Tim Lukas Holch[4], Fabian Leuschner[1], Johannes Schäfer[2] and Simon Steinmassl[3], with great support by Konrad Bernlöhr[3], Stefan Funk[2], Jim Hinton[3], Stefan Ohm[4] and Gerd Pühlhofer[1]

Additional info:
*: Simulations of γ-ray and charged CR induced air showers, transmission of and system response on these
**: e.g., exchange of camera or mirrors
*** dominated by CR

Validation of Monte Carlo simulations for an analysis chain in H.E.S.S.+ – Motivation

Imaging Air Cherenkov Telescopes (IACTs):

- Analysis depends highly on simulation*-based lookup-tables

After system change**: Analysis might not match earlier results anymore

→ Need to tune the hardware simulations to the new system

- Check and adjust low level parameters
- Telescope trigger rate*** and Hillas parameters are good measures

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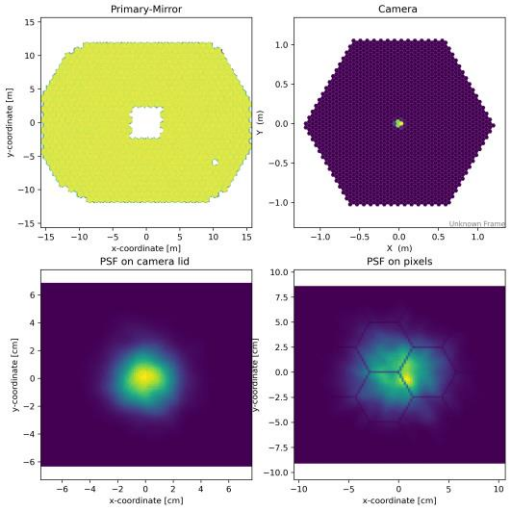
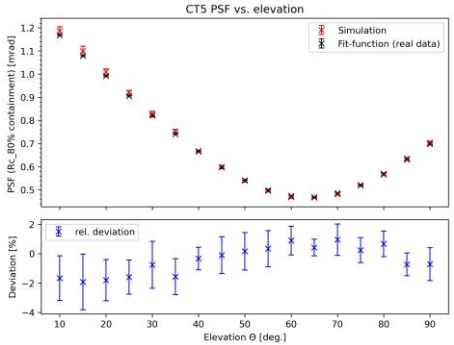
+:H.E.S.S. is an array of five IACTs: one 28 m telescope, and four 12 m telescopes

Check telescope optics

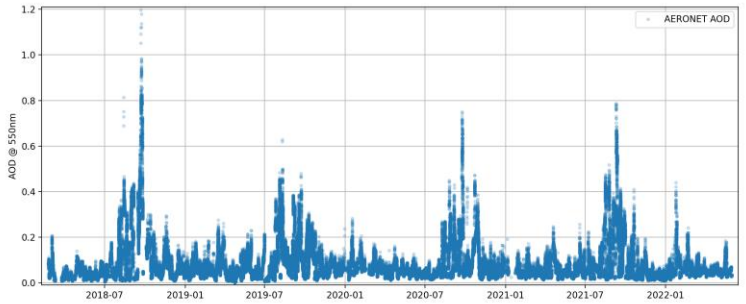
- Ray-tracing simulations: Is the mirror alignment implemented correctly?
- Point-Spread-Function (PSF): do simulations match, including zenith angle dependency?
- Does the optical throughput match?





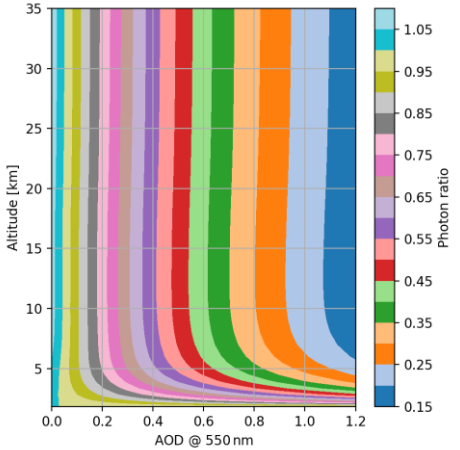
Top: Raytracing for the 28 m telescope
Left: Comparison of simulated and measured PSF for the same telescope

Check the atmosphere



Top: aerosol optical depth (AOD) measured on site from 2018 on

Bottom: Ratio of photons arriving at telescopes relative to model atmosphere for different emittance altitudes and AODs



Additional info:
See also the contribution of Tim Lukas Holch to the AtmoHEAD workshop, happening next week in Capri, Italy.

The atmosphere is γ-ray conversion- and Cherenkov light propagation medium → essential for event reconstruction

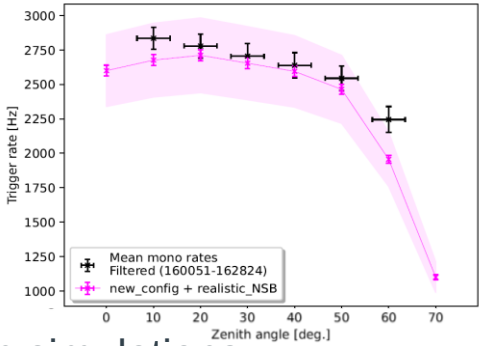
- Density- and transmission profiles heavily influence observations → must be correctly modeled in simulations.
- At the H.E.S.S. site: significant changes in $\mathcal{O}$(hours) of the atmospheric transmission → impacts energy threshold and energy calibration
- Approach: use mean atmospheric parameters in simulations and derive a correction on a runwise basis

Night sky Background (NSB)*

- Compare measured pedestal width with simulations under standard assumptions
- In case of mismatch: verify expected** NSB rate
- NSB rate also impacts trigger rate near threshold

*: Diffuse photon emission, mainly from airglow, (diffuse) starlight and zodiacal light (the latter close to sunset/-rise only)
**: the expected NSB rate measured in the cameras is a product of the averaged, total NSB-rate in photons per sr, m^2 and s and telescope/camera parameters

Simulated and real trigger rate of the large telescope CT5. Butterfly: 10% uncertainty of simulation software



Systematics

Important influences on simulations:

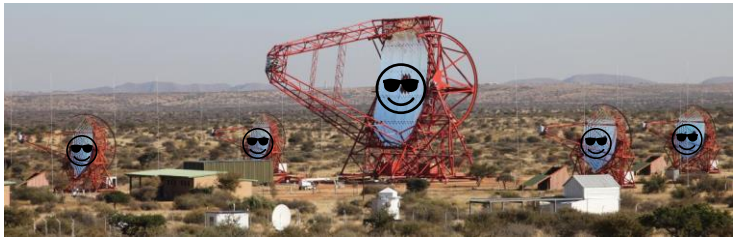
- Choice of proton spectrum
- Choice of nuclear interaction model
- Systematic uncertainties, e.g., in calculation of optical throughput or in simulation software

→These systematics have a high impact on trigger rates, but not on γ-shower reconstruction → perfect match of trigger rates not necessary, only within systematics

Validation of Monte Carlo simulations for an analysis chain in H.E.S.S. – Summary

- MC simulations are crucial for the analysis
- Atmosphere is variable on short timescales and has a significant impact on the simulation/reconstruction → must be corrected for
- NSB-Background and systematics at low energies affect trigger rates by >10% but have little/no impact on reconstruction if shower shapes match
- Detailed knowledge of optics is crucial

→ This way you'll have happy telescopes



Source: https://www.lsw.uni-heidelberg.de/