

# **Simulations of Neutron Background in an ILC TPC using Geant 4**

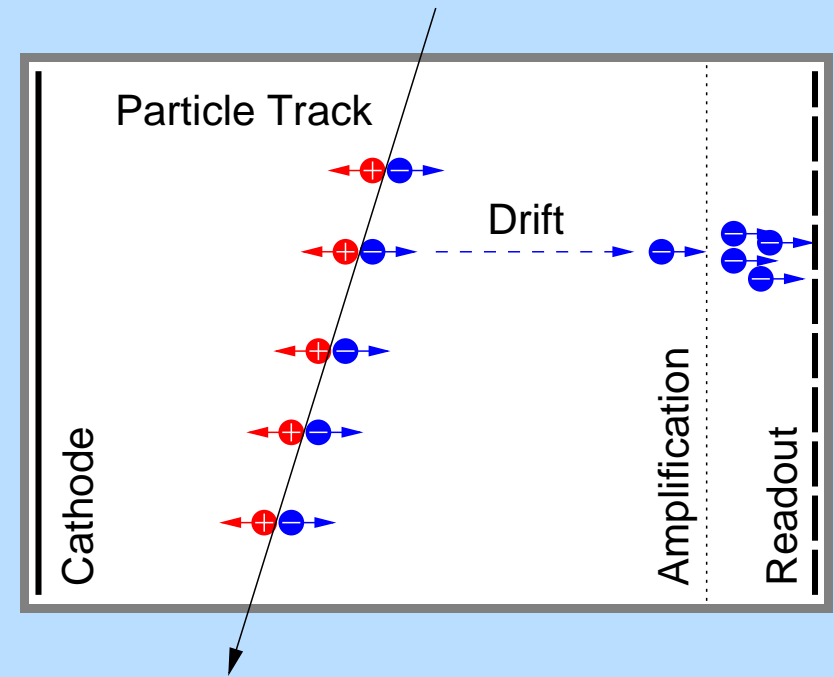
*First Results from Mokka*

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# TPC – Time Projection Chamber

## Principle of operation

- large chamber filled with gas
- tracks from ionising particles drift in a hom. electric field
- signals are amplified and read out at the endplates
- $r\varphi$  measured directly,  $z$  from drift time (“projection”)



## Advantages of a TPC

- good point resolution (goal:  $\sigma_{r\varphi} \approx 100 \mu\text{m}$ ,  $\sigma_z \approx 1 \text{ mm}$ )
- large number of 3D points, robust pattern recognition
- minimum of material in front of calorimeters

# Effects of Neutrons

## In the TPC

- short tracks from recoil protons (hydrogen in the gas)
- tracks from beta decay (after 15 min mean life)
- additional primary ions,  $E$ -field distortions

## In other detectors

- radiation damage to silicon sensors
- many random low-energy hits

## General issues

- the closer created to the IP, the more dangerous!
- bouncing, channelling, thermalisation

# Simulation Tools

## Guinea Pig

- simulates beam-beam interaction
- generates (among others)  $e^+e^-$  pair particles

## Brahms

- simulates interaction of particles with the detector
- based on old Geant 3, Fortran

## Mokka

- successor of Brahms, still under development
- but: based on state-of-the-art Geant 4, C++

# Geant 4 Physics Lists in Mokka

`PhysicsList` (Mokka built-in)

- doesn't support neutron production at all

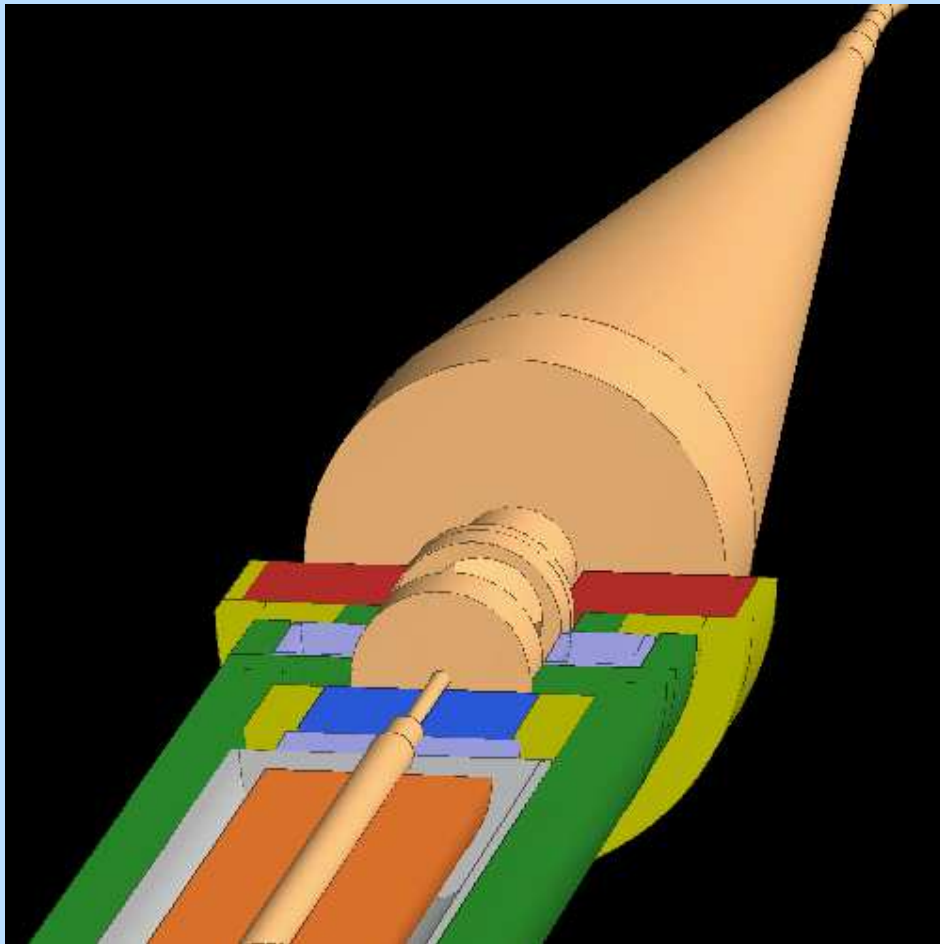
`LCPhys` (dedicated Linear Collider physics list)

- newer versions support neutron production
- but: uses poor models for low energies (up to now)

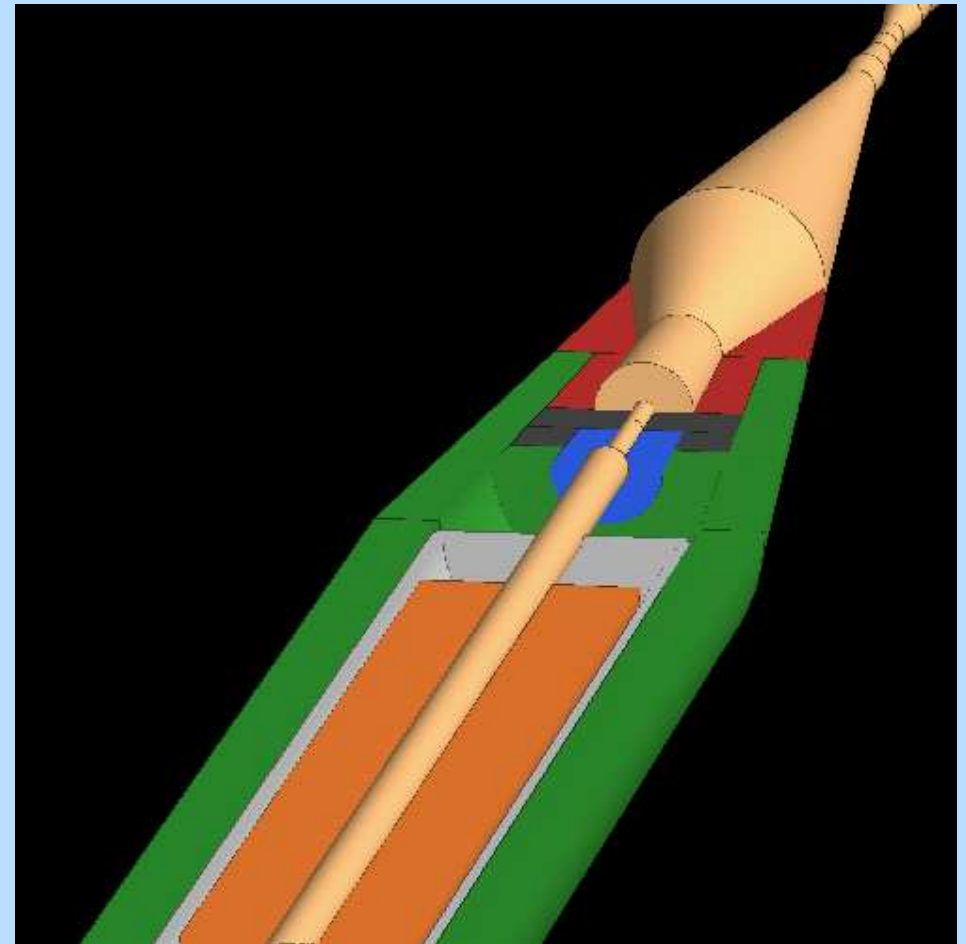
`PhysicsListNeutrons` (extended `PhysicsList`)

- enables electro-nuclear processes (`EM_GNPPhysics`)
- uses high-precision neutron models (`QGSP_HP`)
- features scattering, moderation, interactions with gas

# Geant 4 Detector Geometries in Mokka



Stahl proposal  
( $L^* = 4.05$  m)



TDR layout  
( $L^* = 3.00$  m)

# First Results

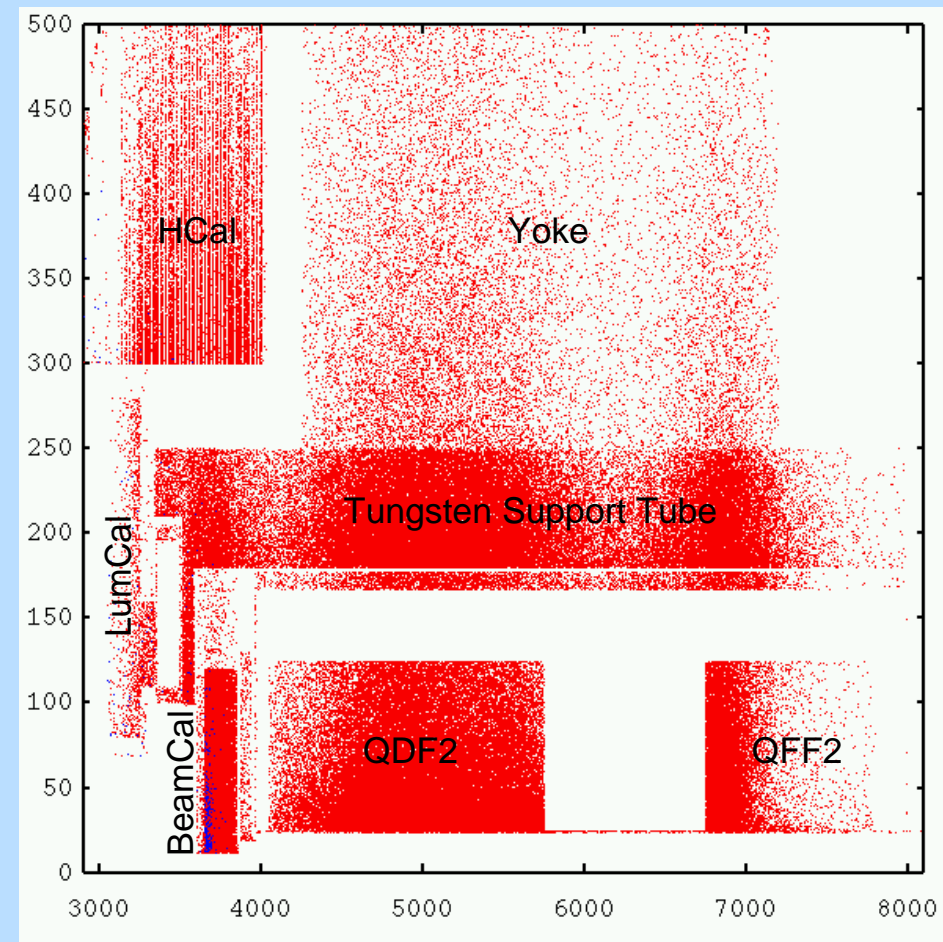
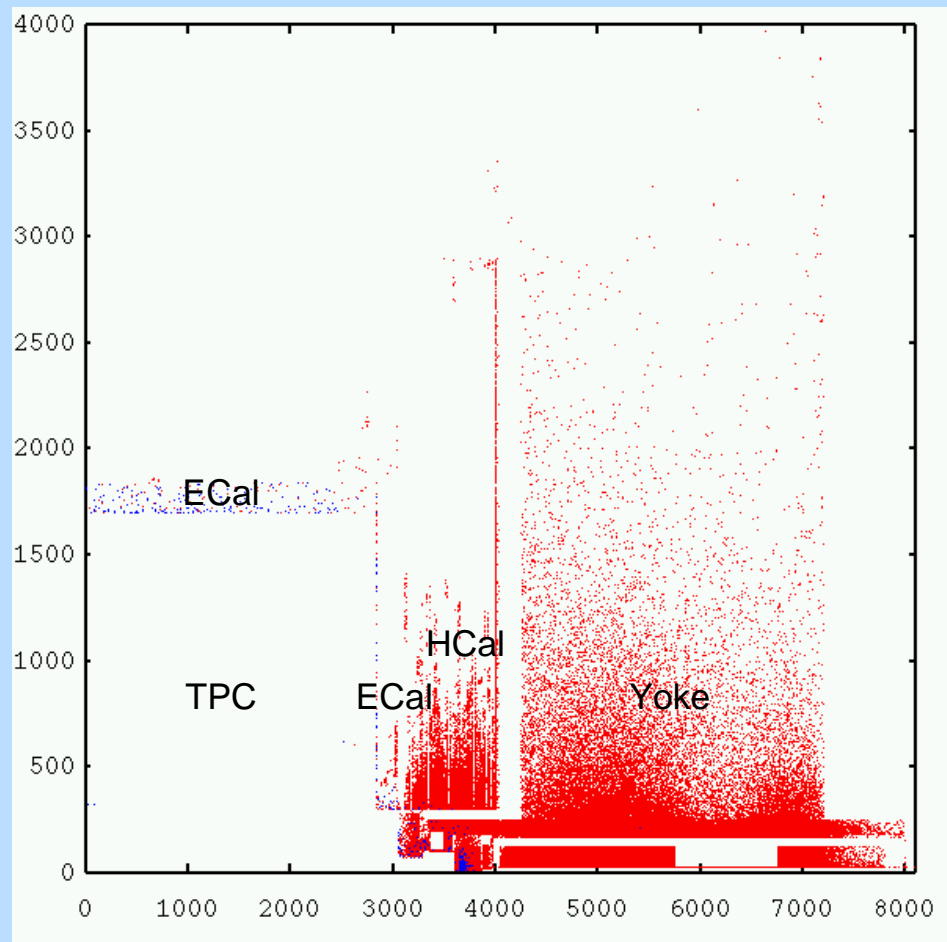
## Simulation

- pairs from one BX (130 000 particles)
- physics list with neutron production
- geometry from Stahl proposal, head-on
- TPC filled with TDR gas (93% Ar, 5% CH<sub>4</sub>, 2% CO<sub>2</sub>)
- standard production and energy cuts, no TPC cut

## Analysis

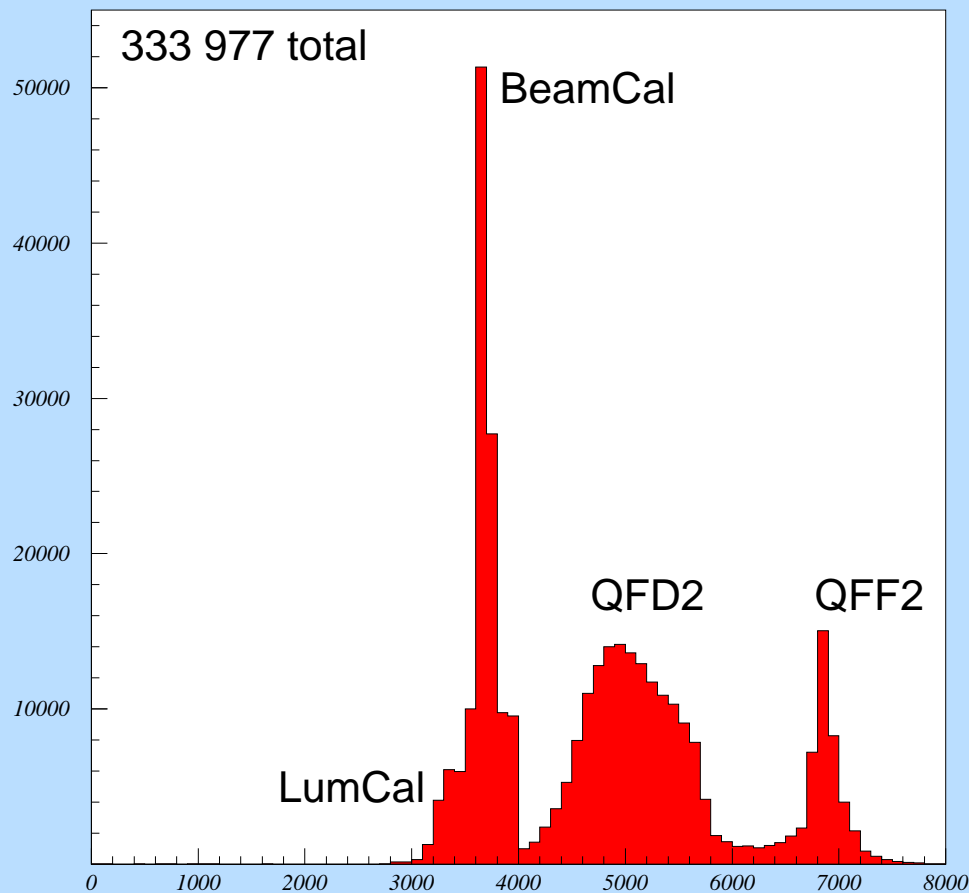
- where are neutrons produced?
- which of these reach the TPC?
- what energies do they have?

# Neutron Production – Cross Section

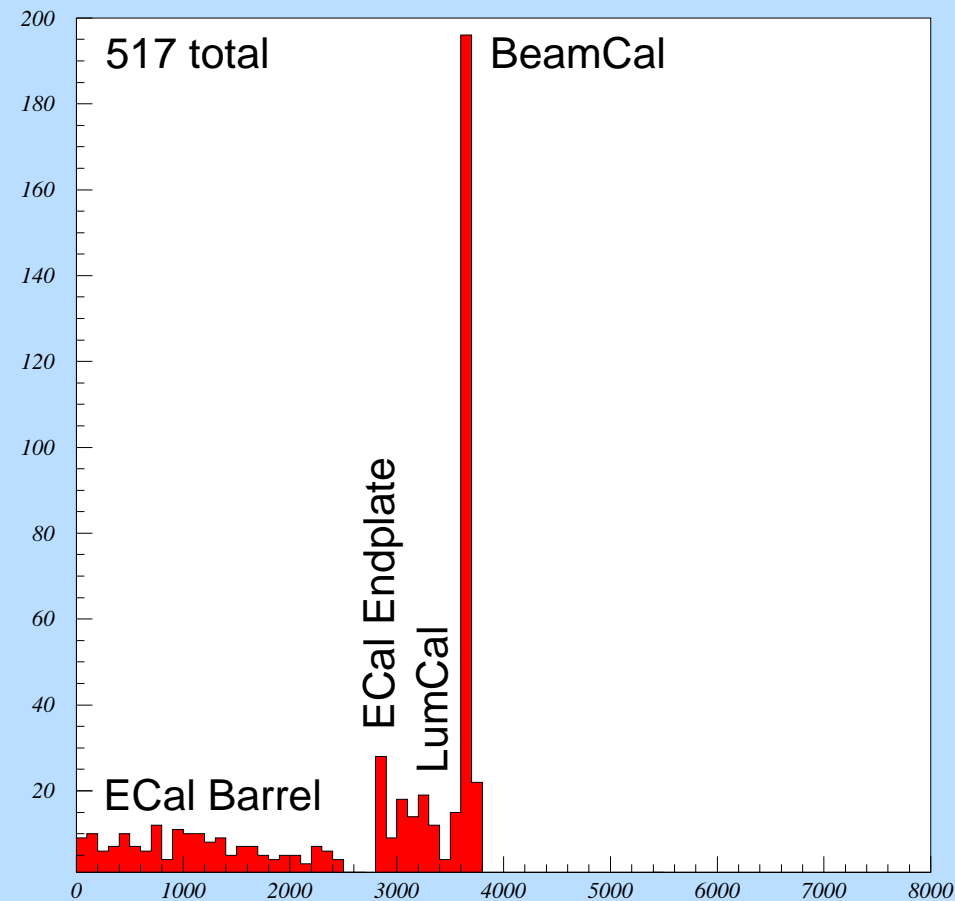


Origins of neutrons (blue ones reach the TPC)

# Neutron Production – Distances

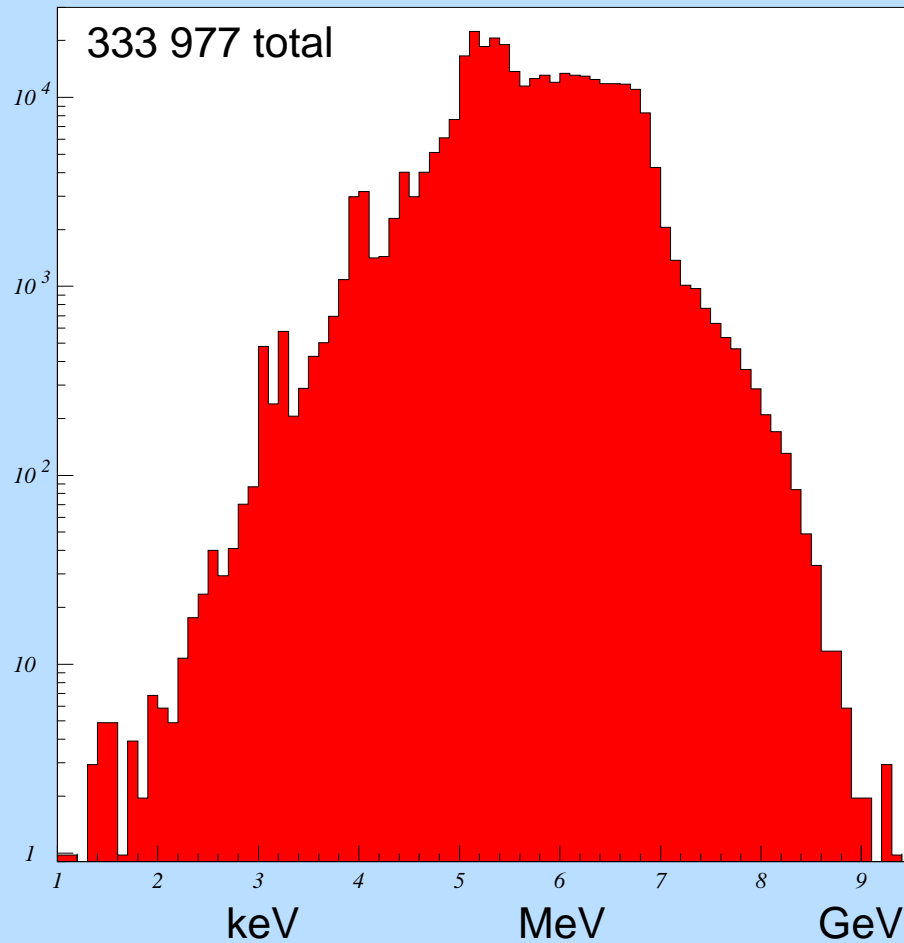


Origins of neutrons...

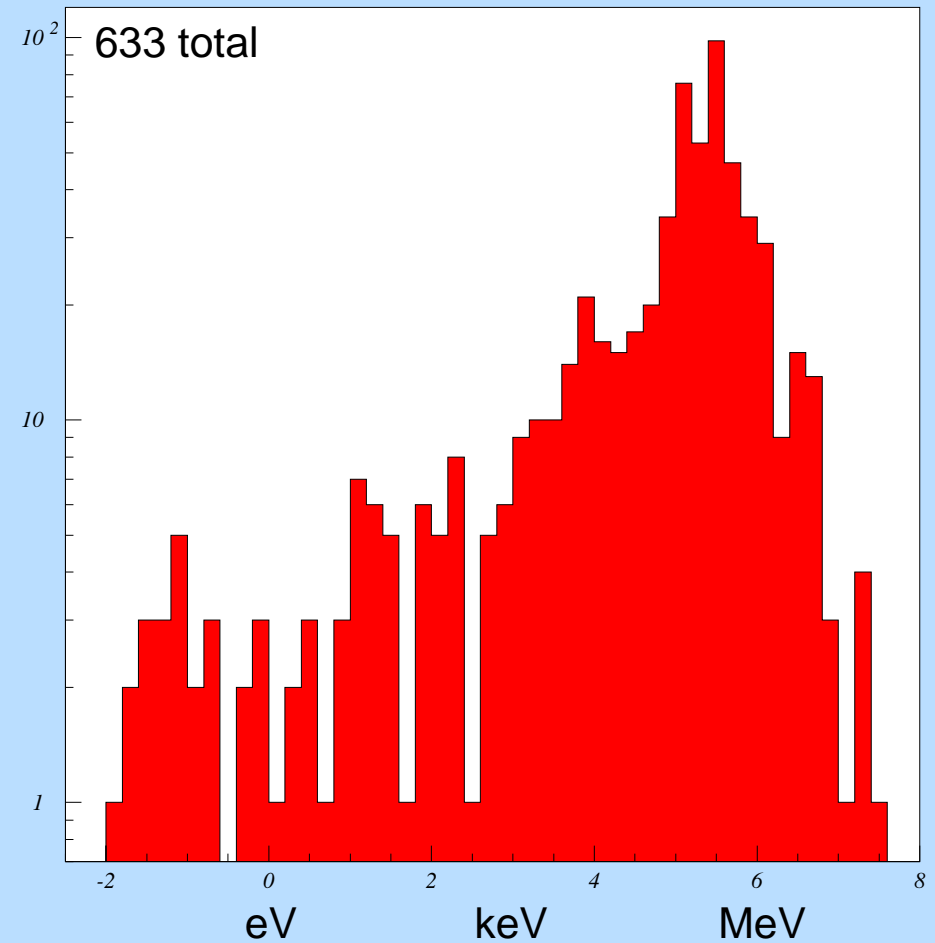


... reaching the TPC

# Neutron Production – Energies

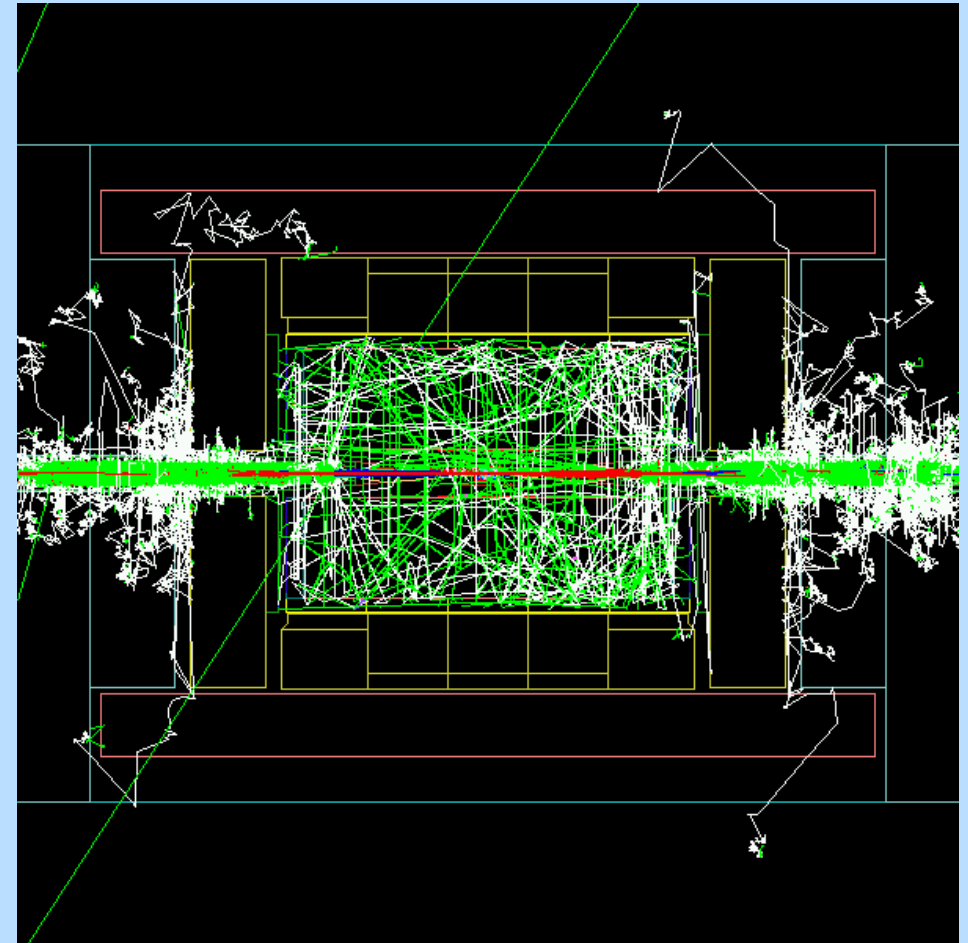
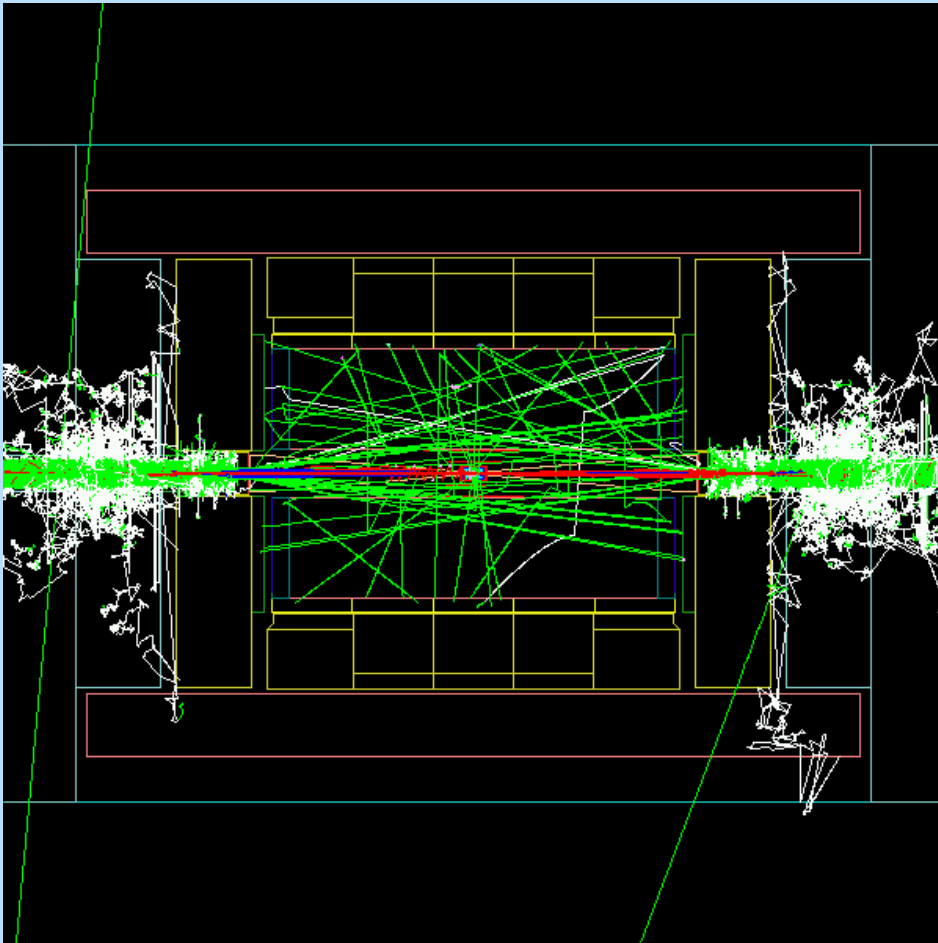


Energies of neutrons...



... when entering the TPC  
(some more than once)

# Comparison Stahl vs. TDR – Events



Stahl proposal

TDR layout

Tracks created by 1000 pair particles ( $\approx 1/100$  BX)

# Comparison Stahl vs. TDR – Numbers

	Stahl	TDR
Total neutrons per BX	333977	413286
Neutrons reaching TPC	517	10959
Bouncing neutrons	20%	20%
Total TPC hits	5361	9881

Only preliminary!

- simulation of one single BX – need more statistics
- how many hits are caused by neutron scattering?

# Outlook

## Next steps:

- comparison with earlier results (G. Wagner)
- better understanding of Geant 4 mechanisms (particle creation, tracking, killing)
- better handling of low-energy neutrons down to thermalisation (fall back to Fluka?)
- simulation of neutron diffusion and decay
- simulations with different gas mixtures

## Final goal:

- estimate of all background tracks in the TPC at a given time (with superposition of 160 BX)