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Design and Construction of Multi-detectors System with 148 Pure CsI Scintillators (SCISSORS)

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As is described in other reports [1], the STB Tagger has been developed to produce real photons up to 1.1 GeV. The photon beam has interesting characteristics; a high energy resolution (ΔE = 3 MeV for the goal), and an energy range covering various meson production thresholds such as π, η, ρ, ω and K, all channels of great interest. One of the main projects using the STB Tagger is, thus, to study meson photoproduction and nucleon resonances. For this purpose and to extend our studies on η-meson photoproduction [2], we have designed and constructed a multi-detector system, which, mainly, aims at observing neutral mesons through a 2γ decay channel.

This is a cooperative development performed by the LNS and the CYRIC (Cyclotron and Radio Isotope Center, Tohoku University), and, hence, the detector system will be used not only at the LNS but also at the CYRIC where it will be mainly used for measurements of high energy gamma rays and π meson emissions in heavy ion reactions. Therefore, we considered the following points as strong restrictions for the detector system; (1) gamma rays with energy up to 1 GeV are measurable by each detector with a reasonable energy resolution, (2) each detector has a good time resolution, (3) the granularity of the system is small enough to obtain a good invariant mass resolution, (4) this is the first phase toward a 4π detector system (because of the limited budget), but the system covers large solid angles as possible, and (5) the system can be easily transfered and assembled from the one experimental vault to the other (a distance between the LNS and the CYRIC is about 8 km).

We have employed a pure CsI crystal as a scintillator because of its good features [3]; high stopping power, good energy and time resolution and good cost performance. A unit of the system is like a honeycomb, i.e., the structure of six-sided cells. It consists of 37 pure CsI crystals and the system of the first phase is composed of 4 units (148 scintillators). The system is called SCISSORS (Sendai CsI Scintillator System On Radiation Search).

In Fig.1 we show the structure of a pure CsI scintillation detector. As shown the crystal is in shape of a tapered hexagonal prism ; the length of a side is 27.5 mm in front and 42.5 mm in back and the

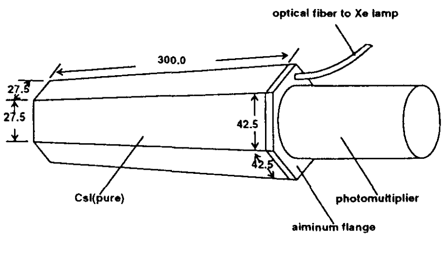

Fig.1. CsI scintillation detector.

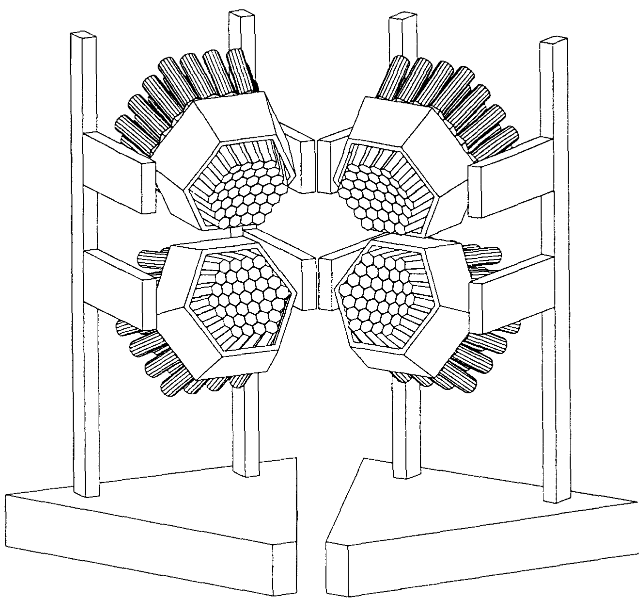

Fig.2. View of the CsI detector system, CSISSORS.

depth is 300 mm, corresponding to 16 radiation length. All surfaces of the crystal are polished to the optical grade and covered with a Teflon tape acting as a reflector. The crystal is inserted into a housing made of 1-mm thick Al plate, for the mechanical protection as well as the light shield. Since the main emission from a pure CsI crystal is 305 nm in wavelength, a photomultiplier (PMT) of EMI 9814WB, 2-inch tube with UV glass window, is employed. An optical fiber is glued on the crystal, in order to check gain stability of the PMT for a long term run.

Fig.2 shows an assembly of the detector system, SCISSORS. As shown, two units of the honeycomb are mounted on an arm plate which can rotate around the target. The distance from the target to the detector fronts can be adjusted, only for both units together. The angle to the horizontal plane and the height of the honeycomb can be adjusted separately. The taper of each crystal is originally designed so as to form a pseudo-spherical surface with 55-cm radius. Four units of detectors, then, subtend a solid angle of 0.96 sr.

The performance of SCISSORS is discussed based on a simulation by the code GEANT3. Although the energy leak from the rear is only 3% of the incident energy, that from the sides amounts to 15%, for a 1-GeV gamma ray bombardment on a single crystal. In this case, the calculated spectrum shows a peak at 820 MeV having a large tail to lower energies, and the energy resolution is only 150 MeV FWHM. Summing up the energies deposited in surrounding detectors is essential to improve the energy resolution. The total energy deposited in seven detectors (bombarded one and six surroundings) amounts to 90% of the incident one, and the energy resolution is really improved to 50 MeV FWHM. Thus, it can be said that the multi-detector system, SCISSORS, is expected to be a good detector to measure neutral mesons as well as high energy gamma rays.

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