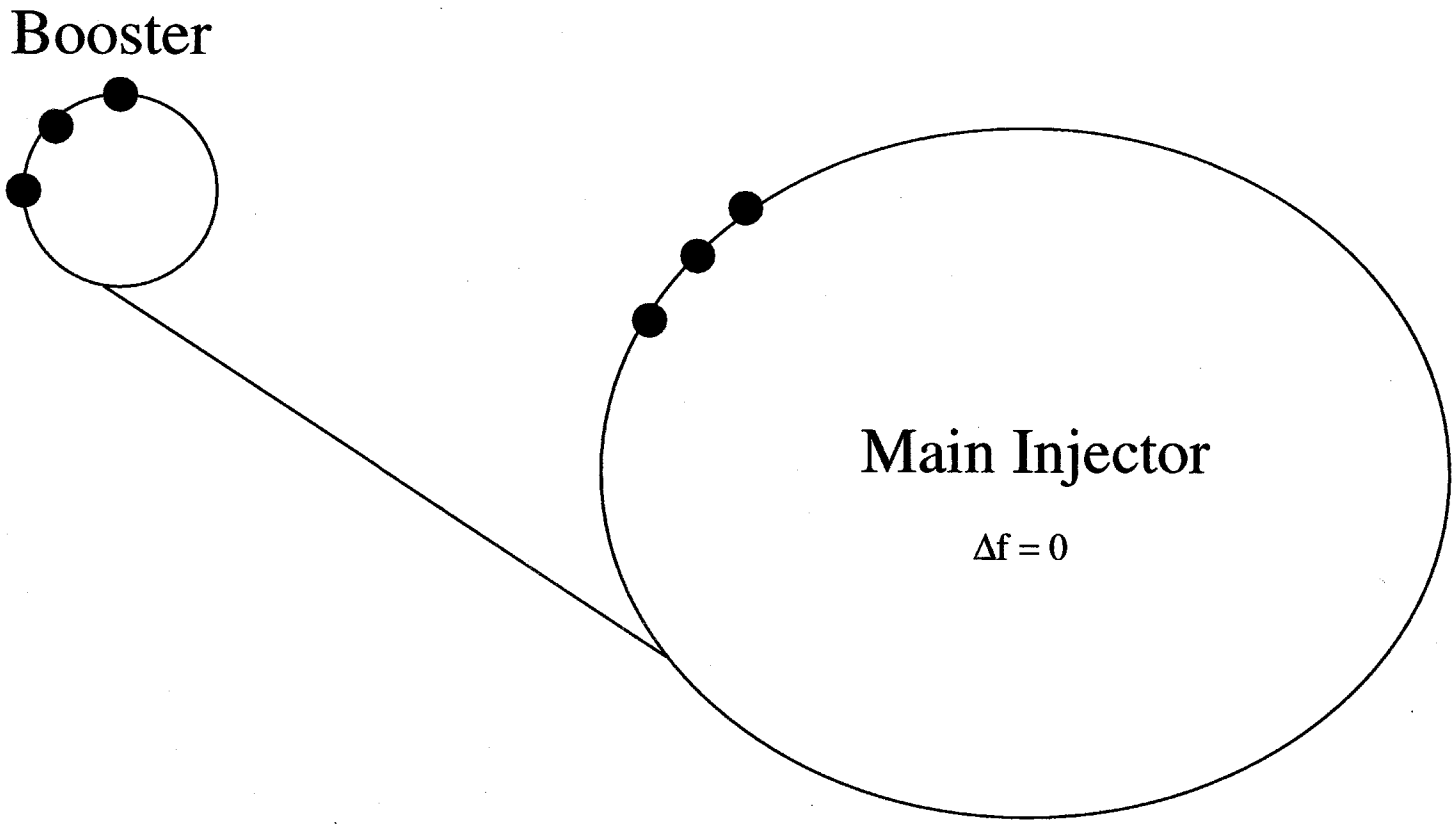
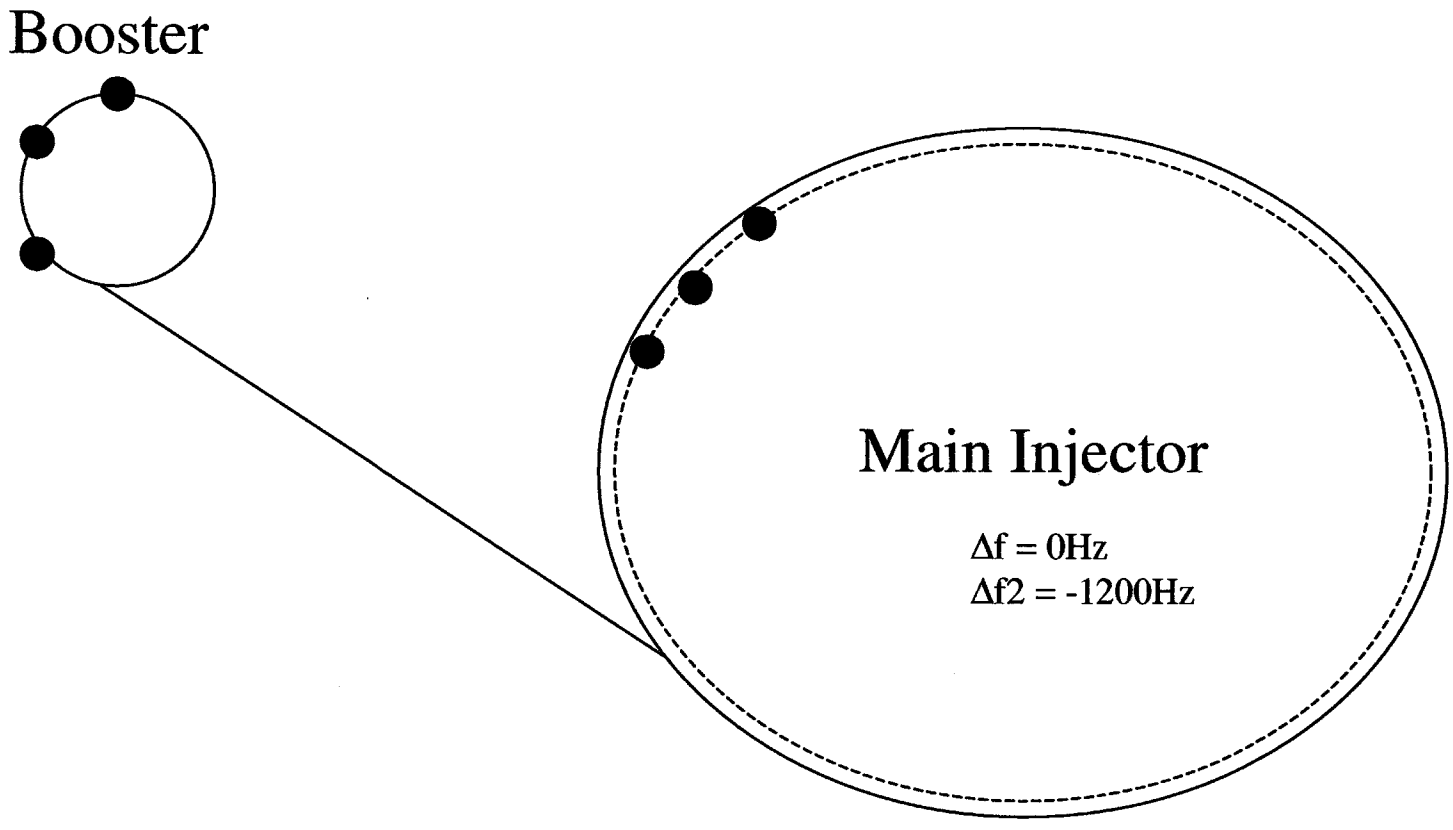
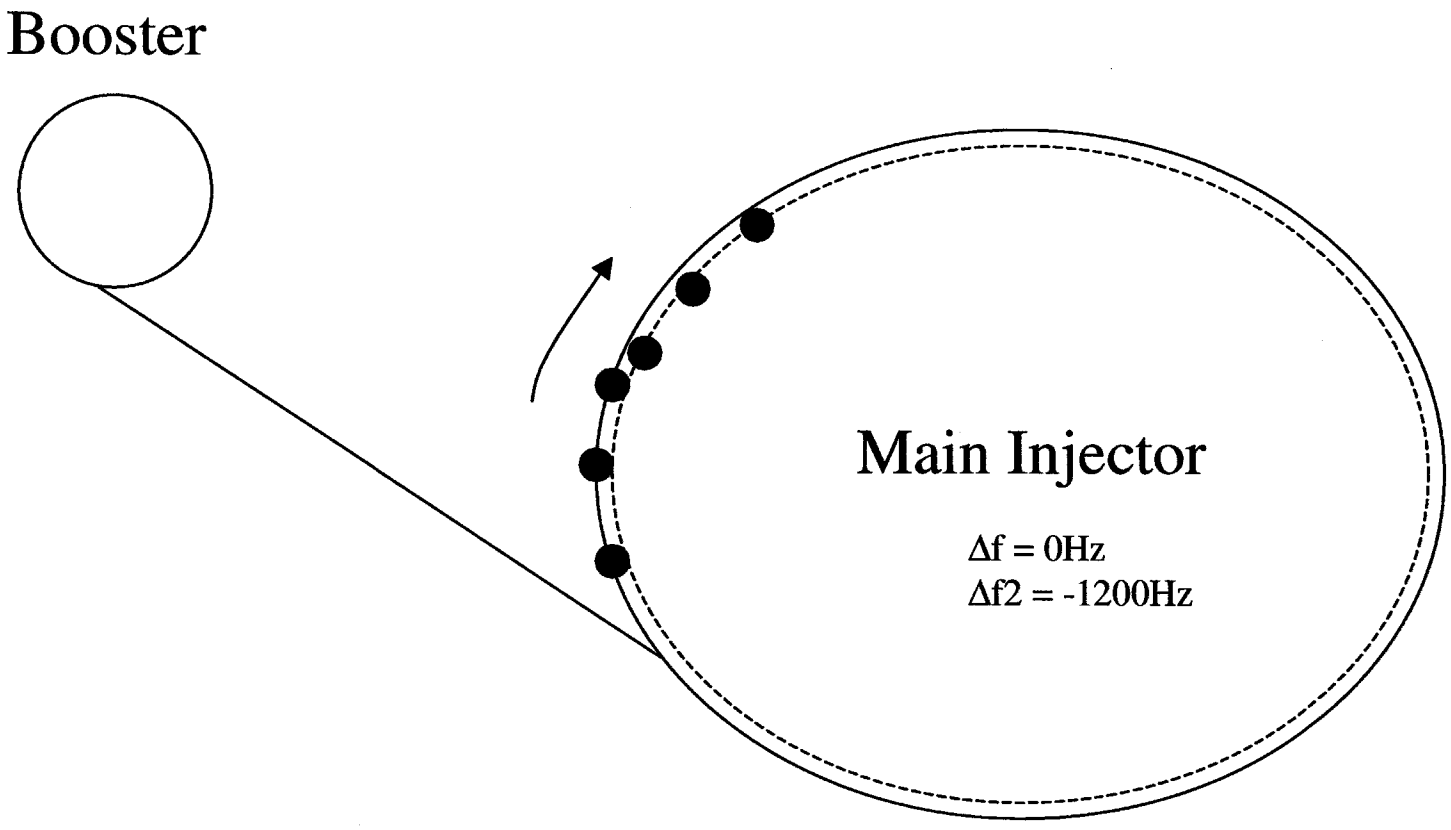
Nominal Orbits/1st Injection



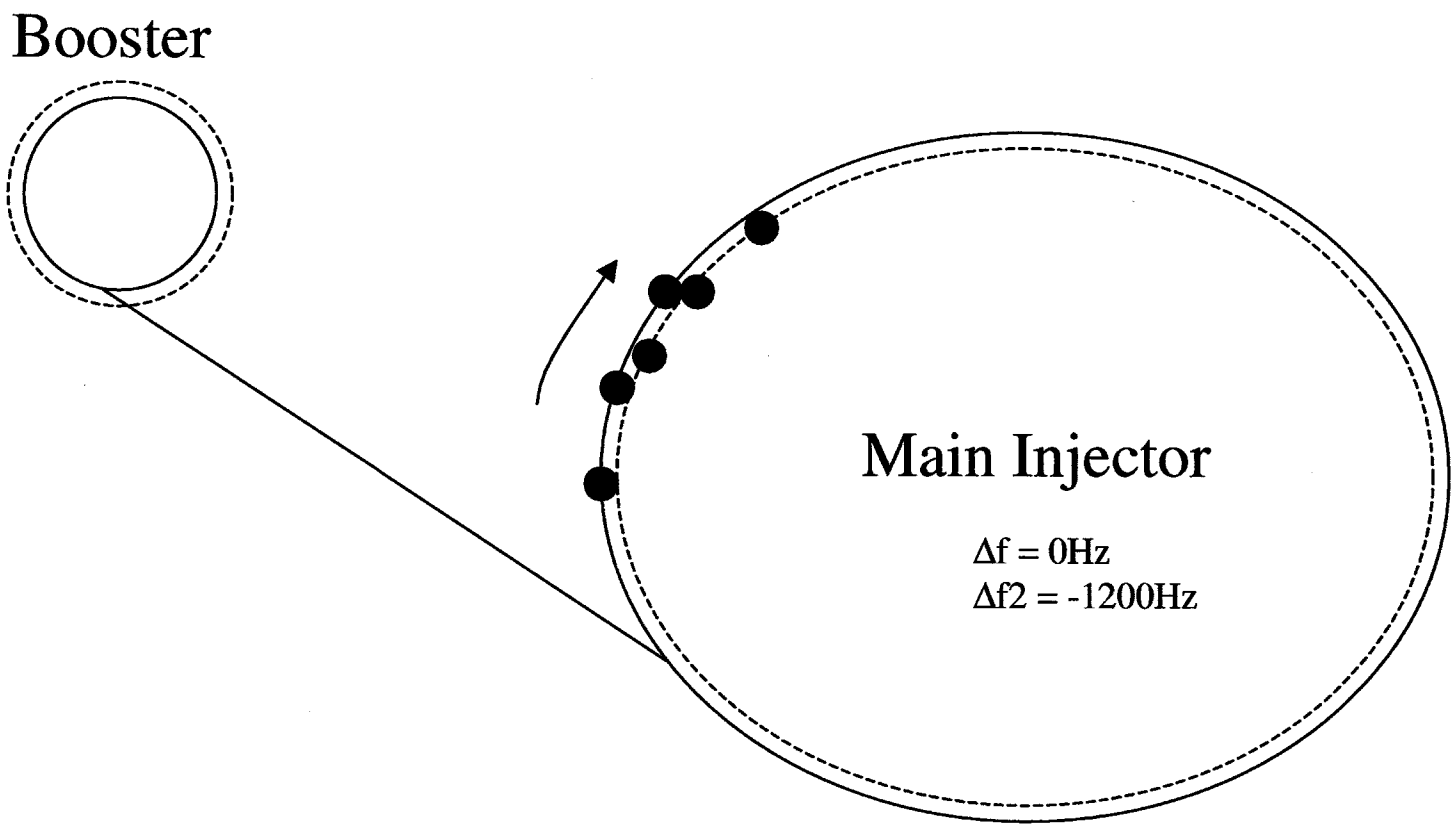
Deceleration

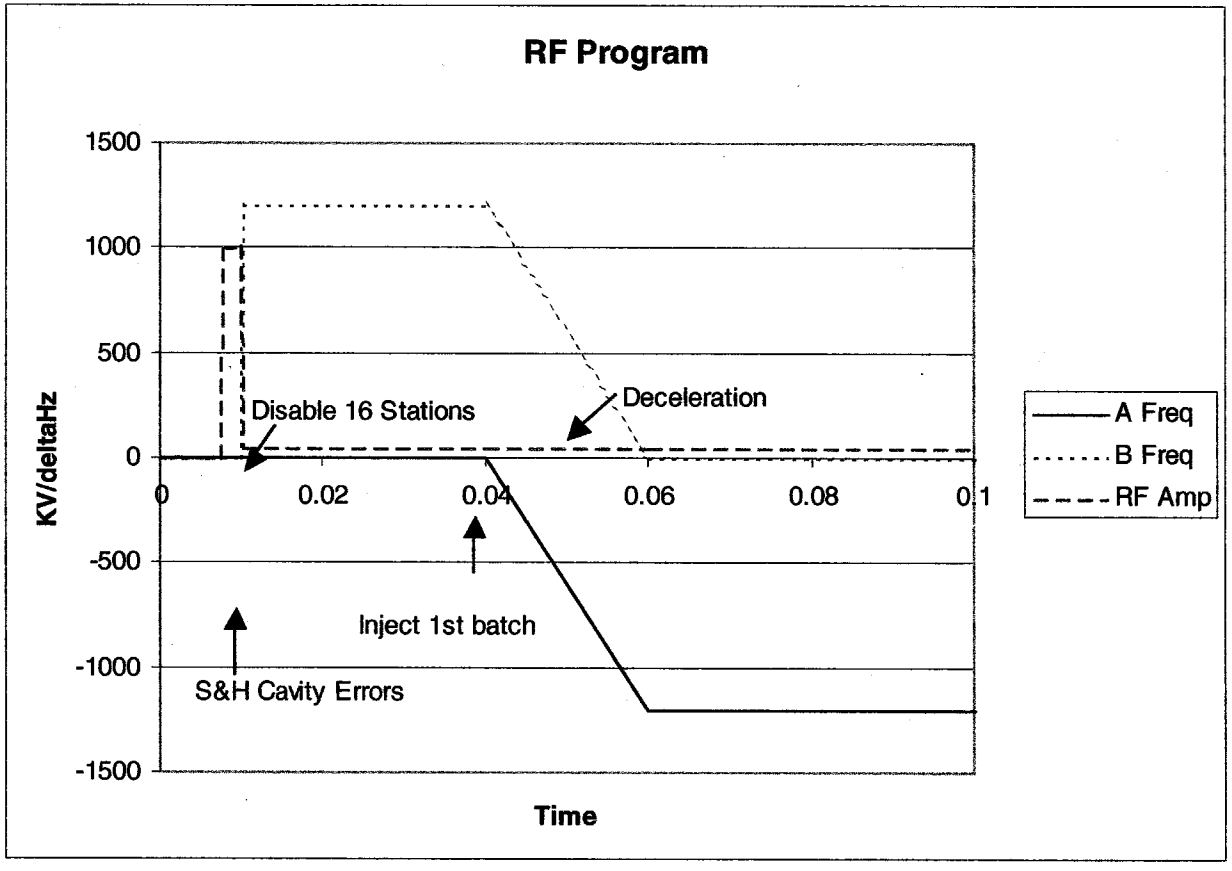


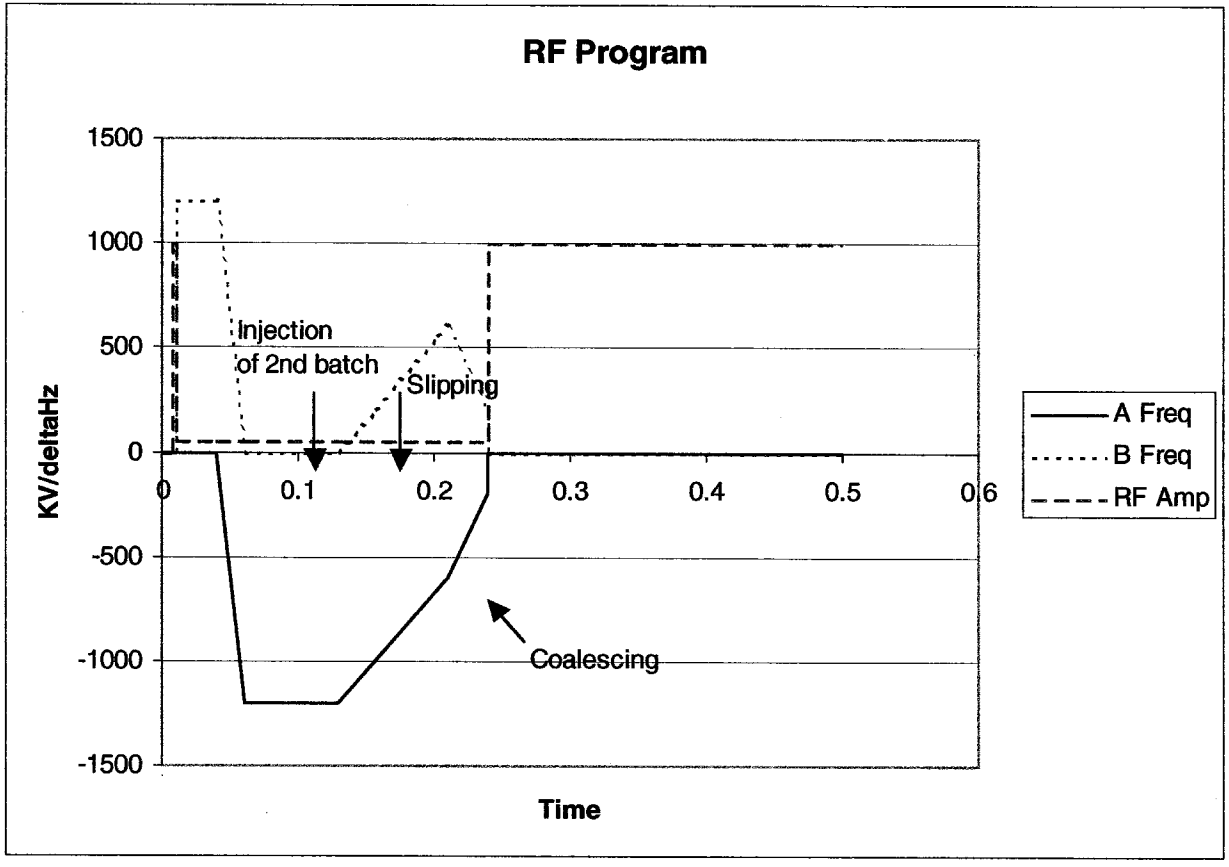
2nd Injection Orbit



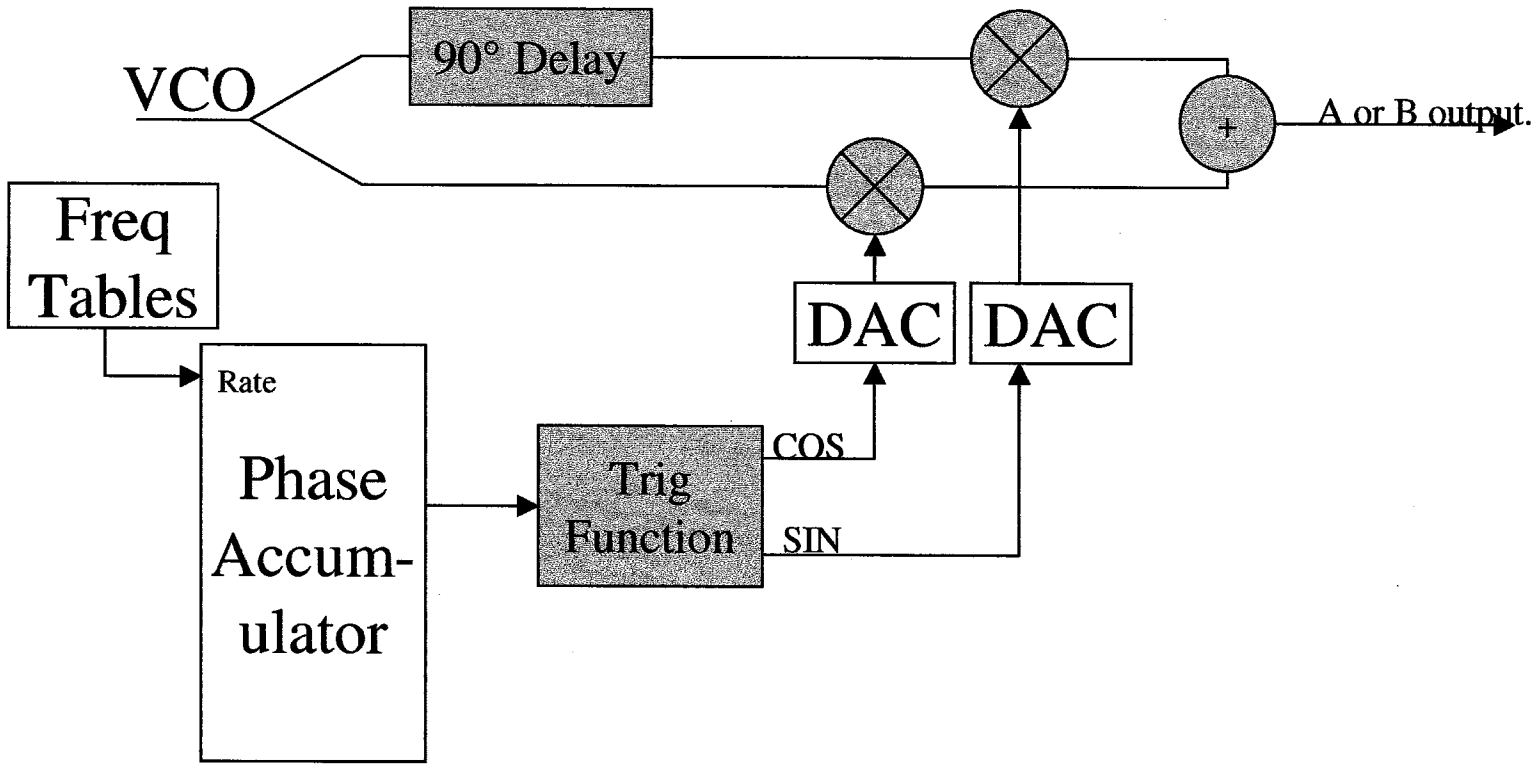
Slipping




RF Program
1500
1000
500
0
-500
-1000
-1500
KV/deltaHz
0
0.02
0.04
0.06
0.08
0.1
Time
Disable 16 Stations
Deceleration
Inject 1st batch
S&H Cavity Errors
A Freq
B Freq
RF Amp

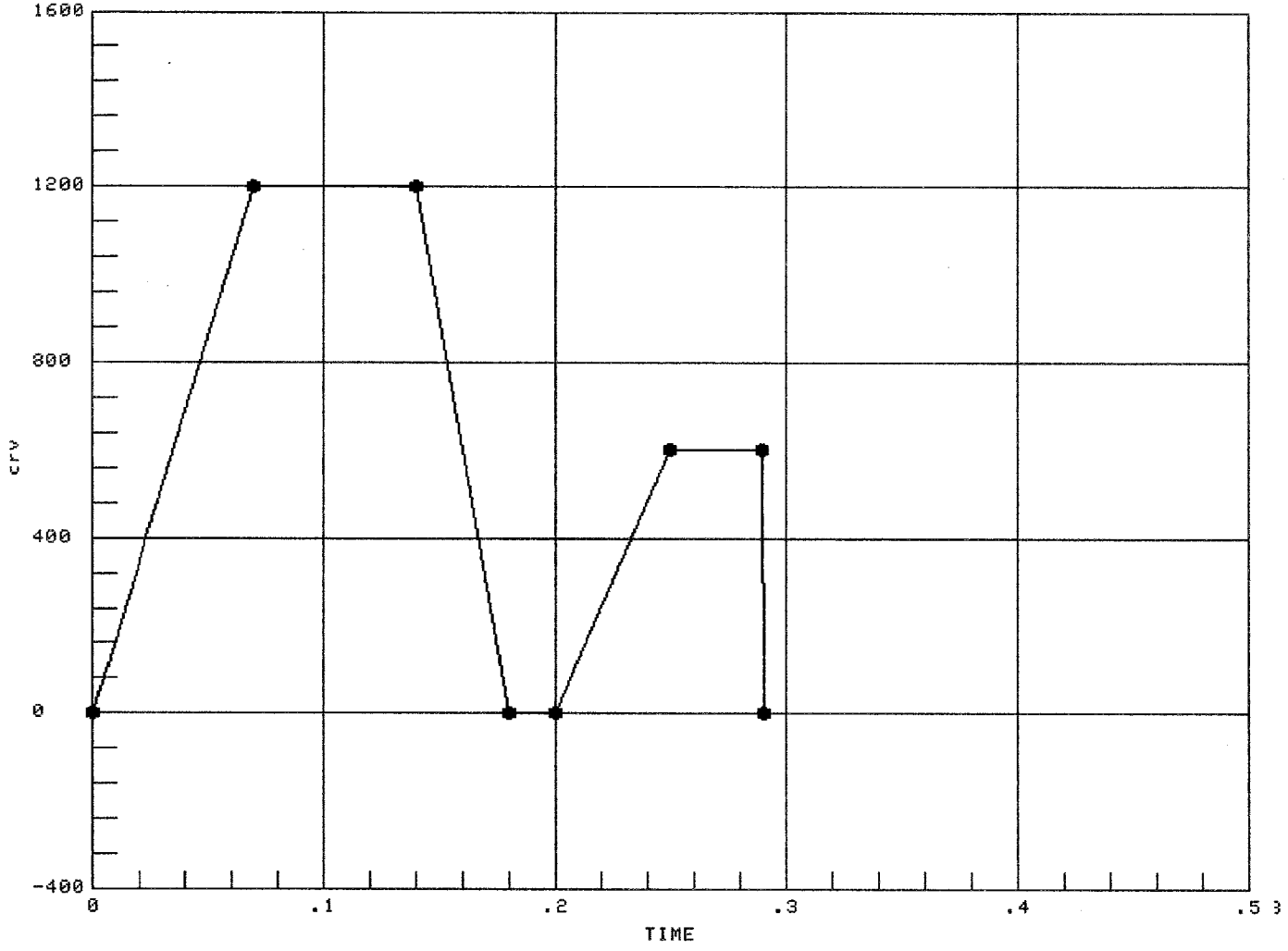

RF Program
1500
1000
500
0
-500
-1000
-1500
KV/deltaHz
0
0.1
0.2
0.3
0.4
0.5
0.6
Time
Injection
of 2nd batch
Slipping
Coalescing
A Freq
B Freq
RF Amp

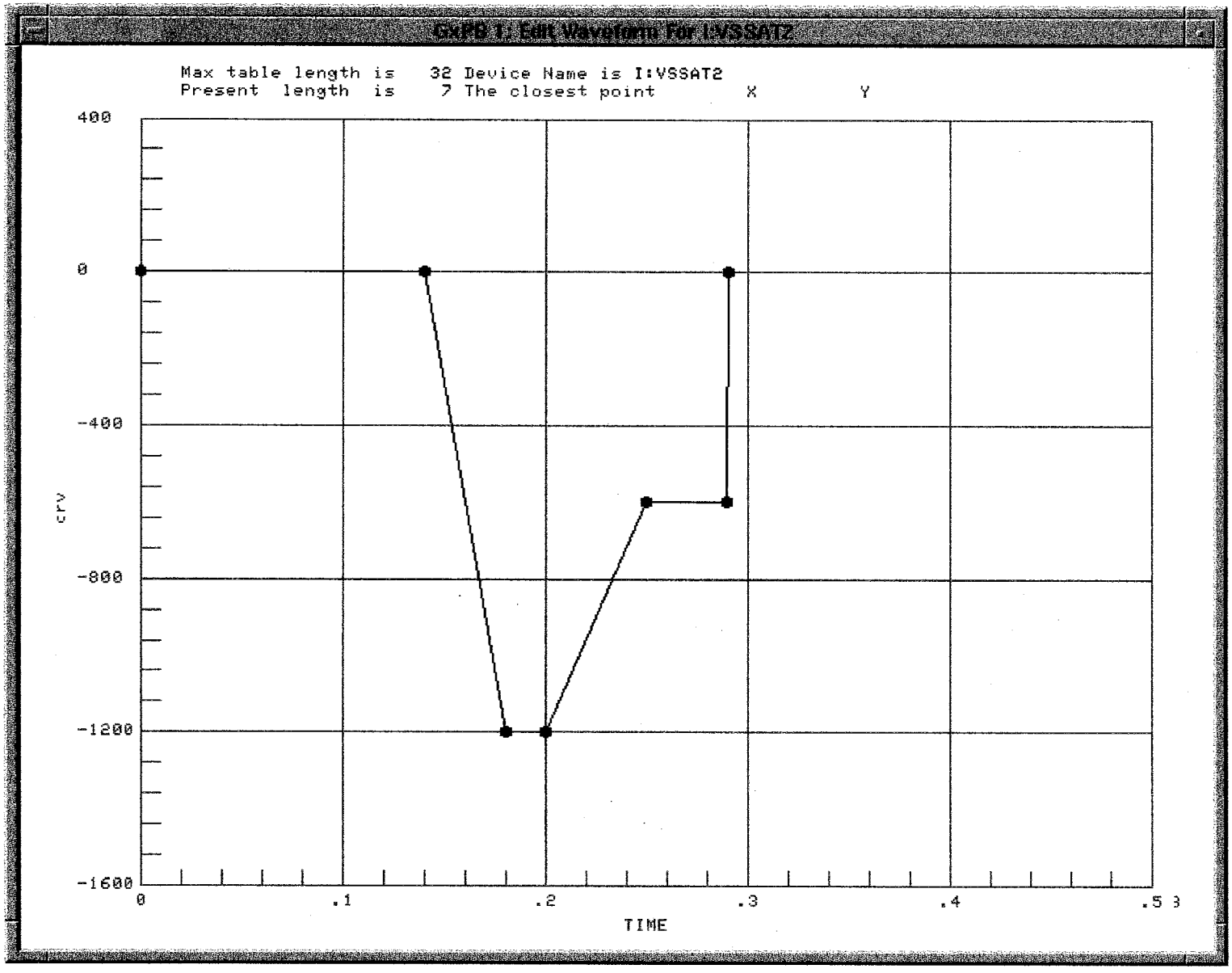
Freq Ramp Block Diagram



GXPB 1: Edit Waveform for I:VSSBT2

Max table length is 32 Device Name is I:VSSBT2
Present length is 8 The closest point ---- X ------- Y -------




ExPB 1: Edit Waveform For I:VSSAT2
Max table length is 32 Device Name is I:VSSAT2
Present length is 7 The closest point X Y
400
0
-400
-800
-1200
-1600
crv
0
.1
.2
.3
.4
.5
TIME

How Close?

The frequency separation of two buckets ΔE apart is

$$\Delta f = -f\eta \frac{\Delta E}{\beta^2 E} \quad .$$

For ΔE equal to the bucket height,

$$\Delta E = \beta \sqrt{\frac{2eV_{\mathrm{rf}} E_s}{\pi h \eta}} \quad .$$

Then, since

$$f_s = f_\circ \sqrt{\frac{h\eta e V_{\mathrm{rf}}}{2\pi\beta^2 E_s}} \quad ,$$

$$\Delta f = -\eta\beta \sqrt{\frac{2eV_{\mathrm{rf}} E_s}{\pi h \eta}} / (\beta^2 E_s) = -2 f_s \quad .$$

Thus, equal size stationary buckets whose separatrices would touch if independent of each other are modulated 100% at $2\nu_s$:

$$\sin(\omega_{\mathrm{rf}} t + 2\omega_s t) + \sin(\omega_{\mathrm{rf}} t - 2\omega_s t) = 2\sin(\omega_{\mathrm{rf}} t)\cos(2\omega_s t) \quad .$$

Each incremental seperation by $\Delta E = H_B$ seperates frequencies by additional $2f_s$

Observation: Bunches can slide by indefinitely with $4H_B$ seperation of bucket centers

Best Results for Current Scheme

- Start far apart so that incoming bunches will not be disrupted on initial orbits - could be > 100 MeV apart

- Change frequency slowly so bunches have minimum height in buckets that are full by time of minimum separation

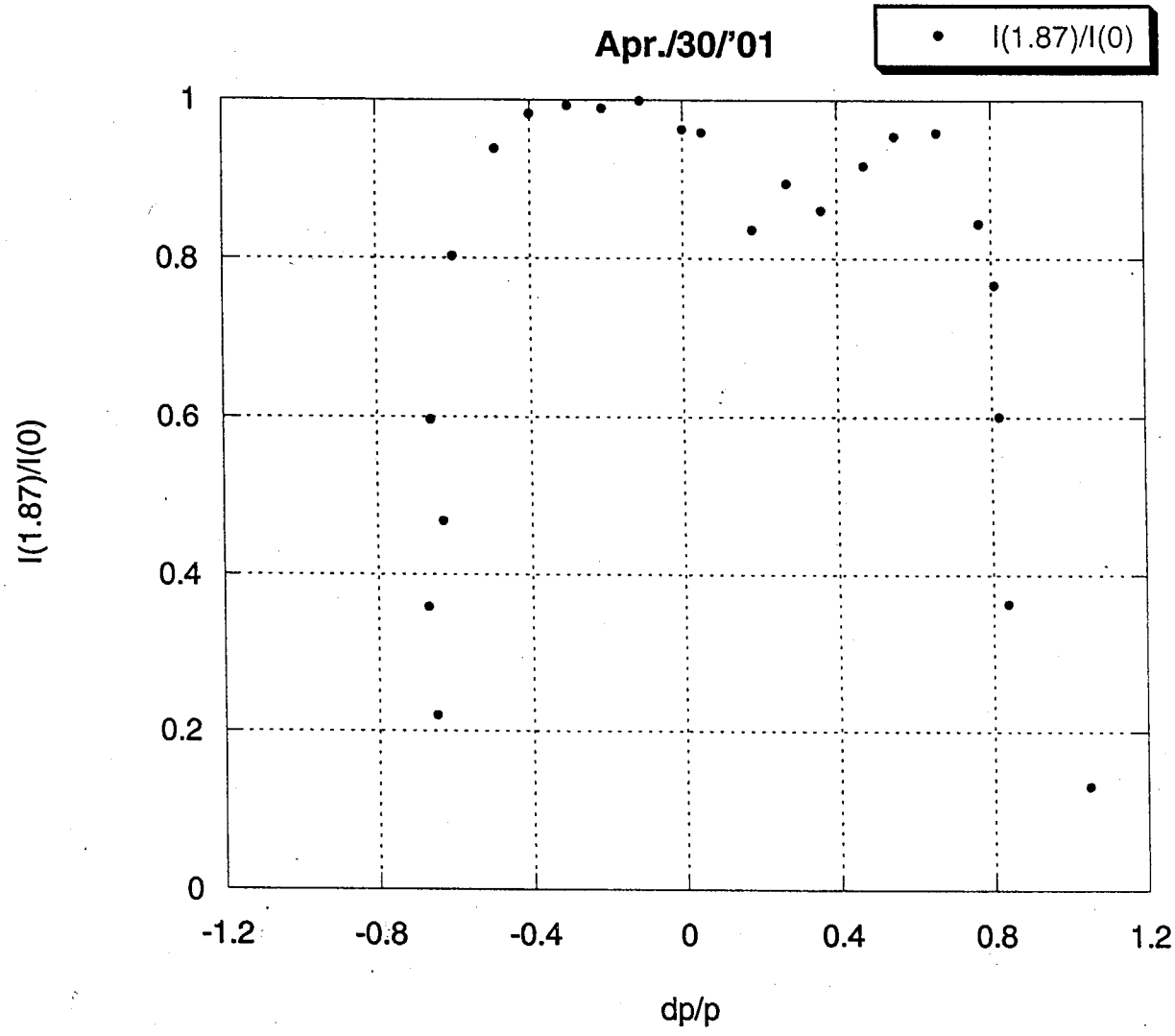
- When bunches are aligned at minimum separation, turn on bucket matched to minimum contour enclosing desired fraction of total charge

  - bunches can be brought to a separation such that an empty bucket of the same size fits between the to full buckets with little dilution

  - bunches can be brought to separation such that a similar bunch will just fit between with visible but acceptable distortion

  - a matched contour surrounding two bunches can be as small as $3\times$ the initial single bunch areas but practically no smaller nohow

- A variety of voltage and frequency programs can lead to equivalent results

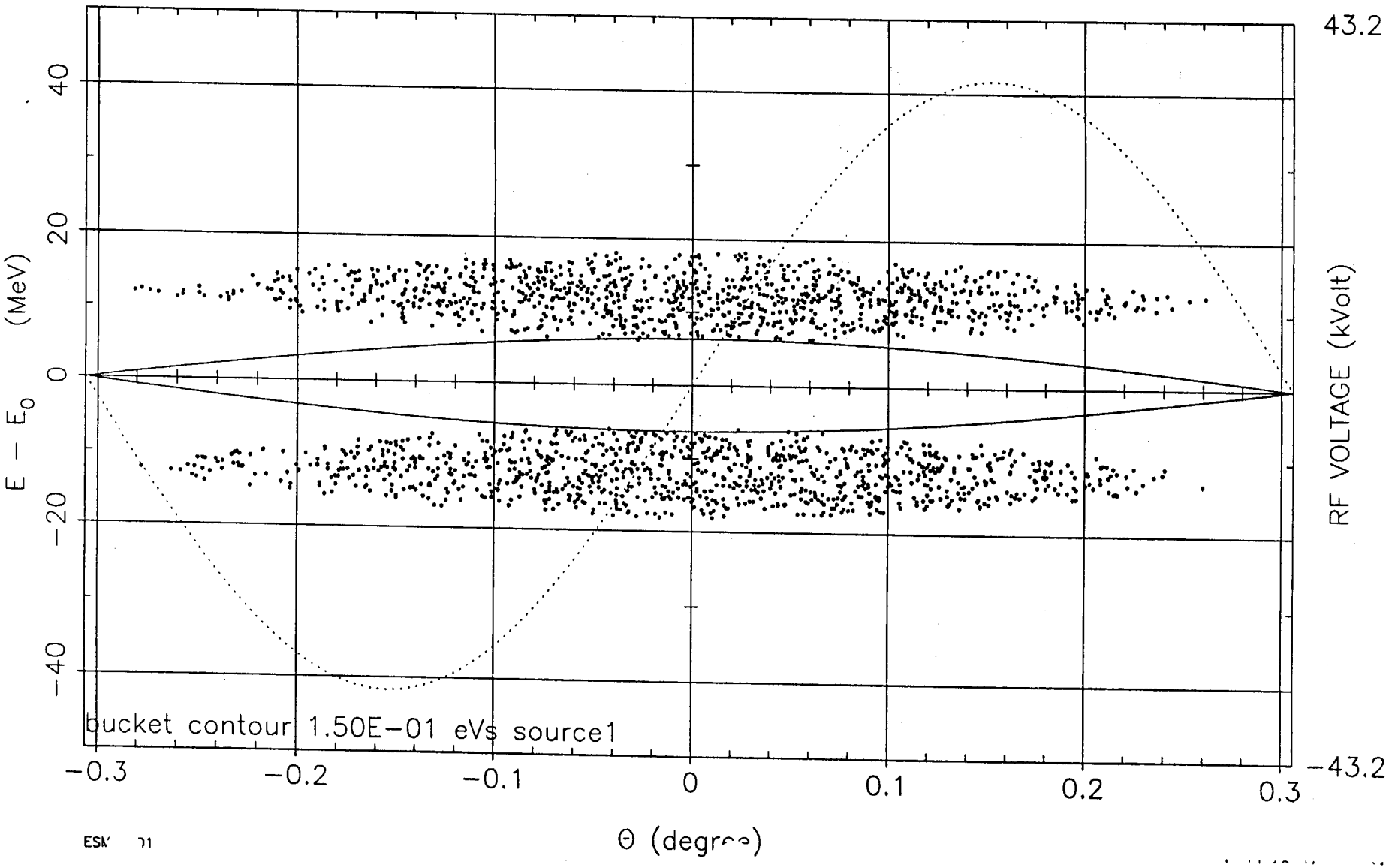

Apr./30/'01
I(1.87)/I(0)
1
0.8
0.6
0.4
0.2
0
-1.2
-0.8
-0.4
0
0.4
0.8
1.2
dp/p
I(1.87)/I(0)

MI Slip Stacking

Iter 0 0.000E+00 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
6.3042E+00	1.5045E−01	8.9384E+03	588	3.600E−02	0.000E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η			
1.8121E−03	0.0000E+00	−8.6160E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	2.6434E−01	2000			

f_s = 163 Hz

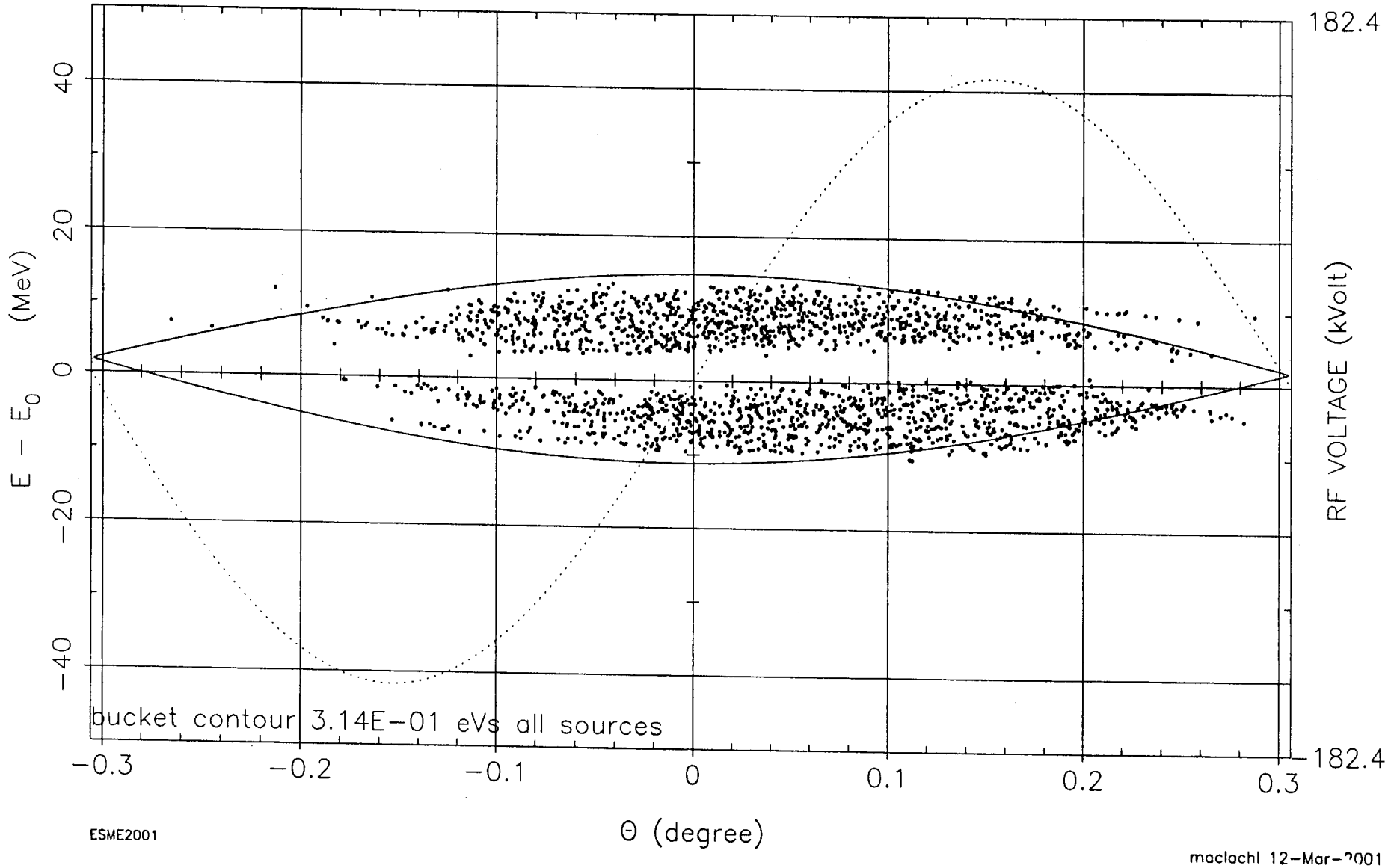


ESN 11

MI Slip Stacking

Iter 2301 2.563E−02 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
1.2999E+01	3.1354E−01	8.9402E+03	588	1.520E−01	0.000E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η			
3.7222E−03	0.0000E+00	−8.6116E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	1.2678E−01	2000			

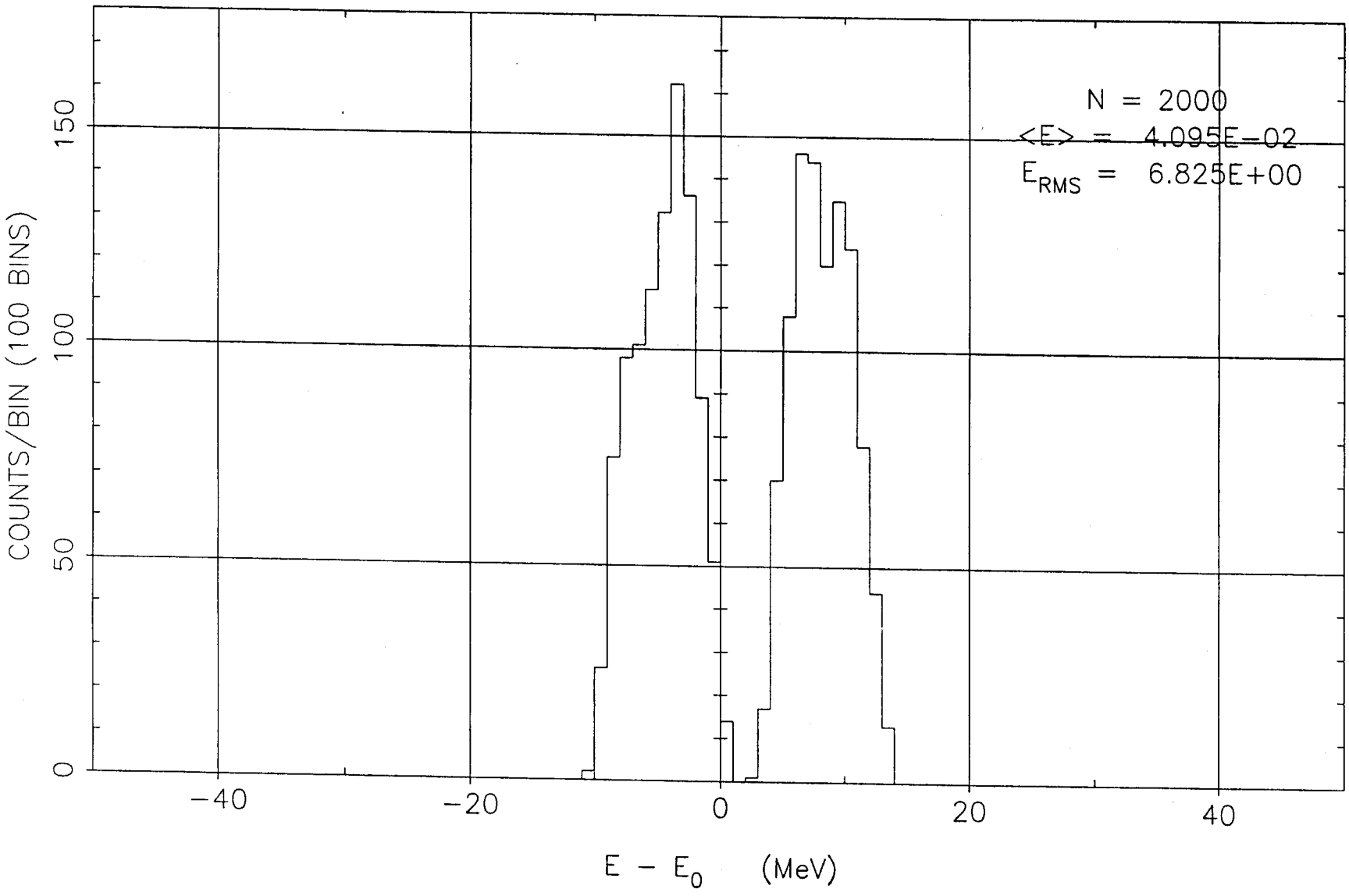


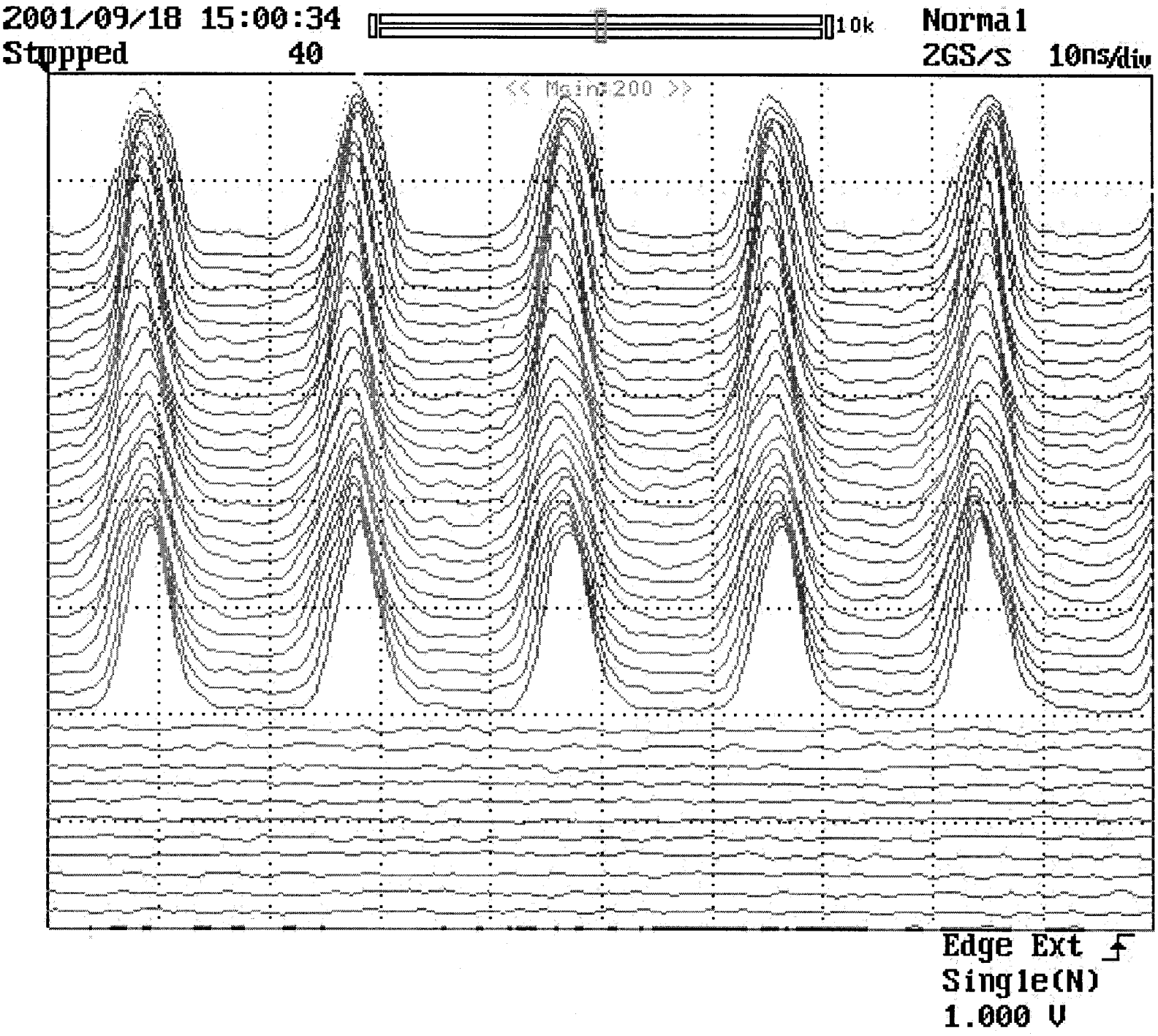
ESME2001

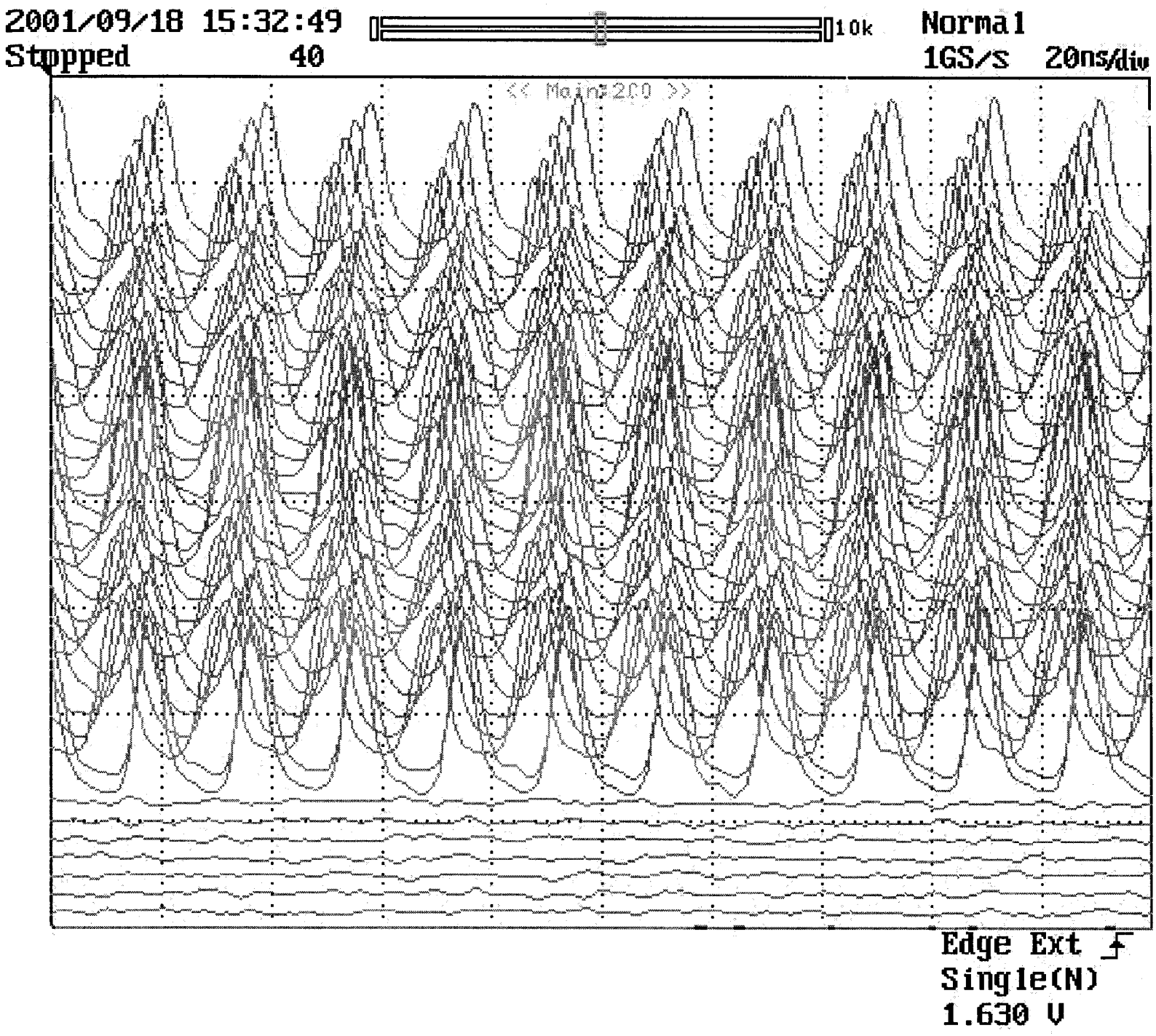
maclachl 12−Mar−2001 06:21

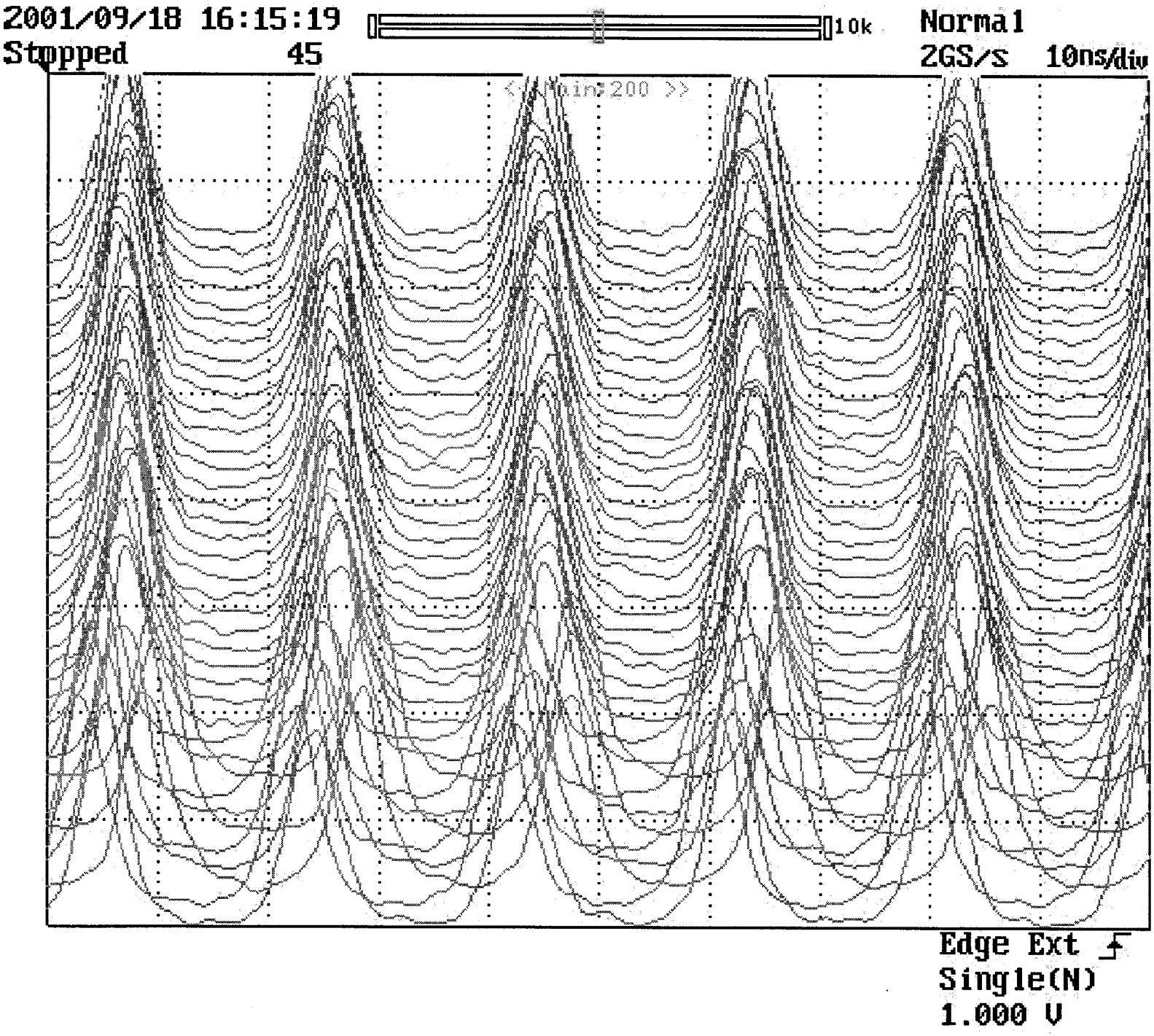
MI Slip Stacking

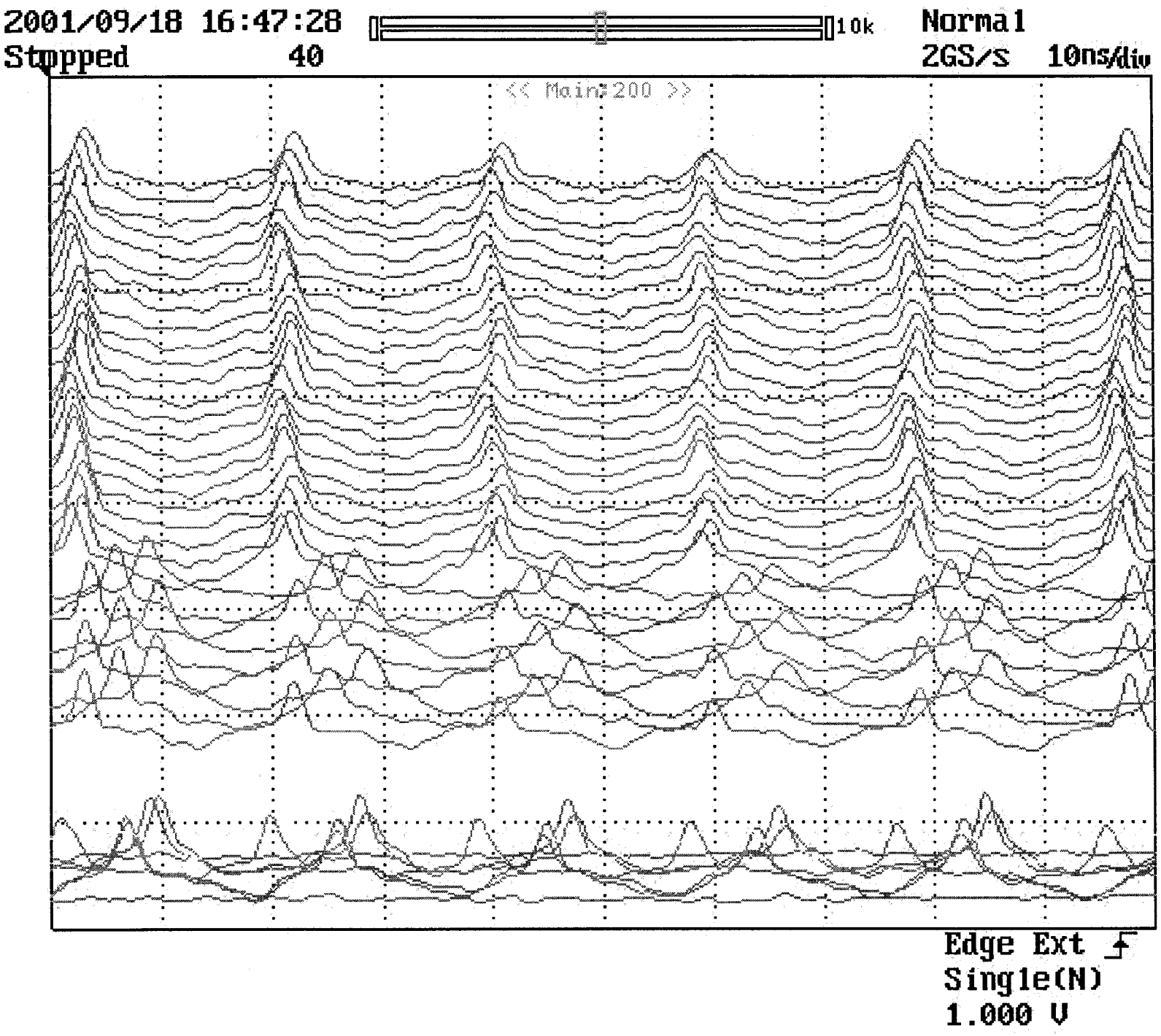
Iter 2301
2.563E−02 SEC

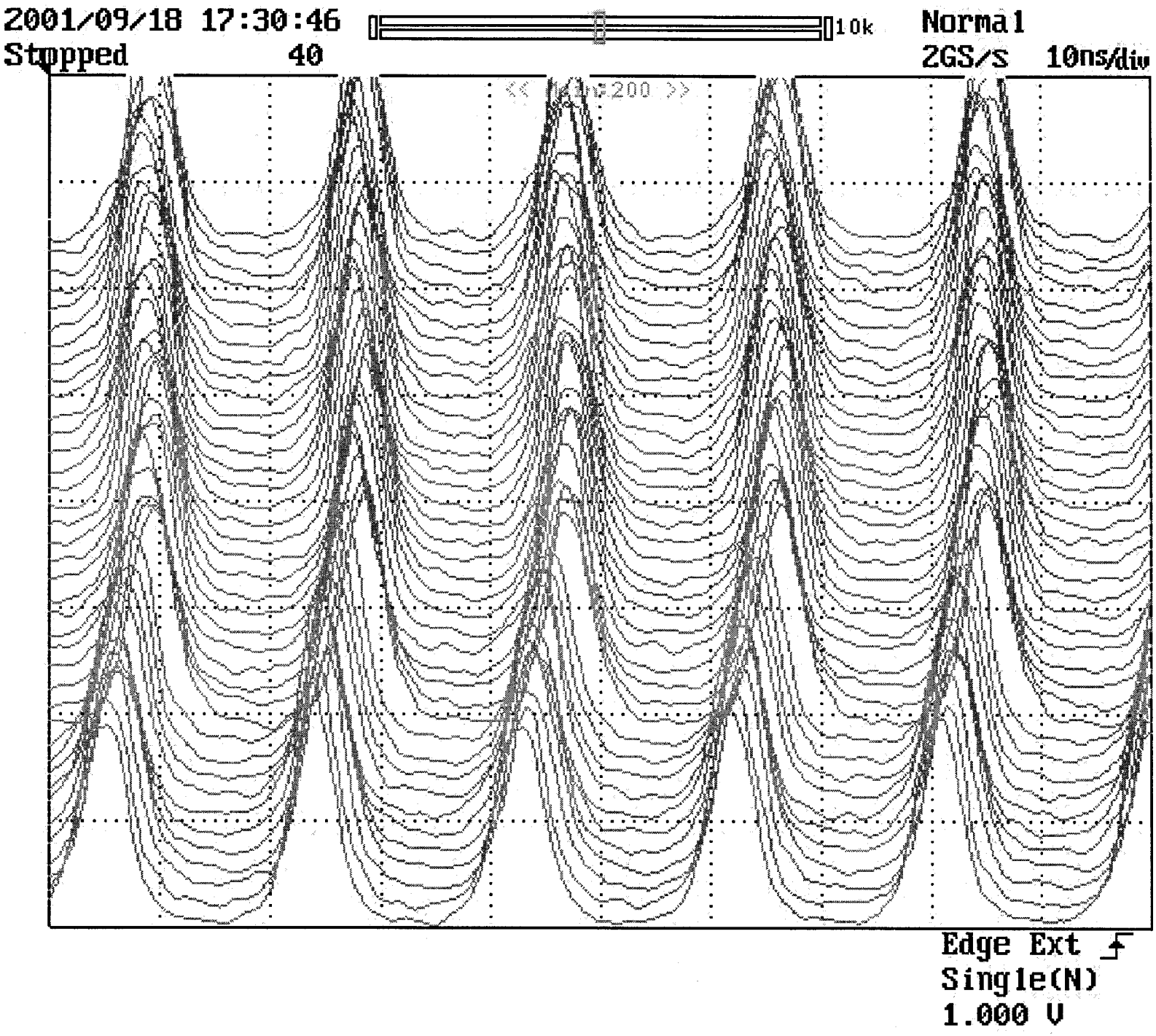



2001/09/18 15:00:34
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V


2001/09/18 15:32:49
Stopped 40
10k
Normal
1GS/s 20ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.630 V


2001/09/18 16:15:19
Stopped 45
10k
Normal
2GS/s 10ns/div
Edge Ext
Single(N)
1.000 V

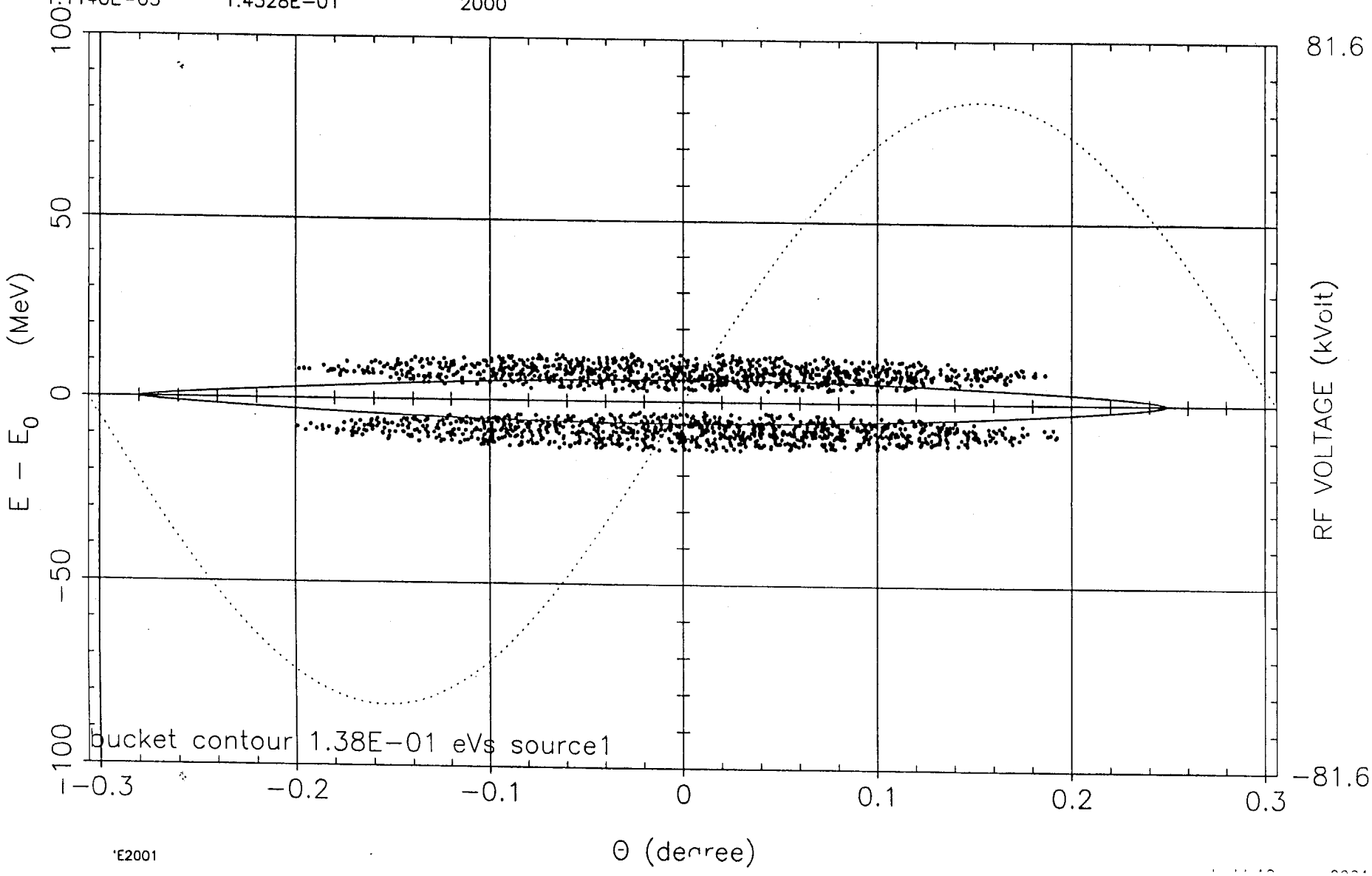

2001/09/18 16:47:28
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V


2001/09/18 17:30:46
Stopped
40
10k
Normal
2GS/s
10ns/div
Edge Ext
Single(N)
1.000 V

MI Slip Stacking

Iter 0 0.000E+00 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
6.0041E+00	1.3778E−01	8.9384E+03	588	3.400E−02	−1.651E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	3.400E−02	1.651E+00
1.7607E−03	0.0000E+00	−8.6160E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	1.4328E−01	2000			

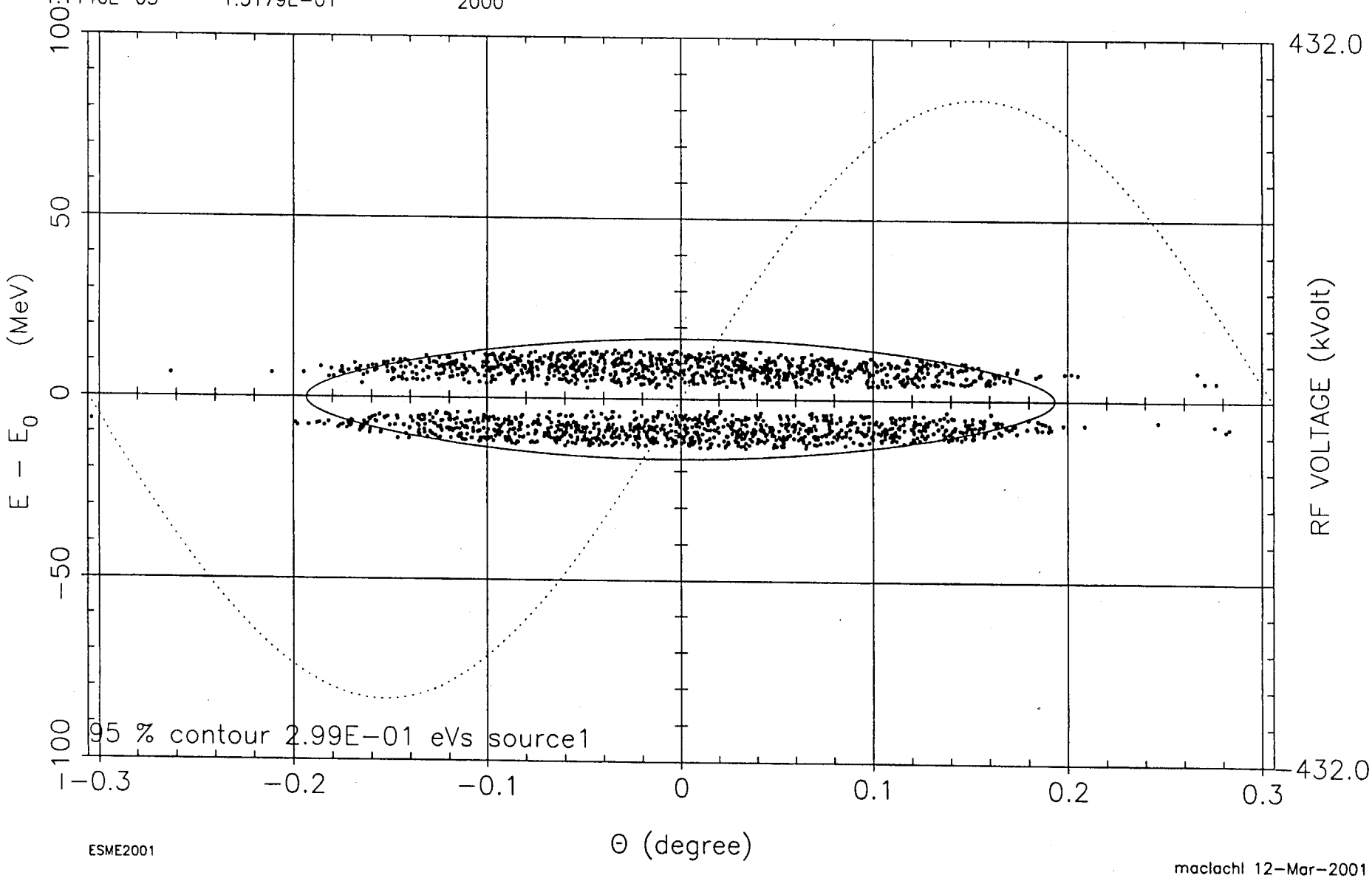


'E2001

MI Slip Stacking

Iter 875 9.747E−03 sec

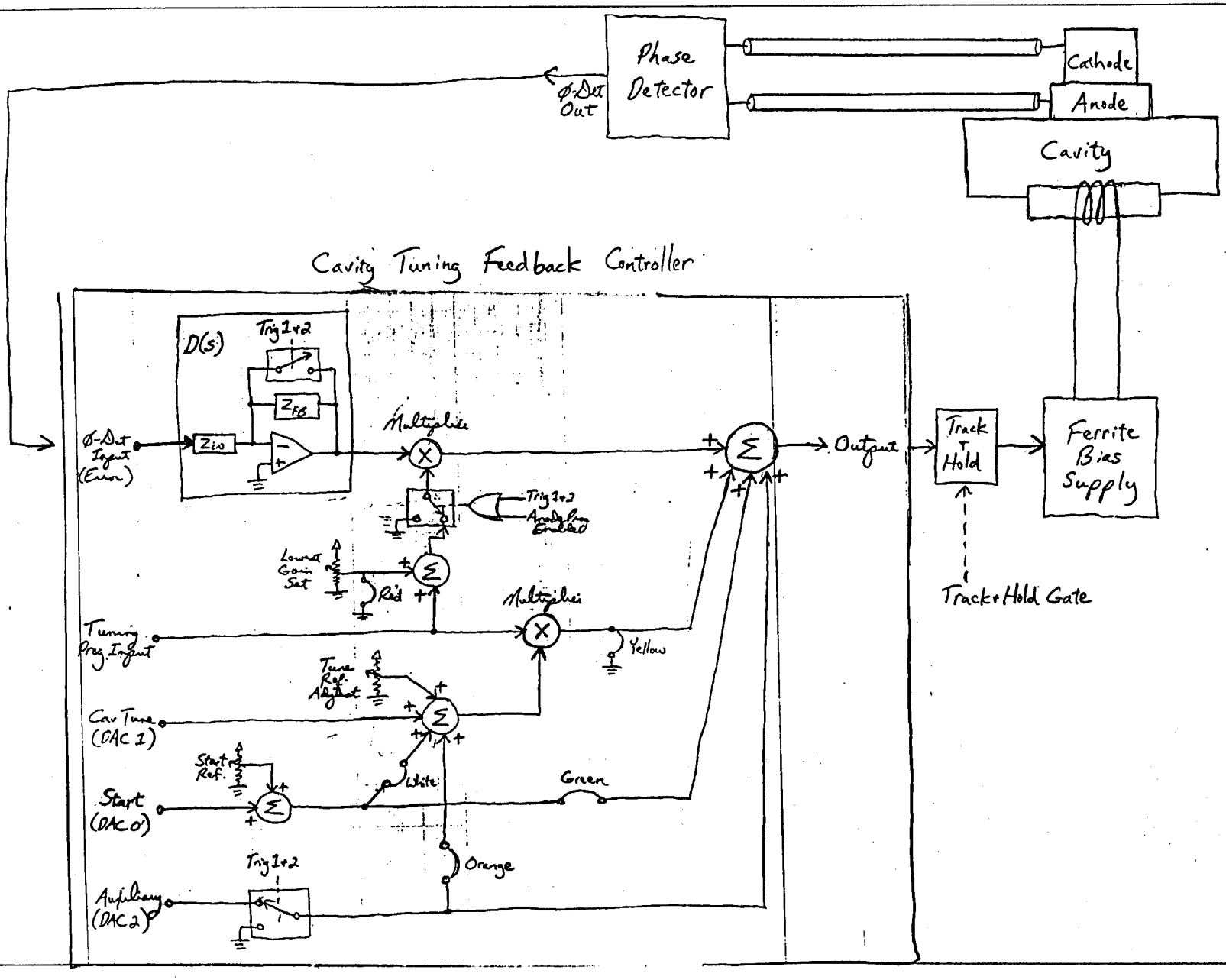
H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
1.9997E+01	4.8236E−01	8.9384E+03	588	3.600E−01	0.000E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η			
5.7303E−03	1.5365E+00	−8.6160E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	1.5179E−01	2000			

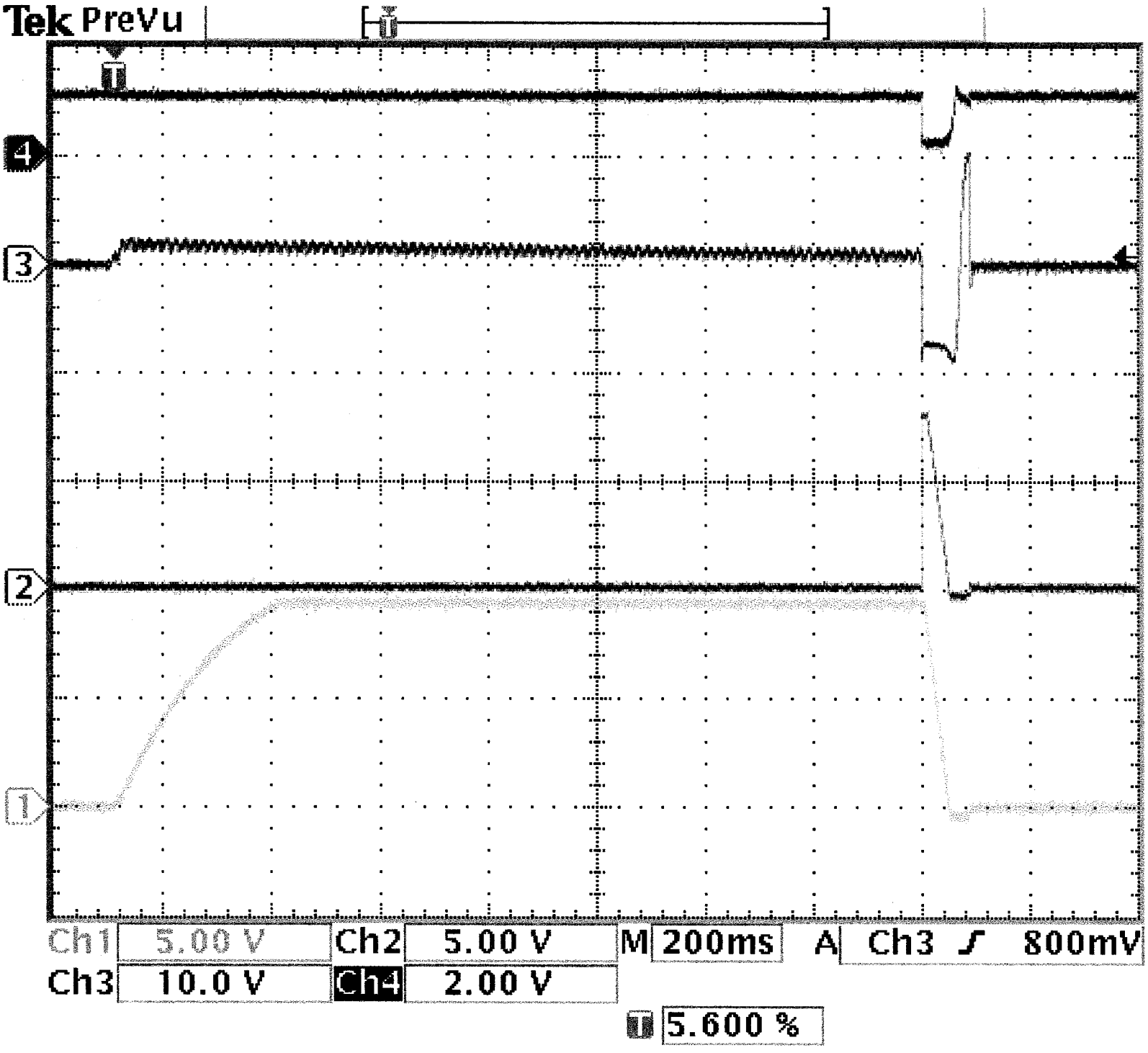


ESME2001

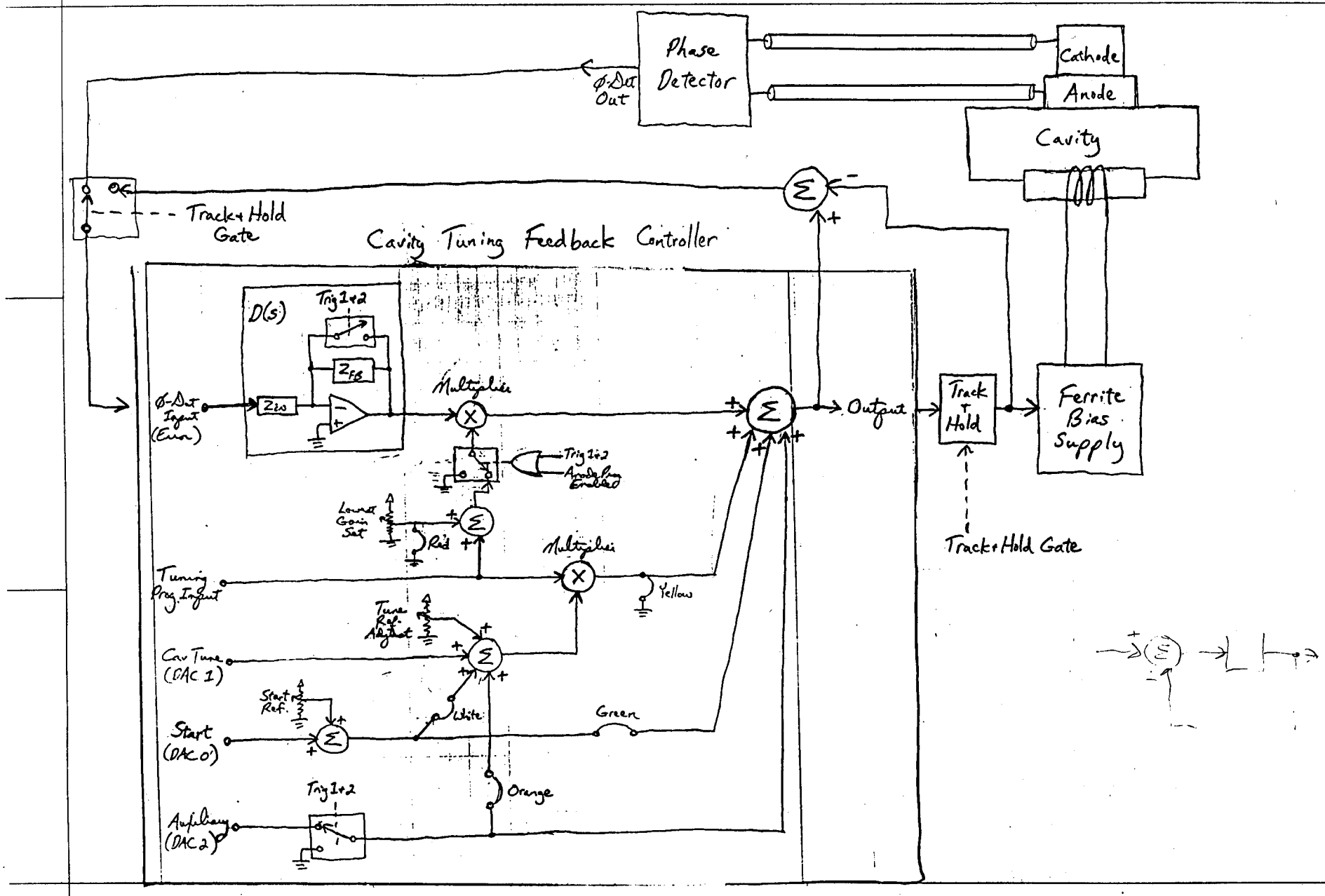
maclachl 12−Mar−2001 06:28

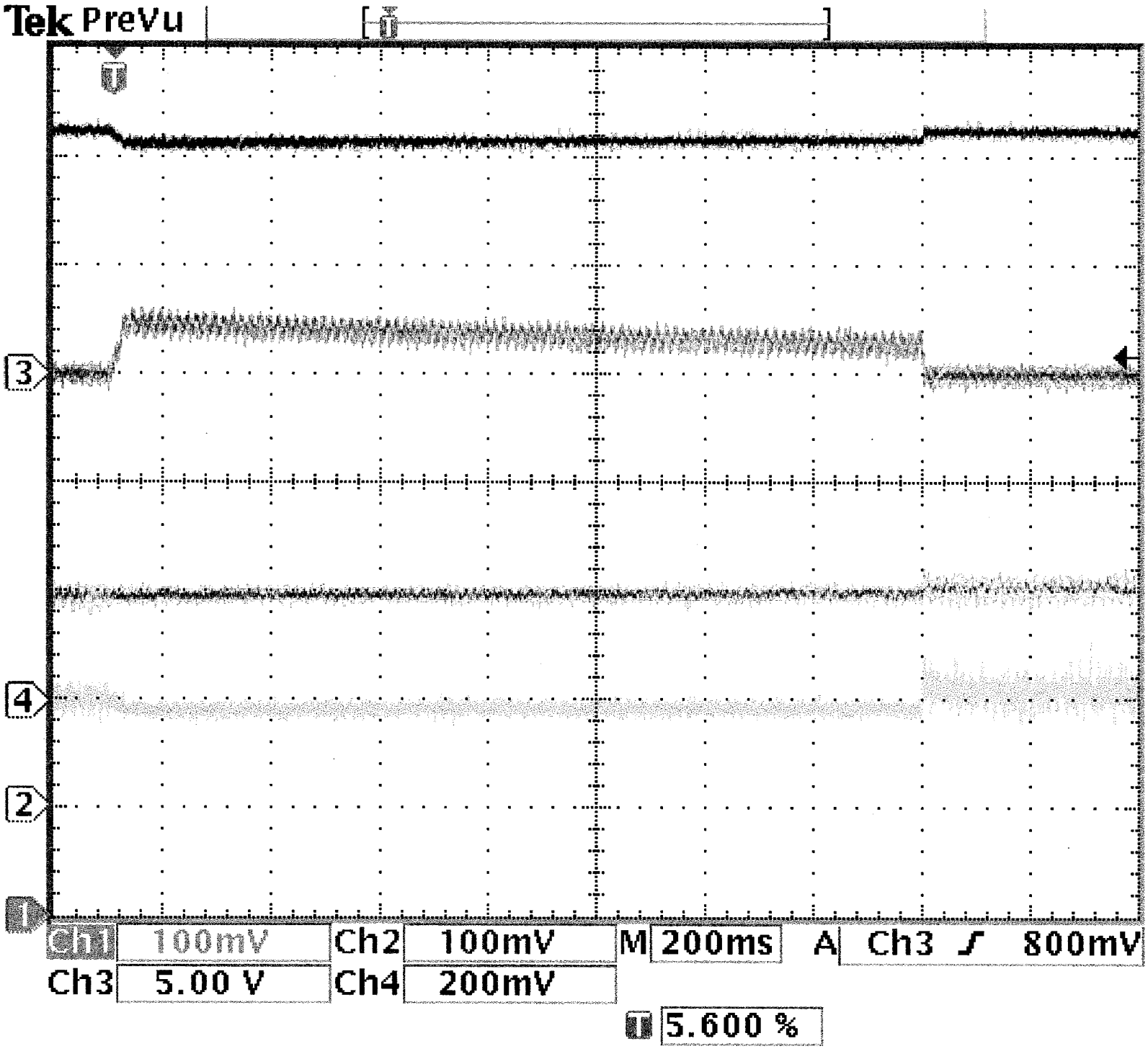
Cavity Tuning System




Tek PreVu
Station 9
without
Track&Hold
Follow Box
Installed
(Typical Station)
Chan1:
Cavity Tuning FB
Controller Output
Chan2:
Track&Hold Out
(FBS Drive)
Chan3:
Anode-to-Cathode
Phase Detector
9 deg / V
Chan4:
RF Gap Envelope
Ch1 5.00 V
Ch2 5.00 V
M 200ms
A Ch3 800mV
Ch3 10.0 V
Ch4 2.00 V
5.600 %
10 May 2001
10:45:15

Cavity Tuning System (Modified)





Station 9 with Track&Hold Follow Box Installed

Chan1: Cavity tuning FB Controller Output

Chan2: Track&Hold Out (FBS Drive)

Chan3: Anode-to-Cathode Phase Detector 9 deg / V

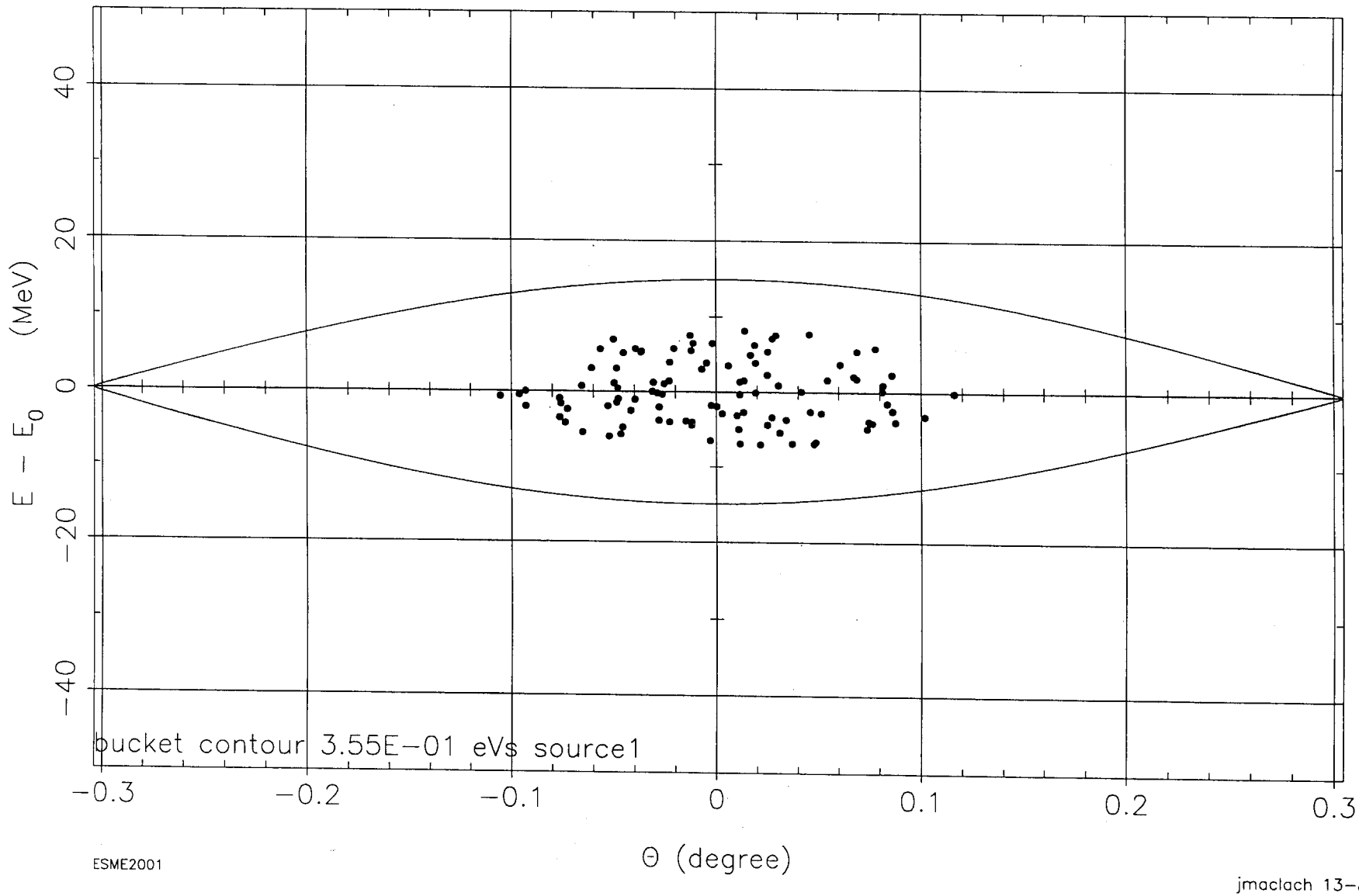
Chan4: RF Gap Envelope

10 May 2001
10:40:13

MI Slip Stacking

Iter 0 0.000E+00 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
1.4860E+01	3.5461E−01	8.9384E+03	588	2.000E−01	0.000E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η			
4.2711E−03	0.0000E+00	−8.6160E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	4.1204E−02	100			



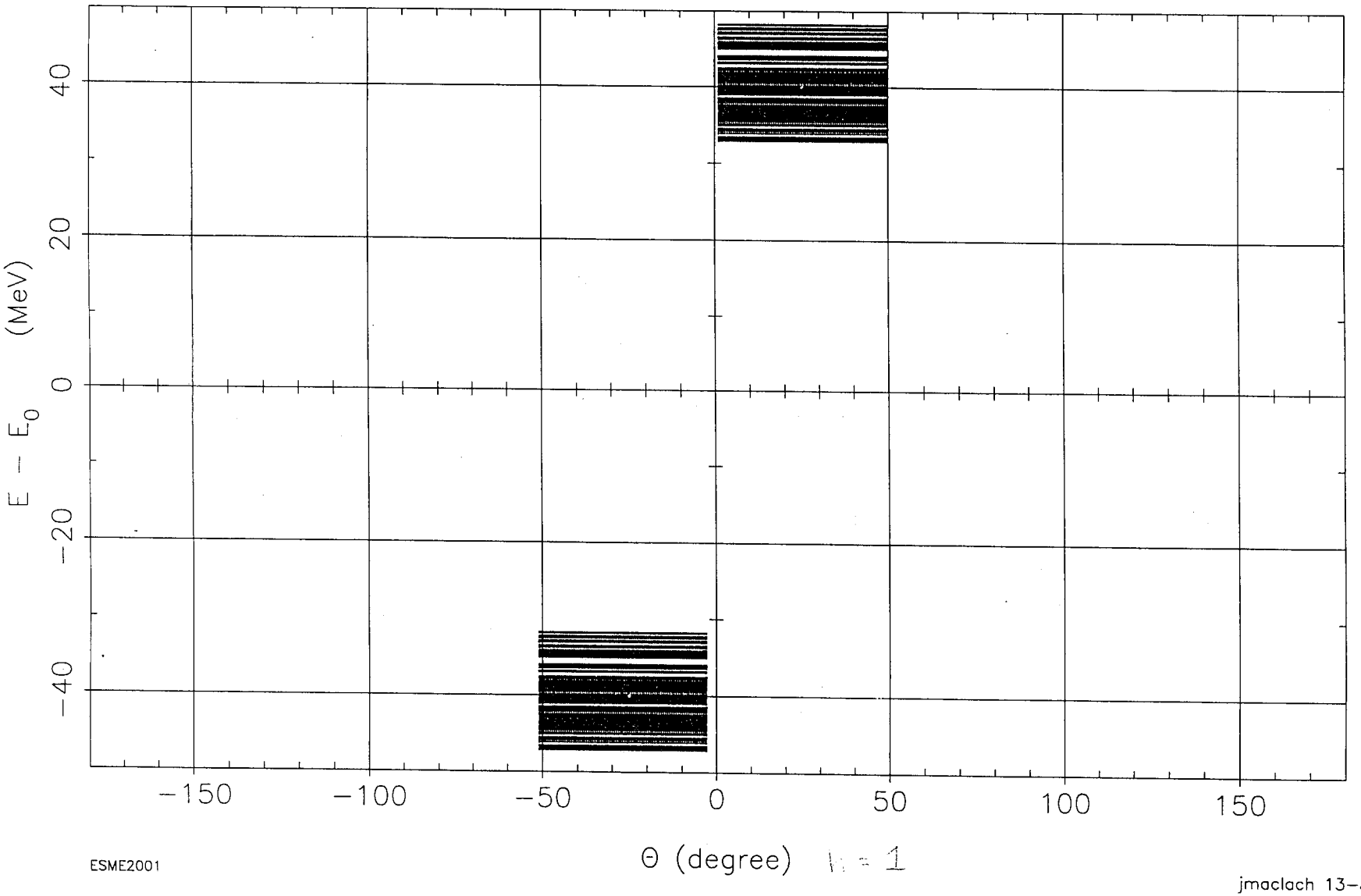
ESME2001

jmaclach 13−Jun−2001 06:10

MI Slip Stacking

Iter 0 0.000E+00 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
1.4905E+01	3.5944E−01	8.9384E+03	588	2.000E−01	0.000E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η			
4.2711E−03	0.0000E+00	−8.6160E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	1.1386E+02	16302			



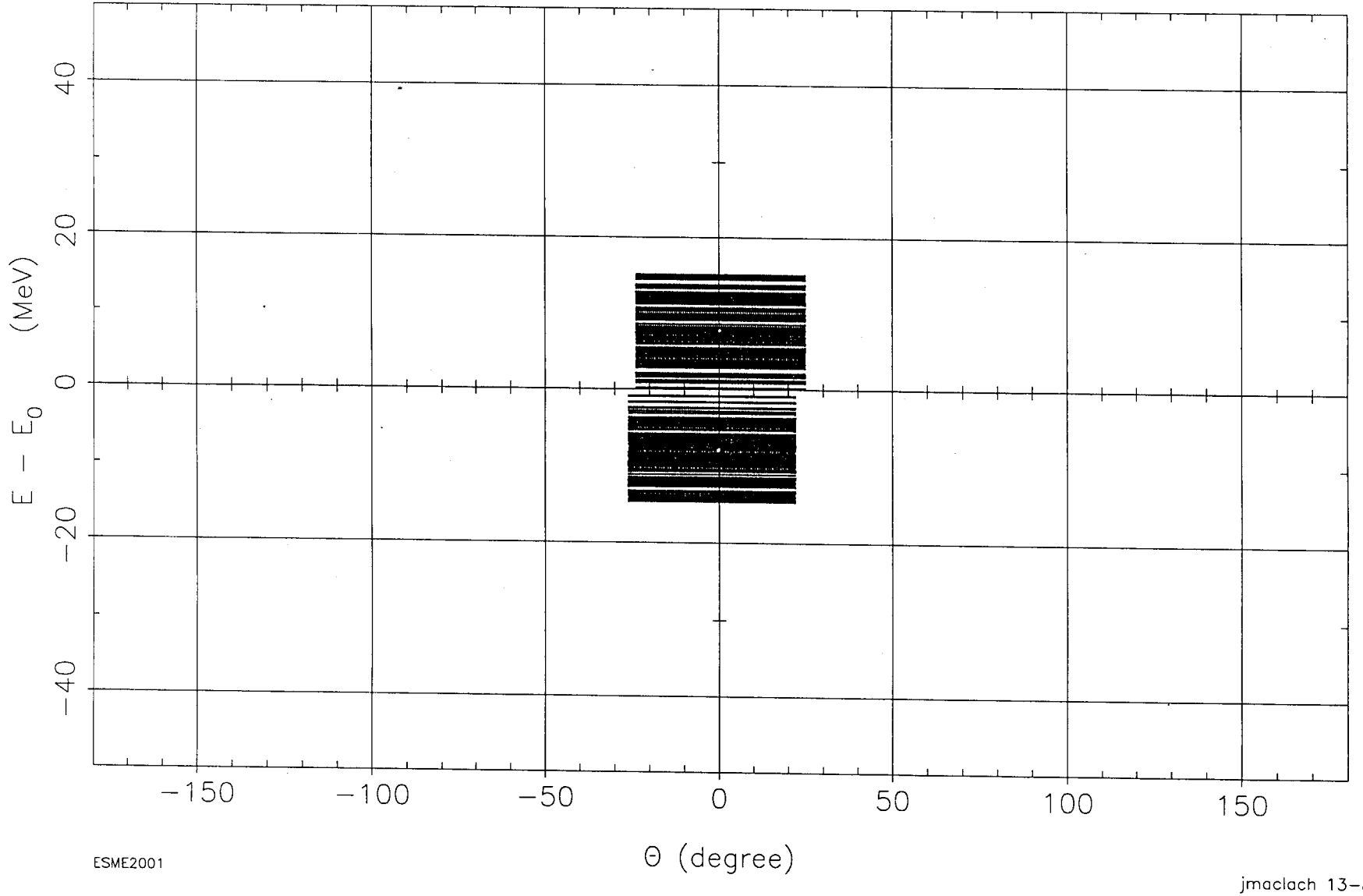
ESME2001

jmaclach 13−Jun−2001 06:10

MI Slip Stacking

Iter 2400 2.673E−02 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
6.2821E+00	8.8114E−02	8.9378E+03	588	1.024E−01	−1.422E+02
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	1.024E−01	1.506E+02
2.8534E−03	−1.1327E+03	−8.6175E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	2.5076E+01	16302			



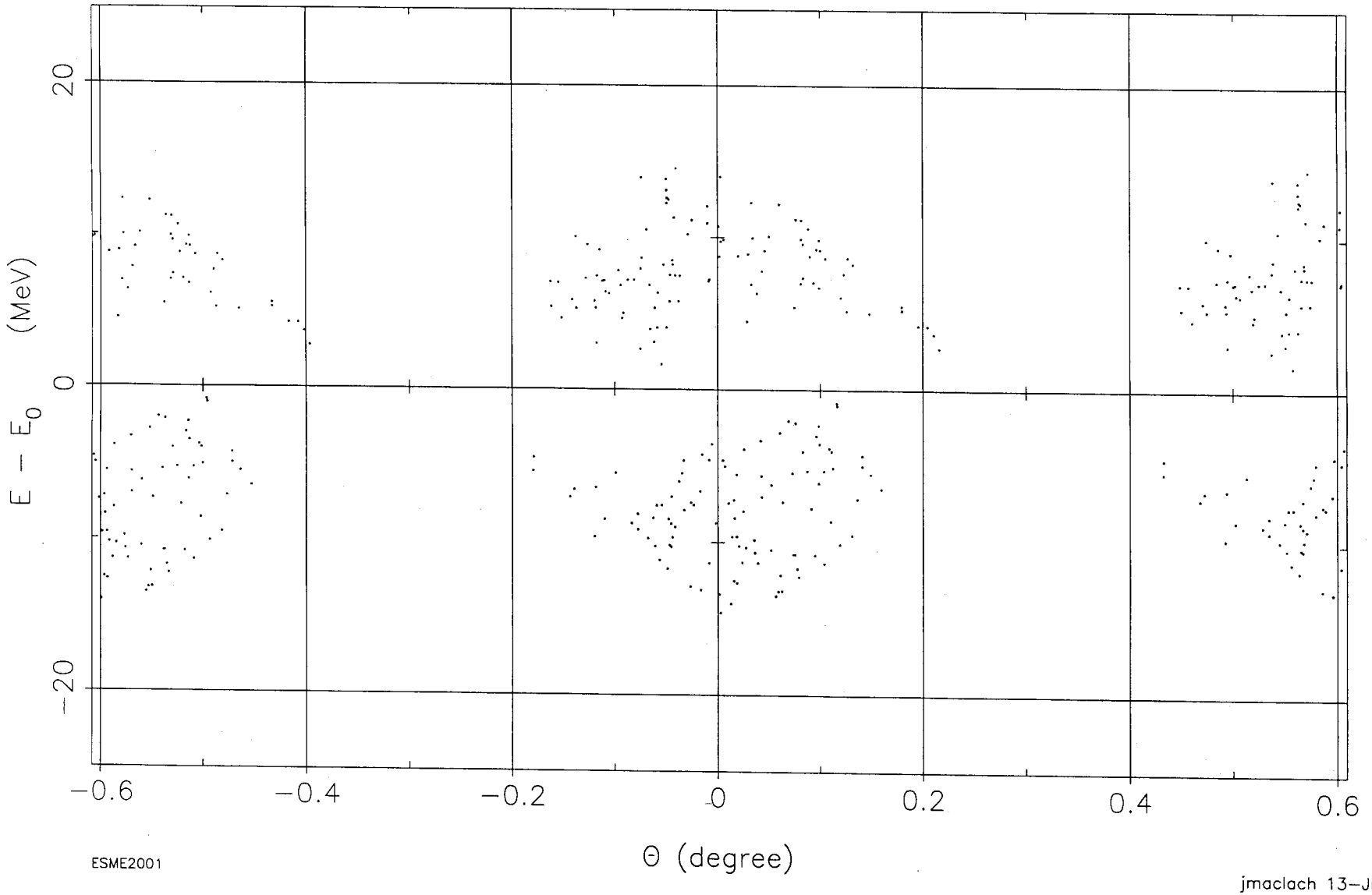
ESME2001

jmaclach 13−Jun−2001 06:11

MI Slip Stacking

Iter 2490 2.774E−02 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
7.5137E+00	1.2184E−01	8.9392E+03	588	1.000E−01	7.612E+00
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	1.000E−01	2.061E+01
2.9214E−03	4.3732E+03	−8.6139E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	6.2340E−01	399			



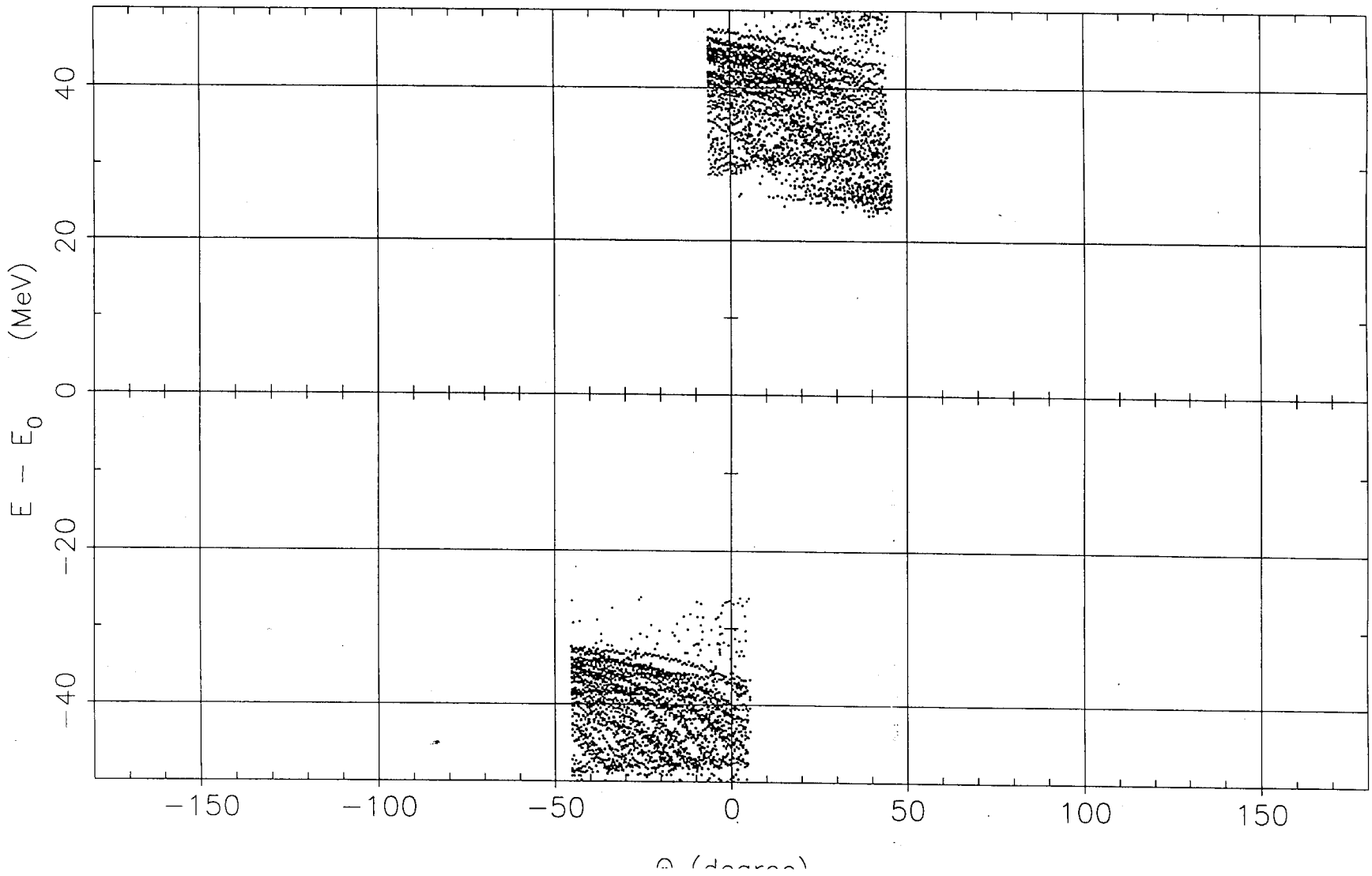
ESME2001

jmaclach 13−Jun−2001 06:11

MI Slip Stacking

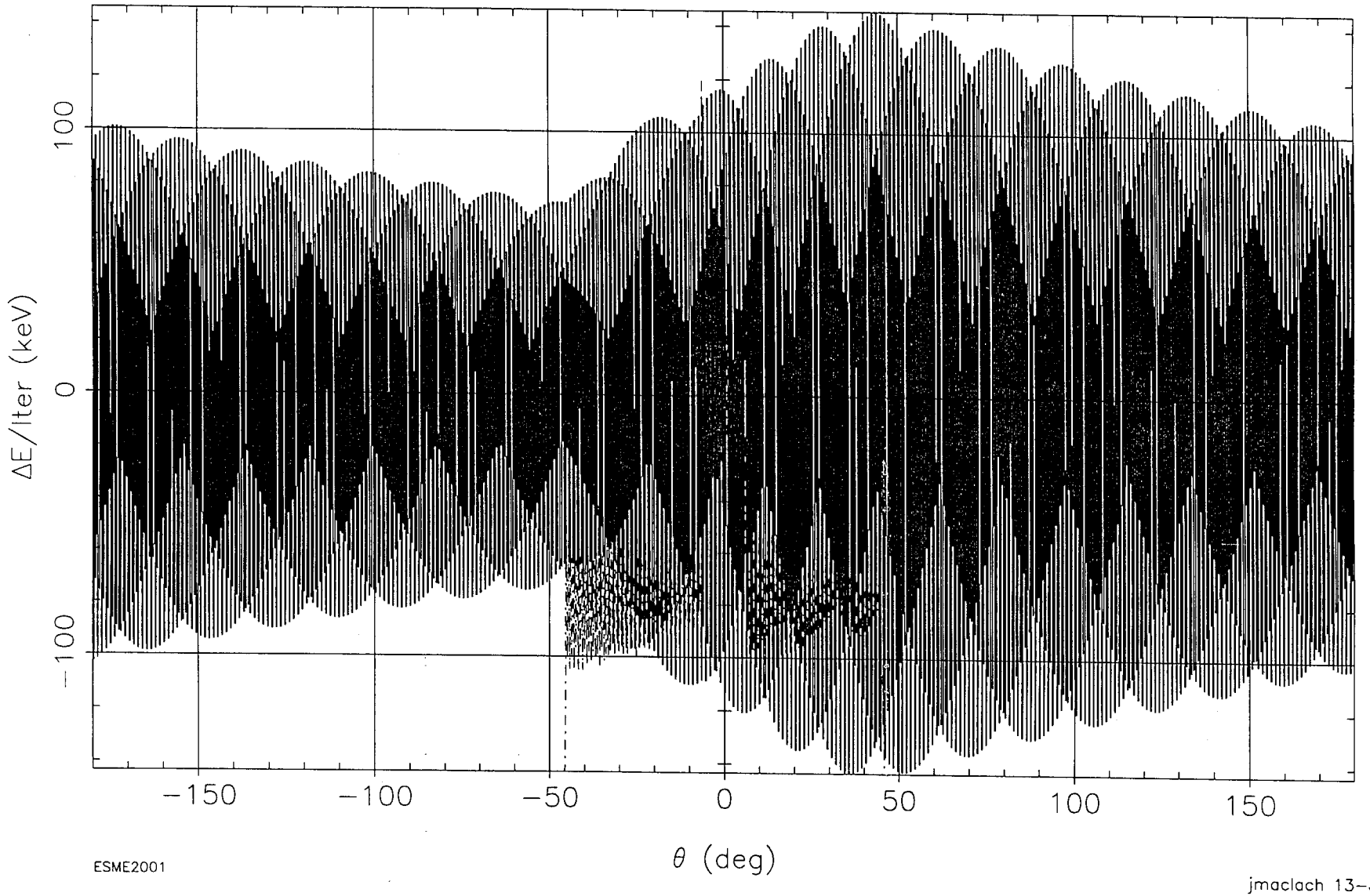
Iter 400 4.456E−03 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
7.0052E+00	8.4849E−02	8.9386E+03	588	1.837E−01	3.939E+01
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	1.837E−01	−3.695E+01
3.6596E−03	5.5517E+02	−8.6155E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	1.1858E+02	58428			



MI Slip Stacking

Iter 400
4.456E−03 SEC



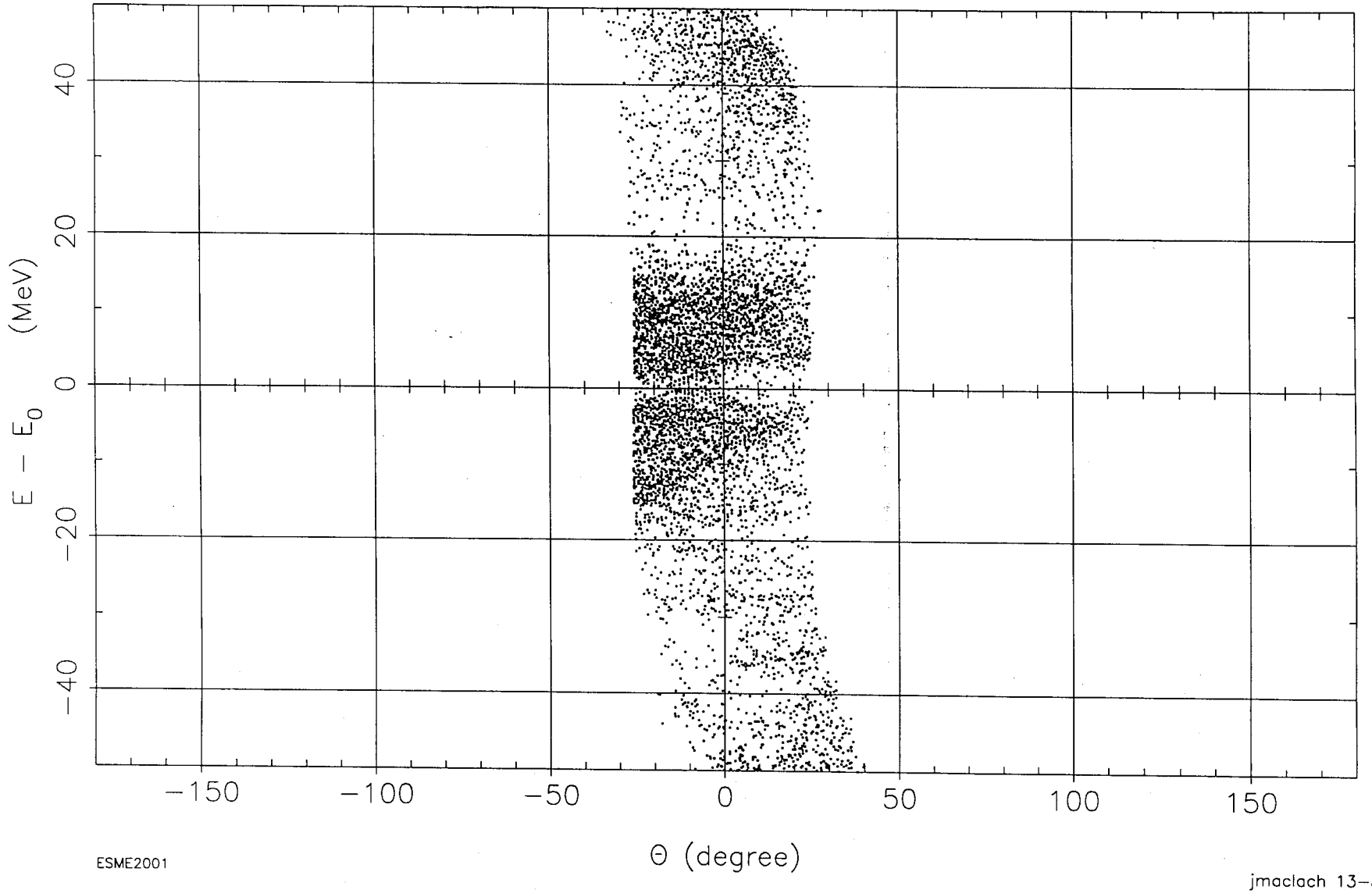
ESME2001

jmaclach 13−Jun−2001 06:59

MI Slip Stacking

Iter 2400 2.673E−02 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
6.2821E+00	8.8114E−02	8.9378E+03	588	1.024E−01	−1.422E+02
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	1.024E−01	1.506E+02
2.8534E−03	−1.1327E+03	−8.6175E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	7.1111E+01	58913			



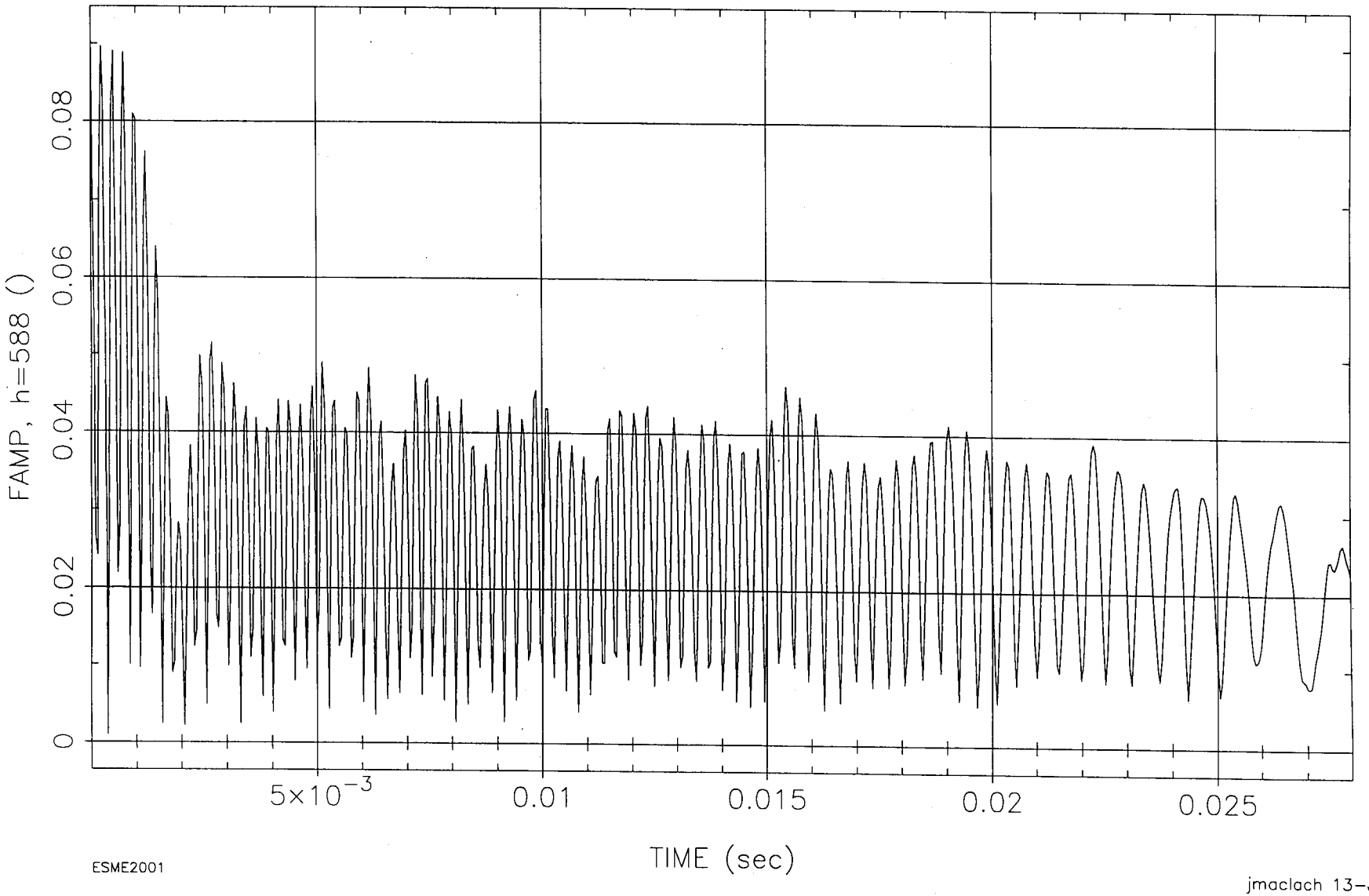
ESME2001

jmaclach 13−Jun−2001 07:16

MI Slip Stacking

FAMP, h=588 VS TIME

Beam Current



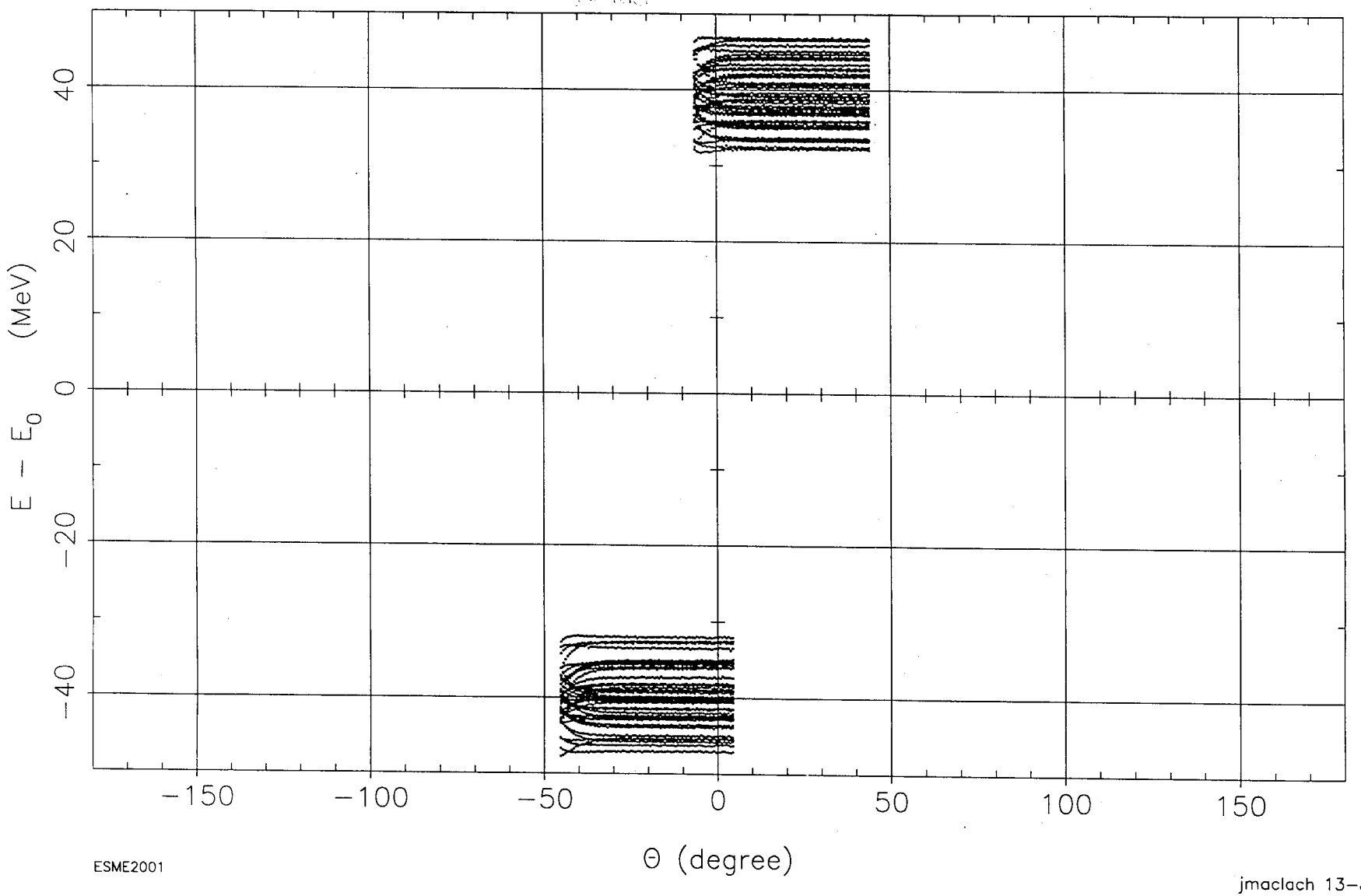
ESME2001

jmaclach 13-Jun-2001 07:17

MI Slip Stacking

Iter 400 4.456E−03 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
7.0052E+00	8.4849E−02	8.9386E+03	588	1.837E−01	3.939E+01
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	1.837E−01	−3.695E+01
3.6596E−03	5.5517E+02	−8.6155E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	1.1430E+02	66402			

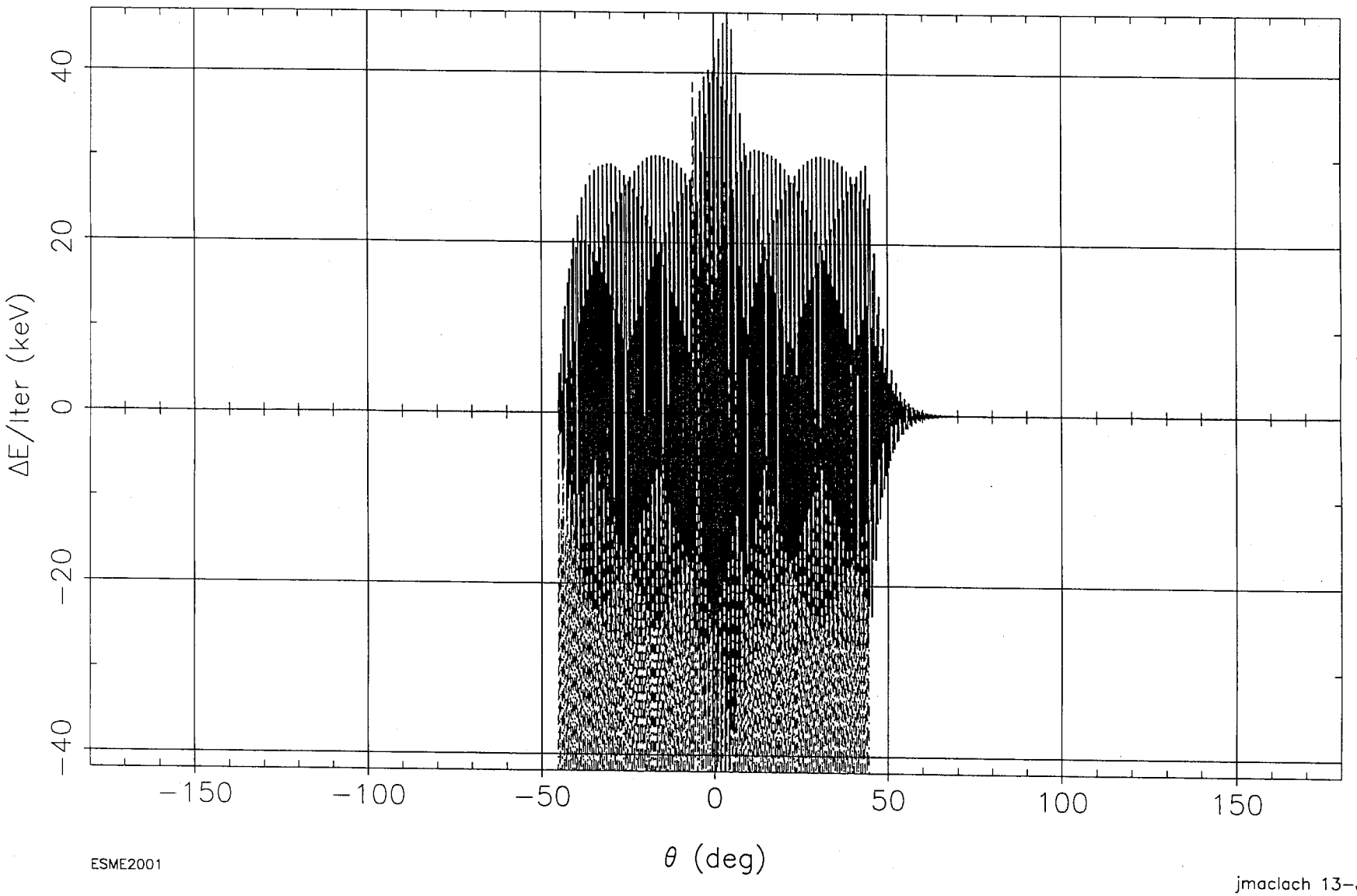


ESME2001

jmaclach 13−Jun−2001 07:30

MI Slip Stacking

Iter 400
4.456E−03 SEC



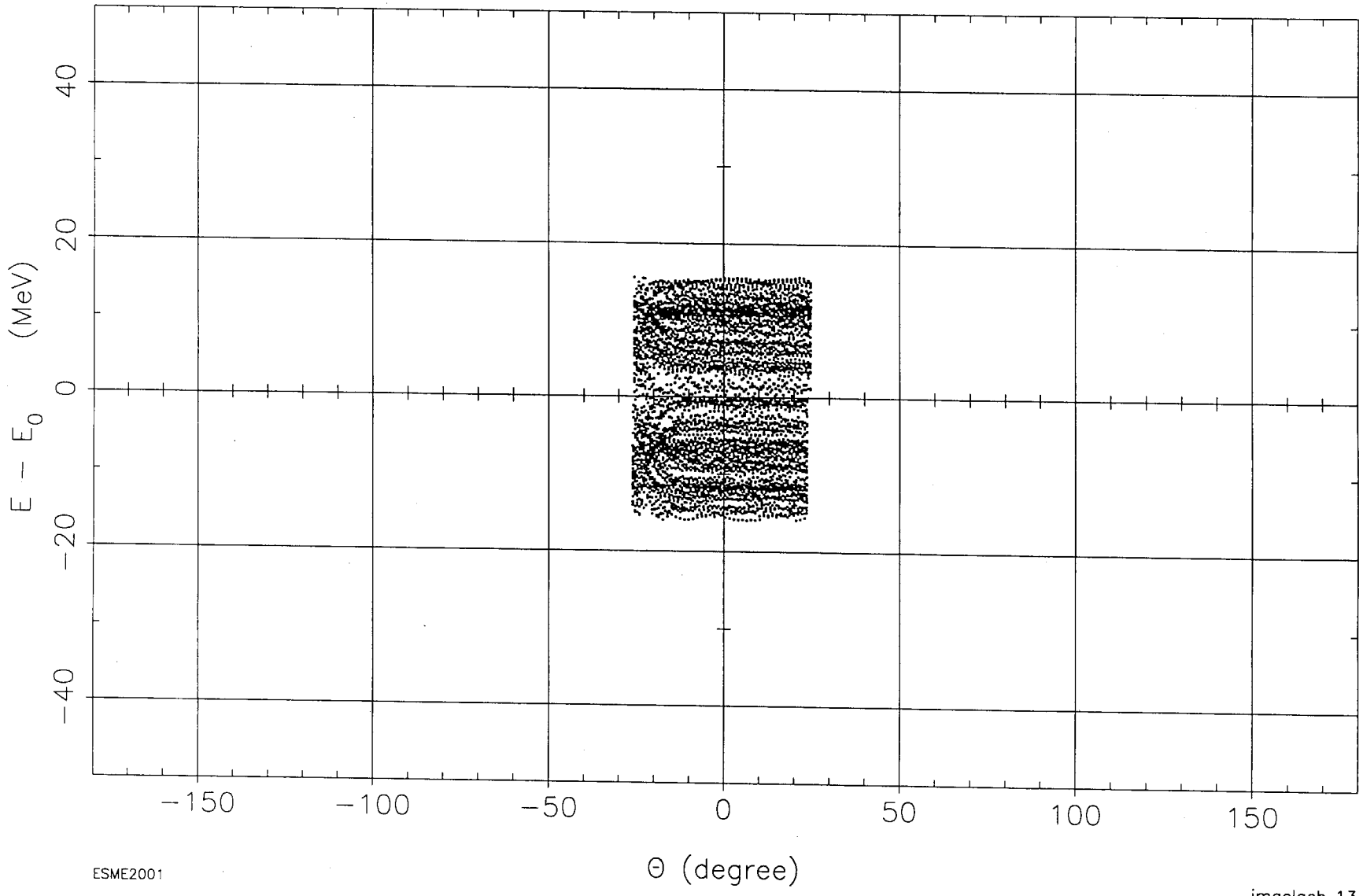
ESME2001

jmaclach 13−Jun−2001 07:30

MI Slip Stacking

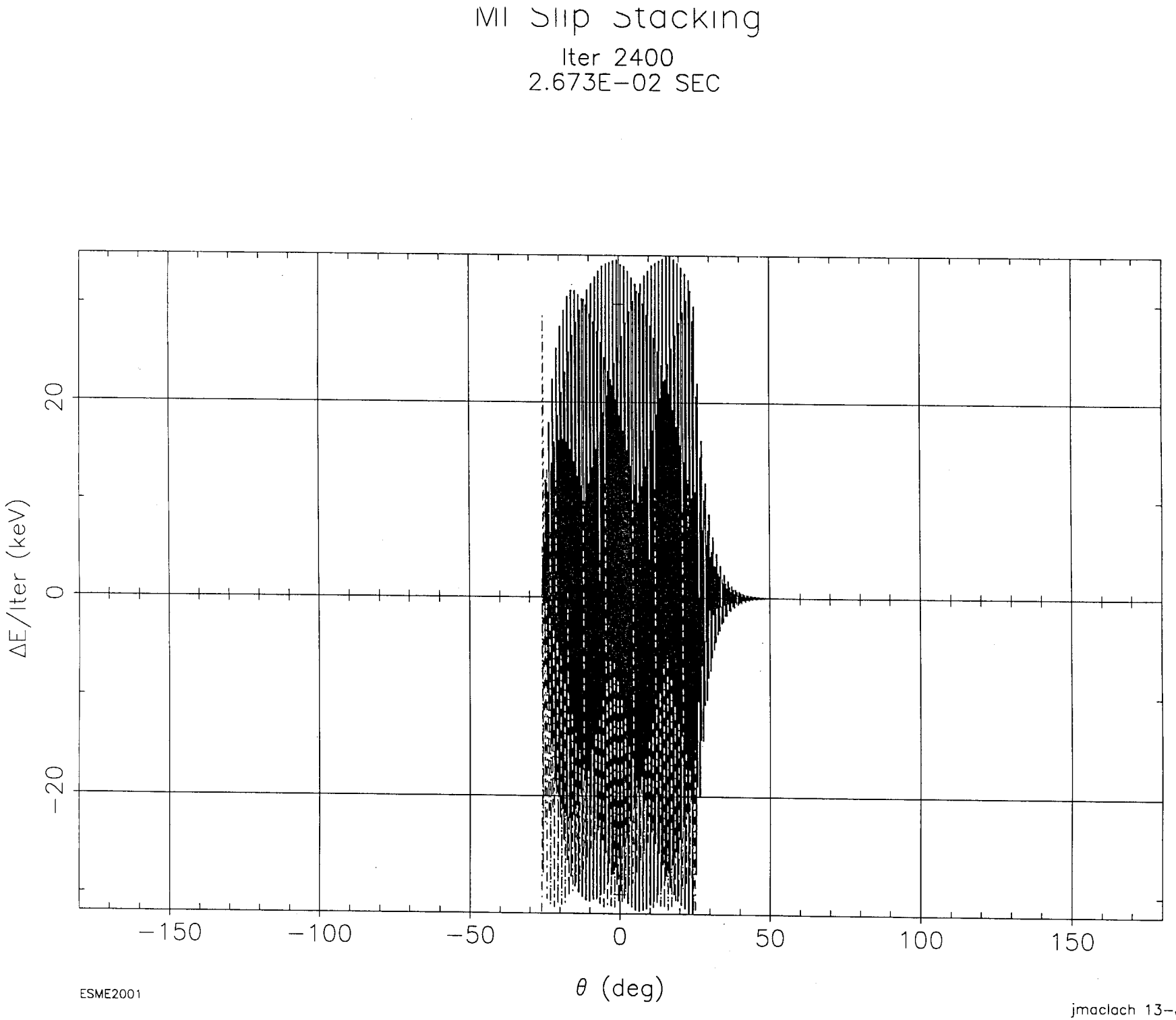
Iter 2400 2.673E−02 sec

H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
6.2821E+00	8.8114E−02	8.9378E+03	588	1.024E−01	−1.422E+02
ν_S (turn^{-1})	pdot (MeV s^{-1})	η	588	1.024E−01	1.506E+02
2.8534E−03	−1.1327E+03	−8.6175E−03			
τ (s)	S_b (eV s)	N			
1.1140E−05	2.6237E+01	66402			

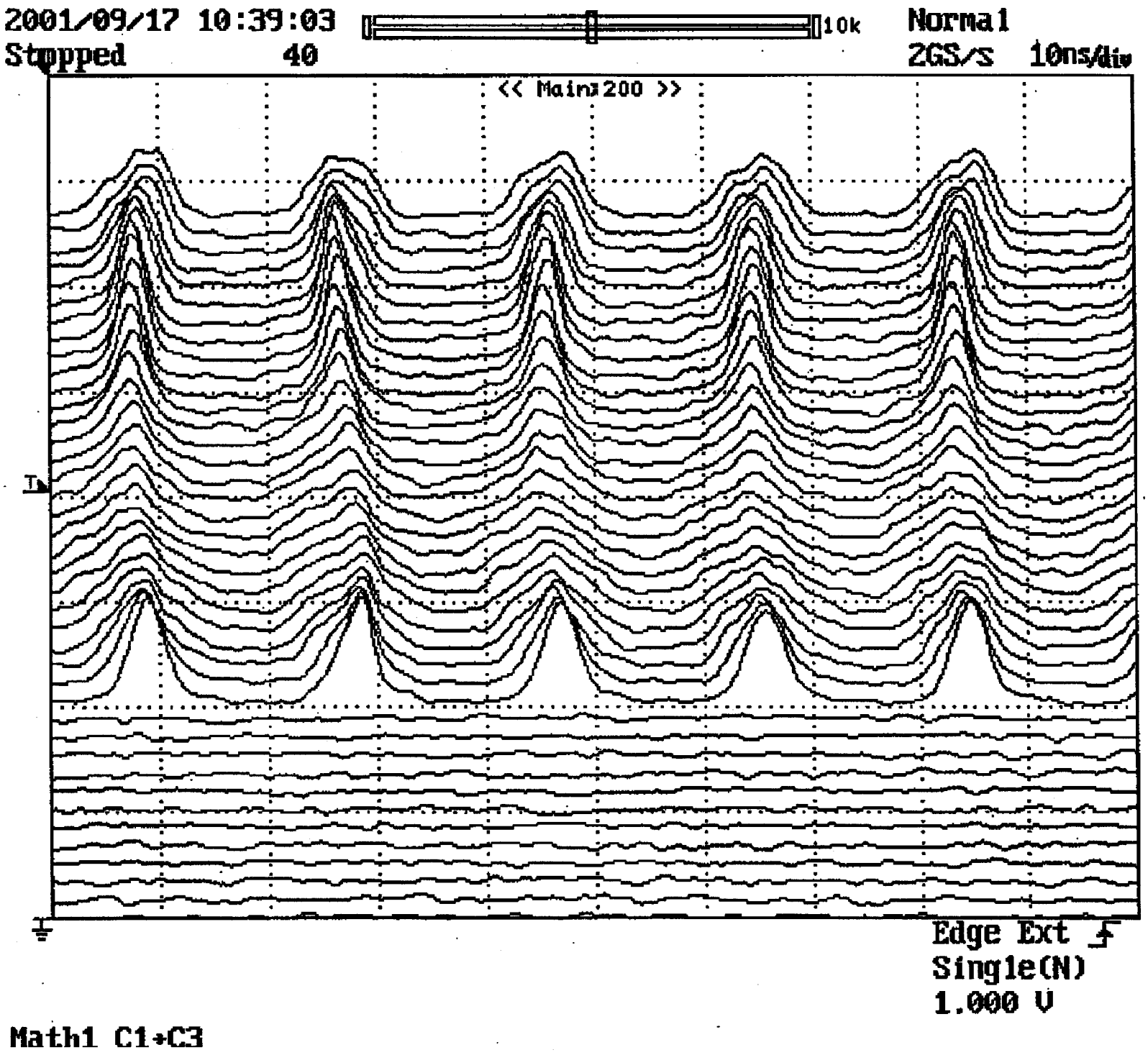


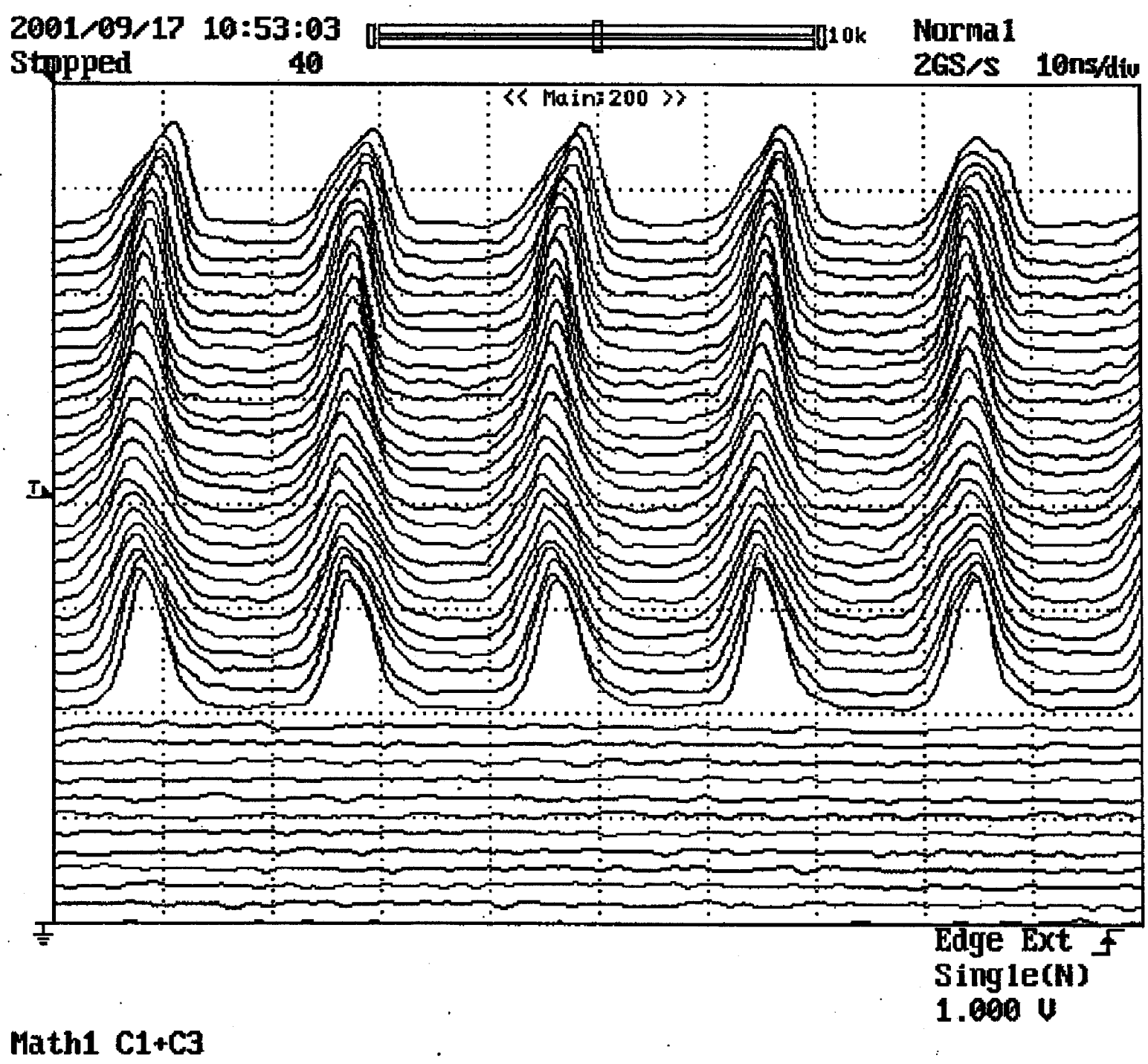
ESME2001

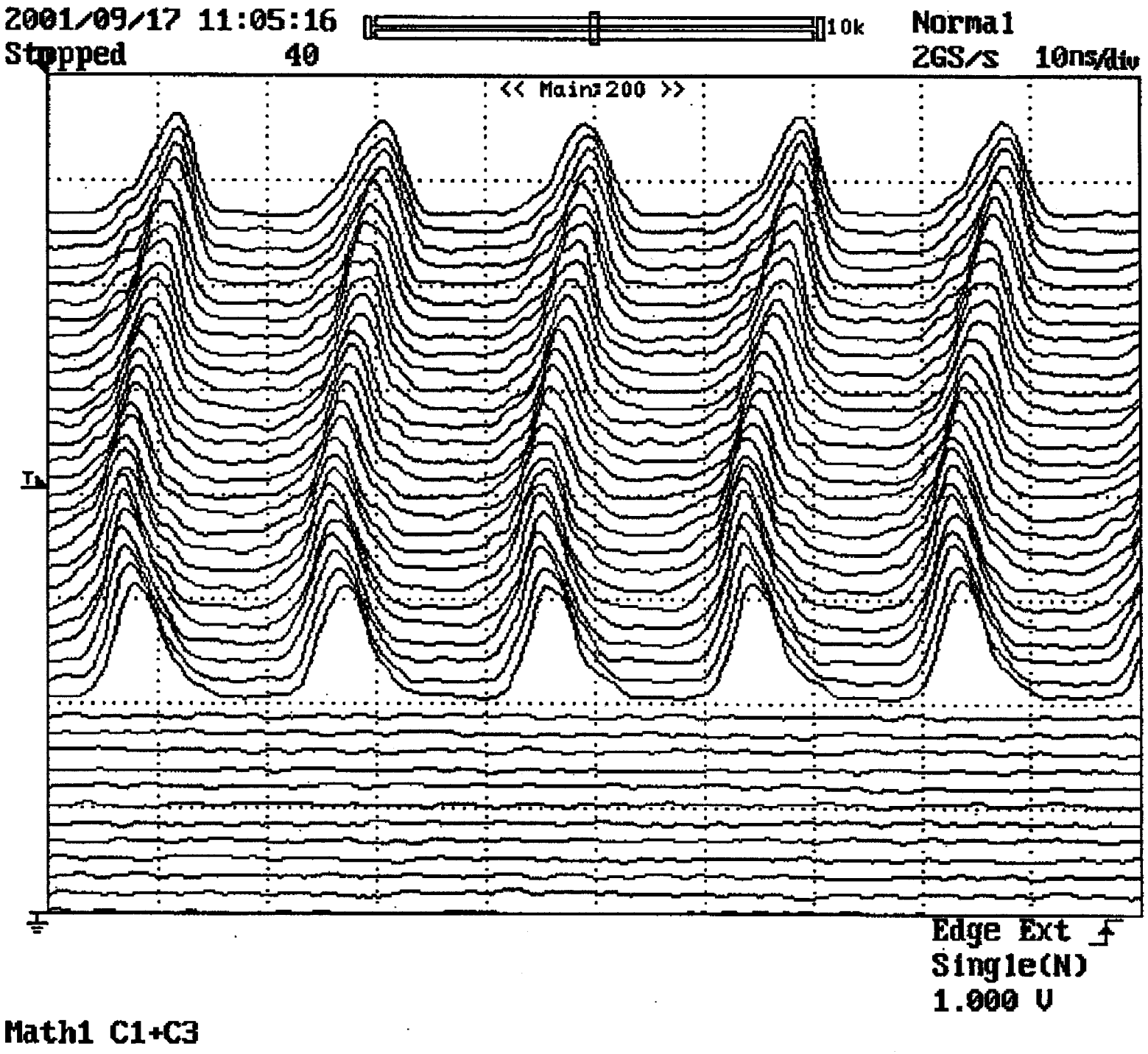
jmaclach 13−Jun−2001 07:34

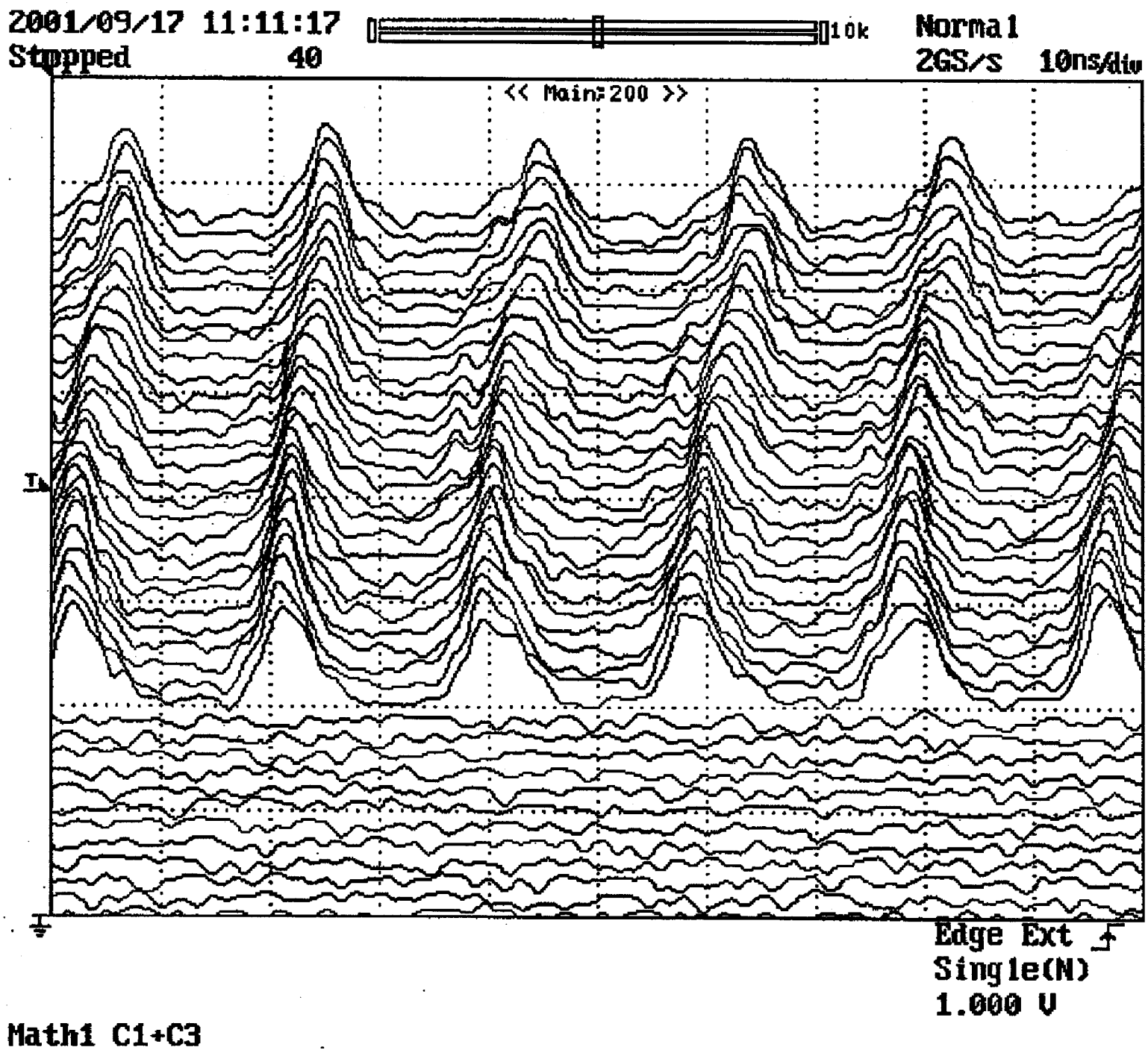


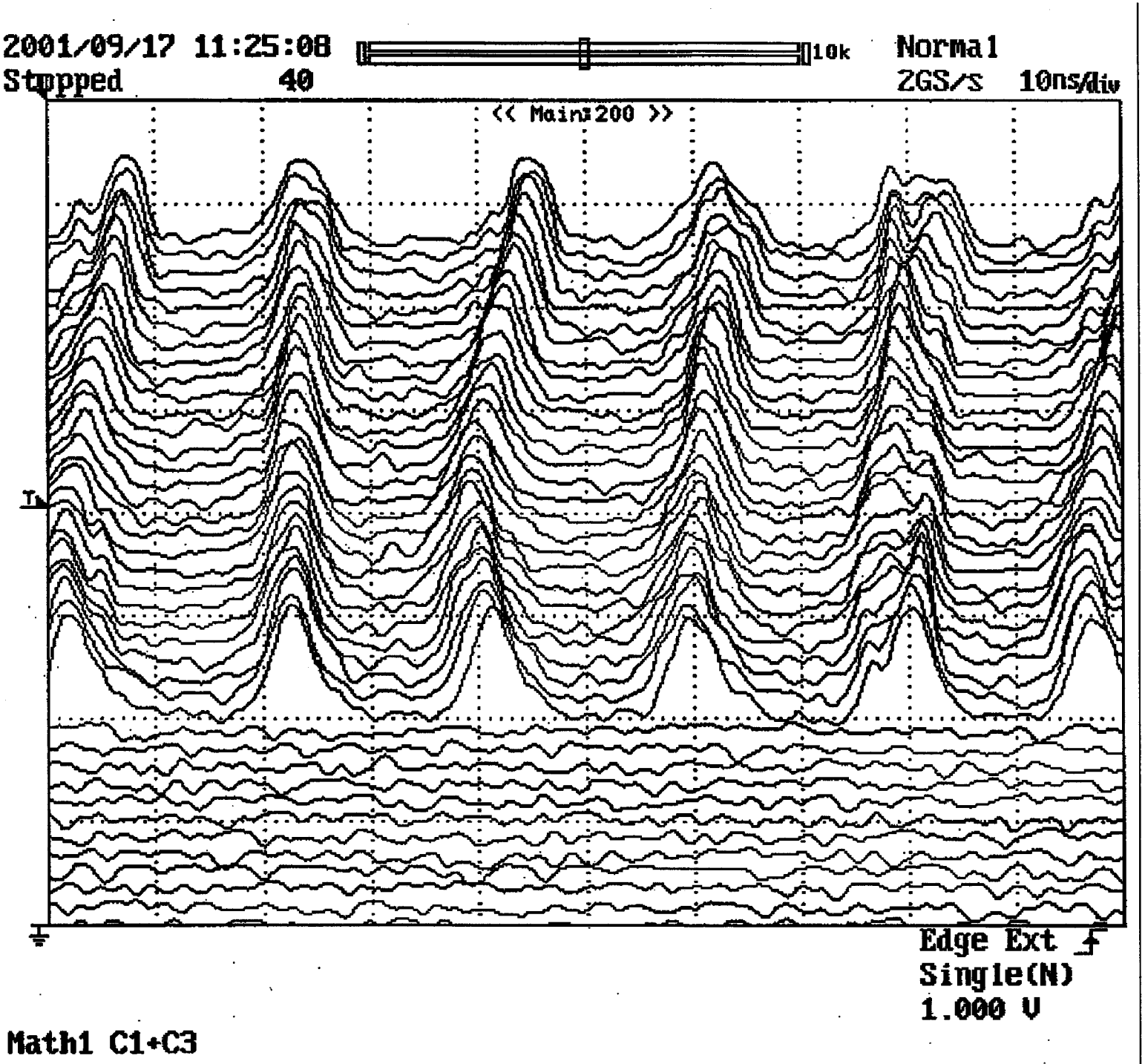
jmaclach 13-Jun-2001 07:34


2001/09/17 10:39:03
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V
Math1 C1+C3


2001/09/17 10:53:03
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V
Math1 C1+C3


2001/09/17 11:05:16
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V
Math1 C1+C3

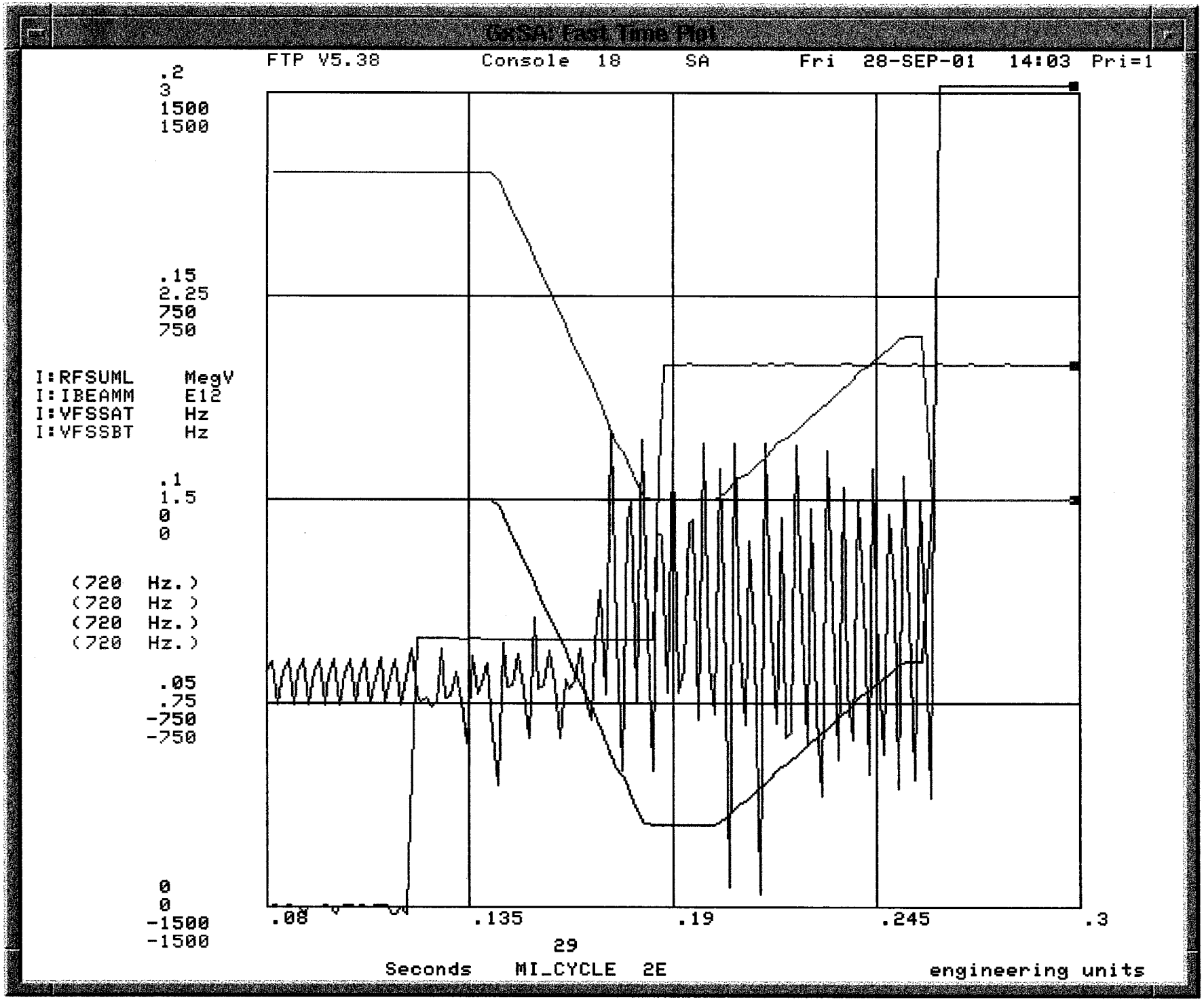

2001/09/17 11:11:17
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V
Math1 C1+C3

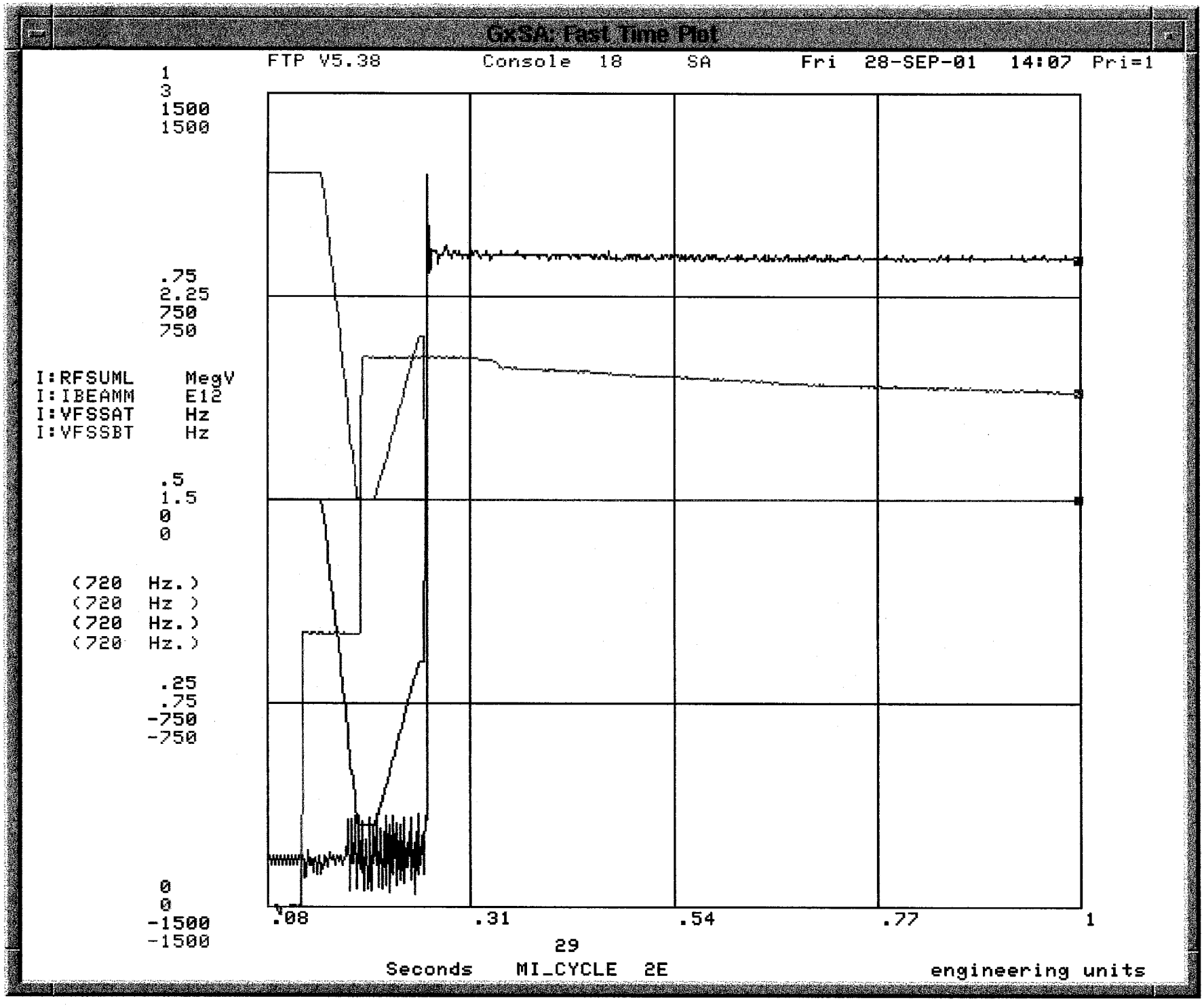

2001/09/17 11:25:08
Stopped 40
10k
Normal
2GS/s 10ns/div
<< Main:200 >>
Edge Ext
Single(N)
1.000 V
Math1 C1+C3

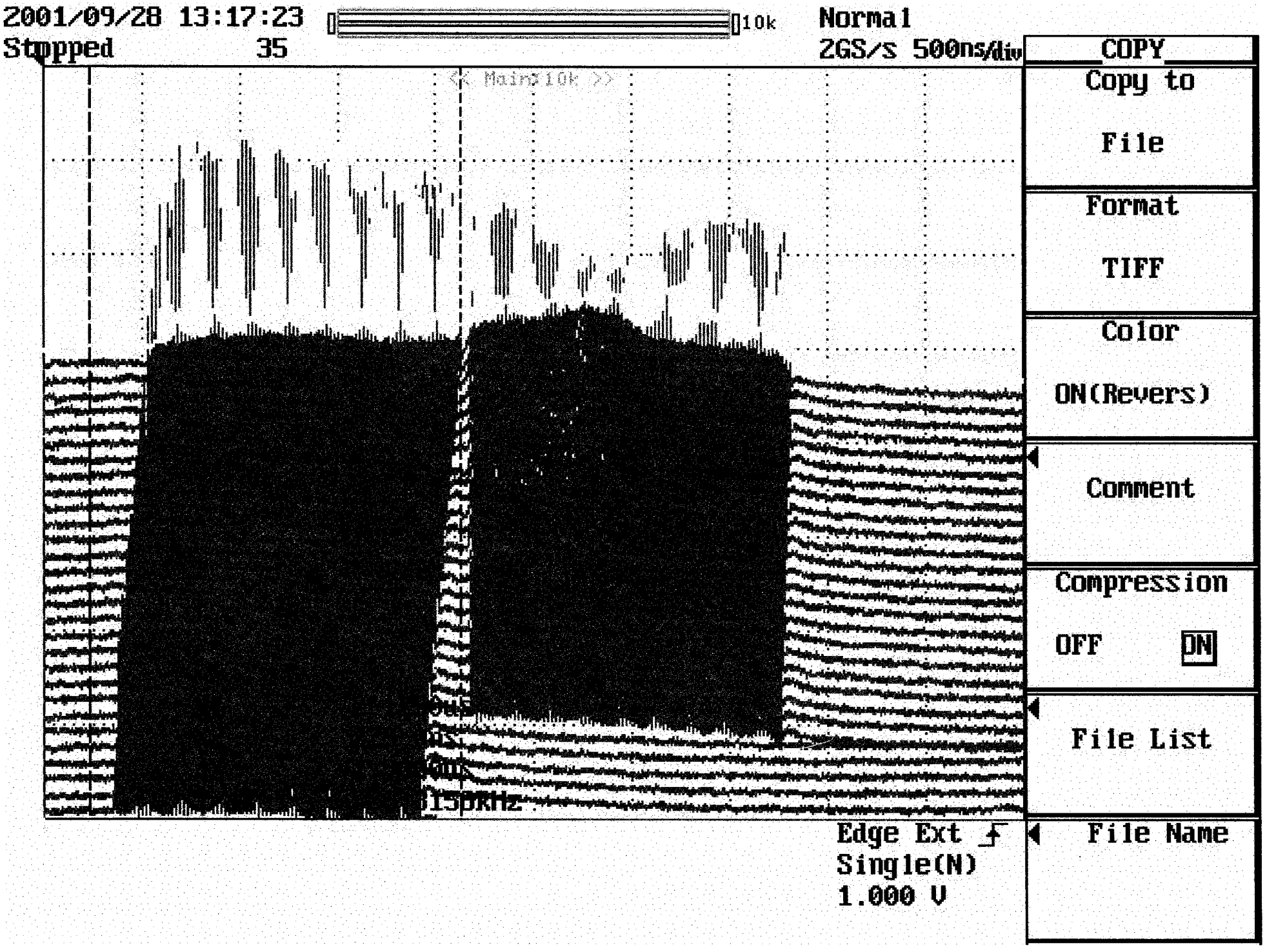
Next Studies

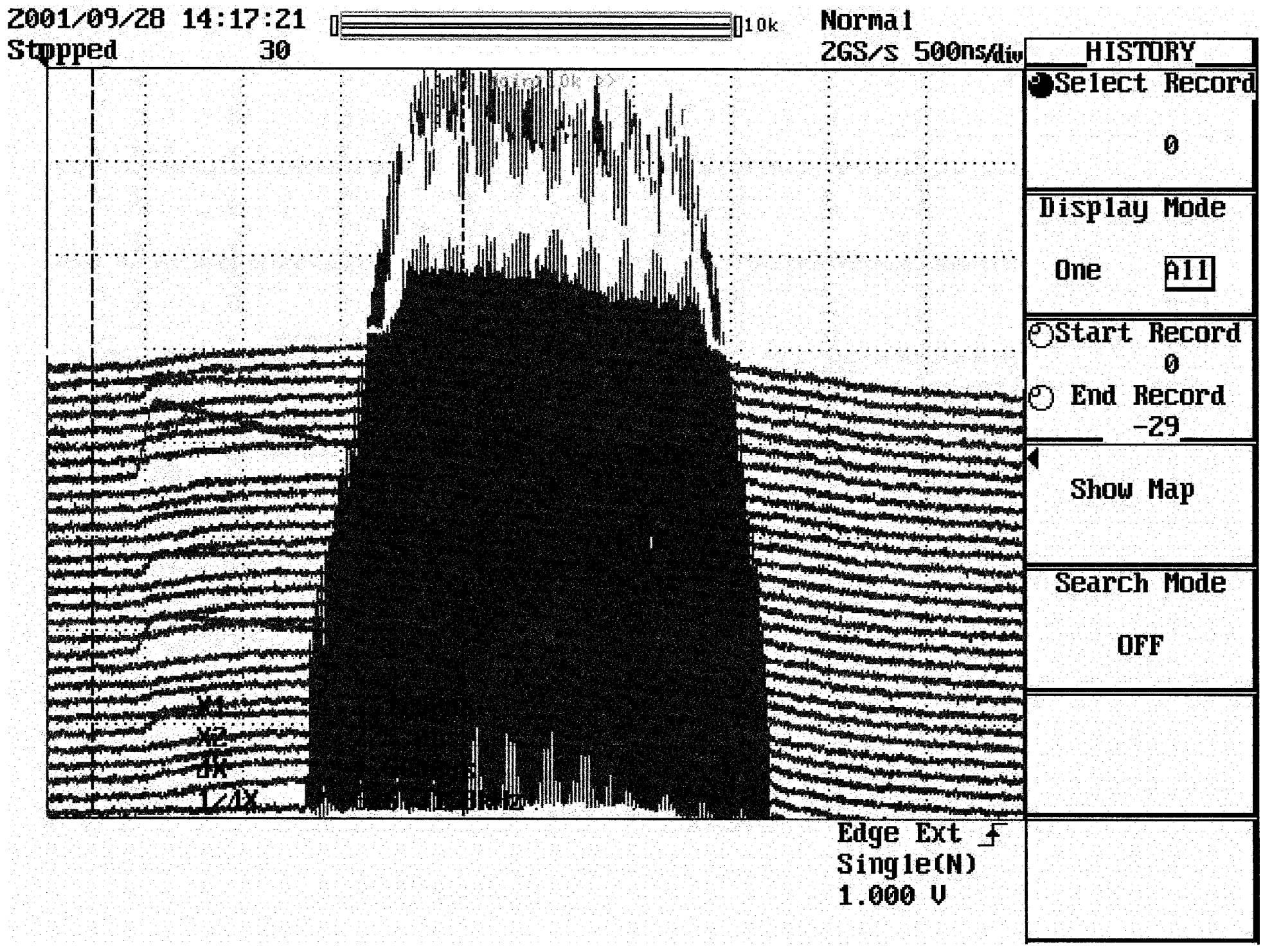
- Second batch injection and slipping
- Capture
- Intensity limitations/ Beam loading
- Acceleration

- Feedforward Commissioning

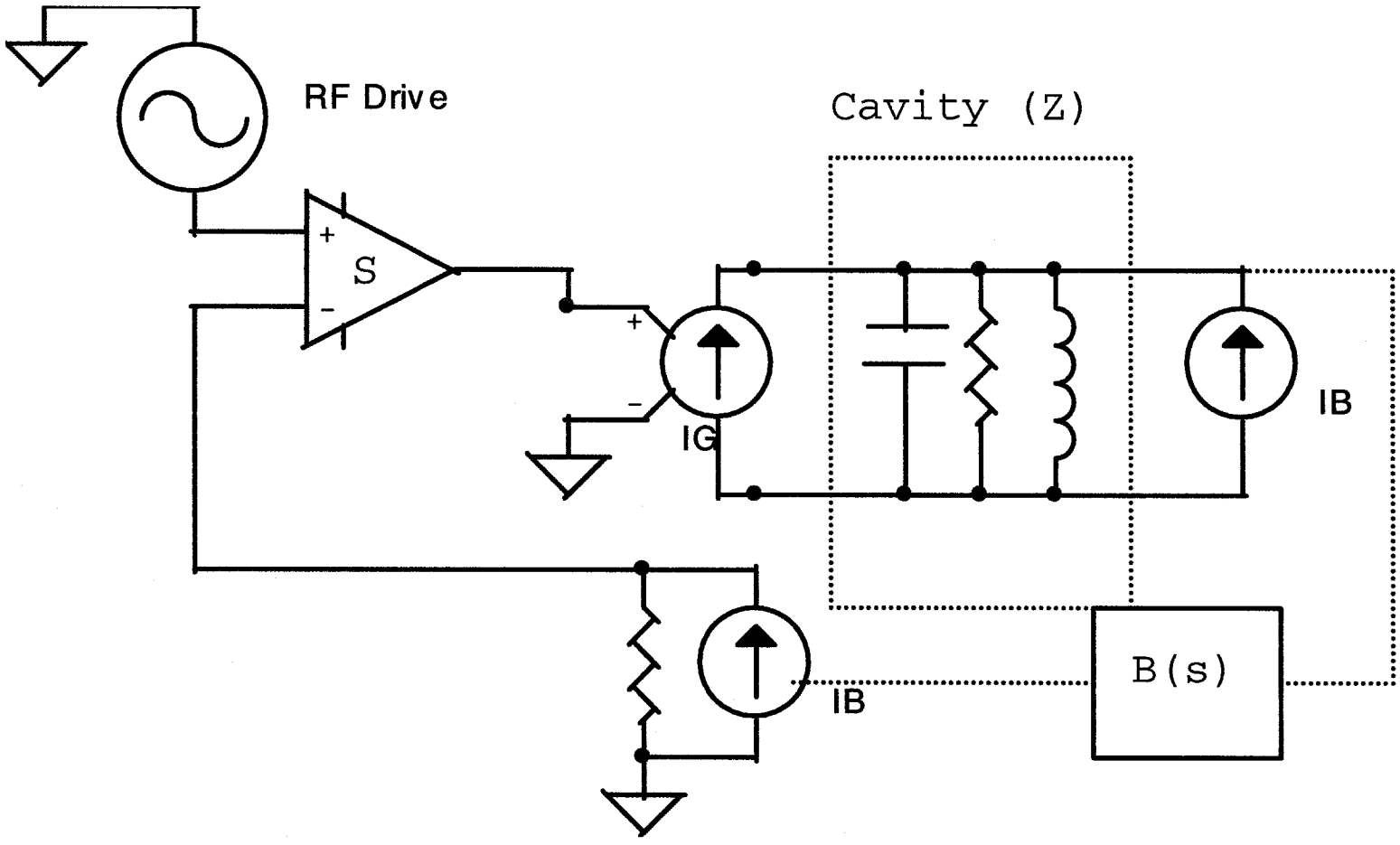

GASA: Fast Time Plot
FTP V5.38 Console 18 SA Fri 28-SEP-01 14:03 Pri=1
.2
3
1500
1500
.15
2.25
750
750
I:RFSUML MegV
I:IBEAMM E12
I:VFSSAT Hz
I:VFSSBT Hz
.1
1.5
0
0
(720 Hz.)
(720 Hz)
(720 Hz.)
(720 Hz.)
.05
.75
-750
-750
0
0
-1500
-1500
.08
.135
.19
.245
.3
29
Seconds MI_CYCLE 2E
engineering units


GxSA: Fast Time Plot
FTP V5.38 Console 18 SA Fri 28-SEP-01 14:07 Pri=1
1
3
1500
1500
.75
2.25
750
750
I:RFSUML MegV
I:IBEAMM E12
I:VFSSAT Hz
I:VFSSBT Hz
.5
1.5
0
0
(720 Hz.)
(720 Hz)
(720 Hz.)
(720 Hz.)
.25
.75
-750
-750
0
0
-1500
-1500
.08
.31
.54
.77
1
29
Seconds MI_CYCLE 2E
engineering units

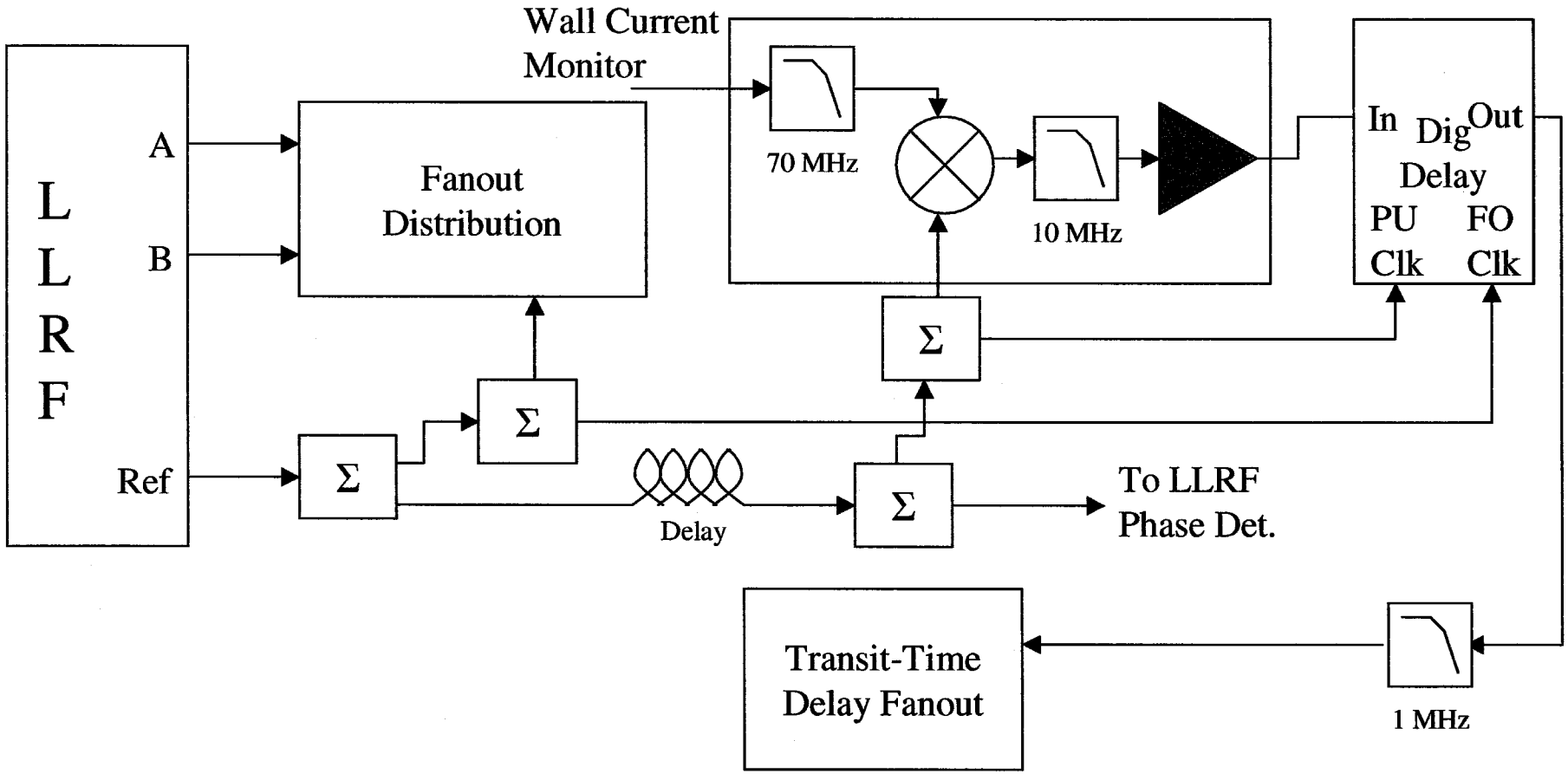

2001/09/28 13:17:23
Stopped 35
10k
Normal
2GS/s 500ns/div
<< Main:10k >>
Edge Ext
Single(N)
1.000 V
COPY
Copy to File
Format TIFF
Color ON(Revers)
Comment
Compression OFF ON
File List
File Name


2001/09/28 14:17:21
Stopped 30
10k
Normal
2GS/s 500ns/div
HISTORY
Select Record
0
Display Mode
One
All
Start Record
0
End Record
-29
Show Map
Search Mode
OFF
Edge Ext
Single(N)
1.000 V

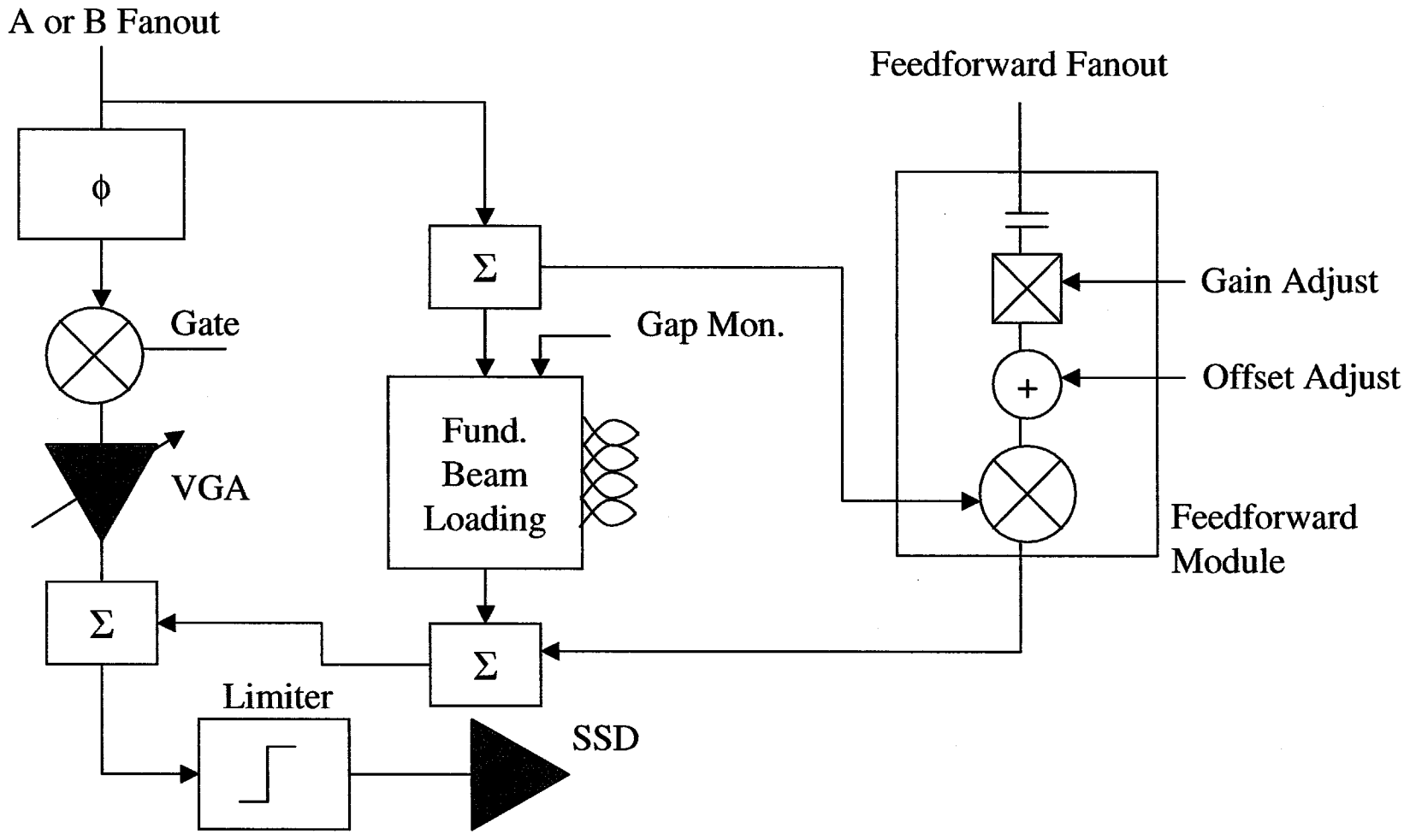
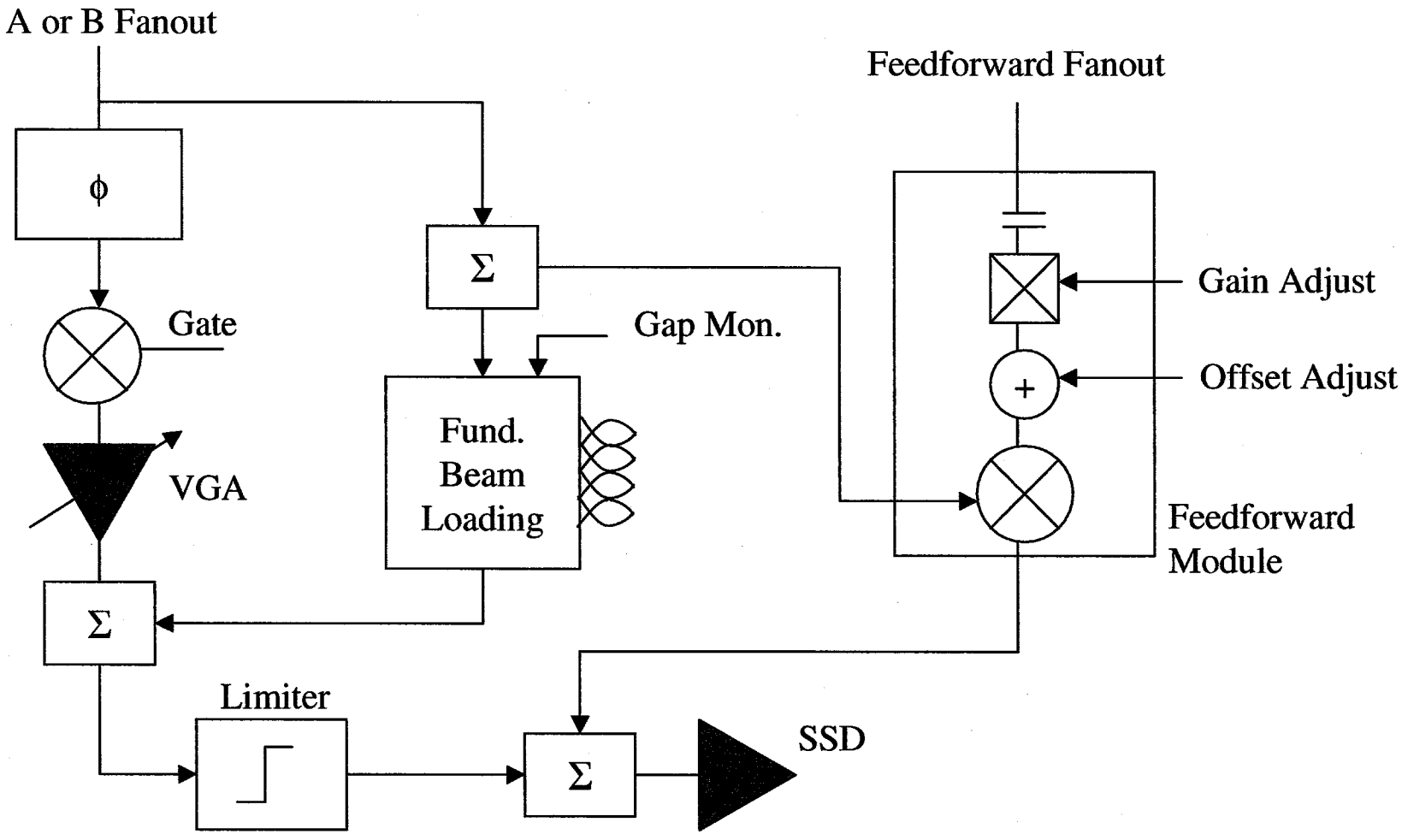
Feedforward



MI-60 Configuration



Cavity Configuration



Cavity Configuration