The Vertex Tracker in the ILD Concept
Parameters and Optimisation

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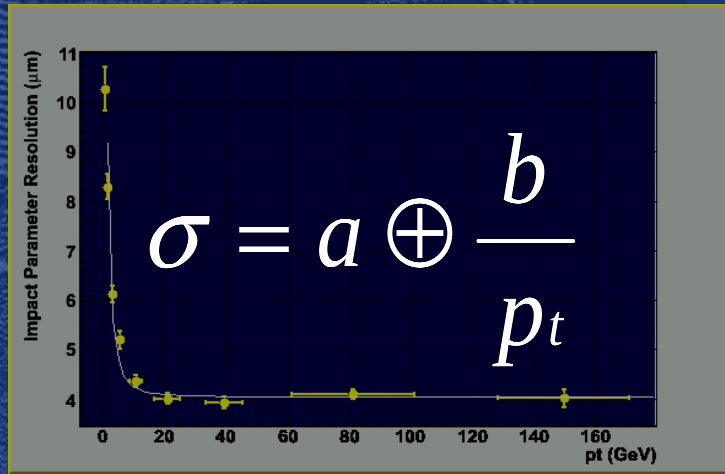
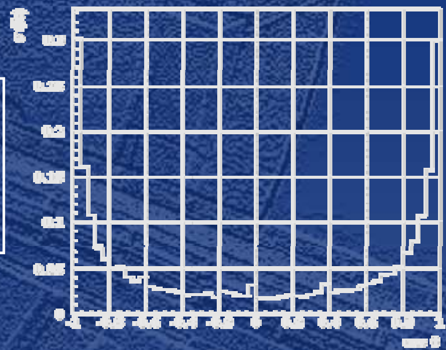
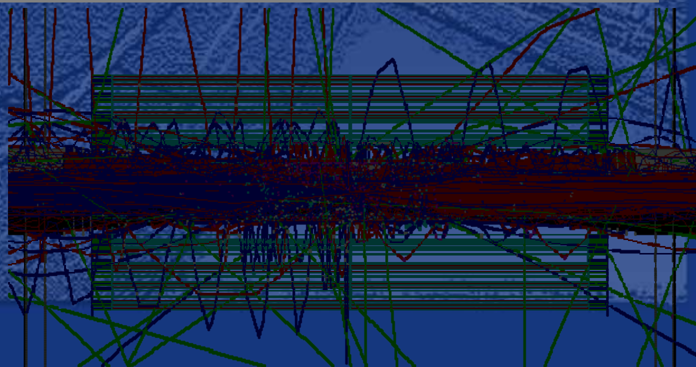
Requirements for the Vertex Tracker

Asymptotic I.P. Resolution [*a*]	Technology (pitch, S/N) Geometry (R_{in}, R_{out})
Multiple Scattering I.P. Term [*b*]	Technology (thickness) Geometry (R_{in}, N_{Layers})
Polar Angle Coverage	Technology (r/o electronics) Geometry (z_{Layers})
Space / Time Granularity	Technology (pitch, r/o architecture, r/o time) Geometry (R_{in})



$$\sigma = a \oplus \frac{b}{p_t}$$





Requirements for the Vertex Tracker

	Testing the SM	Understanding New Physics	Probing the TeraScale
Asymptotic I.P. resolution (a)	**H_{SM}→bb,ττ,μμ** e^+e^-→**HHZ, HHνν**	**HA→bbbb** $\tau_1\tau_1$→ττχχ H^-→τν	
Multiple Scattering I.P. Term (b)	**H_{SM}→cc,gg** e^+e^-→**HHZ**	CP violation H^- $\tau_1\tau_1$→ττχχ	**σ**(e^+e^-→**bb,cc**)
Polar Angle Coverage	A_{FB}		e^+e^-→**HHZ, HHνν**
Space/Time Granularity	Bkg	Bkg	**σ**(e^+e^-→**bb,cc**) Bkg

Physics vs. VTX configuration
Higgs BRs accuracy vs. I.P. Resolution

Effect of VTX performance on accuracy of BR($H^0 \rightarrow$bb, cc, gg) at 0.35-0.5 TeV already assessed by various studies using parametric simulation:

Channel	Change	Rel. Change in Stat. Uncertainty
H→bb **H→cc** **H→gg**	**Geometry:** 5 → 4 layer VTX **Thickness:** 50 μm → 100 μm	+ 0% +15% + 5%
H→cc	σ_{point}: 4 μm → 6 μm 4 μm → 2 μm	+10% -10%
H→cc	**Thickness:** 50 μm → 100 μm	+10%

Yu et al.
J. Korean Phys. Soc. 50 (2007);

Kuhl, Desch
LC-PHSM-2007-001;

Ciborowski,Luzniak
Snowmass 2005

Physics vs. VTX configuration
Charm Tagging vs. I.P. Resolution

Study change in efficiency of charm tagging in Z^0-like flavour composition

Geometry	σ_{IP} (μm)		
R_{in} 1.2 cm ↓ 1.7 cm	$4 \oplus 7/p_t$ $4 \oplus 10/p_t$	c purity=0.7	$\varepsilon_c = 0.49$ $\varepsilon_c = 0.46$
R_{in} 1.2 cm ↓ 2.1 cm	$4 \oplus 7/p_t$ $5.5 \oplus 14/p_t$	c purity=0.7	$\varepsilon_c = 0.49$ $\varepsilon_c = 0.40$
HPS	$11 \oplus 15/p_t$	c purity=0.7	$\varepsilon_c = 0.29$

Hawking,
LC-PHSM-2000-021

Optimising the Vertex Tracker

Optimisation process should be "technology neutral" at this stage, implications of optimal parameters for various technologies & architectures to be addressed by R&D groups;

Important input to sensor R&D, ladder engineering, system issues

Degrees of freedom to be considered in optimisation process:

Radius of innermost layer: 15 mm $< R_{in} <$ 20 mm
Ladder thickness: 0.1% $X_0 < t <$ 0.2%X_0
Magnetic field strength: 3 < B < 4 T
Geometry

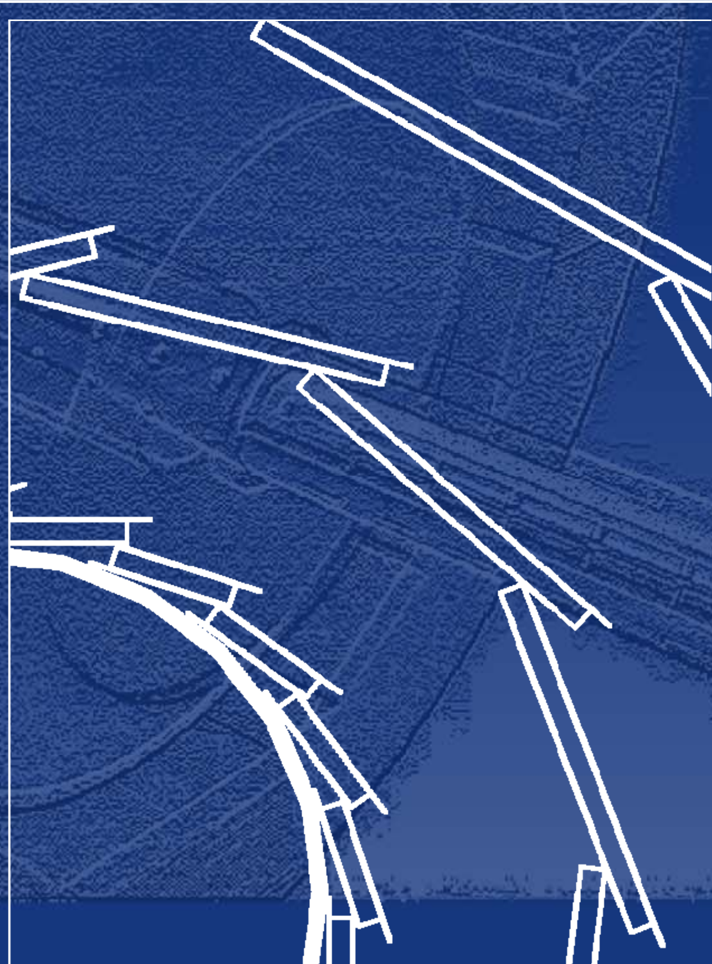
Some studies can be based on parametrisation of track extrapolation resolutions: VTX community committed to provide parameters and counts on feed-back from physics benchmarking effort;
Answering some questions require instead G4+Digi+Reco:
plan analysis effort within VTX community.

Proposed Vertex Tracker Geometries

Propose detailed study of two very different and complementary layouts:

Five-layered Vertex Tracker
thin Si + CF (VXD02)

Three-layered Vertex Tracker
w/ back-to-back sensors (VXD03)



Parametrising the Vertex Tracker Response

Provide extrap. resolution for various set of parameters (R_{in}, ladder thickness, ...) and VXD models obtained using G4 + Kalman Filter Fit:

σ_{extrap} vs. p and θ for isolated trks and ptcs in jets.

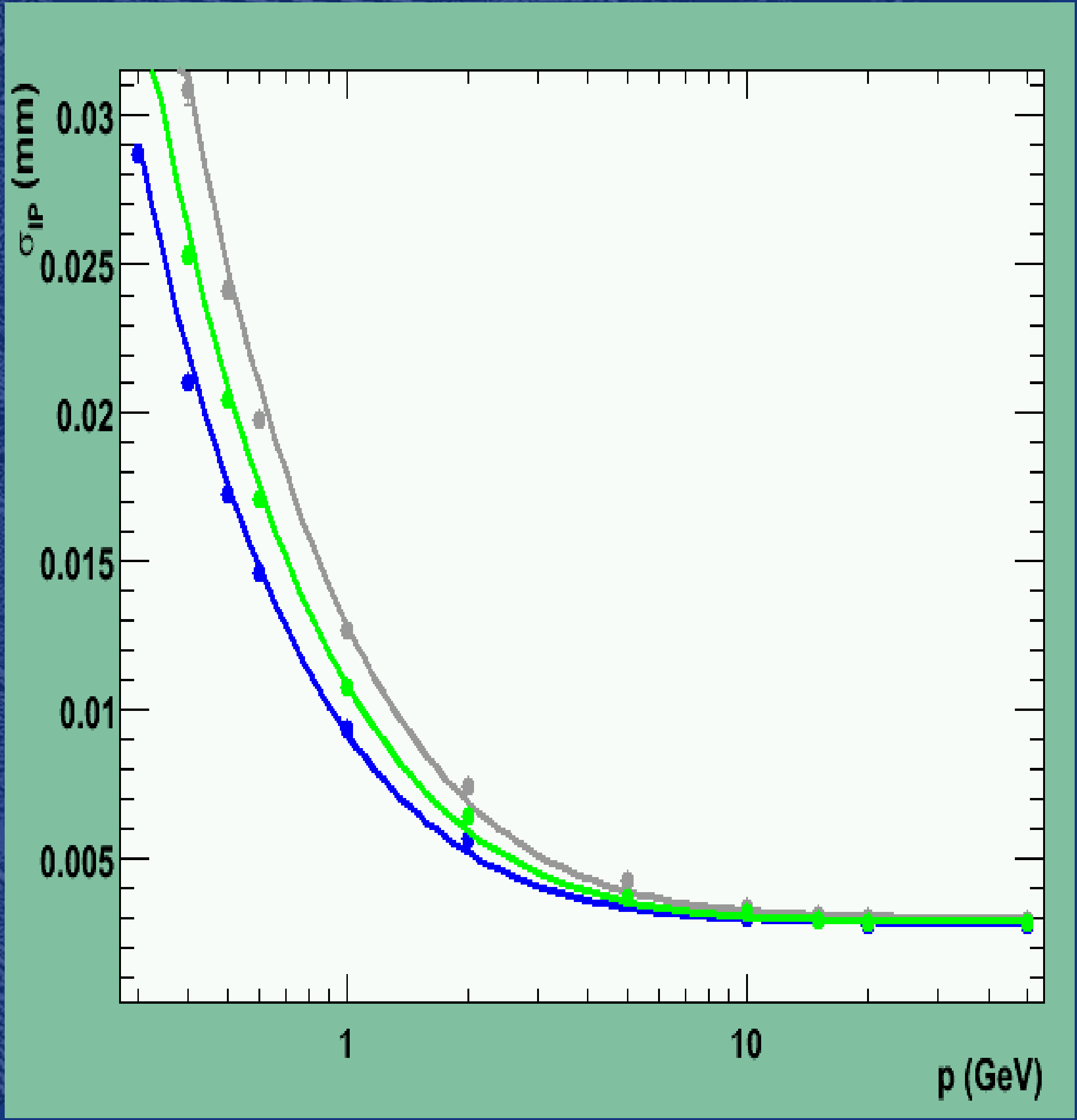
Example:

σ_{extrap} vs. p for isolated μs

baseline VXD02 ,

ladder thickness × 2 ,

R_{in} = 18 mm :



Performance beyond Gaussian Resolutions

Earlier results show physics reach to depend very smoothly on variations in a and b;

Parametric fast simulation studies do not address effect of non-Gaussian tails; such effects originate from patrec failures and local distortions or misalignments;

Important to start addressing these issues within current effort on analyses based on G4+Digi+Reco;
→ clarify effect of occupancy on mistag rate,
define stability constraints for engineering design.

Physics Analysis with Full G4 + Digi + Reco

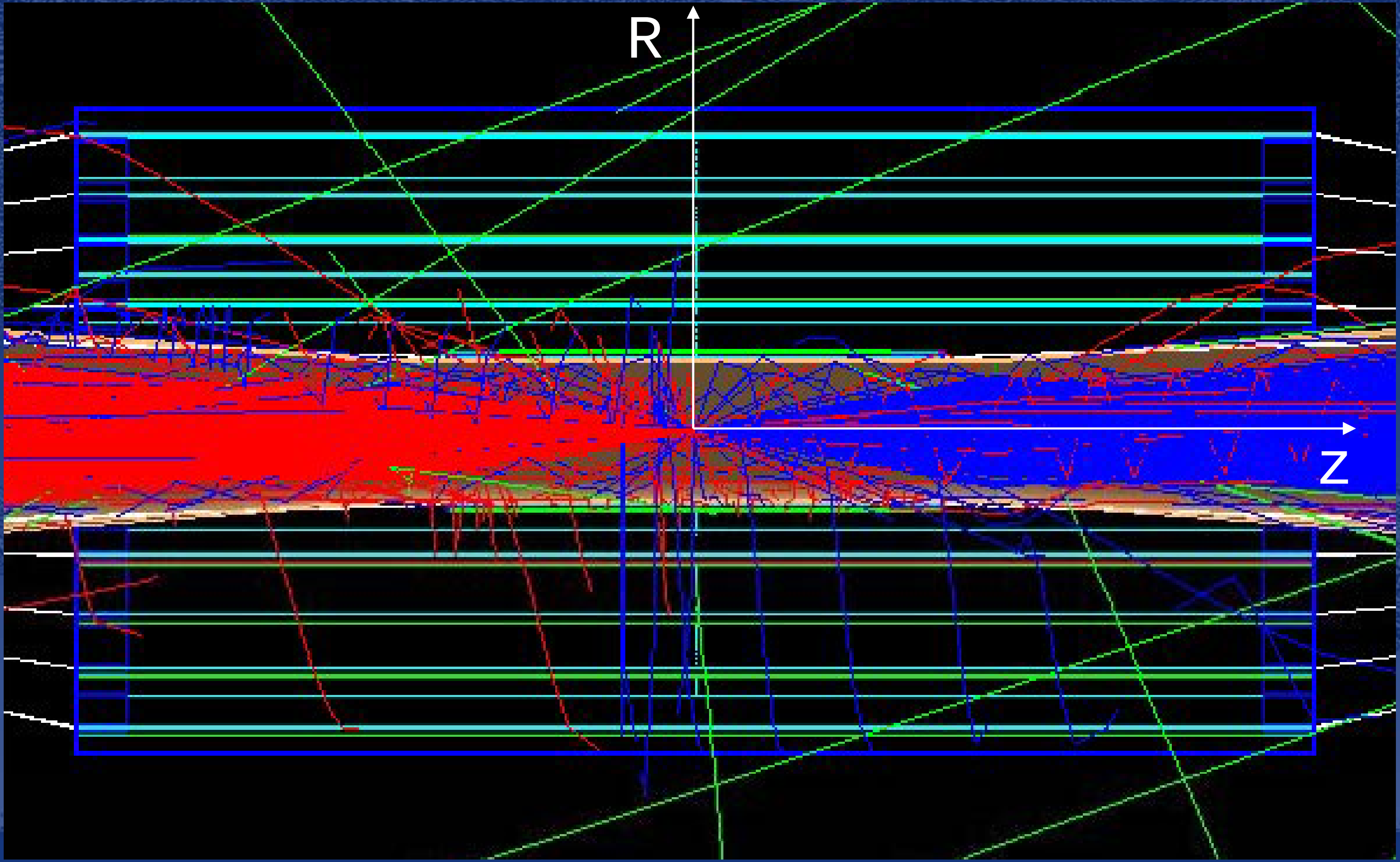
Plan to carry out detailed analyses of few benchmark physics processes with full G4 simulation + Digitisation + Patrec + Physics Object Reco within the Vertex Tracker community;

EU+US groups will study Higgs BRs and EW observables in e+e- → cc with VXD02 geometry;
Asian groups will study Higgs BRs and possibly further channels with VXD03 geometry;

Agreed to have analyses sharing signal stdhep and pair background files;
Generate common Tuples DST and develop together physics analysis programs to ensure results are comparable;

Pair Background and VTX Geometry

Geometry of innermost layer bound by distribution of incoherent pairs;
Study z point of crossing of electrons with cylinder as function of radius R for various magnetic fields B;

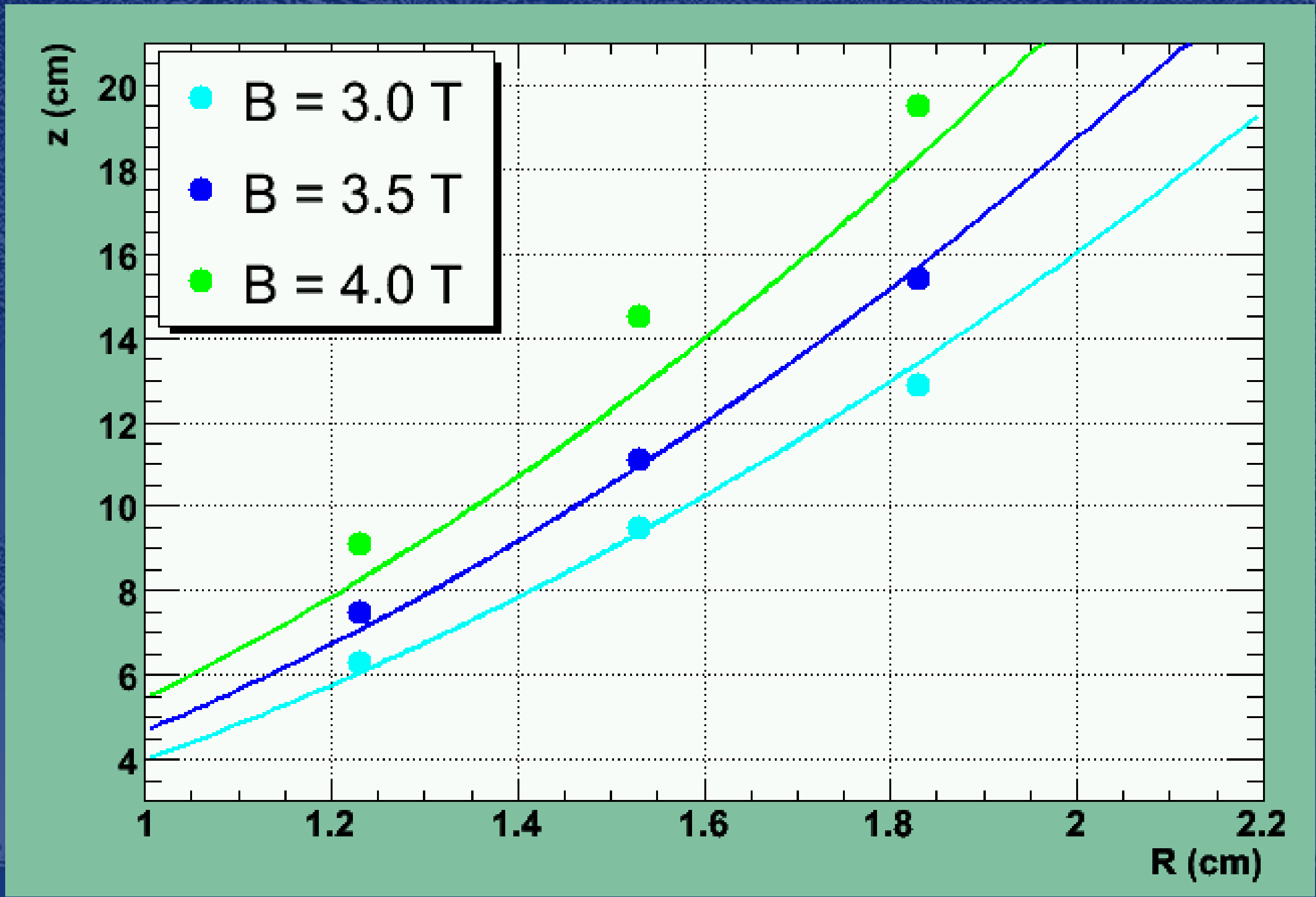


Pair Background and VTX Geometry

Compare results of GUINEA_PIG + Mokka simulation with R^2 scaling:

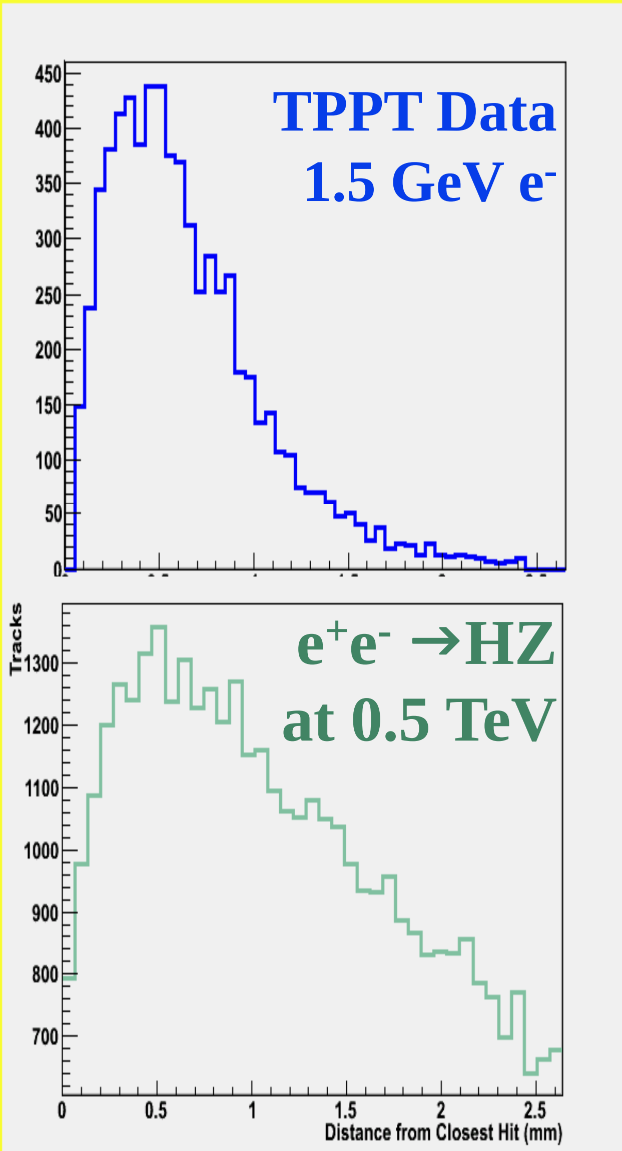
$$z_c[cm] = 8.3\ R^2 B[Tesla]\sigma_z[mm]\frac{10^{10}}{N}$$

M.B., V Telnov, Proc. 2nd Workshop on Backgrounds at MDI World Sci, 1998

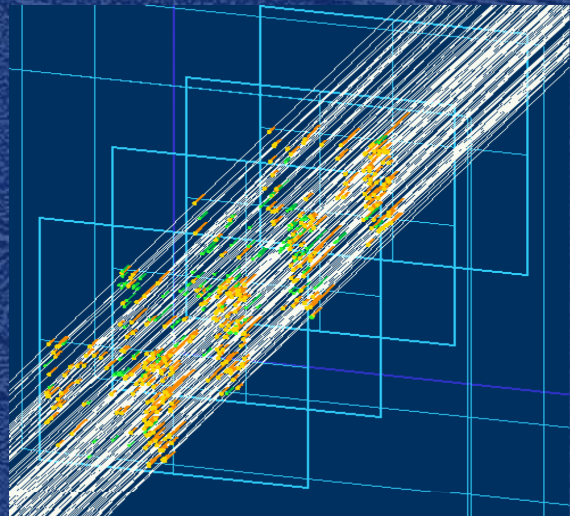


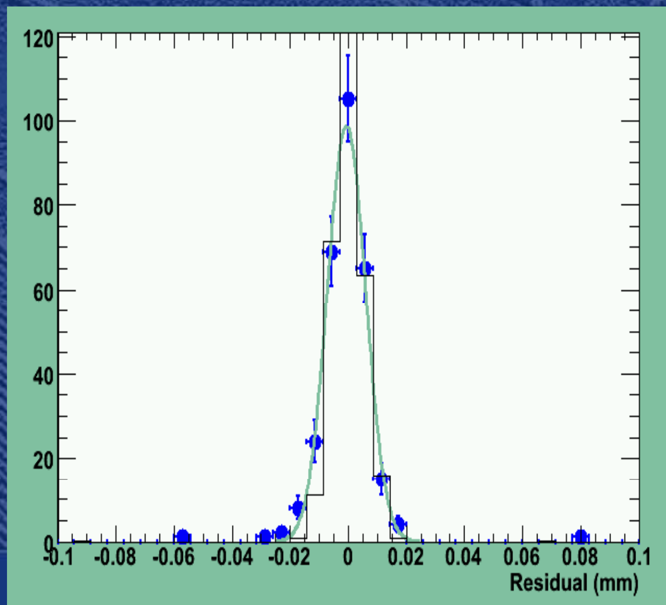
Vertex Tracking Validation at Beam Tests

TPPT@LBNL ALS
1.5 GeV e^- beam

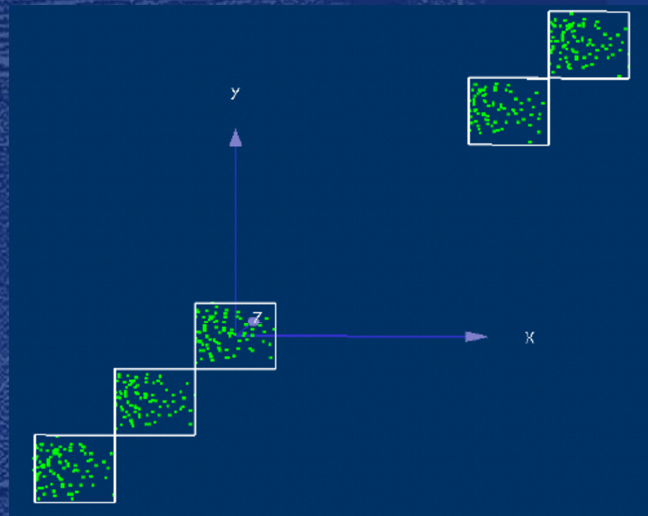


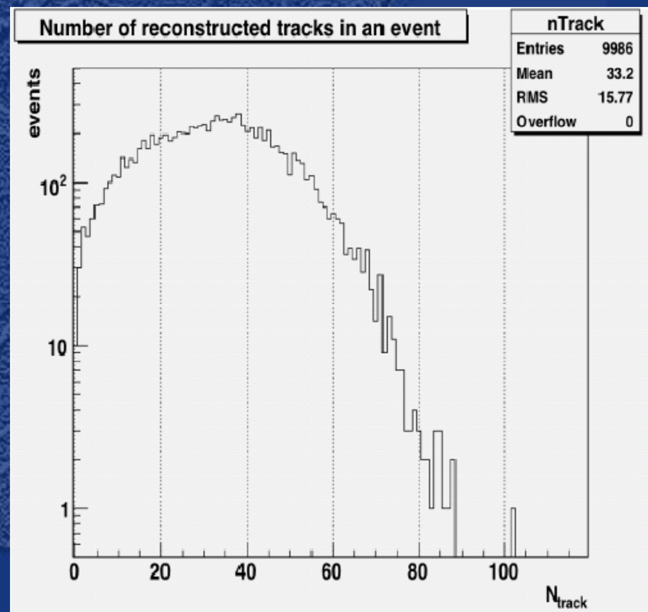
T966@FNAL
120 GeV p beam





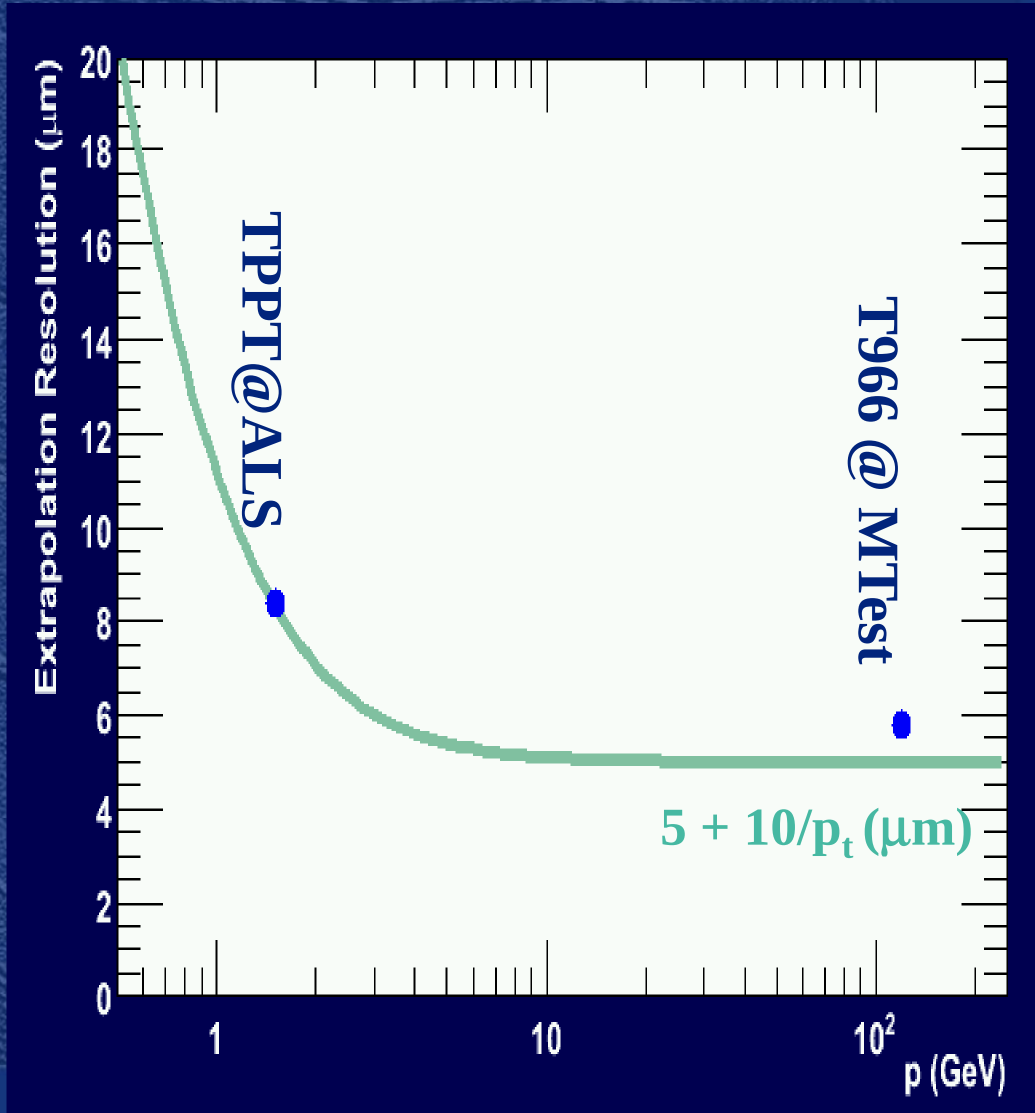
EUDET@CERN
180 GeV π^+ beam





Vertex Tracking Validation at Beam Tests

Measured resolution for extrapolation to 15 mm with Thin Pixel Telescope and R_{out}-R_{in} = 30mm:



Significant amount of beam test data available for validation of digitisation simulation, tracking performance in dense jets and alignment;

Their use will boost realism of assumptions taken in the event simulation and reconstruction;

Planned Effort and Timeline

EU: Strasbourg (G4 geometry, Parametrisations, Beam Test validation, physics analysis [H BRs])
+Warsaw (Digi sw, Beam Test validation)
MPI (LDC tracking, Digi, Bkgs,+...), LCFI, INFN (TBD)

Asia: KEK + Kobe U, Tohoku & others (Bkg rejection, phys. analysis [H BRs])

US: LBNL (Digi&Reco sw, Beam Test validation, physics analysis [$e^+e^- \rightarrow$ cc])
Hawaii (physics analysis)

Feb 08: VXD geometries in Mokka/Jupiter, validation;
generate parametrisations, validate Digi, generate signal stdhep files;
Mar 08: G4 event production & test, define analysis strategy, define Tuples;
Apr 08: test analysis chain, deploy Reco tools;
May 08: Reco production, Tuple production & test
Summer 08: Analysis activity;
Fall 08: writeup.

Personnel very limited, availability of US institutions to be re-assessed, essential to plan a well-coordinated, synergistic effort.
Identify VTX contact persons to ILD JSB shortly after this meeting.

The LC VTX @ Villa Vigoni, Lake Como

April 21-24, 2008

Second in the series of topical workshops started at Ringberg Castle in 2006: Forum for in-depth, informal discussion of technical issues, review of critical points and achievements in sensor R&D, discussion of designs and prototypes for mechanics, integration and services, updates on software tools;

Villa Vigoni meeting scheduled to take place at turning point in LoI process and will benefit the VTX community contributing to various LoIs through contacts and open discussion.

Contact Person: Massimo Caccia (U. Insubria, Como and INFN).