

# GEM detector development for CBM at GSI

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# Outline of the talk

- GEM detector R&D at GSI for CBM
- Tests at GSI detector laboratory
- CERN test beam
- Results
- Summary

# GEM for CBM

- Triple GEM as a precise tracking detector in the Muon Chamber (MUCH) under the extreme conditions of the CBM experiment

# Details of the set up

- Double Mask and Single Mask triple GEM
- Gas mixture: Ar/CO<sub>2</sub>: 70/30
- 7 channel HVG210 power supply
- 2 sum-up boards are used for signal (2×128 6×6 mm<sup>2</sup> pads) for DM GEM
- 4 sum-up boards are used for signal (4×128 4×4 mm<sup>2</sup> pads) for SM GEM
- PXI LabView based DAQ is used

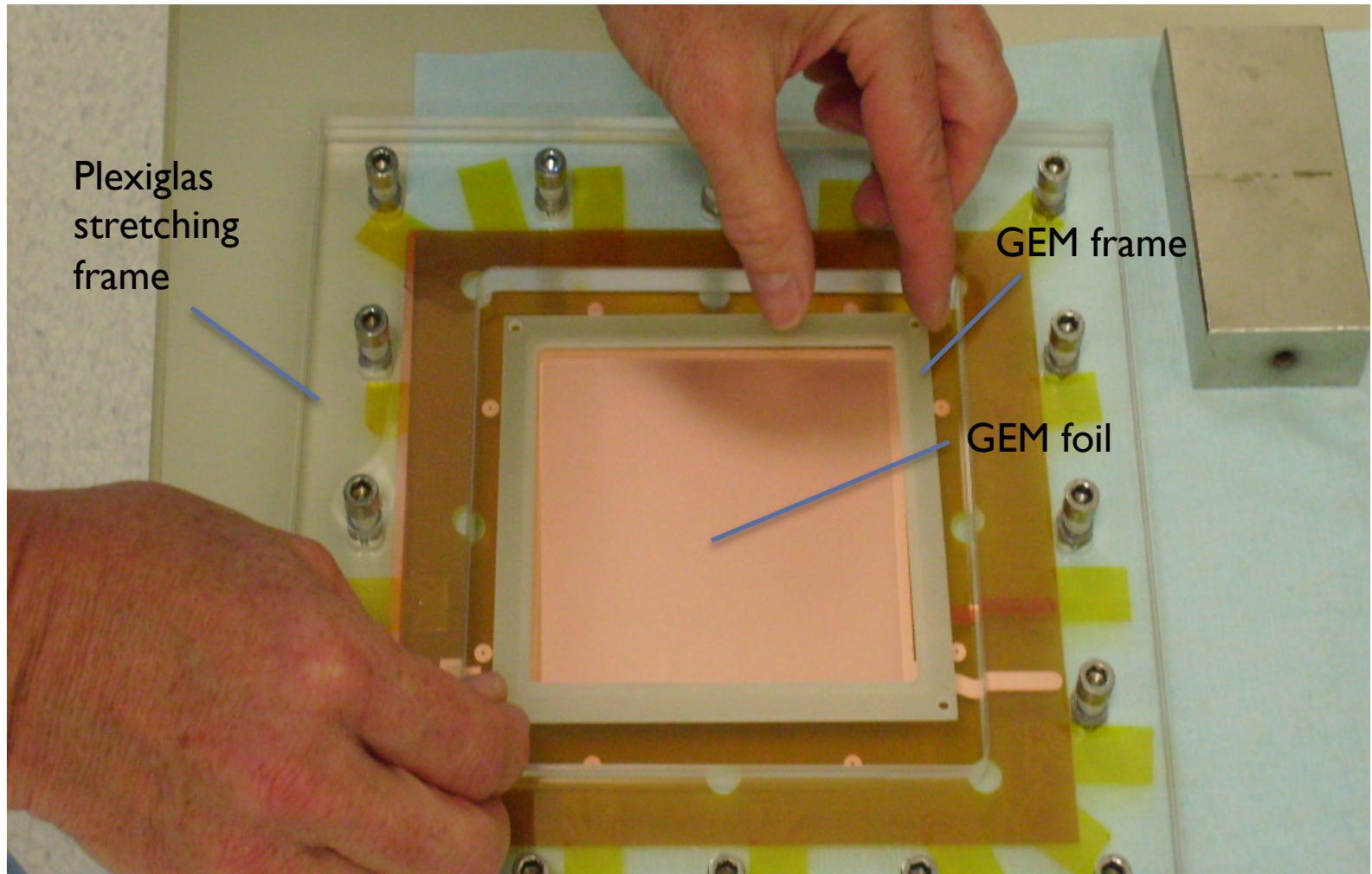


# GEM FOIL:

**STANDARD SMALL GEM: 10x10 cm<sup>2</sup>**

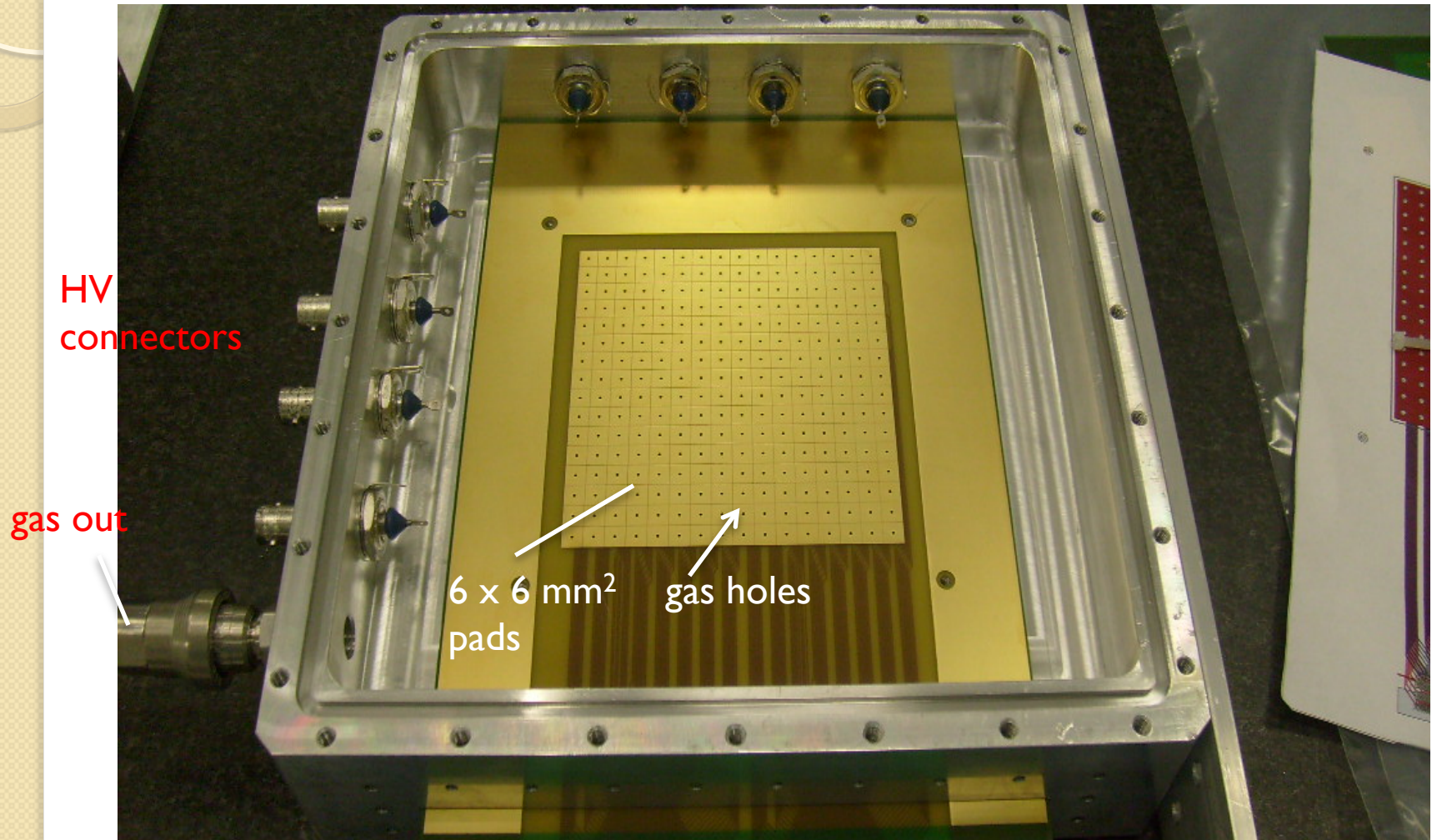


# Stretching frame



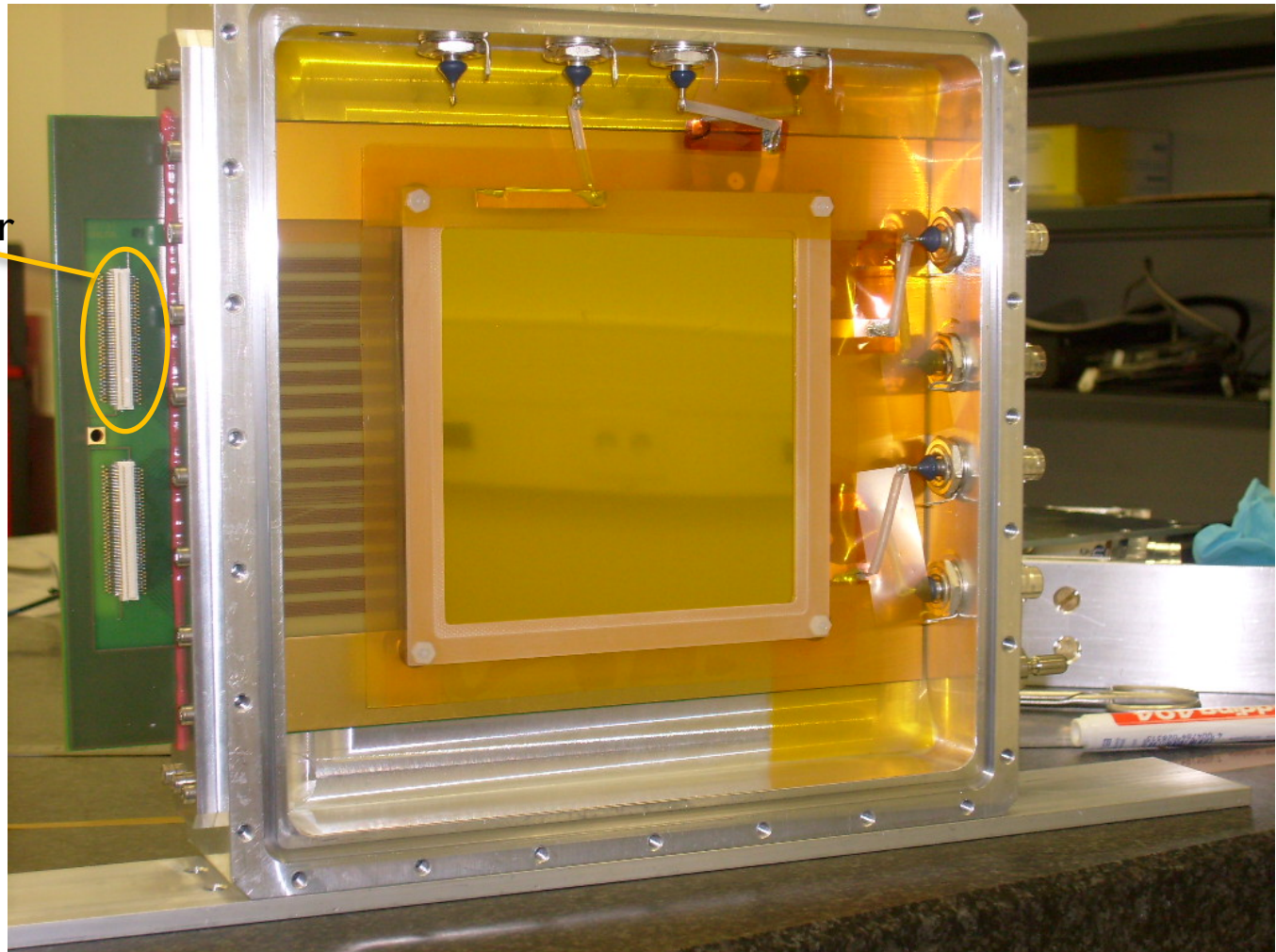


# Pad plane, housing



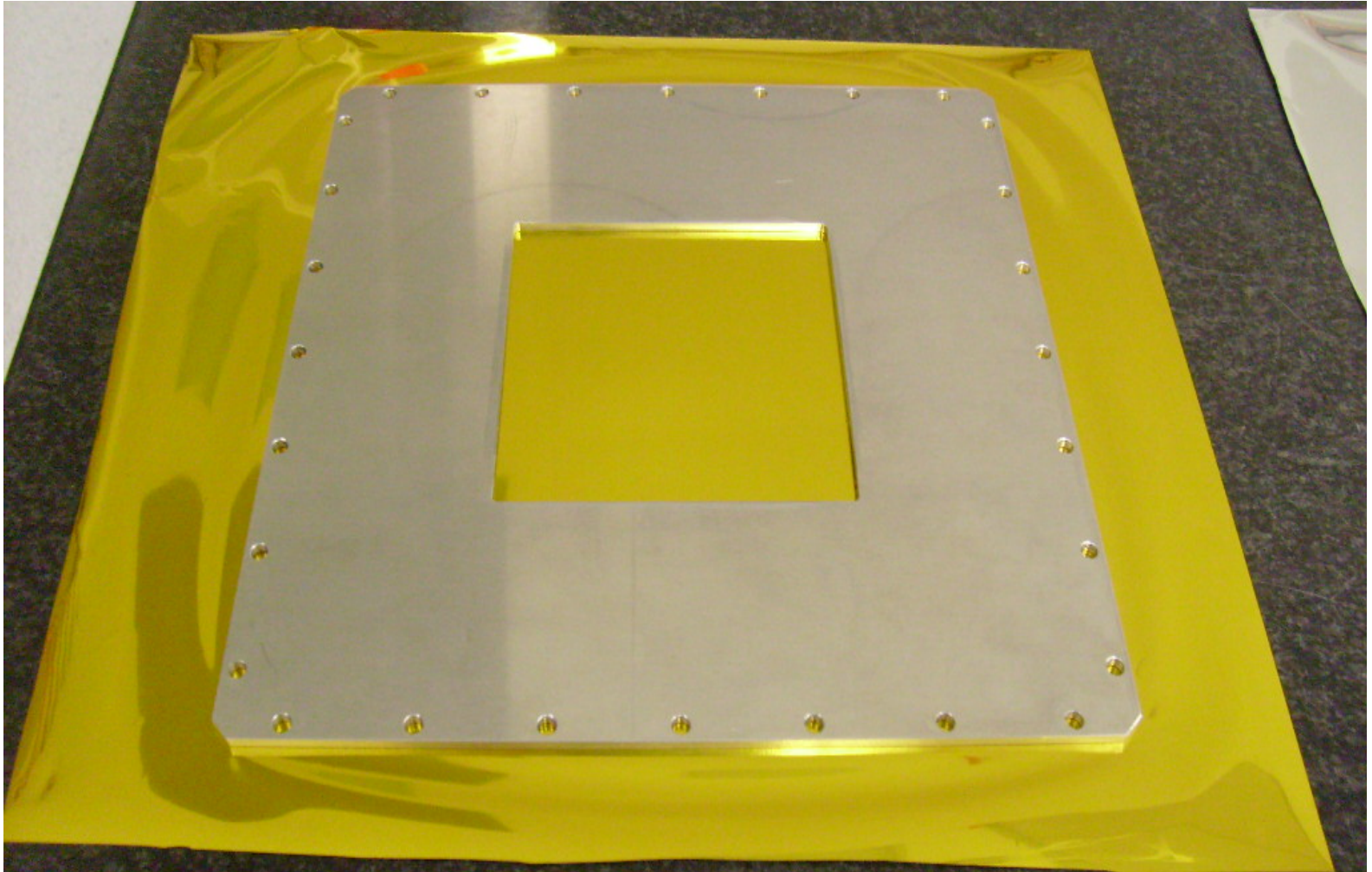
# Assembled GEM

128-pin  
Panasonic  
Connector

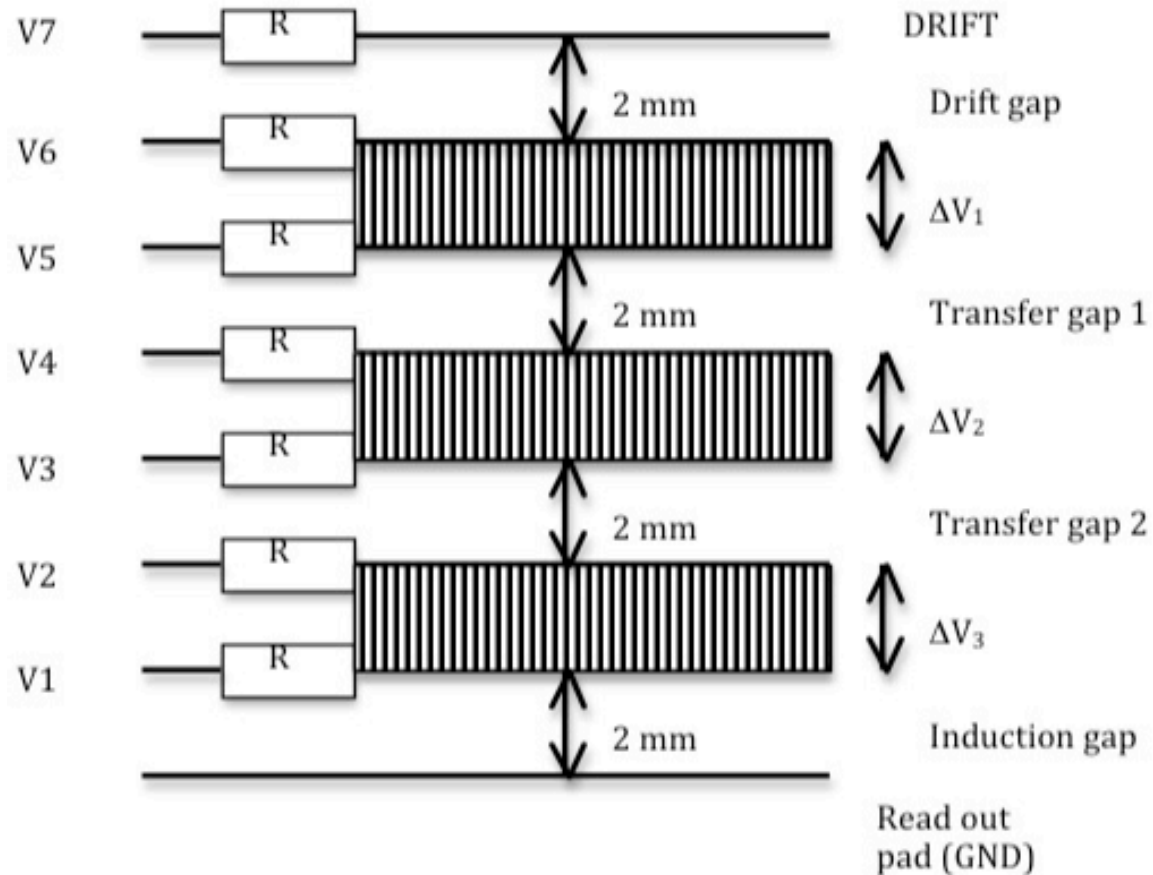




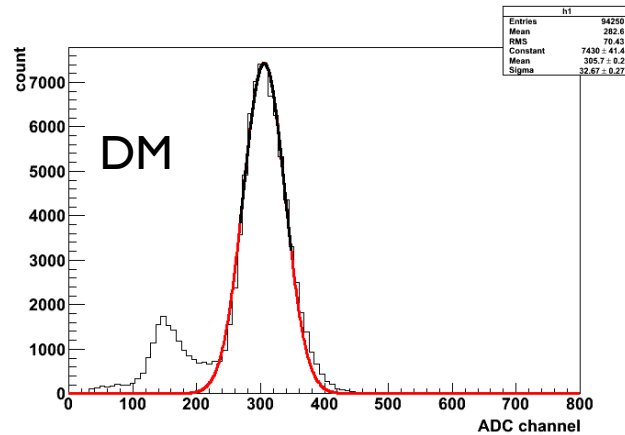
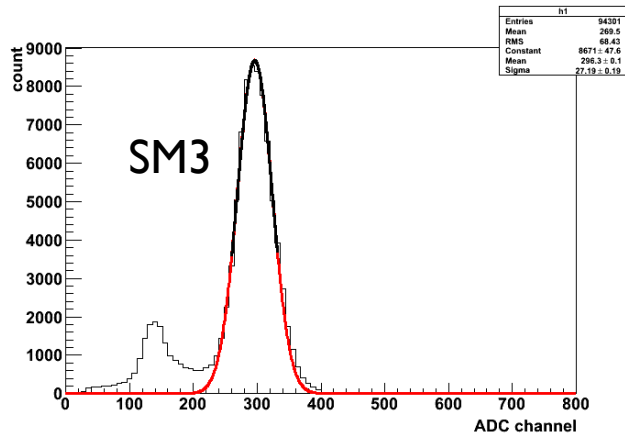
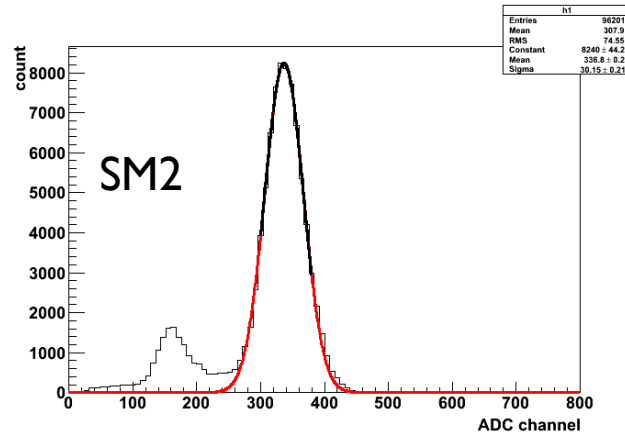
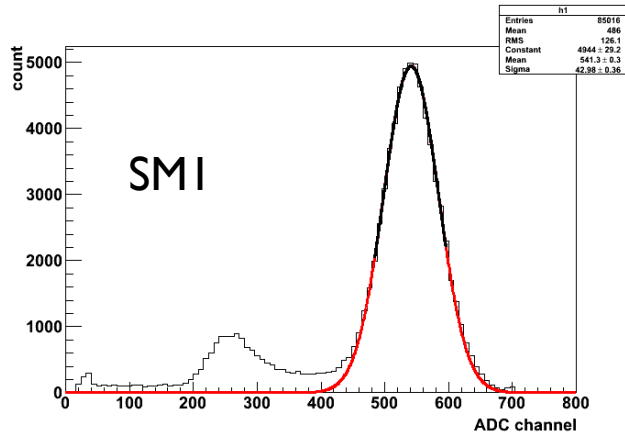
# Cover plate



# Voltage distribution in GEM

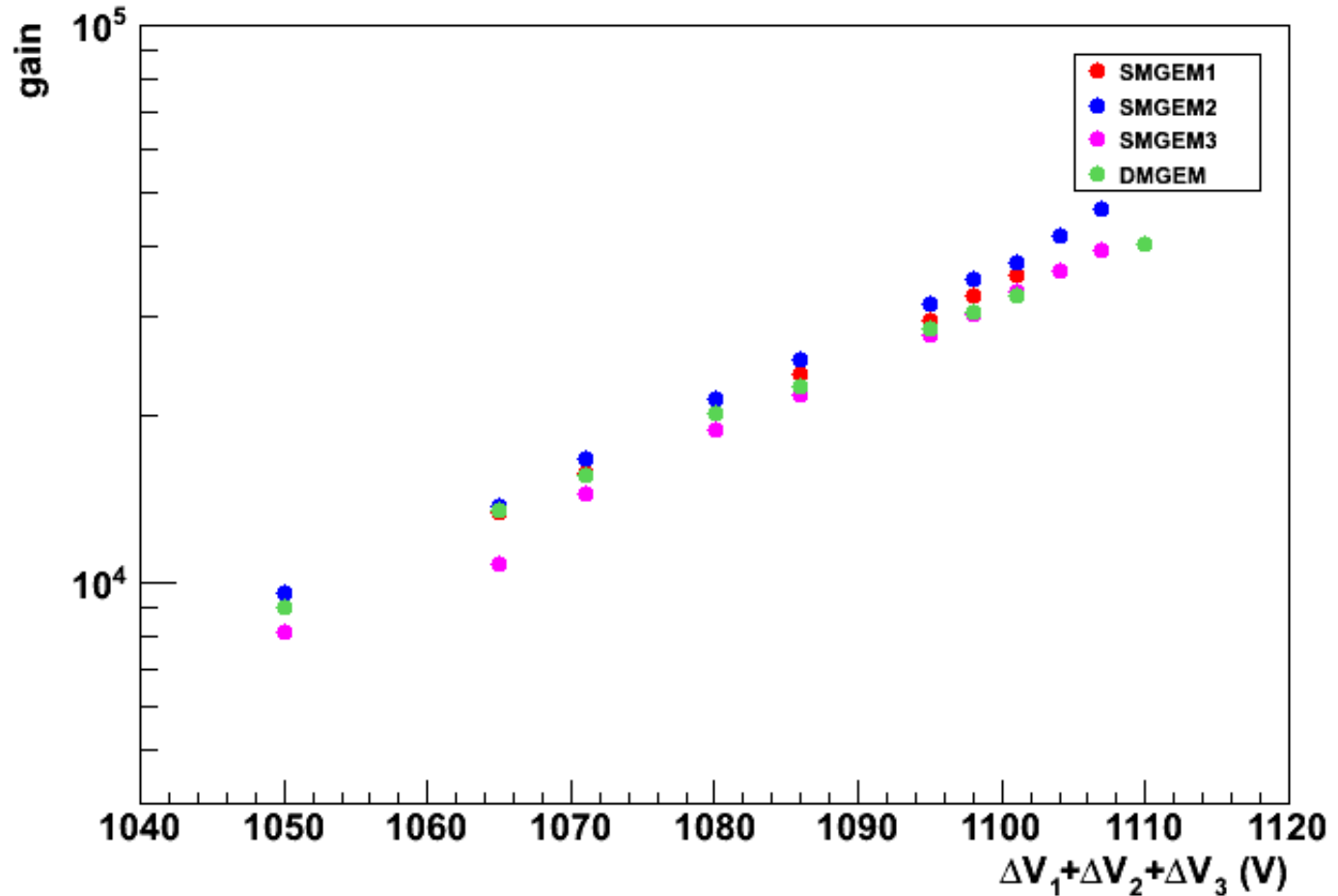


# Fe55 spectra from four modules



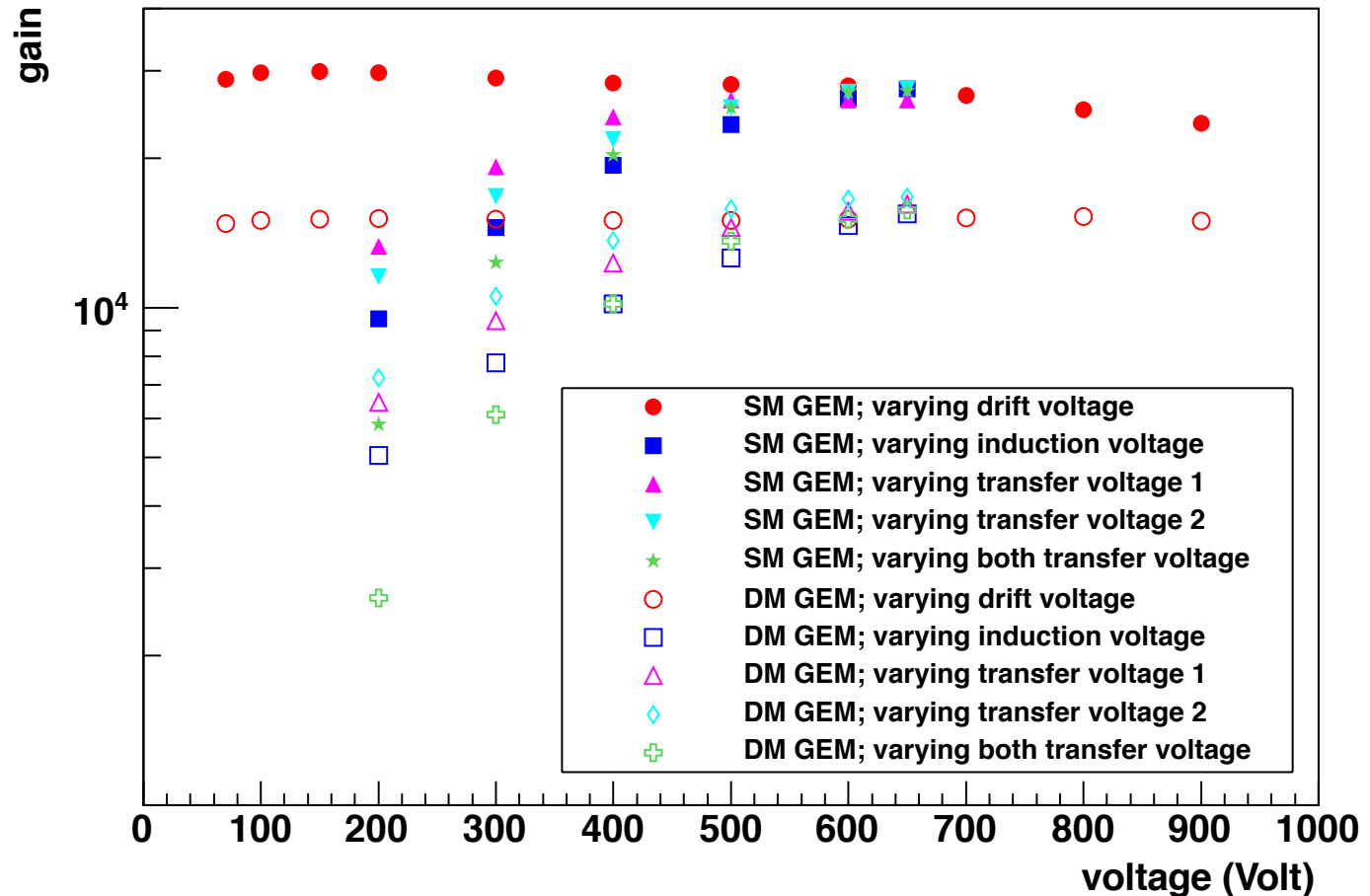
Drift field:  
2.33 kV/cm  
Transfer  
field:  
3.25 kV/cm  
Induction  
field:  
3.25 kV/cm  
GEM  
voltage:  
370-365-360V

# Gain vs. global voltage



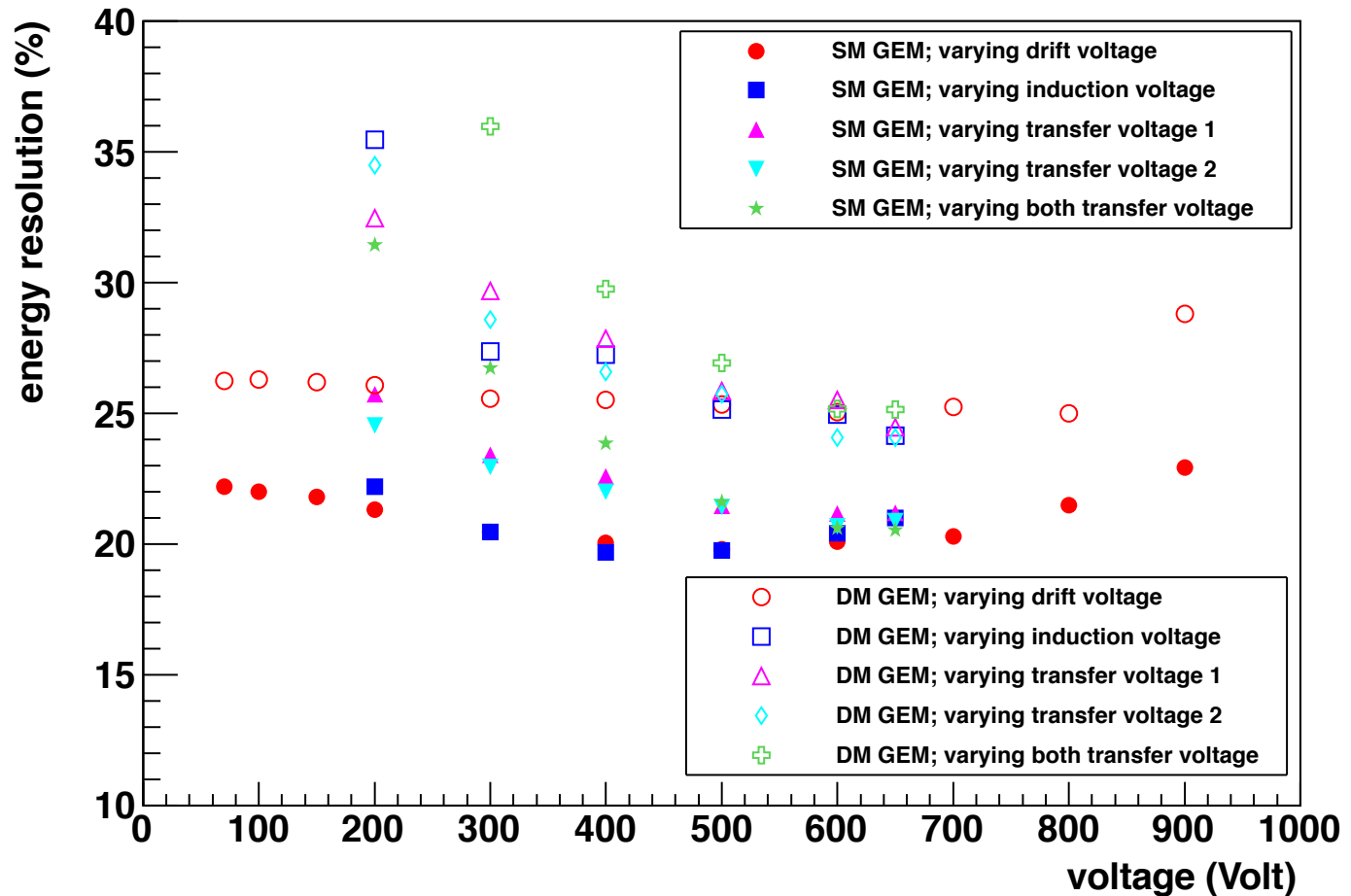


# Gain Vs. voltage

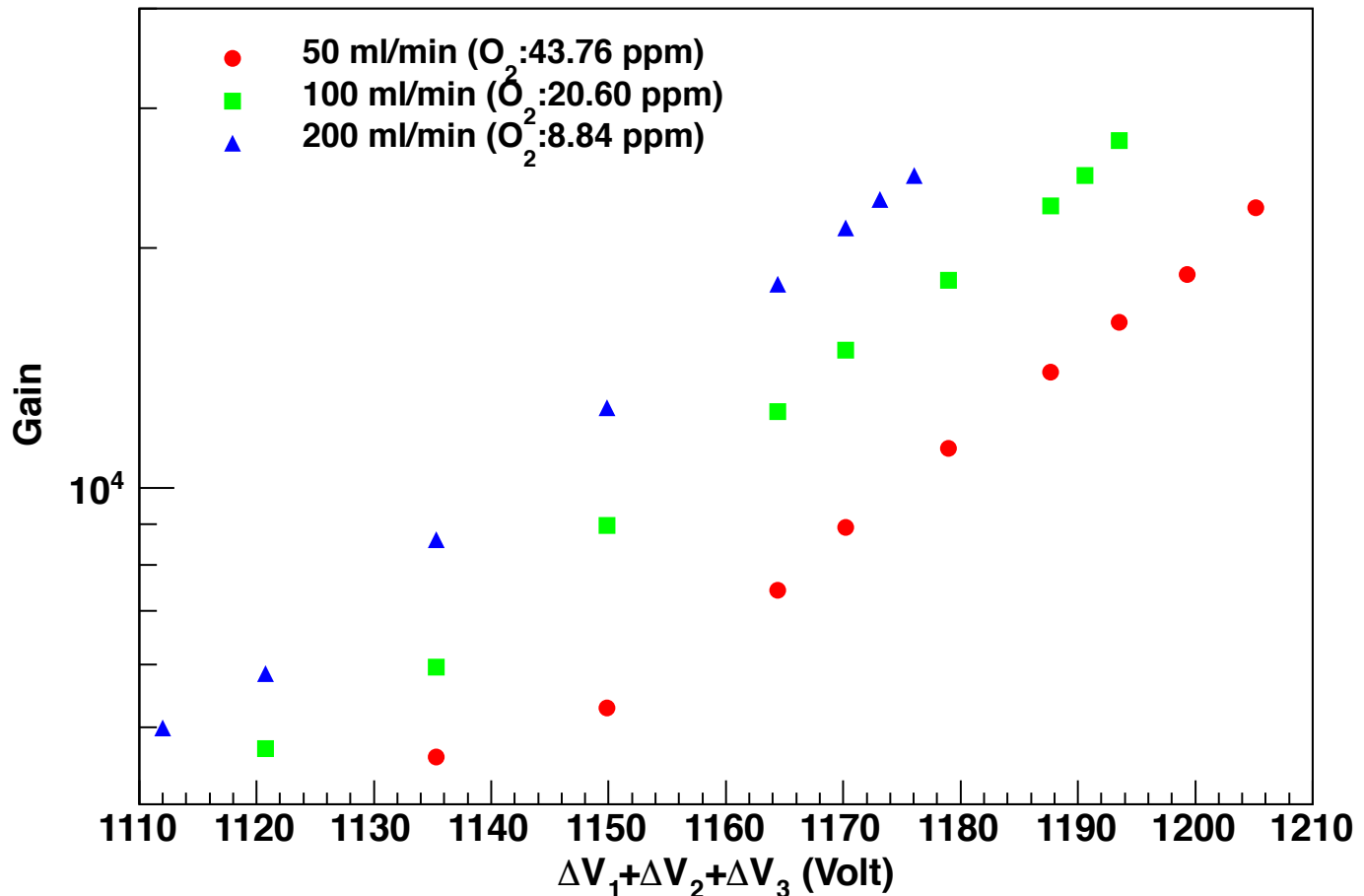


S. Biswas, et al., NIM A <http://dx.doi.org/10.1016/j.nima.2015.11.086>. [arXiv:1505.07767]

# Energy resolution Vs. voltage

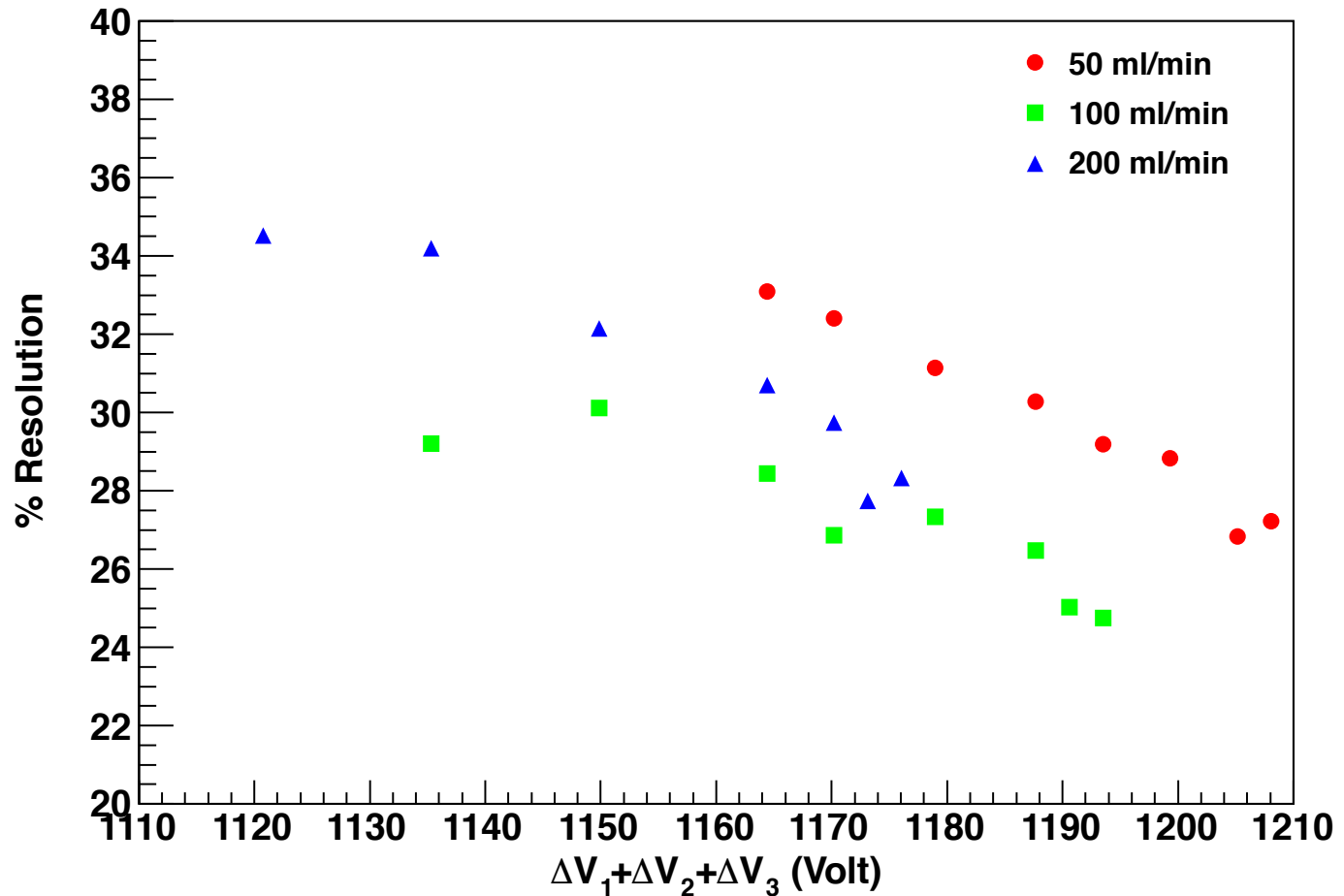


# Effect of flow rate on gain



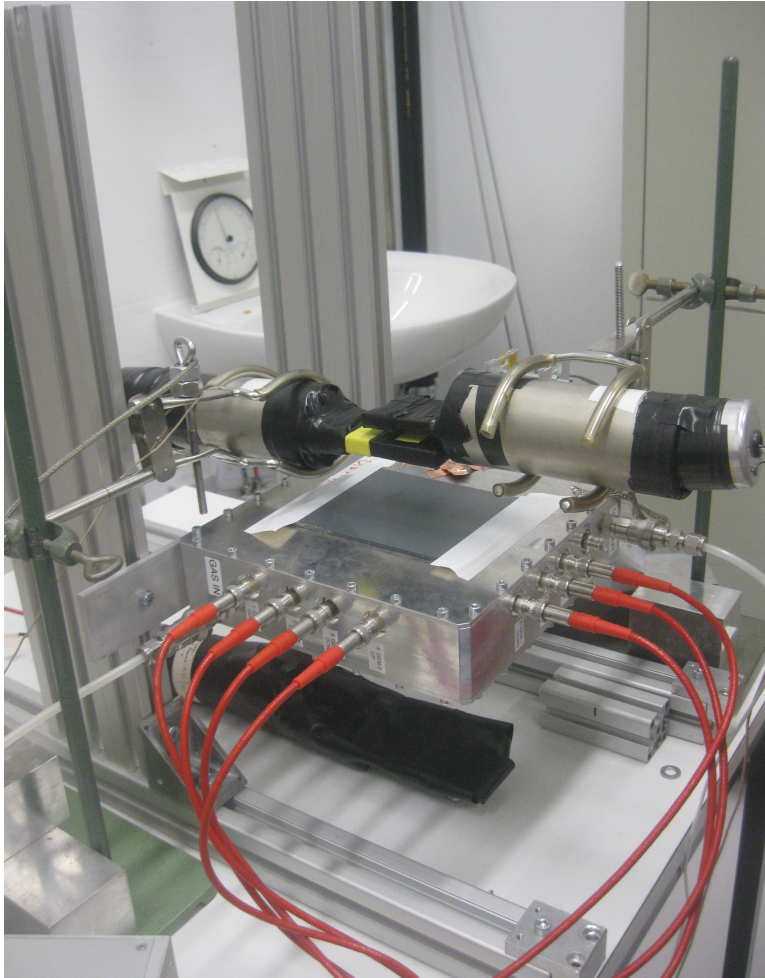
S. Biswas, et al., NIM A 718 (2013) 403- 405.

# Effect of flow rate on energy resolution



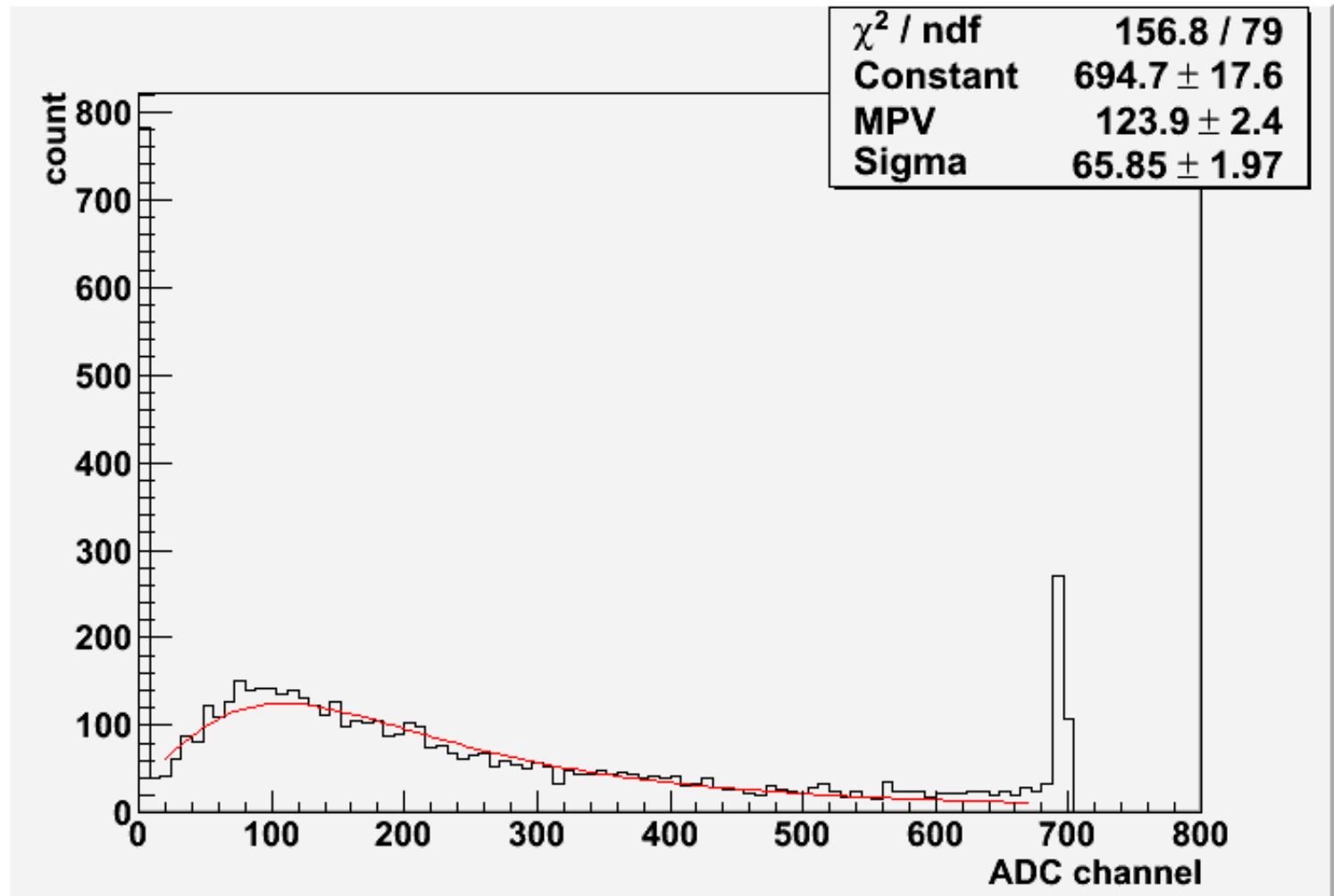
# Cosmic ray tests

# Cosmic ray test set-up

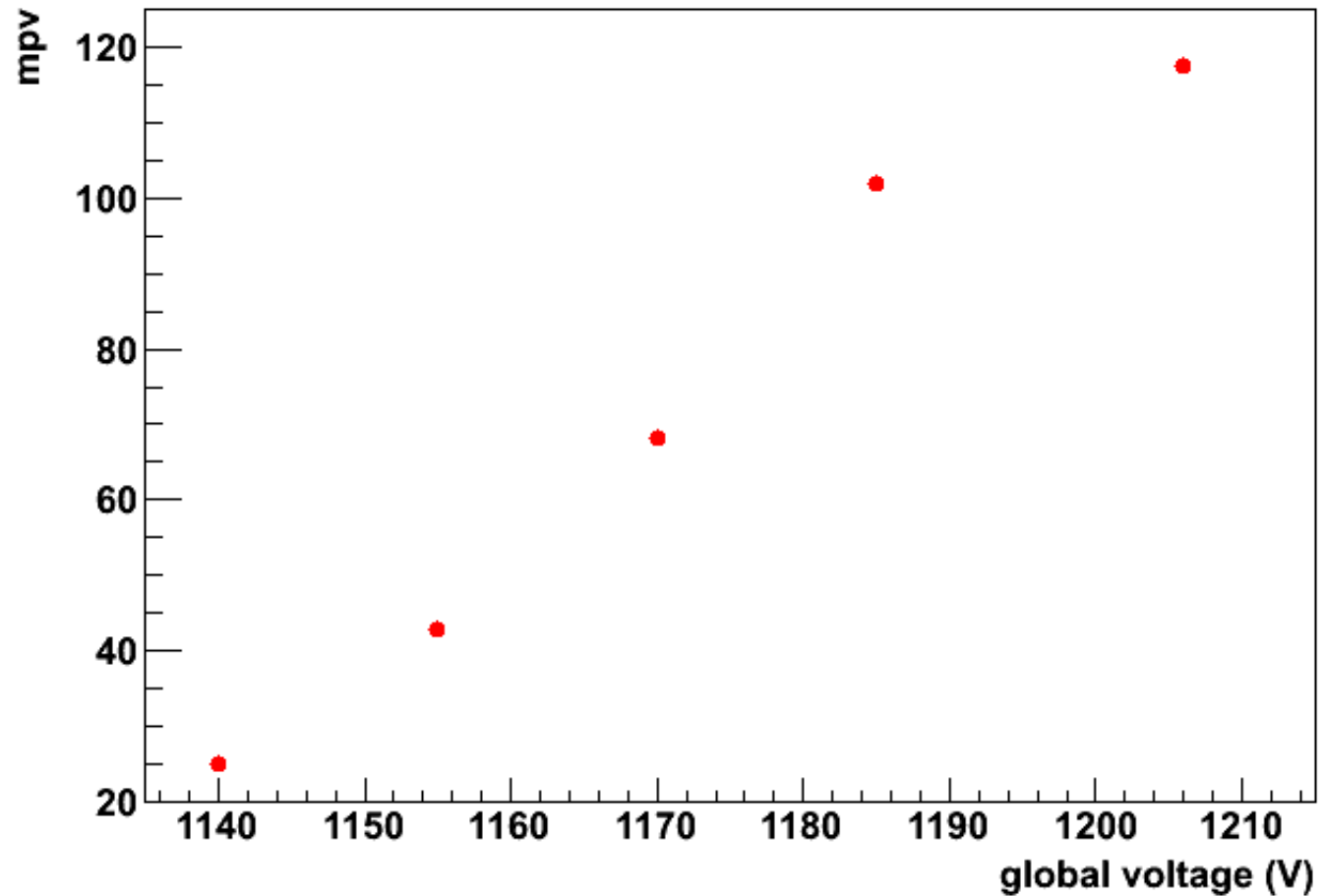


- Trigger: 3 fold Scintillator signal
- Gas: Ar/CO<sub>2</sub> : 70/30

# MIP spectrum @ 400-395-390 V

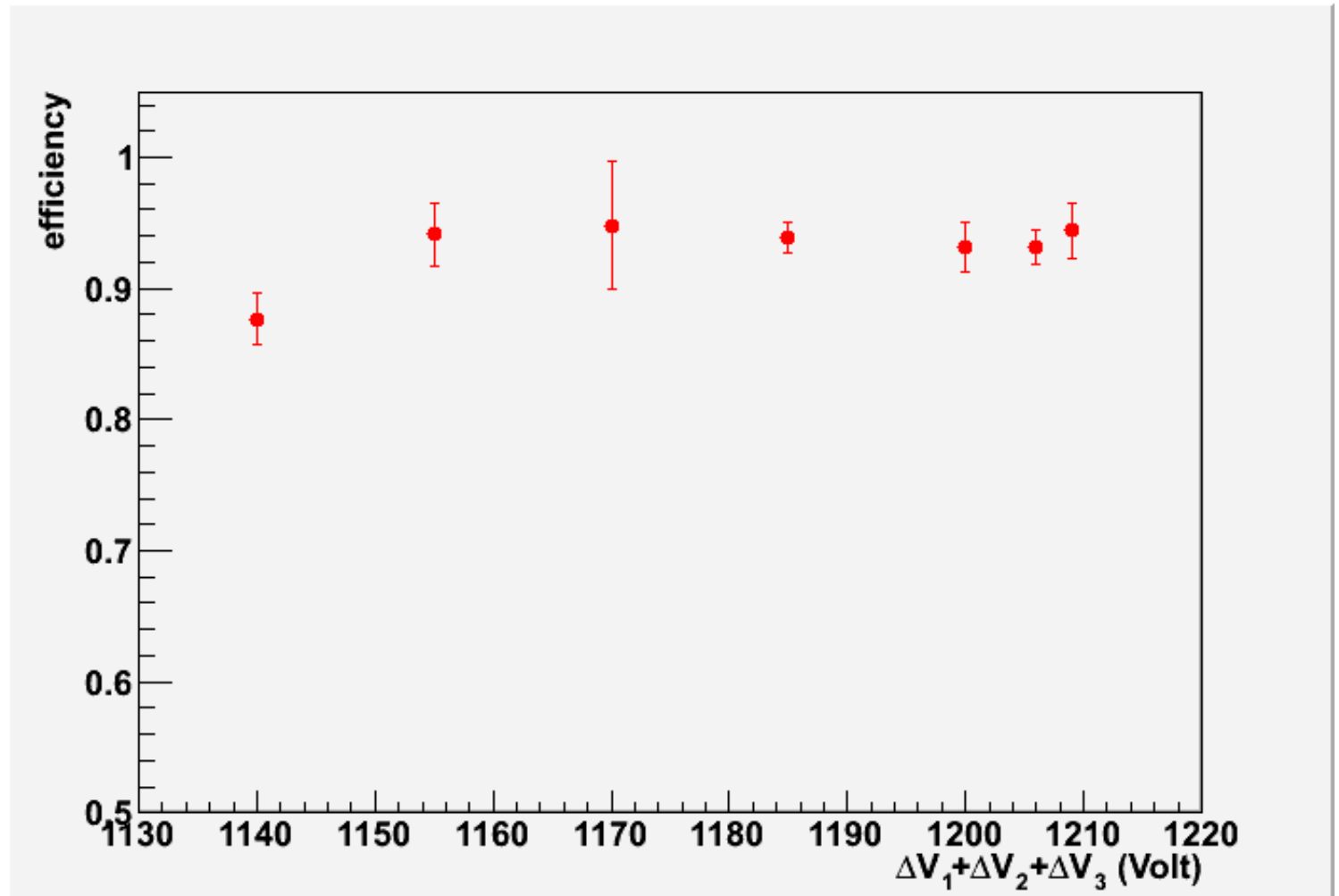


# Gain vs. global voltage





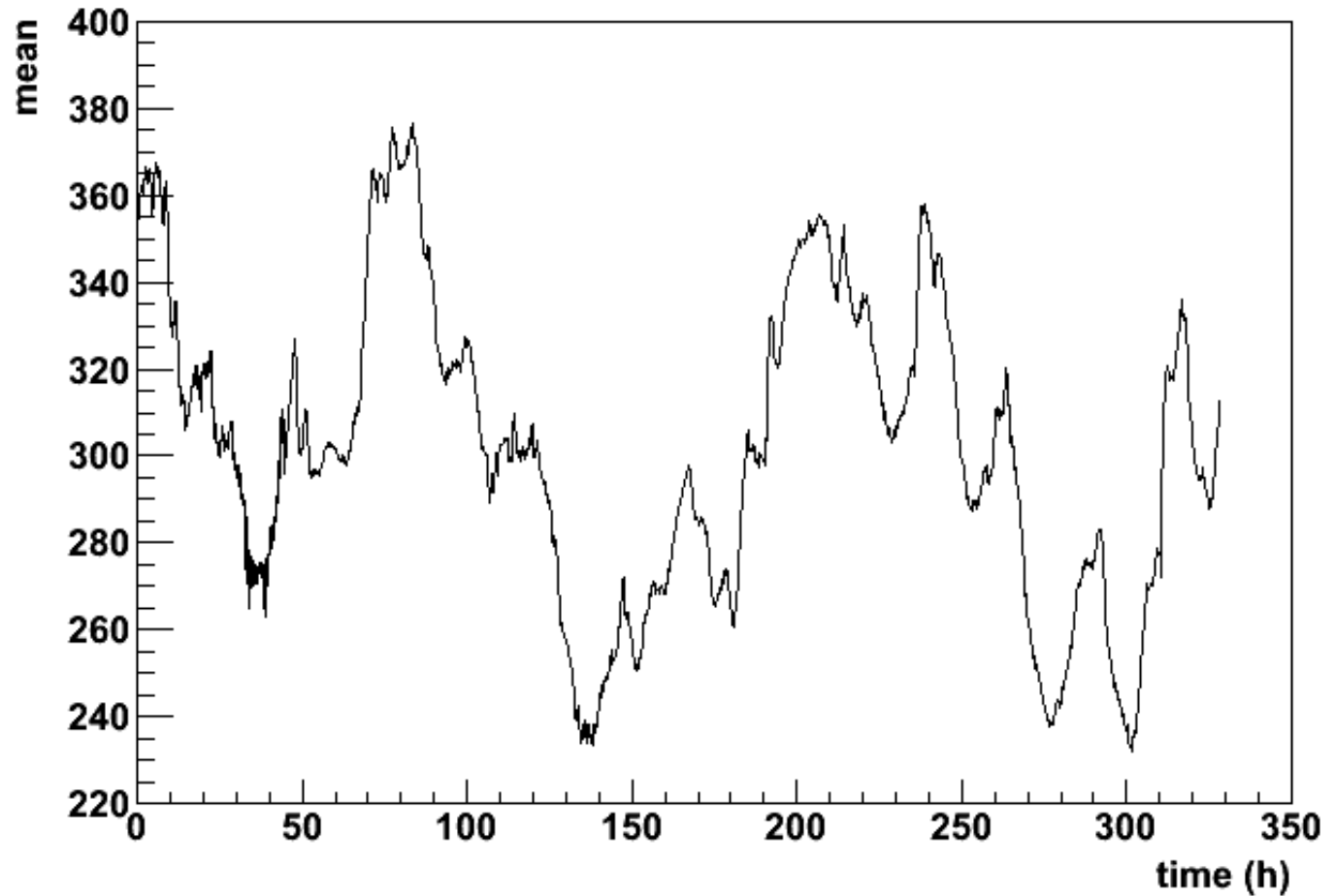
# Efficiency for cosmic ray



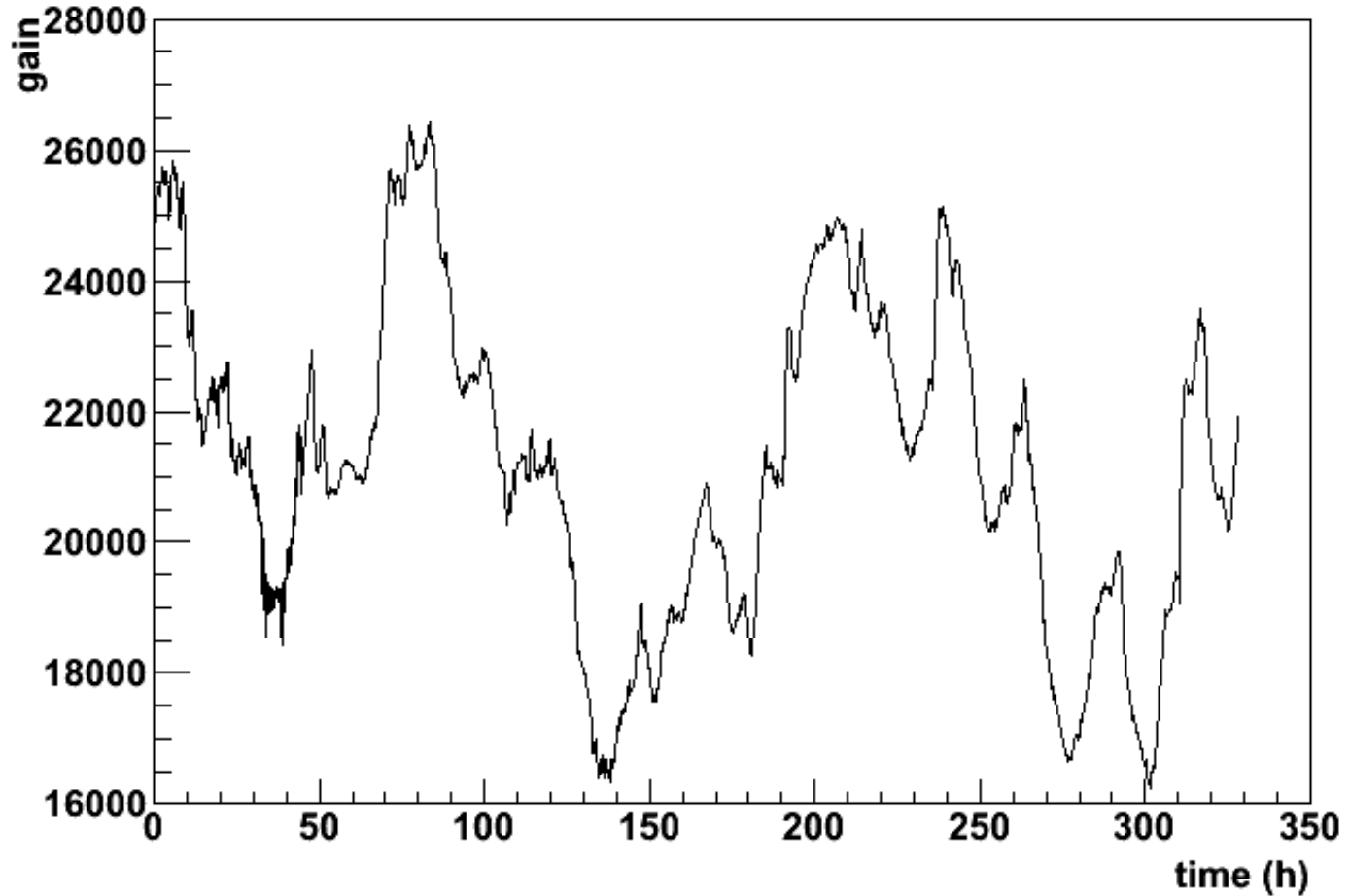
# Long term test of GEM

- High voltage on to the detector  
400-395-390 V
- $E_d = 2.5$  kV/cm;  $E_i = 2$  kV/cm;  $E_t = 3$  kV/cm
- $Fe^{55}$  spectra is taken in 10 min interval

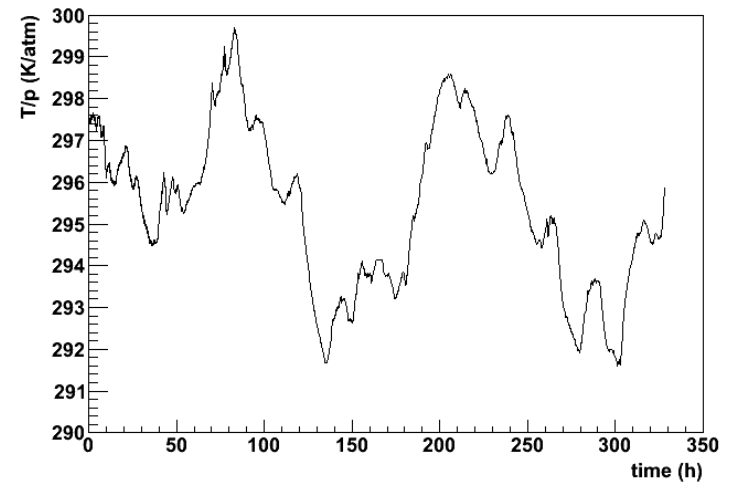
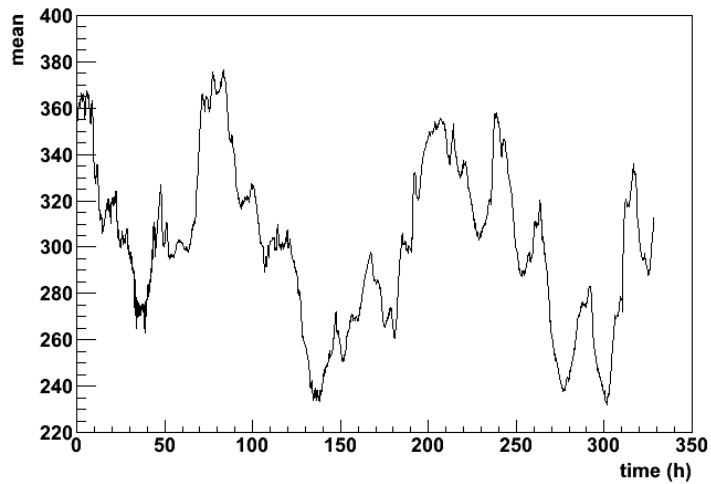
# Mean vs. time



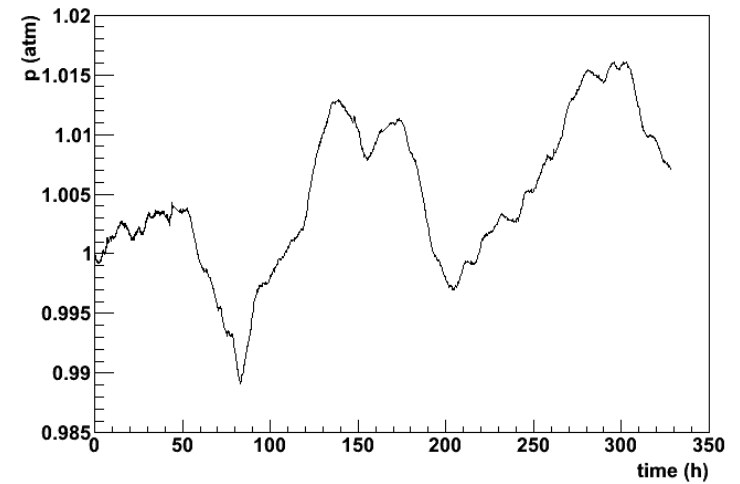
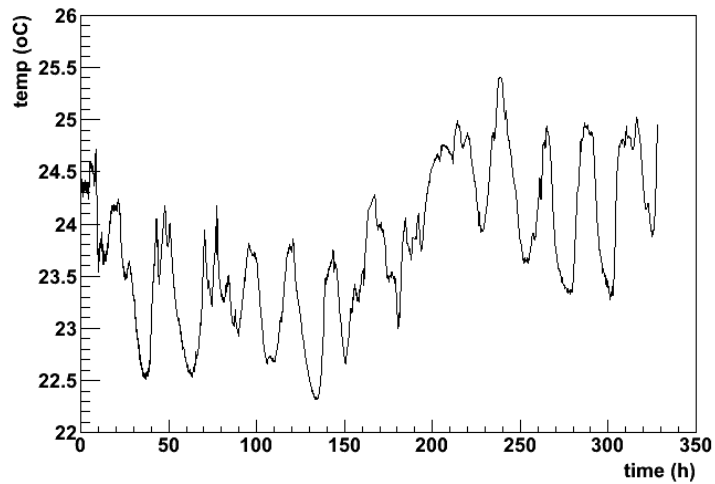
# Gain vs. time



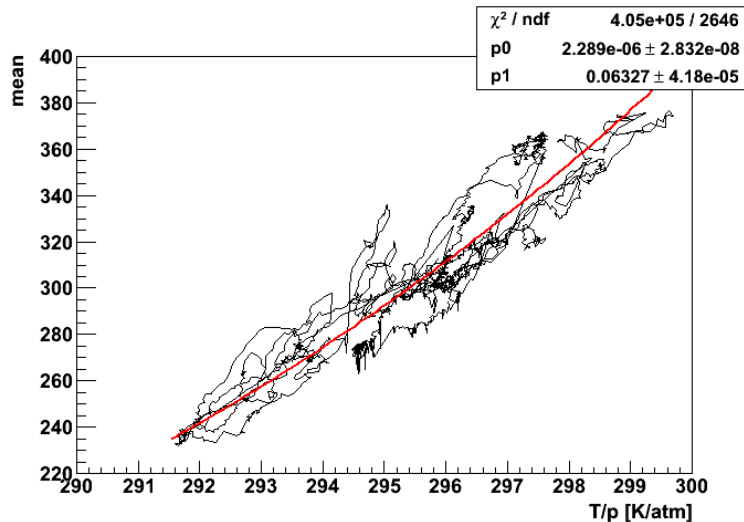
# Mean and T/p correlation



# Temp and pressure vs. time



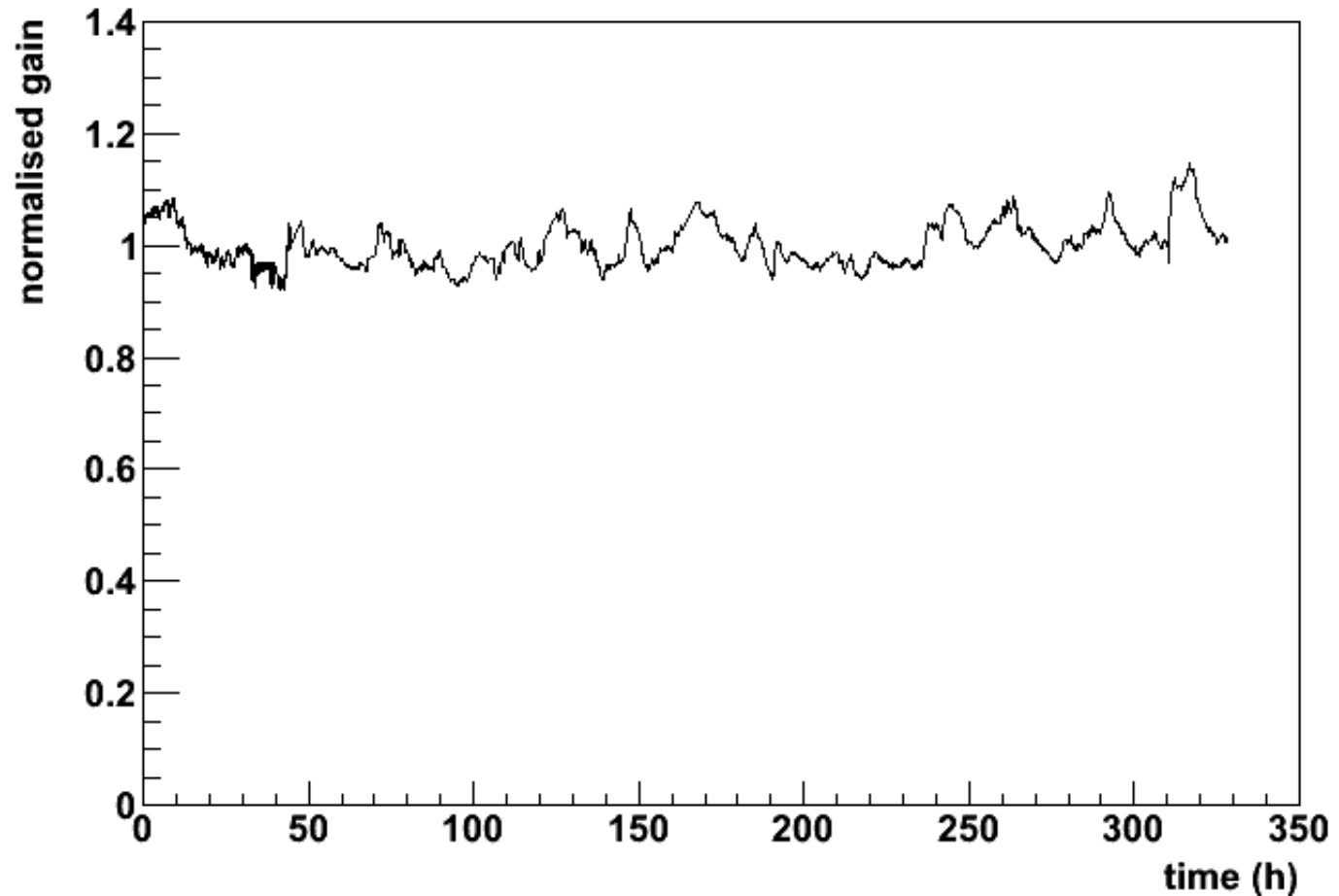
# Correlation plot



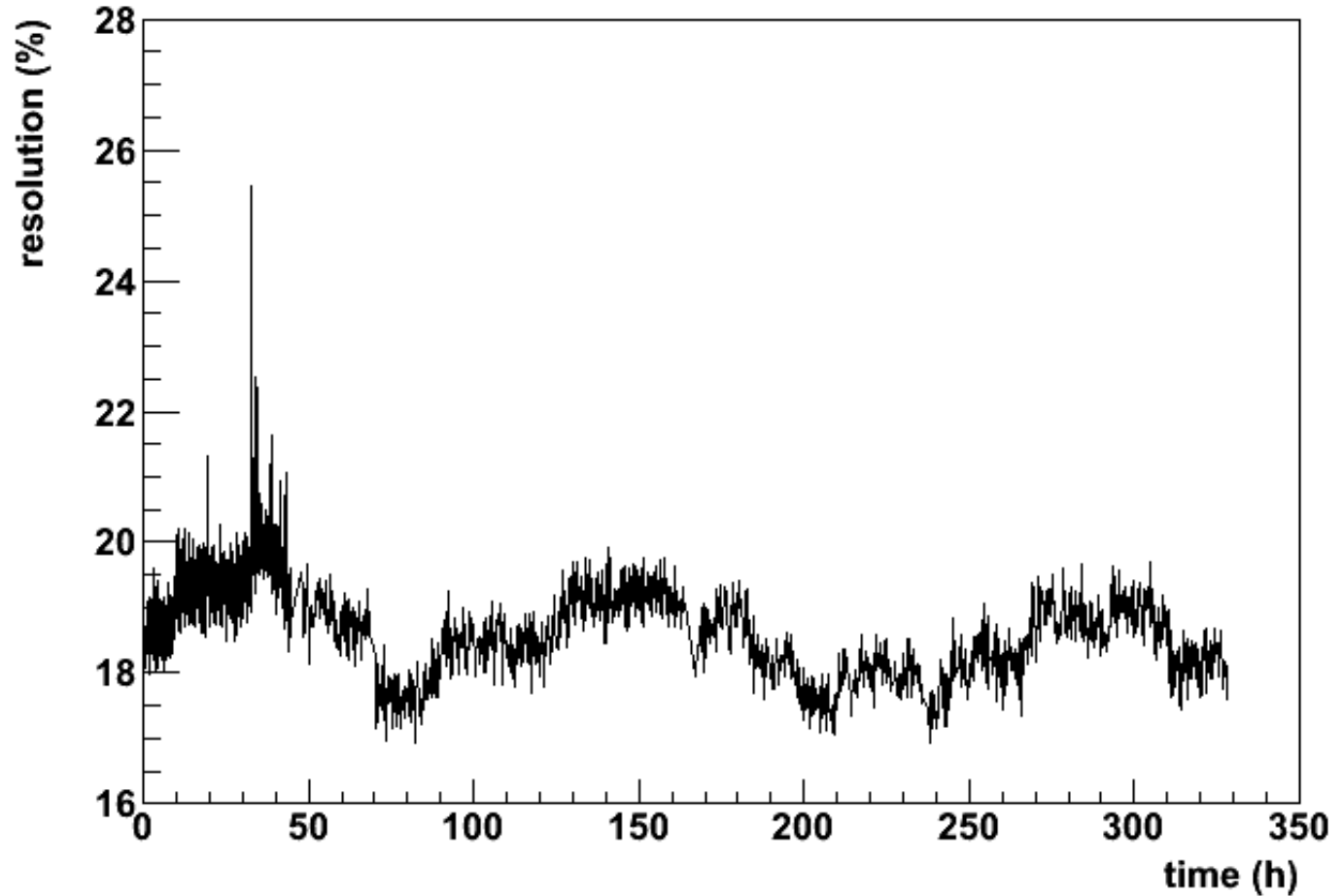
- $g = G/Ae^{BT/p}$
- $G(T/p) = Ae^{BT/p}$
- $G =$  measured gain
- $g =$  normalized gain
- $A$  &  $B$  fit parameter
- Townsend coefficient  
 $\alpha \propto I/\rho \propto T/p$
- $\rho =$  mass density



# Normalized gain vs. time

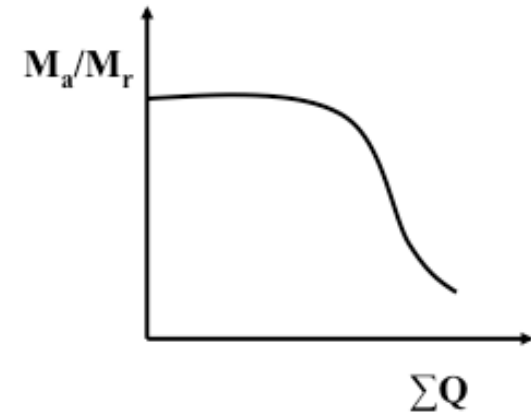
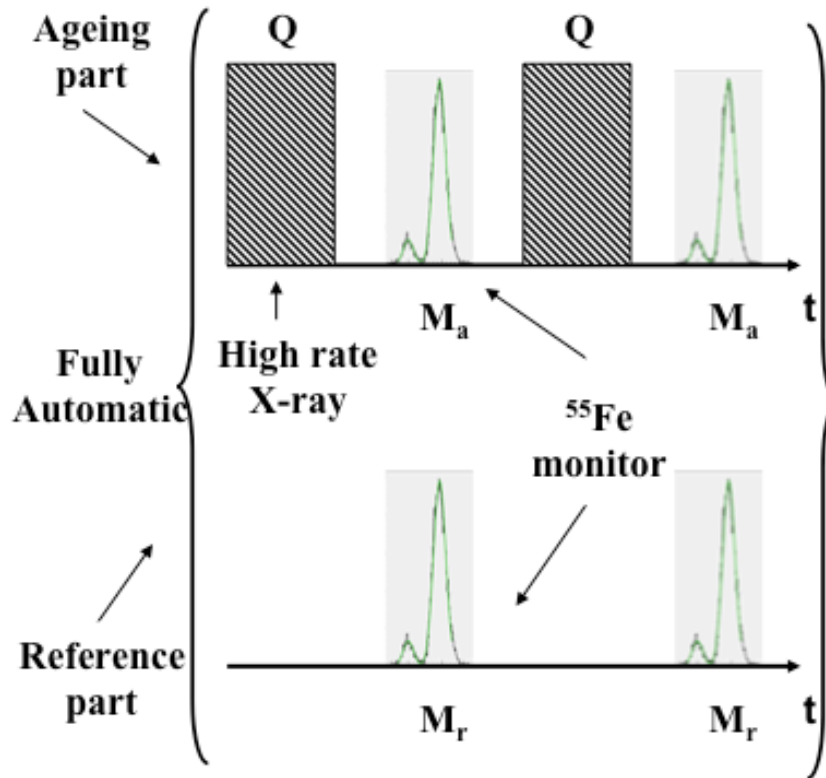


# Resolution vs. time



# Ageing test of GEM

# Work plan

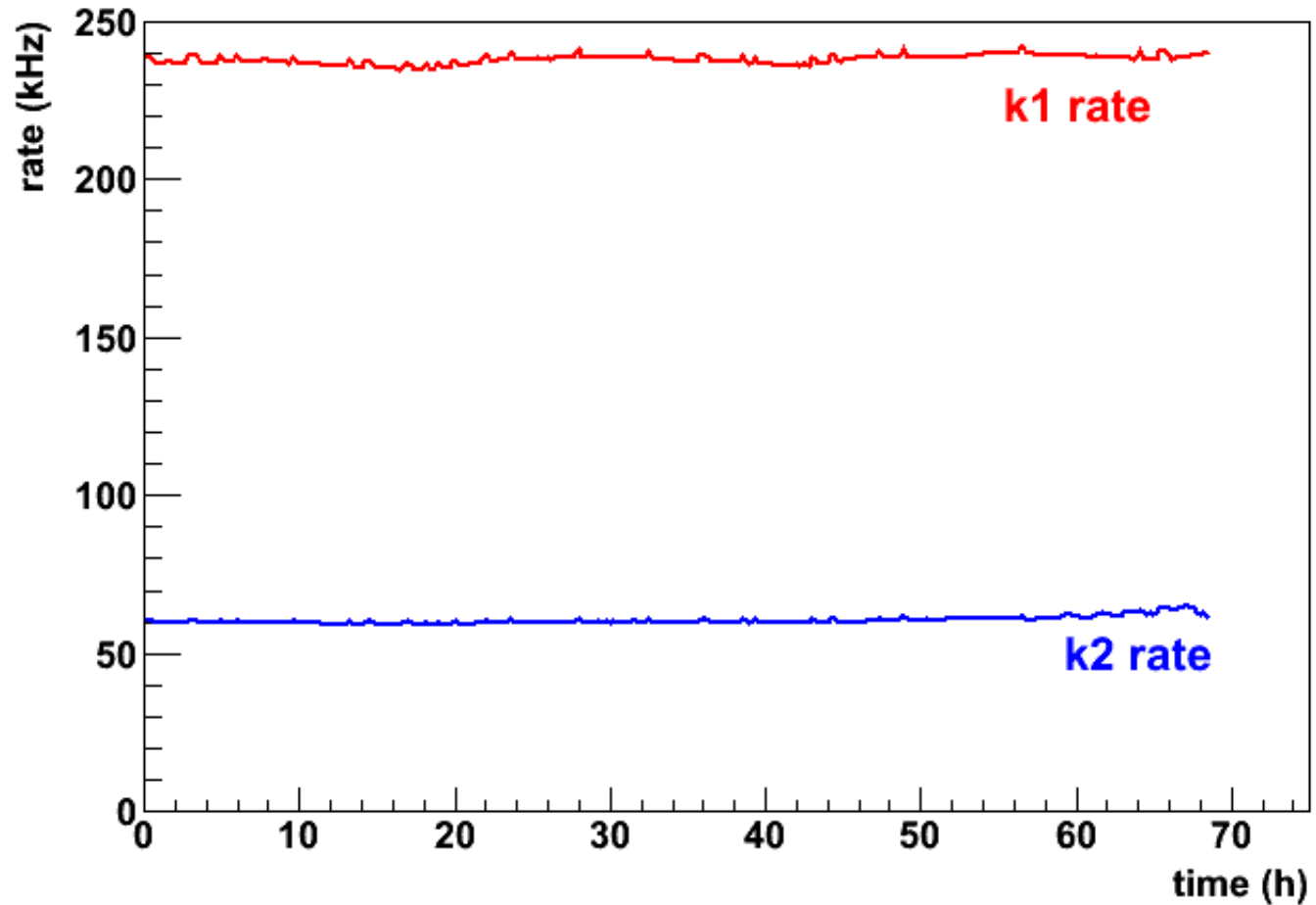


- Correction for Environmental parameters: temperature, pressure, humidity, gas composition
- Precision <math>< 1\%</math>

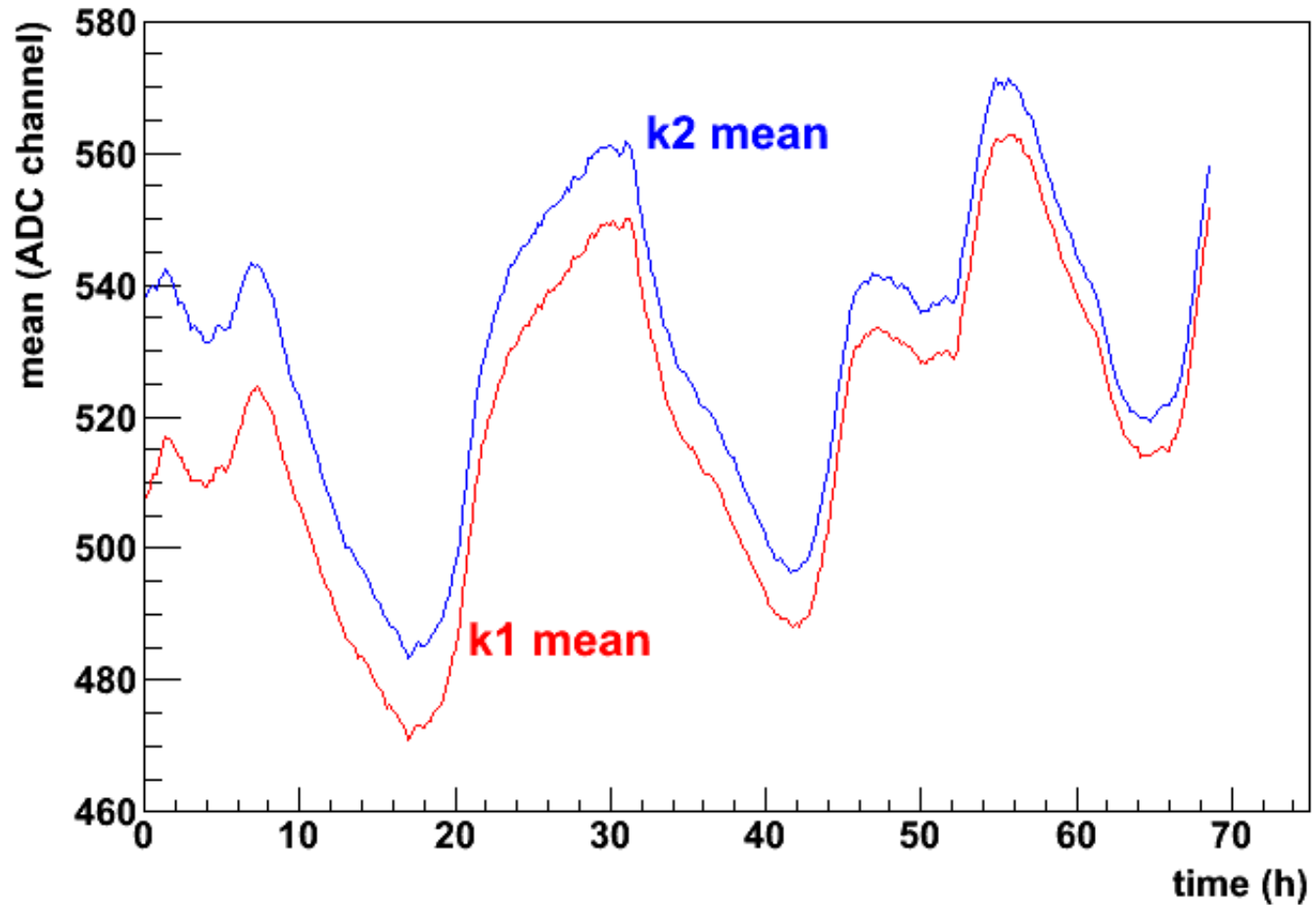
A.Abuhoza, et al., NIMA 718 (2013) 400- 402.

- High voltage on to the detector  
395-390-385 V
- $E_d = 2.5$  kV/cm;  $E_i = 2$  kV/cm;  $E_t = 3$  kV/cm
- During this long term test the upper side of the GEM was exposed to x-rays and  $Fe^{55}$  spectra are taken from both part
- $Fe^{55}$  spectra is taken in 10 min interval

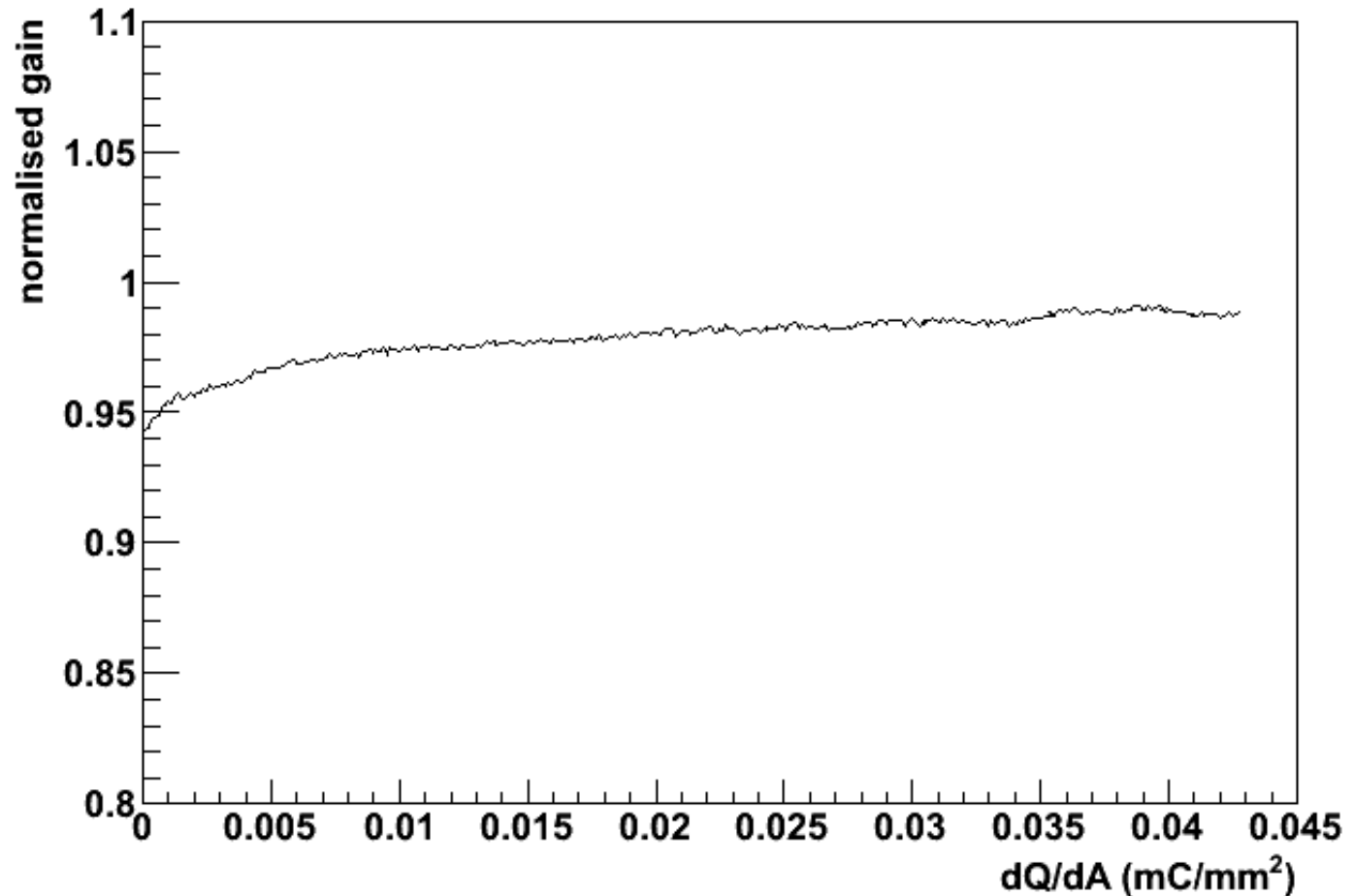
# Rate vs. time



# Mean vs. time

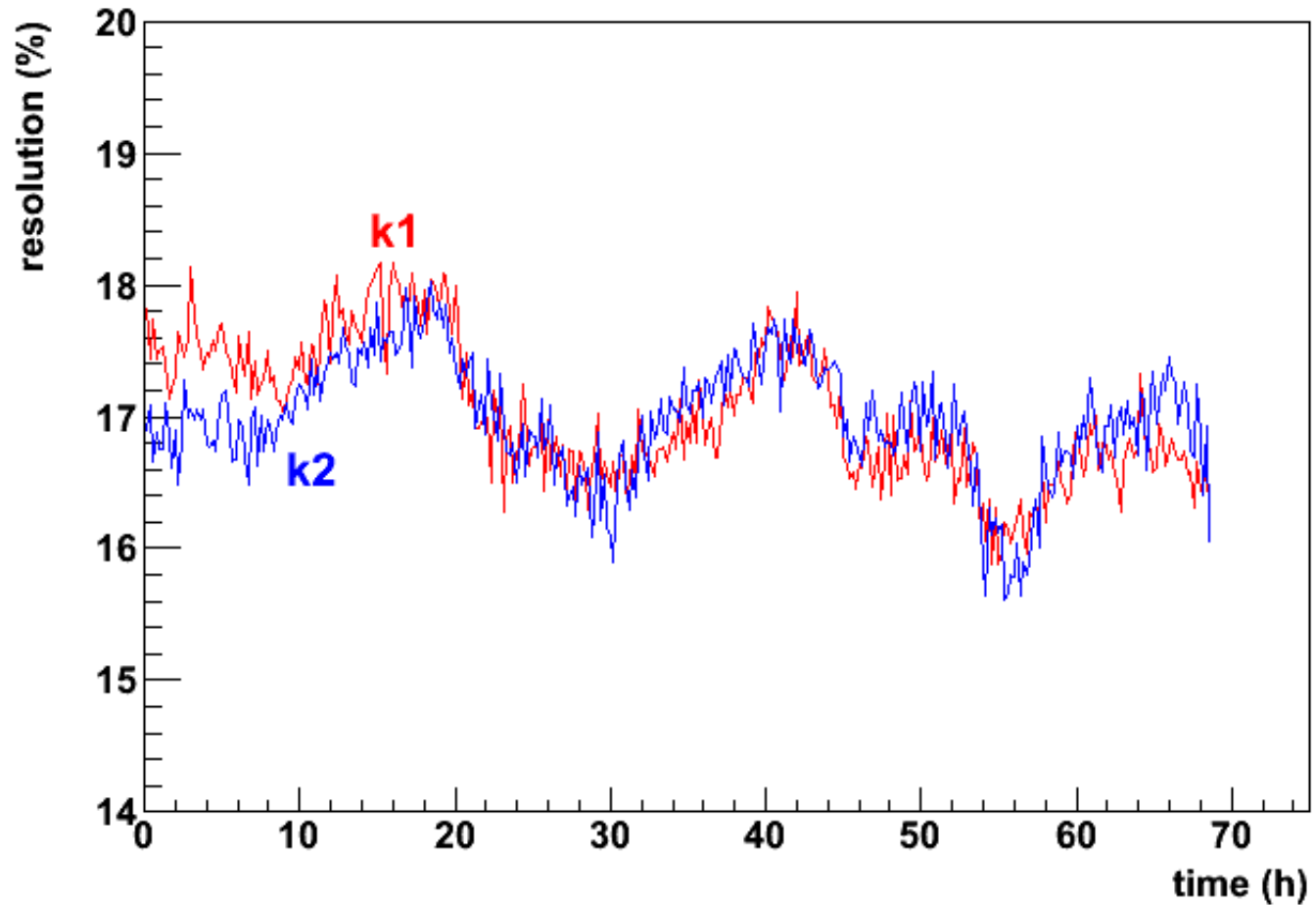


# Normalized gain vs. accumulated charge





# Resolution vs. time



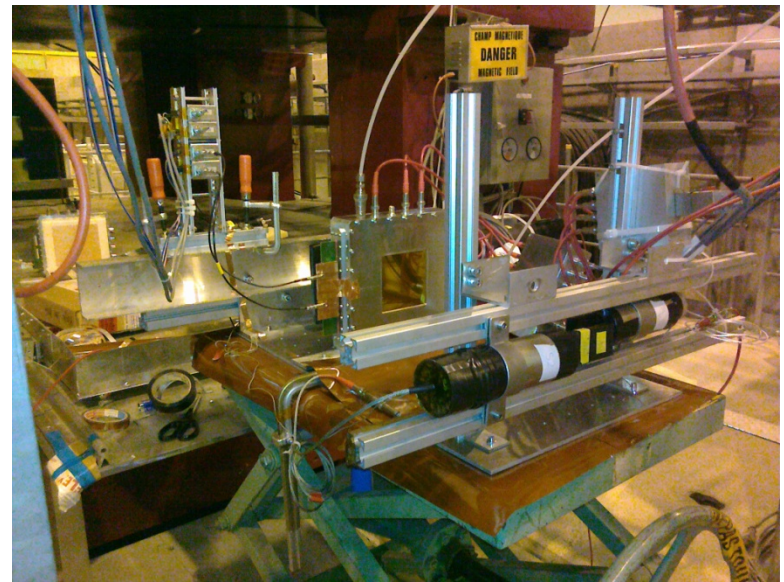
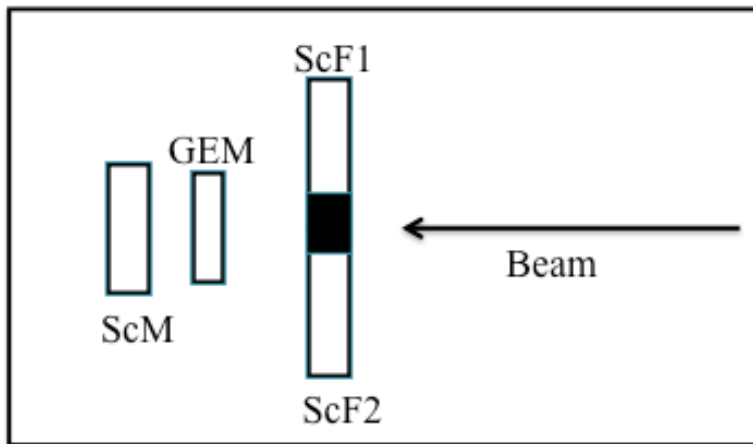
# Objective of the beam test at CERN SPS

- To measure the properties of GEM with shower and in particular Spark probabilities of Double mask and Single mask GEM

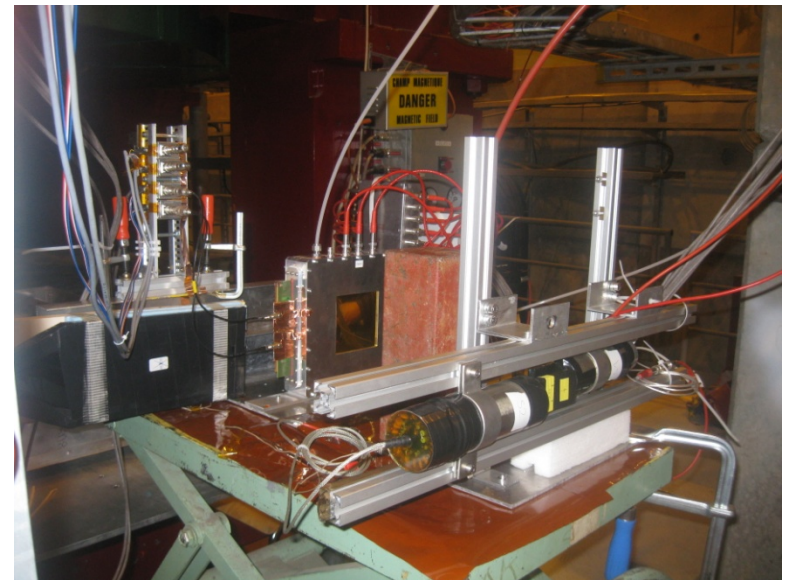
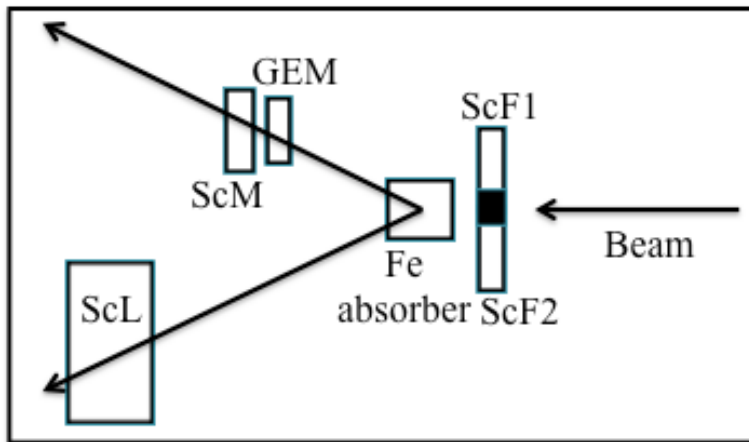
# Summary of beam test

- Detectors
  - 2 Double mask GEM
  - 1 Single mask GEM
- Measurement with
  - Pion beam
  - Pion beam with absorber: Shower
- Measured parameters
  - Current
  - Voltage
  - Trigger and GEM Counts
  - GEM signal

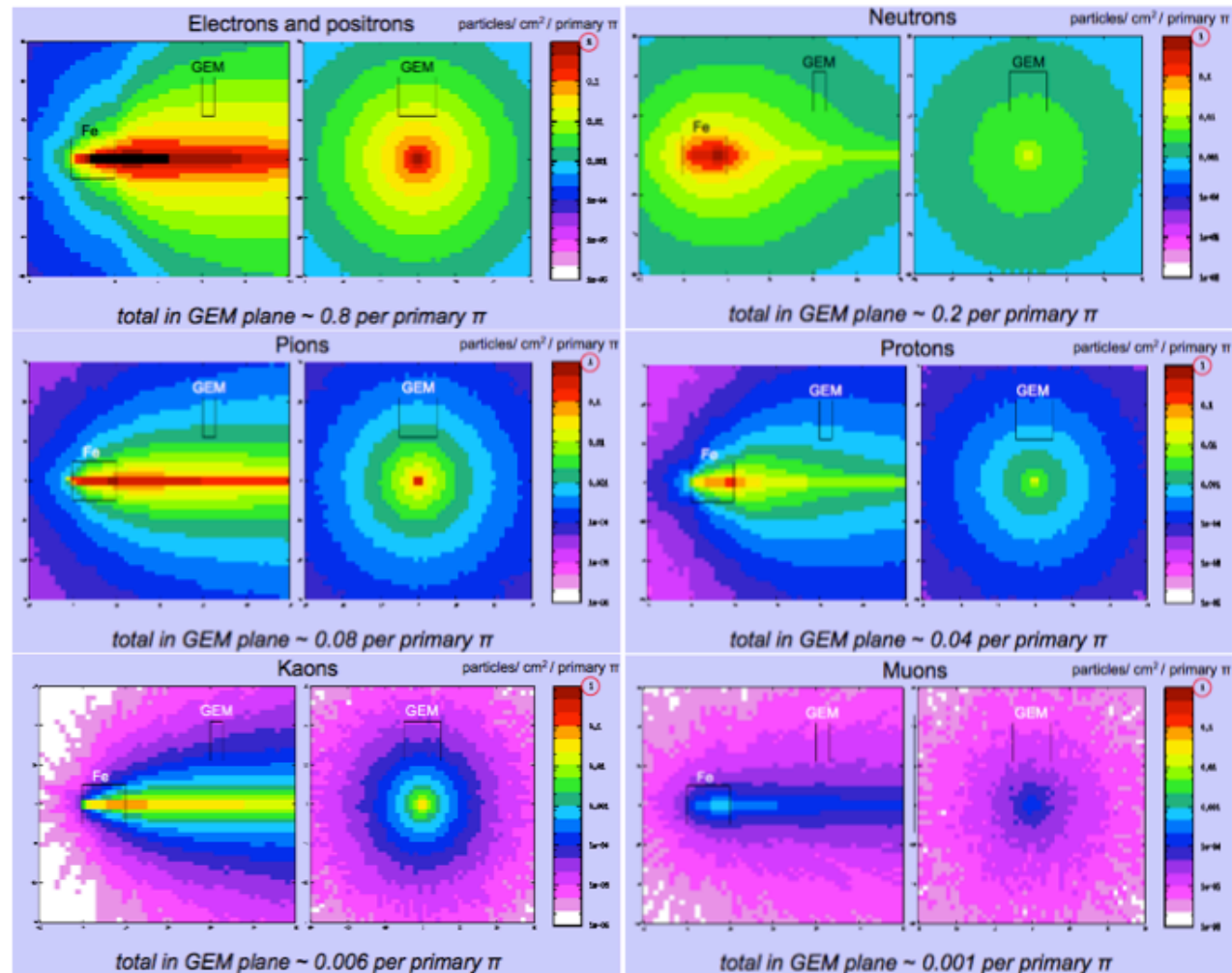
# Set-up for Pion beam



# Set-up for shower



# Particle production during shower from FLUKA simulation

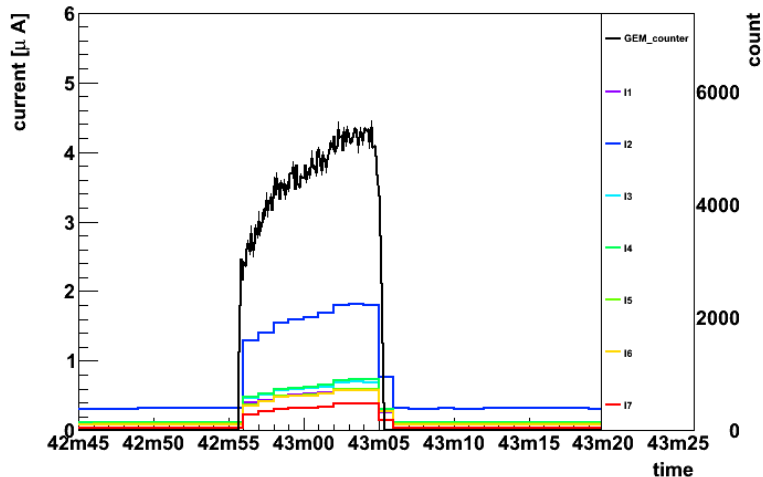


# Methods of Spark detection

- **Absence of signal**
  - Drop in the counting rate of GEM signals
  - Data from sampling ADC
- **Detection of high current**
  - Sudden increase in the Current (Slow)
  - Built in Trip checker in HVG210 Power supply (Fast)

# No spark during a spill

415\_410\_405

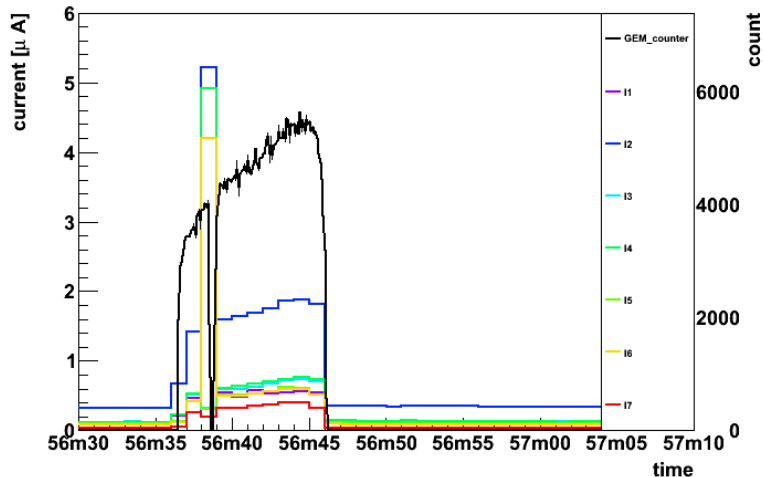


- Double Mask GEM with Fe Absorber
- Gas: Ar/CO<sub>2</sub> : 70/30, Gas flow rate: 5 lt/hr, Particle rate: ~300 kHz, Pion beam



# Drop in GEM counting rate

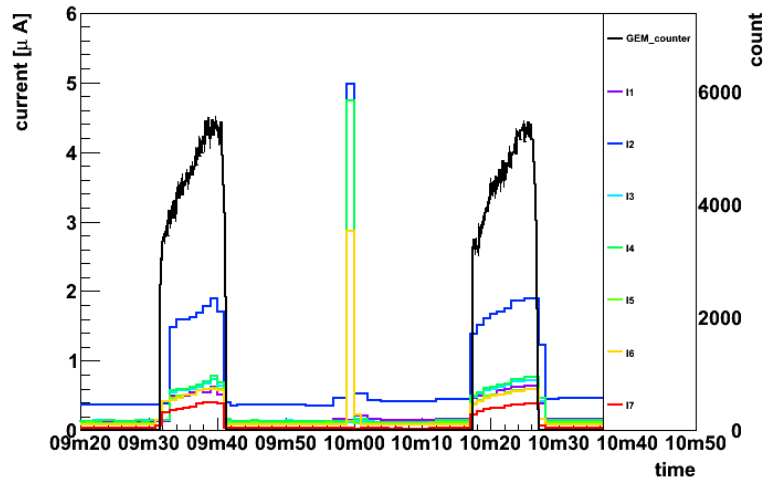
415\_410\_405



- Double Mask GEM with Fe Absorber
- Gas: Ar/CO<sub>2</sub> : 70/30, Gas flow rate: 5 lt/hr, Particle rate: ~300 kHz, Pion beam

# Sudden increase in current

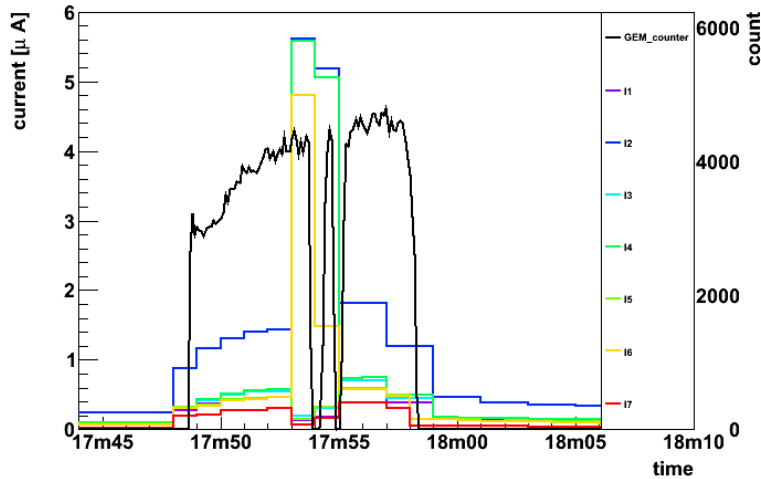
415\_410\_405



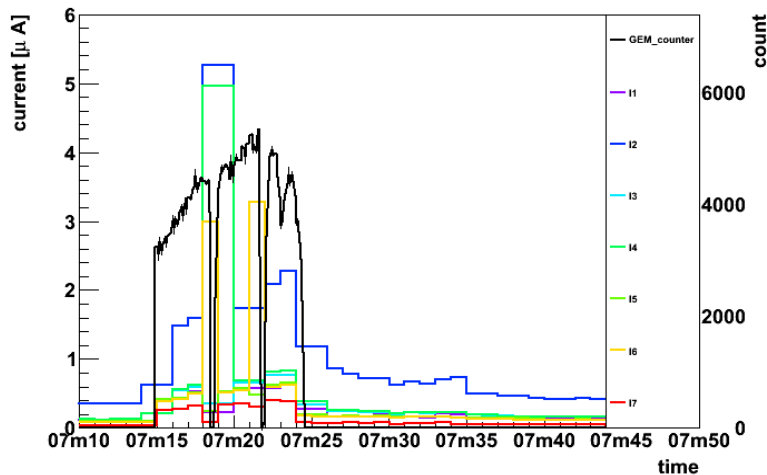
- Double Mask GEM with Fe Absorber
- Gas: Ar/CO<sub>2</sub> : 70/30, Gas flow rate: 5 lt/hr, Particle rate: ~300 kHz, Pion beam

# Two sparks during a spill

412 - 407 - 402

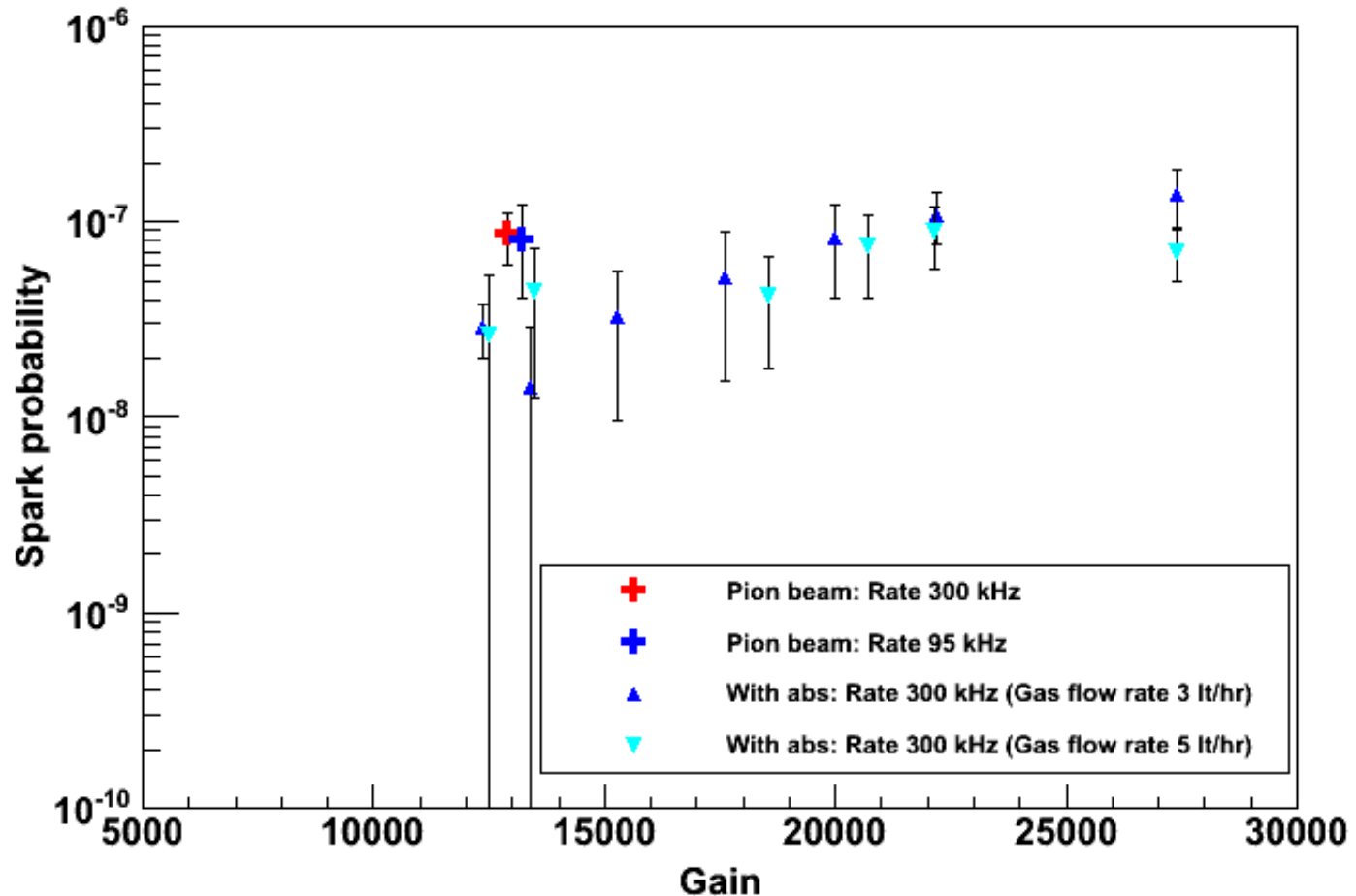


415\_410\_405



- Double Mask GEM with Fe Absorber
- Gas: Ar/CO<sub>2</sub> : 70/30, Gas flow rate: 5 lt/hr, Particle rate: ~300 kHz, Pion beam

# Spark probability vs. gain shower and pion beam



S. Biswas, et al., NIMA 800 (2015) 93–97.

# Summary

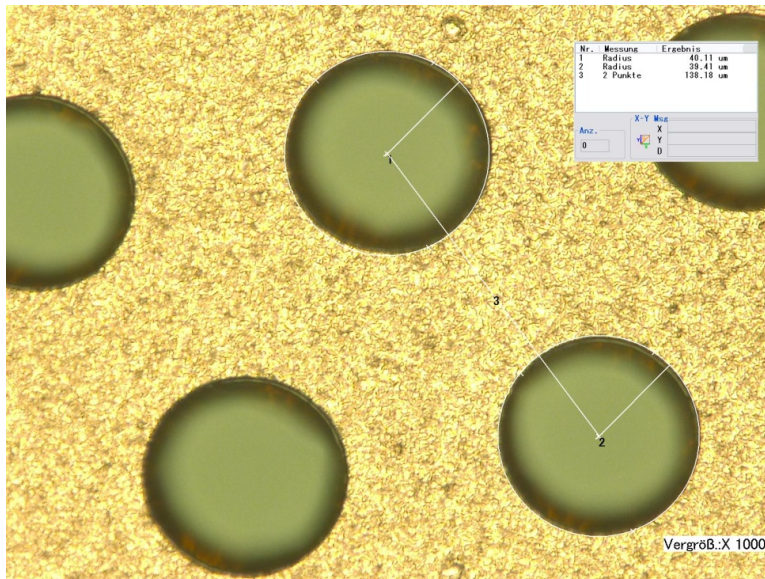
- Long term study and ageing study of GEM is performed by X-ray
- No ageing is observed after accumulation of charge  $>0.04\text{mC/mm}^2$
- MIP spectrum obtained and efficiency is measured for cosmic ray
- SPS test line has good conditions for our purpose
- 4 detectors (3 SM & 1 DM) are build, tested and conditioned at GSI
- Spark probability, Efficiency and tracking will be studied
- The spark probability for pion beam is high

Thank you for your kind attention !

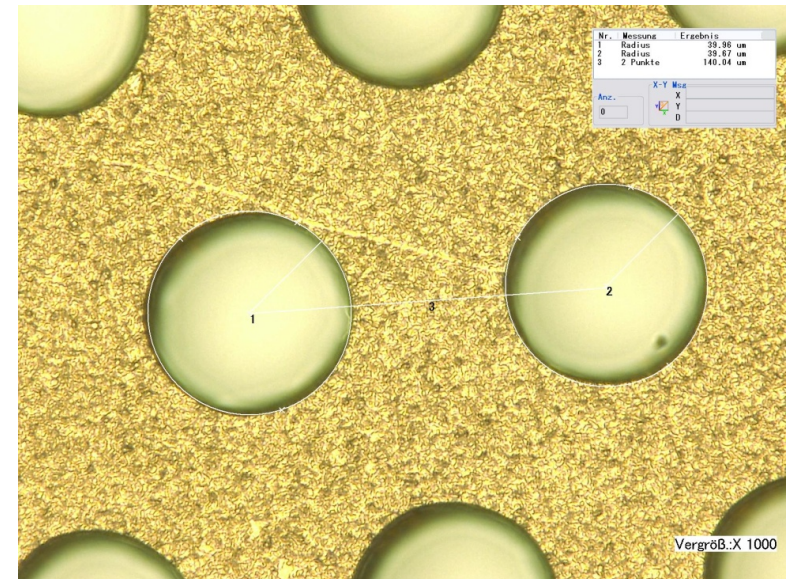
# Back up

# Double Mask foil

**S1: Radius: 39.76  $\mu\text{m}$   
Pitch: 138.18  $\mu\text{m}$**



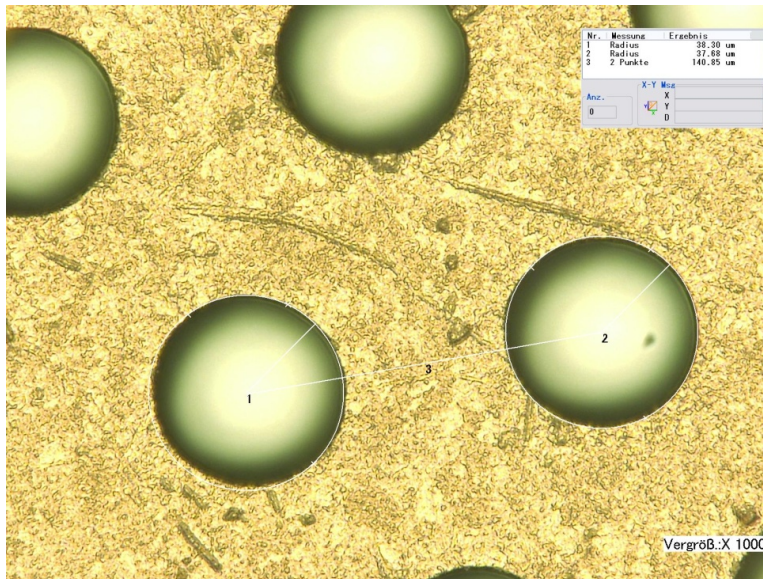
**S2: Radius: 39.82  $\mu\text{m}$   
Pitch: 140.04  $\mu\text{m}$**





# Single Mask foil

**S1: Radius: 37.99  $\mu\text{m}$**   
**Pitch: 140.85  $\mu\text{m}$**



**S2: Radius: 32.71  $\mu\text{m}$**   
**Pitch: 139.20  $\mu\text{m}$**

