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A MEASUREMENT OF STIMULATED EMISSION FROM ^{83m}Kr

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A device that produces stimulated gamma ray emission and generates coherent radiation in the keV photon range (a graser) should be possible utilizing recoilless emission in nuclear transitions. Extensive research in the field has produced many experimental approaches but no conclusive results. The graser isotope we are investigating allows the concentration of radioactivity into a specific volume, addressing one of the more pressing issues in graser development. The lasing transition of interest is the 32 keV gamma from ^{83m}Kr, a decay product of ^{83}Rb which has a half life of 86 days (Fig. 1).

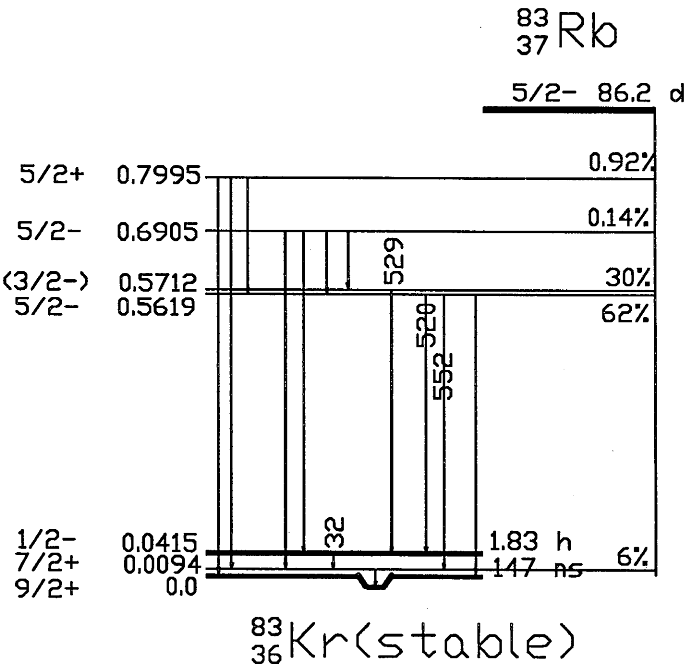

Figure 1. Decay scheme of ^{83}Rb. The transition of interest is the 32-keV gamma from ^{83m}Kr.

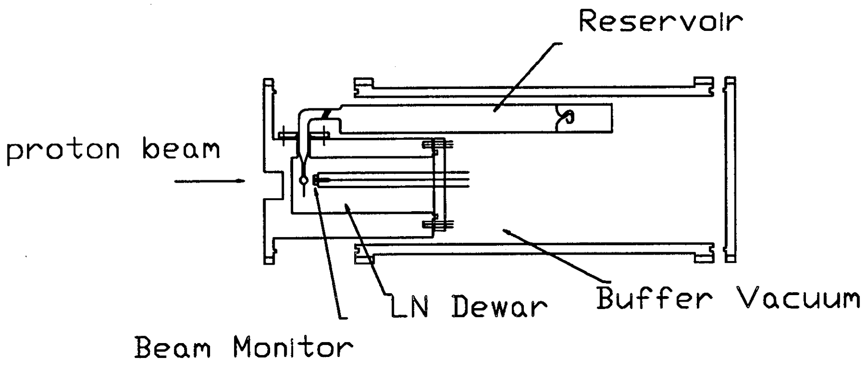

Figure 2. Glass target cell enclosed in aluminum dewar. Note the capillary drawn from the spherical target.

The first step of our experiment is the production of the parent isotope ^{83}Rb via the reaction ^{83}Kr(p,n)^{83}Rb. A three component glass target cell that includes a large reservoir of gaseous ^{83}Kr, a small 4-mm glass sphere, and a 100-μm i.d. glass capillary drawn out from the small sphere was prepared at UNH for proton irradiation. The small sphere is placed in the path of the proton beam and the gaseous krypton frozen into it by flowing liquid nitrogen around the sphere. This required the design of an aluminum dewar system with separate cavities to isolate the warmer glass reservoir from the frozen glass target (Fig. 2). The aluminum design was chosen to minimize radiation exposure of personnel during the removal of the apparatus from the beam line 5 beam dump.

Split beam of 500 nA at a proton energy of 45 MeV was delivered to BL5 for testing, development and production of ^{83}Rb. We have performed successful test irradiations and a full production irradiation this year. The tests allowed us to optimize the design of the aluminum dewar and develop beam quality diagnostics. The production run yielded an active ^{83}Rb source of approximately 0.3 mCi.

The second step of the experiment is the concentration of Rb. The krypton gas is frozen into the reservoir leaving pure ^{83}Rb in the glass sphere, which is then separated from the reservoir by fusing and cutting the glass near the sphere. The sphere is frozen into a cube of water ice before fusing to prevent the ^{83}Rb from vaporizing into the reservoir region. This procedure has been performed successfully at the IUCF target lab. Fig. 3 is a ^{83}Rb spectrum taken to assure the presence of the isotope. After the sphere has been isolated, the ^{83}Rb is formed into a filament by chasing it into the glass needle. This geometry enhances stimulated emission along the filament axis.

The third step is the measurement of coincident photons to confirm the existence of stimulated emission. The 32-keV photons from the transition of interest will be detected by four partially transmitting, cooled silicon surface-barrier detectors, stacked for coincidence detection. The fraction of 32-keV photons emitted without recoil is maximized by cooling to liquid helium temperatures, which we plan to do using an existing liquid helium cryostat modified to accommodate our target and detectors.

All the components of the measurement apparatus have been assembled and tested separately, including the detectors, preamps, and coincidence electronics. Tests of the detectors at UNH confirmed an acceptable energy resolution of 5-keV, sufficient for the

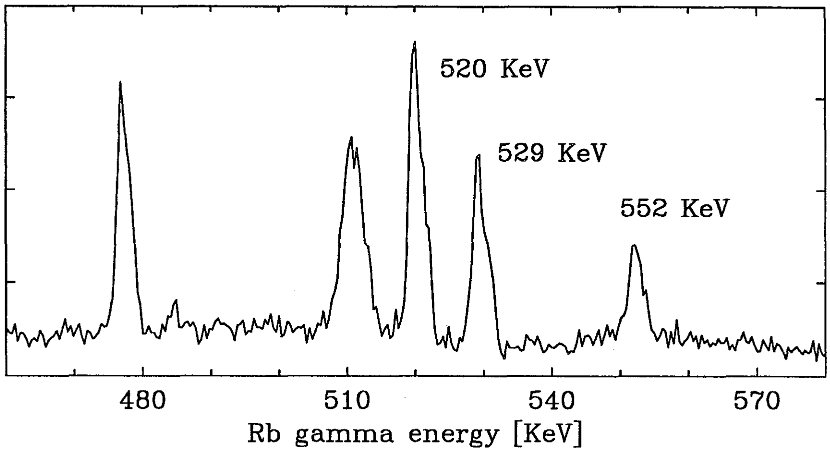

Figure 3. ^{83}Rb spectrum obtained after a test irradiation. Gammas from ^{83}Rb transition are labeled; other peaks are from decays of radioactive isotopes in the glass cell.

detection of the 32-keV photons of interest. Current efforts involving more optimal preamps show promise of improving the system resolution.

Our efforts in the coming year will include continued production of stronger sources, and our goal of a 1.0-mCi source should be achievable with current beam quality, diagnostics and targets. We will also continue to produce target cells with narrower needles, which substantially enhances the expected coincidence rate. Current needle diameters are smaller than 100 μm, and we hope to obtain target cells with 10 μm needles in the future. We will perform calibration measurements with the stimulated emission detection system in the coming months, although the timing of measurements depends on the availability of the liquid helium cryostat, which is also being used as a liquid xenon target. The target from our recent production run will serve as a calibration source for this measurement. We forsee no obstacles to the observation of stimulated emission from ^{83m}Kr, which would represent the most significant breakthrough in this 30 year-old field.