ATMOhead 12.6.13

Data quality monitoring in the presence of aerosols and other adverse atmospheric conditions with H.E.S.S.

Joachim Hahn, Raquel de los Reyes

Outline

- Introduction
- Hardware DQ selection
- Weather DQ selection
  - Clouds
  - Aerosols
- Cherenkov Transparency Coefficient
  - Correlation with satellite measurements
  - Systematic effects on source spectra
- Summary

Data Quality

- H.E.S.S. (Heidelberg analysis) uses a uniform data quality selection mechanism
  → Especially important for surveys etc.!
- Analysers use two standardised sets of cuts:
  - **source detection**:
    Hardware OK, no checks on weather
  - **spectral analysis**:
    Hardware + weather OK

hardware cuts

Hardware Cuts (applied for detection and spectral quality)

	Criterion	cut range (unit)
System	run duration	600:7200 (sec)
	DST check[b]	DST has to exist
Camera	participation fraction	0:0.4 (rel. fraction)
	pixels with 'hardware' flag	0:120 (number)
	pixels with 'HV-off' flag	0:50 (number)
Tracking	RMS of Az dev. distr.	0:10 (arcsec)
	RMS of Alt dev. distr.	0:10 (arcsec)
	mean deviation in RA	0:1 (arcmin)
	mean deviation in Dec	0:1 (arcmin)

- These cuts check quantities that are necessary for Hillas reconstruction
  → They are good enough for maps and detections

atmosphere cuts

DQ selection sensitive to

- Clouds
- Aerosols

Attenuate / completely absorb shower

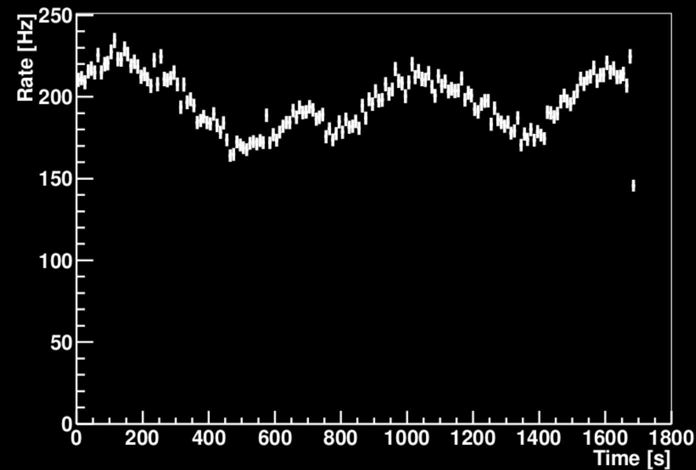
Increase energy threshold

Decrease in trigger rate

→ trigger rate is used in atmosphere cuts

Clouds

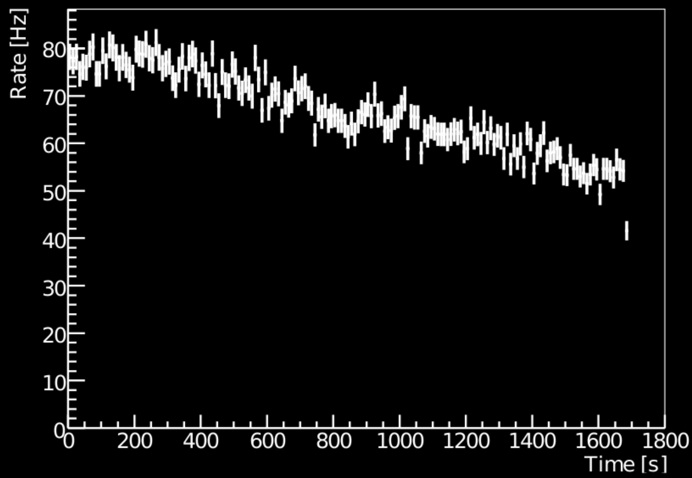
Clouds seen with H.E.S.S.: Small clouds



Fluctuation in system rate within one run

Clouds

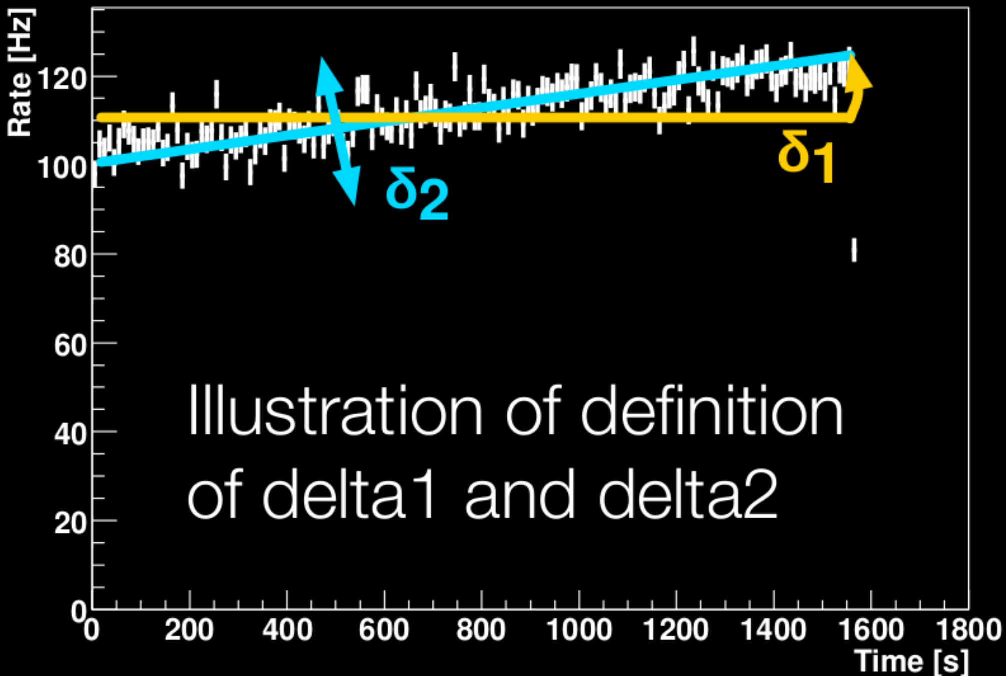
Clouds seen with H.E.S.S.: Large clouds / Cloud layers

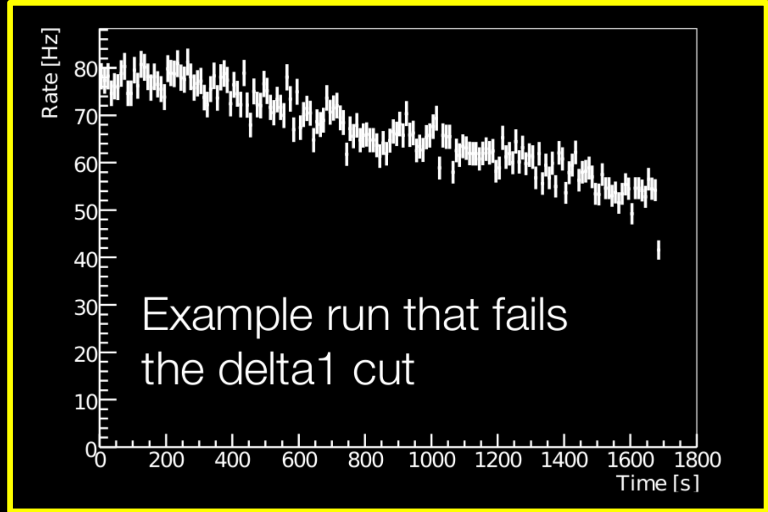


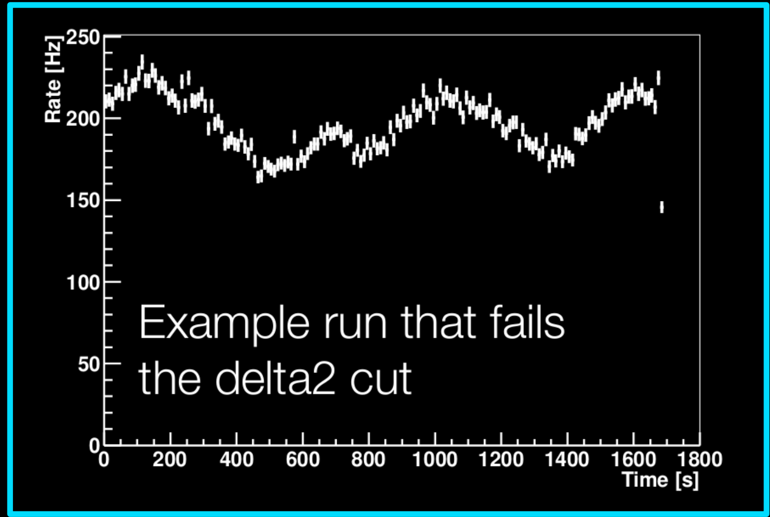
Continuous drop in system rate within one run

Clouds: Cuts

Cuts on these effects:

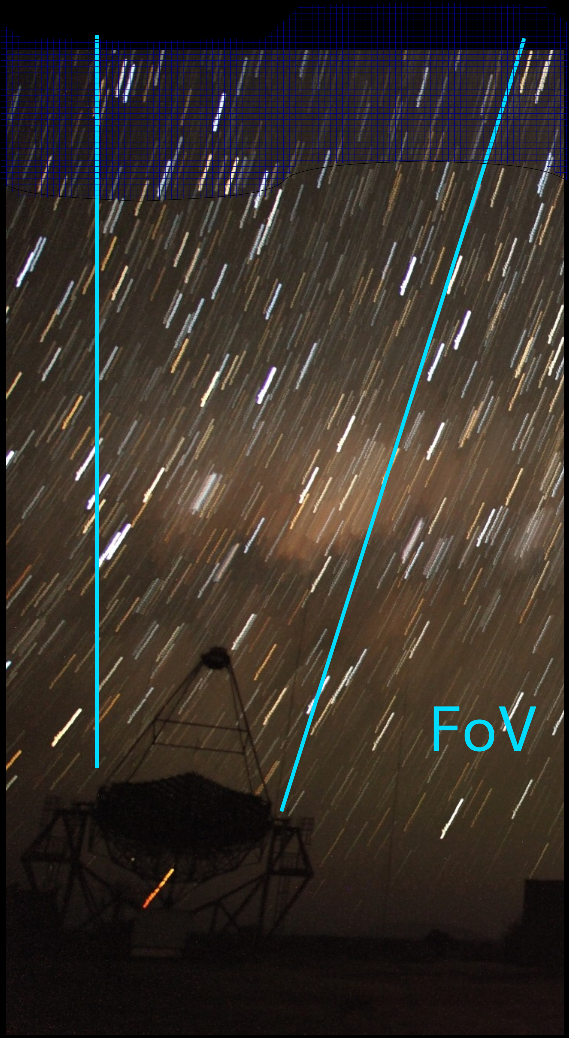


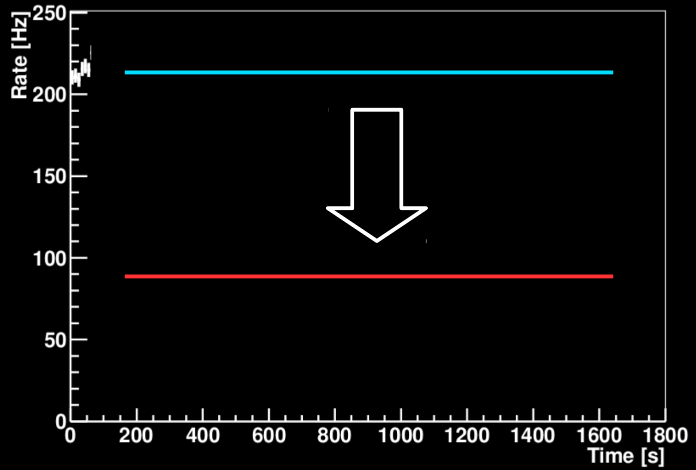




Aerosols

Large scale aerosol aborber structure



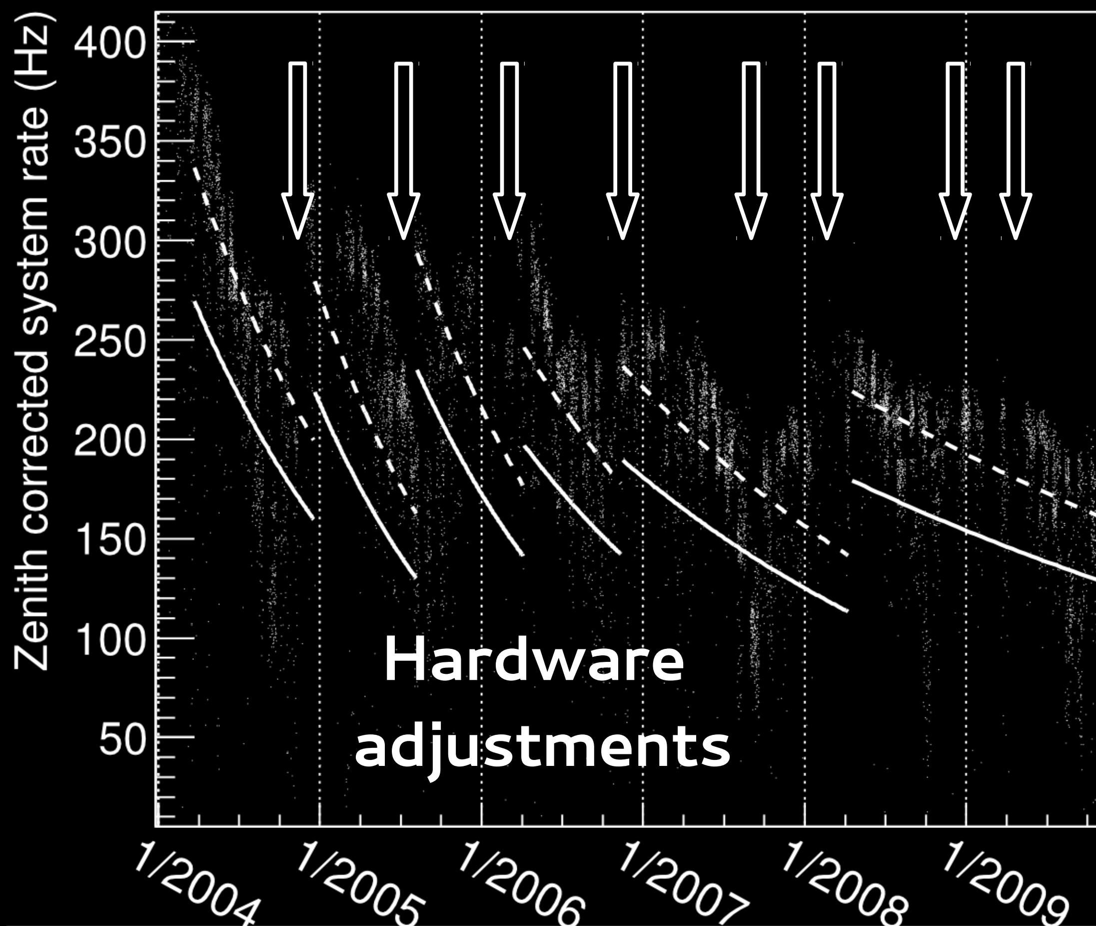


Overall drop in system rate

Not detectable within one run

Aerosols: old cut

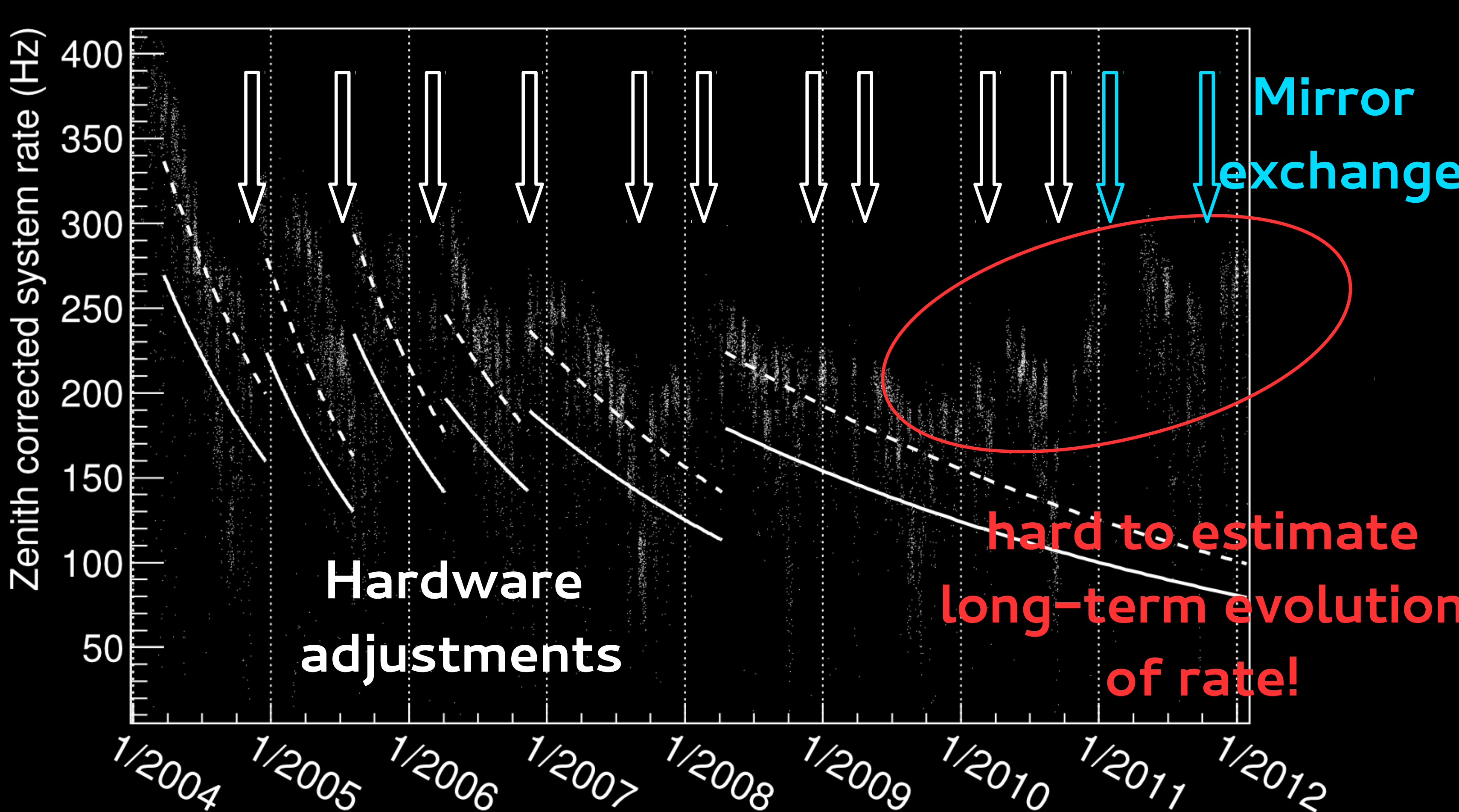
Old method:Get characteristic rate for any time period



Cut on this rate

Aerosols: old cut

Old method:Get characteristic rate for any time period



Aerosols: old cut

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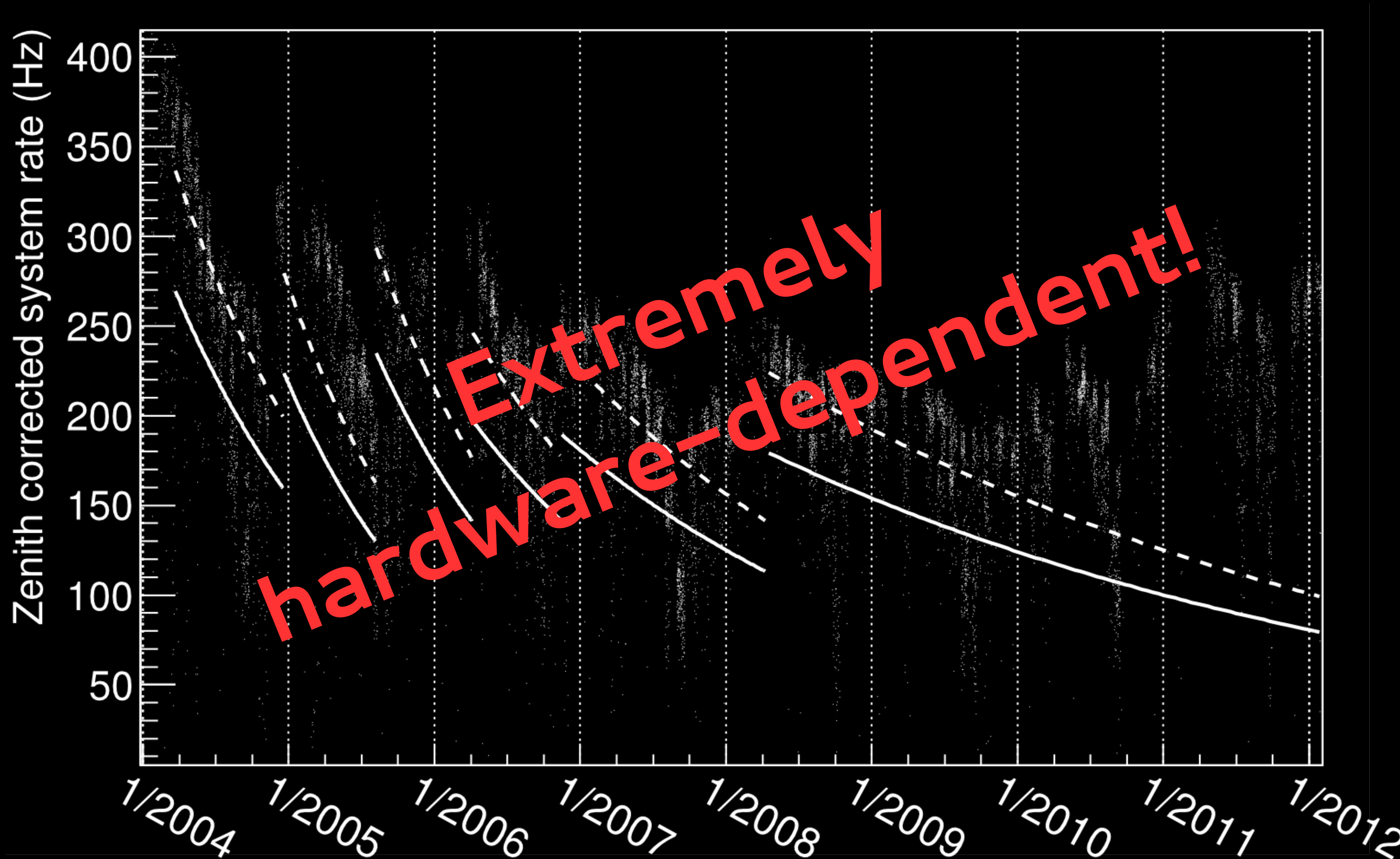


Aerosols: new cut

Is there a more hardware independent quantity isolating the effect of an opaque atmosphere on the trigger rate?

- Assumption 1:

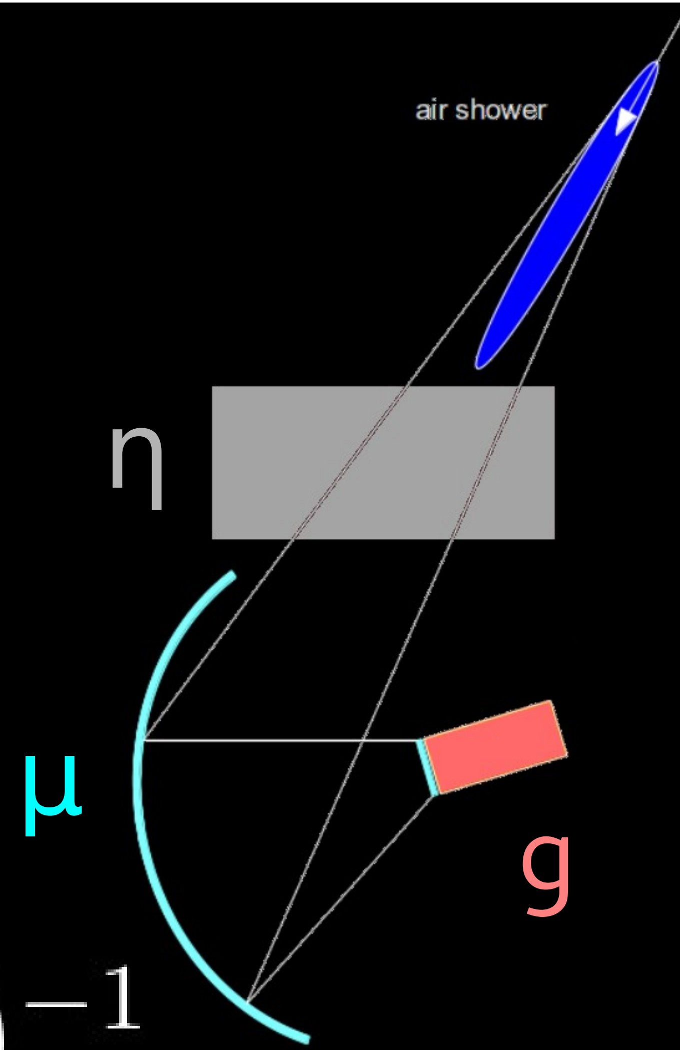
Trigger rate is integrated (local proton spectrum*Eff.area)

$$
\begin{aligned}
R &= \int_{E_0}^{\infty} \mathrm{d}E\, A_{\mathrm{eff}}(E) f(E) \\
&\simeq k \cdot E_0^{-1.7+\Delta}
\end{aligned}
$$

Aerosols: new cut

- Effect of atmosphere opacity symbolised by η
- Most important hardware effects on E_0:
  - pixel gain (g) adjustments
  - Winston cone cleaning, mirror refurbishments → traced by muon-efficiency (μ)
- Assumption 2:

$$E_0 \propto (\eta \cdot \mu \cdot g)^{-1}$$



Aerosols: Transparency Coefficient

- Then for every telescope i you can calculate

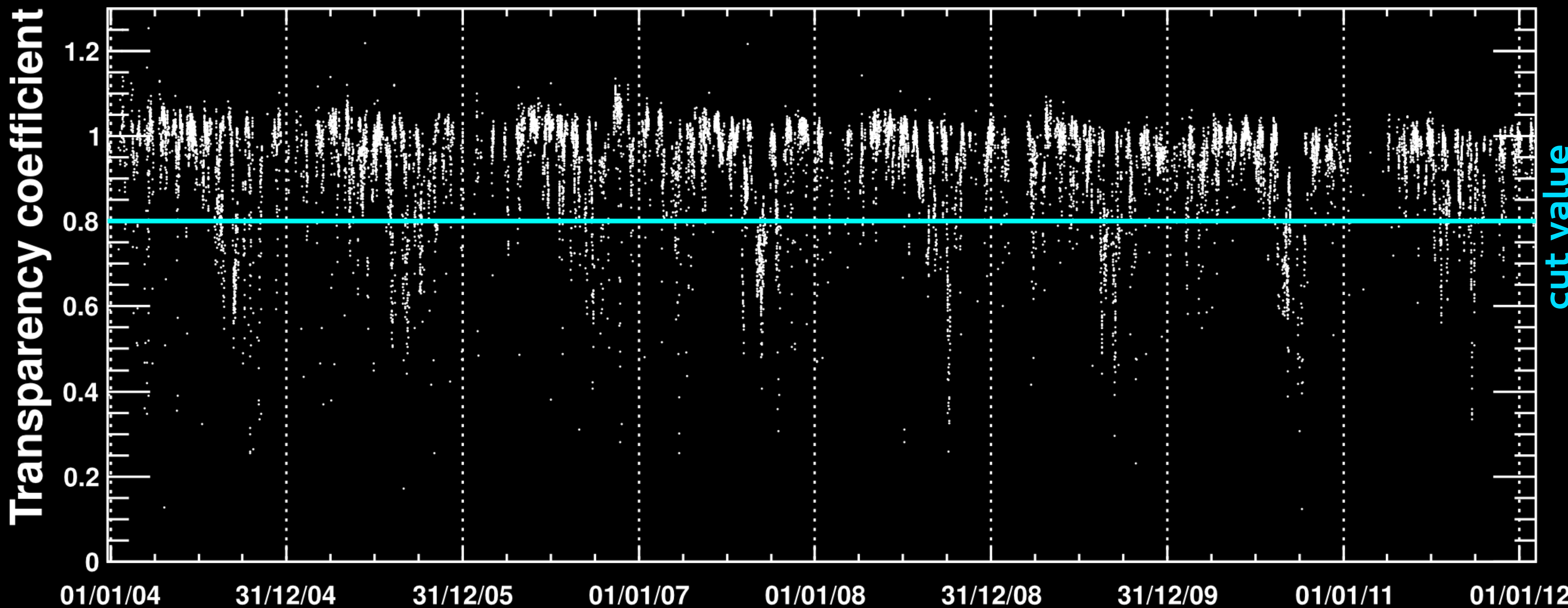
$$\eta \propto \frac{R_i^{\frac{1}{1.7-\Delta}}}{\mu_i \cdot g_i} \equiv t_i$$

- Average over N telescopes for a telescope-wide quantity

$$T \equiv \frac{1}{N \cdot k_N} \sum_i t_i$$

'Cherenkov Transparency Coefficient'

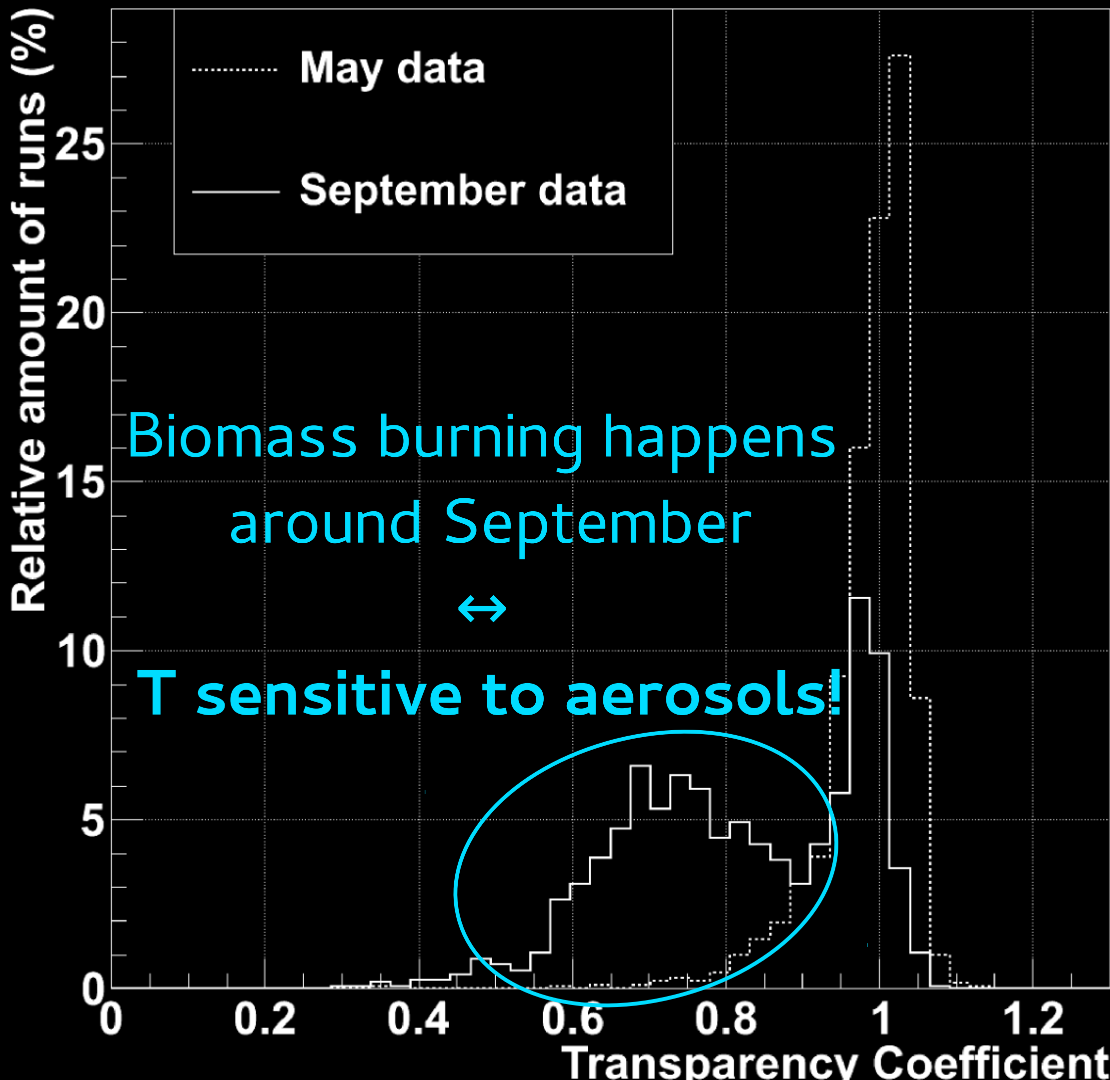
Aerosols: Transparency Coefficient



Hahn et al., 2013

- Remarkably stable over 8 years
  → largely hardware-independent
  → isolates atmosphere conditions ↔ dips around Septembers

Aerosols: Transparency Coefficient



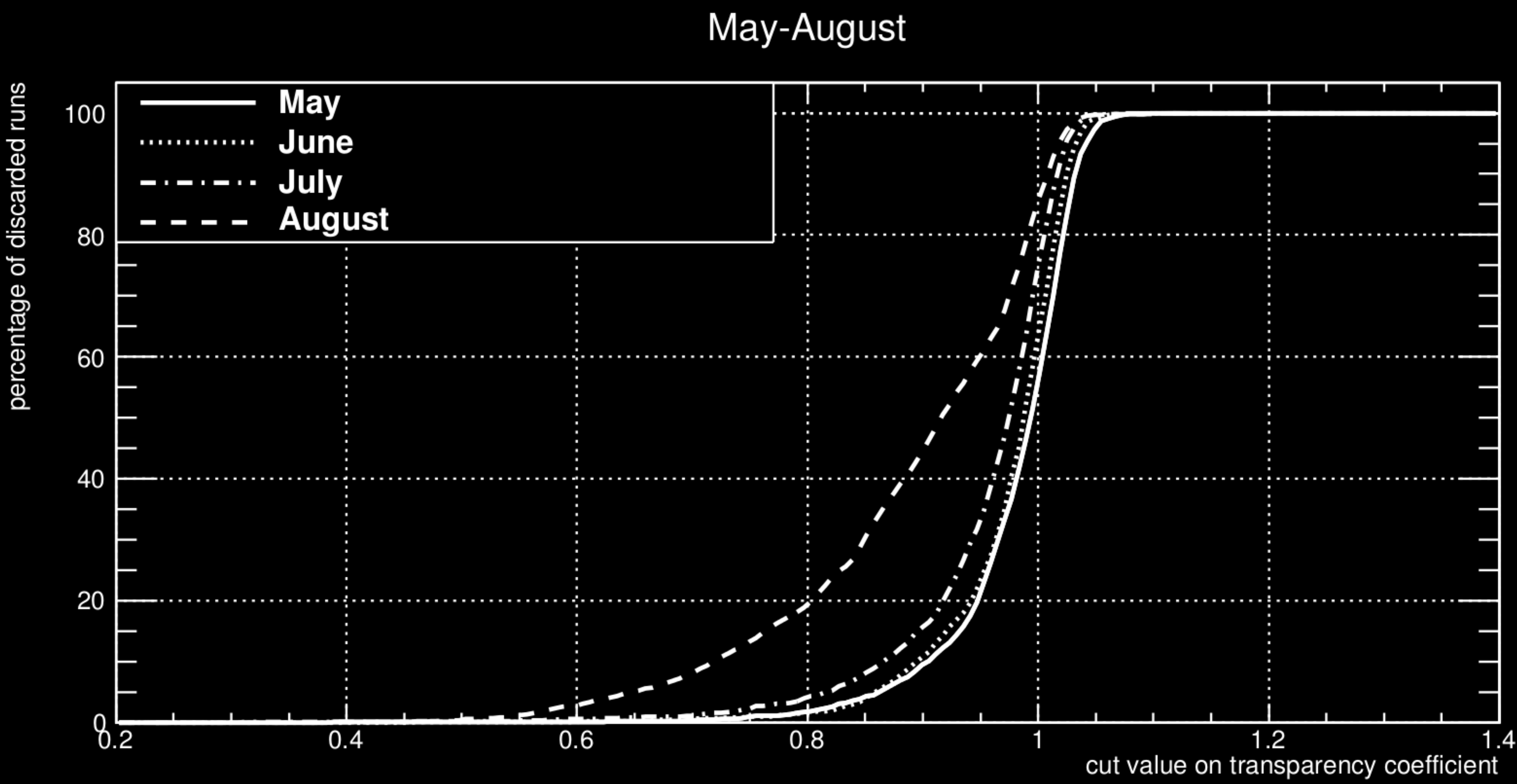
Biomass burning happens around September

↔

T sensitive to aerosols!

Hahn et al., 2013

Aerosols: Transparency Coefficient



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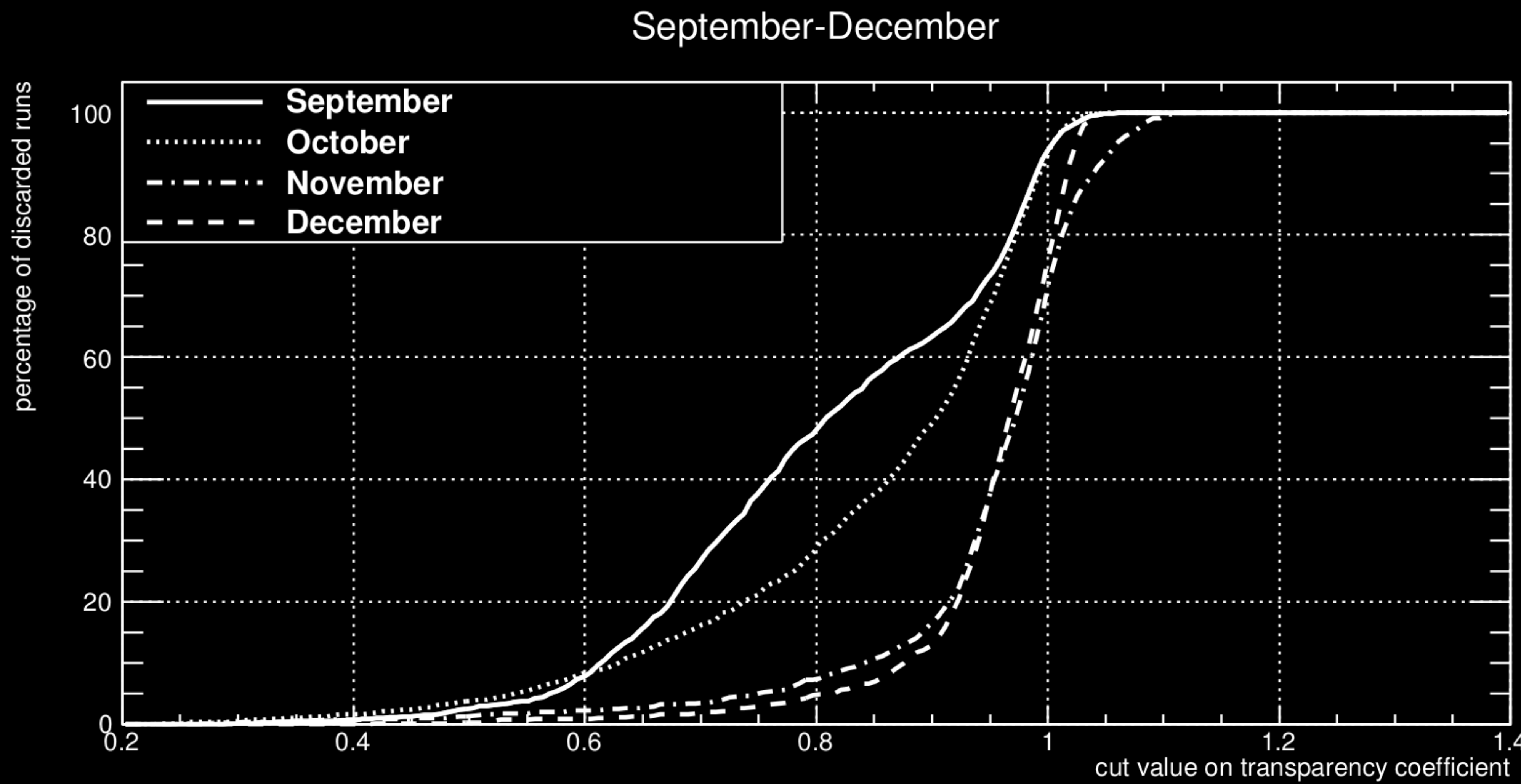
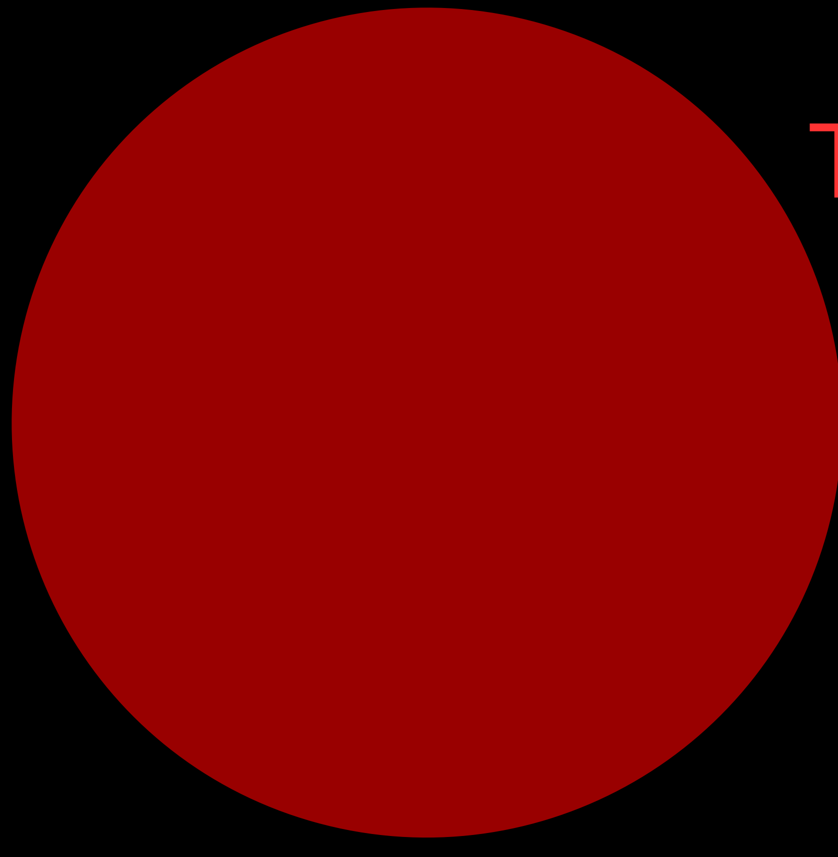


DQ: Impact of cuts



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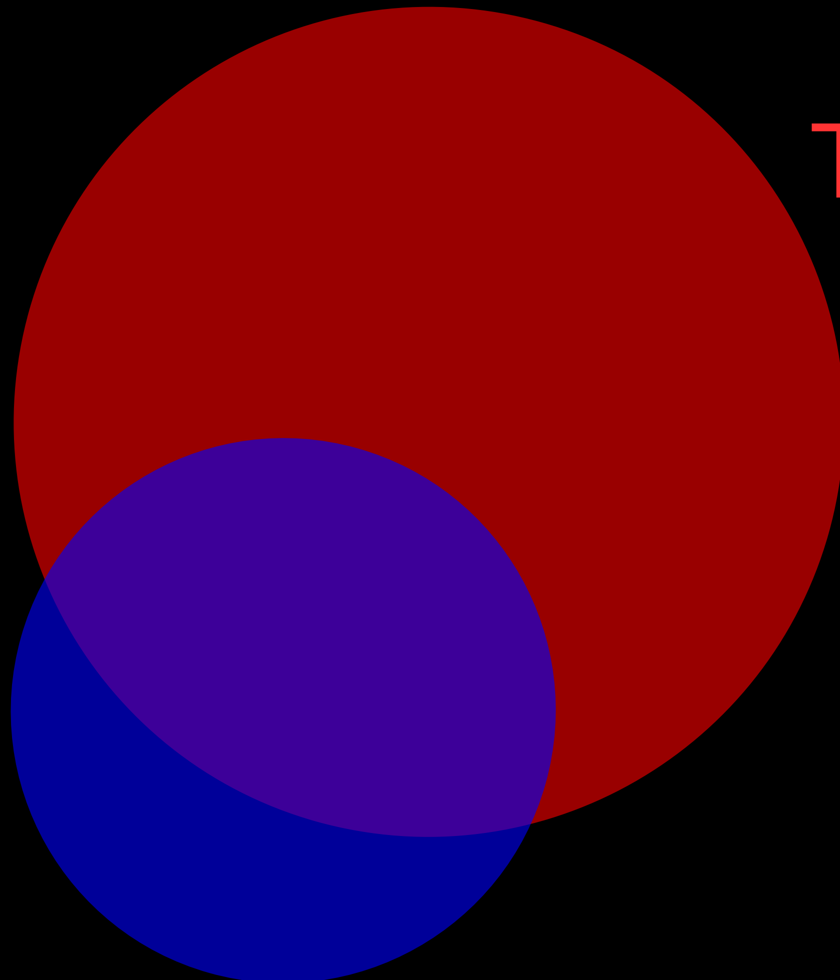
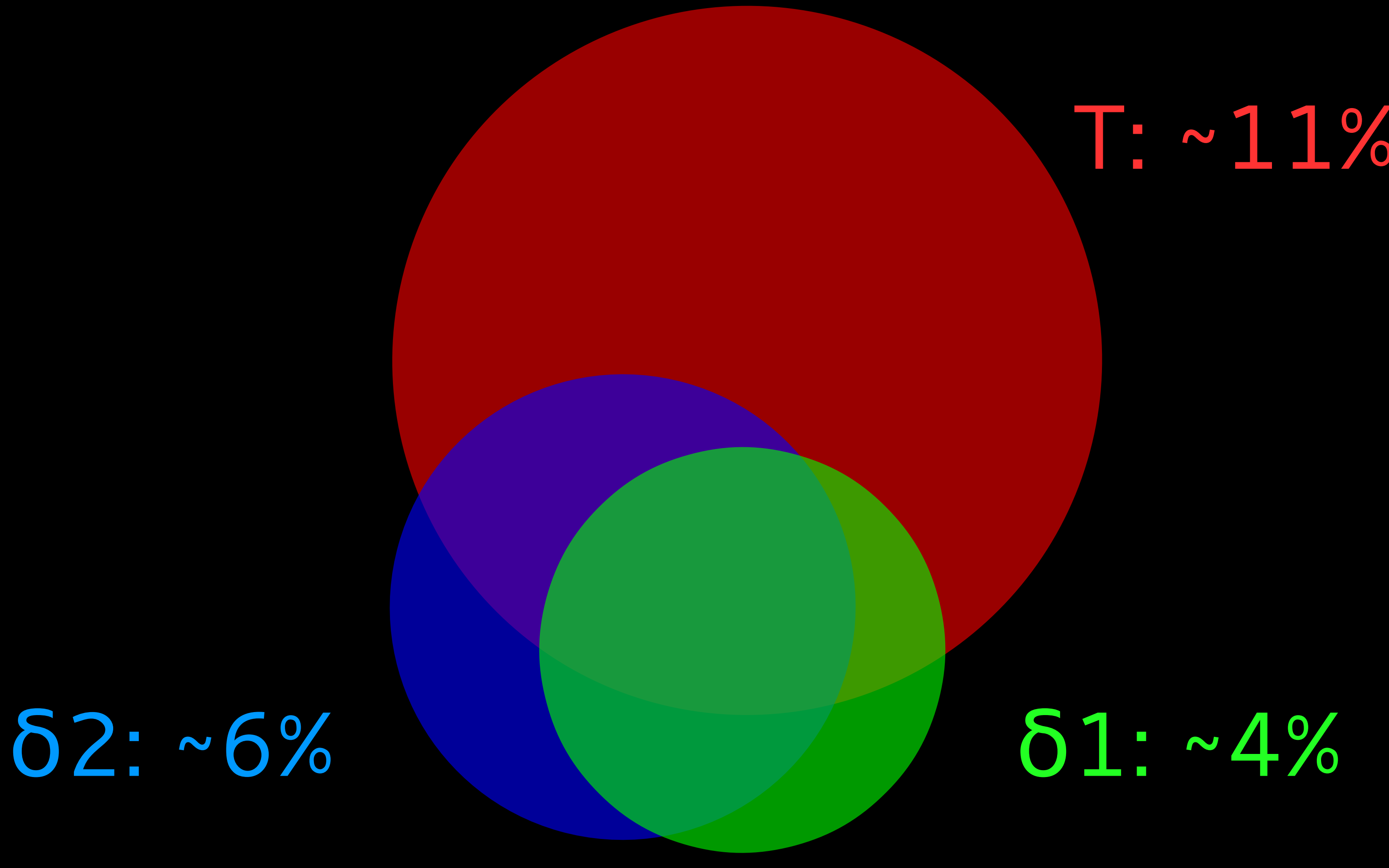


T: ~11%

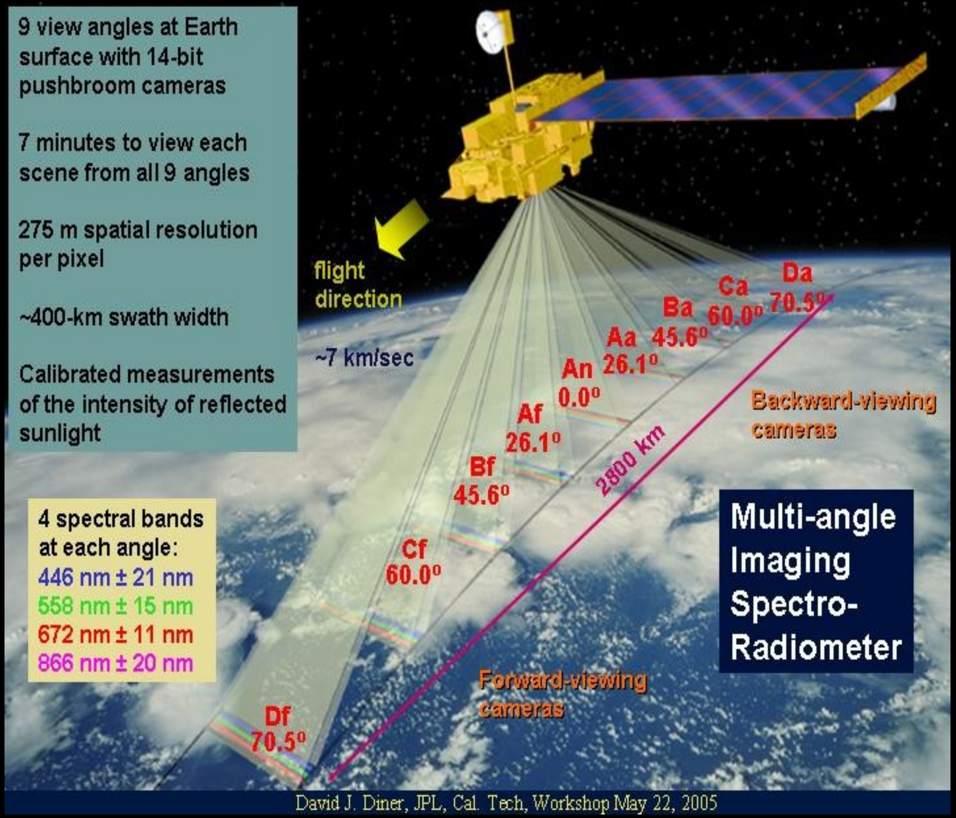
δ2: ~6%

DQ: Impact of cuts



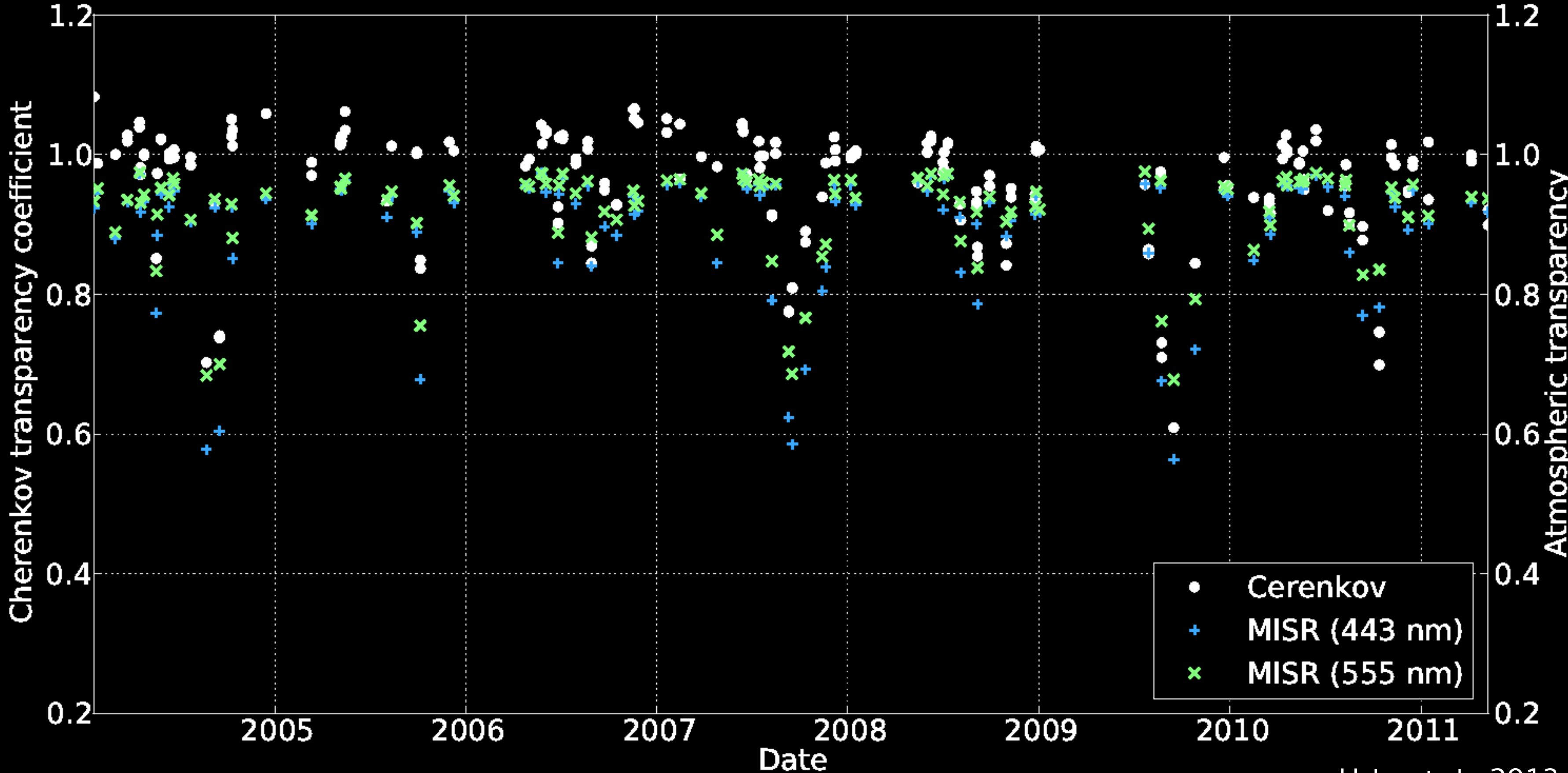
Aerosols: Transparency Coefficient

- Transparency coefficient traces aersols ?
  ↔ Proof: should correlate with independent aerosol measurements from satellites!
- MISR
  - On board TERRA
  - 275m-1.1km resolution
  - Different observation angles → disentangle clouds from aerosols etc.
  - Level 3 data product



Aerosols: Transparency Coefficient

- Select data taken within 24h of H.E.S.S. Measurements → overlap ~2% of H.E.S.S. Data



Hahn et al., 2013

Aerosols: Transparency Coefficient

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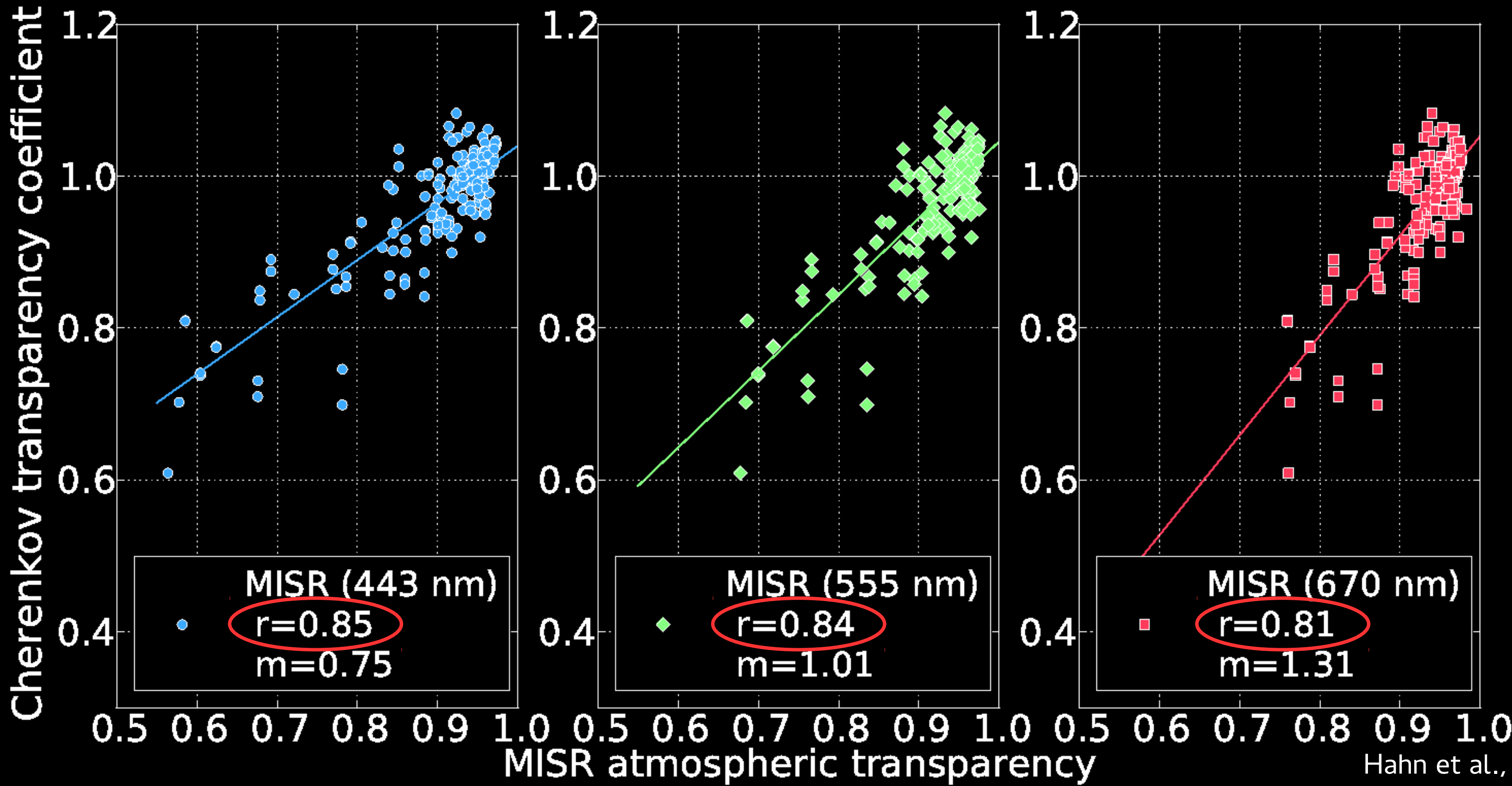


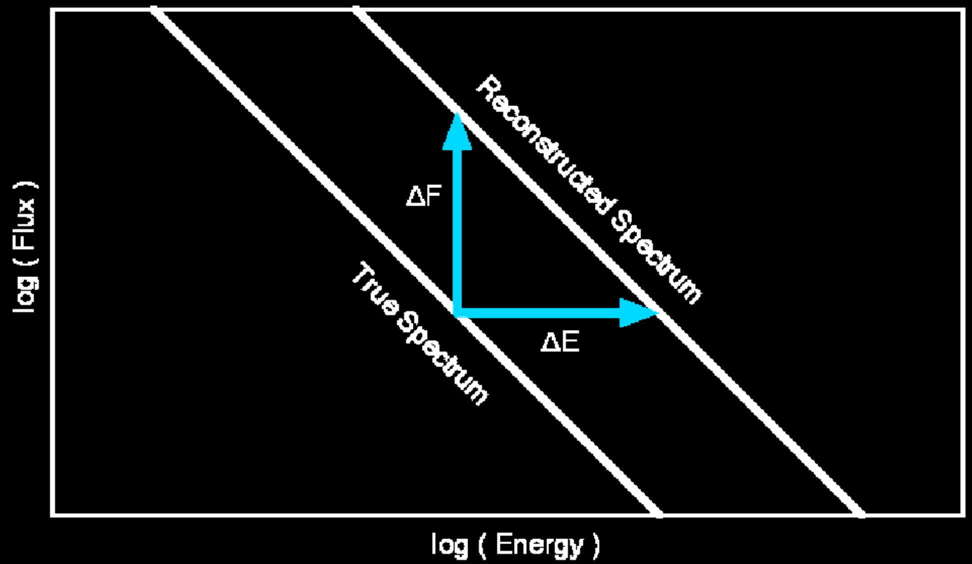
Hahn et al., 2013

Aerosols: Transparency Coefficient

- Strong and positive correlation with independent satellite measurements of aerosols
- Positive and strong correlations also with measurements from LIDAR and Radiometer (see other talks)

Aerosols: Transparency Coefficient

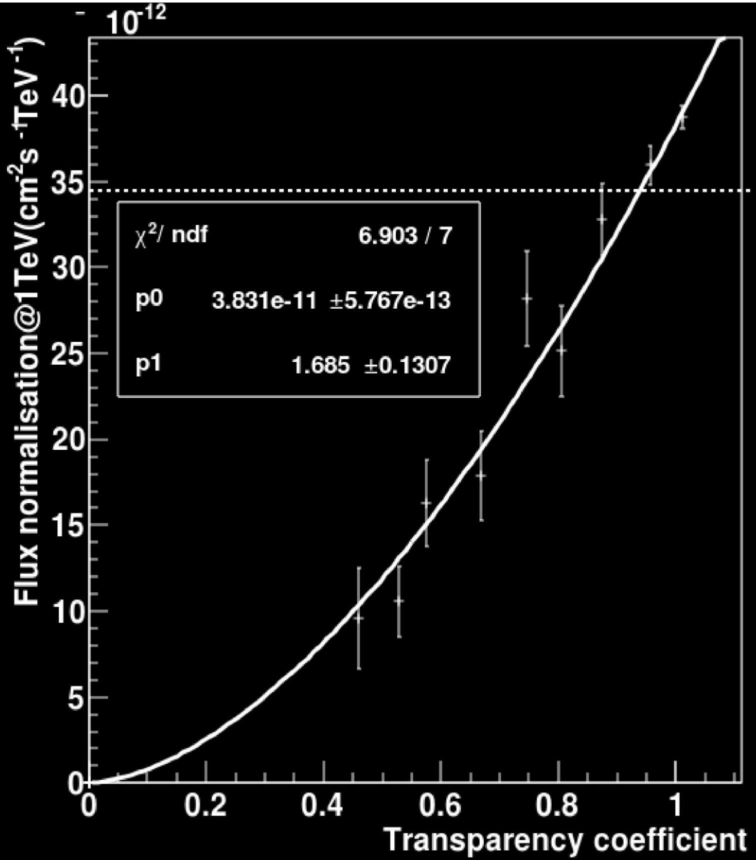
- Effect on reconstructed spectra?

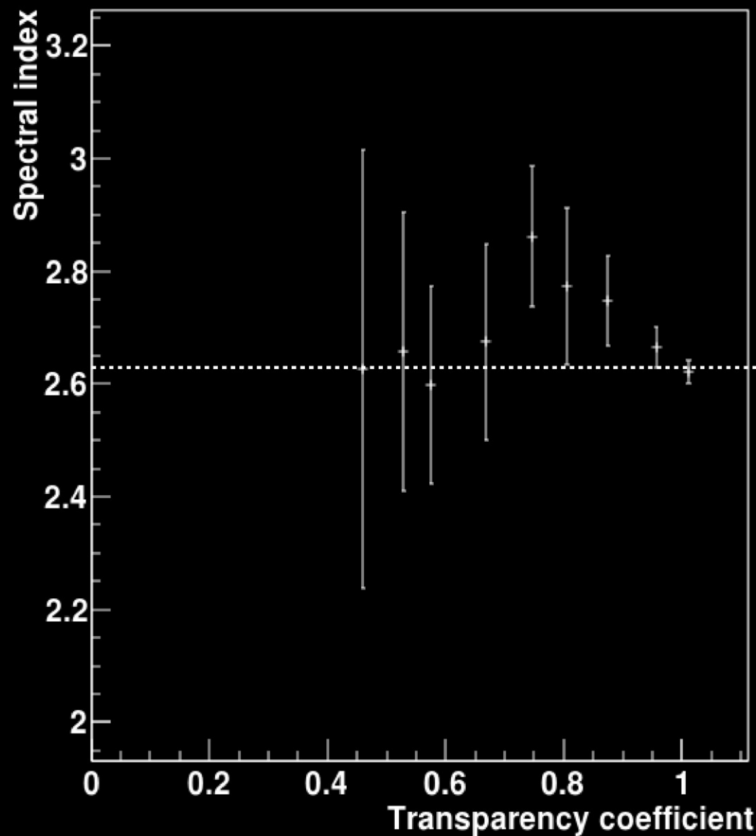


- Under assumption $E_{reco} \propto T \times E_{true}$ it follows for the rec. spectrum

$$\frac{\mathrm{d}F}{\mathrm{d}E_{true}} \propto E_{true}^{-\Gamma} \quad \Leftrightarrow \quad \frac{\mathrm{d}F}{\mathrm{d}E_{reco}} \propto E_{reco}^{-\Gamma} \cdot T^{\Gamma-1}$$

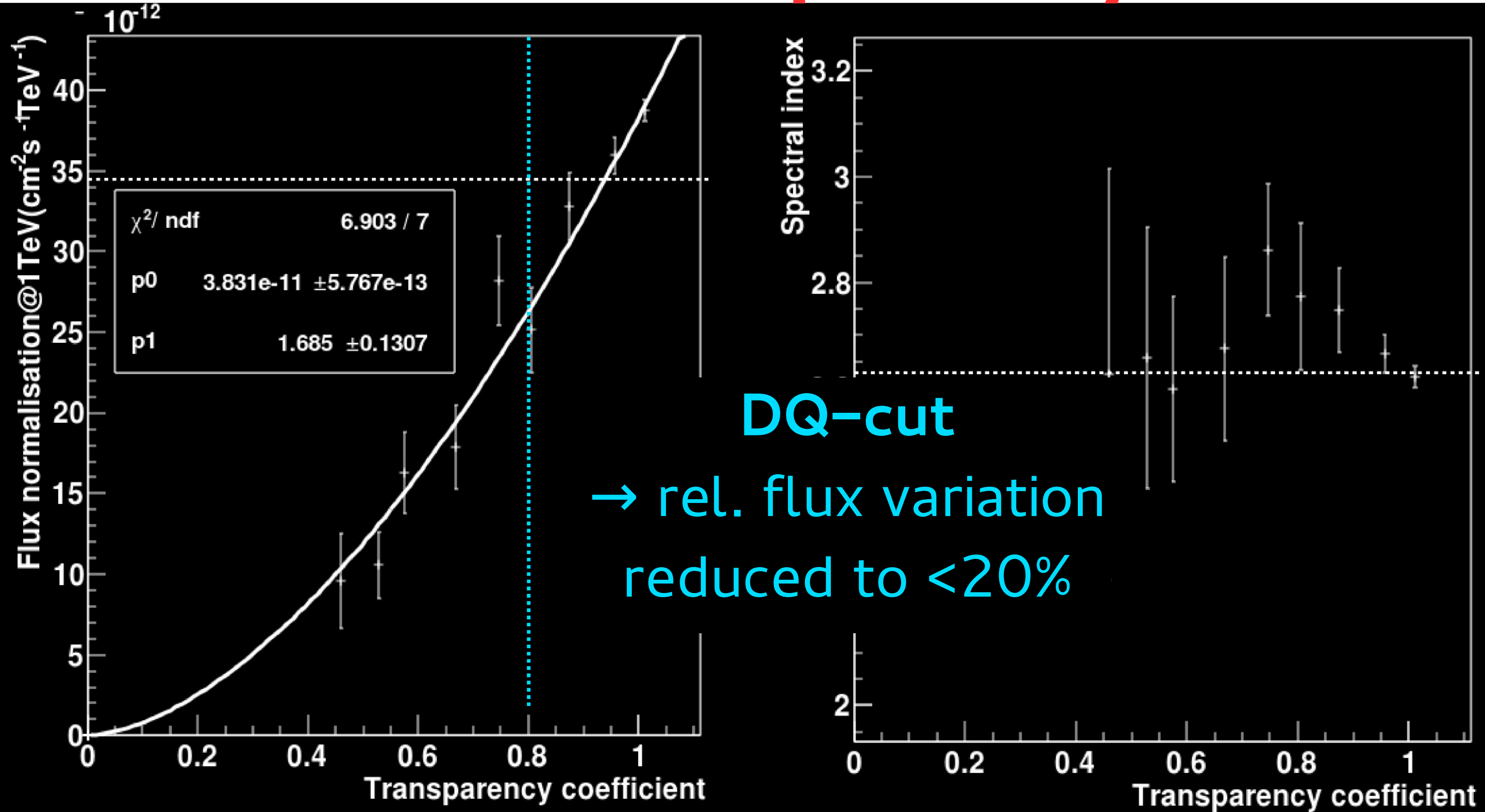
Aerosols: Transparency Coefficient





Hahn et al., 2013

Aerosols: Transparency Coefficient

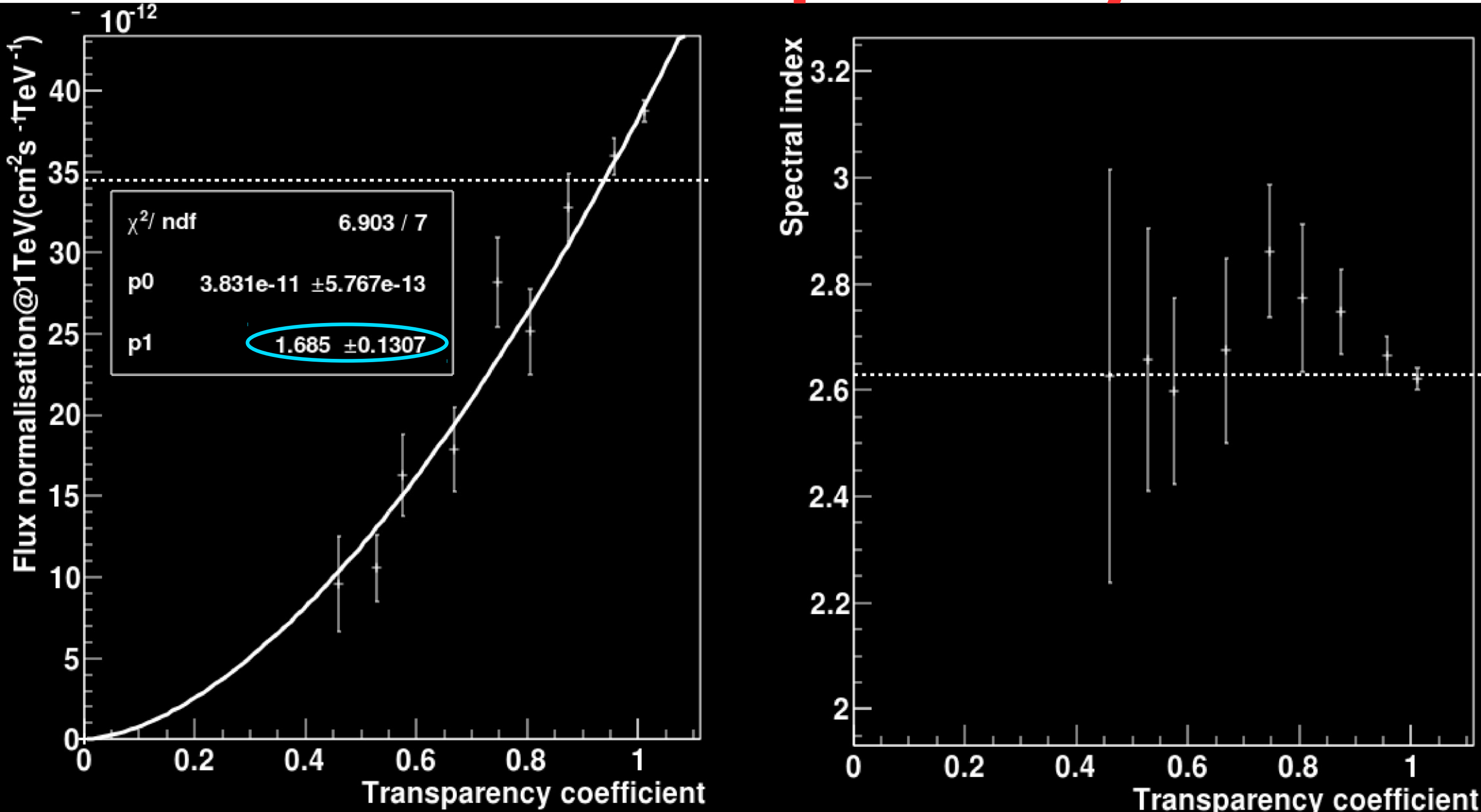


DQ-cut

→ rel. flux variation reduced to <20%

Hahn et al., 2013

Aerosols: Transparency Coefficient



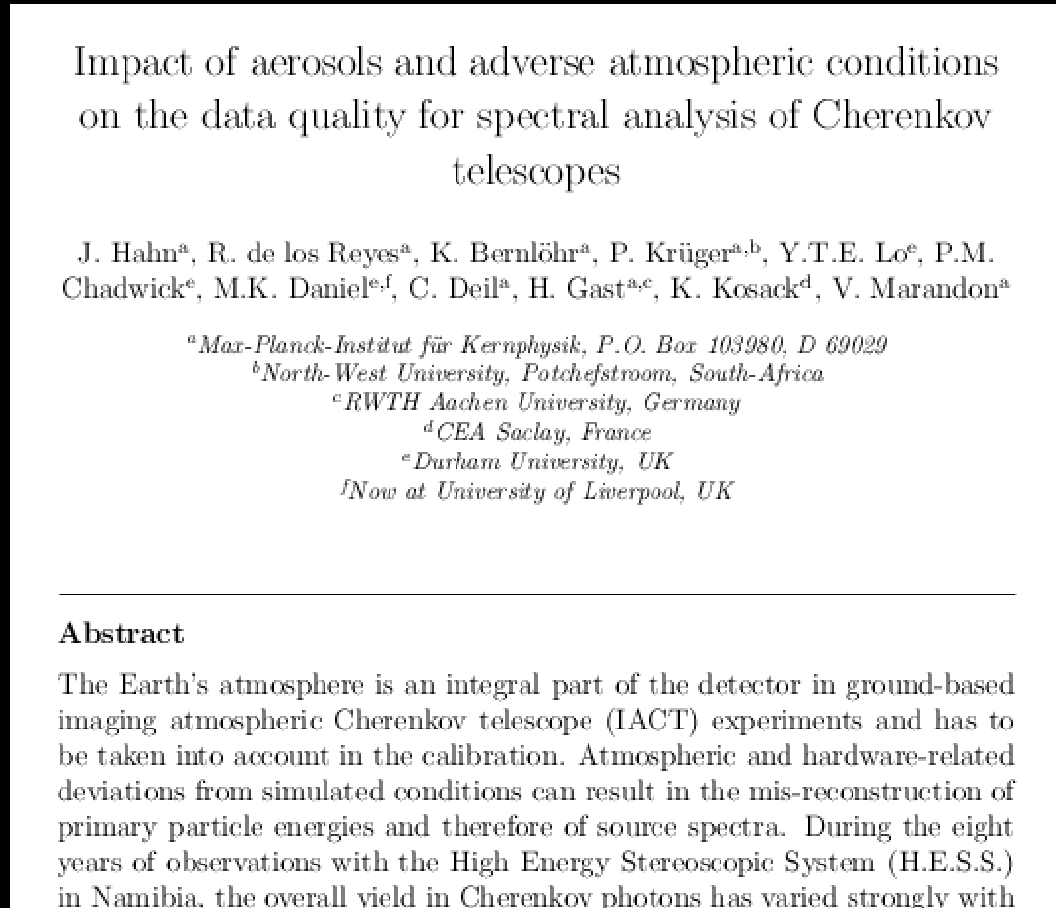
Hahn et al., 2013

- Fit: 1.69 ± 0.13stat ↔ Lit.: 1.63 ± 0.01stat ± 0.10sys

  → perfect match!

- **Use in Flux correction under study → Stay tuned!**

Aerosols: Transparency Coefficient



Impact of aerosols and adverse atmospheric conditions on the data quality for spectral analysis of Cherenkov telescopes

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Abstract

The Earth's atmosphere is an integral part of the detector in ground-based imaging atmospheric Cherenkov telescope (IACT) experiments and has to be taken into account in the calibration. Atmospheric and hardware-related deviations from simulated conditions can result in the mis-reconstruction of primary particle energies and therefore of source spectra. During the eight years of observations with the High Energy Stereoscopic System (H.E.S.S.) in Namibia, the overall yield in Cherenkov photons has varied strongly with

- For more infos:
  - Paper submitted
    → astro-ph version of the paper coming soon

Summary I

- H.E.S.S. uses a uniform DQ selection
- Hardware and Weather checks
- Clouds are relatively easy to detect within one run through trigger rate
- Aerosols and cloud layers more challenging
  → previous cut failed!
- New, hardware-independent quantity:
  Cherenkov Transparency Coefficient T

Summary II

- Cherenkov Transparency Coefficient T
  - Correlates strongly with satellite data (also with LIDAR and Radiometer data)
  - Describes expected Flux reduction due to atmospheric extinction quantitatively
    → use for flux correction under study
  - Is in principle generic and 'free' to all IACT experiments
    → needs standard calibration quantities+trigger rates
    → corresponding implementation in CTA under study