

# Reinforcement Learning in Particle Accelerators: a practical example (1/2)

*Tuesday 25 March 2025 10:00 (1 hour)*

## Proposal: Reinforcement Learning for Particle Accelerator control: A real-world example

### Hour 1: Introduction to Reinforcement Learning for Particle Accelerators

- **Basic Concepts:**
  - Overview of Reinforcement Learning (RL) fundamentals.
  - Definitions and distinctions:
    - Model-free vs. model-based.
    - Off-policy vs. on-policy approaches.
- **Applications and Considerations:**
  - Discussion of problem types and environmental variables affecting model selection in practical scenarios.
  - Analysis of drawbacks and benefits of different RL architectures.
- **Practical examples:**
  - Real-world examples of RL in particle accelerators (e.g., CERN).
  - Case study introduction: Optimization of RF triple splittings in the Proton Synchrotron (PS).

### Hour 2: Optimizing RF Triple Splittings with Reinforcement Learning

- **Problem Definition:**
  - Explanation of PS RF operations and the triple splitting optimization challenge for LHC-type beams.
  - Overview of the physics and parameters involved in optimization.
- **Optimization Approach:**
  - Justification for choosing RL and specific RL architectures.
  - Step-by-step walkthrough:
    - Initial simulations and trials.
    - Challenges and lessons learned.
    - Final operational solution deployed in the control room.

### Exercise Session: Training RL Agents for RF Optimization (1 hour)

- **Objective:**
  - Train RL agents to optimize RF double splitting settings in simulation for improved beam quality.
- **Implementation:**
  - Use SWAN notebooks with provided skeleton code.
  - Define a custom gymnasium environment for the double splitting problem, given:
    - Pre-implemented simulation data loaders.
    - Basic loss function for optimization.

## Number of lecture hours

2

## Number of exercise hours

## **Attended school**

tCSC 2024 (Split)

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