CLAS-NOTE 2000-003

Report on Coherent Bremsstrahlung beam test

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Quick summary

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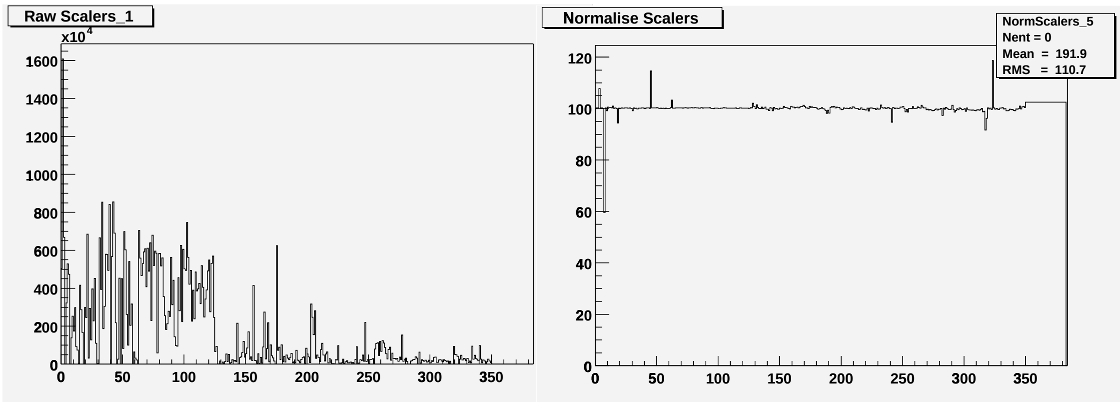
The beam test was moderately successful. We saw coherent peaks, and identified things which need to be fixed / improved in the future. The two main problems were the poor quality output from the tagger e counters, and a loss of position on the goniometer h-axis. The table is a blunt summary of what I think we achieved. (Shown in a bottom up kind of way.)

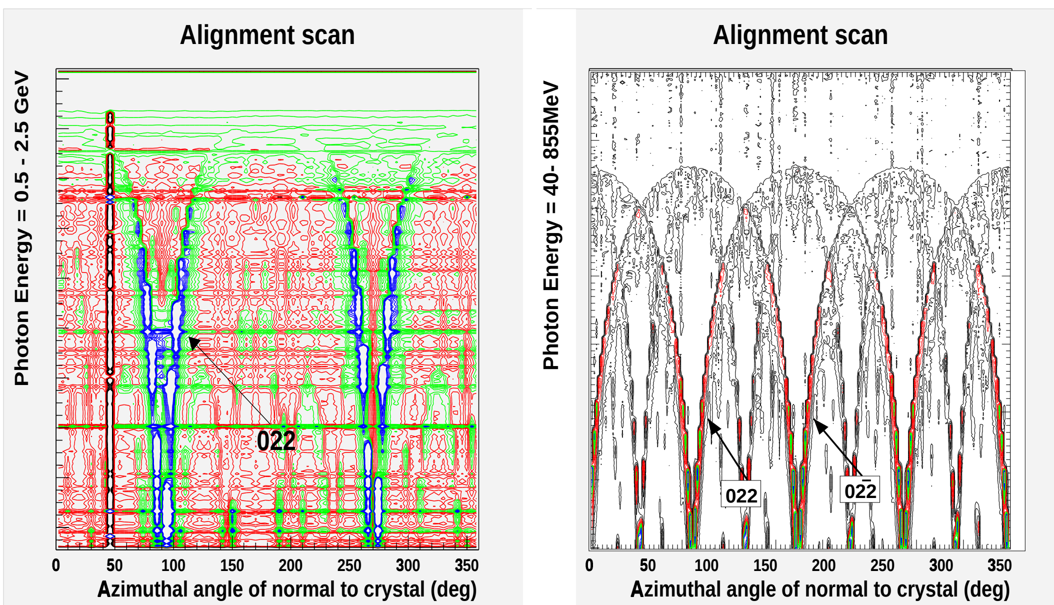
Item	Aim	Did we achieve it?
1	Communicate with EPICS channels from root based GUI	Yes, but in a crappy inelegant way
2	Control goniometer from GUI	Yes
3	Read e_scalers from GUI	Yes, but EPICS code may need improved
4	Obtain a relatively smooth tagger spectrum from e_scalers	No. Yuk. Really needs improving
5	Get usable spectrum of coherent/incoherent	Yes .. well, just about
6	See coherent peaks	Yes. Deep joy!
7	Show relationship between E_peak and crystal angle	Yes, but only on v-axis (YAW)
8	Align crystal	No, only found v-offset at default ϕ angle
9	Select polarisation plane	No
10	Test repeatability /reliability of goniometer	No, but obvious problems on h axis (pitch)
11	Get a working system for polarised photon experiments	A huge amount still to do

Some more detail

- First few hours spent trying to get uniform readout from e_counters. Got wildly non-uniform and non-consistent response, but decided to persevere anyway.
- Put in 50μ natural diamond. Carried out some hv scans. Unable to determine sensible set of offsets. Decided it was better to spend night trying to improve tagger scaler spectrum. The question was "What shall we do with a drunken scaler early in the mornin' ?"
- Here are some e_scaler plots taken with the amorphous carbon. The one on the left is 20s worth of data. It's jaggy. And, this is after ~20hrs adjusting HV's and discriminator thresholds. The plot on the right shows the 100 x the ratio of 2 amorphous spectra taken at about an interval of 1 minute. Ideally this should be a dead straight line at 100 counts. It's not too bad, but as later scans show, it is not particularly consistent, and this variation on the amount of *noise* makes alignment difficult, and will also make it difficult (or impossible ?) to measure polarisation by comparing with a code.

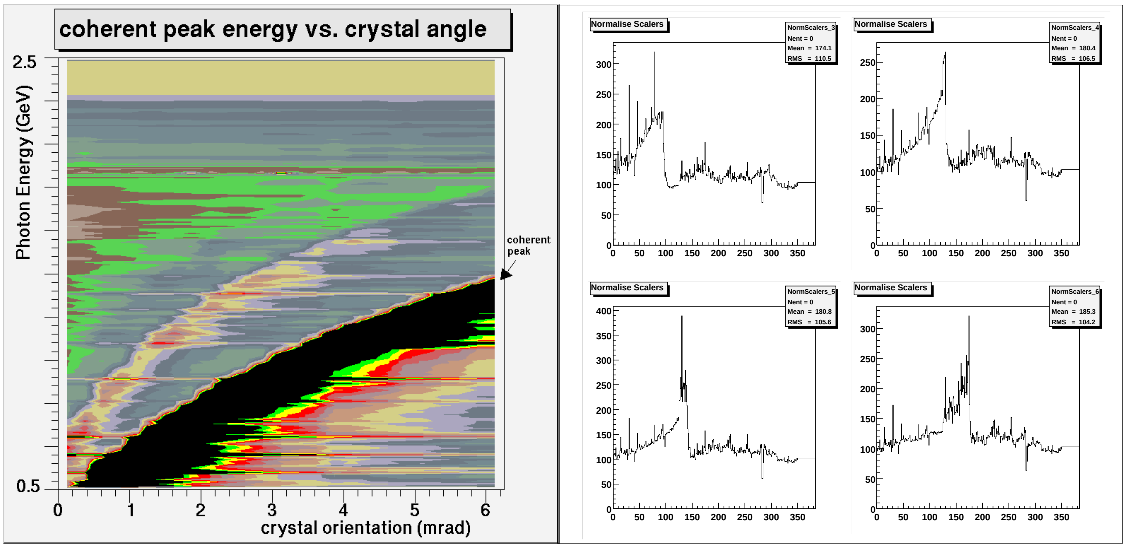


- Redid some scans on 50μ natural diamond. Quality of spectra was slightly improved, but still couldn't determine crystal orientation and measure offsets.
- Decided to use 100μ synthetic diamond, which has been seen to produce high quality coherent spectra in Mainz.
- Did hv scan. It's shown below on the left, and compared with a scan from a correctly aligned crystal taken in Mainz. As can be seen, the curve swept out by the 022 peak is very similar in both, but in the Jlab scan the $02\bar{2}$is not present. This indicates that we were far from the zero position on the h (pitch) axis, or the motion on this axis was not reliable or consistent.



- After trying several scans like those shown above, we eventually abandoned all attempts to do a complete alignment. During the process, the h-axis lost some steps somewhere, and while attempting to initialise it the -ve end stop jammed on.
- We were able to deduce the v-offset (a few mrad) and the default azimuthal orientation (˜ -3deg) from the scan shown above.

- The crystal was rotated (by +3 deg) to put the 022 planes in the vertical orientation, and the assumption made that the h rotation was far from zero. A few sample spectra were taken at small v angles to confirm that the offset seemed reasonable. A scan from 0 -> 6 mrad was made on the vertical axis. Here's the 2 histogram with some vertical slices. I suppose we could say that these represent the high points of the test time.



In the slices, the gradual slope on the left rising to a peak then falling sharply is the region of high polarisation from the [022] vector. A similar, but much smaller contribution from the [044] is just about visible higher up the spectrum. The spikiness of the plots is not due to statistics, it's due to the variation in the tagger output (noise, pickup, gain drifts, threshold drifts, whatever).

What needs done

Arne's has already produced a useful to do list covering the coherent brem and g8 in general. Here's my contribution. I think some decisions need to be made fast to allow work to be done during the august down time. Jim Kellie and I will come for a week at the beginning of august and do whatever we can then.

We're running with a detector that's has (almost) rotational symmetry around the beam axis. It is essential from the point of view of controlling systematic errors, that we run with a series of different orientations of the polarisation plane. This is straightforward in principle, but requires a full measurement of all the offsets associated with the crystal, beam and goniometer. So far we have only managed to measure a restricted subset of these, and could only produce photons polarised in the horizontal plane. This is the most pressing concern.

Goniometer Problems

1. Find the problem on h-rotation (PITCH) axis.
2. Fix end stop problem on h-rotation axis.
3. Install home switches on 3 rotation axes.
4. Re check reliability of all rotation axes

5. Measure the alignment of the goni; apparently it's not quite horizontally mounted.
6. Adjust the video camera position.

Tagger e counters

1. Check / improve the EPICS readout of the scalers. I think Arne's already working on this.
2. Improve the HV to get more flexibility. People have suggested various ways of improving this. Here's my quick, cheap and dirty contribution:

   (a) There are currently 96 separate HV's each feeding 4 tubes. Allocate 8 HV lines to each batch of 32 e counters by simple patch panels with banana plugs. The 8 lines can provide 8 different HV levels and each tube can be patched to the voltage closest to its ideal (as determined by Arne's automated software). Tubes which are really crap can be unplugged completely. This is roughly how it's done with the Glasgow tagger. Each time there is tagger maintenance some tubes are connected to higher HVs on the patch panels. The voltages on the lines are changed sometimes if needed. Batches of 32 can be still switched off remotely. It's not as nice as having individual HV's for each channel, but it would involve less cost, and less manpower (maybe?).

3. Discriminators. Ideally it would be nice to have CAMAC discriminators individually adjustable for each channel. Given the complicated role of the ADML boxes I don't know how this can be done. One possibility, is to have a block of high quality instrumentation for only 32 or 64 channels, and to make this pluggable to the section where the coherent peak (s) are. I favour this because it would be ideal to for gating the scalers (next item). Is it possible to T off signals from the inputs to the ADLMs to feed to a batch higher quality electronics?
4. Gating the scalers with a downstream detector will have 2 advantages: 1) It will clean up the spectra since a timing coincidence is introduced (provided real/random is kept low), and 2) It will allow us to see the effect of collimation. Both of these can already be done by reading the TDC's. However this requires a data acquisition system, which adds complexity and limits the rate. There is no need to have the whole tagger gated. Ungated scalers should be good enough to do any alignment. Once alignment is achieved only the region of the peak (s) needs to be monitored. This can serve 2 purposes: 1) Monitor the beam drift (peak intensity + position will change). 2) Measure the polarisation continuously online by fitting with output of analytic brem code. Both of these require decent statistics. If we have a 100% efficient photon detector with lower threshold set similar to tagger's lower range then:

   $$N \approx \frac{\epsilon R}{\tau}$$

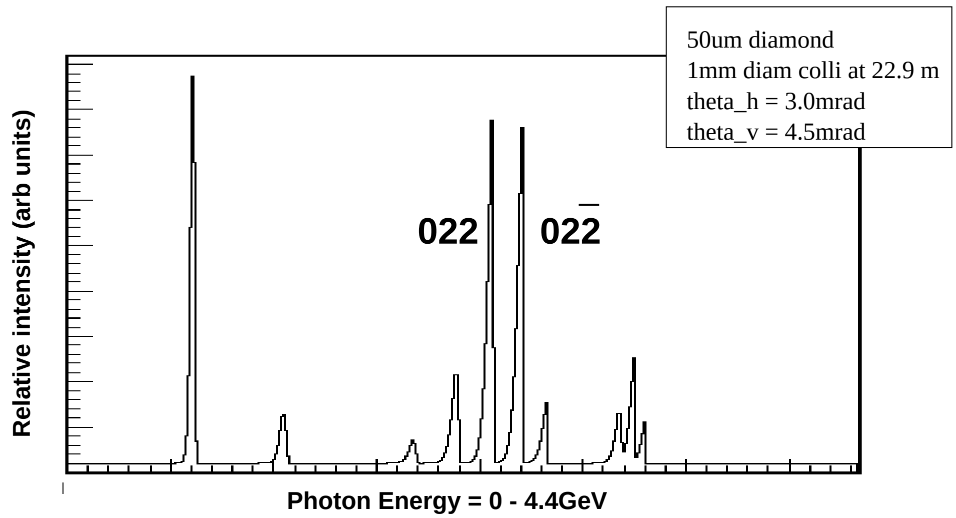
   Where: N =Rate of gates, ϵ =tagging efficiency, R =random/real ratio, τ =gate width

   If we require R = 0.01, and assume $\epsilon = 0.1$ and $\tau = 50$ns, this gives a rate of 20kHz.

   Spread across the whole tagger this is not particularly high. If the photon detector was a thin piece of plastic with an efficiency of 1%, then the figure would drop to 200Hz, which is hardly worth using. The best way to improve on this is concentrate on the 64 channels around the coherent peak. Use (say) a lead glass detector downstream of CLAS, with threshold set as high as possible. Delay the 64 signals of interest and align them to within a couple of ns (with programmable digital delays), feed them to the scalers which are gated from the Pb glass with a ˜10ns gate. This would allow continuous on-line monitoring with a gate rate of ˜100kHz on the scalers.

Collimation

1. **Active collimation**. Phil Cole is working on this over the summer.
2. **Feedback form coherent peaks**. (... and double your money). With the collimator design from Phil (0.5 mm radius at 22.8m), the coherent peaks are very sharp. So sharp, in fact, that two separate coherent peaks can be obtained with the appropriate angular settings. A simulation is shown below:



The two peaks have roughly the same polarisation, but orthogonal polarisation planes. This can almost double the statistics, and has the further advantage of providing feedback on the angle between the crystal and beam in 2 orthogonal directions simultaneously; ie another source of feedback on the beam position though the collimation. Ideally this would run with the scalers gated on (say) a lead glass detector downstream of CLAS. See previous section. I'd hope to test this when the collimator is installed.

Software

1. Normalise on beam current
2. Get analytic code to fit on line data and measure polarisation
3. Various improvements to user interface.

What next?

- Test time at 5.6 GeV might be available in July. I propose that we do not use this. We have already shown that coherent peaks can be produced, the next priority needs to be improving the tagger readout and fixing the problems with the goniometer. I can work on this in August, but it would be better checked out as soon as possible (ie next time the chamber can be opened).
- We need a fast decision on how, to improve the tagger e_counter readout. Who can make this decision?
- Another beam test. This should be after the goniometer is fixed and the collimator (active or passive) is installed, and there is some means of gating the scalers around the coherent peak.