The Catholic University of America

A future
π^0 detection facility in Hall C

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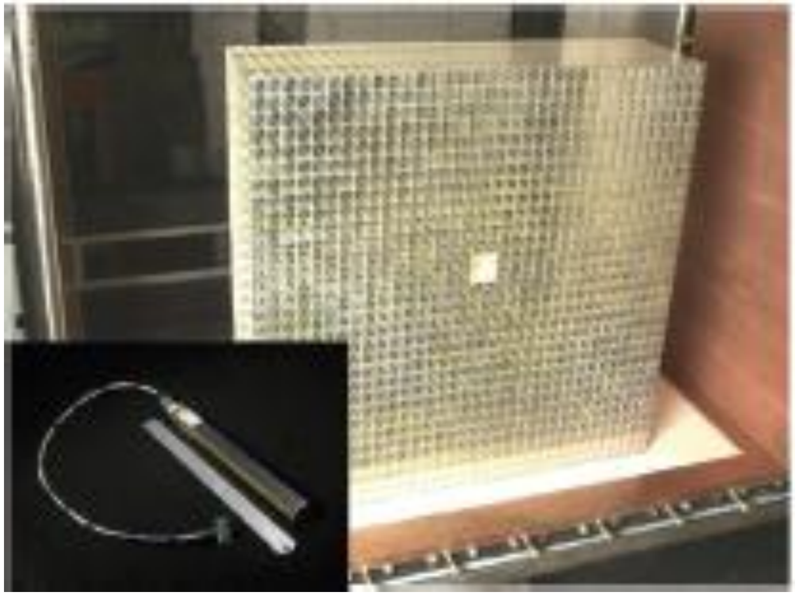
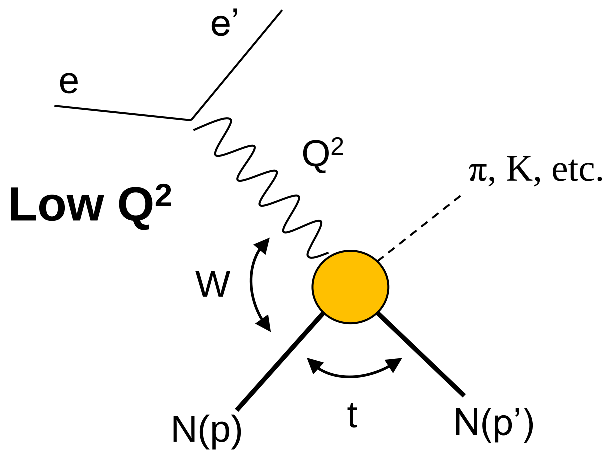
A future π^0 detection facility in Hall C

- Scientific motivation
  - L/T cross section sepatation
  - A π^0 detector for Hall C
- Detector design
  - PbWO4 crystals
  - Temperature controlled frame
  - Sweeping magnet
  - fADC
  - PMT base modification for high rate
- Simulations
  - GEMC/GEANT4 simulation
  - Cluster finding

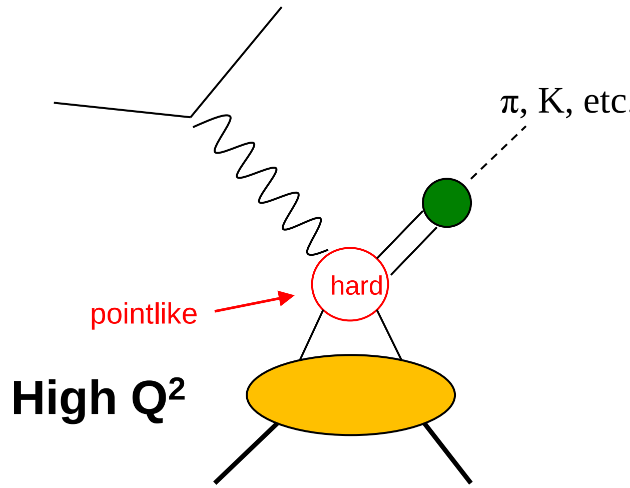


Scientific motivation

Meson Reaction Dynamics



t-channel process



handbag

<u>Small –t and large W → t-channel process</u>

– Meson form factor describes the spatial distribution of the nucleon

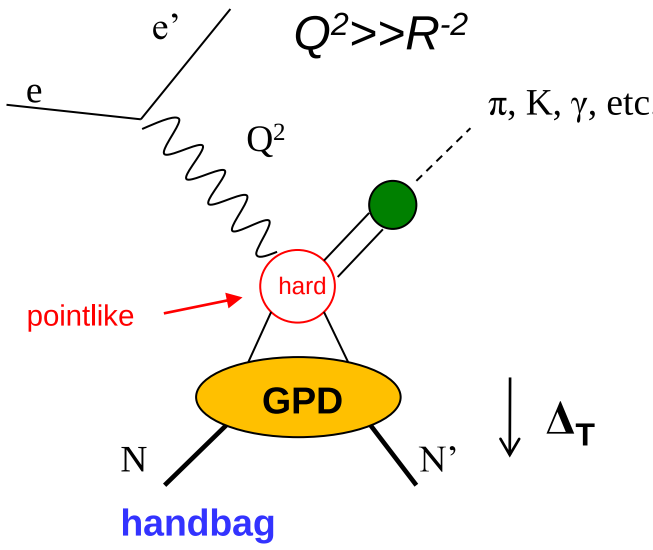
<u>High Q^2 → " handbag" diagram</u>

– The non-perturbative (soft) physics is represented by the GPDs
  - Shown to factorize from QCD perturbative processes for longitudinal photons *[Collins, Frankfurt, Strikman, 1997]*

Example: Ratio $R=\sigma_L/\sigma_T$ in the Exclusive limit

- Production of π^+ and K^+ feature a meson exchange contribution in the t-channel (pole term), whose impact on factorization has to be understood

- In π° production the pole term is suppressed
  - The t-dependence at small t can thus be associated with the structure of the nucleon rather than its pion cloud
    - A large $R=\sigma_L/\sigma_T$ would imply the realization of the factorization theorem
  - A large response in σ_L may indicate non-pole contributions in π^+ production

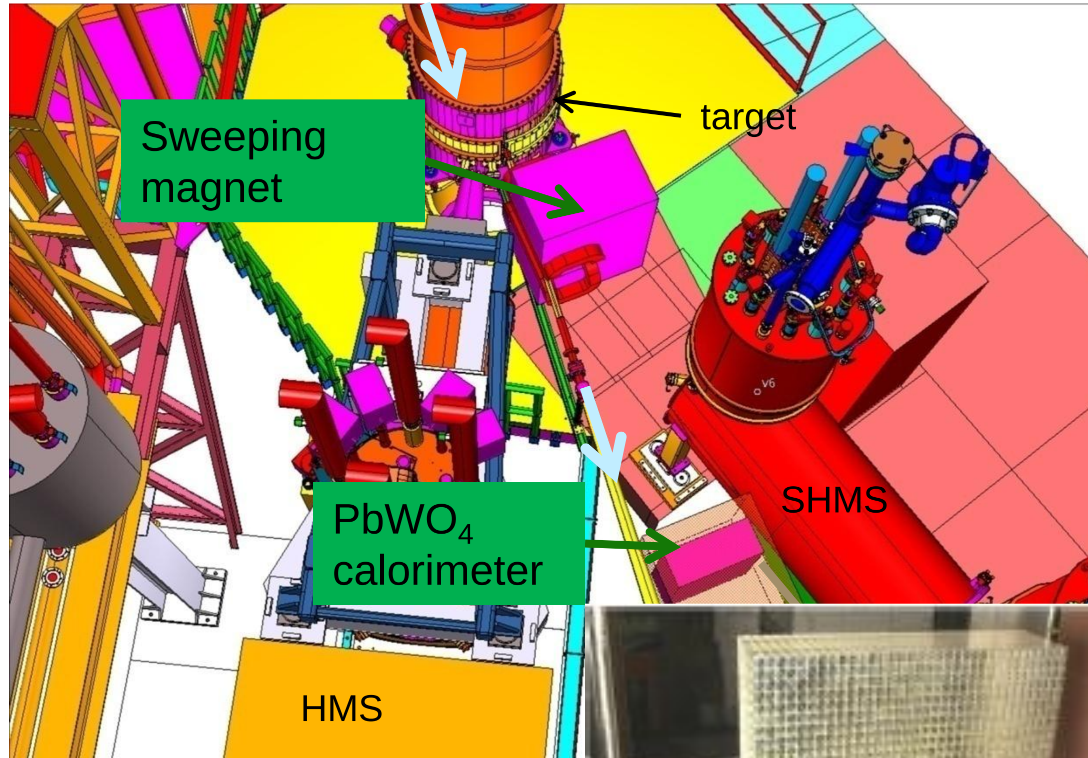


- Comparison of R in π° and π^+ production important for understanding:
  - Pole and non-pole contributions in nucleon (spin) structure studies
  - Non-pole contributions in F_π extraction

A new π^o L/T facility in Hall C

- New $PbWO_4$ calorimeter provides π^o detection facility in Hall C

- Provides opportunities to extend separations program for DVCS
  - initial DVCS separation
  - extensions to a broader kinematic range anticipated



MRI Consortium proposal submitted Jan 2012:
CUA, ODU, FIU, JLab, Yerevan

Detector design

Concepts the π^0 calorimeter

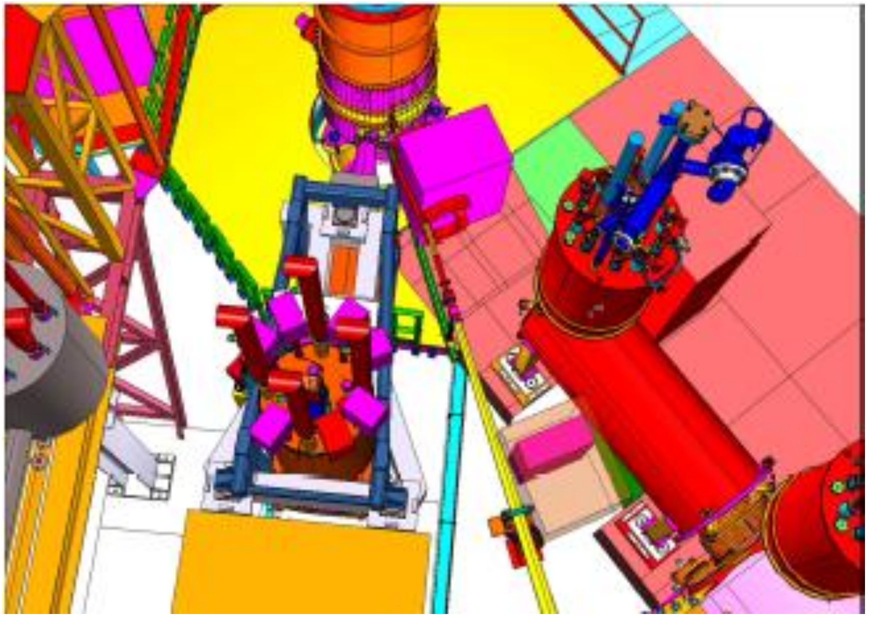
- The detector system will consist of

PbWO4 blocks of the PRIMEX setup in a new temperature controlled frame

Essentially deadtime-less digitizing electronics

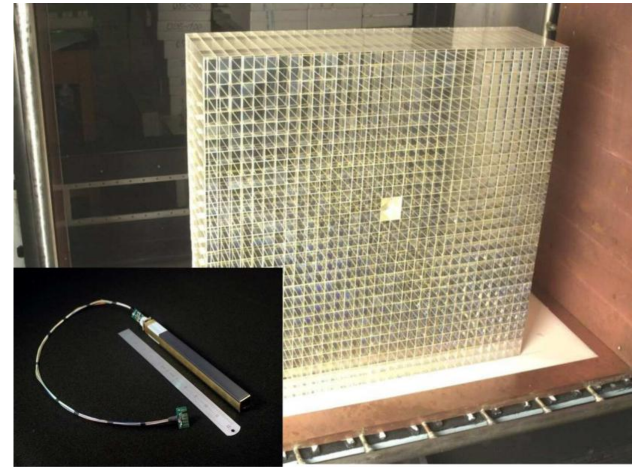
A sweeping magnet

HV bases with built-in amplifiers



$PbWO_4$ crystals

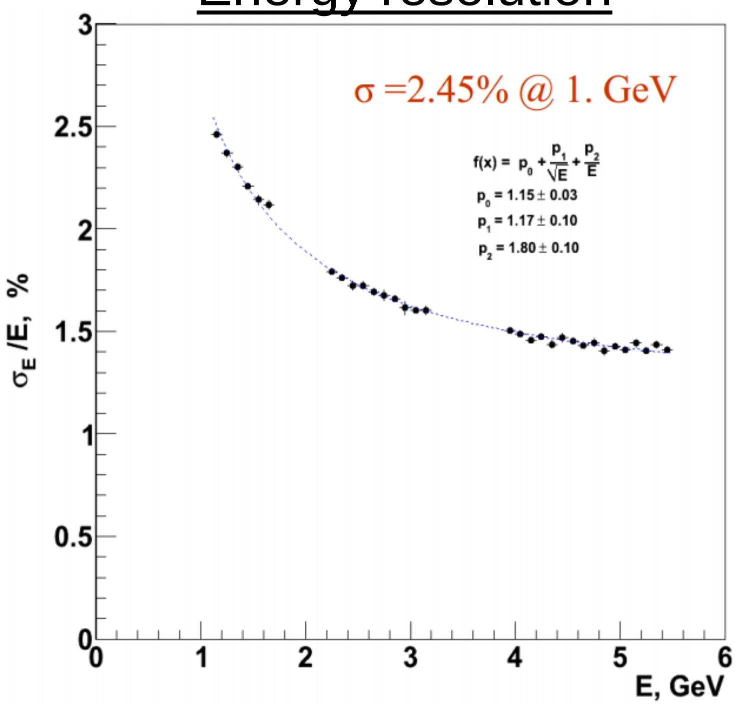
- **Existing crystals from Primex Experiment**



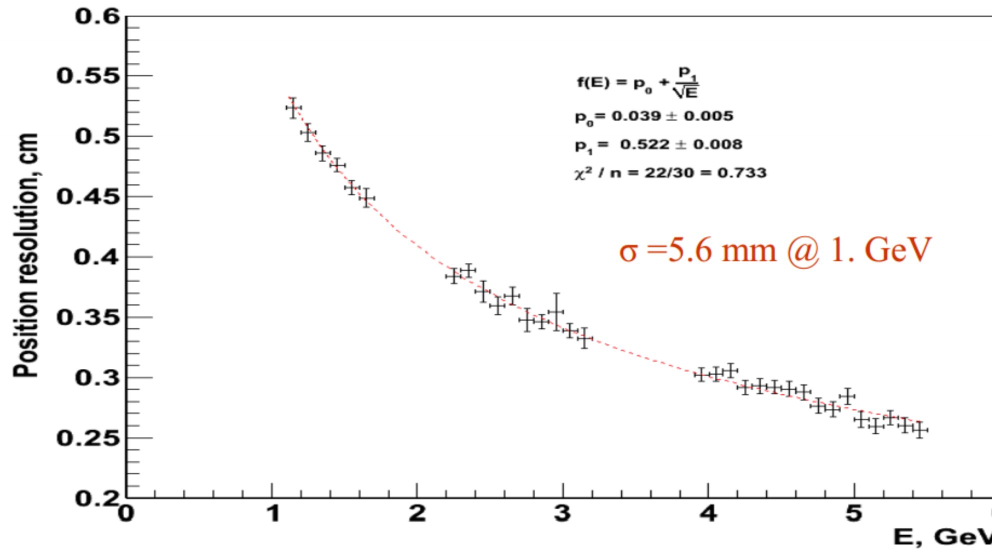
π^0 detector features:

31 x 36 matrix of $PbWO_4$ crystals
2.05 x 2.05 x 18 cm^3 each crystal

Energy resolution



Spatial resolution



Temperature Controlled Frame

- **$PbWO_4$ crystal has light yield of 2.5% / ^{o}C (at $25^{o}C$)**

- **For measurement, temperature must be stable to ~$0.1^{o}C$ to achieve energy resolution of 0.5%**

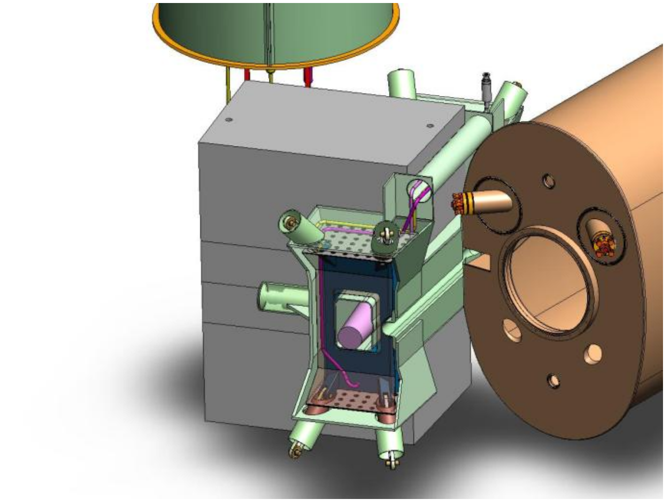
- **Construction of a frame to control the setup temperature:**

  - Temperature sensors
  - Cupper plates to refrigerate system
  - Water cooling system

Sweeping magnet

➢ **Resistive magnet based on the Horizontal Bend (HB) magnet design**

- ✓ Normal-conducting copper coil magnet
- ✓ Aperture of 35x36 cm^2
- ✓ Magnetic field strength of 0.3 T.m
- ✓ Design similar to the super-conducting dipole (HB) of the SHMS



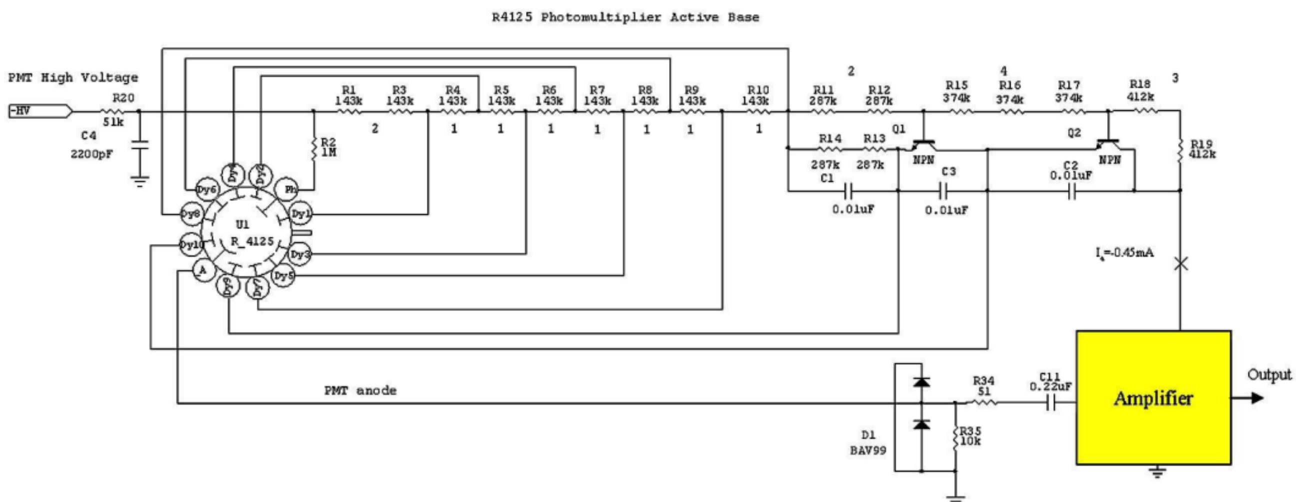
Hall C Horizontal Bend(HB) SC Magnet Cutaway
(shown with HMS Q1)

Digitizing electronics

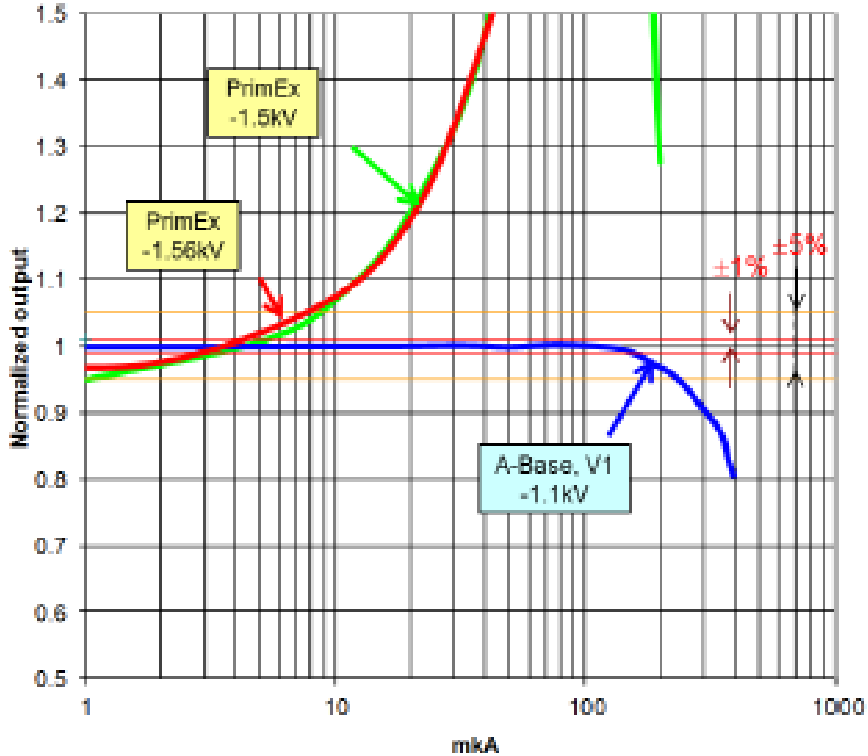
- **Usage of flash ADCs**
  - ✓ Continuos sampling of the signal – 4ns window
  - ✓ Internal buffer for pre-trigger sampling
  - ✓ FPGA for sampling and bufferizing signal. Also possible to create advanced online processing for trigger system, e.g. cluster finding, ...
  - ✓ FPGA → real parallel processing → “no” electronic deadtime

High Voltage Base Design

- ➢ Adding two high-voltage transistors to the last two dynodes:
  - Drain current and do not change the division ratio



Active bases for PMTs



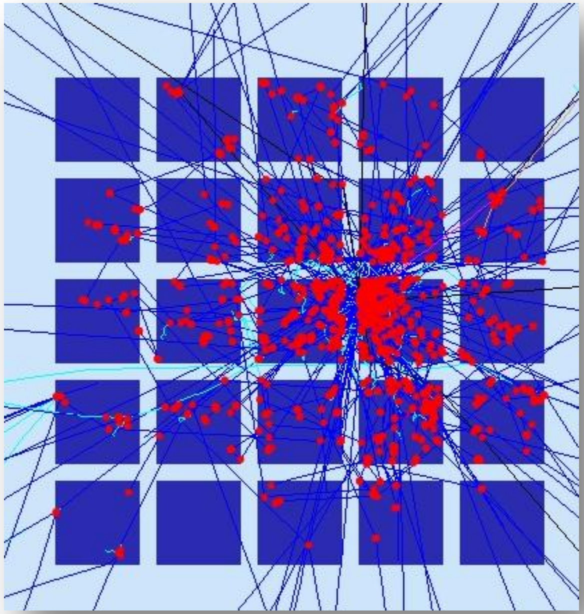
➢ The new active base design out performs the Primex PMT/base by a factor of ~25:

- ➢Increases the maximum linear count rate: from 30kHz to 1.2MHz
- ➢Changes the gain stability from ±5% to ±1%

Simulations

Simulation of the calorimeter

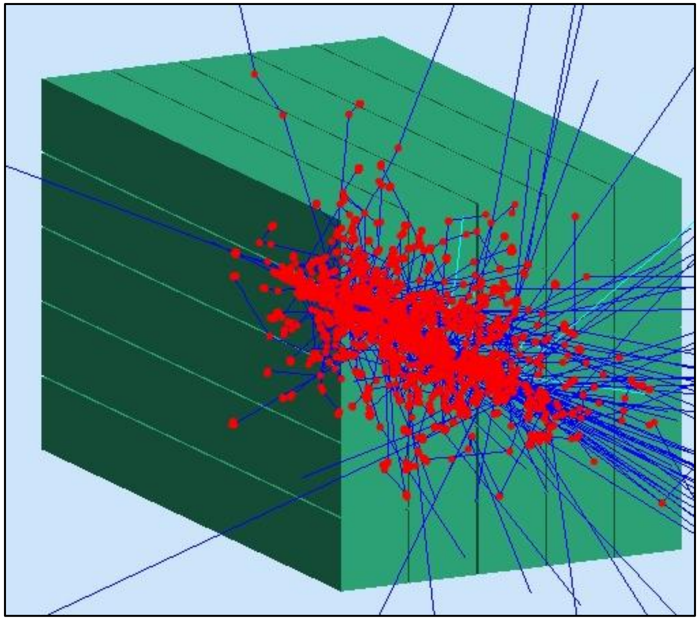
- **Single photon hitting the small detector in GEMC/GEANT4**



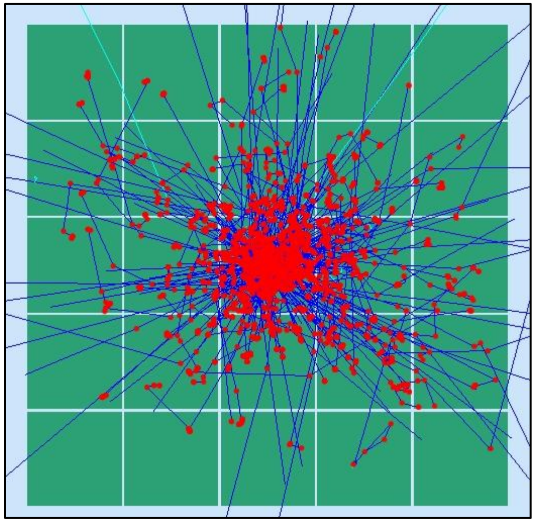
Shower spreads in the neighbor crystals, making possible a sub-crystal resolution

Shower profile simulation

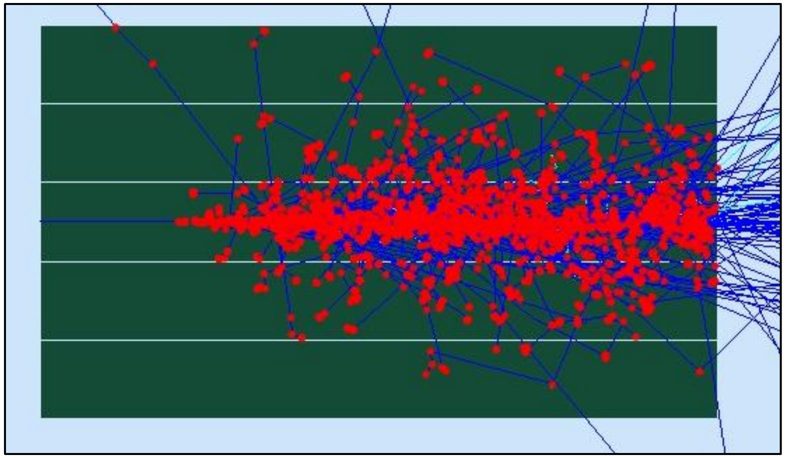
3 GeV photon hitting the center of the crystal



3D view



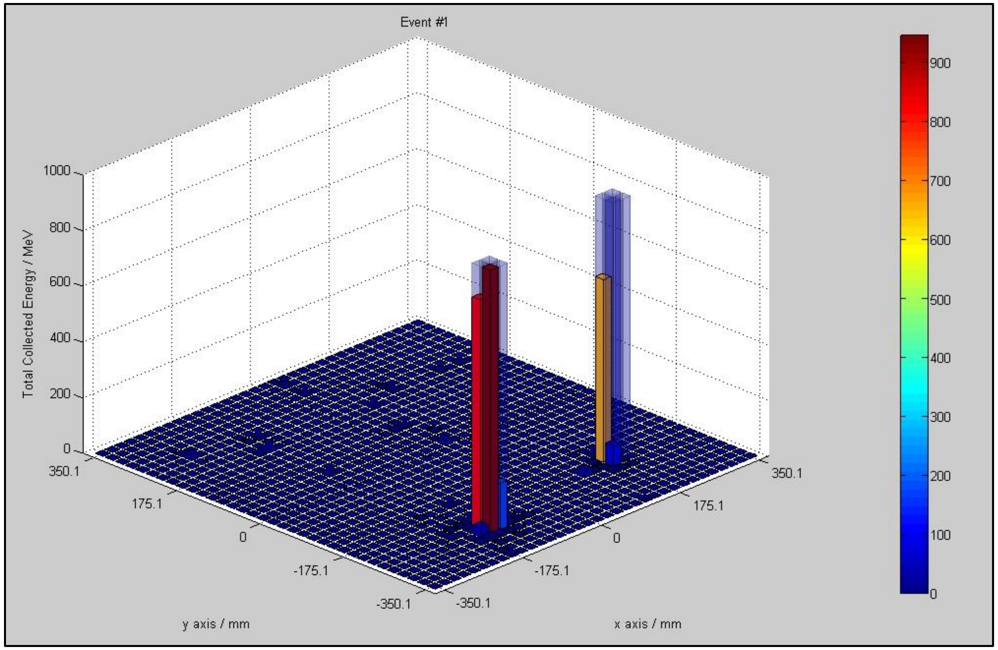
Front view



Side view

Cluster finding algorithm

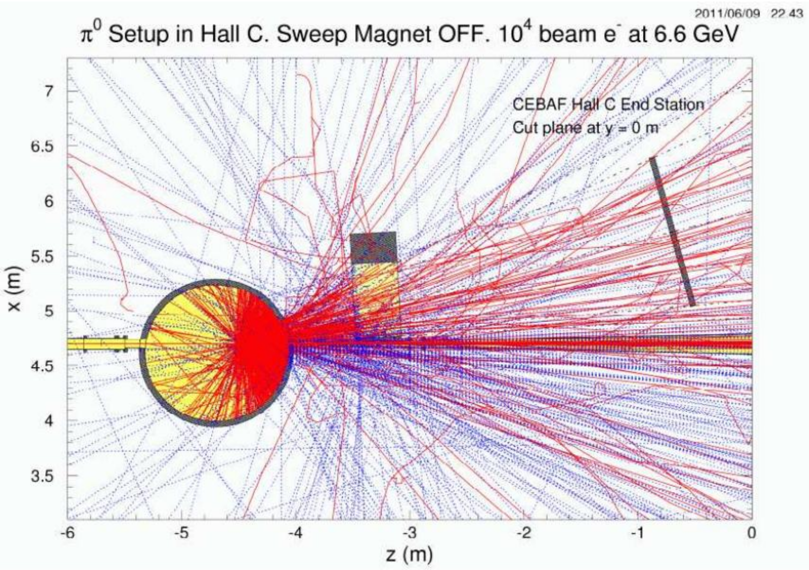
Simple case: no background

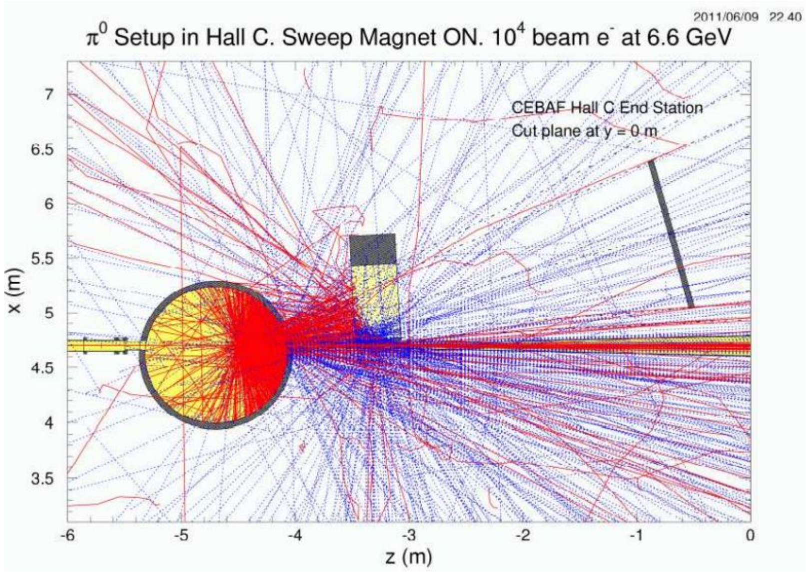


- Find two crystals with greatest energy and with a minimum distance between them
- Make a square cluster using the energetic crystal, in order to maximize energy in the cluster
- Fit a 3D gaussian using crystals in the clusters

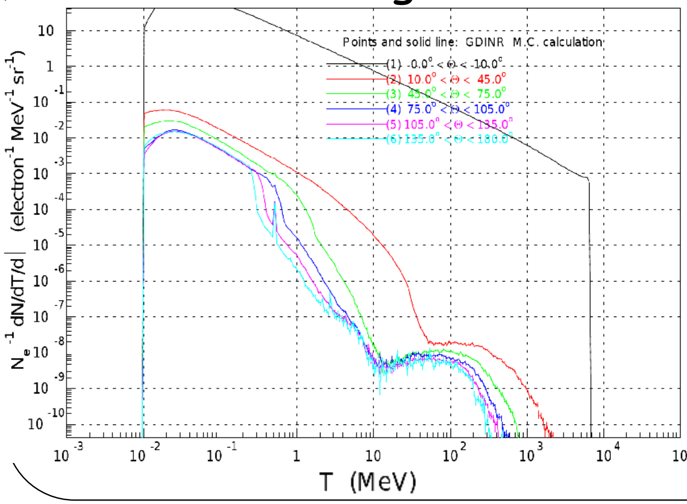
Simulating background

➢ **Magnetic field before the detector to reduce charged particles background**

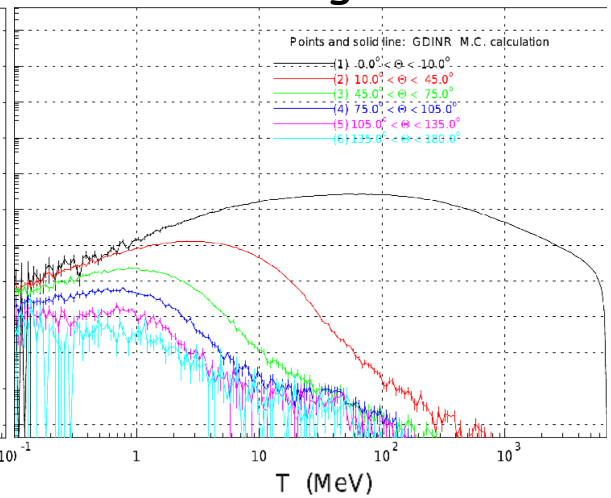




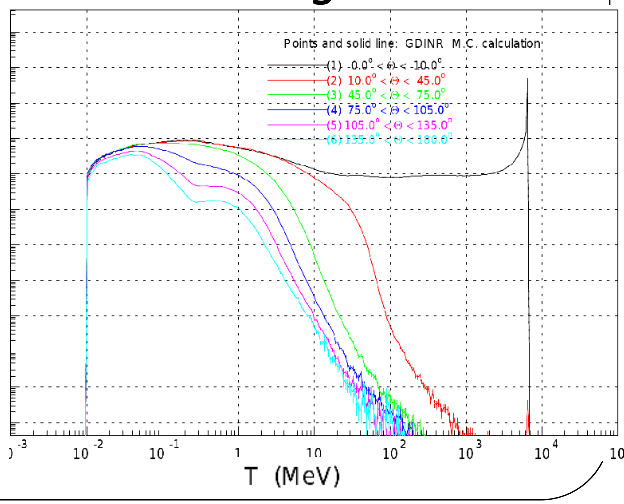
γ background



e^+ background

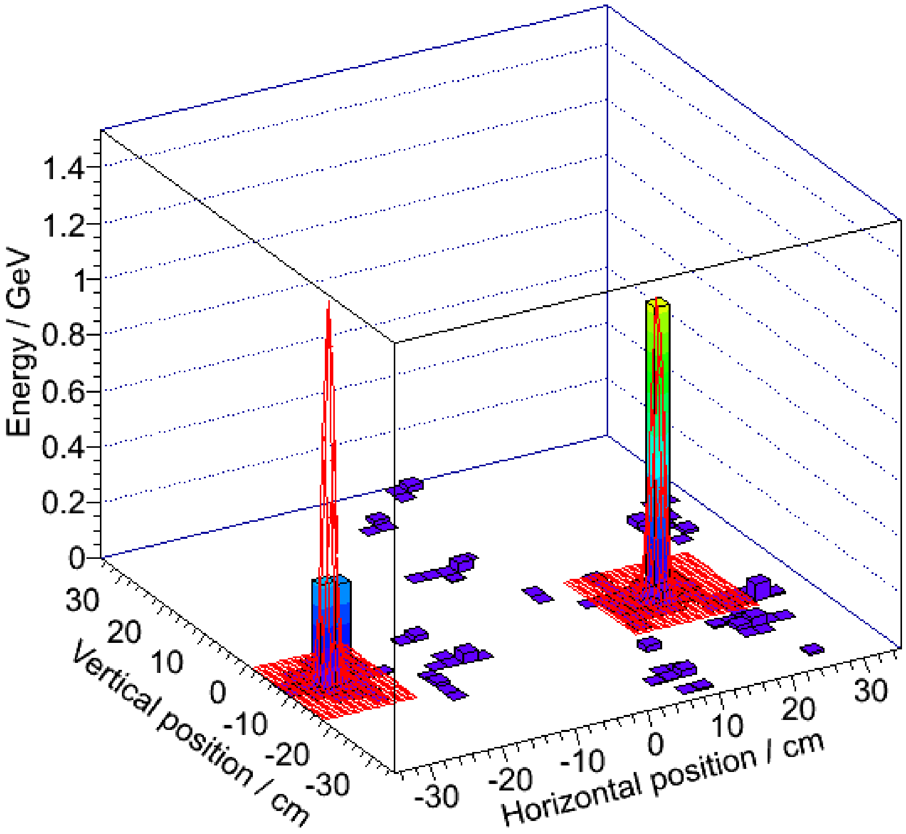


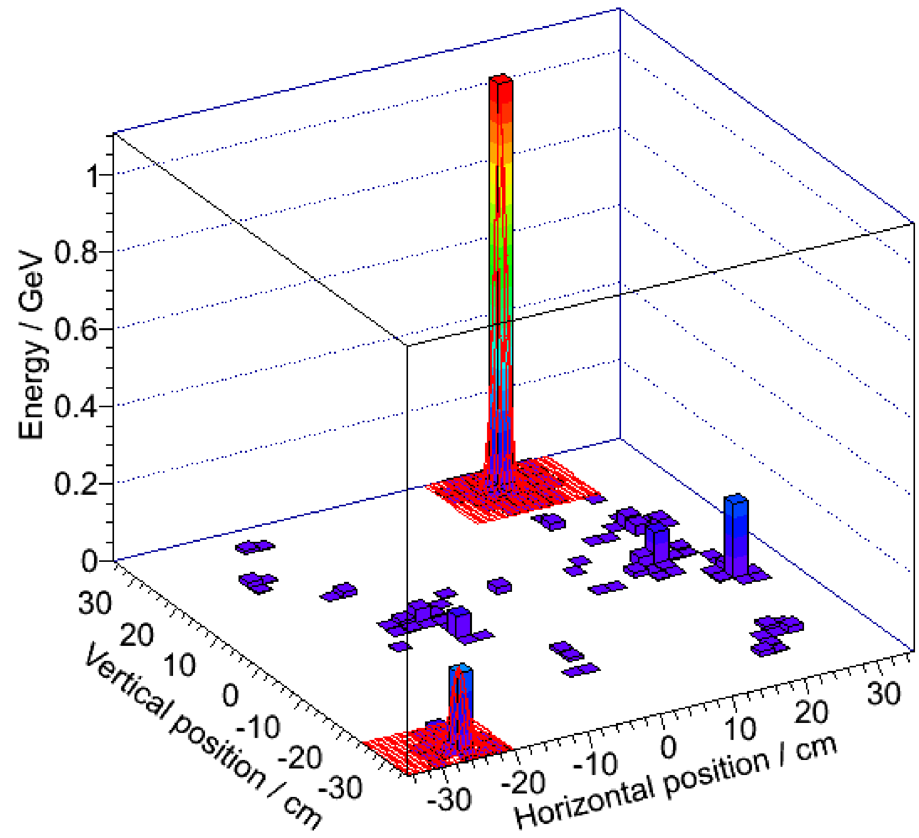
e^- background



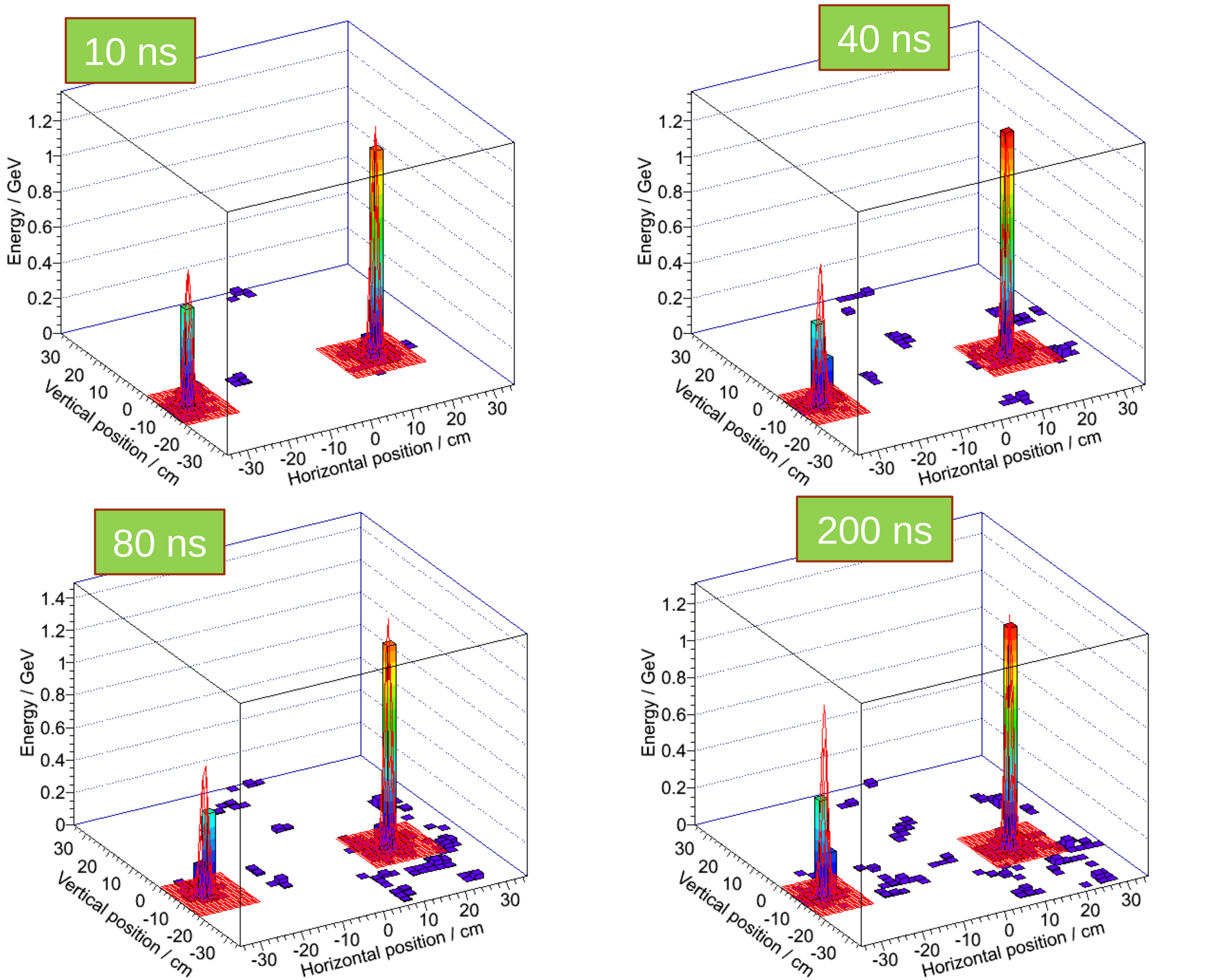
Considering background

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





Changes in integration time window



Outlook

- π^0 calorimeter pre-design tests are ongoing
- MRI/NSF has been submitted in January/2012
- Detector simulations and existing components are being studied