

## Sharpening the sight of the MAGIC telescopes

Truzzi Stefano<sup>1,2</sup>, Paoletti Riccardo<sup>1,2</sup>, Bonnoli Giacomo<sup>1,2</sup>, Bellizzi Lorenzo<sup>1,2</sup>  
 1. Department of Physical Science, Earth and Environment, University of Siena, Siena, Italy;  
 2. INFN Section of Pisa, Pisa, Italy

### MAGIC Telescope

The Major Atmospheric Gamma Imaging Cherenkov (MAGIC) is a system of two imaging Cherenkov telescopes exploring the Universe by collecting gamma rays at energies above few tens of GeV.

More precisely MAGIC collects the Cherenkov radiation generated from the extended air showers originated by cosmic rays impinging the atmosphere. The atmosphere is used like a calorimeter stopping the particles that arrive on earth surface. Among these, photons are a subdominant fraction, but given that they are not deflected by the magnetic fields filling the Universe at various scales, they can be used to trace back the source emitting them allowing astronomy at these energies and the astrophysical study of individual sources. The much more abundant charged cosmic rays act instead as an isotropical background that needs to be discriminated, mainly by the morphology of the shower images.

**Keywords:** Cherenkov telescope, Very High Energy gamma rays, image cleaning



Fig1: MAGIC Cherenkov Telescopes at La Palma, Canary Islands, Spain

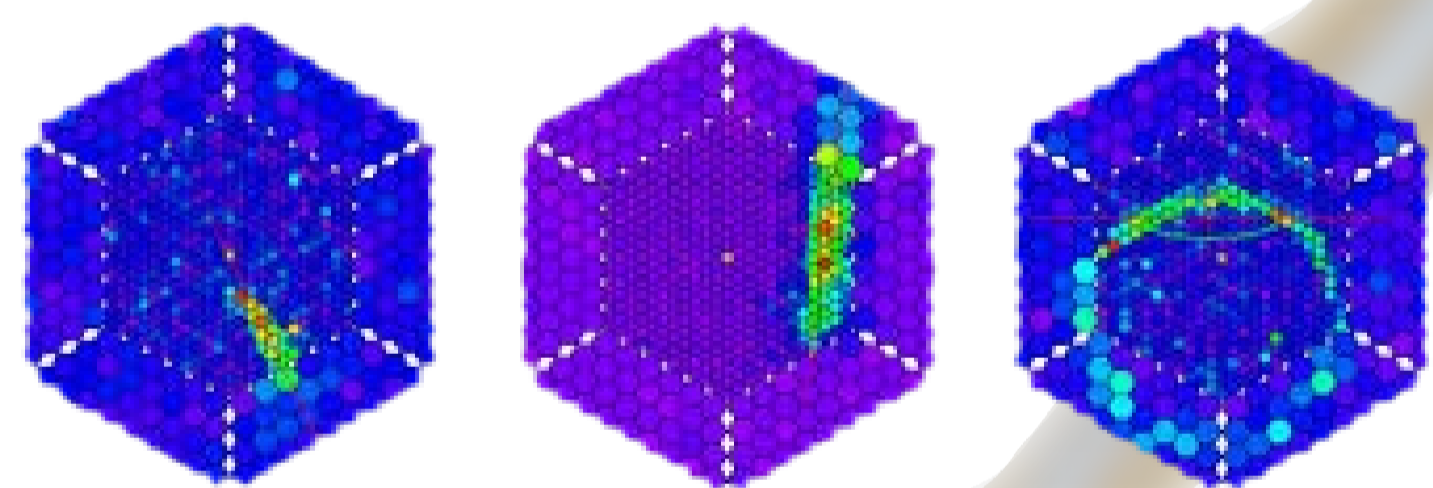


Fig 2: three examples of images of the air showers originated by different primary particles: photon (left), hadron (center), muon (right).

### The Idea

Sum T analysis led to development of an improved image cleaning optimizing the performance of the system below 100 GeV. Early attempts showed that this cleaning can also be successfully applied to data taken with standard trigger. MAGIC gathered a large database of standard observations of sources where a very soft spectrum with signal concentrated only around the energy threshold of the system is expected, but no signal was found with standard analysis. Thus, some solid detections of potential TeV sources might be

already at hand in archival data, waiting only for the application of a more performant analysis.

On the other hand, this cleaning is computationally much demanding (in terms of storage and CPU) and mass application to the whole database is not viable with standard systems.

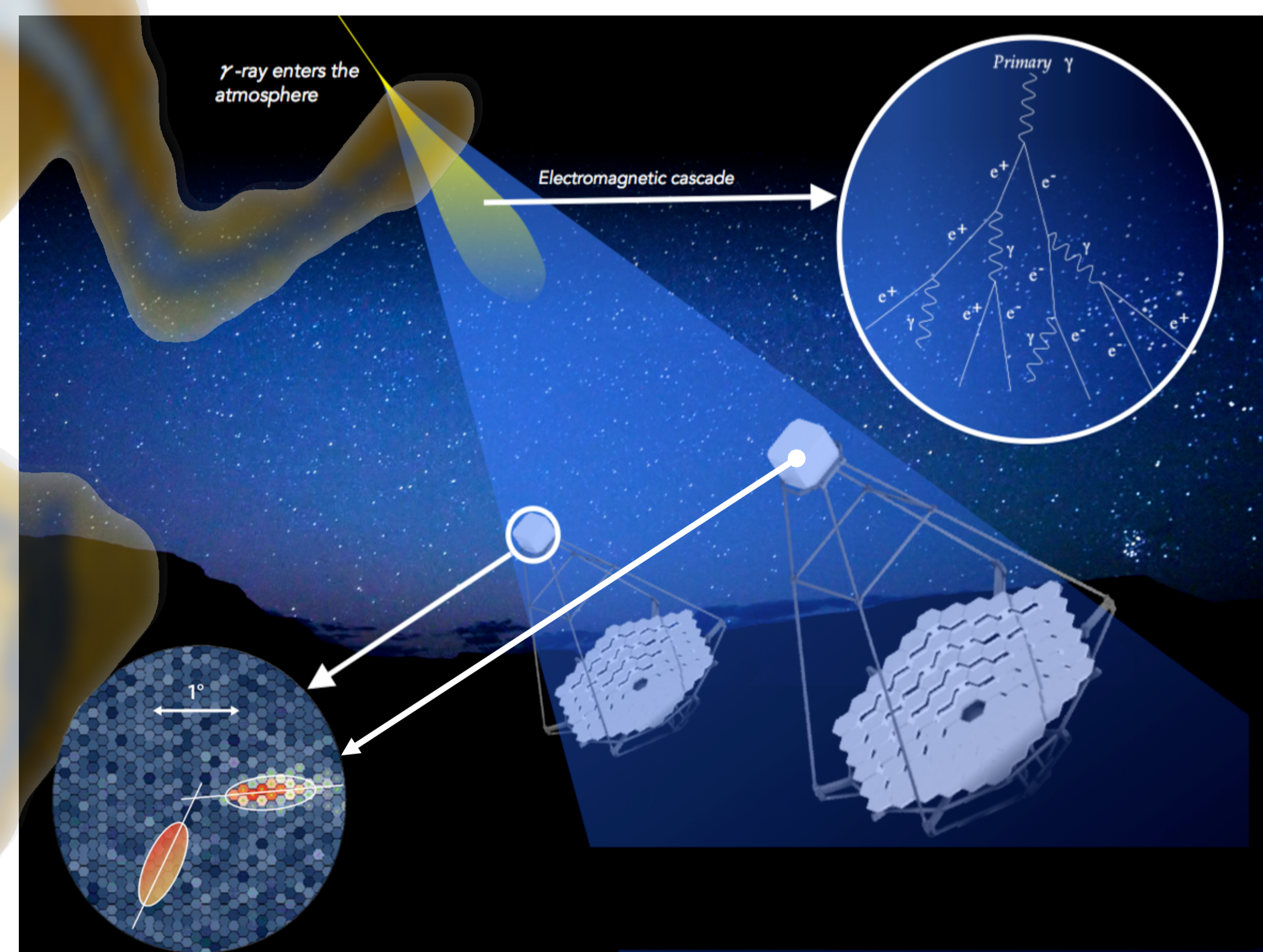


Fig3: cartoon of the detection of a photon: the primary photon generates an extended air shower (top-right box); the Cherenkov light shines the two telescopes (main image); the superimposition of the two images of the same event, allowing determination of the source position in the sky at the intersection of the major axis (bottom-left box)

### The Quest

Achieving the lowest possible energy threshold is crucial in order to detect sources characterized by a soft gamma-ray spectrum and/or far enough to suffer a significant extinction due to absorption of gamma rays against Extragalactic Background Light.

To improve the performance of MAGIC lowering the threshold a new trigger system called Sum Trigger (SumT) was installed. Together with the SumT a dedicated new image cleaning (NIC) algorithm that increases the fraction of low energy (meaning  $E < 100$  GeV) events surviving the cleaning, at the price of some losses at high energies was necessary.

### Acknowledgment

The main reason because I join this school is to learn/study new image cleaning techniques based on machine learning and to apply it on MAGIC and, I hope in a near future, Cherenkov Telescopes Array experiment data. For this reason I thank the school organizers: Prof. Qingguo Xie, Prof. Aurore Savoy-Navarro and Prof. Nicola D'Ascenzo, the professors, the teachers and the students that made it possible. Moreover I thank my supervisor Prof. Riccardo Paoletti for sending me to INFIERI, my co-supervisor Giacomo Bonnoli for advice regarding research topic and my colleague and friend Lorenzo Bellizzi.

### My work

I selected small data samples taken observing extragalactic sources expected to be detectable only around the energy threshold, that were observed with standard trigger under good weather and technical conditions, and where hints of signal were found with standard analysis, but no firm detection. Applying NIC, significance of excess is improved as expected for a genuine signal. Cross-checks in order to exclude that random fluctuations are enhanced by the new procedures, and that no fictitious signals are generated, are still in progress.