The LCTPC Large Protoype at the DESY Testbeam

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DESY

TILC08 Sendai

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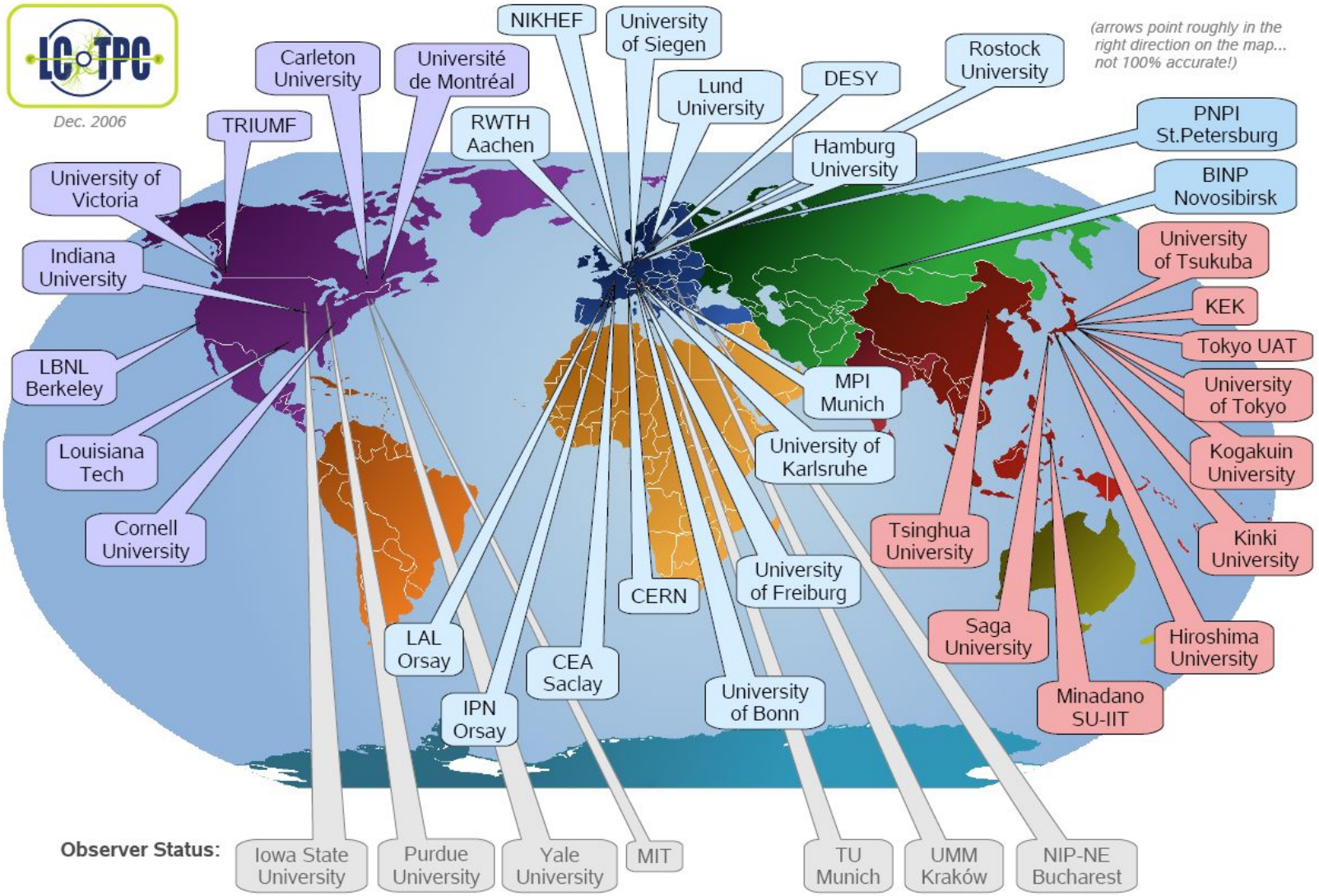
LCTPC Collaboration



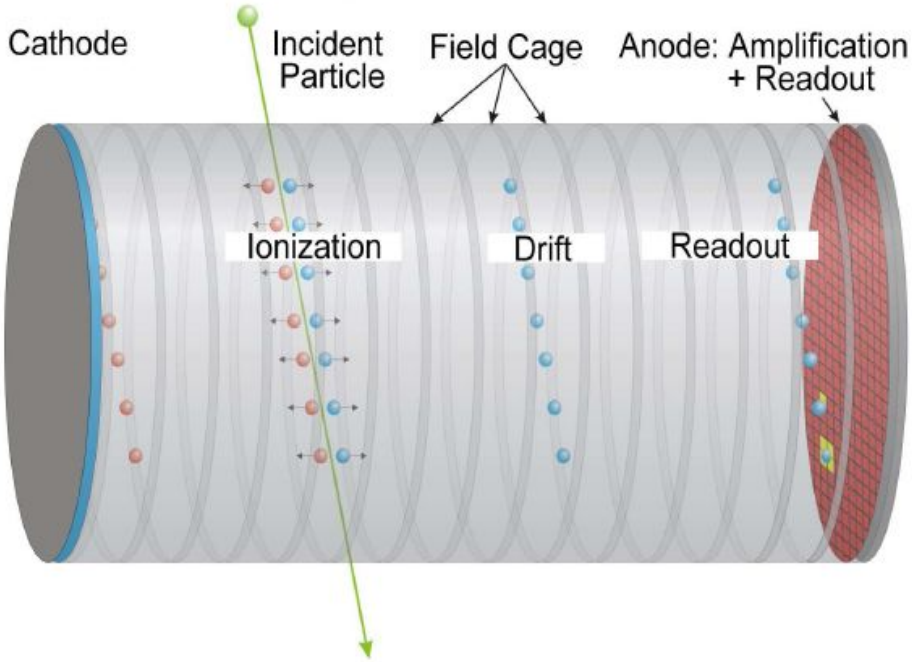
LCTPC Collaboration

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

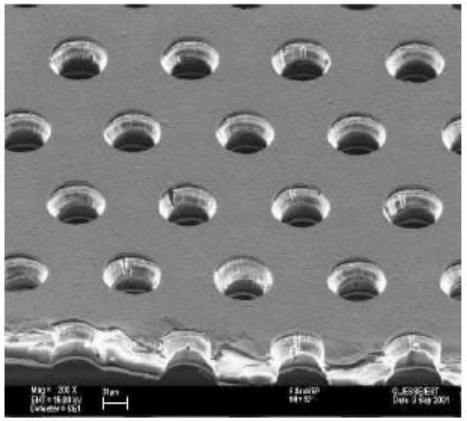
Size (LDC–GLD average)	$\phi = 3.6$m, L = 4.3m outside dimensions
Momentum resolution (B=4T)	$\delta(1/p_t) \sim 10 \times 10^{-5}$/GeV/c TPC only; $\times$ 0.4 incl. IP
Momentum resolution (B=4T)	$\delta(1/p_t) \sim 3 \times 10^{-5}$/GeV/c (TPC+IT+VTX+IP).
Solid angle coverage	Up to at least $\cos\theta \sim 0.98$
TPC material budget	$< 0.03X_0$ to outer fieldcage in r
	$< 0.30X_0$ for readout endcaps in z
Number of pads	$> 1{\times}10^6$ per endcap
Pad size/no.padrows	$\sim$ 1mm$\times$4–6mm/$\sim$200 (standard readout)
$\sigma_{\text{singlepoint}}$ in $r\phi$	$\sim 100\mu$m (for radial tracks, averaged over driftlength)
$\sigma_{\text{singlepoint}}$ in rz	$\sim$ 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.

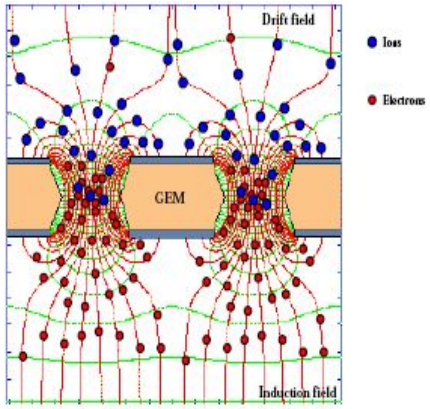
with MPGD

MPGD Based TPC

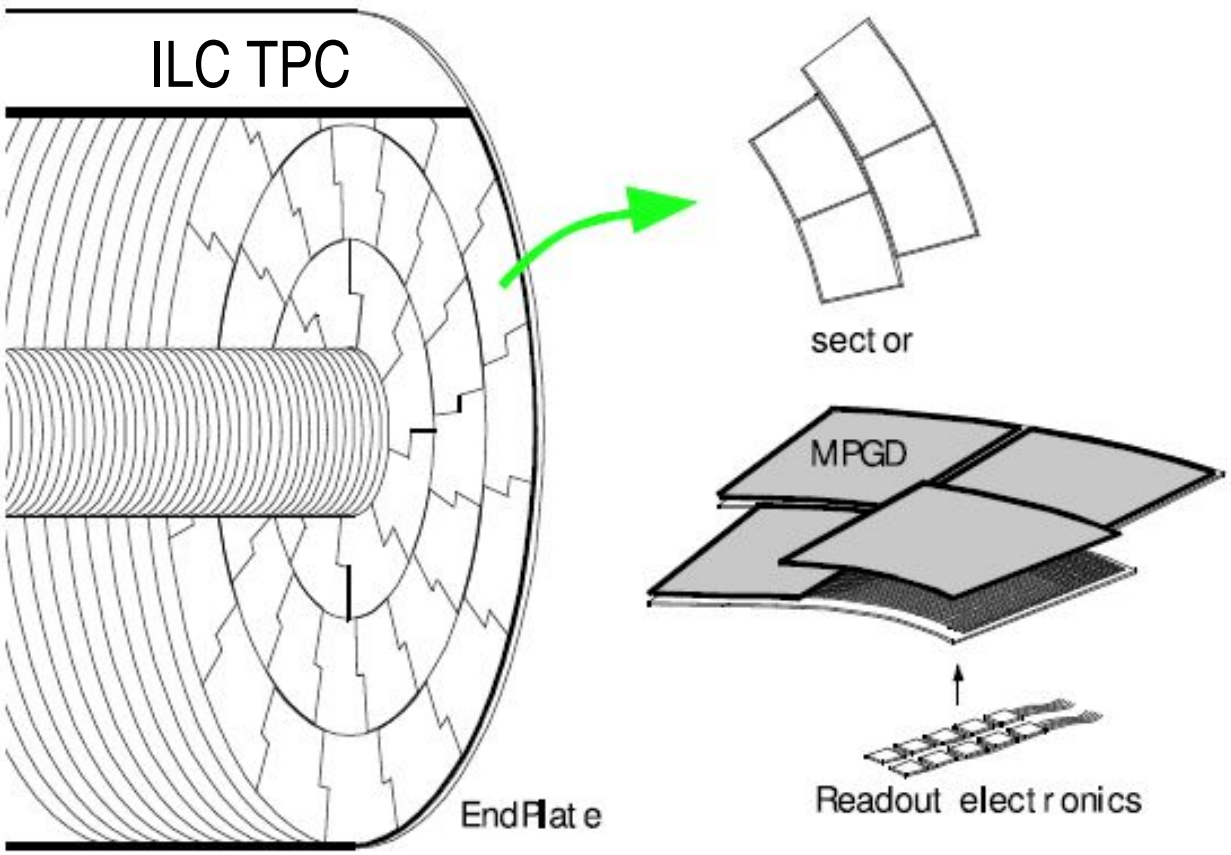


MicroPatternGasDetector
MPGD
not limited by **E** x **B** effects

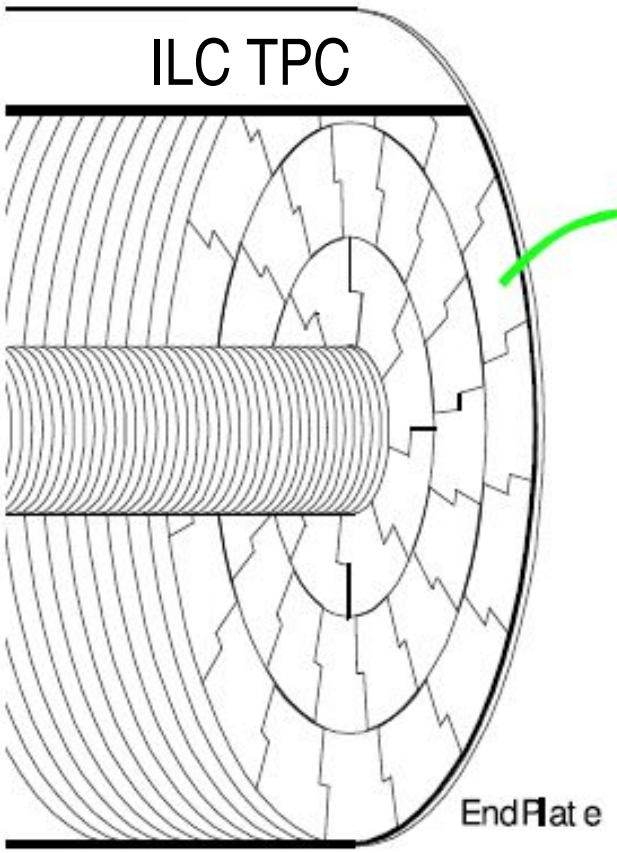


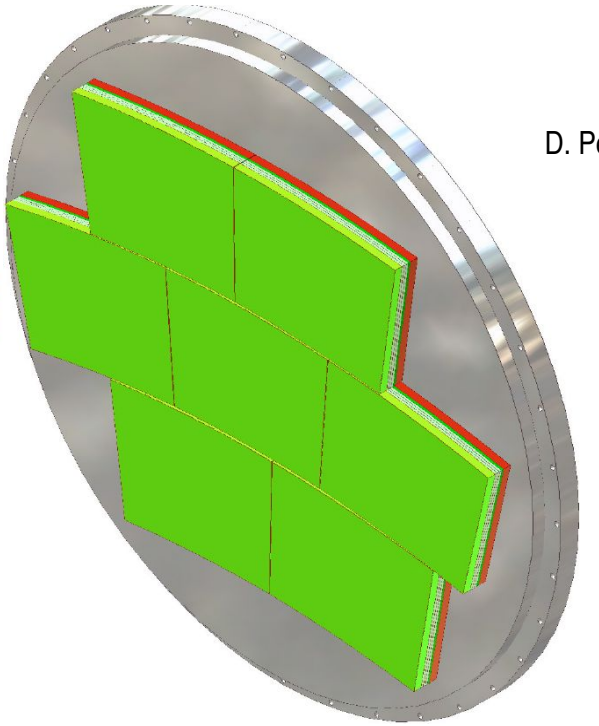


MPGD Based TPC



MPGD Based TPC





D. Peterson, Cornell

LP endplate as excerpt of ILC TPC endplate

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

➔ Consolidation phase

- Large prototype

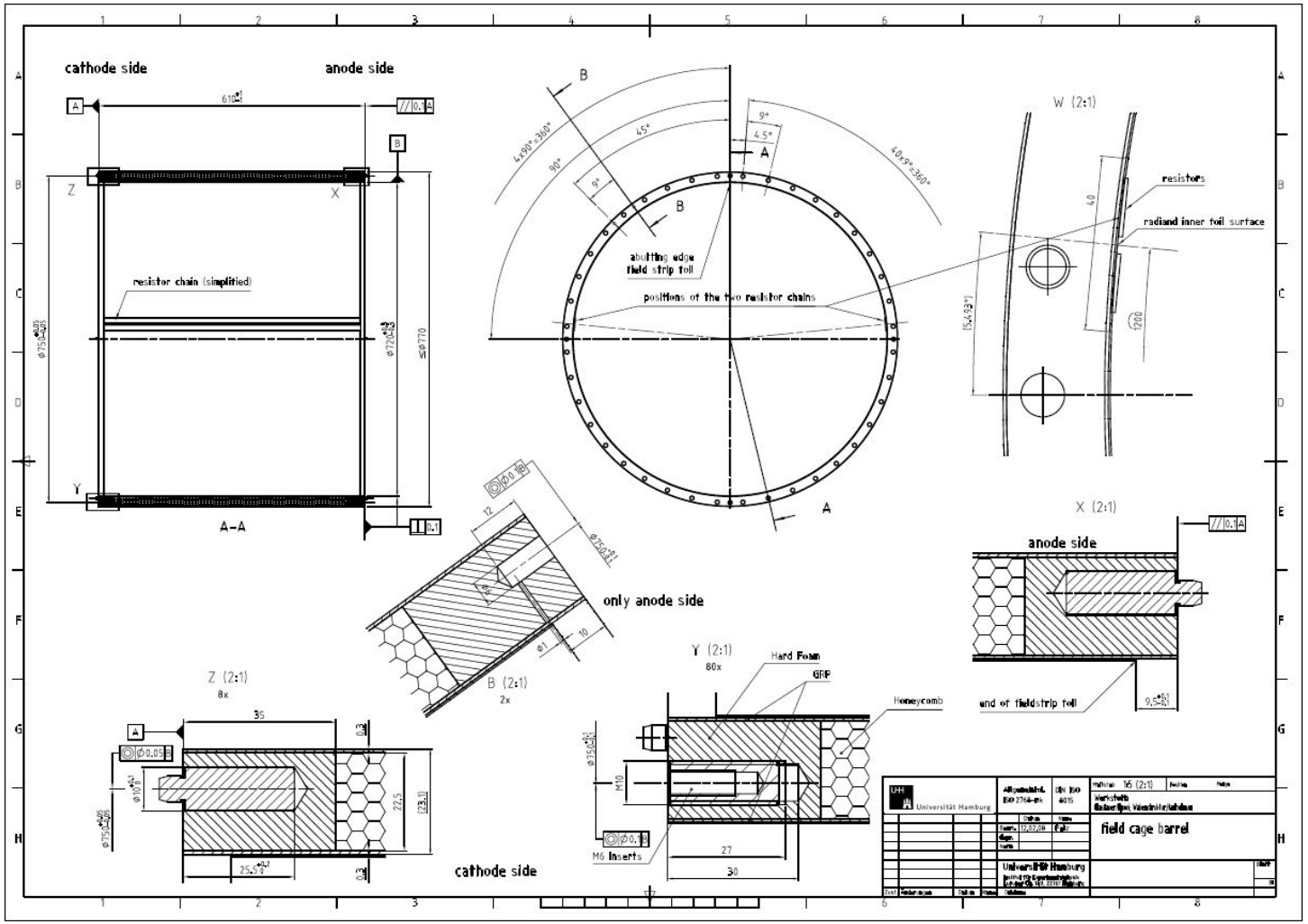
Consolidation Phase

- **Build and operate a "Large Prototype LP"**
- **First iteration of TPC-design details of the LCTPC can be tested**
- **Larger area readout can be operated**
- **Tracks with a large number of measured points are available for analyzing correction procedures**
- **Tasks have been divided into WorkPackages (WP)**

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

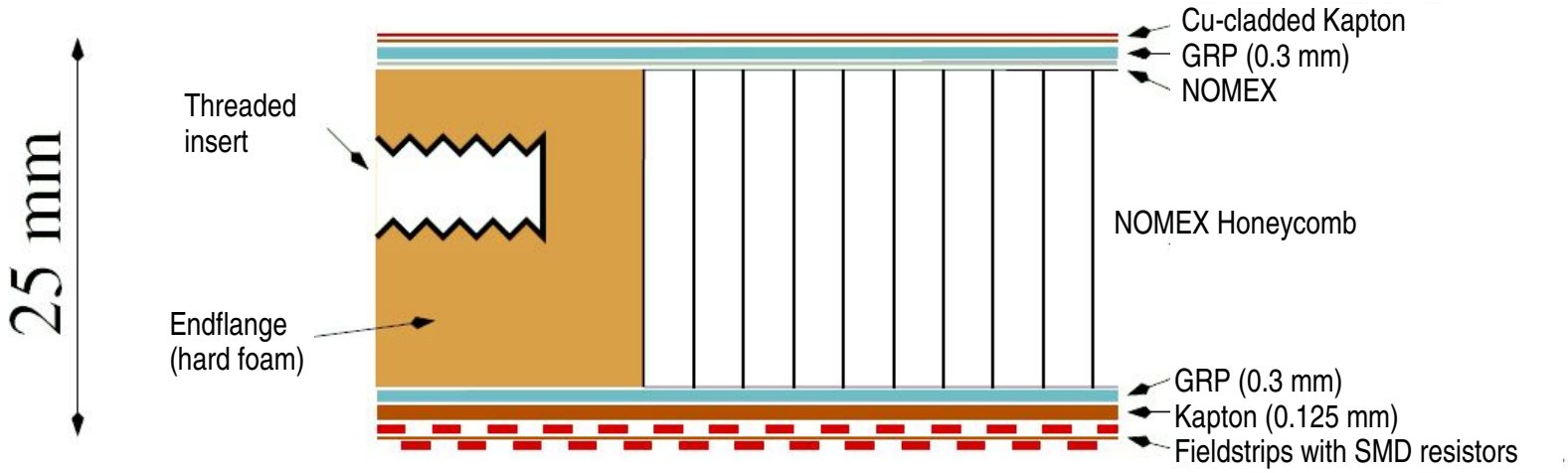
LP-TPC FC



Length: 610 mm; Diameter: inner 720 mm, outer 770 mm

LP-TPC FC

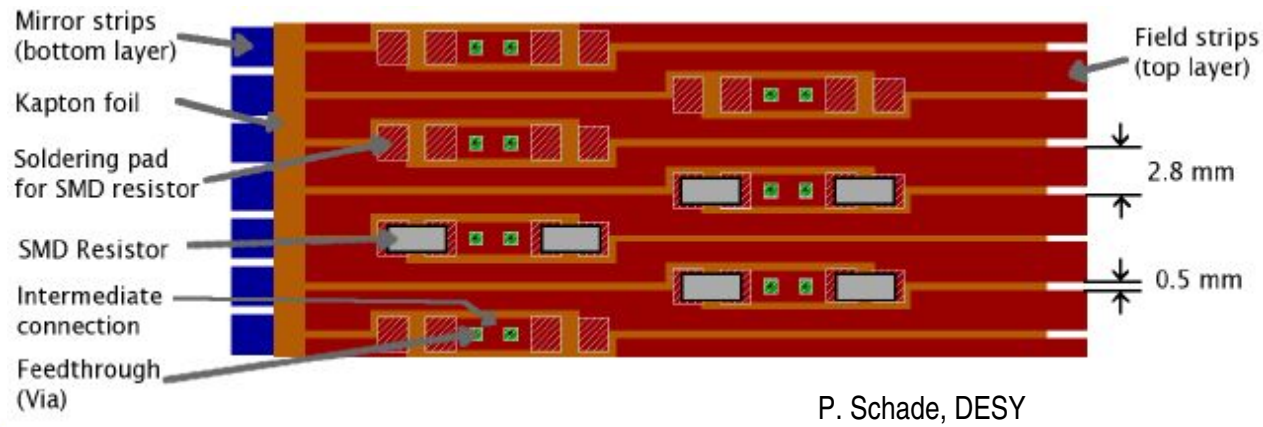
- Composite material
- Layers of GRP and NOMEX honeycomb
- Fieldstrips

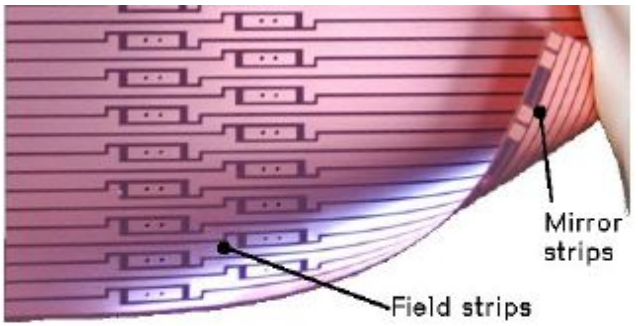


P. Schade, DESY

LP-TPC FC Field Strips

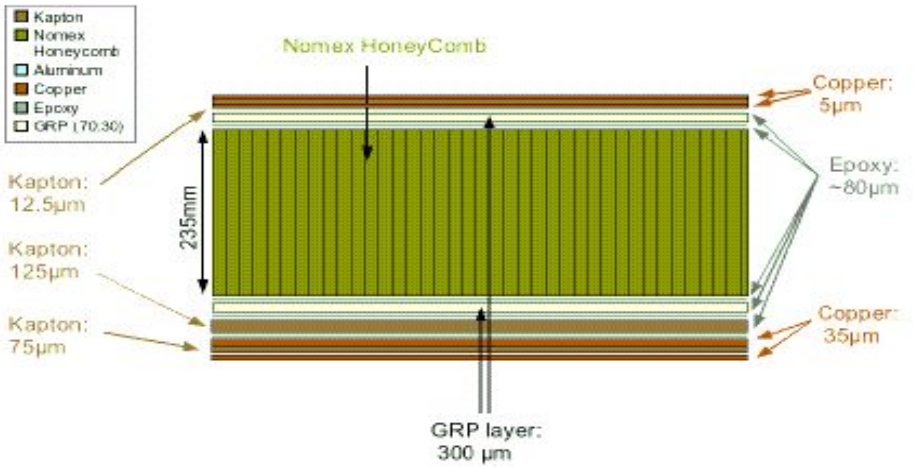
- Kapton, coated with Cu-strips
- Divider chain with SMD resistors
- 90 V between neighboring strips,
  i.e. $E_{drift,max}$ = 320 V / cm

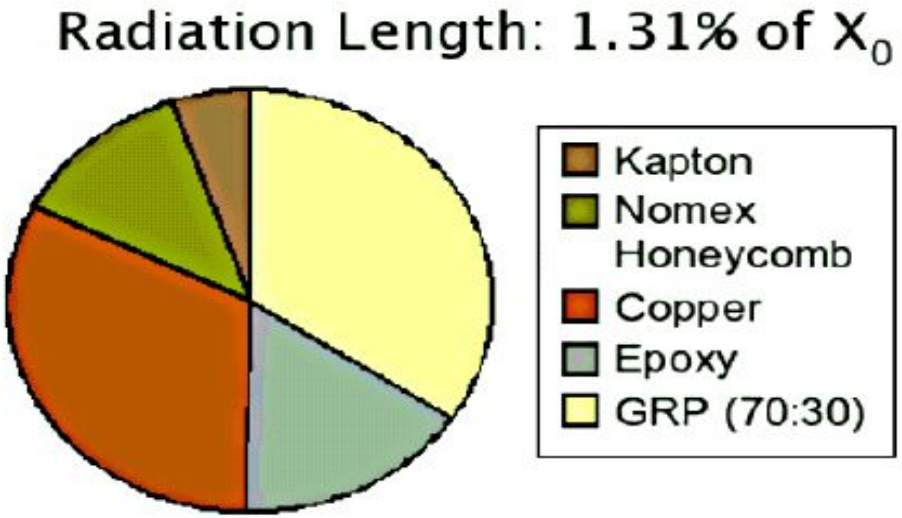




P. Schade, DESY

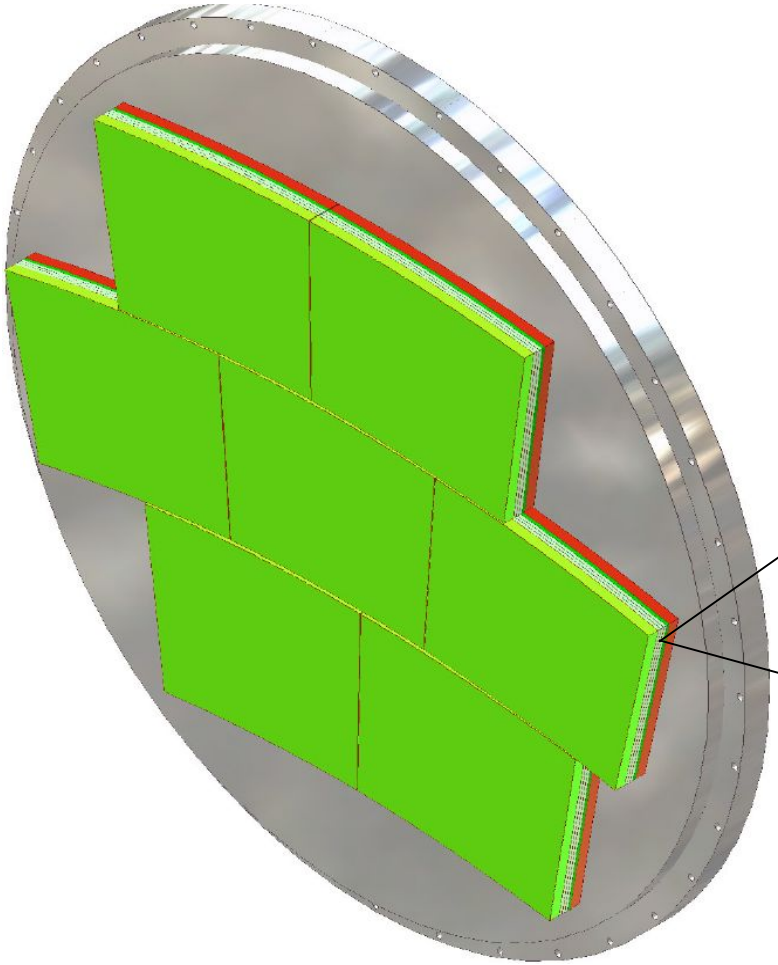
LP-TPC FC

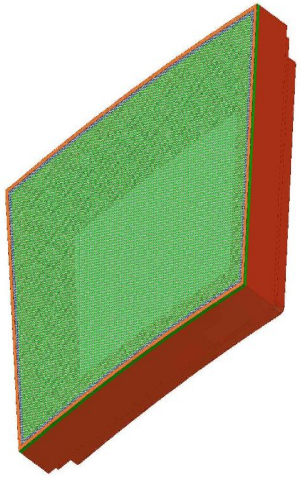

Kapton
Nomex Honeycomb
Aluminum
Copper
Epoxy
GRP (70:30)
Nomex HoneyComb
Copper: 5µm
Epoxy: ~80µm
Copper: 35µm
Kapton: 12.5µm
Kapton: 125µm
Kapton: 75µm
235mm
GRP layer: 300 µm


Radiation Length: 1.31% of X_0
Kapton
Nomex Honeycomb
Copper
Epoxy
GRP (70:30)

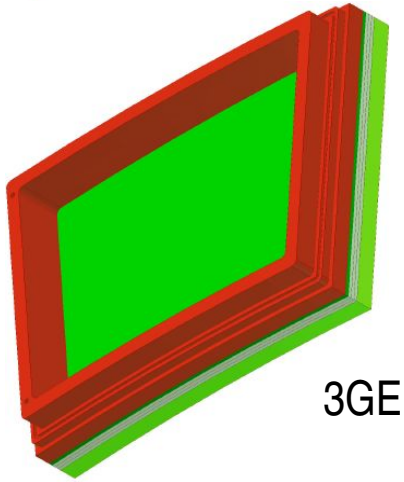
LP-TPC Endplates

Interchangeable amplification/readout structure





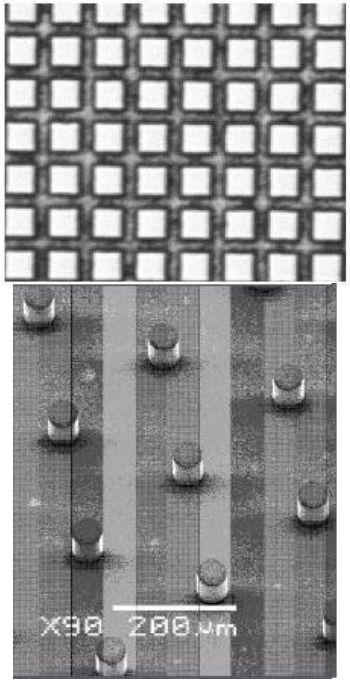
MicroMegas



3GEM+Gate

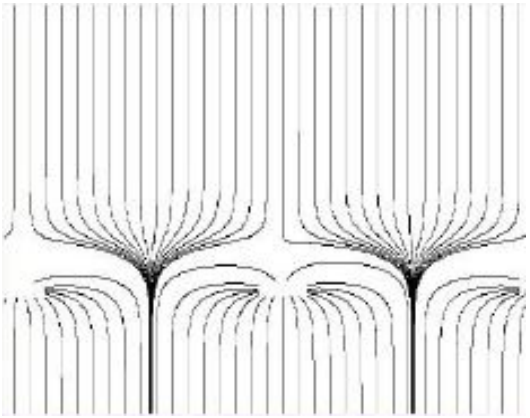
D. Peterson, Cornell

MPGD MicroMegas

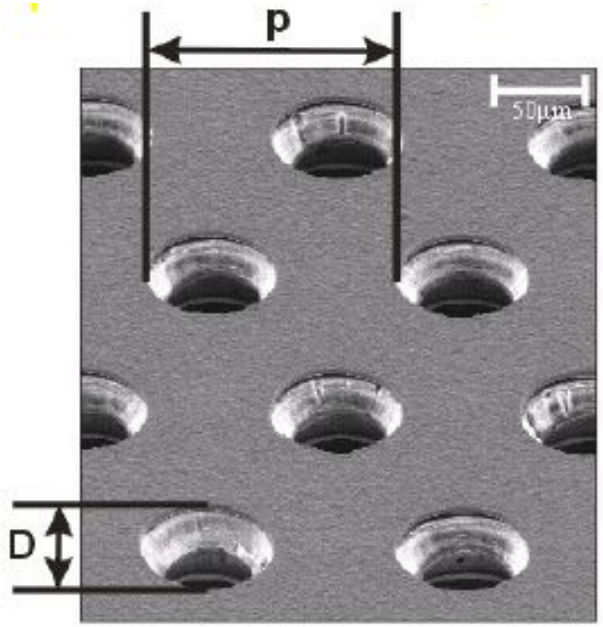


MicroMeshGaseousStructure
(Micromegas):
micromesh sustained by 50 µm pillars,
multiplication between anode and mesh;
one stage

Multiplication

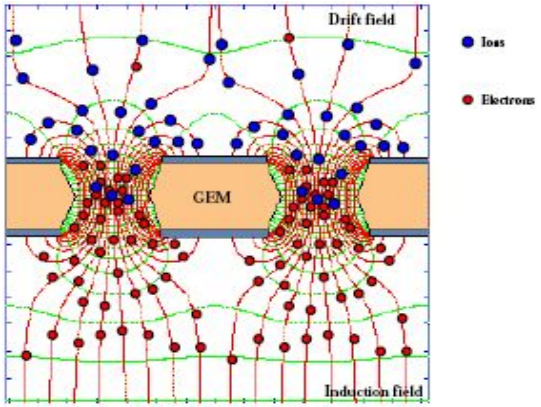


MPGD GEM



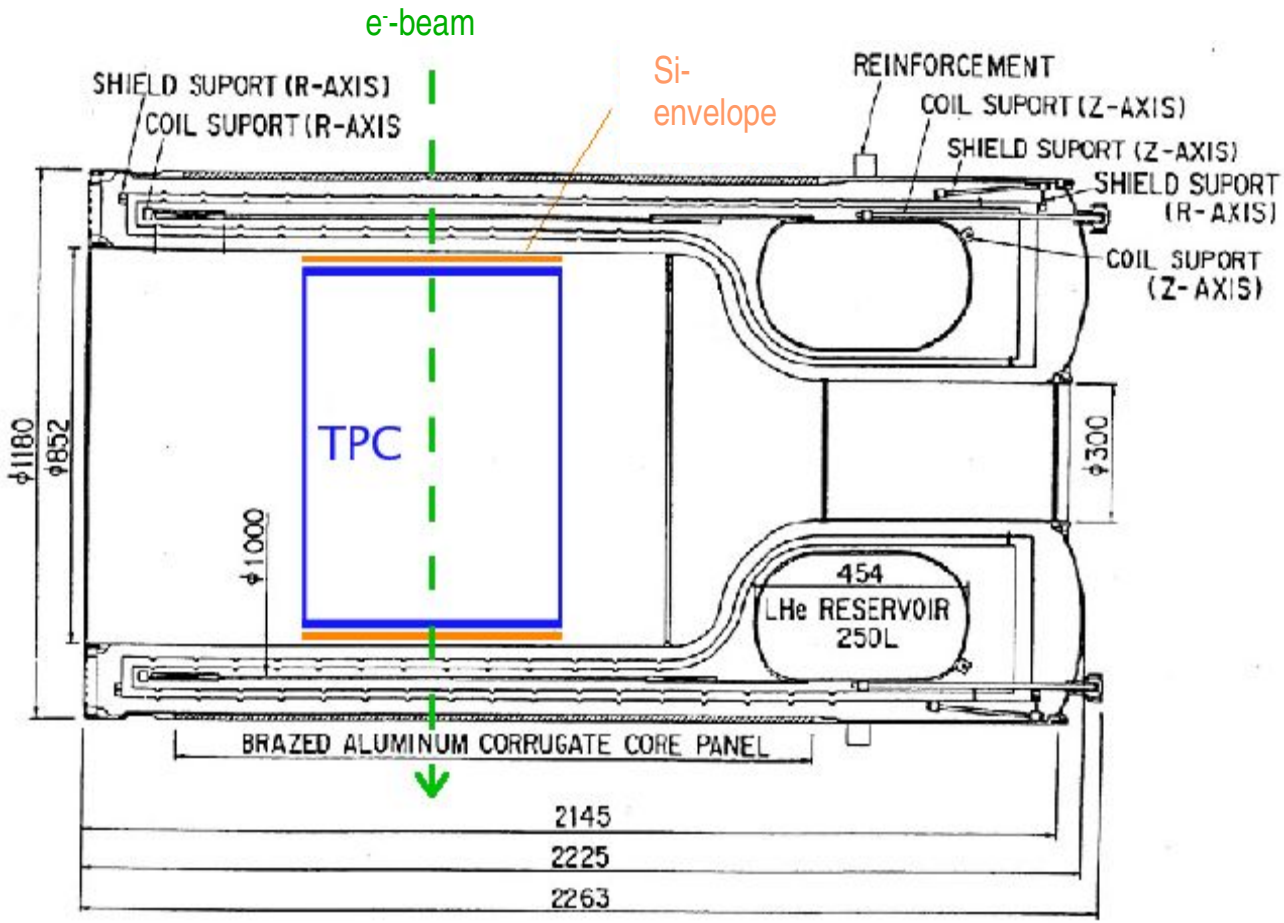
p=140 µm
D=70 µm

Multiplication



GasElectronMultiplier (GEM):
50 µm Kapton foil, each side covered with 5 µm Cu clad;
multiple stage

Magnet PCMAG at DESY

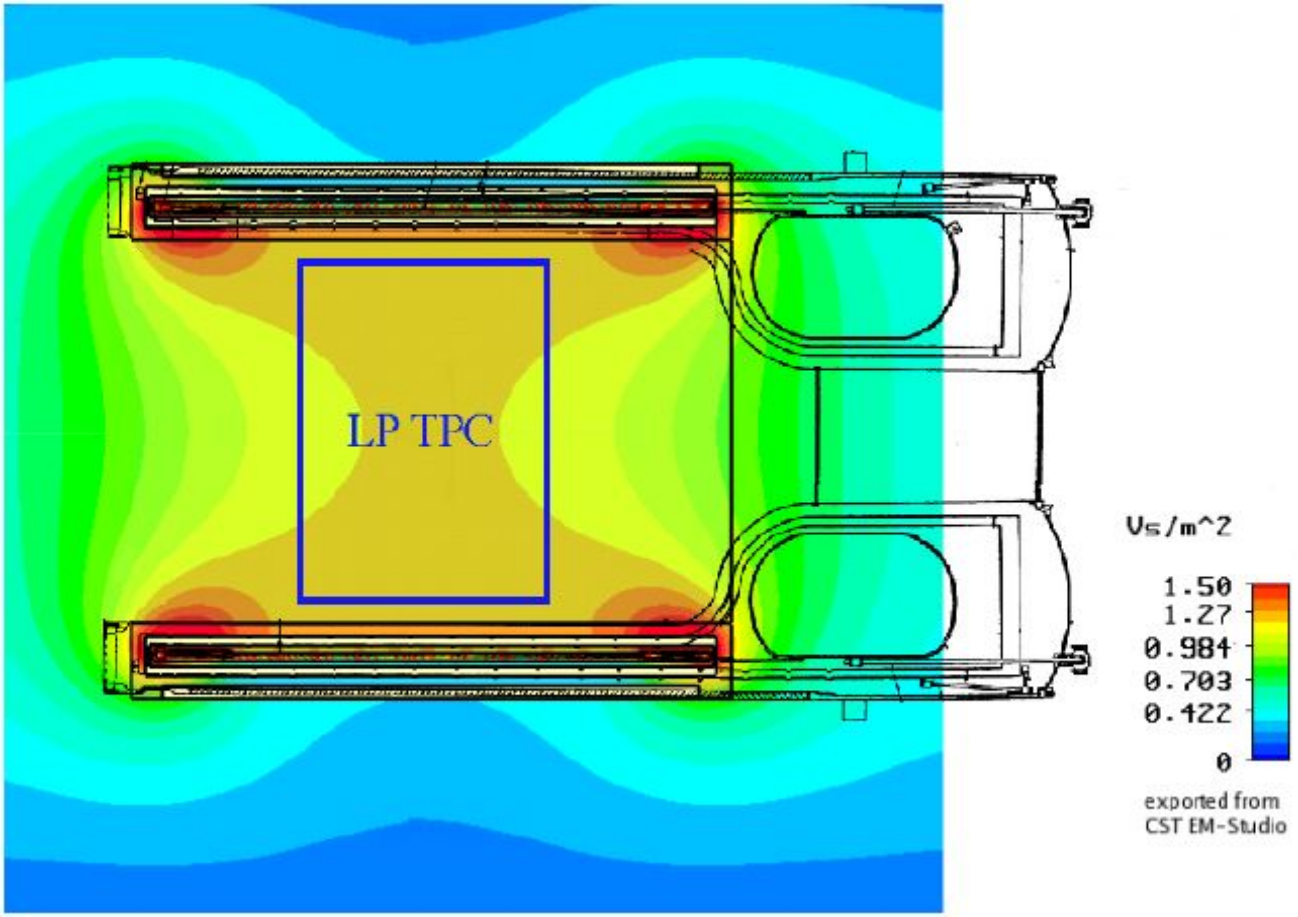


$B_{max} \cong 1.25$ T

L. Hallermann, DESY

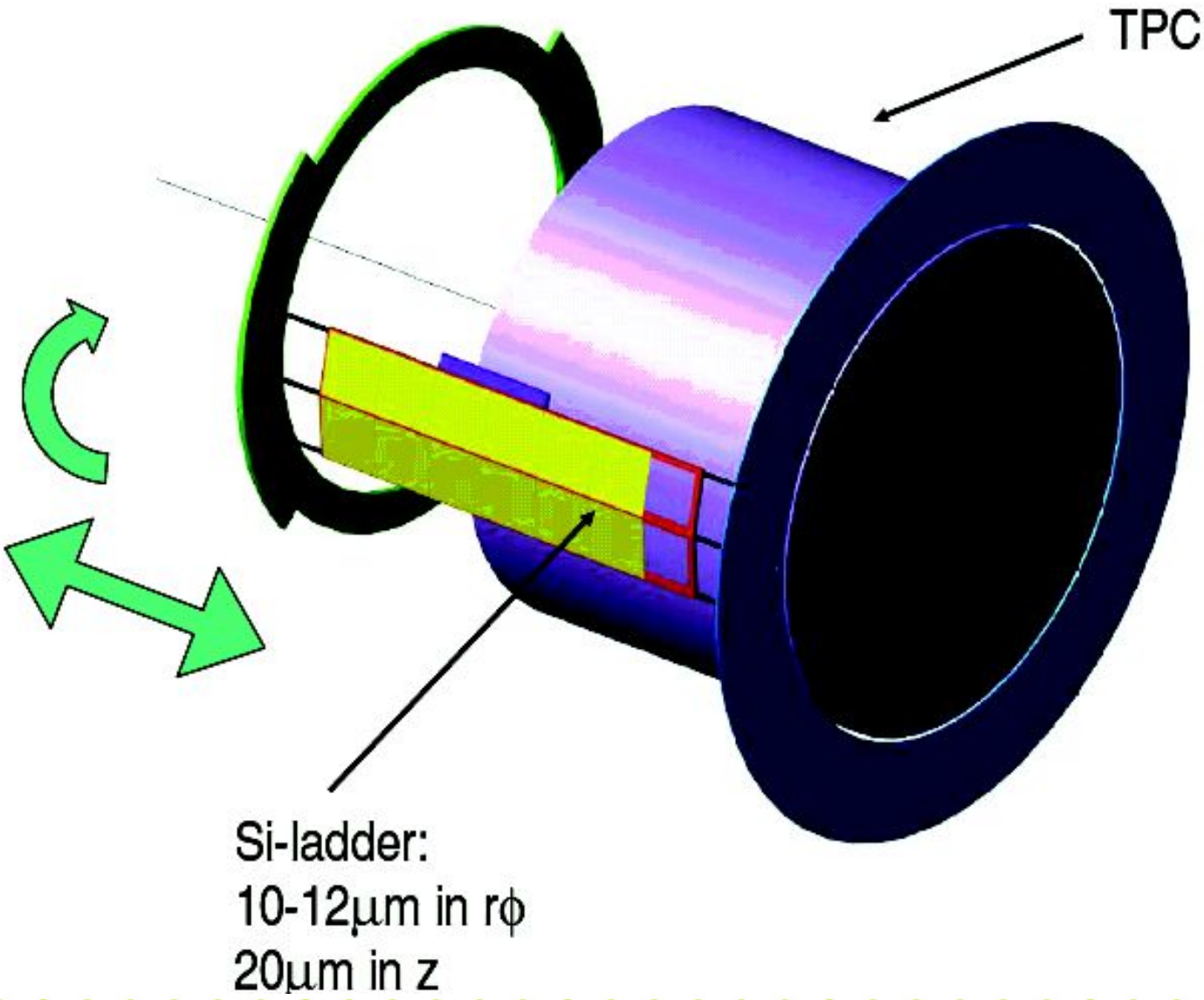
Magnet PCMAG at DESY

"Inhomogenous" B-Field ⇒ Scan TPC at various regions



P. Schade, DESY

Si-Envelope



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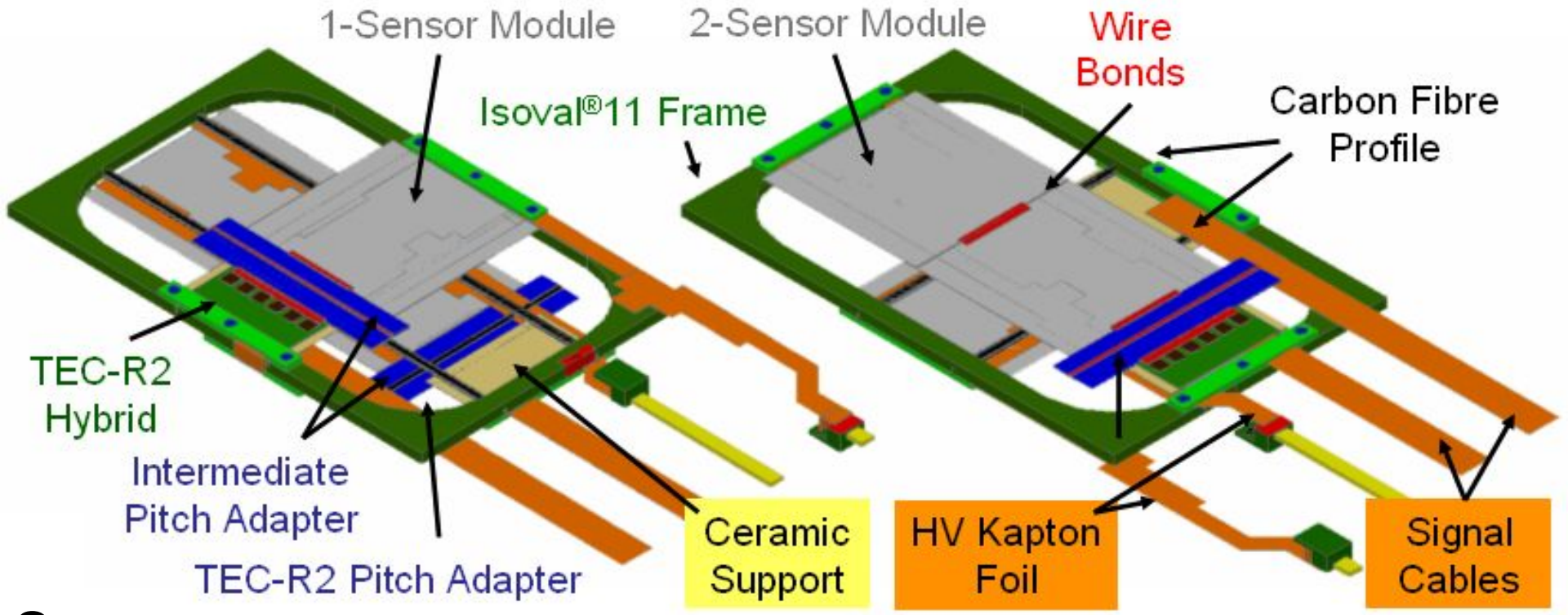


Sensors

- first setup: only 768 channels can be read out
  - ➢ the readout sensitive area is reduced to 38,4 x 38,4 mm² (only the intersecting readout area of the two modules on top of each other is interesting)

⇒ Need for a sophisticated stage system

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

Schedule & Summary

- Components are being collected and assembled
- FC – Cathode – Anode expected in April
- First amplification panel (MicroMegas) expected in April
- Commissioning will start in April/May
- Commissioning / Calibration with Cosmic Muon Trigger Setup
- ALTRO electronics available in May
- GEM amplification panel(s) available in August
- DESY II testbeam available in September 2008
- LP is under way

LCTPC Outlook

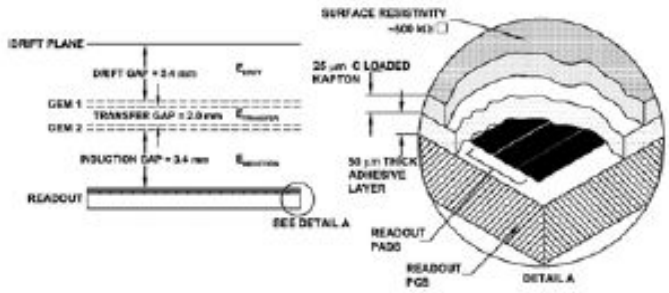
Large Prototype R&D

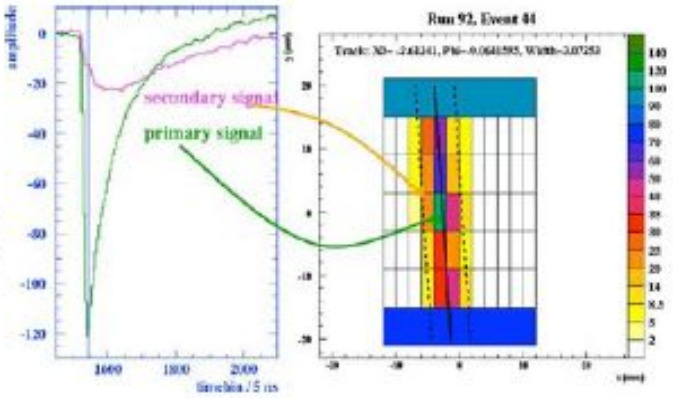
Device	Lab(years)	Configuration
LP1→1.5	Desy/Eudet(2007-2009)	Fieldcage⊕2 endplates: GEM+pixel, Micromegas+pixel
Purpose: Test construction techniques using 10000 Alice/Eudet channels, demonstrate measurement of 6GeV beam momentum over 70cm tracklength, including development of corrections procedures		
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		


DESY

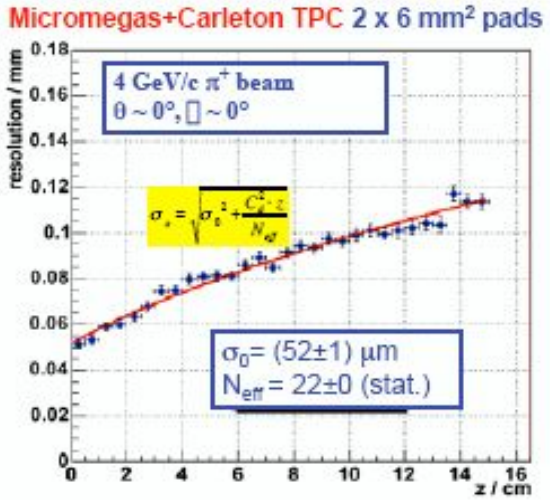
TPC Prototype

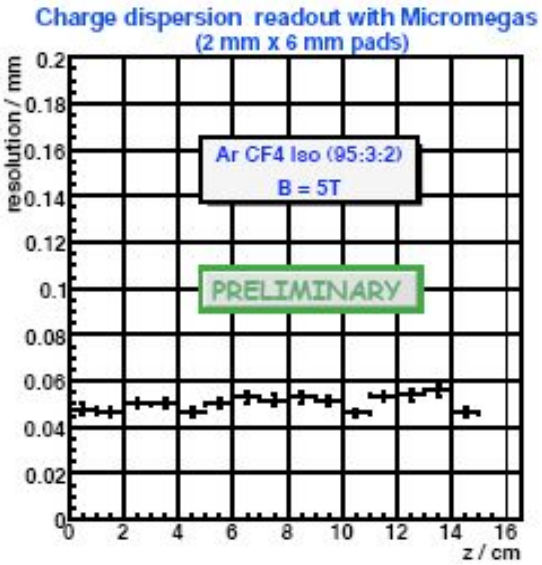
- Track Point Resolution measurements with MicroMegas





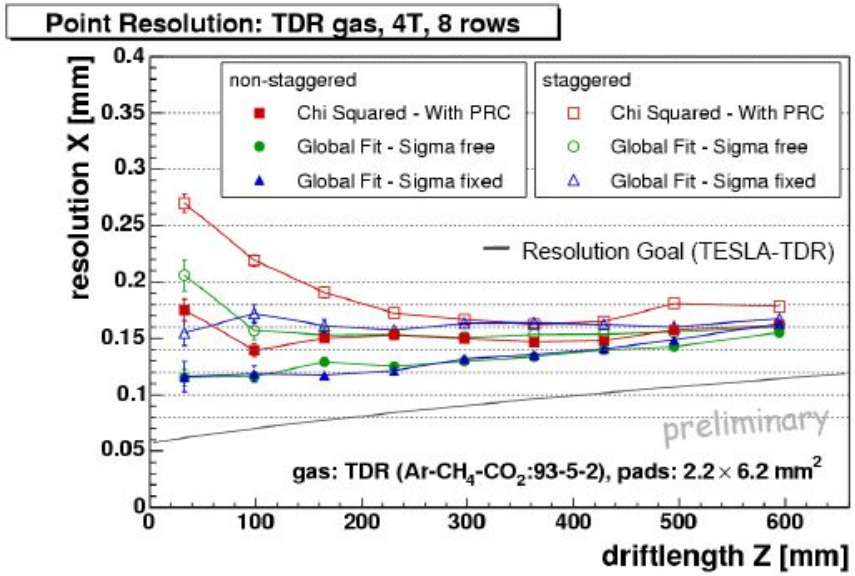
without and with resistive anode



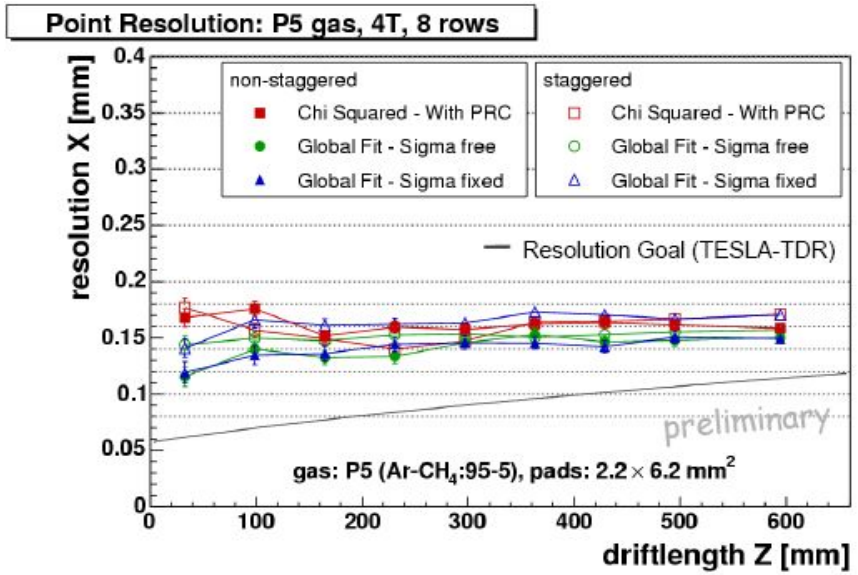


TPC Prototype

- Track Point Resolution measurements with GEMs



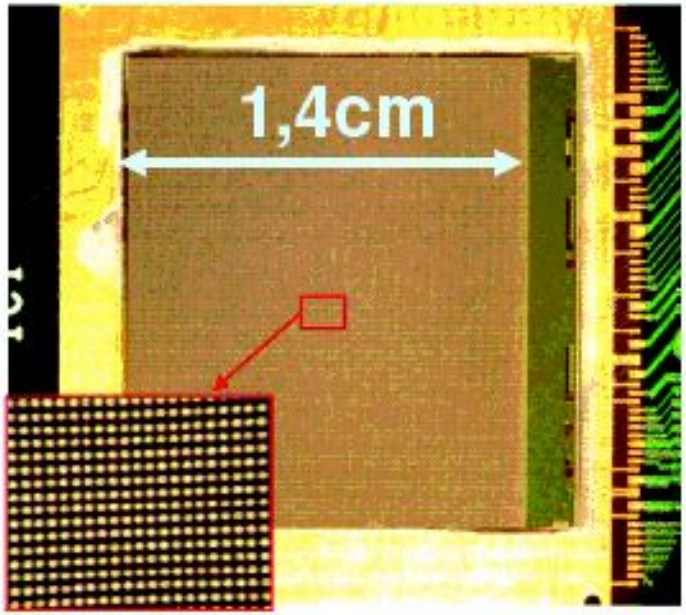
Cosmic Muon tracks
Pad layout:
24 columns, 8 rows
pitch 2.2 mm x 6.2 mm



Resolution between
120 μm and 180 μm
for drift distances
≤ 600 mm

TPC with CMOS Pixel Readout

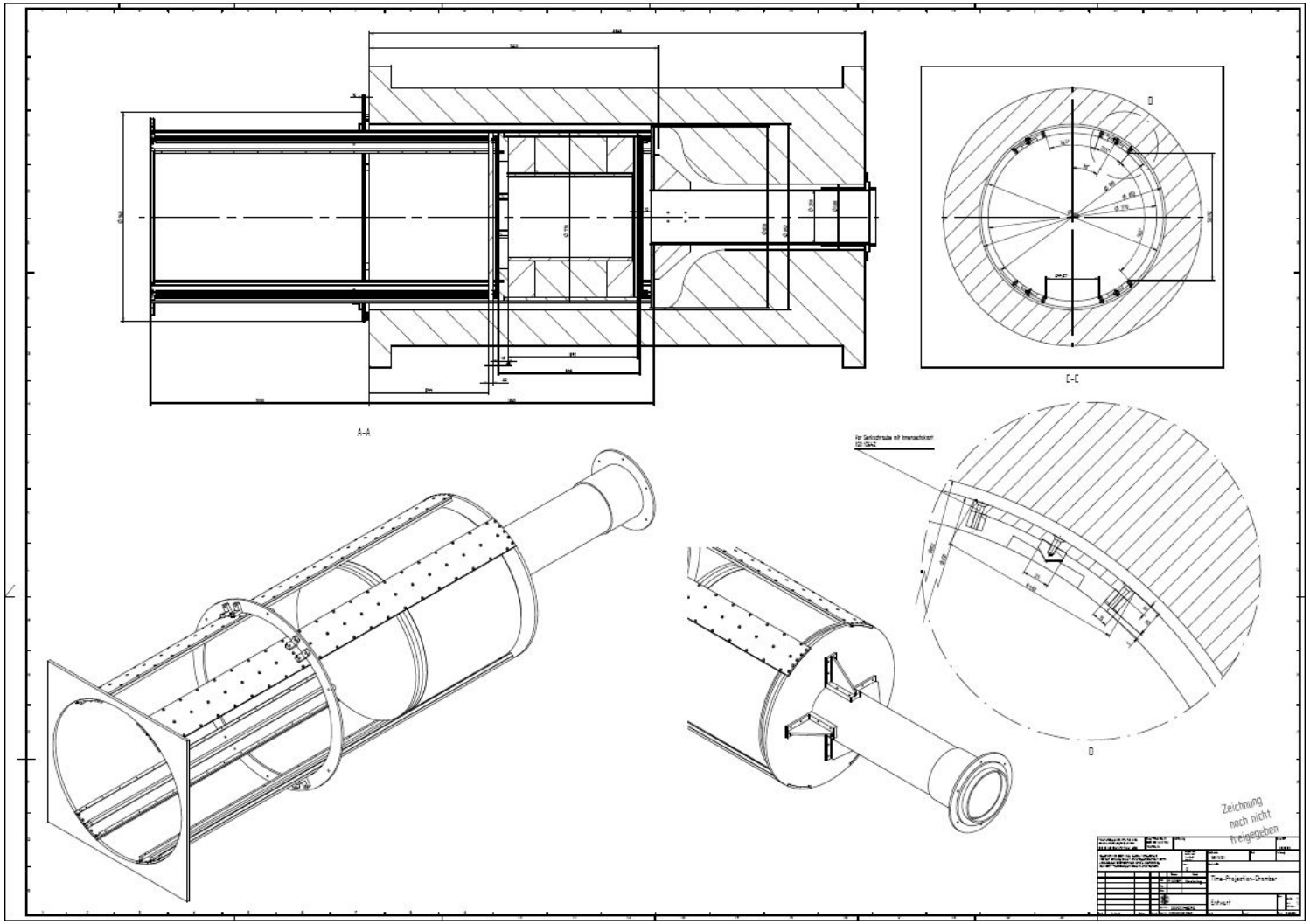
- TPC with ASIC readout
- MediPix2/TimePix state of the art readout
- Initial “proof-of-principle” tests



Medipix2/TimePix similarities

- Pixel size 55µm, arranged in a 256x256 Matrix
- dimensions of the *sensitive area*: *1,4x1,4cm²*
- Used equalized and calibrated chip with lower threshold of
  - Medipix2 990 e⁻
  - TimePix ≈ 700 e⁻

Support Structure



Cosmic Muon Setup