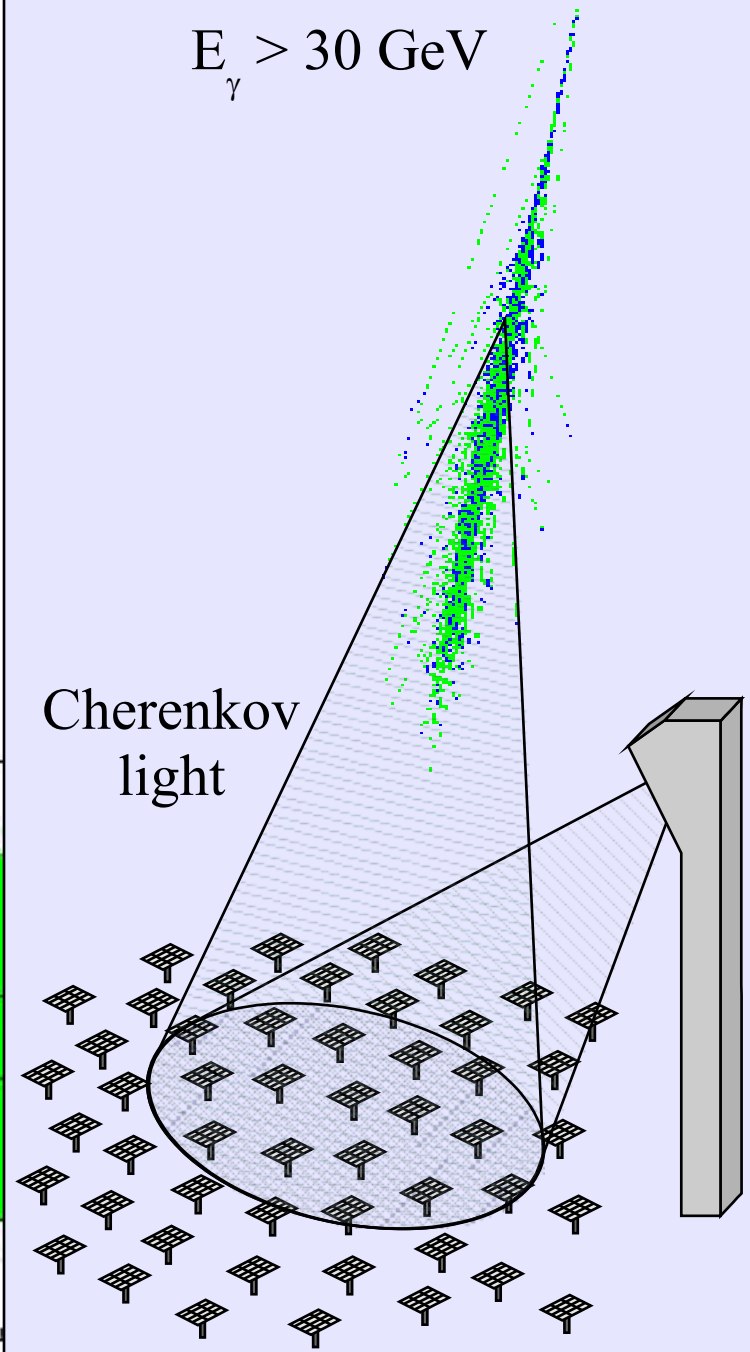
Atmospheric Monitoring for CELESTE
Cerenkov Low Energy Sampling & Timing Experiment

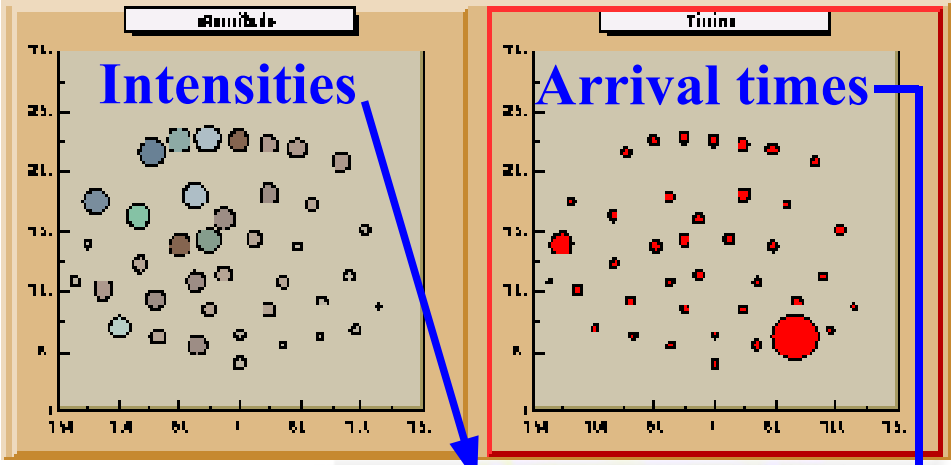
Javier Bussons Gordo, Groupe d'Astroparticules de Montpellier (France)

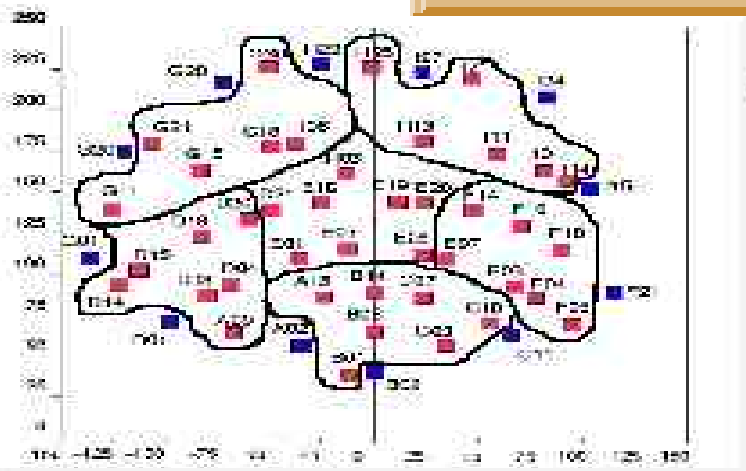
DETECTION PRINCIPLE

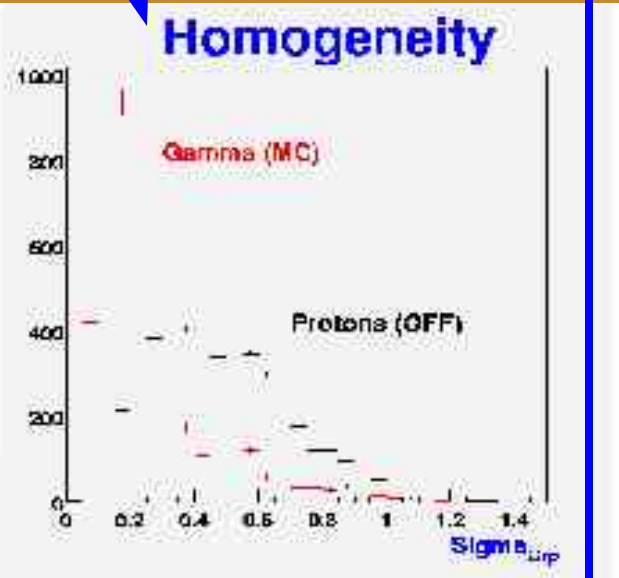
$E_\gamma > 30$ GeV

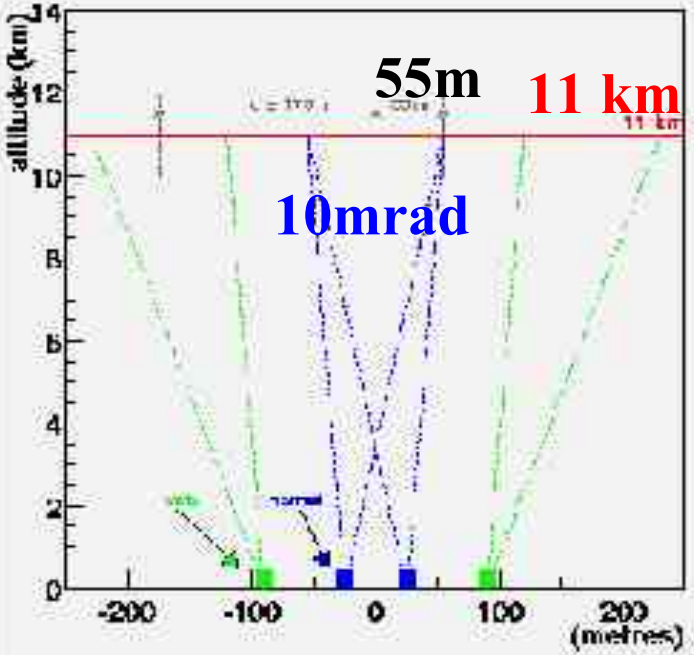


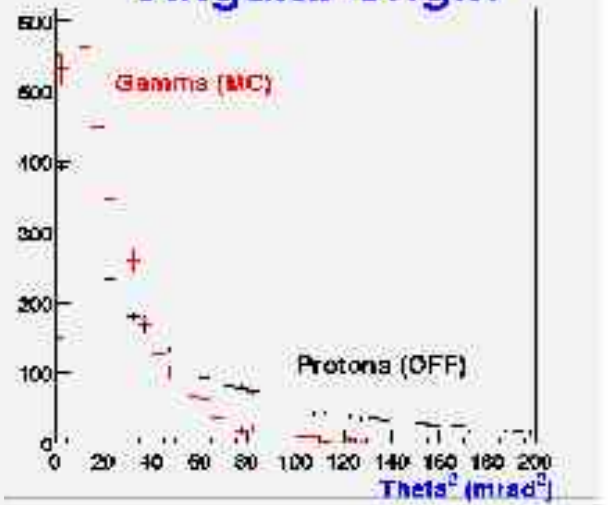
Thémis:
42.50 N
1.97 E
1650m a.s.l.
Pyrenees



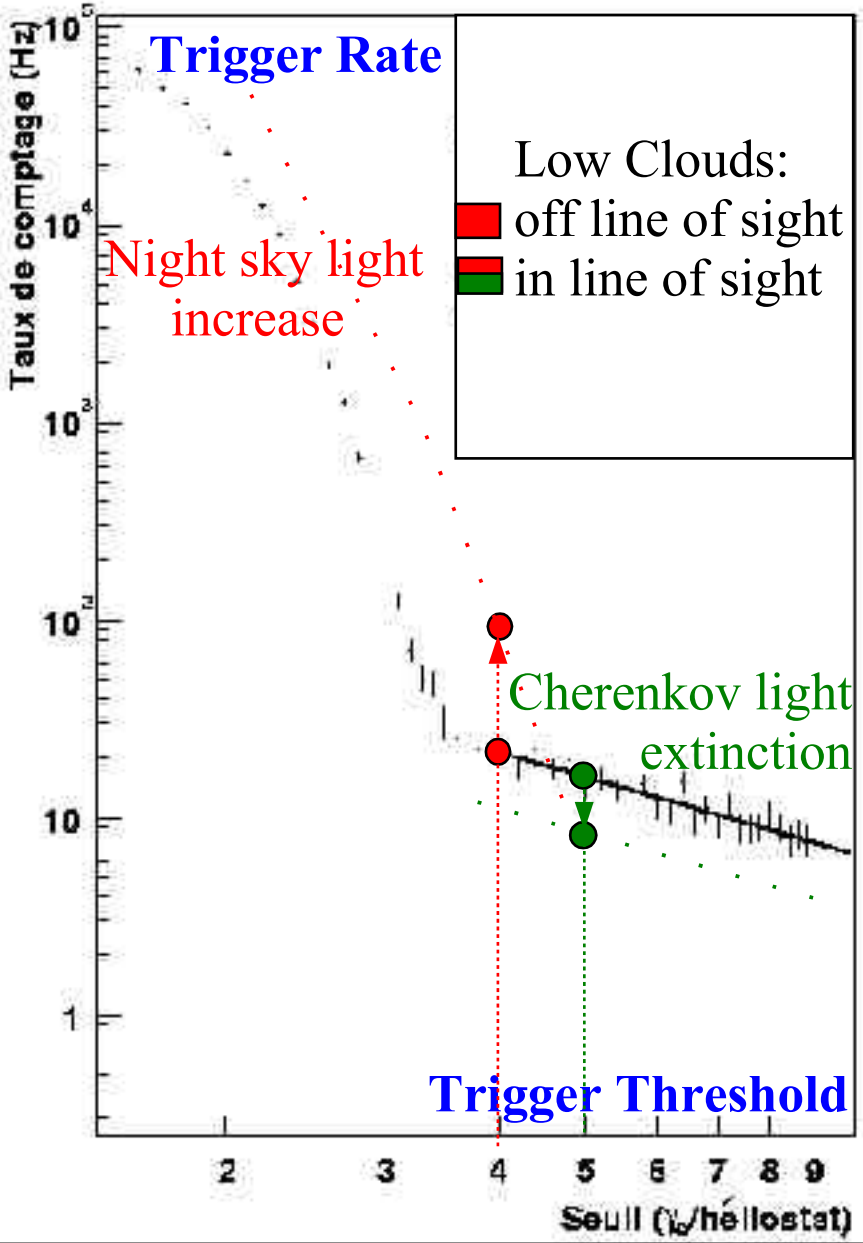








ATMOSPHERIC EFFECTS

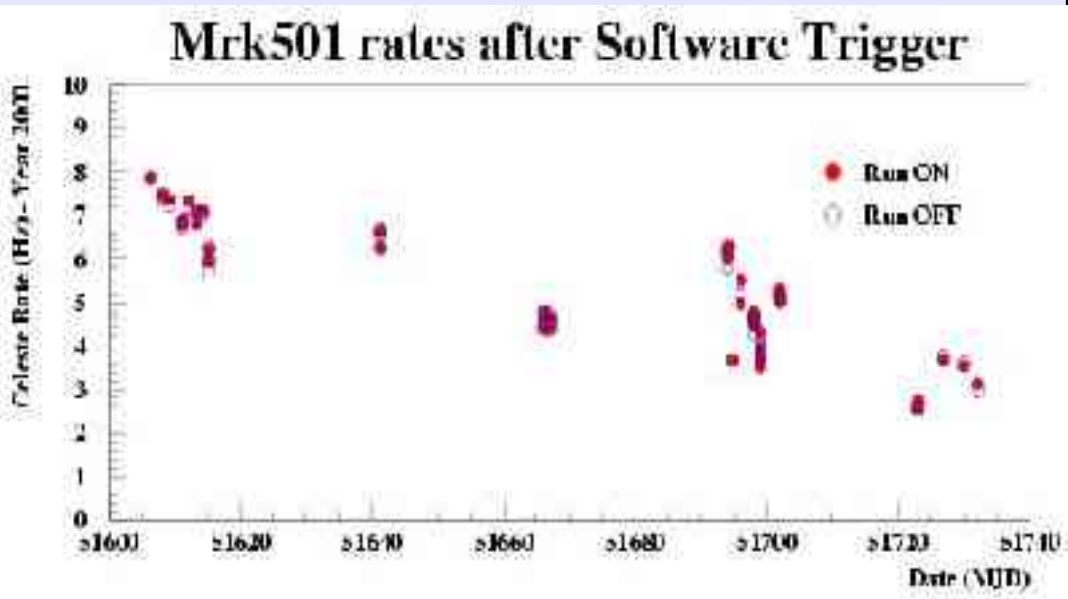


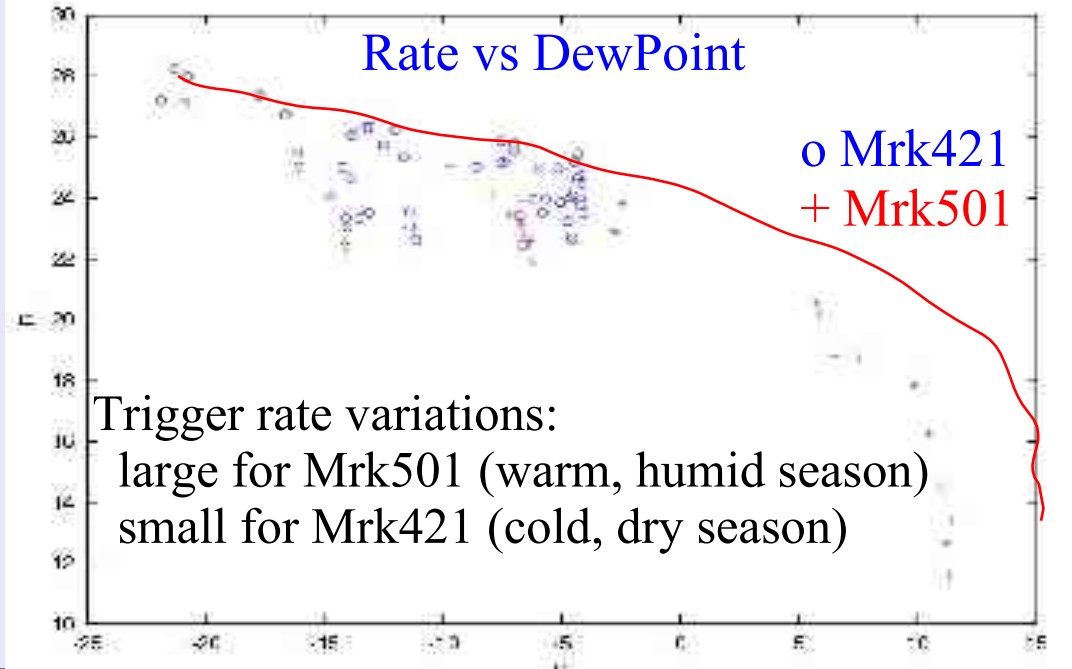
High clouds: moderate effect
Aerosols: strong, homogeneous effect
Dew setting in: falling rates, low PMT current

Systematic effects

Energy Threshold, Acceptance, Primary Energy
Dependent on trigger threshold choice

Seasonal effects





SIMULATIONS

Predictions (Bernlöhr, Snabre) for attenuation of Cherenkov light density on ground (50GeV):

[standard atm.: 25%] ...+aerosols: 40% ...+clouds: 70%

Seasonal variations: 20% at mid-latitude sites

Correct total charge Q => estimated energy

Model **THEMIS ATMOSPHERE**

ATMOSPHERIC PROFILE

Cherenkov light generation

Radiosounding data: z, P, T, DewPoint, Wind

MSIS-E-90 input: date, latitude, longitude

output: z, density(O,N_2,O_2,Total), T

EXTINCTION TABLES $\alpha(\lambda, z)$

Cherenkov light attenuation

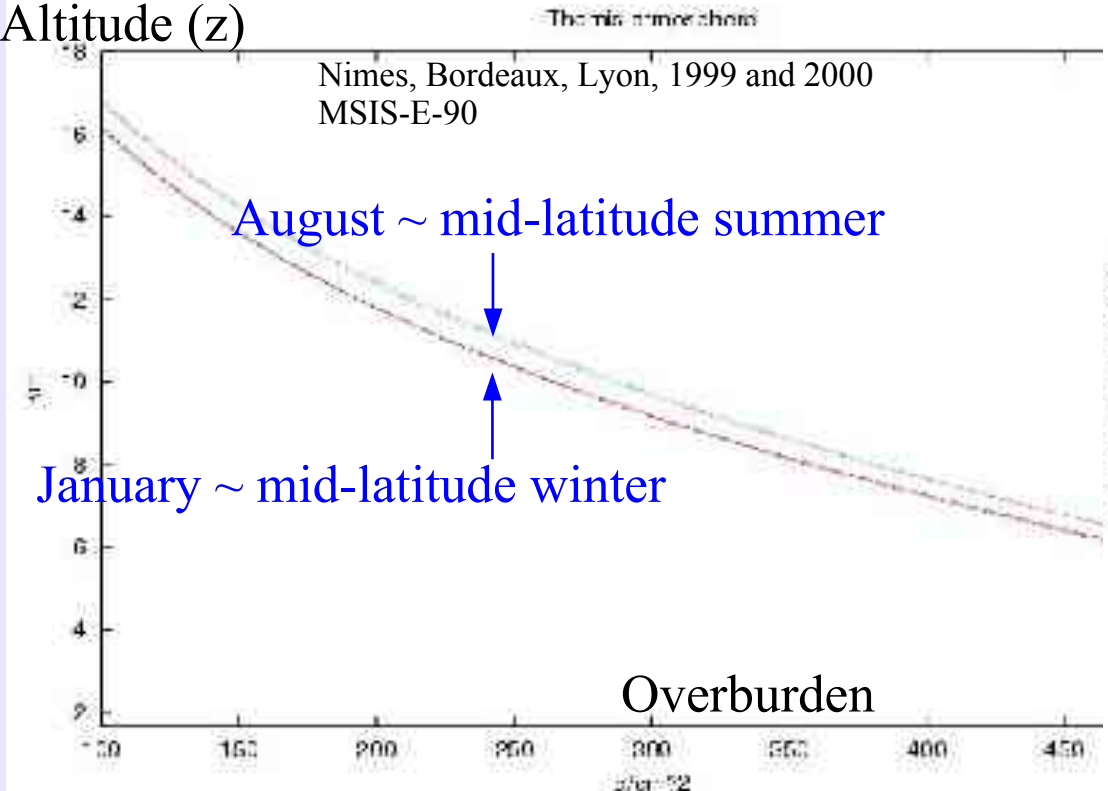
MODTRAN / STREAMER transmission code:

Gasconcentrations, cloud phase functions, albedo, ...

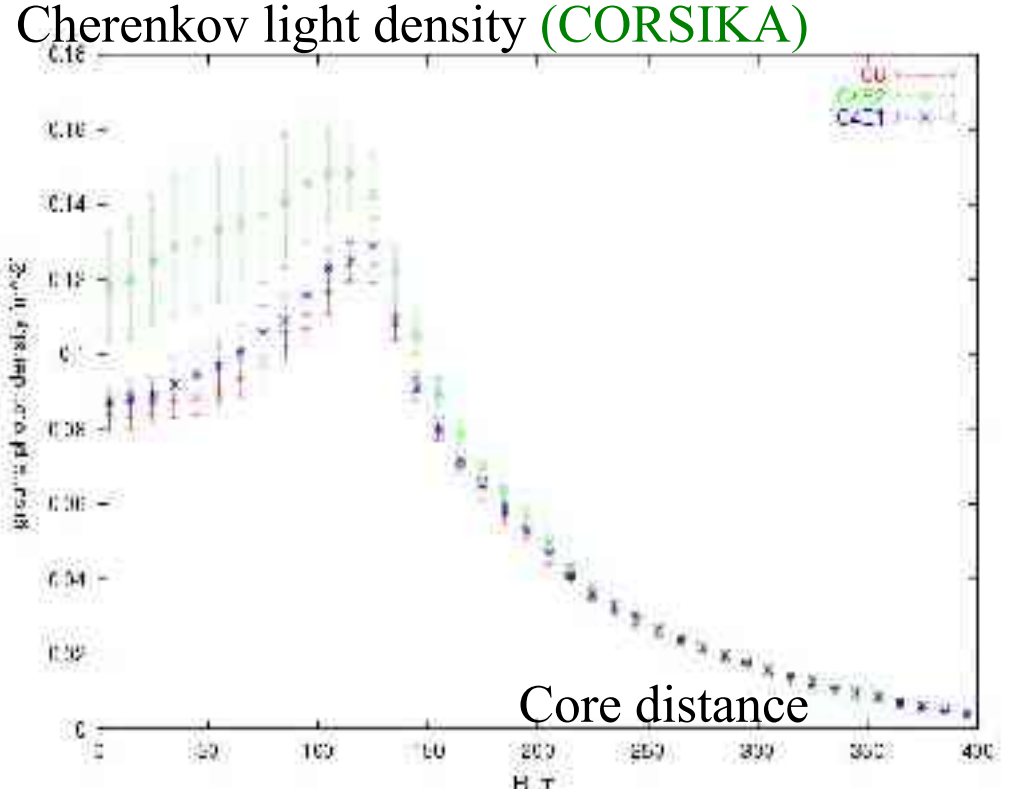
Aerosol distribution: boundary, tropo, strato, upper

Compare output transmission to CCD measurements

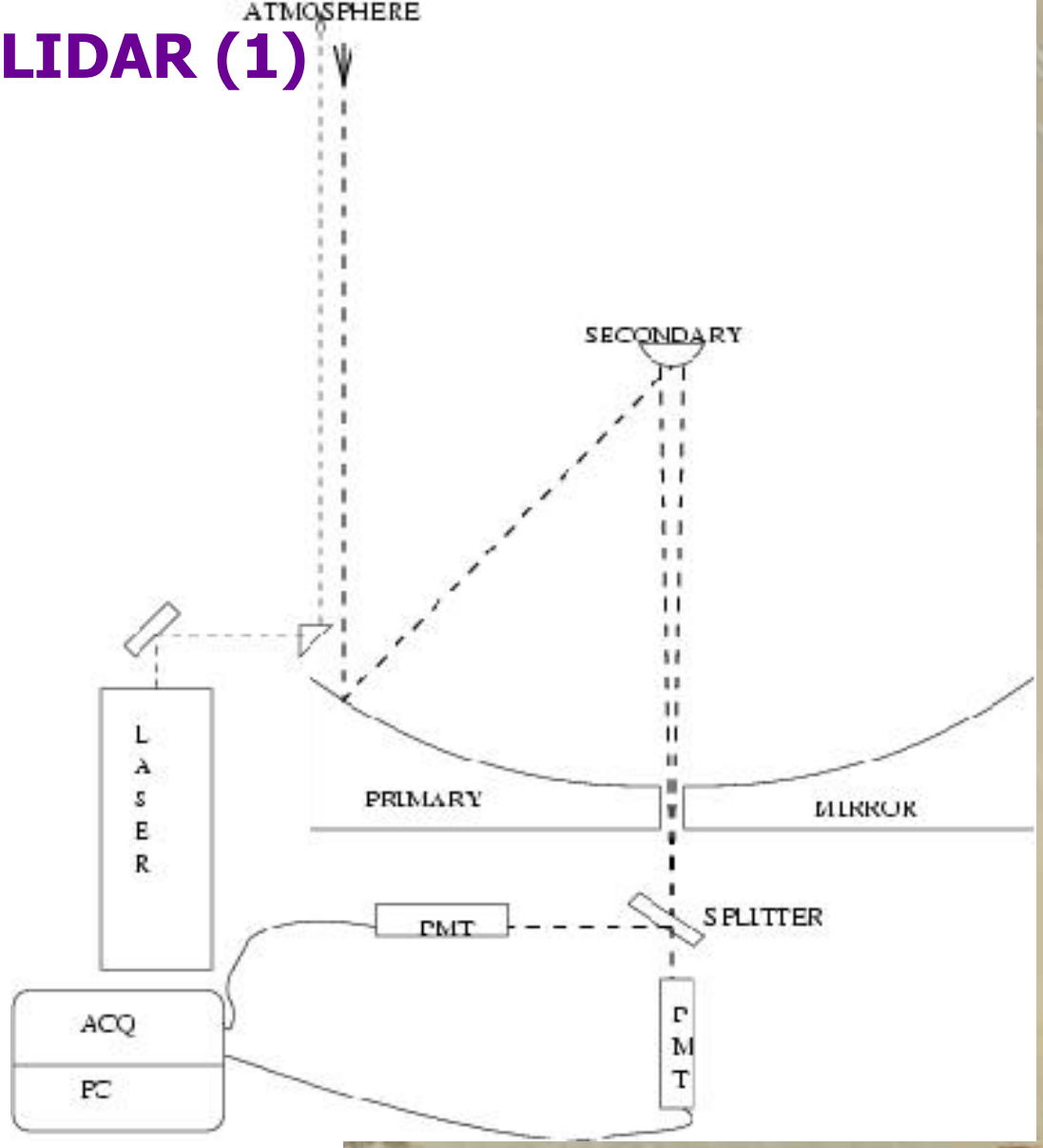
Altitude (z)



Cherenkov light density (CORSIKA)



LIDAR (1)



Laser: Nd-YAG
- rep rate 10 Hz
- λ=1064, 532, 355 nm
- pulse width τ=4ns
- pulse E=180mJ (532nm)
  70mJ (355nm)
- beam divergence 0.5mrad

Optics: Cassegrain + dichroic splitter
- primary mirror Ø 60cm ,f=102cm
- secondary Ø 8cm, f=10cm
- reflectivity(300-600nm) = 80%

PMTs: Philips XP2020

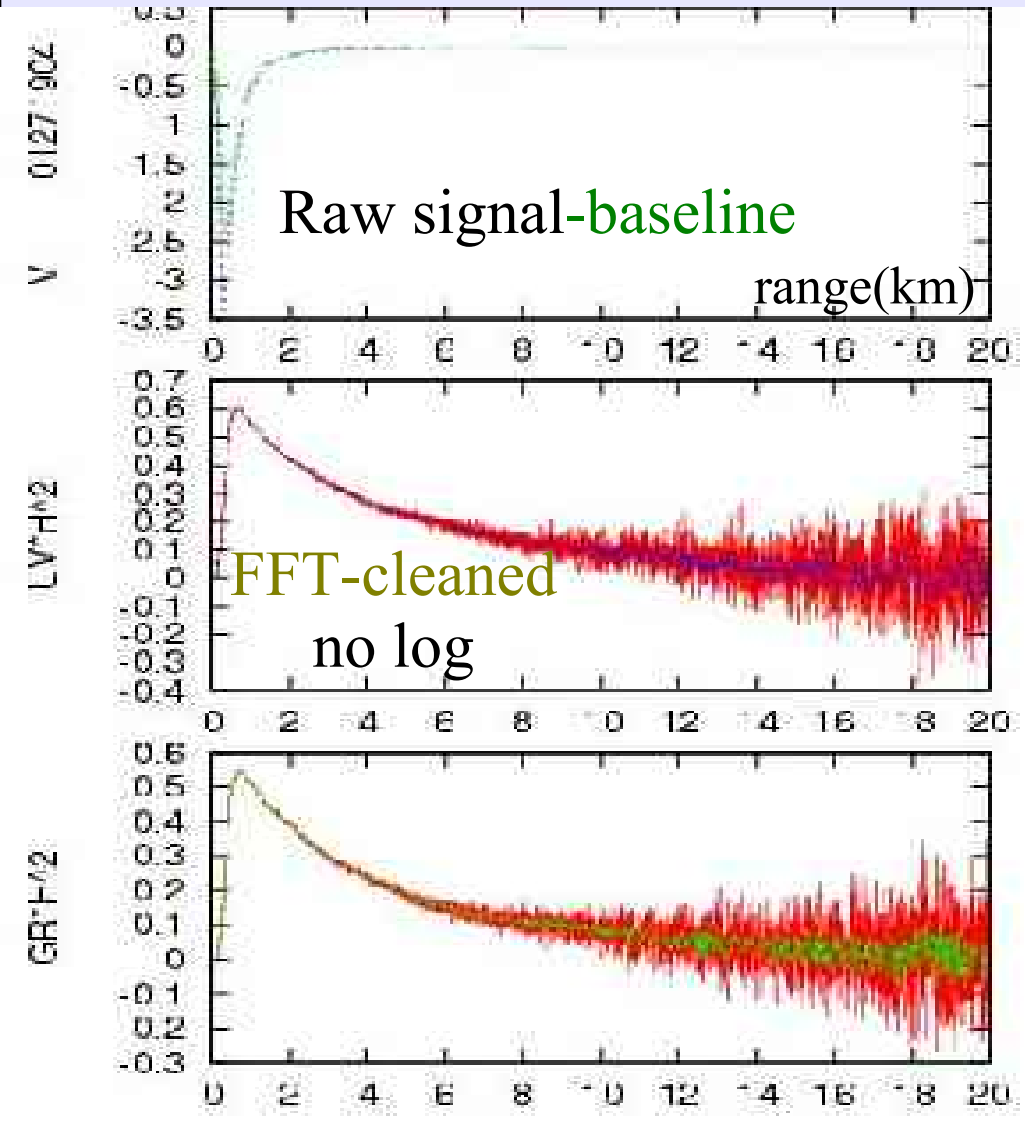
Acquisition:
- 12-bit, 5000-word card, 2 inputs
- 30 Mhz (33ns/sample), 5m resolution

Pointing:
- azimuth 0-359°
- elevation 36-89°
- encoder step 0.14°

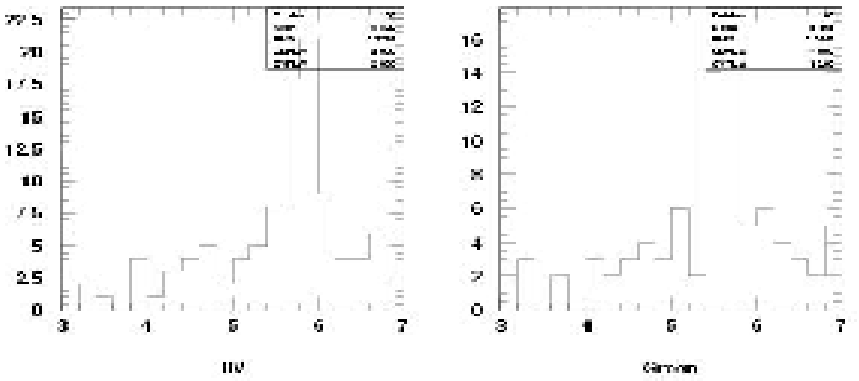
_ http: //doc.in2p3.fr/themis/LIDAR

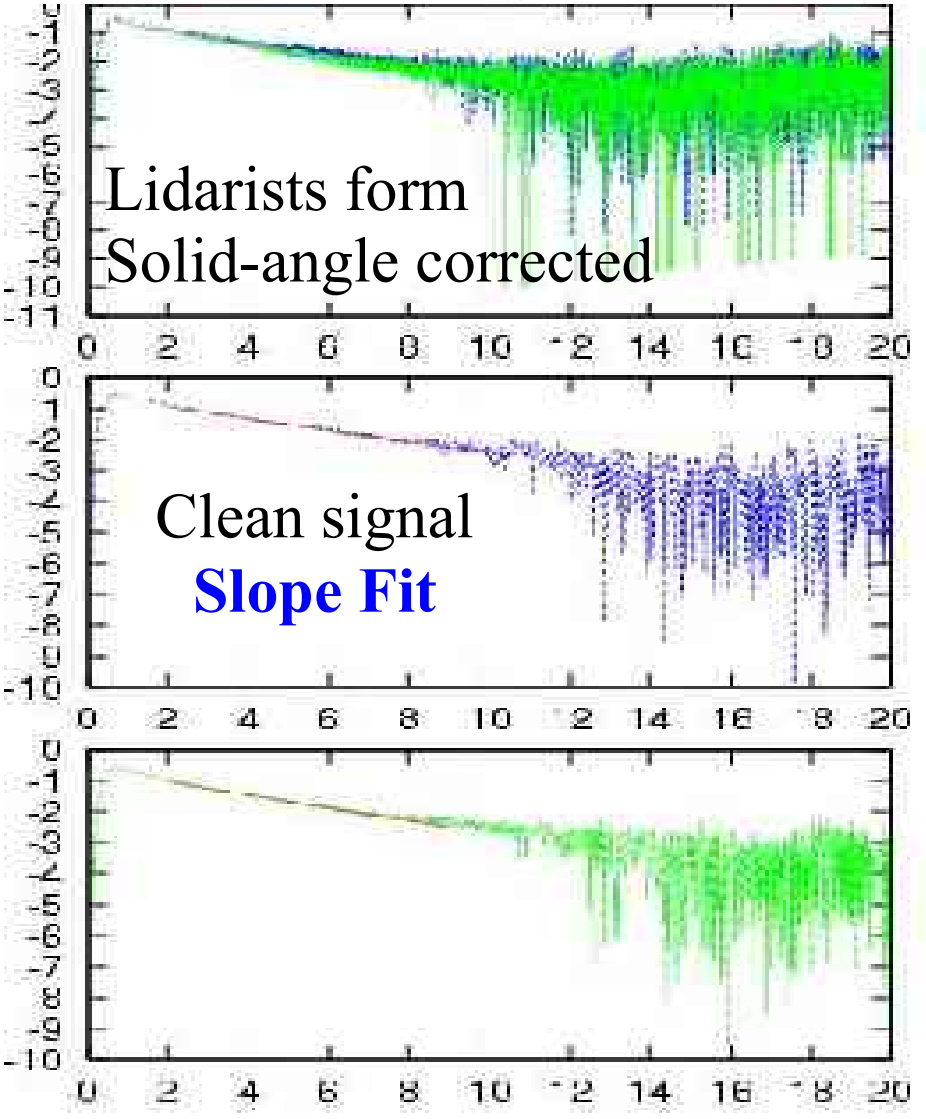
LIDAR (2): «quicklook»

Goals: on-line atmospheric monitoring
select good quality data
Lidar runs several times per night:
typically at zenith, 200-500 shots
Remove noise baseline as per 20-25km range (<10mV)
FFT: remove 15% fastest harmonics



Slope^{-1} distributions





LIDAR (3)

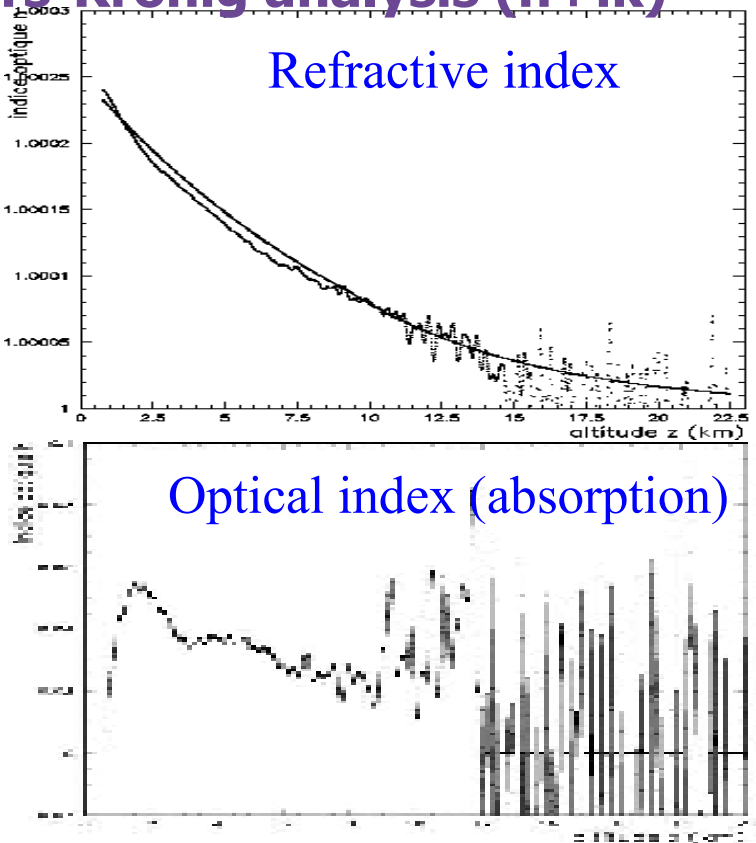
Analysis of first full season data (2002-2003) in progress:

Search for lidar slope to CELESTE rate correlation

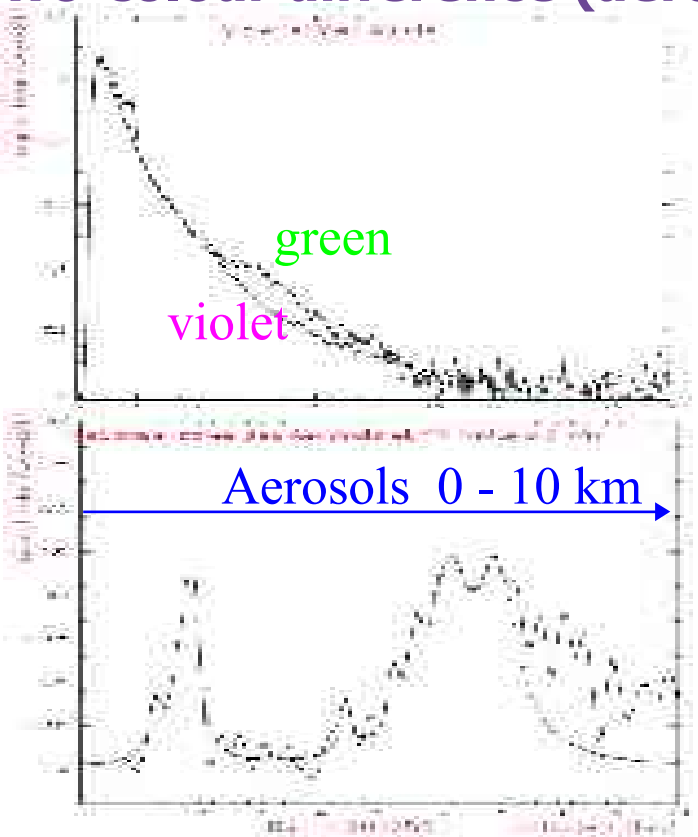
Study low elevation lidar runs (36-55°) => boundary layer
Compare lidar runs at different sampling rates (spatial resolutions)
Use binned slope method, but which bin size? 100m? (MAGIC?)
Evaluate potential of multi-elevation lidar runs (Auger?)

G. Debiais, B. Fabre (Univ. Perpignan)]:

Kramers-Kronig analysis (n+ik)



Two-colour difference (aerosols)



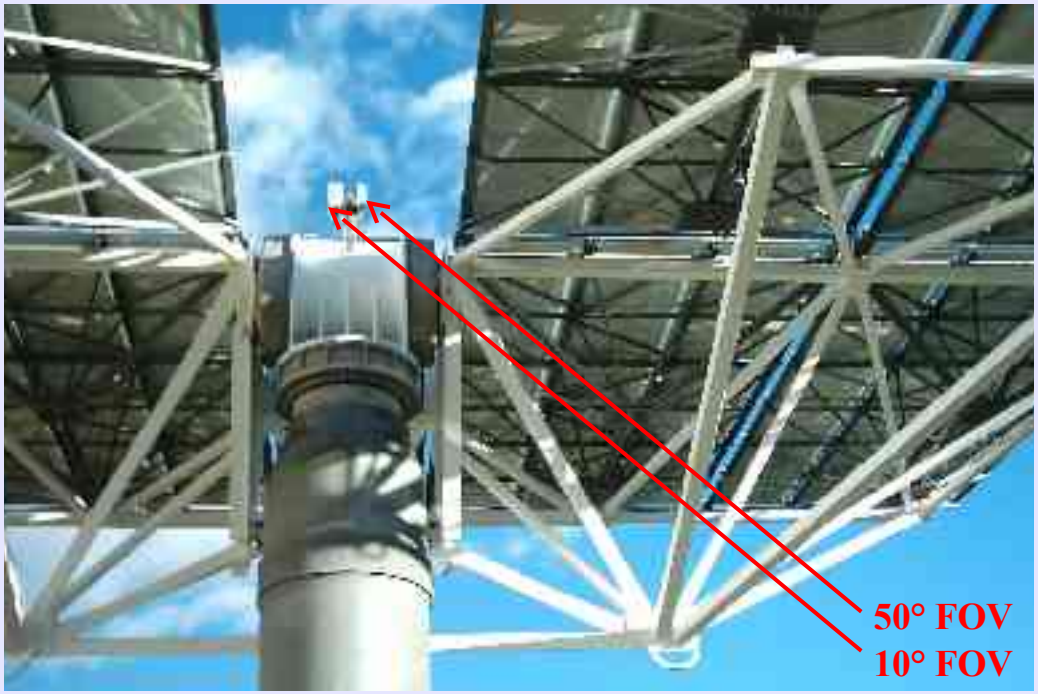
RADIOMETRY

Two radiometers (Auger and STACEE type):

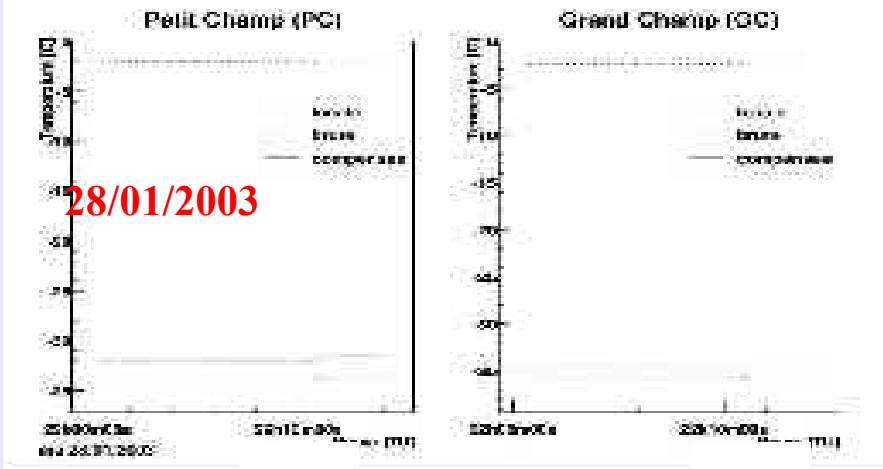
- FOV : 10° and 50° (full angle)
- power supply : 12 V
- usage range : 0 to 70 °C
- measurement range : -50 to 50 °C
  0 to 5 V => T (°C) = 20 V - 50

Three signals:

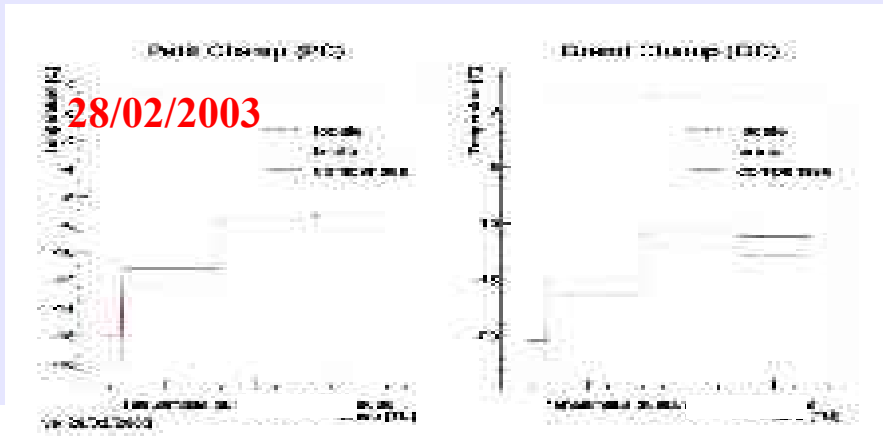
- thermistor output (ground temperature)
- uncompensated output
- compensated output = thermistor + uncompensated

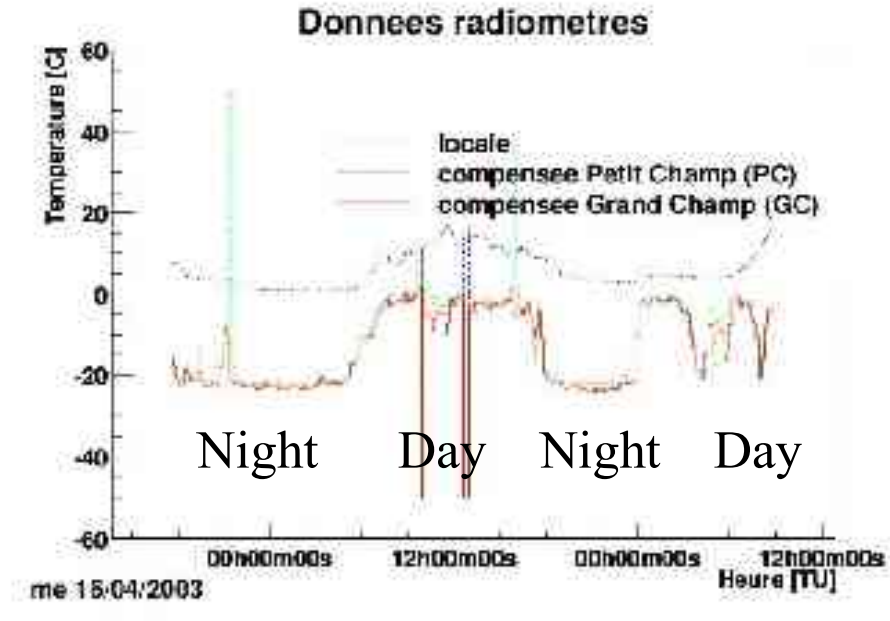


Beautiful night →



Passing clouds →





PHOTOMETRY

Telescope: equatorial, Celestron C8 Ultima
20cm diameter, f/D 10 (or 6.3).

CCD: Starlight Express HX516
16-bit, 660 x 500 pixels.

Filters:
blue (390 - 490nm)
green (500 - 560nm)
red (610 - 660nm).

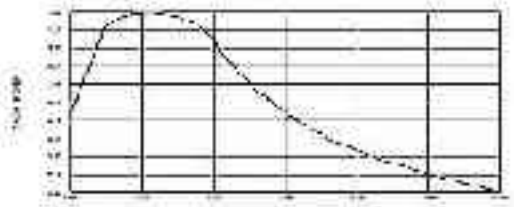


Figure 6. Efficacité quantique du chip SONY ICX084AL.

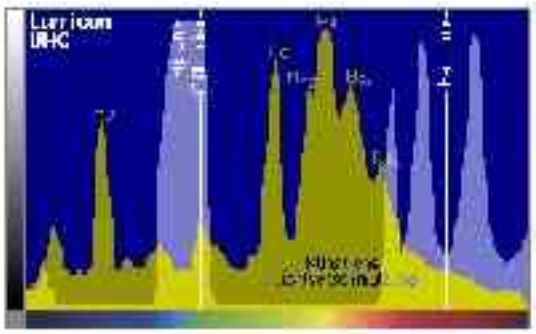
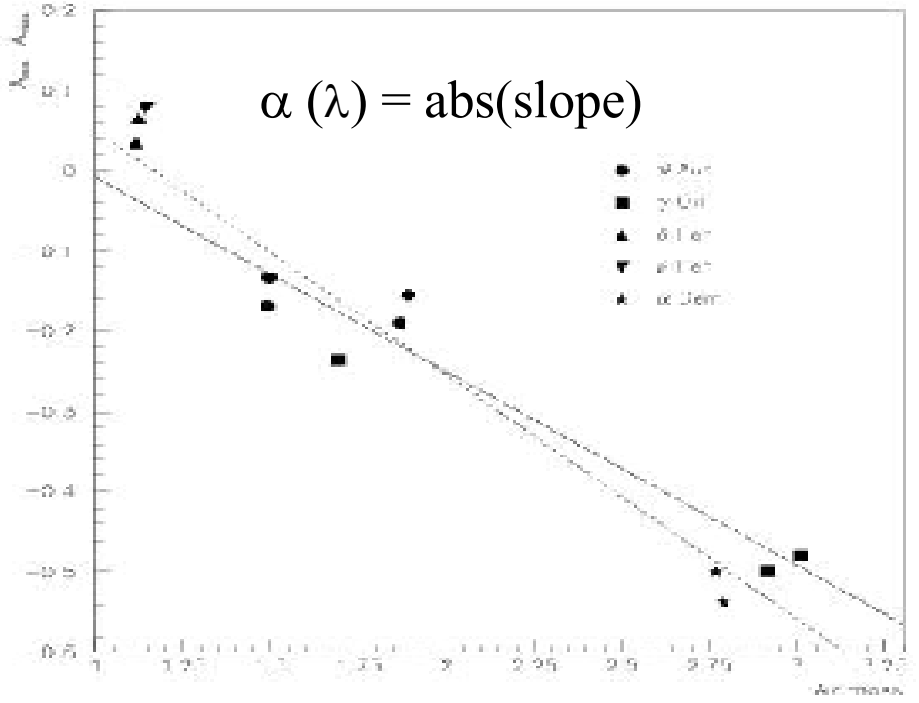
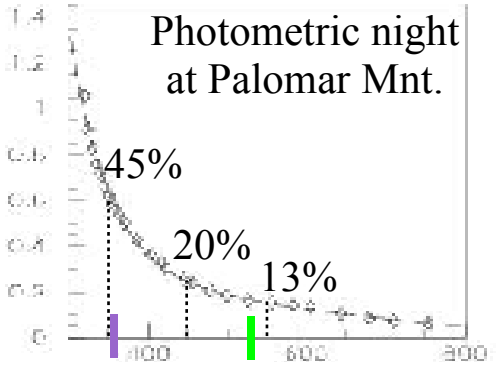
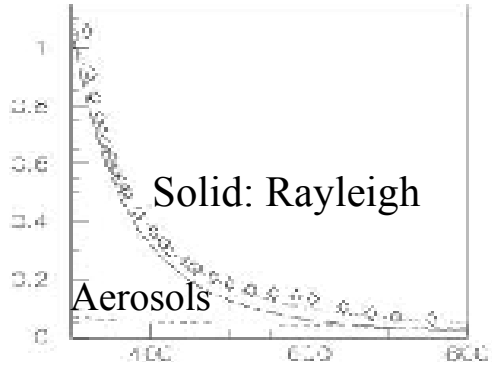


Figure 7. Courbe de transmission du filtre UHC (zone claire) en fonction de λ, le domaine de λ s'étendant de 390 à 780 nm.

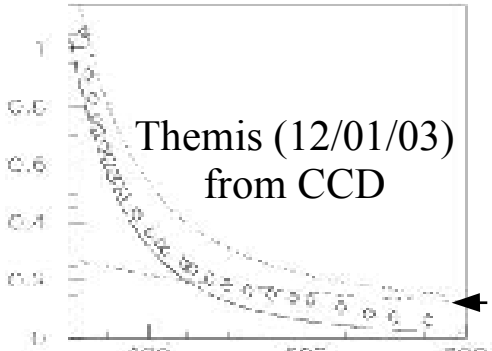


Extinction (mag)





Wavelength (nm)



Attribute Total-Rayleigh
to aerosols

QUESTIONS

How can we obtain α (λ) and even α (λ , z) experimentally?
... or how to go from β or β (z) to extinction (%, mag/airmass, ...)

How separable are atmospheric profiles and extinction tables (simulations)?

Timescales in models: which variables can be averaged, say, monthly or nightly?

Lidar slopes: shouldn't green light undergo less absorption than UV?

How may we interpret radiometer data in terms of cloud altitude and water content?

...

LIDAR EQUATION (α, β unknowns)

$$P \geq P_o L_{eff} \Omega \beta(R) T^2$$

Transmittance

$$T = I/I_o = \exp\left(-\int_0^R \alpha(r)\,dr\right)$$

α: extinction (scattering + absorption)

β: backscattering

gas + particles
Rayleigh + Mie

R: range; Ω : solid angle; $L_{eff} = c\,\tau / 2$