CHARACTERISATION OF METAL BY GEM DETECTOR USING ION BEAM FACILITY AT IOP

Alekhika Tripathy, S.Swain, P.K Sahu, S.K Sahu
Institute of Physics,Bhubaneswar

CONTENTS

INTRODUCTION

- GEM is a gaseous ionization detector in the field of radiation detection which has tremendous advantages over other type of gaseous detectors.

- The advanced features of GEM include excellent spatial and temporal resolution,minimisation of ion backflow fraction,gain stability over a large area,etc.

- The simplest GEM setup consists of a standard GEM foil placed in between a drift (acts as the cathode) and an induction (acts as the anode) plane enclosed within a chamber for gas flow.

- A triple GEM detector has been used in this work to characterise different metals using the proton beam at the ion beam laboratory (IBL) of IOP.

GEM Configuration

- The Gas Electron Multiplier (GEM) is a two sided copper-clad Kapton foil, perforated with a high density of holes of the order of 50-100 per mm^2.
- These holes have typical diameters of about 70μm and a pitch of usually 140μm as shown in figure 1.

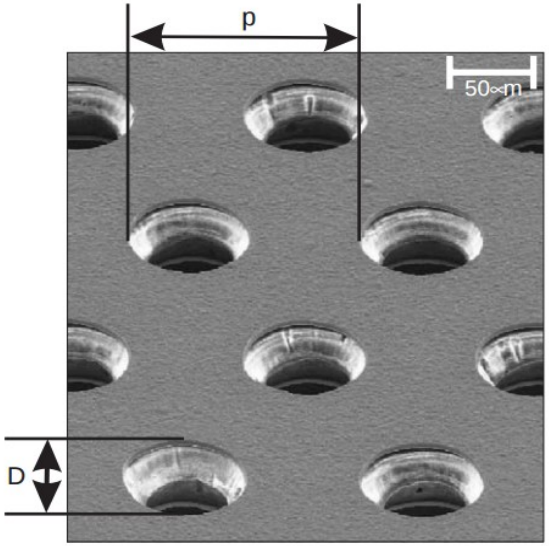


Fig.1: Photograph of a GEM foil with standard geometry (p = 140 μm pitch and D = 70 μm outer hole diameter.

TRIPLE GEM DETECTOR GEOMETRY

- A triple GEM detector is shown schematically in Fig. 2.The device consists of a gas filled chamber with a drift plane, three cascaded GEM foils and a read-out plane.
- The Drift Plane is a Kapton foil (50μm) with a copper layer of 5μm on one side.
- The gap between the bottom of drift plane and the top of GEM-1 is 3 mm and is called the Drift Gap.
- A continuous gas flow is maintained inside the detector.We have used Ar and CO_2 gas in 70:30 ratio.
- When a charged particle enters the detector,primary ionization occurs in this drift region.

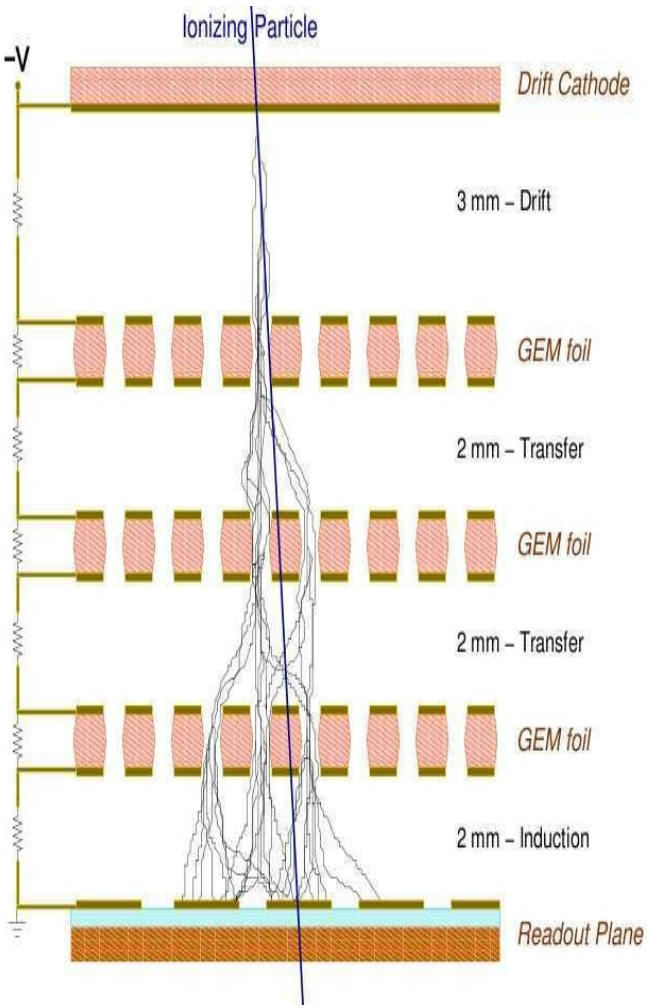


Fig.2.Triple GEM detector geometry

Continued...

- Fig. 3 shows the voltage divider circuit used to distribute the appropriate voltages to all electrodes.
- Once, the electrons come out of the GEM-1, they enter Transfer gap-1.
- Again, avalanche multiplication occurs in GEM-2 holes and electrons are transferred to GEM-3 holes through Transfer gap-2 for even further amplification.
- The electric field guide the primary electrons into these holes and an avalanche multiplication occurs.
- After all the amplification is done,the electrons from the holes of GEM-3 move towards the anode plane, where they are collected.

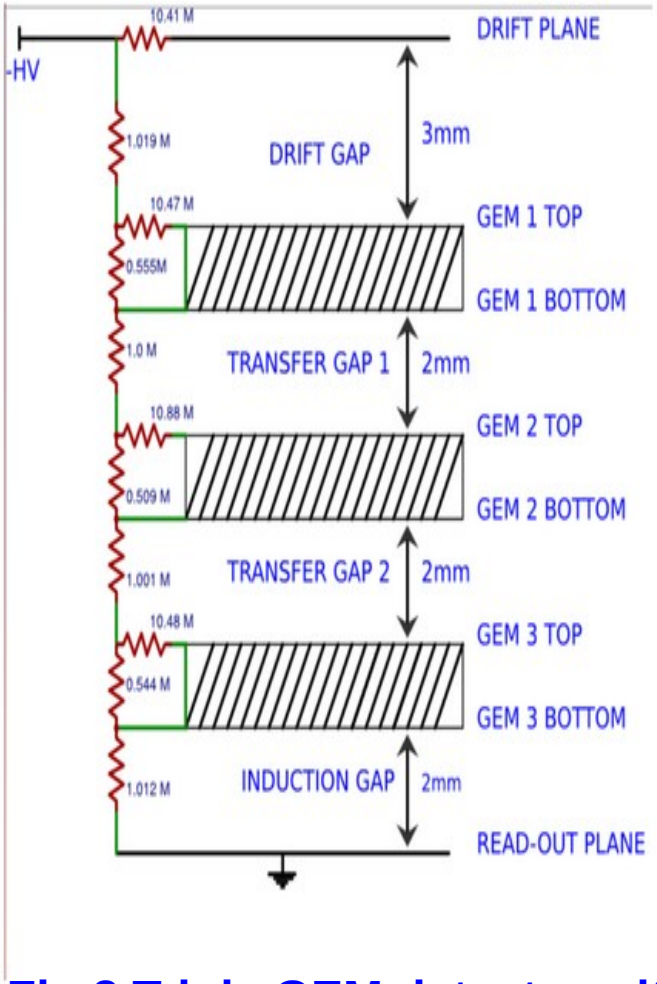
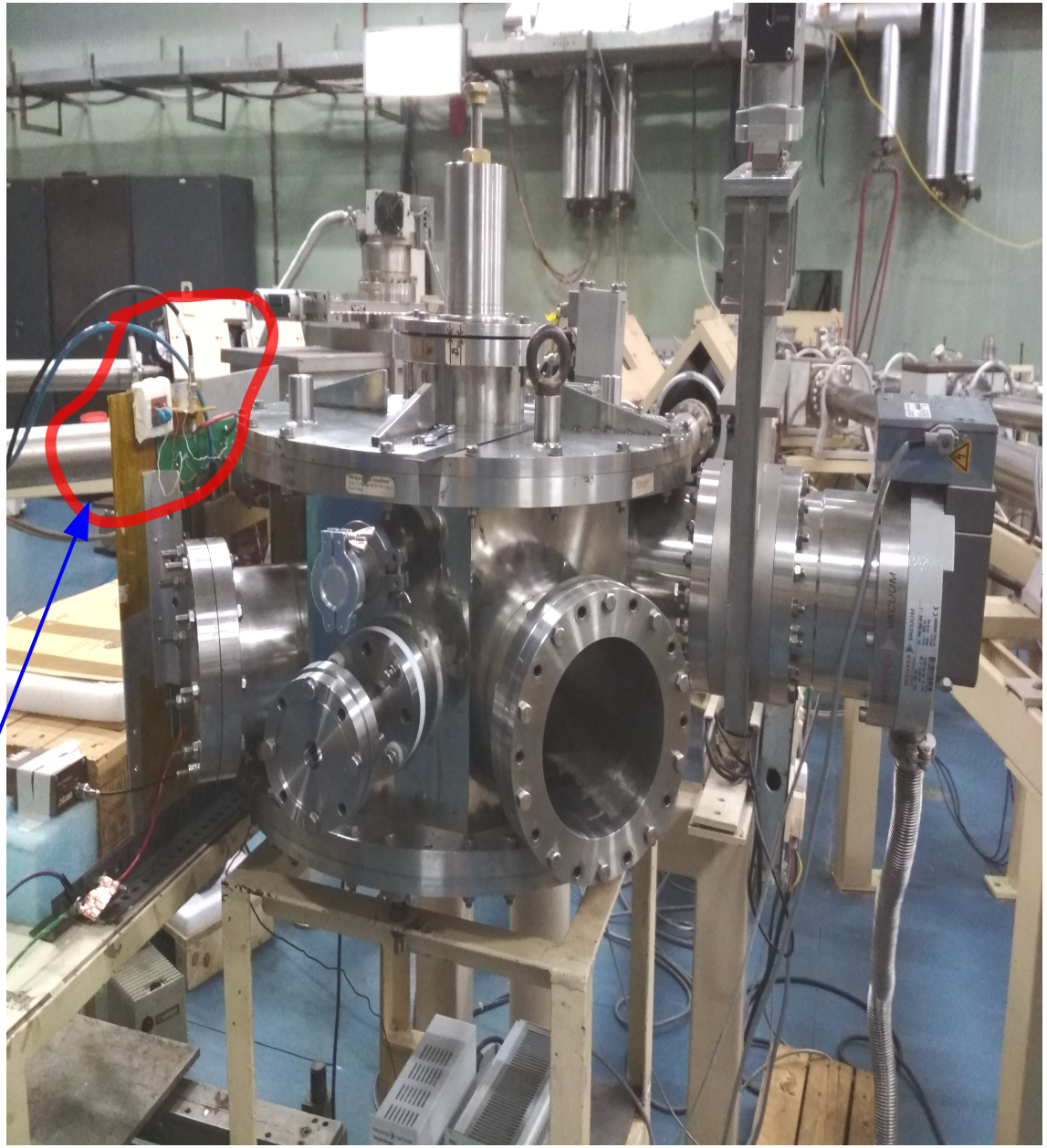


Fig.3.Triple GEM detector with the voltage divider circuit

EXPERIMENTAL SETUP

- Energetic negative ions are injected into the accelerator, they lose their electrons due to several collisions with stripper (argon) gas atoms.
- At high terminal voltage positive ions are emitted with huge amount of energy.
- These positive beams are incident on the target.
- The emitted X-ray from the target is incident on GEM detector for further characterisation purpose.



GEM detector

Fig.4.Experimental Setup in IBL.

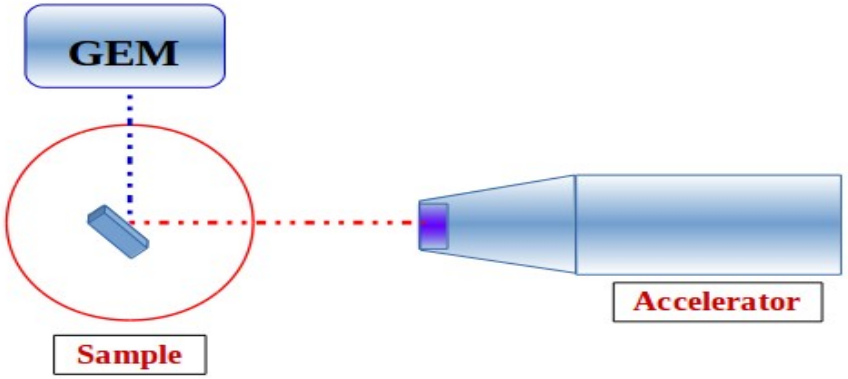
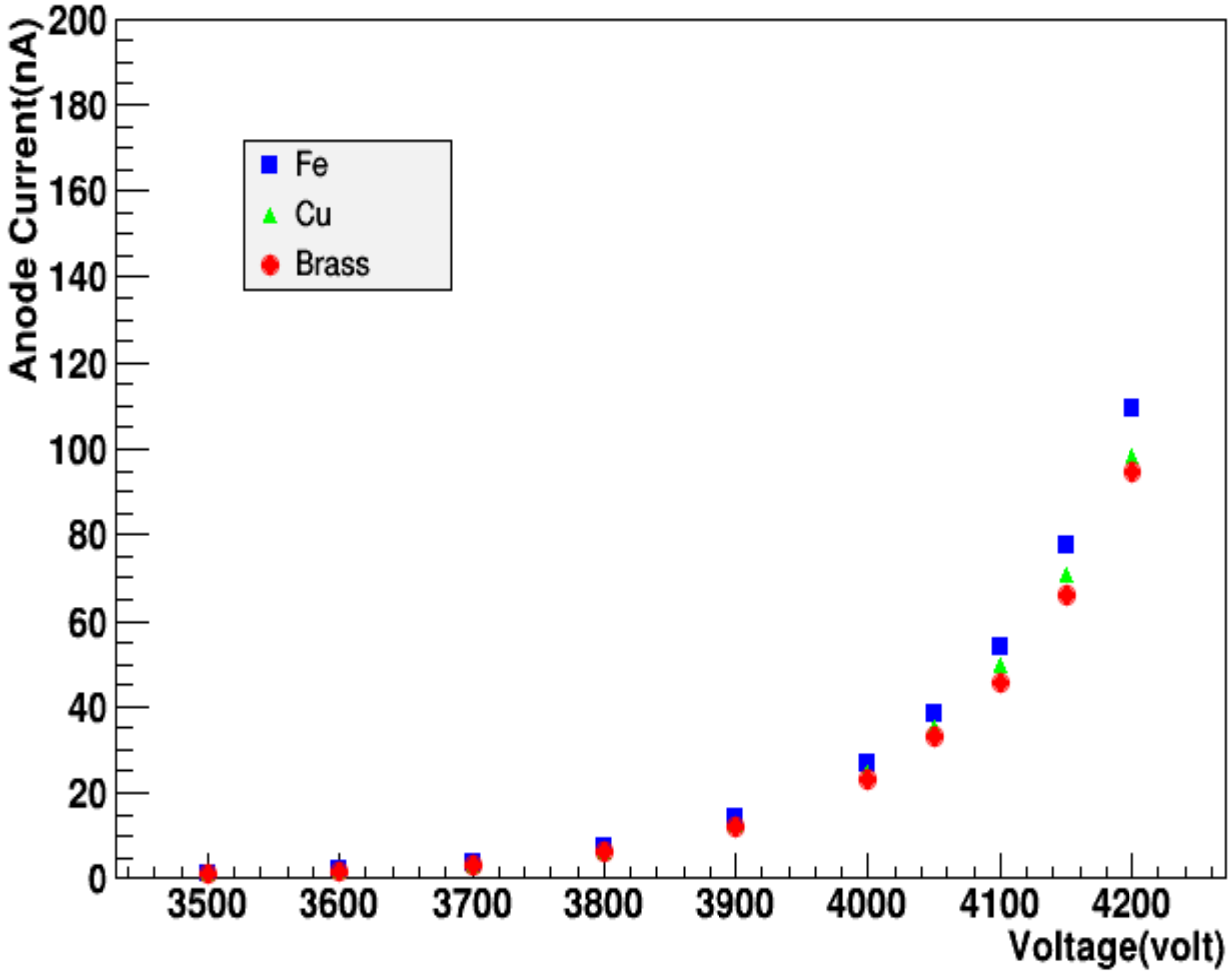


Fig.5. Schematic view of detector setup with Ion beam

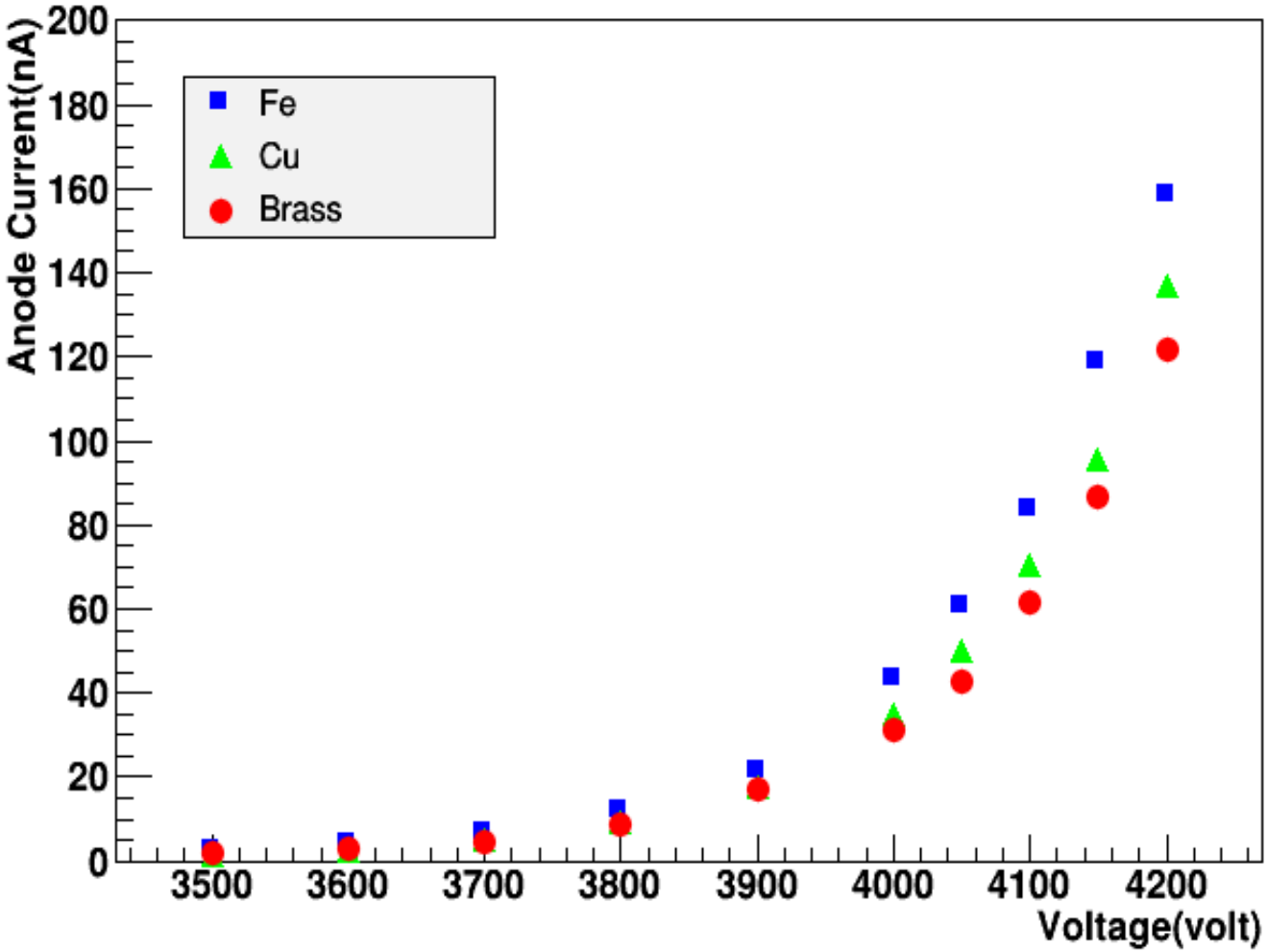
The target current varied from 50nA to 200nA is applied during the experiment.
Anode current from the detector was observed with different GEM voltages.

Anode current Vs GEM voltage



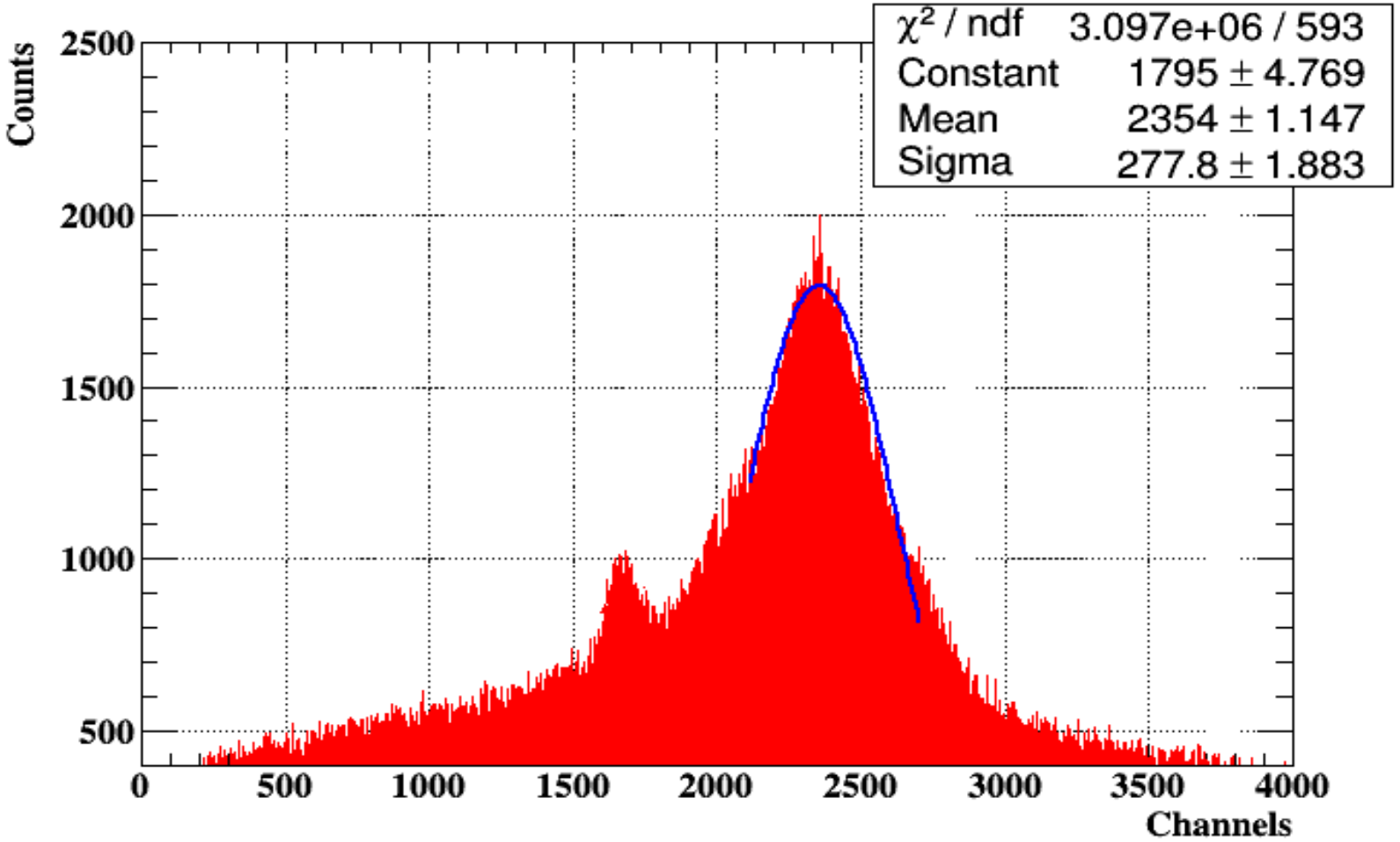
Target Current=150 nA

Anode current Vs GEM voltage



Target Current=200 nA

MCA Spectra for Fe55 source



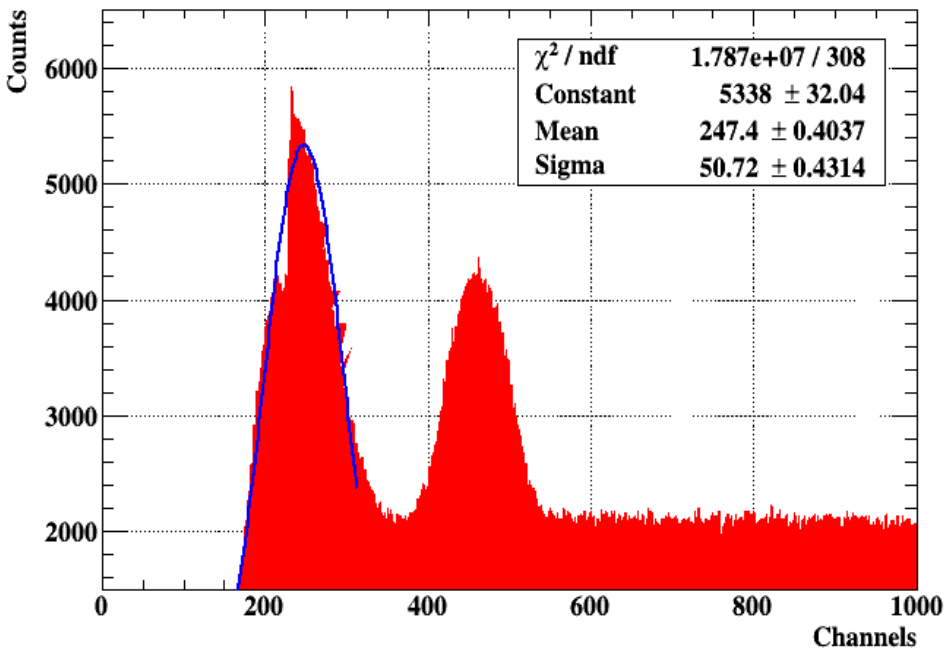
Ar:CO_2 (70:30)

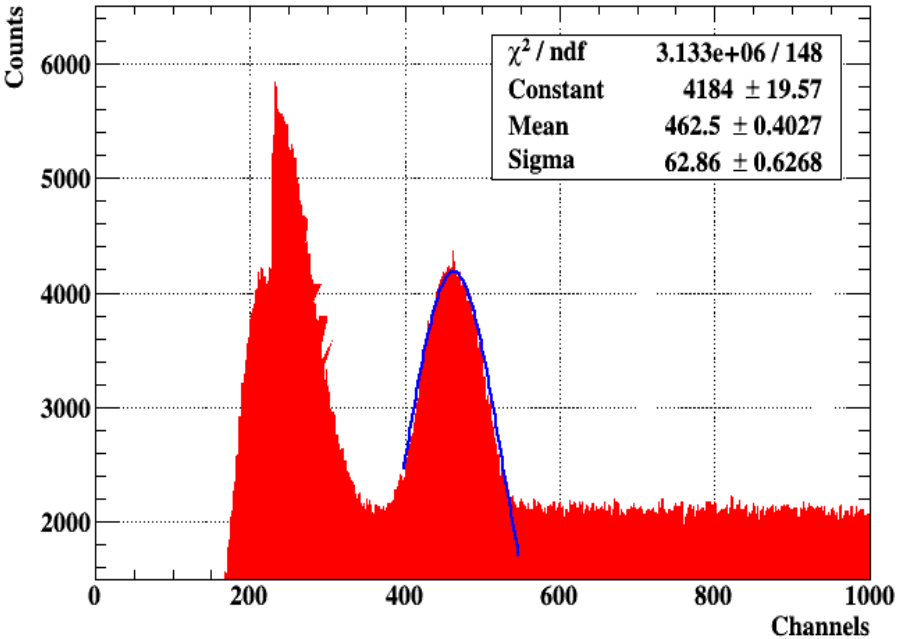
Target Current = 200nA

GEM volatge = 4200V

Brass Spectrum

Ar/CO_2 70:30
Target current: 200 nA
GEM voltage: 4200V





Mean peak (channel number)

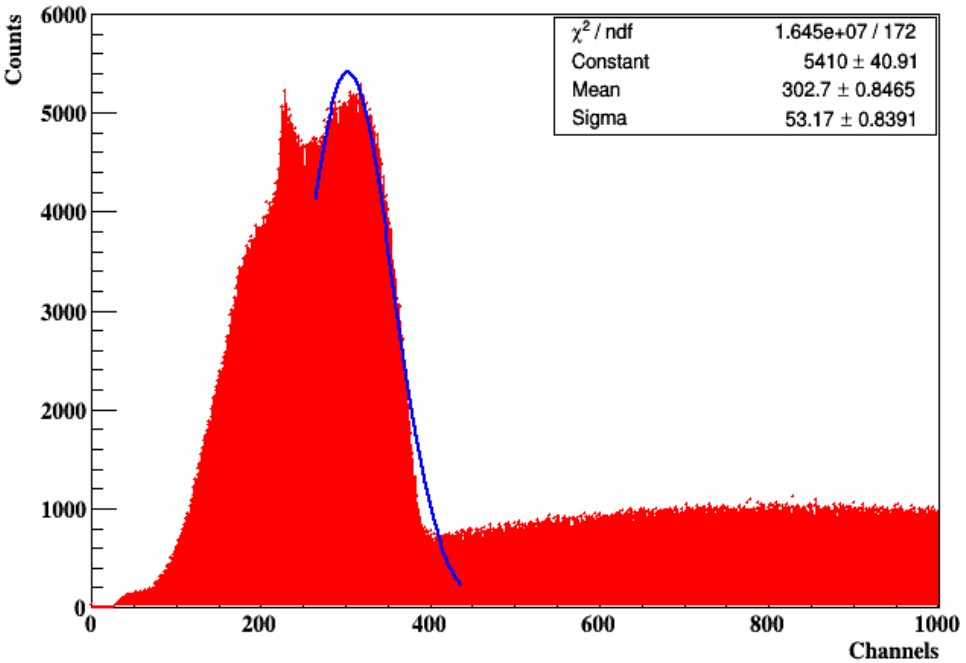
Ar:CO_2 70:30

Target current = 200 nA

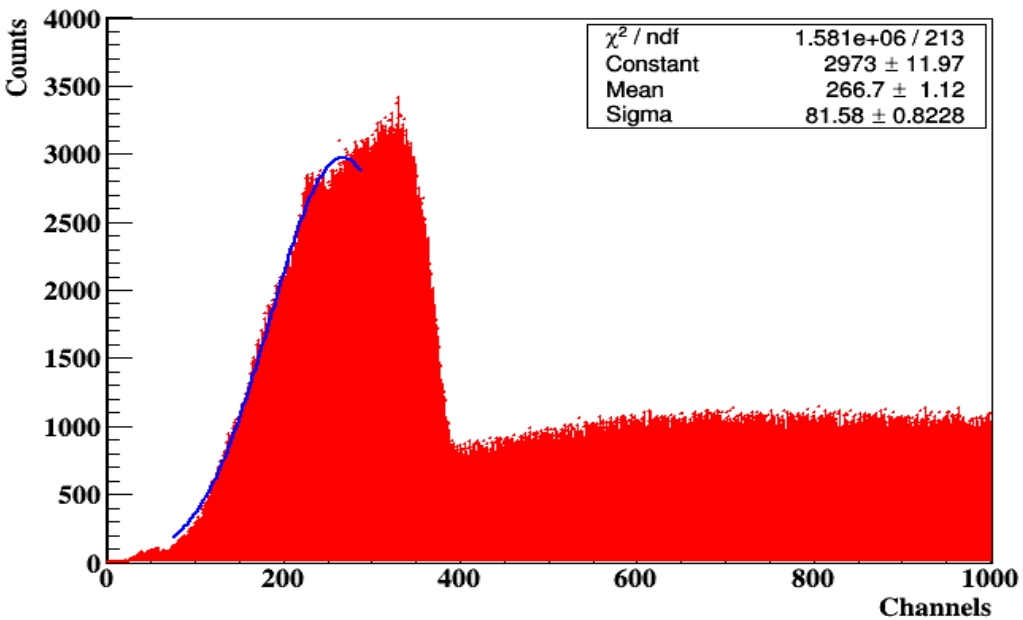
GEM volatge = 4200V

Amplifier : 1000 gain,

6µs shaping time



Target : Cu

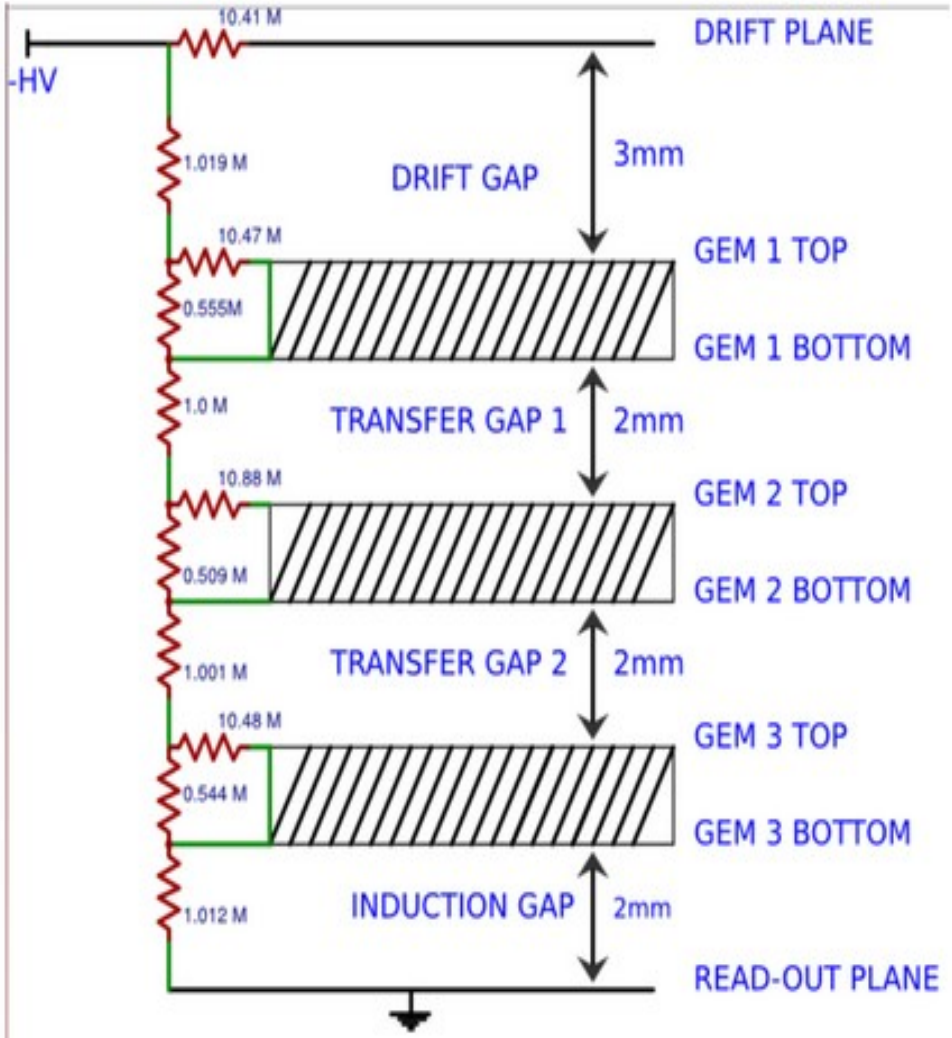


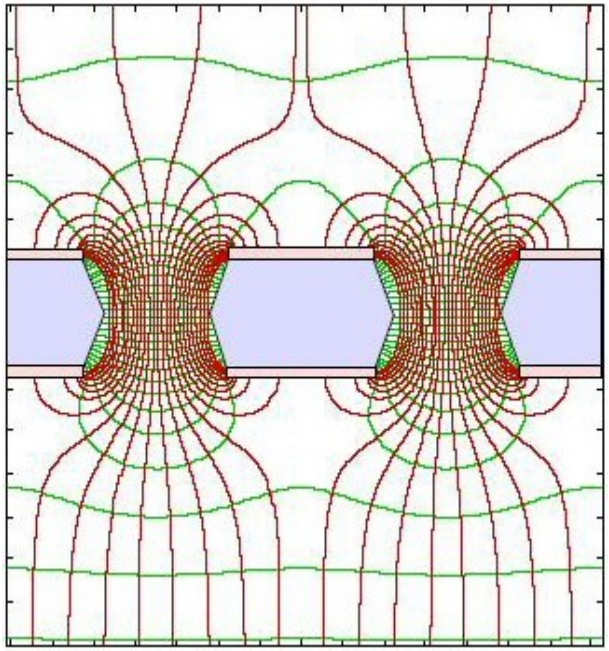
Target : Fe

CONCLUSION

- Different metal samples are detected by the GEM using the proton beam.
- We are able to get the two characteristic main peaks from the MCA spectra of brass.
- The spectra of the other two samples,Cu and Fe, also show their respective x-ray main peaks.

Thank you





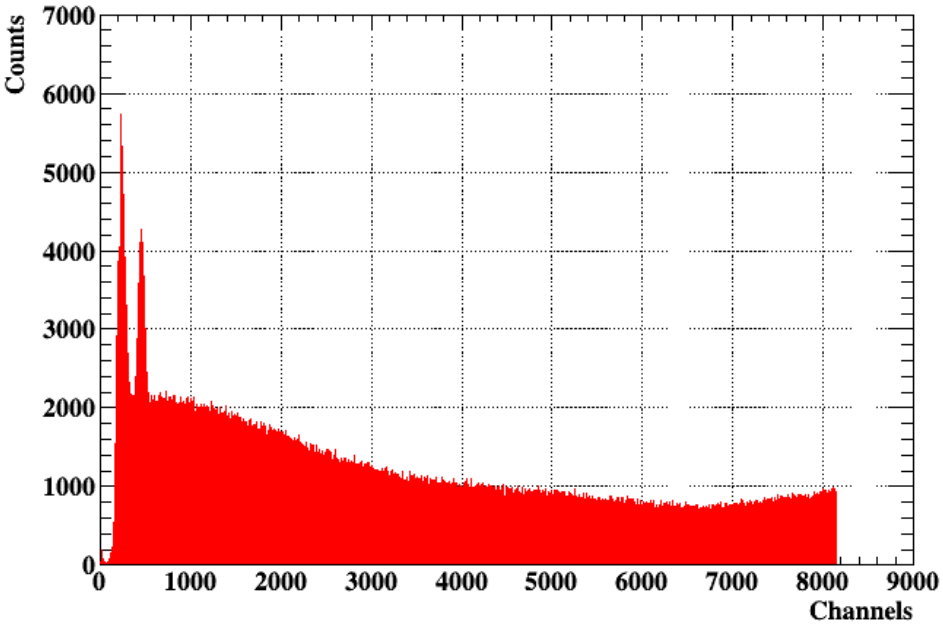
Triple GEM detector with the voltage divider circuit

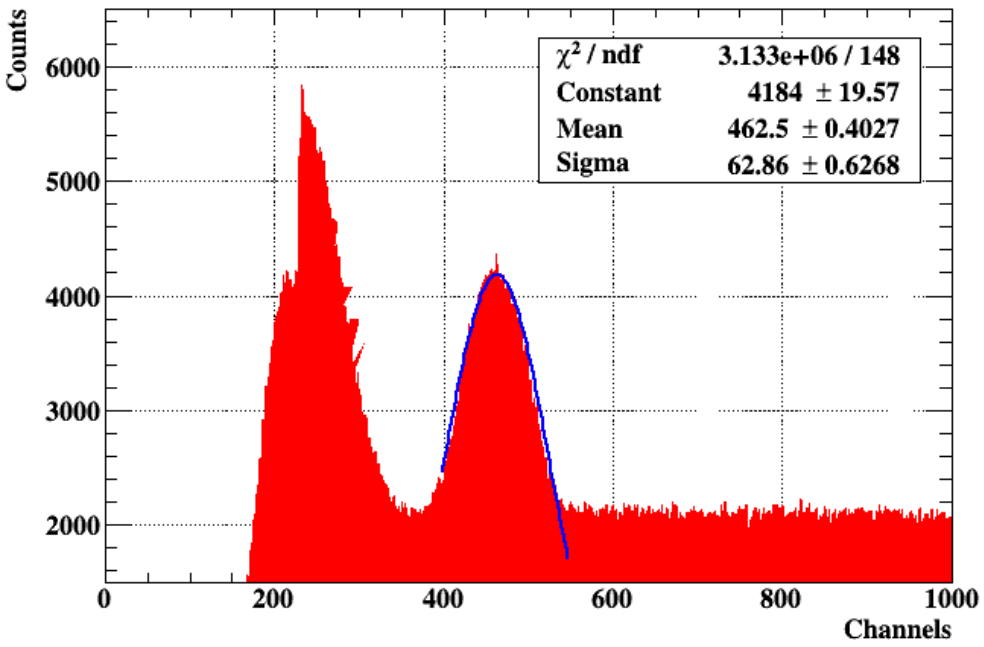
Absolute gain of the detector can be expressed as:

$$\textit{Gain} = \frac{Q_{out}}{\textit{number of primary electrons} \times e}$$

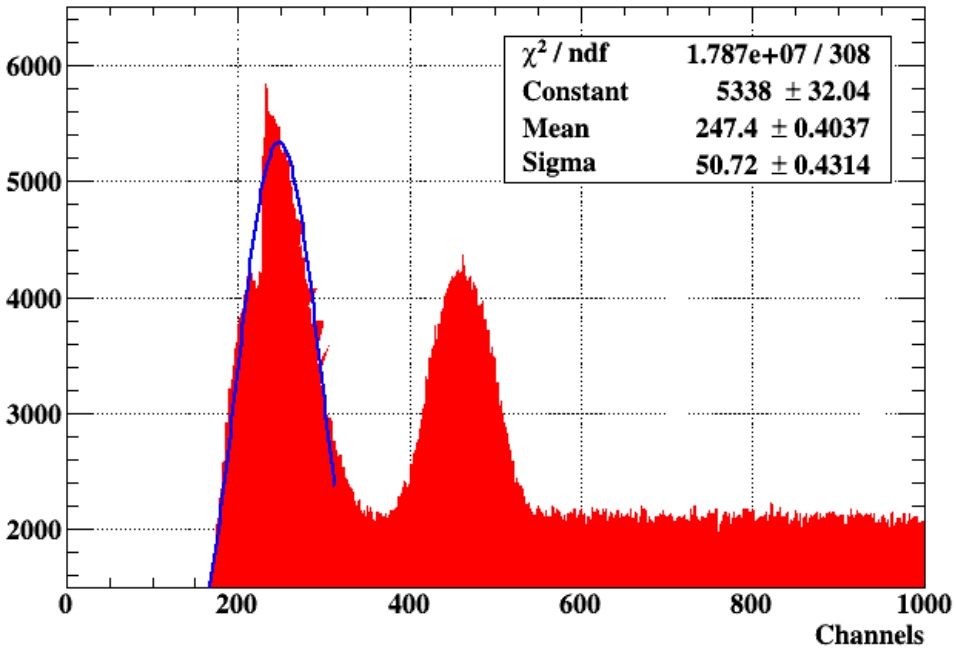
The detector gain with Fe^{55} source is calculated to be of the order of 10^4.

MCA2
Sample: Brass
Target current: 170 nA
GEM volatge: 4200V
Amplifier : 1000 gain,
6us shaping time

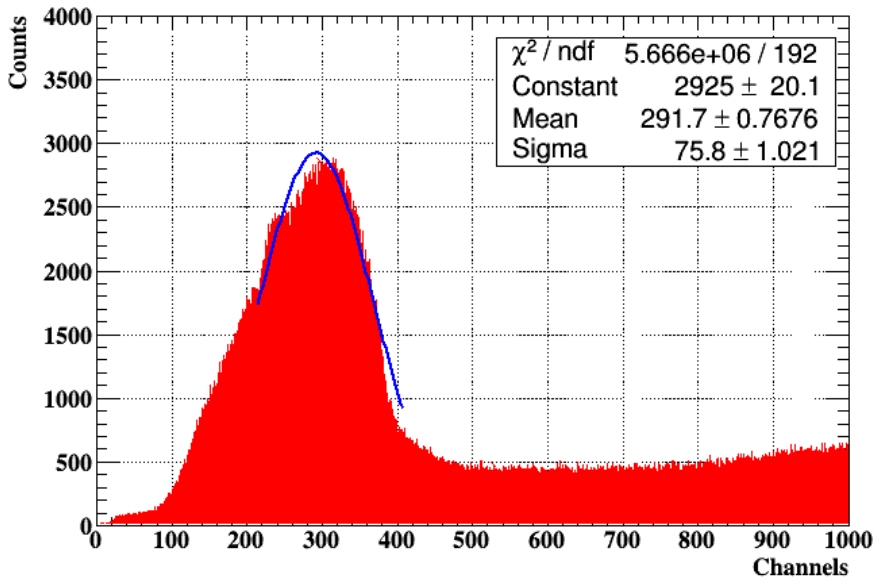




Mean: 462.5



Mean: 247.4



Target : Cu, 291.7

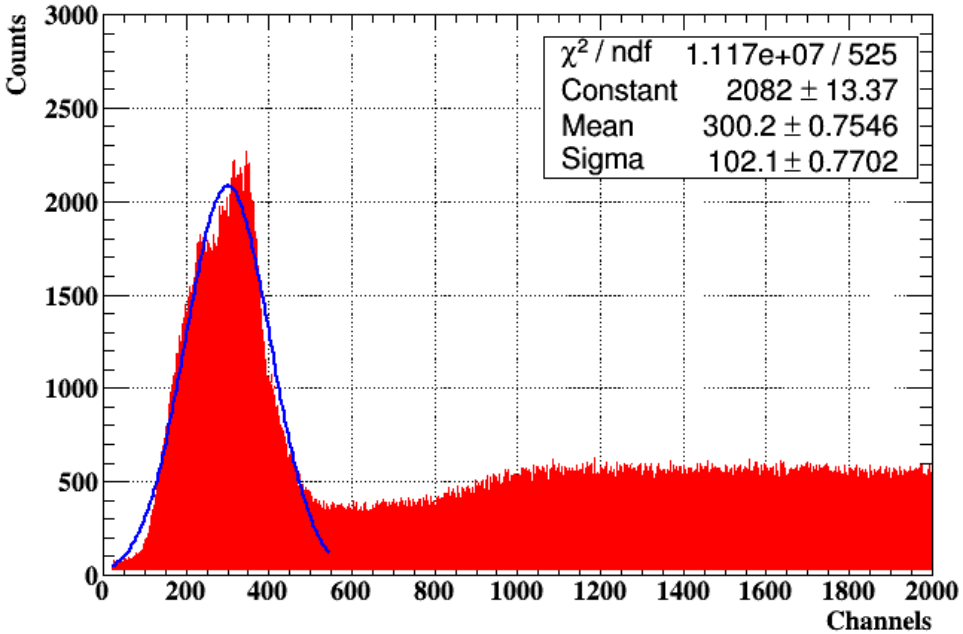
MCA2, Ar:CO_2 90:10

Target current: 150 nA

GEM volatge: 3700V

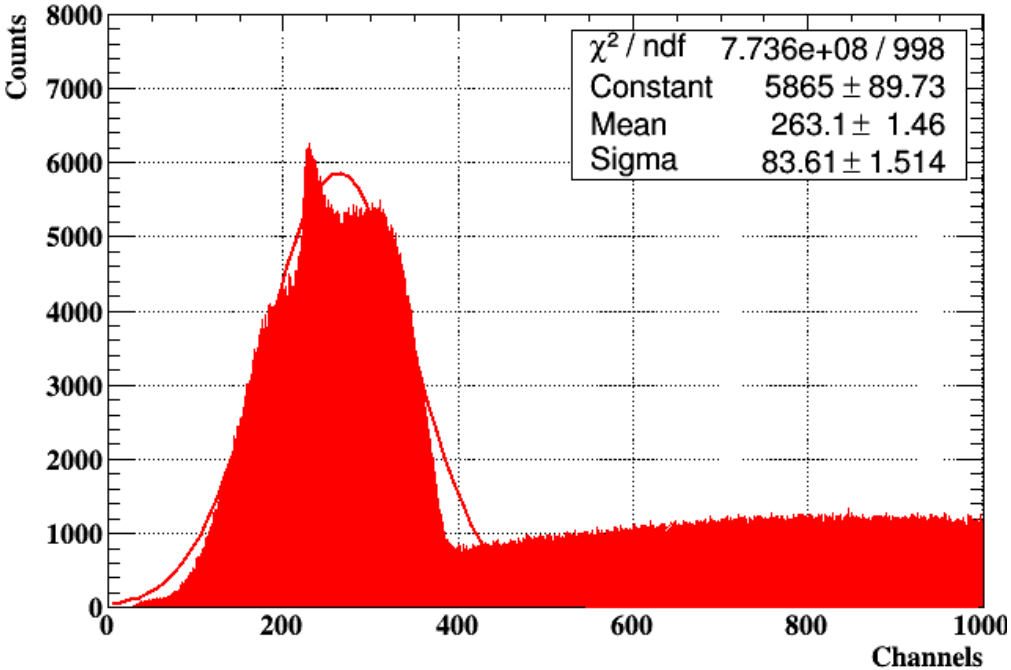
Amplifier : 1000 gain,

6us shaping time

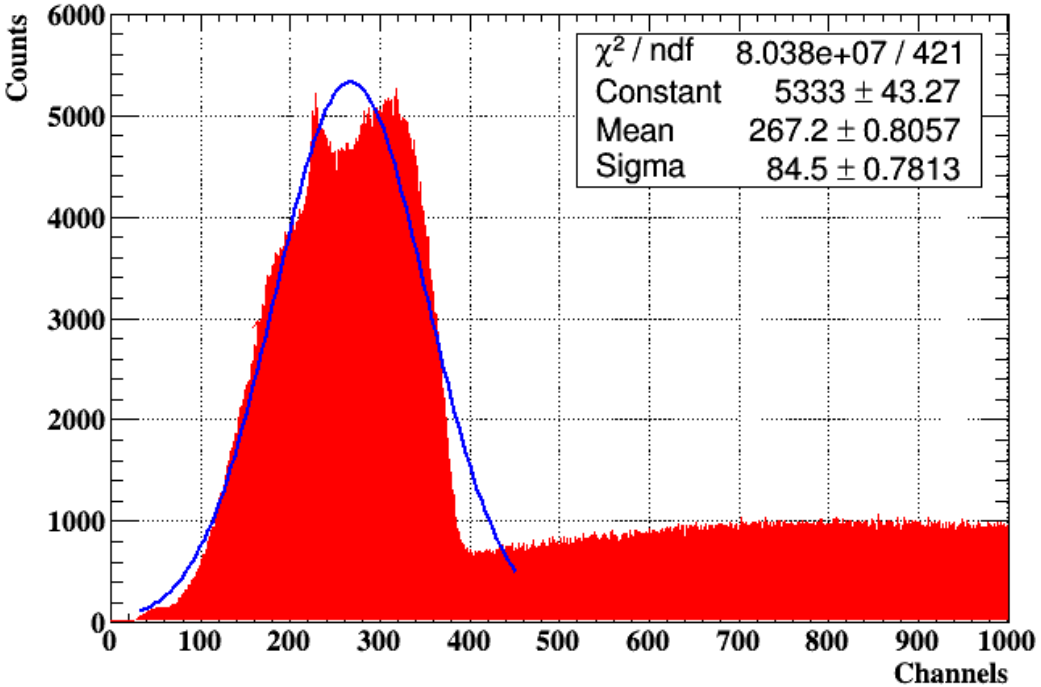


Target : Fe, 300.2

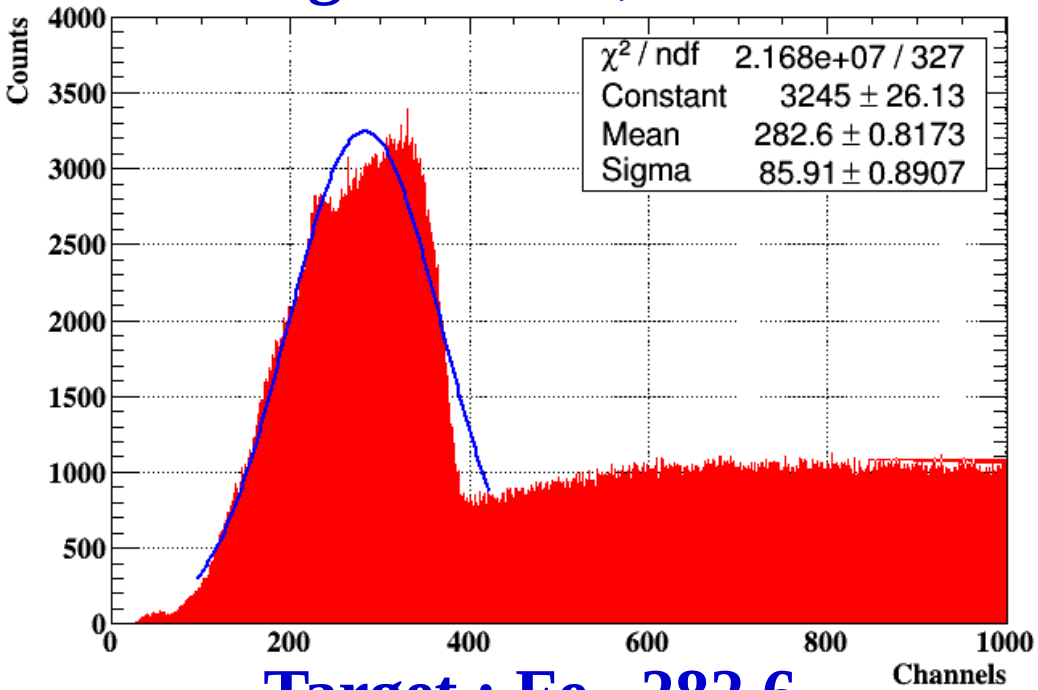
Mean peak (channel number)



Target : Brass, 263.1



Target : Cu, 267.2



Target : Fe, 282.6

MCA2, Ar:CO_2 70:30

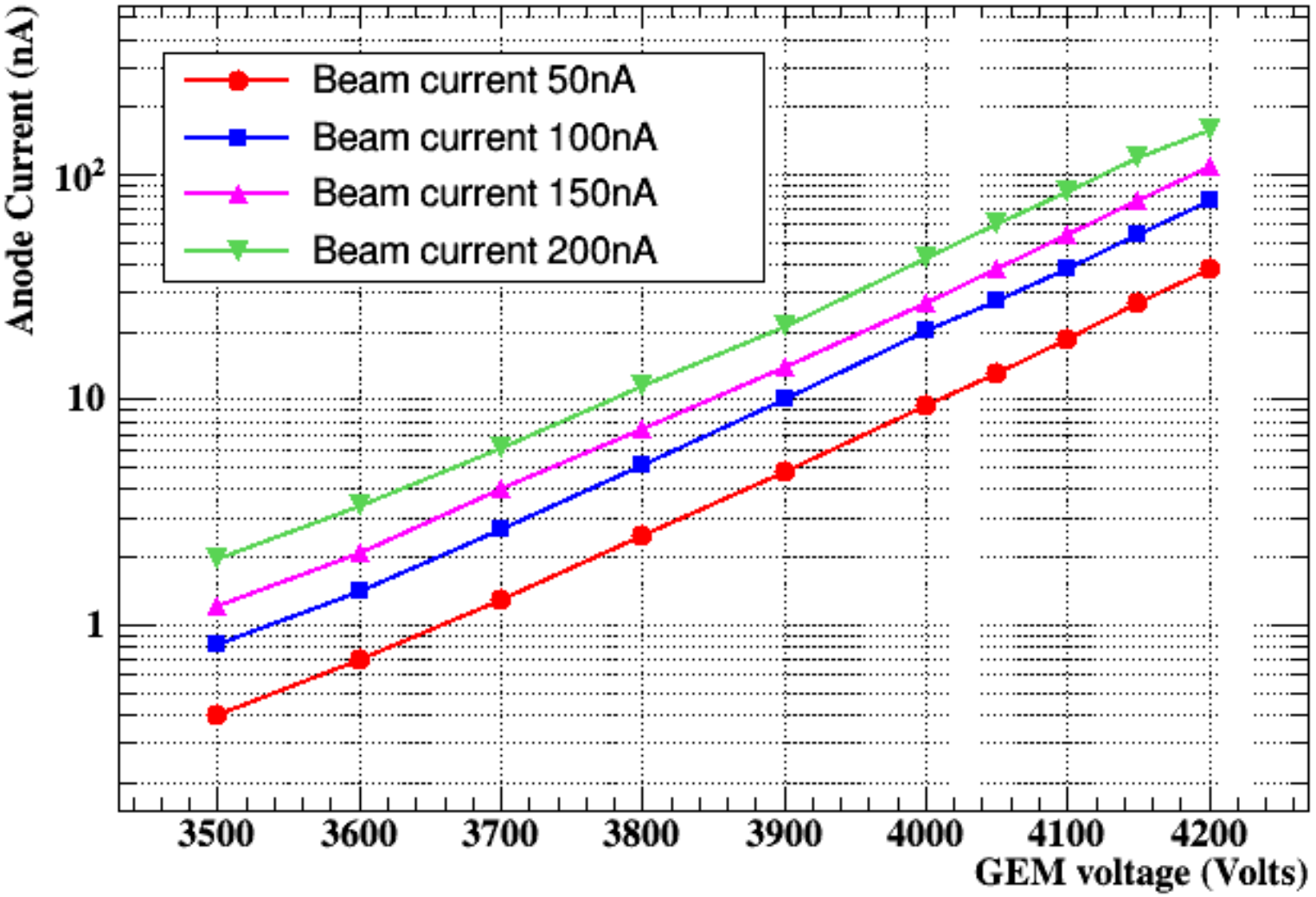
Target current: 200 nA

GEM volatge: 4200V

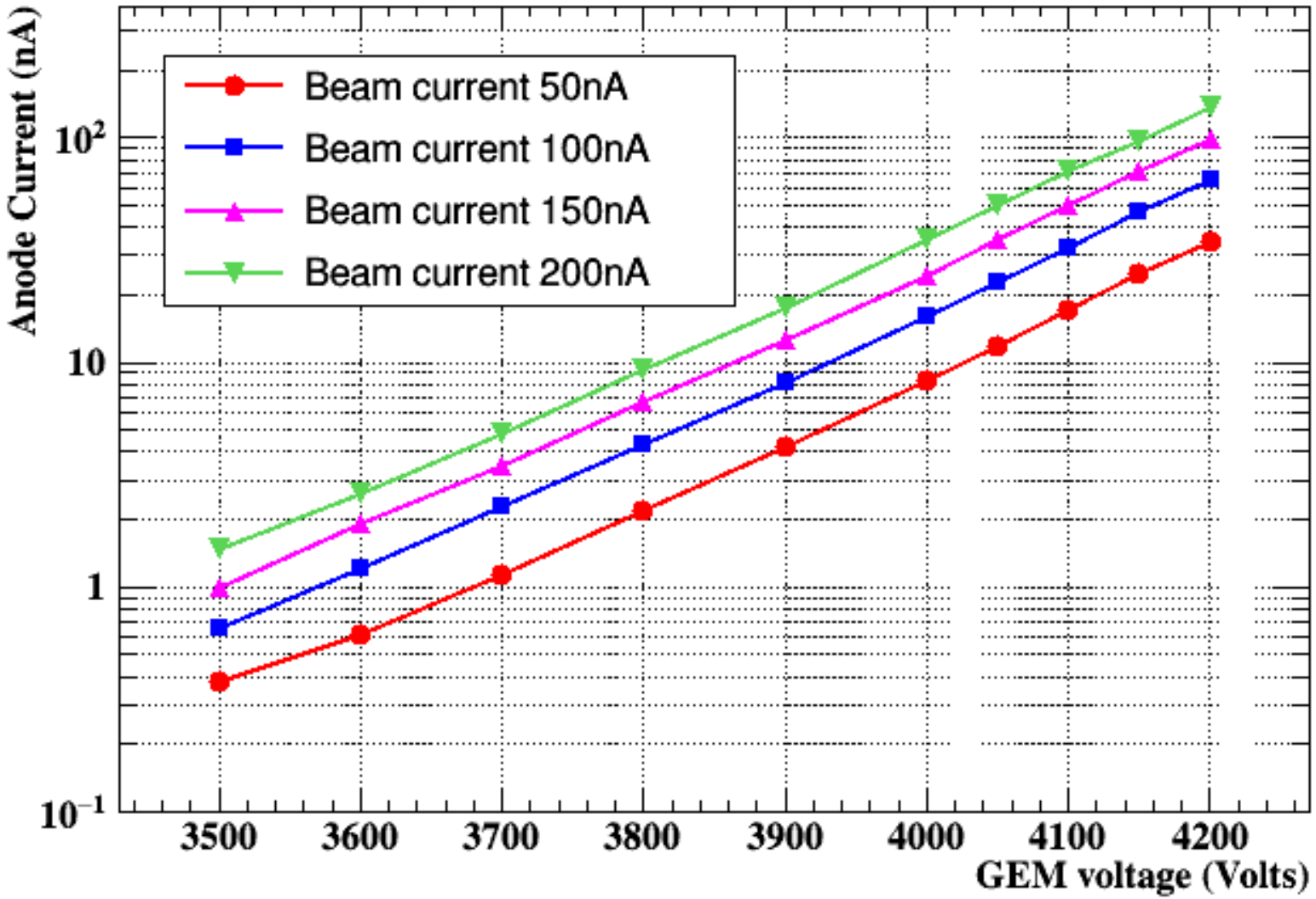
Amplifier : 1000 gain,

6us shaping time

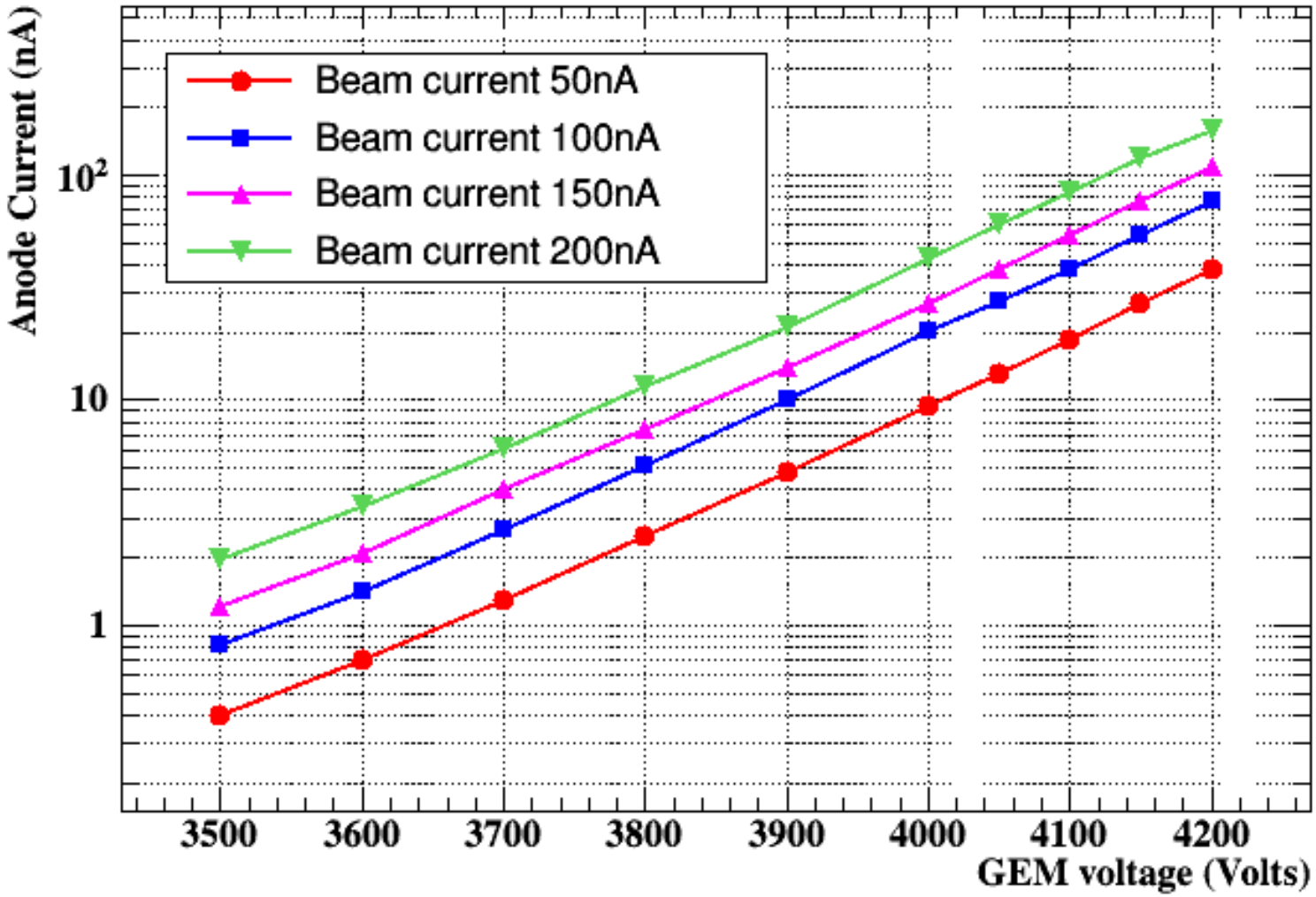
Traget : Brass

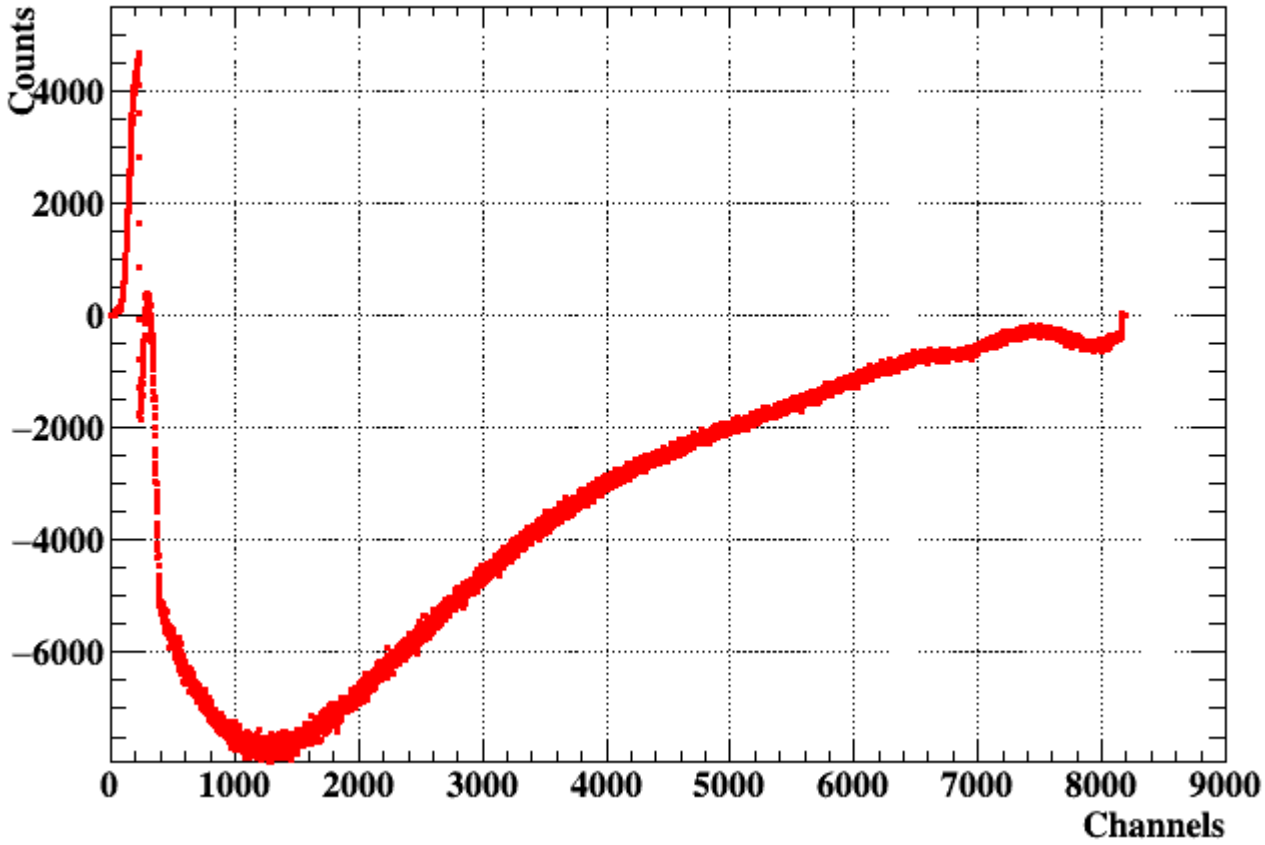


Traget : Cu


Beam current 50nA
Beam current 100nA
Beam current 150nA
Beam current 200nA
Anode Current (nA)
10^2
10
1
10^{-1}
3500
3600
3700
3800
3900
4000
4100
4200
GEM voltage (Volts)

Traget : Fe


Beam current 50nA
Beam current 100nA
Beam current 150nA
Beam current 200nA
Anode Current (nA)
10^2
10
1
3500
3600
3700
3800
3900
4000
4100
4200
GEM voltage (Volts)


Counts
4000
2000
0
–2000
–4000
–6000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Channels

Target : Fe

- Gas Electron Multiplier (GEM) is a novel gas detector in the field of radiation detection.