ESR1 – Eleni Aza

A new Micro-Pattern Gaseous Detector (MPGD) for neutron spectrometry

4th ARDENT Workshop
Prague, 22.06.15

Outline

1. Introduction to the Bonner Sphere Spectrometer (BSS)

2. Design of a new neutron spectrometer

3. Construction & acquisition system

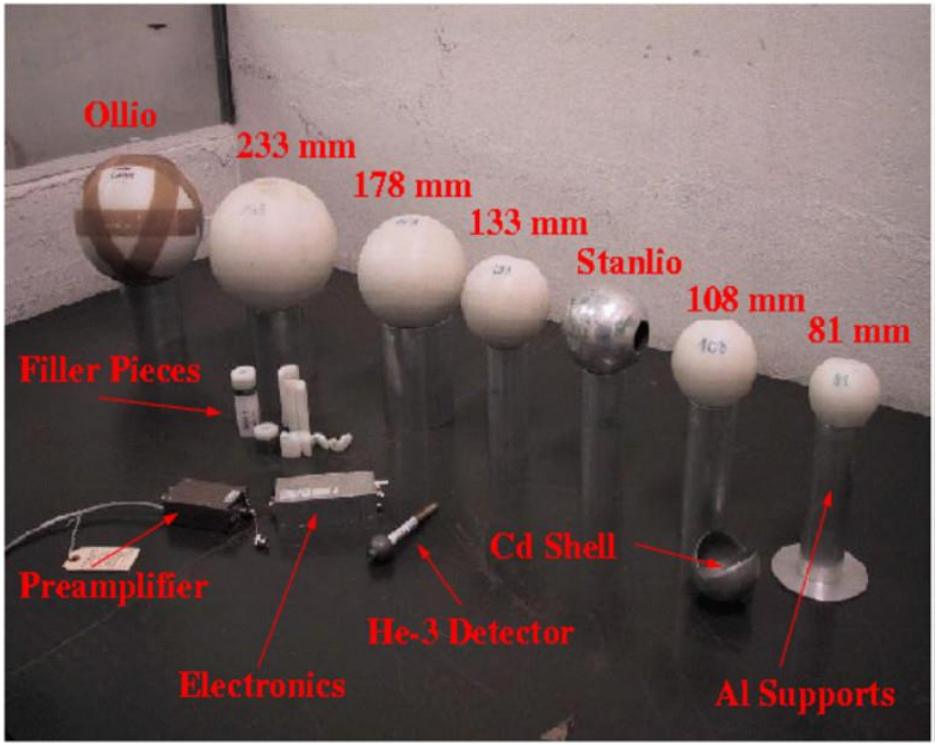
4. Neutron spectra measurement

i. ^{241}AmBe spectrum
ii. Spectrum on iron CERF roof

5. Future Improvements

Neutron spectrometry

The Bonner Sphere Spectrometer (BSS)
is the most common instrument in Radiation Protection



Advantages

- Isotropic response
- Extended energy range

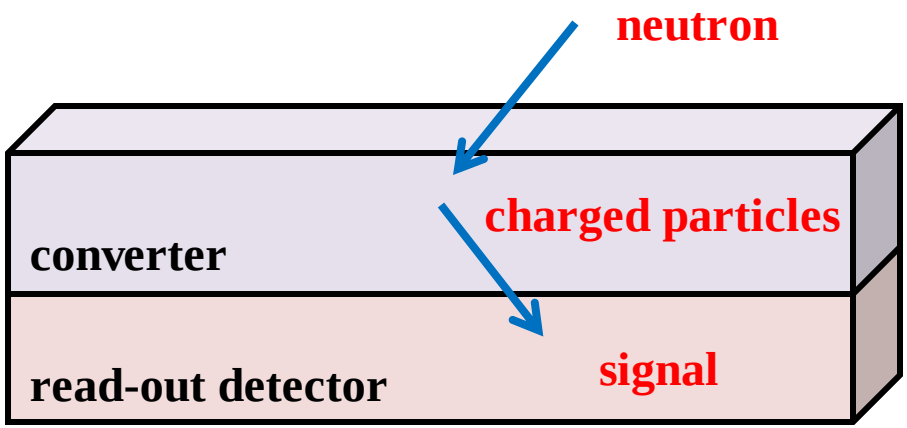
Disadvantages

- Long exposure time
- Heavy system
- Low efficiency

A new MPGD for neutron spectrometry
Designed, constructed and tested

Employs the same operation principle as the BSS

Regions instead of spheres are defined
for different neutron energy ranges



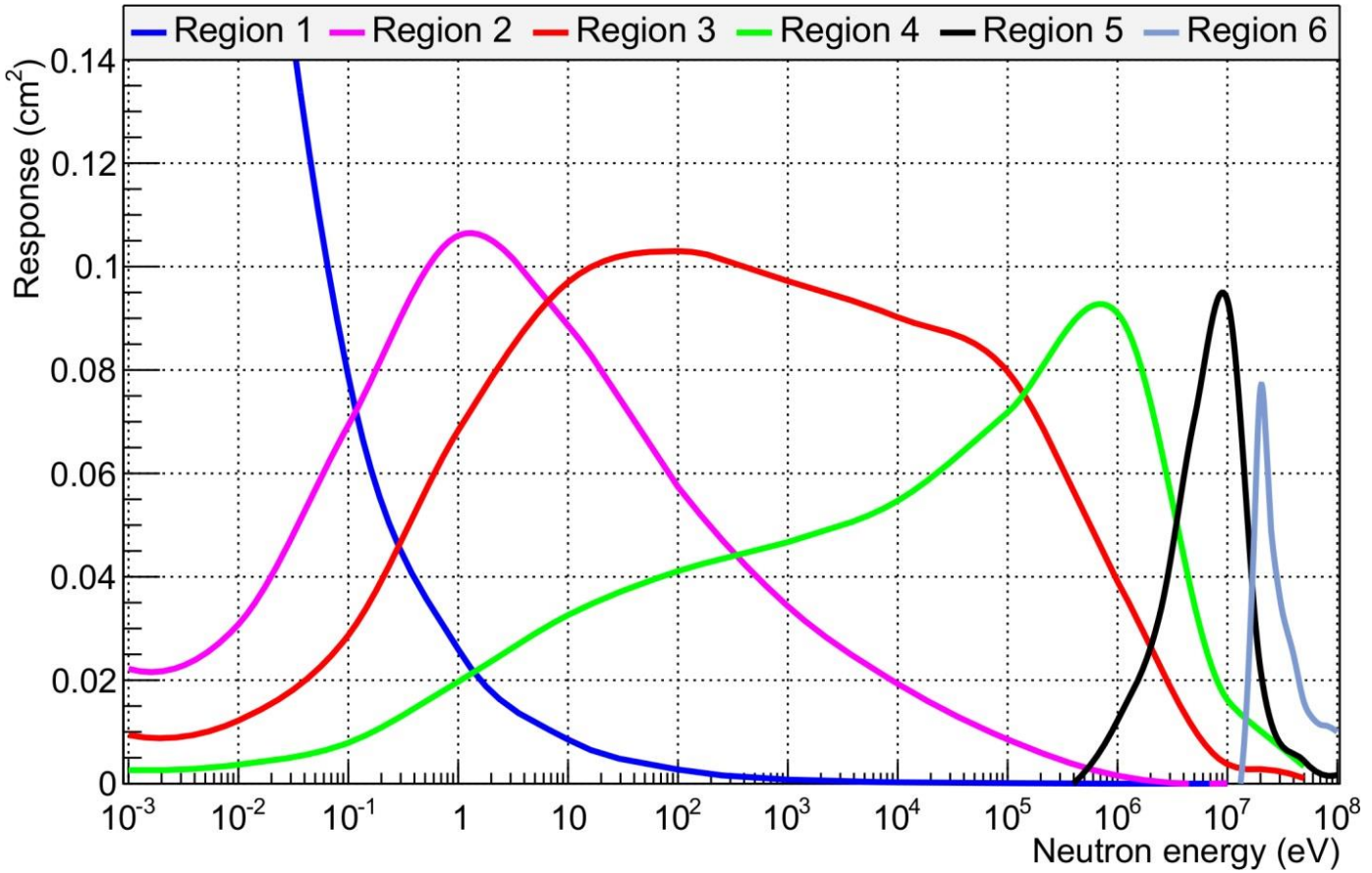
Triple GEM for the read-out

- Active area 35 x 21 cm^2
- Pad size 22 x 13 mm^2 (256 pads)
- Six regions

Region	Material	Detection Method	Particles	Pads
1	B_4C (1 μm)	Conversion	Alpha, ^7Li	2
2	PE (2 cm) +B_4C (1 μm)	Moderation + Conversion	Alpha, ^7Li	6
3	PE (5 cm) +B_4C (1 μm)	Moderation + Conversion	Alpha, ^7Li	18
4	PE (8 cm) +B_4C (1 μm)	Moderation + Conversion	Alpha, ^7Li	28
5	PE (1 mm)	Conversion	Protons	12
6	PE (2 mm) + Al (1 mm)	Conversion	Protons	18

Response matrix of the spectrometer simulated with FLUKA

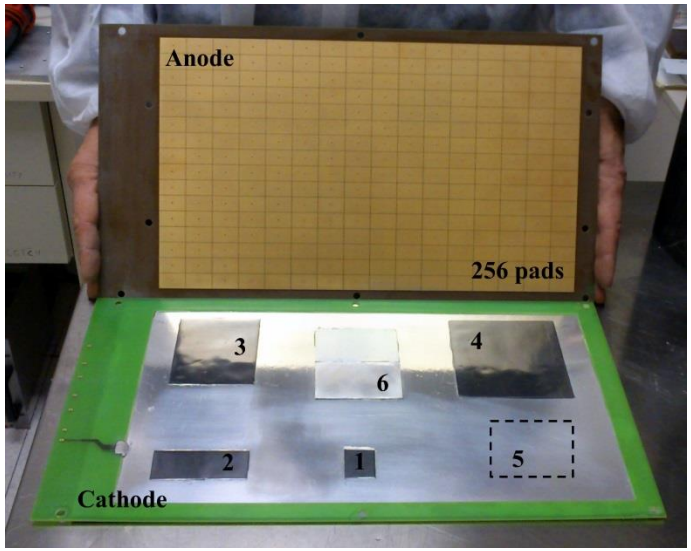
Reg1	B_4C	**Reg4**	B_4C + 8 cm PE
Reg2	B_4C + 2 cm PE	**Reg5**	PE
Reg3	B_4C + 5 cm PE	**Reg6**	PE+Al



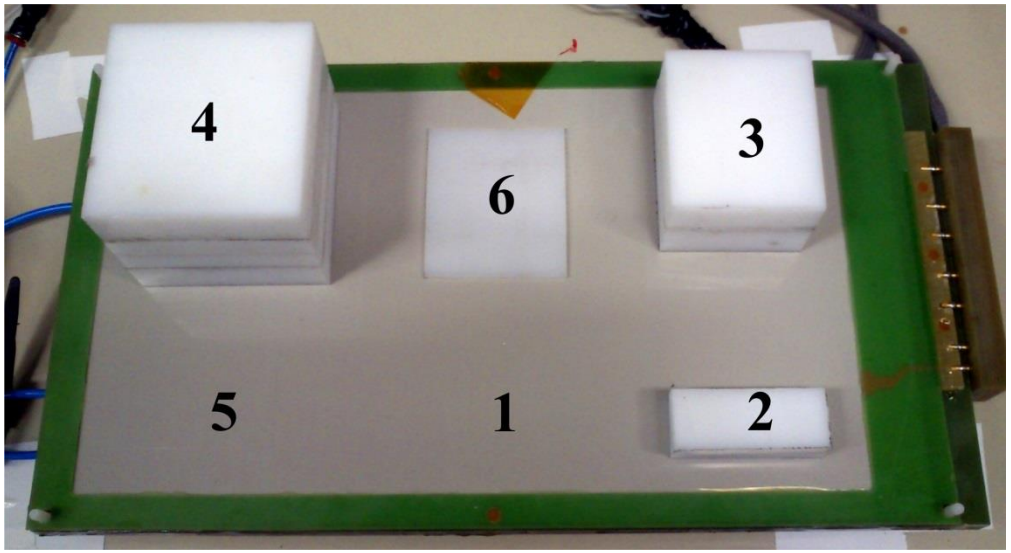
A new MPGD for neutron spectrometry
Designed, constructed and tested

Constructed at the INFN-LNF with F. Murtas

Inside

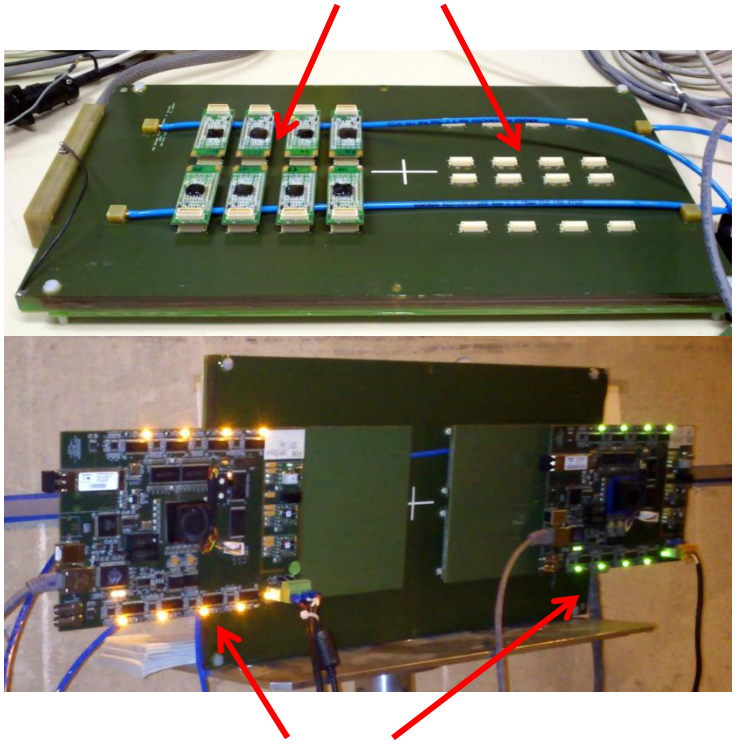


Outside



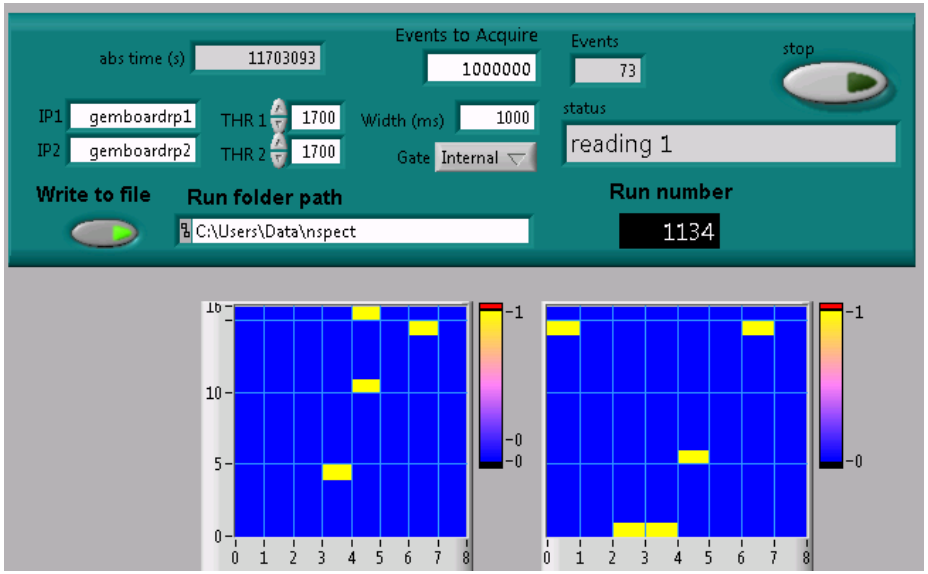
The acquisition system

16 CARIOCA chips



2 FPGAs

Labview-based program



FPGA 1
128 pads

FPGA 2
128 pads

A new MPGD for neutron spectrometry
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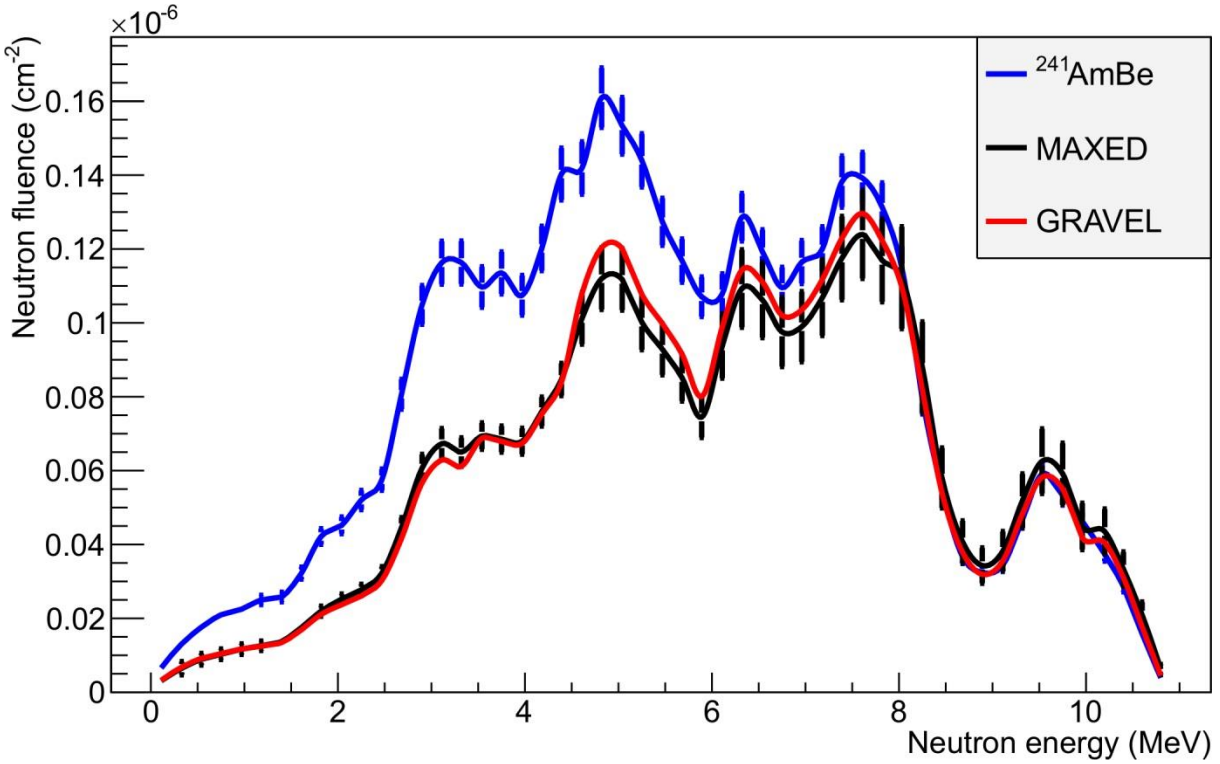
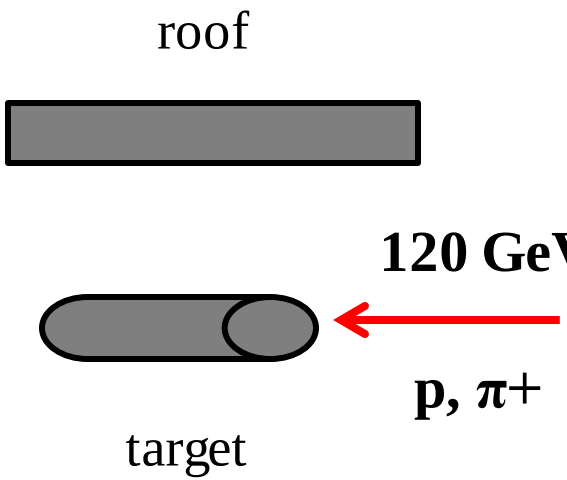
^{241}AmBe neutron spectrum
at the CERN Calibration Laboratory

Region	Counts
Reg3	2.5e-9
Reg4	5.2e-9
Reg5	2.9e-9

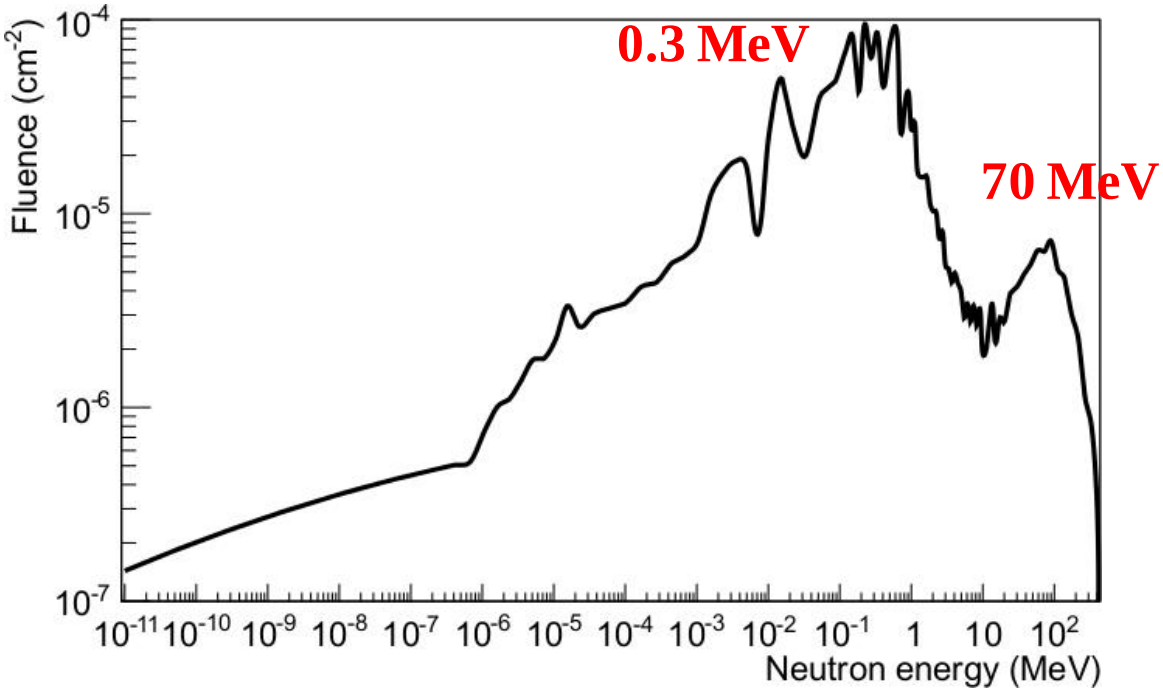
per emitted neutron



Neutron spectrum on the iron CERF roof

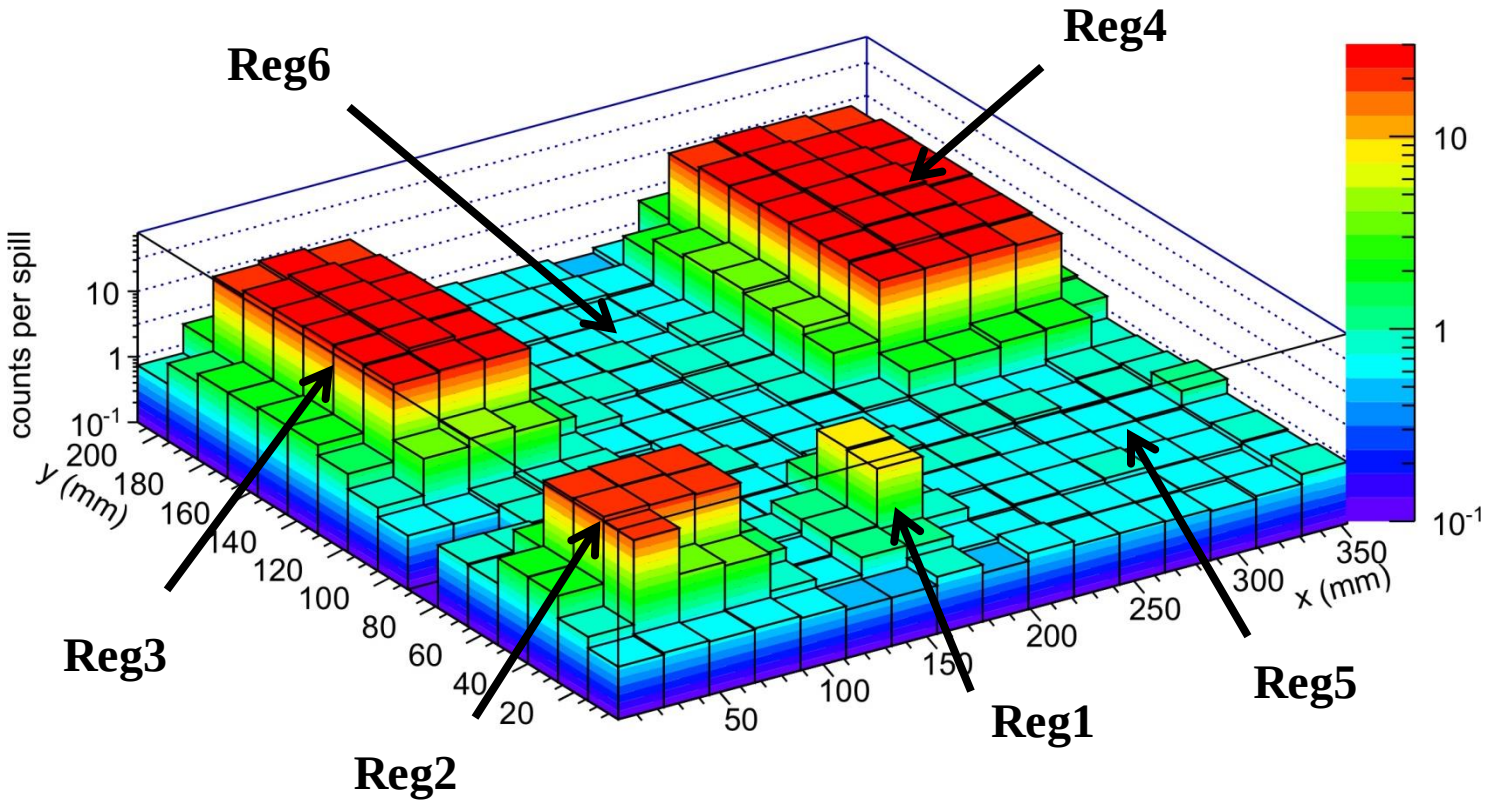


Neutron spectrum at IT4, simulated with FLUKA



Neutron spectrum on the iron CERF roof

Image at position IT4

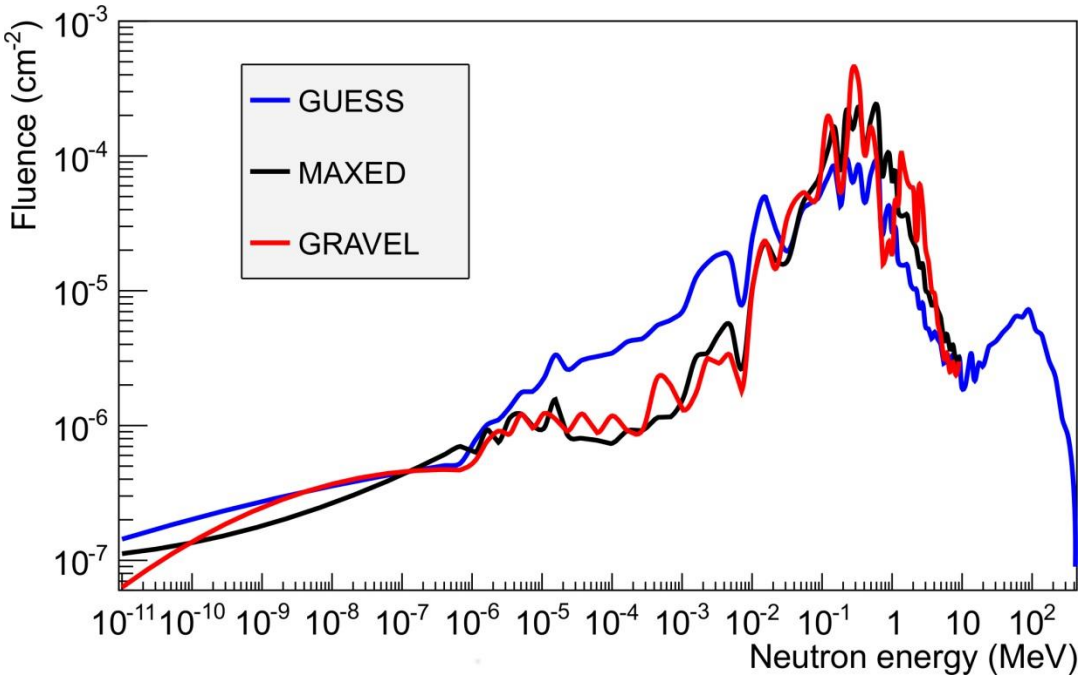


Reg1	B_4C	**Reg4**	B_4C + 8 cm PE
Reg2	B_4C + 2 cm PE	**Reg5**	PE
Reg3	B_4C + 5 cm PE	**Reg6**	PE+Al

- Active area 35 x 21 cm^2
- 256 pads of 22 x 13 mm^2 each

Neutron spectrum on the iron CERF roof

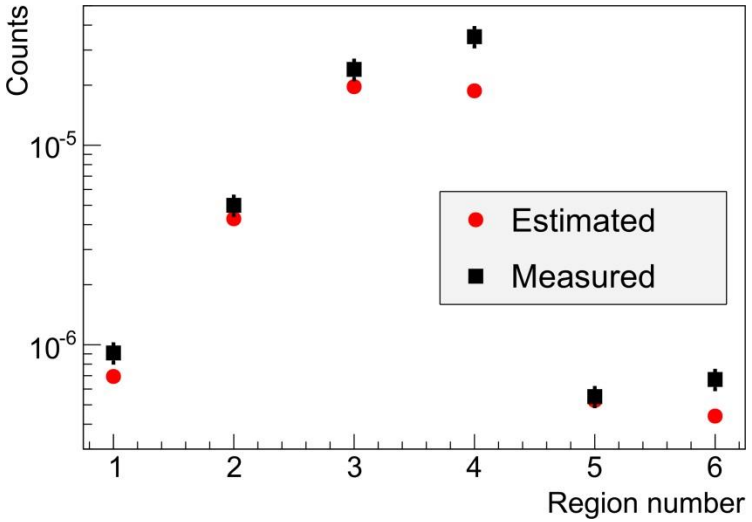
Solution spectra with MAXED and GRAVEL



Using the default spectrum binning

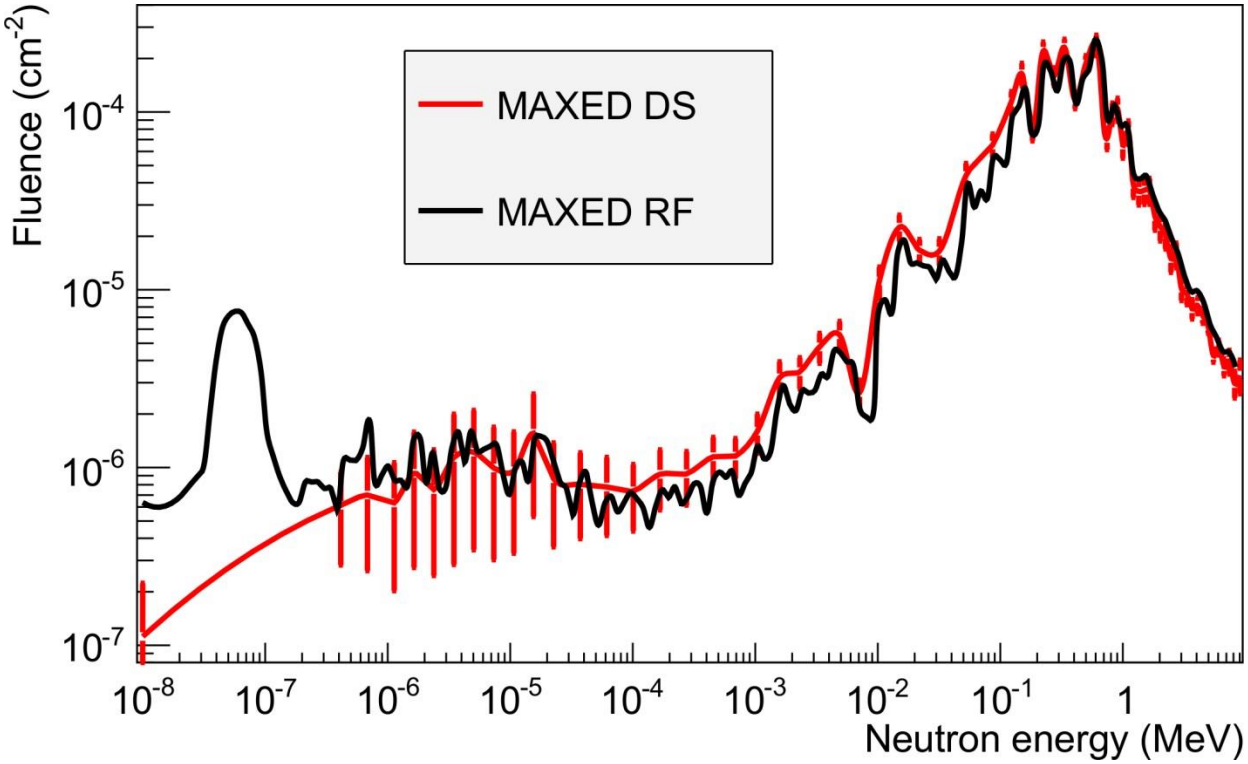
Spectrum measured in 20 min

Counts per region



Neutron spectrum on the iron CERF roof

Solution spectra with MAXED at IT4



Using the Default Spectrum (DS) and Response Function (RF) binning

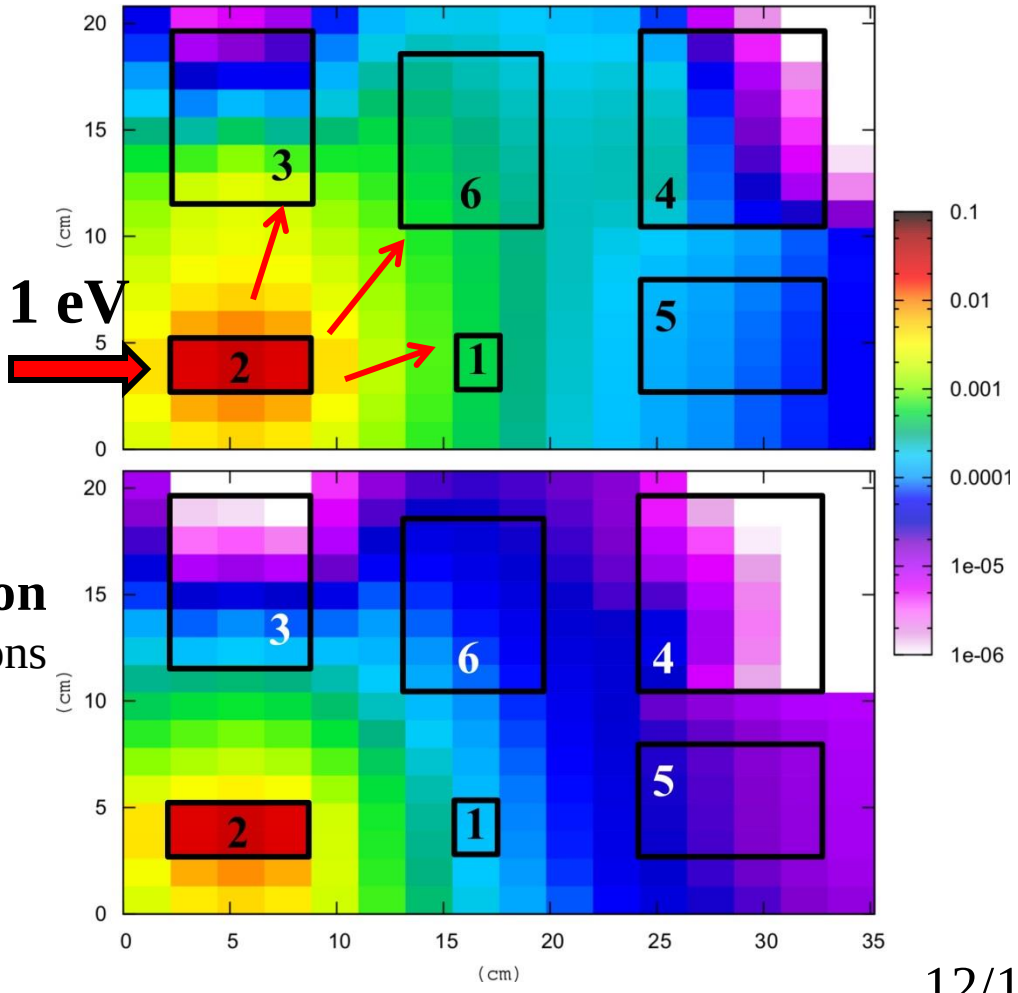
Future Improvements

The large polyethylene pieces (Reg3 & 4) need to be shielded from scattered radiation

Simulation with FLUKA
Region 2 irradiated with 1 eV neutrons
Neutrons are scattered and detected in neighbouring regions

Shielding Regions with **3 mm flex boron** the neutron fluence in neighbouring regions decreases 10 times

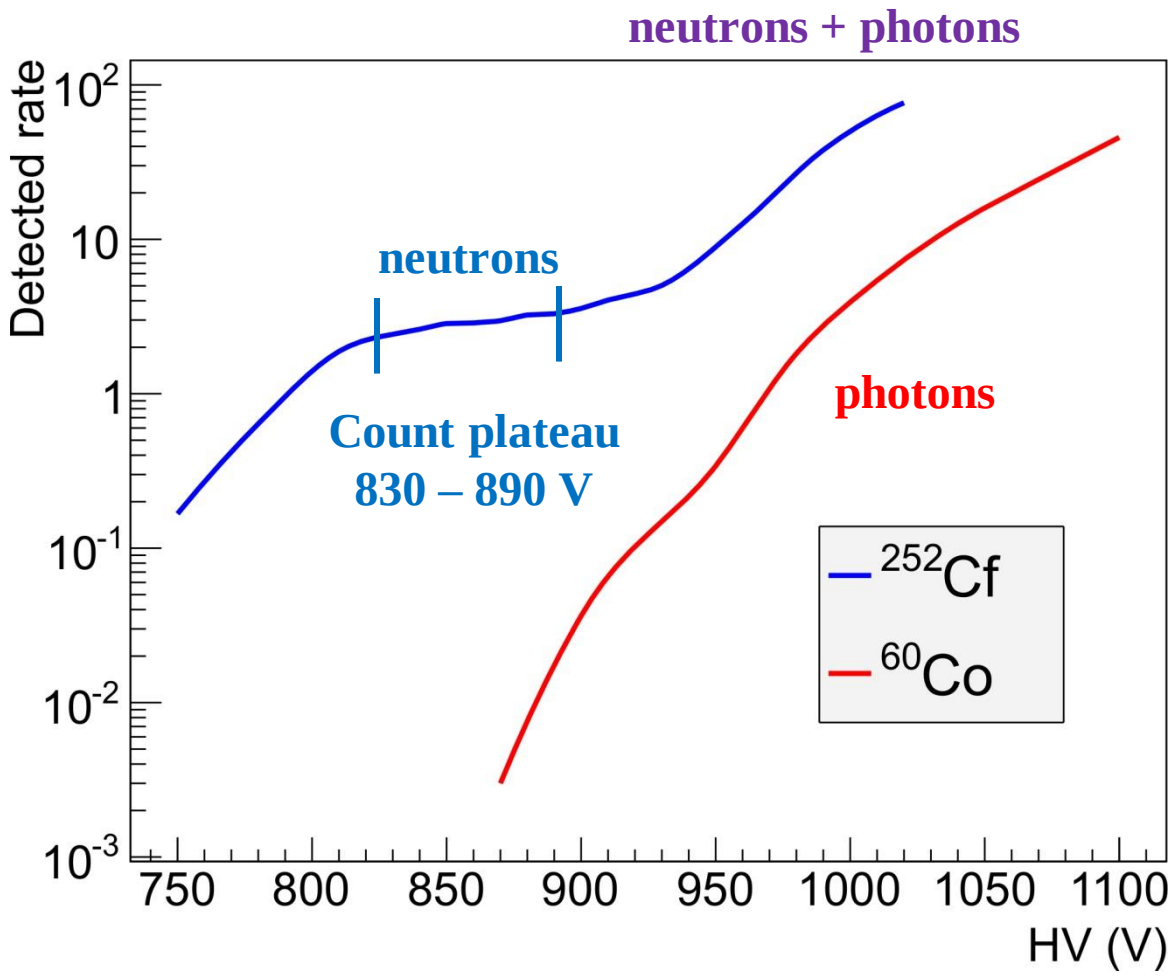
Neutron fluence



Conclusions

- A new MPGD for neutron spectrometry was designed, constructed and tested
- It is able to measure quite accurately neutron spectra up to ~50 MeV
- A single and short irradiation is required to obtain results
- Vulnerable to scattered radiation from surrounding material. Geometry improvements are investigated for shielding the device
- Its directional geometry can be used in cases where isotropic response is not adequate

Photon signal elimination method



Efficiency to photons ~10^{-7} at 870 V