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**Update**
Scintillation Detectors

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Distribution: WNC,NMC,PVD,BRF,RAH,JSL,WDMR,GT,DLW

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# Progress on Scintillation Detectors

Progress on the scintillation detectors for the CHARISSA project, comprising the notes for the CHARISSA meeting on 4th March 1992, plus additional information for the meeting on 29th April 1992:

1. **Tests on existing scintillators**

   Last year Gary Tungate and I bought 2-off 18 mm square CsI(Tl) scintillator/photodiode detectors (with 18 mm square PIN diodes and built in preamps). These have been tested with alpha particles ( $\approx$ 120 keV resolution) and with 50 MeV $^7$Li ions ( approx 700 keV with main amplifiers in counting room, approx 600 keV with main amplifiers next to scattering chamber); the problem at the NSF seems to be related to noise ( $\approx$ 50 mV) on the lines from the area 2. This is not large, but the preamp gain on the photodiode is only 1 mv/MeV for alpha particles, so 50 MeV $^7$Li are only 50 mV coming up the line! Optimum resolution ( for alpha particles) occurs for 2 ms time constant, but is still not too bad for 1 ms; I have a lengthy internal report on the alpha tests if anyone wants it.

2. **Inquiries about new scintillator for the new CHARISSA array**

   On 20/1/92 I sent letters to John Caunt Scientific ( agents for Quartz & Silice) and Southern Scientific (Bicron) decribing our ideas for the CsI(Tl)/ Photodiode detectors. The specification was 50 mm $\times$ 50 mm square crystals (10 mm or 25 mm thick) , window 6 $\mu$m aluminized mylar, packing at 60 mm centres, 18 mm square photodiode with built in preamp; all connections by simple PCB edge connector. I asked if the preamp gain could be raised from the 1mV/MeV that I have in the 2 Q&S detectors which have been tested so far.

John Caunt replied with lots of info from Paul Schotanus at Q&S in Netherlands — he is the expert! Paul pointed out that with a light guide, tapering $50 \times 50$ mm down to a 18 mm square diode we would probably lose 50% of the light, so our resolution for charged particles might be about 1.2 MeV at best. [ Paul Schotanus built some $48 \times 48$mm $\times$ 10mm thick detectors at Utrecht, coupled to 10mm diodes; he obtained a 18% light collection efficiency with a plastic light guide. These detectors gave 750 keV for 5.5 MeV alphas and 2.8 MeV for 34 MeV $^{12}$C ions, correcting for entrance window effects; since our $18 \times 18$ diodes would have twice the area, we could expect to (at least) halve these values]. Paul recommended preamps close coupled on the diode, he is investigating a higher gain (10mV/MeV) but says this might limit the count rate peformance since pulseheight $\times$ count rate is approx a constant. There is no problem biasing 40 diodes from one supply ( $3 \times 9$V Duracell!) nor any problem about supplying 40 preamps from one set of $\pm$15V supply.

Schotanus is unhappy about Q&S doing all the assembly work*, he feels he has a lack of manpower and that it would be too expensive, and he has suggested that they might deliver all the components to Birmingham , where we would do all the assembly and testing. Brian has suggested that we might get a CASE studentship to work with John Caunt/Q&S on this.

Trevor Nicholls at Southern sent me a quote from Bicron; they suggest the idea of using a tapered CsI(Tl) crystal to save any light loss at interfaces, I have passed this onto Paul Schotanus asking for his response. The disadvantage of this is that one has a detector which is capable of stopping higher energies in the middle. This might be an asset in some situations, but it might also yield a higher background count from neutron induced pulses and from gamma rays, to which CsI(Tl) is particularly sensitive My own feeling is that one should have a detector which is only just thicker than the highest energy one wants to detect; this minimizes gamma sensitivity. A thickness of 10 mm of CsI(Tl) will stop 52 MeV protons or 205 MeV alphas; 25 mm CsI(Tl) will stop 86 MeV protons or 348 MeV alphas. Of course we might want to detect gamma rays as well, so the tapered crystals might serve a dual purpose! Choice of crystal thickness also may affect our choice of preamp gain. I understand that most of these preamps saturate at about 1V so if we went to 10 mV/MeV we would have a maximum energy of 100 MeV (at zero count rate!), whereas the present 1 mV/MeV would give us a max of 1000 MeV. Bicron claim their preamp has a gain of 2.4 mV/MeV — this is for gammas and converting that for alphas is difficult, since it depends on the time constant, but I guess it works out about 1.6–1.8 mV/MeV, not much greater than the ones I have at present.

*But see item 3 below, for more recent opinion.

3. **Prices and orders**

Bicron have quoted a price for a one-off test piece of £1890 + VAT ; they expect the price for 40 off to be about half this — say £950 + VAT, making a total of about £45K. Q&S gave a quote of £1750 + VAT for the one off test piece. They are now much happier about this order, since they were under some misapprehension that they were being asked to build the complete hybrid detector! In the event, orders for one detector were placed with both companies in early April, delivery is expected within about 2 months. Since the ordering, I have had to get back to Bicron, who seemed to have got the wrong ideas, and proceeded to mount the whole detector inside a big rectangular can (!) with a large PCB sticking out at the back, so I have had to ask them to rework the design.

4. **Results from Paul Schotanus at Q&S**

Paul Schotanus has now tested the proposed design, a 50 $\times$ 50 $\times$ 25 mm thick crystal — i.e. a 10 mm thick rectangle tapering to the 18 $\times$ 18 mm$^2$ photodiode, and has tested it with different preamps. He expects a total light collection efficiency of about 30%. This is much better than with a similar crysatl on a 10 $\times$ 10 mm$^2$ photodiode where he measured 18%. The standard preamp gave a gain of 0.26 mV/MeV for alpha particles, whereas the new preamp gave 1.2 mV/MeV. The standard preamp has a maximum output of 1V and an output impedance of 1k$\Omega$ — this may be the cause of some of our noise problems when sending into long 50$\Omega$ cables. The new preamp has a maximum output of 4.4V into 50$\Omega$, but higher gain so the dynamic range is the same (3800 MeV for alphas).

The resolution was about 22% for 662 keV *gamma rays* for both preamps - this is about a factor more than 2 worse than we get with our present 18 $\times$ 18 mm$^2$ crystals coupled to the same 18 $\times$ 18 mm$^2$ photodiode. Paul Schotanus thus calculates an expected resolution of 400 keV for *alpha particles*, about a factor 3 worse than we get now. However, I expect to do a bit better than this, since my tests with our existing scintillators show that the response to alphas is very non-linear at low energies; calculating the resolution from the peak width/ peak height for a single energy alpha source gives about a factor two worse than one gets with a 3–energy $\alpha$–source.

Paul Schotanus recommends an 8–way ribbon cable with an earth wire on each side of the signal out. There will be a test input on each PCB.

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