Final Technical Report on DOE Grant No. FG05-91ER79044 for construction of a "Multi-Beam Mossbauer Scattering Facility".

The Mossbauer instrument construction which was financed by the DOE grant of \$74,065 and MU matching funds of \$52,000 is essentially completed and awaiting installation at the Missouri University Research Reactor (MURR) facility. All of the DOE funds have been spent and all of the matching funds plus about \$4,000 to \$5,000 of additional physics department funds have been committed to finishing the first phase of the new instrument, QUEGS-II (for QUasiElastic Gamma-ray Scattering--generation II). This phase includes computer controls, detectors, and instrumentation for two of the four beam lines afforded by QUEGS-II. Included in this commitment of funds is \$8,700 for equipment and machine shop services which have not yet been paid and \$19,700 for a Ge detector for which bids are ready to be let.

The three main improvements of QUEGS-II over QUEGS are (1) four beam lines instead of one, (2) 2.0" x 3.0" beam areas instead of 0.2" x 1.0" (3,000 Ci sources of ^{183}Ta instead of 100 Ci), and (3) a cryorefrigerator to cool sources to 20 K instead of 80 K (an improvement in recoilless fraction from 0.47 to 0.62). The advantage of multiple beam lines is clear since the same source can be utilized for different experiments. A 30x larger beam area can give a large increase in counting rate when the area of the sample to be studied is of the same size as the beam (as for q-dependent experiments planned on liquid samples) and if Soller collimators are used (as in neutron scattering experiments) to limit angular divergences. The third improvement, which will give source temperatures down to 20 K, will give the enhanced Mossbauer "dip" noted above and will also permit studies using Mossbauer isotopes that have not been possible before. One of these isotopes, ^{153}Sm , could have a significant impact on our future program because the photon flux on samples can be increased by a large factor, possibly as large as 75, if the cryorefrigerator can accommodate the heating caused by the radioactivity.

A main concern in the design of QUEGS-II was whether the cryorefrigerator used to cool the sources would cause vibrations that would broaden or materially affect the experimental lineshape. The answer to that concern is still unknown but we are quite hopeful because the primary thermal connection between the cryorefrigerator cold-head and the source holder is through 4,000, 0.002" diameter, curved, low-oxygen Cu wires which feels mechanically smooth and which are not expected to transmit significant vibrations. Experimental tests showed that the thermal conduction through these thin wires was able to cool the source holder to 20 K with no heat load (except radiation losses) and was able to maintain 30 K with a 2 watt load. We think that during installation the radiation losses can be reduced by using more super-insulation in the beam lines to allow operation at 20 K.

Another concern is the intensely radioactive sources and our being able to handle and shield them safely. The lead cask used to transport the sources from the hot cell at MURR to the instrument area has a nominal shielding thickness of 6" (2" thicker than that used for QUEGS to accommodate the factor of 30 increase in source strengths). The stationary cask which holds the sources and allows the cryorefrigerator to be coupled to them (from below) has been fabricated into 3 sections with nominal lead shielding thicknesses of 8" (versus 5.5" for QUEGS). Each of these sections weighs close to 2000 lbs. Health physics considerations may require extra shielding at strategic places and/or a restriction of the size (area) of the sources which can be used.

We are, of course, disappointed by the delays in implementing this new facility, but it presented major design challenges to accommodate the cooling system and large source areas. In addition, the reactor has benefited in the past few years from a number of other instrumentation

grants for neutron scattering and other research. As each instrument is unique and must be "home built", the machine shops in the Physics Department and at MURR have been unusually busy. Scheduling the construction and installation of QUEGS-II, therefore, has represented compromises with the other projects, and the reactor has expanded its engineering staff and facilities in response.

The original QUEGS was a unique facility, carrying out the only Mossbauer studies with a source other than 57 Fe. The factor of 500 increase in source strength for QUEGS over 57 Fe has enabled us to perform noteworthy studies, especially in the area of liquid scattering and Mossbauer line shape analysis. However, many of the experiments which we hoped could be performed proved to be impossible because of signal-to-noise limitations. With the larger beam areas and increased source strength of QUEGS-II we are quite optimistic that new domains of research will be opened to us, in the same way that neutron scattering has evolved with better sources and improved instrumentation. We expect initial experiments to begin in November 1994, and eagerly anticipate a productive and exciting era of research.

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