Micromegas Detectors in CAST

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DT Science-Techno Meeting
23 June 2011

Outline

- Micromegas Detectors
- Micromegas Detectors in CAST
- Improvements – Background
- Event Selection
- Cast Detector Lab

The Micromegas Detector

Gaseous detector with two regions

Conversion region

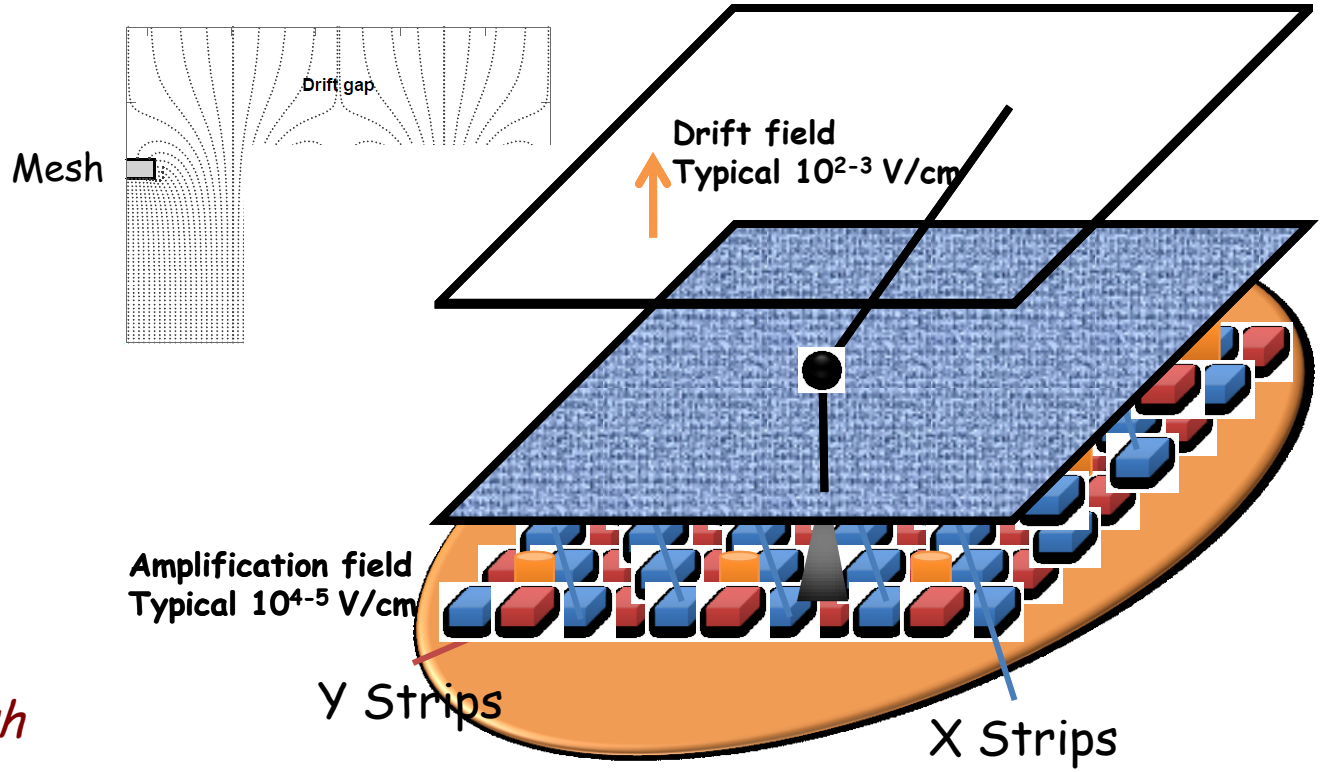
- Primary ionization
- Charge drift

Amplification region

- Charge multiplication
- Readout layout

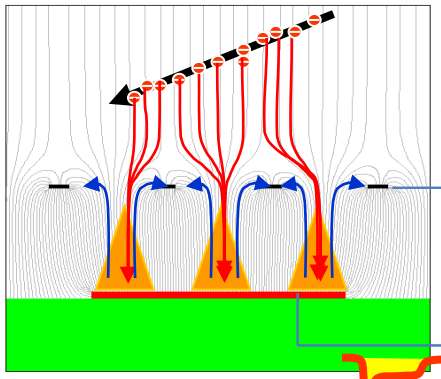
Separated by a Micromesh

- Very strong and uniform electric field



192 X Strips
192 Y Strips

Trigger and Readout



Mesh signal

strips signal

Amplifier + Shaper

FI/O

MATACQ

Discriminator

Timing Signals

Sequencer

Data ready

Gassiplex card

CRAM

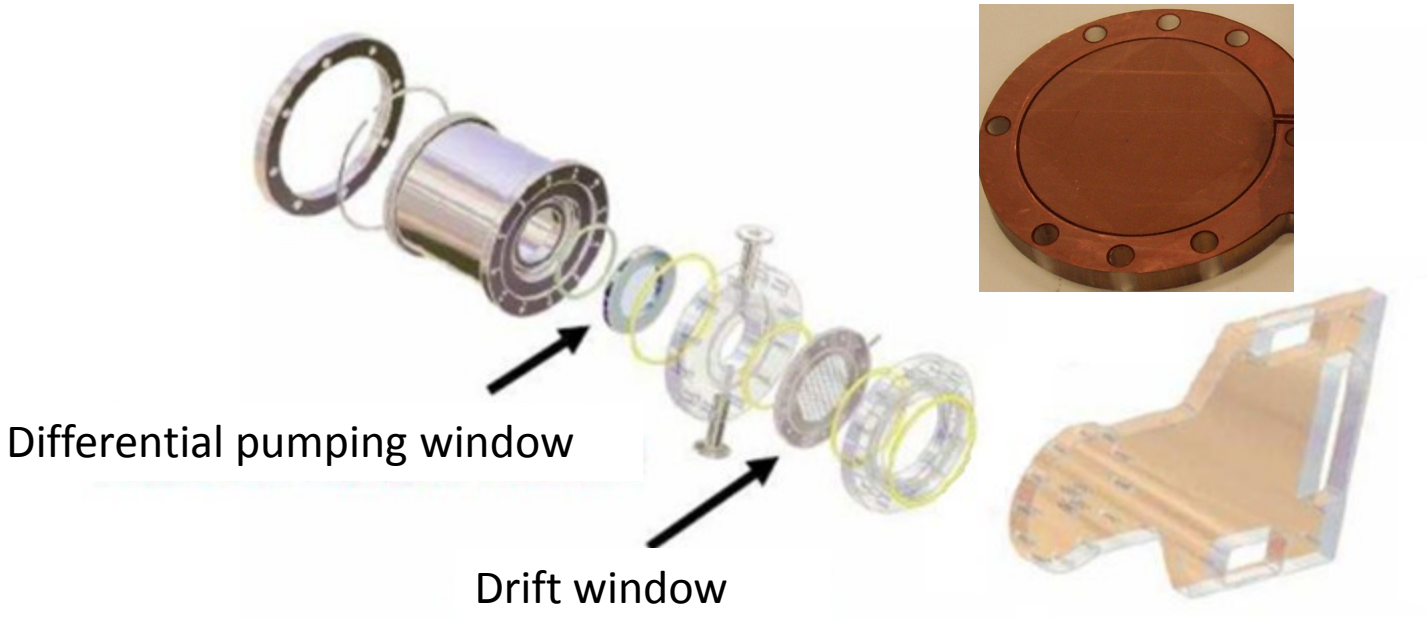
Clear

Micromegas Detectors in CAST

Classic technology (CAST Phase I & CAST Phase II ^{4}He run)

Bulk technology (CAST Phase II ^{3}He run)

Microbulk technology (CAST Phase II ^{3}He run - present)



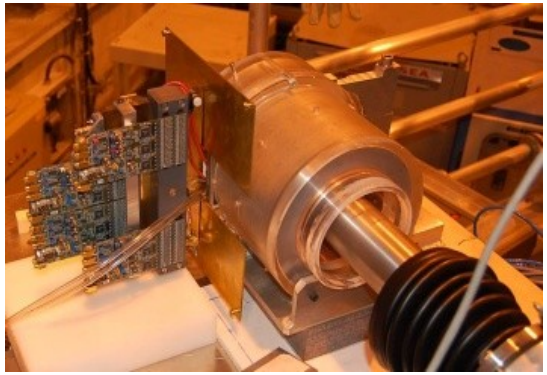
Improvements

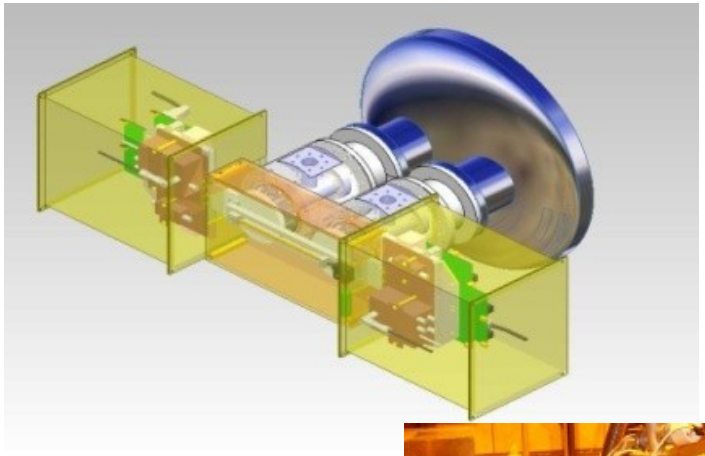
In line improvements

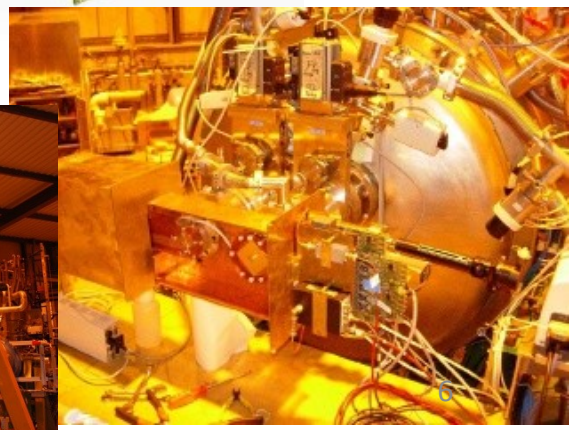
- The μM Sunrise line has been redesigned for introducing Shielding.

Sunset side:

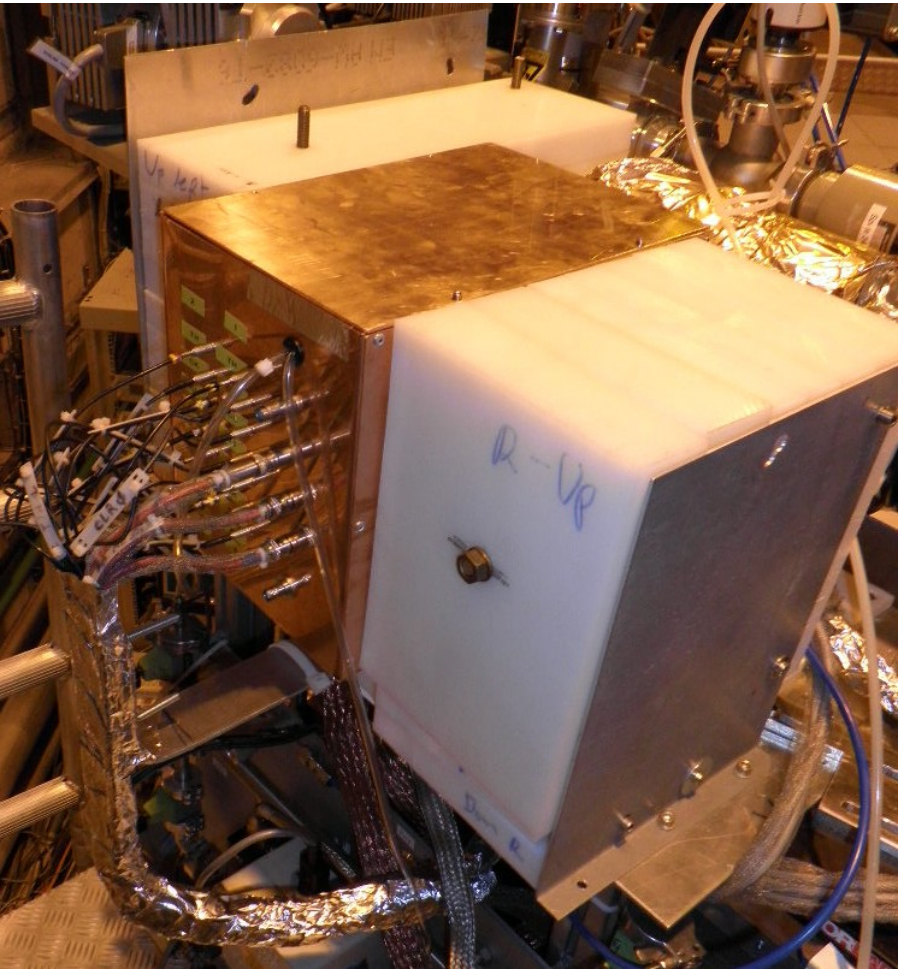
- Both detectors are μM
- Very good shielding!!

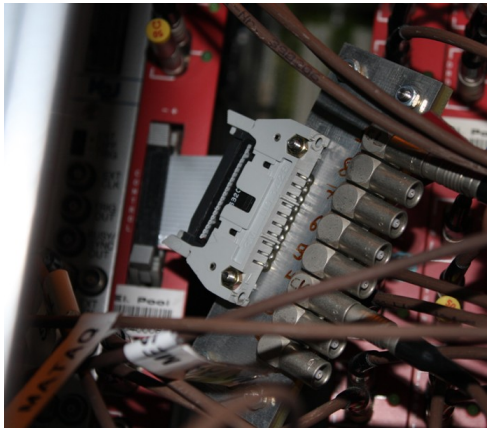


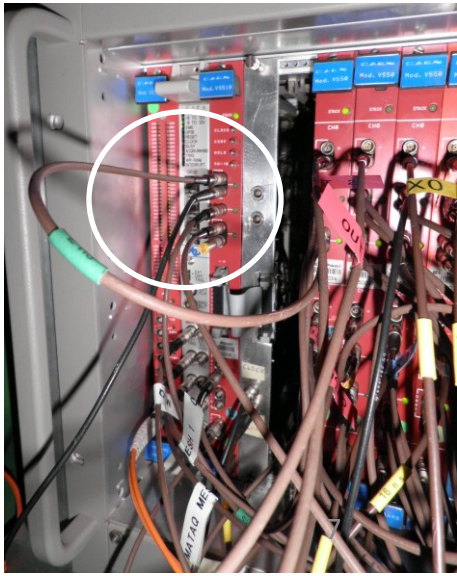




Intervention mid April 2010

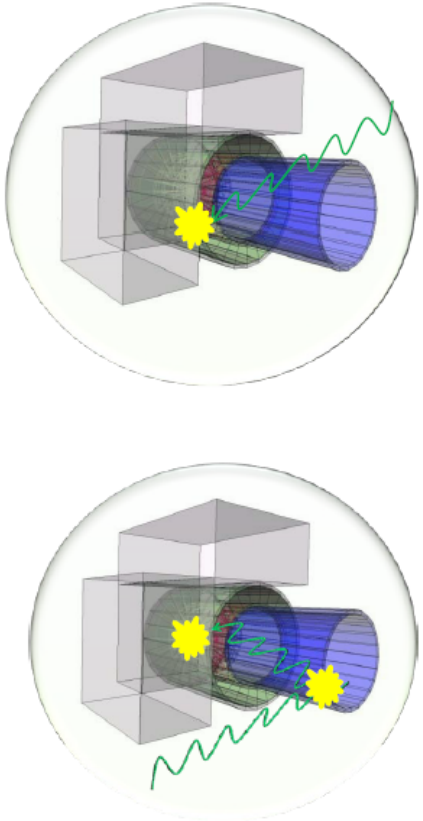




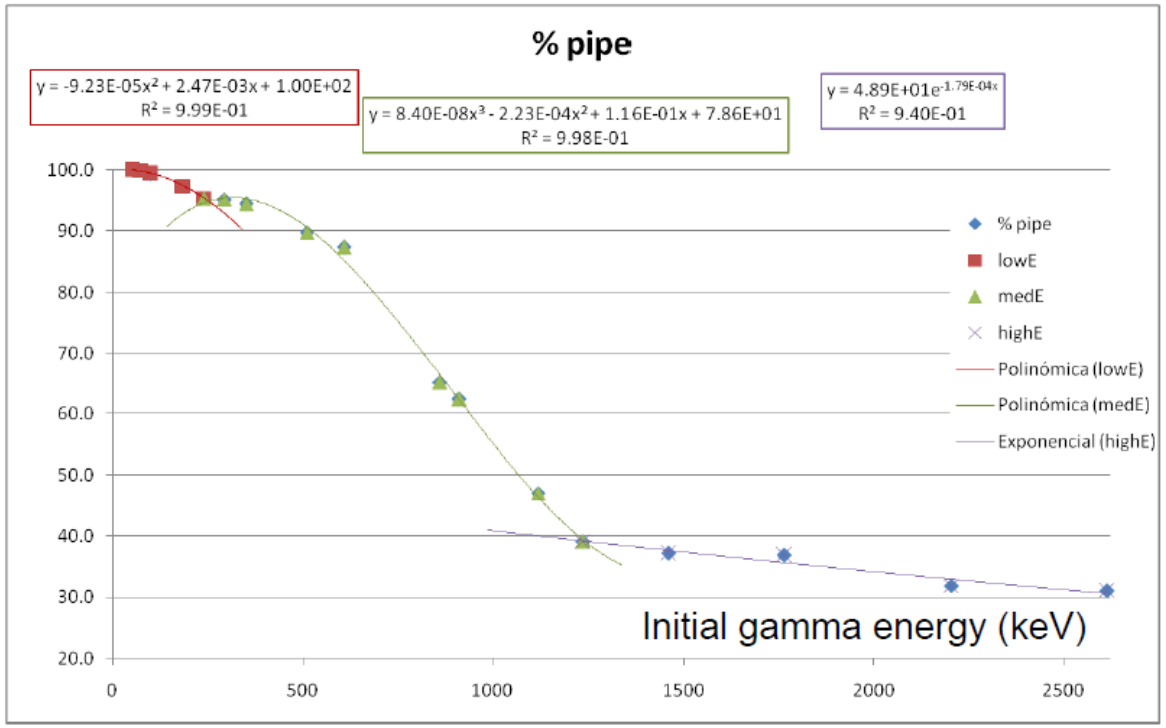


Simulation Studies

Building a Model: contribution of the pipe.

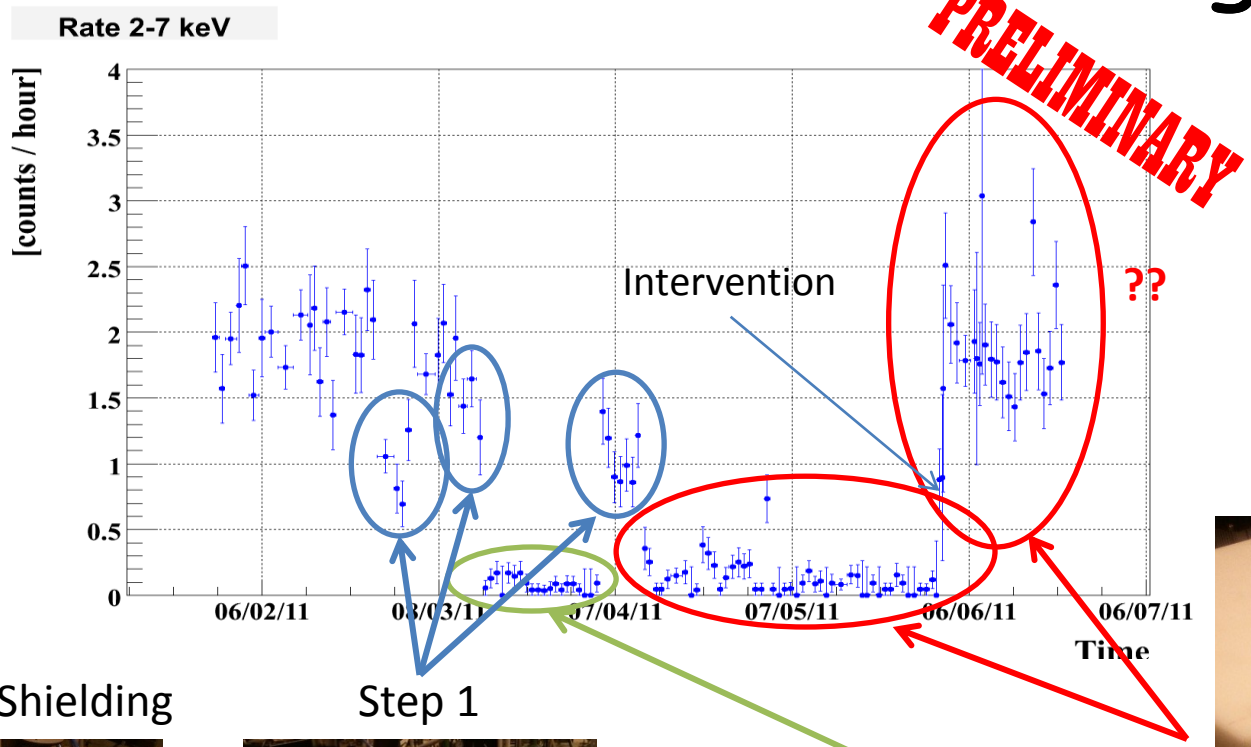


Virtual sphere radius ≈ active length of the pipe
= 37,5 cm



Total contribution for all the Energies from the pipe : 50%

Intervention February 2011
New front shielding

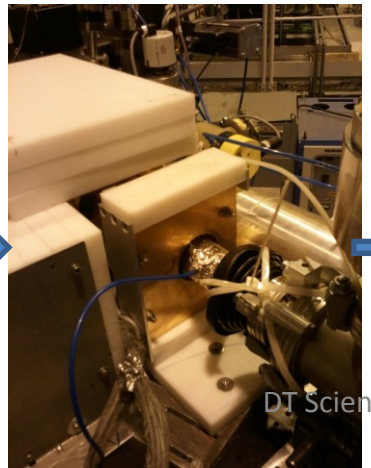


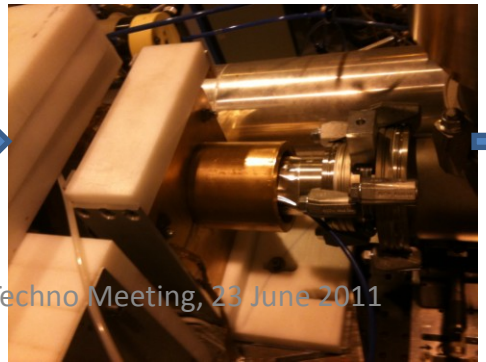
No Front Shielding

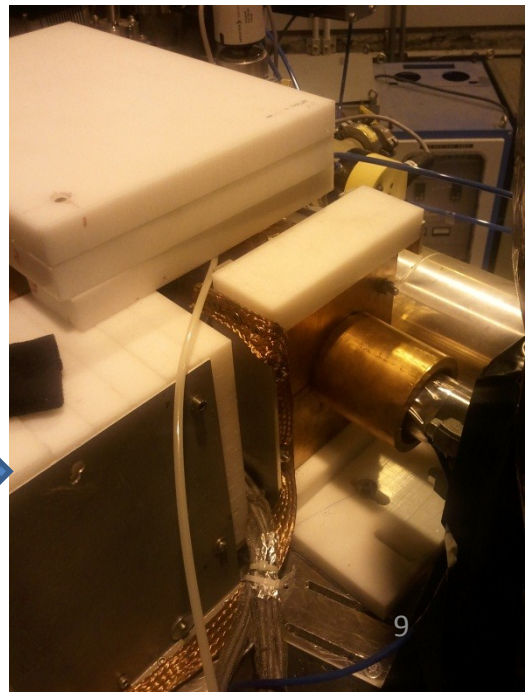
Step 1

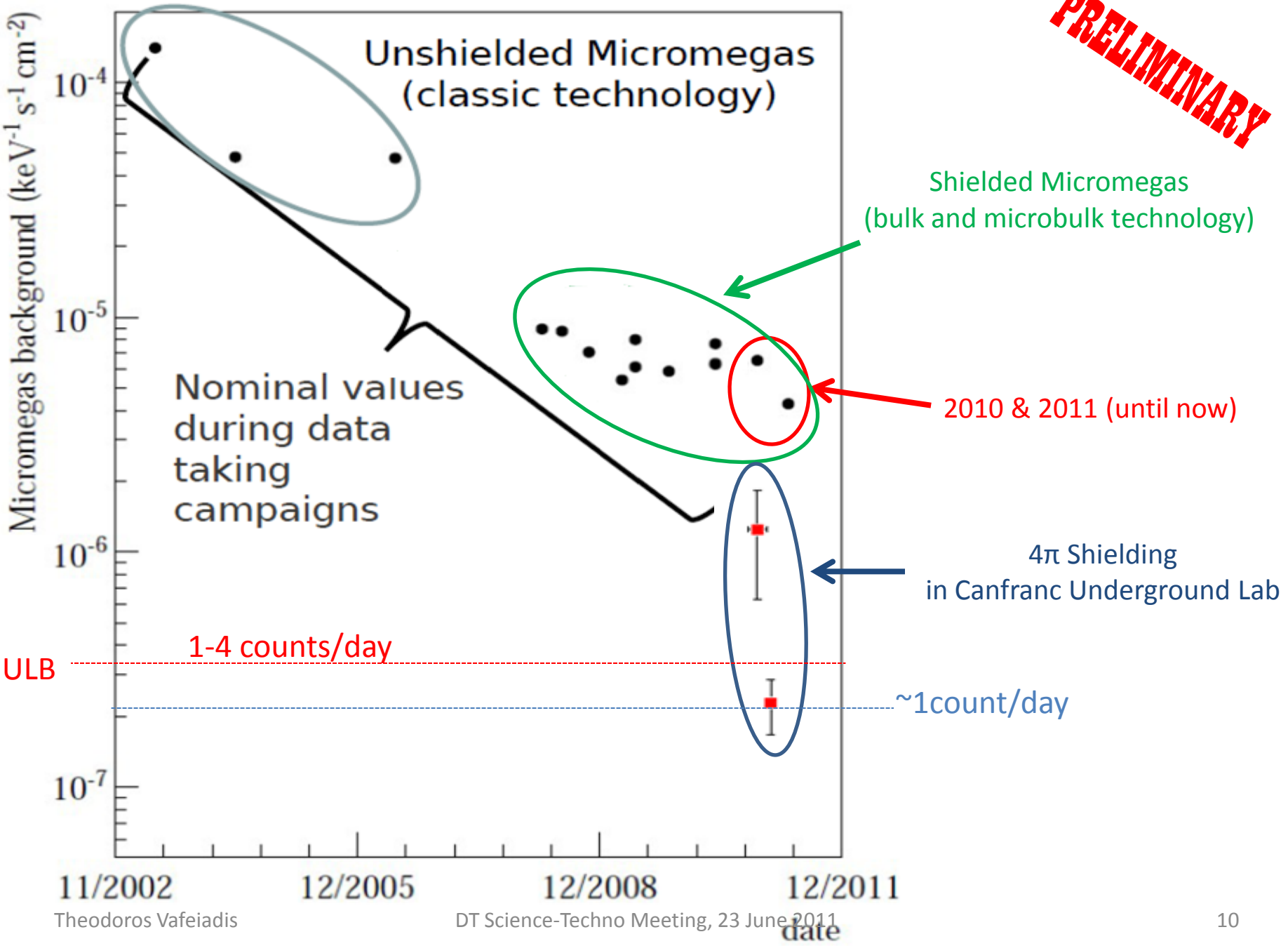
Step 2

Step 3








PRELIMINARY
Unshielded Micromegas
(classic technology)
Micromegas background (keV^{-1} s^{-1} cm^{-2})
10^{-4}
10^{-5}
10^{-6}
10^{-7}
Nominal values
during data
taking
campaigns
Shielded Micromegas
(bulk and microbulk technology)
2010 & 2011 (until now)
4π Shielding
in Canfranc Underground Lab
1-4 counts/day
ULB
~1count/day
11/2002
12/2005
12/2008
12/2011
date

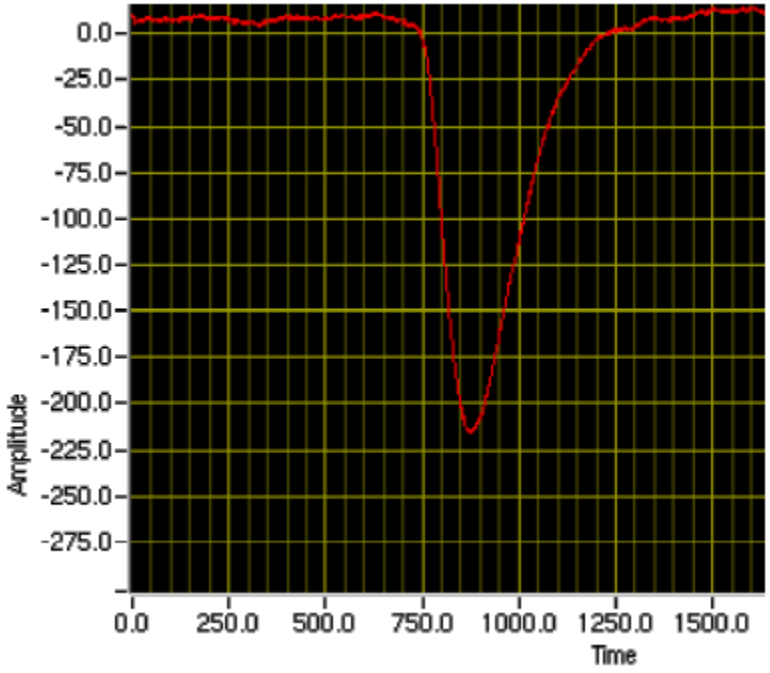
Event selection

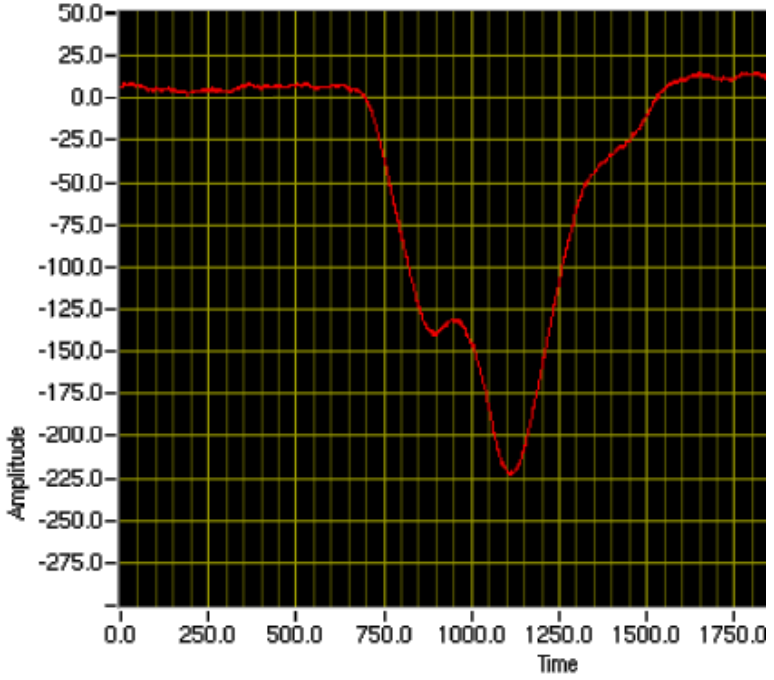
- Electronics trigger Threshold : <1keV

- Daily calibration with ^{55}Fe source (X-Ray signal characteristics)

X-Rays :

- Short risetime and pulse width for the analogue signal
- Charge in one cluster of few strips per axis





Event selection

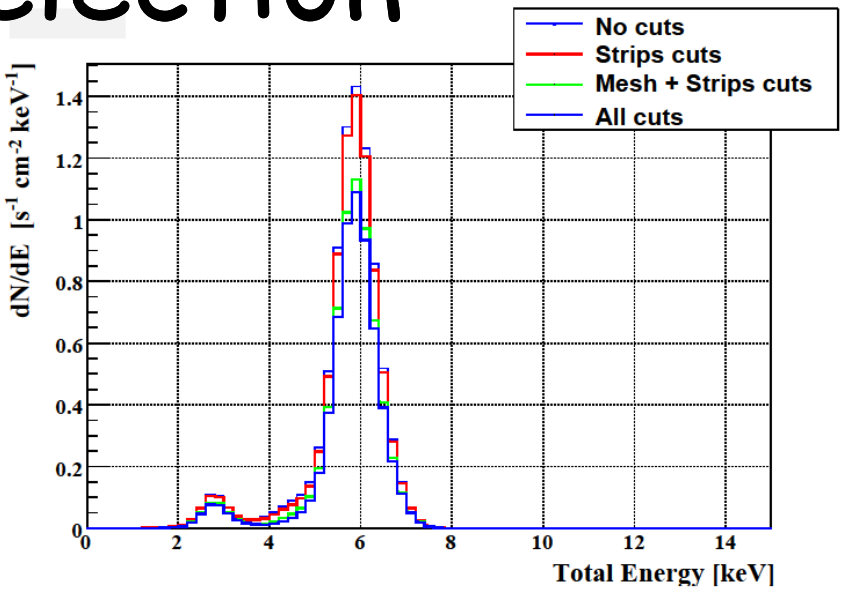
Event Selection : distinguish the X-Ray signals from the background (mainly cosmic)

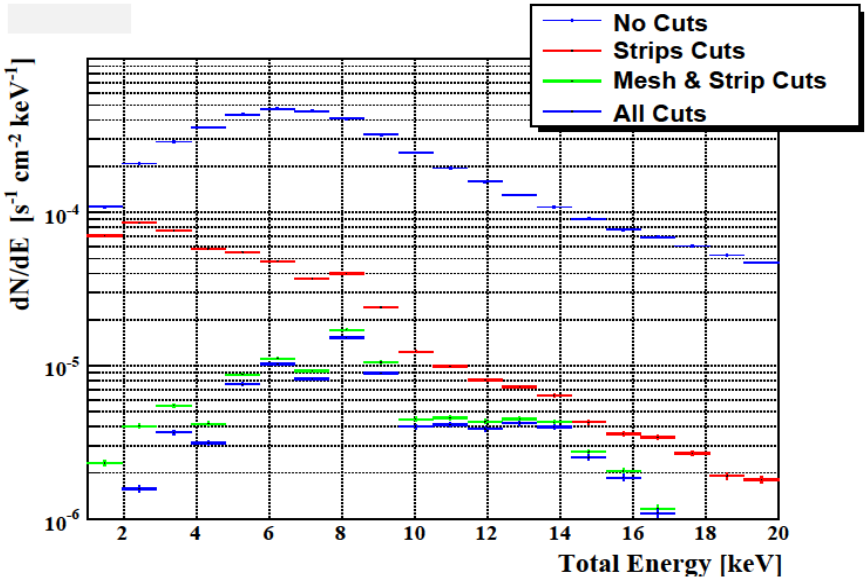
- Time information of the charge measured on the mesh (risetime, width, amplitude, pulse integral)
- Space information of the charge on the strips (multiplicity, width, topology of clusters)

Three different types of cut selection:

- Sequential
- Multivariate analysis
- Neural networks

Data reduction: Better than 3 orders of magnitude!

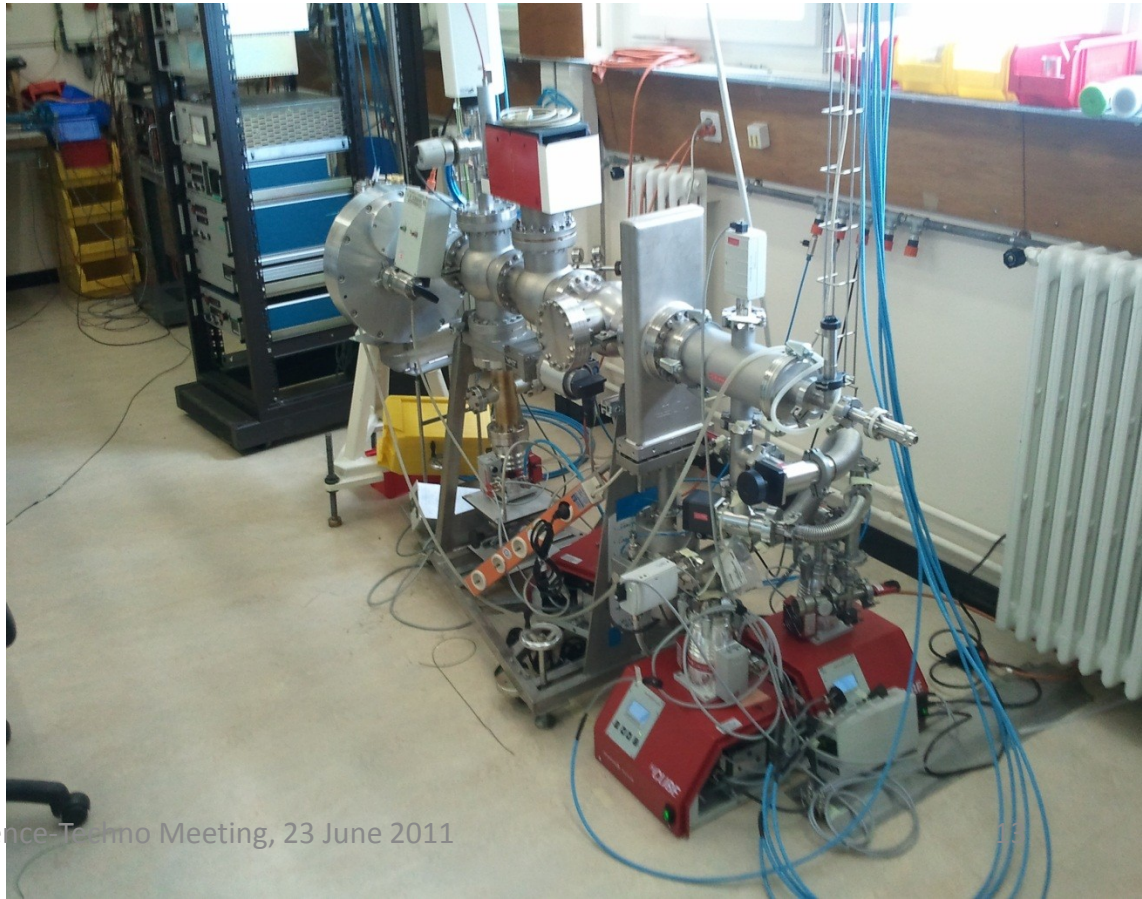




Cast Detector Lab

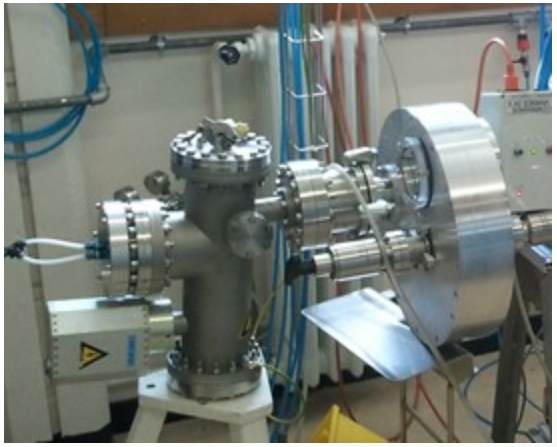
- Need to Calibrate detectors for the whole energy range of interest (2-7 keV)

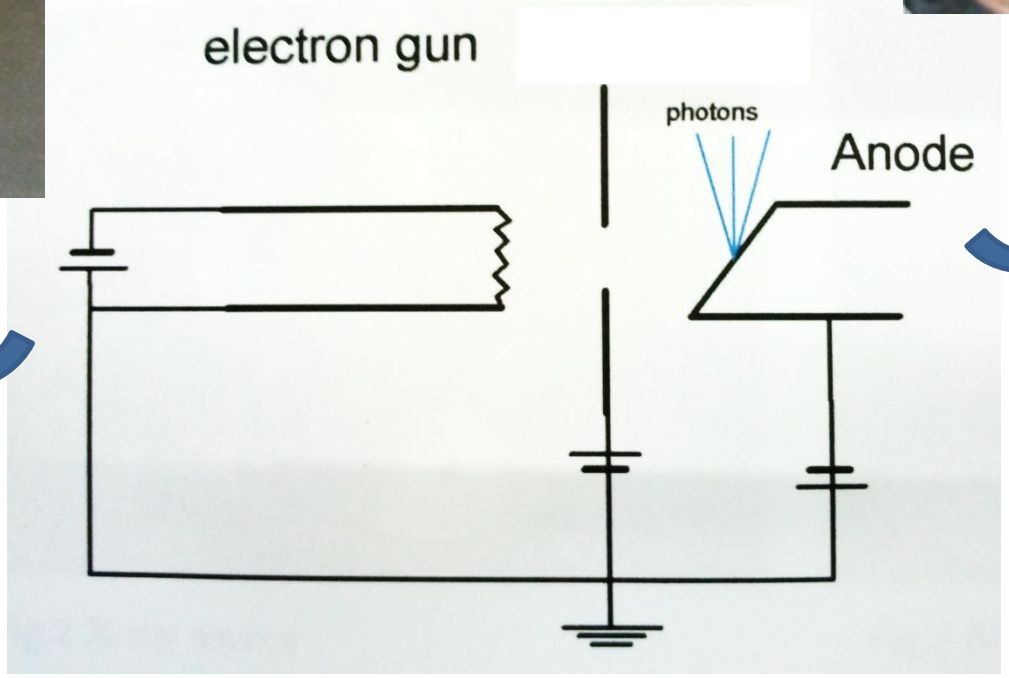
X-ray tube:
Designed built and tested in Max-Planck institute



X-ray tube : details

Emission lines:
0.28keV < E < 17.4keV





Labview Based:

- ✓ Slow Control
- ✓ Data Acquisition
- ✓ Radon Detector

- ✓ Ready on bench calibration setup
- ✓ Will be fully tested next week
- ✓ Ready to mount a detector on the X-ray tube by end of July??????

Thank you

Micromegas Detectors in CAST

Classic technology

- The pillars are attached to the mesh. A supporting ring or frame is adjusting the mesh on top of the readout plane
- Typical dimensions: mesh thickness 5 μm, gap 50 μm

Bulk technology

- The pillars are attached to a woven mesh and to the readout plane
- Typical dimensions: mesh thickness 30 μm, gap 100 μm

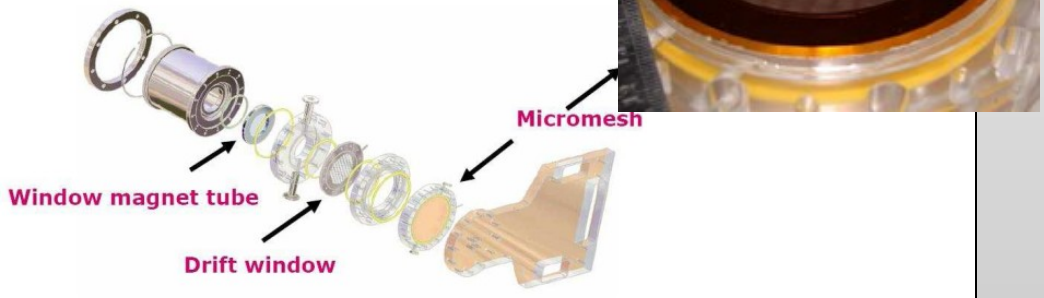
Microbulk technology

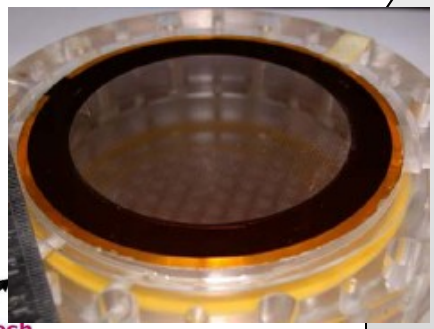
- The pillars are constructed by chemical process of a kapton foil, that is attached to the mesh and to the readout plane
- Typical dimensions: mesh thickness 5 μm, gap 25 or 50 μm

Micromegas Detectors in CAST

CAST Phase I & CAST Phase II ^{4}He run

- Conventional technology Micromegas - not shielded. (Sunrise side)
- Typical dimensions: mesh thickness 5 μm, gap 50 μm
- Readout :192 x 192 strips, 350 μm pitch
- Gas mixture: 95% Ar, 5% Isobutane @ 1 bar (flamable)





The pillars are attached to the mesh or the readout plane. A supporting ring or frame is adjusting the mesh on top of the readout plane

✓All "Micromegas advantages" (material selection, spatial resolution, field uniformity, stability…)

✓Good energy resolution (mesh quality)

✓Mesh can be replaced easily

Mesh not attached + support frame:

×Resolution limitations

×Dimension limitations / large detectors

×Large scale production

×Curved surfaces

X-Ray detection Threshold: ~0.6keV

Background 4.8×10^{-5} events $keV^{-1}s^{-1}cm^{-2}$

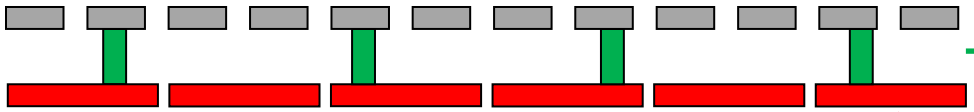
Micromegas Detectors in CAST

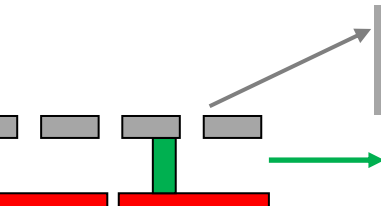
CAST Phase II ^{3}He run

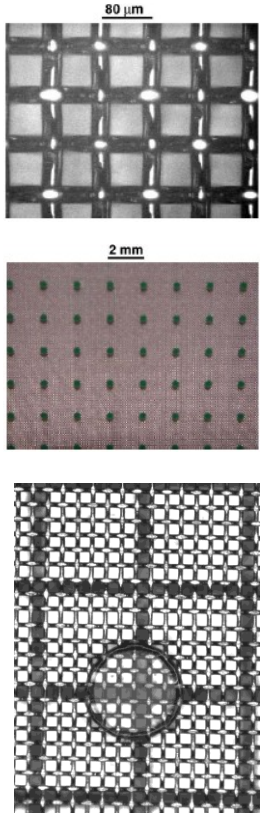
- two new types of MICROMEGAS technologies : Bulk and Microbulk

Bulk

- Stainless steel woven mesh of 30 mm thickness is placed on top of the readout strips by insulating pillars

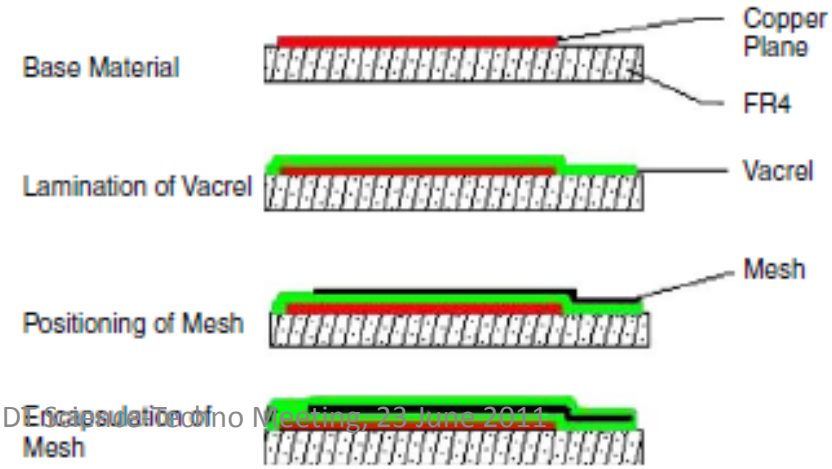






Advantages:
Uniformity, Reachable resolution (~18 FWHM, due to the thickness of the mesh), very robust, low noise due to lower capacity, easy to construct

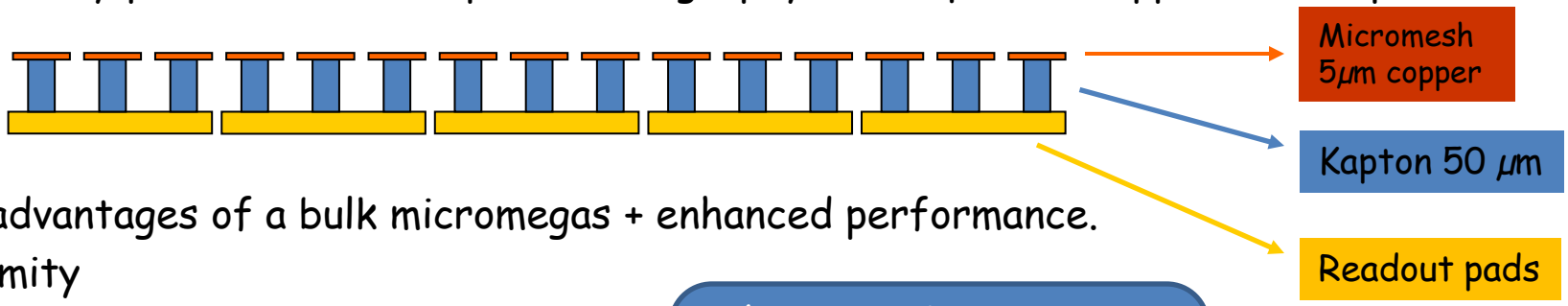
Disadvantages:
higher risetime, sensitive to pressure variations in the CAST operating conditions, stability in the same conditions.



Micromegas Detectors in CAST

Microbulk

High accuracy photo-chemical & photo-lithography techniques on copper-clad Kapton foils



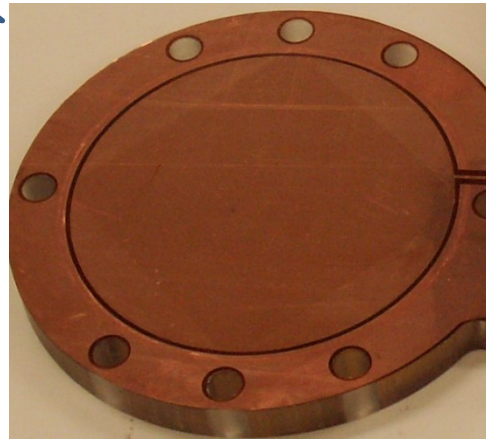
All the advantages of a bulk micromegas + enhanced performance.

- Uniformity
- Clean materials
- Very flexible structure
- Stability at long term runs
- Less sensibility to pressure variations
- Energy resolution (<13% FWHM @ 6 keV)
- Low intrinsic background & better particle recognition
- Low mass detector

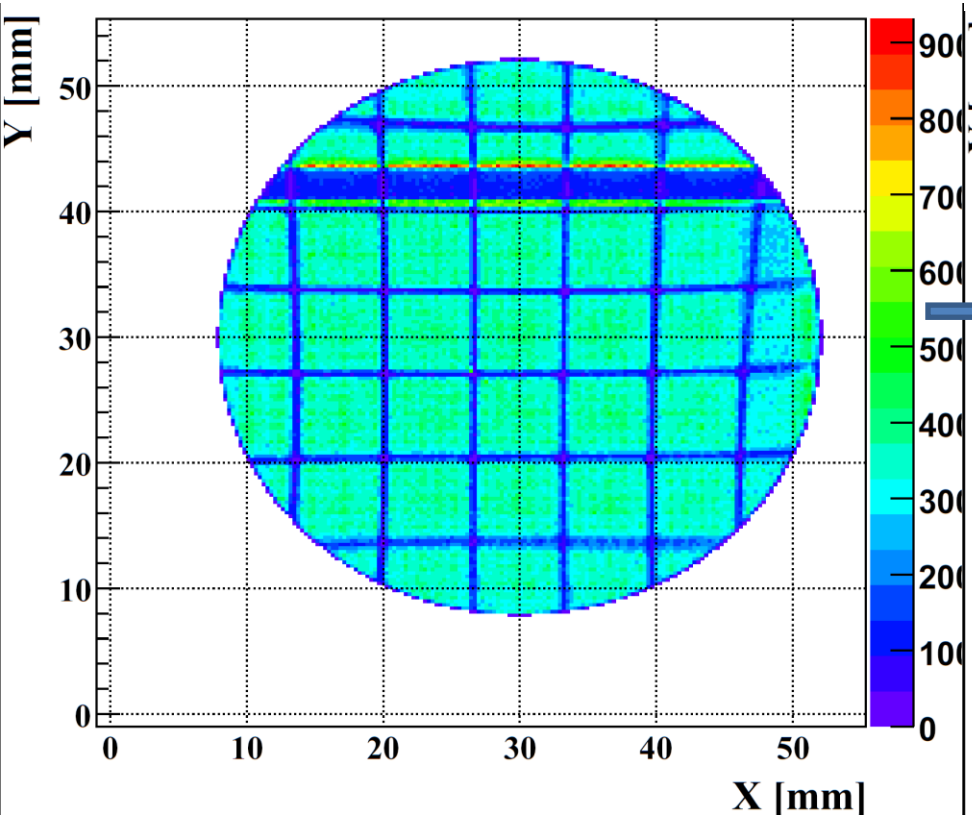
best option versus the Bulk technology for the CAST experiment.

Disadvantages

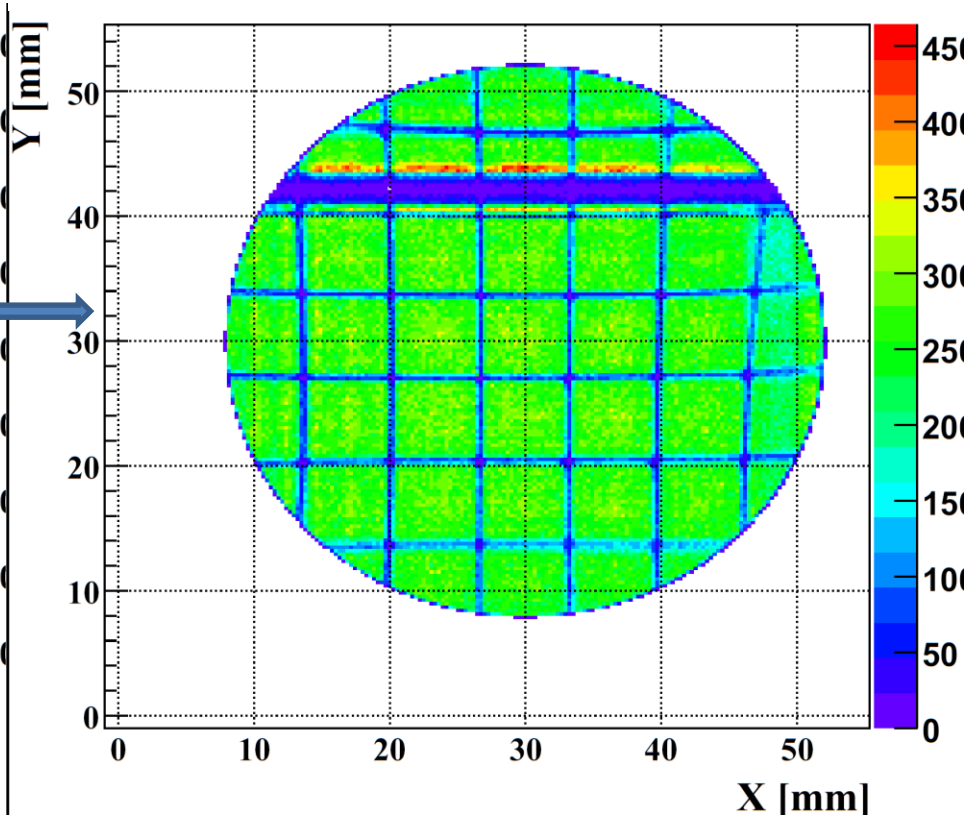
- Higher electronic noise due to higher capacity
- Complexity of the fabrication process
- Fragility / mesh can not be replaced



Event selection



before cuts



after cuts