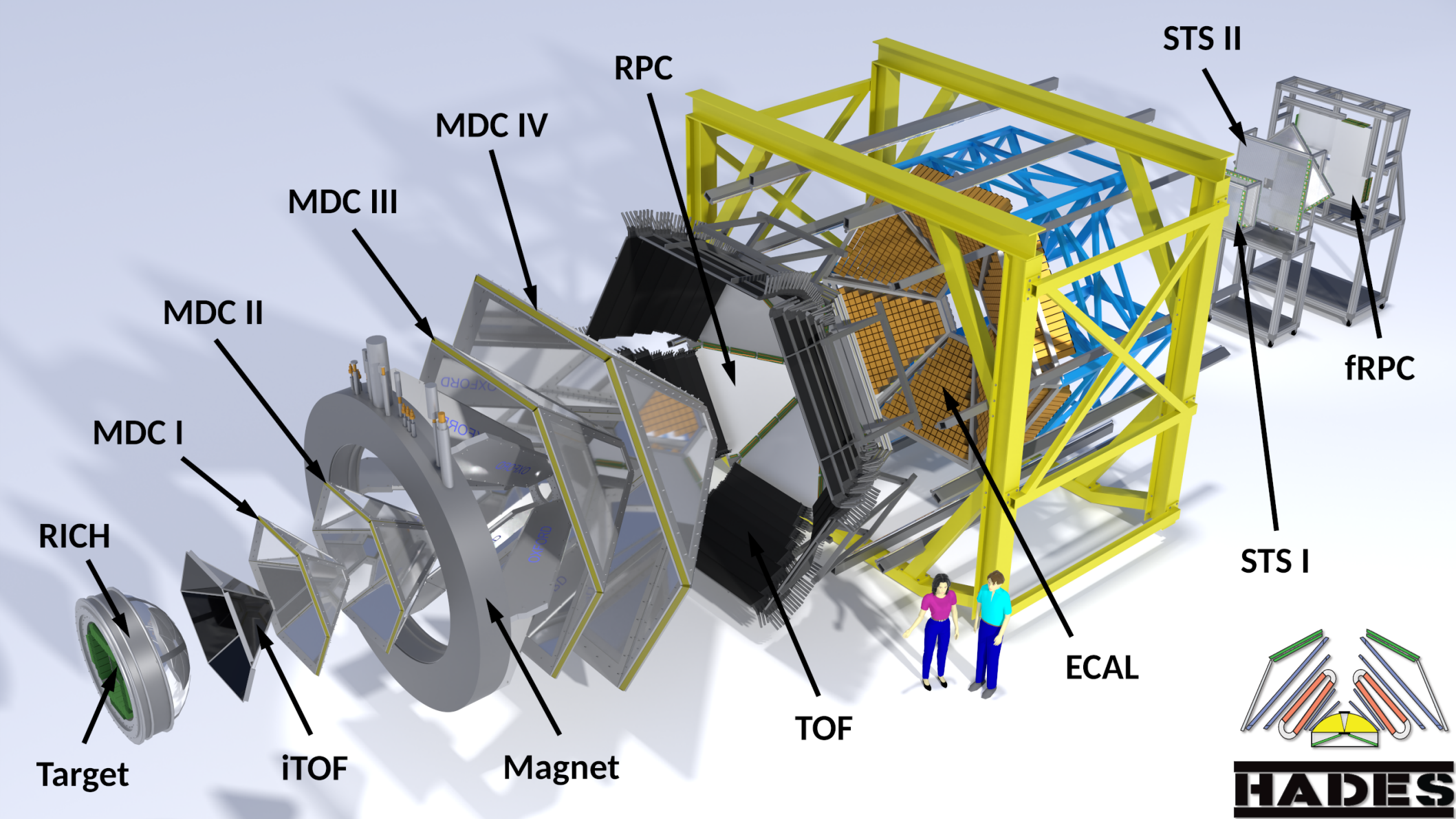
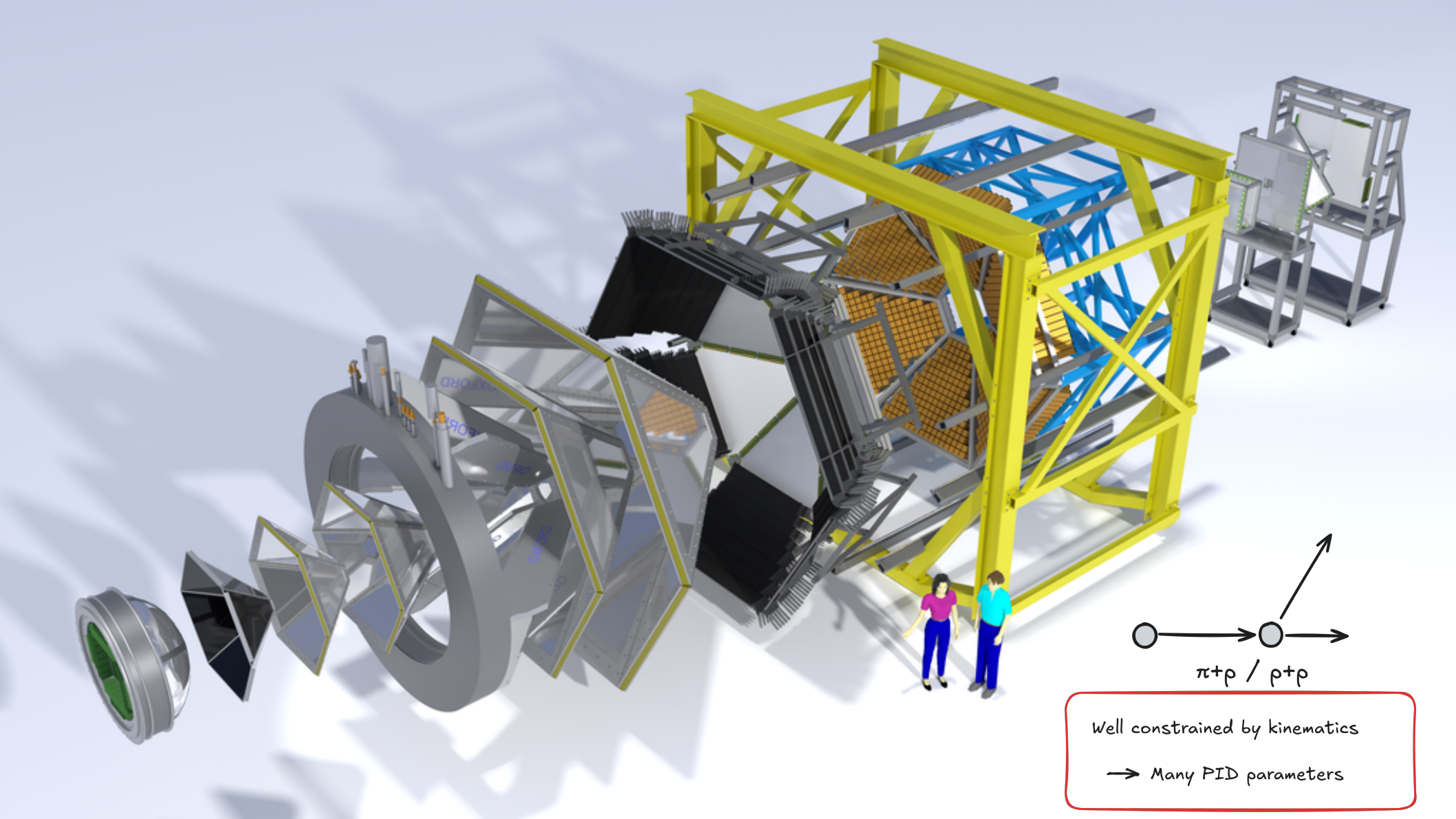
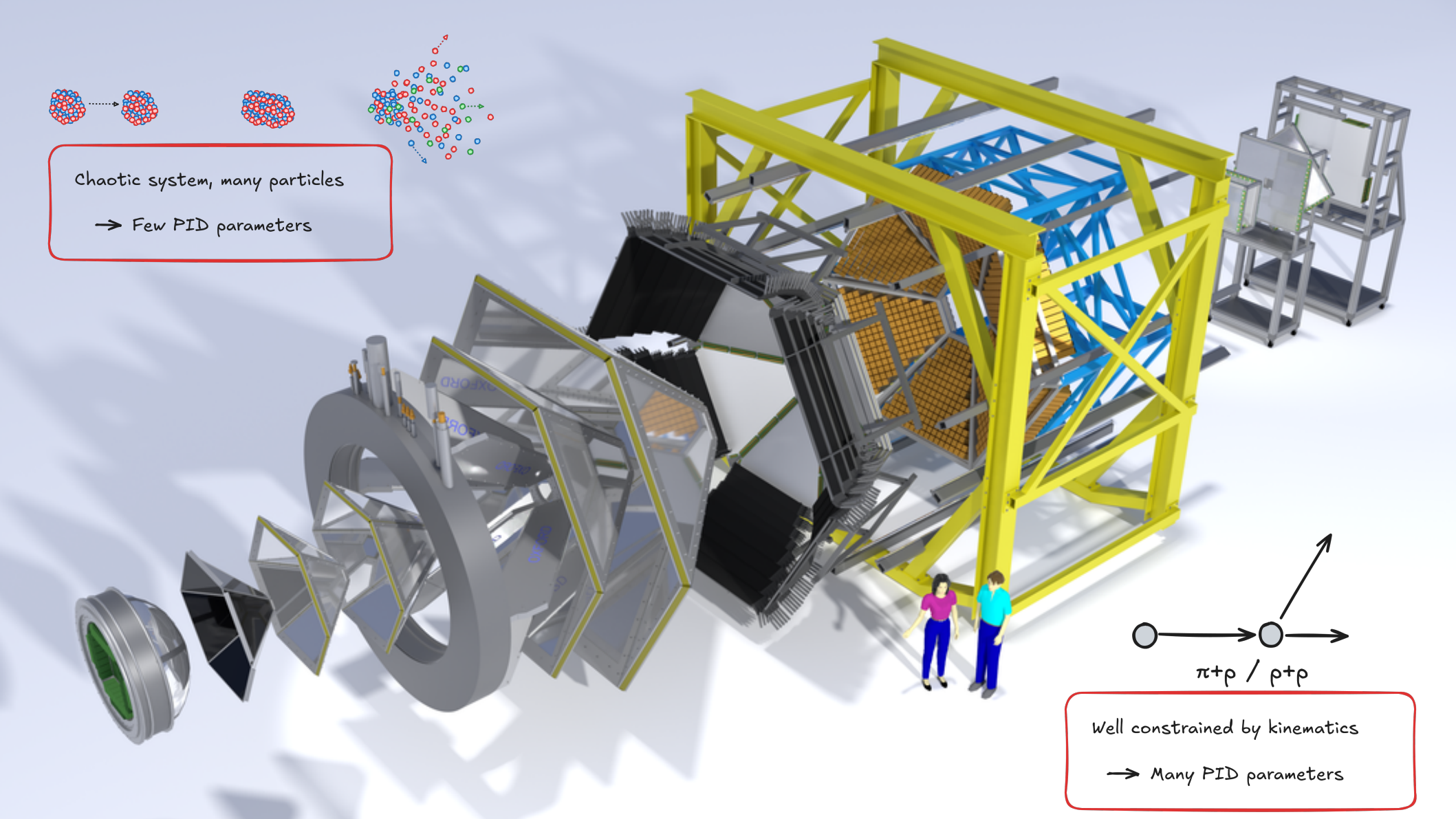
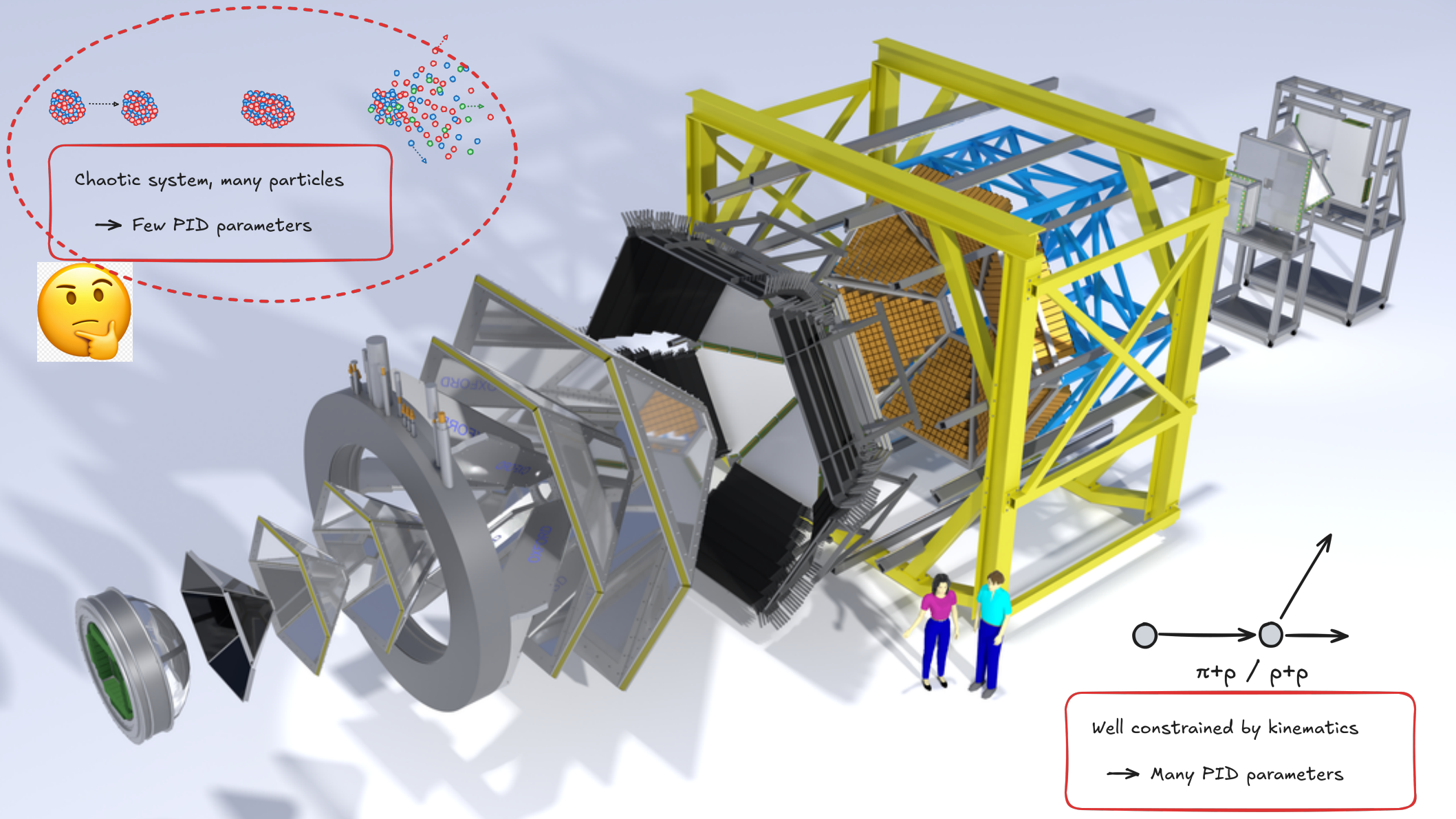

STS II
RPC
MDC IV
MDC III
MDC II
MDC I
RICH
fRPC
STS I
ECAL
TOF
Target
iTOF
Magnet
HADES

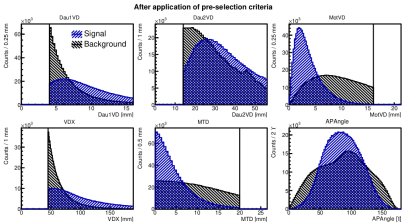

π+p / p+p
Well constrained by kinematics
→ Many PID parameters

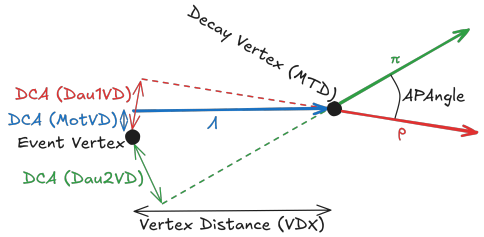

Chaotic system, many particles
→ Few PID parameters
π+p / p+p
Well constrained by kinematics
→ Many PID parameters


Chaotic system, many particles
→ Few PID parameters
π+p / p+p
Well constrained by kinematics
→ Many PID parameters

Existing PID Methods

Decaying Particles

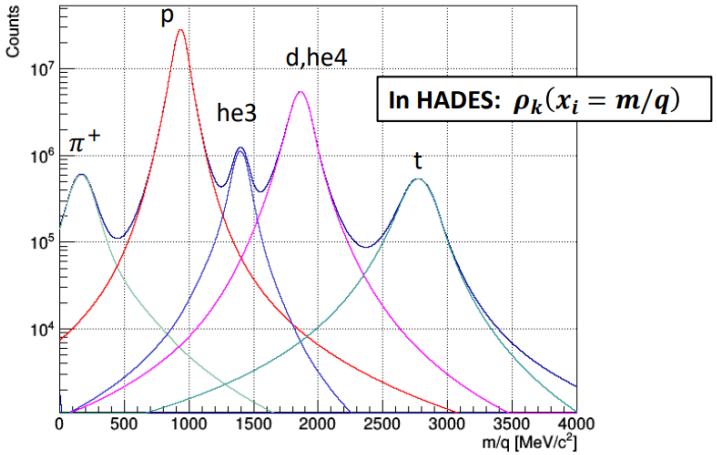




Multi-Layer Perceptron

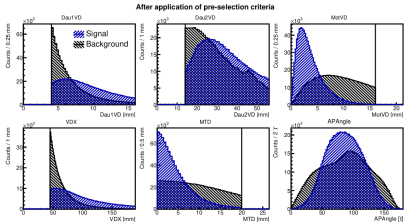
Existing PID Methods

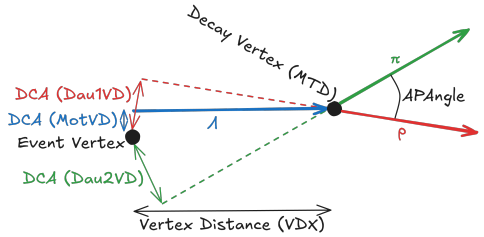
Abundant Particles



Bayesian Methods

Decaying Particles

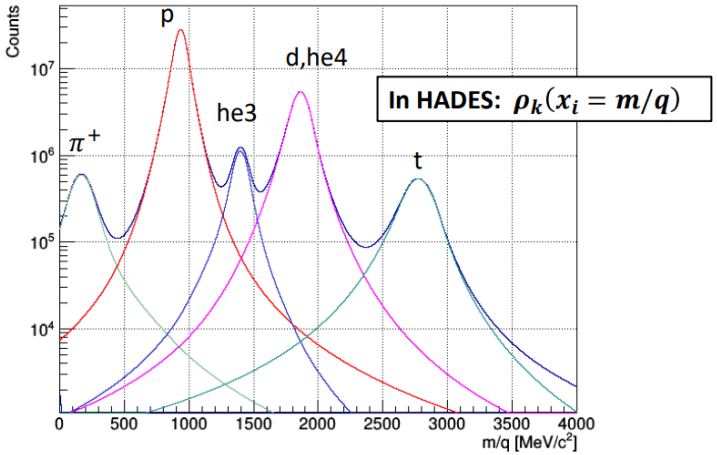




Multi-Layer Perceptron

Existing PID Methods

Abundant Particles



Bayesian Methods

Rare Particles????

Physics Informed Loss Function

[Input Features]
- dE/dx (energy loss)
- momentum (ρ)
- chi² (track quality)

↓

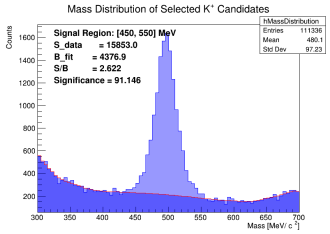
Neural Network → K^+ / not K^+

↓

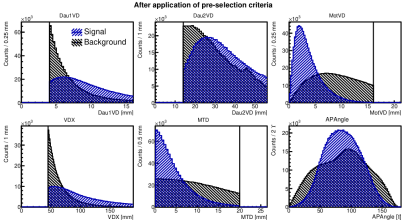
[Physics-Informed Loss]
(Bethe-Bloch)

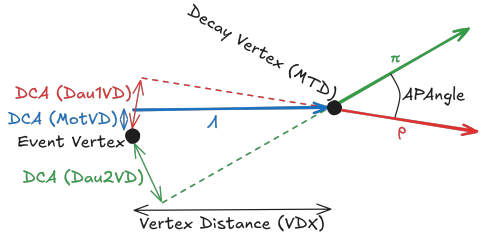
↓

Compare predicted class vs expected dE/dx(ρ)



Decaying Particles

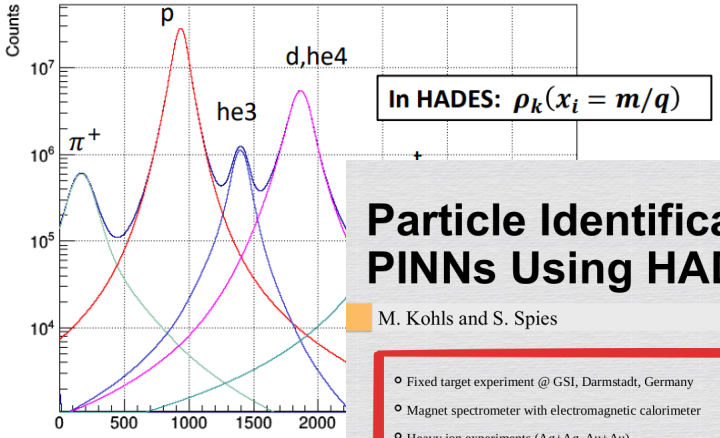




Multi-Layer Perceptron

Existing PID Methods

Abundant Particles



In HADES: $\rho_k(x_i = m/q)$

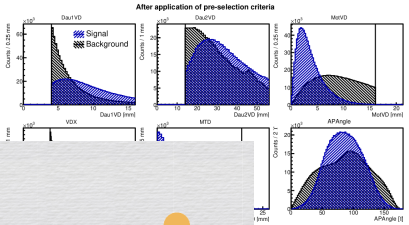
Bayesian Metho

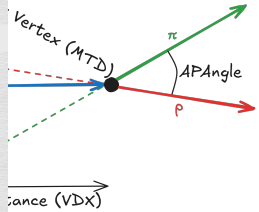
Rare Particles????

Physics Informed Loss Function

[Input Features]
⊢ dE/dx (energy loss)

Decaying Particles





Perceptron

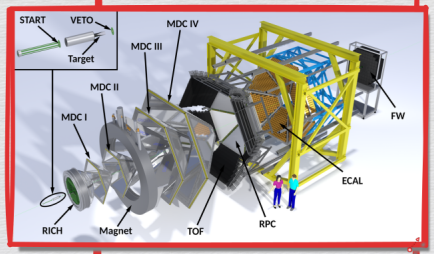
Particle Identification with MLPs and PINNs Using HADES Data

GSI

M. Kohls and S. Spies

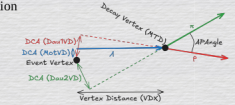
- Fixed target experiment @ GSI, Darmstadt, Germany
- Magnet spectrometer with electromagnetic calorimeter
- Heavy ion experiments (Ag+Ag, Au+Au)
  - Average particle multiplicities per event ~100
  - Complex systems with kinematically overlapping channels
  - Identification limited to measured final state properties and their resolution
- Elementary reactions (p+p, π+p)
  - Average particle multiplicities ~3
  - Kinematically well-defined channels
  - Identification via measured final state properties and kinematic constraints

High Acceptance Di-Electron Spectrometer



Current Methods

- Decaying (off-vertex) particles [1]:
  - MLP (FFNN) training on geometric variables and kinematic constraints
    - Simulation of decaying particles as signal
    - "Mixed Event" technique for data-driven combinatorial background emulation



- "Stable" charged particles:
  - Currently user-defined criteria (heavy ion) combined with kinematic constraints (elementary)
  - Studying the performance of Physics Informed Neural Networks (PINNs) for this task is hoped to improve the PID

PIDANN Setup

Domain-Adversarial Neural Network is composed of :

MLPs for Off-Vertex Particles