POLITECNICO DI MILANO

NESCOFI@BTF
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Experimental tests of CYSP and SP^2

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NESCOFI@BTF Closure meeting 26-02-2014

1) Establishment of the Thermal Neutron Pulse Detectors (TNPDs) individual sensitivity

2) Irradiation campaign of the CYlindrical SPectrometer (CYSP) at the National Physical Laboratory (NPL - UK);

3) Irradiation of the SPherical SPectrometer (SP^2) with a 1Ci Am-Be neutron source;

4) Irradiation campaign of the SPherical SPectrometer (SP^2) at the Frascati Neutron Generator facility (FNG Enea - Italy);

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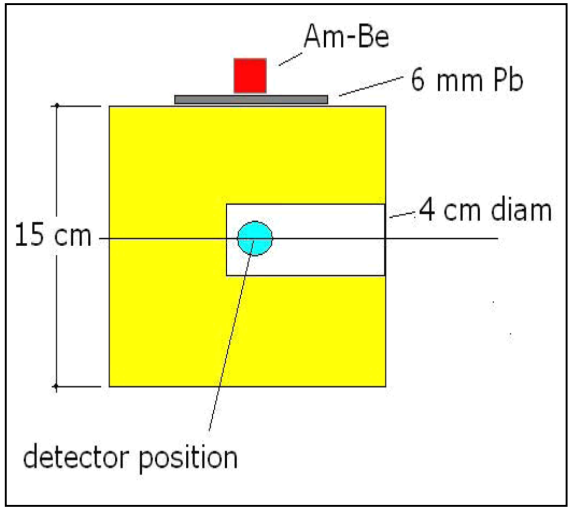
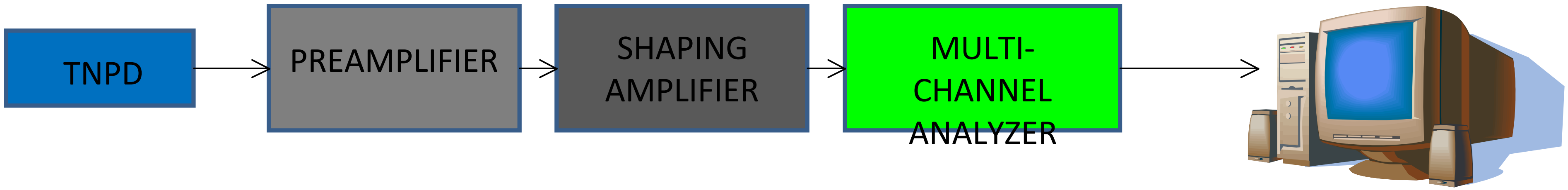
Experimental SET UP

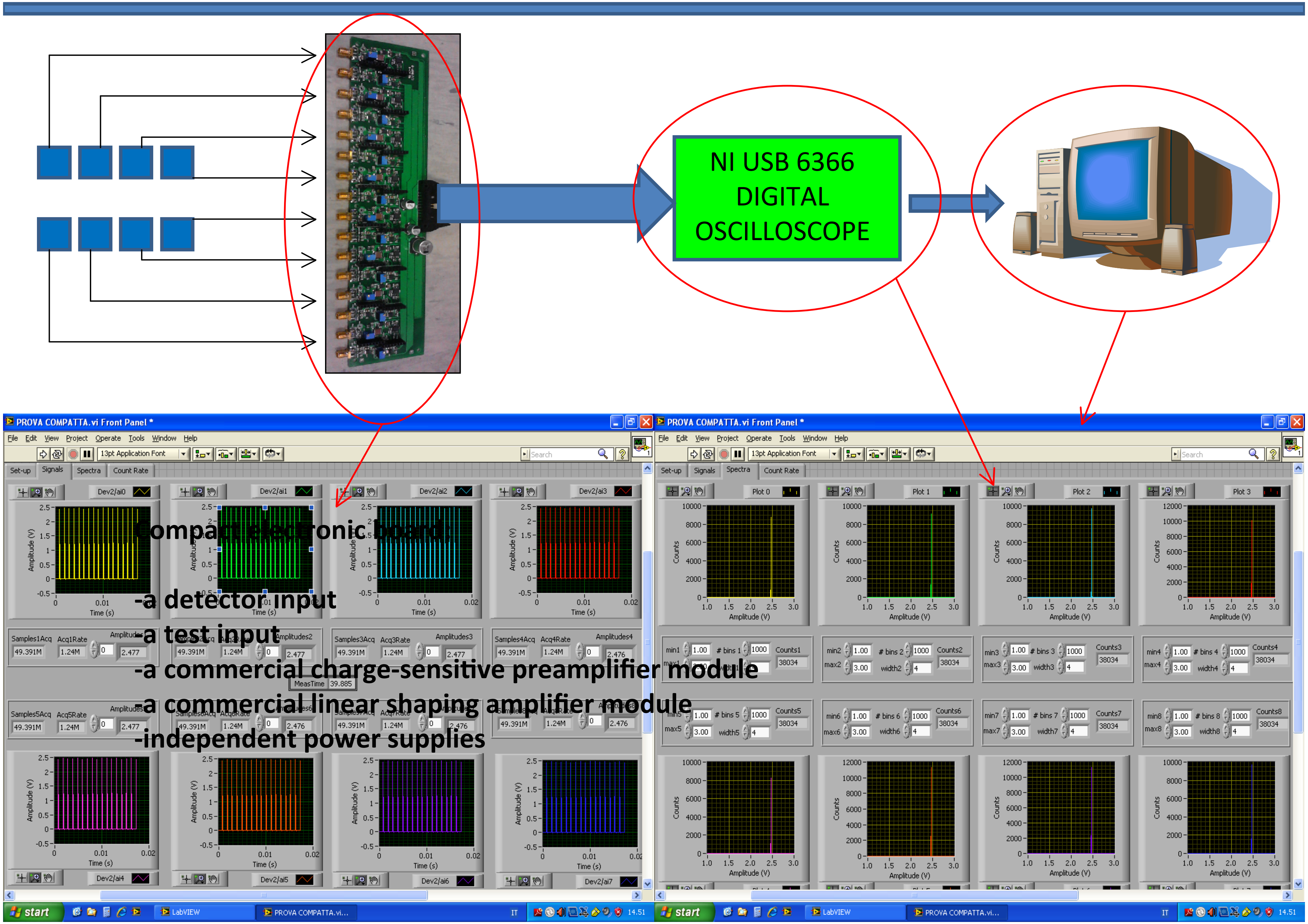
TNPD#1
TNPD#2
TNPD#3
TNPD#4
TNPD#5
TNPD#6
TNPD#7





The INDIVIDUAL sensitivity of the TNPDs that will be embedded in the final spectrometers, in terms of counts per second, was obtained by irradiating each detector with the same experimental conditions

Data Acquisition System for CYSP and SP² spectrometers



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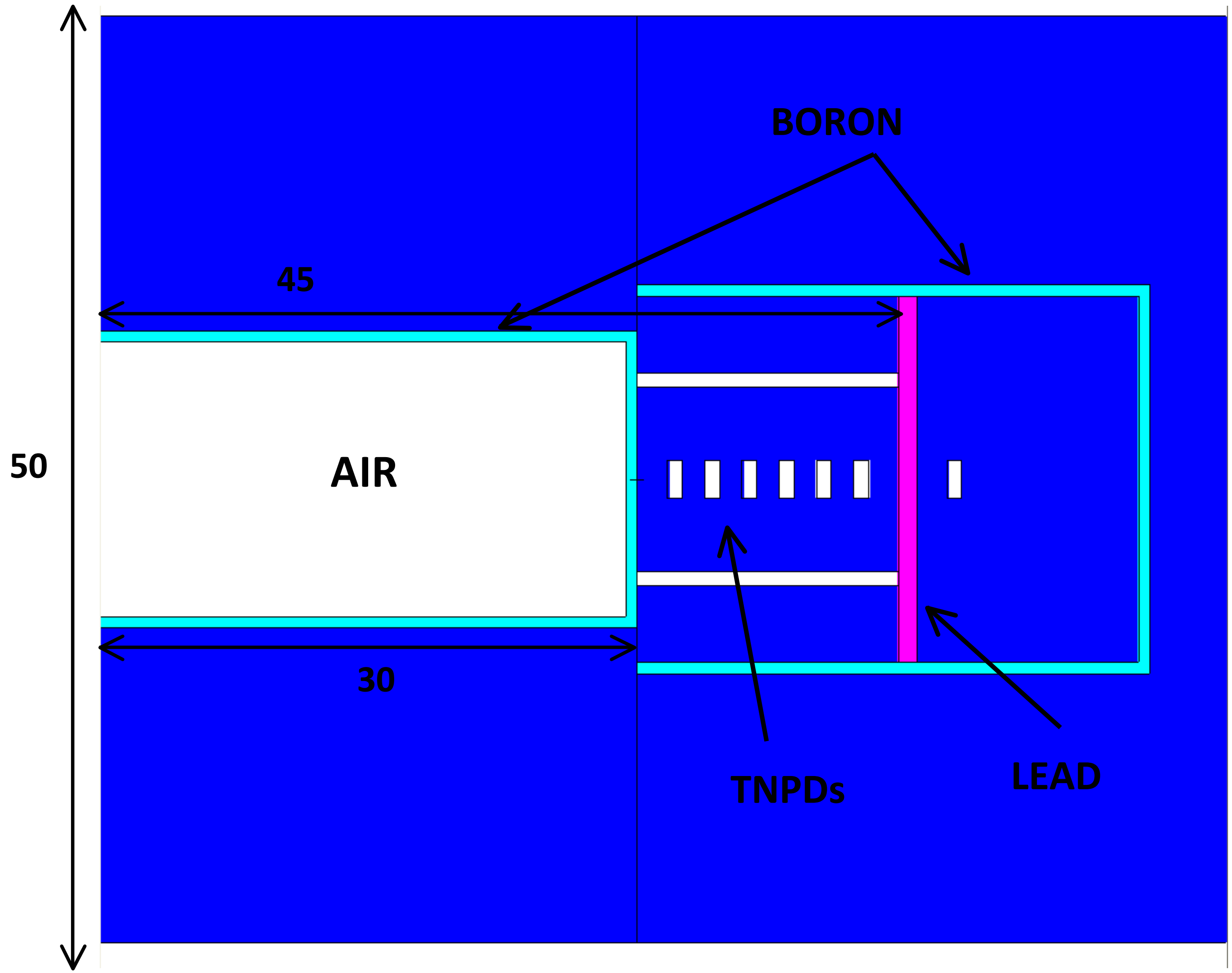
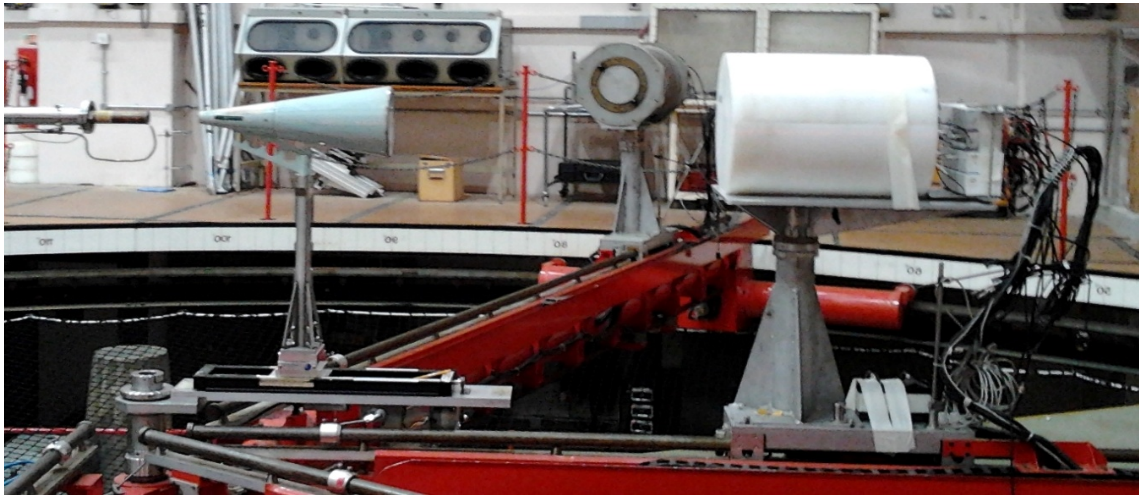


2) Irradiation campaign of the CYSP at the National Physical Laboratory (NPL – UK)

NPL
National Physical Laboratory



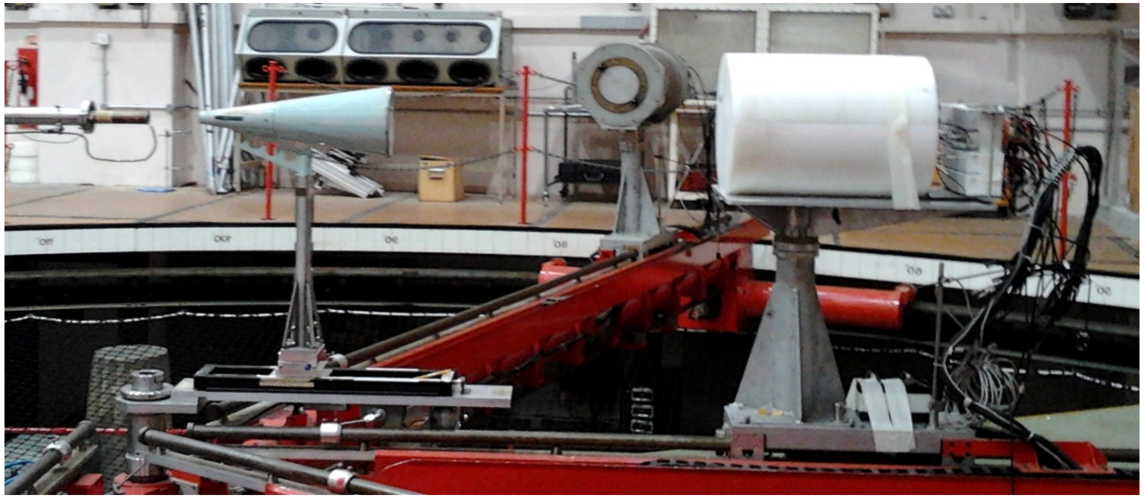
Neutron Energy [MeV]	Angle of Fluence Measurement	Shadow Cone
0,144	0°	YES
0,565	0°	YES
2,0	0°	YES
3,5	70°	NO
5,0	0°	YES
16,5	0°	YES*

Neutron Source	Fluence rate [$cm^{-2}\,s^{-1}$]	Shadow Cone
Cf-252	54,41	YES

* Further measurement with a blank target to correct for neutrons produced by interactions in the titanium layer and the gold backing

2) Irradiation campaign of the CYSP at the National Physical Laboratory (NPL – UK)

NPL
National Physical Laboratory



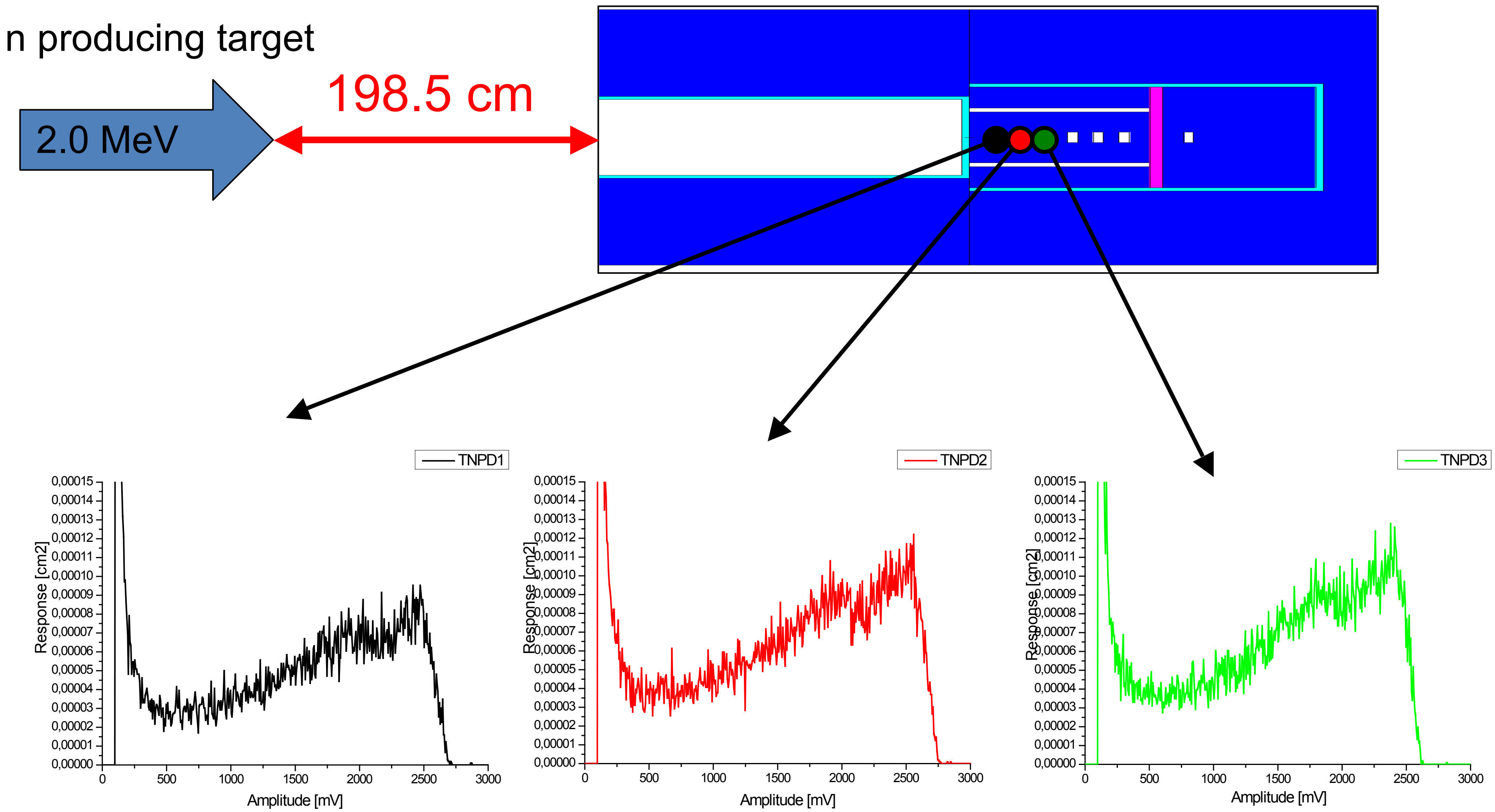
2 measurements to determine the response of the CYSP, for each neutron energy:

a) **Total neutron field** (neutrons arriving directly from the target + neutrons scattered from the room and the surroundings)
b) **Scattered component of the neutron field** (with a suitable shadow cone between the target and CYSP)

$$C_{NET}/\Phi\ [cm^2] = C_{TOTAL}/\Phi_{TOTAL}\ [cm^2] - C_{SCATTER}/\Phi_{SCATTER}\ [cm^2]$$

* In the case of 16.5 MeV (further measurement with the blank target), we have:
$C_{NET}/\Phi\ [cm^2] = C_{TOTAL}/\Phi_{TOTAL}\ [cm^2] - C_{SCATTER}/\Phi_{SCATTER}\ [cm^2] – (C_{BT}/\Phi_{BT}\ [cm^2] - C_{BTSCATTER}/\Phi_{BTSCATTER}\ [cm^2])$

2) Irradiation campaign of the CYSP at the National Physical Laboratory (NPL – UK)



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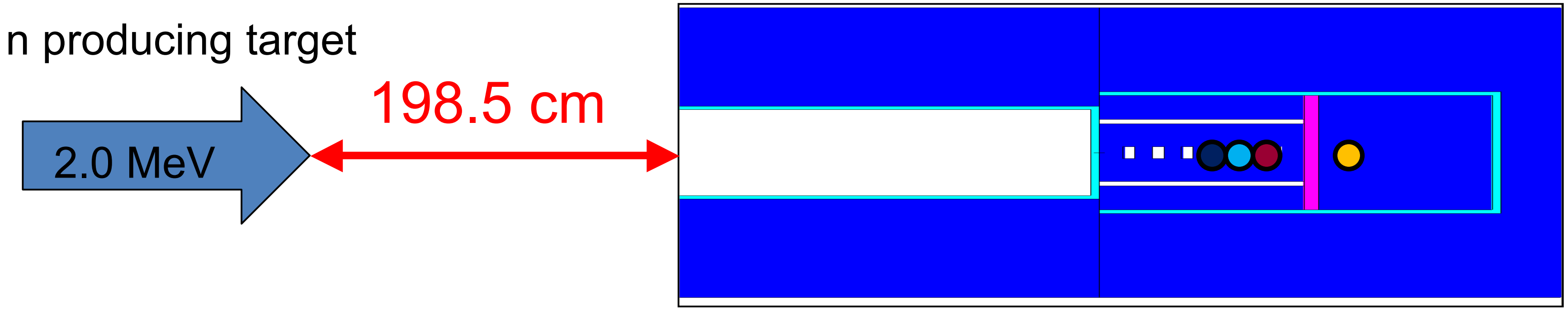
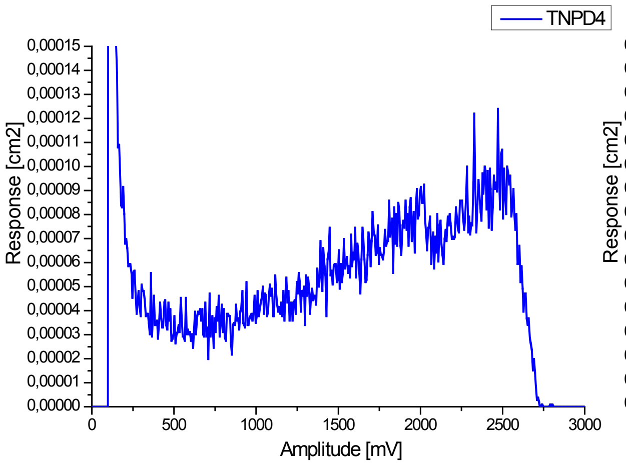
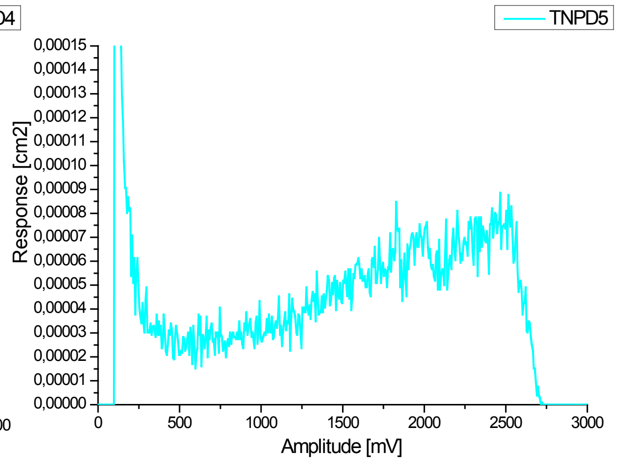
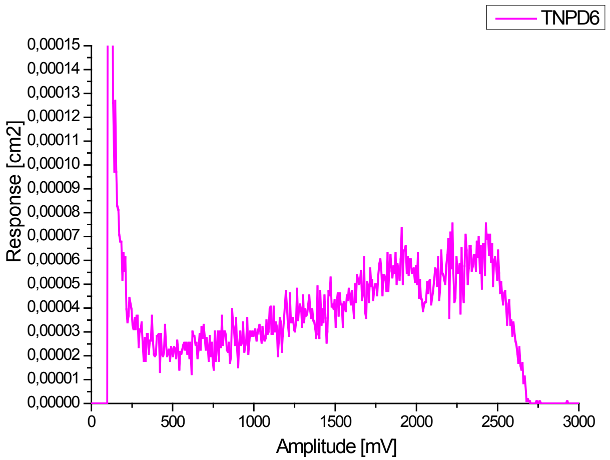
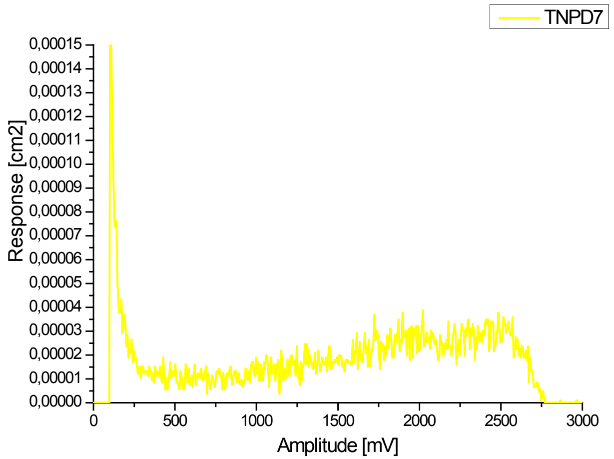
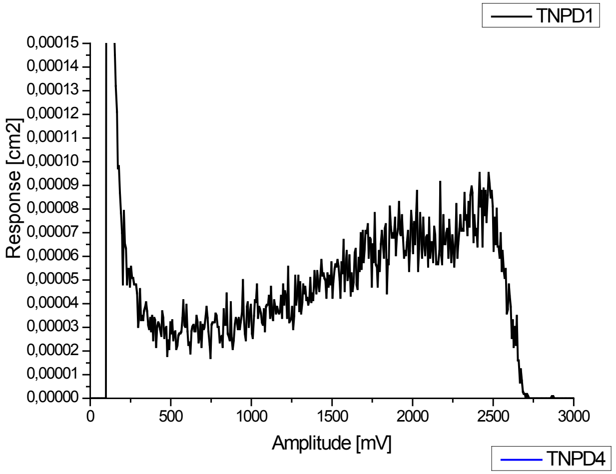


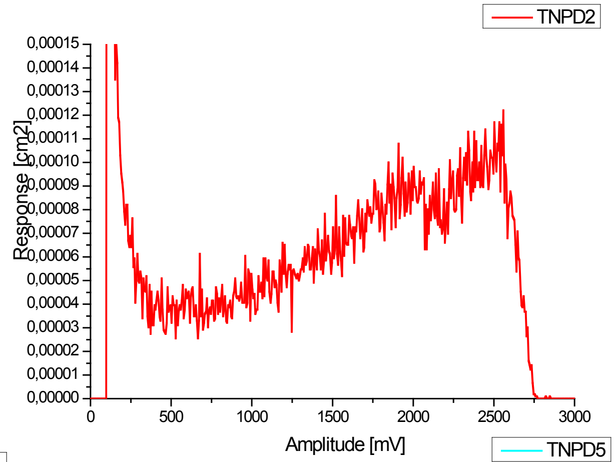


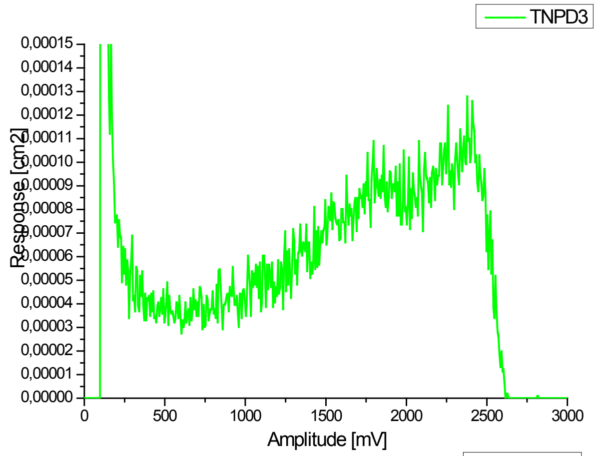


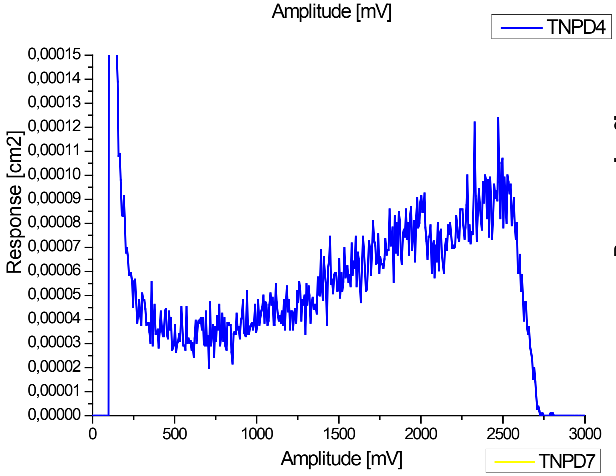


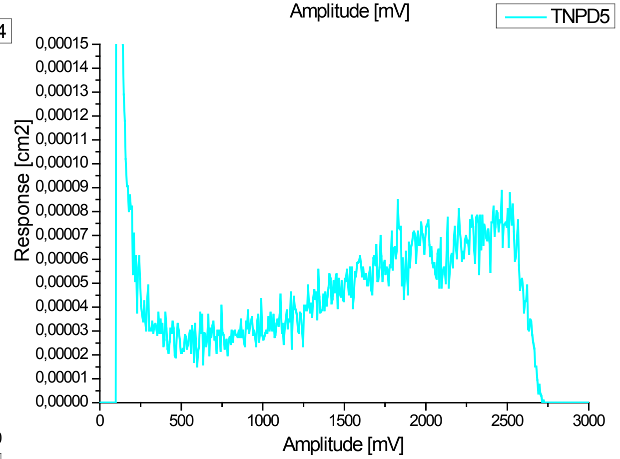


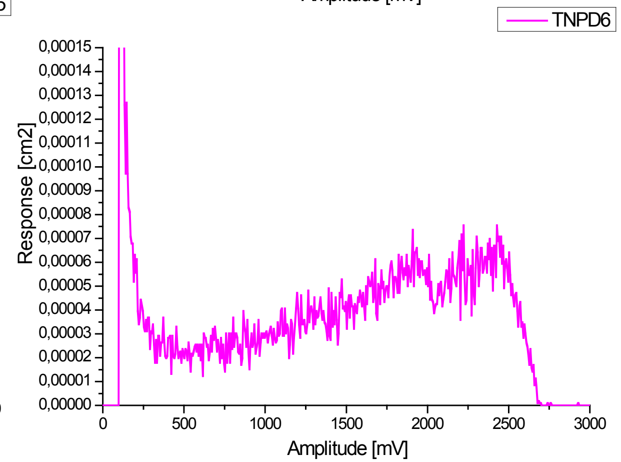

TNPD1
Response [cm2]
Amplitude [mV]

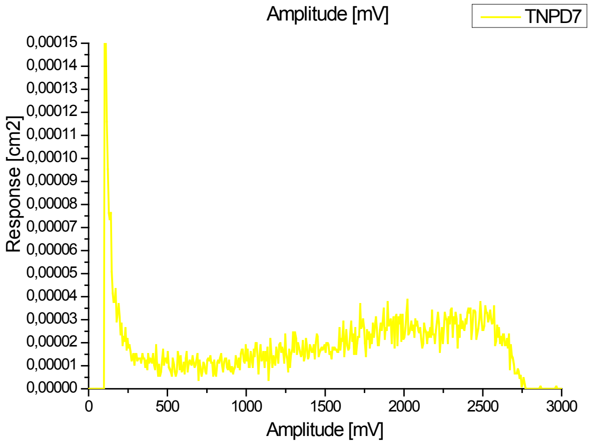

TNPD2
Response [cm2]
Amplitude [mV]


TNPD3
Response [cm2]
Amplitude [mV]


TNPD4
Response [cm2]
Amplitude [mV]


TNPD5
Response [cm2]
Amplitude [mV]


TNPD6
Response [cm2]
Amplitude [mV]


TNPD7
Response [cm2]
Amplitude [mV]

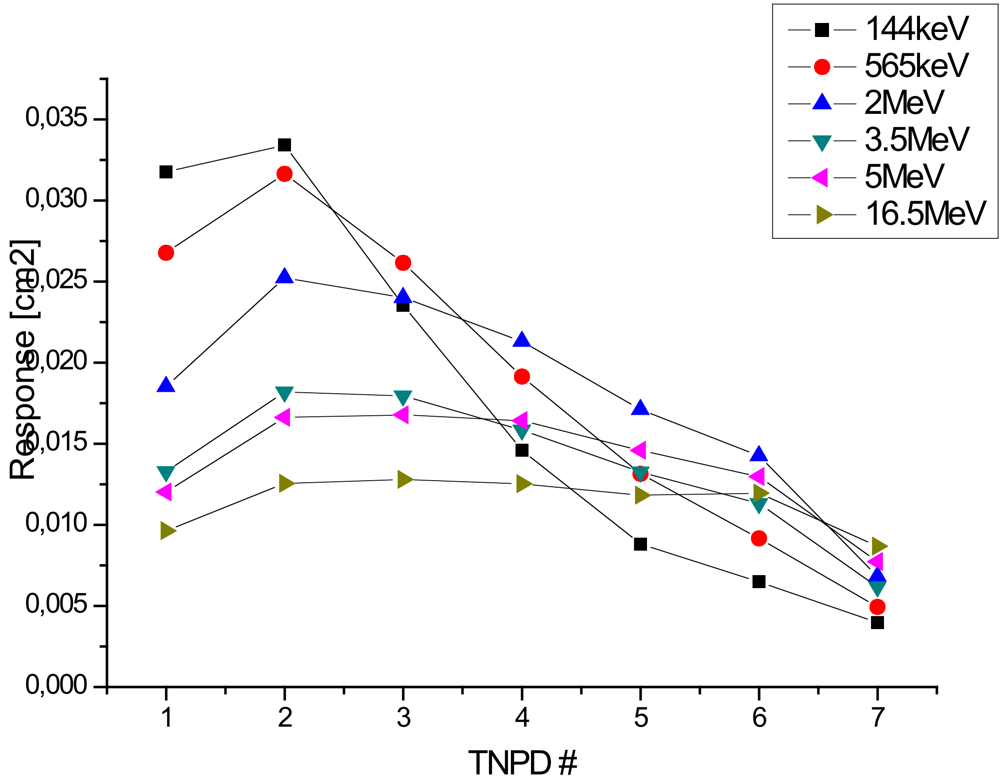
2) Irradiation campaign of the CYSP at the National Physical Laboratory (NPL – UK)

Data elaboration

1) **C_{TOTAL} and $C_{SCATTER}$** obtained with every TNPD are normalized by considering the experimental individual sensitivity of each TNPD

1) **C_{NET}/Φ [cm^2] = C_{TOTAL}/Φ_{TOTAL} [cm^2] - $C_{SCATTER}/\Phi_{SCATTER}$ [cm^2]**

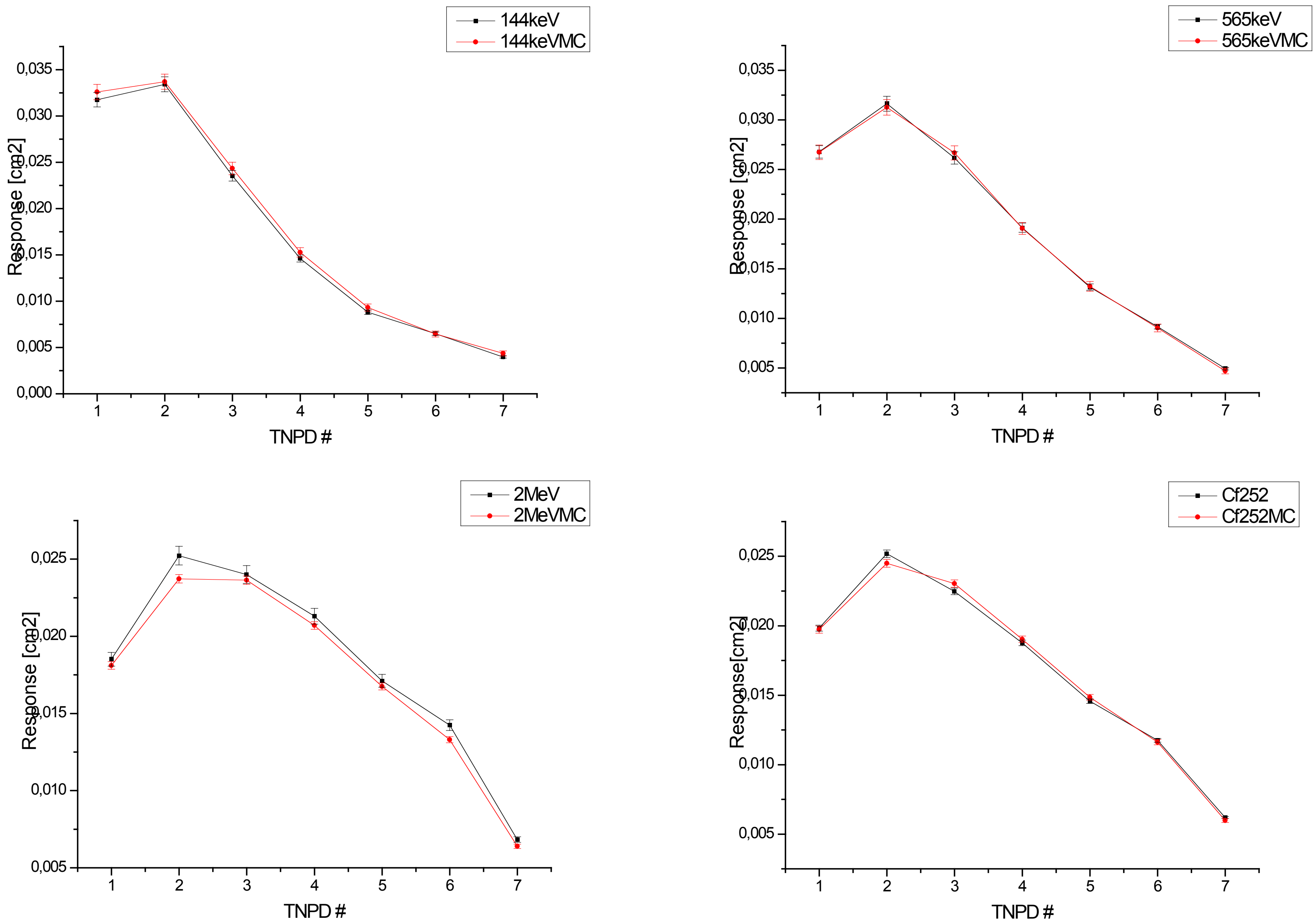
3) **C_{NET}/Φ [cm^2]_corrected = C_{NET}/Φ [cm^2] * W**
where W is a factor that takes into account the target-scatter effect



Experimental profile of the response of the different TNPDs along the axis of the CYSP for different mono-chromatic neutron beams

2) Irradiation campaign of the CYSP at the National Physical Laboratory (NPL – UK)

Comparison between Experimental and Simulated responses (obtained from MC simulations) for different neutron beams



2) Irradiation campaign of the CYSP at the National Physical Laboratory (NPL – UK)

The ratio between the *experimental response* and the *simulated response* of each TNPD ($\mathbf{F}_{\mathbf{i, E}}$) for every mono-chromatic energy is given in the following table:

	144 KeV	565 keV	2 MeV	3,5 MeV	5 MeV	16,5 MeV	Cf-252
1	0,195	0,200	0,204	0,196	0,202	0,214	0,201
2	0,198	0,202	0,213	0,201	0,206	0,205	0,206
3	0,194	0,196	0,203	0,193	0,193	0,194	0,195
4	0,191	0,201	0,206	0,188	0,199	0,193	0,197
5	0,189	0,199	0,204	0,184	0,194	0,190	0,196
6	0,201	0,203	0,214	0,190	0,199	0,203	0,202
7	0,182	0,210	0,214	0,199	0,199	0,204	0,207

Considering each mono-chromatic irradiation as a separate experiment, a best estimation of the calibration factor $\mathbf{F}_{\mathbf{E}}$ was derived for every energy. The different values of $\mathbf{F}_{\mathbf{E}}$ are in agreement:

Average	0,193	0,202	0,208	0,193	0,199	0,200	0,201
Uncertainty	3,2%	2,2%	2,4%	3,2%	2,3%	4,2%	2,3%

The global calibration factor **F** of the CYSP spectrometer is obtained by a weighted average of the $\mathbf{F}_{\mathbf{E}}$ values, using the inverse square of uncertainty as weighting factor :

Weight average	**0,200**
Weight Unc.	**1,35%**

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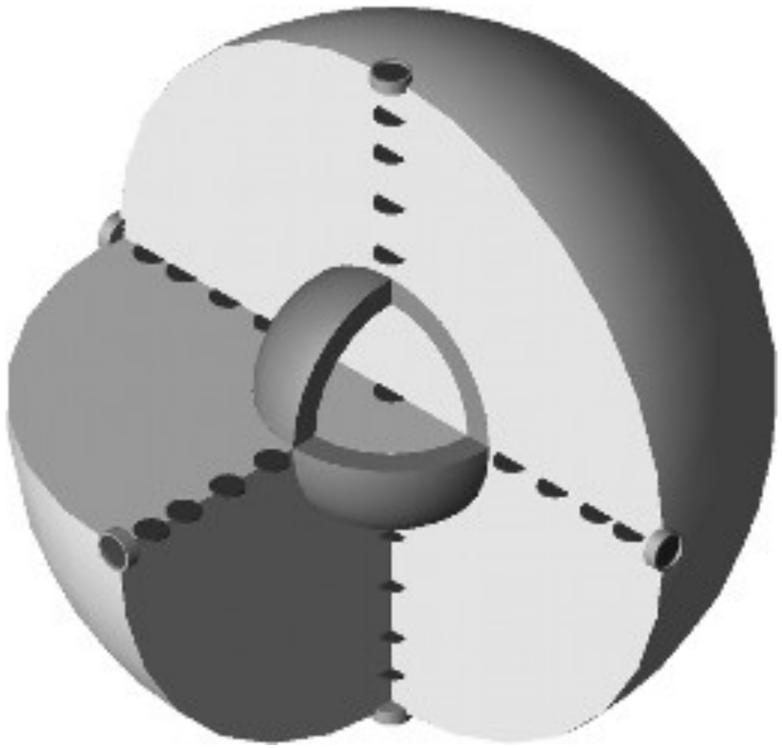
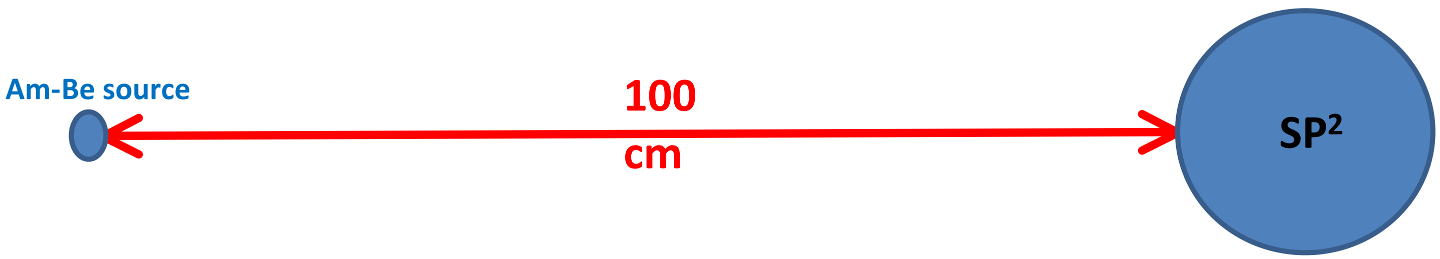


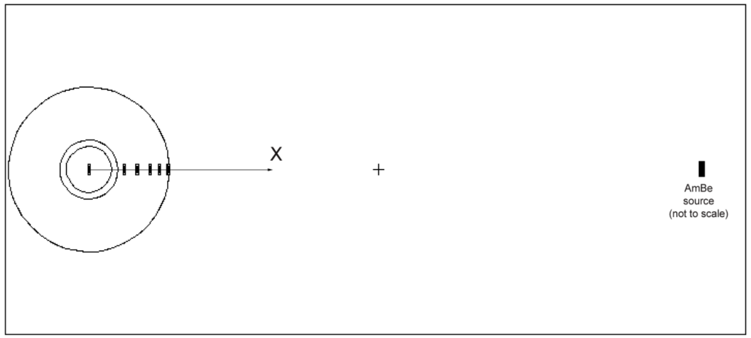
- 25 cm diameter
- 31 measurement positions
- Lead shell

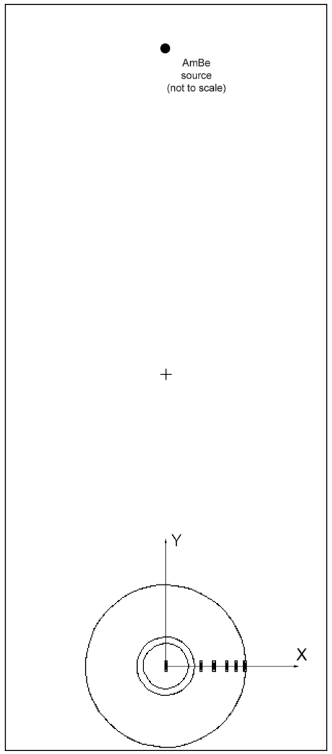
Distance of the TNPDs from the sphere centre along the x,y,z axis:

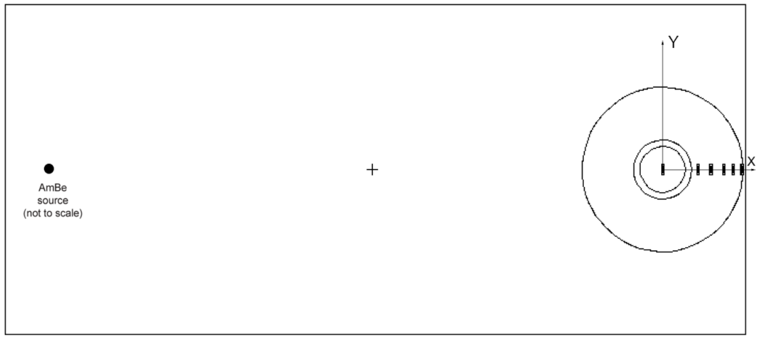
0 cm
5.5 cm
7.5 cm
9.5 cm
11.0 cm
12.35 cm

3) Irradiation of the SPherical SPectrometer (SP²) with a 1Ci Am-Be neutron source







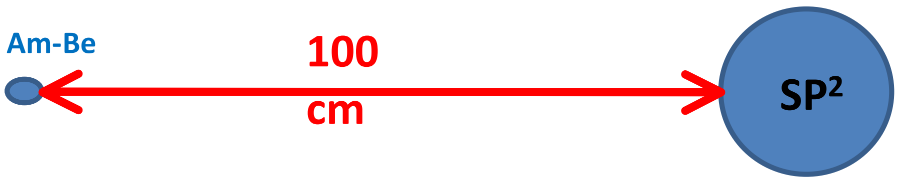


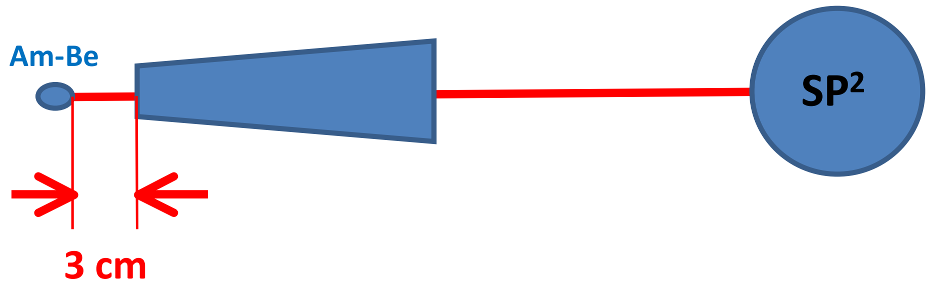
1 0 0

-1 0 0

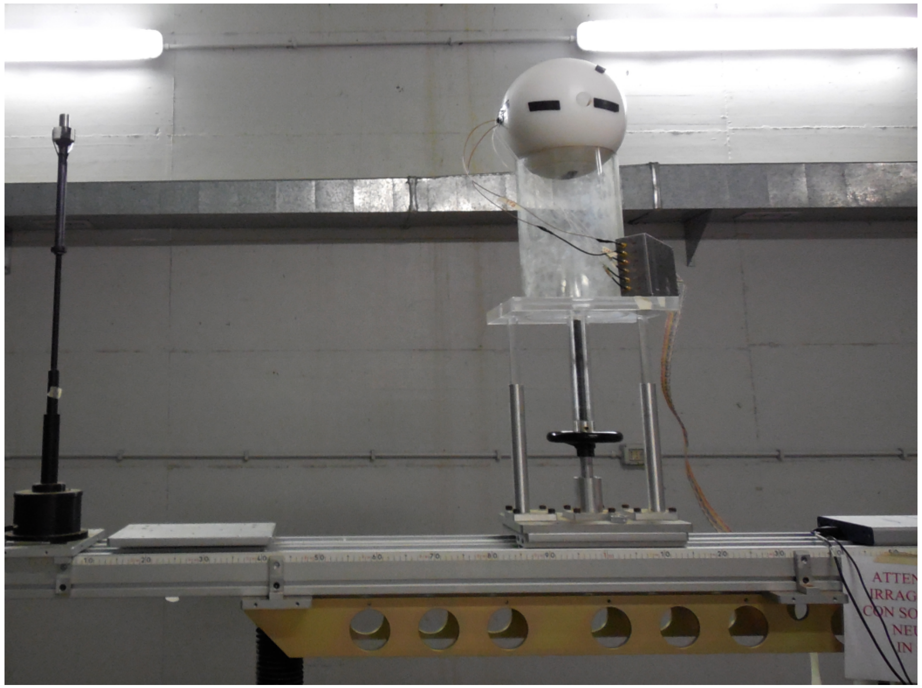
lateral

3) Irradiation of the SPherical SPectrometer (SP^2) with a 1Ci Am-Be neutron source

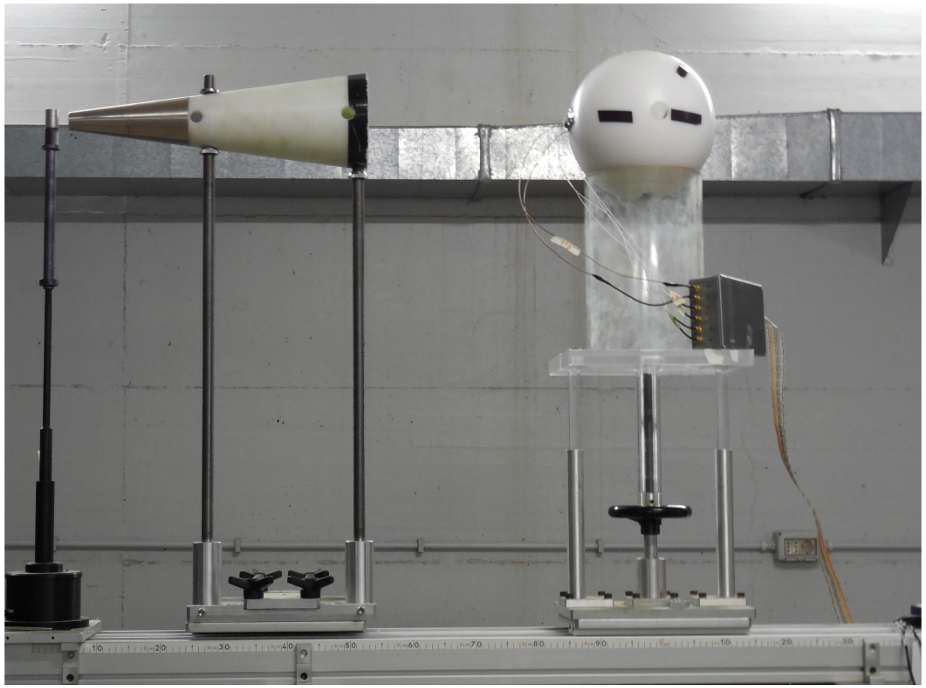




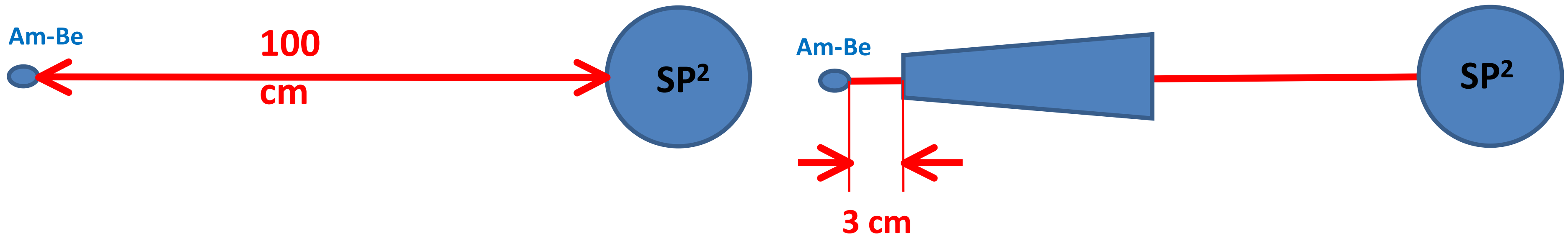
TOTAL FIELD



SCATTERED COMPONENT



3) Irradiation of the SPherical SPectrometer (SP^2) with a 1Ci Am-Be neutron source



a) **Total neutron field** (neutrons arriving directly from the source + neutrons scattered from the room and the surroundings)
b) **Scattered component of the neutron field** (with a suitable shadow cone between the source and SP^2)

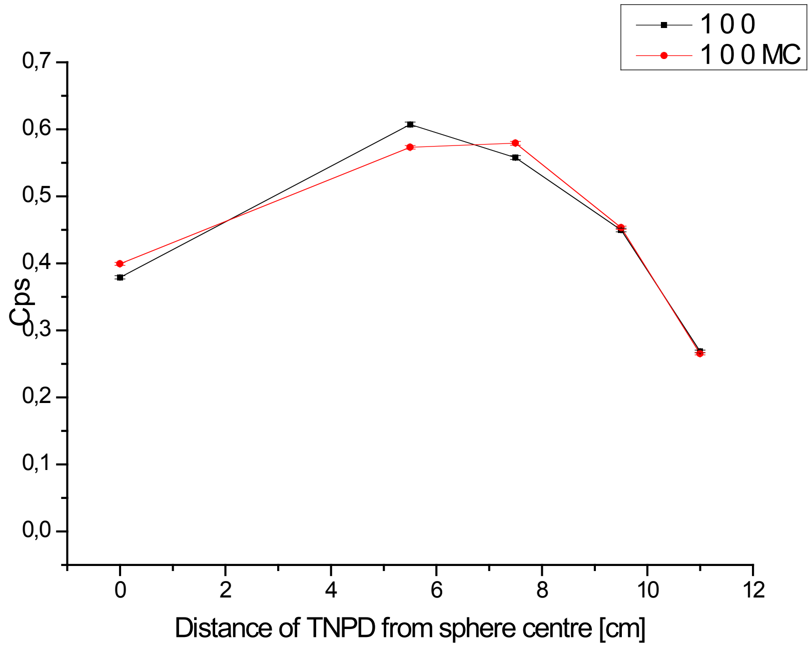
Data elaboration

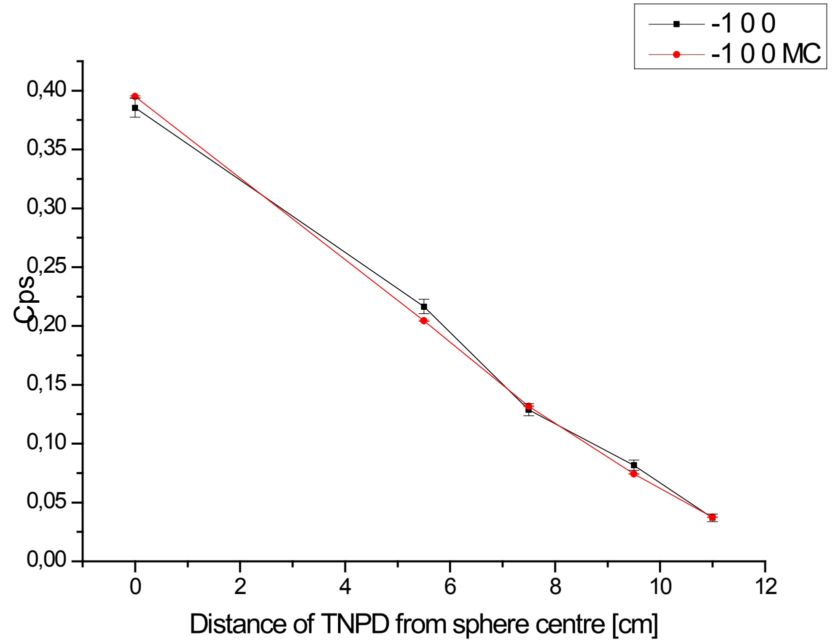
1) **CPS_{TOTAL} and $CPS_{SCATTER}$** obtained with every TNPD are normalized by considering the experimental individual sensitivity of each TNPD

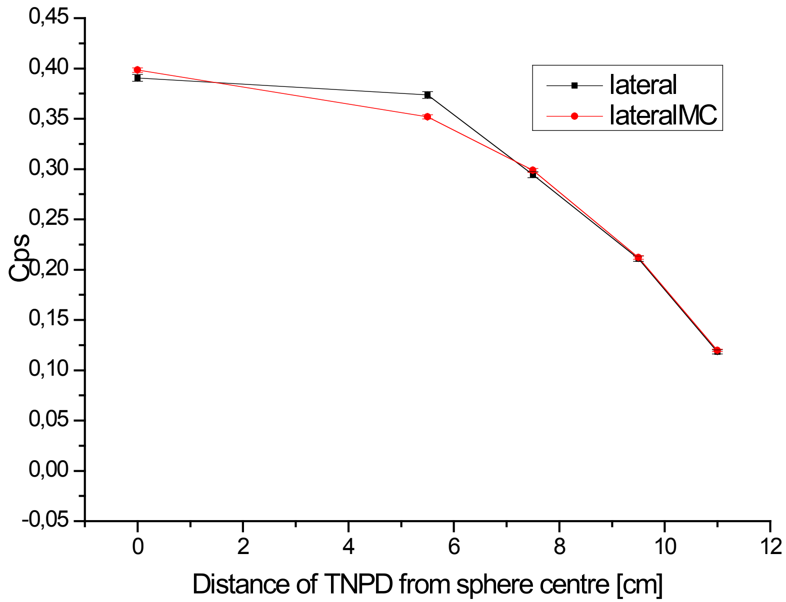
2) **CPS_{NET} [s^{-1}] = CPS_{TOTAL} [s^{-1}] - $CPS_{SCATTER}$ [s^{-1}]**

3) Irradiation of the SPherical SPectrometer (SP²) with a 1Ci Am-Be neutron source

Comparison between Experimental and Simulated Cps (obtained from MC simulations) for different orientations







3) Irradiation of the SPherical SPectrometer (SP^2) with a 1Ci Am-Be neutron source

The ratio between the *experimental Cps* and the *simulated response* of each TNPD per emitted neutron is given in the following table:

Position	1 0 0	-1 0 0	lateral
0	3,64E+05	3,73E+05	3,75E+05
5,5	4,06E+05	4,06E+05	4,06E+05
7,5	3,69E+05	3,74E+05	3,77E+05
9,5	3,80E+05	4,20E+05	3,81E+05
11	3,87E+05	3,78E+05	3,78E+05

The best estimation of the ratio between the *experimental Cps* and the *simulated response* is obtained by a weighted average, using the inverse square of uncertainty as weighting factor.

By considering the number of neutrons per second emitted by the source, the calibration factor of the **SP^2** resulted equal to **0.185**, with a final uncertainty of **2%** (considering the contributions given by the statistics, the emission rate and the distance between the source and the **SP^2**)

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3) Irradiation of the SPherical SPectrometer (SP^2) at the Frascati Neutron Generator (Enea)

Fusion reaction T(d,n)α
Deuteron Energy = 260 keV
Neutron Energy = 14.6 MeV

SOURCE TO DETECTOR DISTANCE = 120 cm
SOURCE TO CONE DISTANCE = 3.5 cm
ANGLE OF MEASUREMENT = 45°
CONFIGURATION GEOMETRY = 1 0 0

TOTAL FIELD + SCATTERED COMPONENT

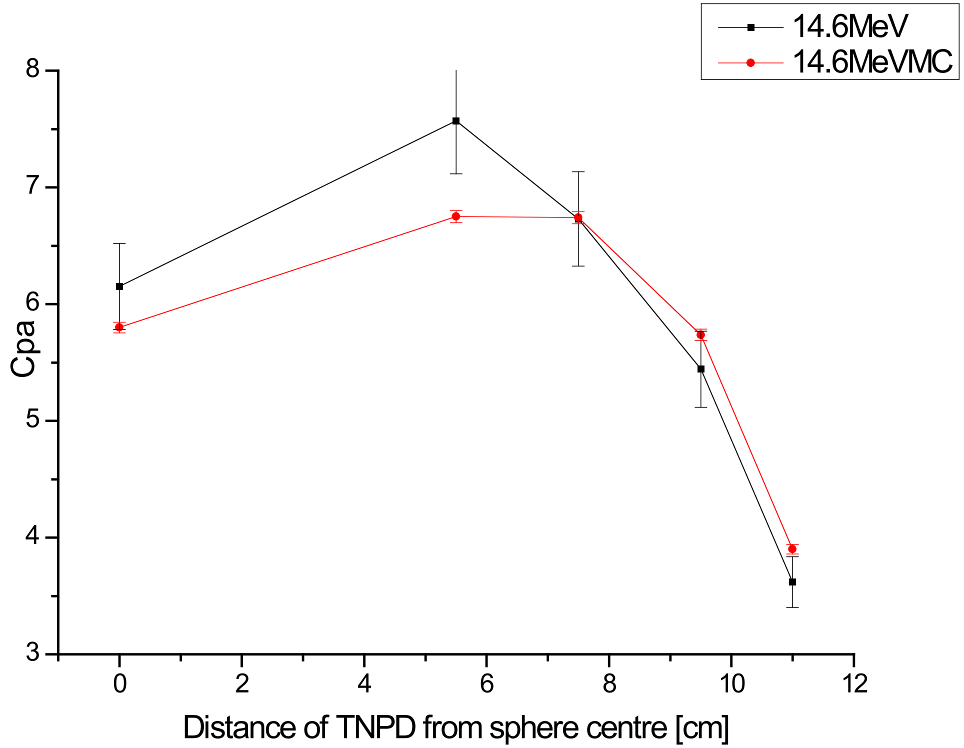
Data elaboration

1) **$CP\alpha_{TOTAL}$ and $CP\ \alpha_{SCATTER}$** obtained with every TNPD are normalized by considering the experimental individual sensitivity of each TNPD

2) **$CP\alpha_{NET}\ [s^{-1}] = CP\alpha_{TOTAL}\ [s^{-1}] - CP\alpha_{SCATTER}\ [s^{-1}]$**

3) Irradiation of the SPherical SPectrometer (SP^2) at the Frascati Neutron Generator (Enea)

Comparison between Experimental and Simulated responses (obtained from MC simulations) for the 1 0 0 geometry



3) Irradiation of the SPherical SPectrometer (SP^2) at the Frascati Neutron Generator (Enea)

The ratio between the *experimental Cpα* and the *simulated Response per emitted neutron* is given in the following table:

Position	1 0 0
0	1,26E+07
5,5	1,34E+07
7,5	1,19E+07
9,5	1,13E+07
11	1,10E+07
Average	1,19E+07
Dev.Std/Average	8%

F	0,191
Uncertainty	6%

By considering the total fluence per alpha particle, the calibration factor of the **SP^2** resulted equal to **0.191**, with a final uncertainty of **6%** (considering the contributions given by the statistics, the fluence and the distance between the target and the **SP^2**)

Thanks for your Attention!