ICANS IX

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SUMMARY OF INSTRUMENT SESSION - PART II

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Formal presentations on various instruments and techniques continued in the afternoon of Tuesday. There were several things covered there: Phil Seeger gave two talks, one discussing the low-Q spectrometer and the other giving an overview of the status of the rest of the instrumentation at LANSCE. That was followed by a presentation by Mike Johnson of a very innovative idea on the use of computed Tomography to extract inelastic information from total-scattering data. Then Yasuo Endoh discussed the status of the TOP spectrometer as well as talking about the current status of instruments at KENS. Mike Johnson talked about some of the future problems that can be expected for data acquisition systems as instruments become more sophisticated and sources keep improving. Then since that exhausted all the available time on Tuesday, we had a spill-over session in which the more wide-based discussions took place (that was on the Thursday morning); I will go on to that after a brief walk through the instrument presentations.

The low-Q diffractometer that Phil talked about is, I think, going to be a very exciting machine. It has been carefully designed to make good use of the available neutrons and a lot of care has been put into the shielding to avoid various problems which have been anticipated with the detector. Unfortunately they have only just got the machine together (not all the pieces are there yet) and there has only been a very small amount of running time; so the main experimental results Phil had to report on were that he has successfully measured (to one significant figure!) the gravitational constant at Los-Alamos, and that he measured the spectrum from the LANSCE hydrogen moderator. They found that everything that they were able to test did work.

Other instruments that are operational at LANSCE include the filter difference spectrometer which has been running successfully for a number of years. It's a quite high data rate instrument and uses the slightly different Bragg cut-off edges of Be and Be-oxide filters which are placed alternately around the sample. The sample has a large solid angle for scattering. There's very little Q-resolution in this machine but it's designed for a very high data taking rate or alternatively to measure from very small samples. This instrument has been going for some time and has been reported in some detail at earlier ICANS. There's a constant-Q spectrometer which has also been reported at earlier meetings. I guess it's best to say it's still in a development mode. They have measured phonon dispersion curves and it works more or less as anticipated. There are still various problems associated with this machine. There's a single crystal diffractometer which has been running fairly routinely for several years and that again is a standard sort of instrument. Then there are a couple of powder diffractometers, one of which - the high intensity diffractometer - has been running more or less routinely for quite a while. They have recently moved it to a larger distance, so there will be some work to get it going again.

I am now going to go on to Mike Johnston's approach: what got him thinking about this was the idea of computerised tomography. This has been around for a long time in terms of the various body scanning computerised tomography techniques. The idea in X-Ray computed tomography is to send some beams through a sample from several directions, each of which measures an integral of what is along its path. If you have enough of these different path integrals going across the volume you are interested in, you can deconvolute and end up with what's in each of the elements within the volume. Whereas for computed tomography for medical applications these are paths in physical space, X & Y, there's no reason why you have to restrict yourself to these sorts of paths. If you are looking at any other two-dimensional space, you can do a similar thing. For example, if you have a diffractometer with a number of detectors in it, then each of these detectors is actually measuring a path integral along all the elastic and inelastic scattering on some locus in $(Q - \omega)$ space. If each of the detectors is located at a different angle it is measuring along a different locus in $(Q - \omega)$ space, and if you move to sufficiently different angles you can get some of these loci crossing one another and build up a pattern of what's really happening in the elastic and inelastic scattering processes. In the region where you have enough of these crossings, you can figure out what's going on in individual elements of $(Q - \omega)$ space. He's done some (at this stage limited) simulations of this technique, starting out with some arbitrary inelastic contour patterns in $(Q - \omega)$ space. After grinding away for several hours on the VAX he came out with a reconstruction of the original patterns. There are a lot of things which still have to be looked at in terms of this technique. It was pointed out that possibly combining this with the correlation technique (this will provide a different sort of path integral and somewhat more information) might be the most efficient way to go. But that is something which has the capacity of eating up many hours of the VAX before it's clear how useful it may be.

The next paper was on the TOP spectrometer at KENS; this is a time-of-flight spectrometer for low energy polarised neutrons. They use a curved mirror to do the polarising and have the appropriate flippers and other polarisation handling and analysing devices; part of the paper was concerned with the development of some of these. The paper was primarily devoted to talking about the new data-acquisition system for this instrument. This system is based on using personal computers, so it's quite inexpensive and has turned out to be very successful for tackling the task. They have done quite a bit of software development on the system, so it has the flexability to present the data in a variety of ways and to control the various aspects of the experiment. Several different scientific measurements that have been made on this instrument were also reported.

The final formal presentation was on problems of data acquisition with future sources or future developments of current sources. Now, the most sophisticated and refined data acquisition system is that of ISIS. They have done a pretty careful optimisation, to build a system that can handle the size of data arrays that were anticipated along with the expected data rates. The problem comes when you have to go beyond this, because one of the first limits you find is that if you make data arrays significantly bigger than the present ones, you are going to start to involve hours to move them through the physical links in the system. If you can measure a spectrum in half an hour and it takes you two hours to get it out of the system and into the computer, you are not really in a good situation. So there has to be thought given as to how you can compress the data; how much you can compress on the fly; how much you can compress immediately after you get the data. This is a question which is far from being resolved.

That leads on to the spill-over section, where we had several topics; we started out talking about background and monitors and spent some more time talking about the state of the data treatment problem and got back to backgrounds. Let's talk about these separate topics.

Contrary to what has been said earlier, there is a fairly universal concensus that **NOT** every neutron is a good neutron. In fact, the only ones that are any good are the ones that have gone through the process you are intending to measure, and any one that reaches your detector by any other route is a bad neutron. In fact, most of what goes on in instrumentation is figuring out how to get rid of bad neutrons. Measuring the good ones is relatively easy; handling of the bad ones is the difficult problem. There was some general discussion of various background problems that people have encountered but there wasn't anything terribly unique. I think that as far as instrumentation was concerned, the message that came through was that you have to do everything right, in some sense, and pay attention to everything you should, use the right materials, worry over your shielding process. If the target and moderator people have made life difficult for you, then you have to do something for the beam before it gets out, such as using a chopper or a rotating collimator or sticking filters in the beam.

One of the things which is showing up is that, it seems fairly certain that - even when using He-3 detectors - in some situations you do have to worry about gammas, so you had better be careful about the shielding, the collimation, etc. from the gamma point of view as well as from the neutron point of view. People who have been working with scintillation detectors have recognised from the beginning they are going to have to worry about this problem. Depending on where your detector is this can mean direct target beam gammas or those from (n, γ) capture. In the low-Q instruments at ANL or LANSCE, some (gas detectors) are placed in the incident beam, and the direct γ's produce a measurable (significant) pulse. Probably a reasonable fraction of the overloading of the detector with the primary pulse comes from the gammas; cross-sections are similar to, if not higher than, those for fast neutrons for these detectors. We have found gas position-sensitive detectors are quite gamma-sensitive - calculations show that as well. You can do some electronic discrimination to help you out.

but it depends on how sophisticated it is just how far you can improve things, and even then you can only go so far.

There was a short discussion of technical details of gas detectors.

Moving onto the question of beam monitors. One problem found to be common to both Los Alamos and Argonne concerned using BF_3 for the low efficiency detectors to be used as beam monitors. It has, so far, been impossible to get commercial detectors with a specified efficiency. The monitors that are used at ISIS use a different technique: these have, I think, been reported before and involve using tiny beads of scintillator. These seem to work quite well.

One of the things that came out of the meeting was, that a monitor need which we are not sure is really being addressed, is that for small-angle instruments. You would like a beam monitor which sits downstream from the sample and can be operated at the same time as you are measuring on, and without interfering with the information from, your area detector (which means presumably you mount it just in front of the beam stop or somewhere like that). What comes out (neutrons and gammas) from the beam stop is a restriction, but this type of monitor would provide the capability of making transmission measurements concurrently with the actual scattering measurement, which would be very useful for small angle instruments.

- *It was pointed out from the audience that ISIS does in fact have a detector like that in place now; these monitors consist of a (normal size rather than beads) scintillator element array embedded in Boron Carbide, so the monitor is a beam stop, but the perfomance has not yet been evaluated. Some advantage may come because they use a beam bender for the instrument and operate this detector system outside the main beam.*

- *A LiF coated surface barrier detector was tried at Argonne that sort of worked until what was assumed to be fast neutron radiation damage wiped it out!*

Finally, on the data treatment problem there are really two problems caused by increasing data set size. If you expand much beyond what you have planned for in designing the system, transfers take longer than is reasonable. There is not only a problem for transfer but also of what-do-you-do with the data after you get it. The other thing is that for an instrument to be very useable, you have got to be able to see whether you are doing things right and to do this in a reasonable time (a reasonable time is thought to be about 5 mins). Some of the instruments produce their data in a very intelligible form, so that you can see what it is you are measuring. With a lot of others, this is not the case (for example many time-of-flight instruments) and you have to do some combining or other type of manipulation on the data in order to get anything which remotely resembles what it is you are trying to measure. When this process takes too long a time (as it will with very large data sets) it becomes much less satisfactory. This is a problem not so much for now, but certainly for the future.

At the moment, the data acquisition systems at ISIS and IPNS are at the opposite extremes. These are dictated by the planned level of intensity of the two facilities; ISIS was forced to go for high speed and so they don't do much operation on the data on-line. I think they do about as much as they can, but it does limit the flexibility of what they can do, for example, for data compression. IPNS, on the other hand, knew from the beginning it was not going to be a super-intense source and so were able to go for the opposite approach and do everything in software. Hence they have quite a flexible system and do quite a lot of data compression on-line, and their data-sets are not nearly so large. Some time in the future there has to be a marriage of these two approaches to keep data sets from growing. There remain the questions of: at what stage should one put in data compression? how much can be done on the fly? how much has to wait until everything is collected? One of the problems is that some of the corrections may be, for instance, wavelength dependent and you may have to collect all data before you can do any compression.