Palacký University Olomouc
Faculty of Science
Joint Laboratory of Optics

BACHELOR THESIS

Calibration and monitoring of astroparticle telescopes

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Study program:	B0533A110007 Applied Physics
Field of study:	1702R001 Applied Physics (AFYZ)
Form of study:	Full-time
Supervisor:	Ing. Ladislav Chytka, Ph.D.
Deadline:	April 2022

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

Autor's first name and surname	Daniel Staník
Title	Calibration and monitoring of astroparticle telescopes
Type of thesis	Bachelor
Department	Joint Laboratory of Optics
Supervisor	Ing. Ladislav Chytka, Ph.D.
The year of presentation	2022
Abstract	Lorem ipsum dolor sit amet, consectetur adipiscing elit. Curabitur et lectus sit amet lectus vestibulum dignissim. Cras sit amet enim vitae mi elementum blandit eget nec tortor. Curabitur eget eros vitae arcu luctus varius commodo vel mauris. Nam elementum convallis pretium. Nunc dignissim pulvinar urna, nec blandit ante fringilla at. Ut et magna purus, vel pellentesque massa. In tortor nisi, faucibus condimentum cursus ut, sollicitudin quis leo. Ut at purus nec arcu accumsan tincidunt id id massa. Nam id vehicula mi.
Keywords	keyword 1, keyword 2, ...
Number of pages	xx
Number of appendices	x
Language	czech

Bibliografická identifikace

Jméno a příjmení autora	Daniel Staník
Název práce	Kalibrace a monitorování astročásticových teleskopů
Typ práce	Bakalářská
Pracoviště	Společná Laboratoř Optiky
Vedoucí práce	Ing. Ladislav Chytka, Ph.D.
Rok obhajoby práce	2022
Abstrakt	Lorem ipsum dolor sit amet, consectetur adipiscing elit. Curabitur et lectus sit amet lectus vestibulum dignissim. Cras sit amet enim vitae mi elementum blandit eget nec tortor. Curabitur eget eros vitae arcu luctus varius commodo vel mauris. Nam elementum convallis pretium. Nunc dignissim pulvinar urna, nec blandit ante fringilla at. Ut et magna purus, vel pellentesque massa. In tortor nisi, faucibus condimentum cursus ut, sollicitudin quis leo. Ut at purus nec arcu accumsan tincidunt id id massa. Nam id vehicula mi.
Klíčová slova	klíčové slovo 1, klíčové slovo 2, ...
Počet stran	xx
Počet příloh	x
Jazyk	český

Contents

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

FAST telescope

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4.2 Remote control and monitoring

4.3

Conclusion

We are completely f****d.

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