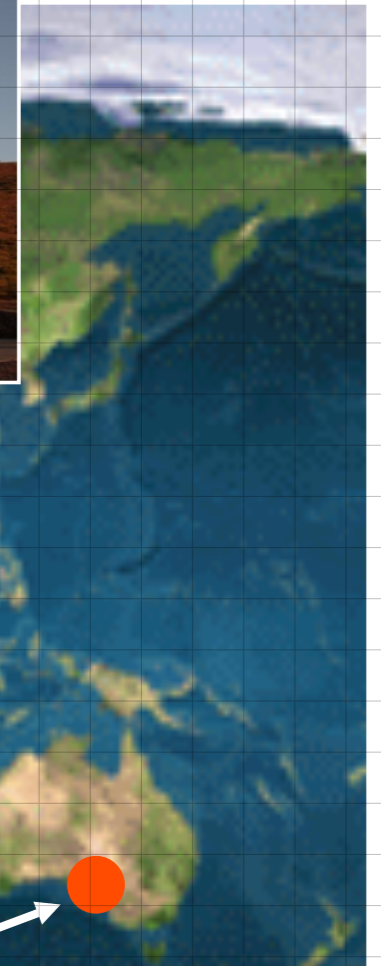


Indirekte Messung: Cherenkov-Teleskope (ii)





Wichtigste Cherenkov-Teleskope

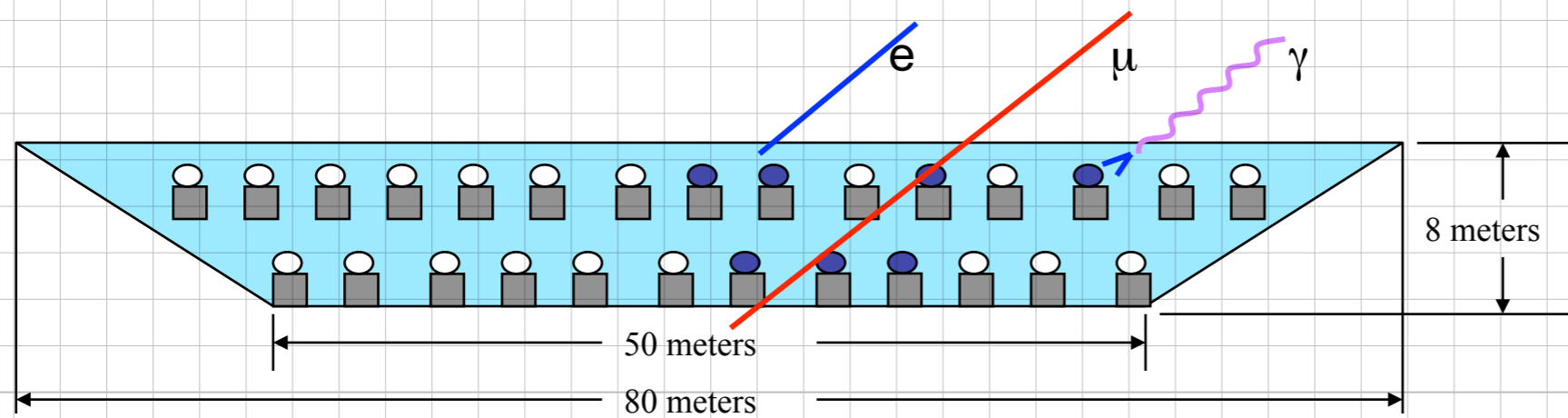
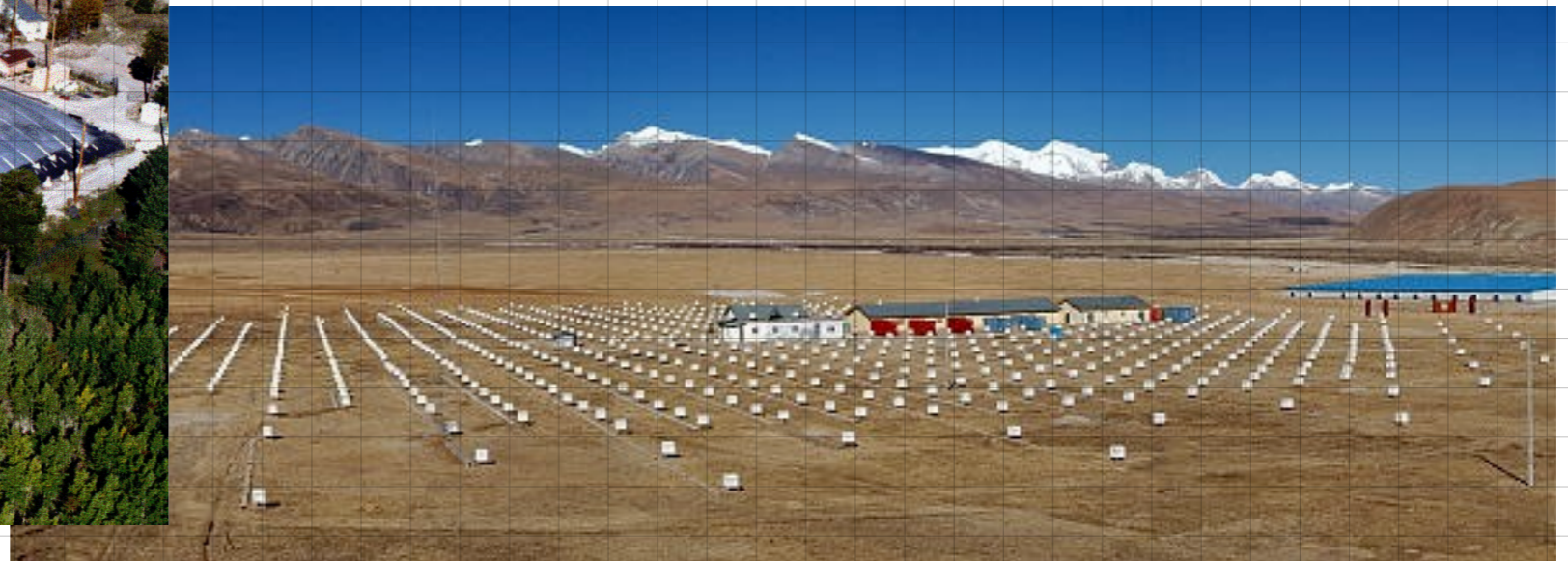


Indirekte Messung: Luftschauerfelder

Milagro, Los Alamos, 2350m



ARGO-YBJ, AS-gamma, Tibet, 4300m



High Altitude Water Cherenkov Experiment (HAWC)



Mapping the Northern Sky in High-Energy Gamma Rays

HAWC Observatory

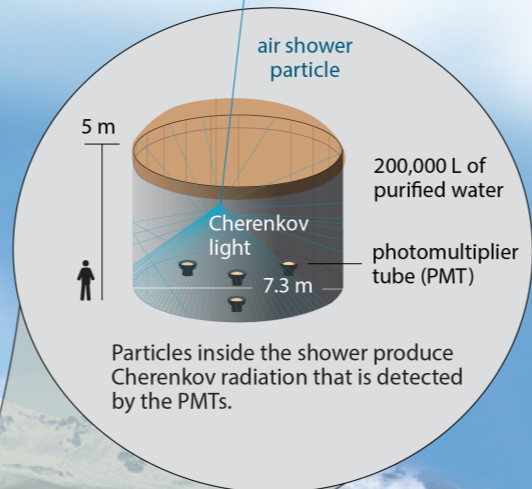
HAWC operates day and night, providing a large field of view for the observation of the highest energy gamma rays.



Pico de Orizaba (5,626 m)

Water Cherenkov tank

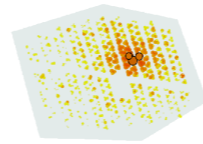
HAWC comprises an array of 300 tanks that record the particles created in gamma-ray and cosmic-ray showers.



Gamma rays vs cosmic rays

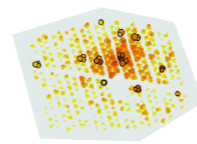
HAWC selects gamma rays from among a much more abundant background of cosmic rays.

gamma-ray shower



"hot" spots concentrate around the core

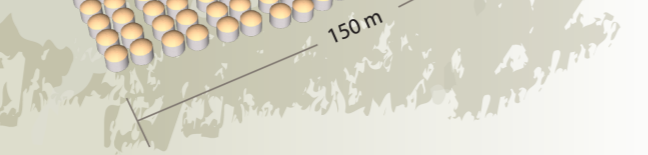
cosmic-ray shower



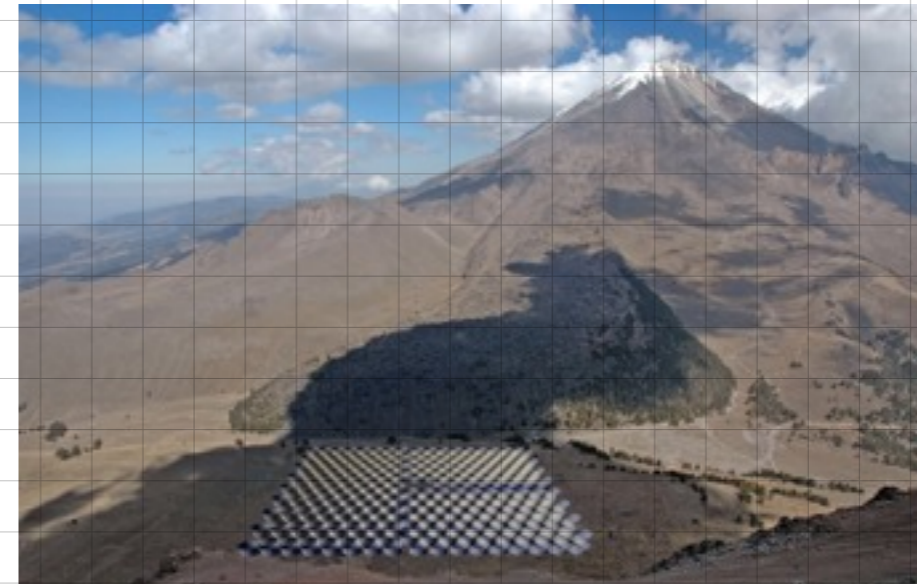
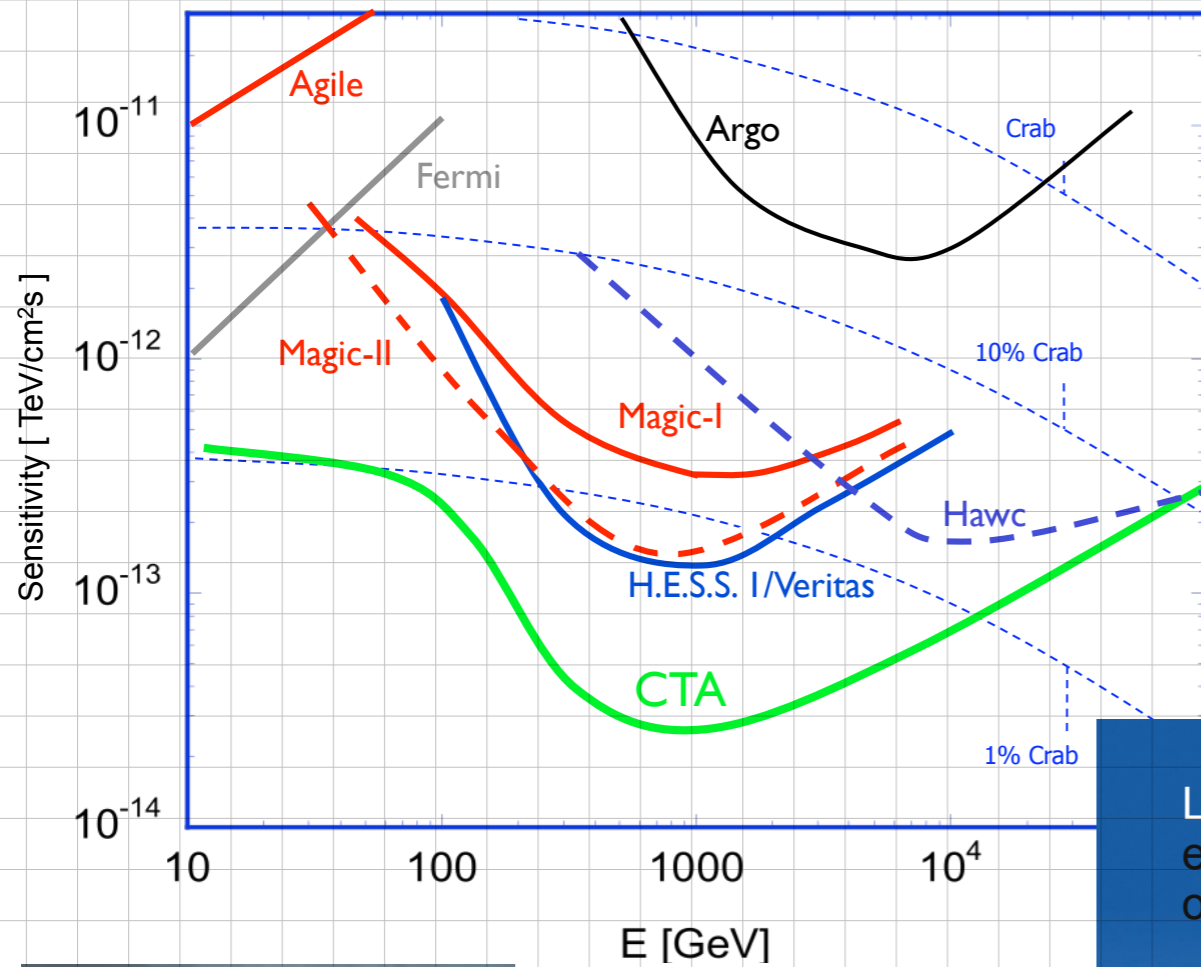
"hot" spots are more dispersed



HAWC is located at 4,100 m above sea level, covering an area of 20,000 m².



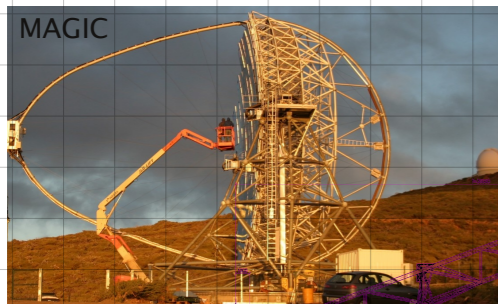
Ausblick



Low-energy section
energy threshold
of some 10 GeV

Core array:
mCrab sensitivity
in the 100 GeV–10 TeV
domain

High-energy section
10 km² area at
multi-TeV energies



identical
scale
HESS I



HESS II
under construction

