

## The ceramic GEM-based neutron detectors at China Spallation Neutron Source

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China Spallation Neutron Source (CSNS) is a large-scale scientific facility which is a source of high-flux pulsed neutrons. It contains a 80 MeV linear proton accelerator, a 1.6 GeV rapid cycling synchrotron, a target station, and a suite of modern neutron instruments mainly for application to neutron scattering, imaging, and other kinds of neutron science research to promote high-level material science and technological development in China. Until 2023, the 11 neutron instruments have been built with the 9 remaining to be planned. The facility has been in public operation at a power of 140 kW since 2021. Many new instruments require  $^3\text{He}$ -free neutron detectors with high counting rate capability to match the high neutron flux. At CSNS, a novel ceramic GEM was developed to meet the demand of high counting rate for the neutron detection and an alternative to  $^3\text{He}$  detector. Many types of ceramic GEM-based neutron detectors have been developed for neutron instruments. More than 20 beam monitors (Fig 1) were installed and used with 2D position sensitivity and wide neutron-flux measurement range. Two highly efficient GEM detectors ( $\sim 50\%$ @4 Å, Fig 2) were used to detect the small angles scattered neutrons at Very Small Angle Neutron Scattering Instrument (VSANS). Two large area (200mm\*200mm) GEM detectors were applied to carry out Bragg-edge imaging for Energy-resolved Neutron Imaging Instrument (ERNI). A fast neutron GEM detector (Fig 3) based on natU was developed for the beam measurement at the Atmospheric Neutron Irradiation Spectrometer (ANIS). And a sealed GEM detector (Fig 4) was developed to obtain the long-term stability. In all the applications, the detector stability and aging phenomena were observed, which need to be optimized and resolved in the future.

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