QUARTERLY PROGRESS REPORT #4

Contract NASw-917

3 May 1965

1. Review of Calculations for Plane Gratings

A thorough re-examination of about eighty percent of the previous grating mosaic calculations was completed during this quarter. This portion of the calculations includes all results obtained for mosaics made of plane grating elements and the first few results found using curved grating elements. Because of our own difficulty in getting reacquainted, and the few mistakes found, a new and hopefully more understandable terminology is introduced here. Hence forth, a quantity proportional to the resolution of the grating mosaic for a photon of energy E will be used. This quantity is arbitrarily defined as $E/\Delta E$, when ΔE is the full-width at half maximum on a plot of the number of photons in a given energy interval (which reach a given point in the image plane) versus energy. The goal of the calculation effort then amounts to trying to design a mosaic with a theoretical value of at least 200 for $E/\Delta E$, in hopes of attaining a value of 100 in actual practice.

The essence of the results from the plane grating calculations is given in Figures 1-3. The curves in Figure 1 show $E/\Delta E$ for a given source-grating-image-plane configuration as a function of the pairs of wavelengths selected for optimizing resolution. All mosaics had 32 elements NEL, each ruled with six different line spacings NSUB, the initial spacing d_o being 12,000A between grooves. Because $E/\Delta E$ values did not exceed 60, grating curvature was eventually introduced (see section 2 below).

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Figure 1 is based on results like those shown in Figure 2, which indicates that a variety of photon energies may be associated with a given point in the image plane, the details depending upon the pair of wavelengths selected for optimum resolution. The two histograms apply to the ~8A radiation for mosaics designed to best handle the pairs of 5 and 40A and 8 and 16A. The results were obtained by simply calculating the wavelength diffracted to a given point in the image plane by each of the 192 elemental gratings in the mosaic. Figure 3 depicts the change in resolution produced by a 3' change in x-ray input angle, and by halving the number (from 6 to 3) of different grating spacings used. The line drawn in at $E/\Delta E = 100$ means that no time should be wasted constructing a mosaic whose response has values of $E/\Delta E < 100$.

Because appropriately ruled gratings of the desired large radius of curvature are not available, the initial mosaic mockup will be made from off-the-shelf plane elements.

2. Improvement from Curved Gratings

It is clear from Figure 3 that $E/\Delta E$ of the grating mosaic is not particularly dependent on the exact angle of incidence or the number of subelements in the mosaic. The lack of dependence arises because the grating elements considered in Figure 3 were not curved. Figure 4 indicates the considerable improvement realized in one of the Figure 3 cases when the mosaic is subdivided into gratings which possess one of three different curvatures. Use of a parabolic surface may produce even better results.

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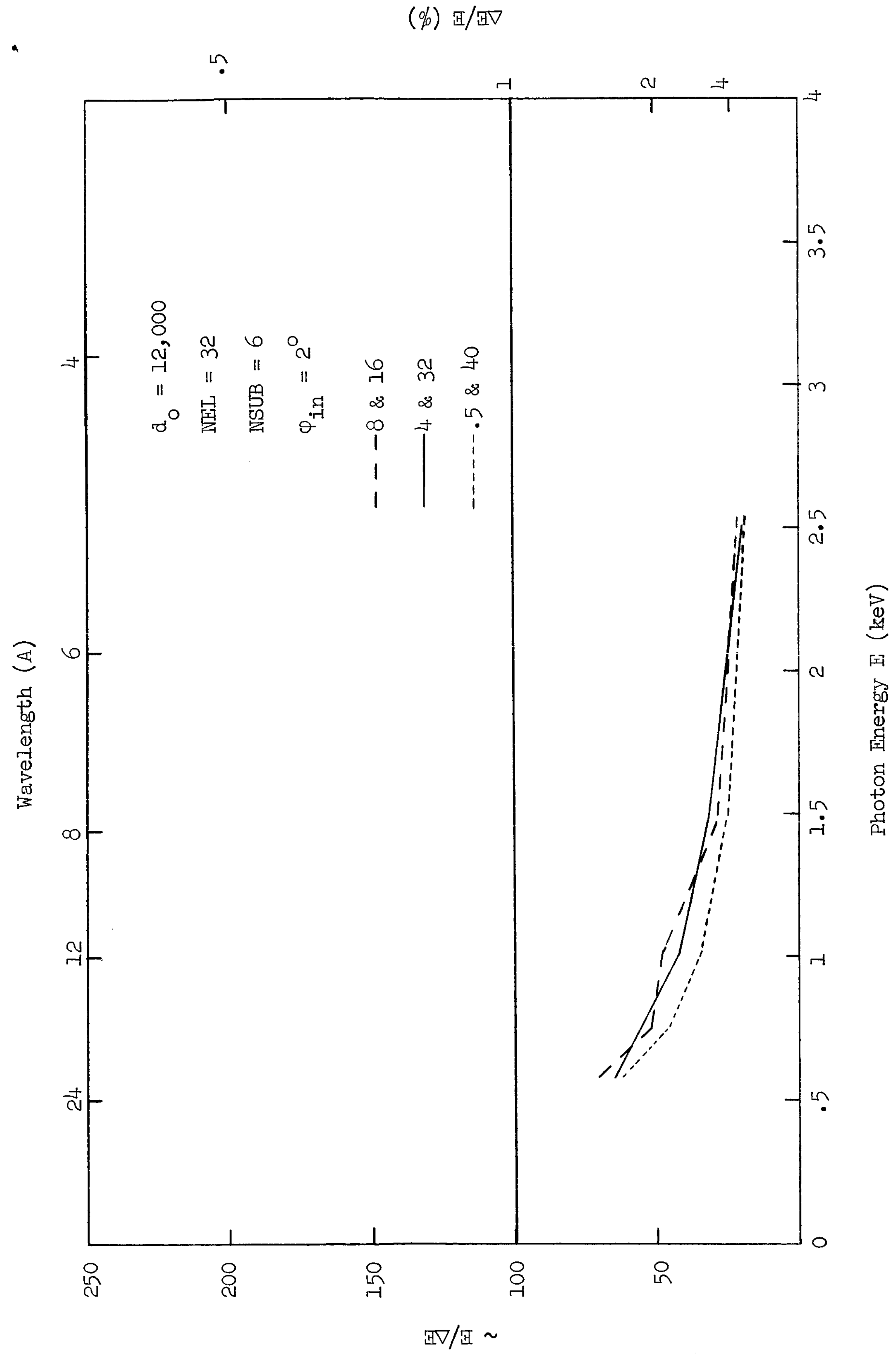


Wavelength (A)
24
12
8
6
4
~ E/ΔE
250
200
150
100
50
ΔE/E (%)
.5
1
2
4
Photon Energy E (keV)
0
.5
1
1.5
2
2.5
3
3.5
4
d_o = 12,000
NEL = 32
NSUB = 6
φ_in = 2°
8 & 16
4 & 32
.5 & 40

FIGURE 1

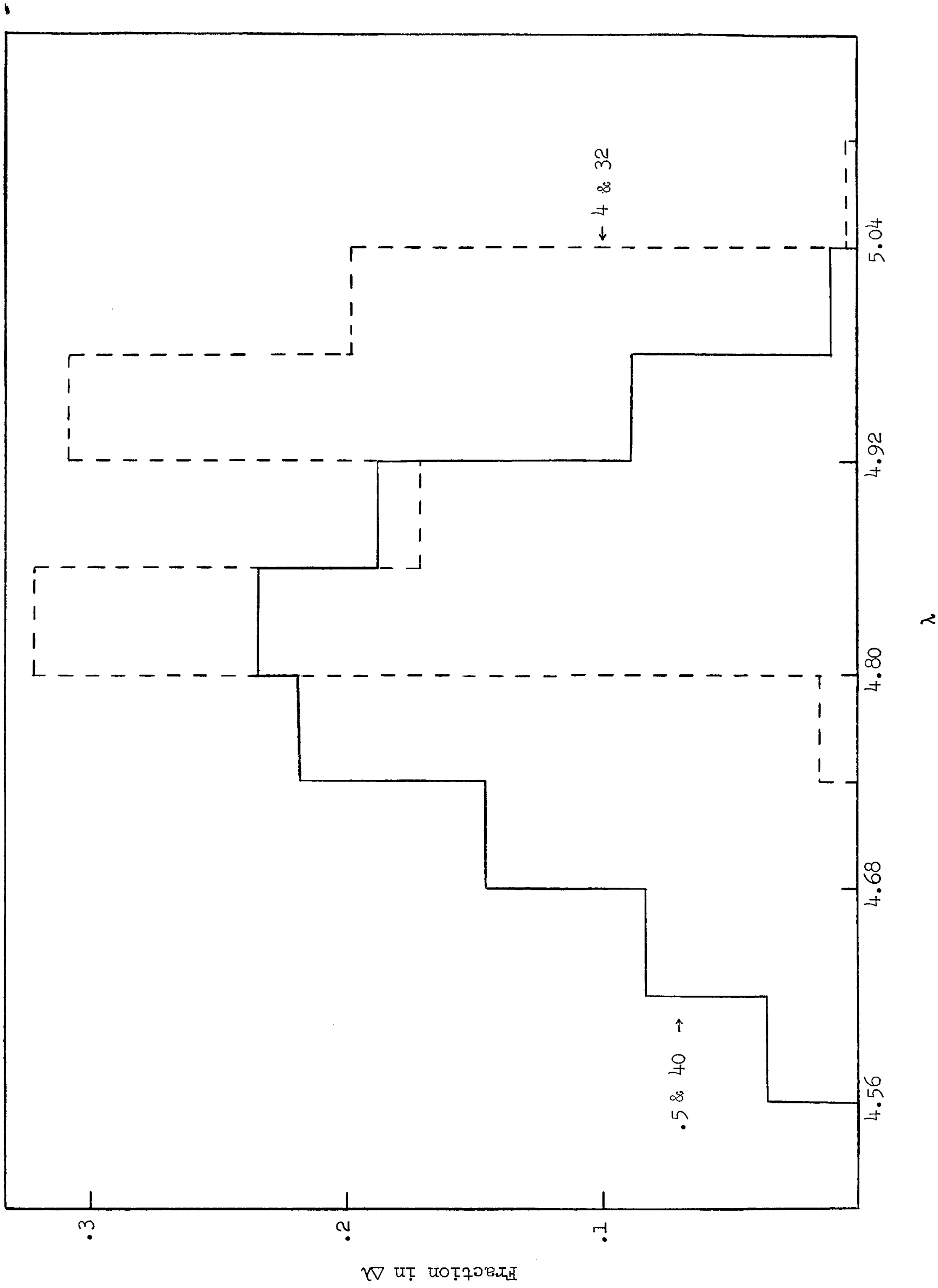
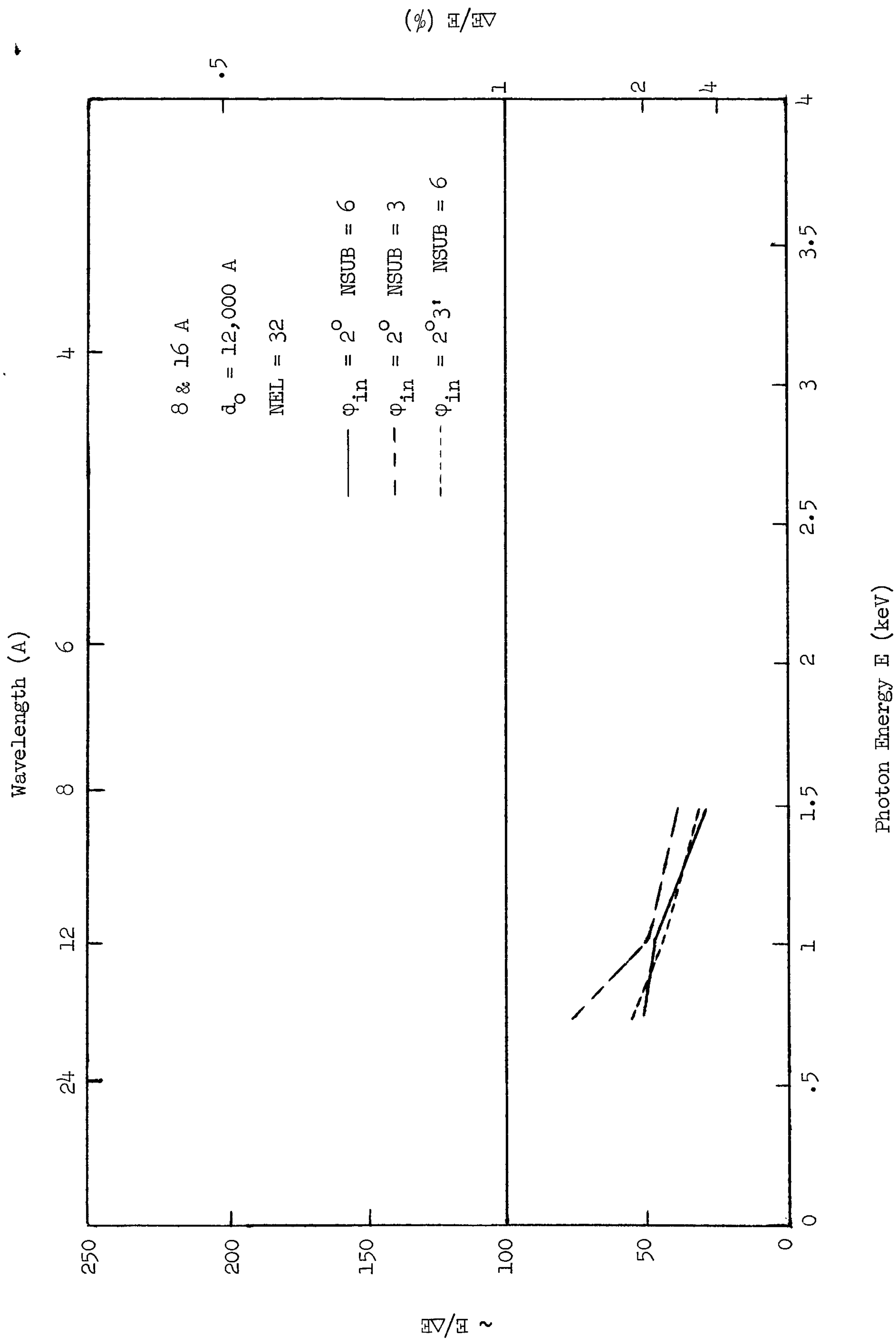
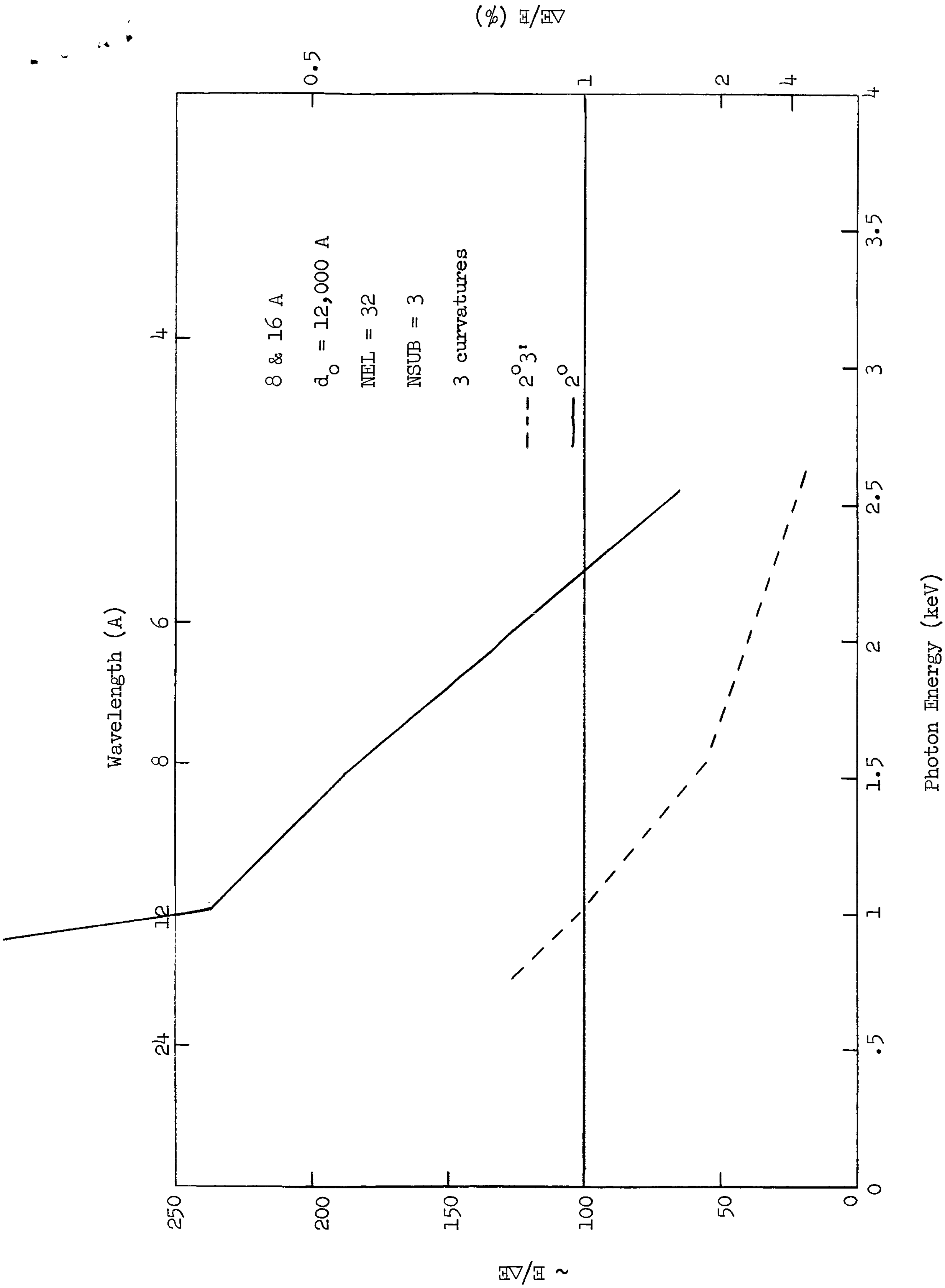


FIGURE 2



ΔE/E (%)
.5
1
2
4
Wavelength (A)
4
6
8
12
24
8 & 16 A
d_o = 12,000 A
NEL = 32
φ_in = 2° NSUB = 6
φ_in = 2° NSUB = 3
φ_in = 2°3' NSUB = 6
~ E/ΔE
250
200
150
100
50
0
.5
1
1.5
2
2.5
3
3.5
4
Photon Energy E (keV)

FIGURE 3



Wavelength (A)
24
12
8
6
4
ΔE/E (%)
0.5
1
2
4
8 & 16 A
d_o = 12,000 A
NEL = 32
NSUB = 3
3 curvatures
$2^o 3'$
2^o
~ E/ΔE
250
200
150
100
50
0
.5
1
1.5
2
2.5
3
3.5
4
Photon Energy (keV)

FIGURE 4