TPC R&D, status and plans

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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 ($\times$ 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	$\sim 1{\times}10^6$/1000 per endcap
Pad size/no.padrows	$\sim$ 1mm$\times$4–6mm/$\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 > 1GeV/c), and
	> 99% all tracking (p_t > 1GeV/c) [82]
Background robustness	Full efficiency with 1% occupancy,
	simulated for example in Fig. 4.3-4(right)
Background safety factor	Chamber will be prepared for 10 $\times$ worse backgrounds
	at the linear collider start-up

with MPGD

Technology options considered

- Pad readout (‘analog’ TPC, ADC digit.):
  - Double-GEM, triple-GEM
  - Micromegas (with resistive pad plane)

(also TDC readout being explored)

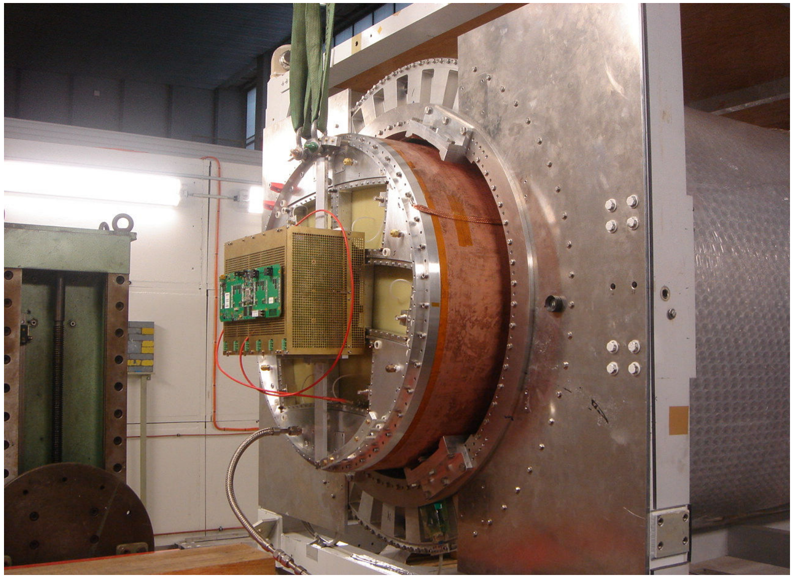
- Pixel readout (‘digital’ TPC, Timepix):
  - Triple-GEM
  - Ingrid (integrated ‘Micromegas-like’ grid)
- Gating studies w. GEM or wire plane

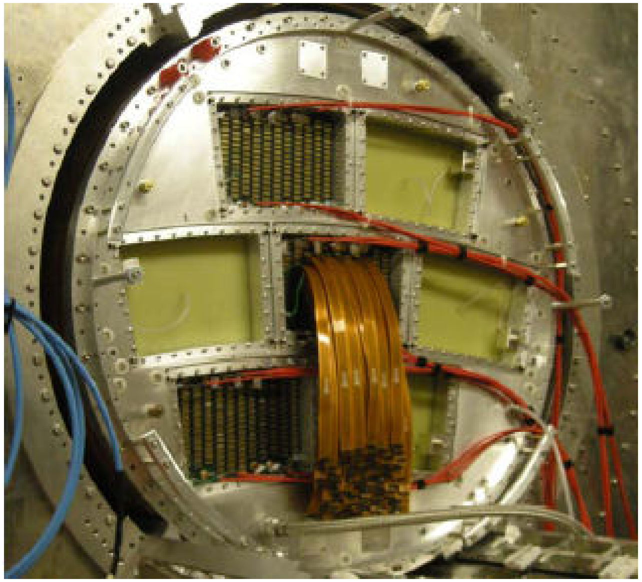
Current status: LCTPC/EUDET infrastructure at DESY electron testbeam (5 GeV)

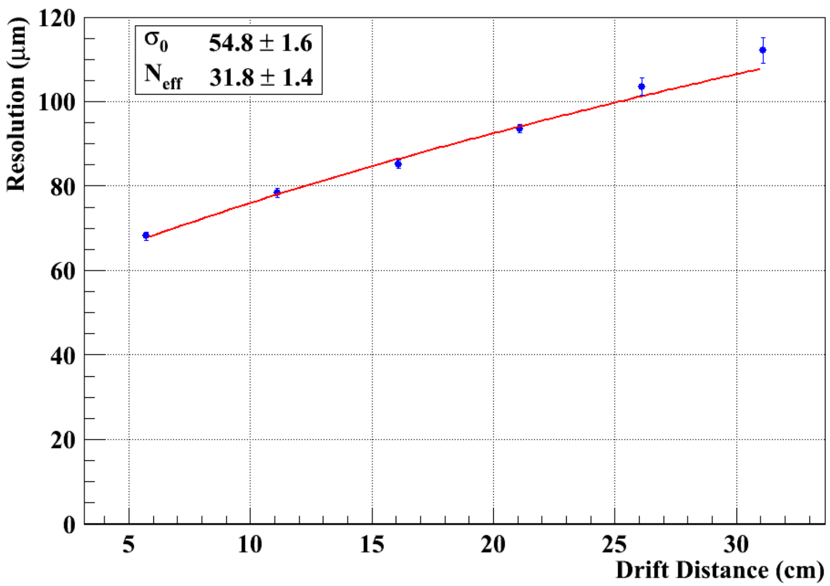
- 1T solenoid PCMAG
- LP (fieldcage, endplate, cathode) + services
- Endplate modules tested sofar;
  - Micromegas (3 different modules); T2K electr.
  - 3 (Asian) dual-GEMs; ALTRO electr.
  - Triple-GEM with Timepix readout (8 chips)
  - Triple-GEM with ALTRO pad readout
- Software development (MarlinTPC) ongoing; more work than anticipated

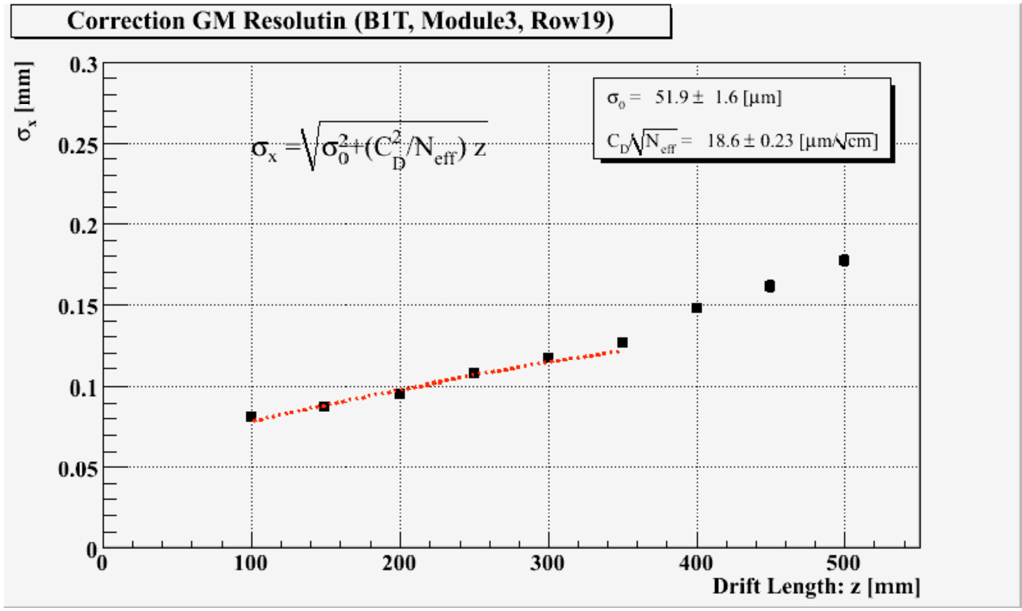
Micromegas (1 module 1700 ch.)

3 double-GEM modules (3300 ch.)



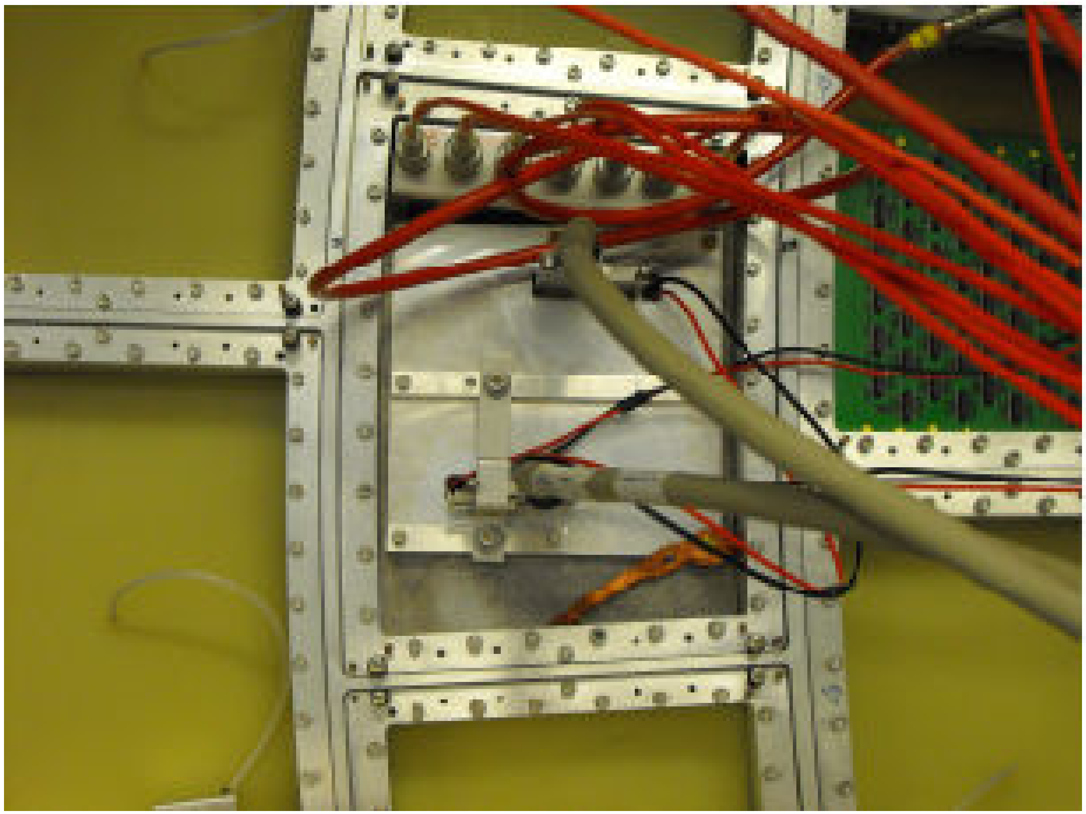


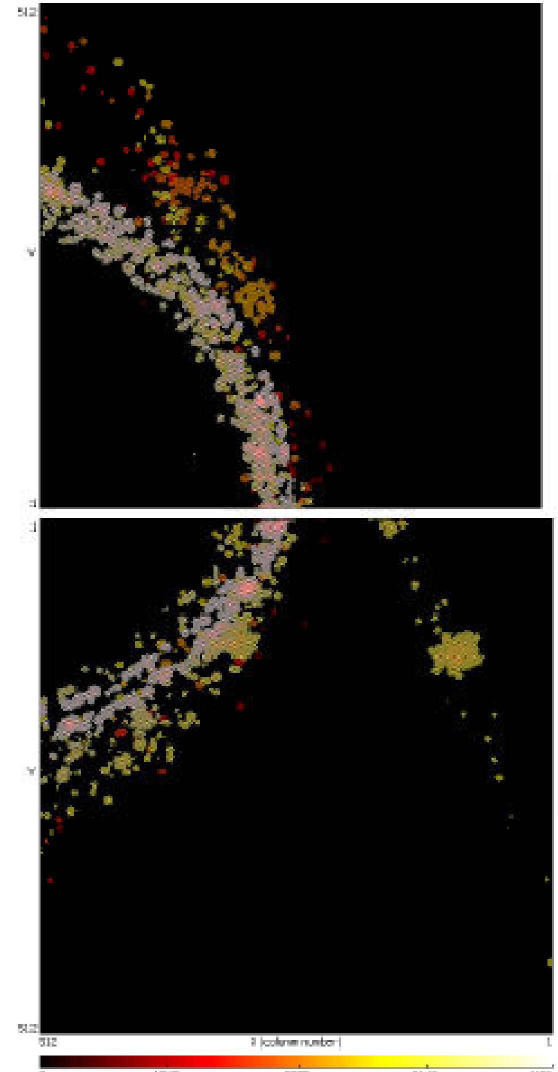




Triple-GEM module with readout by 8 Timepix chips: 16 cm2 active area, 0.5M channels

Bonn/Freiburg





Near future plans (~2010)

- 7 modules Micromegas w. T2K electr. in ‘flip-chip’ mounting (7x1700 ch.)
- Up to 4 modules of (Asian) double-GEM + gating-GEM w. 10,000 ch. ALTRO electr.
- Development of new ‘stiffer’ GEM module/mounting
- Development S-ALTRO 0.13um chip; 16ch prototype Spring 2010; final 64ch version needs funding
- New endplate (some funding available):
  - Thinning of present design: could reach close to .15 X_0 (2 yrs)
  - New technology (e.g. C) or spaceframe design study (~3 yrs)
- Development “full” endplate module w. Timepix (64/119 chips)
- Development new fieldcage w. laser tracking capability, including improved HV cathode connection

Further studies up to 2012+

- Power pulsing and cooling tests:
  - Start in 2010 with (Japanese) dummy modules
  - Using both LP and smaller prototype detectors
  - These studies can be done without beam in e.g. 5T solenoid at DESY
- Ion backflow studies; include in order of priority:
  - Simulation studies
  - Development of gating device
  - Development of device for producing ILC-like ion sheet

TPC R&D priorities

1a) development endplate (max. 15% X_0 including cooling) (2010-2011+)

1b) continue tests with electron beam for correction procedures (2010)

2a) future tests in hadron beam (2011):

- for momentum resolution
- for two-track separation in a ‘jet’ environment

2b) powerpulsing/cooling tests both on LP and SP (2010+)

3) ion backflow studies (2010++):

- simulations of ion sheets for GEM, Micromegas
- development gating device
- development device for producing ILC-like ion sheet

Resources

- LCTPC collaboration has no (common) funding; groups have more or less funding. Inventory has to be (re)made
- EUDET funding has ~ finished
- New EU proposal in preparation; however (if accepted) will be less €€€ than EUDET

- Some funding available for:
  - Endplate studies
  - Powerpulsing
  - Cooling
  - If Timepix2 development, large contribution from Medipix Coll. and RD51 groups

Next steps, from the LOI

- 2009-12 Continue R&D on technologies at LP, SP, pursue simulations, verify performance goals
- 2009-11 Plan and do R&D on advanced endcap; power-pulsing, electronics and mechanics are critical issues.
- 2011-12 Test advanced-endcap prototype at high energy and power-pulsing in high B-field.
- 2013-18 Design and build the LCTPC.

At the beginning of the period 2012-18, the selection must be made from the different technological options – GEM, MicroMegas, resistive anode, pixel, electronics, endcap structure – to establish a working model for the design of the LCTPC. This design will be used for the ILD proposal in 2012 and include pad segmentation, electronics, mechanics, cooling and integration, so that performance, timeline and cost can be estimated reliably. [2] For the technology selection, a scenario could be that questions must be answered as to which options give the best performance based on R&D results from LP, SP, electronics and endcap studies. Main performance criteria could be endcap thickness and σ_{point}, double-hit and momentum resolution for single tracks and for tracks in a jet environment. Choice of criteria to use will be decided over the next two years.