Laser Applications at Accelerators Conference, Mallorca 2015

Neutron Production From Nuclear Reactions Driven by TW Laser-Target Interactions

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26.03.2015

Outline

- Neutron production
- Experimental setup and results
- Simulations of the experimental conditions
- Conclusion and future work

Neutron Production

An intense flux of neutrons can be obtained by using laser systems:

- production of protons in laser-target interaction;

- interaction of the produced protons with a secondary target in order to produce neutrons;

- the neutron flux can be studied by using a proper neutron detection setup.

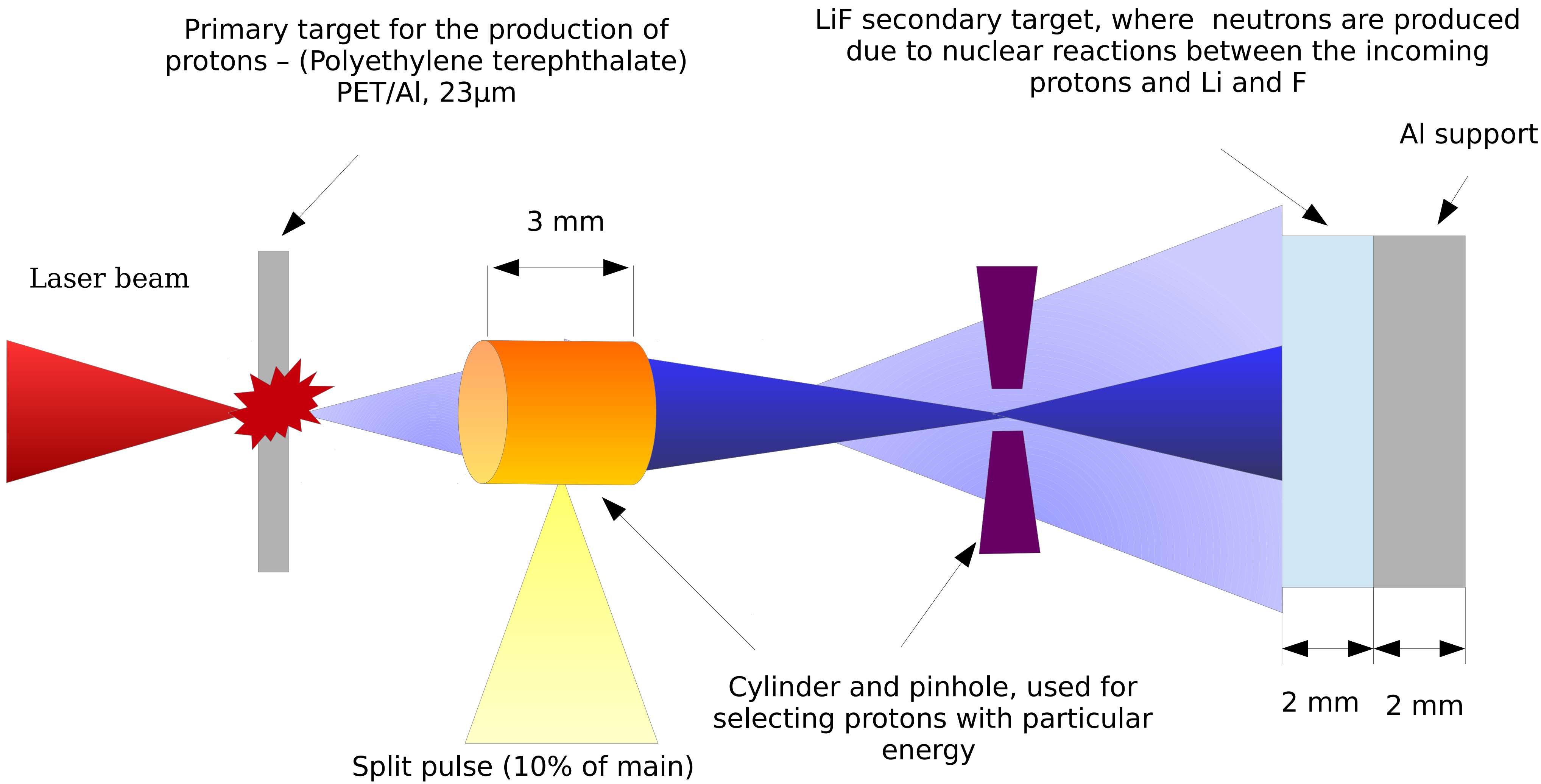
Neutron Production

The TITAN facility at Lawrence Livermore National Laboratory (LLNL), Livermore, California, USA was used for performing an experiment for neutron production:

- λ=1054 nm, CPA
- 0.4 - 10 ps laser pulse duration
- peak power up to 1 PW
- focus intensity 10^{19} – 10^{20} W/cm^2

Studying the properties of the produced neutrons was the main focus of the performed experiment.

Experimental setup

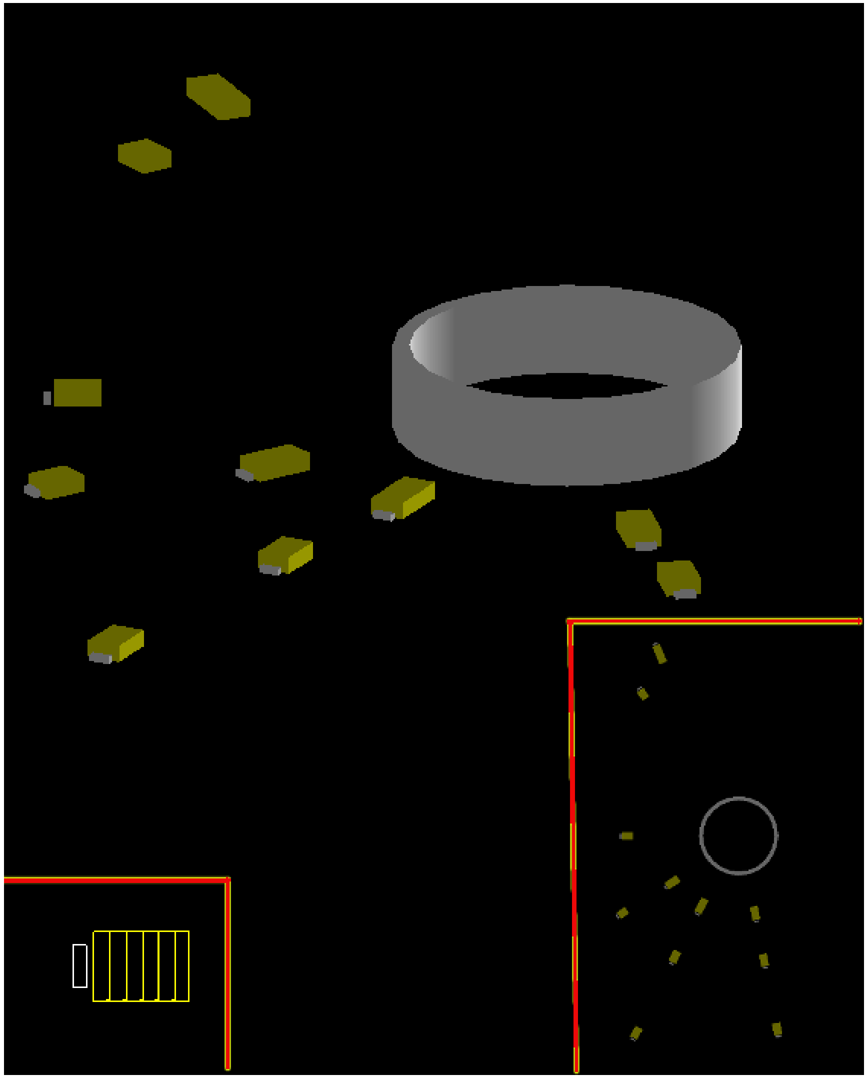


Experimental setup

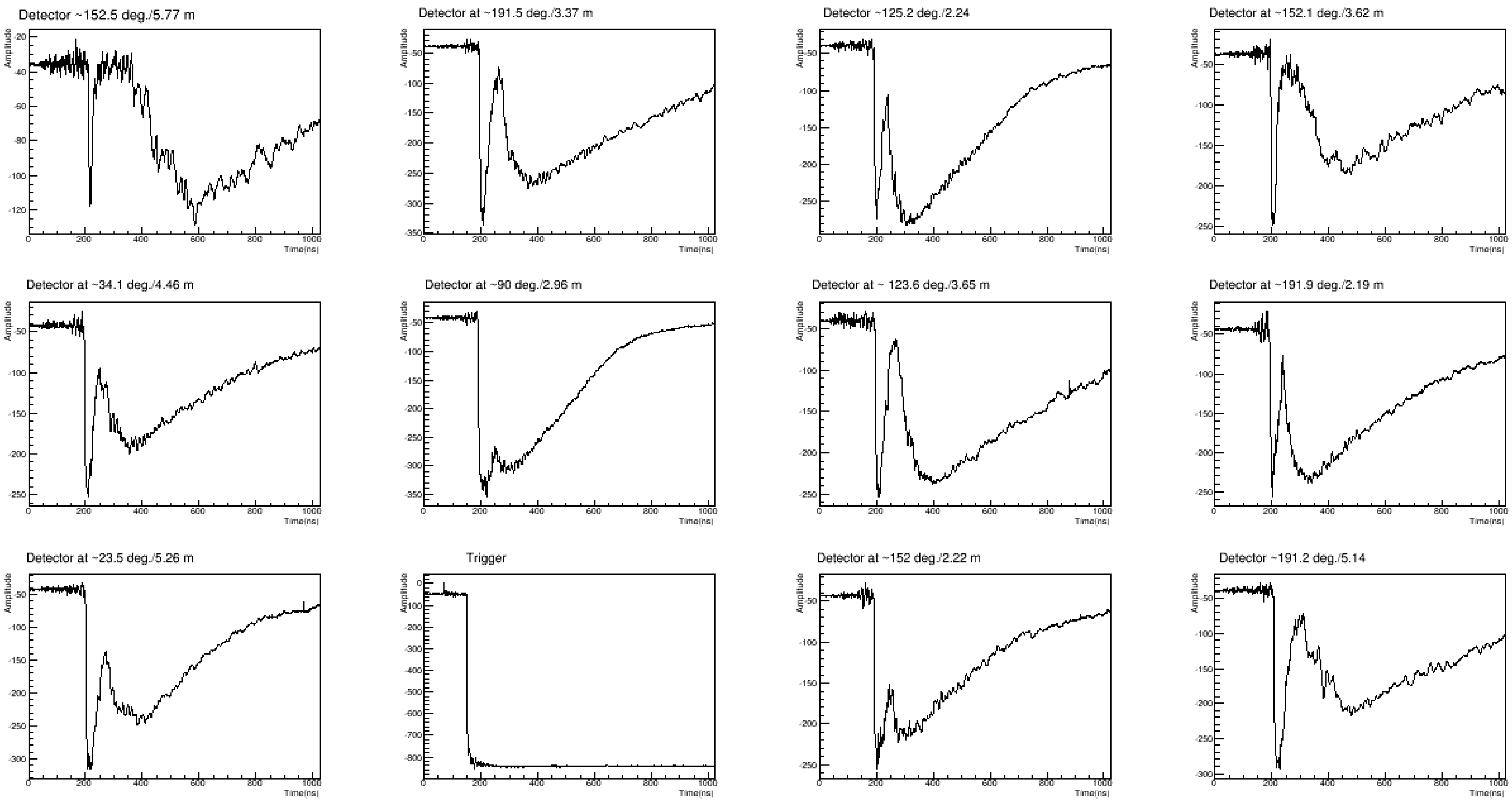
- 11 plastic scintillators BC400, coupled to PMT, were used.

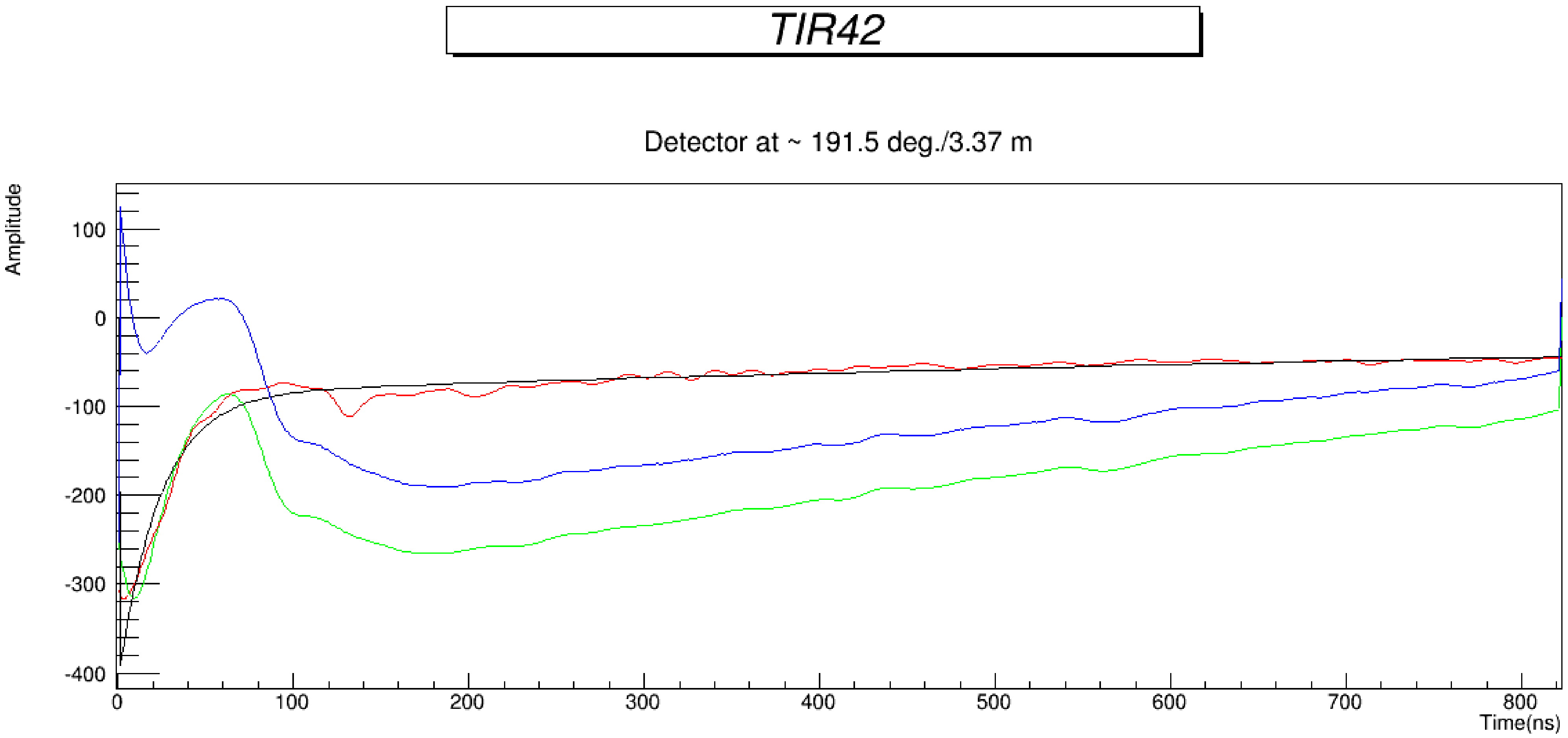
- The neutrons were detected and their Time-of-Flight was used in the data analysis.

More than 70 shots with different configurations of the proton selection part and the detector setup were made.

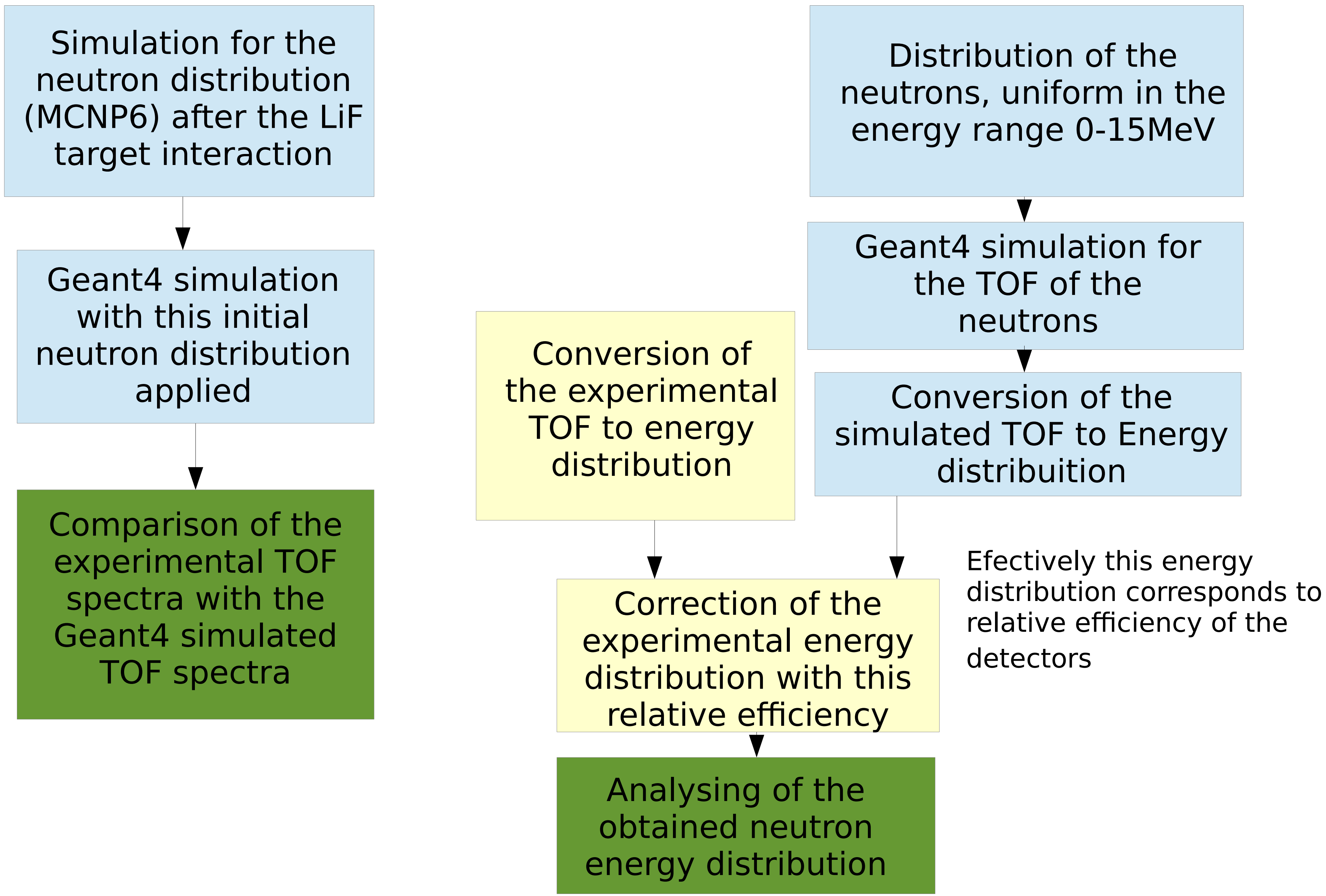


TIR42


Detector ~152.5 deg./5.77 m
Detector at ~191.5 deg./3.37 m
Detector ~125.2 deg./2.24
Detector at ~152.1 deg./3.62 m
Detector at ~34.1 deg./4.46 m
Detector at ~90 deg./2.96 m
Detector at ~ 123.6 deg./3.65 m
Detector at ~191.9 deg./2.19 m
Detector at ~23.5 deg./5.26 m
Trigger
Detector at ~152 deg./2.22 m
Detector ~191.2 deg./5.14
Amplitude
Time(ns)

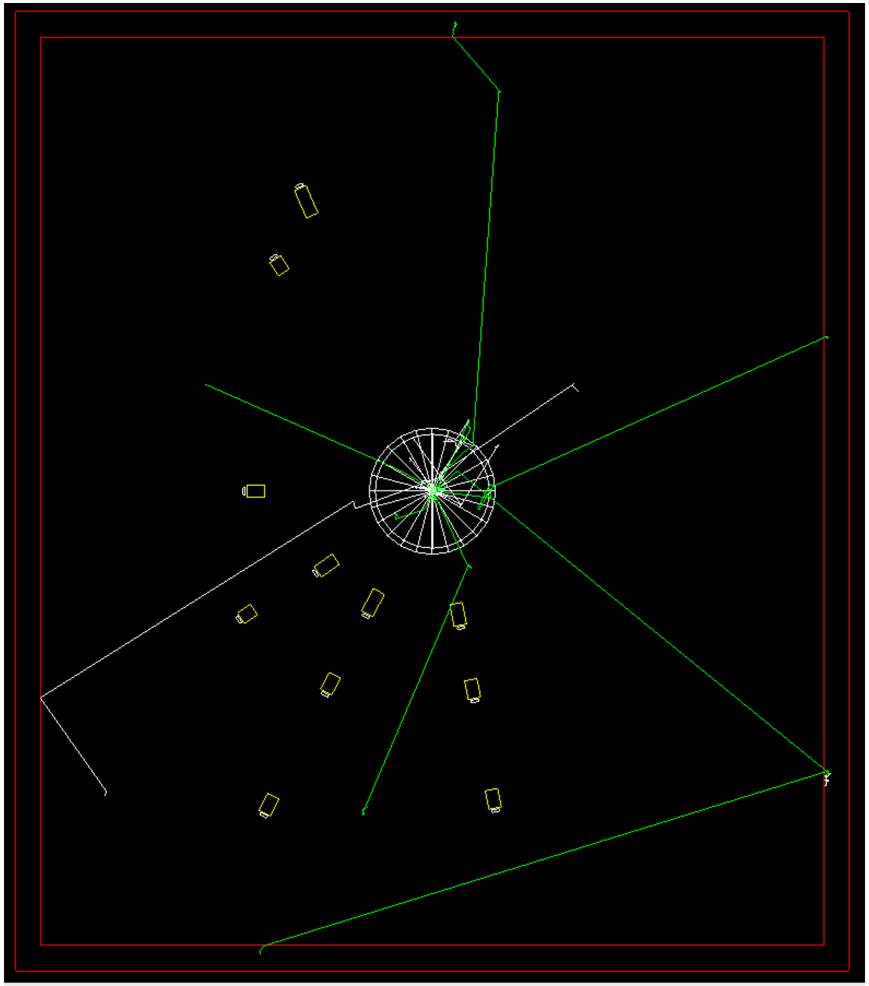

TIR42
Detector at ~ 191.5 deg./3.37 m
Amplitude
100
0
-100
-200
-300
-400
0
100
200
300
400
500
600
700
800
Time(ns)

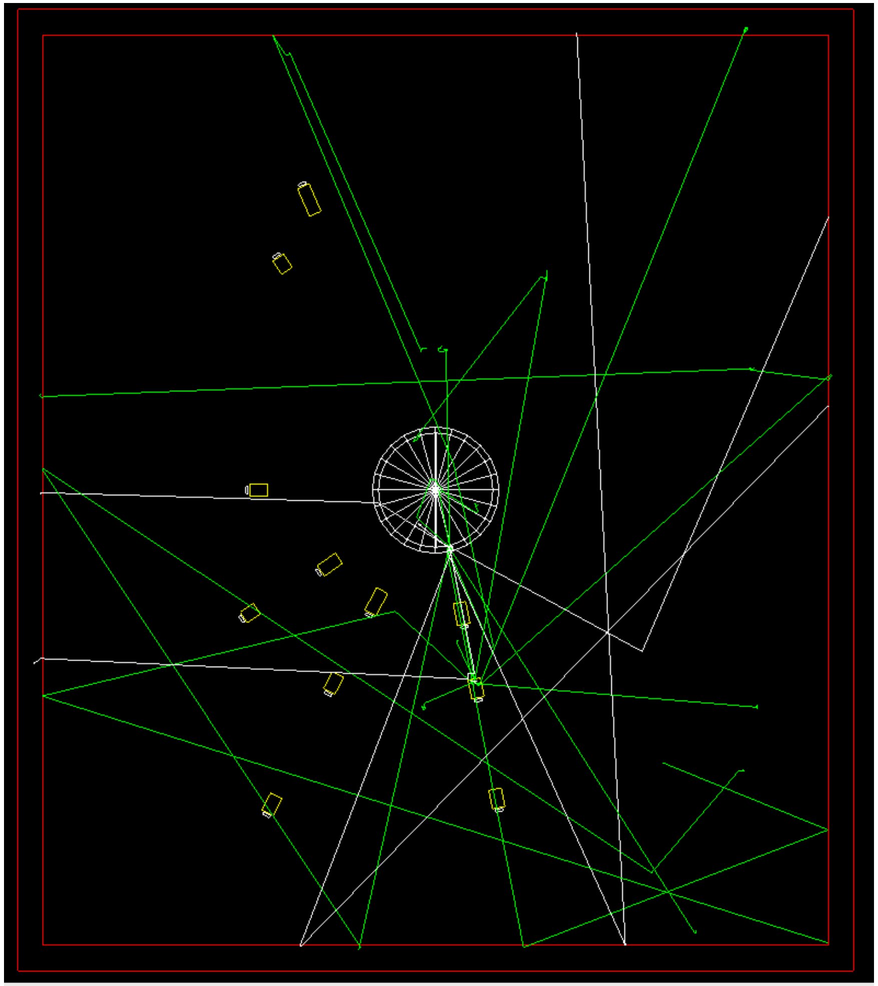
Alternative ways for data analysis



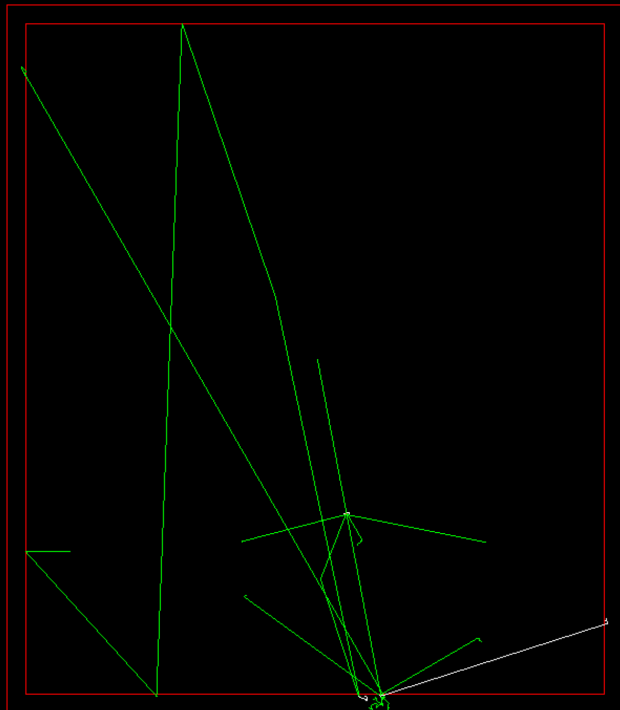
Different approaches to the initial angular distribution of the neutrons

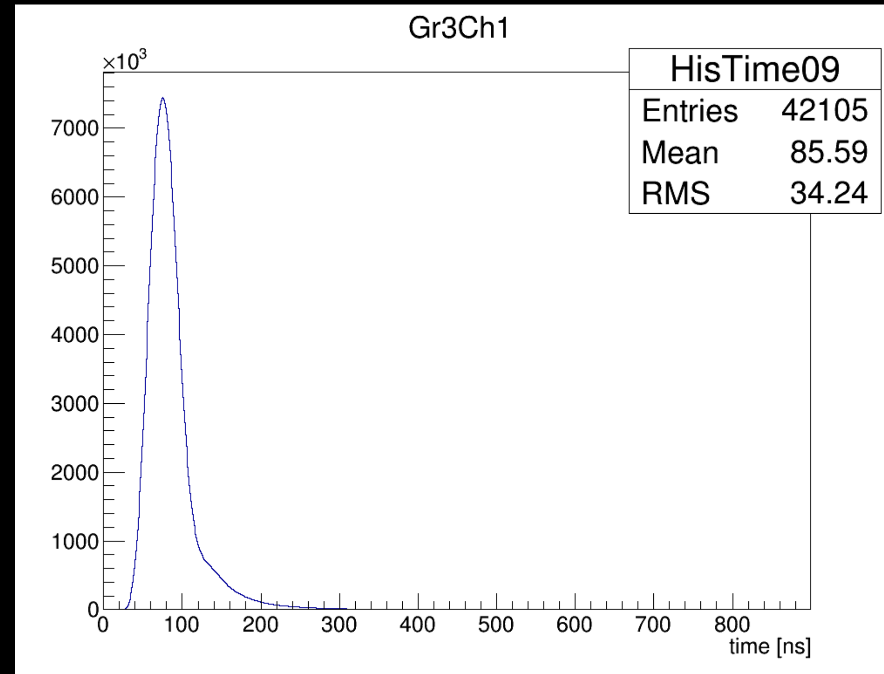
Geant 4 simulations   Physics list: QGSP_BIC_HP



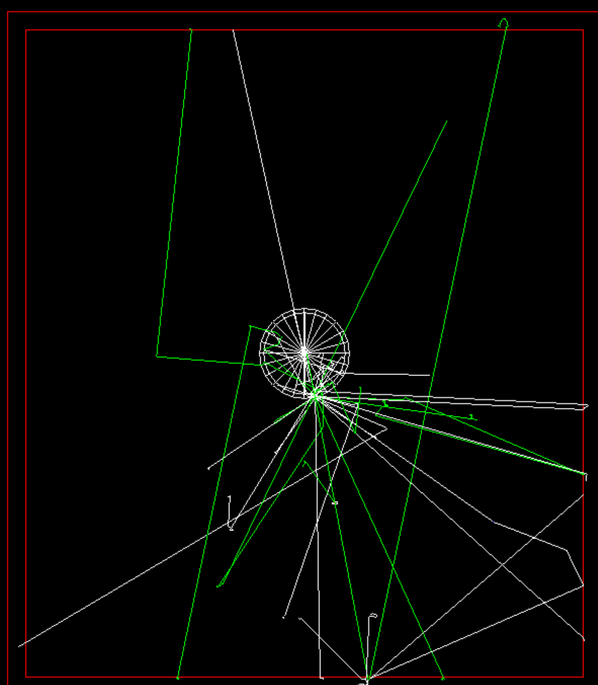


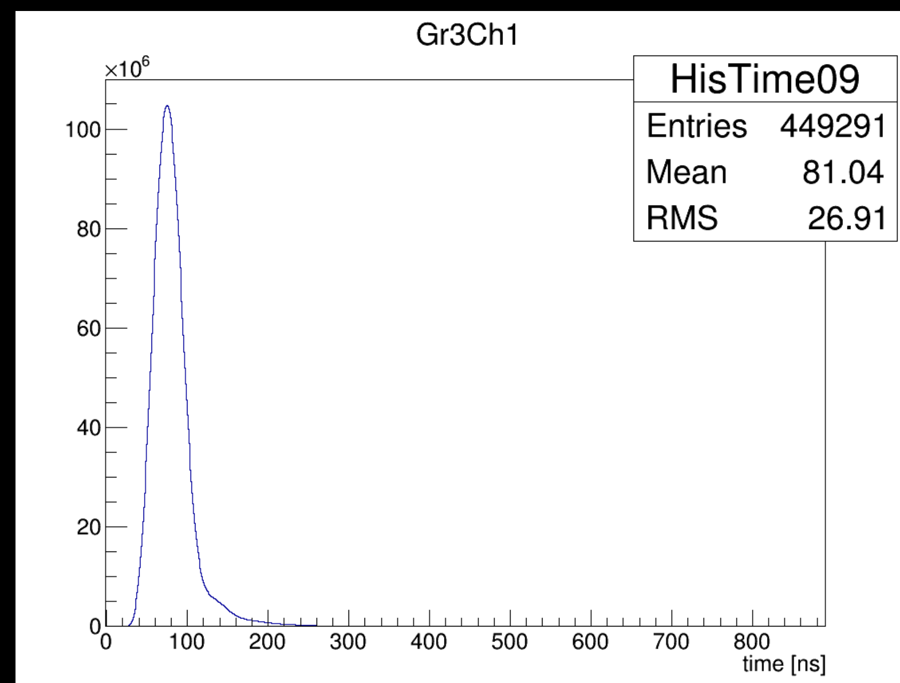
10^5 initial neutrons





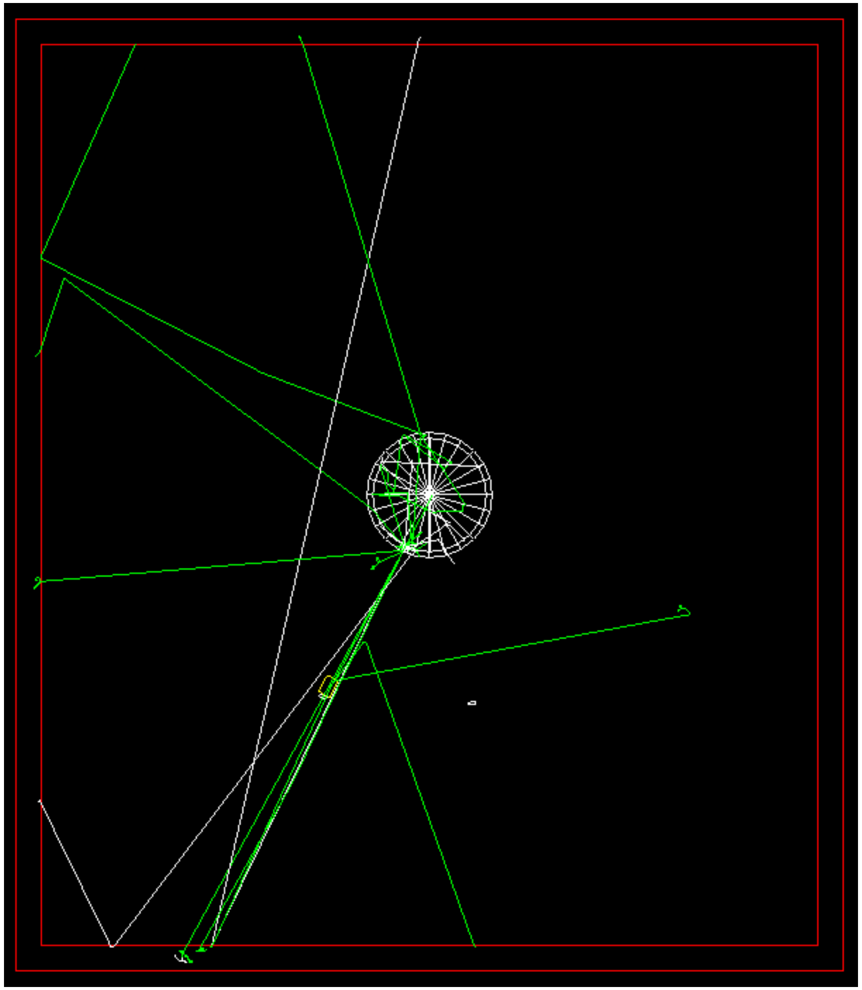
$3x10^6$ initial neutrons

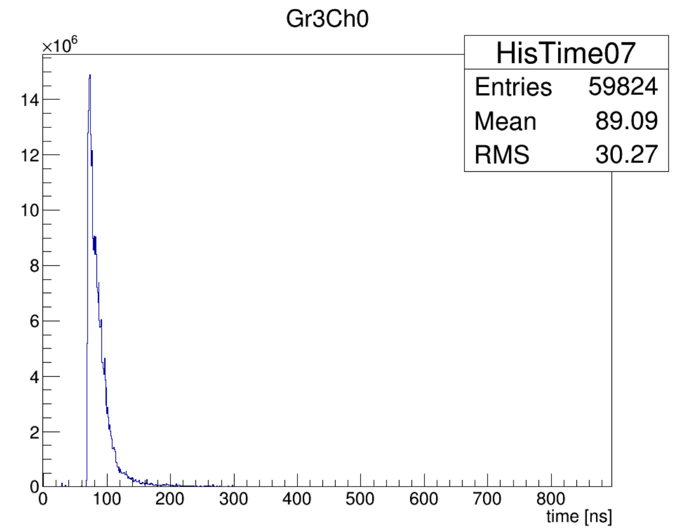


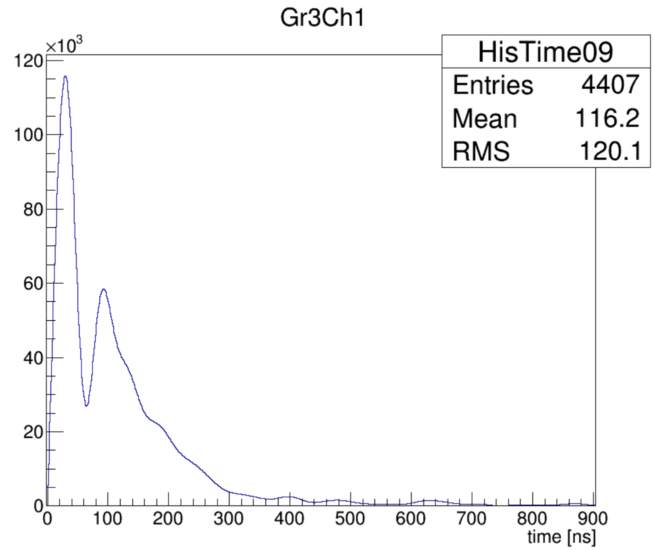


Scattering from the Pb shielding of neighbouring detectors

3.6x10^7 initial neutrons

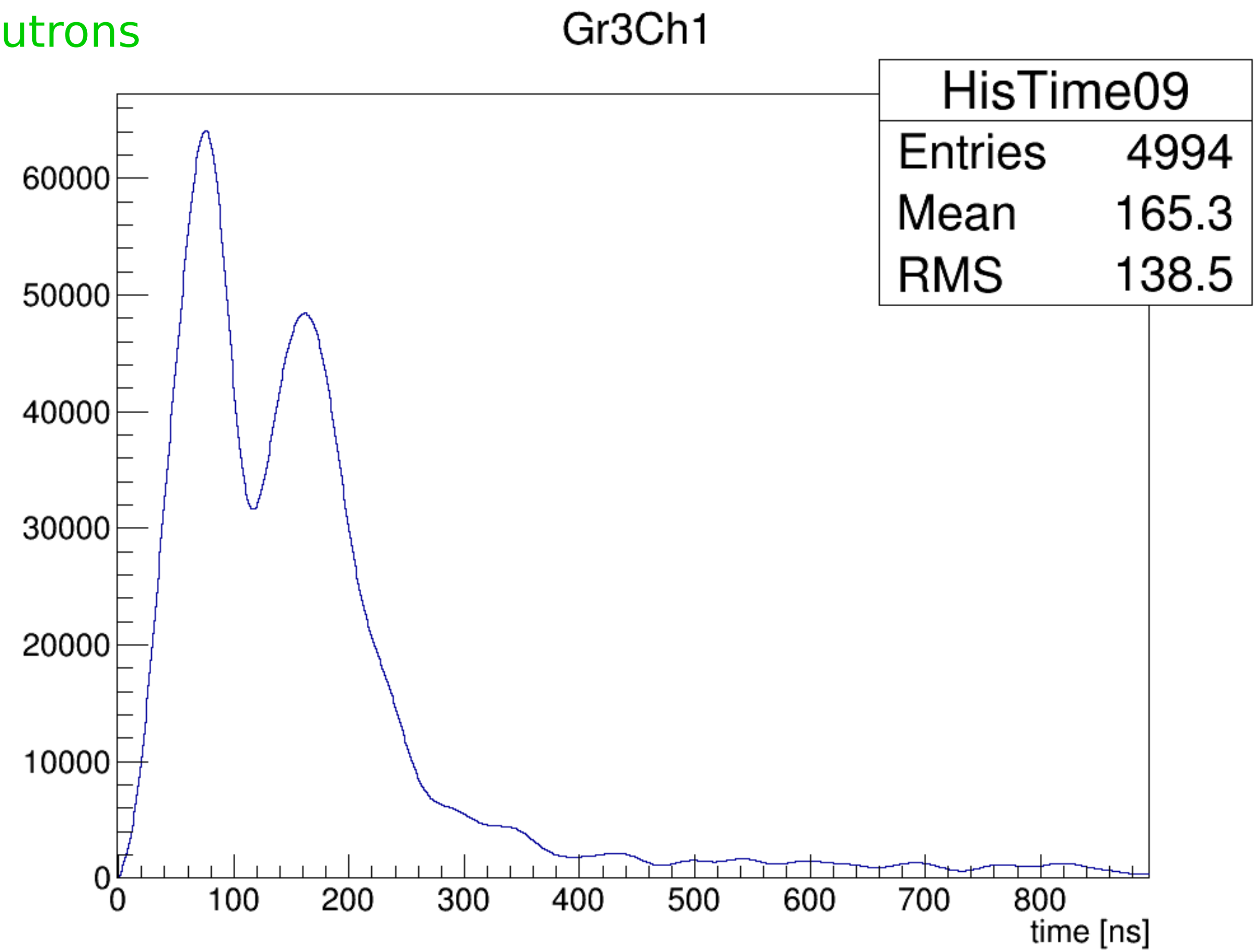






Using simulated energy and angular distributions for the neutrons

10^7 initial neutrons



Conclusion

- The TOF of neutrons, produced from reactions driven by laser-target interactions was studied
- The shape of the TOF signal can be qualitively explained with scatterning from the Pb shielding of neighbouring detectors, but only the effect of the closet was studied up to now

- Future work

  - Geant 4 simulations in full geometry with uniform and with simulated initial energy distributions of the neutrons

  - Comparison of the distributions from detectors at different angles and distances, according to the beam line

  - Analysis of the selected energy proton shots

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 289191.

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