BCV
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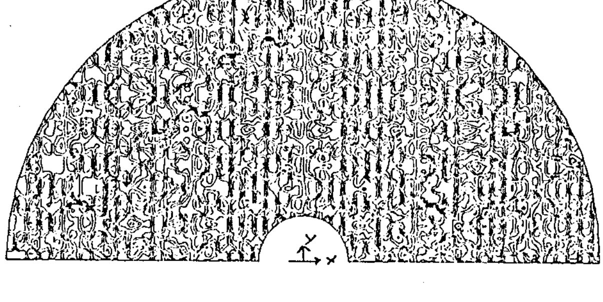
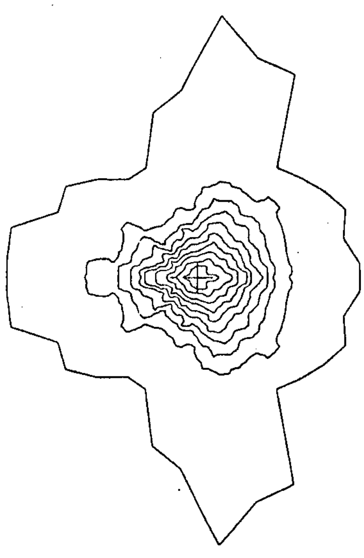
COLUMBUS PROJECT

MIRROR BLANK 8. mt diam F1.2

THERMAL TEST : Random Temperature Distribution

Report N. 111 Rev. 0
Milano, 1988, April 30th





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1. INTRODUCTION

In this report we describe the results obtained for the 8 meter blank mirror F1.2 subject to a random temperature distribution.
The analysis has been performed using the numerical model M4 (half mirror plane elements) described in our report N. 104.
The mirror is subjected to a random temperature distribution in the plane X-Y while the temperature values are constant along the mirror thickness. We have put symmetry constraints in the plane X-Z and therefore we have supposed that the random temperature distribution is symmetrical as to such a plane.

The random temperature distribution has been computed as follows:

- A square grid having side 250 mm approximately has been superimposed to the mesh.
- A random temperature value has been attributed to each grid vertex. The maximum value was +0.05 °C and the minimum value was -0.05 °C.
- Since in the SAP program we must define the nodal temperature, we computed the temperature T of each node using the following expression:

$$T = T_a\sqrt{\frac{d_b+d_c}{d_a+d_b+d_c}}+T_b\sqrt{\frac{d_a+d_c}{d_a+d_b+d_c}}+T_c\sqrt{\frac{d_a+d_b}{d_a+d_b+d_c}}$$

where

$T_a \; T_b \; T_c$

are the temperatures of the three grid vertices nearest to the mesh node and

$d_a \; d_b \; d_c$

are the distances between these three grid vertices and the mesh node.

In this way we obtain a random temperature distribution as "spots of a leopard" where the spot dimension is approximately 250. mm (nearly two times the cell side).

The characteristic nodal temperature values applied on the mesh are:

Average temperature value	$0.959 * 10^{-5}$ °C
Maximum temperature value	+0.0645°C
Minimum temperature value	−0.0626°C

In figure 1 are reported the isocontours of the random temperature distribution applied to the nodes (isocontour step = 0.02 °C).

2. RESULTS

The optical performances of the mirror are reported in the following table:

optical performances	
RMS as to the undeformed paraboloid *RMS as to the bestfit paraboloid* *axial displacement Peak to Valley* *average axial displacement*	36.8 nm 15.7 nm 158.9 nm 1.1 nm

In figure 2 are plotted the isocontours (step = 10 nm) of the axial component of the displacement perpendicular to the optical surface as to the bestfit paraboloid.

The bestfit paraboloid displacements are the following:

bestfit paraboloid displacements	
axial rigid displacement *Y rotation* *focal variation*	-23.7 nm $-0.15 * 10^{-7}$ *rad* -1065.0nm

2.1. Zernike polynomials

We have calculated the coefficients of the upper plate strain expansion in Zernike polynomial serie. These polynomials are reported in our previous reports.
The first 45 coefficient values are reported in the following table (we have neglected the values some order of magnitude lesser than the maximum coefficient):

ZERNIKE POLYNOMIAL COEFFICIENTS		
$c_{00} = 0.000$	$c_{11} = 1.25 * 10^{-6}$	$d_{11} = 0.000$
$c_{20} = -4.74 * 10^{-8}$	$c_{22} = -1.00 * 10^{-5}$	$d_{22} = 0.000$
$c_{31} = -3.07 * 10^{-6}$	$d_{31} = 0.000$	$c_{33} = -8.85 * 10^{-7}$
$d_{33} = 0.000$	$c_{40} = -5.51 * 10^{-6}$	$c_{42} = -4.94 * 10^{-7}$

ZERNIKE POLYNOMIAL COEFFICIENTS		
$d_{42} = 0.000$	$c_{44} = 3.73*10^{-6}$	$d_{44} = 0.000$
$c_{51} = -3.09*10^{-6}$	$d_{51} = 0.000$	$c_{53} = -4.17*10^{-7}$
$d_{53} = 0.000$	$c_{55} = 8.26*10^{-6}$	$d_{55} = 0.000$
$c_{60} = 7.84*10^{-6}$	$c_{62} = 1.84*10^{-6}$	$d_{62} = 0.000$
$c_{64} = -1.70*10^{-5}$	$d_{64} = 0.000$	$c_{66} = -6.76*10^{-6}$
$d_{66} = 0.000$	$c_{71} = -6.28*10^{-6}$	$d_{71} = 0.000$
$c_{73} = 9.01*10^{-6}$	$d_{73} = 0.000$	$c_{75} = -1.50*10^{-6}$
$d_{75} = 0.000$	$c_{77} = -1.38*10^{-5}$	$d_{77} = 0.000$
$c_{80} = 1.52*10^{-6}$	$c_{82} = 4.00*10^{-7}$	$d_{82} = 0.000$
$c_{84} = 2.91*10^{-6}$	$d_{84} = 0.000$	$c_{86} = 2.06*10^{-6}$
$d_{86} = 0.000$	$c_{88} = -6.65*10^{-6}$	$d_{88} = 0.000$

2.2. Structure function

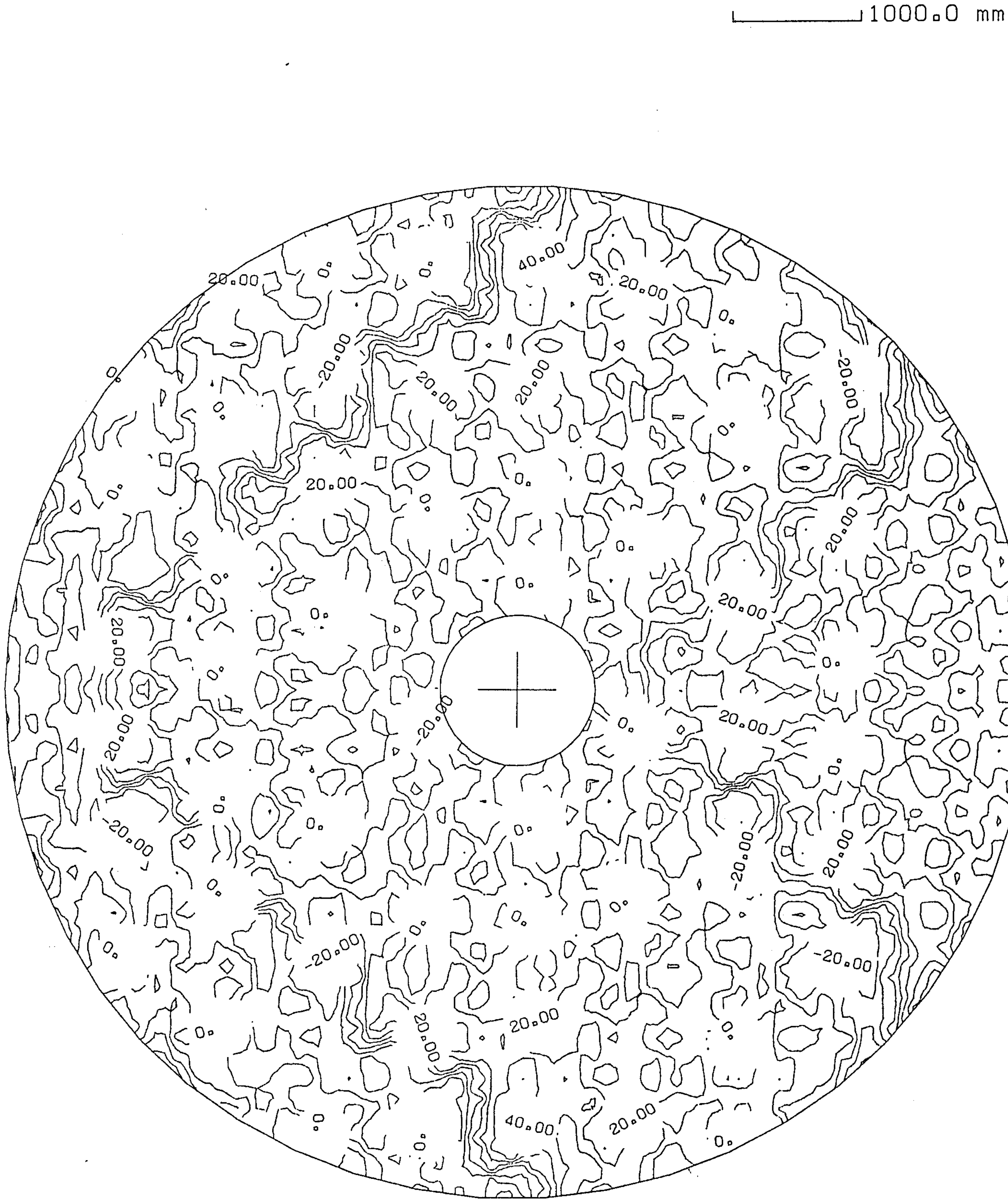
The results related to the structure function are reported in the following table:

STRUCTURE FUNCTION			
DISTANCE cell side	COUPLE NUMBER	AVERAGE VALUE (mm)	STANDARD DEVIATION (mm)
1 side	12924	0.0	$0.974*10^{-5}$
2 sides	12658	0.0	$0.148*10^{-4}$
4 sides	12254	0.0	$0.189*10^{-4}$
8 sides	11358	0.0	$0.206*10^{-4}$
16 sides	9437	0.0	$0.220*10^{-4}$
32 sides	6739	0.0	$0.231*10^{-4}$

In figure 3 is reported the Structure Function "distance - standard deviation".

2.3. Ray deviation

In figure 4 are reported the isocontours of the areas around the focus related to an assigned percentage of the total energy (step 10.0%).
The 90. % of the total energy is included in a "cone" having ~0.14 arcsec angle.



ISOCONTOURS OF THE AXIAL COMPONENT OF THE PERPENDICULAR ONE (AS TO THE BESTFIT PARABOLOID)

Isocontour step = 10 nm

Figure 2

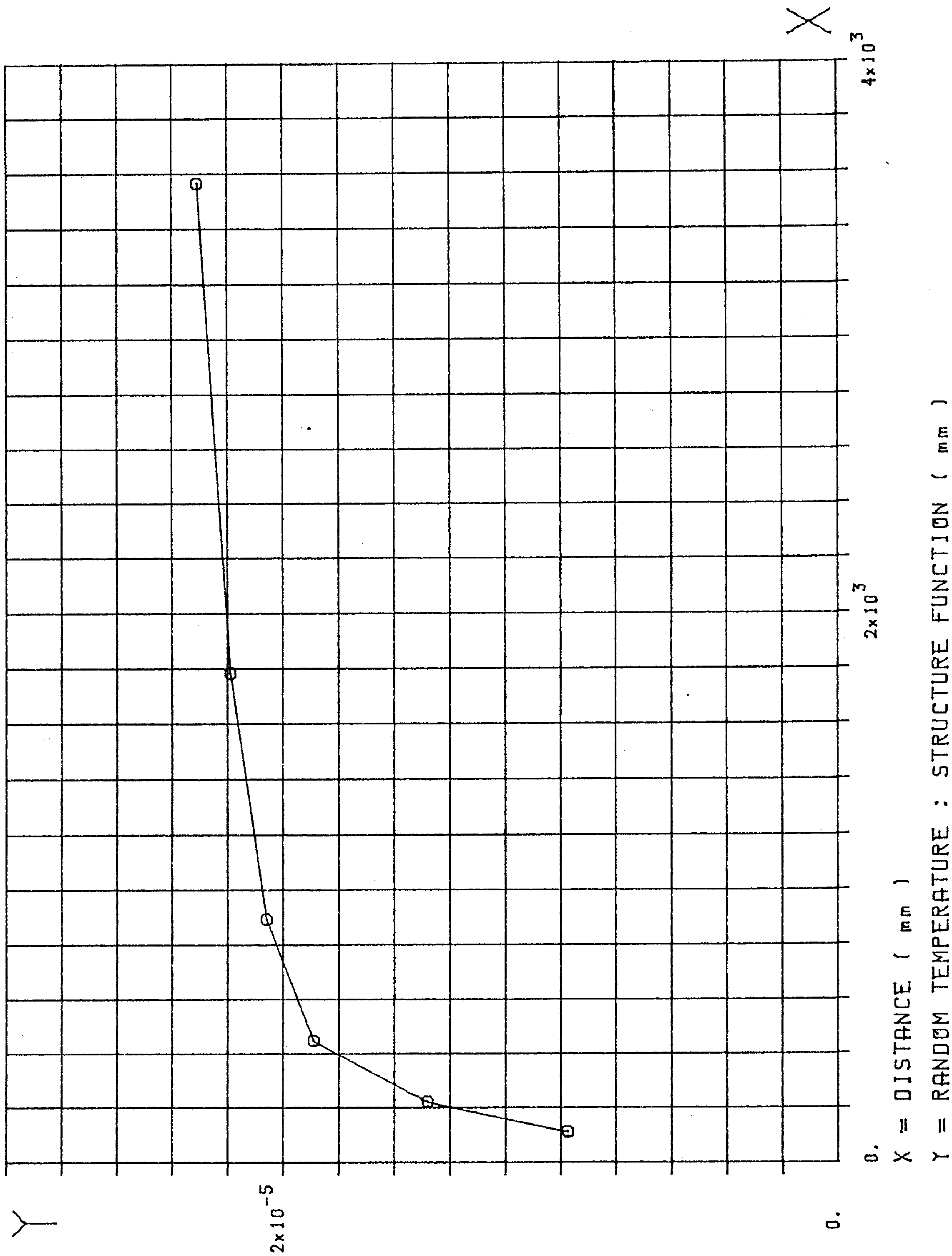

X
Y
4x10^3
2x10^3
0.
2x10^-5
0.
X = DISTANCE (mm)
Y = RANDOM TEMPERATURE : STRUCTURE FUNCTION (mm)

Figure 3

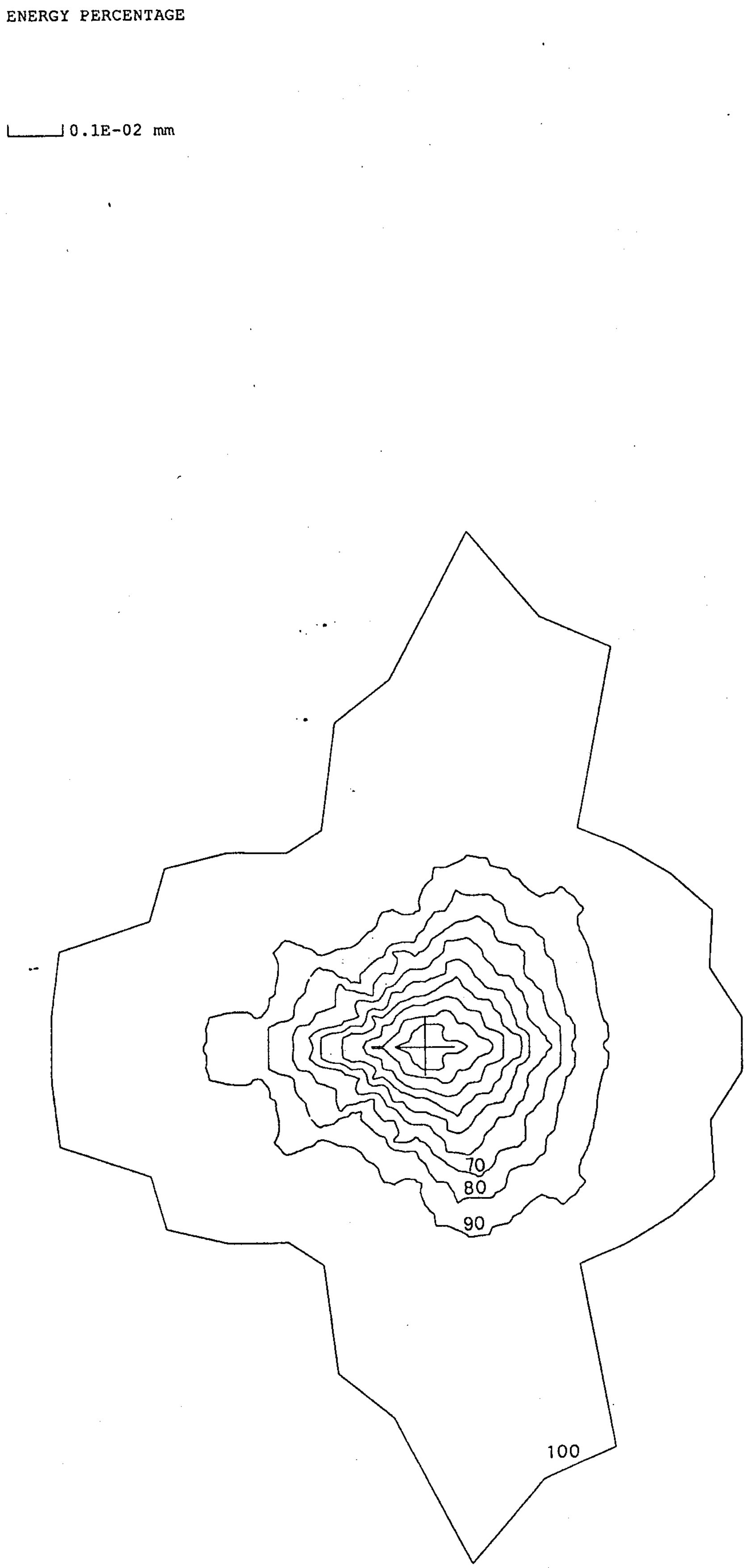


Figure 4