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Energetic Neutron Detection with Timepix

Neutrons in space are primarily produced as secondaries from charged particle interactions with the spacecraft material and are a concern for astronaut dosimetry. Space-based neutron measurements on the International Space Station (ISS) via the Radiation Assessment Detector (RAD) measured that fast neutrons contribute as much as a third of the total dose equivalent on the ISS. Neutron impact on human health can be quantified using a fluence-to-dose conversion, which becomes significant after about 1 MeV. However, the response for neutrons in a silicon sensor is not proportional to the response in tissue, so using silicon-based sensors is an imperfect method of quantifying neutron impact.

Several silicon Timepix-based instruments are currently used on the International Space Station and as part of the Artemis program. These instruments are primarily used for charged particle measurements rather than neutron detection. Timepix has been applied to neutron detection in prior work outside of space-based radiation measurements. These measurements have primarily been done using neutron sources with converter foils (e.g. polyethylene, aluminum, Li-6), enabling indirect neutron detection via secondary products.

By contrast, we discriminate neutrons from mixed radiation fields and demonstrate direct measurement of fast neutrons with Timepix. This technique allows neutron measurements from existing instrumentation already in space without modification. We present a unique signal in Timepix from neutron hits due to elastic scattering of neutrons in the silicon. We took data using an AmBe source and examined hits in the detector ("clusters") to determine which unique combination of cluster properties can be attributed to direct neutron hits. We then used a database containing beamline data from Ar, C, Fe, Li, Ne, O, and Si with energies up to 1 GeV to confirm that our selected cluster properties emerge only in the presence of neutrons. We provide an energy calibration from neutron data collected at the Kansas State D-D and D-T facility and at the monoenergetic neutron source PTB. We use measurements from a space-representative neutron field at the CERN-EU high-energy Reference Field (CERF) facility to get a calibration factor between Timepix counts and neutron dose. We then apply the neutron identification and dosimetry calibration to data from the International Space Station and provide preliminary corrections to dosimetry.

Workshop topics

Applications

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