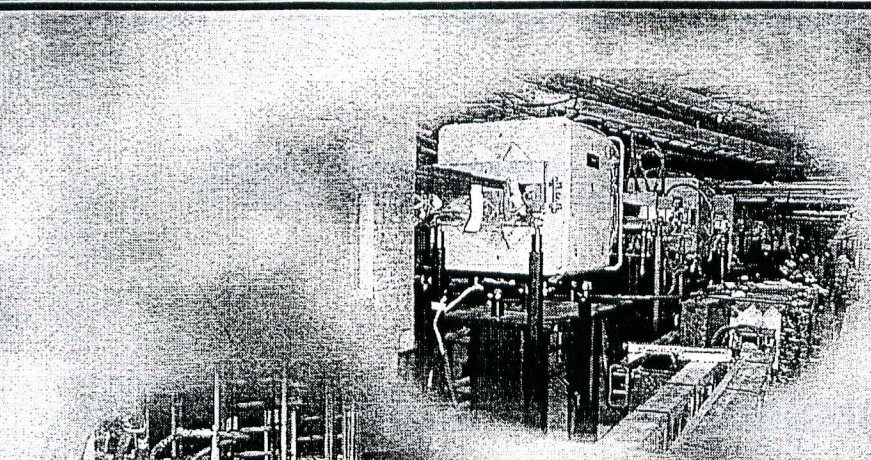
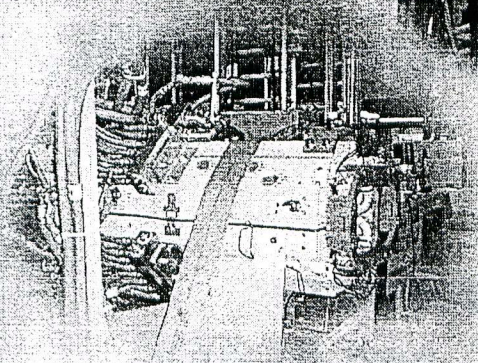
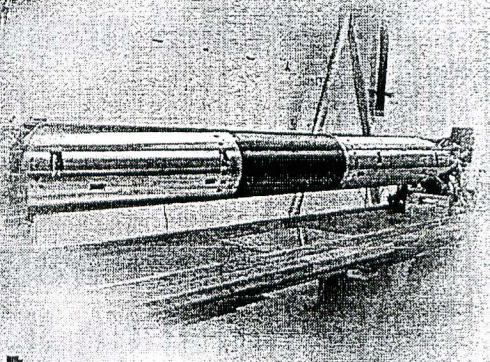


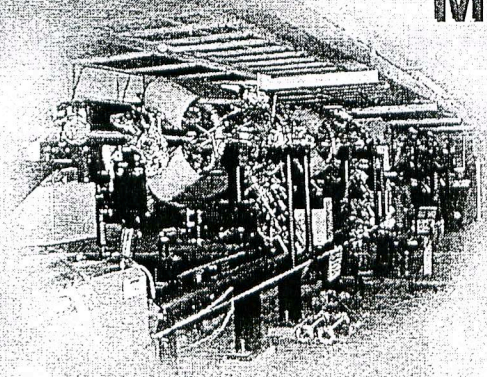


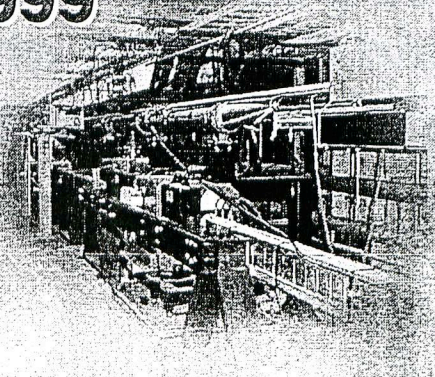


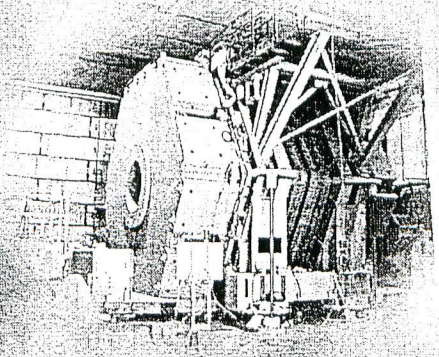
PEP-II
Status & Plans

John Seeman

Visit to KEK
March, 1999







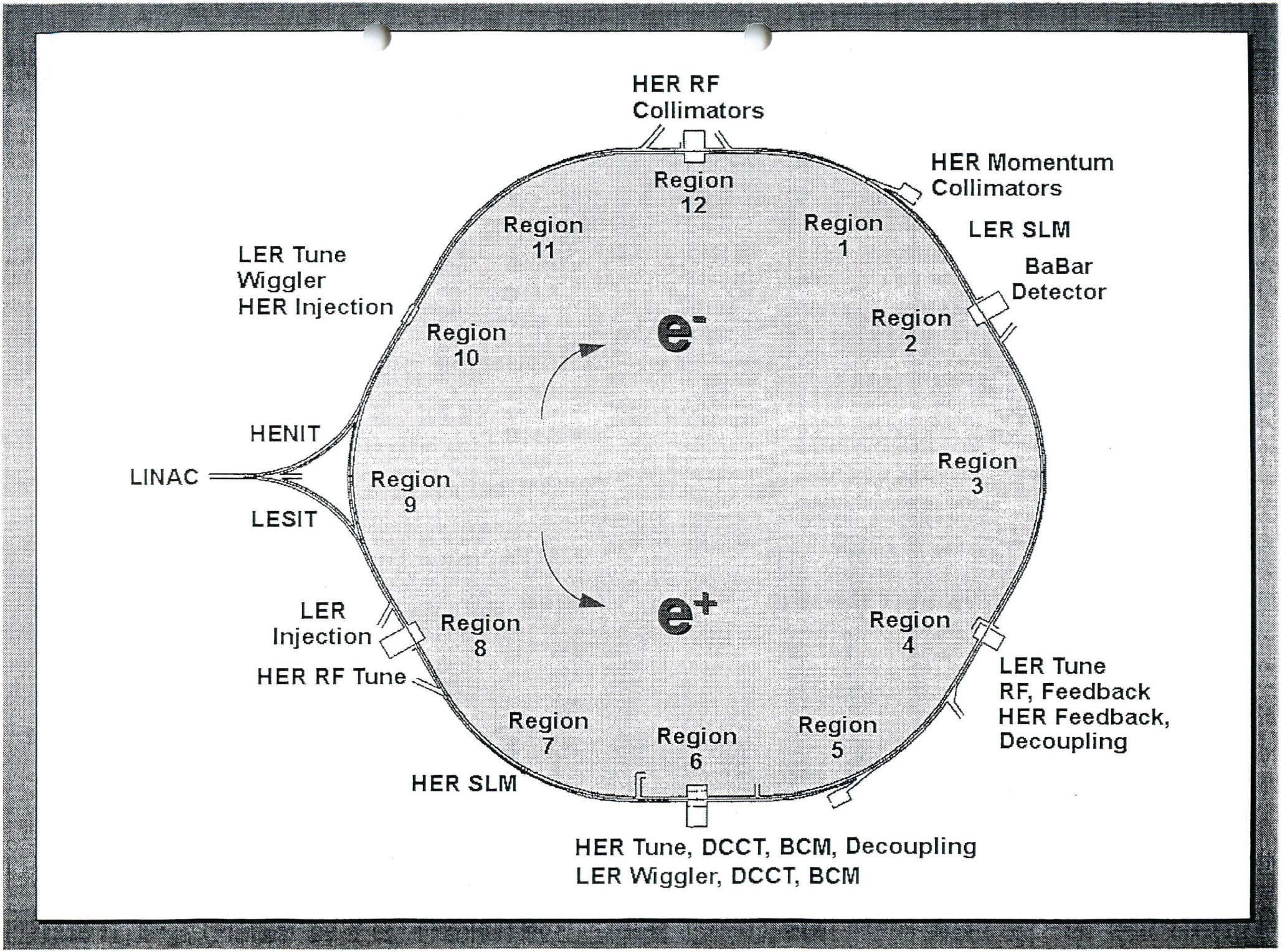
PEP-II Construction

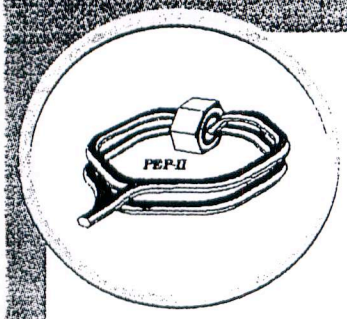
The PEP-II project started construction in 1993.

The project was a three laboratory collaboration (LLNL, LBNL, and SLAC).

This collaboration was strong and worked well. It is a good model for future projects.

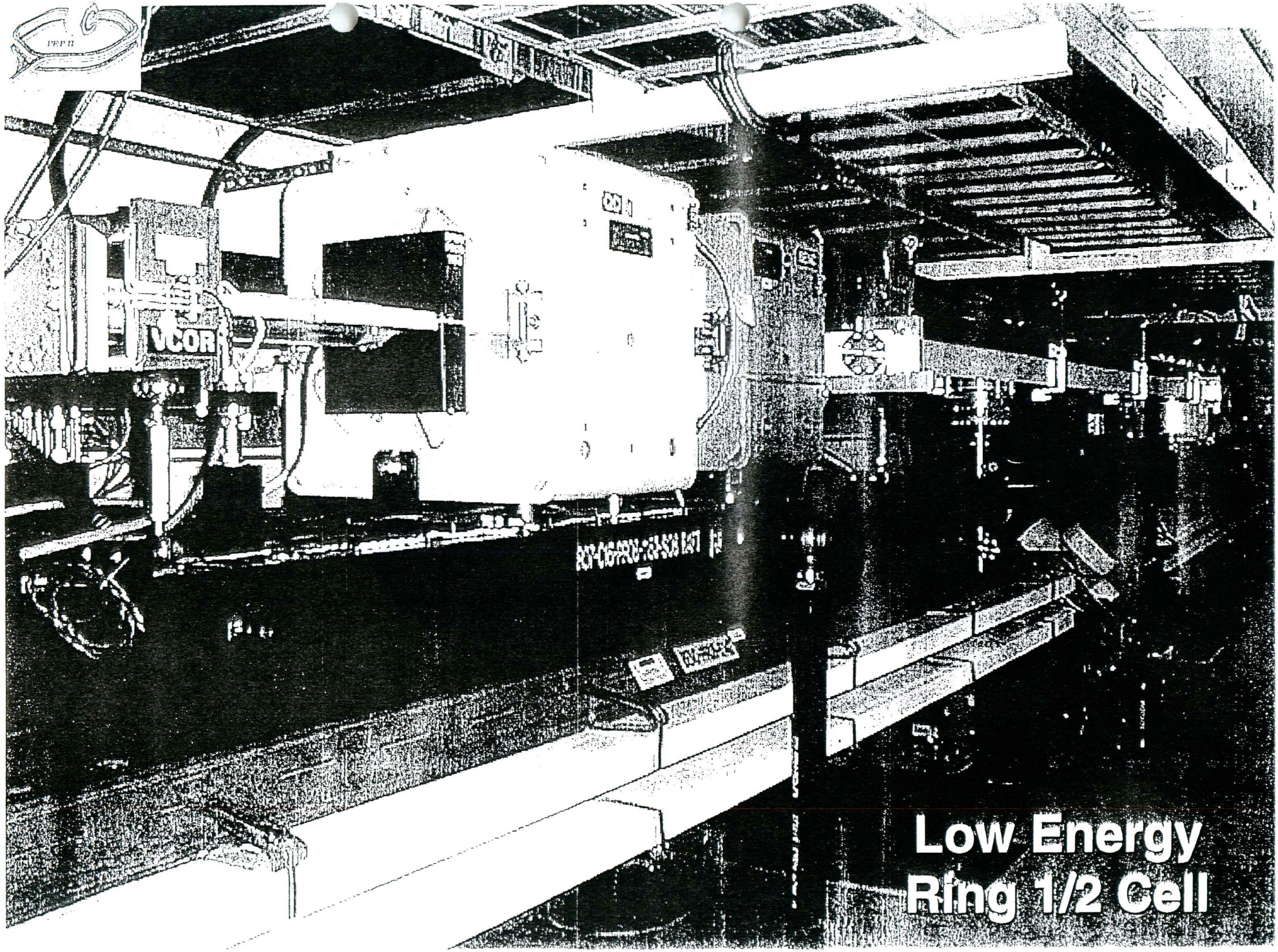
We also had strong support from the DOE and Congress which allowed us to finish in a timely manner and efficiently.


HER RF
Collimators
HER Momentum
Collimators
LER SLM
BaBar
Detector
LER Tune
Wiggler
HER Injection
HENIT
LINAC
LESIT
LER
Injection
HER RF Tune
HER SLM
HER Tune, DCCT, BCM, Decoupling
LER Wiggler, DCCT, BCM
LER Tune
RF, Feedback
HER Feedback,
Decoupling
Region 12
Region 11
Region 1
Region 10
Region 2
Region 9
Region 3
Region 8
Region 4
Region 7
Region 6
Region 5
e-
e+

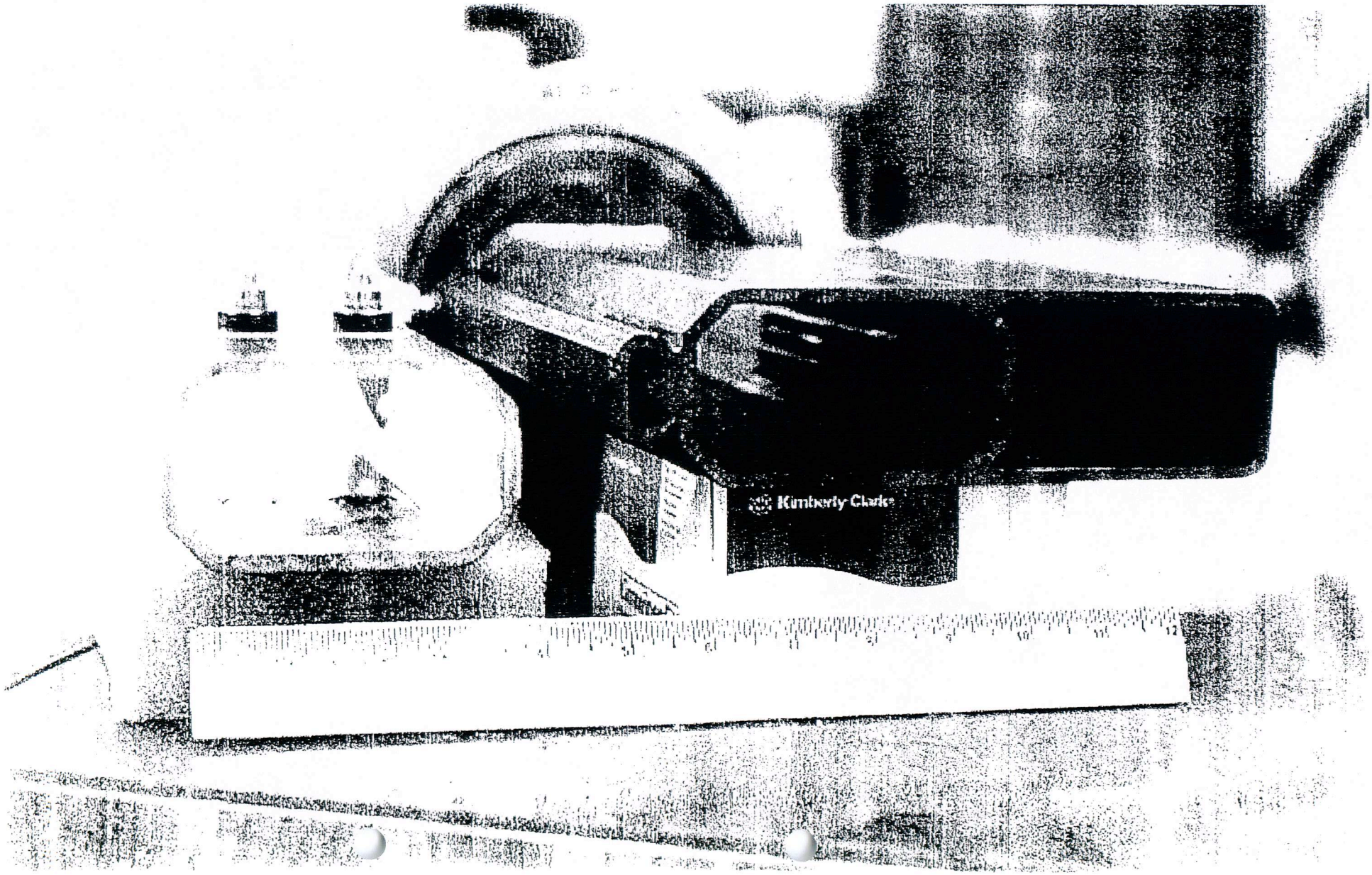


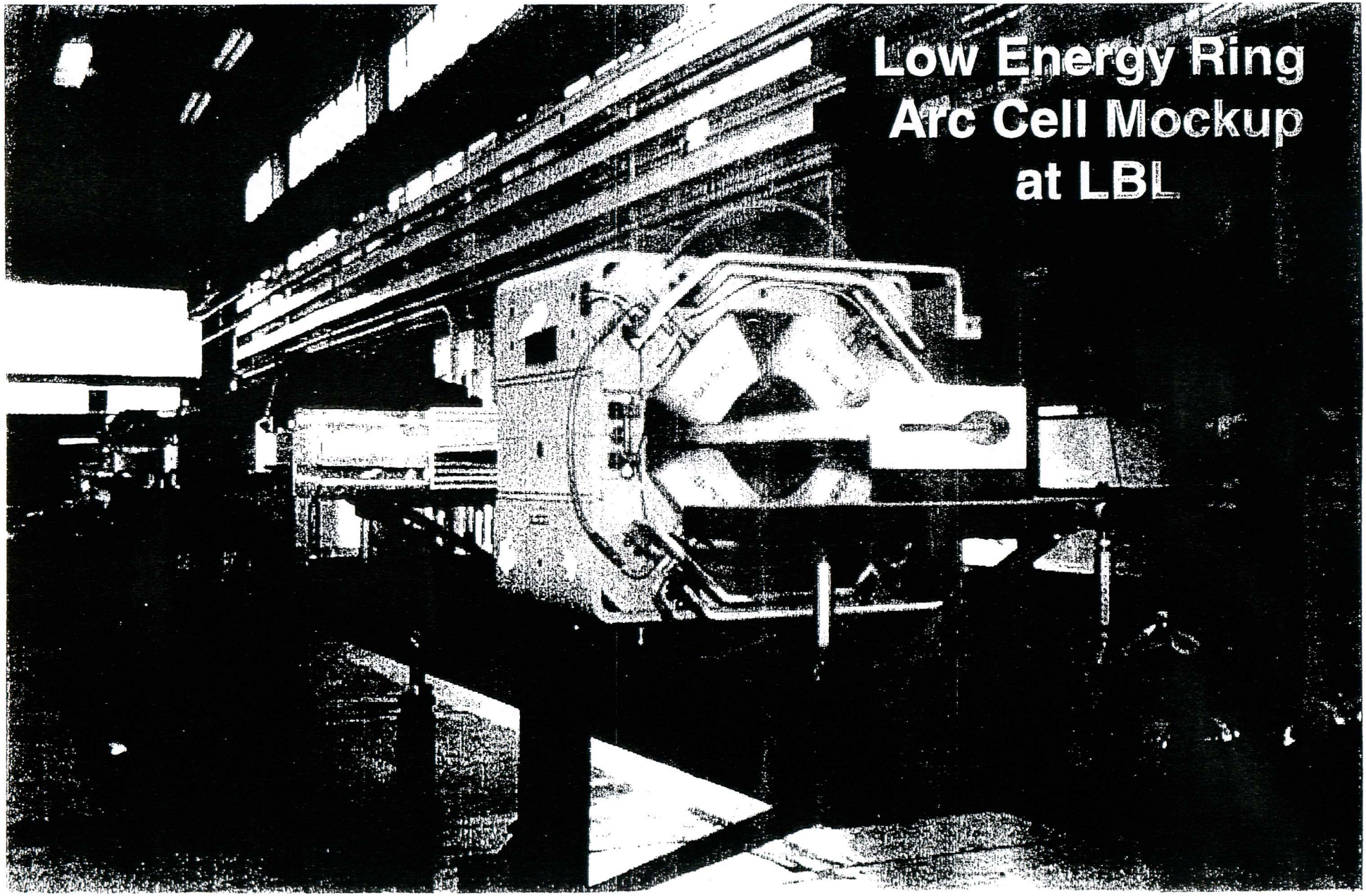
PEP-II Parameters

	e^+	e^-
Beam energy (GeV)	3.1	9
Beam current (A)	2.14	0.75
β_y^* (cm)	1.5	1.5
ε_x (ε_y) (nm)	49 (1.5)	49 (1.5)
σ_x (μm at IP)	157	
σ_y (μm at IP)	4.9	
σ_z (cm)	1.0	1.15
Luminosity	3×10^{33} cm^{-2}s^{-1}	
Tune shift	0.03	
Beam aspect ratio (v / h at IP)	0.04	
Number of beam bunches	1658	
Bunch spacing (m)	1.26	
Beam crossing angle	0 (head-on)	


VCR
Low Energy
Ring 1/2 Cell

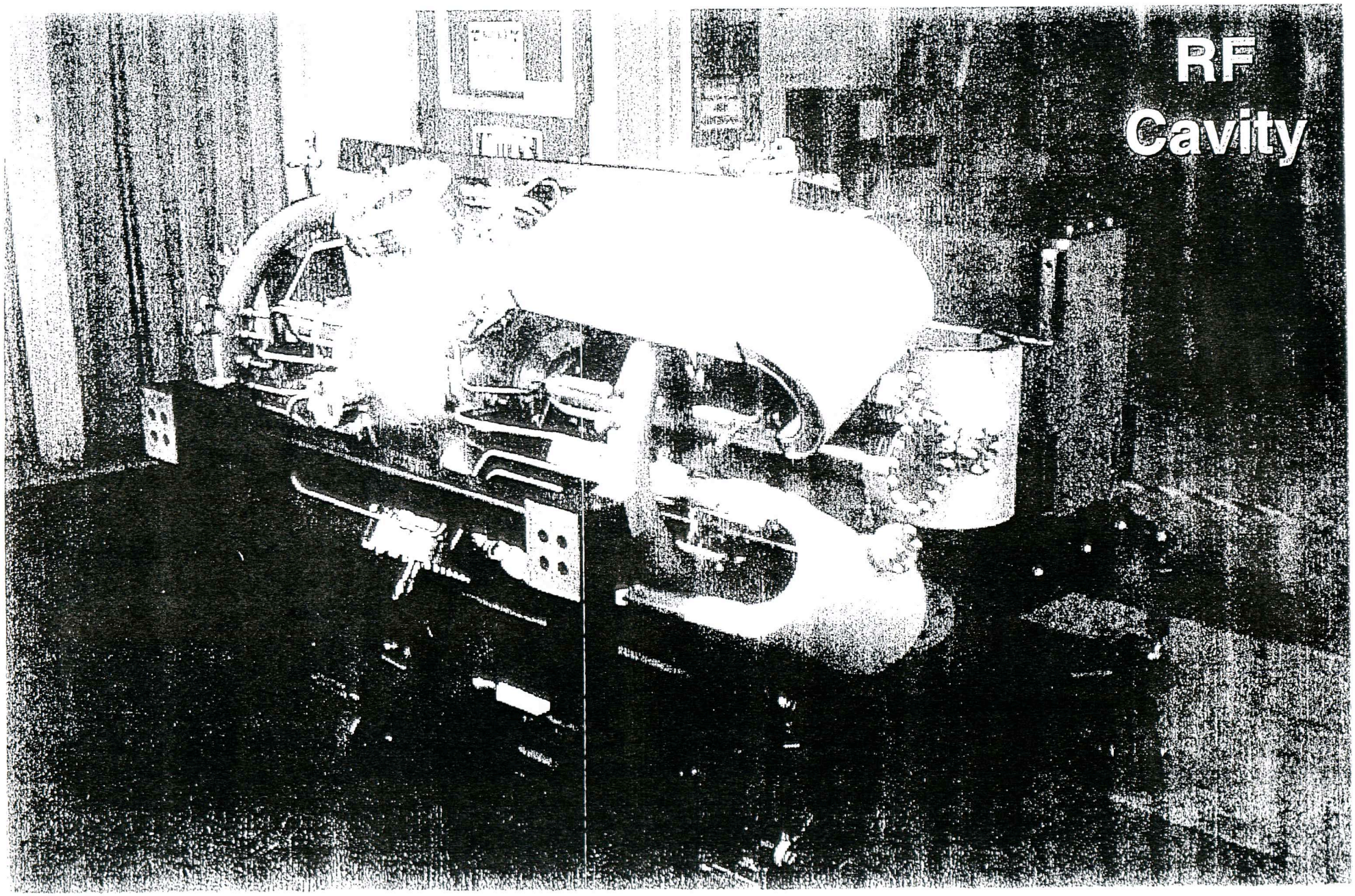
PEP-II *B*-Factory



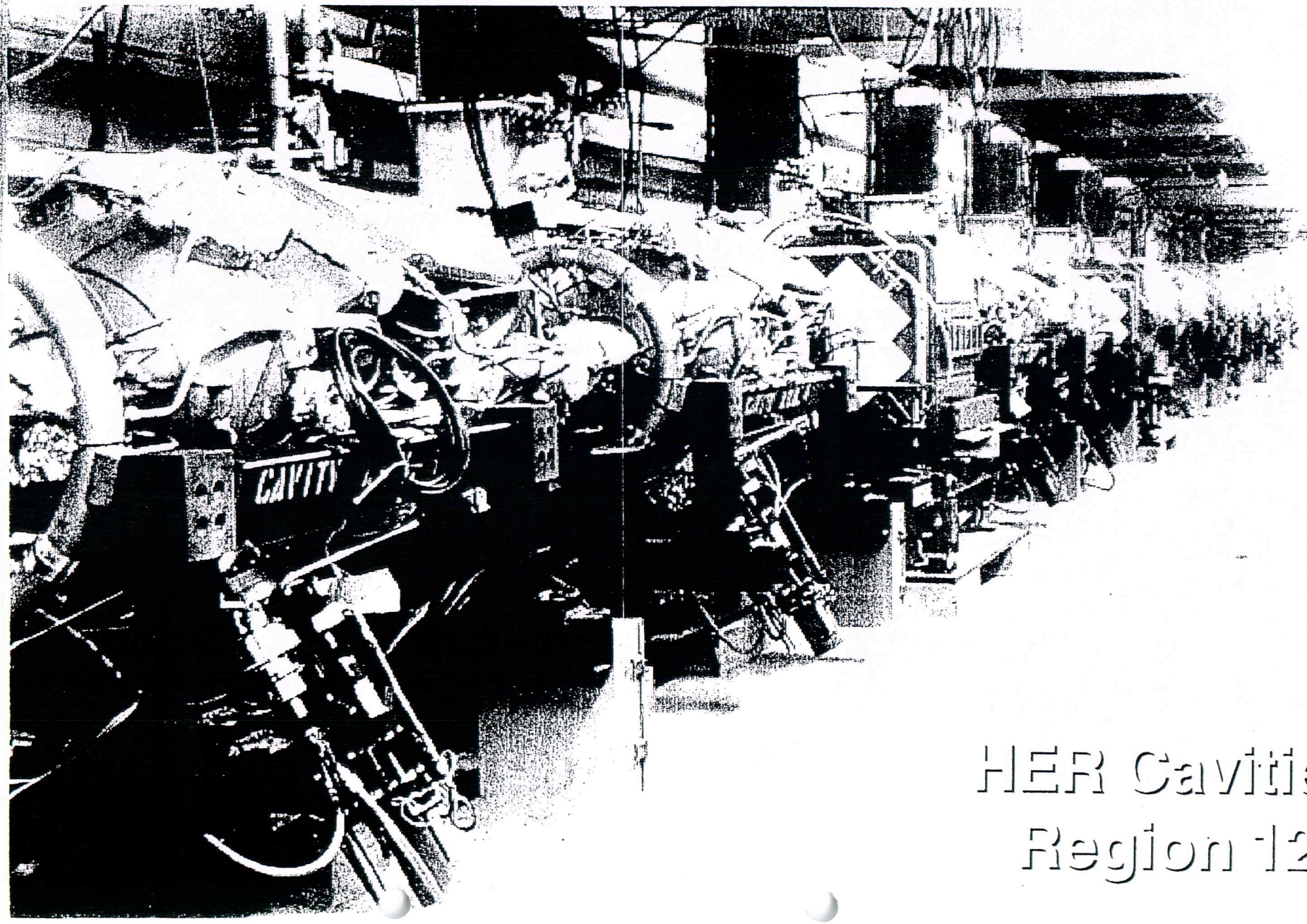


Low Energy Ring Arc Cell Mockup at LBL

RF Cavity Production

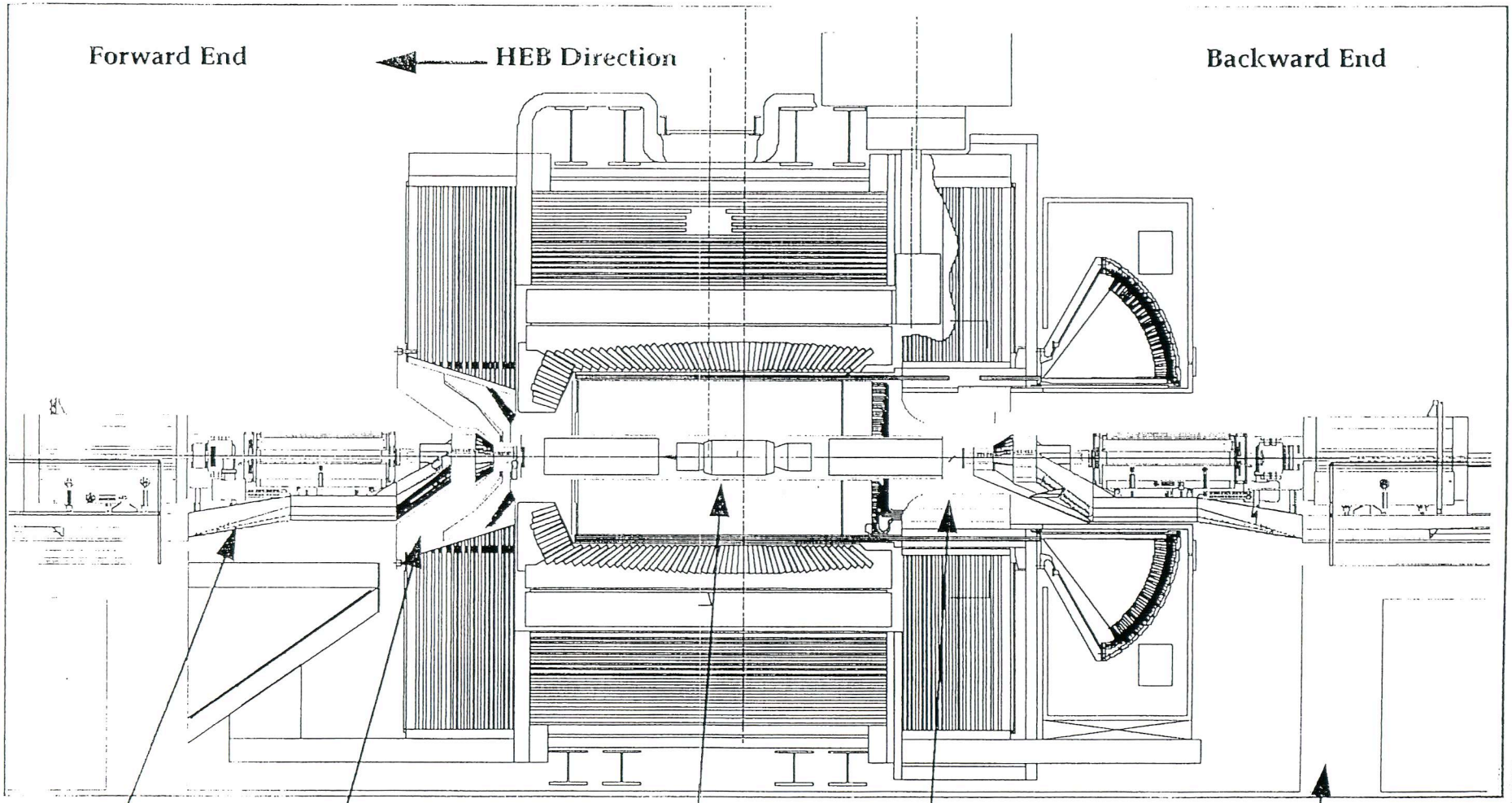


RF Cavity



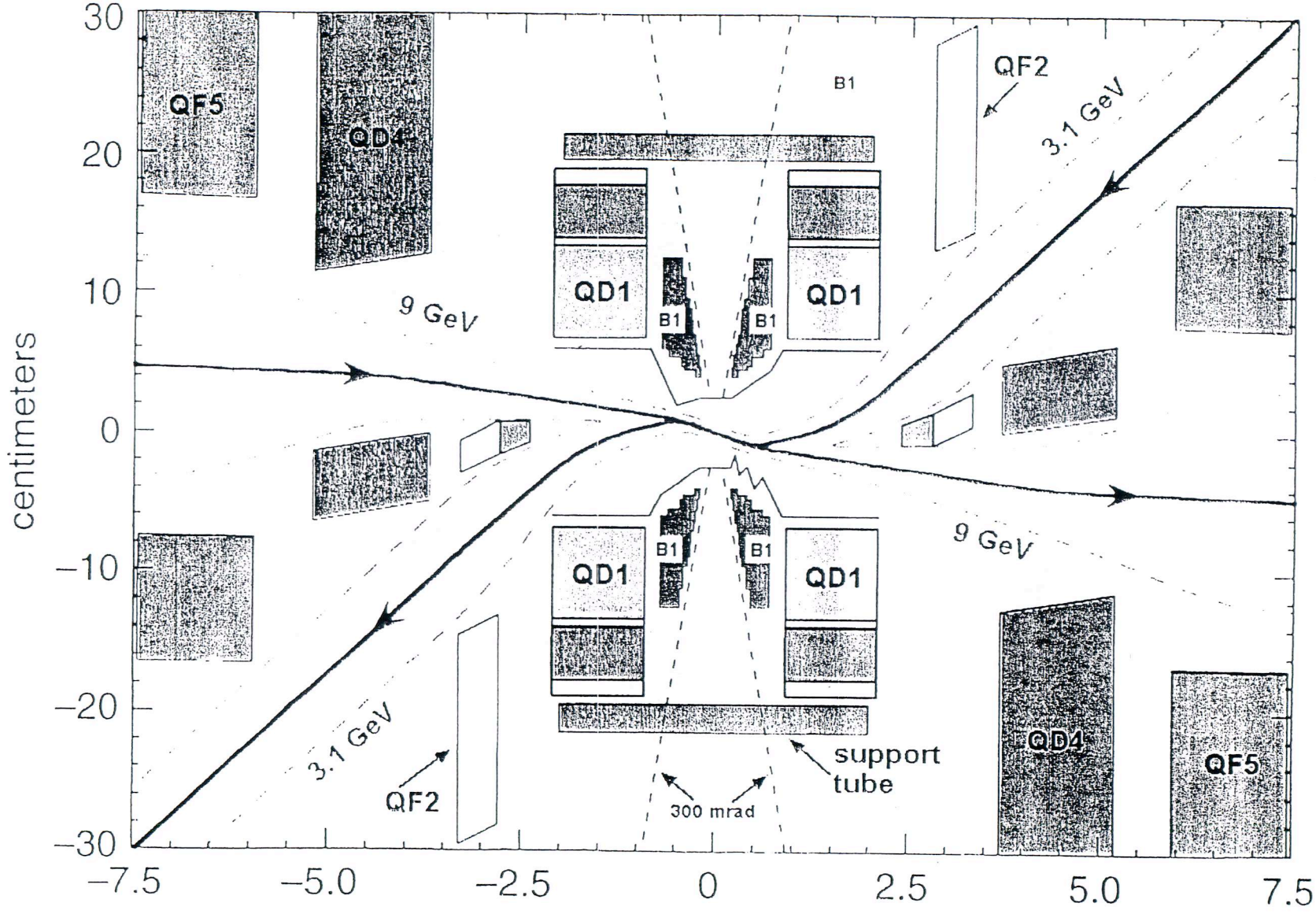
HER Cavities Region 12

PEP-II I.R. and BaBar Detector in IR-2



Elevation View of PEP-II I.R. and BaBar

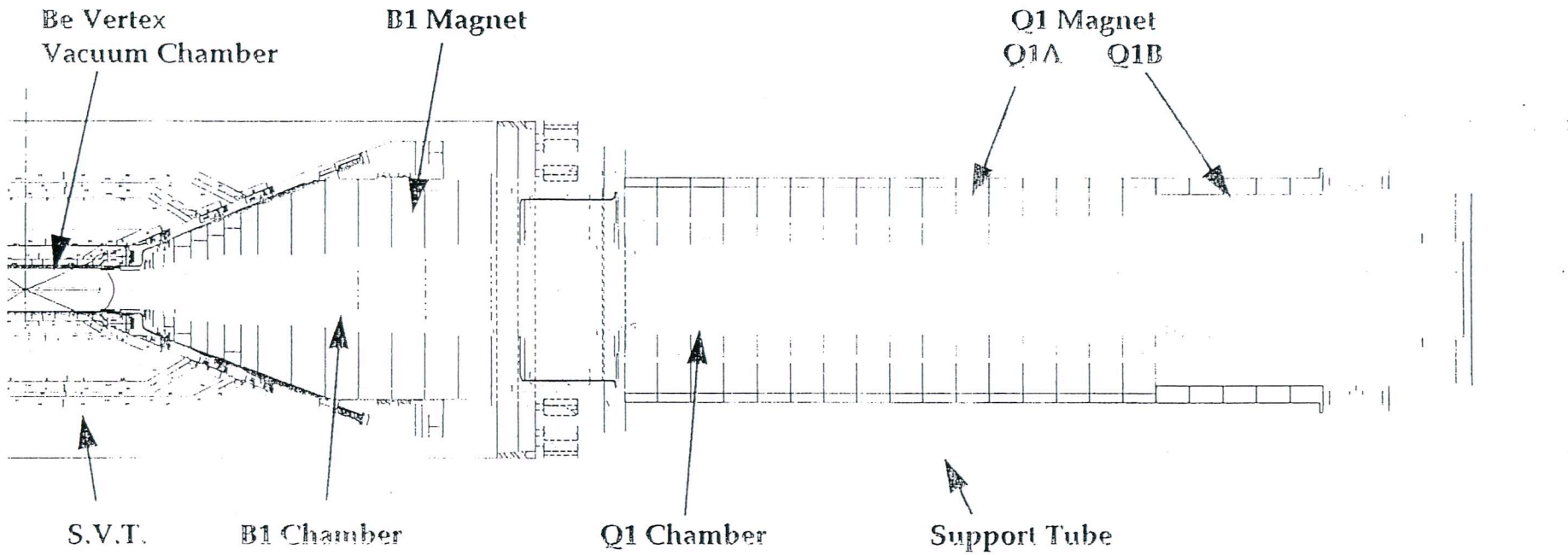
Interaction Region



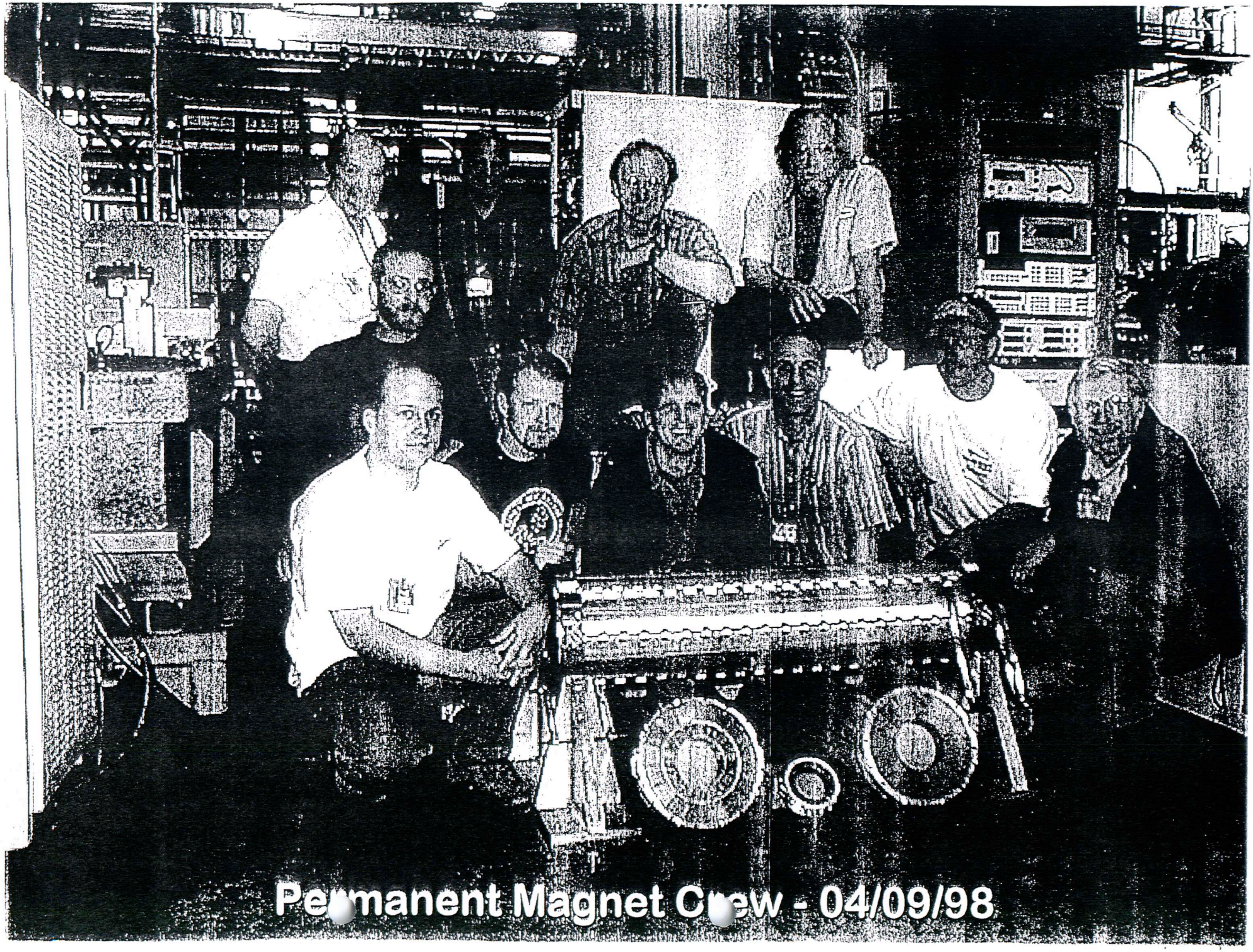
IR WBS
(± 3m)

Apiary 8.6C
M. Sullivan
Jun 21, 1995

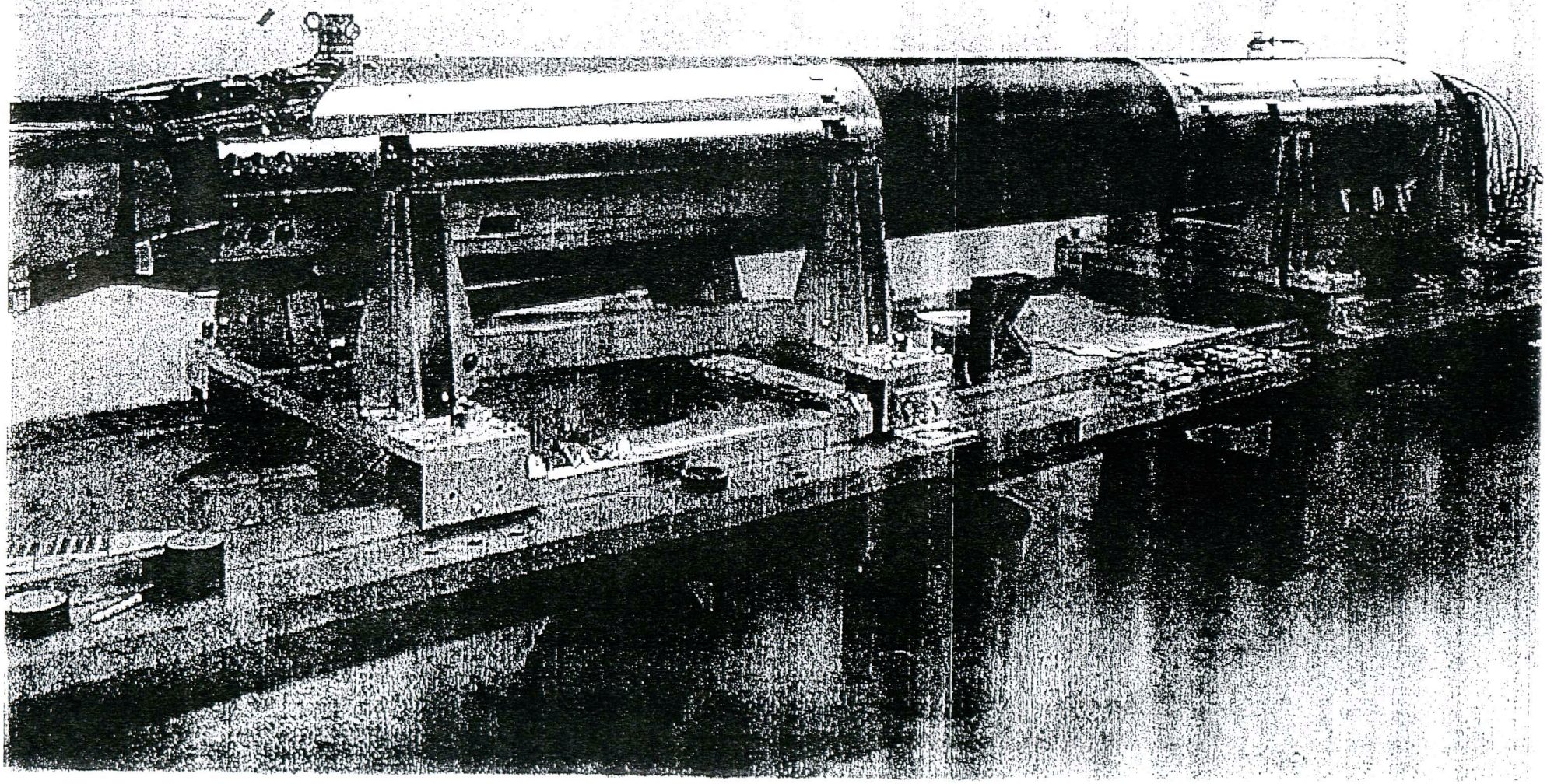
Plan View of Near I.R. Components

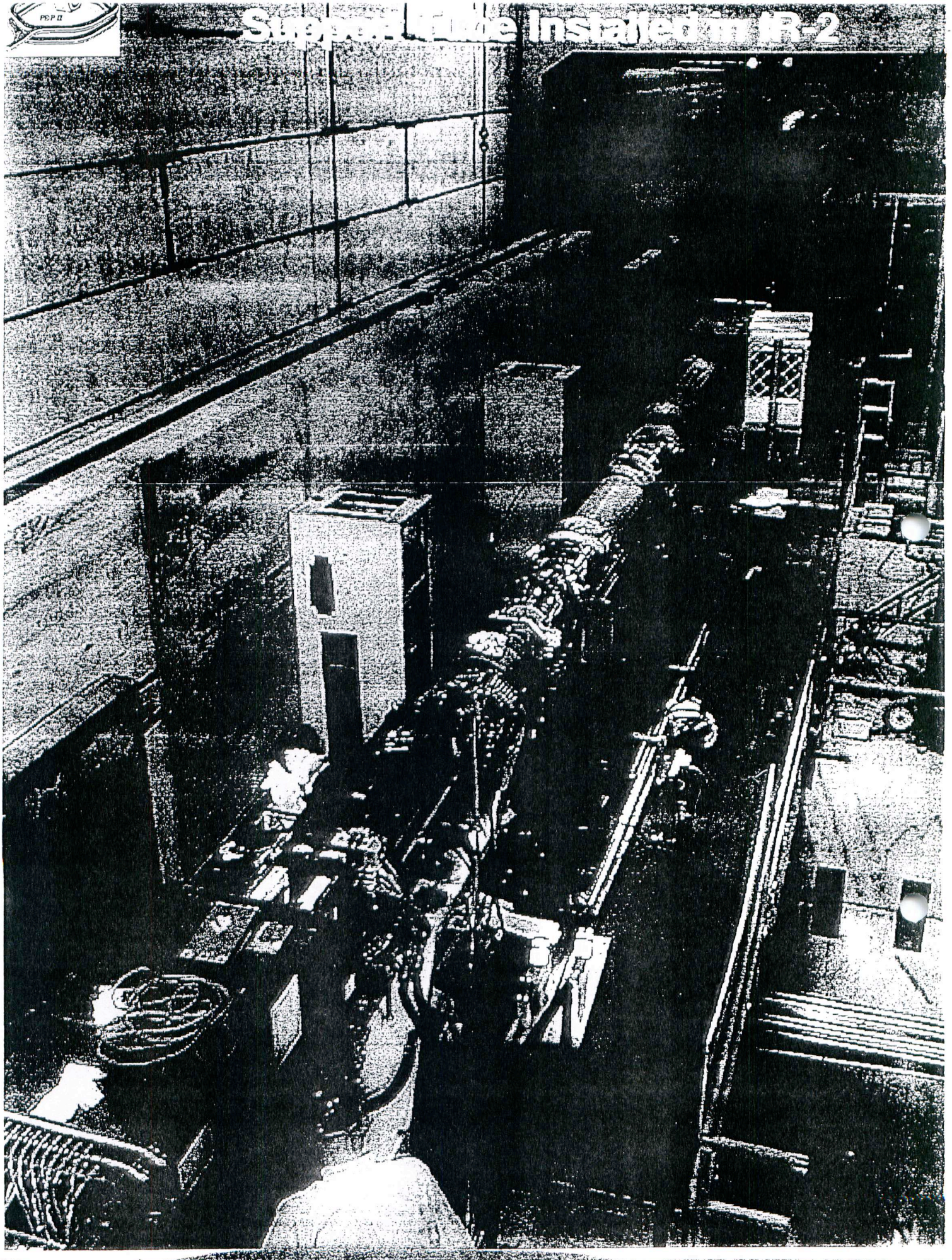


- Magnets are buried inside Support Tube, inside BaBar
- Immersed in 15 kG BaBar solenoid field
- B1 is surrounded by BaBar SVT

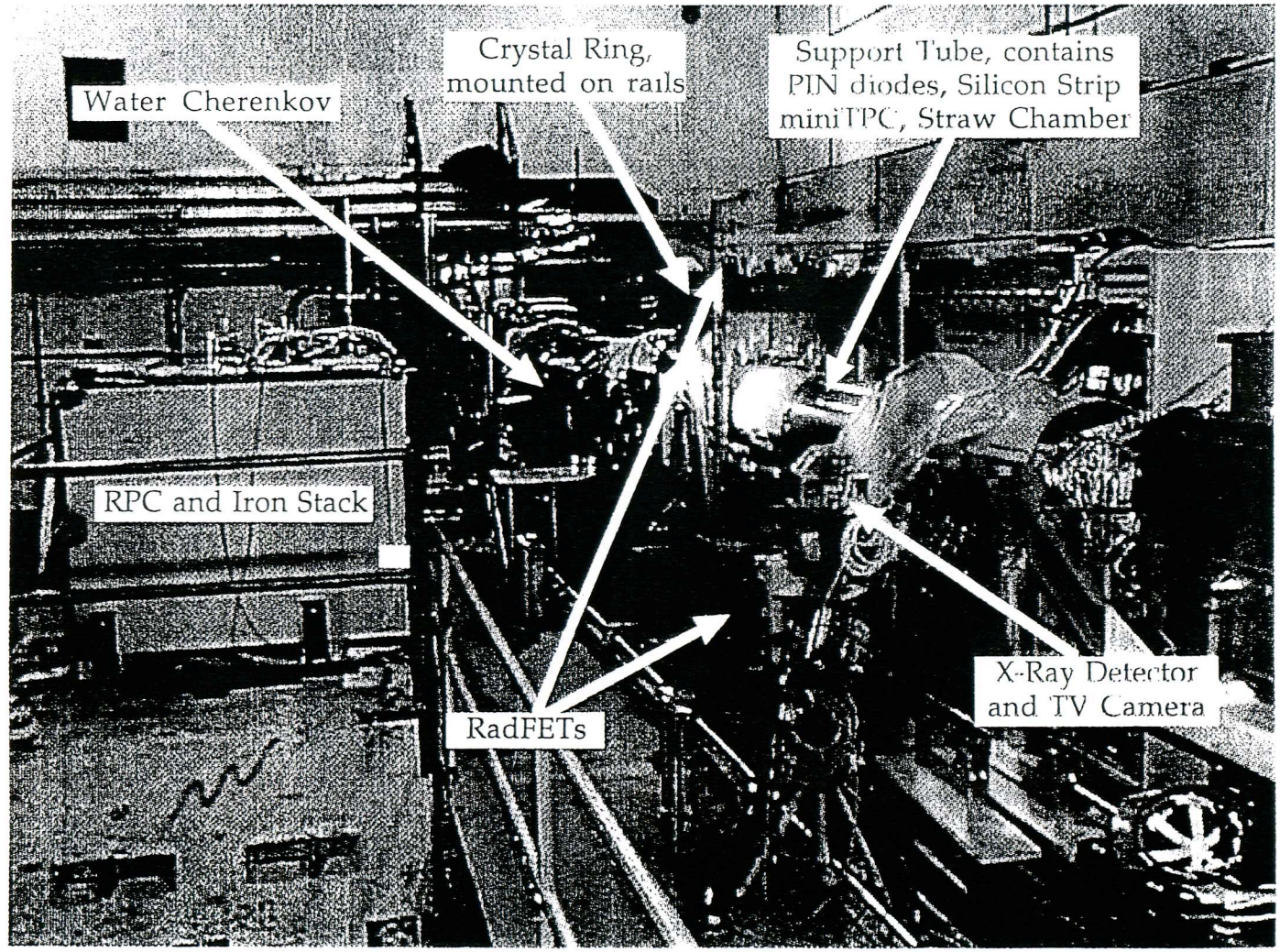

Permanent Magnet Crew - 04/09/98

Q1 Magnet Support Tube Assembly




Stryker Limbe Installed in IR-2

Background Detectors in IR-2, Fall 1998



PEP-II
Commissioning Overview

Our overall plan was for phased commissioning to allow staging time to fix problems.

The HER was finished in June 1997 with commissioning time in June and September, 1997, and January 1998.

The LER was finished in July 1998.

Both rings were commissioned in July , November, and December 1998 and January and February 1999. Progress has been very rapid.

First collisions were observed in July 1998, two months ahead of our collision milestone.

PEP-II was turned off February 22, 1999, to install BABAR. The PEP-II beams are scheduled to resume May 7.

A dedication ceremony with Secretary Richardson was held October 26, 1998.

Commissioning Team

J. T. Seeman	PEP-II Commissioning
T. Himel	PEP-II Run Coordinator
M. Zisman (LBNL)	LER Commissioning
U. Wienands	HER Commissioning
D. Schultz / R. Iverson	Injection Commissioning
T Mattison, W Kozanecki (Saclay)	Backgrounds
M. Sullivan	Collisions

Regular Shift Takers - 39 total

SLAC:	V. Bharadwaj	Y. Cai
J. Ciendenin	F. J. Decker	M. Donald
S. Ecklund	R. Erickson	T. Fieguth
A. Fisher	S. Heifets	T. Himel
R. Iverson	P Krejcik	A. Kulikov
T. Mattison	M. Minty	N Phinney
I. Reichel	M. Ross	J. T. Seeman
M. Stanek	M. Sullivan	J. Turner
U. Wienands	F. Zimmerman	
LBNL:	W. Barry	J. Byrd
S. Chattopadhyay	J. Corlett	W. Decking
M. Furman	D. Li	H. Nishimura
G. Portmann	R. Rimmer	S. Zholents
M. Zisman		
Saclay:	W. Kozanecki	
CERN:	A. Hofmann	M. Placidi
B. Zotter		

Systems Experts - Come in for specially scheduled activities

RF:	P Corredoura	H. Schwartz
R. Tighe		
Transverse Feedback:	W. Barry	D. Li
Longitudinal FB:	J. Fox	S. Prabhakar
D. Teytelman		
Backgrounds:	T. Mattison	W. Kozanecki

Background Commissioning Team

System manager: Tom Mattison

Roy Aleksan, Dave Aston, Henry Band, Jed Beach, Abdel Benabed, Steve Berridge, Tom Borak, Abdel Boucham, Dominique Boutigny, Bill Bugg, Pat Burchat, Bob Byers, Fred Catania, Chih-hsiang Cheng, Richard Cizerone, Dave Coupal, Gianni DeDomenico, Shiral Devmal, Hobey Destaebler, Sandrine Emery, Jean-Claude Faivre, Ted Fieguth, Andre Gaidot, Terry Geld, Cherie Goodenough, Fred Goozens, Joe Hargis, Adil Hasan, Carsten Hast, David Huffaker, Xinh Huynh, Jim Johnson, John Kadyk, Yannis Karyotakis, Lewis P. Keller, Roy Kerth, David Kirkby, Witold Kozanecki, Trevor Lanting, Francois LeDiberder, Vincent LePeltier, Rusty Malchow, Benjamin Mayer, Adrian McKemey, Brian Meadows, Tim Meyer, Eric Nehrlich, Ralph Nelson, Jean-Yves Nief, Jim Olsen, Patrick Petitpas, Sibylle Petrak, Mark Petree, Ed Potter, Chris Roat, Natalie Roe, Mike Ronan, Sumit Sen, Vivek Sharma, Art Snyder, Mike Sokoloff, Aron Soha, Mike Sullivan, Hiro Tanaka, Vincent Tisserand, Walter Toki, Nicolas Treps, Sophie Trincaz-Duvoid, Andrea Valassi, Sophie Versillé, Steve Wagner, Achim Weidemann, Guy Wormser, Katerina Zachariadou

In addition, I would like to offer special thanks
to <u>those junior members</u> of the participating groups
who have toiled so hard to <u>acquire and/or analyze the data</u>!

PEP-II
Commissioning Results

Both rings perform very well. The uptime is very good.

The control system, extended from the SLC system and EPICs, is mature and has helped a great deal in rapid commissioning.

The RF system and the feedback systems are real technical successes.

Injection is rapid with easy complex bunch patterns changes in minutes.

Top-off and filling occur in minutes for both beams.

There are a few vacuum chambers with elevated temperatures at high beam currents. These chambers will be cooled or replaced during the present down. Full current capability will be ready for both beams in May.

The vacuum pressure in the HER is great and is still scrubbing.

The vacuum pressure in LER is improving but slowly. There are a few leaks in the Arcs which keep the pressure-rise-with-current higher than we hoped for. Extensive leak checking work is underway for this down. There is a non-linear pressure rise in the LER straight sections due to, most likely, electron multipactoring which outgasses the stainlees steel chambers. There is evidence that these chambers will scrub with time.

We have a good understanding of the detector backgrounds which can be traced, to a large degree, to these rising vacuum pressures. The LER pressure increases will likely dominate the backgrounds for our early data taking. This summer, we will scrub with care, find ways of increasing the luminosity at low currents, and will actively implement fixes.

PEP-II
Winter Run Highlights

- Peak LER current = 1171 mA (lifetime ~ 25 min)
- Peak HER current = 507 mA (lifetime ~ 180 min)
- LER integrated current = 153 Amp-hr
- HER integrated current = 115 Amp-hr
- Peak Luminosity = 5.2×10^{32} /cm^2 /sec
- Averaged luminosity over 72 hours ~ 2×10^{32}
- Feedbacks are all working!
  (Transverse, Longitudinal, RF, Woofer)
- One LER Arc recovered nicely from a bad vacuum leak (0.1 Torr of tunnel air)
- Injection is often 100% efficient at over 2 mA per second at 10Hz

PEP-II Bunch Injection
HER

Print | Exit

Bunch Currents

Raw-Ped

equiv mA

Filled Buckets 1059

Fit Lifetimes based on
10 Seconds

Current Transformer

DCCT-Ped 724.581790 mA

DI/DT -74.986 uA/sec

Linear 160.58 min

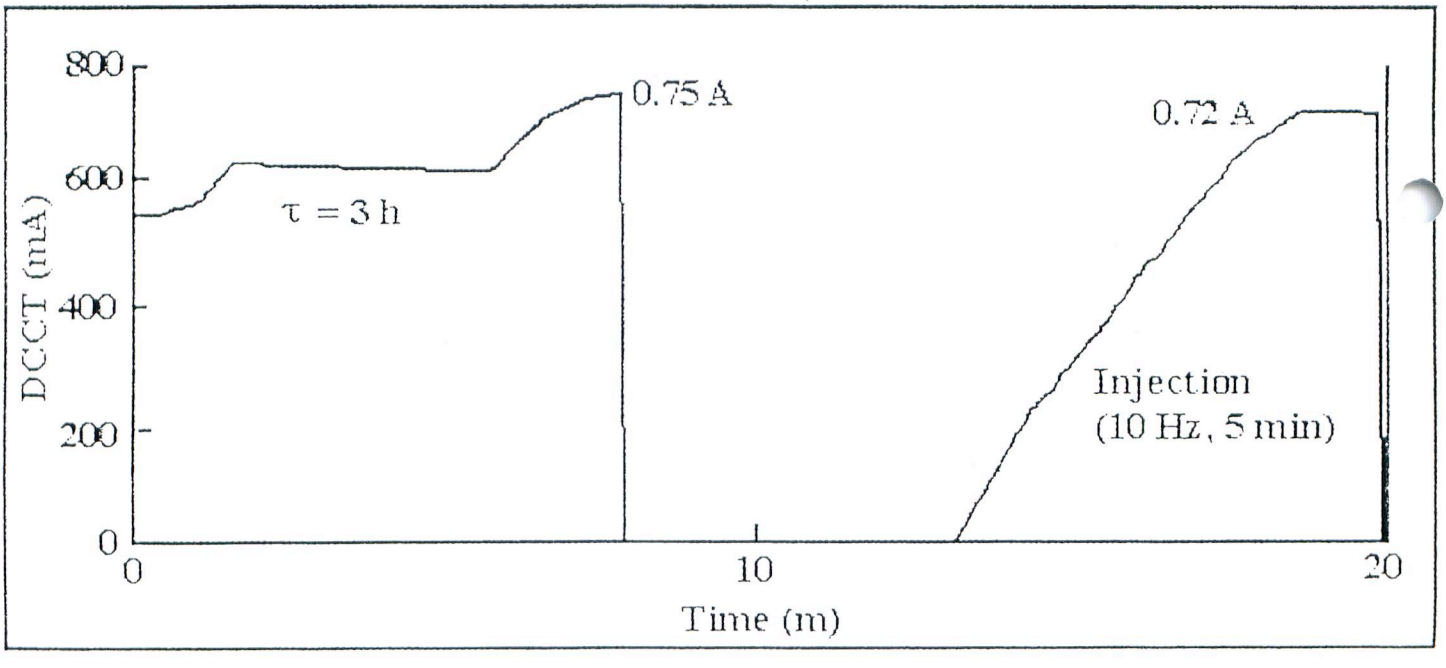
Exponential 160.65 min

BIC STATE: Quiescent STOP INJECT

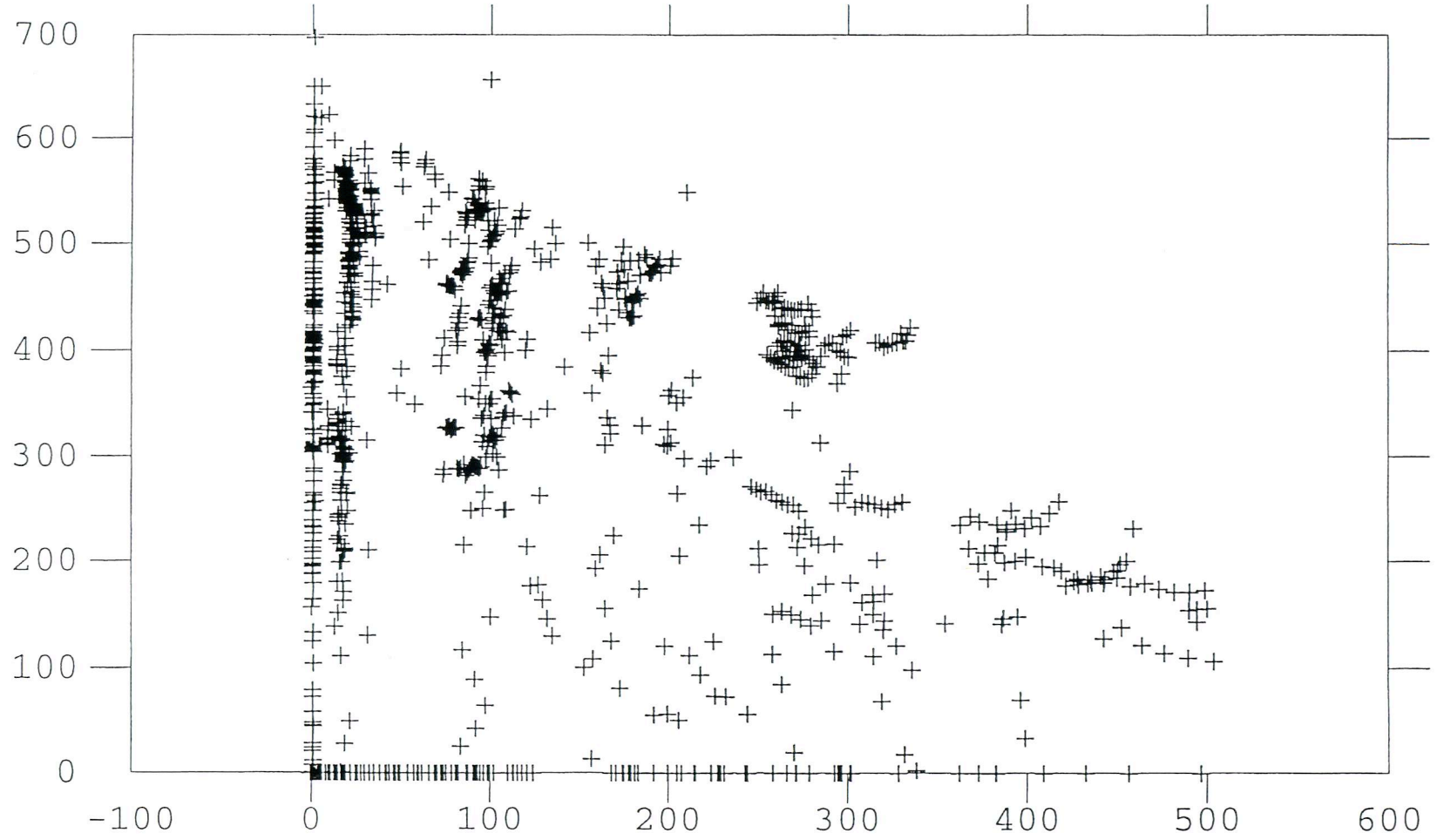
Calib Status	Goal Status	MPG Status
All old	Okay	MPG on/BIC off

Injection Stopping

DCCT Current; 5 second bins; 20 minute full scale

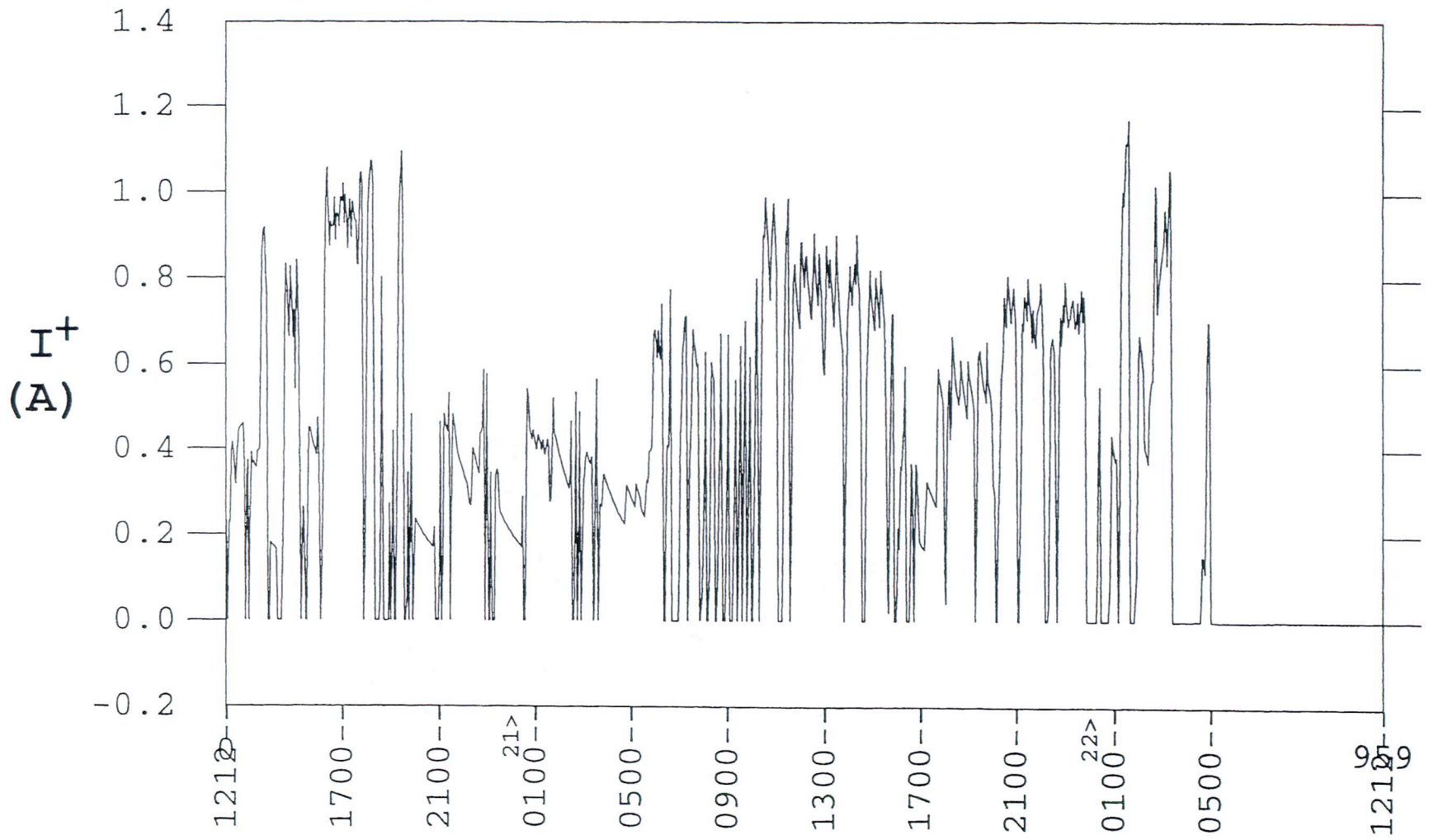


Electron Lifetime (min)



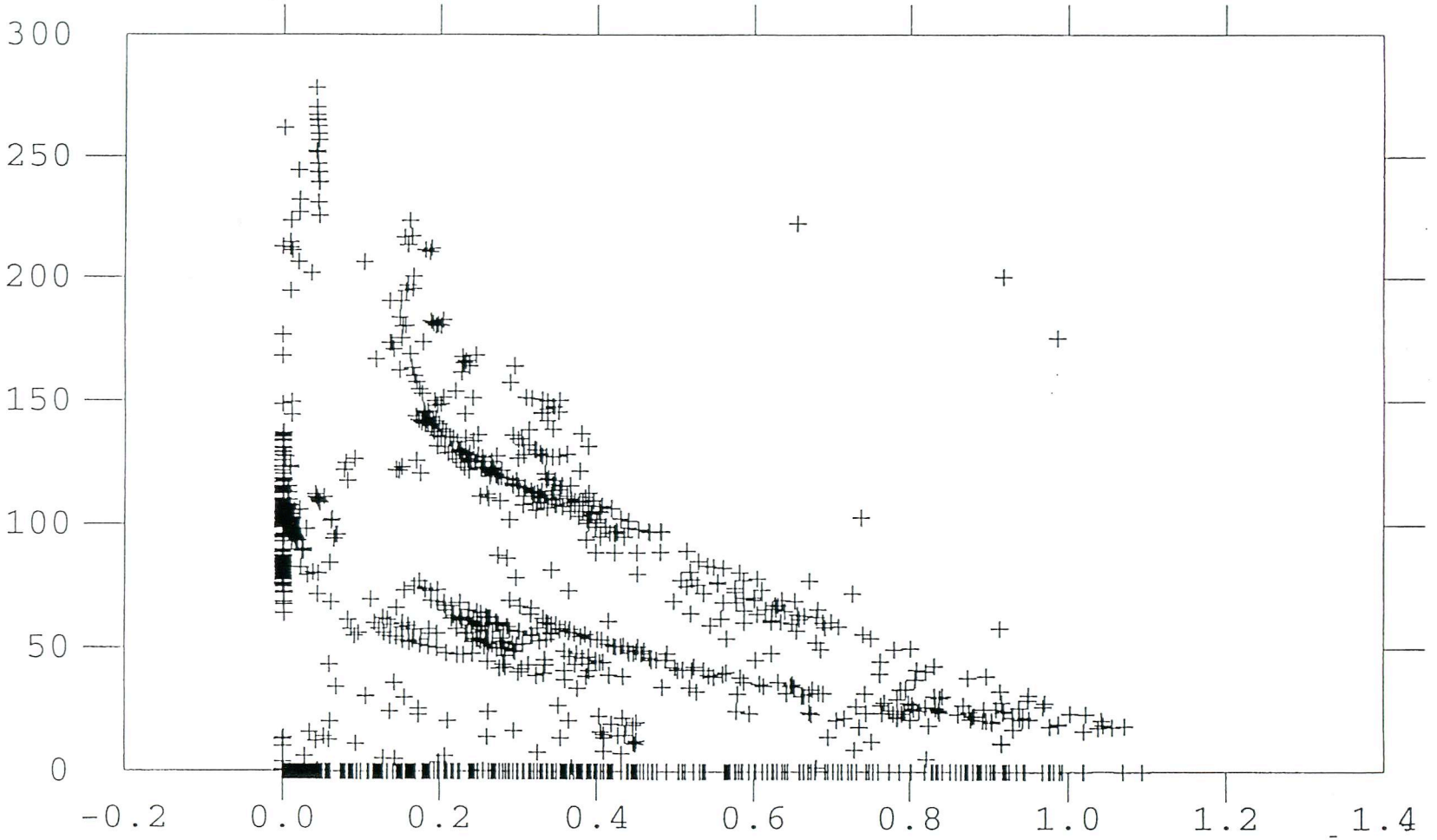
Electron Current (mA)

LER Current vs Time



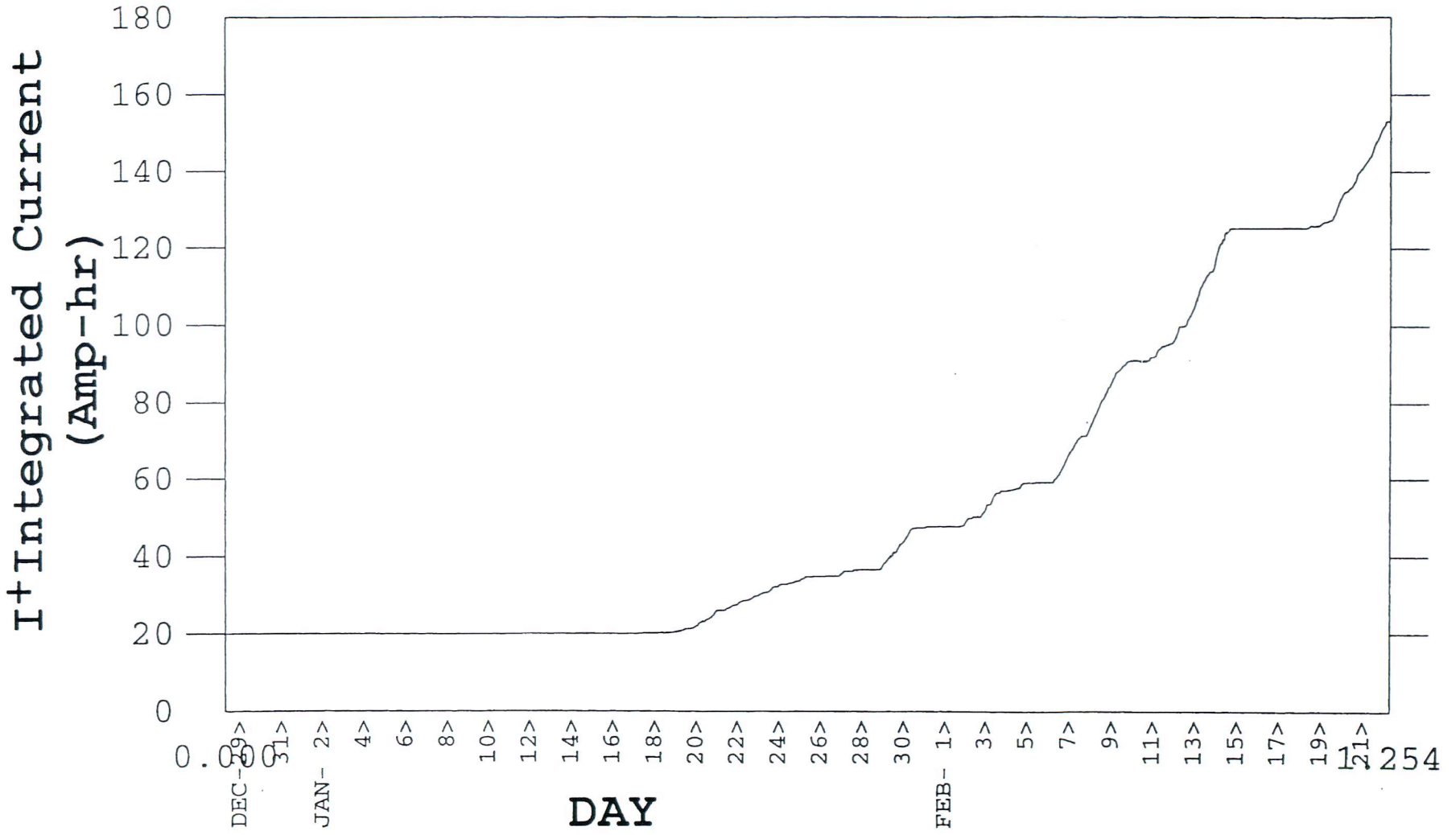
MIN: -.2687
MAX: 1171.4
MAX-MIN: 1171.7
22-FEB-99 12:11:39

Positron Lifetime (min)



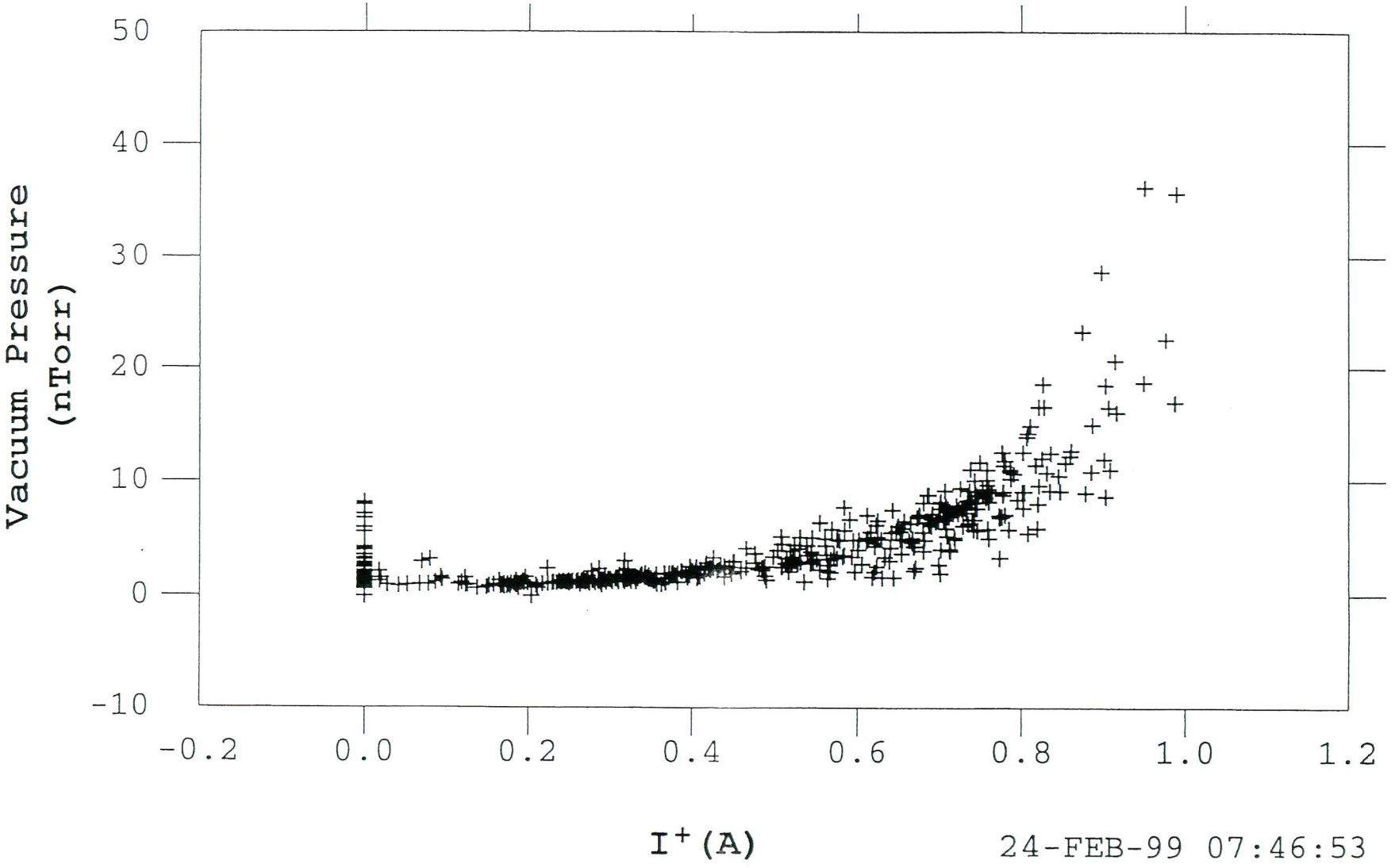
Positron Current (A)

LER Integrated Current vs Time



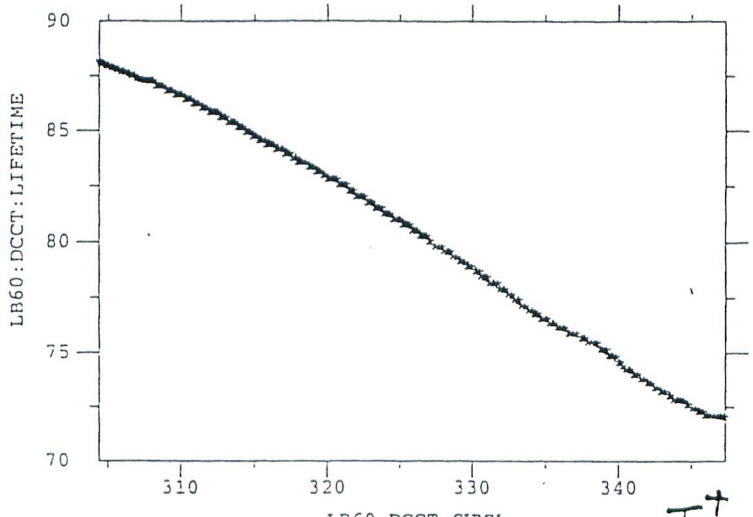
MIN: 20.100
MAX: 153.26
MAX-MIN: 133.16
22-FEB-99 08:24:48

LER Straight Vacuum Pressures vs Current



LER Straight Vacuum

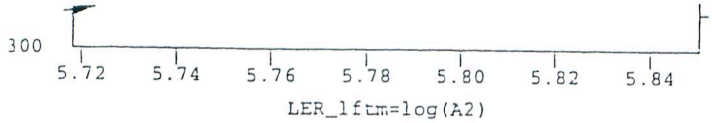
e^+ Lifetime



I^+ (mA)

STEP VARIABLE = TIME STEPS = 300 DELAY = 1.000

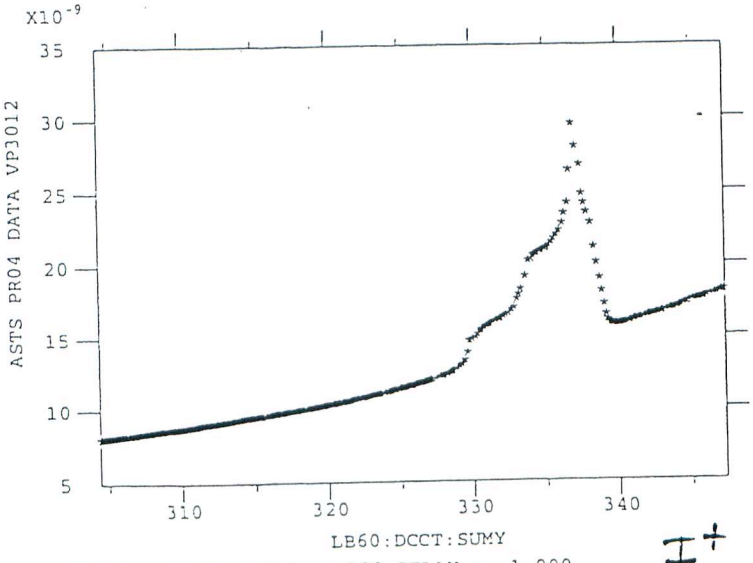
25-JAN-99 01:53:04



ARIABLE = TIME STEPS = 300 DELAY = 1.000

25-JAN-99 01:53:51

Pump Pressure

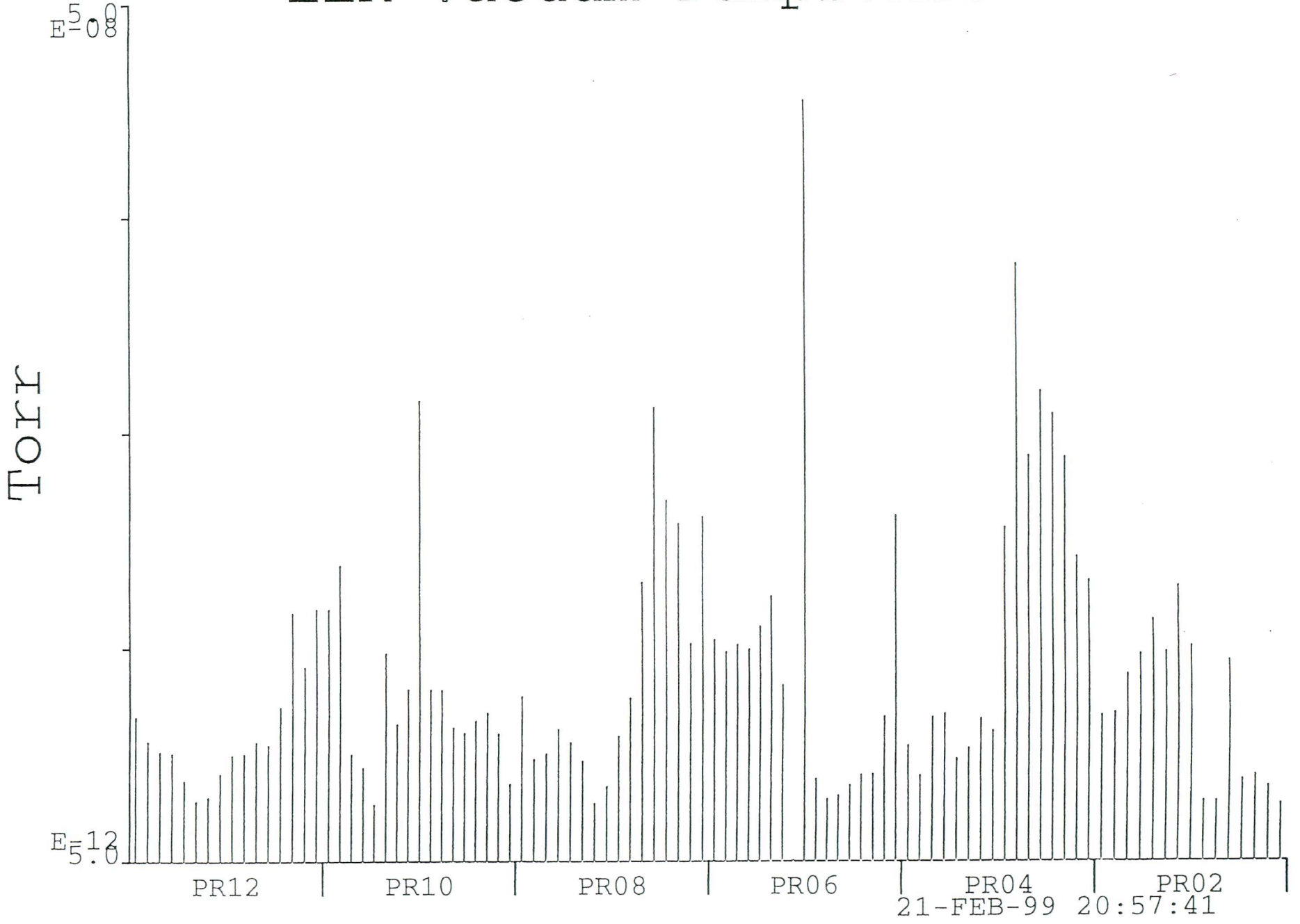


I^+

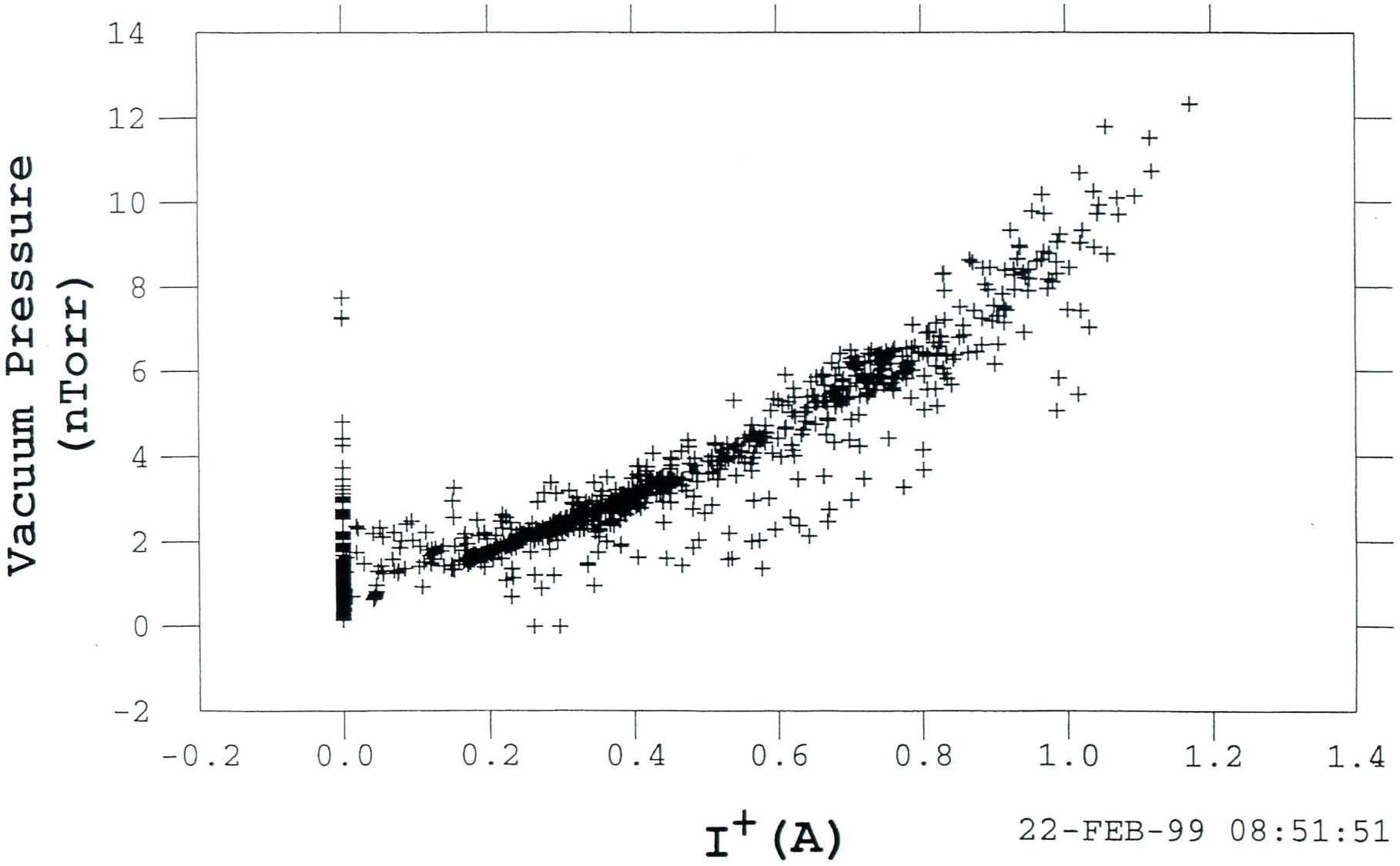
EP VARIABLE = TIME STEPS = 300 DELAY = 1.000

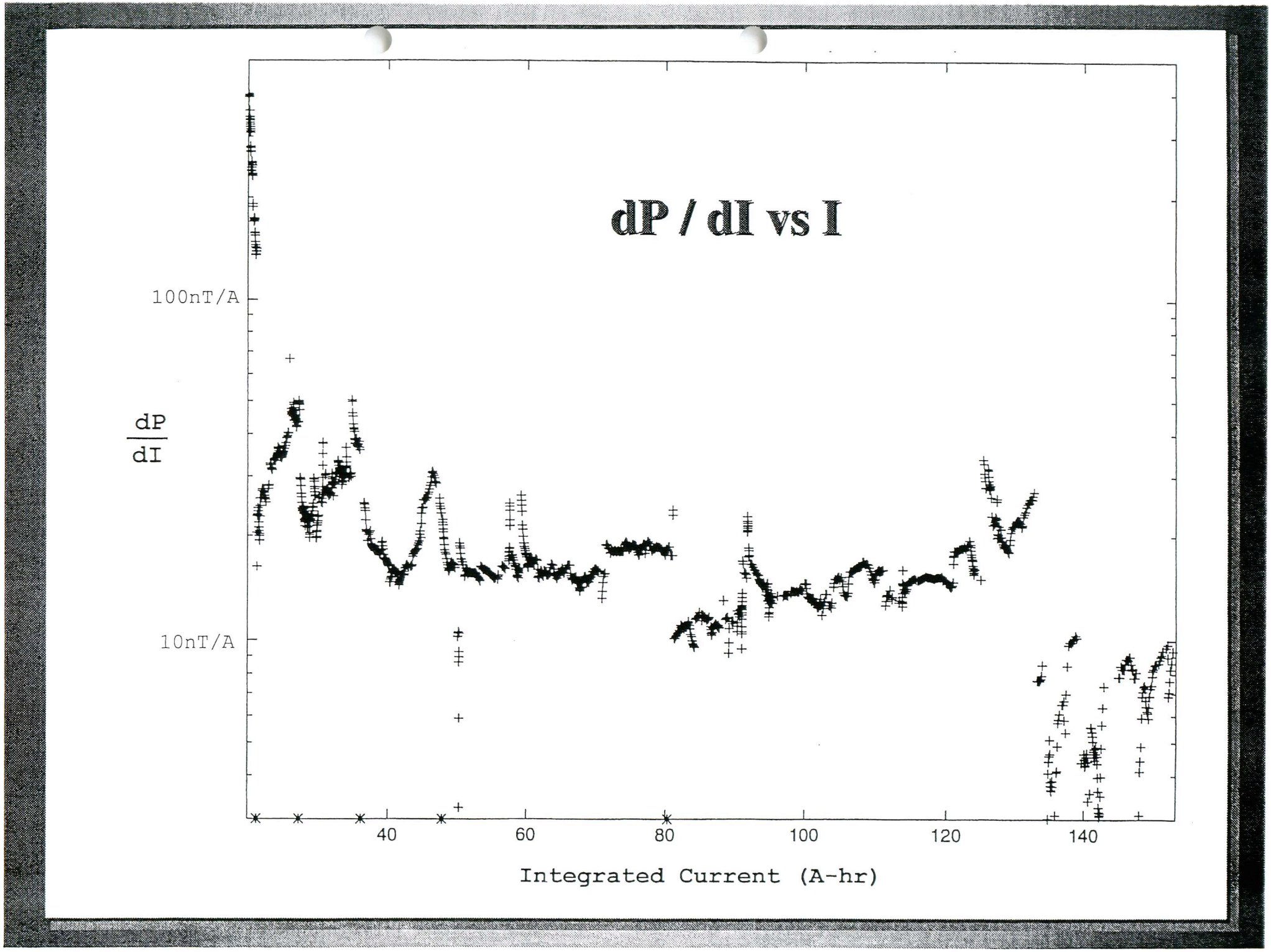
25-JAN-99 01:55:19

LER Vacuum Pumps:Arc



LER Arc Pressure vs Current




dP / dI vs I
100nT/A
dP
dI
10nT/A
40
60
80
100
120
140
Integrated Current (A-hr)

MKS-PPT 4.30/D46

2/19/1999 10:37 AM TOTAL PRESSURE
< 5e-7 Torr

BAR MODE PLOT

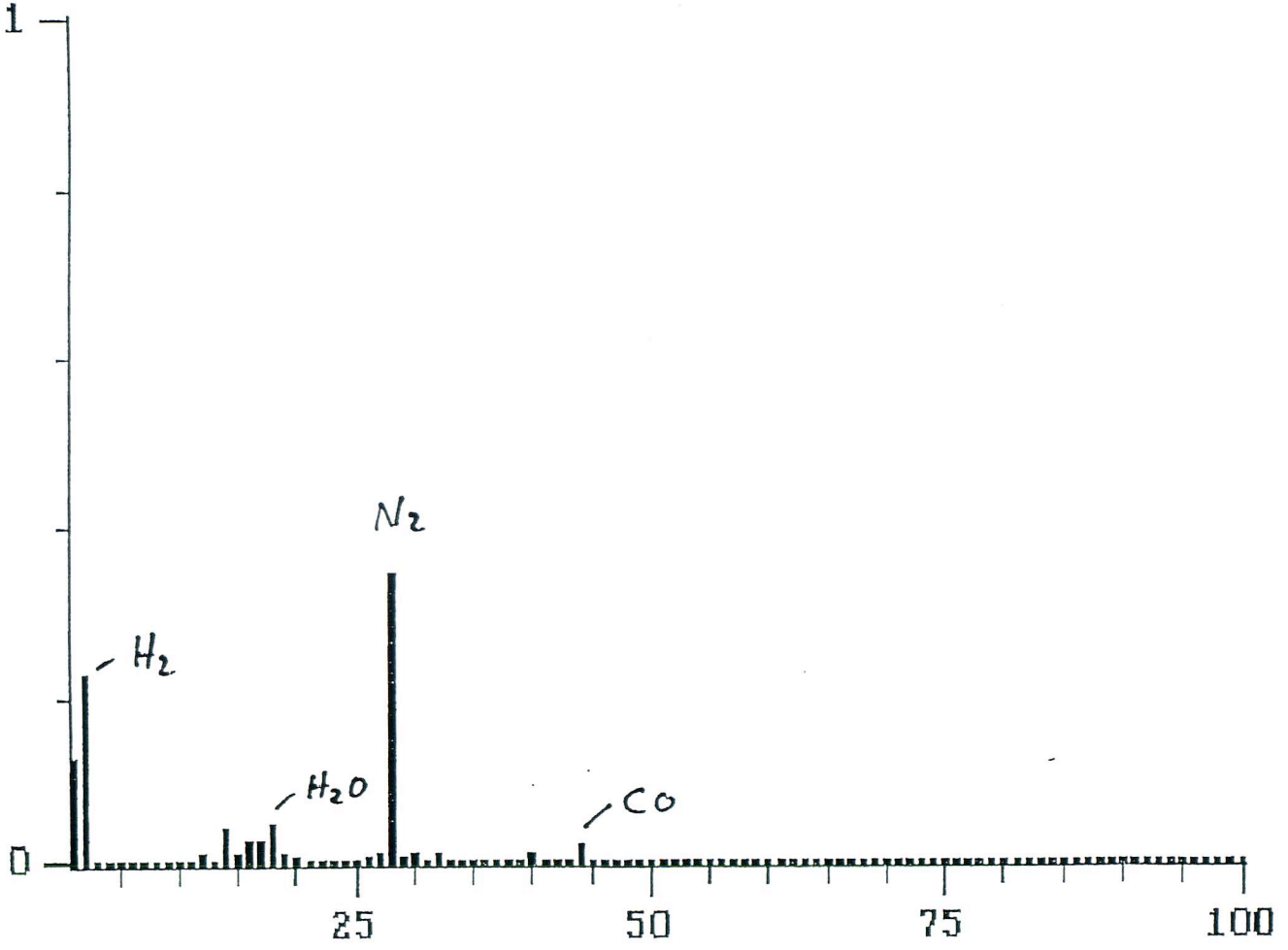
N Subtraction <Switches> DataLog N

1.00e-07 Torr

$P = 1.8 \times 10^{-8}$ T

No Beam

$I^+ = 0$



SEM Adjs.
Volts 820
Gain 1000
OP Prot. Y

Begin Mass = 1 Dwell = 16 100 = End Mass

< 5e-7 Torr

BAR MODE PLOT

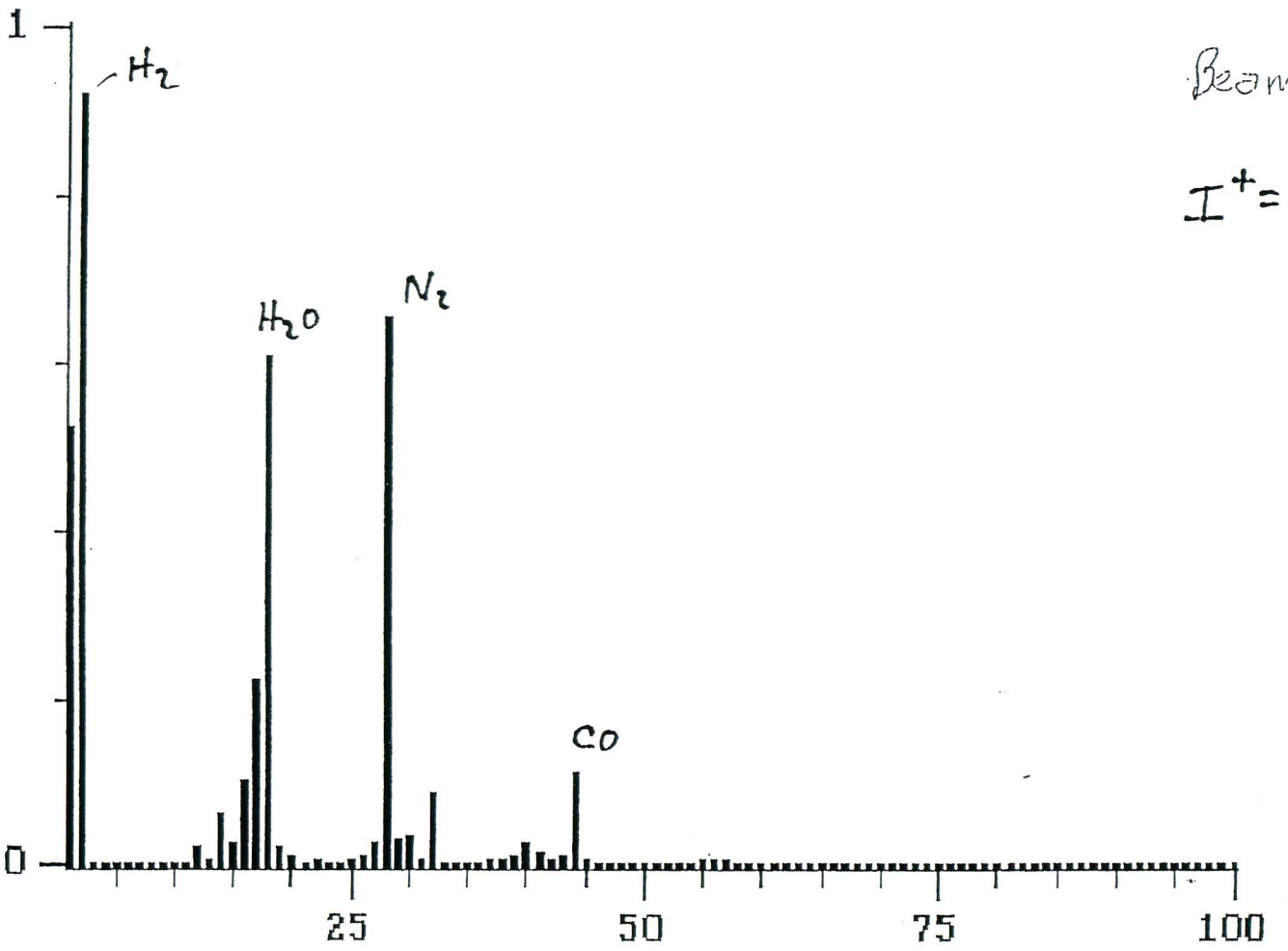
N Subtraction (Switches) DataLog N

1.00e-07 Torr

$P = 4.4 \times 10^{-6}$ T

Beam = 340 mA

$I^+ = 340$ mA

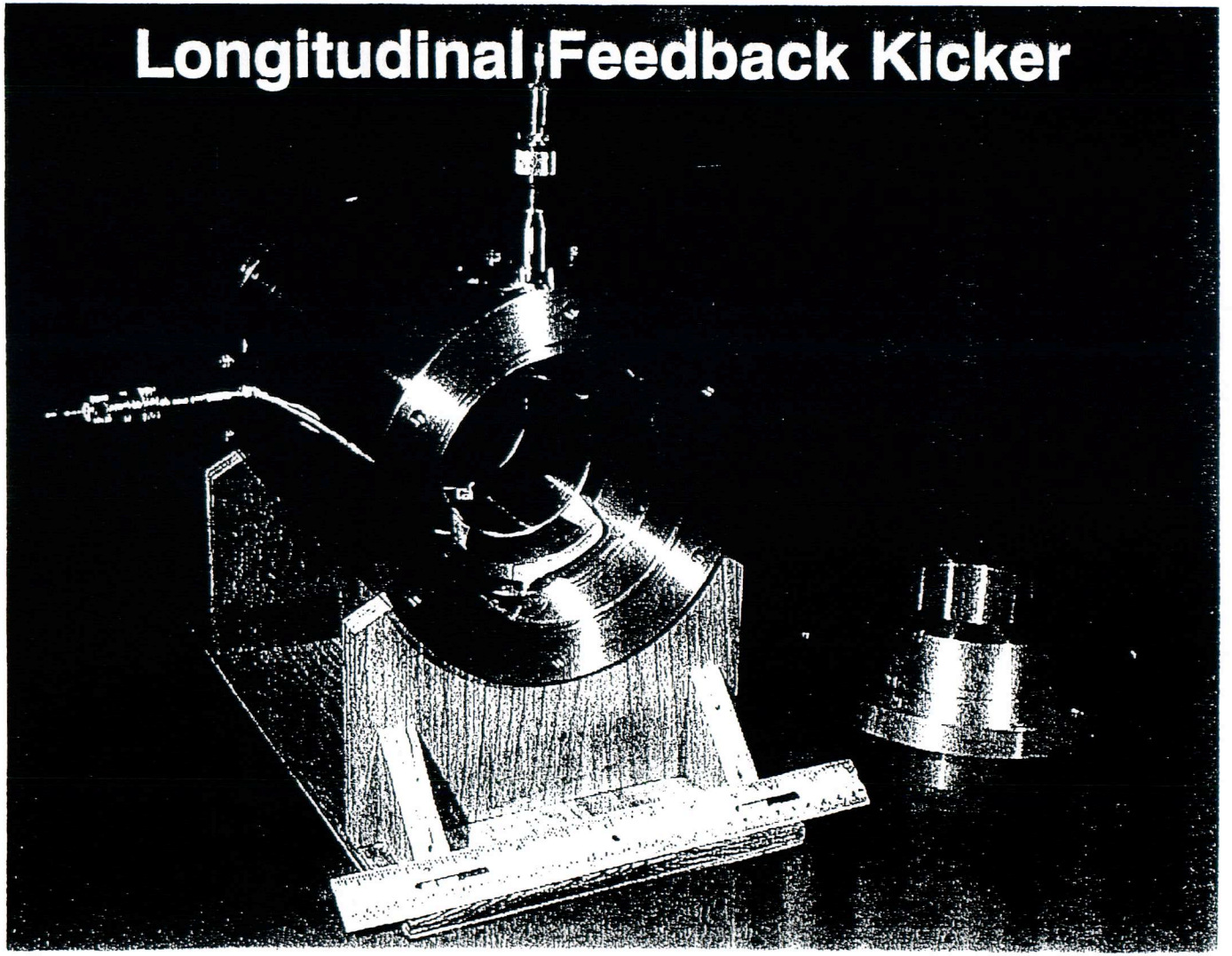


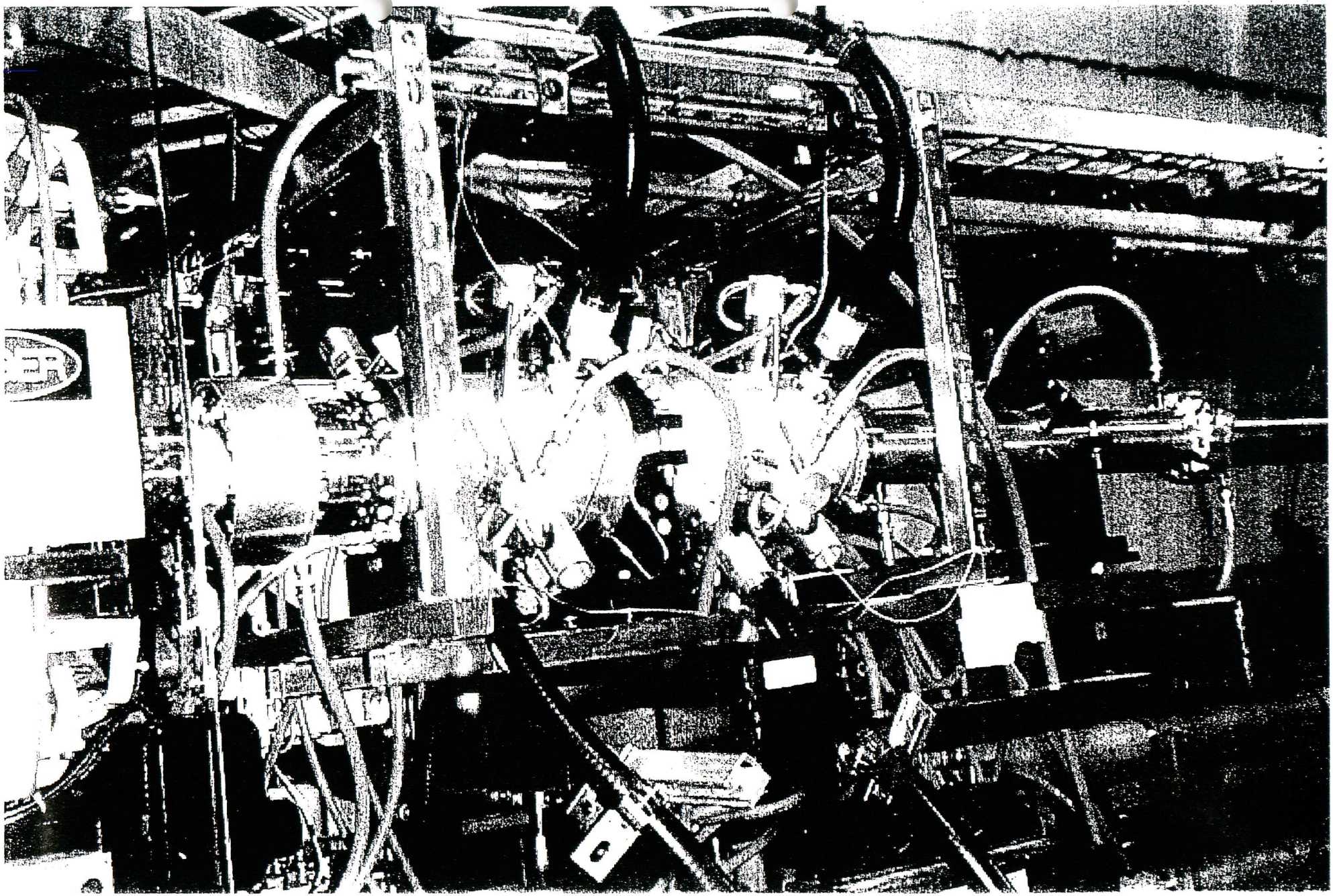
SEM Adjs.
Volts 820
Gain 1000
OP Prot. Y

Begin Mass = 1

Dwell = 16

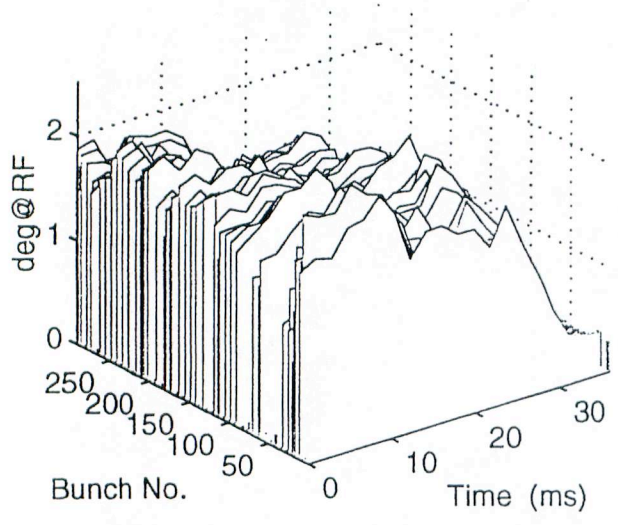
100 = End Mass


Longitudinal Feedback Kicker

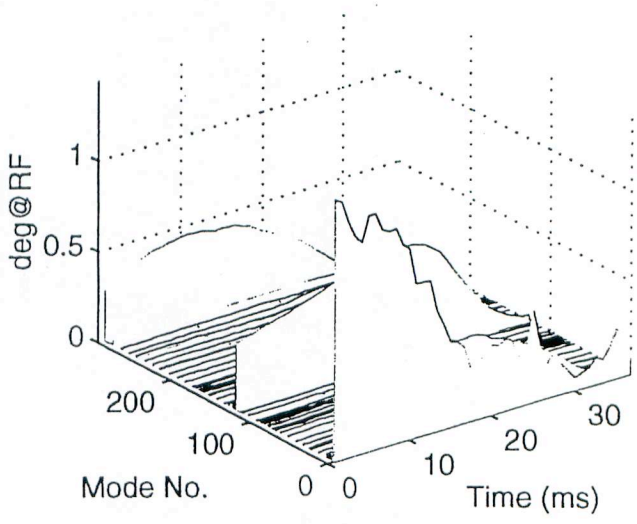


Low Energy Ring Longitudinal Kicker

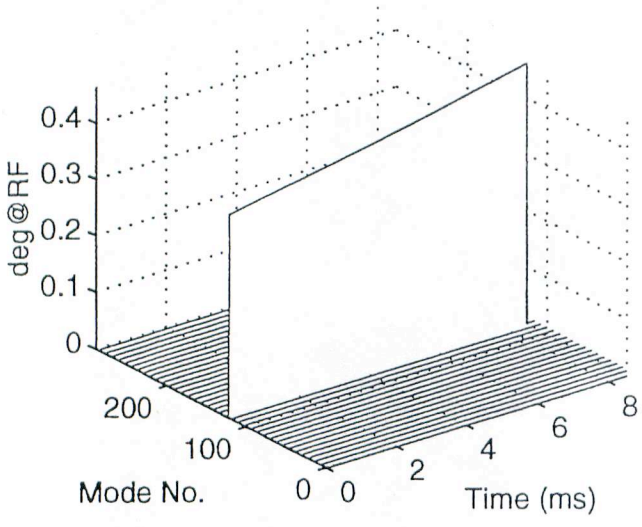
a) Osc. Envelopes in Time Domain



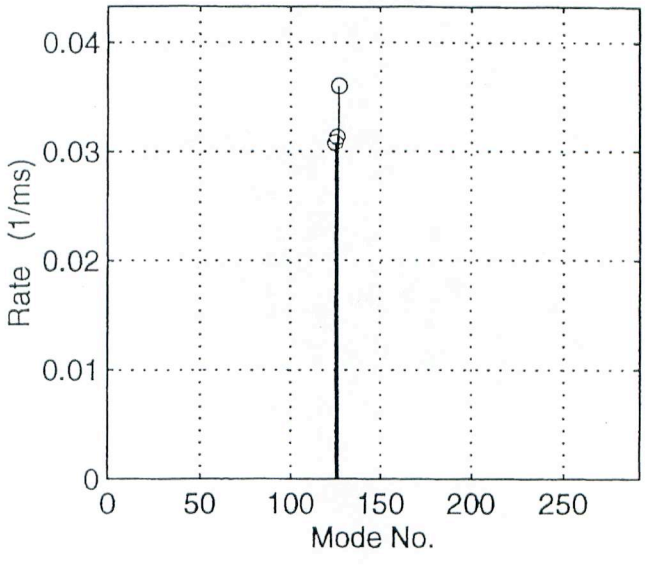
b) Evolution of Modes



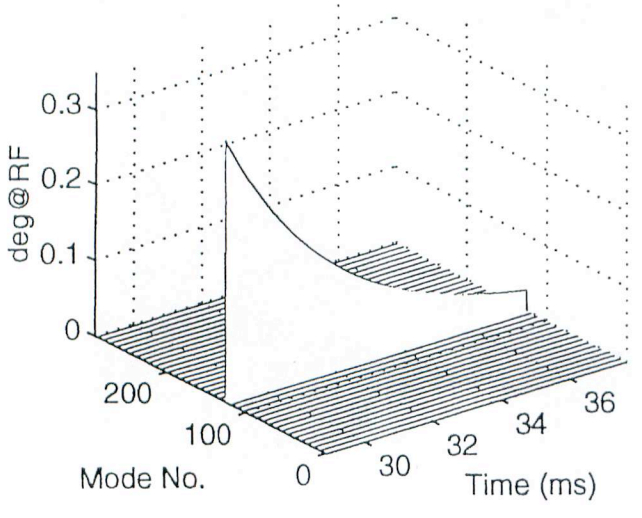
c) Exp. Fit to Modes (pre–brkpt)



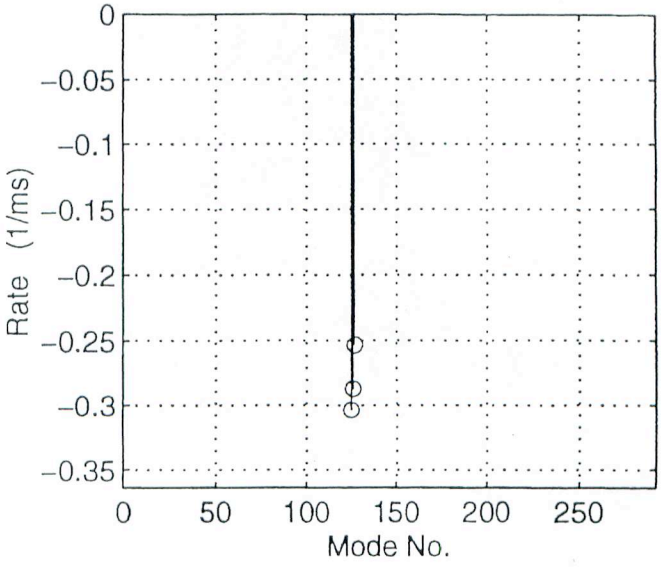
d) Growth Rates (pre–brkpt)



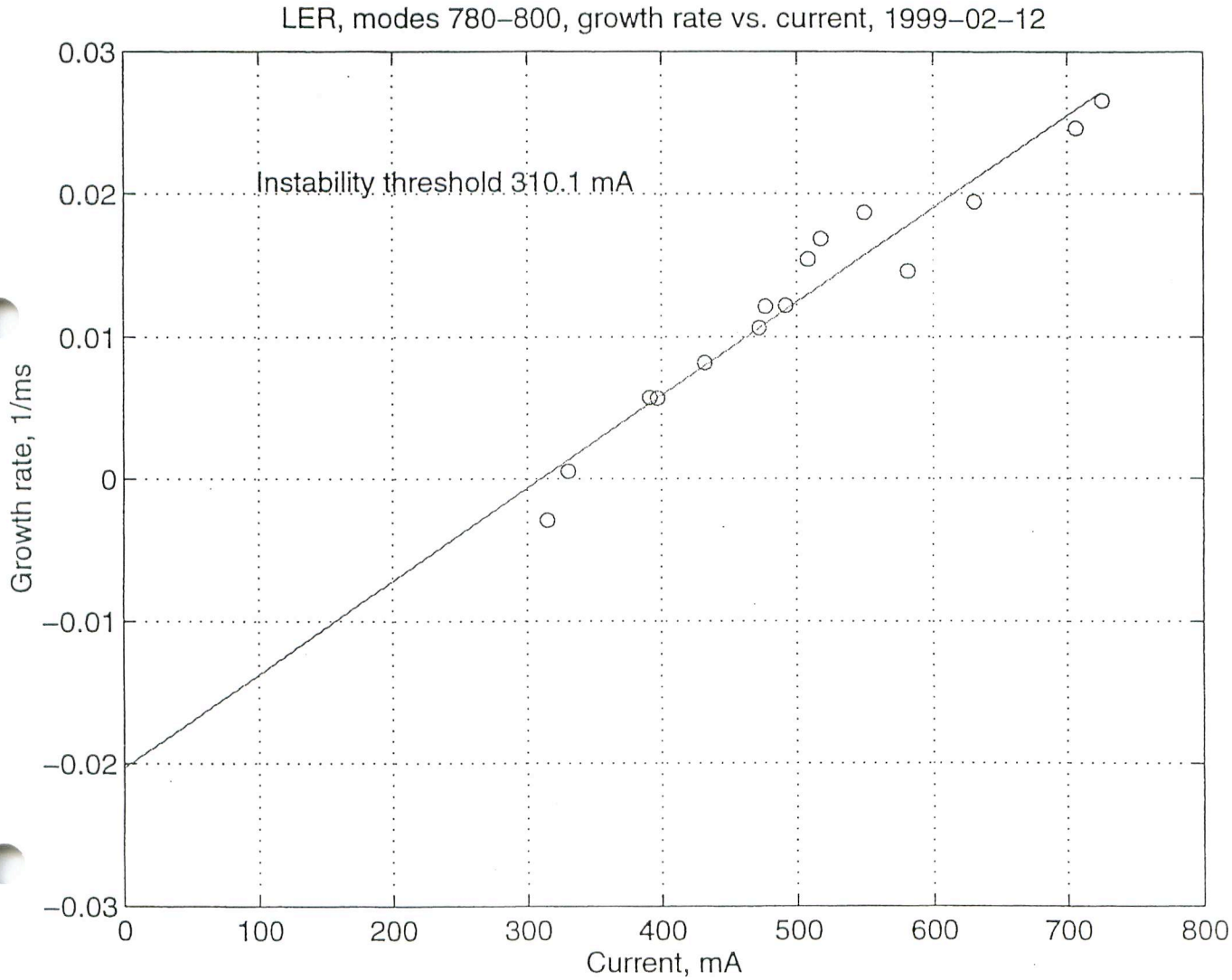
e) Exp. Fit to Modes (post–brkpt)



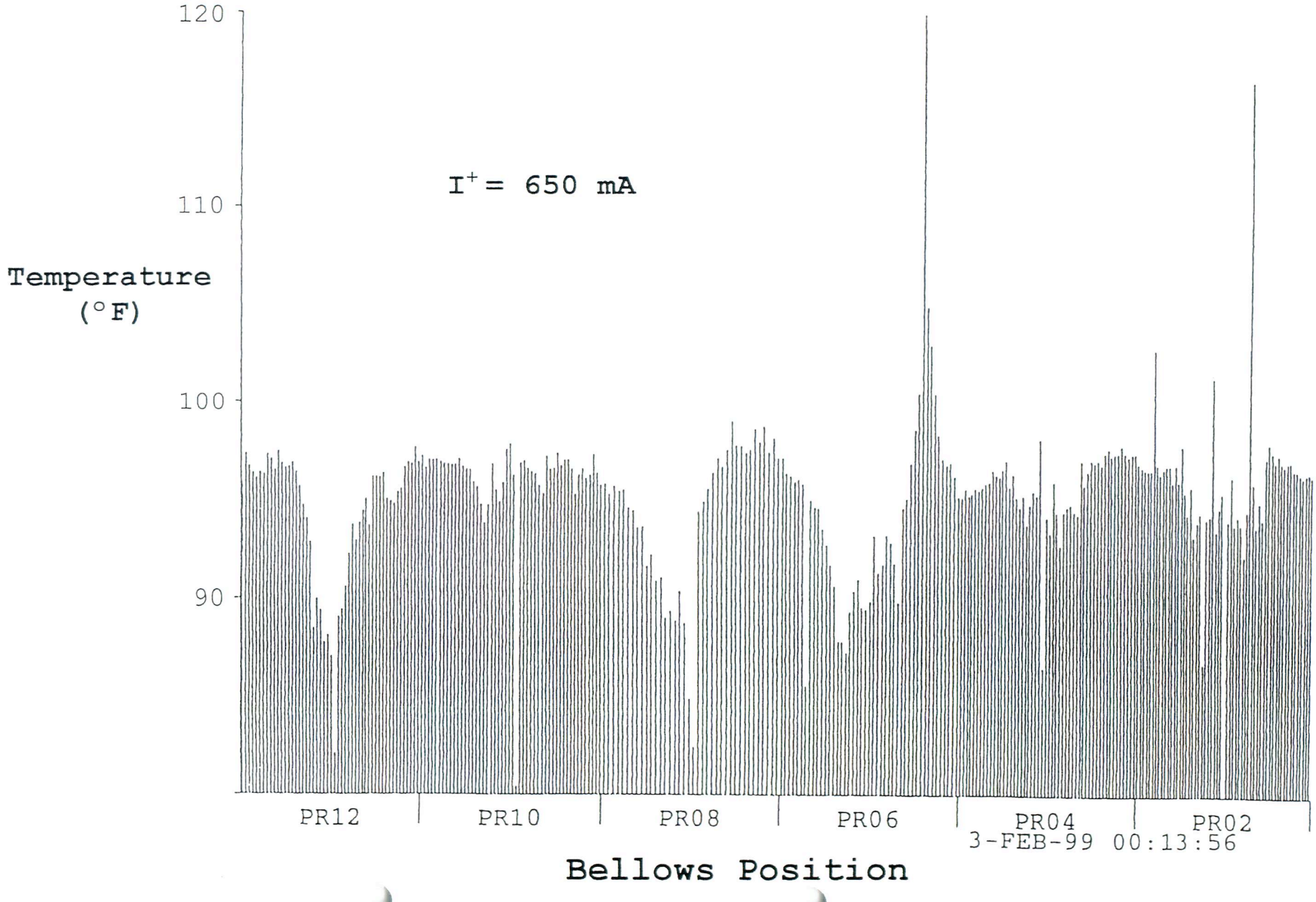
f) Growth Rates (post–brkpt)



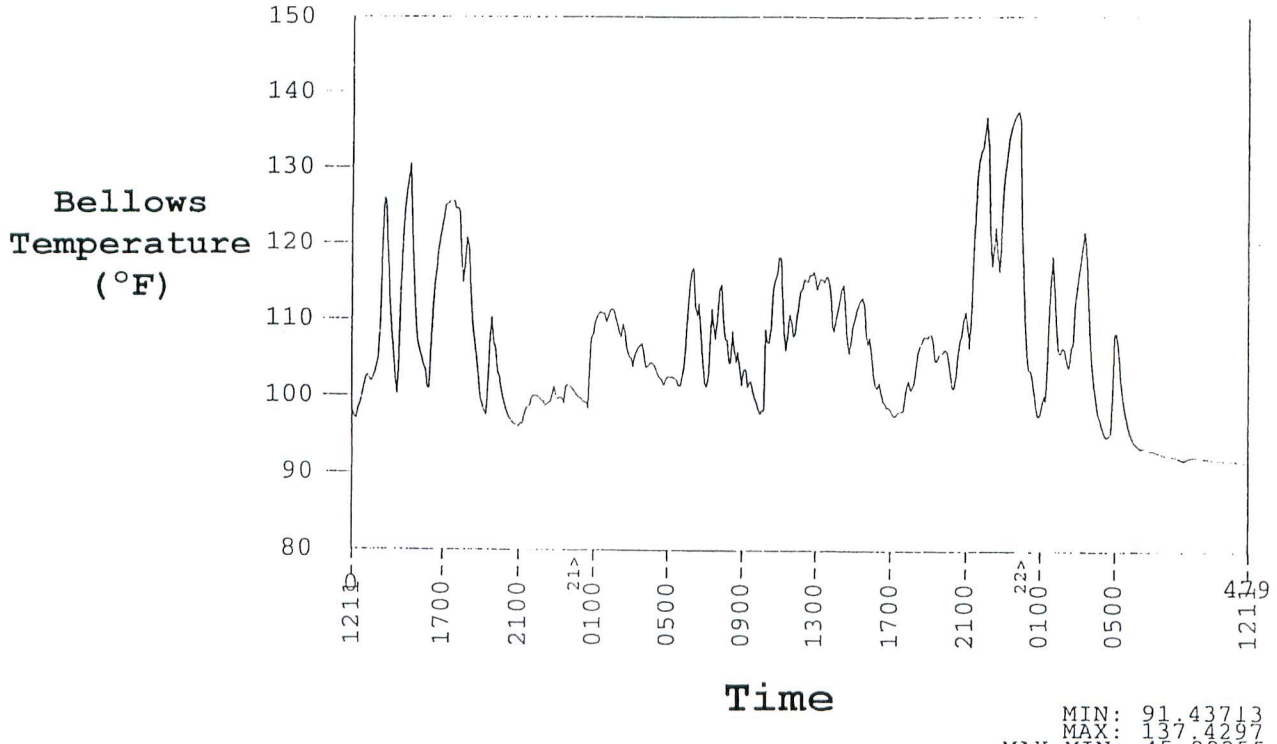
PEP–II LER/jan2999/LER/1247: Io= 414.1mA, Dsamp= 6, ShifGain= 3, Nbun= 290,

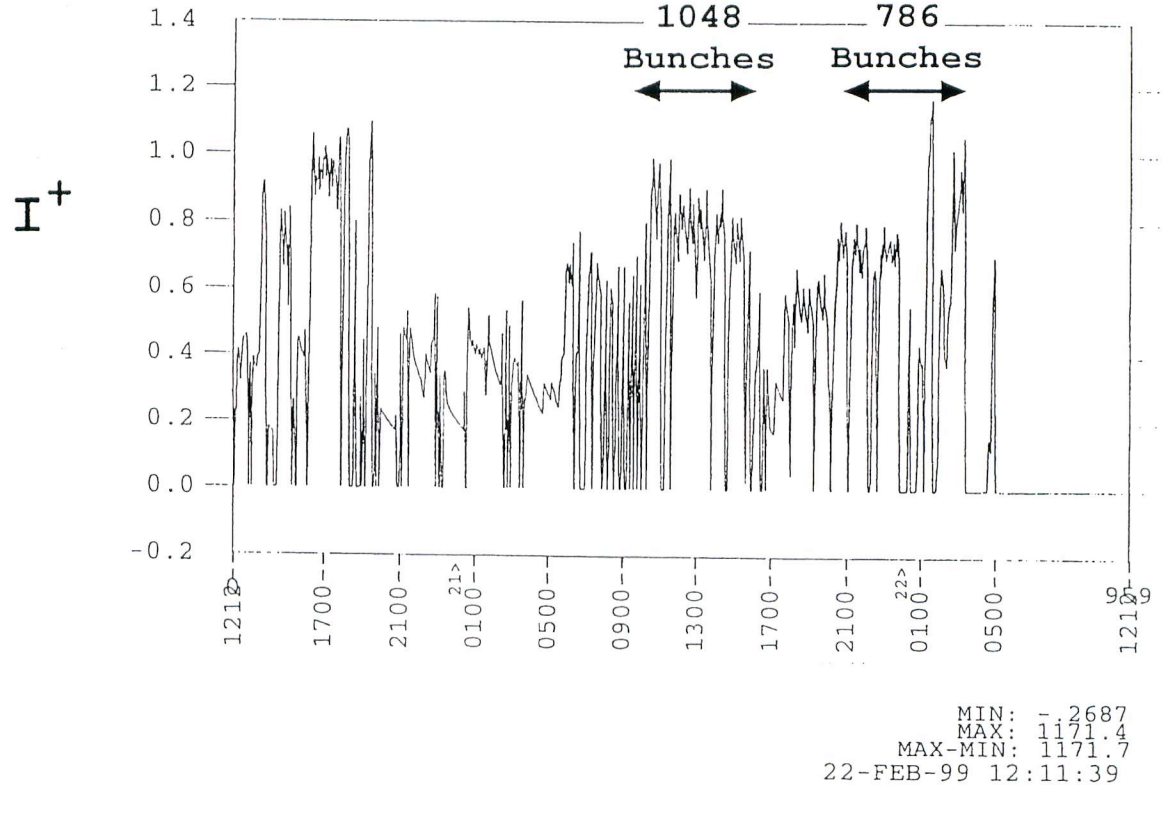

LER, modes 780–800, growth rate vs. current, 1999–02–12
Instability threshold 310.1 mA
Growth rate, 1/ms
Current, mA
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
0
100
200
300
400
500
600
700
800

LER Bellows Temperature

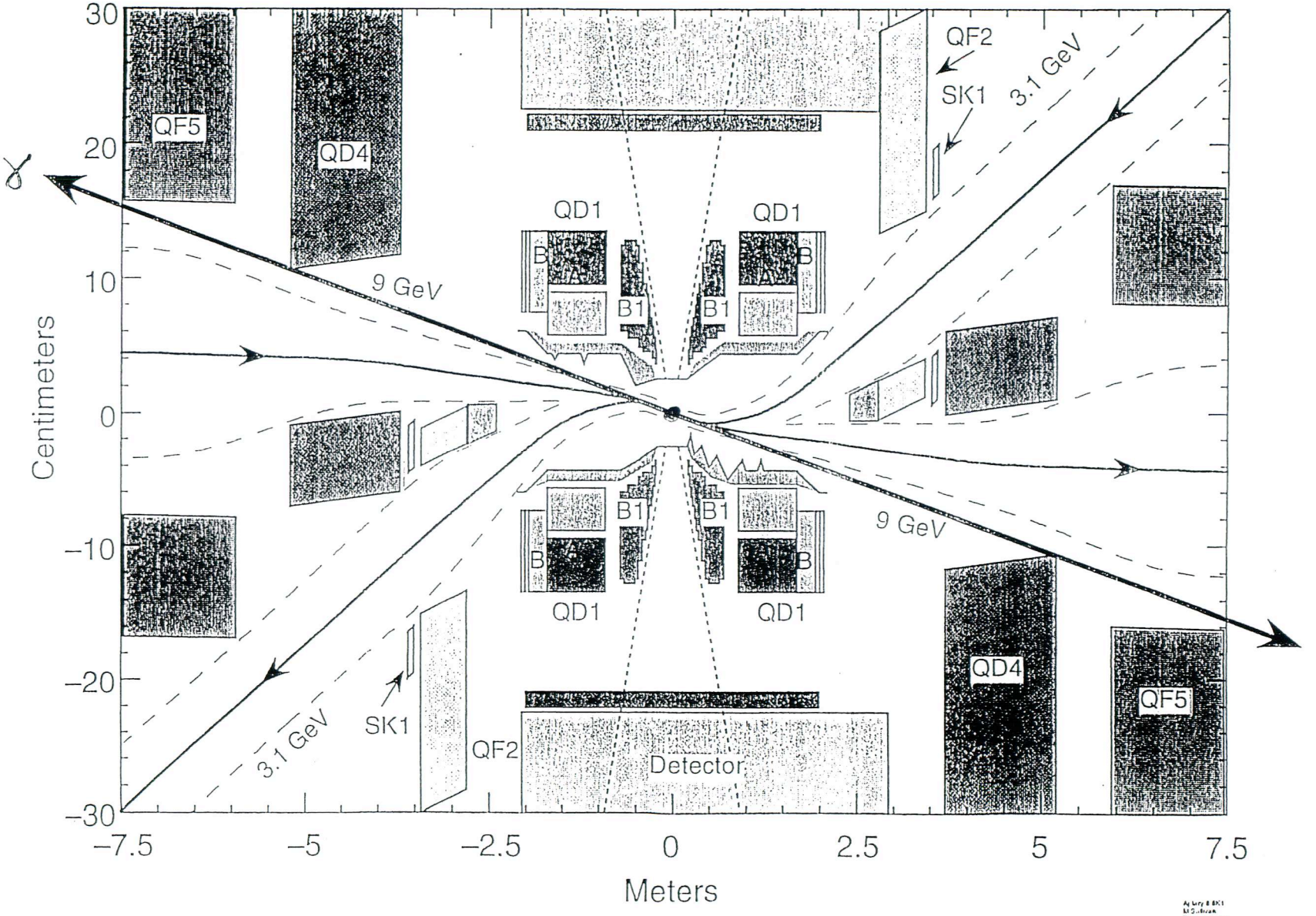


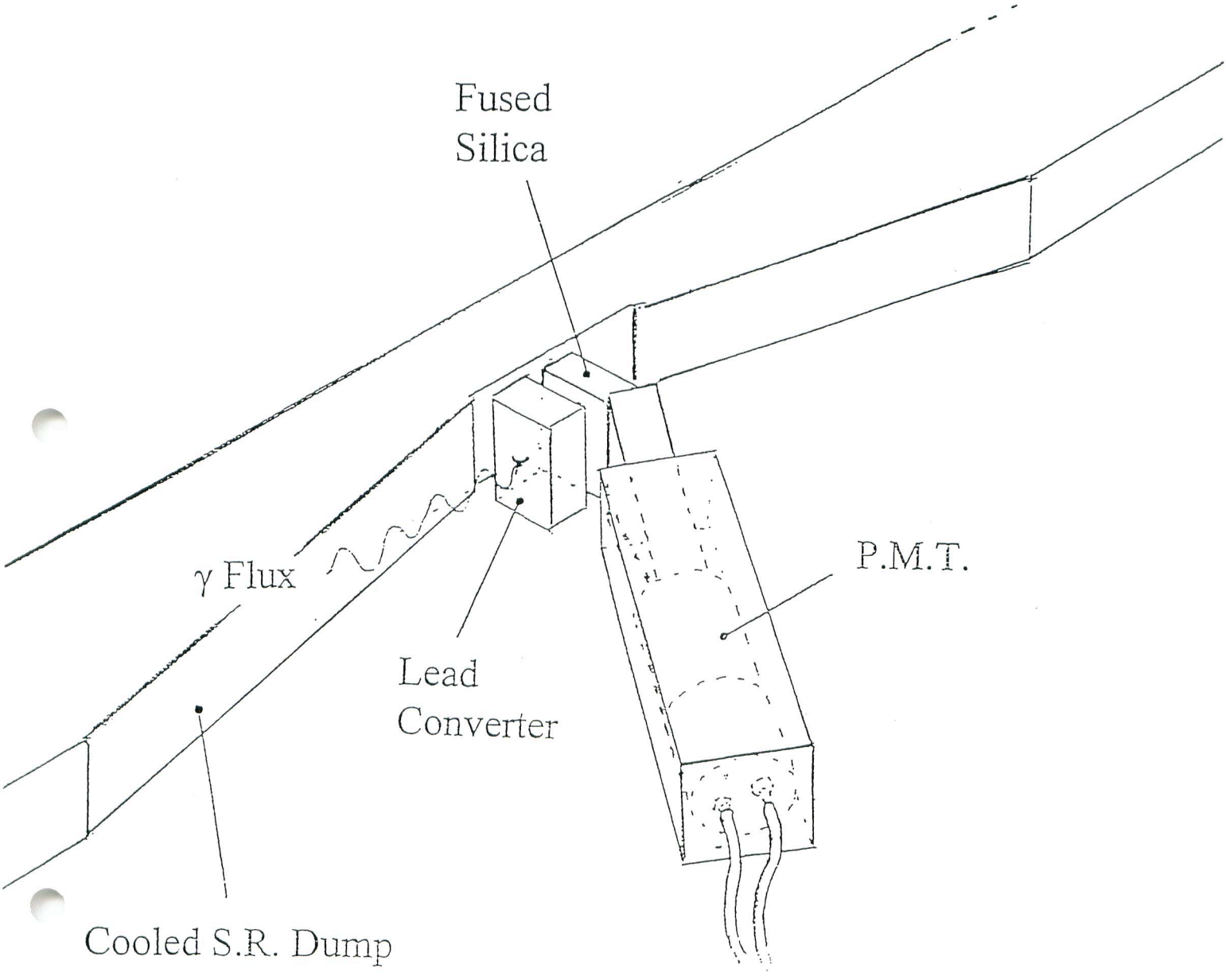
Bellows Temperature and Current vs Time





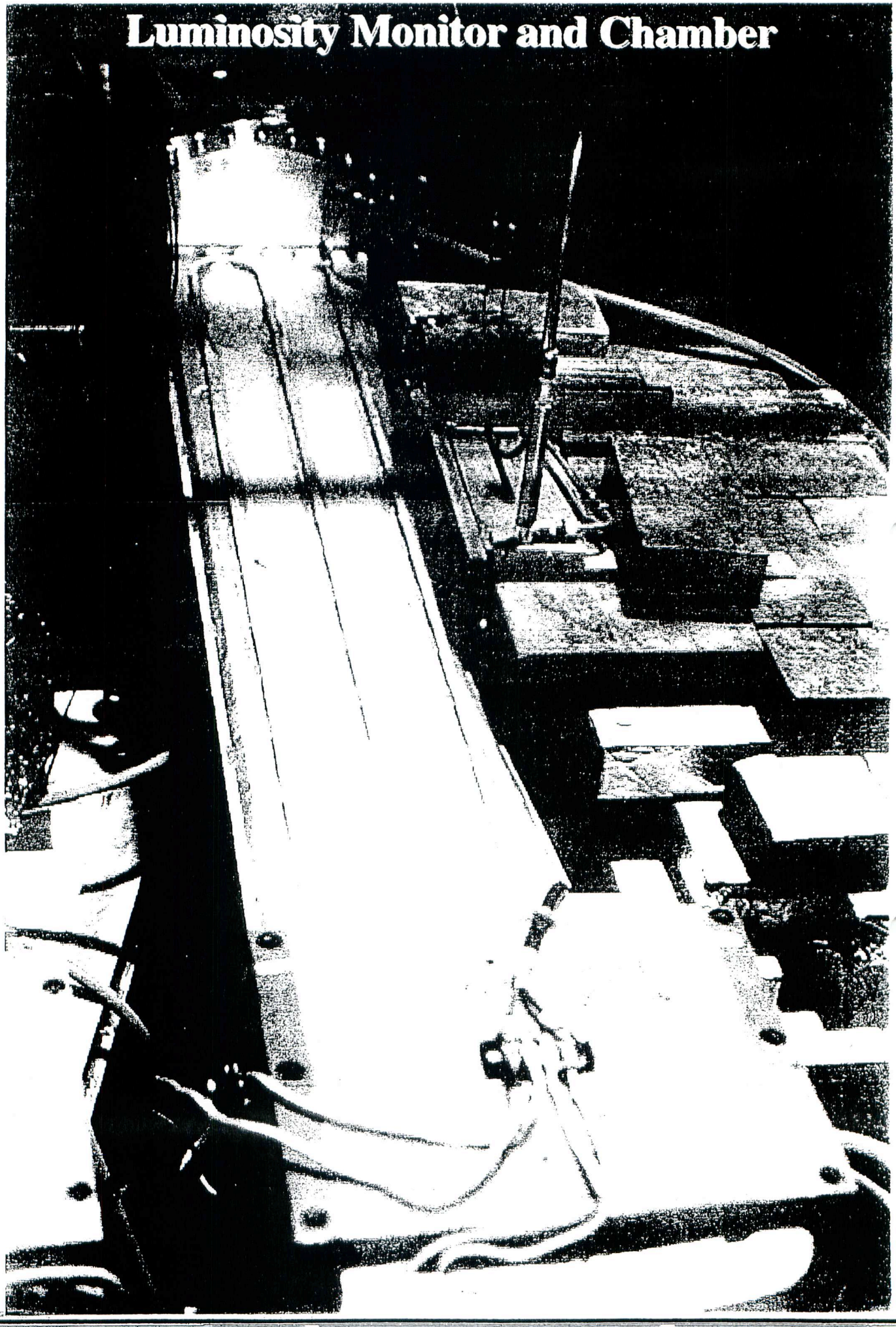
PEP-II Interaction Region

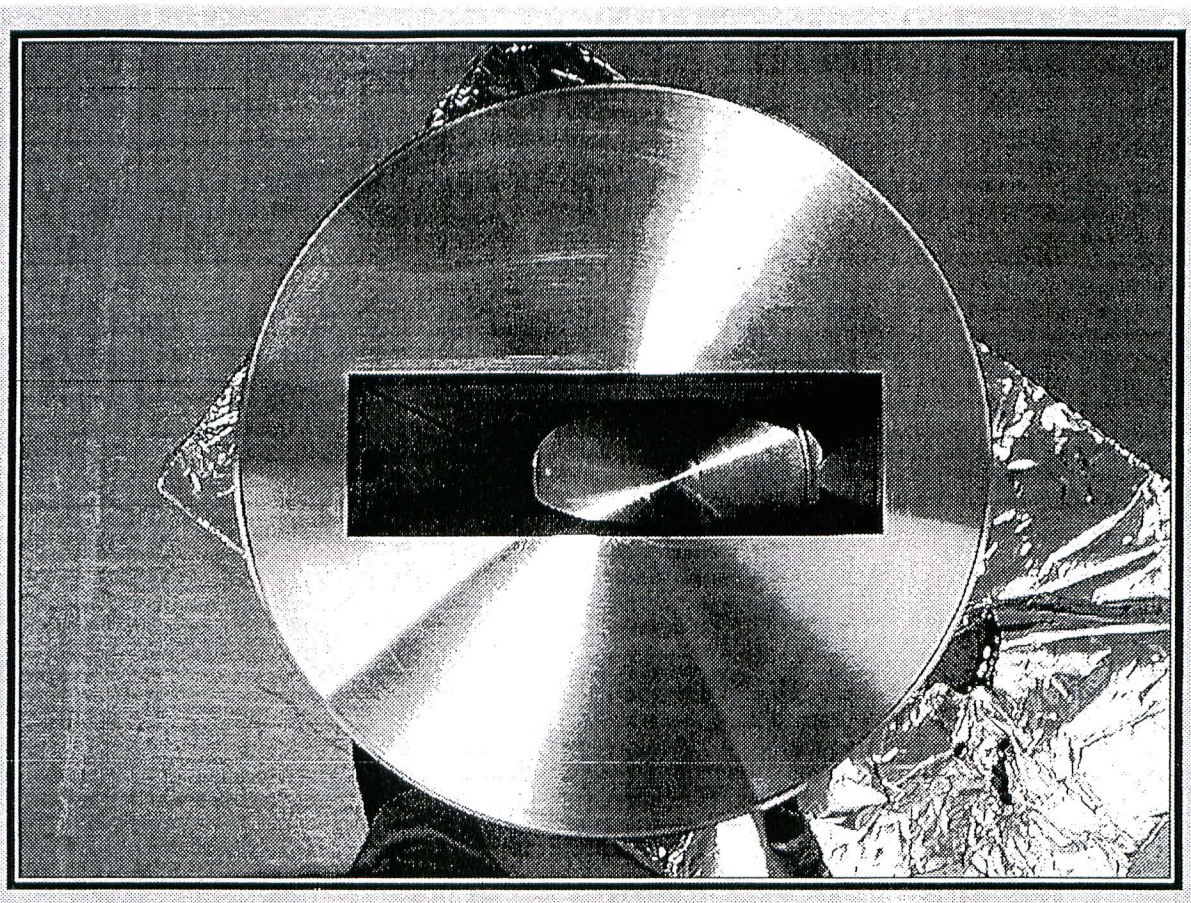




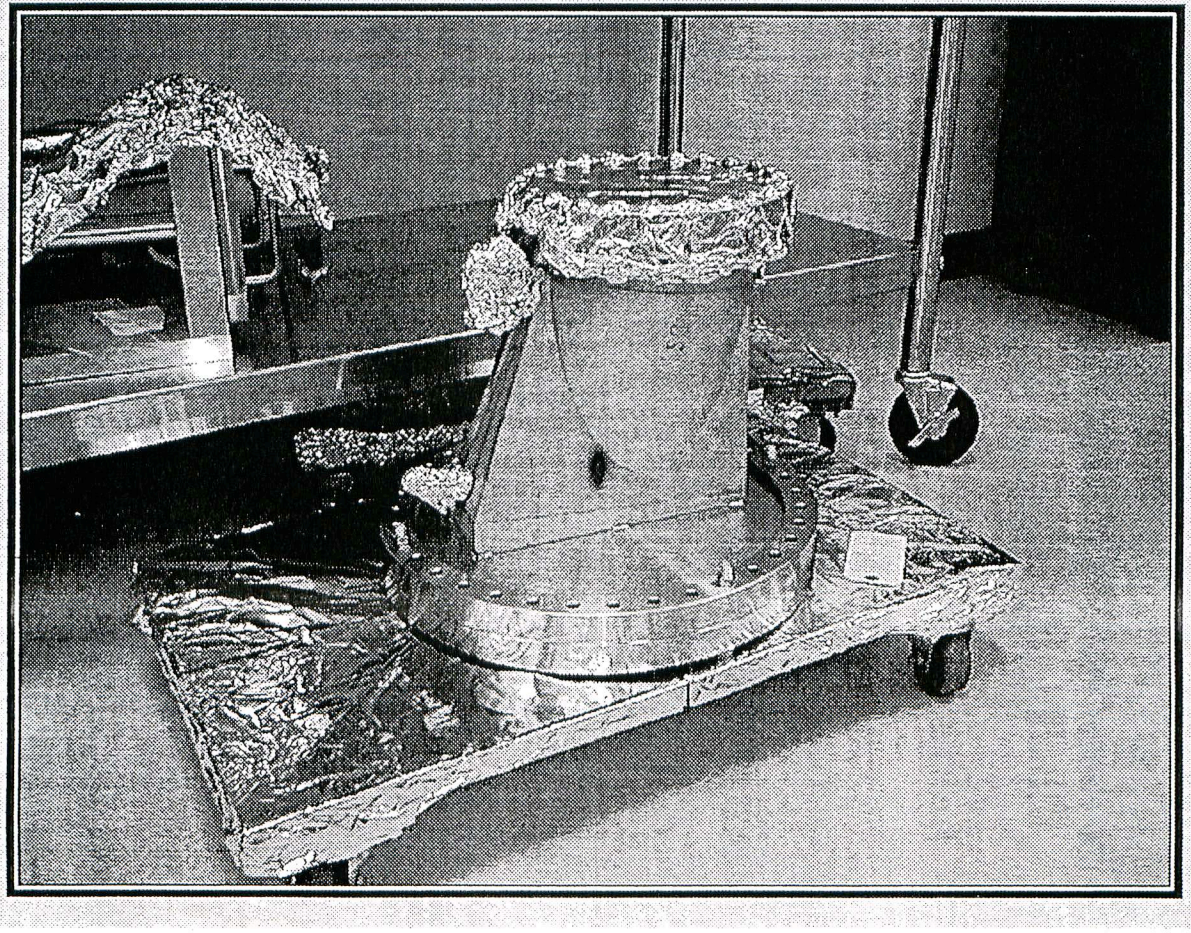
— Radiation Shielding Not Shown —

Luminosity Monitor and Chamber



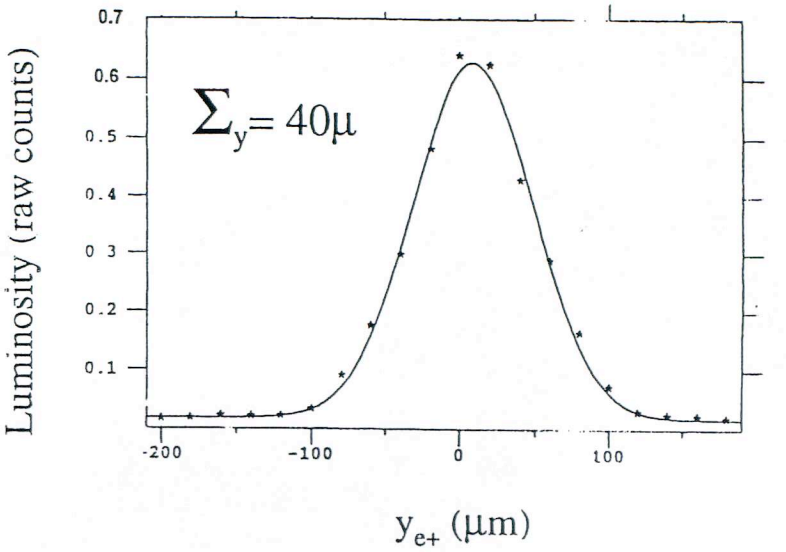


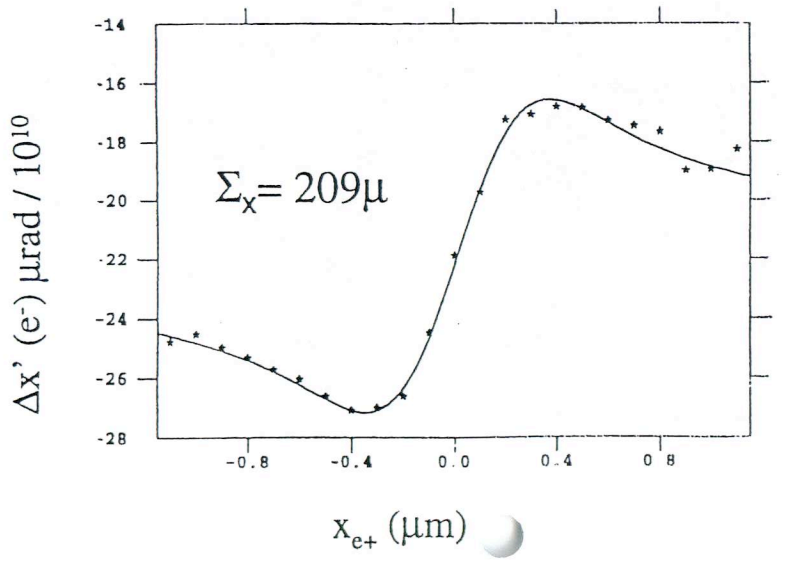
HER Downstream IR-2 Transition
Q5 to "Fant" Chambers

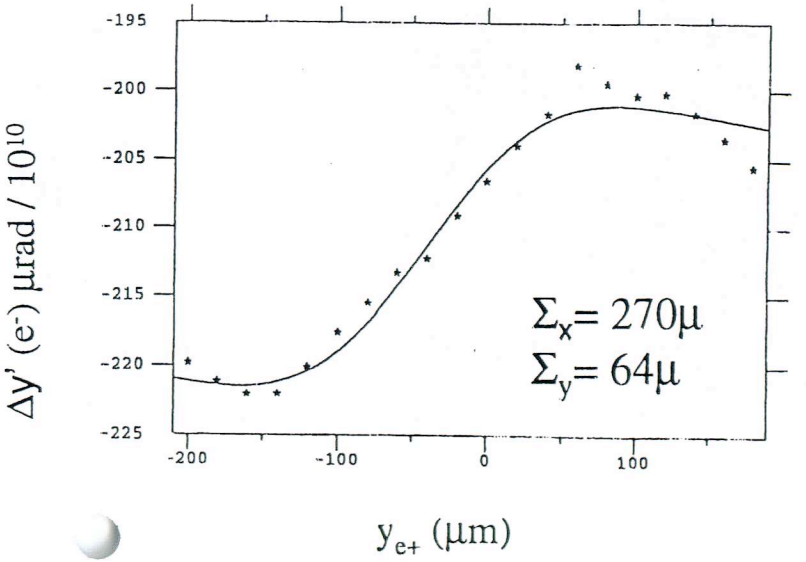


First Measured Luminosity 10 Nov 98

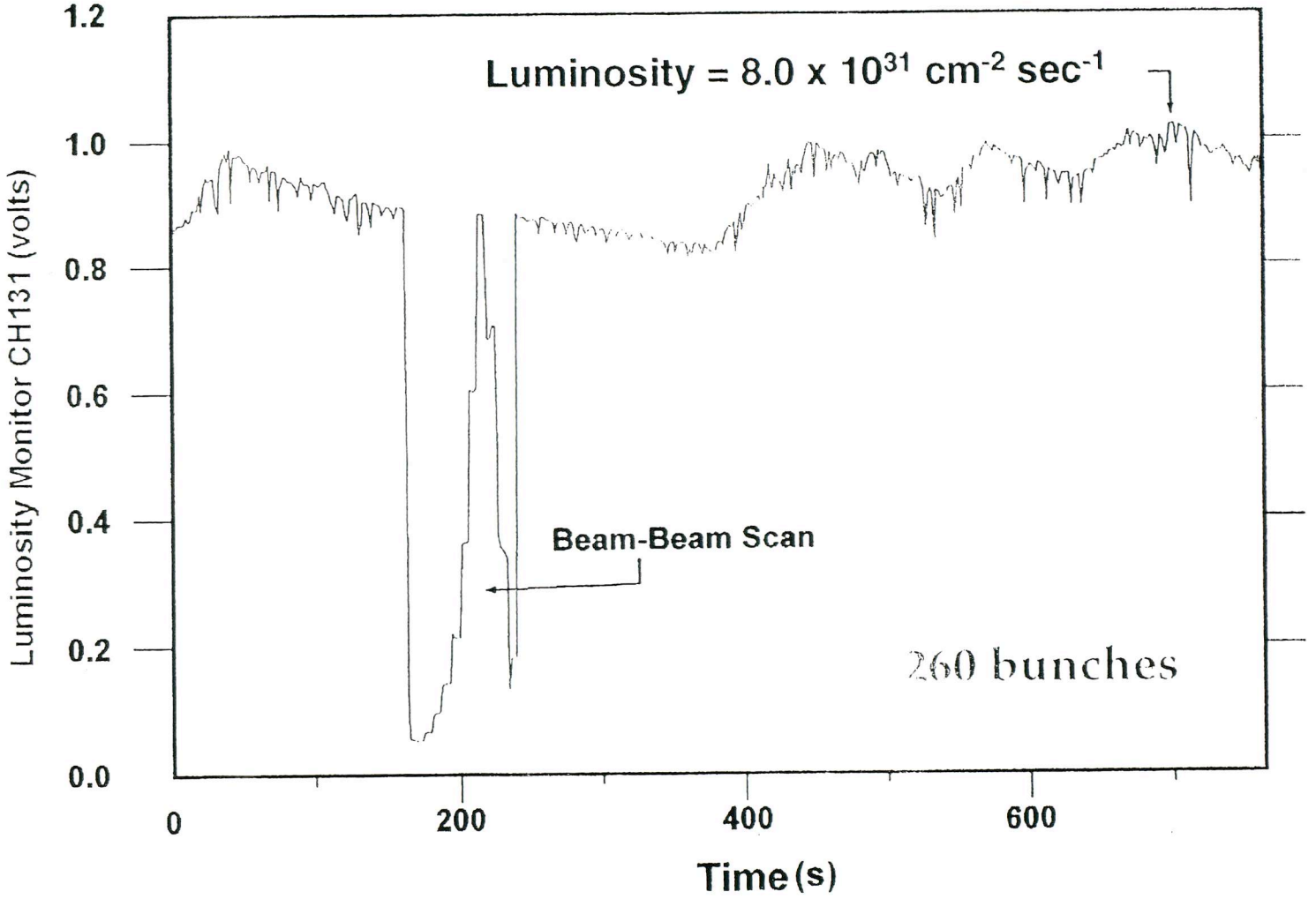
- 0.6 mA in single HER bucket
- 1.3 mA in single LER Bucket
- Stays stored even when not centered
- $\mathcal{L}$ from deflection beam sizes and currents ~ 2 x10^{29}
- $\mathcal{L}$ from radiative Bhabha rate ~ 2.7 x 10^{29}
- 11 Bunches gave ~11 times luminosity







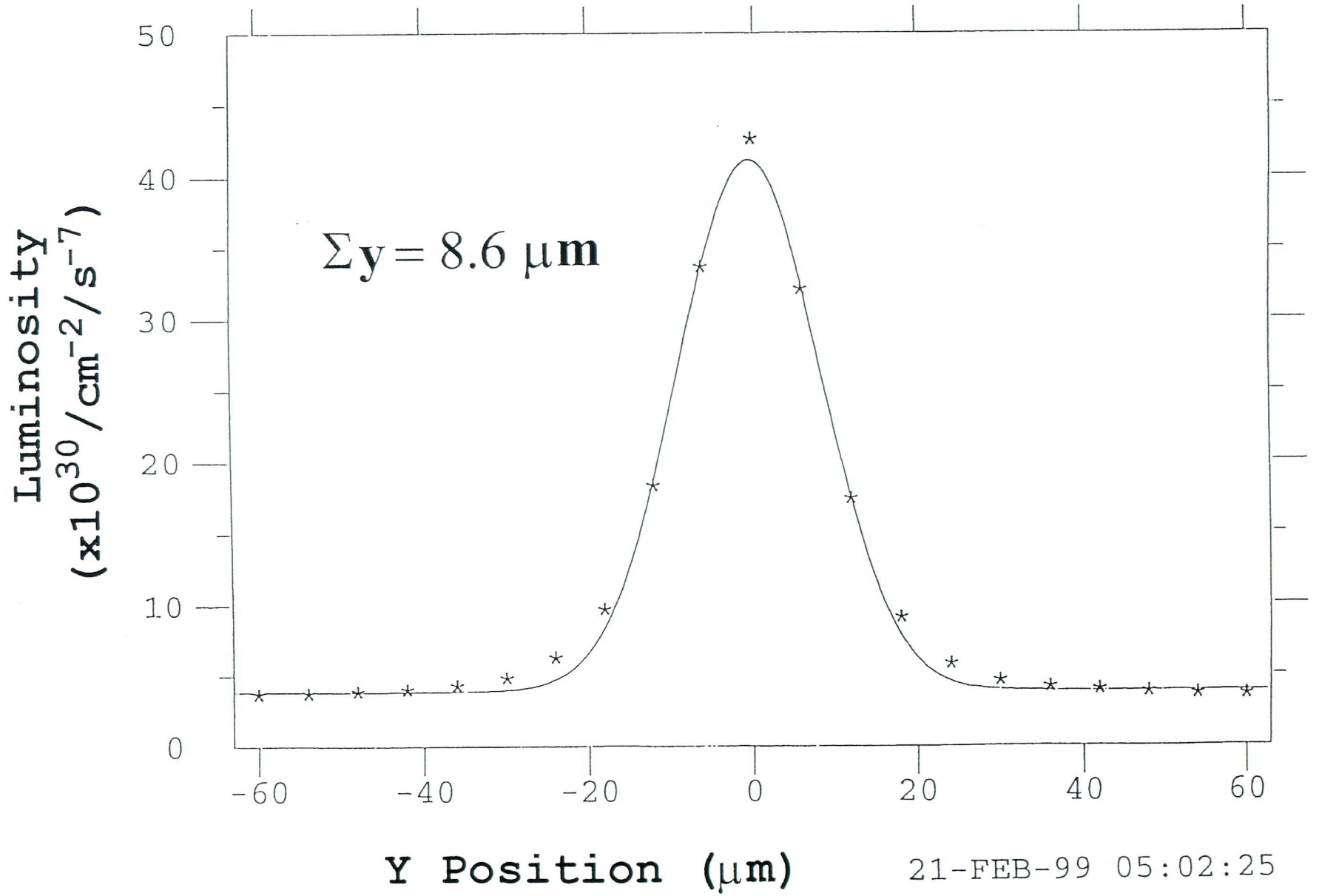
PEP-II Luminosity Record - Dec. 10, 1998



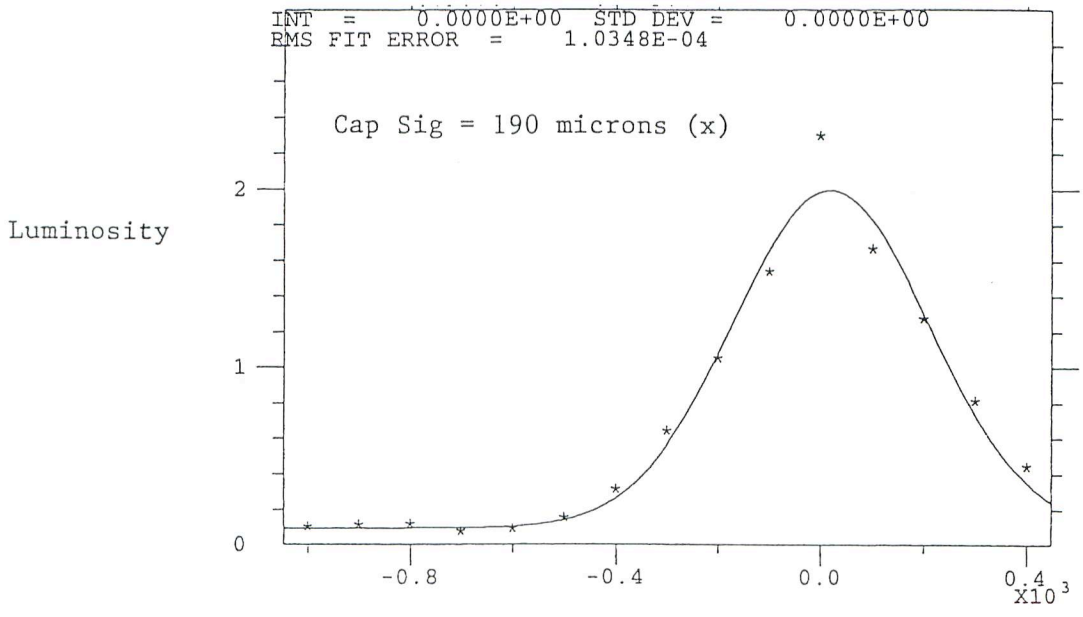
$\mathcal{L}_{measured} = 8.0 \times 10^{31}\ cm^{-2}\ sec^{-1}$ $I^+ = 260$ mA $\Sigma_y = 14$ um $\tau_+ = 24$ min

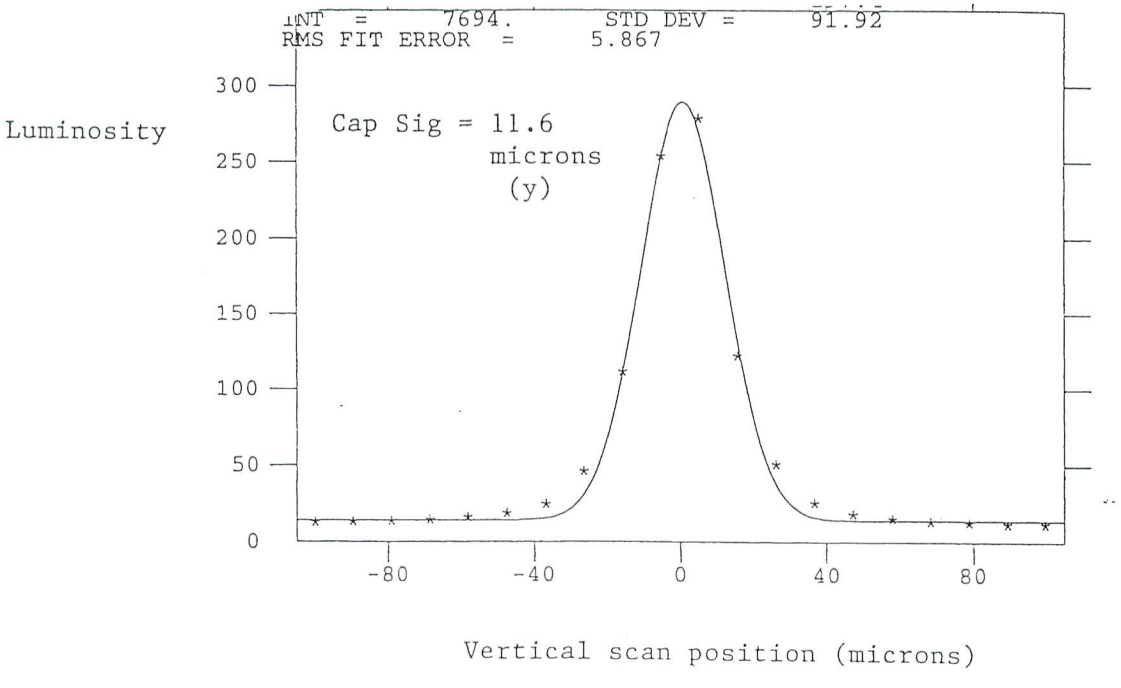
$I^- = 84$ mA $\Sigma_x = 320$ um $\tau_- = 470$ min

Vertical Beam-Beam Scan



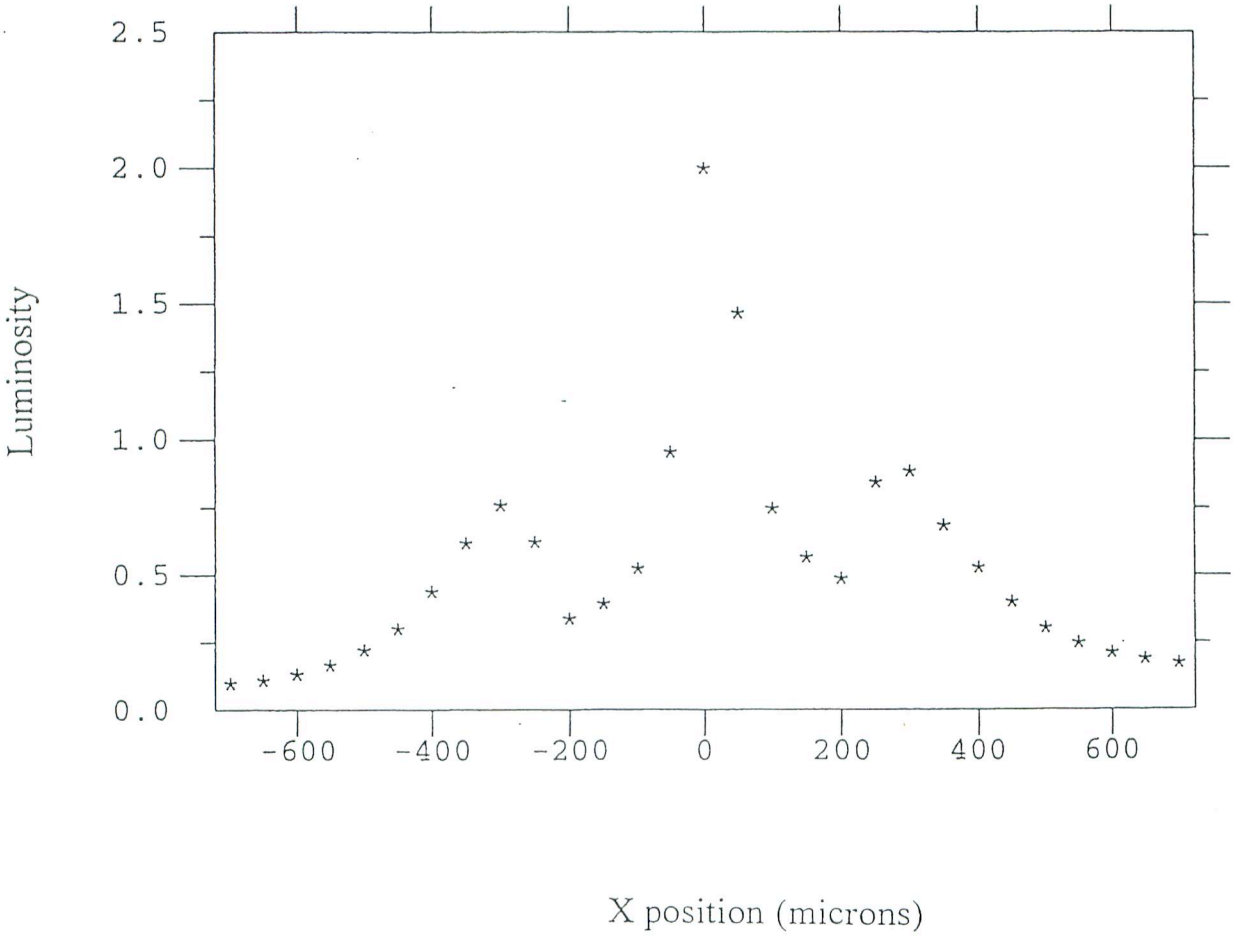
PEP-II Horizontal and Vertical Beam-Beam Scans



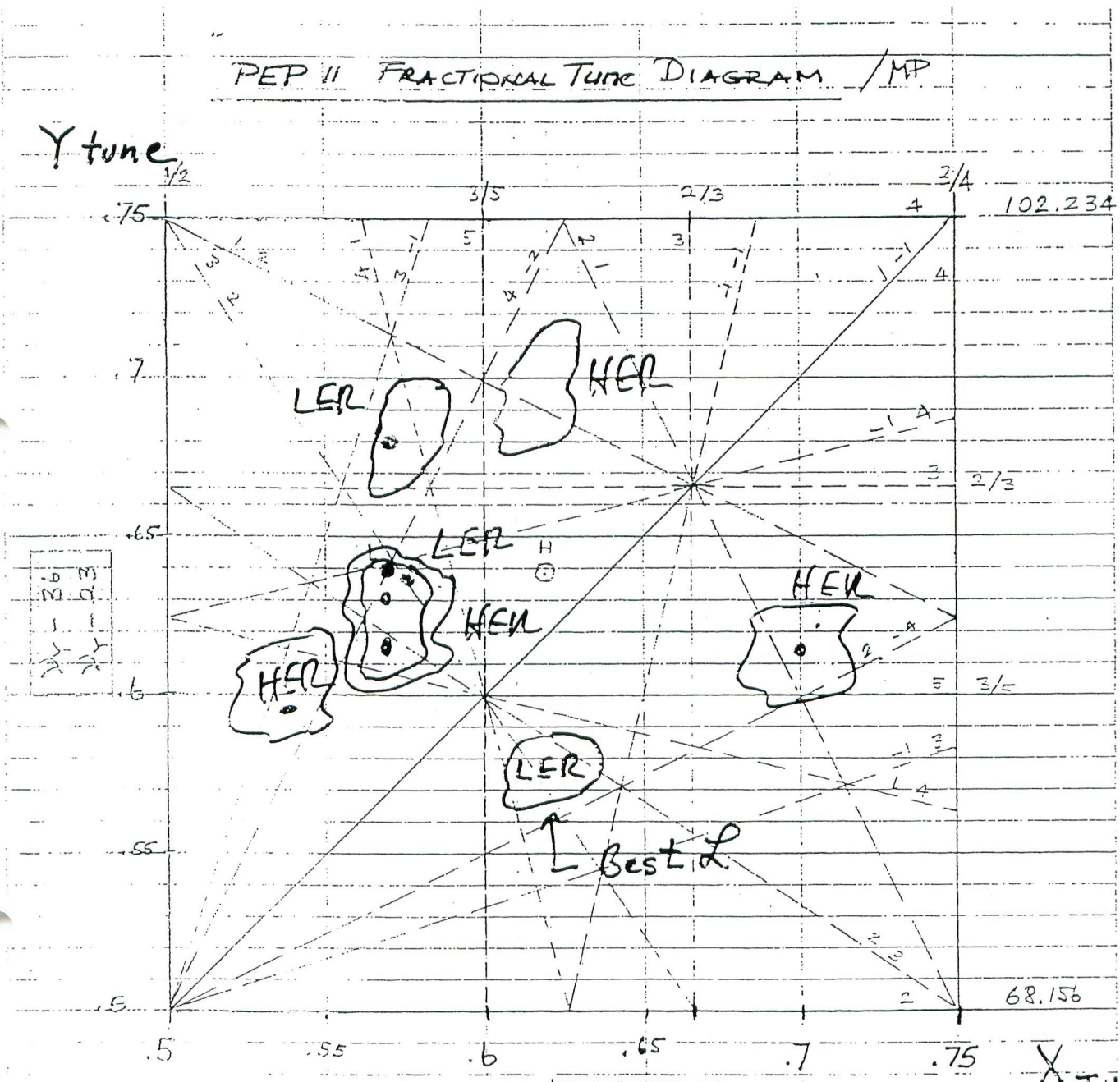


PEP-II Horizontal Beam-Beam Scan at High Current

Note the distorted scan due to beam enlargement when the two beams are separated by about one sigma.



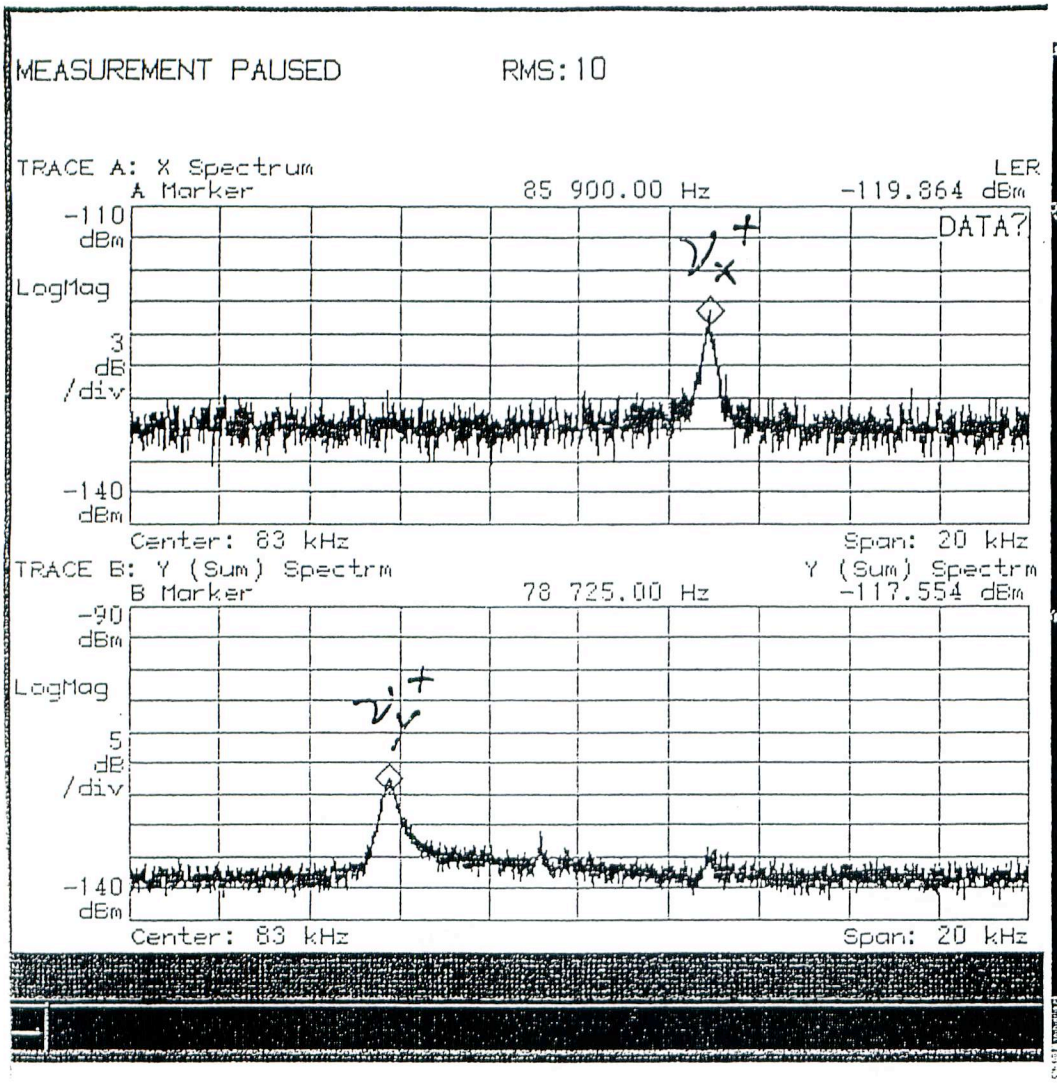
PEP II FRACTIONAL TUNE DIAGRAM /MP

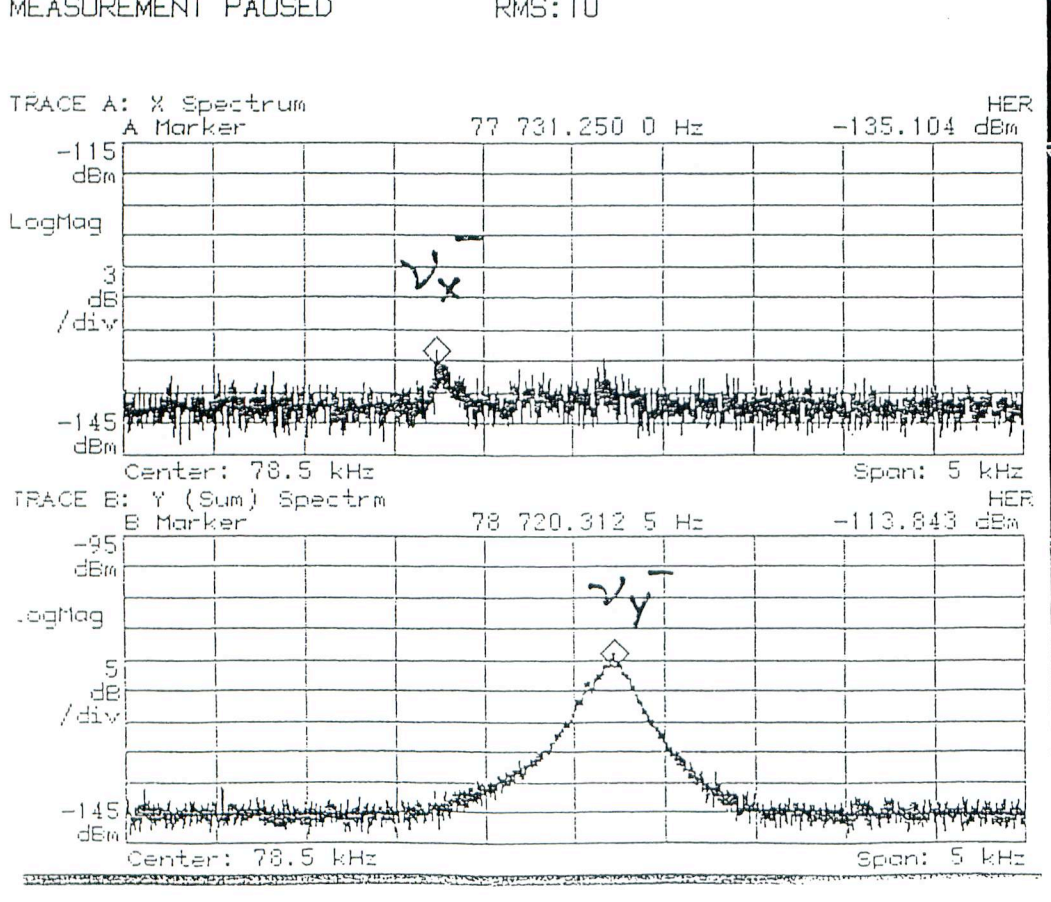


DESIGN	⊕ LER	(.570 / .642)	(77697 / 87512)
	⊖ HER	(.518 / .638)	(84241 / 86967)

$\nu_x - 38$
$\nu_x - 24$

as per M. Donald / 11.03





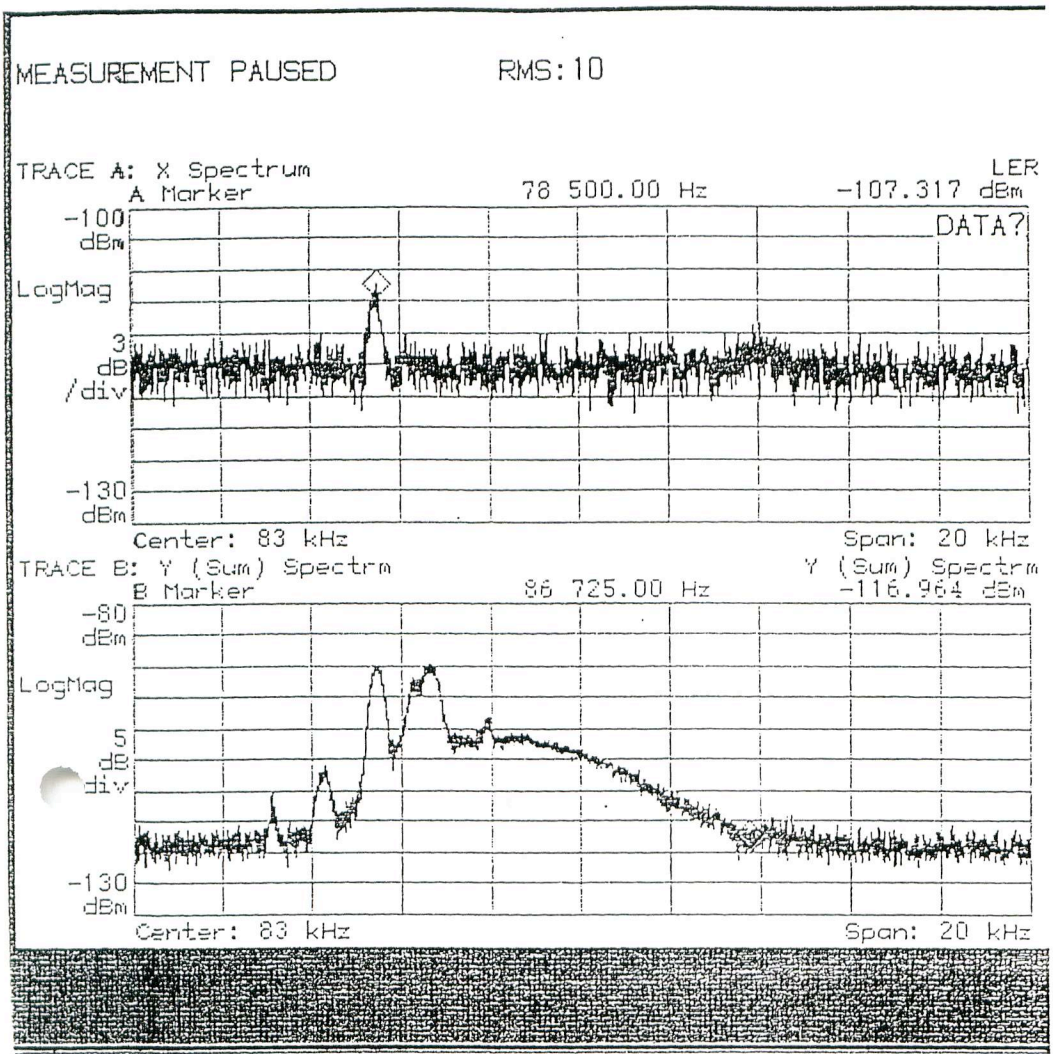
* pilot bunch time measurement

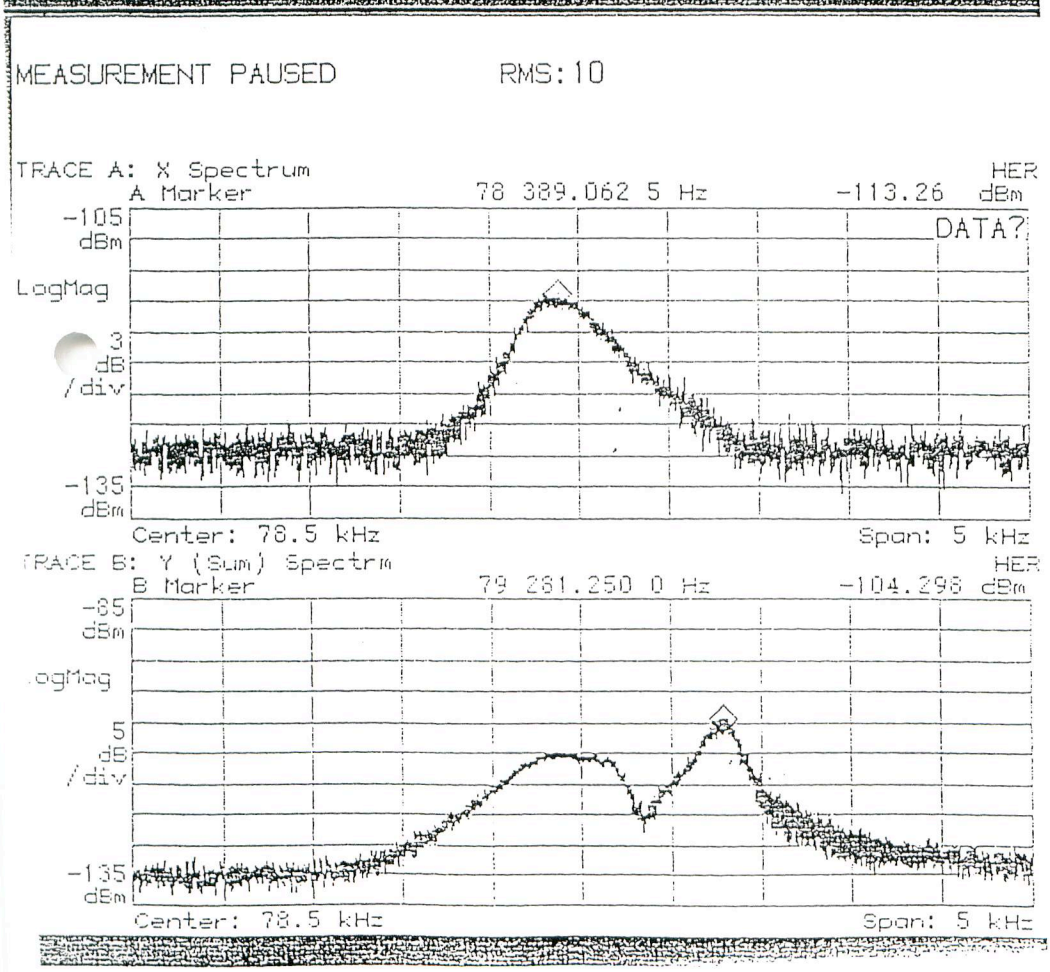
first pilot measurement

0.630 Z
0.5775
} e^+

Single bunch tunes

0.5702
0.5775
} e^-





fine mushroom during collision

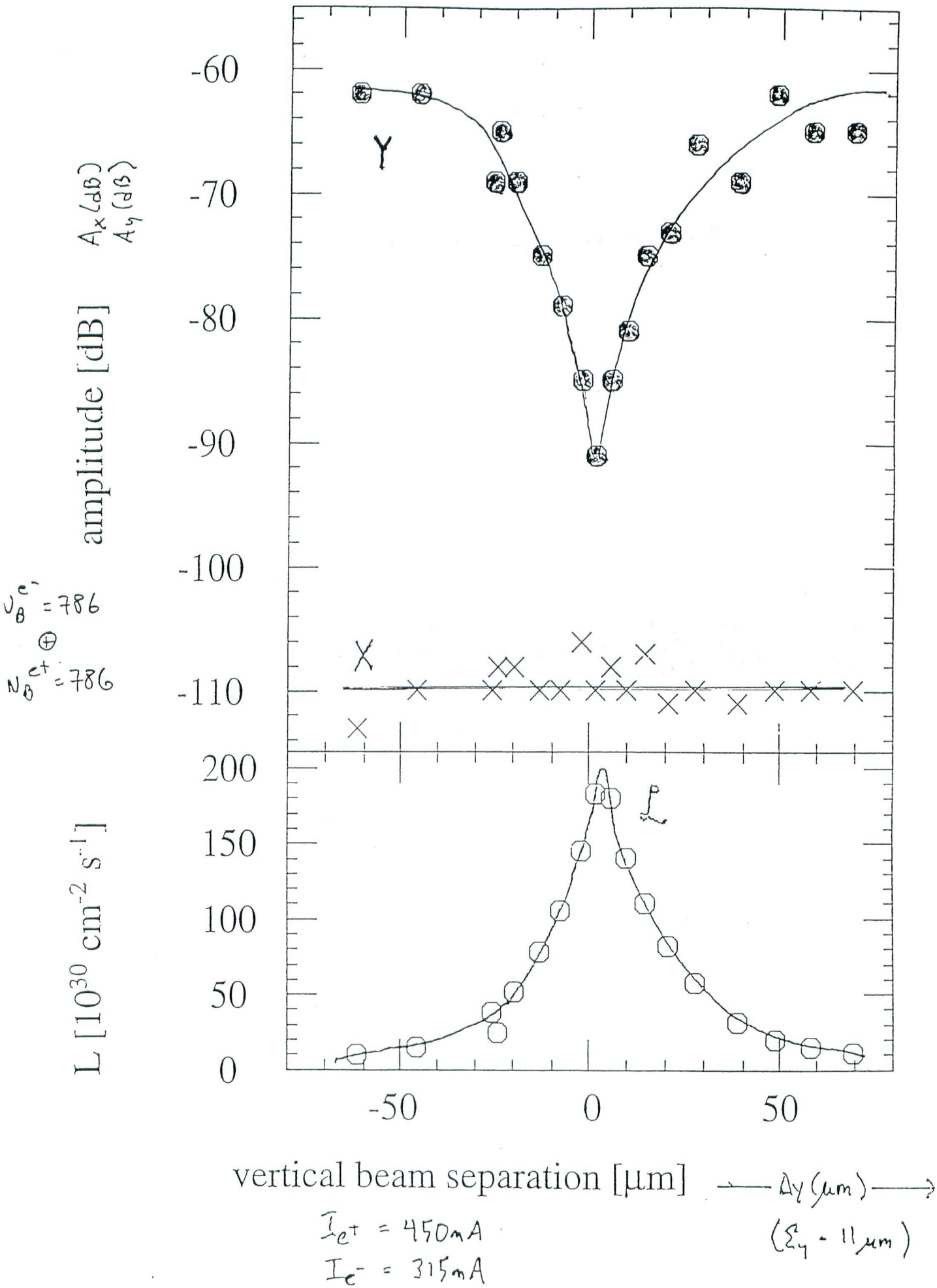
$I^{+} = 613$ mA

$I^{-} = 278$ mA

first measurement

Beam-Beam Tune Spectra

OUT OF COLLISION, PART II (HER/LER 2/9/99)



$N_B^{e^-} = 786$

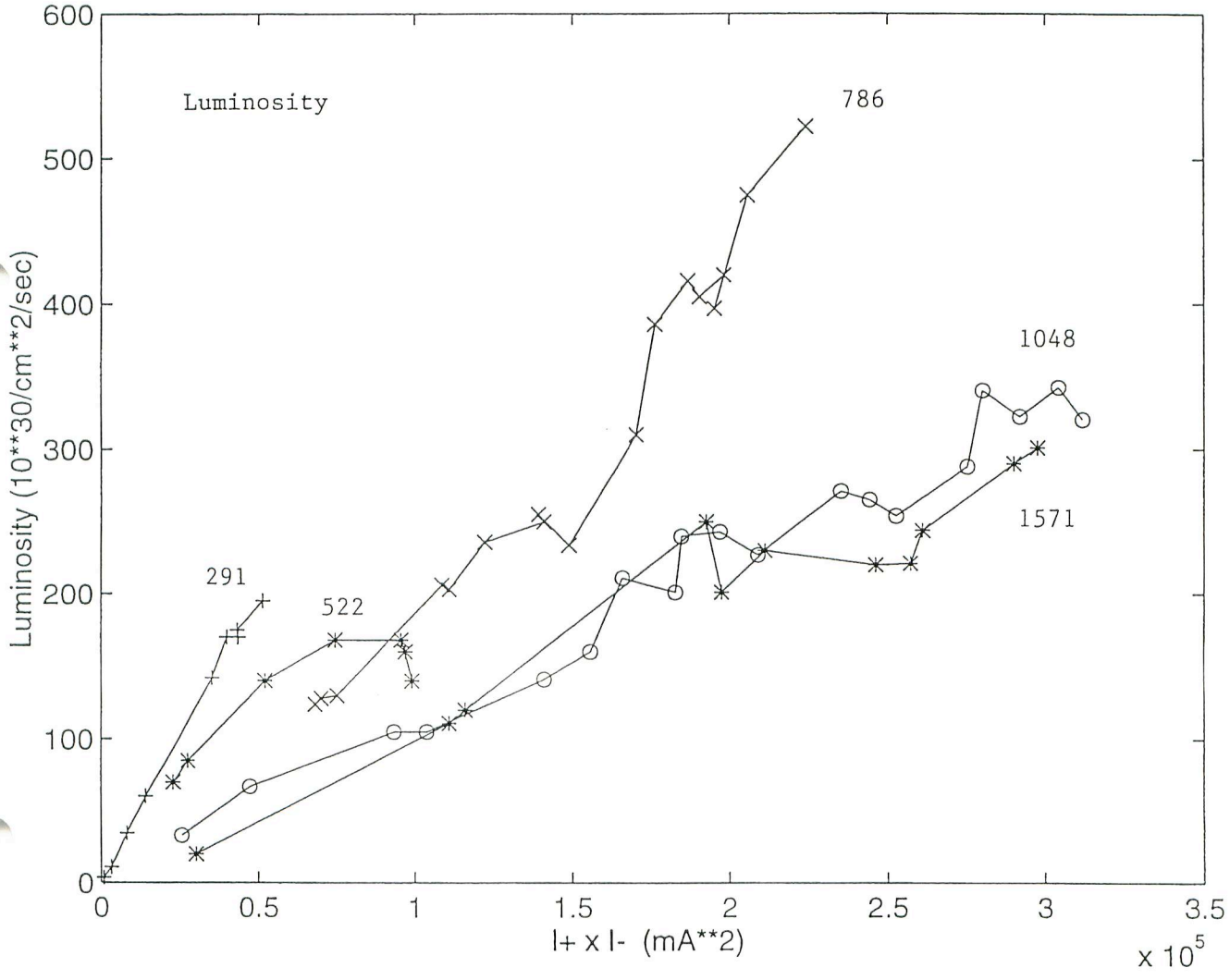
⊕

$N_B^{e^+} = 786$

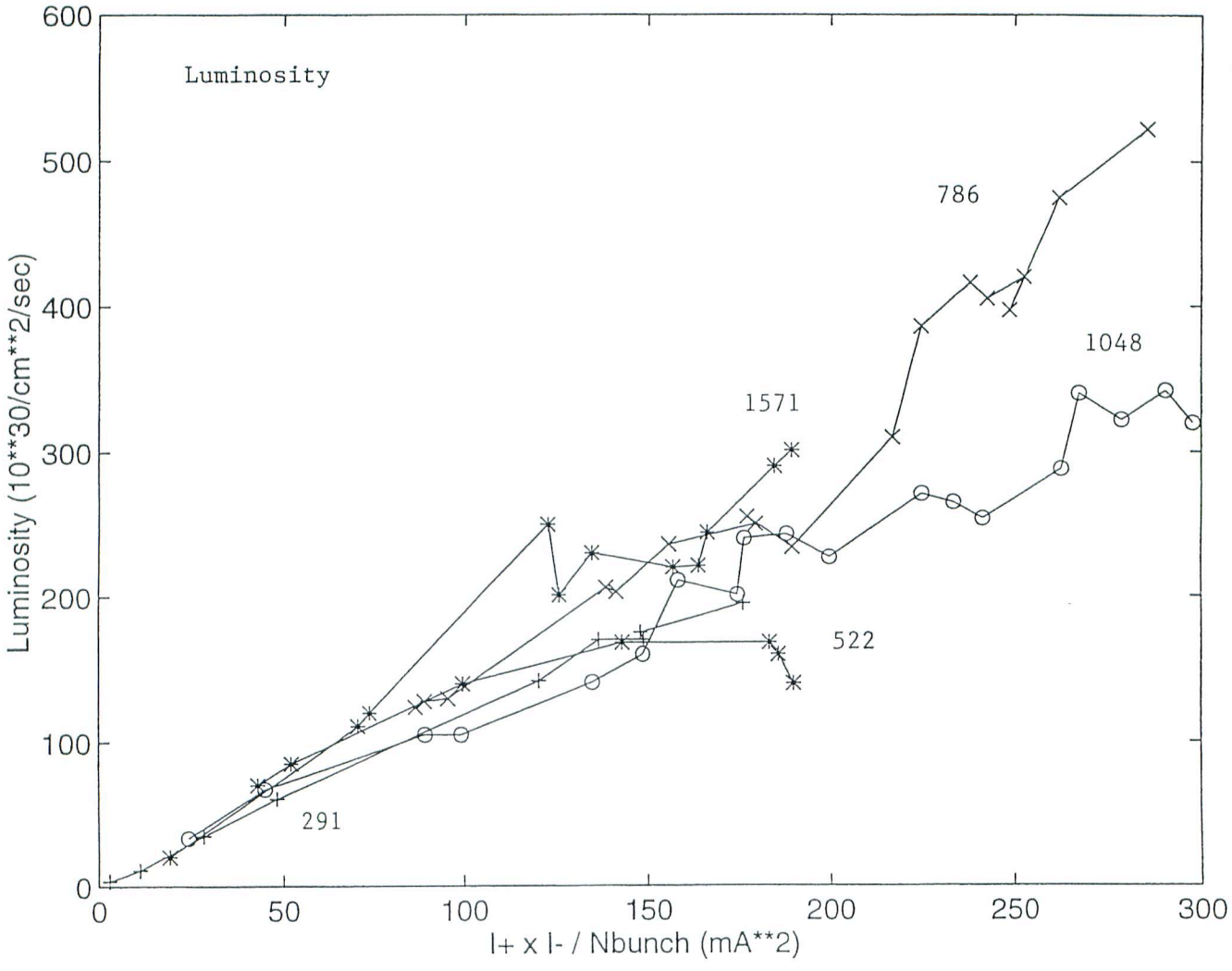
$I_{e^+} = 450\,mA$

$I_{e^-} = 315\,mA$

($\Sigma_y \sim 11\,\mu m$)



e+ current x e- current



e+ current x e- current / Nbunch

March 1, 1999

Maximum PEP-II Tune Shifts

Design tune shift = 0.03

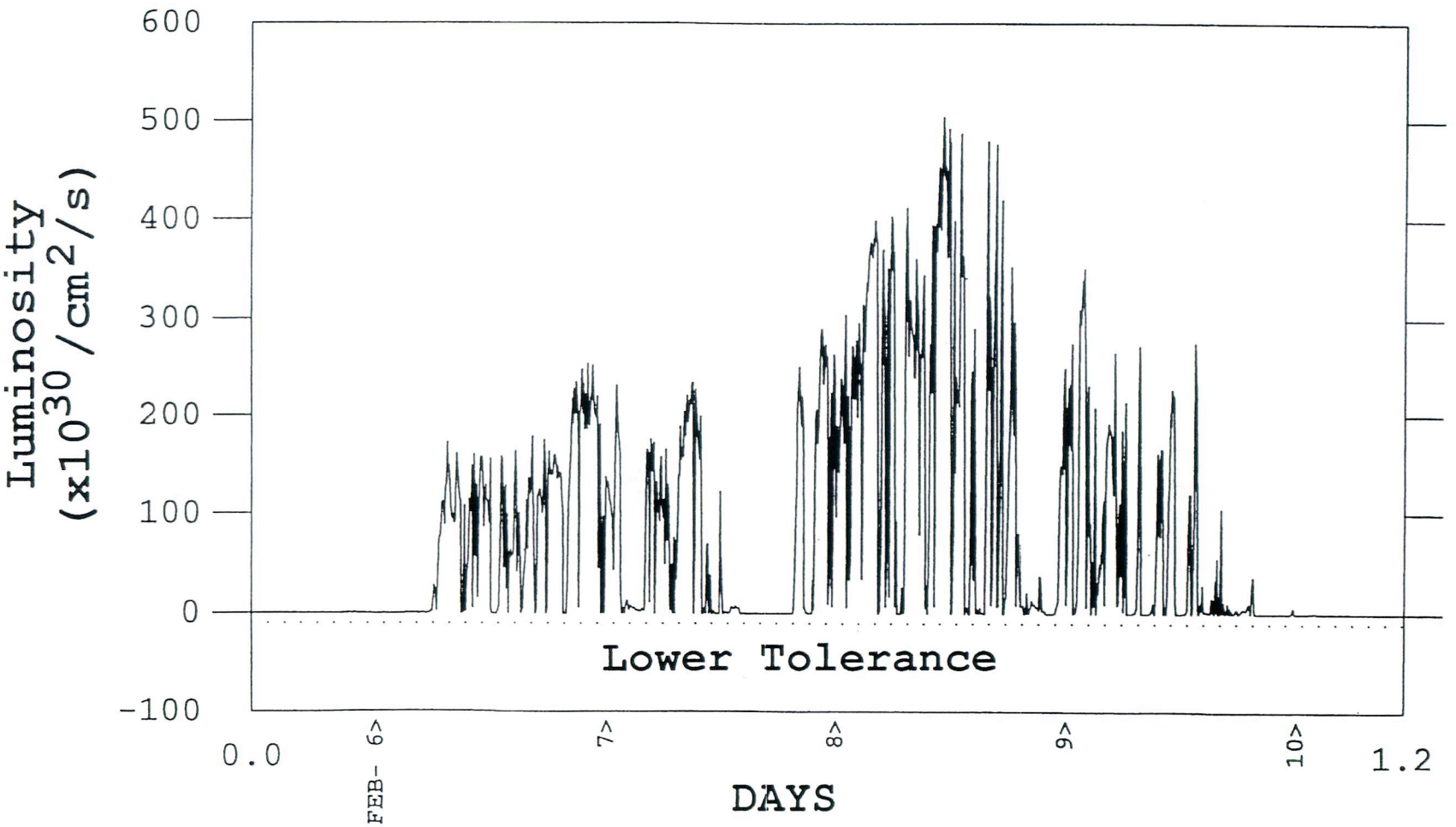
e+ x tune shift ~ 0.032

e+ y tune shift ~ 0.017

e- x tune shift ~ 0.031

e- y tune shift ~ 0.013

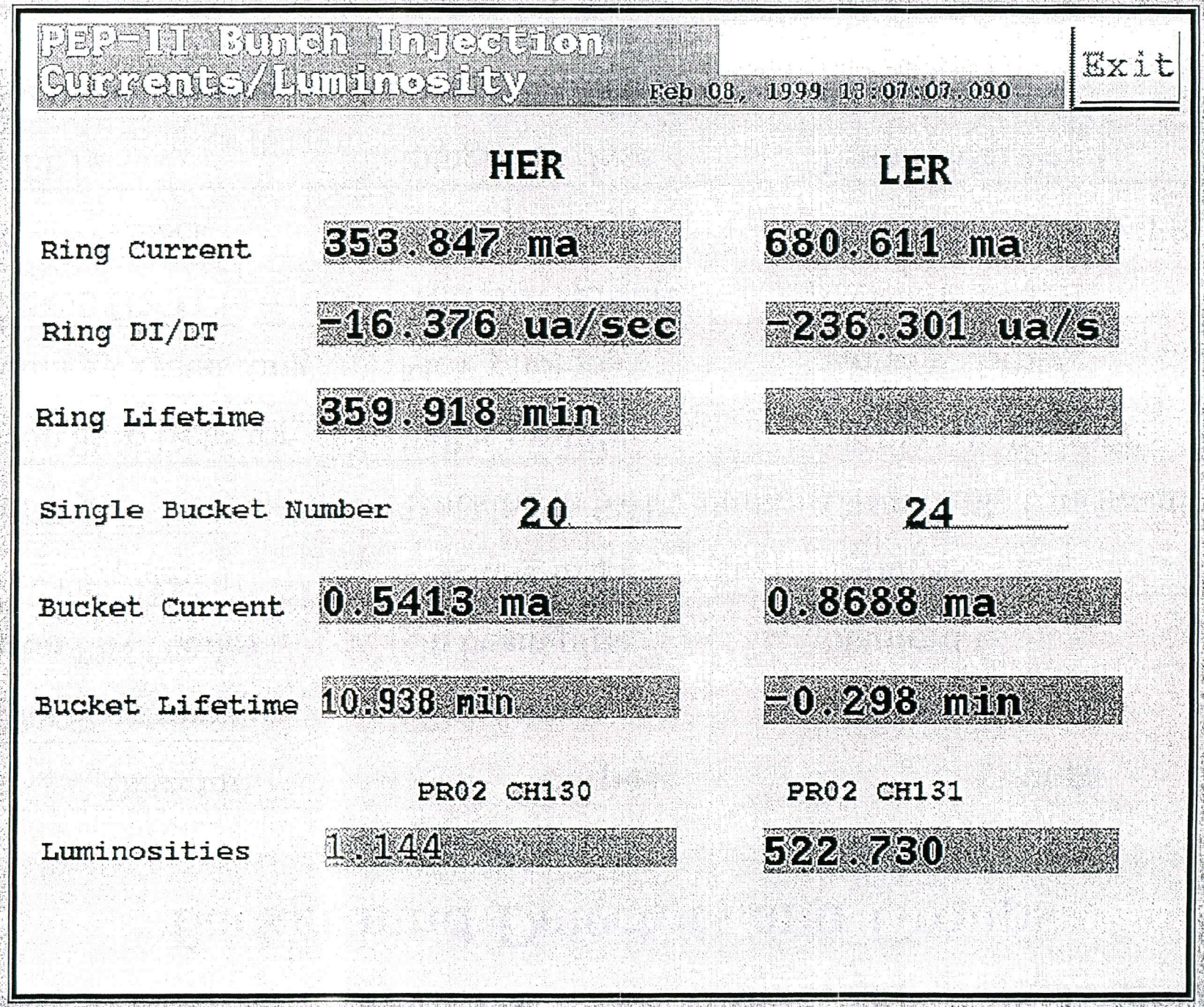
PEP-II Luminosity vs Time



LAST DATA POINT: 10-FEB-1999 11:12:48

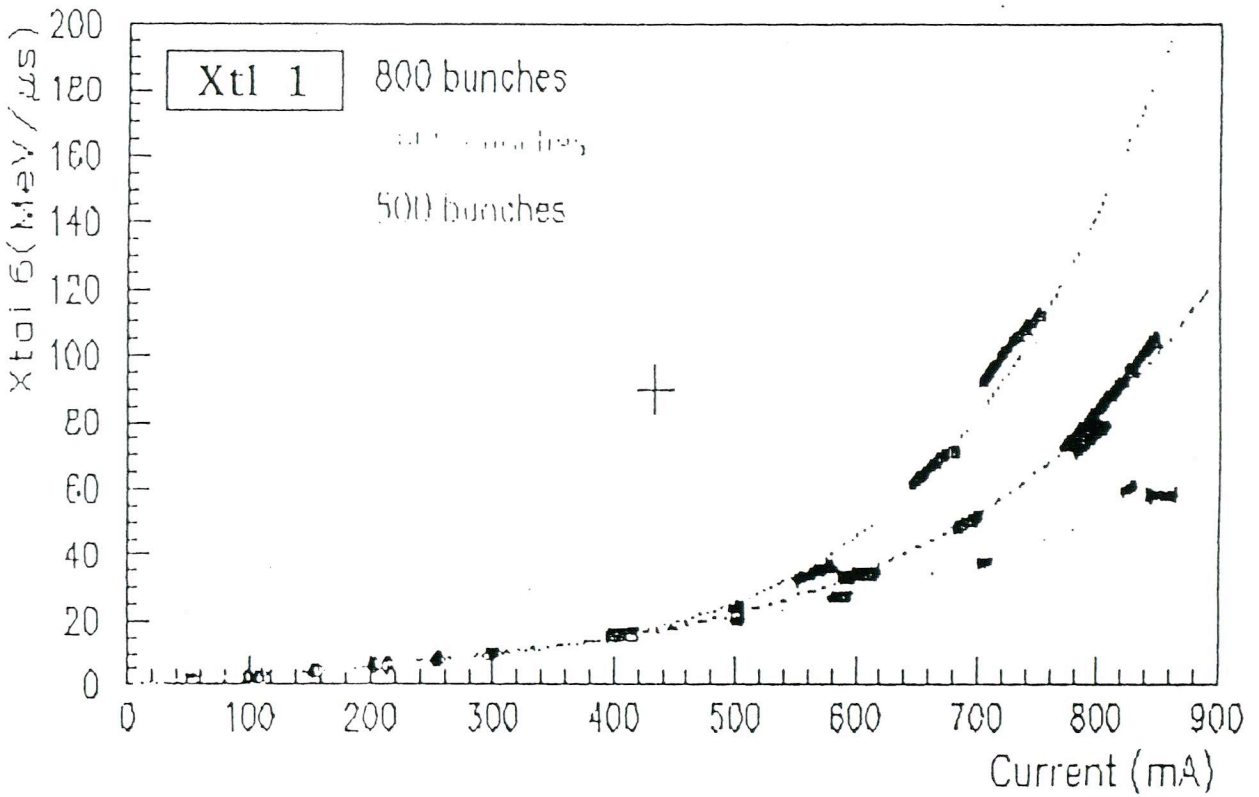
MIN: -.033744
MAX: 504.4453
MAX-MIN: 504.4791
25-FEB-99 11:13:22

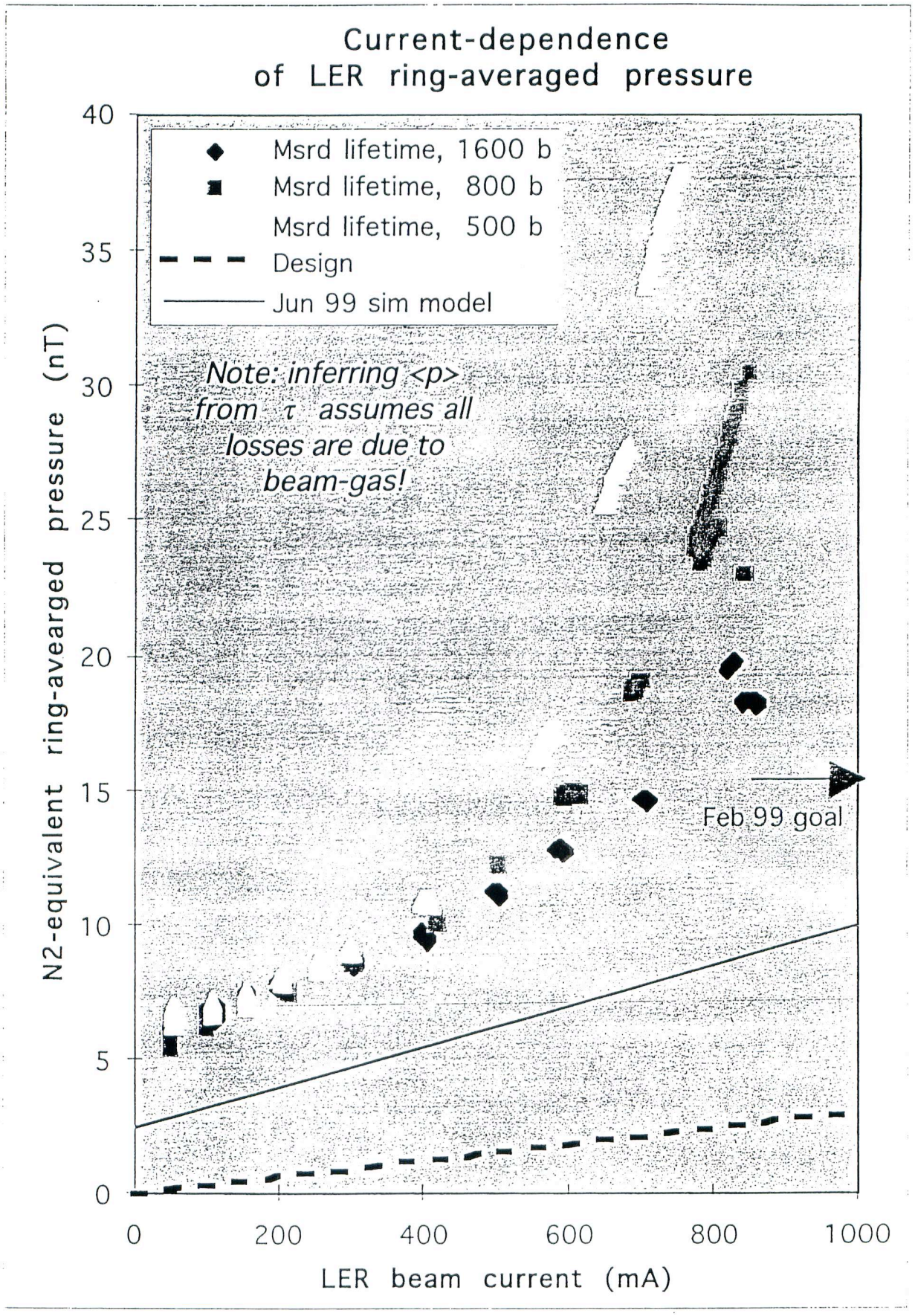
PEP-II Luminosity Record 5.2 x 10^{32} / cm^2 / s February 8, 1999



Background Detectors and Groups

Detector	Purpose	Groups
X-Ray Spectrometer	SR spectrum	CSU + LBL
Silicon PIN Diodes	On beam pipe	Stanford U.
Straw Chamber	Tracking in SVT volume	Tennesee, et al.
MiniTPC	Tracking in SVT volume	Orsay, LBL, Cincinnati
Silicon Strip Detector	BaBar prototype	UCSD + BaBar SVT
Scanning Crystal Ring	MeV photons	Annecy, Saclay
miniSOB H2O Cherenkov	DIRC backgrounds	Cincinnati + LBL
RPC+Iron Stack	BaBar prototype	Wisconsin + BaBar IFR
RadFETs	Integrated dose	Brunel, Maryland
Calorimeter Crystals	Energetic photons	Brunel, SLAC


Xtl 1
800 bunches
500 bunches
Xtal 6(MeV/μs)
200
180
160
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
900
Current (mA)


Current-dependence
of LER ring-averaged pressure
Msrd lifetime, 1600 b
Msrd lifetime, 800 b
Msrd lifetime, 500 b
Design
Jun 99 sim model
Note: inferring <p>
from τ assumes all
losses are due to
beam-gas!
Feb 99 goal
N2-equivalent ring-averaged pressure (nT)
LER beam current (mA)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000

HER Commissioning Results

Parameter	Units	Design	"Best" by Feb 22. 1999
Energy	GeV	9.0	9.0, ramp to 9.1 and back
Single bunch current	mA	0.6	12
Number of bunches		1658	1658
Total beam current	A	0.995	0.75
y/x coupling	%	3.0	down to 0.8
RF voltage/cavity	MV	0.70	0.79
Synchrotron tune		0.045	0.0447
Bunch separation	m	1.26	0.63<--->2200
Chromaticity		-43, -54 (natural)	-43.6, -55.4 (natural)
Beam Lifetime	hours	4	10 hrs @ 50mA 8 hrs @ 270mA 2.5 hrs @ 725mA
Maximum Injection Rate	mA/s	2.1 @ 60Hz	2.5 @ 10Hz

LER Commissioning Results

Parameter	Units	Design	"Best by Feb 22. 1999
Energy	GeV	3.1	3.1
Single bunch charge	mA	1.3	7.0
Number of bunches		1658	1658
Total charge	A	2.14	1.171
RF voltage / cavity	MV	0.85	0.80
Synchrotron freq.		0.045	0.024
Bunch separation	m	1.26	1.26 $\leftrightarrow$ 2200
Beam Lifetime		4 hours	50 min @ 800 mA
Maximum Injection Rate	mA / sec	5.9 @ 60Hz	3.0 @ 10 Hz

What is PEP-II doing to help May running for BABAR

- **Installing 13 collimators**
- **Installing larger-bore higher-power Q2 chambers**
- **Turn on four new vacuum pumps near the detector**
- **Install forward-backward tunnel shield walls**
- **Improve Arc 3 LER vacuum pumping (?)**
- **Further bake IP vacuum chambers (HER)**
- **Find operational ways to make more luminosity with less current (ie lower backgrounds)**
  - Reduce observed IP beam sized
  - Lower (raise) beta y*
  - Increase beta x*
  - Reduce beam emittances
  - (not necessarily compatible with maximum luminosity)

PEP-II Turn-On Schedule

April 30	**PEP-II Tunnel Locked for Personnel Protection System (PPS) Certification**
May 6	**PPS Certification Finished**
May 7,8	**PEP-II Power Supplies and RF on Damping Rings and e^+ Source on**
May 9	**Beams to PEP-II**

PEP-II Summary

In a few short commissioning periods the LER has reached 1.2 A and the HER 0.75 A.

With high currents, small IP spot sizes, and many bunches, PEP-II has a measured luminosity of over 5x $10^{32}/cm^2/sec$. [There was more luminosity to be extracted but it was time to install BABAR.]

Backgrounds will be a problem but we have definite paths to reduced them.

We are very excited about the upcoming PEP-II run with BABAR.