

## COLLABORATION AGREEMENT

### IN2P3 - COPIN

#### I. Identification of the laboratories

Partner	COPIN
IN2P3 laboratories	LAPP
Partner laboratories	Cracovie (IFUJ)

#### II. Identification of the collaboration

Title of the collaboration	Precision measurements with W and Z events in the first phase of the LHC
Number of the collaboration	11-142
IN2P3 spokesperson	L. DI CIACCIO
COPIN spokesperson	E. RICHTER-WAS
Scientific Domain	Hadronic and Particle Physics

#### Status of the collaboration

Status	The renewal of the collaboration is requested for the period January 1st - December 31st, 2023
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#### III. Status report for the period January 1st to December 31st, 2022

##### III.1 IN2P3 scientists in COPIN

Total time approved for 2022	10
Total time used for 2022	0
List of scientists	

##### III.2 COPIN scientists in France

Total time approved for 2022	10
Total time used for 2022	0
List of scientists	

##### III.3 Scientific results of the above-mentioned collaboration

Description	
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During the last few (pandemic) years the members of the present IN2P3 agreement have pursued analyses leading to precision measurements with single W, Z and diboson WZ final states, using the full 8 TeV (for single boson) and 13 TeV (for diboson) datasets collected by the ATLAS detector at the LHC. The common aim was to extract information on the polarisation of these bosons as a tool to investigate the nature of the production process of single boson or diboson states and the electroweak symmetry breaking mechanism.

For single Z boson production, the novel technique of the measurement of the fully inclusive  $A_i$  coefficients (polarisation coefficients) published in JHEP 08 (2016) 159, has been extended to the measurement of the weak mixing angle,  $\sin^2 \theta_W$ , published in ATLAS-CONF-2018-037 and to the  $A_i$  measurement in W boson production (analysis in progress using 8 TeV data). The measurement of the Z boson transverse momentum spectra (analysis in progress with the 8 TeV and 13 TeV LHC data) is also being pursued.

Thanks to the effort of the members of the present IN2P3 agreement, in WZ production, single boson polarisation measurements were published in 2019 in Eur. Phys. J. C 79 (2019) 535, based on a partial dataset of the 13 TeV data. A new analysis of the WZ production was developed by the members of the present IN2P3 agreement using multivariate techniques and extended to the full 13 TeV dataset and was published in 2022 in ATLAS-CONF-2022-053. This publication, which is the thesis subject of the LAPP student, Luka Selem and includes measurements of the joint helicity fractions of W and Z bosons integrated over the fiducial region, will appear soon in a peer-reviewed journal.

Joint helicity fractions of W and Z bosons were never measured before, and represent an important milestone in the process of achieving a better understanding of the EWSB.

In this paper individual helicity fractions of the W and Z bosons are also measured and found to be consistent with joint helicity fractions within the expected amount of correlations. Both the joint and individual helicity fractions are also measured separately in  $W^+ Z$  and  $W^- Z$  events.

## IV. Renewal of the collaboration for 2023

### IV.1 Proposed scientific program

Description
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In 2023, the ATLAS data taking at the Large Hadron Collider with 13.6 TeV will continue (Run 3) in parallel with the finalisation of precision Standard Model measurements using the 8 TeV and 13 TeV datasets.

In addition to pursuing measurements of the polarisation state of the W and Z bosons, the work plan foresees the finalisation of the measurement of the vector boson scattering cross section in WZ events. New analyses including an extended set of differential distributions will be also performed with the aim of extracting limits on anomalous gauge couplings or on the coefficients of an operator expansion of a BSM Lagrangian in the context of an Effective Field Theory. These studies represent an important way of accessing beyond SM effects, in a way that is largely model independent.

The exchange of expertise between the French and the Polish colleagues is very important for the success of this program. A very relevant aspect of the collaboration in the past is represented by the regular visits of LAPP PhD students at IF UJ (A. Burger and L. Portales) and the participation of the project coordinator (E. Richter-Was) in committees for thesis defenses of LAPP students (L. Selem in 2022).

### IV.2 Estimated duration for IN2P3 scientists in COPIN

Total time requested for 2023	10
List of scientists	1. Emmanuel Sauvan (5 days) 2. Leo Boudet (5 days)

### IV.3 Estimated duration for COPIN scientists in France

Total time requested for 2023	10
List of scientists	1. Elzbieta Was (10 days)

Comment Validation	
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