THE CATHOLIC UNIVERSITY of AMERICA

NEUTRAL PARTICLE CALORIMETER: SIMULATIONS

Tanja Horn, Marco A. P. Carmignotto, Ibrahim Albayrak, Jullianna Couto

01/24/2013

Hall C Users Meeting

Overview

<u>Neutral Particle Calorimeter</u>

→ Concepts and options

→ Features used in the simulations

<u>GEMC/GEANT4 simulations</u>

→ Set up of the detector

→ Signal and background consideration

→ Sensitivity to parameters:

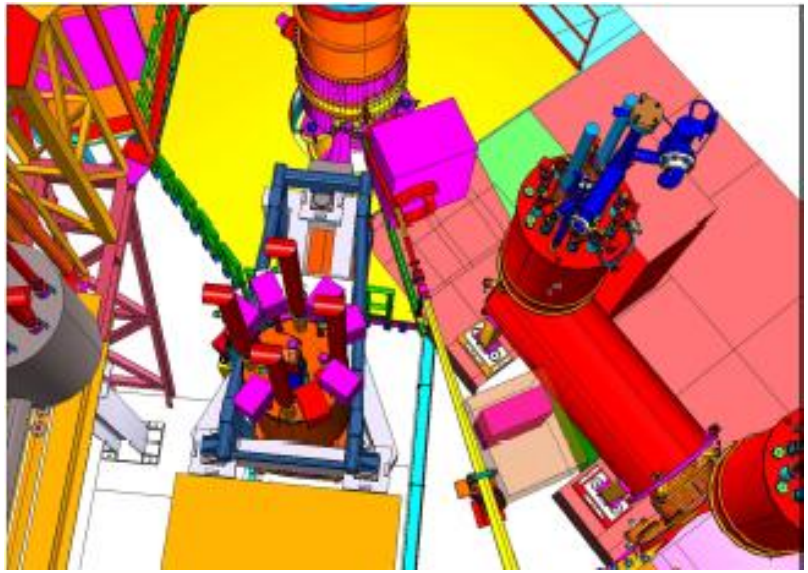
- Size of integration time window
- Beam current

Detector design

Neutral Particle Calorimeter

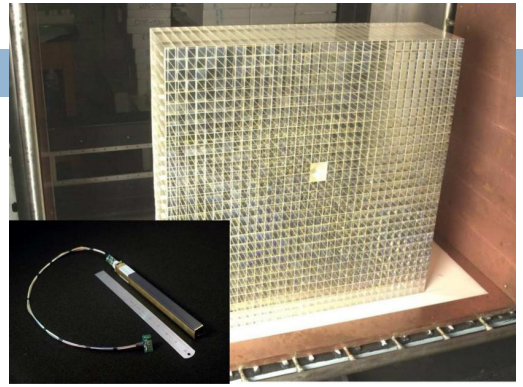
Concepts of the calorimeter

- Here, we will consider a neutral particle spectrometer with the following characteristics:
  - **$PbWO_4$** or **PbF_2** crystals
  - Temperature controlled frame
  - Essentially deadtime-less digitizing electronics (flash ADC)
  - A sweeping magnet
  - HV bases with built-in amplifiers



These concept were considered to take advantage of existing detector (components) from, e.g., PrimEx or DVCS

Studies using option: $PbWO_4$ crystals



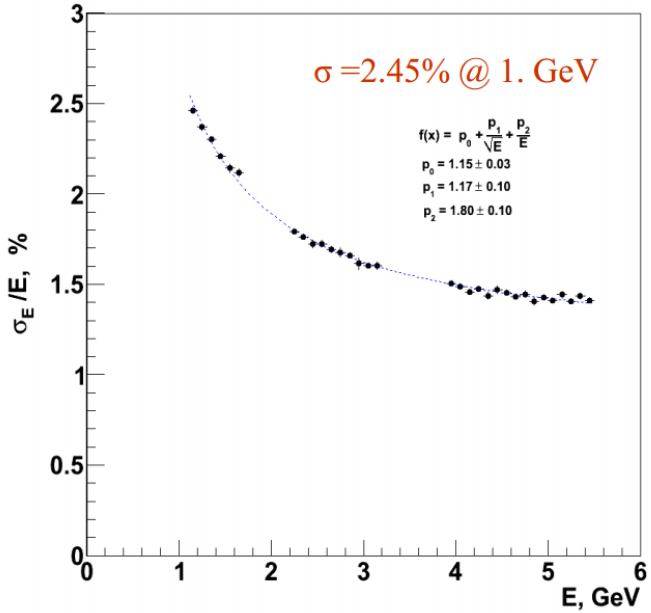
Detector dimensions:

31 x 36 matrix of $PbWO_4$ crystals

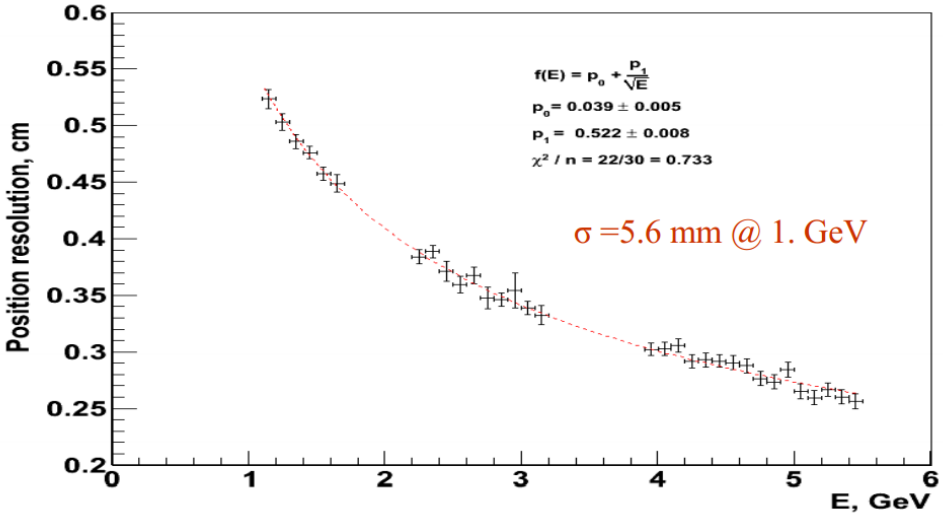
2.05 x 2.05 x 18 cm^3 each crystal

<u>Assuming we will have crystals from PrimEx experiment:</u>

Energy resolution



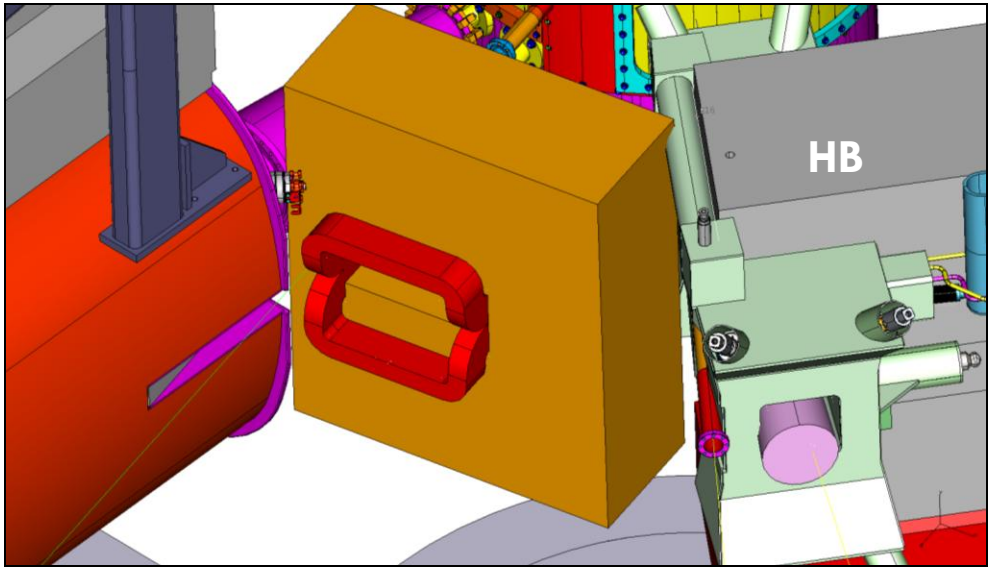
Spatial resolution



More details of the crystals in talk:
H. Mkrtchyan, "Neutral Particle Detector: Crystal Properties"

Sweeping magnet

- Resistive magnet based on Hall C horizontal bend (HB) design for SHMS
  - Normal-conducting copper coil magnet
  - Aperture: 35x36cm^2
  - Magnetic field strength: 0.3 T-m
- Designed to work with existing JLab power supplies *[P. Brindza, 2012]*



Sweeping magnet schematic shown with HB

Treated in the simulation as:

Magnetic field for background charged particles bending

Digitizing electronics

- **Usage of flash ADCs**

  - ✓ Continuous sampling of the signal – 4ns window
  - ✓ Internal buffer for pre-trigger sampling
  - ✓ FPGA for sampling and bufferizing signal. Also possible to create advanced online processing for trigger system, e.g. cluster finding, …
  - ✓ FPGA → real parallel processing → "no" electronic deadtime

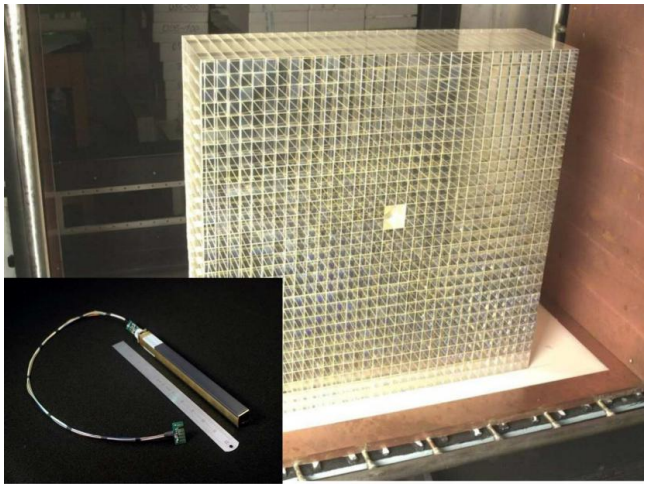
Treated in the simulation as:

Different time window for signal integration

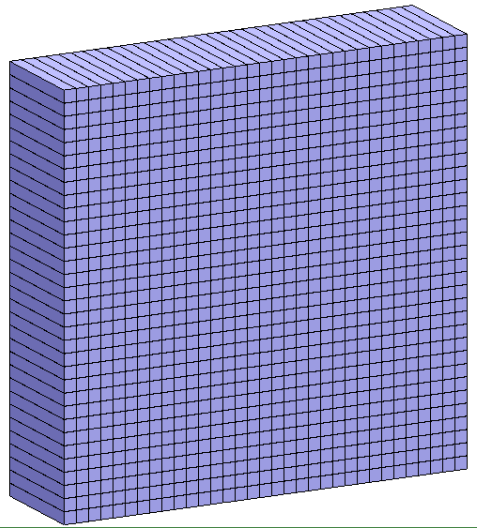
Simulated Detector Features

Neutral Particle Calorimeter

Calorimeter design



- ✓ GEMC / GEANT4 framework
- ✓ Studies based on the option of using $PbWO_4$ crystals.
- ✓ Studies with lead fluoride are on the way.



Detector features:

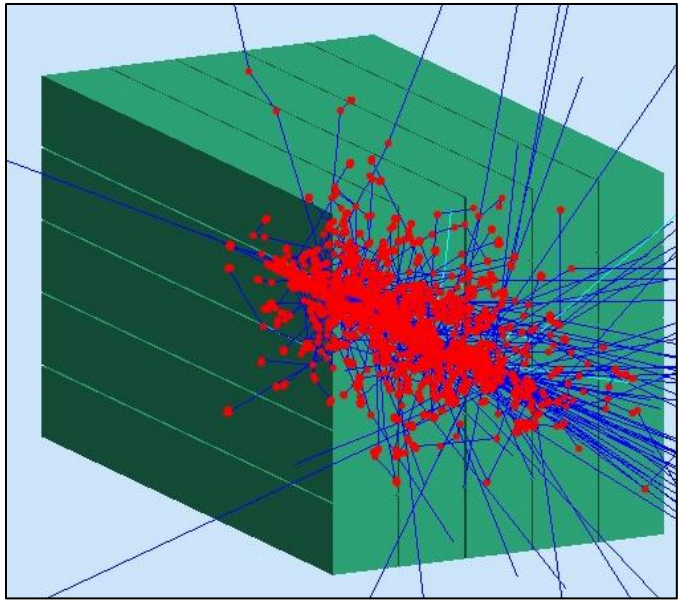
34 x 34 matrix of PbWO4 crystals

2.05 x 2.05 x 18 cm^3 each crystal

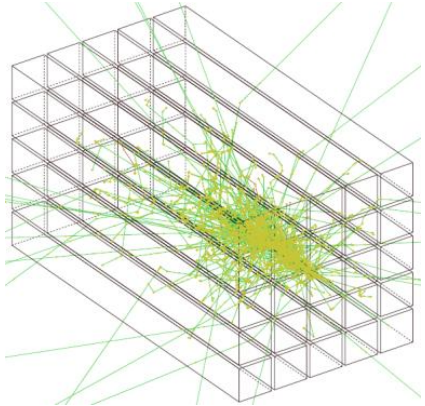
No PMT/detector efficiency simulated

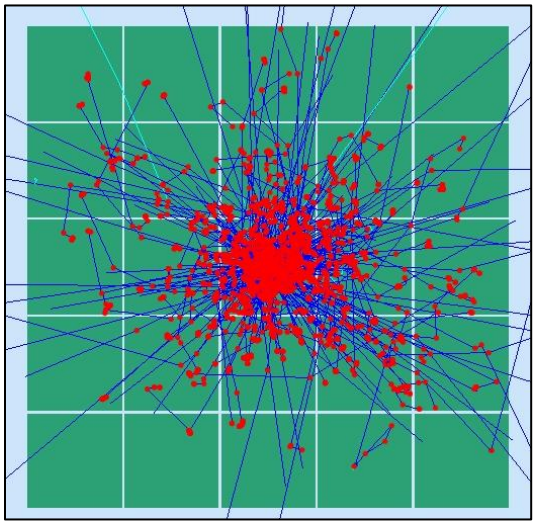
Shower profile

3 GeV photon hitting the center of the crystal

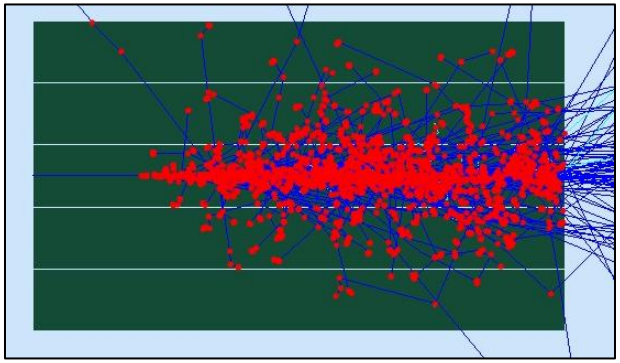


3D view





Front view

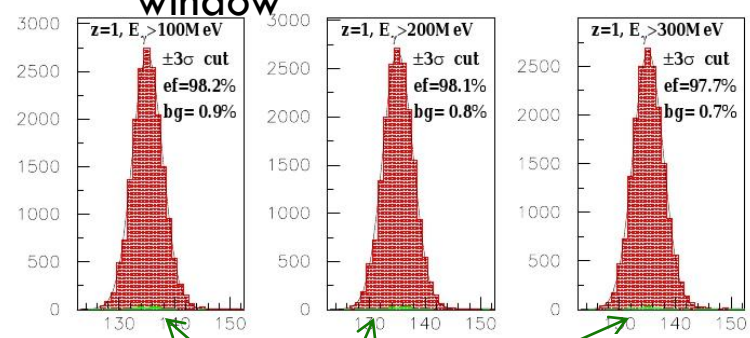


Side view

π^0 decay simulation

- Includes photons from π° decay
  - Simulate π° signal normalized to rate.
  - For each event decay π° into 2 γ
- Simulated background consists of realistic fluxes of neutral and charged particles, the latter suppressed by sweeper magnet [P. Degtiarenko, 11+]
- Photon pair is selected from other processes in the calorimeter using a cluster finding algorithm
- π° invariant mass reconstructed for each hit in the calorimeter

100 ns $\gamma\gamma$ coincidence time window

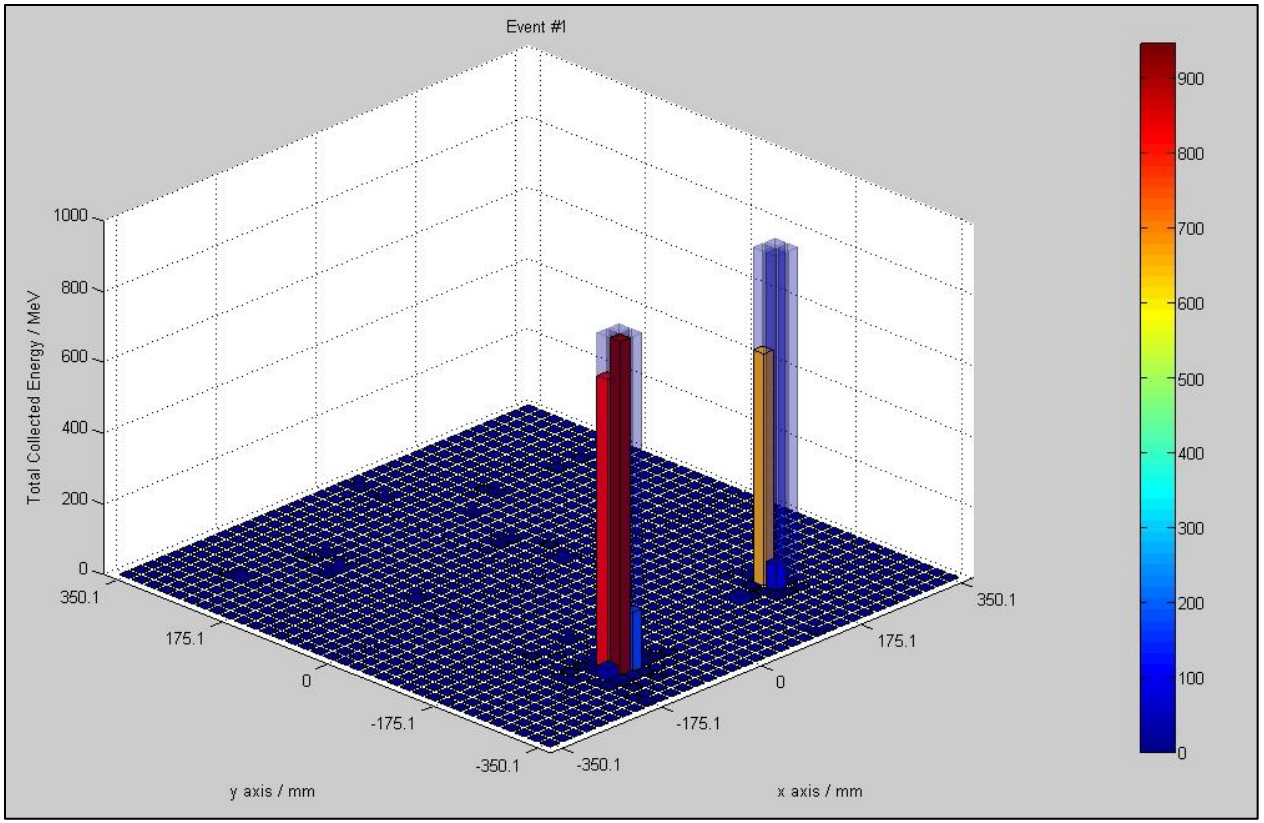


m_{π° m_{π° m_{π°

Combinatorial background

Combinatorial background is small (<1%)

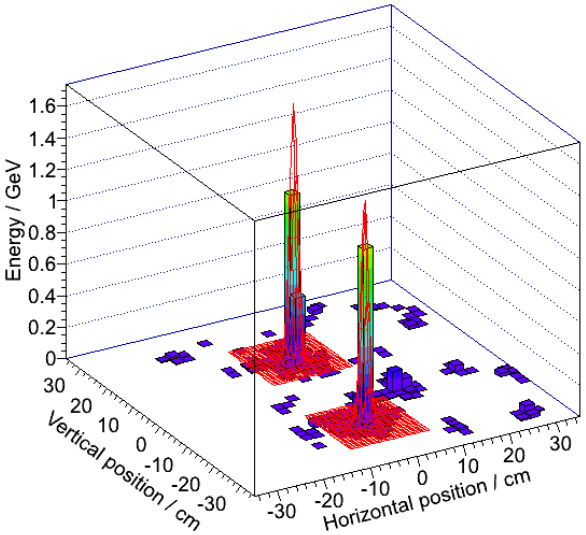
GEMC – π^0 detector simulation



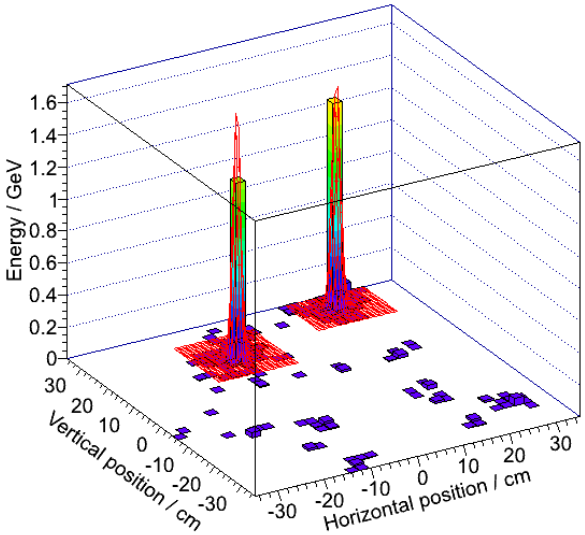
Total energy deposited in each crystal. The shadow blue peaks show the cluster analysis for finding the two greatest peaks on the detector. In this case, it was used a cluster size of 2x2 crystals

Studies on the π^0 detector

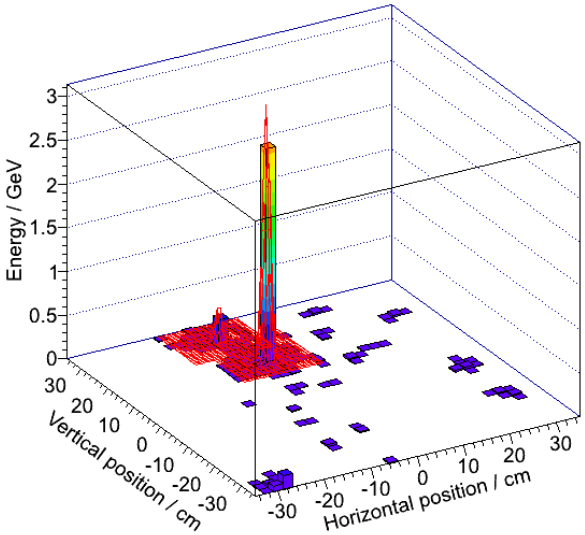
Each event contains 2 photons from π^0 decay and background.



One typical analysis (almost no background)



Fitting peaks close to the edges of the detector

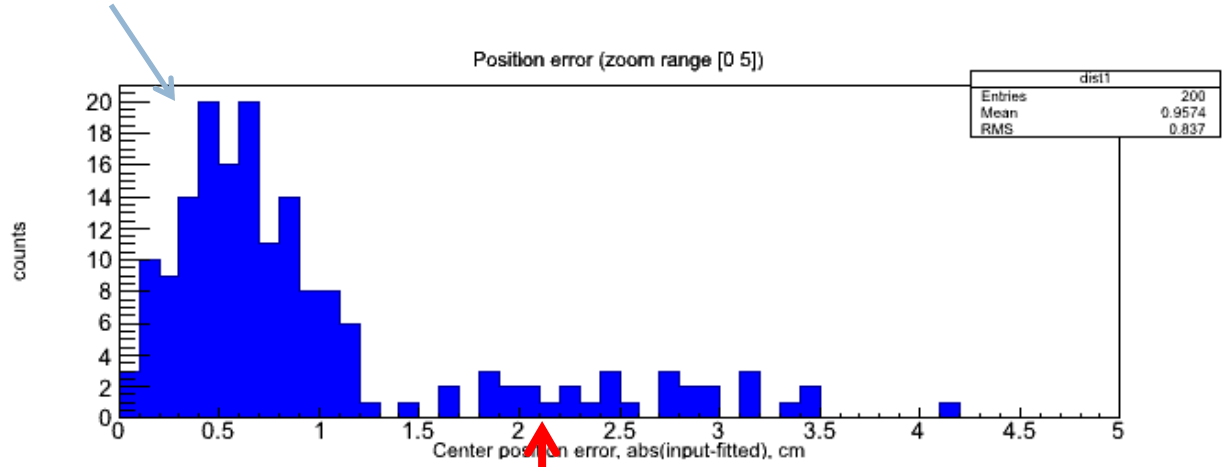


Fitting two peaks close to each other

Studies on the π^0 detector

Distance of the simulated peak to the original peak (input photon position)

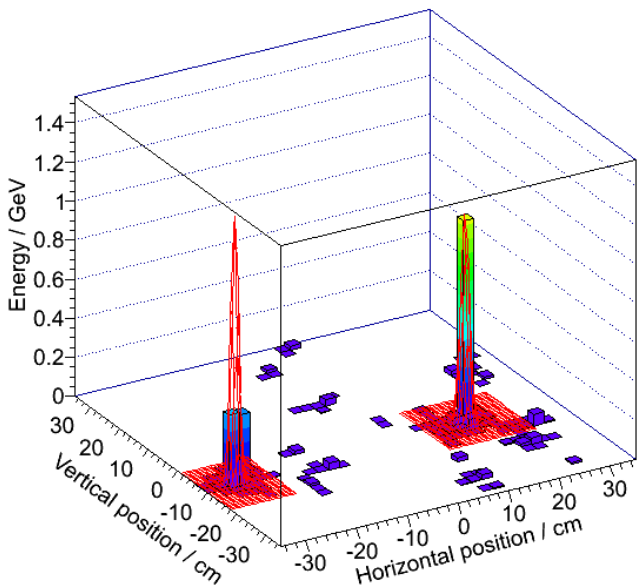
Sub-crystal resolution!

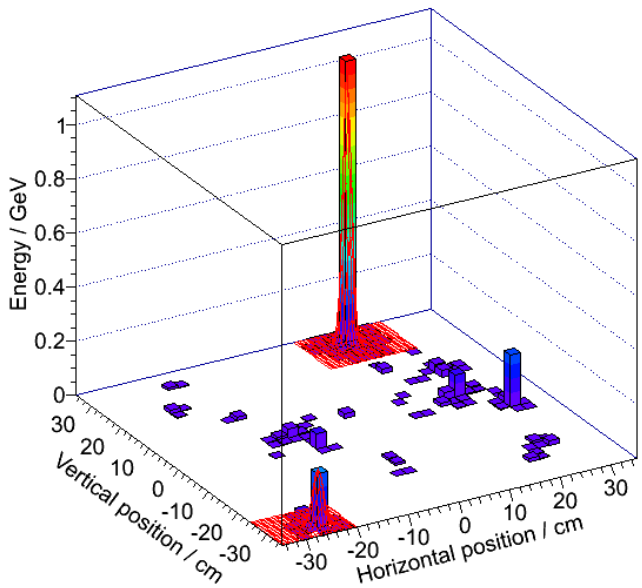


Crystal dimension

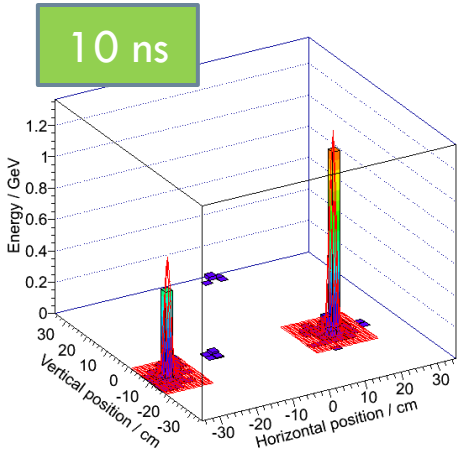
Simulations including background

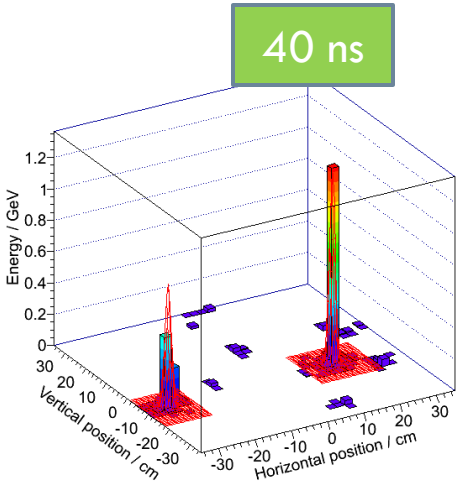
- **Events with two photons from π^0 decay and background**

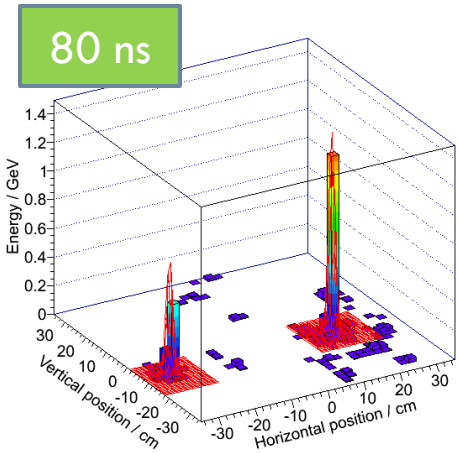


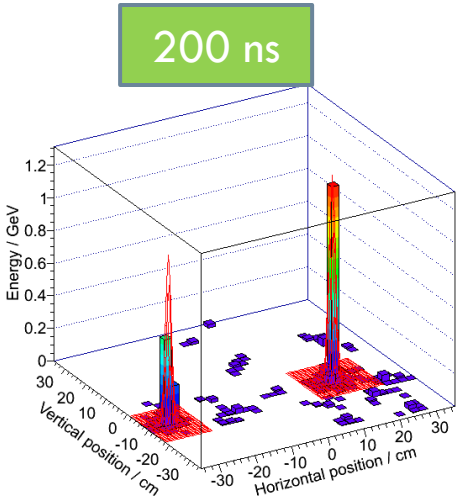


Simulations including background



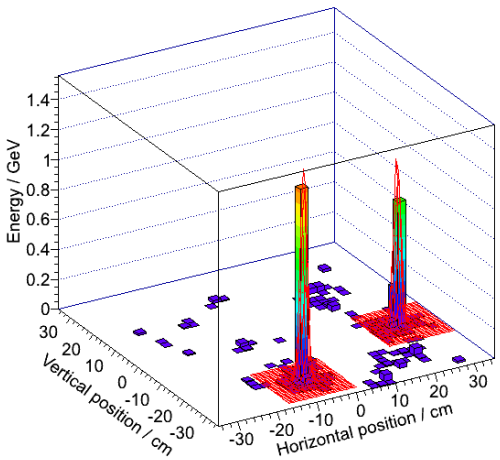




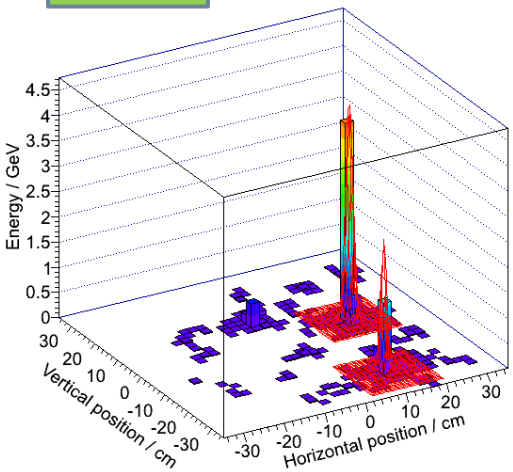


Simulations with higher currents

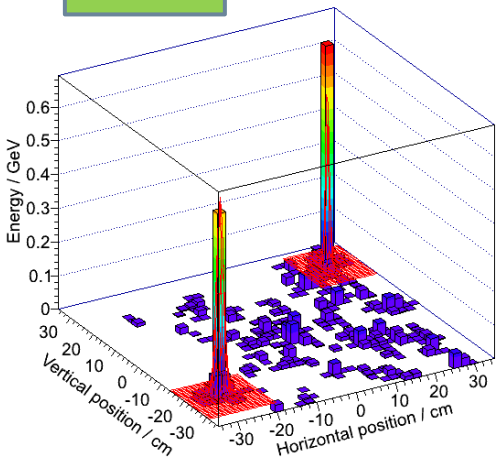
1 uA



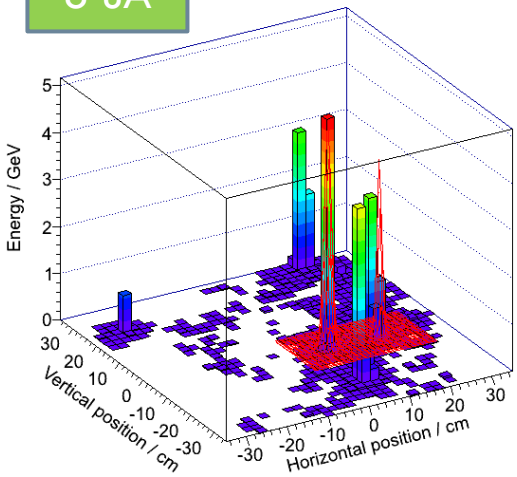
2 uA



5 uA



8 uA



Next steps

Neutral Particle Calorimeter

Next steps...

<u>On the detector concept</u>

→ Simulate same situation with PbF_2 crystals (from DVCS)

<u>On the parameters of the simulation</u>

→ Simulation for different angles of SHMS (changing signal to background ratio)

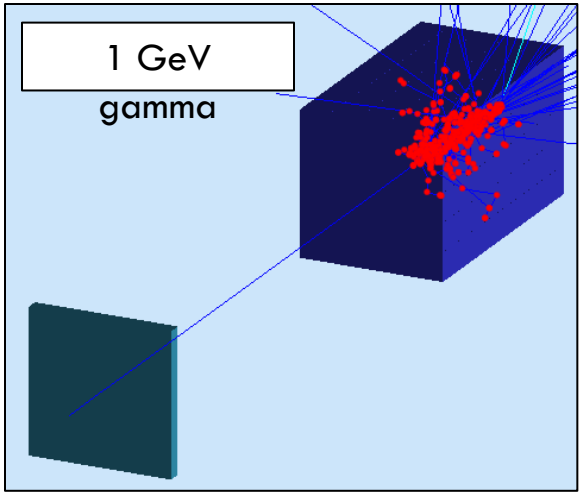
Simulations including a pre-shower

Possibility of working with pre-showers:

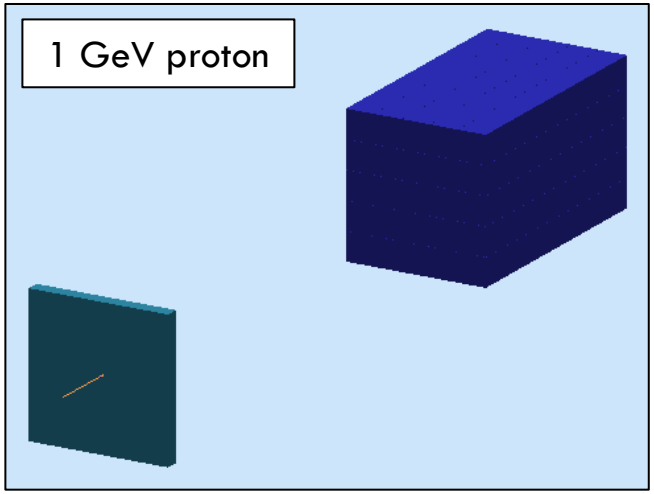
- Particle identification (e, p, gamma)
- A problem for two photons too close in a π^0 decay

<u>First simple pre-shower:</u>

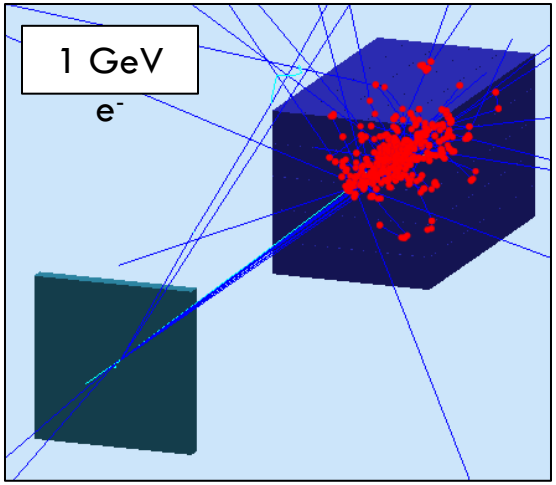
10mm thick $PbWO_4$ crystal



"No" interaction



Absorbed



Pre-shower created