NATIONAL RADIO ASTRONOMY OBSERVATORY
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2010 NORTH FORBES BLVD.
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TELEPHONE 602-882-8250

September 25, 1979

Dr. A. Dalgarno
Letters Editor
The Astrophysical Journal
Center for Astrophysics
60 Garden Street
Cambridge MA 02138

Dear Dr. Dalgarno:

Enclosed are three revised copies of the manuscript, with glossies of the five figures, for the paper "Structure of the Magnetic Field in the Radio Jets in 3C 31 and NGC 315", by E. B. Fomalont, A. H. Bridle, A. G. Willis, and R. A. Perley, originally submitted to you on 16 August 1979.

We have made a number of revisions suggested by the referee's comments. In particular, we now emphasize that what is required of the thermal matter is only that it freeze the fields into the flow, so that the field components would evolve with beam radius approximately as described by Blandford and Rees (1978). The referee's questions about dynamical dominance of the thermal matter can properly be answered only if there were an independent means of estimating the magnetic field strengths in these jets. We are reluctant to apply the standard equipartition assumptions to these systems until there are more independent observational clues to their nature; only with those assumptions could the referee's question about limits to the thermal content of the jets be answered. We have therefore reworded our discussion on page 8 slightly so as not to leave the impression that we might be assuming energy or mass dominance by the thermal matter. We have also added a note on page 8 to the effect that the observed Faraday rotations are consistent with an origin in galactic foreground material.

We agree that this manuscript cannot be significantly shortened without loss of essential content. We therefore request that it be published in Part I of the Journal, as you suggested.

Please send further correspondence regarding this manuscript to:

Dr. E. B. Fomalont
National Radio Astronomy Observatory
Edgemont Road
Charlottesville VA 22901

Yours sincerely,

Dr. A. H. Bridle

AHB/drg

Enc.

UNIVERSITY OF MANCHESTER
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CHESHIRE
SK11 9DL

DS/ecb

13th September, 1979

Dr. A. Bridle,
Astronomy Group,
Physics Department,
Queen's University,
Kingston,
Ontario,
CANADA.

Dear Alan,

Attached is a summary of our polarization measurements of 3C31 at 962 MHz taken as part of our study of the component polarization of 3CR sources in general.

The source is so complex that probably all we will publish will be the integrated polarization from our low resolution observations and the parameters of the central component from the Mk III data.

At a quick glance there seems little obvious correlation with the data of Burch.

With regards,

Dave Stannard

Dr. D. Stannard.

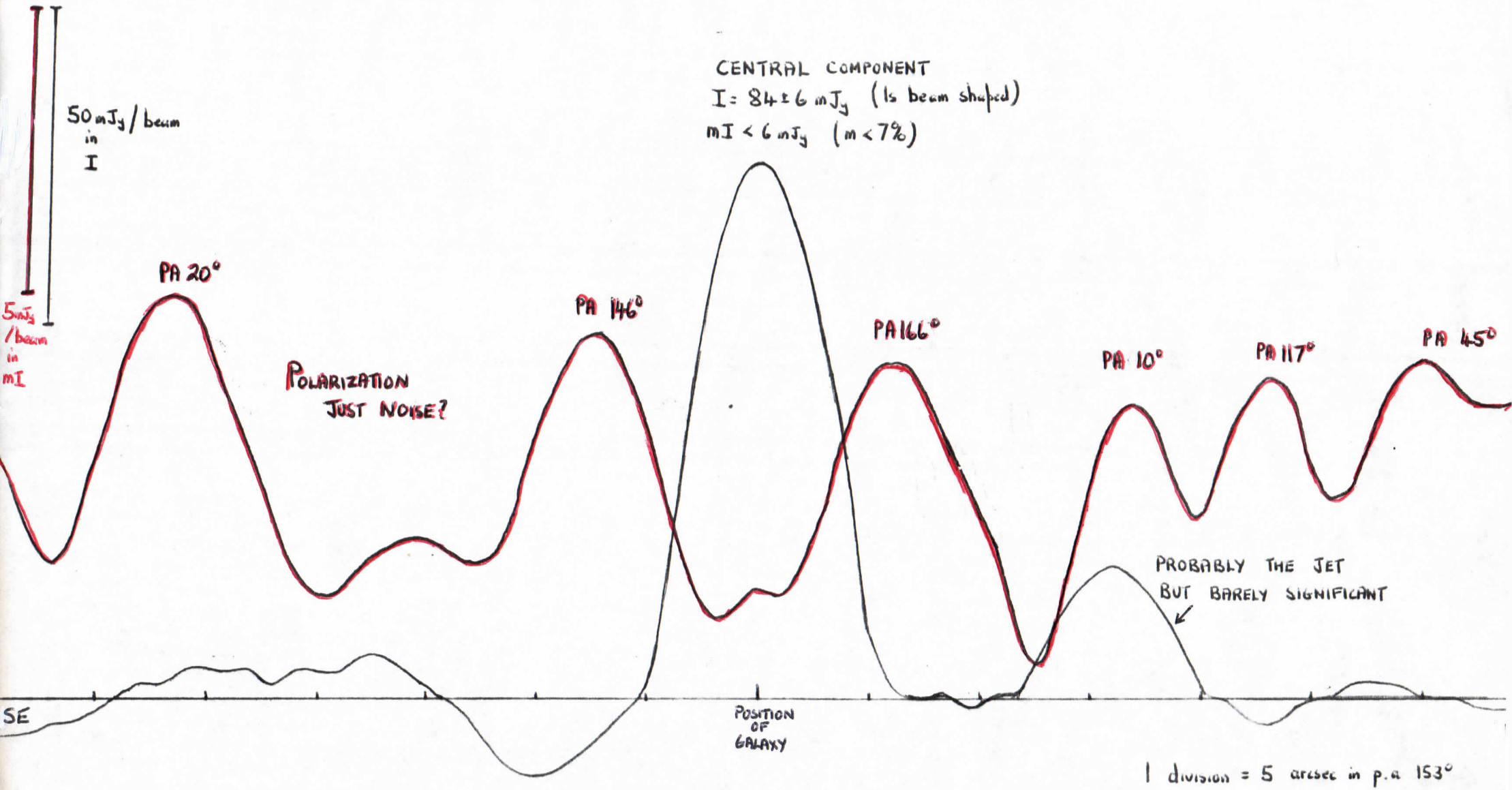
Encl.

HIGH RESOLUTION STRIP DISTRIBUTION

3C31

JODRELL – Mk III 962 MHz 1976 MAY

= TOTAL INTENSITY DATA
POLARIZATION DATA



LOW RESOLUTION STRIP DISTRIBUTION

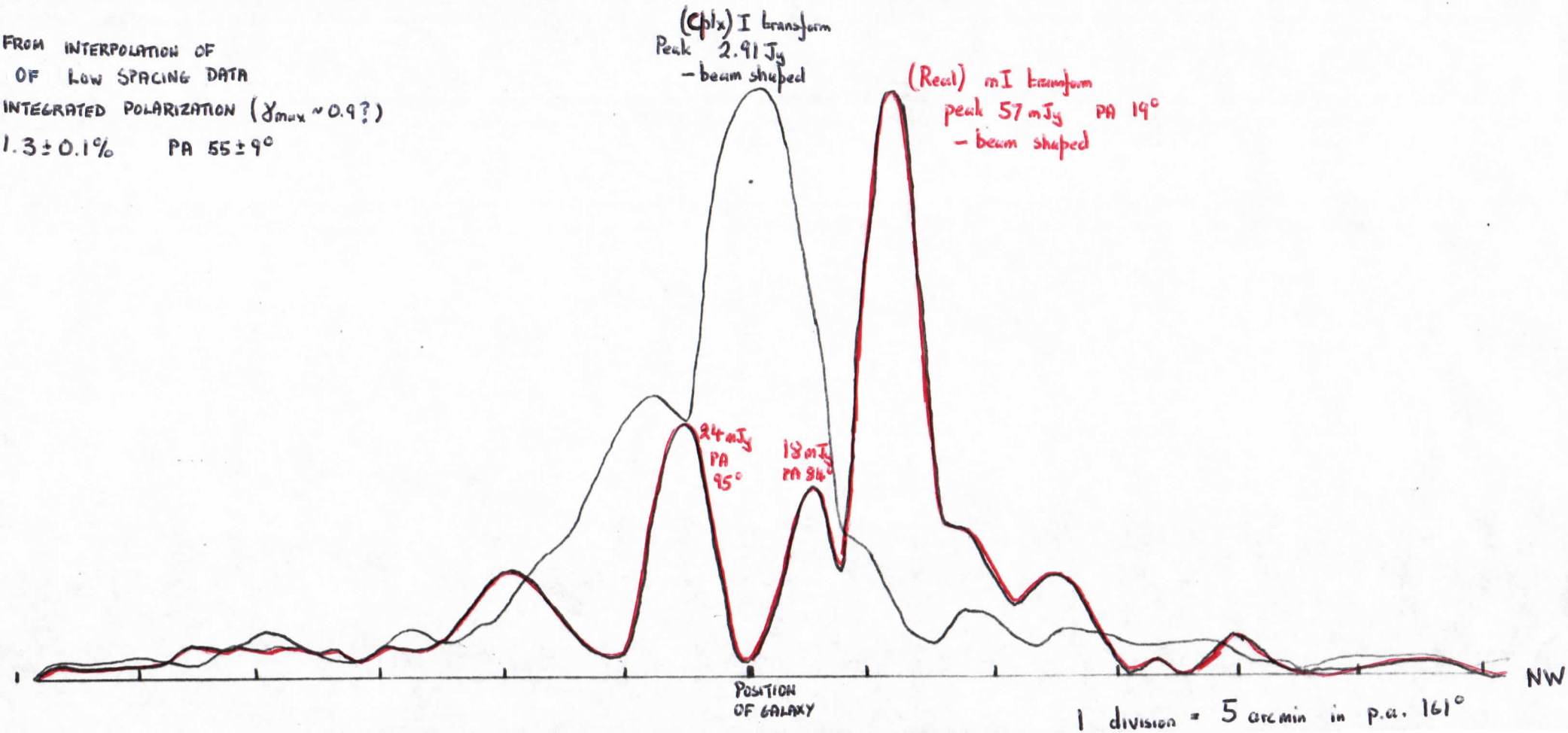
3C31

JODRELL MkI-II INTERFEROMETER 1976 MARCH

— TOTAL INTENSITY
— POLARIZATION

962 MHz

FROM INTERPOLATION OF
OF LOW SPACING DATA
INTEGRATED POLARIZATION ($\gamma_{max} \sim 0.9$?)
1.3 ± 0.1% PA 55 ± 9°



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7 July 1979

Dr A.G.Willis,
Radiosterrenwacht Westerbork,
Schattenberg 4,
9433 TA Zwiggelte,
The Netherlands

Dear Tony,

We enclose the drafts of two papers associated with the VLA data on 3C31 and NGC 315. The first, Fomalont et al., discusses the linear polarization maps and the magnetic field configurations. The second, Bridle et al., deals with the collimation properties and their possible relationship to the magnetic field organisation. The first paper is simple phenomenology and we feel it is nearly in final form for submission to Ap.J.Letters; EBF is taking it to the VLA tomorrow so we hope to have Rick's comments by the time you receive this. The second paper awaits printouts of the NGC 315 maps (to measure off the collimation data in more detail now that we have found the increasing-collimation effect in 3C 31 also) and some further work on the jet dynamics. EBF will get the printouts at the VLA this week, and AHB will confer with Dick Henriksen back at Queen's re the magnetohydrodynamics. If you and Rick are agreeable we would like to bring Dick Henriksen in on the discussion if he can help us with the MHD on a reasonably short time scale.

Although both papers deal most extensively with 3C 31, we feel the addition of the inner jet properties of NGC 315 from the VLA data adds to the idea that we are seeing something of general significance in this luminosity range - i.e. that 3C 31 is not a freak. The WSRT data lend themselves to different displays which we cannot easily match, and really deal with a different scale of phenomena : they do not have the resolution to show the interesting details at the bases of the jets but do give a more striking representation of the large-scale ordering of the fields and of the field structures in the lobes. We feel that the WSRT data would best be written up separately for NGC 315, with you and Richard as the primary authors.

It is urgent to get the first paper out as soon as possible. The Cambridge people appear to be guessing the answer correctly for 3C 31 and others (e.g. Frazer Owen) are now finding similar results on other sources. We therefore want to separate the field-configuration and collimation stuff in order to keep each short enough for the Ap.J.Letters and thus to minimise publication time as well as writing time. The papers could be combined but the first is basically phenomenology and needs little more work; the graphics can be done in Charlottesville very soon. We hope to submit the first paper not long after the IAU (last week of August). The second paper needs some more map-reading and more detailed work on the instabilities and will have a slightly longer timescale even if we hit no unforseen snags. The emphasis on the WSRT paper should be on the outer regions of the jet and the properties of the radio lobes, with some interpretation of the RM variations; you and Richard will probably set the timescale for that one.

If you are in agreement with the basic publishing scheme, please send comments on Fomalont et al. to EBF in Charlottesville as soon as possible, and comments on Bridle et al. to AHB at Queen's when convenient (many more drafts

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anticipated for that one).

Regarding the WSRT diagrams of NGC 315 - (1) the marked change of RM between the two jets is very striking, as is the change over the North-preceding radio lobe. If we believe that the background RM is fairly constant (i.e. the galactic component) we should try to interpret these variations in terms of the 3-d field geometry. Is there sufficient polarized intensity in some of the background point sources to sample the fluctuations in the galactic RM over the field ? Presumably the RM variation in the jets around the galaxy indicates the <u>opposite</u> helicities of the jet fields as seen by the observer (<u>same</u> helicity at the center of the galaxy as seen by someone sitting there looking out along each jet). (2) We are worried that most journals will probably screw up the reproduction of the present white-on-black displays and leave the field-organisation data difficult to see. The grey-scale displays of the intensity data really have very little effective dynamic range in this form and we wonder if a safer and clearer display might not be to show a contour map next to a field map that was superimposed on just one or two contours from the full contour map. The RM data could be displayed similarly. In this case the field map and the RM data could be black on white and so be much less vulnerable to loss of contrast with the intensity display in the event of a journal misjudging the exposure for their plates.

We do 3C 341, 3C 277.3 and one of the "quasar jets" at the VLA this week. The 20cm polarizers are now available and we intend to repropose 3C 31 and NGC 315 for polarization mapping at 20cm, to help sort out the fine-scale rotation measure variations.

How's life back in Holland ?

Best wishes,

Max-Planck-Institut für Radioastronomie

Auf dem Hügel 69
D-5300 Bonn 1,
Telefon: (0 22 21) 52 51
Durchwahl 525 /
Telex: 08 86 440 astrod

Commerzbank A. G.
Bonn, Nr. 1.031.061
(BLZ 380 400 07)

17 Jan. 1979

RW/gb

Dr. A.H. Bridle
Department of Physics, Astronomy Group
Queen's University

Kingston, Ontario K7L 3N6

Canada

Dear Alan,

Thank you for the reprint of NGC 315. We now have, in addition to our λ6.2 cm map which I gave you last June, λ2.8 cm observations of both total power and linear polarisation. The same for NGC 6251 and some other similar sources. This brings up a point which I took up with Richard Strom who suggested that I contact you. Could we get your λ49 cm array of NGC 315 and the beam data to do spectral comparisons with our λ6.2 cm map? We have a CDC Cyber 172 machine but have managed to read even IBM tapes.

It seems we have many parallel projects (V.L.R.G., clusters, etc.) and I hope we can exchange preprints even more often in the future.

Sincere regards,

Richard

R. Wielebinski

100 ≡ 182mJy

3C31 4885 MHz
0".58 × 1".49 resolution

K&E 5 X 5 TO THE CENTIMETER 46 1610
18 X 24 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

3C31 Hi-Res % POL ON RIDGE OF JET [0".5 × 1".49 resolution]

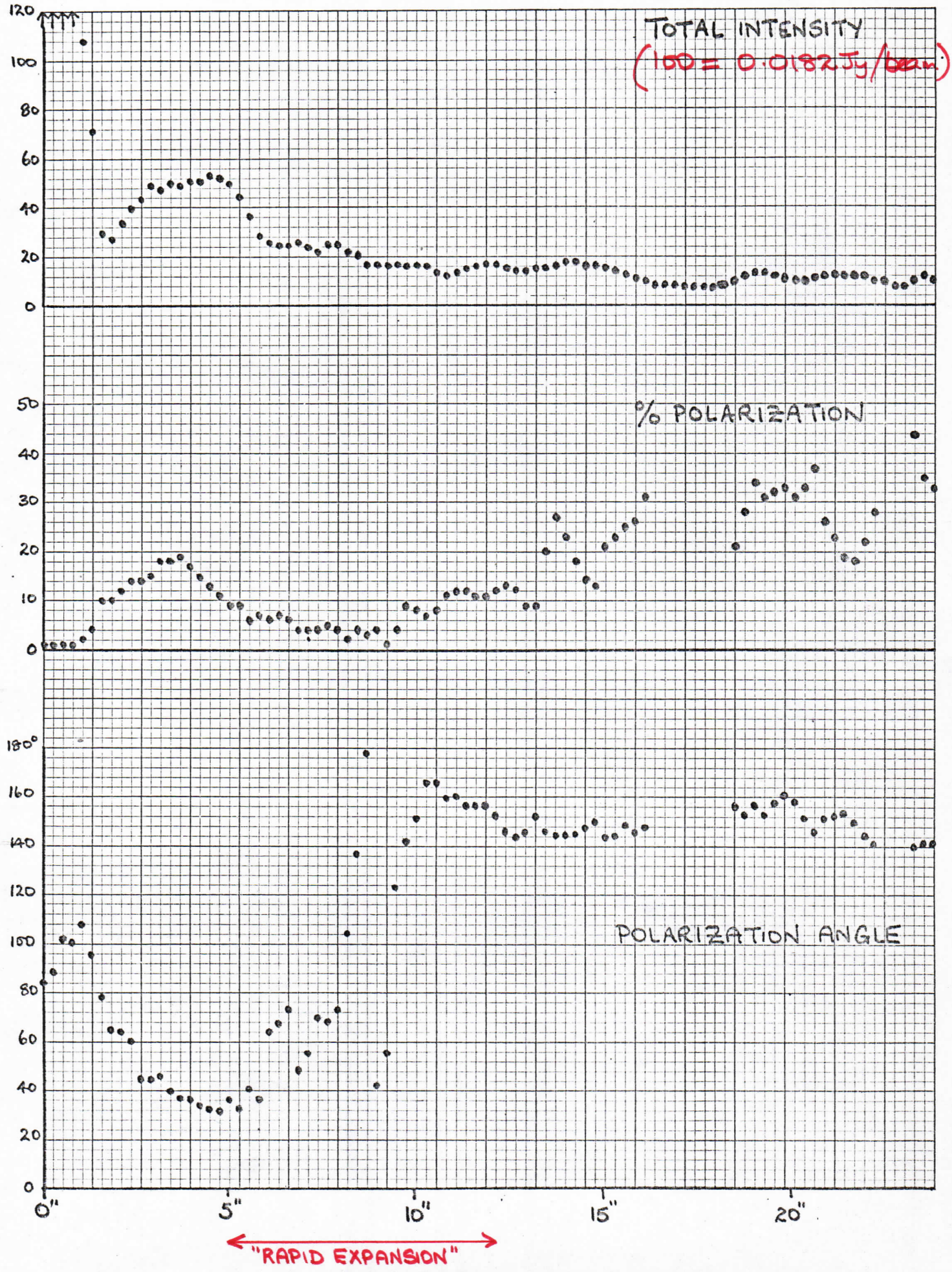
Phase Center is 64, 163 Cellsize = 0".25

MAP CELL #	I (100 = 0.0182)	%	Angle	
65, 159	108	2	-72	108
65, 158	51	4	-85	95
65, 157	30	10	78	
66, 156	27	10	65	
66, 155	34	12	64	
66, 154	39	14	60	
67, 153	43	14	45	
67, 152	49	15	45	
67, 151	47	18	46	
68, 150	50	18	39	
69, 149	49	19	37	
69, 148	51	17	36	
70, 147	51	15	34	
70, 146	54	13	32	
70, 145	52	11	31	
71, 144	50	9	36	
71, 143	44	9	32	
72, 142	36	6	41	
72, 141	29	7	36	
73, 140	26	6	64	
74, 139	25	7	67	
74, 138	25	6	73	
75, 137	26	4	48	
75, 136	24	4	55	
74, 135	22	4	70	
74, 134	25	5	68	
74, 133	25	4	73	
74, 132	22	2	-76	104
75, 131	20	4	-43	137
76, 130	17	3	-2	178
76, 129	17	4	42	
76, 128	16	1	55	
77, 127	17	4	-57	123
78, 126	16	9	-38	142
78, 125	17	8	-29	151
78, 124	16	7	-14	166
79, 123	14	8	-14	166
80, 122	13	11	-21	159
81, 121	14	12	-20	160
81, 120	15	12	-24	156
81, 119	16	11	-24	156
81, 118	17	11	-24	156
81, 117	17	12	-28	152
81, 116	15	13	-34	146
81, 115	14	12	-37	143
81, 114	14	9	-34	146
81, 113	15	9	-28	152

82, 112		15	20	-34	146
83, 111		16	27	-36	144
83, 110		18	23	-36	144
83, 109		18	18	-35	145
83, 108		16	14	-33	147
83, 107		16	13	-30	150
84, 106		15	21	-37	143
84, 105		14	23	-36	144
84, 104		13	25	-31	149
85, 103		11	26	-34	146
85, 102	$\theta = \sqrt{21^2 + 61^2} \times .25 = 16''.1$	10	31	-32	148
		9,9,9,8,8,8,8,9			
88, 93		10	21	-24	156
89, 92		12	28	-27	153
89, 91		13	34	-23	157
90, 90		13	31	-27	153
90, 89		12	32	-22	158
90, 88		10	33	-19	161
90, 87		10	31	-22	158
90, 86		11	33	-29	151
90, 85		12	37	-34	146
91, 86		12	26	-29	151
91, 85		12	23	-28	152
91, 84		12	19	-27	153
91, 83		12	18	-30	150
92, 82		11	22	-36	144
92, 81		11	28	-39	141
		9,8			
95, 75		10	44	-41	139
95, 74		11	35	-39	141
95, 73		10	33	-39	141
65, 160		205	1	-79	101
64, 161		? 312	1	-78	102
64, 162		? 364	1	89	
64, 163	(P.C.)	?	1	84	

12.2 plot units = 16".1

1 plot unit = 1'.3197



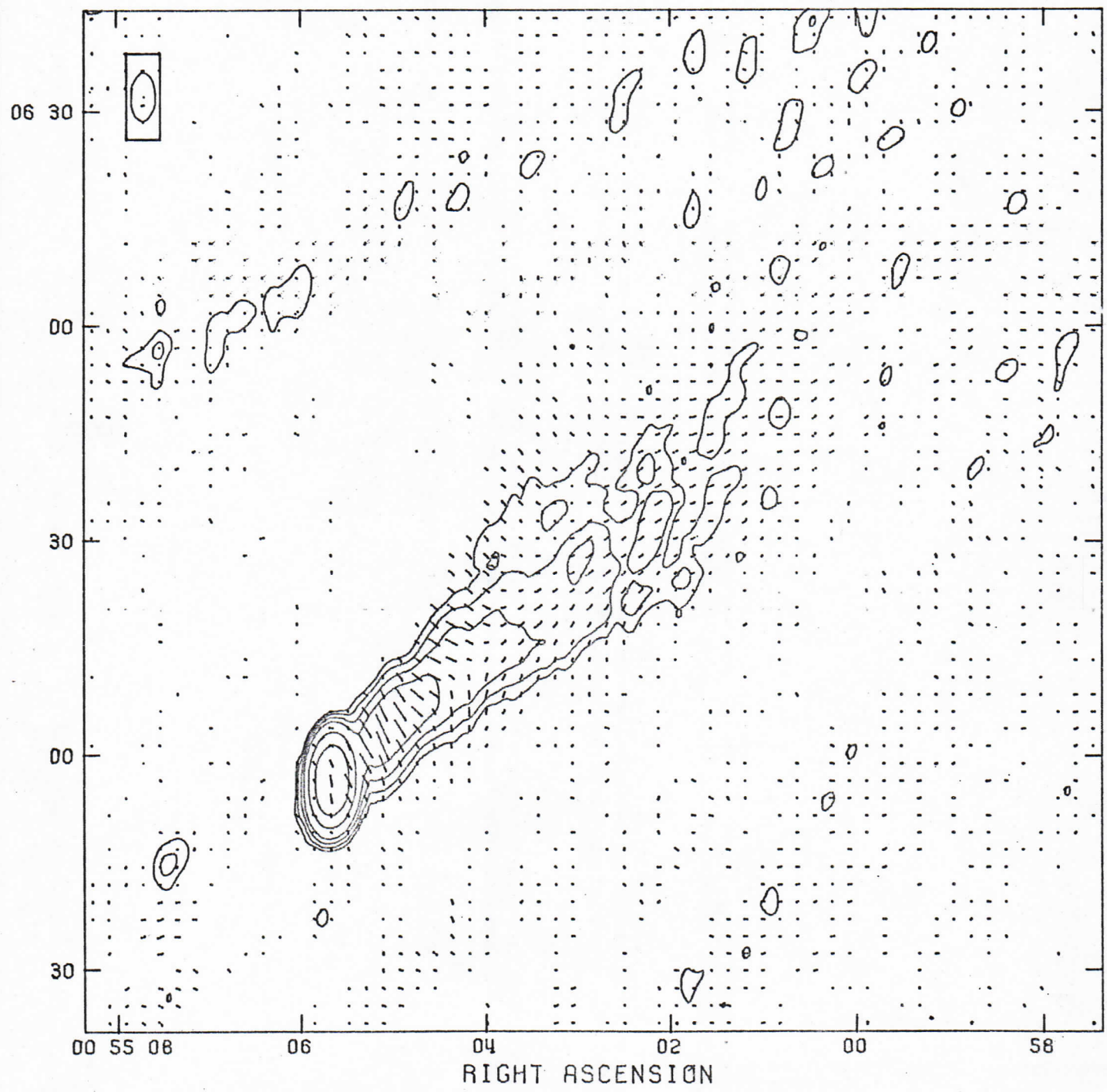
5 X 5 TO THE CENTIMETER 46 1610
10 X 24 CM.
KEUFFEL & ESSER CO.
MADE IN U.S.A.

3C31 2".5 × 5".0 in p.a. 150°
% POL'N ON RIDGE OF JETS
100 = 0.1105 Jy Cellsize 1".

[Map phase center = optical nucleus = cell #89, 148]

MAP CELL#	I	%	χ
(101, 108)	8	16	-34°
	8	19	-33
	7	21	-38
	7	23	-41
	7	23	-38
	7	22±3	-35
	7	19	-30
	8	19	-26
	9	20	-26
	10	23	-29
	10	30	-22
	10	35	-24
	9	41	-23
	9	46±5	-26
	10	44	-29
	11	42	-34
	12	37	-39
	15	32	-37
	17	27	-41
	18	23	-39
	19	20	-39
	20	17	-35
	20	16	-34
	20	17	-33
	20	16	-33
	21	17±2	-32
	22	16	-31
	22	14	-33
	23	11	-35
	24	9	-30
	24	6	-20
	26	2	-7
	29	3	25
	31	5	33
	37	6	46
	39	8	42
	44	9	47
	56	7	46
	70	4	47
	91	2	52
P.C. (89, 148)	100	1	62
	80	1	83
	59	1	-81
	27	1	-84
	14	2	-80
	7	6	-60
	4	13	-44
	4	20	-38
	4	22	-33
	5	20	-32
	6	17	-33
	7	17	-35

MAP CELL	I	%	χ
	7	18	-35°
	7	18±2	-41
	7	18	-41
	7	20	-44
	6	23	-43
	7	27	-42
	7	28	-40
	7	30	-39
	7	33	-38
	8	32	-38
	8	35	-39
	8	35±3	-39
	8	35	-37
	8	36	-36
	9	33	-34
	9	26	-34
	9	28	-35
	8	24	-39
	8	29	-39
	7	31	-39
	7	33	-40
	6	33	-41
	6	39±5	-40
	5	36	-39
	5	38	-38
	5	27	-41
	6	15	-42
	5	11	-43
	5	9	-39
	5	9	-30
	4	13	-26
	4	17	-37
	4	26	-47
	3	30±5	-45
	3	30	-48
	3	25	-54
	3	22	-57
	3	14	-51
	3	6	-44
	3	2	-38
	4	4	-44
	4	7	-46
	4	9	-37
	4	12	-41
	4	13	-35
(62, 205)	4	17	-44
	3	15	-35
	3	16±10	-33
	3	23	-36
	3	28	-42
	3	25	-43
	3	18	-42



PEAK FLUX = 398.8 MJY

LEVS = 1.00 = 1 100 30 8 4 2 1 1

CLEAN BEAM: MAJ, MIN, PA 6.65 3.37 -3.2 NITER = 600

CENTER POSITION 00 55 05.640 30 04 58.60

NGC 315 Med Res P.C. = 100, 100.

Cell # Y	X	Intensity (100=0.0399)	%	Angle	
98,	102	105	1	26	
		42	7	30	
		31	14	30	
		42	13	27	
		47	11	25	
		47	9	26	
		44	8	33	
		38	8	43	
		34	7	50	
		29	8	55	
		22	9	60	
		16	10	63	
		15	8	63	
		16	6	65	
		15	3	65	
		15	2	85	
		16	2	-48	132
		14	4	-50	130
		11	8	-53	127
		11	10	-51	129
		10	12	-47	133
		9	15	-47	133
		9	18	-51	129
		9	15	-51	129
		9	13	-53	127
		7	11	-51	129
		9	6	-53	127
		11	6	-53	127
		11	9	-52	128
		11	8	-53	127
		11	10	-52	128
		8	11	-52	128
		6	13	-48	132
		3			
		3			
		4			
		6	22	-48	132
		8	16	-53	127
69,	138	9	12	-58	122

$\equiv \sqrt{29^2+36^2} \times 1.199$
$= 55''.4$

First ~~two~~ two cells

?	0	11 P.C.
?	0	22
?		

NGC315 cr broadening ~ 40" out (19 kpc) ~ 10 mJy at 1465
$\alpha = 0.5$ per beam 2".5 × 5"
depth ~ 15"?

$L = 2.7 \times 10^{32}$ watts
→ $E_{min} = 3.74 \times 10^{47}$ joules
$B_{eq} = 12$ μgauss
$V = 3.00 \times 10^{59}$ m^3
$\Big\}$ $\mathcal{E} = 1.25 \times 10^{-12}$ J/m^3.