R&D plan for ILC (ILD) TPC in 2010 - 2012

(LC TPC Collaboration)

LCWA09 Tracker Session
02 October 2009

LC TPC Collaboration
Takeshi MATSUDA
DESY/FLC

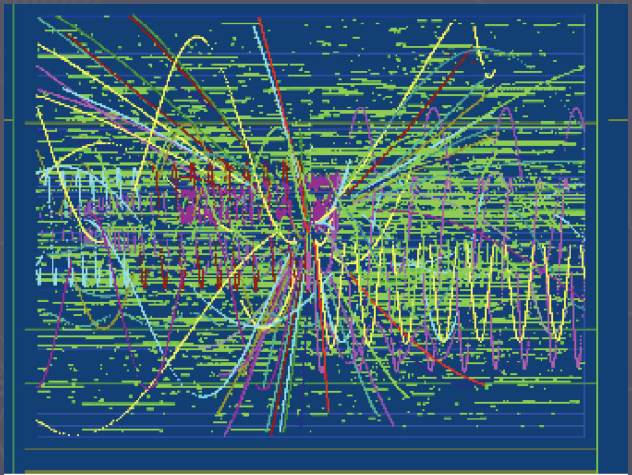
R&D Goals for ILC (ILD) TPC

- **High Momentum resolution**: δ(1/pt) ≦ 4 x 10-5 (TPC alone)

  → 200 position measurements along each track with
  the point resolution of $\sigma_{r\varphi}$ ~ 100μm at 3.5T → MPGD_TPC

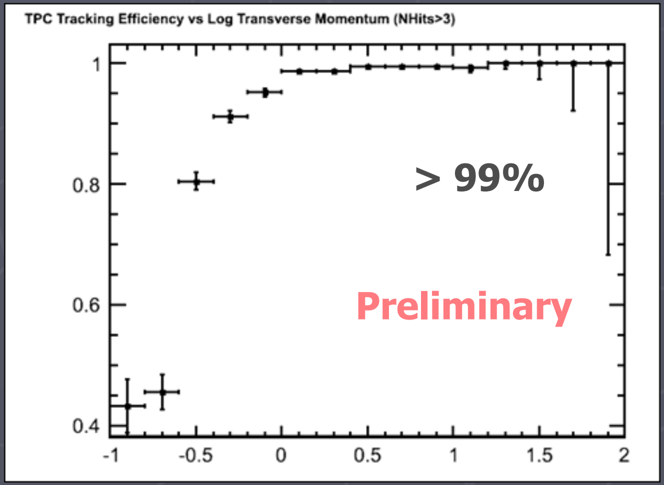
  [→ a several position measurements with $\sigma_{r\varphi}$~ 10μm at 5T → SiTR]

- High tracking efficiency down to low momentum for PFA
- Minimum material of TPC for PFA : 4%X0 in barrel/15% X0 in endplate
- dE/dX : 5%



ttbar overlayed
with 100BX of pairbackgrounds

->



Tracking efficiency w pair background
(S. Aplin & F. Gaede)

Options of MPGD for ILC TPC

Based on the studies with small MPGD TPC Prototypes

Analog TPC: Immediate options if the current ILC schedule

(1) **Multi layer GEM + Narrow (1mm wide) pad readout:**
Defocusing by multilayer GEM
Narrow (1mm) pads → Larger readout channels
Effective No. of electrons (Neff): ~ 20

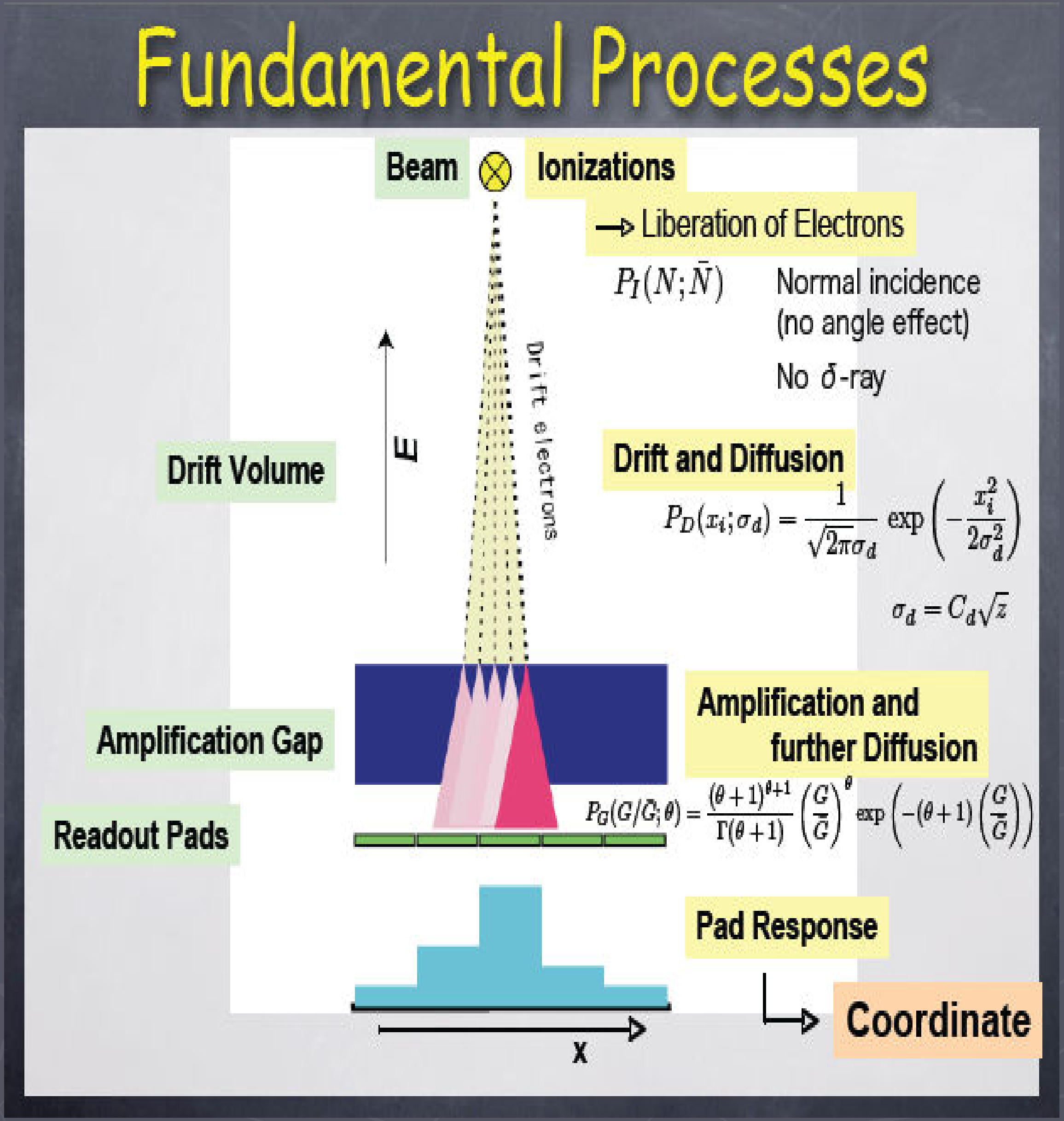
(2) **MicroMEGAS + Resistive anode pad (2-3mm wide)**
Widening signal by resistive anode
Wider pads → Less readout channels
Neff: ~ 30

Digital TPC:

(3) **Ingrid-MicroMEGAS + Timepix:**
Digital → Free from the gas gain fluctuation
More information from primary electrons and
Thus better position resolution (to be demonstrated)

(4) Multilayer GEM + Timepix:
Need to improve the efficiency for primary electrons

TPC



Fundamental Processes

Beam ⊗ **Ionizations**

→ Liberation of Electrons

$P_I(N;\bar{N})$ Normal incidence (no angle effect)

No δ-ray

Drift Volume

E

Drift electrons

Drift and Diffusion

$$P_D(x_i;\sigma_d) = \frac{1}{\sqrt{2\pi}\sigma_d}\exp\left(-\frac{x_i^2}{2\sigma_d^2}\right)$$

$$\sigma_d = C_d\sqrt{z}$$

Amplification Gap

Amplification and further Diffusion

$$P_G(G/\bar{G};\theta) = \frac{(\theta+1)^{\theta+1}}{\Gamma(\theta+1)}\left(\frac{G}{\bar{G}}\right)^{\theta}\exp\left(-(\theta+1)\left(\frac{G}{\bar{G}}\right)\right)$$

Readout Pads

Pad Response

→ **Coordinate**

x

TPC Gas: Gas physics

- No. of primary electrons
- Fluctuation of ionization
- Attachment
- Diffusion
- Drift velocity
- Aging

Filed caeg in Magnet

- E & B field
- Distortions (ExB)
- Ions

MPGD

Gas amplification:

- MicroMEGAS or GEM
- Gain fluctuation
- Ion backflow

Position measurement:

- Conductive pad
- Resistive anode pads
- Pixels

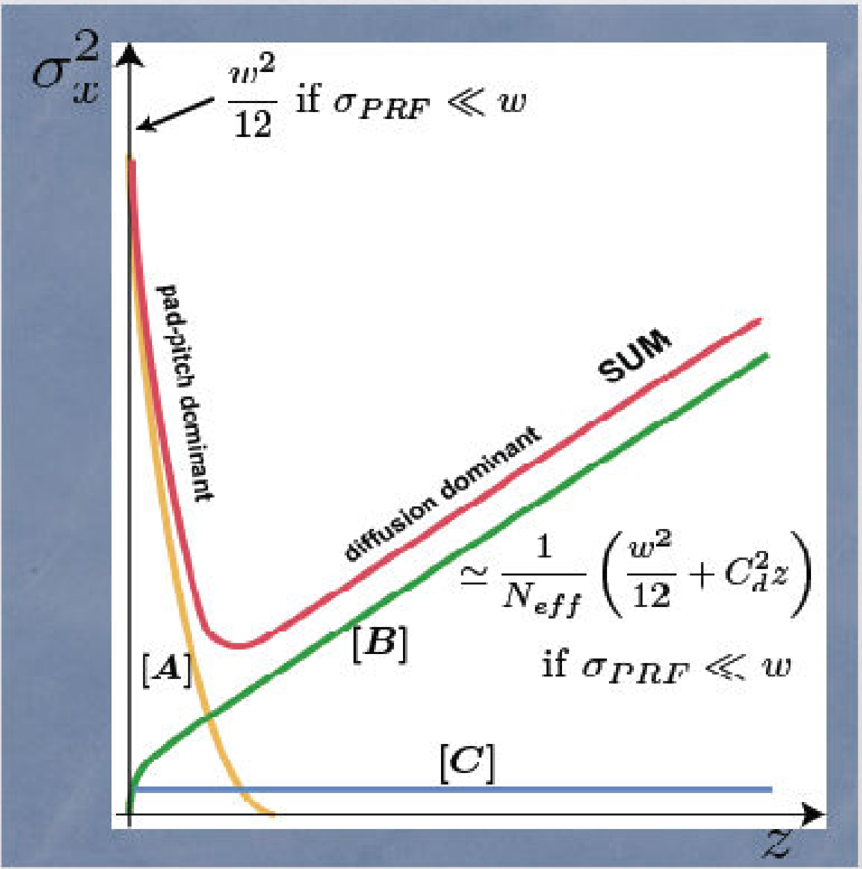
Low noise electronics:

- Analog/digital redaout

http://www-jlc.kek.jp/subg/cdc/lib/DOC/TPCSchool/200801/Fujii_Keisuke/TPCfundamentals-1.pdf (42MB)

Spatial Resolution of MPGD TPC

Full Analytic Calculation for Analog Readout



[A] Purely geometric term (S-shape systematics from finite pad pitch): rapidly disappears as Z increases

[B] Diffusion, gas gain fluctuation & finite pad pitch term: scales as $1/N_{eff}$, for delta-fun like PRF asymptotically:

$$\sigma_{\bar{x}}^2 \simeq \frac{1}{N_{eff}}\left(\frac{w^2}{12}+C_d^2 z\right)$$

[C] Electronic noise term: Z-independent, scales as $\langle 1/N^2 \rangle$

D.C Arogancia et at., arXiv: 0705.2210v1 [hep-ex] 15 May 2007.
Talks at ILC TPC School at Beijing, Jan. 2008:
http://www.hep.tsinghua.edu.cn/talks/TPCSchool2008/

Spatial Resolution of MPGD TPC

Comparison between different MPGD options

From the full analytic calculation of point resolution of MPGD TPC (*), σ(x) may be parameterized as:

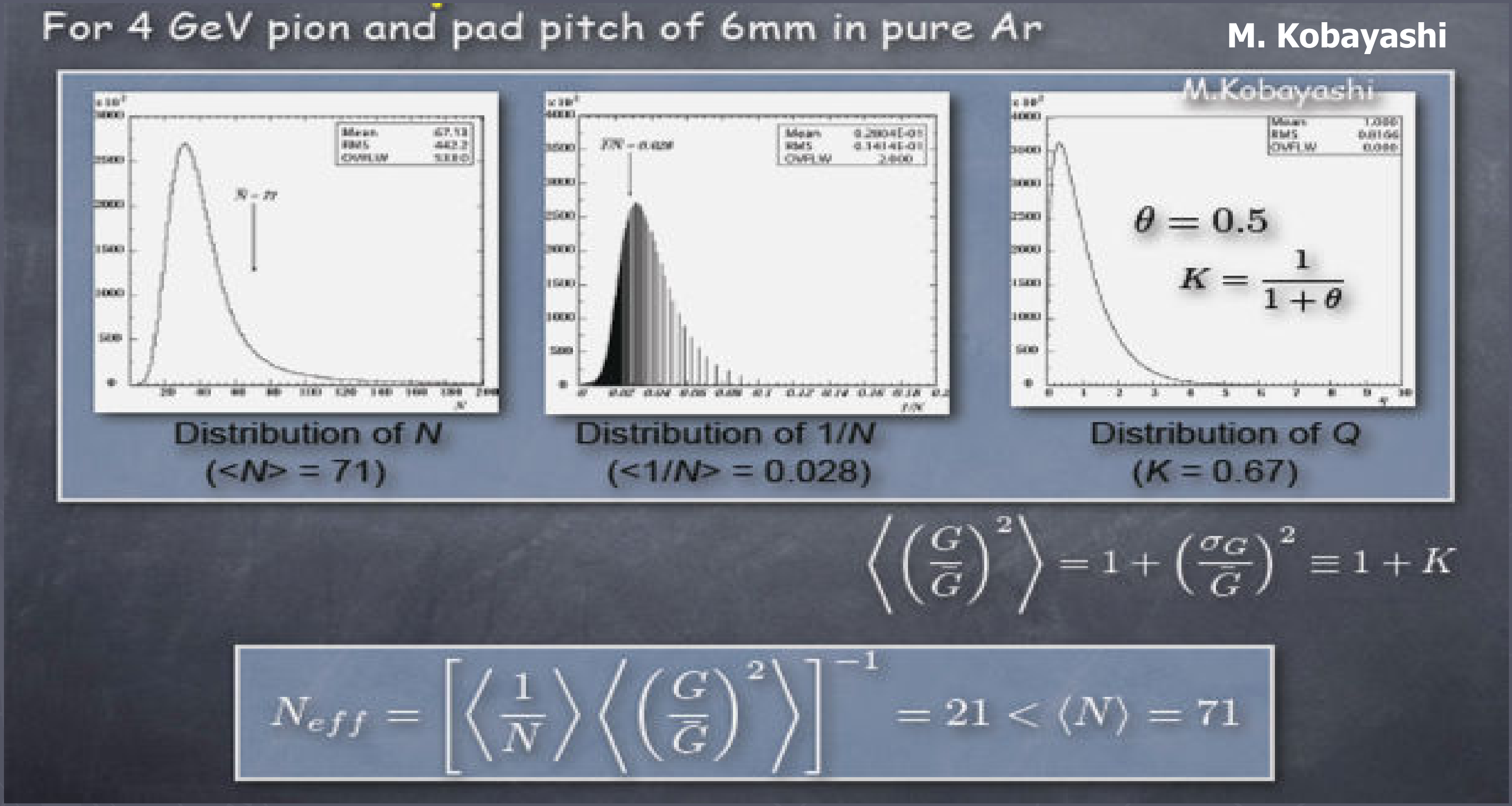
$$\sigma_x = \sqrt{\sigma_0^2 + \frac{C_d^2 \cdot z}{N_{eff}}}$$

Where Neff is the number of effective electrons, and Cd the diffusion constant of gas. σ(0) is determined by the configuration of MPGD detector and electronics. This formula itself may be applicable empirically to digital TPC.

(*) D.C Arogancia et at., arXiv: 0705.2210v1 [hep-ex] 15 May 2007.
Talks at ILC TPC School at Beijing, Jan. 2008:
http://www.hep.tsinghua.edu.cn/talks/TPCSchool2008/

Spatial Resolution of MPGD TPC:
Neff

M. Kobayashi



For 4 GeV pion and pad pitch of 6mm in pure Ar

M.Kobayashi

Distribution of *N*
(<*N*> = 71)

Distribution of 1/*N*
(<1/*N*> = 0.028)

Distribution of Q
(*K* = 0.67)

$$\theta = 0.5$$

$$K = \frac{1}{1+\theta}$$

$$\left\langle \left(\frac{G}{\bar{G}} \right)^2 \right\rangle = 1 + \left(\frac{\sigma_G}{\bar{G}} \right)^2 \equiv 1 + K$$

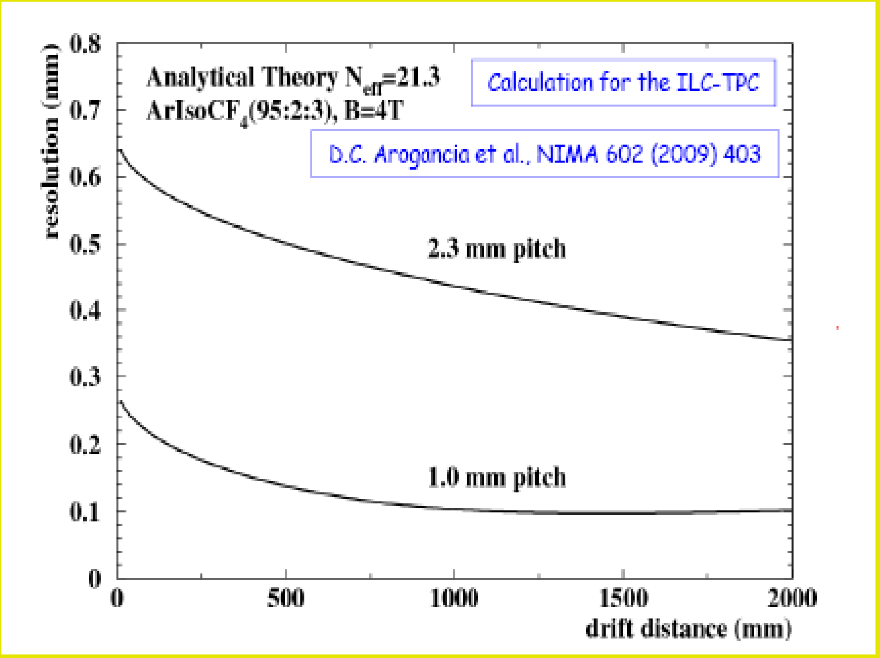
$$N_{eff} = \left[\left\langle \frac{1}{N} \right\rangle \left\langle \left(\frac{G}{\bar{G}} \right)^2 \right\rangle \right]^{-1} = 21 < \langle N \rangle = 71$$

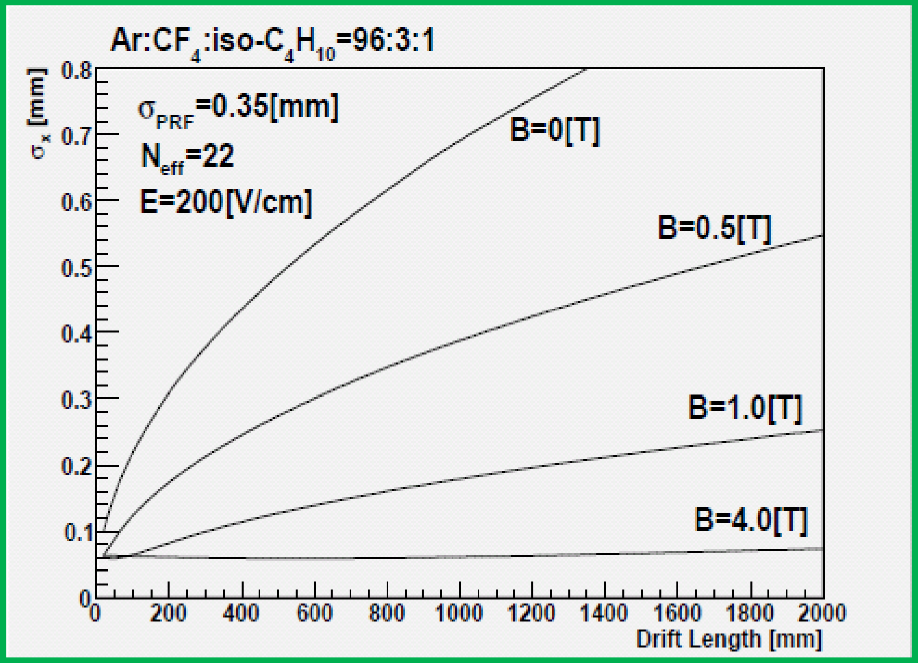
K may be dependent of the amplification scheme. If K is small, then Neff can be → 35. In the case of GEM, Neff seems to be 20-25.

Position Resolution
GEM and MicroMEGAS

MicroMEGAS
RMS (avalanche) on pads = 15μm

GEM
1mm x 6 mm pads
RMS (avalanche) 350μm

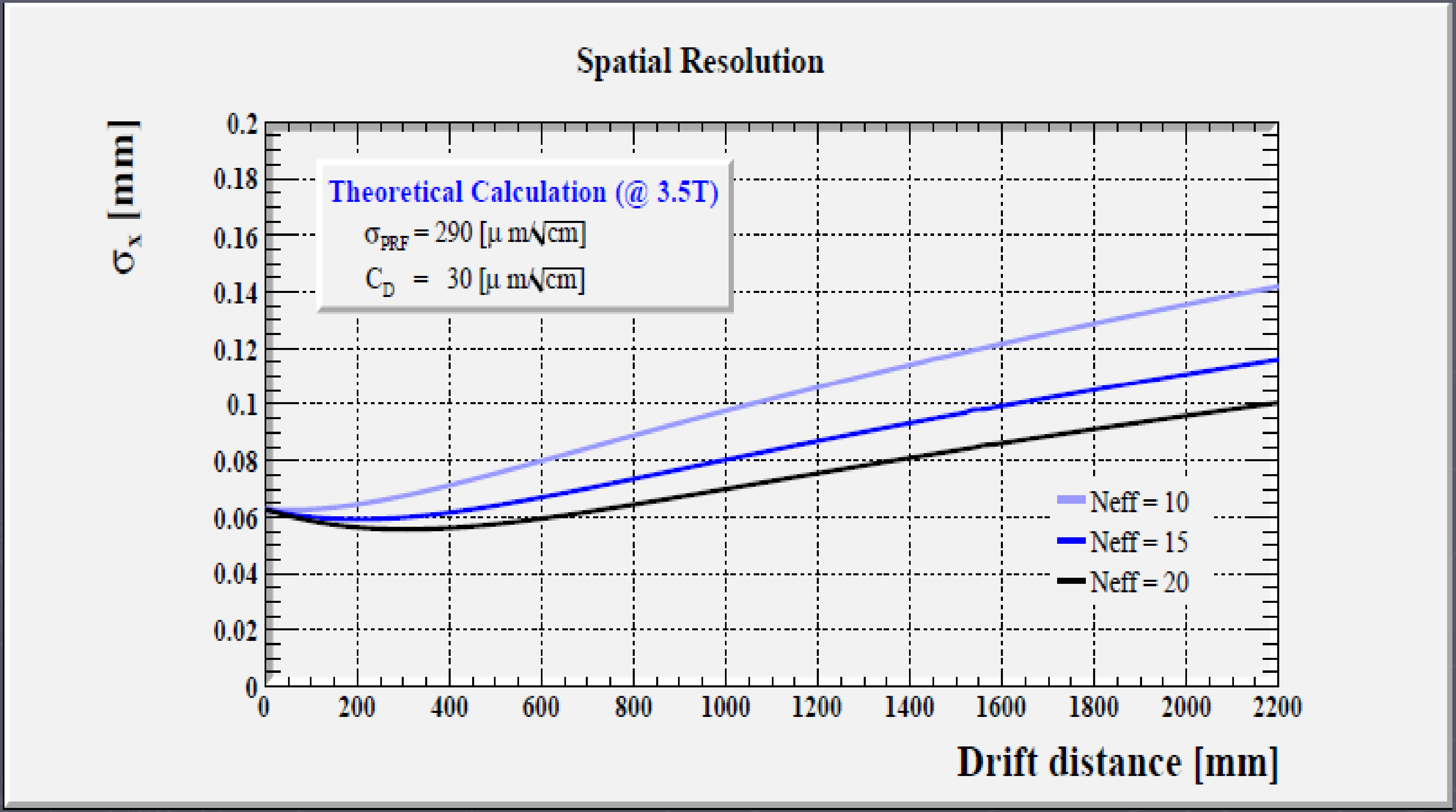




MicroMEGAS needs a resistive anode to widen the signal.

Position Resolution: Neff

Calculation for ILC TPC

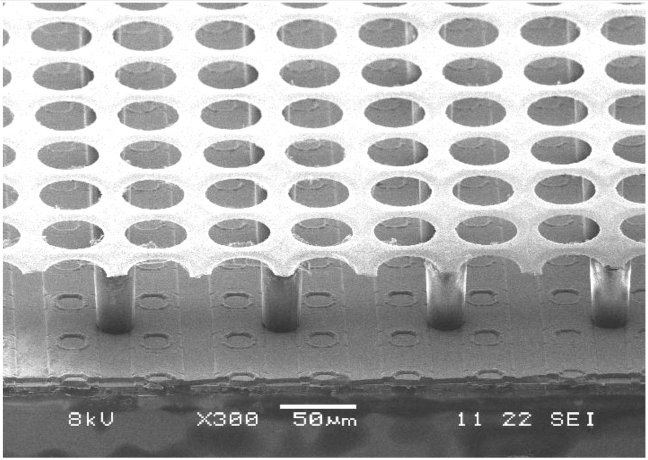


These calculations are for GEM. The dependence on Neff is similar for MicroMEGAS in large drift distance.

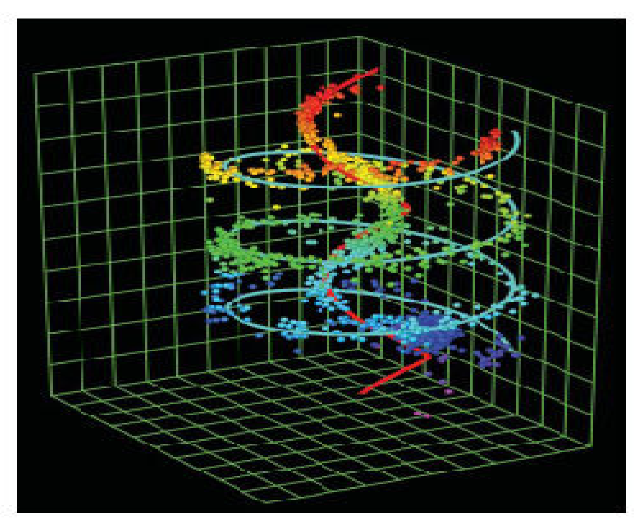
NIKHEF, Saclay

Silicon Pixel Readout of MicroMEGAS TPC:

- **Ingrid MicroMEGAS Timepix**: Integrated grid, i.e., MicroMEGAS mesh on the top of the CMOS chip. Now even two layers.
- To prevent discharge (in particular in Ar-based gases) to kill the chip, a discharge protection of high-resistive (~10^{11}) Ω·cm amorphous Si layer (3→ 20 μm thick) on top of CMOS chip was processed. Now also Si(rich) N protection.
- Good energy resolution of Ingrid devices
- Ion backflow of a few per-mil level at high field ratio.
- Still need higher gain (a few 1,000).
- MicroMEGAS + TimePix can be **Digital TPC avoiding the effect of the gain fluctuation**, possibly improving the spatial resolution by a few 10 %.
- **More R&D needed**: silicon trough hole to minimize dead region and 3D chip technology to implement high speed DAQ.



"Ingrid" + a-Si protection



5 cm^3 Digital TPC with MicroMEGAS
Two electron tracks from ^{90}Sr source

DIGITAL TPC : Toward Ultimate Resolution

(1) Detect all drift electrons individually along track with microscopic pixel

(2) Measure position of each primary electron digitally with necessary precision (50 μm pixels)

→ No deterioration due to the gas gain fluctuation

(Narrow signal spread of MicroMEGAS ~10 μm is the key.)

To beat out the analog MPGD TPC in term of momentum resolution of TPC, need very high detection efficiency of primary electrons:

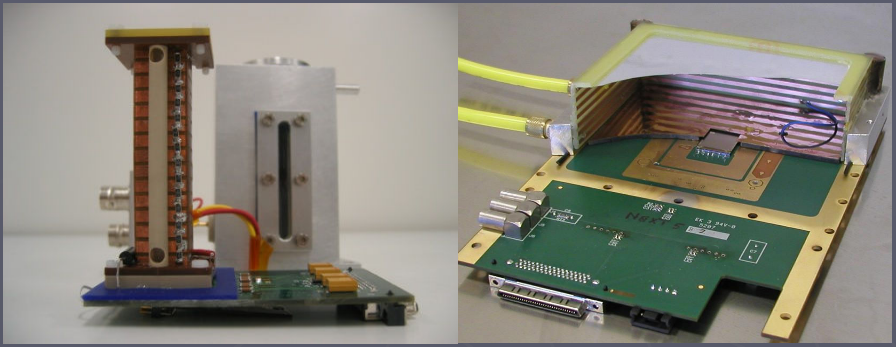
(a) At the chip level (actually measured to be close to 100%: next slide)

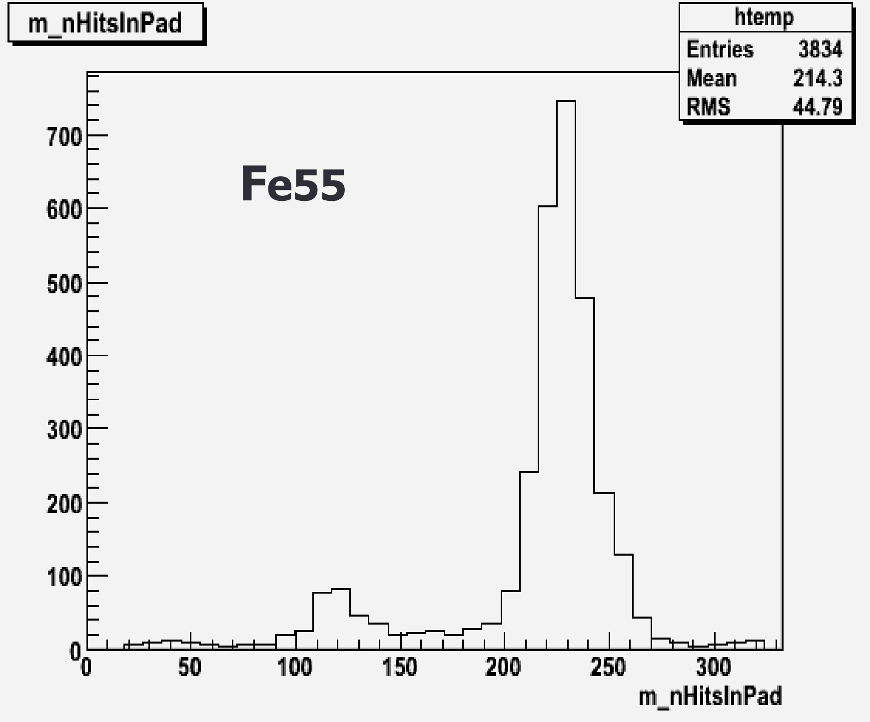
(b) No geometrical dead space in TPC application (continuous measurement along track) requires;
(i) Silicon through-hole to route TimePix signal to its backside, and
(ii) compact/high speed data readout

DIGITAL TPC : Ultimate Resolution
MicroMEGAS + Timepix

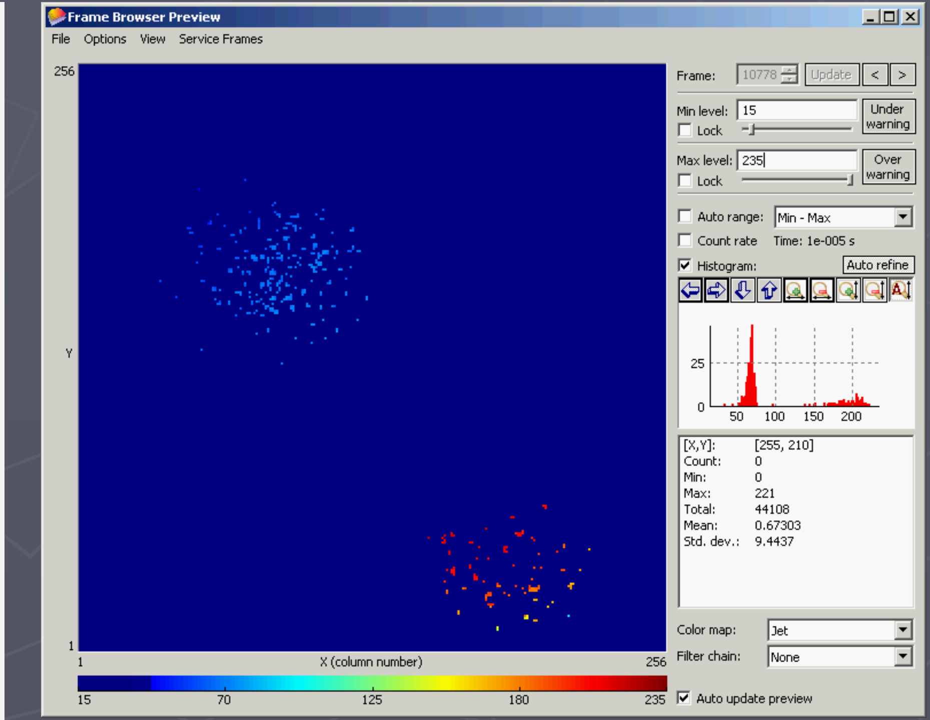
Measure electrons from an X-ray conversion and count them and study the fluctuations (Nikhef-Saclay)

→ **Single electron efficiency seems to be high enough.**





htemp	
Entries	3834
Mean	214.3
RMS	44.79



Frame: 10778

Min level: 15

☐ Lock

Max level: 235

☐ Lock

☐ Auto range: Min - Max

☐ Count rate Time: 1e-005 s

☑ Histogram:

[X,Y]:	[255, 210]
Count:	0
Min:	0
Max:	221
Total:	44108
Mean:	0.67303
Std. dev.:	9.4437

Color map: Jet

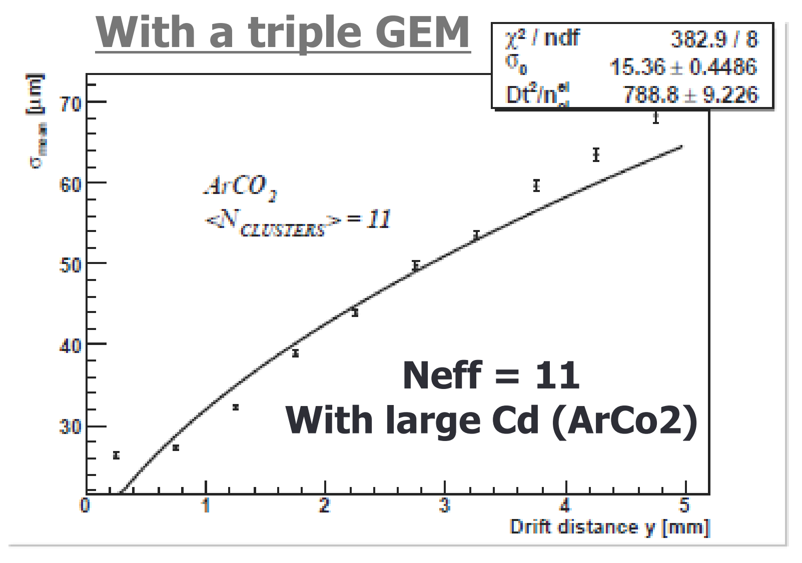
Filter chain: None

☑ Auto update preview

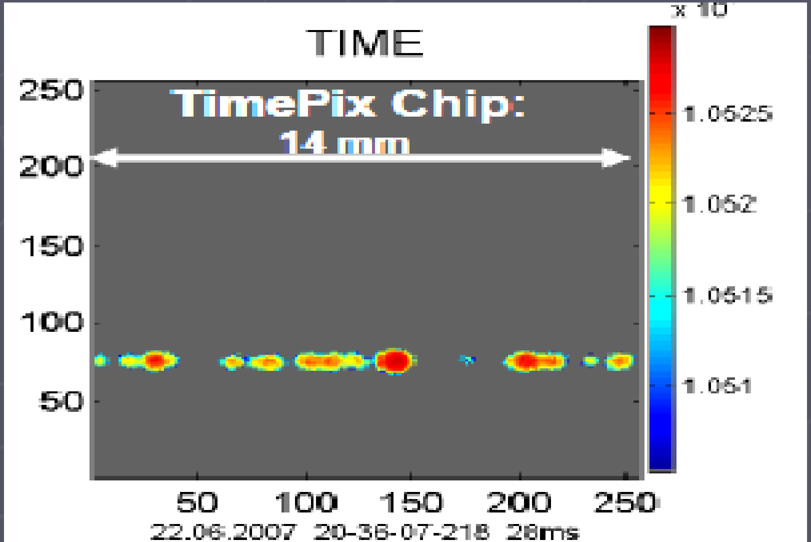
Silicon Pixel Readout of MPGD TPC
GEM

Freiberg & Bonn

- From Medipix to Timepix chip in 2006 (CERN): 256x256 pixels of 55x55μm^2 with a preamp, a discriminator and a counter to measure drift time.
- Detailed beam test at DESY since 2007. GEM+Timepix sees "bubbles" which show the size of signal spread of GEM and may contain more than one primary electrons.
- Detection efficiency of the primary electron, or Neff, is an issue to apply to ILC TPC. (The rapid deterioration of the position resolution as drift distance increases.)
- It is very attractive with its powerful graphic capability though.

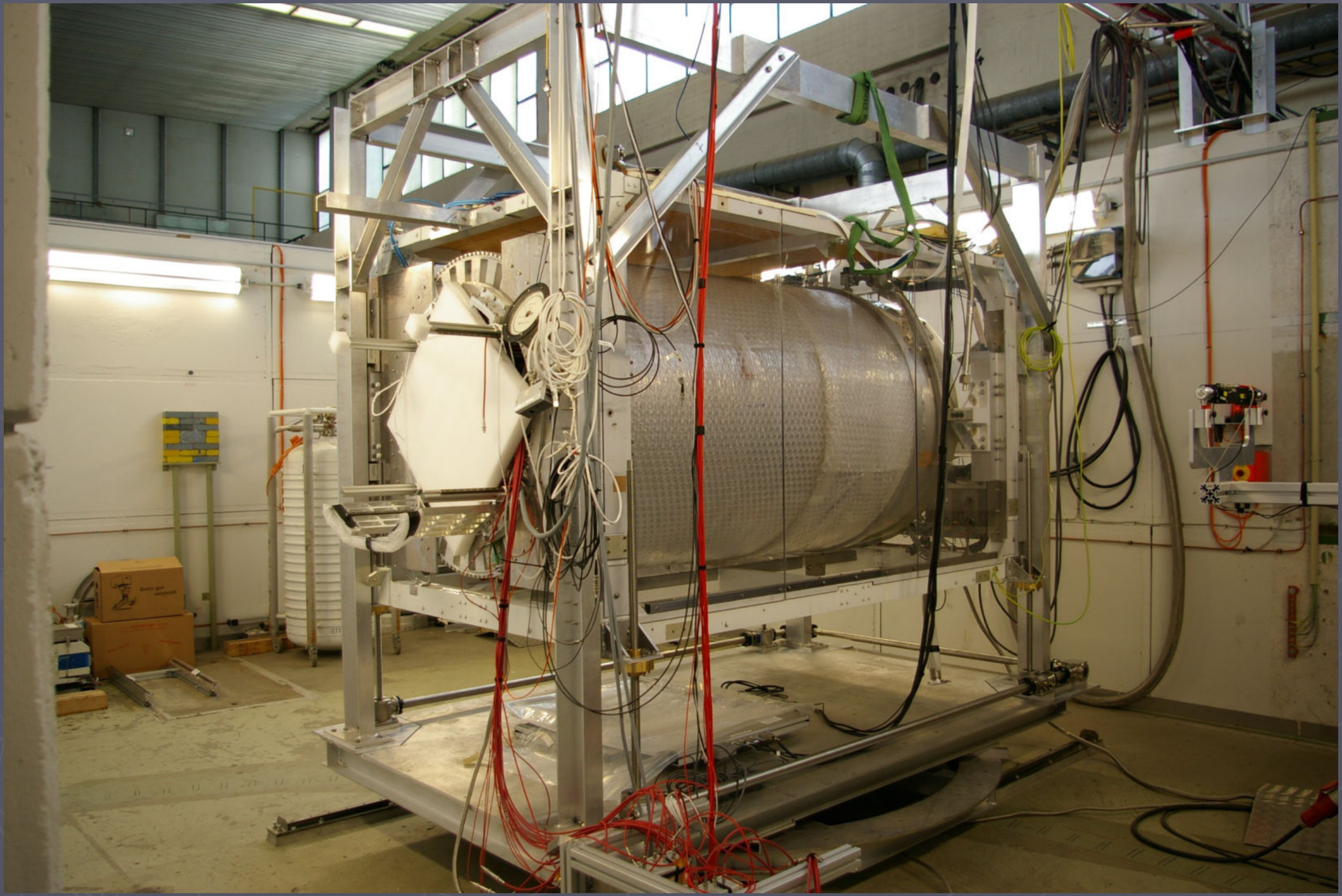


Neff = 11
With large Cd (ArCo2)



Results of DESY beam test
riple GEM +Timepix (Freiberg + Bonn)

TPC Large Prototype Beam Test (LP1)



LP1 at DESY T24-1 beam area

Please refer to Klaus Dehmelt' stalk

TPC Large Prototype Beam Test at DESY (LP1 Test)

Goals

1. Study, in practice, design and fabrication of all components of MPGD TPC in larger scale; field cage, endplate, detector modules,, front-end electronics and field mapping of non uniform magnetic field. (But not yet the engineering stage.)

2. Demonstrate full-volume trucking in non-uniform magnetic field, trying to provide a proof for the momentum resolution at LC TPC.

1. Demonstrate dE/dX capability of MPGD TPC.
2. Study effects of detector boundaries.

3. Develop methods and software for alignment, calibration, and corrections.

(Beijing tracker review, Jan 2007)

(What we have done by 2009 are 1 and 2)

TPC Large Prototype Tests: LP1

2008:	
Nov-Dec	MicroMEGAS modles w/ resistive anode (T2K electronics)
2009:	
Feb-Apr	3 (2) Asian GEM Modules w/o Gating GEM (3,000ch ALTRO electronics)
Apr	TDC electronics with an Asian GEM Module
Apr-May	Maintenance of PCMAG
May-Jun	MicroMegas w/ two different resistive anodes (New T2K electronics) Setup and test of laser–cathode calibration
Jun	GEM+Timepix
Jun	Instalation of PCMAG lifting stage and Si support structure
July	TDC electronics with an Asian GEM module ALTRO electronics w/ an Asian GEM module
July-Aug	Installation of PCMAG lifting stage
Aug	MicroMegas w/o resistive anode with laser-cathode calibration
Sept	A Bonn GEM module (A small aria GEM with ALTRO electronics)

TPC Large Prototype Beam Test: LP1

Ready for Momentum Measurement

(1) Confirmed the point resolutions of MicroMEGAS and GEM observed in small prototypes (2008-2009)

(2) Tested larger and new resistive anodes for MicroMEGAS (2009)

(3) Commissioned two new electronics; ALTRO with new preamp PAC16 and new T2K electronics. Found their excellent performances.

(4) Precision mapping of PCMAG (2008)

(5) Tested a calibration method of laser–cathode pattern (2009).

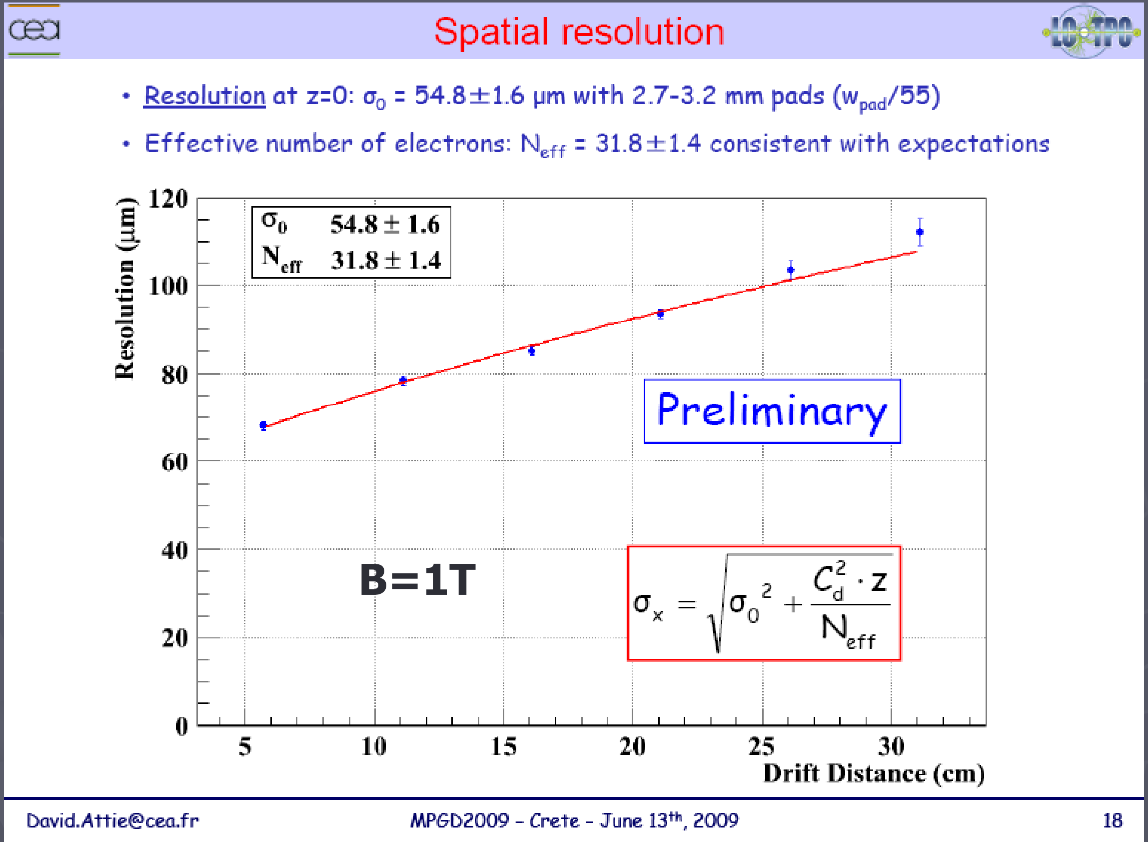
(6) Test with Si envelop (2009-2010)

(+) From mid Nov 2009 to March 2010 no Liq He supply at DESY. The DESY Liq He plant is moved inside DESY.

LP1 Result
MicroMEGAS with Resistive Anode

Scalay/Carleton

Special Resolution



Spatial resolution

- Resolution at z=0: σ_0 = 54.8±1.6 μm with 2.7-3.2 mm pads (w_{pad}/55)
- Effective number of electrons: N_{eff} = 31.8±1.4 consistent with expectations

σ_0	54.8 ± 1.6
N_{eff}	31.8 ± 1.4

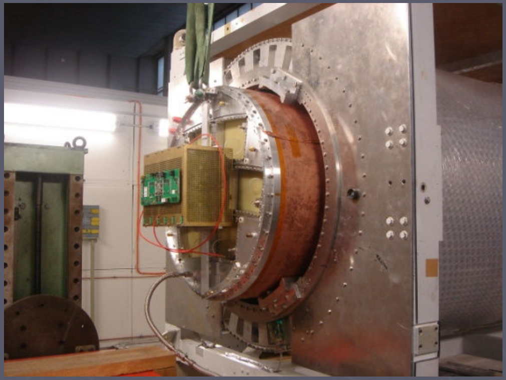
Preliminary

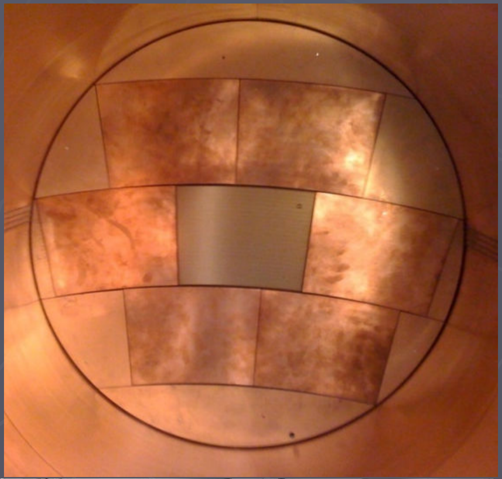
B=1T

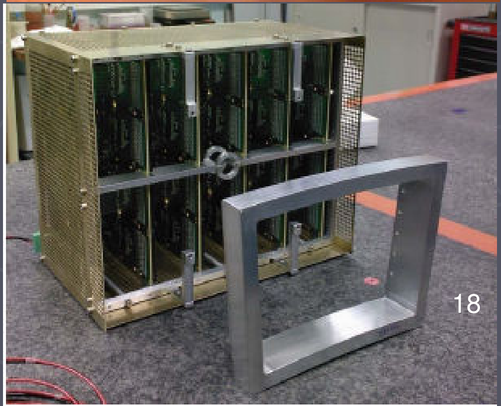
$$\sigma_x = \sqrt{\sigma_0^{\,2} + \frac{C_d^2 \cdot z}{N_{eff}}}$$

David.Attie@cea.fr

MPGD2009 - Crete - June 13th, 2009



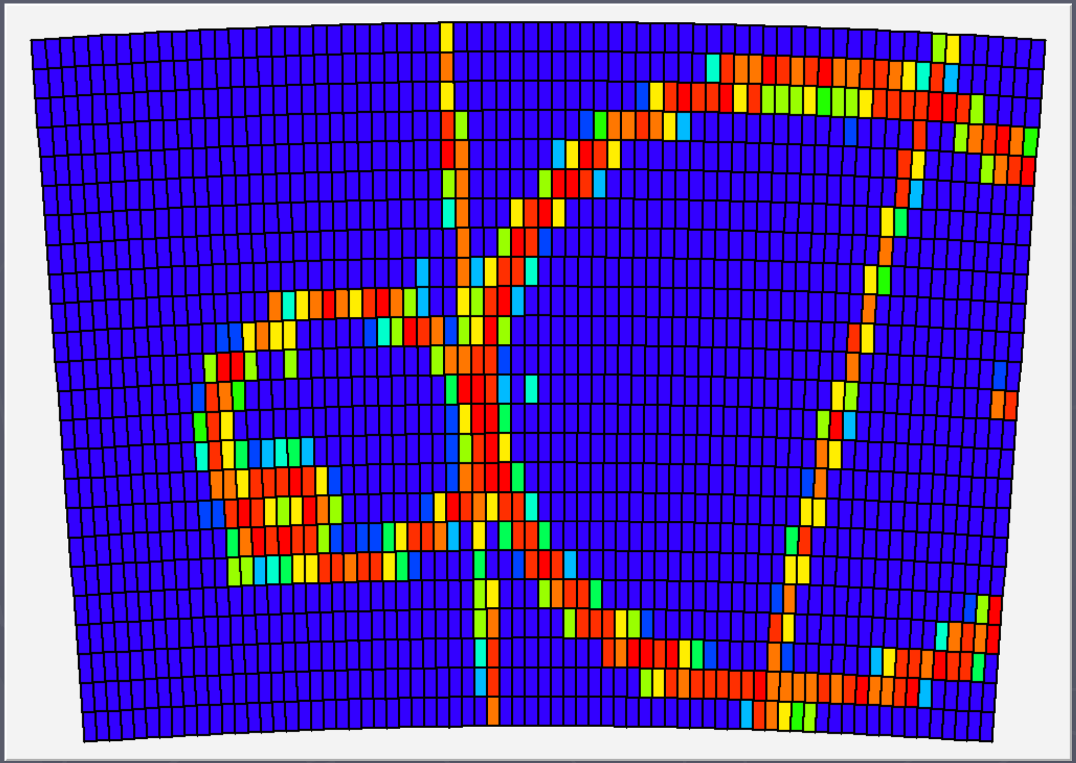




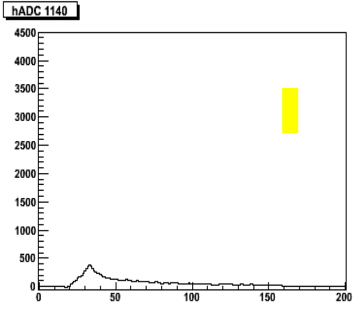
Consistent with the result from the small prototype. Neff ~ 32, σ(0) ~55 μm

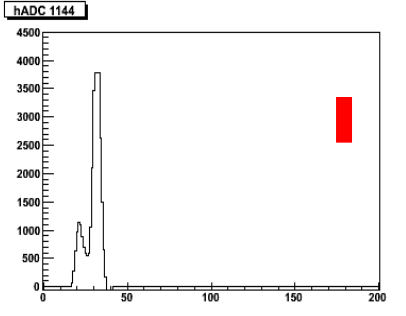
MicroMEGAS with Resistive Anode

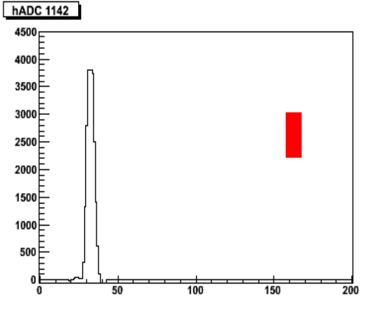
David Attie

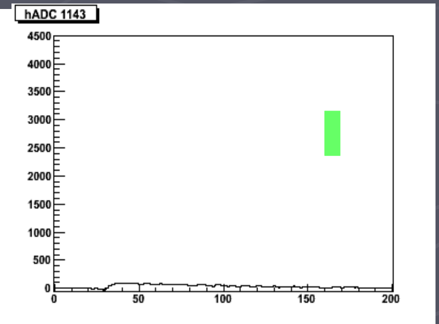


- B = 1T
- T2K gas
- Peaking time: 100 ns
- Frequency: 25 MHz
- z = 5 cm



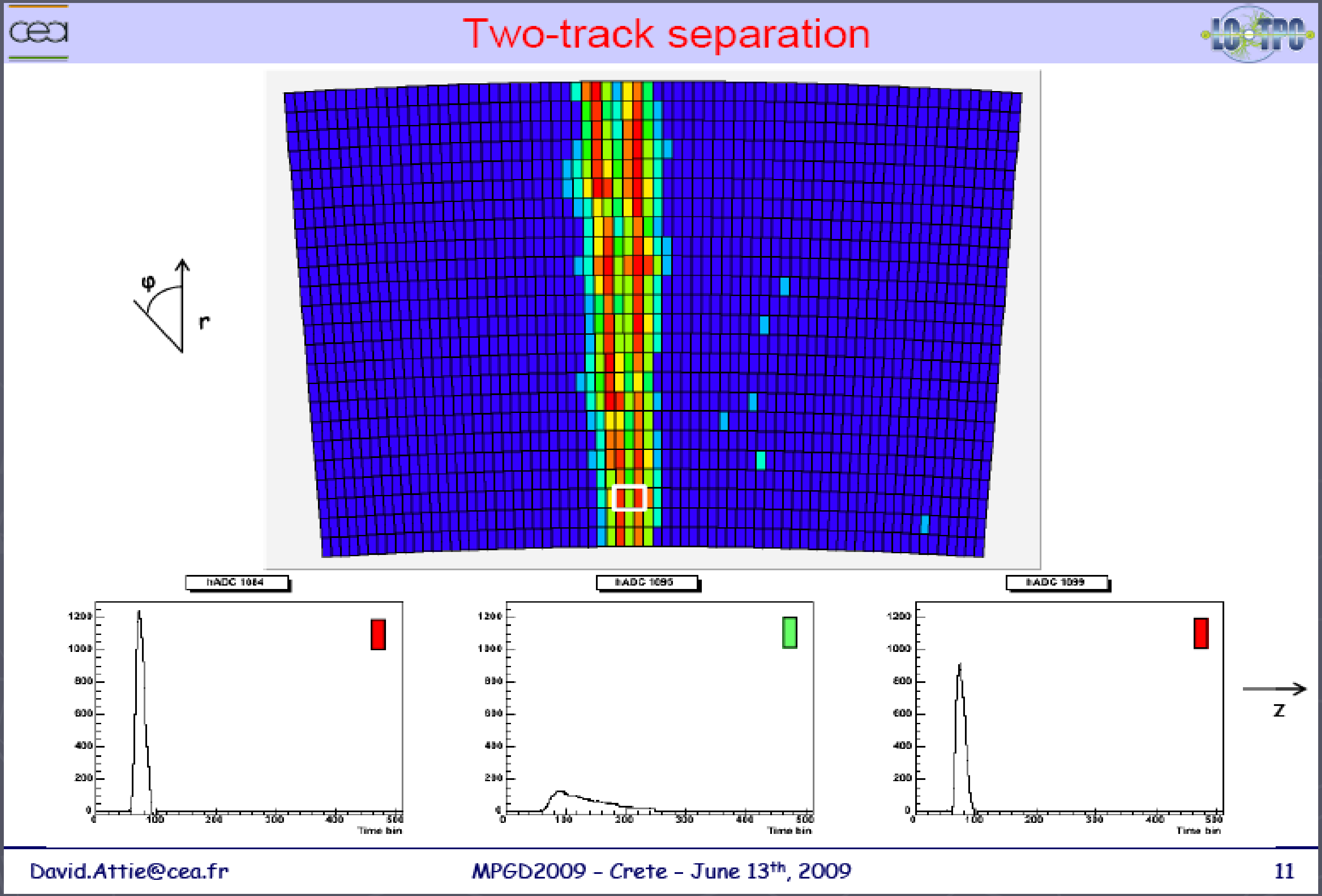






MicroMEGAS with Restive Anode

Double Track separation and signals in time.

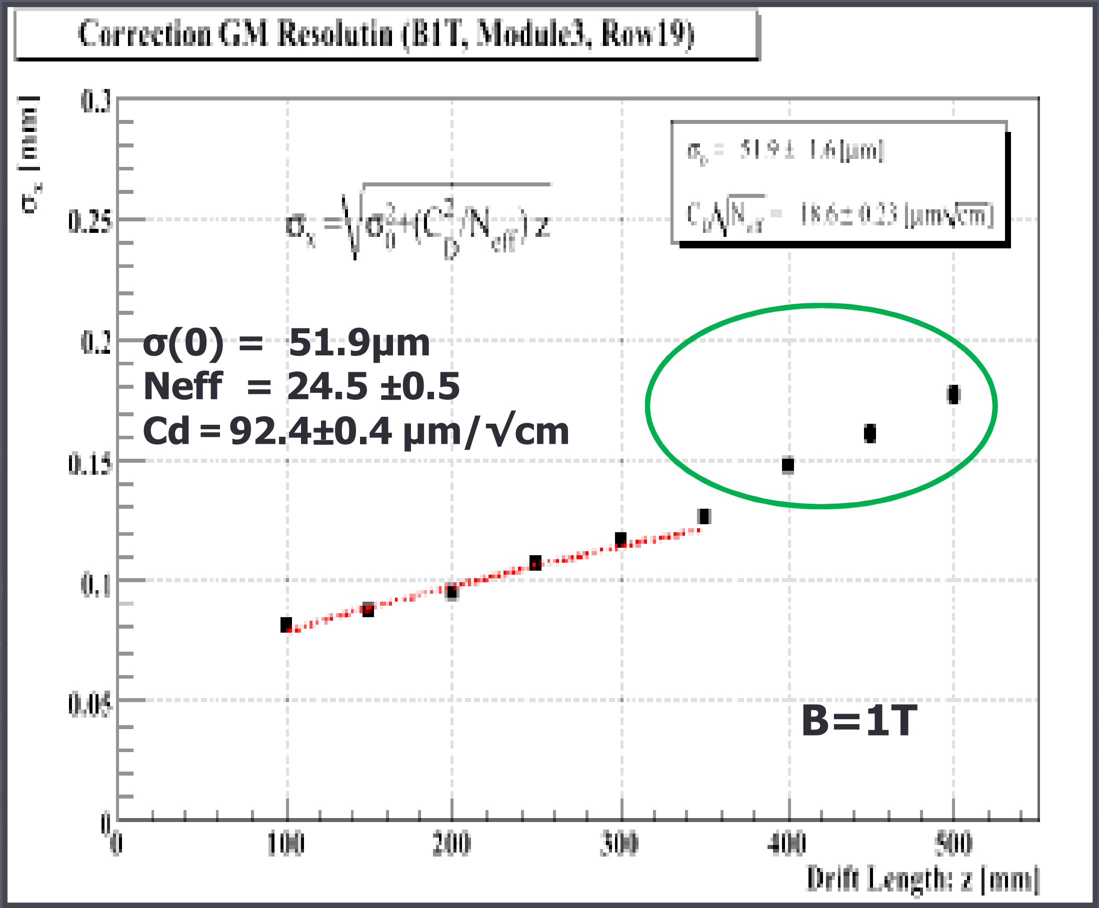


Two-track separation

David.Attie@cea.fr MPGD2009 – Crete – June 13th, 2009 11

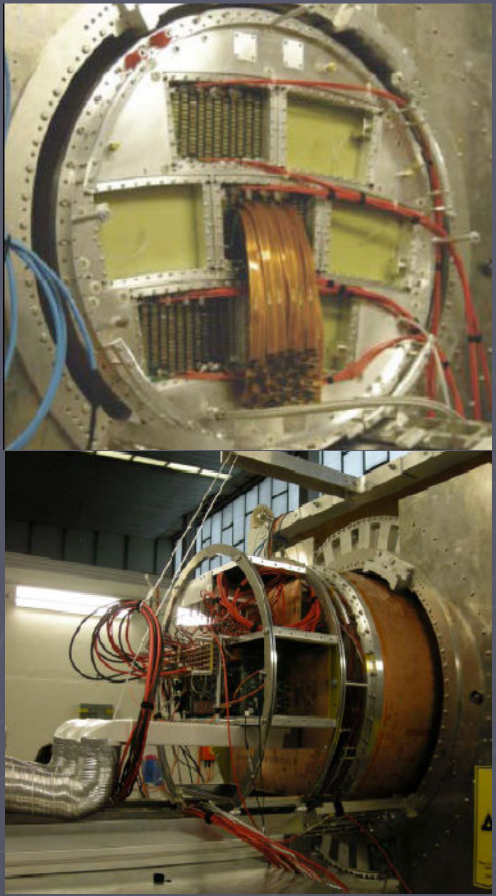
(Long duration of signals on side pads)

Asian GEM Module: Position Resolution



σ(0) = 51.9µm
Neff = 24.5 ±0.5
Cd = 92.4±0.4 µm/√cm

B=1T

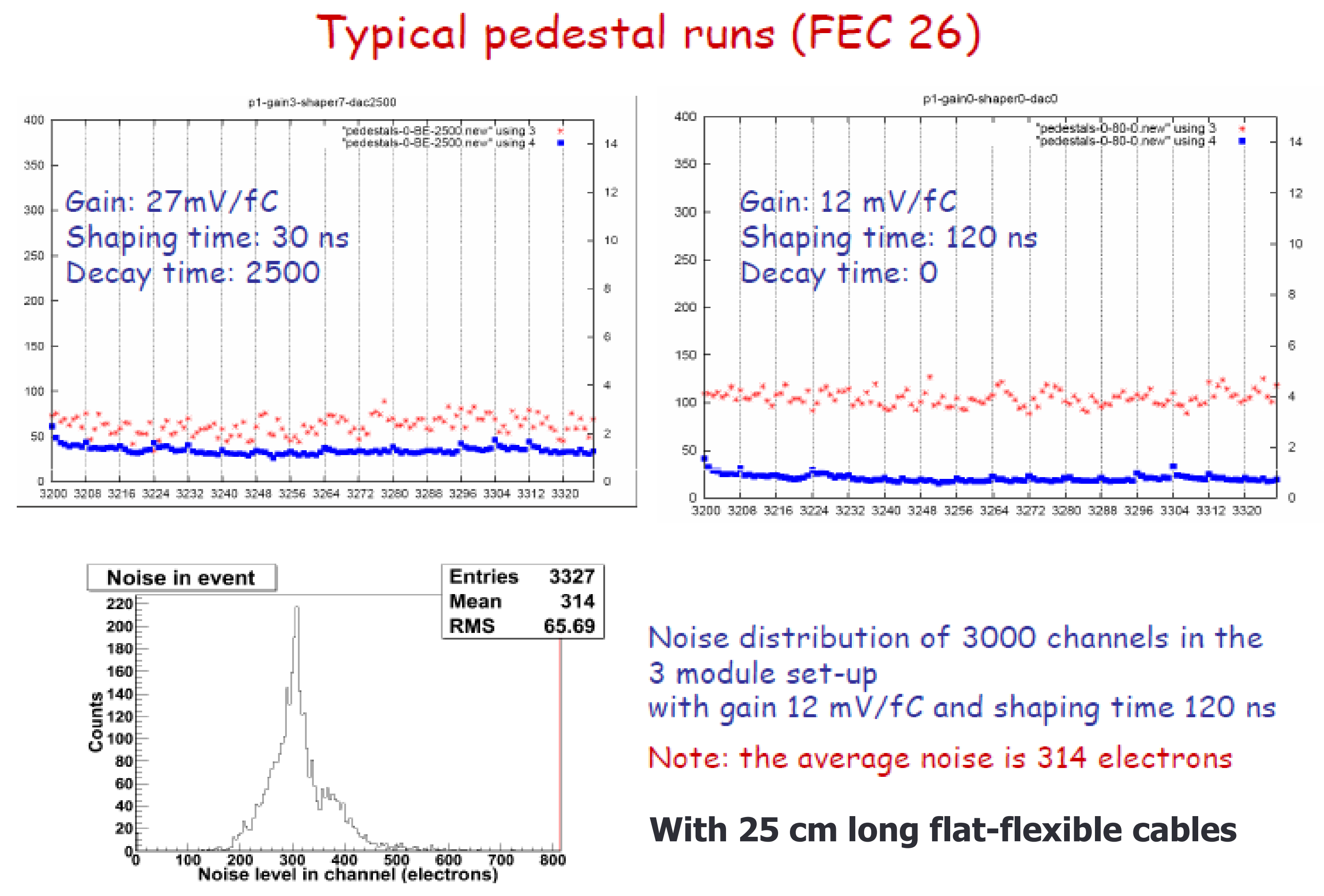


Consistent with results from small prototype tests: σ(0) ~ 52µm, Neff ~ 24-25.

Deviation from expectation in the large drift distances is due to the change of PCMAG field seen by MPGD module. At the time of beam test the PCMAG lifting stage was under preparation.

Asian GEM Modules + 3,000ch ALTRO Electronics

Beam Test in Spring 2009 w/o gating GEM



Typical pedestal runs (FEC 26)

Gain: 27mV/fC
Shaping time: 30 ns
Decay time: 2500

Gain: 12 mV/fC
Shaping time: 120 ns
Decay time: 0

Noise distribution of 3000 channels in the 3 module set-up
with gain 12 mV/fC and shaping time 120 ns

Note: the average noise is 314 electrons

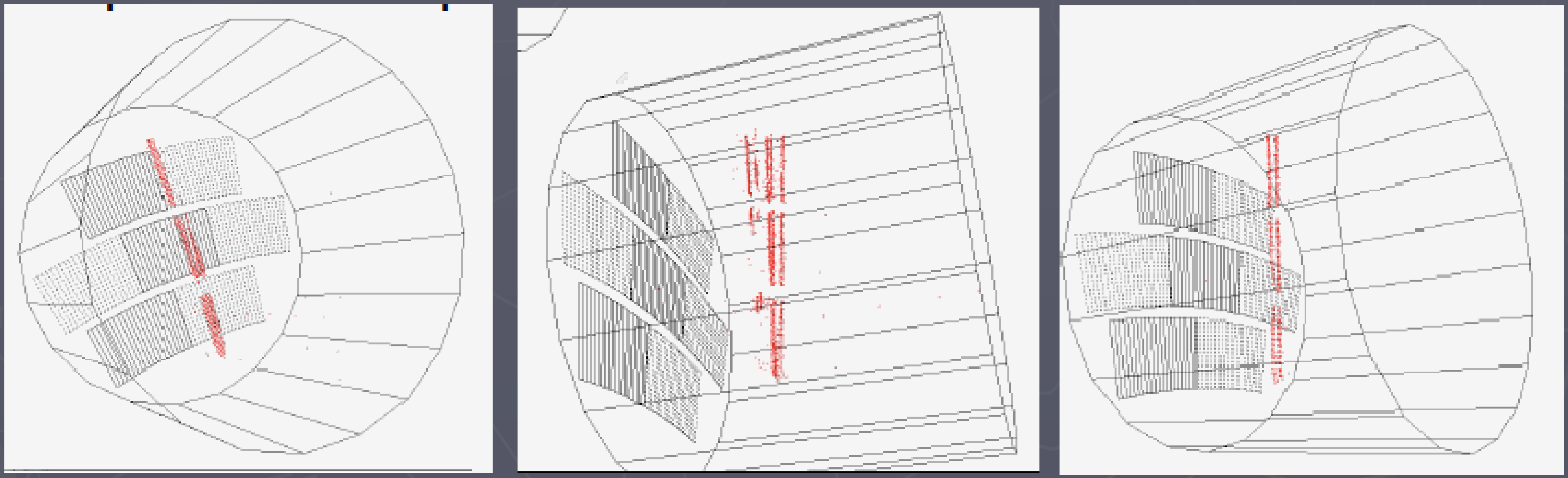
With 25 cm long flat-flexible cables

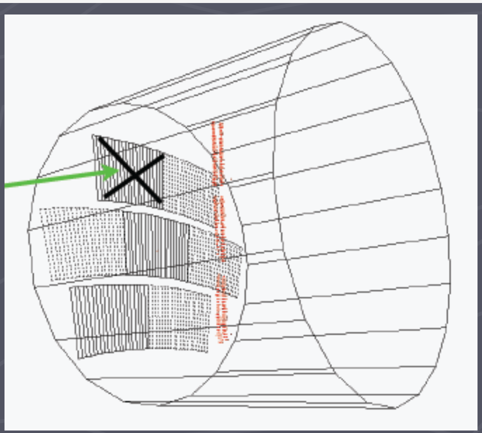
Asian GEM Modules + 3,000ch ALTRO Electronics

Beam Test in Spring 2009 w/o gating GEM

3,000ch ALTRO electronics distributed in a limited area along beam
→ Missing track elements.

The noise level of ALTRO electronics is 340 electrons with the 25 cm long flexible flat cables.





One of the modules started to draw current due to the provisional electrode on the frame of the top GEM in the absence of the gating GEM. The rest (most) of the data taking was performed only with two modules.
Missing gate GEM causes some distortion.

Practice of the LP1 goals No. 1 (!?)

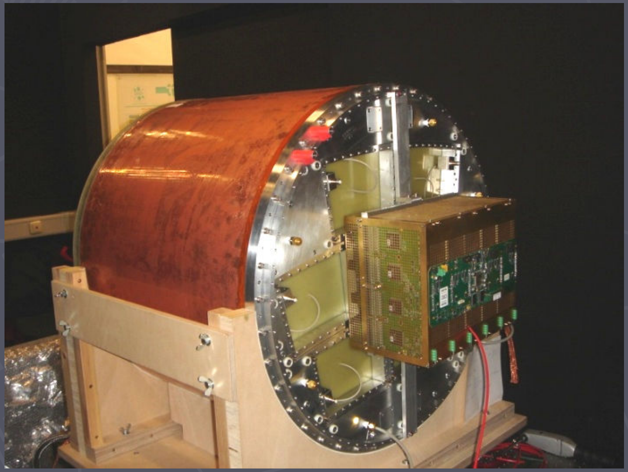
TPC Large Prototype Beam Test: LP1 in 2010

"Demonstrate full-volume trucking in non-uniform magnetic field, trying to provide a proof for the momentum resolution at LC TPC"

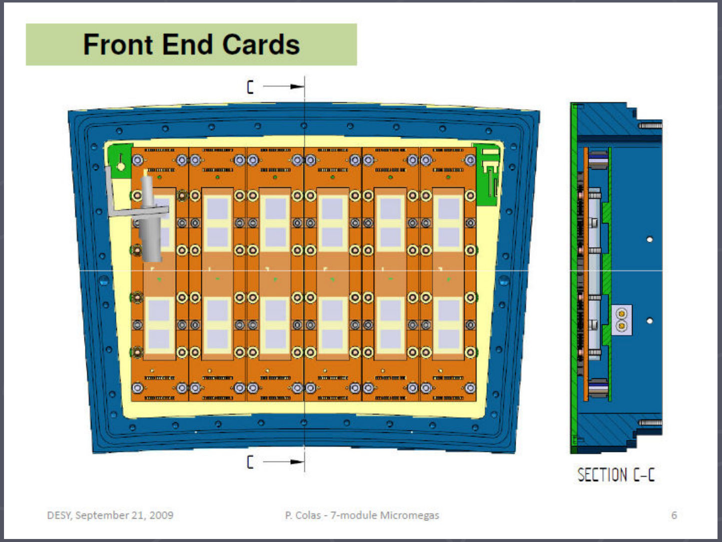
2010:

Spring 3-4 Asian GEM Modules w/ gating GEM (10,000ch ALTRO electronics)
DESY GEM modules (w/ wire gating?) (10,000ch ALTRO electronics)
Fall 7 MicroMEGAS modules w/ resistive anode (12,000ch T2K electronics)

MicroMEGAS module



Over sized electronic in 2008-2009



Front End Cards

DESY, September 21, 2009 P. Colas - 7-module Micromegas 6

MicroMEGAS modules in 2010

(Unfortunately T2K electronics can not be used at ILC TPC!)

Measurement of Momentum Resolution
LP 1

Two steps:

(1) $\sigma_{r\varphi}$: OK

← MPGD TPC
← Gas of low diffusion (high ωτ) : Ar:CF4:Isobutene (T2K gas)

(2) **Momentum resolution:**

← Non uniformity of PCMAG magnetic field (in purpose → ILC)
← Distortion of other sources: Field cage, endplate
← Distortion due to ion feedback (Ion disks)

→ Tracking Software for the non uniform magnetic field (Urgent!)

TPC Large Prototype Beam Test (LP2) from 2011

Current Plan

2010 Continue LP1 test at DESY

2011 Move to a high momentum hadron beam:

← Limitation using electron beam to measure momentum.

→ Options of magnet
Move the current PCMAG
Find a proper high filed magnet accommodates current LP1 TPC (Solenoid preferable).
→ Build also a new field cage with a laser track calibration
→ With TPC "Advanced Endplate" (need resources!)

Two Important R&D Issues in 2010-2012

Advanced endplate:

Requirement: thickness 15% Xo

Thin endplate
High density, low power electronics to match small pads (1 x 4mm) surface-mounted directly on the back of pad plane of MPGD detector module
Power delivery, power pulsing and cooling

LP2 with Advanced endplate

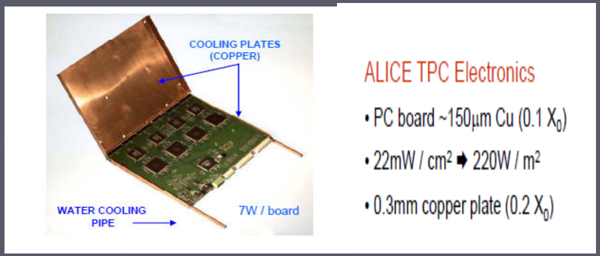
Ion Feed back and Ion disks:

Ion feed back ration and beam backgrounds

Estimate distortion due to the ion disks (simulation)
Options of gating device: Wire gating, GEM gating
Methods of calibration

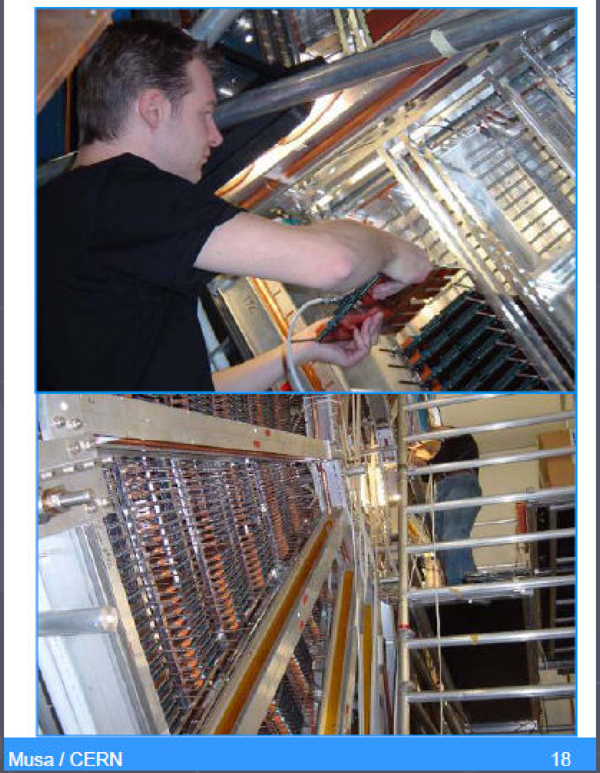
Advanced Endplate: S-ALTRO

High density, low power , low material electronics for TPC



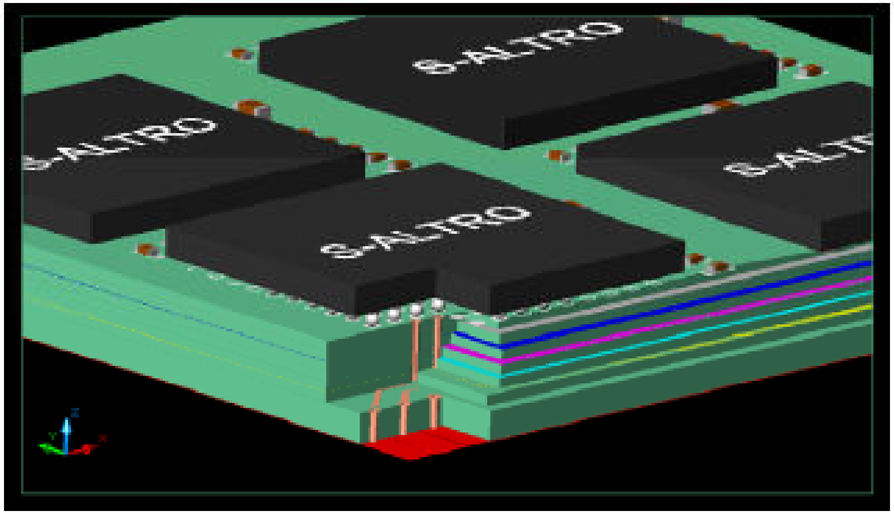
ALICE TPC Electronics

- PC board ~150μm Cu (0.1 X_0)
- 22mW / cm^2 ➡ 220W / m^2
- 0.3mm copper plate (0.2 X_0)



Musa / CERN 18

ALICE TPC



The S-ALTRO team at CERN

P. Aspell, H. Franca Santos, E. Garcia,
A. Junique, M. Mager, C. Patauner,
A. Ur Rehman, L. Musa

ILC (ILD) TPC

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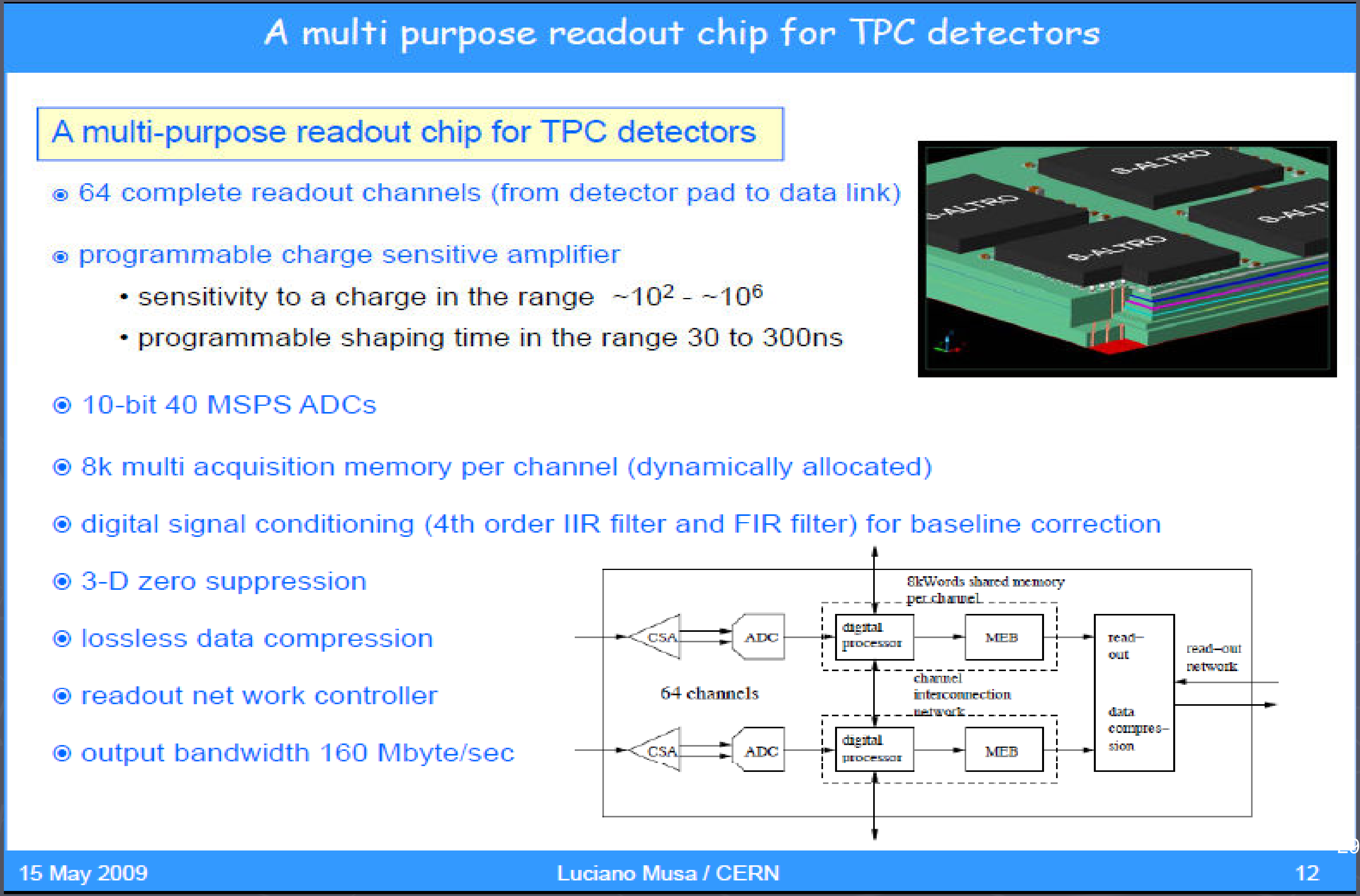
High density, low power electronics for TPC



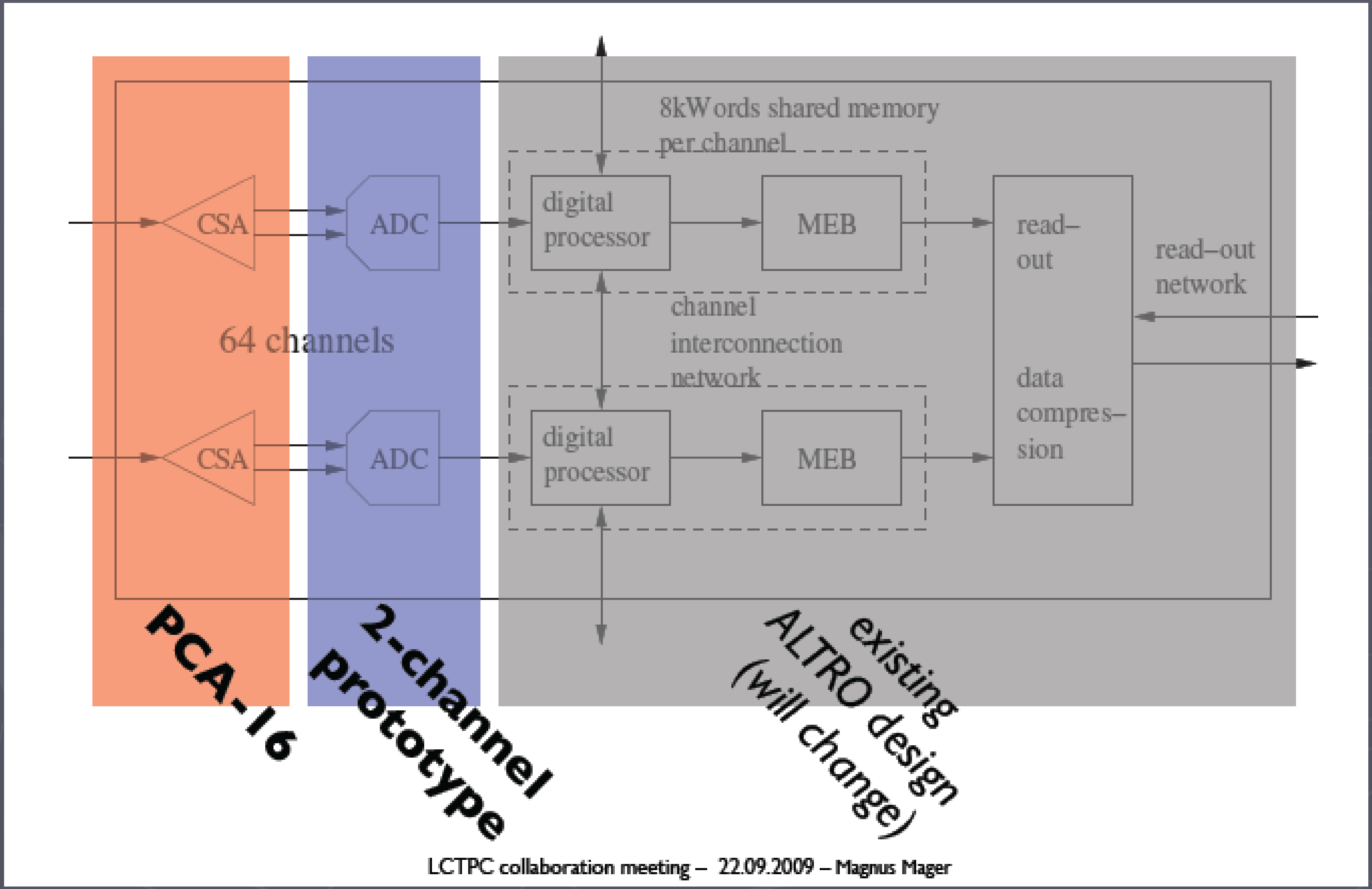
A multi purpose readout chip for TPC detectors

A multi-purpose readout chip for TPC detectors

- 64 complete readout channels (from detector pad to data link)
- programmable charge sensitive amplifier
  - sensitivity to a charge in the range ~10^2 - ~10^6
  - programmable shaping time in the range 30 to 300ns
- 10-bit 40 MSPS ADCs
- 8k multi acquisition memory per channel (dynamically allocated)
- digital signal conditioning (4th order IIR filter and FIR filter) for baseline correction
- 3-D zero suppression
- lossless data compression
- readout net work controller
- output bandwidth 160 Mbyte/sec

Advanced Endplate: S-ALTRO

High density, low power electronics for TPC



LCTPC collaboration meeting – 22.09.2009 – Magnus Mager

Advanced Endplate: S-ALTRO

Chip size and Power consumption

L. Musa

Chip size: (*estimate)

Shaping amplifier	0.2 mm^2	
ADC	0.7 mm^2	(*)
Digital processor	0.6 mm^2	(*)

When 1.5mm^2/channel

64 ch/chip ➡ ~ 100 mm^2

PCB board ~ 27 x 27 cm^2

⇨ ~16400 pads or 256 chips/board

Bare die flip-chip mounted or chip scale package

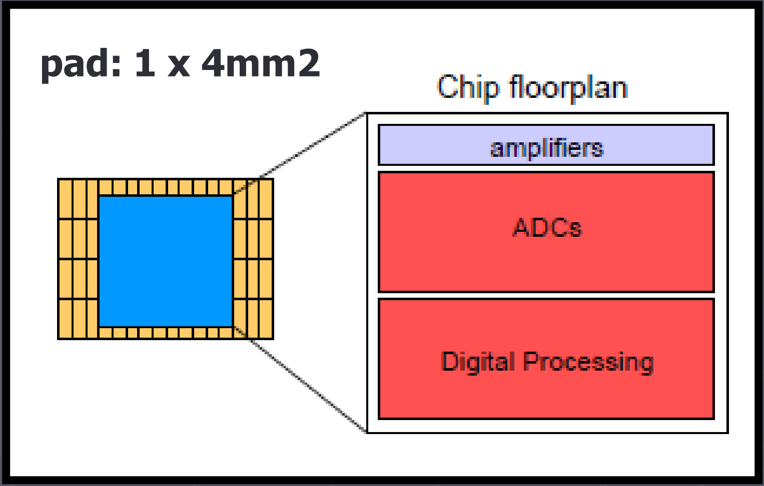
Minimum-size capacitors (0.6x0.3x0.3mm3)

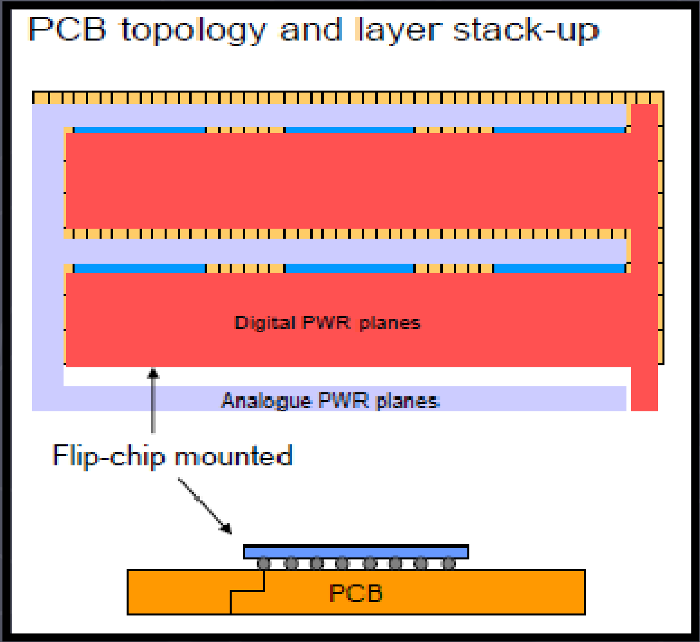
Standard linear voltage regulators

Data link based on ALICE SPD GOL MCM

Power consumption: (*) 10 -40MHz

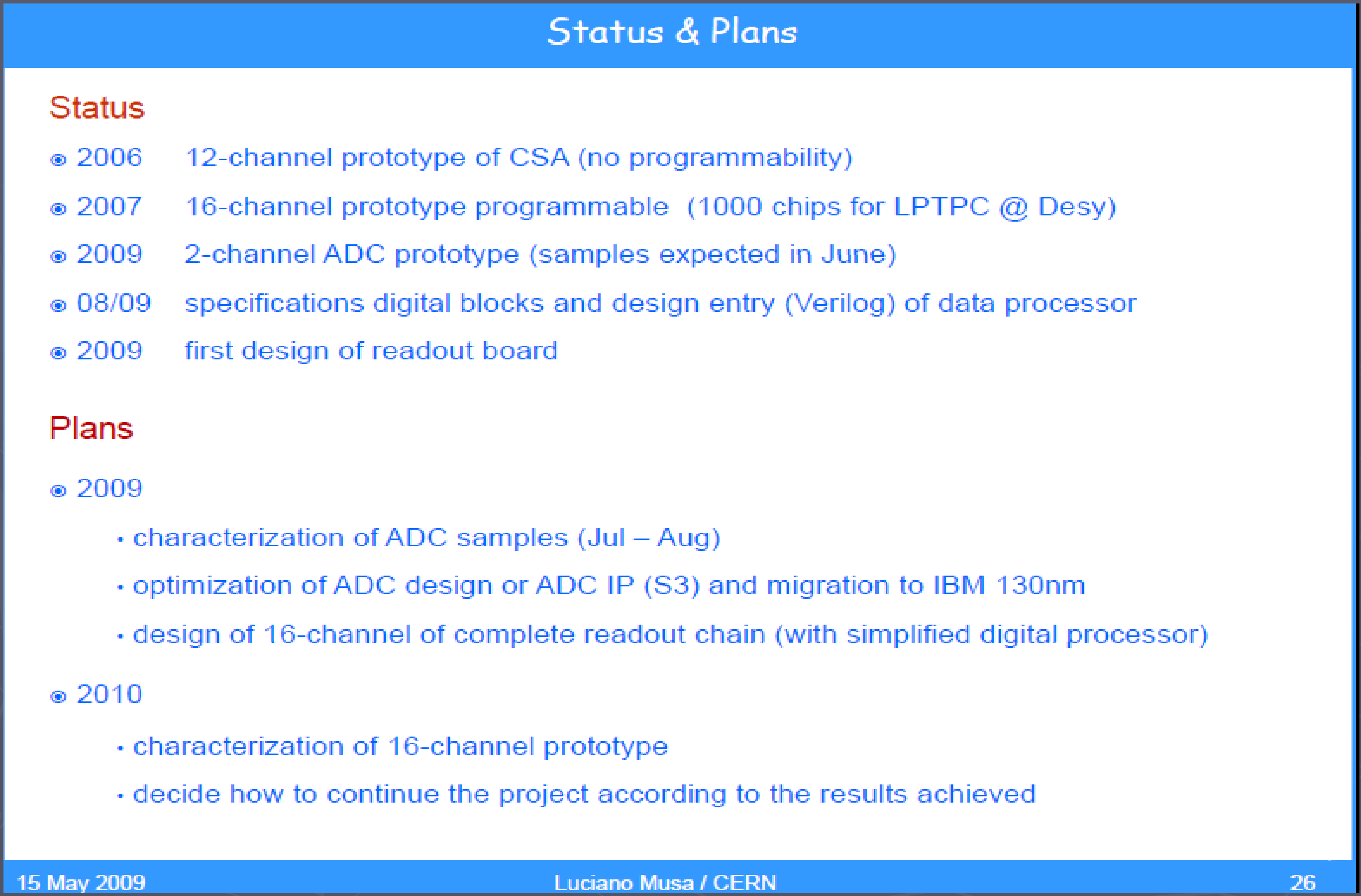
Amplifier	8 mW/channel
ADC	12-34 mW/channel (*)
Digital Proc	4 mW/channel
Power reg.	2 mW/channel
Data links	2 mW/channel
Power reg. eff.	75%
Total	32-60mW/channel (*)
Duty cycle:	1.5% (Electrical duty)
Average power	0.5 mW / channel
	100 -200W/m2 (*)





Advanced Endplate: S-ALTRO

Status and Schedule



Status & Plans

Status

- 2006 12-channel prototype of CSA (no programmability)
- 2007 16-channel prototype programmable (1000 chips for LPTPC @ Desy)
- 2009 2-channel ADC prototype (samples expected in June)
- 08/09 specifications digital blocks and design entry (Verilog) of data processor
- 2009 first design of readout board

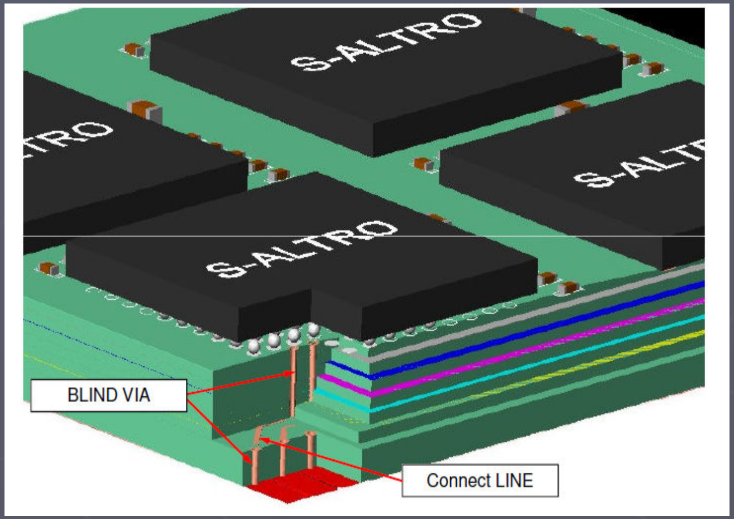
Plans

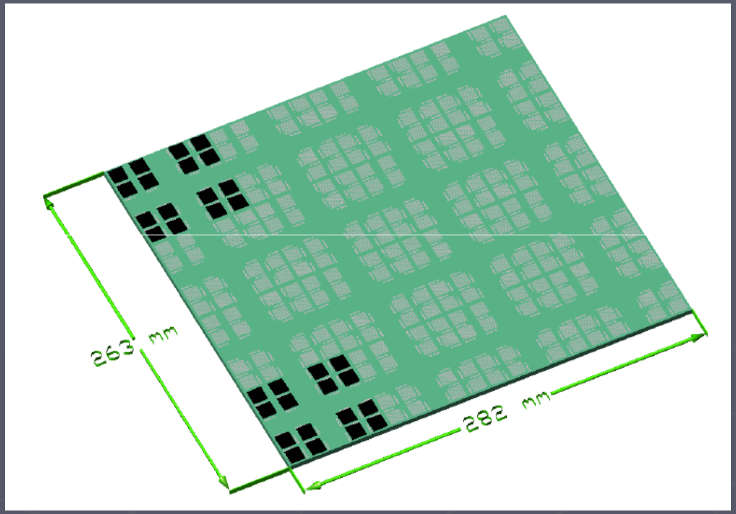
- 2009
  - characterization of ADC samples (Jul – Aug)
  - optimization of ADC design or ADC IP (S3) and migration to IBM 130nm
  - design of 16-channel of complete readout chain (with simplified digital processor)
- 2010
  - characterization of 16-channel prototype
  - decide how to continue the project according to the results achieved

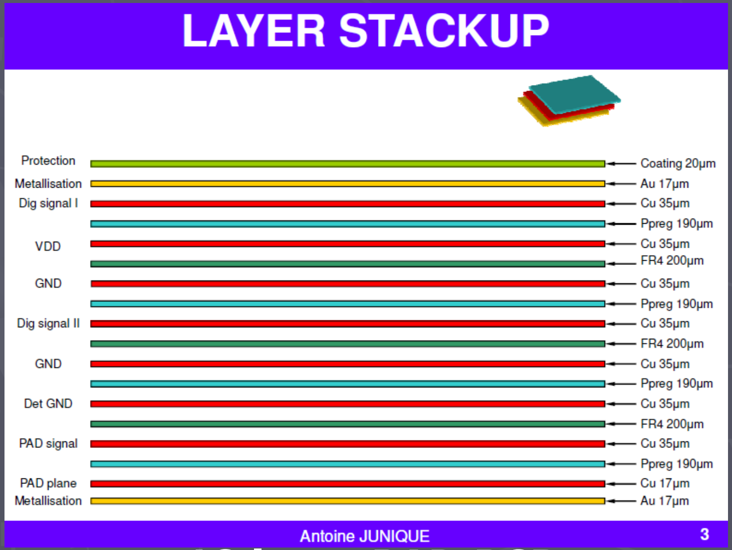
15 May 2009 Luciano Musa / CERN 26

Advanced Endplate: S-ALTRO

Design of Pad Board





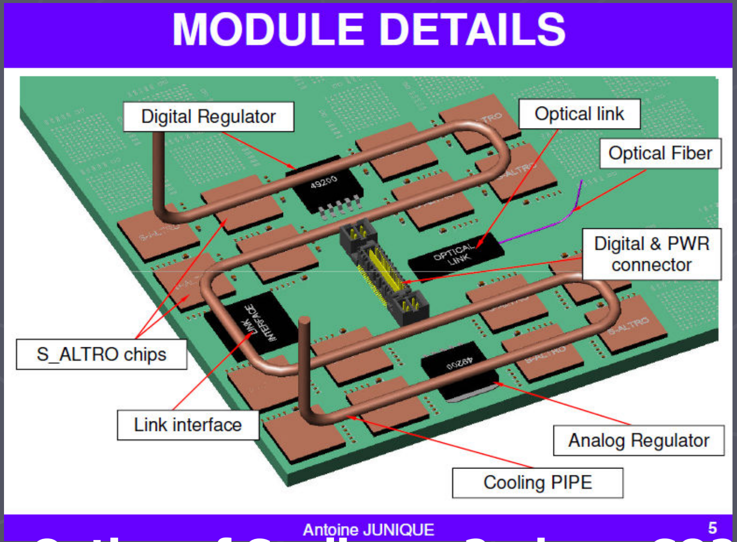


LAYER STACKUP

Protection	Coating 20µm
Metallisation	Au 17µm
Dig signal I	Cu 35µm
	Ppreg 190µm
VDD	Cu 35µm
	FR4 200µm
GND	Cu 35µm
	Ppreg 190µm
Dig signal II	Cu 35µm
	FR4 200µm
GND	Cu 35µm
	Ppreg 190µm
Det GND	Cu 35µm
	FR4 200µm
PAD signal	Cu 35µm
	Ppreg 190µm
PAD plane	Cu 17µm
Metallisation	Au 17µm

Antoine JUNIQUE 3

18 layer PAD PCB



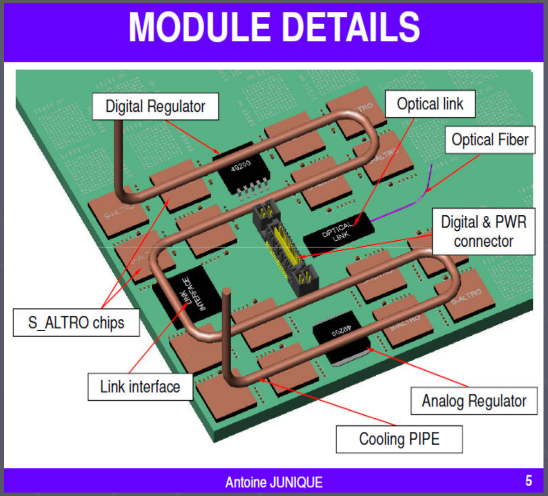
MODULE DETAILS

Antoine JUNIQUE 5

Option of Cooling: 2-phase CO2 cooling/traditional H2O cooling

Advanced Endplate: PCB Test
Test with Dummy Pad PCB

S-ALTRO Team
LC TPC groups



MODULE DETAILS

Antoine JUNIQUE 5

Test:

- Power switching
- Power delivery
- Cooling:
- Thermo-mechanical test of pad PCB

Dummy Pad PCB:

- Realistic design of pad PCB with all components
- 64ch S-ALTROs replaced by proper FPGAs and OP amp/ADC as current load and heat source.
- Connect pads to the FPGA analog outputs
- Try cooling by the 2-phase CO2 cooling (AMS and LHCB: Bart Verlaat/Nikhef)
- Test also digital software model/communication in FPGA
- Test in high magnetic field

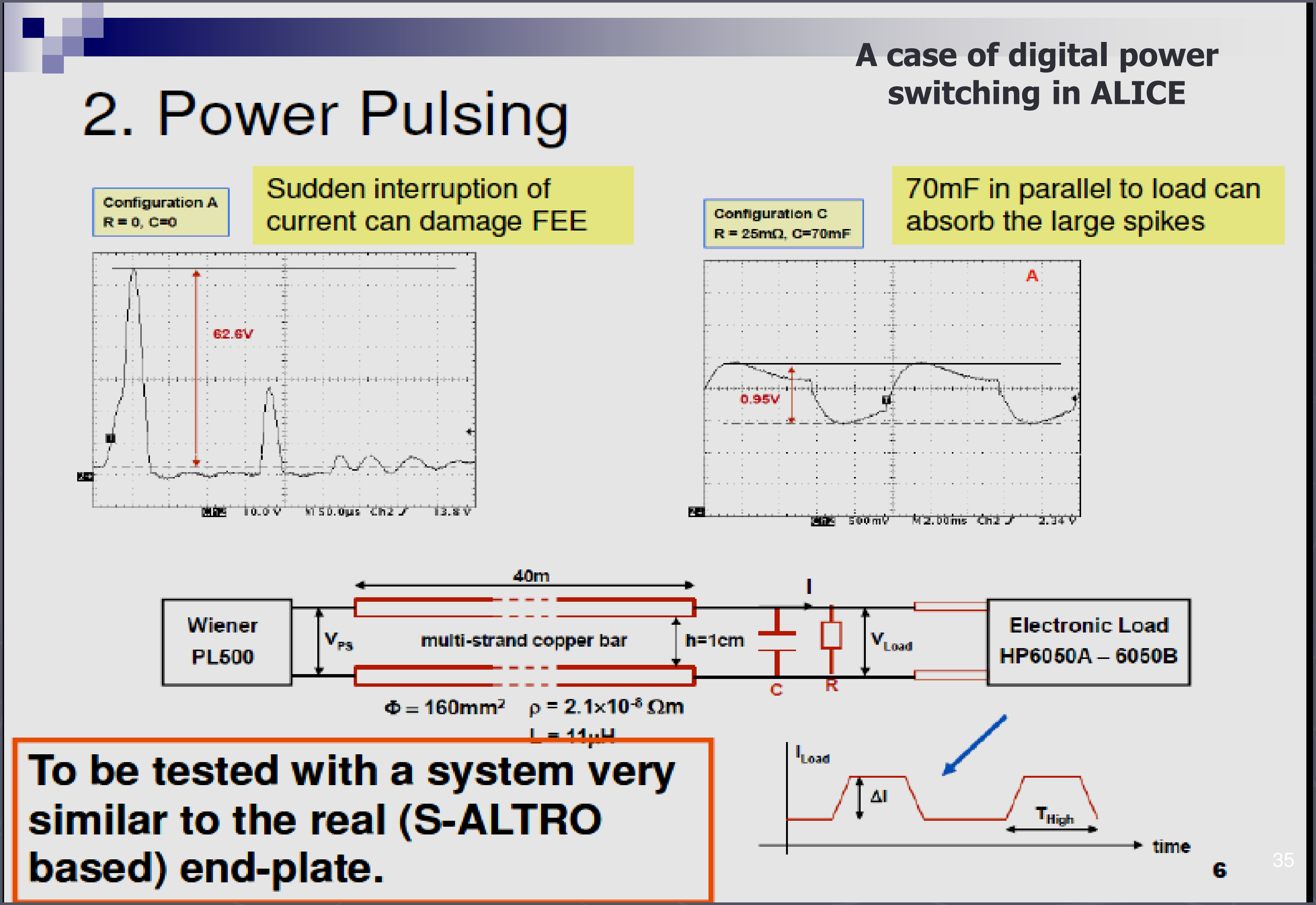
Schedule: 2010

Advanced Endplate: S-ALTRO

Power switching

L. Mussa
T. Fusayasu

A case of digital power switching in ALICE



2. Power Pulsing

Configuration A
R = 0, C=0

Sudden interruption of current can damage FEE

Configuration C
R = 25mΩ, C=70mF

70mF in parallel to load can absorb the large spikes

$\Phi = 160\,\text{mm}^2$ $\rho = 2.1\times10^{-8}\ \Omega\text{m}$

$L = 11\,\mu\text{H}$

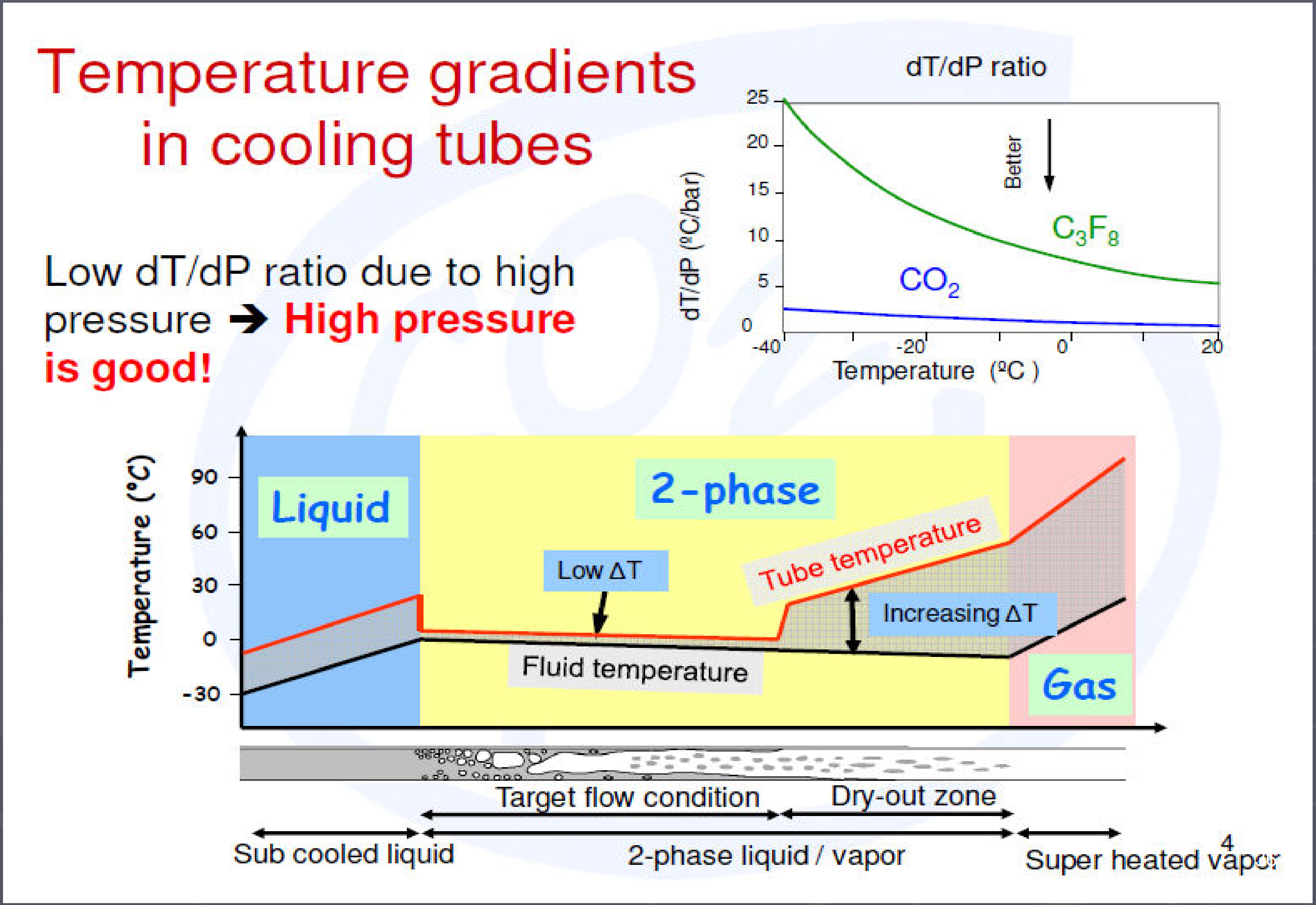
To be tested with a system very similar to the real (S-ALTRO based) end-plate.

6

Advanced Endplate: Cooling

The option of the 2-phase CO2 cooling

Bart Verlaat/Nikhef



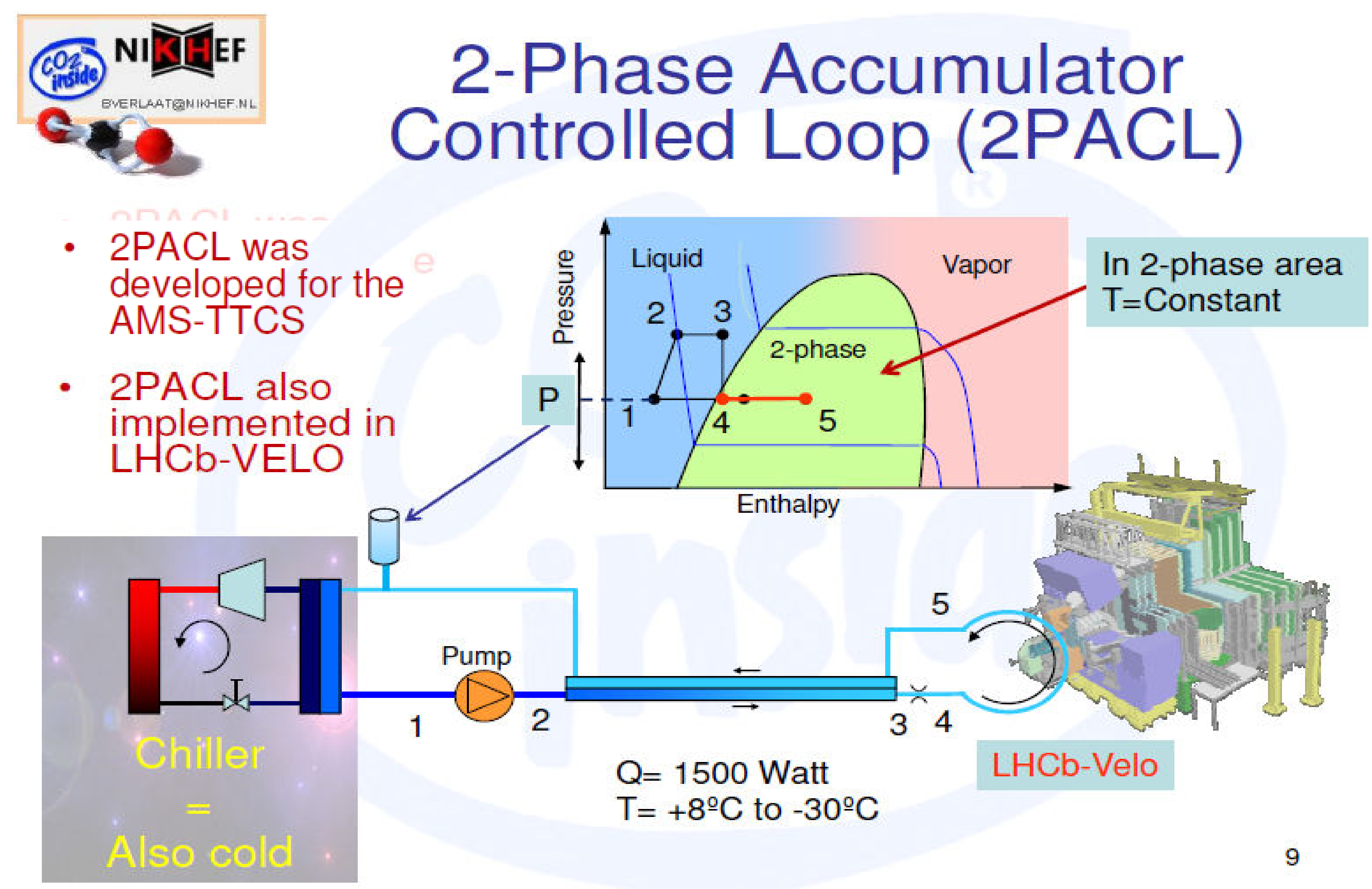
Temperature gradients in cooling tubes

Low dT/dP ratio due to high pressure ➔ **High pressure is good!**

Bart Verlaat/Nikhef

Advanced Endplate: Cooling

Option of the 2-phase CO2 cooling



2-Phase Accumulator Controlled Loop (2PACL)

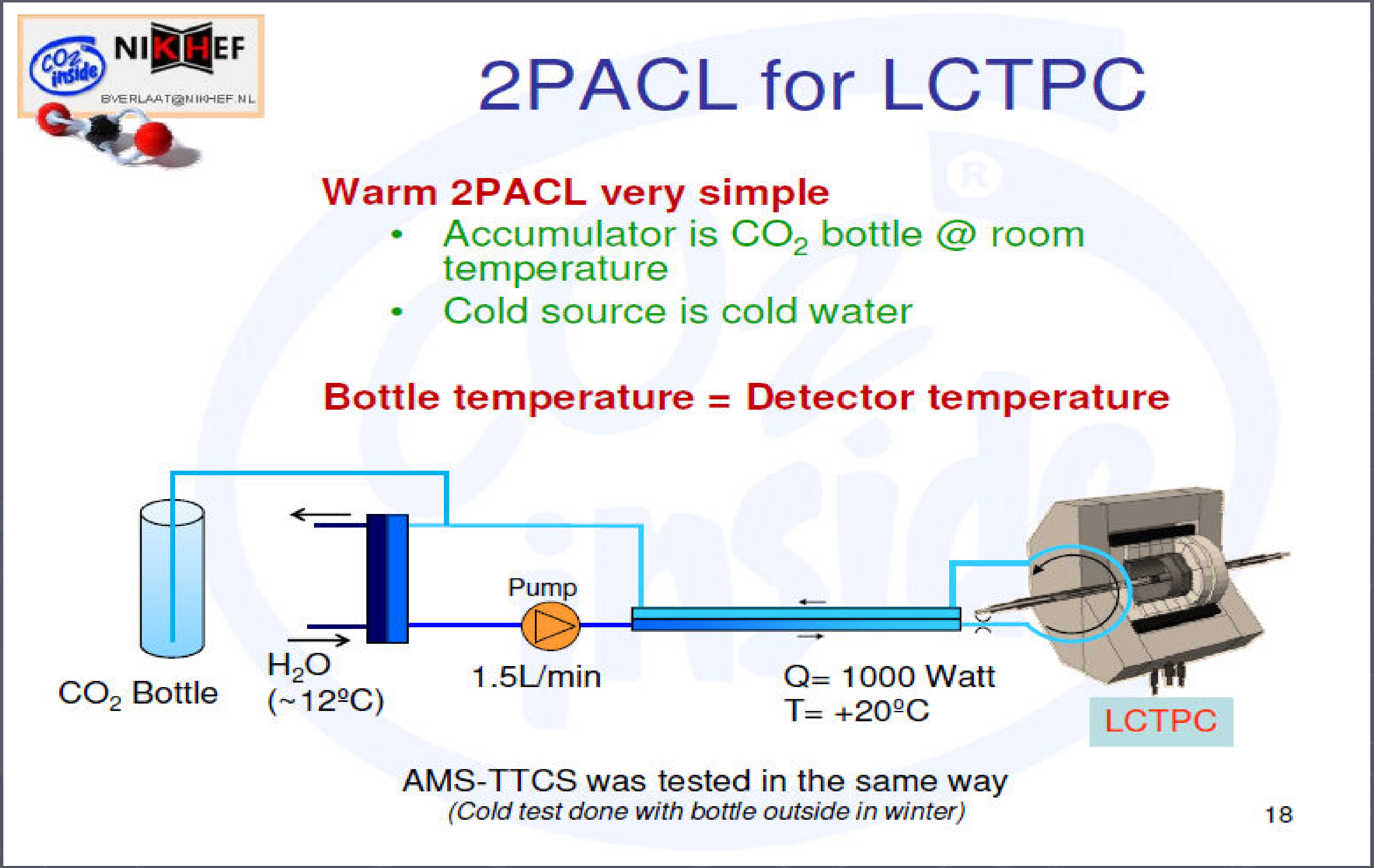
- 2PACL was developed for the AMS-TTCS
- 2PACL also implemented in LHCb-VELO

In 2-phase area
T=Constant

Q= 1500 Watt
T= +8ºC to -30ºC

Advanced Endplate: Cooling

Option of the 2-phase CO2 cooling



BVERLAAT@NIKHEF.NL

2PACL for LCTPC

Warm 2PACL very simple

- Accumulator is CO_2 bottle @ room temperature
- Cold source is cold water

Bottle temperature = Detector temperature

AMS-TTCS was tested in the same way

(Cold test done with bottle outside in winter)

18

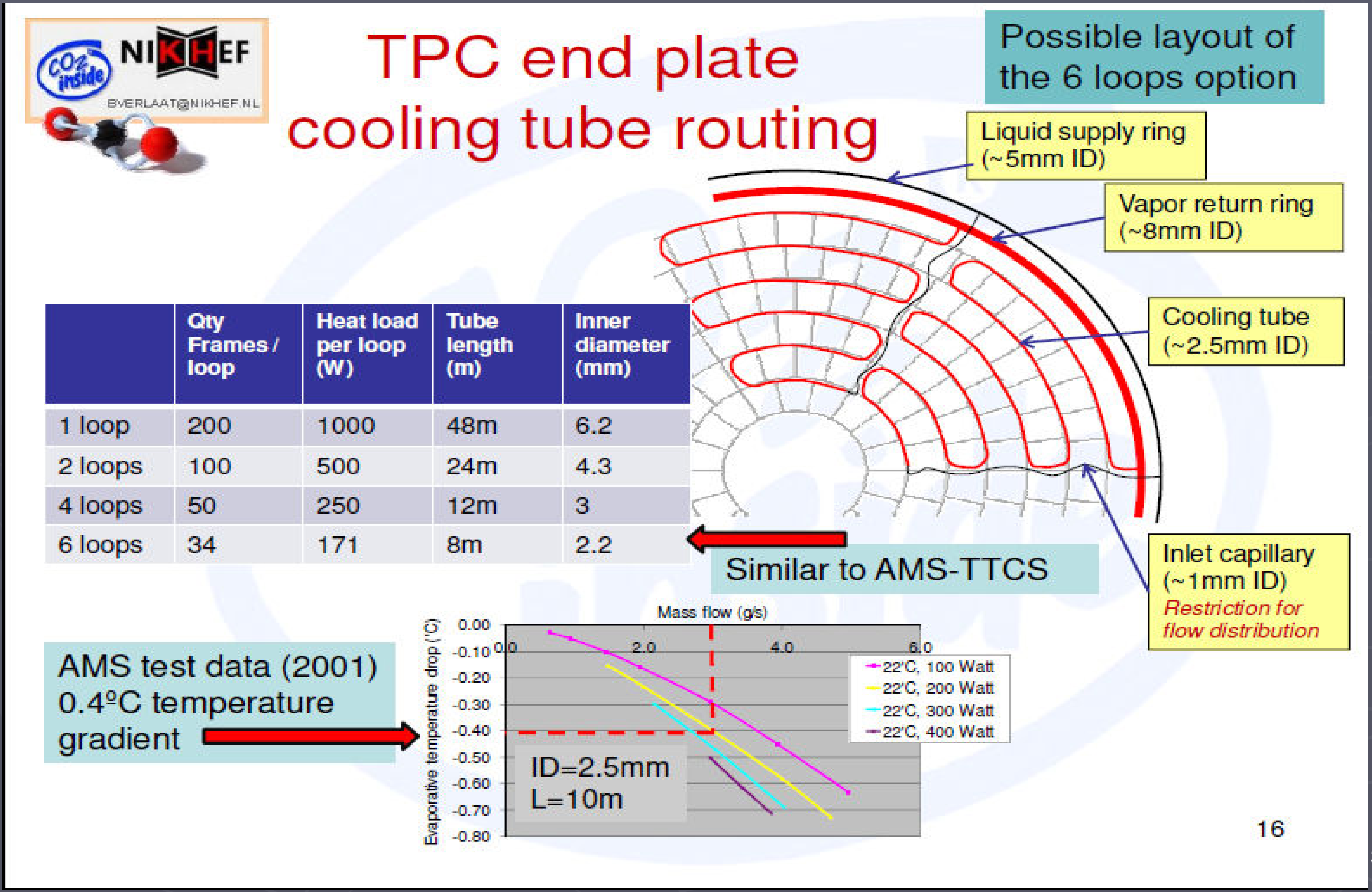
Applied to AMS and LHCb

Bart Verlaat/Nikhef

Advanced Endplate: Cooling

Preliminary Design Consideration for ILC TPC

Advantage of thin piping (high pressure)



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TPC end plate cooling tube routing

Possible layout of the 6 loops option

Liquid supply ring (~5mm ID)

Vapor return ring (~8mm ID)

Cooling tube (~2.5mm ID)

Inlet capillary (~1mm ID)

Restriction for flow distribution

	Qty Frames / loop	Heat load per loop (W)	Tube length (m)	Inner diameter (mm)
1 loop	200	1000	48m	6.2
2 loops	100	500	24m	4.3
4 loops	50	250	12m	3
6 loops	34	171	8m	2.2

Similar to AMS-TTCS

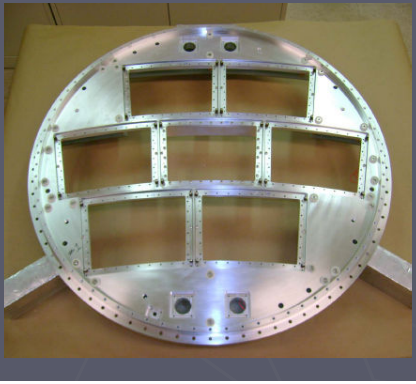
AMS test data (2001) 0.4°C temperature gradient

ID=2.5mm
L=10m

16

D. Peterson/Cornell

Advanced Endplate
Thinning Endplate Structure

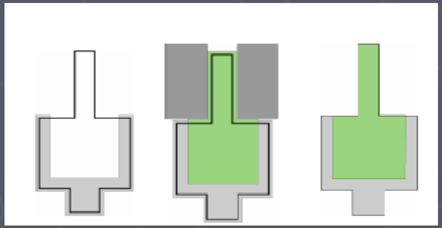


Current LP endplate: Al

Effective thickness:
Bare endplate: 1.4cmt Al (average)
Loaded with modules: 2.6cmt Al equiv.
(29% Xo)

Next LP endplate:

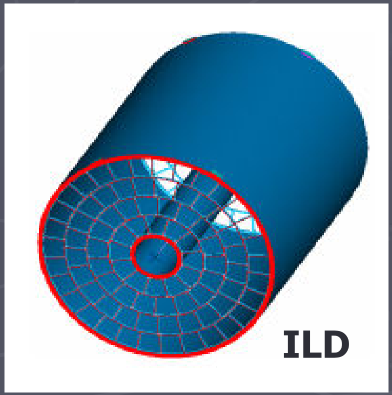
Thinning the outer support area
Hybrid composite/aluminum on the mullions
→ already 15% Xo from 29% Xo



Next LP endplate:
Gray: AL & Green: fiber glass

Study more advanced designs for ILC:

Composite (JWST primary mirrors)
A rigid bonded structure attached to a relatively thin gas-seal and module support structure
Space-frame of adjustable struts, etc



Ions Feedback and Ion Disks

The ion feedback ratios

0.2-0.3% for MicroMEGAS and for a certain triple GEM configuration.

When MPGD gas gain < 1,000, the average density of feed back ions in the drift region is same to that of primary ions.

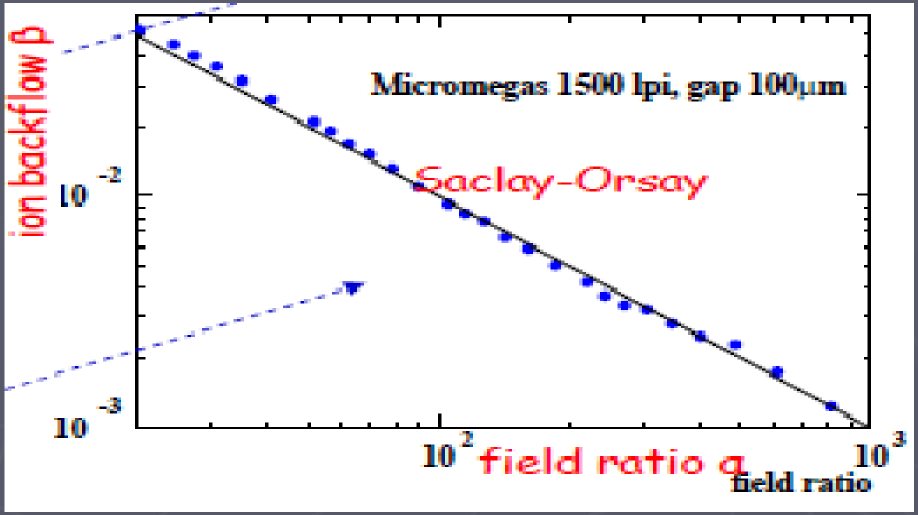
Ion disks:

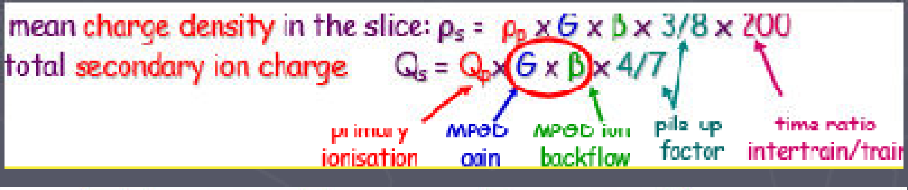
Note that the density in ion disks higher by a factor of ~ 200.

Urgently need to estimate the level of track distortion due to the disks by a full simulation for different background consitions

(Thorsten Krautscheid/Bonn)

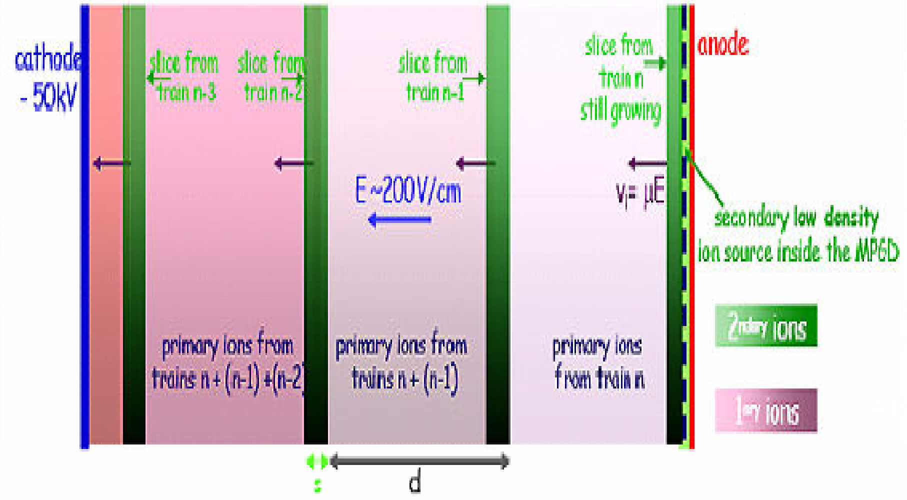
Still to complete Marlin TPC!





mean charge density in the slice: $\rho_s = \rho_p \times G \times \beta \times 3/8 \times 200$

total secondary ion charge $Q_s = Q_p \times \boxed{G \times \beta} \times 4/7$



Ion Feedback: Gating Device

Gating GEM (By Asian LC TPC group)

Stop ions at the level of 10-4 only by the gating GEM.

Transmission of primary electrons by special thin (14µmt) gating GEM:
50% or less by simulation and measurements.
Neff then becomes one half (20 → 10 for GEM, 30 → 15 for MicroMEGAS)
deteriorating position resolution at large drift distances.

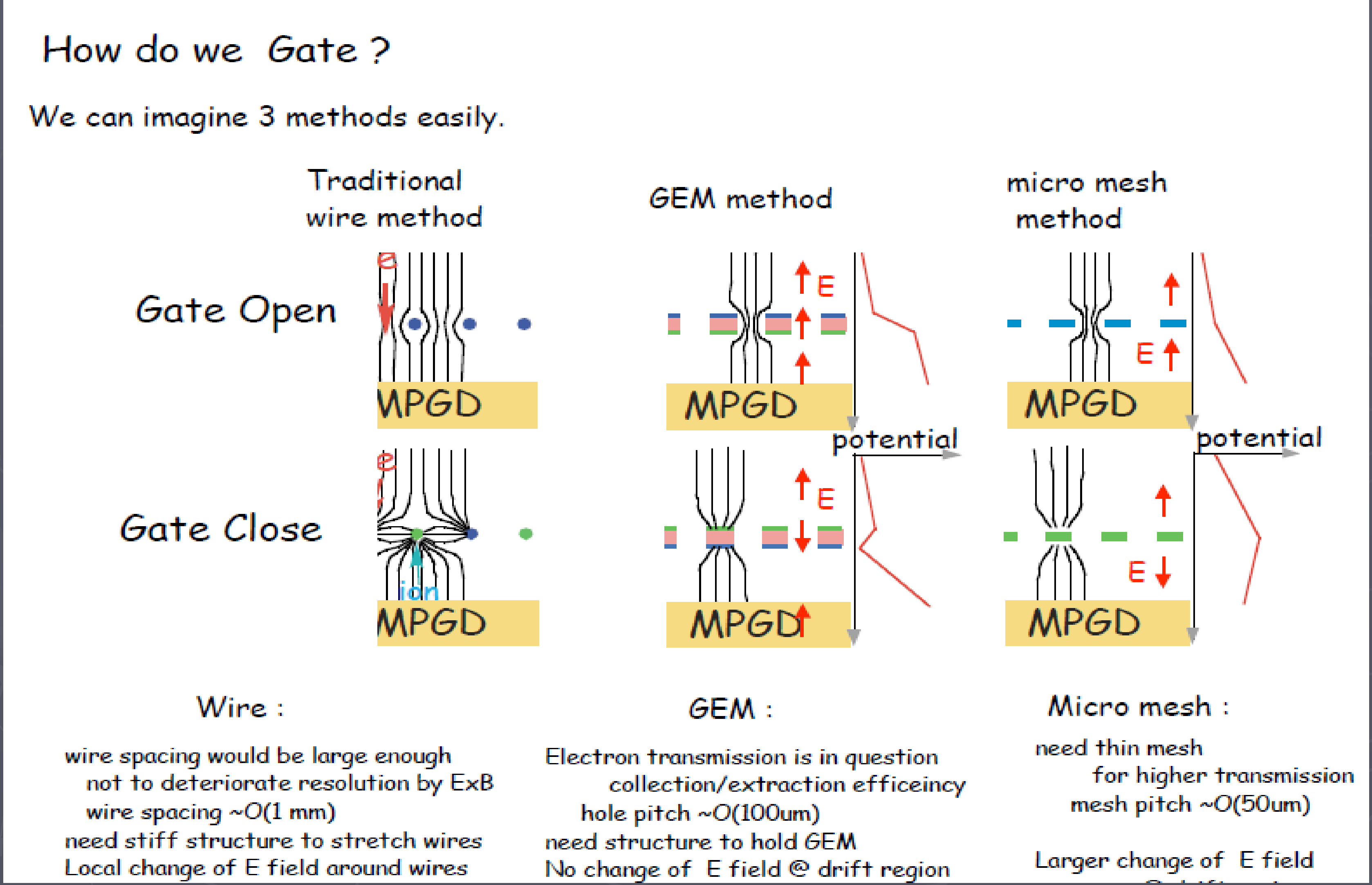
Gating wire plane

Well established method.
100% ion stopping and closed to 100% electron transmission.

Introduce mechanical complication MPGD detector modules.
Need design study, in particular, on the impact to material budget/dead space.

A. Sugiyama

Ion Feedback: Gating



How do we Gate ?

We can imagine 3 methods easily.

Traditional wire method

GEM method

micro mesh method

Gate Open

Gate Close

Wire :

wire spacing would be large enough
not to deteriorate resolution by ExB
wire spacing ~O(1 mm)
need stiff structure to stretch wires
Local change of E field around wires

GEM :

Electron transmission is in question
collection/extraction efficeincy
hole pitch ~O(100um)
need structure to hold GEM
No change of E field @ drift region

Micro mesh :

need thin mesh
for higher transmission
mesh pitch ~O(50um)

Larger change of E field

Conclusions

MPGD TPC options at ILC (ILD) TPC provide a large number of space points (200) with the excellent point resolution down to 100microns over 2m drift distance. It is a truly-visual 3D tracker works in high magnetic filed providing the performance necessary for the experimentation at ILC.

The TPC Large Prototype test at DESY (LP1) by LC TPC collaboration using the EUDET facility is being carried out successfully since November 2008.

We look forward to performing momentum measurement in non uniform magnetic field of PCMAG with full length tracks in the multi modules setup in 2010.

From 2011 we plan to perform beam test with a high energy hadron beam.

There are important engineering issues to realize MPGD TPC for ILC (ILD): R&D for the advanced endplate and R&Ds for ion feed back/gating devices.