Palacký University Olomouc
Faculty of Science
Joint Laboratory of Optics

BACHELOR THESIS

Calibration and monitoring of astroparticle telescopes

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DECLARATION

I hereby declare that I elaborated this bachelor thesis independently under the supervision of Ing. Ladislav Chytka, Ph.D., using only information sources referred in the Literature chapter.

In Olomouc August 21, 2021

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Bibliographical identification

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Introduction

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Chapter 1

Astroparticle detection

More than 100 years have passed since Victor Franz Hess first encontered cosmic radiation. Since those times the techniques and methods of detection have been strongly improved. We have moved up from elevating electroscopes by ballons to observe growing electric charge to specialized techniques, which allows us to measure particles' energies, trajectories, etc.

1.1 Cosmic rays and particles

1.2 Ultra-high energy cosmic rays (UHECRs)

1.3 Detection principles

Chapter 2

FAST telescope

The Fluorescence detector Array of Single-pixel Telescopes (FAST) is an international project of fluorescence telescope sensitive to UHERCs.

Until today there are four prototypes in active service. Three of them are situated in Black Rock Mesa site of the Telescope Array experiment in central Utah and one in Argentina near Pierre Auger Observatory.

2.1 Principle of operation

Main detection part of telescope consists of superreflective UV mirrors and photomultipliers.

The entire telescope along with monitoring systems and other instruments is situated in a hut with remote shutter, where it is protected from negative metrological phenomena, such as rain or fast wind, but also from dust and aerosols. Exposure of mirrors to any of this phenomena could lead to reduction of theirs reflectivity. It is also neccessary to monitor and protect PMTs from unwanted light sources. Even a low-intensity sources could decrease PMT's service life.

2.2 Remote control and monitoring

2.3

Chapter 3

Instrumentalization and measurement preparation

To perform all of neccesary measurements we need to use various types of optical and electronical equipment.

3.1 Integration sphere

The Integration sphere (IS) is a special optical equipment, which can be used either as extended uniform light source (EULS) or with spectrometer in determining the material reflectance. In our experiments we use general purpose Labsphere (Fig. 3.1).

Figure 3.1: General purpose Labsphere.

The IS inner surface consist of white optical diffusive material ($BaSO_4$ and Polytetrafluoroethylene). The inner surface is part where light intergration happens. The effect which takes place here is Lambertian scattering. After one spot of inner surface is hit by a ray, the energy should be uniformly radialy distributed. In output port this produces homogenous light source. The homogenity decreases with increasing number and sizes of input/output ports.

More deeper explanation of IS working principles and characterization of optical properties of identical IS, which we use, can be found in [2].

For our pusrposes, in case of FAST calibration, we use IS as EULS in UV specre. In case of testing optical calibration source, we don't even care about homegenity. The reason why we use IS in this case is that it focuses the entire optical power of the source into output ports, where our detectors are mounted, and blocks any other external light source, which could affect our detectors.

3.2 Photomultiplier

Photomultiplier (PMT) is considered to be a high voltage optoelectronical part.

3.3 Silicon PM

3.4 Hardware for experiment and measurement control

3.4.1 Raspberry Pi

3.4.2 STM32 based microcontrolers

Chapter 4

Calibration UV optical source

Blah blah we need it.

4.1 Karlsruhe UV source

4.2 Testing and measurement of UV source

4.3 Adding optical feedback

4.4 Modified UV light for drone calibration

Chapter 5

FAST Calibration data analysis

5.1 Photomultiplier relative calibration

5.2

5.3

Conclusion

We are completely f****d.

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