AtmoHEAD

RAMAN LIDARS FOR CTA

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University and INFN Padova, Universitat Autonoma Barcelona & CERES
+Markus Gaug + work of many others from UAB, IFAE, CEILAP, LUPM

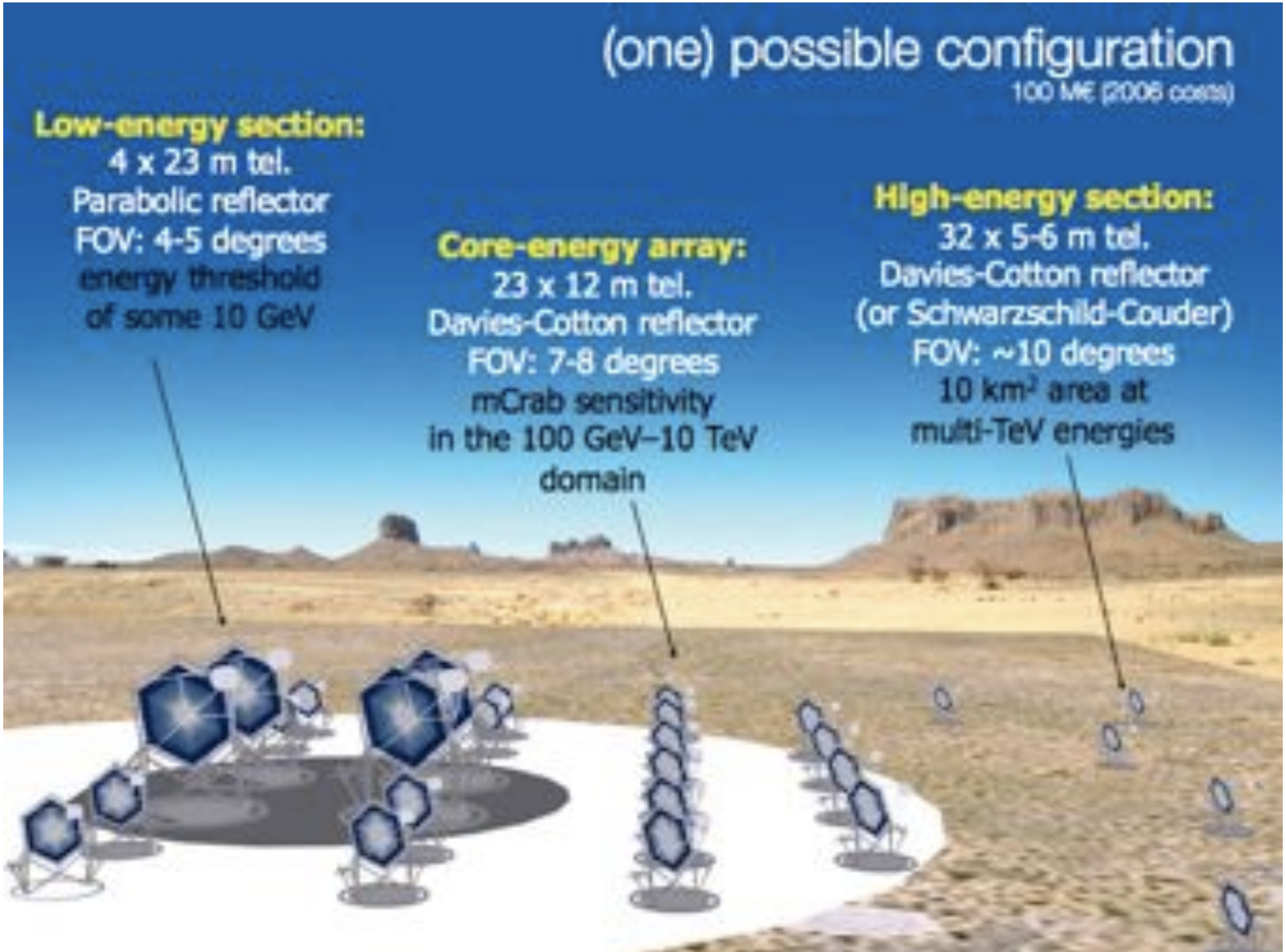
Contents

- Why Raman LIDAR for CTA
- Raman LIDAR prototypes
  - Buenos Aires
  - Barcelona
  - Montpellier
  - Adelaide
- Other instruments?
- Comments and conclusions

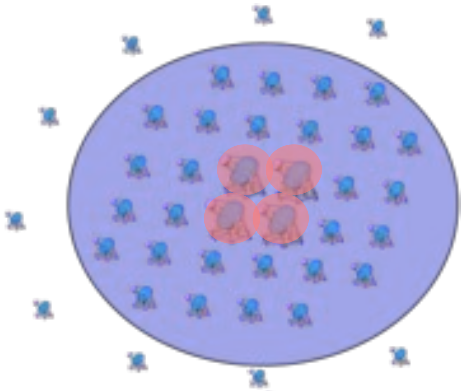
WHY DOES CTA NEED RAMAN LIDAR(S)?

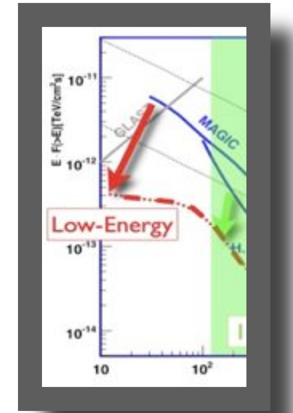
See also talks by K. Bernloher, M. Gaug, S. Nolan, C. Rulten at this conference

CTA Concept

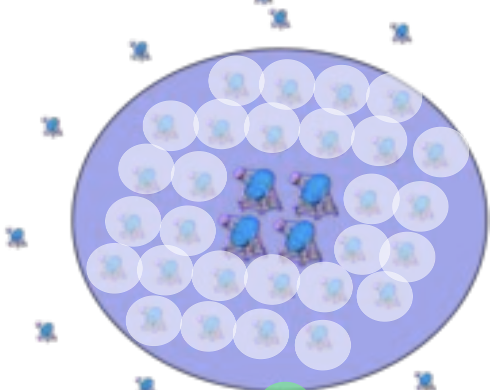


(one) possible configuration
100 M€ (2006 costs)
Low-energy section:
4 x 23 m tel.
Parabolic reflector
FOV: 4-5 degrees
energy threshold
of some 10 GeV
Core-energy array:
23 x 12 m tel.
Davies-Cotton reflector
FOV: 7-8 degrees
mCrab sensitivity
in the 100 GeV–10 TeV
domain
High-energy section:
32 x 5-6 m tel.
Davies-Cotton reflector
(or Schwarzschild-Couder)
FOV: ~10 degrees
10 km² area at
multi-TeV energies



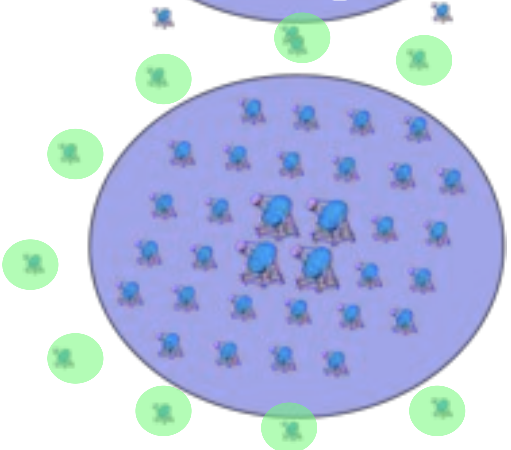


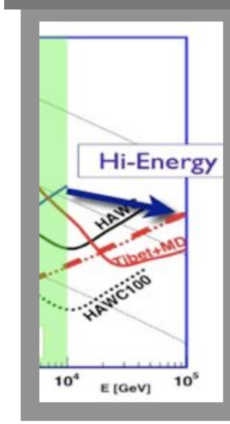
- Few Large Size Telescopes should catch the sub-100 GeV photons
  - Large reflective area
  - Parabolic profiles to maintain time-stamp
  - FOV ~ 4 deg
  - Challenging technology on all sides



Several Medium Size Telescopes perform 100 GeV-50 TeV search

- well-proven techniques (HESS, MAGIC)
- goal is to reduce costs and maintenance
- core of the array





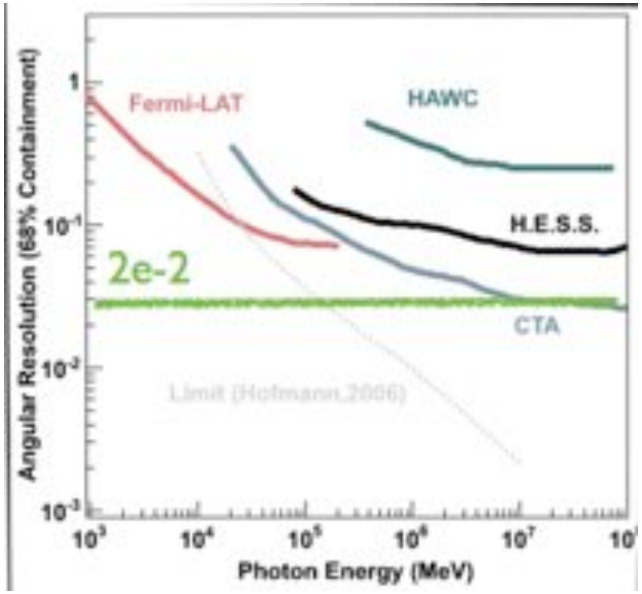
Several Small Size Telescopes perform ultra-50 TeV search

- very simple construction
- price should be small compared to full observatory

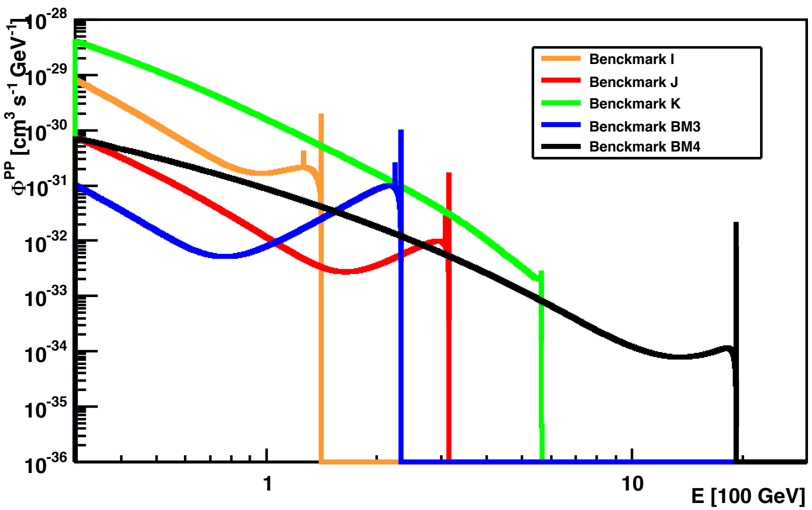
Sites

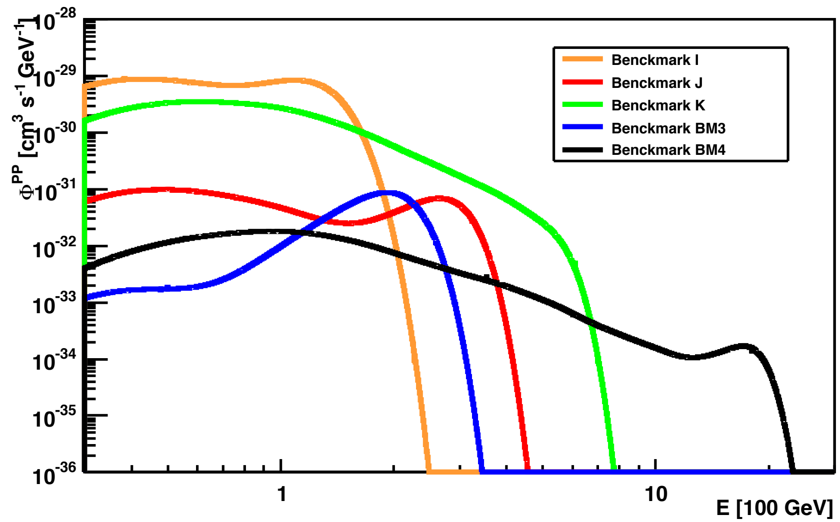
SITE DECISIONS
SOUTH: 2013
NORTH: 2014?

The energy resolution and energy bias

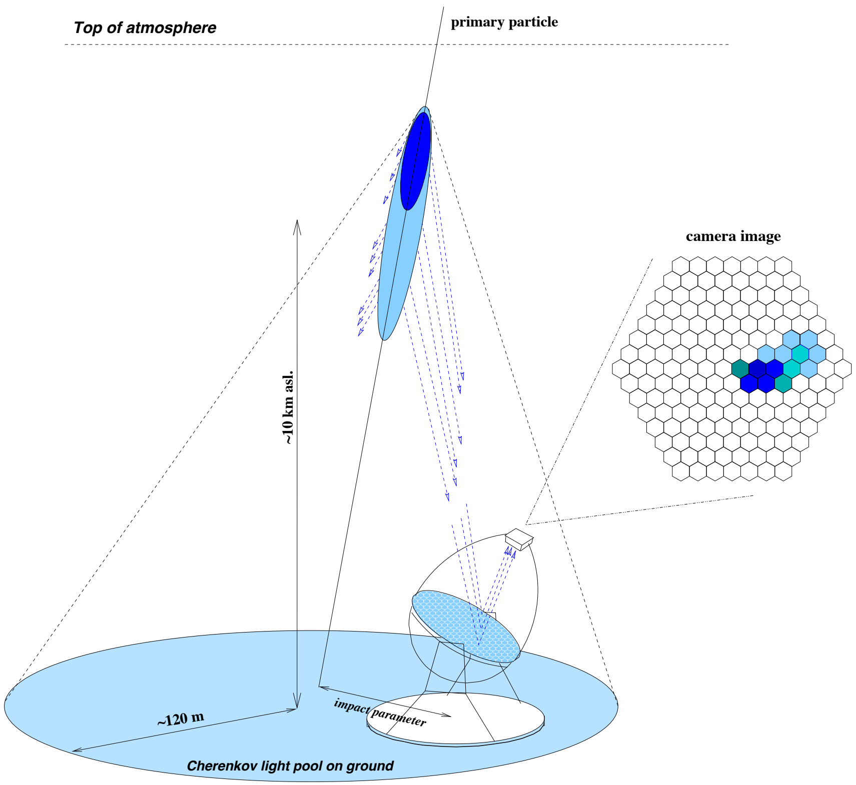


- The energy resolution and bias strongly affect **spectral reconstruction** which is of utmost importance in some cases: dark matter spectra, pulsar cutoffs, EBL cutoffs, axion-like particles, etc





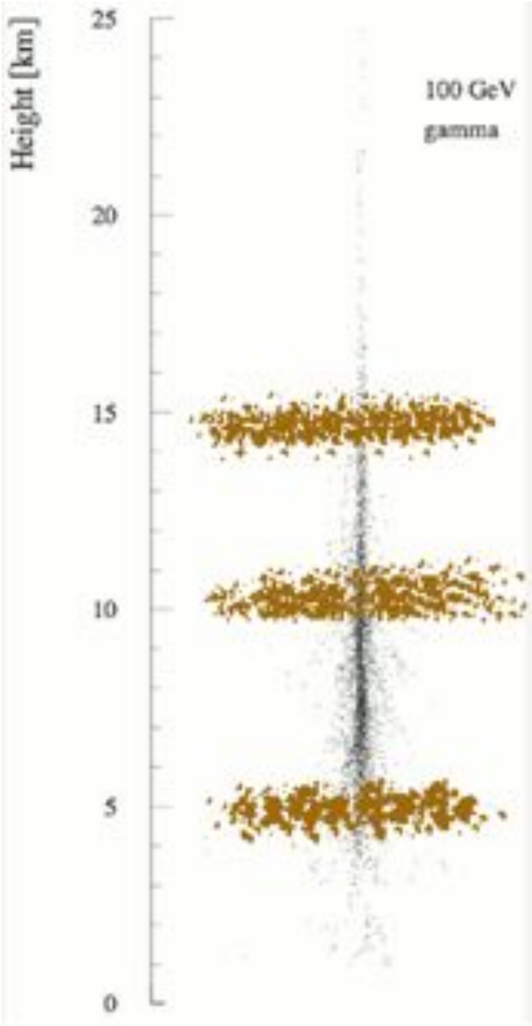
Energy reconstruction



- Primary gamma-ray is reconstructed via the e.m shower
- Size (= sum of phe in the camera) is given by:
  - Cherenkov photons at ground
  - Dish reflectance
  - PDE of PMTs
  - Etc
- Cherenkov photons undergo absorption and scattering (Mie, Rayleigh)

Need MC of atmosheric shower + atmospheric transmission to reconstruct primary gamma-ray energy from size

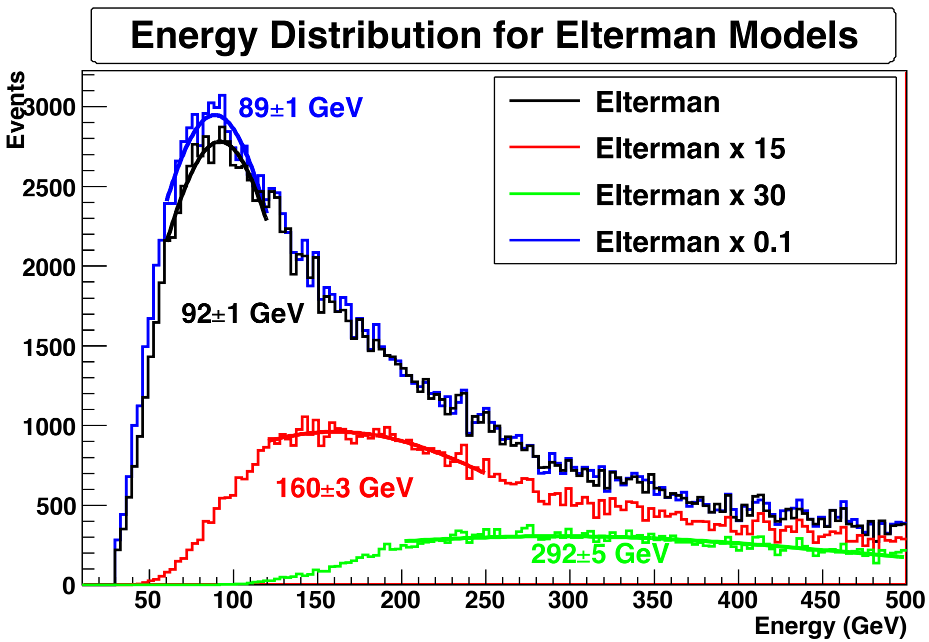
Do we need Raman LIDAR for CTA?

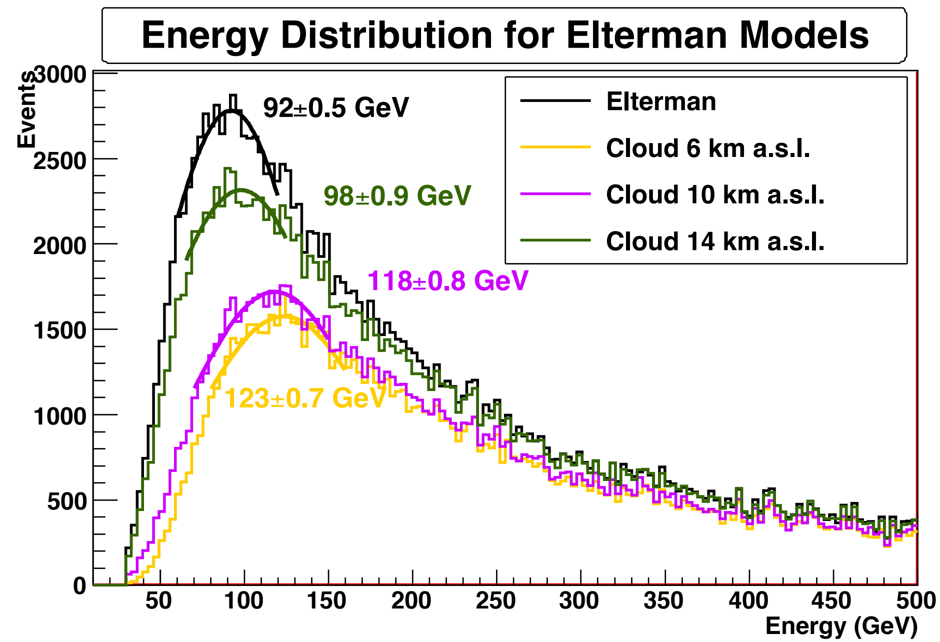


- To answer this question, in Barcelona, we have made simulations of different atmospheres for MAGIC
  - Results should be akin for CTA but still to do
  - **Please refer to poster of Daniel Garrido at this conference** and ICRC 2013 ID xxxx
  - See also M. Gaug's talk monday
- 3 models
  - Changing global density
  - Changing "cloud" position
  - Changing "cloud" density
- Comparison between
  - Wrong MC
  - Good MC
  - Correction method

Result 1

- Using correct MC, energy and flux reconstruction is correct, at the only expense of a larger energy threshold





Result 2 (see Gaug's talk)

- In case the aerosol overdensity or cloud is below the electromagnetic shower, simple correction method can be used to restore correct energy and flux reconstruction

For aerosol layers found until about 6 km a.s.l., the energy threshold of gamma-ray showers scales as the inverse of the total atmospheric transmission at 385 nm wavelength.

$$E_{\mathrm{thr}} = E_0 \cdot \left(\frac{T}{T_{\mathrm{ref}}}\right)^{-0.9} \quad . \tag{3.3}$$

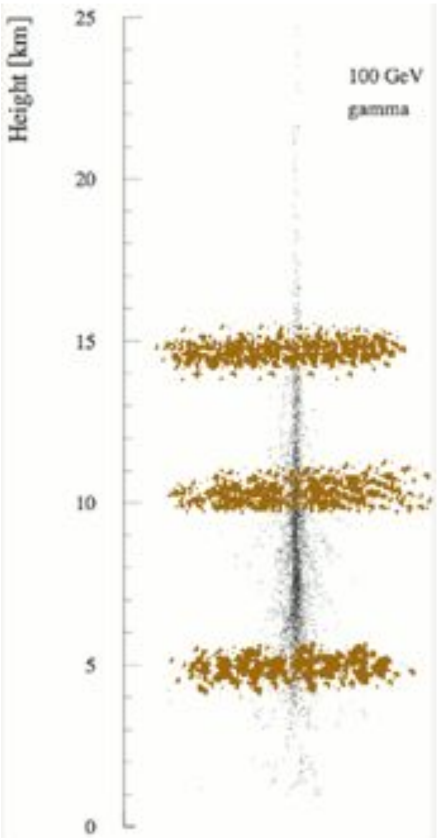
For aerosol layers found until about 6 km a.s.l., the bias of reconstructed energies of gamma-ray showers above the threshold scales with the total atmospheric transmission at 385 nm wavelength:

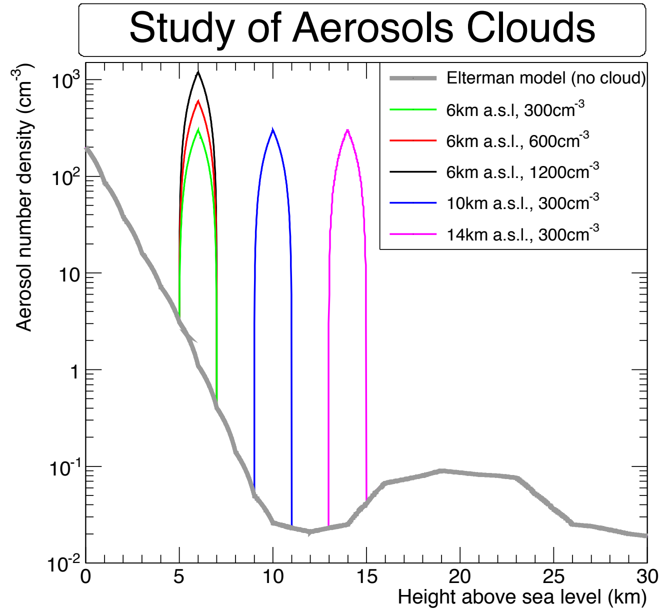
$$B^{\mathrm{above\ threshold}} = (T - T_{\mathrm{ref}})/T_{\mathrm{ref}} \quad . \tag{3.4}$$

For aerosol layers found until about 6 km a.s.l., the reconstructed energy correction of gamma-ray showers above the threshold scales with the total atmospheric transmission at 385 nm wavelength:

$$E_\gamma / E_{\mathrm{rec}} = T_{\mathrm{ref}}/T \quad . \tag{3.6}$$

Result 3

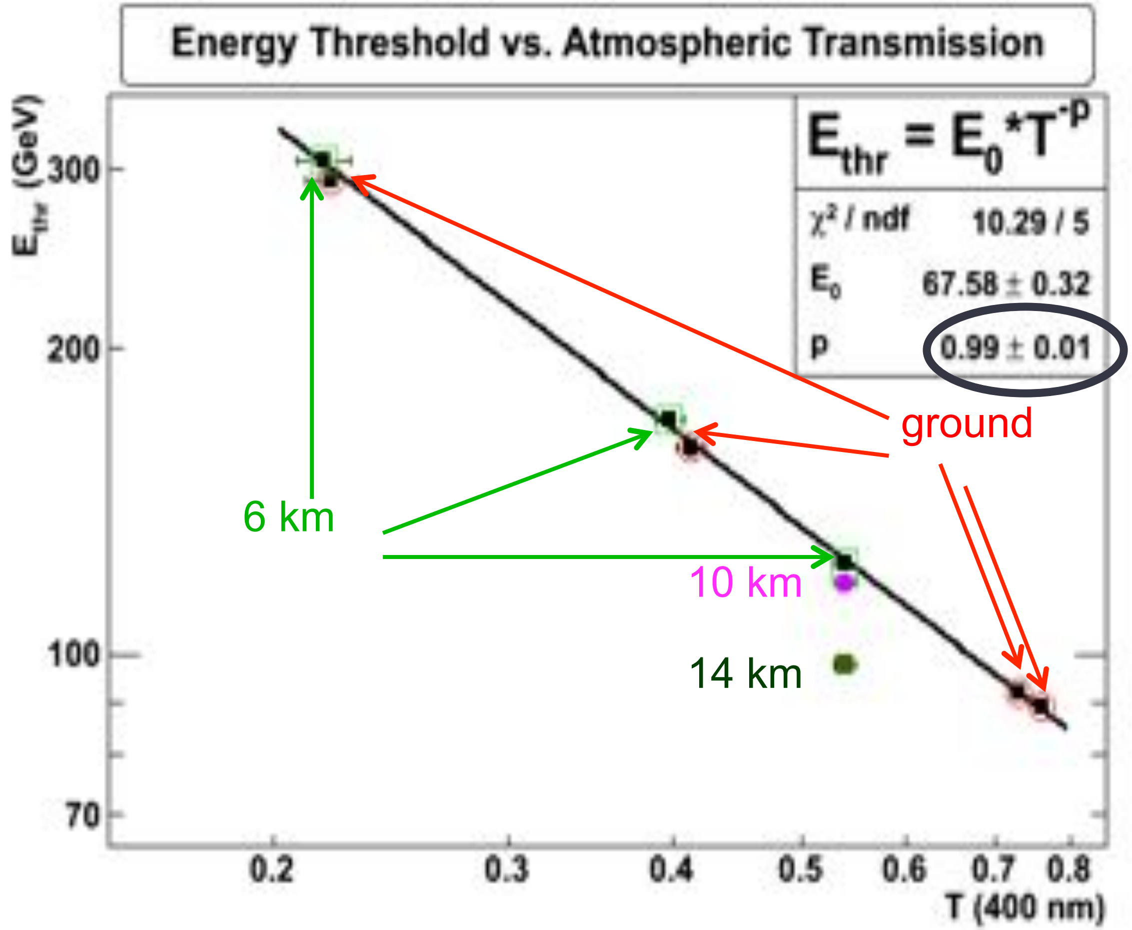




- When the clouds or aerosol layer is at the shower development region or above, the **total extinction is no longer an useful parameter**

It is therefore important to know the **differential atmospheric tranmission.** We need a LIDAR!

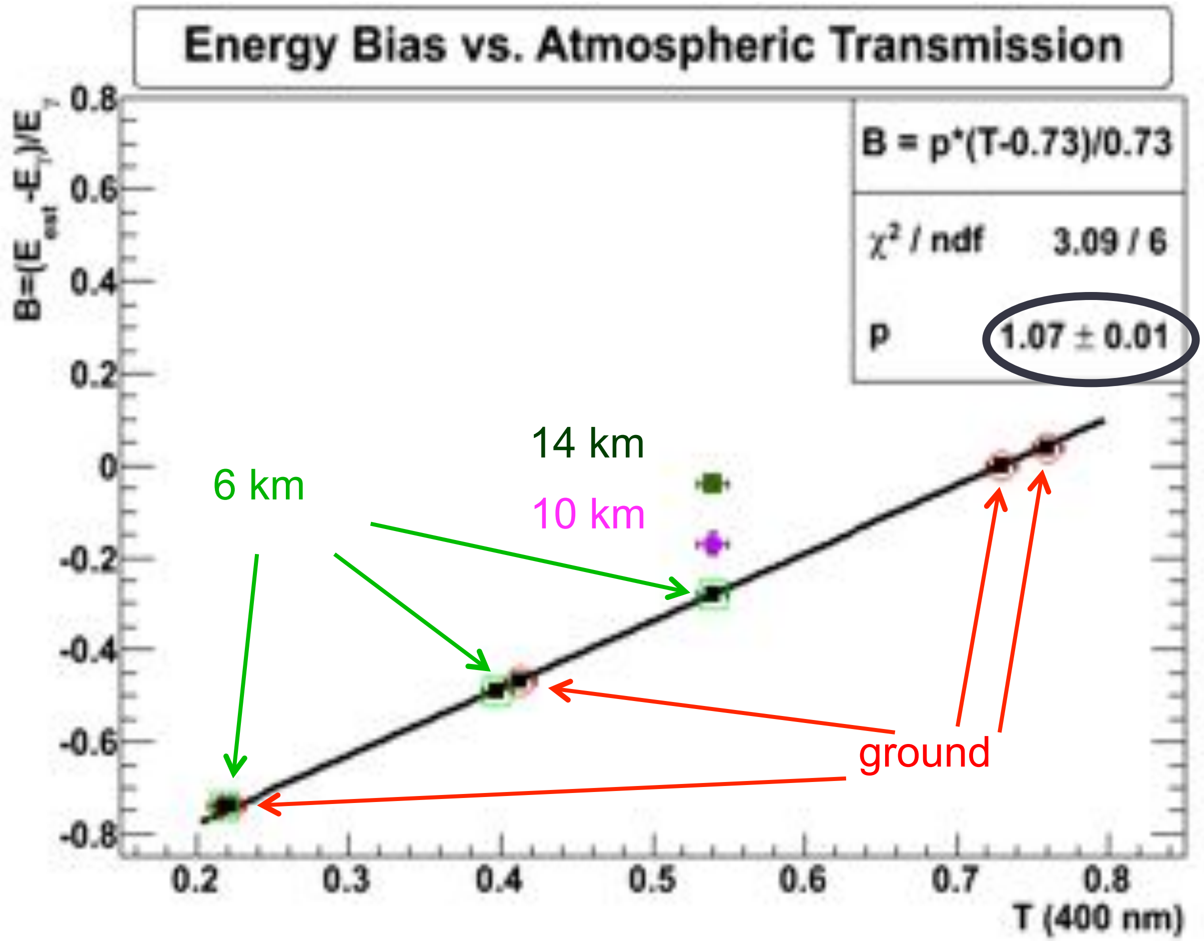
e.g. Energy threshold



Up to >6 km a.s.l.:

$$E_{thr} = E_0 / T\ (400\ nm)$$

e.g. energy bias

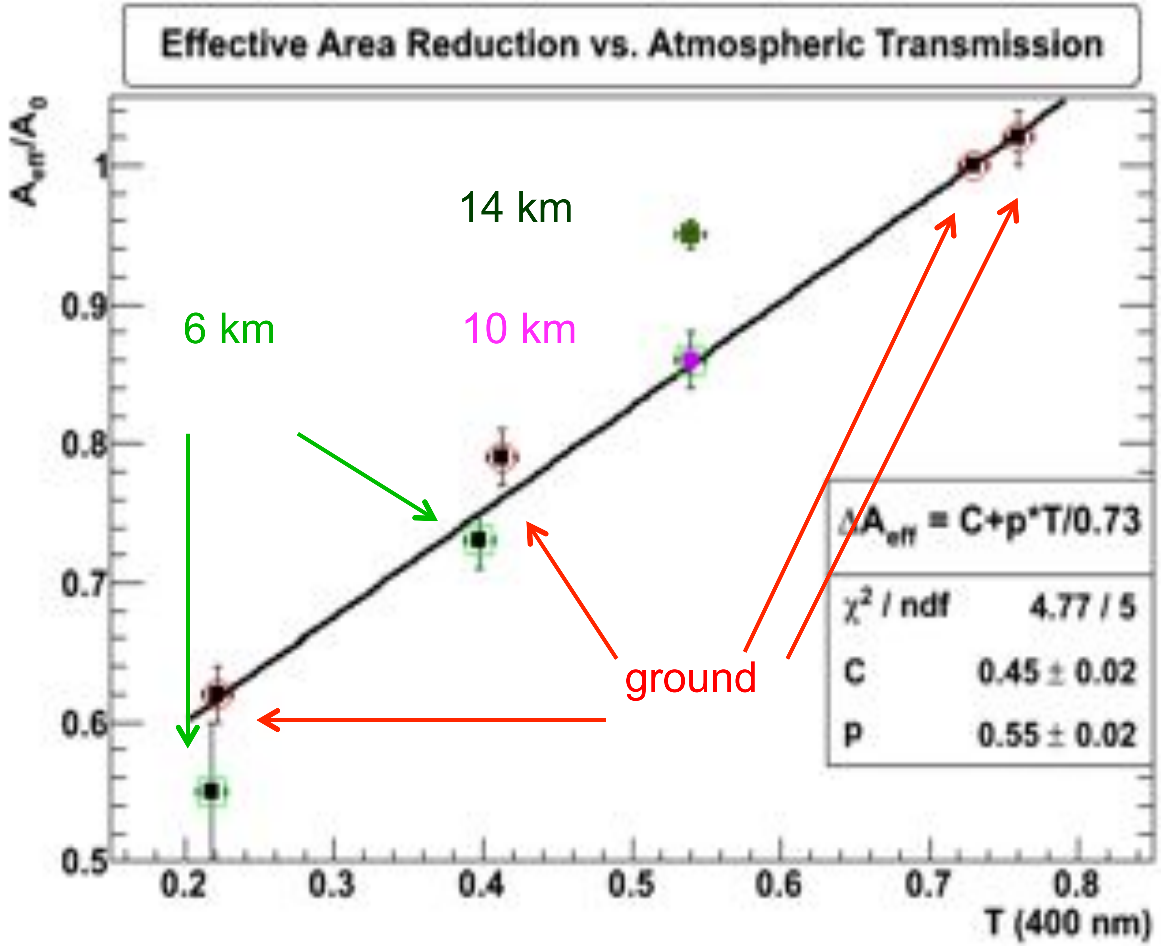


Up to >6 km a.s.l. (until 5 TeV):

$$\mathbf{(E_{rec}-E_{\gamma})/E_{\gamma} = (T-0.73)/0.73}$$

(can be corrected using only total atmospheric transmission)

e.g. effective area



Up to >6 km a.s.l. (until 5 TeV):

$$\mathbf{A_{aerosols}/A_{ref} = 0.45+0.75*T}$$

Atmospheric Calibration in CTA

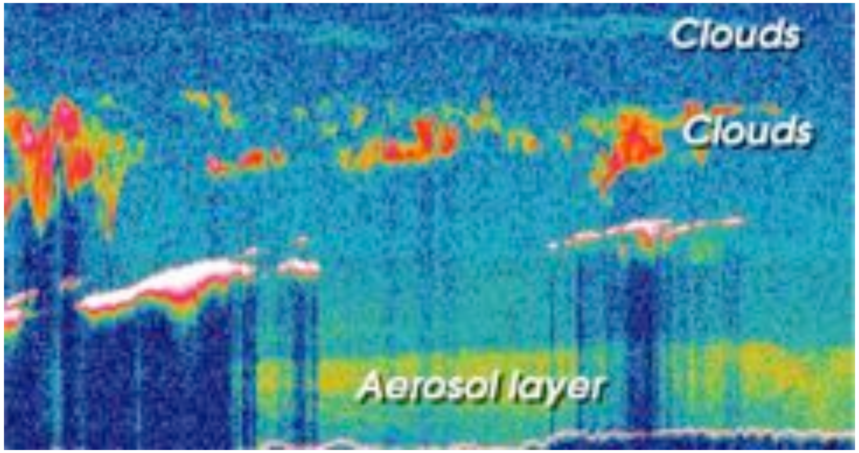
- A working group has been created to centralize atmospheric calibration activities: CCF (Common Calibration Facility)
  - Convener: Markus Gaug (markus.gaug@uab.cat)

Issues to be addressed:

- Atmospheric profile
- Atmospheric spectral transmission
- Aerosol size distributions and climatology
- Cloud sensing
- Temperature and water-vapor profiles
- Inclusion in data reconstruction
- Inclusion in smart scheduling

Possible instrumentation:

- Raman Lidars
- UV-scopes
- All-sky cameras
- Photometers
- Radiometers



Goals of CTA atmospheric calibration

- Purposes:
  - **Increase amount of data** taken by saving data taken in moderate atmospheric conditions normally discarded by standard analysis
  - **Reduce systematics** in energy and flux reconstruction for all data taken
  - **Smart scheduling**: online information about atmospheric status can allow to optimize targets by e.g. knowing the energy threshold online
- Other purposes
  - Telescope safety
  - Data archive of site important for other atmospheric searches

CTA technical requirements #1

- **SPEC**: TPC-SPECS/110331a (Level-A requirements), CTA aims to a precision on the energy scale of 10%, therefore the uncertainty on the energy scale coming from the measurement of the atmosphere absorption should be at the 5% level only.
- **RANGE:** The shower develops at about 10 km a.g.l, however, observation are often performed at 45 deg and up to 60 deg. The latter indicates that covering a range up to 20 km would be useful.
- **FREQUENCY**: The atmosphere needs to me monitored during the data taking, in order to keep track of possible changes, at best every 30 to 60 minutes.

CTA technical requirements #2

- **AVAILABILITY**: available time for data taking during good dark nights by more than 1% and one must be able to operate them fully functional 95% of the observation time.
- **MAINTENANCE**: The short term periodic maintenance of the LIDAR should not exceed 2 hours per week of 2 people to ensure the requested reliability and availability. Similarly, any long term periodic maintenance should not exceed one day every 6 month of two people.
- **LIFETIME**: The life time of the LIDAR should exceed that foreseen for the CTA observatory, which is 20 years.

Atmospheric Calibration

CTA

Atmospheric calibration for CTA

Ref : COM-CCF:xxx
Version: 1.0
May 16, 2013
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Atmospheric Calibration for CTA

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List of Abbreviations			

History		
Version	Date	Comments
v 1.0	2013.03.11	First version with the CTA format

Distribution	Public

Related Documents		
Acronym	Title	Link

- Document about full Atmospheric Calibration Strategy for CTA written by the Barcelona groups
- A public version in Doro+ ICRC 2013-0151

RAMAN LIDAR PROTOTYPES

THE BUENOS AIRES RAMAN LIDAR

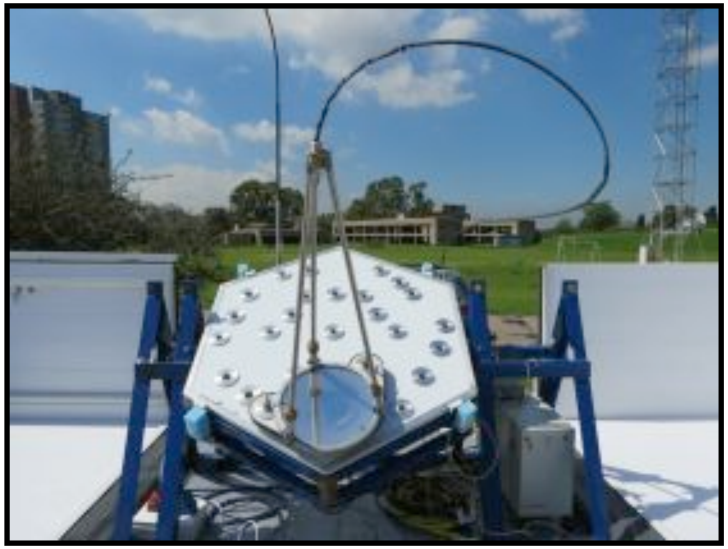
Pablo Ristori, Lidia Otero, **Juan Pallotta**, Fernando Chouza, Raul D'Elia, Mario Proyetti, Jeric Fabian, Alberto Etchegoyen, Eduardo Quel

CEILAP (Buenos Aires, Argentina)

Argentine Multi-angle Raman LIDAR

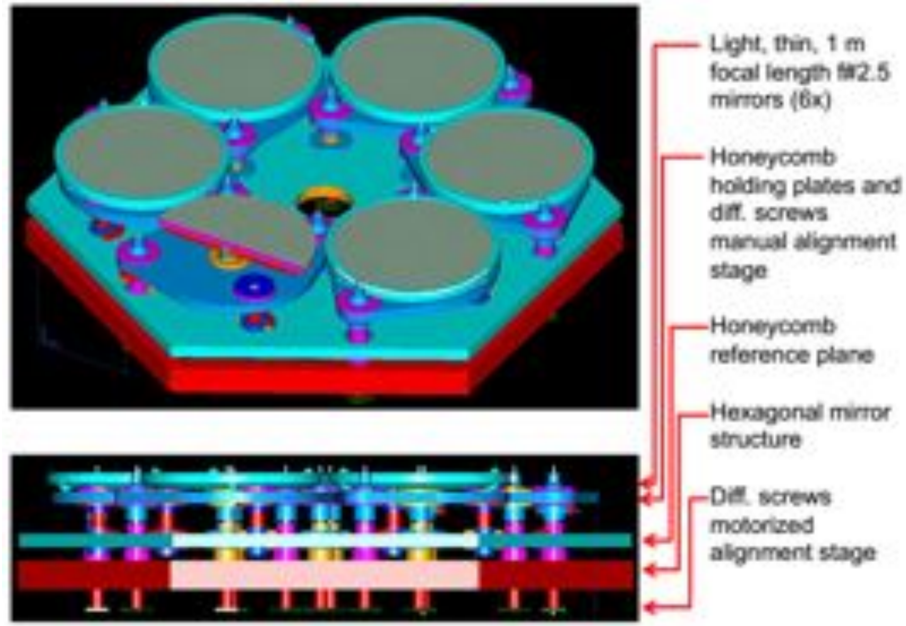
Main Features:

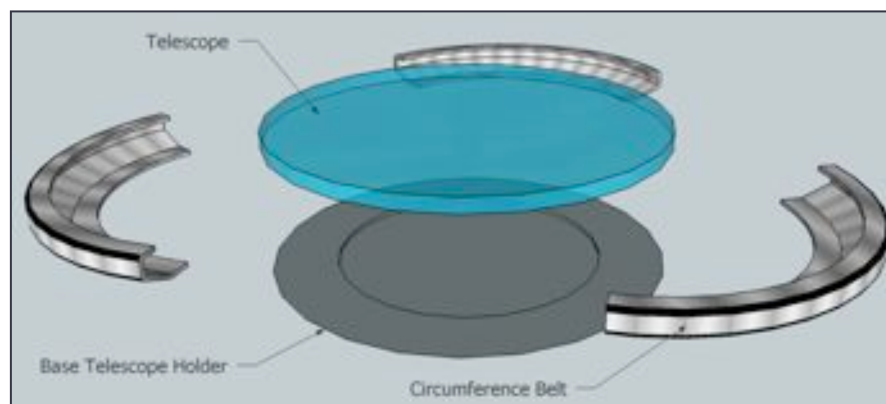
- Emission:
  - Q-switched Nd:Yag laser. Energy per pulse 60mJ @ 532nm.
- Reception Optics:
  - 6 reception mirrors:
    - Ø = 40cm
    - F=1m.
    - Optical fiber Ø = 1 mm at its focus.
- Detection lines: 3 elastic and 3 Raman.
  - Elastic: 355, 532 and 1064 nm
  - Raman: 387, 408 and 607 nm.
- Licel readout.



Mirrors

- 6 light glass 400 mm diameter and 1 m focal length. 15 mm width at the border and 6 mm at the center. Total weight about 3 kg each.
- Mirrors mount must hold the mirror without generating internal tension.
- To minimize deformation on its surface, mirror disk is supported over an aluminum disk and fixes by a belt over its circumference.





Laser

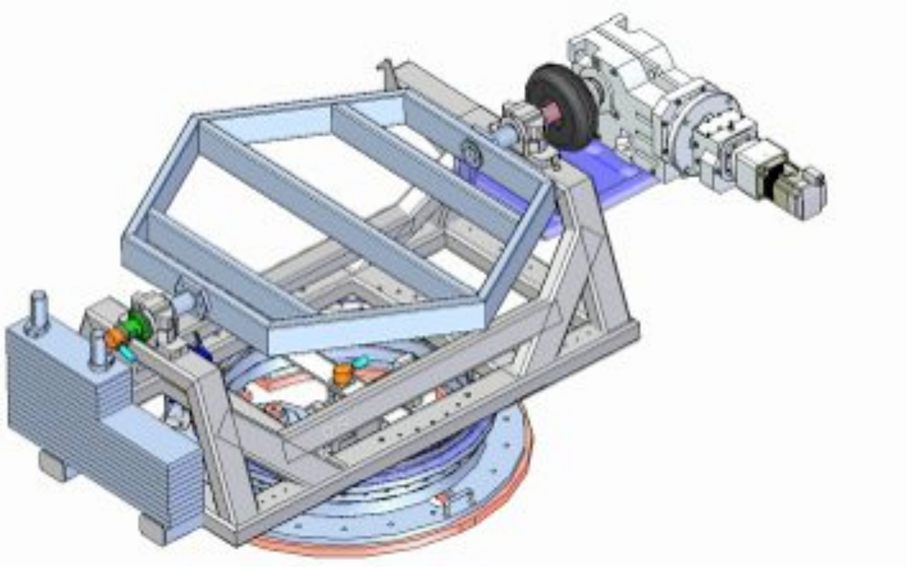
INLITE II SPECIFICATIONS

DESCRIPTION	INLITE II-20	INLITE II-30	INLITE II-50
Repetition Rate (Hz)	1-20	30	50
Energy (mJ)			
1064 nm	250	200	125
532 nm	125	100	60
355 nm	40	35	20
266 nm	20	15	10
Pulsewidth (nsec)			
1064 nm	6-8	7-9	9-11
532 nm	5-7	6-8	7-9
355 nm	5-7	6-8	7-9
266 nm	5-7	6-8	7-9
Linewidth (cm^{-1})	1	1	1
Divergence (mrad)	<0.75	<0.75	<0.75
Beam Diameter (mm)	6	6	6
Jitter (±ns)	0.5	0.5	0.5
Energy Stability (3σ; ±%)			
1064 nm	2.0; 0.6	2.0; 0.6	3.0; 1.0
532 nm	4.0; 1.3	4.0; 1.3	5.0; 1.6
355 nm	6.0; 2.0	6.0; 2.0	7.0; 2.3
266 nm	8.0; 2.6	8.0; 2.6	9.0; 3.0
Polarization			
1064 nm	HORIZONTAL	HORIZONTAL	HORIZONTAL
532 nm	VERTICAL	VERTICAL	VERTICAL
355 nm	HORIZONTAL	HORIZONTAL	HORIZONTAL
266 nm	HORIZONTAL	HORIZONTAL	HORIZONTAL

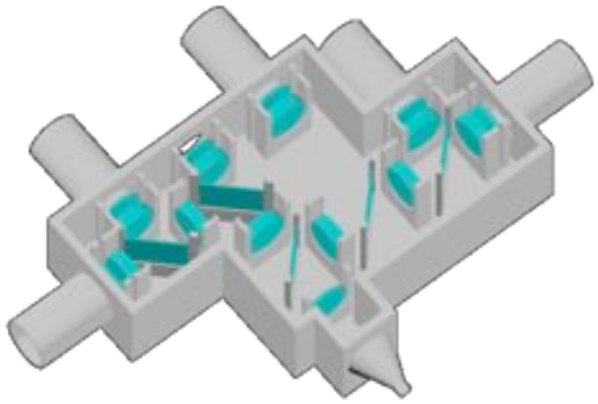
- **Inlite II-50 from Continuum.**
- Hardened design and compact size for reliable operation in industrial environments.
- Easy flashlamp replacement for future manteinance.
- Cast aluminum resonator structure ensures long-term thermal and mechanical stability.

Work in progress

- Final telescopes' steering system under development. Motorized azimuth-zenithal mechanism in acquisitionn process.



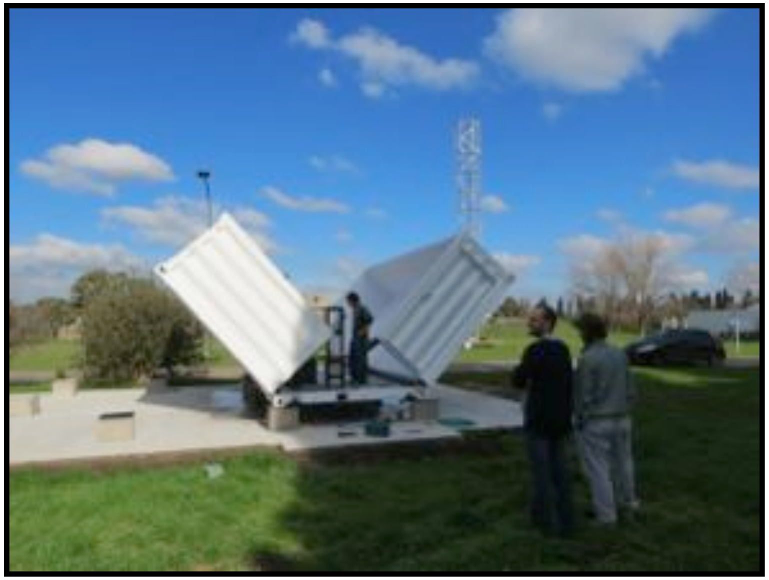
- Spectrometric box in desing phase.



- Electronic control being build at its final version.

Summary

- Argentinean lidar is the only full-custom lidar of CTA
- Lidar is already hosted in its shelter-dome and can be operated remotely via WiFi.
- Lidar signals were taken with only one telescope. The rest of them rest to be installed in near future.
- Rest to implement the new scanning bench and program the scanning software.



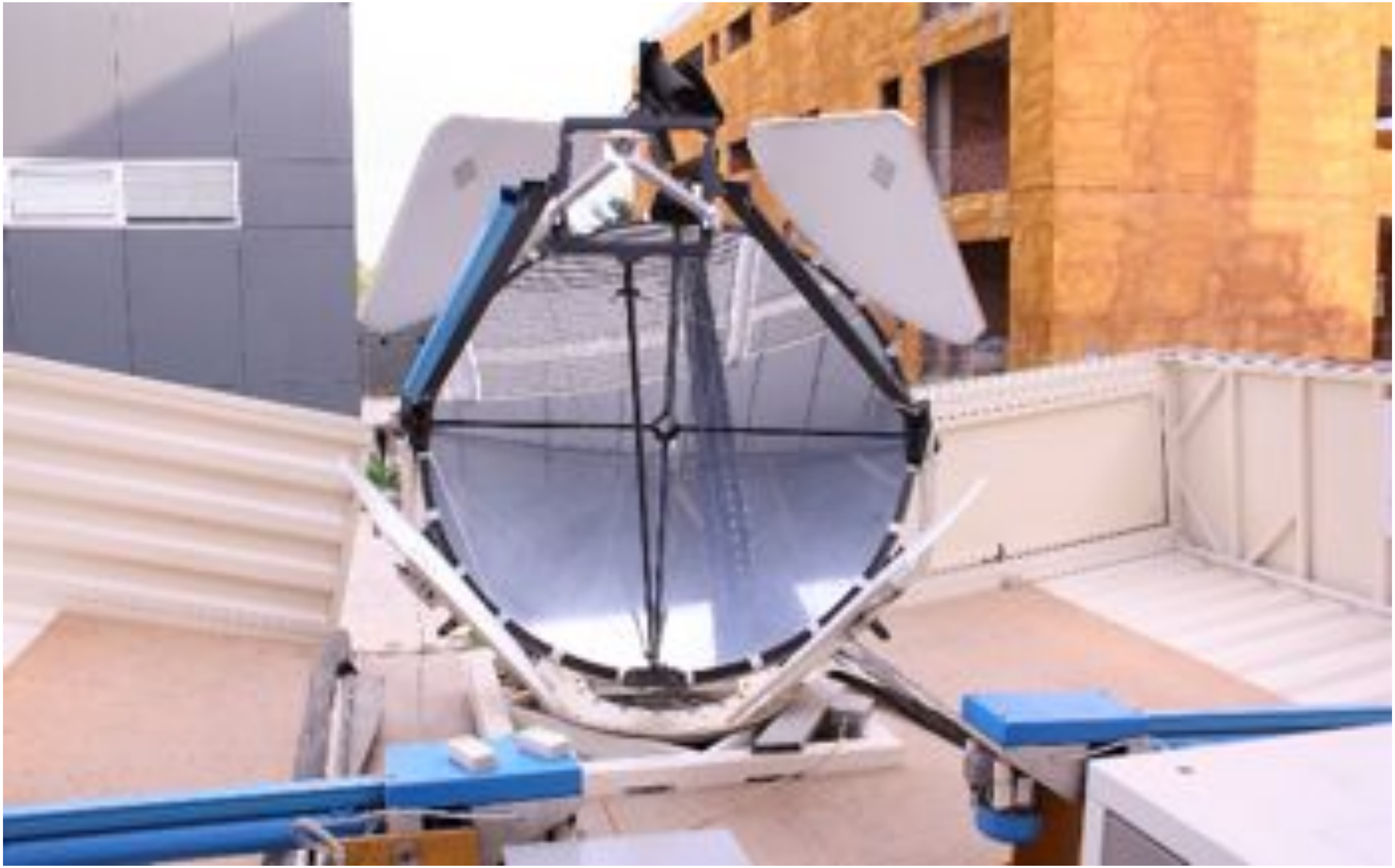
THE BARCELONA RAMAN LIDAR

Manel Martinez, **Oscar Blanch**, Alicia Lopez, Oscar Abril, Joan Boix (IFAE, Barcelona, Spain)

Lluis Font, **Markus Gaug**, Michele Doro* (UAB, Barcelona, Spain)

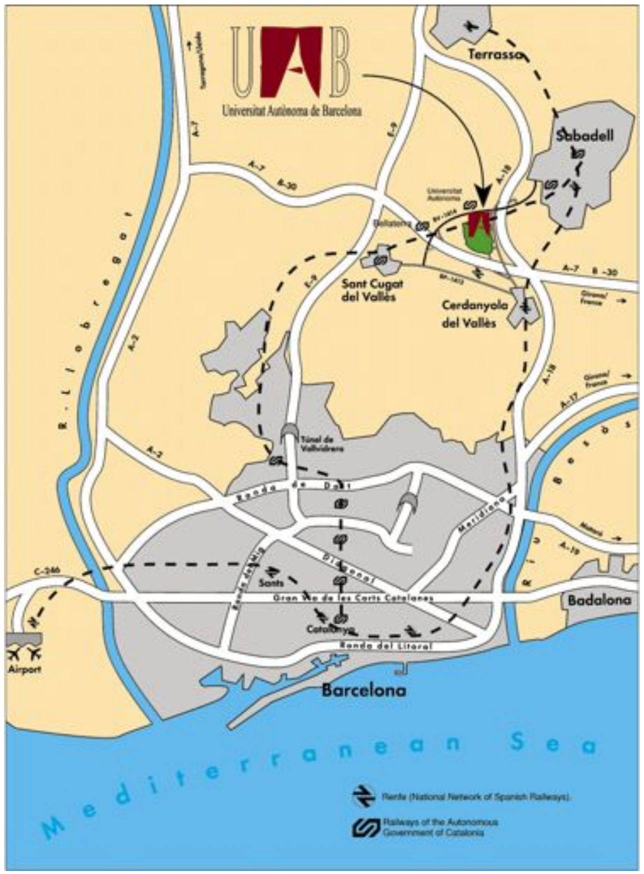
* also University and INFN Padova (Italy)

At the beginning we had a CLUE…



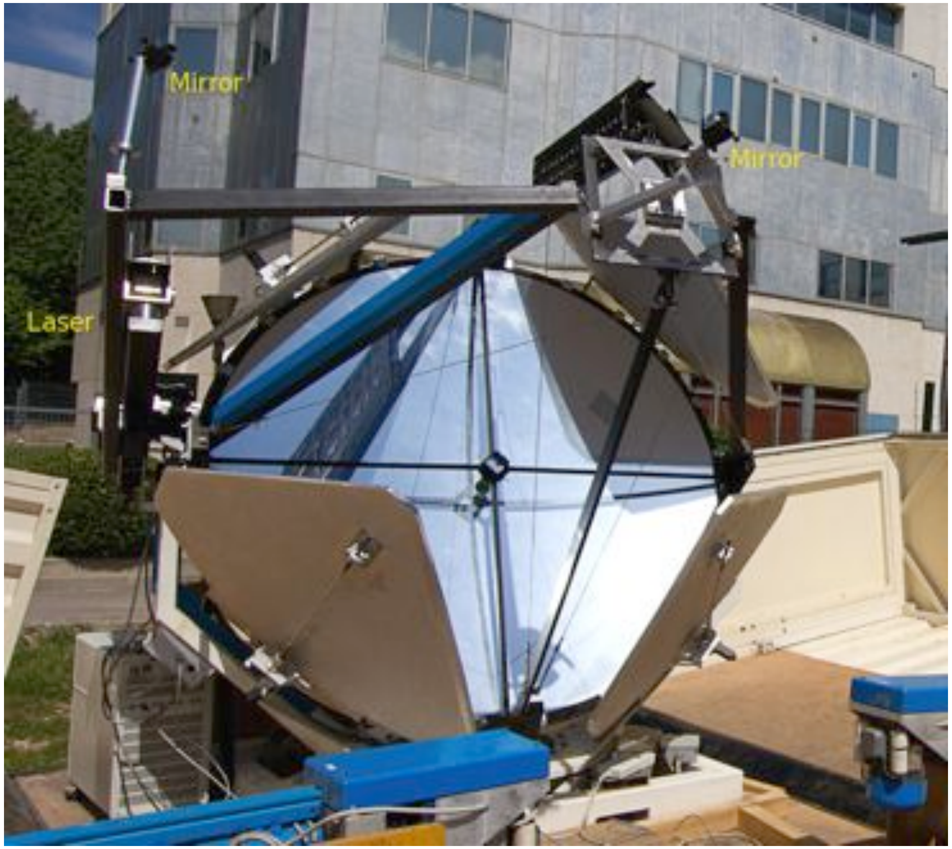
The CLUE containers

The container is a 20 ft **standard** maritime container, the dimensions of which are $5.90 \times 2.35 \times 2.39$ m. It weighs about 3 t (2.3 t from the container and 700 kg from the telescope). The container protects against rain and dust **the instrumentation inside and it was mechanized to allow the operation of the telescope from inside the container. For that, the container can be open in two halves (see 4.1).**



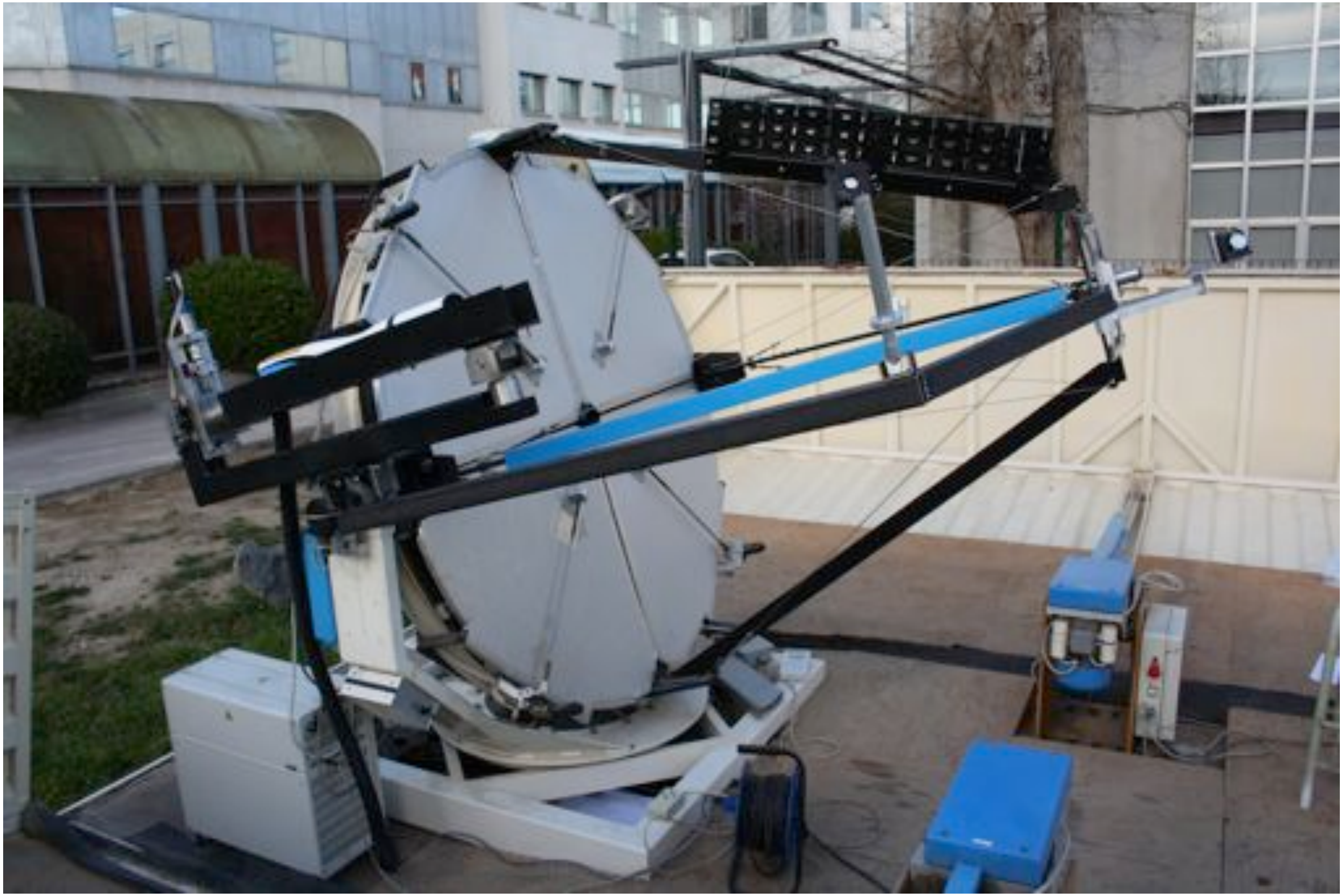
- **One container is in Barcelona** (UAB campus) and is currently being equipped.
  - Tests will be done in the campus
- **A second container is already in La Palma, at the MAGIC telescope site**.
  - Once the Barcelona LIDAR will work, this guy will be equipped and possibly operated in sinergy with the MAGIC telescopes
  - If this will be the case, it will be moved to CTA site

General design ideas

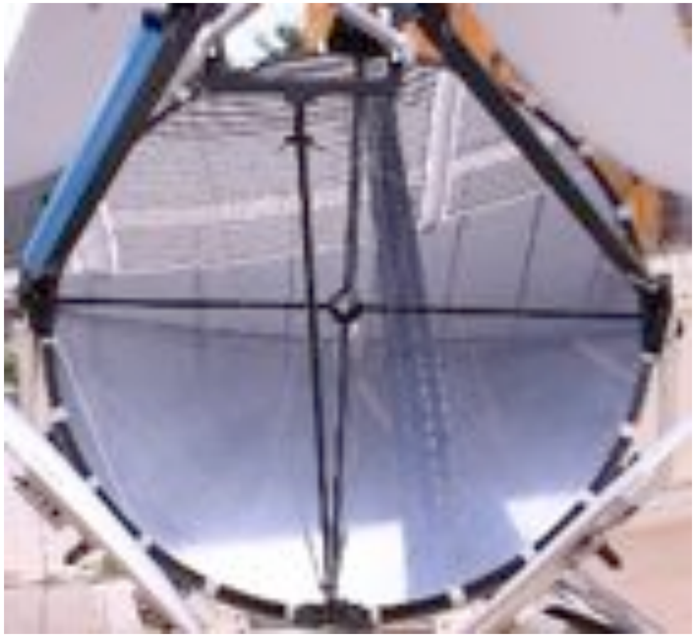


- Primary mirror = 1.8m diameter
- Focal distance = 1.8m
- Q-switched Nd:YAG laser (1064, 532, 355 nm)
- Mono-axiality
- Liquid light guide
- Custom optical module with 1.5 inch PMTs and 4 readout channel (2 elastic+ 2 N_2 Raman)
- LICEL readout
- Custom analysis software

The telescope structure



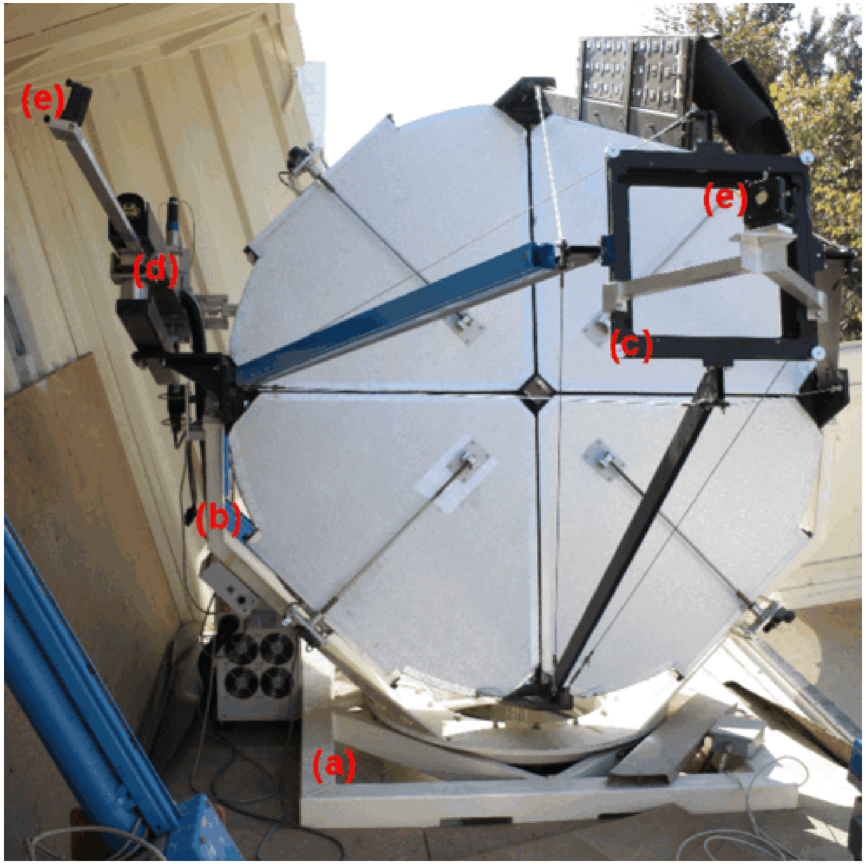
The primary mirror



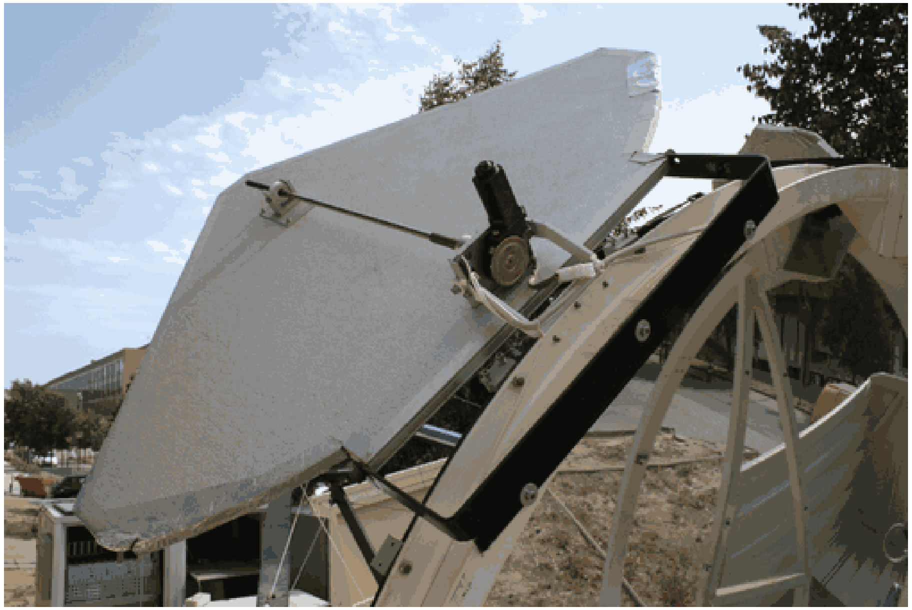
- Parabolic float glass mirror made with hot-slumping on high precision mould at CERN
- 1.8 m diameter, 6 mm thickness
- Maintained very good geometry over time: D90 is 6.2 mm as 15 years ago
- Initial reflectivity of 95% has degraded to 64% (measured by us)
- Hole at the center of about 5 cm

The plan is to either re-aluminize and coat the glass or other alternative solutions

The petals



- Made of polystyrene
- Protect mirror from dust
- Four petals per dish
- Actuated by 12 V motors and controlled by 8 final switches connected in series.



The Quantel Brilliant Q-switched laser

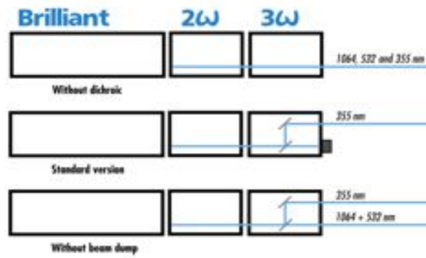
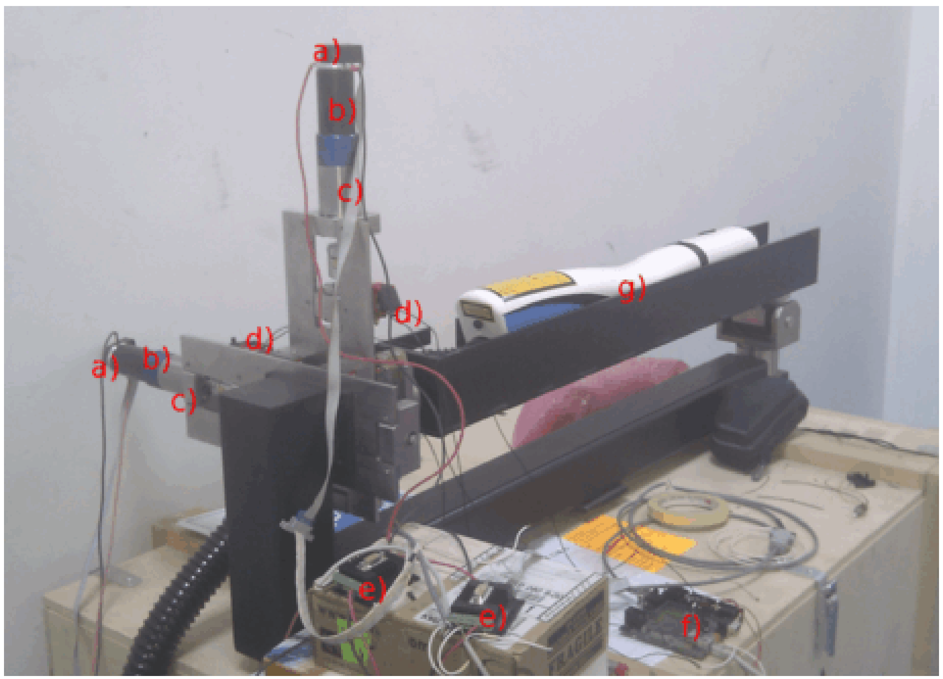


Figure 4.14: : Quantel Nd:YAG 1064 Laser.

General characteristics	
Pulse repetition rate	20 Hz
Power drift	3%
Pointing Stability	$< 75\ \mu$rad
Jitter (1064 nm)	$\pm$ 0.5 ns
Beam divergence (1064 nm)	0.5 mrad
Beam diameter (1064nm)	6mm

Works between 18-28 deg. T-stabilized

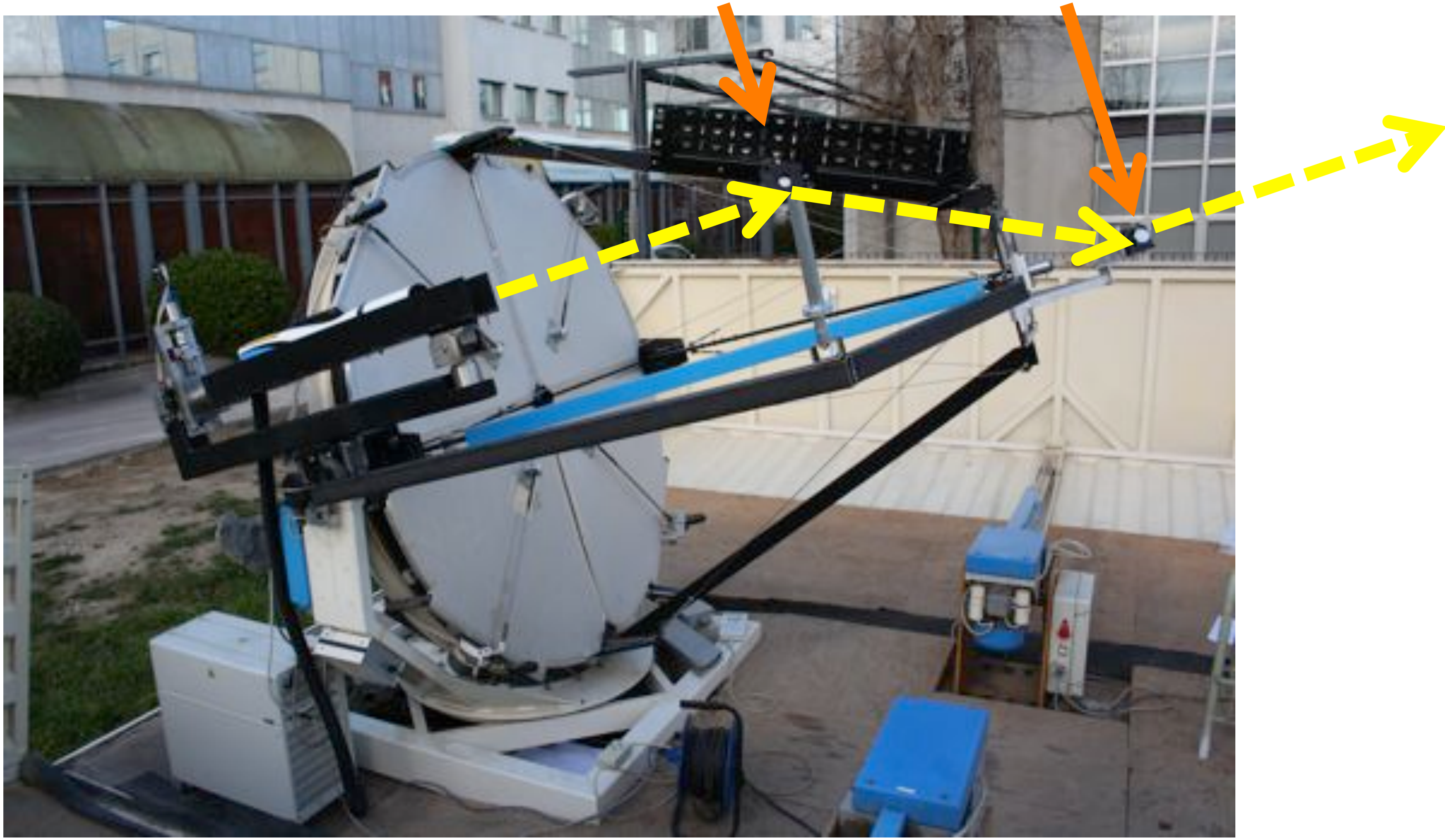
1064 → 360 mJ/p,
532 → 100 mJ/p,
355→ and 100 mJ/p



The laser is mounted on a rail controlled by an x-y translator system to allow orientation.

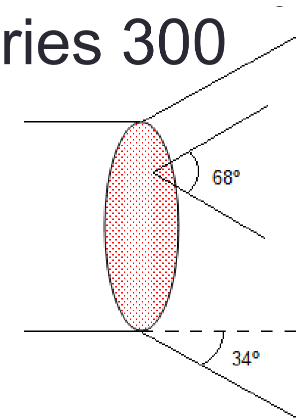
Folding 45deg mirrors

- To make the lidar coaxial
- Can stand laser, but can be rotated to change damaged surface

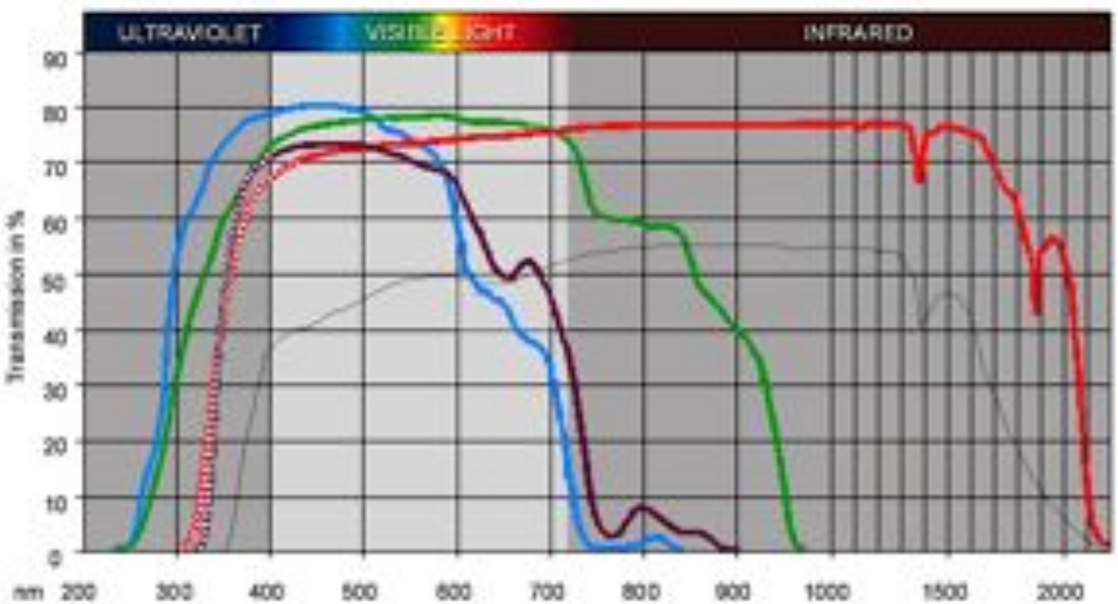


The LLG

- Liquid light-guide Lumatec Series 300
  - **8 mm diameter**
  - 2.5 m length
  - 0.59 NA (34deg half-angle)
  - **Does not survive 1064 nm line!**



	Minimum	Maximum
Indefinitely	- 5° C	+35° C
Maximum of few hours	-20° C	+70° C
Maximum of few days	-15° C	+50° C

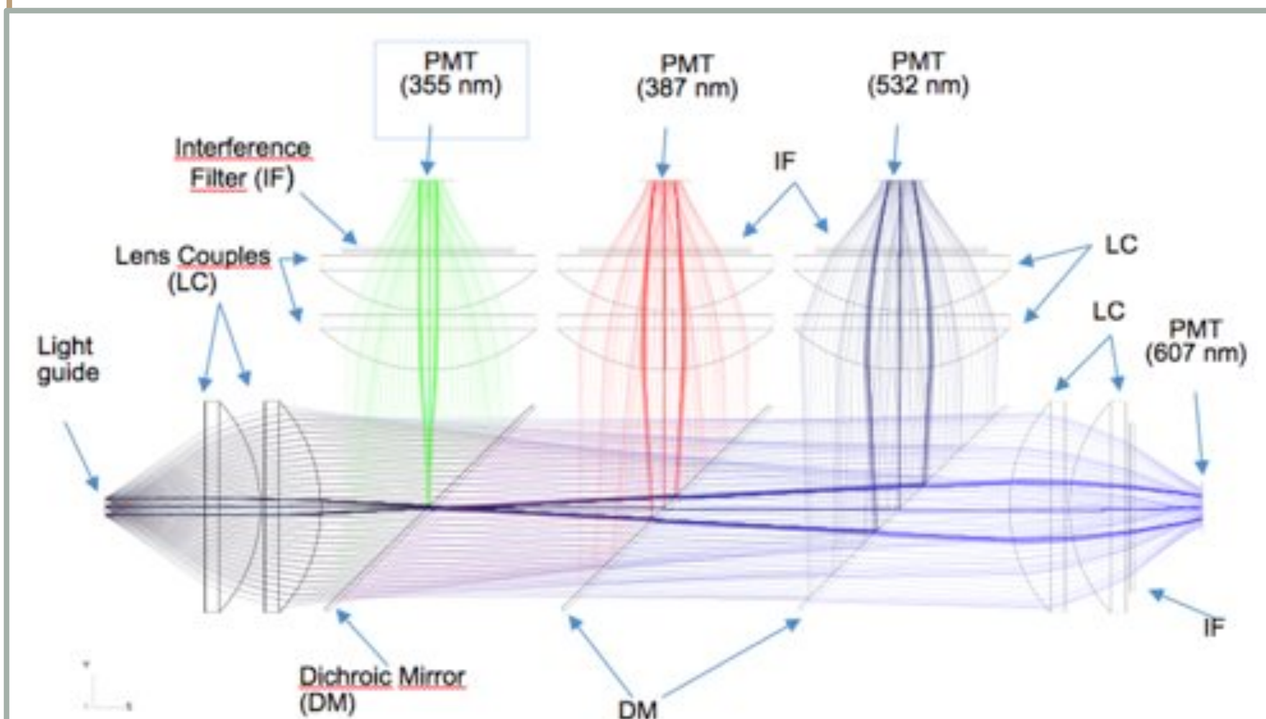


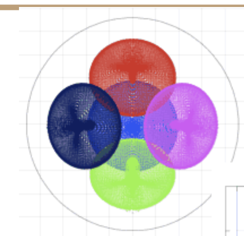
- Checked dependence on temperature and NA in various conditions
- Quite stable results!

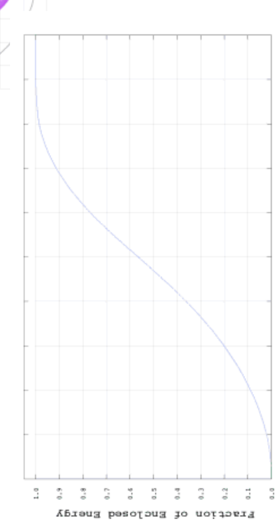
Optical module

Da Deppo et al., Proc. of SPIE Vol. 8550 85501V and poster at this conference

- Goals:
  - 4 lines read-out: 2 elastic (355, 532nm) + 2 Raman (387, 607 nm)
  - Because of the big aperture of the LLG, we needed very large custom optical components
  - PD of 1 or 1.5 inch diameter (22mm needed for full throughput)
  - Procurement of optical components made me sick







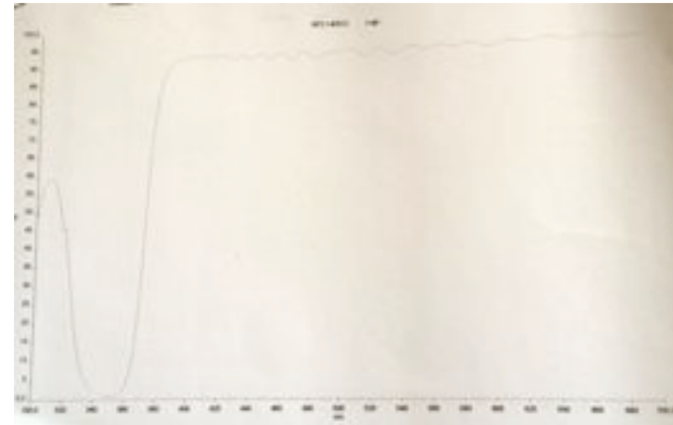
Optical module position

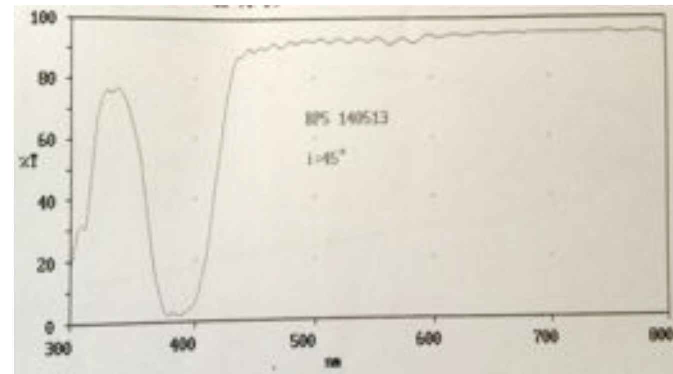
The optical module is mounted on the back and co-moving with the telescope structure

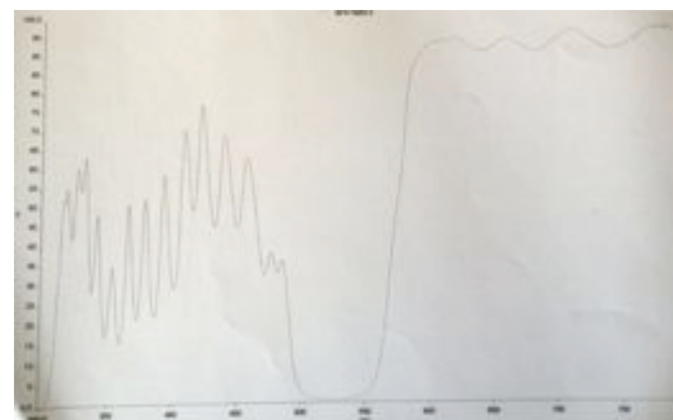
We need to careful check the stability for different observation points + temperature stability

Dichroics

- Dichroic mirror 1
  - R(355 nm)>95%, T(387, 532, 607 nm)>90%
- Dichroic mirror
  - R(387 nm)>95%, T(532, 607 nm)>90%
- Dichroic mirror 3
  - R(532 nm)>95%, T(607 nm)>90%
- Incidence angle = 45°
- Random polarization

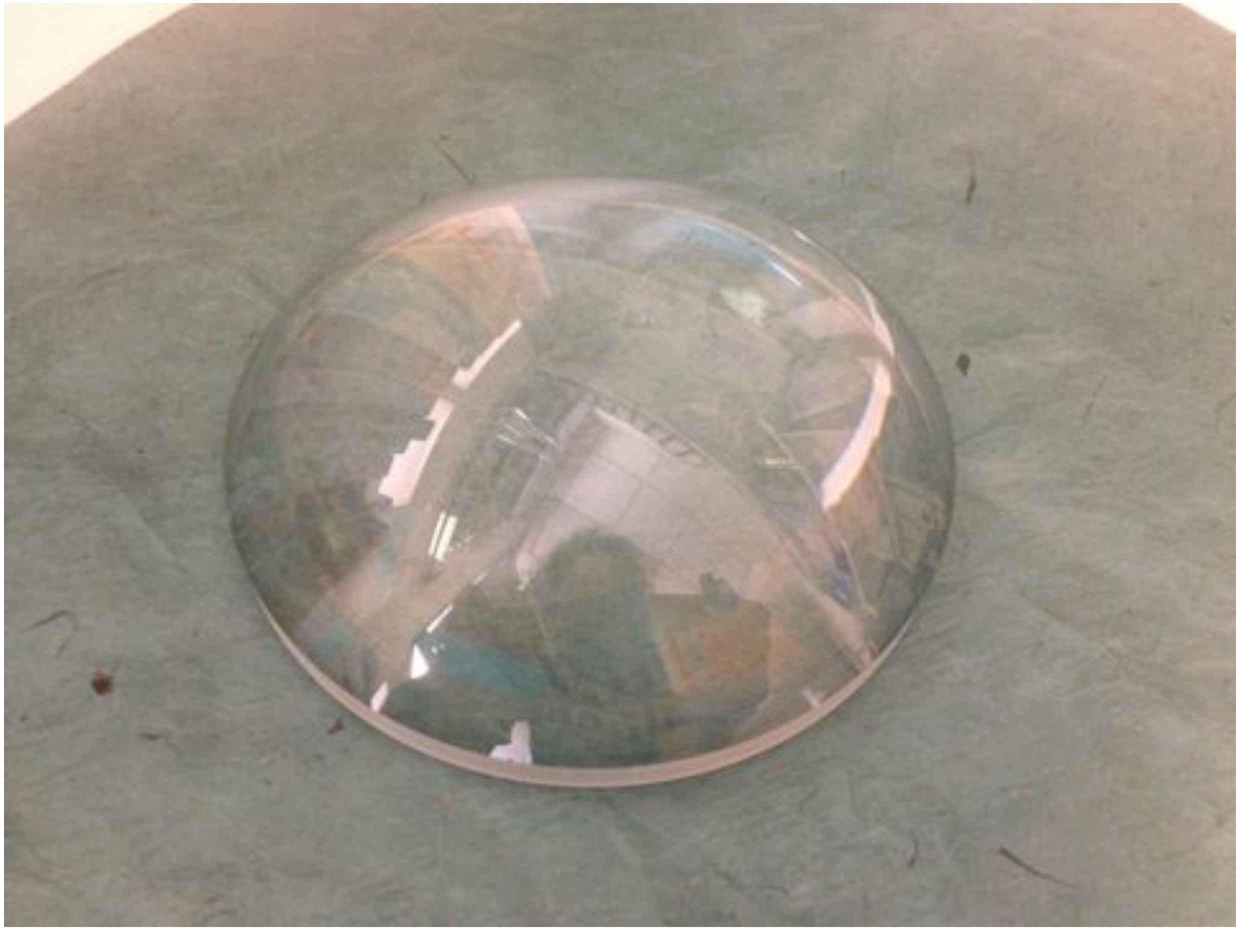






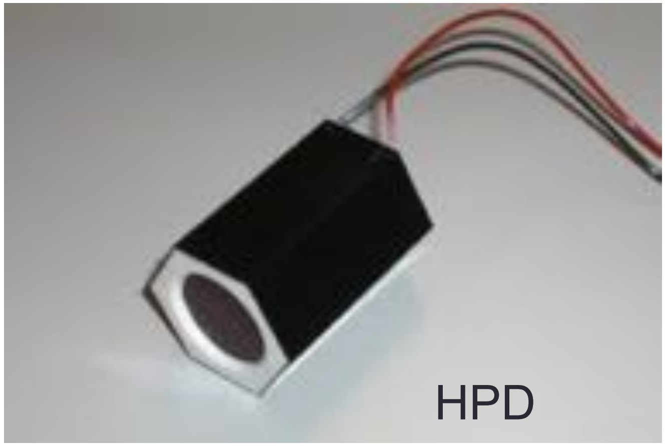
Lenses

- Plano-spherical lens 100mm diameter



PMTs selection

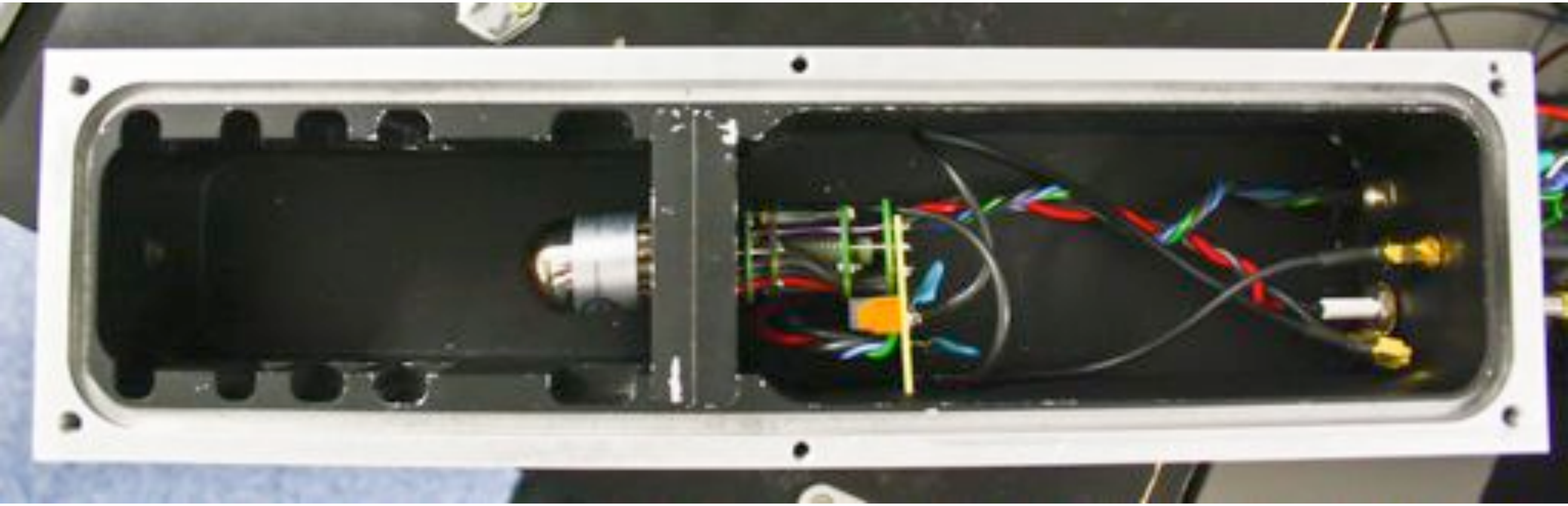
- Design of optical module demands 1' or larger PD
- Not sure whether to use PMT or HPD or other PDs
- Possible solutions
  - Hamamatsu R1925A
  - Hamamatsu R11920-110 (candidate for CTA LST cameras)
  - HPD from MAGIC cameras



LICEL

Single-line optical module

- We have prepared a single-line optical module to check easily the lidar + readout



What is the link-budget?

EMITTER		
LASER	Type Model Emitted wavelength, λ Energy per pulse, E Pulse Repetition Frequency, PRF Beam waist (diameter) Beam Divergence, θ Pulse duration, τ_L	Nd:YAG Quantel Brilliant 355 nm 60 mJ 20 Hz 6 mm 0.5 mrad 5 ns
RECEIVER		
Telescope	Geometry Diameter, d Shadow diameter, d_{sh} Focal length, f Transmissivity, ξ_t	Parabolic mirror 1.8 m 0.08 m 1.8 m 0.55
	Liquid-guide-to-telescope coupling efficiency, ξ_{LG}	0.9
Liquid Guide	Manufacturer & Model Active area diameter, d_{lg} Numerical Aperture, NA Transmissivity, ξ_{lg}	Lumatec Series 300 8 mm 0.58 (34° half-angle) >0.7 (in the UV)
Photodetectors	Type Active area diameter, d_d PMT model	PMT 22 mm Hamamatsu R1924A
Acquisition unit (transient recorder)	Type Model	Mixed analog-to-digital converter (ADC) / Photon-counter (PC) ADC 20 Msps 12bit / 250-MHz PC LICEL TR20-160
CHANNEL SPECIFICATIONS		
Wavelength [nm]	355	387 (N_2)
Type	Elastic	Raman
Resolution [m]	Up to 15 m in analog mode (10-MHz bandwidth), up to 7.5 m in photon-counting mode (50-ns bin)	
Polychromator TX, ξ_{poly} (Fig. [11])	$0.90\times0.90^3\times0.60 = 0.39$	$0.90\times0.90^3\times0.65 = 0.43$
Channel transmissivity, ξ_{ch} (Fig. [11])	0.15	0.16
Channel responsivity R_v [V/W]	8.0×10[illegible]	8.7×10[illegible]
Spectral Bandwidth, $\Delta\lambda$ [nm]	10	10
Type of Detector	PMT	PMT
Model	R1924A (Hamamatsu)	R1924A (Hamamatsu)
Transimpedance gain (input impedance of the transient recorder) [Ω]	50	50
Internal Gain, M	2×10[illegible]	2×10[illegible]
Noise Factor, F	1.8	1.8
Current responsivity, R_i [A/W]	1.1×10[illegible]	1.1×10[illegible]
Dark current, I_d [nA]	3	3

Series of equations with components inputs (and atmosphere) to characterize LIDAR outputs

$$\sigma_{sh,s}^2(R) = 2qG_T^2FM^2R_{io}P(R)\xi\ \left[\frac{V^2}{Hz}\right],$$

$$\sigma_{sh,b}^2 = 2qG_T^2FM^2R_{io}P_{back}\xi\ \left[\frac{V^2}{Hz}\right],$$

$$\sigma_{sh,d}^2 = 2qG_T^2FM^2I_{db}\ \left[\frac{V^2}{Hz}\right],$$

$$\sigma_{th}^2 = 4kTR_{in}\ \left[\frac{V^2}{Hz}\right],$$

$$SNR_a(R) = \frac{R_{io}MG_T\xi P(R)}{\sqrt{\left[2qG_T^2FM^2R_{io}\xi[P(R)+P_{back}] + 2qG_T^2FM^2I_{db} + 4kTR_{in}\right]B_N}}\left[\frac{V}{V}\right]$$

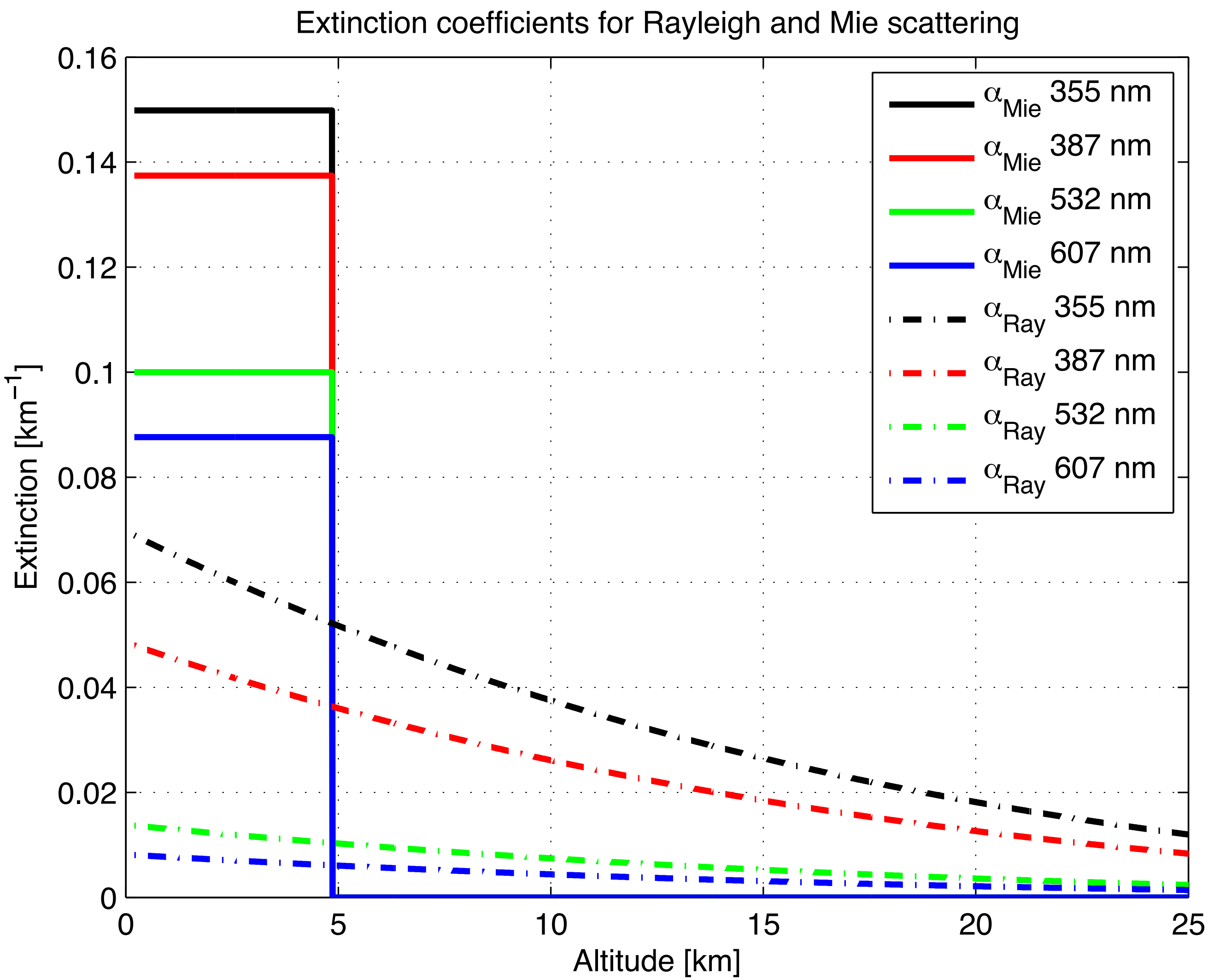
$$\mathrm{SNR_{pc}}(R) = \frac{N_{ph}(R)\sqrt{\tau}}{\sqrt{N_{ph}(R) + 2(N_b + N_d)}},$$

$$N_{ph} = P_{ram}L_rR_{io}/q\ [\text{counts/sec}],$$

$$N_b = P_{back}L_rR_{io}/q\ [\text{counts/sec}],$$

$$N_d = I_{db}/q\ [\text{counts/sec}],$$

Atmospheric modeling

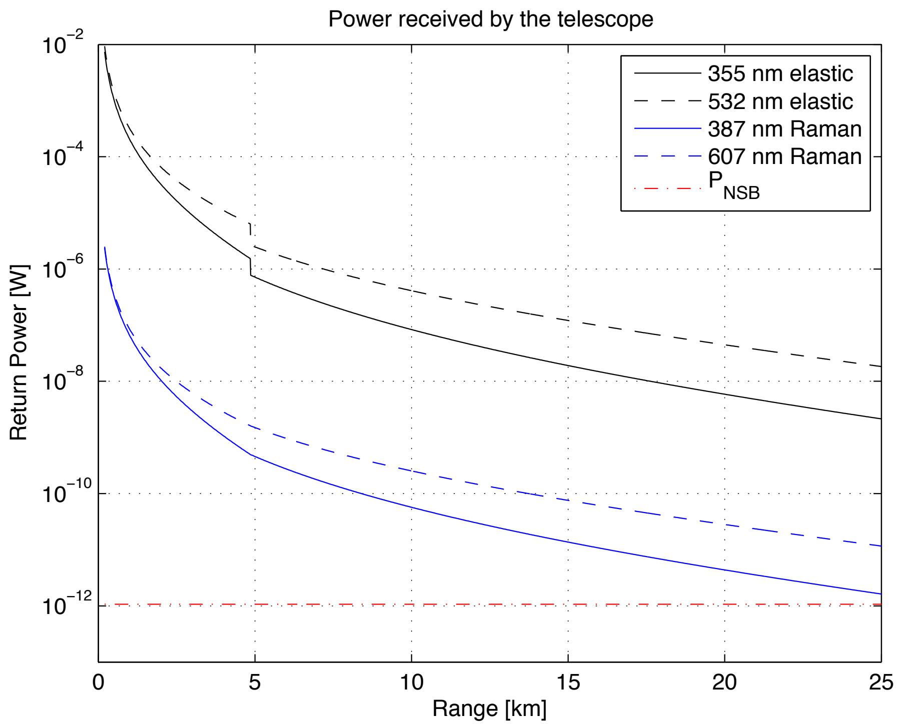


Return power

$$P_{\lambda_0}(R) = O(R)\,\frac{K}{R^2}\,[\beta^m_{\lambda_0}(R) + \beta^p_{\lambda_0}(R)]\;\exp\left(-2\int_0^{R'} (\alpha^m_{\lambda_0}(R') + \alpha^p_{\lambda_0}(R'))\,\mathrm{dR'}\right)$$

$$P_{\lambda_{R,0}}(R) = O(R)\,\frac{K}{R^2}\,[\beta^m_{\lambda_R}(R)]\;\exp\left(-\int_0^{R'} (\alpha^m_{\lambda_0}(R') + \alpha^p_{\lambda_0}(R') + \alpha^m_{\lambda_R}(R') + \alpha^p_{\lambda_R}(R'))\,\mathrm{dR'}\right)$$

$$P_{\mathrm{bkg}}(\lambda) = L_{\mathrm{bkg}}\,A_R\,\mathrm{d}\Omega\,\mathrm{d}\lambda \quad \text{La Palma: } 2.7\cdot 10^{-13}\ \mathrm{W\ cm^{-2}\ nm^{-1}\ sr^{-1}}\ \text{[Mirzoyan, 1998].}$$



- Sensitivity up to 25 km
- Still to check precisely the overlap factor

S/N ratio

Signal-to-noise ratio in analog detection mode

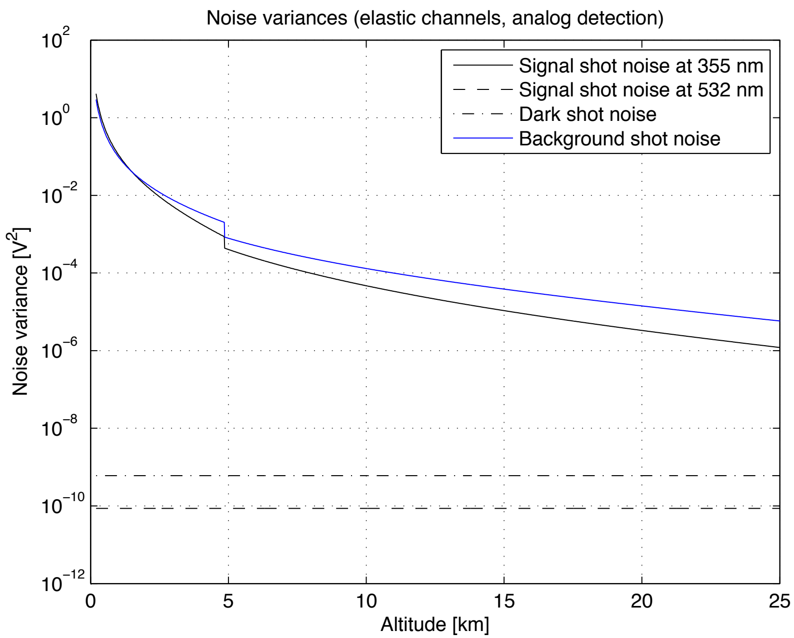
$$\begin{aligned}
\sigma^2_{sh,s}(R) &= 2\,q\,G_T^2\,F\,M^2\,R_{i0}\,P(R)\xi \quad [\mathrm{V^2/Hz}]\\
\sigma^2_{sh,b} &= 2\,q\,G_T^2\,F\,M^2\,R_{i0}\,P_{\mathrm{bkg}}\xi \quad [\mathrm{V^2/Hz}]\\
\sigma^2_{sh,d} &= 2\,q\,G_T^2\,F\,M^2\,I_{\mathrm{db}} \quad [\mathrm{V^2/Hz}]\\
\sigma^2_{th} &= 4\,k\,T\,R_{in} \quad [\mathrm{V^2/Hz}]
\end{aligned}$$

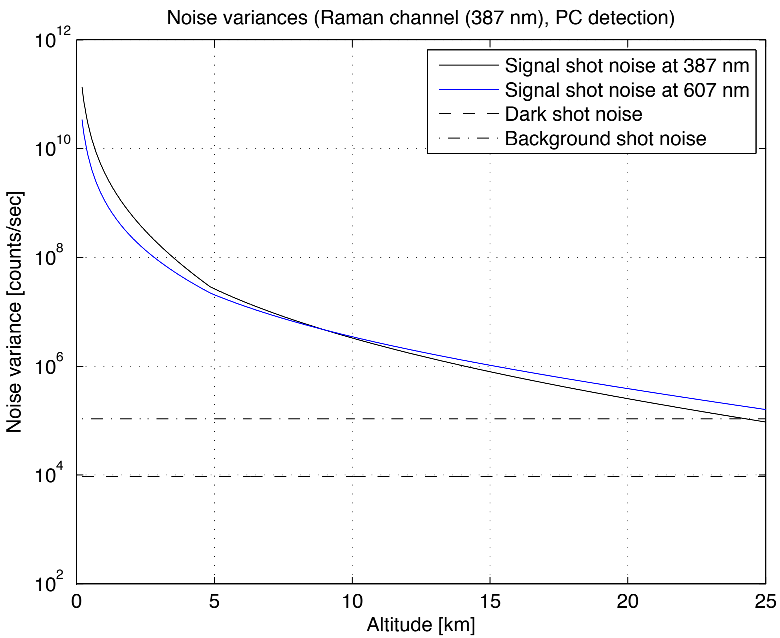
$$SNR_a(R) = \frac{R_{i0}\,M\,G_T\,\xi\,P(R)}{\sqrt{[2\,q\,G_T^2\,F\,M^2\,R_{i0}\,\xi\,(P(R)+P_{bkg}) + 2\,q\,G_T^2\,F\,M^2\,I_{db} + 4\,k\,T\,R_{in}]\,B_N}}$$

Signal to noise ratio in photon counting mode

$$\begin{aligned}
N_{ph} &= P_{\mathrm{Raman}}\,L_r\,R_{i0}\,/q \quad \mathrm{cts/sec}\\
N_b &= P_{\mathrm{bkg}}\,L_r\,R_{i0}\,/q \quad \mathrm{cts/sec}\\
N_d &= I_{\mathrm{db}}/q \quad \mathrm{cts/sec}
\end{aligned}$$

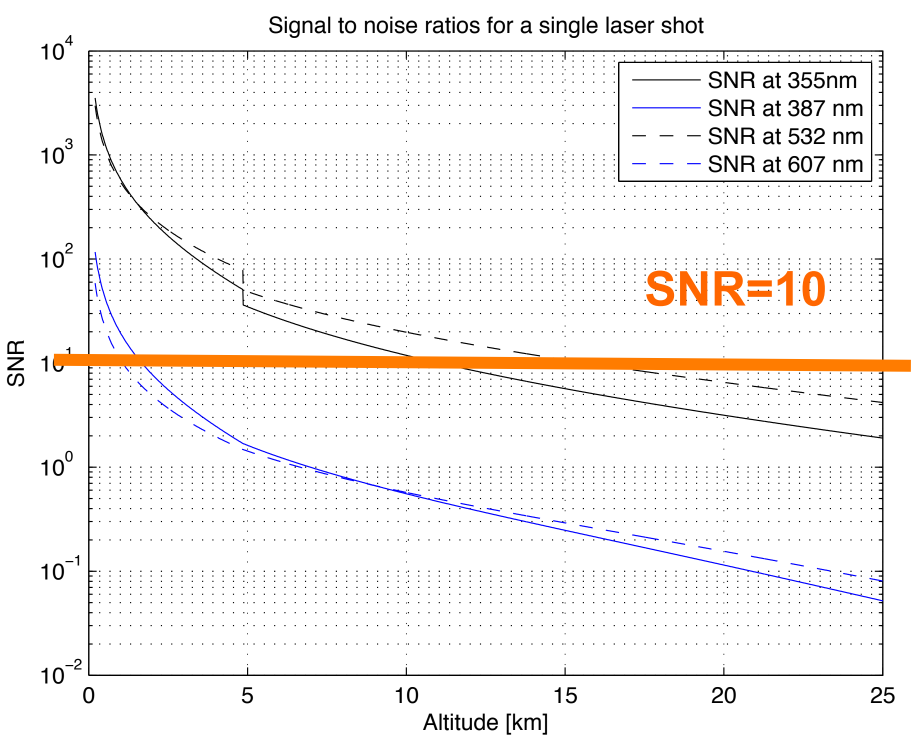
$$SNR_{pc}(R) = \frac{N_{ph}(R)\sqrt{\tau}}{\sqrt{N_{ph}(R) + 2(N_b + N_d)}}$$

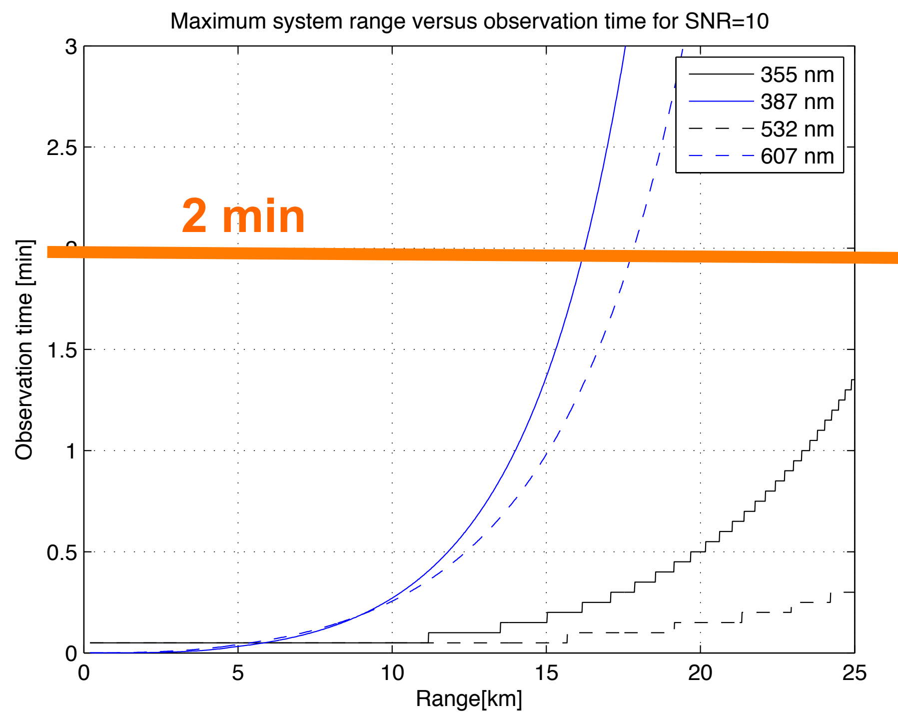




Integration times

$$t_{obs} = \frac{N}{PRF} = \left(\frac{SNR_{goal}}{SNR_{single}}\right)^2 \frac{1}{PRF}$$





Further documentations

- M. Doro et al., LIDAR Letter of Intent. CTA internal document.
- M. Doro et al., Towards a full Atmospheric Calibration system for the Cherenkov Telescope Array, ICRC2013-0151
- M. Gaug et al. LIDAR Technical Design Report, CTA internal document, in prep.
- M. Barcelo et al. Development of Raman LIDARs made with former CLUE telescopes for CTA ICRC 2011
- Da Deppo et al., Preliminary optical design of a polychromator for a Raman LIDAR for atmospheric calibration of the Cherenkov Telescope Array, Proc. of SPIE Vol. 8550 85501V
- M. Eizmendi, IFAE-UAB Raman lidar link budget and components Phd thesis 2011

- M. Gaug, Atmospheric monitoring of MAGIC, talk at this conference
- D. Garrido et al. Influence of atmospheric aerosol on the performance of the MAGIC telescope, poster at this conference
- M. Doro et al. Design of a 2-elastic plus 2-Raman lines optical module for a Raman lidar for CTA, poster at this conference

THE MONTEPELLIER LIDAR

Geroges Vasileiadis (LUMP, Montpellier, France) +
LUPM workshops

LUPM Raman LIDAR

- Based on same mirrors and container as Barcelona Lidar.
- Includes more commercial elements,
- Lot of **experience from the HESS lidar**.

ADELAIDE LIDAR

Contacts: Iain Reid and Andrew MacKinnon.

Information extracted from their webpage

Univ. of Adelaide

- Not yet full members of CTA!
- Are interested in getting involved in construction of Raman and differential Lidars for the CTA in the future.
- Current work based on monitoring of greenhouse gases and climate change

Buckland Park Lidar Facility

- http://www.physics.adelaide.edu.au/atmospheric/lidar.html
- The Atmospheric Physics Group in collaboration with the Optics and Photonics Group at The University of Adelaide is setting up a new lidar facility at Buckland Park.
- The aim is to measure **atmospheric temperature, wind and dynamical from 10 to 110 km altitude.**
- First stage of project:
  - Lidar building is already finished
  - The development of a in-house diode pumped power laser (@532 nm) is in progress
  - Two channel data acquisition
- Second stage of project:
  - Apply a second laser system to probe the Sodium resonance line (see guide star and Sodium lidar project) to derive temperatures in a altitude range from 75 to 110 km
- Scientific Propose
  - Study the thermal structure at 35° S covering the troposphere, stratosphere and mesosphere (10-110 km)
  - Study chemical and dynamical processes in the Sodium layer (75-110 km)

OTHER DEVICES INTO CONSIDERATION

Additional instruments

- We have seen in this conference, that different other instruments can allow to retrieve very useful information other than the lidar
  - A microwave spectrophotometer to measure continuously the molecular profile with high precision
  - All-sky cameras, to monitor clouds and provide now-cast (passive)
  - Sun photometers can allow to predict datataking observation (at night) during the previous daytime
  - Stellar or Lunar photometer can allow to retrieve with very high precision (1-2 %) the total light extinction, useful e.g. for online monitoring and corrections
  - Other?
- Discussion ongoing in CTA CCF group

CONCLUSIONS

Conclusions

- CTA is pursuing an extensive program for atmospheric calibration
- The atmosphere has a strong influence on the data, but a wise use of MC and atmospheric measurements can solve the issue
- The Raman lidar is needed for differential atmospheric transmission
- Several institutes are currently building Raman lidar, and in some cases the realization is advanced
- Still to be defined how many lidars per site and overall strategy
- Additional commercial instruments could very much help and complete the lidar information as well as improve the final energy and flux reconstruction

Calibration Meeting Barcelona