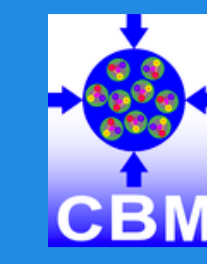


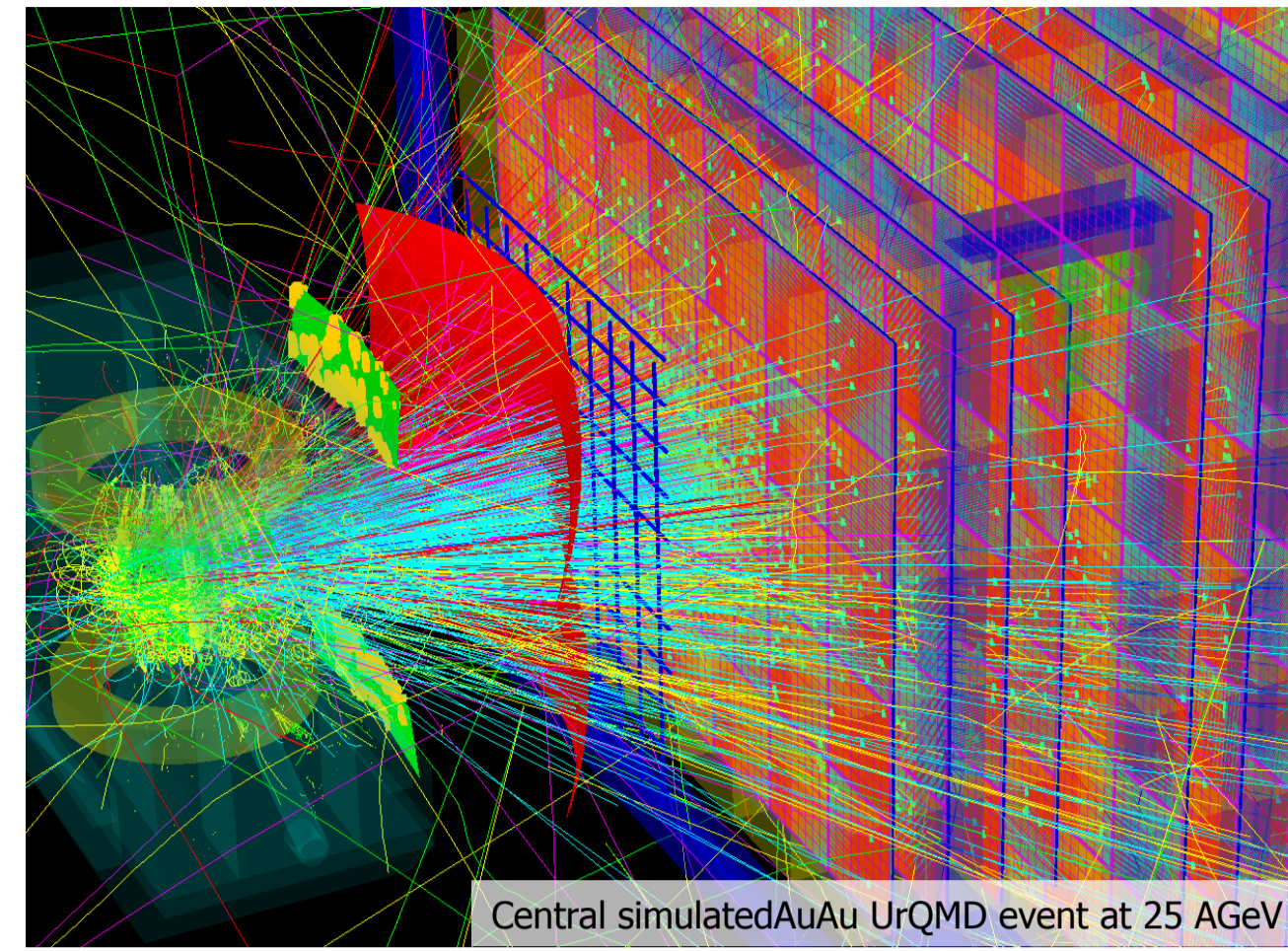
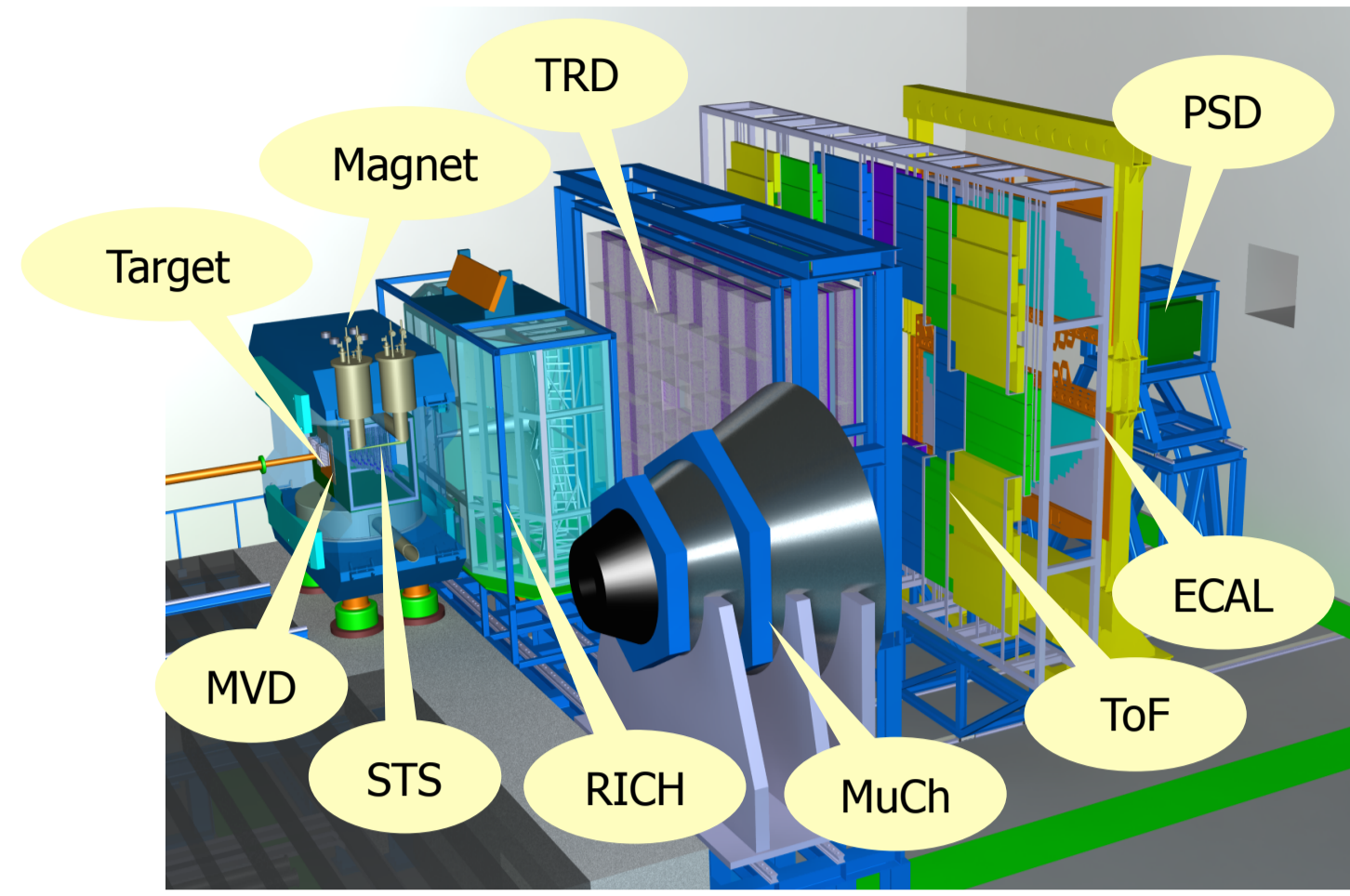
Reconstruction of short-lived particles with the KF Particle Finder package in the CBM experiment



M. Zyzak¹ for the CBM Collaboration
1 – GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany



Reconstruction challenge in the CBM Experiment



- CBM — future fixed-target heavy-ion experiment at FAIR, Darmstadt, Germany.
- 10^5 - 10^7 collisions per second.
- Up to 1000 charged particles/collision.
- Free streaming data.
- No hardware triggers.
- On-line event reconstruction and selection is required in the first trigger level.

- On-line reconstruction at the on-line farm with 60000 CPU equivalent cores.
- High speed and efficiency of the reconstruction algorithms are required.
- The algorithms have to be highly parallelised and scalable.
- CBM event reconstruction: Kalman Filter and Cellular Automaton.

KF Particle package for construction of short-lived particles

Concept:

- Mother and daughter particles have the same state vector and are treated in the same way
- Geometry independent
- Kalman filter (KF) based

State vector Position, momentum and energy

$$\mathbf{r} = \{ x, y, z, p_x, p_y, p_z, E \}$$

$$\mathbf{C} = \langle \mathbf{r} \mathbf{r}^T \rangle$$

Covariance matrix

Functionality of KF Particle package:

- Construction of mother particles
- Addition and subtraction of the daughter particle to (from) the mother particle
- += and -= operators
- Accessors to the physical parameters (mass, momentum, decay length, lifetime, rapidity, etc)
- Transport: to an arbitrary point, to the decay and production points, to another particle, to a vertex, on the certain distance
- Calculation of a distance: to a point, to a particle, to a vertex
- Calculation of a deviation: from a point, from a particle, from a vertex
- Calculation of the angle between particles
- Constraints: on mass, on a production point, on a decay length
- KF Particle Finder

KF Particle Functionality

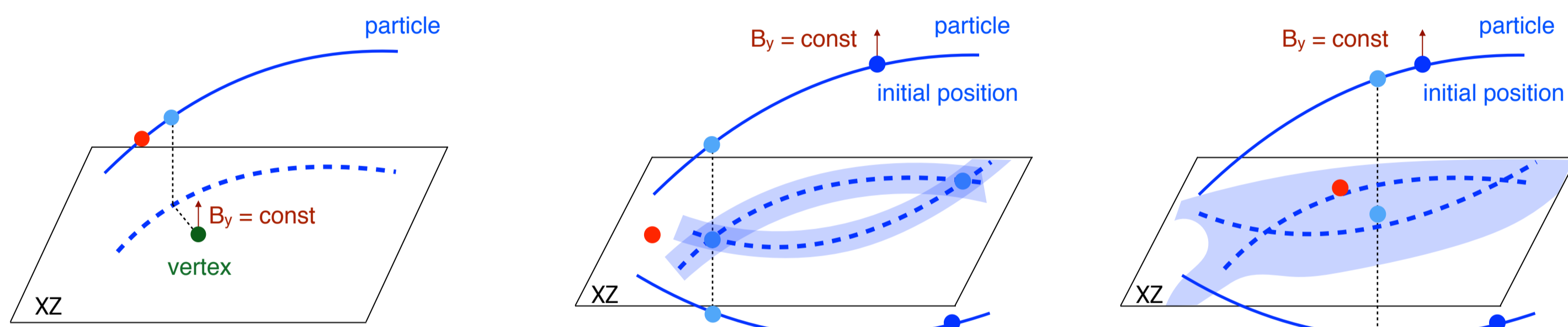
Initial approximation for the point of DCA

Assumptions:

- distance between the point of closest approach and particle is short;
- constant one-component field B_y , valid for short distances.

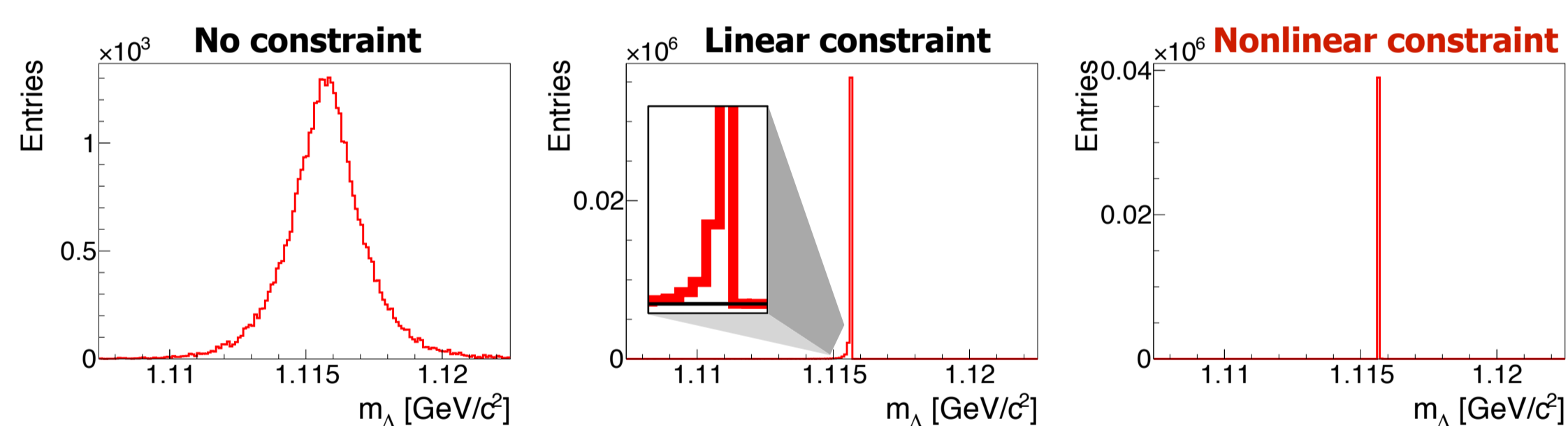
Method:

- find points in 2D (is solved analytically) and select the closest approximation taking into account errors and distance in 3D;
- transport particles to that point;
- assuming small distance between 2D and 3D point, find point in 3D by Taylor expansion.

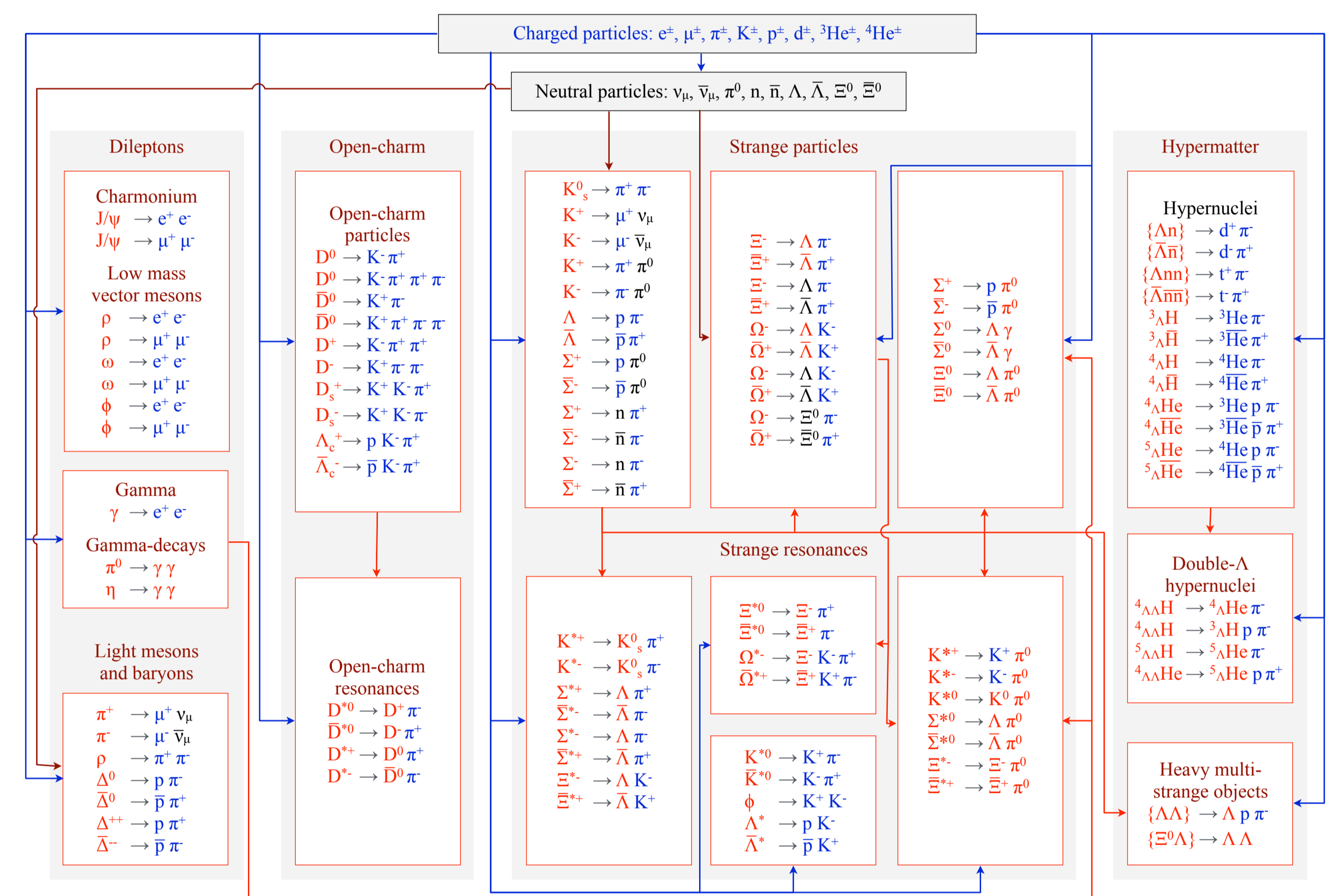


Mass constraint

- The mass constraint is a powerful tool for decay chain reconstruction.
- Conventional method is a linearized mass constraint: approximate and can not guarantee the exact value.
- Nonlinear approach is implemented in KF Particle for setting the exact mass constraint.

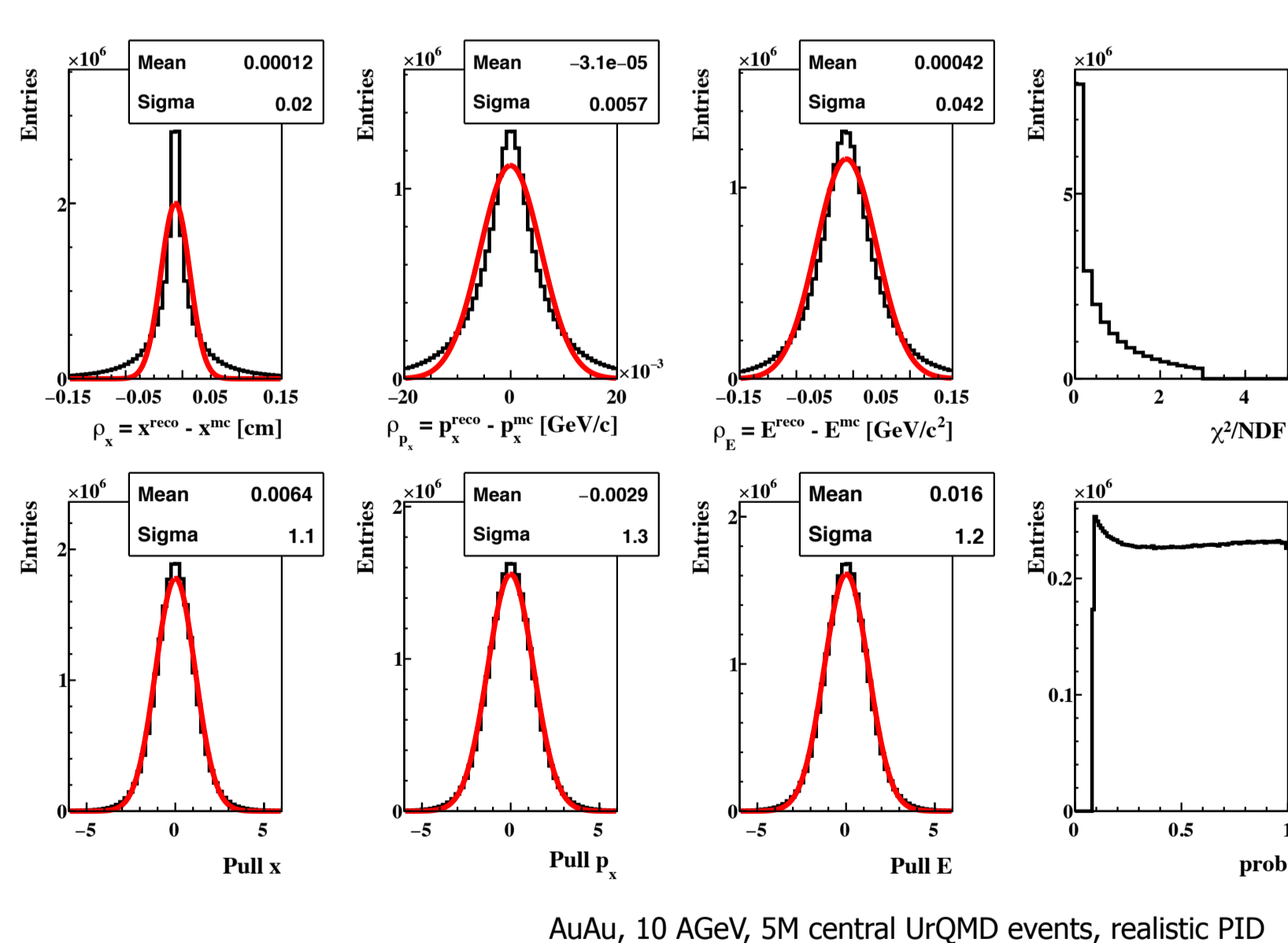


KF Particle Finder



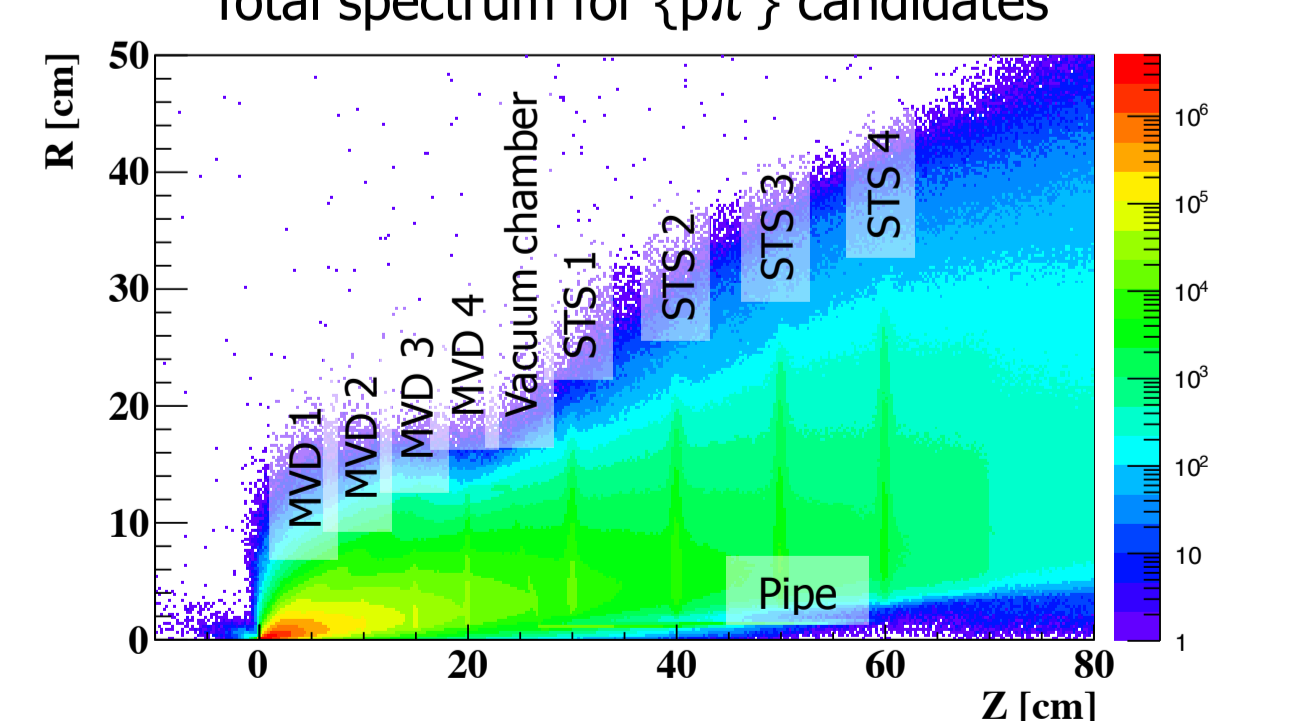
- More than 100 decays.
- KF Particle Finder searches for short-lived particles combining tracks and reconstructed particles according to the PID hypothesis.
- The input are reconstructed tracks.
- The package is highly optimized and vectorized.

Reconstruction quality

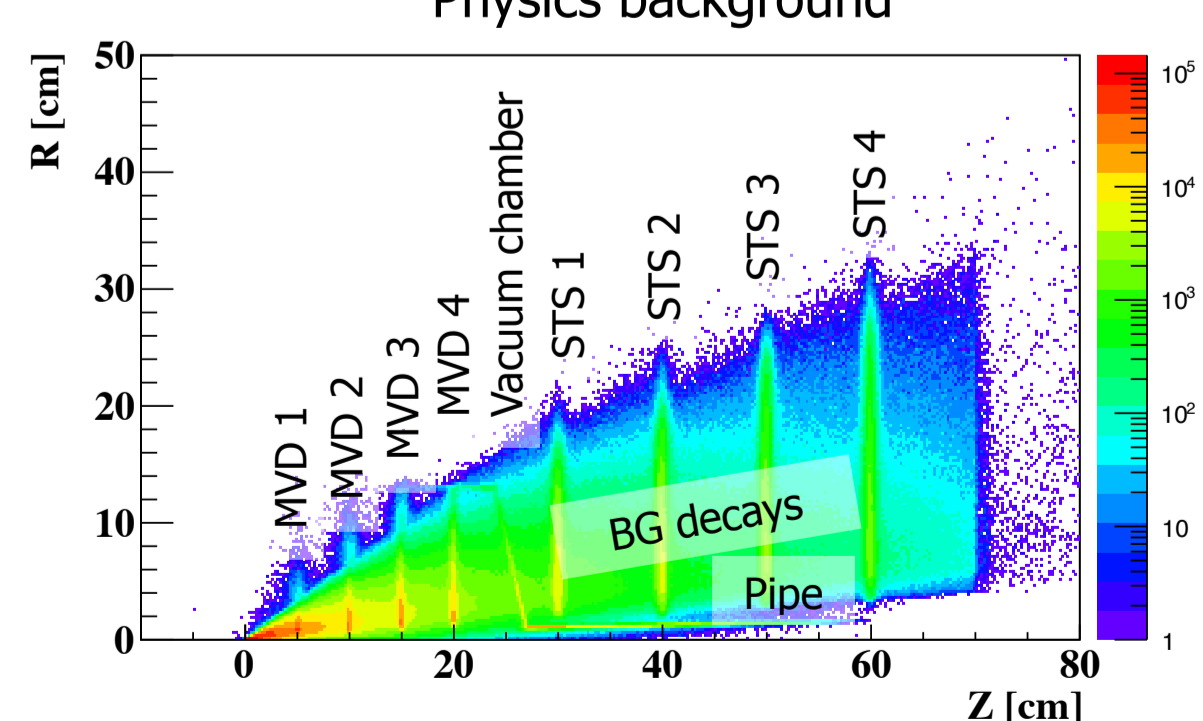


- The fit quality is demonstrated, for example, at Λ hyperon.
- Y and Z components have similar distribution to X.
- The KF Particle mathematics allow to obtain correct errors and, as a result, correct pulls (unbiased, width about 1), χ^2 and flat prob (p-value) distributions.
- High quality of the reconstruction allow to perform the detector tomography.
- The vertices on the stations are due to the interaction of the primary particles with the material.

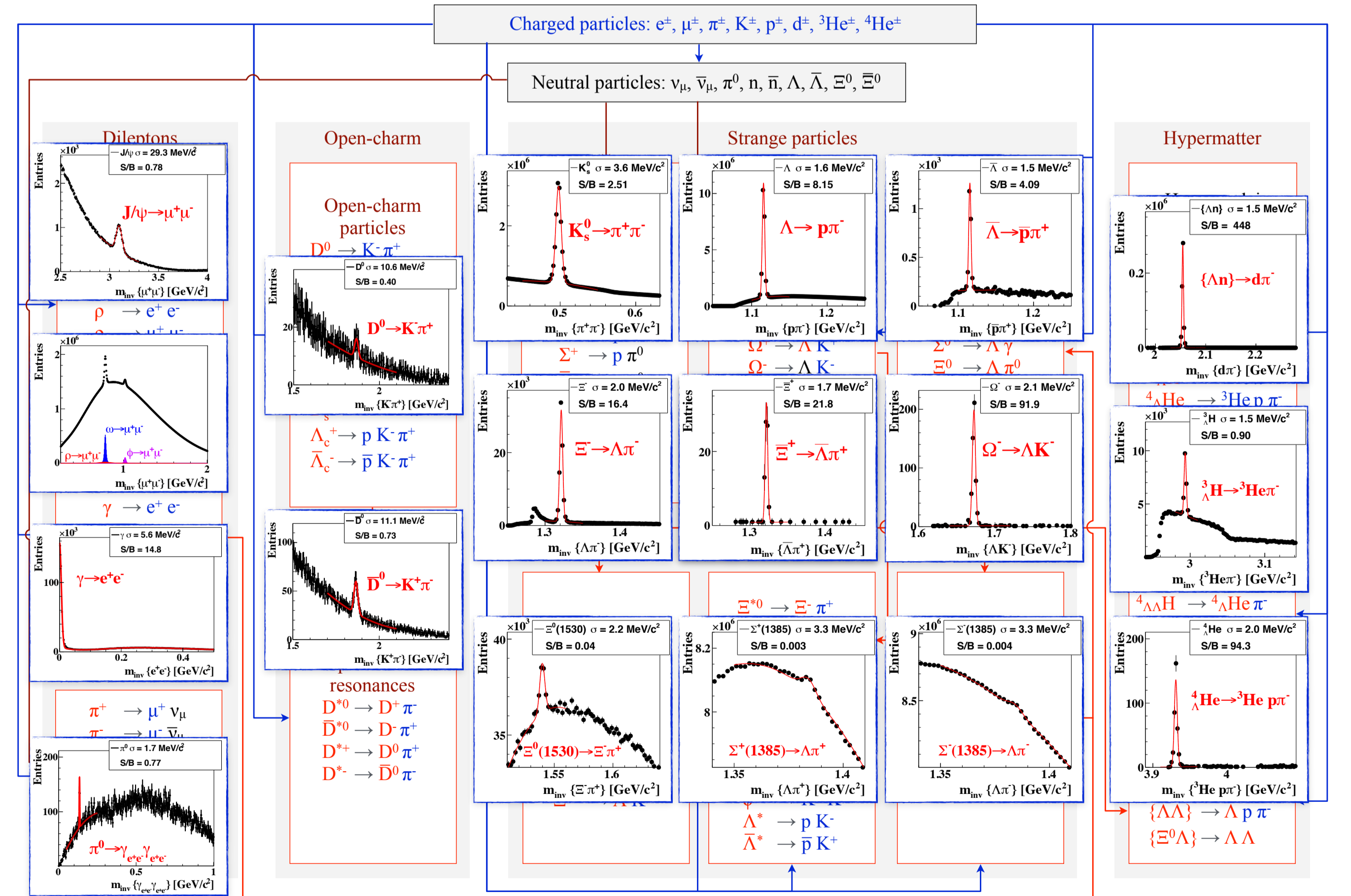
Total spectrum for $\{p\pi\}$ candidates



Physics background



Physics analysis with KF Particle Finder



The sophisticated mathematics of KF Particle Finder is perfectly suited for the analysis of the whole range of the CBM physics

Conclusions

- ✓ KF Particle package provides rich functionality for short-lived particles reconstruction and decay trees.
- ✓ Use of the Kalman filter method provides accurate and mathematically correct procedures for reconstruction of particles with high precision and efficiency.
- ✓ KF Particle Finder covers a wide range of short-lived particles for the CBM experiment.

- ✓ KF Particle Finder is highly optimized and vectorized for fast online operation.
- ✓ The KF Particle Finder package is geometry independent, that makes it a universal platform for short-lived particles reconstruction and physics analysis in High Energy Physics experiments.