Background Studies for the Large Detector Concept

Status and Prospects

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Background Sources at the ILC

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

- beams have to be focused very strongly (σ_y = 5 nm)
- beam-beam interaction creates beamstrahlung
- beamstrahlung photons scatter to e^+e^- (10^5 / BX)
- e^+e^- crash into forward calorimeters and magnets
- lots of photons, neutrons, and charged particles are created close to the tracking detectors

Other sources are supposed to be negligible
(beam dump, synchrotron radiation, radiative Bhabhas)

Problems with Background

Inner trackers (VXD, SIT, FTD)

- hits from charged particles (direct / indirect)
- silicon bulk damage from neutrons

Main tracker (TPC)

- Compton scattering, photon conversion
- neutron-proton collisions in the TPC gas (recoil)
- additional primary ionisation, field distortions

Calorimeters (ECAL, HCAL)

- more photons from nuclear reactions, neutron capture
- random low-energy hits, radiation damage (?)

Simulation Tools – Guinea Pig

Input

- set of beam parameters (E, $\vec{\sigma}$, $\vec{\beta}$, Q, ...)

Output

- particles in the disrupted beams
- beamstrahlung photons
- e^+e^- pair particles
- hadronic scattering products (“minijets”)

Existing simulation data

- TESLA beam parameters (500 GeV, 800 GeV)
- various ILC parameter sets (500 GeV, 1000 GeV)

Simulation Tools – Mokka

Mokka is a full detector simulation

- based on the Geant 4 framework
- written in C++, modular design
- main development at LLR, France
- now: contributions from many different users
  (the idea of “open software” seems to work!)

Mokka Input / Output

- detector geometry data is stored in MySQL databases
- primary particles are read from generator files
- output (MC particles, detector hits) is written to LCIO

Mokka Features

What Mokka does

- build a detector geometry (shapes, materials, fields)
- shoot primary particles and track them
- apply various physics processes (at random)
- register energy depositions in the material
- perform a simple kind of pseudo-digitisation

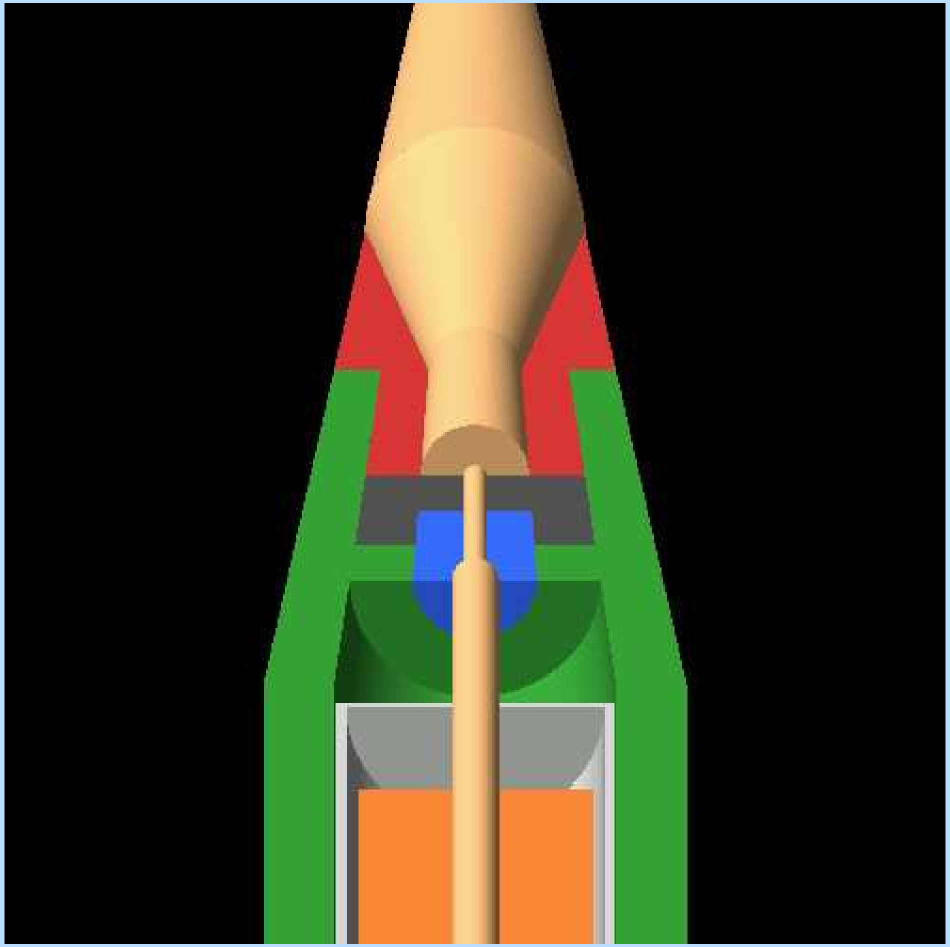
What Mokka does not do ($\longrightarrow$ Marlin)

- digitise hits to simulate amplification / electronics
- reconstruct clusters, tracks, and particles
- analyse the results for physics observables

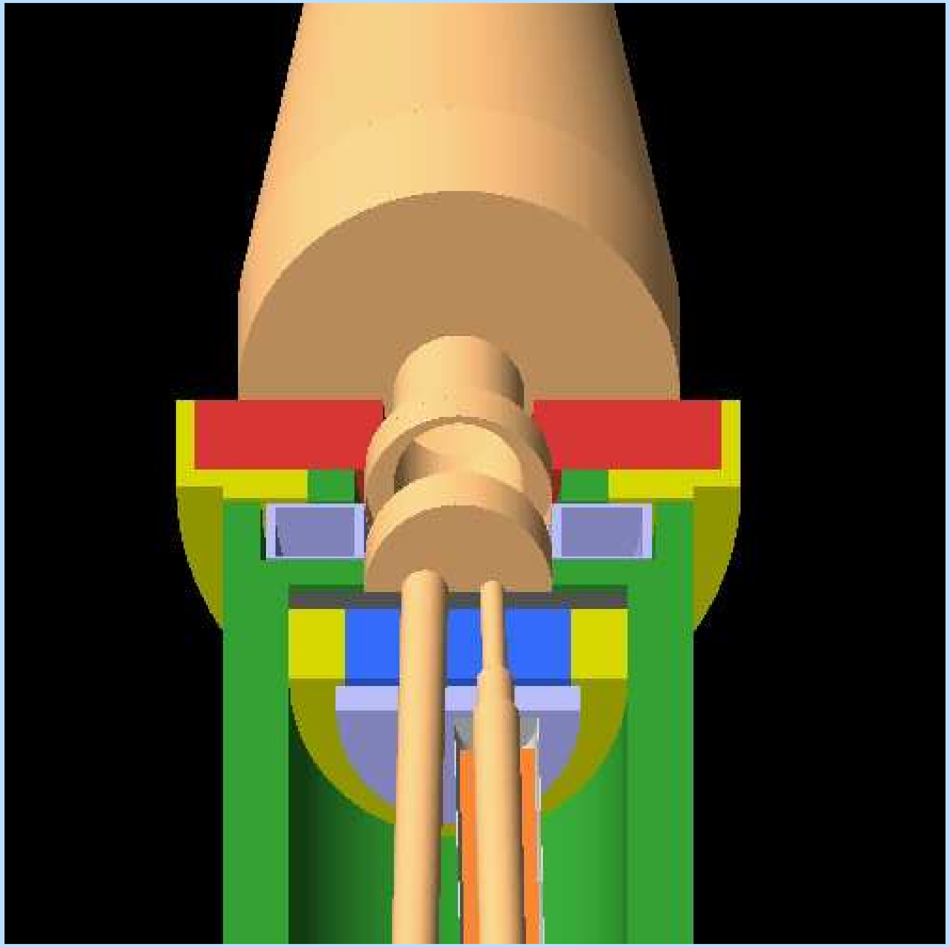
Work on Mokka

- Interface to Guinea Pig (from P. Wienemann)
- Improved description of the forward geometries (beam tube, crossing angle, mask, magnetic fields)
- TPC with a selectable gas (TDR, P 5, P 10, CF_4, . . .)
- “Physics list” with better treatment of neutrons
- Simplification of makefiles
- Debugging and extension of some core functionalities
- Detection of overlapping detector volumes
- Utility plugins for various tasks
- Improved TPC geometry with 3D voxels (ongoing)

Mokka – Forward Geometries

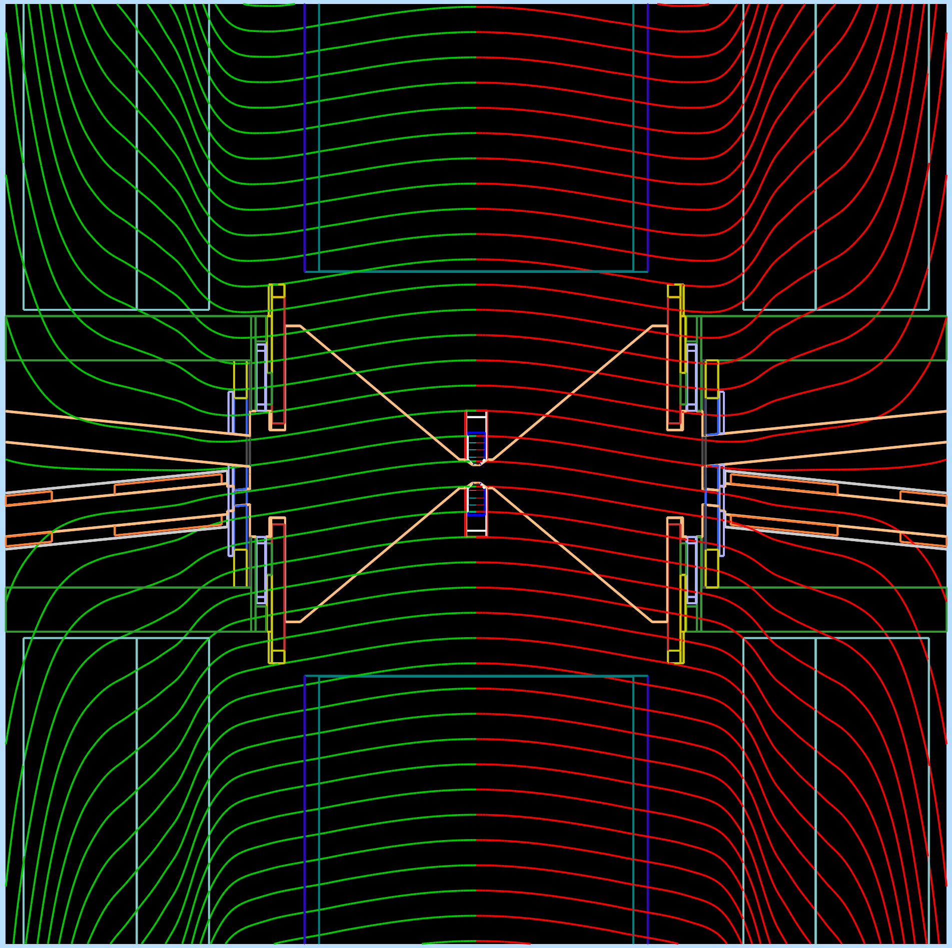


TDR layout
(head-on)

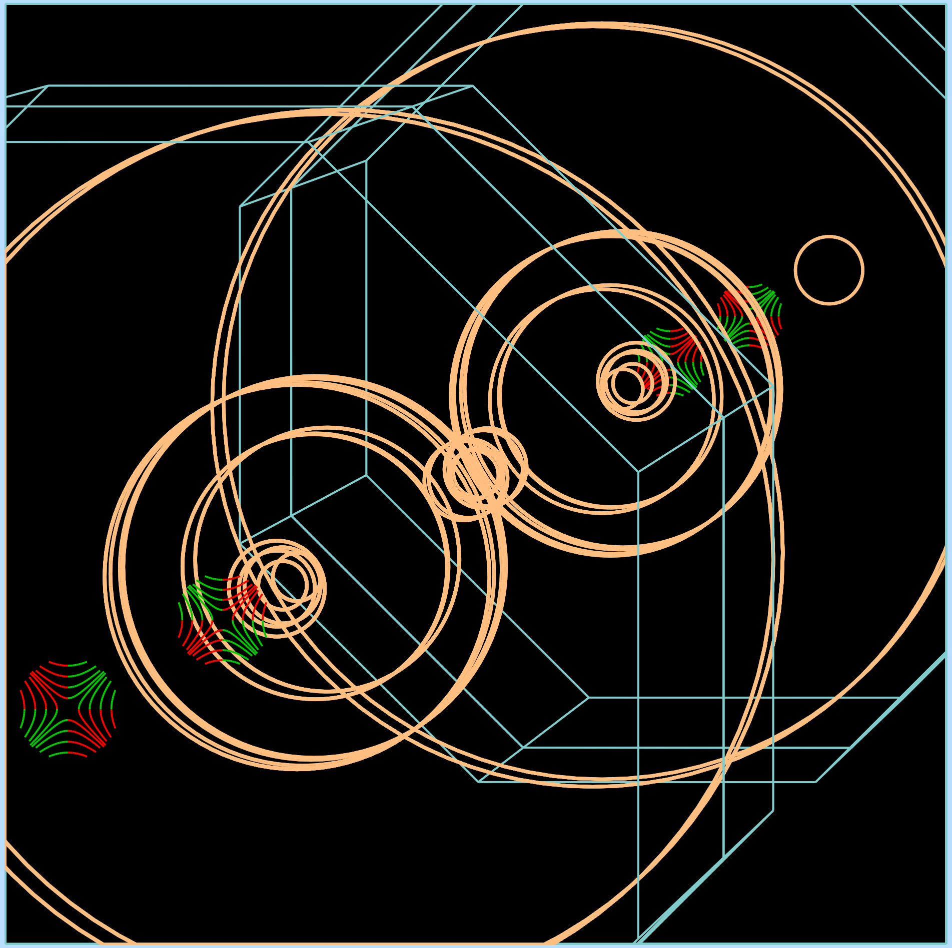


Modified Stahl proposal
(20 mrad crossing angle)

Mokka – Magnetic Fields



Solenoid with DID
(realistic field maps)



Final focus quadrupoles
(simplified)

Mokka – TPC with Voxels

Before

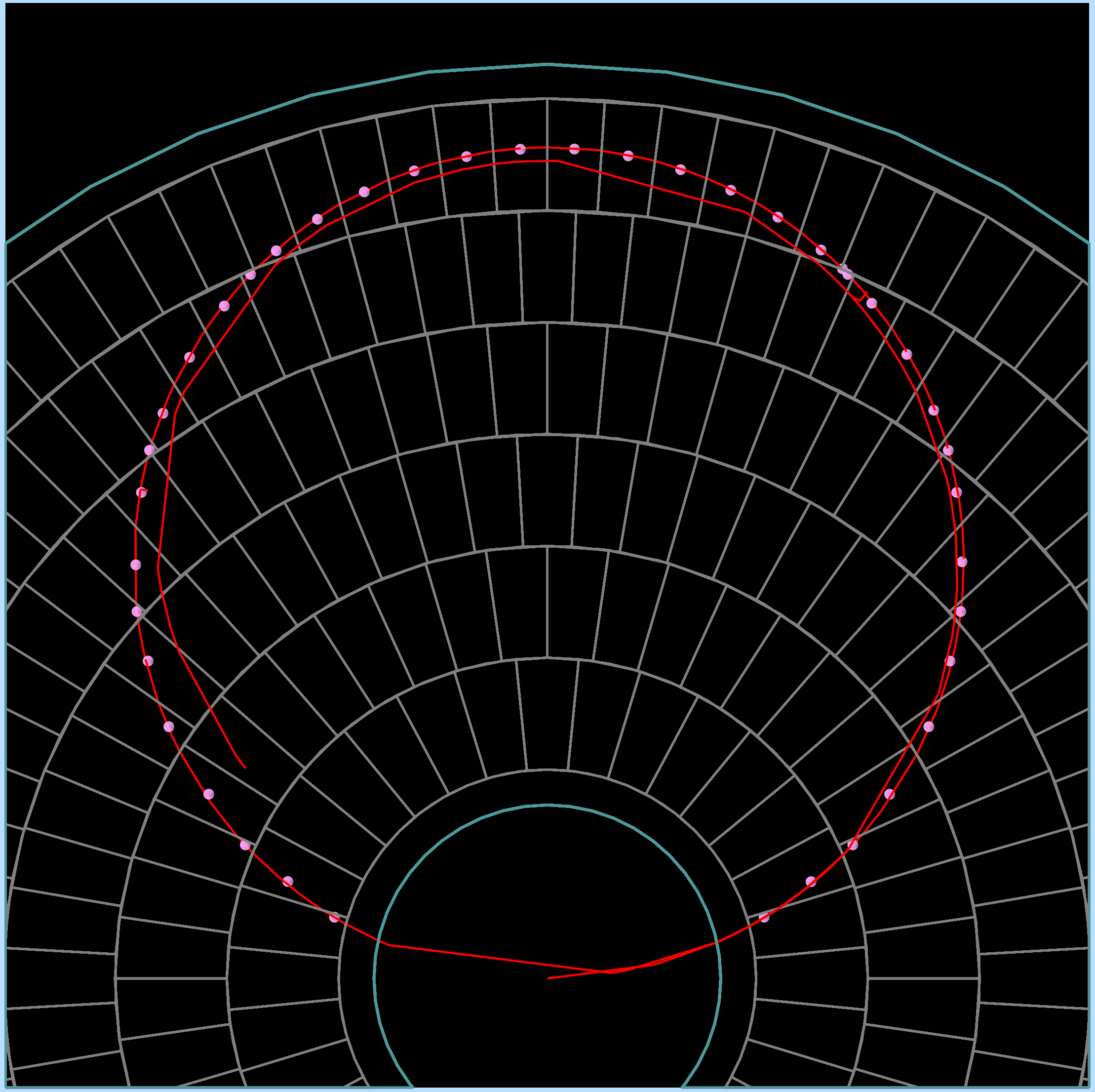
- 200 gas “layers”
- one “hit” per layer

After

- pads and time bins ($2.5 \cdot 10^9$ voxels)
- one “hit” per voxel

Pending questions

- speed, files sizes?
- proper digitisation?

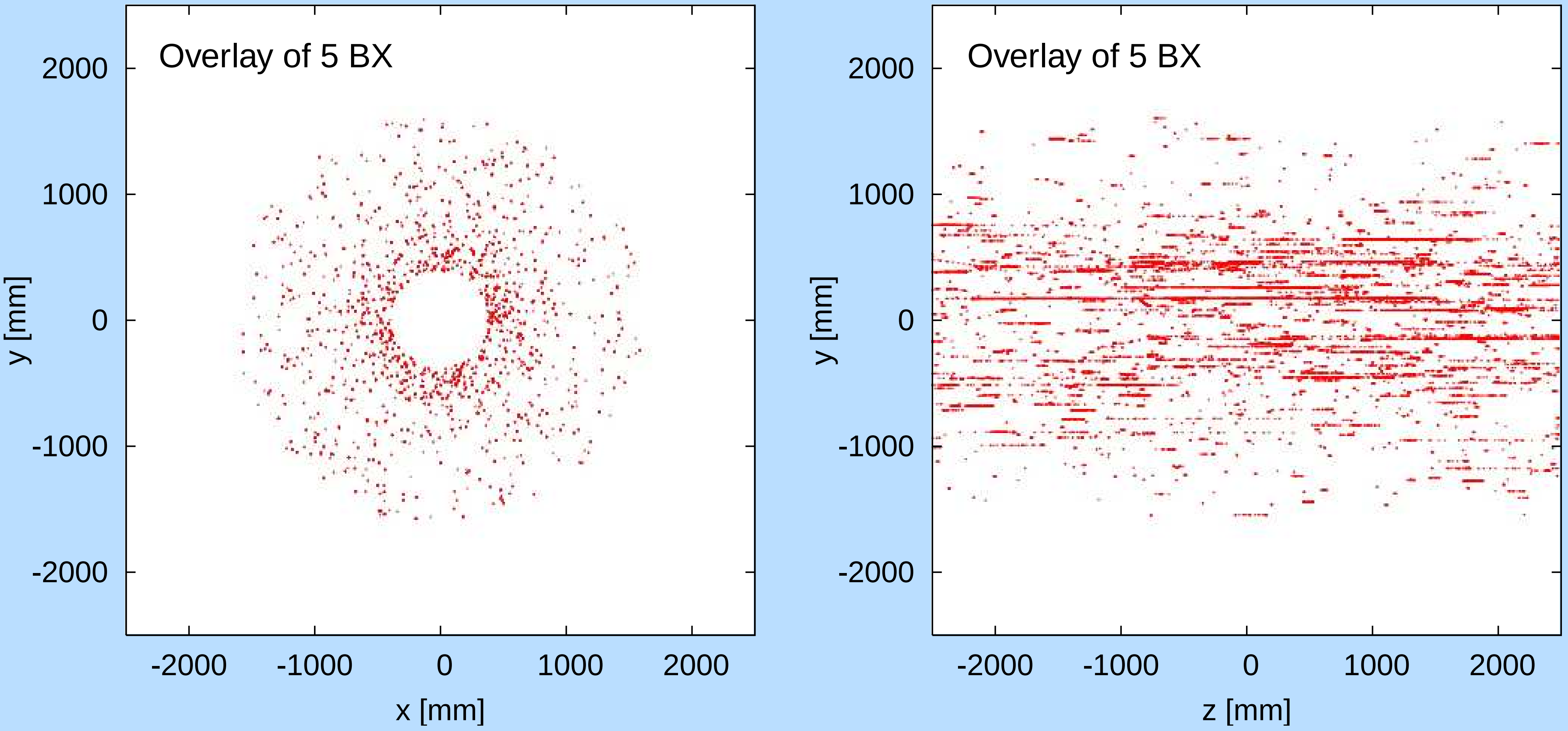


(pad sizes for demonstration)

TPC Simulations – Questions

- Where are background particles created? How?
- How many reach the TPC? With which energies?
- How many TPC hits will you get per BX?
- What will crossing angles, DID fields, . . . do?
- What is the influence of the TPC gas? (H content)
- What can A. Münnich's Marlin processors do for us?
- How are neutrons modelled correctly? (Use Fluka?)
- Can neutron moderators / absorbers help? Where?
- What will neutrons do at low / very low energies?

Results – TPC Hits



Stahl layout, TDR gas: 5500 ± 900 Mokka hits / BX

Stahl layout, P 10 gas: 5000 ± 600 Mokka hits / BX

Results – Particles in the TPC

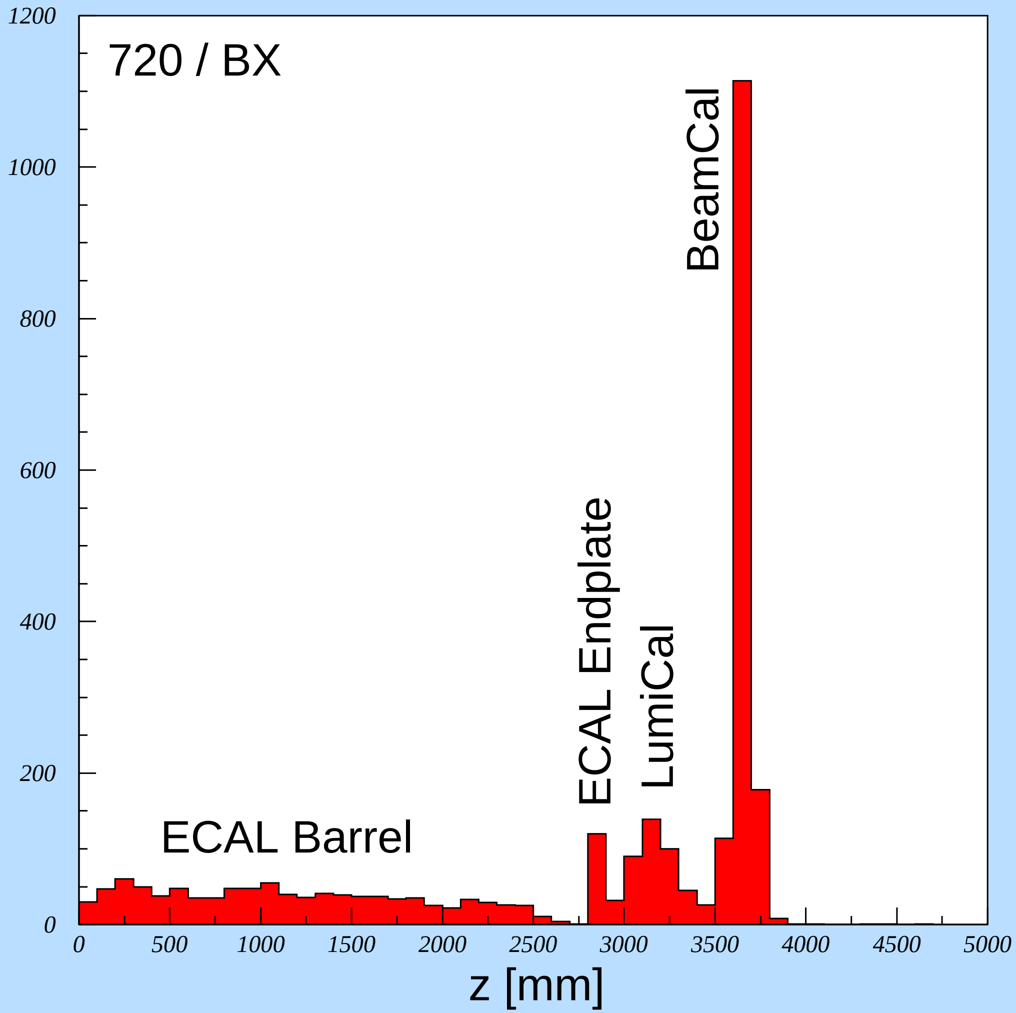
- Particles entering the TPC per BX

	TDR layout	Stahl layout
Neutrons	14700 ± 400	720 ± 70
Photons	9400 ± 200	5500 ± 100
Electrons	70 ± 60	40 ± 40

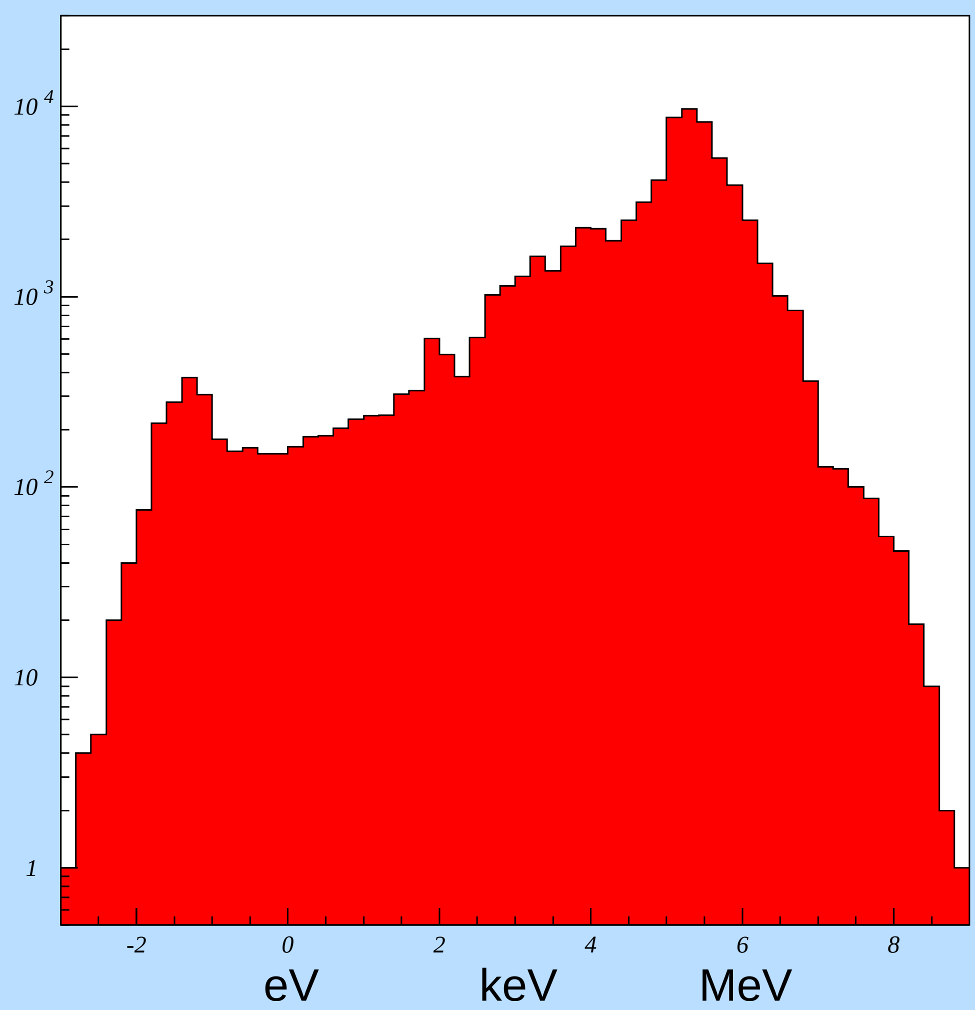
- Particles created inside the TPC per BX

	TDR layout	Stahl layout
Electrons	3700 ± 400	2550 ± 350
Protons	150 ± 10	12 ± 2

Results – Neutron Origins and Energies



Origins of neutrons reaching the TPC (Stahl)



Energies of neutrons when entering the TPC

TPC Simulations – Final Goals

Tasks to accomplish

- estimate all background tracks and the occupancy at a given time (with superposition of 160 BX)
- create a "background library" with ready-to-use events (e. g. similar to the "minimum bias events" of CMS)

Questions to answer

- how much background will the TPC be able to handle? (before its performance decreases significantly)
- which design decisions affect the TPC, and how?
- will a TPC be feasible as a main tracker at the ILC?

Further Activities

Current / ongoing

- simulation of the TPC cosmic trigger with Geant 4
- support for Mokka users: local MySQL databases
- laboratory exercises: nonlinear dynamics and chaos
- graphics for everybody (logos, detector views, . . .)

Planned / suggested

- redesign of the FLC TPC web site
- participation in building the large EUDET prototype? (some experience from the Aachen TPC)