

Work package 1 summary

“Search for New Physics Signals at Belle II”

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WP1 tasks

Task 1.1: Detector performances assessment. Determine and optimize detector resolutions and efficiencies using real data, in order to provide precise inputs to physics analyses. Each sub-detector has to be studied both by itself and in combination with the others, thus requiring the collaboration of all sub-detector experts from different groups.

Task 1.2: Study of CP violation and search for new phenomena in rare decays. Physics analyses to test CKM matrix unitarity (measurement of $|V_{cb}|$ and $|V_{ub}|$ using leptonic and semileptonic decays; measurement of the angles of the CKM unitarity triangle, in particular the gamma angle), studies of rare B decays ($B \rightarrow X_s \gamma$; charmless hadronic B decays) and of rare charm decays are developed in this task.

Task 1.3: Lepton flavour and lepton universality violations. Hints for lepton flavour non-universality are currently seen in the $B \rightarrow D^* \tau \nu$ and $B \rightarrow X_s l+l-$ channels by the BaBar, Belle and LHCb experiments. These anomalies can be interpreted within various new physics models but require final experimental confirmation, for which Belle II measurements are essential. Lepton flavour violation is best tested in tau decays, where many channels can also be studied. Missing energy due to neutrinos requires in turn full event reconstruction to reject backgrounds.

Task 1.4: Dark sector and exotics. Production of the so called “dark photon” and of other Z-like or Higgs-like particles will be searched for. Limits on exotic processes including axions and WIMPS can also be improved. All such events require hermeticity and excellent control of machine and accidental backgrounds.

Task 1.5: Quarkonium Spectroscopy. This task aims at performing quarkonium spectroscopy in B decays, ISR and two-photon processes.

WP1 partners

| Partner number and short name ¹⁰ |
|---|
| 1 - INFN |
| 2 - DESY |
| 3 - OEAW |
| 4 - JSI |
| 5 - CNRS |
| 9 - UKP |
| 10 - IFJ PAN |
| 12 - TAU |
| 13 - METU |
| 18 - KEK |

WP1 milestones

May 2023

Done

| Milestone number ¹⁸ | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|--------------------------------|---|------------------|----------------------|--|
| MS1 | Report on detector performances | 1 - INFN | 24 | Belle II internal reports on detector performances |
| MS2 | Conference presentation on CPV | 3 - OEAW | 24 | Presentation to international conference of the preliminary Belle II results on CPV |
| MS3 | Conference presentation on LFV and LFUV | 2 - DESY | 24 | Presentation to international conference of the preliminary Belle II results on Lepton Flavour Violation and Lepton Flavour Universality Violation |
| MS4 | Conference presentation on dark sector | 3 - OEAW | 24 | Presentation to international conference of the preliminary Belle II results on dark sector searches |
| MS5 | conference presentation on spectroscopy | 4 - JSI | 24 | Presentation to international conference of the preliminary Belle II results on quarkonium spectroscopy |

WP1 deliverables

May 2025

| Deliverable Number ¹⁴ | Deliverable Title | Lead beneficiary | Type ¹⁵ | Dissemination level ¹⁶ | Due Date (in months) ¹⁷ |
|----------------------------------|-------------------------------------|------------------|--------------------|-----------------------------------|------------------------------------|
| D1.1 | Publication on detector Performance | 1 - INFN | Report | Public | 48 |
| D1.2 | Publication on CPV | 3 - OEAW | Report | Public | 48 |
| D1.3 | Publication on LFV and LFUV | 2 - DESY | Report | Public | 48 |
| D1.4 | Publication on dark sector | 3 - OEAW | Report | Public | 48 |
| D1.5 | Publication on Spectroscopy | 4 - JSI | Report | Public | 48 |

D1.1 : Publication on detector Performance [48]

Journal(s) publication(s) on detector performances and calibration

D1.2 : Publication on CPV [48]

Paper on CP violation analysis with Belle II detector

D1.3 : Publication on LFV and LFUV [48]

First publication on searches for Lepton Flavour Violation and Lepton Flavour Universality Violation

D1.4 : Publication on dark sector [48]

First publication on searches for dark sector processes

D1.5 : Publication on Spectroscopy [48]

First publication on quarkonium spectroscopy

Preparation of WP1 deliverables

- Belle II has now 67 publications and it is easy to identify a publication on CPV, on LFV/LFUV, on dark sector physics and on spectroscopy (deliverables D1.2 to D1.5).
- The Belle II detector paper is still in internal review and might not be public by public by May 2025 — two options
 - We make this deliverable private/internal
 - We take another detector publications, e.g. the Belle II SVD paper ([JINST 17 \(2022\) no.11, P11042](#))

WP1 secondment status (as of March 14, 2025)

Including planned (future) secondments

| Institution | WP1 done (months) | WP1 planned*) | WP1 % done |
|--------------|-------------------|---------------|----------------|
| INFN | 72.8 | 56.0 | 130.0 % |
| DESY | 73.4 | 70.0 | 104.9 % |
| OEAW-HEPHY | 27.6 | 22.0 | 125.5 % |
| JSI | 20.1 | 15.0 | 134.0 % |
| LAL-CNRS | 27.3 | 26.0 | 105.0 % |
| UKP | 1.8 | 9.0 | 20.0 % |
| IFJ-PAN | 11.7 | 11.0 | 106.4 % |
| TAU | 5.8 | 6.0 | 96.7 % |
| METU | 5.1 | 6.0 | 85.0 % |
| Total | 245.6 | 221.0 | 111.1 % |

*) Before redistribution of PMs in November 2024

This table assumes that all secondments declared are recognised by REA
(the sum of split secondments must exceed 1 PMs to be recognised (paid) by REA)

Presentations on scientific output of WP1

- “Operational challenges for Belle II CDC in 2024 and beyond”
Carsten Niebuhr (DESY)
- “Rare beauty and charm decays: an overview of searches at JSI”
Gaetano De Marino (Ljubljana)