University of Pisa

DEPARTMENT OF NATURAL, MATHEMATICAL AND PHYSICAL SCIENCES
Master's degree in Physics

Optimization of the trigger system and data acquisition of the FOOT experiment at CNAO

Thesis advisor:
Luca Galli

Research supervisor:
Bisogni Maria Giuseppina

Candidate:
Lorenzo Marini

Academic Year 2021–2022

Abstract

This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract. This is the abstract.This is the abstract.
This is the abstract.This is the abstract.

Contents

List of Figures

List of Tables

Chapter 1

Charge Particle Therapy

Prova del capitolo 1.

$$F = ma \tag{1.1}$$

$$F = ma \tag{1.2}$$

$$F = ma \tag{1.3}$$

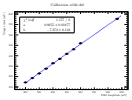
$$F = ma \tag{1.4}$$

1.1 Physics of Charged Particle Therapy

Qui ci scrivo qualcosa.

1.1.1 Electron magnetic energy loss of heavy charged particles

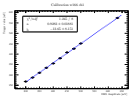
Scrivo qualcosa[Pan95].



0.15

(a) b

Figure 1.1: $y = x$



0.15

(a) b

Figure 1.2: $y = 3sinx$

1.1.2 Multiple Coulomb Scattering

Scrivo qualcosa[Pan95].

1.1.3 Nuclear interaction

Scrivo qualcosa[Pan95].

1.1.4 Range

Scrivo qualcosa[Pan95].

1.2 Radiobiology in CPT

Qui ci scrivo qualcosa.

1.2.1 Dose deposition

Scrivo qualcosa[Pan95].

1.2.2 DNA damage

Scrivo qualcosa[Pan95].

1.2.3 Linear Energy Transfer

Scrivo qualcosa[Pan95].

1.2.4 Cells survival models

Scrivo qualcosa[Pan95].

1.2.5 Relative Biological Effectiveness

Scrivo qualcosa[Pan95].

1.3 Thesis objectives

Qui ci scrivo qualcosa.

Chapter 2

The FOOT experiment

Prova del capitolo 1.

$$F = ma \tag{2.1}$$

$$F = ma \tag{2.2}$$

$$F = ma \tag{2.3}$$

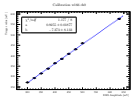
$$F = ma \tag{2.4}$$

2.1 Measurements and strategies

Qui ci scrivo qualcosa.

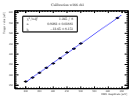
2.2 Experimentla setup

Qui ci scrivo qualcosa.



0.15
(a) b

Figure 2.1: $y = x$



0.15
(a) b

Figure 2.2: $y = 3sinx$

2.2.1 Upstream region

Scrivo qualcosa[Pan95].

2.2.2 Tracking system

Scrivo qualcosa[Pan95].

2.2.3 Downstream region

Scrivo qualcosa[Pan95].

2.3 Current status and research program

Qui ci scrivo qualcosa.

Chapter 3

Methods and materials

Prova del capitolo 1.

$$F = ma \tag{3.1}$$

$$F = ma \tag{3.2}$$

$$F = ma \tag{3.3}$$

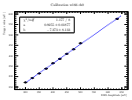
$$F = ma \tag{3.4}$$

3.1 Overview

Qui ci scrivo qualcosa.

3.2 Detection system

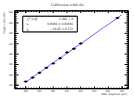
Qui ci scrivo qualcosa.



0.15

(a) b

Figure 3.1: $y = x$



0.15

(a) b

Figure 3.2: $y = 3sinx$

3.2.1 Start Counter

Scrivo qualcosa[Pan95].

3.2.2 TOF-Wall detector

Scrivo qualcosa[Pan95].

3.2.3 The WaveDAQ system

Scrivo qualcosa[Pan95].

3.3 Trigger update

Qui ci scrivo qualcosa.

3.3.1 WaveDREAM channels calibration

Scrivo qualcosa[Pan95].

3.4 Data taking

Qui ci scrivo qualcosa.

3.5 Data precessing

Qui ci scrivo qualcosa.

3.5.1 Start Counter waveforms analysis

Scrivo qualcosa[Pan95].

3.5.2 TOF-Wall waveforms analysis

Scrivo qualcosa[Pan95].

3.5.3 Clock analysis

Scrivo qualcosa[Pan95].

3.5.4 Time resolution

Scrivo qualcosa[Pan95].

3.5.5 Time of flight evaluation

Scrivo qualcosa[Pan95].

3.5.6 Charge evaluation

Scrivo qualcosa[Pan95].

3.5.7 Energy evaluation

Scrivo qualcosa[Pan95].

Chapter 4

Results and discussion

Prova del capitolo 1.

$$F = ma \tag{4.1}$$

$$F = ma \tag{4.2}$$

$$F = ma \tag{4.3}$$

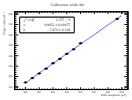
$$F = ma \tag{4.4}$$

4.1 Trigger efficency

Qui ci scrivo qualcosa.

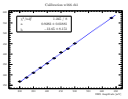
4.2 Charge reconstruction

Qui ci scrivo qualcosa.



0.15
(a) b

Figure 4.1: $y = x$



0.15
(a) b

Figure 4.2: $y = 3sinx$

Appendix A

Capitolo 1

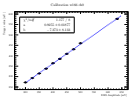
Prova del capitolo 1.

$$F = ma \tag{A.1}$$

$$F = ma \tag{A.2}$$

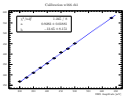
$$F = ma \tag{A.3}$$

$$F = ma \tag{A.4}$$



0.15
(a) b

Figure A.1: $y = x$



0.15
(a) b

Figure A.2: $y = 3sinx$

Bibliography

[Pan95] D. Pan. A tutorial on mpeg/audio compression. *IEEE Multimedia*, 2:60–74, Summer 1995.