TPC optimization wish-list for the ILD-TDR

ILD collaboration meeting Paris, 27-30 January 2010

LCTPC Collaboration

- Performance goals and design parameters for a TPC with standard electronics at the ILC detector

Size	$\phi = 3.6$m, L = 4.3m outside dimensions
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 9 \times 10^{-5}$/GeV/c TPC only (× 0.4 if IP incl.)
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 2 \times 10^{-5}$/GeV/c (SET+TPC+SIT+VTX)
Solid angle coverage	Up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\sim 0.04X_0$ to outer fieldcage in r $\sim 0.15X_0$ for readout endcaps in z
Number of pads/timebuckets	$\sim 1\times10^6/1000$ per endcap
Pad size/no.padrows	$\sim$ 1mm×4–6mm/$\sim$200 (standard readout)
σ_{point} in $r\phi$	$< 100\mu$m (average over $L_{sensitive}$, modulo track ϕ angle)
σ_{point} in rz	$\sim$ 0.5 mm (modulo track θ angle)
2-hit resolution in $r\phi$	$\sim$ 2 mm (modulo track angles)
2-hit resolution in rz	$\sim$ 6 mm (modulo track angles)
dE/dx resolution	$\sim$ 5 %
Performance	> 97% efficiency for TPC only ($p_t > 1$GeV/c), and > 99% all tracking ($p_t > 1$GeV/c)
Background robustness	Full efficiency with 1% occupancy
Background safety factor	Chamber will be prepared for 10 × worse backgrounds at the linear collider start-up

with MPGD

There is not much improvement possible the TPC performance (also for CLIC) because this is about the best you can do with standard readout.

What about pixels?

Potentially somewhat more accurate, but still many unknowns…

From the LCTPC MOA-Addendum2009

4.1 RD/IDAG Workplan

General statements can be made as to the RD's workplan in Section 1.2. With regard to "demonstration of proof of principle on critical components and definition of a feasible baseline with options", these have already been demonstrated using the Small Prototypes, are being verified using the Large Prototype, and have been presented in the ILD LOI. The LCTPC performance parameters presented in the LOI are reproduced below (Table 5).

The remaining points mentioned in Section 1.2, "completion of mechanical design and development of a realistic simulation", are the subjects of Workpackage 5 in Sections 2.3 and 3.3.2 and belong to the category "work in planning". Preliminary solutions to these points have also been included in the ILD LOI, and details will be further developed in 2010.

Performance table in the ILD LOI

Performance and design parameters for an LCTPC with standard electronics are recalled here. Understanding the properties and achieving the best possible point resolution have been the object of R&D studies of Micro-Pattern Gas Detectors, MicroMegas and GEM, and results from this work used to define the parameters in Table 5. The parameters in this preliminary design represent the best technical solution at the moment and have been agreed upon by the LCTPC Collaboration in 2009.

Table 5

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Size	$\phi = 3.6$m, L = 4.3m outside dimensions
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"Critical" R&D

"Shown" with SP/LP

Summary of TPC performance goals

- See Jan's TPC talk at yesterday's "critical-R&D-for-subdetectors" session
- Executive summary: many parameters in the table on the preceding slide have been derived from SP R&D and will be confirmed by LP measurements; there are still several "critical" things to do for the TDR.
- For the TDR studies we have created a new workpackage →

Table 2	
Workpackage	**Convener**
Workpackage (0) TPC R&D Program	LCTPC collaboration

Workpackage (1) Mechanics	
a) LP endplate structure, design	**Dan Peterson**
b) Fieldcage, laser, gas	**Ties Behnke**
c) GEM panels for endplate	**Akira Sugiyama**
d) Micromegas panels for endplate	**Paul Colas**
e) Pixel panels for endplate	**Jan Timmermans**
f) Resistive anode for endplate	**Madhu Dixit**

Workpackage (2) Electronics	
a) Standard RO/DAQ sytem for the Large Prototype	**Leif Joensson**
b) CMOS RO electronics	**Harry van der Graaf**
c) Standard electronics for LCTPC	**Luciano Musa**

Workpackage (3) Software	
a) LP software + simulation/reconstruction framework	**Christoph Rosemann**
b) LP DAQ	**Gilles De Lentdecker**
c) LCTPC simulation/performance/backgrounds	**Keisuke Fujii**

Workpackage (4) Calibration	
a) Field map for the LP	**Lucie Linsen**
b) Alignment	**Takeshi Matsuda**
c) Distortion correction	**Dean Karlen**
d) Outgassing properties of materials	**Anatoliy Krivchitch**
e) Gas/HV/Infrastructure for the LP	**Klaus Dehmelt**

To prepare for the TDR, this structure will be supplemented with fifth workpackage:

Workpackage (5) LCTPC preparations for TDR	**Convener**
a) Advanced endcap mechanics + alignment	**Dan Peterson**
b) Advanced endcap with SAltro, cooling, power pulsing	**Luciano Musa**
c) Gating device	**Akira Sugiyama**
d) Fieldcage	**Peter Schade/ Klaus Dehmelt**
e) ILD TPC Integration	**Robert Volkerborn/ Michael Carty**
f) LCTPC Software	**Christoph Rosemann**
g) Testbeams	**Takeshi Matsuda**

Coveners of the new workpackages overlap significantly with the previous structure because the issues are closely related. The new workpackages are meant to specifically guide the TDR preparations; more explanation is presented in Section 3.3.2.

What about optimizing (improving) the performance?:

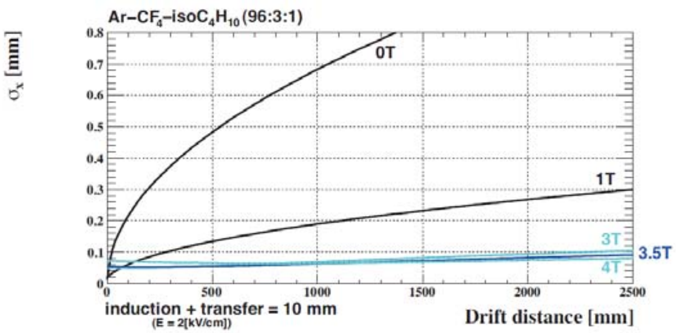
Some candidates:

- Technology options
- Endcap thickness
- Resolution
- Size

LCTPC performance goals

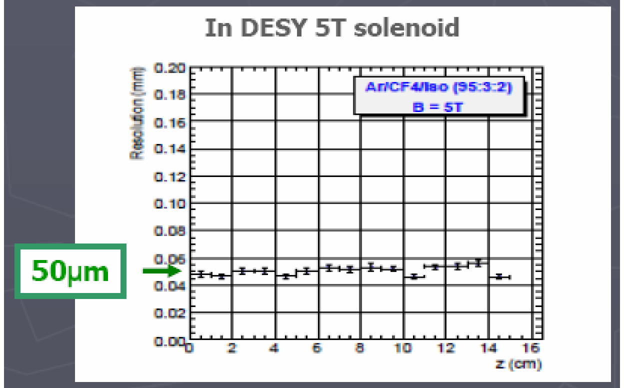
Present goals based on results from small prototypes using cosmics or beams at KEK, DESY, CERN. Three options left →

GEM gas-amplif. for a TPC

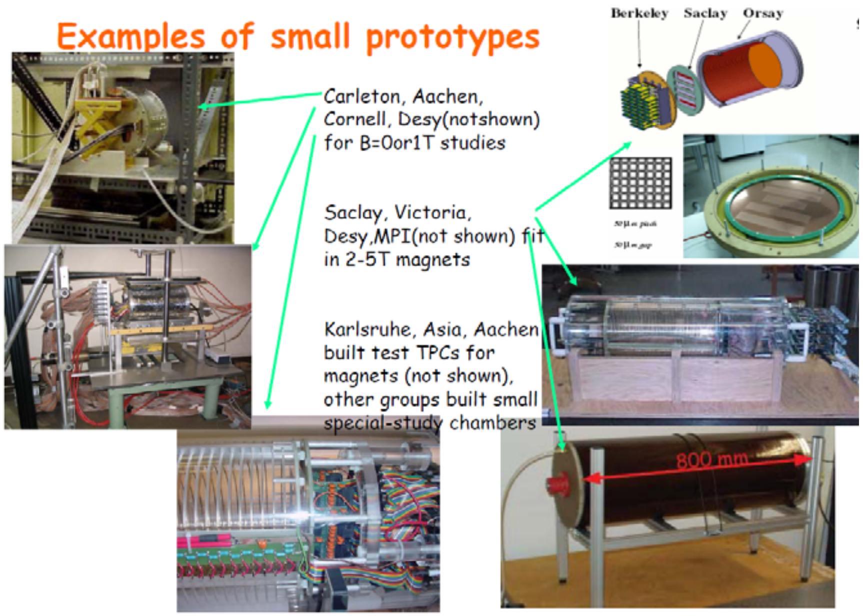


MicroMEGAS TPC with resistive anode

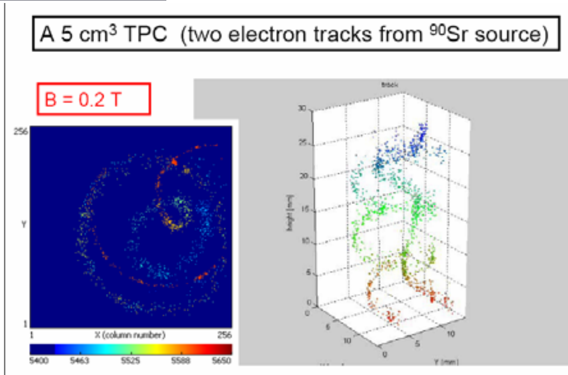
Carleton TPC (M. Dixit et al., 2007)



Examples of small prototypes



Silicon Pixel Readout for a TPC



We don't have to decide which option yet, we just have to show that the performance table for the TDR is achievable…

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What needs more MDI-study?

- Details related to dead spaces for material and supports (none of these things should affect the performance much):
  - fieldcage thicknesses
  - − will there be a redesign after vibration studies?
  - we don't know yet the exact number of cables; will take a while...
  - the design of supports and endcap modules...

The TPC wish-list of questions… using the 'final' PFA algorithm:

-How does the PFA performance in the forward direction change as the endplate X_0 changes from 15% to 30% to 45%? This will tell us how critical our 15%-goal is.

-How does the forward PFA performance change as a function of TPCendplate↔ECALendcap distance? E.g., is the TPC endcap mechanical thickness or is the ETD mechanical thickness affecting the PFA performance?

-Revisit the aspect ratio of the TPC ? E.g., can we make the detector shorter, say 2000mm instead of 2200mm for the TPC, if required by other boundary conditions (like endcap coils, ℓ^*, *etc*)?

-Other suggestions? The floor is open for discussion…