Click to open our web site in your browser:
www.detectors.saint-gobain.com

Position Measurement

Detector Applications Information Note

In many applications, it is desirable to know where the radiation of interest originated or where it interacted with the detector. Position measuring detectors and systems generate information used to locate a source of radiation, to select foreground events, or to determine the density along the path of the photon from source to detector. The imaging techniques rely on position information derived from detectors with a point, line, plane, or volume sensitive geometry.

Discrete Elements, or "Point" Detectors

The point system is the simplest. Each detector defines an interaction region or an extended "point" in space. Radiation measured in each detector is assigned to the detector's position, and the spatial resolution is equal to the detector size. Examples are:

1. 4π Detectors

Spheres or cylinders of NaI(Tl), CsI(Tl) or BC-412 scintillator elements (or liquid cells) are used to cover 4π solid angles about a source. Our new BrilLanCe®*350 ($LaCl_3$:Ce) and BrilLanCe®380 ($LaBr_3$:Ce) materials would also be excellent candidates for this application. The discrete detector elements define the direction (θ, ϕ) of the radiation from the origin to the detector position. Often, these elements are truncated pyramids.

2. PET Detectors

Positron EmissionTomography (PET) requires a coincidence between discrete detectors to define a straight line. Each detector is an extended point in space. These straight lines are converted into a two-dimensional, cross-section image. Detector arrays of BGO or CsI(Tl) crystals are most commonly used. Some designs use bars of NaI(Tl) to replace banks of BGO detectors, thereby reducing complexity and cost. Currently, our new scintillators BrilLanCe 380 and PreLude®420 (LYSO) are gaining favor because of their excellent timing property and better energy resolution.

3. Scintillating Fiber Imagers

Plastic scintillating fibers are scintillator and fiber optic combined. These fibers are arrayed in layers to form the detector. Two layers aligned at 90° to each other give position information coordinates and define the intersection (interaction) point.

4. CT Detectors

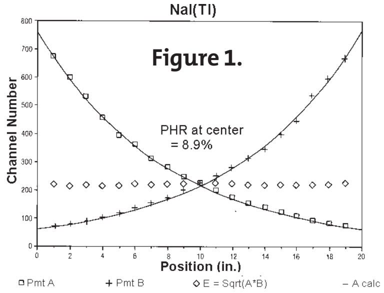
Computed Tomography (CT) systems view collimated beams of photons. The systems utilize $CdWO_4$ on photodiodes as discrete detectors. These detectors operate in a current mode and require higher radiation fields than individual photon counting devices.

5. Pixellated Detectors

Instead of a continuous crystal, scintillators can be made of an array of discrete pixels. These can be read out individually with an optical sensor attached to each pixel or by use of an imaging multi-anode photomultiplier tube. The data can then be used to generate an image.

Scintillator Bars, or "Line" (one-dimensional) Detectors

Scintillator bars of NaI(Tl), CsI(Tl) or CsI(Na) with signal readouts (e.g. PMTs) at each end can give one-dimensional position information. These so-called position sensitive bars are constructed by changing the reflective properties at the surface of the crystal so that an exponential attenuation of the scintillation light is achieved along the length of the bar for each photomultiplier tube (Figure 1). The approximate position resolution (PR) of such a device is the average pulse height resolution (PHR) times the 1/e attenuation length.



Two examples, both NaI(Tl) detectors:

Scintillator Size	PHR FWHM	1/e Length	PR
5 x 5 x 50 cm	14%	25 cm	3.5 cm
7.5 x 7.5 x 100 cm	8%	51 cm	4.2 cm

These PR values agree quite well with the measured FWHM values. (Note: these are not necessarily the best possible results. For example, the 5 x 5 x 50 detector can be optimized further with better PMTs to obtain 9% PHR. The PR would then be 2.25 cm).

Anger Cameras, or "Plane" (two-dimensional) Detectors

A detector which has a plane or sheet of scintillator (typically 9 mm thick), with PMT's covering one face, is called an Anger camera. Such a detector can give the two-dimensional coordinate of the radiation interaction point (or

continued on back...

SAINT-GOBAIN CRYSTALS

Position Measurement

continued from front...

region) in the detector material. The Anger camera is often used in nuclear medicine applications.

For example, the patient is injected with a tagged pharmaceutical, and the individual (or "single") emitted photons are detected. The line to the origination point of the photon is defined by a lead collimator. The position is calculated as the weighted mean of the coordinate (X or Y) where the weighting factor is the PH or PH squared.

Three-dimensional measurements in a volume have been attempted (proposed) for Anger camera imaging at higher photon energies. The X and Y coordinates are obtained as previously described for the 9 mm thick camera. The Z dimension (depth) is determined from a mean diameter of the light cone at the PMTs.

Table 1. summarizes detector configurations for various applications.

Table 1.

Material	Photosensitive Device	Construction Style	Design Considerations	Applications
$CdWO_4$ CsI(Tl)	Photodiode	Scintillator coupled directly to photodiode	Crystal and diode sizes, pitch	Computed tomography Luggage scanners
BCF-10 BCF-28	Micro-channel plate (MCP)	Clad fiber array	Optical isolation; MCP type/size	Neutron imaging
BC-408 BC-412	Photomultiplier tube (PMT)	Scintillator strips machined to have trapezoidal cross-sections	Overall length; PMT; light pipe	Neutron time-of-flight experiments
NaI(Tl), CsI(Tl) BrilLanCe, BGO, BaF_2, plastic	PMT	Truncated pyramids	4π, solid angle	Nuclear physics HEP
NaI(Tl) BrilLanCe	PMT	NaI(Tl) disk or sheet hermetically sealed in aluminum	Edge light collections; PMT pre-load; position sensitive PMT	Anger cameras Handheld imagers
NaI(Tl)	PMT	NaI(Tl) bars with PMT mounted on both ends	PMT; exponential roll-off; cross-section	Position sensitive detector bar

For additional product information, request the following SGC literature:

Plastic Scintillating Fibers Brochure;
Organics (Plastic & Liquid) Products Brochure;
Arrays (BGO, CsI, $CdWO_4$) Brochure;
Pixellated NaI(Tl) Data Sheet;
Individual Scintillation Materials Data Sheets.

All are available in print and as PDF files in web site library.

The data presented are believed to be correct but are not guaranteed to be so.
**Patent pending on BrilLanCe materials.*
BrilLanCe and PreLude are registered trademarks of Saint-Gobain

 (07-06)

SAINT-GOBAIN CRYSTALS

USA

Saint-Gobain Crystals
12345 Kinsman Road
Newbury, OH 44065
Tel: (440) 564-2251
Fax: (440) 564-8047

Europe

Saint-Gobain Crystals
104 Route de Larchant
BP 521
77794 Nemours Cedex, France
Tel: 33 (1) 64 45 10 10
Fax: 33 (1) 64 45 10 01

P.O. Box 3093
3760 DB Soest
The Netherlands
Tel: 31 35 60 29 700
Fax: 31 35 60 29 214

Japan

Saint-Gobain KK, Crystals Division
3-7, Kojimachi, Chiyoda-ku,
Tokyo 102-0083 Japan
Tel: 81 (0) 3 3263 0559
Fax: 81 (0) 3 5212 2196

China

Saint-Gobain (China) Investment Co., Ltd.
15-01 CITIC Building
19 Jianguomenwai Ave.
Beijing 100004 China
Tel: 86 (0) 10 6513 0311
Fax: 86 (0) 10 6512 9843

www.detectors.saint-gobain.com