

# UNIVERSITY OF CALIFORNIA OBSERVATORIES LICK OBSERVATORY

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TECHNICAL REPORT

## **Analysis of Incidence Angles for the ESI Spectrograph**

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January 21, 1997

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This technical report is a summary of the distribution of light beam incidence angles at material-air boundaries throughout the ESI spectrograph. This information is required in order to design multi-layer dielectric anti-reflection coatings which are tuned to each surface.

The ESI spectrograph has three modes: a direct imaging mode, a high-dispersion, prism-cross-dispersed echellette-grating spectrograph mode, and a low-dispersion, prism-dispersed mode. Approximately 200,000 rays were traced in each mode. Each ray contribution was added to the final angle distribution of a surface, weighted by the azimuthally averaged primary pupil density due to the irregularly shaped primary and the (relatively small) absorption losses in the transmissive materials. Losses from mirror surfaces and the grating were not included.

For the direct imaging mode, the imaging field was sampled on a square grid of field angles with a spacing of 0.2 arcminutes at a single wavelength. For the echellette mode, each of the 10 orders was sampled at a density of 30 wavelengths distributed along the free spectral range. The wavelengths outside the free spectral range of each order were included as well, since these regions contain a significant amount of the total energy. For the low-dispersion mode, 10 wavelengths were sampled every 0.5 arcminutes along the central long-slit and at 0.5 arcminutes off of the central long-slit to each side. The TV guider system was also sampled with approximately 20,000 points on a square grid of 36 field angles. Each field angle and wavelength in all these modes was sampled with 500 points covering the telescope aperture.

Table 1 shows the angle of the peak for each distribution, as well as the angle where the lower and upper tails of the distribution contain 5.0% of the total energy. The angles for each ray were binned at 1.0-degree intervals, so these values are to that level of accuracy. Figures 1 through 20 show the final distribution of field angles.

5% Integrated Tails and Peak Locations, in Degrees													
Fig	Surface Name	Imaging			Echelle			Low Disp			TV		
		-5%	Peak	+5%	-5%	Peak	+5%	-5%	Peak	+5%	-5%	Peak	+5%
1	Instrument Entrance Window	0	1	3	0	1	3	0	1	3	0	1	3
2	Collimator Mirror	1	2	4	1	2	4	1	2	4			
3	Direct Imaging Flat Mirror	25	26	28									
4	Double-Pass Prism Face 1 Pass 1				47	47	48	47	47	47	47	47	49
4	Double-Pass Prism Face 1 Pass 2				64	64	70	63	64	64	63	64	69
5	Double-Pass Prism Face 2 Pass 1				32	32	34	31	32	32	31	32	34
5	Double-Pass Prism Face 2 Pass 2				19	19	21	19	20	20	19	20	22
6	Low Dispersion Flat Mirror							5	6	9			
7	Single-Pass Prism Face 1				56	60	62	56	60	60	56	60	63
8	Single-Pass Prism Face 2				22	23	27	21	22	22	21	22	27
9	Doublet Front Surface	2	7	13	2	9	18	2	8	19			
10	Doublet Back Surface	0	2	6	0	1	5	0	2	5			
11	Singlet First Surface	2	9	18	3	11	24	3	10	26			
12	Singlet Back Surface	2	7	11	2	6	12	2	6	13			
13	First Triplet Front Surface	2	8	15	2	9	20	3	9	21			
14	First Triplet Back Surface	2	6	11	2	6	9	2	6	9			
15	Second Triplet Front Surface	2	8	17	2	7	16	2	8	16			
16	Second Triplet Back Surface	3	10	21	3	8	16	3	9	15			
17	Dewar Window Front Surface	4	11	18	3	13	24	3	11	25			
18	Dewar Window Back Surface	3	11	19	3	10	16	4	11	16			
19	TV Guide Focal Surface Mirror										8	11	14
20	TV Folding Flat Mirror										19	23	28

Table 1

Figure-1 Instrument Entrance Window

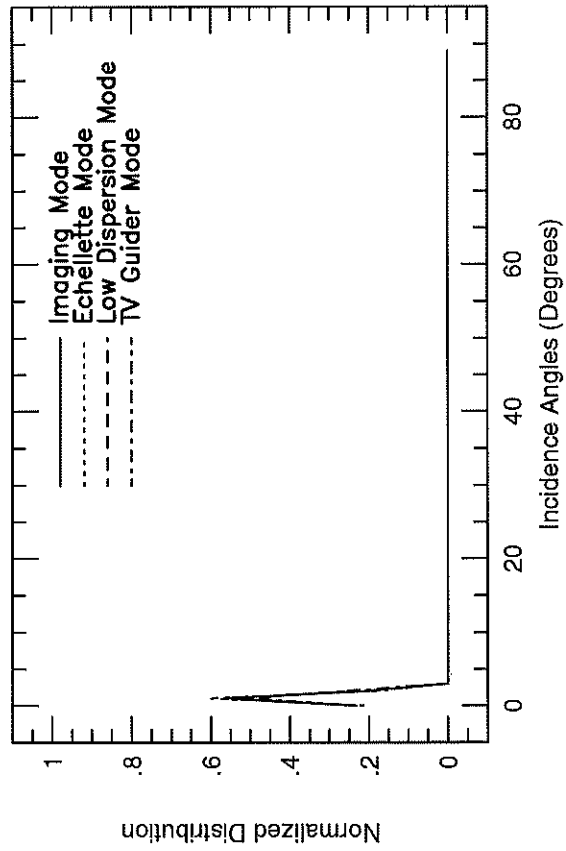


Figure-2 Collimator Mirror

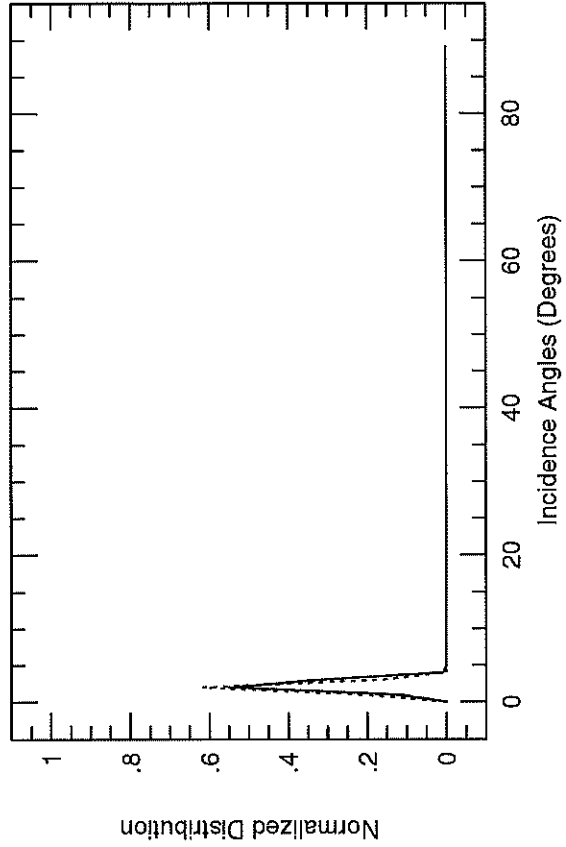


Figure-3 Direct Imaging Flat Mirror

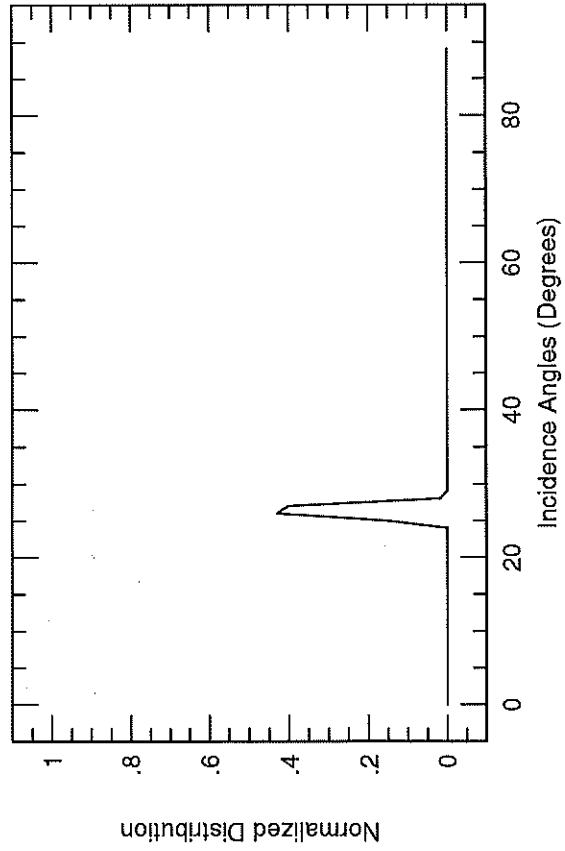


Figure-4 First Face of Double-Pass Prism

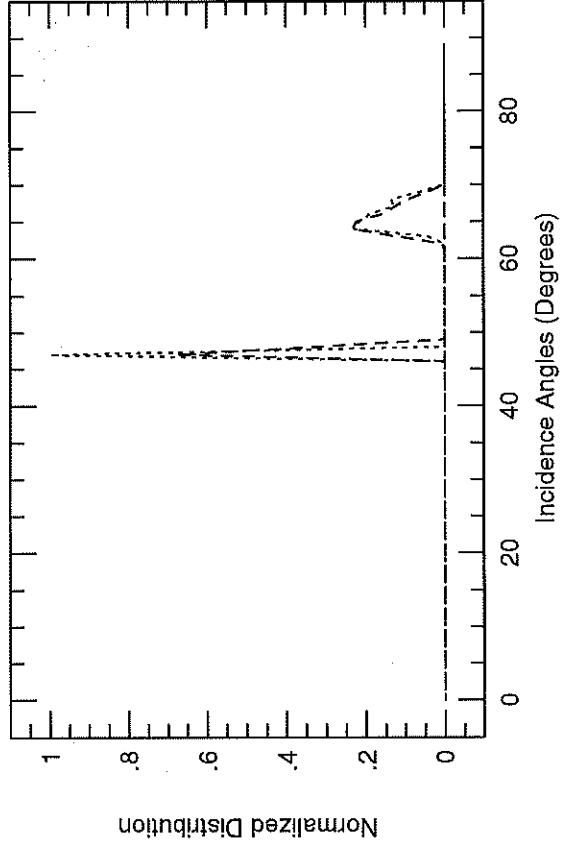


Figure-5 Second Face of Double-Pass Prism

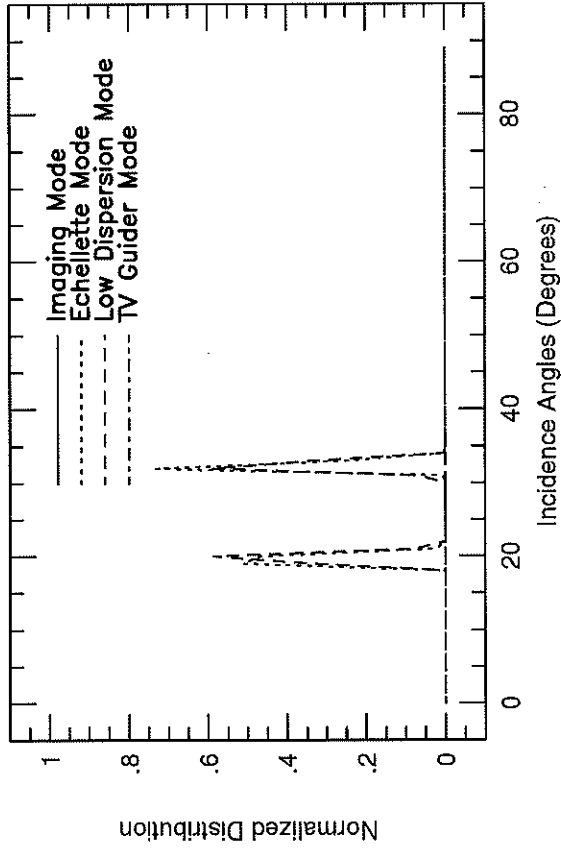


Figure-6 Low Dispersion Mirror

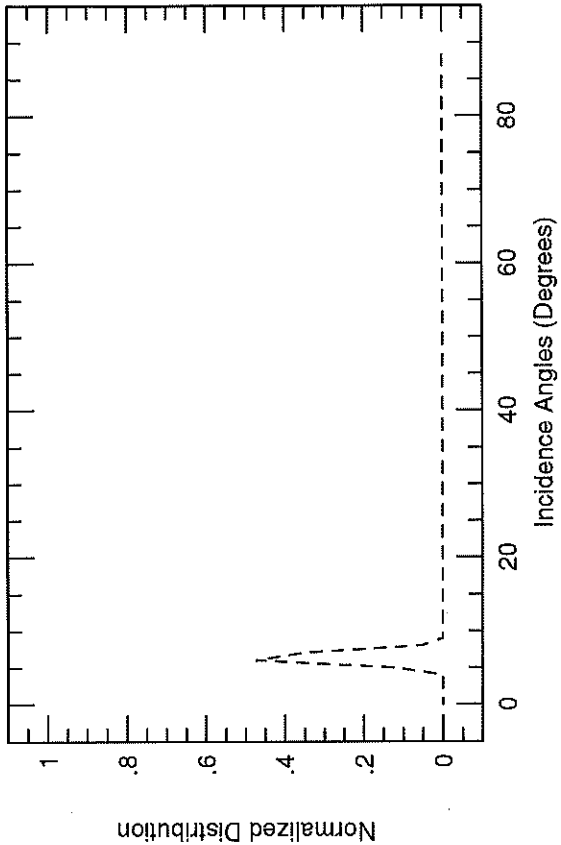


Figure-7 First Face of Single-Pass Prism

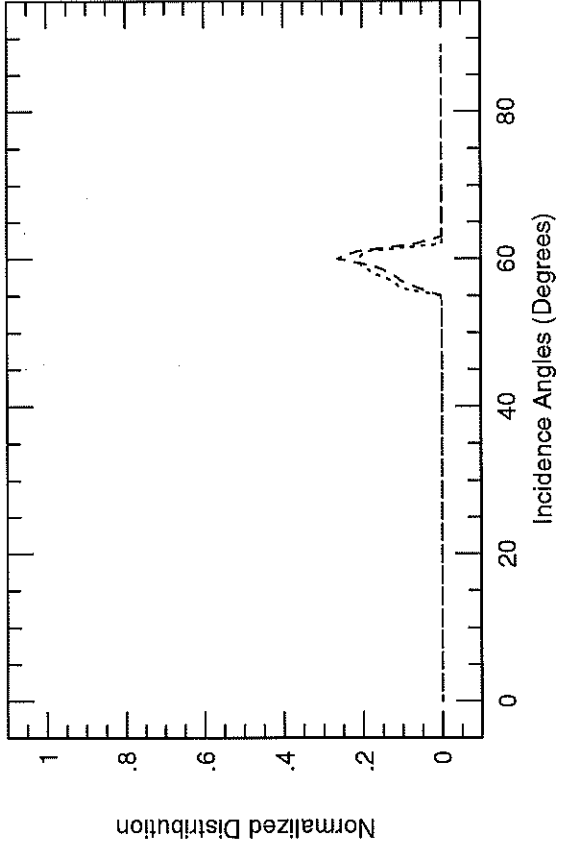


Figure-8 Second Face of Single-Pass Prism

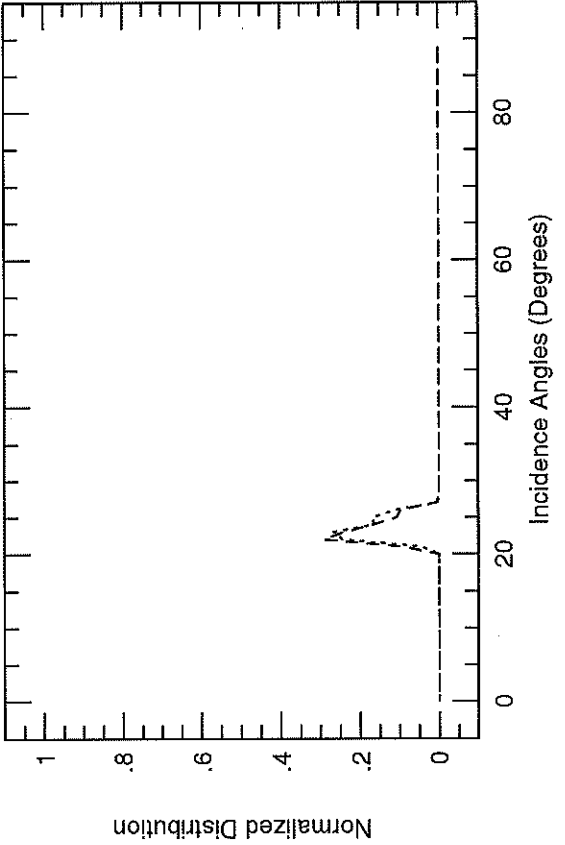


Figure-9 Front Doublet Surface / Air - CaF<sub>2</sub>

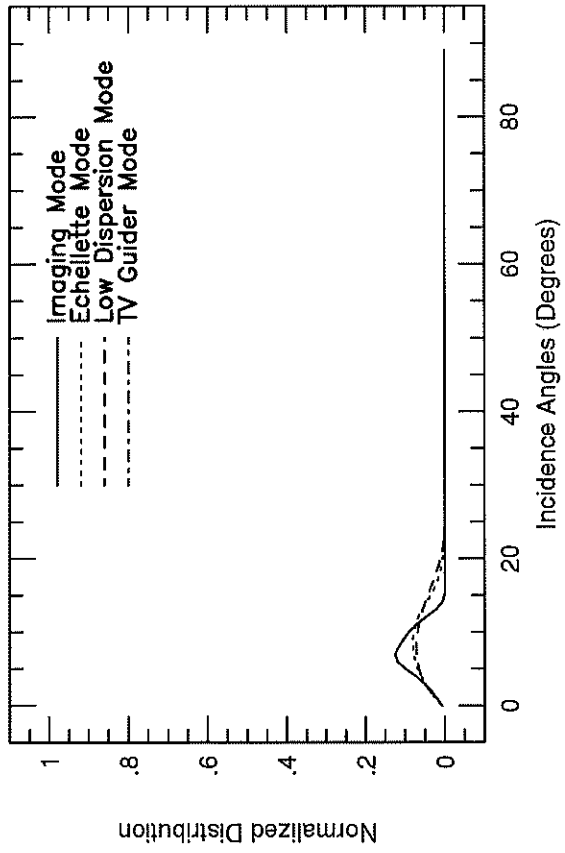


Figure-10 Back Doublet Surface / S-LAL7 - Air

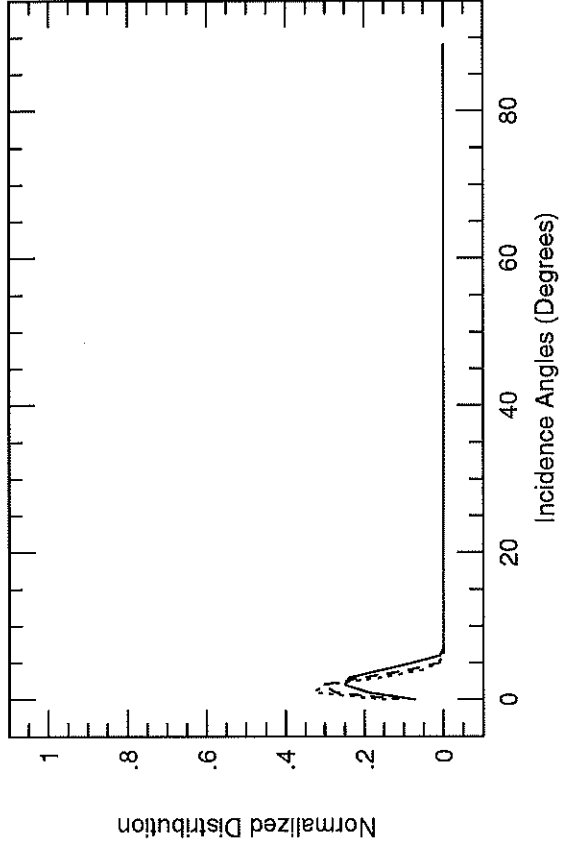


Figure-11 Front Singlet Surface / Air - CaF<sub>2</sub>

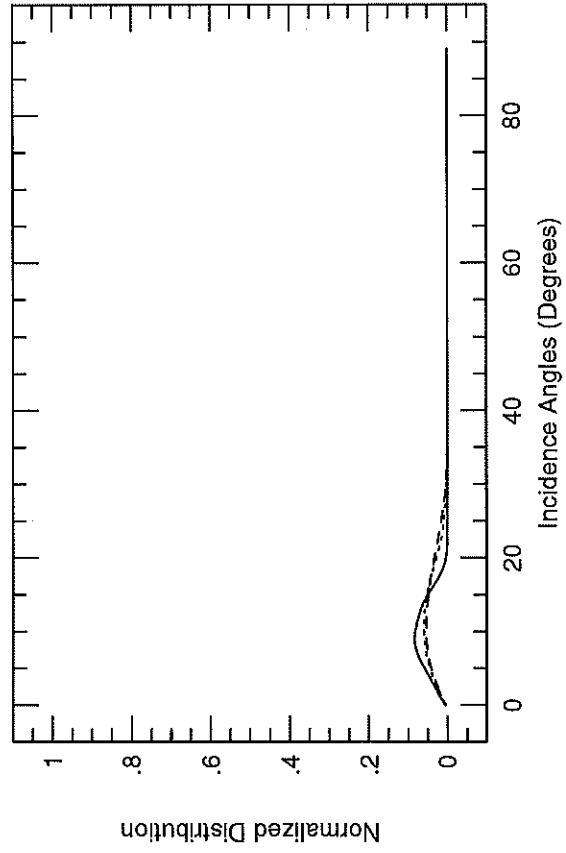


Figure-12 Back Singlet Surface / CaF<sub>2</sub> - Air

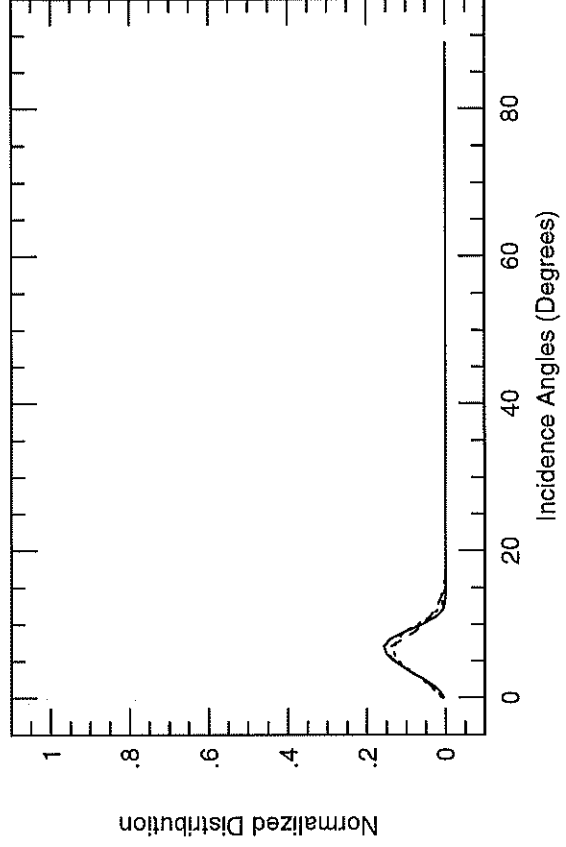


Figure-13 Front First Triplet Surface / Air - BSM51Y

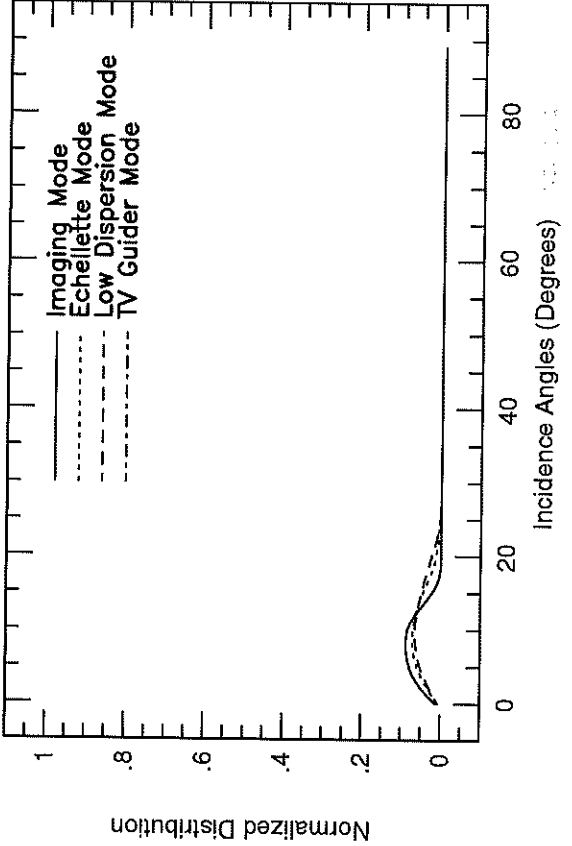


Figure-14 Back First Triplet Surface / PBL25Y - Air

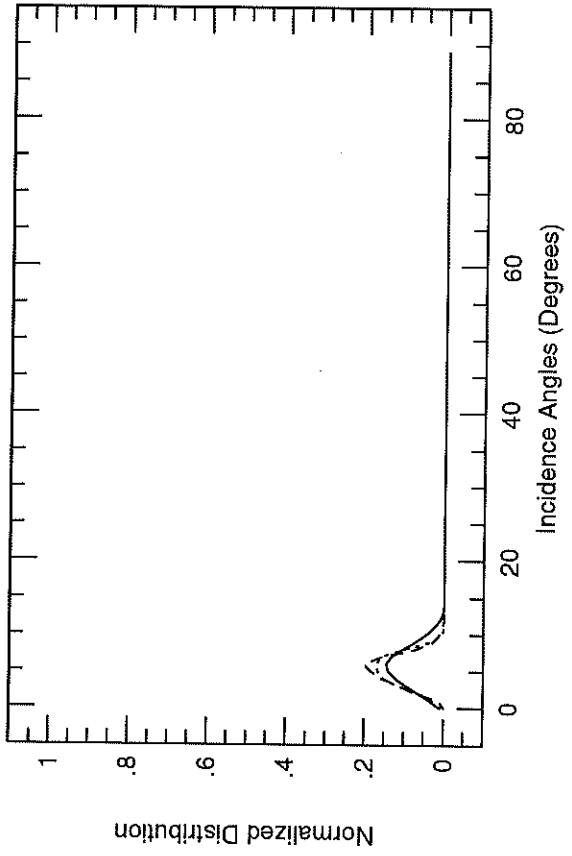


Figure-15 Front Second Triplet Surface / Air - S-LAL.12

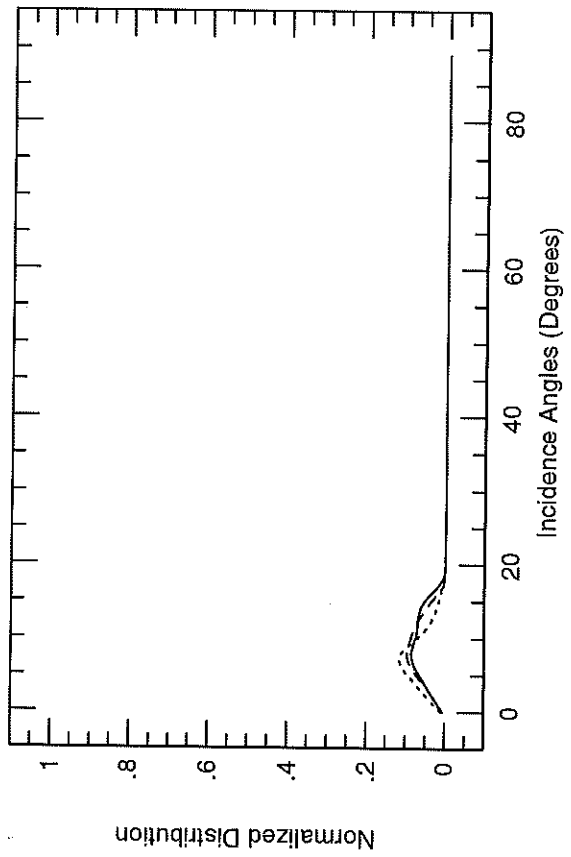


Figure-16 Back Second Triplet Surface / S-LAL7 - Air

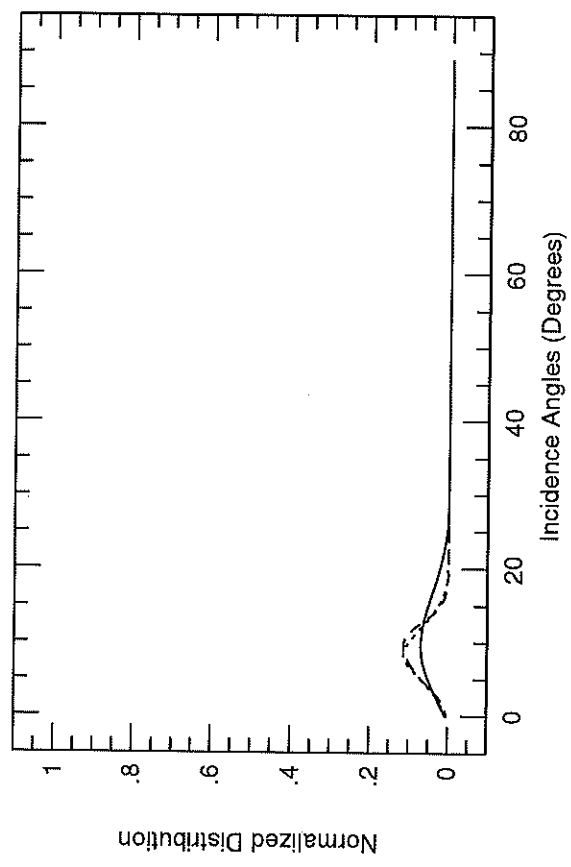


Figure-17 Front Dewar Window Surface / Air - Fused Silica

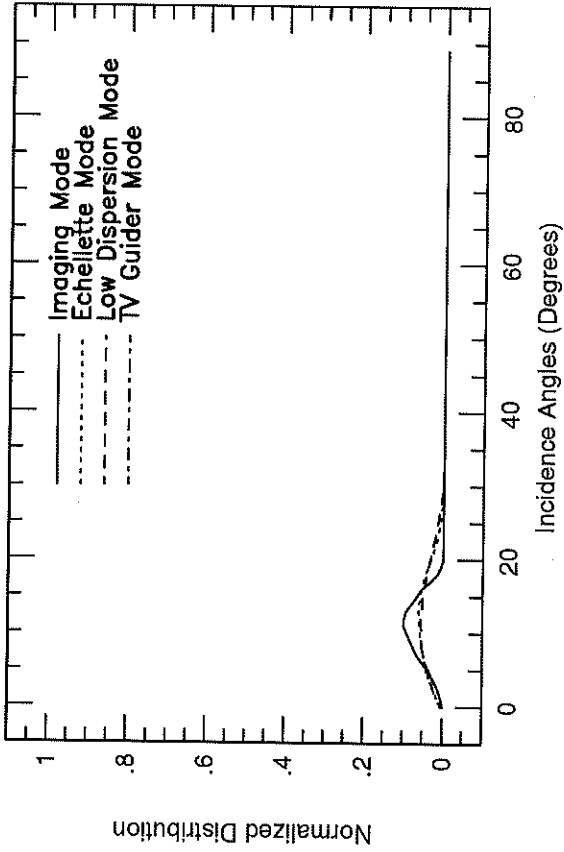


Figure-18 Back Dewar Window Surface / Fused Silica - Vacuum

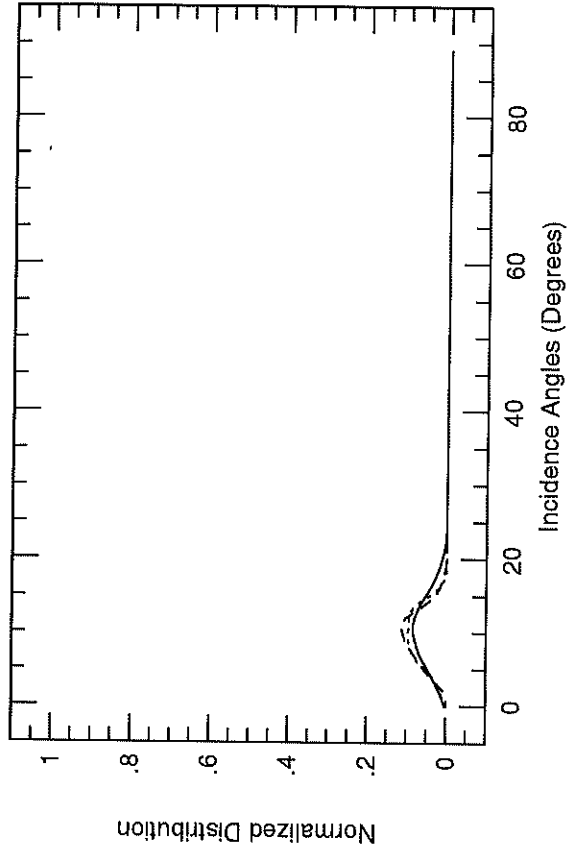


Figure-19 TV Guider Focal Surface Mirror

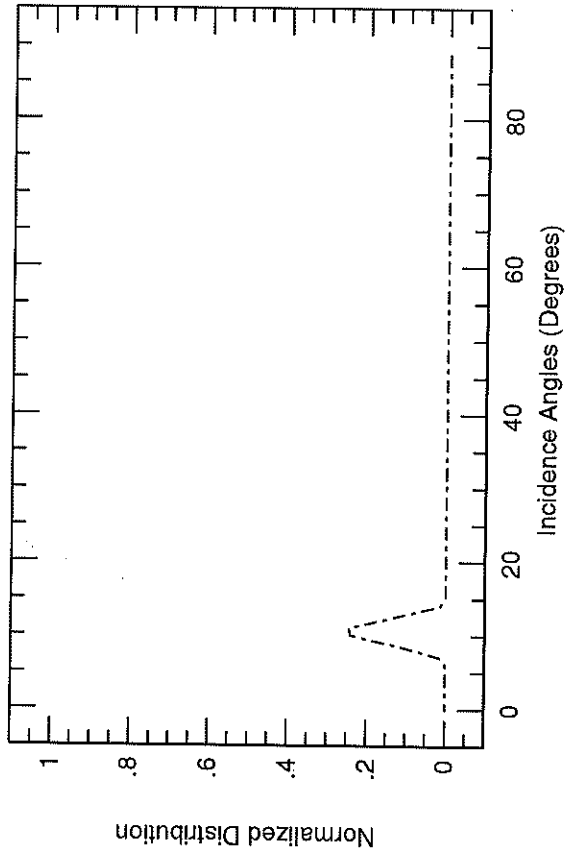


Figure-20 TV Guider Fold Flat Mirror

