Los Alamos National Laboratory
Spallation Neutron Source

SNS DTL BPM
Final Design Review

Response to the Review Committee Report

Work Package Manager: ______________________________
Mike Plum

SNS-2 Group Leader: ______________________________
Mike Lynch

SNS-3 Group Leader: ______________________________
Kirk Christensen

SNS-4 Group Leader: ______________________________
Stan Brown

Physics Review: ______________________________
Jim Stovall

Project Office Review: ______________________________
Will Fox

Division Director: ______________________________
Don Rej

Work Package Manager:
The Work Package Manager is responsible for generating constructive and specific responses to the review committee's recommendations. Responses should be generated in a timely manner. Responses should incorporate the action to be taken, who is responsible for the action, the time frame by which the action will be completed if required before the Final Design Review, and any impact to the project cost, schedule or scope. Work Package Manager signature means that all responses having no significant impact on project cost, schedule, or scope will be incorporated into the design of the system. Responses that involve a significant impact to project cost, schedule, and scope must include a description of the impact and be approved prior to implementation by the Project Office.

SNS-2 Group Leader:
Reviews responses for overall technical merit, cost effectiveness and reasonableness for implementation. Reviews responses relative to interfaces with other accelerator systems and for potential impact to these systems.

SNS-3 Group Leader:
Reviews responses for overall technical merit, cost effectiveness and reasonableness for implementation. Reviews responses relative to interfaces with other accelerator systems and for potential impact to these systems.

Physics Review:
Reviews responses for impact to physics design.

Project Office Review:
Review responses for impact to project cost, schedule and scope. Approves or disapproves responses which impact project cost, schedule or scope prior to their implementation.

Division Director:
Provide final review and approval of responses prior to distribution.

Responses to the Design Review will be distributed to:

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J. Stovall
W. Fox
D. Rej
M. Gardner
SNS Division Office File
SNS Document Control Center (Oak Ridge)
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The SNS DTL BPM Final Design Review was held at LANL on September 19, 2001. The scope of this review was limited to the DTL BPM pickup, since that was the only portion of the BPM system ready for a final design review, and a review of this component was necessary to accommodate the DTL tank 3 assembly schedule.

We received the review committee's report on October 19, 2001. We thank the review committee for their insightful observations and suggestions, and their timely response. In this document we shall address each observation and suggestion.

Observations and Suggestions

Committee Recommendation – As was discussed in the meeting, they might be well advised to devise some scheme such as a soft vacuum to enable the facility to operate if one of their BPM units develops a leak. (It also might not hurt to have such a capability for other items too!) *Browman*

LANSCE has an extensive retrofitted cryo-pumped "soft vacuum" system which pumps the sealing surfaces between the drift tubes and main RF tanks, and has also contracted with National Nuclear Corporation in the UK to license their technology of clay-epoxy leak sealing for water to air or water to vacuum leaks. This technique has been successfully used at ISIS and CERN. *Borden*

Response – LANL's SNS Linac vacuum system design team explored this issue over the preliminary and final design phases of the DTL and CCL vacuum systems. The LANSCE soft vacuum system was inspected and its design was discussed in detail between SNS and LANSCE vacuum system engineers. In addition, the SNS BPM designs were carefully reviewed by SNS LINAC vacuum engineers and revised to provide for safe and acceptable vacuum operation. The LANL SNS LINAC Vacuum System design team decided that a soft vacuum system on the DTL drift tubes was not warranted. The cost of such a system was excessive and the design of the DTL drift tubes and BPMs were determined to be adequate for long term operation in a vacuum environment. It is believed that if a BPM were to develop a leak, retrofits could still be provided to allow continued operation of the DTL.

Committee Recommendation – At least one entire BPM system really ought to be constructed (all the way to a position output on some computer system) so the dynamic range; linearity, stability, calibration and temperature dependence of the system can be documented using the standard wire techniques. If this is impossible, the total error budget (see Gilpatrick's efforts along these lines for suggestions) should be constructed to get a feel for the position sensitivity attainable. I suspect that the hoped for 100 microns may well be quite optimistic.

It would be unfortunate, however, if at least a millimeter absolute could not be obtained, since my experience is that at or near this level the halos of the beam are affected. *Browman*

Response – We agree. We plan to test at least one system all the way from the detector to the user interface. Tests of the dynamic range, linearity, and stability will be included.

Committee Recommendation – A walked-thru assembly checklist appears to be critical for proper assembly of these units. Cable location inside the BPM is particularly a concern during final welding. Final welding of stem parts may cause significant warping of the unit. Several tests should be conducted prior to committing to all of the drift tubes. *Borden*

Response – We agree. The DTL BPM Quality Assurance Plan includes the assembly steps and the tests that will be performed at each step. The first two drift tubes, for DTL tank 3, will be thoroughly tested for welding and warping problems.

Committee Recommendation – The attenuation calculated between the enormous fields outside the drift tube and the modest fields in the BPM gap are quite impressive. I don't know exactly what this attenuation ratio depends on, but it might be appropriate to ensure that the system could handle, say, 10X the calculated 400 MHz gap voltages without accuracy degradation in case the actual field shape outside the drift tube differs from the shape assumed in the calculations. *Browman*

Response – The Mafia simulations we ran yielded a cavity field interference level of much less than 10 mW (10 dBm). If the actual level is 100 mW (20 dBm), this should not be a problem. With the cable loss of 6 dB we would see 25 mW at the analog electronics input, which can easily be handled by the rf switches and bandpass filters.

Committee Recommendation – Initially I was worried about the choice of polyethylene near the beam line due to its rather limited temperature range, however the presenters satisfied me that the operating temperature of the drift tubes was very modest so this should present no problems except, possibly, during beam spill conditions. I feel that long term deposition of a few tens of watts of beam power is probable, but not as much as 100 W. I would suggest that a quick calculation of the ΔT expected for about 10 W might be useful, although I expect that the calculation will show the effect is negligible. *Browman*

Response – The recommended calculation was done using the model shown during the review (the model used to calculate the drift tube operating temperature). An additional load of 10 W was applied to the electrode portion of the BPM. The analysis assumes steady state conditions. The peak temperature *occurred at the electrode end and was 307 K (93 F). This is slightly higher than the predicted peak operating temperature of 300 K.*

An additional load case using 100 W applied to the electrode portion of the BPM showed a peak operating temperature at the electrode end to be 367 K (201 F).

Since the possibility of beam spilling onto the electrode is very real, and our ability to predict the amount of beam spill is limited, it was decided that the prudent course of action was to change the dielectric within the connector nearest the beam line a poly-imide material. Cost and schedule impact was minimal.

Committee Observation – The BPM internal insulating components have been designed with radiation resistant materials. If beam tuning and spill limits are maintained these materials should last the lifetime of the facility. *Borden*

Response – observation noted.

Committee Recommendation – It was not clear to me how important the beam phase measurements were to this project. I fear that determining the absolute phase of the beam with long-term accuracy of 1-2° will be very difficult. If this is important, I suggest that the possibility of measuring the phase of the 400 MHz RF (using this apparatus-same cables, front end, etc.) be investigated, since it might well be more accurate to compare the relative phases of the RF and the beam using the same apparatus. One might also need to determine (at least roughly) the shape of the beam in order to achieve these accuracies. *Browman*

Response – There are no requirements or plans for absolute beam phase measurement. We plan to process the BPM signals at a frequency that is not the same as the adjoining cavities at this time. Measurement of the absolute beam phase would require processing the BPM signals at the same frequency as the cavity, and adding an additional "BPM" processor to measure the cavity phase from a cavity pickup signal. This cavity channel could be properly calibrated with the same technique as the BPM phase, as long as the cavity pickup is designed to limit the power to something near that of a BPM lobe, or about 0-3 dBm.

Committee Observation – The BPM pickup seems rugged, conservatively designed and well thought out. *Browman*

Response – observation noted.

Committee Observation – The construction of these devices is quite complicated, but I see no reason why their performance should not be perfectly stable once they have been fabricated and tested. *Browman*

Response – observation noted.

Committee Observation – The team seems to me to have thought quite thoroughly about the problems of building these devices and I think they should go ahead and start construction and testing. I do see, however, that considerable work lies ahead after the BPMs are built before they can be integrated into a satisfactory system. *Browman*

Response – observation noted.

Committee Recommendation – Helium leak check the welded assemblies prior to water pressure testing. Water may freeze in small leaks during vacuum leak checking and pass a helium test. The helium leak test note on design drawings lists 10^{-3} Torr as being an acceptable vacuum. I would insist that this be at least 5 X 10^{-5} or 1 X 10^{-6} Torr gauged at the output of the BPM. *Borden*

*Response – The drawing note only references the calibrated minimum sensitivity of the leak detector (2.0 * 10^{-10} std cc (He)/sec). I believe the note in question was the vacuum integrity check in the DTL BPM QA plan. This note was developed for the drift tube manufacturing specification by the SNS-3 drift tube team. We used the note to be consistent with the other groups within SNS. The offending passage has since been changed to read as follows:*

*"**All leak testing shall be done using a Mass Spectrometer Leak Detector (MSLD) calibrated to a minimum sensitivity to Helium of 2 x 10^{-10} std cc/sec and the part being tested will be pumped down to a pressure of at least 5 x 10^{-4} Torr or lower."***

*We contacted Scientific Sales Associates in Albuquerque (SSA) a commercial vendor who specializes in vacuum leak checking. SSA stated that the vacuum level achieved during testing depended upon the particular part under test, it's size, materials, time available for pump down, etc SSA was actually recently involved in the leak checking of our DTL BPM prototypes. While leak checking our parts, SSA pumped the BPMs down to the 1*10^-9 Torr range. Since lower levels are achievable with our parts it makes sense to change the specification.*

*We will change our specification according to the committee's recommendation of at least 1*10^{-6} Torr.*

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Committee Recommendation – Define how the water is going to be removed after pressure testing and consider anti-freezing the cooling passages prior to shipping. Trucks travel over mountain passes in winter, many-many accelerator components have been ruined by forgetting this step. *Borden*

Response – The issue of water freezing within the water cooling passages of the drift tube was discussed with Rick Martineau, who is responsible for the mechanical design of the DTL. Rick stated that LANL is requiring the drift tube vendor to remove the water from the cooling lines by "blowing out" the lines with pressurized air. I discussed the committee's comment with Rick and he stated that there are currently no plans to use anti-freeze in the cooling lines during transportation of accelerator parts.