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Summary Report for the Working Group "Needs for Target Systems and Instrument Materials, Beamline Components, Detectors, and Beamline Technology"

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Abstract
A discussion is given of about the needs for components and systems which are critical for future spallation neutron sources, from the target systems down to the neutron detectors and data analysis software. We first describe the data logging requirements for the neutron generation system, which are crucial for the diagnosis of the system. For the moderator system, the role of the intensity distribution at the surface of the moderator is discussed. By properly designing a neutron flight path, with or without an appropriate optical device, which takes into account the moderator intensity distribution, we will be able to optimize the whole system more efficiently. Normally, a neutron flight-path will have several windows along it, which are one of the sources of background. Some of the many ways of improving this situation are discussed. Also a discussion about chopper systems is given, particularly the phasing problems. Detector development is a key issue to the success of the future spallation neutron sources. There have been continuing efforts to develop new kind of detector systems, other than He-gas based detector systems, which are widely used at current sources.

1. Data logging for neutron generation for the diagnostic purposes
The diagnostic information pertaining to a proton beamline, such as, the proton beam-current, profile, and position, are usually recorded by an accelerator control and monitoring system, while the target and moderator temperatures are normally recorded by a separate target-control system, because of safety requirements. The monitoring of a target-moderator system based on the measurement of neutron spectra in an absolute manner by using a fission detector would be a very powerful technique from a maintenance and diagnostic point of view. Unfortunately, few facilities currently have a dedicated and reliable monitoring system for the target-moderator assembly. Very often they are maintained by a neutron-scattering instrument group and may be modified by the user's needs. An online measurement of the ortho/para ratio of a liquid hydrogen moderator would be an interesting option, although we do not know how to accomplish this.
For the logging system, we should use the same scheme for both the accelerator control and target/moderator control systems, and we should be able to record the data in and retrieve the data from a common database.

2. Moderator
Information about the intensity distribution over the surface of a moderator is useful in the design of a neutron spectrometer. With this information we would be able to take advantage of the distribution, and could design the spectrometer so that it looks at the brightest spot on the moderator. Despite of this obvious usefulness, we have little information about the distribution. It is known that there is an intensity variation in the vertical direction, but far less is known about the two dimensional variation. There are some efforts being made to measure it, but it is not yet satisfactory.
In order to make full use of the a knowledge of the intensity distribution, we could employ a single or multiple-grooved moderator concept. A single-grooved moderator combined with one of the optical devices would be a very promising option.

3. Neutron optical devices

The technology for fabricating super mirror material is still evolving. Nowadays, it is easy to get a super-mirror guide which has a critical-angle which is two to tree-times that of a Ni mirror (2-3 Q_c). However, there is a supply problem for this type of mirror material. As a consequence guide tubes with applications for thermal or even epithermal neutrons rather than solely for cold neutrons can be envisaged. For these applications, a mirror which has higher Qc is indispensable. While the development of 4 Q_c super mirror is underway we should however push this limit even further.

There are irradiation problems for a guide tube which is very close to a target-moderator-reflector (TMRA). For a such environment, super mirror material deposited on a metal plate is indispensable. The surface polishing technique for the deposition of super mirror onto metal has been available for a while, but it is a rather expensive procedure.

The combination or optimization of the moderator-optical devices should be exploited and in this aspect, the knowledge of the intensity variation over the moderator surface would be crucial for the optimization of the spectrometer.

Focusing devices, such as a toroidal or ellipsoidal-mirror will also be important. Mirrors which have a surface-irregularity in the order of the mrad range have been developed for the X-ray astronomy field. These mirrors can be used for the focusing device for neutrons. There are actually several examples of this kind of device and there are many future possibilities in this field.

One of the promising fields for a high-power spallation neutron sources is to be able to make everyday use of a neutron-polarization technique. A white-beam neutron polarization and analysis technique which would work for potentially any beam-line is a welcome option. A magnetic mirror method is one way of getting such polarized neutrons, but a dynamical polarization filter method using proton-polarizations is another. Nowadays, proton-polarization can be done at around liquid-nitrogen temperatures, and room temperature proton polarization is not a dream. A He-3 neutron-polarization filter technique has been developed at several laboratories around the world. Although this technique is almost at a practical level, one of the current limitations is its polarization-decay time problem. The development of He-3 polarized-neutron detector would be a very nice option.

4. Windows

Any neutron flight-path will have several windows along it, which are sources of neutron background, and thus we would like to avoid these windows if possible. For example, Al-windows have Bragg cut-off edges, and although it should be theoretically straight forward to correct for this effect, in reality, it is a tedious problem.

The window materials for a small-angle diffractometer should have a very low small-angle scattering background. Single-crystals of Si or sapphire are the candidate materials to reduce such effects.

While it is rarely mentioned it is the case that prompt-γ's are produced by Al-windows, and thus produce a background. This effect is especially serious for scintillation detectors and Zr-windows could be an alternative to Al-windows in such situations.

If the material used in a window cannot be changed, we could reduce the thickness of such windows. Nowadays, by means of finite element methods (FEM), we can design very thin membrane windows. For example, the chopper spectrometer MAPS at ISIS has very thin detector windows of 0.5 mm thickness, which can withstand a vacuum/atmosphere interface. Note that the size of the windows are 1 m by 1.8 m. Another example is the small-angle diffractometer SAD at IPNS. It has a membrane window for the scattering chamber for the small-angle detectors, in which the get-lost pipe is welded onto the membrane window so that there is no window at the main neutron beam exit position.

We could push this concept to the limit. It is obvious that no window is the best available solution and we could realize this by employing a plasma window together with fast acting shutter for safety if needed.

5. Chopper

Choppers are important components for future spallation sources and we need to develop a t_0 chopper system which has very fast opening time to cope with high-energy neutrons up to multi-eV neutrons. An alternative approach would be to use a filter such as single crystals of sapphire to avoid high energy neutrons, which would help in reducing the background produced by such high-energy neutrons.

For the fast chopper, the phasing of more than two such devices could be a problem. If we could have a master clock for an accelerator system, this problem becomes less important, but it is not clear whether this is a strict requirement or not.
Flame-overlap choppers or a mirror system are also indispensable.

6. Detector

Detector development is key to the success of the future pulsed-spallation neutron sources, but we did not go into detail for the detector part, because a "Detector workshop" was to be held shortly afterwards at BNL on 24-26 September 1998.

Our goal is to develop a detector system which will have, i) high-spatial resolution, ii) high-counting rate, iii) high-stability, and which is iv) low cost. The last item is important, since we have to cover a very wide area with position sensitive detectors (PSD). For example, in the case of MAPS, 16 m^2 is covered by He-3 gas linear PSDs, which cost $2M.

Although a few new breeds of detector systems have been developed during the last few decades, it seems that gas detectors are still the most widely used. There are several ways to improve this type of detector. Multi-wire gas chambers and micro-strip He-3 gas detectors are two of them. These have been developed and installed at several sites. There are also new kinds of detector under development, such as, (Li, ZnS) scintillation counter + CCD, a two-dimensional position-sensitive solid-state detector system, an amorphous Si + converter system and so on. A neutron image-plate detector which has a time-resolving capability of the order of a msec is also proposed and under development.

While the detector system itself is a key development issue, we can not forget about the software system. With the increasing spatial-resolution, together with a huge number of detectors, we are faced with a huge number of pixels but which contain dilute information. We have to develop a properly designed software system, or more generally an architecture, to handle this kind of huge data-set. Some sort of data compression mechanism should be built into the upstream of the data acquisition system. The human interface should also be properly incorporated into this architecture. For example, a real-time display-feedback should be built into such a system. For this kind of display device, high-energy physics and NMR-tomography groups have a lot of experiences and we should learn from them.