



Calorimeter based vertexing for the ATLAS Next Generation Trigger

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Introduction

Project goal: Reconstruct particle tracks and vertex positions by only using calorimeter information for the Phase-II ATLAS Global Trigger.

- **Calorimeter**: A type of detector used in HEP for measuring the energy of particles. Consists of a dense material that particles interact with (e.g. LAr and iron for ATLAS).
- **Vertexing**: The process of identifying the position (“**vertex**”) of a particle interaction inside a detector (e.g. where beams collide within the LHC experiments).

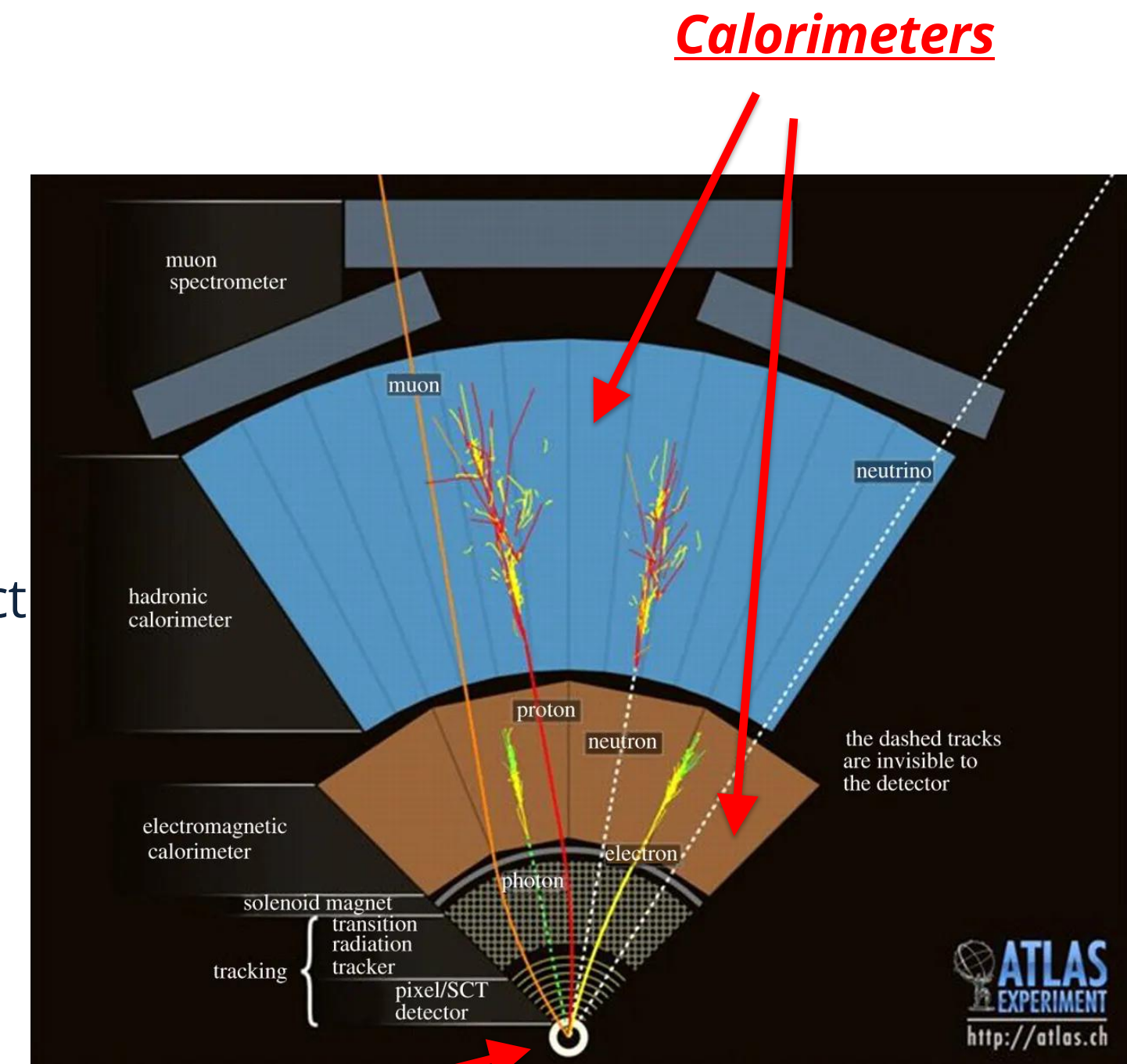


Figure 1: ATLAS detector

Vertex

ATLAS Trigger and DAQ system

- **4 MB/25ns** → Amount of data produced from proton collisions.
We have **only 10μs latency** to read these data!
- Most interactions/events uninteresting. We need to select ("**trigger**") only the important ones (e.g. Higgs)
- To do that we **check some parts of the detector** (i.e. only calorimeter) for **certain characteristics** such as energy and momentum
- Knowing the **vertex position** as well will be beneficial for selecting interesting events

ATLAS Trigger Data Reduction Flow

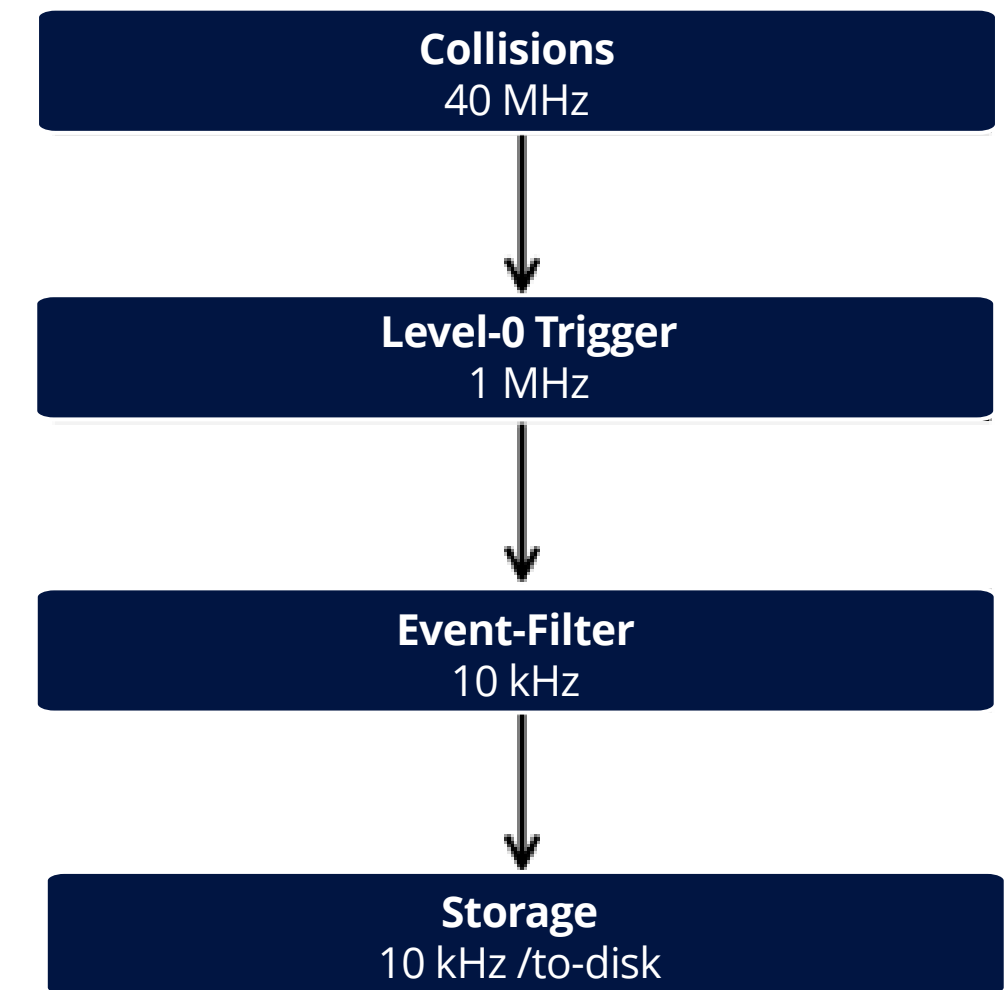


Figure 2: ATLAS Data reduction Flow

The Kalman Filter approach

- One way to reconstruct tracks and consequently vertices is to use an **extended Kalman Filter**
- A Kalman Filter (KF) is a Bayesian algorithm that **makes guesses** on the evolution of a model and **updates its guesses based on measurements**
- It's **sensitive to the starting conditions and uncertainties** (in our case the input is calorimeter data)
- But real life isn't perfect, and the reconstructed tracks **don't always align** with the measurements :

$$f_{meas}(x, y) = f_{truth}(x, y) + \mathcal{O}(\text{perturbations})$$

- One possible solution to this is :
 - Use **Symbolic Regression Neural Network** (SRNN), to calculate the perturbations template function

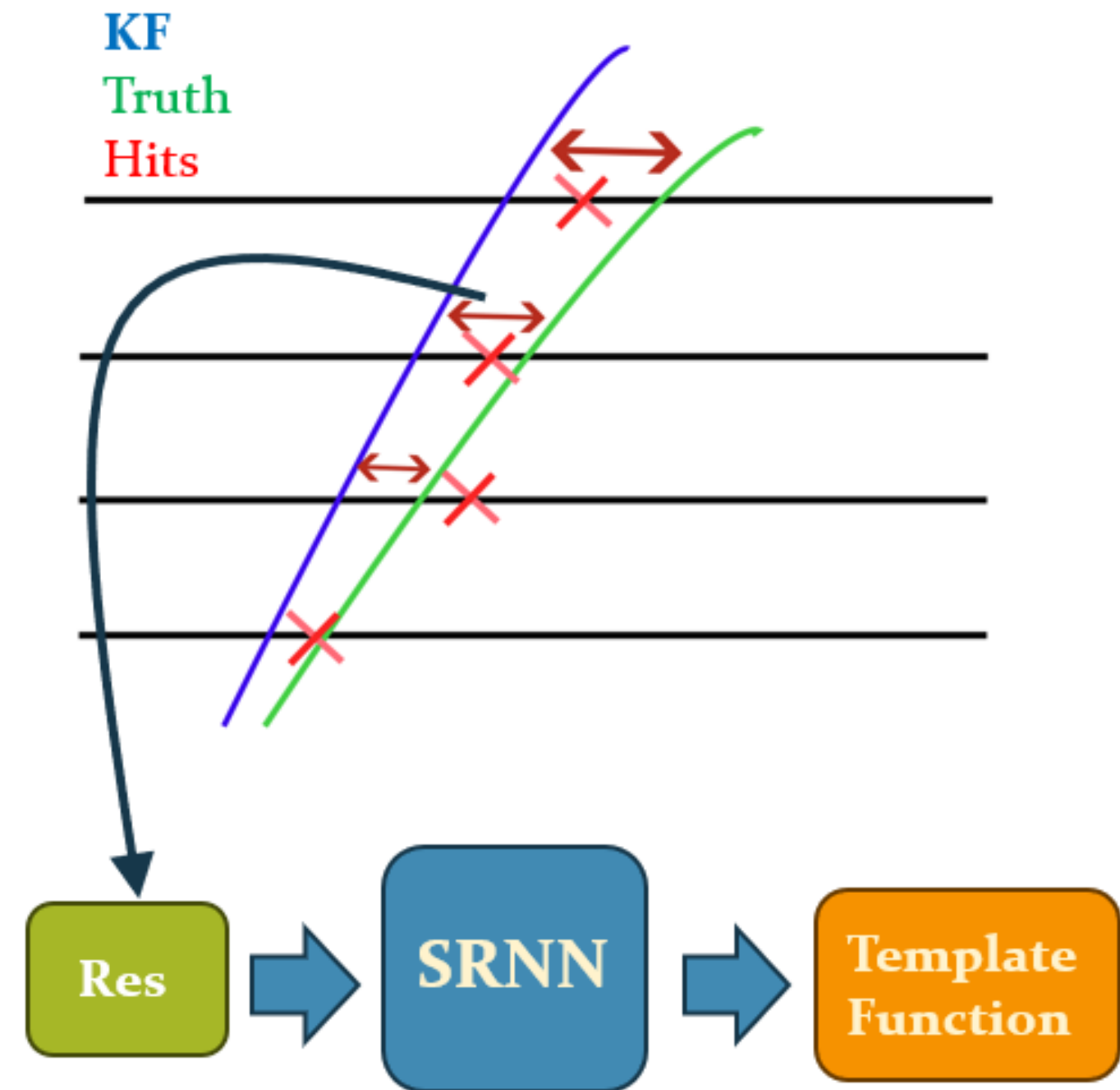


Figure 3: Algorithm pipeline flow chart

Project Status

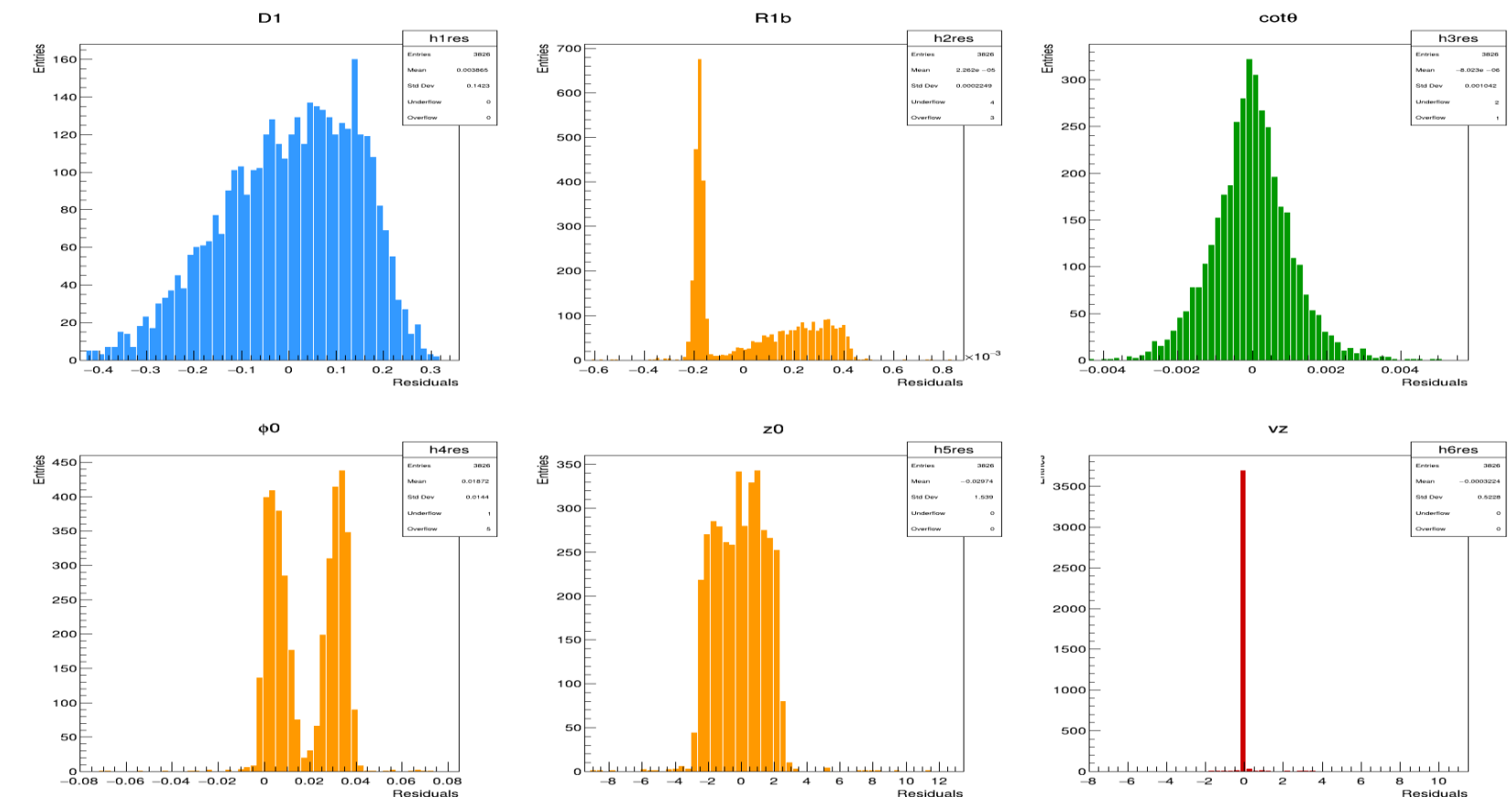
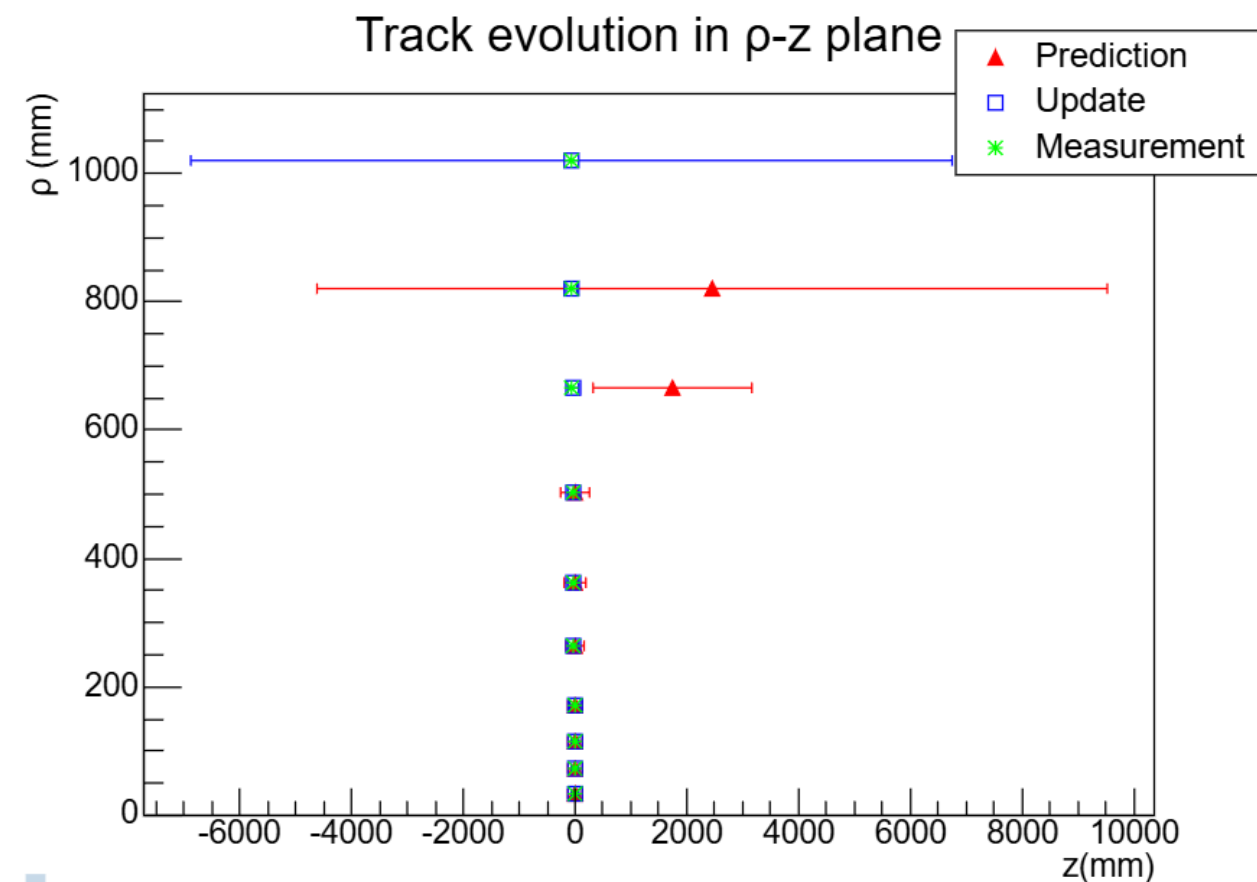
So far :

- Developed a KF
- Implemented utility class to monitor KF performance
- Derived metrics of performance (i.e. residuals, pulls)

Pending :

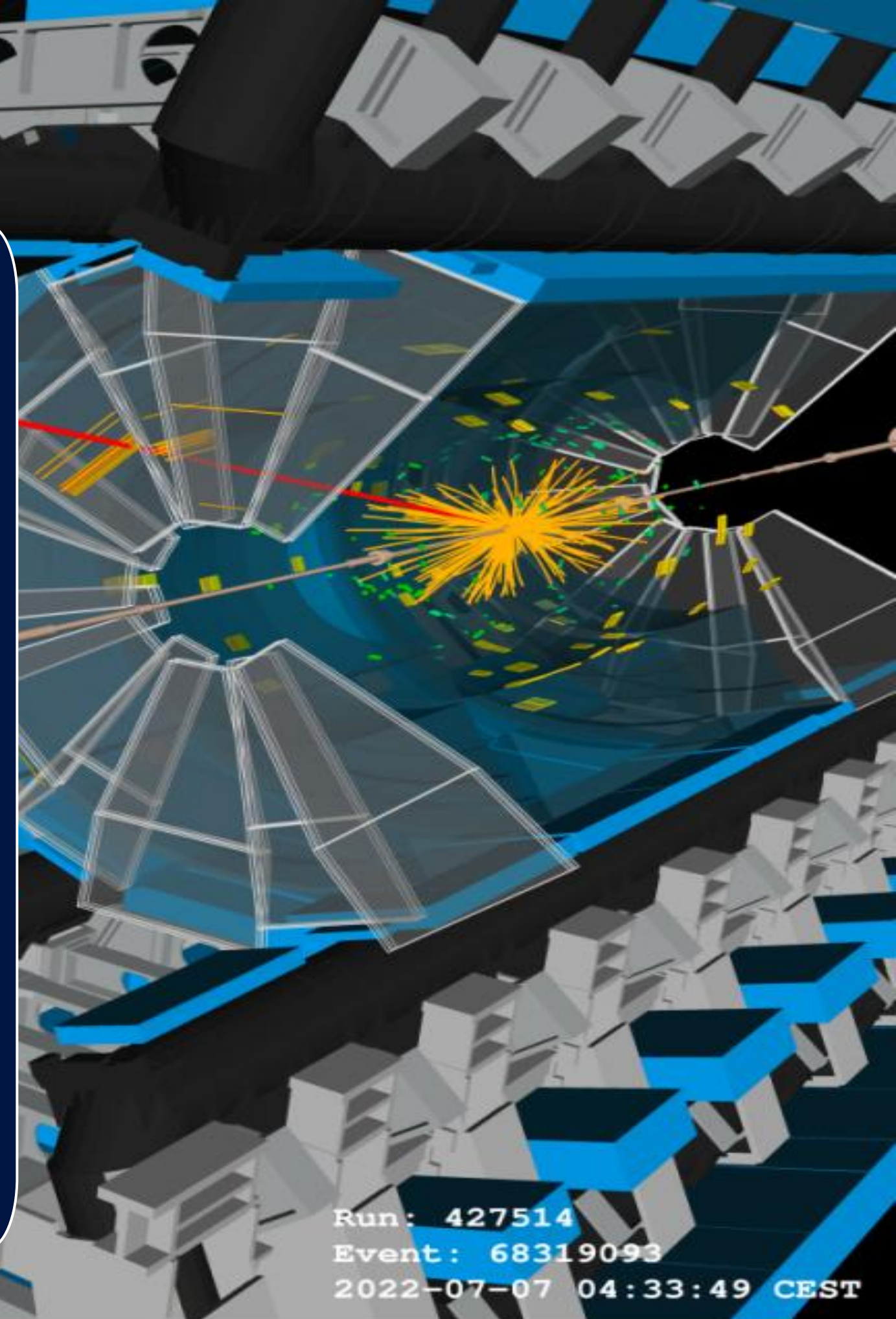
- Derive template functions for detector effects using SR
- Seed the KF with calorimeter data and extrapolate to the vertex without any other track information

Figures 4, 5 : (left) Track evolution plot in ρ - z plane, (right) track parameters residual distributions



In conclusion

- We want to make an inference about the vertex position in the ATLAS Phase-II Global Trigger
- For this reason, we use seeds from the calorimeter as a starting point for Kalman Filter
- The Kalman Filter provides a first estimation of the reconstructed particle track.
- Then we combine this with the perturbations effect template function that was provided by the SRNN to get a more accurate model for our track
- Lastly, we extrapolate this track to the beamline to get the vertex position



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Thank you!

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