Mokka simulation studies on the Very Forward Detector components at CLIC and ILC

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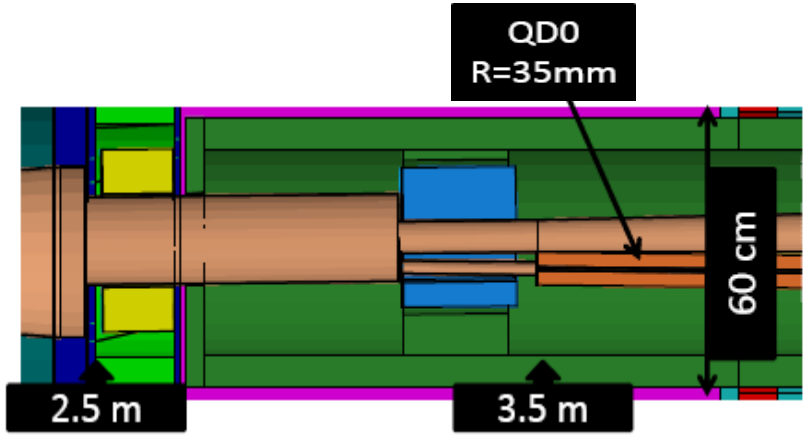
Overview

- What is QD0
- QD0 in Mokka
- Electromagnetic doses for incoherent e+e- pairs
- Electromagnetic doses for Trident pairs
- Ongoing study on neutrons in QD0
- New Mokka user – BeamCal studies in Mokka

Final Focussing (FF) Quadrupole doublet at CLIC

QD0 Prototype

- Should fit into forward region
- **L* = 4.6 m**
- Length 1.63 m
- Centered on the incoming beam-pipe
- 10 mrad space for outgoing beam-pipe
- Ri = 4.125 mm, Ro = 35mm
- Coils extend a little beyond Z=3.5 m
- gradient 575 T/m
- Has to be stable to ≈ 0.1nm



Superconducting quadrupole not feasible (unlike ILC, vibr. < 50nm)

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

Hybrid QD0: permanent magnet + electro-magnet

Final Focussing (FF) at CLIC: quadrupole doublet

• Simplified QD0 model implemented in Mokka for CLIC_ILD detector concept

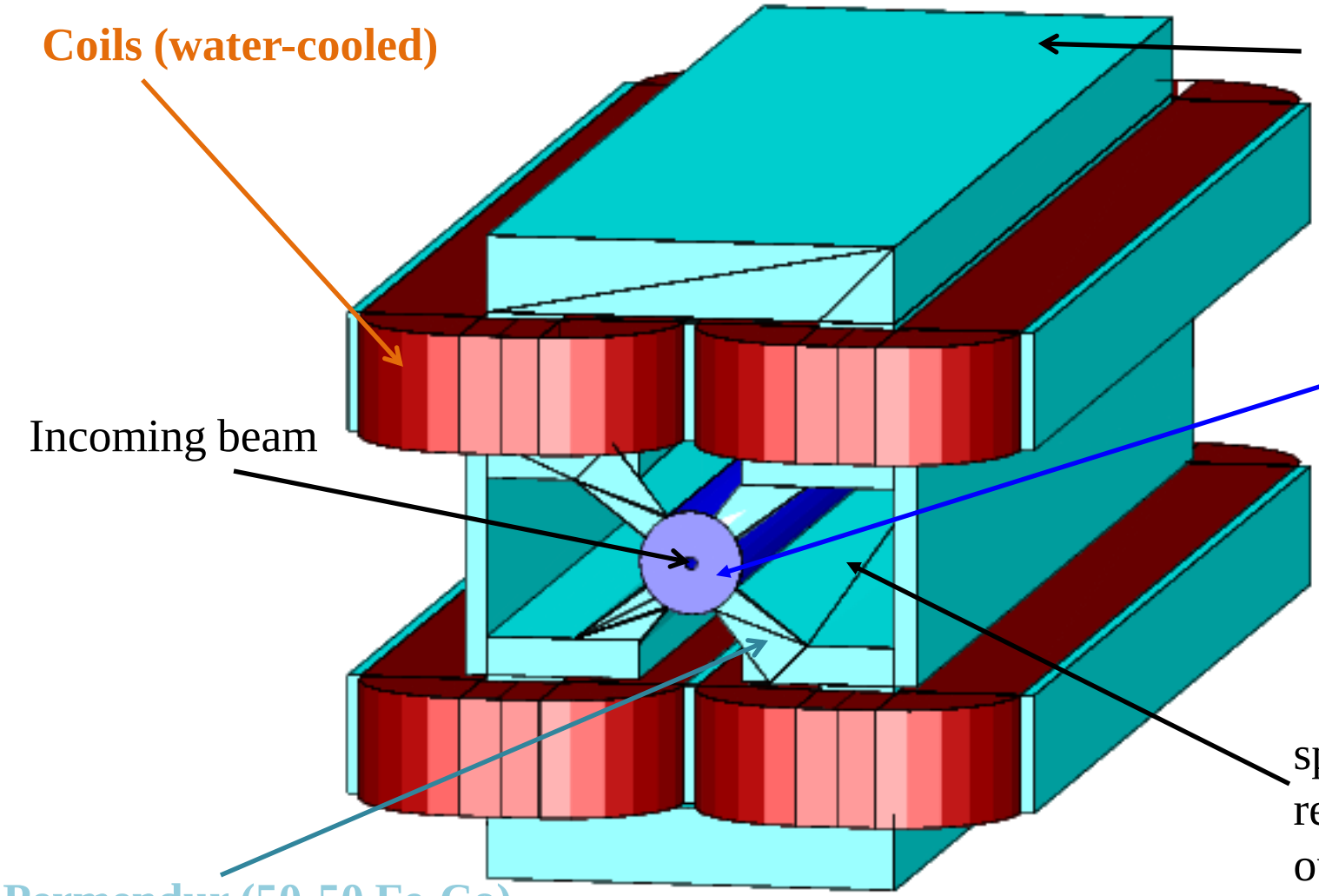
• What is the radiation dose onto the QD0 at nominal CLIC operating conditions? (sensitivity of permanent magnet material to radiation depends on material choice)

Software

• **GuineaPig** - e+e- incoherent and trident pairs generation
• **Mokka** - detector geometry simulation and particle showering (QGSP_BERT_HP)
• **Marlin** - lcio files processing, analysis and reconstruction
• **Root** - data analysis

Simplified Model of QD0 Prototype

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



Defined as sensitive detector for simulation studies

QD0 Results

Effect of the background produced during 1 BX at
- nominal CLIC 2008 parameters
- 20 mrad crossing angle

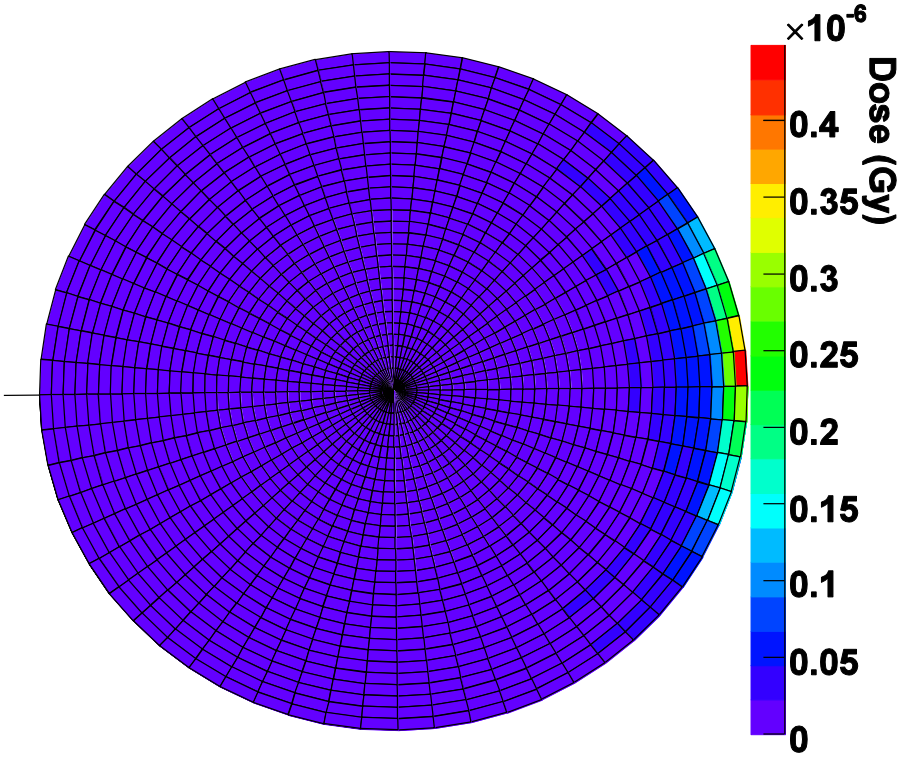
-For incoherent processes (e+e- Incoherent Pairs)
-For coherent processes (e+e- Trident Pairs)

Incoherent Pairs - Electromagnetic dose

Electromagnetic distributions in the X-Y and X-Z planes
Fine segmentation for all components

Cylinder:

• 30 radial and 60 azimuthal sections (1mm high and 6 degree wide segments)
• Higher dose on the right: QD0 close to outgoing beam-pipe



• Highest dose: up to $0.5_{*}10^{-6}$ Gy/BX ($1.35_{*}10^{5}$ Gy/yr)
• Lowest dose: $0.05_{*}10^{-6}$ Gy/BX (~kGy/yr)

1 year = 200 days of 100% accelerator efficiency

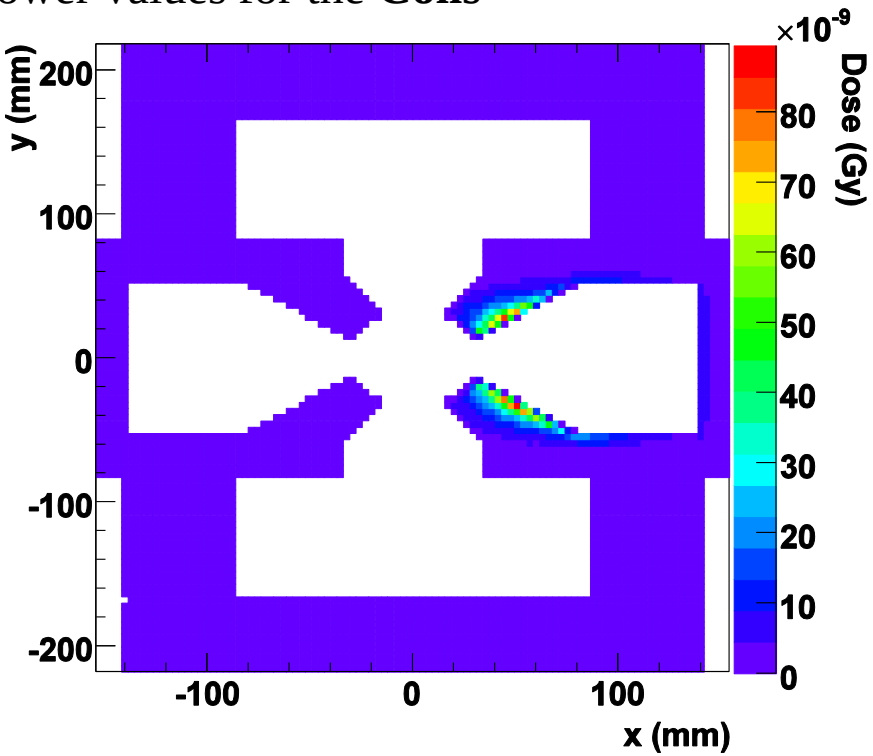
Incoherent Pairs - Electromagnetic dose

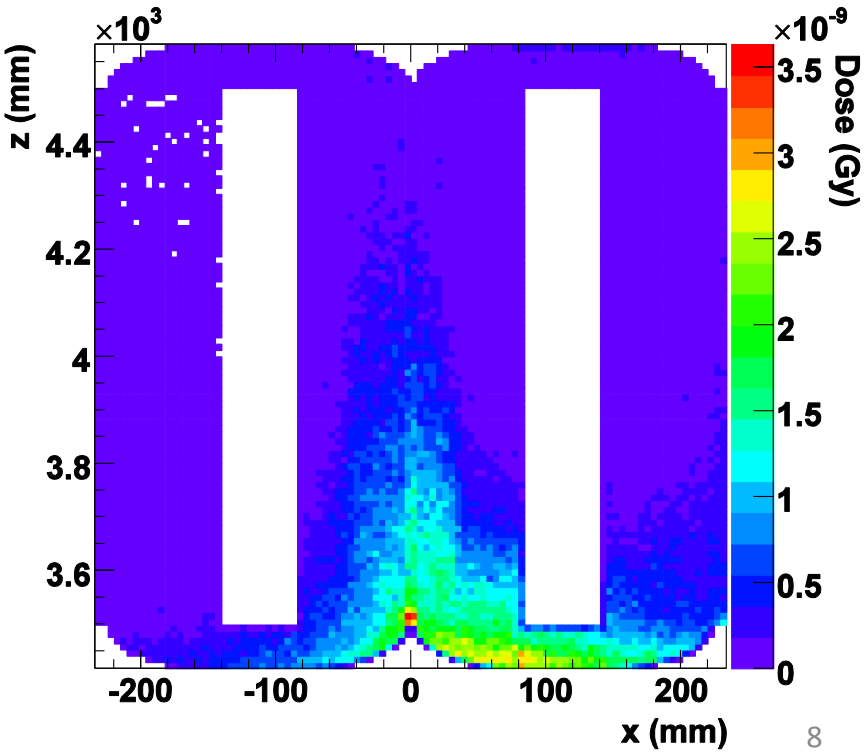
Yoke and Coils

Much smaller doses than in the cylinder

100 layers along X-, Y- and Z- axes:
- 4.5x4.5 mm^2 in the X-Y plane
- 4.5x10 mm^2 in the X-Z plane

Yoke:
- Increase around the outgoing beam-pipe,
- Highest dose: $8_{*}10^{-8}$ Gy/BX ($21.5_{*}10^{3}$ Gy/yr)
- Lowest dose: $1_{*}10^{-8}$ Gy/BX ($2.7_{*}10^{3}$ Gy/yr)
- Lower values for the **Coils**

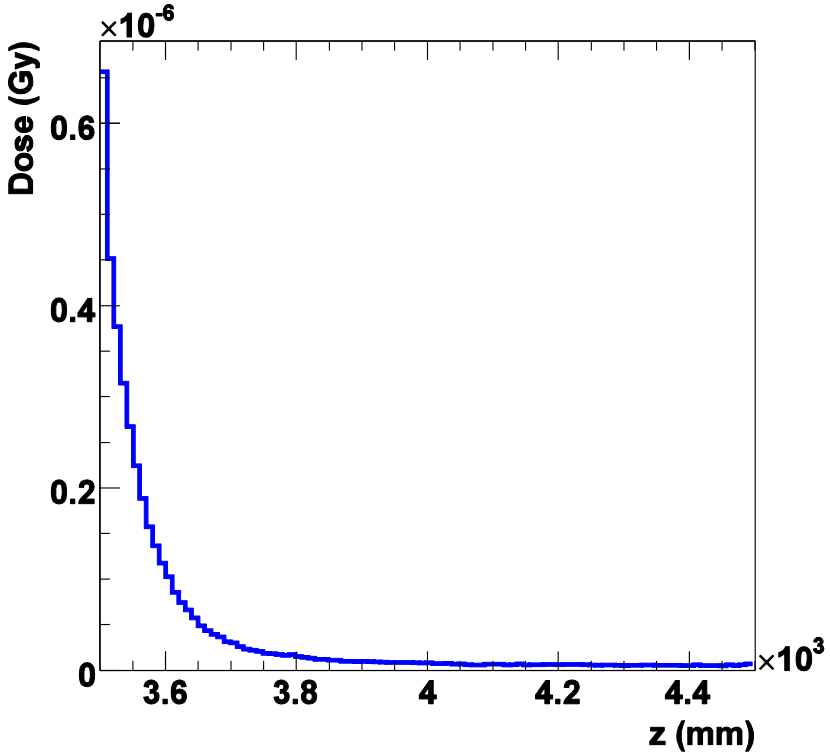


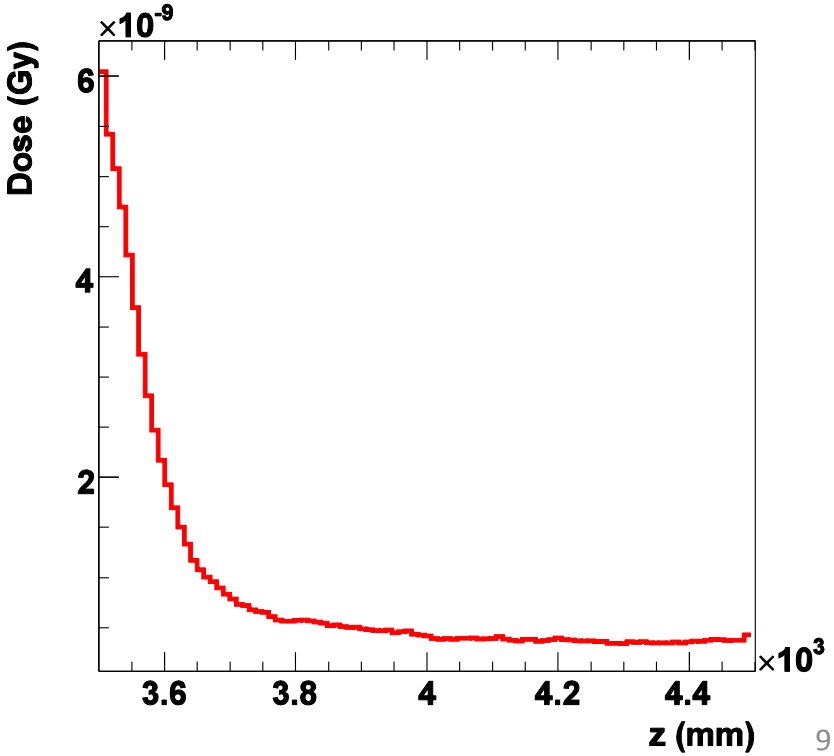


Incoherent Pairs - Electromagnetic dose

Electromagnetic dose along the depth of the Cylinder, Yoke and Coils

Cylinder and Yoke: after the first quarter of their length the dose is very close to 0
Coils: negligible dose only after the first half of the length





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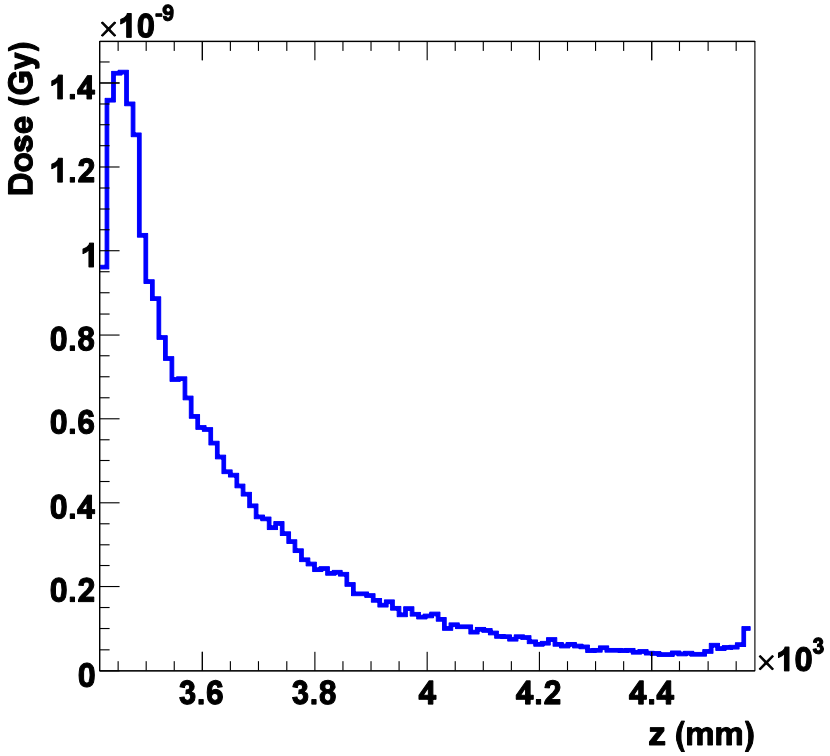
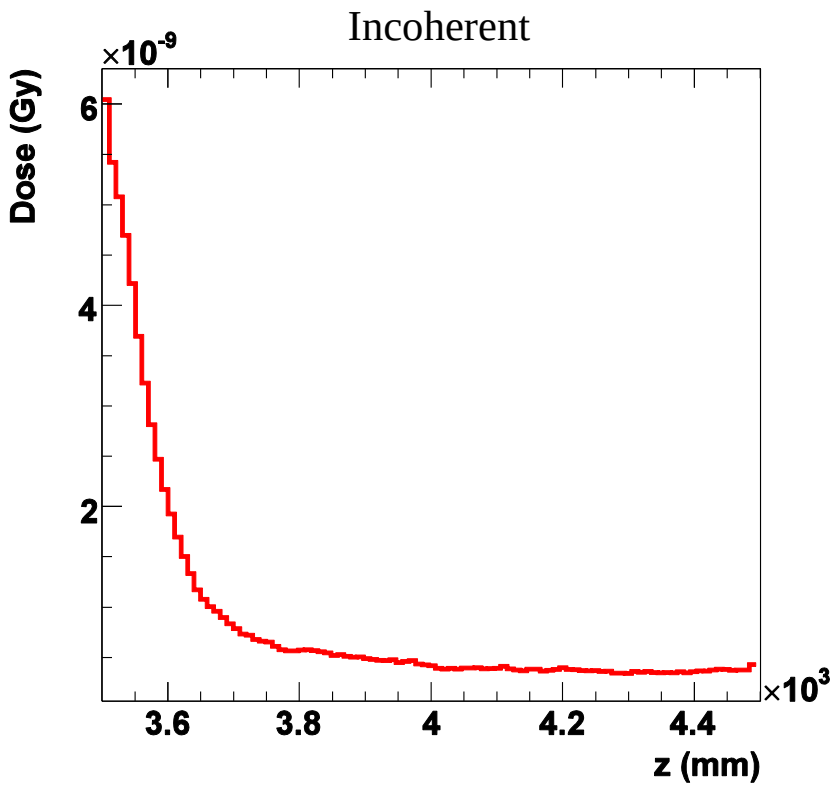


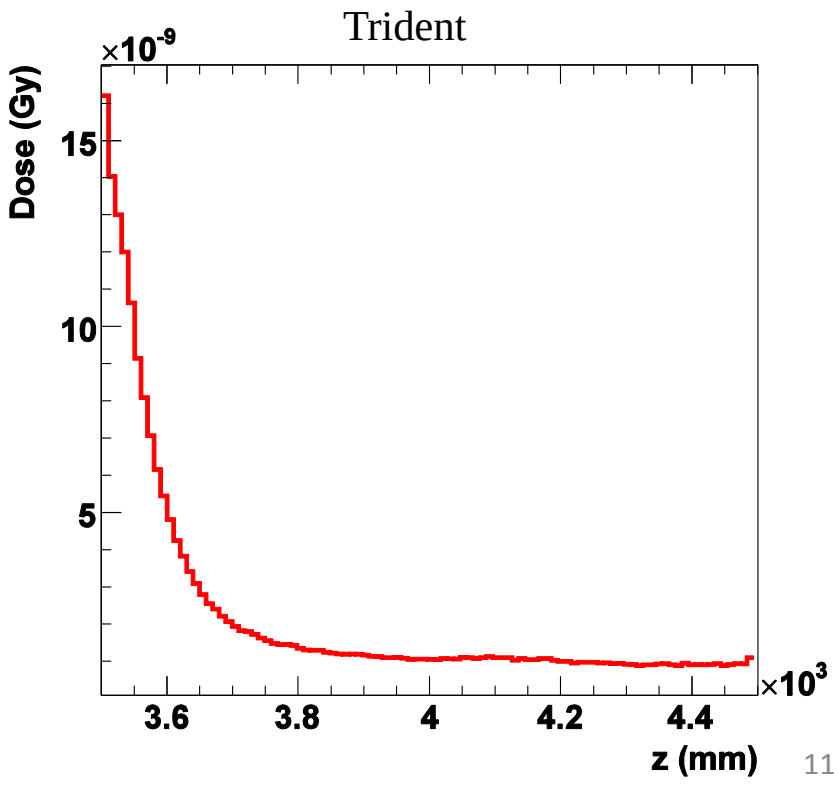
Trident Pairs - Electromagnetic dose

- Input files = 64% of a full BX (results rescaled to one BX)
- Dose behavior similar for incoherent and trident pairs but:
 - larger number of particles and higher energies:

The doses from trident pairs are up to a factor three larger

Yoke





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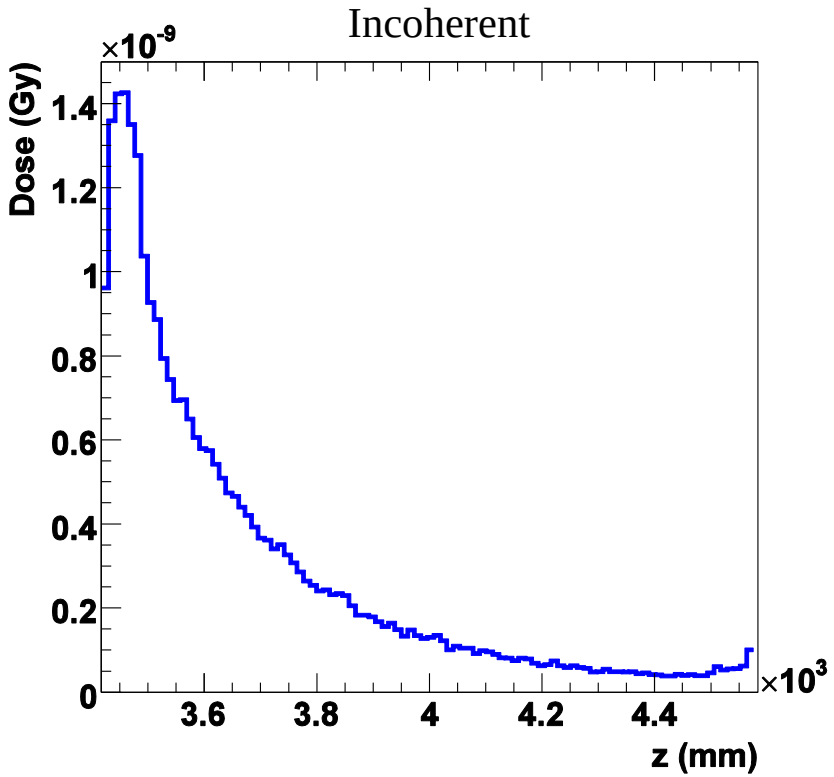
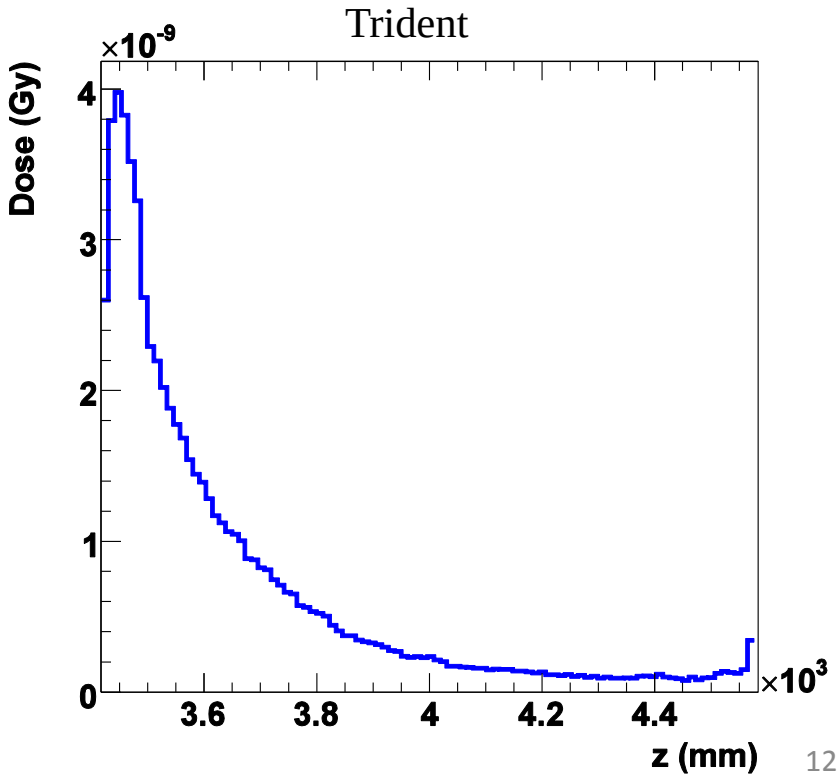
Coils

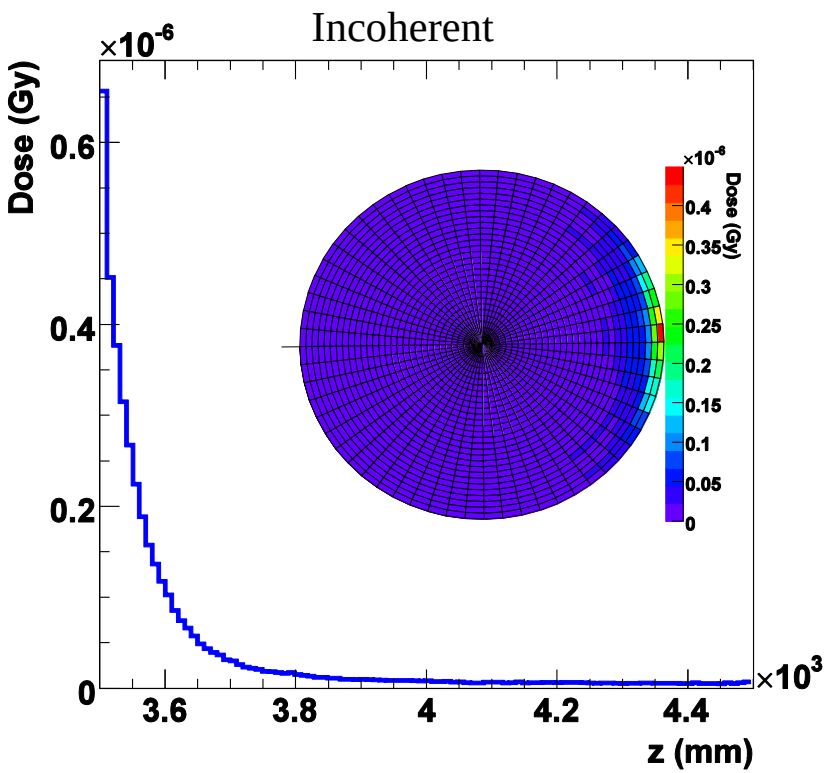


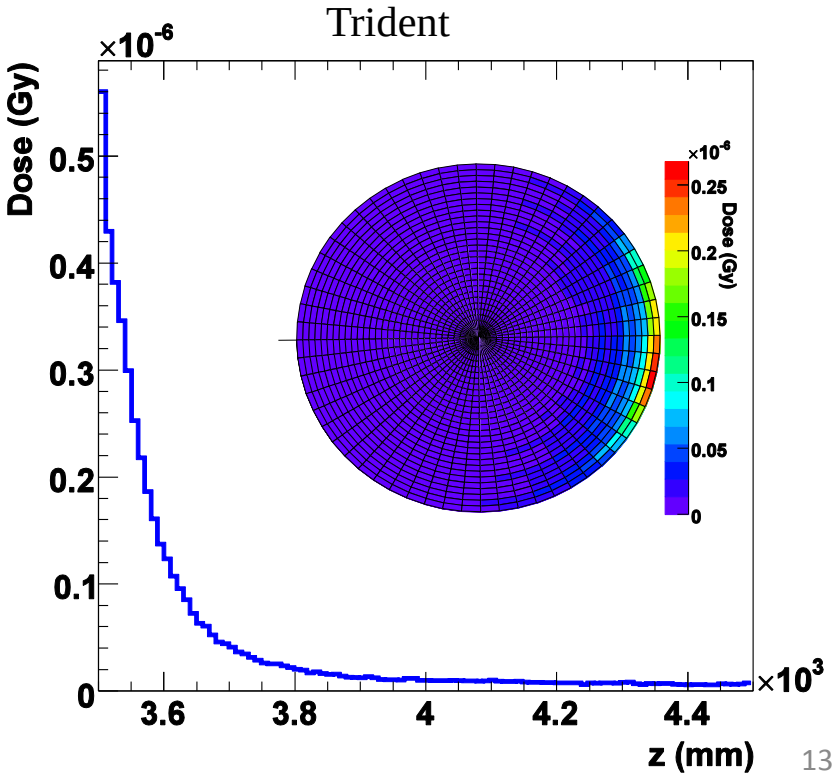


Trident Pairs - Electromagnetic dose

- The doses from trident pairs are up to a factor three larger except for the cylinder
- Trident pairs:
  - wider distributions
  - larger total energy deposited (1.8 TeV compared to 1.6 TeV)
- This is also mirrored in the maximum dose in a single cell

Cylinder





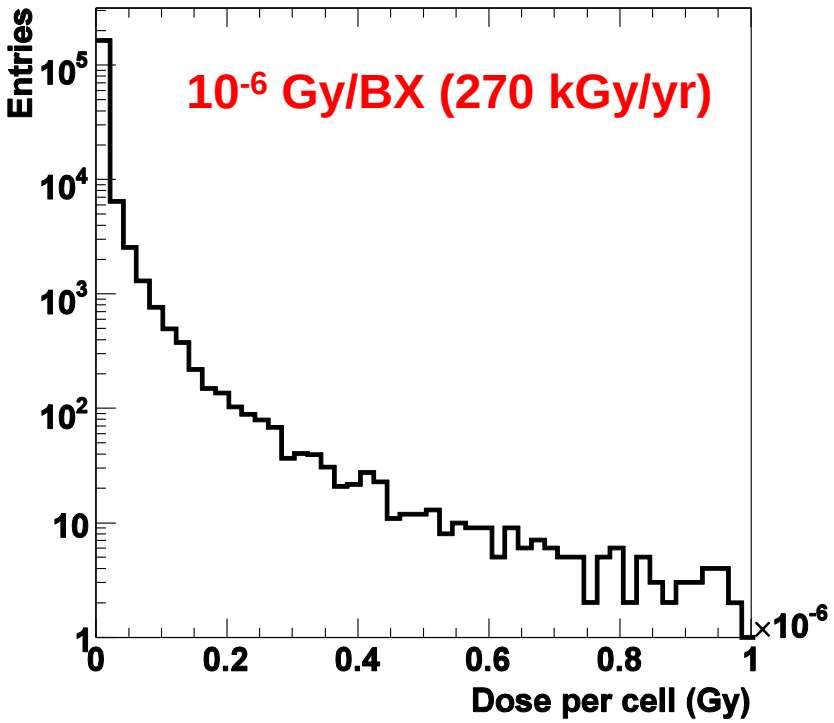
Incoherent vs.Trident Pairs - Electromagnetic dose per cell

Complementary info on electromagnetic dose:
Few cells are exposed to the highest dose

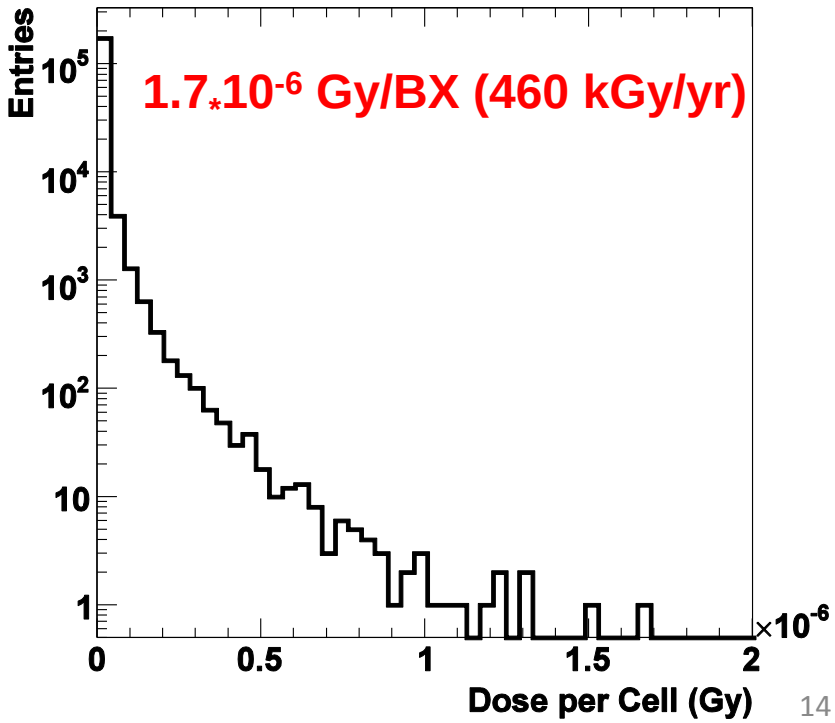
Total Dose (Coherent + Incoherent) in the permanent magnet ~ 1 MGy/yr

Cylinder

Incoherent



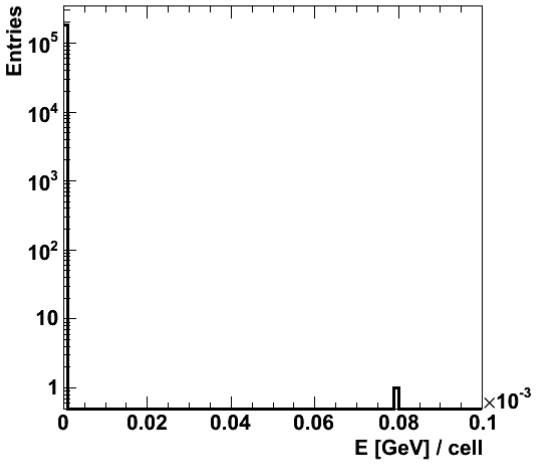
Trident



Neutrons in QD0 – ongoing study

Incoherent Pairs

One single neutron!

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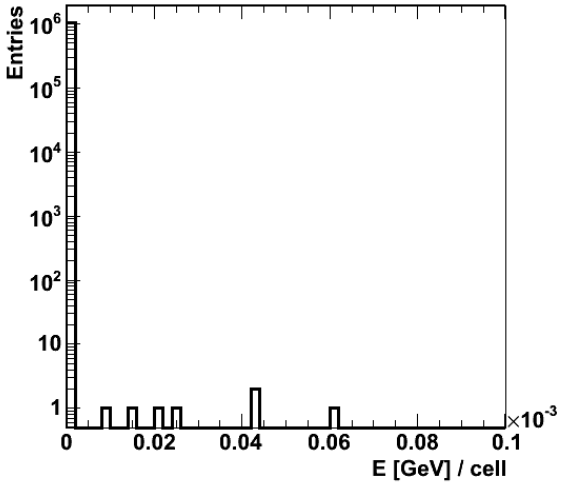
Trident Pairs

7 neutrons!

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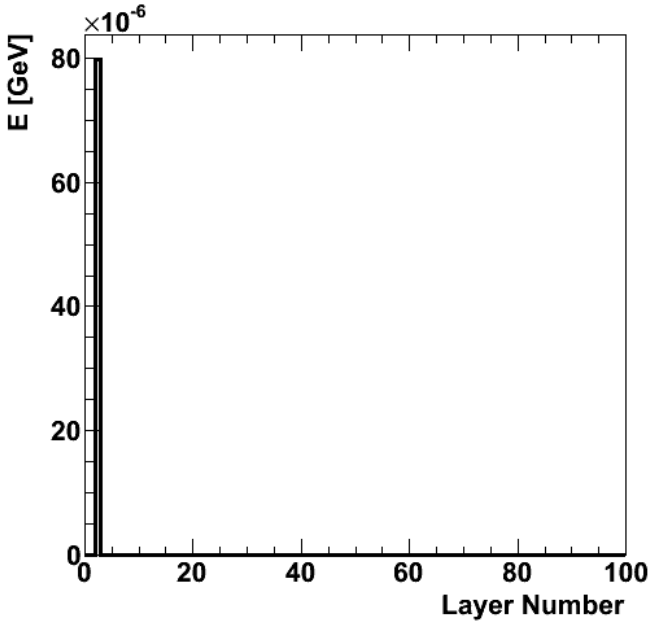
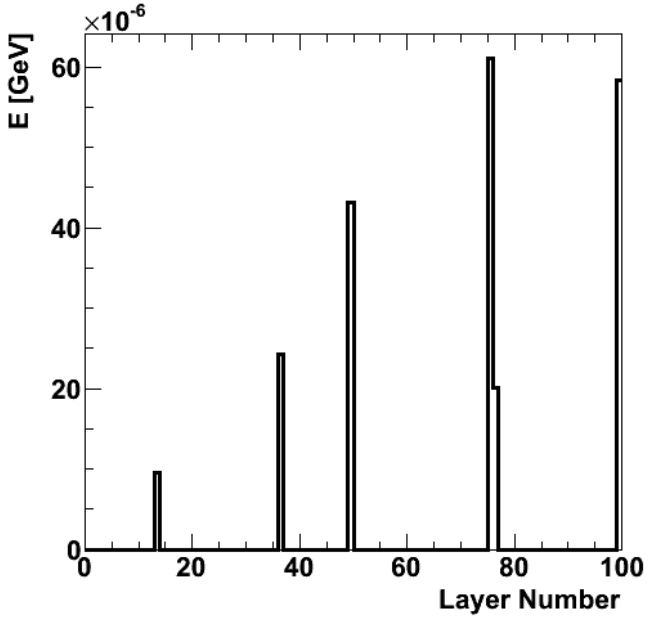
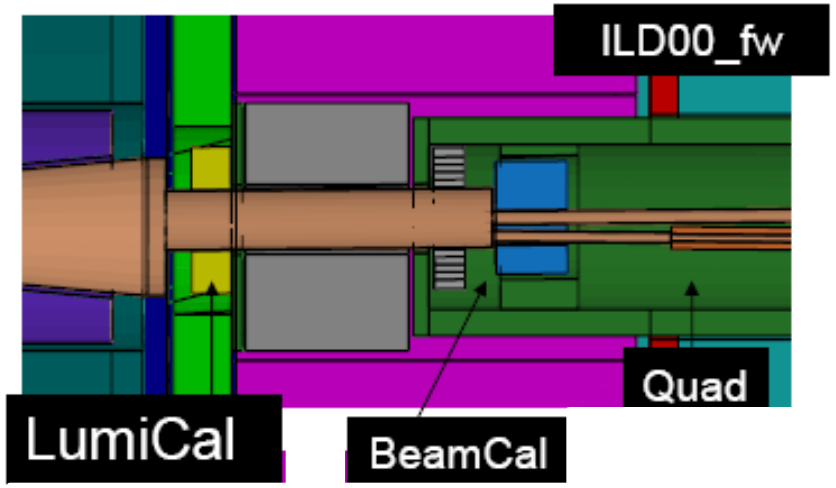
Neutrons in QD0 - ongoing study





BeamCal at ILC

- Sandwich Calorimeter
- Centered on outgoing beam pipe
- Inner radius: 2.0 cm
- Outer Radius: 15 cm



Using the new BeamCal driver (by André Sailer): BeamCal01
- include it into ILD_00fwp01 Mokka model
-write the Marlin processor to convert lcio to root files

- Comparison between Becas and Mokka results

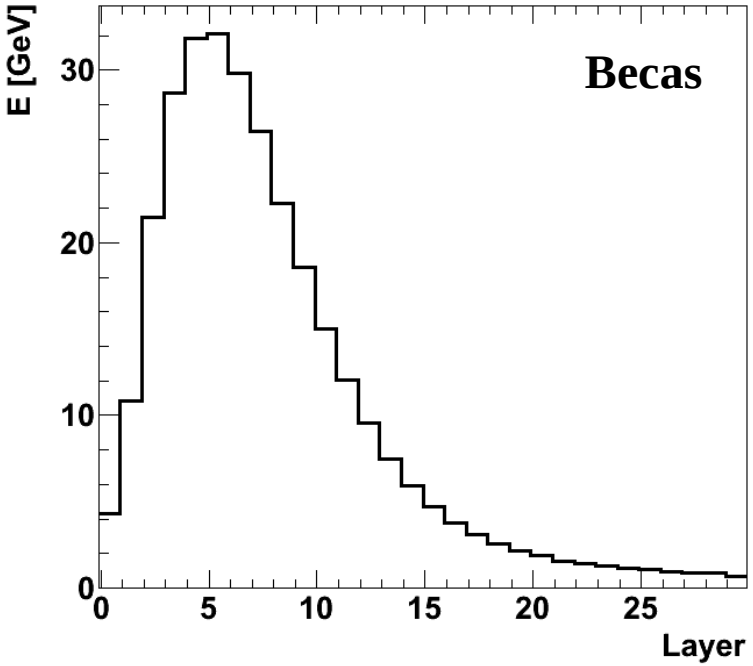
Electromagnetic dose

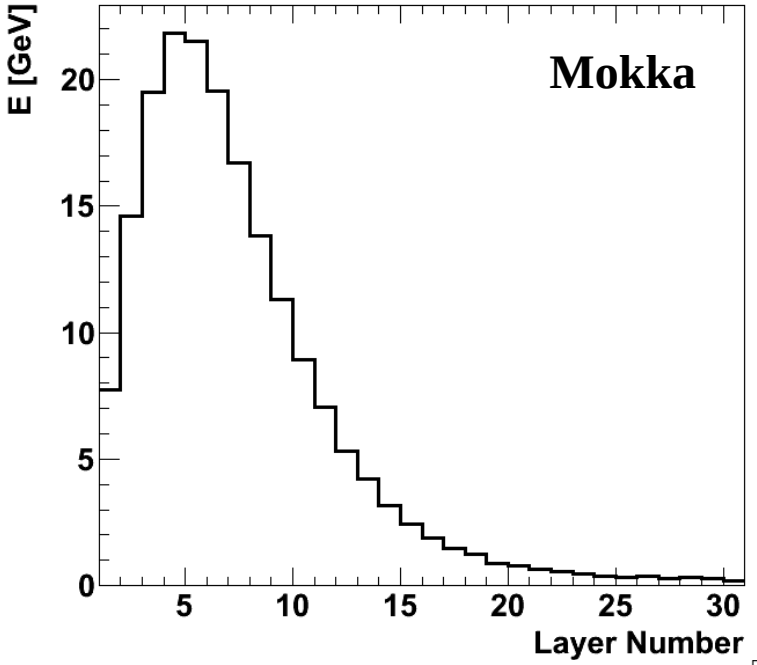
Becas - almost double energy deposition

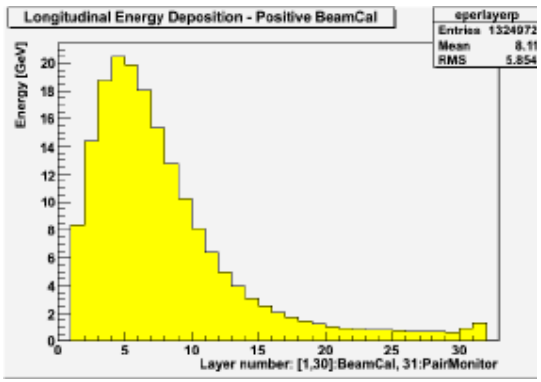
Slight difference in the maximum depth

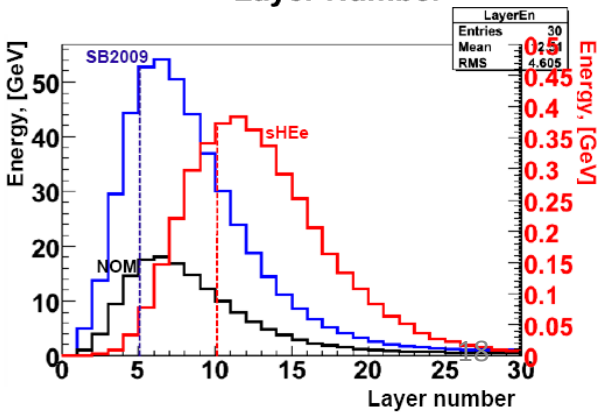
Becas, layers 5-6

Mokka, layers 4-5



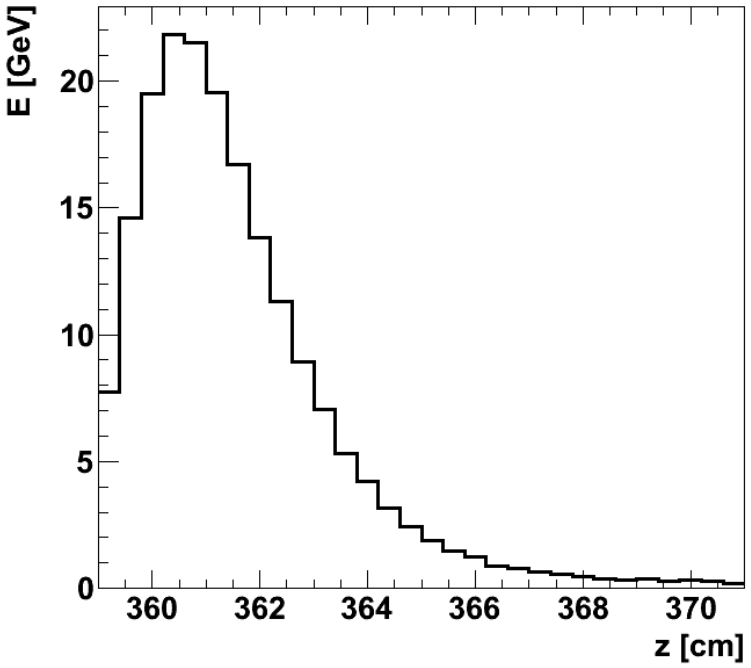


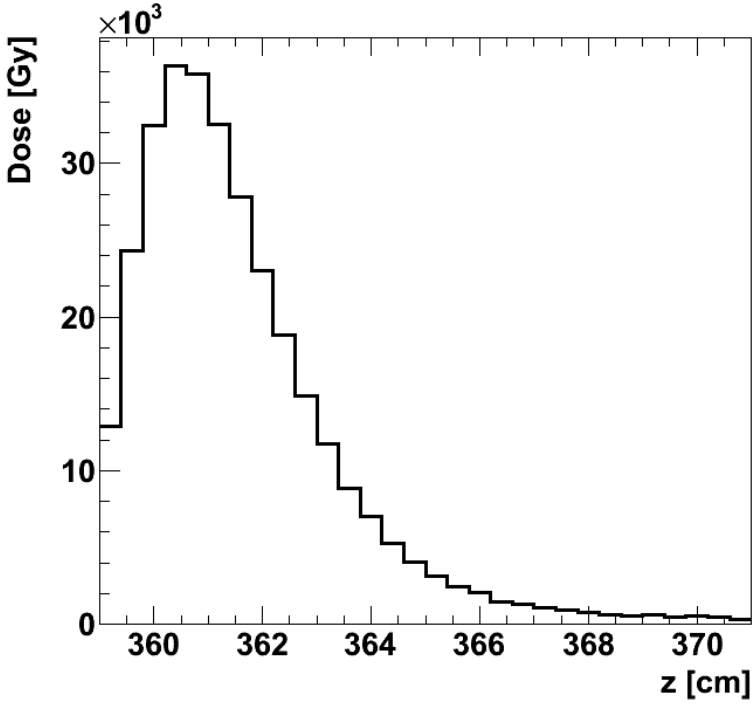




Electromagnetic dose

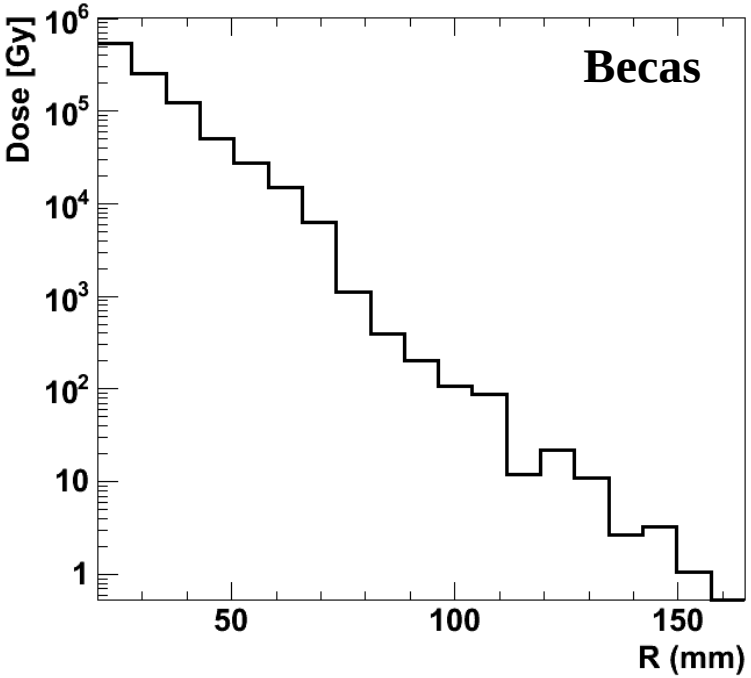
Mokka Case

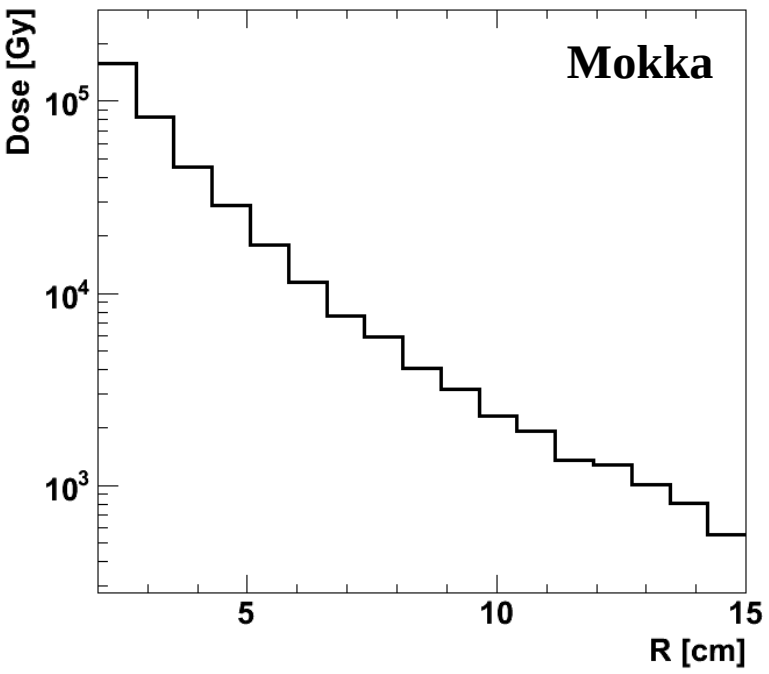




Maximum Dose ~35 kGy/yr (layer 4)

Electromagnetic dose at the maximum of the shower

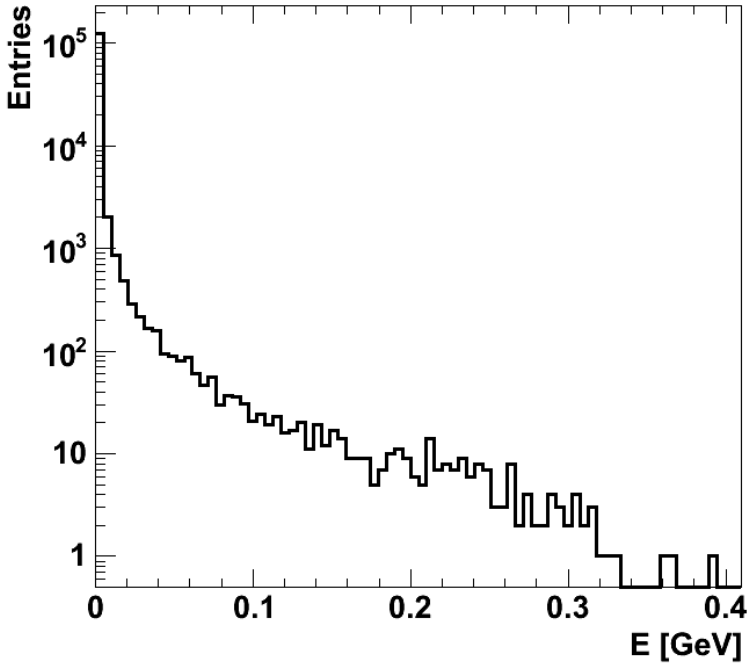


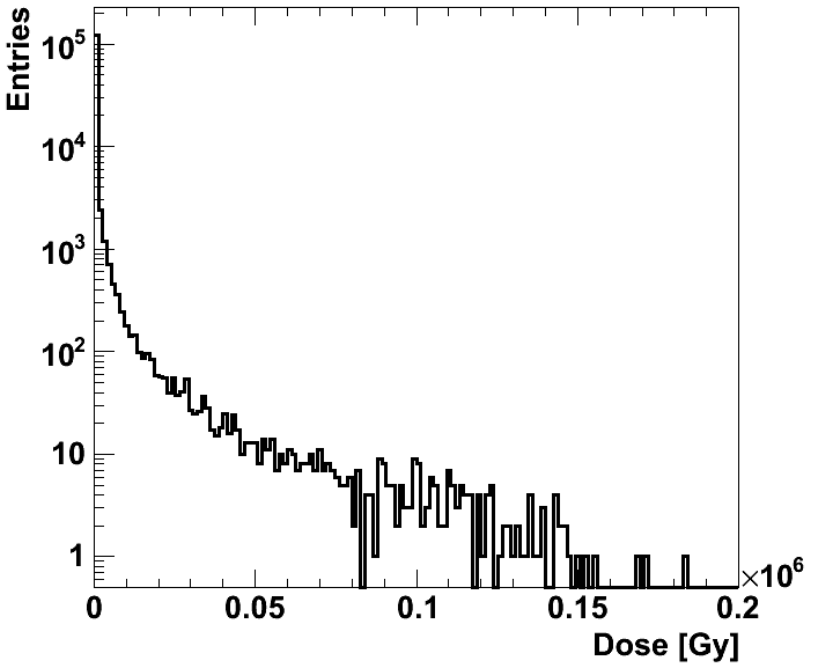


The dose is twice as large with Becas (at the maximum, lr.5 and 4, respectively)
Mokka: ~0.2 MGy/yr closest to the beam-pipe

Electromagnetic dose per cell

Mokka Case





Energy per cell:
0.4 GeV/BX

Dose per cell:
~0.2*10^{6}Gy/yr

Mokka Neutrons in BeamCal – ongoing study

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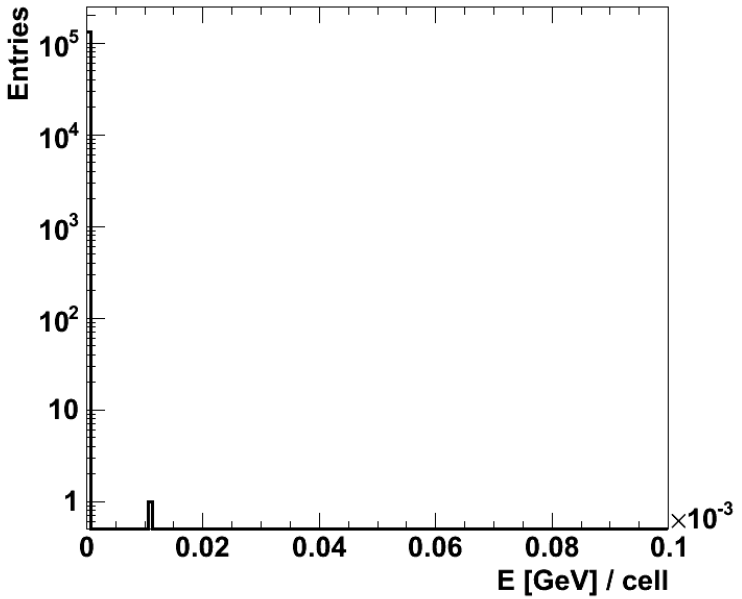
One single neutron!



Conclusions

- Detailed but simplified model of the final focus quadrupole magnet implemented in Mokka
- Estimated the electromagnetic dose in different components of QD0
- Dose decreases rapidly in the beam direction
- Highest dose for the permanent magnet less than 270 kGy/yr for Incoherent Pairs and ~500 kGy/yr for the Trident Pairs
- Highest dose in the CLIC QD0 permanent magnet for one year of operation approaches 1 MGy/yr
- In the yoke and coils much smaller doses: highest is 80 kGy/yr (yoke) and 3kGy/yr (coils)
- Electromagnetic doses in BeamCal with Mokka are ~2 times lower than with Becas
- Two magnitude order difference between inner and outer regions of the sensor, with Mokka
- Ongoing study on neutrons both for QD0 and BeamCal in Mokka

Thank you!