Young Researchers &
Young Engineers Days

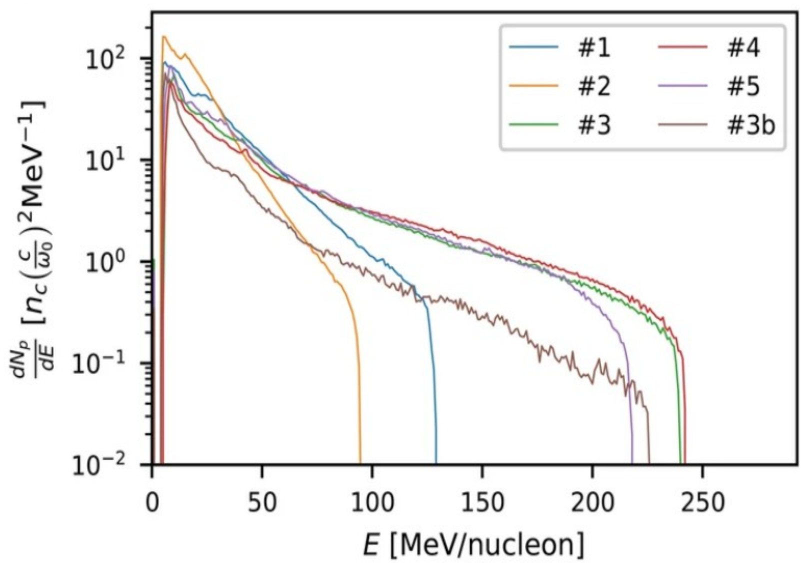
Neutron detection in high intensity laser environment

Vincent Lelasseux

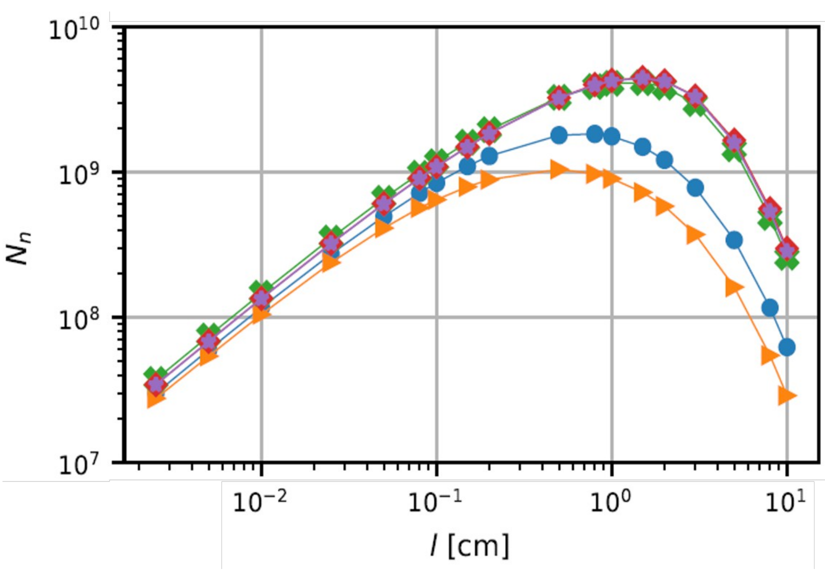
30/01/2024

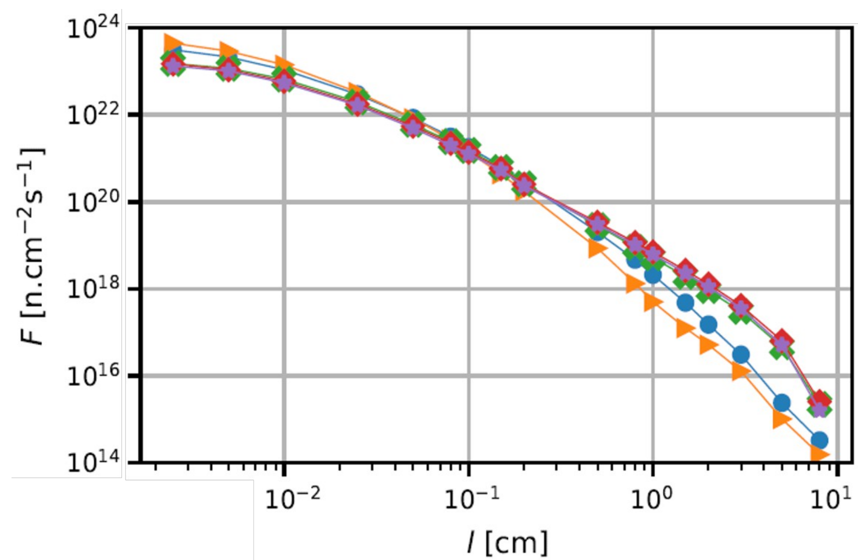
Introduction :

European Spallation Source (Lund) : 2.10^{17} neutrons.cm^{-2}.s^{-1}



+ Lead converter





V. Horny et al, *Scientific Reports* (2022)

I Challenges of high intensity laser environment :

1 min repetition rate

→ active diagnostic (~~bubble detectors~~, ~~image plates~~)

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Strong EMP

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Strong EMP

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X-ray/gamma flash

→ ability to discriminate contribution (~~long decay times~~)

ZnS:Ag

$LaBr_3$

I Challenges of high intensity laser environment :

Gamma/neutron separation

→ use of nuclear reaction

Neutron capture reaction with positive Q value

→ need neutron thermalisation

→ loss of energy information

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Neutron capture reaction with positive Q value
→ need neutron thermalisation
→ loss of energy information

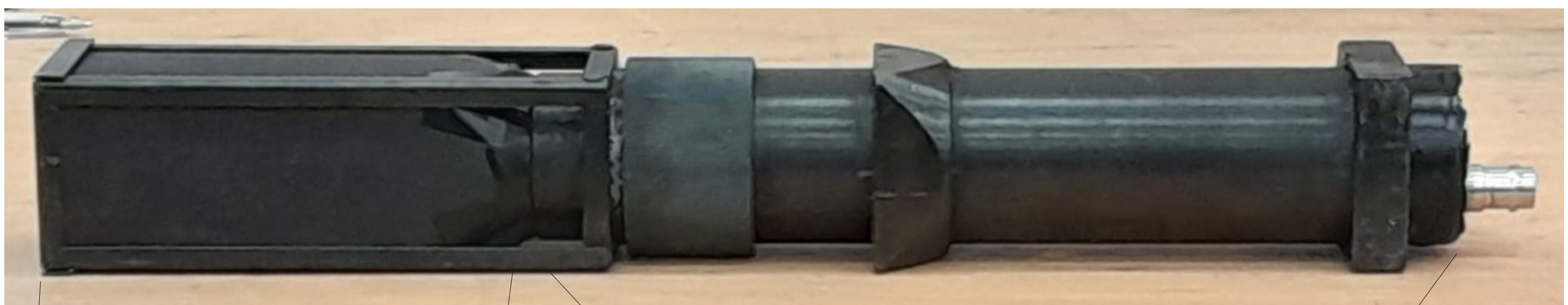
Activation based detection
→ only a few energy steps
→ limitation on the repetition rate

I Challenges of high intensity laser environment :

Gamma/neutron separation
→ time of flight

Chosen solution : fast plastic scintillator associated to PMTs

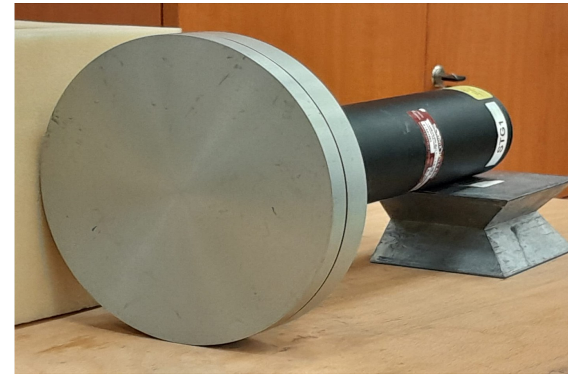
II Architecture of the detection setup :



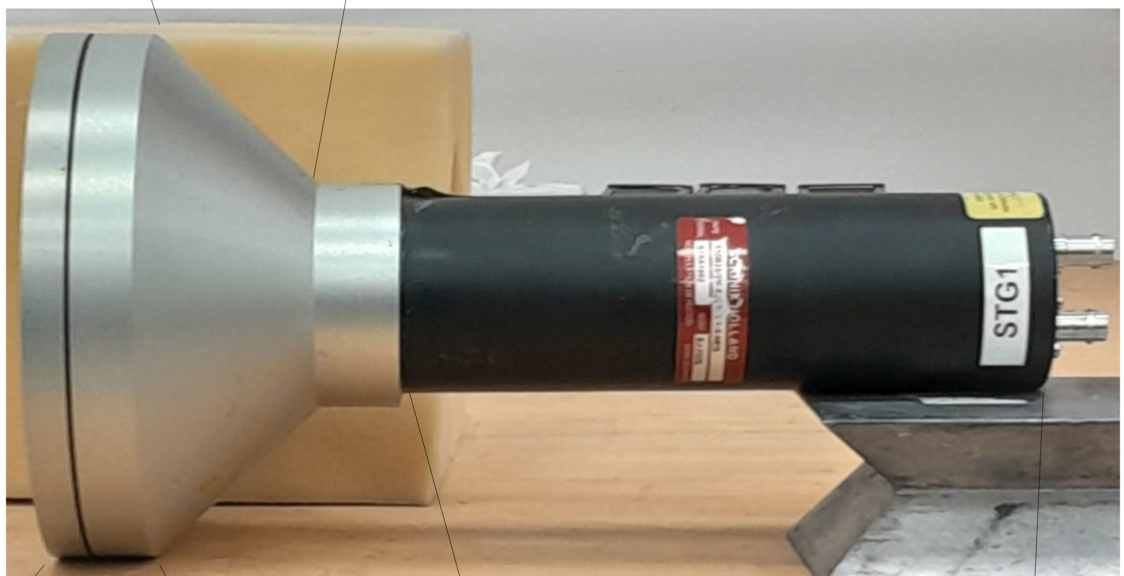
Fast plastic scintillator
BC400
Pulse FWHM : 2.7 ns
12 cm depth
4x4 cm front

PhotoMultiplier Tube
Philips XP2972
Transit spread FWHM : 3.5 ns

II Architecture of the detection setup :



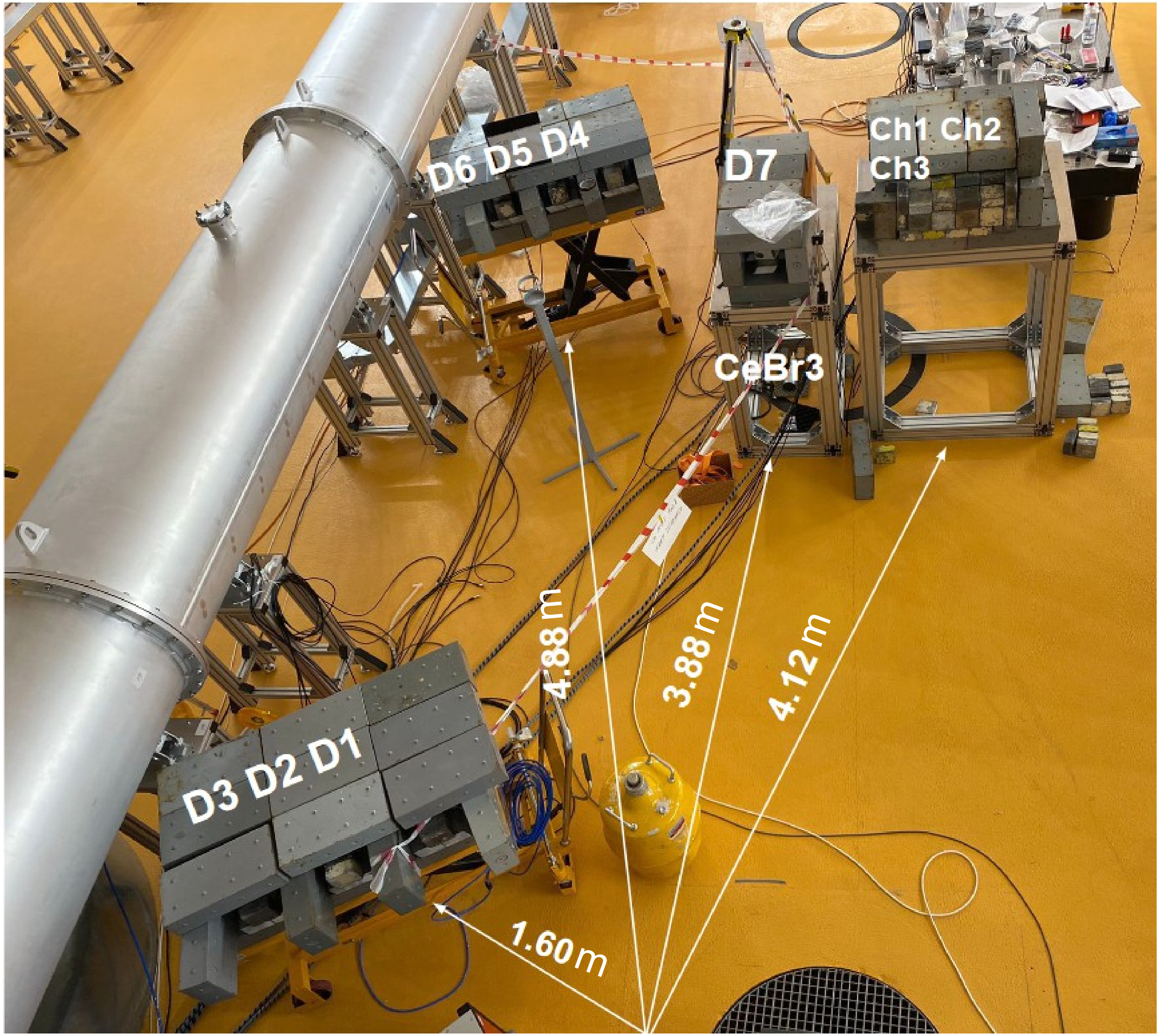
Optical cone guide

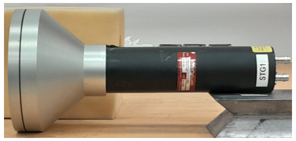


Fast plastic scintillator
EJ232Q
Pulse FWHM : 360 ps
2.7 cm depth
15.8 cm diameter

PhotoMultiplier Tube
Hamamatsu R3377
Transit spread FWHM : 370 ps

III E1 commissioning : 05/2023



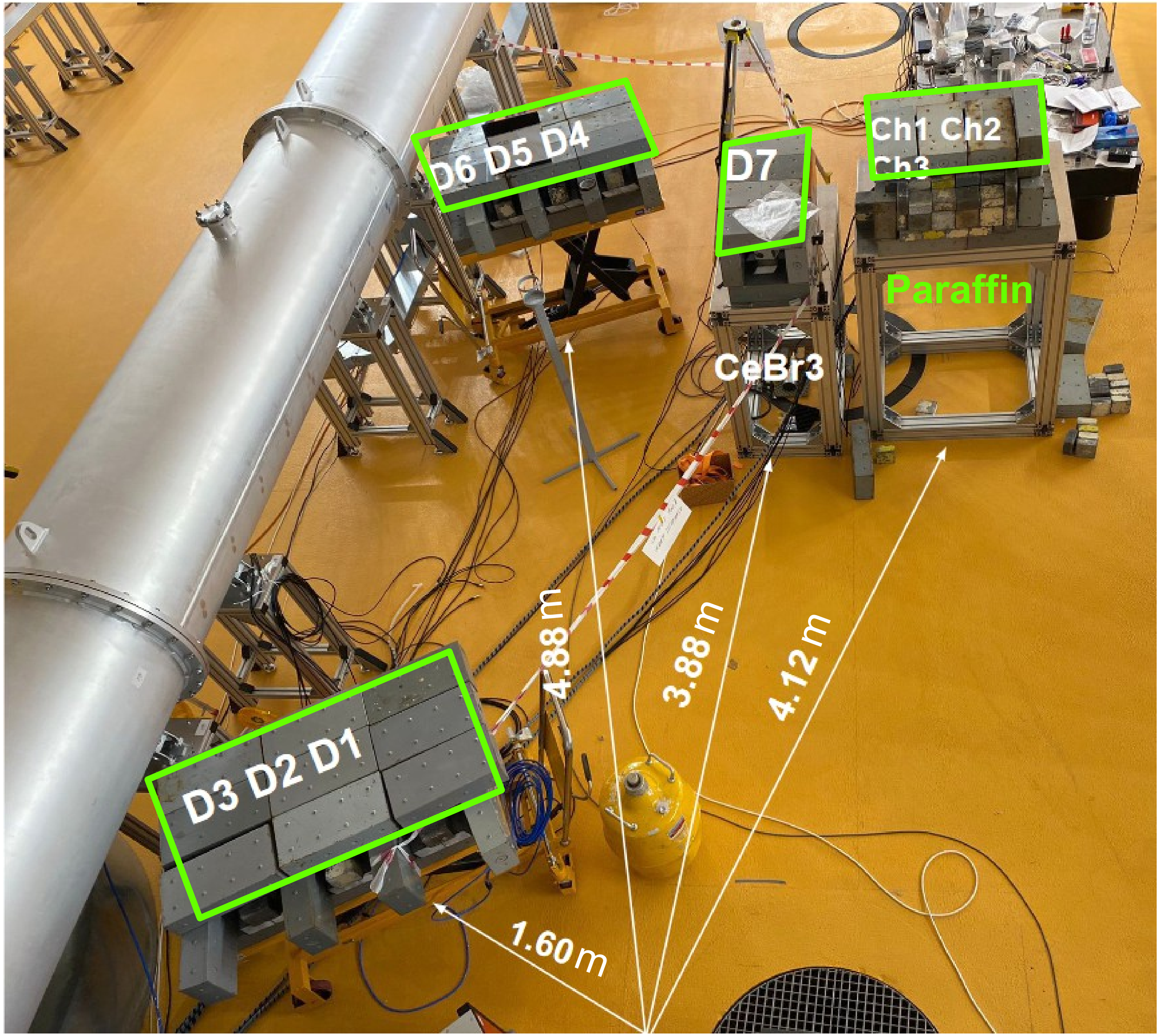
Ch

x2

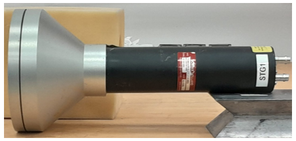
D

x7

Experimental chamber

III E1 commissioning : 05/2023



Ch  x2

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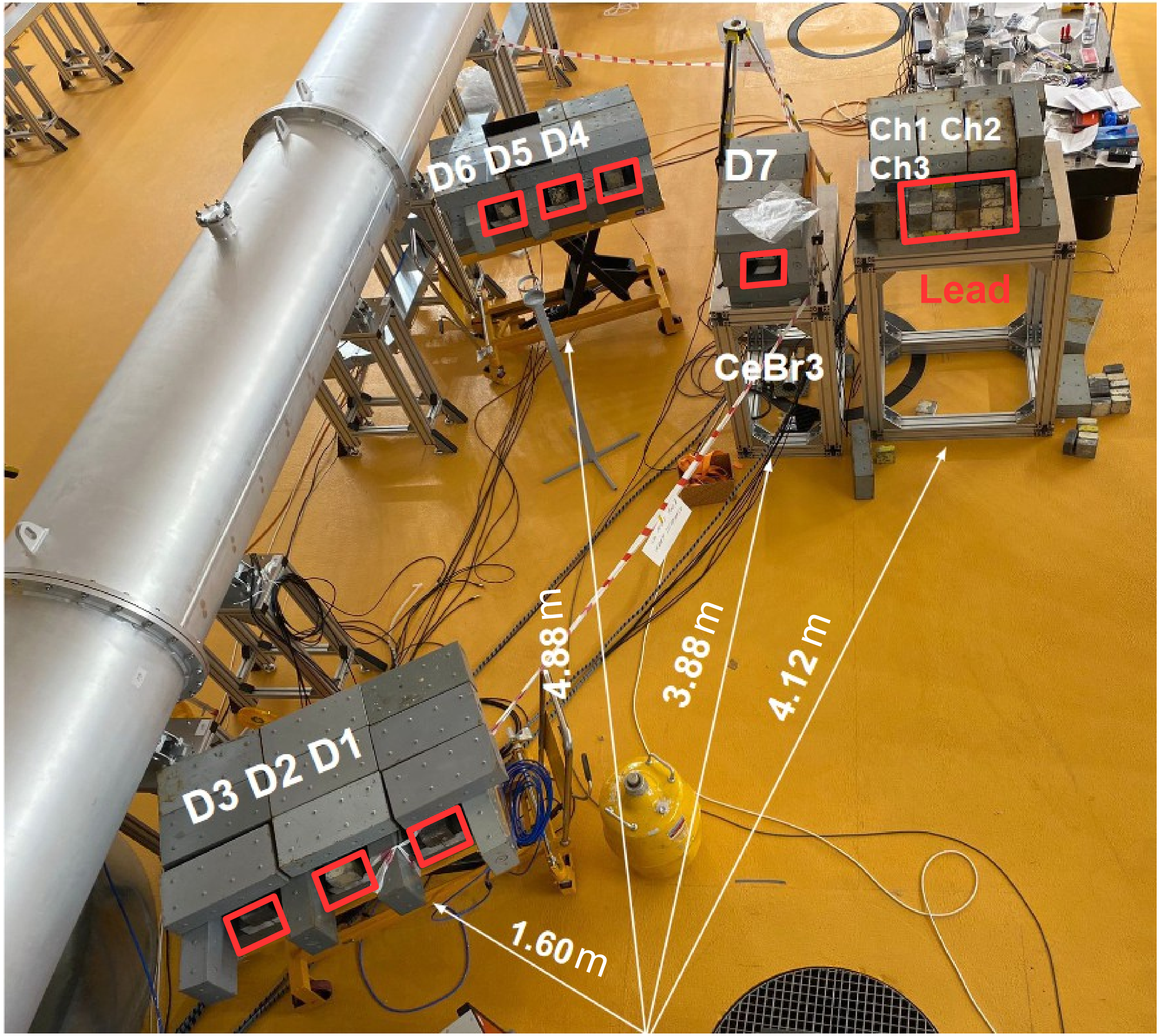

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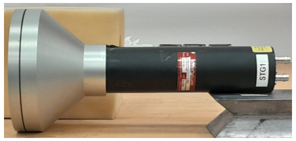
Ch  x2

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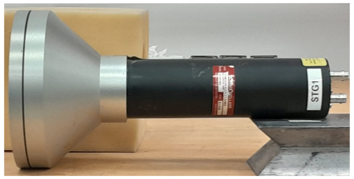
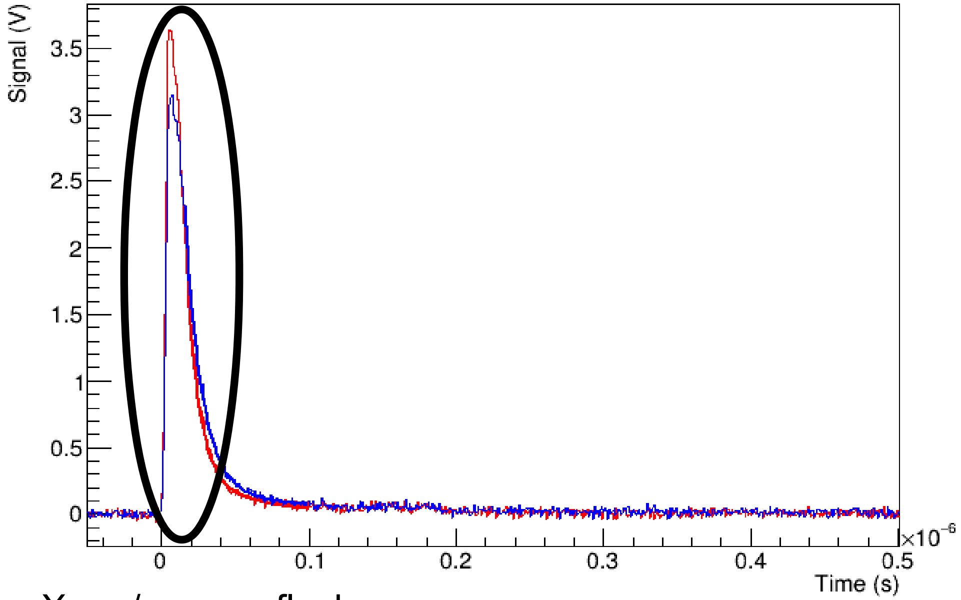
2x



Shot without neutrons

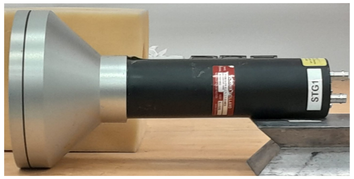


X-ray/gamma flash

III E1 commissioning :

05/2023

2x



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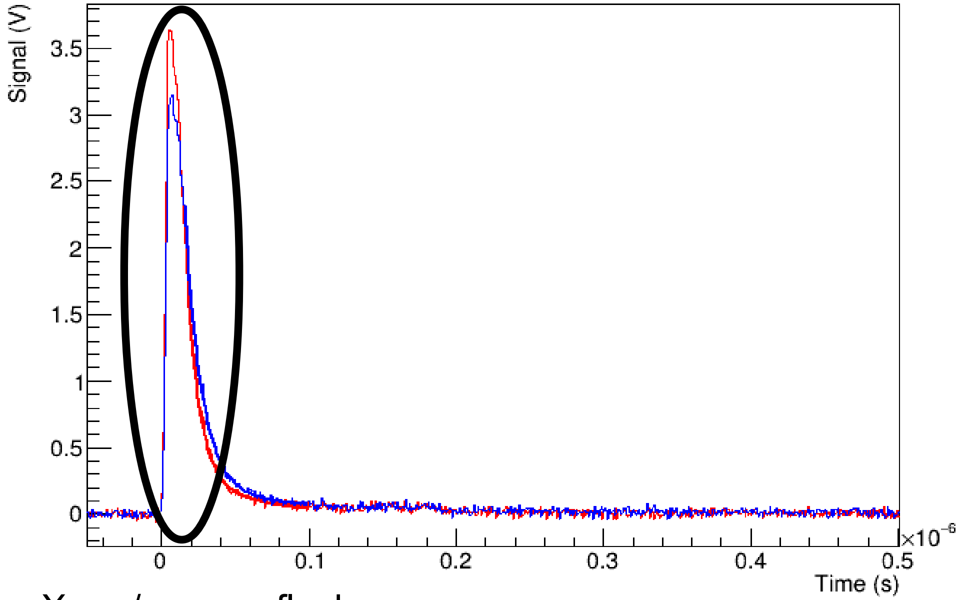

X-ray/gamma flash

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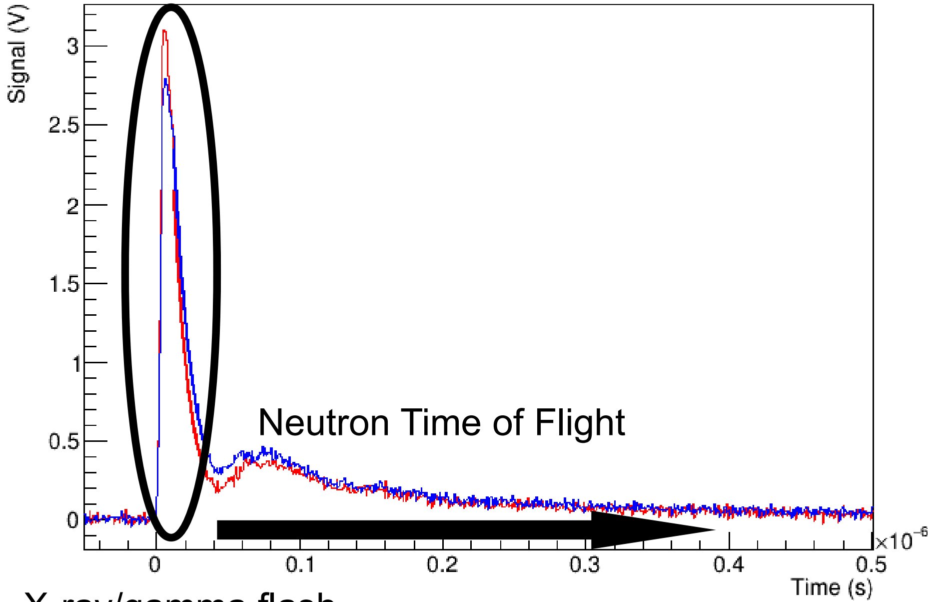

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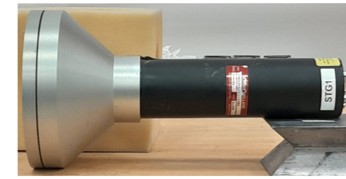
2x 

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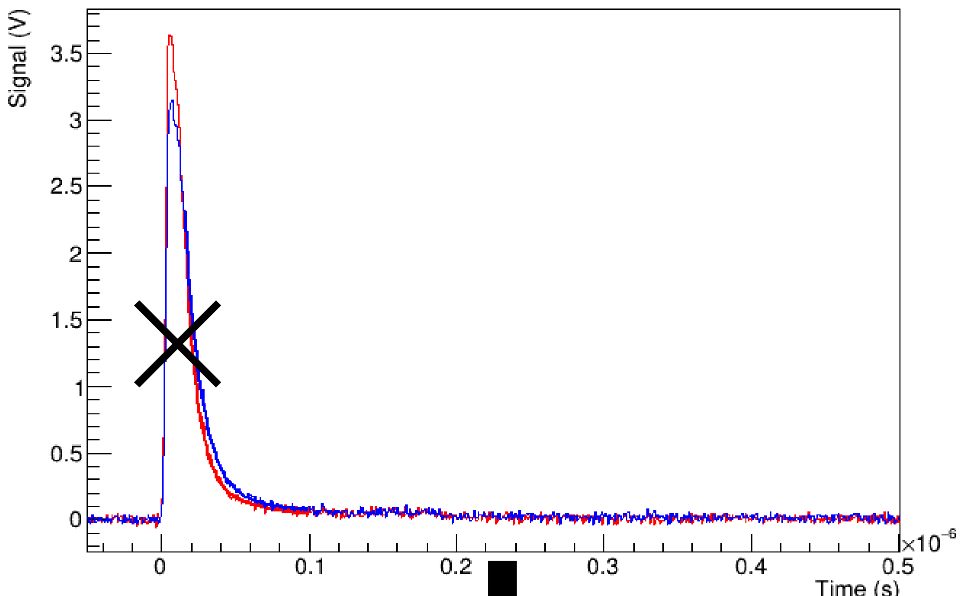

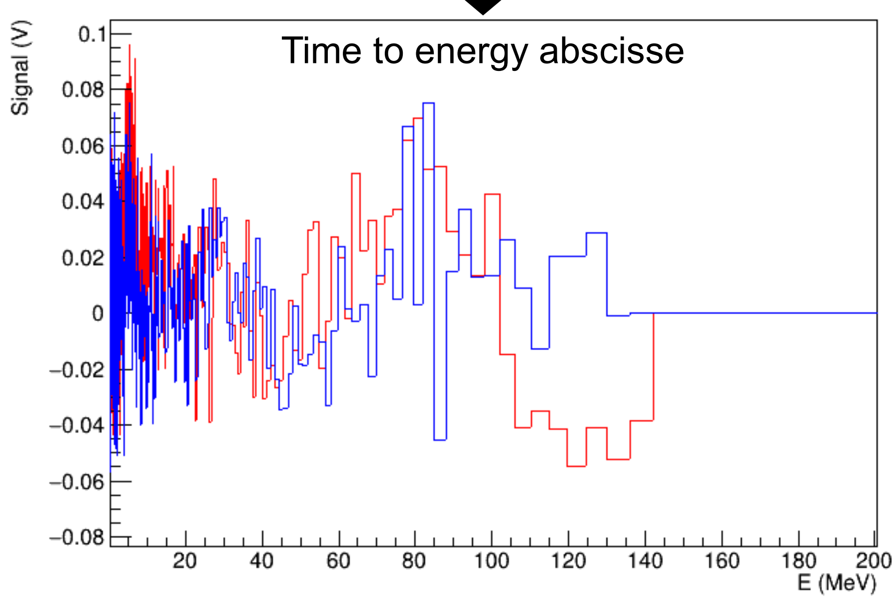

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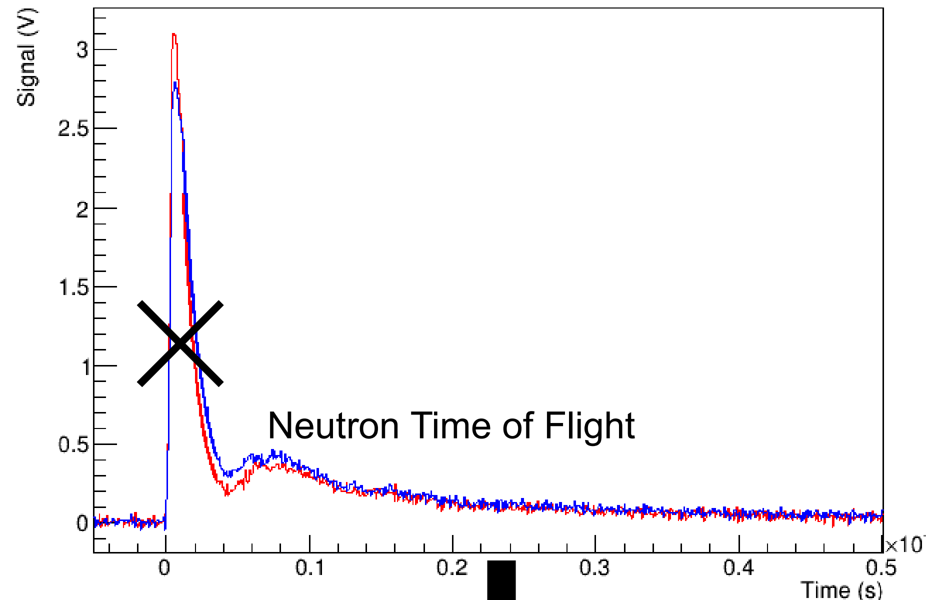

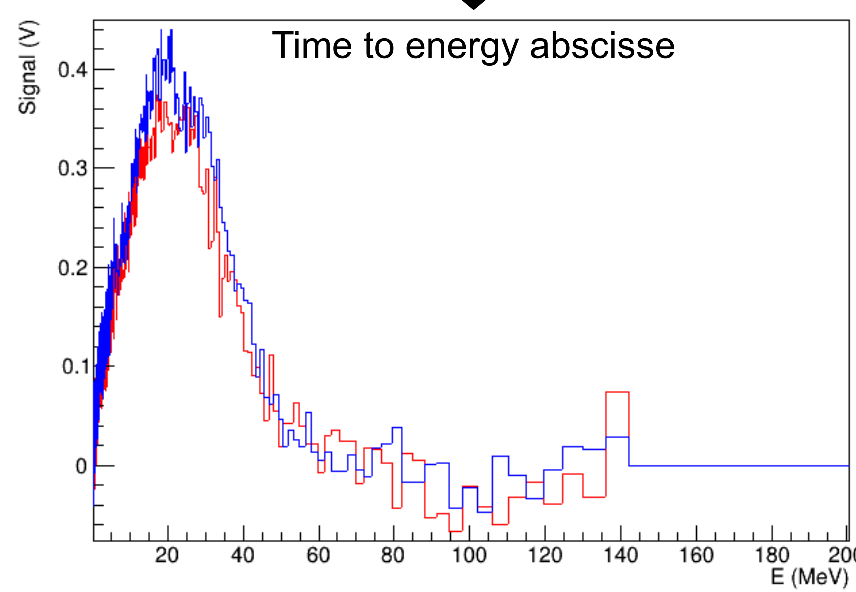

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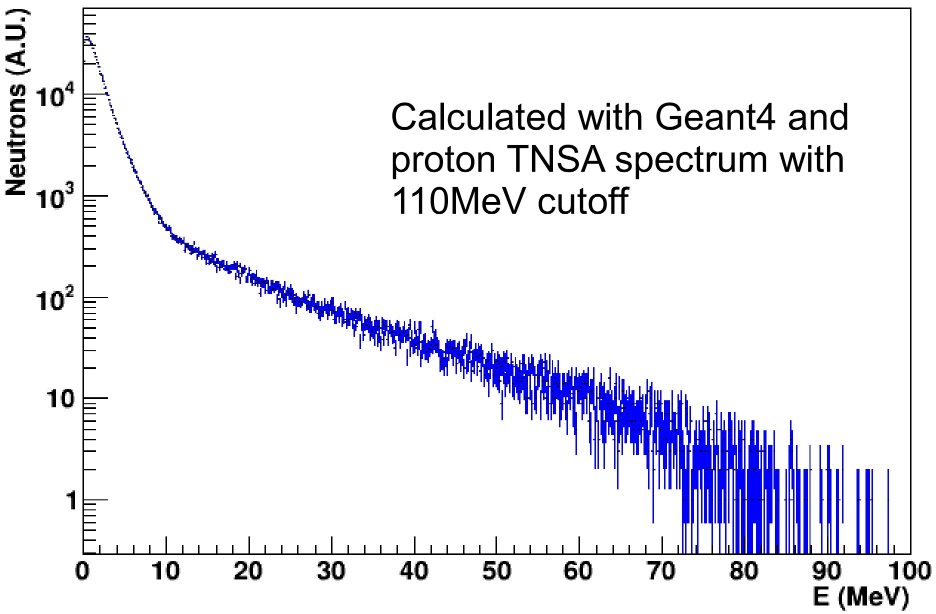

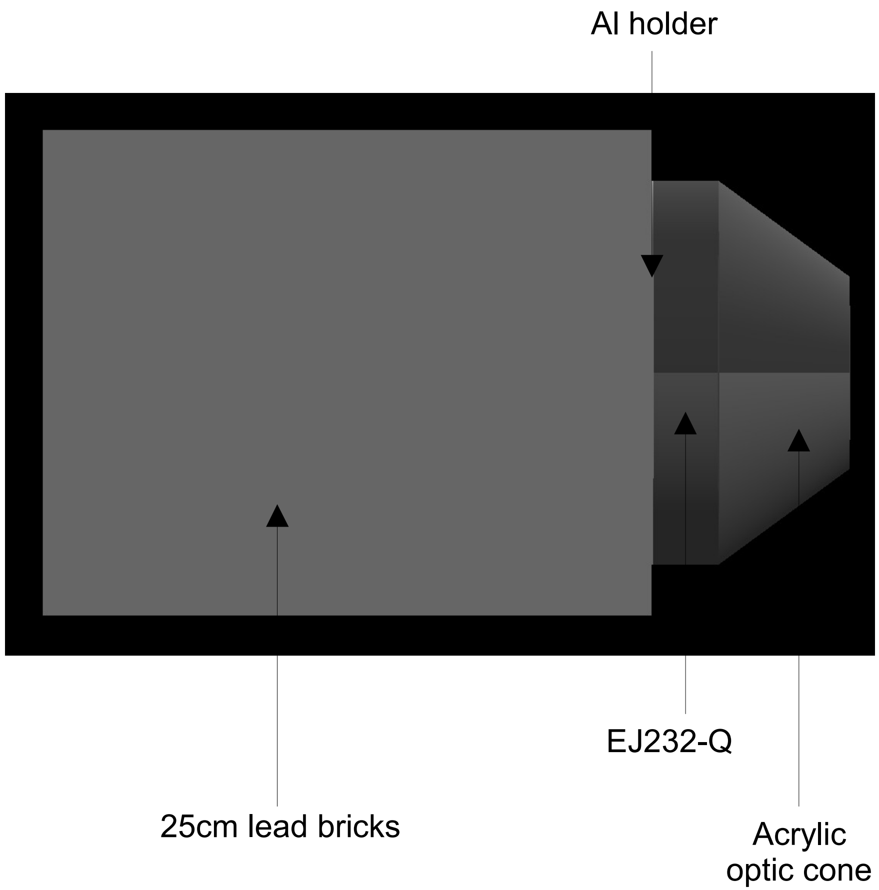

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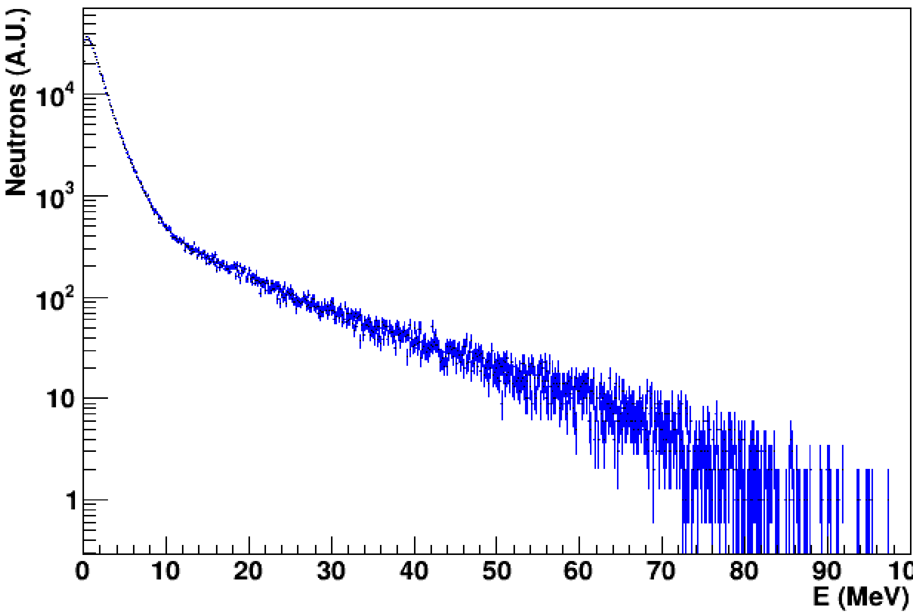
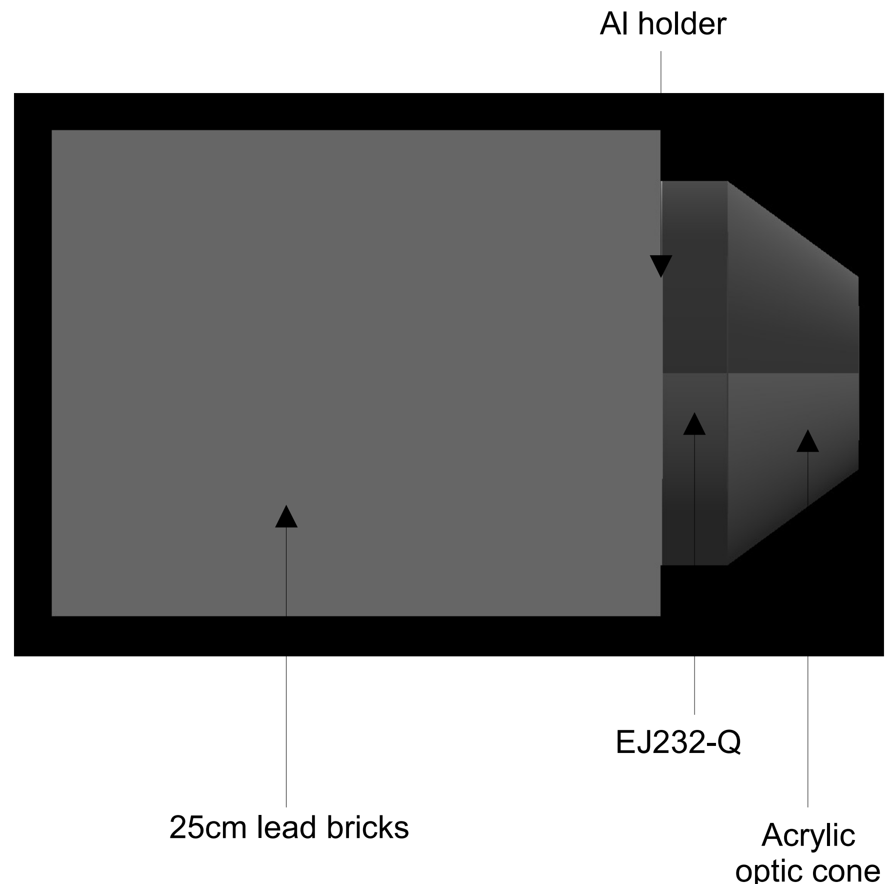
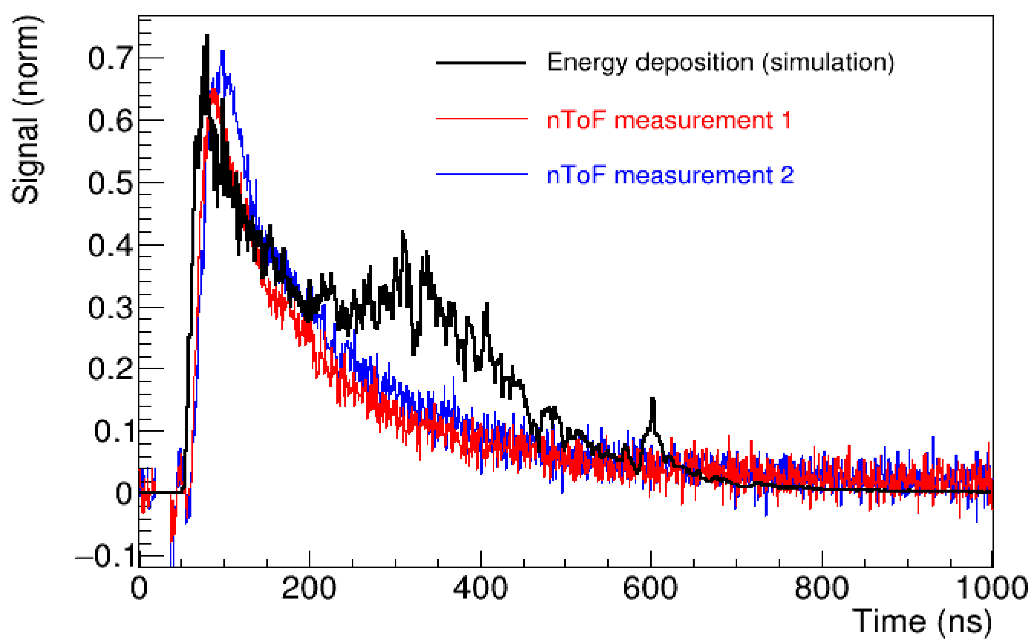




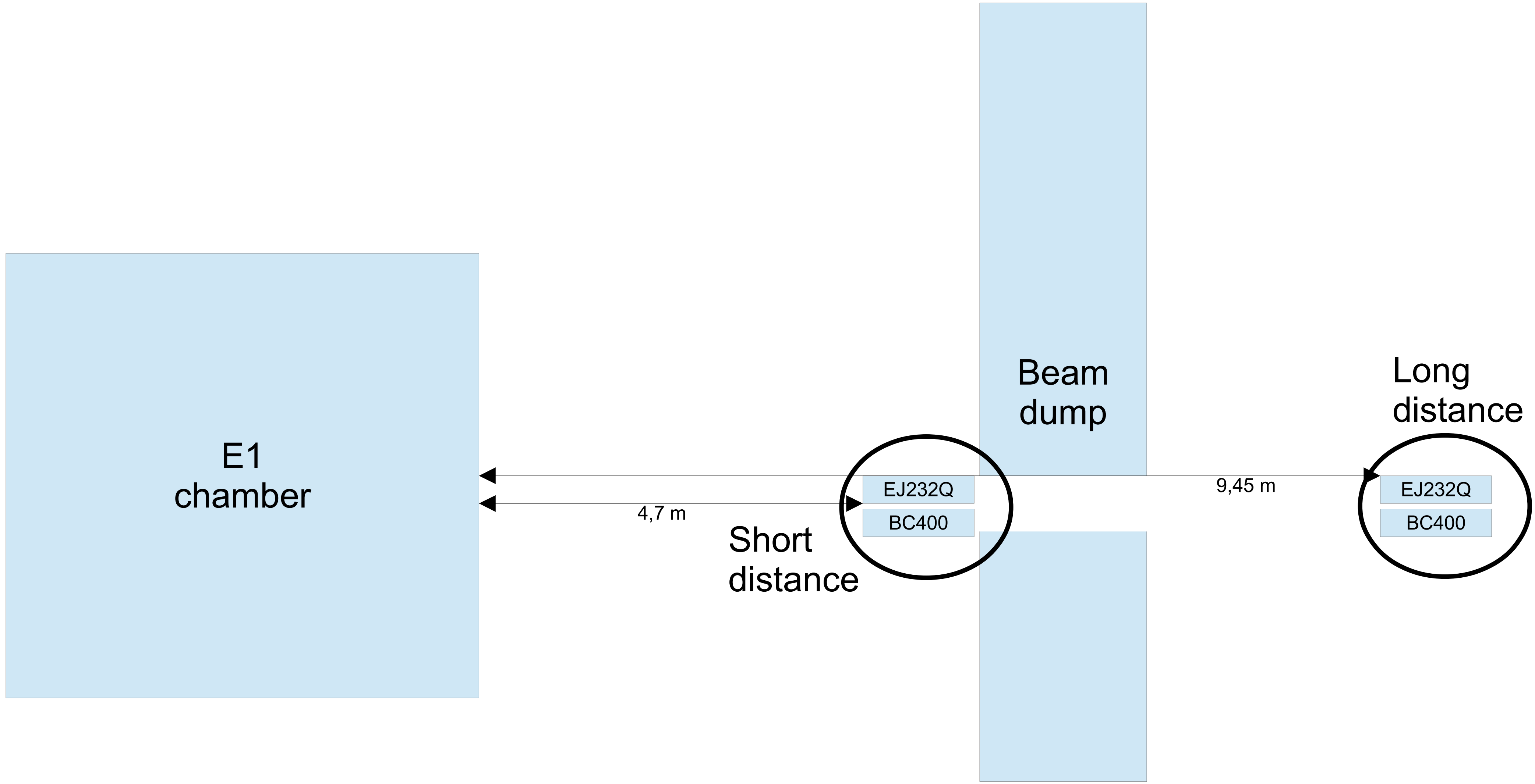
Comparison of temporal neutron contribution



- Overall shape agreement !!!

- Additional structures in simulations, to be further investigated

III E1 commissioning : 09/2023



III E1 commissioning : 09/2023

E
chamber

Beam
dump

Long
distance

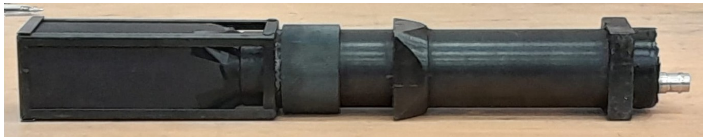
9,45 m

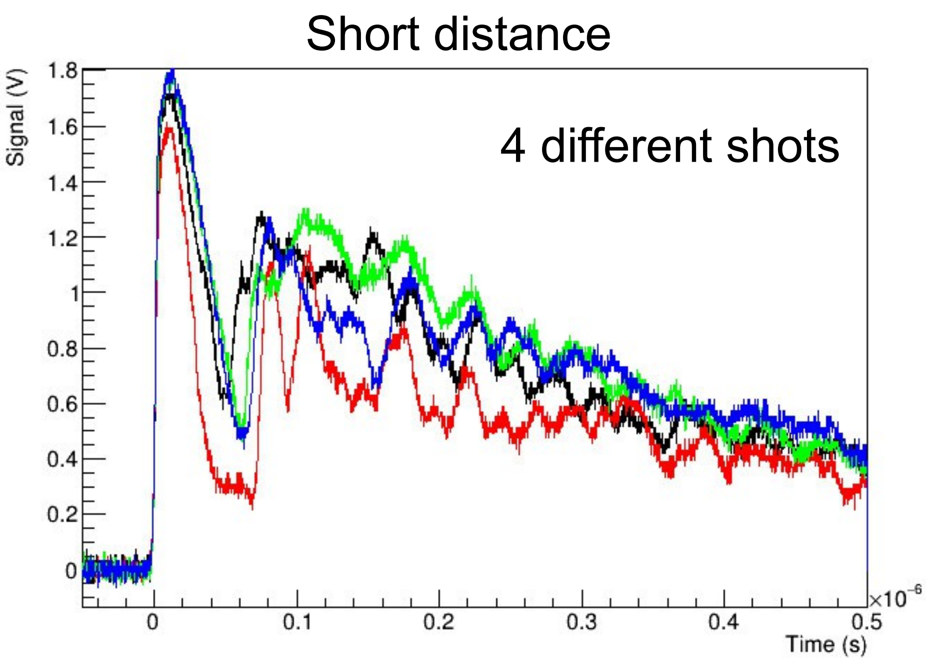
4,7 m

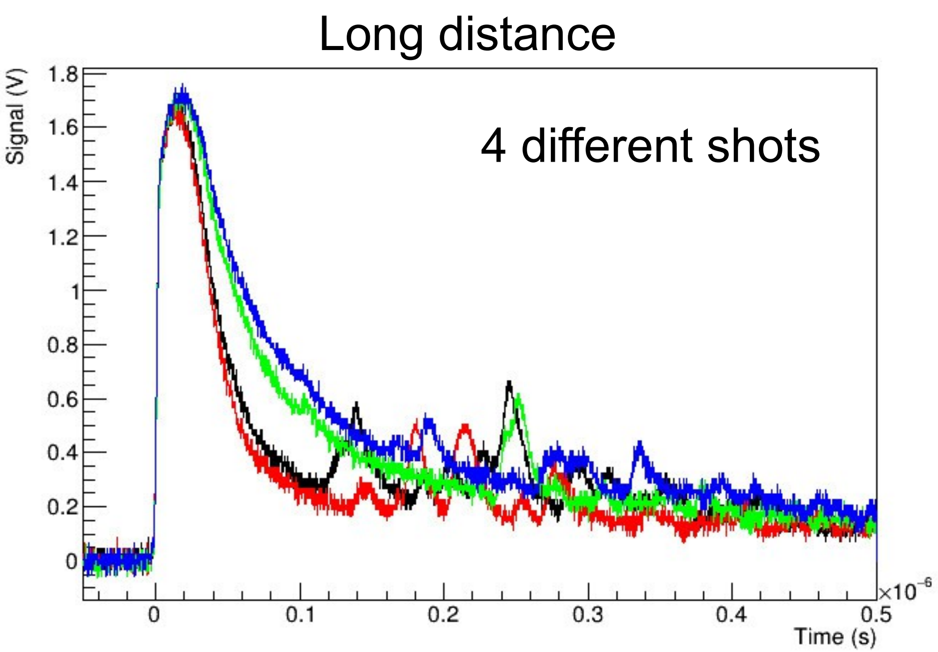
Short distance	Long distance
EJ232Q	EJ232Q
BC400	BC400

Short
distance

III E1 commissioning : 09/2023







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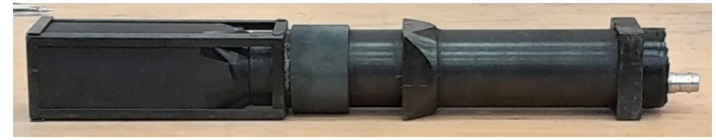
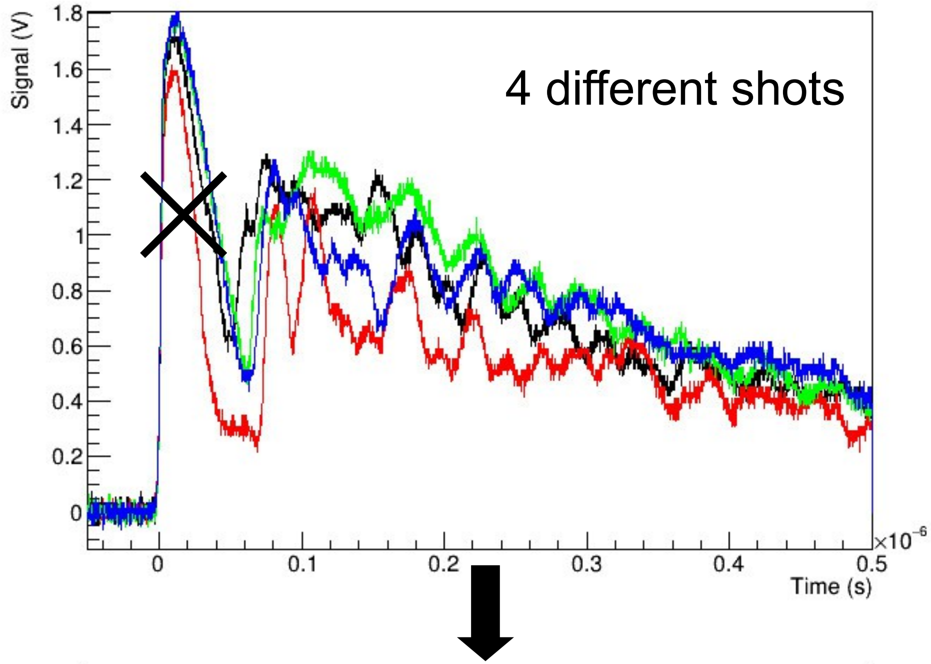
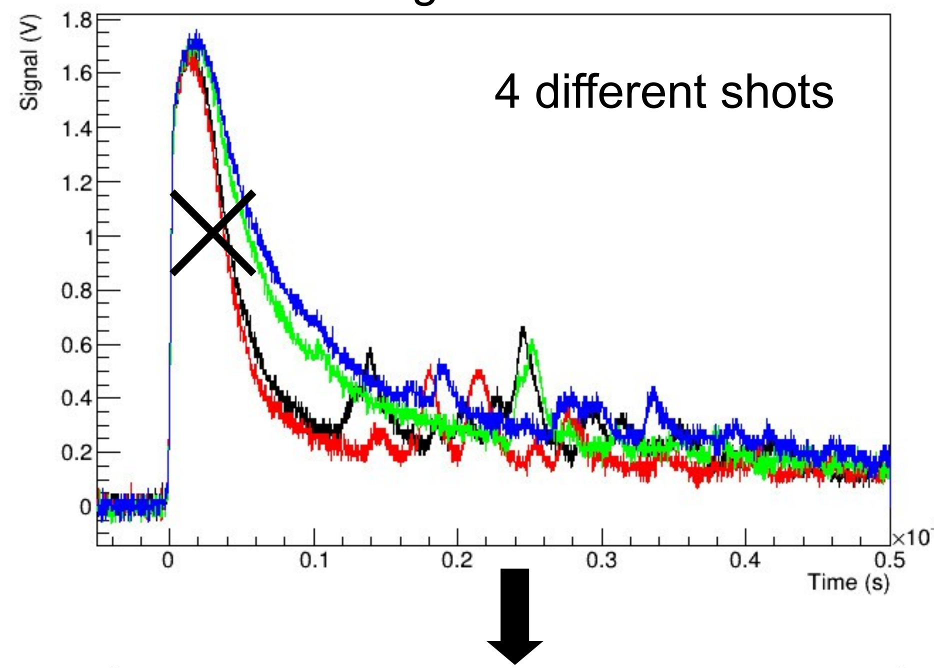
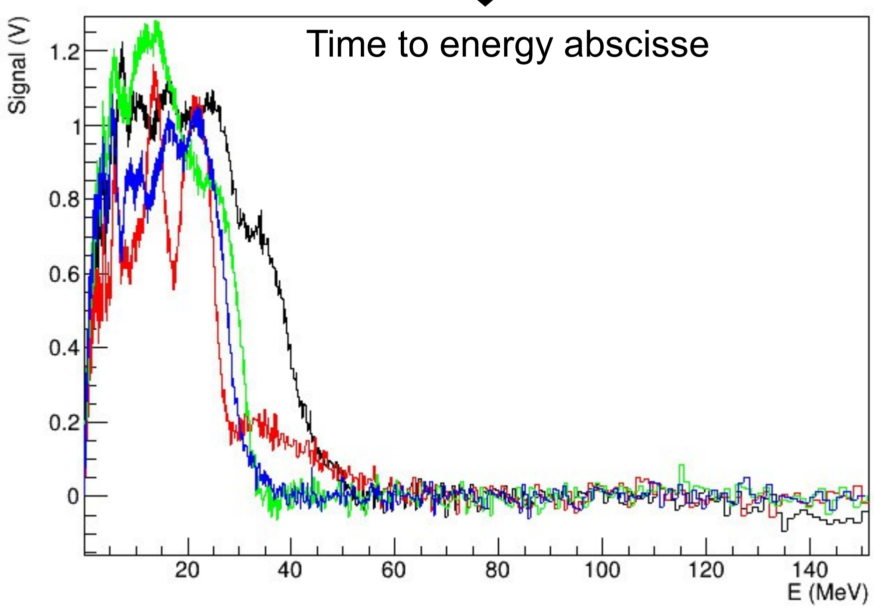


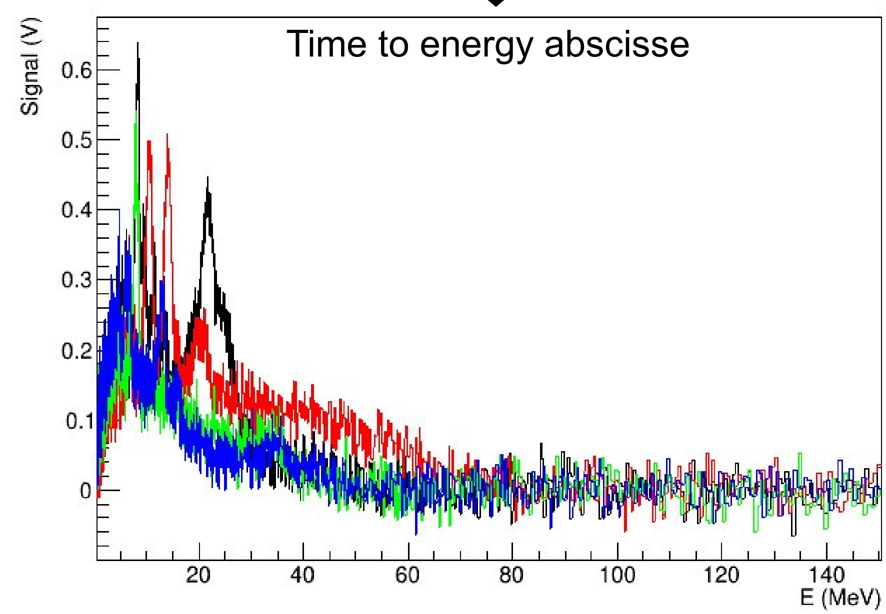
Short distance



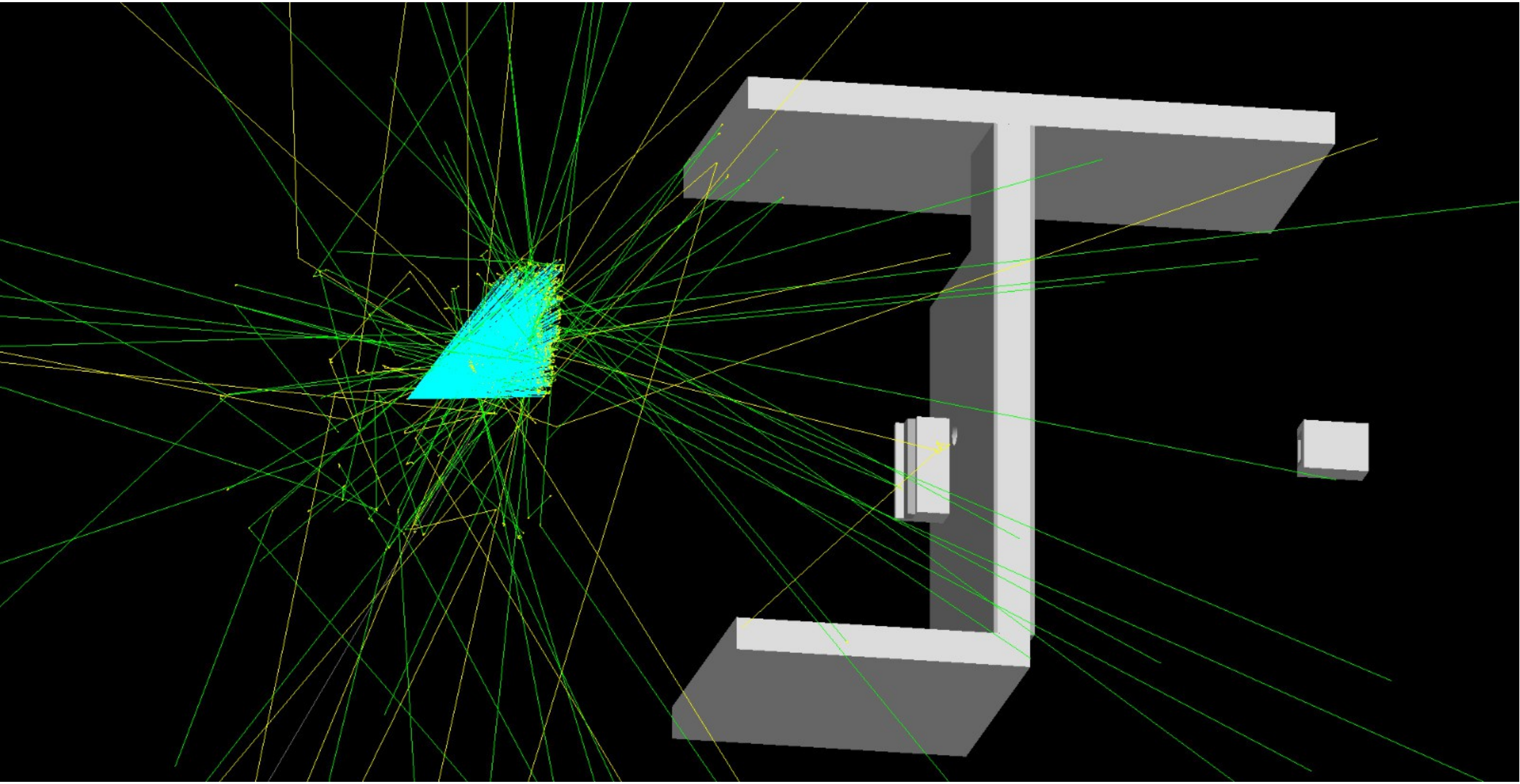
Long distance







<u>**III E1 commissioning :**</u>



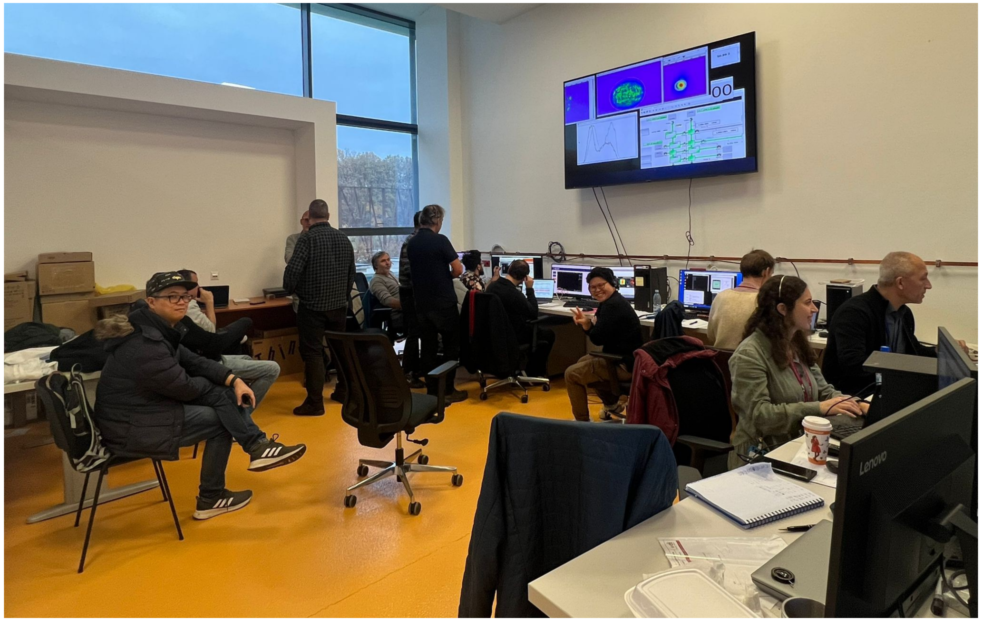
See you next year for the results !

IV Conclusion :

- Measurement of neutron Time of Flight signal
  During two E1 commissioning phases and one E6 commissioning phase

- Energy and efficiency calibration using PuBe source

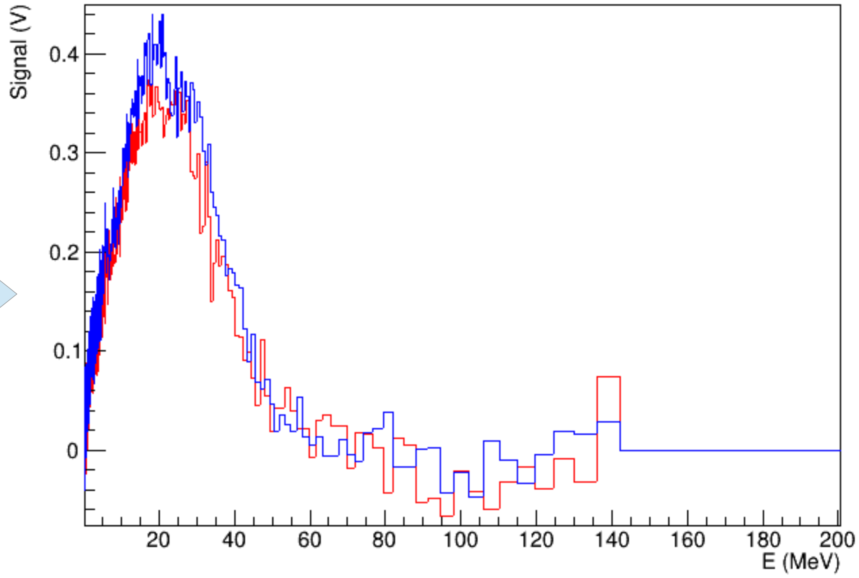
- Simple and Elaborate Geant4 simulations



Thanks to Mihai, Rebeca and Radu for the help setting up and all GDED
Domenico, Alexandru, Lucian and all LDED for the E1 commissioning
Petru, Maria, Flanish, Arujash, Septimiu, … for the E6 commissioning
Chloe and Satya from QUB for their help

Thanks a lot
for your attention !

UAU !



III Calibrations :