Low Energy Proton Detection

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Using a CsI(Tl) crystal protons of 18.5 keV energy could be measured and completely separated from the noise background.

The neutron life time can be determined in an ultra cold neutron(UCN) trap experiment by measuring the protons from the neutron β decay(maximum p energy $(T_p)_{max} = 752\,eV$) using a large area p detector. Different detection methods using p induced δ electrons [1] and a Tl doped CsI crystal are being investigated. More interesting are thin scintillator layers connected to photo diodes or avalanche photo diodes, which are insensitive to γ rays and can be used in a large magnetic field.

δ electrons produced by p accelerated to, e. g., 20 keV, passing through a $4\mu g/cm^2$ C foil, were measured, after having been accelerated also to, e. g., 20 keV, with a 0.4 mm thick 2 inch diameter plastic scintillator contacted by optical grease to a photomultiplier tube(PMT, R329-02, Hamamatsu). The scintillator was coated with a thin Al layer, which was grounded. An incomplete separation of the signal and the background due to secondary electrons emitted from the foil and the foil holder resulted for a setup with only one C foil.

A complete separation with a signal/background ratio of better than 5 for 18.5 keV p was obtained by exposing a cube shaped 1 cm^3 Tl doped CsI crystal directly to the p with the crystal being contacted to the PMT by optical grease(fig. 1). The PMT quantum efficiency at $\lambda = 540$ nm(maximum light output of CsI(Tl)) is about 8%(fig. 2).

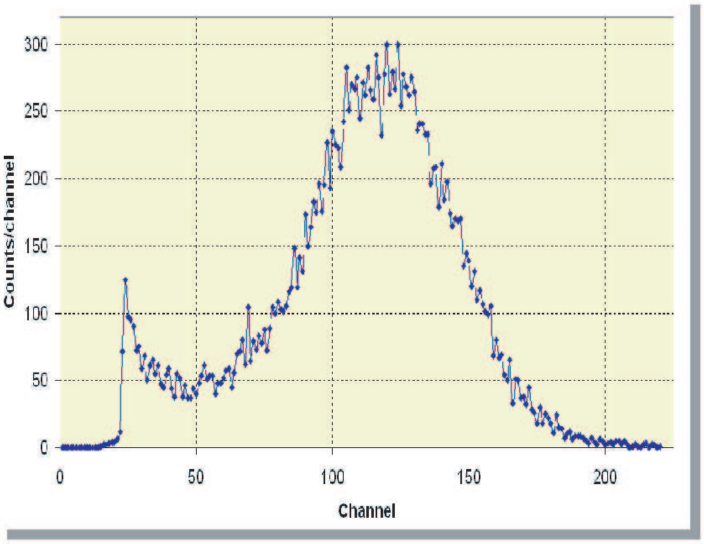

Fig. 1: Measured charge spectrum of 18.5 keV protons impinging onto a CsI(Tl) crystal with a 2 inch diameter photomultiplier tube

For the UCN trap it is planned to build a large area p detector by evaporating a 0.5 μm thick CsI layer onto a glas substrate being part of a light guide to the PMT (fig. 3).

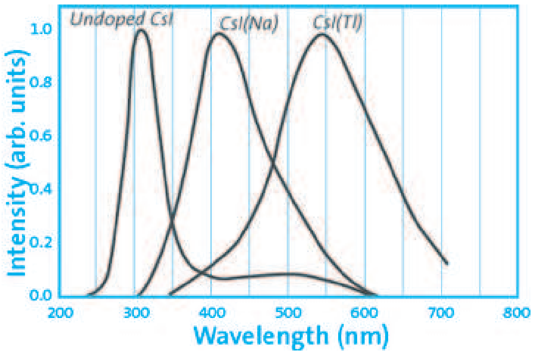

Fig. 2: Light output of CsI crystals vs wavelength

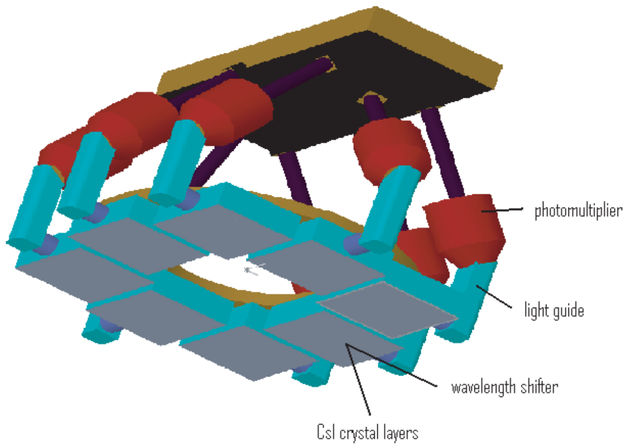

Fig. 3: p detector setup for the UCN trap

Undoped CsI with light output rising towards lower temperature(fig. 4) must be used for the UCN trap p detector being operated at 4.2 K [2]. The PMT quantum efficiency at $\lambda = 310$ nm(maximum light output for undoped CsI, fig. 2) is still ca. 15%.

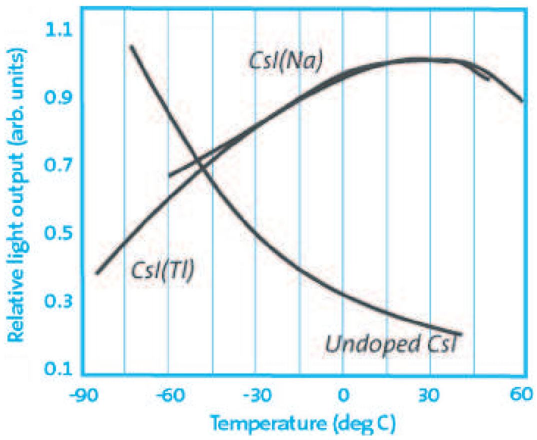

Fig. 4: Light output of CsI crystals vs temperature

References

[1] W. Carli et al., Annual report 2002, p. 108
[2] I. Altarev et al., this report p. 97