Background Simulations for the International Linear Collider

Looking a Few Years Down the Road

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The International Linear Collider

Will be the next large-scale project in High-Energy Physics

- superconducting linear accelerator up to $\sqrt{s} = 1\,\text{TeV}$
- e^+e^- collisions (point-like particles)
- high luminosity, possibility of polarised beams

Will be a high-precision tool, complementary to the LHC

- well-defined initial state
- clean environment, low backgrounds
- sensitivity to quantum corrections (up to multi-TeV)

Will thoroughly examine the Higgs and SUSY (if they exist) and perhaps some “totally unexpected” new physics

The Large Detector Concept

The ILC needs a detector with maximum performance

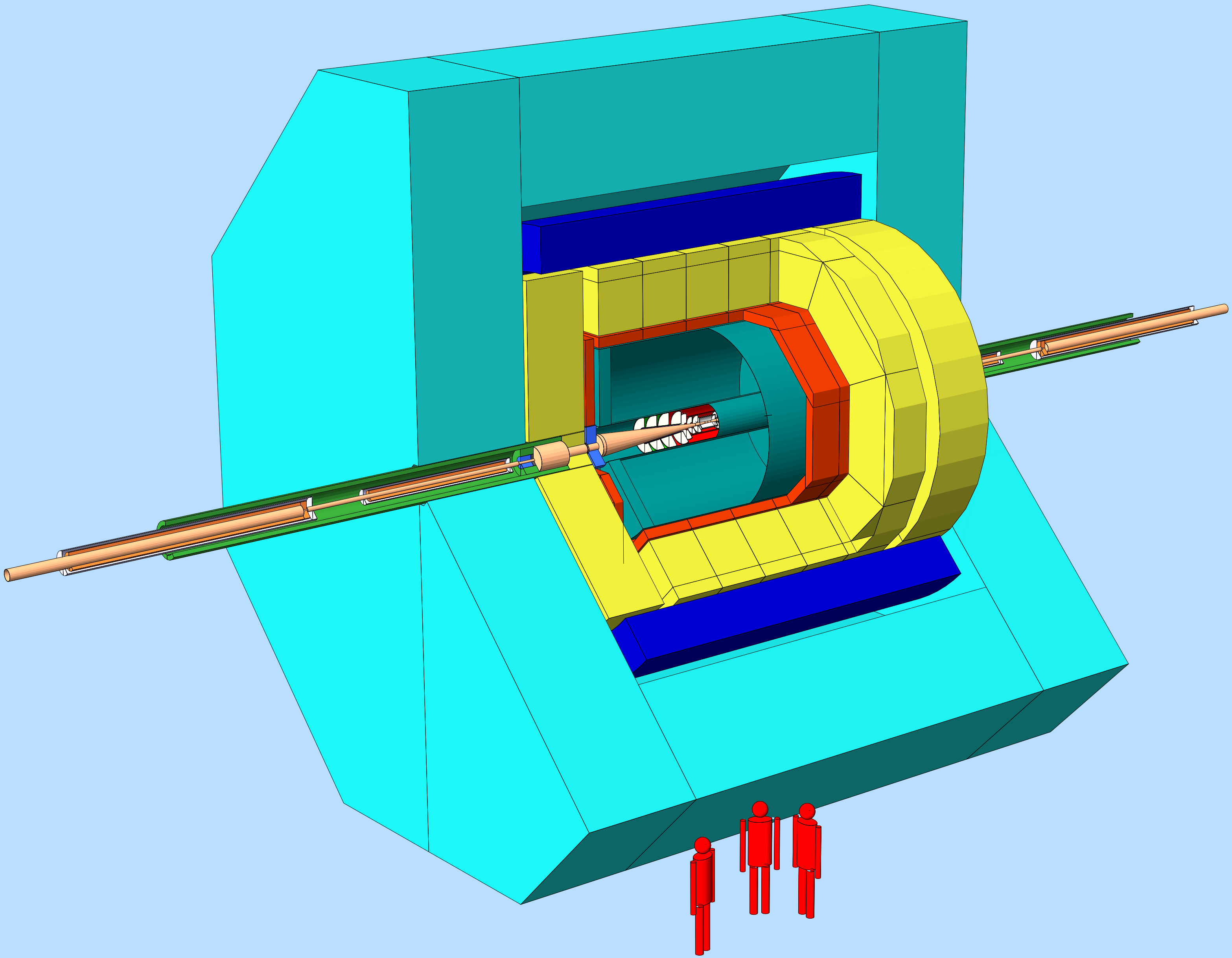
- reconstruction of individual particles (also in jets)
- excellent momentum resolution ($\leftarrow$ tracker)
- excellent vertex reconstruction ($\leftarrow$ vertex detector)

The LDC is one of currently four detector concepts

- silicon pixels around the interaction point
- main gaseous tracker (Time Projection Chamber)
- highly granular calorimeters (also the HCAL)
- solenoidal magnetic field of 4 Tesla

"Particle Flow" reconstruction is the most promising idea

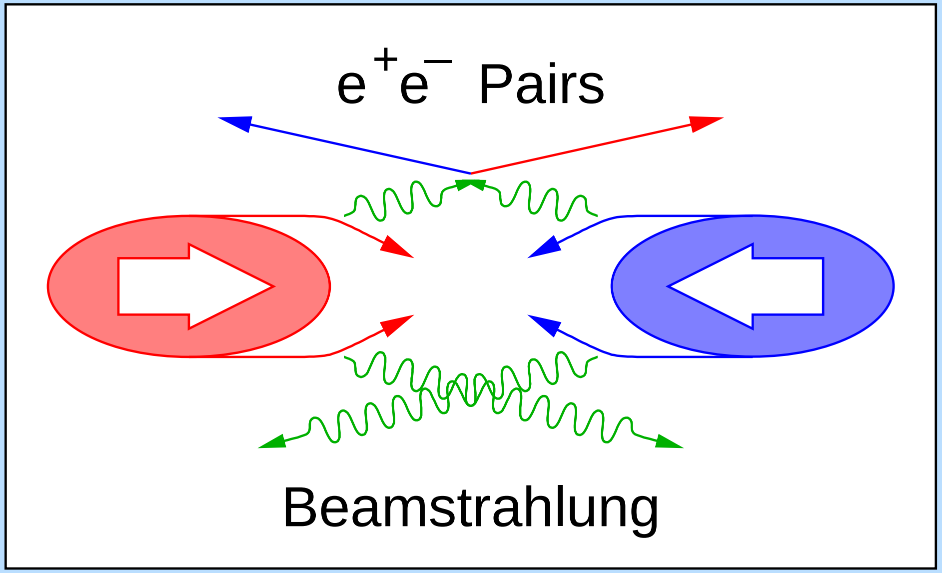
The Large Detector Concept – View



Beamstrahlung at the ILC

The ILC has the novel problem of beamstrahlung

- high luminosity is essential for measurements
- beams have to be focussed to an extremely small spot at the IP (σ_x = 500 nm, σ_y = 5 nm, this is $\left(\frac{1}{1000}\right)^2$ LEP)
- bunches have a very high electric space charge
- particles in the oncoming bunch are deflected and can emit photons (beam-beam interaction)
- photons may scatter and create e^+e^- pairs



Pairs from the Beamstrahlung

e^+e^- pairs are a main source of background (10^5 / BX)

- energies up to several GeV (100 TeV / BX in total)
- strongly focussed in the forward direction (small θ)

Particles hit different parts of the detector

- direct hits on the vertex detector (only if θ is large)
- lots of hits on the "BeamCal" forward calorimeter
- magnets and other parts of the extraction line

Backscattering from particle showers

- indirect hits on the vertex detector
- photons and neutrons can reach the TPC

Simulation Tools

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

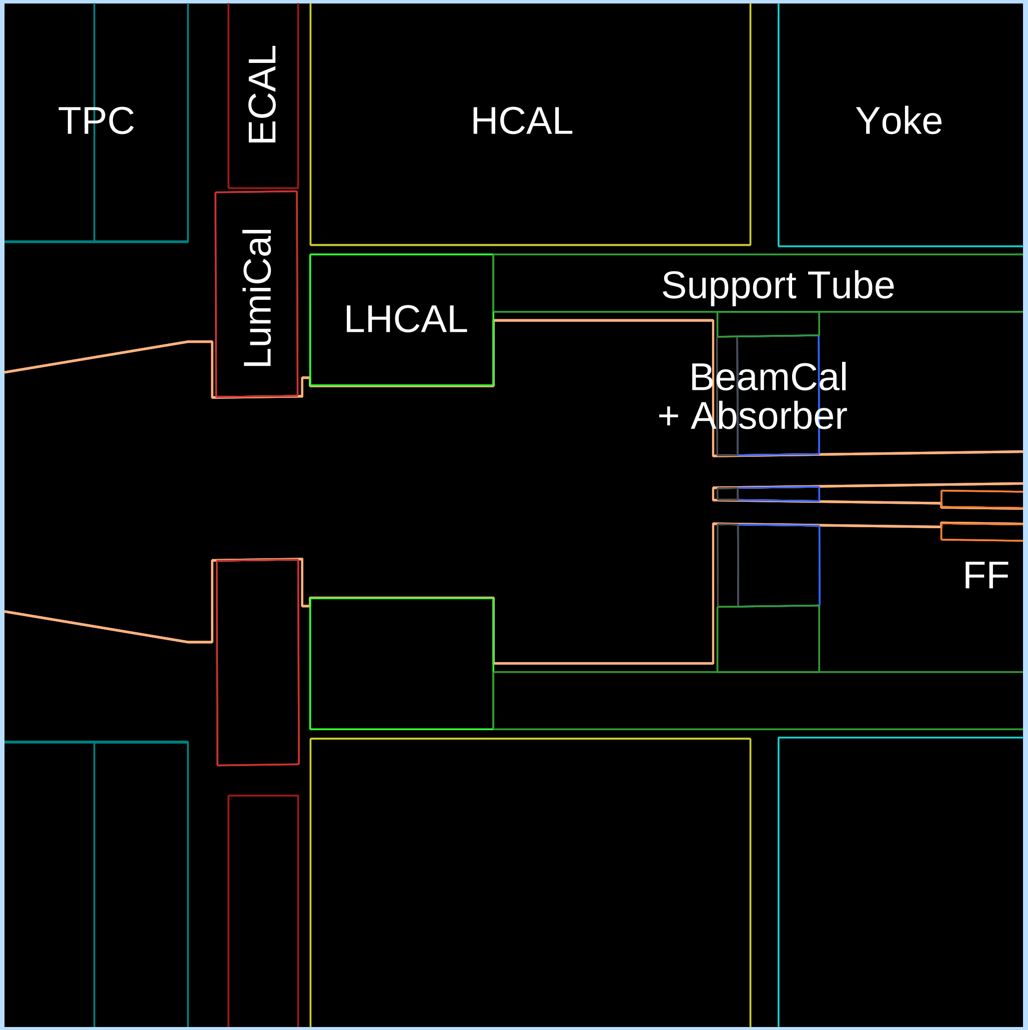
- simulates the beam-beam interaction
- used with different ILC beam parameter sets

Mokka (full detector simulation)

- based on the Geant4 framework
- simulates interaction of particles with matter
- contains the latest LDC detector models
- reads pairs from Guinea-Pig as input
- writes out hits in the different subdetectors

Geometry – Forward Region

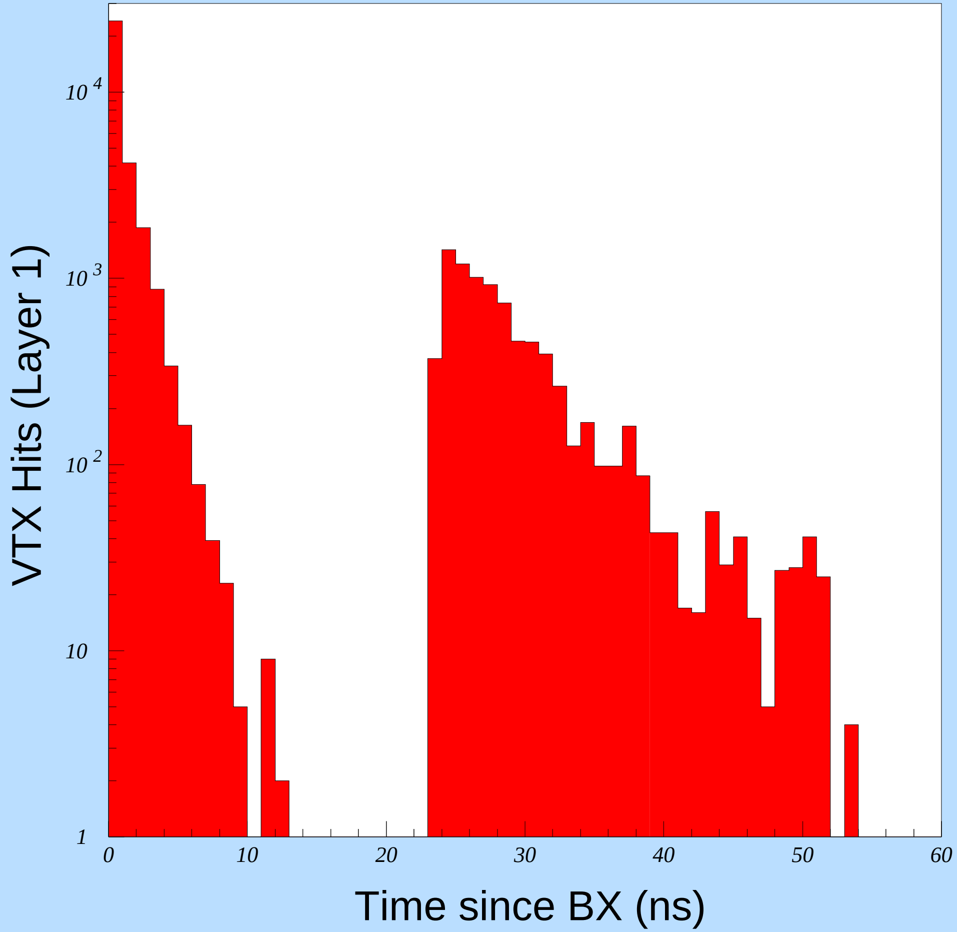
- LumiCal (red)
  $R_{\mathrm{i}} = 120\,\mathrm{mm}$
- Low-Z absorber
- BeamCal (blue)
  $R_{\mathrm{i}\,1} = 15\,\mathrm{mm}$
  $R_{\mathrm{i}\,2} = 20\,\mathrm{mm}$
- Centered on the downstream axis
- Crossing angle of 14 mrad
- Anti-DID field



Compressed view 1:2

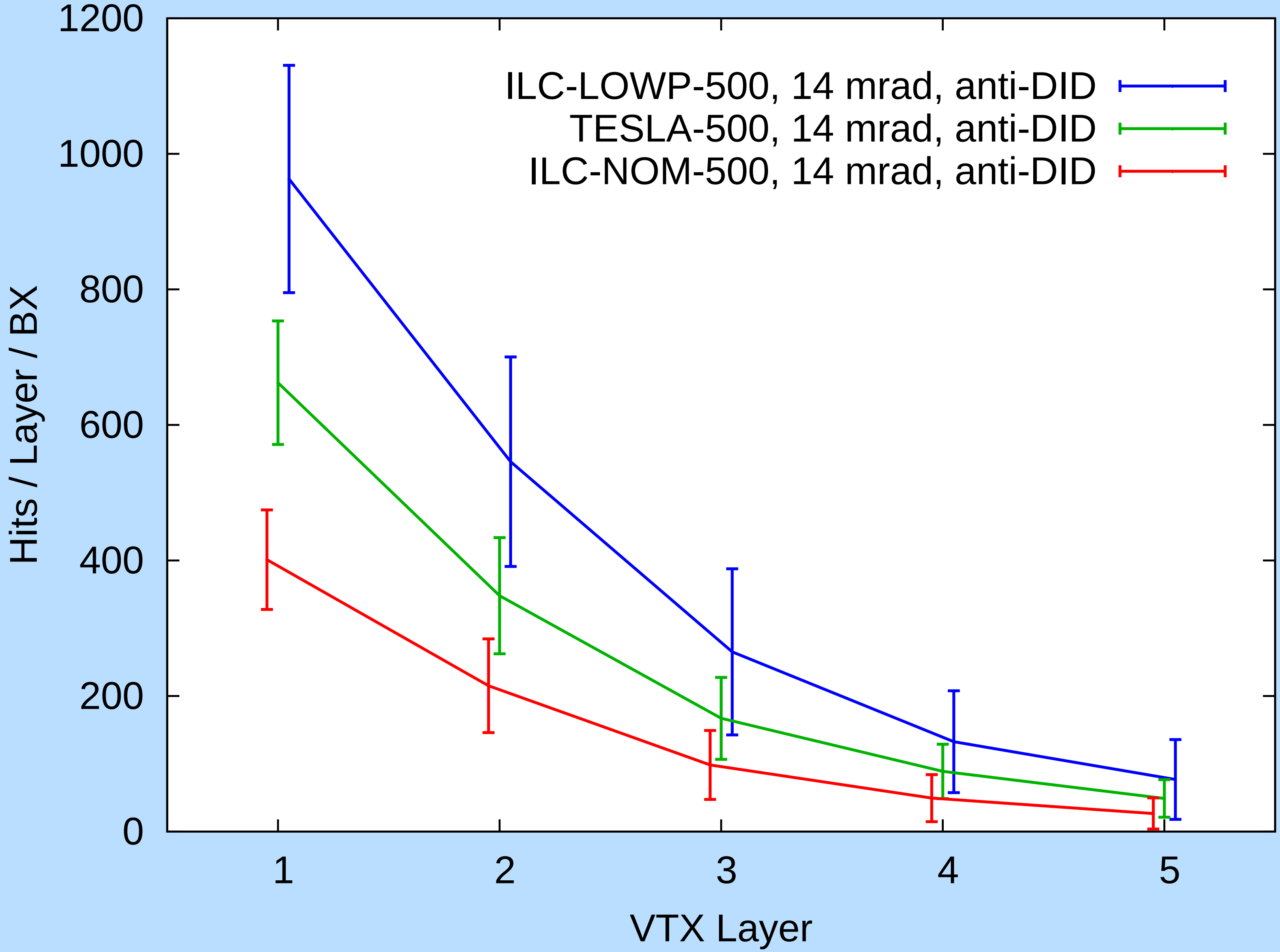
VTX Hits – Time Structure

- Clear separation between direct hits and backscattered particles
- $t \approx 23\,\text{ns}$ corresponds to a distance of 7.0 m (3.5 m in each direction)
- Most backscatterers come from the BeamCal



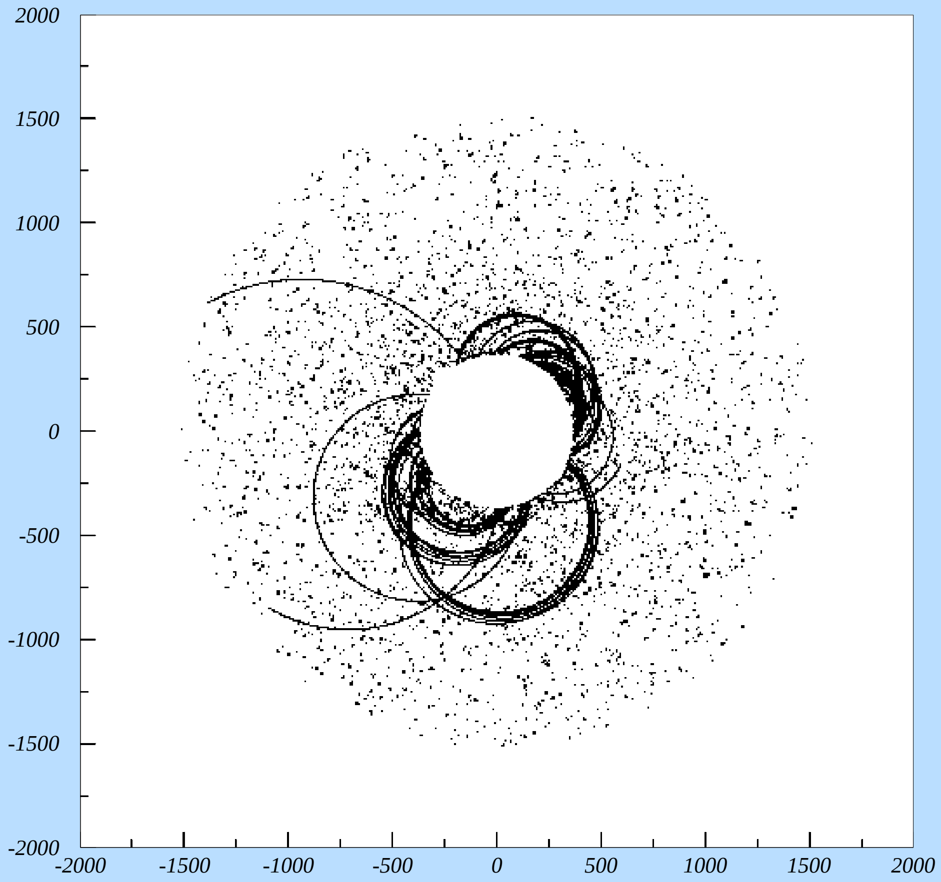
Note the log scale:
Most hits are direct

VTX Hits – Beam Parameters

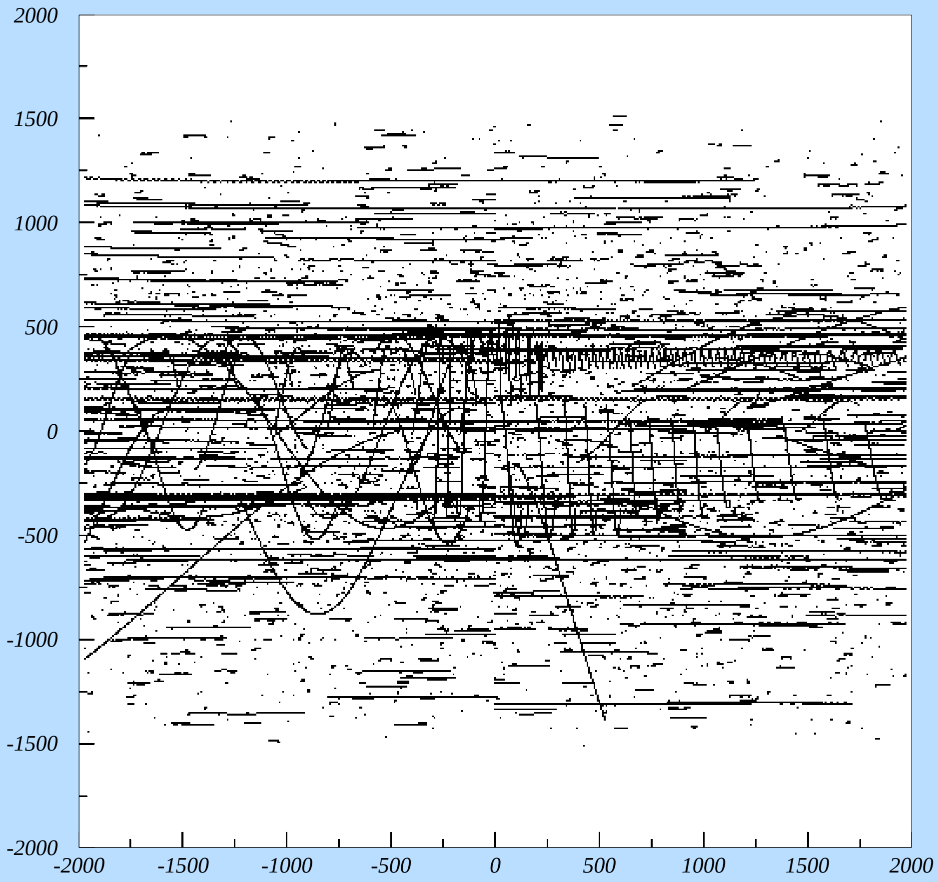


TPC Hits – “Salt and Pepper”

Mokka hits in the TPC (overlay of 100 BX)



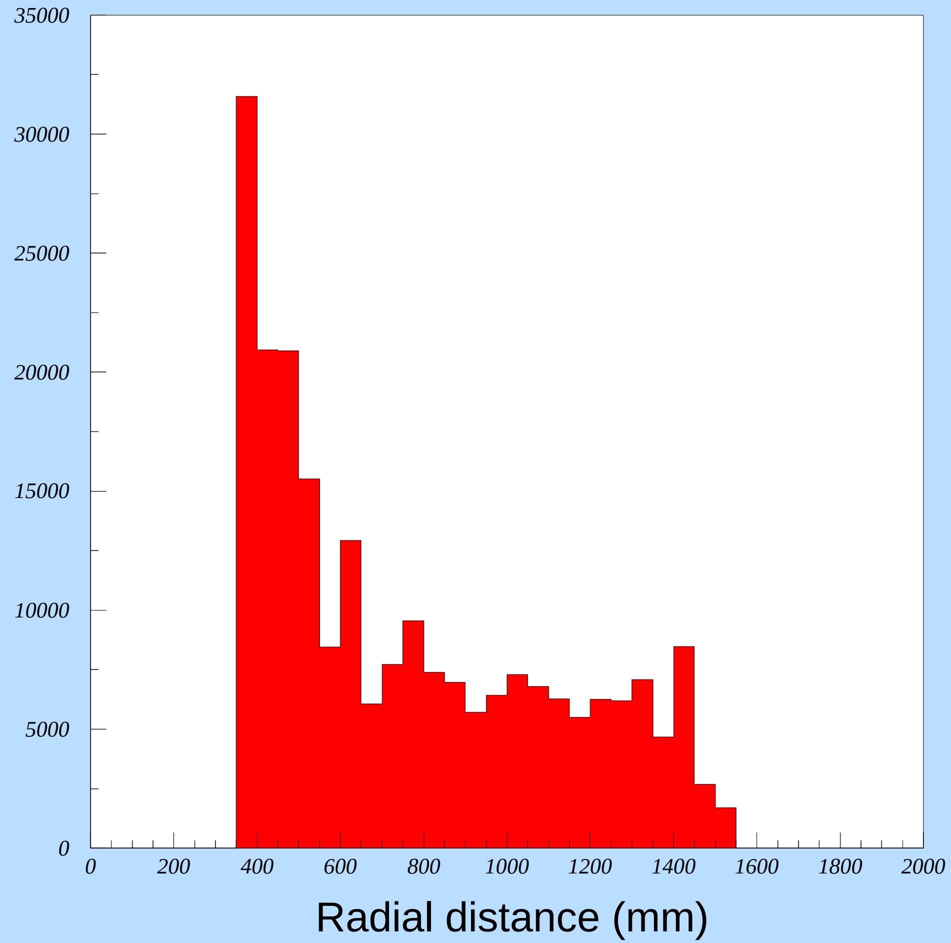
Front view



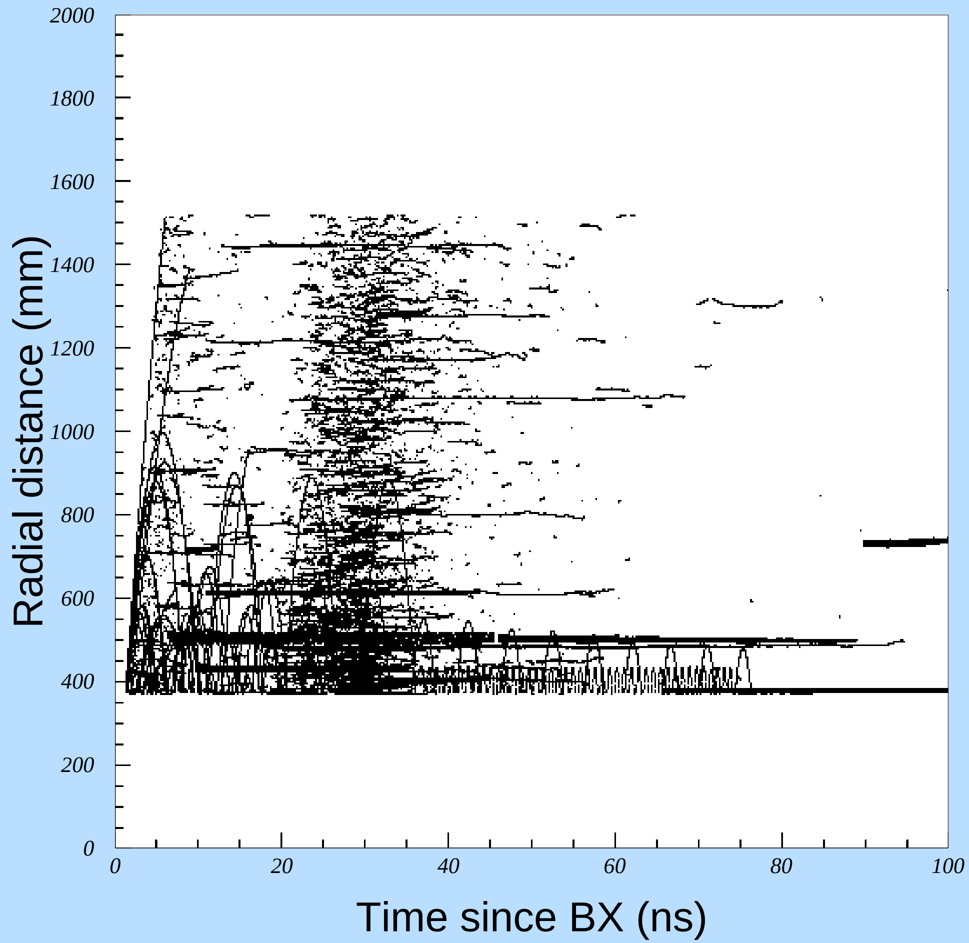
Side view

TPC Hits – Distributions

Mokka hits in the TPC (overlay of 100 BX)



Radial distribution



Time structure

Summary and Outlook

e^+e^- pairs are a main source of background at the ILC

- quantity and energies depend on the beam parameters
- careful design of the forward region is important!

The vertex detector is most sensitive to the pairs

- background occupancy drives the VTX design
- suppression of backscattering is the key

Impact on the TPC seems manageable

- occupancy should be no problem for reconstruction
- will the background (with pile-up from 160 BX) finally affect pattern recognition, efficiencies, resolutions?