Next-day observation processing for the LST-1 and MAGIC.

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Introduction:

The first CTAO Large-sized (LST-1) and MAGIC telescopes are two Imaging Cherenkov Atmospheric Telescopes (IACT) systems located at the Roque de los Muchachos Observatory on La Palma, Canary Islands. Rapid availability of reliable analysis products to both collaborations is crucial for physics alerts, scheduling, and data quality assurance. Additionally, the large size of the raw data makes its transmission to off-site data centers within a short time window challenging.

On-Site Analysis (OSA) pipelines have been operational for MAGIC (since 2012) and LST-1 (since 2021). Both pipelines automatically analyze data using the full analysis chain. These data are the input for the daily checks performed on the data and the fast analysis activities. In the case of MAGIC, an automatic analysis chain also calculates the observed sources' detection significance, spectra, and light curves. These last steps of the analysis are also currently being included for LST-1.
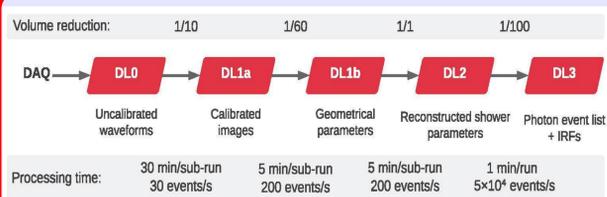
MAGIC ⇒
A two telescopes stereo system. With a trigger rate of ~300 evts/s they record up to 2 TB of raw data per day. The OSA pipeline reduces data reaching up to high-level products (sky maps and spectra). The system consists of ~50 cores and 40 TB of disk.
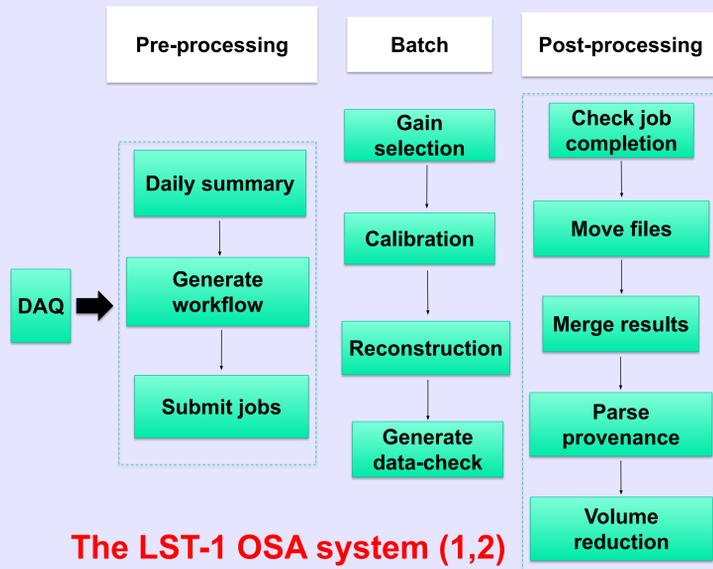
⇐ LST1
One telescope. With a trigger rate of ~7-8 kevts/s producing up to 30 TB raw data per day. OSA processes raw to reconstructed events (DL2, see below), using an on-site data center of 1800 cores and more than 5 PB of disk.

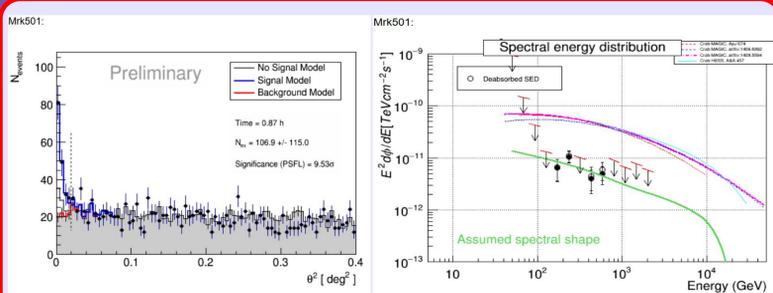**In both cases processing finishes ~ 14:00 LT**

Data analysis of both observatories is similar. From raw data, with 40 or 80 samples per pixel (DL0), charges and times per pixel are obtained (DL1). Images are reconstructed and physical parameters of the original particle estimated (DL2). Photon candidates are then selected and Instrument Response Functions produced.

The LST-1 OSA system (1,2)

OSA code is mostly python. Scripts are launched by crontab jobs and their flow is controlled by the existence of key files. The analysis is coordinated with DAQ through a set of daily summaries for the observation and pointing. Analysis is parallelized to the lowest possible level using a batch system (SLURM or Torque). In the LST-1 several hundred cores are used in parallel.

LST-1 OSA integrates the production of data check summaries for the day and their transfer to websites where experts review them.

Some of the high-level plots produced by MAGIC OSA in a recent observation.
LHS: the classical θ^2 plot of Mrk 501, with the significance of its detection.
RHS: the SED, convoluted with the EBL absorption. These plots are produced automatically everyday and made available on the web.

OSA operates automatically, but several tools allow to supervise its functioning. Screens as the one on the left track the daily analysis and in the case of non-recoverable errors the scripts alert the OSA teams by email. A separate system triggers transfer to the data centers when data analysis is complete.

Lessons learned:

- Developing and maintaining a full next-day analysis is a challenge, but also a must for a VHE observatory.
- The pipelines should be coordinated with the observatory databases and simulation tools.
- Tasks should be automatic, but means for easy human intervention are always needed.
- A full scheme for error detection and recovery should be set up since the first design.

Conclusion:

- OSA Analyses have been working continuously for 13 (5) years in MAGIC and the LST-1 in the challenging environment of a mountain observatory.
- Simple in design and effective they have contributed to the success of both collaborations, providing fast high-quality data, data check measures and, for MAGIC, quick basic physic results.
- They can serve as a prototype, test bed and check for the future CTAO onsite pipelines.

References:

[1] D. Morcuende. PhD Thesis (2023) and references therein.
[2] A. Baquero Phd Thesis (2022) and references therein.