Notes from Neutron Beta Decay "Common Magnet" Meeting

North Caroline State University, January 8, 2006
(Compiled by Geoff Greene with help of many workshop participants)

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Geoff Greene

The primary goals for the meeting were identified as:

1) To respond to the PRAC recommendation regarding the feasibility of a common magnet for the three proposed neutron beta decay experiments at the SNS.
2) To organize ourselves in a fashion that will allow us to move the process forward.

In addition to these high level goals, a number of issues were raised that must eventually be considered as part of the magnet design process. These include:

- Development of a conceptual design
- Develop a plan for funding
- Schedule – initial goal is to have a working magnet should in 2009
- Fringe field - According to the SNS magnetic field policy "Policy on Magnetic Interference" which sets stray magnetic field variations on the sample location. The stray field from the spectrometer magnet on the dividing line between neighbors should be less than 50 mGauss. Note that fields can exceed this but must be specifically approves after detailed discussion of impact on other experiments. Dipole field dies out as r^{-3} and thus an active+passive shielding could do the job but this needs to be verified – not the highest priority.
- Floor space in FPNB allows only a vertical magnet orientation – digging a hole to the floor is possible but needs to be addressed by the FNPB project team.
- Warm or cold bore for the magnet.

As a result of the discussion it was agreed that the design group coordinator should be Geoff .
Provisionally we will work under that assumption that the magnet will be procured as a piece of capital equipment by ORNL. However, this funding model may change depending on agency requirements.

David Bowman

A comprehensive presentation outlining the expected statistical uncertainties and the main sources of systematic errors involved in the measurements of the neutron beta decay coefficients, with special emphasis on the *a* and *A* coefficients. The implications of the identified systematic errors on the magnetic field configuration were discussed in detail.

The major sources of systematic errors were:

1. Back-scattering of electrons at the detector surfaces and its implications on the timing resolution. This would be addressed with the on-going Monte Carlo simulations.

   There was extensive discussion about this issue concerning the size of the effect. It was pointed out that one has to be careful about distinguishing between the chance of backscattering for perpendicular particles as opposed to that from a realistic distribution of angles. Also, the effect of the theta-pinch on back-scattered particle significantly reduces the fraction of particles that reach the second detector. Detailed simulations are clearly needed here, perhaps using PENELOPE as well as GEANT.

2. The mapping of the magnetic field in the decay and expansion region. The required precision needs to be quantified in more detail. A strategy needs to be worked out for mapping the field.

3. Trapping of electrons -the symmetric field in the decay region (from the split pair) can produce electron trapping and a slightly non-symmetric configuration can address it.

4. The largest source of systematic error on the requirements for precision neutron polarimetry comes from beta-delayed neutrons from the SNS. This has to be measured in a commissioning run.

It was also pointed out during the presentation that the spectrometer needs for the *Nab* and *abBA* experiments are compatible.

The presentation finished with a detailed discussion on the neutron depolarization in the RF spin flipper and in the zero in the spectrometer field. This can be addressed with an additional perpendicular magnetic field of the order of 1 kG around the zero of the

spectrometer field. Though this needs to be simulated carefully because the situation is much more important off-axis.

Dinko Pocanic

1. As a result of the work done by the collaborations since the first PRAC meeting in September 05 the design of a common magnet for the *Nab* and *abBA* experiments is approaching a first "Physics Model." But many details remain to be worked out.
2. A strong effort is underway at Virginia to address the main sources of systematic errors with a code based on GEANT4.
3. We should work on how best to divide the tasks ahead and work to converge on a schedule of activities.

Scott Wilburn

The presentation outlined the required profiles for the electric and magnetic field. The design requirements for the *abBA* magnet were presented in terms of magnetic field strength, field homogeneity requirements, magnet length and its connection with detector timing resolution, and the required bore magnet dimensions.

The presentation also included simulations results for neutron depolarization and the solutions being investigated.

Geoff Greene

On behalf of Tim Chupp the requirements for the PANDA magnet were discussed. The requirements for the magnetic field are a uniform field of 1-2 T. This should be attainable in a reasonably straightforward way in any of the Nab or abAB designs. The electric field requirements are different (and in principle probably more demanding) that those of the *Nab* and *abBA* experiments.

Ricardo Alarcon

A baseline design that the collaborations have been working out since the PRAC meeting was presented. This design is based on a set of design requirements that include magnetic field strength, magnet dimensions (diameter and length), homogeneity field requirements, and the demands imposed by the dimensions of the decay region and the transmission of a polarized neutron beam through the magnet.

The baseline design consists of a 20-cm diameter split pair followed by a pair of 25-cm diameter, 2-m long solenoids. The design accommodates the required field strengths and field expansions up to 18:1. The decay region is a conservative 10 cm gap with no magnetic elements. The homogeneity requirements in the decay region are satisfied for 4T and 2T fields, with the latter almost an order of magnitude better. A uniform magnetic field for the PANDA experiment is feasible in the region of varying electric field.

The discussion generated the following short-term tasks to be investigated in the design:

- A uniform diameter for the split pair and the long solenoids.
- Relax the Helmholtz condition on the split pair and evaluate its effects on homogeneities.
- Make a first pass at the fringe fields and how to shield them to meet the stringent SNS requirements.

Geoff Greene

In summarizing the meeting it was agreed that there is a positive response for the PRAC to the question of a common magnet. Geoff pointed out on the need to move forward being very vigilant about the fact that compromises will be a reality as we are dealing with different experiments, issues of affordability, engineering feasibility, and operational feasibility.

The action items put forward were:

- Send minutes to Geoff as soon as possible (notes were taken by Dinko, Ricardo, Scott, and Seppo). DONE
- Prepare for the FNPB review on February 9. Dinko will make a 10-minute presentation on behalf of the collaborations.
- Work on a draft for a "Functional and Operational Requirements" document. Ricardo was charged to produce this draft on a 1-month time scale.
- Keep working on the Conceptual Design.
- Launch simulations based on the Conceptual Design. Iterate and evaluate changes to the Conceptual Design.

The issue of when to approach manufacturers to get a cost estimate was discussed. It was felt that a feasibility consultation was more appropriate in the short term.