LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

2020 INTERNSHIP PROGRAM

IV LIP Internship Program / 2020

toward the end …

Braga, Coimbra, Lisbon (Zoom!) — September 11th, 2020

... thank you for taking part !

and for making this edition of the LIP Internship Program another <u>great success despite</u> the exceptional global circumstance (pandemic) we're in

Thanks

to the **student** participants

to the project **supervisors**

to LIP **researchers** in general
for lectures, tutorials, topical chats, session convening, etc

to everyone who helped with the **organisation**

including Sofia (outreach), Ricardo (lectures), Liliana (workshop)

to the LIP support structures:
IT (Hugo et al), Secretariat (Natalia et al), ECO (Catarina, Sonia, et al), directorate, …

to everyone @ LIP

For this edition we needed to make some **adaptions** relative to past ones …

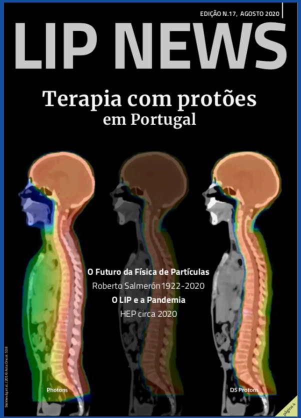
Successful transition to **online** format through **collaborative** apps

For this edition we needed to make some **adaptions** …

COFFEE TIME

For next year's edition we hope and should aim at making up for the in-person **social** interactions and activities that we've (forcibly) lacked this time …

Summaries



FORMAÇÃO AVANÇADA

LIP Internship Program

LIP Internship Program is now a well establis[…] flagship event of LIP. Since 2018, the program[…] integrated all three LIP nodes, and has receiv[…] 60 students each Summer. The programme in[…] a preparatory week (lectures, thematic discu[…] hands-on tutorials) in mid July, and ends earl[…] September with a two-day long final worksho[…] where the students present their work. In be[…] the students carry out their research project[…] proper. Thematic discussions in smaller grou[…] and informal gatherings such as the "August c[…] "Churrasco" and "Coffee hour" allow student[…] researchers to meet and discuss in a more inf[…] way.

Yet another novelty, introduced in 2019, is th[…] possibility to describe the work in a scientific[…] (LIP note), following a prepared format, a cha[…] that was readily taken by several students. It[…] worth stressing that the programme counts v[…] a broad and rather intense participation of LI[…] researchers, who serve as project supervisor[…] deliver tutorials and lectures, guide topical discussions, and take part in the discussion at final workshop.

The programme of the 2020 edition — while retaining the same underlying organization, f[…] and timings — moved entirely online. This po[…] new challenges, which were met with needed adaption, exploration of new tools, and some inventiveness. The same level of participatio[…] both students and researchers as in previous was attained.

ABSTRACTS (2019 edition)

AMBER – Physics simulations for a experiment at CERN

Student: Rita Silva / Supervisor: C. Quintans

AMBER is a project for a fixed target experiment at CERN. One of its goals is to investigate quark and gluon dynamics inside hadrons. Simulations were performed using Pythia8 in order to analyze a very r[…] process, Drell-Yan. Drell-Yan is a quark antiquark annihilation where the resulting virtual photon deca[…] into a pair of muons. The starting point was to study […] accompanying particles produced. We then focused on the kinematic variables associated to the muon pair (dimuon), from the transverse momentum to the fraction of hadron momentum carried by the struck quark, Bjorken-x. The acceptance of the detector was simulated by applying selection criteria on the muons' polar angle. Finally, we analyzed the effects of proton misidentification as a pion.

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bosons coupling to top pairs provide unique signatures at the LHC and we have used single lepton events collected by the ATLAS experiment to search for it. Machine learning techniques, namely deep neural networks, were used to distinguish this signal from the expected background. A statistical interpretation of the obtained results was also done.

Kinematic reconstruction of ttbar events using the ATLAS open dataset

Student: Ana Alexandra Oliveira / Supervisors: Nuno Castro, Tiago Vale, Ana Peixoto, Emanuel Gouveia

Single lepton events were used to study the ttbar process. A cut-based analysis was developed to select these events and the full reconstruction of the ttbar system was performed using the measured kinematic variables.

Search for Supersymmetry using a Machine Learning tool

Students: Artur Cordeiro, Timothée Cabos / Supervisors: P. Bargassa, Diogo de Bastos

We stayed at LIP for only 5 weeks but we have developed a new Neural Network architecture to separate background from signal in the stop 4-body decays. The objective was to improve the performance compared to the BDT that was developed by our supervisor last year. We have achieved a significant improvement of performance (yet to be verified in detail). We learned a lot during this internship, we hope that our work might be useful for the lab. It was certainly useful to us.

B mesons as novel probes of the QGP

Students: Alexandra Pardal, João Gonçalves / Supervisors: N. Leonardo, J. Silva

Quantum chromodynamics (QCD) predicts that under extreme conditions of temperature and/or density the Quark-Gluon Plasma (QGP) is formed. The QGP existed microseconds after the Big Bang and it is a state of matter formed by deconfined quarks and gluons. It can be recreated at the LHC by colliding heavy nuclei at the highest energies (Pb-Pb collisions). B mesons are composed of a bottom antiquark (b) bound to an up, down, strange or charm quark. In this experimental work we studied the B+ meson (bu) and the Bs meson (bs). Bottom quarks are created in the initial hard scattering stage and retain their identity while traversing the medium, thus recording information about its evolution. By comparing p-p collisions (vacuum medium) with Pb-Pb collisions (QGP), we can therefore use B mesons as probes to study the QGP properties. The goal of this internship was to measure the B mesons' cross-section in Pb-Pb collisions and to study how the QGP affects the hadronization of the b quark, using data collected by CMS in 2018 at the LHC. The raw signal yields were extracted by fitting the data, with an unbinned maximum likelihood implementation. The fits were validated using toy simulations. The detector and selection efficiency was calculated using simulated samples. These had to be validated against the data, which was achieved with sideband subtraction and SPlot statistical methods. Systematic uncertainties were calculated. Results were documented in a CMS internal note as part of the review materials of a CMS analysis.

Geant4 simulations on argon transparency to neutrons

Student: Leonardo S. R. Oliveira / Supervisor: S. Andringa

As the largest neutrino experiment to date, the DUNE experiment will have record-sized detectors, of which some will be liquid argon time projection chambers (LArTPC). One of the candidate calibration methods for these detectors is the pulsed neutron source (PNS) calibration, which relies on an anti-resonance peak in the cross section of argon-40. The upcoming Argon Resonance Transport Interaction Experiment (ARTIE) seeks to confirm the existence of such anti-resonance peak and, thus, the feasibility of the PNS method. In this project, Geant4 simulation results for the ARTIE experiment are present[…] reconstruction of the initial en[…] even with a 150 ns time smear[…] reconstruction principle is the[…] the upcoming experiment's rol[…] methodology.

Measurement of J/ψ […] collisions at √s = 8 T[…]

Students: Francisco Albergari[…] M. Araújo, P. Faccioli, J. Seixas

The polarization of prompt J/ψ […] proton collisions at data sampl[…] at the LHC. The prompt polari[…] from the dimuon decay angula[…] The J/ψ results are obtained ir[…] 12<pT <70 GeV and in the rap[…] of large polarization is seen in […] agreement with past results us[…] of this analysis are shown here[…]

Development of nov[…] techniques for low-e[…] showers

Students: Hugo Lóio, Luis Lou[…] M. Pimenta, B. Tomé

The Southern Wide field-of-vie[…] is a newly formed internationa[…] a new observatory to be place[…] m. This experiment aims to co[…] times bigger than the initially […] being entirely composed of hy[…] provide the timing) and Water[…] explores a revolutionary detec[…] a WCD (1.5x1.5x1 m3) with a […] record the Cherenkov light pro[…] particles.
The challenge of our work was[…] reconstruct the shower geome[…] well defined in time, but instea[…] trace.
The WCD signal time trace ha[…] that hits the SiPMs directly; sc[…] former has a sharp pulse that c[…] the arrival of the shower parti[…]

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Study of the Higgs couplings to quarks at ATLAS

Student: Gonçalo Fernandes / Supervisors: R. Gonçalo, R. Pedro, P. Conde

Since the discovery of the Higgs boson, the precise measurement of its properties became a fundamental part of the ATLAS programme. The announcement last year of the observation of Higgs production in association with top quarks by ATLAS and CMS opened the possibility to study the CP structure of the ttH vertex. This measurement could give a strong indication of new physics, especially if hints of a mixed-CP-parity interaction between top and Higgs were found. In this project, the feasibility of simulating mixed-CP signals by interpolating CP-even and CP-odd simulated templates was demonstrated, which much simplifies the measurement. This interpolation was studied in many kinematic variables, including sensitive angular discriminants.

Física Experimental de Partículas com os detectores ATLAS, LUX e LZ.

Students: André Filipe Silva, Ângelo Ferreira e Tiago Azevedo / Supervisors: P. Brás, A. Lindote e F. Veloso

As experiências ATLAS, LUX e LZ procuram dar resposta a várias das questões que o modelo padrão da física de partículas deixa em aberto. Desvios das previsões do SM relativas às propriedades da produção e decaimento do quark top no detector ATLAS do LHC fornecem testes independentes de modelos específicos para nova física. O estudo dos recuos nucleares medidos pelos detectores LUX e LZ permite procurar matéria escura, o principal ingrediente da receita de matéria do Universo e do qual se sabe muito pouco. A detecção da assinatura esperada das interacções de matéria escura com matéria comum revelaria física nova, com fortes implicações para o SM e para a cosmologia. Neste estágio foram analisados dados das experiências ATLAS, LUX e LZ.

Machine Learning to improve the Higgs to b-quarks analysis in ATLAS

Student: Dmytro Ostapchuk / Supervisors: P. Conde, R. Pedro

The announcement in 2018 of the first observation of the Higgs decay to b-quarks and of the associated production of Higgs and top quarks by ATLAS and CMS probed directly the coupling of the Higgs to quarks. The use of more advanced analysis techniques and the reduction of systematic uncertainties can further improve current measurements, fully exploiting the LHC data potential.

We explored the possibility of improving the current ATLAS analysis of the H->bb decay in associated production with a vector boson using Machine Learning techniques, not only to separate signal from background, but also to define the control regions. A multi-class Neural Net (NN) was used to classify events in six different categories: signal, W+jets, top quark pair production, single top production, WZ and WW. The parameters of the NN were varied to find the optimum network configuration. Signal events where correctly classified in 87% of the cases.

Extending the functionality of a 3D graphic viewer of the Pierre Auger Observatory

Students: Leonardo Ramalho, Luís Neto / Supervisors: Henrique Carvalho, Raul Sarmento

The 3D graphic viewer "Auger Visualizer" is a project for the visualization of the Pierre Auger observatory events. It started last year as part of the LIP summer internships. This year new features were implemented in the viewer, namely the support for loading data into the JSON format, addition of PMT information in the form of a graph, filters and event search, and also the implementation of the visualization of the extensive atmospheric shower. For this last task, the Heitler Model was used, with some simplifications to fulfill performance requirements, while maintaining a correct and appealing representation.

Exploring the public data of the Pierre Auger Observatory

Students: Osvaldo Freitas, Pedro Branco, Pedro Passos / Supervisor: Raul Sarmento

During this summer internship we proceeded with the study of the public data given by the Pierre Auger Observatory, located in Argentina. This observatory aims to study the cosmic rays which reach the Earth's surface, specially to the most energetic ones we analyzed the public data given by the observatory which corresponds to 10% of the total data. Our first goal was to analyze the energy spectrum of the events. After this, we analyzed the anisotropies of the cosmic rays in large angular scales, where we drafted the spectrum in declination bands and maps with the aim to check for the existence of anisotropies. Finally, we proceeded with the analysis of the primary particle composition, where we intended to study the relation between the mass of the accelerated particles and the energy which is associated with them.

Measurement of the ttbar cross-section in events with leptons using ATLAS open data

Students: Maria João Portela, Tomás Ferreira / Supervisors: Nuno Castro, Tiago Vale, Ana Peixoto, Emanuel Gouveia

In our internship at LIP Minho, we analysed events from ATLAS open data and tried to get the cleanest signal we could, in order to measure the cross section of the ttbar production, both from semi leptonic and dileptonic events. We did this using and improving our knowledge from quantum physics and python programming, to achieve the best outcome out of this work.

Search for Z'->ttbar events using machine learning techniques

Students: Maria do Céu Neiva, Nuno Morujão / Supervisors: Nuno Castro, Tiago Vale, Ana Peixoto, Emanuel Gouveia

Despite the excellent experimental success of the standard model of particle physics we have strong indications that there might be new physics phenomena beyond it. Models predicting new Z'

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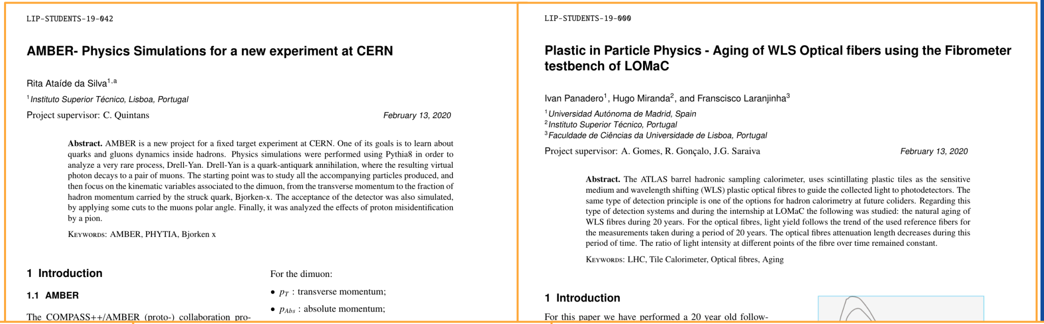
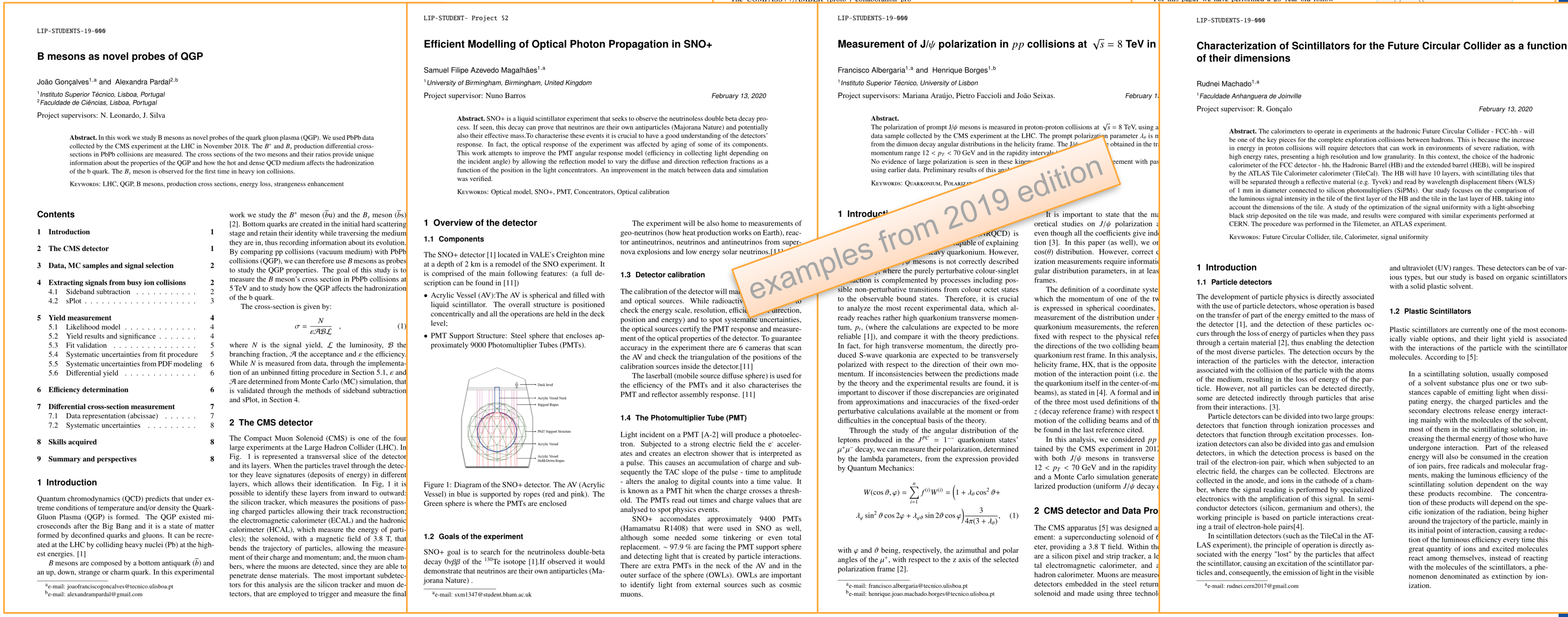
2019 edition

Research papers

LIP-STUDENT-20-33

made available from public database





Paper write-up

A **research paper** documenting the results obtained in your project

Papers to be submitted as a LIP document shared in a **public** repository

All students **strongly encouraged** to submit the report

How much: 5 -10 pages

When: by mid October

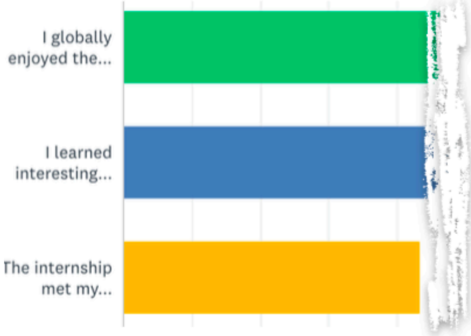
Consider writing in **LaTex** — a template in **OverLeaf** will be provided and is recommended for ensuring format uniformity. Other document formats may be also accepted. Message will be sent with instructions.
You may contact us as always at estagios@lip.pt (and @slack).

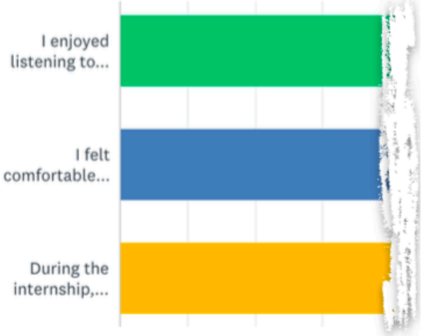
Your Feedback

You shall receive an invitation to fill in a survey to share with us your feedback on the program

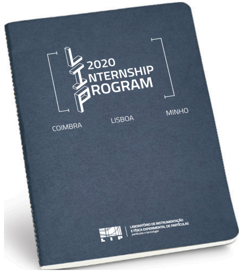
- what you think went well
- how it could be improved

Your feedback is important so we can improve on future editions of the program





Your LIP ‘package’



some goodies available for you to **pick up** from your nearest LIP location!

Thanks. Farewell.
Please stay all safe.