Simulations for the atmosphere with clouds

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Outline

→ Transmission of Cherenkov light

→ Transmittance simulations with MODTRAN

→ EASs simulations - CORSIKA

→ Detector simulations

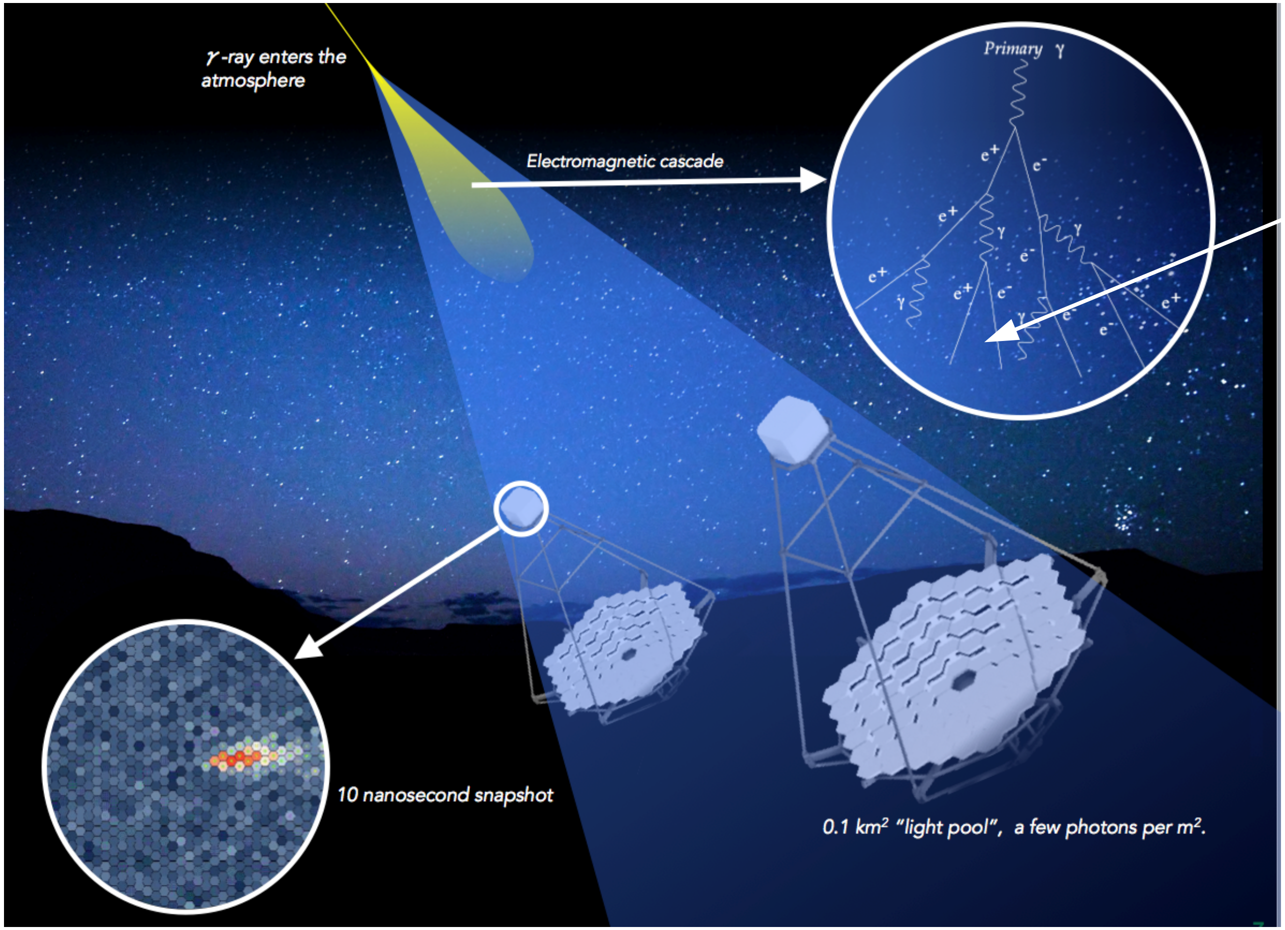
→ Problems

→ Summary

What is the biggest difference between an **air Cherenkov telescopes** in respect to satellites, lab experiments, underground detectors etc?

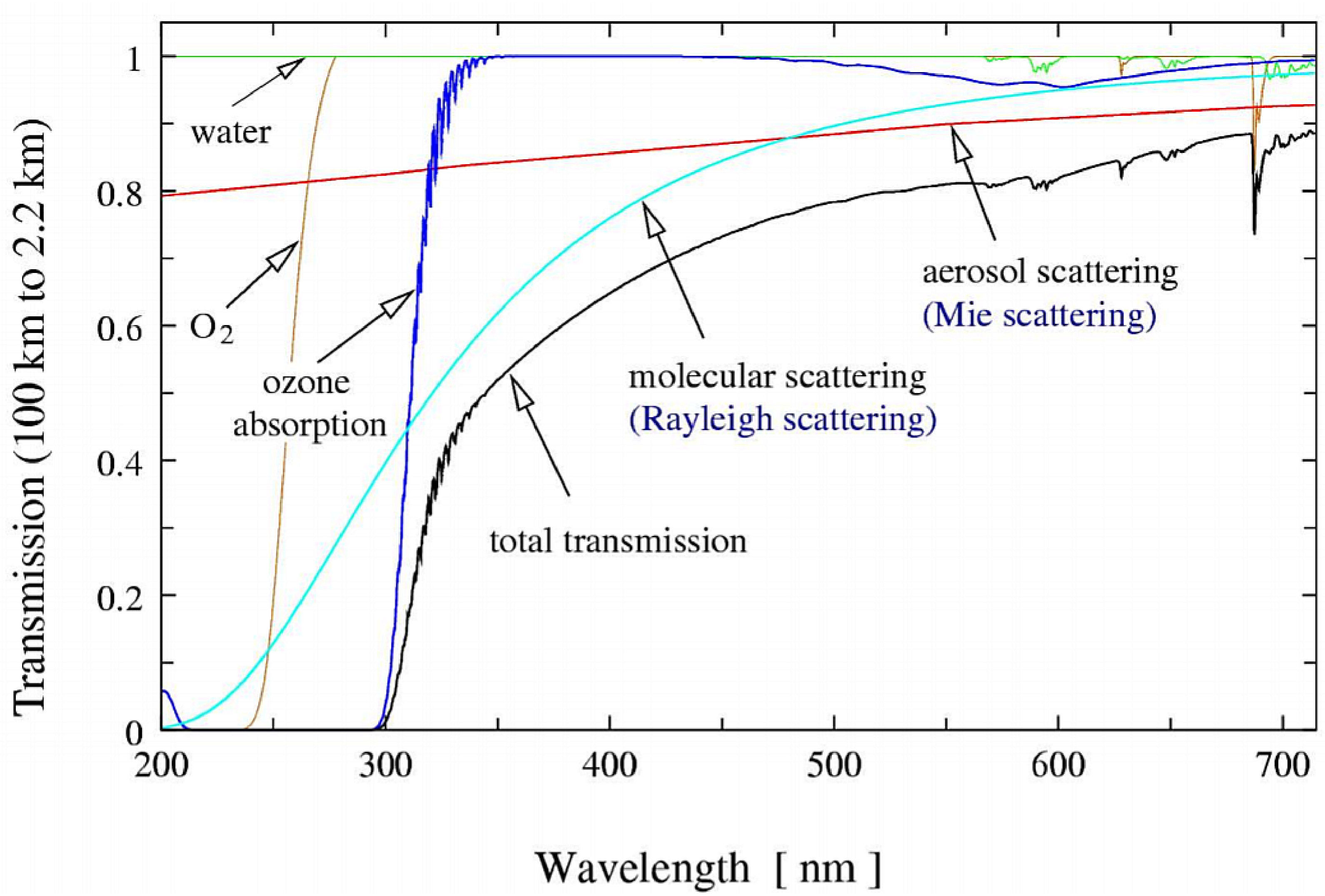
→ At the top of mountains, we are exposed to variable weather conditions.

IACT



$$\frac{d^2 N}{dx\, d\lambda} = \frac{2\pi\alpha z^2}{\lambda^2}\left(1 - \frac{1}{\beta^2 - n^2(\lambda)}\right)$$

Transmission of Cherenkov light



Adopted from Bernlöhr, K.

Transmittance simulation

→ MODTRAN 5.2.2 at warp.zeuthen.desy.de

→ Wavelengths range: 203 nm to 999 nm (step 1 nm)

→ Atmospheric model: 6 (US Standard Atmosphere)

→ Zenith angle: 20.0°

→ Ground altitude: 2147 m

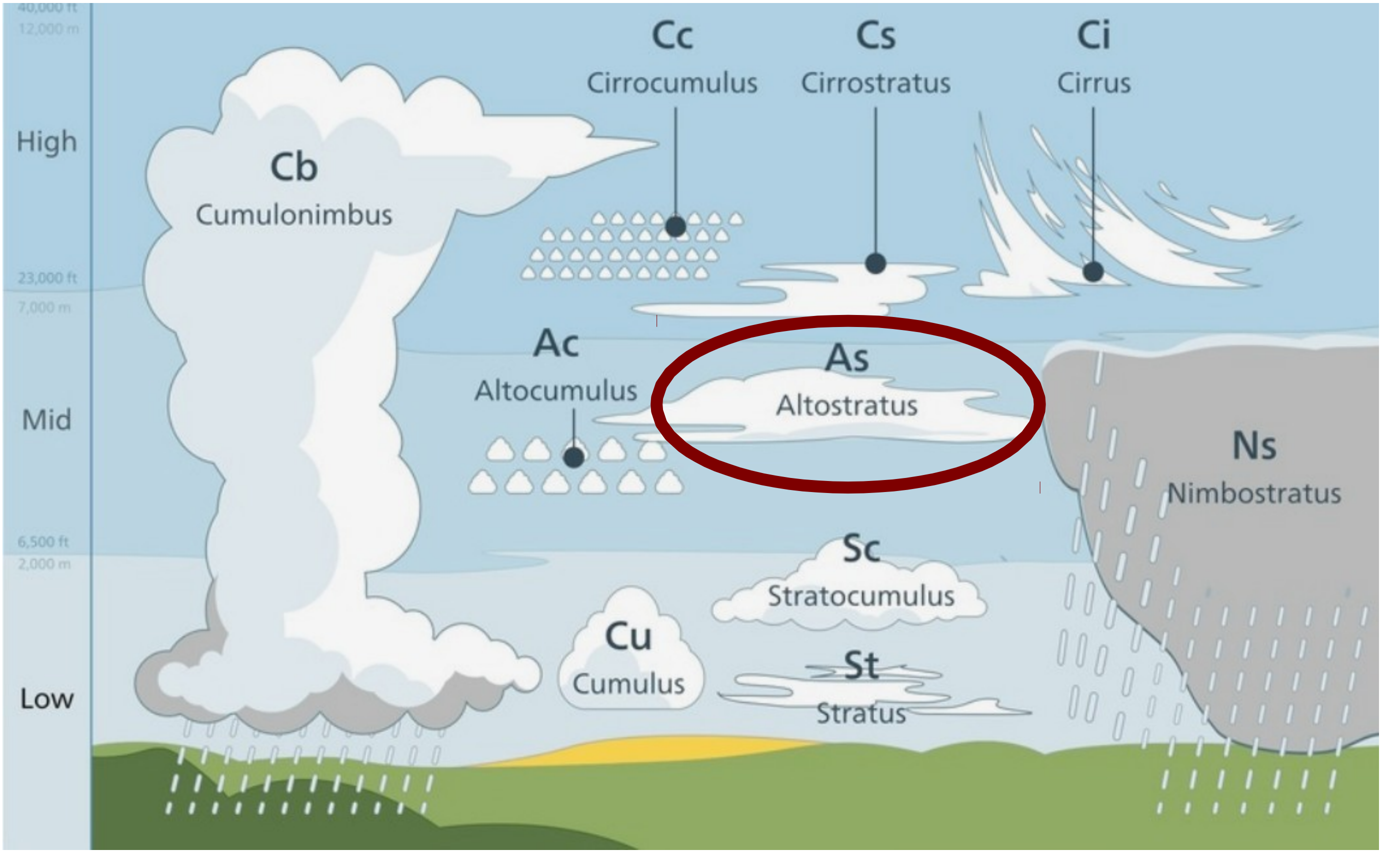
→ Gray clouds 1 km thick

→ Uniform extinction through the cloud

Set NO.	Cloud NO.	Height of cloud base a.g.l. (m)	Total AOD
1	15-20	3000, 5000, 7000, 9000, 11000, 13000	0.05
2	21-26	3000, 5000, 7000, 9000, 11000, 13000	0.1
3	27-32	3000, 5000, 7000, 9000, 11000, 13000	0.2
4	33-38	3000, 5000, 7000, 9000, 11000, 13000	0.3
5	39-44	3000, 5000, 7000, 9000, 11000, 13000	0.5
6	45-50	3000, 5000, 7000, 9000, 11000, 13000	0.7

Transmittance simulation

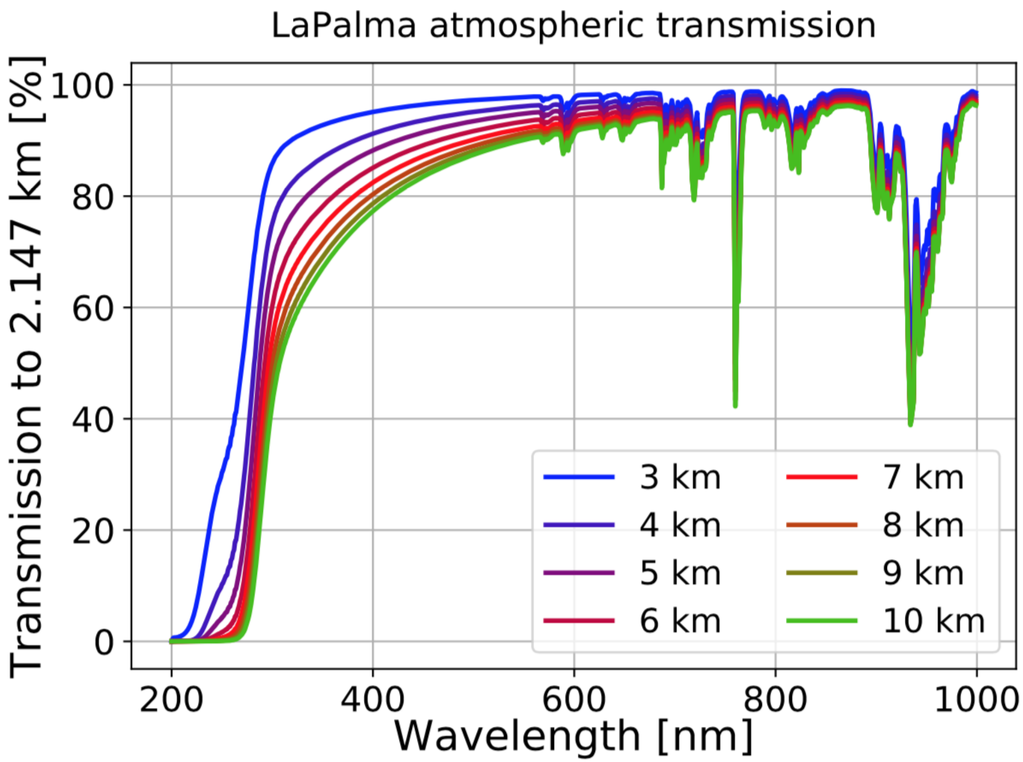
→ only for altostratus clouds



Transmittance simulation

→ for each wavelength and each altitude MODTRAN produce a single number - transmittance

→ transmittances are converted to AODs using Python code



Motivation

→ due to atmospheric conditions, data can be altered; solutions to this problem:

- T: 0.00-0.55 → **reject data**
- T: 0.55-0.85 → **apply correction using LIDAR informations**
- **make special MCs**

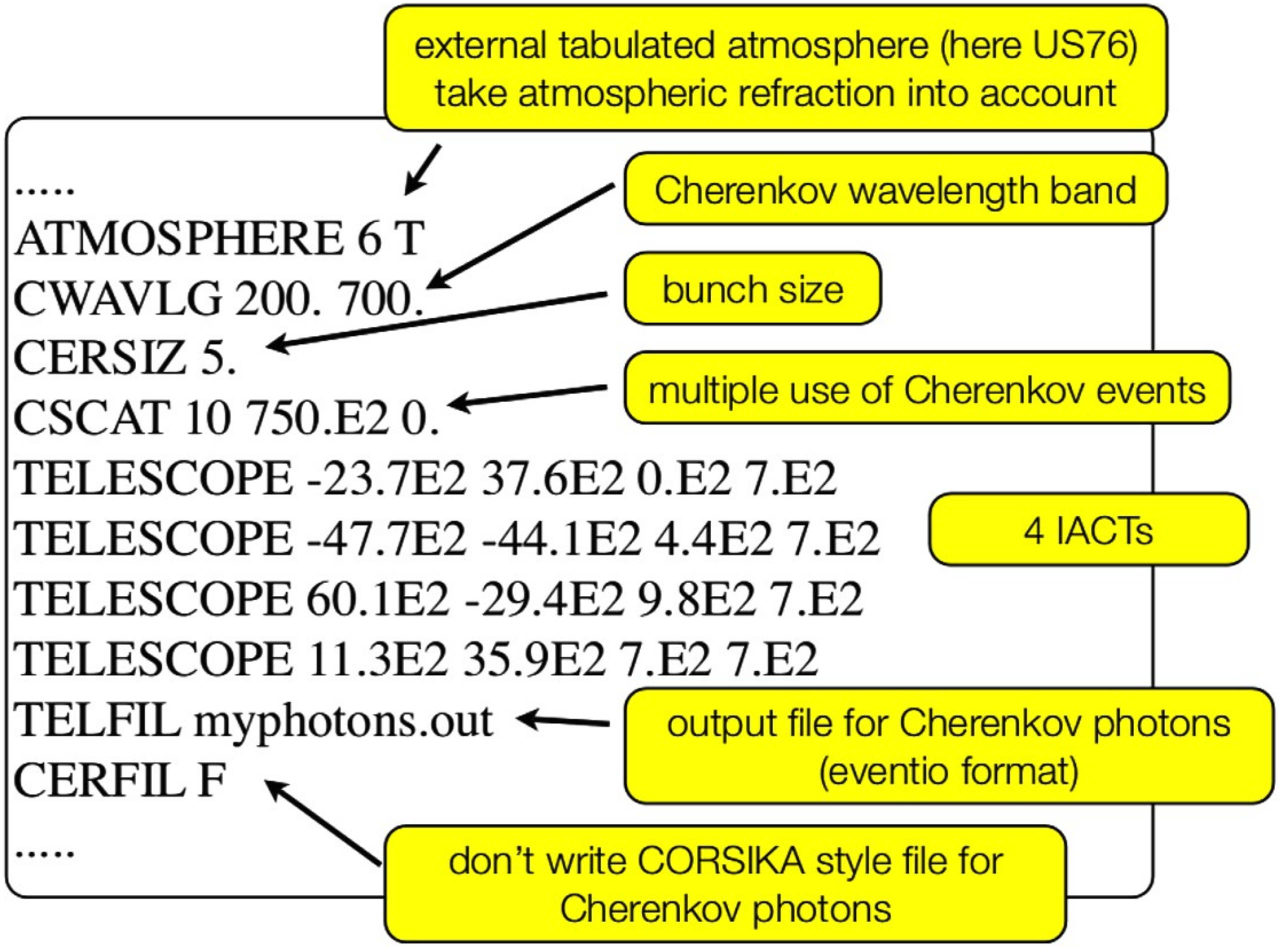
→ adaptive observation scheduling
→ data correction
→ duty-cycle prolongation
→ the improvement of energy calibrations

EASs simulations - CORSIKA

→ Using the IACT option for machine independent output based on the *eventio* library

→ Particle interactions and decays in the atmosphere up to 10^{20} eV

→ Simulation carried on for CTA use QGS-II model

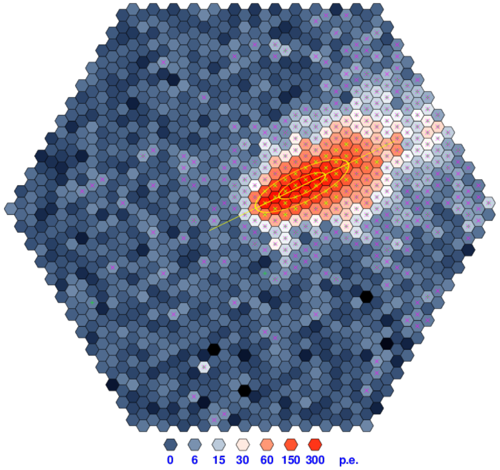


Telescope simulations

→ Atmospheric transmission can be simulated by CORSIKA or by sim_telarray (the latter is usually preferred because of the flexibility)

→ **sim_telarray** reads extinction coefficient as a function of wavelength, takes care of all the extinction processes relevant for Cherenkov light

→ sim_telarray can accurately simulate: atmospheric transmission, photon ray-tracing through the telescope optical system, shadowing by secondary mirror, camera, masts, camera window transmission, photon detection, trigger electronics, night Sky Background, ...



Problems, Sumarry, Future plans

→ MODTRAN allows changes of cloud parameters (optical depth, thickness) only in combination with MODTRAN predefined atmospheres

→ When custom atmosphere is introduced (for La Palma) calculation was possible only for the case of no cloud

→ Any impacts of clouds on EAS development?

→ CORSIKA is a key tool for CTA - long term support from CTA collaboration

→ For CORSIKA 8.0 version: coordinate the needs of the different IACT experimental groups in order to obtain a single, unique Cherenkov module?