IFAE/UAB RAMAN LIDAR

S. M. Colak, C. Maggio, M. Gaug

Full-time Working Group

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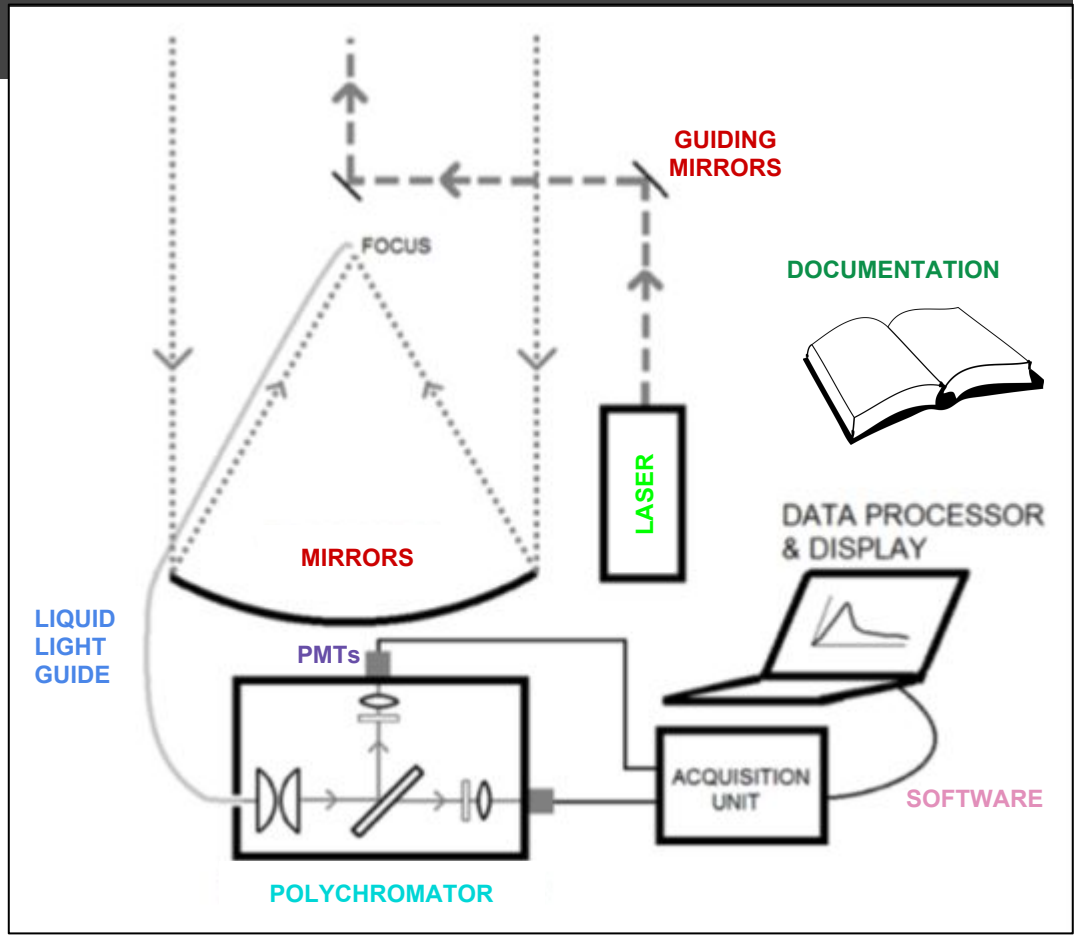
- **Pere Munar**
- **Camilla Maggio**
- **Manel Martinez**
- **Oscar Martinez**
- **Scott Griffiths**

Outline

- Mirrors
  - Primary mirror characterization
  - Guiding mirrors characterization
- Liquid light guide
  - Characterization
  - Vibration tests NEW
- Laser
  - Beam characterization NEW
- Near range
- PMTs
  - Characterization NEW
- Polychromator
  - Characterization NEW
- Software
- Documentation
- Strategy and future plans



Overview on IFAE/UAB Raman LIDAR

Remote-sensing instrument, optimized for CTA, obtained thanks to the recycling of old components of the CLUE experiment (telescope and container).

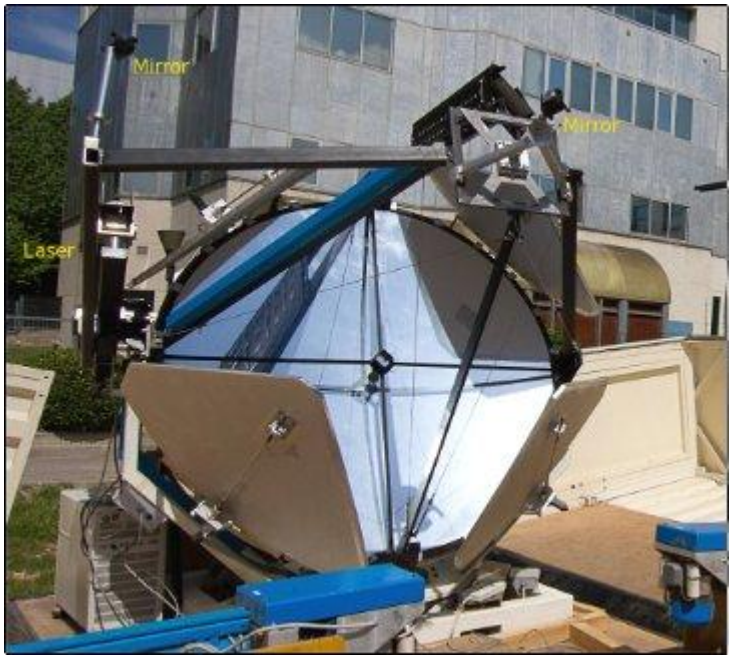
Coaxial structure: interest in characterizing atmosphere at the boundary level.

Brilliant Compact Q-Switched laser Nd:YAG 1064nm, frequency tripler head, 20Hz pulse repetition rate, 5ns pulse duration, --- beam divergence

Configuration 2 + 2: elastic and Raman (N_2) scattered light for an initial 355nm wavelength (**355nm, 387nm**) and for an initial 532nm wavelength (**532nm, 607nm**) -> home-made **polychromator**.

Standard **LICEL** for the acquisition unit.

Study of atmospheric molecular and aerosol transparency in function of range and wavelength **P(R,λ)**.

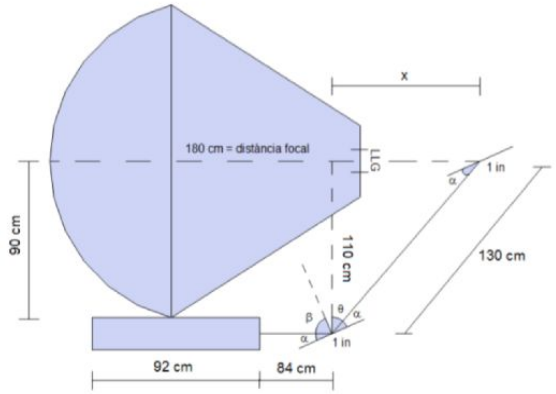


Mirrors

- Telescope mirror PSF (for a 90% of light enclosed) ~ 6.5mm in 2012 (see Alicia López Oramas PhD thesis)

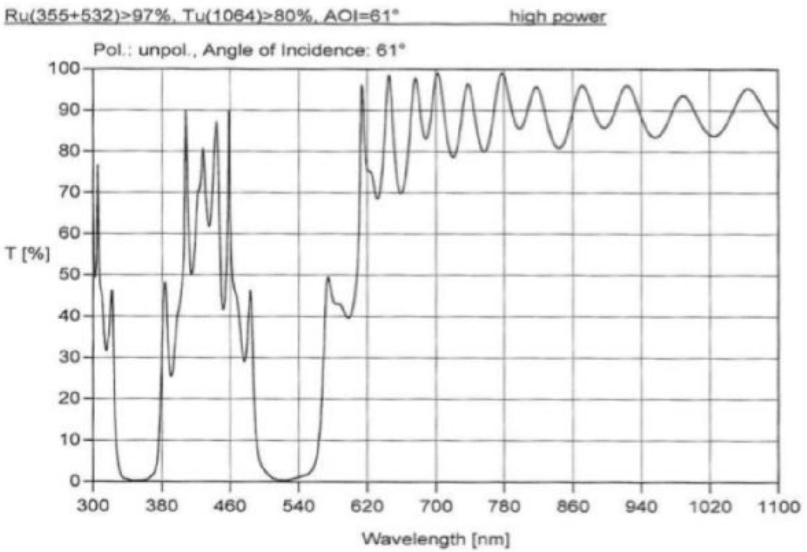
PSF < 8mm -> fitting well the entrance of the liquid light-guide

Reflectivity of 64% at 350nm in 2012.



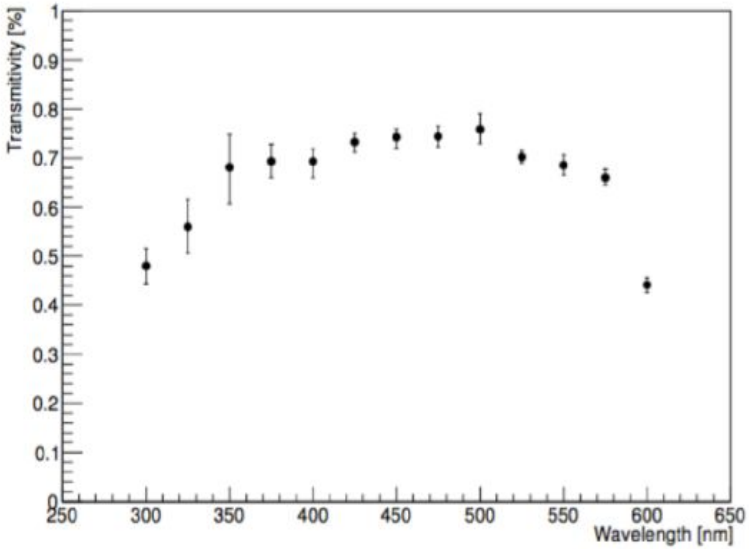
Design of the guiding mirrors

(see Eudald Font Pladevall Bachelor thesis)

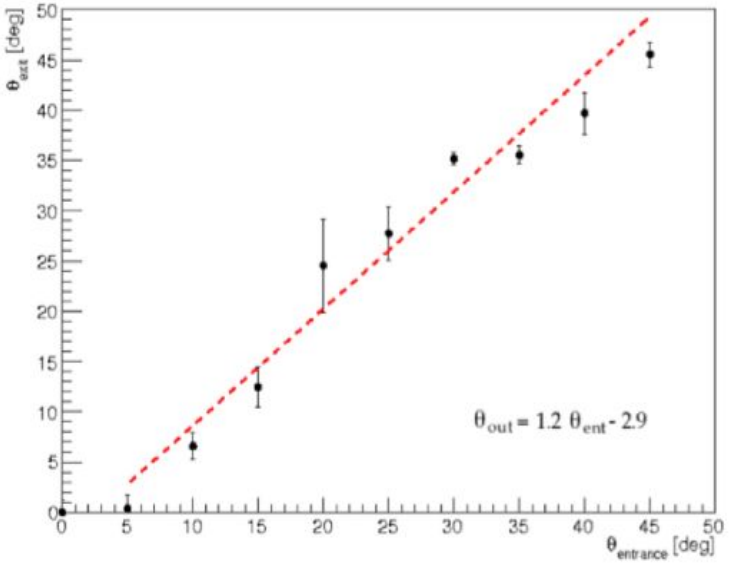


Transmission vs. wavelength guiding mirrors

Liquid light guide - Characterization



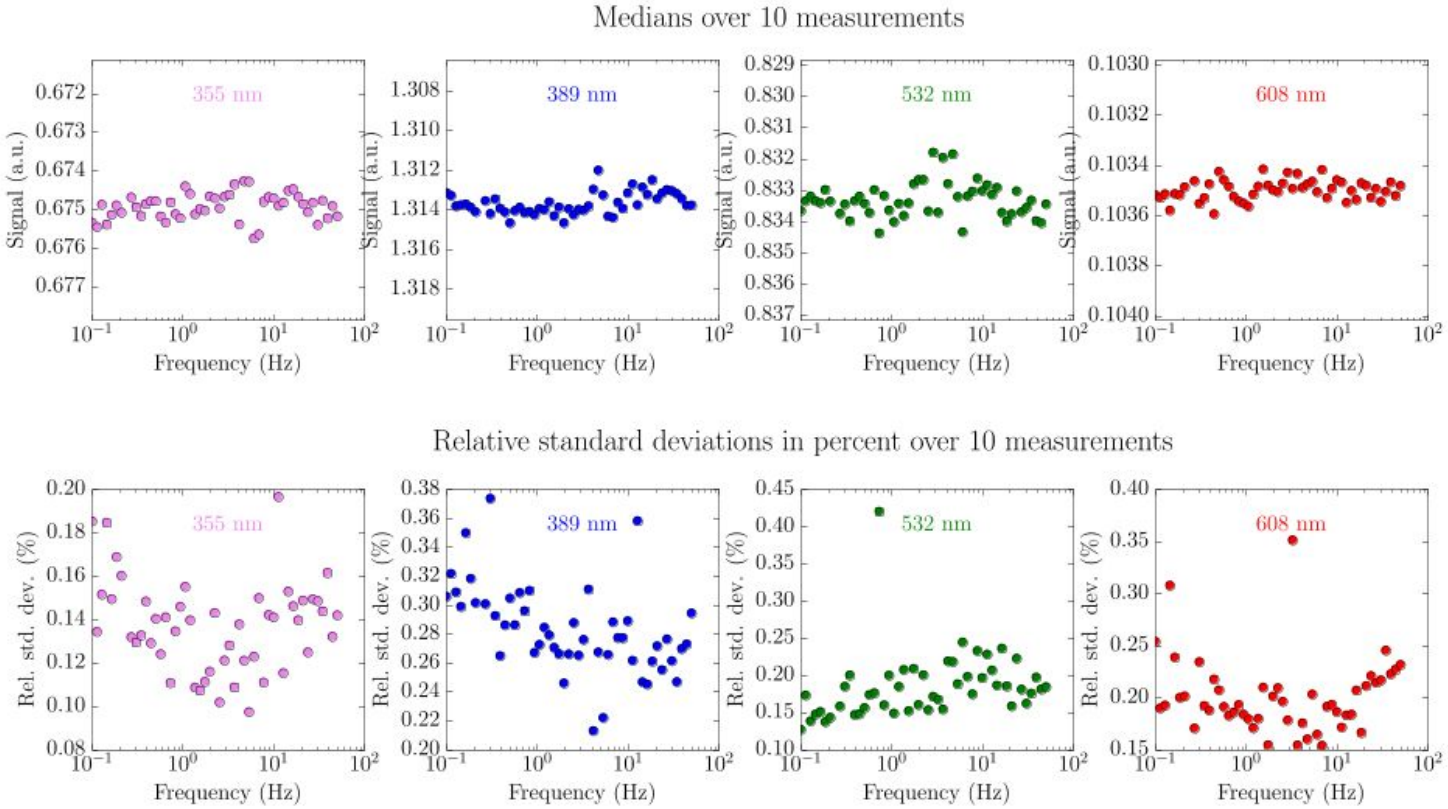
Transmission vs. wavelength



Ouput angle vs. input angle

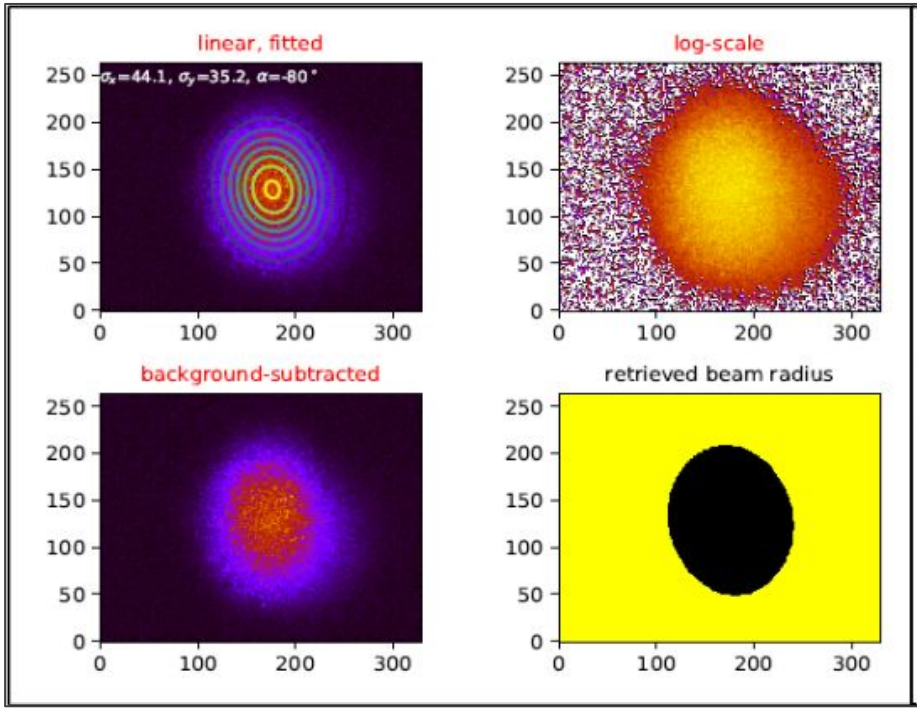
(see Alicia López Oramas PhD thesis)

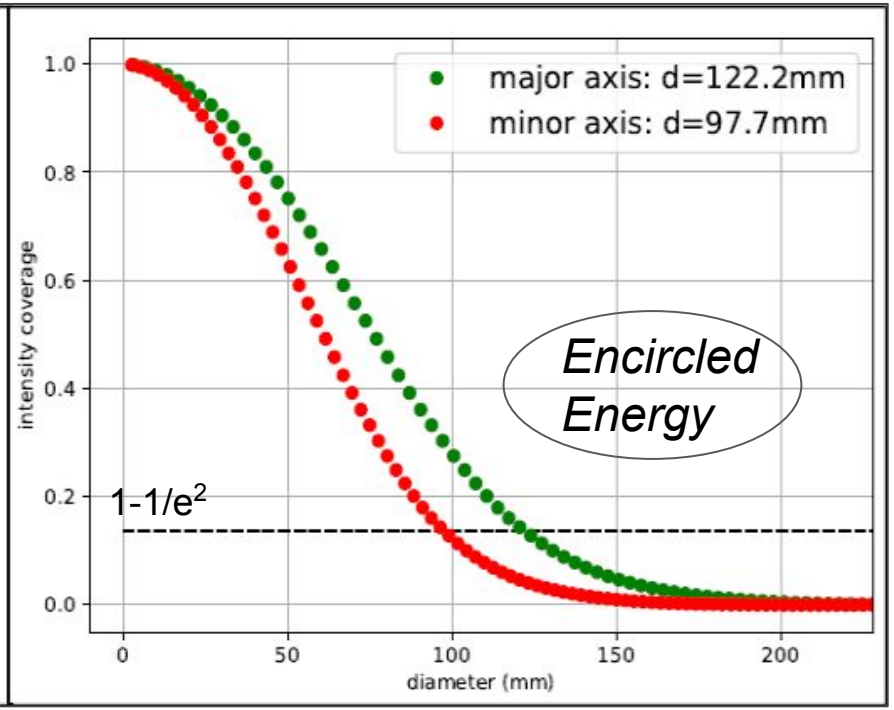
Liquid light guide - Vibration test



Laser

- Distance laser-spot ~ 84m
- Used ND filters
- *Canon* / *Nikon* cameras





Laser - Results

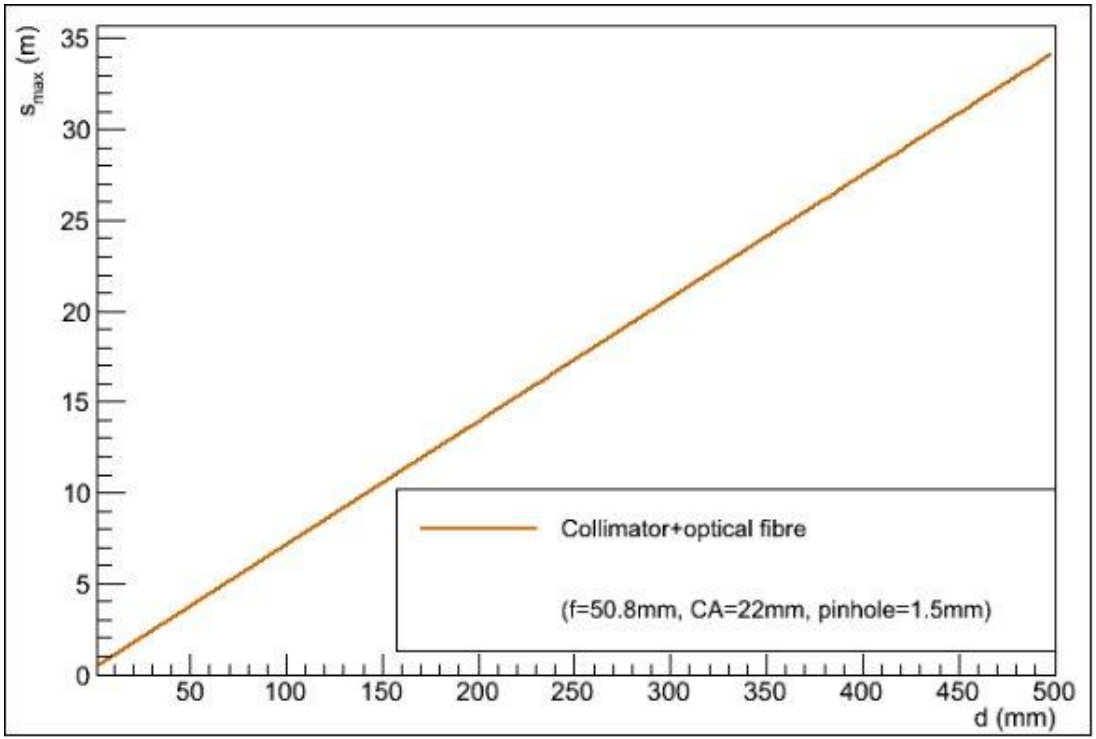
intensity	month	distance (m)	Θ_x (mrad)	Θ_y (mrad)	asymmetry	α (deg.)	comments
high	July	(84.4±0.1)	1.42±0.04	1.06±0.09	1.34±0.13	102±5	analysis 1
high	July	(84.4±0.1)	1.39±0.05	0.98±0.04	1.43±0.08	100±4	analysis 2
medium	July	(84.4±0.1)	1.28±0.02*	0.80±0.02*	1.61±0.06*	100±5	analysis 1
medium	July	(84.4±0.1)	1.41±0.05	0.93±0.03	1.50±0.08	99±3	analysis 2
lowest	April	(72.6±0.1)	0.87	0.51	1.71	104	analysis 3

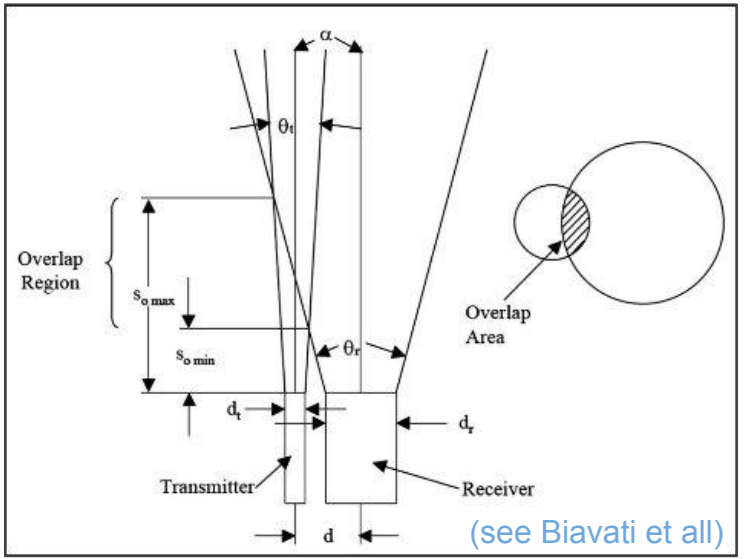
intensity	month	distance (m)	d_{0x} (mm)	d_{0y} (mm)	asymmetry	α (deg.)	comments
lowest	Jan.	(2.40±0.05)	5.5	3.5	1.6	101±2	analysis 3
low	Jan.	(1.80±0.05)	$\lesssim$4.9	$\lesssim$3.9	1.2	98±2	analysis 3

Div = 0.5mrad (20Hz) / 0.7mrad (50Hz)

(from Quantel Brilliant Specifications)

Near Range



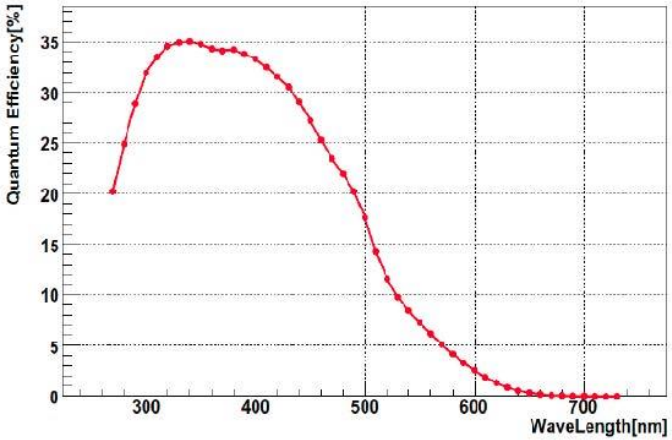


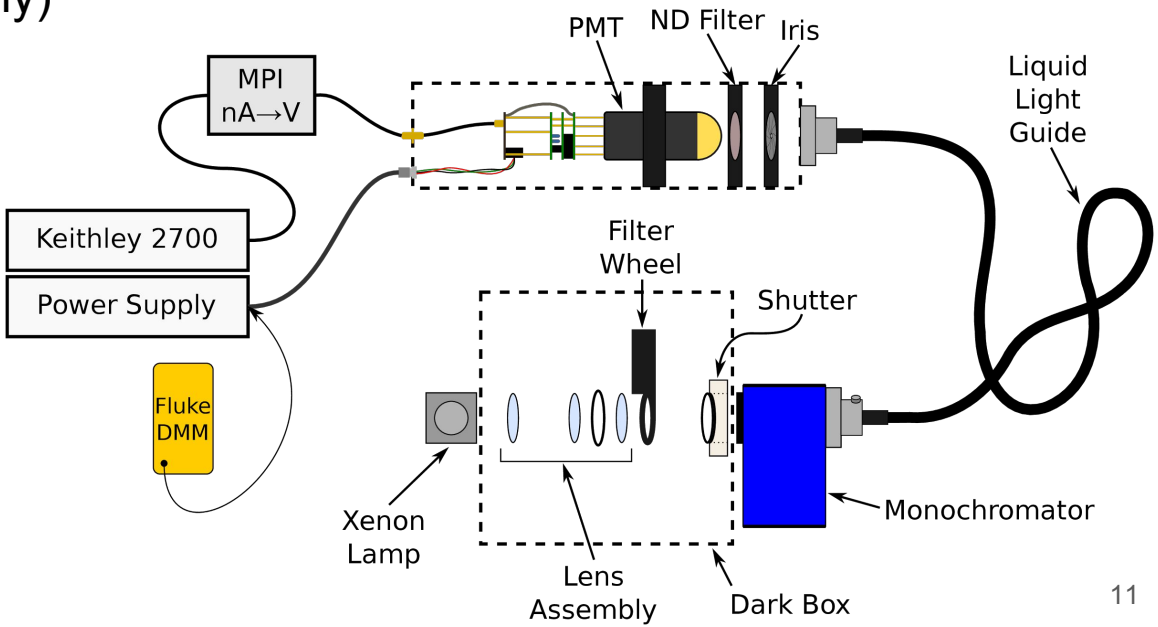
(see Biavati et all)

PMTs

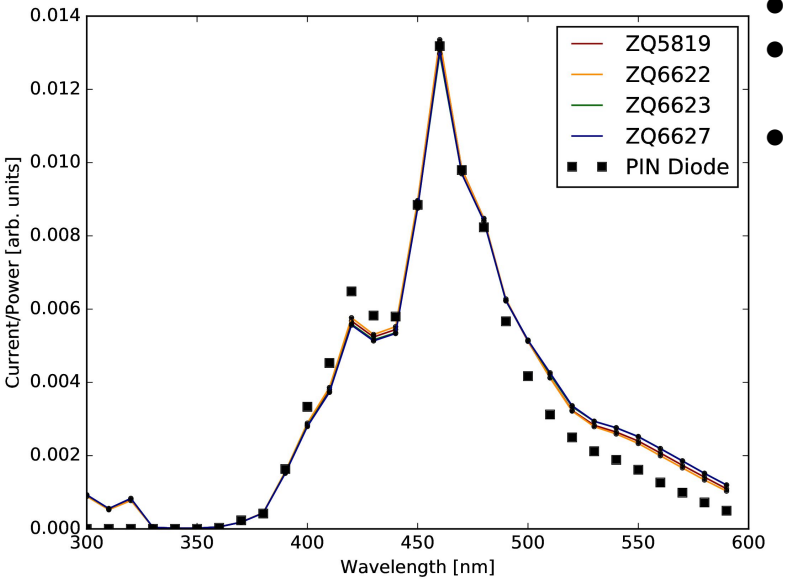
- 4 Hamamatsu R11920-100 high quantum efficiency PMTs for the polychromator
- Newport 818-UV PIN photodiode is used for calibration
- V=1200V (chosen arbitrarily)

C=QE x HV-dependent-gain

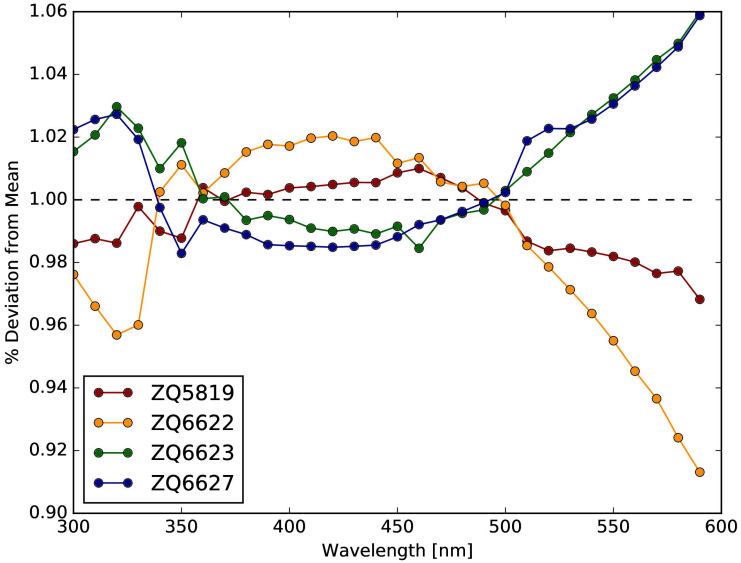




PMTs



- Wavelength increased 10nm(±2nm) between 300nm to 600nm
- PMT current measured with the shutter open and closed. Then background subtracted.
- Comparison with the PIN-diode background subtracted data (PIN-diode data multiplied by the PMT QE and ND filter transmission)



Elastic channels

Raman channels

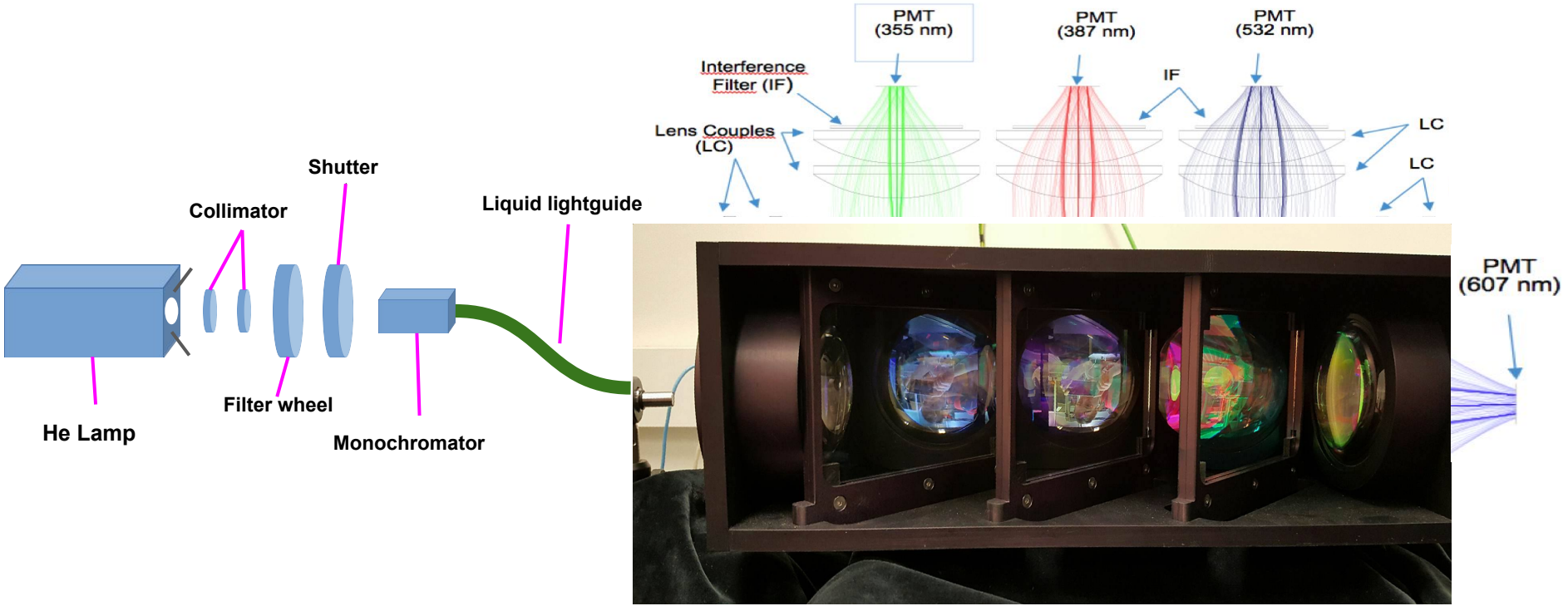
355nm → ZQ5819

387nm → ZQ6622

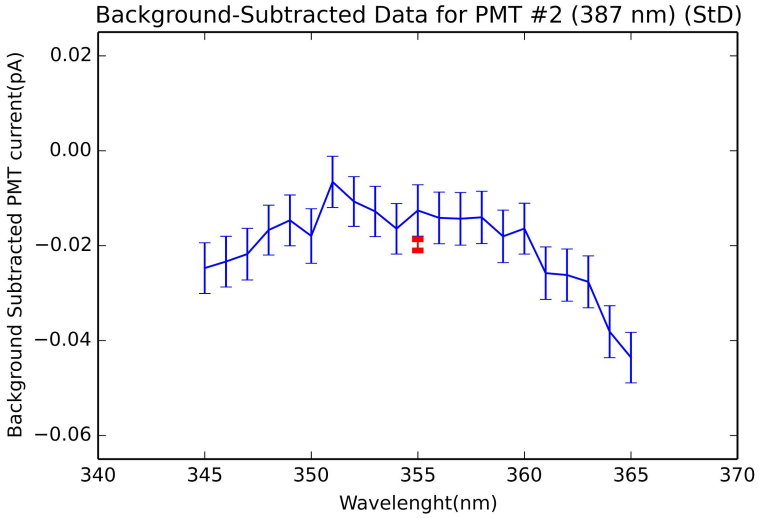
532nm → ZQ6623

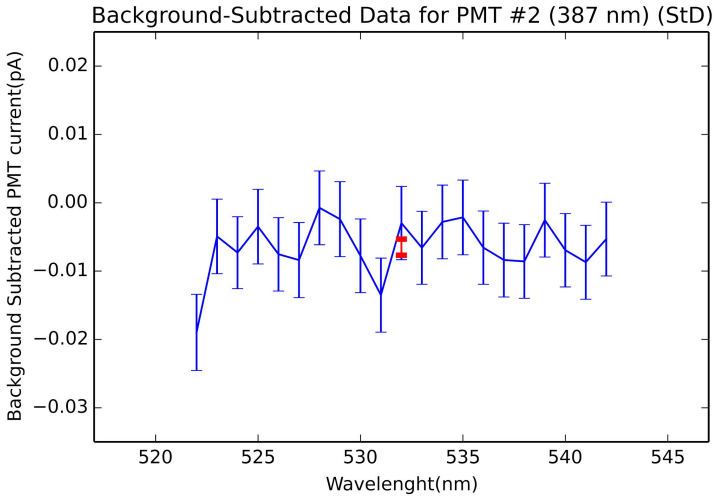
607nm → ZQ6627

Polychromator - Light Leakage Tests



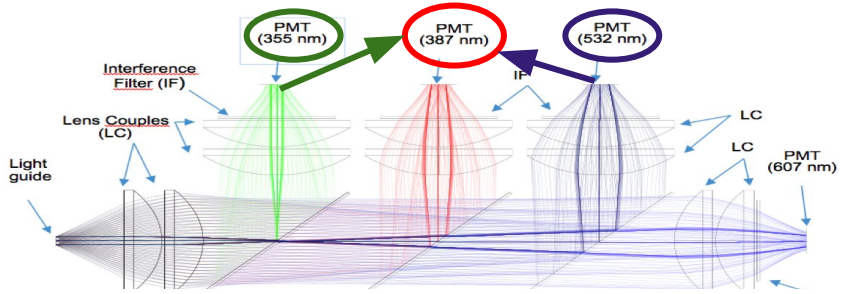
Search for Light leakage on 387nm Raman Channel





Binned Mean+STD/√21000:
0.02 ± 0.0 pA

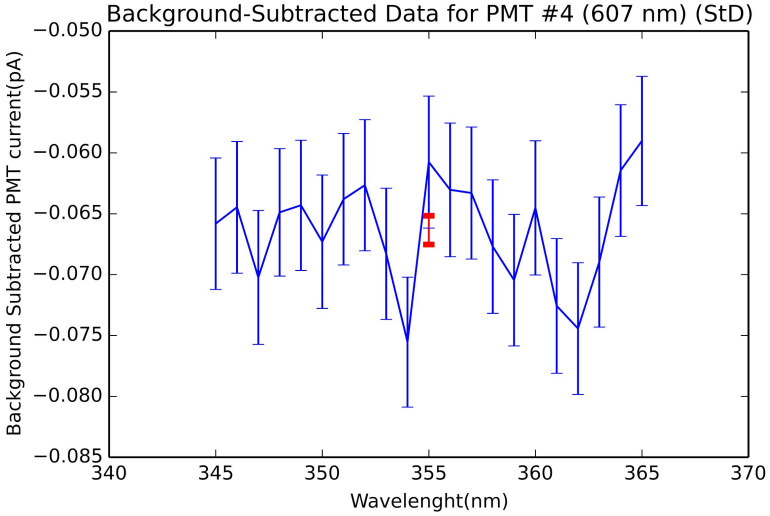
Signal to Noise (Median):
0.44 10^6 / 0.02 = 22 10^6

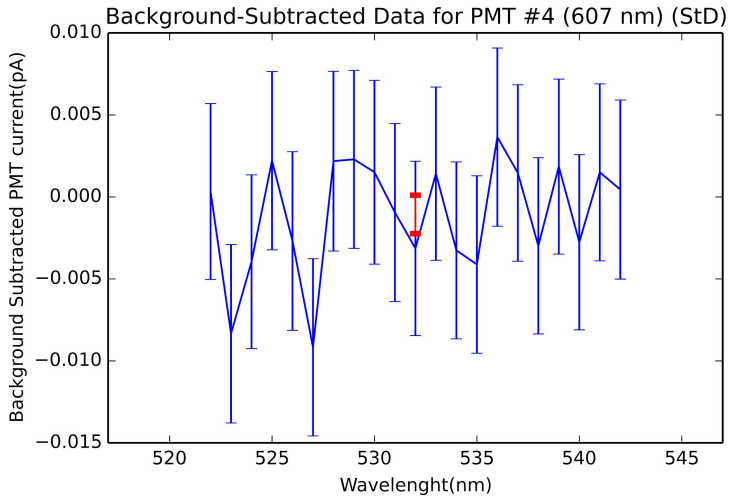


Binned Mean+STD/√21000:
0.01 ± 0.0 pA

Signal to Noise (Mean):
0.44 10^6 / 0.01 = 44 10^6

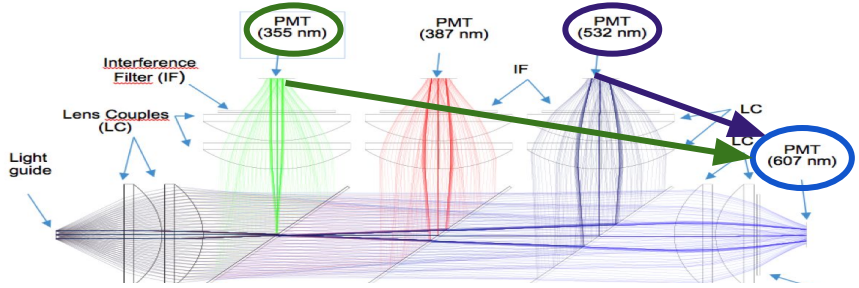
Search for Light leakage on 607nm Raman Channel





Binned Mean+STD/√21000:
0.07 ± 0.0 pA

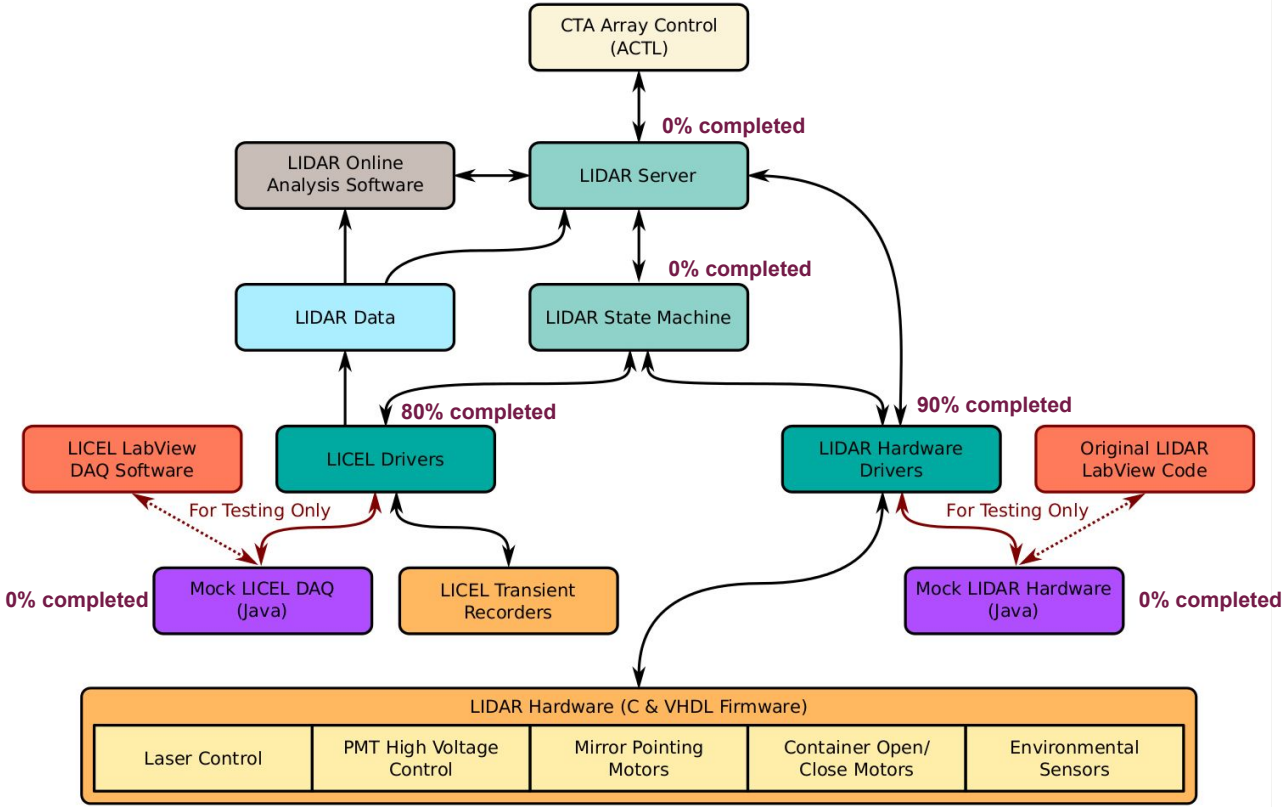
Signal to Noise (Mean):
0.44 10^6 / 0.07 = 6.2 10^6



Binned Mean+STD/√21000:
0.001 ± 0.001 pA

Signal to Noise (Mean):
0.44 10^6 / 0.002 = 220 10^6

Software


CTA Array Control (ACTL)
0% completed
LIDAR Online Analysis Software
LIDAR Server
0% completed
LIDAR Data
LIDAR State Machine
80% completed
90% completed
LICEL LabView DAQ Software
LICEL Drivers
LIDAR Hardware Drivers
Original LIDAR LabView Code
For Testing Only
For Testing Only
0% completed
Mock LICEL DAQ (Java)
LICEL Transient Recorders
Mock LIDAR Hardware (Java)
0% completed
LIDAR Hardware (C & VHDL Firmware)
Laser Control
PMT High Voltage Control
Mirror Pointing Motors
Container Open/ Close Motors
Environmental Sensors

Software

- Interface with Hardware in progress:
  - Interface with LICEL almost ready
  - Interface with Containers Sensing Hardware complete
  - Interface with Containers Moving Hardware in progress

- Hardware Mock Test Units, State Machine and Server pending.

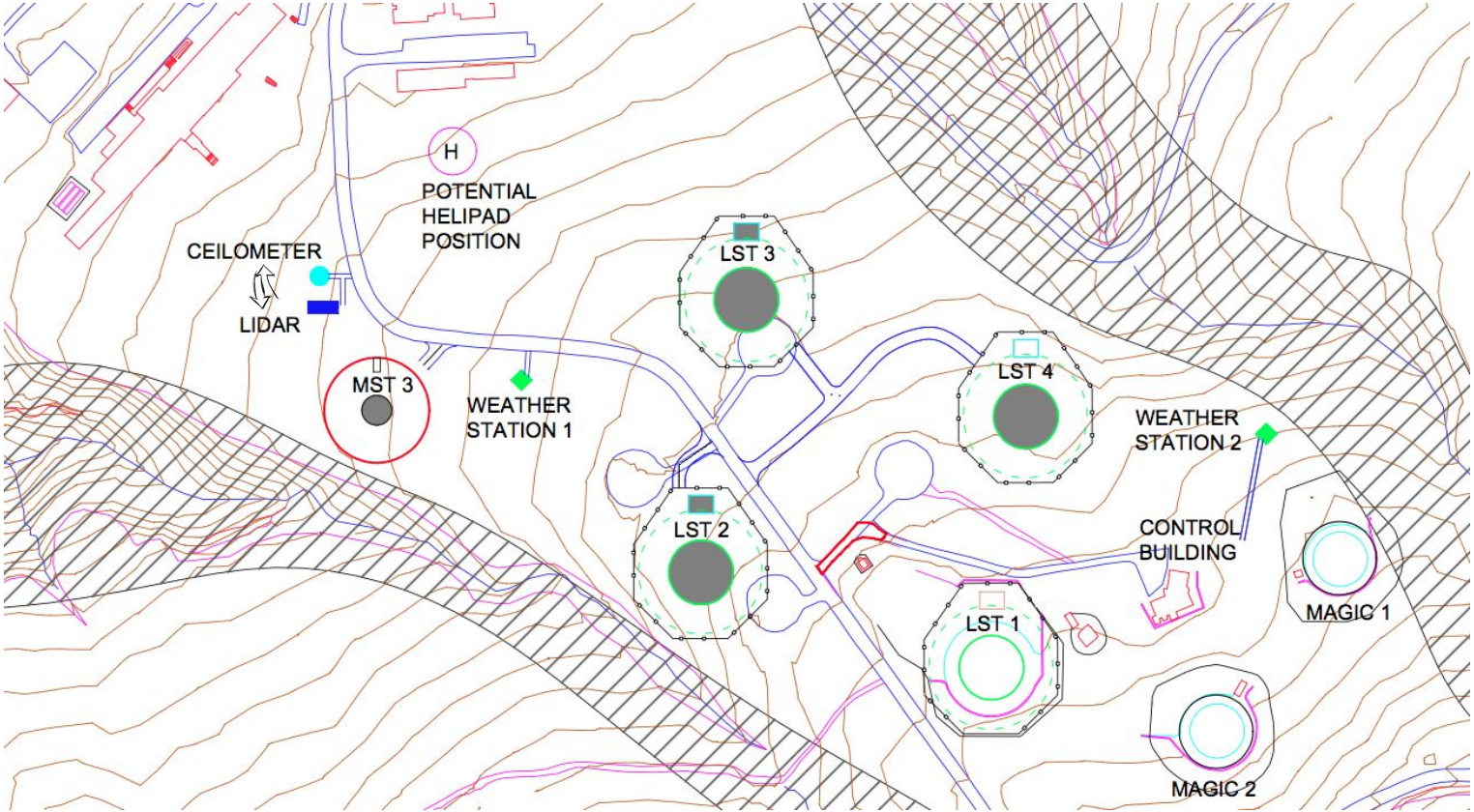
Documentation

- S. Grrifiths; **IFAE-UAB Raman Lidar PMT Characterization.** (Almost done)
- **IFAE-UAB Raman Lidar PMT Characterization.** (Under progress)
- C. Maggio, S. Llorens, S. M. Colak, M. Gaug; **Measurement of the repaired Quantel Brilliant beam profiles**, 2017.
- O. Calpe; **CTA, Lidar i Near Range.** Bachelor's thesis, Universitat Autònoma de Barcelona (UAB), 2017.
- E. Font; **Stand alone performance of the first Large Size Telescope for the Cherenkov Telescope Array.** Master's thesis, Universitat Autònoma de Barcelona (UAB), 2015.
- A. Lopez; **Multi-year campaign of the gamma-ray binary LS I +61º 303 and search for VHE emission from gamma-ray binary candidates with the MAGIC telescopes.** PhD thesis, Universitat Autònoma de Barcelona (UAB), 2014.
- M. Doro, M. Gaug, O. Blanch, M. Eizmendi, L. Font, D. Garrido, A. López, and M. Martinez. **Atmospheric Calibration for CTA, 2013.** CTA internal report COM-CCF/130311
- V. Da Deppo, M. Doro, O. Blanch, L. Font, A. Lopez, M. Gaug, and M. Martinez. **Preliminary optical design of a polychromator for a Raman LIDAR for atmospheric calibration of the Cherenkov Telescope Array.** In Proc. SPIE, volume 8550, pages 85501V–85501V–7, 2012.
- M. Eizmendi. **IFAE-UAB Raman LIDAR Link Budget and Components.** Master's thesis, Universitat Polit´ecnica de Catalunya (UPC) & Universitat Autònoma de Barcelona (UAB), 2011.
- Sánchez, C. **Caracterització del LIDAR de CTA**, Master's thesis, Universitat Autònoma de Barcelona (UAB), 2011.
- ICDs created (except for the one with ACTL)
- UCs written in google docs

Strategy

- **Permission:** have not yet received permit, but can do prelim. tests
- **Robotization:** part of current funding application, support from IEEC
- **Tests in La Palma:** would like to long-term test at La Palma, still to find a suitable place (beside the ARCADE LIDAR)
- **Funds:** Asked for additional development funds for the next 3 years, but will need to rely on 200 kEUR from the Spanish contribution to CTA-N.

LIDAR location at CTA-N



Thank you for listening !