**Template JRA**

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| **Work package number** | WP19 | **Start date** | 01/06/2019 |
| **Activity Type** | Joint Research Activity | | |
| **Work package acronym** | JRA1-LHCCombine | | |
| **Work package title** | Inter-experiment combination of heavy-ion measurements at the LHC | | |

# Work carried out and overview of progress

* 1. **Project objectives**

*[Please give an overview of the project objectives for the third reporting period (June 2022 – July 2024), with regard to the overall objectives as described in the Annex 1 of the Grant Agreement and summarized below.]*

The first (2010-12) and second (2016-18) runs of the Large Hadron Collider at CERN provide a wealth of results from heavy-ion collisions.

The four large LHC collaborations, ALICE, ATLAS, CMS and LHCb, contribute to this programme with very different and complementary capabilities, both in terms of angular coverage and particle identification. The aim of this WP is to improve communication between the four collaborations in the heavy-ion field, and establish an LHC data-combination working group. These objectives can be split into two tasks: the animation of a common forum (task 1) to ensure a regular communication between the four collaborations; and cross-experiment combination work (task 2), such as detailed comparisons of techniques or optimized statistical combination of results, leading to common publications.

* 1. **Progress made during the reporting period towards the objectives**

*[Please describe the progress made during the third reporting period in line with your Gantt chart and the project overall tasks as described in the Annex 1 of the Grant Agreement and summarized below.]*

***Table 1.2 Progress made during the reporting period for each task***

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| --- |
| ***Task 1: Creation of a forum to guarantee a regular communication of information between the four collaborations*** |
| Done during period 1, a mailing list of 120 people exists and 18 meetings occurred, four of them in the current reporting period.  Moreover, during period 2, a heavy-ion working group was created within the LHC Physics Center at CERN (<https://lpcc.web.cern.ch>) upon the initiative of the WP19 spokespersons (who, together with two theorists and an extra person from each collaboration, acted as first conveners of the this officialized activity). This new group insures **the perennity of the WP19 activity** beyond Strong-2020, and it can also be used when official endorsement is needed from the collaborations. The legitimacy of coordinating the activities started within the current work package now falls in that group.  During period 3, two of the collaborations rotated the convenership and new individuals were identified to steer the group. It is worth noting that the group was not very active during the reporting period, probably because a) there was no burning issues, b) people are very busy within their collaborations, c) some work was still going on within the current WP. However, the group exists and can be summoned when needed. |
| ***Task 2: Comparisons of techniques or optimized statistical combination of results. Examples :***  ***• Constrain nuclear parton distribution function (nPDFs)***  ***• Light-by-light scattering***  ***• Open charm cross sections***  ***• Quarkonia et al topics***  ***The activity will start by hiring one postdoctoral position per each experiment, for 12-18 months. The postdoctoral fellows will thus spend continuously, during three years, a third of their time on cross-experiment projects, the two other third being used to convey work in their collaboration.*** |
| All of the above-mentioned examples were discussed in meetings. The first one (nPDF) was judged not worth starting a working group, since fitters already exist and incorporate new data in nPDF sets. The two others (open charm cross section and quarkonium feed-downs) were identified as a priority, and subgroups are working on combining data. Other topics were also reviewed (top quarks, jets…) and one of them (light-by-light scattering) was identified as a third priority. During period 3, new topics were discussed (electroweak bosons, ditau…) Global observables were also discussed: centrality and high multiplicity. Additional ideas emerged: listing and solving tensions in published results; producing and endorsing comparison plots.  After having been delayed for several administrative and sanitary reasons, the hiring of postdocs occurred:   * Florian Damas (from Alice) in CMS @ Polytechnique joined in Feb. 21 * Sándor Lökös in ALICE @ INP Krakow, started in Sep. 21 * Yuriy Volkotrub in ATLAS @ AGH UST Krakow, started in Nov. 21 * Jiayin Sun in LHCb @ INFN Cagliari, started in Sep. 21, hired before on other funds   Though not all of them were still paid by Strong-2020, they were mostly still active during period 3. |

**1.3 Highlights of significant results**

*[Include an overview of the project results towards the objectives in line with the structure of the Annex 1 to the Grant Agreement*.*]*

Holding 18 meetings is in itself an achievement (<https://indico.cern.ch/category/11797/>), with 20 to 50 people attending (none of them being paid by Strong-2020 for a long while). But creating the perennial LPCC working group can be seen as the first highlight.

Another highlight is that a first combination work) was terminated (individuals from ATLAS and CMS) with a parallel talk (<https://indico.cern.ch/event/895086/contributions/4703027/>) given at the Quark Matter conference, and an article (few authors) submitted to the preprint server:

* <https://arxiv.org/abs/2204.02845>

During period 3, a second combination work paper was terminated, and published (individuals from ALICE, CMS, LHCb and Theory). An invitation to present the result to the DIS conference was also received.

* *Eur.Phys.J.Plus* 139 (2024) 7, 593 ; <https://arxiv.org/abs/2311.11426>

Other work, including an advanced study on quarkonium feed-down fractions was kept internal.

# Critical Implementation risks and mitigation actions

## 2.1 Risk materialization

*[Provide the information on the project risks described in Annex 1 to the Grant Agreement*.*]*

1. LHC delays (low)

Whether the risk has materialized? (Yes) But the sanitary situation impacted more the group by preventing early meetings at CERN, than by delaying the LHC restart.

1. Lack of involvement of the collaborations in cross experiment work (medium)

Whether the risk has materialized? (Yes) Though the collaborations are generally favorable to the activity, individuals are legitimately too busy with their intra-collaboration work to spend time on inter-collaboration work. Moreover, the collaborations are naturally reluctant to let the work involving their members go without collaboration endorsement, even if based on available data. The first preprint mentioned above was not submitted to a peer-reviewed journal because one of the collaborations preferred us not to.

## 2.2 Risk-mitigation measures applied

*[Please indicate whether the risk-mitigation plan described in Annex 1 to the Grant Agreement and corresponding to the risk number was applied in the reporting period*.*]*

1. Though the recent history shows that LHC is now working in a steady mode, one cannot exclude an accident. Should this happen, the HonExComb work will focus on existing data, and adapt to the new schedule.

Whether the risk-mitigation plan was applied? (Yes) The first work was based on run 2 data.

1. We believe that one of the impediment to cross collaboration activity until now has been the lack of manpower, particularly in the “smaller” heavy ion collaborations. The HonExComb postdocs we ask for will be dedicated to the task and likely to entice others to contribute.

Whether the risk-mitigation plan was applied? (Yes) Though the Strong-2020 postdocs arrived much later than expected, they worked efficiently on the project. This being said, it was difficult to motivate others to work on the project.

## 2.3 Comments/new risk-mitigation measures proposed

*[Provide any significant comments on the risks encountered and the mitigation plan applied. Give any unforeseen risks encountered during the reporting period and not mentioned above*.*]*

No new risks were faced. And the risk-mitigation measures allowed to handle the situation in a reasonable way.

# 3. Deviations from Annex 1 (Description of Action) and Annex 2 (Estimated budget for Action) (if applicable)

**3.1 Deviations from planned objectives and tasks, and their impact on the progress of the work package**

*[Explain the reasons for deviations, the consequences and the proposed corrective actions.]*

No significant deviations from the planned objectives and tasks are observed. Two facts slowed down the work: a) the late hiring of our postdocs, b) the lack of global involvement within the collaboration.

**3.2 Deviations between actual and planned person months**

*[Explain deviations between actual and planned person-months. If applicable, propose corrective actions.]*

Same.

1. Deliverables and milestones tables

**4.1 Deliverables**

*[Please list all the deliverables due in this reporting period, as indicated in Annex I.*

*Deliverables must also be accompanied by a short report (deliverable description and technical documentation, such as photo, list of publications, etc.), so that the European Commission has a record of their existence.]*

***Table 4.1 List of deliverables***

| **Deliverable No.** | **Deliverable name** | **Lead Beneficiary** | **Nature** | **Dissemination level[[1]](#footnote-1)** | **Delivery month from Annex I** | **Delivered**  **(yes/no)** | **Actual delivery month** | **Comments** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| D19.3 | Cross-experiment papers | 1 - CNRS | Report | PU | 54 | yes | 54 | Three studies were pushed to an advanced level, one of them published (Nov 11), another one publicly released, the third one kept internal. |
| D19.4 | Outlook report paper | 1 - CNRS | Report | PU | 62 | yes | 62 | Though the legitimacy and responsibility of delivering such a document now falls within the LPCC working group, a short document is being prepared by the WG conveners. |

*In case a deliverable has been delivered in the reporting period and a report exists in the Participant Portal, you can indicate “uploaded report” in correspondence of a deliverable*

**4.2 Milestones**

*[Please complete the table if milestones are specified in Annex I.*

*Milestones will be assessed against specific criteria and performance indicators as defined in Annex I.]*

***Table 4.2 List of milestones***

| **Milestone number** | **Milestone name** | **Lead beneficiary** | **Delivery month from Annex I** | **Delivered**  **(yes/no)** | **Actual delivery month** | **Comments** |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |

**No Milestones in the RP3 (months 37-62)**

**4.3 Deliverable Reports**

*[Please provide, per each deliverable listed in Table 4.1, a brief description, including if possible some technical documentation (photos, list of publications, etc.). Use as many pages as needed per each report.]*

D19.3

* Light-by-light scattering cross-section measurements at LHC, G. K. Krintiras, I. Grabowska-Bold, M. Kłusek-Gawenda, É. Chapon, R. Chudasama, R. Granier de Cassagnac, <https://arxiv.org/abs/2204.02845>
* Open charm production cross section from combined LHC experiments in pp collisions at √s=5.02 TeV, Christian Bierlich, Jeremy Wilkinson, Jiayin Sun, Giulia Manca, Raphael Granier de Cassagnac, Jacek Otwinowski, Eur.Phys.J.Plus 139 (2024) 7, 593 ; <https://arxiv.org/abs/2311.11426>

D19.4

* To be released

1. PU = Public

   PP = Restricted to other programme participants (including the Commission Services).

   RE = Restricted to a group specified by the consortium (including the Commission Services).

   CO = Confidential, only for members of the consortium (including the Commission Services). [↑](#footnote-ref-1)