

Harmonics At Lab 2

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Magnetometer III

Uses Morgen coils and timing gates with up/down counters to yield two scalars per channel which are then converted to normal and skew components for each winding.

Reasons to replace it:

- Morgen coils only
- Limited to primary harmonic of winding
- Sensitivity is limited
- Electronics are channel dependent, not interchangeable
- Limited spare parts
- Very finicky
- No diagnostics

Data Acquisition Capability

Zscans and single measurements at
fixed currents.

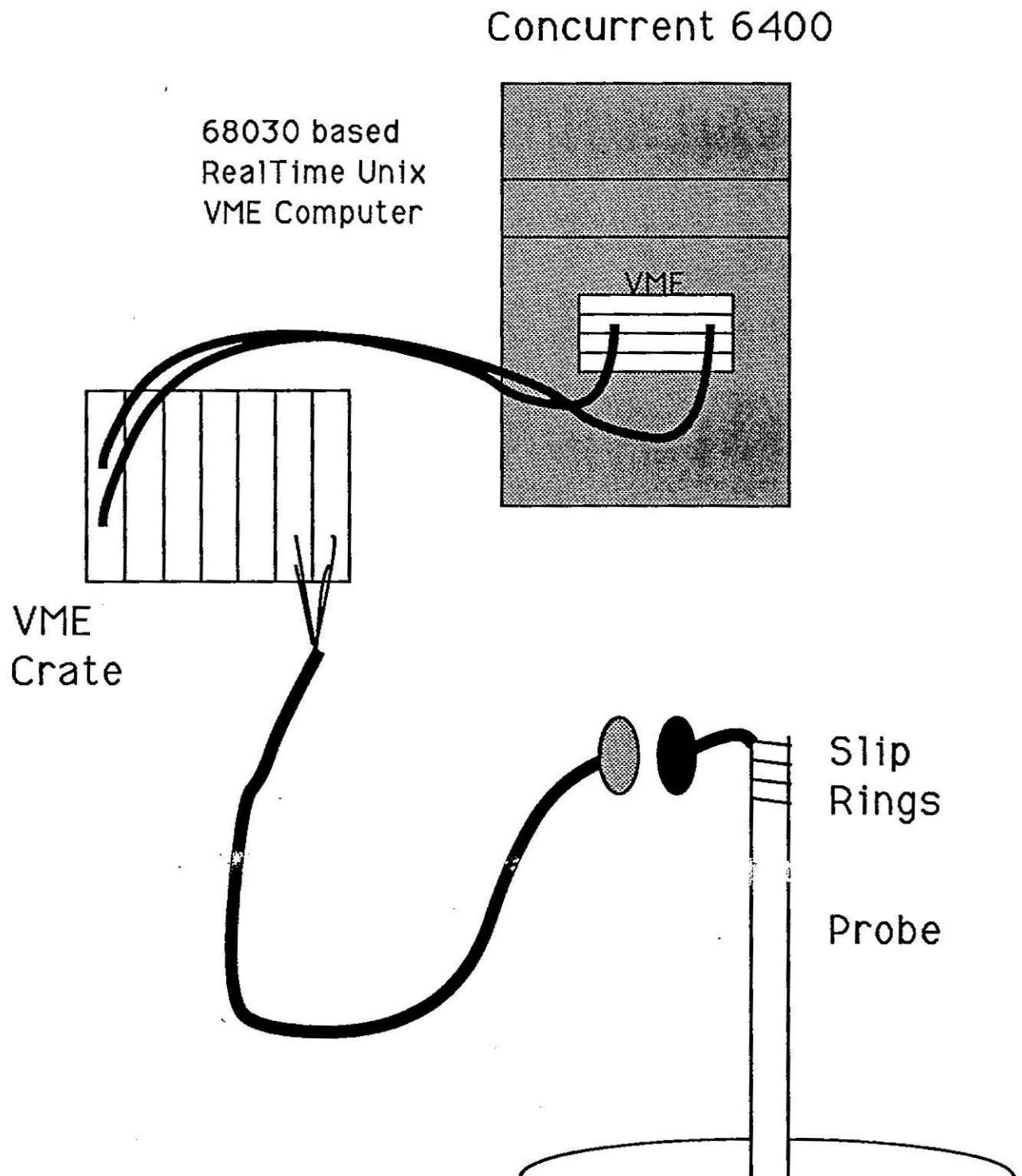
"AC" data - fixed probe location,
ramp magnet current.

We already take faster data than most people -
probe rotates at 6 Hz, data can be obtained on
every other rotation (i.e. 3 meas per second).

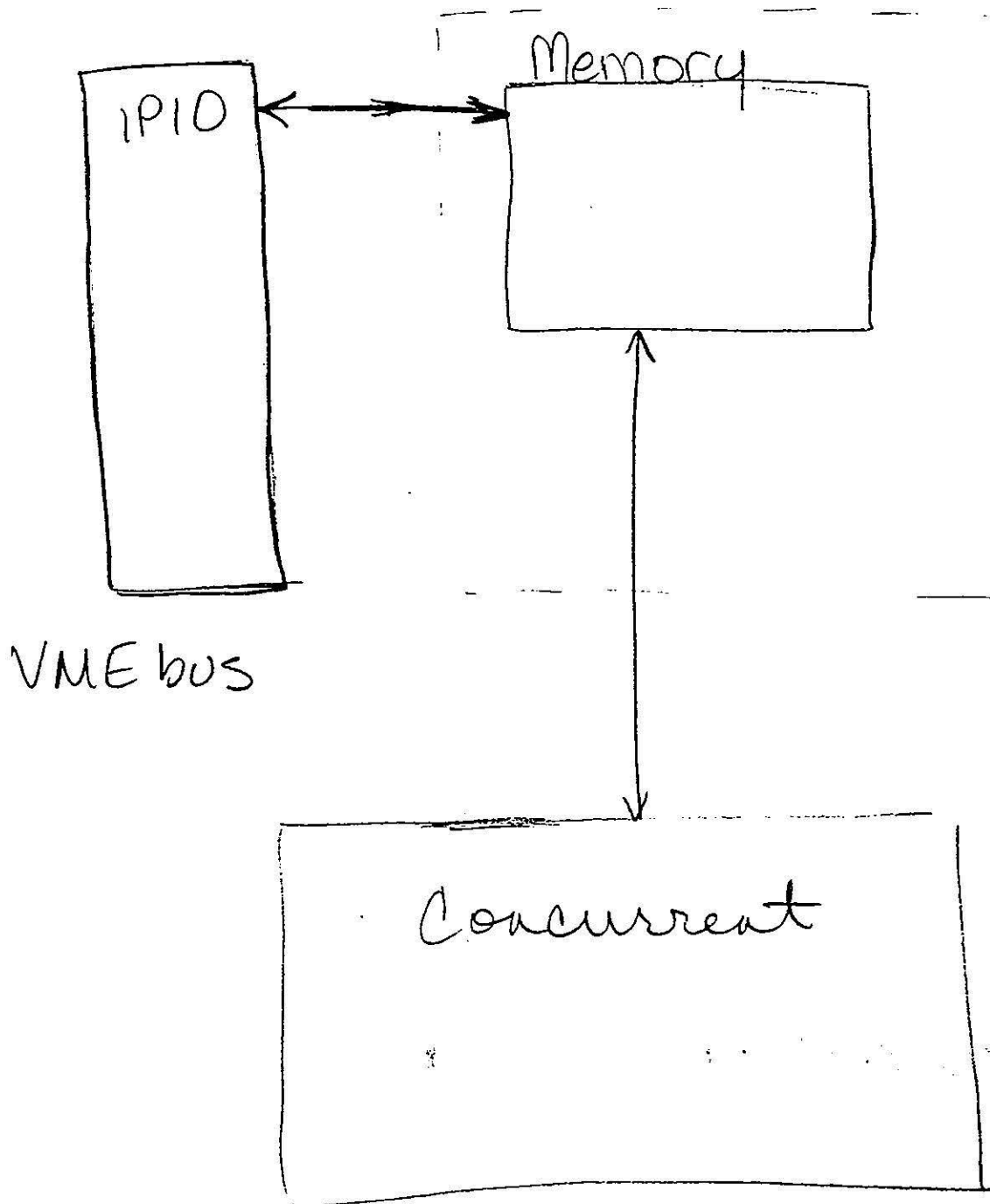
HAL2 Goals

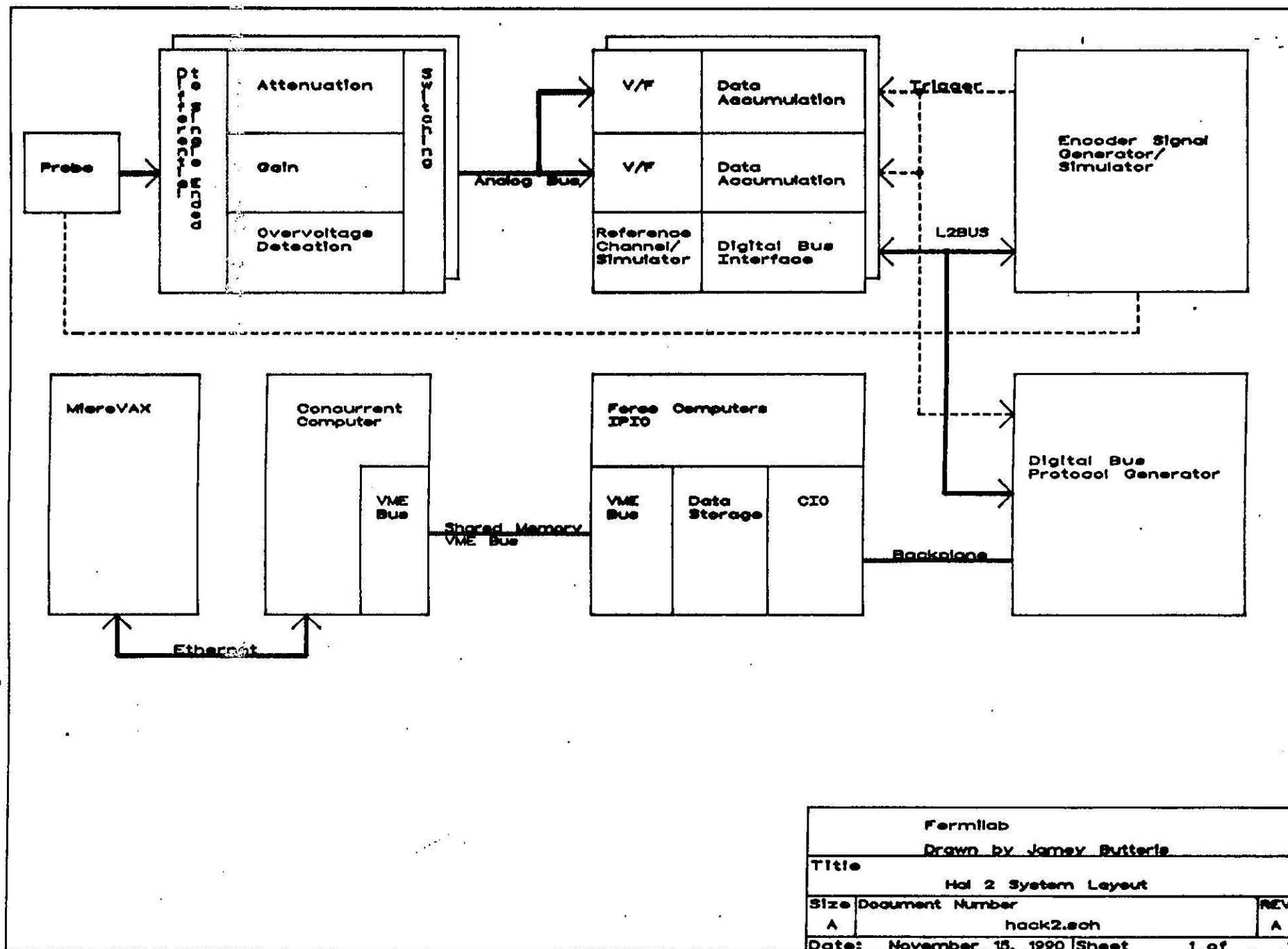
- Capture entire waveform from given channel.
- Provide greater sensitivity
- Make each channel of electronics identical and independent of signal type.
 - Morgen coils: obtain primary AND higher harmonics.
 - Tangential coils.
- Provide diagnostic capabilities through software.
- Provide greater flexibility in data acquisition capability.

HAL2 System Architecture



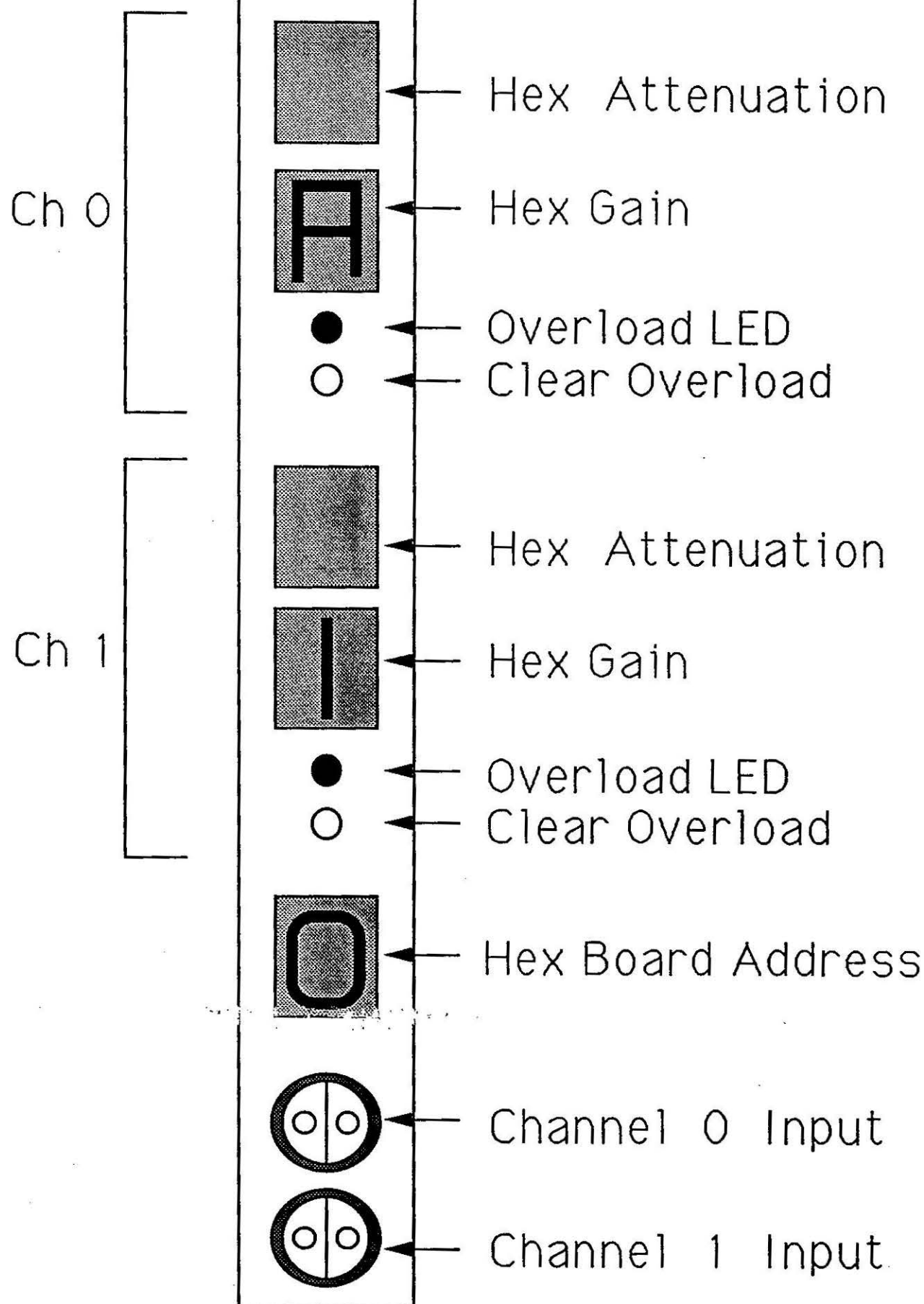
Memory Mapped I/O



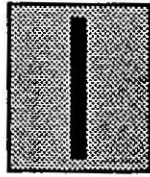


Fermilab		
Drawn by Jamey Butters		
Title		
Hal 2 System Layout		
Size	Document Number	REV
A	hack2.sch	A
Date: November 15, 1990 Sheet 1 of 1		

HAL 2 Analog Board



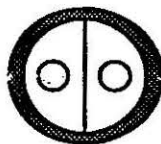
HAL2 V/f Board



← Hex Board Address



← Active Indicator LED

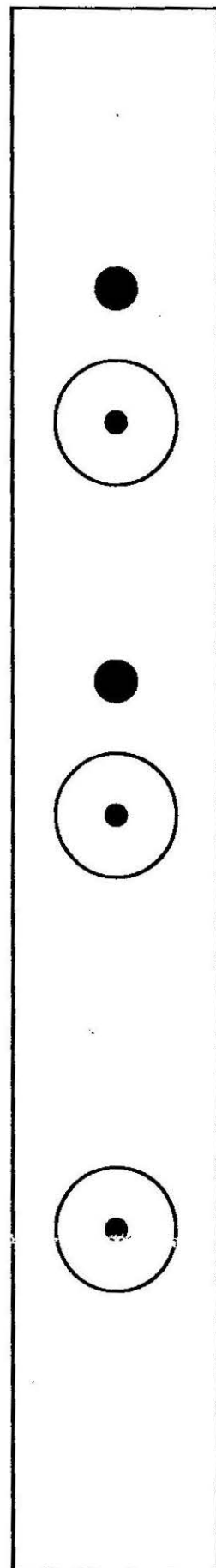


← Channel 0 Voltage Out



← Channel 1 Voltage Out

HAL2 Encoder Board



← Reset Pulse LED

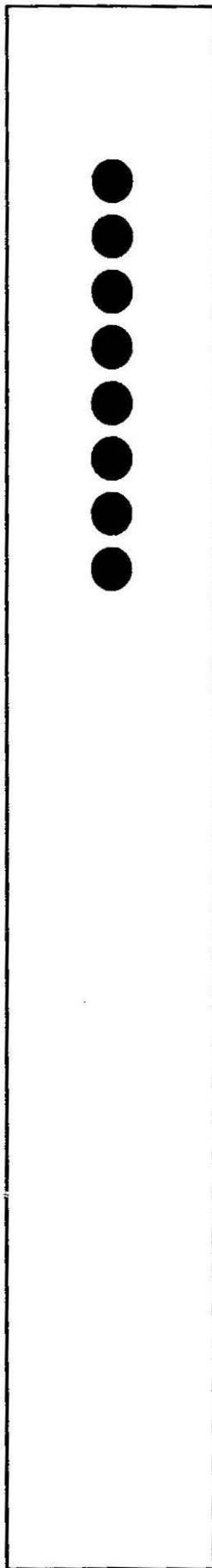
← Encoder Reset In

← Encoder Pulse LED

← Encoder Pulse In

← External Pulse In

HAL2 Protocol Generator

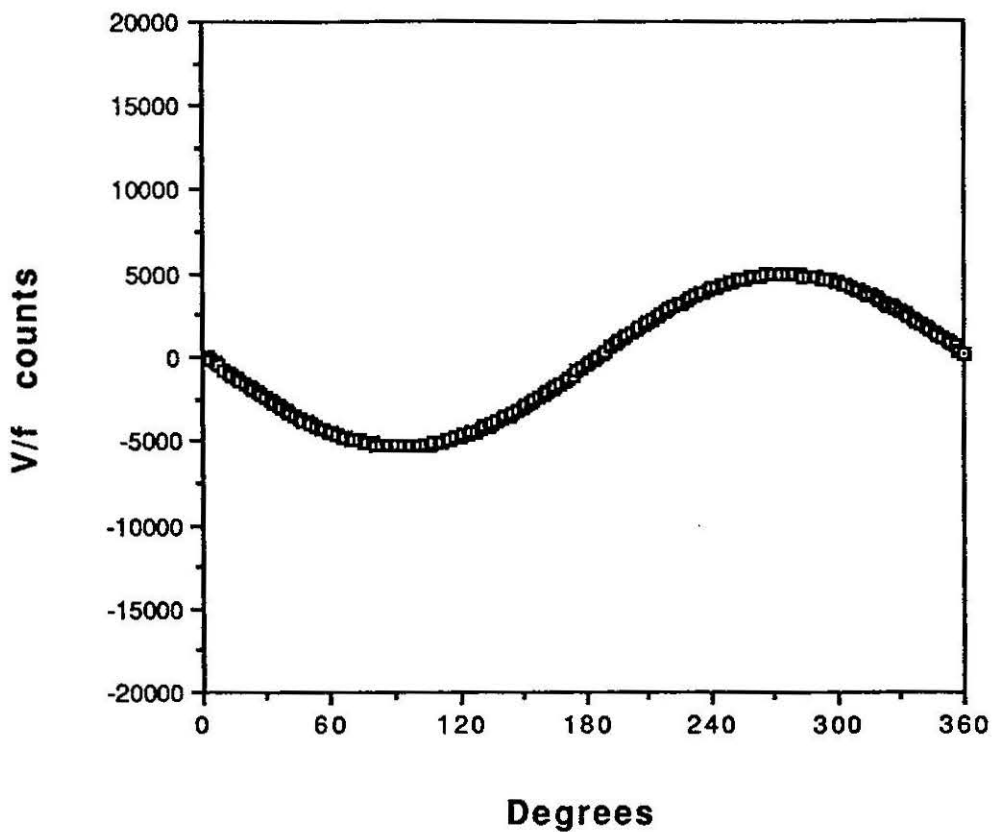


Status Register LED's

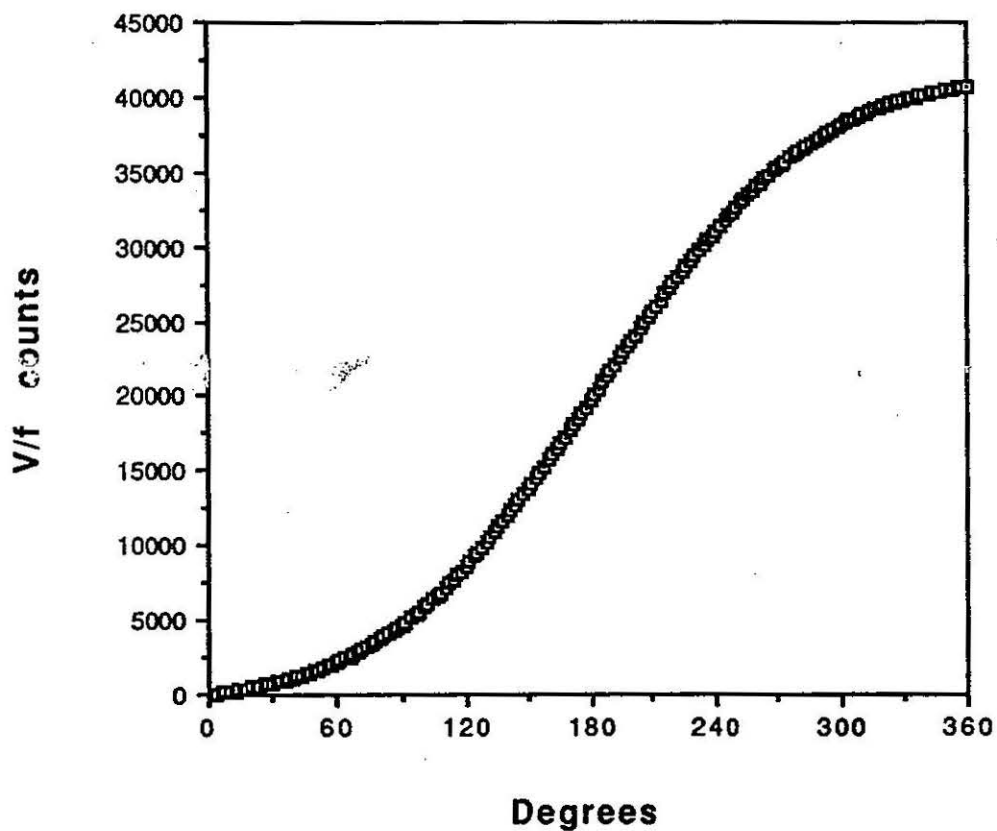
Echo contents of
status register:

- watchdog timer
- encoder pulse
- reset pulse
- reserved
- sync
- auto-increment
- control/data
- read/write

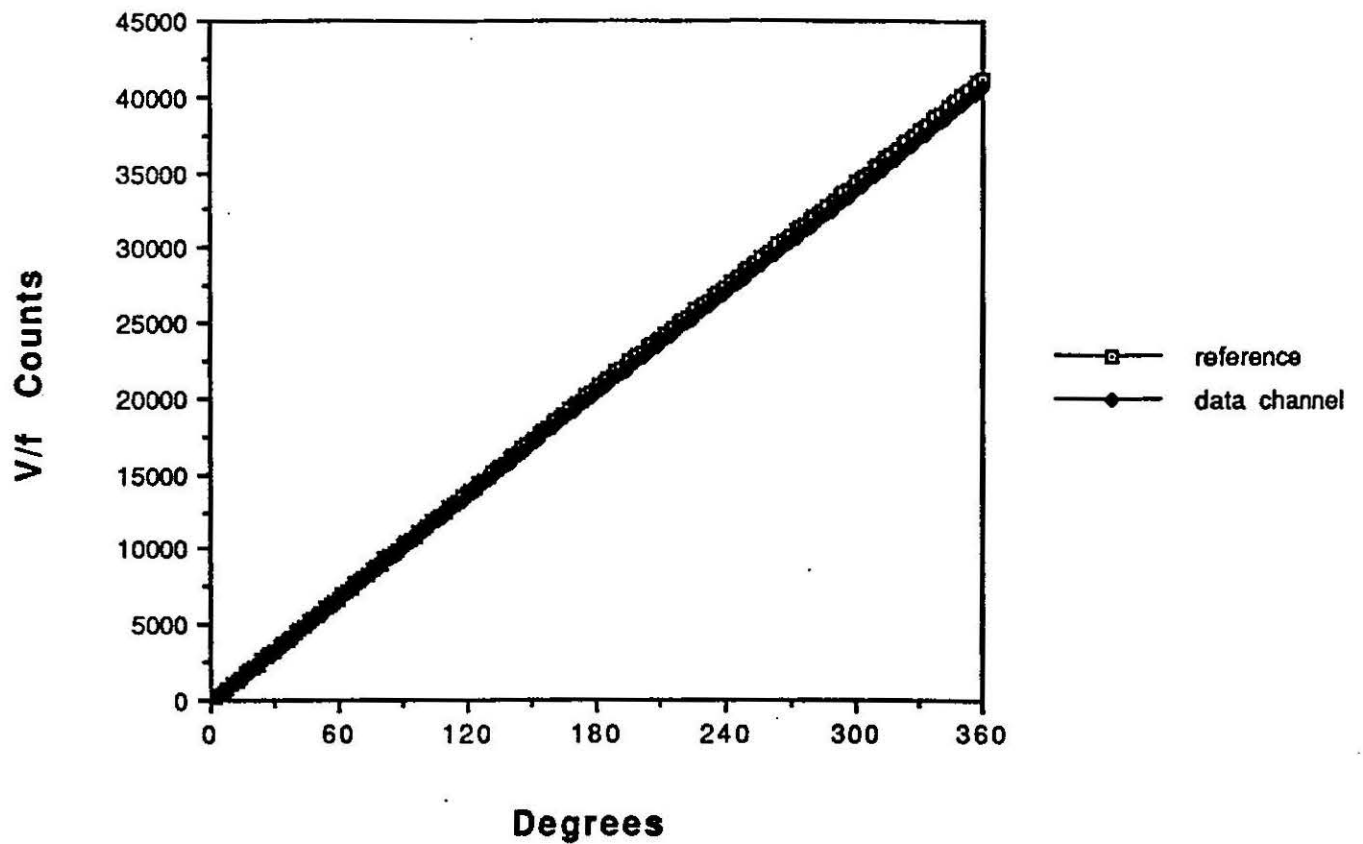
V/f counts -- No V/f offset
0 volts = 0 Hz (0 counts)



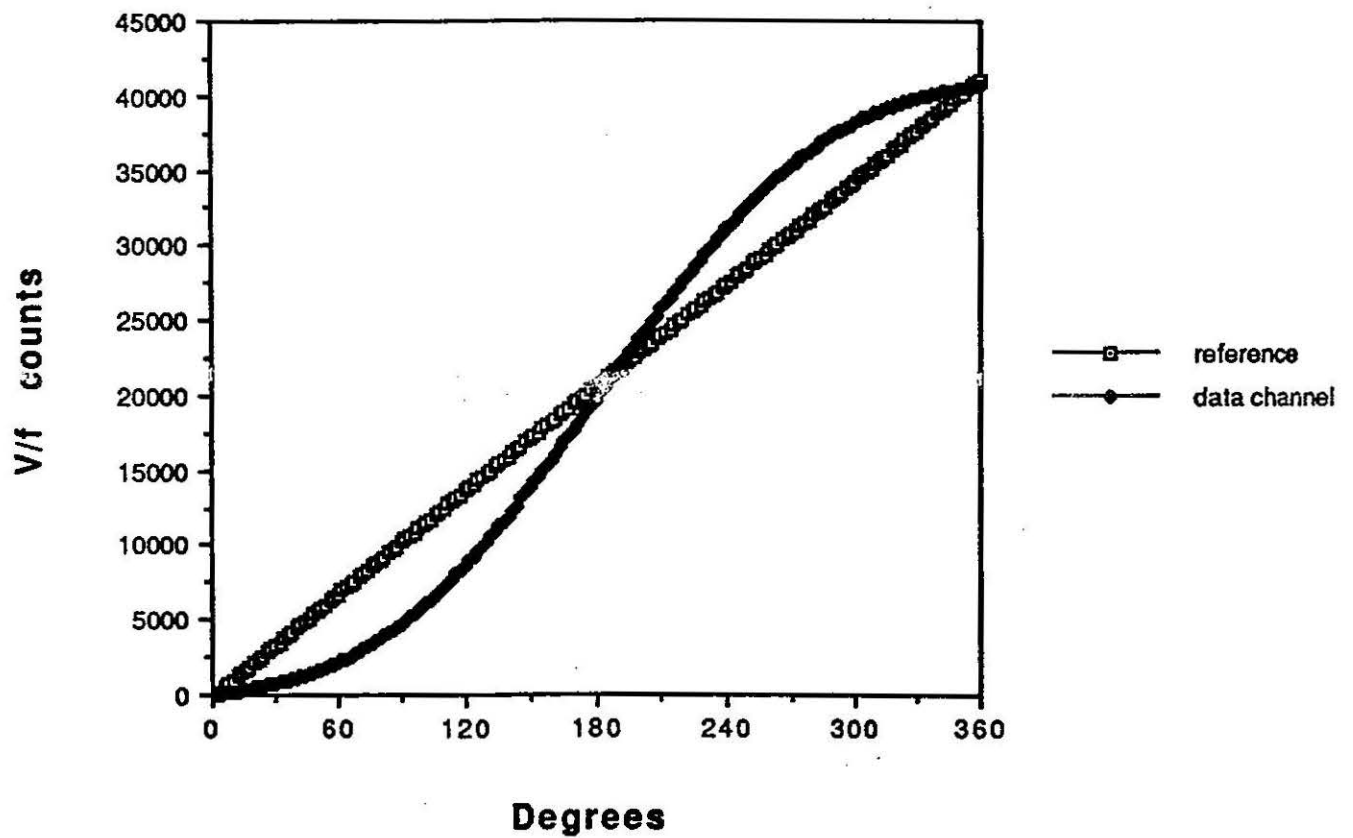
V/f counts -- V/f has offset
0 volts = 250 kHz



Calibration Run "dipw0311.cal"

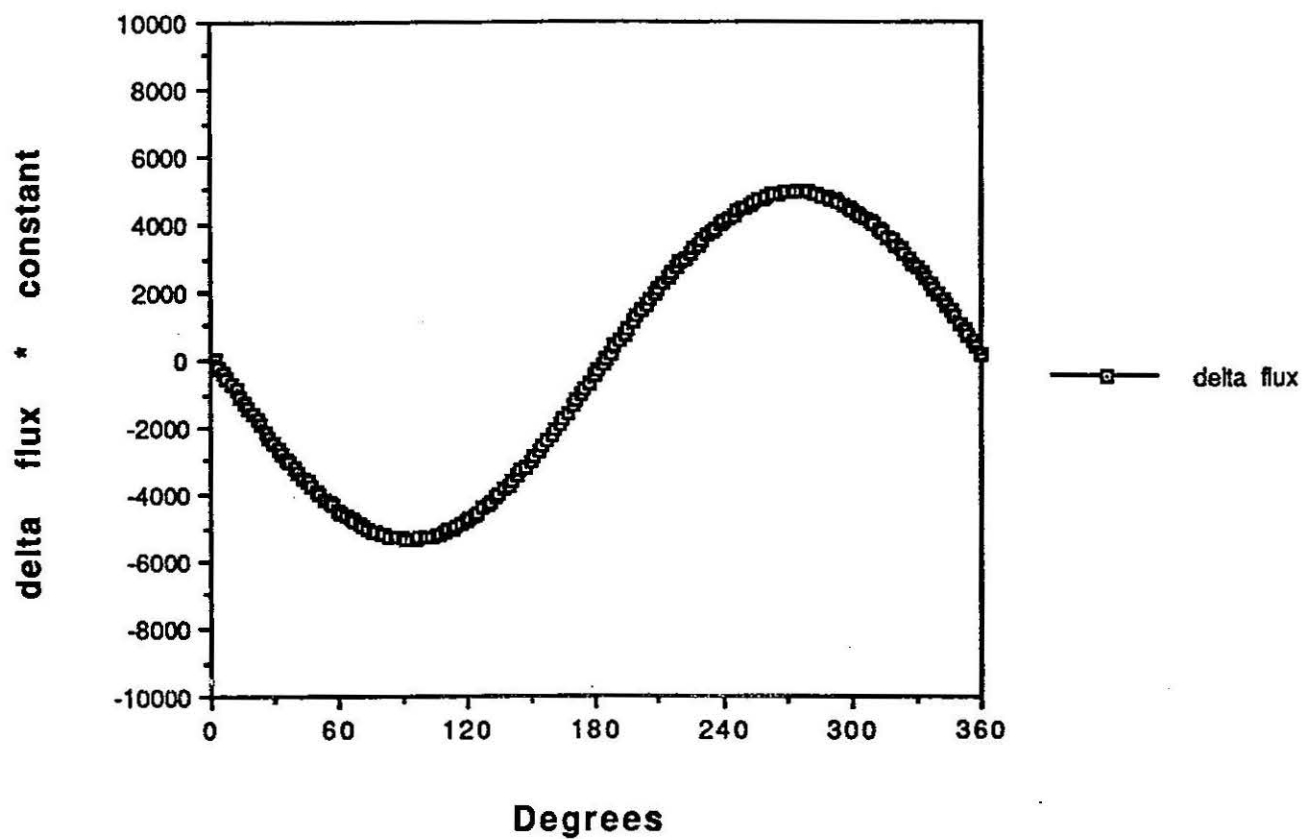


Data Run "dipw0311.dat"



$$\Delta \text{flux} = \overbrace{\text{data} - \text{reference}}^{\text{data run}} * \overbrace{\text{data}/\text{reference}}^{\text{calibration run}}$$

Change in flux from Run "dipw0311"



Data Analysis

Δflux



Fourier Transform



sine and cosine coefficients



harmonic amplitude and phase

Data Acquisition Program Main Menu:

Choose an Option :

1. Take Data
2. Calibration Run
3. Change Gain Settings
4. Change Channel Assignments
5. Exit Program
6. Read/Write IPIO Address

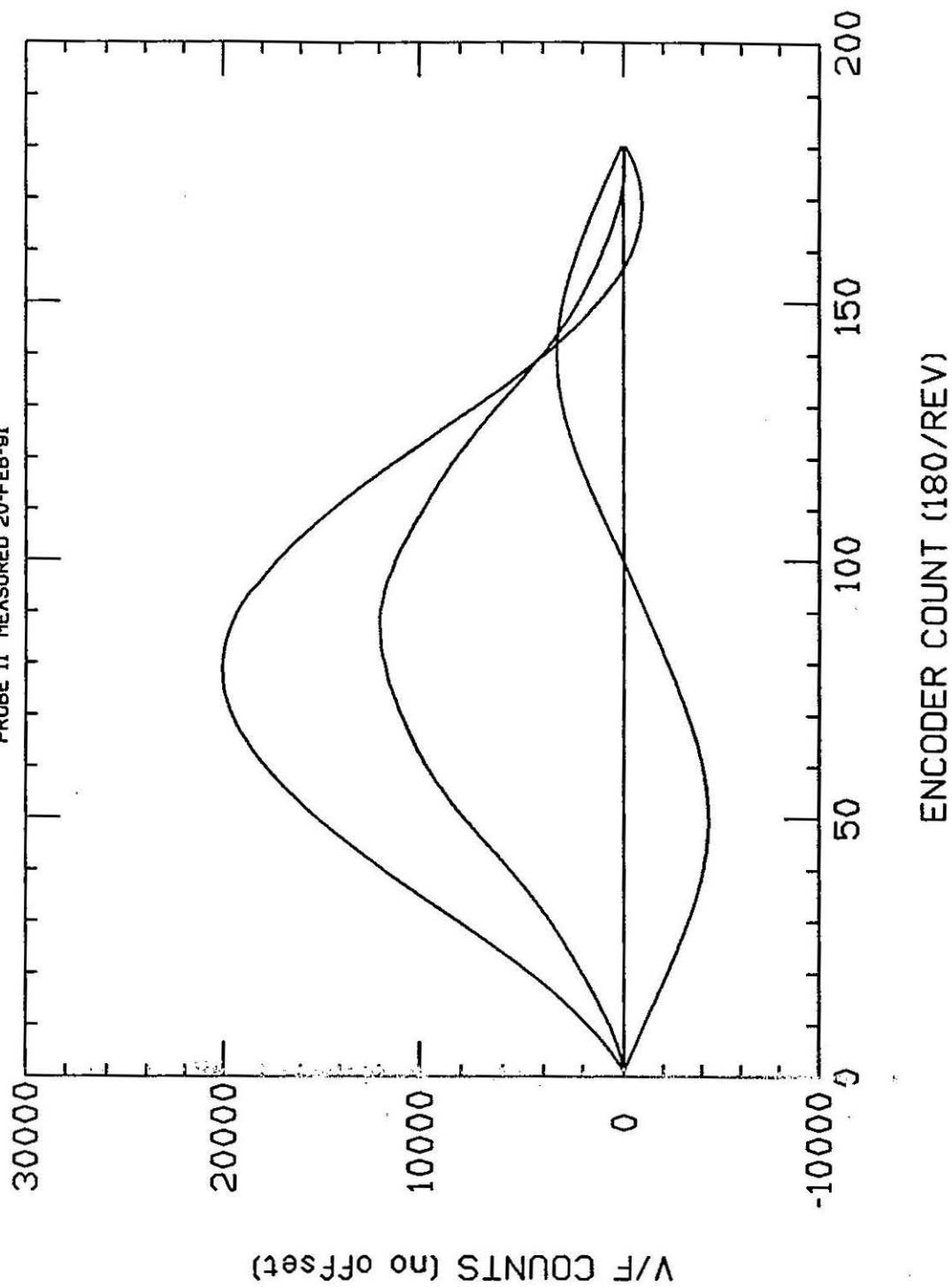
Enter :

Sample Data File Header:

magnet_name: DS0315
probe_id: 11
num_channels: 4
num_points: 180
channel_map: 3 5 1 0
gains: 200.0 400.0 2.0 1.0
z-position: 41.50
magnet_current: 5048.0
date: Wed Feb 20 17:22:37 1991
comments: zscan run B
data:
0 0 0 0
210 222 171 257
593 635 471 717
●
●
●

DS0315 Signals Run # 037

PROBE 11 MEASURED 20-FEB-91



ds0315.u037

CHANNEL 1 --> SEXTUPOLE CHANNEL

COS	SIN	AMPL	DO	D90	AMPL
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
-7.77977	-8.97258	11.8757	7.73207	9.39534	12.1679
0.324973E-02	0.242688E-03	0.325878E-02	0.206790	-0.150688E-01	0.207338
1.07804	-0.404818	1.15155	-1.14966	0.486454	1.24834
0.377828E-02	-0.118578E-02	0.395999E-02	0.172900E-01	-0.116675	0.117950
0.242355E-02	-0.206325E-02	0.318286E-02	0.148358E-01	0.988180E-01	0.999254E-01
0.414973E-02	-0.854787E-02	0.950192E-02	-0.844086E-01	-0.108311	0.137317
-0.188804E-01	-0.640270E-02	0.199365E-01	0.547556E-01	-0.203227E-01	0.584054E-01
-0.660662E-02	-0.401922E-03	0.661884E-02	-0.118245	-0.176219E-01	0.119551
-0.761035E-02	0.152150E-01	0.170121E-01	0.713689E-01	-0.698472E-01	0.998607E-01
0.247362E-02	-0.162395E-01	0.164268E-01	-0.550170E-01	0.141830	0.152127
0.268179E-02	-0.407947E-02	0.488202E-02	-0.196856E-01	-0.585722E-01	0.617918E-01
0.936828E-02	-0.103905E-01	0.139903E-01	0.172490E-01	0.501693E-01	0.530517E-01
-0.331082E-01	-0.121898E-01	0.352810E-01	0.548460E-02	-0.949566E-02	0.109658E-01
-0.223777E-01	0.449641E-01	0.502248E-01	0.450938E-01	-0.639916E-02	0.455456E-01

CHANNEL 2 --> DECAPOLE CHANNEL

COS	SIN	AMPL	DO	D90	AMPL
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
10.3327	-5.37859	11.6488	-10.5298	5.44500	11.8543
0.965884E-02	-0.680070E-03	0.968275E-02	0.400793E-01	0.545804E-01	0.677153E-01
-0.263758E-02	0.554925E-02	0.614418E-02	0.233347E-01	-0.425114E-01	0.484946E-01
-0.106132E-02	-0.349578E-02	0.365334E-02	0.769491E-01	-0.131013	0.151940
-0.743373	-0.747571E-01	0.747122	0.709244	0.713325E-01	0.712822
-0.312533E-02	0.121569E-01	0.125522E-01	0.629051E-01	0.144020E-01	0.645327E-01
0.301571E-02	-0.810399E-02	0.864691E-02	0.195844	-0.150664	0.247092
0.683461E-02	-0.126183E-02	0.695012E-02	-0.484305E-01	0.872148E-01	0.997594E-01
0.579804E-02	-0.874978E-02	0.104965E-01	0.141696E-01	0.272830E-01	0.307431E-01
0.846145E-03	0.583871E-02	0.589970E-02	-0.424541E-01	0.407660E-01	0.588576E-01
0.209306E-02	-0.903300E-02	0.927232E-02	-0.286365E-01	-0.643569E-02	0.293508E-01
-0.736967E-03	0.703856E-02	0.707704E-02	0.117905	-0.558226E-01	0.130452
0.171042E-01	-0.219103E-01	0.277960E-01	-0.688598E-01	0.830755E-01	0.107904
-0.139848E-01	-0.548079E-01	0.565640E-01	0.958629E-02	-0.611217E-01	0.618689E-01

CHANNEL 3 --> DIPOLE CHANNEL

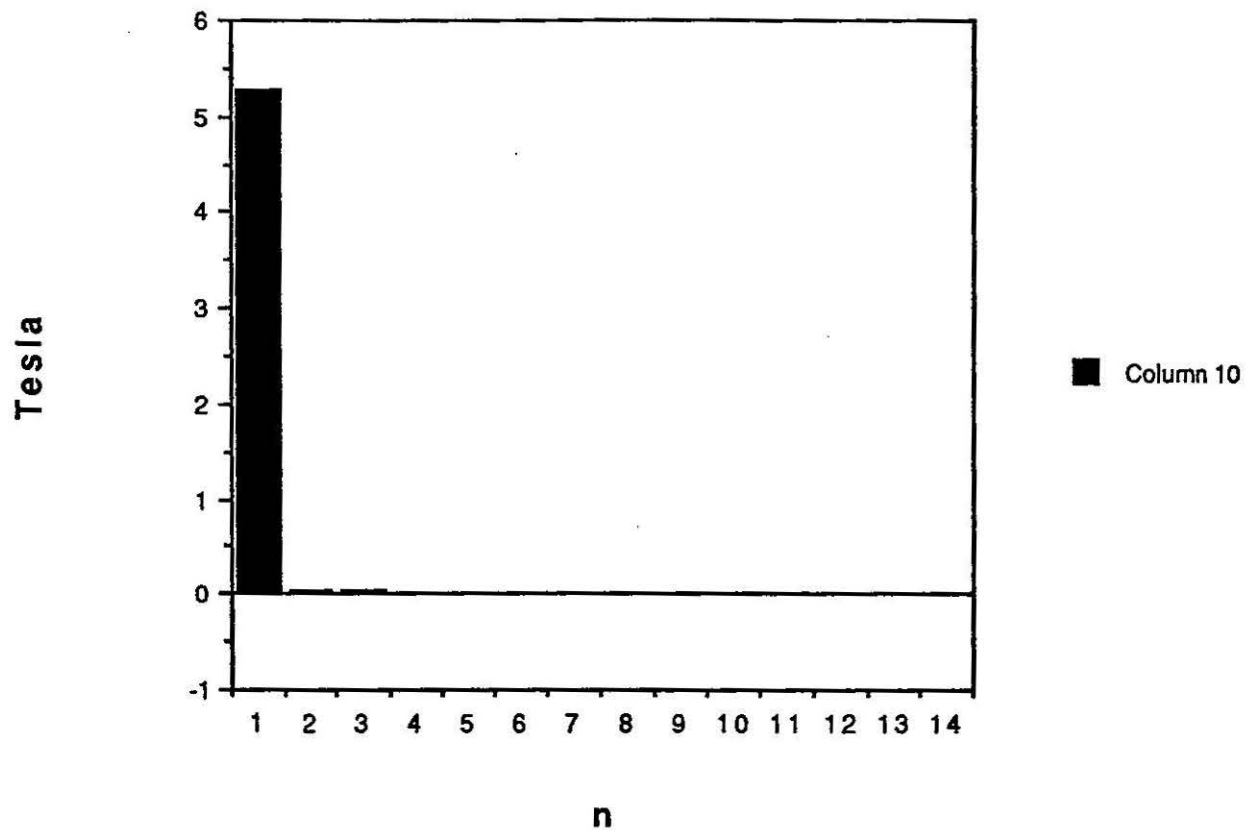
COS	SIN	AMPL	DO	D90	AMPL
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
5.25306	0.596046E-06	5.25306	5.24304	0.476837E-06	5.24304
0.197235E-01	0.133725E-01	0.238294E-01	0.377794E-01	-0.109490E-01	0.393341E-01
0.161534E-01	-0.211182E-02	0.162909E-01	-0.458580E-02	-0.145142E-02	0.481001E-02
0.123218E-01	-0.127377E-01	0.177221E-01	-0.330114E-01	0.281178E-01	0.433632E-01
0.703745E-02	-0.168294E-01	0.182415E-01	0.178645E-02	-0.227465E-02	0.289231E-02
-0.526029E-02	-0.113671E-01	0.125252E-01	-0.423460E-02	-0.363354E-01	0.365813E-01
-0.707228E-02	-0.116658E-01	0.136422E-01	-0.487677E-01	-0.862736E-01	0.991031E-01
-0.120638E-01	-0.427639E-02	0.127993E-01	0.163010E-02	0.159312E-01	0.160143E-01
-0.132595E-01	0.522219E-02	0.142508E-01	-0.467571E-03	0.190412E-02	0.196068E-02
-0.822091E-02	0.740853E-02	0.110666E-01	-0.208464E-01	0.688532E-02	0.219541E-01
-0.340245E-02	0.116892E-01	0.121743E-01	0.152150E-04	0.149917E-01	0.149917E-01
0.464640E-02	0.936902E-02	0.104579E-01	0.127509E-01	-0.328323E-01	0.352214E-01
0.540050E-02	0.100443E-01	0.114041E-01	-0.977215E-02	0.658763E-01	0.665971E-01
0.345610E-02	0.263909E-01	0.266163E-01	-0.157096E-01	-0.261211E-01	0.304812E-01

CHANNEL 4 --> REFERENCE CHANNEL

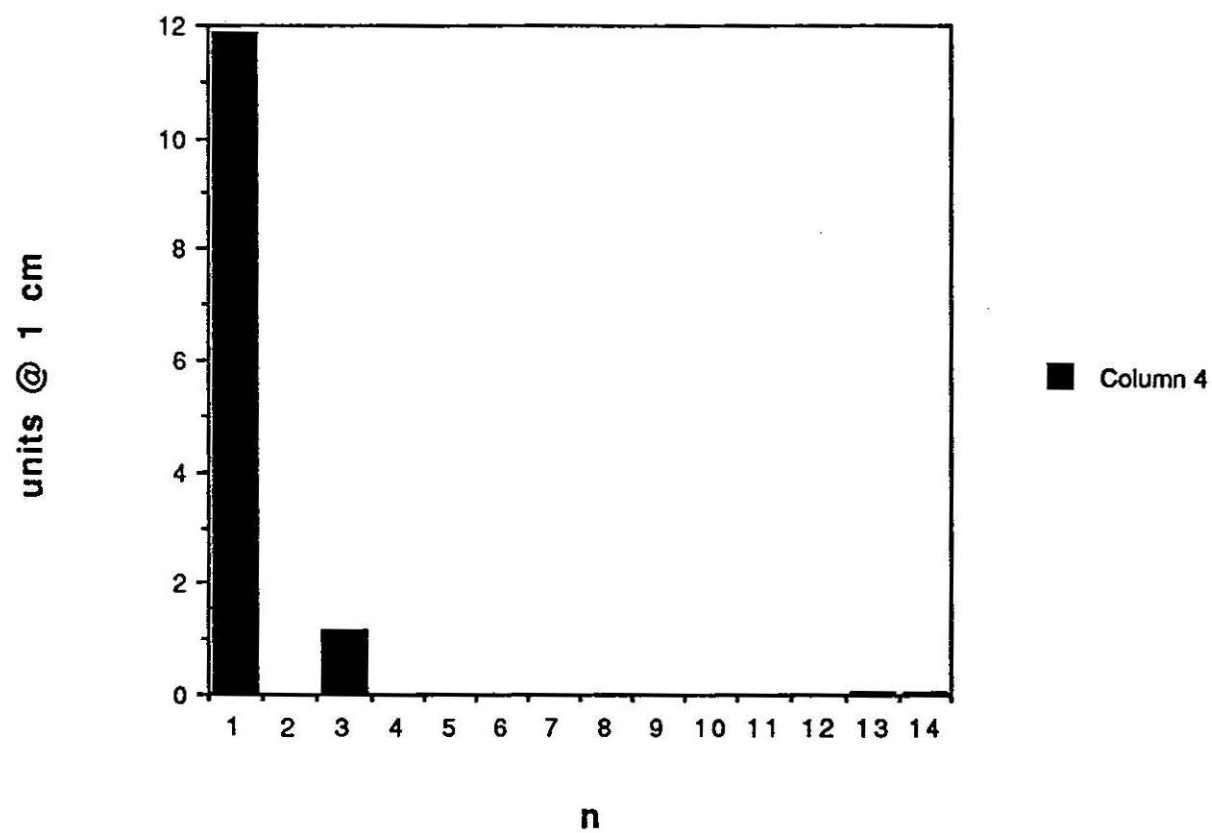
Wed Feb 20 17:12:48 1991

FILE	CURRENT	ZPOS	SEXTUPOLE		DECAPOLE		DIPOLE	
			NORMAL	SKEW	NORMAL	SKEW	NORMAL	SKEW
DS0315.d001	: 5052.10	41.50	1.078	-0.343	-0.770	-0.086	5.252	0.000
DS0315.d003	: 5052.10	41.50	1.112	-0.333	-0.773	-0.095	5.248	0.000
DS0315.d005	: 5052.10	61.50	3.039	-1.727	0.783	-0.129	3.574	0.000
DS0315.d006	: 5052.10	61.50	2.966	-1.545	0.794	-0.121	3.579	0.000
DS0315.d007	: 5052.10	59.50	-1.329	-1.790	-0.192	-0.272	4.133	0.000
DS0315.d008	: 5052.10	59.50	-1.267	-2.110	-0.216	-0.302	4.109	0.000
DS0315.d009	: 5048.00	57.50	-0.991	-2.296	-0.825	-0.432	4.702	0.000
DS0315.d010	: 5048.00	57.50	-1.028	-2.073	-0.827	-0.438	4.641	0.000
DS0315.d011	: 5048.00	55.50	-0.476	-0.896	-0.967	-0.377	5.022	0.000
DS0315.d012	: 5048.00	55.50	-0.492	-0.832	-0.972	-0.374	5.017	0.000
DS0315.d013	: 5048.00	53.50	1.437	-0.272	-0.883	-0.363	5.182	0.000
DS0315.d014	: 5048.00	53.50	1.713	-0.280	-0.889	-0.318	5.155	0.000
DS0315.d015	: 5048.00	51.50	1.452	-0.549	-0.890	-0.159	5.217	0.000
DS0315.d016	: 5048.00	51.50	1.382	-0.430	-0.884	-0.150	5.220	0.000
DS0315.d017	: 5048.00	49.50	0.876	-0.378	-0.822	-0.125	5.261	0.000
DS0315.d018	: 5048.00	49.50	0.881	-0.561	-0.856	-0.135	5.228	0.000
DS0315.d022	: 5048.00	47.50	0.927	-0.530	-0.786	-0.119	5.237	0.000
DS0315.d023	: 5048.00	47.50	0.935	-0.555	-0.792	-0.119	5.236	0.000
DS0315.d024	: 5051.00	45.50	1.082	-0.458	-0.830	-0.124	5.240	0.000
DS0315.d025	: 5051.00	45.50	1.089	-0.447	-0.821	-0.118	5.238	0.000
DS0315.d026	: 5051.00	43.50	1.066	-0.397	-0.784	-0.083	5.239	0.000
DS0315.d027	: 5051.00	43.50	1.090	-0.404	-0.789	-0.083	5.241	0.000
DS0315.d028	: 5050.00	41.50	1.418	-0.383	-0.701	-0.043	5.219	0.000
DS0315.d029	: 5050.00	41.50	1.273	-0.314	-0.766	-0.089	5.240	0.000
DS0315.d030	: 5051.00	39.50	1.338	-0.306	-0.817	-0.073	5.246	0.000
DS0315.d034	: 5051.00	39.50	1.319	-0.281	-0.824	-0.065	5.238	0.000
DS0315.d035	: 5048.00	37.50	1.118	-0.322	-0.766	-0.077	5.240	0.000
DS0315.d036	: 5048.00	37.50	1.106	-0.333	-0.770	-0.074	5.239	0.000
DS0315.d037	: 5048.00	35.50	1.078	-0.405	-0.743	-0.075	5.253	0.000
DS0315.d038	: 5048.00	35.50	1.098	-0.400	-0.753	-0.087	5.238	0.000
DS0315.d039	: 5048.00	33.50	1.036	-0.485	-0.813	-0.090	5.237	0.000
DS0315.d040	: 5048.00	33.50	1.075	-0.485	-0.809	-0.082	5.235	0.000
DS0315.d041	: 5048.00	31.50	1.334	-0.478	-0.838	-0.064	5.226	0.000
DS0315.d042	: 5048.00	31.50	1.381	-0.466	-0.844	-0.061	5.225	0.000
DS0315.d043	: 5048.00	29.50	1.735	-0.536	-0.856	-0.101	5.186	0.000
DS0315.d044	: 5048.00	29.50	1.764	-0.536	-0.855	-0.099	5.182	0.000
DS0315.d045	: 5048.00	27.50	1.304	-0.814	-0.928	0.071	5.110	0.000
DS0315.d046	: 5048.00	27.50	1.654	-0.826	-0.939	-0.105	5.089	0.000
DS0315.d047	: 5048.00	25.50	-1.057	-0.680	-0.319	-0.176	4.865	0.000
DS0315.d048	: 5048.00	25.50	-1.089	-0.677	-0.322	-0.170	4.868	0.000
DS0315.d049	: 5048.00	23.50	-9.407	-0.504	-1.395	-0.189	4.392	0.000
DS0315.d050	: 5048.00	23.50	-9.424	-0.506	-1.388	-0.176	4.395	0.000
DS0315.d051	: 5048.00	21.50	-12.207	-0.513	-1.403	-0.182	3.812	0.000
DS0315.d052	: 5048.00	21.50	-12.253	-0.491	-1.385	-0.186	3.817	0.000
DS0315.d053	: 5048.00	41.50	1.051	-0.315	-0.781	-0.058	5.240	0.000
DS0315.d054	: 5048.00	41.50	1.101	-0.057	-0.909	-0.037	5.211	0.000

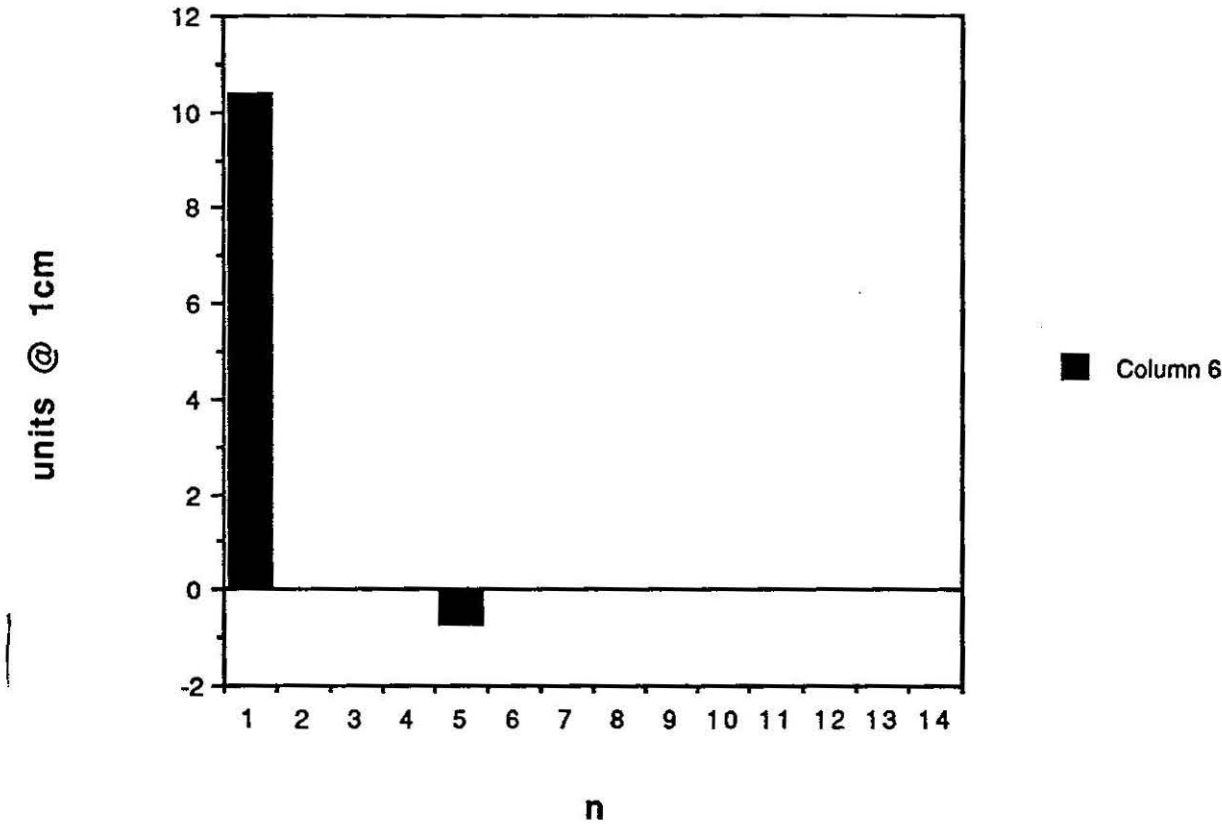
Normal Coefs from dipole winding from DS0315.u037



Normal Coefs from sextupole winding from DS0315.u037



Normal Coefs from decapole winding from DS0315.u037



DATA Summary

DS0311 - Single channel + reference
dipole } zscan
sextupole }

T6009 - measure 36-pole

DSA321 - 3 channels + reference
dipole }
sextupole } zscan
decapole }

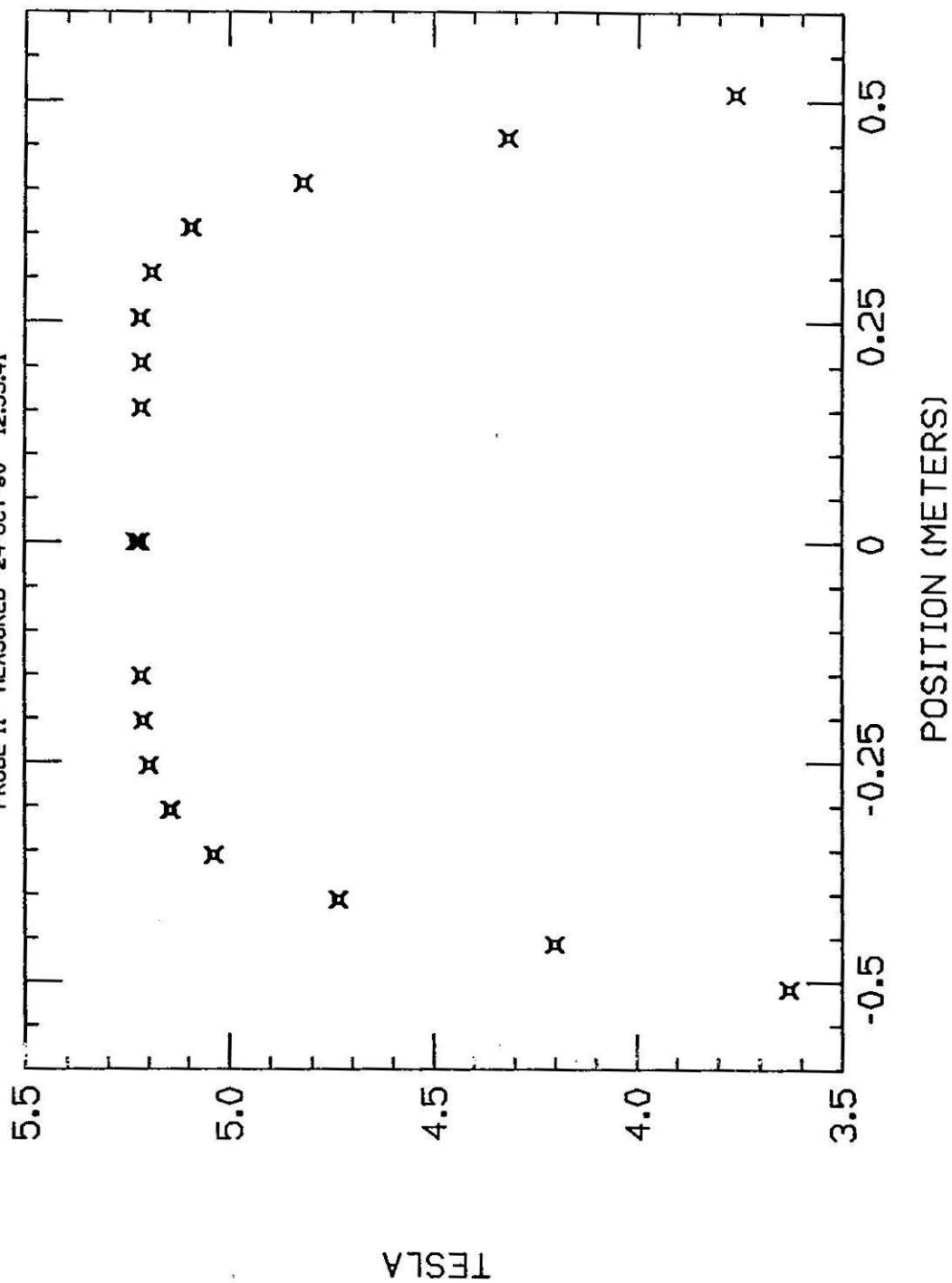
DS0315 - 3 channels + reference
dipole }
sextupole } zscan
decapole }

DS0311 Zscan:

- standard pre-ramp cycle
- hold magnet at fixed current (5000 amps)
- measure harmonics vs. z-position
dipole and sextupole windings

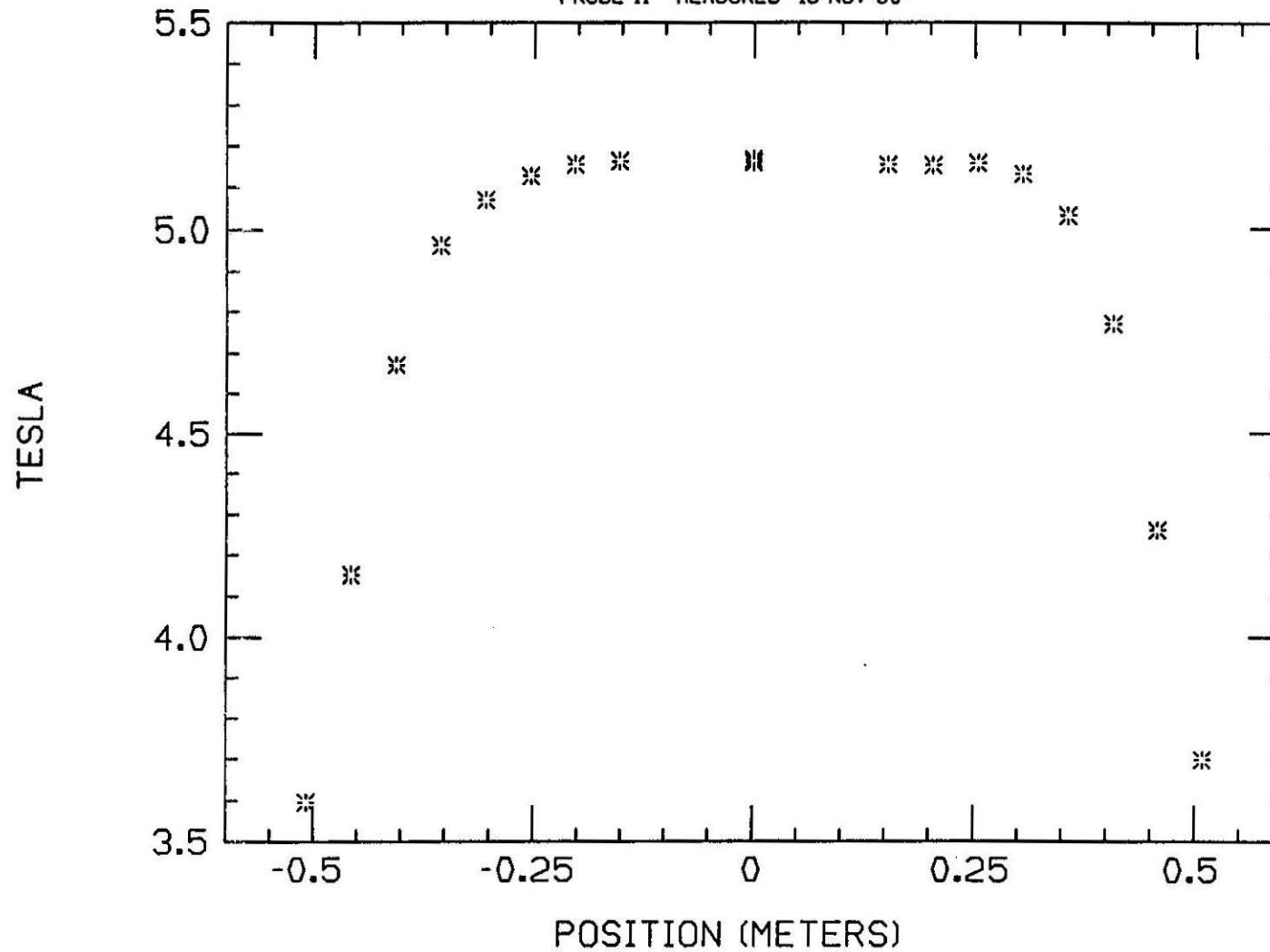
DIPOLE DS0311.EA001

PROBE 11 MEASURED 24-OCT-90 12:55:41



DIPOLE DS0311 HAL2

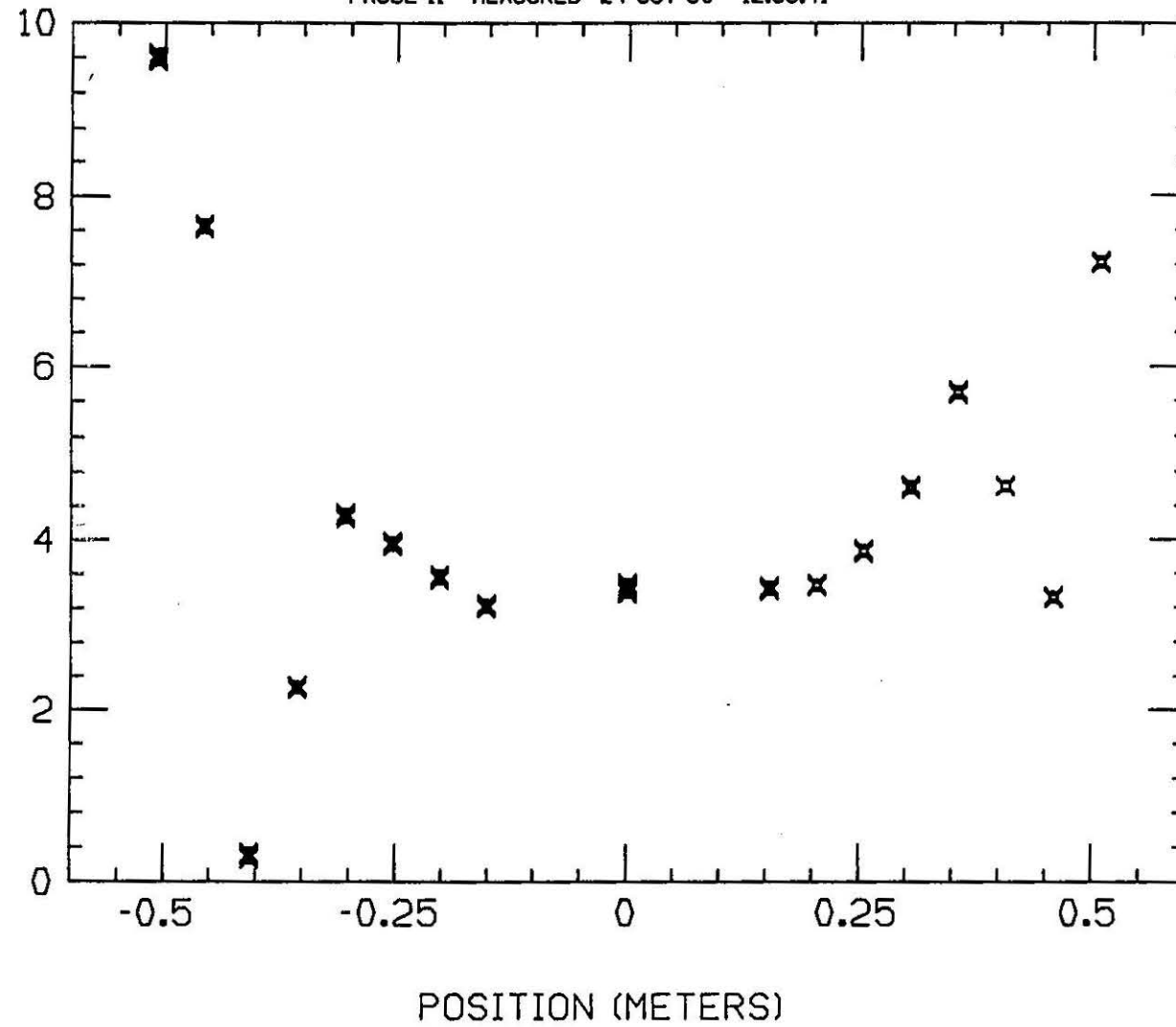
PROBE 11 MEASURED 13-NOV-90



SEXTUPOLE AMPLITUDE DS0311.EA001

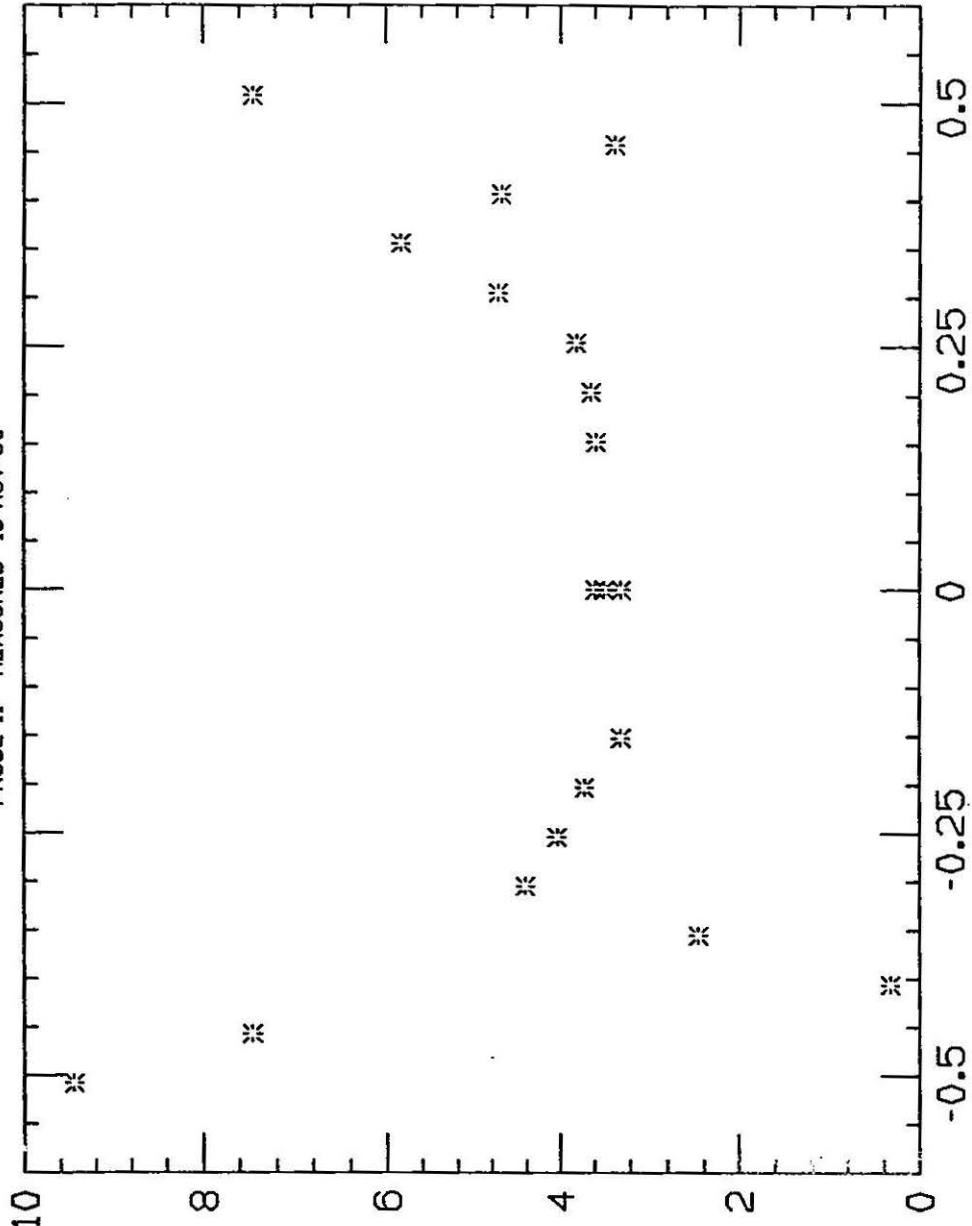
PROBE 11 MEASURED 24-OCT-90 12:55:41

UNITS @ 1 CENTIMETER



SEXTUPOLE AMPLITUDE DS0311 HAL2

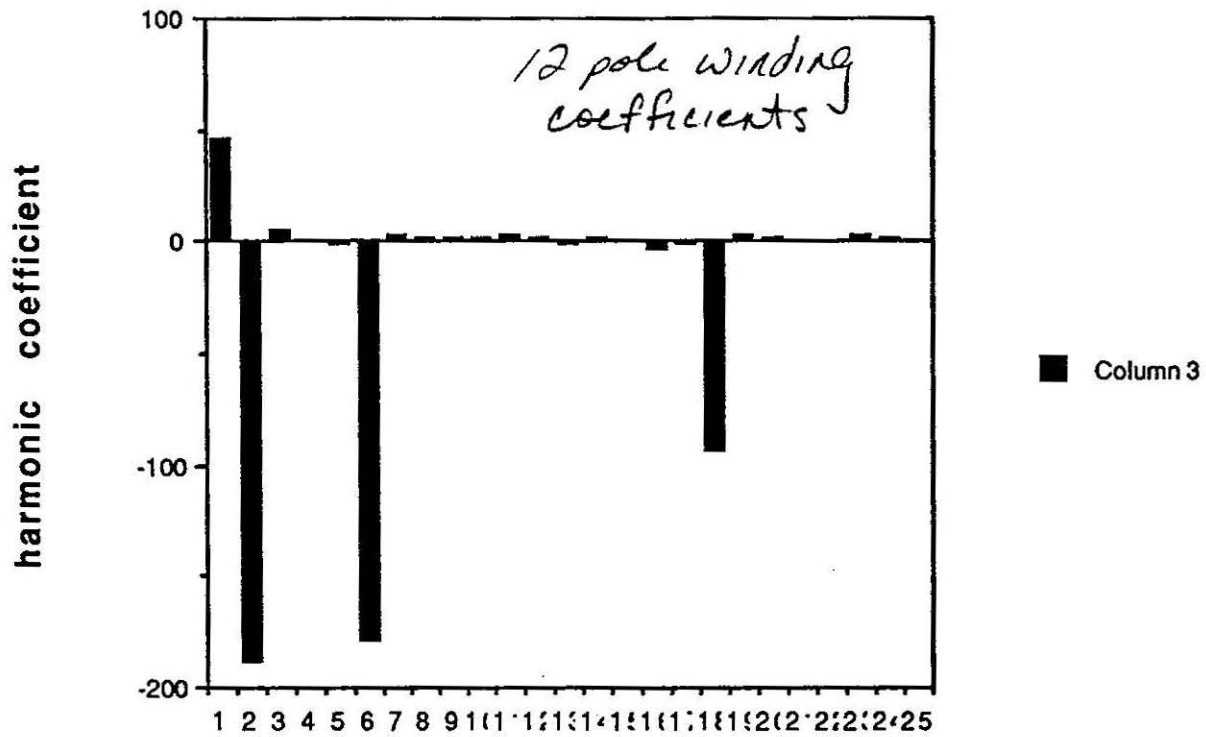
PROBE 11 MEASURED 13-NOV-90



UNITS @ 1 CENTIMETER

POSITION (METERS)

Data from T6009 at 5000 amps, Probe 9

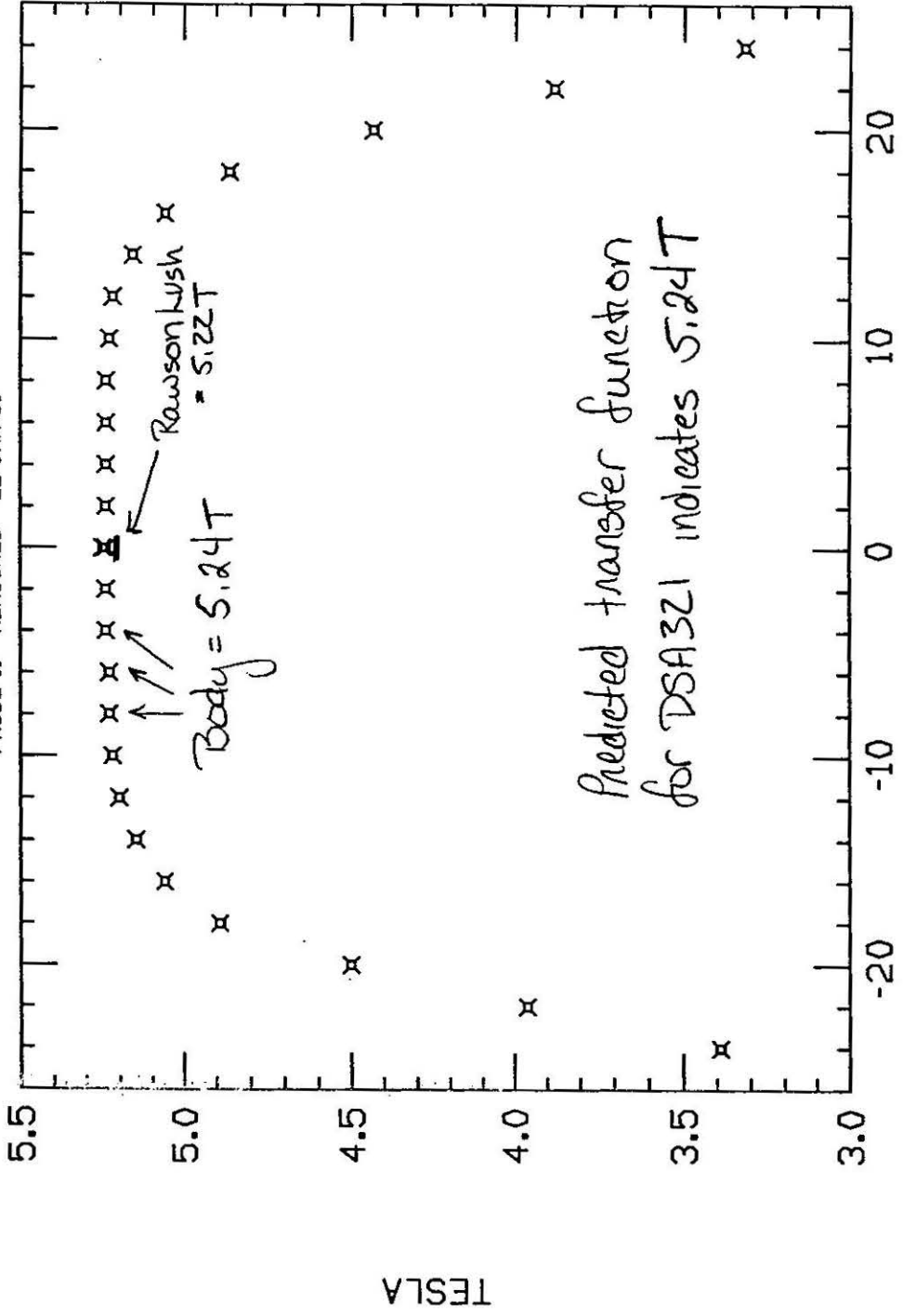


n -- 2=> quad, 6=> 12-pole, 18=> 36-pole

Quad = 37.08 kgauss/cm
 12 pole = 1.74 units
 36-pole = .558 units

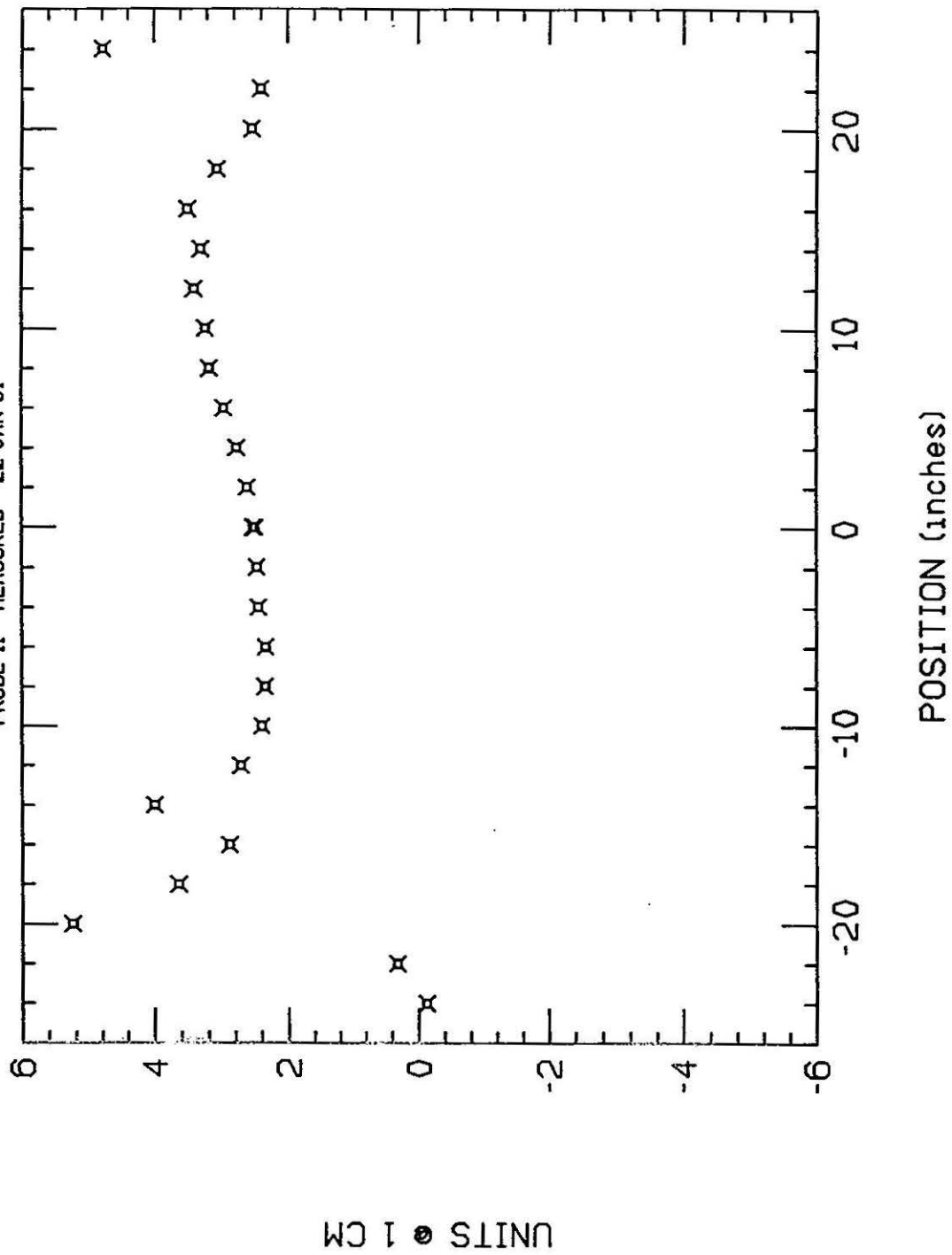
DSA321 / HAL 2 ZSCAN -- DIPOLE

PROBE 11 MEASURED 22-JAN-91



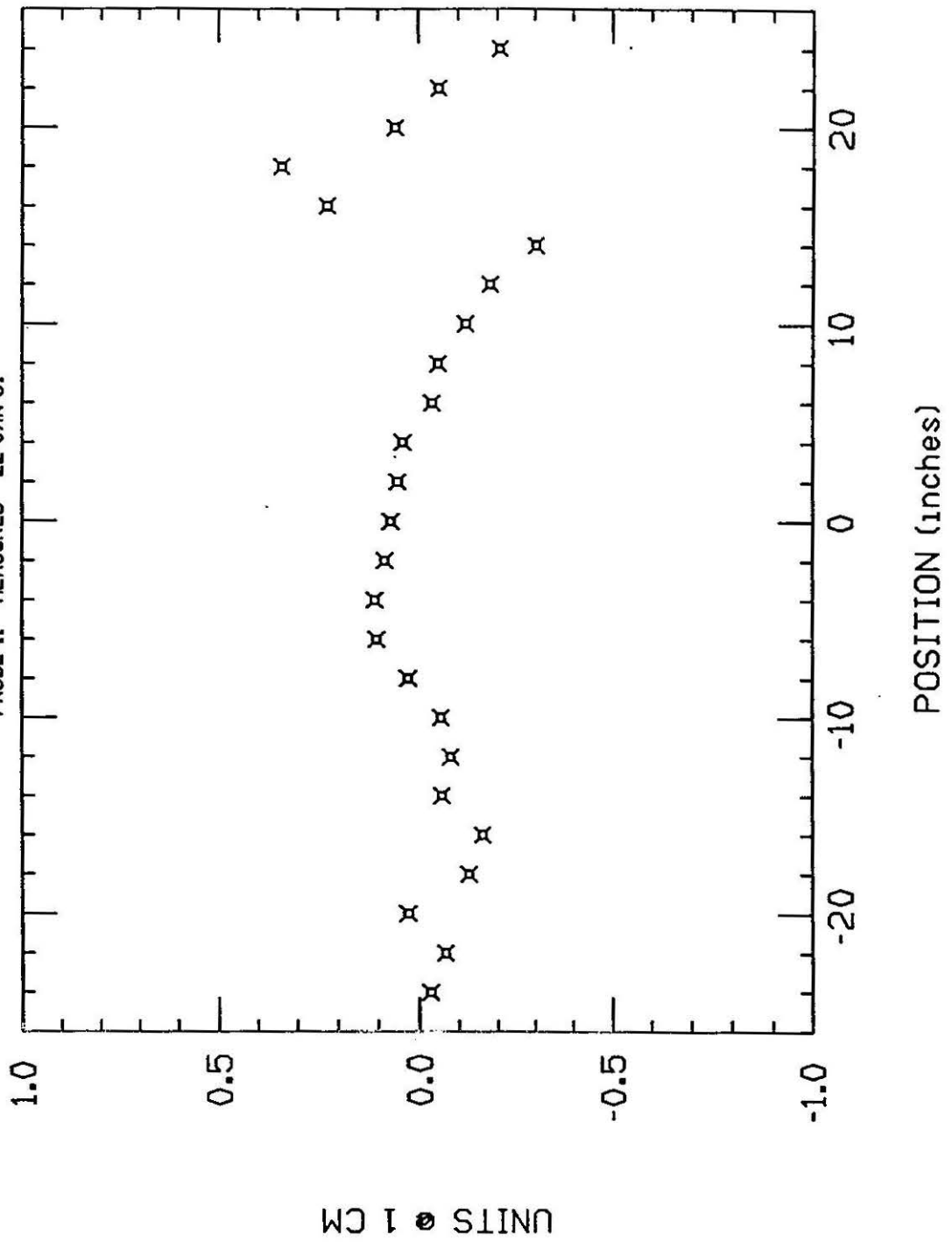
DSA321 / HAL 2 ZSCAN -- NORMAL SEXTUPOLE

PROBE 11 MEASURED 22-JAN-81



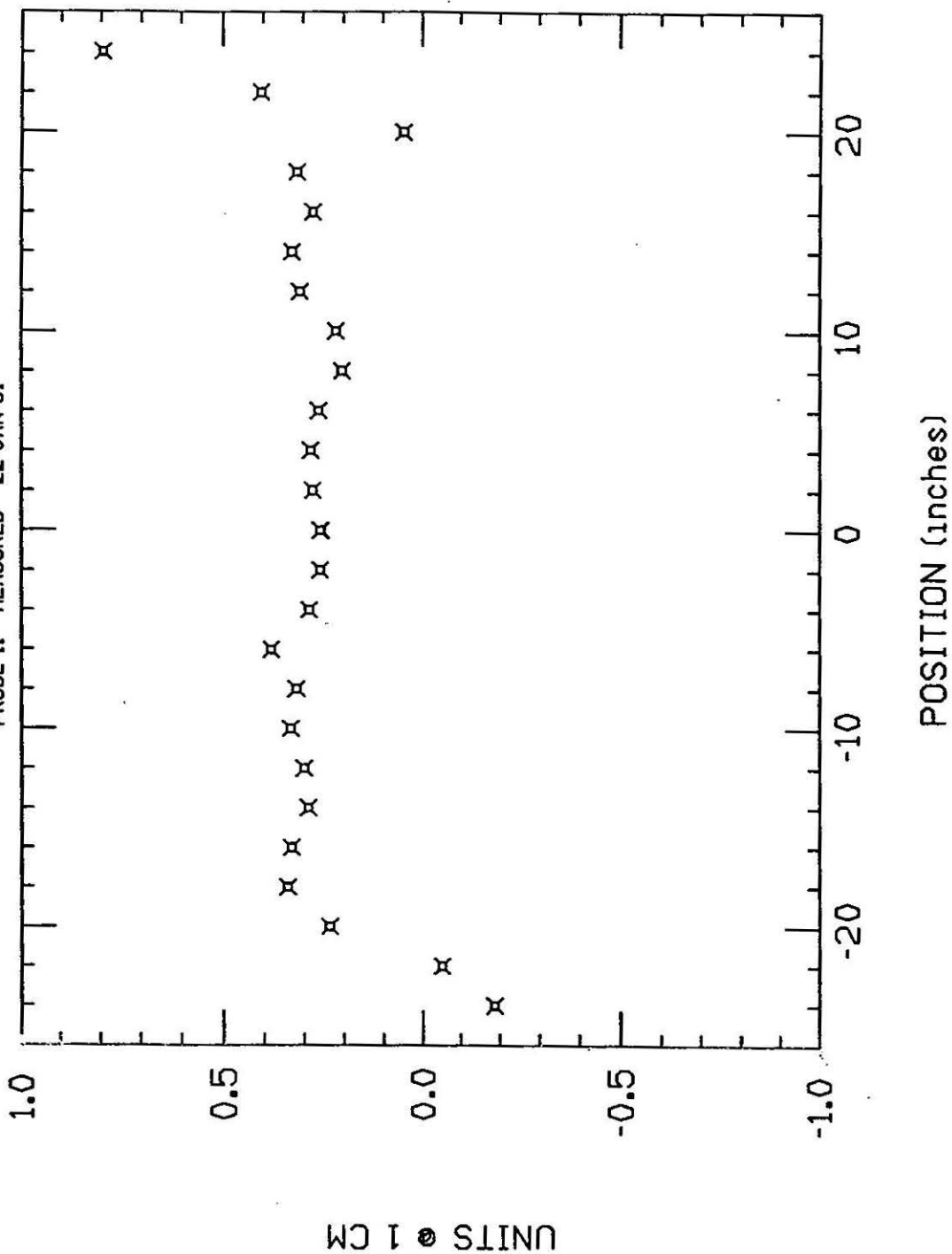
DSA321 / HAL 2 ZSCAN -- SKEW SEXTUPOLE

PROBE 11 MEASURED 22-JAN-91



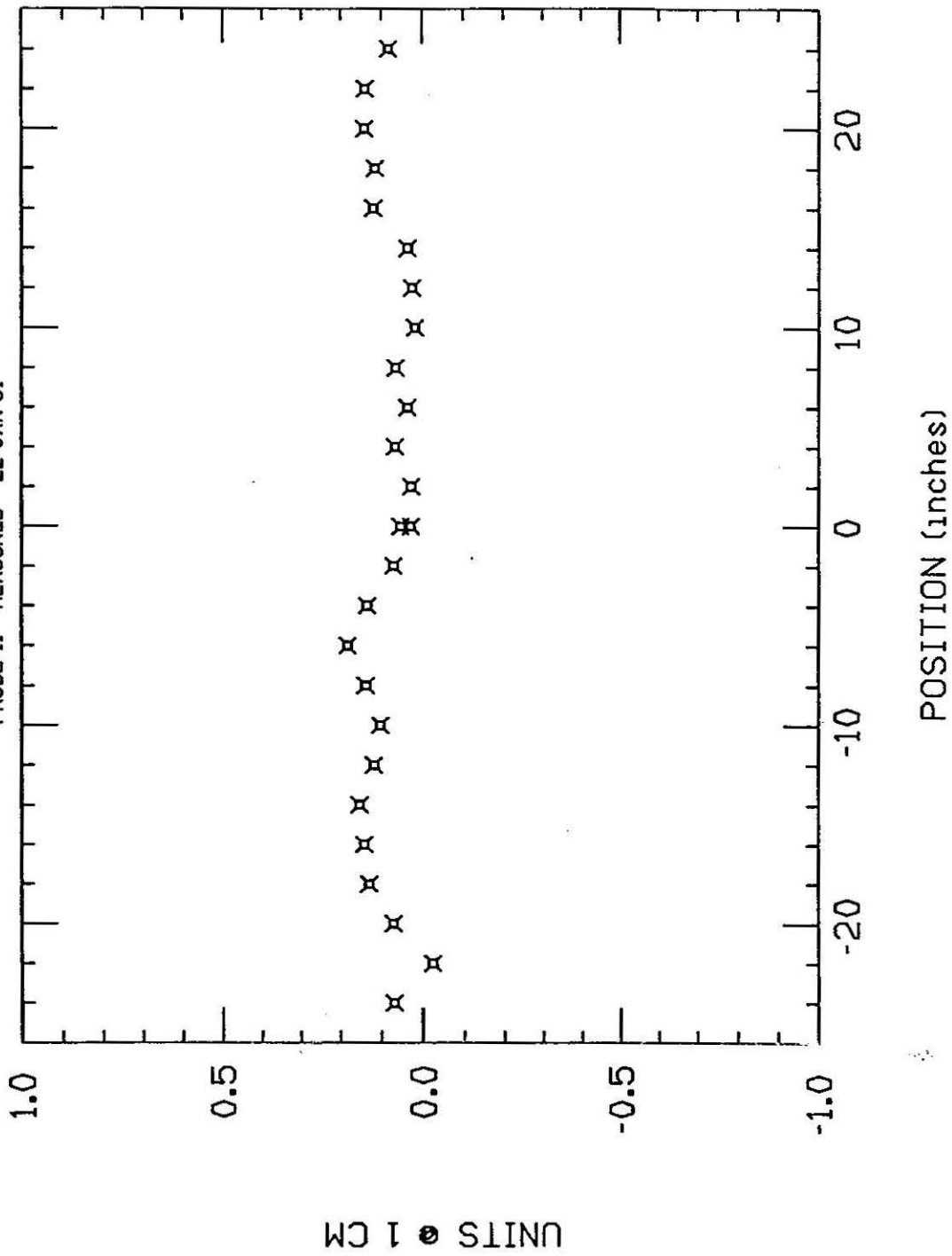
DSA321 / HAL 2 ZSCAN -- NORMAL DECAPOLE

PROBE 11 MEASURED 22-JAN-91



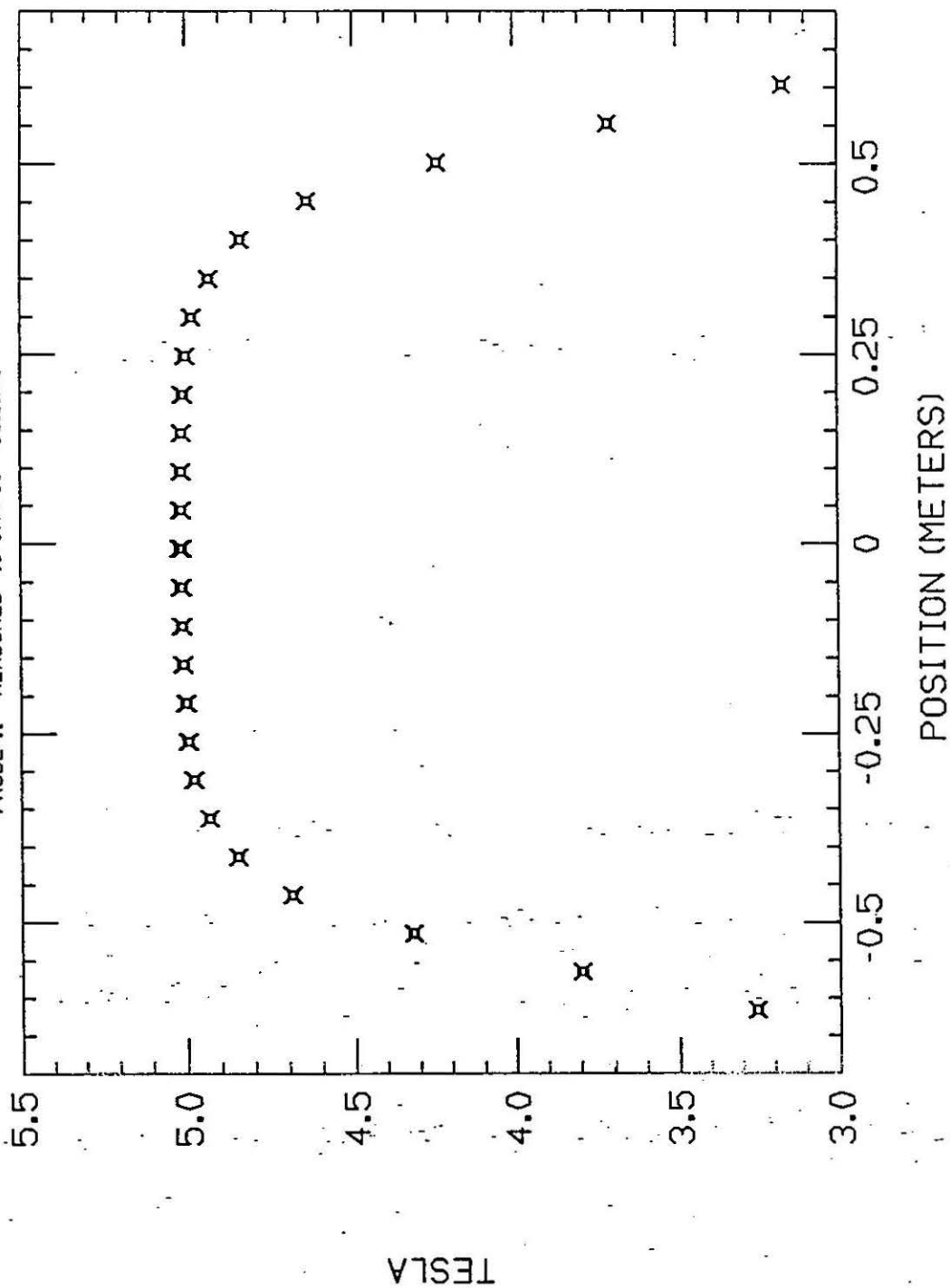
DSA321 / HAL 2 ZSCAN -- SKEW DECAPOLE

PROBE 11 MEASURED 22-JAN-81



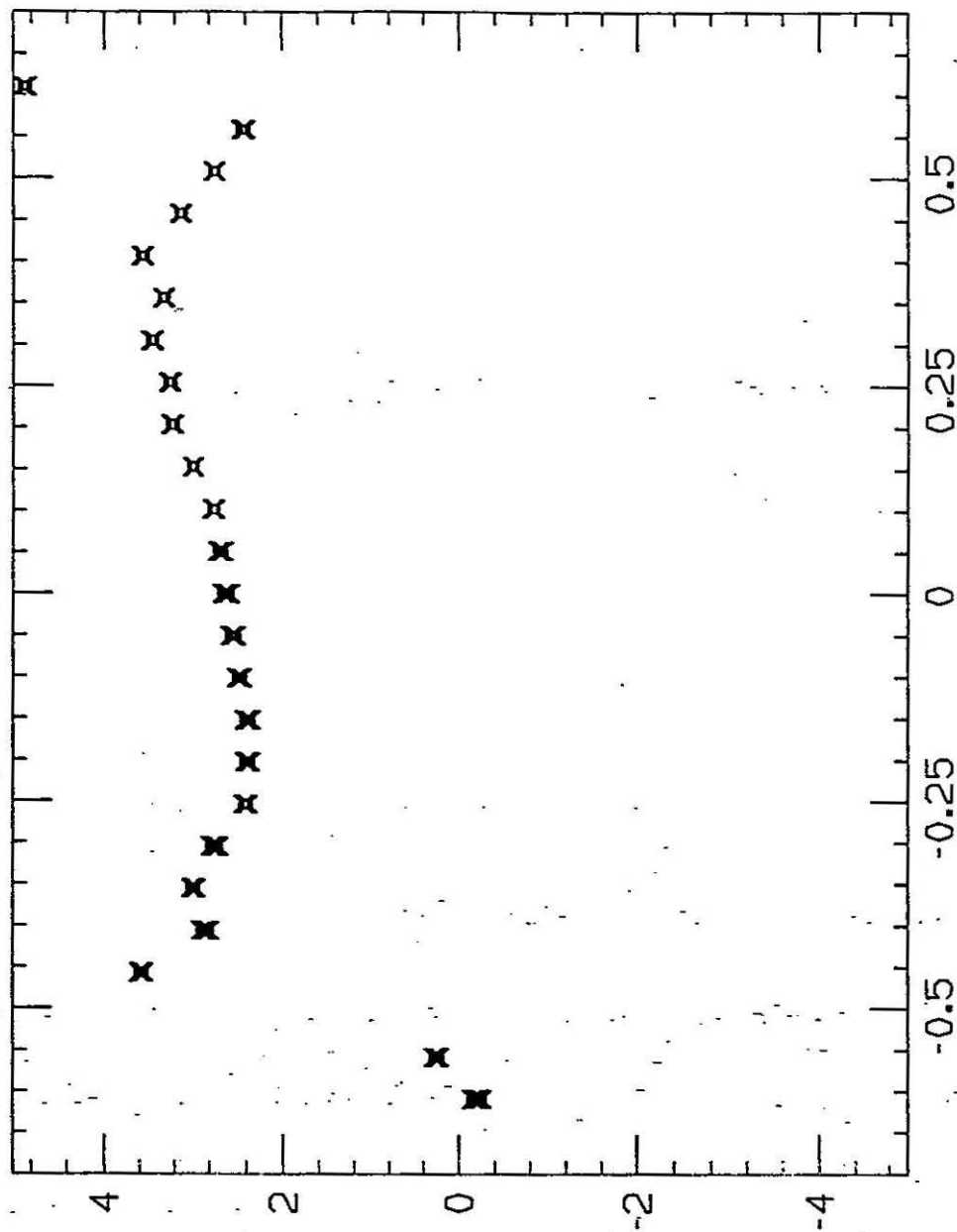
DIPOLE DSA321.EA002

PROBE II MEASURED 10-JAN-91 09:11:41



NORMAL SEXTUPOLE DSA321.EA002

PROBE II, MEASURED 10-JAN-91 09:11:41

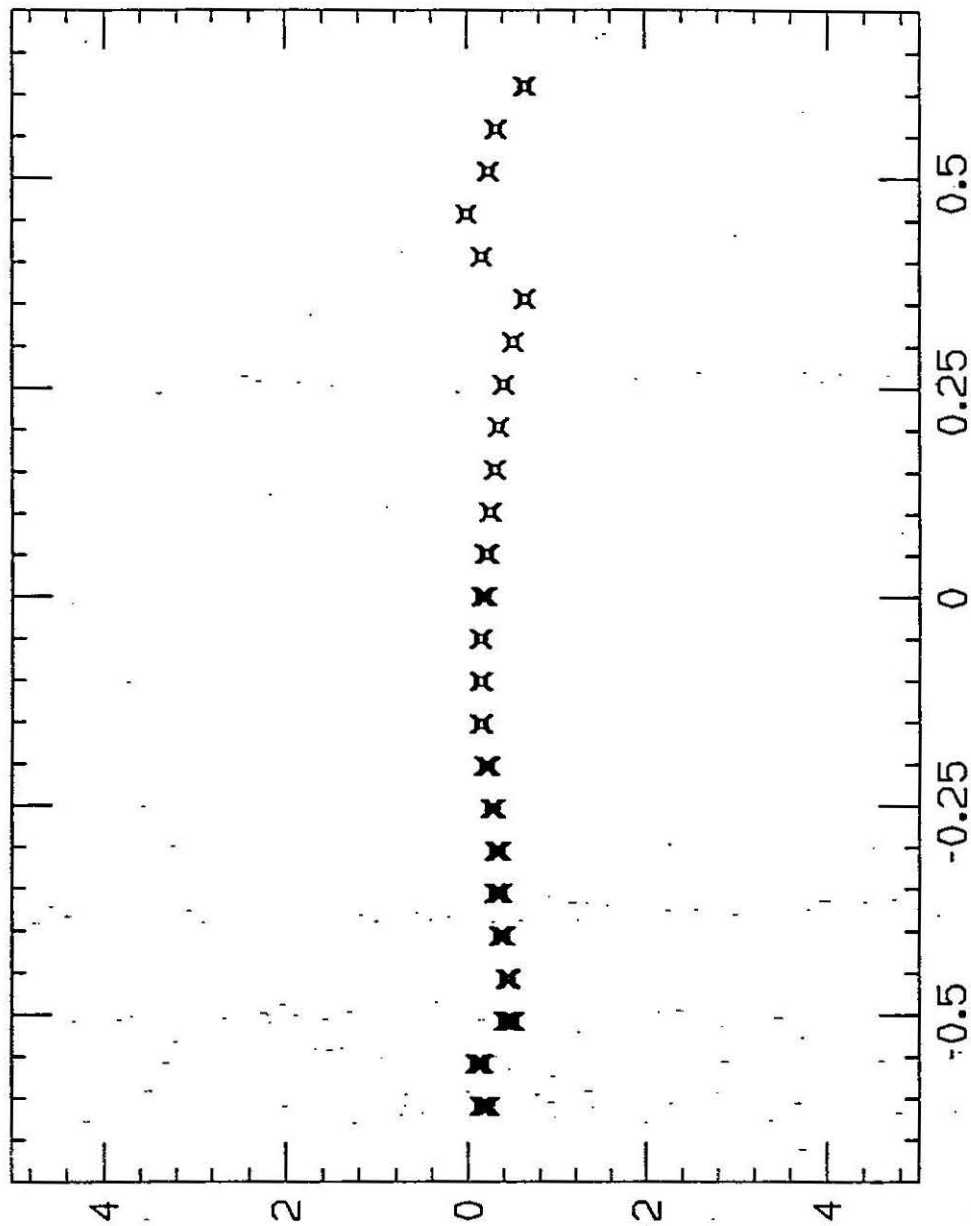


UNITS @ 1 CENTIMETER

POSITION (METERS)

SKREW SEXTUPOLE DSA321.EA0002

PROBE 11 MEASURED 10-JAN-91 09:11:41

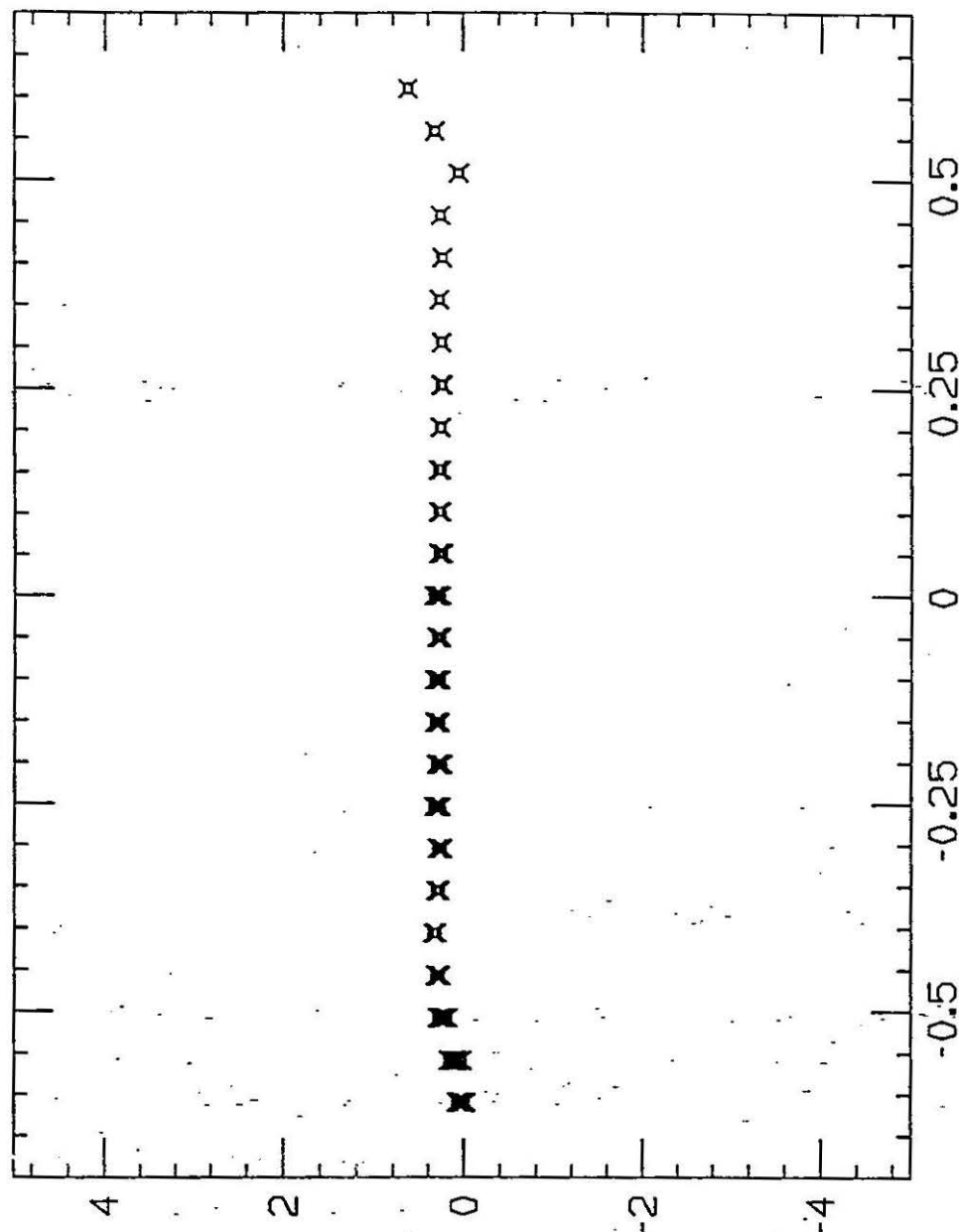


UNITS @ 1 CENTIMETER

POSITION (METERS)

NORMAL DECAPOLE DSA321.EA002

PROBE 11 MEASURED 10-JAN-91 09:11:41

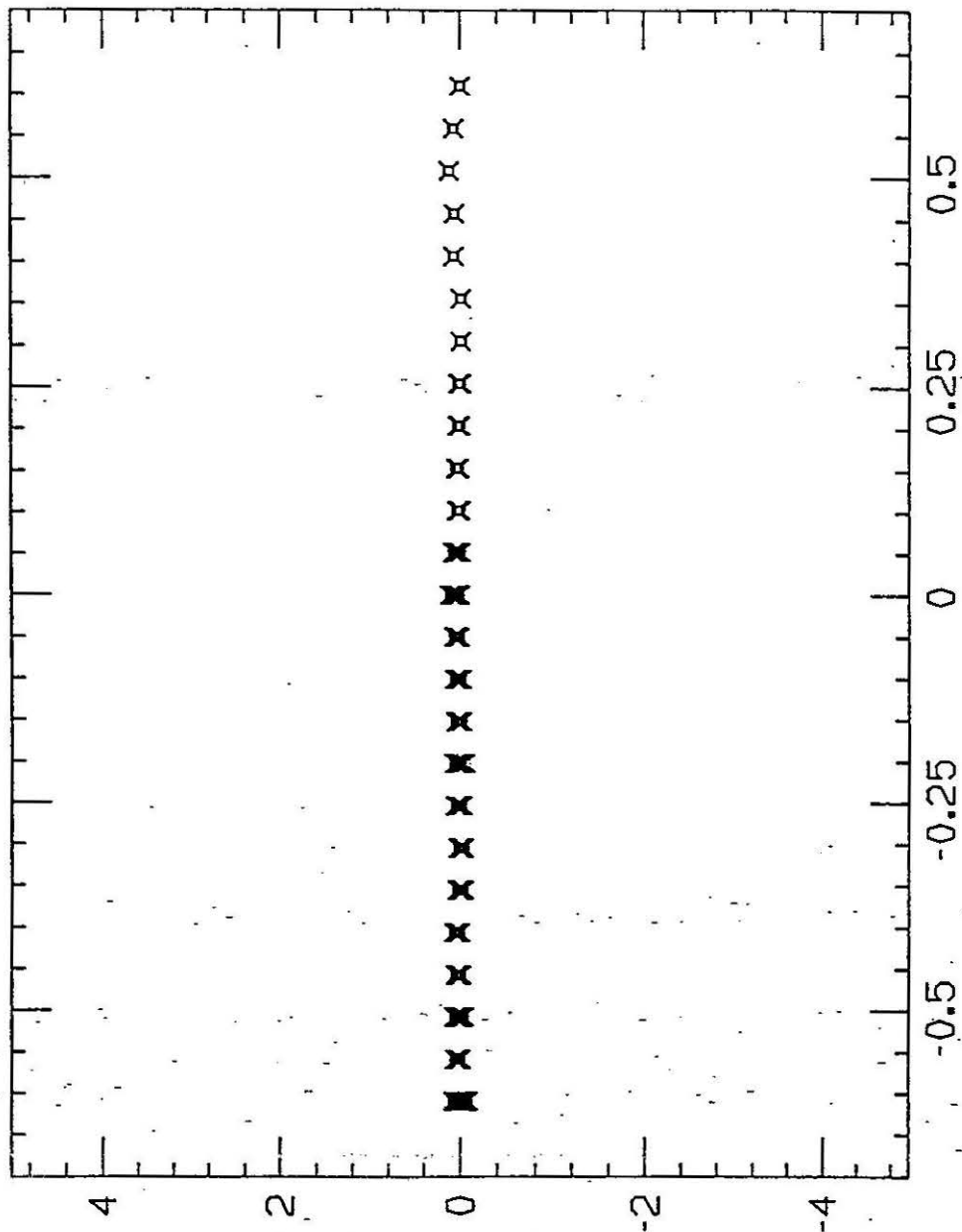


POSITION (METERS)

UNITS @ 1 CENTIMETER

SKEW DECAPOLE DSA321.EA002

PROBE 11 MEASURED 10-JAN-91 09:11:41

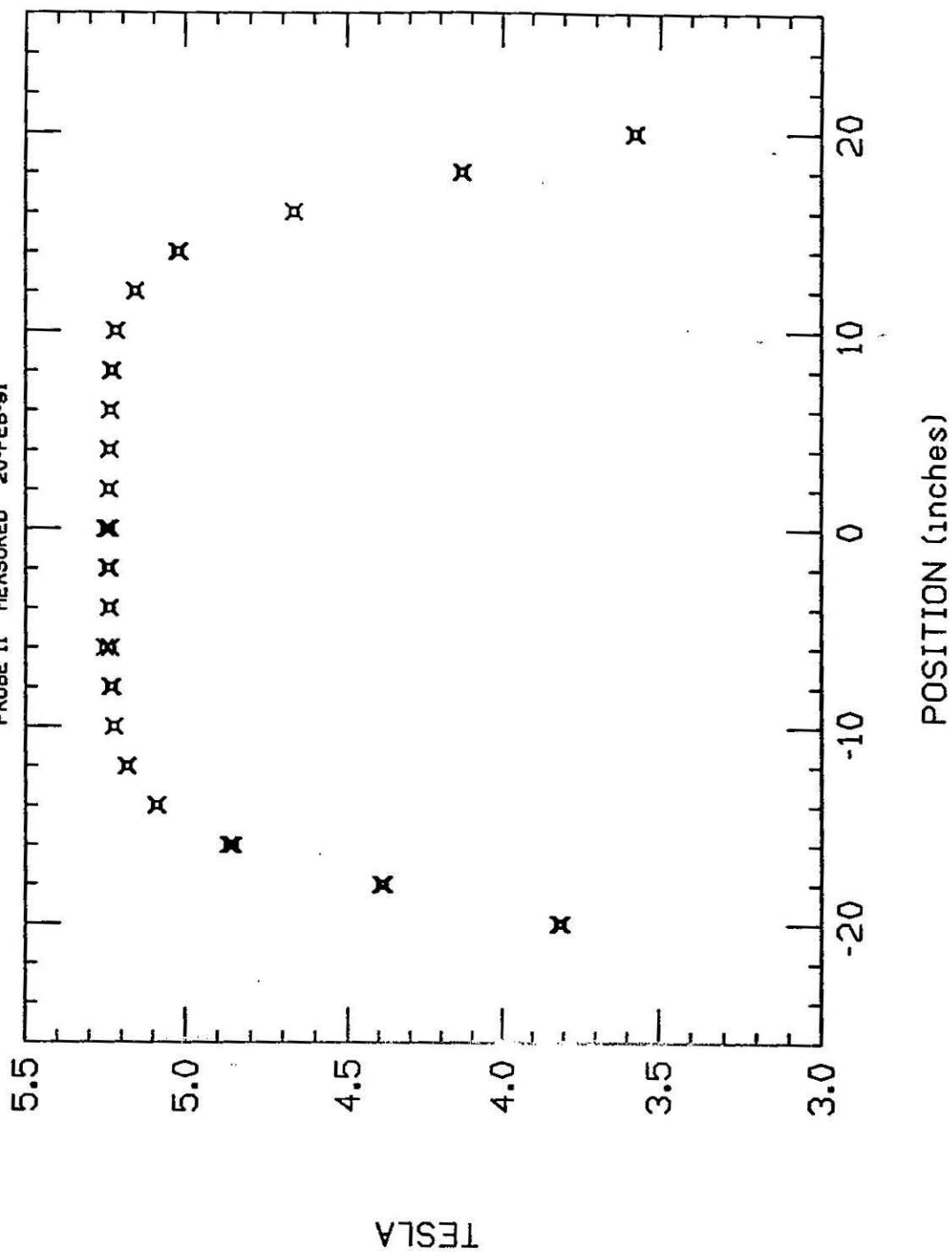


UNITS @ 1 CENTIMETER

POSITION (METERS)

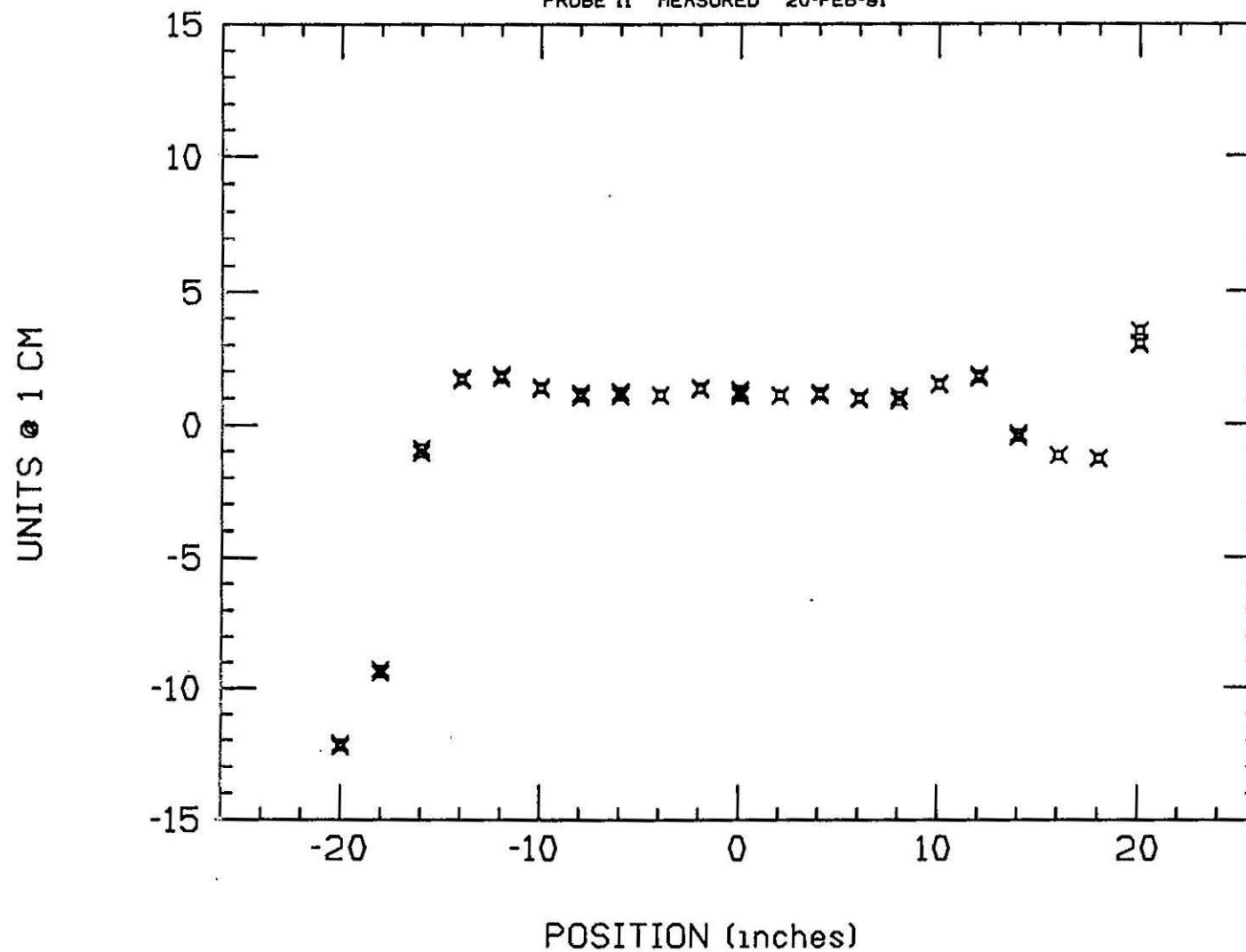
DS0315 / HAL 2 ZSCAN -- DIPOLE

PROBE 11 MEASURED 20-FEB-91



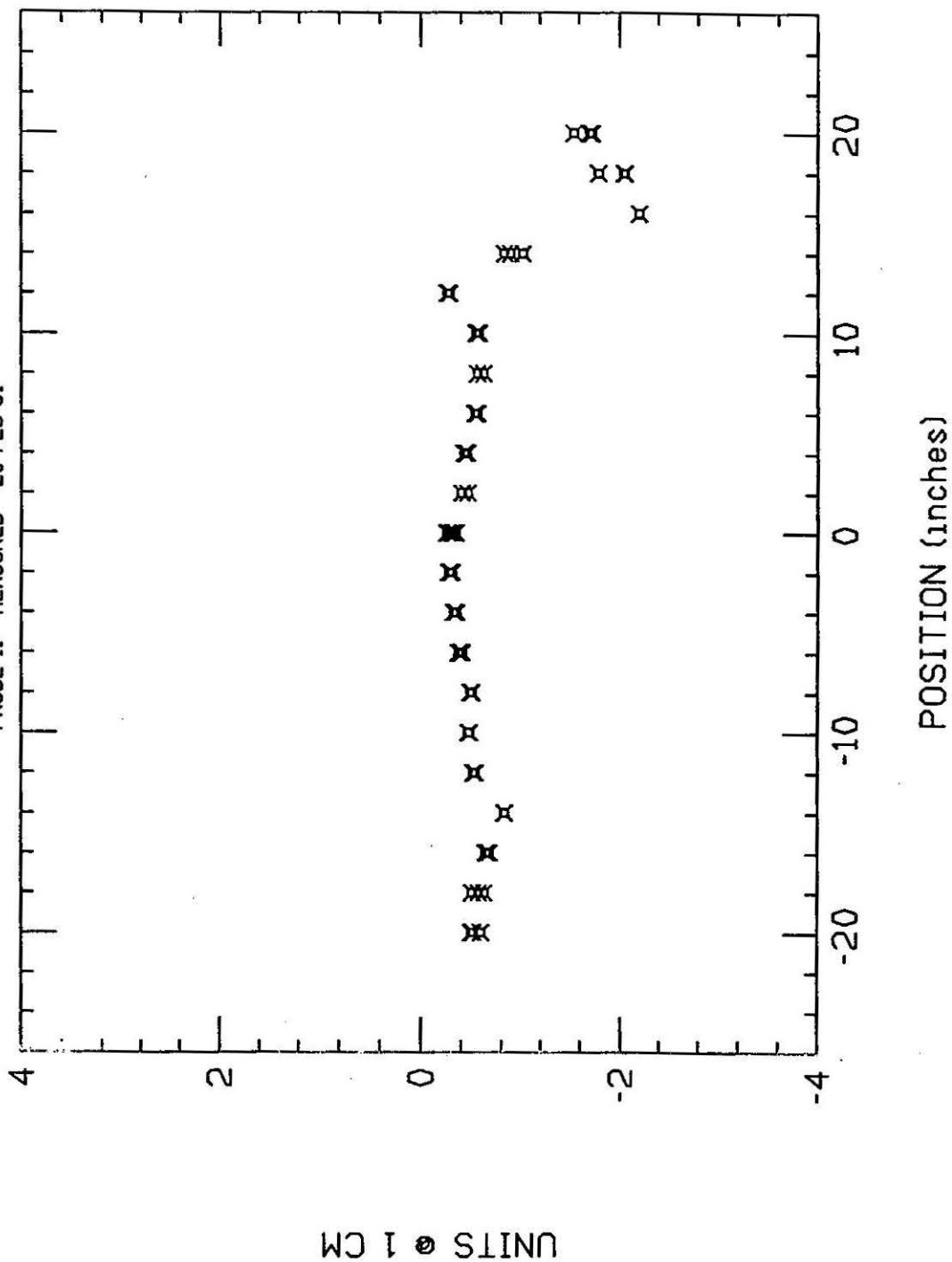
DS0315 / HAL 2 ZSCAN -- NORMAL SEXTUPOLE

PROBE 11 MEASURED 20-FEB-91



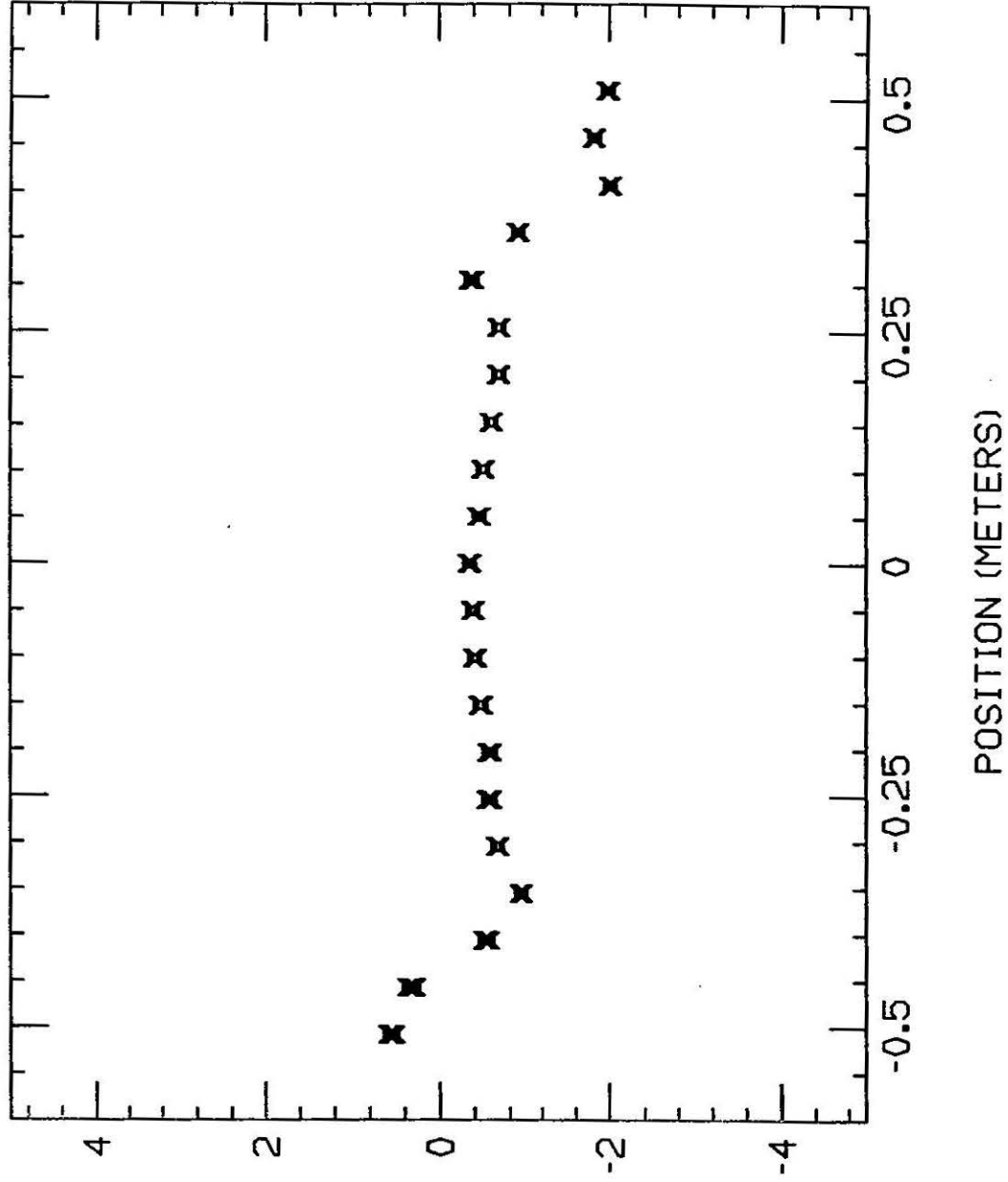
DS0315 / HAL 2 ZSCAN -- SKEW SEXTUPOLE

PROBE 11 MEASURED 20-FEB-91



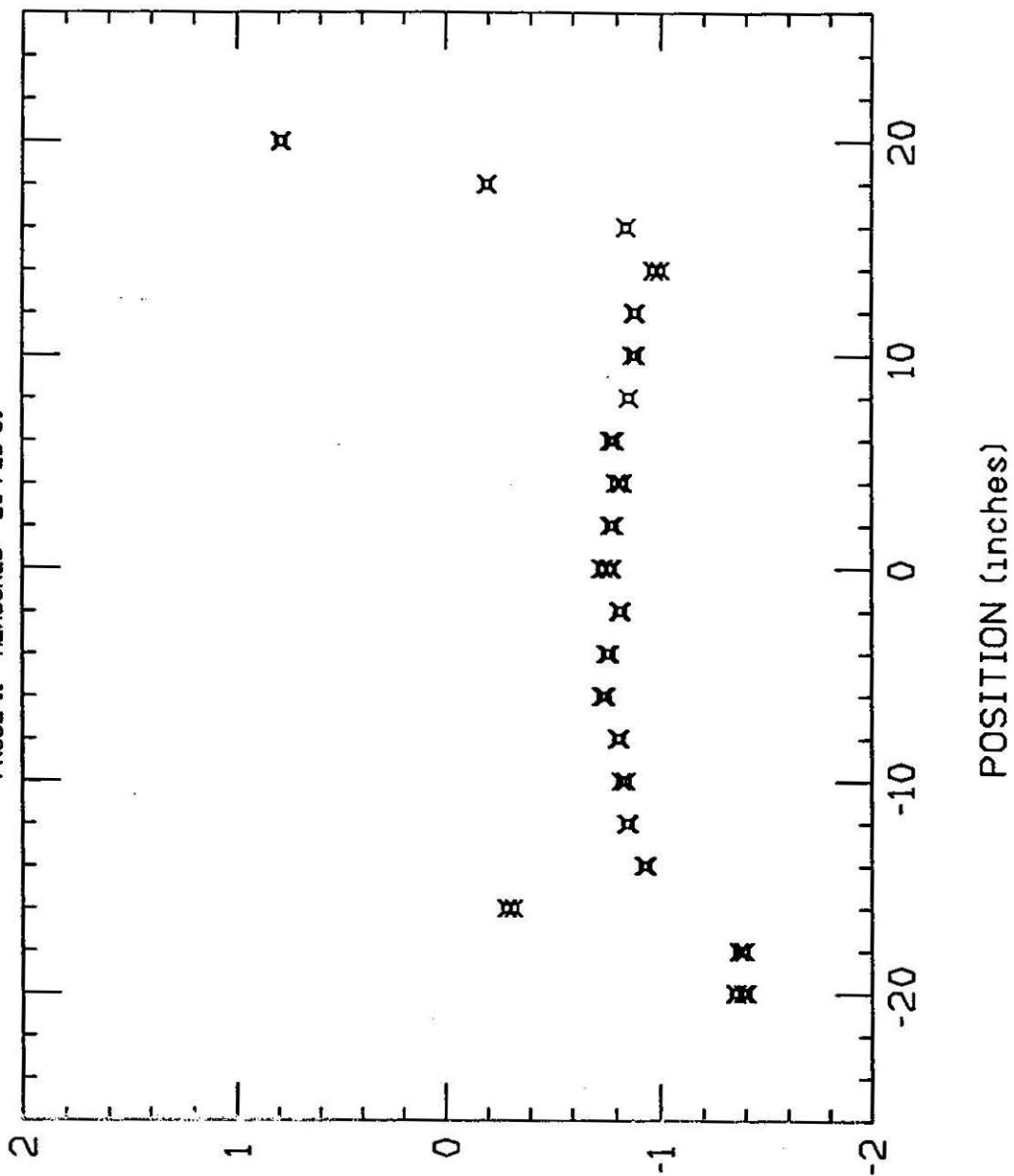
SKEW SEXTUPOLE DS0315.EA005

PROBE 11 MEASURED 20-FEB-91 14:35:48



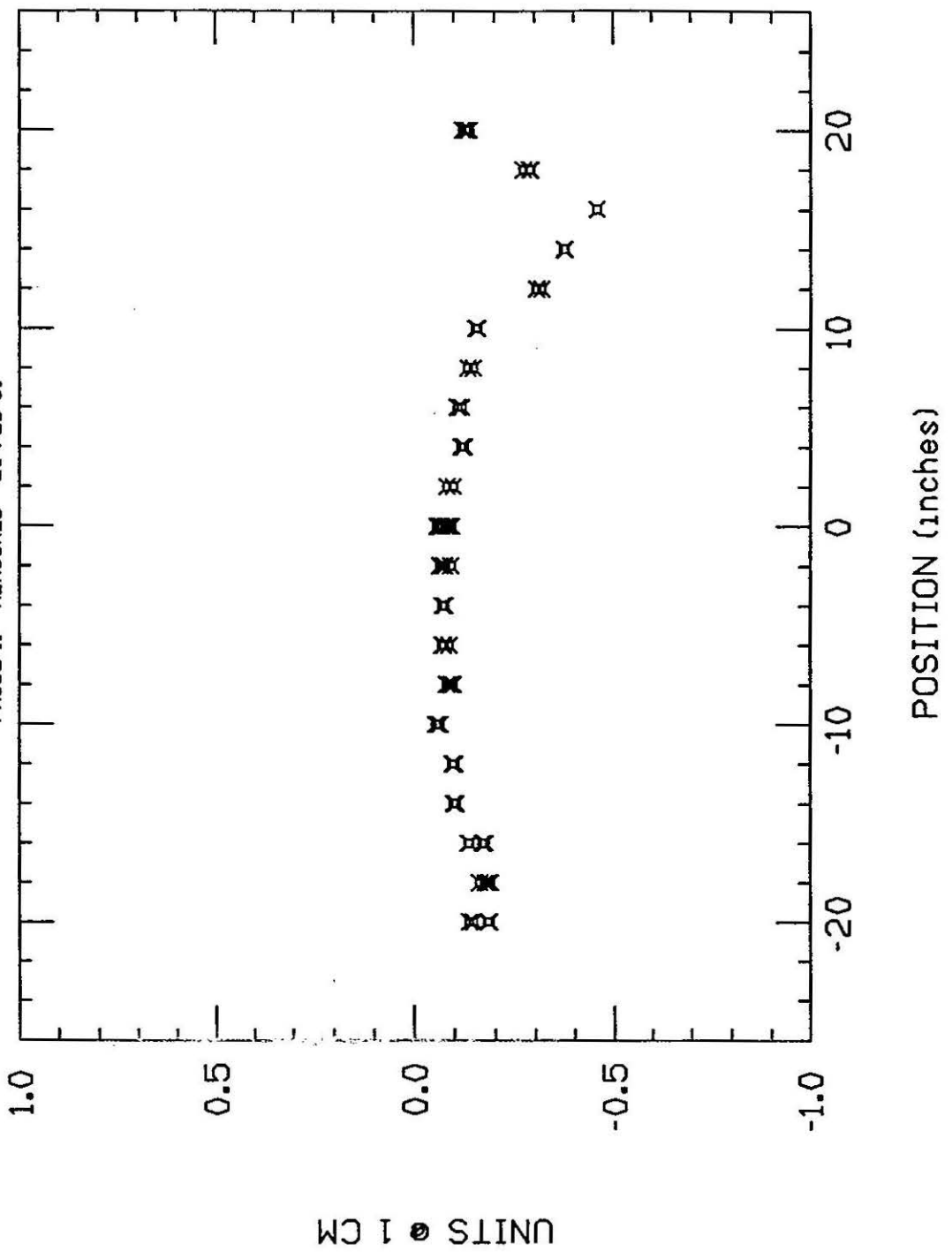
DS0315 / HAL 2 ZSCAN -- NORMAL DECAPOLE

PROBE 11 MEASURED 20-FEB-81



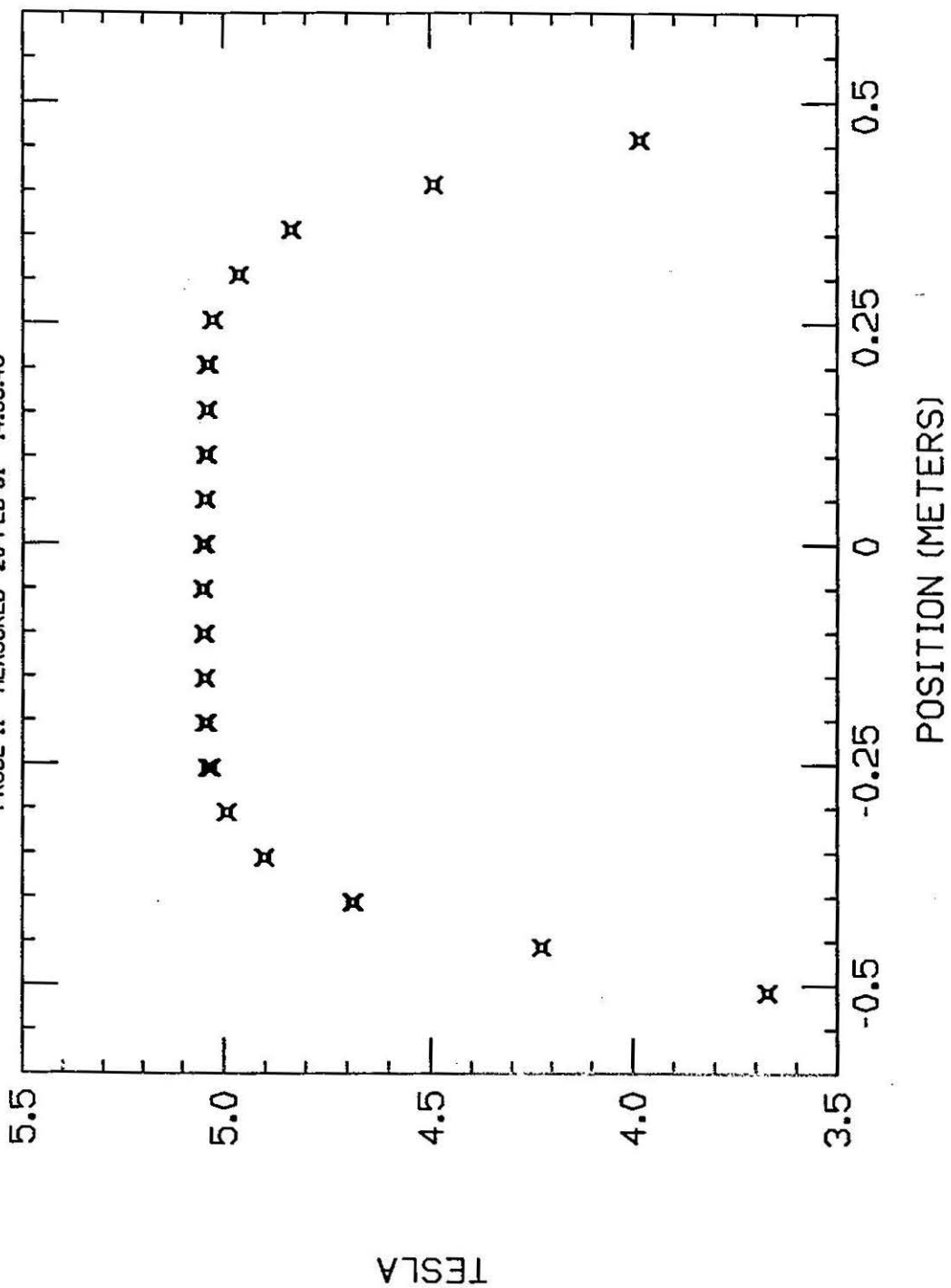
DS0315 / HAL 2 ZSCAN -- SKEW DECAPOLE

PROBE 11 MEASURED 20-FEB-81



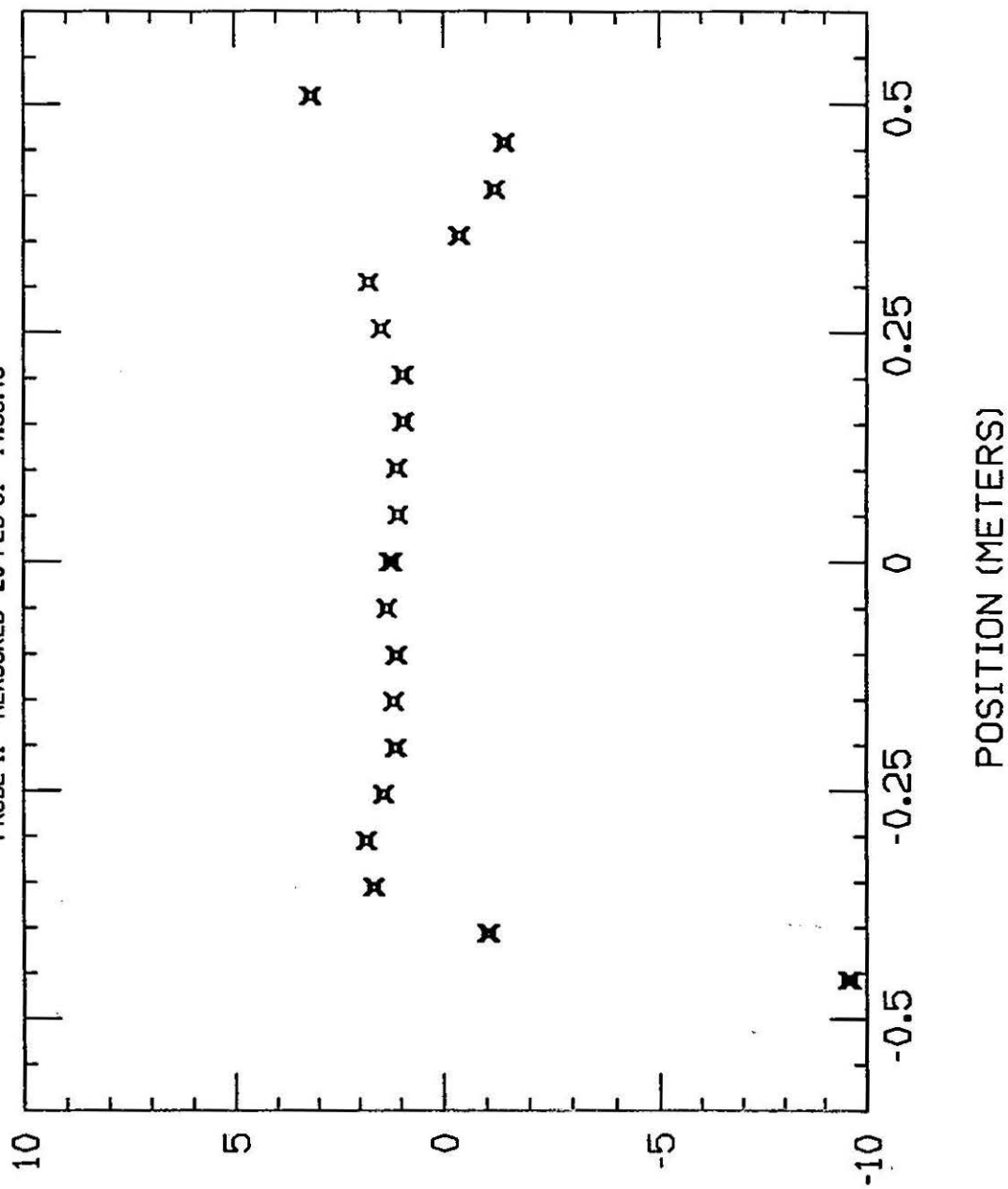
DIPOLE DS0315.EA005

PROBE 11 MEASURED 20-FEB-91 14:35:48



NORMAL SEXTUPOLE DS0315.EA005

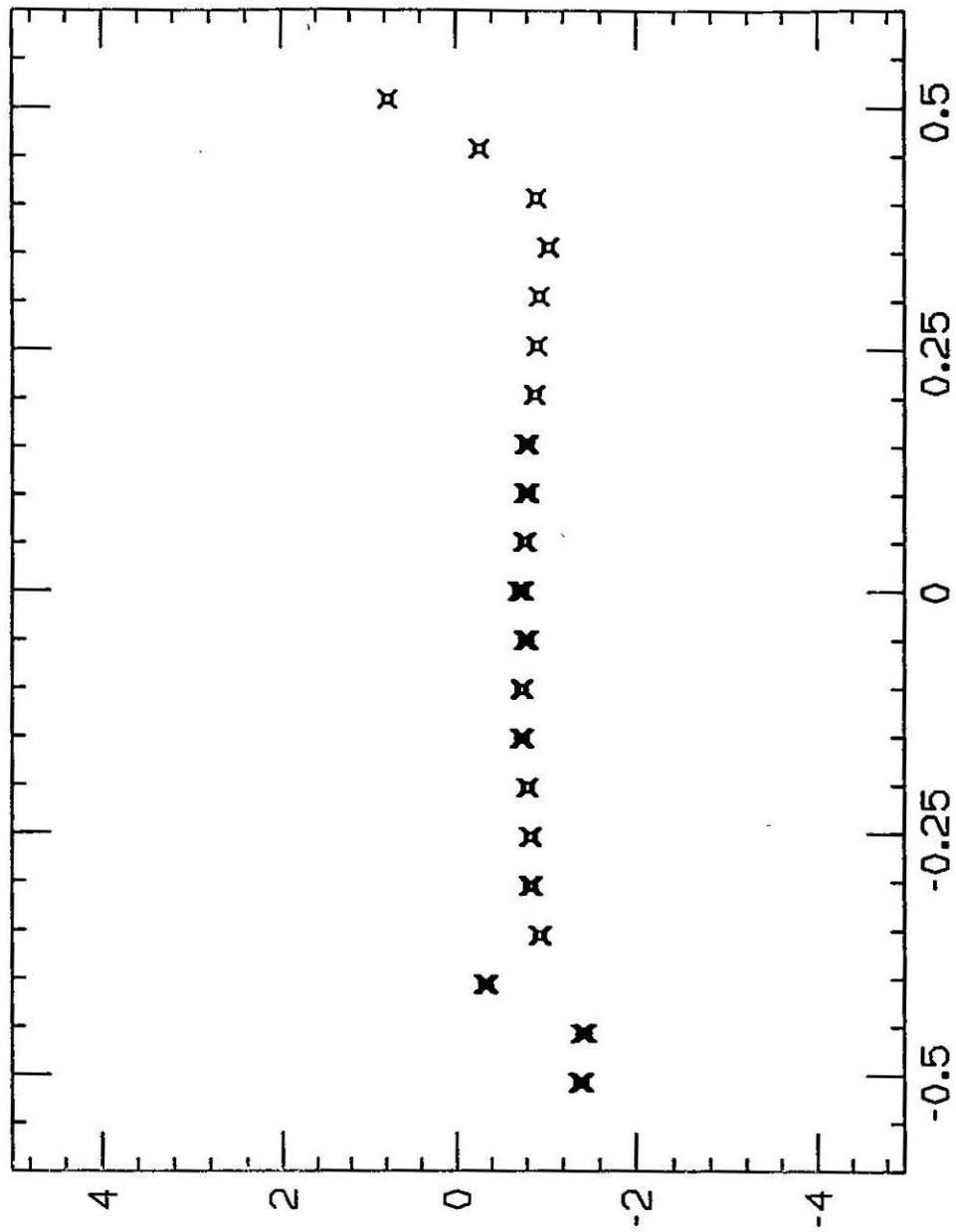
PROBE 11 MEASURED 20-FEB-81 14:35:48



NORMAL DECAPOLE DS0315.EA005

PROBE 11 MEASURED 20-FEB-91 14:35:48

UNITS @ 1 CENTIMETER

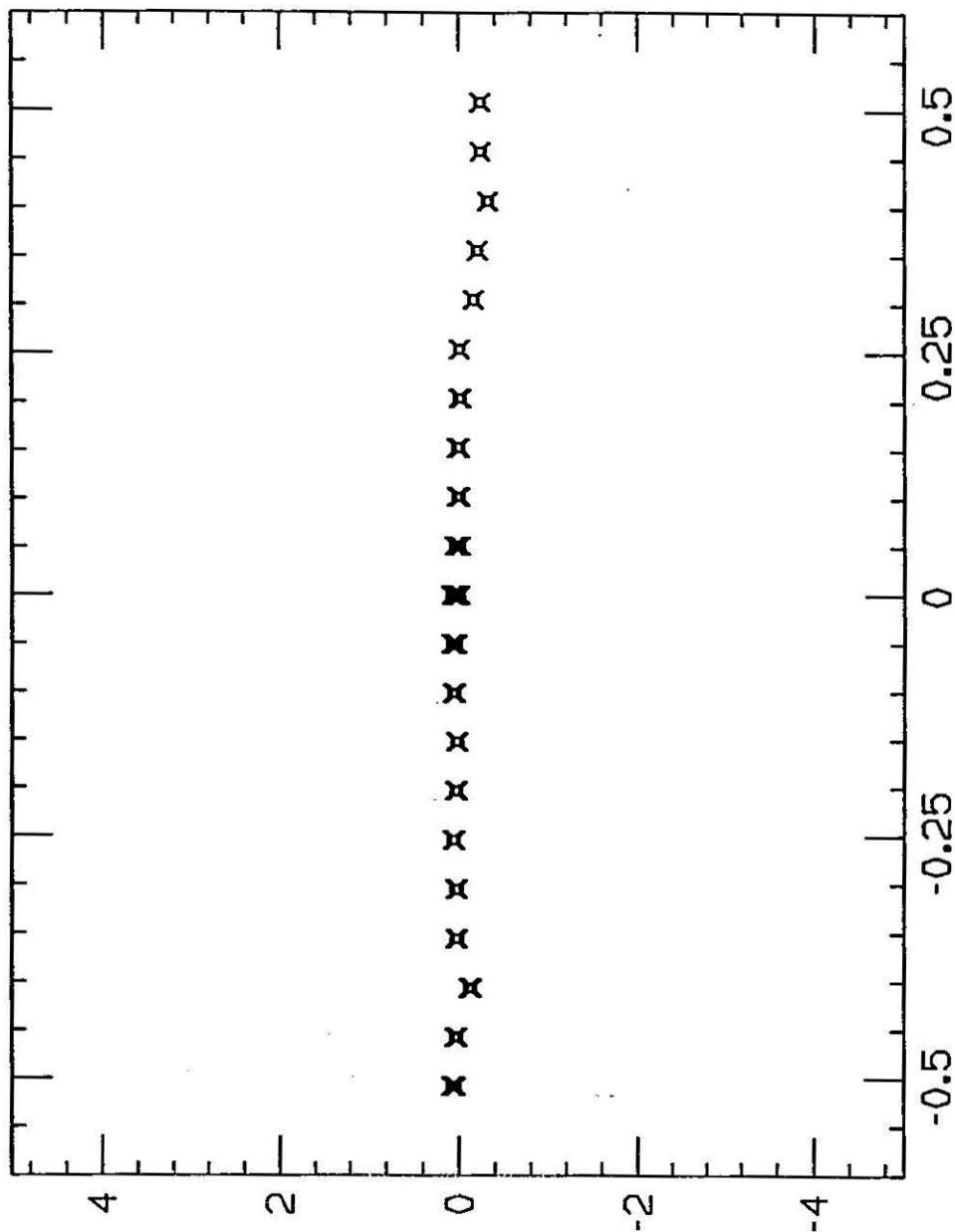


POSITION (METERS)

SKEW DECAPOLE DS0315.EA0005

PROBE 11 MEASURED 20-FEB-91 14:35:48

UNITS @ 1 CENTIMETER



POSITION (METERS)

Next for HAL2:

- More channels
- Greater sensitivity
- Add current readout
- Add tangential winding analysis to software
- Enhance operator control of electronics via software interface

Later:

- Power supply control
- Automated probe drive system and probe position readout