TPC in ILD

ILC/ECFA - Warsaw

11 June 2008

Jan Timmermans

NIKHEF

LC TPC Collaboration

Asia

*Hiroshima Univ.
*KEK
*ISAS, JAXA
*Kinki Univ.
*Kogakuin Univ.
*Minadanao State Univ.
*NiAS
*Saga Univ
Tsinghua Univ.
Univ. of Tokyo (ICEPP)
*TUA
(*) CDC group

Americas

Carleton Univ.
&
TRIUMF
Univ. de Montreal,
Univ. of Victoria
&
TRIUMF
BNL
Cornell Univ.
Indiana Univ.
LBNL
Louisiana Tech

Europe

IIHE
LAL, IN2P3
IPN, IN2P3
Univ. de Paris-Sud
CEA Saclay
RWTH Aachen
Univ. Bonn
DESY & Univ. Hamburg
Albert-Ludwigs Univ.
Univ. Karlsruhe
MPI-Munich
Univ. Rostock
Univ. Siegen
NIKHEF
BINP, Novosibirsk
PNPI, St. Petersburg
Lund Univ.
CERN
EUDET

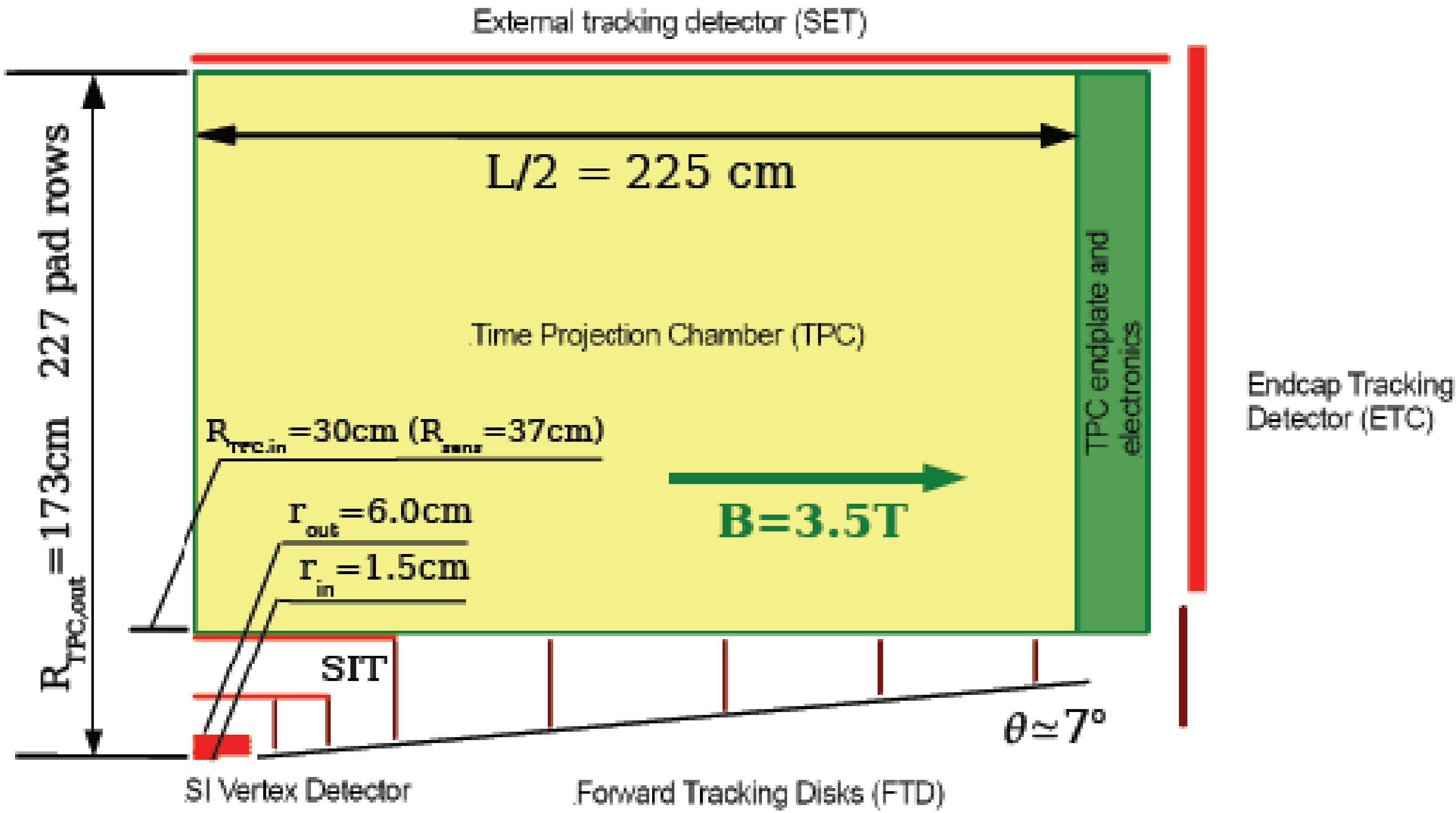
Contact persons for ILD:
Keisuke Fujii, Ron Settles

R&D Phase

1. **Demonstration Phase**: Provide a basic evaluation of the properties of an MPGD TPC and demonstrate that the requirements (at ILC) can be met using small prototypes.
2. **Consolidation Phase:** Design, build and operate a "Large Prototype" (of large number of measured points) at the EUDET facility in DESY.
3. **Design Phase:** Start working on an engineering design for aspects of the TPC at ILC.

We are mostly in the phase 2. However, there are still important studies of the phase 1 left, and the phase 3 is now starting together with the new ILD group.

ILD Tracking System
Mokka Model LDCPrime_02Sc



From Alexei Raspereza 10/6/2008

Digitization Procedure & Spatial Point Resolutions

- Simple digitization : Gaussian smearing of **SimTrackerHits** positions ⇒ **TrackerHits**

- **TPC** :

$$\sigma(r\text{-}\phi)^2 = \sigma_0^{\,2} + D^2 \cdot L_{drift} / N_{eff}$$

$$\sigma_0 = (50\mu m)^2 + (900\mu m \cdot \sin\phi_{local})^2$$

$$N_{eff} = 22 / (\sin\theta \cdot pad\_height[mm] / 6)$$

$$D = 25\mu m / cm^{1/2}$$

$$\sigma(z)^2 = (400\mu m)^2 + L_{drift}[cm] \cdot (80\mu m)^2 / cm$$

Realistic parametrization of the TPC resolutions provided by LCTPC group (Ron Settles) [implemented by Steve]

- **VTX** : $\sigma(z) = \sigma(r\text{-}\phi) = 4\mu m$

- **SIT, SET** ... $\sigma(r) = 10\mu m$

... detectors has been neglected

TPC: Aim for rφ resolution <100 μm

Spatial Resolution of MPGD TPC

The performance requirements for an ILC TPC greatly exceed the achievements of existing TPCs, in particular, in the momentum resolution; $\sigma(1/p_t) \sim 5 \times 10^{-5}\ \mathrm{GeV}^{-1}$:

→ > 200 position measurements

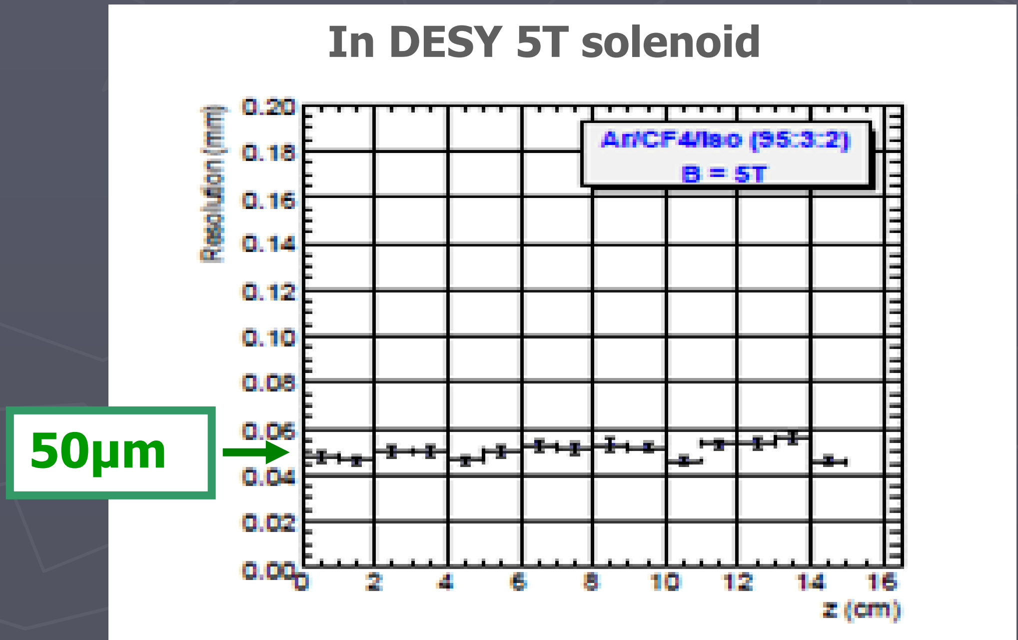
with the point resolution $\sigma_{r\varphi} < 100\ \mu m$.

(From ILC RDR Vol. 4)

A demonstration by MicroMEGAS TPC with resistive anode

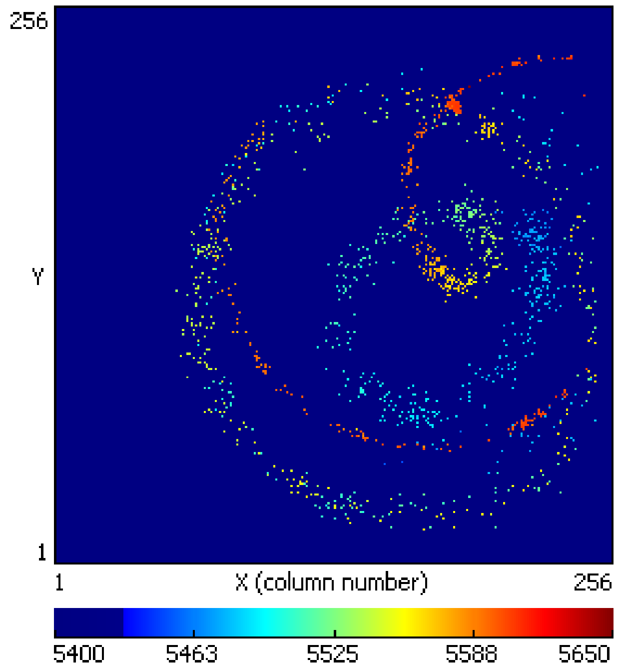
In the DESY 5T magnet with Carleton TPC (M. Dixit et al., 2007)

- 2 mm x 6mm pads + resistive anode
- The small diffusion constant (20 $\mu m/cm^{1/2}$) of Ar-CF4-Isobutene (95:3:2) .
- 50 µm (constant) resolution in the drift distance (max. 16 cm) .
- Neff (at 0.5T) = 27-29.
- Still need to understand why 50 µm but not less.



- Similar results obtained for both 3-GEM and Micromegas amplification structures with pad (analog) readout
- Both these options keep being pursued

- In addition: working hard on (digital) pixel readout



B = 0.2 T

Syst. error due to B-field distortions

- Allow max. 5% increase momentum error $\rightarrow$ hit measurement syst. error < 30 μm
- "old" requirement: $\int B_r / B_z \, dz < 2$ mm, but with anti-DID is already ~20 mm
- "abandon" old requirement;

  but B field must be mapped to sufficient accuracy to have syst. error < σ_0
- This implies $\delta B_{r\ (or\ \varphi)} / B_z \approx 1 \times 10^{-4}$

MDI/integration at/after Sendai

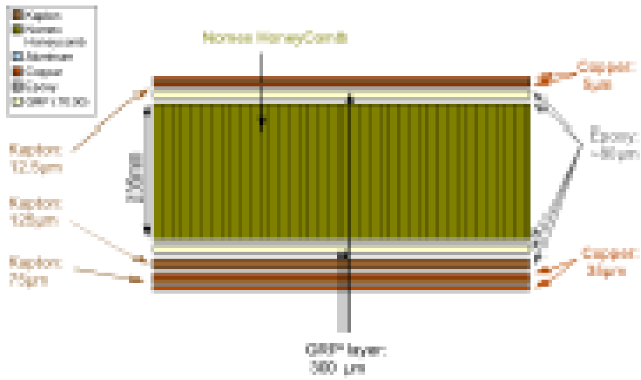
- with anti-DID: $\Delta Bz/Bz < 4.10-4$ within 50 cm around central electrode
- The thickness of the TPC end plate is the responsibility of LCTPC, currently 10cm seems OK.
- The end cap tracker thickness depends on SiIC. The distance between the two is taken as being 10cm.

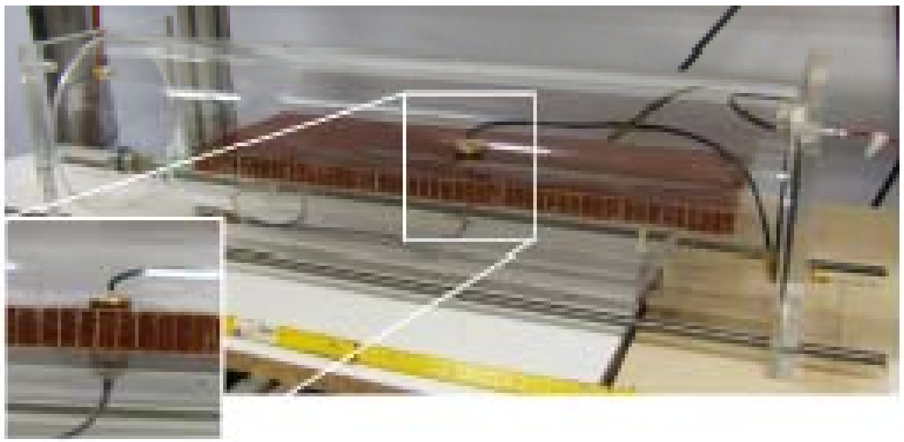
Current estimate endplate material

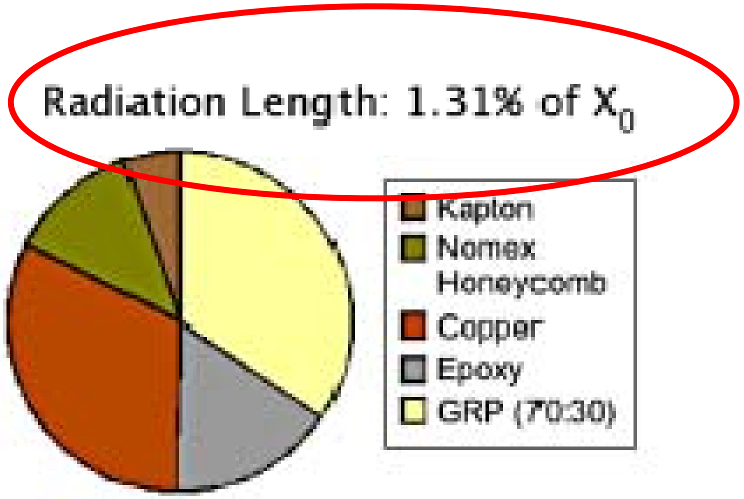
- 15% X_0
- More precise numbers, depending on different electronics options and cooling, to be worked on in next months

Sample pieces of the wall

- different possible cross sections of the investigated with sample pieces
  - $\hookrightarrow$ high voltage tests up to 30 kV
    - $\longrightarrow$ no breakdown in 48 h
  - $\hookrightarrow$ mechanical tests
    - $\longrightarrow$ 4-point bending tests
- final layout has 1.3 % of an radiation length







Consolidation Phase
TPC Large Prototype Beam Test at DESY

Pixel beam telescope
(EUDET)

Si strip detector
(EUDET/SiLC)

Magnet: PCMAG
(LC TPC)

Field cage &
All Mechanics
(EUDET)

Endplate
(LC TPC)

Test beam (DESY)

Gas system
(EUDET)

MPGD Detector
Modules
(LC TPC)

DAQ & Monitoring
(EUDET)

Cosmic trigger
(LC TPC)

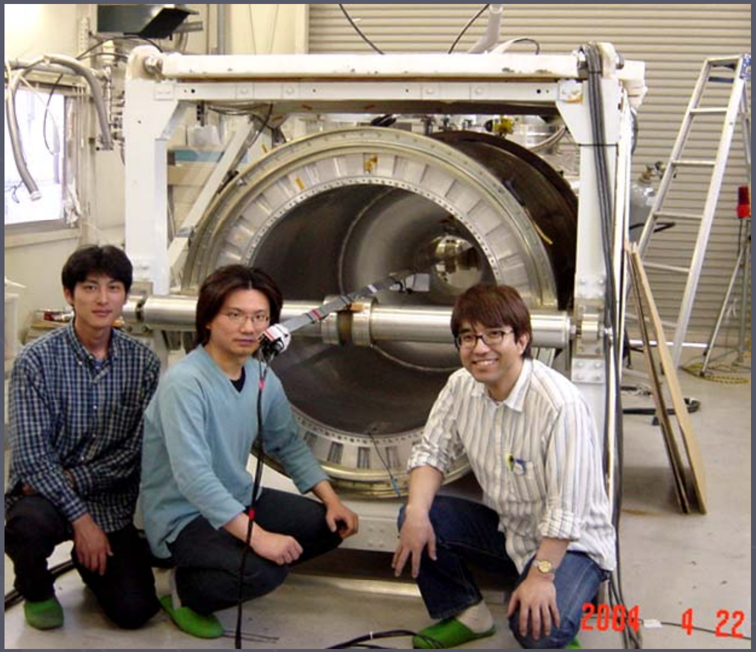
Readout electronics
(EUDET & LC TPC)

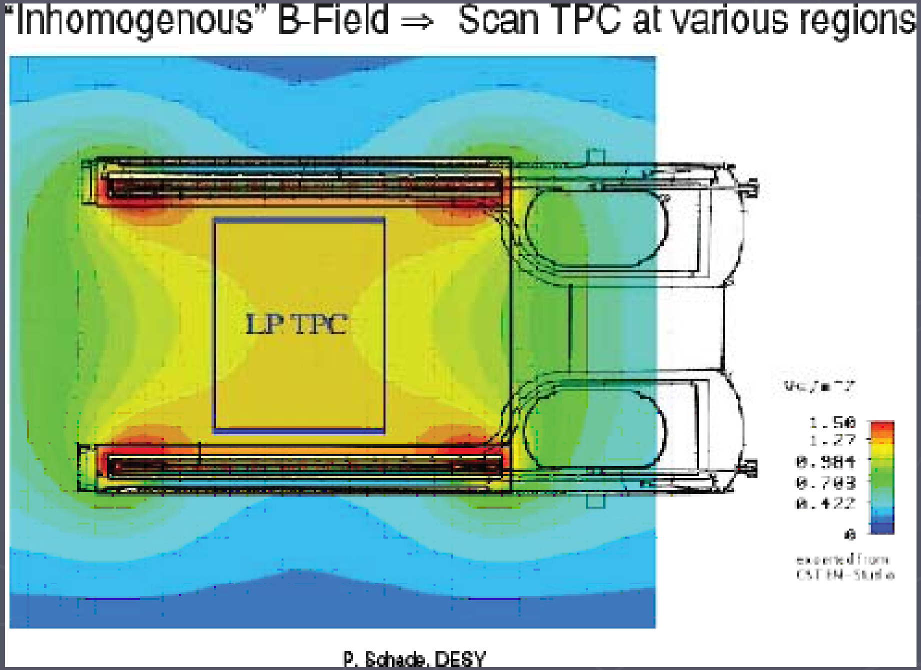
Software development
(EUDET & LC TPC)

Magnet (PCMAG)

KEK

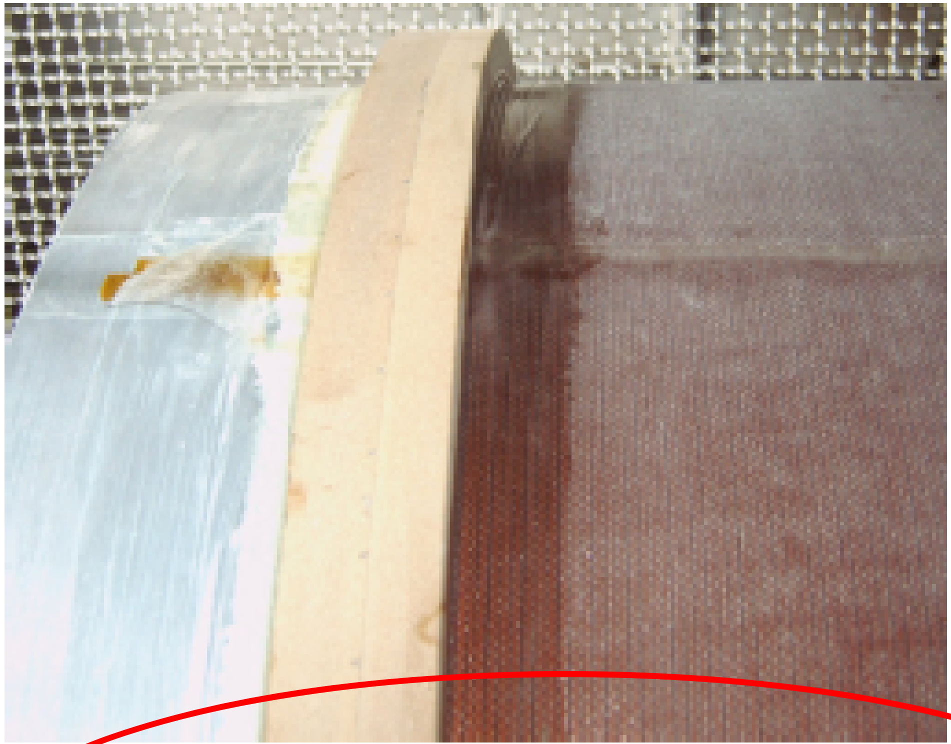
PCMAG is a Persistent Current, superconducting MAGnet with thin (0.2X0) coil and wall. It has no yoke. PCMAG was used in MP-TPC beam tests at KEK PS in 2004-200, and moved to DESY in Dec 2006 for LP1 beam test. The magnet has been tested and mapped at DESY in 2006-2007 under the cooperation of DESY, KEK and CERN groups. A new transfer tube is expected in April for safer operation, but PCMAG is essentially ready.





Coil diameter: 1.0 m, length: 1.3 m, weight: 460 kg, central magnetic filed: up to 1.2T, liq. He capacity and life time: 240L and max. 10 days, Operational current: 430A (1T), filed decay time: > 1 year, Transparency: 0.2X.

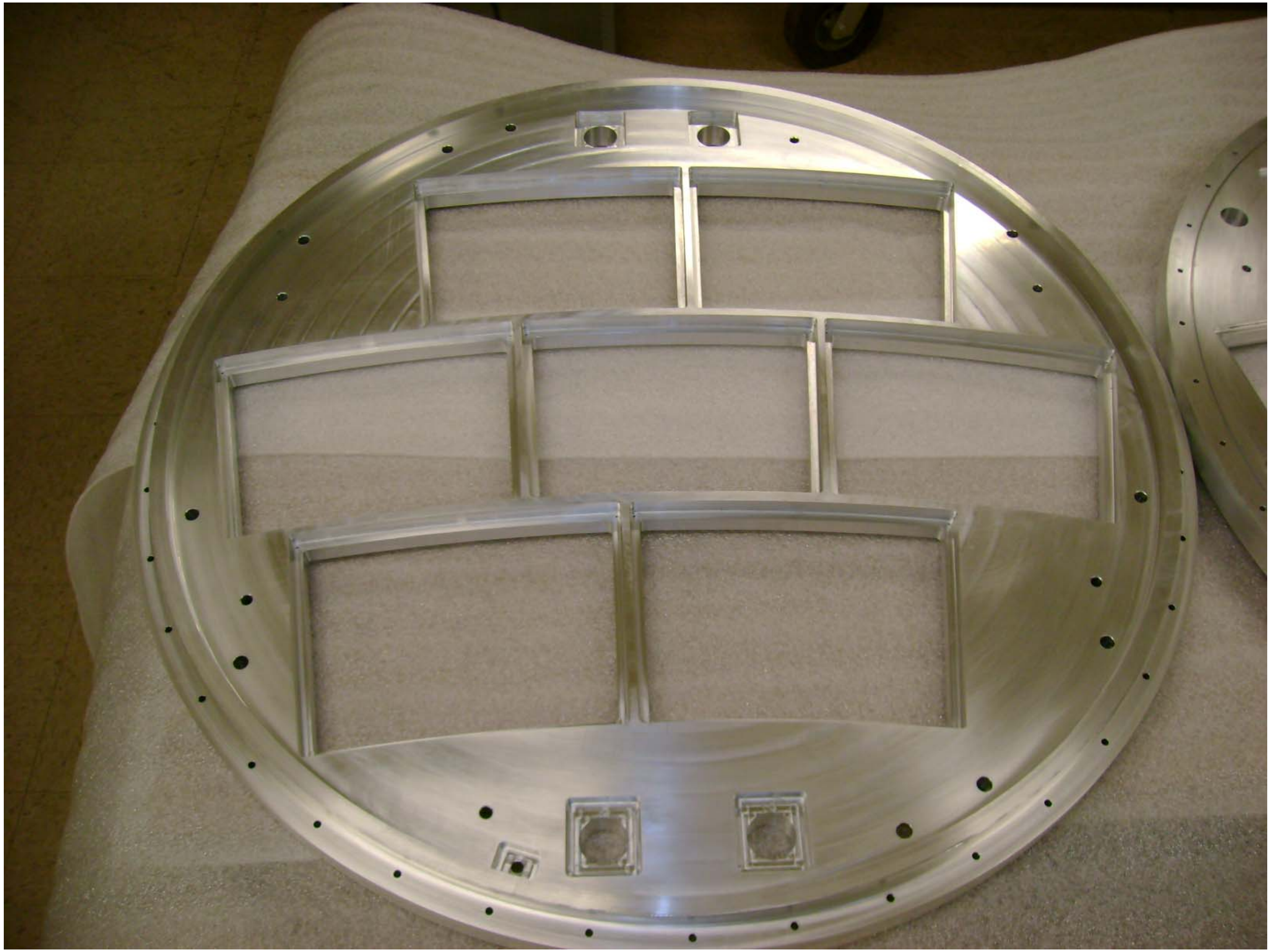
Status of the construction



- mandrel made of aluminium
  - ↪ diameter: $\Delta d \approx 0.5\,\mathrm{mm}$
  - ↪ position of slot corrected
- field strip foil mounted
  - ↪ remaining slot $< 0.5\,\mathrm{mm}$
  - ↪ alignment worked well
- Kapton glued onto the foil
- first GRP layer attached
  - ↪ air inclusions reduced by under pressure treatment
- epoxy is tempered at $60\,^{\circ}\mathrm{C}$
- flange machined and glued onto the GRP layer

- construction is expected to be finished this week
- field cage will be available at DESY end of June

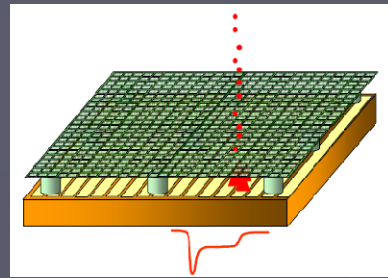
LP endplate ready



Single point resolution: three possible options for gasmultiplication + readout

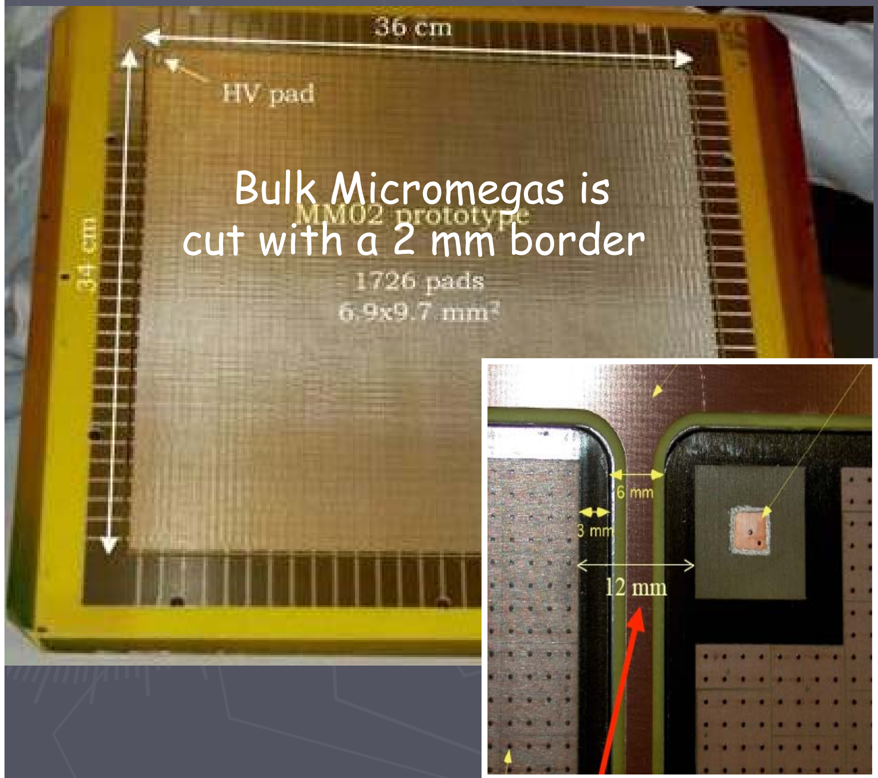
- Need to reduce pad size relative to pad response function:
  - Resistive anode with Micromegas
  - Defocusing + narrow pads (1 mm) with GEMs
  - Digital pixel readout; avoids effects due to gain fluctuations

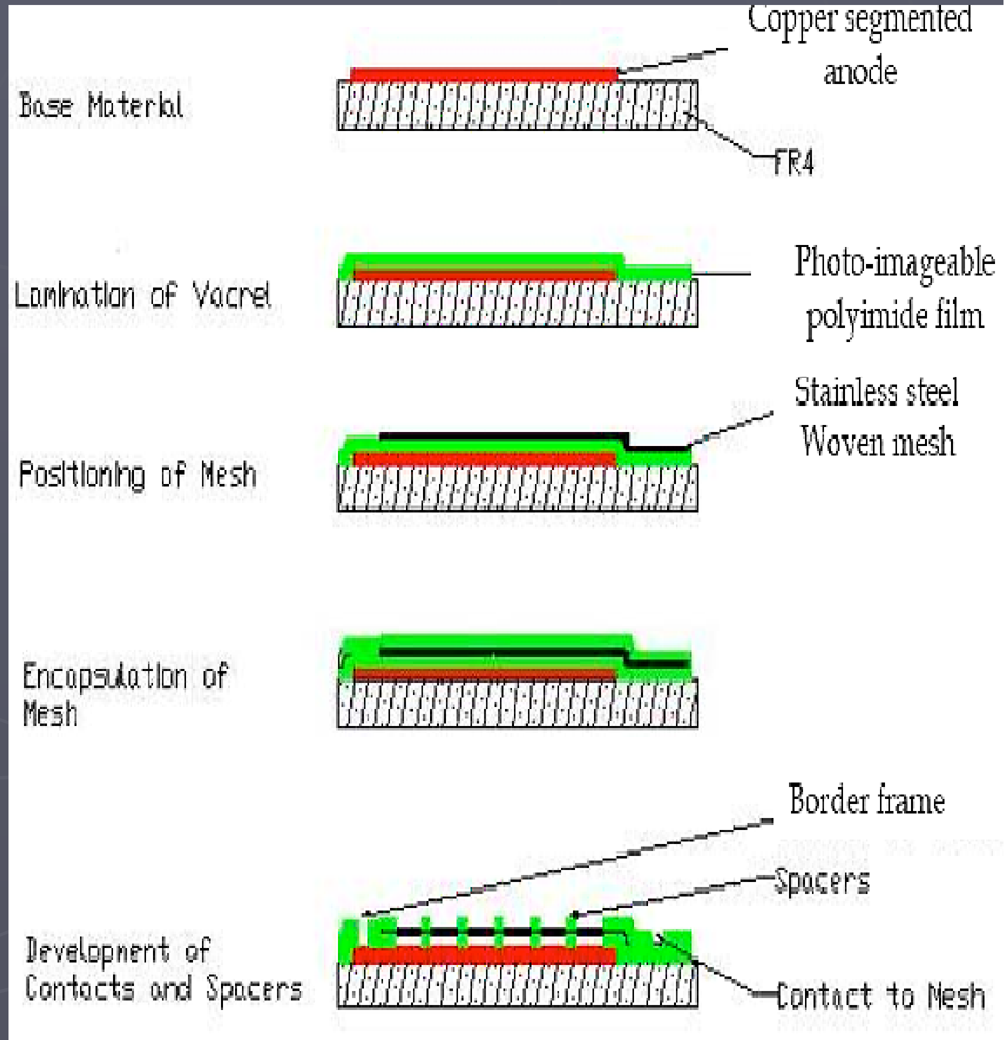
Detector Module: MicroMEGAS with Resistive Anode



(1) MicroMEGAS detector by the "bulk" technology (2004):

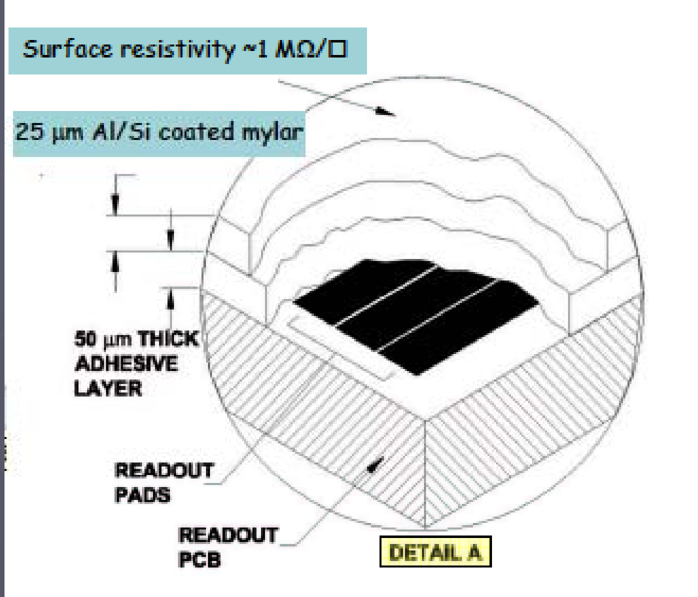
Mesh fixed by the pillars themselves :
No frame needed :
fully efficient surface
Very robust : closed for > 20 µ dust
Used by the T2K TPC under construction





Detector Module: MicroMEGAS with Resistive Anode

(2) Resistive anode (RA) for the "bulk" detector:



3 techniques for the resistive coating:

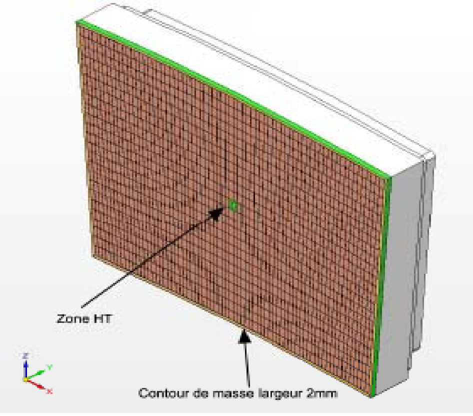
- The standard thick kapton foil laminated and covered with a resistive layer (Carleton)
- The application of amorphous silicon and doped a-Si by thin layer techniques (Neuchatel)
- Serigraphy of resistive pastes (CERN)

(3) LP1 detector module

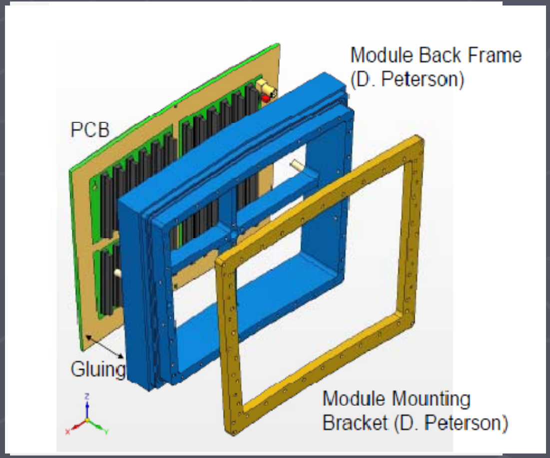
24 rows x 72 pads
Av. Pad size: 3.2 x $7mm^2$

Layout of pad plane ready.
To be submitted this week.

Depending on (2), deliver one without resistive anode at the beginning.



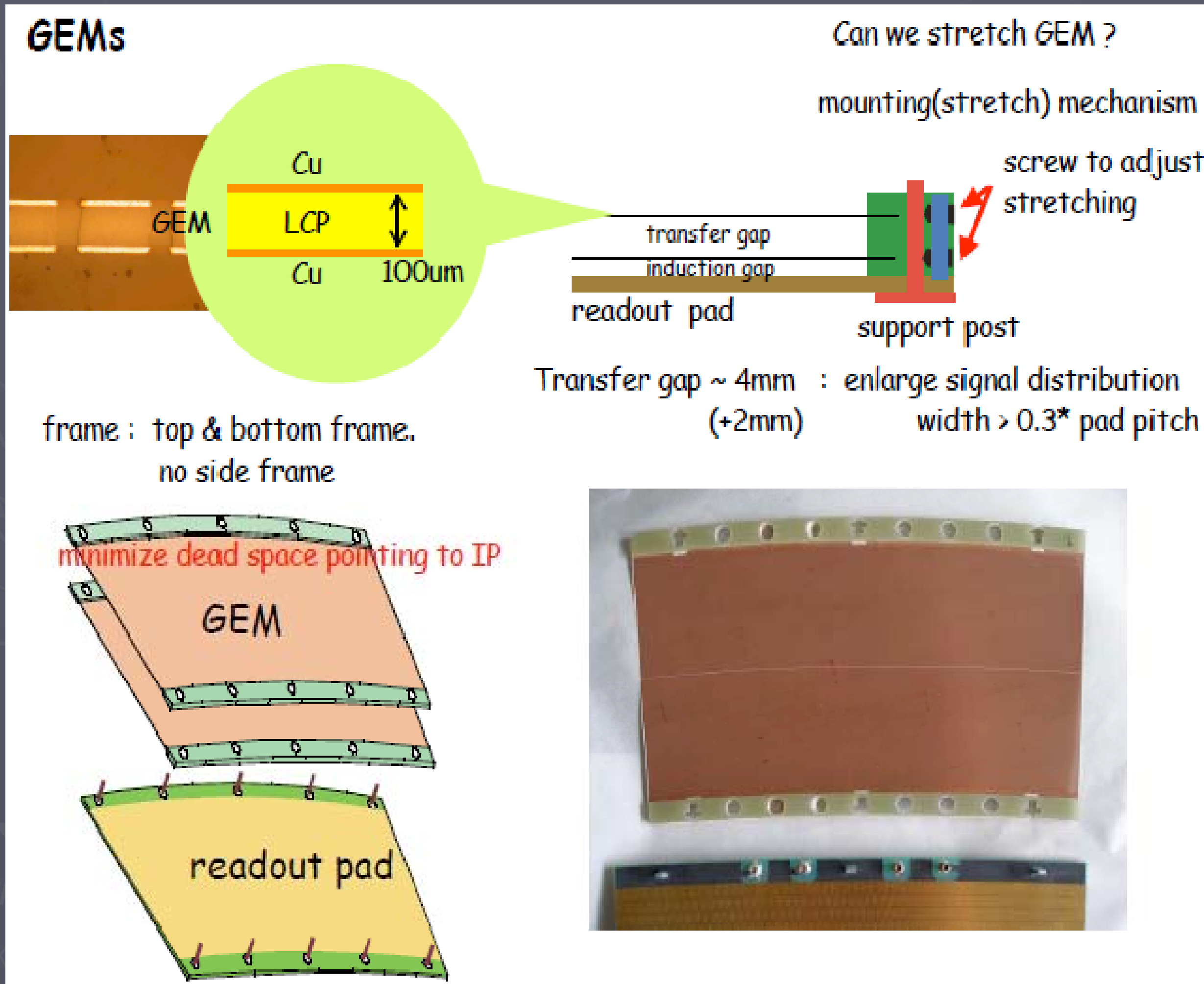
Detector side

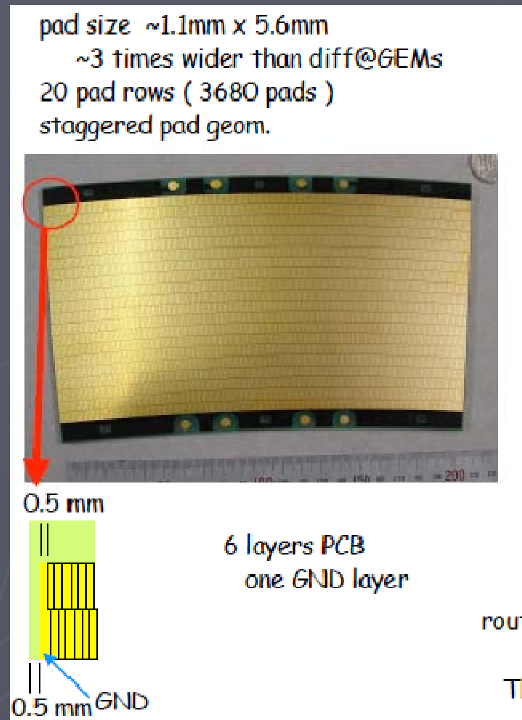


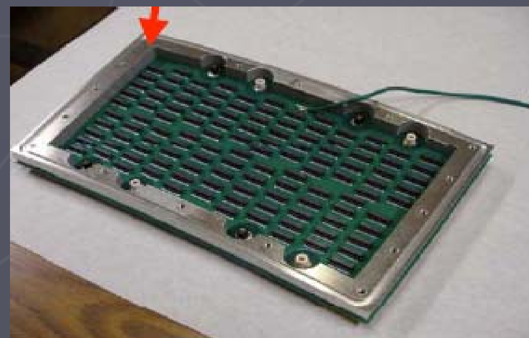
Detector Module: Double GEM with a gating GEM

(1)   Double thick (100 μm)   GEM   with a (thin) gating GEM:

(Gating GEM is not drawn)







Detector Module: Double GEM with a gating GEM

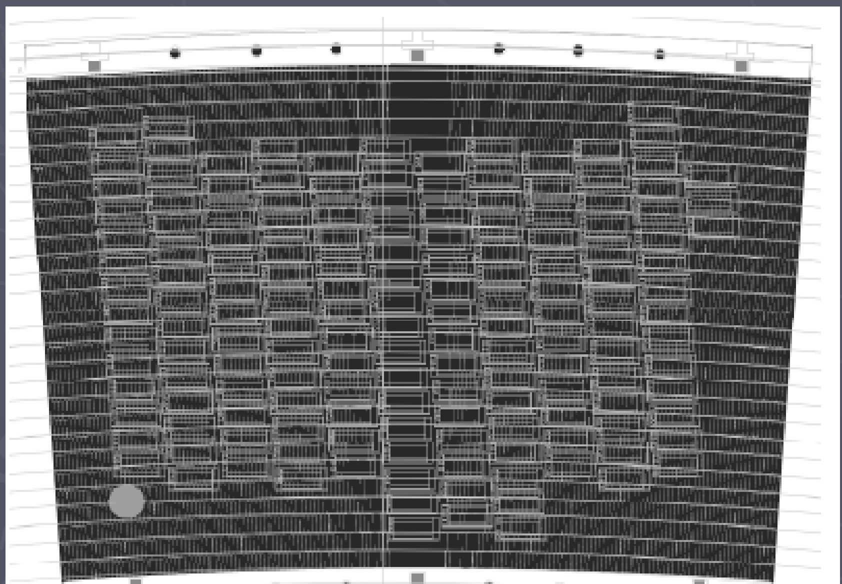
(2) Pad PCB board: 8 layers

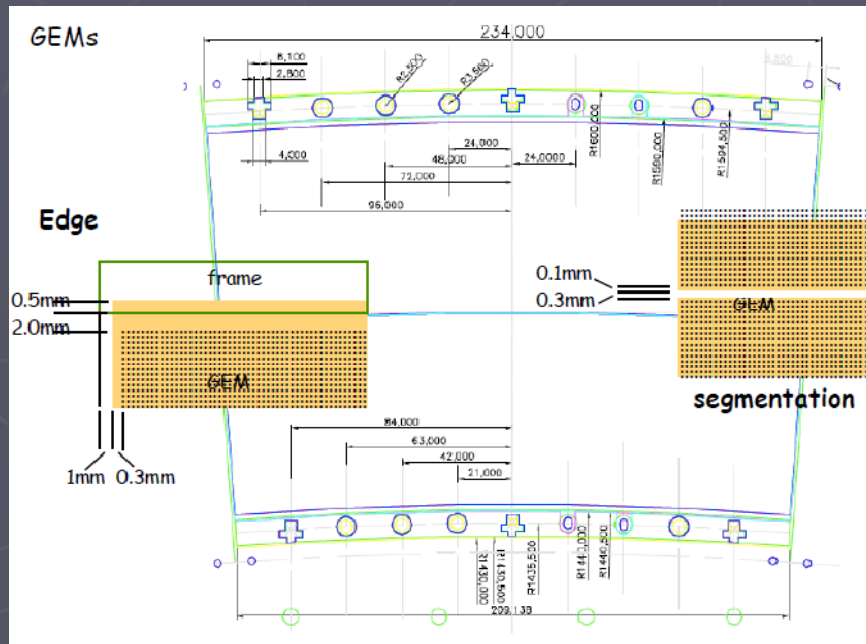
28 pad-rows x 176(192) pads for inner (outer) 14 rows
Pad size: ~1.2 x 5.4 mm2 pads

PCB layout being completed at Tsinghua Univ.
Routing of GEM HV is a issue.

(3) GEM:

Thick GEMs are ready. The thin gating GEMs are still under work at the company (Si-energy).

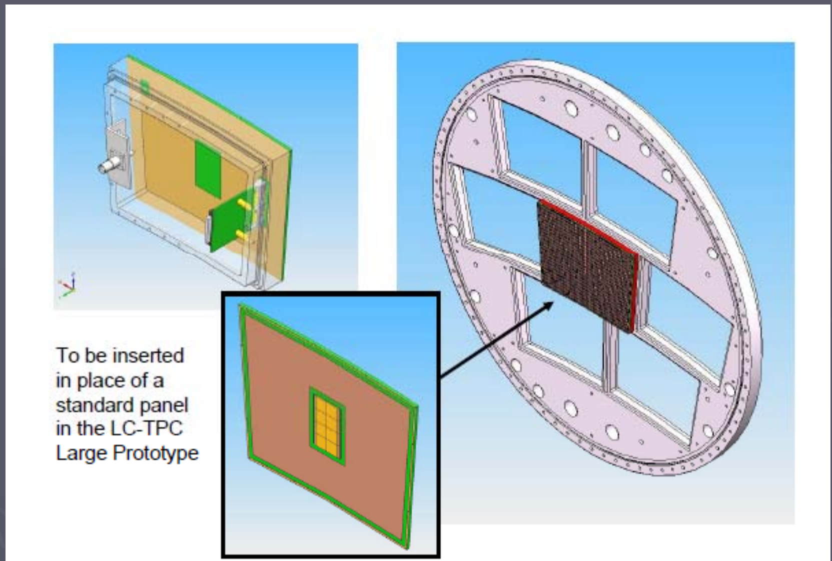


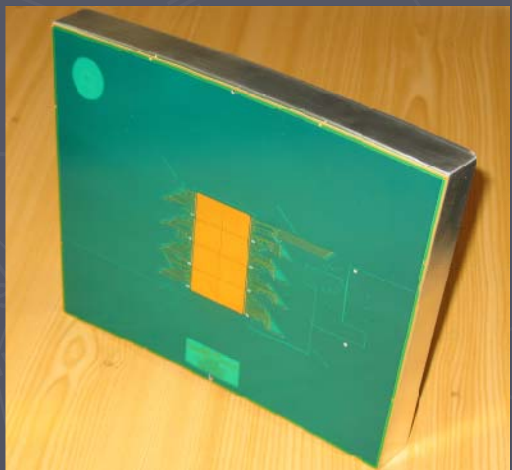


Detector Modules with Timepix Chips

With MicroMEGAS (Saclay-NIKHEF)

8 chips (16 cm^2)

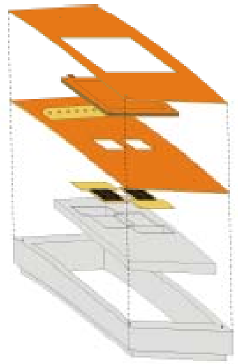




With triple GEM (Bonn)

LP Module with 3GEM + TimePix

- 3 standard GEMs 10 × 10 cm^2
- 1 mm transfer gaps and induction gap
- Two quad-boards (NIKHEF) with 4 TimePix chips each



- Currently testing quad-board

universitätbonn

Design Phase: Advanced Endplate

To prove our crude estimations of 15% Xo for the TPC endplate thickness and about 170W/m^2 for an improved ALTRO-type electronics with power switching, we need to start a design study of the whole readout electronics chain including data transfer, and then a design study and R&D of the pad PCB plane with the flip-chip assembly. The R&D may includes simulations of power delivery, cooling and thermo mechanical features, and a test of pad PCB plane models mounted with dummy chips.

This also holds for the pixel readout option.

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