

Welcome

LIP-CMS Internships

10th edition



The LIP Internship Program

— The first 5 years —

NUNO LEONARDO (LIP), PROGRAM COORDINATOR

The Internship Program is the Lab's flagship initiative for undergraduate students. The program is LIP-wide, involving all three nodes, and all research lines and groups. The participating students acquire initial common training, become integrated in research teams over a period of up to two months, and present their work at a final workshop. The successful organisation and the paradigm established result in the demonstrated sustainability of the program. It has been held annually, since 2017, over the Summer period. It has attracted the interest of students since it started, and in a sustained fashion, with a record number of candidates received in the most recent edition. Over its first five editions, it enrolled over 300 students involving about 200 projects. The program has successfully achieved the goal of rendering LIP and its research widely known to physics students at the different universities. It has been systematically providing advanced training, facilitating both technical and soft skills, in a collaborative environment, to university students, with some of them pursuing further research with the Lab, in the context of courses and theses. The program has been run on a zero-€ budget, free-of-cost for participants, and based on the collaborative involvement of the researchers and structures at LIP.



LIP CMS Summer Student 2016 Workshop

Thursday 6 Oct 2016, 10:00 → 17:00

Europe/Lisbon

Joao Varela (LIP Laboratorio de Instrumentacao e Fisica Experimental de Part)

Nuno Leonardo (LIP)

Description

Estágios Verão

LIP-CMS 2016

LIP

TÉCNICO LISBOA

10:00 → 17:00

Summer Student Project Reports

areas

poster

projects

slides

students

10:00

welcome

5m

10:05

Di-Higgs searches

20m

Project: Boosted Decision Trees for classification and regression in di-Higgs searches

Project: Artificial Neural Networks for di-Higgs searches, and model-architecture engineering

Speakers: Antonio Costa, João Pedro Gonçalves, Ricardo Barrue

finalpresentation_d...

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10:25

Quarkonia

20m

Project: A study of the Metropolis-Hastings algorithm's convergence for global fits

Speaker: João Pedro Gonçalves

finalpresentation_o...

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Speakers: Beatriz Lopes, Bruno Bento

finalpresentation_s...

14:30

B hadrons with fresh Run2 data

20m

Project: Measurement of the B0 production cross-sections at 13TeV at the LHC

Project: Measurement of the Bs production cross-sections at 13TeV at the LHC

Speakers: João Melo (LIP), Júlia Silva (LIP)

finalpresentation_b...

15:00

coffee break

20m

15:20

Searches for new hadron states

20m

Project: Search for excited Bc(2S) at CMS

Speaker: Bruno Alves

finalpresentation_b...

15:50

Quarkonia

20m

Project: Quarkonium production in the LHC

Speaker: Mariana Araujo

final_presentation....

16:20

Top in heavy ions

20m

Project: Optimising the b-jet selection criteria for the search for PbPb -> tt production at 5.02TeV using the CMS detector

Speakers: Joao Barata (LIP Laboratorio de Instrumentacao e Fisica Experimental de Part), Maria Laura Lisboa (LIP Laboratorio de Instrumentacao e Fisica Experimental de Part)

finalpresentation_t...

16:50

farewell

10m



Operation and physics analyses at the CMS experiment at the CERN LHC

LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

Mariana Araújo¹ Cristóvão Beirão¹ Alessio Boletti¹ Tiziano Camporesi¹ Daniela Cardoso¹ Giacomo da Molin¹ Madalena Ferreira¹
Michele Gallinaro¹ Jonathan Hollar^{1,2} Henrique Legoinha¹ Nuno Leonardo¹ Giovanni Marozzo¹ Matteo Pisano¹ João Varela¹
João Seixas¹ Johan Wulff¹
¹LIP Lisbon ²CERN

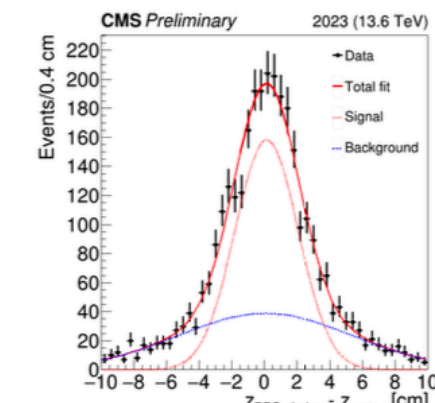


LIP-CMS group activities

LIP is a member of the CMS experiment since its creation in 1992. Activities include:

- **Physics analyses:** Electroweak, Top, Higgs, BSM, B-physics, Quarkonia, Heavy-ions;
 - **Experiment operation & maintenance:** PPS, physics objects (taus, protons), computing.
- The group is involved in different analyses at the frontier of particle physics.

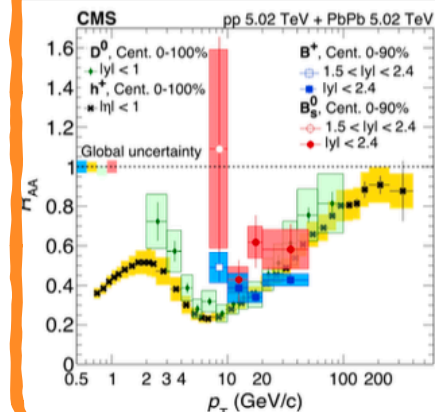
Maintenance and Operation



The group participates in the detector maintenance and operation.

- Precision Proton Spectrometer (PPS): project manager
- Other coordination positions: B-Physics Data Analysis, Standard Model PAG MC contact, MTD/BTL electronics systems, LHC HF WG
- Tagged Protons Physics Object Group
- Tau lepton identification and proton timing calibration [CMS-DP-2024-009, 2024]
- Group members are regularly selected to participate in Analysis Review Committees (ARC) and Detector Review Committees
- The group provides central shifts and EPR work according to the rules of the CMS collaboration

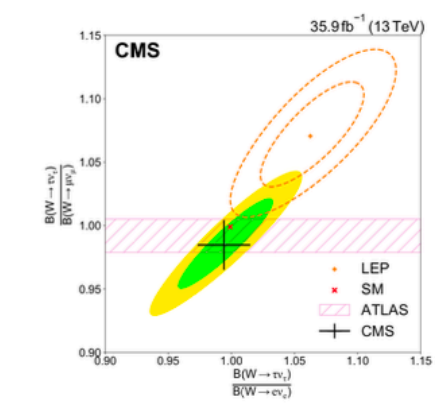
Probing the primordial fluid



We explore **heavy flavour** as probes of the Quark-Gluon Plasma (QGP)

- *B* mesons reconstructed for **first time** in nuclear collisions [PLB, 829:137062, 2022]
- Measured **relative production** of *B* mesons in pp and PbPb (*R_{AA}*) [arXiv:2409.07258]
- Probing QGP medium-induced effects on heavy quark **hadronization**
- **Strangeness enhancement** evidence in the beauty sector in QGP
- Investigating the nature of **exotic hadron** *X*(3872) using PbPb [PRL, 128(3), 2022]

Lepton Flavour Universality (LFU)

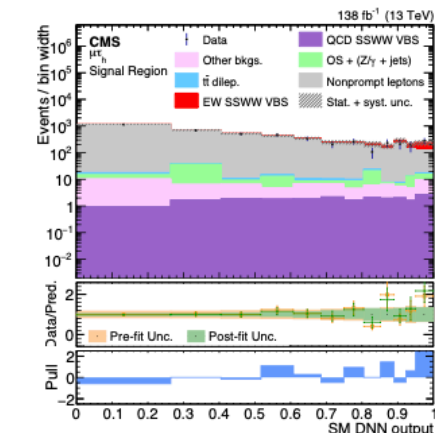


We perform a precision study of the lepton couplings to the *W* bosons in *tt* events.

- Measured *tt* cross section in dilepton events containing a *τ* lepton [JHEP, 02:191, 2020]
- Different behaviour of the leptons (**LFU violation**) would be a clear signal of new physics
- Study **top quark** decays to obtain a pure sample of *W*-bosons in final states with all lepton families
- Observables carefully crafted to minimise effects of leading systematics
- **Machine Learning** tools employed at different levels in the analysis
- Extracting a high precision measurement to test the predictions on the **Weak Nuclear interactions** competitive with the state-of-the-art [PRD, 105:072008, 2022].

Multiboson production

We study **multiboson production** in final states with **hadronically decaying tau leptons**. Studies are ongoing on Vector Boson Scattering (VBS) as well as inclusive production.



Motivation:

- Insight into the EW and Higgs sectors can be achieved through measurements of VBS processes [Rev. Phys., 8:100071, 2022]
- Tau leptons provide **unexplored** final states, which can increase our sensitivity to **rare processes** [arXiv:2410.04210]
- Tau leptons have strong **couplings to new particles** in many bSM models
- Tau leptons carry **polarization** information through their **decay**

Challenges:

- Rejection of hadronic **jets misidentified** as taus
- Careful **modelling** of non-prompt backgrounds

Acknowledgements

We acknowledge support from: CERN/FIS-INS/0029/2021 (FCT), CERN/FIS-PAR/0005/2021 (FCT), PTDC/FIS-PAR/1214/2021 (FCT), AMUSE - EU MSCA-RISE-2020 101006726, MuCol - EU HORIZON-INFRA-2022-DEV-01-01 101094300



LABORATÓRIO DE INSTRUMENTAÇÃO
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Collaboration in the Phase-2 Upgrades of the CMS experiment

Mariana Araújo¹ Cristóvão Beirão¹ Alessio Boletti¹ Tiziano Camporesi¹ Daniela Cardoso¹ Giacomo da Molin¹ Madalena Ferreira¹ Michele Gallinaro¹ Jonathan Hollar^{1,2} Henrique Legoinha¹ Nuno Leonardo¹ Giovanni Marozzo¹ Matteo Pisano¹ João Varela¹ João Seixas¹ Johan Wulff¹
¹LIP Lisbon ²CERN



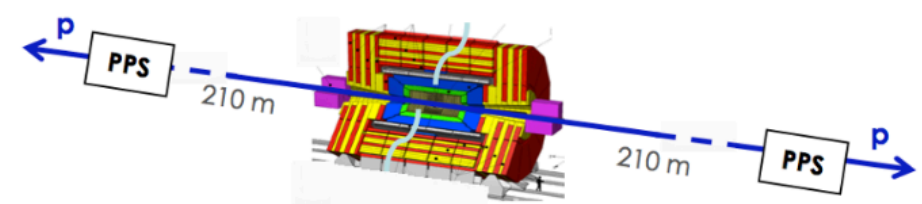
LIP Contributes to

- Calorimeter Endcap**
 - 3D showers and precise timing
 - Si, Scint+SiPM in Pb/W-SS

- Muon systems**
 - DT & CSC new FE/BE readout
 - RPC back-end electronics
 - New GEM/RPC 1.6 < η < 2.4
 - Extended coverage to η = 3

LIP Contributes to

- Barrel Calorimeters**
 - ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
 - ECAL and HCAL new Back-End boards



High Granularity Calorimeter (HGCal)

HGCal is a new high-granularity sampling calorimeter replacing the endcap calorimeters. LIP collaborated with industry supplying a high-current low voltage regulator ASIC resistant to radiation for the HGCal front-end system. The group participated in test beam at CERN to evaluate the performance of the first prototypes.

Precision Proton Spectrometer (PPS)

The new near-beam proton spectrometer will include timing and tracking detectors. For the detector technology, synergies with the ongoing developments for the Phase-2 upgrades of central pixel system and MTD are considered.

The LIP group is pursuing R&D studies of LGAD silicon sensors and associated electronics for timing measurements.

- Submitted Lol and CERN approved for HL-LHC [arXiv:2103.02752]
- R&D for the PPS timing detectors: Develop LGAD sensors and associated electronics for use as timing detectors, resistant to highly non-uniform radiation and with good (40-50 ps per plane) time resolution
- Simulation studies to optimize geometry and radiation resilience of final design
- ETROC ASIC being developed for the CMS Endcap Timing Layer (ETL). The group is closely collaborating with Fermilab team for **characterization of ETROC+LGAD**
- Functionality tests of the latest version of the ETROC2 performed at Fermilab
- **Time resolution of 35 ps** measured in test beam for ETROC2+LGAD system
- **Characterization of the full 16x16 channels** ETROC2 bonded to the LGAD sensors performed with cosmic rays and later with particle beams
- Characterization of LGAD sensors were performed before and after **irradiation**

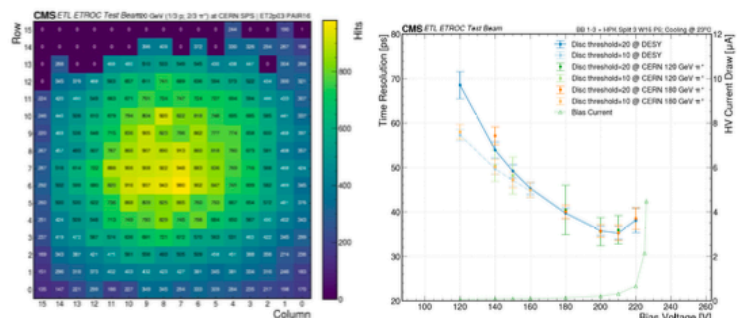


Figure 1. 16 x 16 channel ETROC2 exposed to beam (left); ETROC2 time resolution (right).

LIP contributes to

- Precision Proton Spectrometer**
 - Detector design and physics prospects

Electromagnetic Calorimeter (ECAL)

Full replacement of the barrel Electromagnetic Calorimeter (ECAL) electronics is required to meet the new trigger requirements, to minimize the impact of event pileup and provide a precise time measurement of e.m. showers. In collaboration with industry, LIP provided a high-performance ADC ASIC for the ECAL front-end electronics resistant to radiation.

MIP Timing Detector (MTD)

The MTD [CERN-LHCC-2019-003] will **precisely measure the arrival time** of charged particles. It consists of barrel (BTL) and endcap (ETL) using different technologies, i.e. LYSO+SiPM and LGAD silicon sensors, respectively. It will improve the rejection of particles from simultaneous collisions, and allow particle identification.

The LIP group leads the design, production, and validation of the BTL front-end electronics with the development of a **high-performance ASIC**, TOFHIR2, for sensor readout.

- TOFHIR2, a 32-channel ASIC, was produced and tested successfully JINST 19 (2024) 05, P05048. Front-end electronics is fully produced and being validated

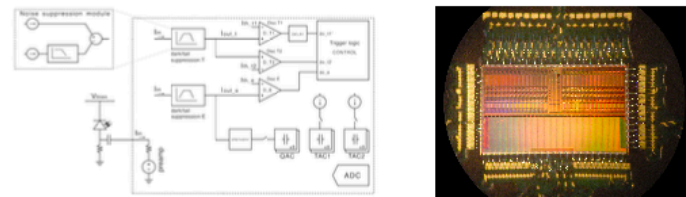


Figure 2. Block diagram of the TOFHIR2 channel (left); TOFHIR2 ASIC (right).

- Performance of BTL module prototypes studied in beams. A MIP time resolution of 28 ps measured for unirradiated devices [JINST 16 (2021) 07, P07023]
- Timing performance measured in beam test campaigns for prototypes with different construction and operation parameters [arXiv:2410.08738]

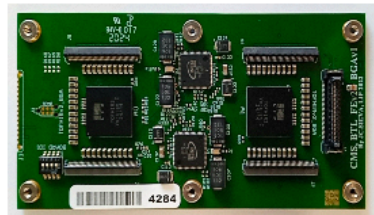


Figure 3. BTL front-end board (left); BTL time resolution vs integrated luminosity (right).


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LIP Summer Internships - Lectures and Tutorials

 Jun 4, 2025, 9:00 AM → Jul 10, 2025, 11:30 PM Europe/Lisbon

 Francisco Neves (LIP Coimbra) , Helena Santos (LIP) , Inês Ochoa (LIP) , Luis Margato (Laboratório de Instrumentação e Física Experimental de Partículas) , Raul Sarmento (LIP) , Sofia Andringa (LIP)

Description LIP Lisbon: Seminar Room (3rd floor) - LIP

LIP Coimbra: Sala E.3, Physics Department, University of Coimbra, Coimbra

LIP Minho: Sala do LIP, Ed. 3 - 3.02, Campus de Gualtar, University of Minho, Braga

Zoom link (for general lectures):

<https://videoconf-colibri.zoom.us/j/9339297238>

Fort tutorials, see link under the session in the agenda

Recordings: [aquí](#)

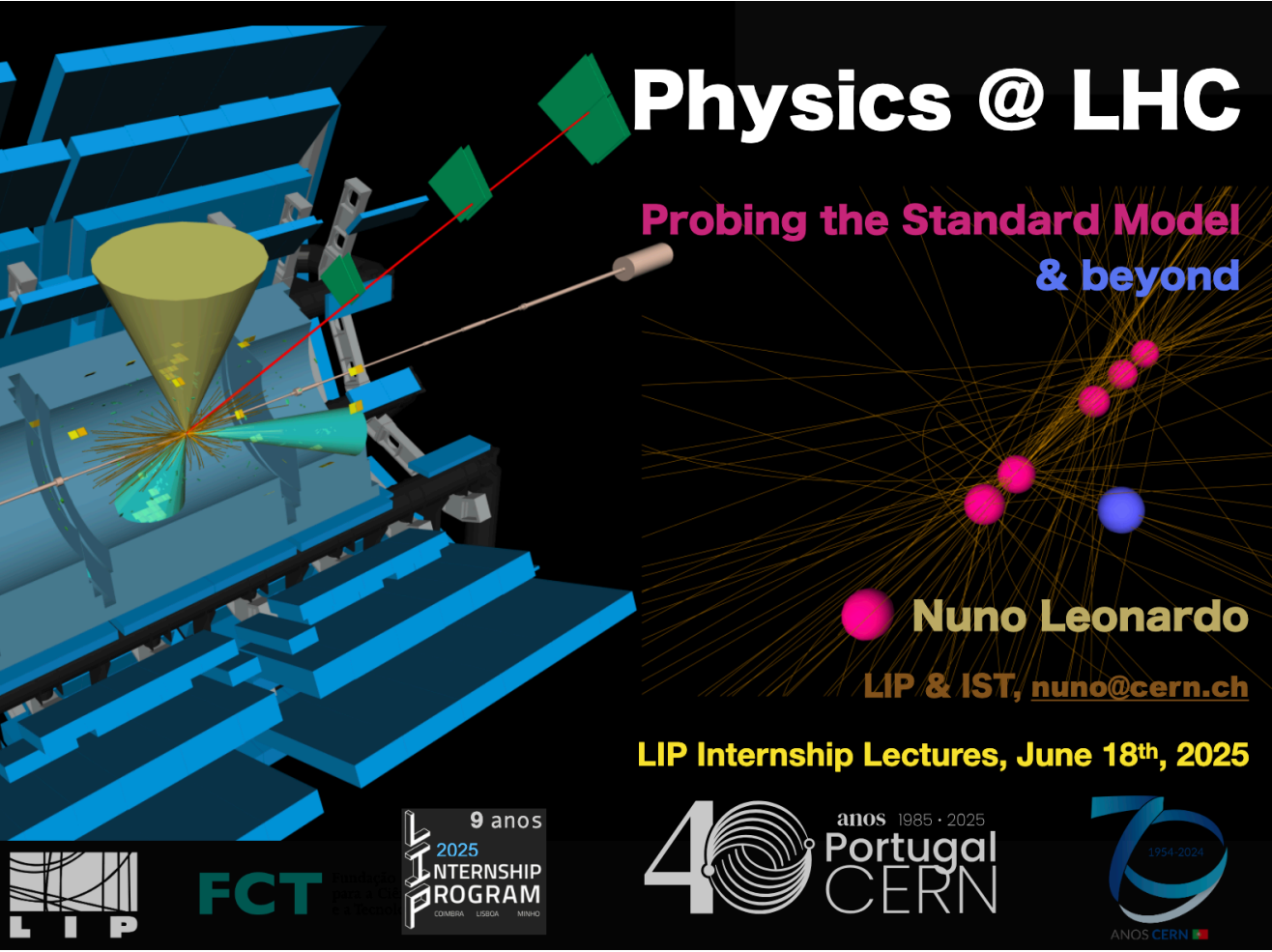
Introduction to Particle Physics

LIP Summer Internships

Joao Varela

LIP, Lisboa

Tutorial on Data Analysis



LIP internship program, 2025

LIP Summer Internship - Final Workshop

 Sep 4, 2025, 9:00 AM → Sep 5, 2025, 6:00 PM Europe/Lisbon

Description Seminar Room, 311 @ Lisbon / Room D19A @ Coimbra

To connect to the sessions remotely use the Zoom link

<https://videoconf-colibri.zoom.us/j/98665021075?pwd=a00enfElVoaqbEu63DOCZerIGrWkbl.1>



Your reports

