Time-of-flight Measurement on the Neutron with a Maximum Energy in KOMAC

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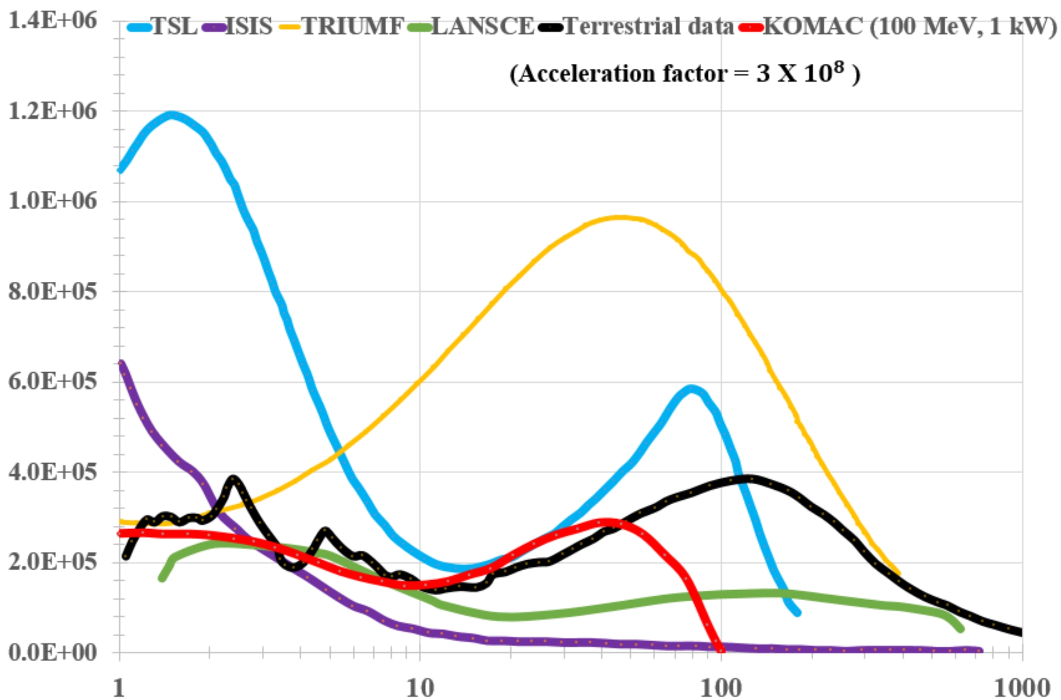
1. Introduction

KOMAC
Korea Multi-purpose Accelerator Complex
양 성 자 가 속 기 연 구 센 터

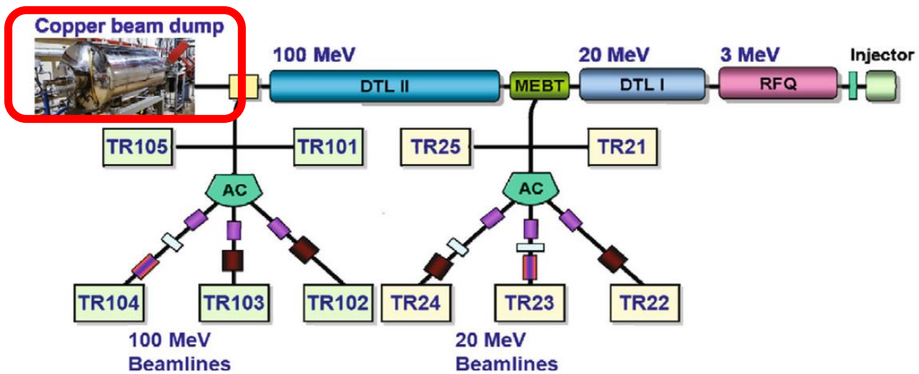
- **A particle accelerator** capable of generating high-energy particles similar to those of nature may play a role in determining the frequency of occurrence of semiconductor soft error due to terrestrial cosmic radiation.
- **KOMAC** is currently experimenting with generating neutrons with a white spectrum by reacting with a target composed of copper using a proton beam that can accelerate up to 100 MeV.



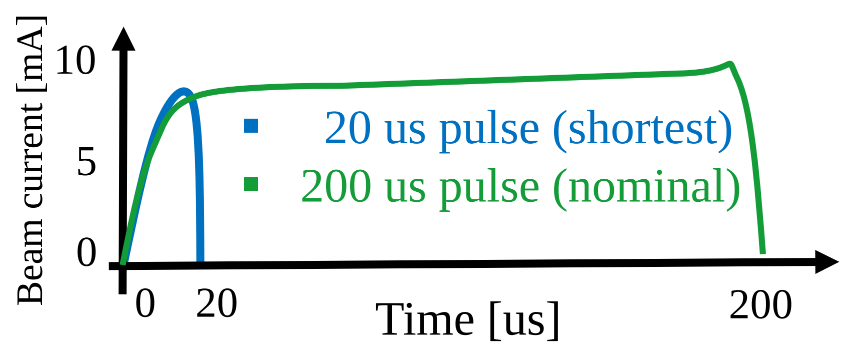
➢ Lethargy representation of white neutron sources and terrestrial neutrons[1,2]

1. Introduction

- In order to certify this facility as one of **the global standard white neutron sources**, a study is needed with measurements and calculations of the neutron flux and the energy spectrum in depth [3].
- Since KOMAC do not have a short pulse beam extraction system yet, it was necessary to devise a method that can measure neutron energy using a long pulse beam of 20 microseconds or more.
- This paper presents the specific time-of-flight measurement on a maximum energy of proton-induced neutrons and comparison with Monte-Carlo simulation results.



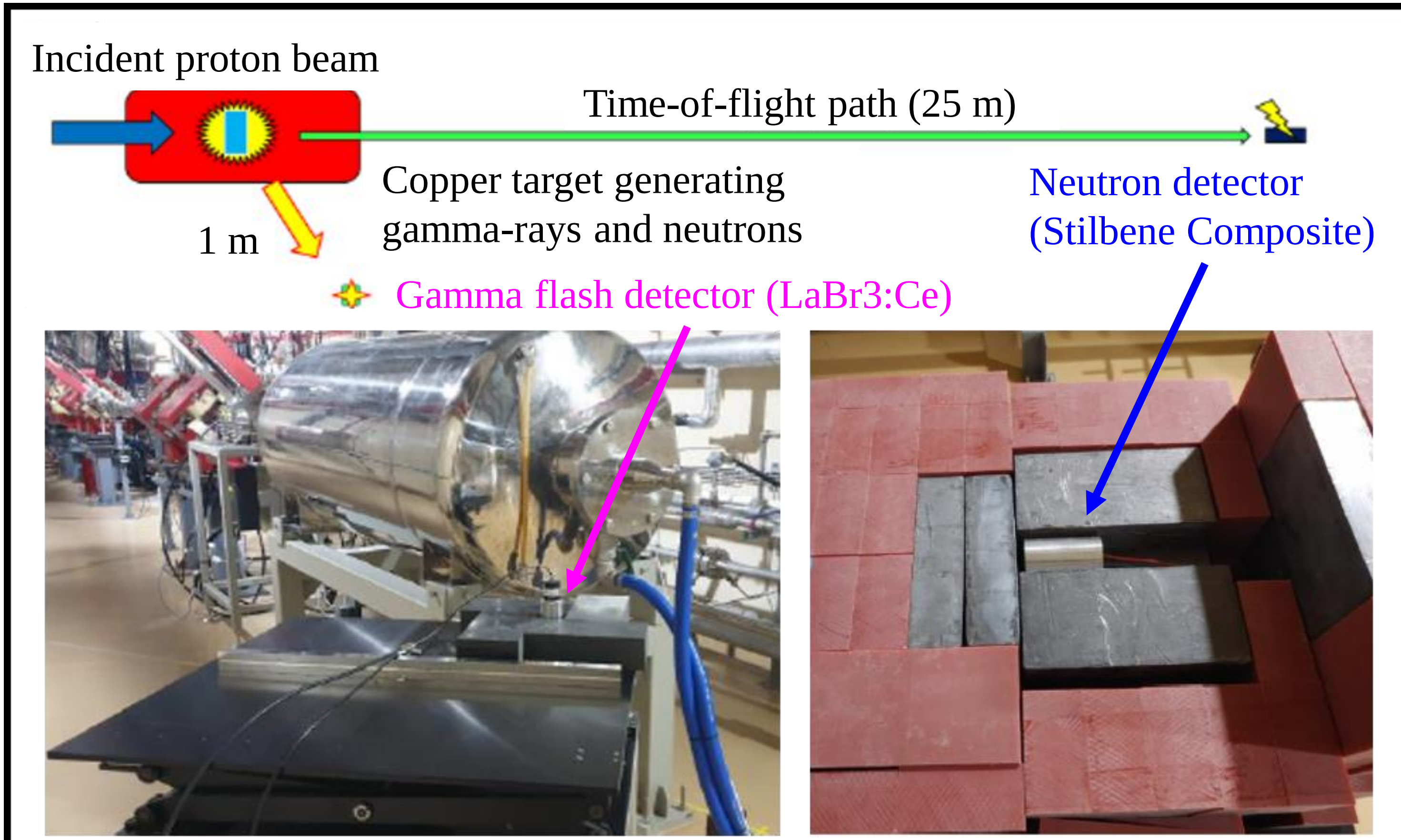
➢ Layout of the KOMAC beamline and dump



➢ Typically measured proton beam current at the 100 MeV beamline in KOMAC.

2. Methods – Experimental Setups

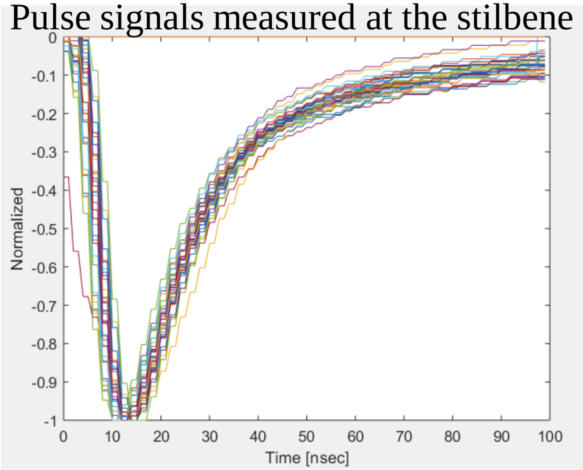
- The gamma-flash detector is used to tag the timing at which the beam-target reaction occurs, and the fastest, that is, the energy of the neutron with the highest energy is measured using only the earliest part of the beam pulse.

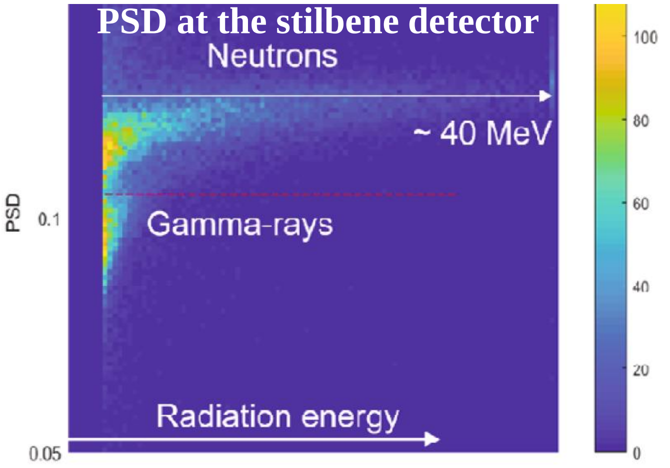


➢ Overview of gamma-flash tagging neutron time-of-flight measurement

2. Methods – Radiation Detectors

- Gamma scintillator LaBr3(Ce) was adapted as a gamma-flash detector and installed at 1 m away from the beam dump because of its fast responsibility.
- Stilbene neutron scintillator was selected as a neutron time-of-flight detector due to its fast response and superior neutron/gamma discrimination ability by a difference in pulse shapes.
- To achieve good energy resolution for the fast neutrons up to 100 MeV, stilbene detector was located 25 m away from the beam dump and enclosed by neutron/gamma shielding structures made up of borated polyethylene and lead.





➢ Fast signals measured by the detectors and neutron/gamma discrimination by pulse shape.

3. Results – Timing Signal Processing

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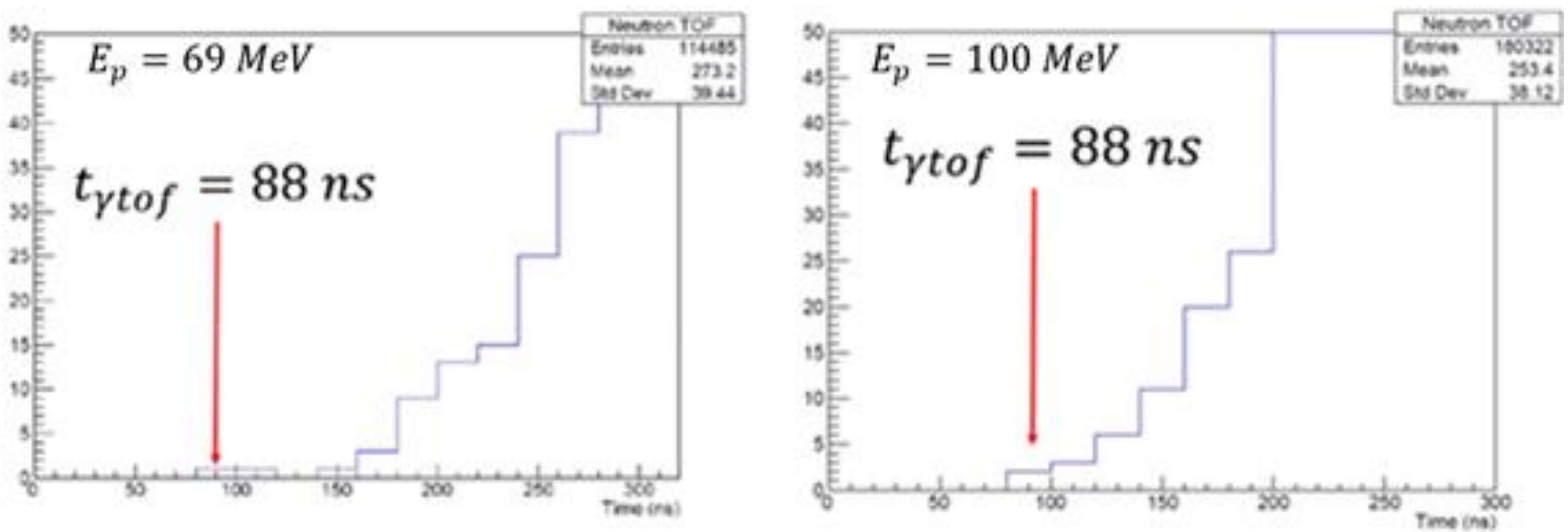
- Timing delays between the gamma-flash detector and neutron detector were recorded by 500 MS/s fast digitizer within preset coincidence windows.
- The windows are much narrower than the beam pulse width, such as 500 ns (TOF gate) and 20000 ns (pulse width).
- Stilbene detector have the same gamma TOF delay of 88 ns to the different proton beam energy; 69 MeV and 100 MeV. This result supported the consistency of the timing delay with the preceding gamma flash detector.



➢ Gamma time-of-flight histogram at 69 MeV and 100 MeV proton beam experiments

3. Results – Time-Energy Conversion

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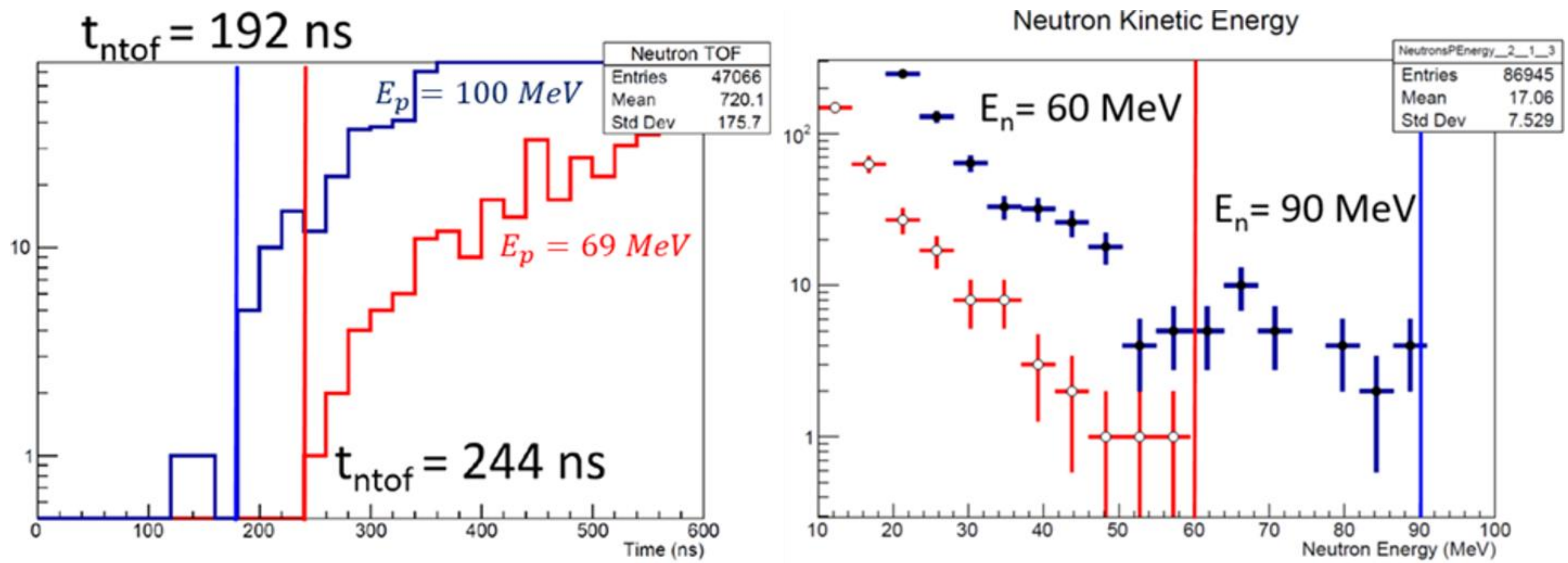
- Coincidence delays were accumulated during repetitive beam pulses, and converted into the kinetic energies of neutrons in the post processing.
- Estimated neutron energy was a little lower than the incident proton beam energy; 60 MeV for the 69 MeV proton and 90 MeV for the 100 MeV proton.



➢ Neutron time-of-flight histogram and processed energy histogram at 69 MeV and 100 MeV proton beam experiments

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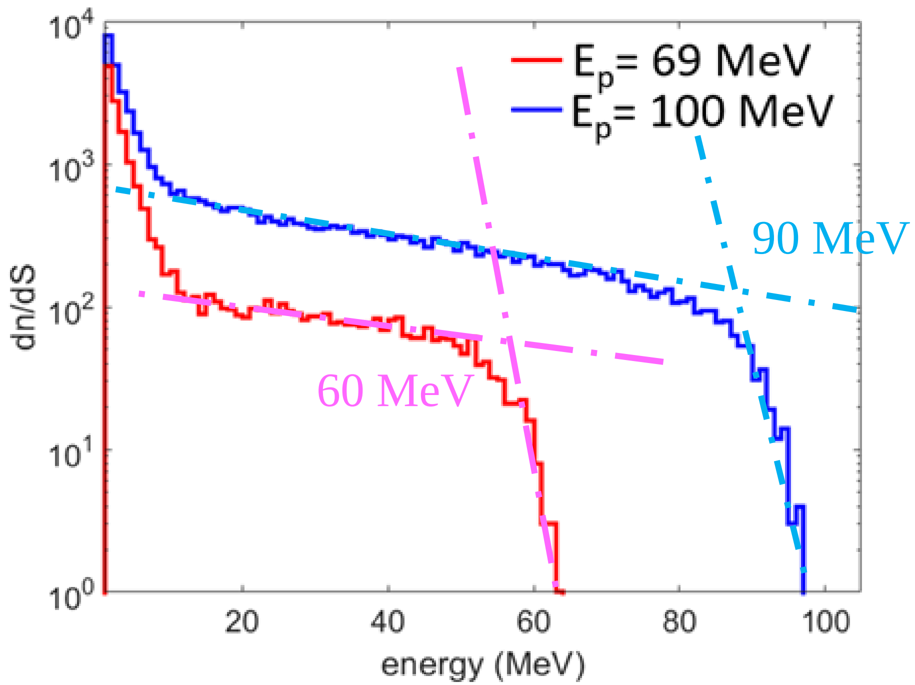
3. Results – Comparison with Monte-Carlo simulation results

- Monte-Carlo simulation codes – Geant4 and MCNP6 were utilized to numerically calculate neutron energy spectra at the detector [4,5].
- Simulation results showed steep drop in partial neutron fluxes nearby 60 MeV and 90 MeV, respectively.
- Therefore, it can be inferred that there are little chances to measure the corresponding incident proton beam energy within the limited number of beam pulses.



➢ Neutron energy spectra calculated by Monte-Carlo simulation

4. Conclusion

- Time-of-flight measurement of a maximum on the neutron with a maximum energy was performed by using gamma-flash time-tagging method.
- Neutron energy up to 60 MeV and 90 MeV was estimated for the 69 MeV and 100 MeV long-pulsed proton beam.
- The discrepancy could be comprehended with Monte-Carlo simulation results.
- To obtain more accuracy, repetition rates of experiment needed to be drastically increased by introducing additional beam chopping system before the beam dump.

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