Summary: Gas Tracking

IWLC2010
20 October 2010
Geneva

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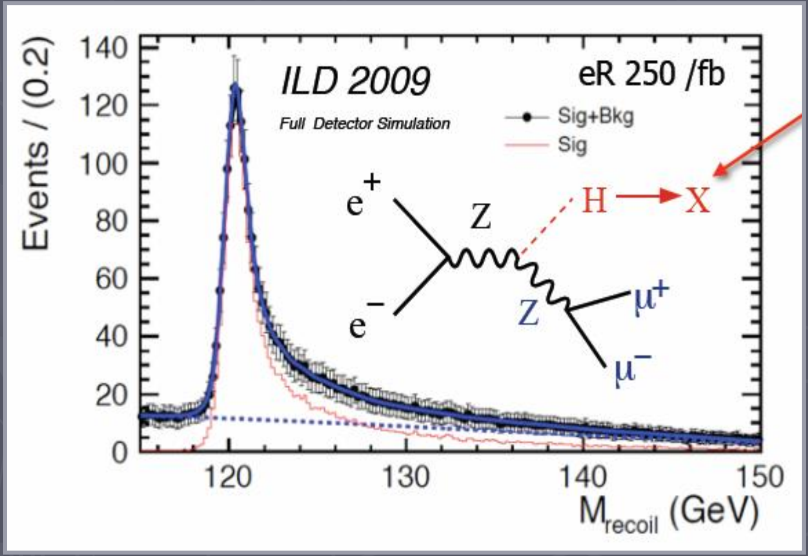
DESY/FLC and KEK/IPNS

Momentum Resolution at ILC
(What is the goal at CLIC?)

ILC-RDR
LDC LOI

1. Higgs recoil mass: $e^+e^- \rightarrow ZH\ (Z\rightarrow\mu\mu/ee) + X$:
   The beam energy spread dominates when $\delta(1/pt) \leqq 5 \times 10^{-5}$.
2. Slepton and the LSP masses though the end point measurement:
   σ_M (Momentum resolution) ~ σ_M (Parent mass) at 1 ab^{-1}
   when $\delta(1/pt) \leqq 5 \times 10^{-5}$
3. E_{cm} determination from $e^+e^- \rightarrow \mu^+\mu^-(\gamma)$
4. Rare decay Br ($H \rightarrow\mu\mu$) in $e^+e^- \rightarrow ZH$ and $H\nu\nu$:



Higgs mass resolution by ILC-ILD

MPGD TPC: Goal at ILC

$\sigma_{r\varphi}$ ≦ 100 μm
points/track ~ 200
Lever arm ~ 1.5 m
High B Field 3.5T (no ExB)
Alignment and corrections

$\delta(1/p_t)$ ~ 9×10^{-5}
(TPC alone)

Specifications of TPC at ILC (ILD)

ILC-RDR
LDC LOI

TABLE 4.3-5
Goals for performance and design parameters for an LCTPC with standard electronics.

Size	$\phi = 3.6$m, L $= 4.3$m 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)
$\sigma_{\rm point}$ in $r\phi$	$<$ 100μm (average over $L_{sensitive}$, modulo track ϕ angle)
$\sigma_{\rm point}$ 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) [83]
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

Options of MPGD TPC for LC

Analog TPC:

(1) Multi layer GEM + Narrow (1mm wide) pad readout:
Defocusing by multilayer GEM

(2) MicroMEGAS + Resistive anode pad redaout:
Widening signal by a resistive anode

Beam test results → $\sigma_{r\varphi}$< 100μm @ILD TPC

(3) Multilayer GEM + Timepix
A good efficiency for primary electrons
→ A larger pixel size but still a higher granularity.

Digital TPC:

(4) Ingrid (MicroMEGAS) Timepix: (Also the GEM-like Ingrid structure)
Digital → Free from the "gas gain fluctuation"
→ Expect a further improvement in $\sigma_{r\varphi}$
→ To be demonstrated soon in beam test soon.

TPC R&D by LC TPC Collaboration

Demonstration Phase: Small prototype tests

Provide a basic evaluation of the properties of **MPGD TPC** by using small prototypes, demonstrate that the requirement of the point resolution may be achieved.

Consolidation Phase: Large prototype tests (2008-)

Design, build and operate a "Large Prototype" using the EUDET facility at DESY comparing tecnologies and demonstrating the momentum resolution in a way.

Design Phase: ILD LOI → ILD DBD → ....

Start working on engineering design of TPC at ILC (ILD).

(LC TPC collaboration: MOU)

Perform beam tests at all stages.

Talks in the ECFA Parallel Sesions Tracking & Vtx (TPC) @IWLC2010

20 October

09:00	The S-Altro chip design for TPC pad readout by Paul Aspell	- (1)
09:20	Design status of the Timepix2 pixel detector chip by Xavier L. Cudie	- (2)
09:40	ILD-TPC end plate studies by Steve Aplin	- (3)
10:00	I-DEAS for an ILD-TPC by Volker Prahl	- (4)
10:15	Test beam needs for TPC R&D by Takeshi Matsuda	- (5)

21 October

16:00	ALICE TPC by Peter Braun-Munzinger	- (6)
16:30	Studies for a TPC in a CLIC Detector by Martin Killenberg	- (7)
16:50	Test beam Results from JGEM/Tracking Software by Ryo Yonanime	- (8)
17:10	Recent Analysis Results from MicroMegas by Wen Wenxin	- (9)
17:30	Single Point Resolution Studies and Development and Analysis of Grid GEMs by Lea Steder	-(10)
17:50	Towards a 7-Module Large Prototype by Paul Colas	- (11)
18:10	The LP Setup at DESY: a Status Report by Klaus Dehmelt	- (12)

EUDET TPC Beam Test Facility at DESY

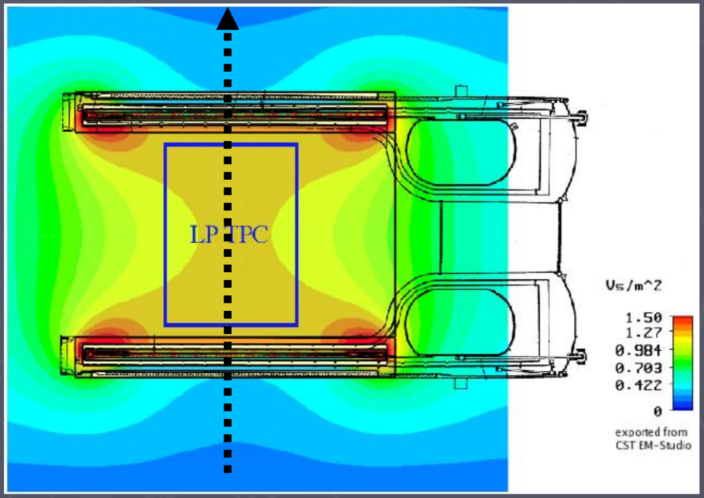
By K. Dehmelt

PCMAG :
- Open SC magnet (1T)
- Coil/cryostat of 20%X0
- On a moving stage (2010)

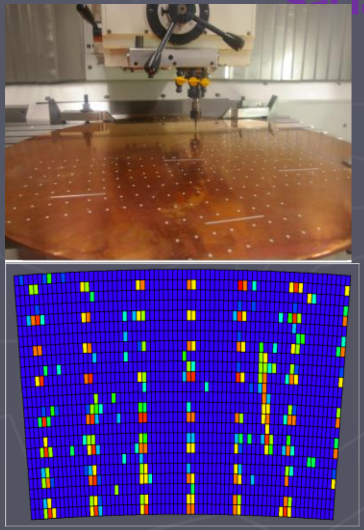
T24-1 test beam:
- 1-6 GeV/c electron beam

Cosmic trigger counters:

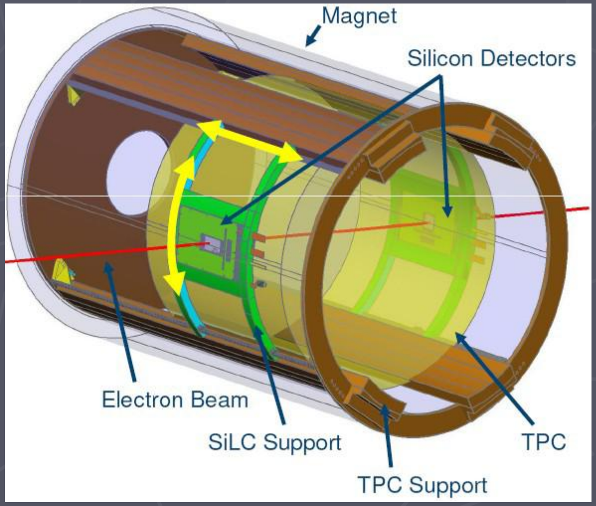
PCMAG on a moving stage (2010)



Non-uniform magnetic filed (on purpose)



Laser pattern on cathode for calibration



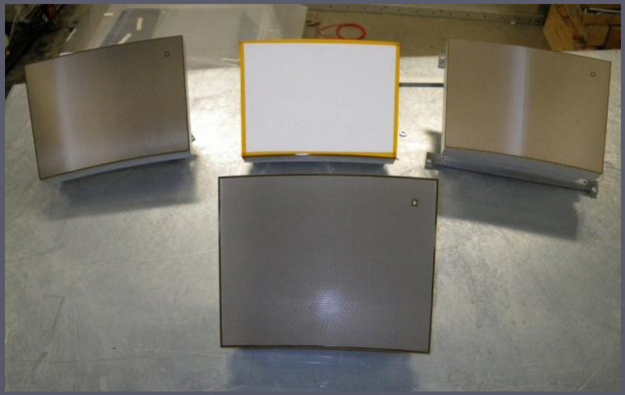
Si Envelope

TPC Large Prototype Tests: LP1

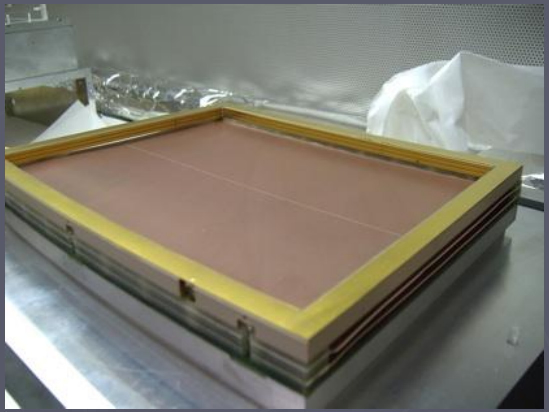
2008:
Nov-Dec MicroMEGAS modle w/ resistive anode (T2K electronics)
2009:
Feb-Apr 3 Asian GEM Modules w/o Gating GEM (3,000ch ALTRO electronics)
Apr TDC electronics with an Asian GEM Module
Apr-May Maintenance of PCMAG
May-Jun MicroMEGAS w/ two different resistive anodes (New T2K electronics)
Setup and test of laser–cathode calibration
Jun GEM+Timepix (Bonn)
Jun Installation of PCMAG moving stage and SiTR support
July TDC electronics with an Asian GEM module
ALTRO electronics study w/ an Asian GEM module
July-Aug Full installation of PCMAG moving stage
Aug MicroMegas w/o resistive anode with laser-cathode calibration
Sept A Bonn GEM module (A small aria GEM with ALTRO electronics)
Nov MicroMEGAS with SiTR
Dec MicroMEGAS with the carbon loaded kapton resistive anode.
2010:
March MicroMEGAS using PCMAG movable table.
March and Sept 3 Asian GEM modules w/ gating GEM or a field shaper) using the PCMAG movable table (7616ch ALTRO electronic)

TPC Large Prototype Beam Tests: By R. Yonamine and Wen Wenxi

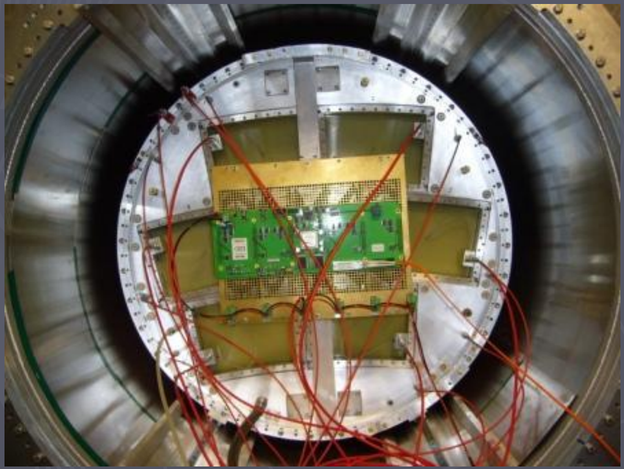
MicroMEGAS (MM) module/Three Asian GEM Modules



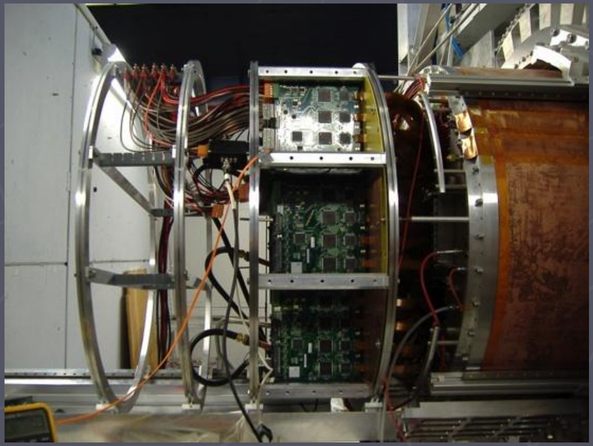
Four different MM modules
with different resistive anode



An Asian GEM modules with a field shaper
in the place of the gating GEM

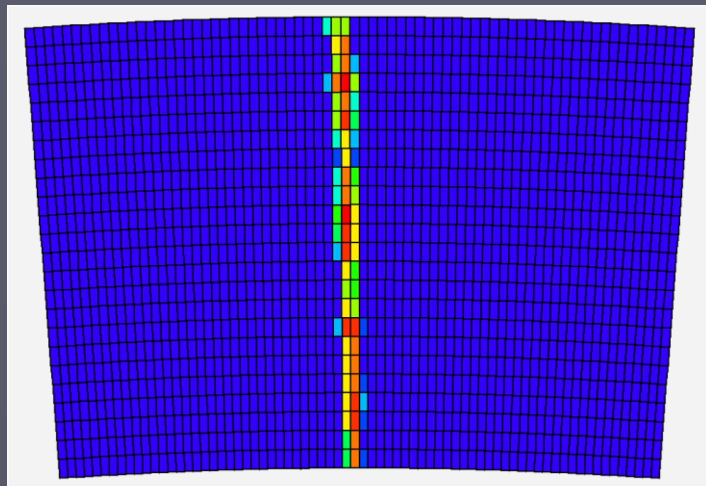


With one of the MM module
readout by T2K electronics (1724ch)



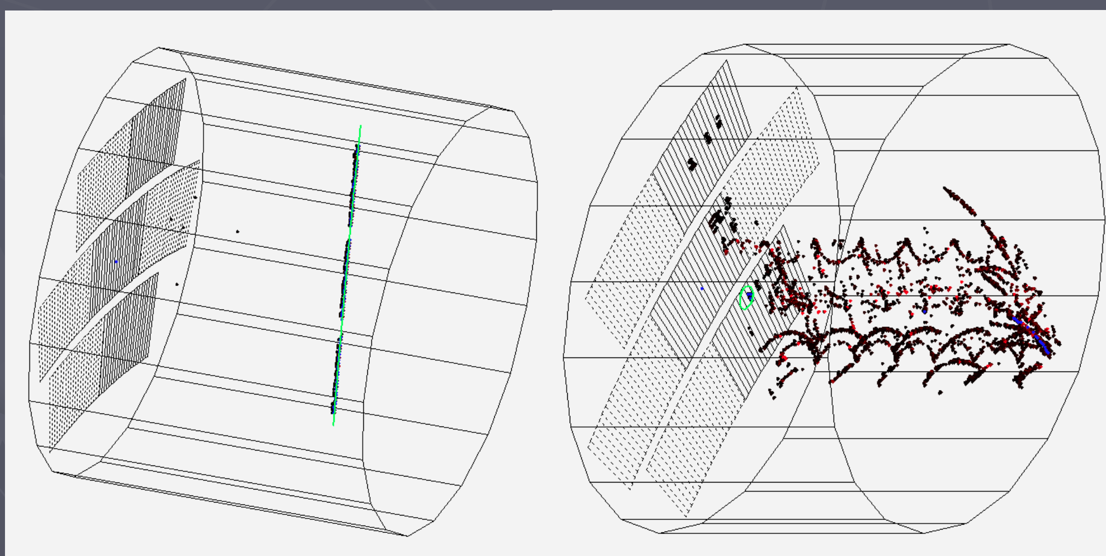
Beam test with three Asian GEM modules
readout by PCA16-ALTRO electronics (7616ch)

TPC Large Prototype Beam Test: Events



One MicroMGAS modul (9)

With a restsive anode
24 rows x 72 pads
Pad: 2.7-3.2 mm wide, 7 mm long
T2K electronics (1728ch)

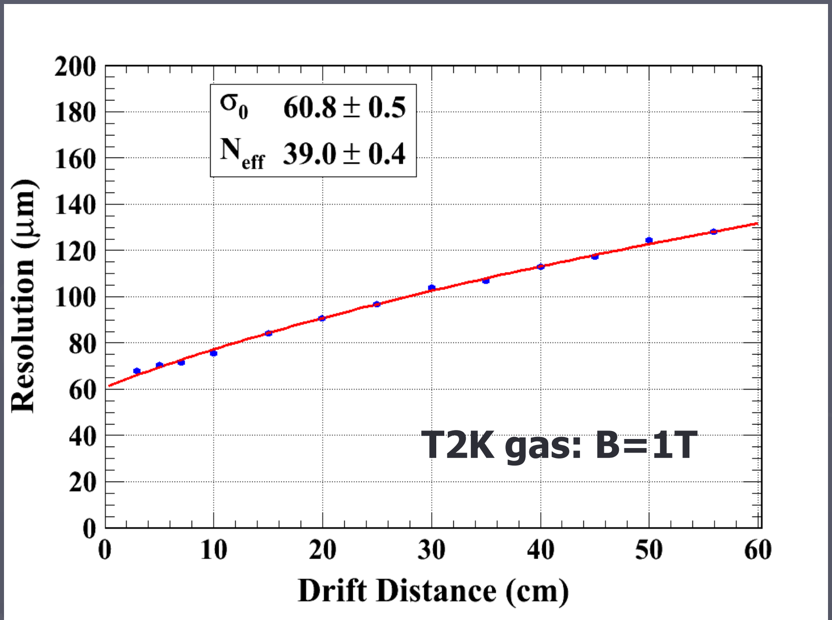


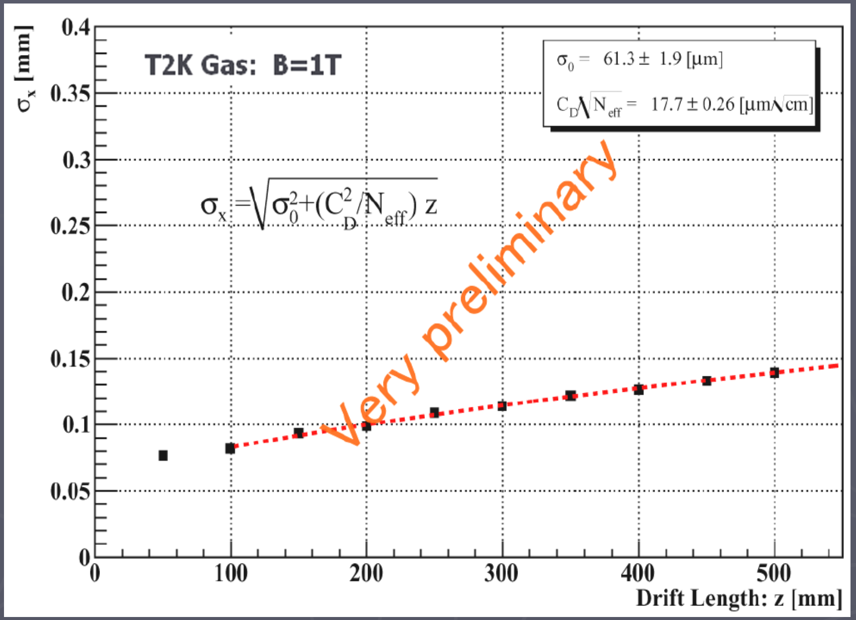
Three GEM modules (8)

Without gating GEM
28 rows x 176 -194 pads
Pad: ~ 1.1 x 5.4 mm^2
PCA16/ALTRO electronics
(7616ch
Only a part of the three GEM modules quipped with readout electronics.

A typical single track event (left), and an event with many low-energy curling tracks from the TPC cathode plane where a beam electron hits (right).

TPC Large Prototype Tests: Results





MicroMEGAS module with a carbon-loaded kapton resistive foil (T2K electronics)

GEM module of two layers of 100μmt GEM (PCA16/ALTRO electronics)

Point resolution for   ILD TPC (2m drift in B=3.5T)
→ 100μm or better.

80μm for the parameters obtained by MicroMEGAS. The drift velocities and constant measured were consistent with Magboltz simulation.

Marlin TPC for LP Beam Test:

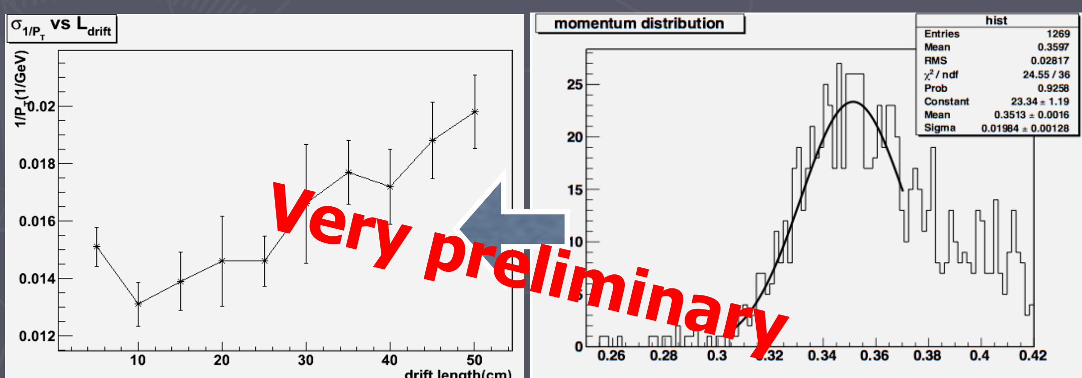
By R. Yonamine

Tracking software for multi-modules: Toward Marlin TPC

(a) "YokalowMo" with Track-Finding Kalman Filter Processor:
Input data: DAQ format
Use Kalman filter algorithm only in track fitting.

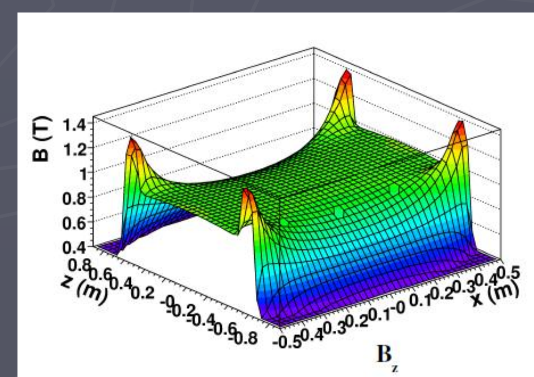
(b) "Marlin TP" with Track-Making-Kalman-Filter-Processor:
Input data : LCIO format
Use Kalman filter algorithm both in track finding and track fitting .

Implementation of the non-uniform magnetic filed: Now under work



Resolution of $1/P_t$ $1/P_t$ distribution

(No serious selection of track/no correction for non-uniform magnetic field, module misalignment and distortion)

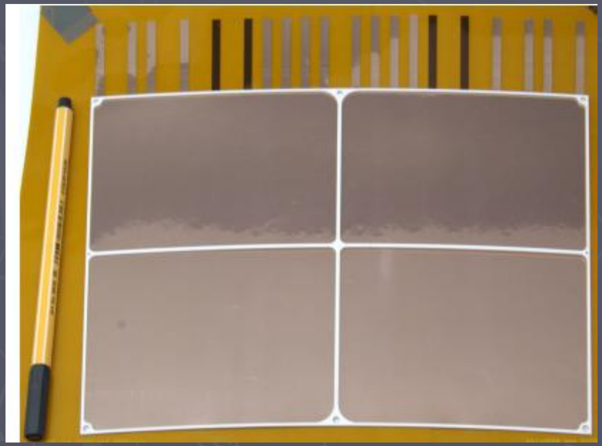


A field model by a precision field measurement (2007)

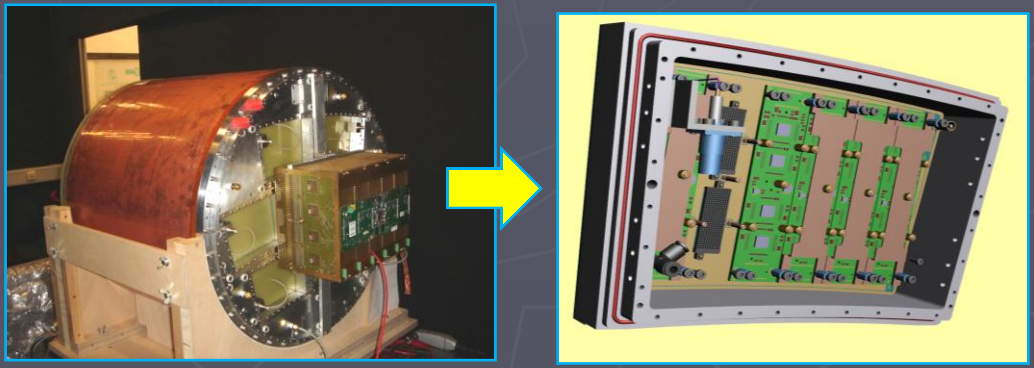
LP1 Beam Test before 2012

By L. Steder. P Colas and TM

2010:	
Nov-DEC	**A prototype of DESY GEM module: A GEM module of three GEM**
layers	**supported by thin ceramic spacers.**
2011:	
Spring	**A module with 8 Ingrid Timepix (Octopus).**
	The first MicroMEGAS module with compact T2K electronics.
	More DESY GEM modules.
June-Dec	**PCMAG modification for "Liq. He less"**
2011-2012:	**7 MicroMEGAS modules with compact T2K electronics (Full volume tracking in LP).**



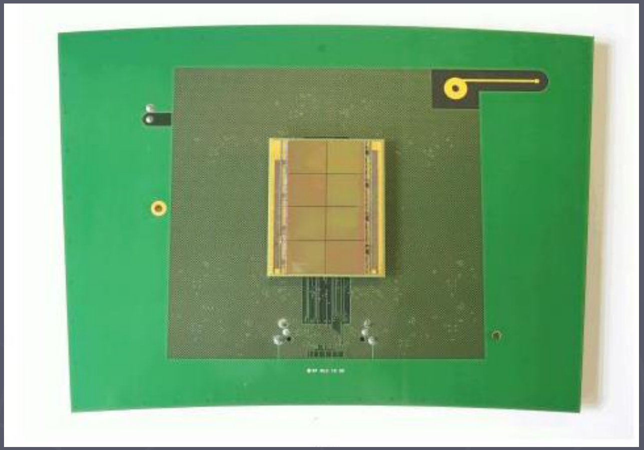
A GEM glued on a thin ceramic Spacer (DESY GEM module) Based on a test by a small prototype

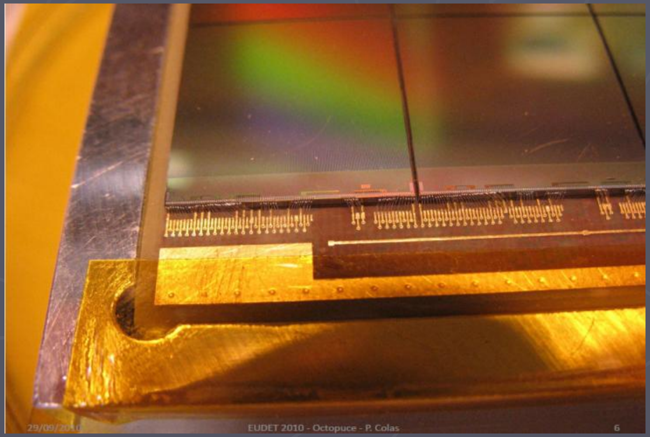


7 MicroMEGAS modules with new and compact T2K electronics

LP1 Module with 8 Ingrid Timepix: Octopus

(No talk in this meeting)



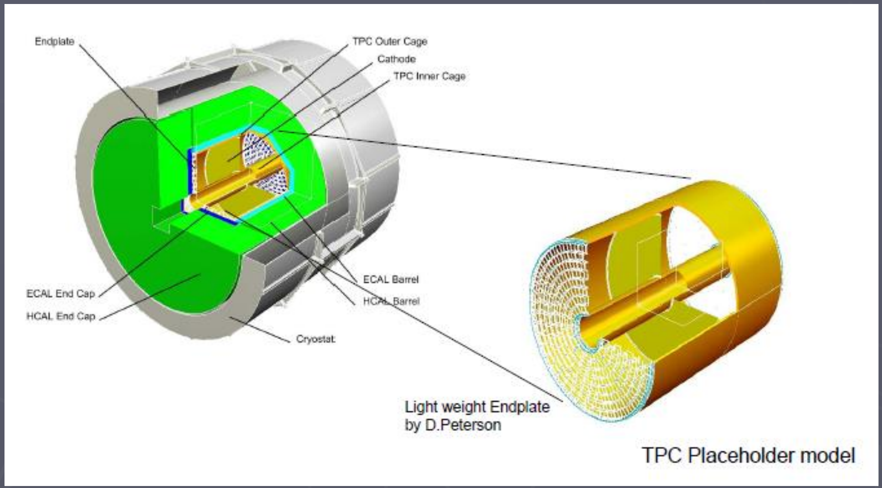


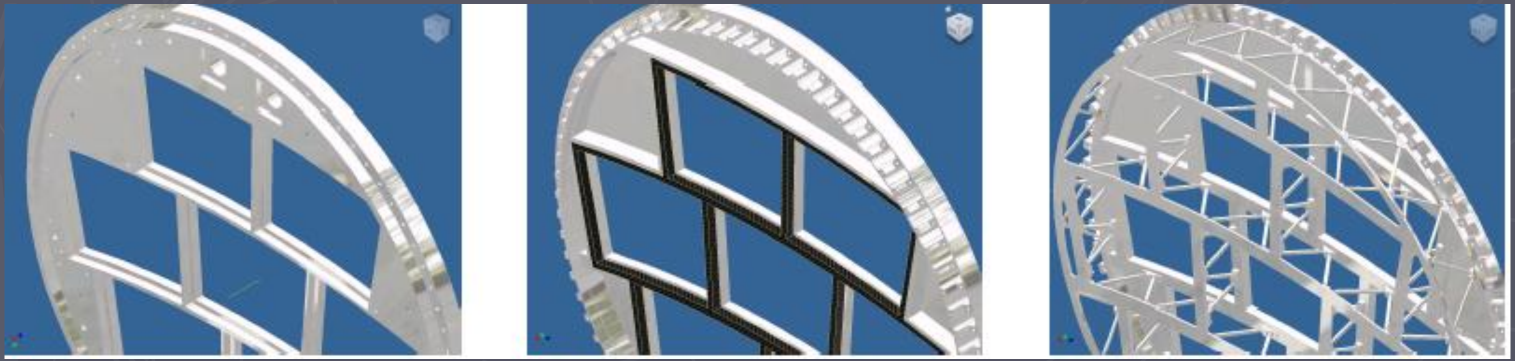
To be the first test of the Digital TPC module in TPC LP

I-DEAS for ILD TPC: By Volker Prahl

3D Placeholder Model and Engineering Design of ILD TPC

Stability of field cage
Advanced endplate (LP model)
Central cathode
HV feedthrough
TPC support structure
Installation and installation tools
....





Current LP1 endplate mechanical structure

LP1 endplate Hybrid construction (Av: 7-8%X)

LP1 endplate Spaceframe constructio (Av: 7-8%X)

Simulation Studies:

Influence of the material/geographical thickness of TPC endplate on qqbar (usd) energy resolution at 91/200/500GeV (by S. Aplin)

ILD LOI: TPC endcap of 15%X0 with 20cm spacing to the ECAL surface

Used Mokka v01-07 with the ILD_00 detector model

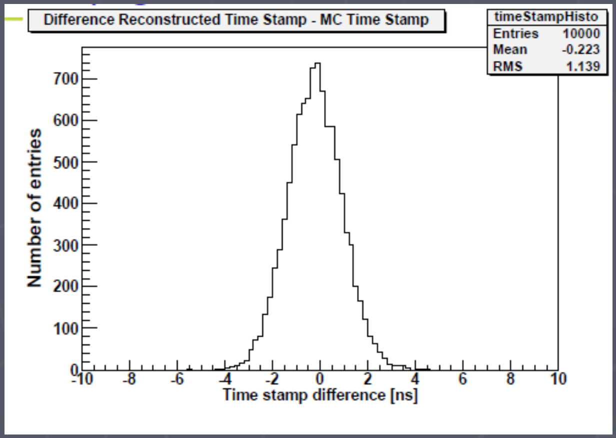
→ No real change for 15-60%X0

→ No real change for the distance of 20-30cm

(A comment: how about the change of jet angle)

Jet Energy Resolution (sigmaE/E) in 0.8<|cos(theta)|<0.9

	45 GeV	100 GeV	250 GeV
15 %	4.1+-0.1	3.2 +- 0.1	3.0+-0.1
30 %	4.4+-0.1	3.1 +- 0.1	3.0+-0.1
45 %	4.5+-0.1	3.2 +- 0.1	3.3+-0.1
60 %	4.8+-0.1	3.3 +- 0.1	



Time stamping at CLIC by TPC-Si envelopes (SET) (By M. Killenberg)

TPC measures $z = (t_{drift} + B_X \Delta t_{BX}) v_{drift}$ while SET measures z directly.

Use muons (2-200GeV/c) from the interaction point and stand alone Marlin TPC. SET resolution of 50μm.

→ With multiple scattering and realistic SET resolution < 1.5 ns

(A comment: Try to use SIT → TPC tracking/extrapolation with backgrounds)

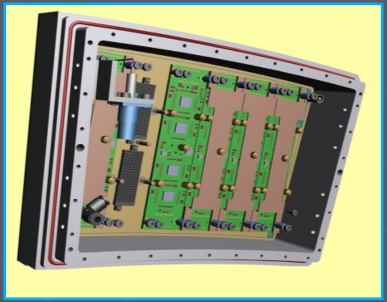
S-Altro16 Demonstrator

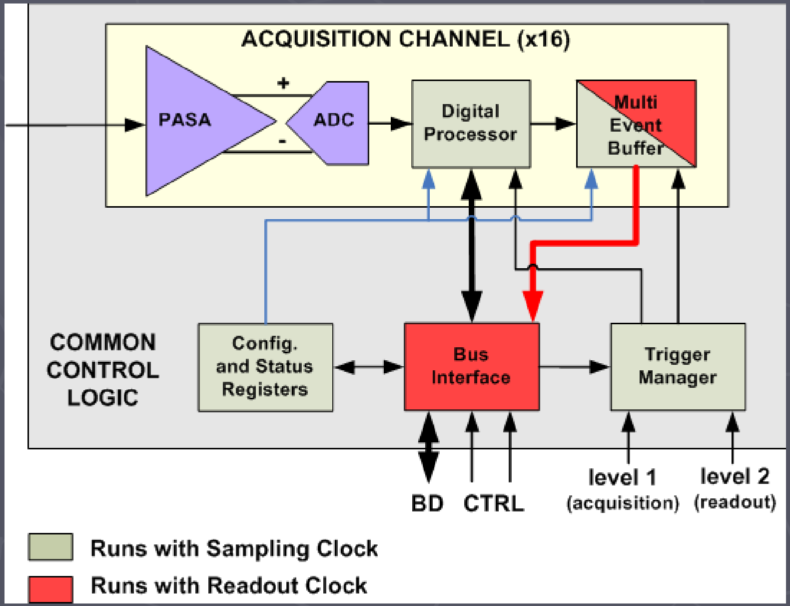
By Paul Aspell

To demonstrate integration per channel of an analog front-end (PCA16), an ADC and digital signal processing (ALTRO) in a single chip by IBM 130nm CMOS.

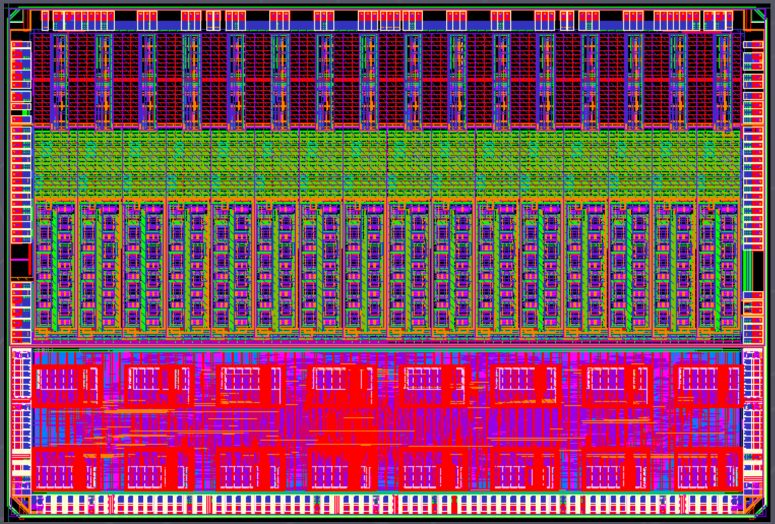
Data processing of 25/50/100us of data sampled at 40/20/10MHz. 8mW/channel.
4 gains and 4 shaping times with power switching mode.
Submitted in summer 2010 and ready in 2010.

S-Altro16 in MCM will be compatible with the pad size of 1x6 mm^2. Will be used in next GEM and Micromegas modules.





S-Altro16 Architecture



S-Altro16

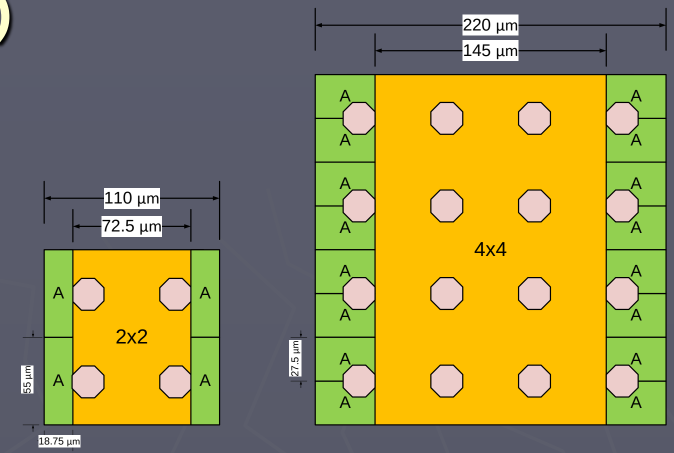
Timepix2: Talk (7)

Limitations of Timepix1:

- Single (or sparse multiple) event readout
- No trigger capability
- Full frame readout only
- Arrival time OR energy information OR particle counting
- Time-walk > 50ns
- Large periphery -> Non active area (~2000µm)

Timepix2:

- Broad applications: HEP → LHCb, CLIC interest
- To be submitted by the end of 2011.



Super pixel architecture

Pixel size	55 µm x 55 µm
Pixel matrix array	256 x 256
Sparse readout	YES
PC, TOA or TOT recorded simultaneously	YES (2 at a time)
Minimum detectable charge	≤ 500 e-
TOA resolution	>1.5ns (25ns/16) 4bits (Gossipo3 style)
Peaking time	< 25 ns
TOT resolution	<5% channel to channel spread
Technology	IBM 130nm DM 3-2-3
Power consumption	<1.5W/cm^2 (~45 µW/pixel) @1.2 V
Target floorplan	3 sides buttable and minimum periphery
TSVs possibility	YES. Multi-dicing scheme as Medipix3

TPC LP Beam Test: Status

(1) Point resolution $\sigma_{r\varphi}$: Demonstrated in TPC LP beam test

GEM & MicroMEGA with analog readout
T2K gas of low diffusion (high $\omega\tau$) in high magnetic fields

(T2K gas: Ar/CF4(3%)/isobutene(2%)

(2) Momentum resolution: - 2011

To get momentum resolution match to the point resolution

(3) Still need to demonstrate:

dE/dX
Performance of the digital TPC in LP beam test

Ion gating: the low electron transmission of gating GEM

TPC Large Prototype (LP) Beam Test: Schedule

By TM

2010-2011	Continue LP1 at DESY to complete the measure of momentum resolution and others.
2011	PCMAG modification: Potable PCMAG without Liq. He.
2012	Continue LP1 at DEST T24-1 beam line while preparing advanced endplate.
2012 -	LP2 beam test with advanced endplate at DESY Then visit a hadron beam (10-100GeV/c)