

# A Comparison Study of *In situ* and External Beam Current Normalization in External (in air) PIGE for Determination of Boron Concentrations in Neutron Absorbers

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**Keywords:** External (in air) PIGE, Proton Beam, Boron, *In situ* and External Current Normalization

Conventional and external (in air) Particle Induced Gamma-ray Emission (PIGE) methods using low energy proton beams (2 to 5 MeV) from particle accelerators are used for materials characterization by quantifying low Z elements from Li to Ti in various samples including glass and ceramics. Beam current monitoring/normalization is an important aspect for quantitative elemental concentration determination. In conventional vacuum chamber PIGE, for thick targets current is measured from target (if conducting) or by RBS method using thin gold foil. However, in external PIGE set up beam current monitoring by both methods is difficult. Different approaches have been used like detection of X-rays or gamma rays from the window materials, characteristic X-ray peak of Ar in air, using beam chopper in the beam path made of elements like Al to detect gamma rays or with high Z materials like Ag or Au to detect the backscattered particles by SSB detector in vacuum. As in PIGE we are detecting prompt gamma rays, hence it will be advantageous if the signals for current monitor can be detected with the same detector set up without any interferences to gamma rays of interests from the samples. For vacuum chamber PIGE, our lab has developed in situ current normalization approach by mixing a known amount of element (not present in the sample) like Li or F having high sensitivities in PIGE using proton beam. In our external PIGE set up, we have extracted the proton beam (collimated with 2-5 mm Ta) in atmospheric air using thin Ta foil. In the present work, we have used 135 keV of  $^{181}\text{Ta}(p,p'\gamma)^{181}\text{Ta}$  from window material and 2331 keV prompt gamma rays of  $^{14}\text{N}(p,p'\gamma)^{14}\text{N}$  from air as external current normalizers to monitor the beam current fluctuations, if any, during the sample irradiation. Boron concentration

determination (11-78 wt%) was carried out for B<sub>4</sub>C and other ceramic neutron absorbers using boric acid standard. The external beam current normalization was validated by comparing total boron mass fractions determined in different sample pellets using in situ current normalized PIGE using F as the current normalizer using 197 keV gamma-ray. Fig. 1 shows a gamma-ray spectrum of a B<sub>4</sub>C pellet irradiated with 3.5 MeV proton beam from FOTIA in external PIGE indicating gamma-rays of Ta (135 keV), F (197 keV) and N (2331 keV).

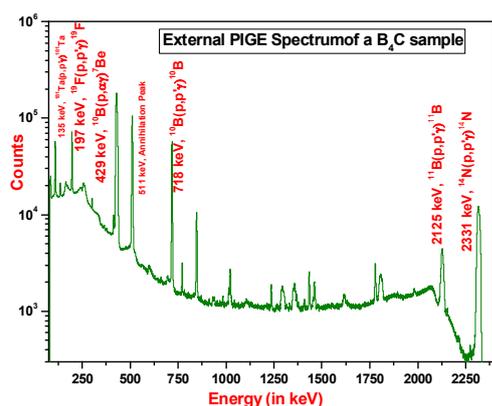


Fig. 1. Gamma-ray spectrum of a boron carbide pellet irradiated with 3.5 MeV proton beam in Ext-PIGE

**Acknowledgments:** Authors thank FOTIA operation crew for their help during experiment.

