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Involvement in RL:

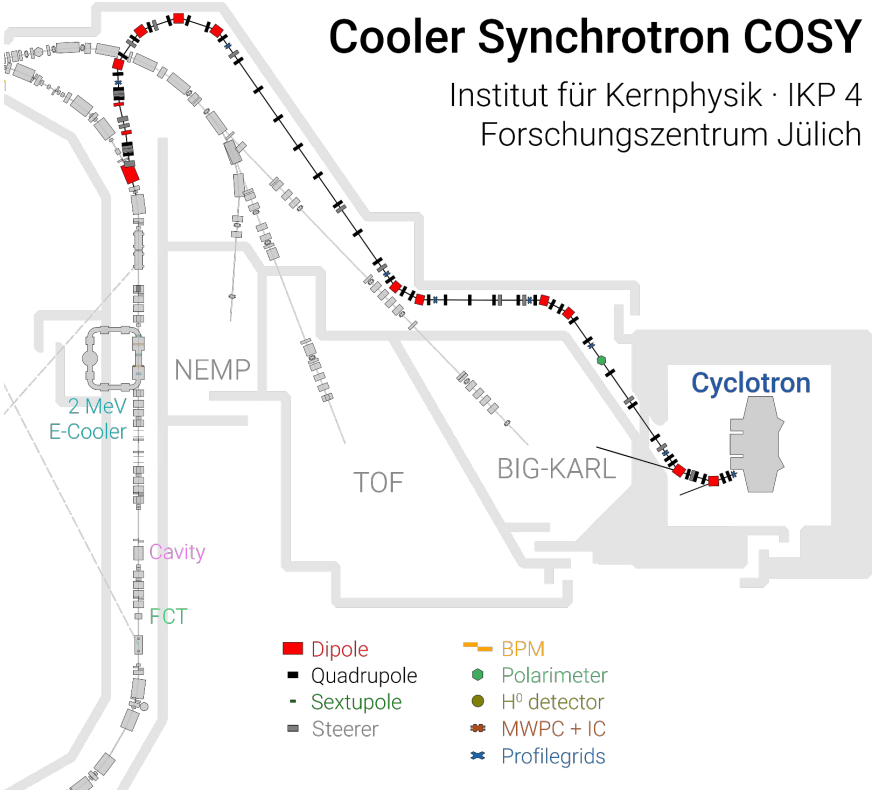
- Optimization of the Injection Beam Line (IBL)
- Autonomous injection optimization of the beam into the Cooler Synchrotron COSY

Interests in RL:

- Sim2real
- Hierarchical RL
- Derivative-free optimization
- Sample efficiency
- Multi-agent RL

Cooler Synchrotron COSY

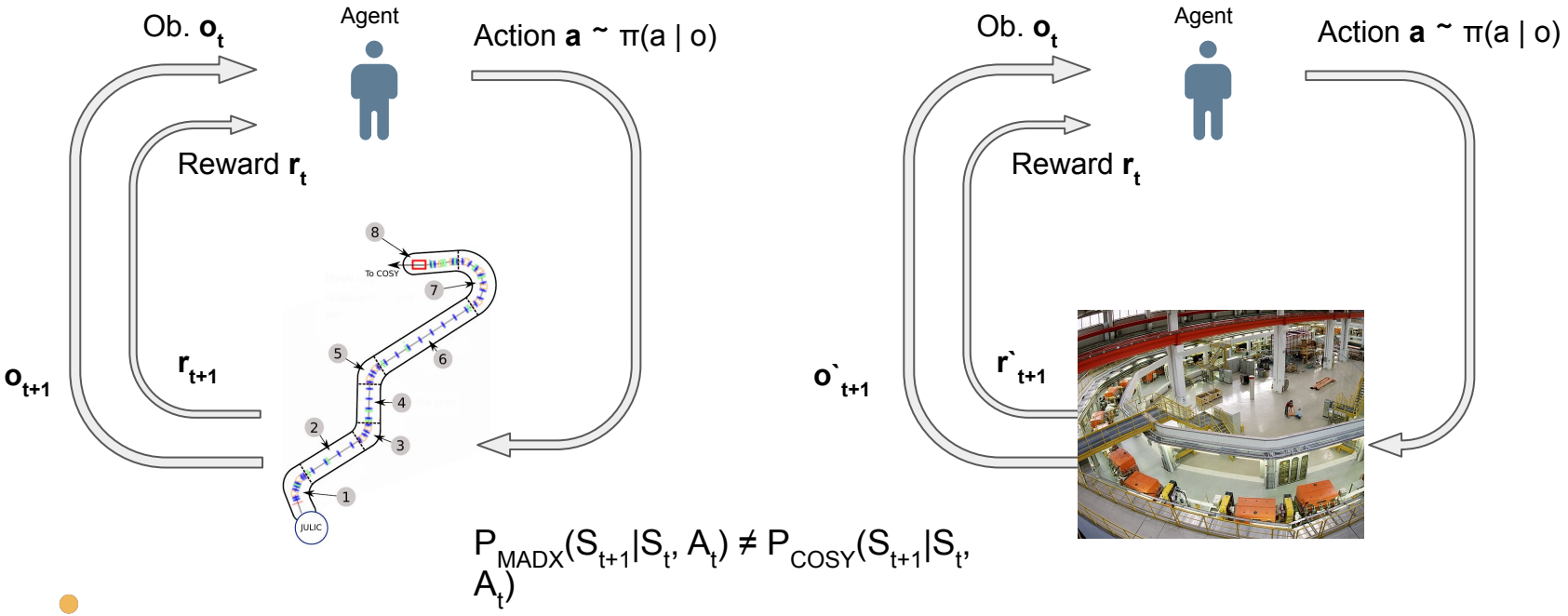
- Designed for protons and deuterons
  - Polarized and unpolarized proton beams in energy range upto 2.7 GeV
  - Deuteron beams in energy range upto 2.1 GeV
  - Stochastic cooling
- Injection beam line (IBL) is the transfer line from the cyclotron (JULIC) to COSY
  - Transferring negatively charged protons and deuterons throughout the IBL
  - 45 MeV protons & 76 MeV deuterons
- Electrons are stripped at the injection point through a stripping foil
- IBL length ≈ 94m. Operated manually through 15 quadrupoles and 27 steerers



RL in Simulation and Real Environment

Training

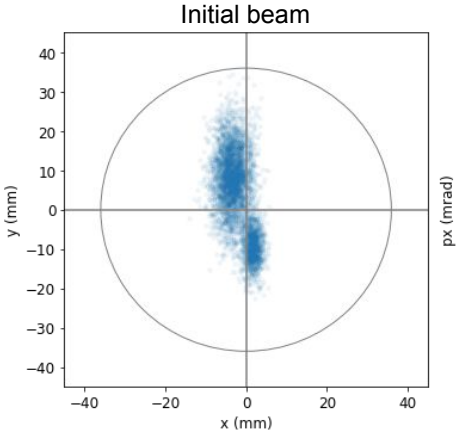
Real world

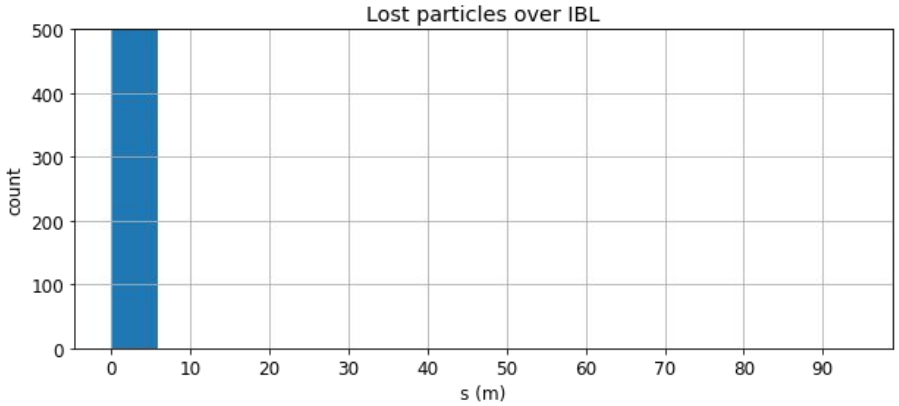


$P_{MADX}(S_{t+1}|S_t, A_t) \neq P_{COSY}(S_{t+1}|S_t, A_t)$

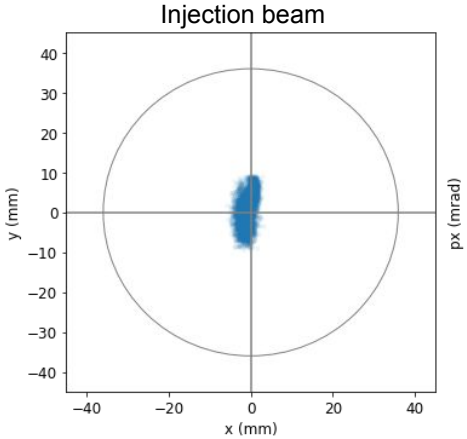
IBL Optimization

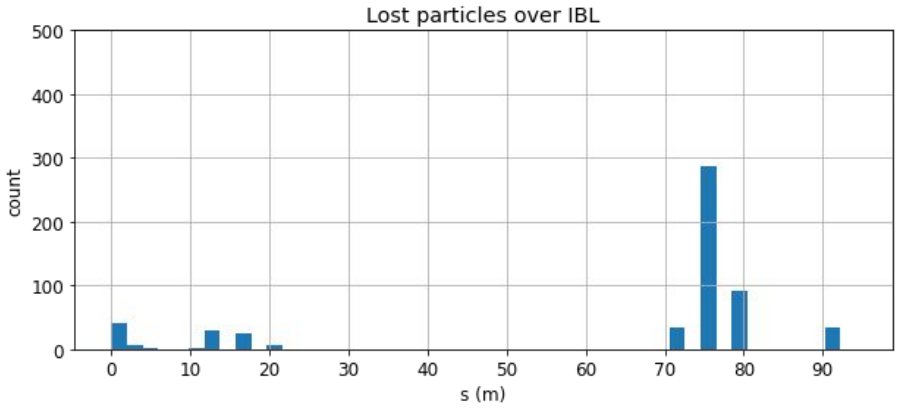
5000 particles
Step 0
Efficiency: 0%





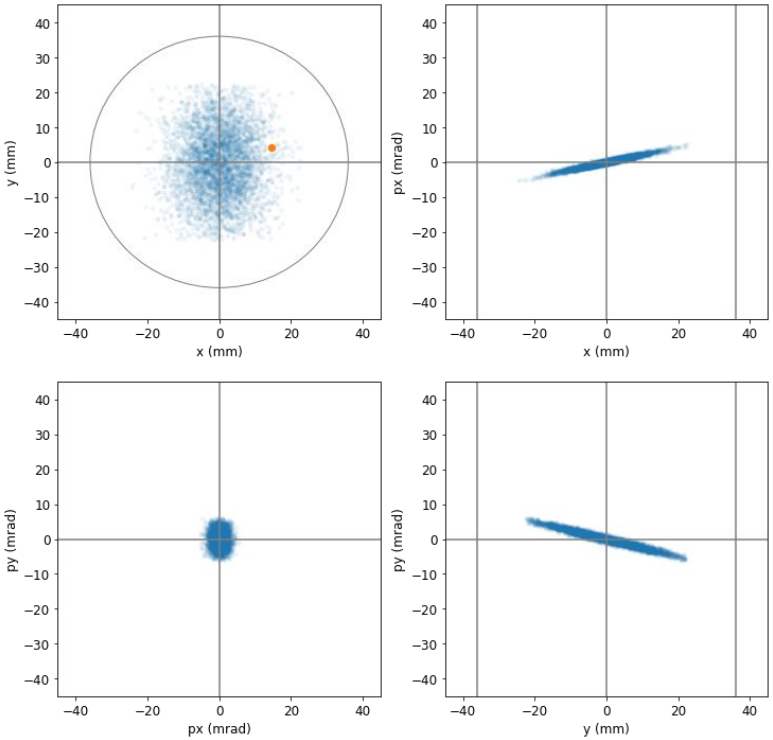
5000 particles
Step 32
Efficiency: 89.9%





Autonomous Injection

Before



After