CTAO SOUTH-LIDAR

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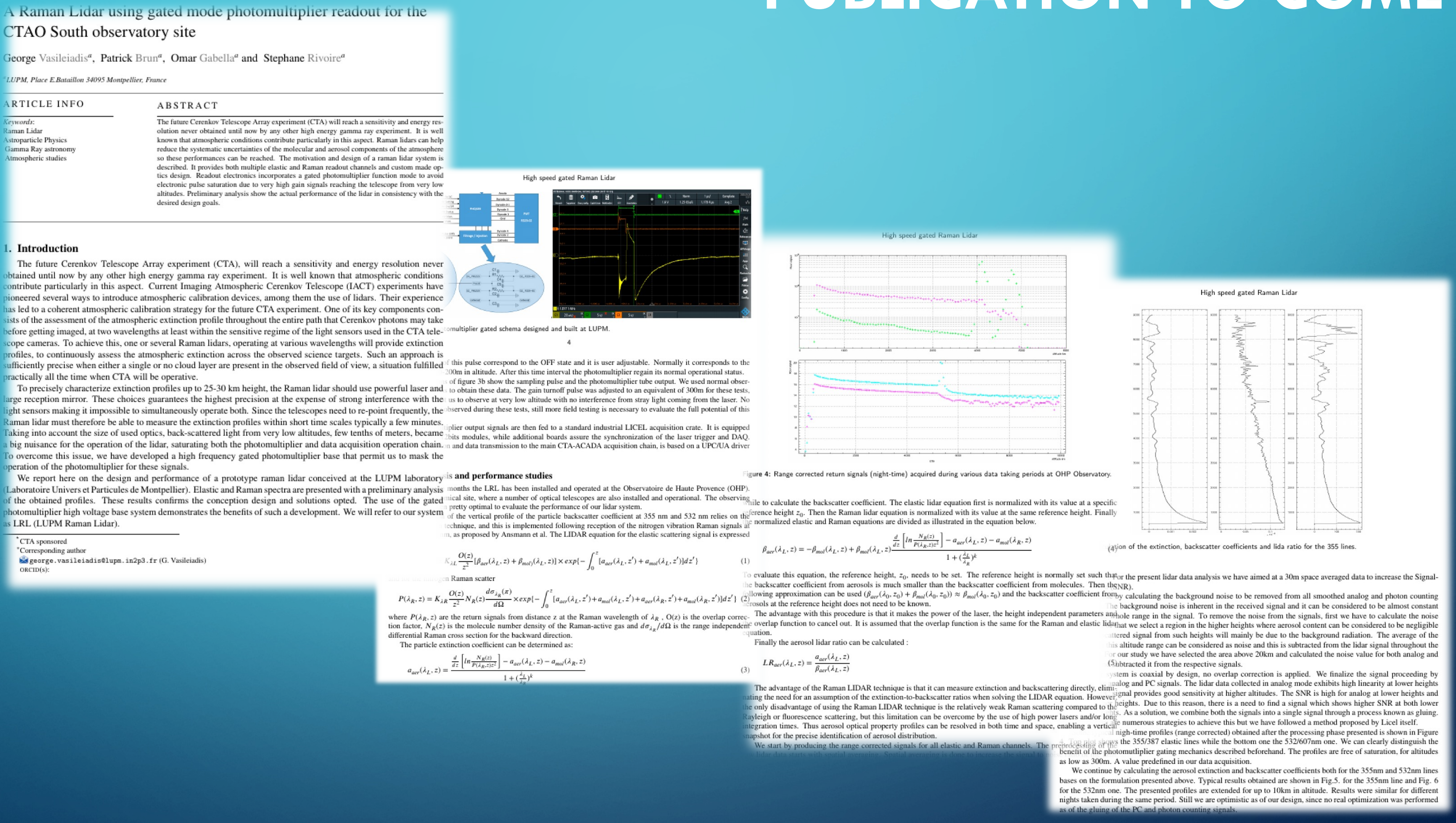

A Raman Lidar using gated mode photomultiplier readout for the CTAO South observatory site

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ABSTRACT

The future Cerenkov Telescope Array experiment (CTA) will reach a sensitivity and energy resolution never obtained until now by any other high energy gamma ray experiment. It is well known that atmospheric conditions contribute particularly in this aspect. Raman lidars can help reduce the systematic uncertainties of the molecular and aerosol components of the atmosphere so these performances can be reached. The motivation and design of a raman lidar system is described. It provides both multiple elastic and Raman readout channels and custom made optics design. Readout electronics incorporates a gated photomultiplier function mode to avoid electronic pulse saturation due to very high gain signals reaching the telescope from very low altitudes. Preliminary analysis show the actual performance of the lidar in consistency with the desired design goals.

1. Introduction

The future Cerenkov Telescope Array experiment (CTA), will reach a sensitivity and energy resolution never obtained until now by any other high energy gamma ray experiment. It is well known that atmospheric conditions contribute particularly in this aspect. Current Imaging Atmospheric Cerenkov Telescope (IACT) experiments have pioneered several ways to introduce atmospheric calibration devices, among them the use of lidars. Their experience has led to a coherent atmospheric calibration strategy for the future CTA experiment. One of its key components consists of the assessment of the atmospheric extinction profile throughout the entire path that Cerenkov photons may take before getting imaged, at two wavelengths at least within the sensitive regime of the light sensors used in the CTA telescope cameras. To achieve this, one or several Raman lidars, operating at various wavelengths will provide extinction profiles, to continuously assess the atmospheric extinction across the observed science targets. Such an approach is sufficiently precise when either a single or no cloud layer are present in the observed field of view, a situation fulfilled practically all the time when CTA will be operative.

To precisely characterize extinction profiles up to 25-30 km height, the Raman lidar should use powerful laser and large reception mirror. These choices guarantees the highest precision at the expense of strong interference with the light sensors making it impossible to simultaneously operate both. Since the telescopes need to re-point frequently, the Raman lidar must therefore be able to measure the extinction profiles within short time scales typically a few minutes. Taking into account the size of used optics, back-scattered light from very low altitudes, few tenths of meters, became a big nuisance for the operation of the lidar, saturating both the photomultiplier and data acquisition operation chain. To overcome this issue, we have developed a high frequency gated photomultiplier base that permit us to mask the operation of the photomultiplier for these signals.

We report here on the design and performance of a prototype raman lidar conceived at the LUPM laboratory (Laboratoire Univers et Particules de Montpellier). Elastic and Raman spectra are presented with a preliminary analysis of the obtained profiles. These results confirms the conception design and solutions opted. The use of the gated photomultiplier high voltage base system demonstrates the benefits of such a development. We will refer to our system as LRL (LUPM Raman Lidar).

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High speed gated Raman Lidar

…omultiplier gated schema designed and built at LUPM.

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…is and performance studies

High speed gated Raman Lidar

Figure 4: Range corrected return signals (night-time) acquired during various data taking periods at OHP Observatory.

Finally the aerosol lidar ratio can be calculated :

$$LR_{aer}(\lambda_L, z) = \frac{\alpha_{aer}(\lambda_L, z)}{\beta_{aer}(\lambda_L, z)}$$

High speed gated Raman Lidar

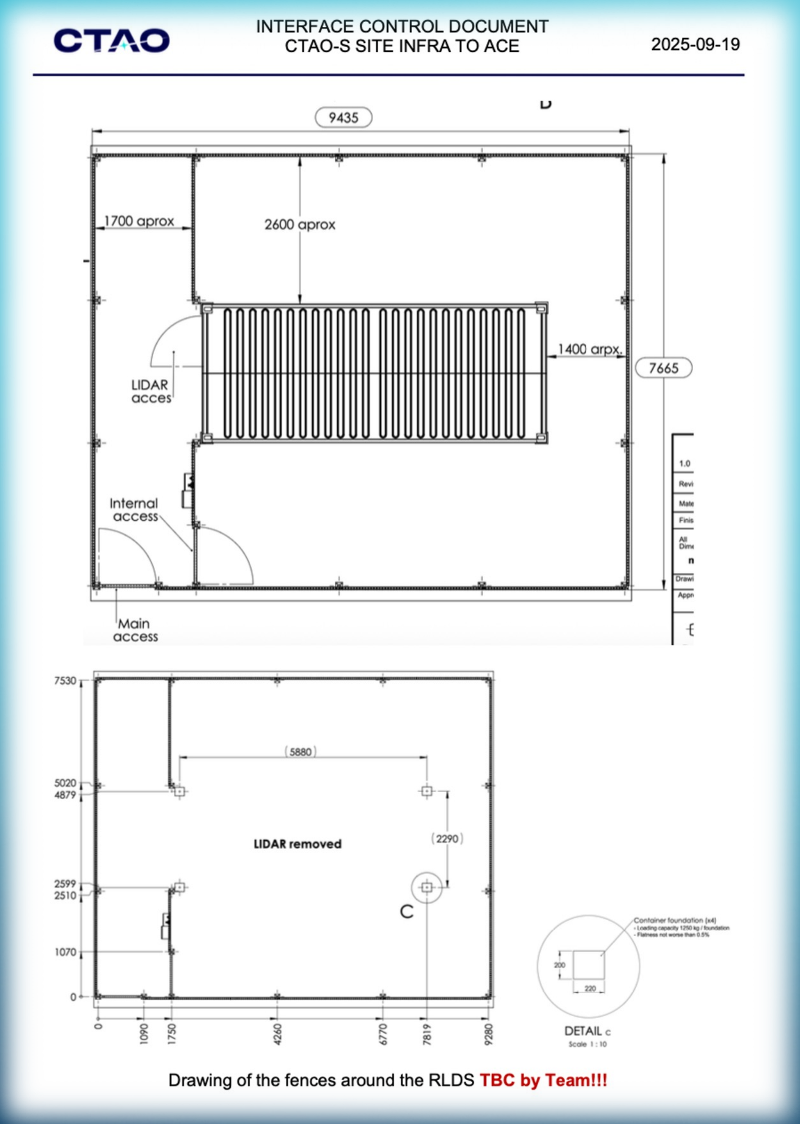
…tion of the extinction, backscatter coefficients and lida ratio for the 355 lines.

BUDGET

2025

- 28k€ (LUPM)
- 6k€ (CTA-TGIR)
- Transport OHP-Montpellier / Chapiteau
- Missions OHP

@CTAO PREPARATIONS



CTAO South site foundation preparations

PERSONNEL

P.Brun	• End 2026 • NSIP : 20% • Current : 2-3 days/week
G.Vasileiadis	• 5/5/2029 • Normally available…
O.Gabella	• NSIP : 40-50 % ?
S.Rivoire	• ?

LIDAR SCHEDULE

Installation on site

- Chile ..2027/2028
- Transport protocol 3-4m
- 3-4m commissioning

CDMR

- Documentations (a lot)
- FMEA/ Hazard analysis
- Seismic studies (*LLR/IJCLab*)
- Air traffic protocols (*CTAO*)

Montpellier on site

- Upgrade the Automation System
- Auto Alignment Optimization
- Measure individual Optical components (*L2C*)
- Production Electronics spares and tests (PMTs gating)
- Comply to CTAO security regulations
- Re-verify all operations

CDMR

Title	Doc. Number	Type	Panel Members
Level-B Requirements for the Raman LIDAR		Reference	
Raman LIDAR Project Management Plan		Review	All
Raman LIDARs Technical Design		Review	All
Raman LIDARs Optical Design		Review	All
Raman LIDARs PBS		Review	All
Raman LIDARs Block Diagram		Review	All
Raman LIDARs Technical Drawings		Review	All
Raman LIDARs Tendering Specifications for relevant subsystems		Review	All
Raman LIDARs Verification Plan		Review	All
Raman LIDARs QA Plan		Review	All
Raman LIDARs Hazard Analysis		Review	Karl Tegel
Raman LIDARs Risk Register		Review	Karl Tegel
Raman LIDARs Safety Plan		Review	Karl Tegel
Raman LIDARs lightning protection plan		Review	Karl Tegel Uwe Steinborn
Raman LIDAR -CTAO-S Seismic Protection Plan		Review	Karl Tegel
Raman LIDARs FMEA		Review	George Pruteanu
Raman LIDARs Maintenance Plan		Review	George Pruteanu
LIDAR-Manager software design		Review	Igor Oya
CTA Project Management Plan	CTA-PLA-MGT-000000-0003, V1c, 2020	Reference	
CTA Construction Project Quality Plan	MAN-QA_110405	Reference	
CTAO Documentation Control Plan	CTA-PLA-MGT-000000-0009	Reference	
Calibration Concept for the CTAO	CTA-DER-ACS-00000-0001, v2.0	Reference	
ICD Between ACADA – Raman LIDAR	CTA-ICD-SEI-000000-0038-1a	Review	Igor Oya Andrea Cremonini
Power Distribution System South (PDSS) to Array Common Elements (ACE) Generic ICD	CTA-ICD-SEI-000000-0021 1a	Review	Uwe Steinborn Andrea Cremonini
Layouts of the CTAO Arrays	CTA-SPE-PSC-000000-0001 2a	Reference	
CTAO – South Seismic Risk Specification	CTA-SPE-SEI-400000-0001-1c	Reference	
Telescope Grounding – Lightning and LEMP Protection	CTA-SPE-TEL-000000-0002-1c	Review	Uwe Steinborn Karl Tegel

CDR Document List to provide

(partially in common with the Spanish Lidar)