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SOLENOIDAL DETECTOR NOTES

TEST OF COMPRESSED STACKS

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A. Byon-Wagner and D. Hicks
FERMILAB

D. Gustafson and C. Leggett
University of Michigan

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A. Byon-Wagner, D. Hicks : FNAL
D. Gustafson, C. Leggett : University of Michigan

Light yield as a function of pressure and radiation damage for compressed stacks were measured. The scintillating tiles used are SCSN81, 2.65 mm thick polystyrene-based plastic scintillators from Kuraray Co. with a design shown in figure 1. The edges of tiles were painted with BC600 reflected paint. The wavelength shifting fiber, BCF91A from Bicron Co., was routed out through the key hole shape groove path and spliced to Kuraray clear fiber, 1 mm in diameter and 40 cm long. The ends of fiber were polished to get a consistant optical contact between the PMT and the fiber. Optical coupling grease (at FNAL bench test) or oil cup (at U of M) was also used during all the measurements.

1 Light yield as a function of pressure

The ^{90}Sr induced current from a scintillating tile/fiber was measured with a picoammeter, Keithley 485. Photomultiplier (XP2081B) dark currents were measured and subtracted from the current readout. PMT gain stability during a measurement (less than one hour) was estimated to be less than 1% by comparing the output currents of the reference tiles measured before and after the sample measurements. A systematic uncertainty of measurement is ~3% mostly coming from the reproducibility.

Different pressure was applied by stacking up weights on top of the flat surfaced aluminum plates (~ 4" × 5" and 1/2" thick) which was placed over the tile. Figure 2 shows the light yield of tiles wrapped with aluminum foil as a function of pressure applied on tile surface. The output current measured with different weights was normalized with the light output measured without any pressure. A sizable initial drop (~7%) was observed with the first 0.1 lb/in^2. The last data point at 50 lb/in^2 was measured during the test described in next section using the tile-compressing fixture (shown in Figure 4). To verify whether this decrease in light yield is due to the surface effect, we tested the followings:

- After the measurement with 7.4 lb/in^2 of weights, the weights were removed except 0.1 lb/in^2. The output current was identical with the previous measured value. By removing rest of the weight, the light output from the tile/fiber went back to its initial value.
- To see the surface effect, we repeated the measurements with 4 different type of wrappers. Since some of the sample papers were curling up on the surface, the reference

points were taken at at 0.3 lb/in^2 by putting a flat aluminum plate on the surface. Figure 3 shows the light yield of tiles wrapped with different materials. The values on y-axis were the ratio of light output with pressure (x) to the light output at 0.3 lb/in^2. White and black papers give small changes in light yield between 0.3 lb/in^2 and 8.2 lb/in^2.

2 Radiation hardness of compressed tile

We compare the radiation hardness of tile/fiber combinations irradiated with and without pressure. Radiation hardness of each sample was measured by taking a ratio of the light yield measured after irradiation to that measured before. To supply a uniform pressure on the tile during and after the irradiation, a spring loaded fixture as shown in Figure 4 was built. A 0.625" hole was milled from the back side of the inner aluminum pressure plate leaving a 0.020" pressure window for test illumination of the tiles with a 1 millicurie ^{90}Sr source.

Two sets of pressurized irradiations were carried out. In each set two tiles (#1 and #2) were irradiated under 50 lb/in^2 pressure; another tile(#3) was irradiated with no pressure, and a last tile (#4) was left in the measurement apparatus. In the first set the unpressurized tile was exposed to about 13% more dose, due to the dose difference induced by the pressure plates shielding; this required a dose-damage model to interpret the results. We report here the second irradiation set where an equal thickness plate shielded the unpressurized tile. The conclusions are the same.

The tiles were read out with a phototube equipped with a dark slide and oil cups to read out the waveshifting fibers; this setup had a re- producibility for connect/disconnect of about 1%. The current levels were 20 to 100 nA, with subtracted dark currents of order 4 nA. The currents measured were normalized to correct for long term drift of the PM response using tile #4; these correction were of order 3%. The irradiation dose was about 1.0 MRad delivered over 21 hours from the University of Michigan Phoenix 60^Co Facility. We estimate the uniformity of dose was ±3%.

The currents were measured before pressurization, after pressurization, about 40 minutes after the 21 hour irradiation, and at selected times for a few days until they stopped changing; they were again measured after the pressure was released. Table 1 shows the output currents measured as a function of time and pressurization. Note tile #1 is generally excited a factor of 7 less than tile #2 because of the shielding of tile #2; tile #3 is excited with a different geometry, hence the different current level. We see the following;

- The tiles lose about 25% output from 50 lb/in^2 pressure.
- The pressurized tiles recover/anneal fractionally to more relative to before irradiation than unpressurized tiles. This is seen in both sets of irradiations: 52% vs 48% (see Figure 5).

Table 1: Current response of tile-fiber-PMT system as a function of pressure, radiation dose, and time.

time(minutes)	-60	0	42	349	1650	3040	> 3040*
pressure(lb/in^2)	0	0	50	50	50	50	0
tile #1 (nA)	23.2	18.7	7.0	9.3	10.1	10.1	12.1
tile #2 (nA)	189.2	135.7	39.7	62.6	70.1	70.7	98.1

Ratios to $t = 0$ (at 50 lb/in^2, does = 0)

tile #1	1.24	1.00	0.37	0.50	0.54	0.54	0.50
tile #2	1.39	1.00	0.29	0.46	0.52	0.52	0.50

reference tile irradiated with 0 lb/in^2

tile #3 (nA)	790.2	766.7	227.7	332.6	367.7	371.1	370.0
ratio to $t = 0$	1.03	1.00	0.30	0.43	0.48	0.49	0.49

* Ratios in this column were to $t = -60$ minutes.

- When the pressure is removed, the damage is the same regardless of the pressure history: 50% vs 49% (see Table 1).

One can understand the pressure induced attenuation as due to a pseudo wetting of the scintillator surface by the Al foil wrapping. In the same spirit one can attribute the lesser FRACTIONAL damage of the pressurized tiles as being due to the radiation damage attenuating most severely the long paths already attenuated by the surface absorbtion induced by the pressure; both effects attenuate the large angle light. We conclude:

- A 1 Mrad dose over about 24 hours damages these SCSN81 tiles with BCF91A readout fibers such that the output is reduced about 50%.
- There is no difference in the intrinsic damage at the 2% level associated with a pressure of 50 lb/in^2
- There is an apparent lessor RELATIVE damage (loss) at the 5-10% level for the pressurized tiles.

WE SEE NO ANOMALOUS CHANGE IN RADIATION DAMAGE ASSOCIATED WITH PRESSURE.

Acknowledgement

We would like to thank Robert Blackburn in Phoenix Memorial Laboratory at University of Michigan for performing the ^{60}Co irradiation to the scintillator samples.

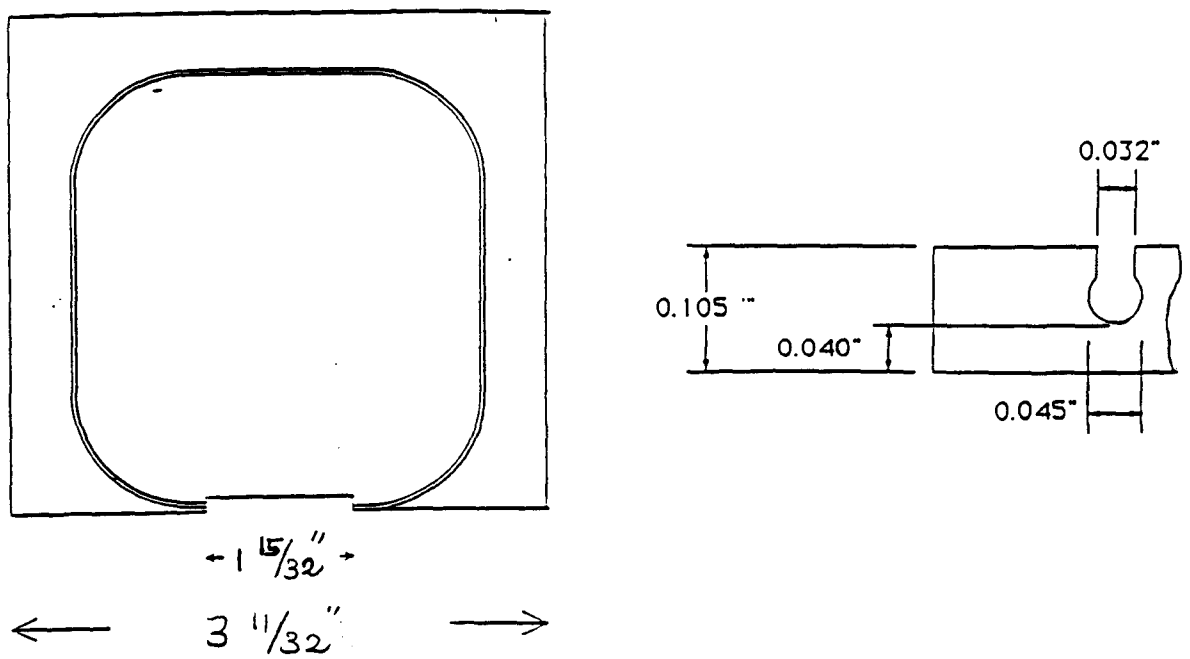

Figure 1: A schematic diagram of sample scintillating tile/fiber.

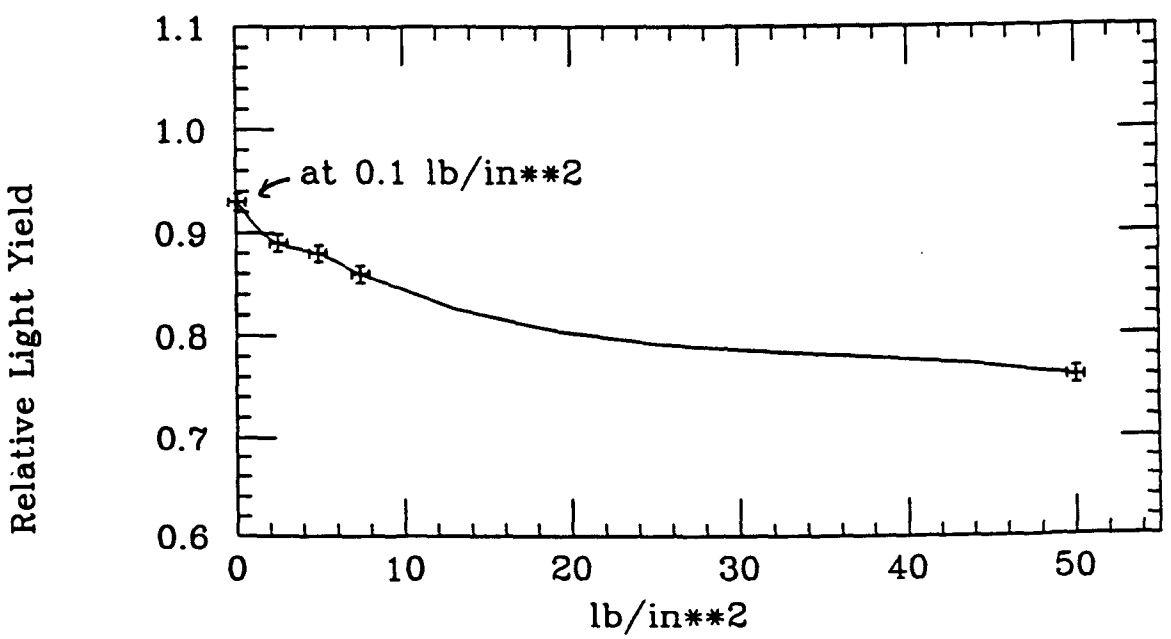

Figure 2: Light yield as a function of pressure with an aluminum foil as a wrapper. Relative light output at each points were taken by normalizing the light output measured without any pressure.

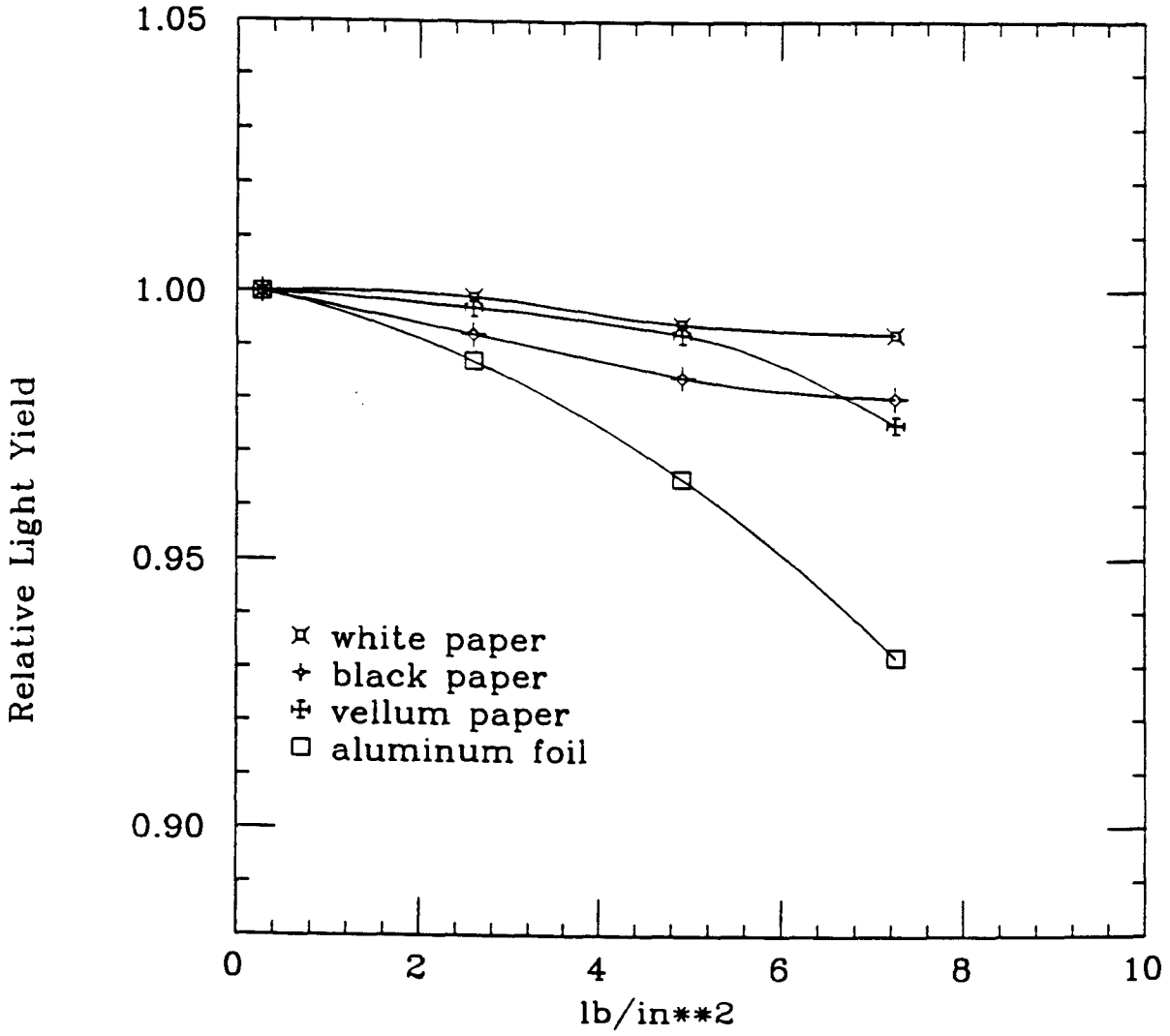

Figure 3: Light yield as a function of pressure for different surface conditions. Light output at each points were normalized by the light output measured at 0.3 lb/in^2.

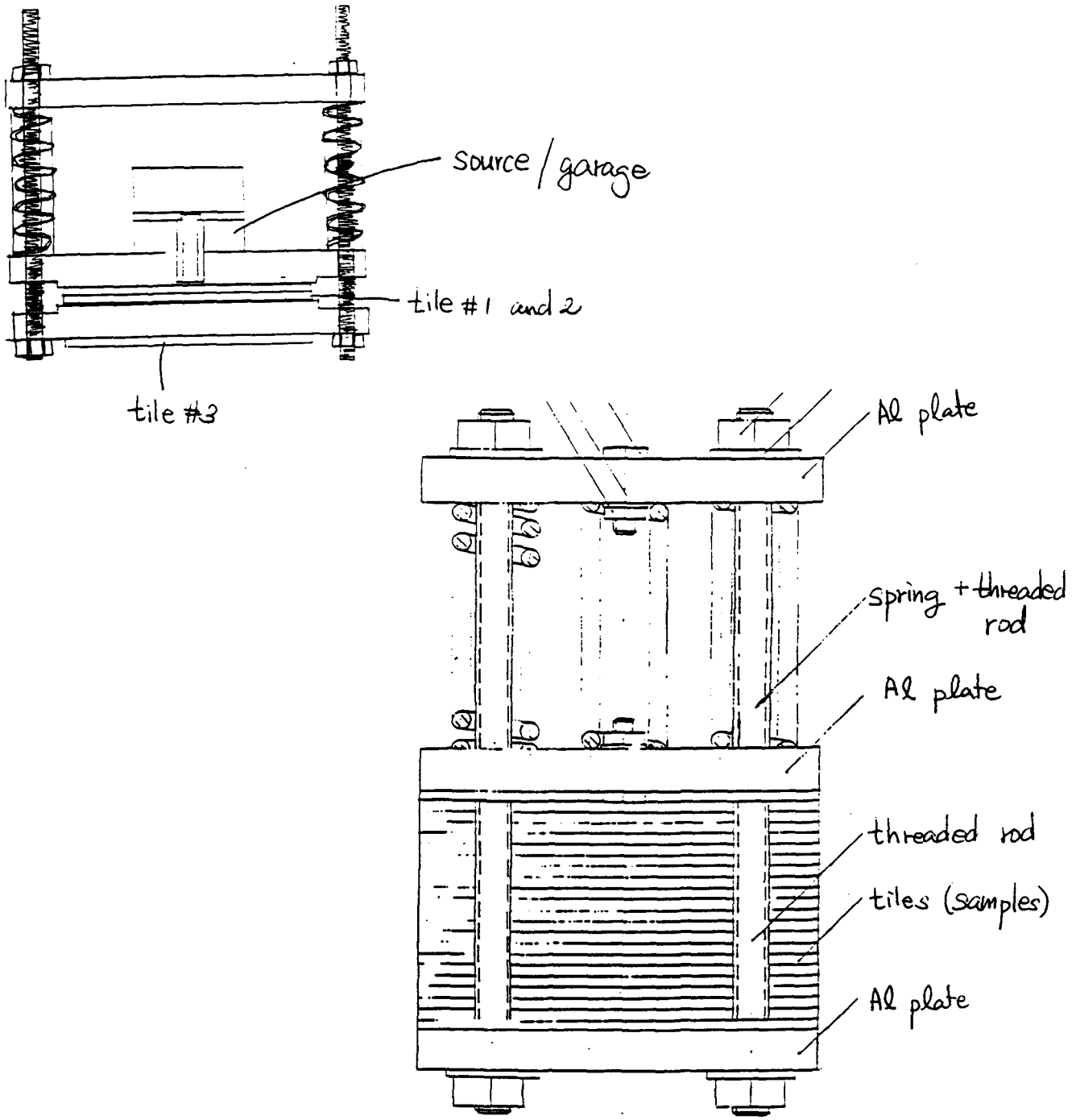

Figure 4: Fixture used in radiation hardness of compressed tile. The scheme of mounting source is also shown (see the text).

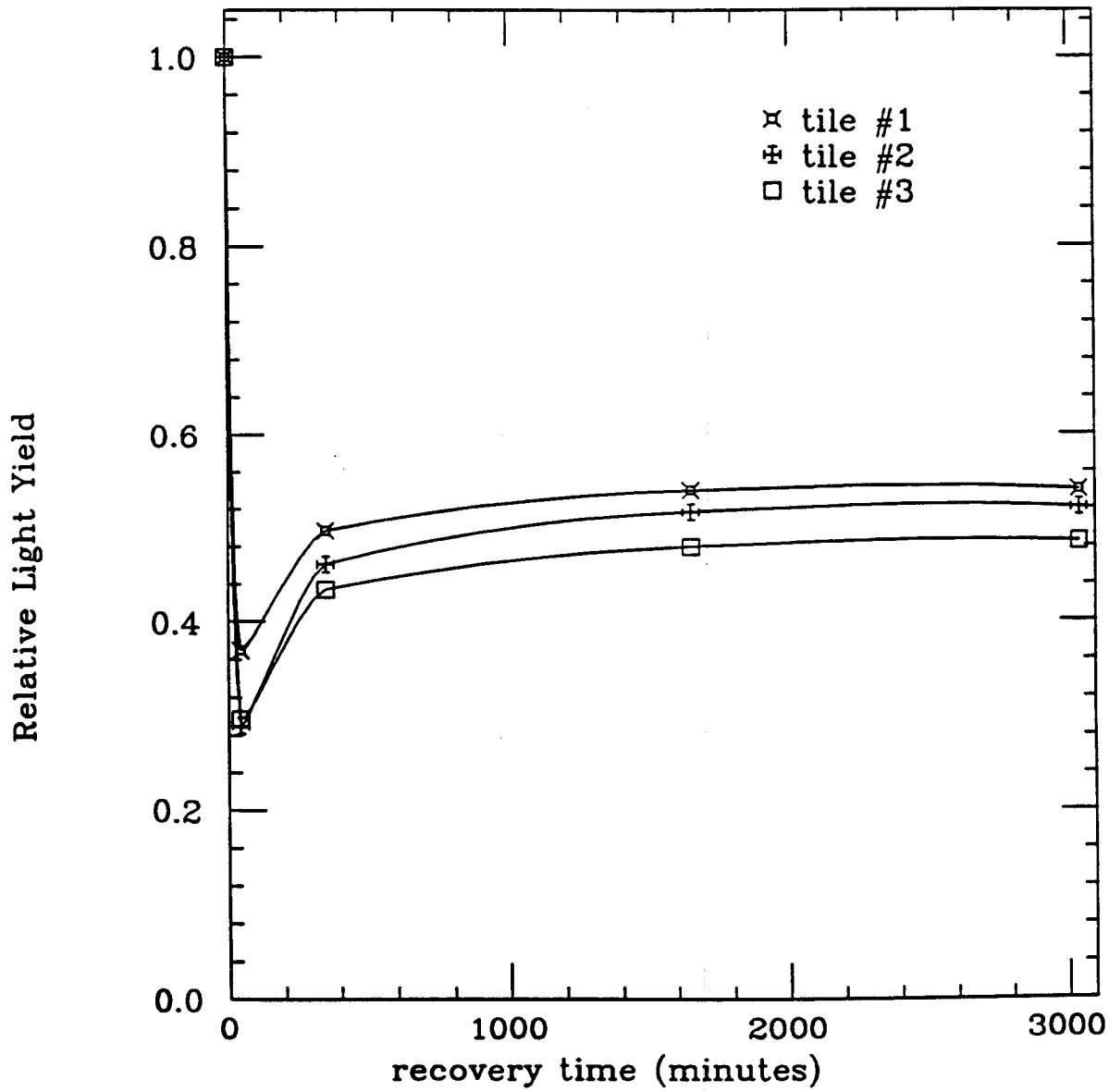

Figure 5: Comparison of damage and recovery for tiles with/without pressure as a ratio of light yield after to before the irradiation.