Design of novel GEM-based neutron spectrometer

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A directional neutron spectrometer has been designed and simulated with FLUKA [1,2]. It consists of six sections, each one measuring in a different neutron energy range, with a total area of 400 cm^2. Counts from each section can be measured simultaneously by a read-out detector attached to the section-board and therefore the neutron spectrum information can be acquired in a single acquisition via an unfolding method. The detected neutron energy ranges from 10^{-3} eV to 1 GeV.

The BSS (Bonner Sphere neutron Spectrometer)

The CERN BSS [3] consists of 7 spheres: five polyethylene spheres with outer diameter of 81, 108, 133, 178 and 233 mm, complemented by two other spheres, nicknamed “Ollio” and “Stanlio”, where cadmium and lead inserts were introduced in order to increase the sensitivity for energies up to the GeV range. Every sphere is sensitive to a different neutron energy, depending on the moderating material, so that charged particles from $^3He(n,p)^3H$ reaction are detected with the ^3He proportional counter. The inner geometry of the 81 mm sphere is shown in Fig. 1.

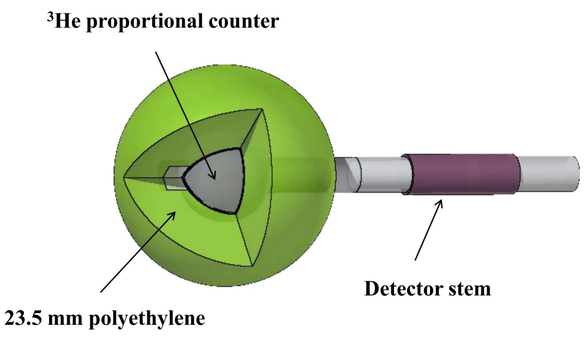


Fig.1: A ^3He detector is placed at the centre of the polyethylene sphere., counting the number of charged particles from the $^3He(n,p)^3H$ reaction.

A response function corresponds to each sphere, indicating the number of counts * cm^2 for different imping neutron energies. The 7 response functions were recalculated with the new FLUKA version (2011). The results are shown in Fig. 2. The main disadvantages of this system is time consumption and transportability.

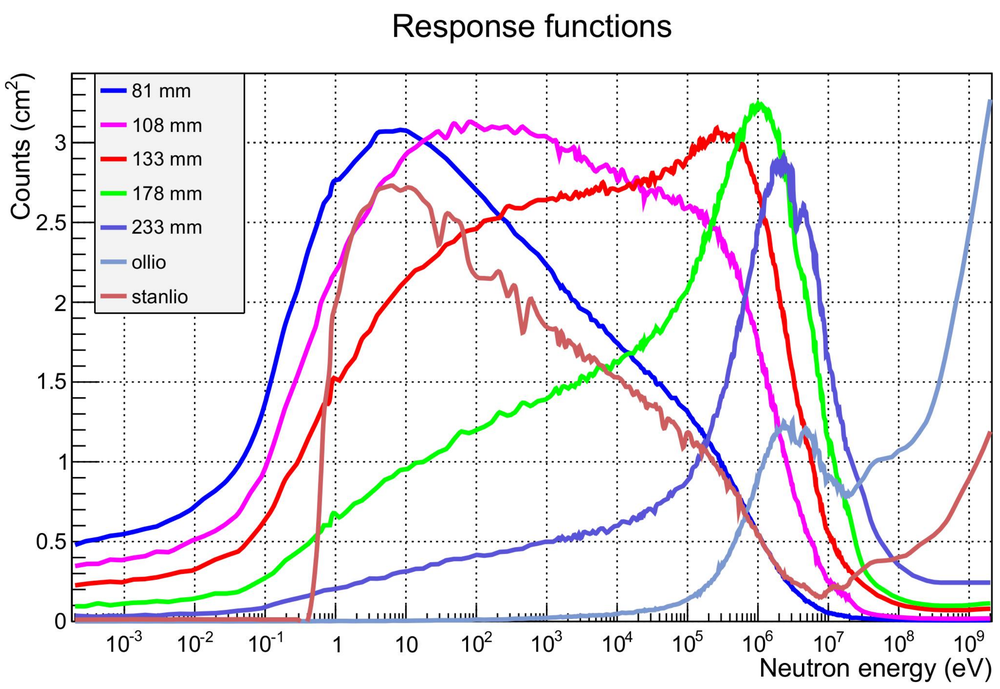
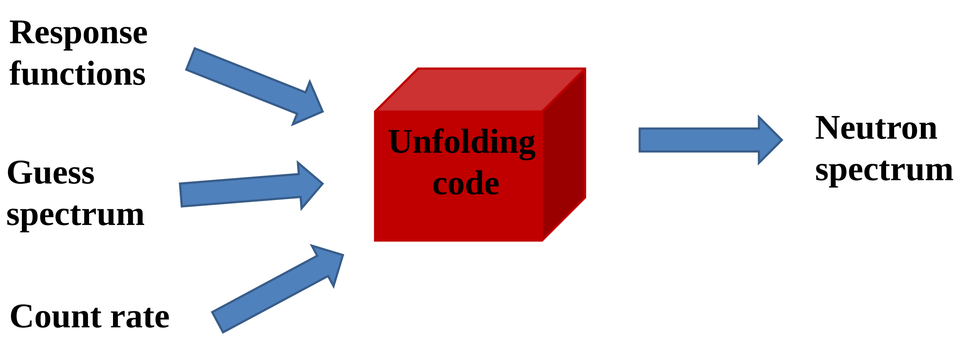


Fig.2: BSS fluence responses as a function of the impinging neutron energy, as calculated via FLUKA simulations.

Data unfolding

The neutron spectrum at a specific position is acquired via an unfolding method, which requires the count rate measured by each sphere, the response functions and a guess spectrum for this position. Common codes dedicated to this so-called “unfolding method” are MAXED [4], GRAVEL [5] and FRUIT [6].



The new spectrometer

A novel spectrometer has been designed with FLUKA as a replacement of the BSS for certain applications, employing the same detection principles and Unfolding procedure, but with the advantages of giving the spectrum information in one acquisition and weighing a lot less. The read-out detector with be a Triple GEM [7], attached right under the conversion board.

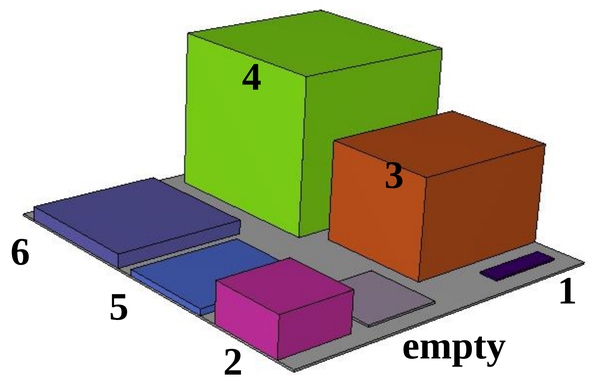


Fig.3: Layout of the spectrometer

The dimensions of each section are shown in Table 1. The detection methods are:

- Thermal neutron conversion (^{10}B)
- Moderation and thermal neutron conversion (^{10}B+PE)
- Recoil proton from $^{10}B(n,p)$ (PE, PE+Al)

Table 1: Characteristics of the sections

	Height (mm)	Area (cm^2)	Energy region	Material
Section 1	0.001	4	thermal	^{10}B
Section 2	20	16	epithermal	^{10}B + PE
Section 3	50	48	epithermal	^{10}B + PE
Section 4	80	81	intermediate	^{10}B + PE
Section 5	0.7	50	fast	PE
Section 6	3.2	30	fast	PE + Al
Section 7	-	16	background	empty

The corresponding response functions are shown in Fig. 4.

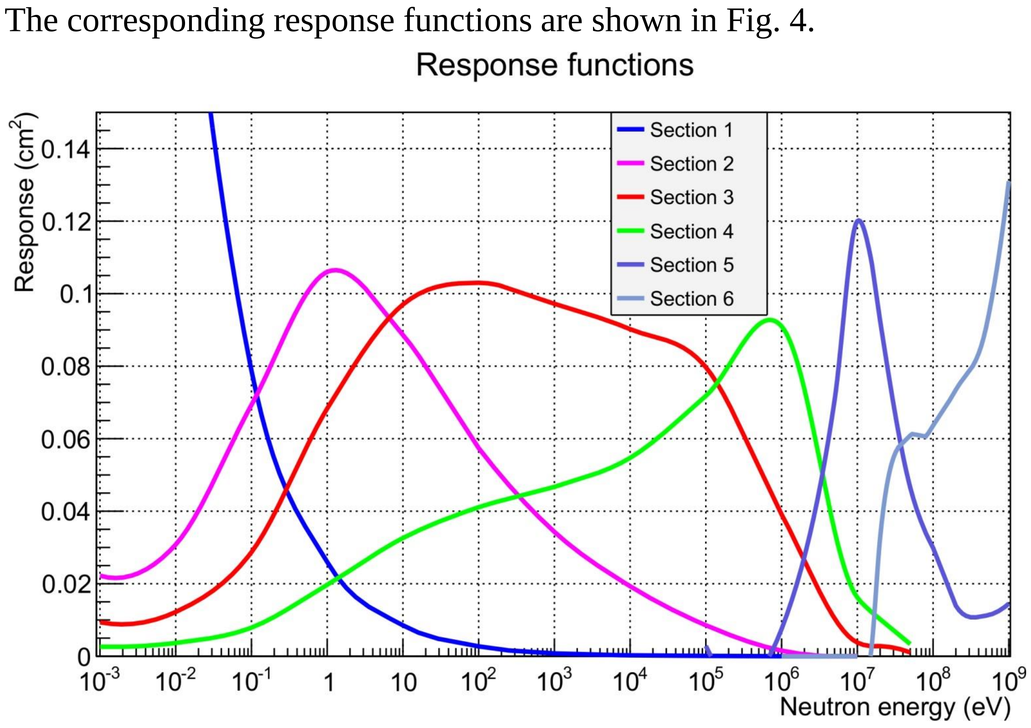


Fig.4: Simulated response functions for each section. The detected neutron energy ranges from 10^{-3} eV to 1 GeV.

References

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