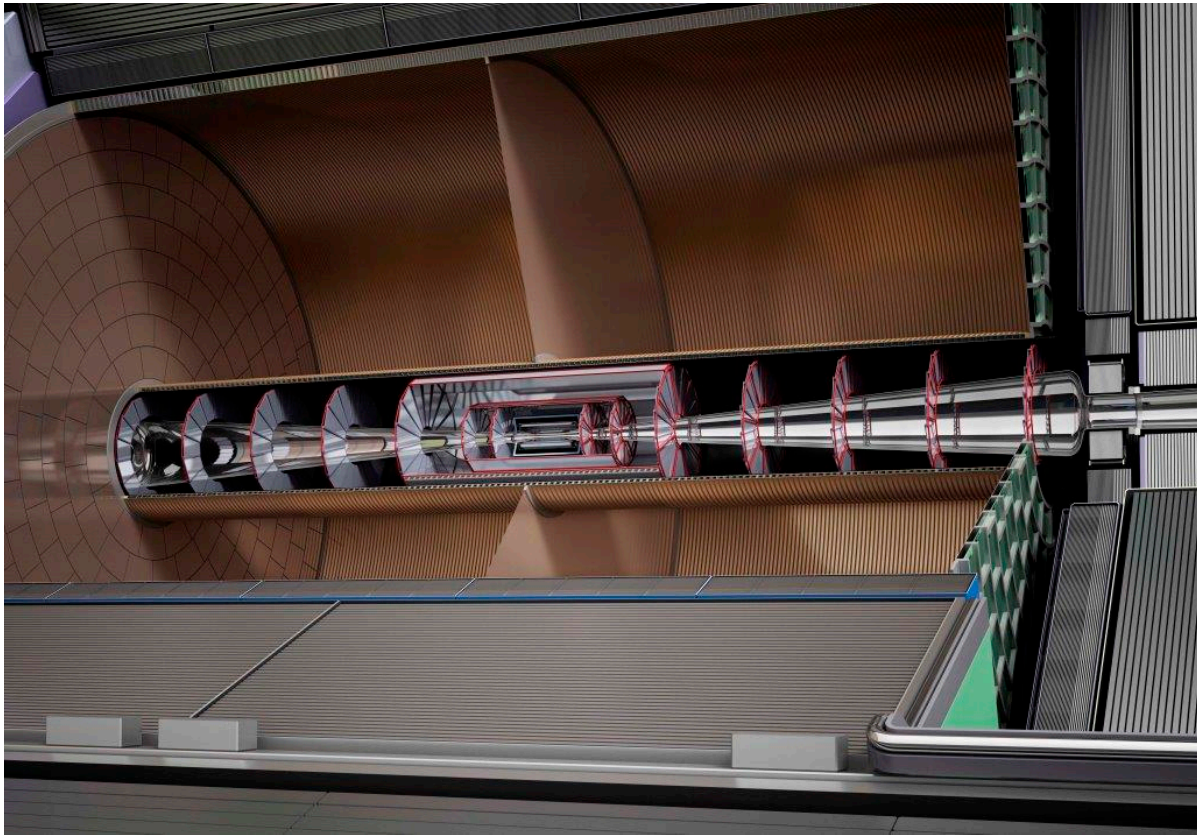
A TPC for ILD

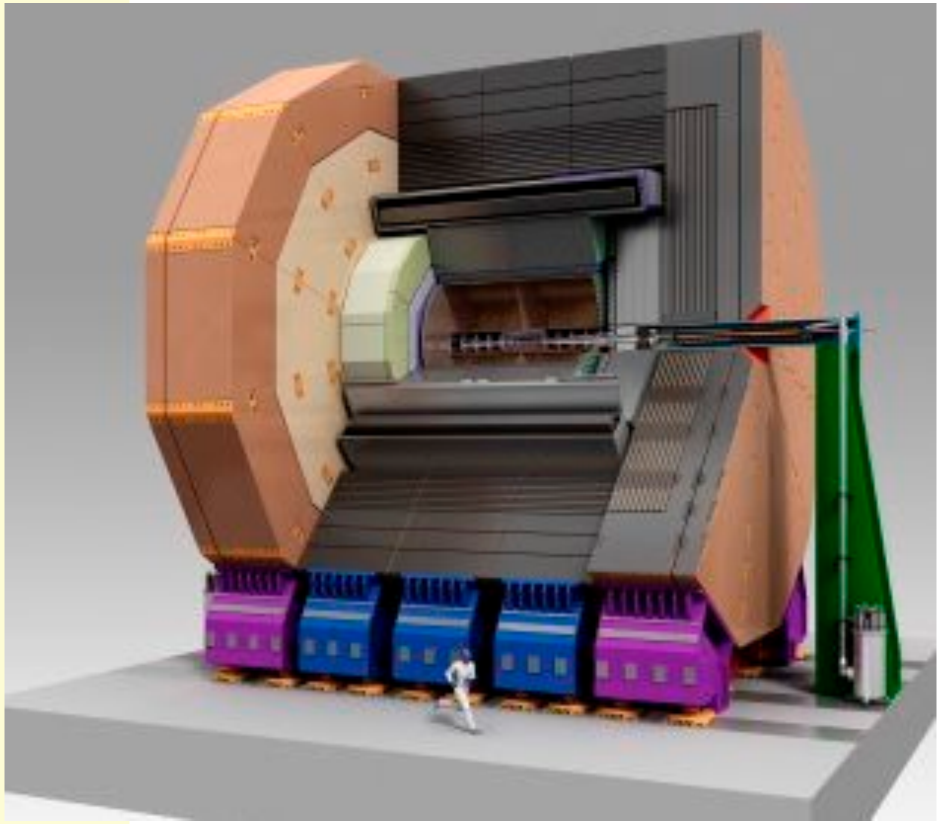


Peter Kluit - Nikhef
on behalf of the LCTPC collaboration

American Workshop Linear Colliders 28 June 2017

The ILC and the ILD detector

ILC: a superconducting linear e^+e^- collider, 31 km long, starting at $\sqrt{s}$=240 GeV, upgradable to 350, 500 and 1000 (max) GeV. To be hosted in Japan.



The ILD concept comprises :
A highly segmented calorimeter
A tracker combining Silicon detectors and **a large TPC**
A pixel vertex detector

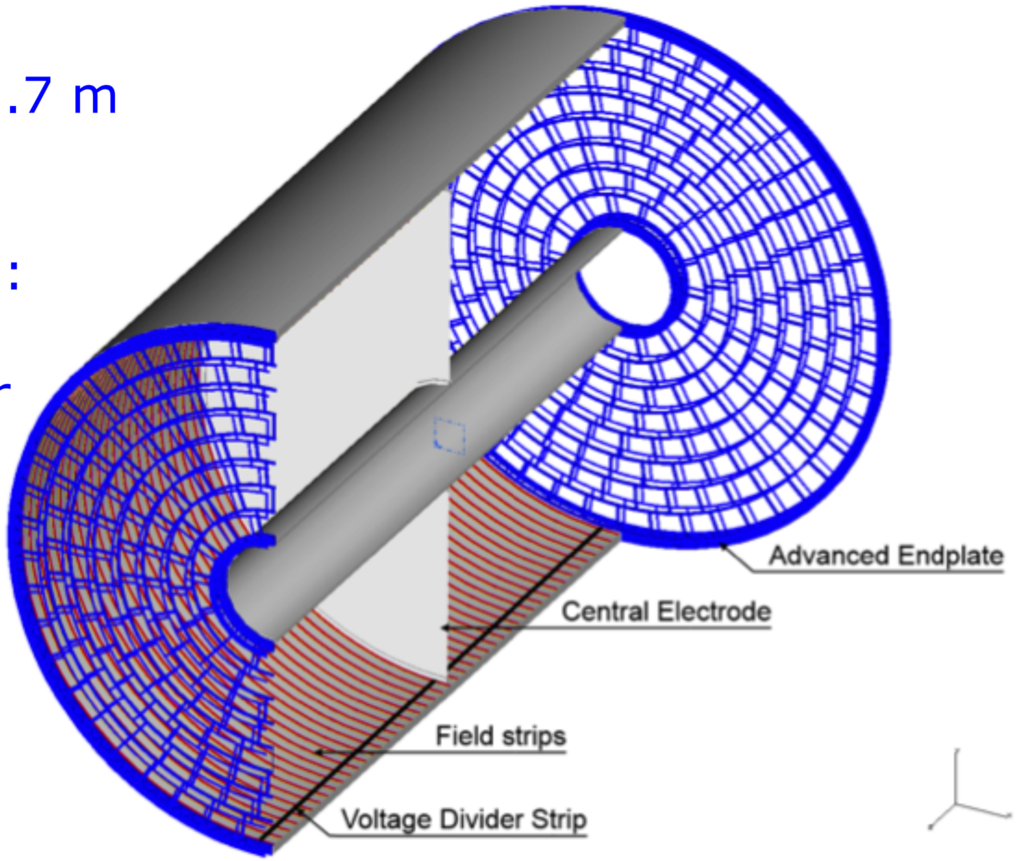
Jet measurement relies on the 'Particle Flow' concept

The ILD collaboration organization built up in the last two years: spokesperson, Institute Assembly, Executive team, Technical team

The ILD TPC

Length 2 x 2.3 m
Inner/Outer Radius 0.35/1.7 m
B field 3.5 T

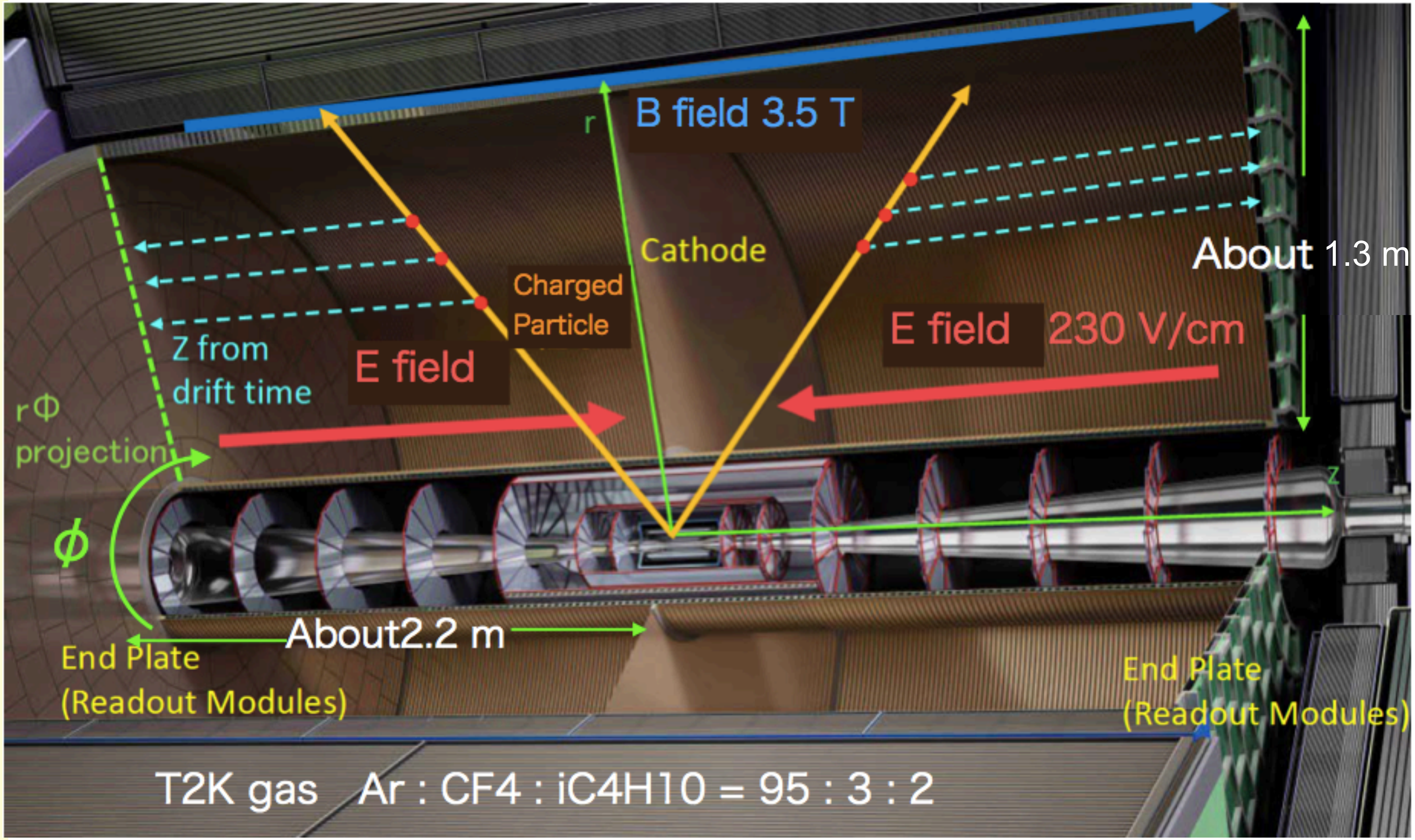
TPC momentum resolution:
$\sigma(1/pT) = 1\ 10^{-4}\ GeV^{-1}$
Motivated by resolution for
Higgs recoil Z→ ll
σ(dE/dx) ~ 5%



Calibration & alignment
- sagitta σ = 10 μm
- internal syst < 22 μm
- TPC-VTX syst < 10 μm

Needs:
- survey, laser tracks, laser dots cathode
- data B field on/off
- mass V0, tracks etc.

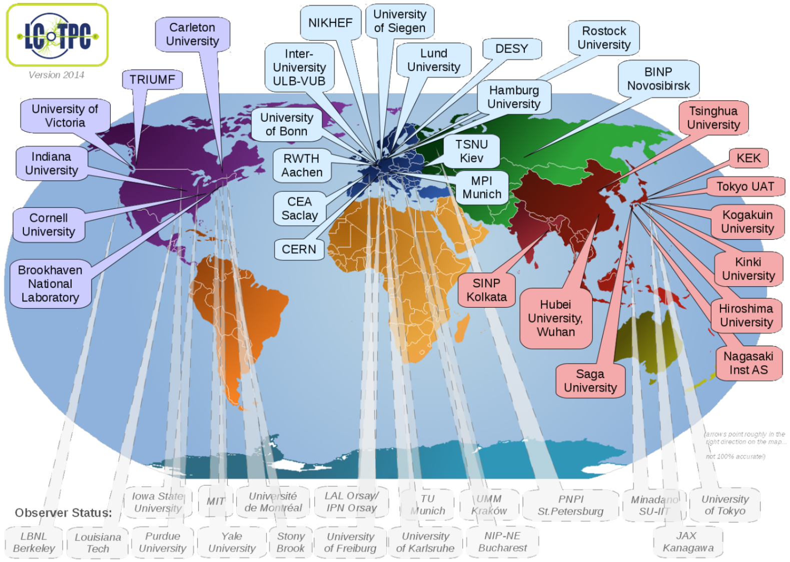
The ILD TPC



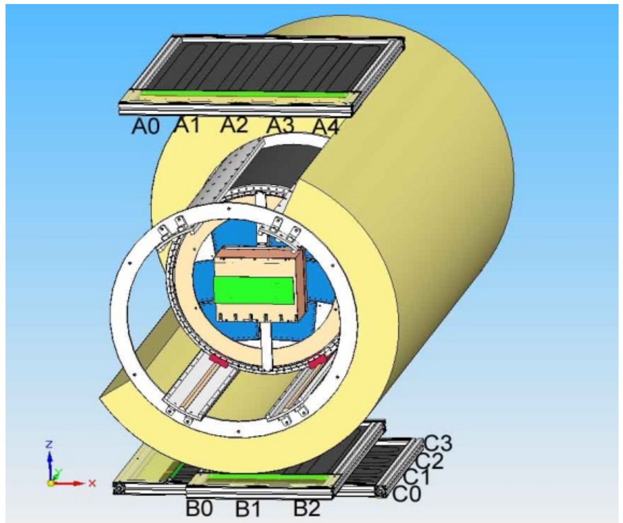
B field 3.5 T
r
Cathode
Charged
Particle
About 1.3 m
E field
230 V/cm
Z from
drift time
E field
rΦ
projection
ϕ
About2.2 m
End Plate
(Readout Modules)
End Plate
(Readout Modules)
T2K gas Ar : CF4 : iC4H10 = 95 : 3 : 2

LCTPC collaboration

All the TPC R&D is gathered.
www.lctpc.org



LCTPC shares a test facility:
DESY test setup (Field cage, magnet, endplate, cosmic-ray trigger, telescope (>2017), CO_2 cooling, ancillaries)

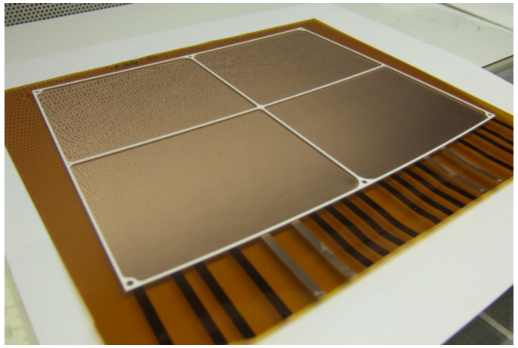


Allows testing & comparing several technologies and ideas with cost-awareness

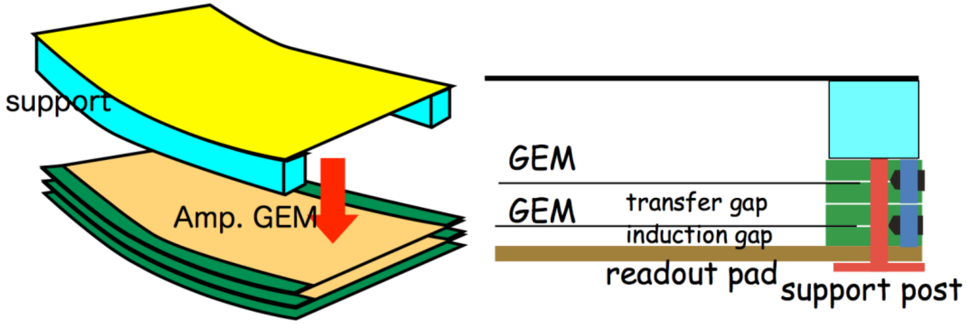
Four read-out technologies studied

European GEM

Standard kapton triple GEM with ceramic spacers

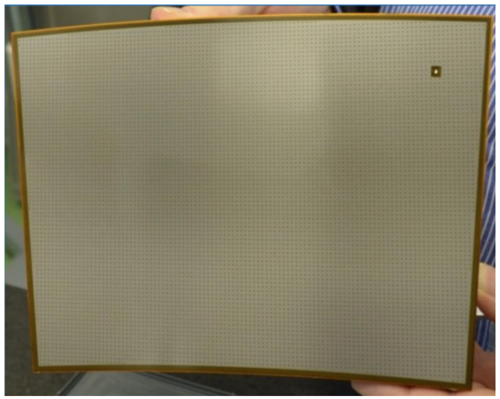


Asian GEM



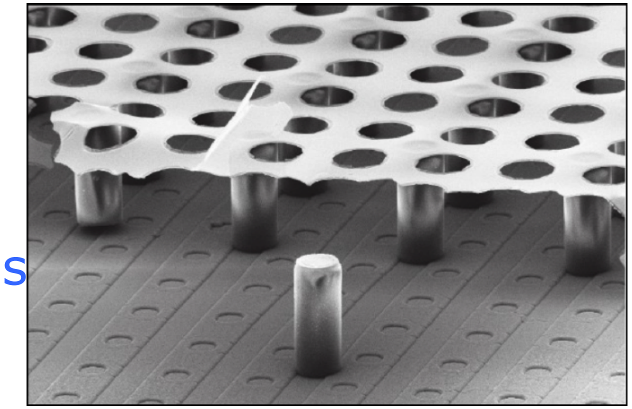
Micromegas

Mesh on top of a charge dispersing resistive anode



GridPix

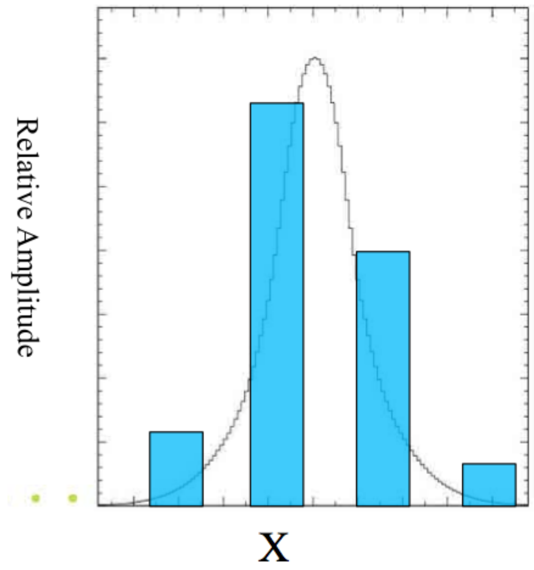
Integrated grid on 55x55 μm^2 digital pixels

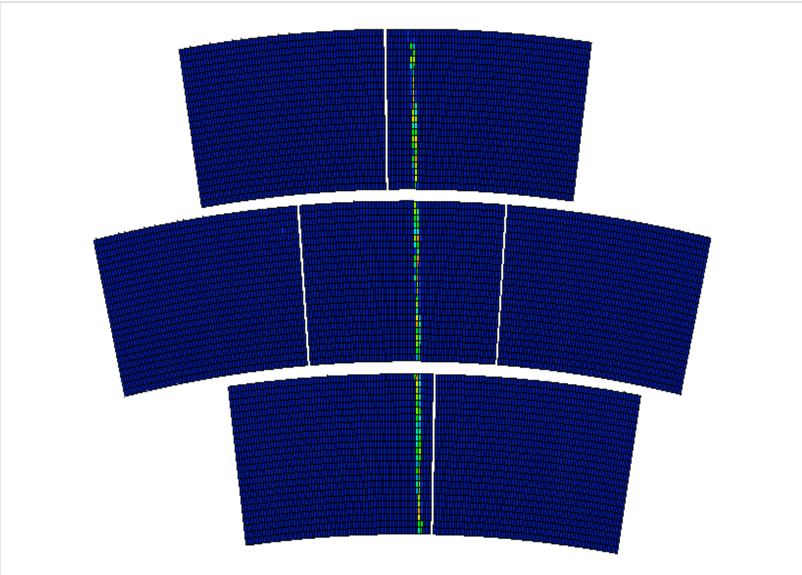


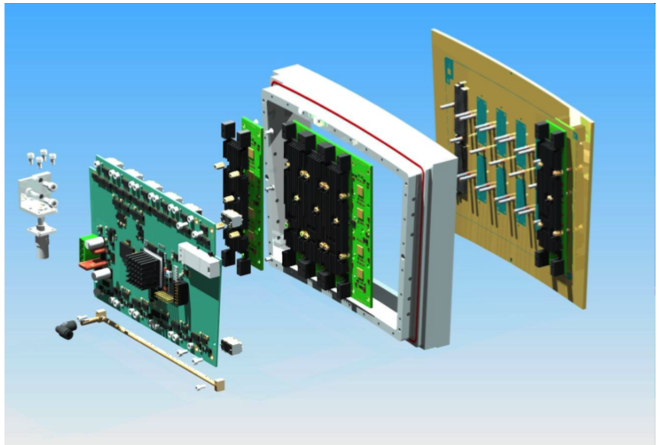
Micromegas with charge dispersion

Pad pitch of 3x7 mm² limits transverse resolution

Use resistive anode to spread the charge







Fully integrated design: 0.25 X0

Eu GEM modules flatness

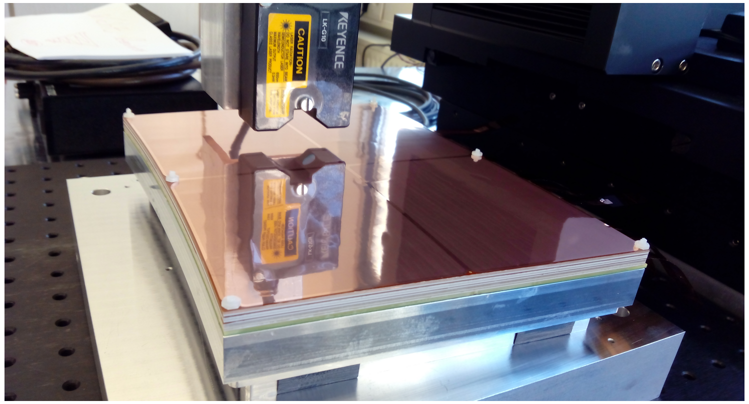
GEM stack of 2 modules flatness

prev	RMS: 50-90 μm
new	RMS: 30-50 μm

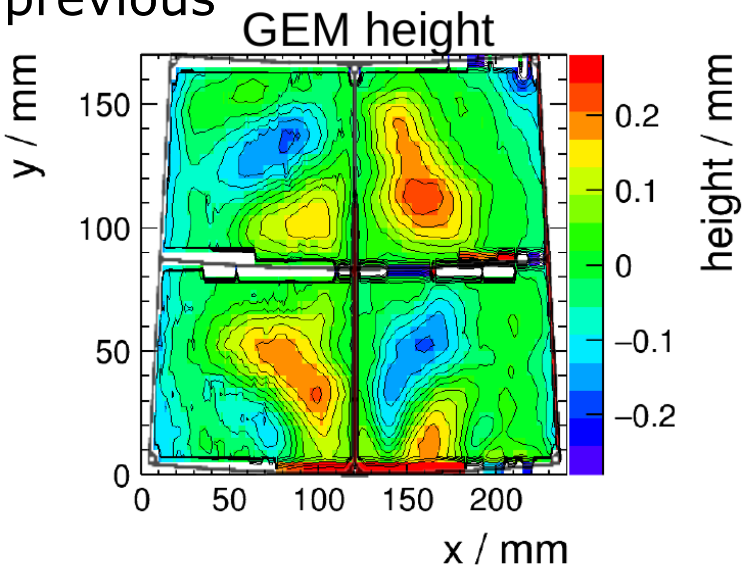
New flatter by almost a factor 2

Calculated gain fluctuation for triple GEM stacks: 6.1% → 4.2%

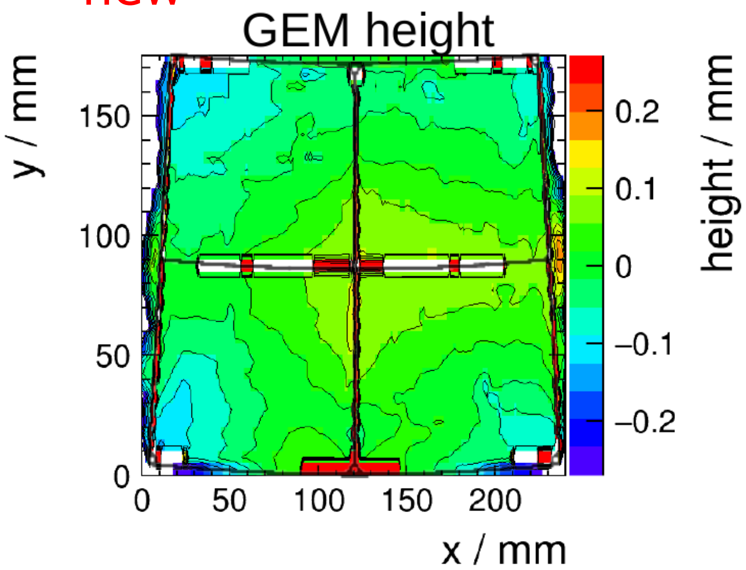
Pad pitch 1.26 x 5.85 mm²



previous



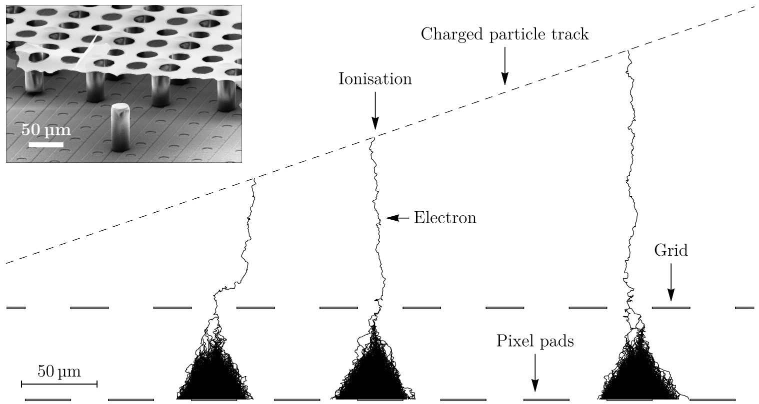
new

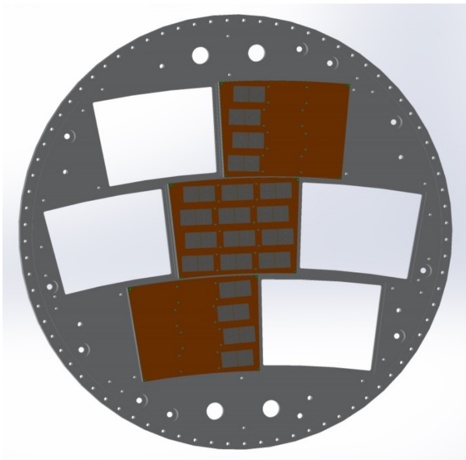


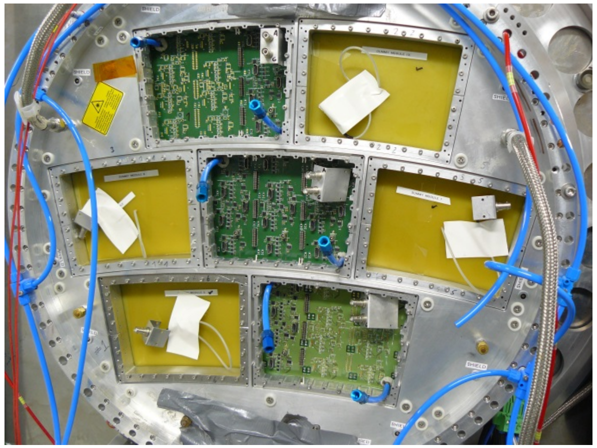
GridPix: gaseaous pixel TPC

Detect and reconstruct every single ionization electron with a high efficiency. Measure dE/dx by cluster counting.

55x55 μm²



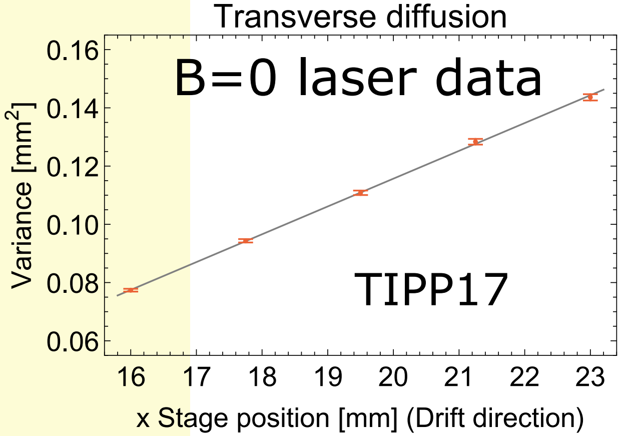




Module 8x12 = 96 chips with 23 (width) x 17 (height) cm²

GridPix: pixel TPC

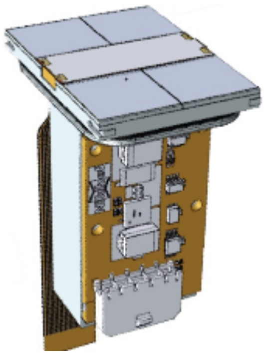
Large potential improvement wrt pad technologies.
Full simulations show that the resolution of a pixel TPC is a factor 1.8-6 better than for pads, due to the fact that all single electrons contribute to the measurement.



- Problem with the modules that were made (2015) with the TimePix chip: 19/160 chips stopped working. This is understood and solved by growing a protective Si_xN_y layer at IZM (2016).

- In the next generation of TPX3 chips this is also done. Single electron resolutions are understood & deformations are small (TIPP17 and MPGD17).

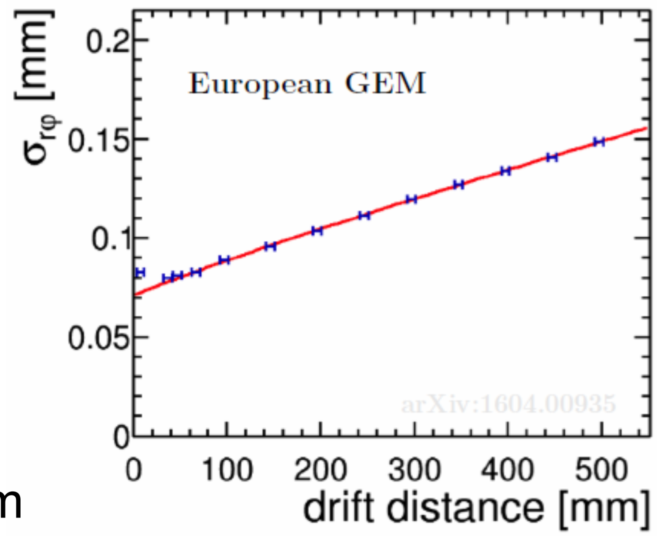
QUAD



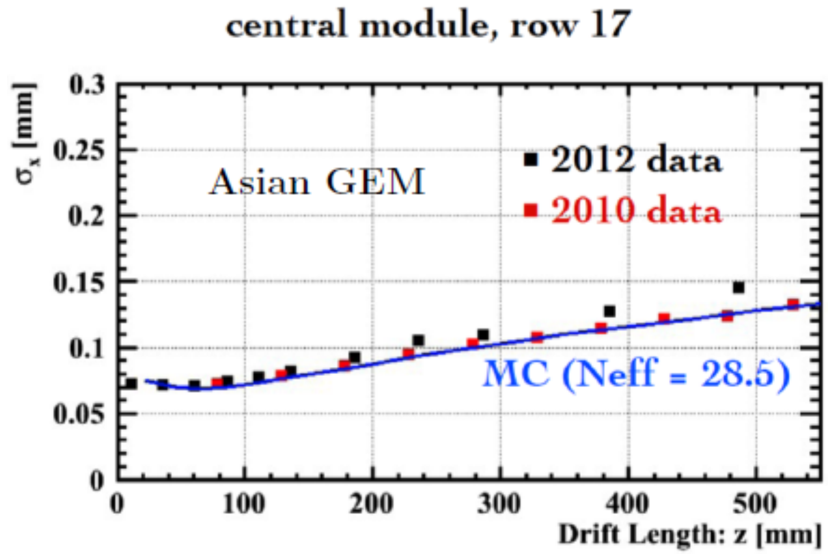
- The next step is to make a QUAD of four TPX3 chips, with high precision mechanics and positioning to keep the E field deformations well below 20 μm.

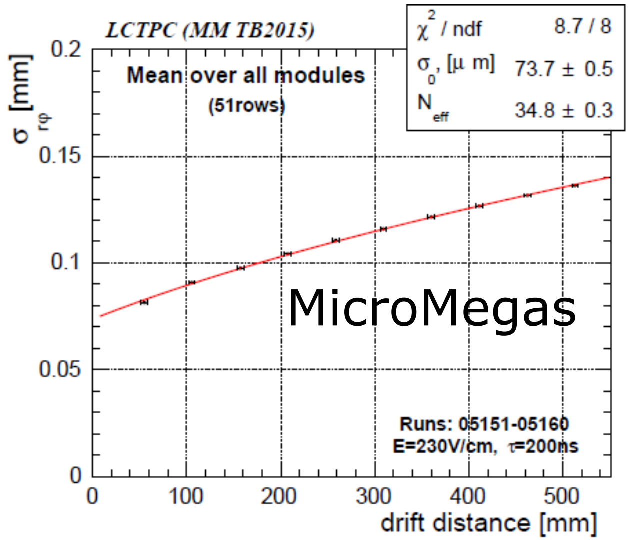
- After that a 96 chip module can be produced.

Module resolutions for pads



B = 1T
test beam

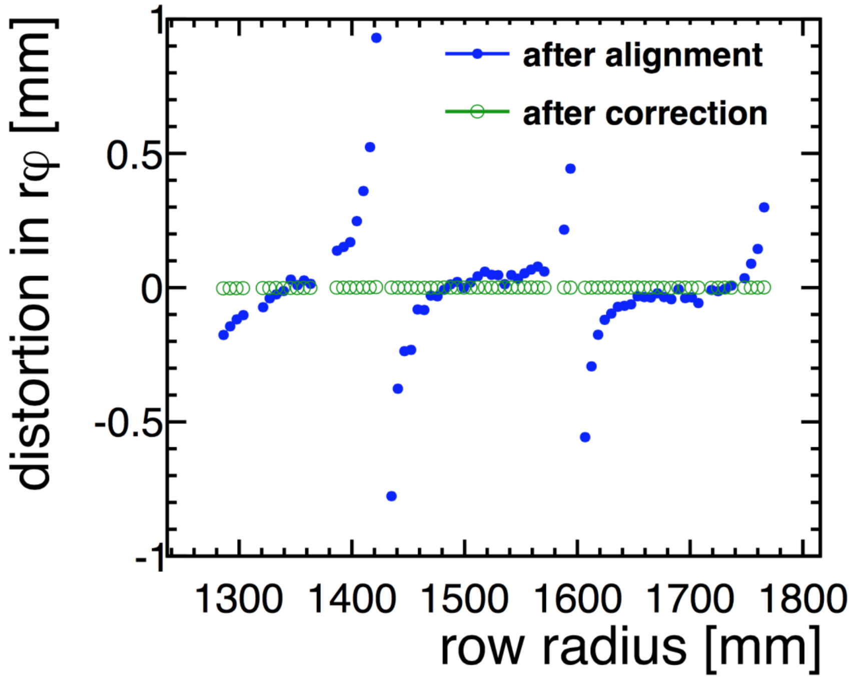


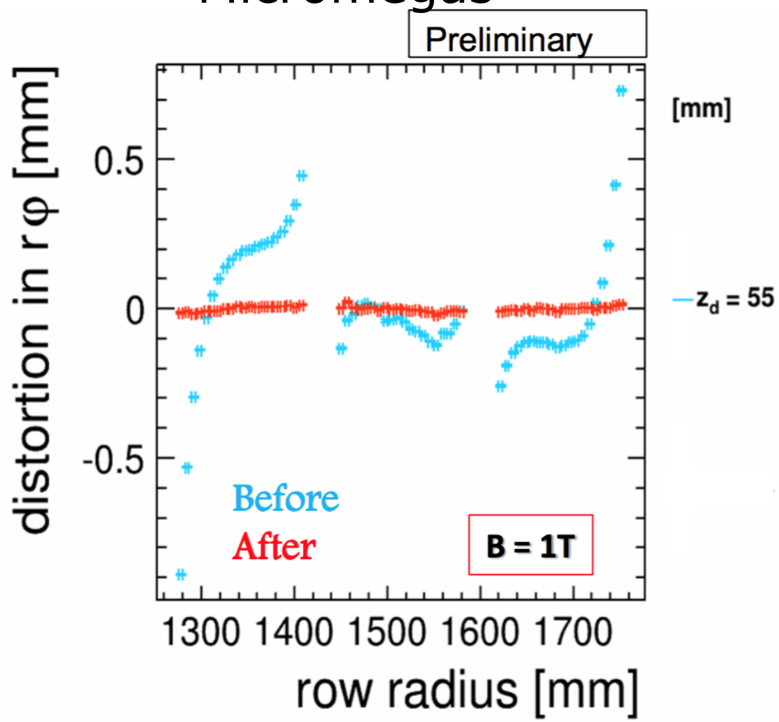


All pad TPC technologies give similar results for a pad: height of 5.26-7 mm

σ = 70 μm (d=0, B = 1T)

Distortions for pad read-out

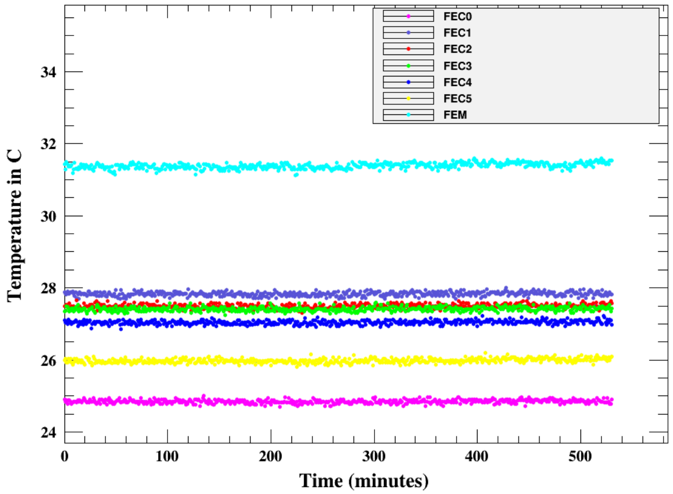


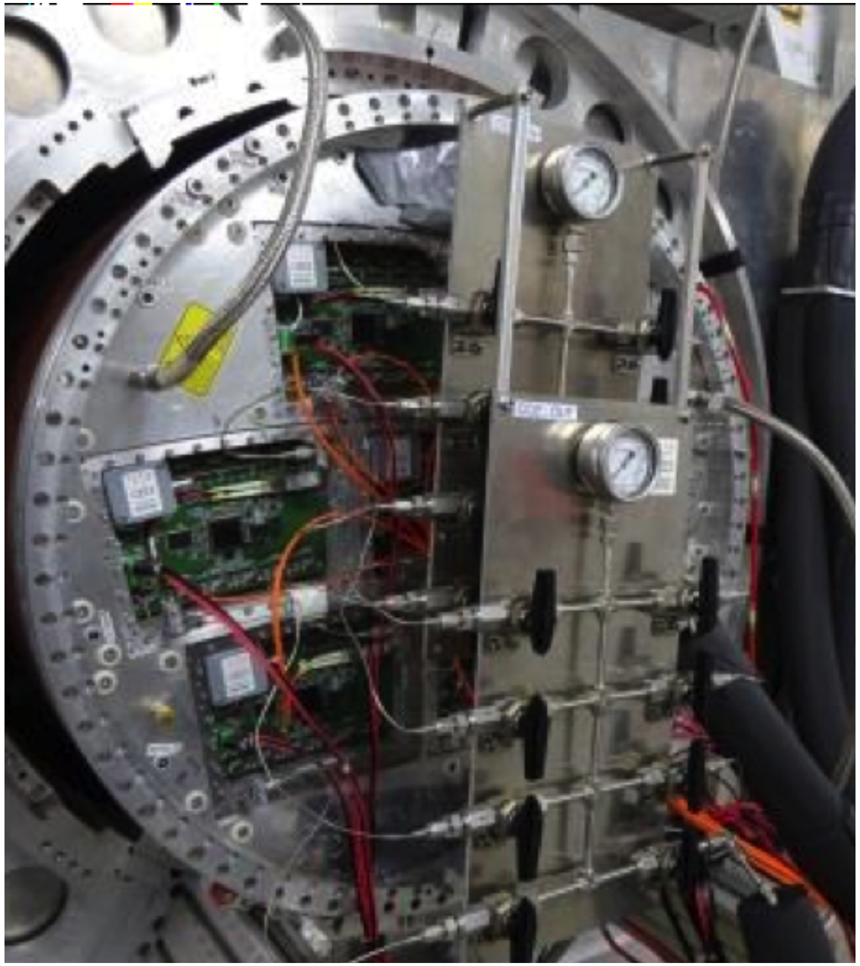


O (1 mm) distortions at edges of the modules.
Eu GEM has HV at edges, while MM has ground.
To ensure a homogenous field a new design of Micromegas module is needed.

Two phase CO2 cooling

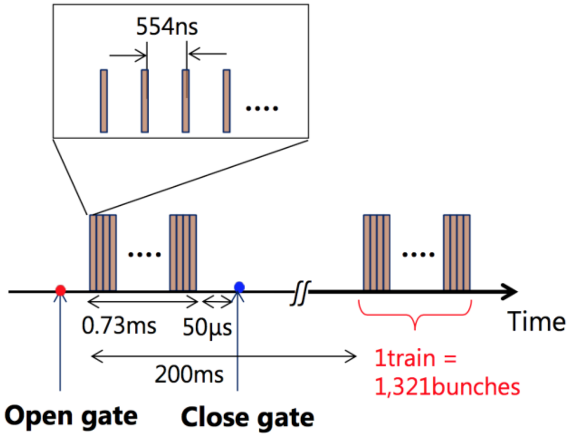
High latent heat, high specific heat: 10 °C at 50 bar (0.8 mm pipes)
Tested in 2014 and 2015 in test beam.

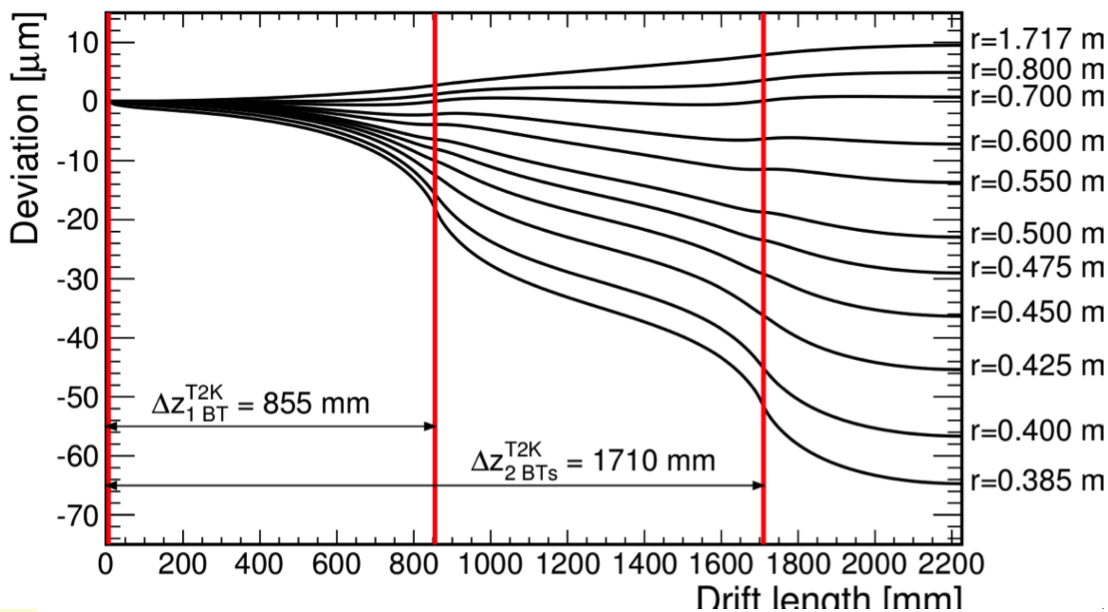




Why gating at the ILC?

At the ILC, the bunch trains last about 1ms every 200 ms, giving rise to ion disks slowly (1 m/s) drifting to the cathode. This gives field distortions.

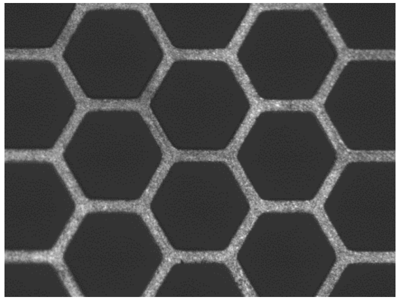




After 2 ion disks, the electrons receive a kick of up to 60 μm, too much wrt the systematics.

Gating options

Here gating using a transparant GEM is shown.

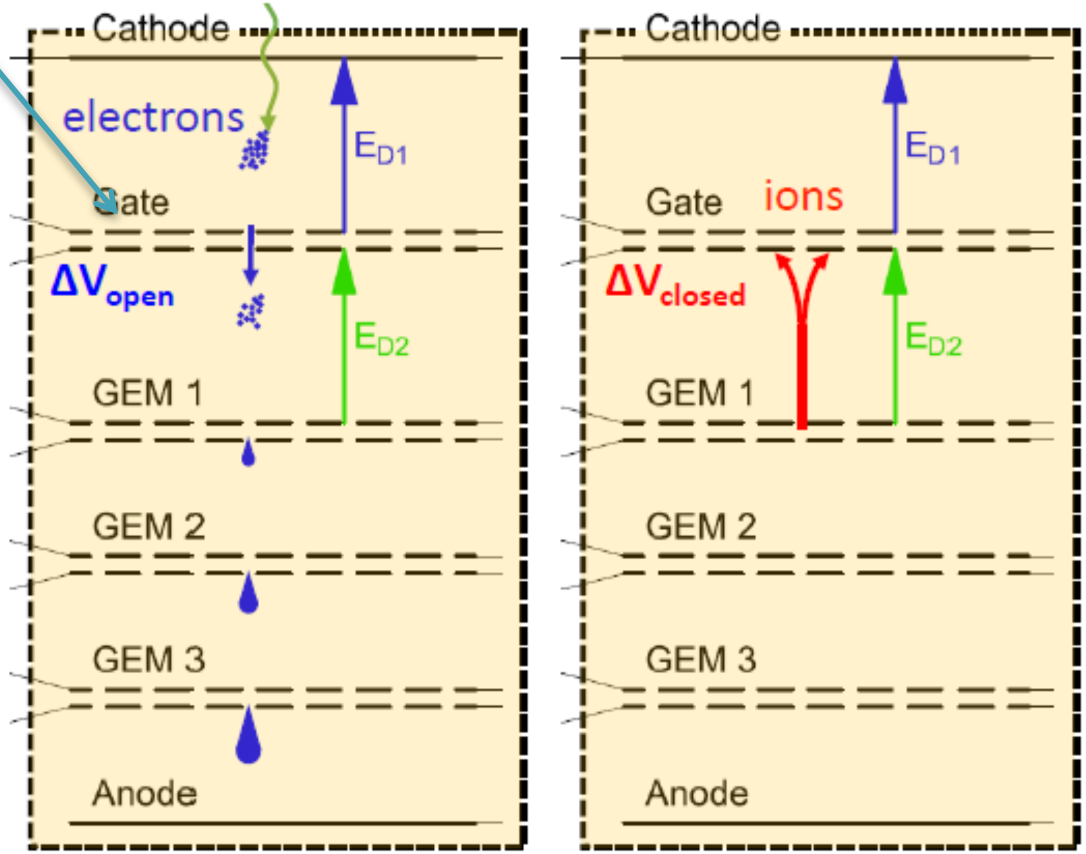


25µm

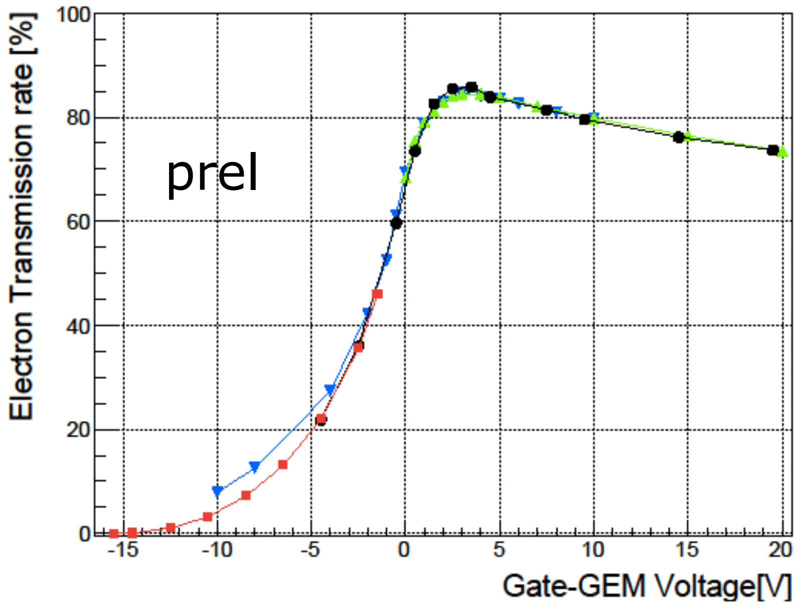
It is also possible to use a mesh.

In principle this device can also be put on MM or GridPix technologies.

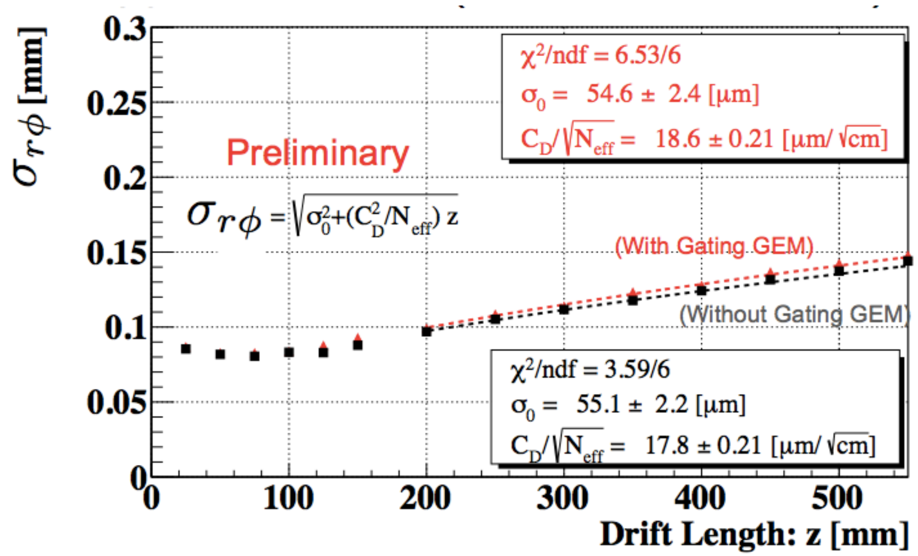
The ions must be stopped before penetrating into the drift region. The device must be transparent to electrons.



Gating GEM results



Resolution B = 1 T dV = 3.5 V



Preliminary results (MPGD17): transmission 80% and the resolution is mildly worsened (5% expect 10%).

Towards a final design of the ILD TPC

2014 expected timeline

2014-15	R&D on ion gates and a decision on the ion gate:
2015-17	Beam tests of new LP modules with the gate
2017	Prioritization of the MPGD technology and module
2017	ILC LAB & ILD detector proposal
2017-19	Final design of the readout electronics for ILD TPC
	Design of ILD TPC
2018-19	TDR for the ILD tracking system:
2019-23	Prototyping and production: Electronics(chips→boards)
	Prototyping and production: Modules
	Production: Field cage/endplate and other items
2024-25	TPC integration and test
2026	TPC Installation into the ILD detector
2027	ILC commissioning

Prospects and conclusions

After 3 years, the goals have been attained and the expectations for the timeline are still valid.
This is true, however, in the new context of a staged ILC with cost reductions.

In conclusion, most of basic questions and a large part of engineering questions have been answered for all technologies, matching the ILC requirements.

We expect a timely decision to build the ILC.