THE 2018 INTERNATIONAL WORKSHOP ON HIGH ENERGY CIRCULAR ELECTRON POSITRON COLLIDER

MicroRWell for preshower and muon detector

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On behalf of the IDEA working group

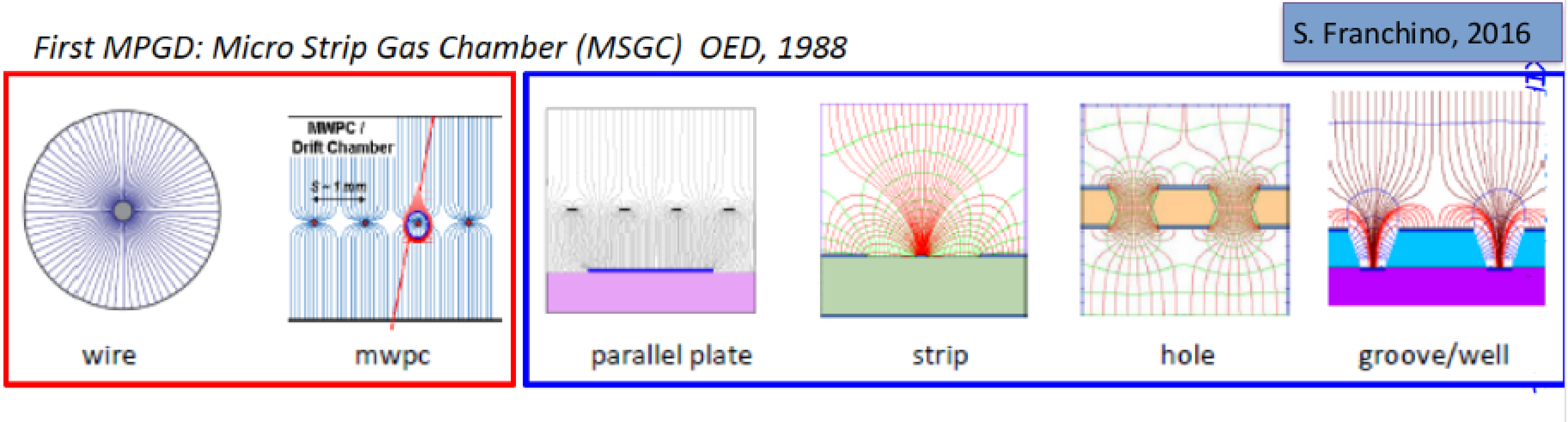
The 2018 International Workshop on the High Energy CEPC

Outline

- MicroRWell as innovative MPGD
- Performance at test beams
- Application at CEPC

Micro Pattern Gas Detectors

Recent generation of gas detectors that overcomes the traditional limitation of gas detectors: slow ion motion (low rate capability) and limited multi-track separation (spatial resolution)



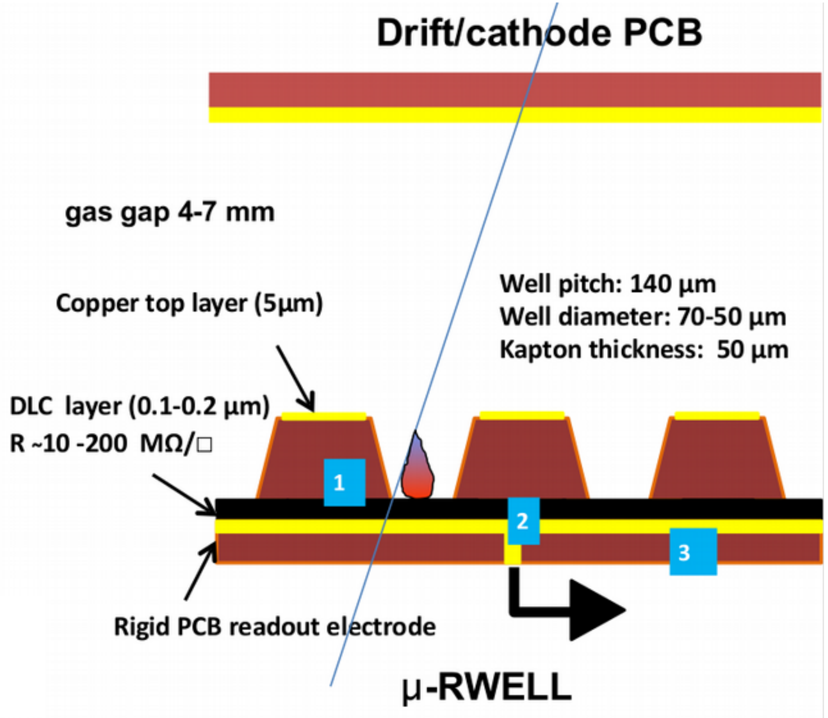
Reduce multiplication region size
Faster ion evacuation
Higher spatial resolution

MicroRWell: half a GEM, twice the fun

MicroRWells are innovative Micro Pattern Gas Detectors

They inherit all the advantages of "traditional" MPGD:
- from GEM: amplification stage
- from MicroMegas: construction scheme

But have unique features:
- Higher resistance to sparks
- Simplier components construction and final assembly

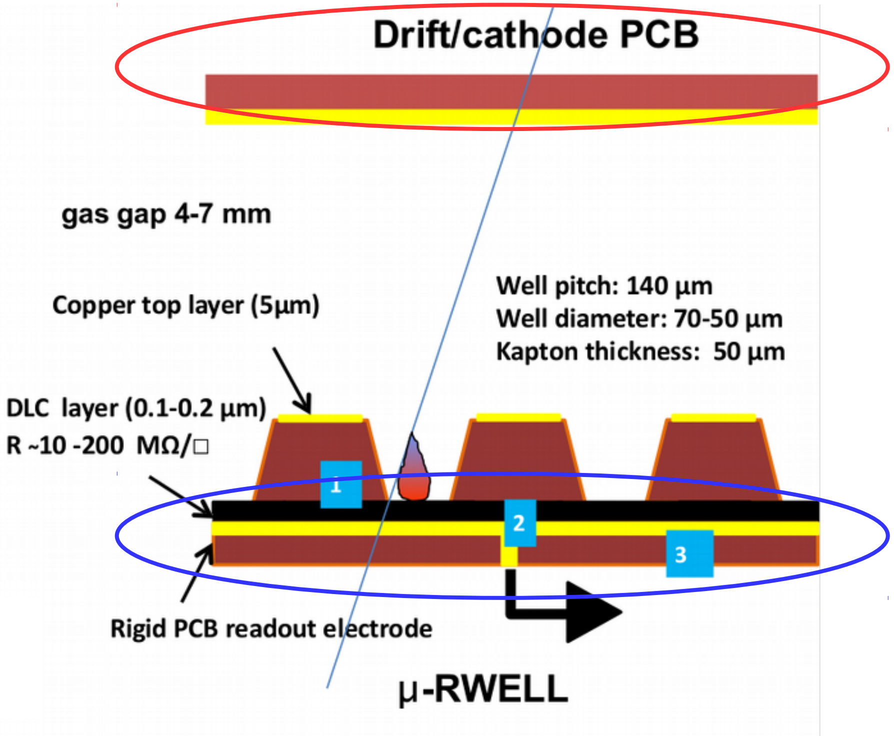


G. Bencivenni et al., 2015_JINST_10_P02008

MicroRWell: half a GEM, twice the fun

MicroRWELL detector is composed of two elements: cathode and the MicroRWell_PCB

MicroRWell _PCB is realized by coupling:
- a WELL patterned kapton foil:
- a Resistive layer
    - resistivity can be tuned to match the expected rate
- a standard readout PCB



G. Bencivenni et al., 2015_JINST_10_P02008

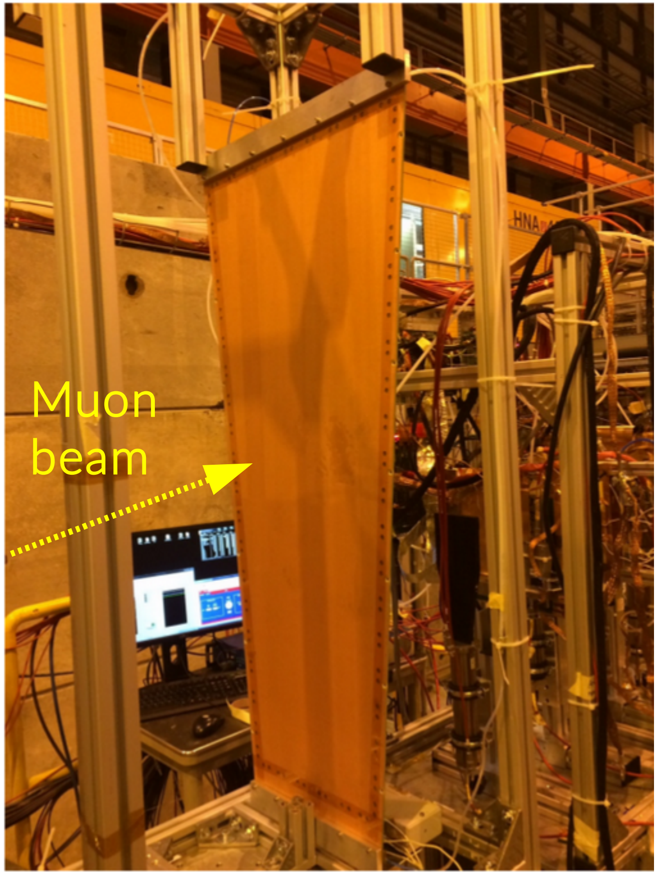
Technology trasfer to industry (Eltos, Techtra) started already 2 years ago.

Performance in test beam

Test beams: general info

- Test on large area prototypes (designed for CMS GE1/1 and GE2/1)
  - Surface Resistivity ~ 100 MOhm/□
  - Rate up to 100 kHz/cm^2
- Two test beams performed in CERN North Area :
  - H8 line:
    - Tested GE1/1 prototype with $Ar/CO_2/CF_4$ (45/15/40) gas mixture and VFAT FEE
    - Efficiency and time resolution
  - H4 line:
    - Tested GE2/1 prototype in Ar/CO_2 (70/30) gas mixture and custom electronics
    - Efficiency, uniformity and spatial resolution

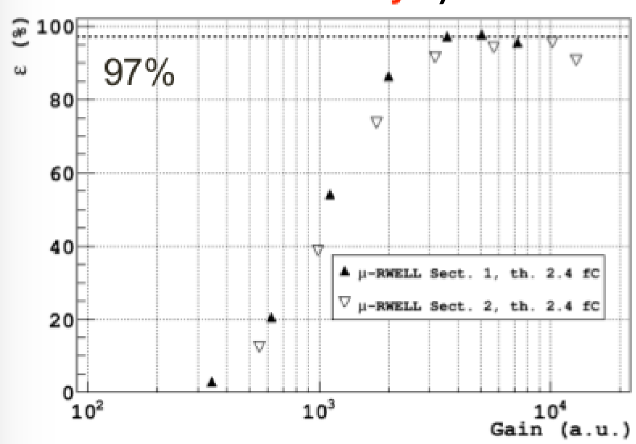
H8 test beam



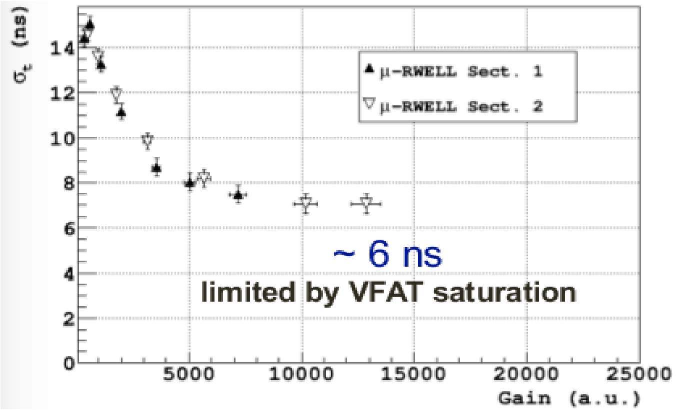
Ar/CO_2/CF_4
gas mixture

Refer to
L. Borgonovi
poster for more
details

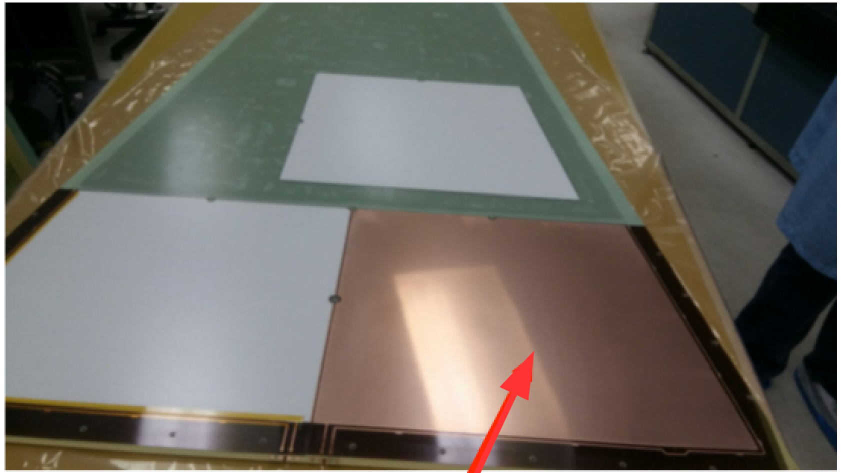
Efficiency



Time Resolution



H4 test beam



M4 MicroRWell

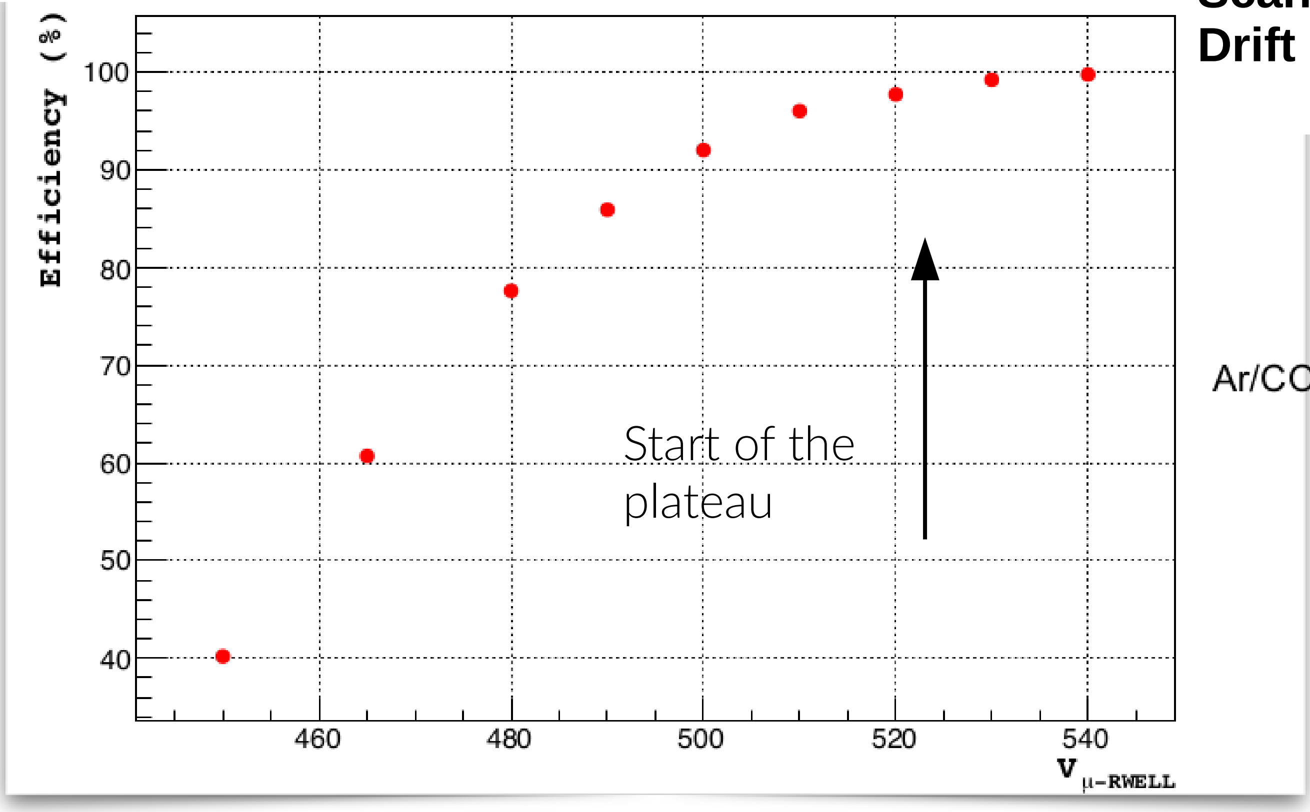
Trapezoid of ~55/60x 50 cm2
LARGEST ever built and operated

Great success of the collaboration between
INFN, ELTOS and Rui de Oliveira's workshop

Efficiency test

$$\text{Efficiency} = \frac{\text{\# hits (Tracker 1 \& Tracker 2 \& M4 right)}}{\text{\# hits (Tracker 1 \& Tracker 2)}}$$

Scan of HV
Drift field = 3.0 kV/cm



Ar/CO_2 70/30

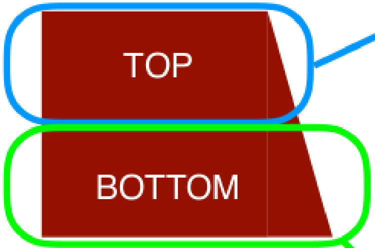
Homogeneity test

Efficiency = # hits (Tracker 1 & Tracker 2 & M4 right) / # hits (Tracker 1 & Tracker 2)

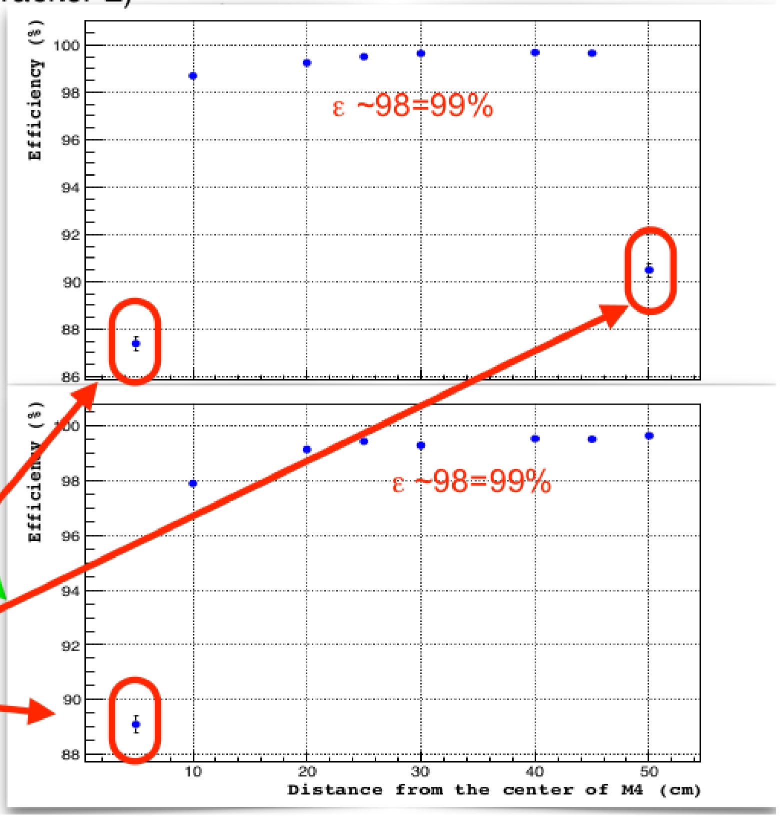
Muon beam

M4 right side:

- Drift Field = 3.0 kV/cm
- $V_{\mu\text{-RWELL}}$ = 530 V



M4 right scheme



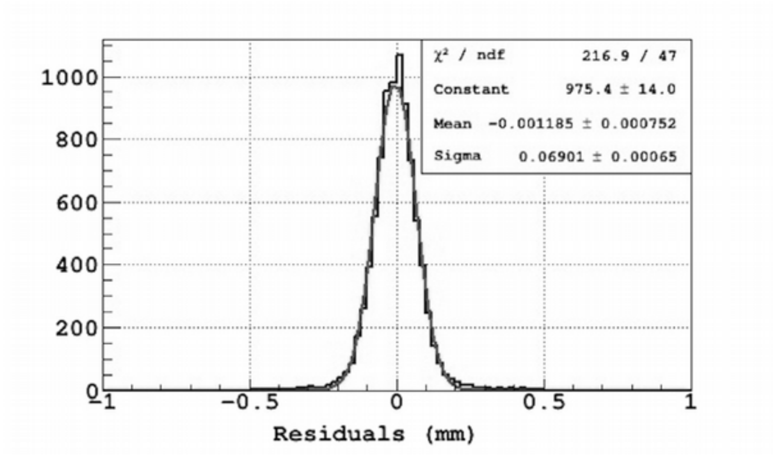
Beam on the edge of the detector

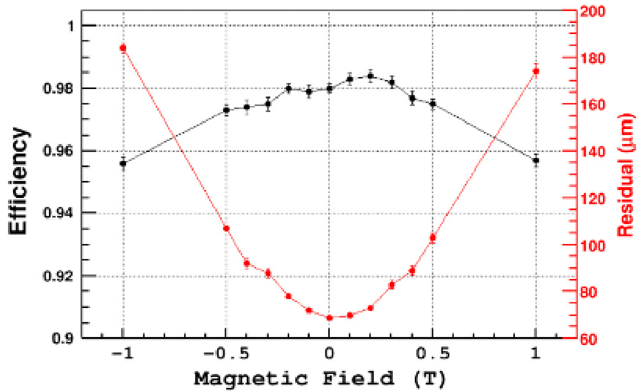
NOT inefficiency!!

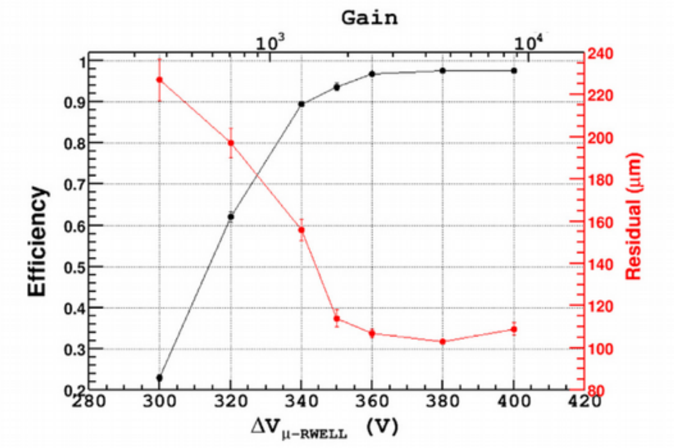
Position resolution

M. Poli Lener et al, NIMA 824 (2016)

Residual distribution to estimate the spatial resolution







With no magnetic field at gain ~ 3000,
σ_{xy} ~ 60 µm, degrades rapidly with magnetic field

Improvements on the spatial resolution can be obtained by implementing the microTPC readout

More on M. Poli Lener Poster

Summary of results

- At H8 line
  - Very good time resolution, σ_t < 6 ns (limited by Front End Electronics!)
  - Efficiency plateau for gain > 3000
  - Rate capability up to ~100 kHz/cm^2; tested on beam up to 35 kHz/cm^2
    - Test limited by maximum beam rate

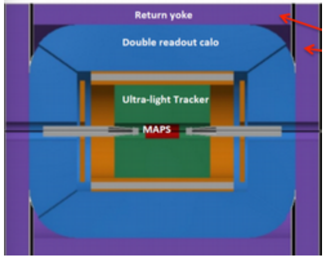
- At H4 line
  - Position resoluiton ~ 60 μm (no magnetic field)
  - Large Uniformity

Applications for CEPC

A technology reaches its full maturity once it is deployed in one HEP experiment

Applications

Muon tracker



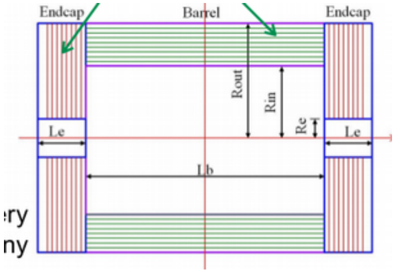
IDEA

Pre-Shower

MicroRWell

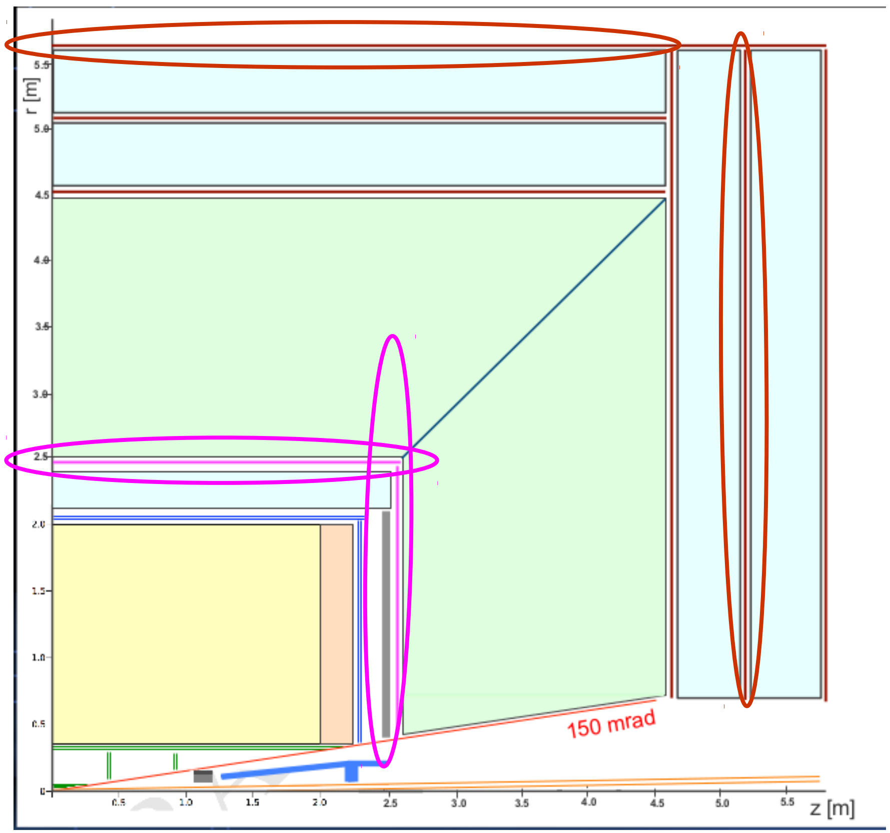
Muon tracker?

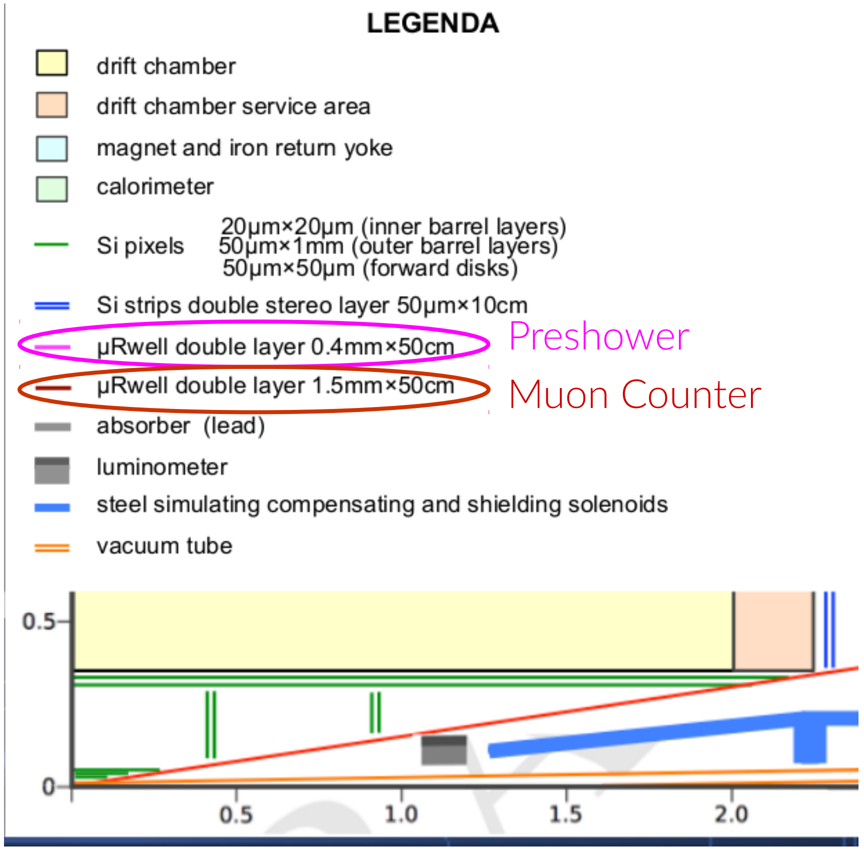
BASELINE



Active part of the high granularity calorimeter?

MicroRWell @ CEPC

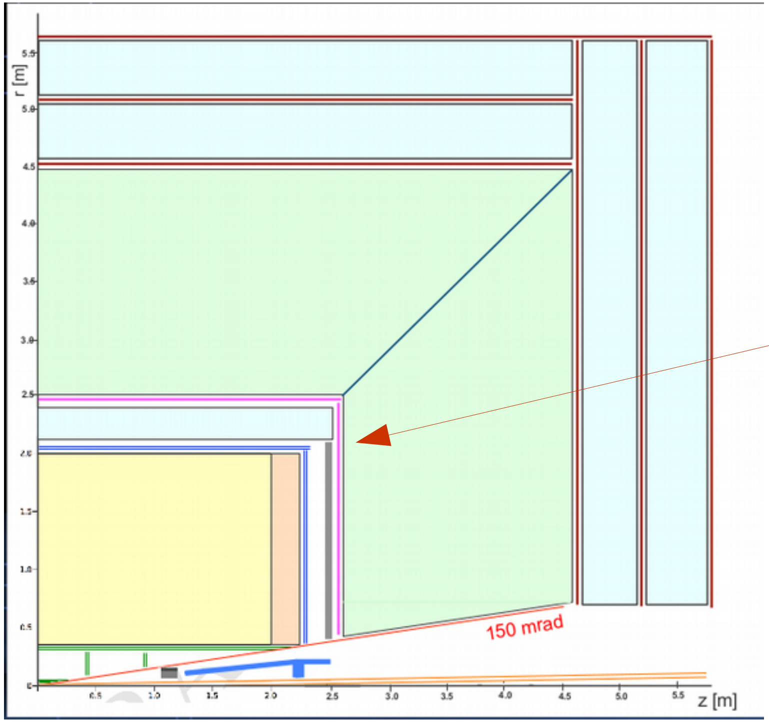




From F. Grancagnolo “IDEA Layout”

MicroRWell as IDEA Preshower

Preshower used to start the avalanche before the calorimeter to improve energy resolution and position measurement



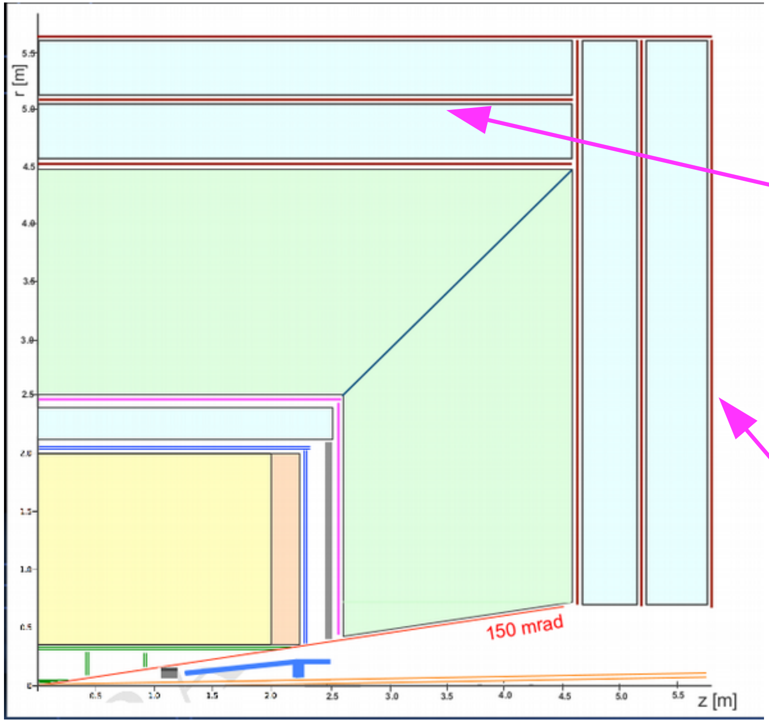
R [mm]	Length [mm]	Thickness [mm]	pixel size [mm]	area [cm^2]	# of channels
2450	±2550	20	0.4×500	785K	392K

Spatial resolution improves thanks to the use of micro-TPC algorithm

MicroRWell as IDEA Muon detector

Muons represents are crucial for the future CEPC physics program

$Z \to \mu\mu$
$W \to \mu\nu$
$H \to ZZ \to 2\mu$ or 4μ
J/ψ and $\Upsilon \to \mu\mu$
SUSY
Exotica



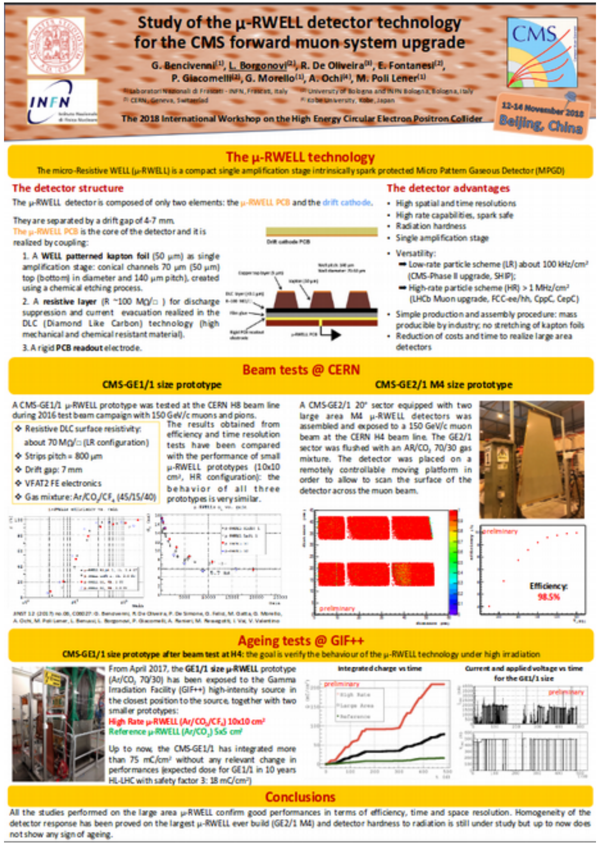
Layer	R [mm]	Length [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# of channels
μRwell	4550	±4600	20		1.5×500	2.6M	350K
iron	4600	±4600	500	2.5			
μRwell	5150	±4600	20		1.5×500	3.0M	400K
iron	5200	±4600	500	2.5			
μRwell	5750	±5900	20		1.5×500	4.3M	570K

Disk	R_{in} [mm]	R_{out} [mm]	z [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# of channels
μRwell	685	5540	±4650	20		1.5×500	1.9M	250K
iron	685	5540	±4540	500	2.5			
μRwell	685	5540	±5250	20		1.5×500	1.9M	250K
iron	685	5540	±5060	500	2.5			
μRwell	685	5540	±5560	20		1.5×500	1.9M	250K

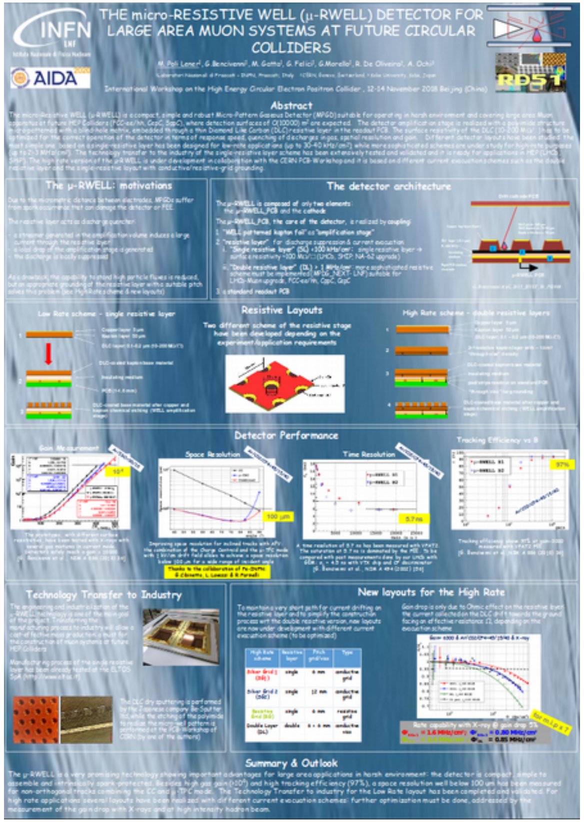
MicroRWell as IDEA Muon detector

- Each station will be composed of two layers of mono-dimensional MicroRWell
  - Better one layer of bi-dimensional MicroRWell: prototype available to be tested
  - Standalone muon momentum measurement
- Total surface to be covered: ~1000 m^2 barrel and ~600 m^2 endcap
- Today's dimension for single microRWell 50x50 cm^2
  - ~500 channels per detector
  - Spatial resolution ~270-300 μm (will remain the same thanks to the microTPC technique)
  - Time resolution: ~5-7 ns
  - Effiicency > 98% per station (with 3 station ~ 100%)

Two posters!



Lisa Borgonovi



Marco Poli Lener

Summary and outlook

- MicroRWell are a innovative Micro Pattern Gas Detectors
  - Inherit the multiplication stage from GEM, construction scheme from MicroMegas
  - Improves spark protections
- First indications on large area prototypes show:
  - Very good time resolution
  - Large Effiiciency
  - Competitive spatial resolution with pitch > 1 mm
  - Very good homogeneity
- They are th natural candidate for the future CEPC muon detectors
  - Thanks to the resistive bulk they can also be used as Preshower

THANKS!

Artwork © 2009 Phil Allora

ADDITIONAL MATERIAL

MicroTPC readout

First Developed by ATLAS for MicroMegas

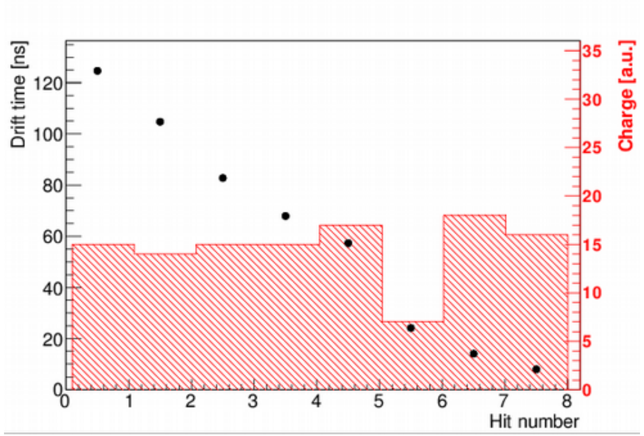
Take advantage of the knowledge of time information to extract the position of the track

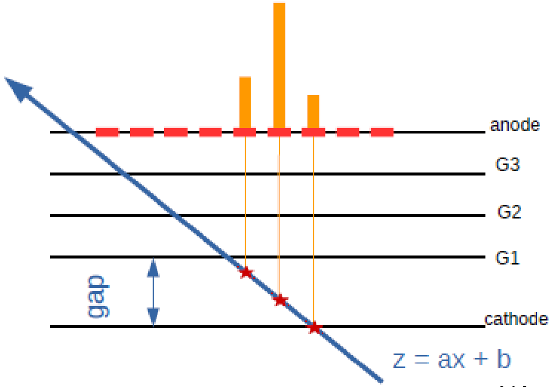
Drift velocity is extracted from GARFIELD simulation.

Produce a collection of bi-dimensional points in the conversion region

Position is extracted from a linear fit

$$x = \frac{\frac{gap}{2} - b}{a}$$





Muon detector dimensions, channels, cost

- Muon detector with 3 layers in both barrel and endcaps
  - Barrel surface ~1000 x 2 (layers) = 1200 m^2
  - Endcap surface ~600 x 2 (layers) = 1200 m^2
- μRWELL Detector dimensions 50 x 50 cm^2
- Strip pitch ~ 1000 μm (1 mm)
- Total number of channels ~7 million
- Position resolution ~300 μm per layer in both spatial directions
- Time resolution ~ 5 ns

- Today's μRWELL cost ~5 keuro/m^2
  - Mass production by industry should decrease this cost by at least a factor of 2 → 2.5 keuro/m^2
  - Cost for the whole muon detector ~8 Meuro
  - Cost of electronics and services ~13-16 Meuro
  - Total cost ~21-24 Meuro

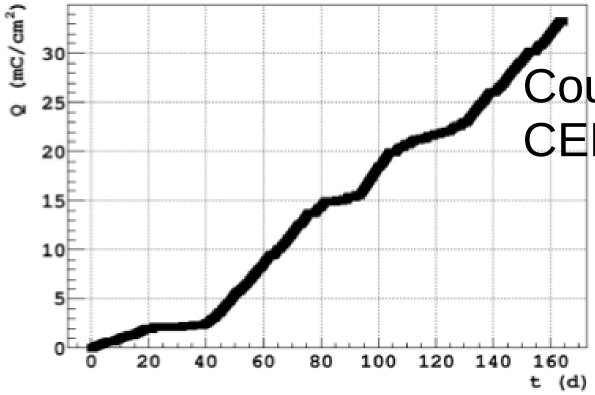
Courtesy of P. Giacomelli
CEPC CDR Int. Review

CMS GE1/1 μ-RWELL: GIF++ ageing test

1) **GE1/1 μ-RWELL** ($ArCO_2$)

2) **“high rate” μ-RWELL**
($ArCO_2CF_4$) 10cmx10cm

3) **reference μ-RWELL**
($ArCO_2$)
10cmx10cm



Courtesy of P. Giacomelli
CEPC CDR Int. Review

GE1/1 has accumulated a dose of ~32 mC/cm^2 (more than 10 times the dose after 10 years of HL-LHC)

μRWELL prototypes exposed inside the GIF++