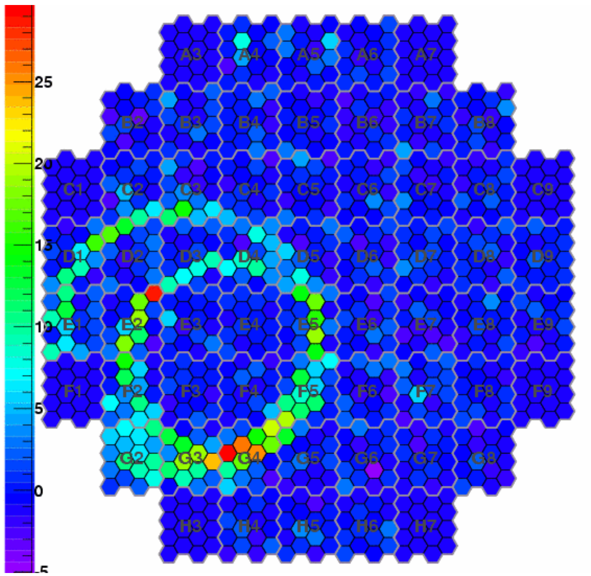
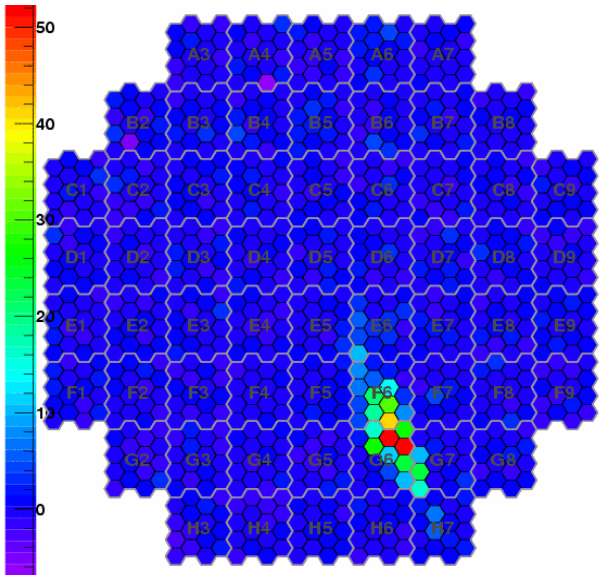
Calibration results of the first two H·E·S·S· telescopes

Nicolas Leroy for the H·E·S·S· collaboration



Muons



Gamma-like

Calibration coefficients

To provide data analysis for physics we need on short time-scales:

- Conversion factor between ADC and photo-electron (p.e.)
- Correction of camera inhomogeneities
- Pedestal position and excluded pixels

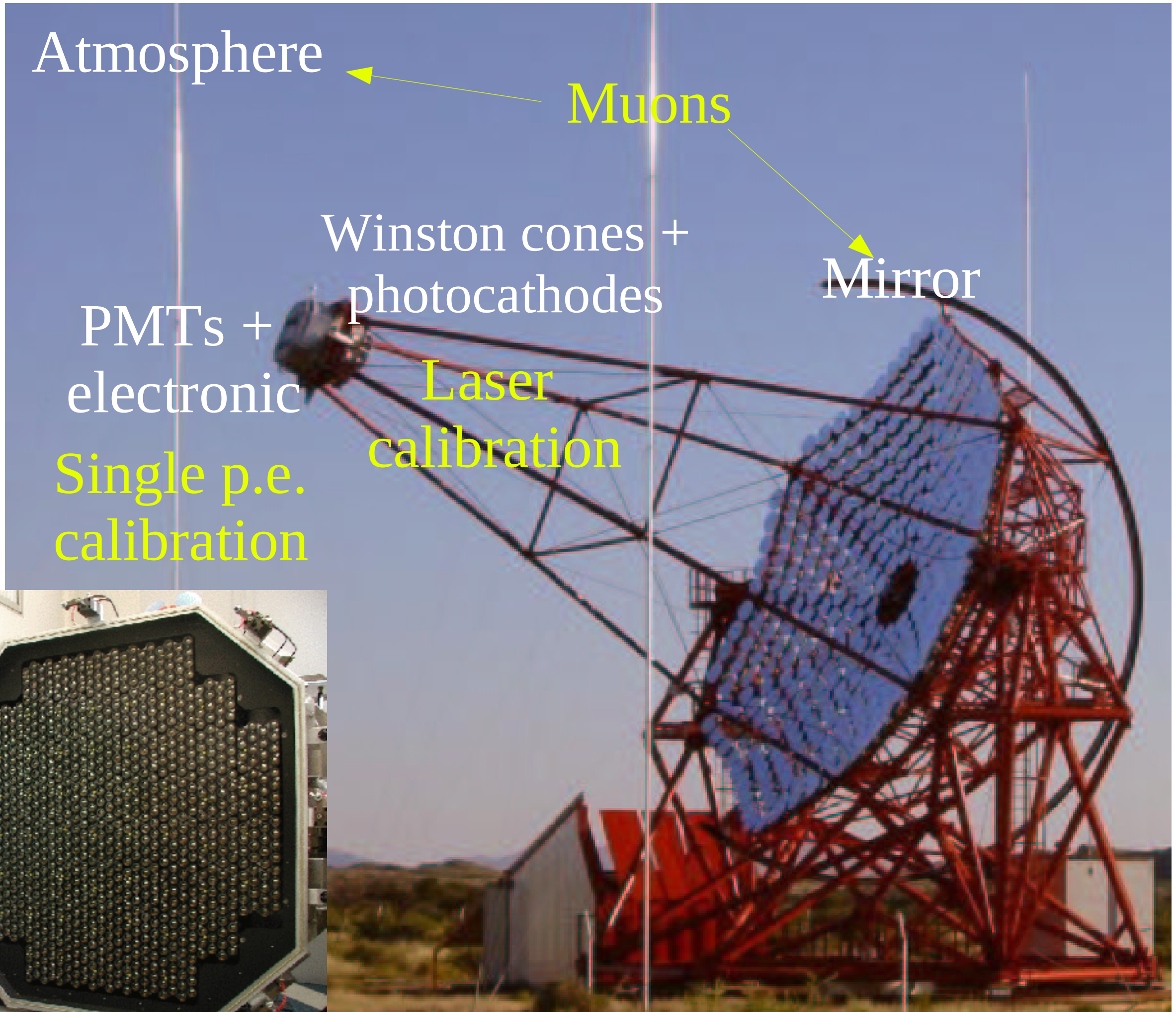
i.e., Classical Calibration

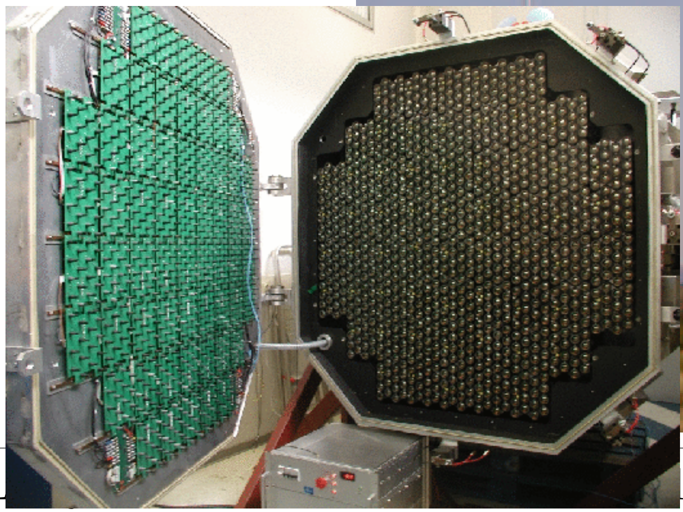
we also use muon images to monitor the detector and check our calibrations

Calibration coefficients

Calibration of the detection system:

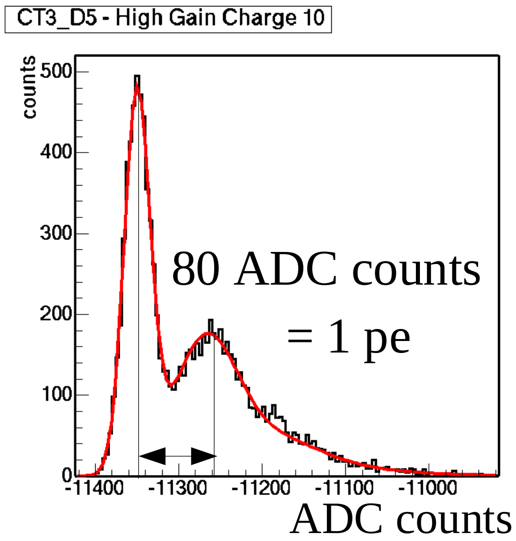
atmosphere, mirror, Winston cones, PMTs, and electronics



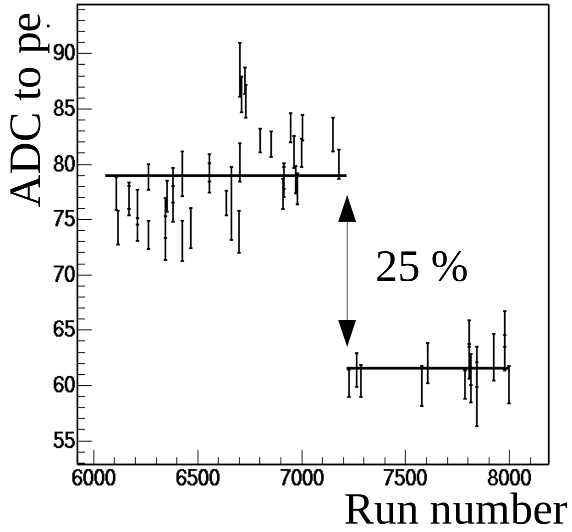


Classical methods - Calibration runs

- ADC to photo-electron conversion factor using a LED system



Fit with a sum of Gaussians



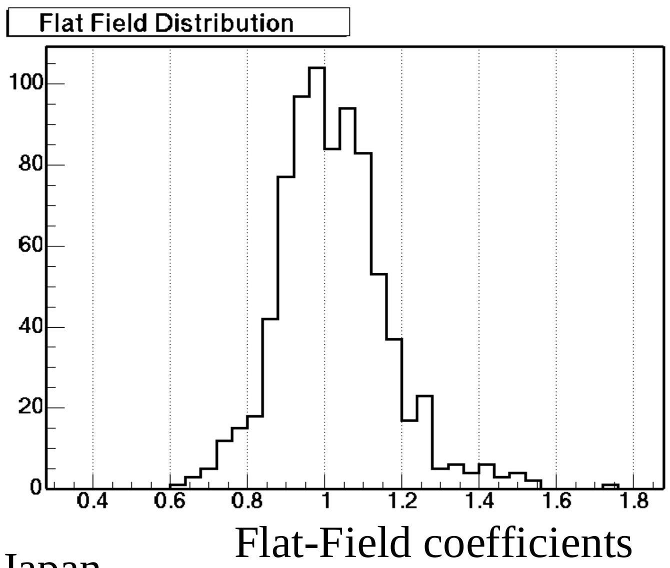
➜ Detection of a damaged pixel (excessive illumination)

- Width of electronic Pedestal: 0.18 p.e.

- Flat Fielding

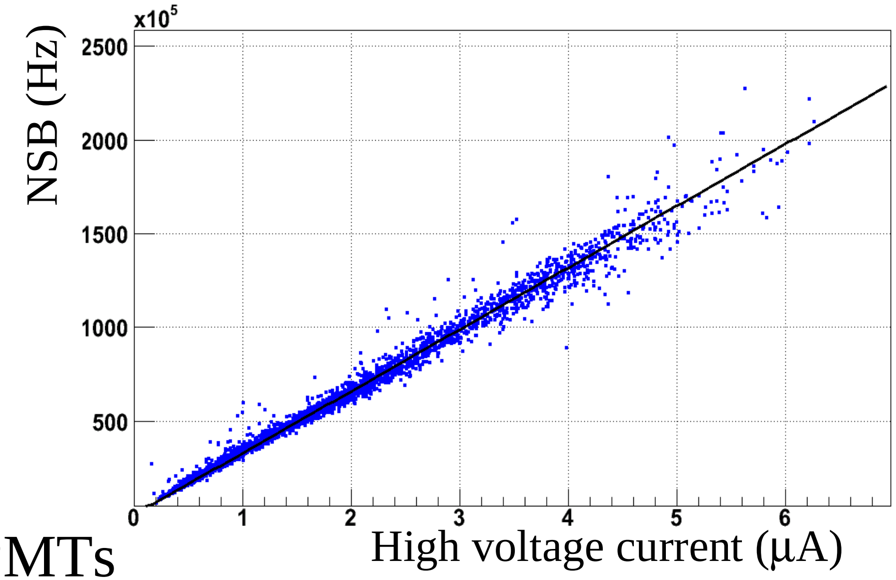
Correction factor for each pixel
→ uniform response of the camera

Using a UV laser or a pulsed LED
at the centre of the mirror

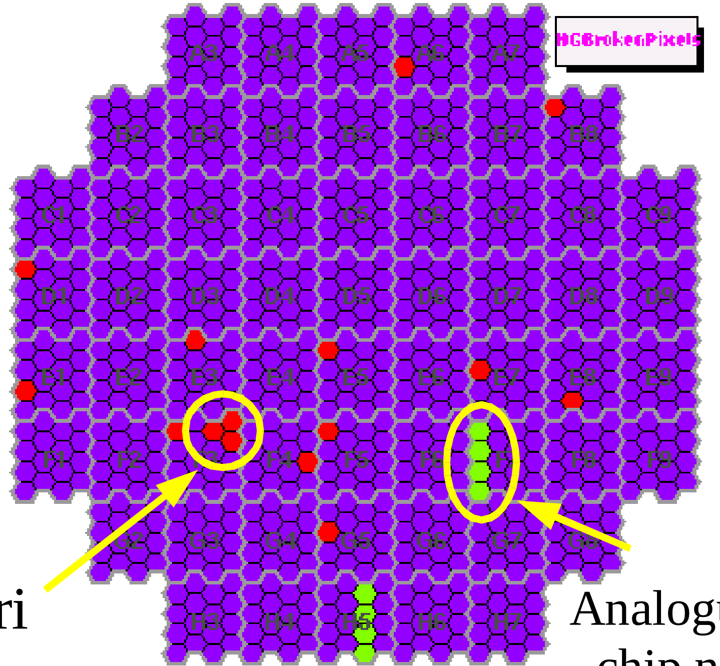


Classical method - In data runs

- Pedestal position determined every minute in presence of Night Sky Background
  - Night Sky Background determination using High Voltage Current information from the PMTs



Crab Nebula field of view



- Excluded Pixels
  HV Off
  HV unstable
  stars, highly-illuminated pixels

  - ~4 % of the pixels per run are excluded from the analysis

ζ Tauri

Analogue Ring Sampling chip not synchronised

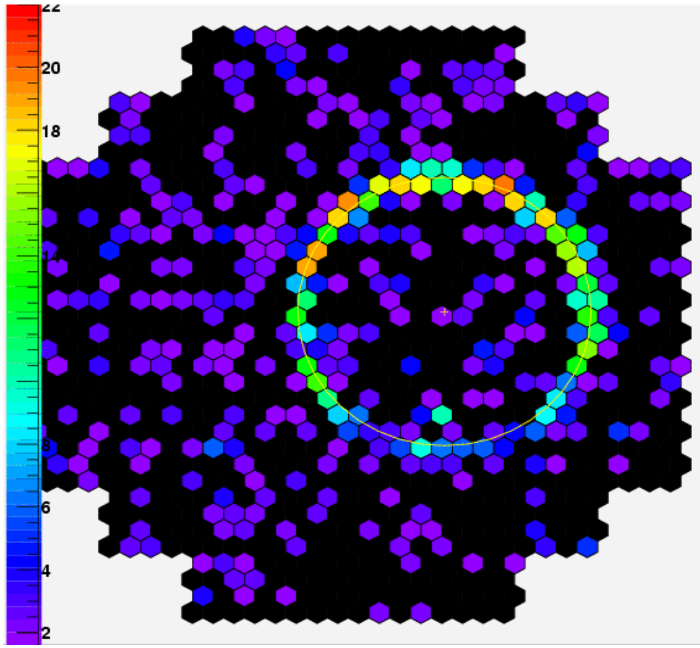
Muons from hadronic showers are also very useful for calibration purposes

- Cherenkov emission of a single particle

- Muons represent half of the trigger rate (~150Hz) in single-telescope trigger configuration

- Unique calibration tool providing information on the whole detection system with a real Cherenkov spectrum

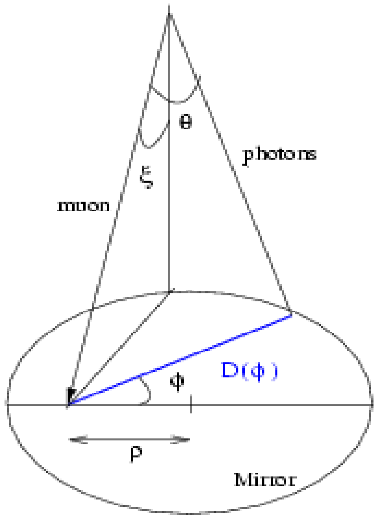
- Validation of detector simulation



Geometry of Cherenkov emission from a muon

falling in the mirror

- complete ring in the camera (~1Hz)



x, y: ring centre in the camera

R: ring radius

ϵ : total collection efficiency

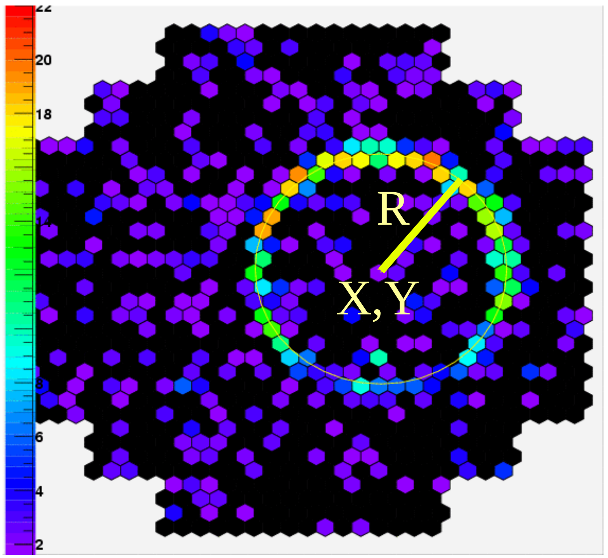
ρ: impact parameter

σ : ring width

ϕ_{max}: azimuth of the maximum in intensity

Simple geometrical fit

Cherenkov emission



θ_c is the Cherenkov angle, i.e., the ring radius in the camera

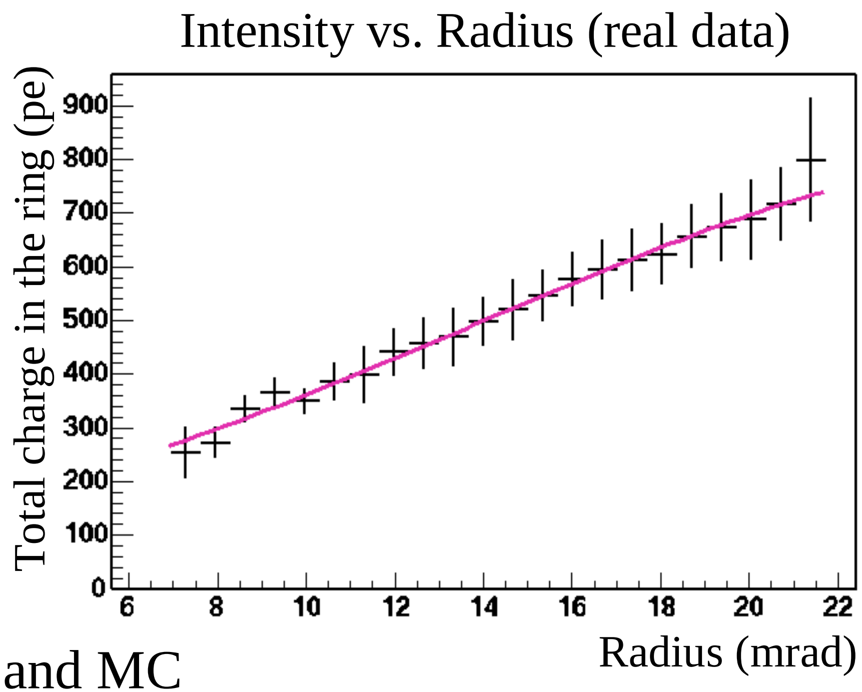
ϵ is the conversion factor between p.e. and photons

$$200 \text{ nm} < \lambda < 700 \text{ nm}$$

For each pixel, we determine ϵ from

$$I(\phi) \propto \sin(2\theta_c) D(\phi) \epsilon$$

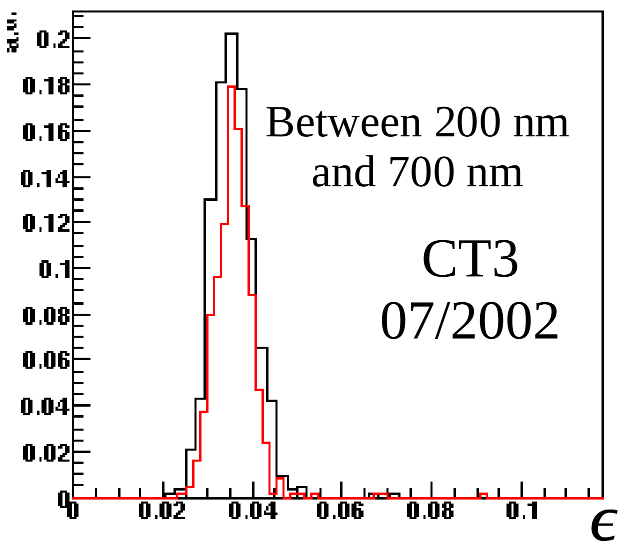
Reconstruction



Conversion factor and MC

Conversion factor between Photon and photo-electron

Distribution for one run

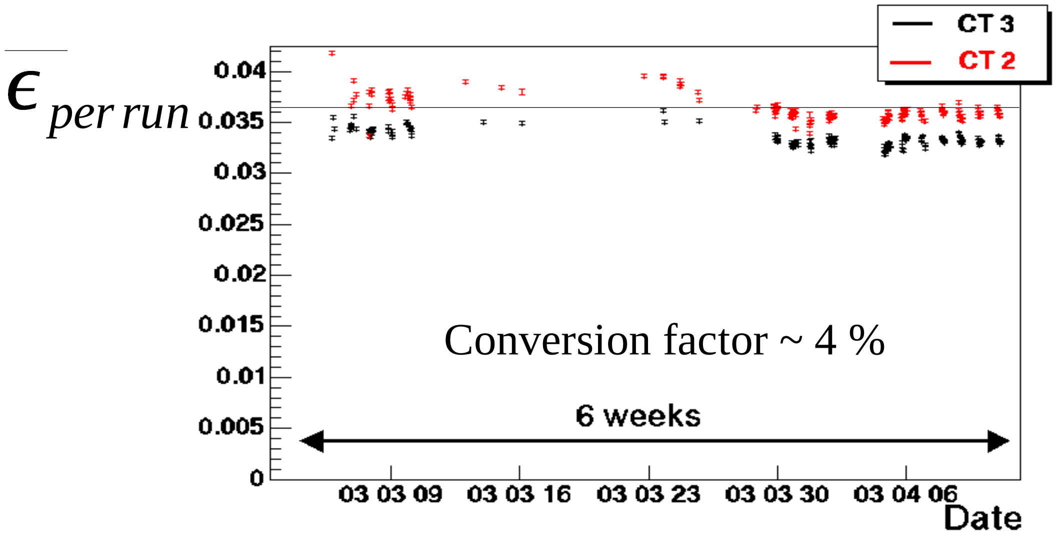


Simulations

Data

➡ provides a good modelling of the detector in simulations

Monitoring of the telescopes

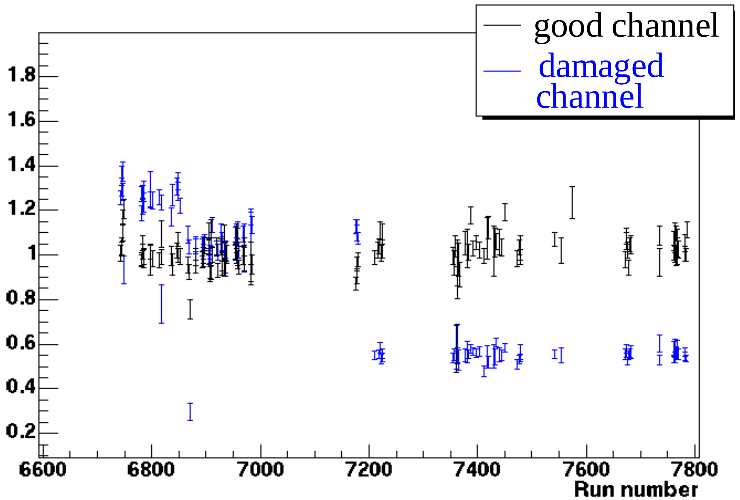


Average conversion factor between 200 and 700 nm as a function of time

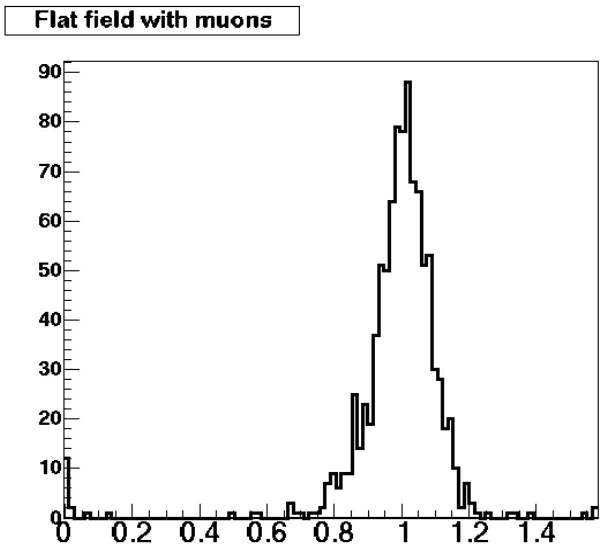
- Small shift in efficiency for CT3
- Same behaviour between CT2 and CT3

→ Atmospheric effects ?

Flat Fielding with muons using fit residuals per pixel



Average muon fit residuals for two pixels as a function of time



Distribution of average muon fit residuals

Conclusions

- H·E·S·S· uses different independent methods of calibration
  - Classical methods with LEDs and laser systems
  - Muon ring images in data

- Allow a realistic calibration of our detector simulation
- Monitoring of each detector performance at the few percent level
- Accurate correction on flat-fielding
- Muons also provide information for selection of good-quality runs