# CERN AWAKE steering problem

- Well studied in several papers/thesis

- Linear Dynamics with 10 degrees of freedom in actions and states

- Non-trivial due to action limitations

- Analytical solution for the optimal policy

- Easy to understand, focus on the RL problem not the MDP

- The <u>simulation corresponds exactly to the real system</u> (measured optics)

- <u>All our algorithms were tested on the real machine</u>

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Markov decision process: $(S, A, R, P, \rho_0, \gamma)$
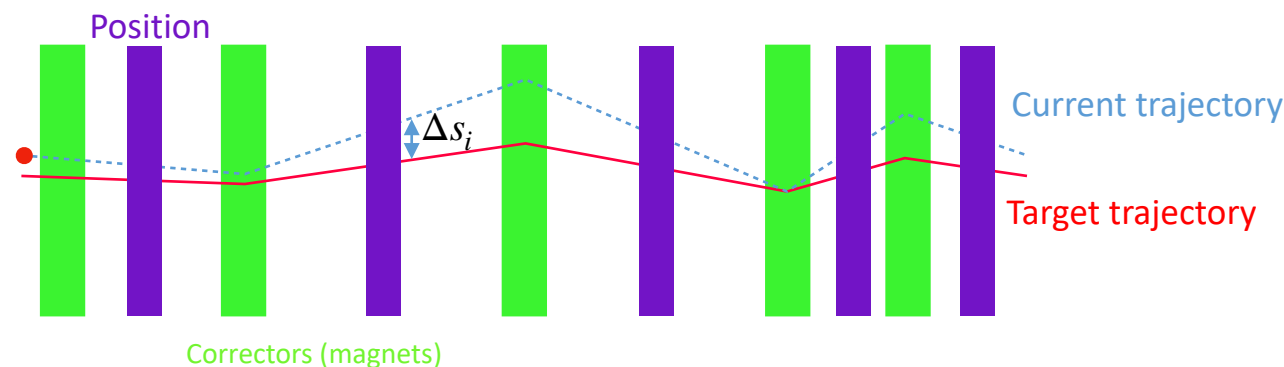
- 10 continuous states S and actions $A \in [-1,1]$ **(actions are bounded/constraints)** (10 DoF problem - observation is state)

- Rewards R negative of RMS of states $r_i \propto - \sqrt{\sum \Delta s_i^2}$

- Actions are done in $s_{t+1} = \mathbf{R} a_t + s_t$

- Episodic training

- Initial criteria: Initial distribution ρ_0 is away from low RMS - to make problem a bit challenging

- Termination criteria:
  - Maximal number of interactions (truncation)
  - RMS below measurement uncertainty (successful termination)
  - States s_i > beam pipe (termination or clipping)

- Transitions P are deterministic os stochastic, γ =1

- If we speak about different tasks i (MPDs) we mean different matrices $\mathbf{R}_i$