LiC Detector Toy

Vienna fast simulation and track fit tool for
flexible detector optimization studies

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Abstract

The “LiC Detector Toy” allows investigation of the track parameter resolution via Monte Carlo, for the purpose of optimizing a detector set-up. It features:

- Simulation of the track sensitive part of a ring or linear collider detector with a solenoid magnetic field, and its material budget;
- Support of measurements by semiconductor pixel and strip detectors, and a TPC;
- Track reconstruction by a Kalman filter, including tests of goodness of the fits.

Written in **MatLab**® (a language and IDE by MathWorks).

Version 2.0 available for **GNU Octave**

Motivation

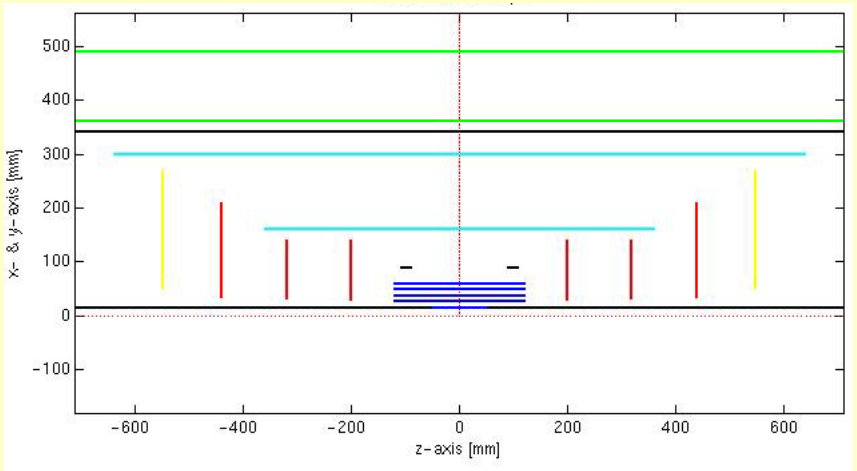
- Compare track parameter resolutions of various detector set-ups, for both barrel and forward/backward regions;
- Optimize size and position of the track sensitive devices, and of the detector material budgets;
- A simple tool – easy to understand, handle and modify;
- Can easily be adapted to meet individual needs;
- Can be installed on a desktop or laptop PC;
- Quick results by “shorter than a coffee break”;
- Live demonstration at a conference possible;
- An integrated graphics user interface (GUI) available.

Program Features (general)

- Measurements by single or double layers, or by a TPC;
- Efficiencies uncorrelated (strips), or strictly correlated (pixels); passive layers defined by zero efficiency;
- Thickness of scatterers given in radiation lengths;
- Homogeneous magnetic field (by a solenoid), rotational symmetry w.r.t. the z-axis of the detector set-up; however, an asymmetry w.r.t. the z coordinate possible;
- Start parameters for simulated tracks are user-defined:
  - Vertex position range,
  - Transverse momentum range,
  - Range of polar angle θ,
  - Number of tracks from the vertex;
- Goodness of the fit monitored by pull quantities and χ^2.

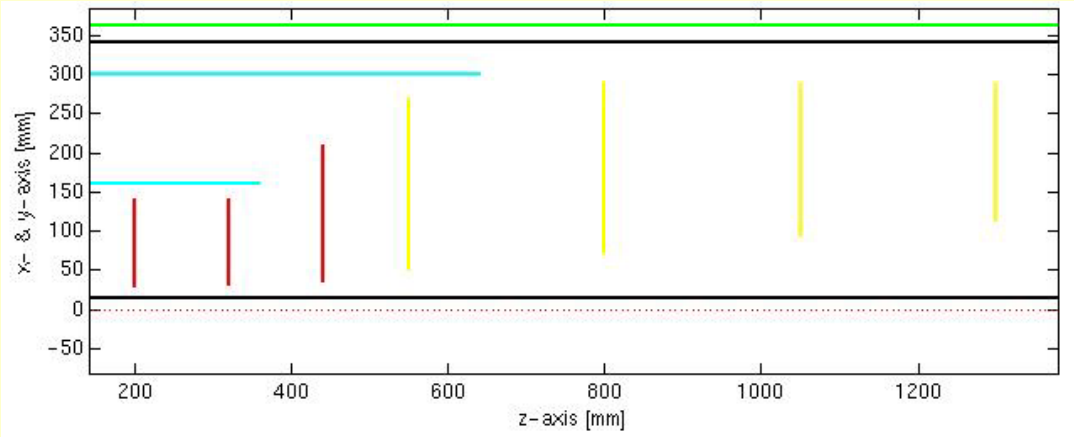
Program Features (barrel region)

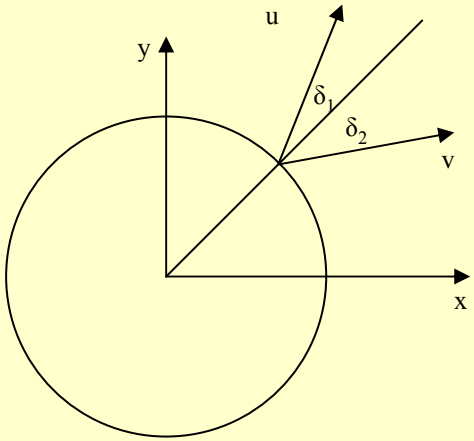
- Coaxial cylinder layers of arbitrary length and position;
- Any number of passive layers;
- Measurement of two coordinates: azimuth (RΦ), position along the cylinder (z);
- Optional stereo angle for strip detectors (z' instead of z);
- Resolution in TPC gaussian, and may depend on z.



Program Features (fwd/bwd region)

- Circular plane layers, perpendicular to z-axis;
- Arbitrary z position and inner/outer radius;
- Any number of passive plane layers;
- Measurements of two coordinates (u and v), directions depend on intersection point, defined by angles δ_1, δ_2.





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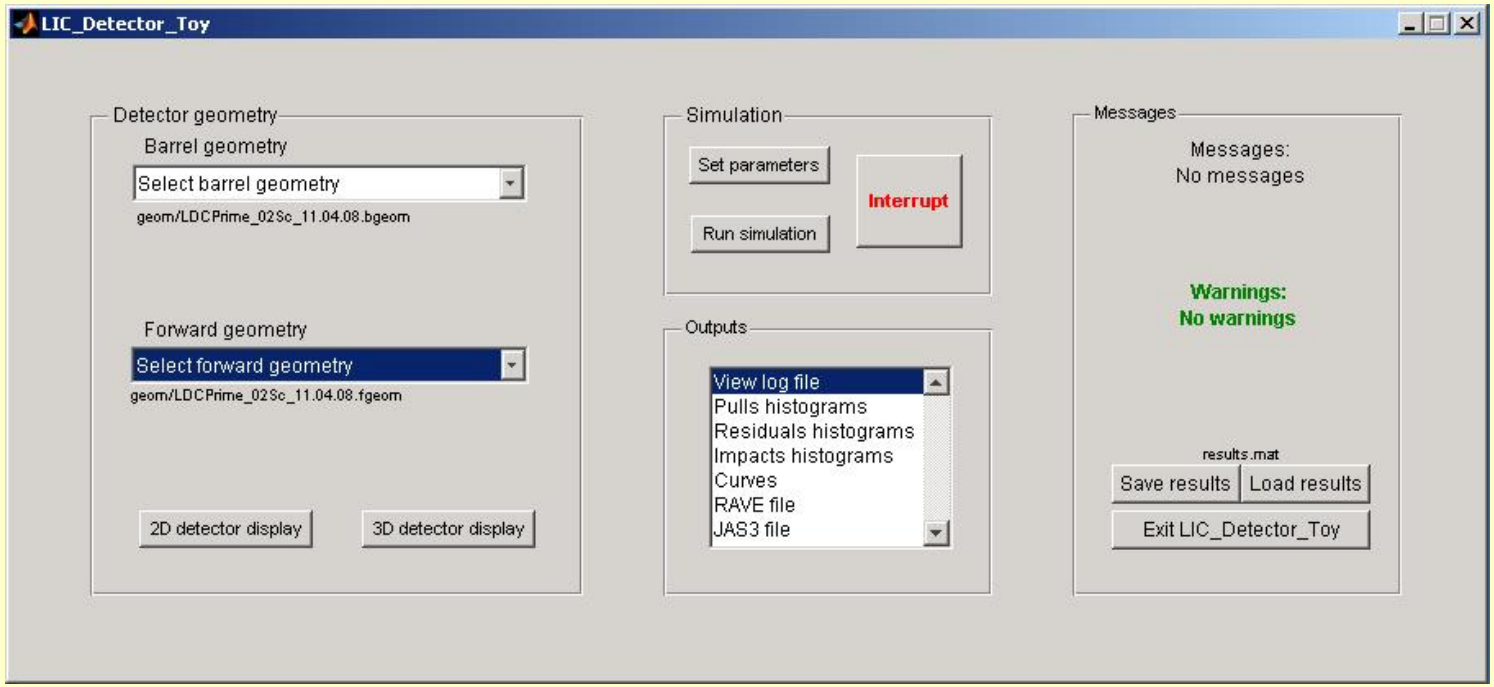
Simulation

- Single tracks originating from a vertex, assumed at (x, y, z);
- Solenoid magnetic field, rotational symmetry w.r.t. z-axis;
- Exact helix track model, with kinks for multiple scattering;
- Multiple scattering at discrete “thin” layers:
  - Measurement layers and scattering material treated separately,
  - Correct path length traversed, material budget averaged over layer,
  - Scattering angles gaussian distributed (in the track’s local coordinate frame) according to the Highland formula;
- Gaussian (TPC) or uniformly distributed measurement errors;
- Systematic and/or stochastic inefficiencies included.

Reconstruction

- **No Pattern Recognition !**
- Track fit by an exact Kalman filter:
  - Inclusion of multiple scattering ("process noise"),
  - Fitting performed from outside inwards;
- Linear track model:
  - Expansion point is a "reference track" (method similar to that of the DELPHI experiment);
- Parameters:
  - Fitted parameters defined at the inside of the innermost layer,
  - DELPHI-like parameter vector and error matrix:
    $\{ \Phi, z, \theta, \beta = \varphi - \Phi, \kappa = \pm 1/R_H \}$ with $\text{sign}(\kappa) = \text{sign}(d\varphi/ds)$, and corresponding 5x5 covariance matrix;
  - Optional CMS-like Cartesian parameters and errors:
    $\{ x, y, z, p_x, p_y, p_z \}$ with a 6x6 covariance matrix of rank 5.

Graphic User Interface (GUI)



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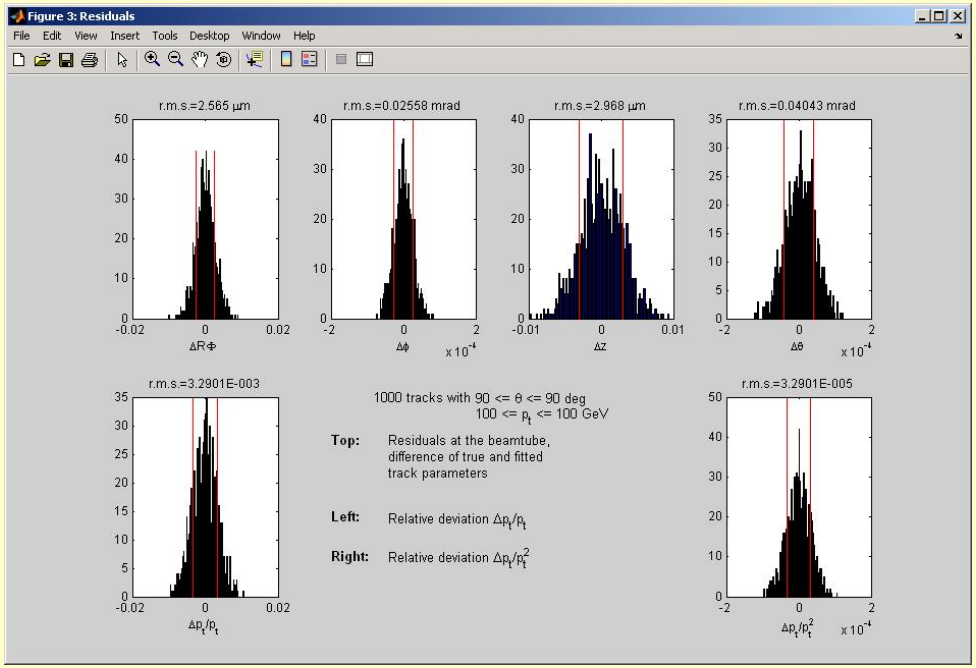
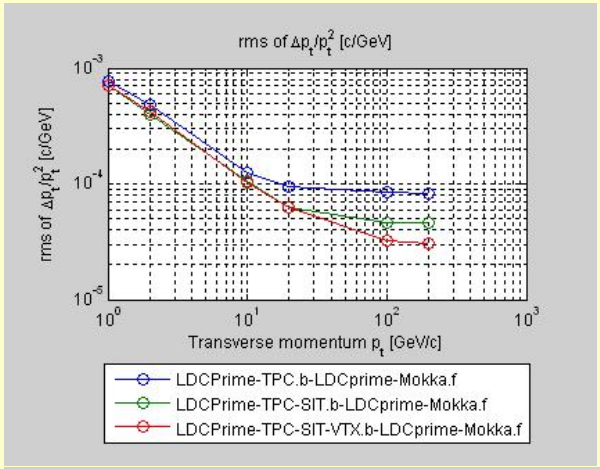
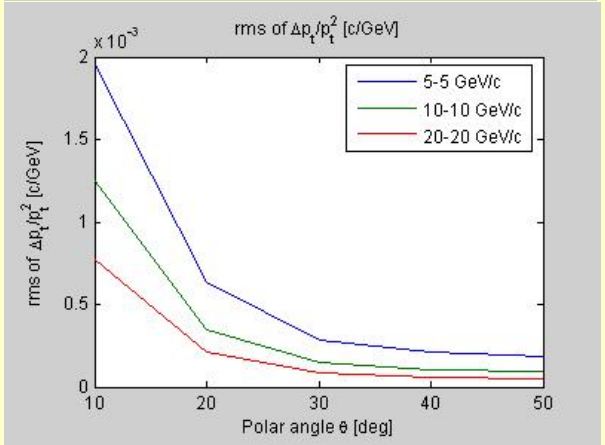
Simulation Results







Up: Histograms of residuals

Right: Looping over detector setups and/or start parameters

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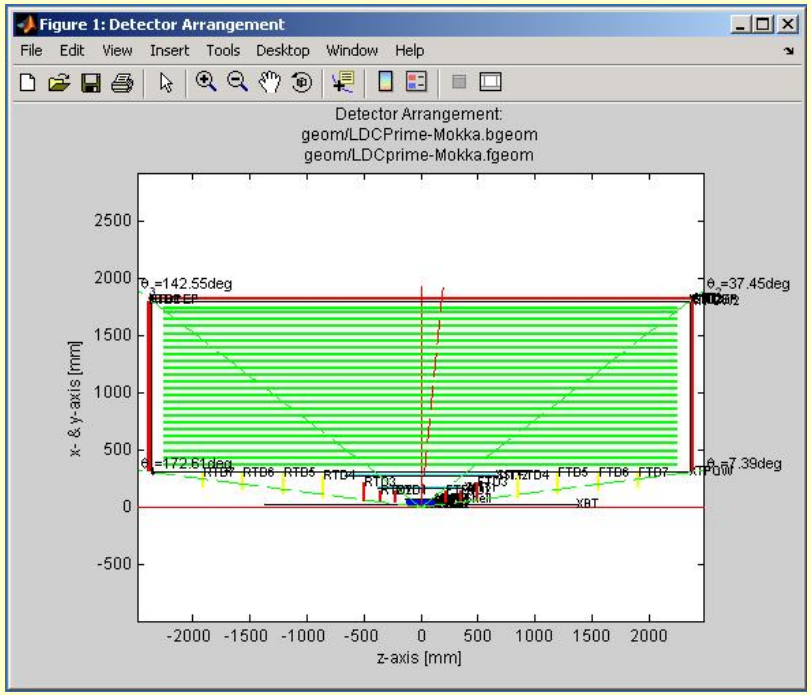
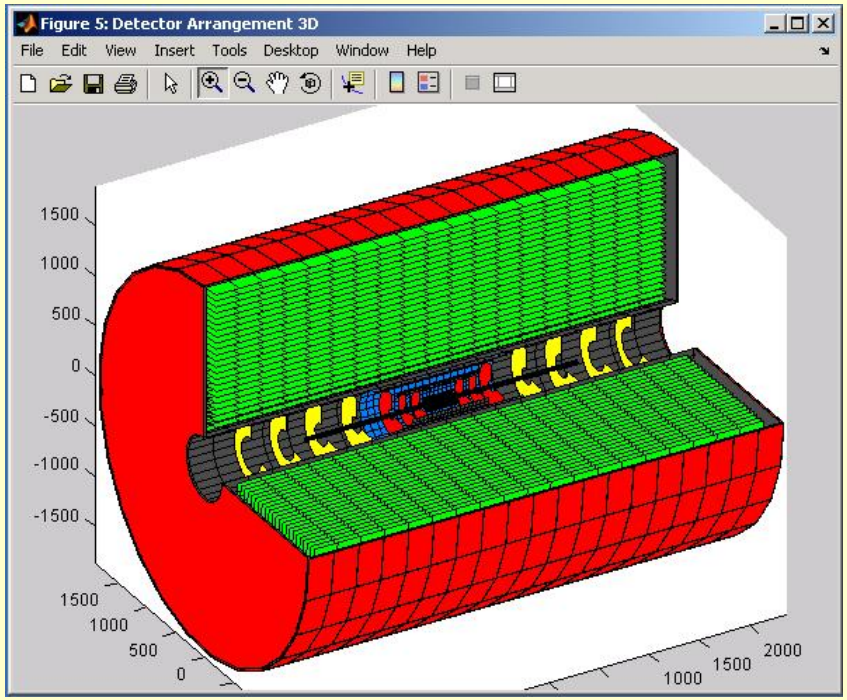
Detector Display
(LDCPrime_02Sc, April 2008)





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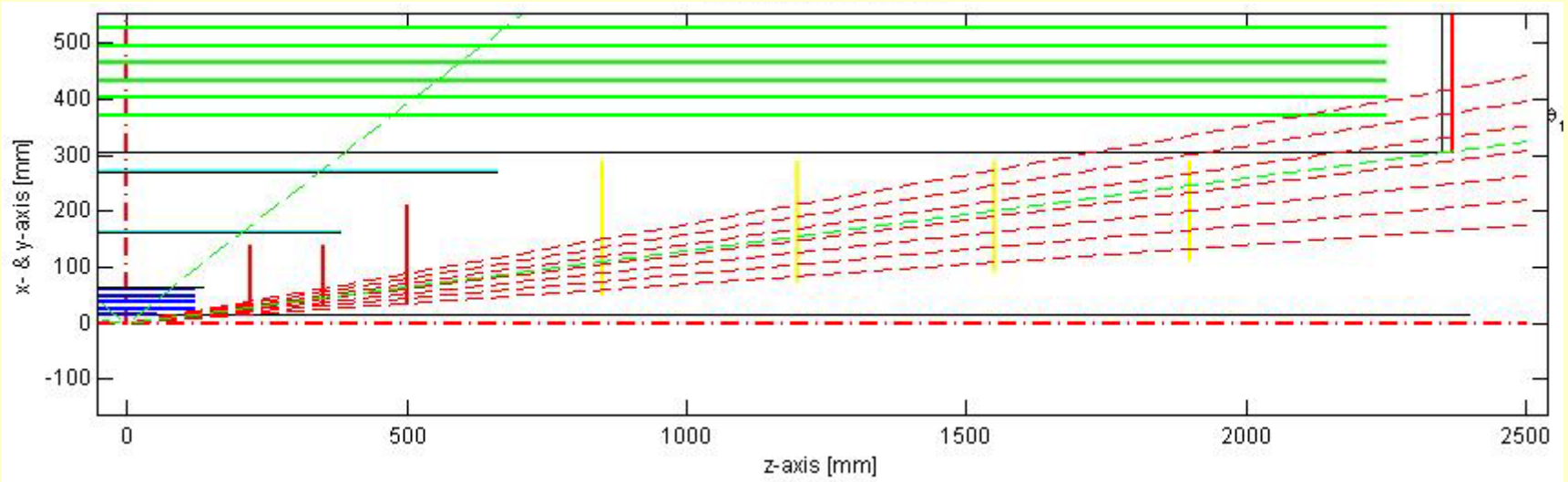
Short study on forward region
(LDCPrime_02Sc, April 2008)



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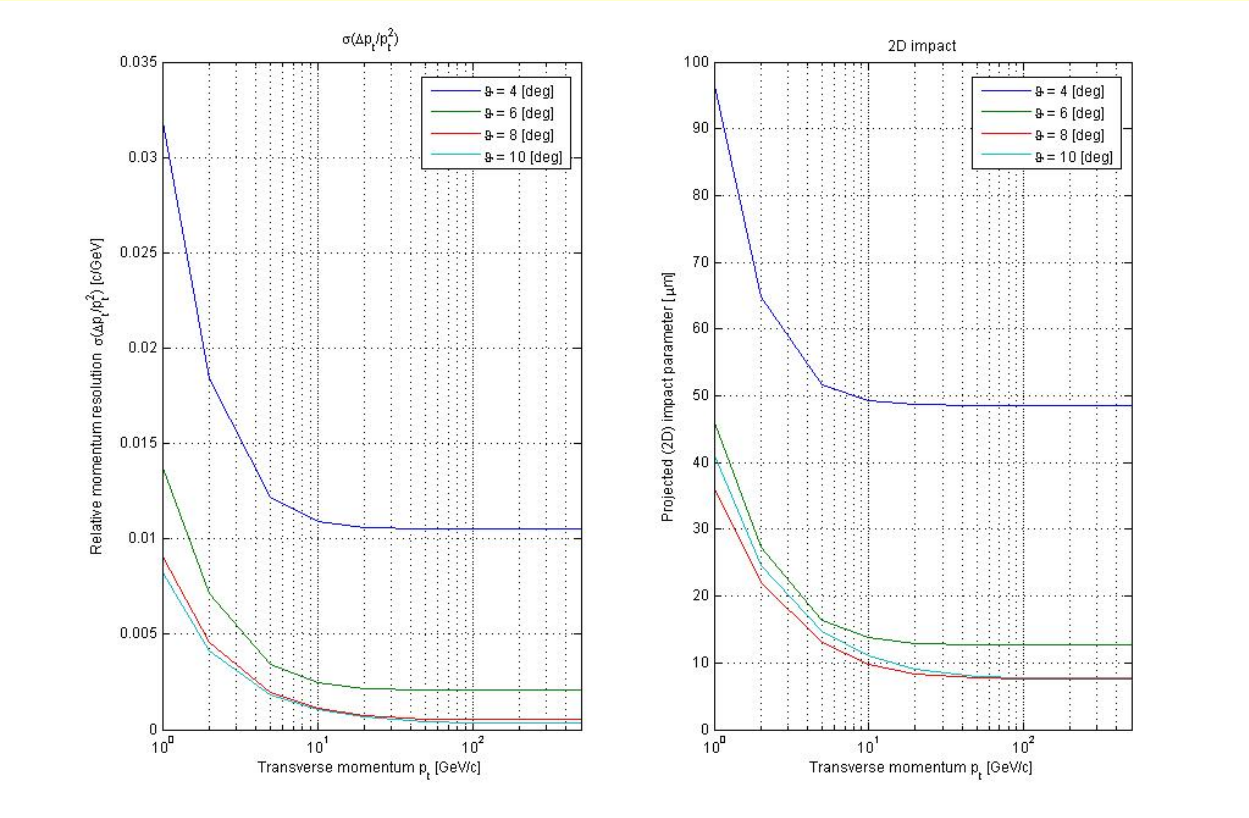
Momentum resolution and transverse impact parameter as function of p_t



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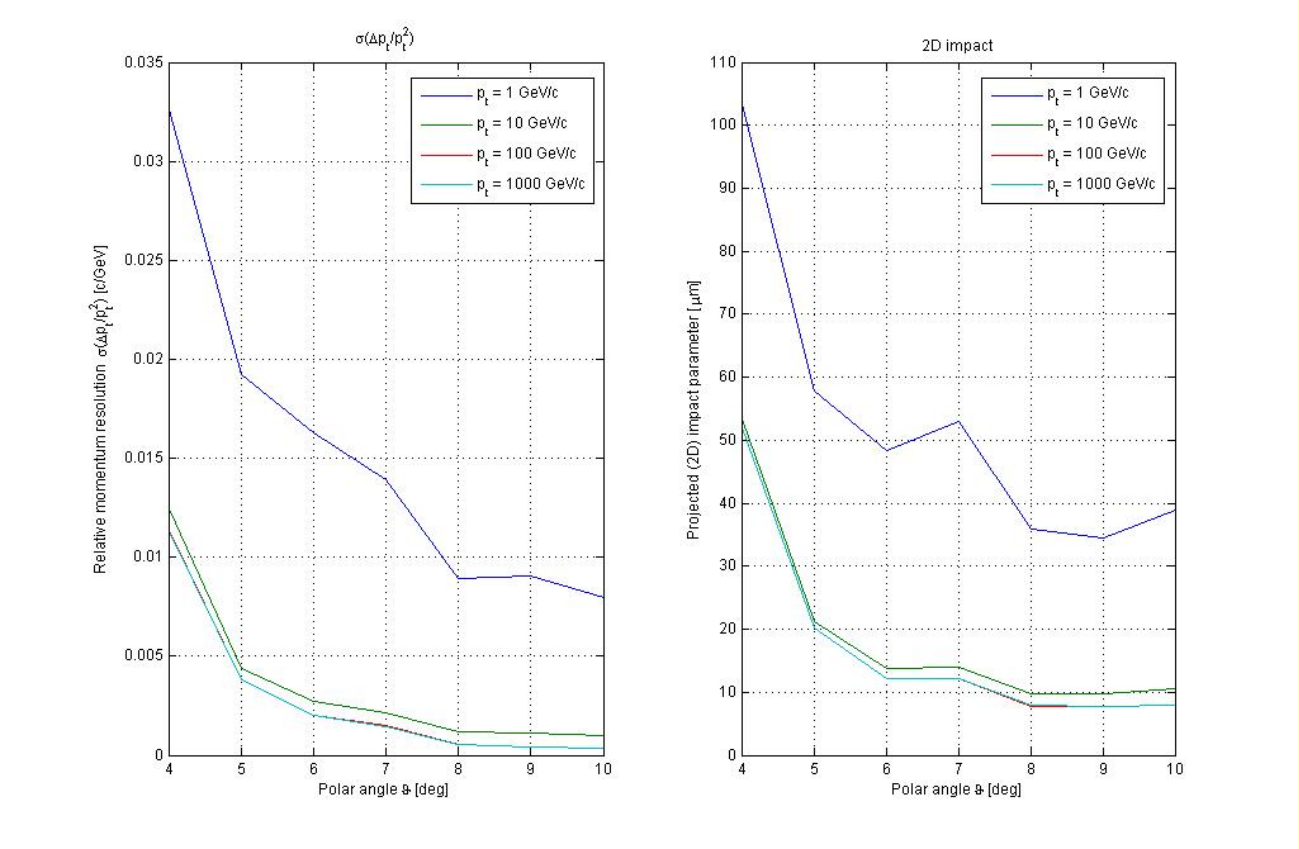
Momentum resolution and transverse impact parameter as function of θ



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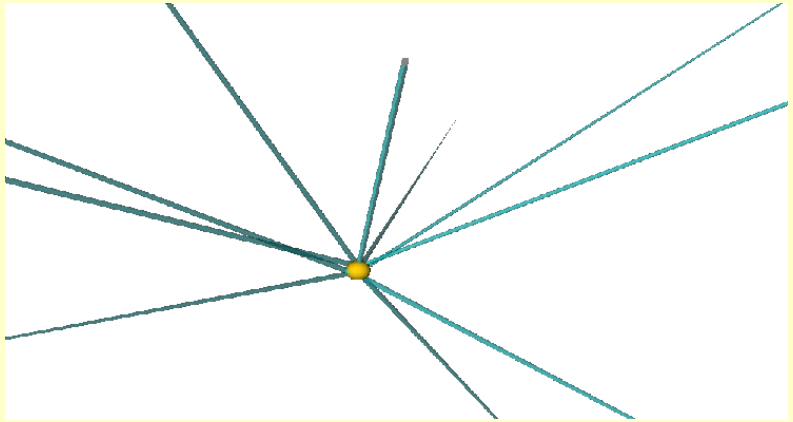
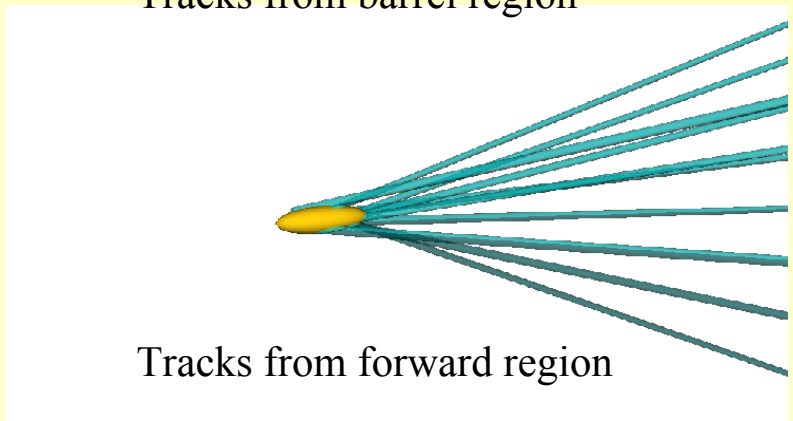
Subsequent vertex fit by RAVE

- Fitted tracks as input to the VERTIGO/RAVE vertex reconstruction toolkit;
- Interface is the Harvester's standard CSV text format;
- Successfully tested with 10- and 1000-prong events.



Tracks from barrel region



Tracks from forward region

LDT on the Web

http://wwwhephy.oeaw.ac.at/p3w/ilc/lictoy/

LDTsource_20.zip

UserGuide_20.pdf

Conference Proceedings

http://wwwhephy.oeaw.ac.at/p3w/ilc/reports/LiC_Det_Toy/Proceedings/…