Cherenkov Transparency Coefficient for CTA

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with the help of

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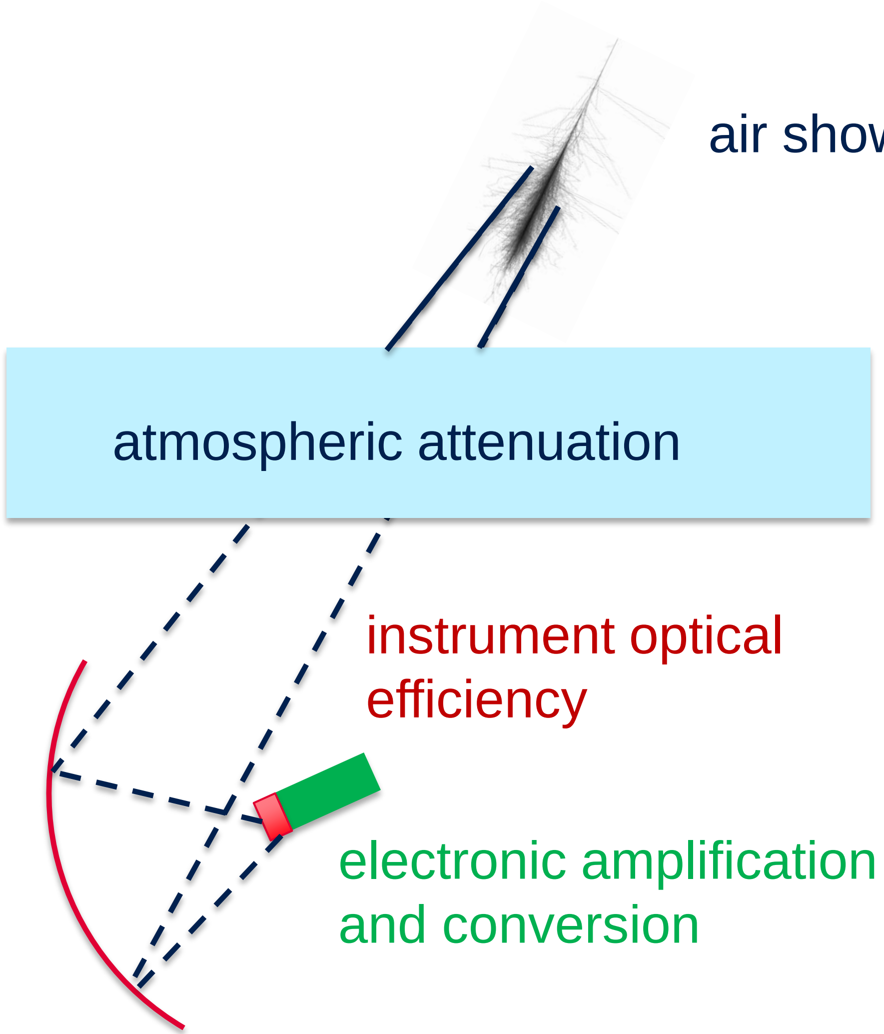
Cherenkov Transparency Coefficient



$$n_{ph}$$

$$\Big\downarrow \eta$$

$$n'_{ph} = n_{ph} \,.\, \eta$$

$$\Big\downarrow \mu$$

$$n_{pe} = n'_{ph} \,.\, \mu = n_{ph} \,.\, \eta \,.\, \mu$$

$$\Big\downarrow g$$

$$n'_{pe} = n_{pe} \,.\, g = n_{ph} \,.\, \eta \,.\, \mu \,.\, g$$

Cherenkov Transparency Coefficient

$$CTC = \frac{1}{N_{tel}} \sum_{i}^{N_{tel}} t_i$$

$$= \frac{1}{N_{tel}} \sum_{i}^{N_{tel}} \frac{\left[\frac{1}{\mathcal{N}} \frac{1}{M} R_i(\theta_{zen} = 0°)\right]^{\frac{1}{1.7}}}{\mu_i . g_i}$$

J. Hahn et al., Astropart. Phys. 54, 25, 2014

- CTC introduced in H.E.S.S. phase I to assess the transparency of atmosphere
- calculated on per run basis as a mean over all active telescopes
- hardware independent for H.E.S.S.-I, sensitive to atmospheric conditions only

Cherenkov Transparency Coefficient

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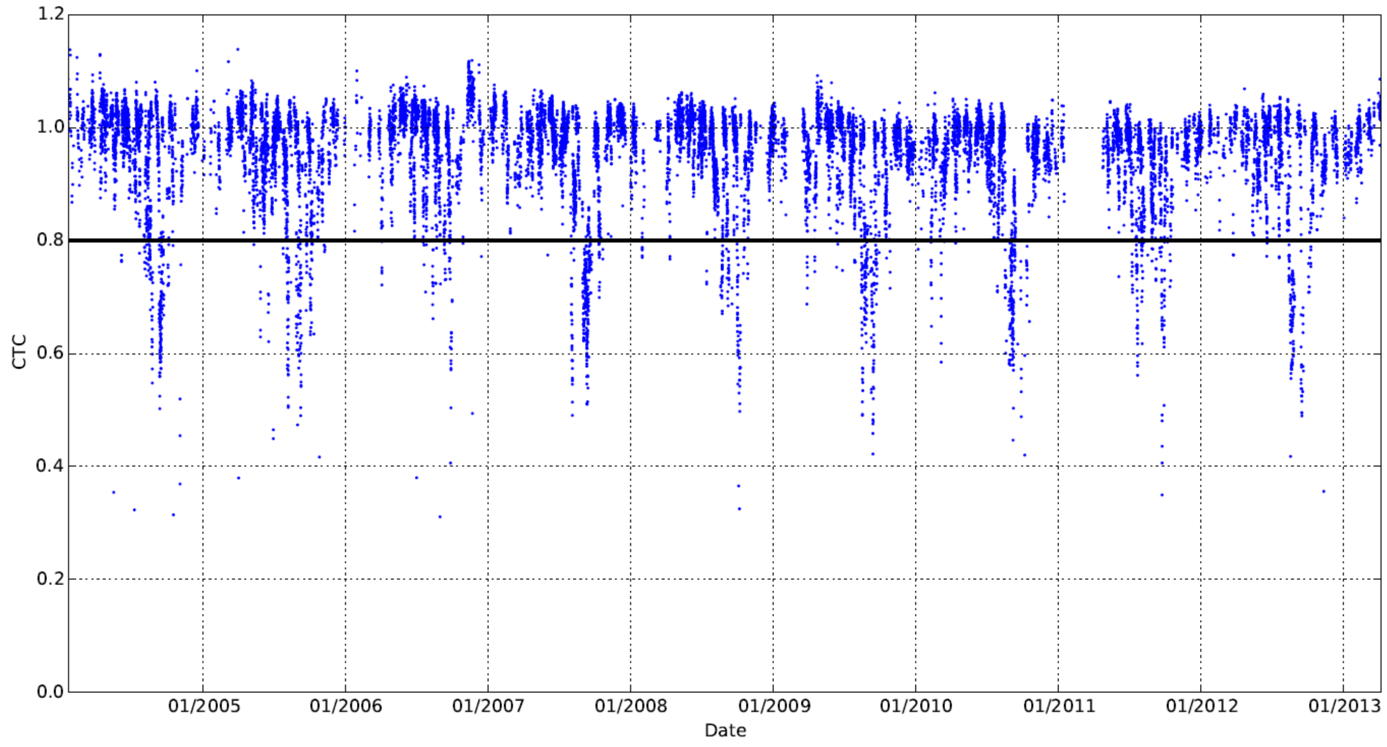

Atmospheric monitoring using CTC in H.E.S.S.

CTC for CTA

- plan to use the CTC within Atmosphere calibration WP

- atmosphere monitoring using CTC:
  - contemporaneous with the data taking
  - performed in the same direction and FoV as the actual observation

- consequently, CTC can be used for data correction
  - first attempt made by Hahn et al. (2014) for H.E.S.S. observations of Crab Nebula
  - more detailed feasibility study foreseen for CTA

CTC for CTA

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Problems applying the original scheme from H.E.S.S. to CTA:

- multiplicity factor *M*:
  - corrects for different telescope rates in runs with various numbers of active telescopes
  - does not account for different patterns of telescope layout
  - hard coded as one mean value taken over all possible layout scenarios
- not a solution for CTA: >> 4 telescopes, different telescope types, enormous number of possible subarray layouts
- different trigger thresholds between scheduled observations

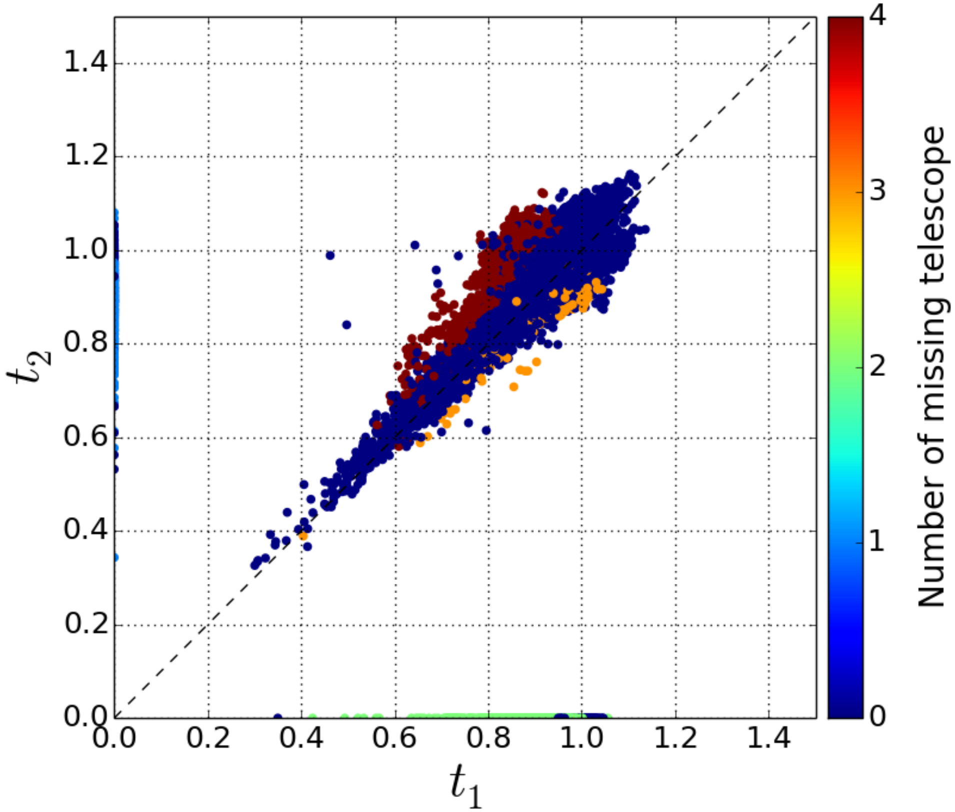
⟶ unrealistic look-up tables needed

Influence of telescope pattern

Lessons learned from H.E.S.S. data:

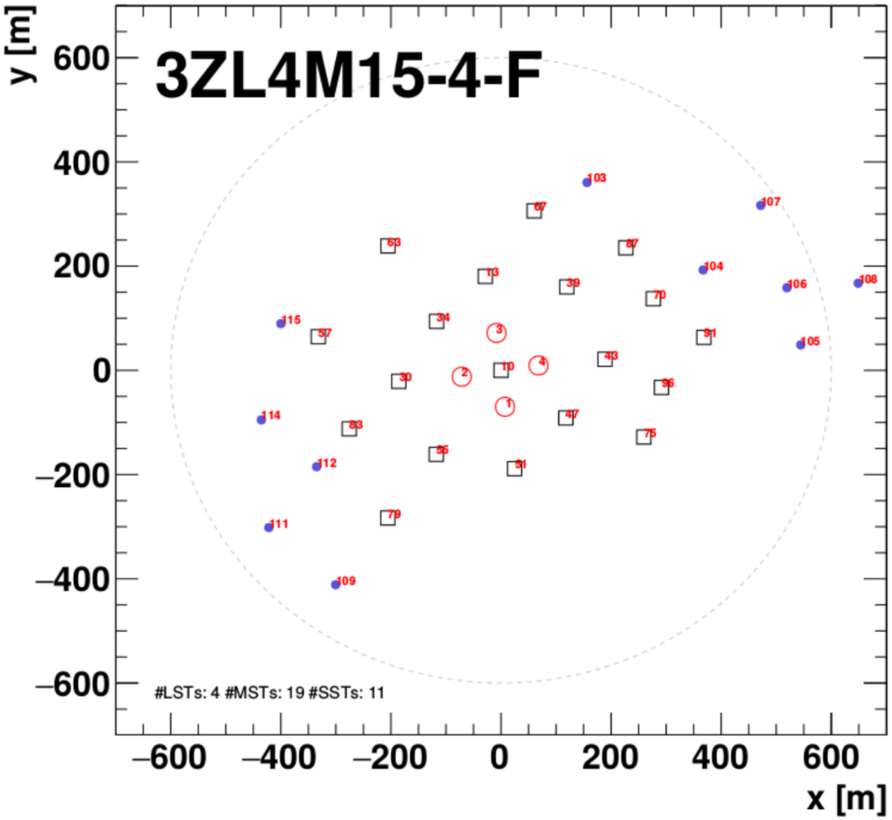
(many thanks to people at MPIK and H.E.S.S. coll. for providing me with data and advice)

- expect $t_i = t_j; i, j = 1 \ldots 4$ (at least for MC)
- formerly: RMS ~ 9%
- main cause: read-out rates strongly depend on relative positions of telescopes
- goal: mitigate the factors that contribute to RMS of CTC distribution
  - see more tomorrow in CTC array calibration talk



CTC for CTA: Used MC dataset

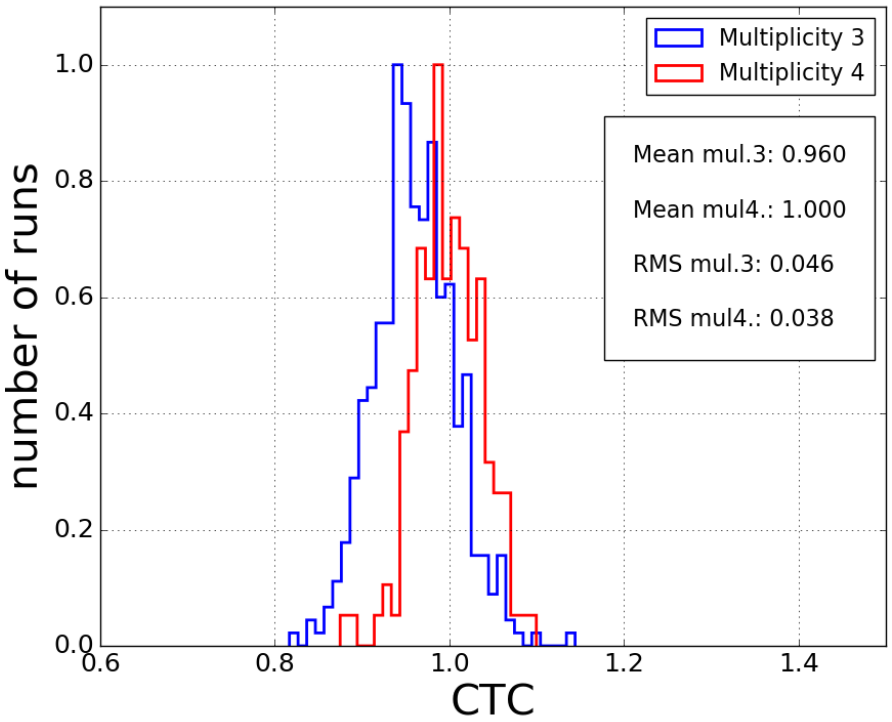
- Prod 3, La Palma
- 146 runs
- 250000 showers per run
- zenith angle 20°
- azimuth angle 180° (protons coming from north)
- $\mu, g = const$
- no simulated absorbers
- so far only max. 4 active telescopes considered



CTC for CTA

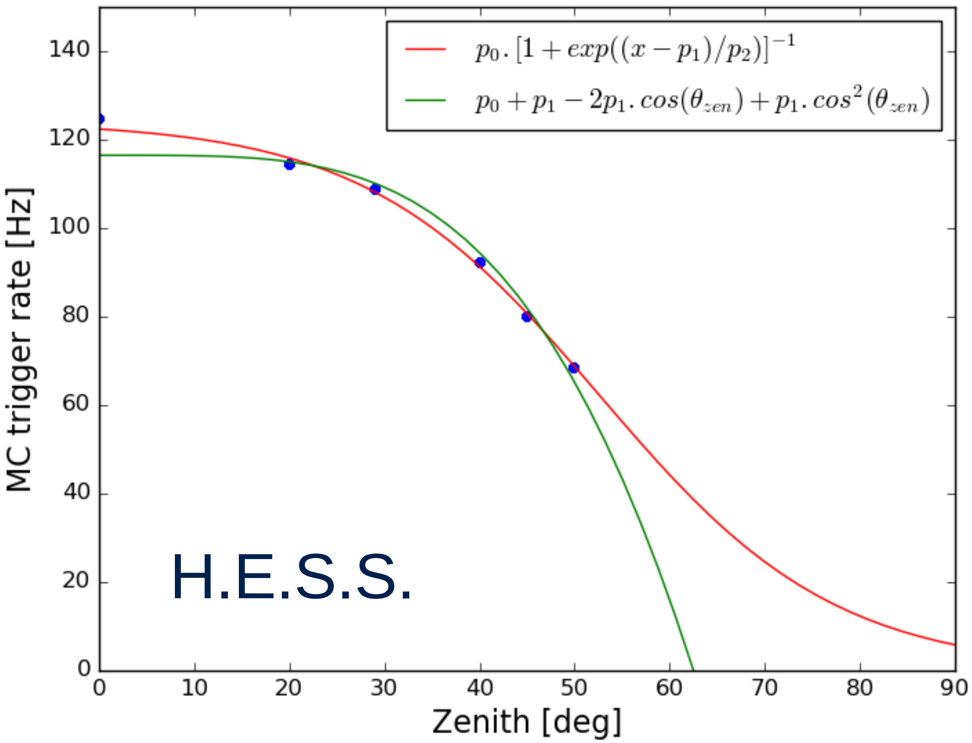
- so far limited statistics but the results seem to be consistent with previous study
- only good atmosphere and no hardware degradation
- width of distributions given only by statistical fluctuations

⟶ gives the limit for CTC estimation



Zenith angle correction

- applied descriptions of dependence not ideal (unphysical)
- bad zenith correction introduces additional uncertainty in CTC distributions
- better approach under study
- CTA: investigate for some range of angles



Data correction using CTC

$$\frac{\mathrm{d}F}{\mathrm{d}E_{true}} \propto (E_{true})^{-\Gamma} \quad \leftrightarrow \quad \frac{\mathrm{d}F}{\mathrm{d}E_{reco}} \propto (E_{reco})^{-\Gamma}.T^{\Gamma-1}$$

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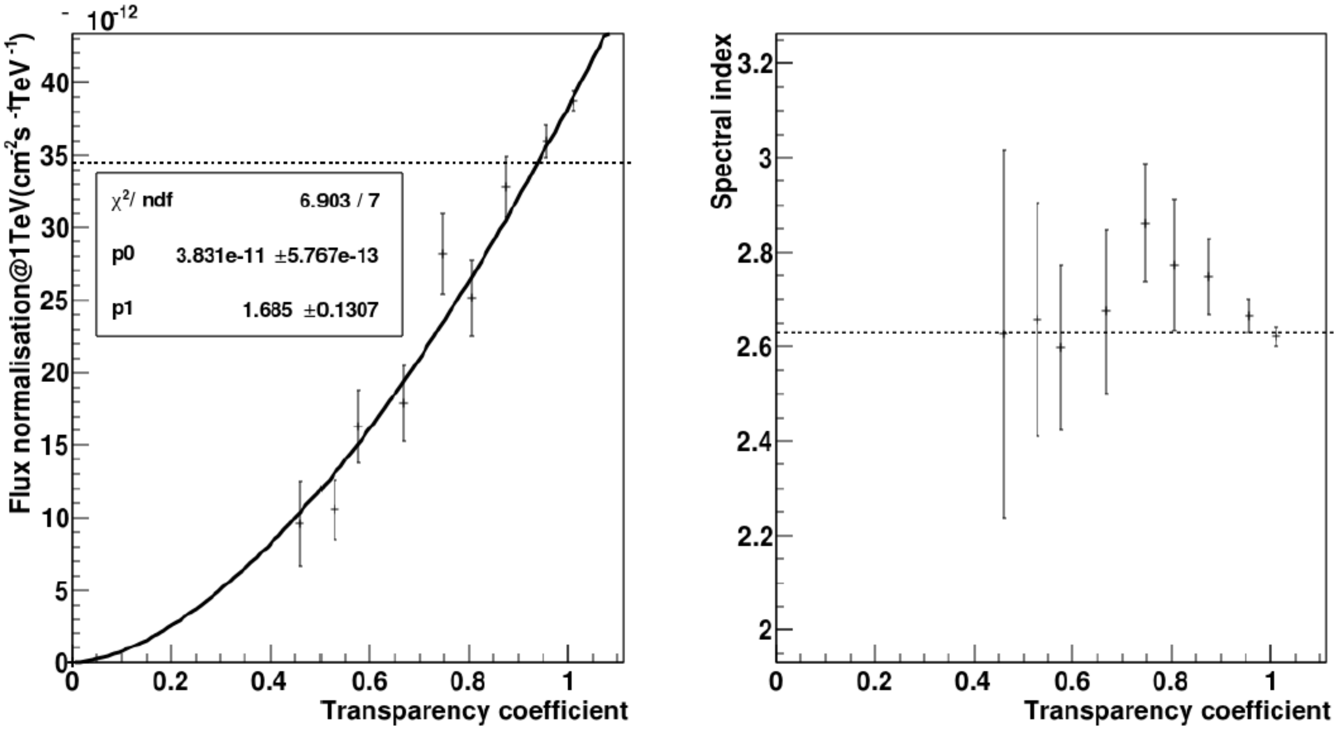


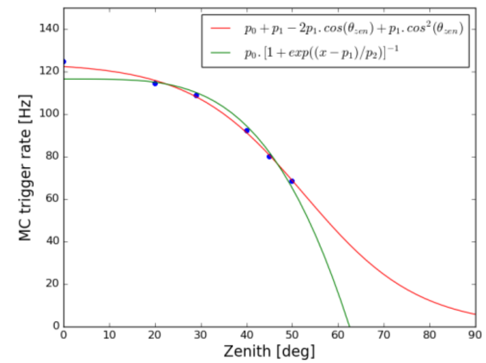
$\Gamma_{Crab} = 2.63 \pm 0.01_{stat} \pm 0.10_{syst}$

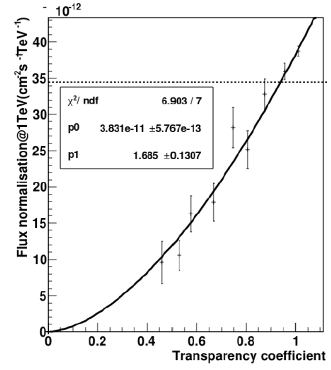
(F. Aharonian et al., A&A 457, 899-915, 2006)

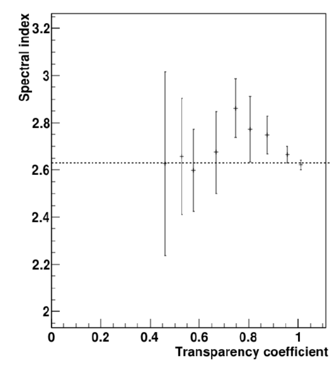
$\Gamma_{fit} \quad = 2.69 \pm 0.13$

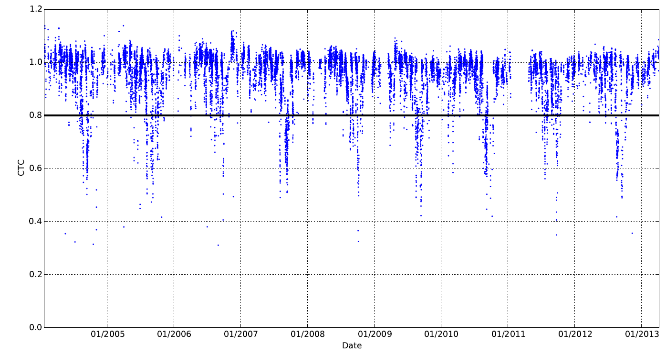
Future plans

- zenith angle dependence
- geomagnetic field:
  - azimuthal dependence
  - explore CTC for Paranal
- mirror & hardware degradation
- need to check the performance for worse atmospheric conditions
- none of this could be done so far









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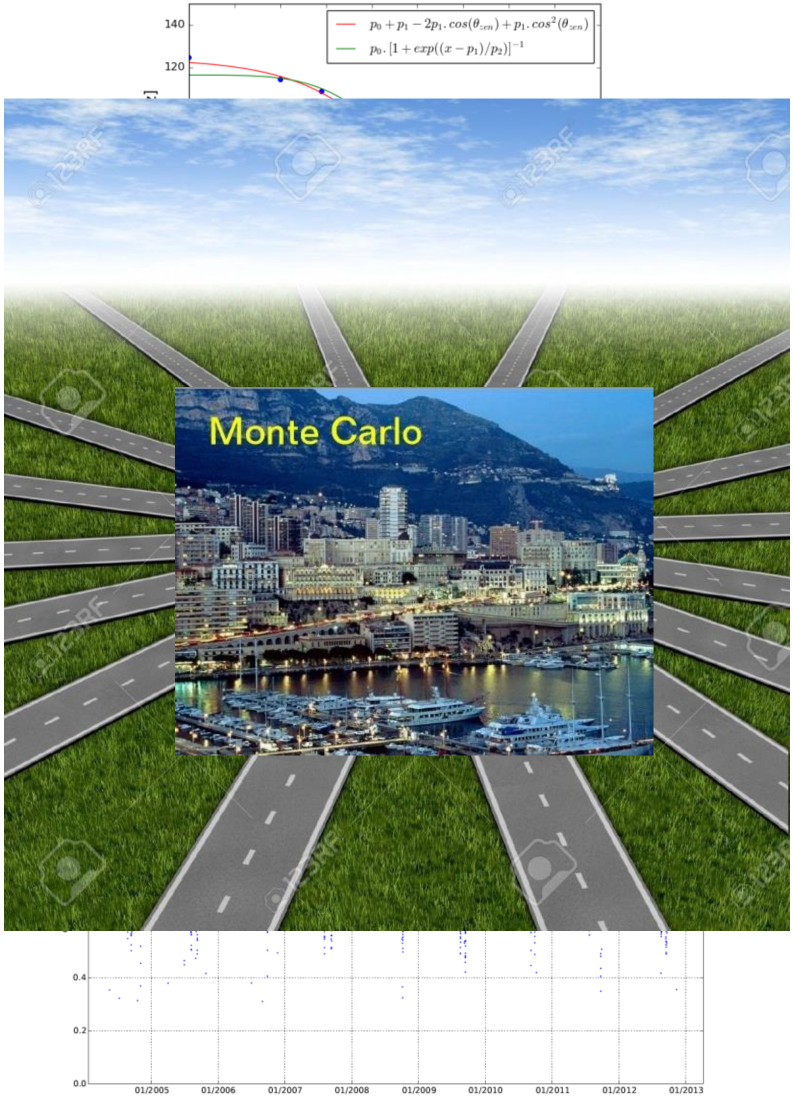
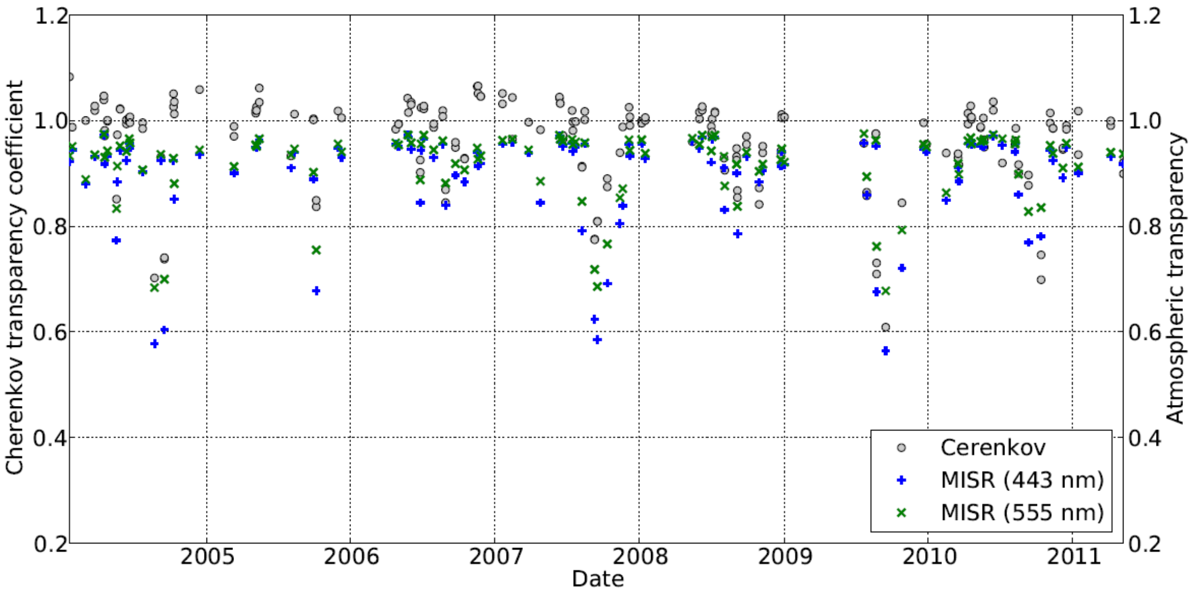
- none of this could be done so far
  - all roads lead to Monte Carlo: simulations of specific observational conditions would be very helpful



Further future plans

- intent to periodically cross-calibrate CTC with other atmospheric monitoring devices planned for CTA
  - especially important after hardware changes
  - collaboration within the Atmo. Calibration WP
- example: H.E.S.S. vs MISR satellite
  - cross-check with CTA data



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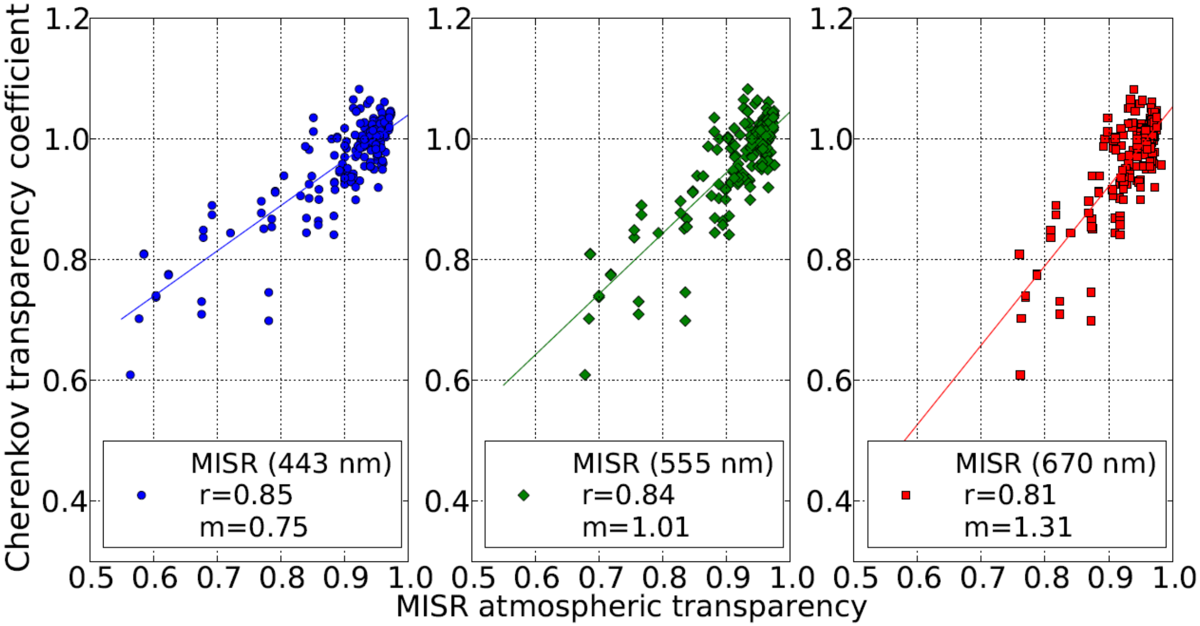

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Summary

- Feasibility study of the CTC for CTA started and ongoing
- available simulations for protons allow only limited progress
- new MC crucial for further feasibility study – but it is the only "investment" needed for this method
- CTC atmospheric measurement is a mean seen over all telescopes which should observe the same conditions
- Tomorrow: calculation of CTC improved in terms of geometrical configuration of array, cross-calibration