

TPC in ILD

ILC/ECFA - Warsaw

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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.
LBL
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

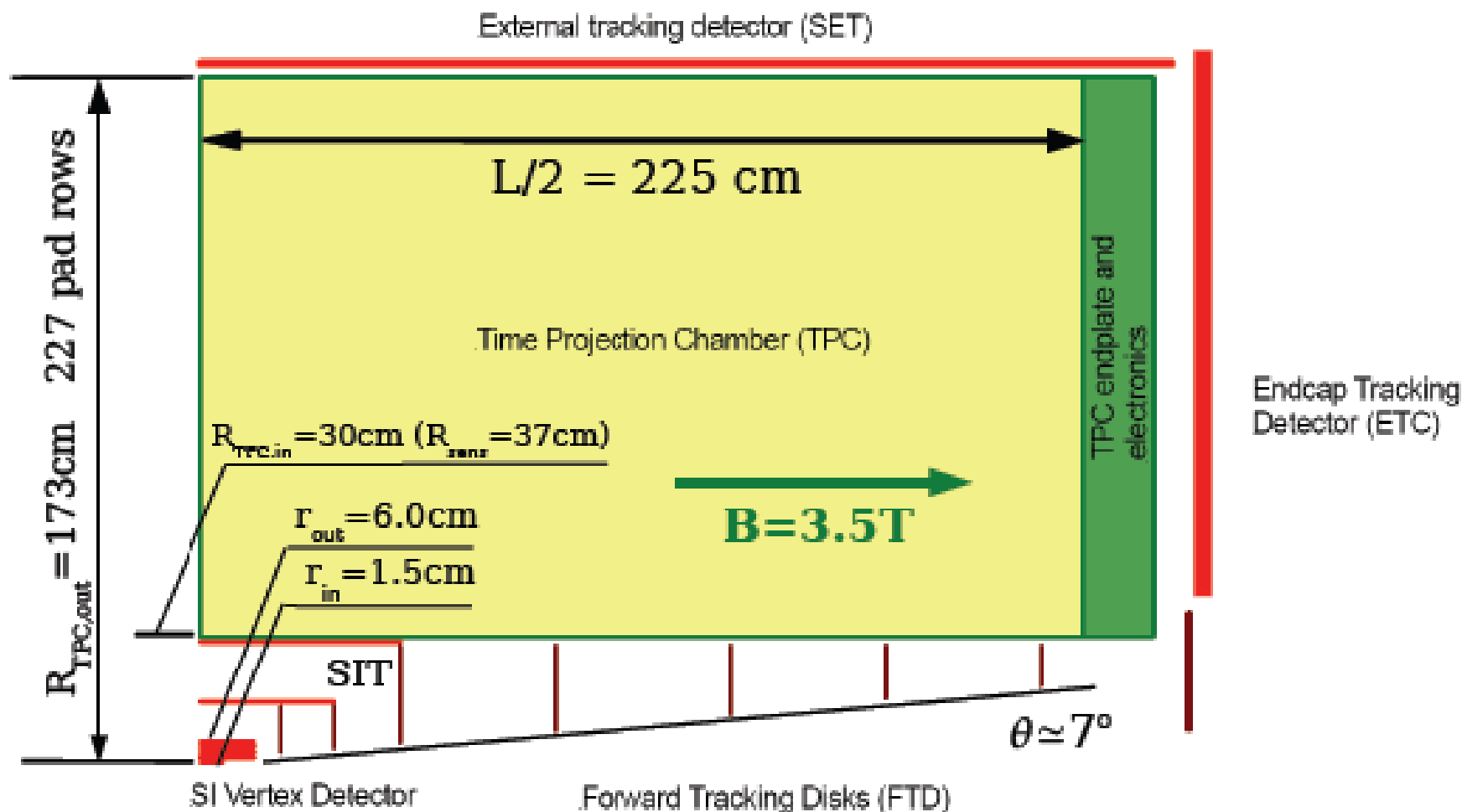
R&D Phase

- 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 \Rightarrow `TrackerHits`

- TPC :

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

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

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

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

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

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

- VTX : $\sigma(z) = \sigma(r-\phi) = 4\mu m$

- SIT : $\sigma(r-\phi) = \sigma(r) = 10\mu m$

TPC: Aim for $r\phi$ resolution $< 100\mu m$

detectors has been neglected

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; $\sigma(1/p_t) \sim 5 \times 10^{-5} \text{ GeV}^{-1}$:

→ **> 200 position measurements**

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

(From ILC RDR Vol. 4)

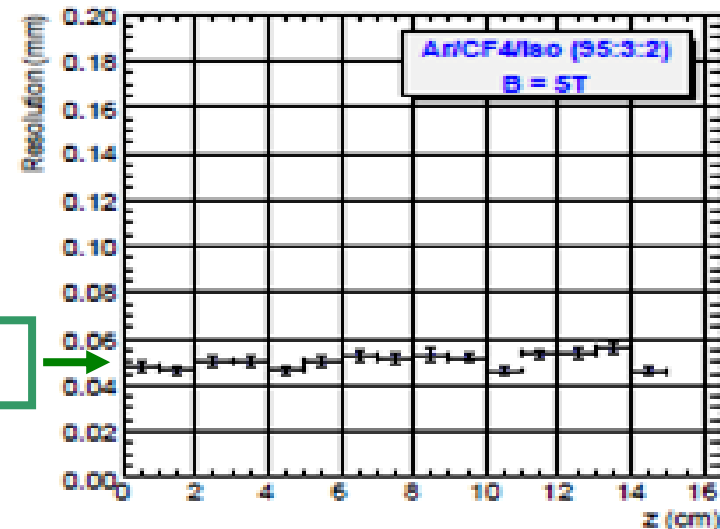
A demonstration by MicroMEGAS TPC with resistive anode

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

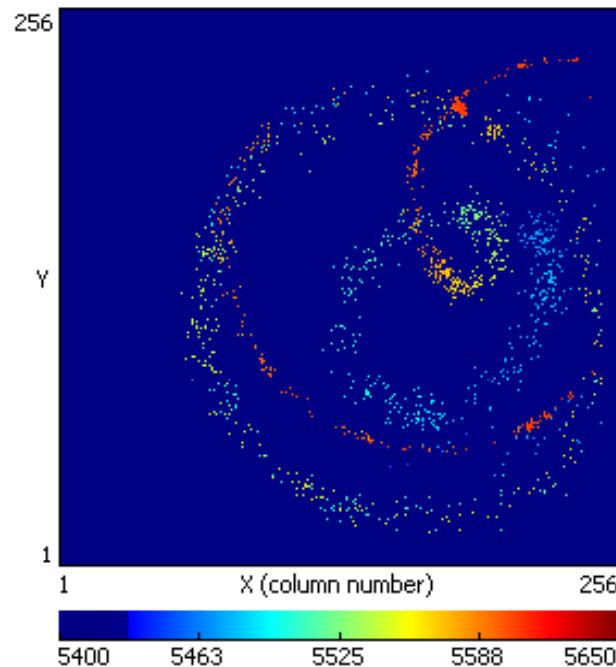
- 2 mm x 6mm pads + resistive anode
- The small diffusion constant ($20 \mu\text{m}/\text{cm}^{1/2}$) of Ar-CF₄-Isobutene (95:3:2) .
- 50 μm (constant) resolution in the drift distance (max. 16 cm) .
- Neff (at 0.5T) = 27-29.
- Still need to understand why 50 μm but not less.

50 μm

In DESY 5T solenoid



- 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



$B = 0.2 \text{ T}$

Syst. error due to B-field distortions

- Allow max. 5% increase momentum error
→ hit measurement syst. error < 30 μm
- “old” requirement: $\int B_r / B_z dz < 2 \text{ mm}$, **but with anti-DID is already $\sim 20 \text{ mm}$**
- “abandon” old requirement;
but B field must be mapped to sufficient accuracy to have syst. error < σ_0
- **This implies $\delta B_{r \text{ (or } \varphi)} / B_z \approx 1 \times 10^{-4}$**

MDI/integration at/after Sendai

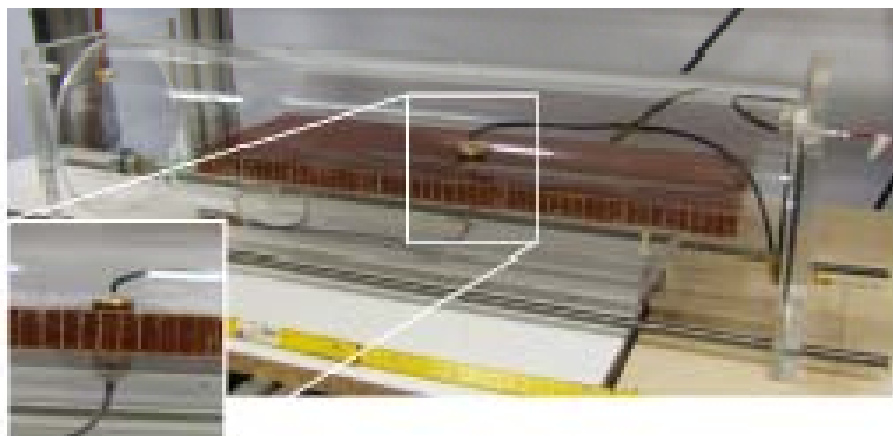
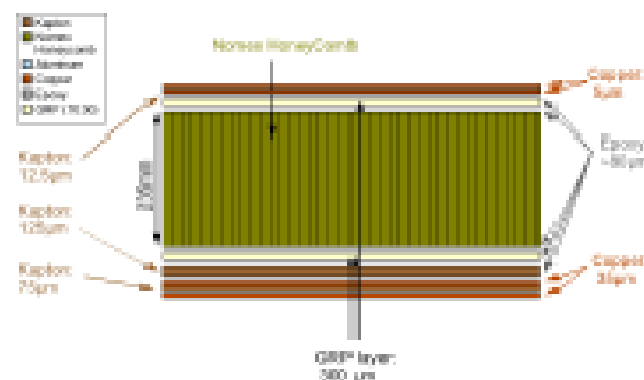
- with anti-DID: $\Delta B_z/B_z < 4 \cdot 10^{-4}$ within 50 cm around central electrode
- The thickness of the TPC end plate is the responsibility of LCTPC, currently 10cm seems OK.
- The end cap tracker thickness depends on SiC. The distance between the two is taken as being 10cm.

Current estimate endplate material

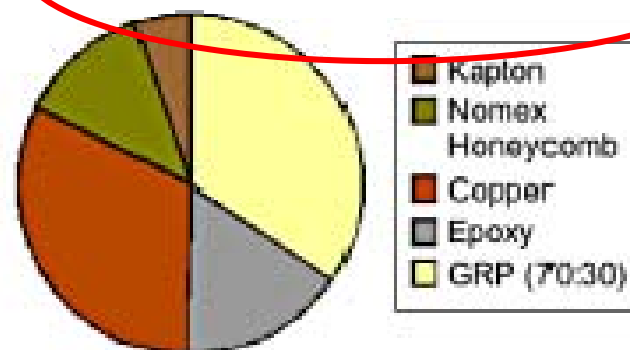
- 15% X_0
- More precise numbers, depending on different electronics options and cooling, to be worked on in next months

Sample pieces of the wall

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



Radiation Length: 1.31% of X_0



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)

Gas system
(EUDET)

MPGD Detector
Modules
(LC TPC)

DAQ & Monitoring
(EUDET)



Test beam (DESY)

Cosmic trigger
(LC TPC)

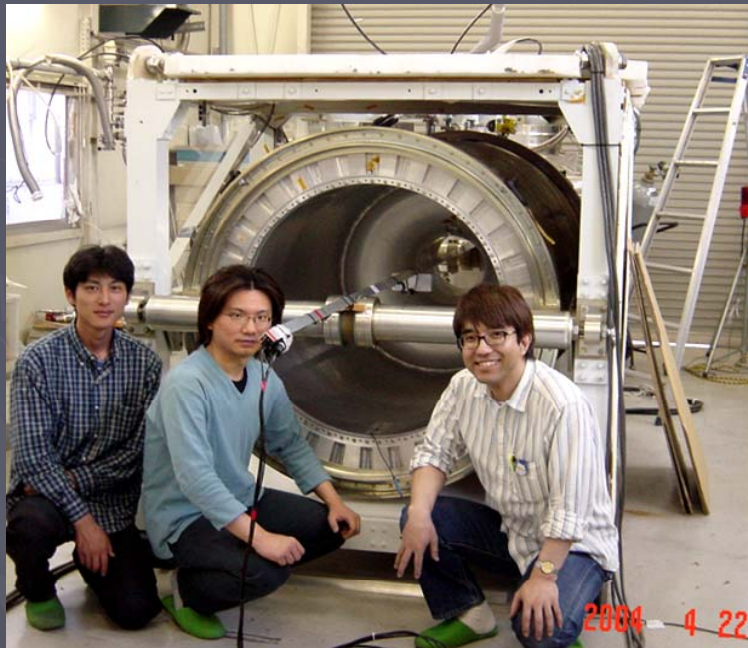
Readout electronics
(EUDET & LC TPC)

Software development
(EUDET & LC TPC)

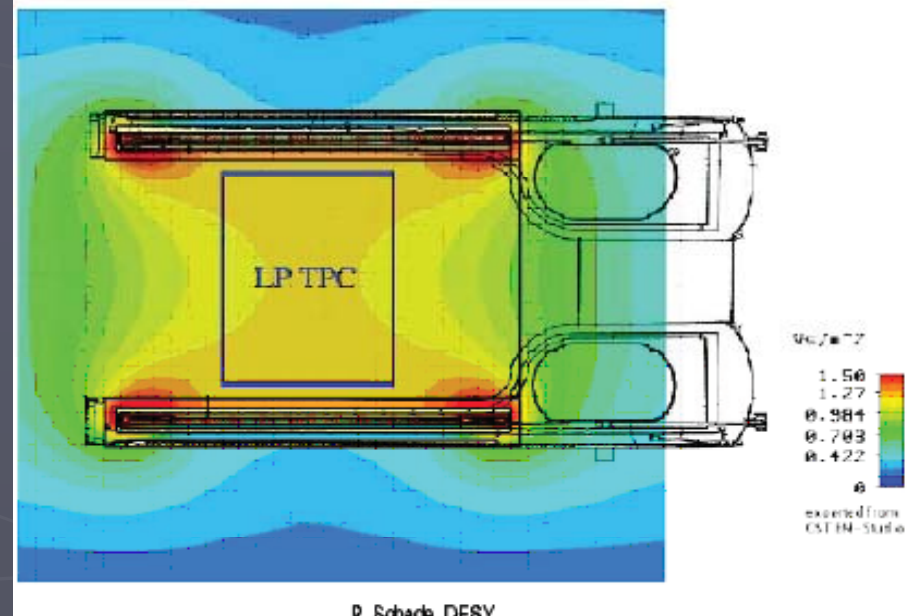
Magnet (PCMAG)

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**.

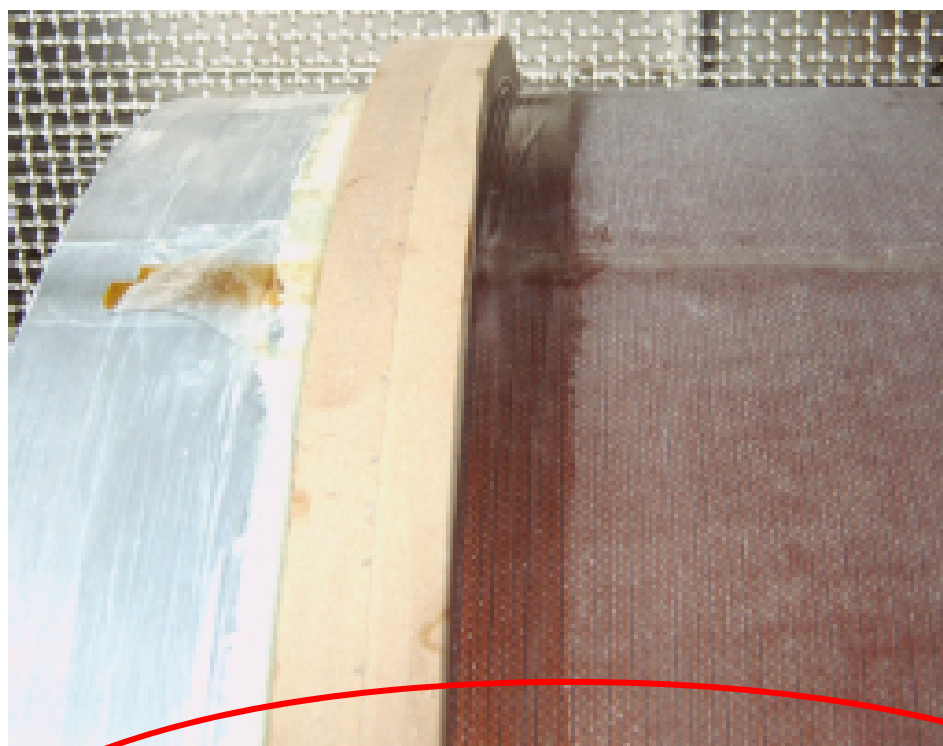


"Inhomogenous" B-Field \Rightarrow Scan TPC at various regions



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

Status of the construction



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

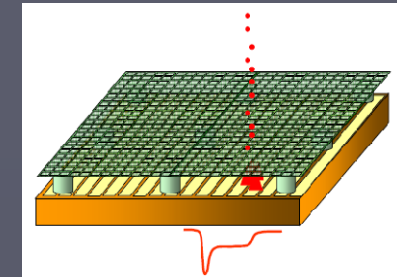
LP endplate ready



Single point resolution: three possible options for gasmultiplication + readout

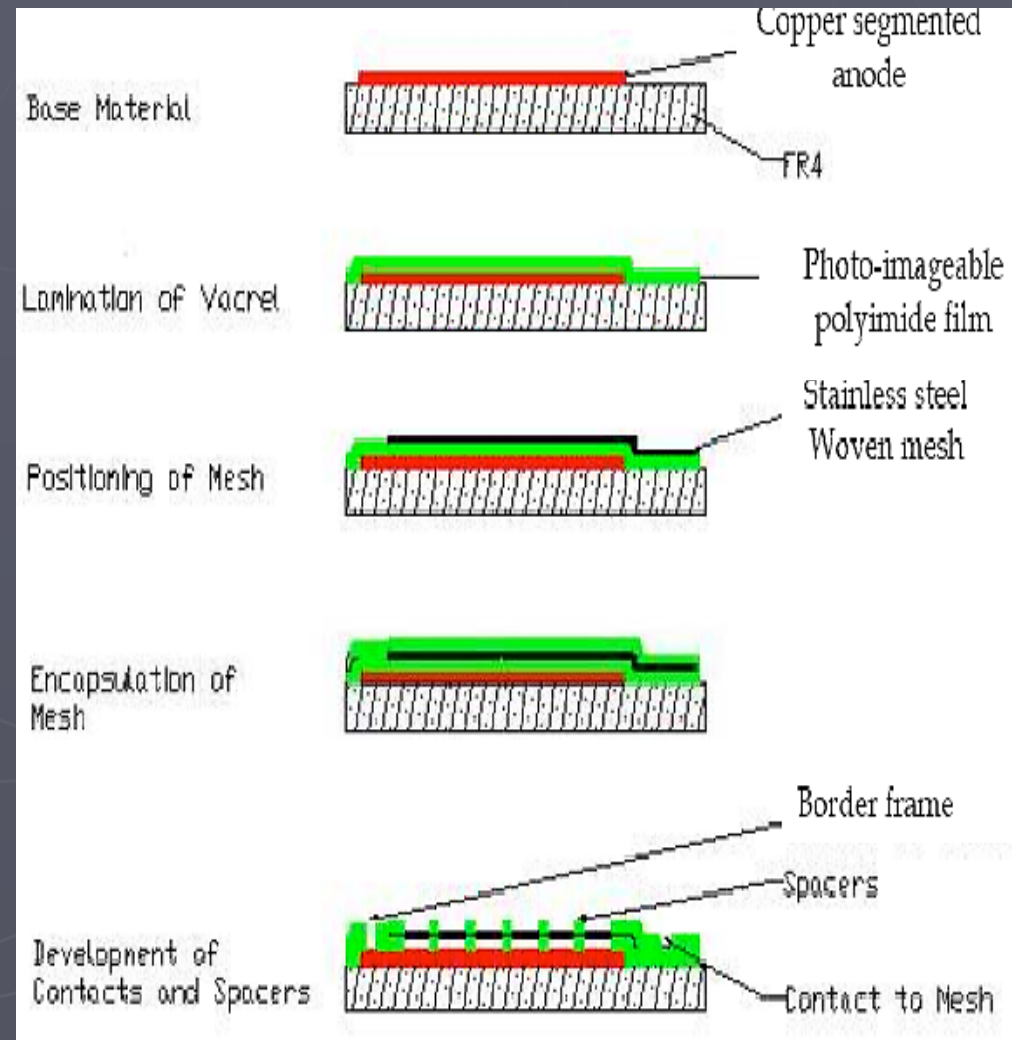
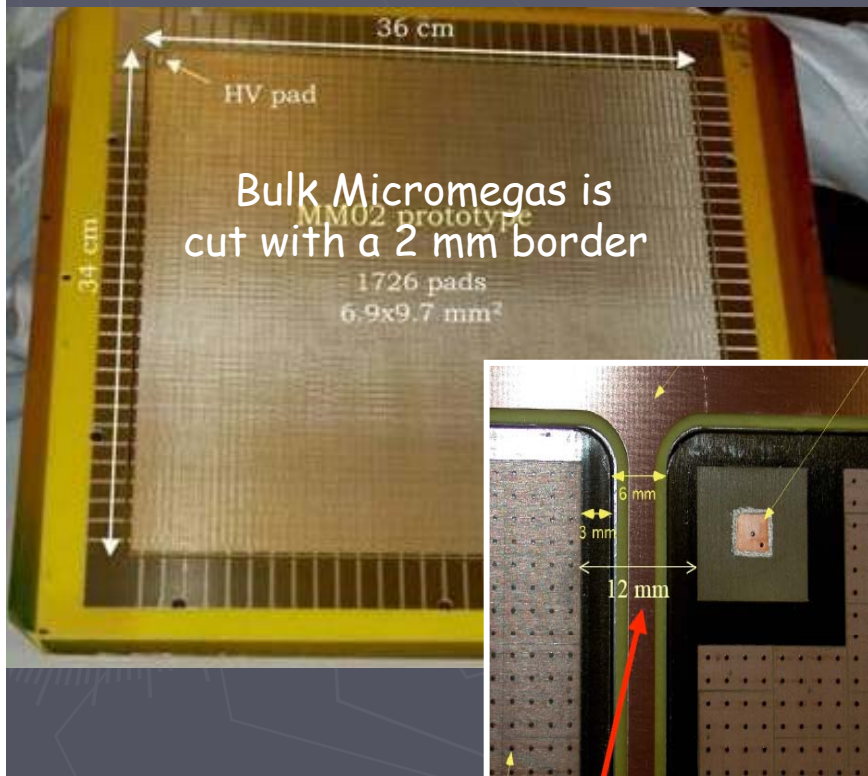
- Need to reduce pad size relative to pad response function:
 - Resistive anode with Micromegas
 - Defocusing + narrow pads (1 mm) with GEMs
 - Digital pixel readout; avoids effects due to gain fluctuations

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 $> 20 \mu$ 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:

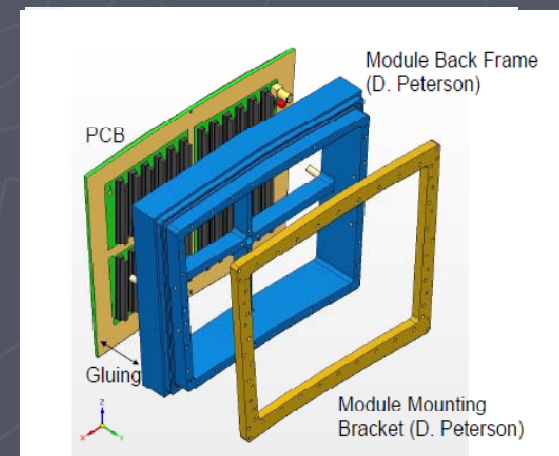
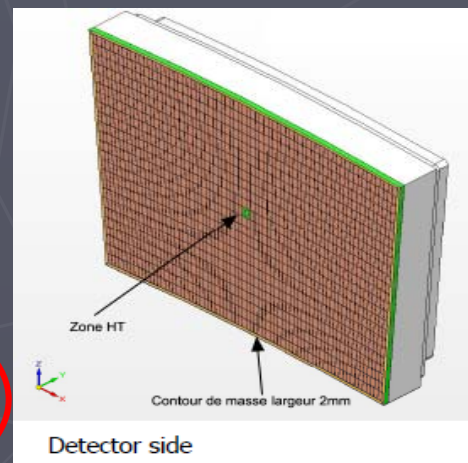
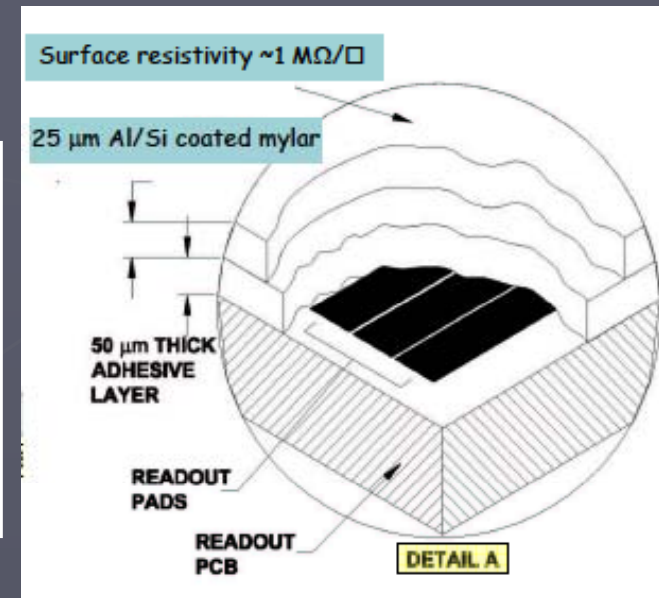
- The standard thick kapton foil laminated and covered with a resistive layer (Carleton)
- The application of amorphous silicon and doped a-Si by thin layer techniques (Neuchatel)
- Serigraphy of resistive pastes (CERN)

(3) LP1 detector module

24 rows x 72 pads
Av. Pad size: 3.2 x 7mm²

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

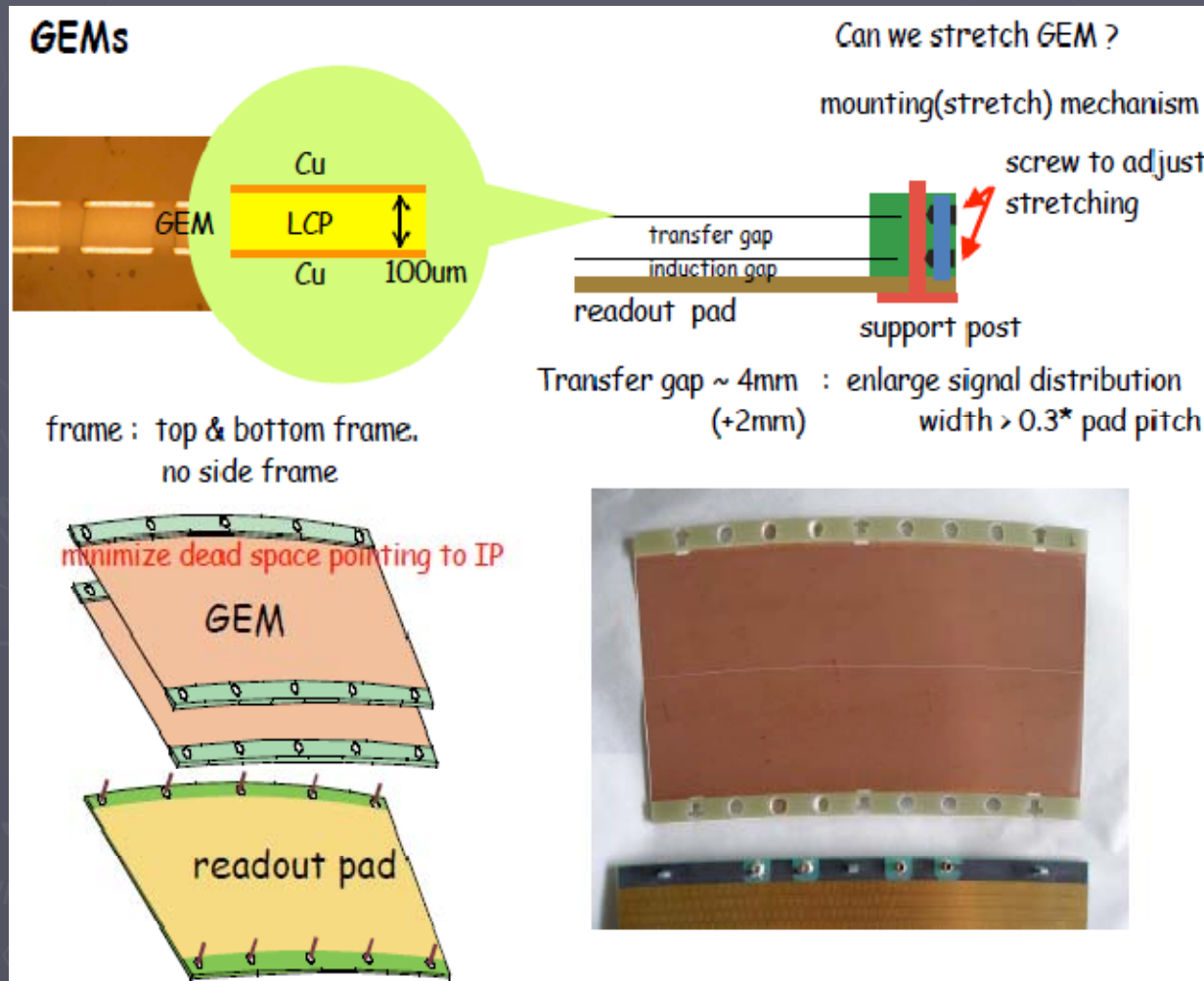
Depending on (2), deliver
one without resistive anode
at the beginning.



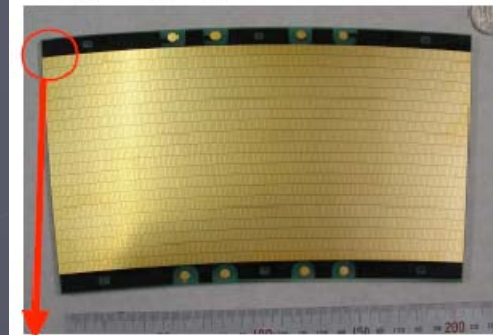
Detector Module: Double GEM with a gating GEM

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

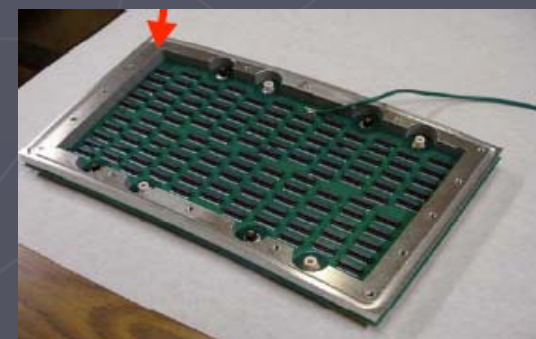
(Gating GEM is not drawn)



pad size ~1.1mm x 5.6mm
~3 times wider than diff@GEMs
20 pad rows (3680 pads)
staggered pad geom.

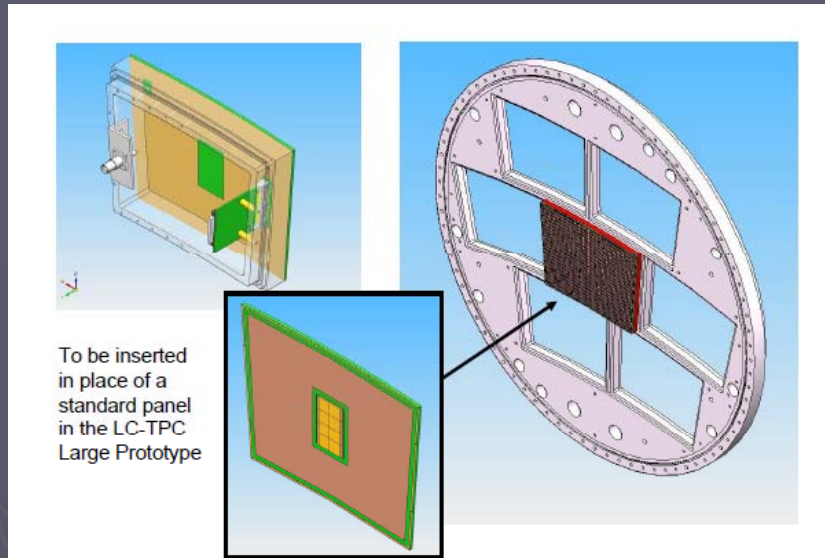


0.5 mm



Detector Modules with Timepix Chips

With MicroMEGAS (Saclay-NIKHEF)



8 chips (16 cm²)

With triple GEM (Bonn)

LP Module with 3GEM + TimePix



- 3 standard GEMs 10 × 10 cm²
- 1 mm transfer gaps and induction gap
- Two quad-boards (NIKHEF) with 4 TimePix chips each



anode plane

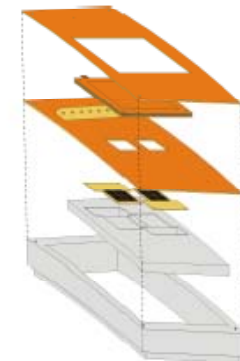
GEMs

readout plane

quad-boards

reinforcement of anode plane

redframe



- Currently testing quad-board



Design Phase:

Advanced Endplate

To prove our crude estimations of 15% X_0 for the TPC endplate thickness and about 170W/m² 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 include 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.