Florida Academy of Sciences

# Development of Novel Gas-Based Micro-Channel Plates (MCPs) for Subatomic Particle Detection.

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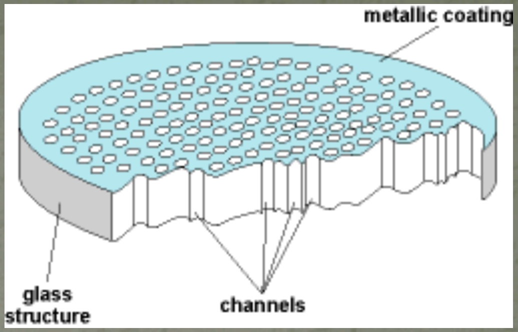
# What are they?




- Made from a borosilicate glass functionalized with a resistive and a secondary emissive coating both applied by atomic layer deposition (layer of metal oxide) …
- Kind of a hybrid detector where gain comes from two mechanisms :
  - Metal oxide layer
  - Gas gain
- The biggest assets of these detectors is their robust performance in magnetic fields. (Va'vra 2003 *IEEE Nuclear Science Symposium*)

# History of MCPs

- They have been there since 1985. (Probably the first paper)

IEEE Transactions on Nuclear Science, Vol. NS-32, No. 1, February 1985 687

ELECTRON TRANSMISSION AND AVALANCHE GAIN IN NARROW LEAD GLASS TUBING*

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Abstract

Electron drift structures have been manufactured from small diameter lead glass tubing. Baking the tubing in a reducing atmosphere produces a resistive metallic layer which can be used as a continuous

The solution usually proposed to suppress this photon feedback is to mechanically block the transmission of the avalanche light from regions where it might initiate secondary avalanches which could multiply to full amplitude. As an alternative to the somewhat awkward "cloison" scheme described by

- The earliest MCPs were used as pre-amplifiers to the Multi Wire Proportional Chambers (MWPCs) or as a standalone proportional counter.

# History contd …

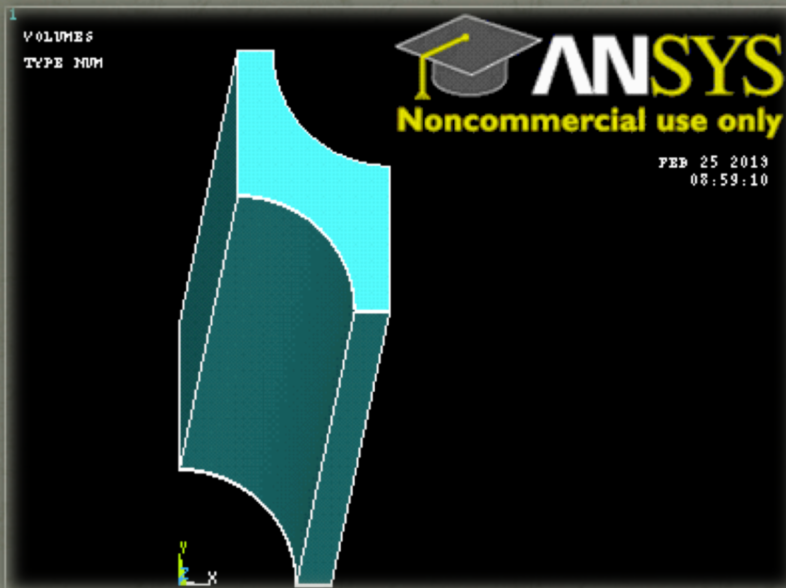
- The first successful operation of MCPs (both single and double) as standalone detectors used along with photo-cathodes was shown by V. Peskov. *
- Gas gains as high as $10^4$ (single MCPs) were observed .
- Most of the testing done on GCPs (Glass capillary tubes), which are MCPs not treated with $H_2$. Significant charging up

*(NIM A 433 (1999) 492-501)

# So why is it NOVEL then?

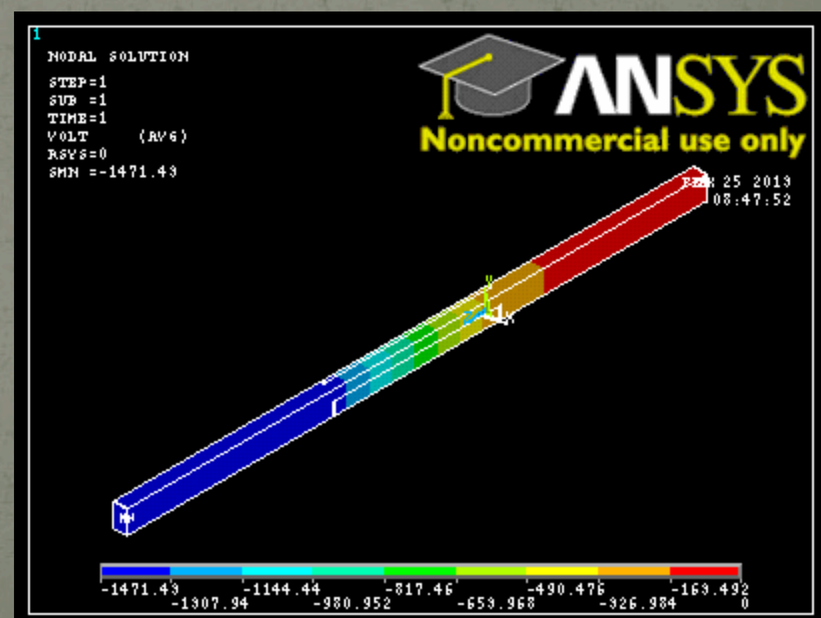
- Gas-based MCPs with emissive coating have never been tested.
- Also the use of MCPs as a standalone detector for measuring the position of the extracted electron clouds (an approach similar to GEMs) has not been properly investigated.
- No prior knowledge of a gas mixture which could work for metal oxide coated gaseous MCPs(Magboltz simulation tells us it has to be a helium based mixture, still undecided about the quencher …)

# Ansys model of MCPs

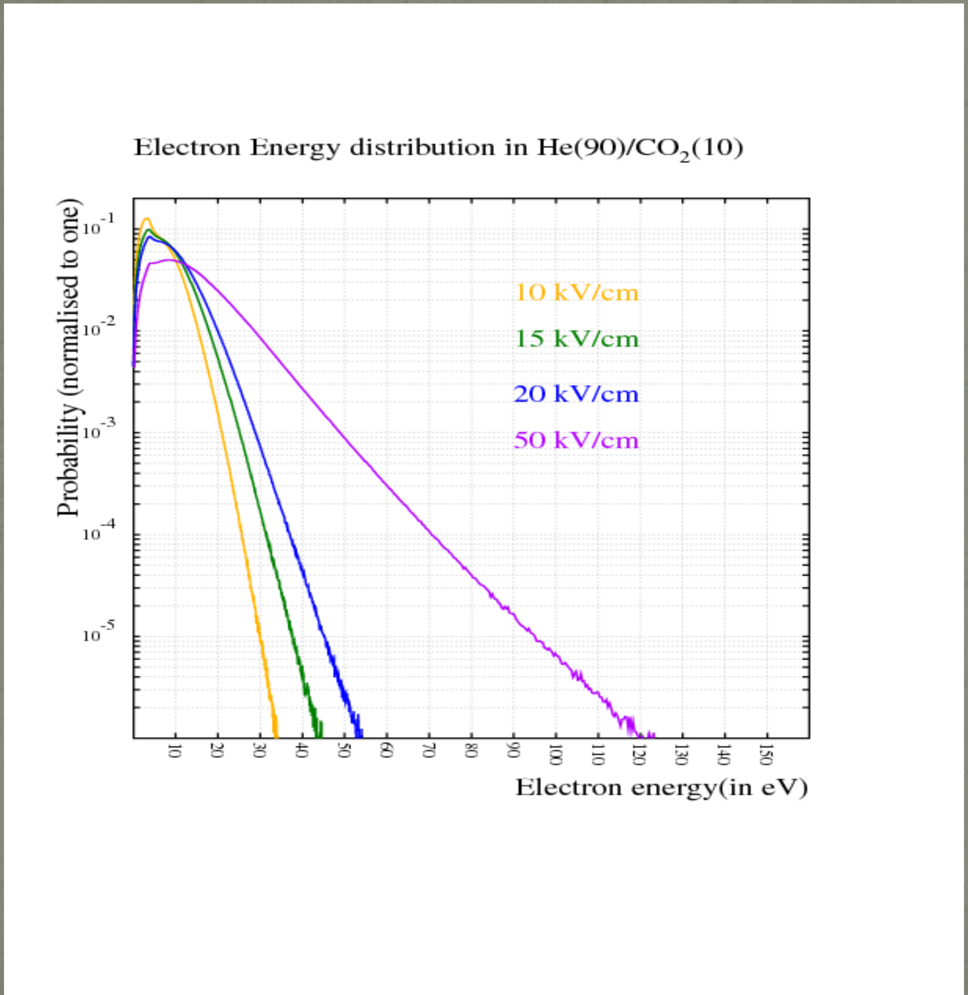



Just the dielectric, simulating half a hole …

Post-processed MCP (potential map from cathode to anode)

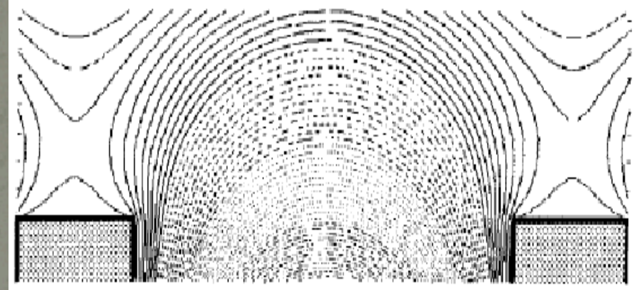


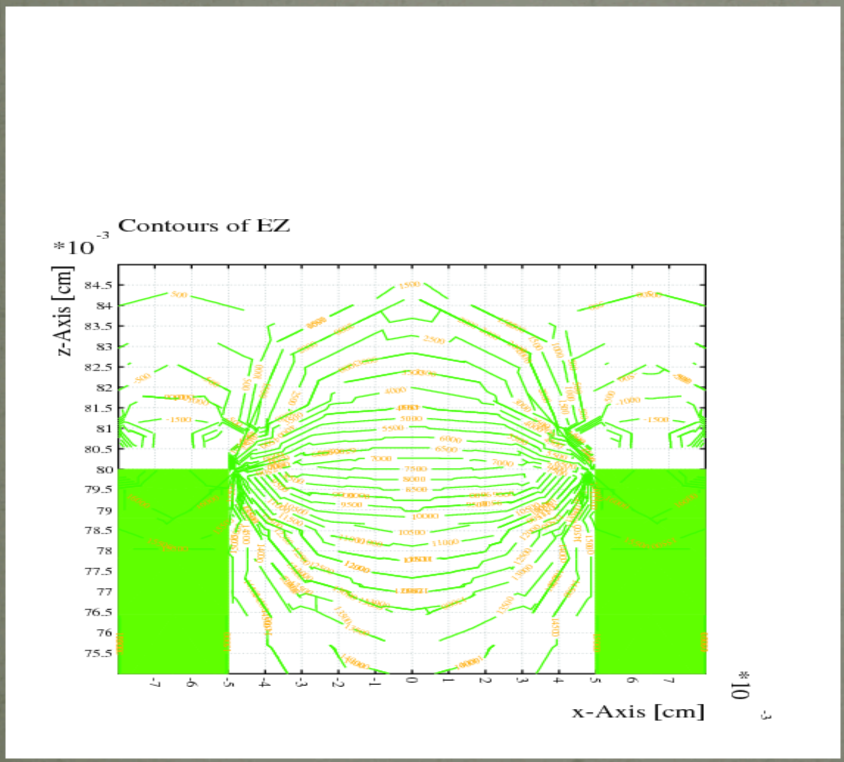
# Energy distribution in gas (Magboltz)

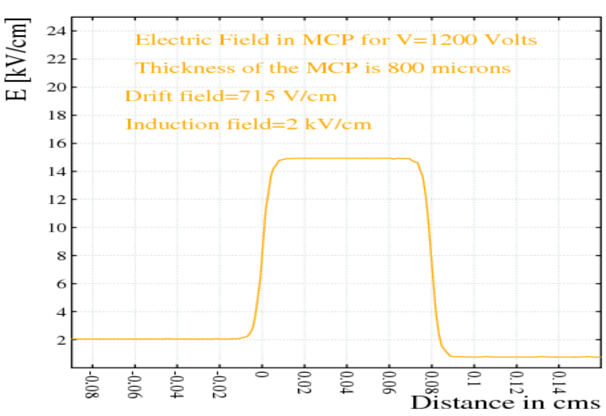



Only gas mixture where the probability of electrons having an energy more than 80 eV is non-negligible

# Electric field in GCPs (T.Tamamura *et al*)

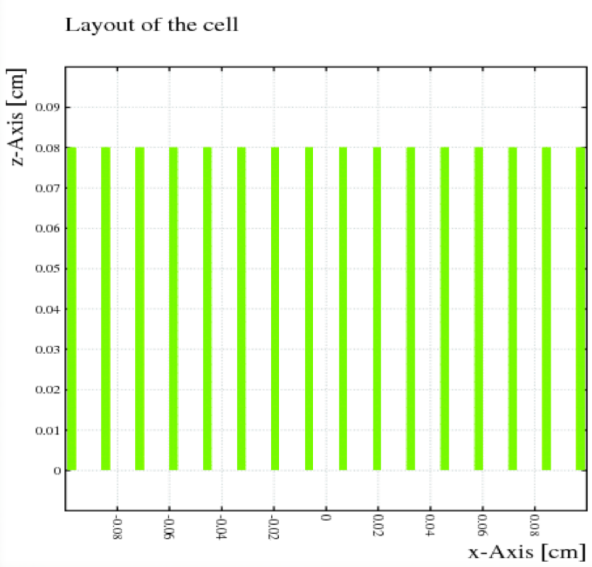




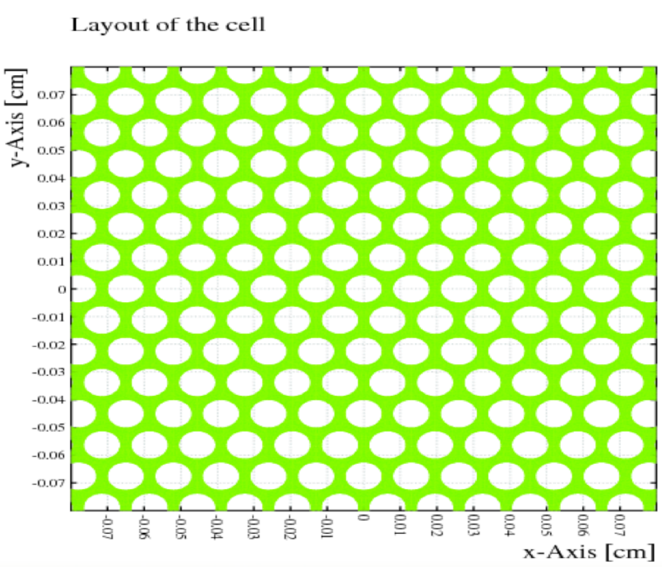




Simulated

# MCPs in Garfield (A check to see if the field map files are read properly)

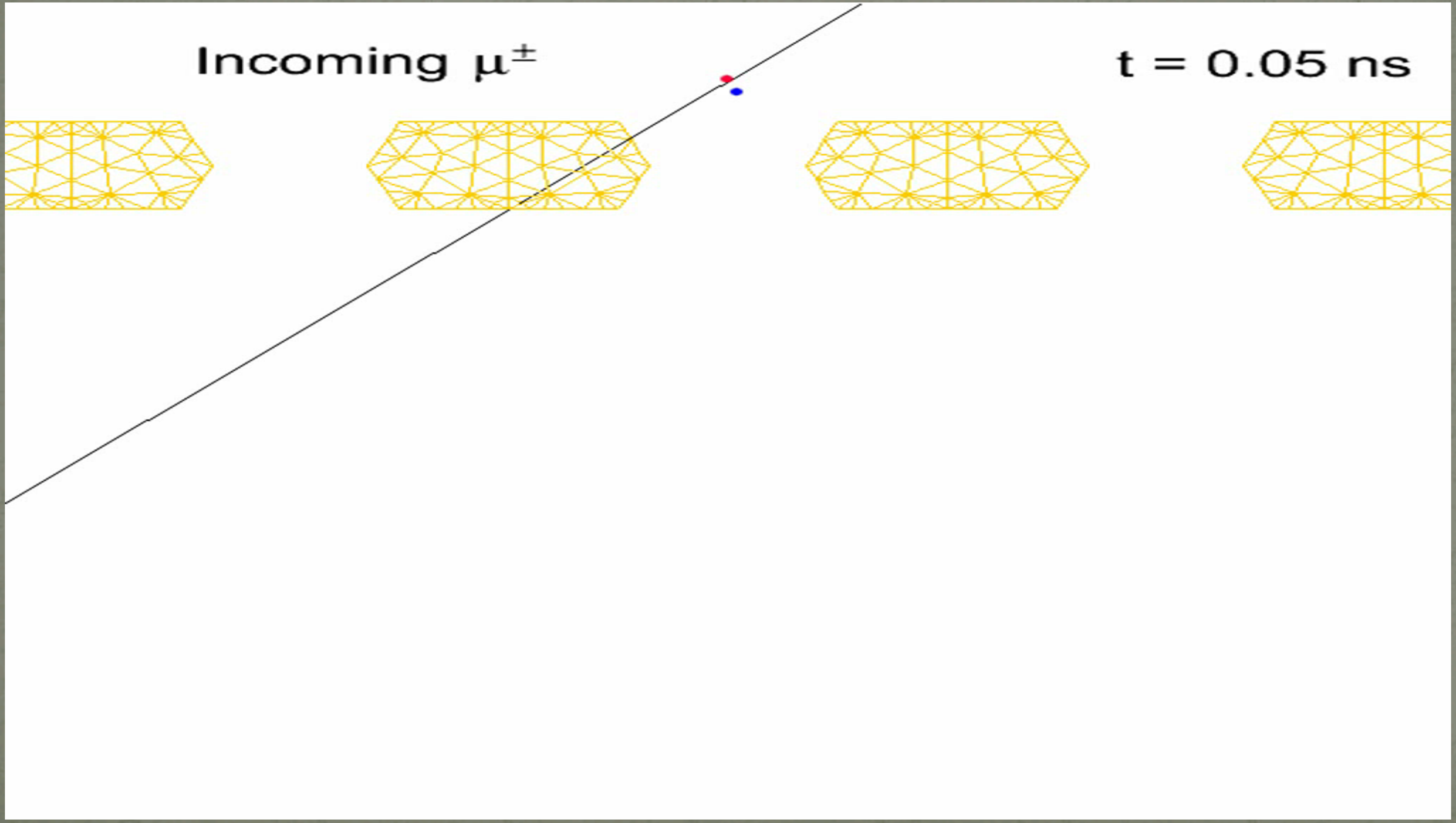



X-Z view



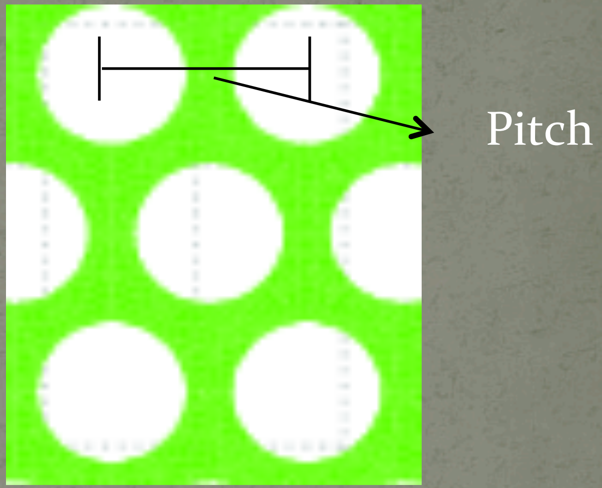

X-Y view

- Motion of electrons and ions in GEMs/MCPs (Sven Dildick)



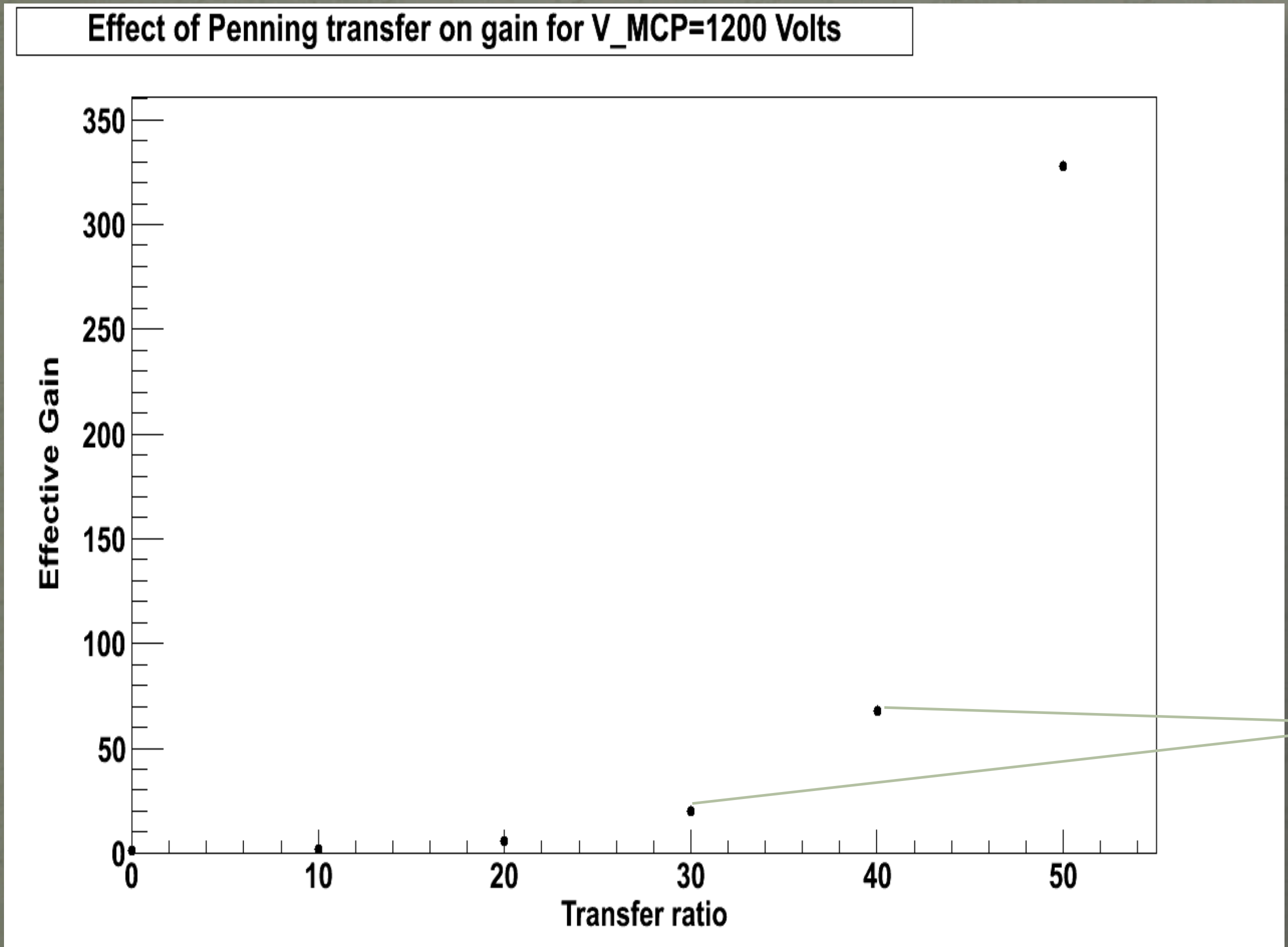
# Simulating the Gain

- First we try to match the simulated gain with the experimental gain in GCPs from Peskov's paper.
- The parameters are :
  - Pitch : 130 microns
  - Diameter : 100 microns
  - Thickness : 800 microns
  - Drift field : 720 Volts/cm*
  - Drift space : 1 mm
- The gas mixtures used is Argon(95)/Methane(5)



- The main parameter to be fine-tuned in the simulation is the penning transfer ratio. Studied extensively in 2008 for Argon based mixtures (O.Sahin-JINST 2008)
- Penning transfer – group of processes by which excitation energy is used to increase the gas gain
- Literature suggests that the ratio should be ~20 % for Argon(95)/$CH_{4.}$ However we find it to be in the range 30-40. (Preliminary simulations have ruled out ratio greater than 50%), but we have not scaled the gain yet … (preliminary, it is a statistics game)

# Effect of Penning transfer on gain

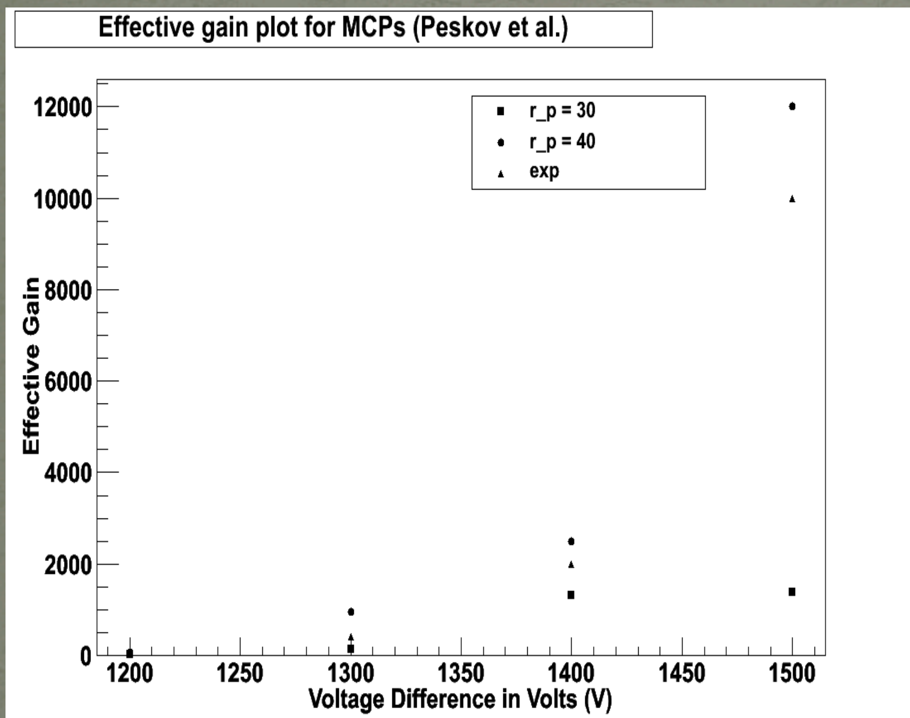


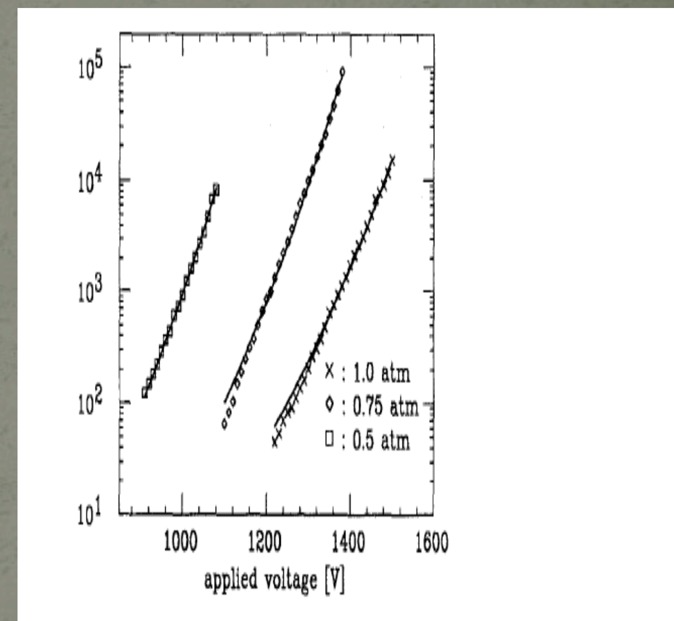

Interestingly, the simulated gain would match with the measured gain if $r_p$ lies between 30 and 40

One can see that with increase in transfer ratio from 0 to 50, the gain increases exponentially

# batch

The higher potentials have lesser statistics (the batch jobs are still running …)

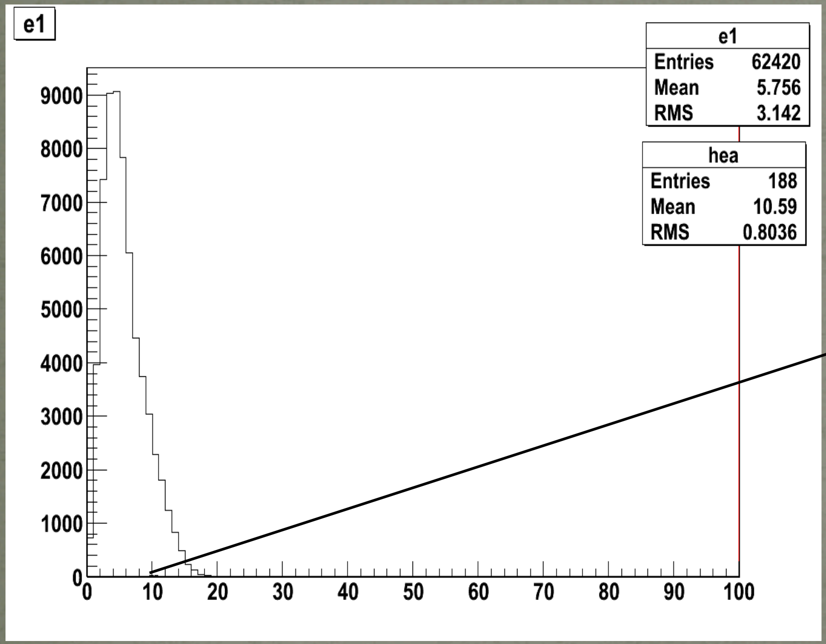


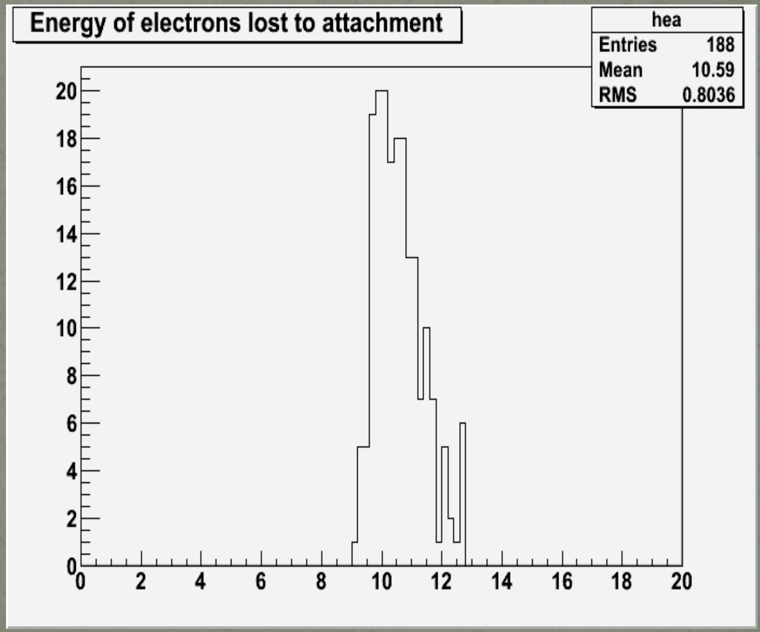




From preliminary simulation, $r_p$ should be between 30 and 40 (not in agreement with theory) (from Garfield++)

Gain From Tamamura/Peskov's paper

- We can see that the gas mixture is not suitable for our purpose. (the mean energy is ~ 5 eV). The loss to attachment is very less (as expected ).



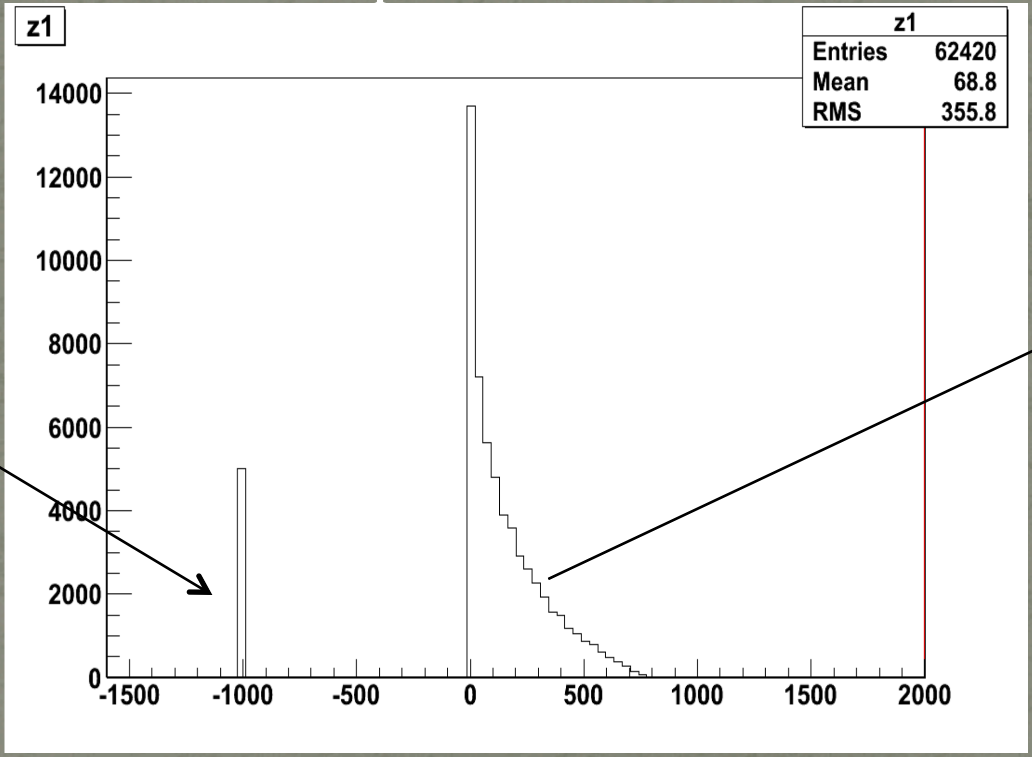




Electron energy in eV

Electron energy in eV

- A plot of the z-coordinates gives us an idea of how the geometric loss compares with the effective gain.

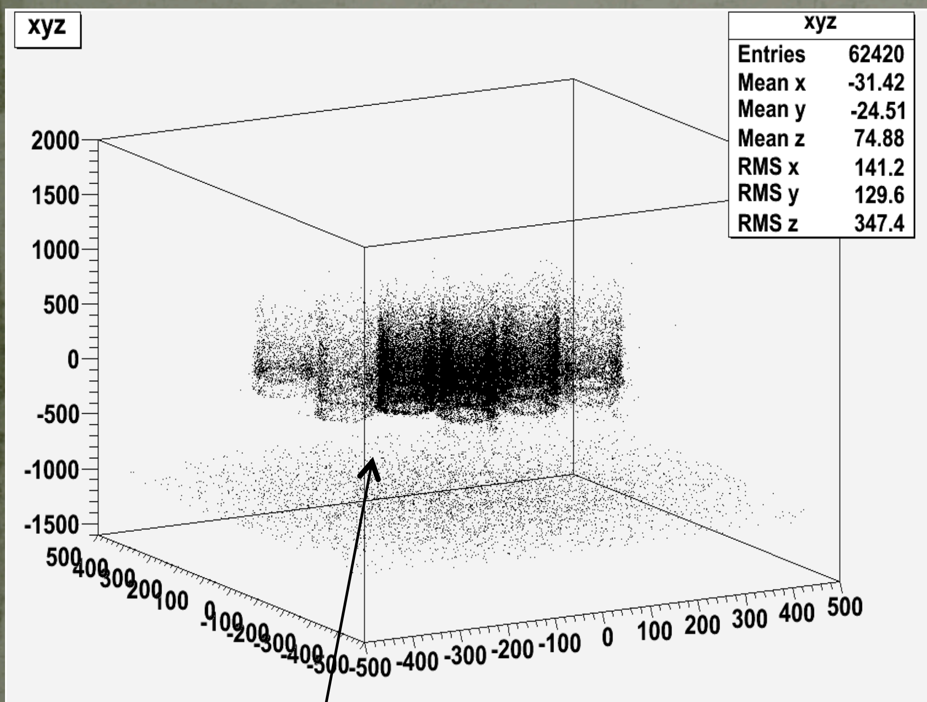
Effective gain when we want to extract the electron cloud

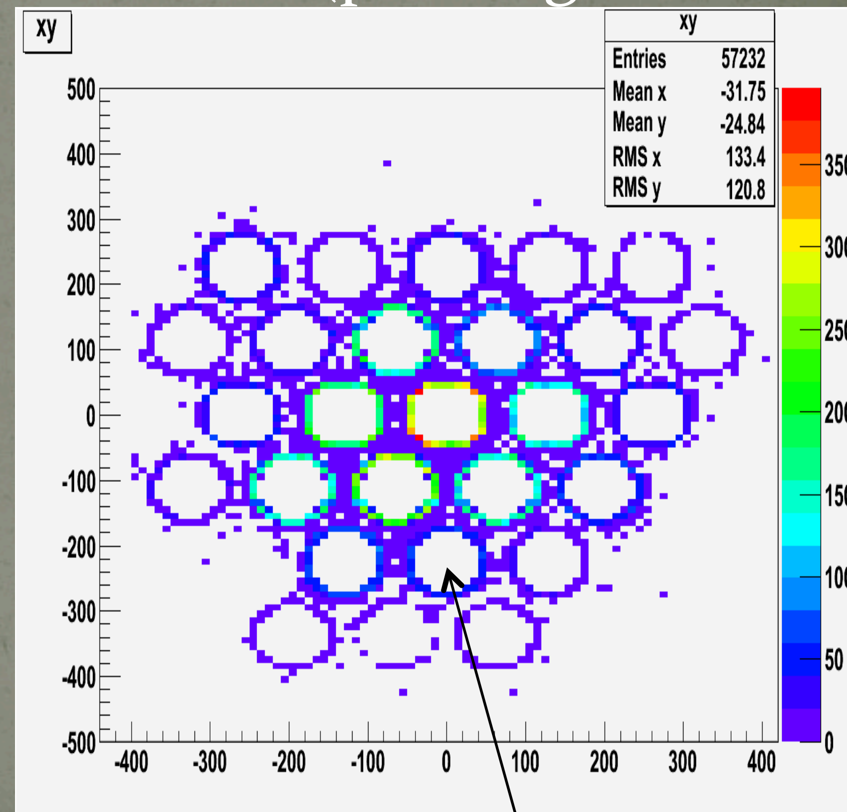



Includes Geometric loss as well as the gain in Peskov's scenario

Z-coordinate in microns

- A cleaner look at the geometric losses (plotting the electron end-points):




The cylindrical structure can be seen

One can see the holes clearly

# Future Work ....

- Collect more statistics to pin-point the penning transfer ratio for argon as well as helium based mixtures. (already have an estimate for He(90)/ $CO_2$(10) at ~34.5 % (from O.Sahin ...) )
- After that, predict the gain for the MCPs we have in the lab (1200 microns metal oxide coated)
- Compare it with the hardware results.

Thanks ….