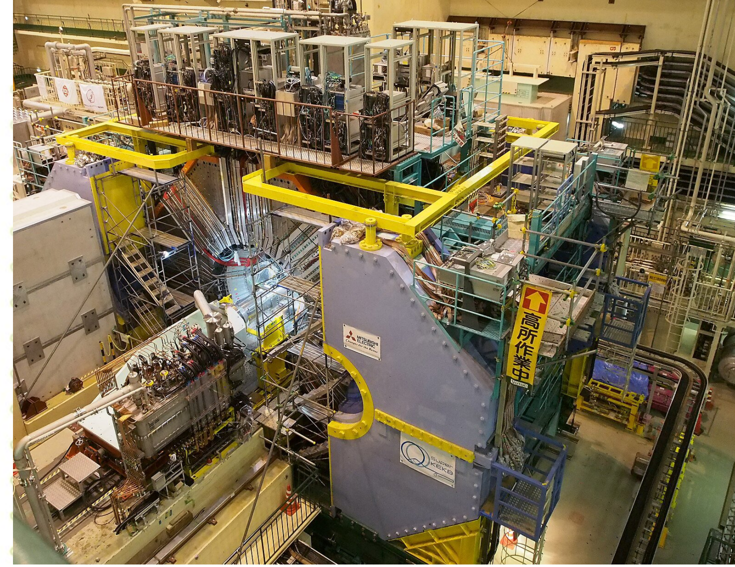
Master and Bachelor Topics



Belle II Group

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https://www.mpp.mpg.de/forschung/belle-ii

Belle II

MAX PLANCK INSTITUTE FOR PHYSICS

Boosting the performance of particle identification at Belle II

The Belle II detector in Tsukuba, Japan, detects asymmetric e+ e- collisions. In these reactions, final state particles of different species, such as electrons, pions or protons, are produced. A major experimental challenge is to identify the species of the final state particles using the information from several subdetectors. Our group is taking a leading role in developing the particle identification at Belle II.

You can help further improve these algorithms or study the performance of the particle identification. You will learn the principles of particle identification, how to develop and implement particle identification algorithms using machine learning techniques, and how to measure their performance.

Are you interested in working with us on the fascinating and challenging particle identification at Belle II? Let's have a talk!

Contact: Stefan Wallner (swallner@mpp.mpg.de)
Level: Bachelor / Master

Study of Quantum Entanglement and Coherence at Belle II

Entanglement is a fundamental property of quantum mechanics. Though well established with photons and light particles it hasn't been well studied with heave particles and at high energies. At Belle II B0/B0bar pairs are supposed to be in an entangled state. This is the basis of our measurement of time dependent CP violation. Though this assumption is well motivated it hasn't been tested rigorously. The topic of this thesis is to study various models of decoherence (spontaneous decoherence, finite coherence lifetime, etc) and investigate how these models can be tested (or excluded) with Belle II data.

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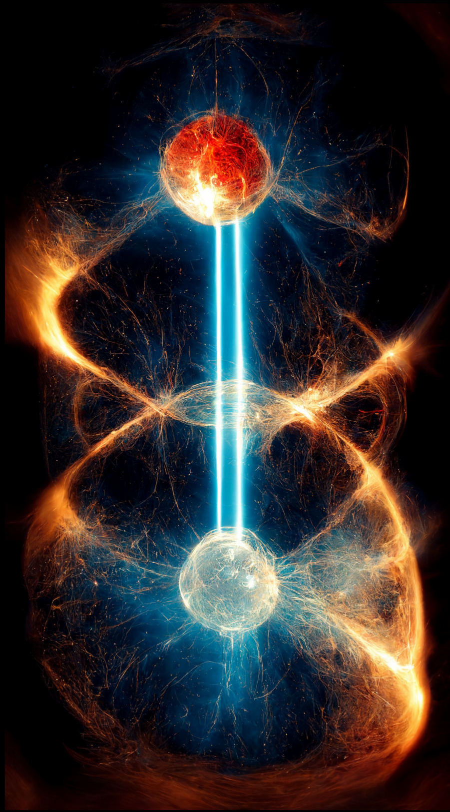

(Credit: Augusto / Adobe Stock)

Determination of Combinatorial Background using Event Mixing

Combinatorial background is a major background when reconstruction B.-Mesons in Belle II. It stems from B-events when random tracks are combined to form a fake signal events. Presently it is mainly determined using Monte-Carlo generators. Event mixing, however, opens the possibility to determine this background using real data. In events with a reconstructed B-Meson, the tracks of the meson are removed and two such events are combined to a new 'event' which is then used to search for random combinations faking certain signal events. The topic of this thesis is to develop this tool and study to what extend it offers a suitable tool for background determination.

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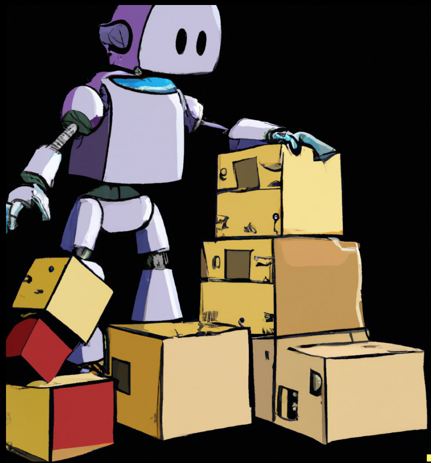

Study Systematic Effects in Partial-Wave Analyses

At Belle II detector in Tsukuba, Japan, we explore the frontiers of the unknown by recording asymmetric electron-positron collisions. In these collisions, various types of particles are produced, such as B mesons or tau leptons. Decays of these particles into multi-body hadronic final states allow us study the Standard Model and probe for new physics. This is done using the so-called partial-wave analysis, where the decay dynamics of these final states are modeled.

The measurement results depend on various assumptions and choices make in the analysis. You will have the opportunity to investigate these systematic effects. By doing so, you will have the opportunity to learn state-of-the-art analysis in high-energy physics, master partial-wave analysis fits using our Python framework, and gain an understanding of uncertainty estimation.

Are you interested in working in an exciting group and help us to get the best out of our data? Let's have a talk!

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Selecting Model Components in Partial-Wave Analyses using Regularization

At Belle II detector in Tsukuba, Japan, we explore the frontiers of the unknown by recording asymmetric electron-positron collisions. In these collisions, various types of particles are produced, such as B mesons or tau leptons. Decays of these particles into multi-body hadronic final states allow us study the Standard Model and probe for new physics. This is done using the so-called partial-wave analysis, where the decay dynamics of these final states are modeled.

The models used typically consist of a large set of components, and it is not clear a priori which components need to be included. Your task can be to apply state-of-the-art regularization techniques from machine learning that allow us to infer the set of included components from the data. You will master partial-wave analysis fits to data using our Python analysis framework, implement regularization in these fits to control the large model space, and interpret the obtained results.

Are you interested in working in an exciting and challenging environment with state-of-the-art technologies and push with us the high-precision frontier in particle physics? Let's have a talk!

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Level: Master