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FINAL REPORT

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## INTRODUCTION

The Thermal Ion Dynamics Experiment (TIDE) is a science investigation aimed at understanding the contributions of the Earth's ionosphere to the total plasma population in the magnetosphere. The TIDE instrument combines differential measurements of angle, energy, and mass to determine the detailed distribution function of low energy magnetospheric ions in the range of 0 to 100 ev. One component of this instrument is an electrostatic analyzer which would select the incident particles from the angle analyzer and transmit them to the mass analyzer. This analyzer is called HARP. There were three design goals for this component:

1. a 1 $cm^2$ entrance aperture,
2. minimum trajectory divergence at exit aperture,
3. minimize internal scattering.

Three tasks were identified.

Task 1. Code the analytic formulation of the particle trajectories in the HARP electrostatic field. From this code produce images of the exit rays for particular entrance ray orientation and aperture geometries.

Task 2. Design and construct the HARP analyzer section using the results of task 1.

Task 3. Deliver the analyzer to MSFC for testing in the laboratory for verification of design.

## DESIGN STUDY

The analytic formulation that was coded included the azimuthal direction which resulted in a 3-dimensional trajectory analysis of the particle. This was in contrast to the meridianal (2-dimensional) analysis that has been considered before (Shyn and Sharp, Rev. Sci. Inst., 1976). The nominal direction of incidence was normal to the slit plane as was the exit direction. The resolution is only a function of the energy band width for this entrance geometry. The calculations predicted a resolution $\Delta E/E$ of 15%. The ratio of the focusing potential to the incident energy was calculated to be 1.10.

## FABRICATION

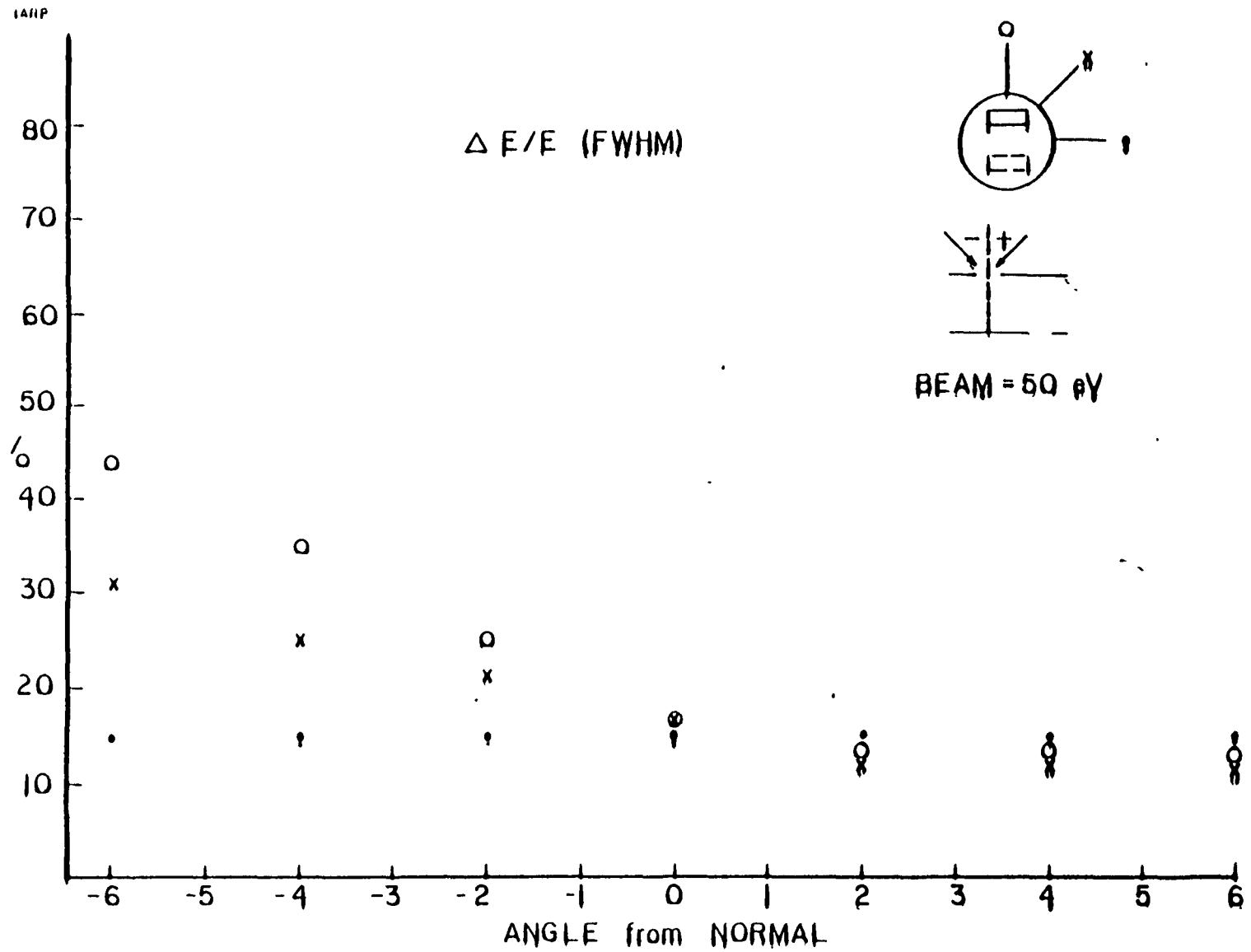
The consideration of the design parameters were used to construct a laboratory test model. This was delivered to MSFC in the fall of 1982 for laboratory testing.

## LABORATORY TEST RESULTS

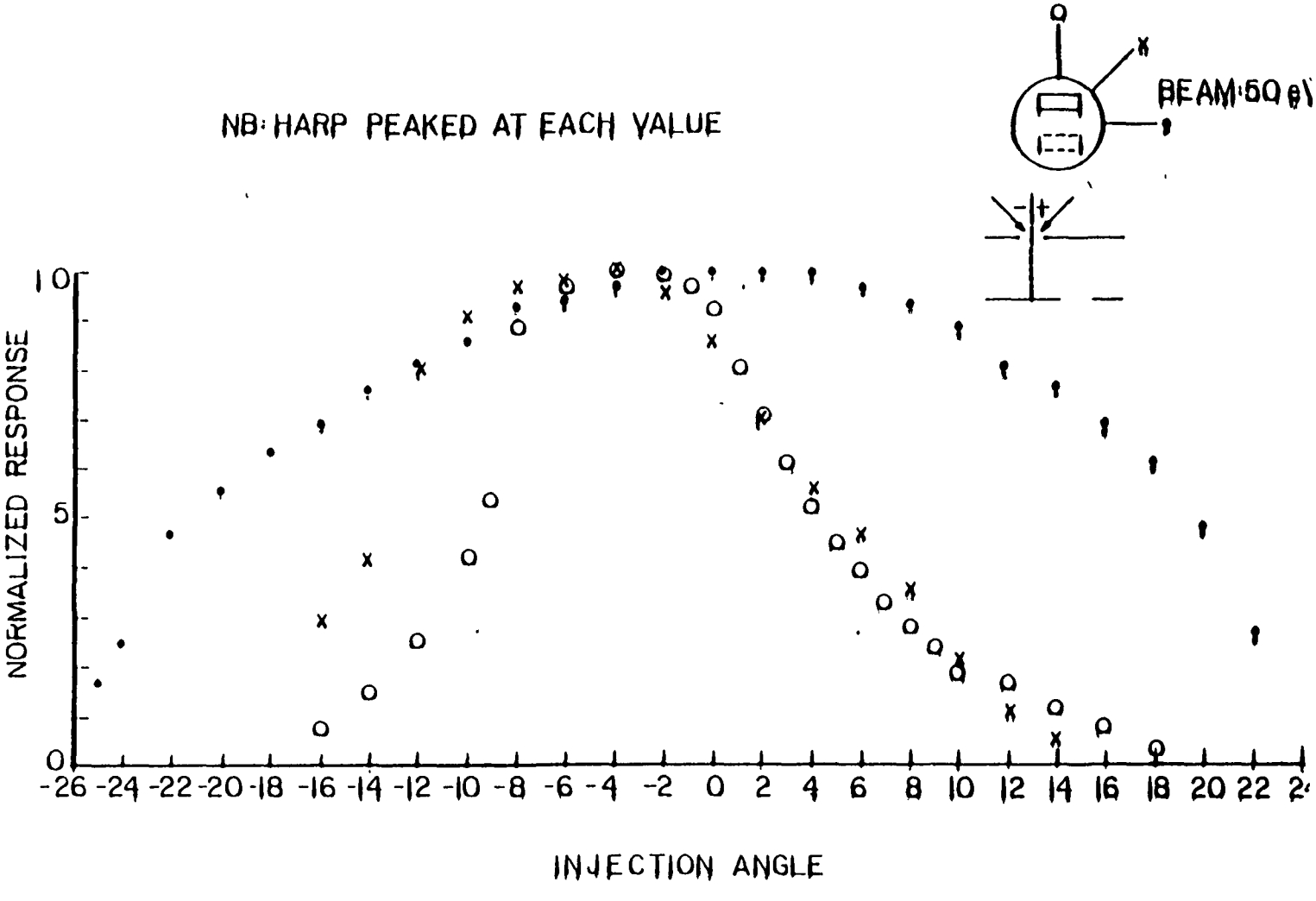
Figure 1 is a study of the resolution for a 50 eV ion beam incident on the slit plane. At normal incidence the resolution is 16%. This compares with the predicted 15%. Incidence angles that are toward the central axis of the instrument lead to a broadening of the resolution.

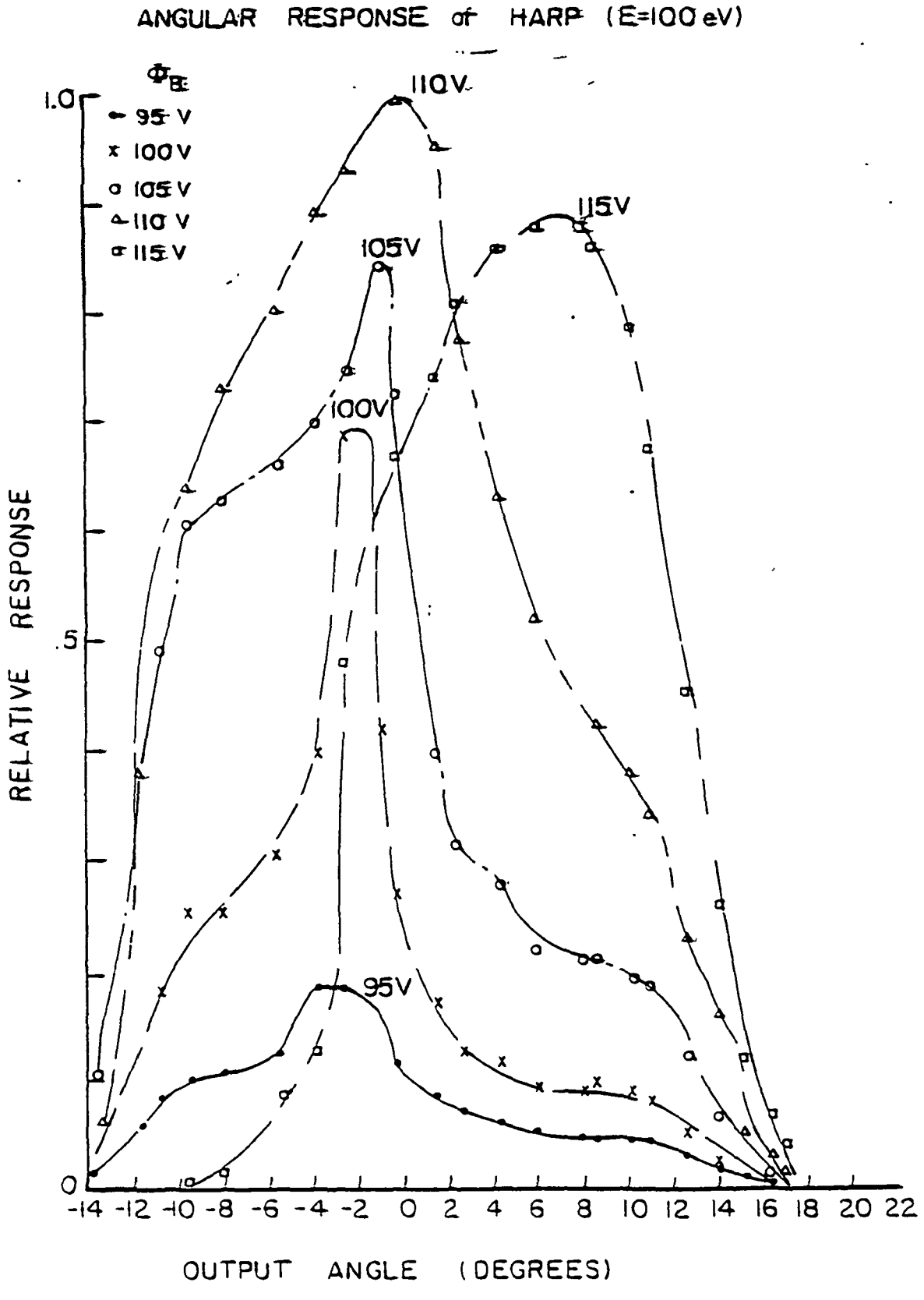
Figure 2 shows the results of the response to the angle of injection across the width of the slit (open circles) and along the slit (closed circles). The width at half maximum when the beam is injected across the slit width is 12 degrees. This is within the specification of the exit angle of the DIF probe which sets over the entrance slit. While the response along the slit indicates a rather wide angle, 40 degrees, the length of the slit contributes to most of this.

Figure 3 indicates the output angular response to a monoenergetic input beam of 100 eV at normal incidence. The peak output energy at 110 volts on the analyzer corresponds to the selection voltage input energy ratio from the design; 1.10.


Δ E/E (FWHM)
BEAM = 50 eV
%
80
70
60
50
40
30
20
10
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
ANGLE from NORMAL

SHARP


NB: HARP PEAKED AT EACH VALUE
BEAM (50 GeV)
NORMALIZED RESPONSE
10
5
0
-26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22
INJECTION ANGLE


ANGULAR RESPONSE of HARP (E=100 eV)
$\Phi_E$
95 V
100 V
105 V
110 V
115 V
110V
115V
105V
100V
95V
1.0
.5
0
RELATIVE RESPONSE
-14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22
OUTPUT ANGLE (DEGREES)