2nd ECFA/DESY Study on
Physics and Detectors for a
Linear Electron - Positron Collider
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Optimisation of the Vertex Tracker Design

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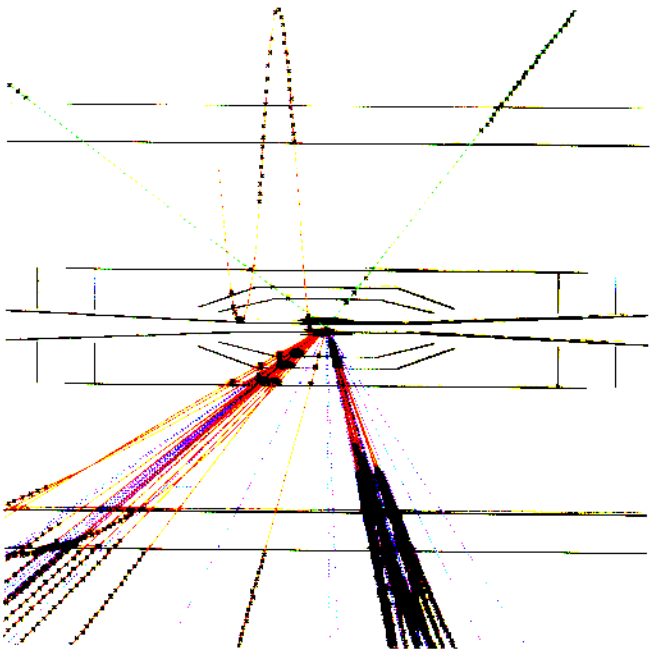
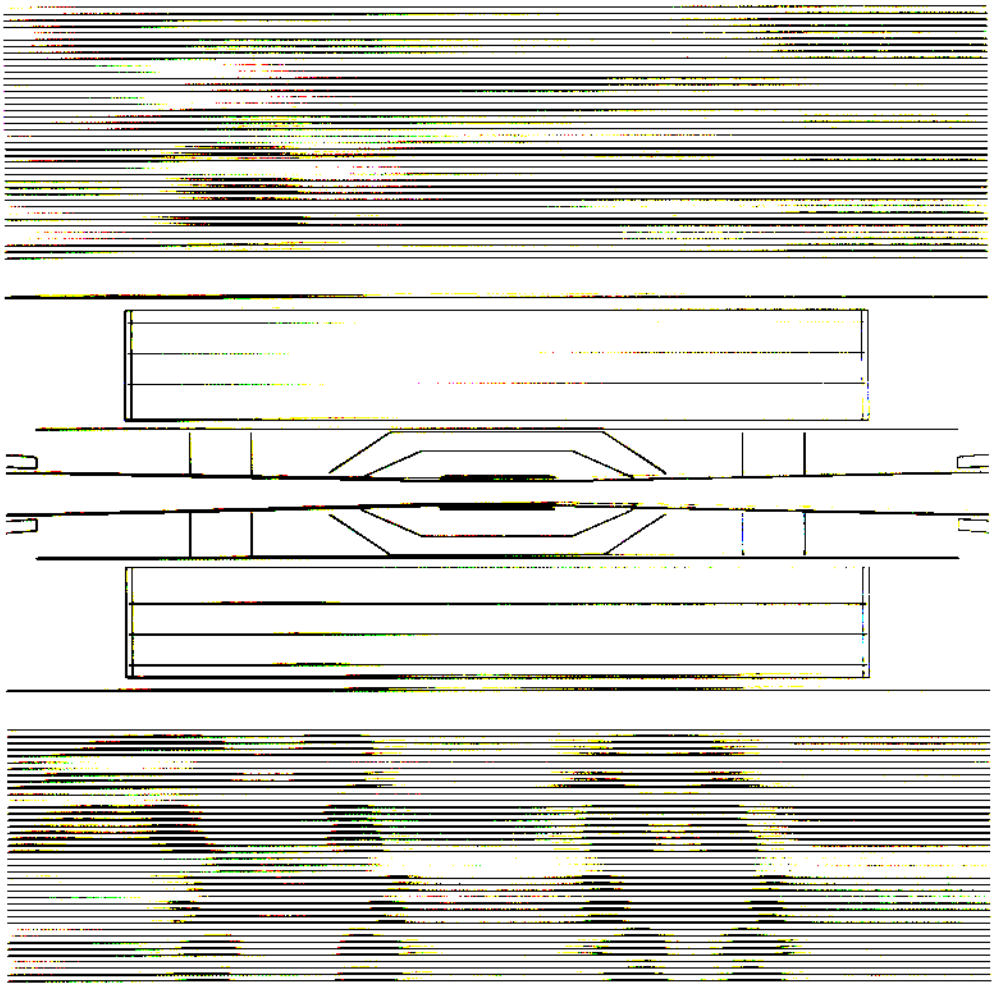


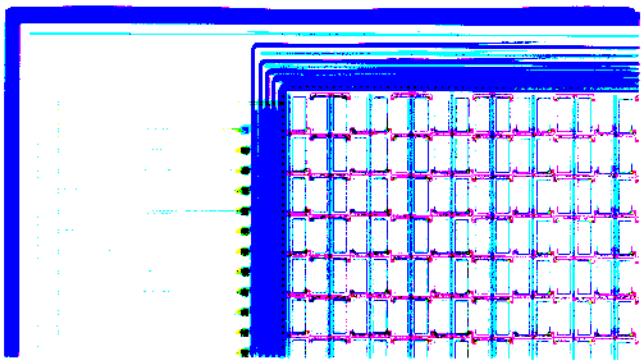
A Vertex Tracker based on APS Pixel Detectors

M. Battaglia, M. Caccia, K. Österberg

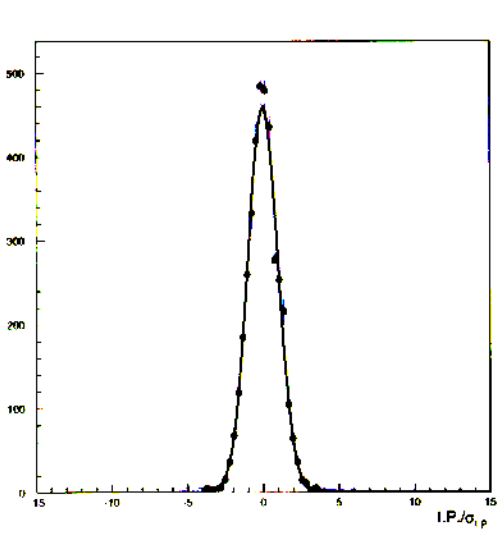


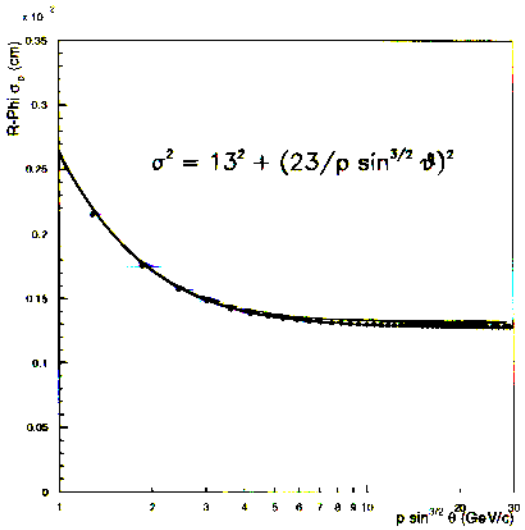
- APS Vertex tracker in 1997 CDR:
  - three layers of pixel detectors in with coverage down to $|\cos\theta| < 0.87$ (3 hits)
  - closer layer and end-cap layers of pixel detectors with coverage down to $|\cos\theta| < 0.96$ (3 hits)
  - forward pixel detector disks with coverage down to $|\cos\theta| < 0.995$ (3 hits)

- Areas of specific detector R&D have been identified:
  1. definition of achievable single point resolution using charge sharing,
  2. determination of minimum pixel size and feasibility of back-thinning,
  3. design of analog read-out electronics.
- Joint R&D started by the Helsinki, Kracow, Milano and Warsaw groups



- Studies of mechanical structure being started
- Simulation of APS vertex tracker in GEANT with BRAHMS:
  - take advantage from DELFIT Kalman filter full track fit and material description:
  - evaluate impact parameter resolution and optimise detector geometry,



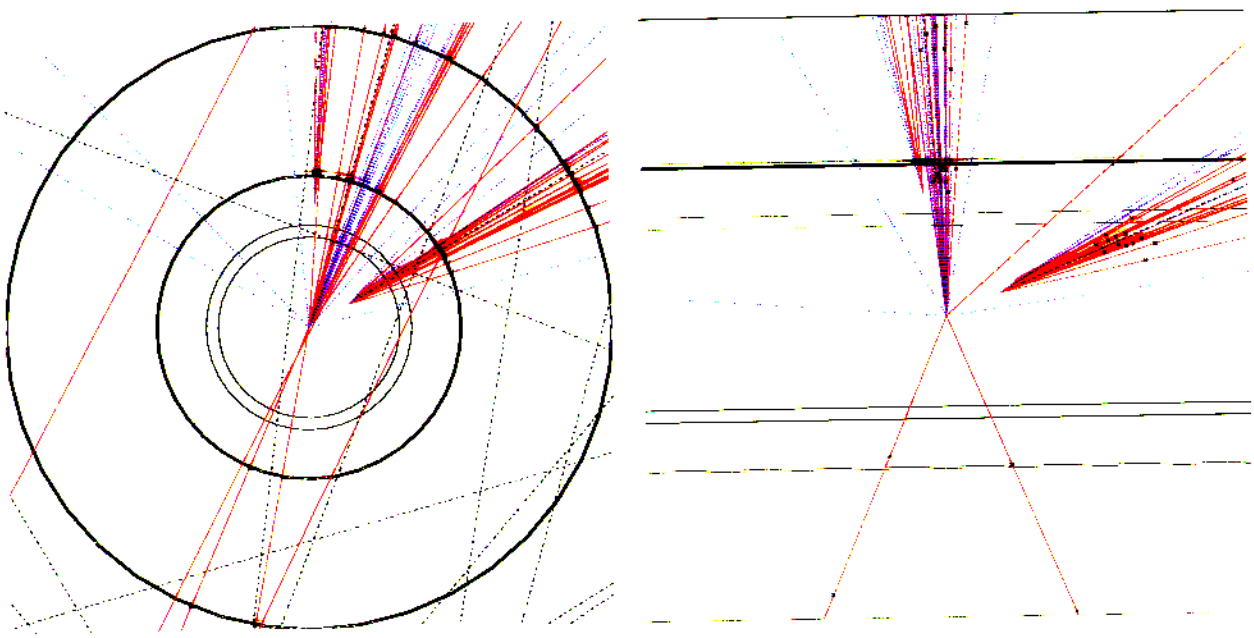


  - test jet flavour tagging performances,
  - develop pattern recognition and study distortions from backgrounds and track density.

Optimisation of Beam-Pipe Radius and of First Vertex Detector Layer

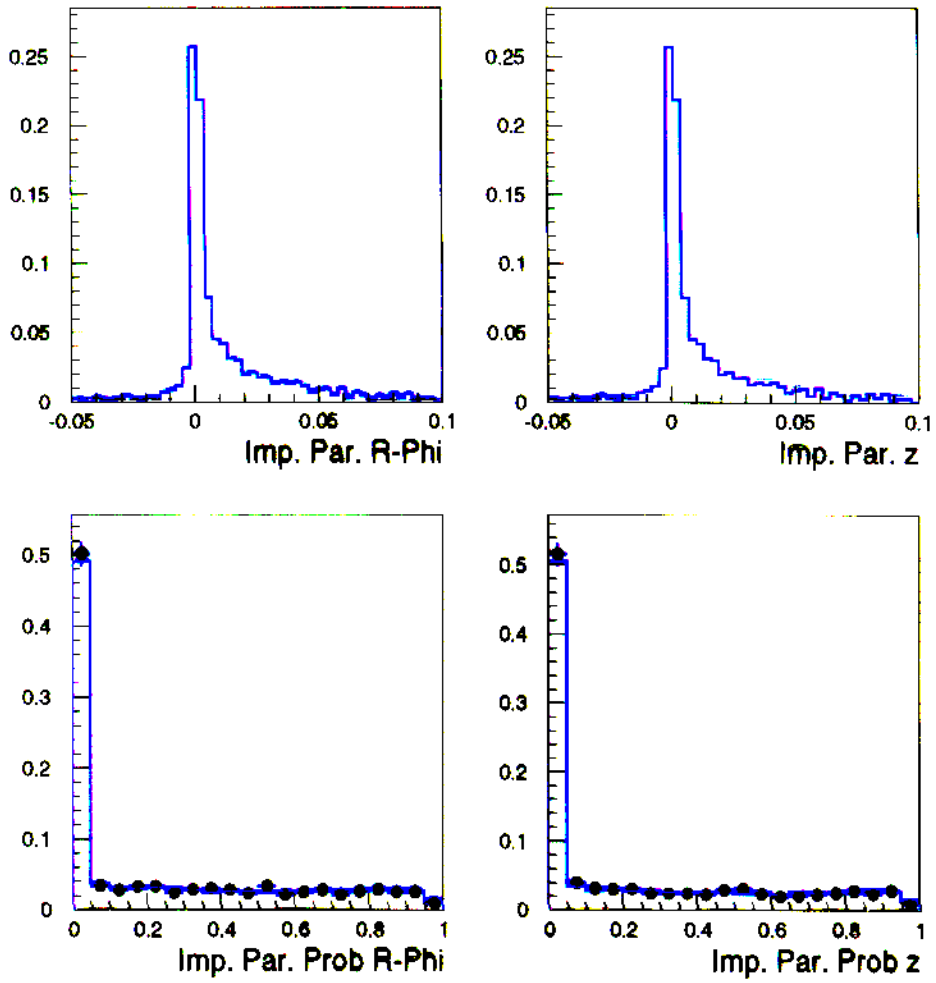
- Tagging of heavy flavour jets and efficient b/c separation provide a very important tool in new particle searches and in the detailed study of a light neutral Higgs boson;
- searches in channels with several b jets to be tagged like $H^0A^0 \to b\bar{b}b\bar{b}$ and $H^+H^- \to t\bar{b}t\bar{b}$ demand highly efficient single b jet identification;
- Accurate determination of $H^0 \to b\bar{b}$, $c\bar{c}$ and gg branching ratios identify the SM or MSSM nature of light Higgs and possibly provide indirect information on the A boson mass;
- Efficient flavour tagging by reconstruction of displaced vertex topology of long-lived hadrons requires accurate track extrapolation at interaction region.

$e^+e^- \to H^0Z^0$, WITH $H^0 \to b\bar{b}$, $Z^0 \to \mu^+\mu^-$



Detector Simulation for the e^+e^- Linear Collider-

A Comparison of BRAHMS and SIMDET Response



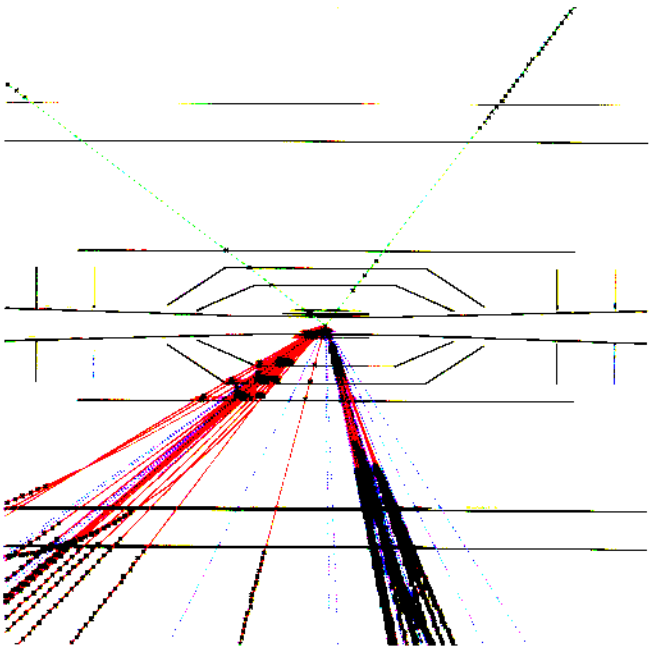
- Satisfactory agreement between BRAHMS and SIMDET response,
- signing of impact parameter needs some further tuning.

Impact Parameter Resolution for different Tracker Geometries

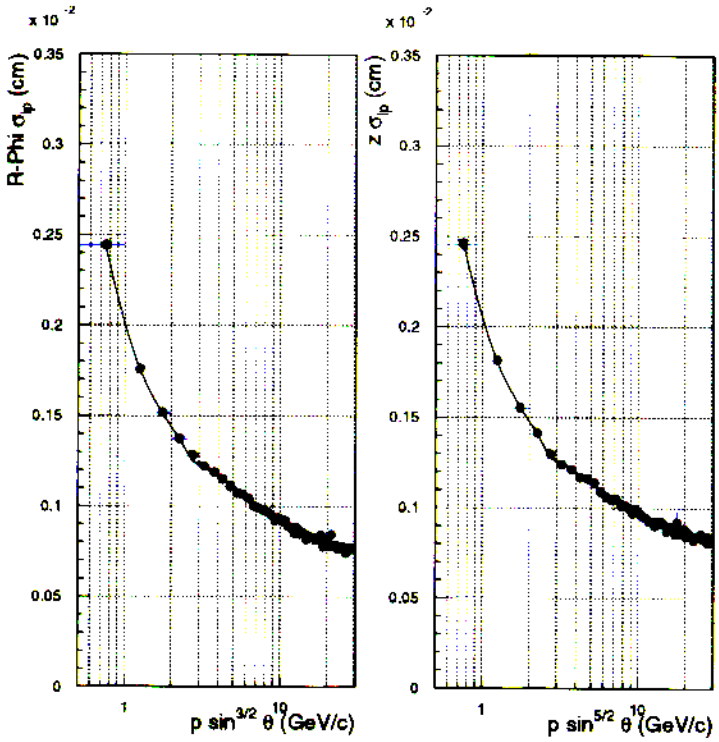
Geometry	R_{bp}	R_1	R_2	R_3	R_4
Default	2.0	2.2	7.0	10.0	
1	1.9	2.0	7.0	10.0	13.0
2	1.9	2.0	5.0	10.0	13.0
3	1.9	2.0	5.0	10.0	15.0
4	1.5	1.6	7.0	10.0	13.0
5	1.5	1.6	5.0	10.0	13.0
6	1.1	1.2	5.0	7.0	10.0
7	1.1	1.2	3.5	6.5	9.5

- Use TPC + Vertex Tracker,
- Force correct hit association,
- Perform Full track fit and compute lifetime signed impact parameter w.r.t. beam-spot
- Using combined tracking, impact parameter resolution σ is not described by simple $\sqrt{A^2 + (B/(p \sin^{3/2}\theta))^2}$ formula

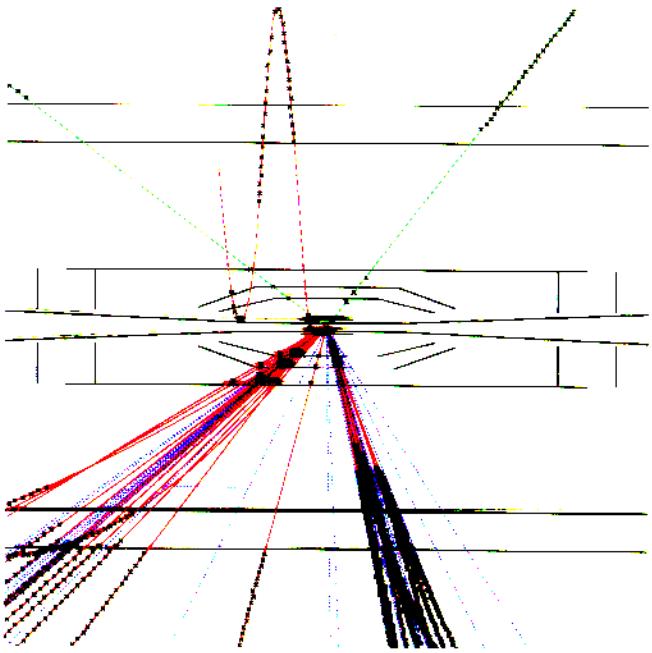
Geometry 1



$R-\phi$ and $R-z$ Impact Parameter Resolutions



Geometry 6



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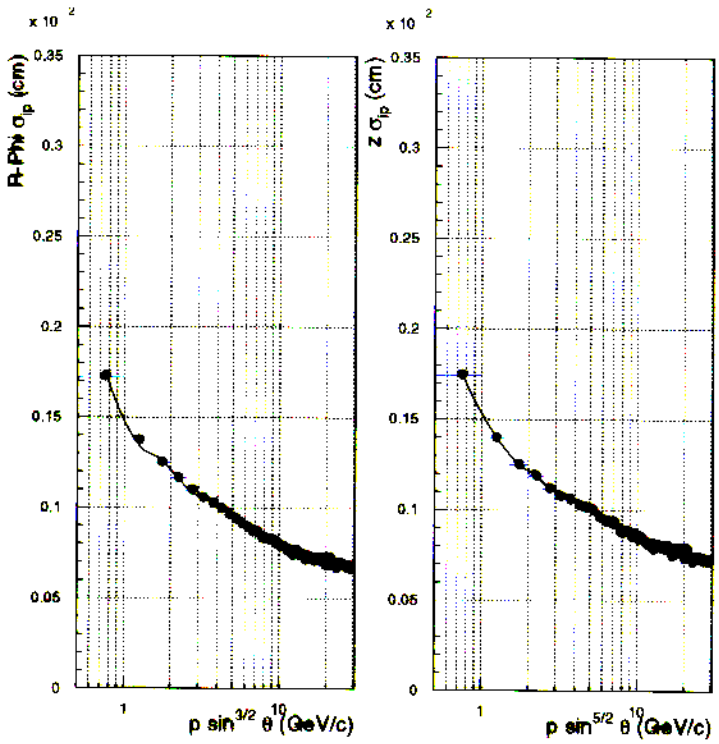

Jet Flavour Tagging Results for Higgs Physics

- Follow main ideas developed for b-tagging at LEP:
  - Use measured track impact parameter to define the probability for all tracks in a jet to originate at colliding beam position;
  - Add information from topological reconstruction of sec. vtx:
- Combine individual probabilities to define jet, di-jet or event likelihood for each flavour.
- use full simulation of Vertex Tracker pattern recognition and track fit to include non gaussian tails due to outlier hits.

Di-Jet Flavour Tagging Performances