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# SUMMARY OF INSTRUMENT SESSION - PART I

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I am going to share this summary with my co-chairman Kent Crawford. We had the oral sessions on Tuesday and an ad hoc round table discussion yesterday morning. I will summarise the Tuesday morning session which was concerned mainly with what I would call conventional inelastic spectrometers.

We had three direct geometry chopper spectrometers which are all at various stages of development. First was the HET spectrometer, which we have heard a lot about at this meeting. The main components are the Fermi chopper and the large detector which is concentrated in the forward scattering direction. The Fermi chopper can work up to very high incident energies (there is one case where it was used up to 2 eV) and the versatility of the instrument comes from the ease with which you can change the incident energy (just by rephasing the chopper - in fact about three slit packages will cover the incident energy range from about 100 meV to 2 eV). The detector in the scattered flight path is in two main sections: in the forward direction between 3° and 7° there are $^3He$ detectors and then the high angle detectors, from 9° to 29°, which was a scintillator bank but since the last meeting we have decided to replace this with $^3He$ detectors. This is simply because the scintillator detector backgrounds were too high for the experiments we are trying to do with this instrument. Another thing that we learnt about is the effect of the Nimonic chopper (also called the background chopper). This is a rotating ultra-fast shutter, which lowers the level of the signal at short times so that it now approaches the detector noise level, and this has been a very important factor in at least two of our experiments. There is a vigorous scientific programme taking place on the instrument and I'd like to mention just three experiments; two are magnetic, in which we have measured high energy crystal field levels in $UO_2$, and the J=5/2 to J=7/2 spin orbit excitation in $SmPd_3$; both involved transition energies >100 meV. Currently the high angle (80° – 140°) is being used to measure momentum distributions in He-4.

Now for the ANL correlation spectrometer which is similar in principle to HET, but uses a cross-correlation technique where a "multi-energy" chopper replaces the "single-energy" Fermi chopper in the incident beam. This is a correlation chopper, which is a wheel with a series of open and shut slits and slots in what is called a pseudo random sequence; it is run asynchronously with the source. The advantage of this sort of chopper spectrometer is in the duty cycle. You are actually using simultaneously a whole range of incident energies rather than the single incident energy in the conventional spectrometer. What you actually do is you build up a two dimensional histogram - in one dimension you use the phase of the chopper and in the other the total time of flight; from this information you can actually pick out the spectra you would observe at a whole series of runs at individual energies, and you get all that information at the same time. We discussed the disadvantages of this sort of spectrometer; one is that the resolution varies quite considerably over the $(Q,\omega)$ space you are measuring although this is not seen to be a disadvantage in many of the experiments actually carried out. The instrument is probably most useful for measuring S$(Q,\omega)$ in liquids and amorphous solids, and that in fact is what it is being built for. For example, by integrating over all $\omega$ you can get a good measure of S(Q) and this does not require the complex inelasticity corrections of normal S(Q) measurements on a liquids diffractometer. There is a result from a very short run with Vanadium, which shows that the technique does in fact work and the spectrum contained just a hint of a very weak inelastic signal. It seems, at least in principle, that the method actually works and we look forward to further developments.

The third chopper spectrometer, the one at NBS, was described by Ian Anderson. Again a Fermi chopper is placed immediately before the sample, but an important feature is the double crystal monochromator which takes the beam out from the main tube, and this will improve considerably the background on this machine. The resolution is determined both by the collimation provided between the two crystal monochromators as well as the chopper open time. Pyrolitic graphite crystals give an excellent performance at low energies. The incident energy can be changed continuously between 2 and 20 meV. The elastic resolution is typically 20 $\mu$eV for 20′ of arc collimation and they are going to add a PSD at angles somewhere between 0° and 10°. A relevant question for the future is to ascertain whether the beam transmitted through the first crystal can be used by a second spectrometer, since this opens up the possibility of multiplexing beam lines. This will become very important at our sources as the beam tubes get used up. I am very conscious of this already at ISIS and I think the same will be true at other sources, so we should look carefully to see how this spectrometer works out over the next few years.

- *It was pointed out that this would be a very suitable instrument for use at the hydrogen source on SINQ: the double monochromator system would solve at least part of the background problem; and the energy range matches the neutron spectrum expected from the hydrogen source.*

- *This sort of spectrometer could also be useful at a conventional pulsed source. It is an instrument type being considered for ISIS and its actual performance will be of considerable interest.*

Now I come on to the inverted geometry spectrometers, and first ROTAX. Over the last five or six years, perhaps more, there have been a number of crystal-analyser spectrometers built at pulsed sources. They have been used very successfully for incoherent scattering but as yet there isn't a solution to the problem of doing coherent excitation work with single crystals. We have heard over the years about constant-Q spectrometers: the MAX spectrometer in Japan; the constant-Q spectrometer at Los Alamos; we have a spectrometer being built now at ISIS called PRISMA, which is rather similar to MAX; all these spectrometers have the problem of how to get a good constant-Q scan so as to try and compete in some way with the excellent performance you get from the triple-axis machine. We heard about an idea by Tietze and Geick in which if you actually oscillate or rotate the analyser crystals in a carefully phased manner, you can do scans which are at least intermediate between what you get on a constant-Q and a high symmetry spectrometer. It gives you more flexability, is what is claimed, in the $(\omega, \underline{Q})$ scans possible. It's a paper study at this stage and what is now needed is a development programme to build suitable drive mechanisms to rotate these crystals. Some of the scans require abrupt accelerations and decelerations of the crystal rotation and these may well be difficult to achieve; others require a simple monotonic variation of the analyser Bragg angles. I think we will have to wait a year or so to find out what can actually be done with this method. I think it is interesting and something one should actually pursue as this problem of doing the coherent excitation work with single crystals is still with us. We still haven't found a pulsed source equivalent to the triple-axis spectrometer.

> *At this point there was a short discussion about triple-axis machines which is summarised by saying, the triple-axis will not be replaced. It was also suggested that adequate attention has not yet been given to the focussing properties of time-of-flight instruments.*

Finally the Argonne eV spectrometer presented by Kent Crawford: this again has been with us for many years and is a method of doing eV spectroscopy using nuclear-resonance analysers; the prompt gammas emitted when neutrons are captured at a resonance (they use the 4.28 eV Tantalum resonance and a BGO detector) are measured, so that the energy at that resonance defines the scattered neutron energy. The resolution is determined by the width of the resonance. This spectrometer was designed mainly to measure low-Q processes; this means measuring at very small scattering angles so a major problem is to get good signal to noise conditions. Let me talk about another of the problems first: both the resolution width in the energy transfer and Q may be too large for many experiments and I'm sure that this problem needs to be addressed much more seriously than in the past. Nuclear resonance analyser methods are more easily applicable to momentum distribution work at high angles. The question that people should address more seriously is the suitability of the resonance detector and resonance filter techniques for low-Q spectroscopy. We have to decide at some point whether we are going to achieve the energy transfer- or Q-resolution we need to do interesting physics experiments. Even the possible experiments have not been defined as well as we would like; this, I realise, is partly because we are entering a completely new regime of physics. Progress has been made but it is taking lots of effort in all labs

- at KENS, LANSCE, ANL and ISIS. Kent showed some very nice results where the signal to background has improved as time has gone along, but I think we are still falling far short of the point where we can do actual experiments. Well, that's my view! Kent has also used the technique, developed by Phil Seeger, of using difference measurements with thin and thick resonance foils to improve resolution. The improvement you actually get is still quite modest; you typically reduce the width by about 10 or 20 meV in a line width that is closer to 100 meV (so you are getting a 20% reduction). You do get a much better line shape: it's a nice shape but still 80 meV wide!

*There was a long discussion in which the following main points appeared:*

- *The present resolution (80 to 100 meV) is possibly sufficient to tackle many physics problems. However, it is also likely that such resolution could be achieved using different spectrometers.*
- *There are ways of improving the resolution (further development of the difference technique, use of "better" resonances, use of cooling techniques etc); taken all together they could allow resolutions of the order of 30 meV to be reached (this caused the comment "That sounds interesting!"). The number of scattered neutron energies would nevertheless be limited. There are still more basic problems which have to be solved first, principally that of signal to background. If one is going to make the effort (and it does take some effort to do it), there is undoubtedly some nice physics to be done.*