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Information on Nuclear Shapes at High Spins from Lifetime Measurements

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For a more detailed understanding of the structure of high spin states and for a stringent test of the nuclear models describing them, it is necessary to measure the static and dynamic electromagnetic multipole moments. Using Doppler shift techniques, we have measured lifetimes of high spin states in a number of nuclei near N = 90 in order to get their dynamic electric quadrupole moments which are a direct reflection of the collective aspects of the nuclear wave functions.

The potential energy surfaces of ^{160}Yb (N = 90) reveal that it is very shallow in the γ degree of freedom as well as in ε_2 and thus should be quite susceptible to deformation driving influences. Quadrupole transition moments (Q_t) extracted from our lifetime data show that especially in ^{160,161}Yb this is true. The data shown in Fig. 1 have a reduction in collectivity at the higher rotational frequencies, a pattern which may be interpreted as the nucleus' moving toward a triaxial shape as predicted by both self-consistent and cranked shell model calculations.

In another look at shape evolution at high spin in N = 90 nuclei, we have recently carried out lifetime measurements on ^{158}Er in the γ-γ coincidence mode. Many times, the problems associated with side feeding into a level create considerable difficulty in extracting the lifetime of that level. By gating on transitions above the level, one is able to bypass the feeding into it. A plunger-detector arrangement similar to that shown in Fig. 2 was used in these measurements (During the experiment, the array of detectors is moved forward around the cylinder containing the target-stopper arrangement.).

The ^{158}Er data were analyzed in four ways. Shifted and unshifted peak intensities were first extracted from the total-projected coincidence spectra (T). Similarly they were extracted from spectra generated by the sum of all gates (S) below the state of interest, by the gate on the first transition above (G) and by the gate on the second transition above (H) the one of interest. Fig. 3 shows the program fits to the data from each of these four types of spectra for the $8^+ \rightarrow 6^+$ transition. The lifetime values extracted for the 8^+ state were 1.3, 1.16, 1.2 and 1.3 pico seconds, respectively.

Figure 4 shows transition quadrupole moments from our best lifetime values for members of the yrast band of ^{158}Er through $I = 22^+$. There is clear evidence for centrifugal stretching in the ground band and a dropoff of collectivity in the s band. The dropoff, as in $^{160,161}Yb$, is probably due to the onset of triaxiality as a result of the deformation driving influence (to + γ values) of the low Ω, $i_{13/2}$ quasi neutrons. In further tests of these ideas, additional measurements are being made on nuclei whose Fermi surface lies higher in the $i_{13/2}$ neutron shell.

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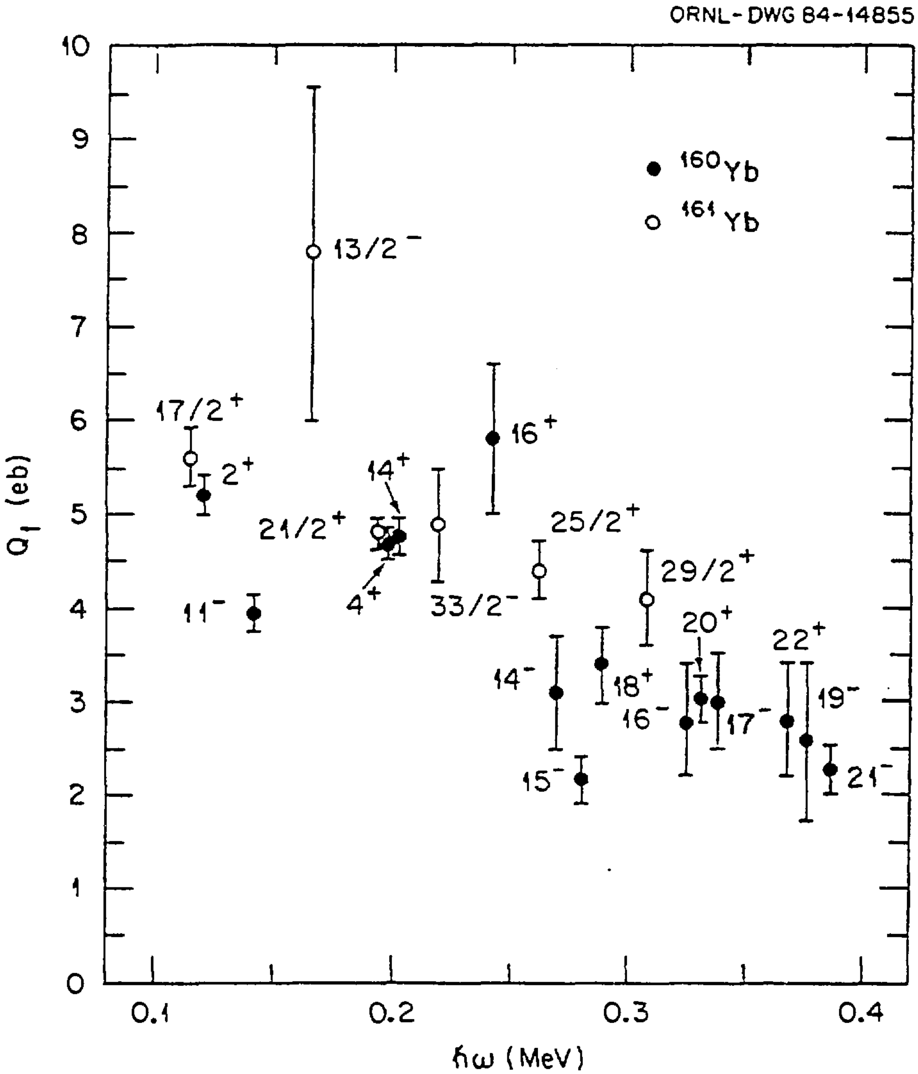

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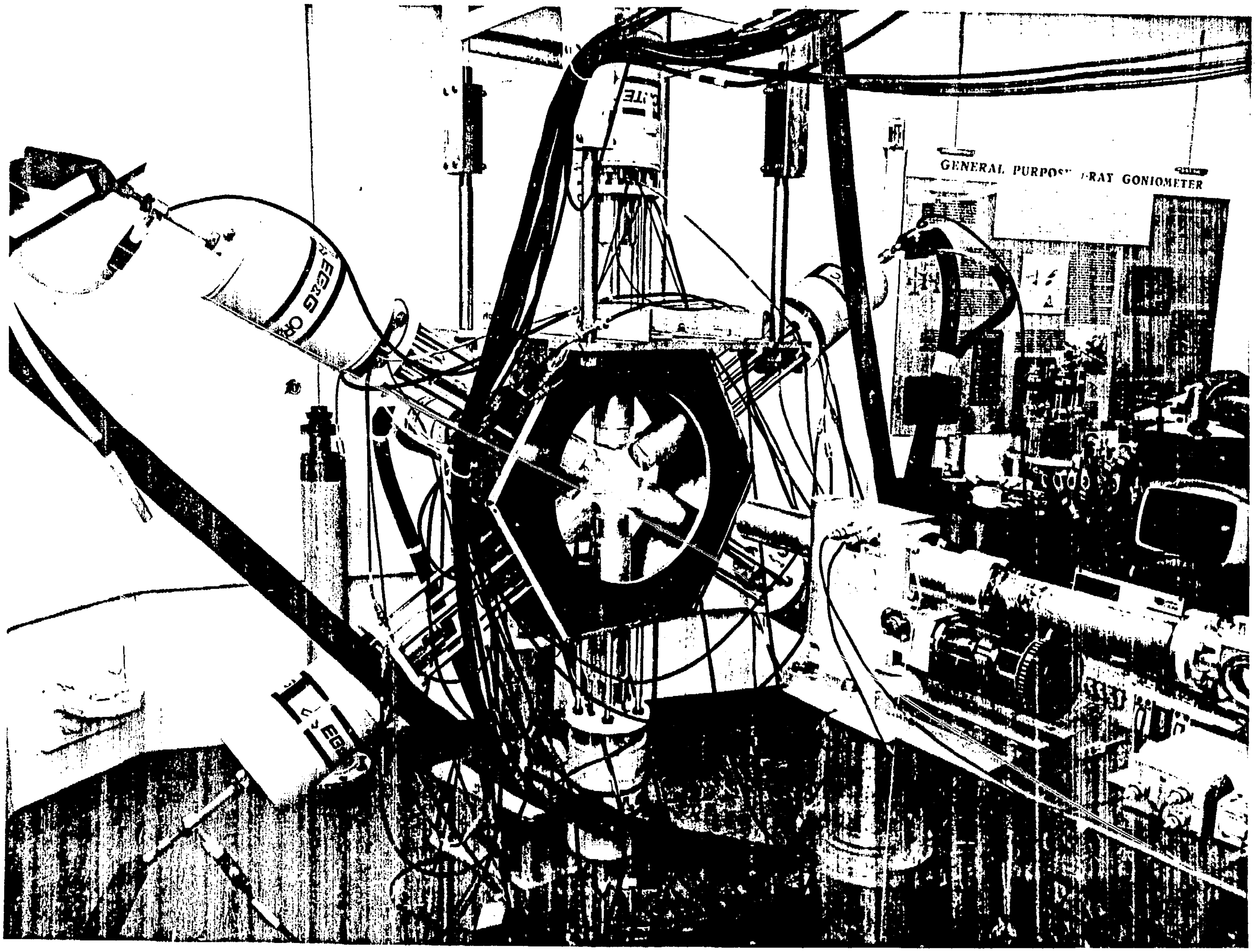
160Yb
161Yb
13/2−
17/2+
2+
16+
14+
21/2+
25/2+
4+
33/2−
29/2+
11−
20+
22+
14−
18+
19−
16−
17−
15−
21−
Q1 (eb)
ħω (MeV)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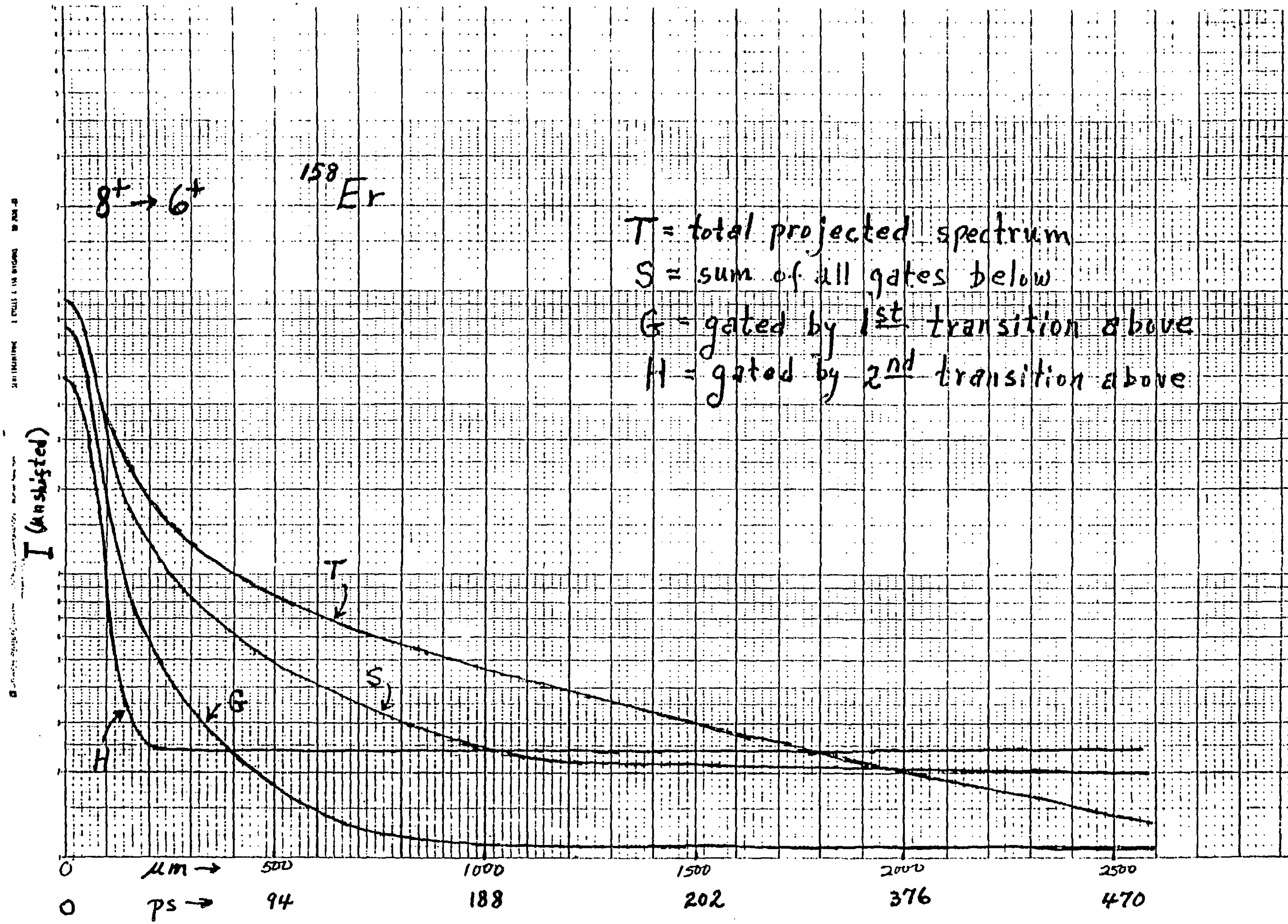
EG&G OR



$8^+ \rightarrow 6^+$
^{158}Er
T = total projected spectrum
S = sum of all gates below
G = gated by 1st transition above
H = gated by 2nd transition above
T
S
G
H
I (unshifted)
0
μm →
500
1000
1500
2000
2500
0
ps →
94
188
202
376
470

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