Input from the sessions on

"Modules, endplate, fieldcage/cathode, support mechanics"

A draft for the “extended outline”
for the TPC section
of the DBD

The latex file starts out with…

```
\section{The ILD TPC System}
\label{ild:sec:TPC}
\writer{Takeshi Matsuda, Ronald Settles}
Extended Outline for The ILD TPC System.
Draft 20120323.
\subsection{Overview}
……..
```

A DBD "reader": Jan Timmermans
(+ everybody)

note that the
dbd section numbers
are not correct
in this draft

1 The ILD TPC System

Extended Outline for The ILD TPC System.

1.1 Overview

The ILD concept group has chosen a Time Projection Chamber as central tracker with performance goals superior to those achieved in past and include:
- ca.200 pad-hits per track, giving ~ 100% tracking efficiency required for good momentum and good pfa resolution
- single point resolution better than 100 μm in rphi and approximately 0.5 mm in rz
- transverse momentum resolution of $\delta(1/p_t) \sim 10^{-4}$/GeV/c for the TPC alone
- two-hit resolutions of 2 mm in rphi and 6 mm in rz
- dE/dx accuracy of 5%
- the overall size of 3.6m diameter and 4.6m length, similar to that of past TPCs
- a material budget of 0.05%X0 in r and 0.25%X0 for the readout endcaps, as is important for good pfa resolution

1.2 R&D Efforts for the LCTPC

The R&D carried out by the LCTPC Collaboration has confirmed the above goals. In addition to many small prototype (SP) tests around the world, a Large Prototype (LP) of a TPC was built.
- The SP and LP tests are being used to optimize the TPC design for ILC and CLIC.
- The LP, the focus of recent R&D, is installed at Desy, is located in the T24 testbeam, includes the 1.25T superconducting magnet PCMAG and has the necessary infrastructure for carrying out the R&D studies.

1.2.1 LP measurements

LP measurement campaigns since end of 2008 have studied the technical options
- modules of Micromegas type
- modules of of GEM type
- modules with CMOS (Timepix) chips

1.2.2 LP and SP Achievements

Achievements based on LP and SP studies include
- the LCTPC endcap layout with modules of size used in the LP has been agreed on
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- with T2K gas and 3.5T Bfield the resolution goal of better than 100 m is realistic, confirmed using both Gem and Micromegas prototypes
- pixelised readout using CMOS asics has been shown to work, both with GEMs and Ingrids (integrated Micromegas-like grid) as gas multiplier

1.3 Alignment Studies

Alignment studies were performed for the LOI. Using a simple model of the track-parameter dependence on alignment tolerances, limits for the alignment of each of the tracking subsystems were derived and were of order a few μm. These values must be confirmed by further studies.

1.4 Remaining Tasks

Still in progress:
- software for simulation and reconstruction
- continue tests in electron beam to perfect correction procedures which will be reviewed in the DBD
- advanced endplate studies with a maximum of 25% X0 including cooling
- powerpulsing/cooling tests using both LP and SP
- ion backflow simulations of ion sheets for Gem, Micromegas
- design/test gating device
- future tests in hadron beam for momentum resolution and for performance in a jet environment

1.5 Possible figures for the dbd

Figures: examples that may (it is too early to decide) appear in the DBD are
- Tracking efficiency
- PFA Performance vs endcap thickness
- Occupancy vs voxel size
- Microcurler removal
- Need for a gating device
- Some of the latest Gem R&D results
- Some of the latest Micromegas R&D results
- Some of the latest Pixel R&D results

Please give your feedback if anything more should be included in the “extended outline” for the TPC chapter:
the final version is due March 30

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From the addenda, updated every year (will also be in the DBD)

These studies will continue for the next few years in order to improve on the performance. Upgrades to the preliminary design and Table 5 will be implemented where improvements are warrented by R&D results and are compatible with the LC timeline. The options with standard electronics are MicroMegas with resistive anode or GEM. The pixel TPC with CMOS electronics is compatible with MicroMegas or GEM.

Table 5

Performance/Design	
Size	$\phi = 3.6$m, L = 4.3m outside dimensions
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 10^{-4}$/GeV/c TPC only ($\times$ 0.4 if IP incl.)
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 2-3 \times 10^{-5}$/GeV/c (SET+TPC+SIT+VTX)
Solid angle coverage	Up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\sim 0.05X_0$ including the outer fieldcage in r
	$< 0.25X_0$ for readout endcaps in z
Number of pads/timebuckets	$\sim$ 1 - 2$\times 10^6$/1000 per endcap
Pad pitch/no.padrows	$\sim$ 1mm$\times$5–10mm/$\sim$150–250 (standard readout)
$\sigma_{\rm point}$ in $r\phi$	$< 100\mu$m (average over $L_{sensitive}$ for straight radial tracks)
$\sigma_{\rm point}$ in rz	$\sim 0.4 - 1.4$ mm (for zero–full drift)
2-hit resolution in $r\phi$	$\sim$ 2 mm (for straight radial tracks)
2-hit resolution in rz	$\sim$ 6 mm (for straight radial tracks)
dE/dx resolution	$\sim$ 5 %
Performance	$>$ 97% efficiency for TPC only ($p_t >$ 1GeV/c), and
	$>$ 99% all tracking ($p_t >$ 1GeV/c)
Background robustness	Full efficiency with 1% occupancy,
Background safety factor	Chamber will be prepared for 10 $\times$ worse backgrounds
	at the linear collider start-up

The Pixel TPC

The pixel TPC R&D is progressing and will provide corresponding table of performance parameters as soon as feasible.

Please give your feedback if anything more should be included in the “extended outline” for the TPC chapter:
the final version of the “extended outline” is due March 30

Status reports were give on "Modules, endplate, fieldcage/cathode, support mechanics“

Note I will show only sample slides, not try to give full “summarys”.

Comments/discussion welcome…

- Endplate – Dan Peterson
- Micromegas – Paul Colas, Madhu Dixit
- Desy Gem – Felix Mueller
- Support Mechanics – Volker Prahl
- Asian Gem – Akira Sugiyama
- Pad-angular effect – Ryo Yonamine
- European pixels – Jochen Kaminski
- Testbeam setup – Ralf Diener
- PCMAG – Takeshi Matsuda

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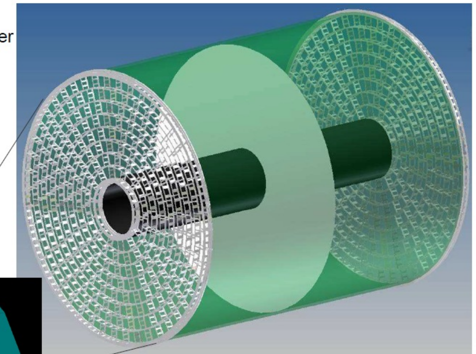
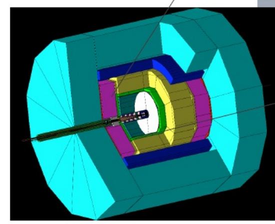
• Endplate – Dan Peterson

2012-03-26 LCTPC Group Meeting - D. Peterson 1

The TPC is the central tracker for the ILD

with
outer radius 1808 mm
inner radius 329 mm
half length 2350 mm





This is a report on the proposal for the mechanical endplate of the ILD TPC and the studies leading to this proposal.

2012-03-26 LCTPC Group Meeting - D. Peterson 2

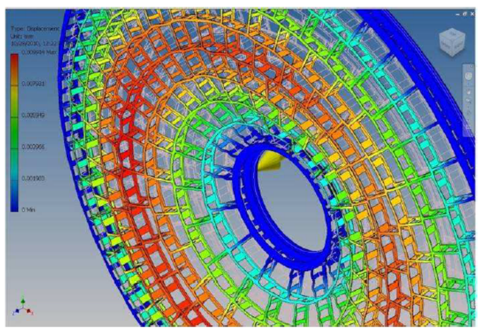
FEA calculations of deflection and stress (stress is not shown)

Endplate deflections were calculated with finite element analysis (FEA).

Endplate Support:
outer and inner field cages

Maximum deflection
0.00991 mm/100N

Calibration: 100N is the force on LP1
due to 2.1 millibar overpressure
ratio of areas: (area of ILD)/(area of LP1) =21.9



deflection for 2.1 millibar overpressure on the ILD TPC endplate (2200N)

= 0.22 mm

Without the space-frame structure,
the simple endplate deflects by 50mm.

Much of the remaining part of this study is to validate that this calculation is accurate for the complicated structure.

2012-03-26 LCTPC Group Meeting - D. Peterson 6

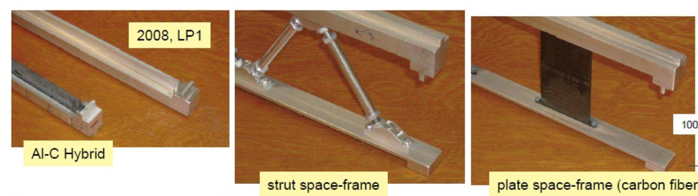
Validation of the FEA with small test beams

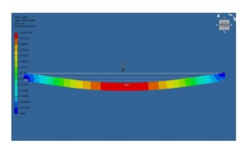
The small test beams represent sections of the LP1 endplate across the diameter of the LP1/LP2 endplate.

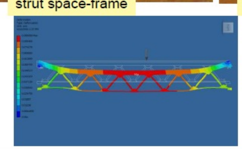
For each small test beam, there is a solid model that was used for the FEA.

Deflection of the physical prototypes was compared to the FEA.

(Carbon fiber plates are specified to have the same rigidity as the aluminum in the solid model.)







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Summary

There has been modeling and FEA at several scales of ILD development:
small beams, LP1, ILD.

The space-frame design is expected to provide the required rigidity and is a viable construction.

The FEA calculations of longitudinal deflections are validated with small test beam and LP2 endplate measurements.

Lateral rigidity and stability: much more work is required. We are, after all, most concerned about the affect of lateral stability on the calibration. The new space-frame version of the LP2 endplate will be used in this study.

This ILD spaceframe design can provide
0.22 mm deflection (2.1 millibar overpressure)
with a contribution of 6% X_0 material (bare endplate)
and 2% X_0 from the module back-frames.

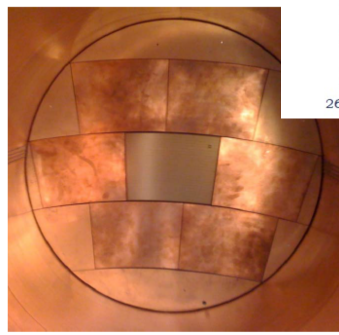
- Micromegas – Paul Colas

Micromegas modules

Towards the 7 module test

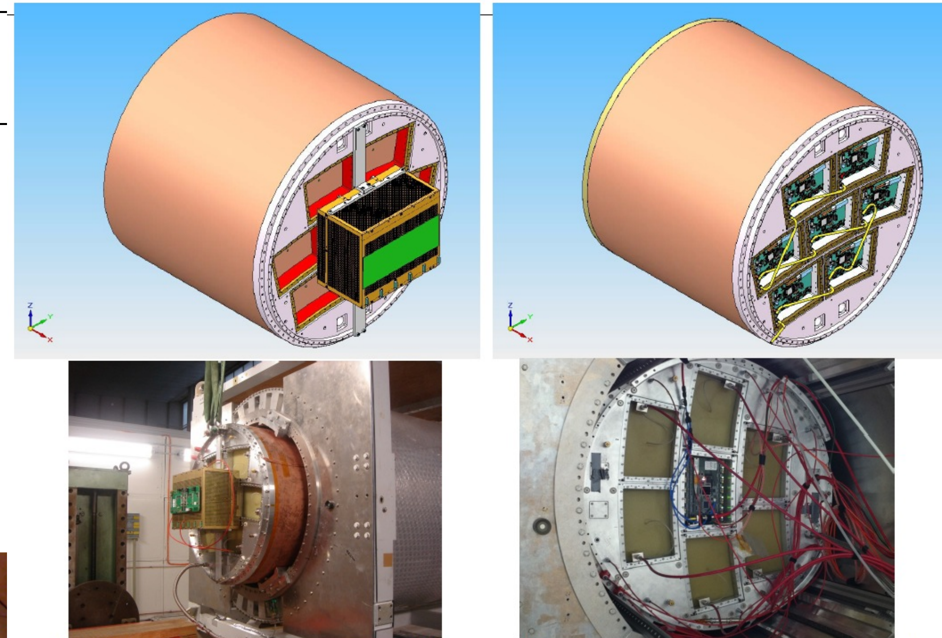
Micromegas panels

- **Phase I**: 'Large Prototype' Micromegas modules were built and tested in beam (2008-2011): 7 up to now with various resistive coatings, PCB routings and technology, electronic integration, etc…
- **Phase II** (2011-2012+): build 9 identical modules and address all integration issues, serial production and characterization, multimodule issues (alignment, distortions). Testbench at CERN starting now (^{55}Fe source scan) and beam test mid-June at DESY.
- **Phase III** (>2013): build and test one large O(10^4) channels module possibly with new techniques (Piggyback with resistive ceramics, thin meshes) and smaller O(1 mm) pads for inner wheel.



26/03/2012 Micromegas modules 2

Phase II: 7 module project – electronic integration



26/03/2012 Micromegas modules 4

Outlook

- Building and characterizing detectors with a radioactive source is underway.
- Plan to be ready for mounting at DESY in May and start data taking mid-June 2012.

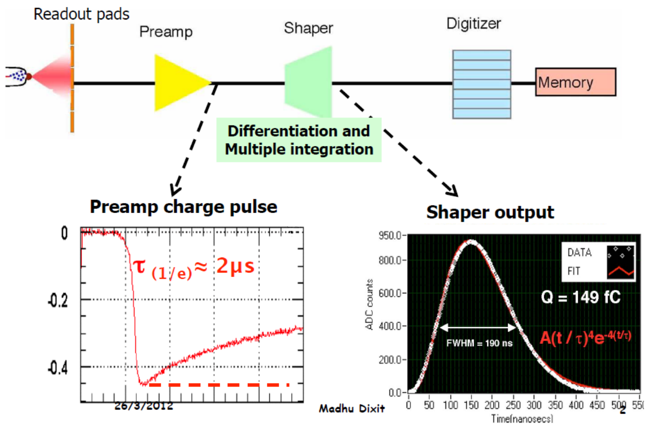
• Micromegas – Madhu Dixit

Analysis of May 2011 Micromegas LP TPC beam test data
and some considerations on pulse pileup

Madhu Dixit
TRIUMF & Carleton University

DESY LCTPC meeting 26 March 2012

Conventional MPGD-TPC Readout á la ALTRO



GEM/Micromegas-TPC signal characteristics

Similar signals, different mechanisms:

- GEM - electron drift, ~ mm wide induction gap
- Micromegas – ion drift, ~100 µm induction gap

The charge pulse rise time is ~100 ns, for a single avalanche cluster, both for the GEM and the Micromegas

The track charge pulse rise time:

- Pad has to collect ~ 30 avalanche clusters
- Plus longitudinal diffusion, MPGD induction time, electronics
- ~300 ns to collect 95% of electrons at 2 m drift (GEMs & Micromegas)
- Rise time gets larger for charge dispersion readout

Long integration times needed - previous LP Micromegas results best with 500 ns peaking time

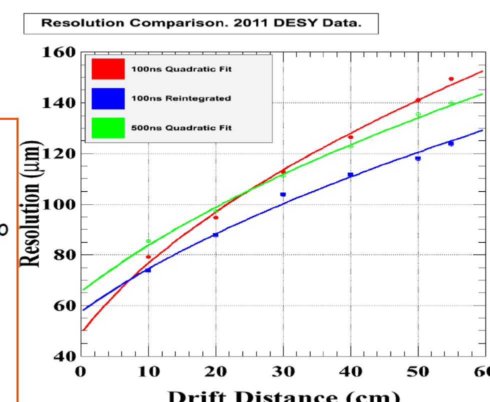
- Not good for timing and two hit resolving power

How to get good Micromegas resolution with short peaking time?

Beam test results presented based on Nicholi Shiell's MSc thesis research at Carleton

26/3/2012

Resolution Comparison



Nicholi Shiell

Comments

- Compared to normal readout, the pileup for charge dispersion is less due to the signal coming down to zero faster than the decay time of the front-end charge preamplifier
- For the adjacent pads with charge dispersion signal, one should be able to easily measure a direct charge signal piling up
- We already measure the pedestal dynamically. We can also determine the pedestal with a slope in case of pileup
- Some artifacts seen in our data not fully understood. It should be possible, however, to reduce the undershoot observed by better pole zero cancellation

26/3/2012 Madhu Dixit 16

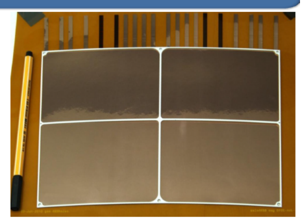
• Desy Gem – Felix Mueller

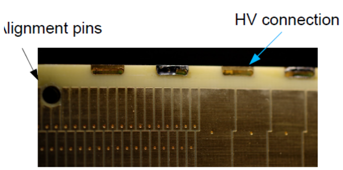
Status of the DESY GEM Module

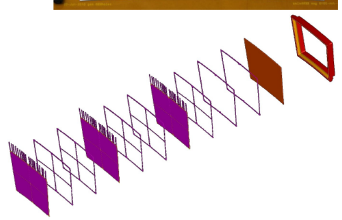
Felix Müller
LCTPC collaboration meeting
26.03.2012

Current Module

- Ceramic mounting structure
  - Mechanical support
  - Improve GEM flatness
  - Minimal dead space
- Small pads only at the center ($1.26 \times 5.85\ mm^2$)
- Larger pads connected to ground

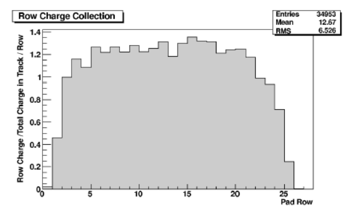


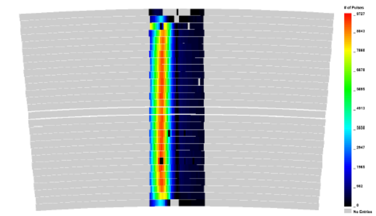




Problems Observed

- Reduced efficiency on the pads at the edge of the board
- Field distortions due to the gap between two modules





Number of reconstructed pulses

Improvements for the new Module

- Full sensitivity
- High voltage distribution
- Reduction of field distortions
- More defined production process
- Enhancement of the GEM flatness?

Status of the new Module

- Nearly everything is ordered
  - HV cable, pad board, back frame, ceramics
- Or arrived
  - GEMs, HV connectors
- Todo: testing the single components
- Todo: testing assembled module
  - GEM flatness
  - Gain uniformity
- Go to the test beam at the end of summer with <u>three</u> modules

• Support Mechanics – Volker Prahl

ILC / ILD TPC

status of the support mechanics

Volker Prahl

Hamburg 26.03.2012

HELMHOLTZ | GEMEINSCHAFT

Requirements of the TPC support structure

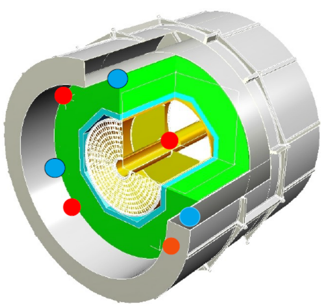
The support structure has to be fulfill the following tasks

> Non-magnetic material
> Low thermal expansion coefficient

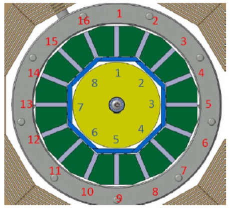
Carbon fiber structure preferred

> Robust system in x,y,z,
> Accuracy and stability has to be constant over the lifetime
> Earthquake-safe system
> Short support structure (more a wish than a realistic option)
> Vibration absorption in Z direction
> Required accuracy 100 µm or better for Vertex, SIT, FTD !
> Min free space of 10 mm in all directions ! Gaps !

Fixing points of the TPC support structure



Main dimensions of the TPC (outside)
Ø Od = 3616, r=1808
Ø Id = 658, r=329
Length = 4700 incl. endplate and cabling



3 Point 3x120°, preferred gaps: 1,12, 6

4 Point 4x90°, preferred gaps: 3, 15, 11, 7

Only the cryostat is foreseen to support the TPC

Conclusion and outlook

Conclusion

- Support system with min. 4 bars necessary
- Required space is an issue with the infrastructure and gaps between and in the middle of the HCAL octagons
- Alternative approaches have to be considered
- Various cross sections of the cantilever will be calculated
- Alternative system design maybe required

Outlook

- Availability of space in the gaps has to be evaluated
- More FEA studies in progress
- Minimize the cross section of the cantilevers
  - Depends on the requirements
- Placeholder has to be defined before the next Integration meeting Paris

• Asian Gem – Akira Sugiyama

Asian Module

What is our concept
The status of LP1
What we propose ??
What can we do for coming year

Basic concept

To achieve good resolution and efficiency

- optimize pad size for GEM operation
  O(1mm) pad pitch @~300um diff. at gas amp.
  routing of signal/HV
- minimize dead region pointing IP
  no frame in the side
  GEM stretching
- simplify the structure
  double GEM w/ Gate (separate function)
  Gate is necessary

Good 100um thick GEM @RIKEN(Tamagawa) is processed

(1) CO_2 Laser etching LCP holes
(2) de-smearing (cleaning) hole by dry etching (Plasma)
this is regular process but intensive care of (2) for RIKEN GEM

We are asking same process for our GEMs

GEM is ready to be checked at KEK soon

What we have done

1st beam test @ 2009 Feb.
w/o Gate : we observe a big distortion

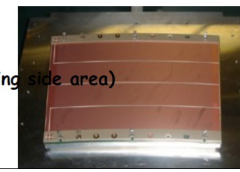
2nd beam test @ 2010 Mar.
w/ Gate : Gate oversize/ HV connection btw neighbor gates
HV leak to pad plane -> damage to readout electronics
and/or GEM discharge ->

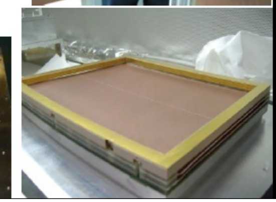
we found thin GEM Gate cannot provide enough transmission

3rd @ 2010 Sept.
we need good data anyway to investigate mom. resolution

w/o Gate w/ field shaper
but many GEM discharge

to Next
modify GEM 4 div. (sacrificing side area)
not finished yet





What happen to us

GEM itself
we observe many discharge
the problem of 100um thick LCP GEM ?
itself ? -> see gain and discharge test @KEK
the way to supply HV

Stretch method
- too much tolerance
  difficulty of precise fabrication -> touching to neighbor module
  HV mis-connection
  HV leak btw gates
- metal post
  distortion of field -> need field shaping w/o Gate
- complication of HV connection -> washer fall down
  HV leak

What can we do for coming year

Momentum resolution using 3 modules -> using current modules
w/o Gate
w/ field shaper -> like a test of field shaping

or cutting metal posts and putting spacer to backframe ?
(treatment of FR4 frame is another issue)
==> within this year (depending on situation of GEM)

Next module MCM will not be ready until the end of this year

Stretching ? GEM ?
Gate ???

• Pad-angular effect – Ryo Yonamine

Study on Angle Pad Effect

Status report

Ryo Yonamine

Analytic Expression of the Spatial Resolution

Helpful to understand how the point resolution is determined.

This work is based on the past work, in which only a perpendicular track to pad-rows was discussed. (Nucl.Instrum.Meth.A641:37-47,2011)

New points :
- de-clustering effect ・・・ diffusion and pad response function in a direction of pad-rows act on Neff
- angular pad effect ・・・ track angle is a factor affecting the spatial resolution

We will also check the validity of approximation used in our calculation by a Monte-Carlo simulation.

Resolution

definition:

$$\langle(\boldsymbol{x}-\tilde{\boldsymbol{x}})(\boldsymbol{x}-\tilde{\boldsymbol{x}})^T\rangle = \int_v \frac{d\tilde{\boldsymbol{x}}}{v}\int d\boldsymbol{x}\ P(\boldsymbol{x};\tilde{\boldsymbol{x}})(\boldsymbol{x}-\tilde{\boldsymbol{x}})(\boldsymbol{x}-\tilde{\boldsymbol{x}})^T$$

$\boldsymbol{x}$: measured values

$\tilde{\boldsymbol{x}}$: true values to be measured

$P(\boldsymbol{x};\tilde{\boldsymbol{x}})$: probability to be measured $\boldsymbol{x}$

v : readout unit (pad , pixel , voxel , ...)

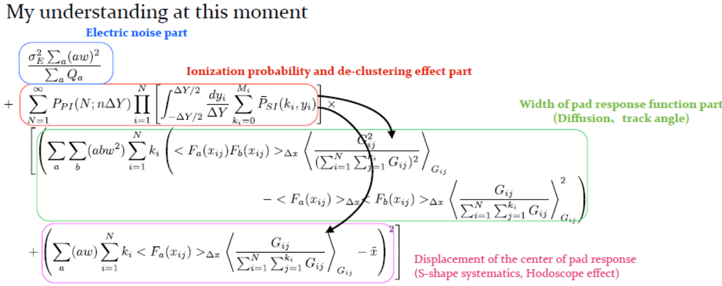
$P(\boldsymbol{x};\tilde{\boldsymbol{x}})$ Components

- Primary ionization — $P_{PI}(N;n\Delta Y)$ — N : # of primary electrons; n : gas density; ΔY : projected track length to y axis, to be considered In general $\Delta Y \to \infty$
- y position of i-th primary ionization along a track — $P(y_i)=\frac{1}{\Delta Y}$ — y_i : projected position to y of i-th cluster
- Secondary ionization — $P_{SI}(M_i)$ — M_i : # of secondary electrons from i-th primary electron
- Diffusion — $P_D(\Delta x_{ij}), P_D(\Delta y_{ij})$ — Δx_{ij}, Δy_{ij} : displacement of the j-th electron in i-th cluster, by the diffusion in drift region
- Gas amplification — $P_G(G_{ij})$ — G_{ij} : gain of the j-th electron in i-th cluster
- Electric noise — $P_E(\Delta Q_a;\sigma_E)$ — ΔQ_a : noise charge; a : pad number
- Pad response function
  - x direction : $F_a(x_{ij})$ — x_{ij} : position where j-th electron in i-th cluster arrives at; $x_{ij}=\tilde{x}+y_i\tan\phi+\Delta x_{ij}$; ϕ : track angle; y_i : projected position to y of i-th cluster
  - y direction : $R_r(y_{ij})$ — r : row ID (omit if not necessary); y_{ij} : position where j-th electron in i-th cluster arrives at

5

Summary and Plans

My understanding at this moment



- To obtain more detailed relation, we need further calculation.
  --> Need to continue this work.

- Approximations used in the calculation should be validated by a Monte-Carlo simulation.

- Try to find the possibility to calculate resolution in the case of arbitrary angle of a track faster than a Monte-Carlo simulation.

- We would also like to study on the correlation effect between pad-rows.

7

• European pixels – Jochen Kaminski

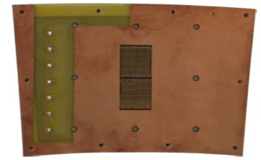
Status of the European Pixel Modules

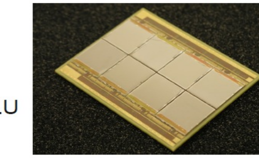
J. Kaminski
for
U. Bonn, NIKHEF, SACLAY

LCTPC Collaboration Meeting, DESY
26th-27th March 2012

Past LP-modules

LP-modules were built with the two different gas amplification stages





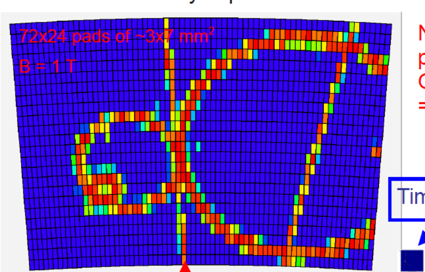
Triple-GEM U Bonn/Freiburg
3 standard CERN-GEMs
2 NIKHEF-Quadboards read out by MUROS
synchronized with EUDAQ/TLU

InGrid SACLAY/NIKHEF
8 InGrids on a custom designed board Octopuce
read out by one MUROS

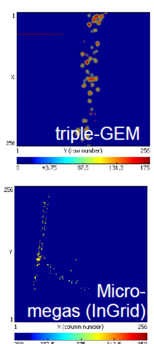
J. Kaminski
LCTPC Collaboration Meeting 3/2012, DESY 5

Why highly pixelized modules?

Standard MPGDs use pads of the size O(mm^2) or long strips with a pitch of O(100-200 µm).
This does not fully exploit the resolution of MPGDs.



Need smaller pads
O(50-100 µm)
=> Timepix



5 GeV ... J. Kaminski LCTPC Collaboration Meeting 3/2012, DESY 2

What remains to be done?

- Improve protection layer
- Implement improvements in SRS readout
- Work on layout of module:
  - Where to place chips (small carrier with 8 chips vs. large one)
  - Services
    - Cooling
    - Power distribution
    - HV distribution
- Minimize field distortions in case of InGrids
- Improve 'pixel-branch' of MarlinTPC code (tracking, •-exclusion..)

Possible roadmap: first a module with DESY-GEMs gas amplificatior (chips are easier to handle – some issues can be addressed) then one with InGrids, where handling is more delicate

J. Kaminski
LCTPC Collaboration Meeting 3/2012, DESY 20

• Testbeam setup – Ralf Diener

Test Beam Setup

LCTPC Collaboration Meeting, March 27. 2012

R. Diener, DESY

Test Beam Setup

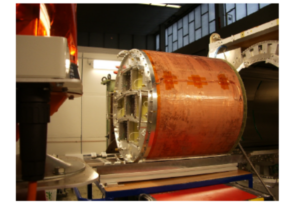
Test Beam Usage

- **2008:**
  - Nov-Dec Micromegas module 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
  - Jul TDC electronics with an Asian GEM module ALTRO electronics study w/ Asian GEM
  - Jul-Aug Full installation of PCMAG moving stage
  - Aug Micromegas w/o resistive anode with laser-cathode calibration
  - Sep Bonn GEM module (small area GEM with ALTRO electronics)
  - Nov Micromegas with SiTR
- **2010:**
  - Mar Micromegas using PCMAG movable table.
  - Mar+Sept 3 Asian GEM modules w/ gating GEM or a field shaper using the PCMAG movable table (7616ch ALTRO electronic)
  - Dec Octopuce (8 Ingrids) test on LP with 1T (Saclay/Nikhef)
- **2011:**
  - Apr First test of DESY GridGEM module (B=0T)
  - May New AFTER electronics for Micromegas Installation of new cosmic trigger logic
  - Jun/Jul DESY GridGEM module with ALTRO read-out
  - Jul PCMAG shipped to Japan
- **2012:**
  - Mar Return of PCMAG
  - Apr-Jun Installation of upgraded PCMAG
  - Summer / Autumn (tentative):
    - Test with 7 Micromegas modules with integrated AFTER electronics
    - Test of Japanese GEM modules
    - Test of DESY GridGEM module

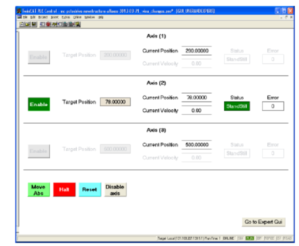
Test Beam Setup

Movable Stage

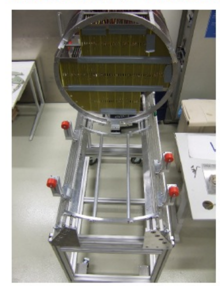
- New movable table for LP and ALTRO rings installation and mounting (currently being modified to include height adjustment ↔ uneven ground)

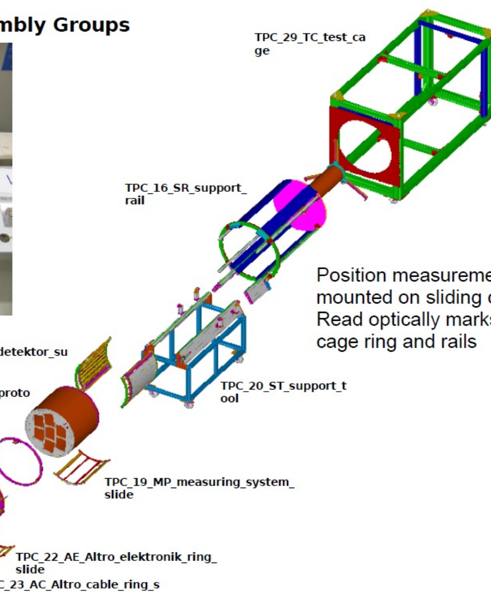


- New steering software
  - Includes position measurement from new, external system and signal from end switches
  - Basic user part (nearly) ready
  - Expert GUI under development



Overview of Assembly Groups





Position measurement heac mounted on sliding carriage Read optically marks on fiel cage ring and rails

• PCMAG – Takeshi Matsuda

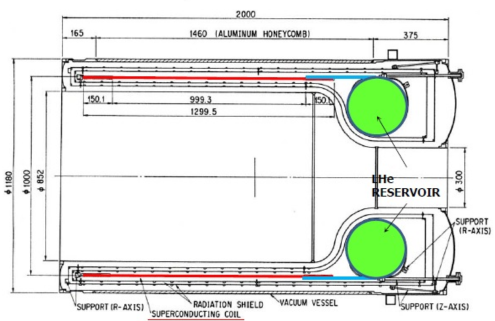
PCMAG without Liq. He

The LC TPC collaboration Meeting
26-17 March, 2012 at DESY

KEK/IPNS Cryogenic Group
&
LC TPC Japan

These slides were originally prepared by M. Kawai/Cryogenic group in Japanese. TM translated it in English, and modified/added with some more information.

PCMAG without Liq. He



Before the modification

Conduction cooling by
Liq. Cooling in
the reservoir tank
(in green) in PCMAG

After the modification

Conduction cooling by
two GM (Gifford McMahon) crycoolers;
One of two stages (4K), and
another of one stage (10K).
The reservoir tank remains as a heat sink.

A Quench during the De-excitation

18:55 May 10, 2012	Switch on the breaker for de-excitation. The coil quenched during the switching-off Max coil temperature: 50K Max coil voltage: -59.572V The protection beaker functioned by the voltage (3mV) across the HTc current leads, while the setting was 1mV at the time.
00:40 May 20	Coil cooled down and ready for excitation. Excited PCMAG up to 200A . Confirmed no damage of PCMAG. Switch-off from 200A to 50A alright through the diode built-in the power supply. (The limiter for the voltage across the HTc current leads was set to be 4mV.) From 50A to 0A, de-excited through the current dump resistor.
01:30	Switch all off for the shipping on March 21. Remove high pressure He gas in the cryo-cooler system.
10:00 May 21	Shipping out from Toshiba: Coil temperature: 28K Hold the vacuum
08:00 May 24	PCMAG arrived at the Hamburg airport.

1.3 Alignment Studies

Alignment studies were performed for the LOI. Using a simple model of the track-parameter dependence on alignment tolerances, limits for the alignment of each of the tracking subsystems were derived and were of order a few μm. These values must be confirmed by further studies.

1.4 Remaining Tasks

Still in progress:
- software for simulation and reconstruction
- continue tests in electron beam to perfect correction procedures which will be reviewed in the DBD
- advanced endplate studies with a maximum of 25% X0 including cooling
- powerpulsing/cooling tests using both LP and SP
- ion backflow simulations of ion sheets for Gem, Micromegas
- design/test gating device
- future tests in hadron beam for momentum resolution and for performance in a jet environment

1.5 Possible figures for the dbd

Figures: examples that may (it is too early to decide) appear in the DBD are
- Tracking efficiency
- PFA Performance vs endcap thickness
- Occupancy vs voxel size
- Microcurler removal
- Need for a gating device
- Some of the latest Gem R&D results
- Some of the latest Micromegas R&D results
- Some of the latest Pixel R&D results

Good progress. What we put in the DBD can be decided later…

Question for discussion: is the software good enough to analyze the LP data?

Need more results and study of correction procedure.

Question for discussion: do we need to go to a hadron beam to test the “jet environment”?