A triple GEM Detector exposed to high flux neutrons beam

Gabriele Croci, Matteo Alfonsi, Serge Duarte Pinto, Leszek Ropelewski, Marco Villa (CERN), George Fanourakis, Theodoros Geralis, Kostantinos Karakostas, Eleni Ntomari, Yorgos Tsipolitis (Demokritos - NTUA)

RD51 Miniweek, 23-25 February 2010

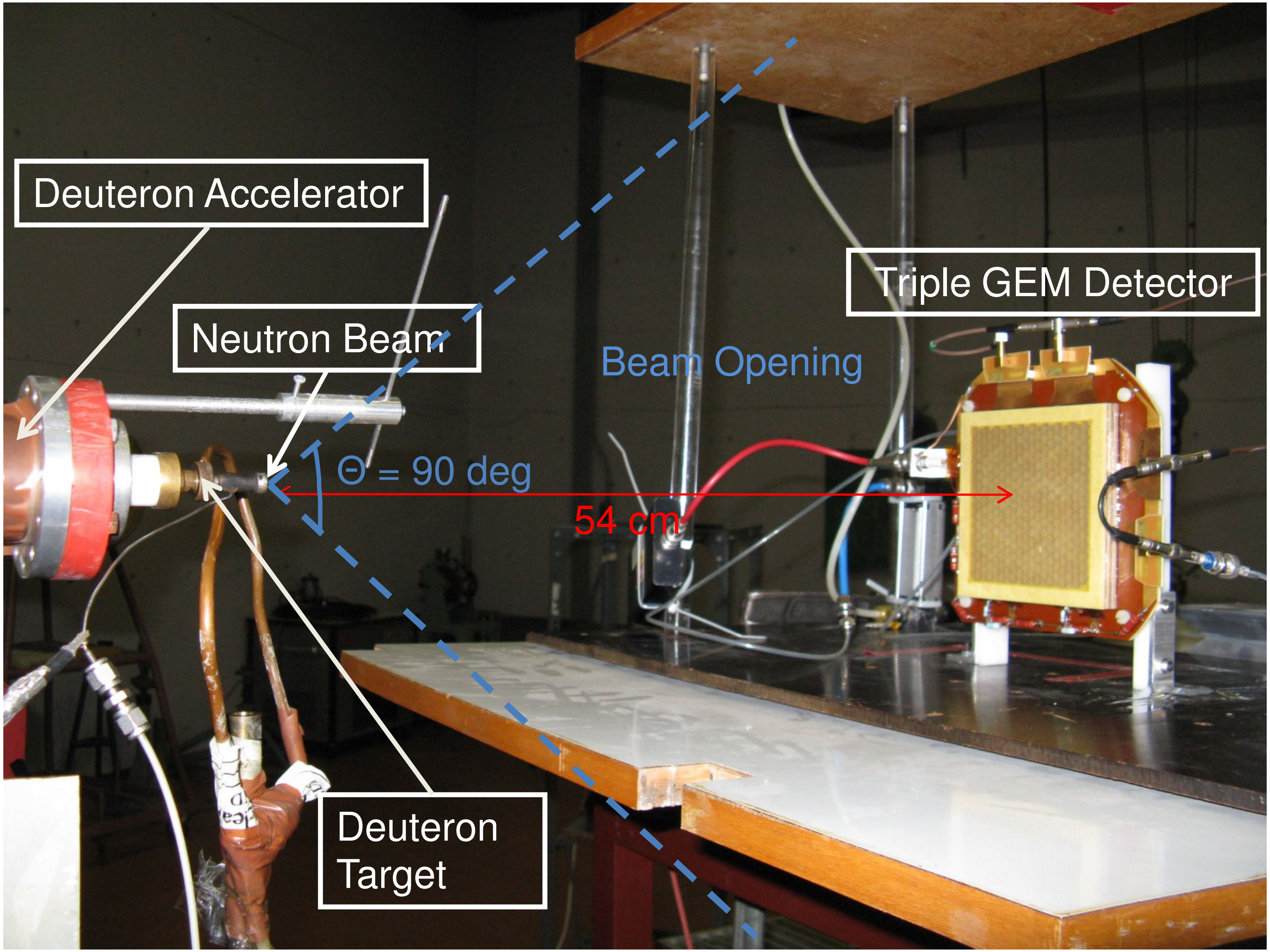
Aim

- Measure discharge probability of a Triple-GEM detector exposed to a high neutron flux
- Test if the GEM copper is activated
- Neutron Flux created by collisions of accelerated deuterons on a deuteron target
- The test took place in Demokritos (Athens) in December 2009.

Experimental Setup

- Triple GEM RD51 tracking detector 10 x 10 cm^2 active area powered using a resistor divider
- Standard GEM Foils (140 µm pitch, 50 µm hole diameter)
- Gas Mixture: Ar/CO_2 70%/30%
- Full plane readout
- Pulse Height measurements: ORTEC 142 IH preamplifier and ORTEC 450 research amplifier
- Current Measurements (only on the anode): Keithley PicoAmp 6517 (1 pA resolution)
- 5.5 MeV neutrons from 2.8 MeV deuteron beam collision on a deuteron target
- Two different neutron fluxes

Picture of the experimental setup



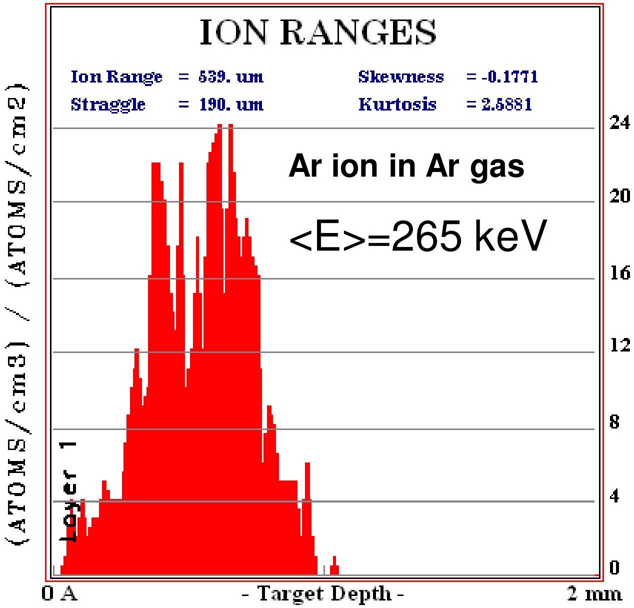
Neutrons interaction with Gas (1)

- In a Ar/CO2 based gas mixture, the most probable phenomenon of gas /neutrons interaction is the elastic scatterin of neutrons with:
  - Ar-> Creates Ar^{+} - cross section σ_{Tot} (5.5 MeV) = 3b
  - O-> Creates O^{+} - cross section σ_{Tot} (5.5 MeV) = 1.5b
  - C-> Creates C^{+} - cross section σ_{Tot} (5.5 MeV) = 1.5b

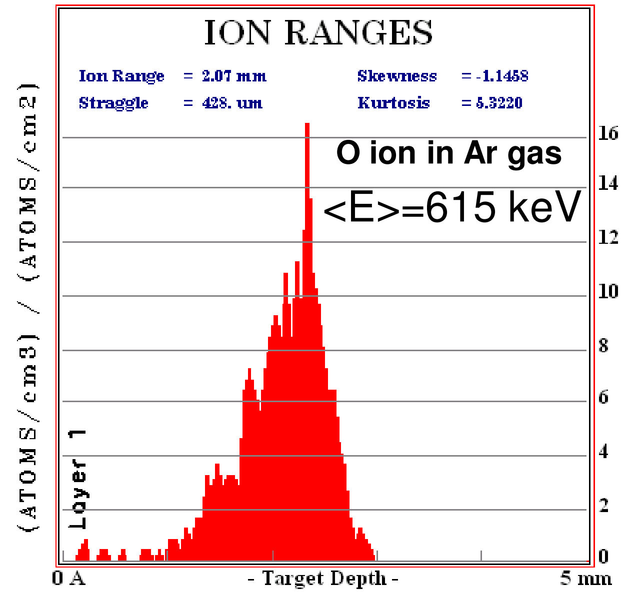
cross section calculated using ExFor Program

http://www.nndc.bnl.gov/exfor/exfor00.htm

Neutrons interaction with Gas (2)

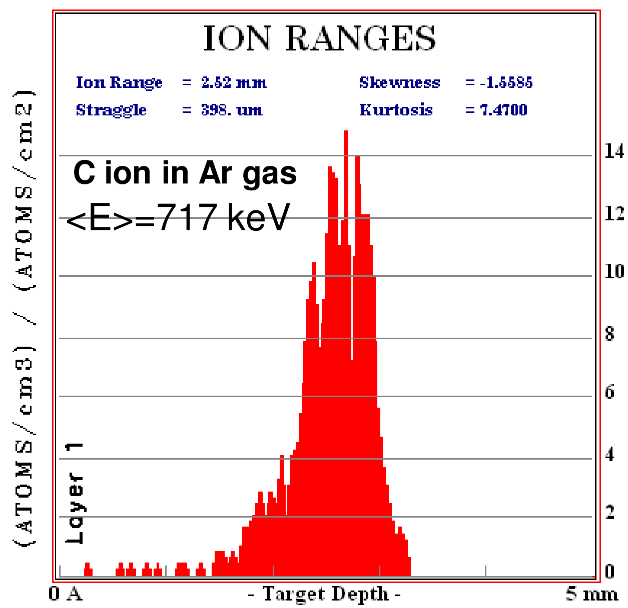


Range of created Ions in Ar based mixtures



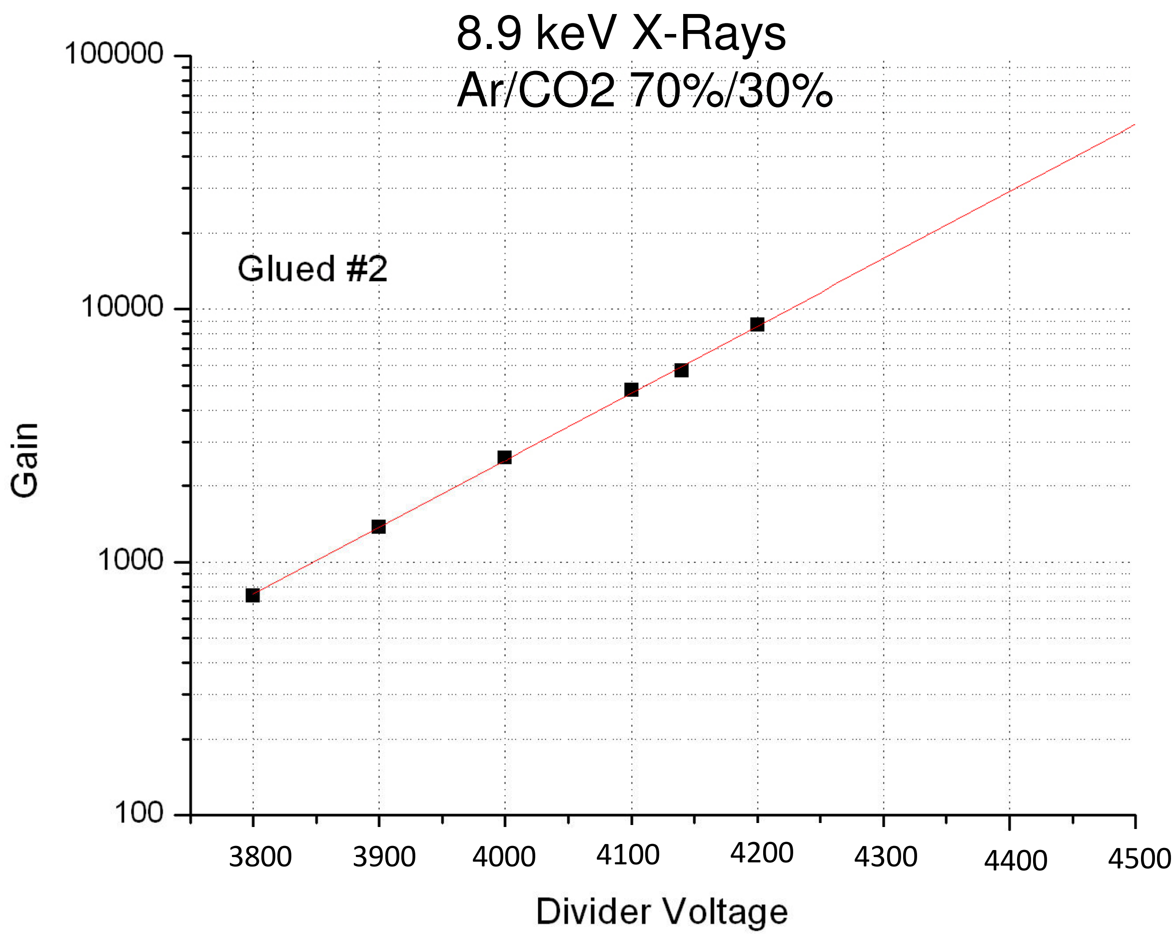
Energy calculated
By NTUA-Demokritos Group

Detector Drift Gap = 3 mm



SRIM
*www.**srim**.org*

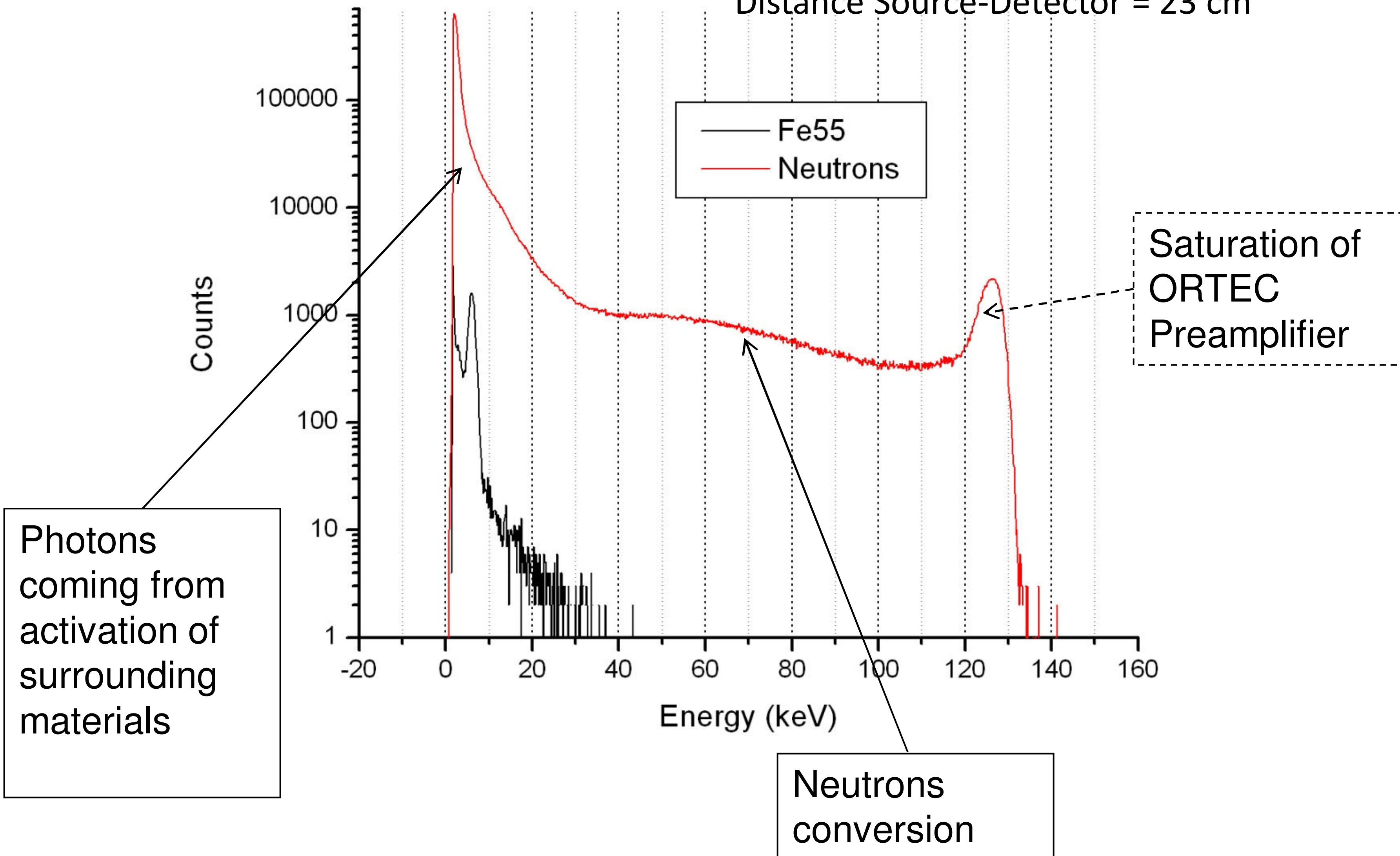
Previous Measurements of the Gain



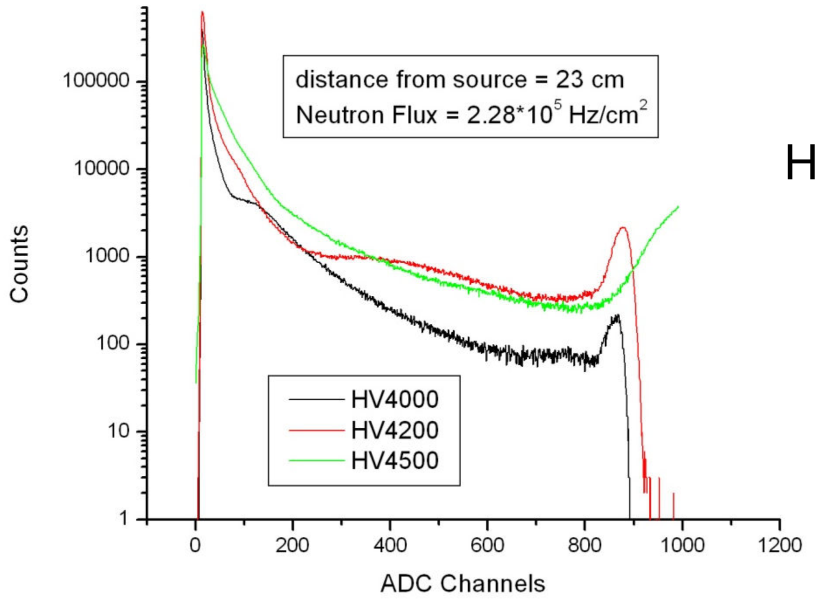
Neutrons and Iron Spectra

Detector HV = 4200 V
Detector Gain = 5000

Neutrons Flux = $2.2*10^5$ Hz/cm^2
Neutrons Energy = 5.5 MeV
Distance Source-Detector = 23 cm

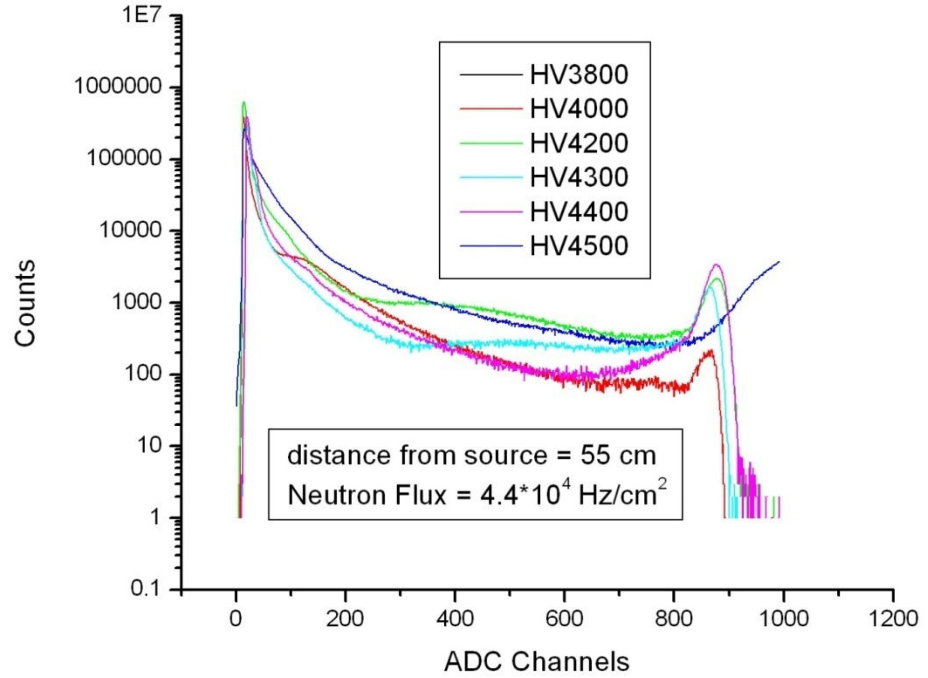


GEM High Voltage Scan: PH spectra



Higher Flux

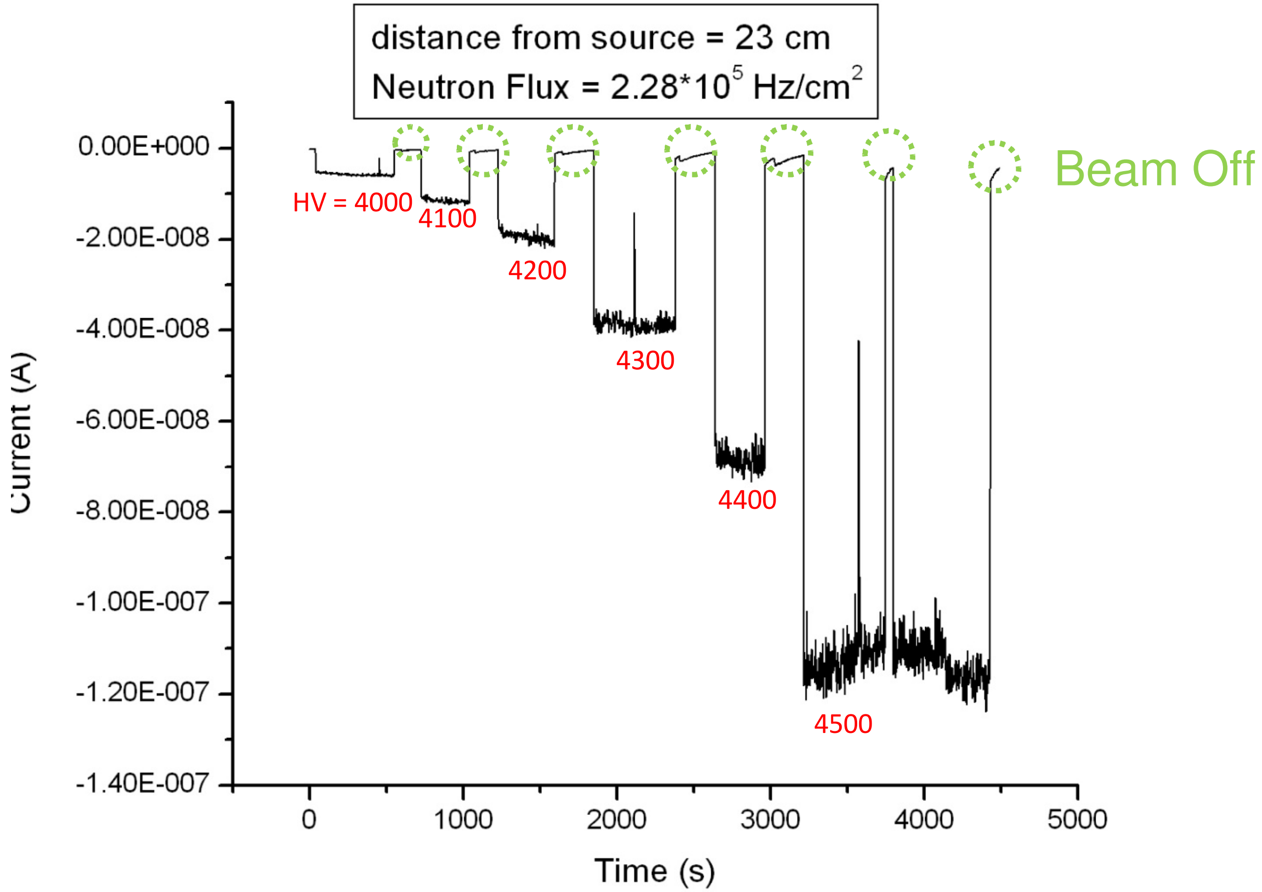
Lower Flux



Discharge Probability measurement description

- Measurement of the current only on the anode not on each electrode
  - What we see is the effect of a discharge: if one GEM discharges, there is a voltage drop and the current seen on the anode will be lower.
  - Since the Keithley PicoAmp measures the sign of the current, we expect “a more positive current”

Discharge Probability Measurement



This is the "real-time" measurement: we were changing HV over time and measuring the anode current. We saw three current drops: we do not know if they are discharges or period during which the beam was off

Measurement of material activation

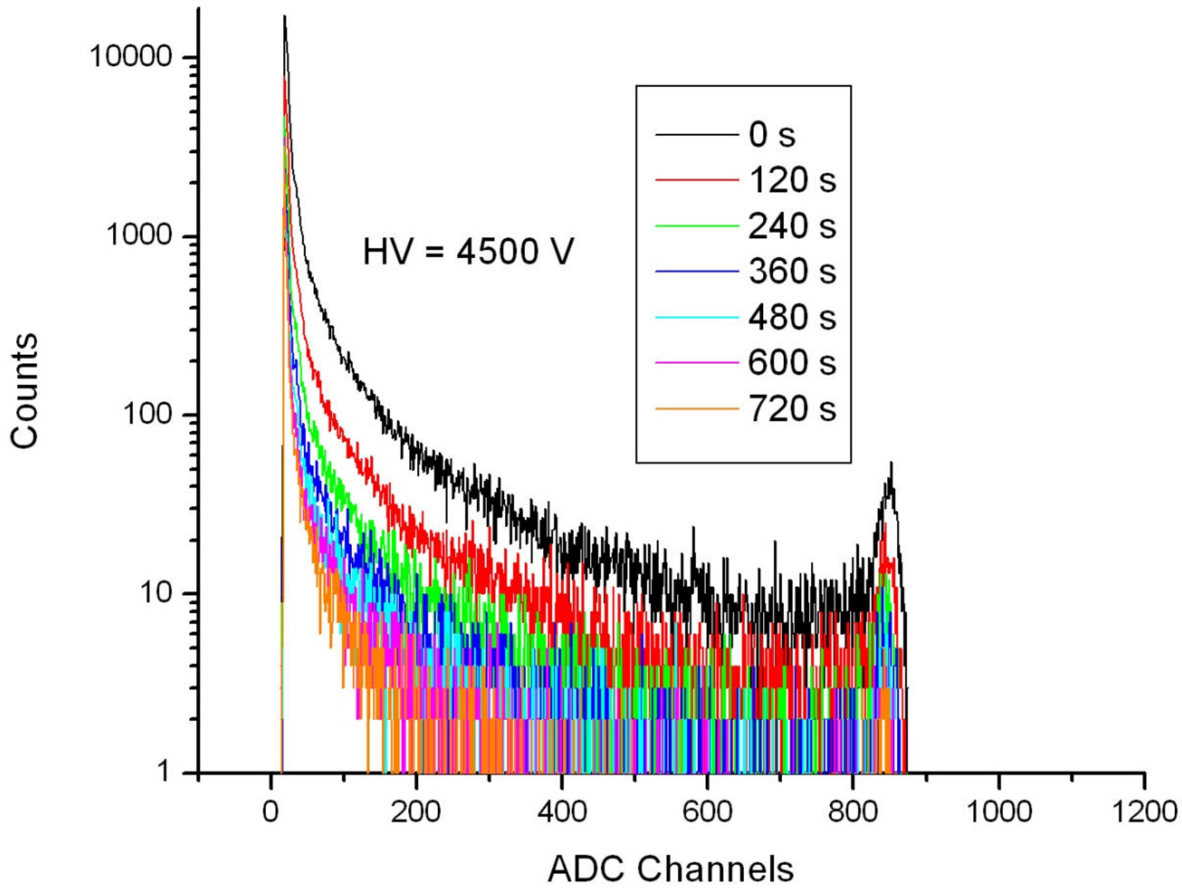
- After the beam has been on for 2 hours, we switched it off and measure the decay time of materials that have been activated by neutrons.

The chamber was completely covered with a copper foil in order to shield it from electromagnetic noise

The materials that could have been activated are copper, aluminium or fiberglass

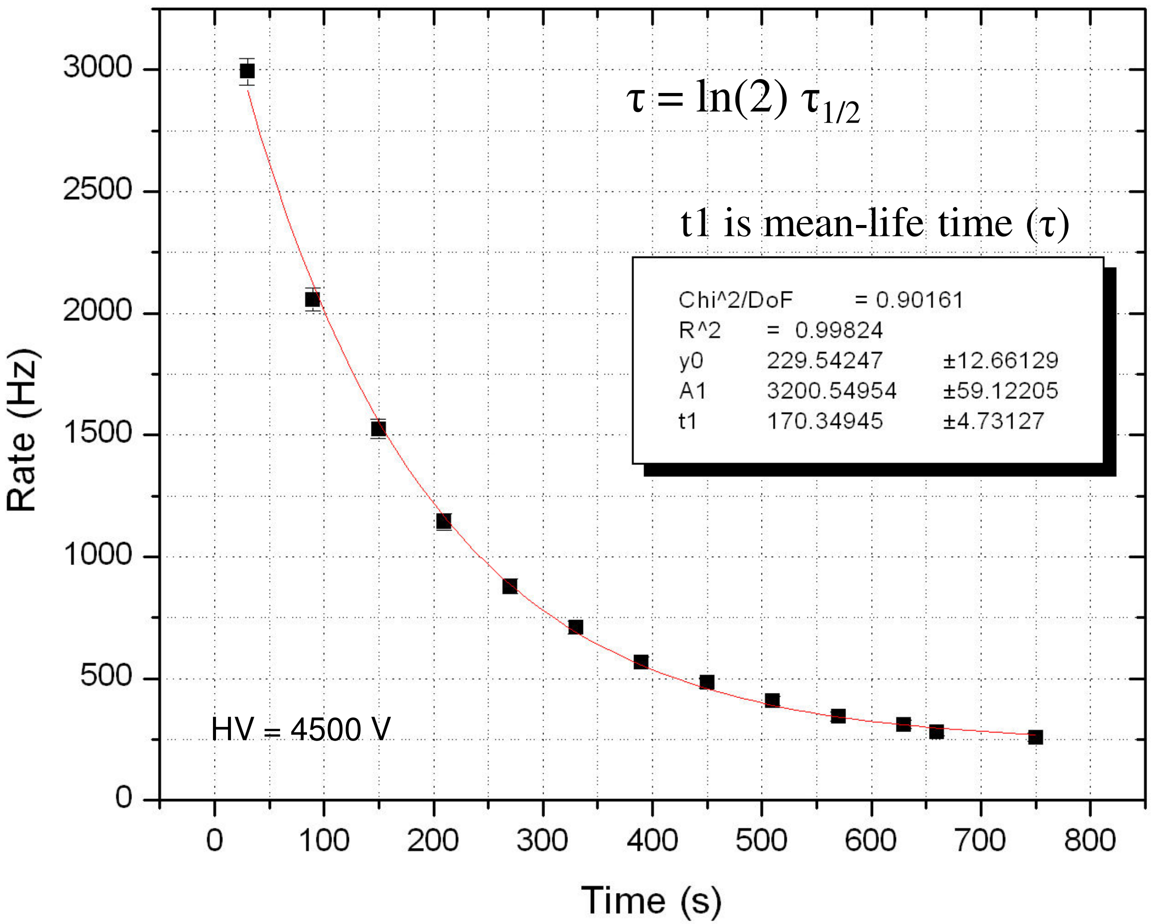
De-excitation PH Spectra

After switching the beam off, we acquired a PH spectrum every minute for half an hour



Decay time measurement

From prevoius PH plot we measured how many counts we had in 60 seconds and we plotted it versus time.



We tried to find a process that may explain this decay time

$n + {}^{65}Cu \rightarrow \alpha + {}^{62}Co$

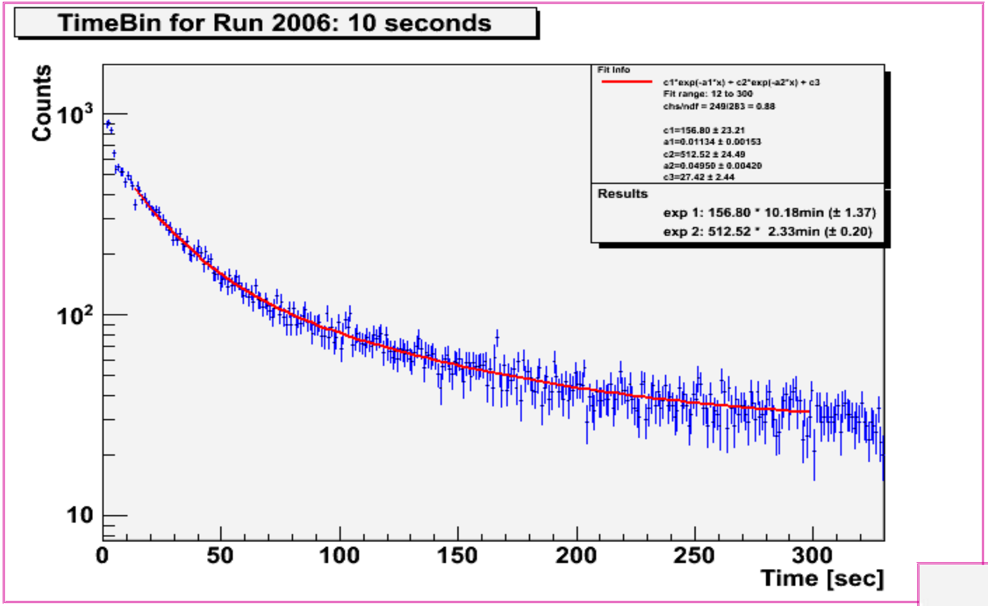
$\sigma(5.5\ MeV) = 10^{-5}$ b (exfour)

${}^{62}Co\ (\beta-) \rightarrow {}^{62}Ni$

$\tau_{62Co} = 1.5$ m

This decay time is quite different From the one in the fit but it was the best we could find

Bulk Micromegas Results



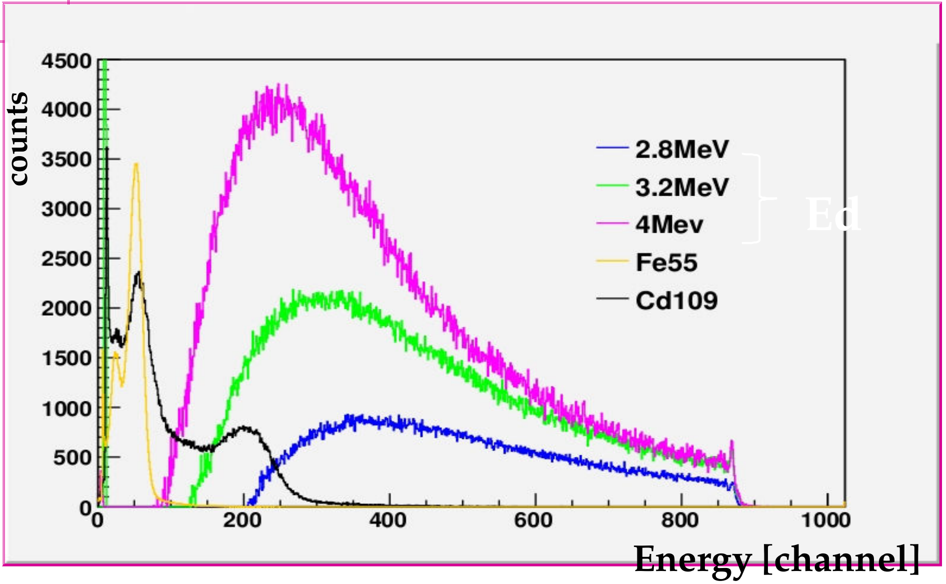
For more details see:

"A study of a micromegas chamber in a neutron beam"

E. Ntomari et Al

MPGD2009, Crete

- **Lifetimes of :**
  - **^{27}Mg (9.46 min (^{27}Al(n,p)^{27}Mg))**
  - **^{28}Al (2.24 min)**



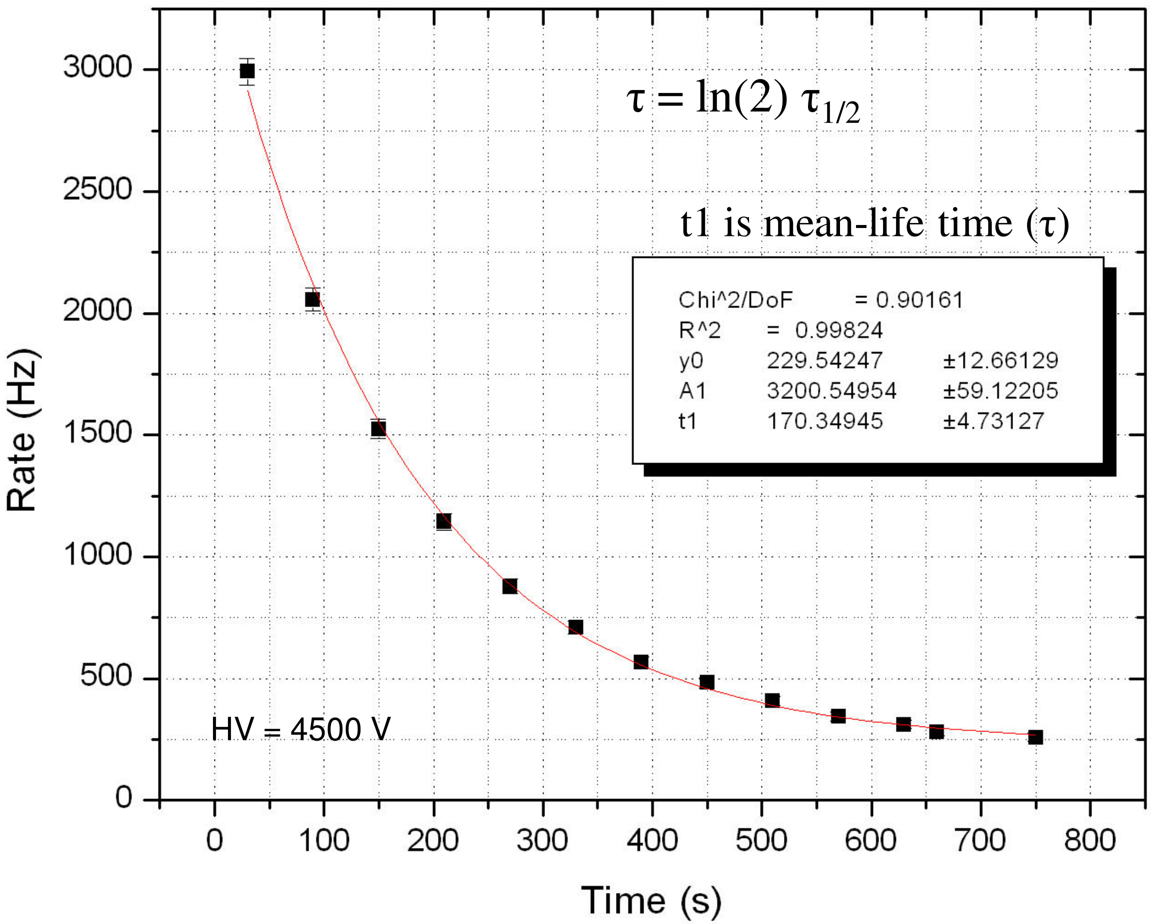
Conclusions

- A triple GEM detector was tested for the first time in a high flux neutron beam
- The detector performance has not been affected at all
- The discharge probability at a gain $3*10^4$ is very small (maybe 3 discharges in few hours)
- We have still to understand which are the processes that we measured during de-excitation: we still do not know if the Copper of GEM is activated→ Geant4
- It is possible that this test will be repeated in the future
- Thanks to NTUA-Demokritos institute for all the support

Spare Slides

Decay time measurement

From prevoius PH plot we measured how many counts we had in 60 seconds and we plotted it versus time.



Two reactions that could explain the observed mean-life time are

$^{27}Al + n \rightarrow\ ^{28}Al \rightarrow\ ^{28*}Si \rightarrow\ ^{28}Si + \gamma$

$\tau_{1/2\ (28Al)} = 137$ s

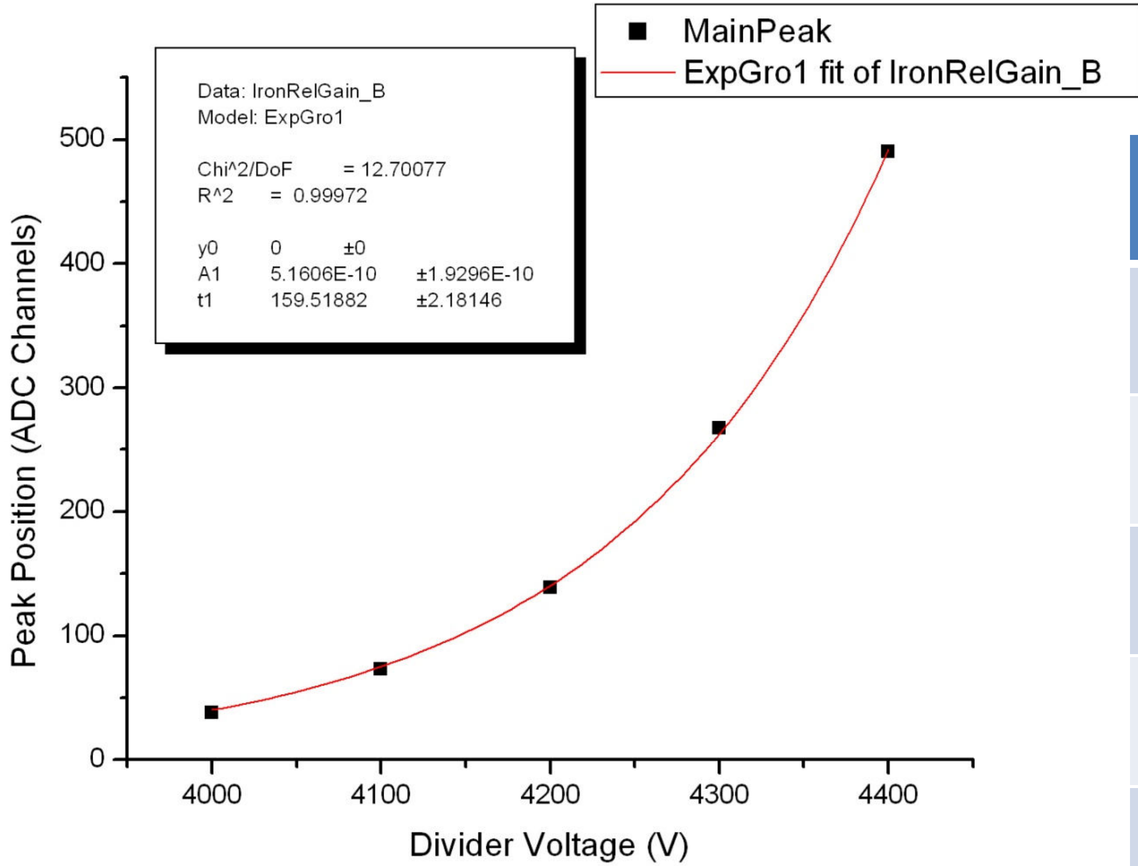
$^{65}Cu + n \rightarrow\ ^{66}Cu + \gamma$;

$^{66}Cu \rightarrow\ ^{66}Zn + e^-$

$\tau_{1/2\ (66Cu)} = 307$ s

We may see an average between this two processes

Relative Gain with Iron in Athens



From Previous Measurements

HV	Gain
4000	1500
4100	3000
4200	5000
4300	9000
4400	15000
4500	30000

Discharge Probability: Lower Rate