Status of MAGIC-II

Abelardo Moralejo Olaizola[1] for the MAGIC collaboration

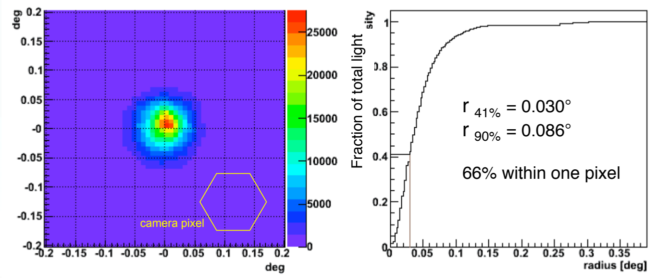
[1] IFAE, Edifici Cn, Campus UAB, E-08193 Bellaterra, Spain

Status report of the second phase of the MAGIC ground-based gamma-ray facility, recently upgraded with a second telescope.

MAGIC, a gamma-ray imaging atmospheric Cherenkov facility [1] composed up to now of a single telescope, has become a stereoscopic system with the inclusion of a second telescope, MAGIC-II. MAGIC is located on the Canary island of La Palma (28.8° N, 17.9° W), and operates in the very high energy spectral band (photon energies above 30 GeV). MAGIC-II saw its first light in Spring 2009, and is now approaching the end of its commissioning phase. Whereas from the mechanical point of view MAGIC-II is essentially a clone of the first telescope, it features significant improvements in other aspects, like a more finely pixelized camera and a lower-cost, more compact readout system.

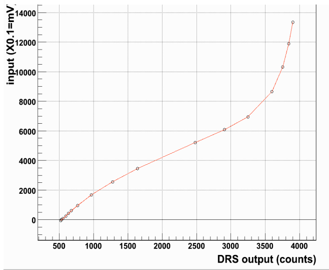
The mirror dish of MAGIC-II is a tessellated paraboloid of 17 m focal length and f/D=1. Each of the 247 square tiles is a spherical mirror with a surface of 1 m^2, mounted on two motors which allow to adjust its orientation to ensure that the parabolic shape is maintained, despite the sagging of the telescope structure, for different orientations of the instrument. The reflecting surfaces of the inner 143 mirror tiles [2] are diamond-milled aluminum plates (the same technology used in MAGIC-I), whereas the outer 104 are equipped with thin aluminum-coated glass sheets [3]; in both types of mirrors the needed mechanical stiffness is provided by an underlying aluminum honeycomb structure. The optical properties of MAGIC-II are similar to those of the first telescope. About 66% of the light from a point source is contained within the area of one camera pixel. ▸

Optical PSF of the MAGIC-II mirror dish

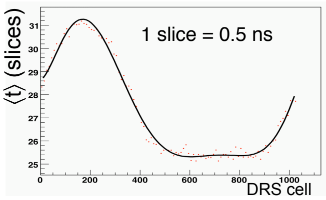


The camera of MAGIC-II is composed of 1039 photomultiplier tubes of 0.1° ∅, for a total field of view of 3.5°. The innermost 559 pixels take part in the trigger (covering a 70% larger area than in M-I).

Signal processing. The signals from the 1039 PMTs on the MAGIC-II camera are converted into analog optical pulses which are sent to the control building 80 m away via optical fibres, where they are converted back into electronic pulses and then split to provide the input for the trigger and the signal sampling systems. The readout system of MAGIC-II is based on version 2 of the Domino Ring Sampler chip (DRS2). The chip samples the input signals analogically at 2 Gsample/s using an array of 1024 capacitors (so-called *cells*). In case of a trigger, the sampling is stopped and the data are digitized with a 12-bit resolution ADC at 40 MHz. Data management is based on a digital board called PULSAR that handles up to 80 analog channels [4].

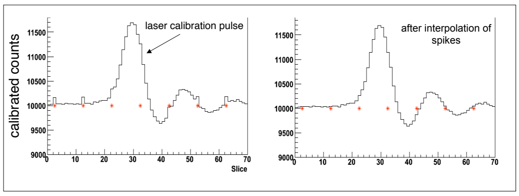


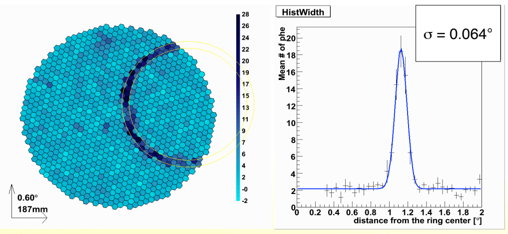
◂ DRS2 amplitude calibration. The response of DRS2 chip is not linear, and amplitudes have to be corrected as the first step in the processing of the data. A dedicated calibration of every capacitor in every channel (>10^6 instances) is performed once per night for this purpose. Saturation of the signal occurs at about 900 photoelectrons.



Occasionally, data are contaminated by sharp regular *spikes* ▸ (in the example, affecting a laser calibration pulse) which can be identified and have to be cured by software as part of the signal extraction process.

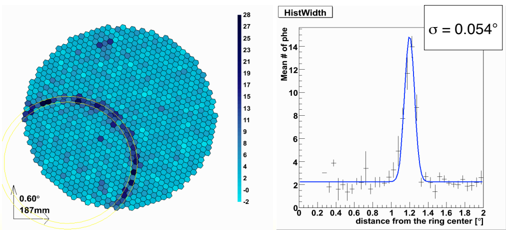
◂ DRS2 timing calibration. A cell-dependent correction of the signal timing is also needed. On the left, the reconstructed arrival time of laser calibration pulses is shown as a function of the number of the first DRS cell written out in each event.

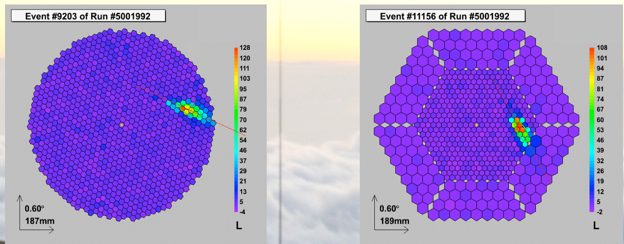




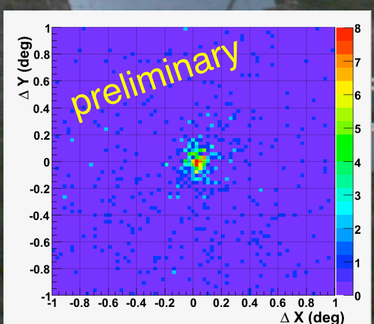
◂ Muons ▸

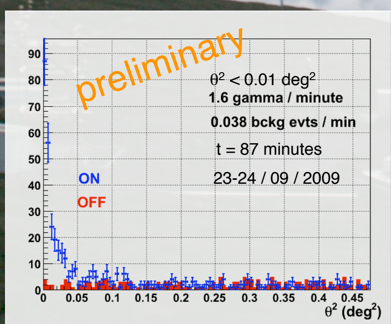
Two muon ring images recorded by MAGIC-II in September 2009. On the right pads, the transversal light profile of the rings. The optical properties of the reflector are similar to those of the first MAGIC telescope.





A typical stereo event as seen by MAGIC-II and MAGIC-I





◂ Stereoscopic observations of the Crab Nebula in "software stereo" mode: map of reconstructed event directions (in camera coordinates) with respect to the Crab Nebula, and the corresponding θ^2 plot. No offline pointing correction has been applied. The selected sample includes only events with at least 400 p.e. in each of the telescopes (peak gamma energy ≈ 400 GeV). A simple geometrical shower reconstruction has been used, with background suppression relying on a Random Forest algorithm fed with shower parameters and trained on MC gammas and real background events. Tuning of the MC simulation is ongoing.

Hardware for stereo trigger (with orientation-dependent adjustable delays) is already installed, and currently being tested to determine the best operation parameters.

References:
[1] J. Cortina et al, *Technical Performance of the MAGIC Telescopes, Proc. of the 31st ICRC, Łódź (2009)*
[2] M. Doro et al, *The reflective surface of the MAGIC telescope*, NIM A, Volume 595, Issue 1, p. 200-203.
[3] G. Pareschi et al, *Glass Mirrors by cold slumping to cover 100 m2 of the MAGIC II Cherenkov telescope reflecting surface*, Proc. of the SPIE, Volume 7018, (2008)
[4] D. Tescaro et al, *The readout system of the MAGIC-II Cherenkov Telescope , Proc. of the 31st ICRC, Łódź (2009)*