QD0@CLIC: Implementation of QD0 in Mokka

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Overview

- From ILC_ILDfwd to CLIC_ILDfwd
- Introduction on QD0
- Simulation details
- QD0 implementation in Mokka
- Results
- Conclusions

Forward region from ILC to CLIC

- **Crossing Angle: from 14 to 20 mrad**

- **Deeper LumiCal and BeamCal (40 layers)**

  LumiCal :

  - 40 Layers Silicon-Tungsten (Si-W)
  - Sandwich Calorimeter
  - Centered on Outgoing Beam axis
  - Inner radius: 10 cm

  BeamCal :

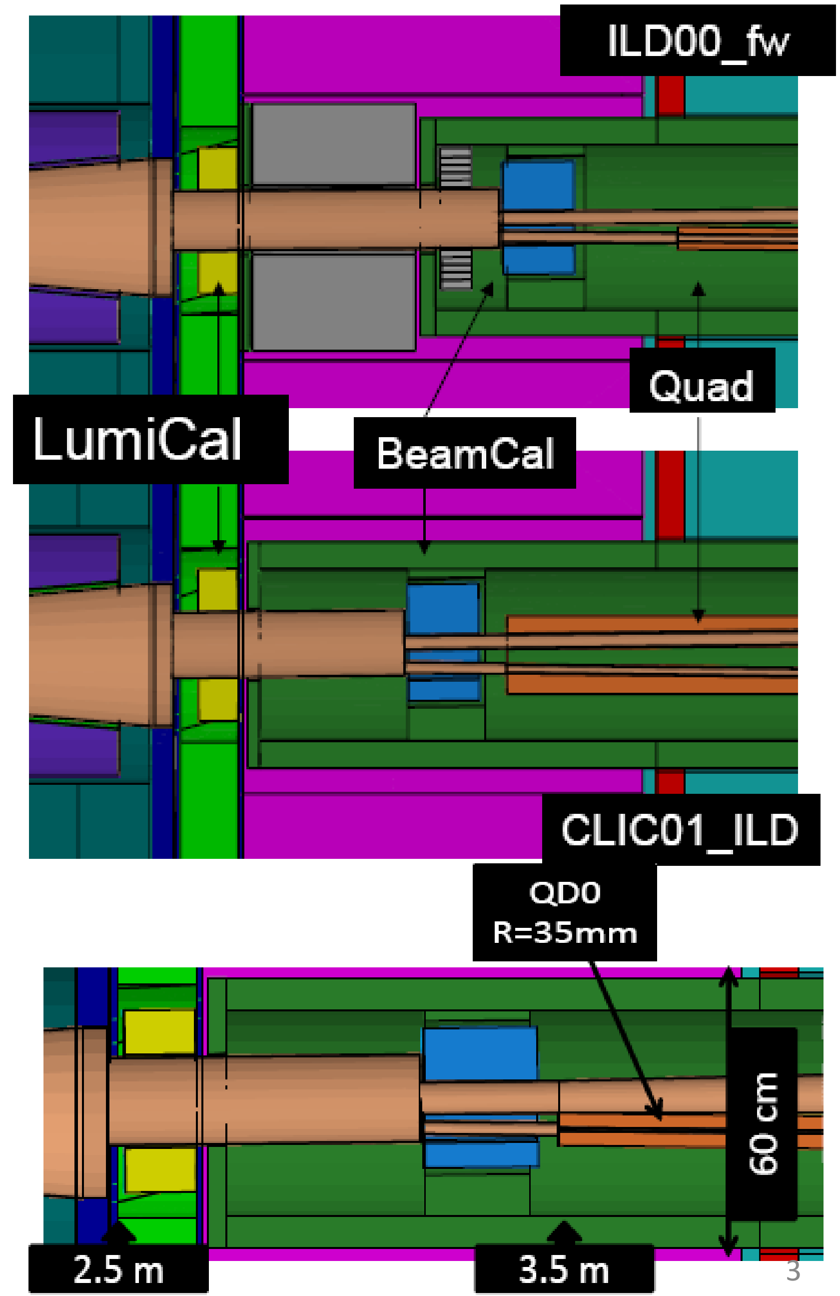
  - Sandwich Calorimeter
  - Move BeamCal to z=3.2m from IP
  - Centered on outgoing beam pipe
  - Inner radius: 3.5 cm (11 mrad)
  - Outer Radius: 15 cm (47 mrad)

- **Removed LHCal**

- **Final Quadrupole: L* = 4.6 m**

  QD0 Prototype

  - Should fit into forward region
  - Has to be stable to ≈ 0.1nm
  - Ri = 4.125 mm, Ro = 35mm
  - Length 1.63 m
  - 10 mrad space for outgoing beam pipe
  - Coils extend a little beyond Z=3.5 m
  - gradient 575 T/m



Final Focussing (FF) at CLIC: quadrupole doublet

• Second but last quadrupole: QF1
  -in the accelerator tunnel

• Last quadrupole: **QD0**
  - inside of the experiment
  - L* = 3.8 m for CLIC_SiD
  - L* = 4.6 m for CLIC_ILD

• Very small beam sizes at CLIC
  (+smaller bunch spacing: 0.5 ns, 312 bunches/train, 50 trains/s)
  - More background accumulated during one train

• FF quadrupole vibrations at <1 nm

Conclusion 1: Superconducting quadrupole not feasible (ILC, vibr. < 50nm)

Studies of QD0: permanent magnets and warm electro-magnets

Conclusion 2: Hybrid QD0: permanent re-enforced with e.magnet

Geometric boundary conditions: e.g. outgoing beamline with 10 mrad opening angle

Other issues

- Beam beam collisions result in a large number of **background particles**

- Synchrotron radiation scatters in the 2 FF QD0 => **condition** on collimation depth =>

  photons must not hit frontally the QD0

- Beamstrahlung photons and e+e- coherent pairs ≈10% number of beam particles =>

  constraints on the quadrupole design

- Coherent pairs energy < beam particles energy => scattering angle = much larger =>

  the coherent pairs production determines the opening angle for the beampipe

- The large number of these particles ->

  loss of even a small fraction of them in the magnet must be avoided

⇓

10 mrad angle around the beam axis

⇕

space for FF QD0 around the incoming beam

⇓

~ 20 mrad crossing angle

- γ–γ incoherent collisions -> e+e- pairs (smaller number, small influence on beam-beam interaction) - they too modify the design of the detector

Questions

- Will such a QD0 modify the backscattering background in the CLIC detector?

- What is the radiation dose onto the QD0 at nominal CLIC operating conditions?

(sensitivity of permanent magnet material to radiation depends on material choice)

Simplified QD0 model implemented in Mokka for CLIC_ILD detector concept

Details about the software

- **GuineaPig** - e+e- incoherent pairs generation

  - Coherent pairs ~10^8 particles, but smaller production angles than incoherent pairs
  - Therefore only looking at incoherent pairs

- **Mokka** - detector geometry simulation and particle showering (QGSP_BERT) (version: 06-07)

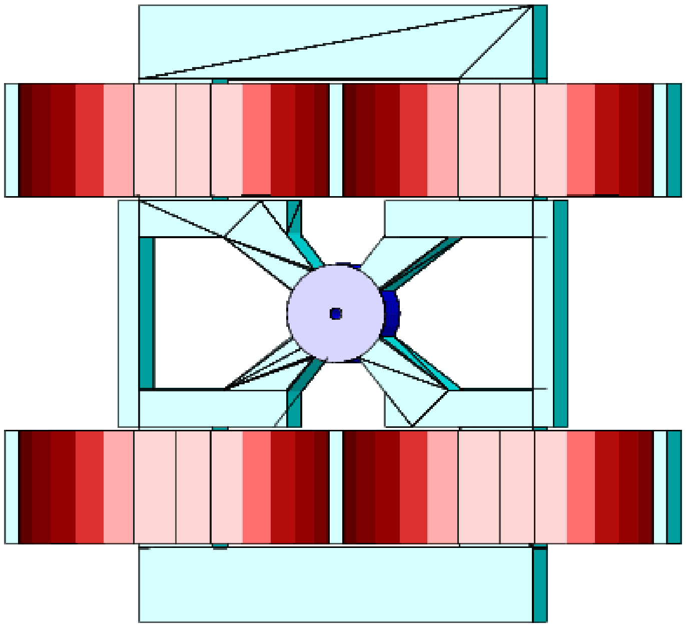
  - geometry data driven software
  - run control and run conditions - executed through a steering file
  - input: HEPEvt file
  - output: lcio (Liniar Collider Input/Output) or ASCII file format (standard European file format for simulation applications)

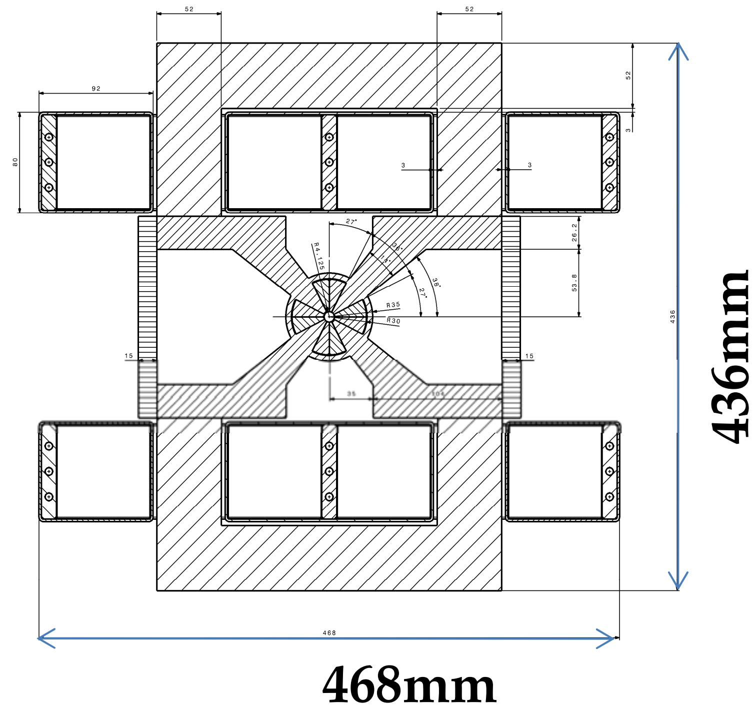
- **Marlin** - lcio files processing, analysis and reconstruction

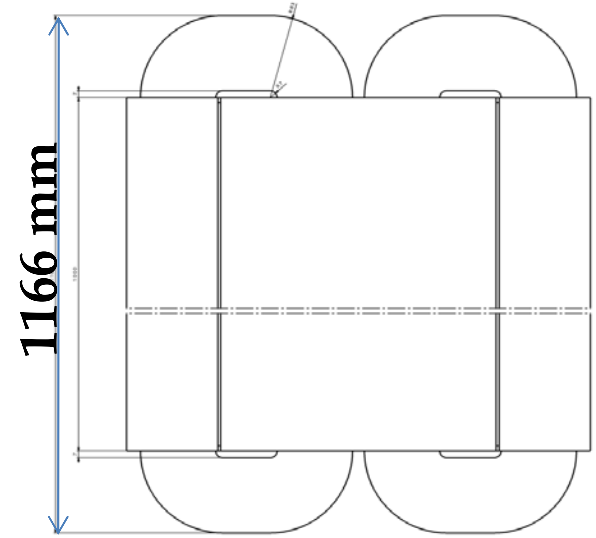
  - every processing command <-> a processor or module (analyzes the events from the lcio files) then creates output collections (added to each event)
  - allows definition of processors (and their order) through a steering file
  - stores the output into a root file

- **Root** - data analysis

QD0 Prototype





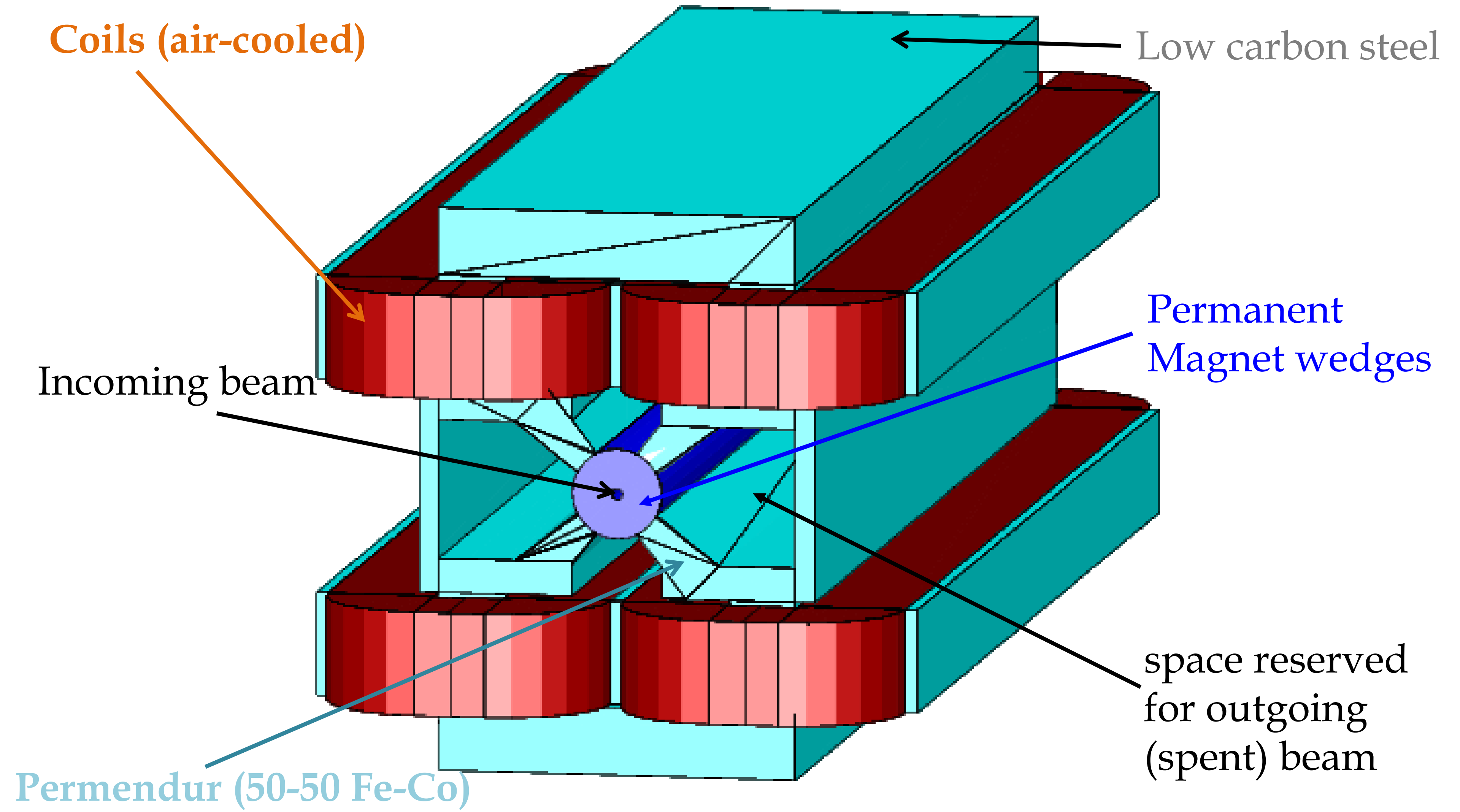


- Fit into forward region
- Stable to ≈ 0.1nm
- Ri = 4.125 mm, Ro = 35mm
- Length 1.63 m
- 10 mrad space for outgoing beam pipe
- Coils extend a little beyond Z=3.5 m
- gradient 575 T/m

Short prototype (10 cm) is under construction

Simplified Model of QD0 Prototype

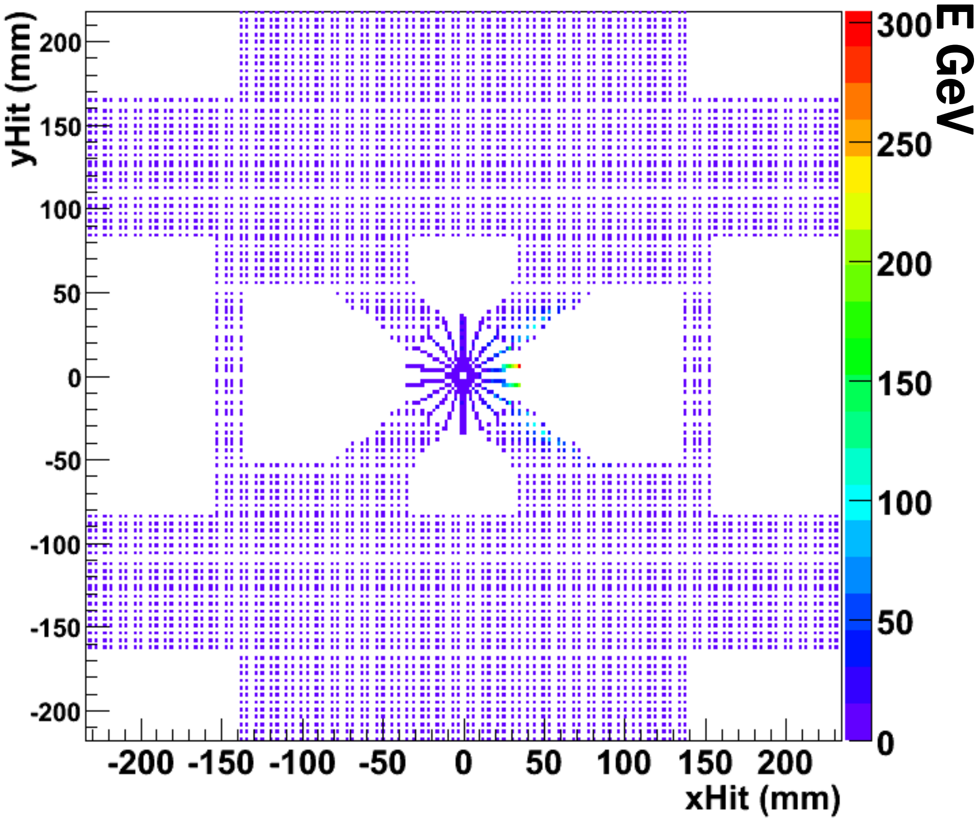
-“8 shape” Quad design: (permits to accommodate the spent beam pipe)

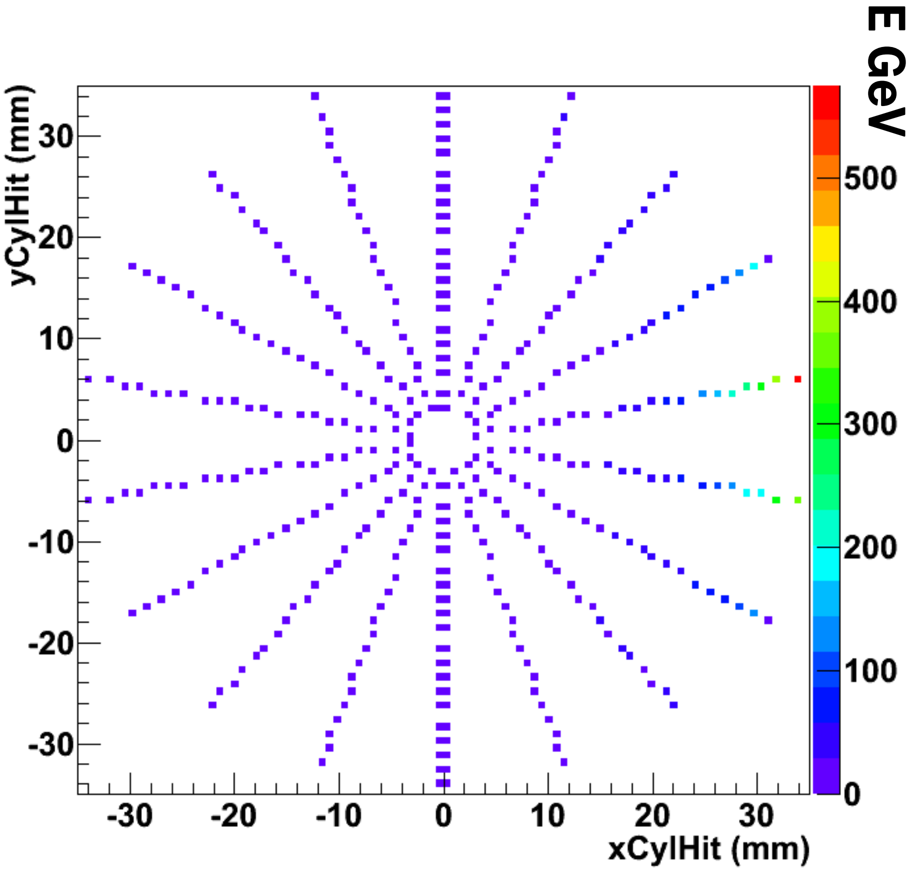


Defined as sensitive detector for simulation studies

Preliminary Results

x-y Energy deposition in QD0 and central cylinder

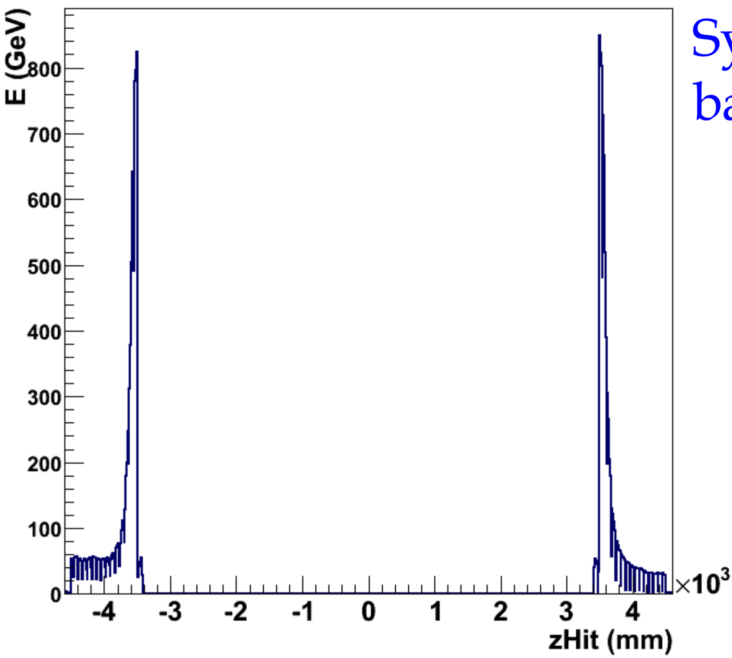




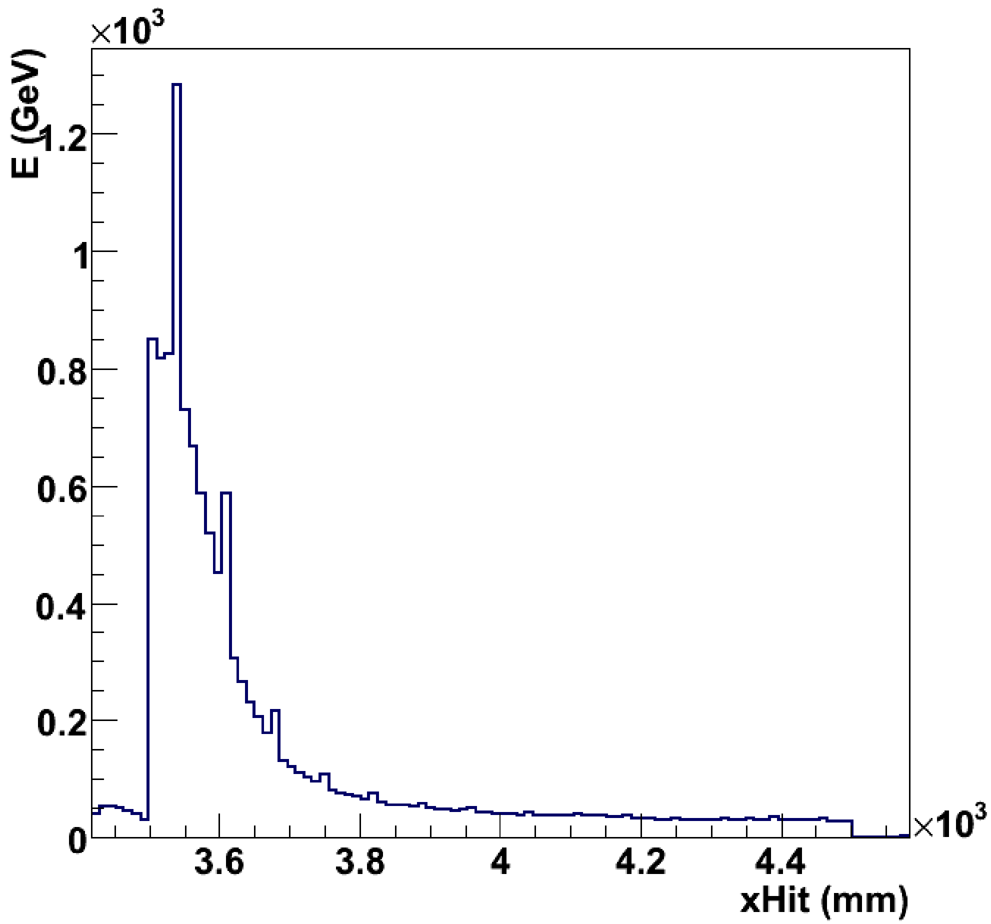
xHit ϵ (-234., 234.) mm, 250 bins
yHit ϵ (-218., 218.) mm, 200 bins

=> 2.18 x 2.18 mm^2 cells

Energy deposition along the whole QD0

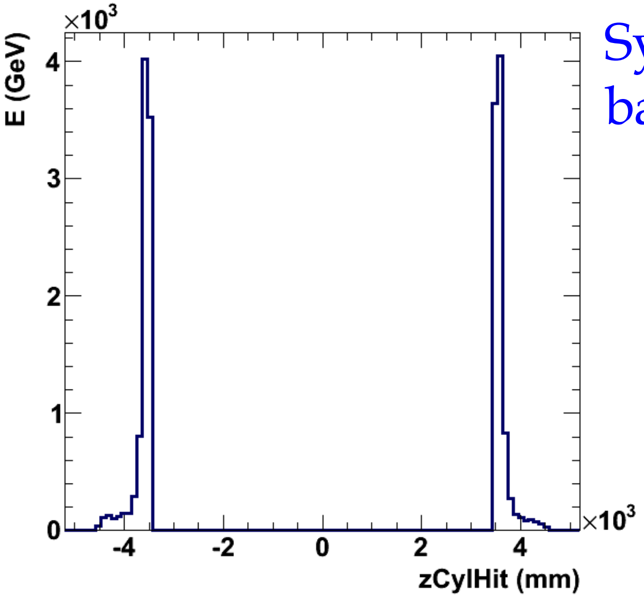


Symmetric energy deposition in the backward and the forward QD0

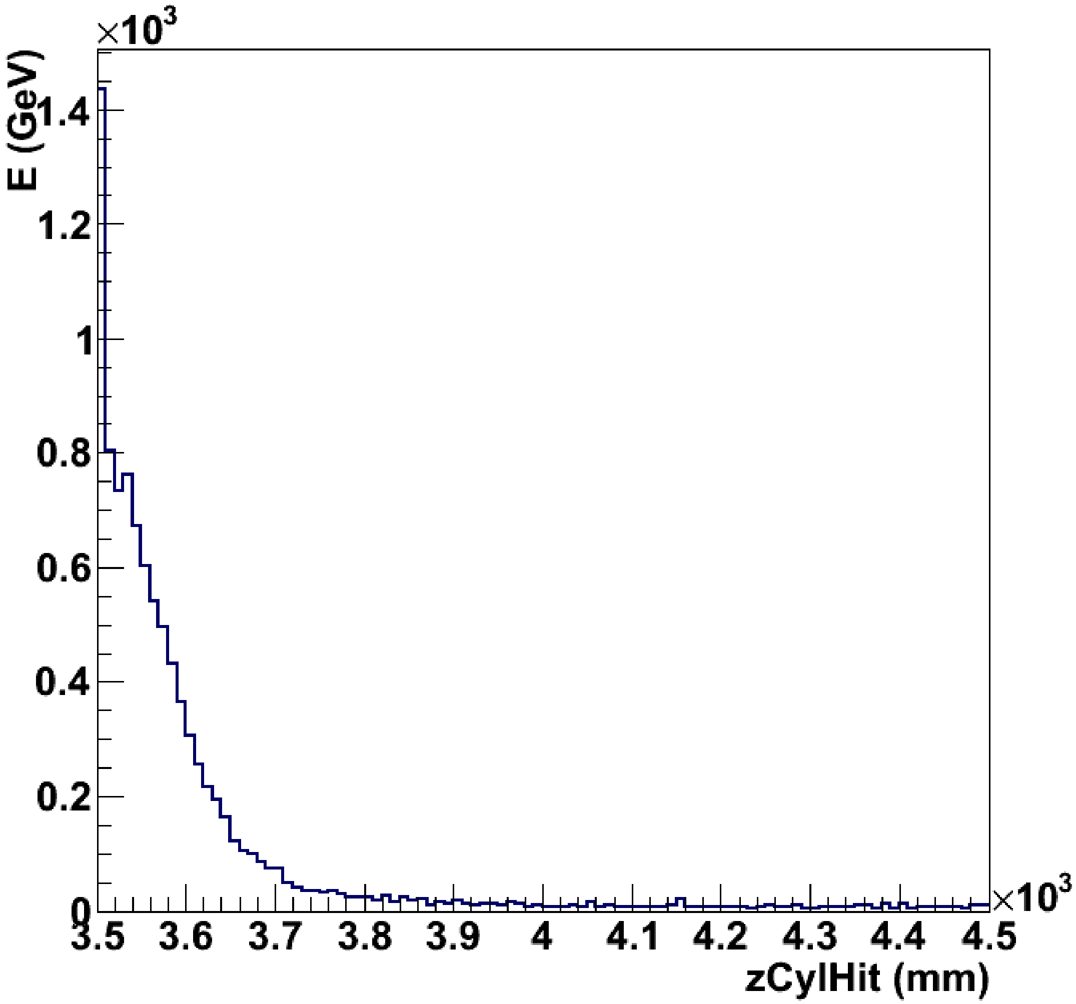


Coil zStart = 3.417 mm
Coil zEnd = 4.583 mm
Divided in 100 layers

Energy deposition along the central cylinder



Symmetric energy deposition in the backward and the forward cylinders

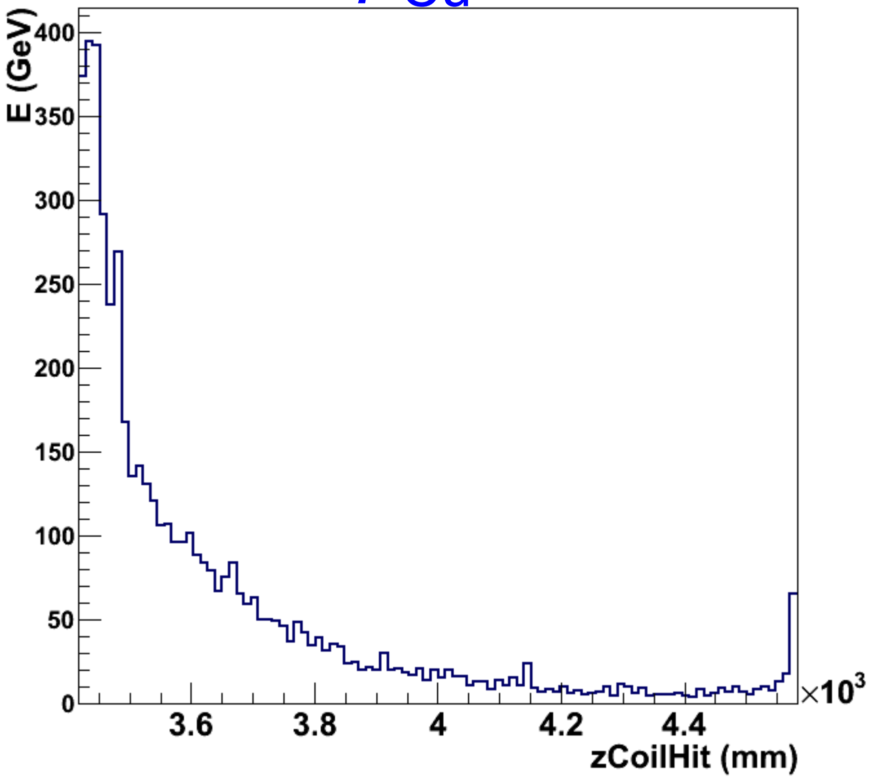


Cylinder zStart = 3.500 mm
Cylinder zEnd = 4.500 mm
Divided in 100 layers

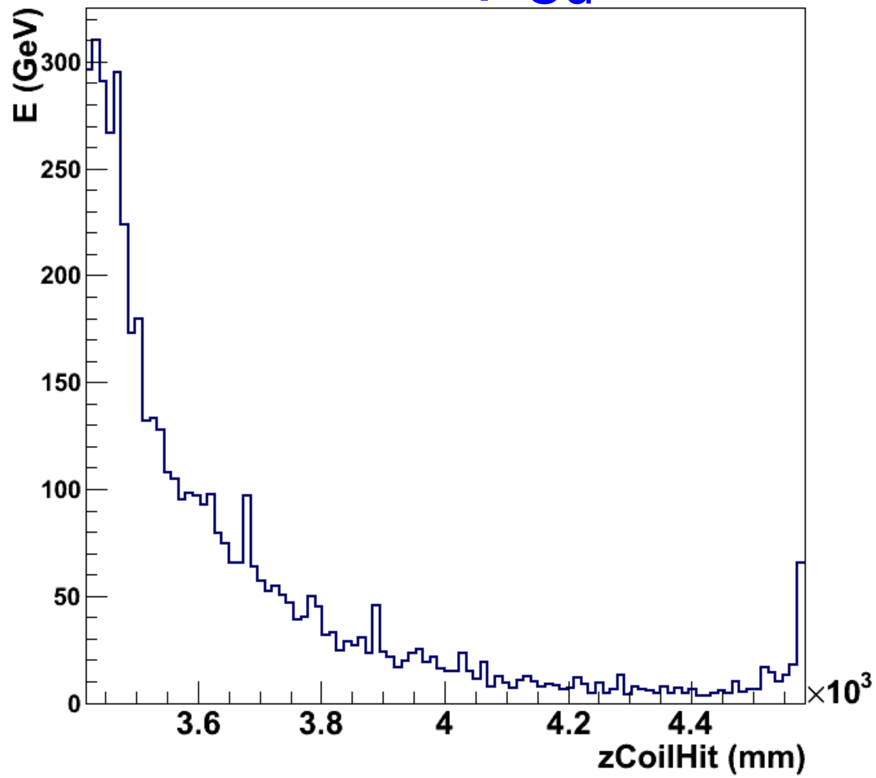
Comparison

Nominal Copper density Coils vs. Lower (2/3) Copper density Coils

ρ_{Cu}



$2/3\ \rho_{Cu}$



25% less energy deposition

Ongoing study - neutrons

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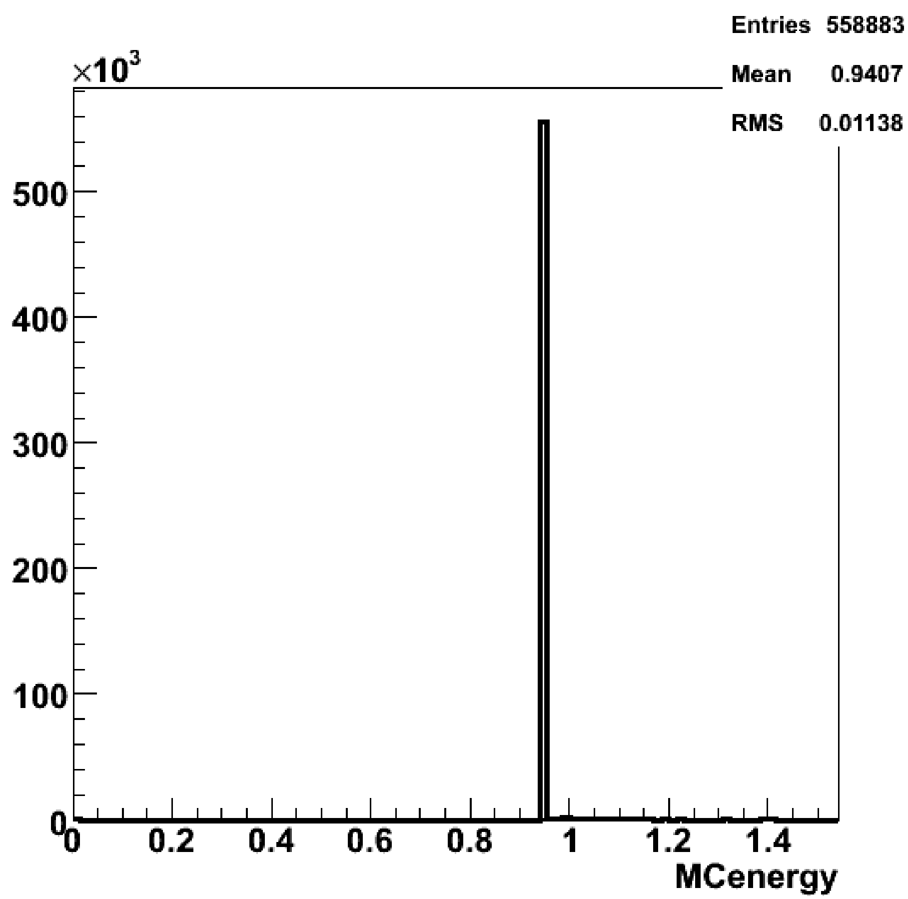


Conclusions

- A simplified model of the QD0 was fully implemented in Mokka

- Defined as sensitive detector for simulation purposes (radiation doses, neutron fluxes)

- Preliminary results on energy depositions for one bx

- Ongoing study on neutrons

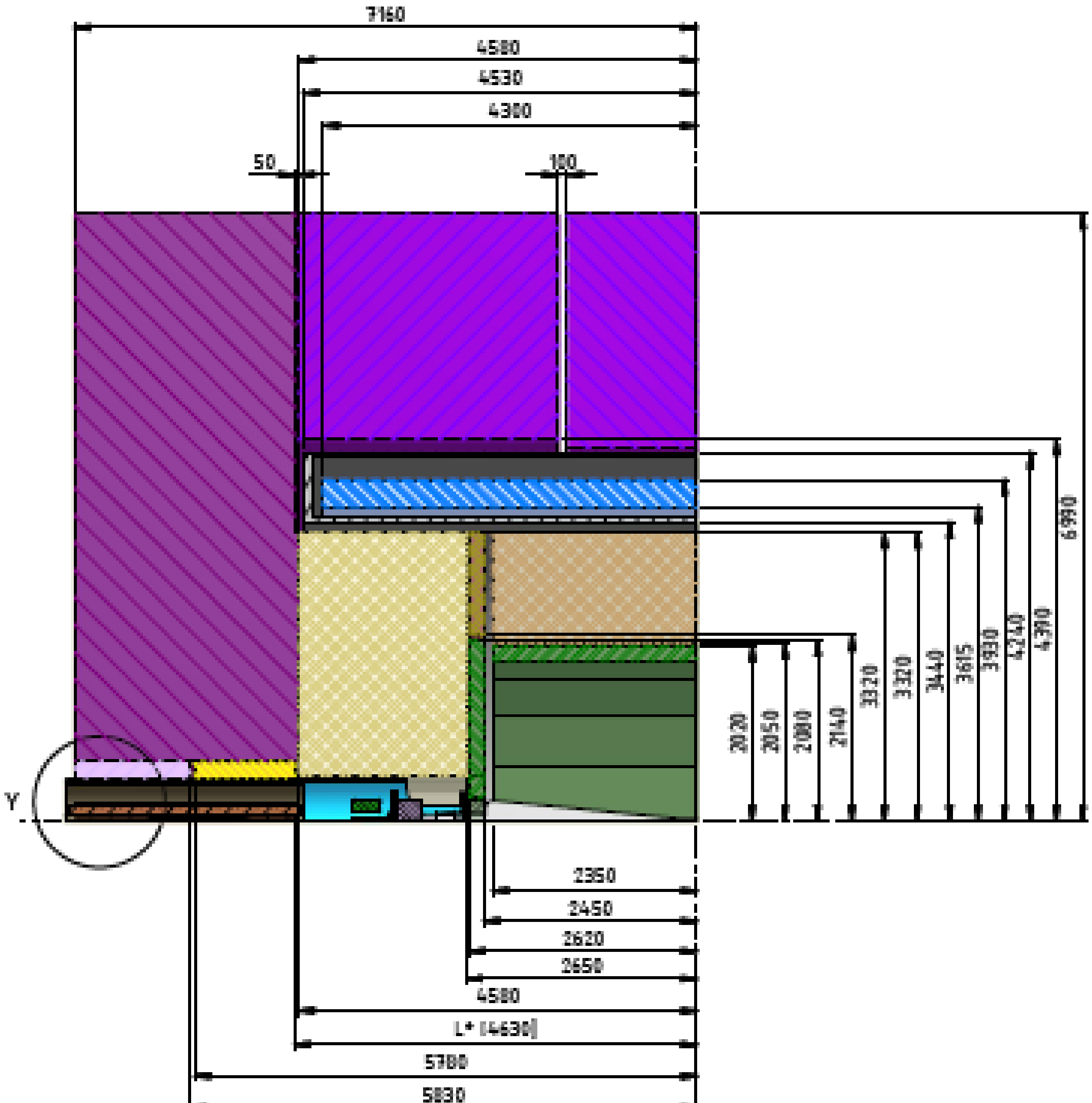
Future plans

- Send through the detector a fully simulated bunch train

- Calculate e.m. radiation dose and neutron flux

Thank you!

CLIC_ILD [4T]



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