Upgrade of the MAGIC telescopes micro power LIDAR system

Dominik Müller, C. Fruck, R. Mirzoyan, J. Hose

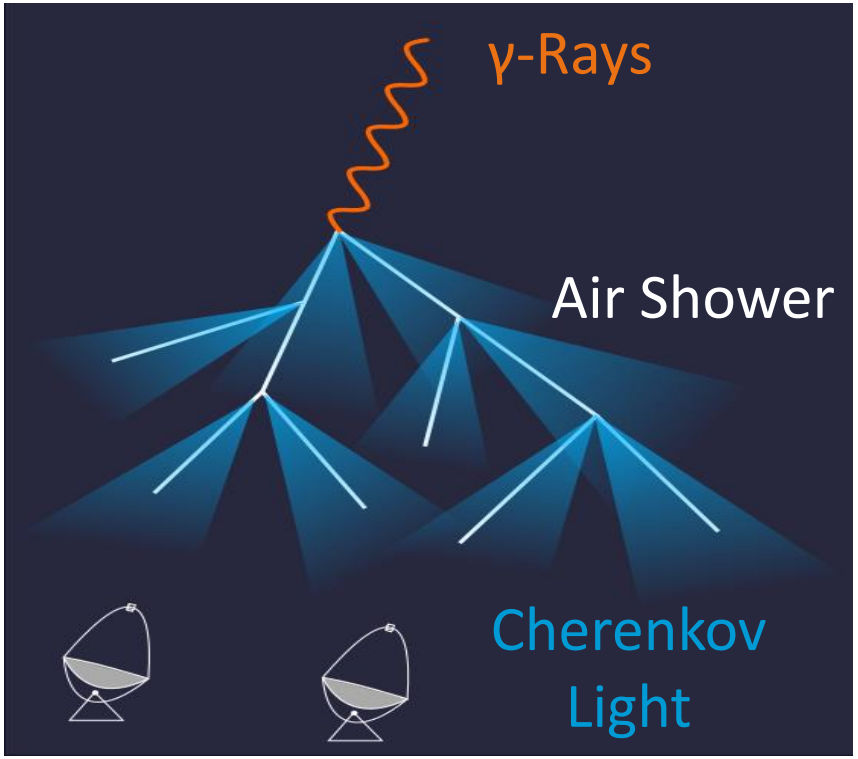
For the MAGIC Collaboration

February, 29th 2016

MAGIC Telescopes

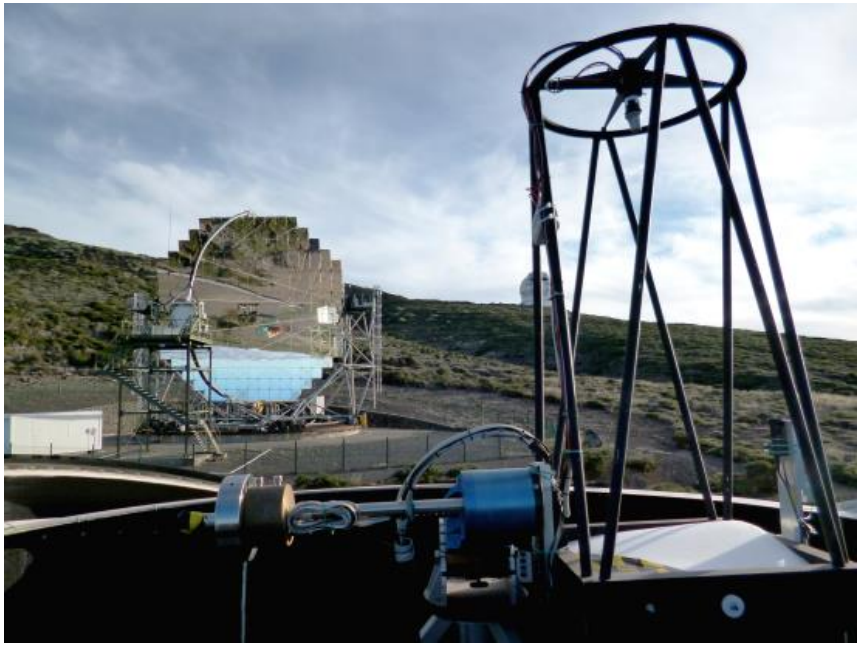
MAGIC Telescopes on the Canary Island La Palma

Imaging Atmospheric Cherenkov Astronomy

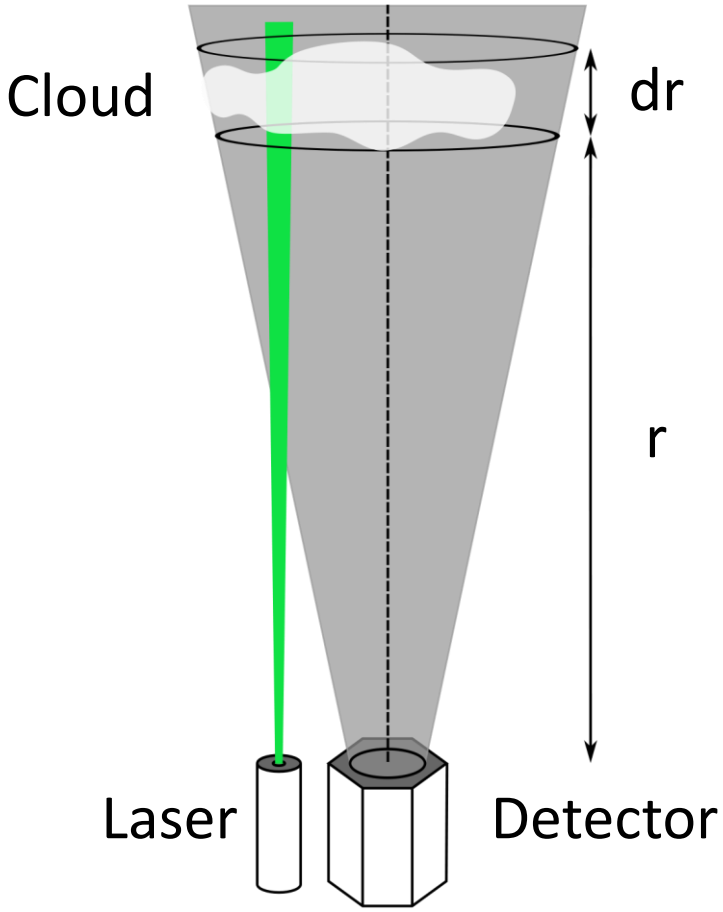


MAGIC LIDAR System

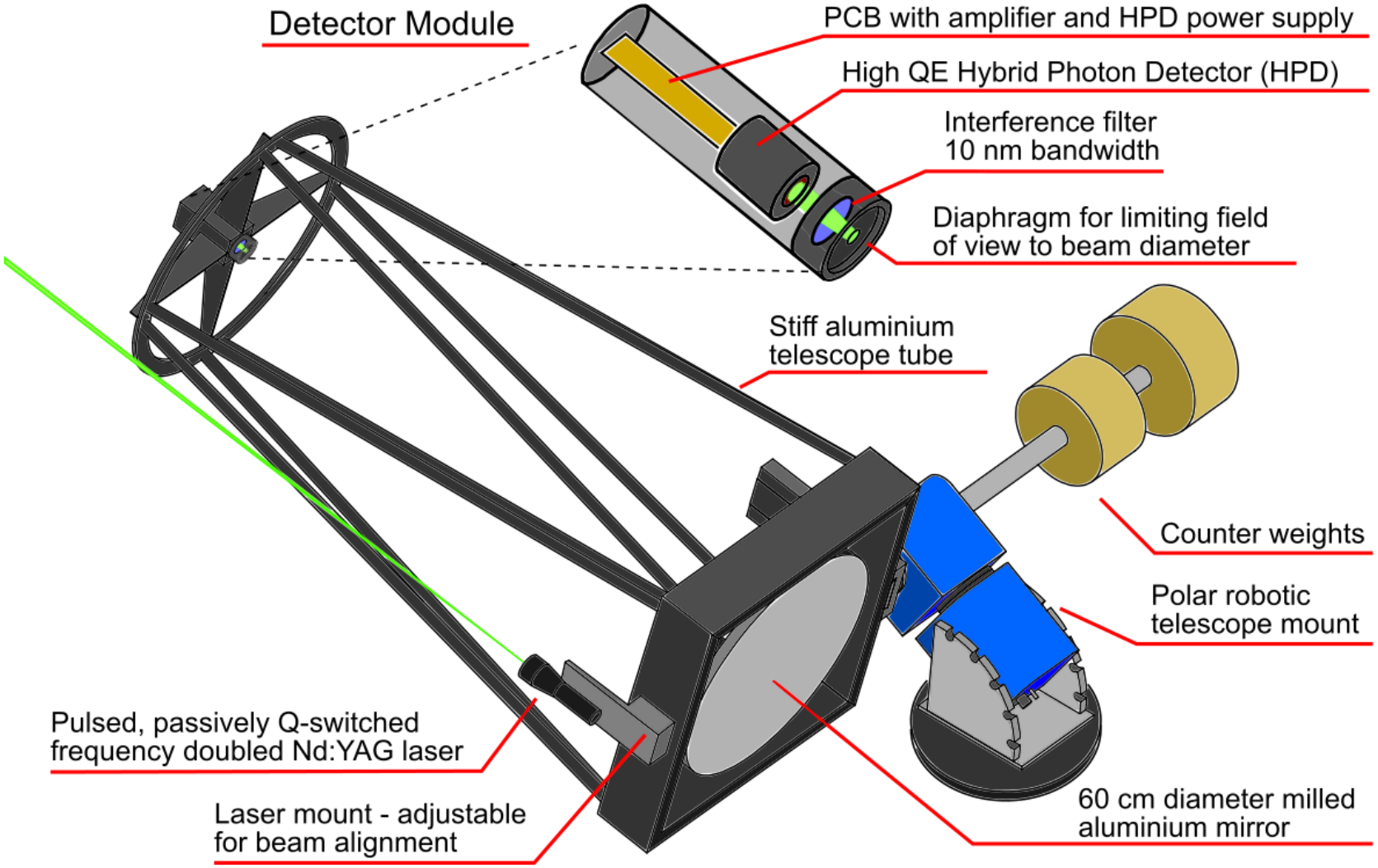
Photograph of the LIDAR System on the MAGIC Site:



Working Principle:



LIDAR Components

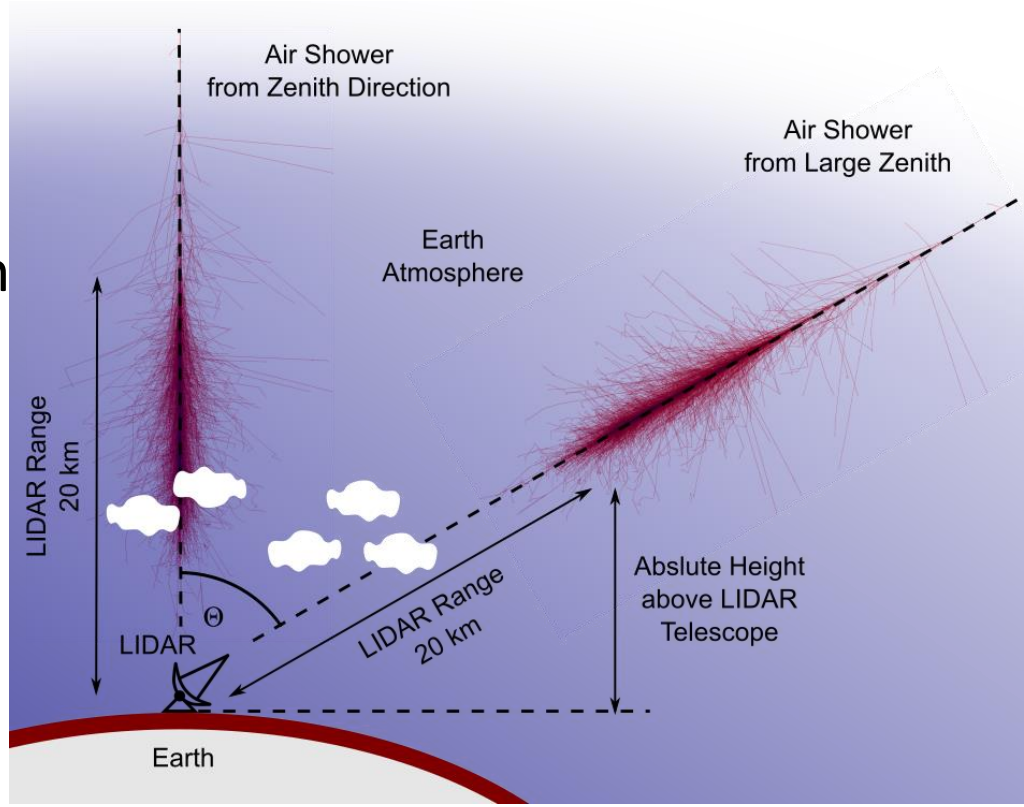


Goals of the Upgrade

1. Extending the measurement range

   a) To short Distances
   - Higher dynamic range of readout electronics
   - Higher amplifier bandwidth

   a) To long Distances
   - Powerful Laser
   - Better S/N for more reliable photon counting



2. Better humidity protection

Transmitter Module

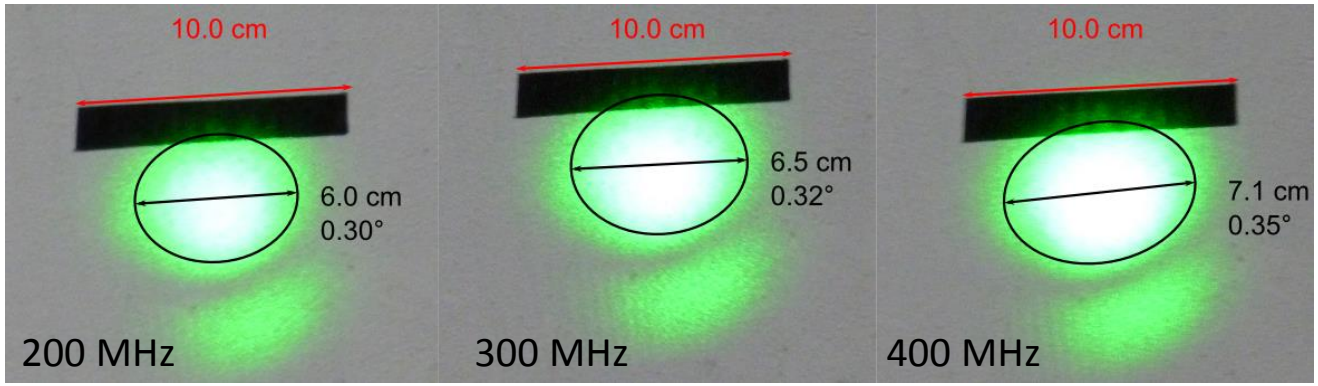
20x beam expander

25 µJ Laser

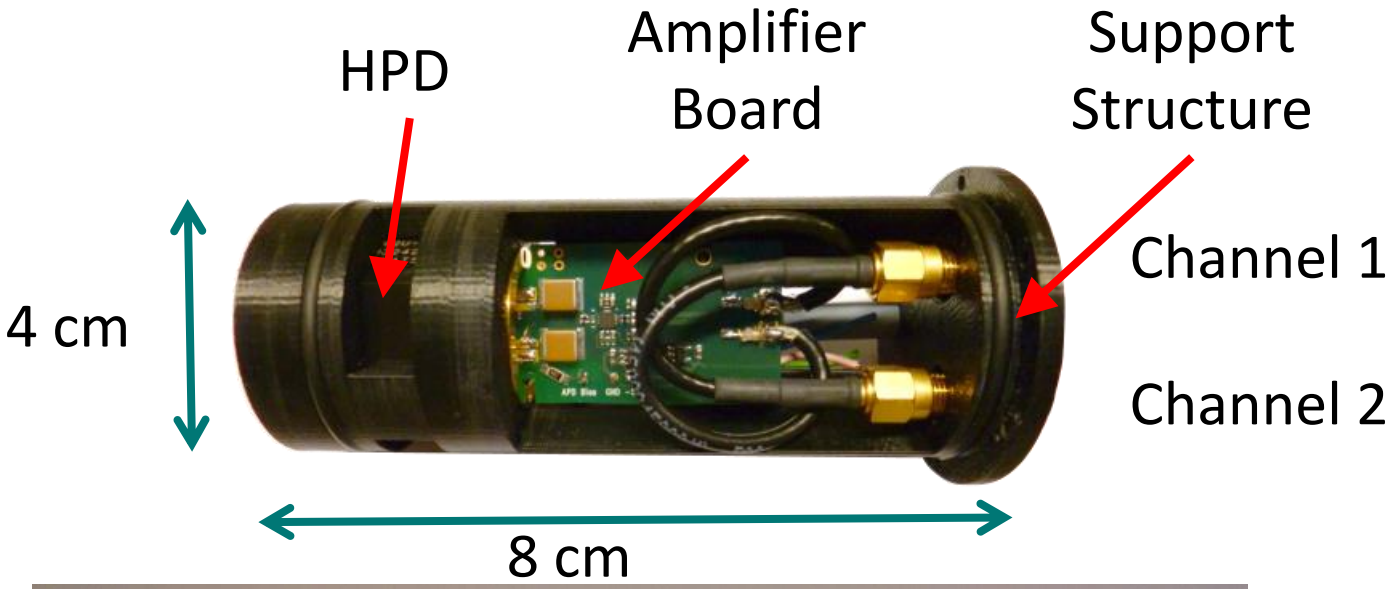
Adjustable Mount Plate

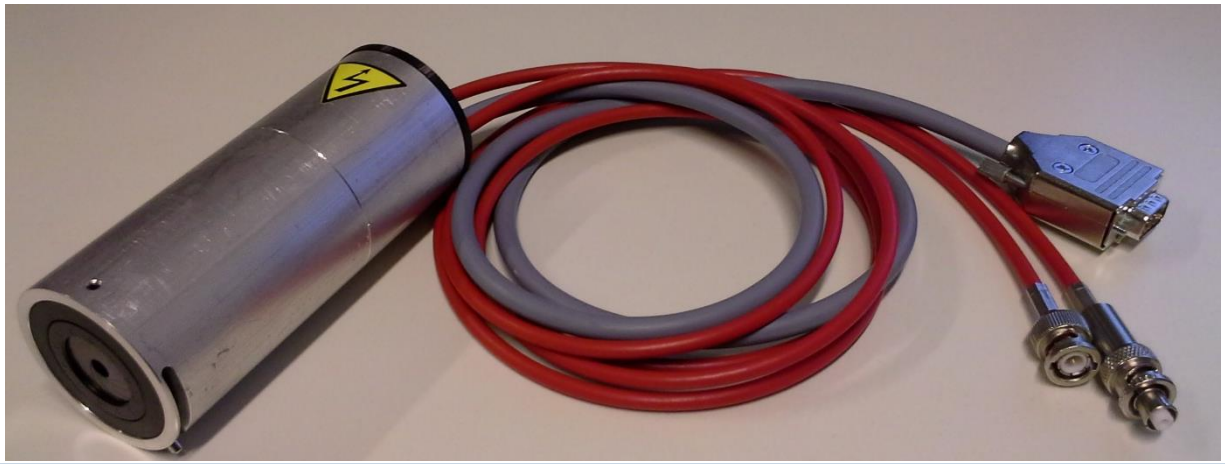
Problem:

Sent back for new calibration



Detector Module

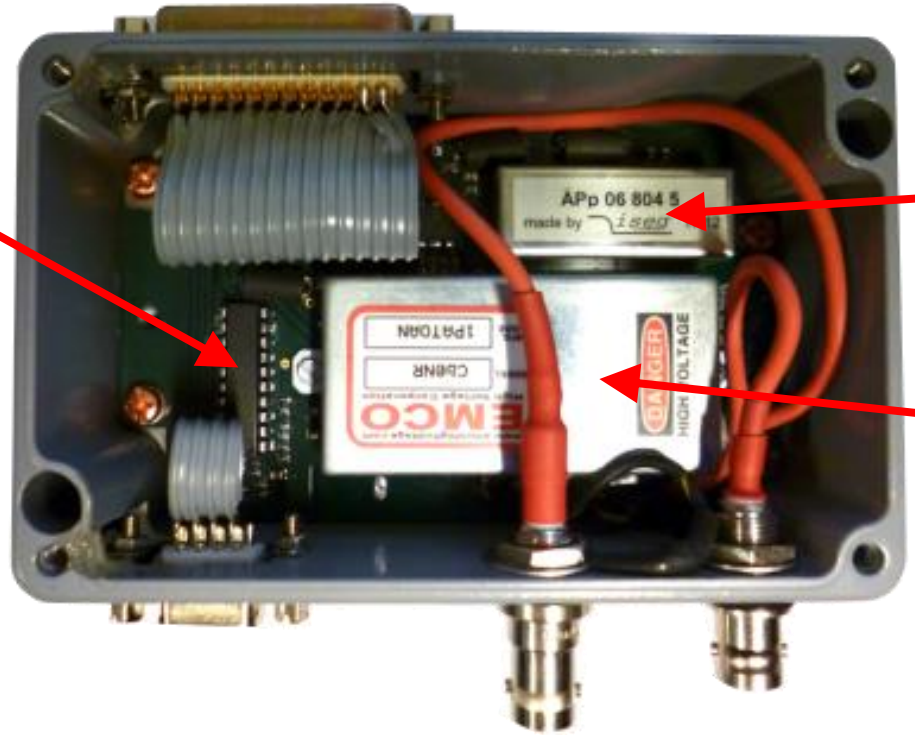




High Voltage Module

Connector to PC

ADC for Monitoring



600 V DC/DC Converter

-8 kV DC/DC Converter

Connectors to Detector

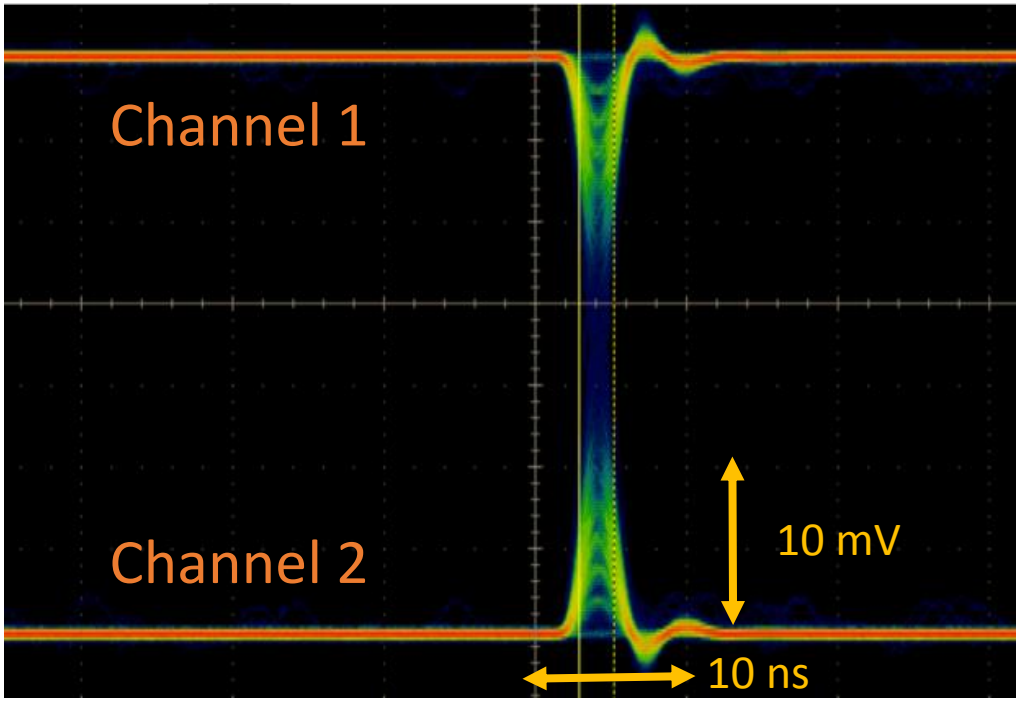
12 cm

HPD Signal Shape

Setup:

- HV: -8 kV
- Bias: 422 V

→ Gain: 150 000

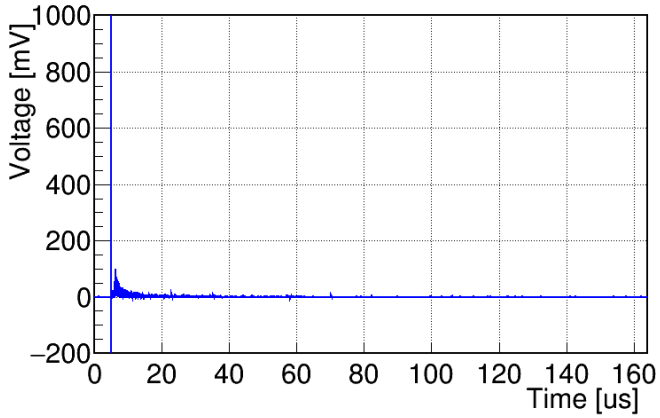


Results:

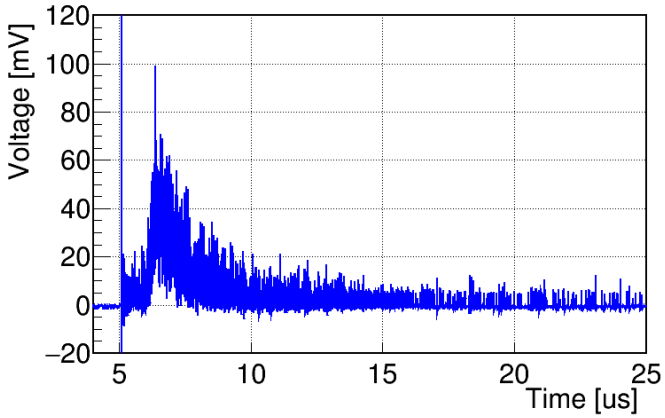
- Good coincidence
- FWHM 2.3 ns
- Up to 6 photoelectrons resolved

LIDAR Raw Signal

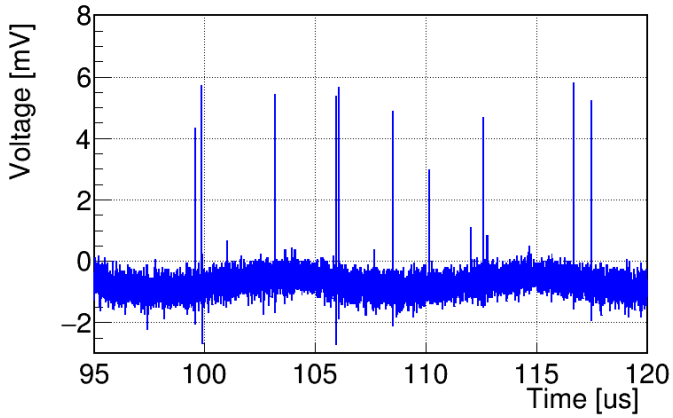
Full Range:



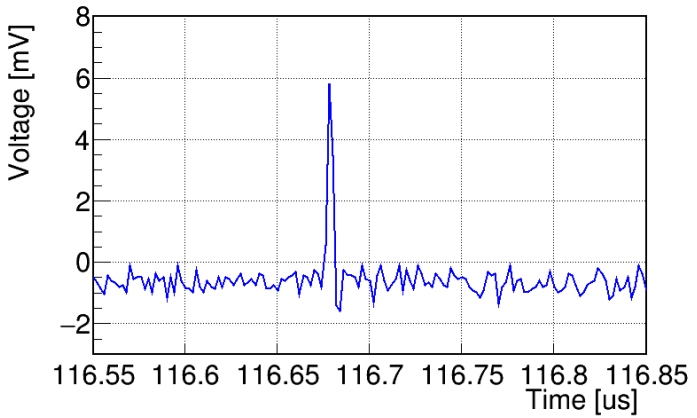
Near-Field:



Far-Field:

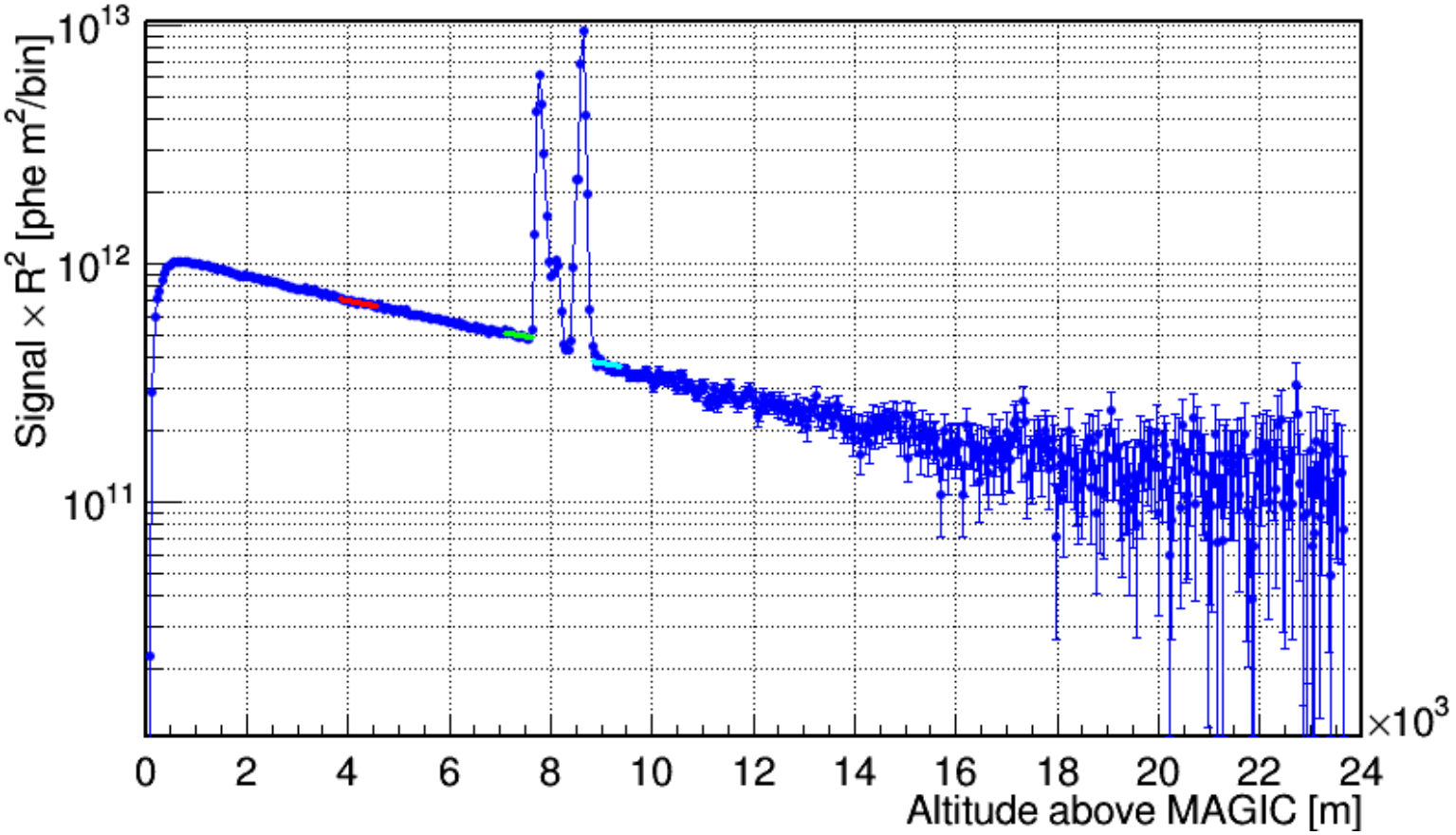


Single Photoelectron:



LIDAR Return

Range Corrected LIDAR Return:



Conclusion & Outlook

Conclusion:

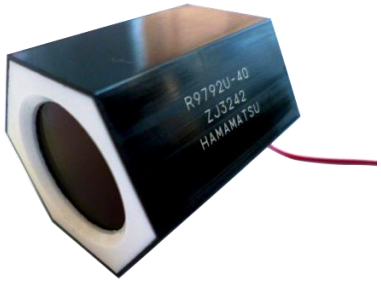
- Construction of new transmitter, detector and HV module
- Implementation of control electronics for HV module
- Successful test of the new detector on site

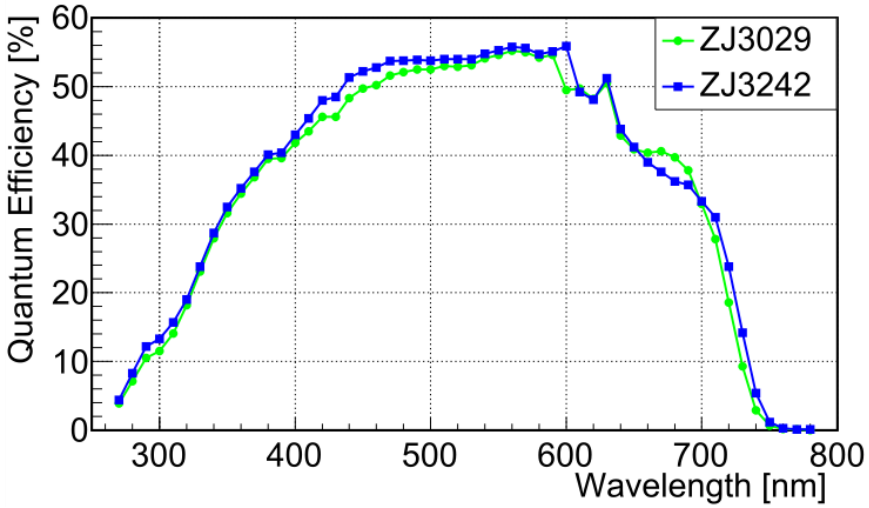
Outlook:

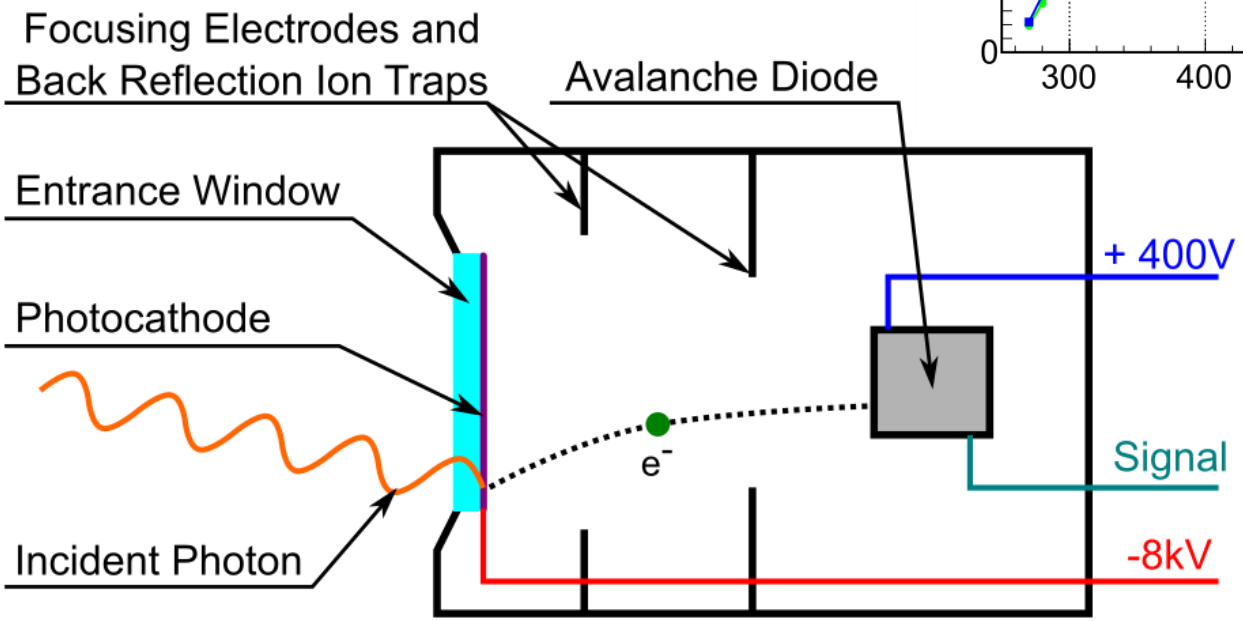
- Installation of the new powerful LASER
- Optimization of detector optics


Δp·Δq ≥ ½ ħ

Hybrid Photodiode (HPD)

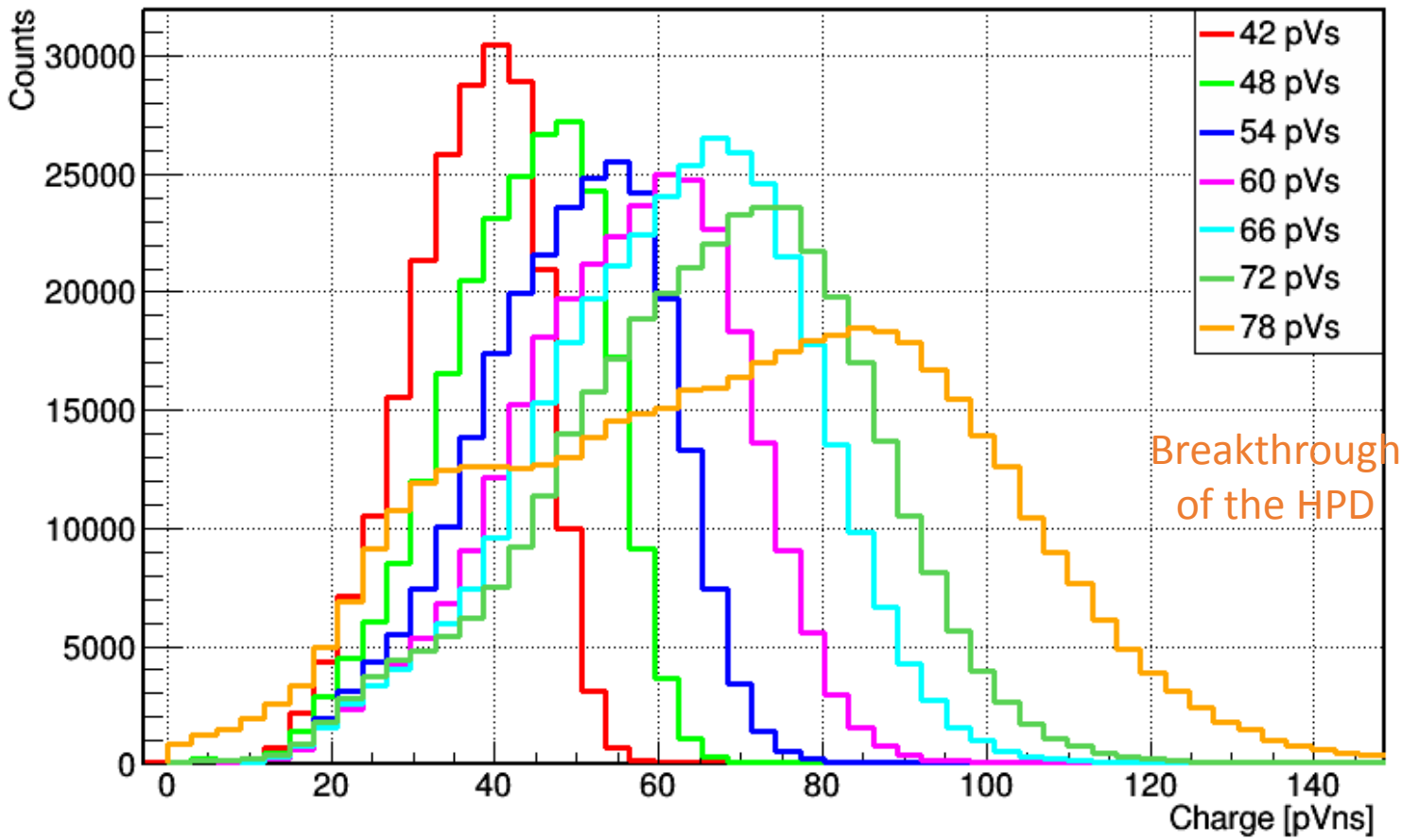






Charge Distribution

1 ph.e Charge Distribution of the HPD for different Bias Voltages:

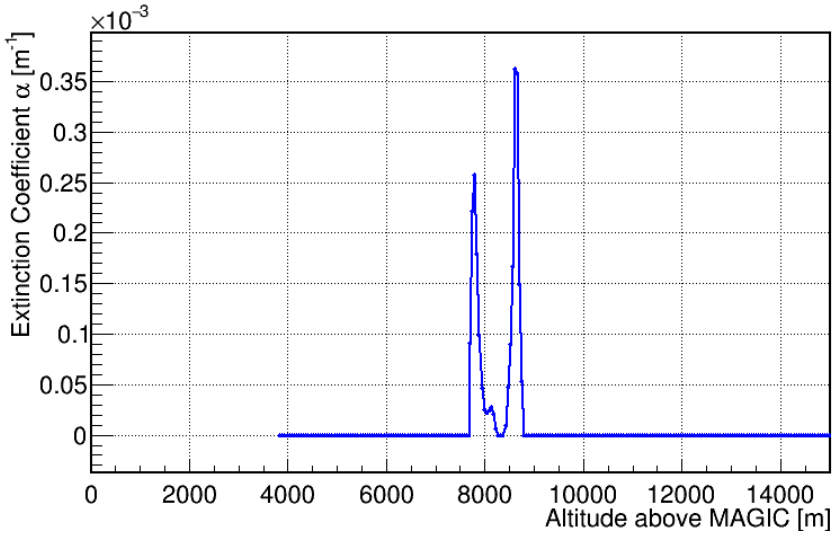


Bias Voltage
416,2 V
418,7 V
420,0 V
421,3 V
422,0 V
422,6 V

Cloud Analysis

Extinction Coefficient:

$$\propto_{aer}(h) = \sqrt{\frac{C_1}{C_2}} \cdot \frac{S(h) - \bar{S}_{mol}(h)}{\int_{h1}^{h2} S(h) - \bar{S}_{mol}(h)}$$



Atmospheric Transmission:

$$\tau_{aer}(h) = \int_{h_0}^{h_1} \propto_{aer}(h')\, dh'$$