A hybrid detector telescope for fission fragments and light charge particles

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Introduction:

Gas detectors play very crucial role in heavy-ion experiments to study the mass, charge, energy, and angular distributions of the reaction products. The main advantages of gas detectors over silicon and scintillation detectors, are due to the versatility of construction, large area coverage, immunity to radiation damage, and less pulse height defect etc. [1]. Hybrid ΔEgas and Es.s telescopes have been developed for particle identification of projectile-like particles and fission fragments by measuring the energy loss in gas (ΔE) and the residual energy in the surface barrier detector [2]. The detection solid angle of such detector telescopes is often limited by the size of the solid state detector used for measuring the residual energies. Moreover, for the detection of high energy light charged particles (LCPs') viz. α, d, t and p, one requires thick Silicon E-detector. Thick (10 - 40 mm) and large area (25 mm x 25 mm) CsI(Tl) detectors are found to be suitable for stopping LCPs' and cost effective. In the present paper we report the performance characteristics of a hybrid ΔE_{1gas}-ΔE_{2gas}-E_{CsI} detector telescope for simultaneous measurement of fission fragment and LCPs'. The Fission fragments were detected in the ΔE_{1gas}-ΔE_{2gas} part of the detector. The LCPs' were detected in the ΔE_{2gas} and CsI(Tl) detector.

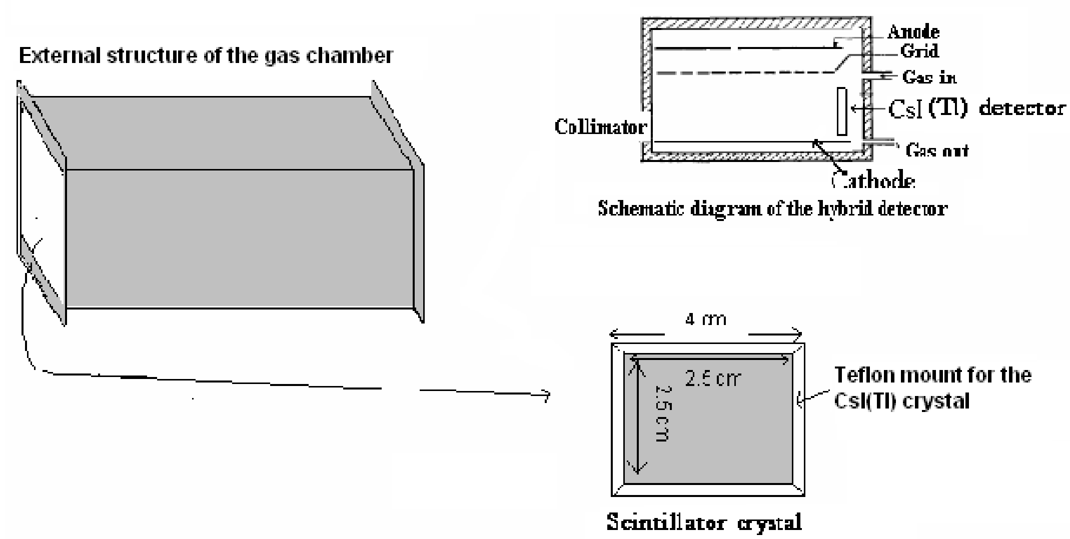

Fig.1. Block diagram of the hybrid detector telescope

Description of the detector:

The schematic diagram of experimental setup is shown in fig. 1. The detector telescope consists of a gas ionization chamber (ΔE_{1gas}= 35 mm and ΔE_{2gas} = 40 mm) for the measurement of energy loss in gas and a CsI(Tl) (thickness=10 mm) coupled with photo diode for the detection of LCPs'. A collimator of diameter 10 mm was placed in front of the detector. The cathode plate, Frish-grid and collector plate are parallel to the ion track. The separation of the grid and anode from the cathode plate are 30 mm and 40 mm respectively. A ^{252}Cf source (strength = 4 x 10^5 fis/min) deposited on a nickel backing was mounted in from of the gas ionization chamber. The chamber was filled with P-10 gas at a pressure of 350 mbar, so that the fission fragments are stopped completely in the gas.

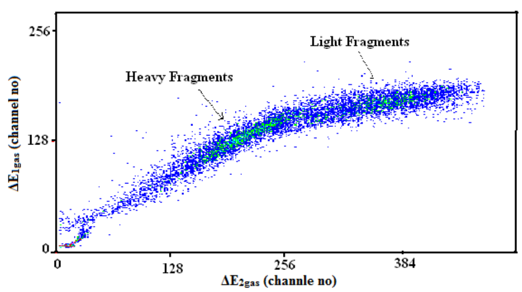

Fig2: 2-D plot of ΔE_{1gas}-ΔE_{2gas} for fission fragments from ^{252}Cf source.

Performance test of the detector:

The cathode, grid and anode were applied bias voltages of -200 V, +100 V and +300 V respectively using charged sensitive pre-amplifiers. The energy outputs of anode (both ΔE_{1gas} and $\Delta E_{2gas)}$ are shaped through shaping amplifier and fed to the data acquisition system. The timing output of cathode pre-amplifier is amplified and filtered through timing filter amplifier (TFA) and fed to constant fraction discriminator (CFD). The CsI(Tl) detector has energy and time output signals for the detection of alpha particles. The master gate has been generated from the 'OR' of the cathode and CsI(Tl) time output. The performance of the CsI(Tl) for alpha particles and fission fragments has been reported earlier [3].

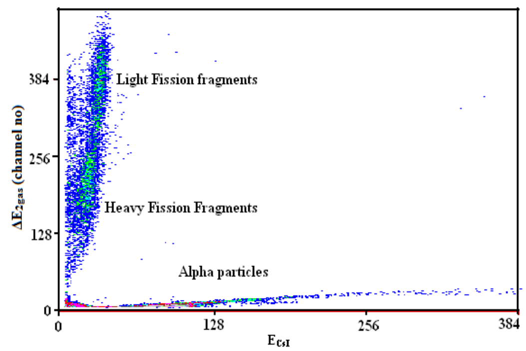

Fig 3: 2-D plot of ΔE_{2gas}-E_{CsI} for fission fragments and alpha particles from ^{252}Cf source

Fig.2 shows a ΔE_{1gas}-ΔE_{2gas} for fission fragments from ^{252}Cf source, where heavy and light fragment groups are clearly seen. In Fig. 3 we have plotted the ΔE_{2gas} vs E_{CsI}, where the fission fragments are separated from the alpha particles. This detector will be very suitable in heavy ion experiments for simultaneous measurement of fission fragments and LCPs'.

References:

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[3] Y.K. Gupta *et al.*, Nucl. Instr. and Meth.A 629 (2011) 14.