The LCTPC Collaboration: Some Key Aspects of Activity

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DESY

Micro Pattern Gas Detectors. Towards an R&D Collaboration.

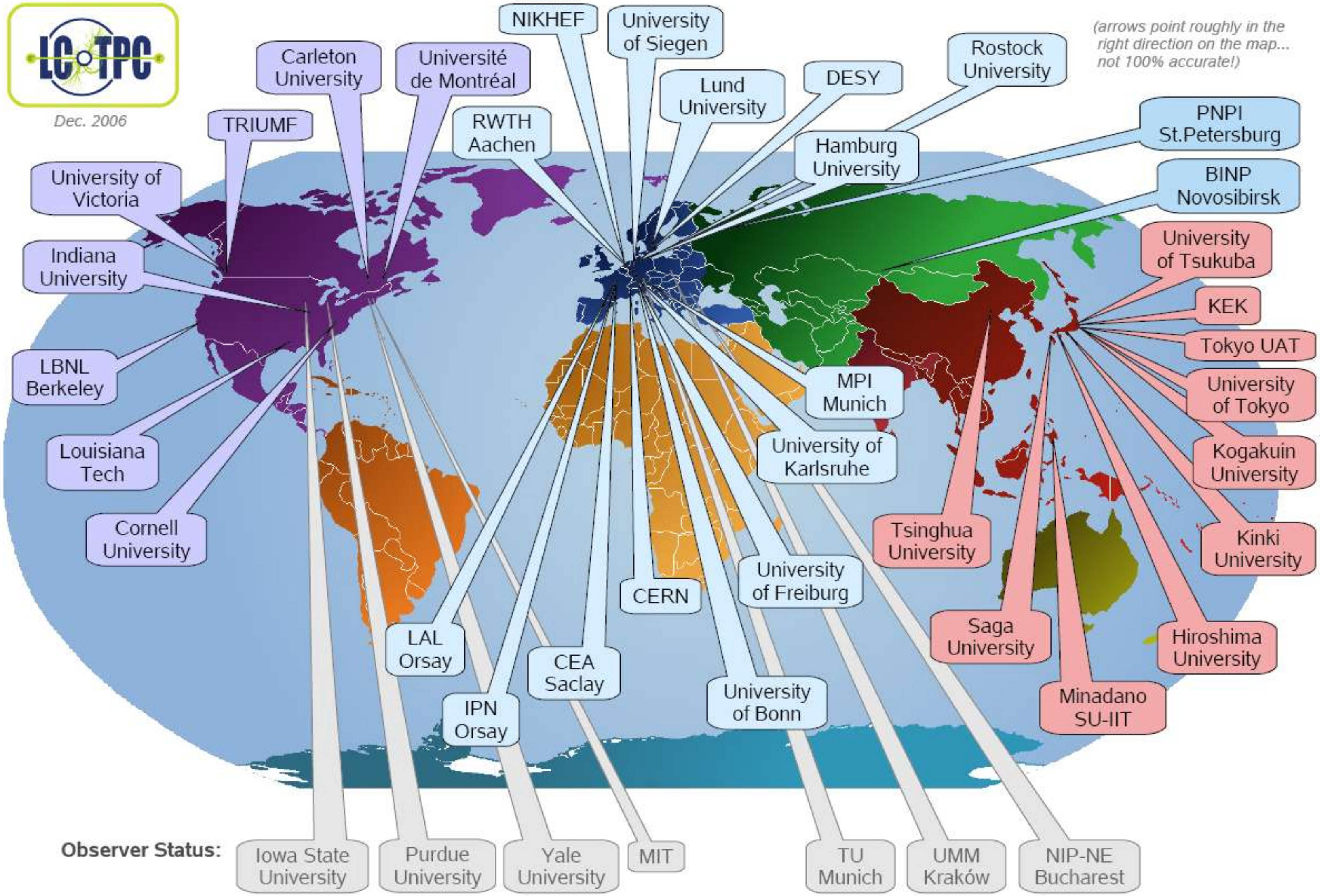
September 11, 2007

LCTPC Collaboration

- Two/Three out of Four ILC Detector concepts (GLD, LDC, 4th Concept) have TPC as central tracking device

- LCTPC: understand how to build a super-high-performance TPC for the linear collider physics up to 1 TeV cms energy

LCTPC Collaboration



LCTPC Collaboration

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

Size (LDC–GLD average)	$\phi = 3.6$m, L $= 4.3$m outside dimensions
Momentum resolution (B=4T)	$\delta(1/p_t) \sim 10 \times 10^{-5}$/GeV/c TPC only; $\times$ 0.4 incl. IP
Momentum resolution (B=4T)	$\delta(1/p_t) \sim 3 \times 10^{-5}$/GeV/c (TPC+IT+VTX+IP).
Solid angle coverage	Up to at least $\cos\theta \sim 0.98$
TPC material budget	$< 0.03X_0$ to outer fieldcage in r
	$< 0.30X_0$ for readout endcaps in z
Number of pads	$> 1\times10^6$ per endcap
Pad size/no.padrows	$\sim$ 1mm$\times$4–6mm/$\sim$200 (standard readout)
$\sigma_{\mathrm{singlepoint}}$ in $r\phi$	$\sim 100\mu$m (for radial tracks, averaged over driftlength)
$\sigma_{\mathrm{singlepoint}}$ in rz	~ 0.5 mm
2-hit resolution in $r\phi$	< 2 mm
2-hit resolution in rz	< 5 mm
dE/dx resolution	< 5 %
Performance robustness	$>$ 95% tracking efficiency for all tracks–TPC only)
(for comparison)	($>$ 95% tracking efficiency for all tracks–VTX only)
	$>$ 99% all tracking[13]
Background robustness	Full precision/efficiency in backgrounds of 1% occupancy
	(simulations estimate $<$ 0.5% for nominal backgrounds)
Background safety factor	Chamber will be prepared for 10 $\times$ worse backgrounds
	at the ILC start-up.

with MPGD

LCTPC Design

- Gas amplification systems
- Endplate
- Electronics
- Fieldcage
- Chamber gas
- Space charge
- Non uniform fields
- Calibration and alignment
- Backgrounds and robustness

LCTPC Phases

- ➔ Demonstration phase
  - Small prototype
- ➔ Consolidation phase
  - Large prototype
- ➔ Design phase
  - Engineering design

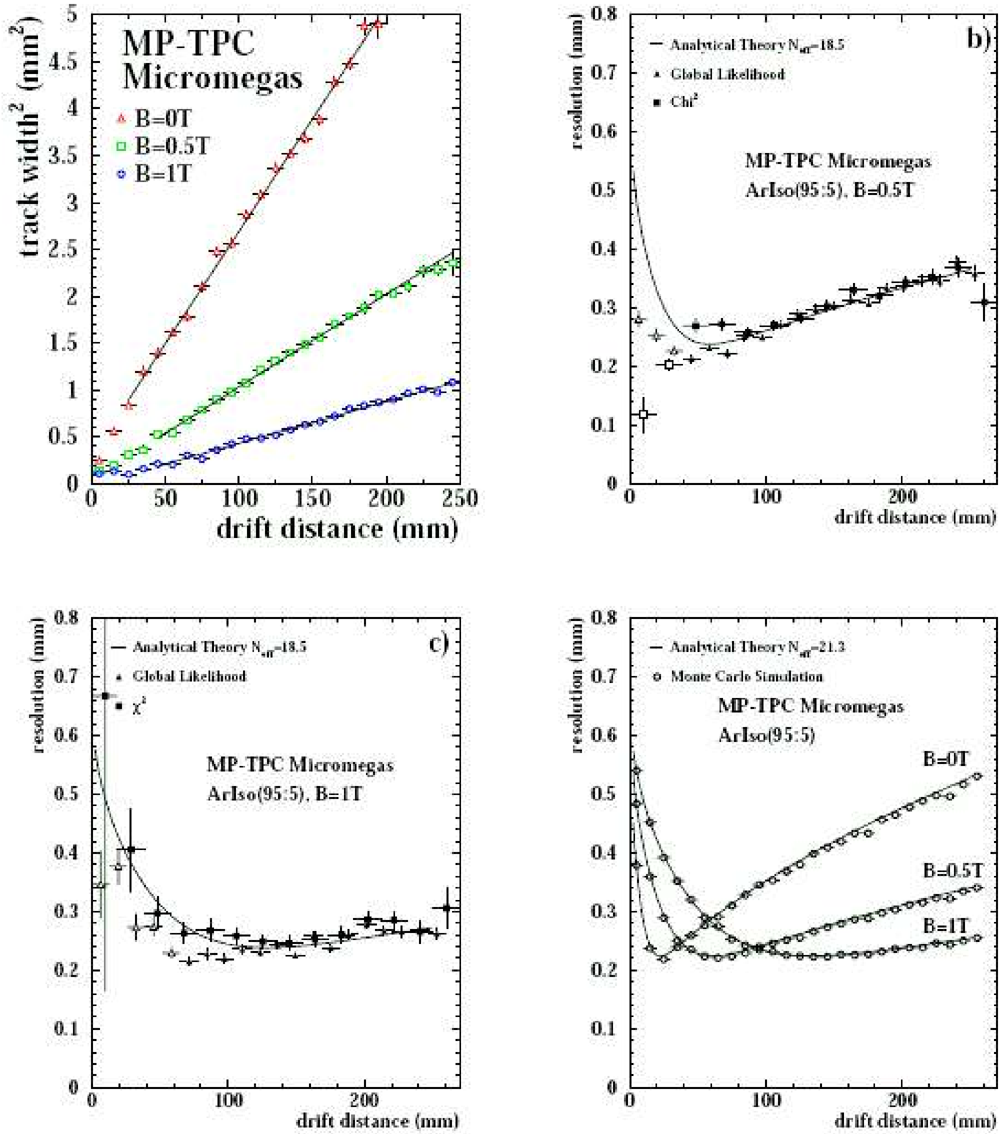
LCTPC Phases

➔ Demonstration phase

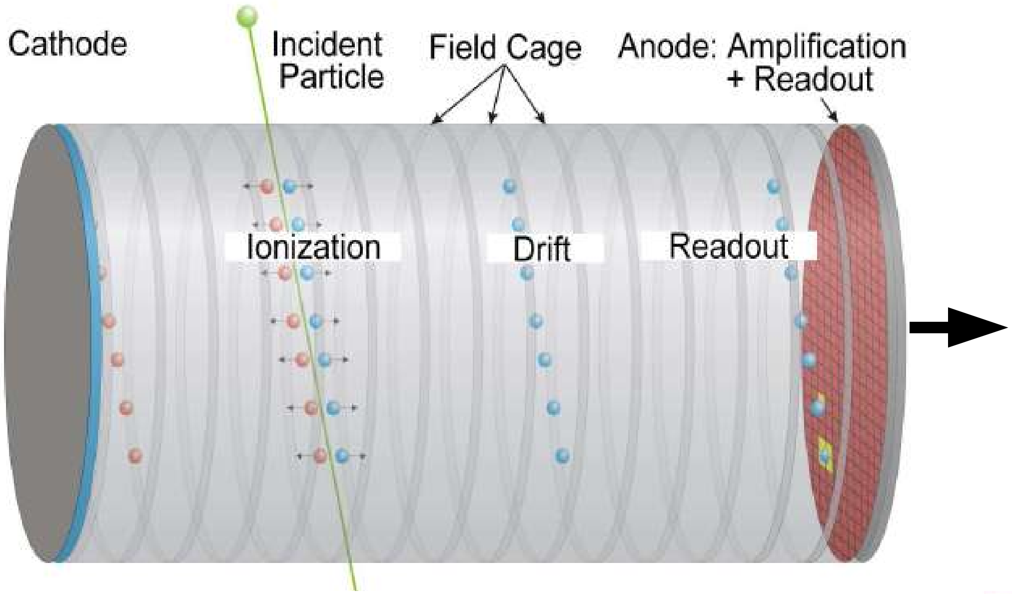
- Small prototype, driven to a large extend by the needs of individual labs

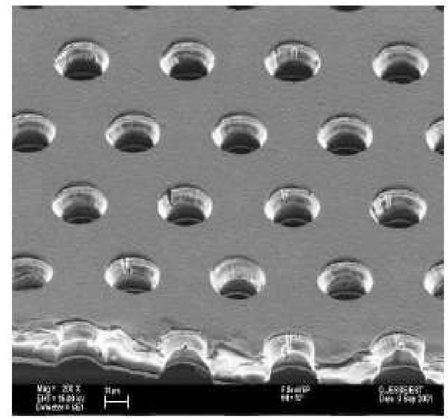
Demonstration Phase

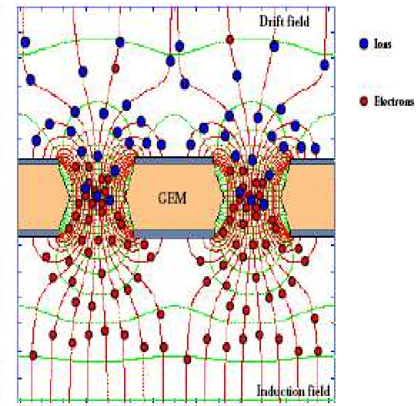
Micromegas:
pad size 2.3 x 6.3 mm^2

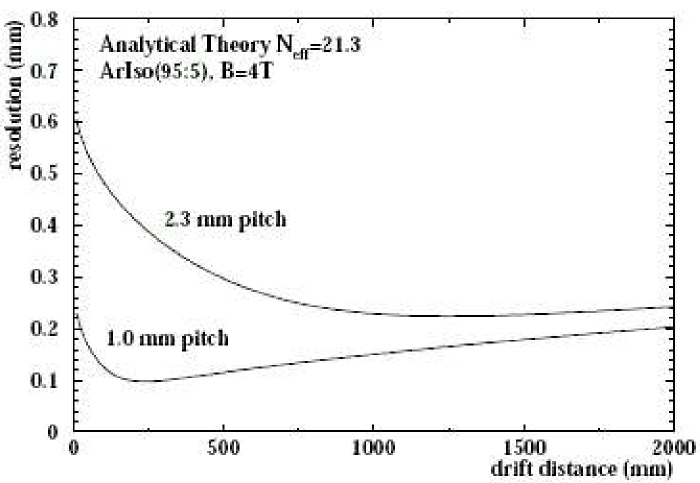


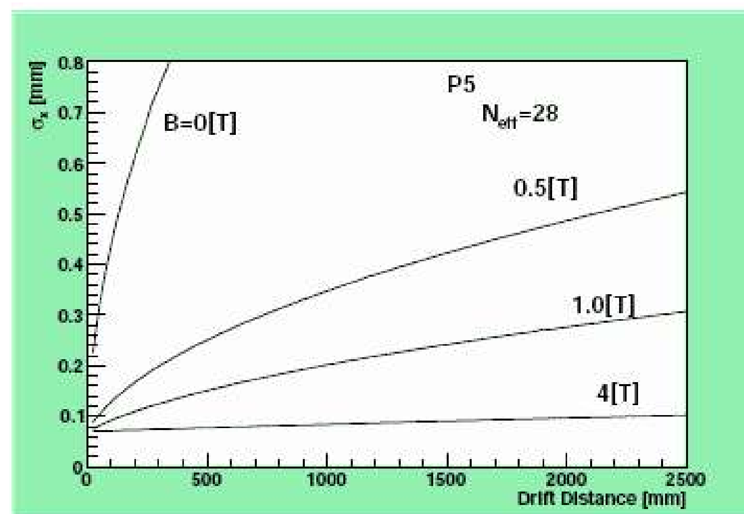
Medium-TPC with GEM











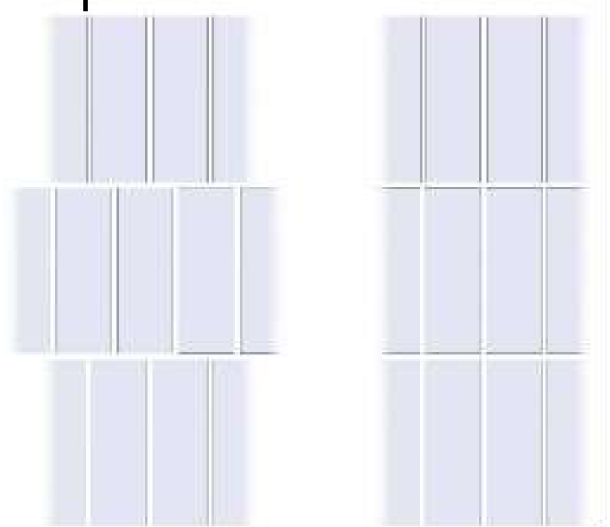
MediTPC Track Reconstruction

- Length: 800 mm, diameter: 270 mm
- Sensitive volume: 660 x 50 x 53 mm^3
- Subjected to B = 0, 1, 2, 4 T

Pad layout:

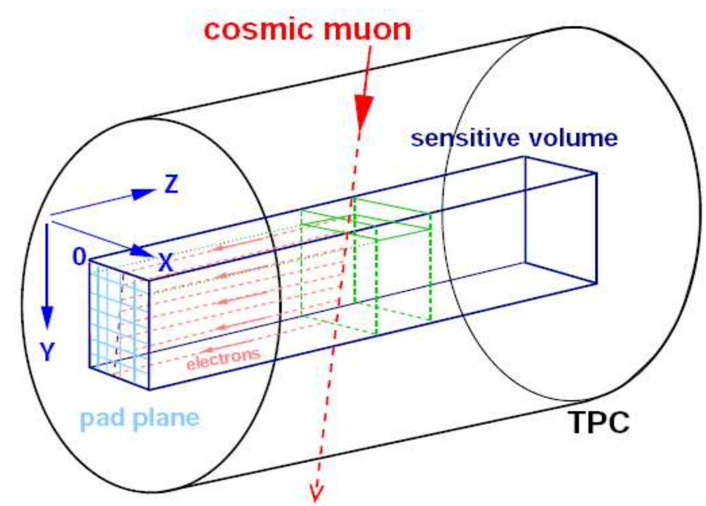
24 columns, 8 rows

pitch 2.2 mm x 6.2 mm

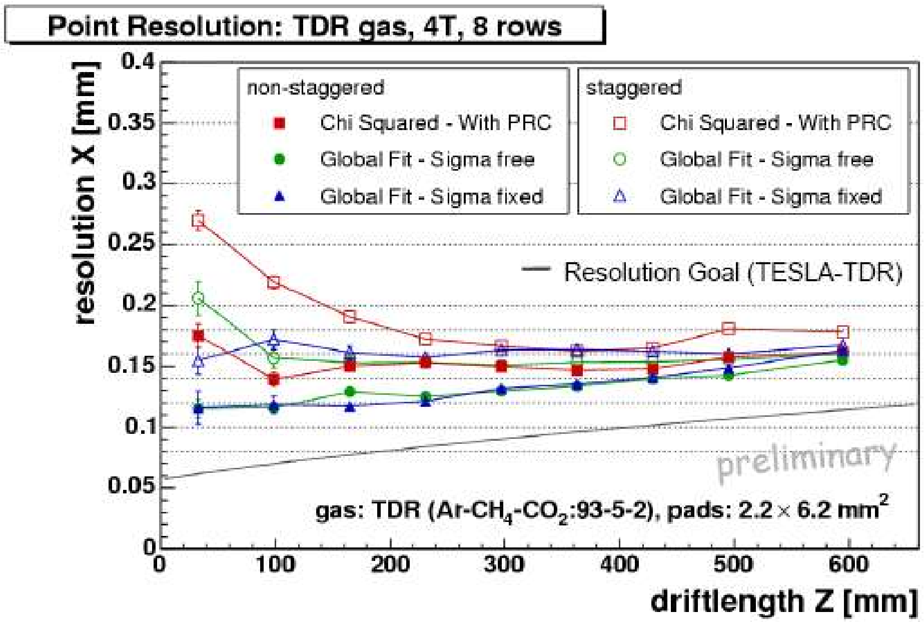


staggered resp.

non-staggered



MediTPC Track Reconstruction

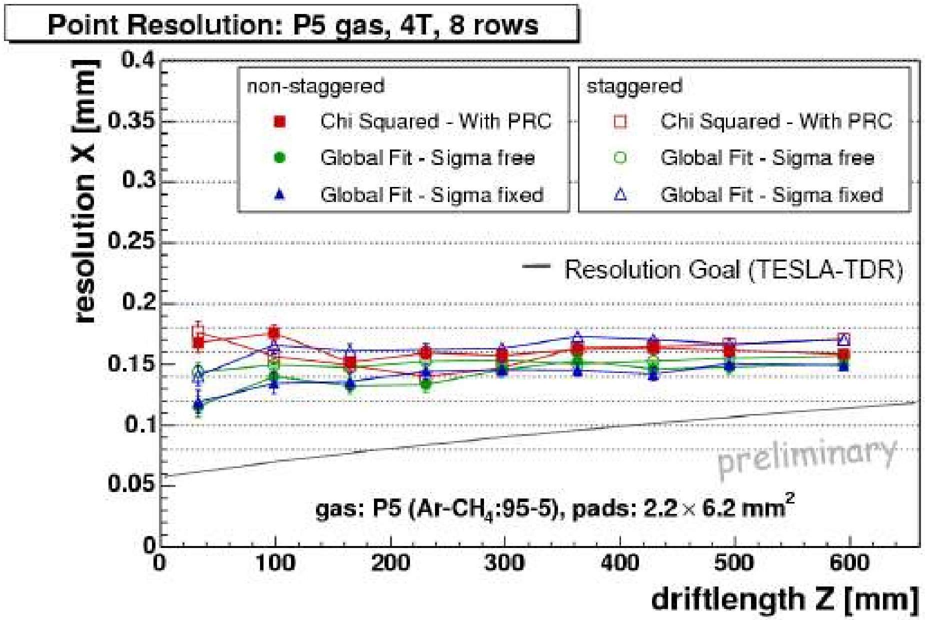


Cosmic Muon tracks

Pad layout:

24 columns, 8 rows

pitch 2.2 mm x 6.2 mm



Resolution between

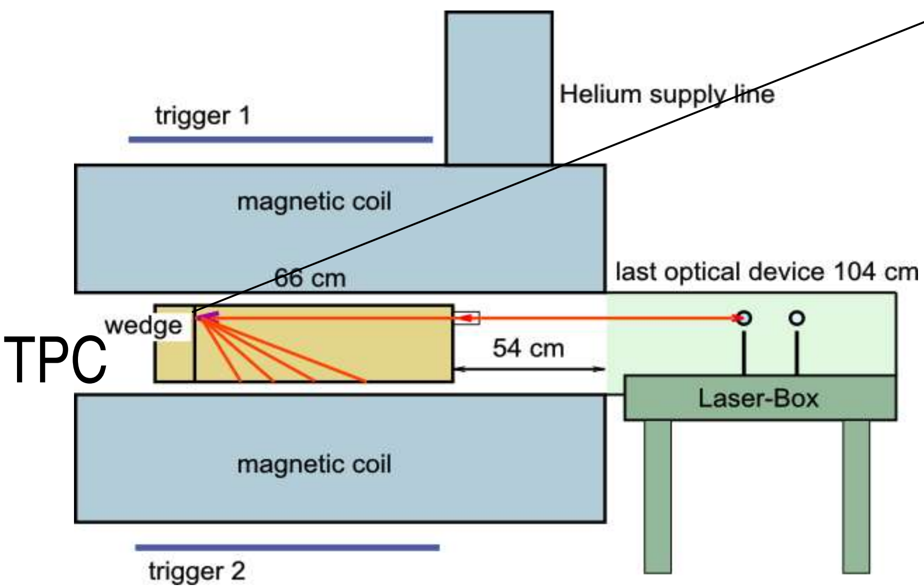
120 µm and 180 µm

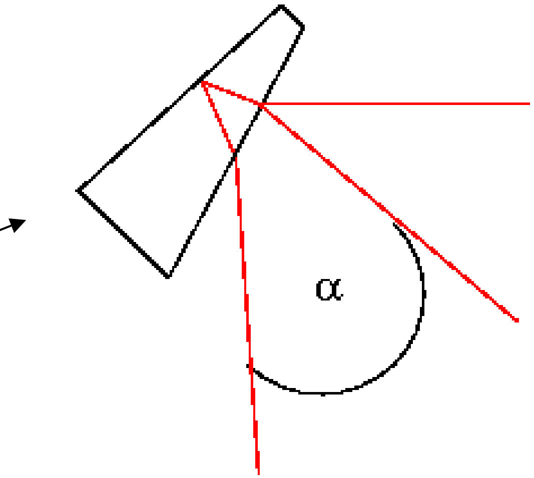
for drift distances

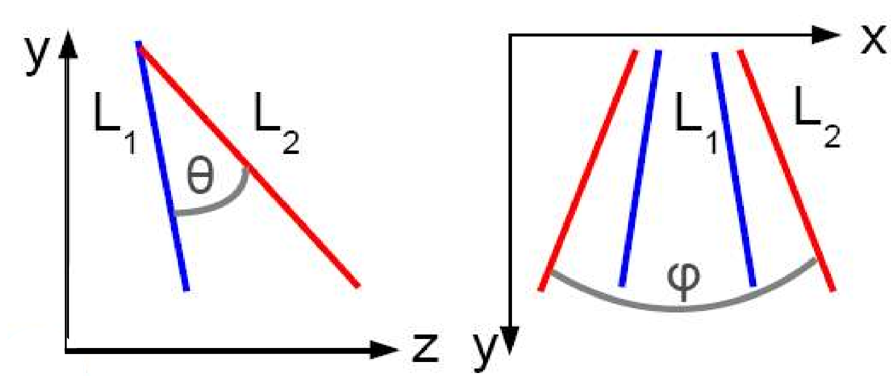
≤ 600 mm

MediTPC Double Tracks

Laser Setup for Double Tracks



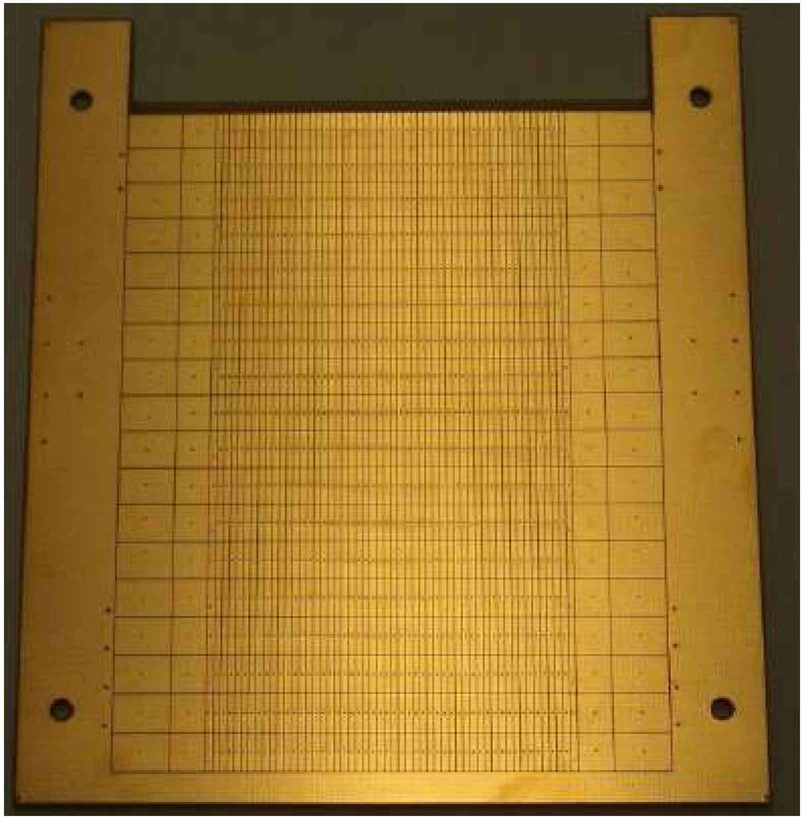




Studies are ongoing

MediTPC Modified Pad-Layout

Cosmic Muon tracks
Pad layout:
- 48 columns, 18 rows
- pitch 1.27 mm x 7 mm



LCTPC Collaboration

TPC gas amplification systems:

Micromegas $\longrightarrow$

Paul Colas, Alain Bellerive, Alain Delbart, David Attie

GEM $\longrightarrow$

Alain Bellerive, Uwe Renz, Klaus Desch

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LCTPC Phases

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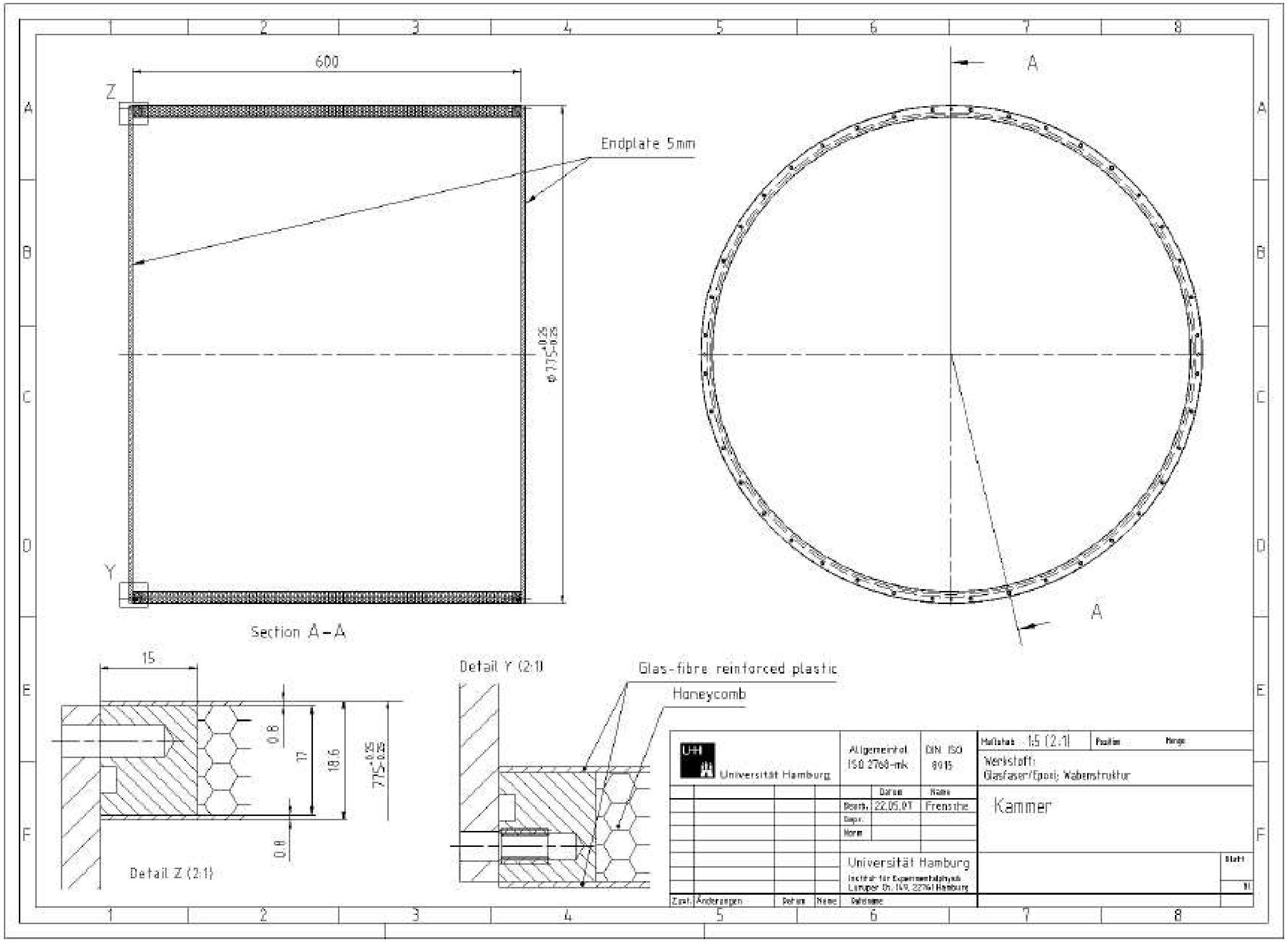
The Large Prototype LP-TPC

- First step towards LC TPC
- Field cage (FC) as EUDET project
- Serves as infrastructure for different readout structures (GEM, MicroMegas)
- First use in KEK-PCMAG at DESY-II test beam
- Silicon envelope

LP-TPC FC

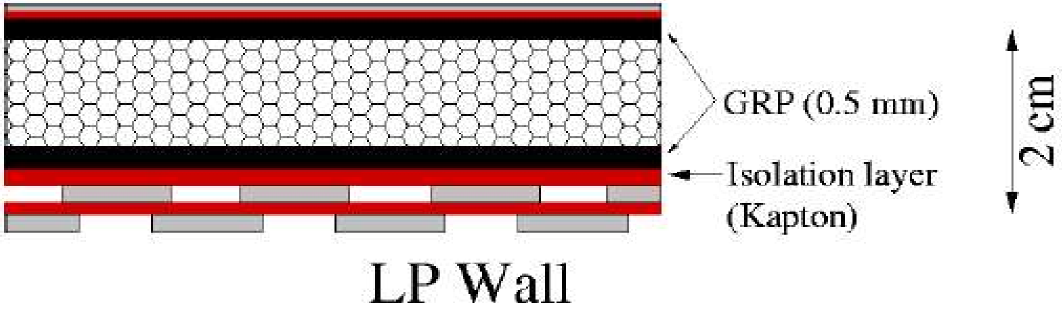


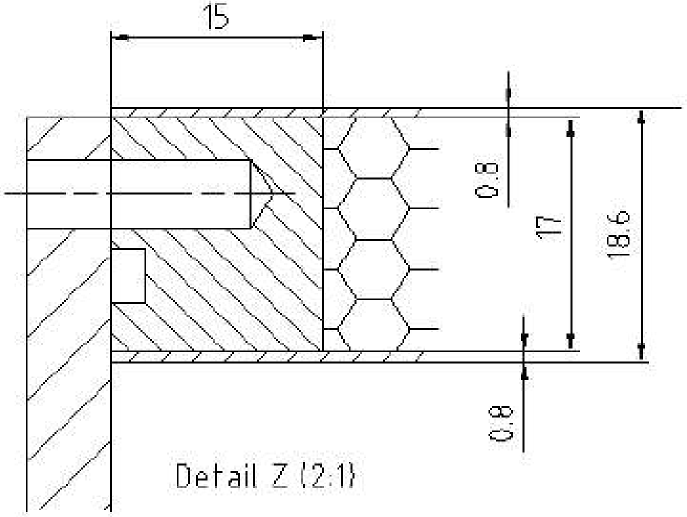
inner diameter: 730 mm, length: 60 cm, wall thickness: 2 cm

L. Hallermann, DESY

LP-TPC FC

- Composite material
- Layers of GRP and NOMEX honeycomb
- G10 flanges

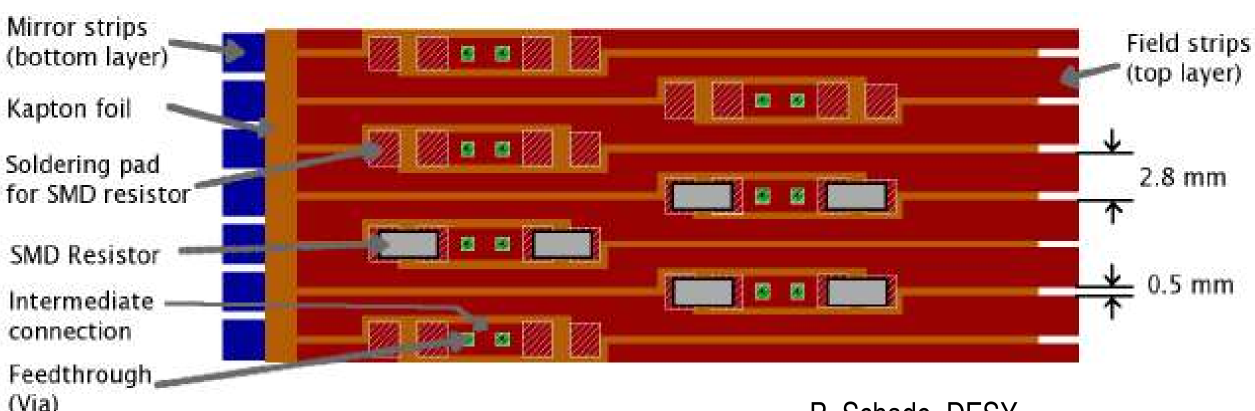


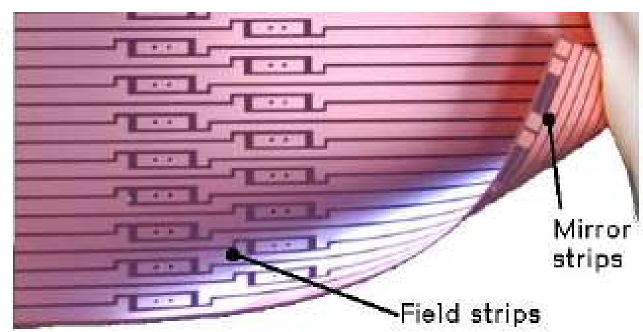


L. Hallermann, DESY

LP-TPC FC Field Strips

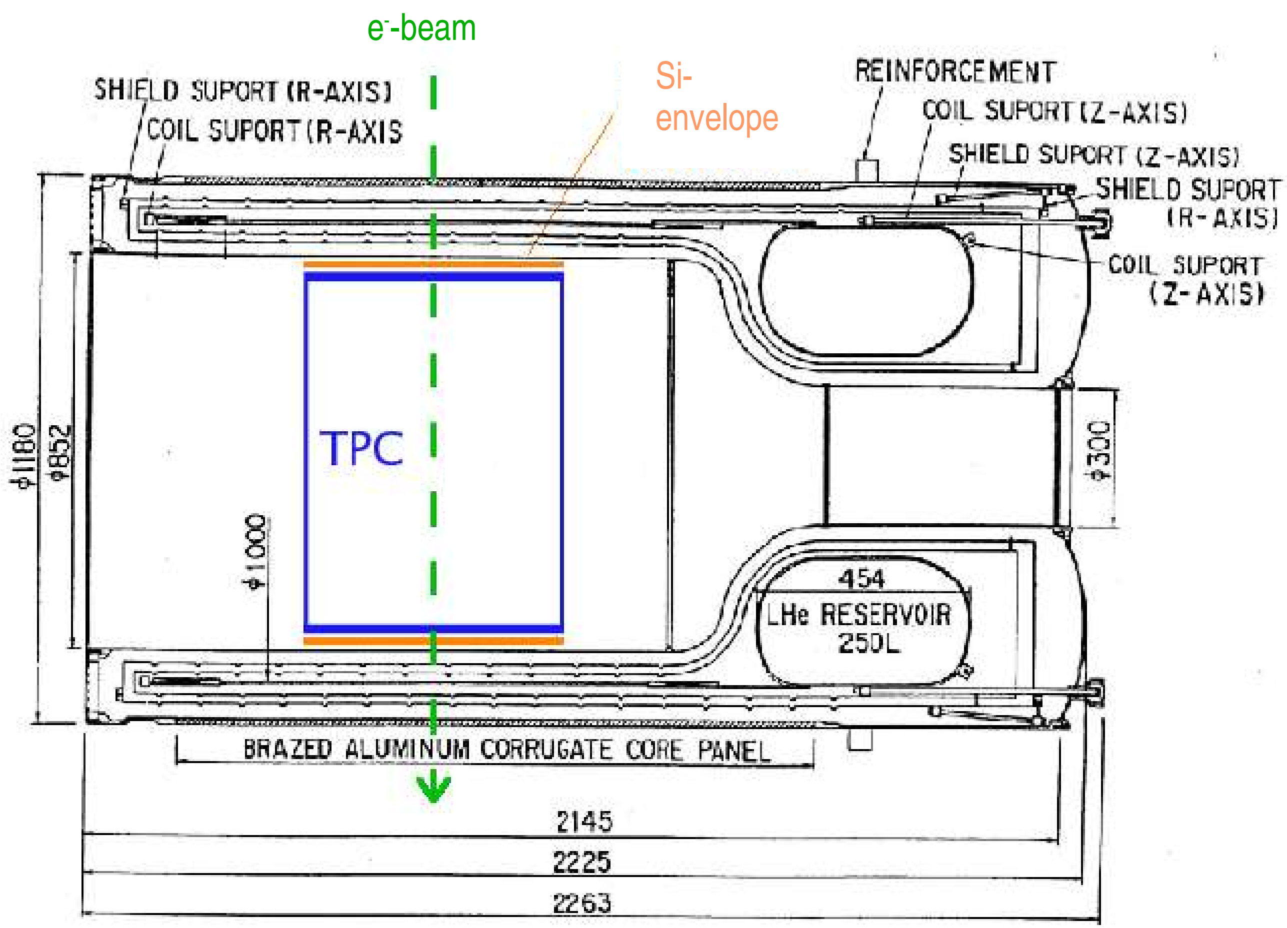
- Kapton, coated with Cu-strips
- Divider chain with SMD resistors
- 90 V between neighboring strips, i.e. $E_{drift,max} = 320$ V / cm





P. Schade, DESY

PCMAG at DESY

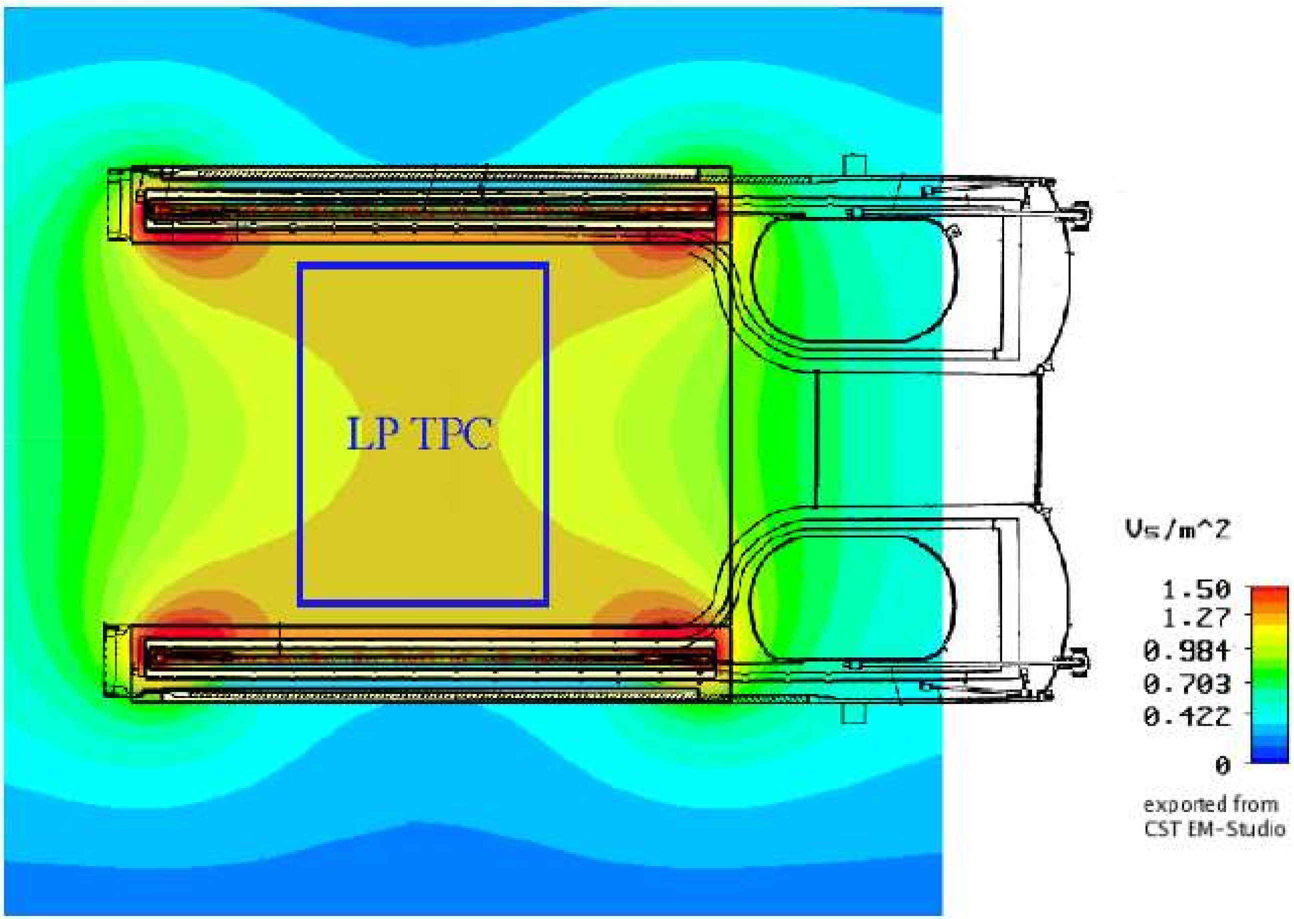


$$B_{max} \cong 1.25\ \mathrm{T}$$

L. Hallermann, DESY

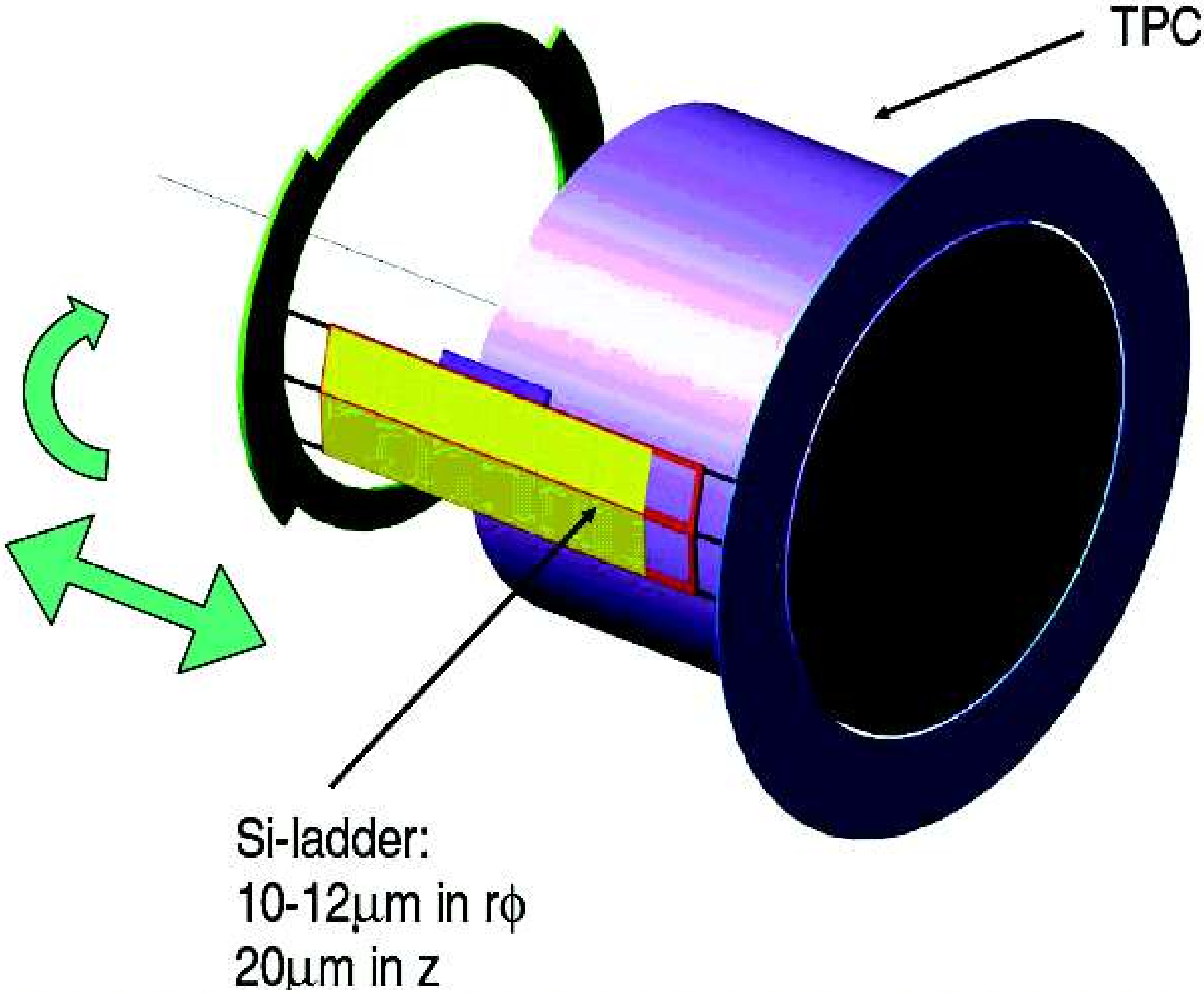
PCMAG at DESY

"Inhomogenous" B-Field

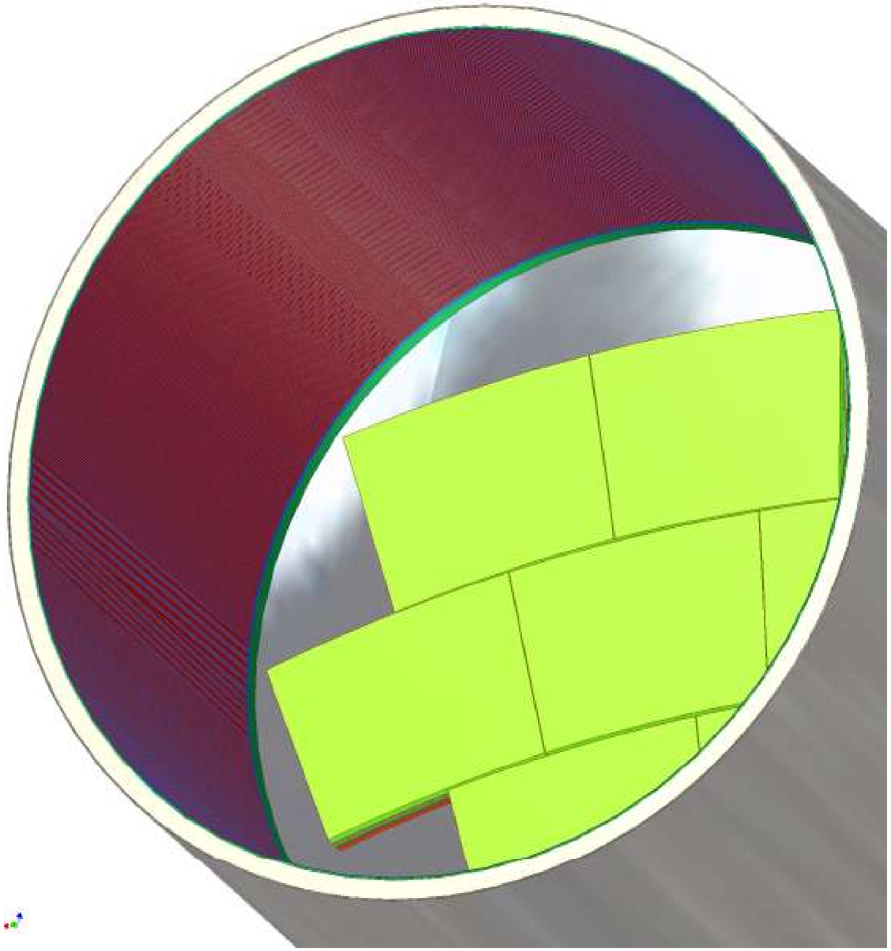


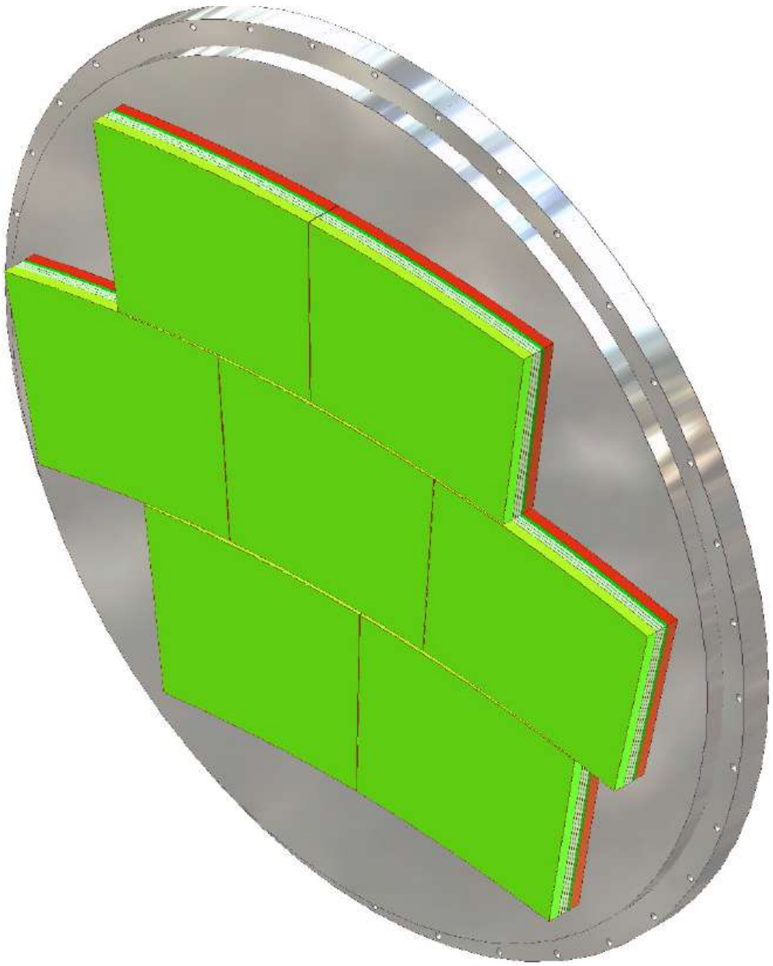
P. Schade, DESY

Si-Envelope



LP-TPC Endplates

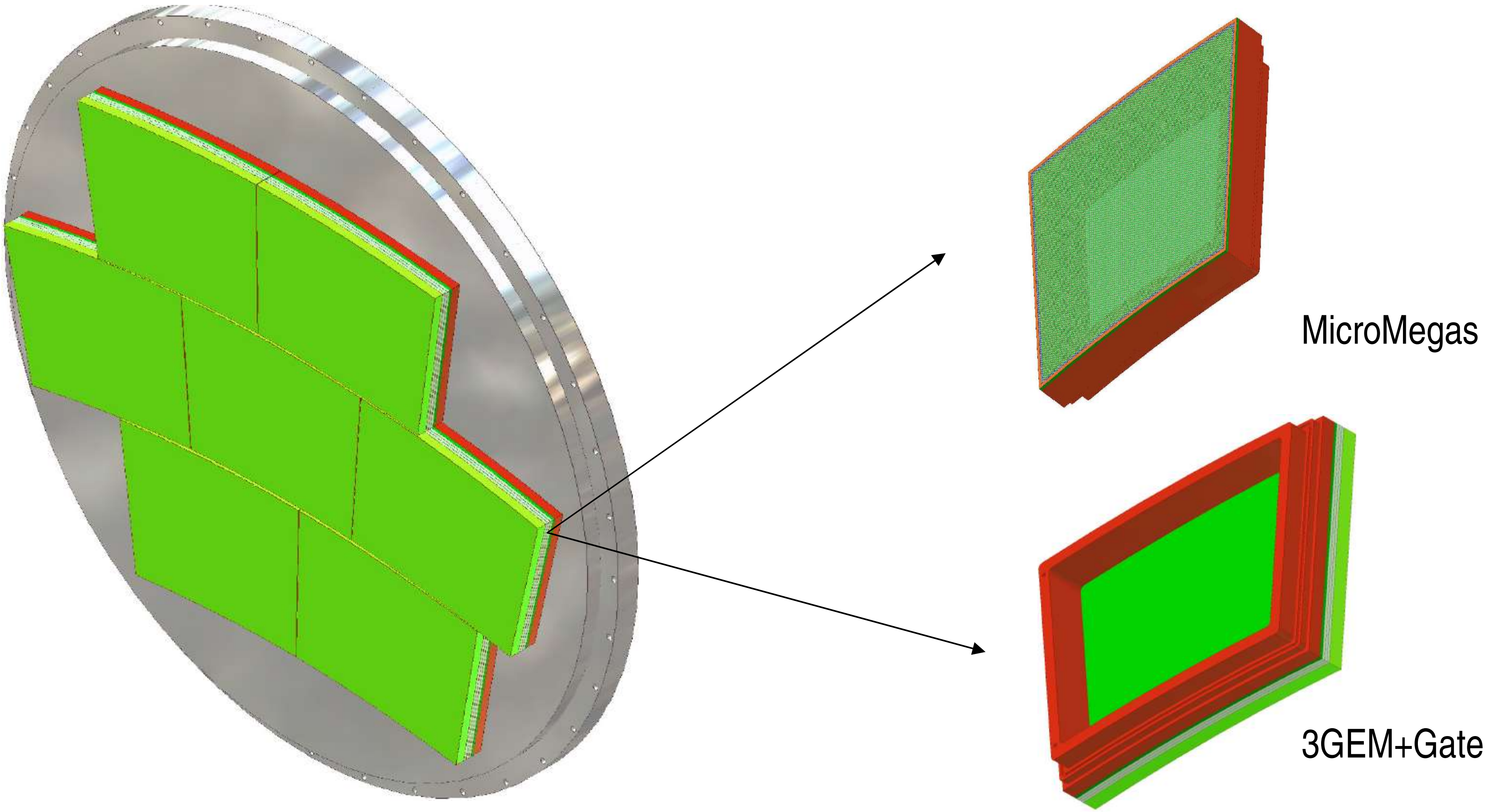




D. Peterson, Cornell

LP-TPC Endplates

Interchangeable amplification/readout structure



D. Peterson, Cornell

LP-TPC Electronics

- Charge sensitive readout-electronics, equipped with charge-to-time conversion circuit and multi-hit TDC for each channel
- Based upon ALTRO chip (ALICE)
- > 10k channels
- Programable charge amplifier
- 10-bit 40 MHz ADC

see Luciano Musa's talk

LCTPC Outlook

Large Prototype R&D

Device	Lab(years)	Configuration
LP1→1.5	Desy/Eudet(2007-2009)	Fieldcage⊕2 endplates: GEM+pixel, Micromegas+pixel
Purpose: Test construction techniques using 10000 Alice/Eudet channels, demonstrate measurement of 6GeV beam momentum over 70cm tracklength, including development of corrections procedures		
LP2	Fermilab/Eudet(2010-2011)	Fieldcage⊕endplate: GEM, Micromegas, or pixel
Purpose: Prototype for LCTPC including gating and other options, demonstrate measurement of 100GeV beam momentum over 70cm tracklength, and in jet evironment, test prototype LCTPC electronics		