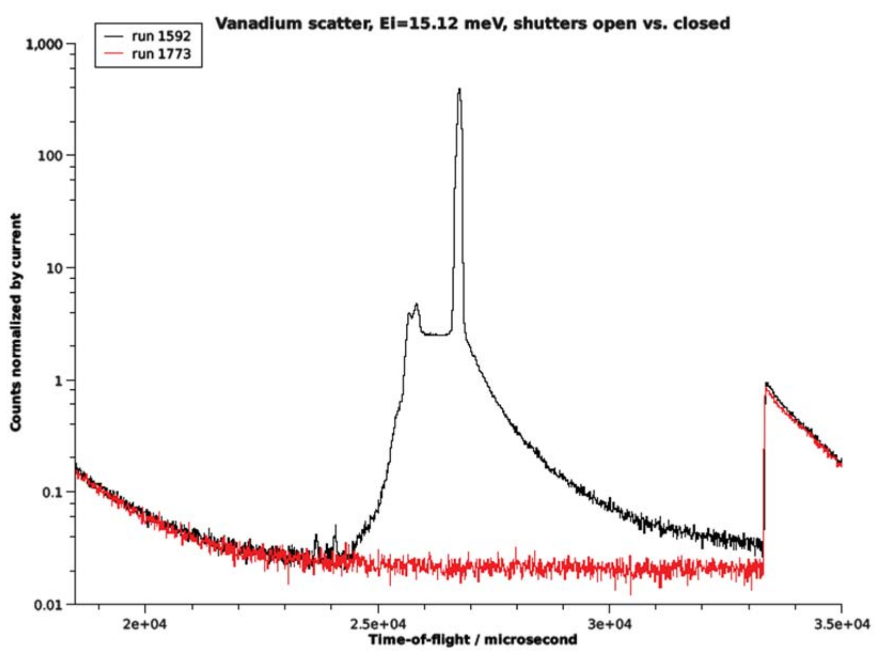
HYSPEC Status, January 25, 2012

At the IDT Executive Committee meeting on October 26, 2011, we reported several problems / challenges that we needed to work on to get HYSPEC fully running. Below is a quick report on each of these issues.

1. Background

   Observations: A time dependent background feature that we call the 'prompt pulse' has a count rate that is comparable to expected inelastic count rate in some regions of the time window (see below). The leading edge of this feature coincides with the proton beam incident on the mercury target, and has a tail that extends ~4 milliseconds. Shown below is a vanadium rod measurement with Ei = 15.12 meV, integrated over our entire detector array. The vanadium rod has a diameter of 6.35 mm and roughly 20 mm along the axis was illuminated, corresponding to ~4 g. Note the intensity scale is logarithmic, so the maximum of the "prompt pulse" is ~400x weaker than the vanadium elastic line, and ~4x weaker than the acoustic phonon peaks in the vanadium density of states. However, if this background term can be eliminated, then the intrinsic background on HYSPEC would be ~17,000x less than the incoherent elastic line from the vanadium, which is the sort of level desired for polarized inelastic neutron scattering from weak single crystal samples. Note the "prompt pulse" neutrons have energies that are "epi-cadmium", which is relatively high energy, but ^{3}He has approximately ~1 bn of cross section even at 1 MeV, and has some sensitivity to high energy neutrons.



   Actions taken: The observation of a slight reduction in count rate of this feature, when the detector vessel is closest to our equipment lift, led to the remarkable finding on November 28 that closing the primary shutter shared by POWGEN and MANDI (BL 11) caused this feature to drop by ~70%. From radiological measurements, and also measurements with an array of 8 ^{3}He detectors, it became apparent that the neutrons appear to originate at BL 10 near the monolith, and then scatter throughout the north side of the target building. This is an unused beamline, which has a temporary core vessel insert, shutter and shielding. We believe that neutrons 'leaking' from BL 11 through the weaker shielding on the BL 10 side. We suspect that the remaining ~30% of the prompt pulse background comes directly through BL 10. Note that none of this is radiologically hazardous; HYSPEC has a very low intrinsic background and is sensitive to this source.

Our Neutronics group has modeled the radiation in this area, both with and without some proposed extra shielding in the BL 10 cavity near the monolith. Radiological levels, most of which are due to neutrons, are expected to drop by 100x with this extra shielding installed.

Current status: Additional shielding will be added to the beamline 10 cavity before the next SNS operations cycle begins. We anticipate this extra shielding will remove this background term.

2. Neutron flux at sample

Observations: The detector array count rate of the neutron beam scattered from vanadium at our sample position were less than we expected from McStas simulations by a factor of ~2x-4x.

Actions taken: For comparison, we have performed with our Neutronics group a gold foil activation measurement. The preliminary finding is that these measurements seem to be consistent with the detector array measurements, and indicated a flux of ~4E5 n/cm^2/s/MW at the sample position, when Ei=15.12 meV.

We have searched for, but not found, possible occlusion from several optics along the beamline.

We have observed a $T_0(E_i)$ offset that was substantially larger at low incident energies than the original MCNP source term predicted. We have performed some measurements with a good quality KTaO3 crystal in order to project out the pulse width for several incident energies. The method is to use the (200) or (400) Bragg peak in KTaO3 to scatter a fixed wavelength (energy) band into the detector, and then to scan the phase time of the Fermi chopper to project out the pulse shape as a function of time. If we take these results at face value, then the pulse width is ~2x-4x broader than expected, consistent with a ~2x-4x lower flux. The Neutronics team has performed pulse shape measurements (described below) on beamline 13, which shares our moderator, and observes pulse widths that are different from these results. In the HYSPEC measurements, there are effects from resolution (Fermi chopper burst time) and $KTaO_3$ mosaic (~10') that need to be accounted for. We are using McStas to simulate these measurements to confirm (or repudiate) the hypothesis that the observed flux loss comes from a broader-than-expected pulse width.

Our Neutronics group has created new MCNP-generated moderator source terms. The MCNP model has been updated to be consistent with as-built drawings, and accounts for the in-place regular water instead of the deuterated water that was planned for cooling. There were significant differences in the as-built moderator from the original design. In addition, backscattering crystal (mica) analyzer results at beamline 13 (Fundamental Physics Instrument, next to HYSPEC and sharing the same moderator) suggest a different ortho-para mixture, ~30% ortho-Hygrogen, compared to the conservative assumption of 0.2% ortho-Hydrogen – equilibrium at 20 K, used for the original source term. This different mixture changes the pulse shape in time, affecting pulse widths by 20-30%. Several source terms have been provided, with a variety of ortho-para mixtures.

Current status: Barry is revising the McStas model in order to make a more realistic comparison with the flux measurements and the KTaO3 measurements, by checking the model against the as-built instrument, and by using the new moderator models developed by the Neutronics group. This outcome will form the basis of our path forward.

3. Vacuum

Observations: Since October 1, 2011, the vacuum level in the T1A chopper box and the curved guide section has been too high to permit spinning of the T1A chopper or to maintain continuous vacuum through to the T1B chopper and Fermi chopper. Therefore, the T1A chopper has been stopped in the open position, and a gate valve with aluminum window has been closed since October 1, 2011.

Actions taken: The heavy concrete shielding blocks have been removed both in the target building and in the HYSPEC external building, in order to search for these leaks. Two leak locations have been found, one under the upstream chopper racks close to the monolith, and one under the chopper racks in the external building.

Current status: The upstream leak is being repaired now, during the SNS shutdown. If the vacuum achieved after this leak is repaired is still too high, then the leak in the external building will be repaired at the start of the next cycle.

4. Detector vessel location, motion and collision avoidance

Observations: The absolute encoder for the detector vessel rotation stage has occasionally been reading erroneous values, making it difficult to calibrate the absolute and relative position of the detectors.

Actions taken: The encoder readout has been monitored closely over the last few months, but the error is intermittent. Most of these errors suggest that the problem may lie in the electronics and not the encoder itself. If the encoder itself is the problem, then the arm of the drum shield will be removed to get access to this encoder, for repair.

To obtain relative positions of individual detector tubes, the incident beam (attenuated, collimated, apertured and un-focused) was directly measured using the detector array at several detector vessel angles.

The motion of the detector vessel has been improved by further tuning of the air-pads, although there are still a few starting positions where the motion is prevented in one or both directions; in these cases we either move the detector vessel in the opposite direction, or drive the drum shield rotation stage, in order to 'kick' ourselves into a better starting position. Fortunately, the areas where we get stuck coincide with configurations we don't normally use, where the detector vessel is in-line with the monochromatic beam. We have purchased high-flow regulators, but it is unclear whether we will install these.

The collision avoidance sensors that point sideways on the detector vessel are reliable, but the downward pointing ones are not, so we are planning to switch all sensors to sideways pointing sensors.

Current status: The latest encoder error will be evaluated during the shutdown, hopefully this week. Analysis to determine relative detector angles and positions is ongoing.

5. General unpolarized instrument characterization

   Observations: Simply getting to know the instrument, and comparing measurements to expectations (energy resolution, etc.)

   Actions taken: Samples included vanadium, silicon powder and a single crystal of KTaO3. For vanadium, incident energies used were 3.803, 6.04, 15.12, 19.82, 31.16, 40.58, 61.9, 83.41 and 93.8 meV; for the other samples some but not all incident energies were used. Measurements were made at a range of Fermi chopper frequencies, from 30 Hz to 180 Hz at low incident energy, and from 180 Hz to 420 Hz at high incident energy. Both the 20' and the 40' Söller collimators were aligned and characterized. The coarse radial collimator has been aligned and the alignment of the fine radial collimator has been checked. The Argon fill of the detector vessel is performing as expected.

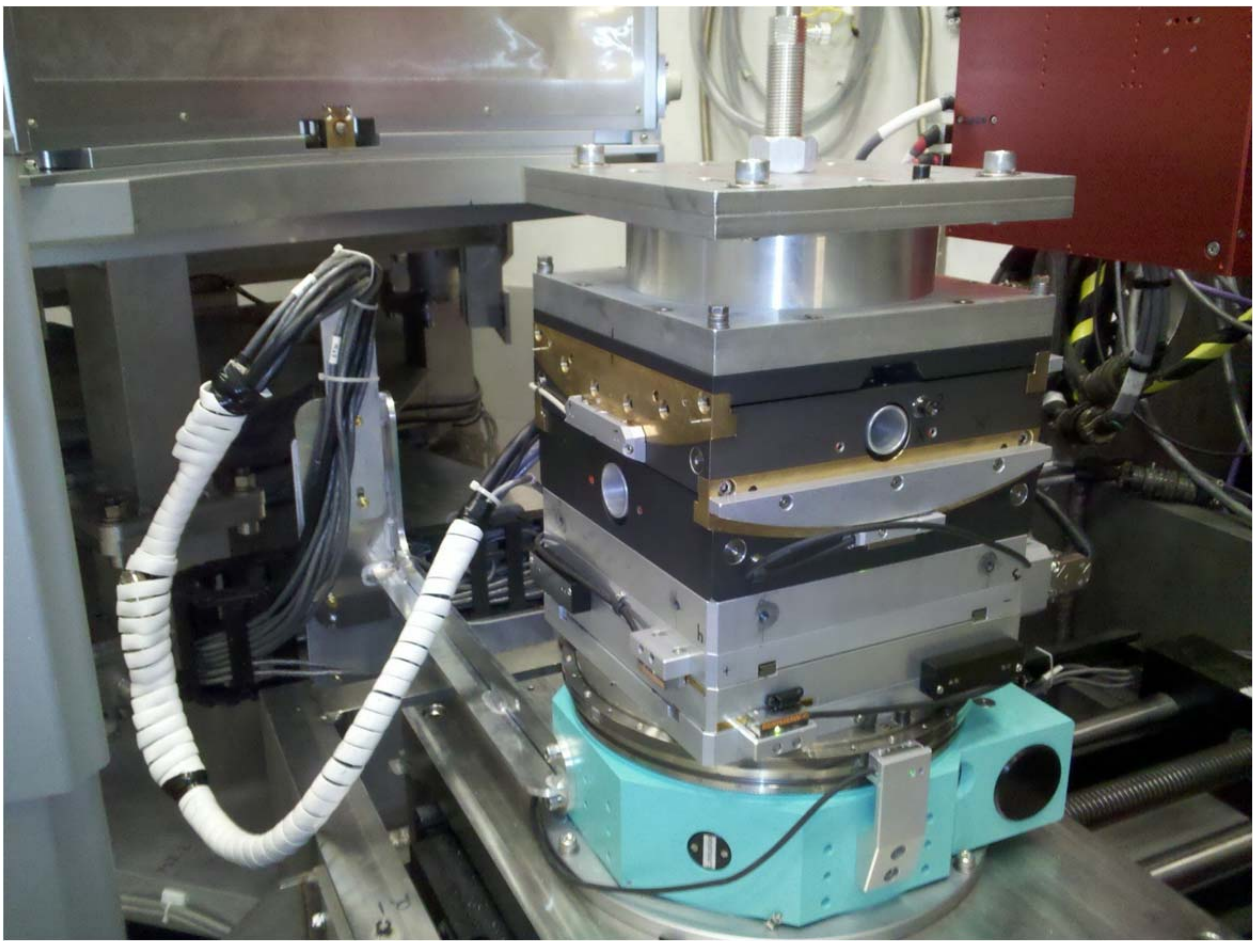
   We determined the angular chopper phase offsets, which are frequency dependent terms that arise from time-to-digital signals being offset with respect to the chopper being open. The T0, T1B and Fermi choppers all seem to change phase and frequency well and quickly. We have also worked out the rotation / tilt / focusing of the HOPG crystals, and they move reliably. We had problems with the incremental encoder for the tilt motion, but this was a problem in the electronics that was quickly repaired.

We had some issues reading from monitors 1 & 2, due to noise in the timing signal when moving the drum shield to large deflection angles (low Ei), and a cabling problem at the monitor for monitor 1. The first problem was fixed by increasing the discrimination for the timing signal, and the cabling problem has now been repaired.

Current status: Analysis of the sample data sets is ongoing.

6. Goniometer & Cable management

Observations: The Huber goniometer arrived on September 27, 2011, and was installed and moving well soon after.



Actions taken: Sample rotation of more than 20 degrees causes the cabling to interfere with the other instrument components.

Current status: The current crude prototype permits full rotation but limits some translation.

Refinement continues.

7. Preparation for polarization

Observation: The offline testing of He-3 polarization had just begun as of October 26, 2011. The HYSPEC polarized ^{3}He filling station was completely assembled. Unpolarized gas was successfully transferred to various gas container (which includes pumping cell, wide angle analyzer cell, gas supply and gas dump tank) with no detectable leakage. Two not-sealed-pumping cells were made and baked and setup for polarizing test. However, the not-sealed-pumping cell was not polarized successfully. A sealed cell was then produced by this filling station to verify the goodness of the gas source. It was successfully polarized to greater than 70% polarization.

Actions taken: ^{3}He permeation and outgassing from Aluminum chamber and viton O-rings have prevented successful optical pumping in the pump cell to date. The polarized gas handling system is being modified to reduce the number of Viton O-rings, and metal seals are developed to replace O-ring seals, in order to reduce outgassing and permeation problem. There is also a development project to replace the O-ring piston system with a titanium welded bellows system. A redesign of the cart and linear slides is undergoing for easier fit and transport purpose.

The aluminum wire of the Mezei flipper is being re-wound by the magnet support group at the SNS, and preliminary results using fixed tension are promising. The Helmholtz-like coil for the filter cell for 3-He polarization analysis is to be strengthened based on FEA modeling and surveyed measurements of the current coil. Magnetic field measurements have been made of the guide fields to be mounted on the optical rail, and of the Helmholtz-like coil. A closed-cycle refrigerator compatible with this Helmholtz-like coil has just been delivered.

Current status: Work is ongoing. Commissioning with neutrons of polarization components is planned for the spring cycle, 2012.