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Onsite Analysis of the MAGIC telescope

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Abstract

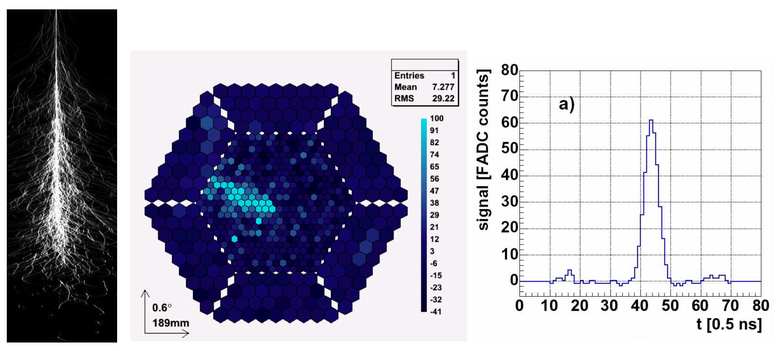
We present the actual scheme for the Onsite Analysis on the MAGIC Cherenkov Telescopes at La Palma. Due to their low energy threshold, MAGIC acquires data of atmospheric showers at a rate of almost 300 Hz, which translates in up to 900 GB per night. A fast on-site data reduction is needed to detect hardware problems and in many cases to decide on observation strategies. The data are calibrated and pre-processed at the MAGIC site using automated scripts on multiprocessor systems. The Onsite Analysis system provides the official data for the MAGIC collaboration.

Introduction

MAGIC is a system composed of two 17 m diameter Imaging Atmospheric Cherenkov Telescopes (IACTs) located at El Roque de los Muchachos Observatory in the Canary island of La Palma. It acquires images of the fast flashes of Cherenkov light created by atmospheric showers, initiated by high energy γ-rays and the much more numerous cosmic ray background. Since 2009 the two telescopes have been operating in stereoscopic coincidence mode, providing a threshold of 50 GeV in normal trigger mode [1].

Data reduction

Approximately 99% of the data volume gathered by the MAGIC telescopes comes from the data acquisition. This volume can be calculated taking into account four parameters: Event rate R, Number of pixels P, Digitalization samples S and dynamic range D.



Event rate
300 Hz approx

Camera
577 pixels

80 samples,
10 bits

The data volume rate will be: R*P*S*D.

Phase	R(Hz)	P	S	D(bits)	1 hour	1 day	1 year
1	300	577	30	8	18 GB	150 GB	20 TB
2	300	577	50	10	39 GB	300 GB	45 TB
3	300	1616	50	10/12	110 GB	875 GB	130 TB

Phase (1) old Siegen 300 MHzFADC, (2) MUX 2 GHz, (3) current MAGIC I+ II

We can divide data reduction in four stages, depending on the data resulting of each step:

Raw data consists of the digitized pulses recorded by the camera for each event.

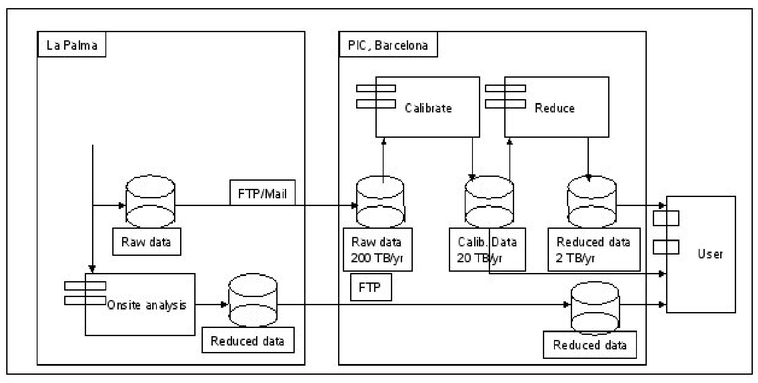
Calibrated data contains physical information at pixel level: light recorded and arrival time with errors. There is a reduction of a factor ten in data volume, partially due to compression .

Images are reconstructed from the calibrated data and expressed in terms of combinations of their first moments; the Hillas parameter [2]. They are 100 times smaller than raw files.

Observation results are obtained from the statistical analysis of images including a strong background rejection.

MAGIC data flow

Data reduction is carried out by the so-called Onsite Analysis software system implemented at La Palma. This system is maintained and supervised on a daily basis by the Grupo de Altas Energías (GAE) at the UCM, and provides the official data for the collaboration. The final repository of the data is the MAGIC database, at PIC (Port d'Informació Científica) at Barcelona, where the data are accessible for all MAGIC members.



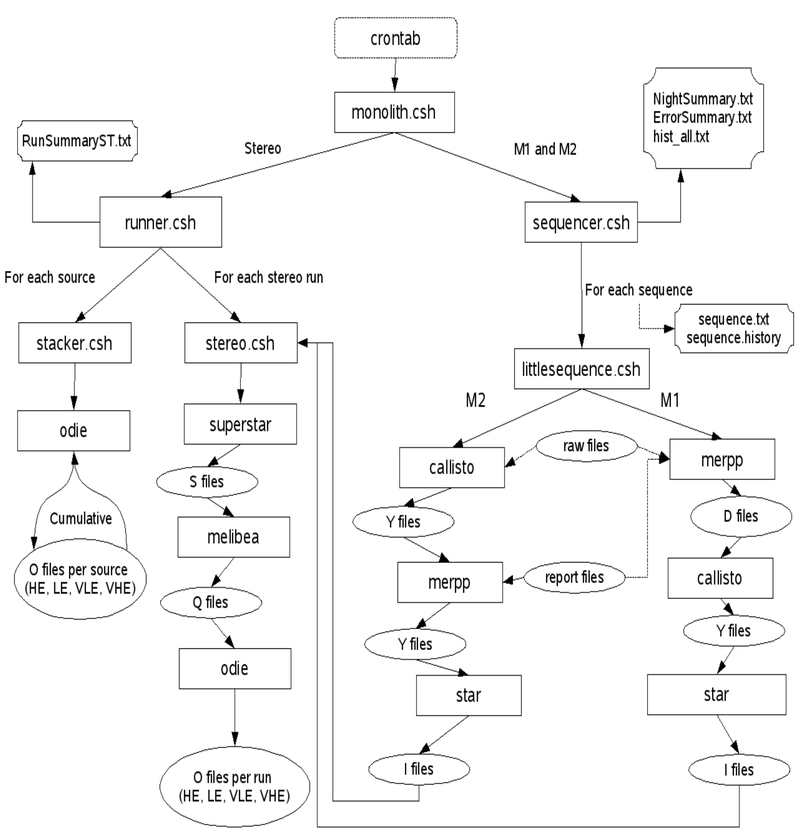
Onsite Computing system

The MAGIC collaboration has deployed a powerful computer system at the telescope site: it contains 2 data acquisition and control computers + 9 multiprocessor analysis systems. For storage purposes we have at our disposal 4 RAID systems with capacities between 7 and 21 Tbytes [3]. Details of the machines are shown in the following table [4].

Number of machines	CPU cores	CPU (Ghz)	RAM (GB)
1	8	2.8	8
2	4	3	3
6	8	2	4
1	8	2.8	4
1	8	2.3	3

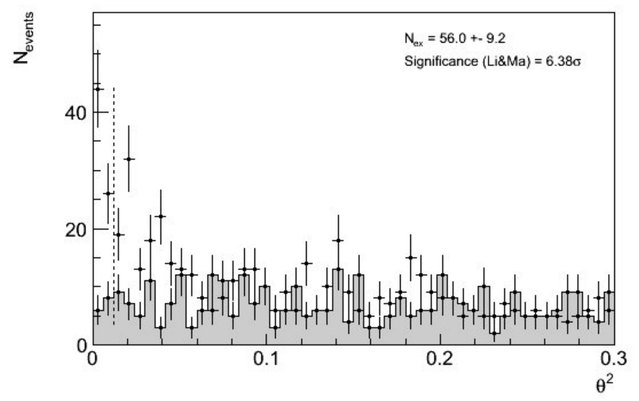
Onsite Analysis

As said before, data go through an on-site reduction before being transferred outside the island. The software is launched as soon as the data is digitalized and observation results are available normally before the next night. The data are divided in batches (about 20 min of data) which run independently in different processors. Its robust design requires minimum human interaction.



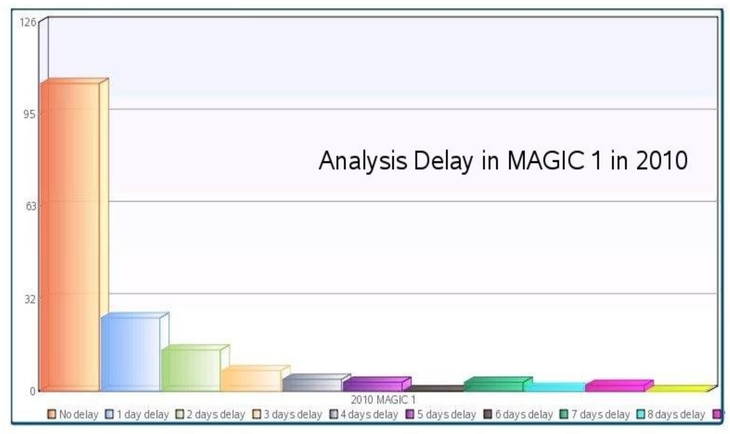
Onsite Analysis

Among the most important products are the angular parameter θ^2 plots, which allow to compute the significance of the excess events coming from the source. They provide a preview of the source activity before the exhaustive analysis takes place, and allow us to alert the collaboration at once so the observation strategy can be adapted. Take for example the following plot, where a >5σ signal from the blazar PKS1222+21 was detected for the first time in the VHE regime by the Onsite Analysis system [5].



Statistics

We have implemented the scripts needed to compute statistics concerning the Onsite Analysis performance. This is accessible via web, where users can find reports about analysis delay, CPU status and disk space, together with summarys for the last three nights.



Outlook

MAGIC is an ever-changing system due to constant hardware and software improvements. Currently we work to make Onsite Analysis more autonomous, stable and impervious to these changes. We also aim to provide users with more complete statistics and other useful information.

Conclusions

- A fast on-site data reduction system has been further developed. Reduced data arrive after few hours at the datacenter, where the collaboration can access the official data.
- Together with the *quick look* online analysis the system allows for fast reaction for source scheduling and follow up observations.
- Onsite Analysis scripts provide a very fast and efficient method to control hardware performance.

References

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[2] VHE Gamma-Ray Observation of the Crab Nebula and Pulsar with MAGIC J. Albert et al., Astrophys. J. 674 (2008) 1037.
[3] A Flexible High Demand Storage System for MAGIC-I and MAGIC-II using GFSm. E. Carmona et aL, Proceedings of the ICRC(2009) .
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