Cluster Counting Drift Chamber as high precision tracker for ILC experiments

G.F. Tassielli [1,2]

(1) **Dipartimento di Fisica dell'Universita' del Salento, Italy and (2) INFN Sezione di Lecce, Italy**

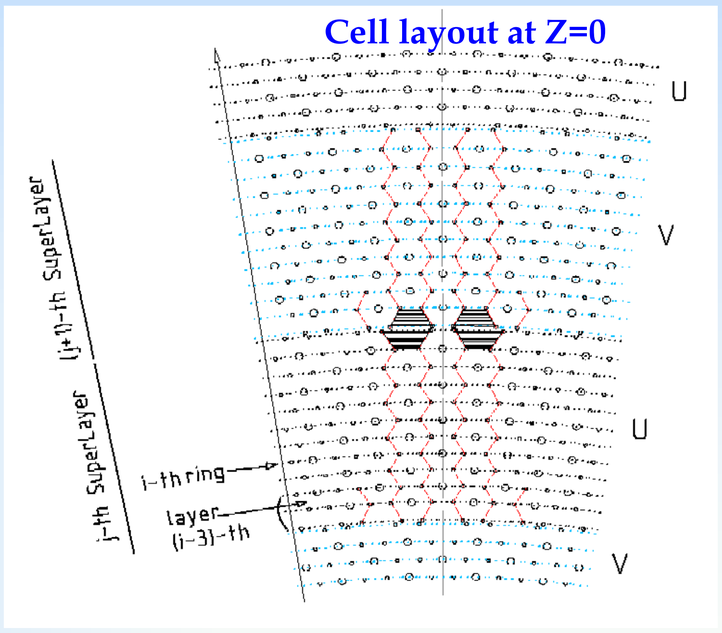
ABSTRACT

We present a Drift Chamber with unprecedented performance proposed for the "4th-Concept" detector at the next International Linear Collider. The helium rich based gas mixture, the aluminum wires and the carbon fiber structure guarantee high transparency and minimal multiple scattering contribution down to .55% X_0 whereas a full stereo geometry allows for an efficient three-dimensional track reconstruction. We show that, with the use of the cluster timing technique, thanks to a dedicated front end electronics, both spatial resolution and particle identification can be pushed to their theoretical limits. Moreover, because of its very high granularity, its total integration time is contained within one ILC bunch crossing length. An assessment of the physics potentials of this detector has been investigated with a detailed simulation of some benchmark reactions at ILC. In this scenario a resolution of the order of $\Delta p_t/p_t^2 = 10^{-5}$ *GeV*$^{-1}$*c* up to momenta as high as 50 *GeV/c* has been achieved. Lastly, due to its potentiality, this Drift Chamber may represent a valid solution for the central tracker of the Super B, in particular for its excellent performance in particle identification.

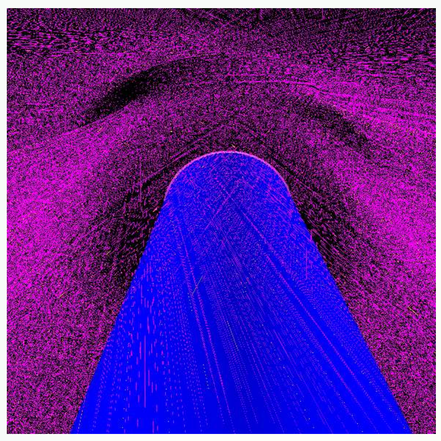
Chamber description: Structure, layout and properties

- Gas Mixture 90% Helium – 10% C_4H_{10};
- Hexagonal cells;
- Cell height 0.8-1.2 cm, Cell side 4-6 mm;
- 24 superlayers with 10 rings;
- Stereo angle ±(55-210) mrad (drop δ=4cm);
- 66000 20 μm W sense wires;
- 156000 80 μm Al field wires;
- Active volume >90%;
- Radius: Inner 19cm, outer 150cm;
- Spherical EndCaps (R=212cm);
- Length: barrel region 300cm, total 428 cm;
- Light Structure:
  - inner wall (0.001 X_0) made of 200 μm carbon fiber foil covered by a 30 μm Aluminum;
  - outer wall (0.020 X_0) made of 6 carbon fiber aluminum hexcell sandwich panels held by 6 structural struts of unidirectional carbon fiber;
  - end caps (0.029 X_0) made of 5 mm carbon fiber;
- Gas + Wires + Inner wall are equivalent to 0.0037 X_0 for a θ=90° track.

Cell layout at Z=0

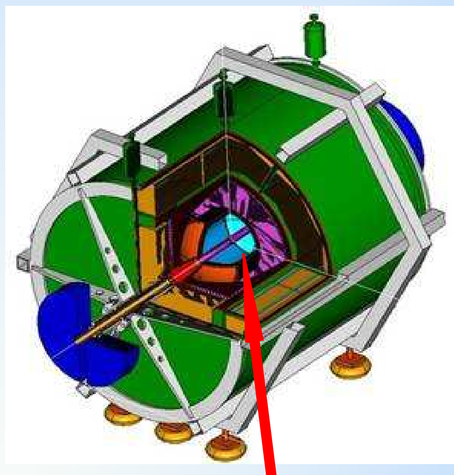


Inside view

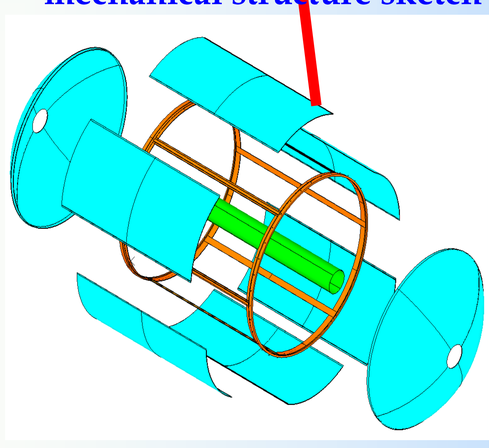


4th-Concept detector at ILC

For a detailed description see:
The 4th Concept Detector for the ILC
A. Mazzacane's poster at this Conference

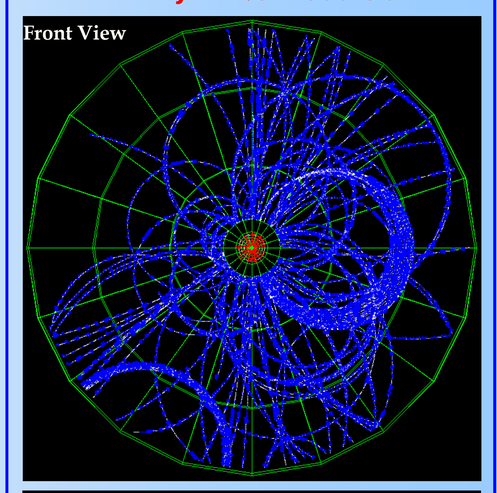


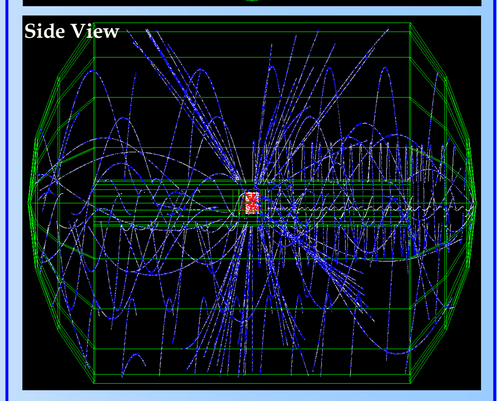
mechanical structure sketch



Designed to work in high multiplicity environment

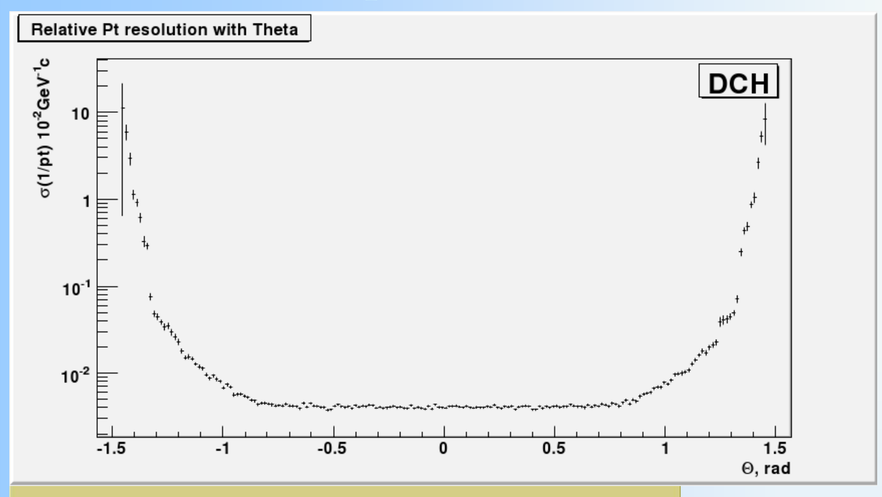
Full tracked
$t\bar{t} \rightarrow$ *6jets* $\sqrt{s}$ = 500 GeV

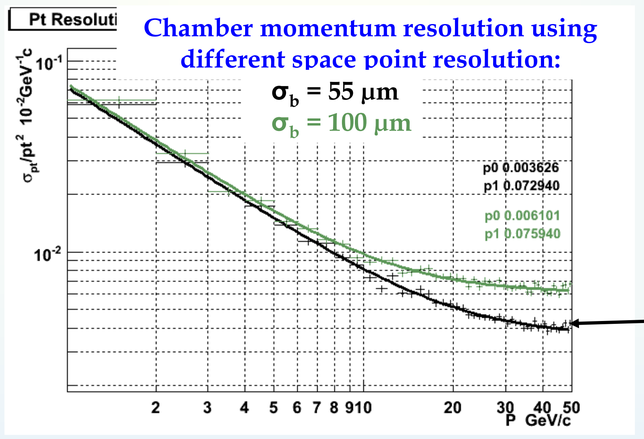


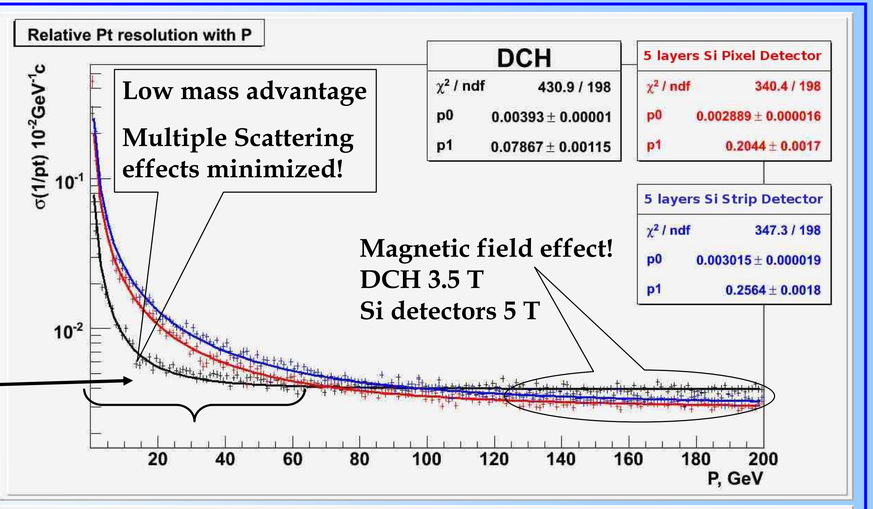


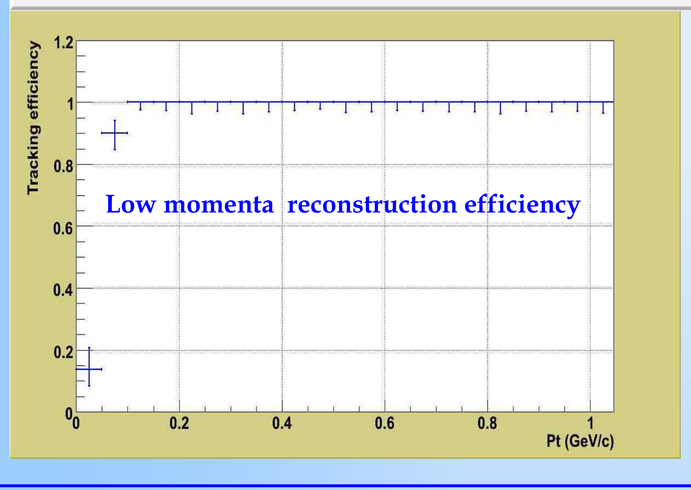
- White line simulated particles
- Blue reconstructed points
- Red reconstructed points by the Silicon Vertex detector

Chamber performance. *Simulation and Reconstruction with* ILCRoot *framework*

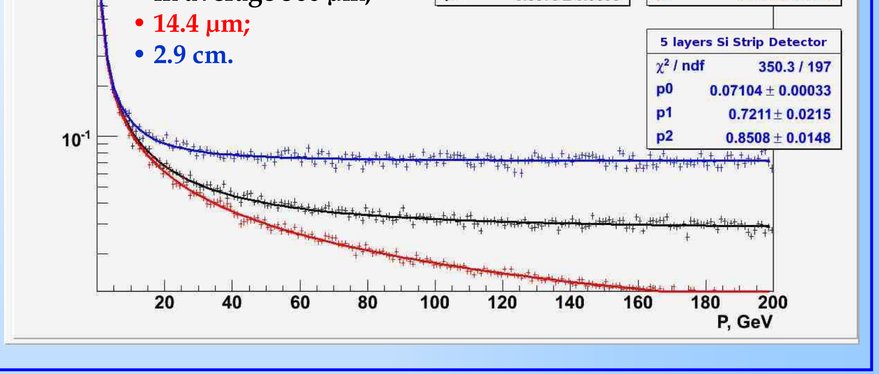








Single muon tracks (p [GeV/c])	Measurement error	Multiple Scattering
$\sigma(1/p_t)$ [c/GeV]	3.9×10^{-5}	$7.9\times10^{-4}/p$
σ_θ [mrad]	0.027	$0.69/p^{0.80}$
σ_φ [mrad]	0.027	$1.25/p$
σ_d [μm]	2.0	$14.9/p^{0.57}$
σ_z [μm]	2.9	$17.7/p^{0.58}$

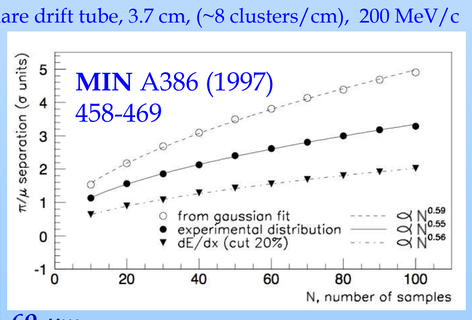


Cluster Counting / Timing

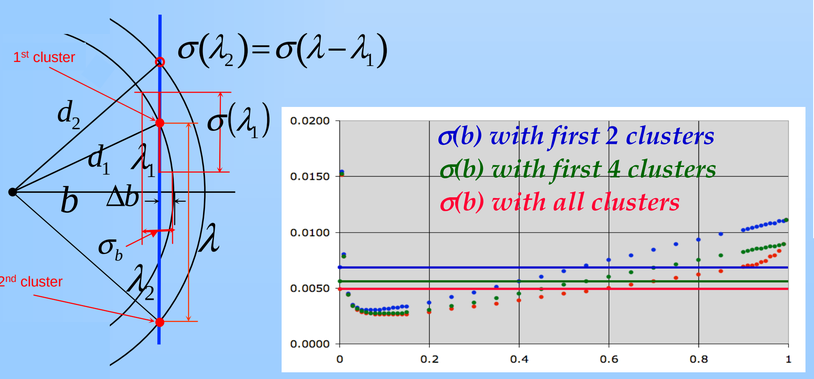
theoretically it can improve single cell spatial resolution

experimentally improves Particle IDentification

square drift tube, 3.7 cm, (~8 clusters/cm), 200 MeV/c



69 μm
56 μm
49 μm



$$b_i^2 = f_i^2(\lambda, d_1, d_i) = \frac{d_i^2 + d_1^2}{2} - \left[\mathrm{int}\left(i/2\right)\left(\lambda/2\right)\right]^2 - \left[\frac{d_i^2 - d_1^2}{2\,\mathrm{int}\left(i/2\right)\lambda}\right]^2$$

1.5 m track ~ 2000 clusters

$$\frac{\sigma(dN/dx)}{dN/dx} \approx 2.2\%$$

CONCLUSIONS

The measurements of the number of ionization clusters and of their drift time in a full stereo Chamber for ILC provides:

- **transverse impact parameter with σ_b ~ 55μm and longitudinal resolution of σ_z ~ 500μm;**
- **track crossing time (trigger and t_0) with a precision of ≤ 1 ns;**
- **particle identification with a σ(dN/dx) of ≤ 2.5%.**

FURTHER STUDIES

A prototype instrumented with a readout electronics in 0.13 μm CMOS technology with a preamplifier, 750 MHz bandwidth and a 6 bit, 1 Gsa/s flash ADC is under design at INFN Lecce.
The prototype will be tested in a beam to prove the cluster counting / timing performance.

for information and details contact: giovanni.tassielli@le.infn.it