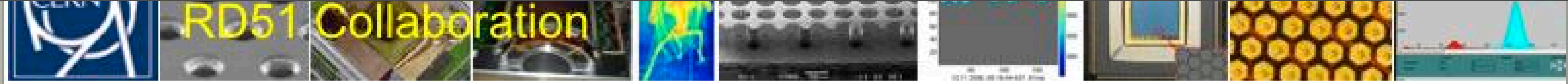
RD-51 Collaboration Meeting

April 13-15, 2011 CERN

https://indico.cern.ch/conferenceTimeTable.py?confId=132080#all.detailed

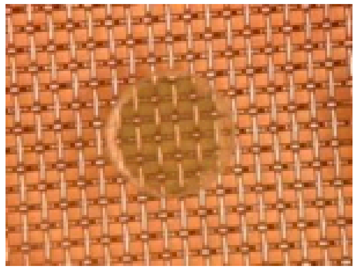


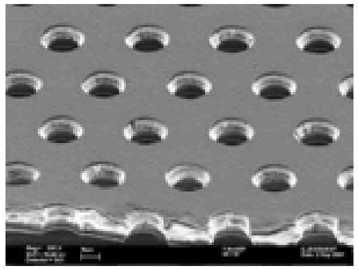
RD51 Collaboration
Development of Micro-Pattern Gas Detectors Technologies

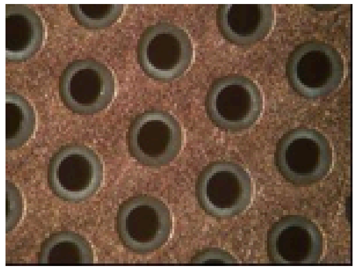
The proposed R&D collaboration, RD51, aims at facilitating the development of advanced gas-avalanche detector technologies and associated electronic-readout systems, for applications in basic and applied research. **The main objective of the R&D programme is to advance technological development and application of Micropattern Gas Detectors.**

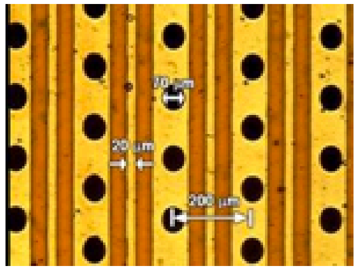
The invention of Micro-Pattern Gas Detectors (MPGD), in particular the Gas Electron Multiplier (GEM), the Micro-Mesh Gaseous Structure (Micromegas), and more recently other micro pattern detector schemes, offers the potential to develop new gaseous detectors with unprecedented spatial resolution, high rate capability, large sensitive area, operational stability and radiation hardness. In some applications, requiring very large-area coverage with moderate spatial resolutions, more coarse Macro-patterned detectors, e.g. Thick-GEMs (THGEM) or patterned resistive-plate devices could offer an interesting and economic solution. The design of the new micro-pattern devices appears suitable for industrial production. In addition, the availability of highly integrated amplification and readout electronics allows for the design of gas-detector systems with channel densities comparable to that of modern silicon detectors. Modern wafer post-processing allows for the integration of gas-amplification structures directly on top of a pixelized readout chip. Thanks to these recent developments, particle detection through the *ionization of gas* has large fields of application in future particle, nuclear and astro-particle physics experiments with and without accelerators.

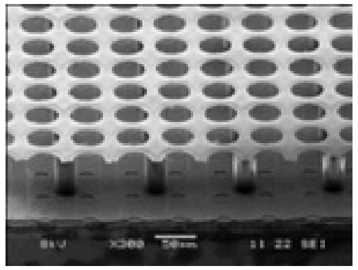
The RD51 collaboration involves ~ 430 authors, 73 Universities and Research Laboratories from 25 countries in Europe, America, Asia and Africa. All partners are already actively pursuing either basic- or application-oriented R&D involving a variety of MPGD concepts. The collaboration established common goals, like experimental and simulation tools, characterization concepts and methods, common infrastructures at test beams and irradiation facilities, and methods and infrastructures for MPGD production.


Micromegas


GEM


THGEM


MHSP


Ingrid

RD51

Co-Spokesmen: Leszek Ropelewski from CERN and
Maxim Titov from CEA Saclay

450 members from 75 institutions

Working groups

- WG1: Technological Aspects and Development of New detector Structures
- WG2: Common Characterization and Physics Issues
- WG3: Applications
- WG4: Simulations and Software Tools
- WG5: MPGD Related Electronics
- WG6: Production
- WG7: Common Test Facilities

details on the RD51 working groups

- WG1: large area Micromegas, GEM; THGEM R&D; MM resistive anode readout (discharge protection); design and detector assembly optimization; large area readout electrodes and electronics interface

- WG2: double phase operation, radiation tolerance, discharge protection, rate effects, single- electron response, avalanche fluctuations, photo detection with THGEM and GridPix

- WG3: applications beyond HEP, industrial applications (X-ray diffraction, homeland security)

- WG4: development of the software tools; microtracking; neBEM field solver, electroluminescence simulation tool, Penning transfers, GEM charging up; MM transparency and signal, MM discharges

- WG5: scalable readout system; Timepix multi-chip MPGD readout

- WG6: CERN MPGD Production Facility; industrialisation; TT Network

- WG7: RD51 test beam facility

- introductory talk by Craig
- medical examples, see next slides

- parallel sessions:
- Simulations software, just the speakers attended, work on getting Garfield++ into Geant4, low energy ionization of noble gases, cross sections ...

Garfield++

Status Update

RD51 Collaboration Meeting WG4
13 April 2011

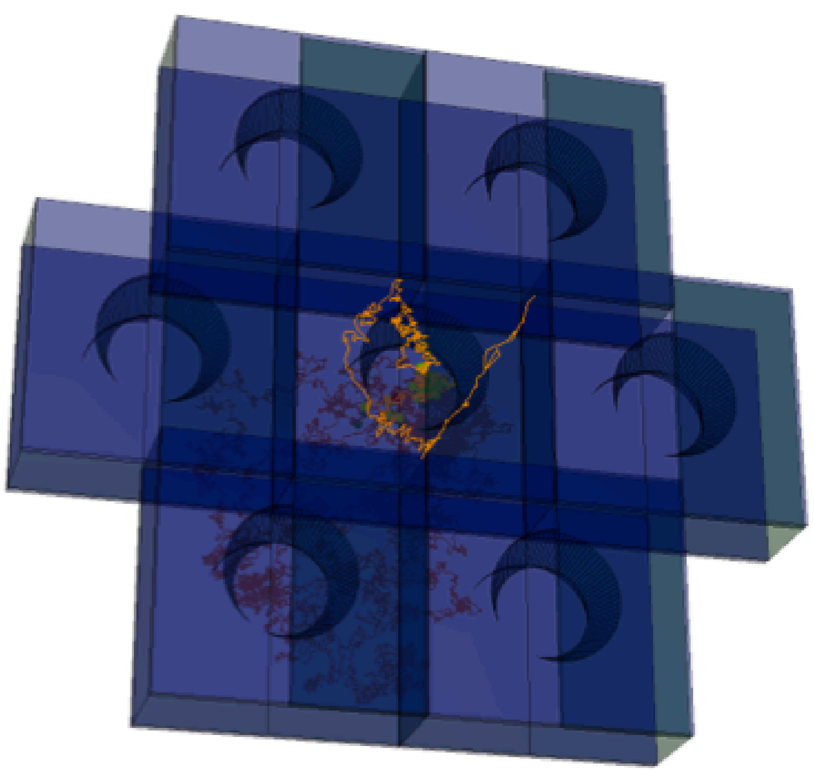
Garfield++

Overview

- Concept:
  - (partial) reimplementation of Garfield functionality in C++, with focus on modern detector technologies
  - provide collection of classes to be used as building blocks for a detector simulation program
  - facilitate combination with other packages (e. g. Root, G4)
- Installation instructions and basic examples are available on a webpage (`http://cern.ch/garfieldpp`).

Microscopic Tracking
Magnetic Fields

- stepping algorithm extended to allow for B fields
- example application: transparency of a gating GEM



electron spiralling into GEM hole

- $B = 4$ T, collinear with E
- T2K gas

CERN workshop upgrade
Aida fund
Transfer to industry

Rui De Oliveira

http://aida.web.cern.ch/aida/index.html

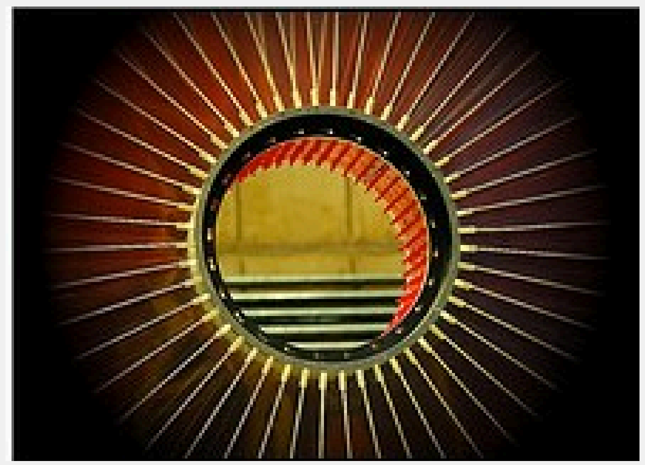
AIDA

Advanced European Infrastructures for Detectors at Accelerators

HOME | ABOUT AIDA | NEWS | EVENTS | NETWORKS | TRANSNATIONAL ACCESS | RESEARCH | RESULTS

Advancing European detector development

The AIDA project addresses infrastructures required for detector development for future particle physics experiments. In line with the European strategy for particle physics, AIDA targets user communities preparing experiments at a number of key potential future accelerators: SLHC (luminosity-upgraded LHC), future Linear Colliders (ILC and CLIC), future accelerator-driven neutrino facilities or future B-physics facilities (e.g. Super-B).



DESY wire chamber, courtesy of Interactions

The infrastructures covered by the AIDA project are key facilities required for an efficient development of the future experiments, such as: test beam infrastructures (at CERN and DESY), specialised equipment irradiation facilities (in several European countries), common software tools, common microelectronics tools and engineering coordination offices. The project, coordinated by CERN, involves more than 80 institutes and laboratories from 23 countries as beneficiaries or associate partners. *Read more >>*

European funding to access test facilities

European researchers from outside the AIDA project can benefit from dedicated Transnational Access funding to access AIDA test beams and irradiation facilities. *Read more >>*

ACTIVITIES

Common software tools

Microelectronics

Relations with industry

Transnational access to test beams and irradiation facilities

Irradiation and beam line R&D

Detector infrastructures R&D

LATEST NEWS

11 Apr'11 Deliverable report D1.1 is now available

4 Apr'11 AIDA Transnational Access featured in CERN Courier

UPCOMING EVENTS

10-12 May: 2011 IEEE International Instrumentation and Measurement Technology Conference

FOR PROJECT MEMBERS

FAQs

Intranet

AIDA is co-funded by the European Commission within Framework Programme 7 Capacities, Grant Agreement 262025. Design based on Ezekiel | Webmaster Kate Kahle | Glossary | Search | Sitemap | Contact us

WG6: TE/MPE/EM Workshop upgrade

- Last year, agreement was reached with CERN management to purchase the subset of machines necessary to carry out R&D on large size GEM (2m x 0.5 m) & Micromegas (2m x 1m) and the associated large size read-out boards in the current CERN TE/MPE/ME facility.

GEM	market survey	call for tender	order	received	ready
– 1 continuous polyimide etcher	x	x	x	x	06/2011
– 1 Cu electroetch line	x	x	x		06/2011
• Micromegas					
– 1 large laminator		x	x	x	06/2011
– 1 large Cu etcher		x			09/2011
– 1 large UV exposure unit	x	x	x	x	06/2011
– 1 large resist developer	x				09/2011
– 1 large resist stripper		x			09/2011
– 1 large oven	x	x	x	x	06/2011
– 1 large dryer	x	x	x	x	06/2011

- UV exposure unit limited to 2m x 0.6m → 2.2m x 1.4m

- Resist developer limited to 0.6m width → 1.2m
- Resist stripper “
- Copper etcher “
- Dryer “

- GEM resist stripping limited to 1m → 2m
- GEM electro etch “

- GEM polyimide etch limited to 1m → 2m

- Ovens limited to 1.5m x 0.6m → 2.2m x 1.4m

- Laminator limited to 0.6m width → 1.2m


RISTON
DU PONT
DU PONT


RISTON
RISTON

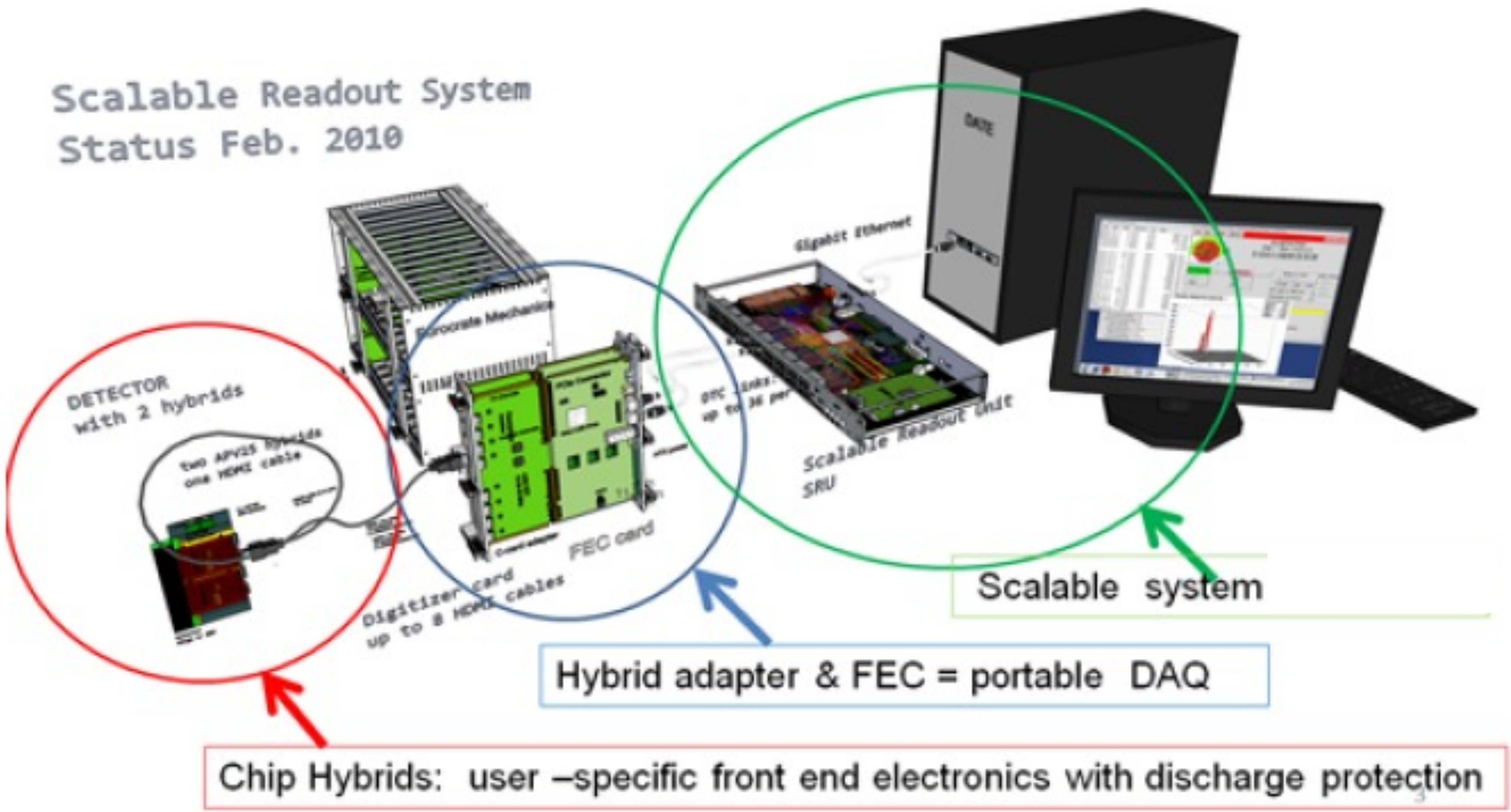

CONDUCTRON DP

SRS of RD51

- Scalable Readout System
- Compact and powerful signal sampling DAQ hardware
- Use of on-Detector PA (APVs)
- Front End Card (FEC) as hub and logic handler (including Trigger facilities) based on FPGA
- Data communication on Giga bit Ethernet (different protocols)
  - 1-Giga Ethernet card needed in the PC only !

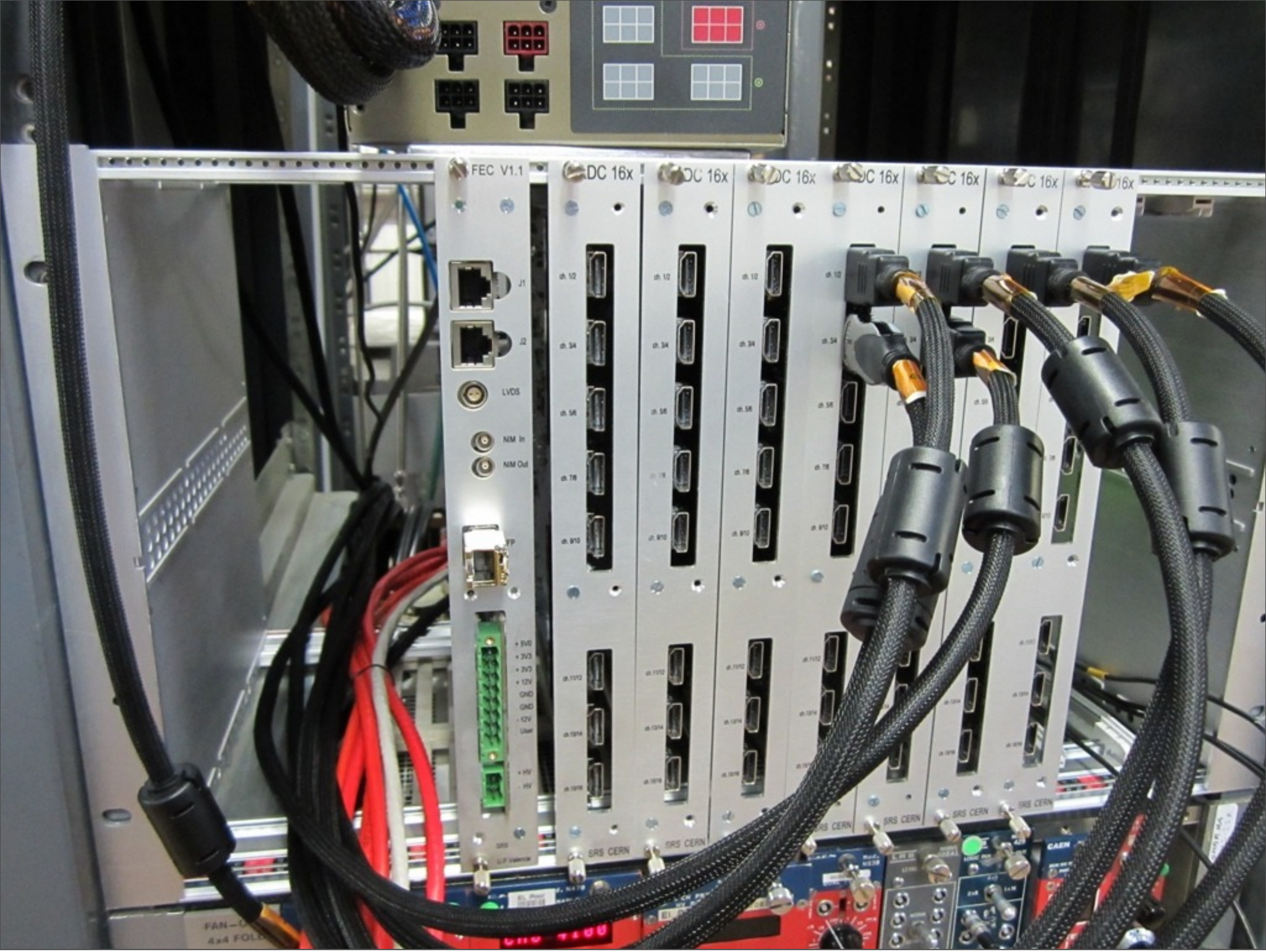
DAQ Software must receive data via UDP protocol

physical overview SRS of RD51



SRS in April 2011

- 1^{st} medium-sized SRS systems deployed (FIT)
- 1^{st} SRS in LHC cavern taking data (MAMMA-Atlas)
- 1^{st} SRU readout backend under test (EMCal-Alice)
- 1^{st} experience with small SRS system (HIP, WIS &Univ.Aveiro,Coimbra)
- 1^{st} APV hybrid micro-via technology in production (ELTOS & HYBRID-SA)
- 14 new SRS systems in production (RD51 CERN)
- 2^{nd} SRS hybrid with Beetle chip under design (WIS)
- New compact Mini-crate 2K channels (RD51 CERN)
- Scalable Detector Controls (SDC) via Ethernet (NTU Athens, RD51 CERN)
- DATE Online (32/64 bit, SLC5) over Network switch (Alice DATE)
- Online Zero-suppression & Feature extraction started (INFN Napoli)
- Commercialization of SRS ongoing (CERN TTN)


FEC V1.1
J1
J2
LVDS
NIM In
NIM Out
SRS CERN

Timepix readout

A readout system for a pixelated TPC

Michael Lupberger

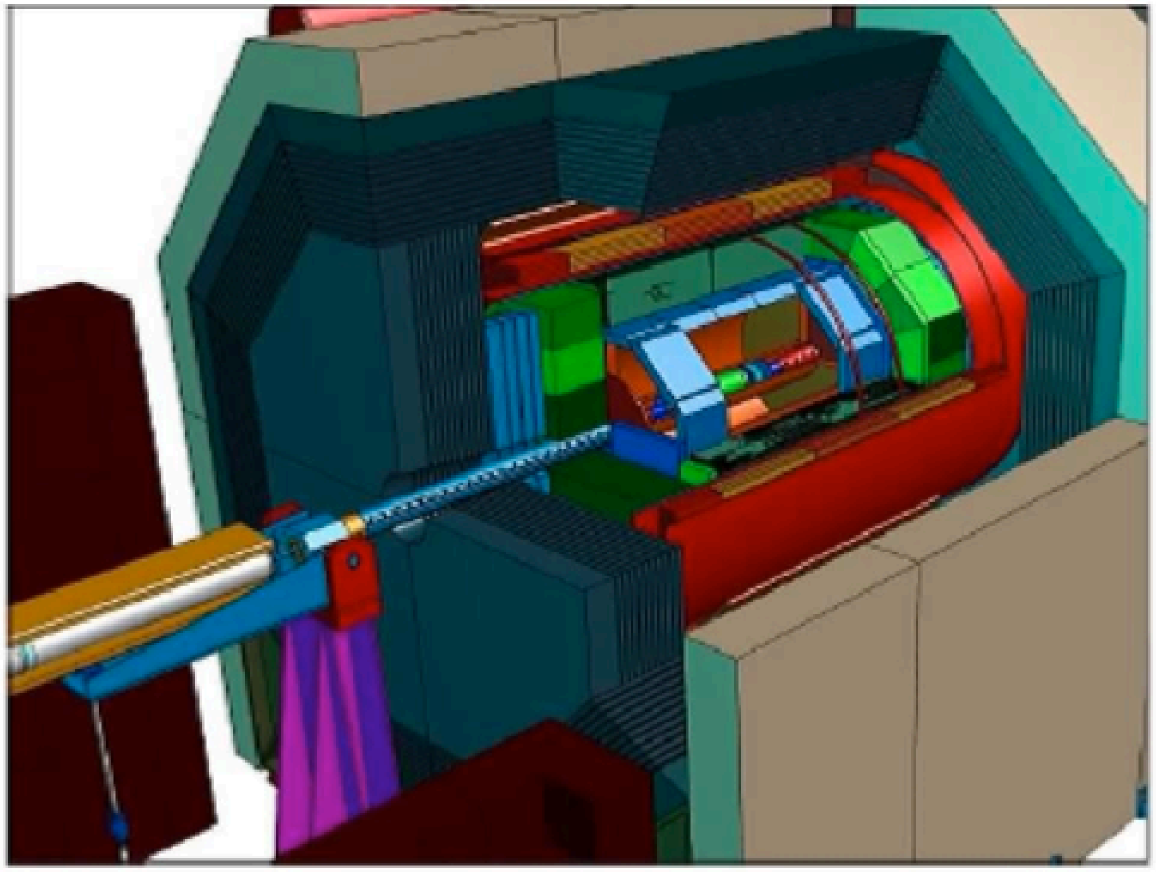
University of Bonn

RD51 7th annual meeting, 13th - 15th of April 2011 CERN

ILD

- International Linear Detector
  - constrains on momentum resolution: $\sigma_{1/p} \sim 5 \times 10^{-5}$/GeV/c
- Use Time Projection Chamber (TPC) as central tracker

Size	$ø = 4.1$ m $L = 4{,}6$ m
Momentum res	$\delta(1/p_t) \sim 10^{-4}$/GeV/c
σ_{point} in $r\Phi$	~100 µm
σ_{point} in rz	~ 0,5 mm
dE/dx res	< 4,5 %



- For high point resolution
  → use micro pattern gaseous detectors

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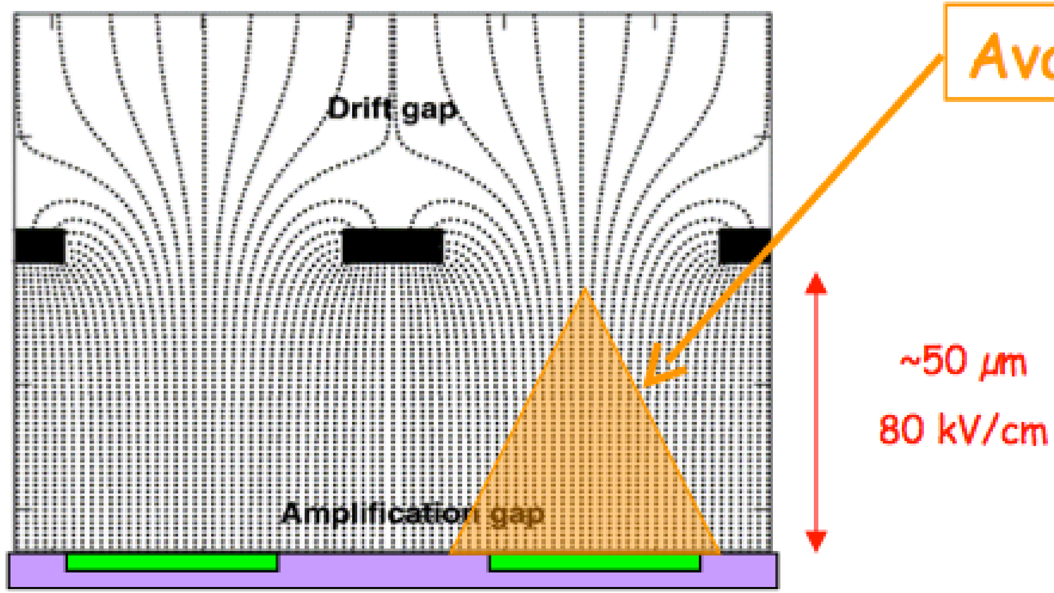
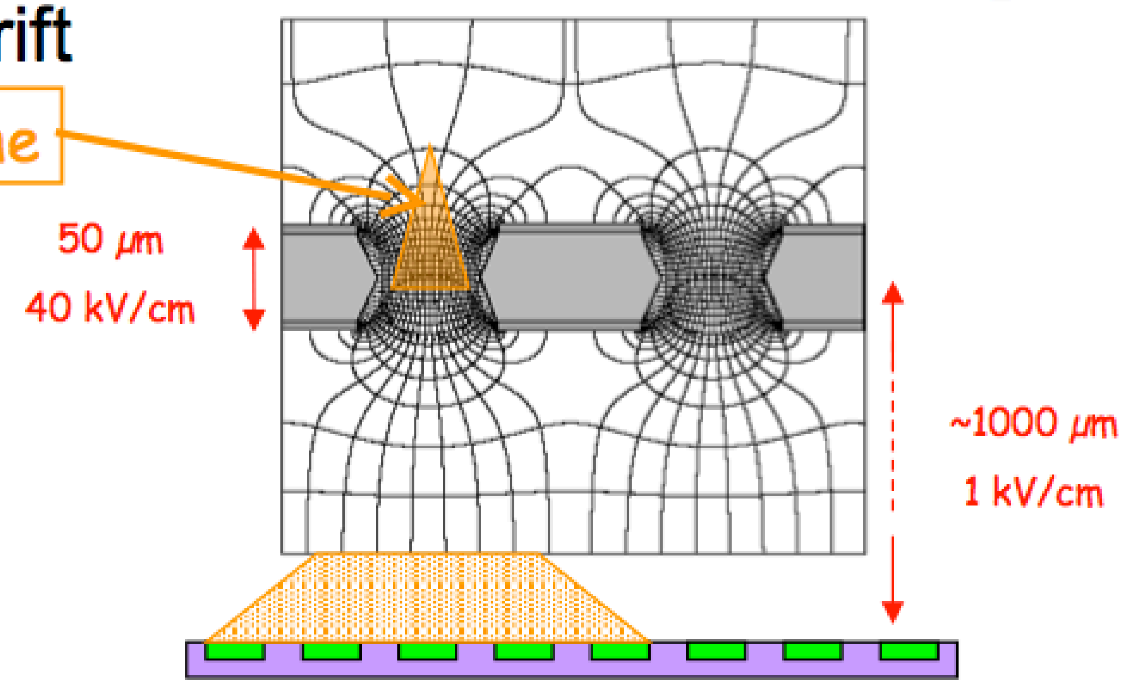
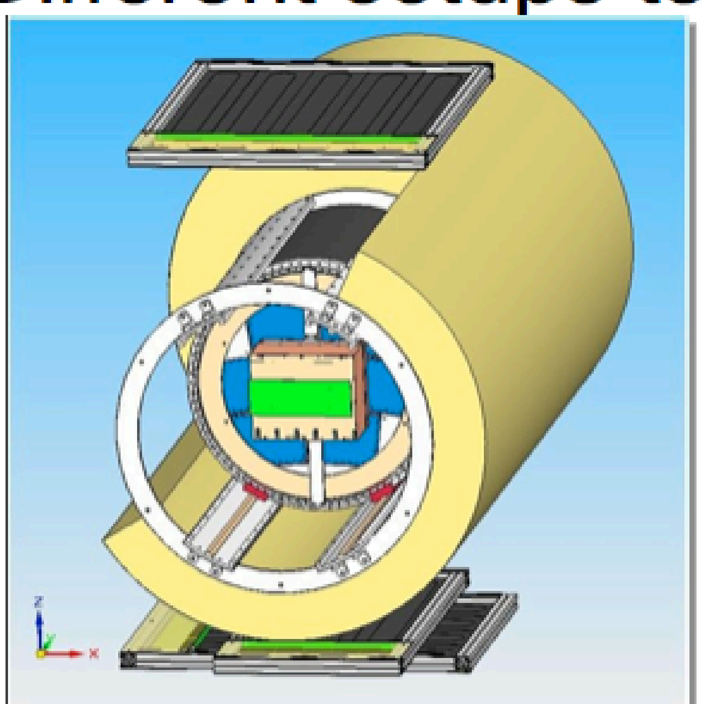
MPGDs

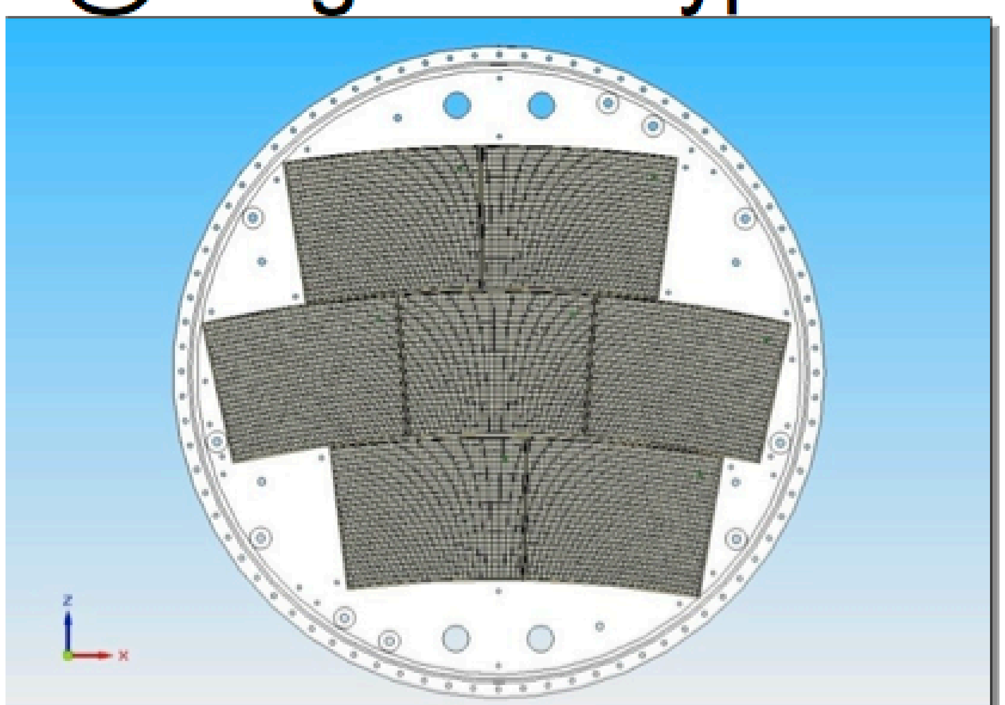
- Gas amplification process: Micromegas or GEM
  - high resolution, low ion backdrift





- Readout structure: Pads or pixel
- Different setups tested @ Large Prototype of LCTPC collab.





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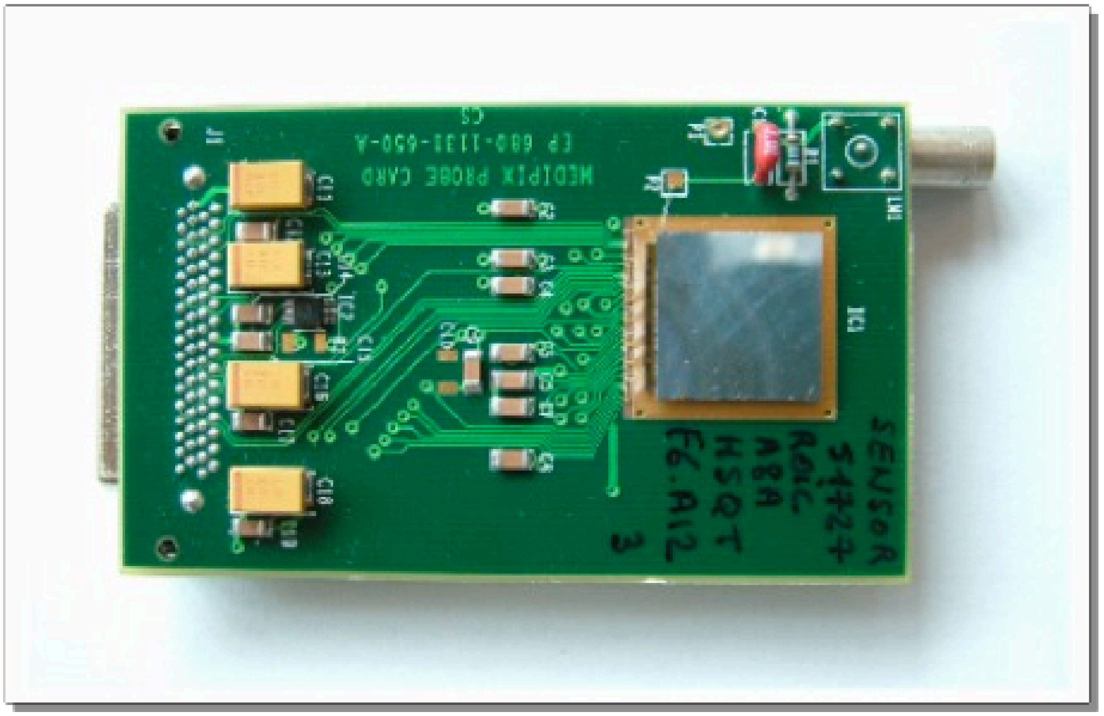
Timepix chip

- Readout chip: The Timepix chip



- Properties
  - 1,4 x 1,4 cm² active surface
  - 256 x 256 pixel matrix
  - CMOS 250 nm technology, IBM
  - 55 x 55 µm² per pixel
  - amplifier/shaper (t_{rise} ~150 ns)
  - 14 bits count clock cycles
    → Pixel pit when/how long
  - clock up to 100 MHz in every pixel
  - lower threshold
  - noise level ~ 500 e-

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Timepix chip

- 4 different modi to operate
  - Medipix:

Pixel hit how often

  - Time-over-threshold:

Pixel hit how long

→ proportional to charge

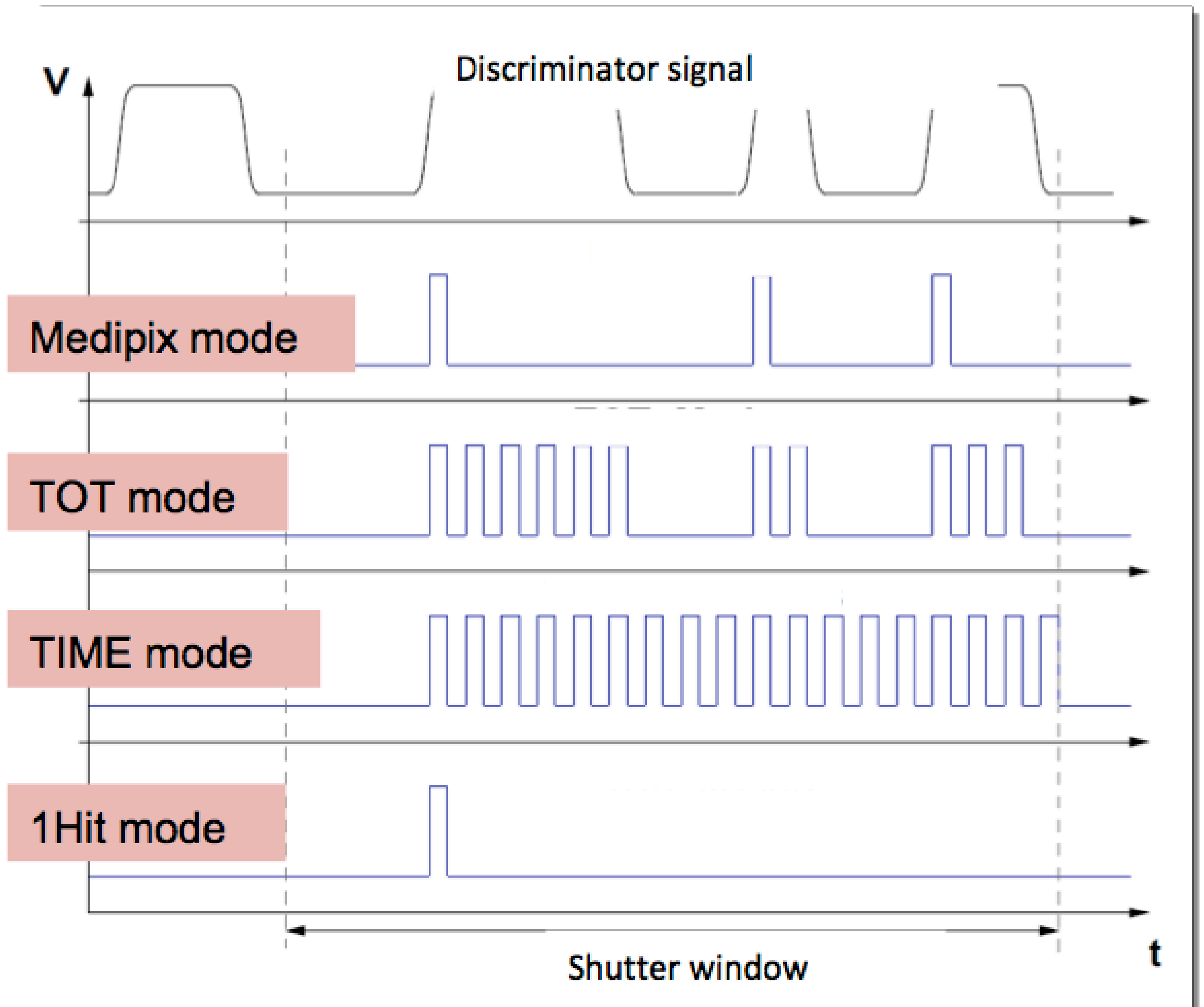
  - Time:

Pixel hit when

→ time of arrival

  - 1Hit:

Pixel hit in shutter window



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Way to go

- Use Modular system: Scalable Readout System SRS:
  - small set of modular components
  - performance at low cost
  - designed for scalability

  (e.g. 1 FEC for 8 chips x

  14 FEC/crate = 112 chips)
  - plugin-choice of frontend ASICs → to do

- Multi chip (first step: 4 or 8) readout with Virtex6 (Bonn)
- Or single chip readout with SRS
- Mechanics of box to house Readout card, including all connectors, supplies, switches and LEDs (Saclay)

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Overview of Nikhef activities

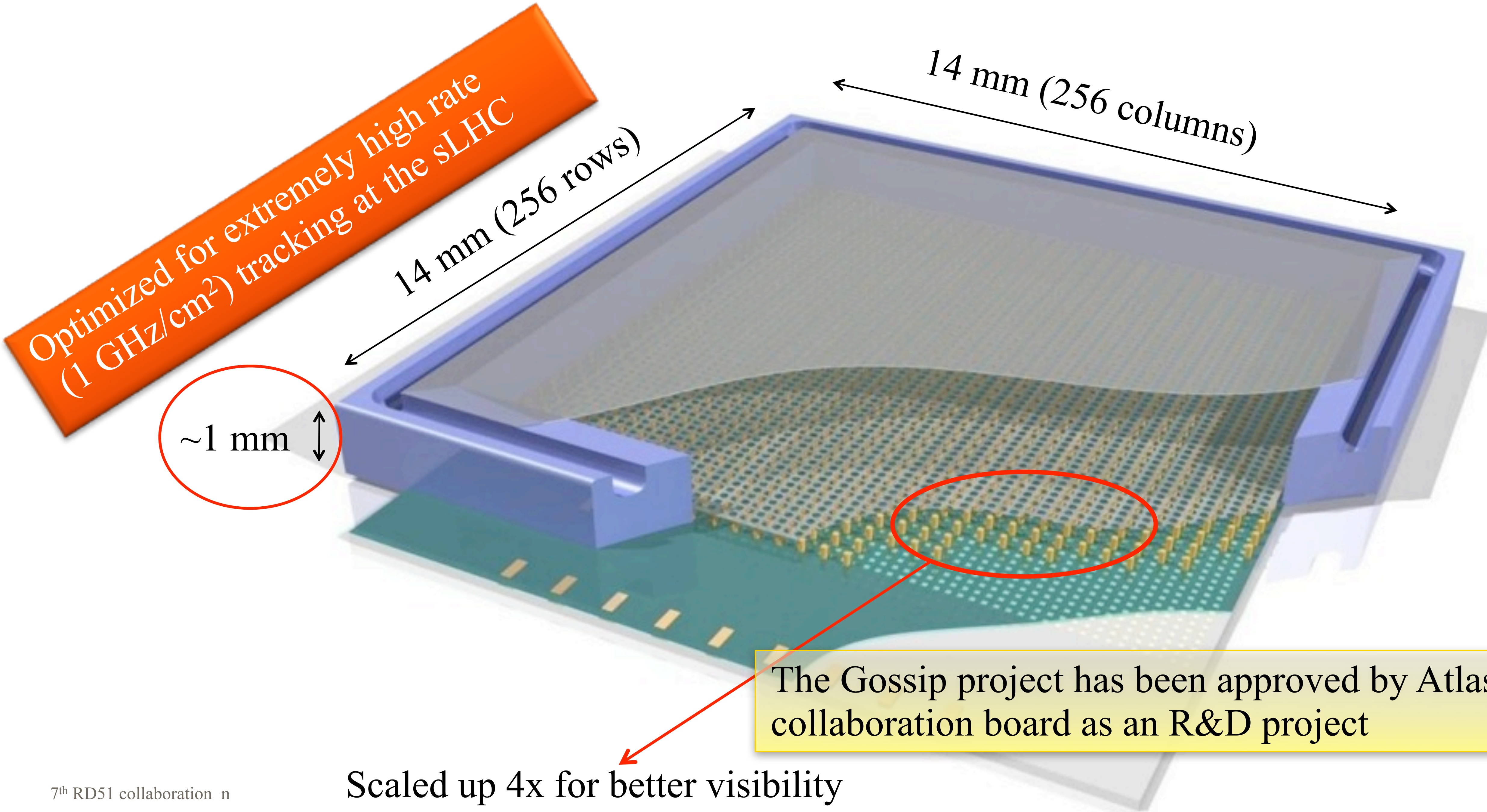
Matteo Alfonsi
Martin Fransen
Harry van der Graaf
Fred Hartjes
Wilco Koppert
Gijs Hemink
Anatoli Romaniouk
Rolf Schön
Rob Veenhof

- **Study on cross talk events at Gossip (Martin Fransen)**
  - **Partly responsible for excessive drift times**
- **Analysis August 2010 testbeam on Gossip (Wilco Koppert)**
  - **Local track fitting**
- **Nikhef's contribution to the DARWIN project**
  - **WIMP search**

7th RD51 Collaboration Meeting, CERN, April 14, 2011

Principle of Gossip

- **High granularity** pixel chip
  - Cell pitch 55 – 60 µm in X and Y
  - Thinned to 50 – 100 µm (not for this testbeam experiment)
- Detection medium: **drift gap ~ 1 mm high**
- Signal (~6 primary electrons) enhanced by **gas avalanche** from a grid
  - Gas gain 5000 - 10000

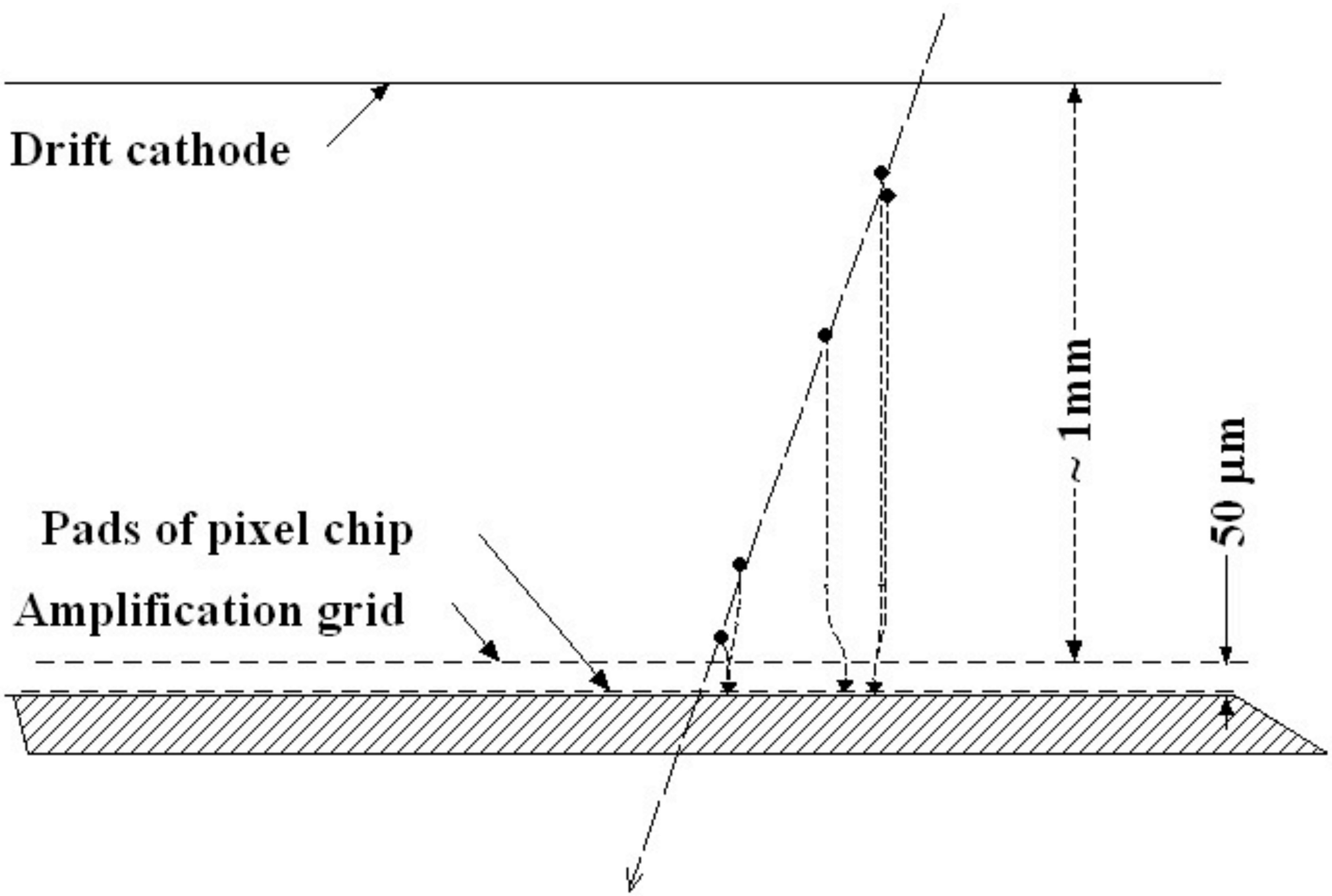


The Gossip project has been approved by Atlas collaboration board as an R&D project

Scaled up 4x for better visibility

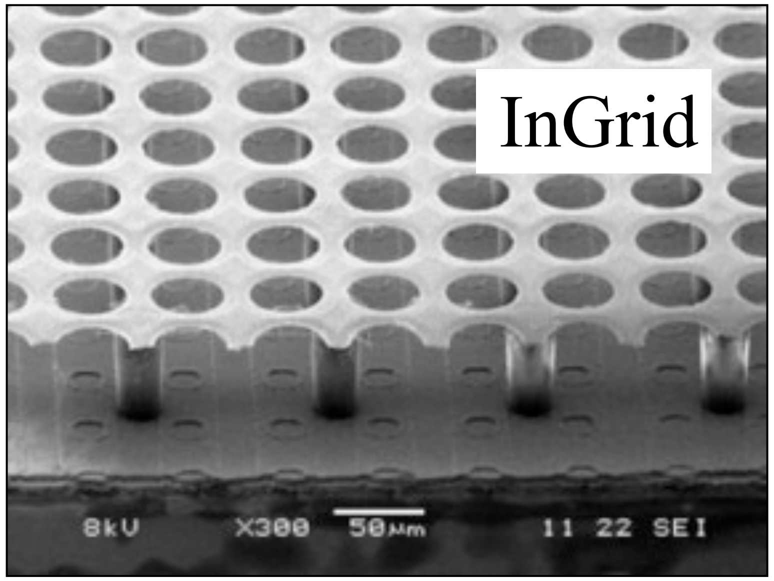
Gossip functioning

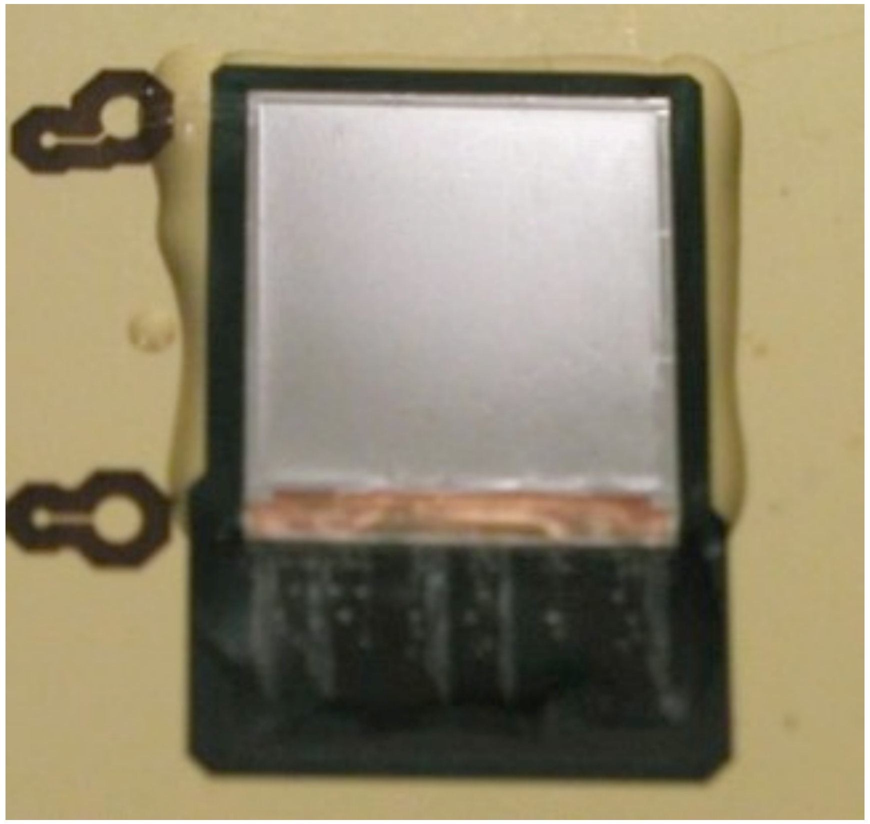
- Pixel chip with integrated Micromegas (InGrid)
- Drift gap height 1 mm
  - Getting > 98% track detection efficiency
- Often detecting **individual electrons**
- Reconstructing track segment characterized by
  - **Crossing point**
  - **Direction**



Timepix as a pixel chip

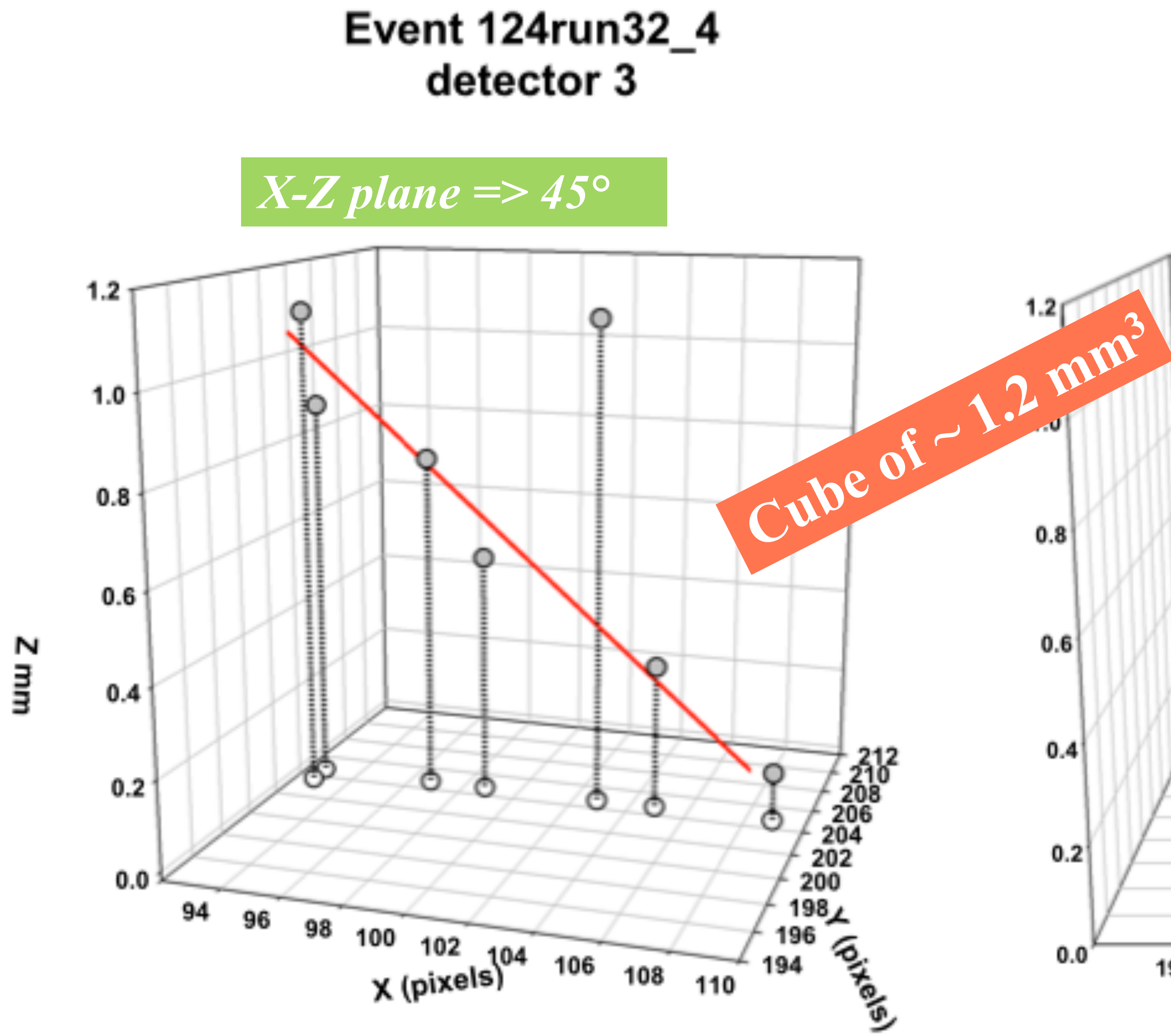
- TimePix
  - Derived from MediPix (X-ray detection)
  - Matrix of 256 x 256 pixels
  - 55 μm pitch
  - => 14.08 x 14.08 mm^2 sensitive area
  - Common clock (100 MHz) to measure drift time for each pixel
  - Also Time-over-Threshold (ToT) mode to measure charge signal spectrum
  - **Not optimized for accurate time measurements => much time walk**
  - Greatly improved TimePix-3 presently in development
- Postprocessing
  - 7 μm Si doped Si_3N_4 for **spark protection**
  - **Amplification grid** (InGrid) on TimePix

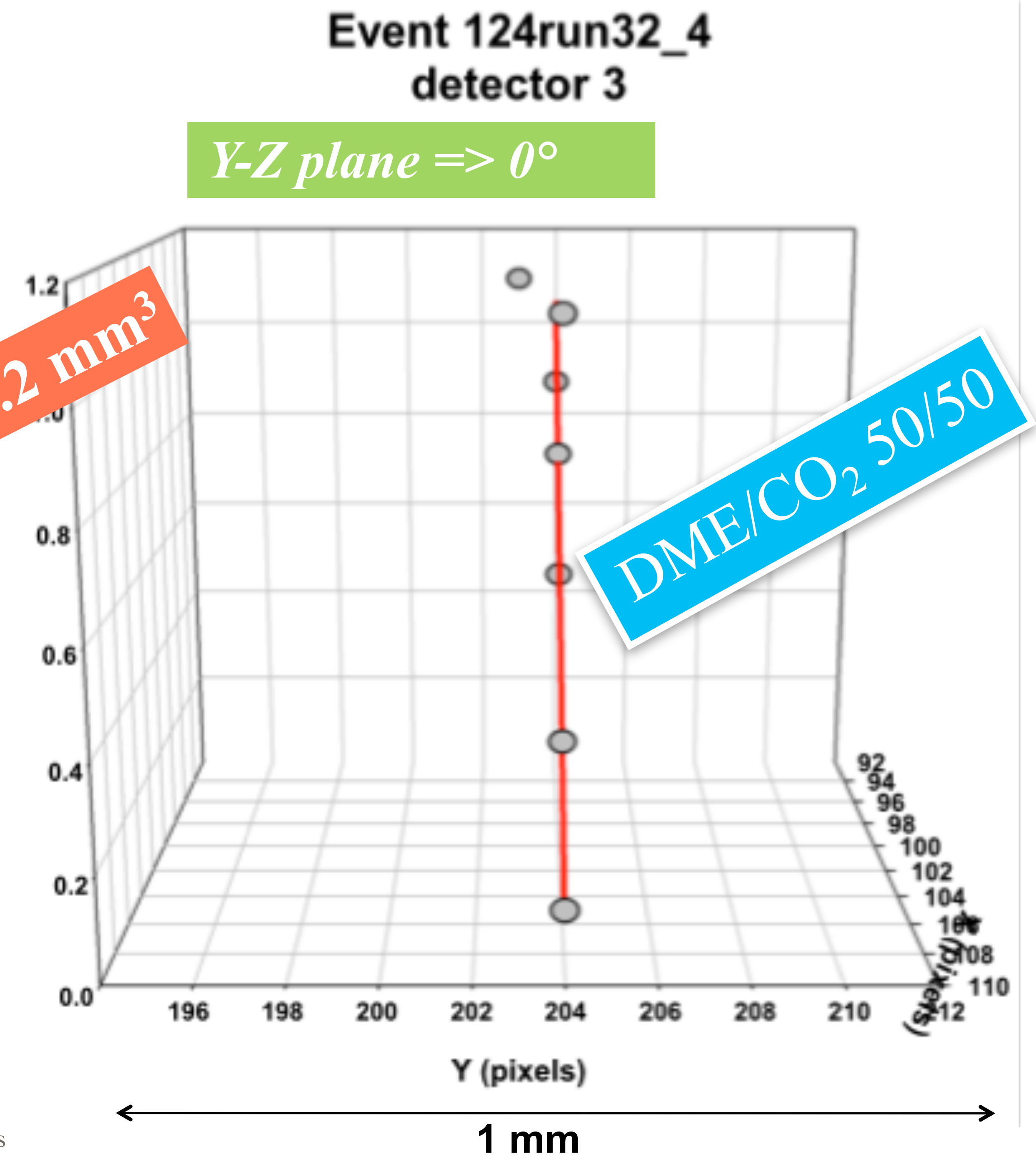




Local fitting of tracks under 45° at Gossip by Wilco Koppert

No global fitting yet



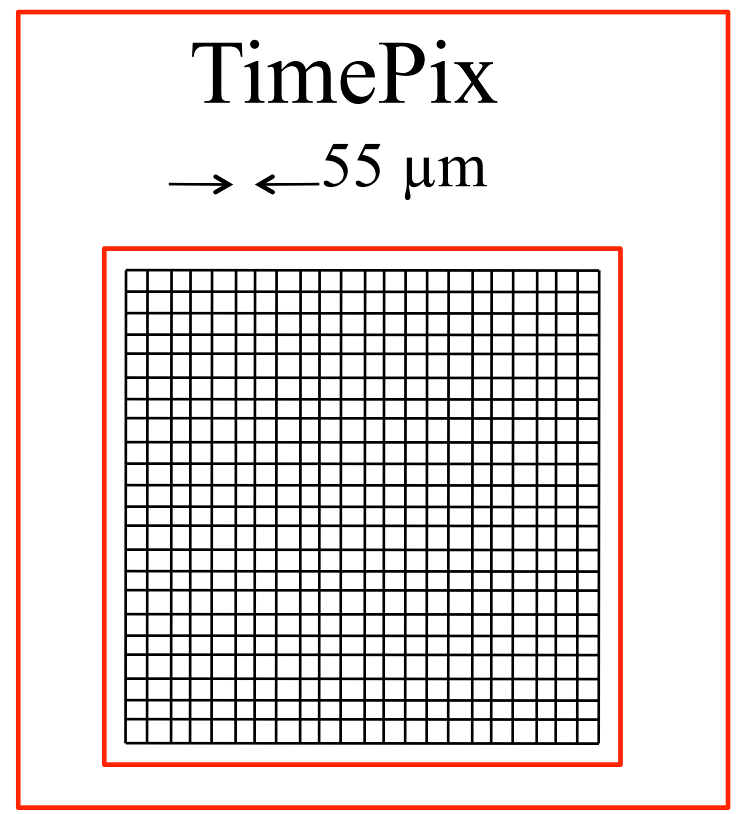


Error estimation

- If errors correct => fit correct
- XY errors
  - $\sigma_{pitch} = 0.055/\sqrt{12} = 0.0159$ mm
  - $\sigma_{DT} = 0.0200$ mm $/\sqrt{mm}$
- Z errors
  - $\sigma_{clock} = 0.01\ (\mu s) * V_{drift} / \sqrt{12} = 0.037$ mm
  - $\sigma_{DL} = 0.0231$ mm (GARFIELD)
  - $\sigma_{Timewalk} \approx 0.2$ mm (data)
- Requiring conf. level to be flat
  - => $\sigma_{Timewalk} \approx 0.13$ mm

DME/CO_2 50/50

Errors given by
- Finite pixel pitch
- Diffusion
- Clock frequency
- Timewalk effect
  - For small signals



From testbeam measurement:
V_{drift} = 11.7 mm/µs
σ_{DT} = 0.0200 mm /√mm (= 63.4 µm/√mm)

Status of GEM DHCAL

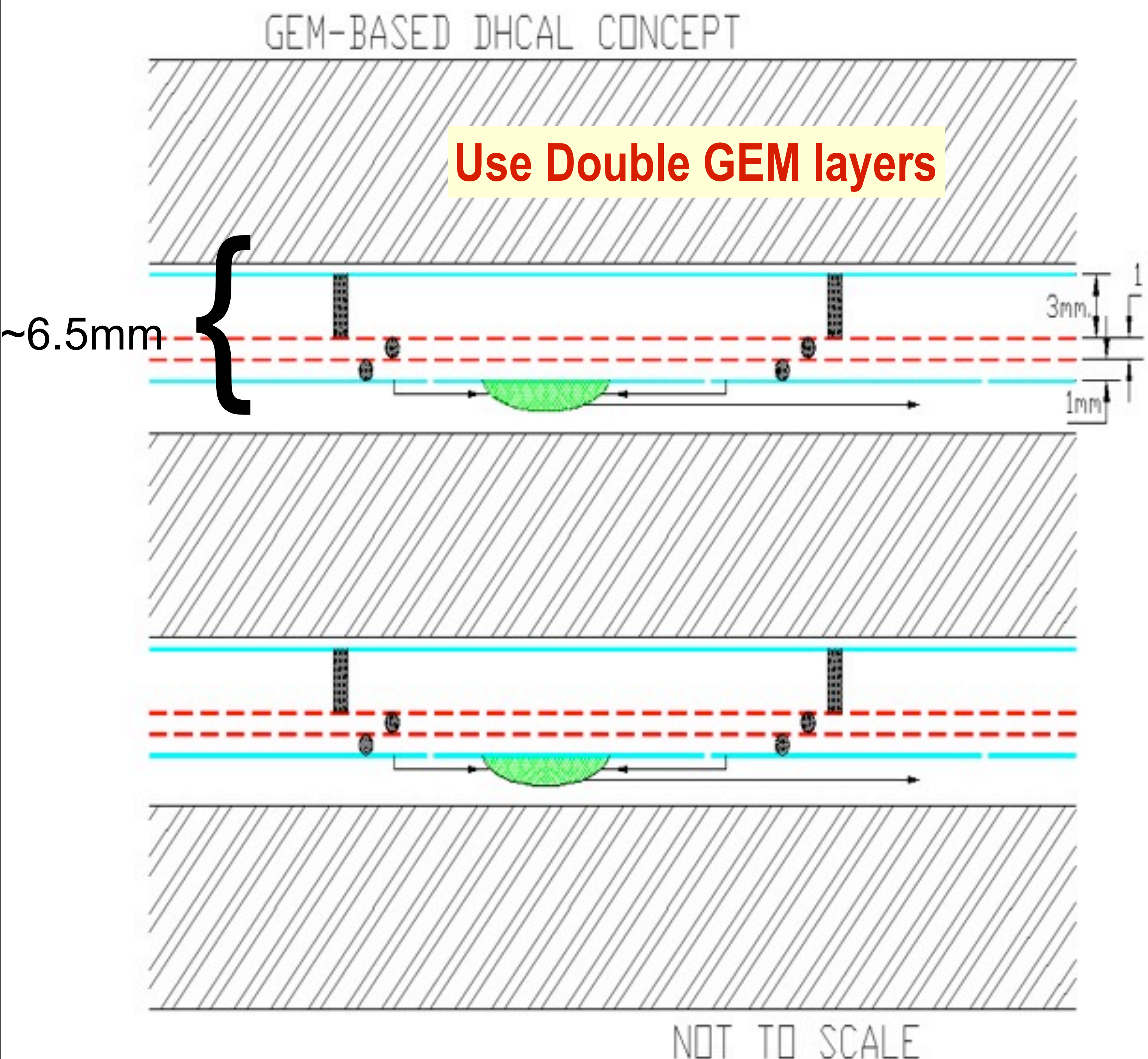
Andy White
For GEM-TGEM/DHCAL Group
April 14 , 2011
RD51 Collaboration Meeting
CERN

- Introduction
- 30cmx30cm 2D readout with KPiX chip
- GEM-DCAL Integration
- TGEM Progress
- Large GEM Foil Certification
- Large Chamber Mechanical Design
- GEM DHCAL Plans
- Summary

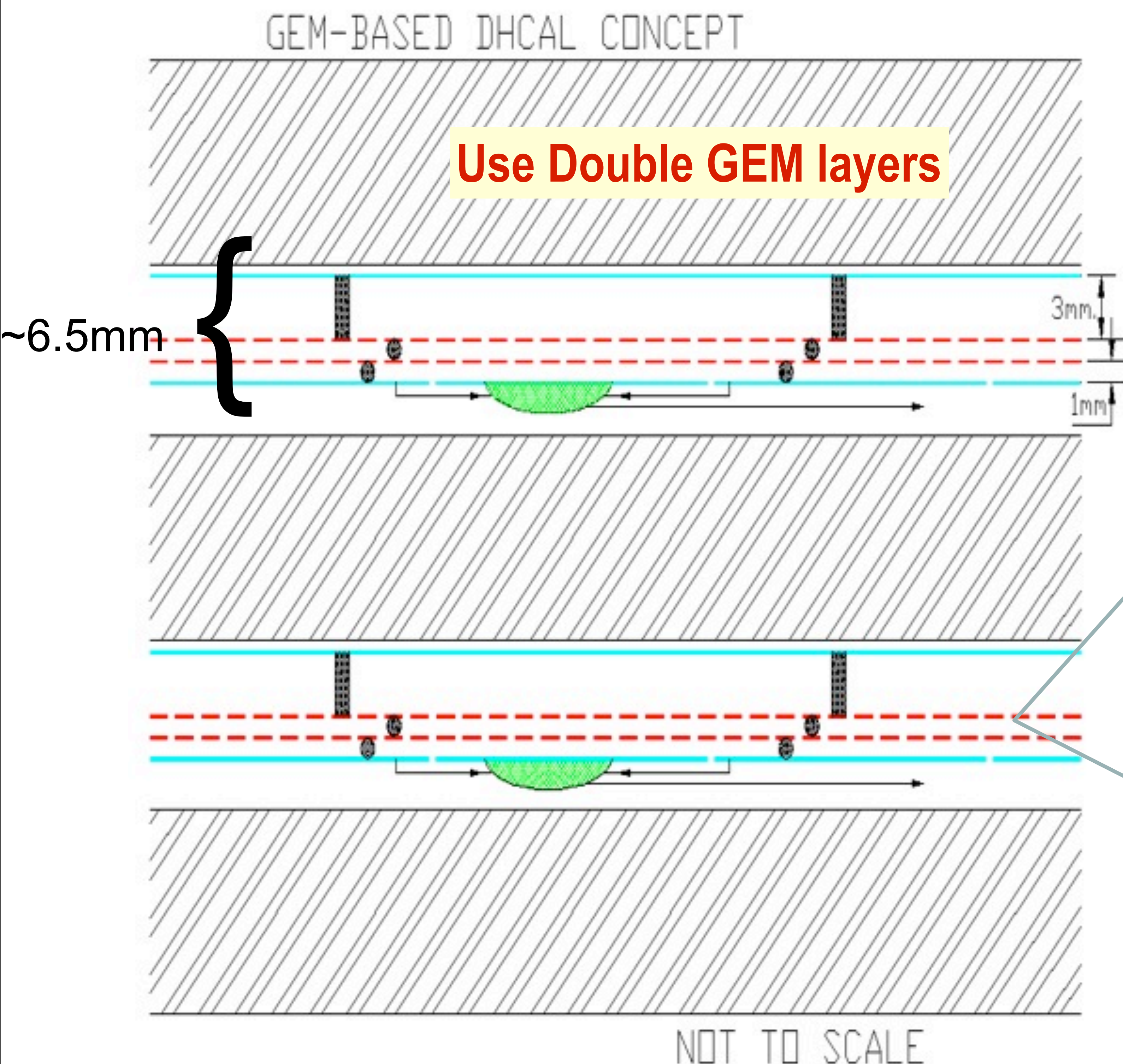
Why GEM?

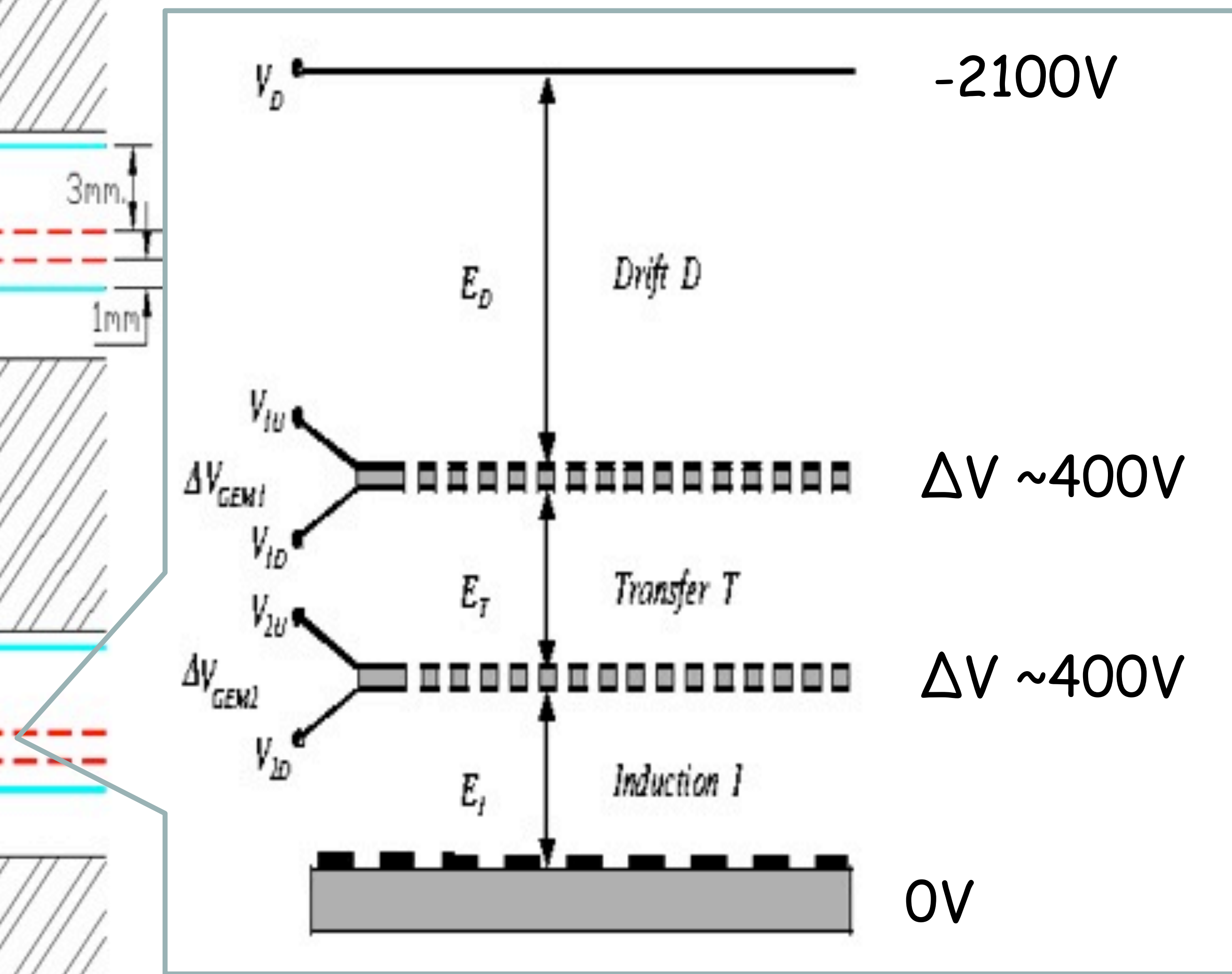
- Flexible configurations: allows small anode pads for high granularity
- Robust: survives ~10^{12} particles/mm^2 with no performance degradations
- Based on electron collection, ~few ns rise time
- Short recovery time ➔ can handle high rates
- Uses simple gas (Ar/CO_2) – no long-term issues
- Runs at relatively low HV (~400V across a foil)
- Stable operations

GEM-based Digital Calorimeter Concept



GEM-based Digital Calorimeter Concept





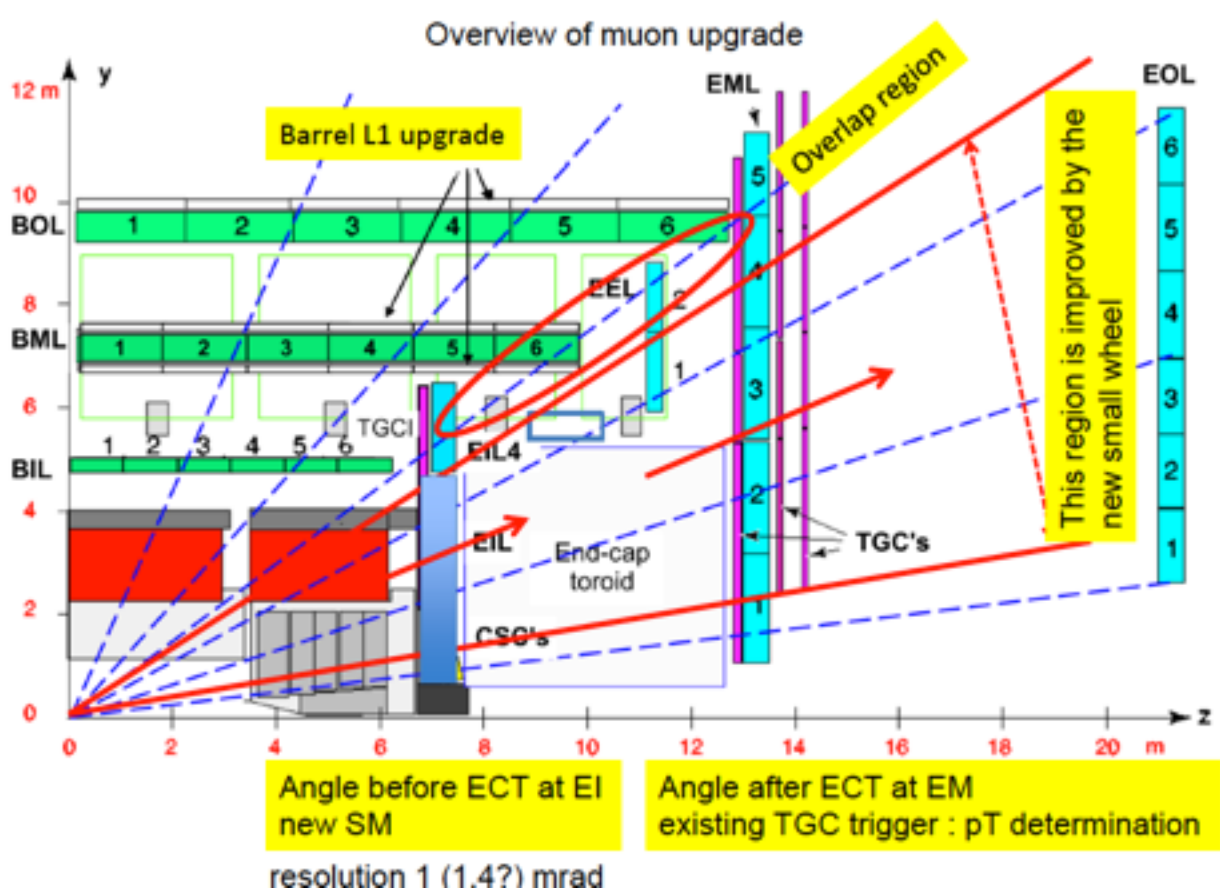
Ap

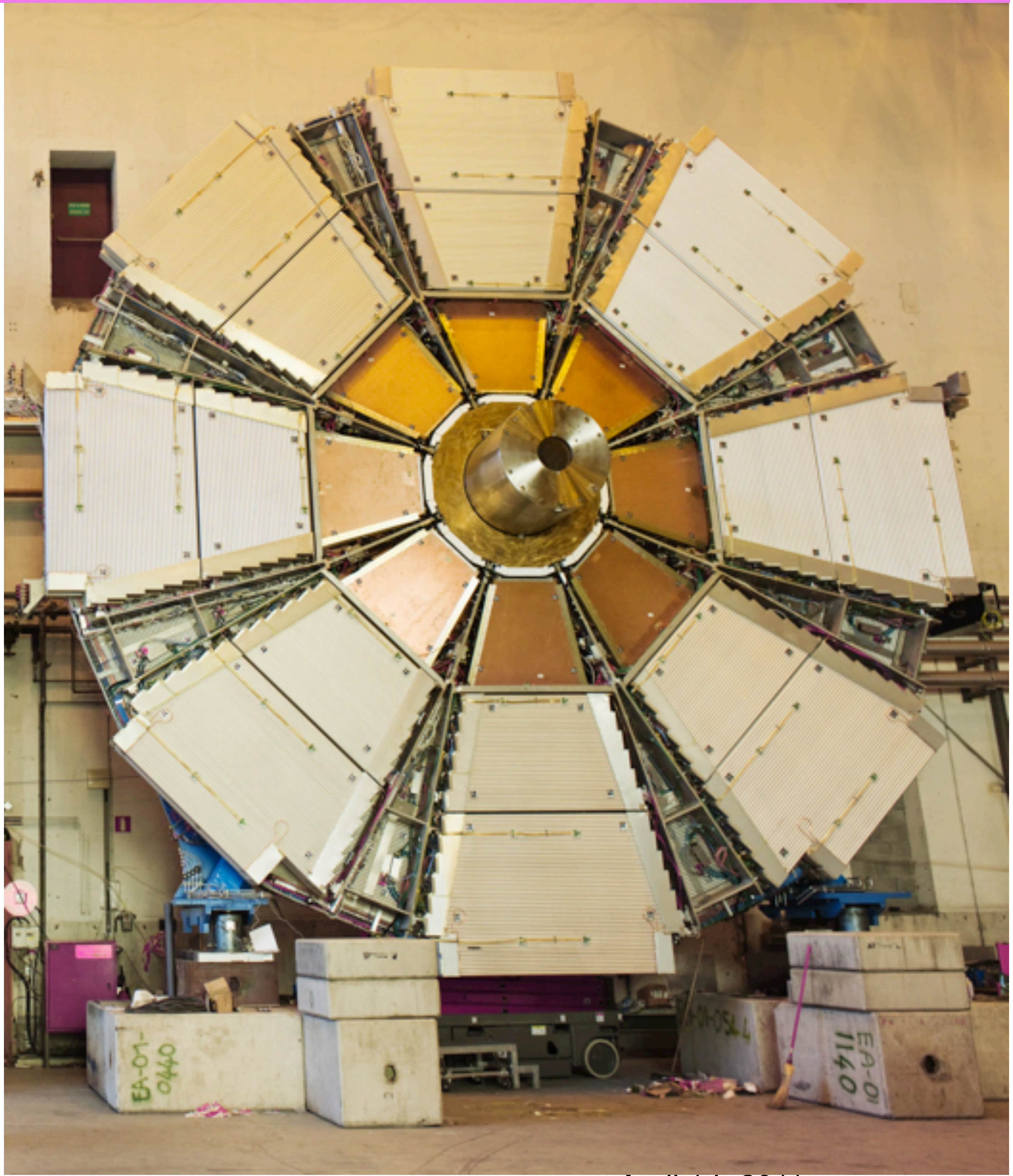
Front End Electronics for the ATLAS Muon Phase 1 Upgrade

Ven. Polychronakos
Brookhaven National Laboratory

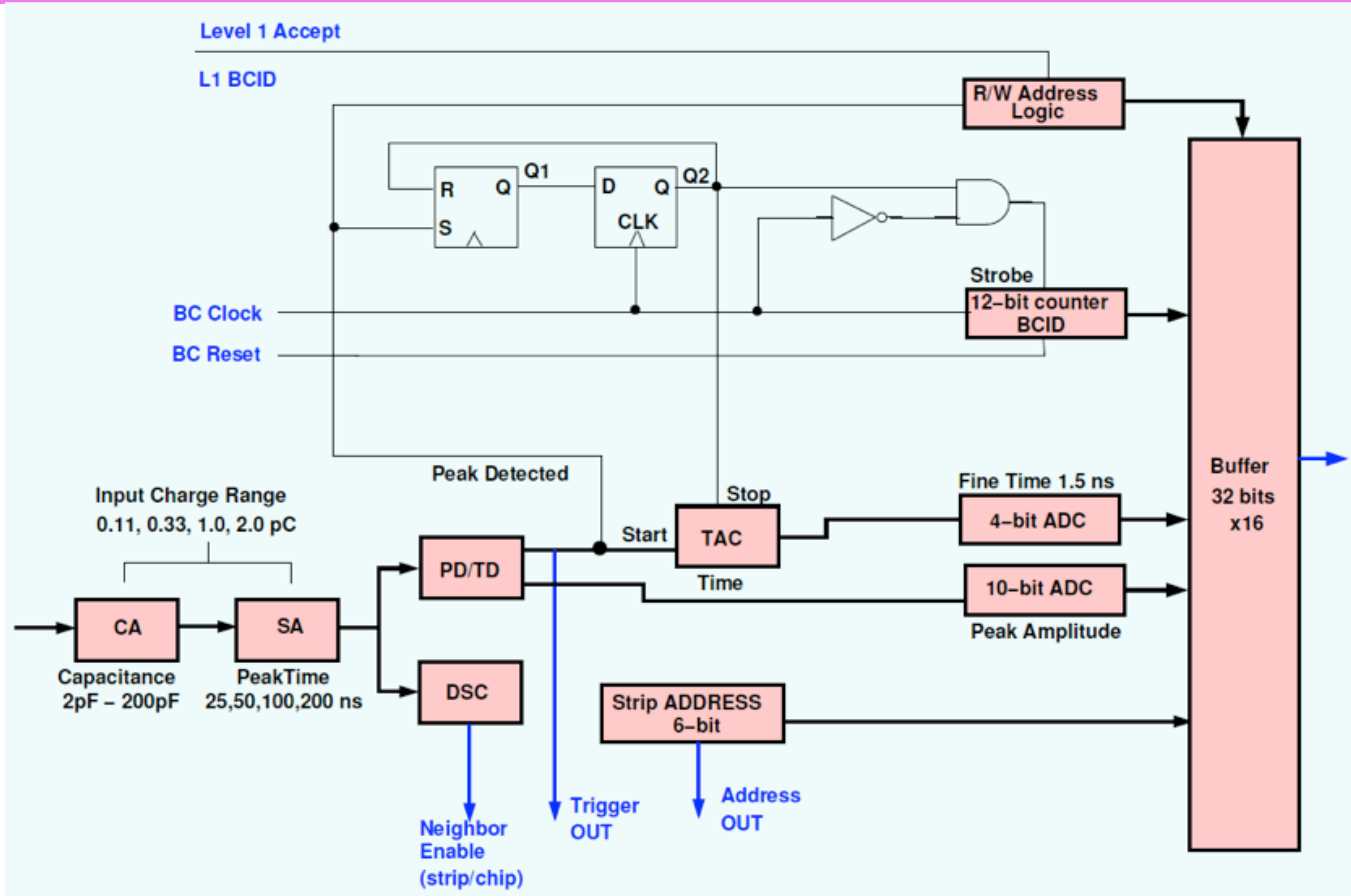
Replacement of the “Small Wheels”

- ❑ Diameter 9 m
- ❑ Currently Drift Tubes and Cathode Strip Chambers provide precision measurement
- ❑ If replaced with 8-layer Mmegas Detectors, would require ~1000 m2 of bulk detectors





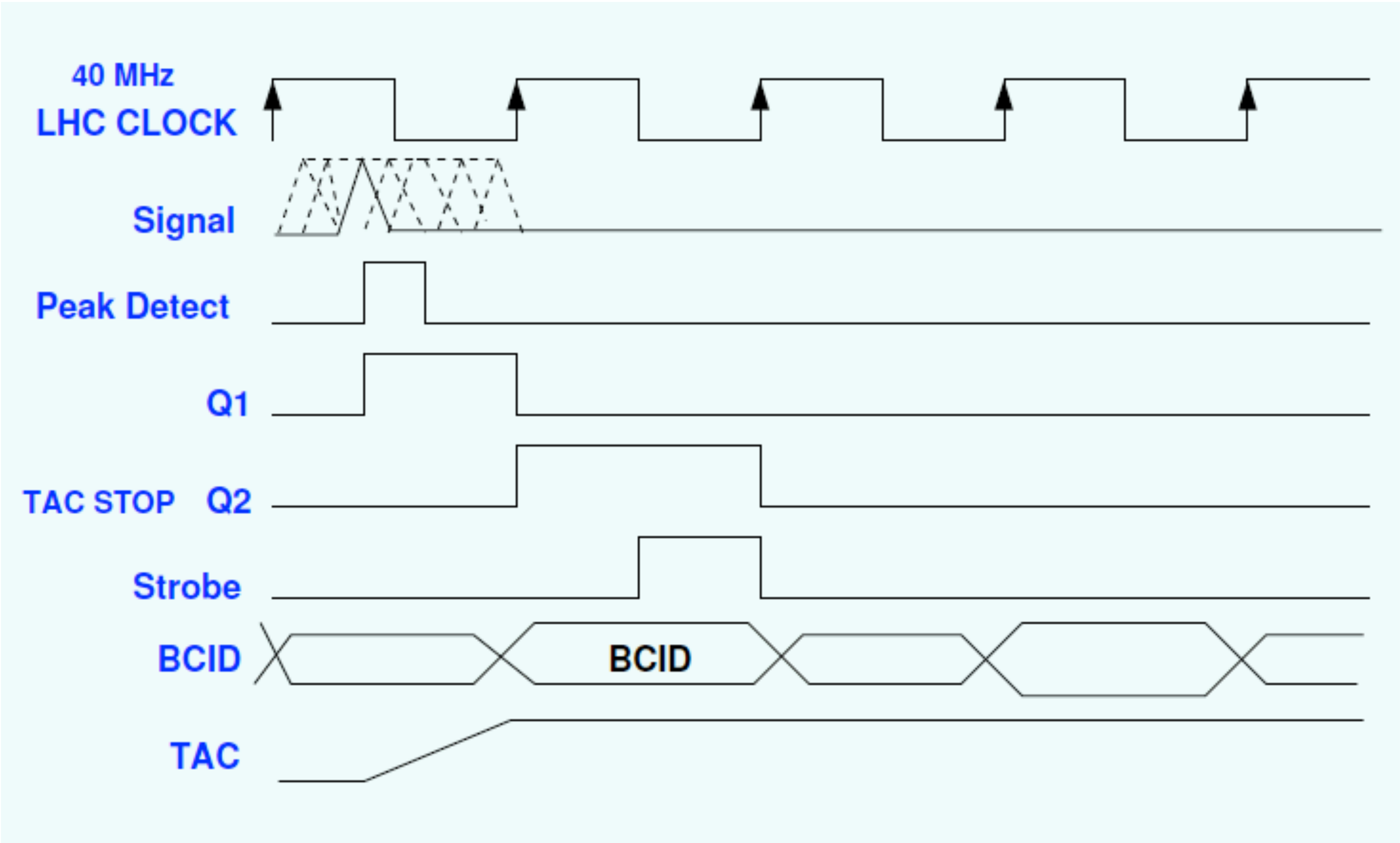
Block Diagram of the IC being designed



For TGC there will be fewer (16 or 32) channels with LVDS outputs of individual discriminators

All other features remain the same

Timing Diagram



40 MHz BC clock convenient for LHC but any clock can be used to related hit with trigger accept

Additional features

- 64 channels
- adj. polarity, adj. gain (0.11 to 2 pC), adj. peaking time (25-200 ns)
- derandomizing peak detection (10-bit) and time detection (1.5 ns)
- real-time event peak trigger and address
- integrated threshold with trimming, sub-threshold neighbor acquisition
- integrated pulse generator and calibration circuits
- analog monitor, channel mask, temperature sensor
- continuous measurement and readout, derandomizing FIFO
- few mW per channel, chip-to-chip (neighbor) communication, LVDS interface

VMM1 IC Schedule and Status

	status / notes
Analog section	**completed**
Peak/time detection	**in progress**
Common circuitry	**in progress**
Digital sections	
Physical layout	
Fabrication 1st prototype	CMOS 130nm, 1.2V, MPW, by Summer 2011

VMM1 IC Schedule and Status

	status / notes
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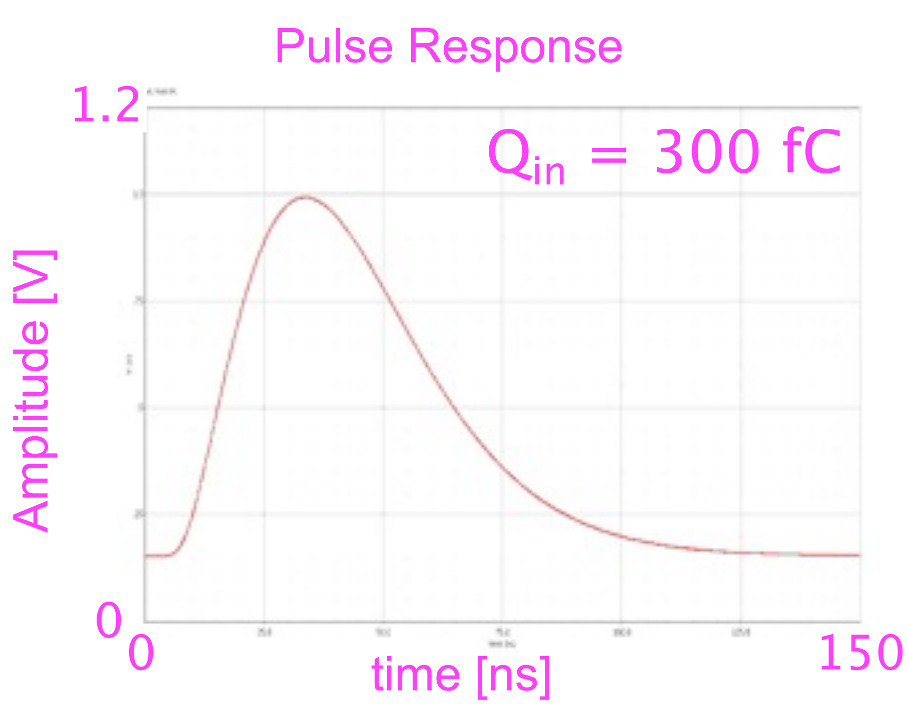
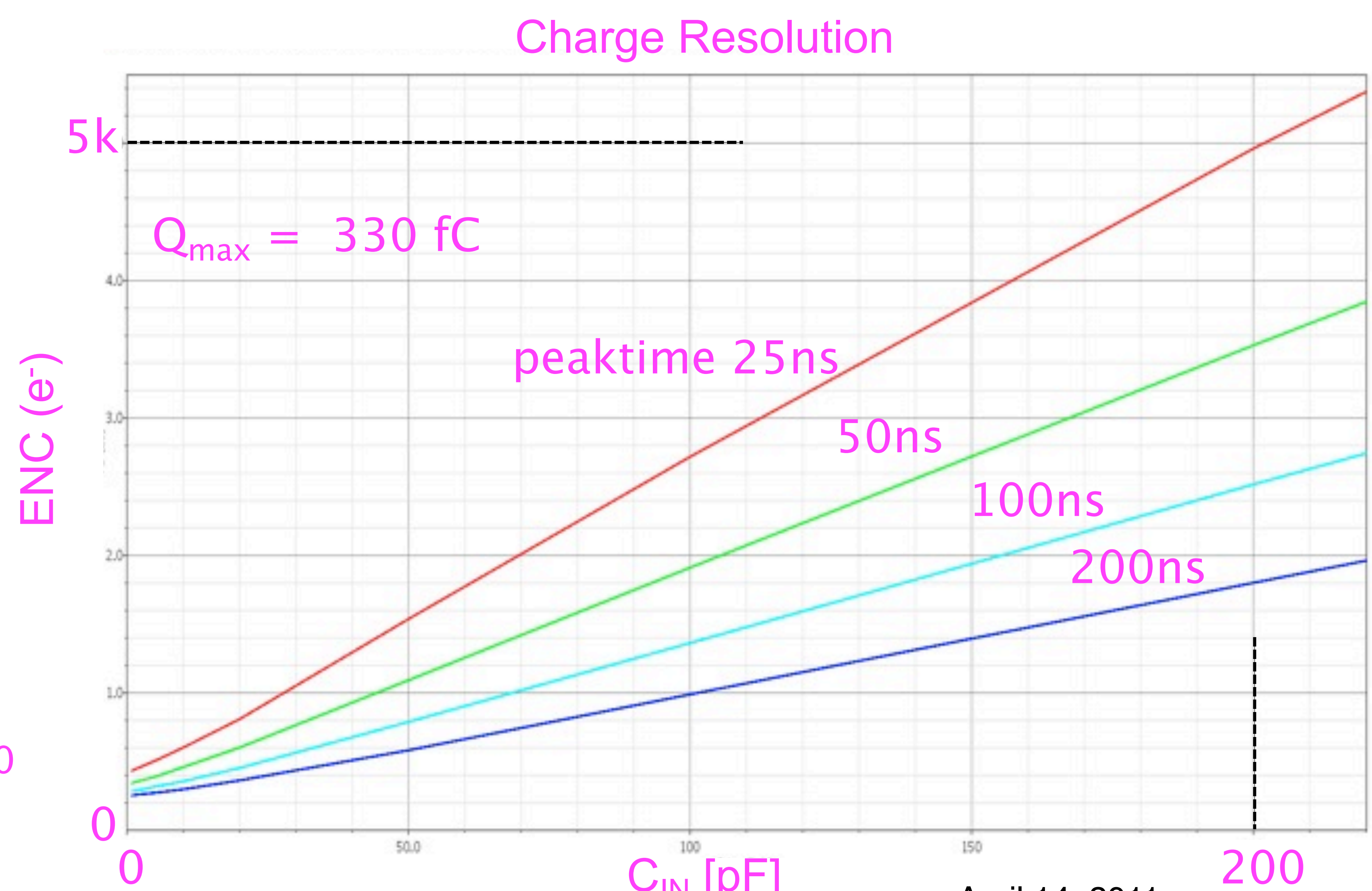
Peak/time detection	**in progress**
Common circuitry	**in progress**
Digital sections	
Physical layout	
Fabrication 1st prototype	CMOS 130nm, 1.2V, MPW, by Summer 2011

Analog section:
transistor-level simulations
power ≈ 4 mW

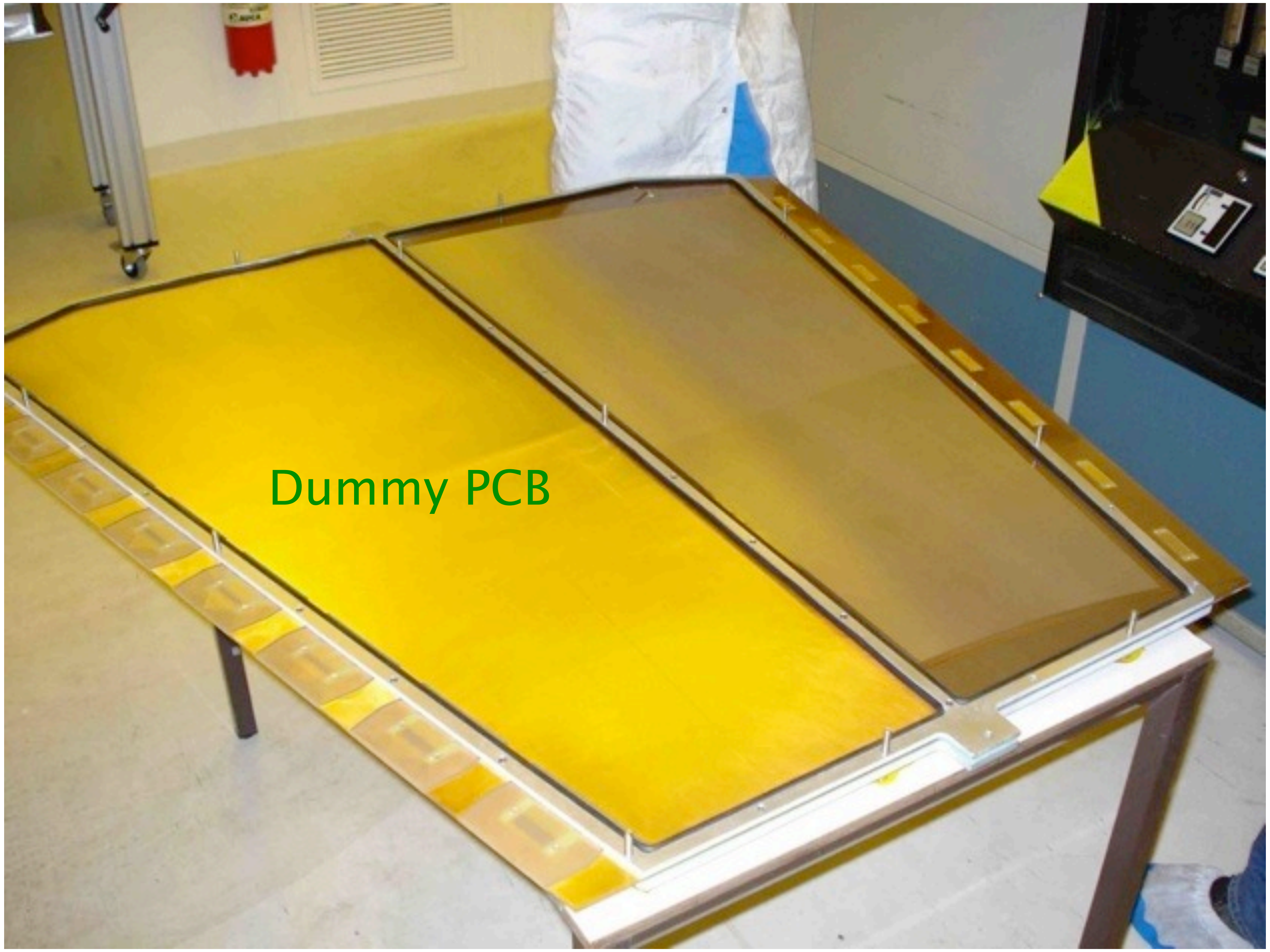




Micromegas for the ATLAS Upgrade

Status & prospects

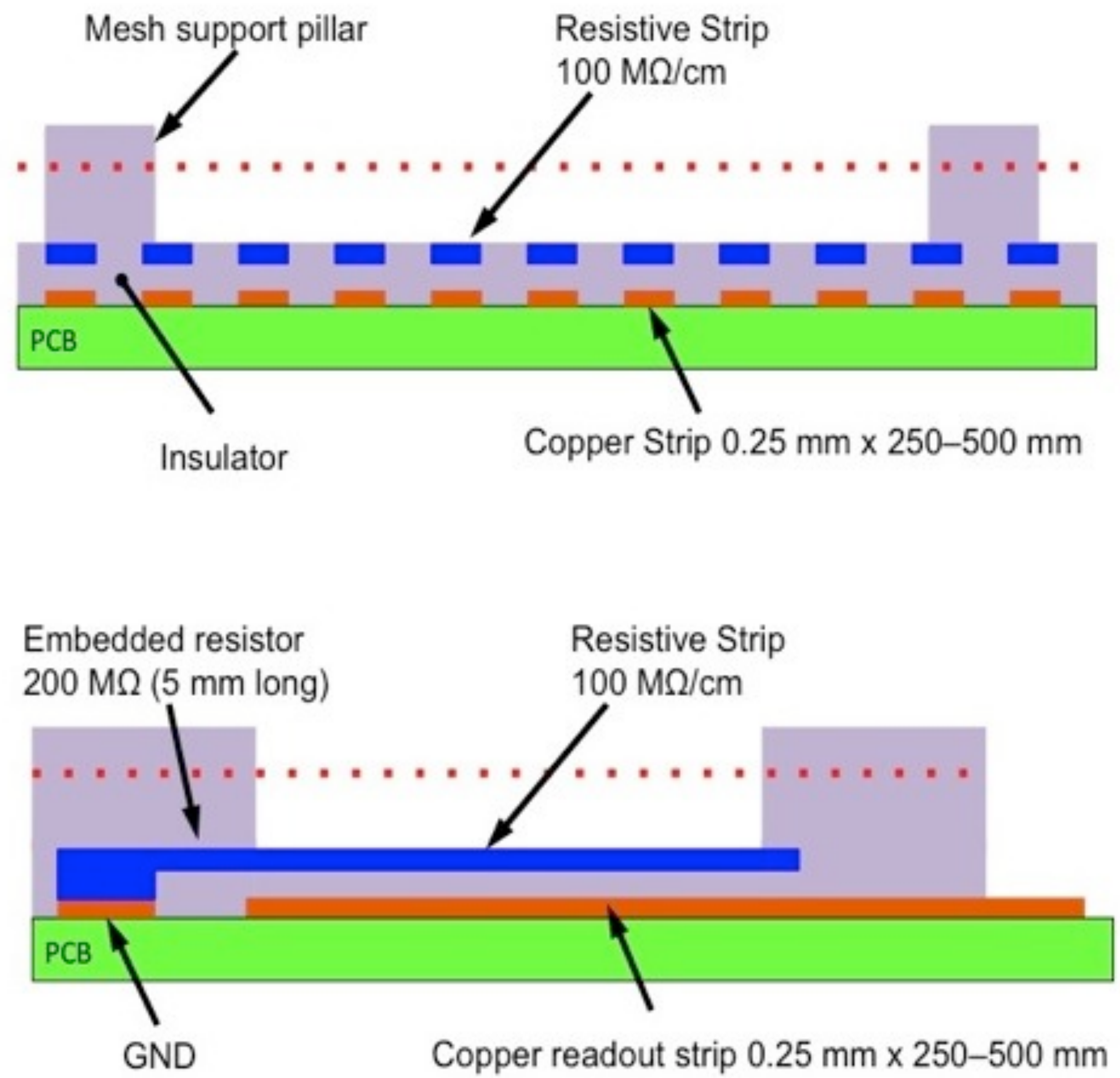
Standard MM 1.2 x 0.6 m^2 (Nov 2010)



- 2048 circular strips
- Strip pitch: 0.5 mm
- 8 connectors with 256 contacts each
- Mesh: 400 lines/inch
- 5 mm high frame defines drift space
- O-ring for gas seal
- Closed by a 10 mm foam sandwich panel serving at the same time as drift electrode

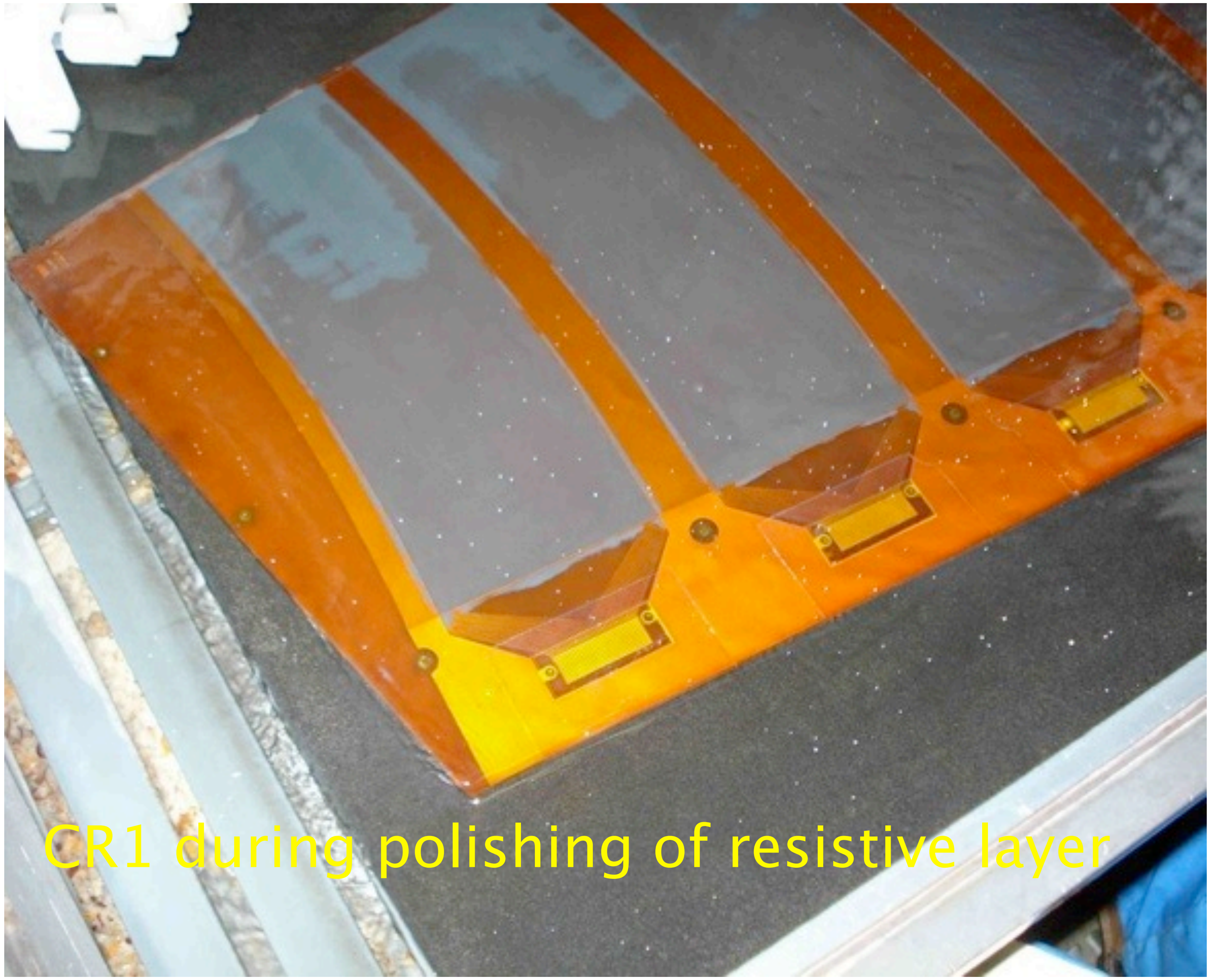
Large MM with resistive-strips (Jan 2011)

- Same spark-protection scheme as for R11-R16
- Thin insulation layer + resistive strips above readout strips
- Resistive strips are connected to ground through $R_{GND} \approx 200\ M\Omega$
- Resistivity along strips



Construction of CR1

- Same PCB as for standard MM
- 500 μm strip pitch
- Same mesh as C1(400 lines/ inch)
- Resistive strips only above connected strips



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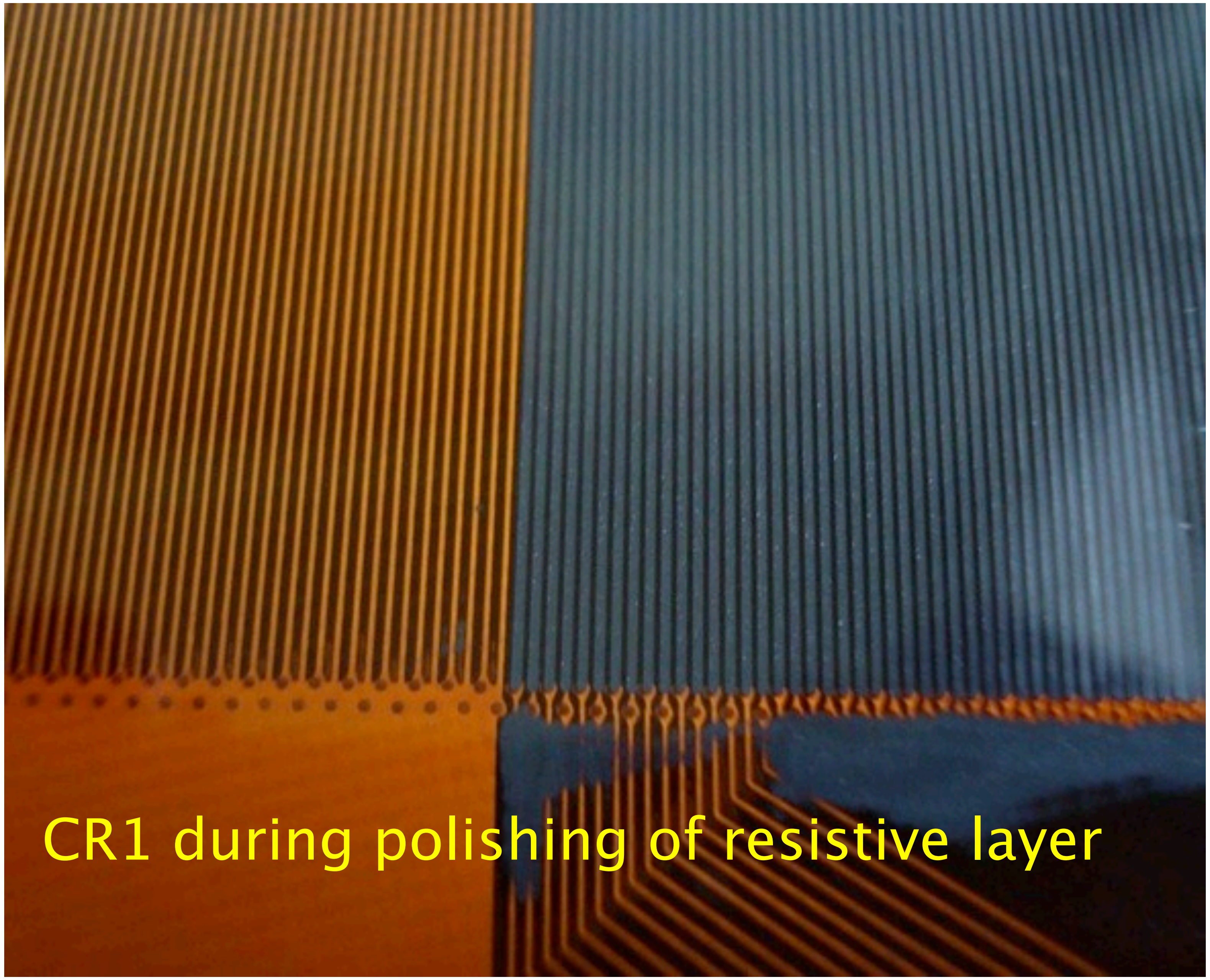
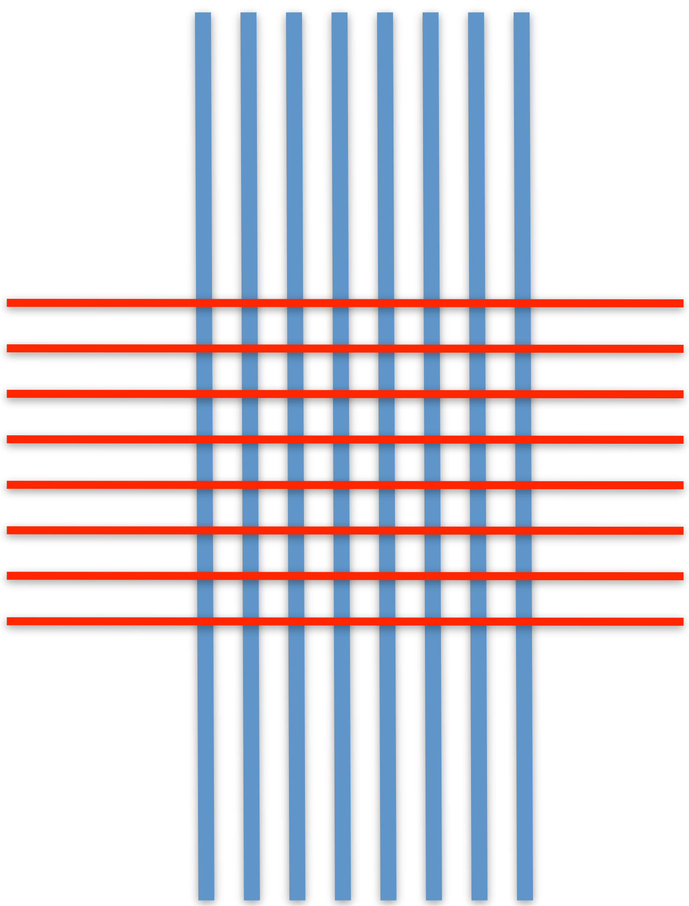


Large resistive-strip chamber

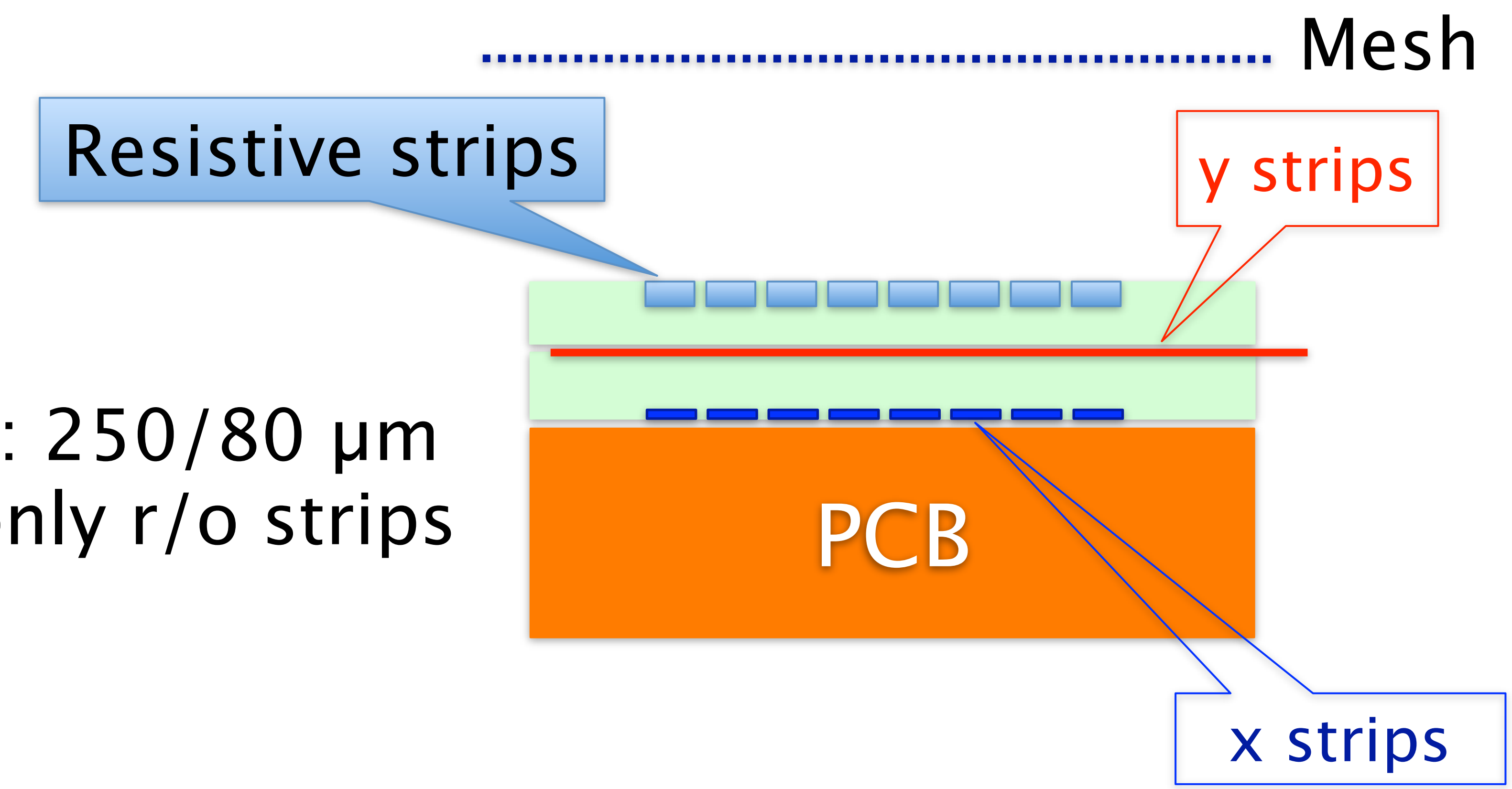
- Production of second large chamber prototype with resistive strips started mid February at CERN/TE-MPE workshop
- Dimensions: 1.2 x 0.6 m^2, 2048 strips with 0.5 mm pitch
- Several provisions to avoid the problems encountered in 1^{st} try
  - Adjustment of laminator
  - Mesh fixed in areas between connected strips, no pillars in this area
  - Careful development & curing

Chamber after pillar development but before curing

R16 with 2D readout



y: 250/80 µm
only r/o strips

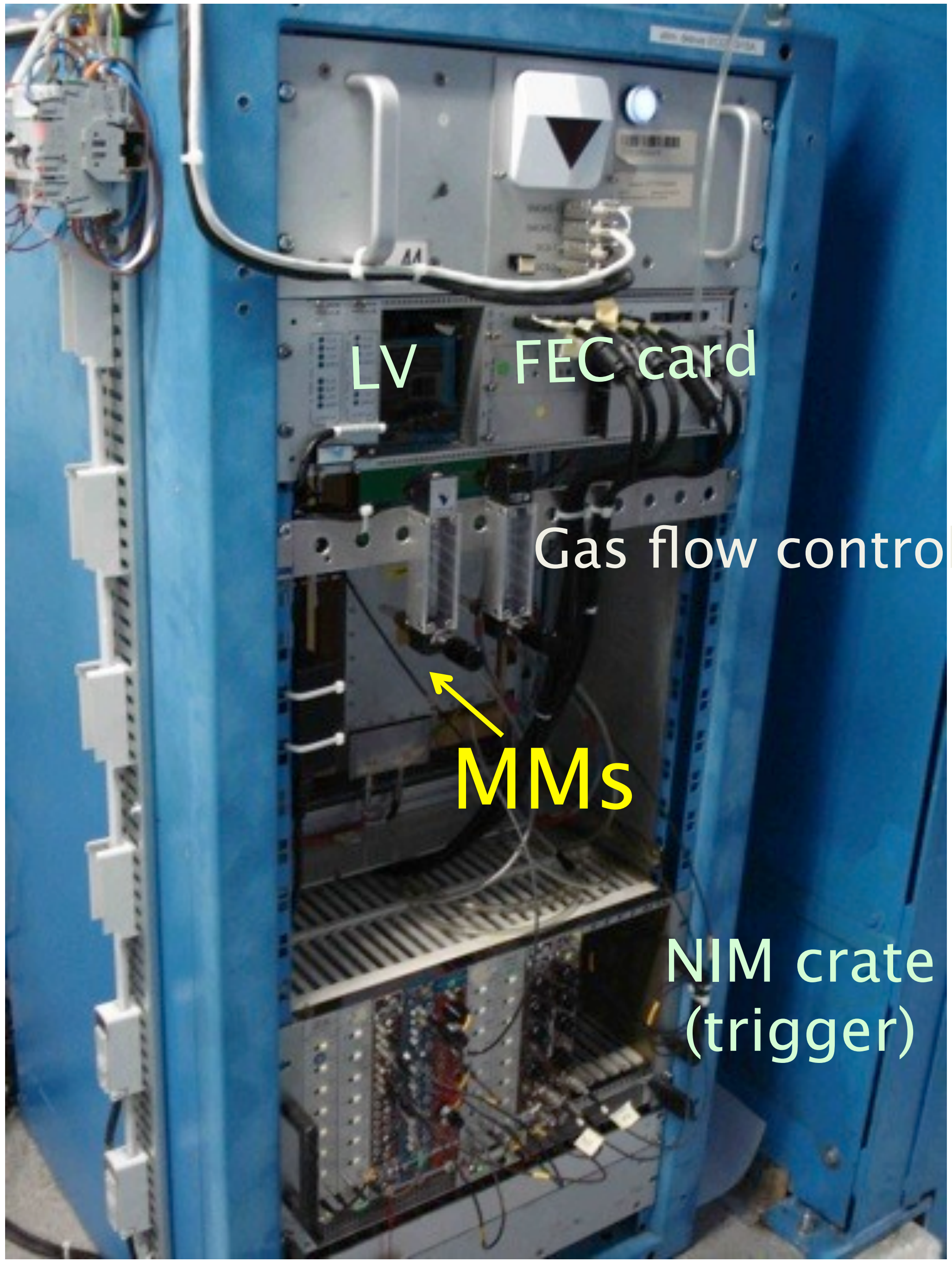


x strips: 250/150 µm
r/o and resistive strips

Resistivity values
$R_G \approx 55\ M\Omega$
$R_{strip} \approx 35\ M\Omega/cm$

MM test in ATLAS cavern

- During February the infrastructure was installed in the ATLAS cavern
  - Location on HO (side A) 6^{th} floor, R=6 m
  - HV and ethernet cables to USA15; HV mainframe and DAQ PC in USA15
  - Gas pipe from GSX1 to location close to rack
  - Small rack connected to safety system
- End of March installation of MMs & DAQ
  - 2 MMs for triggering only (standalone)
  - 2 MMs (R16 with xy readout and R13)
  - DAQ using the SRS system and DCS (Talks by M. Byszewski and G. Iakovidis in WG5 session)
- So far only x strips read out; lack of APV25 hybrids cards



MMs in ATLAS cavern

Trigger MMs

R13

R16