Calorimeter response to particles relevant for Dark Photon studies at the FASER experiment

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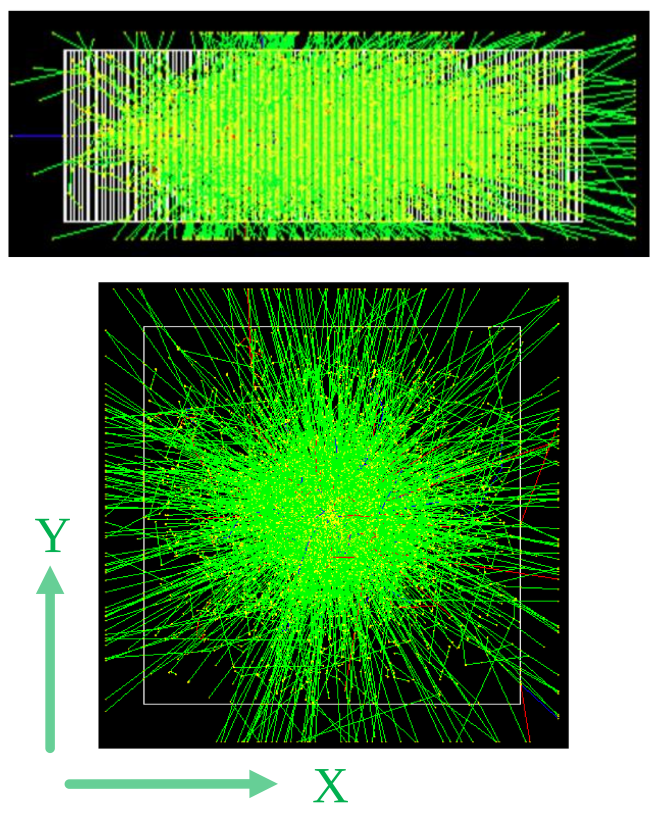
INTRODUCTION

FASER is a new type of detector expected to study hypothetical particles related to Dark Matter which decay far from the primary interaction point, IP, in the LHC.

A variety of studies on particles relevant for Dark Photon research are presented.

The purpose of this work is to understand the energy response of the FASER calorimeter to particles that are typical decay products of Dark Photons.

Geant4



This software package is a body of C++ code that models and simulates the interaction of particles through matter. [2]

In this study, we configured two different calorimeters to perform our studies on.

- Simple design: 1 module calorimeter
- Realistic design: similar to FASER's.
  - 4 modules separated by a 0.2 mm air gap in the X axis and 1.2 mm in Y axis.
  - 50 mrad shift angle in X axis.

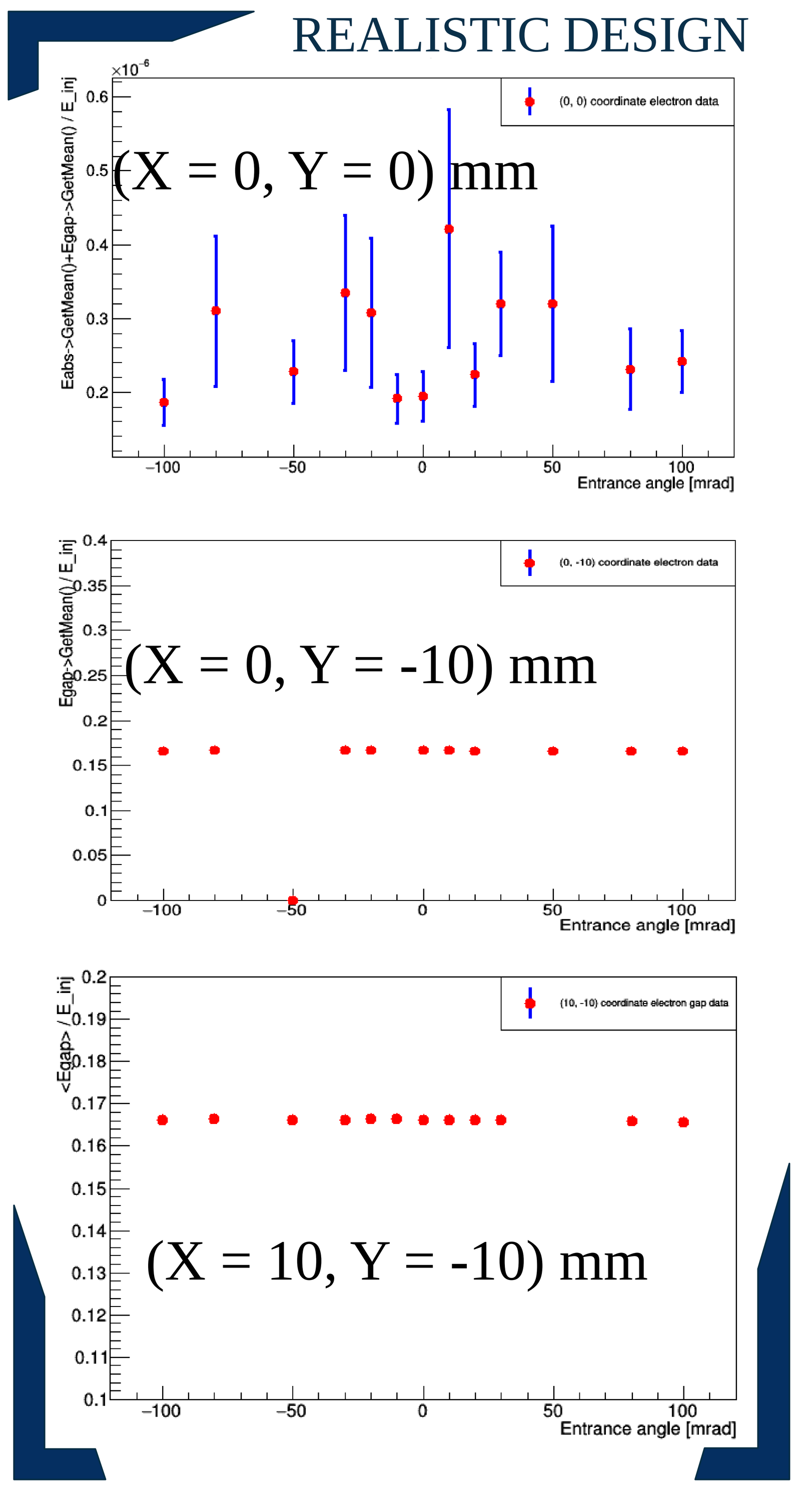
Geant4 provides simulated data files and also 3D visualizations of events

FASER only reads out the deposits on the gap section of each module

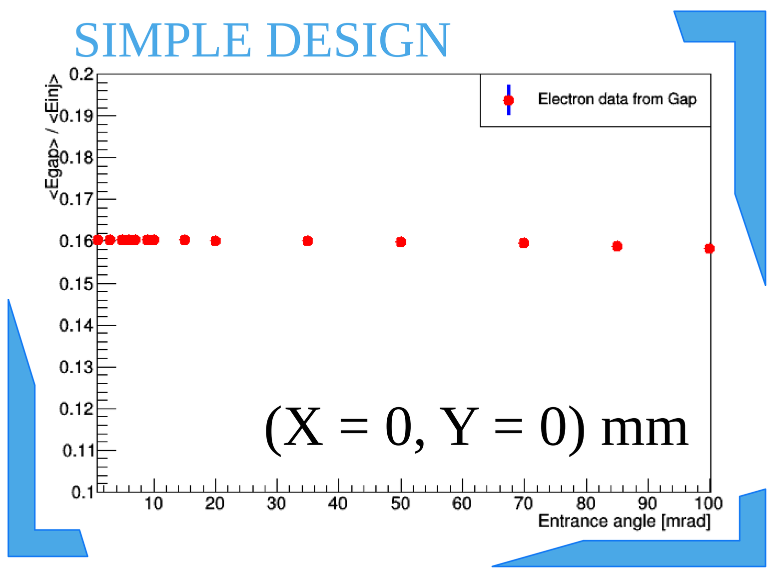
ANALYSIS: Electrons, photons & neutral pions

Particles will enter FASER with different trajectories. Here we study the angular dependences of 100 GeV electrons for 3 trajectory coordinates.

REALISTIC DESIGN



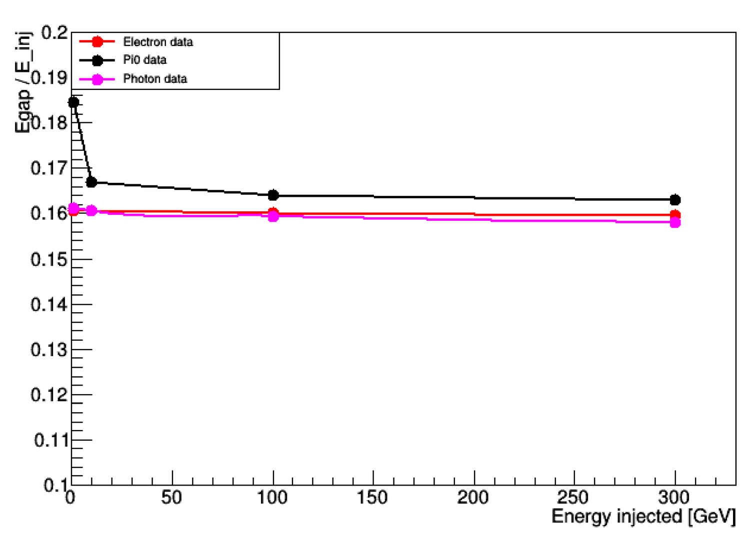
SIMPLE DESIGN



Fraction of energy deposited by electrons, photons and neutral pions.

Expecting similar behaviour since:

$$\gamma \longrightarrow e^+ + e^-$$
$$\pi^0 \longrightarrow \gamma + \gamma$$



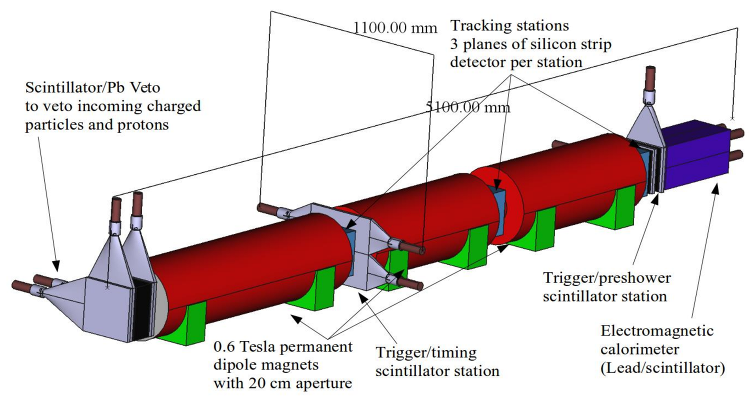
REFERENCES:

[1] FASER: https://faser.web.cern.ch/

[2] Geant4 https://geant4.web.cern.ch/

FASER: ForwArd Search ExpeRiment

FASER is a small cylindrical volume detector. It is 1.5 meters long with 10 cm in the transverse radius. [1]



One of the main goals is to search for Dark Photons, hypothetical particles which can also be long-lived, travelling hundreds of meters from the IP before decaying to visible particles, such as electrons.

Uses ECAL electromagnetic sampling calorimeter from LHCb for detection.

It is placed 480 meters away from ATLAS IP1, in service tunnel TI12 where the LHC tunnel stars to curve.

ANALYSIS: Muons & charged pions

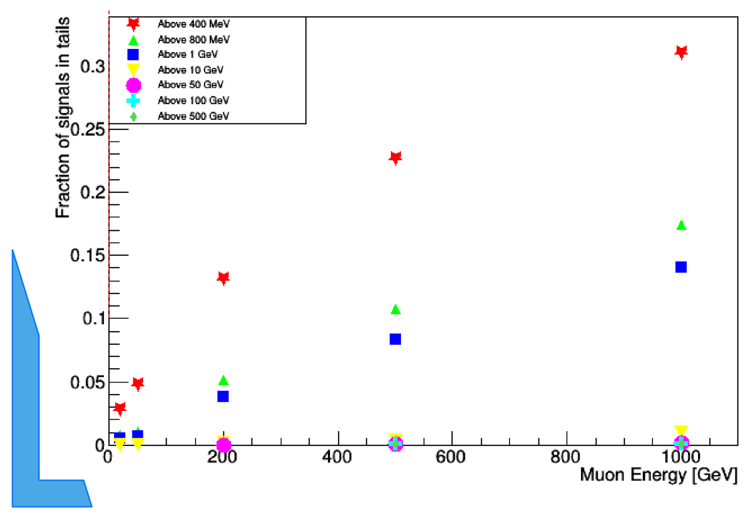
Muons are minimum ionising particles (MIP) and cannot be reconstructed by FASER

Important to understand them since:

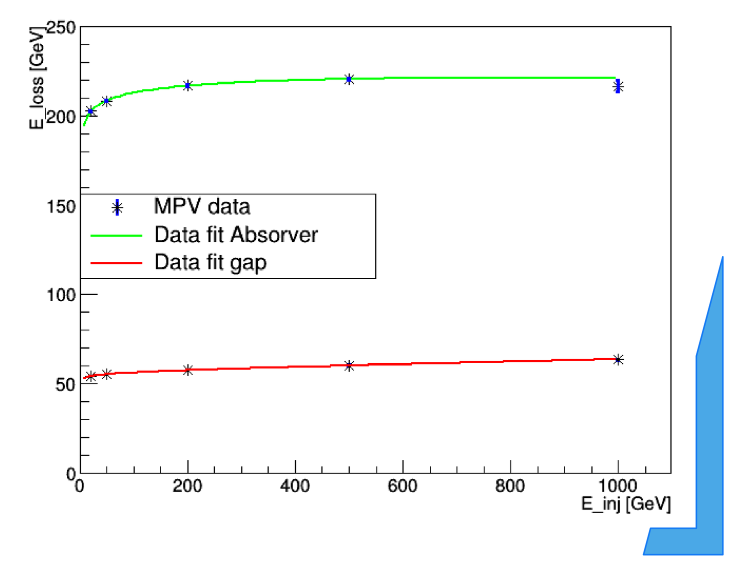
1. Very energetic muons could mimic a signal
2. Between 200 MeV and 100 GeV radiate and produce e^-
3. Will be used for test beams during RUN 3

Fraction of events in tails above given energy thresholds

The higher the fraction →
The higher the chance to fake electrons/photons

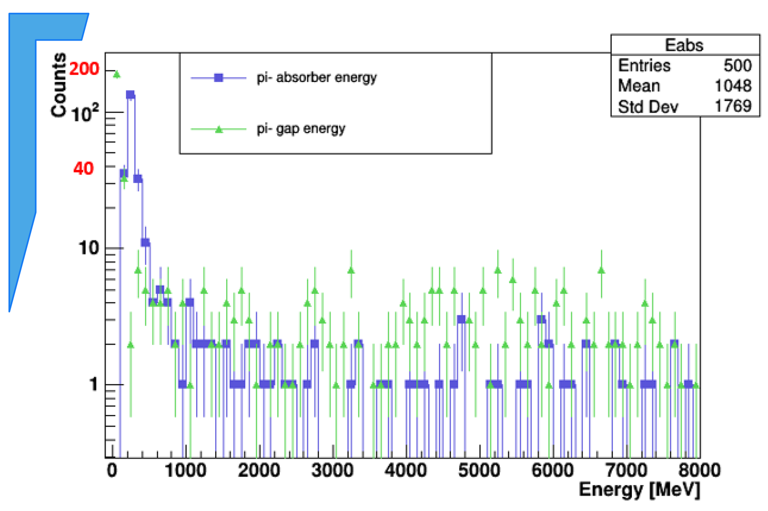


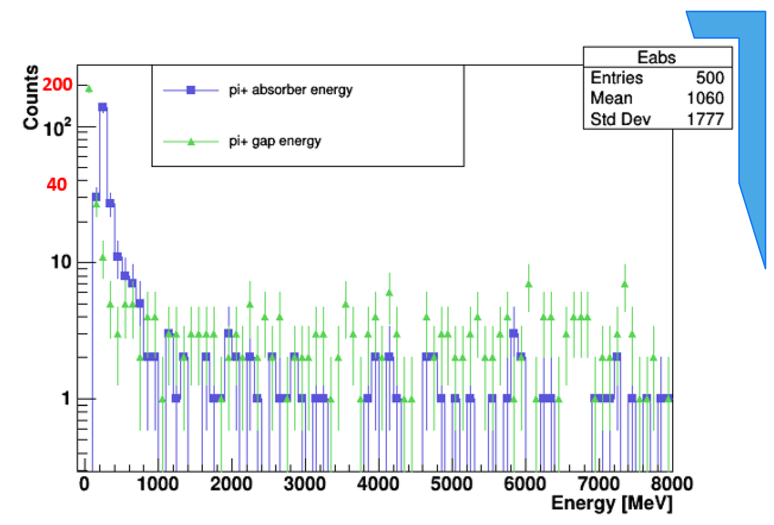
Parametrization muon energy loss



$$E_{loss}^{mpv} E_{inj} = p_0 + p_1\, ln(E_{inj}) + p_{2E_{inj}}$$

Charged pions show low-long tails, signals are diluted and very little is reconstructed





CONCLUSIONS

Particles interacting strongly with the modules deposit a similar fractions with low dependence on the injected energy.

Angular scans show that the fraction of deposited energy is independent on injection angle. However, beams accessing the detector with -50 mrad trajectory will compensate the shift angle and will not interact with the modules. Hence, creating a blind spot.

Muons confirmed their behaviour as MIPs and we showed how the energy loss can be parameterized.

While neutral pions response is equivalent to that of photons and electrons, charged pions deposit low energy in the EM calorimeter, as expected.