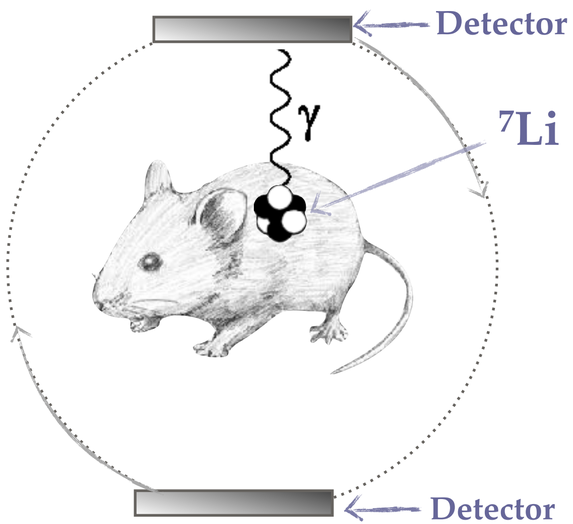
S. Fatemi, S. Bortolussi, C. Magni, I. Postuma, S. Altieri and N. Protti

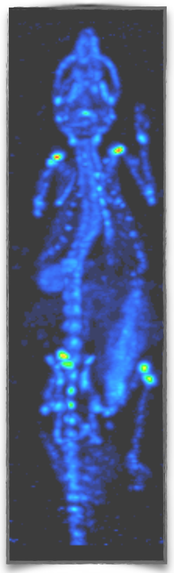
SIMULATED RESPONSE OF A CZT DETECTOR TO THE NEUTRON AND GAMMA RADIATION FIELD OF AN ACCELERATOR BASED BNCT FACILITY.

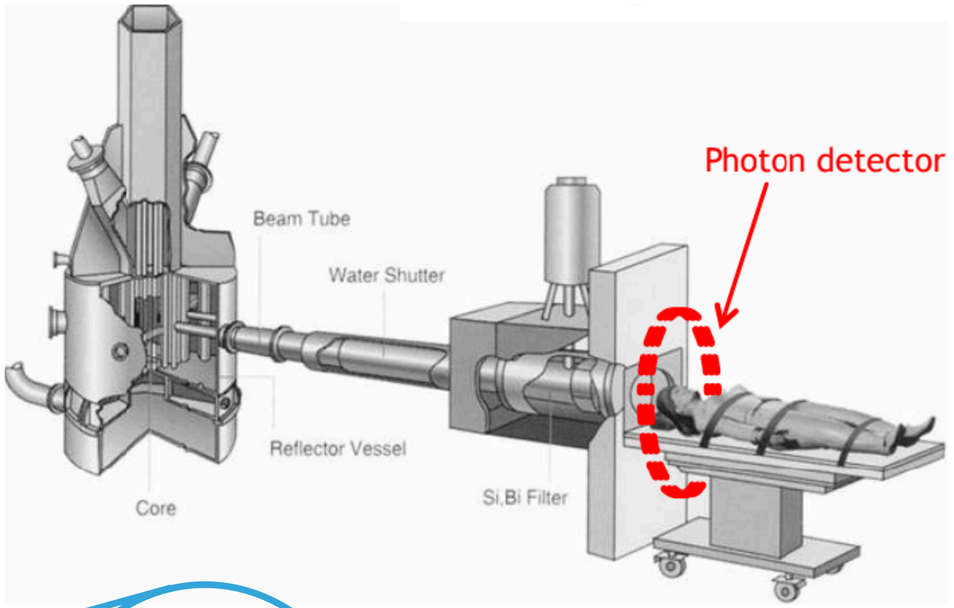
MAECI-MOST: NEU_BEAT WORKSHOP – ROME – 6/7 DECEMBER 2018

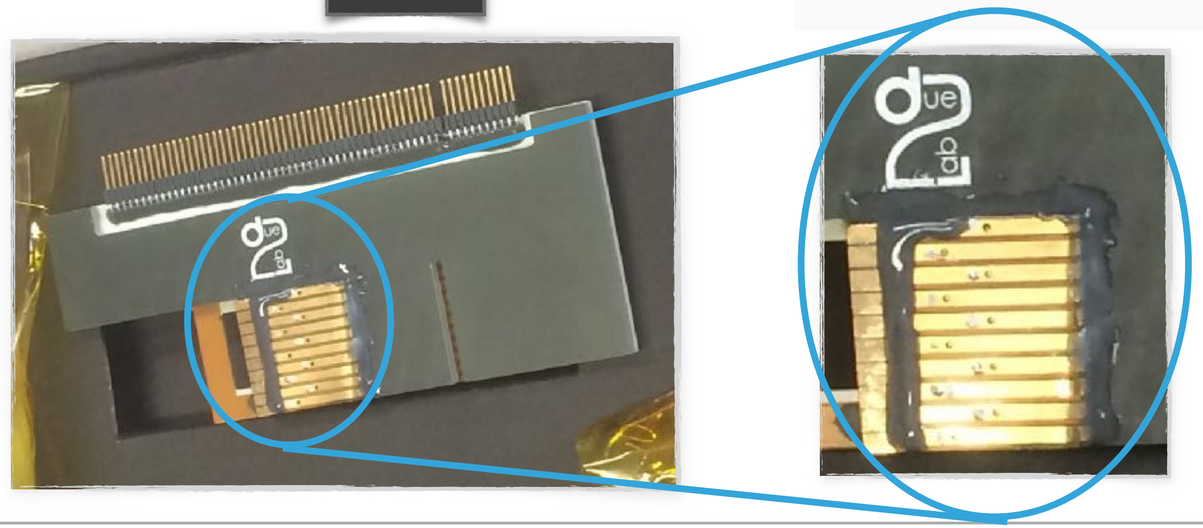
AIM OF THE PROJECT



Live γ counting proportional to dose distribution in the patient

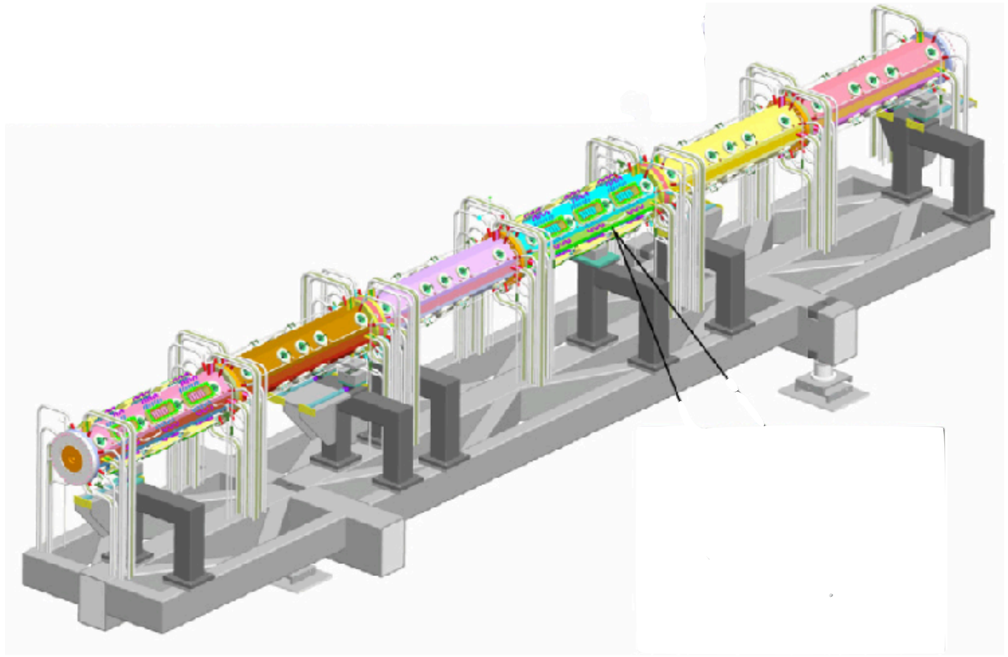




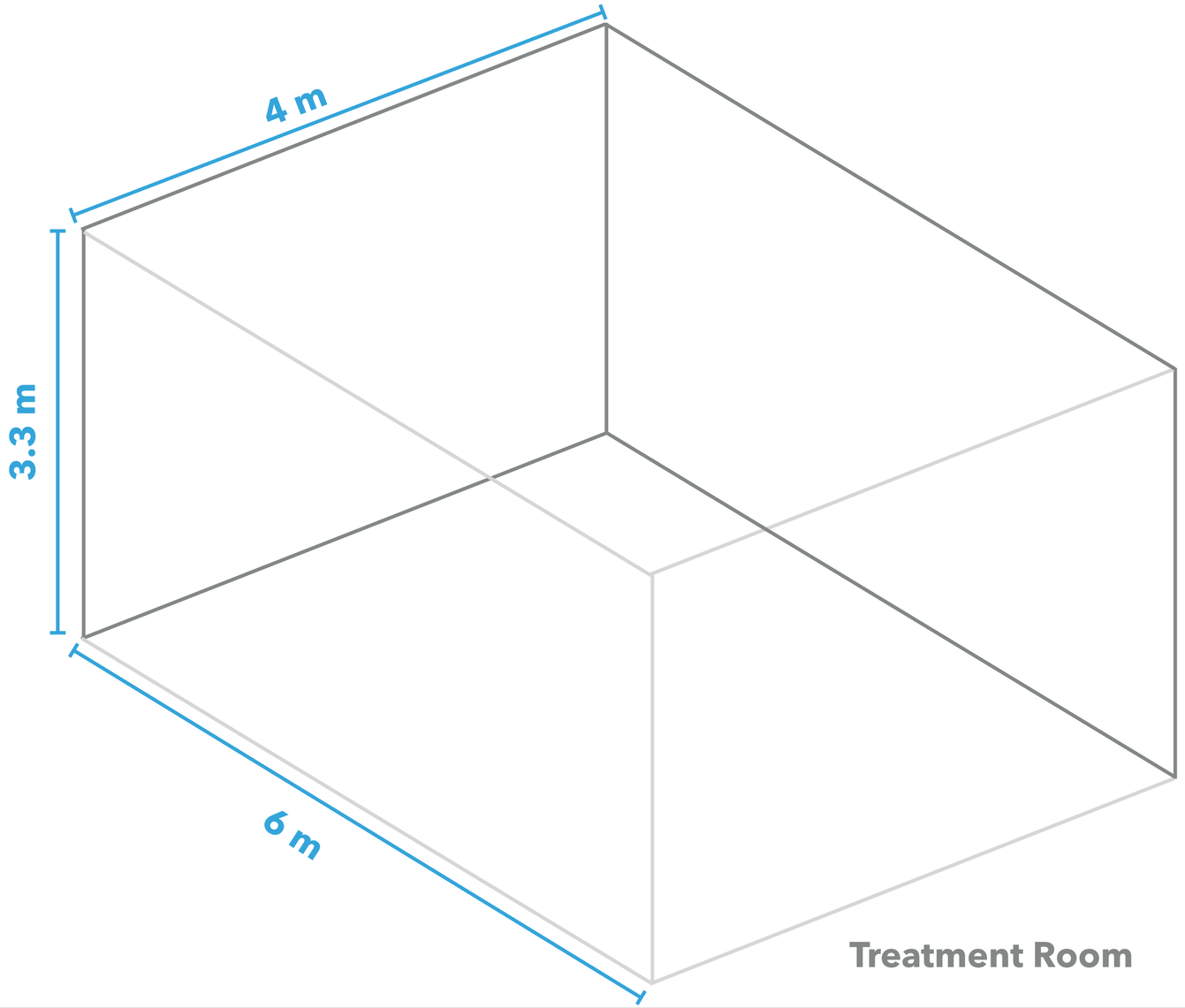


More on BNCT-SPECT in Pavia:
@ Posters: Protti, Fatemi
@ Friday 9:24, Protti

ACCELERATOR BASED BNCT TREATMENT ROOM



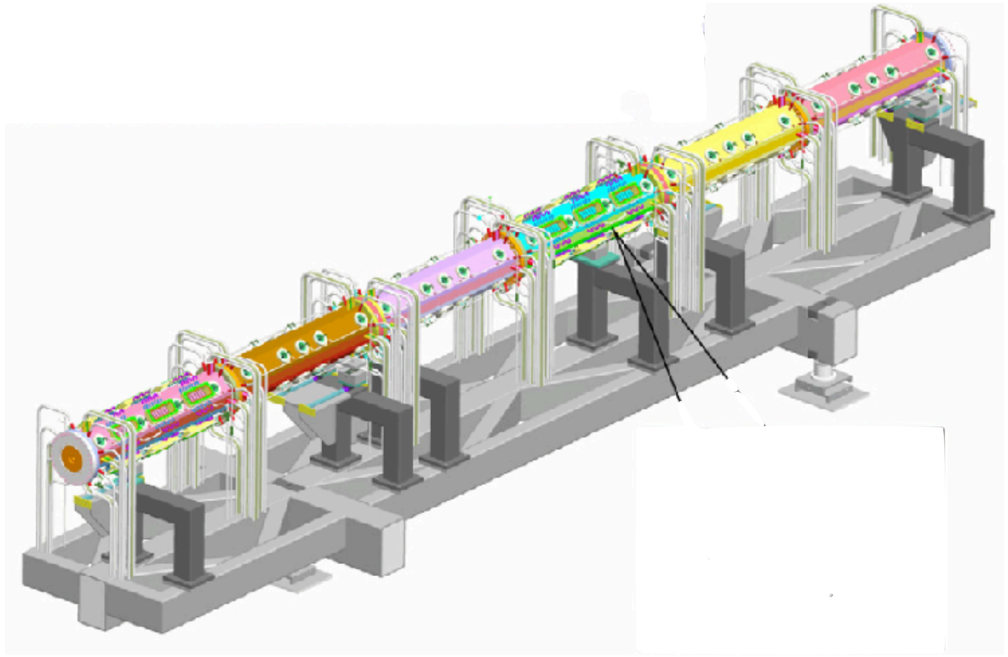
RFQ @ 5 MeV, 30 mA



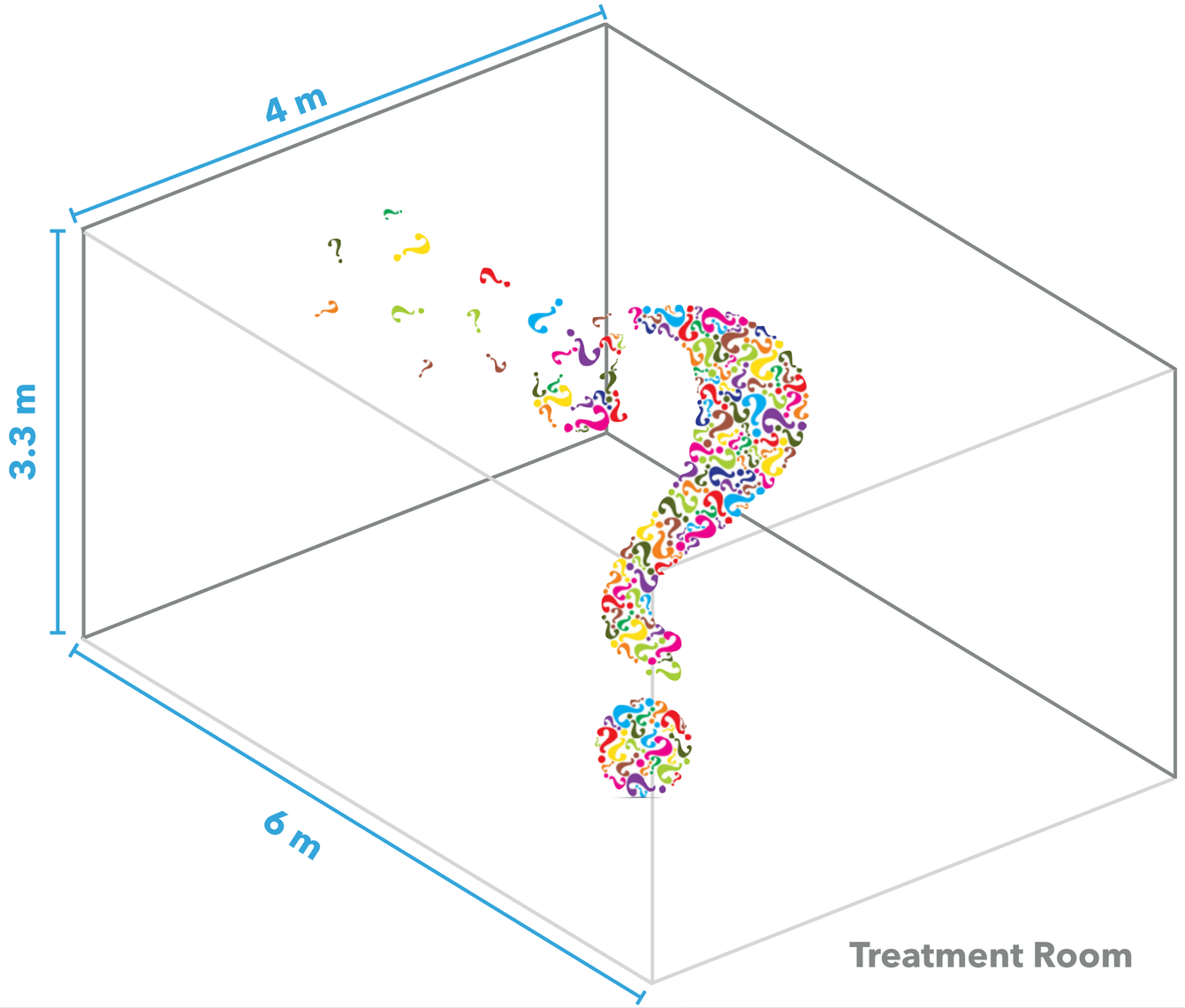
Treatment Room

More on aBNCT treatment room in Pavia:
@ Today, 16:32, Magni

ACCELERATOR BASED BNCT TREATMENT ROOM

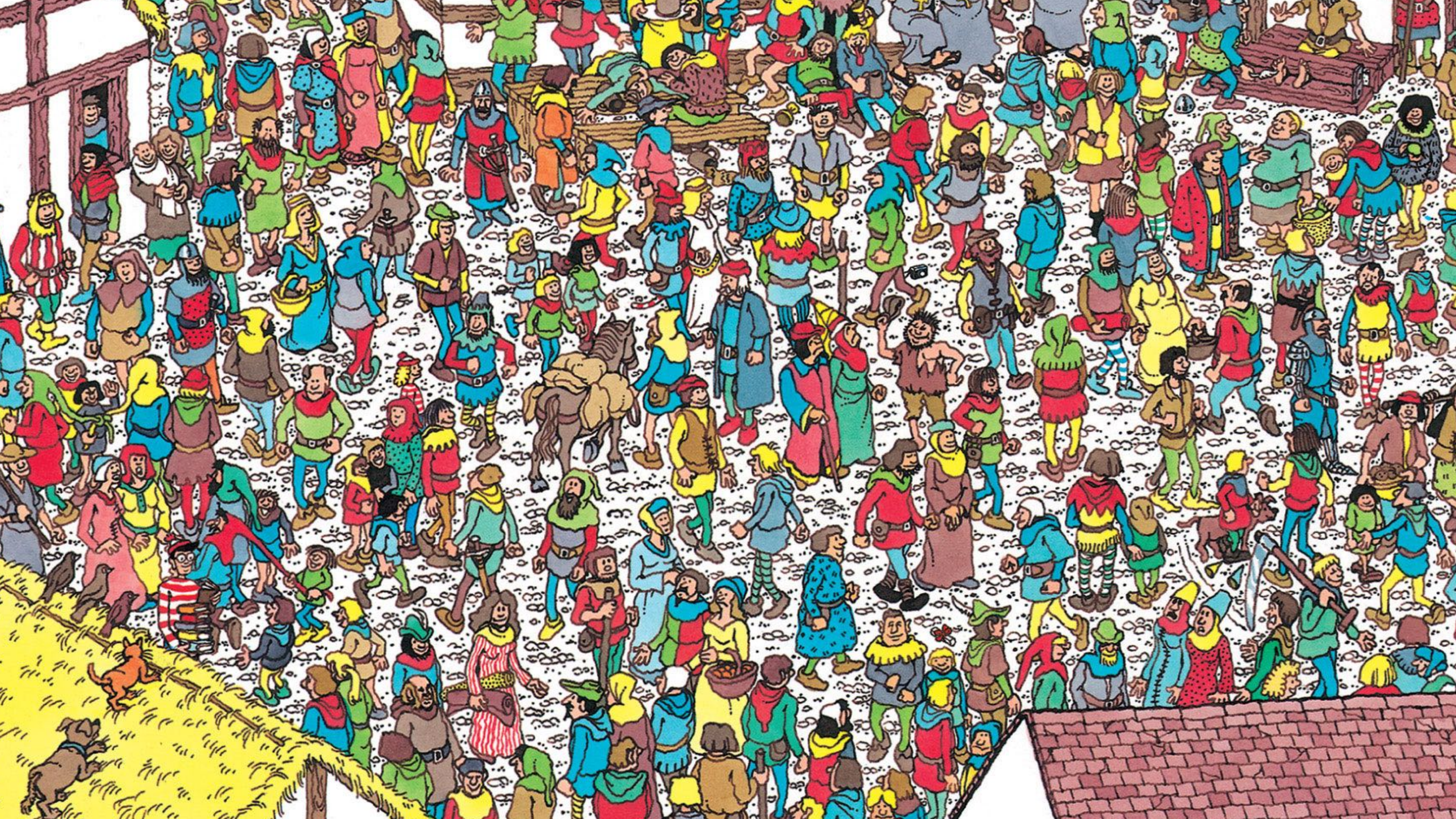


RFQ @ 5 MeV, 30 mA



Treatment Room

More on aBNCT treatment room in Pavia:
@ Today, 16:32, Magni



EXPECTED BACKGROUND

EXPECTED BACKGROUND

Thermal Neutrons

EXPECTED BACKGROUND

Thermal Neutrons

Epithermal Neutrons

EXPECTED BACKGROUND

Thermal Neutrons

Epithermal Neutrons

Fast Neutrons

EXPECTED BACKGROUND

γ from neutron source

Thermal Neutrons

Epithermal Neutrons

Fast Neutrons

EXPECTED BACKGROUND

Thermal Neutrons

Epithermal Neutrons

Fast Neutrons

γ from neutron source

2.2 MeV γ from concrete, polyethylene and patient/phantom

EXPECTED BACKGROUND

Thermal Neutrons

Epithermal Neutrons

Fast Neutrons

γ from neutron source

2.2 MeV γ from concrete, polyethylene and patient/phantom

511 keV γ from 2.2 MeV pair production in high Z materials

EXPECTED BACKGROUND

Thermal Neutrons

Epithermal Neutrons

Fast Neutrons

γ from neutron source

558 keV γ from thermal neutron capture in CdZnTe detector

2.2 MeV γ from concrete, polyethylene and patient/phantom

511 keV γ from 2.2 MeV pair production in high Z materials

EXPECTED BACKGROUND

Thermal Neutrons

Epithermal Neutrons

Fast Neutrons

γ from neutron source

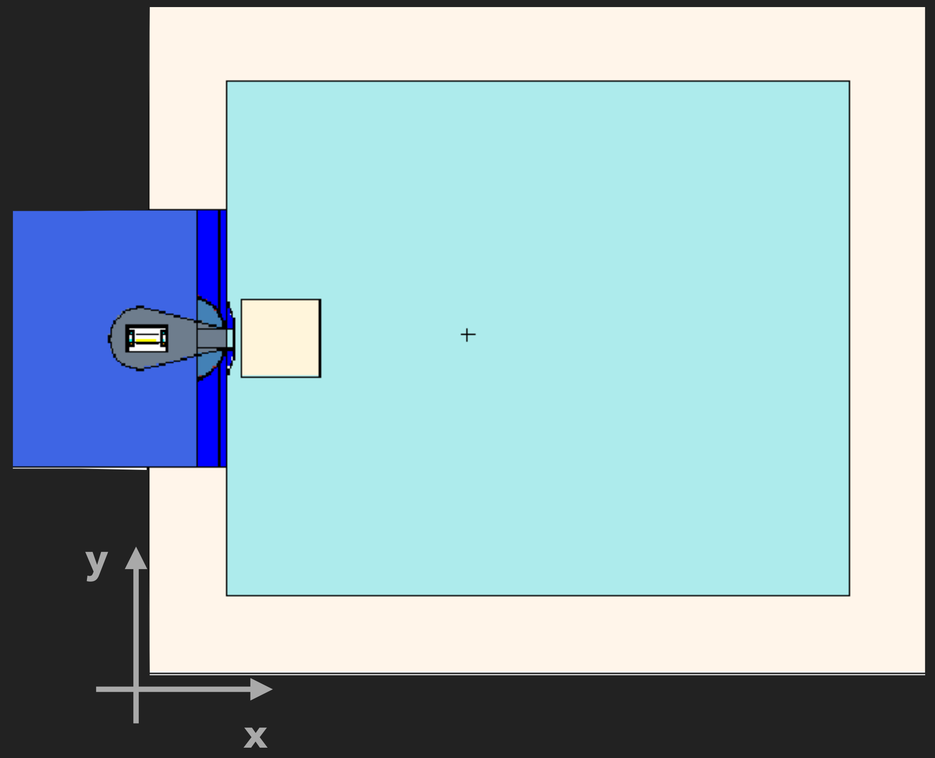
478 keV γ from Li and B materials in BSA and room walls

558 keV γ from thermal neutron capture in CdZnTe detector

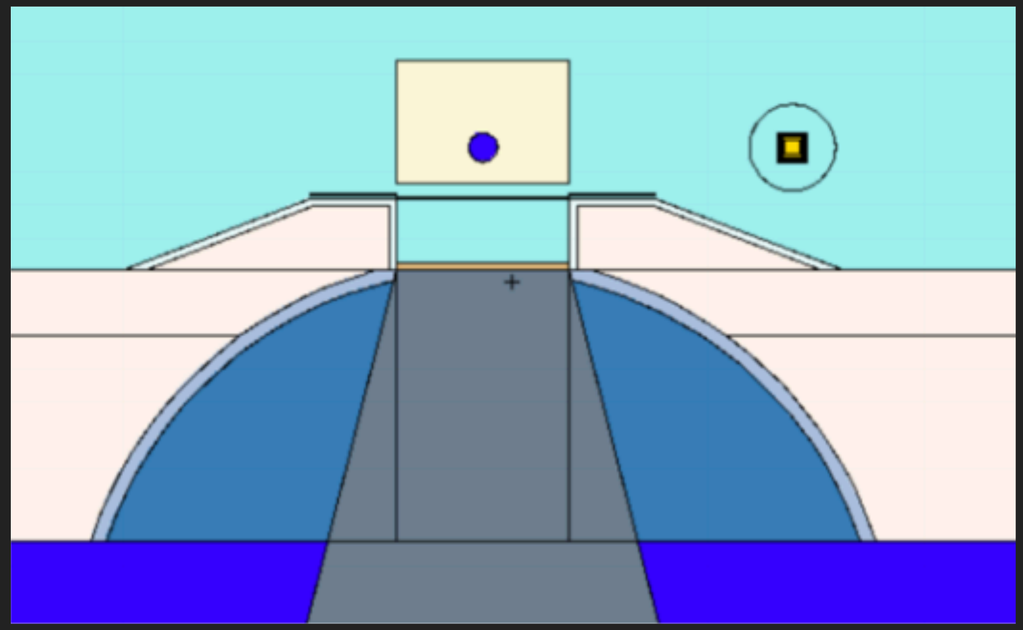
2.2 MeV γ from concrete, polyethylene and patient/phantom

511 keV γ from 2.2 MeV pair production in high Z materials

SIMULATION SETUP

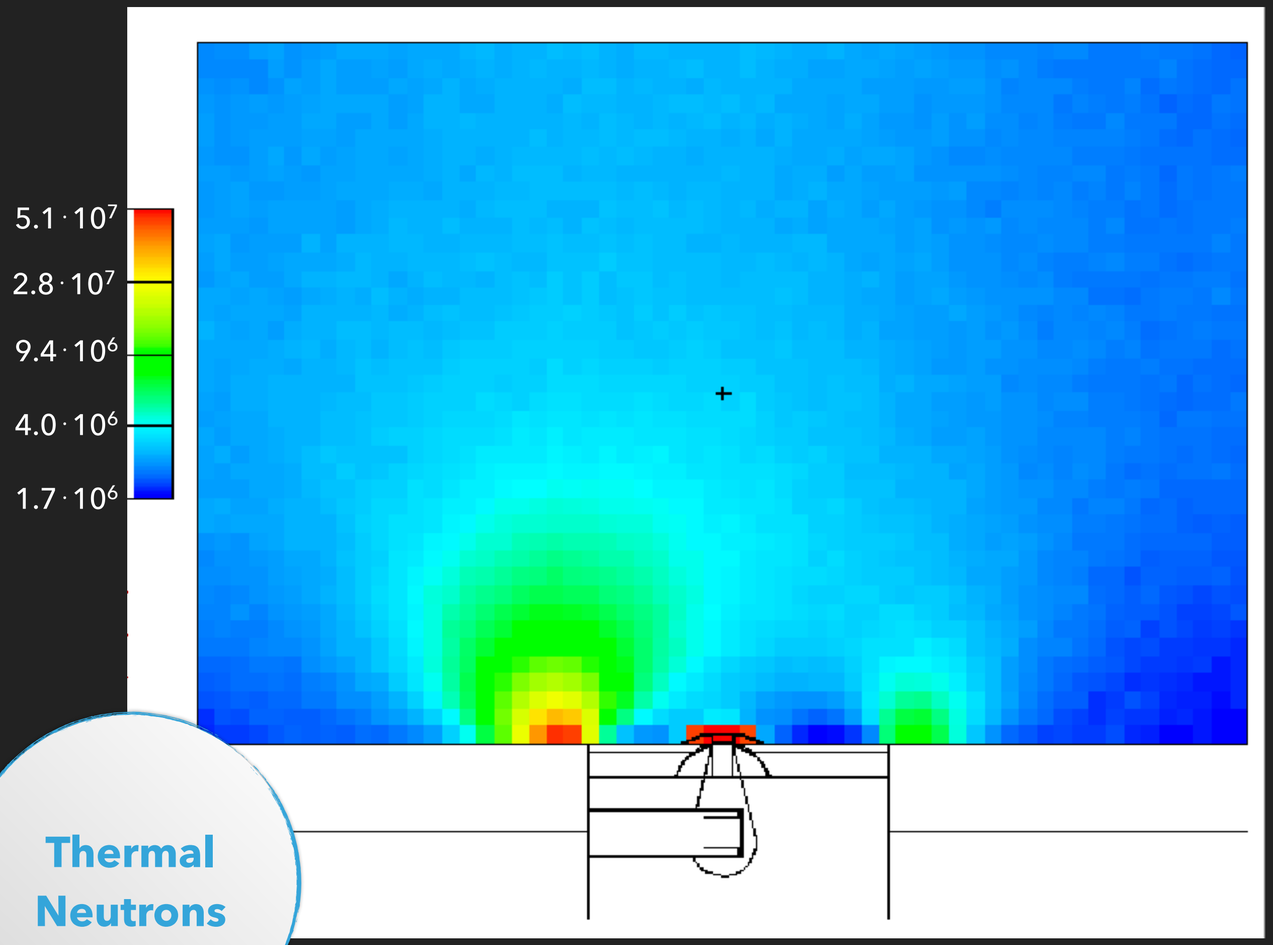


Neutron beam peaked in epithermal region with total neutron flux at the beam port higher than 10^9 $cm^{-2}s^{-1}$



Phantom: 8.5x12x12 cm^3 polyethylene @ 3 cm from the beam port
CZT: 20x20x20 mm^3 @14 cm from the phantom surface.
Tumour: 1 cm radius ICRU-44 tissue sphere

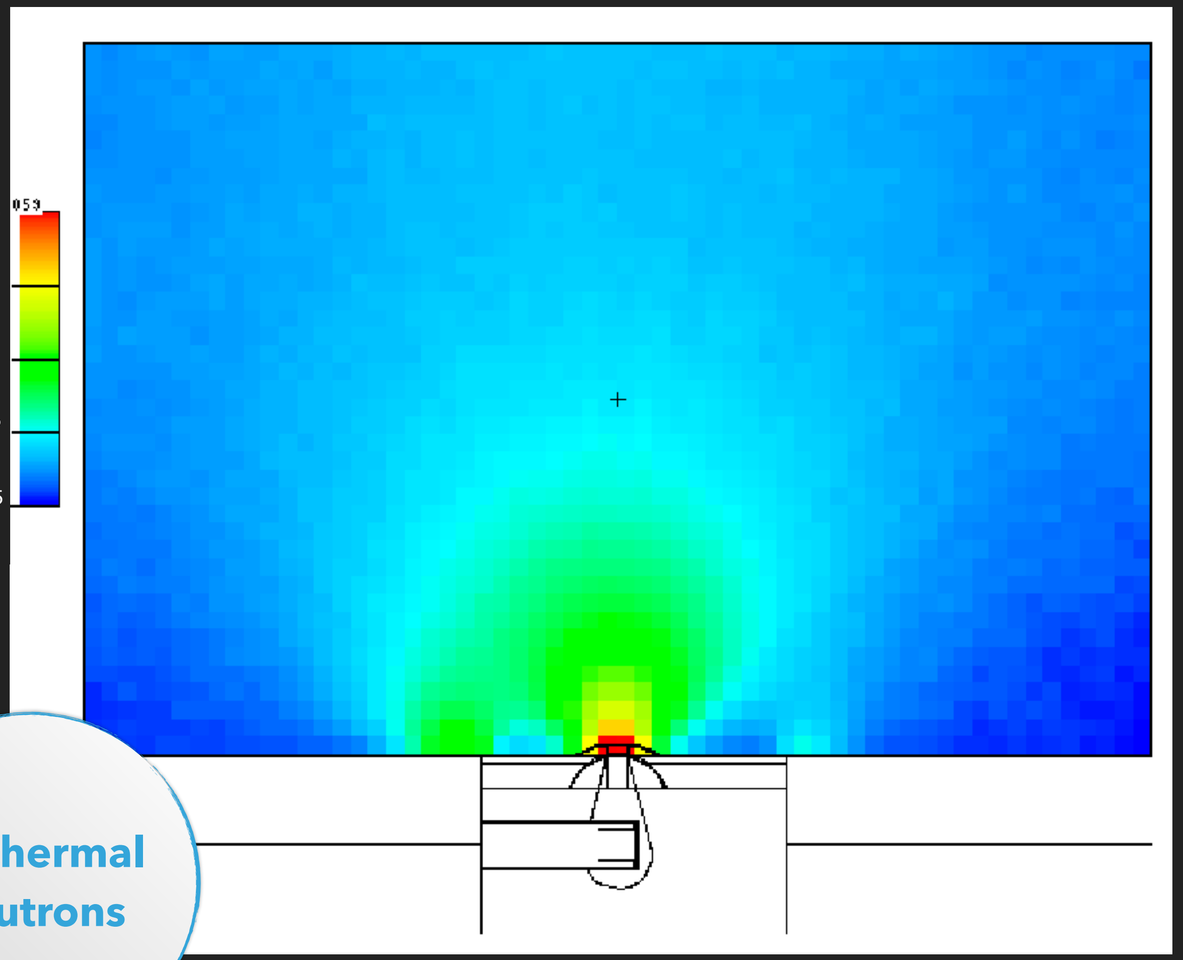
NEUTRONS IN THE BACKGROUND



Thermal Neutrons

E MeV	Neutron Φ @ 25 cm from BP cm^{-2} s^{-1}
$4 \cdot 10^{-7}$	$5.0 \cdot 10^{6}$
$4 \cdot 10^{-7}$ - $1 \cdot 10^{-6}$	$5.0 \cdot 10^{5}$
$1 \cdot 10^{-6}$ - 4	$8.3 \cdot 10^{6}$

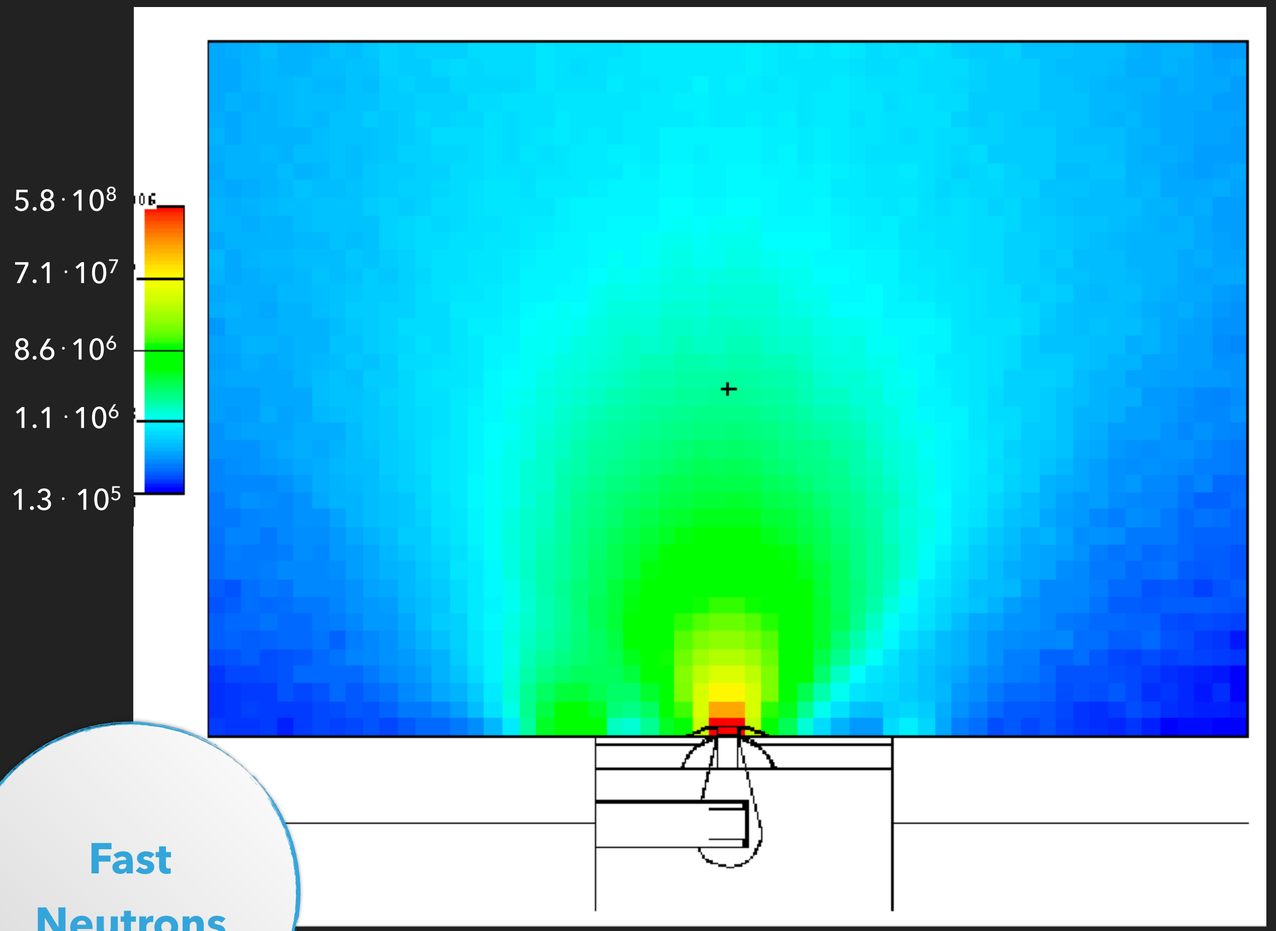
NEUTRONS IN THE BACKGROUND



Epithermal Neutrons

E MeV	Neutron Φ @ 25 cm from BP cm^{-2} s^{-1}
$4 \cdot 10^{-7}$	$5.0 \cdot 10^{6}$
$4 \cdot 10^{-7}$ - $1 \cdot 10^{-6}$	$5.0 \cdot 10^{5}$
$1 \cdot 10^{-6}$ - 4	$8.3 \cdot 10^{6}$

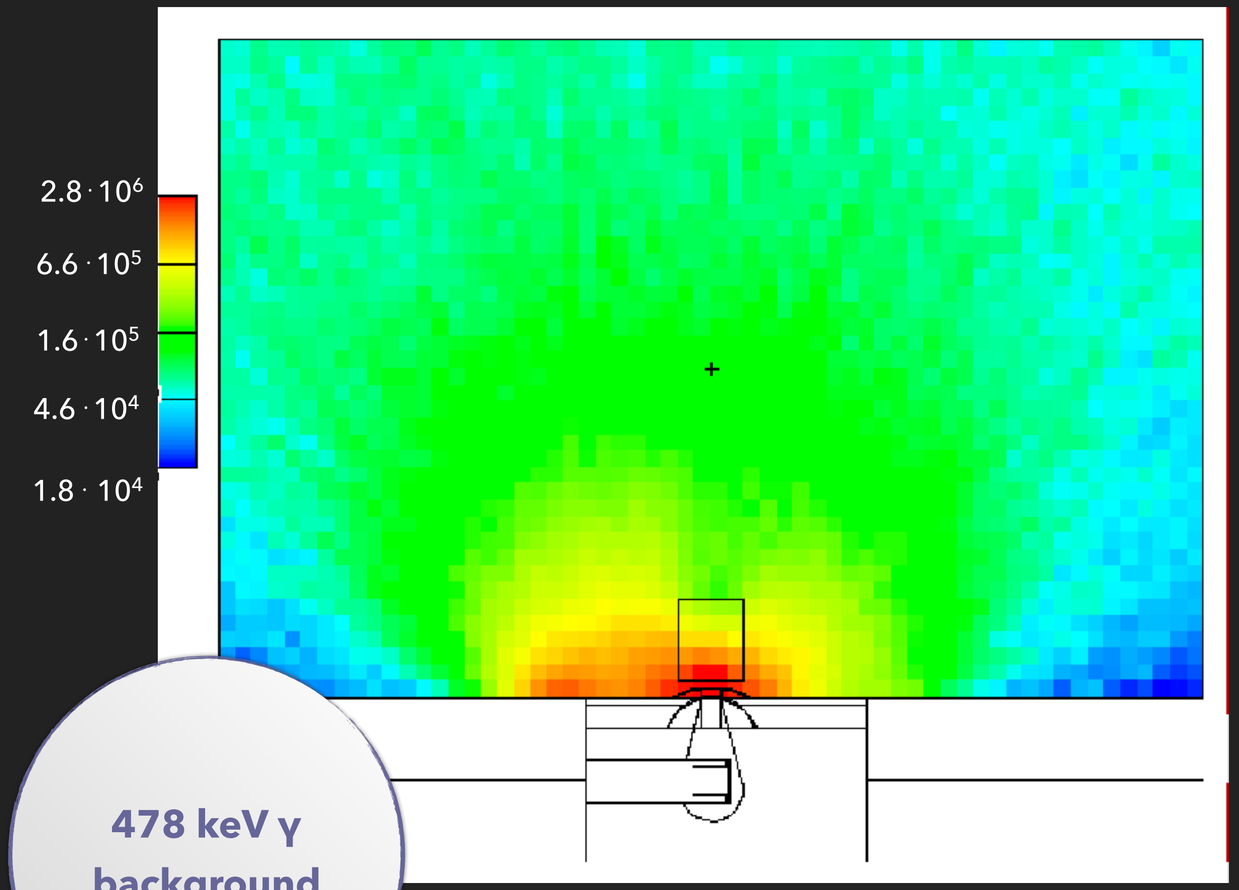
NEUTRONS IN THE BACKGROUND



Fast Neutrons

E MeV	Neutron Φ @ 25 cm from BP cm^{-2} s^{-1}
$4 \cdot 10^{-7}$	$5.0 \cdot 10^{6}$
$4 \cdot 10^{-7}$ - $1 \cdot 10^{-6}$	$5.0 \cdot 10^{5}$
$1 \cdot 10^{-6}$ - 4	$8.3 \cdot 10^{6}$

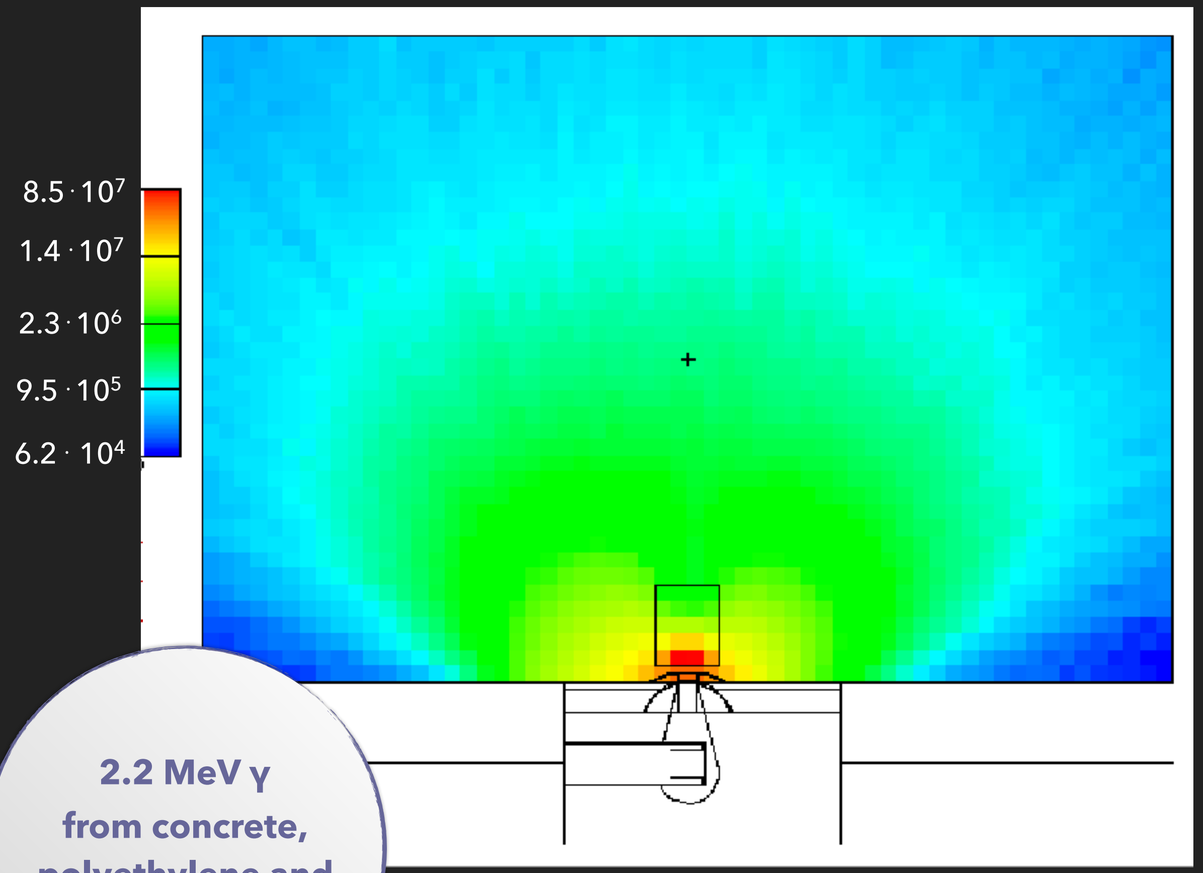
PHOTONS IN THE BACKGROUND



478 keV γ background

E MeV	Photon Φ @ 25 cm from BP $cm^{-2}\ s^{-1}$
0.45 - 0.50	$1.3 \cdot 10^6$
2.1 - 2.3	$1.7 \cdot 10^7$
Total	$1.3 \cdot 10^8$

PHOTONS IN THE BACKGROUND

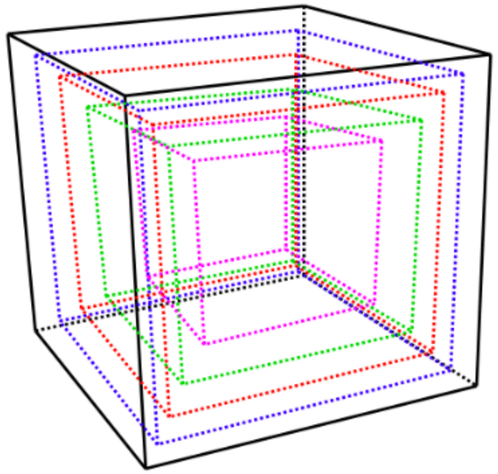


2.2 MeV γ from concrete, polyethylene and patient/phantom

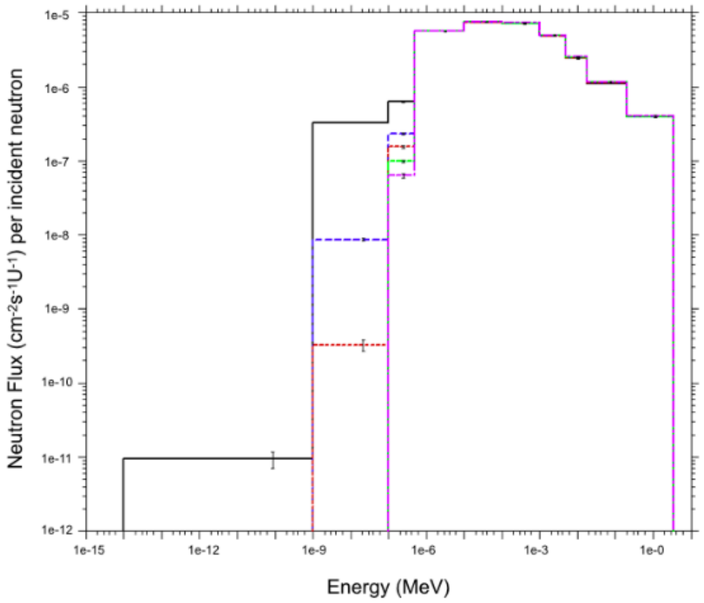
E MeV	Photon Φ @ 25 cm from BP $cm^{-2}\ s^{-1}$
0.45 - 0.50	$1.3 \cdot 10^6$
2.1 - 2.3	$1.7 \cdot 10^7$
Total	$1.3 \cdot 10^8$

THERMAL NEUTRON INTERACTION IN CZT

Schematization of the sub-regions considered in the CZT detector

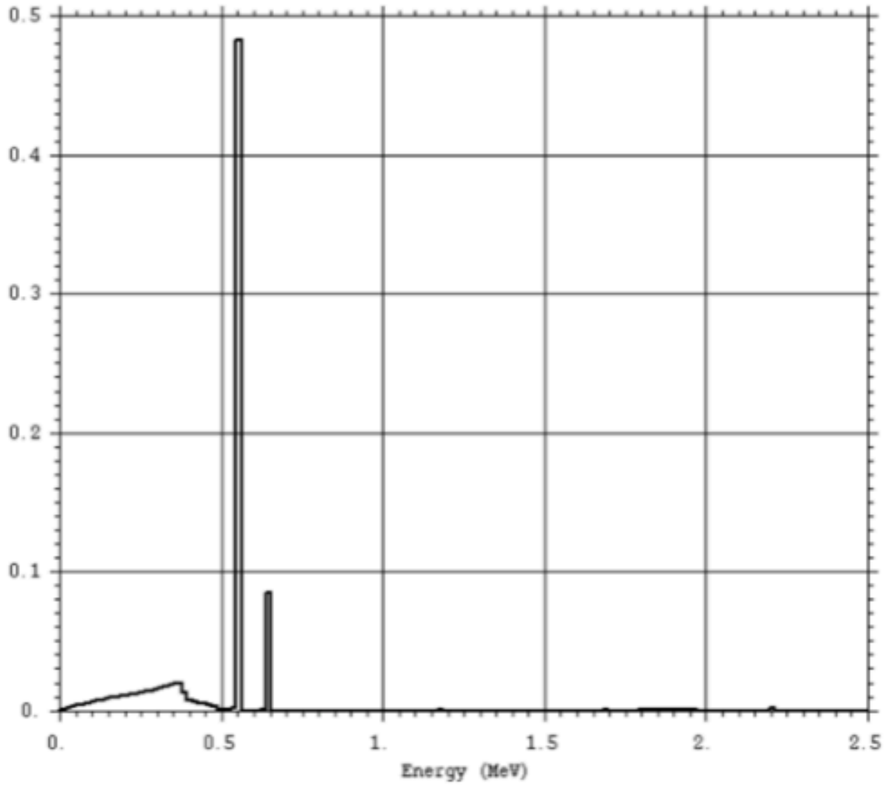


Neutron flux spectra after having crossed different thicknesses of CZT detector.

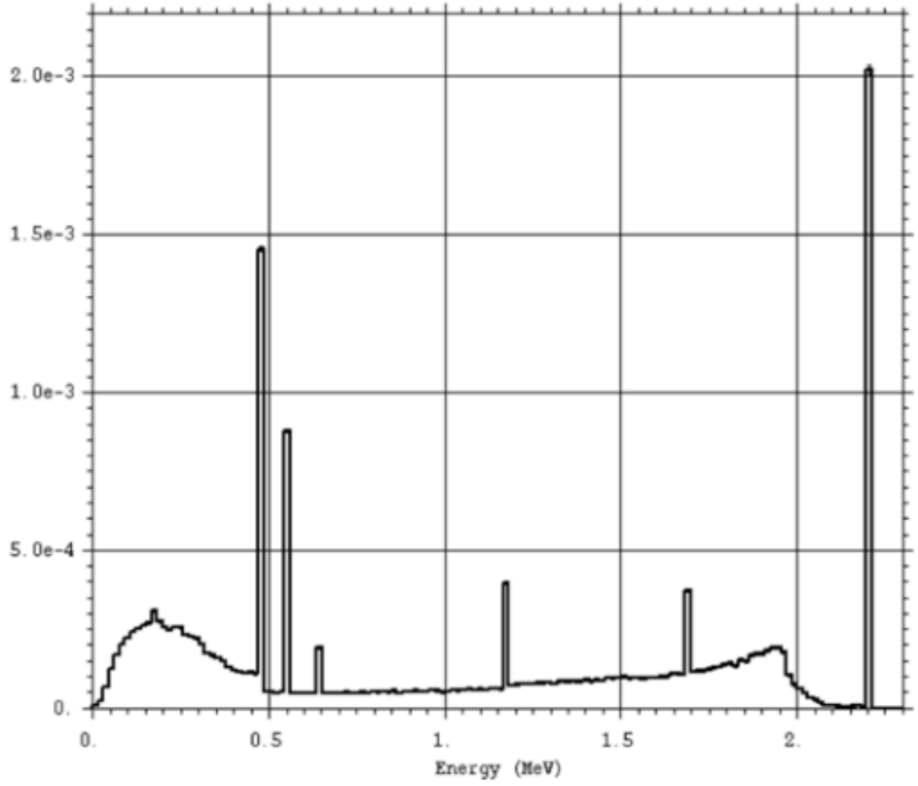


CZT Sub-Volume	Reaction Rate s^{-1}
I (1 mm thick external skin)	$2.45 \cdot 10^{7}$
II (first, 1 mm thick internal skin)	$1.30 \cdot 10^{6}$
III (second, 1 mm thick internal skin)	$5.67 \cdot 10^{5}$
IV (2 mm thick internal skin)	$5.97 \cdot 10^{5}$
V (10 mm side cubic core)	$2.97 \cdot 10^{5}$

SPECTRA RECORDED IN THE CZT DETECTOR

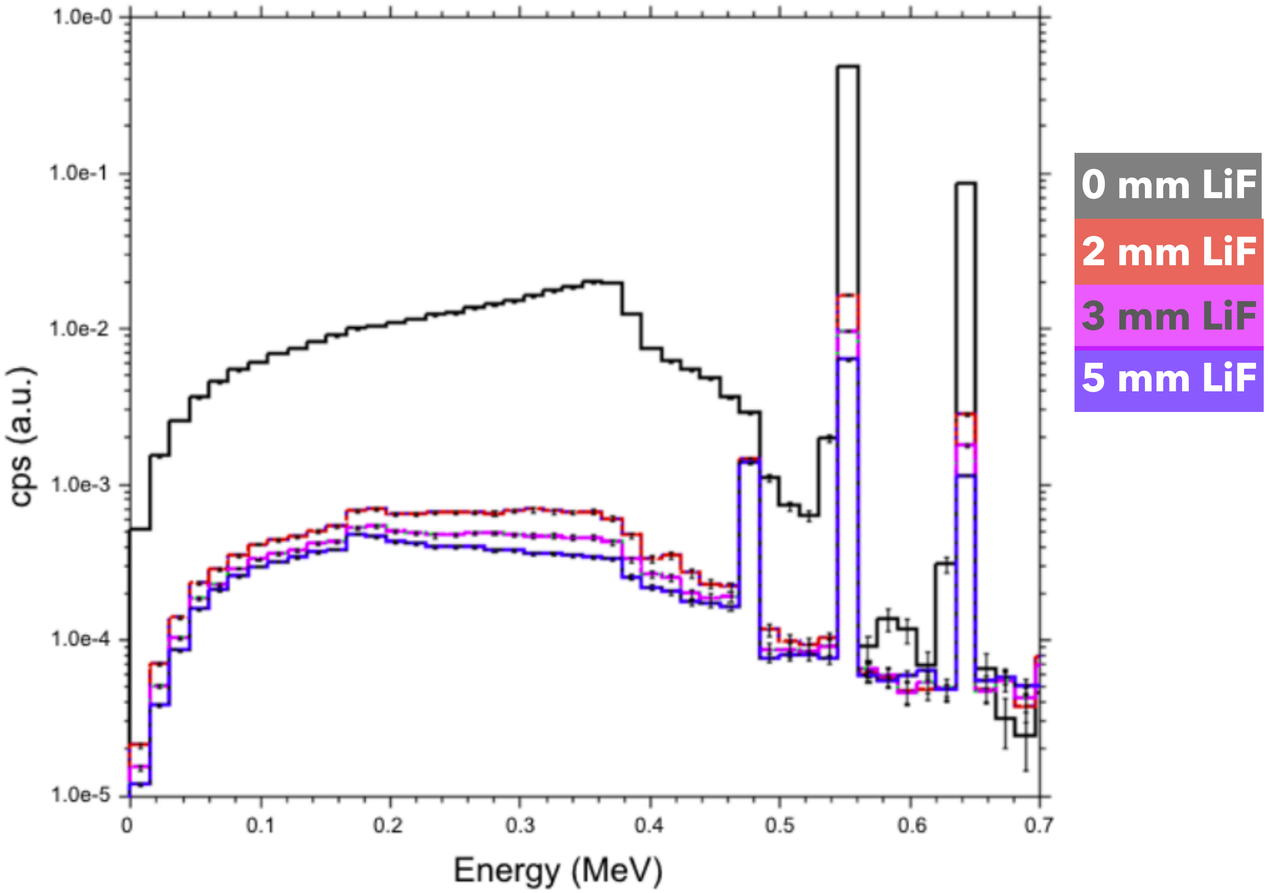


Photon spectrum recorded keeping the real emission probabilities for the ^{113}Cd capture γ rays.

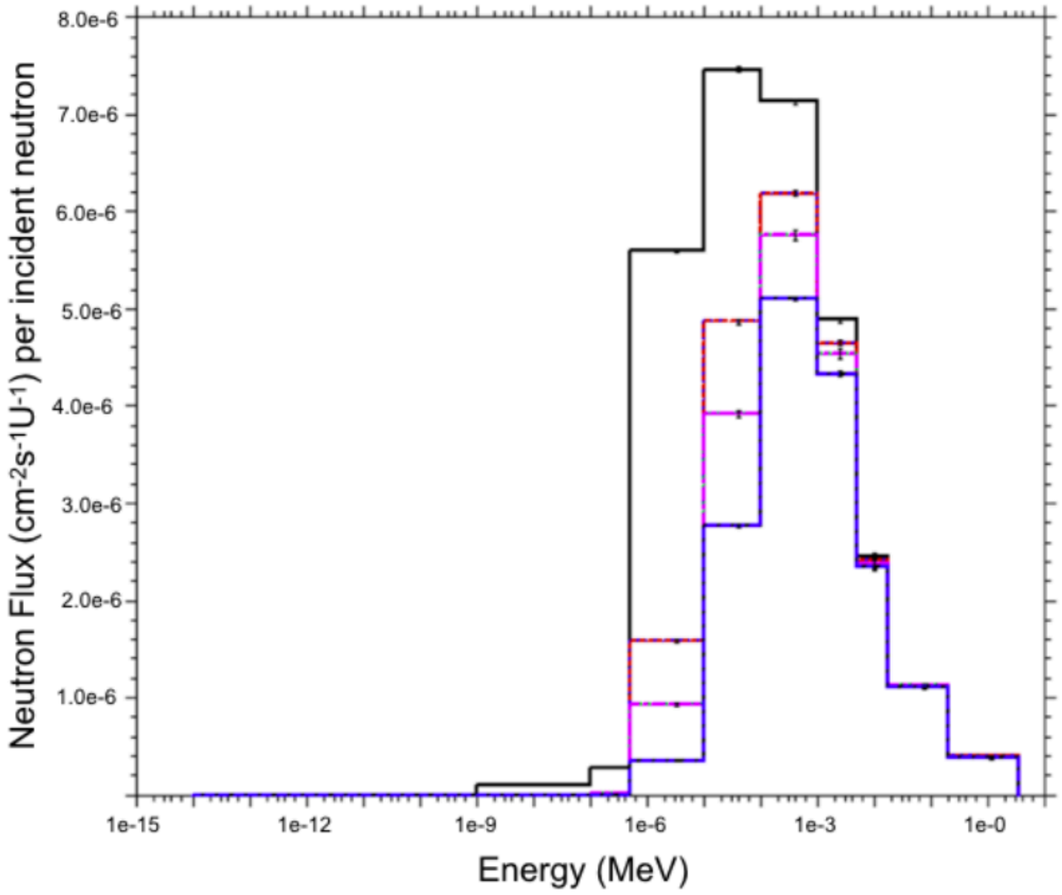


Photon spectrum recorded with a 50 ppm ^{10}B enriched shallow tumour. The emission probabilities for the main γ rays from ^{113}Cd capture were reduced by a factor 10^{-4}

PRELIMINARY ^{6}Li–ENRICHED LiF SHIELDING



0 mm LiF
2 mm LiF
3 mm LiF
5 mm LiF



Gamma spectra

Neutron flux spectra

CONCLUSIONS AND FUTURE STEPS

Background flux is circa 10^6 cm^{-2} s^{-1} both for thermal n and gammas

The BNCT-SPECT system requires a careful shielding from n and gamma

Study the neutron shielding for the detector

Study the gamma shielding for the detector

Build the shielding

Analyze new spectra

THANK YOU!