PIXE characterization of CsI(Tl) scintillators for particle detection in nuclear reactions

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Introduction

CsI crystals doped with Tl atoms are largely employed in Nuclear Physics as charged particle detectors. Many modern arrays based on DE-E telescopes use CsI(Tl) crystals as residual energy detectors owing to their high stopping power and good energy resolution. The scintillation properties and the response to the various absorbed particles critically depend on Thallium concentration and its homogeneity.

The international collaboration FAZIA aims at optimizing the performance of commonly used detectors, in view of the construction of a new large array for heavy ion physics to be used, in particular, in exotic beam facilities. Concerning CsI(Tl), FAZIA plans to study the scintillation yield for heavy ions at high Tl concentrations.

To this purpose crystals (20x20x40 mm³ dimensions) with different Tl content were acquired by different brands and preliminary tested with a and g sources. Tl content and its homogeneity were also directly measured by PIXE.

CsI performance and Tl concentration

The crystals were preliminarily characterised by measuring the a/g ratio (ratio between pulse heights for a particles and gammas with the same energy). We used a three isotopes Am-Cm-Pu a source and a 60Co g source (acquiring also signals from a pulser for noise evaluation and stability corrections).

\[ \frac{a}{g} \text{ ratio as a function of Tl content} \]

It is evident that several of our values do not match the expected trend

Need of checking the actual Tl concentration à PIXE analysis on several crystals

PIXE results

The actual Tl concentration was obtained by processing the PIXE spectra with GUPXWIN, assuming a homogeneous distribution through the probed depth. Results showed strong discrepancies between nominal and actual Tl content; in addition, for some crystals, relevant differences between punctual and average values were also pointed out.

\[ \text{PIXE analysis at LABEC (Florence)} \]

3 MV Tandetron facility

\[ \text{External collimated beam-line} \]
\[ \text{2.9 MeV protons (≈ 85 µm range in CsI)} \]
\[ \text{Beam size } \pm 500 \mu \text{m} \]
\[ \text{Beam current 200-300 pA; 200÷1000 s runs} \]
\[ \text{Two silicon detectors for X-rays} \]
  * SDD with He flow
  * Si(Li) with absorber à 430 µm Mylar + 36 µm Al
\[ \text{Single-spot mode analysis. Average compositional information was also deduced by moving the sample over an area of about 1 cm²} \]

Sporious element contamination

Unexpected contamination of trace elements was found for some crystals, which had shown bad energy resolution for gammas and a particles, even though their surfaces and bulk appeared to be quite similar to the other devices.

\[ \text{PIXE concentration values measured by PIXE, we were able to reposition the } \frac{a}{g} \text{ ratios in the above chart. A good agreement with the expected smooth trend vs Tl concentration is now achieved for all our crystals} \]

Using Tl concentration values measured by PIXE, we were able to reposition the a/g ratios in the above chart. A good agreement with the expected smooth trend vs Tl concentration is now achieved for all our crystals.