强脉冲辐射环境模拟与效应全国重点实验室

National Key Laboratory of Intense Pulsed Radiation Simulation and Effect

Measurement of ^{252}Cf Fission Fragment's Mass Spectrum Through E-v method

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Abstract: This study presents a novel E-v measurement device called E-STONE, designed for the accurate determination of fission product mass spectra. The E-STONE device consists of two self-developed flight time detectors (SED-MCP) with an intrinsic time resolution of 56.5 ps, and an energy detector in the form of a grid ionization chamber, achieving an energy resolution of 0.7%. Utilizing the E-STONE device, the flight time spectra, kinetic energy spectra, and mass yields of fission products from a spontaneous ^{252}Cf fission source were measured. The obtained mass yield data were found to be in good agreement with ENDF/B8.0. Additionally, the study assessed the mass resolution of the E-STONE device to be 0.94 amu (102 amu) and 1.6 amu (142 amu).

An E-v spectrometer called E-STONE was developed (as shown in Fig. 1), which can identify the mass of fission fragment through measure its Energy and flight time in a known distance. It consists of two SED-MCP detectors and a Frisch grid ionization chamber. The SED-MCP was self-developed and has an intrinsic time resolution of 56.5ps (as shown in Fig. 2). The ionization chamber was calibrated in LEAF ion source and has a intrinsic energy resolution of 0.7%(as shown in Fig. 3). A ^{252}Cf spontaneous source was placed upstream of the E-STONE, and the distance between two SED-MCPs was determined to be 44cm. Therefore, the detection efficiency of the E-STONE device is approximately 1×10^{-4}.

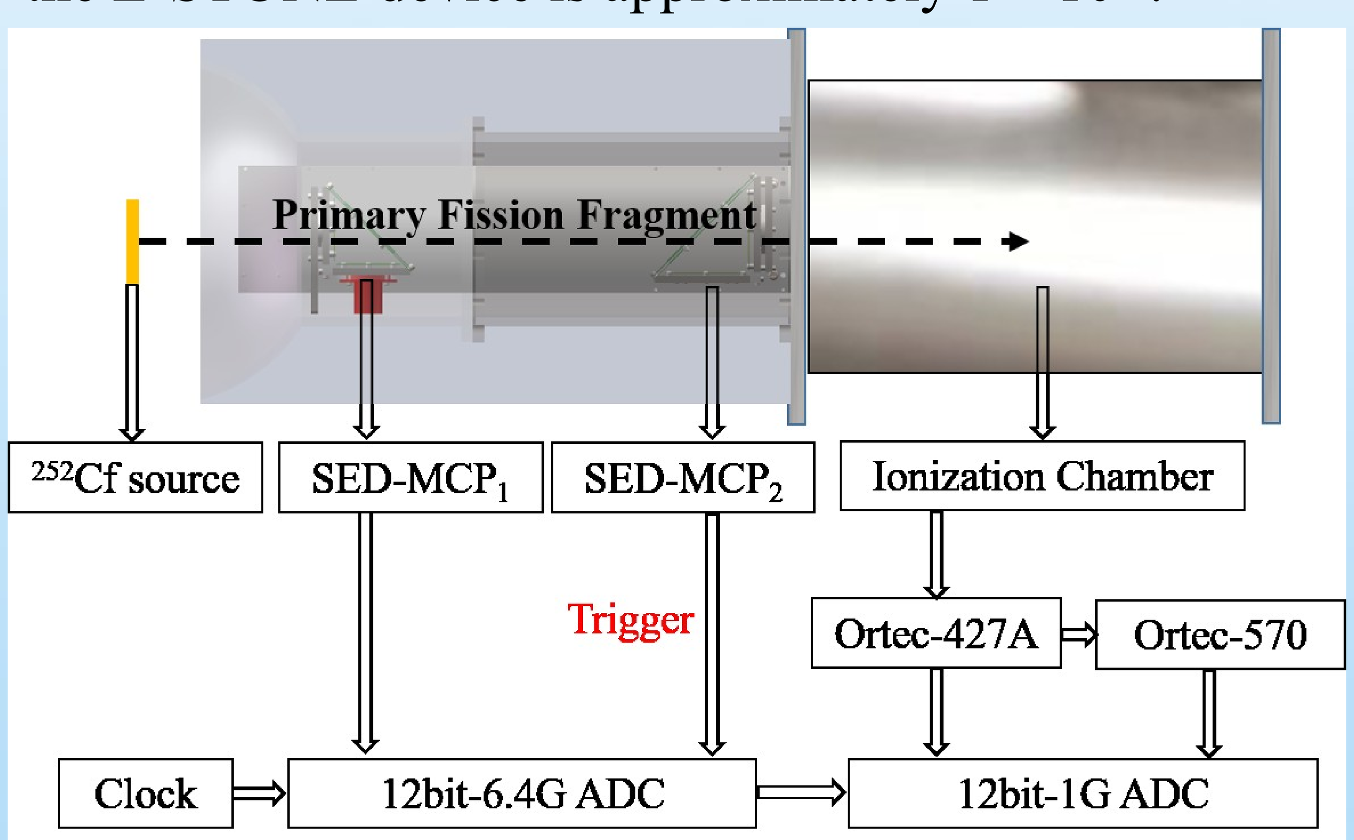

Fig. 1. A schematic representation of the E-STONE device

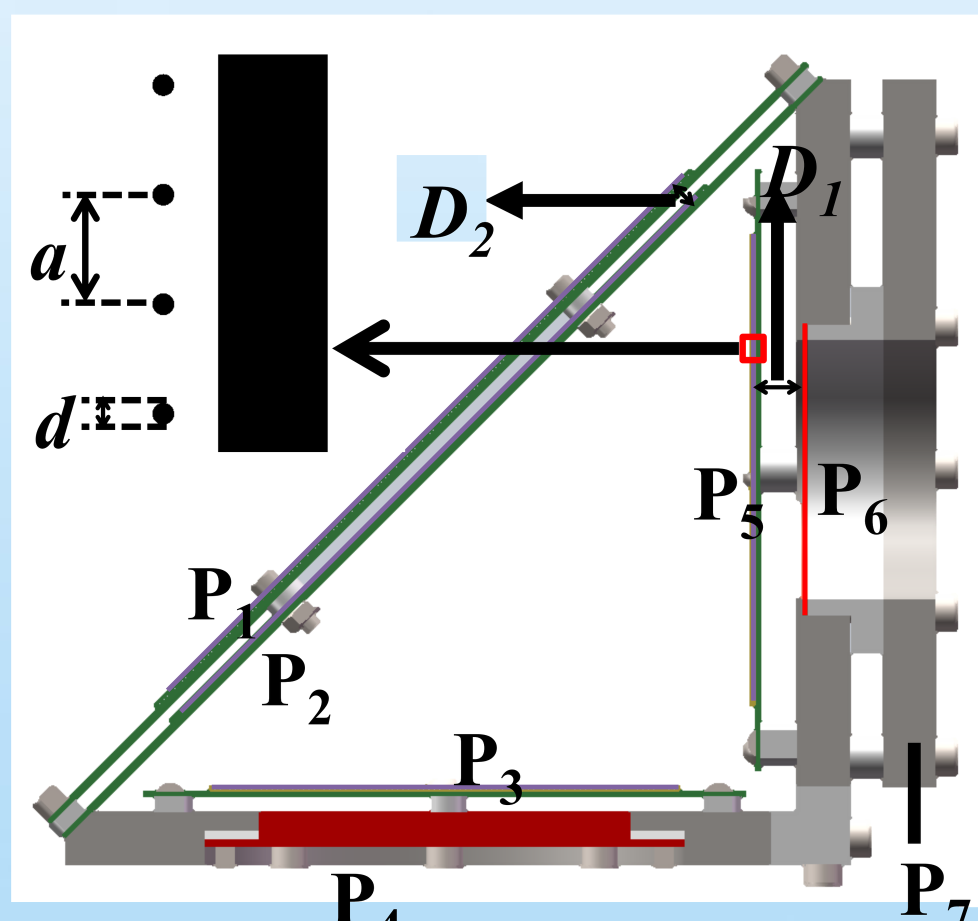

Fig. 2. The composition structure of SED-MCP: P_1, outer side mirror grid; P_2, inner side mirror grid; P_3, MCP guiding grid; P_4, microchannel Plate; P_5, the accelerating grid; P_6, the SE conversion film; P_7, the shielding plate. a and d represent the spacing and diameter of grid wires, respectively. D_1 refers to the distance between P_5 and P_6, D_2 refers to the distance between P_1 and P_2.

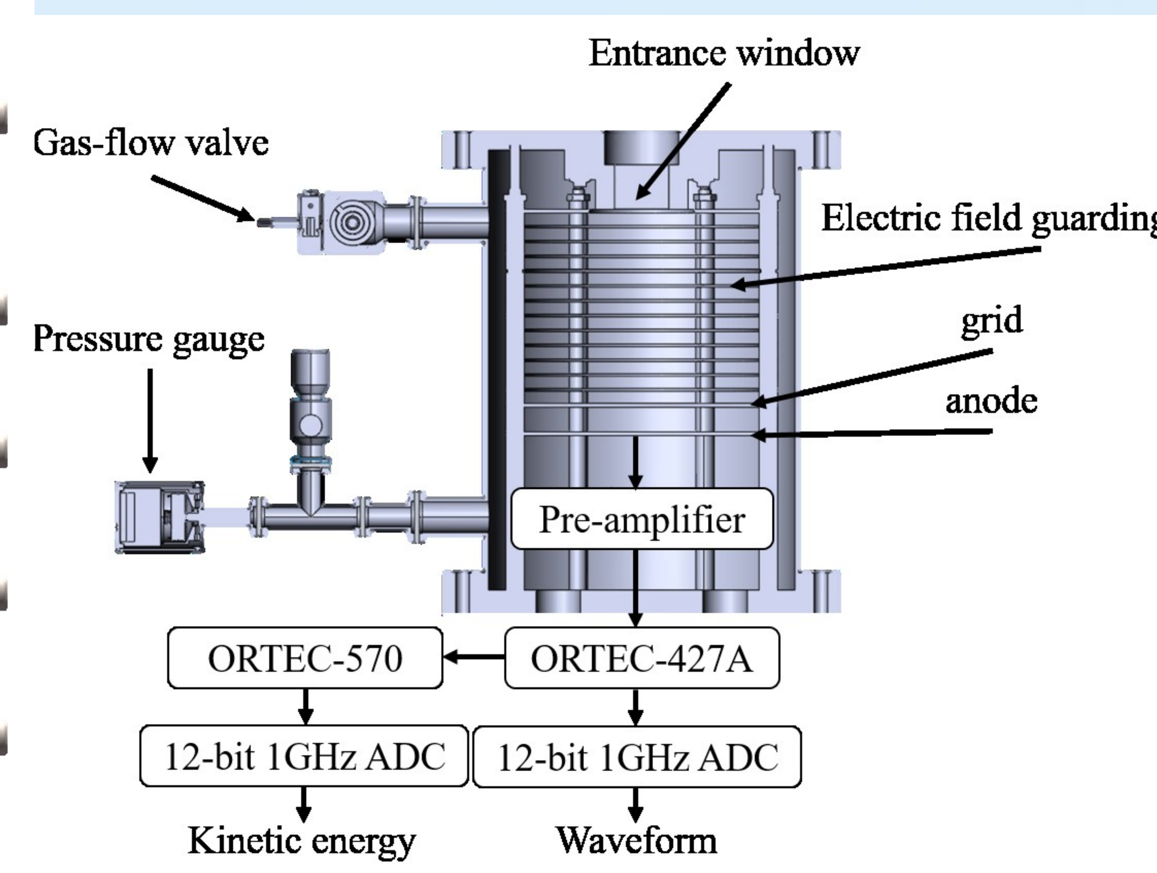

Fig. 3. A schematic representation of the ionization chamber

Based on the E-STONE spectrometer, the energy spectrum and flight time spectrum was measured(as shown in Fig.4 and Fig.5). Subsequently, based on Geant4, the energy loss of fission fragments in the SE film and incident window was iteratively corrected. Finally, the Mass distribution of ^{252}Cf source was obtained(as shown in Fig.6 and Fig.7).

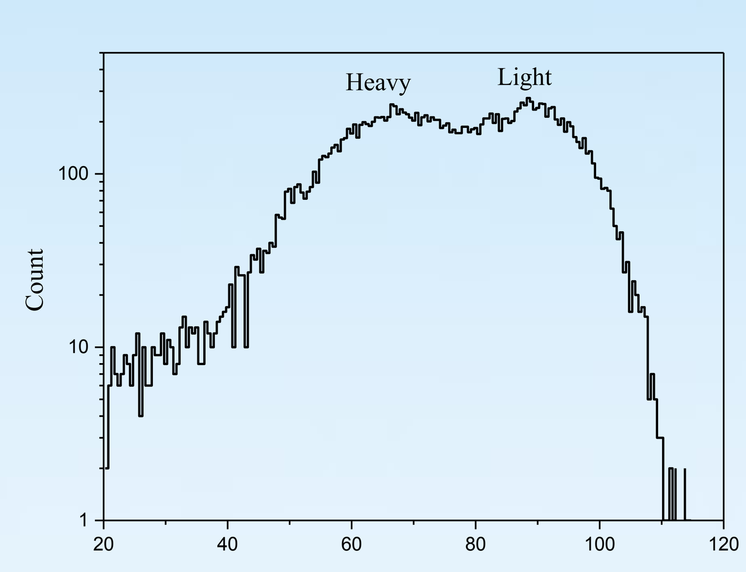

Fig. 4. A plot of the kinetic energy spectrum

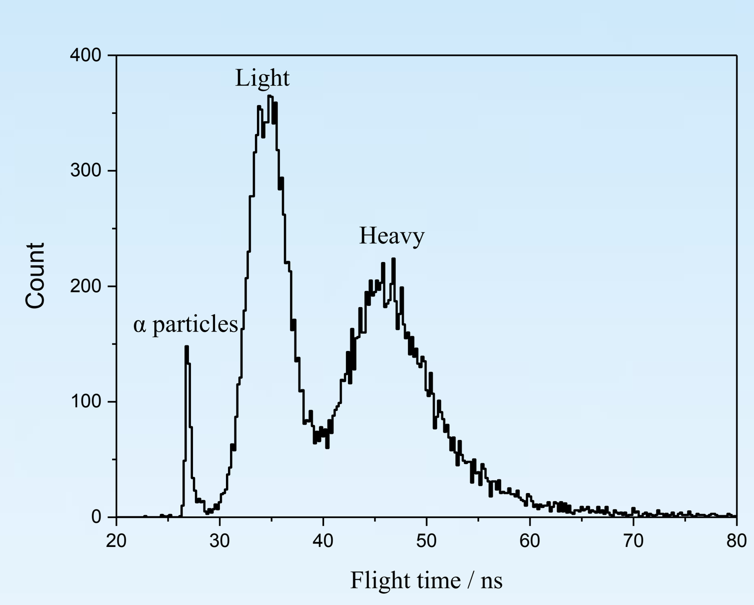

Fig. 5. A plot of the flight time spectrum

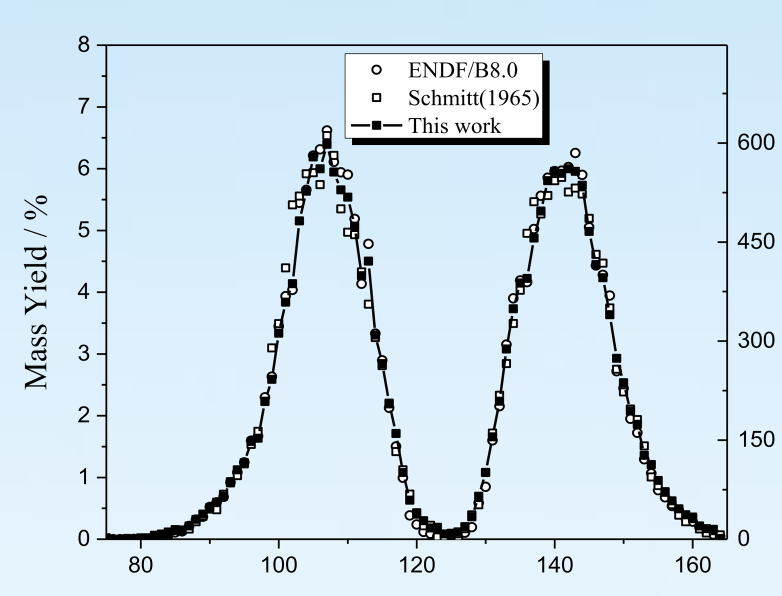

Fig. 6. A plot of the variation of mass yield and count change with mass (linear)

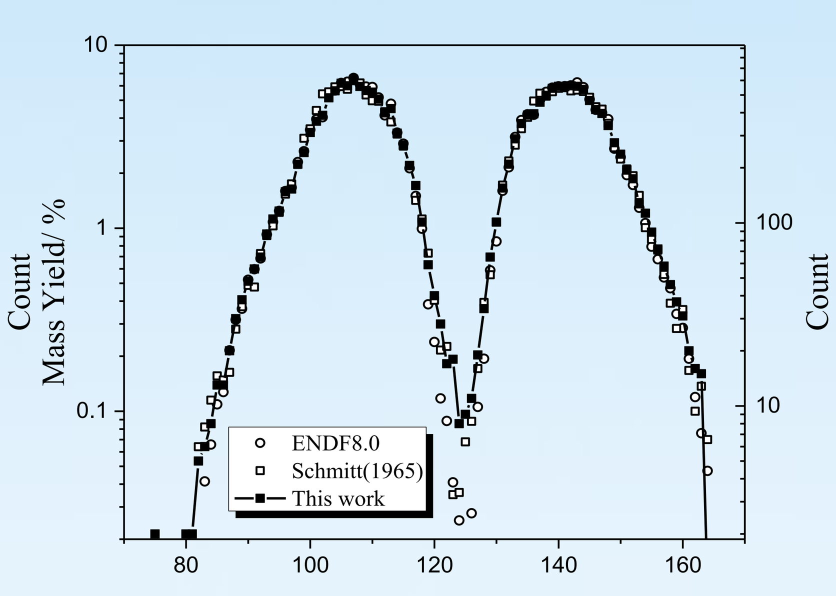

Fig. 7. A plot of the variation of mass yield and count change with mass (log)

The variation of average kinetic energy and average flight time with particle mass was discussed in Fig. 8 and Fig. 9, the mass resolution of E-STONE spectrometer was evaluated based on these discussion. As shown in Fig. 10, the mass resolution of the E-STONE device is 0.94 amu (102 amu) and 1.6 amu (142 amu).

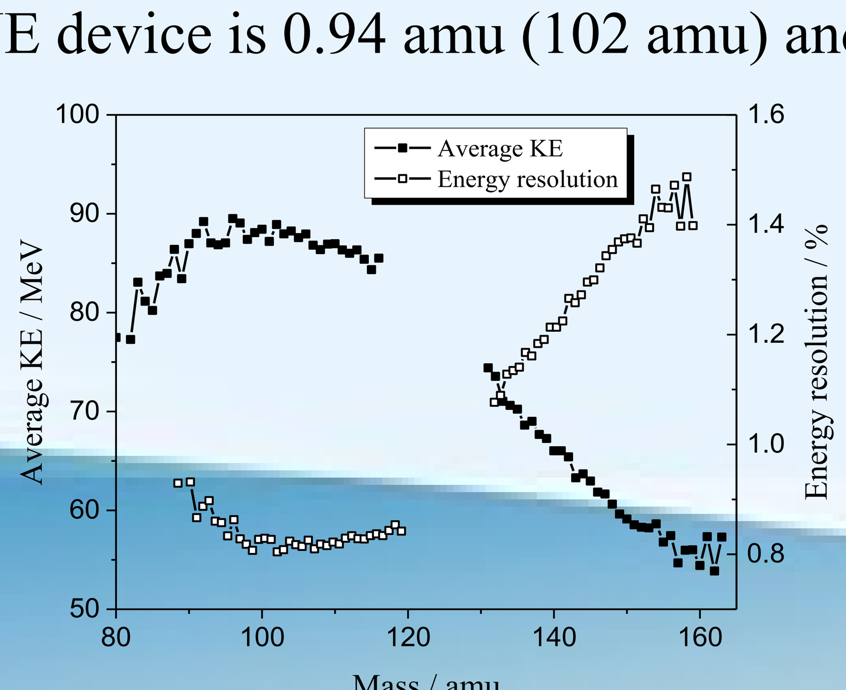

Fig. 8. A plot of the variation of (left) average KE and (right) energy resolution with mass

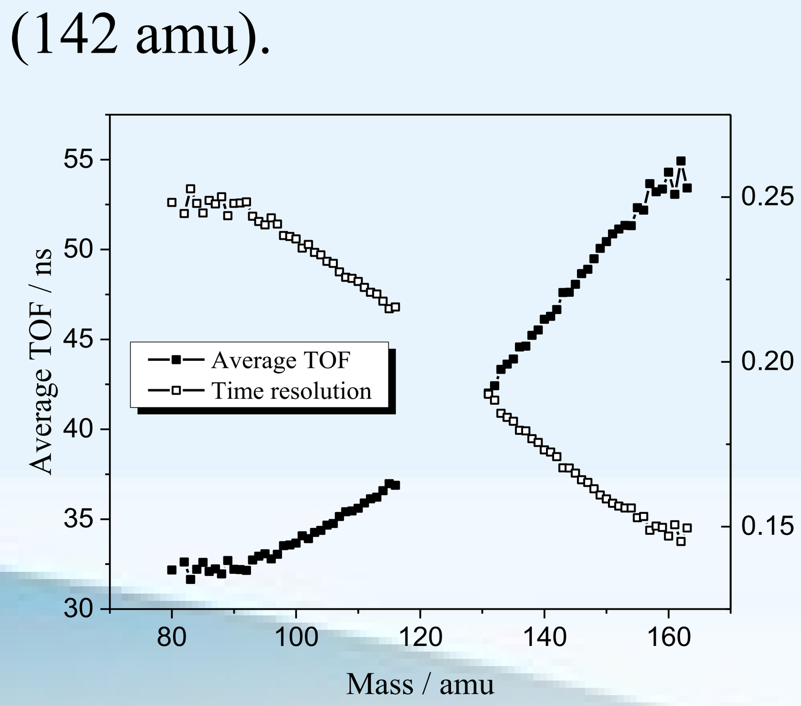

Fig. 9. A plot of the variation of (left) average TOF and (right) time resolution with mass

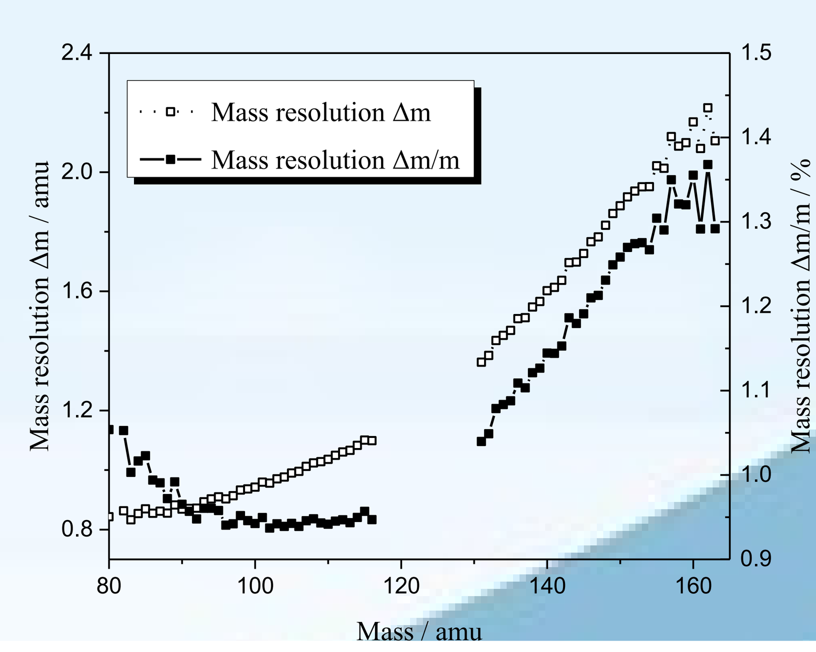

Fig. 10. A plot of the variation of (left) Δm and (right) $\Delta m/m$ with mass