Lecture: Gamma astronomy
2019

Lecture program:

- Introduction
- Processes and source models
- Electromagnetic cascades in the atmosphere
- Detection techniques: satellites, Cherenkov telescopes and EAS

Literature:

1. M. Kachelriess, *Lecture notes on high energy cosmic rays*, (2008) arXiv:0801.4376
2. *Insights Into the High-Energy Gamma-ray Emission of Markarian 501 from Extensive Multifrequency Observations in the Fermi Era*, Astrophys. J. 727 (2011) 129 & arXiv:1011.5260
3. G. Sinnis, *Air shower detectors in gamma-ray astronomy*, New J. Phys. **11** (2009) 055007.

Material for the lecture:

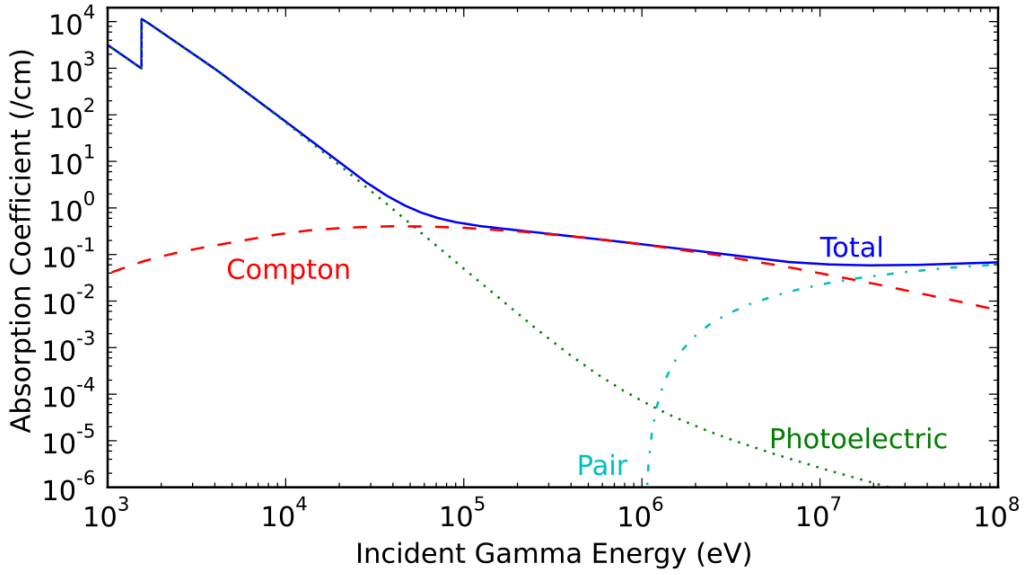

Figure 1: Absorption coefficient of gamma-rays in matter as function of their incident energy. Figure from Wikipedia.

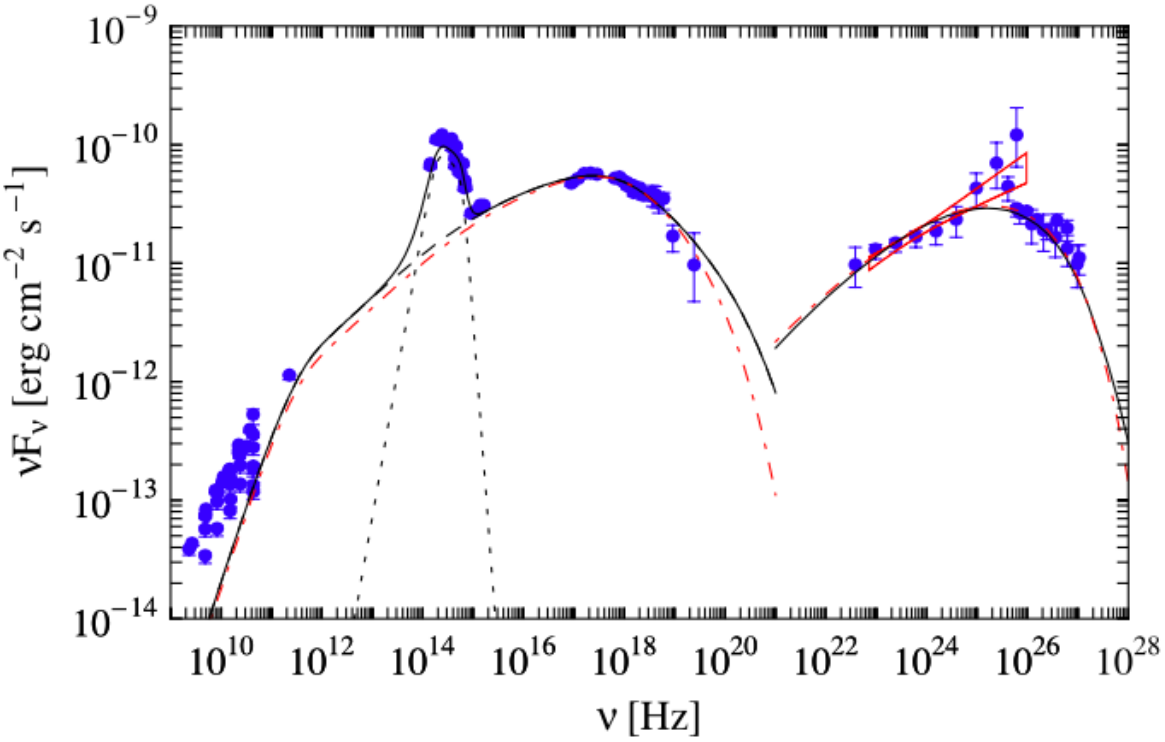

Figure 2: Emission spectrum of Markarian Mrk 501 from a multifrequency campaing. SSC (Synchrotron self-Compton) model fits: lower bump Synchrotron emission, higher bump self-Compton and dotted black: starlight emission of the host galaxy. Figure from Fermi-LAT, MAGIC, Veritas, GASP-WEBT consortium and multi-wavelength partners (2011) [2].

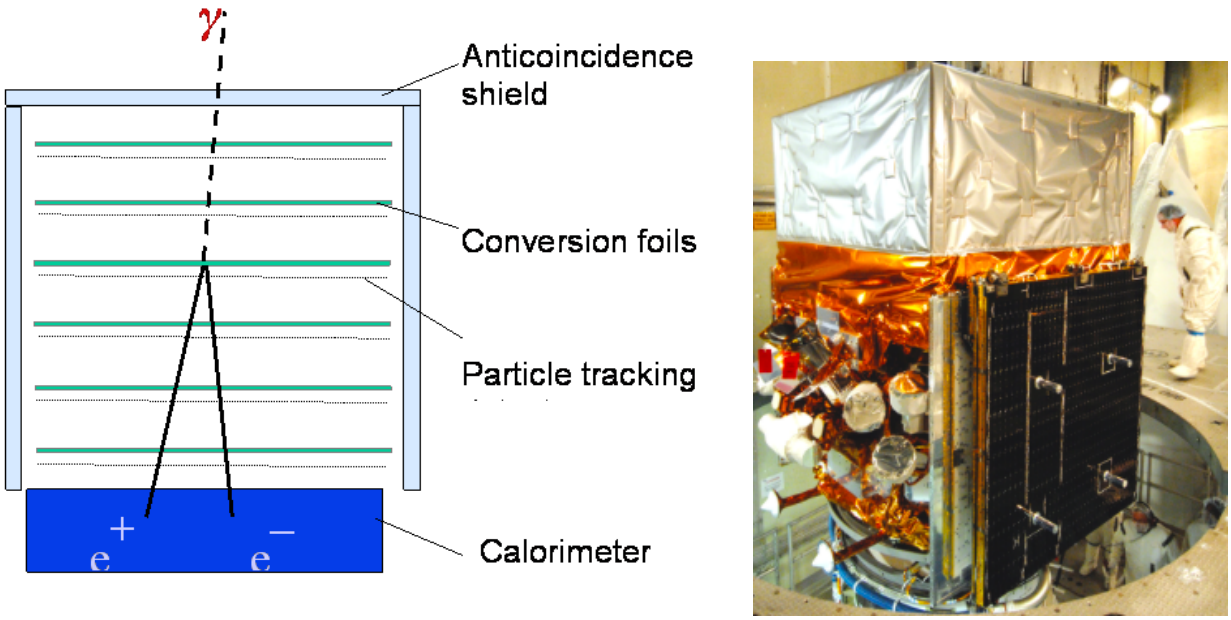

Figure 3: (Left) Scheme of the the FermiLAT instrument from Fermi homepage. (Left) Picture of the Fermi spacecraft shortly before launch. Images from the Fermi homepage

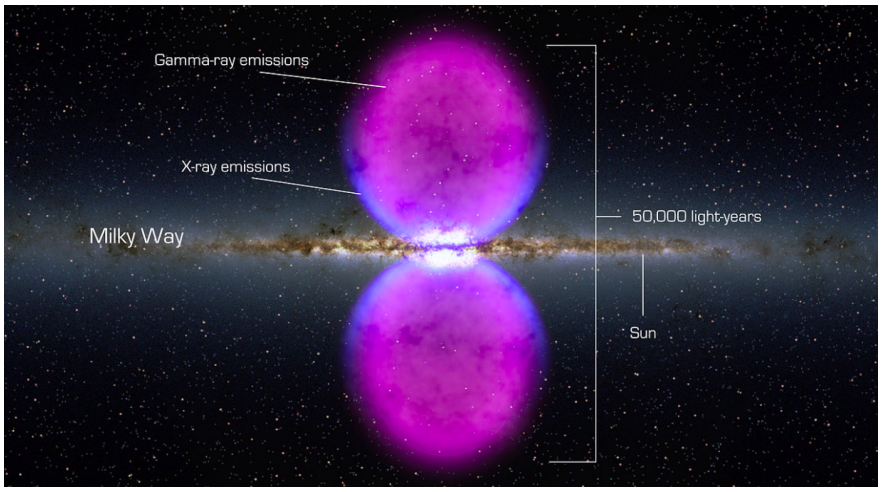

Figure 4: Artist representation of the Fermi bubbles.

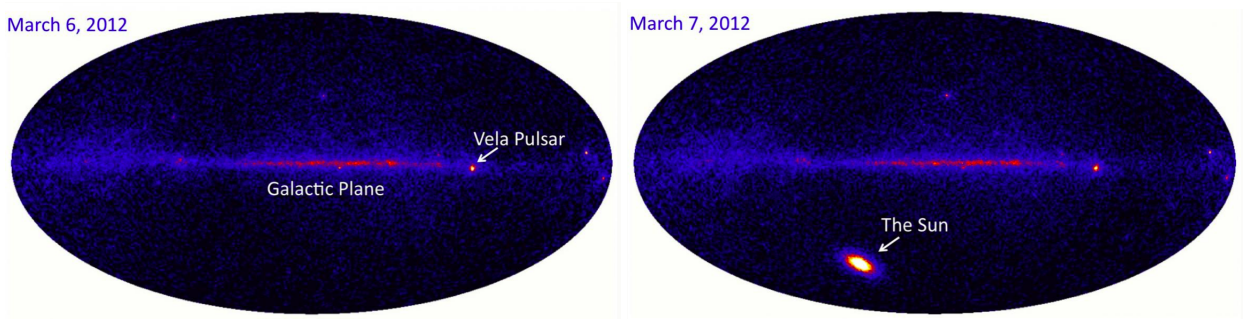

Figure 5: Fermi measurement of a solar flare. Sky image on March 6th and on March 7th, 2012 when the flare occurred.

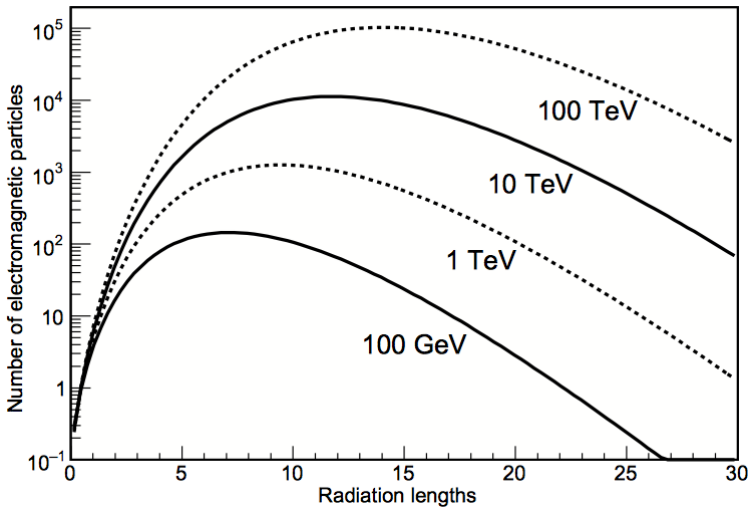

Figure 6: The longitudinal development of an EAS (approximation) for several different primary gamma-ray energies. The x-axis is the atmospheric depth expressed as the number of radiation lengths. The y-axis gives the number of electromagnetic particles in the air shower. Sea level is $\sim$ 28 radiation lengths of atmosphere, 2600 m above sea level is $\sim$ 20 radiation lengths, 4300 m above sea level is $\sim$ 16.5 radiation lengths, and 5200 m above sea level is $\sim$ 14.7 radiation lengths. Figure from [3] above.

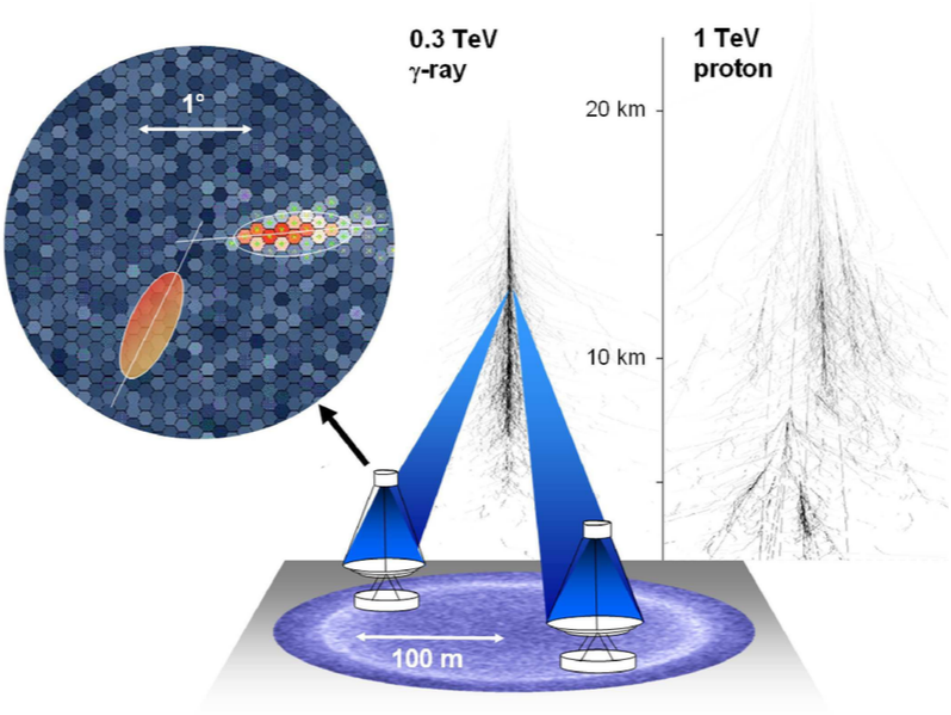

Figure 7: Imaging Cherenkov telescope. Figure from Hinton & Hofmann, Annu. Rev. Astrophys. 47 (2009) 523.

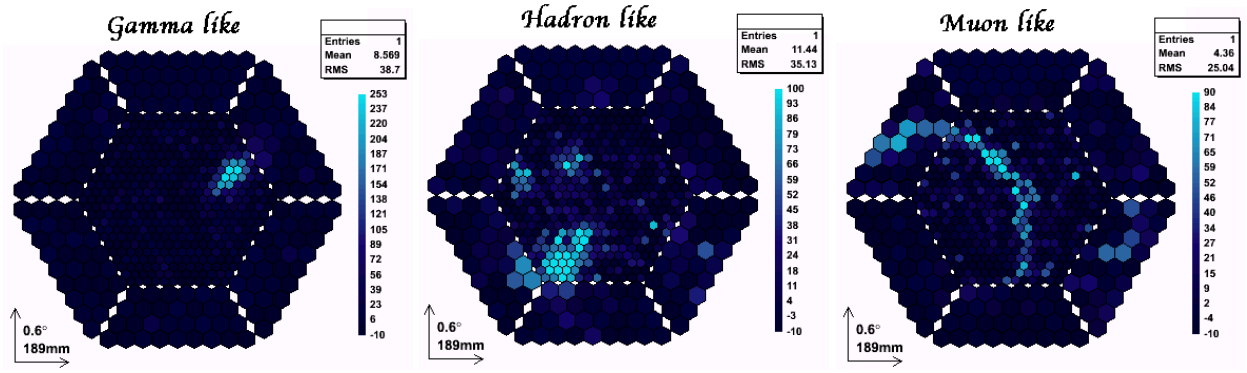

Figure 8: Examples of signals in one of the MAGIC Chrenkov telescopes. Figures from the MAGIC Collaboration (homepage).

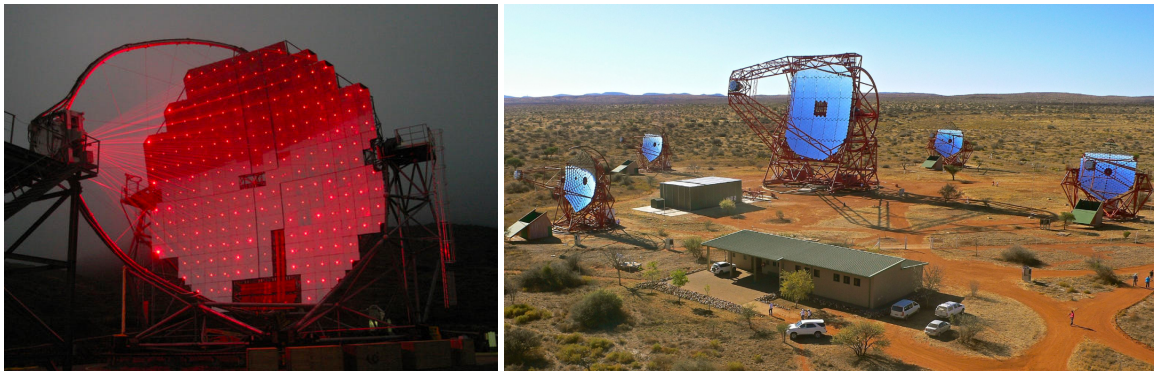

Figure 9: Fotographs of one of the MAGIC telescopes (left) and the HESS telescope array (right). Images from the experiment's homepages.

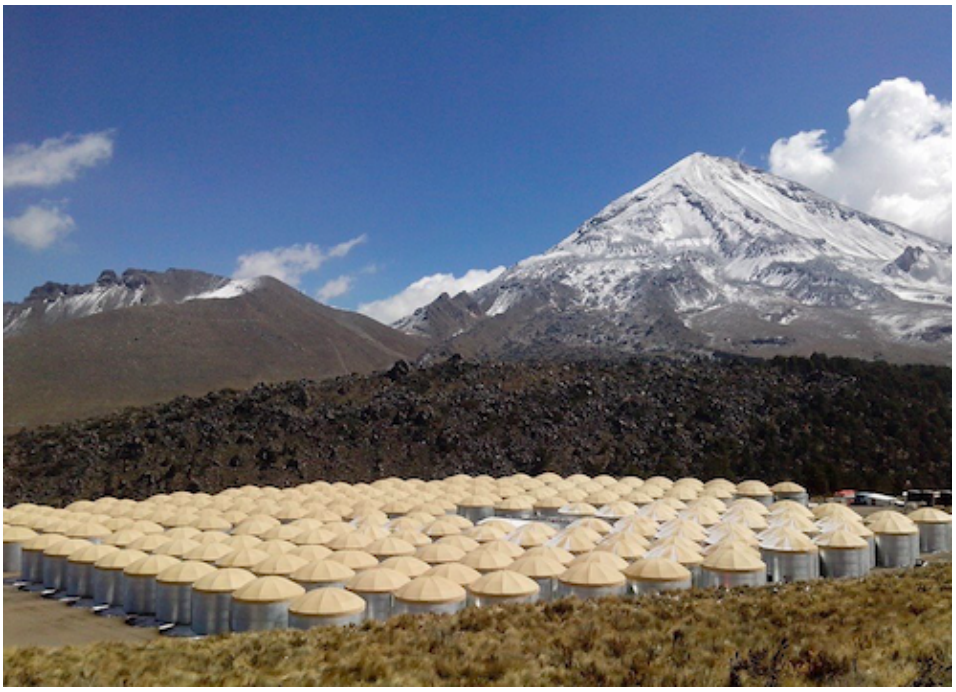

Figure 10: Fotograph of the HAWC observatory, from the HAWC collaboration arXiv:1509.07851.

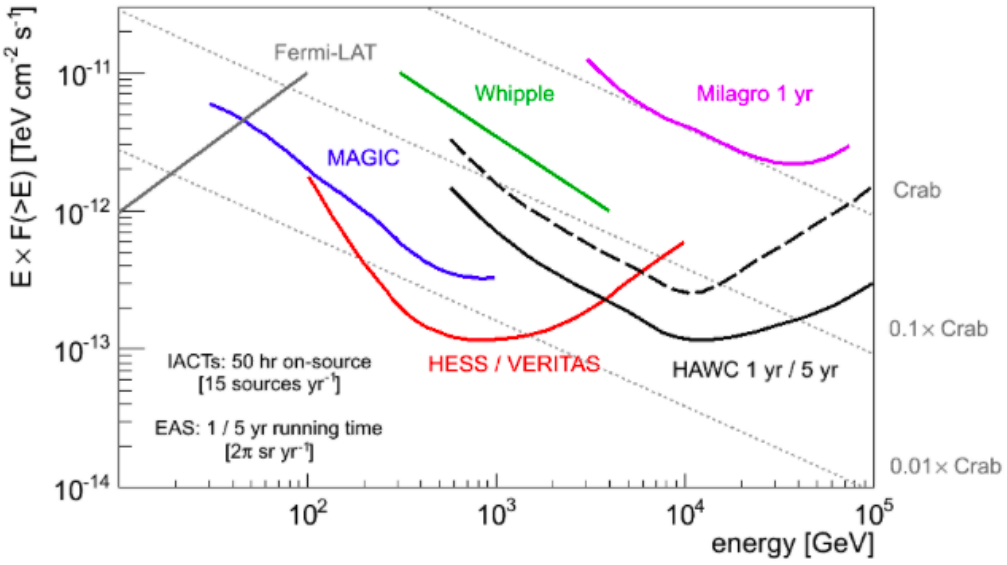

Figure 11: Point source sensitivity of the HAWC detector as a function of energy and integration time compared to other TeV observatories which use the imaging air Cherenkov technique. The Fermi-LAT instrument, which observes in the GeV band, is shown for reference. Figure from the HAWC homepage.