Csl(Tl) crystal detectors: optimization of the response as a function of the Tl concentration for FAZIA.

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Abstract

The development of technologically advanced new apparatus for charged particle detection, to be used in the next generation accelerator complex like SPECS and SPIRAL2, is very important. The FAZIA collaboration is developing a multi-telescope array for studying heavy ion collisions from low up to Fermi energies, characterized by innovative detection solutions implemented with full digitization of the signals. Within this collaboration a working group is devoted to the optimization of the performances of Csl(Tl) crystals, which will be used as residual energy detectors.

The optimal response of Csl(Tl) as a function of different working parameters has been studied. In particular the ion beam induced luminescence (IBIL) method has been used to analyze different Csl(Tl) samples under beam irradiation and to study their emission properties and radiation hardness. The PIXE technique has been used on the same samples to verify the Tl concentration, which resulted in some cases to be very different from the nominal value declared from the manufactures.

Moreover studies have been performed irradiating the samples with alpha and gamma sources to verify the trend in the light output and resolution as a function of different manufacturers and of Tl concentration.

**GARFIELD and FAZIA arrays**

Csl(Tl) crystals are widely used as scintillation detectors for gamma rays and charged particle in nuclear and particle physics because they have high light output, good energy resolution and mechanical stability. In addition, particle identification is possible via pulse shape analysis, due to the dependence of fluorescence emission on the kind of impinging particle.

**EXPERIMENTAL SET UPS**

Experimental set up

**Light Yield measurement analysis**

PIXE measured fluorescence spectrum:

Proton beams of 2.6 MeV have been used to induce on our samples X-ray fluorescence (PIXE) to get a measure of Tl concentration.

Analysing the α/γ ratio for the different samples both as a function of Tl concentration and as a function of shaping time, we observe smooth increasing functions, in agreement with the nominal Tl concentration values of the samples.

On the contrary, from the comparison of the relative light yield of the different samples we observe that sample n.3 (2000 ppm nominal Tl concentration) exhibits the higher light output for gammas, and a very good response also to alpha particles (slightly inferior to that one of the 4000 Tl samples), values which result in better agreement with the concentration measured by PIXE method.

**IBIL – Low Doping**

IBIL spectra of sample 1 (low doping) before and after ⁴He⁺ and H⁺ at 1.8 MeV

**IBIL – High Doping**

IBIL spectra of sample 5 (high doping) before and after ⁴He⁺ and H⁺ at 1.8 MeV

**α and γ spectra**

³²Co γ rays spectra for the different samples as a function of increasing Tl concentration

¹²⁷Cs γ rays spectra for the different samples as a function of increasing Tl concentration

Relative Light Output for the different samples to the ⁴He⁺ α-particles as a function of increasing Tl concentration.