TABLE 1

VELOCITIES (HELIOCENTRIC) IN NGC 3672

Minor Axis PA = 98°		Major Axis PA = 8°			
y (arc sec)	v (km s^{-1})	y (arc sec)	v (km s^{-1})	y (arc sec)	v (km s^{-1})
Hα -32.6 SE	1850	Hα -111.0 NE	2044	+16.1	1757
-27.1	1861	-106.2	2018	+20.9	1696
-23.4	1866	-101.5	2017	+25.6	1668
-19.0	1852	- 96.8	2011	+30.3	1682
-18.8	1850	- 92.1	2030	+32.7	1675
-10.0	1869	- 87.4	2035	+39.7	1705
- 1.7	1901	- 82.7	2030	+44.4	1695
0	1861	- 80.8	2023	+49.2	1696
+ 1.7	1803	- 78.0	2026	+51.3	1692
+ 4.8	1854	- 73.3	2020	+53.8	1688
+ 8.8	1874	- 68.6	2008	+58.5	1655
+12.0	1869	- 59.1	2047	+63.3	1677
+13.9	1871	- 54.4	2037	(+67.8)	1665
+16.5	1857	- 49.8	2047	(+72.7)	1658
+17.7	1840	- 45.0	2039	(+77.4)	1633
+21.4	1849	- 40.3	2038	(+82.1)	1610
+24.1	1869	- 35.6	2015	(+96.2)	1668
+38.8 NW	1894	- 30.9	1999	(+101.0) SW	1658
		- 26.1	1976		
[NII] -10.4	1864	- 21.4	1972	[NII] -96.6 NE	2040
- 1.1	1889	- 16.8	1944	-91.9	2045
+ 1.1	1817	- 12.1	1909	-87.2	2041
+ 6.4	1864	- 7.4	1884	-82.4	2033
+13.1	1868	- 2.7	1861	-80.8	2021
+19.6	1848	+ 0.2	1858	-77.7	2020
		+ 2.0	1857	-73.0	2012
[SII] - 1.0	1889	+ 6.7	1840	-58.9	2019
+ 1.3	1820	+ 11.5	1810	-54.2	2031

y (arc sec)	v (km s^{-1})	
-49.5	2021	172
-44.8	2033	185
-40.0	2022	173
-35.4	2017	168
-30.8	2003	153
-26.0	1991	134
-21.2	1966	114
-16.5	1962	110
-11.8	1931	78
- 7.1	1892	37
- 2.4	1882	26
+ 0.1	1855	
+ 2.3	1852	
+ 6.9	1833	
+11.6	1805	
+16.4	1772	
+21.1	1707	
+25.8	1687	
+30.5	1673	
+35.2	1689	
+39.9	1708	
+44.6	1679	
+49.4	1686	
+51.6	1686	
+54.1	1694	
+58.8	1692	
+62.8 SW	1697	

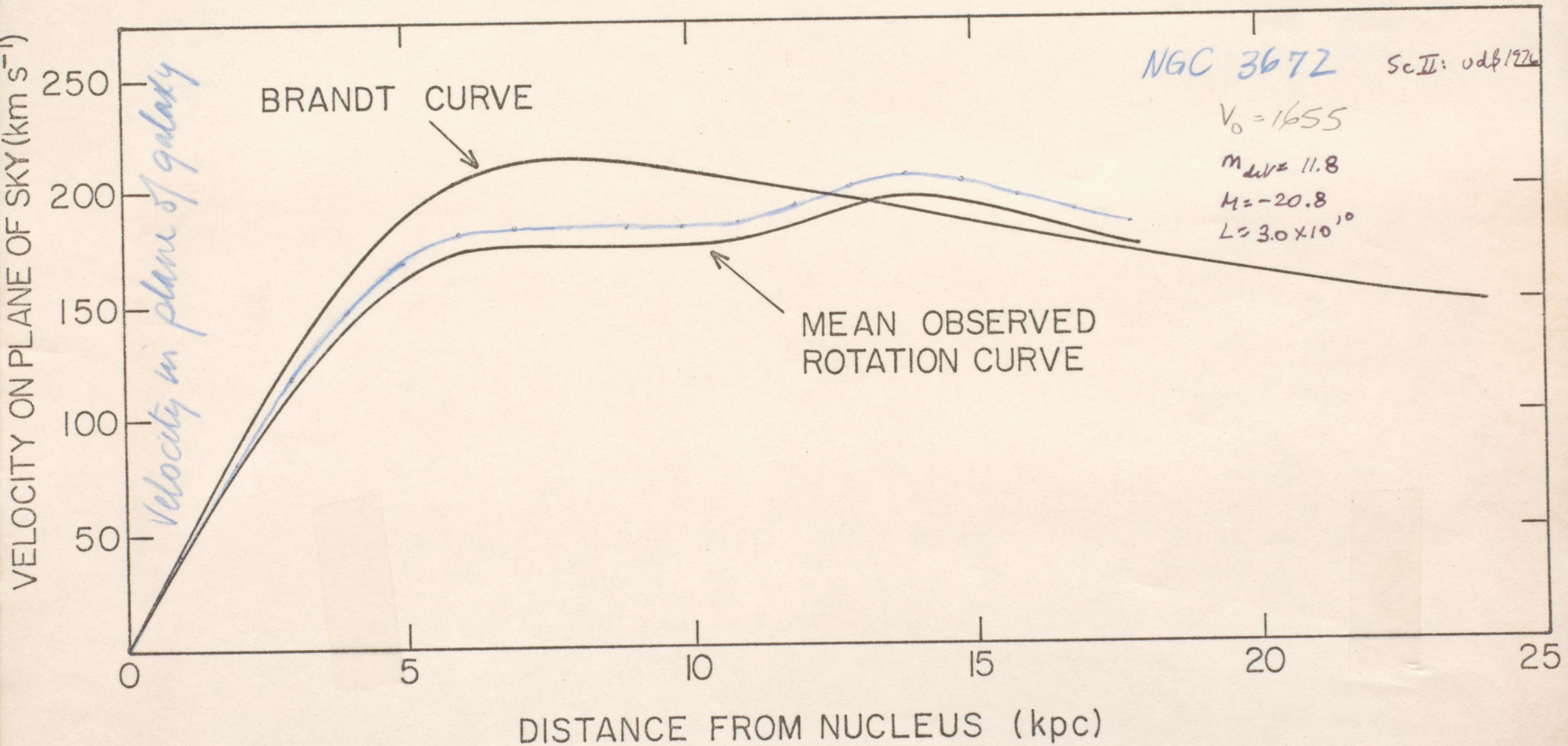
1" = 160 pc.

NE	R"	⟨Hα+NII⟩	R kpc
	-2.6	15	0.4
	-7.2	32	1.2
	12.0	66	1.9
	16.6	100	2.7
	21.3	118	3.4
	26.0	130	4.2
	30.8	151	4.9
	35.5	167	5.7
	40.2	182	6.4
	44.9	188	7.2
	49.6	186	7.9
	54.3	186	8.7
	59.0	185	9.4
	(68.6	159)	11.0
	73.3	167	11.7
	77.8	174	12.4
	80.8	173	12.9

V	R kpc
82.6 184	13.2
87.3 190	14.0
92.0 190	14.7
96.7 177	15.5
(101.5 168)	16.2
(106.2 169)	17.0
(111.0 196)	17.8

SW	"	V	R
	0.15	-0.5	0
	2.35	-2.4	.34
	6.8	-22	1.1
	11.6	-52	1.8
	16.2	-97	2.6
	21.0	-163	3.4
	25.7	-188	4.1
	30.4	-188	4.9
	(32.7)	-191	5.2
	(35.2)	-176	5.6
	39.8	-158	6.4
	44.5	-179	7.1
	49.3	-174	7.9
	51.4	-176	8.2
	54.0	-174	8.6
	58.6	-193	9.4
	63.0	-179	10.1

(67.8)	-202	10.8
(72.7)	-209	11.6
(77.4)	-235	12.4
(82.1)	-259	13.1
(96.2)	-198	15.4
(101.0)	-209	16.2



1-5 x 10 glossy
4 x 5 reg standard

Perkin

$L = 10^{-0.4 (M_0 - 5.41)}$

$-2.5 \log L = -0.4 (M_0 - 5.41)$

$M_0 = 5.41 - 2.5 \log L$

seeing: ~ 1.5 or better

nuclear cont. 1.5 on plates.

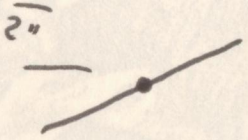
Major Axis:

Y	V(Hα)
-2.7	1861
+0.2	1858
+2.0	1857

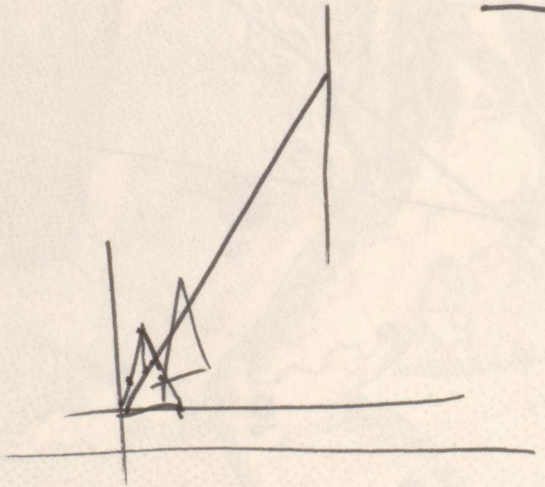
Y	V[NII]
-2.4	1882
+0.1	1855
+2.3	1852

Minor Axis

Y	V	
-1.7	1901	Hα
0	1861	Hα
+1.7	1803	Hα
-1.1	1889	[NII]
+1.1	1817	[NII]
-1.0	1889	[SII]
+1.3	1820	[SII]



4"



3672 11 22.5 -9 31 1737

3660 11 21.1 -8 24

$\theta_{0.5m}$ = 1/2 power measured width

$\phi_{0.5m}$ = " "

$\theta_{0.5}$ = 1/2 power source width

$\phi_{0.5}$ = " "

$\xi_{0.5}$ = 1/2 power beam width

$\xi_{0.5}$ = " "

$$\theta_{0.5m} = \left(\theta_{0.5}^2 + \xi_{0.5}^2\right)^{1/2}$$

$$\theta_{0.5m}^2 = \theta_{0.5}^2 + \xi_{0.5}^2$$

$$\theta_{0.5}^2 = \theta_{0.5m}^2 - \xi_{0.5}^2$$

consider: major axis size = 4.7" max measured extent

Note: for gaussian; 0.5 power = 0.68 x 0.2 power $\theta_{0.5m}$ = 3.2"

minor axis size = 3.4"

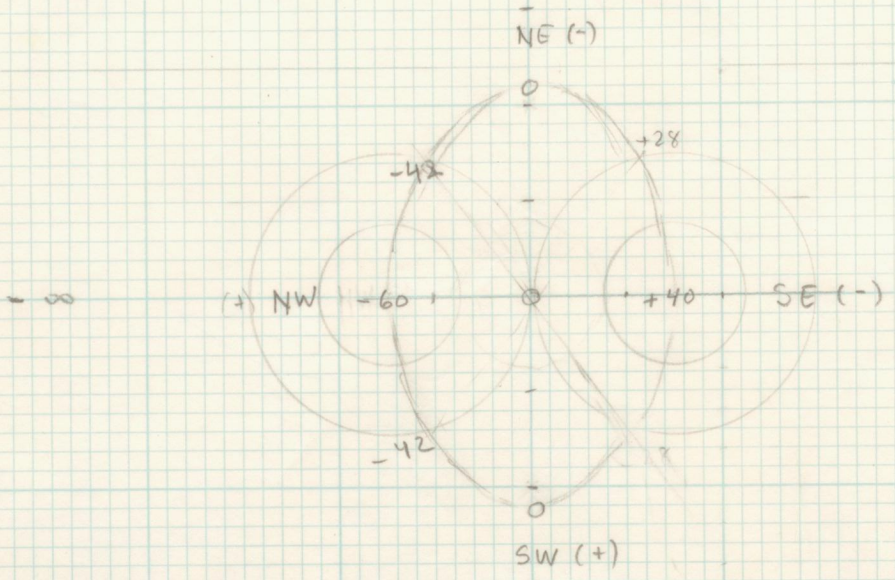
$\therefore$ $\phi_{0.5m}$ = 2.3"

assume 1/2 power seeing = 1.5"

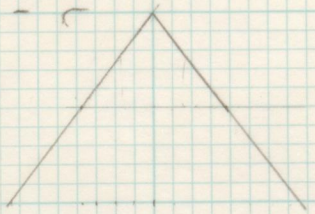
$\therefore$ $\theta_{0.5}$ = 2.8" | if we assume tabulated value is $\theta_{0.5m}$ + $\phi_{0.5m}$

$\phi_{0.5}$ = 1.7" | then $\theta_{0.5}$ = 4.45"

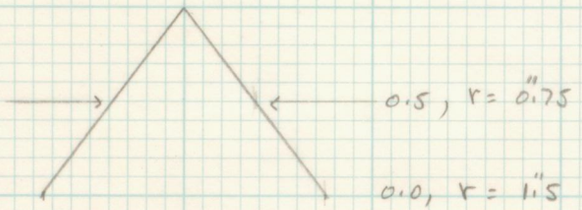
$\phi_{0.5}$ = 3.05"



consider beam of this shape:



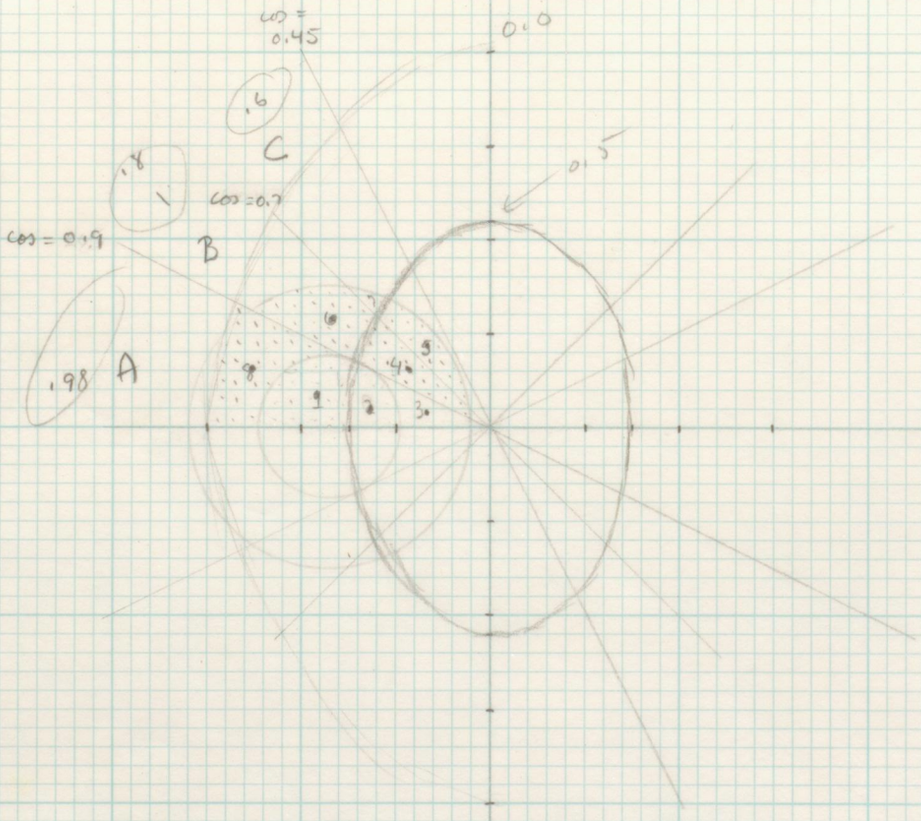
Beam shape:



Major Axis 4".4 max, 2".8 min
data @ ± 2".4
NE, z, SW = 0

Minor Axis 3".0 max, 1".7 min
data @ ± 1".7
NW, z, SE = -60, 0, +40

for symmetry reasons, assume
minor axis Vel = 0 ± 50



0.5 beam area = 44.2 squares

0.0 " " = 176.7 squares

outer " " = 132.5 squares

mean response of outer region = 0.25

mean response of inner region = 0.75

Consider three cases:

case I - no response outside of 0.5 circle, I = const inside
V = linear inside

case II - V = const outside of 0.5 circle, I = const inside, decreases
V = linear inside linearly from 0.5 to 0.0.

case III V increases linearly in all regions, I = 0 in case II

Areas:

1	15
2	7
3	4½
4	10
5	8
6	13
7	1
8	21

Case I

A	V	$I_B \times I_S$		
7	× 0.9	.75 × 1	=	5.25 @ 0.9
4.5	× 0.5	.25 × 1	=	1.13 @ 0.5
10	× 0.5	.25 × 1	=	2.50 @ 0.5
8	× 0.37	.25 × 1	=	2.96 @ 0.37

Weighted mean V

= 0.64

.75
.15

case II

region	A	V	I_B	I_S	I	I x V
1	15	0.98	.75	0.73	8.21	8.05
2	7	0.9	.75	1.0	5.25	4.73
3	4.5	0.5	.25	1.0	1.13	0.56
4	10	0.5	.25	1.0	2.50	1.25
5	8	0.37	.25	1.0	2.96	1.10
6	13	0.80	.25	0.71	2.31	1.85
7	1	0.70	.25	0.88	.0.22	0.15
8	21	0.98	.25	0.27	1.42	1.39
					24.0	19.08

mean weighted V = 0.80

case III

region	A	V	I_B	I_S	I	I x V
1	15	1.18	.75	0.73	8.21	9.69
2	7	0.9	.75	1.0	5.25	4.73
3	4.5	0.5	.25	1.0	1.13	0.56
4	10	0.5	.25	1.0	2.50	1.25
5	8	0.37	.25	1.0	2.96	1.10
6	13	1.00	.25	0.71	2.31	2.31
7	1	0.80	.25	0.88	0.22	0.18
8	21	1.70	.25	0.27	1.42	2.41
					24.0	22.23

V = 0.93

Σ=136.922

⟨Na D⟩ For	Rev.	Σ	Σ-Rev.	⟨ ⟩
67.7	67.719	69.203	136.922	67.719	67.719
.8	721	204	925	719	720
.9	717	205	922	717	717
68.0	714	203	917	719	716
.1	717	202	919	720	718
.2	715	204	919	718	716
.3	716	.205	921	717	716
.4	720	.206	926	716	718
.5	720	69.205	925	717	718

Scale 23.8"/m from 5895.5

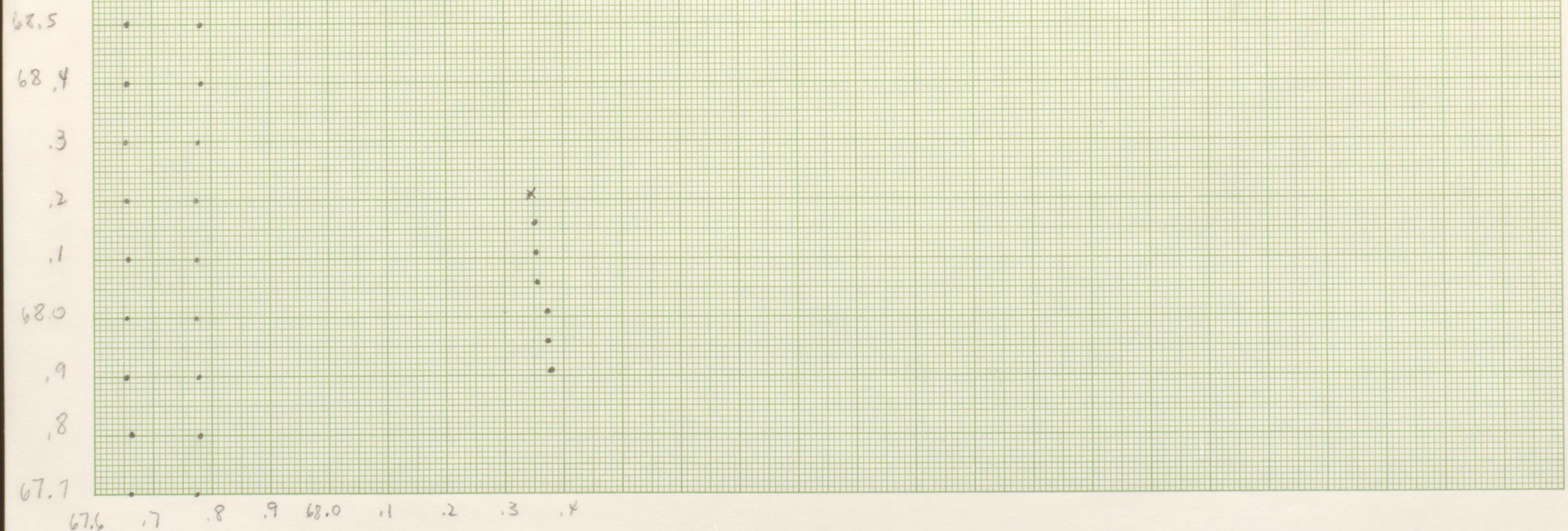
Abs.	Dif	Σ- Rev.	⟨Abs⟩	″	″	Δx (mm)	λ	V
67.91	68.385	368	68.376	0	3.6	+0.598	5922.91	18.94
.96	.382	365	373	1.2	2.4	.595	.77	
.91	.375	365	370	2.4	1.2	.592	.63	
.86	.358	354	356	3.6	0	.578	5921.99	
.81	.353	347	350	4.8	1.2	.572	.72	
.76	.351	339	345	6.0	2.4	.567	.49	
.71	.343	341	342	7.1	3.5	.564	.35	1394

96 A/mm

	Δx (mm)	Δλ (Ang)	km s⁻¹			
						NE
3.6	0	0	0	+47	1904	
2.4	+.003	+.138	+.7	+40	1897	
1.2	+.006	+.276	+14	+33	1890	
0	+.020	+.920	+47	0	1857	
1.2	+.026	+1.196	+61	−14	1843	
2.4	+.031	+1.426	+73	−26	1831	
3.5	+.034	+1.564	+80	−33	1824	SW

67.658
67.778

Na: 5890.0, 5895.5] 5.5A/.120mm = 45.833 A/mm.



use
$\phi = 91°$ $i = 70°$

PA $98° = \eta$

For nuclear disk:

	$V_{obs.}$
$-1.''7$	50 km s^{-1}
0	~~0~~ 0

$$R = 1.7\left[\sec^2 70° - \tan^2 70 \cos^2(7°)\right]^{\frac{1}{2}}$$

$8.55 - 7.44$

1.11

$R = 1.''8 = 290$ pc. radius

$X = 1.7 \cos 7° = 1.69$

$Y = 1.7 \sin 7° = 0.21$

$\theta = \cos^{-1} X/R =$ ~~0~~ 20.1

$\theta = \sin^{-1}(Y \sec 70°)/R = \sin^{-1}(Y/R\cos 70°) =$ ~~19.9~~

use $\theta = 20°$

$V_{o-c} = V(R) \sin i \cos\theta$

~~50~~

$50 = V(R) \sin 70° \cos 20°$

$V(R) = 57$ km s^{-1}

on sky r	on gal r kpc	on gal r kpc	V_{gal}
0	0	0	0
$1.''7$	1.8	.145 .290	28 57

$\sigma_{HI} = 2 \times 10^9 V^2 r \sim 2 \times 10^8$

PA = 98° $\eta = 8°$ $V_o - V_c = 50$

IF Expansion:

$$50 = \frac{E(R) \tan 70° \sin(90°)}{\sec 70}$$

$$E(R) = \frac{146.19}{2.75} = 53 \text{ km s}^{-1}$$

~~Width~~

A rot. curve has been adopted as a mean of the two sides, and rises to a peak rot. V = 206 km s^{-1} at r = 14.4 kpc. The mass implied by the rot curve out to r = 17.6 kpc is $M = 1.1 \times 10^{11} M_\odot$.

The double-peak Hα vel. obs. at $\Delta V = 440$ km s^{-1}, which ~~corr~~ agrees well with $\Delta V_{21\text{-cm}}$ (at 20% of peak vel) $\Delta V_{21\text{-cm}} = 427$ km s^{-1}. The H I mass is 1.4×10^9 so $M_{HI}/M_{Total} \approx 1\%$. The total mass implied for the 21-cm profile (~~total~~ assuming a Brandt-type rot. curve with $n = 3$, Roberts 17) is $M_\odot = 1.6 \times 10^{11} M_\odot$ $r_{max} = 8$ kpc.

$$V_r = \frac{50\left[\sec^2 i - \tan^2 i \cos^2 75\right]^{1/2}}{\sin i \cos 75} = \frac{(1.53)(50)}{.91}$$

for $i = 30$, $V(r) = 104$ $\quad \frac{1.53}{.91} = 1.68(50) = 84$ $\quad \frac{1.02}{.49} = 2.09(50)$

$i = 70$, $V(r) = 84$ $\quad \frac{3.25}{.96} = 3.39(50)$

80 $\quad V(R) = 169$

$i = 45$ $\quad V(R) = 78$ $\quad \frac{1.07}{.69} = 1.55(50) = 78$

$i = 35$ $\quad V = 95$ $\quad \frac{1.03}{.56} = 1.85(50) = 92$

Let $5 = 2''$, $V_{obs} - c = 50$ $\quad R = 2''\left[\sec^2 i - \tan^2 i\,(.93)\right]^{1/2}$

For $i = 30°$ $\quad V_R = 104$ $\quad R = 2''$ $\quad r = 2''.02 = .324$ kpc $\quad V^2 r = 3504$

$i = 45°$ $\quad V(R) = 78$

For $i = 70°$ $\quad V_R = 84$ $\quad R = 2.5''$ $\quad r = 2.47 = .396$ kpc. $\quad V^2 r = 2794$

If we adopt $V(R) \sim 80$ km s^{-1} (i 45°), $R = 2.1 = .33$ kpc., the dynamic mass of the nucleus,

$r < 330$ pc, $= 2 \times 10^8 M_\odot$. = Low mass

Gal (Oort) $r = 200$ pc, $V > 200$ km s^{-1}

$M = 2.5 \times 10^9 M_\odot$

M31: (RF) $r = 200$ pc

$M = 6 \times 10^8$ $\quad V = 165$

Imm rot. curve max ~ 200-300 pc,

$V \sim 165$ km s^{-1}

R	V
.11 kpc	26
.22	27
.33	27
	V
R .11 kpc	26
.22	53
.33	80

50 km s^{-1}, $r = 330$ pc $\quad 2\pi R = 6.22 \times 10^{18}$ km

Circular orbit

$\frac{6.22 \times 10^{18} \text{ km}}{80 \text{ km s}^{-1}} = 7.78 \times 10^{17}$ sec

$= 2.6 \times 10^7$ yr.

Across the nucleus ($r \leq 3''$) the measured emission line velocity gradients are

PA 8°: -3.6 km s^{-1} arc sec^{-1}

PA 98°: -29.5 km s^{-1} arc sec^{-1}

If we assume that these gradients arise from a flattened nuclear disk, with const. angular velocity, then the dynamical major axis of the disk is found from

$$\tan\phi = \frac{+29.5\cos 8° + (-3.6)\cos 98°}{+3.6\sin 98° + (-29.5)\sin 8°}$$

$$\phi = 91°$$

Thus the angle between the major axis of the nuclear disk & the outer disk is $91° - 8° = 83°$.

One plate material is not adequate to tell if the nucleus is elongated in PA 83°. On the major axis (PA = 8°) spectra the nuclear emission extends 4.″7, on the minor axis (PA = 98°), the nuclear emission extends only 3.″4, but this exposure is 70^m, comp. with 120^m on the major axis. Moreover, the total extent is governed by seeing, both by the geom. of the nucleus & by guiding effects. On the small scale we are discussing here, no valid assessment of these later factors can be made. The 4-m direct plate is too overexposed to resolve an adequate nucleus, $r < 2.″2$ is available, then adequate judgement of the nuclear shape. Because of no optical image the orientation of the nuclear disk is completely unspecified.

For a distance of NGC 3672 of 33 Mpc (see below) 1″ = 160 pc, the nuclear disk, the dimensions of the region of the nucleus is about 350 pc; the rotational axis from the nucleus i.e. the vel. gradient through the disk, $V = 50$ km s^{-1} is skewed at a PA (on plane of sky) 15° from the major axis of PA = 83°. (From the vel. gradient plane of the gal must be greater than

minor axis
η = 98°
s = 38".8
R = 113".6

Center knots
16 mm. on 4-m plate Scale: 18".5/mm = 296"
12" body = 222" 111" measured

For the following discussion, we adopt these parameters:

$V_c = \frac{185.7}{50}$ km s^{-1}, r = 36 Mpc

The mass of NGC 3762.

The (heliocentric) central velocity of NGC 3672 is well determined as 1857 km s^{-1} [from the major axis plate; 1856 from nuclear measure on minor axis plate; 1857 km s^{-1} from SE minor axis, r < -10"; 1859 km s^{-1} from NW minor axis], which corresponds to V = 1655 km s^{-1} corrected for gal. rot. We adopt H = 50 km s^{-1}, and consequently a dist of 33 Mpc. At this distance 1" = 160 pc. Along the major axis emission is observed to a distance r = 111" = r = 17.8 kpc; on the direct plate the measured extent of the gal is 111" = disk 17.8 kpc; we adopt i = 70°, values of 66° to 72° are obtained assuming the gal is circular in its principal plane; (in the paper) with faint knots seen out as far as 23.7 kpc. The choice of i is not critical as follows:

csc i = 1.10 for i = 65° and csc i = 1.04 for i = 75°.

We first discuss the ionized gas. The observed rotation curve. The PA of the major axis is chosen as 8°, as the obs. vel. along the major axis in this PA, when corrected by csc i = 1.06, represent the rot. curve. The curve is reasonably symmetrical about r = 0, except that the SW portion rises more steeply, flattens and exhibits more wiggles than the NE side. The dips in the curve are real

Uncertainties in any vel. should not exceed 10 km s^{-1}, so the dips in the obs. vel. & rot. curve, & generally coincide with dust patches or identifiable features in the arms.

Extended Rotation Curves of High Luminosity Spiral Galaxies: I. The axis of rotation of the nucleus of NGC 3672.

A major unsolved problem of galactic dynamics concerns the relation between the axis of rotation for the nucleus and that of the outer galaxy as a whole. At present, there is indirect evidence which indicates that these two spin axes can be significantly different. For radio galaxies, large angles between the radio axes and the rotation axes of the parent ellipticals are common. Because, reasons for believing, there are strong reasons to believe that the radio axes coincide with the nuclear rotation axes (Oort 1977), this implies that nuclei of elliptical galaxies can rotate in planes different from the equatorial plane of the galaxies as a whole.

Additional evidence comes from optical studies of the orientation of the nucleus of M31. Stratoscope observations indicate that for r ~ (pc), the nucleus of M31 is elongated with major axis in position angle °, but with increasing r the major axis varies, settling at r = , the major axis coincides with that of the outer disk, PA = 38° [Johnson, Lindblad ( ), Peterson, Ford, and Rubin 1977]. Even the latest observations are not certain to what extent this observation is affected by dust which extends very close to the nucleus of M31. (Sc , α_{1950} = , δ_{1950} ; l= ; b= ; m=)

We present here dynamical evidence that the nucleus of the spiral galaxy NGC 3672 rotates in a plane different from that of its outer galactic disk. At optical wavelengths NGC 3672 is an attractive multi-armed spiral, but shows many distinct irregularities. A very small nucleus (Sandage 1961). A 4-m blue plate is reproduced, twice enlarged, in Fig 1 (Plate), to emphasize the nuclear and the outer structure. NGC 3672 is a member of a nearby group (de V 1976); its nearest companion on the sky is a striking amorphous galaxy,

Fig. 2.

NGC 36 . At radio wavelengths, NGC 3672 had a broad ($\Delta V > 400$ km s^{-1}) 21-cm velocity profile, arising from a combination of its high inclination and its high intrinsic luminosity (Fisher & Tully 1977). For a sample of over 150 bright spiral galaxies ($m < 14$) for which we have observed 21-cm (Thonnard, Rubin, Ford, & Roberts 1977 unpublished), NGC 3672 is one of only about 30 gal. which have vel. widths greater than 400 km s^{-1}. For these galaxies, we are presently obtaining optical spectra of the major and minor axes to investigate the detailed optical rotation curves at large distances from the nucleus.

Emission line spectra of NGC 3672 at high spectral & hi vel. res. were obtained with the CTIO 4-m R-C spectrograph in March 1977. Along the major axis, PA = 8° (Fig 3a Plate), the rotation pattern of the gal. disk is observed; along minor axis PA 98° (Fig 3b, Plate)

($\langle V \rangle_{SG}$ = $\langle V \rangle_{NW}$ =)

no vel. dispersion is observed in the outer knots; but the nuclear knot appears inclined. Measured velocities from these two plates are shown in Fig 4.

A striking feature of the velocities is the large velocity gradient across the nuclear knot along PA 98°, (minor axis of outer disk) and the apparent lack of rot. across the nucl. in PA 8° (major axis of the outer disk). The velocities in the nuclear region are plotted at a higher scale in Fig. 5. The most direct interpretation of these velo. is that the spin axis of the nucleus of NGC 3672 is not aligned with that of the outer disk.

If we assume that the nucl. gas arises from a flattened rotating disk, then the dynamical major axis of the disk is PA=

The seeing was probably 1.5" or better (more accurate seeing measures are difficult to estimate, for the observer is looking at a TV screen); the nucl. continuum subtends 1.5" on the spectrum.

$A = 58.7 \times 10^{-25}\ Wm^{-2}\,Hz^{-1}\,km\,s^{-1}$

$D = 36 \times 10^6$ pc

$\delta' = 5'$ ~~48 kpc~~

$r_{max} = \frac{\delta'}{6} =$ ~~133~~ 8 kpc.

3351

$M_H = 2.36 \times 10^{19} D^2 \int 10^{-26}$

$\int = 72$

$D = 10 \times 10^6$ pc.

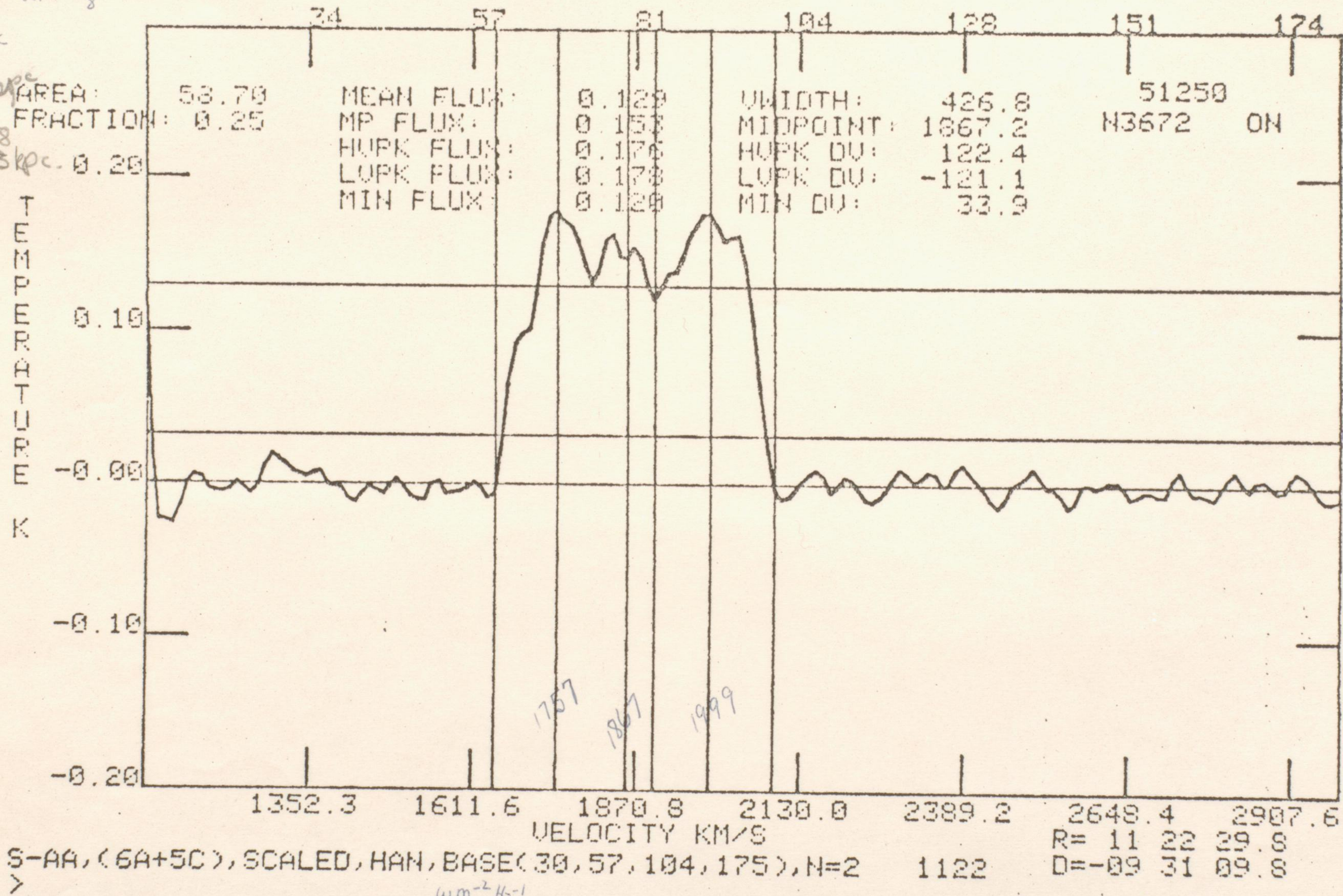
$M_H = \frac{1.7 \times 10^{35}}{10^{26}}$

$M_H = 2.36 \times 10^{-7} D^2 \int$

$= (87)\, 2.36 \times 10^{-7} \times 10^{14}$

139×10^7

1.4×10^9



$M_{HI} = 2.356 \times 10^{19}\, D^2_{(pc)} \int S_\nu\, dV$ ($Wm^{-2}\,Hz^{-1}$; $km\,s^{-1}$)

94 units = 259.2

4.80 km s^{-1} unit^{-1}

$M_{HI} = 1.5 \times 10^{11}$ No corr. for sin i

M_{HI}/L_{opt}

diam in ?

$M_T =$ ~~$2.7 \times 10^{-2} D_{pc}\, \theta' (\Delta V)^2$~~

$= 1.7 \times 10^{-2} D_{pc} \cdot \delta' V^2 / \sin i^2 = 1.7 \times 10^{-2}\, 36 \times 10^6 \cdot .5 \cdot (227)^2$

$M_T = 0.8 \times 10^{11}$

$M = 1.6 \times 10^{11}$

$$V(R) = \frac{V_{max}\,(R/R_{max})}{\left[\frac{1}{3} + \frac{2}{3}(R/R_{max})^3\right]^{1/2}} \quad \text{or} \quad \frac{V}{V_{max}} = \frac{\rho}{\left[\frac{1}{3} + \frac{2}{3}\rho^3\right]^{1/2}}$$

R_{max}=8 R	R/R_{max}	$V(R)/V_{max}$	V_{max}=190 V(R)	V_{max} 213	V_{max} = 200
0	0	0	0		
.8	.1	0.17	32	36	
1.6	.2	0.34	65	72	
2.4	.3	0.51	97	109	
3.2	.4	0.65	124	138	
4.0	.5	0.77	146	164	
4.8	.6	0.87	165	185	
6.4	.8	0.97	184	207	
8	1	1.0	190	213	
9.6	1.2	0.98	186	209	
12	1.5	0.93	177	198	
16	2	.84	160	179	
32	3	.70	133	149	
	4	.60	114	128	
	6	.50	95	107	
14	1.75	.89	168	190	
18	2.25	.80	152	170	
19.2	2.4	0.78		166	
20.8	2.6	.75		160	
22.4	2.8	.72		153	
24.0	3.0	.70		149	

N3672

correction for ~~Amtd~~ Source size:

ϕ_s = N-S extent of source θ_s = E-W extent of source

ϕ_A = N-S extent of beam θ_A = " " " beam

$$g = \left(\left[1 + \left(\frac{\phi_s}{\phi_a} \right)^2 \right] \left[1 + \left(\frac{\theta_s}{\theta_a} \right)^2 \right] \right)^{1/2}$$

beam: 10.3 EW
11.3 NS

E-W = 1.9 NS = 4.9

$g = 1.108$

$$\frac{M_H}{M_\odot} = 2.356 \times 10^{19} D^2 \int S \, dV$$

$D = 3.6 \times 10^7$ pc

$S = 58.7 \times 10^{-26}$ W m^{-2} Hz km s^{-1}

$= 1.79 \times 10^{10}$ $M_\odot$

or 1.93 counted.

PLATE C459 NGC 3672 PA 98 SE REA D FIRST

APR 1 1977

RIGHT ASCENSION = 11. 22. 30. DECLINATION = -9. 31.
UNIVERSAL TIME OF MID EXPOSURE = 4. 22.
LONGITUDE OF SUN AT ZERO HOURS UT = 4. 13. 57. DAILY CHANGE (SECONDS) = 3566.4

LINE	X (MM)	Y (MM)	Y-Y0	GRAD	XDIRECT	X (MM)	Y (MM)	Y-Y0	GRAD	XREVERSE
6506.528	63.8970	40.360	-0.364	0.5	63.8975	72.5560	50.484	-0.302	-0.5	72.5555
	63.8940	40.774	0.050	-0.1	63.8939	72.5590	50.205	-0.023	-0.0	72.5590
	63.8930	41.071	0.347	-0.5	63.8925	72.5620	49.831	0.351	0.5	72.5625
	63.9080	50.779	10.055	-14.2	63.8938	72.5420	40.111	10.071	15.5	72.5575
	63.9080	51.105	10.381	-14.6	63.8934	72.5460	39.731	10.451	16.1	72.5621
	63.9170	51.432	10.708	-15.1	63.9019	72.5390	39.320	10.862	16.8	72.5558
	0.0163	0.015	40.724		63.8955	-0.0167	-0.016	50.182		72.5587
6532.880	64.4350	40.326	-0.371	0.3	64.4353	72.0300	50.549	-0.350	-0.3	72.0297
	64.4290	40.707	0.010	-0.0	64.4290	72.0320	50.228	-0.029	-0.0	72.0320
	64.4290	41.005	0.308	-0.2	64.4288	72.0330	49.871	0.328	0.3	72.0333
	64.4370	50.817	10.120	-7.2	64.4297	72.0240	40.117	10.082	9.5	72.0335
	64.4370	51.169	10.472	-7.5	64.4295	72.0230	39.702	10.497	9.8	72.0328
	64.4350	51.455	10.758	-7.7	64.4273	72.0210	39.295	10.904	10.2	72.0312
	0.0053	0.007	40.697		64.4299	-0.0090	-0.010	50.199		72.0321
6598.953	65.7540	40.312	-0.348	-0.1	65.7539	70.7000	50.550	-0.334	0.0	70.7000
	65.7550	40.672	0.012	0.0	65.7550	70.7060	50.188	0.028	-0.0	70.7060
	65.7480	41.009	0.349	0.1	65.7481	70.7080	49.867	0.349	-0.0	70.7080
	65.7450	50.784	10.124	2.8	65.7478	70.7080	40.139	10.077	-1.0	70.7070
	65.7490	51.155	10.495	2.9	65.7519	70.7060	39.730	10.486	-1.0	70.7050
	65.7510	51.472	10.812	3.0	65.7540	70.7020	39.266	10.950	-1.1	70.7009
	-0.0040	-0.003	40.660		65.7518	0.0007	0.001	50.216		70.7045
6678.276	67.3360	40.296	-0.358	-0.2	67.3358	69.1190	50.553	-0.346	0.2	69.1192
	67.3320	40.685	0.030	0.0	67.3320	69.1200	50.206	0.001	-0.0	69.1200
	67.3300	41.017	0.362	0.2	67.3302	69.1210	49.895	0.312	-0.2	69.1208
	67.3300	50.739	10.084	6.0	67.3360	69.1310	40.185	10.022	-7.2	69.1238
	67.3340	51.103	10.448	6.2	67.3402	69.1270	39.732	10.475	-7.6	69.1194
	67.3300	51.415	10.760	6.4	67.3364	69.1240	39.357	10.850	-7.8	69.1162
	-0.0013	-0.006	40.654		67.3351	0.0073	0.008	50.207		69.1199
6717.040	68.1130	40.291	-0.368	-0.2	68.1128	68.3410	50.472	-0.272	0.2	68.3412
	68.1080	40.669	0.010	0.0	68.1080	68.3460	50.224	-0.024	0.0	68.3460
	68.1100	40.988	0.329	0.2	68.1102	68.3470	49.889	0.311	-0.3	68.3467
	68.1010	50.719	10.060	6.0	68.1070	68.3520	40.172	10.028	-9.1	68.3429
	68.1000	51.099	10.440	6.2	68.1062	68.3550	39.801	10.399	-9.4	68.3456
	68.1010	51.486	10.827	6.5	68.1075	68.3560	39.417	10.783	-9.8	68.3462
	-0.0097	-0.006	40.659		68.1086	0.0097	0.009	50.200		68.3448
6929.468	72.3460	40.237	-0.380	-1.0	72.3450	64.1110	50.585	-0.292	0.8	64.1118
	72.3440	40.661	0.044	0.1	72.3441	64.1120	50.309	-0.016	0.0	64.1120
	72.3390	40.955	0.338	0.9	72.3399	64.1150	49.985	0.308	-0.9	64.1141
	72.3140	50.656	10.039	27.5	72.3415	64.1420	40.248	10.045	-28.3	64.1137
	72.3140	51.023	10.406	28.5	72.3425	64.1400	39.851	10.442	-29.4	64.1106
	72.3160	51.357	10.740	29.4	72.3454	64.1440	39.516	10.777	-30.3	64.1136
	-0.0283	-0.028	40.617		72.3430	0.0293	0.029	50.293		64.1127

D MID = 68.1160 YD MID = 41.0130 XR MID = 68.3385 YR MID = 49.9080

DX DIR =	-0.0062+	0.0001*X+	-0.00004*X**2+	-0.00029* X**3
DX REV =	0.0094+	-0.0022*X+	-0.00016*X**2+	-0.00018* X**3
YD DIR =	-0.3538+	0.0073*X+	0.00064*X**2+	-0.00111* X**3
YD REV =	0.2918+	0.0085*X+	0.00211*X**2+	-0.00121* X**3
YH DIR =	10.4258+	-0.0370*X+	-0.00178*X**2+	0.00209* X**3
YH REV =	-10.4045+	-0.0533*X+	-0.00207*X**2+	0.00272

WEIGHTED MEASUREMENTS

LAMDA= 6717.409 + 50.1680 *X + 0.0241 *X**2 + -0.00538 *X**3 (ANGSTROM)

6 COMPARISON LINES

LINE	XDIR	XREV	MEANX	MEANY	XD-XMEAN ANGSTROMS	LAMBDA	MEAS-CALC	WEIGHT
6506.528	63.896	63.897	63.896	10.785	0.046	6506.516	0.011	5
6532.880	64.430	64.424	64.427	10.831	0.147	6532.897	-0.017	4
6598.953	65.752	65.752	65.752	10.881	0.004	6598.963	-0.010	5
6678.276	67.335	67.336	67.336	10.805	0.028	6678.238	0.038	5
6717.040	68.109	68.111	68.110	10.805	0.068	6717.066	-0.026	5
6929.468	72.343	72.343	72.343	10.758	0.010	6929.467	0.001	5

'MEAN ERROR'= 0.02980
SIGMA = 136.4561

LINE	X (MM)	Y (MM)	Y-Y0	GRAD	XDIRECT	X (MM)	Y (MM)	Y-Y0	GRAD	XREVERSE
24 6562.817										
	65.8250	44.229	3.570	1.1	65.8261	70.6330	46.599	-3.617	-0.5	70.6325
	65.8260	44.474	3.815	1.2	65.8272	70.6250	46.378	-3.838	-0.5	70.6245
	65.8290	44.629	3.970	1.2	65.8302	70.6240	46.225	-3.991	-0.5	70.6234
	65.8240	44.846	4.187	1.3	65.8253	70.6340	46.047	-4.169	-0.6	70.6334
	65.8260	44.826	4.167	1.3	65.8273	70.6340	46.047	-4.169	-0.6	70.6334
	65.8310	45.219	4.560	1.4	65.8324	70.6320	45.674	-4.542	-0.6	70.6314
	65.8240	45.219	4.560	1.4	65.8254	70.6290	45.674	-4.542	-0.6	70.6284
	65.8380	45.557	4.898	1.5	65.8395	70.6070	45.303	-4.913	-0.7	70.6063
	65.8430	45.557	4.898	1.5	65.8445	70.6070	45.303	-4.913	-0.7	70.6063
	65.8300	45.629	4.970	1.5	65.8315	70.6340	45.236	-4.980	-0.7	70.6333
	65.8300	45.629	4.970	1.5	65.8315	70.6290	45.236	-4.980	-0.7	70.6283
	65.8000	45.701	5.042	1.5	65.8015	70.6570	45.161	-5.055	-0.7	70.6563
	65.8050	45.701	5.042	1.5	65.8065	70.6530	45.161	-5.055	-0.7	70.6523
	65.8300	45.835	5.176	1.6	65.8316	70.6380	45.028	-5.188	-0.7	70.6373
	65.8360	46.002	5.343	1.6	65.8376	70.6260	44.858	-5.358	-0.7	70.6253
	65.8350	46.138	5.479	1.7	65.8367	70.6300	44.725	-5.491	-0.8	70.6292
	65.8340	46.220	5.561	1.7	65.8357	70.6270	44.643	-5.573	-0.8	70.6262
	65.8290	46.333	5.674	1.7	65.8307	70.6340	44.530	-5.686	-0.8	70.6332
	65.8210	46.381	5.722	1.8	65.8228	70.6410	44.481	-5.735	-0.8	70.6402
	65.8240	46.526	5.867	1.8	65.8258	70.6360	44.337	-5.879	-0.8	70.6352
	65.8320	46.655	5.996	1.8	65.8338	70.6260	44.208	-6.008	-0.8	70.6252
	65.8620	47.636	6.977	2.1	65.8641	70.6260	43.881	-6.335	-0.9	70.6251
	65.8370	47.225	6.566	2.0	65.8390	70.6190	43.650	-6.566	-0.9	70.6181
	65.8300	46.994	6.335	1.9	65.8319	70.5940	43.239	-6.977	-1.0	70.5930
	-0.003	10.476	40.659			0.001	-10.505	50.216		

	XDIR	XREV	CURV	MEANX	MEANY	XD-MEANX	LAMDA	DELTA L	VELOCITY	Y ARCSEC	V(WRT SUN)
6562.817											
	65.826	65.824	1.6	65.840	-1.383	0.062	6603.396	40.579	1853.7	-32.6	1849.5
	65.827	65.832	1.6	65.845	-1.150	0.112	6603.649	40.832	1865.2	-27.1	1861.0
	65.830	65.833	1.6	65.848	-0.996	0.061	6603.764	40.947	1870.5	-23.4	1866.3
	65.825	65.823	1.7	65.841	-0.799	0.065	6603.407	40.590	1854.2	-18.8	1850.0
	65.827	65.823	1.7	65.842	-0.809	0.115	6603.455	40.638	1856.4	-19.0	1852.2
	65.832	65.825	1.7	65.846	-0.426	0.191	6603.654	40.837	1865.4	-10.0	1861.3
	65.825	65.828	1.7	65.844	-0.426	0.058	6603.554	40.737	1860.9	-10.0	1856.7
	65.839	65.850	1.7	65.862	-0.071	0.257	6604.465	41.648	1902.5	-1.7	1898.3
	65.844	65.850	1.7	65.864	-0.071	0.132	6604.590	41.772	1908.2	-1.7	1904.0
	65.832	65.823	1.7	65.844	-0.002	0.218	6603.591	40.774	1862.6	-0.0	1858.4
	65.832	65.828	1.7	65.847	-0.002	0.093	6603.716	40.899	1868.3	-0.0	1864.1
	65.802	65.800	1.7	65.818	0.072	0.043	6602.268	39.451	1802.1	1.7	1798.0
	65.806	65.804	1.7	65.822	0.072	0.068	6602.493	39.676	1812.4	1.7	1808.2
	65.832	65.819	1.7	65.842	0.205	0.319	6603.493	40.676	1858.1	4.8	1853.9
	65.838	65.831	1.7	65.851	0.374	0.170	6603.942	41.125	1878.6	8.8	1874.4
	65.837	65.827	1.7	65.849	0.508	0.245	6603.814	40.997	1872.8	12.0	1868.6
	65.836	65.830	1.7	65.850	0.590	0.146	6603.862	41.045	1875.0	13.9	1870.8
	65.831	65.823	1.7	65.844	0.703	0.196	6603.559	40.742	1861.1	16.5	1857.0
	65.823	65.816	1.7	65.836	0.752	0.171	6603.183	40.366	1843.9	17.7	1839.8
	65.826	65.821	1.7	65.840	0.896	0.122	6603.376	40.559	1852.8	21.1	1848.6
	65.834	65.831	1.6	65.849	1.025	0.072	6603.820	41.003	1873.0	24.1	1868.9
	65.864	65.831	1.5	65.862	1.679	0.828	6604.484	41.667	1903.4	39.5	1899.2
	65.839	65.838	1.6	65.854	1.589	0.025	6604.078	41.261	1884.8	37.4	1880.7
	65.832	65.863	1.6	65.863	1.679	0.778	6604.549	41.732	1906.3	39.5	1902.2

LINE	X (MM)	Y (MM)	Y-Y0	GRAD	XDIRECT	X (MM)	Y (MM)	Y-Y0	GRAD	XREVERSE
9 6583.400										
	66.2410	45.203	4.548	2.0	66.2430	70.2140	45.684	-4.531	-1.6	70.2124
	66.2440	45.203	4.548	2.0	66.2460	70.2140	45.684	-4.531	-1.6	70.2124
	66.2500	45.595	4.940	2.2	66.2522	70.2020	45.285	-4.930	-1.7	70.2003
	66.2530	45.595	4.940	2.2	66.2552	70.2020	45.285	-4.930	-1.7	70.2003
	66.2270	45.684	5.029	2.2	66.2292	70.2360	45.184	-5.031	-1.7	70.2343
	66.2210	45.684	5.029	2.2	66.2232	70.2390	45.184	-5.031	-1.7	70.2373
	66.2440	45.890	5.235	2.3	66.2463	70.2170	44.936	-5.279	-1.8	70.2152
	66.2420	46.196	5.541	2.5	66.2445	70.2110	44.673	-5.542	-1.9	70.2091
	66.2350	46.473	5.818	2.6	66.2376	70.2210	44.398	-5.817	-2.0	70.2190
	-0.005	10.475	40.655			0.004	-10.494	50.215		

	XDIR	XREV	CURV	MEANX	MEANY	XD-MEANX	LAMDA	DELTA L	VELOCITY	Y ARCSEC	V(WRT SUN)
6583.400											
	66.243	66.244	1.7	66.260	-0.443	0.016	6624.393	40.993	1866.7	-10.4	1862.5
	66.246	66.244	1.7	66.262	-0.443	0.059	6624.468	41.068	1870.1	-10.4	1866.0
	66.252	66.256	1.7	66.271	-0.048	0.090	6624.934	41.534	1891.3	-1.1	1887.2
	66.255	66.256	1.7	66.273	-0.048	0.015	6625.009	41.609	1894.8	-1.1	1890.6
	66.229	66.222	1.7	66.243	0.047	0.185	6623.510	40.110	1826.5	1.1	1822.4
	66.223	66.219	1.7	66.238	0.047	0.110	6623.285	39.885	1816.3	1.1	1812.1
	66.246	66.241	1.7	66.261	0.274	0.135	6624.413	41.013	1867.6	6.4	1863.5
	66.244	66.247	1.7	66.263	0.558	0.064	6624.511	41.111	1872.1	13.1	1867.9
	66.238	66.237	1.7	66.254	0.834	0.012	6624.079	40.679	1852.4	19.6	1848.2

LINE	X (MM)	Y (MM)	Y-Y0	GRAD	XDIRECT	X (MM)	Y (MM)	Y-Y0	GRAD	XREVERSE
6 6717.300										
	68.9290	45.545	4.880	3.0	68.9320	67.5160	45.327	-4.868	-5.2	67.5107
	68.9270	45.545	4.880	3.0	68.9300	67.5180	45.319	-4.876	-5.3	67.5127
	68.9290	45.545	4.880	3.0	68.9320	67.5140	45.319	-4.876	-5.3	67.5087
	68.9140	45.610	4.945	3.0	68.9170	67.5580	45.225	-4.970	-5.4	67.5526
	68.9000	45.646	4.981	3.0	68.9030	67.5490	45.225	-4.970	-5.4	67.5436
	68.8940	45.662	4.997	3.0	68.8970	67.5480	45.225	-4.970	-5.4	67.5426
	-0.006	10.396	40.665			0.011	-10.364	50.195		

	XDIR	XREV	CURV	MEANX	MEANY	XD-MEANX	LAMDA	DELTA L	VELOCITY	Y ARCSEC	V(WRT SUN)
6717.~~300~~ 000											
	68.932	68.945	1.3	68.952	-0.044	0.337	6759.311	42.011	1875.0	-1.0	1870.8
	68.930	68.943	1.3	68.950	-0.040	0.337	6759.211	41.911	1870.5	-0.9	1866.3
	68.932	68.947	1.3	68.953	-0.040	0.387	6759.361	42.061	1877.2	-0.9	1873.0
	68.917	68.903	1.3	68.923	0.039	0.339	6757.884	40.584	1811.3	0.9	1807.1
	68.903	68.912	1.3	68.921	0.058	0.238	6757.759	40.459	1805.7	1.4	1801.5
	68.897	68.913	1.3	68.918	0.065	0.413	6757.634	40.334	1800.1	1.5	1795.9

VELOCITY CORRECTIONS. VS = -4.2 VLS = -2.0

NGC 3672

$$V = \frac{V(R)\sin i \cos(\eta-\phi) + E(R)\tan i \sin(\eta-\phi)}{[\sec^2 i - \tan^2 i \cos^2(\eta-\phi)]^{1/2}}$$

$\sec^2 i - \tan^2 i$

$\frac{1}{\cos^2} - \frac{\sin^2}{\cos^2}$

$\frac{1-\sin^2}{\cos^2} = 1$

$\langle V \rangle$ minor axis 1858

major 1858 $H\alpha$ only
1861 $H\alpha + N\,II$

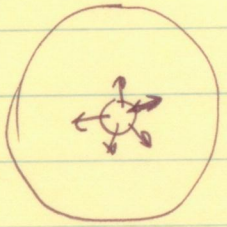
$\therefore$ V_0 minor = V_0 major

$\phi = 8°$ $\eta = 8°$ $\eta - \phi = 0$

$\therefore$ expansion in nucl. does not show along ~~major~~ major axis:

$V = V(R)\sin i$

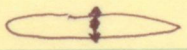
if No rot. in expanding ring, flat as Hb.



Obs.

along minor axis: $\eta - \phi = 90°$

$$V = \frac{E(R)\tan i}{\sec i} = \frac{E(R)\sin i \cos i}{\cos i} = E(R)\sin i$$



From rot. curve: SW is approach NE rec.

for arms to trail **E is near side**

Along minor axis E is ~~hi~~ lo V

W is ~~lo~~ hi V

$\therefore$ motion is ~~expansion~~ contraction

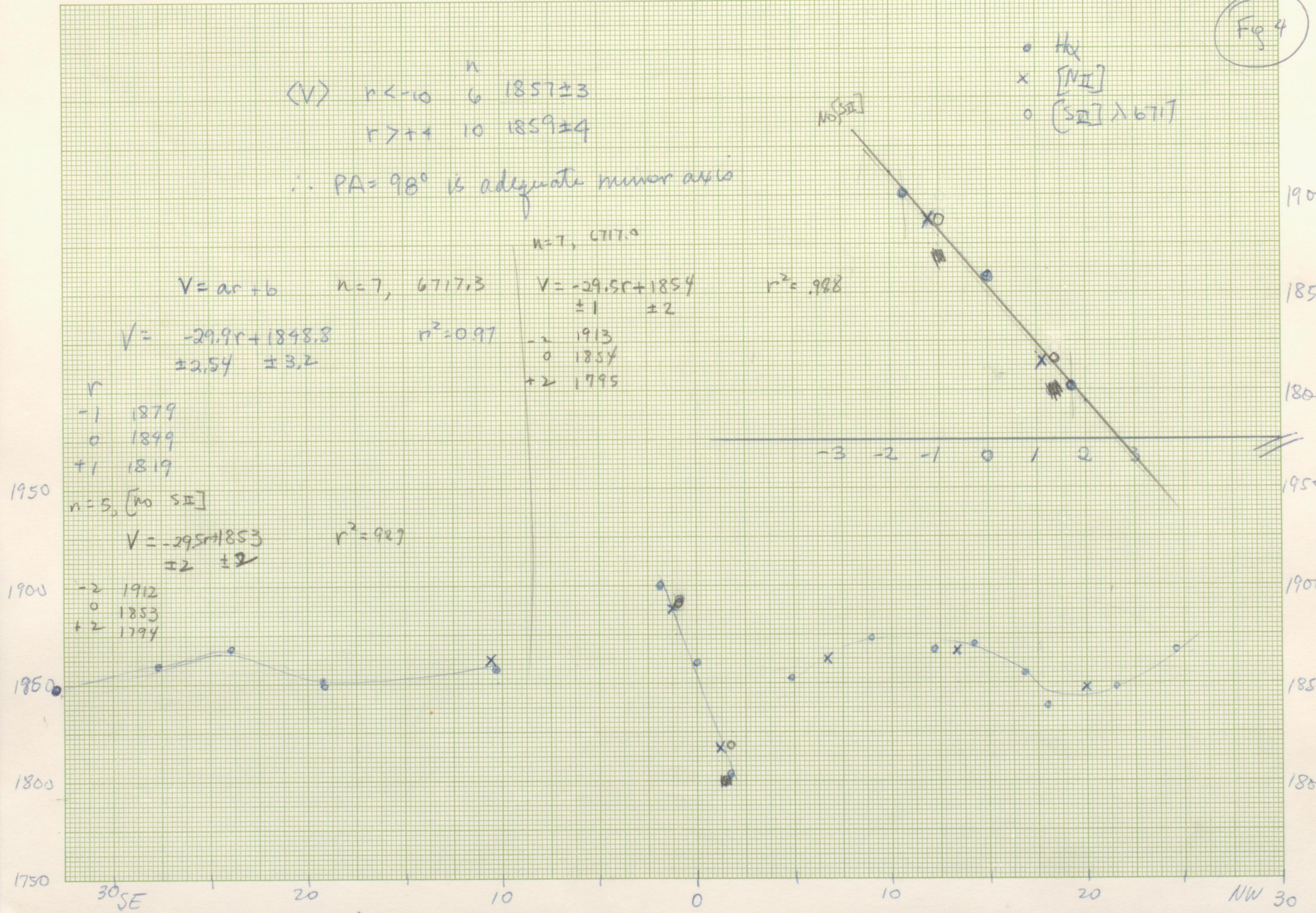
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. 46 1510 MADE IN U.S.A.

$R = s[\sec^2 i - \tan^2 i \cos^2(90°)]^{1/2}$

$R = s \sec i \quad i \sim 70°$

NGC 3672 Minor axis

Fig 4



96".5 on plane of gal. i = 70°; 127".5, i ≈ 75°

SINGLE SPACE

TABLE 1

VELOCITIES (HELIOCENTRIC) IN NGC 3672

Minor Axis PA=98°			Major Axis PA=8°					
	y (arc sec)	V (km s^{-1})		y (arc sec)	V (km s^{-1})		y (arc sec)	V (km s^{-1})
Hα	-32.6 SE	1850	Hα	-111.0 NE	2044		+16.1	1757	-49.5	2021
	-27.1	1861		-106.2	2018		+20.9	1696	-44.8	2033
	-23.4	1866		-101.5	2017		+25.6	1668	-40.0	2022
-19.0	~~-18.8~~	~~1850~~ 1852		-96.8	2011		+30.3	1682	-35.4	2017
-18.8	~~-19.0~~	1850		-92.1	2030		+32.7	1675	-30.8	2008
	-10.0	1869		-87.4	2035		+39.7	1705	-26.0	1991
	-1.7	~~1907~~		-82.7	2030		+44.4	1695	-21.2	1966
	0	~~1861~~		-80.8	2023		+49.2	1696	-16.5	1962
	+1.7	1803		-78.0	2026		+51.3	1692	-11.8	1931
	+4.8	1854		-73.3	2020		+53.8	1688	-7.1	1892
	+8.8	1874		-68.6	2008		+58.5	1655	-2.4	1882
	+12.0	1869		-59.1	2047		+63.3	1677	+0.1	1855
	+13.9	1871		-54.4	2037		+67.8	1665	+2.3	1852
	+16.5	1857		-49.8	2047		+72.7	1658	+6.9	1833
	+17.7	1840		-45.0	2039		+77.4	1633	+11.6	1805
	+21.4	1849		-40.3	2038		+82.1	1610	+16.4	1772
	+24.1	1869		-35.6	2015		+96.2	1668	+21.1	1707
	+38.8 NW	1894		-30.9	1999		+101.0 SW	1658	+25.8	1687
				-26.1	1976				+30.5	1673
[NII]	-10.4	1864		-21.4	1972	[NII]	-96.6 NE	2040	+35.2	1689
	-1.1	1889		-16.8	1944		-91.9	2045	+39.9	1708
	+1.1	1817		-12.1	1909		-87.2	2041	+44.6	1679
	+6.4	1864		-7.4	1884		-82.4	2033	+49.4	1686
	+13.1	1868		-2.7	1861		-80.8	2021	+51.6	1686
	+19.6	1848		+0.2	1858		-77.7	2020	+54.1	1694
				+2.0	1857		-73.0	2012	+58.8	1693
[SII]	-1.0	1889		+6.7	1840		-58.9	2019	+62.8 SW	1697
	+1.3	1820		+11.5	1810		-54.2	2031		

[NII] ≡ λ 6583 ; [SII] ≡ λ 6717.