

LIP

Welcomes You



Coimbra, Lisboa, Minho

- ~ 200 members
- ~ 90 PhD
- ~ 75 students
- ~ 27 engineers, technicians
- 7 administrative staff



- Experimental Particle Physics and Astrophysics
- Development of Instrumentation
- Scientific Computing











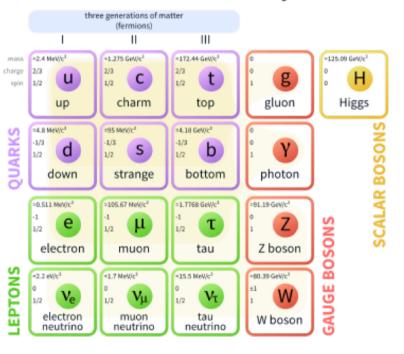




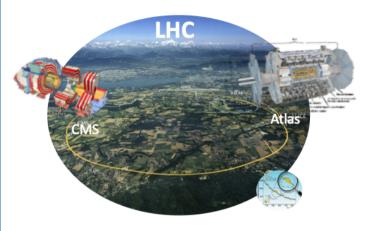


LIP: Particle Physics ■ Baryon Matter ■ Dark Matter ■ Dark Energy

Standard Model of Elementary Particles



Detectors from the bottom of deep mines to outer space

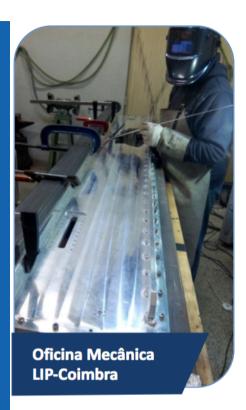




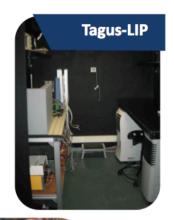


















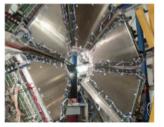
Detectores RPCs



para PET animal e humano,



para a Física de partículas



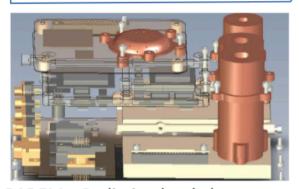
Detectores Xenon



Electrónica digital



Detectores de radiação em missões espaciais



RADEM – Radiation hard electron monitor (LIP: desenho do detector de direcção)

Clear-PEM



Scientific Computing

- Information & Technology R&D
- Participation in digital infrastructures and international consortia
- Support to scientific community







Summer 2021

Registration: 26/4 - 31/5 Internships: Jul - Sept Tutorials: 5/7 - 9/7 Workshop: 8/9 - 9/9

- Students become collaborators in LIP's research teams
- 1 week of introductory lectures + hands-on tutorials
- Integrate research projects from 2 weeks to 2 months
- 2 day long final workshop where each student present his/her work to fellow students and the LIP researchers
- Locations: Remotely (once Covid-19 situation normalised, also at LIP premises and university poles)
- <u>How to apply?</u> Students select up to 5 projects in order of preference; to facilitate selection should share interests and past experience (academic, research, computing, electronics, etc)

https://www.lip.pt/training/internship-program/

















In 2020, we went online!

Last year the pandemic situation led us to explore novel ways of teaching, learning, and collaborating

... it worked quite well!

this year we may adopt a mixed format as feasible

Successful transition to online format through collaborative apps













even if with some needed adaptations...







LIP Student

LIP-STUDENTS-21-XX

Possibility to publish your work as a LIP research paper

B mesons as novel probes of QGP

João Gonçalves^{1,a} and Alexandra Pardal^{2,b} Instituto Superior Técnico, Lisboa, Portugal Faculdade de Cléncias, Lisboa, Portugal Project supervisors: N. Leonardo, J. Silva

Abstract. In this work we study B mesons as novel probes of the quark gluon plasma (QGP). We used PbPb data collected by the CMS experiment at the LHC in November 2018. The P^2 and B_i production differential cross-sections in PbPb collisions are measured. The cross sections of the two mesons and their ratios provide unique information about the properties of the QGP and how the hot and denve QCD medium affects the hadronization of the bquark. The B_i meson is observed for the first time in beavy in collisions.

Contents

1 Introduction 2 The CMS detector

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5.3 Fit validation
5.4 Systematic uncertainties from fit procedure
5.5 Systematic uncertainties from PDF modeling
5.6 Differential yield

6 Efficiency determination

7 Differential cross-section measur 7.1 Data representation (abcissae 7.2 Systematic uncertainties

8 Skills acquired 9 Summary and perspectives

est energies. [1] B mesons are composed by a bottom antiquark (\overline{b}) and an up, down, strange or charm quark. In this experimental

LIP-STUDENTS-20-17

Search for dark matter and supersymmetry using machine learning at SHiP

Francisco Safara^{1,8} and Daúl Santos^{2,b}

Faculdada da Ciânciae da Universidada da Liebna, Liebna, Portugal Instituto Superior Técnico, Lisboa, Portugal

Project supervisors: N. Leonardo, G. Soares

October 2020

Abstract, SHF is an latensity Frontier experiment aimed at the search for particles with extremely feeble interactions, low masses and long lifespans. Such particles are predicted in a number of recently cluborated scenarios for hidden active of particle physics. In his project we used the SHF obstract framework is simulate hidden particles, specifically dark photons and neutralnoss, and study their kinematic properties. We have implemented and tested several machine learning techniques with the aim of rejenting the neutrino background while maintaining a high grait efficiency. We were able to achieve, experienting execution and study clientifications with faranter pre-processing, regression and clientification, in Indexpround and signal efficiencies above 5%s.

KEYWORDS: Hidden Sector, Dark Photons, Neutralinos, Neural Networks

The Standard Model (SM) of particle physics aims to describe the most fundamental properties of matter, it was developed during the second half of the 20th century, in a elobal initiative based on the ideas of unification and su metries. It has provided a consistent description of Na-ture's fundamental constituents and interactions.

However, it fails to explain a number of observed phenomena in particle physics, astrophysics and cosmology nomena in particle physics, astrophysics and cosmology such as the matter-antimatter asymmetry, the nature of dark matter and dark energy. To explain this phenomena, newer particles and/or interactions would be needed, but until this moment no direct experimental evidence exists.

One possible reason for why these hypothetical particles have not yet been observed is that they are too heav cles have not yet been observed is that they are too heavy and require higher collision energies to be detected. This research is pursued through the so-called energy frontier, namely at CERN's LHC.

Another possibility is that their interactions with SM

particles are extremely feeble. Some examples of such particles are extremely feeble. Some examples of such particles that have been theorized in recent years include: Heavy Neutral Leptons (HNL), Dark Photons (DP), and Neutralinos. Here, different kinds of experiments are needed, that explore the intensity frontier. This is the case

LIP-STUDENT- Project 52



Figure 1: Theory landscape of dark matter candidates [2]

with masses in the range from hundreds of MeV to few GeV, inaccessible in other experiments, as well as to make measurements involving the tau neutrino. Hidden parti-cles are predicted by a large number of models beyond the Standard Model, and include Heavy Neutral Leptons (HNL). Dark Photons (DP), and the Neutralinos [3]

A schematic of the SHiP detector is shown in Fig. 2 It consists of a target, where a beam of high intensity (400

Efficient Modelling of Optical Photon Propagation in SNO+

Project supervisor: Nuno Barros

Keywords: Optical model, SNO+, PMT, Concentrators, Optical calibration

1 Overview of the detector

The SNO+ detector [1] located in VALE's Creighton mine at a depth of 2 km is a remodel of the SNO experiment. It is comprised of the main following features: (a full description can be found in [11])

1.3 Detector calibration

The calibration of the detector

Acrylic Vessel (AV):The AV is spherical and filled with liquid scintillator. The overall structure is positioned concentrically and all the operations are held in the deck



Figure 1: Diagram of the SNO+ detector. The AV (Acrylic Vessel) in blue is supported by ropes (red and pink). The Green sphere is where the PMTs are enclosed

SNO+ goal is to search for the neutrinoless double-beta decay $0x\beta\beta$ of the $^{136}{\rm Te}$ isotope [1].If observed it would demonstrate that neutrinos are their own antiparticles (Majorana Nature) .

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The experiment will be also home to measuremen geo-neutrinos (how heat production works on Earth), tor antineutrinos, neutrinos and antineutrinos from se nova explosions and low energy solar neutrinos.[11]

1.3 Defector cultivation
The calibration of the detector will make use of radioactive and optical sources. While radioactive sources serve to record the control of the control

LIP-STUDENTS-19-042

AMBER- Physics Simulations for a new experiment at CERN

Instituto Superior Técnico, Lisboa, Portugal

Project supervisor: C. Quintans

For the dimuon:

p_T: transverse momentum

• n...: absolute momentum

Abstract. AMJIFR: u new protes for a fixed tagget experience at CEDN. Does of its goals a to from about some glowest quantity endings should be about a flower of the contract Kryworns: AMBER PHYTIA Biorken x

1 Introduction

11 AMBER

The COMPASS++/AMBER (proto-) collaboration pro-poses to establish a "New QCD facility at the M2 beam line of the CERN SPS". It will allow a great variety of measurements to address fundamental issues of Quantum Chromodynamics.[1] A beam made of hadrons, with 190 GeV/c will collide • M : invariant mass; Drell-Yan (DY) is a very rare process, which takes place when a quark of one hadron and an antiquark of another hadron annihilate, creating a virtual photon, which then decays into a pair of oppositely-charged muons.

A beam made of hadrons, with 190 GeV/c will collide with a target. It is possible to have a positive or a negative hadron beam. The former is composed of \(\textit{\sigma} \) on the latter of their arithmetics.

A composed of \(\textit{\sigma} \) on the latter of their arithmetics.

The target will consist of three cylinders made of carbon. After that, there will be a hadron absorber in order to absorb the hadrons produced in the interaction. After that, there will be a hadron absorber in order to absorb the hadrons produced in the interaction with the tarsorb the hadrons produced in the interaction with the tar get, since the main goal is to detect the muons. Continuing downstream, there will be many tracking de tectors, including a muon filter, where the muon are de tected.

In between the detectors mentioned, there will be several others and even a lot of associated electronics, however it is not relevant for this article and is not directly related to what is studied.

analysis. For the muons:

It provides valuable information about the parton distribution functions (PDF's), which are essential for calculating all processes at hadron colliders. The PDF's describe the way the momentum of a hadron is partitioned among its constituent partons.

Throughout the work done, it was only simulated Drell-

LIP-STUDENTS-19-000

Measurement of J/ ψ polarization in pp collisions at $\sqrt{s} = 8$ TeV in C

Project supervisors: Mariana Araújo, Pietro Faccioli and João Seixas.

1 Introduction

1 Introduction

Non-relativistic, agnatum chromodynamies (NIOCD) is the most satisfactory effective theory capable of explaining the production and decay of heavy quantonium. However, the polarization of 1/ph mesons is not correctly described the production in complex production is complemented by processes including possible non-perturbative transitions from colour octet states on the otherwish bound states. Therefore, it is crucial work of the complement of the processes including possible non-perturbative transitions from colour octet states on the otherwish bound states. Therefore, it is crucial work of the complement of the processes including possible non-perturbative transitions from colour octet states on the otherwish bound states. Therefore, it is crucial work of the processes in the colour production in the occupant of the more consistent of the more transitions, in the more consistent of the more consistent of the colour processes of the colour processes of the colour processes of the colour processes of the theory.

Through the study of the angular distribution of the processes of the colour processes of

 $\mu^+\mu^-$ decay, we can measure their polarization, determined by the lambda parameters, from the expression provided by Quantum Mechanics:

$$W(\cos \vartheta, \varphi) = \sum_{i=1}^{n} f^{(i)}W^{(i)} = \left(1 + \lambda_{\vartheta}\cos^{2}\vartheta + \lambda_{\varphi}\sin^{2}\vartheta\cos 2\varphi + \lambda_{\varphi\vartheta}\sin 2\vartheta\cos \varphi\right)\frac{3}{4\pi(3 + \lambda_{\vartheta})},$$
 (1)

with φ and ϑ being, respectively, the azimuthal and polar angles of the μ^+ , with respect to the z axis of the selected polarization frame [2].

frames.

The definition of a coordinate system which the momentum of one of the two is expressed in spherical coordinates, is measurement of the distribution under strength of the strength of the programment of the distribution under strength of the programment of the strength of the st the directions of the two colliding beams quarkonium rest frame. In this analysis, w helicity frame, HX, that is the opposite o motion of the interaction point (i.e. the f the quarkonium itself in the center-of-mass decay reference frame) with respect to stion of the colliding beams and of the

The CMS apparatus [5] was designed are ormen: a superconducting solenoid of 6 reter, providing a 3.8 T field. Within the are a silicon pixel and strip tracker, a leat al electromagnetic calorimeter, and a ladron calorimeter. Muons are measured detectors embedded in the steel return y solenoid and made using three technology

Plastic in Particle Physics - Aging of WLS Optical fibers using the Fibrometer testbench of LOMaC

Universidad Autónoma de Madrid, Spain
*Instituto Superior Técnico, Portugal
*Paculdade de Ciências de Universidade de Lisboa, Portugal
Project supervisor: A. Gomes, R. Gonçalo, J.G. Saraiva

KEYWORDS: LHC, Tile Calorimeter, Optical fibres, Aging

For this paper we have performed a 20 year old follow-up study [1] on the natural aging of a set of wavelength shifting fibers identical to ones in the ATLAS [2] Tile Calorimeter (TileCal). The fibers were collected during different stages of the mass production procedure towards the optical instrumentation of this detector.

1.1 The scintillating tiles hadronic calorimeter of ATLAS/LHC

1.1 The acinilizating tiles hadronic calorimeter of TATA611 to Carlo the merel badroics clearimeter of the XT-LAS Tike-Cails of the act the CCBN Large Hadron Collider LAC A Indicate the cell of CCBN Large Hadron Collider Called Child, A hadronic calorimeter is a detector that measures the energy of hadrons. In fact these type of detectors the energy of hadrons. In fact these type of detectors the collision of the Collision o

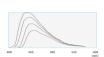


Figure 1. Emission peak in the blue region (400 - 485 nm) for a typical scingillator.



Characterization of Scintillators for the Future Circular Collider as a function

Budnei Machado^{1,a}

Project supervisor: R. Gonçalo

Abstract: The adominant is open in a appriment in the hadronic Faunce Crealin Culdur. LFC this, will be a consistent of the contract of the co will be separated through a robertive material (e.g., Tyvek) and read by wavelength displacement these; Wo of 1 mm in diameter connected to slitten photomultipliers (SIPMs). Our study focuses on the compariso the luminous signal intensity in the tile of the first layer of the HB and the tile in the last layer of HB, laking account the dimensions of the tile. A sludy of the optimization of the signal uniformity with a light-absort black strip deposited on the tile was made, and results were compared with similar experiments perform CBRN. The procedure was performed in the Tilemetera. A RLAS experiment.

1 Introduction

1.1 Particle detectors
The development of particle physics is directly associated with the use of particle detectors, whose operation is based the use of particle detectors, whose operation is based the detector [1] and the detector of these particles occurs through the loss of energy of particles when they pass of the detector in the particle with the detector. Interaction of the particles with the detector, interaction of the most of were particle. The detection occurs by the interaction of the particles with the detector, interaction of the theoretical particles are be detected directly, some are detected inductedy through particles that are the particles detectors are the detected directly.
Particle detectors can be divided into two large grouper-detectors that flanction through total comp processes and

Krawones Fotos Circular Collider tile Colorinater signal uniformit

Particle detectors can be divided into two large groups detectors that fluids in through localization processors and detectors. In the fluids of the control of the control

LAS experiment), the principle of operation is directly as-sociated with the energy "lost" by the particles that affect the scintillator, causing an excitation of the scintillator par-ticles and, consequently, the emission of light in the visible

and ultraviolet (UV) ranges. These detectors can be of various types, but our study is based on organic scintillators with a solid plastic solvent.

1.2 Plastic Scintillators

Plastic scintillators are currently one of the most economically viable options, and their light yield is associated with the interactions of the particle with the scintillator molecules. According to [5]:

In a scintillating solution, usually com of a solvent substance plus one or two of a solvent substance plus one or two sub-stances capable of emitting light when dissi-pating energy, the charged particles and the pating eneigy, the charged particles and the ing mainly with the molecules of the solvent, most of them in the scientification of the solvent, most of them in the scientification of the content and expension of the scientification of the creation undergone interaction. Part of the released energy will also be consumed in the creation ments, making the luminous efficiency of the scirtilisting solution dependent on the way to be consumed to the solution of the solution of these products will depend on the seq-tention of these products will depend on the spec-around the trajectory of the particle, mainly in its initial point of interaction, causing a reduc-ction of these products of interaction, causing a reduc-tion of the products of the scientification of the cent among themselves, instead of restring noncenon denominated as extinction by ion-tization.

Quantum chromodynamics (QCD) predicts that under ex-treme conditions of temperature and/or density the Quark-Gluon Plasma (QGP) is formed. The QGP existed mi-croseconds after the Big Bang and it is a state of matter formed by deconfined quarks and gluons. It can be recre-ated at the LHC by colliding heavy nuclei (Pb) at the high-

work we study the B'' messon fiva and the B, messon for [22]. Bottom quarks are created in the initial hard scattering stage and retain their identity while traversing the medium they are in, thus recording information about its evolution By comparing pp collisions towarum medium) with PelP to the properties. The goal of this study is to measure the B meson's cross section in PelPs collisions a STeV and to study how the QCP affects the hadronization of the b quark.

where N is the signal yield, L the luminosity, B the branching fraction, ∃ the acceptance and ε the efficiency While N is measured from data, through the implementa-tion of an unbinned fitting procedure in Section 5.1, ε and ∃ are determined from Monte Carlo (MC) simulation, tha is validated through the methods of sideband subtraction and sPlot, in Section 4.

2 The CMS detector

The Compact Musco Sedemid (CMS) is one of the four large experiments at the Large Hadron Collider (LHC). It can be compacted to the compact of the Large Experiments at the Large Hadron Collider (LHC). It can did is layers. When the particles true through the detection they leave signatures (disposits of energy) in different possible to identify these layers from inward to outward the silicon tracker, which measures the positions of passible to identify these layers from inward to outward the electromagnetic colorimeter (ECAL), which measure the energy of particles, allowing the measurement of their charge and momentum; and, the muon chain before the contract electron metals. The most interpretate advancement of their charge and momentum; and, the muon chain important subsection of the many contraction contraction. The most interpretation can be detected to be for this analysis are the silicon tracker and muon delicence, that are engloyed to trigger and moment the limit in measure the limit of the contraction of the contrac

1.4 The Photomultiplier Use (PMT). Light insident on a PMT [A-2] will produce a photoelectron. Subjected to a strong electric field the e' acceleration and create an electron shower this interpreted as sequently the TAC slope of the pulse - time to amplitude alers the analog to digital contrain time of a clares the analog to digital contrain time of a contrained of the PMTs read out time and charge values that are analyzed to specify bytics events. In the part of the

TYWORDS: QUARKONIUM, POLARIZATION, NROCD, OCD, HADRON FORMATIO

motion of the colliding beams and of the be found in the last reference cited. In this analysis, we considered pp cotained by the CMS experiment in 2012 with both J/ψ mesons in transverse m $12 < p_T < 70$ GeV and in the rapidity in and a Monte Carlo simulation generated larized production (uniform J/ψ decay dis



Many Projects Various Topics

Do not hesitate to ask questions!

(contact person next to project description)

Physics at the LHC

Precision measurements and searches for physics beyond the Standard Model with data from the LHC experiments

Cosmic Rays, Neutrinos Dark Matter

Physics with cosmic rays, the elusive neutrinos and searches for dark matter

Structure of Matter and Heavy-Ions

Exploring the structure of matter – from nucleons and nuclei to the plasma of quarks and gluons

Detectors & Instrumentation

Characterization and development of (hardware and software) systems that facilitate scientific research.



https://www.lip.pt/training/summer-student-program/

LIP Internship Program

Summer 2021 (July-September)

LIP:: Braga - Coimbra - Lisboa

LIP Internship Program is a LIP summer program for Physics and Engineering students.

The internships last between two weeks and two months.

To consult all the **proposed themes** for this year's edition, access the "Projects" area.

The program includes a week of introductory lectures on Particle and Astroparticle Physics, detectors and experimental methods, and tutorial sessions on the use of computer tools in data analysis, in July.

All the agendas and materials will be available soon at the Agenda and Materials platform.

The program ends with a workshop where each intern contributes a summary presentation of their work in September.

Registration can be done in the "Registration" area.

At the end of the internship, participants are given the opportunity to produce a *final paper* summarising their work.

To consult **all editions** and respective topics proposed, materials for lectures and tutorials and presentations at the final Workshop go to **'Past Events**'.