

# **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)

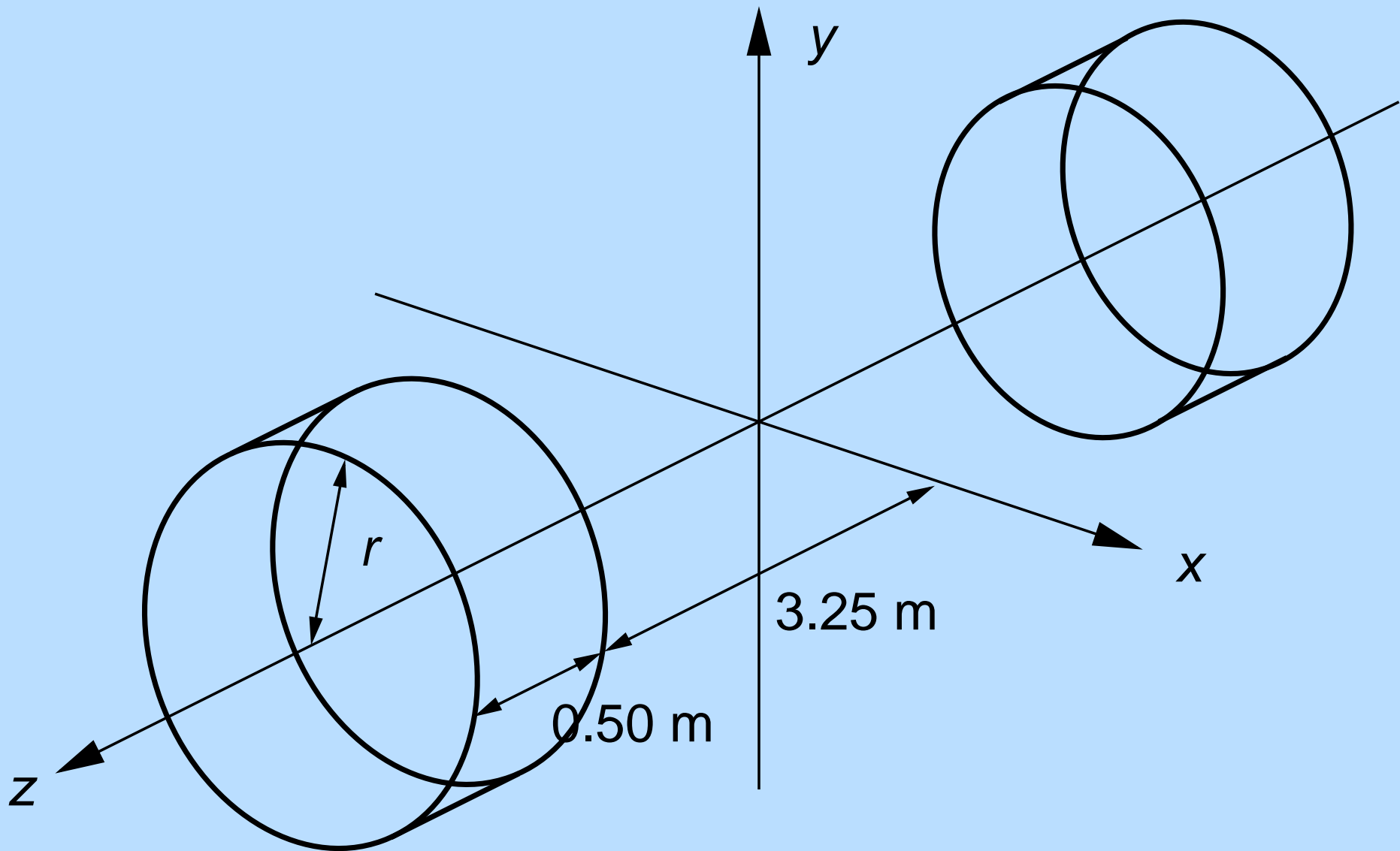
- used with TESLA beam parameters

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 ( $\hat{=}$  5 days)  
with  $\approx$  130 000 pair particles each

# Sensitive Surfaces



# Counting Particles

## Simulation approach

- concentric cylinders as sensitive surfaces:

$$r = 30, 40, 60, 90, 120, 150 \text{ cm}$$

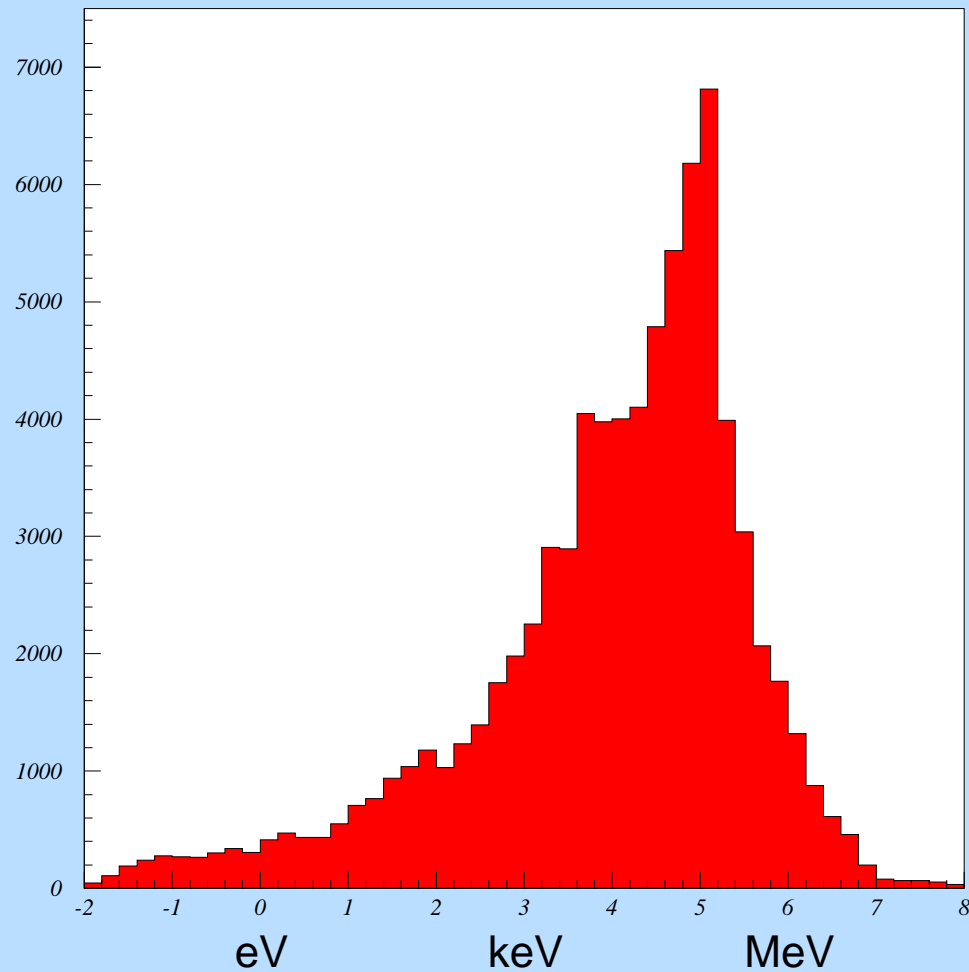
$$|z| = 3.25 \dots 3.75 \text{ m}$$

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

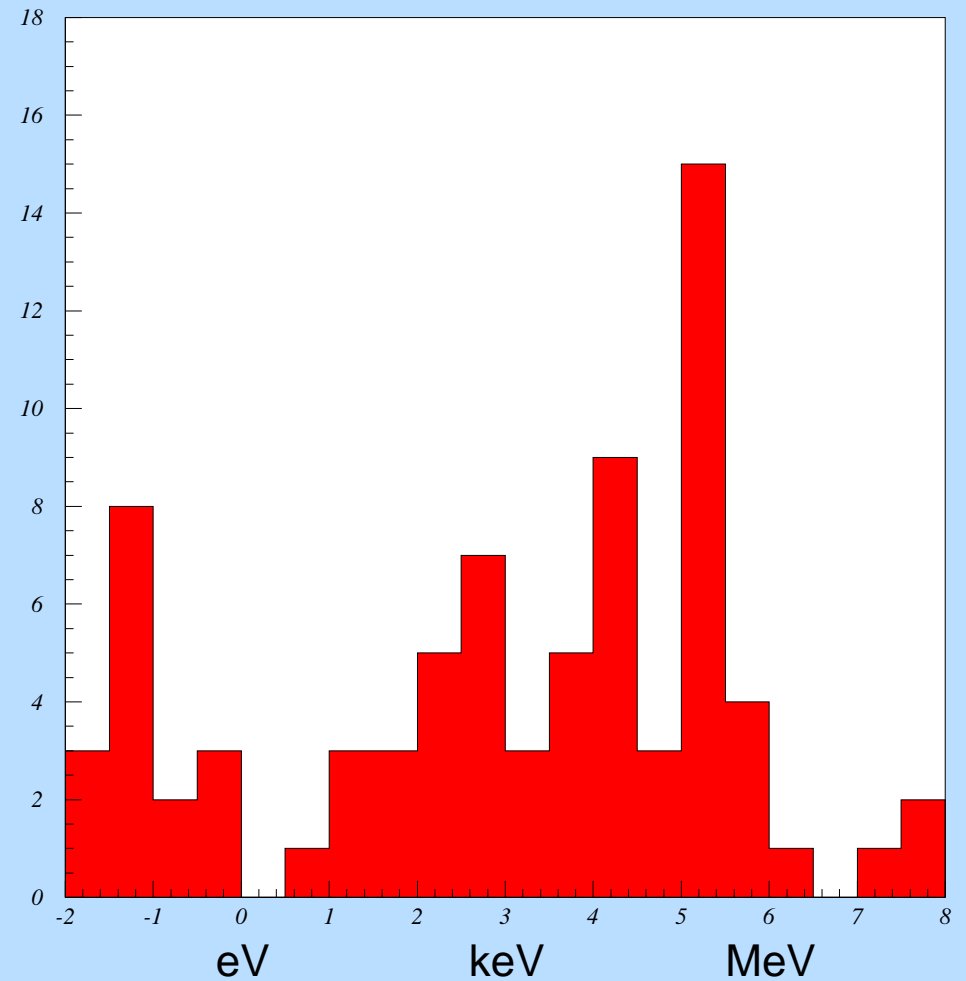
## Technical implementation

- 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

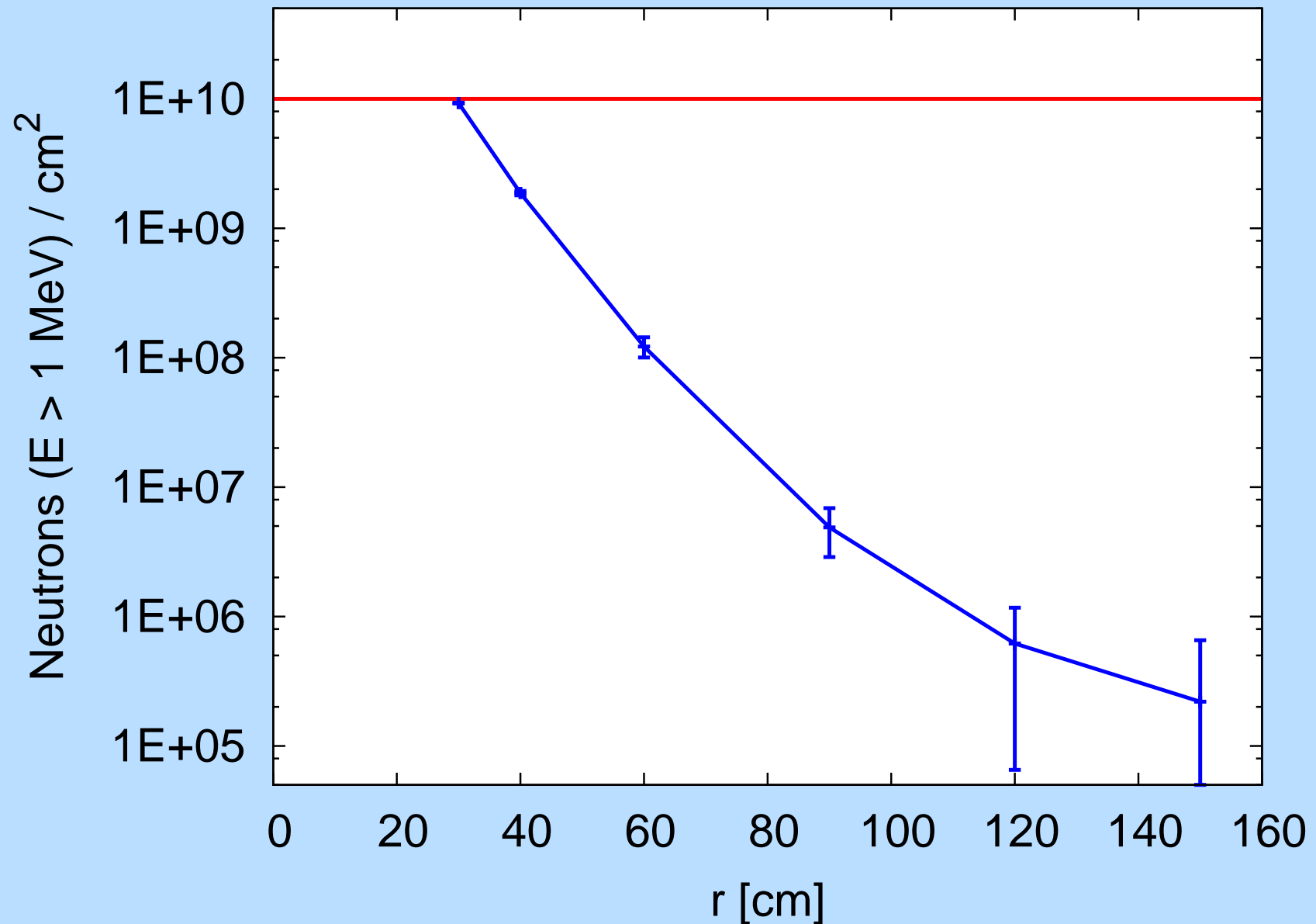
Flux per unit area (1 cm<sup>2</sup>)

- divide by area of sensitive surfaces

Flux per total lifetime

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

# Results – Neutron Flux in the HCAL



# Conclusions

- Maximum neutron flux for SiPMs:  $10^{10} / \text{cm}^2$   
(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