Compton Suppressor Shields NaI(Tl) versus BGO

BGO and NaI(Tl) are the most frequently used materials for making Compton suppressor shields for Ge detectors. (These are also referred to as anti-Compton shields or ACS.) NaI(Tl) was the material of choice for most ACSs. BGO became popular later when ACSs needed to be reduced in size.

To help understand which material is better suited to an application, let us review the properties of NaI(Tl) and BGO in Table 1.

NaI(Tl) has nearly 5 times the light output of BGO, has a slightly shorter decay time and large detectors can be manufactured in one piece. BGO is denser than NaI(Tl), is somewhat slower and has less light output. ACSs made of BGO have to be assembled from several pieces.

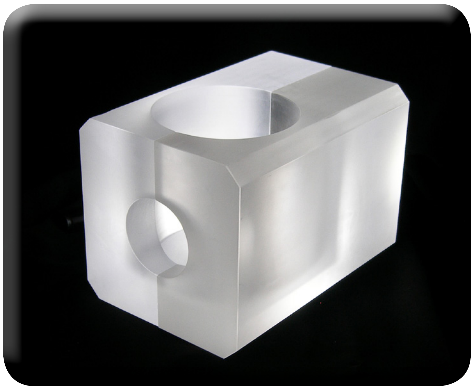
More light output means that the energy resolution for NaI(Tl) detectors is about 2 times better and that the threshold for energy discrimination can be lowered by a factor of 5. This translates into better sensitivity and higher efficiency for low energy photons for the NaI(Tl) ACS.

A shorter decay time means that the NaI(Tl) detector can be operated at a slightly higher data rate than the BGO detectors.

The only real advantage of BGO is its high stopping power due to its higher density and shorter stopping length – 1.0cm vs. 2.5 for NaI(Tl). Typically, a BGO ACS may be 125mm diameter by 150mm long. This is an important factor if it is desirable to have many detectors closely packed about a low yield source such as a reaction chamber for nuclear accelerator beam lines. The small compact size, however, limits, the choice of photomultiplier tubes.

A NaI(Tl) detector would be larger by about 2.5 times or 300mm diameter by about 350mm long. And there is quite a large choice of photomultiplier tubes.

SGC has designed ACSs made of BGO and NaI(Tl), which combines the stopping power of BGO with the sensitivity of NaI(Tl). These are designs in which a section of NaI(Tl) is placed to intercept the low energy back-scattered photons.



Material	**NaI(Tl)**	**BGO**
Density (g/cc)	3.67	7.13
50% attenuation for 662keV(cm)	2.5	1.0
Index of refraction (n)	1.85	2.15
Emission (photons/keV)	38	8
Decay time (ns)	250	300
Maximum size grown (mm)	700	75
Radioactive contamination	^{40}K	^{207}Bi

Table 1 Properties Comparison

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Such low energy photons could be below the discriminator threshold for BGO. The NaI(Tl) section is usually placed near the photon entrance end of the ACS as a nosepiece.

For low background counting applications, NaI(Tl) detectors can be quite clean except for a possible single gamma ray emission from ^{40}K at 1461keV. Natural potassium contamination is small in NaI(Tl) and is less than 0.5ppm by weight. BGO can have varying amounts of ^{207}Bi contamination. There are 5 gamma ray energies emitted from the decay of ^{207}Bi at 470, 1060, 1630 and 2400keV. These gamma rays can be quite a nuisance in the primary Ge detector especially because they are being produced by the ACS itself.

In summary, NaI is the best choice for an ACS because it has much better energy resolution and sensitivity than BGO. BGO is the best choice if compactness is most important. Combination detectors of NaI(Tl) and BGO are a good compromise for a compact geometry when extra low energy sensitivity if desired. For low background applications, there are fewer gamma ray emission energies in NaI(Tl) than in BGO.

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