Simulations of Neutron Background in the HCAL

A First Trial with Mokka

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Neutron Background at the ILC

e^+e^- pairs are the main source of neutron background

- created through beam-beam interaction (IPC)
- crash into forward calorimeters (BeamCal) and quadrupoles of the beam delivery system
- neutrons are created in showers through electro-nuclear / gamma-nuclear reactions

Neutrons can escape through the tungsten shield

- low-energy hits in the calorimeters
- radiation damage, e. g. to SiPMs (to be studied)

Simulation Tools

Guinea Pig (e^+e^- pairs generator)

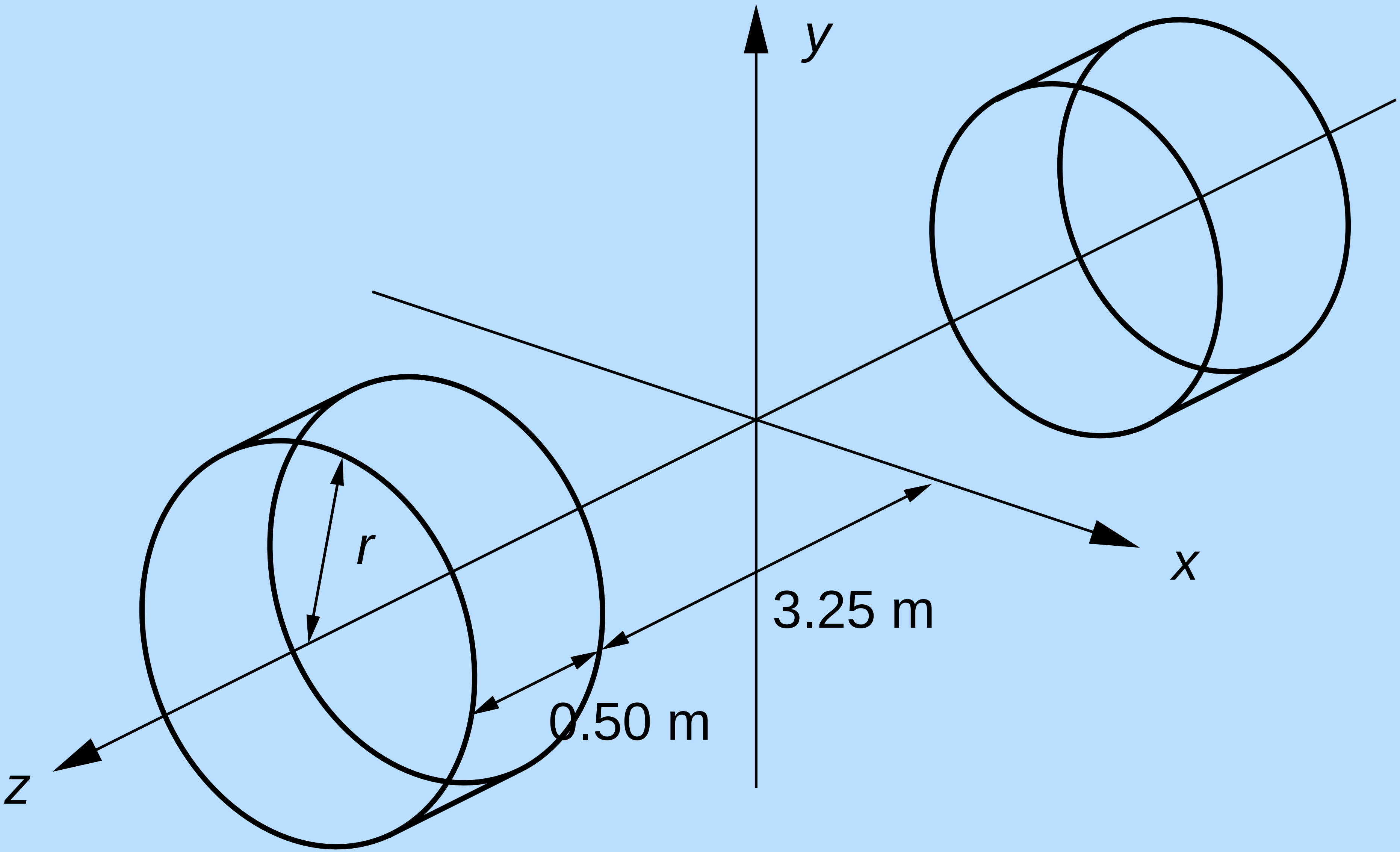
- used with TESLA beam parameters

Mokka (full detector simulation)

- version 05-03 with Geant 4.7.1.p01
- `PhysicsListNeutrons` (uses `QGSP_HP`)
- geometry model `D13Stahl` (TDR-like), but with `hcalFeScintillator`

Simulated 5 bunch crossings ($\widehat{=}$ 5 days) with $\approx$ 130 000 pair particles each

Sensitive Surfaces



Counting Particles

Simulation approach

- concentric cylinders as sensitive surfaces:

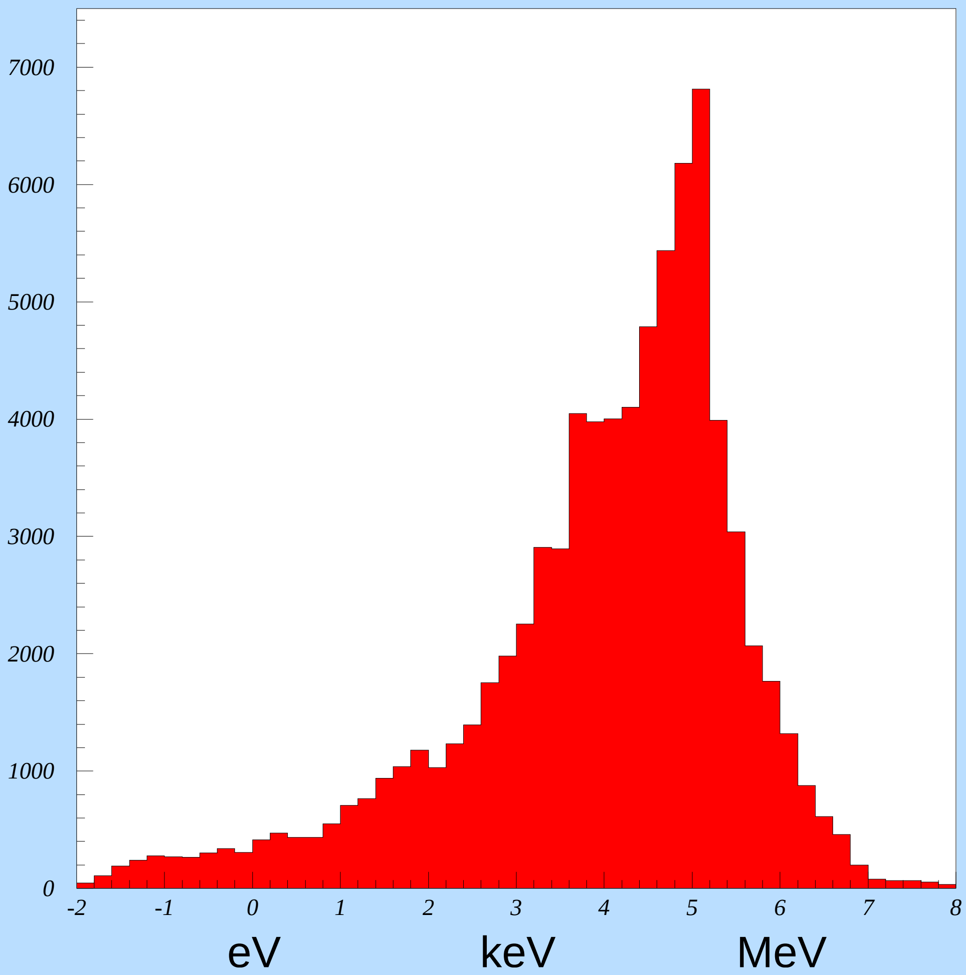
  $$r = 30, 40, 60, 90, 120, 150 \text{ cm}$$
  $$|z| = 3.25 \ldots 3.75 \text{ m}$$

- all crossings of a particle through these surfaces are registered an written out (r, ID, E)
- neutrons with $E > 1$ MeV are counted

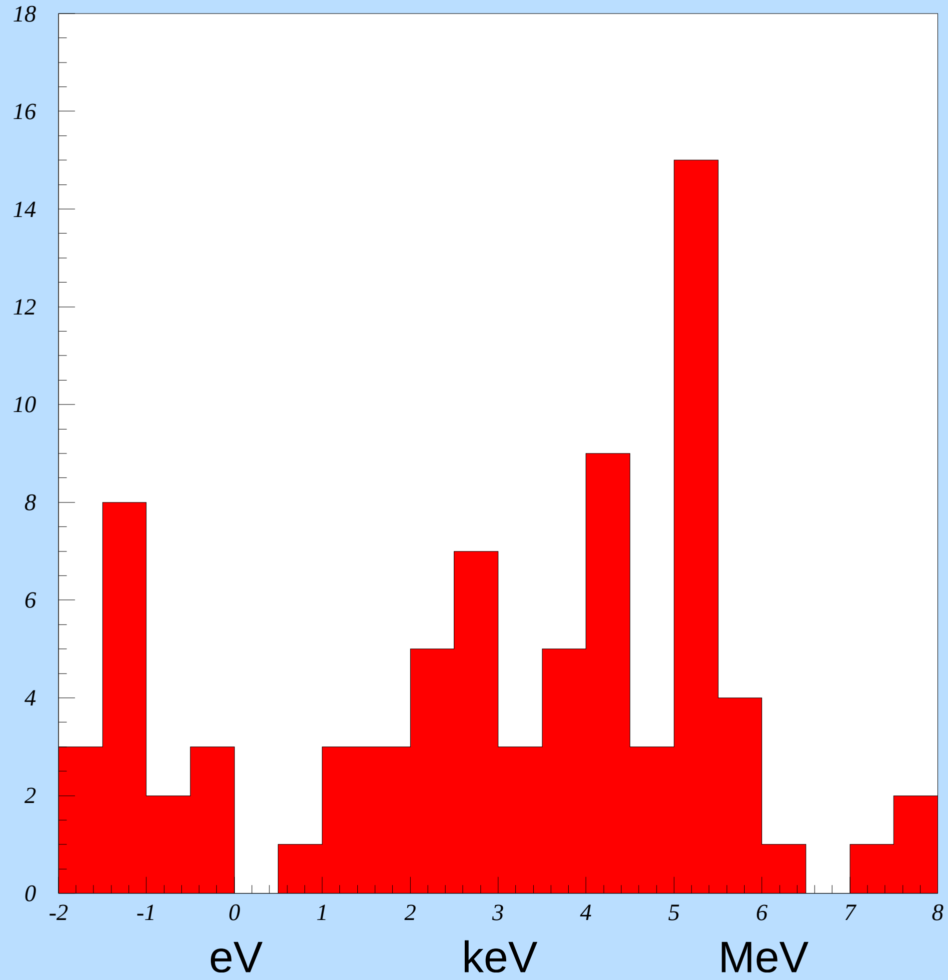
Technical implementation

- plugin for Mokka (around 40 lines of code)
- no need to touch the Mokka core

Neutron Energy Spectra



r = 30 cm



r = 90 cm

(all 5 BX summed up)

Normalisation

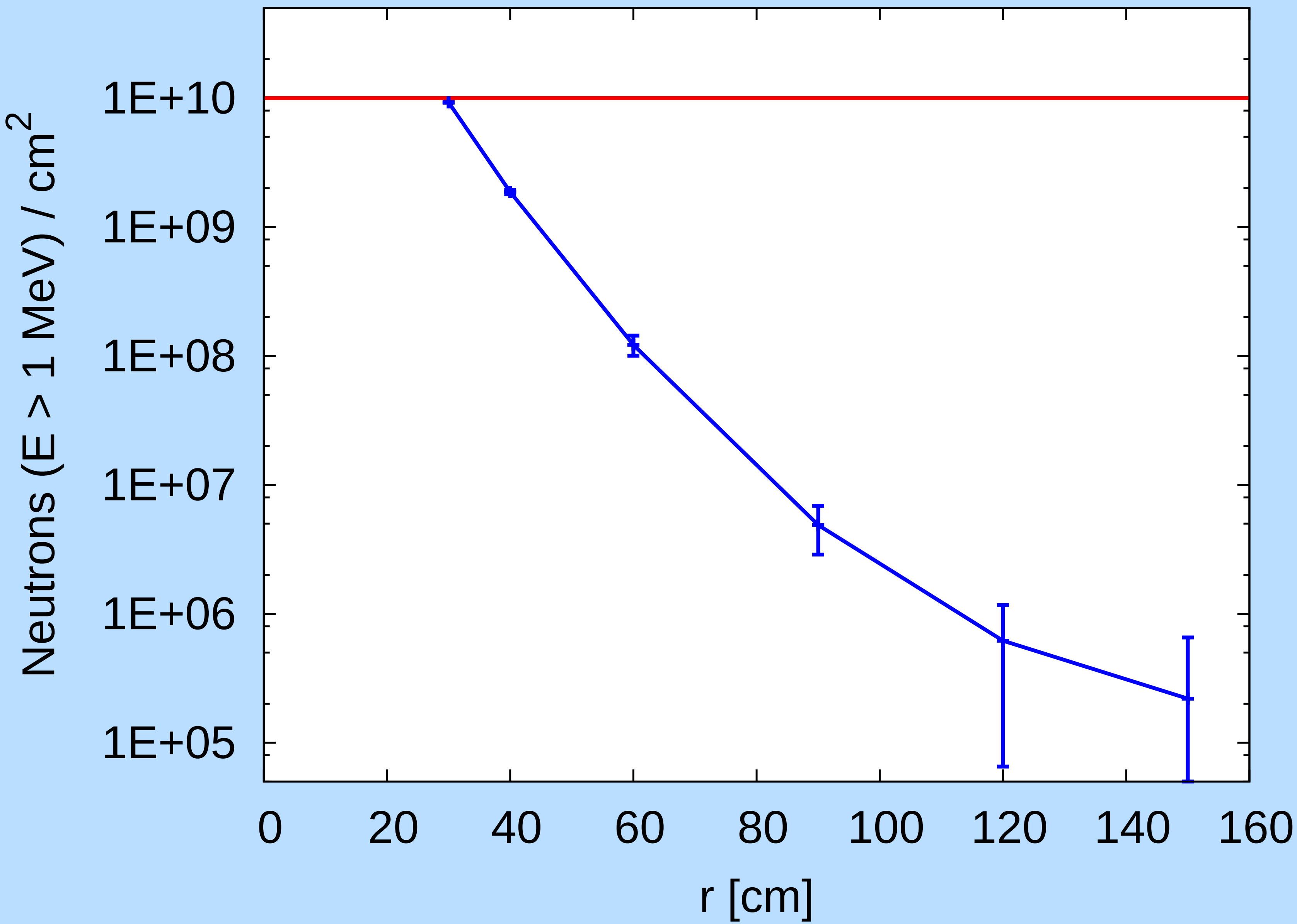
Flux per unit area (1 cm^2)

- divide by area of sensitive surfaces

Flux per total lifetime

- integrated design luminosity: $\int \mathcal{L}\, dt$ = 500 fb^{-1}
- luminosity per BX: $\mathcal{L}$ = 2.2 μb^{-1} / BX
- total number of BX: $N = 2.3 \cdot 10^{11}$ BX
- corresponds to half a year of continuous running at the full luminosity of $\mathcal{L} = 3.4 \cdot 10^{34} / cm^2\, s$
- multiply neutron flux per BX by *N*

Results – Neutron Flux in the HCAL



Conclusions

- Maximum neutron flux for SiPMs: $10^{10}\,/\,cm^2$ (irradiation tests have been done in Moscow)
- Innermost parts of the HCAL approach that limit ("worst-case result")

- Neutron simulations are not very reliable – you'd like a safety factor of 10, better 100!
- This simulation was only a very first approach
- Further work has to be done . . . (as always)

- Addendum: Photons do not seem to be a problem