# The SiLC simulation task force

*past, present, future*

M.Vos, IFIC Valencia, for the SiLC collaboration
special thanks to V. Saveliev

# What's SiLC?

**Si**licon for the **L**inear **C**ollider

SiLC is **NOT** a detector concept. SiLC members are from three continents, and are involved in LDC, SiD and GLD.

SiLC is an R&D collaboration that aims to develop Silicon detector technology for tracking in the international linear collider experiments. Core activities include Front End chip design, sensor and mechanics studies.

R&D must be guided by simulation. Hence, the simulation task force.

# http://silc.in2p3.fr/

# Manpower and contact details

National Centre for Micro-electronics, IMB-CNM, Barcelona (Spain)
Giulio Pellegrini ( giulio.pellegrini@cnm.es )

Obninsk State University (Russia)
Valeri Saveliev ( saveliev@mail.desy.de )

LPNHE, Paris, France
Mikael Berggren ( Mikael.Berggren@cern.ch )
Wilfrid Da Silva ( dasilva@in2p3.fr )
Frederic Kapusta ( kapusta@in2p3.fr )

IPNP Charles University, Prague, Czech Republic
Zbynek Drasal ( drasal@ipnp.troja.mff.cuni.cz )
Peter Kodys ( kodys@ipnp.troja.mff.cuni.cz )

UCSC – SCIPP, Santa Cruz, USA
Bruce Schumm ( schumm@scipp.ucsc.edu )

HEPHY, Vienna, Austria
Winfried Mitaroff ( mitaroff@hephy.oeaw.ac.at )
Meinhard Regler ( regler@hephy.oeaw.ac.at )
Manfred Valentan ( valentan@hephy.oeaw.ac.at )

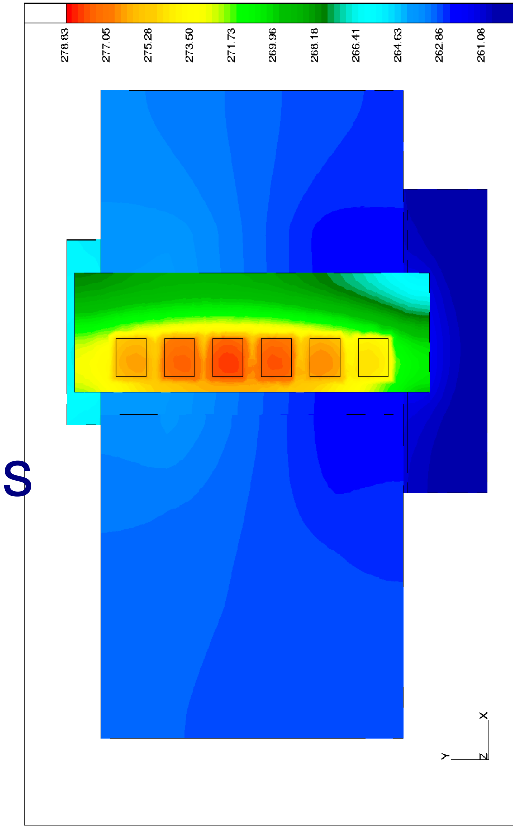
IFIC Valencia, Spain
Angeles Faus ( Angeles.Faus@ific.uv.es )
Carmen Alabau ( Carmen.Alabau@ific.uv.es )
Carlos Mariñas ( carlos.marinas.pardo@cern.ch )
Marcel Vos ( marcel.vos@ific.uv.es )

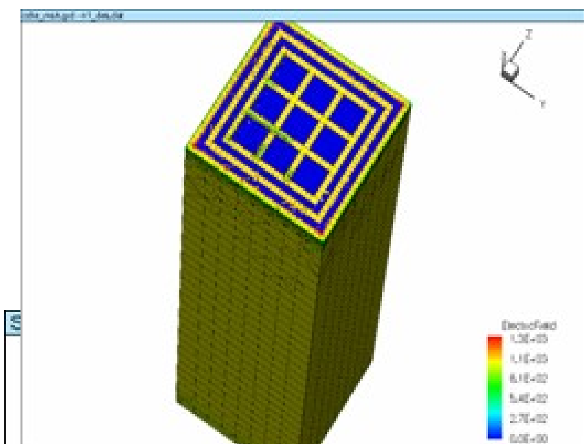
# Microscopic detector simulation

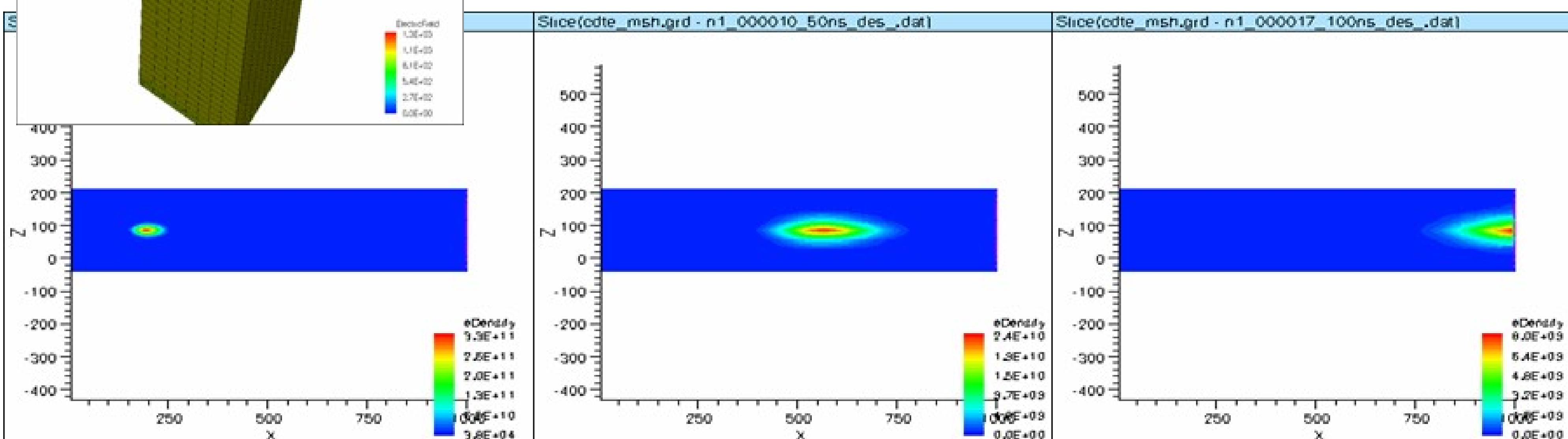
Semi-conductor simulation,

Front-end electronics,

Mechanical/thermal (Finite Element) simulations



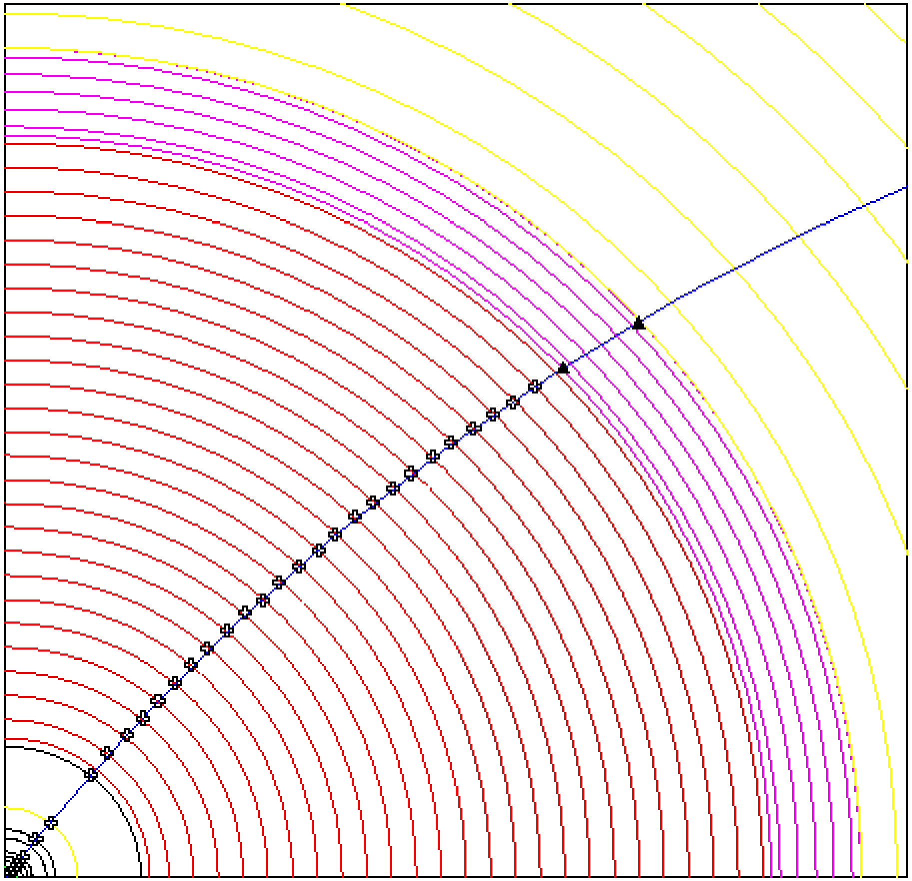




# SiLC assets: SGV

**Simulation a grande vitesse, M. Berggren, LPHNE, Paris**

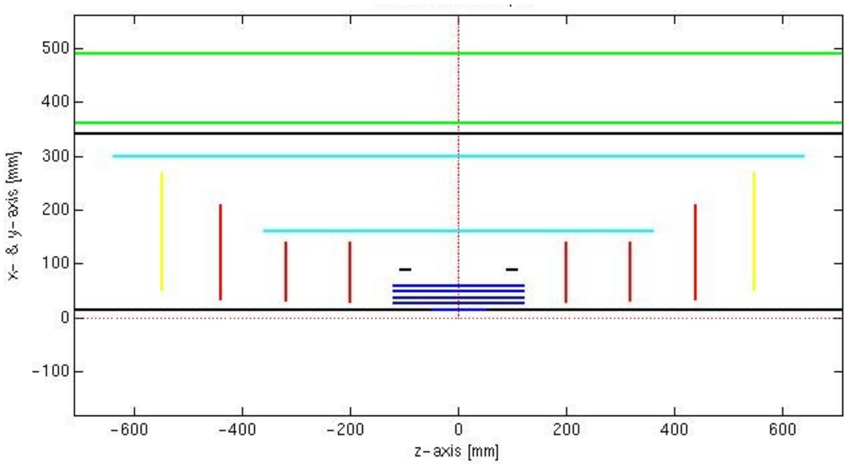
Analytical calculation of track parameter resolution from geometry  LCIO output module (B. Jefferey, Oxford) allows to compare full and fast simulation outcome on the same footing. The program has a long history, and has been thoroughly validated against a running experiment (DELPHI).



# SiLC assets: LiCToy

**LiCToy, M. Regler, M. Valentan, R. Fruehwirth,**

**HEPHY, Vienna**




Fast simulation tool for detector design.

Position measurements are simulated at the intersections of an ideal helix trajectory and a simplified geometry.

Sophisticated Kalman filter track fit, including material effects, yields the parameter covariance matrix.

Validation against experiment and other simulators ongoing.

See presentation by M. Regler, W. Mitaroff in this session.

http://wwwhephy.oeaw.ac.at/p3w/ilc/talks/06_SiLC_Barcel/MK_LiCToy.ppt

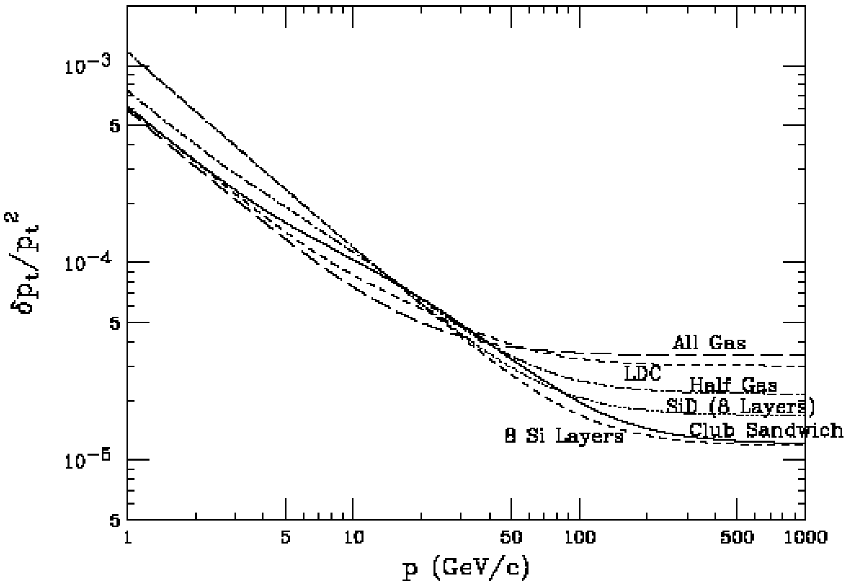
http://wwwhephy.oeaw.ac.at/p3w/ilc/reports/LiC_Det_Toy/UserGuide.pdf

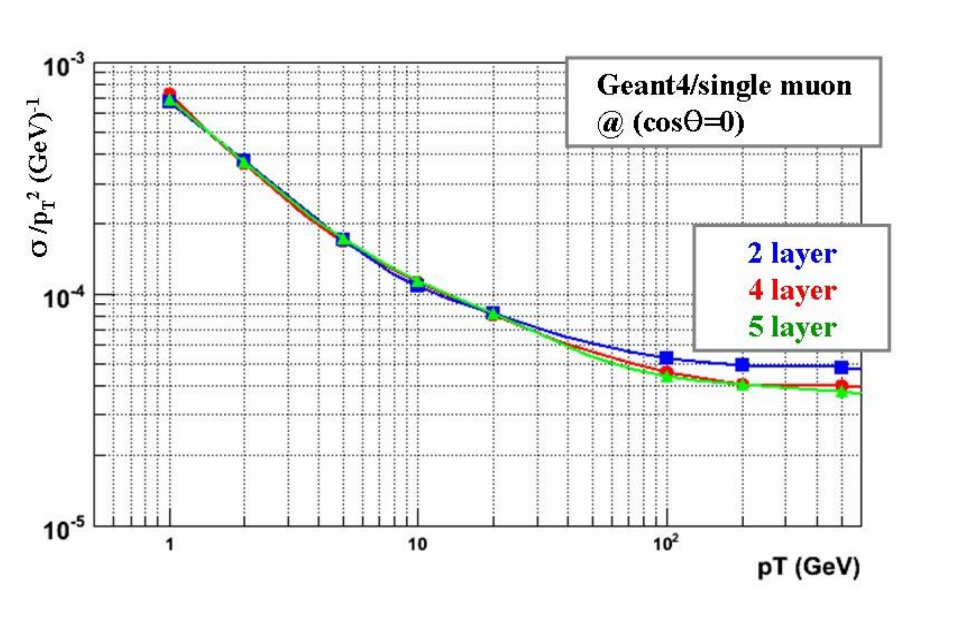
# SiLC assets: LCDTRK

**LCDTRK (Bruce Schumm, SCIPP): analytical determination of momentum resolution for a given layout, space point resolution, material burden**

http://ww.slac.stanford.edu/~schumm/lcdtrk20011204.tar.gz

excellent example: hep-phys-0511038




**GLD fast simulation (Korea): Kalman filter fit of space points from fast simulation**

# SiLC assets: fast simulation

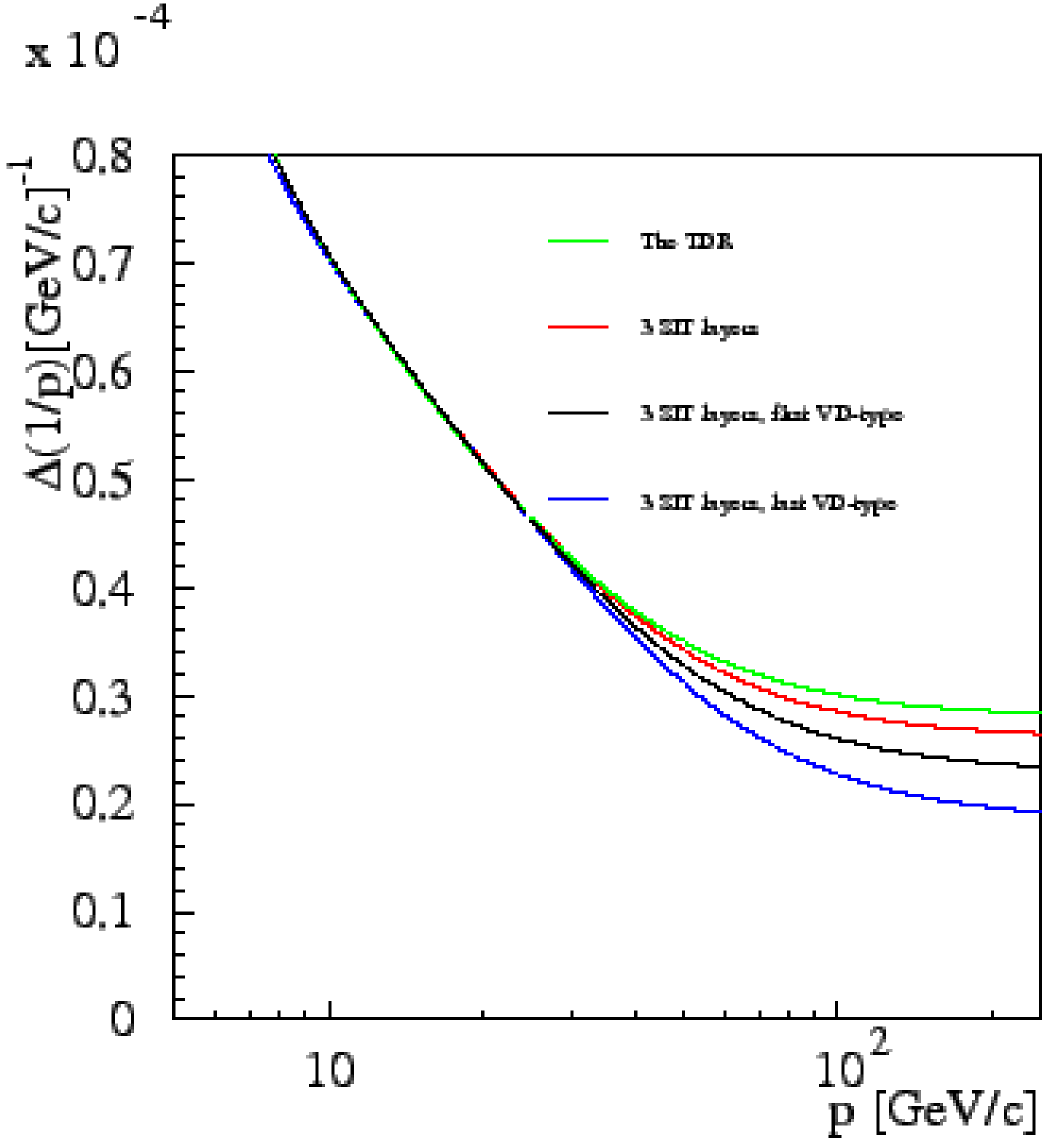
Fast simulation provides important feed-back to layout optimization:

SGV simulation (M. Berggren) of the LDC tracker central region

Momentum resolution for 4 different SIT scenarios.

2-3 layers -> marginal differnce

improved space point resolution yields substantial gain (especially for outer SIT layer)

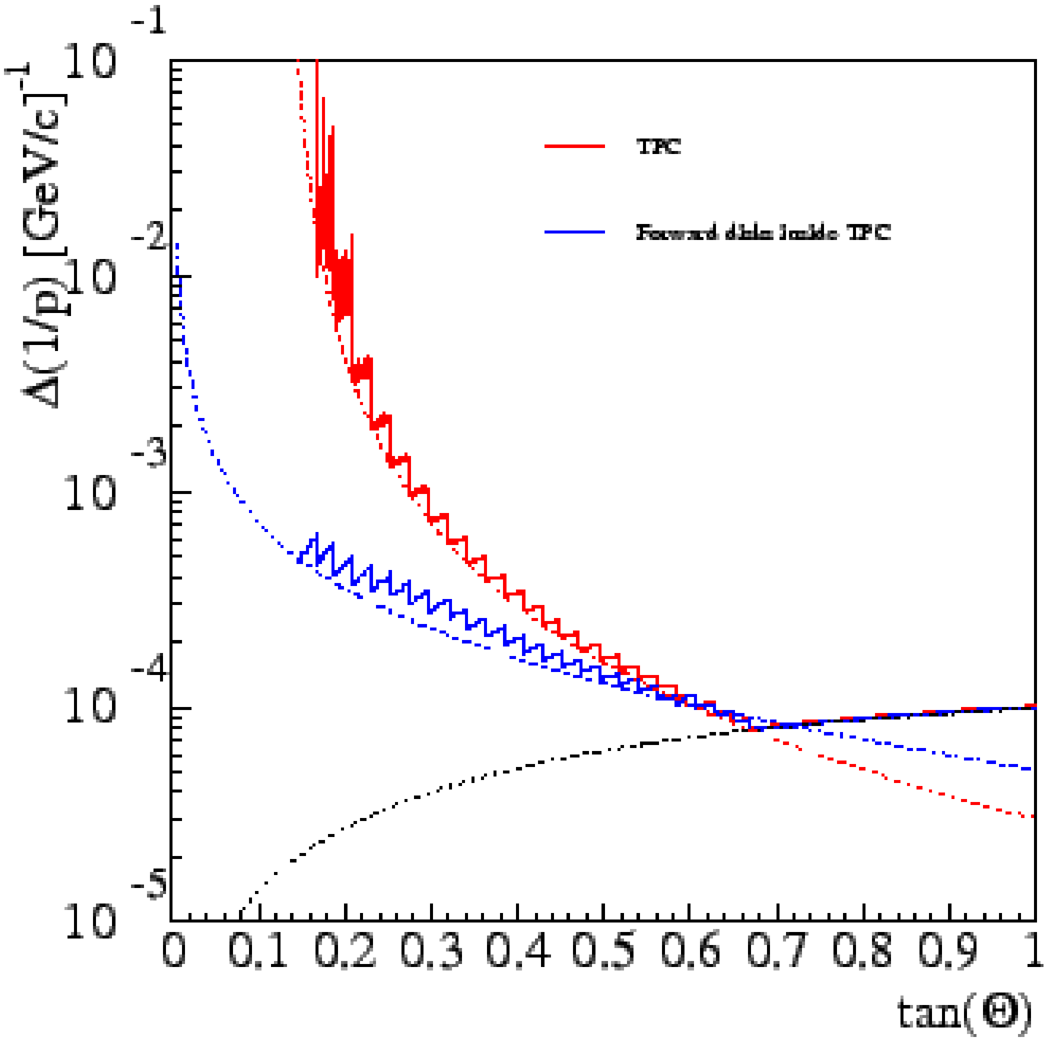


# SiLC assets: fast simulation

SGV simulation (M. Berggren) of the LDC tracker central region

Impact of silicon (FTD) disks on momentum resolution on forward tracking.

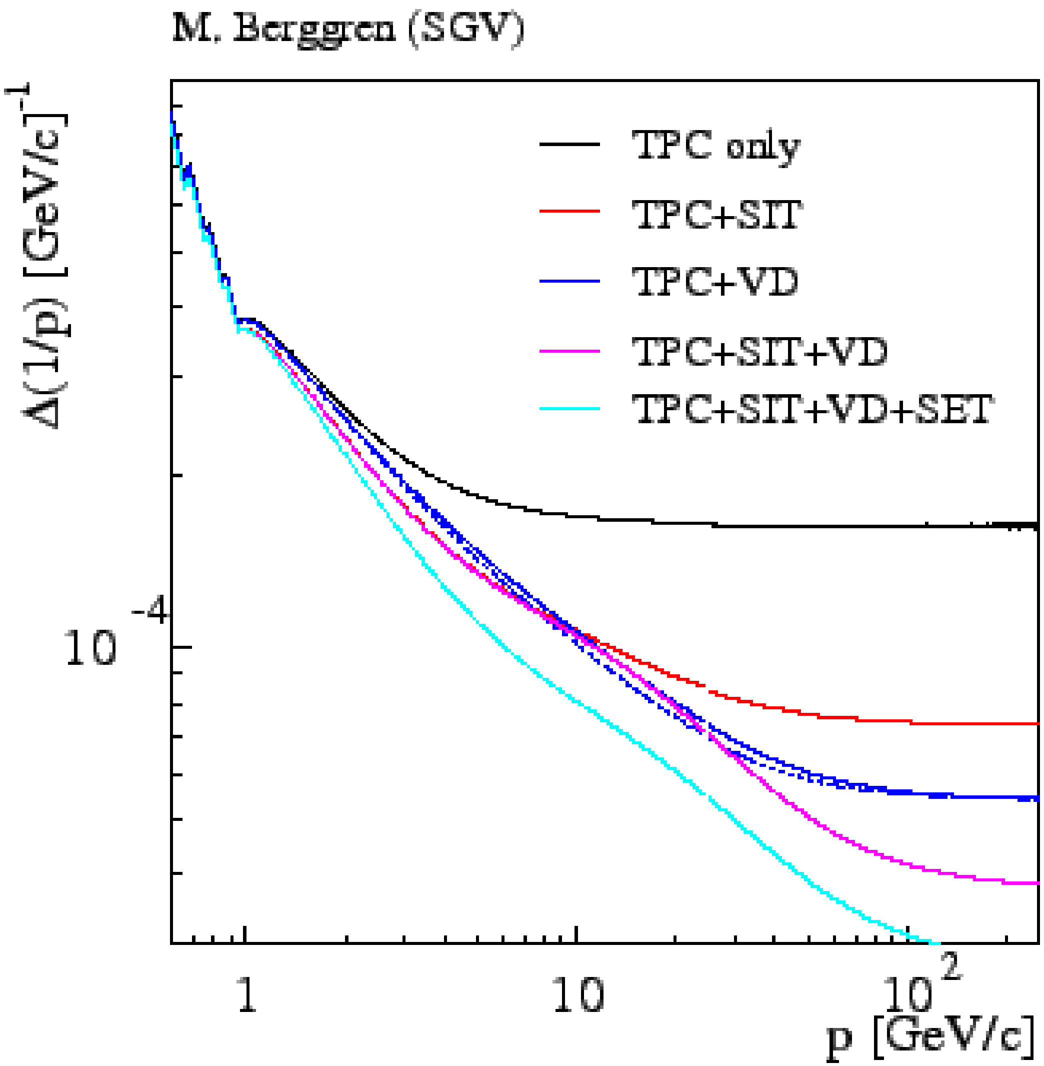
To maintain an adequate performance in the forward region, the TPC must be complemented by silicon.



# SiLC assets: fast simulation

SGV simulation (M. Berggren) of the LDC tracker central region

Silicon envelope for the TPC: a precise measurement extending the lever arm improves resolution for large momentum.



## http://silc.in2p3.fr/ Urgent simulation studies

Tracking in mixed gas-silicon concepts. Issues like the need for a silicon envelope should be studied. Especially important is the transition in the forward region between TPC and forward disks.

Machine and physics backgrounds and their impact on tracking in thevery forward and internal barrel regions. Study background levels in different detector, and study pattern recognition in the presence of this background.

Pattern recognition. While the basic interplay between layout, material, single-point resolution and track parameter estimates is understood, the requirements that derive from pattern recognition are much less studied. This study should tell us what granularity we need in the different tracking regions to ensure that pattern recognition converges even for some of the toughest cases: in dense jet topologies and for non-prompt tracks.

Feedback to global layout optimization. Optimize the overall design based on physics requirements.

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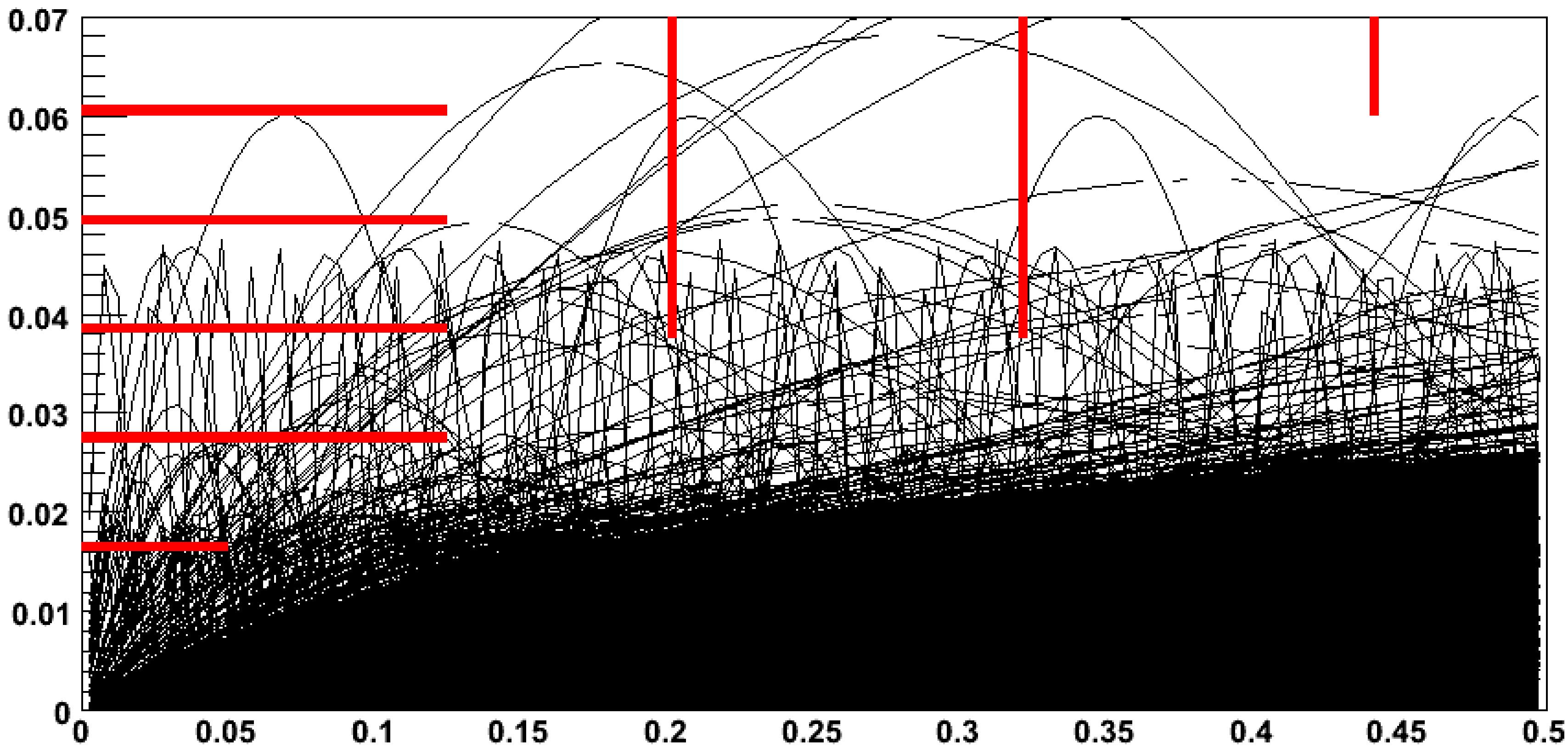
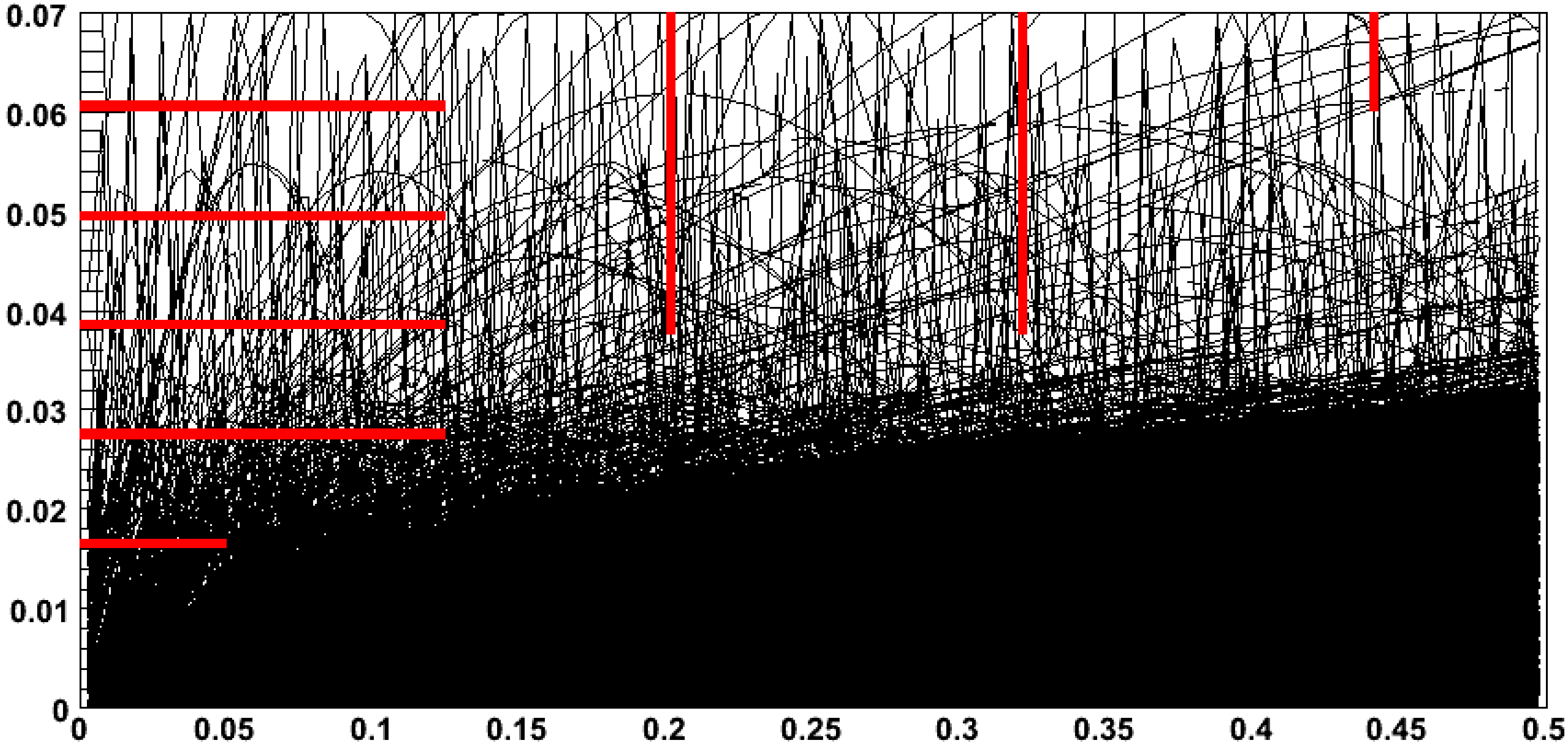
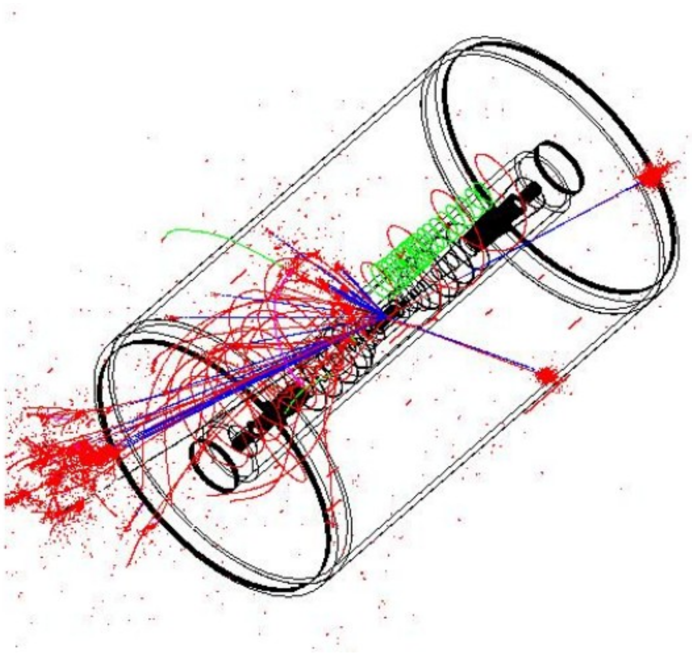
## Fast (simple helix) simulation of pair background: nominal final focus parameters



## Fast (simple helix) simulation of pair background: low-power final focus parameters

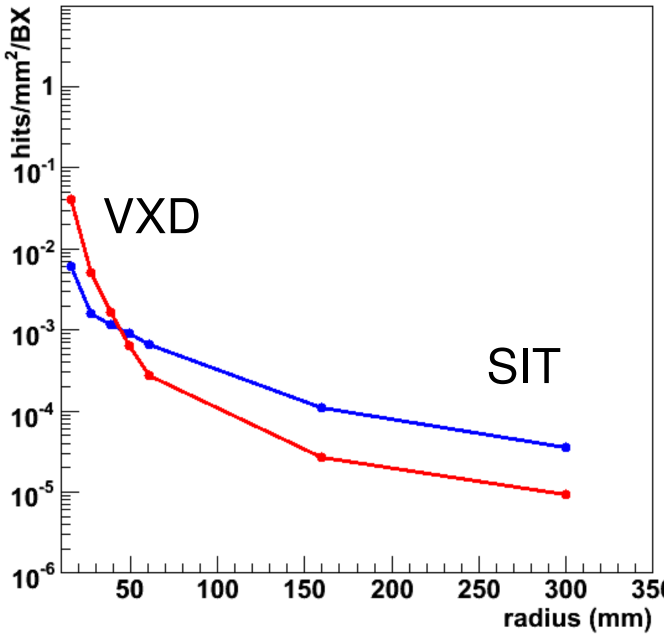


# Occupancy

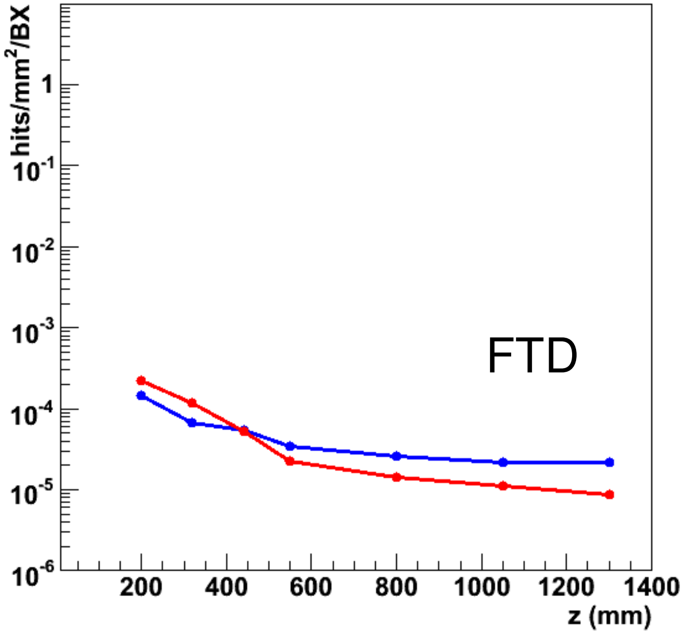


- Dense signal topology (tt events)
- Pair production background due to beamstrahlung, GUINEAPIG simulation by A. Vogel using nominal beam parameters)
- Pair annihilation ($e^+e^-$ -> $\gamma\gamma$ -> charged tracks) in the forward region: missing

Generic occupancy: count number of hits in each layer and normalize to the layer area.





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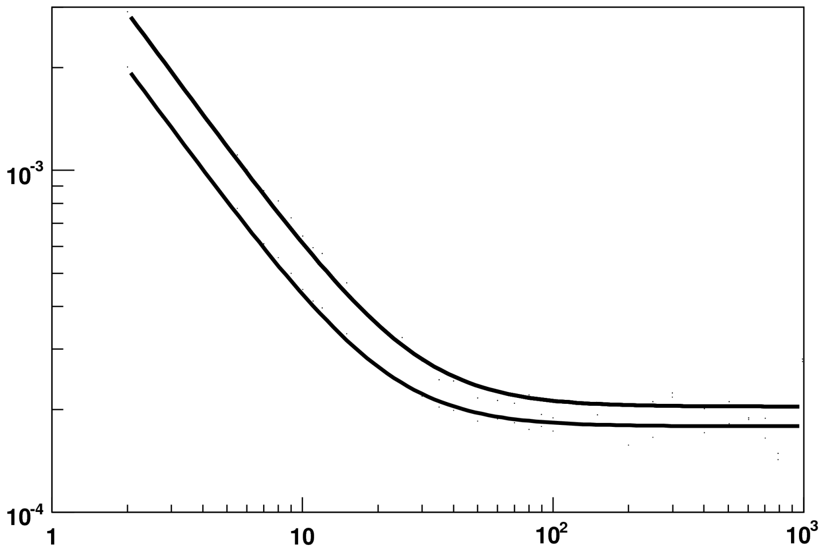
Feedback to global layout optimization. Optimize the overall design based on physics requirements: effect of material budget.

# Material budget for forward tracker

Material: momentum resolution of a toy tracker in a 4 Tesla field:

- 3 VXD barrel layers (1.1 cm R spacing, 1.2 per mil $X_0$, 2 micron resolution in R$\phi$, z)
- 3 pixel tracking disks (12 cm z spacing, 1.2 per mil/1.2 % $X_0$, 5 $\mu$m resolution in R$\phi$, 50 $\mu$m in R)
- 4 DS strip tracking disks (25 cm z spacing, 8 per mil $X_0$, 10 $\mu$m resolution in R$\phi$, 1 $\mu$m in R)




Asymptotic behaviour nearly independent of material: $\sigma(p_T)/p_T^2 = 1.8/2.0 \times 10^{-4}$

Low momentum behaviour:

$\sigma(p_T)/p_T^2 = 4.0 \times 10^{-3}/p_T$ for 0.12 % $X_0$

$= 5.8 \times 10^{-3}/p_T$ for 1.2 % $X_0$ disks

# Material budget for forward tracker

Double-check using an independent tool

**My result**

$\sigma(p_T)/p_T^2 = 1.8 \times 10^{-4} + 4.0 \times 10^{-3}/p_T$ for 0.12 % $X_0$

$= 2.0 \times 10^{-4} + 5.8 \times 10^{-3}/p_T$ for 1.2 % $X_0$ disks

**LiCToy (demonstrator version of Vienna instrumentation conference)**

$\sigma(p_T)/p_T^2 = 1.8 \times 10^{-4} + 4.3 \times 10^{-3}/p_T$ for 0.12 % $X_0$

$= 1.9 \times 10^{-4} + 6.2 \times 10^{-3}/p_T$ for 1.2 % $X_0$

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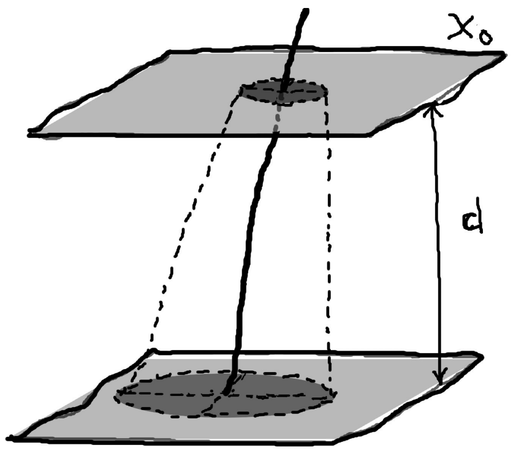
# Pattern recognition

Studies into pattern recognition requirements are ongoing. The aim is to establish a requirement for the granularity of the innermost tracker layers. Currently, the best we can do is estimate for a given layer:

- Search windows for track stub extrapolation
- Occupancy
- Contamination




In the near future this should be extended to “full” reconstruction of signal topologies in the presence of realistic background. This is the driver for our infrastructure requirements.

## http://silc.in2p3.fr/ Urgent infrastructure development

Implementation of detailed models of SiLC detectors in GEANT4 simulation packages. A good basis exists: the LDC geometry has been implemented in Mokka, SiD in Mokka and SLIC. V. Saveliev is the contact person for this effort.

Digitization. A detailed model that represents all our knowledge about the detailed workings of the detectors is required.

Treatment of backgrounds in full simulation studies. This requires the digitization to be aware of out-of-time events. A mechanism like that used for pile-up events in the LHC should be envisaged.

Track reconstruction sofware. Pattern recognition code + track fitters. This code should be as much as possible be generic for the different detector concepts. This is the central and most challenging issue to be addressed in 2007.

Analysis and benchmarking software. Establish a standard format for basic tracking performance results.

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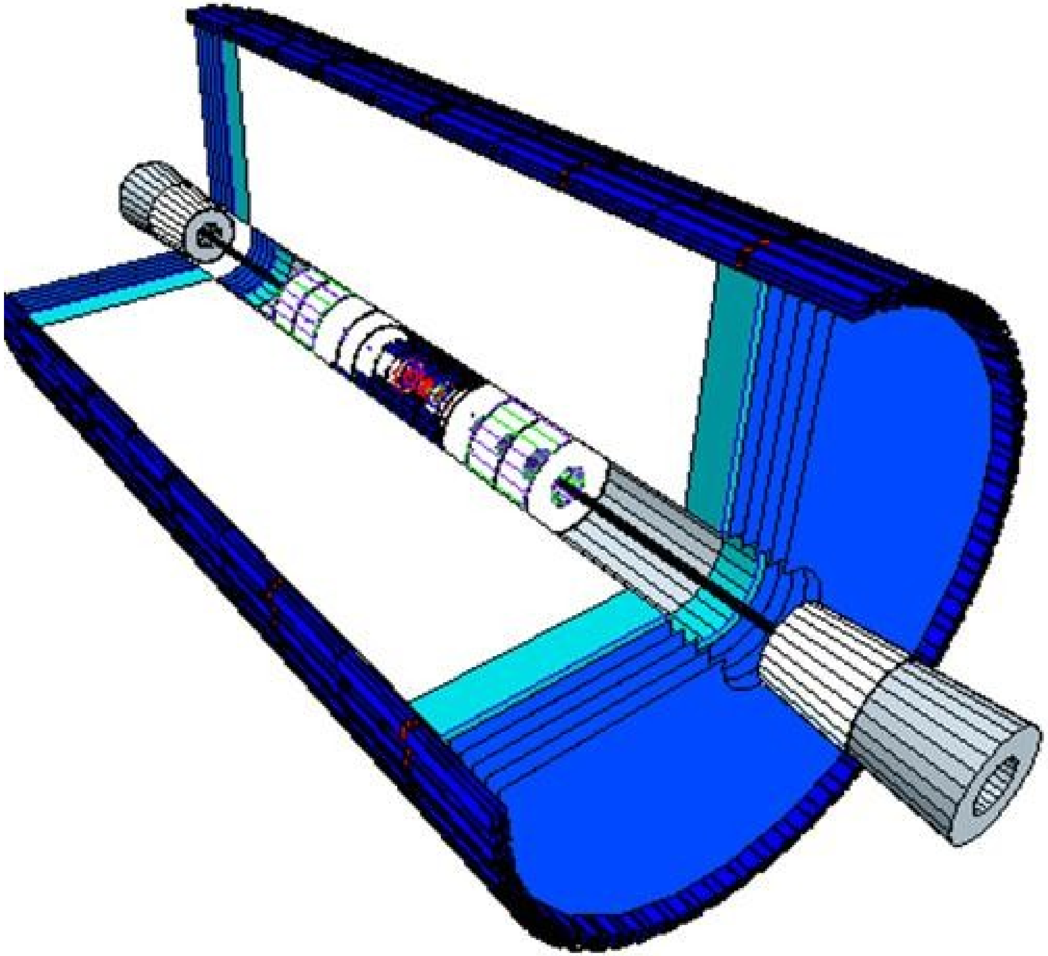
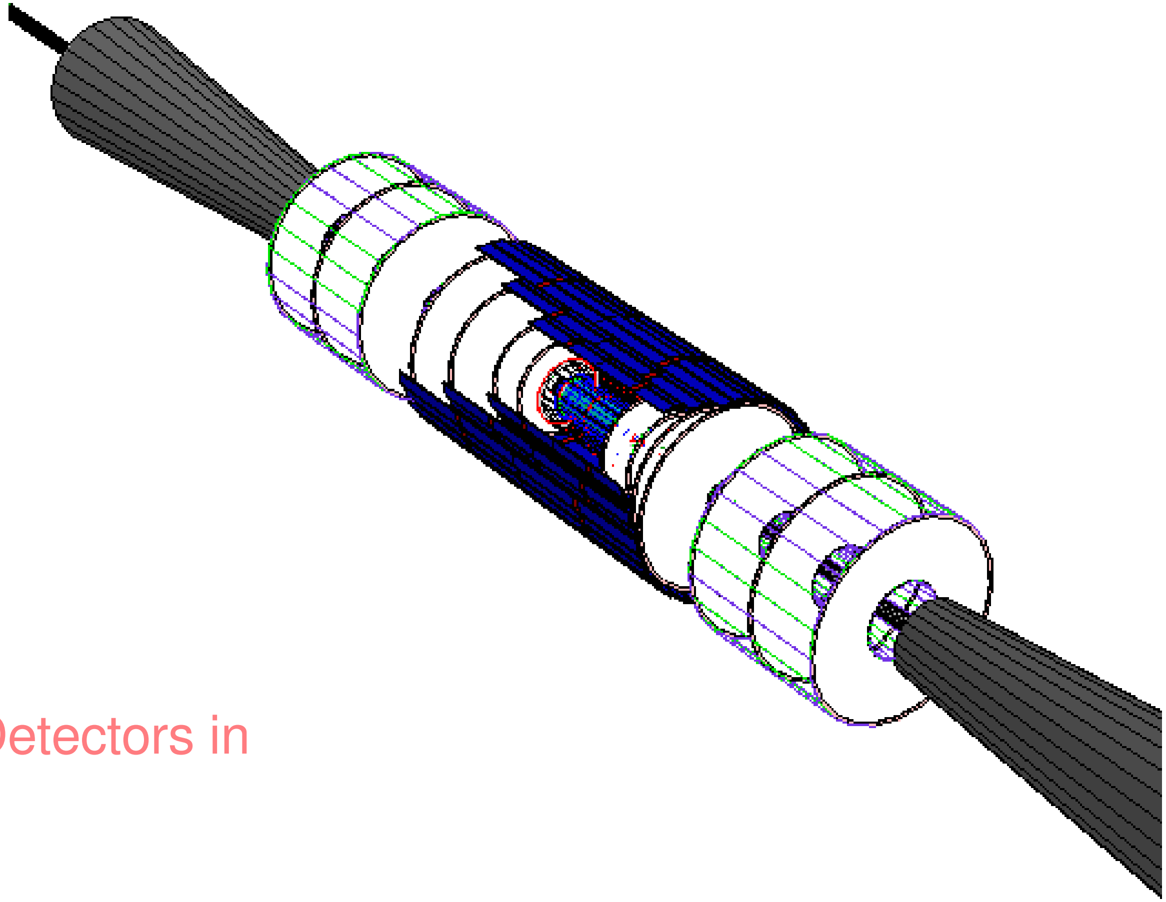
# SILC SILICON TRACKING COMPONENTS OF THE ILC/LDC DETECTOR
(Mokka Geant4 implementation)



View of the SILC Components
Of Silicon Trackers in Mokka
Inner Forward Tracking Discs
Forward Outer Silicon Chamber
Silicon Envelope for TPC

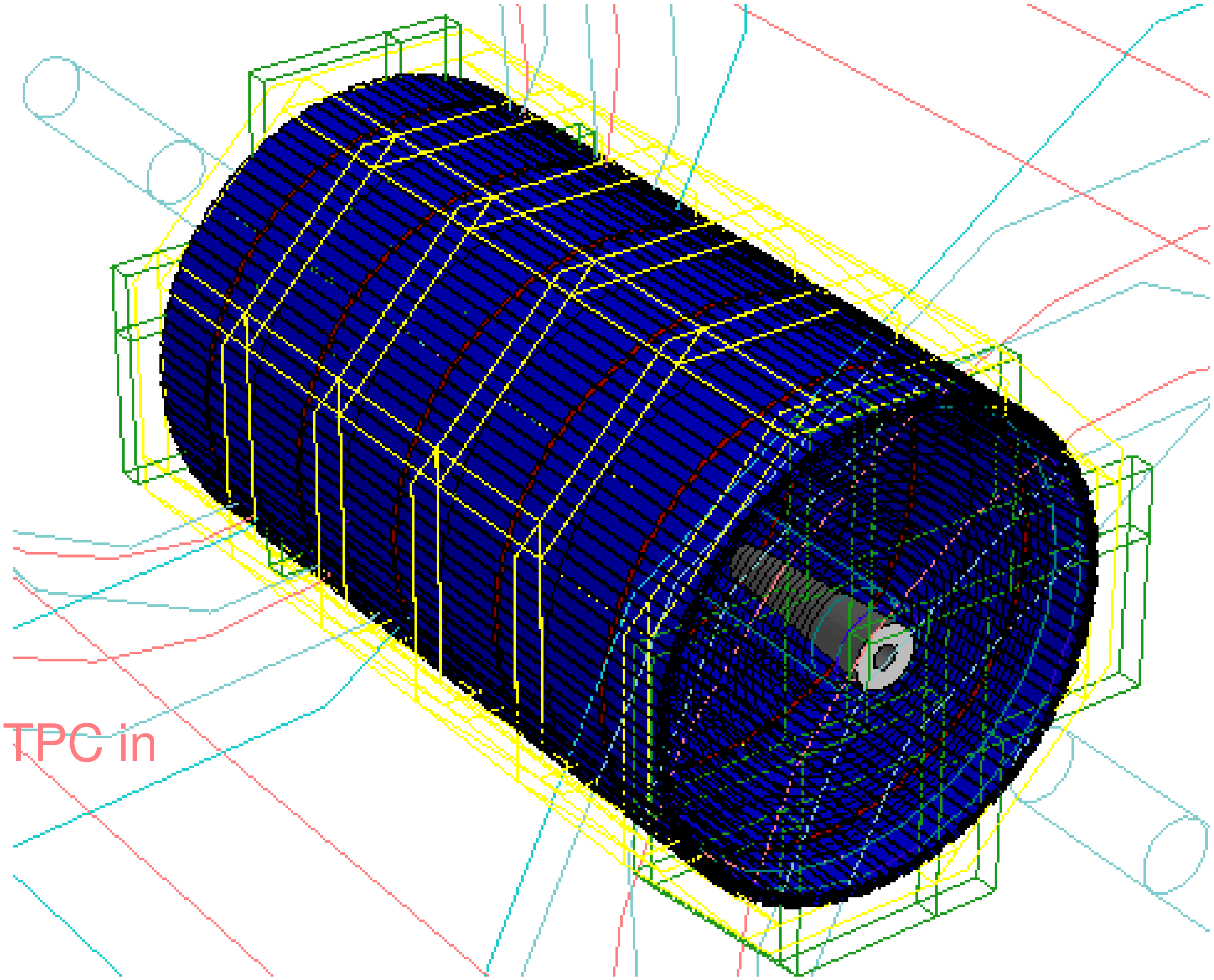
Marcel Vos, ILC-SW, Orsay, May 3rd 2007

# Inner FORWARD Si CHAMBERS OF THE ILC/LDC DETECTOR
## (Mokka Geant4 implementation)



View of the Forward SILC Detectors in Mokka

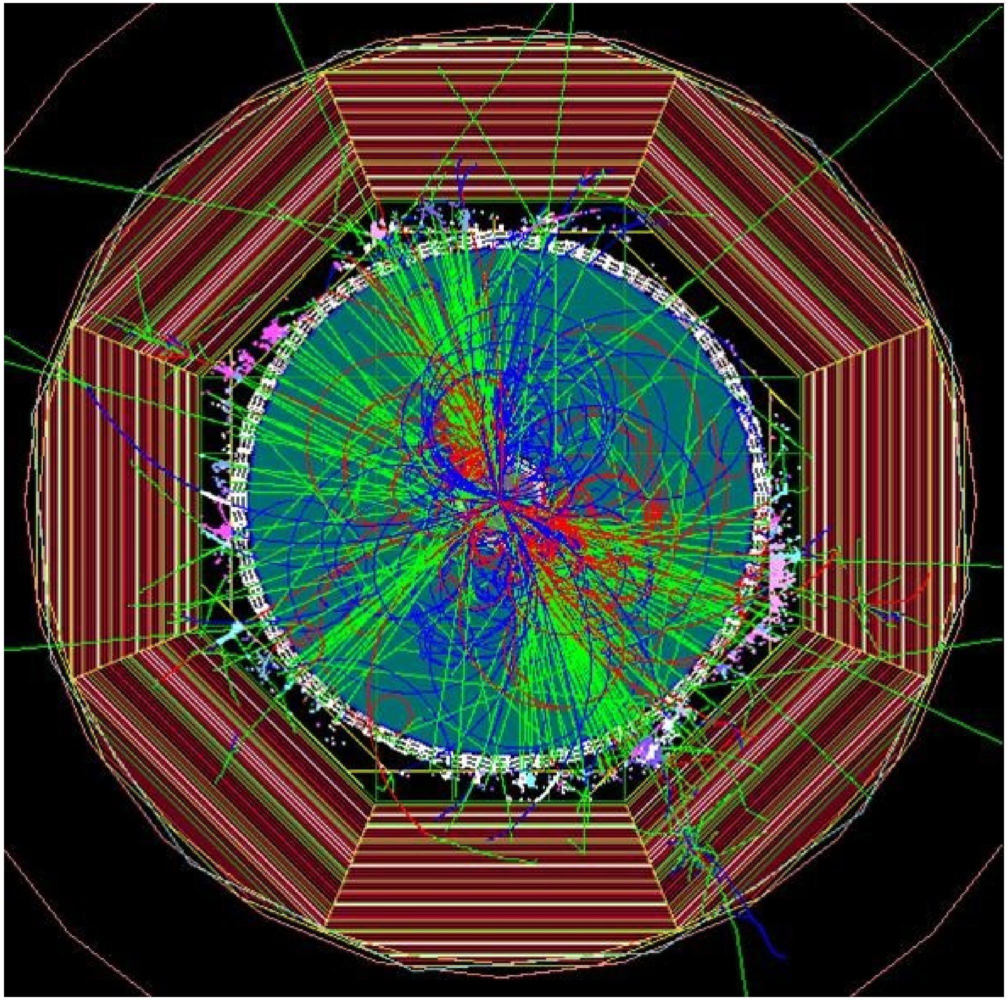
# Si ENVELOPE OF THE ILC/LDC DETECTOR
## (Mokka Geant4 implementation)



View of the Si Envelope of TPC in Mokka

# EVENT SIMULATION with THE ILC/LDC SILC COMPONENTS OF TRACKER (Mokka Geant4 implementation)

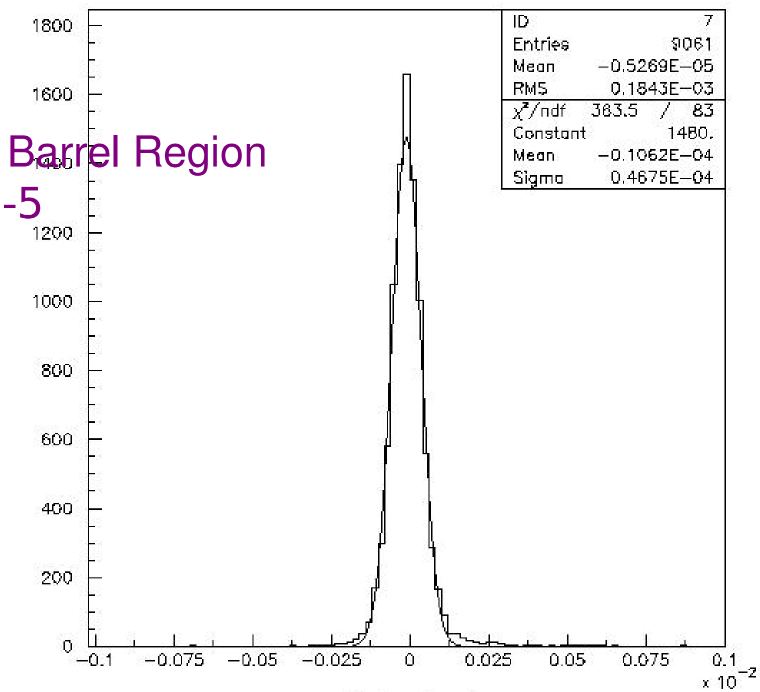
View of the Event in the Mokka (Geant4) Framework



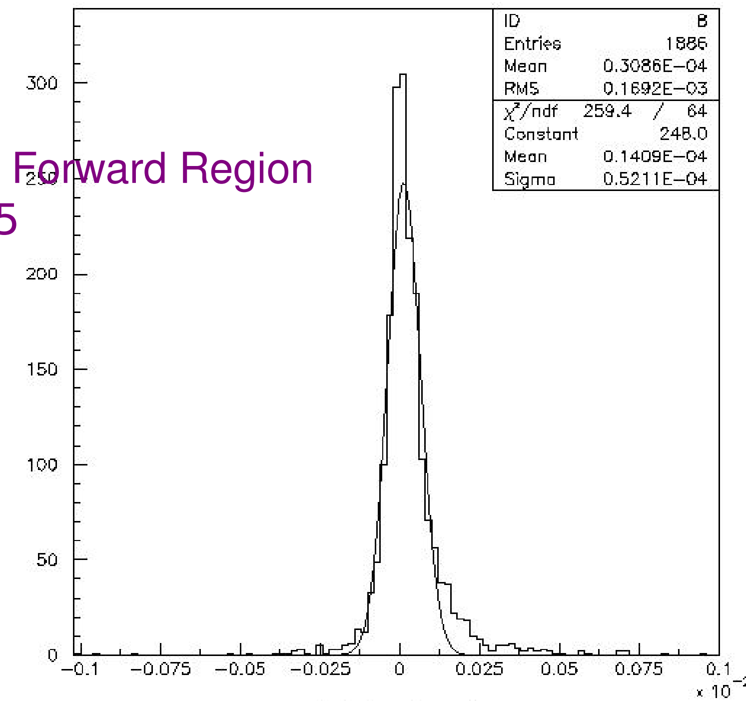
# TRACK RECONSTRUCTION (Marlin implementation)

- LEP Tracking Algorithm is implemented in the MARLIN Reconstruction Framework and shows the Reasonable Results

Central Barrel Region
4.7x10-5




End Cap Forward Region
5.5x10-5



# TRACK RECONSTRUCTION FOR SILC Components (Marlin implementation)

As a First Step (under development)

- Implementation of the LEP Tracking Algorithms as Object Oriented (C++) Processor for MARLIN Reconstruction Chain,
- Implementation of the LEP Tracking Algorithms for the Inner Forward Region of ILC Tracking Detector.

Next Step

- Implementation of the modern Kalman Filter Algorithm to the Tracking Reconstruction Chain

# Full reconstruction “wish list”

SiLC is moving from fast-simulation into the full-simulation era.
Aggressive simulation plans for 2007 require access to sophisticated rack reconstruction software. Manpower not sufficient to lead development, but can definitely make a significant contribution to existing effort.

Track fitter(s) and flexible track finding

- non-prompt tracks
- very forward region
- gaseous+Si vs. Si

Cross-concept nature of collaboration requires generic (as opposed to concept-specific) tools.

Current baseline: Brahmstracking for LDC (in Europe), looking forward to the SLAC tracking toolkit (US/Europe)