

# **SATLAS** Group Report









TÉCNICO UNIVERSIDADE D LISBOA COIMBRA



# **TileCal Operations Activities**

We are a strong group with many leading contributions in different TileCal activity areas

#### Leadership positions

- Full responsibility on the DCS system (F. Martins)
- Leading Data Preparation group (H. Santos)
- Phase II Performance Studies (R. Pedro)
- Run Coordinator (M. Kholodenko, Nov 24-April 25)

#### Leading contribution to

- Cs calibration (production & analysis of calibrations)
- Laser calibration (production & analysis of calibrations)
- Ageing studies: <u>arXiv 2412.16944</u>

# TileCal's status for 2025 data taking from DCS view



#### TDK AC/DC power supply user interface



# **TileCal Operations Activities**

We are a strong group with many leading contributions in different TileCal activity areas

#### Leadership positions

- Full responsibility on the DCS system (F. Martins)
- Leading Data Preparation group (H. Santos)
- Phase II Performance Studies (R. Pedro)
- Run Coordinator (M. Kholodenko, Nov 24-April 25)

#### Leading contribution to

- Cs calibration (production & analysis of calibrations)
- Laser calibration (production & analysis of calibrations)
- Ageing studies: <u>arXiv 2412.16944</u>



#### Glance

# **Forward Detectors & Computing**

#### **Forward Detectors**

#### ALFA:

DCS integrated with AFP DCS system

#### AFP DCS:

- Co-coordination (L. Seabra)
- AFP DCS expert on-call shifts
- AFP DCS maintenance and support during data taking
- Software upgrades (drivers, Alma9, etc)
- Automatic TDAQ chain reset in AFP DCS between fills

#### **Distributed Computing** H. Wolters ES-Cloud coordination • 4% of all ADC resources (5% in 2025?) • Efficiency above 90%. LIP's Tier-2 NCG-INGRID-PT running stable fulfilling pledges • 4% increase in comparison with 2023. • Key grid middleware services upgraded New 100Gbps network connection New authentication & authorization systems ATLAS Computing Run Coordination and Monitoring of Sites and Central Services

 Focus on automatization of services and monitoring



#### Product Management of the

#### development team (G. Pinhão)

- Constant functionality
  - improvements in all the

systems

Software migration

#### Presentation at CHEP24



#### **Operations:**

Coordination roles:

- HLT Jet Signature group (Inês Ochoa, 2023-2024)
- HLT Calo group (Nuno Fernandes, 2024-present)



#### Upgrade: HLTCalo GPU demonstrator

- Only Phase II project ready for deployment at Point 1! Full responsibility of the LIP team
  - Factor 6-10 improvement in execution time
    - But 80% of the time spent in data conversion&transfer!

#### Marionette:

 New generic GPU-friendly Event Data Model implemented Results presented at CHEP2024

#### Plans for 2025:

- Two publications in preparation
- Port data preparation and cluster calibration steps
- Deploy Marionette (cells, clusters classes)



# Upgrade of the TileCal High Voltage Distribution System



# TileCal High Voltage Upgrade

#### HVbus boards pre-production started



Testing of connectivity ongoing



#### 100 units produced





Production Readiness Review of HVbus board by mid-May (production later this year) Production of prototypes of **HVsupply, HVremote** 

and interface boards ongoing





HV interface board

HV supply board

#### HV cables final prototypes

Development and production with PT branch of General Cable



Pre-productions of cables and boards will start in summer

Testbeam at CERN – integration of prototypes and software

In collaboration with LIP's Electronics and Detectors Labs

# **High Precision Timing Detector**

#### **Electronics**:

- HV patch panels/filters
- Front-end chip performance and Total Integrated Dose

#### Luminosity & DCS:

- Interlock: LIP responsibility
- DCS: HV power supply monitoring
- DCS: monitoring of CO2 temperature

#### Infrastructure:

- Production of HV cables and pigtails
- LV cables under discussion

#### Preparing Quality Control of delivered parts Entering final reviews and prototypes

Production next year

#### Producing prototypes for Demonstrator

#### Transfer module





#### Interlock tests @ CERN

# **Higgs Boson Measurements**

# **Heavy Ions Physics**



# **New Physics** Searches





#### Elastic Production V+X



Heavy Resonances Combination





#### Monotop searches



#### Anomaly detection

Train an auto encoder to learn SM background and take the reconstruction error as anomaly score HVT m<sub>v</sub>=700







2HDM+a (gg fusion) m<sub>4</sub>=500 m<sub>2</sub>=250 Monotop (scalar) ma=3000 mv=1 Monotop (scalar)  $m_{\phi}$ =5000  $m_{\chi}$ =1 Monotop (vector) my=1750 my=700

# **ATLAS PhD thesis Award**

## Ana Luísa Carvalho Feb, 2025



#### ttH measurements: cross sections, spin/CP, ttC



# **Breakthrough Prize**

## < ATLAS Collaboration

2025 Breakthrough Prize in Fundamental Physics

For detailed measurements of Higgs boson properties confirming the symmetry-breaking mechanism of mass generation, the discovery of new strongly interacting particles, the study of rare processes and matterantimatter asymmetry, and the exploration of nature at the shortest distances and most extreme conditions at CERN's Large Hadron Collider.



# LIP Group responsibility positions

- A. Gomes, TileCal HV Upgrade responsible person.
- F. Martins, TileCal DCS coordinator.
- I. Ochoa, Jet Trigger Signature coordinator (until June 2024)
- I. Ochoa, Spokesperson Reviewer for charged Higgs boson search paper
- I. Ochoa, contact editor for PUB note on WH(bb) CP measurement
- H. Santos, HGTD Interlock coordinator.
- H. Santos, TileCal Data Preparation and Performance coordinator
- H. Santos, member of the ATLAS Publications Committee
- H. Santos, chair of the ATLAS Authorship Committee
- H.Santos, Spokesperson Reviewer for

'Jet radius dependence of dijet momentum balance and suppression in Pb+Pb collisions at 5.02 TeV with the ATLAS detector'

- H. Wolters, coordinator of the Iberian Cloud.
- H. Wolters, responsible for the Portuguese Federated Tier2 in the Iberian Cloud Squad.
- H. Wolters, member of the ATLAS International Computing Board
- L. Coelho, analysis contact for the ttHH search paper.
- L. Seabra, AFP DCS co-coordinator, ALFA DCS responsible.
- M. Teixeira, analysis contact for the dilepton with AFP analysis
- N. Santos, HLT Calo co-cordinator.
- N. Castro, member of the ATLAS Physics Office and coordinator of the gitlab continuous integration team for the ATLAS publications.
- R. Gonçalo, HGTD Patch Panels coordinator
- R. Gonçalo, contact editor for the ttH(bb) CP paper
- R. Gonçalo, HGTD Speakers Committee
- R. Gonçalo, member of the CB Chair Advisory Board
- R. Pedro, TileCal HL-LHC Software and Performance Co-coordinator (since June 2023)
- R. Pedro, contact editor for the TileCal Run 2 Operation and Performance paper
- R. Pedro, contact editor for the TileCal Run 2 Optics Radiation Hardness paper
- R. Pedro, contact editor for the MonoTop Run 2 paper
- R. Pedro, analysis contact for the jet+MET anomaly detection analysis
- R. Pedro, ATLAS Contact in the DM t-channel white paper

# Remarks

Strong team with many young members (PhD/Master students)

- Important contributions to all fields of activity
- Collaboration with other LIP groups and national research centres
- Connection to many Universities in Portugal and international groups

Weaknesses:

Reduced number of postdocs

#### **Opportunities**:

Exploit collaboration with industry and R&D infrastructure for Upgrade activities

#### Threats:

- Loosing outstanding students after Master due to lack of funding or adequate PhD funding programmes
- Delicate human power situation (technicians, postdocs)
- Unstable funding

# Thanks!

### Acknowledgments:





# Backup

# Operations

#### **Tile Calorimeter DCS**

Main achievements during 2024

- Maintenance of control system
  - Successfully migration of control system to Alma 9 and WinCC 3.19 (detector, laboratories and test beam systems)
- Included an automatic recovery of tripped power supply after over-current event (with auto trimming over-current threshold)
  - · Decreases work load on shifters and operators
- · Main tools for on-call shifters integrated in finite state machine
- Included an expert User Interface for remote control of cooling station (test was delayed for next YETS)
- Quick response in the replacement of power supply failures during night time leading to low downtime of the detector
- User-friendly training for on-call shifters
  - Procedures have been consolidated over the years

DCS for High Lumi-LHC

- · Good understand of the control issues with HV-Supply (upgrade HV) and interface board
  - · Allowed to run the test beam seasons with reliable system and learn from "acidents"
- First prototype for OPC UA for HV crates
  - Included the initial control of an EEPROM to store calibration values and serial number for HV Remote boards
- Manage to connect the TDK Lambda AC/DC power supplies to WinCC using a OPC UA
  - The OPC was later changed and now is being tested

#### **Tile Calorimeter DCS**

Activities for 2025 data taking:

- Maintenance of actual control system
  - · Adjustments of automatic actions or user interfaces when necessary
- Provide training for the DCS on-call shifters
- Take on-call shifts
- · Replace hardware in counting room, due to failure or preventive replacement

DCS for High Lumi-LHC

- Development and/or test of the control software (OPC UA and WinCC OA component), for:
  - TDK Lambda AC/DC power supplies (1<sup>st</sup> prototype under use in laboratory)
  - High Voltage (HV) Remote crate control (tests ongoing)
  - Laser system used for calibration of TileCal (on-going and pending tests)
- Continue the development of QA system for DC-DC low voltage power supplies
- Integration of the LV and HV control components into single WinCC OA system to control the on- and off-detector electronics
  - Aim to have prototype for July's test beam



TileCal's status for 2025 data taking from DCS view



TDK AC/DC power supply user interfac

## **TileCal Laser and Caesium Calibration**

M. Kholodenko, B. Pereira, R. Pedro

- Caesium calibration
  - Responsible by the acquisition scans and calibration calculation

- Laser calibration
  - PMT calibration and monitoring during 2024 data taking
  - Laser calibration of 2022+23 TileCal luminosity measurement
  - Study of new PMT model for Phase II upgrade





#### **TileCal Radiation Hardness and DQ automation**

- Run 2 Radiation hardness study
  - Accepted for <u>publication</u> by JINST
- Exploring Machine learning for the automation of DQ monitoring
  - Using Tier-0 DQ histograms daily analysed by shifters

#### A. Berti, B. Pereira, R. Pedro

#### Data Preparation Coordination of TileCal - LIP responsibility

#### Data Preparation and Performance

#### Calibrations

Cesium, Minimum Bias, Laser, and Charge Injection Systems

#### Databases

COOL and CONDBR2 to manage calibration constants, conditions data, and Data Quality flags

#### Performance

Electromagnetic scale uniformity and validation; Signal reconstruction; E/p analysis

#### Data Quality

Daily monitoring of the full calorimeter to identify and address issues affecting data integrity immediately

## **ATLAS Distributed Computing**

- ES-Cloud:
  - Tier-1 in Barcelona and Tier-2s in Valencia, Barcelona, Madrid, Lisbon, São Paulo and Santiago de Chile
    - ES-Cloud TIER-1 and TIER-2s offer 4% of all ADC resources and strive to reach 5% in 2025.
    - The efficiency for all sites except one is above 90%.
- LIP's Tier-2 NCG-INGRID-PT running stable fulfilling pledges
  - 4% increase in comparison with 2023.
  - several key grid middleware services were upgraded.
  - now connected to the LHC Open Network Environment (LHCONE) via a dedicated 100Gbps network connection and full IPv6 connectivity
  - The new token based authentication and authorization system was deployed.
- ATLAS Computing Run Coordination and Monitoring of Sites and Central Services
  - Lack of manpower for ADC requires continuous efforts for automatization of services and monitoring
  - Ongoing transition to a new issue tracking system, documentation and helpdesk
  - LIP is contributing by organizing the Computing Run Coordination Shifts and developing maintenance and development of monitoring tools

#### Membership

**Speakers** 

and speakers

ATLAS members, institutes, employments, qualifications and author lists



sant

Upgrade Institute Representatives

No Upgrade institutes have been registered thus far

a 🖛 🖬 Lgenesis -

🔤 The GLANCE Project 🛛 🕯 report an iss

#### **Appointments**

ATLAS appointments and categories



#### Nominations/Activities

ATLAS nominations for speaker selection done by activity groups

| PCI Spilopene  | 57KE - Spokesperson                     | 100                    |
|--|---|------------------------|
| <ul> <li>IPD lipper</li> </ul>                                 |   |                        |
| <ul> <li>PC-Paraclastine</li> </ul>                            | Deception                               | S can specified on our |
| 9279 - 927   | Ten.                                    |                        |
| <ul> <li>TOR, -Tile Colorination</li> </ul>                    | Neigenet                                |                        |
| <ul> <li>TDAD - Trigger and Data Association (TDAD)</li> </ul> | Moved Actions                           |                        |
| PR2-Paul   |   |                        |
| 302-30   | Reparatio Applications                  |                        |
| MillS - Repairs  | # Depity Springerson 11                 |                        |
| <ul> <li>D3 - inscholar Several</li> </ul>                     | #KALOw E                                |                        |
| <ul> <li>FBIT - Funned Detectors</li> </ul>                    | #1041bph/dw II                          |                        |
| TEX - Indexing constitution                                    | metal laposki spormets                  |                        |
| NNN- Ran Coordination  | Additional Reportable Mandam            |                        |
| MST -than Specimenter  |   |                        |
| <ul> <li>UAD - Spatchger Calministr</li> </ul>                 | Interlied Additional/Reguradite Manders |                        |
| 100-Tisar  |   |                        |
| DAM - Data Presentar   |   |                        |
| SOIL-NOA   |   |                        |
| CONF-Software and Computing                                    |   |                        |
| Di Geni  |   |                        |
|  |   |                        |
|  |   |                        |

#### ATLAS Publication Tracking

ATLAS Conferences, talks

Analyses, Papers, CONF notes, PUB notes and PLOTs



#### CBM

#### Collaboration Board meetings and its attendees

| 4 ATLAS | F #TUS V 1 Collaboration Board Heatings V 1 Desires  |             |          |                               |   |  |        |  |
|---------|--|-------------|----------|-------------------------------|---|--|--------|--|
|         |  |             |          |                               |   |  | Chapin |  |
| a ceun  |  |             |          | O Calendar                    | E NORT  | - Hereit des   |        |  |
|         | The composite start and a  | 100,000,000 |          |                               | 1001001   |  |        |  |
|         | 10kh ful densite fixed Methy   |             |          |                               |   |  | - C    |  |
|         | within the second s | holes on an | 12.24.44 | (114                          | Alate and   | the second  |        |  |
|         | 1983 Full doction front literation   | 10/2 10 10  | 1100.00  | 100                           | 2007.001  | The shake as have 1 have   | - C    |  |
|         | 100-b Californian Read Mania   | 1000-04-30  | 1100.00  | Automation (1973)200          |   | hours of body a second barren 1 187 181 (  |        |  |
| -       | 1880 Californian Inset Harriss   | 2025-02-17  | 123000   | 005                           | 536-5-881   | International Contemport of Contemport   | - C    |  |
|         | Extractionary Collision Street Martine   | 1000.10.01  | 111000   | Anna A                        |   | March 1997 Barrier Barrier Barrier   |        |  |
|         | 10 hot Call description Record Marchine  | 1002-02-14  | 14.00.00 | Delements of Linkson          | And Manual  | https://www.charles.com/charges/1100014/   |        |  |
|         | formation of all description from the second second  | 2000.00.07  |          |                               | Jacob Contraction of | terre allering and the second state of the   |        |  |
|         | 18 bol Fallabaching Road Medica  | 1272-04-34  | 111000   | 798                           | 2003-001  | International Control of Control  |        |  |
|         | External and Collector size Read Meeting   | 1000-06-08  | 10.00.00 |                               | Terr  | hours all advances of the set of 1 all 1111  |        |  |
| -       | Extraction violateuring Road Martine   | 2022.04.64  | 124140   | 004                           | 536-5.491   | Interview of the second state of the second st | - C    |  |
|         | 1814 Collideration Read Marboo   | 12010-00-73 | 114100   | Aug.                          |   | Inter studies and the second statement   |        |  |
|         | 100hb Call download Read Manufact  | 2000-222-22 | 14.00.00 | (114                          | 100.0.001   | https://www.charlos.com/charges/2004110/   |        |  |
|         | Why Callaboration Reard Meeting  | 2025-02-02  | 1400-00  | June .                        |   | Interview of the second state of the second st |        |  |
|         | NWO Full-should be Road Medical  | 120.00.11   | 14 85 85 | Aug.                          |   | Table - Made - And - Robert March 11   |        |  |
|         | White California Record Mant law   | 2008-22-24  | 1400.00  | here                          |   | have checked as one of leases \$11,000.  |        |  |
| -       | Nith Californiat Road Hostins  | 2028.06.34  | 1400-00  | Just.                         |   | Interview and the second second second second  | - C    |  |
|         | With Full documents Read Meeting   | 1222-02-28  | 1100.00  | (11)                          | 2002.001  | March Market Street Str |        |  |
|         | Mith Californian Roard Heating   | 205/9-10-11 | 1340-00  | Lanamients Vindore Heave      | Lenner Rei L.L. Bre Seel  | Internal Conference on Automatic Television  |        |  |
|         | White California and Insent Manzing  | 2055-06-21  | 120000   | 000                           | 100-1-001   | International Contemport of Contemport   |        |  |
|         | Kind Collaboration Board Meeting   | 2052-00-13  | 13.80.00 | 009                           | 100.3 (87)  | Nacondocorrowwww.mc.mc   |        |  |
|         | Non Orlightentian Based Hereing  | 2058-12-13  | 1340.00  | 0558                          | 100-3-003   | Internal Conference on Advantage 177285  |        |  |
|         | NPC Californian Roard Marries  | 2018-06-15  | 10.0000  | North Intention               | Manary Rules Budinarium, International Cardinanas Carter  | International Contemport And April 1984  |        |  |
|         | END-Databaration Board Meeting   | 2058-00-23  | 11.00.00 | 009                           | 200.3-073   | Maccinetracion de March 17276/   |        |  |
|         | Bibly Californian Roard Heating  | 2017-10-13  | 1340-00  | Heart Course Plans, Buttalana | Ream Landary  | https://www.schimestimity/   |        |  |
|         | KNY- Culture and a feart Marries   | 2182.66.23  | 120000   | 004                           | 536-5.881   | Interview and the second state of the second s |        |  |
|         | and the second second  |             |          |                               |   |  |        |  |

# **Trigger Operations**



- Coordination roles:
  - HLT Jet Signature group (Inês Ochoa, 2023-2024)
  - HLT Calo group (Nuno Fernandes, 2024-present)
- New in 2024:
  - **Legacy** L1 trigger system has finally been disabled.
  - HLT jets successfully completed migration to new Phase-I system.
- Expected in 2025:
  - HLT Large-R jet triggers will use dedicated L1 inputs, more robust across different substructure metrics.
  - On-going at LIP: R&D for new pile-up robust algorithms for multi-jet triggers.

Higher efficiency of Phase-I system due to higher granularity: allows for better resolution of close-by jets.

Feature extractors to process information



# FWD DCS

Activities in 2024:

- Integration of the ALFA vacuum system in AFP DCS
- Migration of the PLC S7 driver items to S7 Plus driver
- Automatic TDAQ chain reset in AFP DCS to be used between fills
- AFP DCS expert on-call shifts
- AFP DCS maintenance
- Lab system migration to Alma 9
- DCS support/tests during debugging camping for VregBoards and controllers malfunctioning doe to raciation damage

Activities for 2025:

- Continuation of the DCS support/tests during debugging camping for VregBoards
   and controllers malfunctioning doe to raciation damage
- AFP DCS expert on-call shifts
- AFP DCS maintenance

# Upgrades

#### The Interlock of the High Granularity Timing Detector - LIP responsibility





The ILK-FPGA is the central decision unit in LISSY responsible for controlling the LISSY outputs based on the sensor and DSS inputs.



The MON-FPGA is responsible for the monitoring of all parameters which are required to debug an interlock event.

Development of the WinCC project for DCS-Interlock monitoring

Master students Rui Vieira and Alexandre Parreira (FCUL) configure the FPGAs

#### The Interlock of the High Granularity Timing Detector - LIP responsibility

The **Transfer Module** in the Main interlock Crate propagates the signals from ATLAS Detector Safety System to the FPGA Interlock Matrix



Master student Maria Miguel Cruz (U. Coimbra) developed this project

# **High Granularity Timing Detector**

#### LIP involved in several HGTD work packages:

Electronics (with Electronics and Detector Labs):

- HV patch panels/filters
- Front-end chip performance and Total Integrated Dose

Luminosity & DCS (with Electronics Lab):

- Interlock: LIP responsability
- DCS: HV and LV power supply monitoring
- DCS: monitoring of CO<sub>2</sub> temperature

Infrastructure (with Detector Lab and Mechanicsl Workshop):

- Production of HV cables and pigtails
- LV cables under discussion

Also producing tools for Quality Control of delivered parts Entering final reviews and prototypes - production phase next year Producing prototypes for Demonstrator



Chemit) Chemits Chemits Chemits Chemits Chemits Chemits Chemits Chemits Chemits Chemits

#### **HGTD DCS**

٠

٠

- Development of monitoring crate back-plane to monitor the temperature probes installed in the HGTD cooling system
  - System based on the CERN's Embedded Local Monitoring Board
  - Development of WinCC test system to test boards and probes
- Integration of the high voltage crates with WinCC OA
  - Development of WinCC OA data structure and user interfaces
  - Initial tests were done using the crate's prototype and it was provided feedback to company
  - Ongoing integration of 2<sup>nd</sup> prototype with the requested changes to the company
- Provide expert assistance/guidance in other parts of the HGTD DCS

|                               | Module 1 Module 2 Module 3 Module 4 Modu  |
|-------------------------------|---|
| on_air                        | Module1                                   |
|                               | NOT_READY                                 |
|                               | Ulah Velkara Shakur                       |
|                               | High voltage status CONFIG                |
| Settings                      | Cable Status                              |
| Actual Over-voltage limit 688 | Channels                                  |
| Actual Temperature Limit 60   | Voltage 0.0 V Channel 1                   |
| Set Protections               | Voltage 0.0 V Chappel 2                   |
|                               | Current 0.0 uA                            |
|                               | Current 0.0 V Channel 3                   |
|                               | Voltage 0.0 V Channel 4                   |
|                               | Current 0.0 uA                            |
|                               | Voltage 0.0 V Channel 5                   |
|                               | Voltage 0.0 V                             |
|                               | Current 0.0 uA                            |
| Fun Status                    | Voltage 0.0 V Channel 7                   |
| Fan1 2337.00 rpm              | Voltage 0.0 V                             |
| Fan2 2251.00 rpm              | Current 0.0 UA                            |
| Fan3 2268.00 rpm              | Voltage 0.0 V<br>Current 0.0 UA Channel 9 |
| Fan5 2243.00 rpm              | Voltage 0.0 V                             |
| Fan6 2253.00 rpm              | Current 0.0 UA Channel 10                 |
|                               | Voltage 0.0 V Channel 11                  |
|                               | Voltage 0.0 V                             |
|                               | Current 0.0 uA Channel 12                 |
|                               | Voltage 0.0 V Channel 13                  |
|                               | Voltage 0.0 V                             |
|                               | Current 0.0 uA Channel 14                 |
|                               |   |
|                               |   |



# HV integration in DCS – User interfaces

- Current Uis are based on first version
  - Crate and modules
  - · Crate and channels setup
  - On/Off







#### Module navigation

# Configure all channels in module

#### Channel Reading &Operation



# **Calorimeter Reconstruction on GPUs**

The only Phase II Trigger GPU project ready for deployment tomorrow (if needed)!

#### Full responsibility of the LIP team

- All the cluster reconstruction ported to GPUs
- 100% agreement in cluster reconstruction
- Few differences in cluster properties calculations
  - Mainly due to floating point exceptions&cuts
- Factor 6-10 improvement in execution time
  - But still 80% of the time spent in data conversion&transfer!

#### Marionette:

- New generic Event Data Model GPU-friendly
  - Fully developed
- Will avoid data conversion time

#### Plans for 2025:

- Port data preparation and cluster calibration steps
- Deploy Marionette (cells, clusters classes)



# Physics

# **Higgs coupling to top quarks**

Most precise ttH cross-section single channel measurement

# Phys. Lett. B 849 (2024) 138469

#### Eur. Phys. J. C 85 (2025) 210





# By-product: measurement of ttc production

#### Phys. Lett. B 860 (2025) 139177



# Higgs coupling to W bosons

Beyong SM physics may modify the HWW interaction

- Possible CP-even:  $c_{HW}h^{\dagger}hW^{I}_{\mu\nu}W^{I\mu\nu}$
- CP-odd couplings:  $c_{H \tilde{W}} h^{\dagger} h \tilde{W}^{I}_{\mu \nu} W^{I \mu \nu}$

Up to now: focus on the CP-odd component

SMEFT formalism

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \sum_{d>4} \sum_{i} \frac{c_i O_i^{(d)}}{\Lambda^{(d-4)}}$$

$$|\mathcal{M}|^{2} = |\mathcal{M}_{SM}|^{2} + \frac{c_{H\widetilde{W}}}{\Lambda^{2}} 2\Re \left( \mathcal{M}_{O_{H\widetilde{W}}}^{*} \mathcal{M}_{SM} \right) + \frac{c_{H\widetilde{W}}^{2}}{\Lambda^{4}} |\mathcal{M}_{O_{H\widetilde{W}}}|^{2}$$



# **Higgs coupling to W bosons**

#### Best observables



M. Kholodenko's PhD thesis (ongoing) R. Barrué PhD thesis (finishing writing) B. Rosalino's Master thesis (done)

#### STSX WH(bb) measurement: arXiv:2410.19611

Constraints on CP-odd HWW couplings:

PubNote under approval

0.4

Combination paper in preparation

Among the best limits for this coupling!



37

#### b-jets in Heavy lons

In Pb+Pb collisions a new state of matter is created - The Quark-Gluon Plasma, matter in the first micro-seconds of the universe



the state of

Jets are suppressed and those surviving are modified when crossing the QGP

We can infer the properties of the QGP by studying this modification - In particular the jets that originate in the bottom quark (b-jets) are very interesting probes



The GN2 flavour-tagging algorithm (2nd generation Graphical Neural Learning) is a new approach which uses a graph neural network to predict the jet flavour taking as inputs the individual track parameters and their uncertainties together with the jet kinematics. The focus is to evaluate the ability of the GN2 tagger to differentiate and consequently identify the flavour of the jets produced in Pb+Pb collisions. Pedro Esperanço's Master thesis ongoing

GN2 at 70% working point (tt events in pp collisions): light-jet and c-jet rejection improve by factors of 2 and 3, respectively, compared to DL1d.

#### GN2 - Testing the implementation of a batch normalisation layer

Master thesis of Pedro Esperanço (IST)



- Batch normalization consists of normalizing the interlayer outputs of a neural network.
- It helps reducing the effect of updating the previous layer's parameters on the current layer (internal covariant shift).
- Can help stabilizing the training process, leading to faster convergence.

# Anomaly Detection in all-hadronic final states

- M. Barros, A. Berti, N. Castro, R. Pedro, I. Moreira, I. Pinto
- Analysing final states with a boosted large-R jet and missing energy
  - Sensitive to a wide class of BSM models (SUSY, Heavy Vectors, Simplified DM, 2HDM, ..)
- Machine learning models trained with SM Monte-Carlo to detect new physics phenomena in data as anomalies
- Explored adversarial training for uncertainty mitigation and graph representation of jets





## Missing Mass Search in Proton-Tagged Dilepton Events with AFP



## **Heavy Resonance Combination**

I. Ochoa: analysis contact in fully hadronic channel

- Combination of searches for new heavy spin-1 resonances, in their decays to bosons (VV,VH), pairs of leptons and quarks
  - $\circ$  WZ $\rightarrow$ qqqq, qqvv, lvqq, qqll, lvll; WW $\rightarrow$ qqqq,lvqq
  - **\*WH→qqbb**, lvbb; **\*ZH→qqbb**, vvbb, llbb
  - II, Iv (including  $\tau v$ ,  $\tau \tau$ )
  - qq, bb, tt fully hadronic, tb
- Large range of V' masses, different production modes and coupling preferences (to SM bosons vs SM fermions).
- Published in <u>JHEP 04 (2024) 118</u>

#### \*WH and ZH analyses by LIP



Exclusions for a heavy vector-boson triplet with mass below 5.8 TeV in a weakly coupled scenario, and below 4.4 TeV in a strongly coupled scenario, and up to 1.5 TeV in the case of production via vector-boson fusion.