*KEKB MAC 98*

# Magnet System

Progress Since Mac 97

M.Masuzawa

## I. Fabrication

Magnet List

Fabrication Update

## II. Magnetic Field Measurements

----- Preliminary Results

# I. Fabrication

## *LER magnets ( newly fabricated )*

| | | | |
|---|---|---|---|
| B.arc | : 134 + 1 | ; | meas. completed |
| Q.arc | : 414 + 2 (284+132) | ; | meas. completed |
| Q.rf | : 36 + 6 | ; | meas. completed |
| B.lc | : 26 | ; | meas. completed |
| Wigg. | : 192 + 2 | ; | 154 (meas. completed) |
| | | ; | 40 wait for contract |
| BV2 (B.v) | : 4 | ; | ~98/3 |
| BS (B.s) | : 3 | ; | ~98/3 |
| BV1 (B.v0) | : 3 | ; | same as ler.stv.wide |
| Q.sk | : 8 + 1 | ; | ~98/3 |
| $Sx.r_B$=56.L=0.3 | : 104 ( +2 ) | : | meas. completed |
| $SxC.r_B$=85.L=0.5 | : 4 ( +1 ) | : | needs to be measured |
| STV | : 413 ( +7 ) | ; | completed |
| STV.wide | : 38 ( +2 ) | ; | ~98/6 |
| STH | : 385 ( +7 ) | ; | 352 completed |
| STH.wide | : 21 ( +4 ) | ; | wait for delivery |
| STH.crossing | : 3 ( + ) | ; | ~ ler.sth.wide |
| STH.rf.crossing | : 6 ( +1) | ; | ~ ler.stv.wide |

## *HER magnets ( newly fabricated and recycle)*

| | | | | |
|---|---|---|---|---|
| B.arc | : 112 + 2 + (2) | : meas. completed | | tr.B.recycle |
| Bh*er | : 3 | : recycle | | tr.B.recycle |
| BS1 (Bs0,-TL,-TR) | : 4 + 1 + 1 | : recycle TR.B | | |
| BS2 (BsFR,-FL ) | : 1 / 1 | : recycle tr.B.short / ler.B.arc | | |
| Bh*eL | : 5 | : her.sth.wide | | 98.5 |
| Bv*eR | : 3 | : her.stv.wide | | |
| Bv*eL | : 2 | : her.stv.wide | | |
| Q.arc | : 80 (+2) | : meas. completed | | |
| Q.arc.strong | : 4 | : ~98/3 | | |
| Q.rf | : 44 | : 22 delivered | | |
| | | : 22 will be delivered in middle Mar. | | |
| QA | : 199 (+2) | : 151 measured | | tr.Q.recyc |
| QB | : 110 (+3) | : 90 measured | | tr.Q.recyc |
| Q.sk | : 7 + 1 | : | | |
| | : 5 + 1 | : ~98/3 | | |
| Sx.$r_B$=56.L=0.3 | : 56 | : meas. completed | | |
| SxD.$r_B$=56.L=1.0 | : 48 + 1 | : meas. completed | | |
| STV | : 393 ( +7 ) | : 300 completed | | |
| STV.wide | : 48 ( +2 ) | : under construction | | |
| STH | : 353 ( +7 ) | : 352 completed | | |
| STH.wide | : 44 ( +5 ) | : delivery scheduled on March 6,98 | | |

* *STV : collaboration with IHEP*

*STH : collaboration with INP*

## II. Magnetic Field Measurements ----- Preliminary Results

### (1) Purpose of the Measurements

*Spot bad magnets
Feedback is given
to the factory productrion line

*Sort magnets (if needed) based on the measurements.

*For use of the data during the accelerator operation.

## (2)Measurement Outline

a)Where:

At KEK (Nikko Experimental Hall B4)

Quadrupole Magnets (~920, both new and recycle)*

Sextupole Magnets (~210)*

Beding Magnets(~200)**

Other places

Bending Magnets(~120,TRISTAN recycle)**

Wiggler Magnets(~190)***

Vertical Steering Magnets(~900)IHEP***

Horizontal Steering Magnets(~900) BINP****

b)Measurement System:

Harmonic coil(DAQ EPICS)*
Flip-flop coil(DAQ PC) * *
Harmonic coil(DAQ PC)***
Hall probe(DAQ PC)****

## (3)Data Resulls from only ~20 LER Quadrupoles
~10 Bends were shown at MAC97

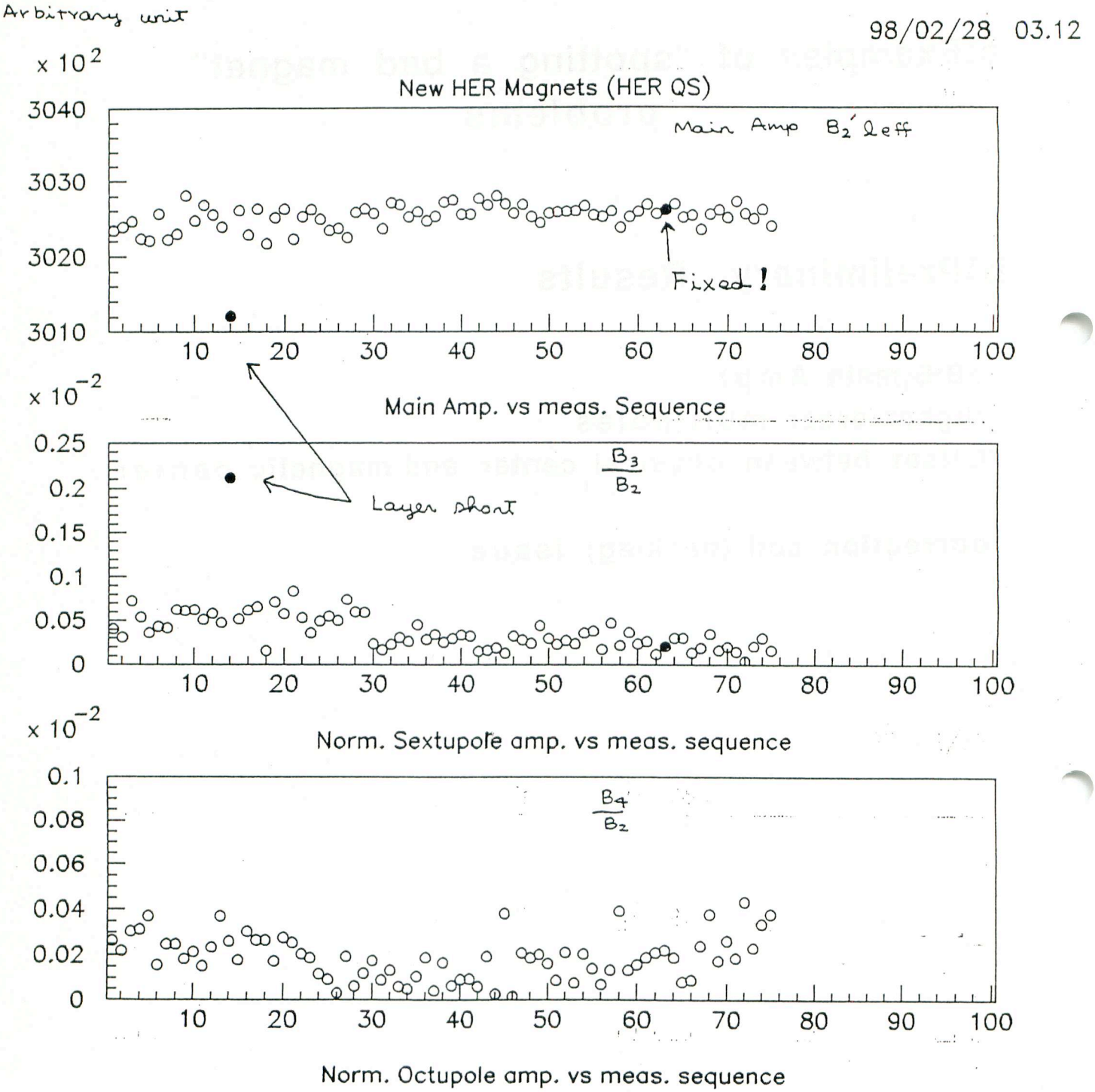
## a)Examples of "spotting a bad magnet" problems

## b)Preliminary Results

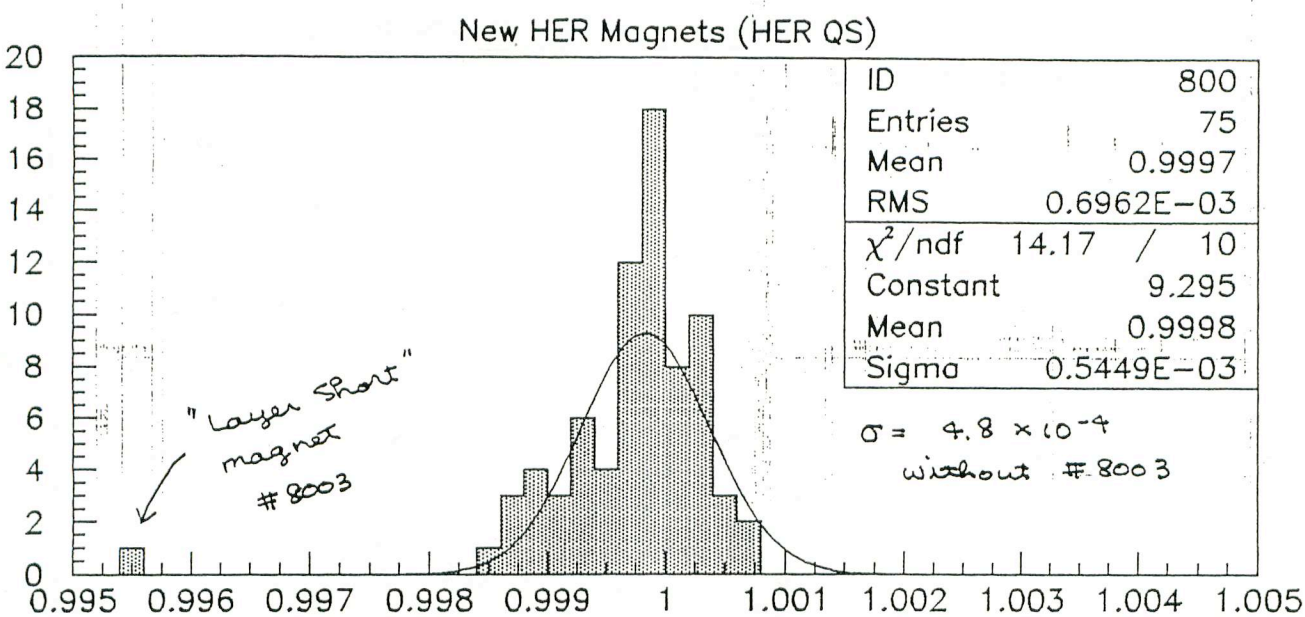
$\Delta B/B$(main Amp)
Higher order multipoles
Offset between physical center and magnetic center

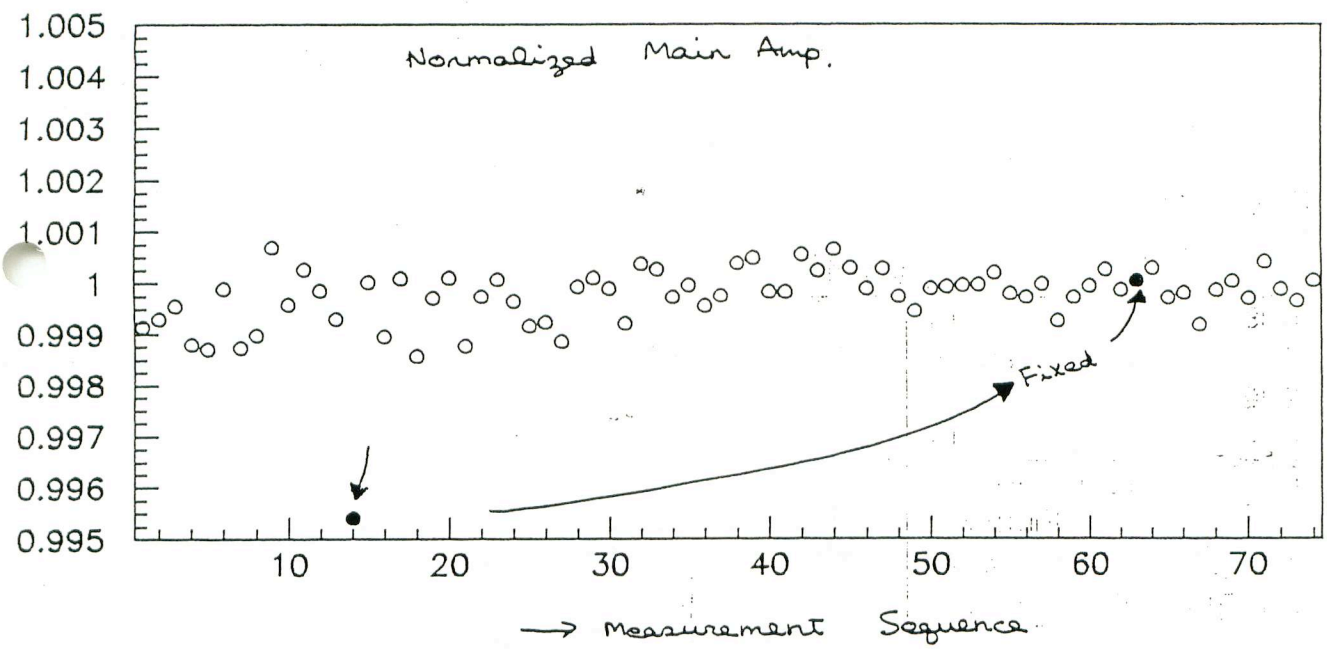
correction coil (backleg) issue

An example of spotting a bad magnet



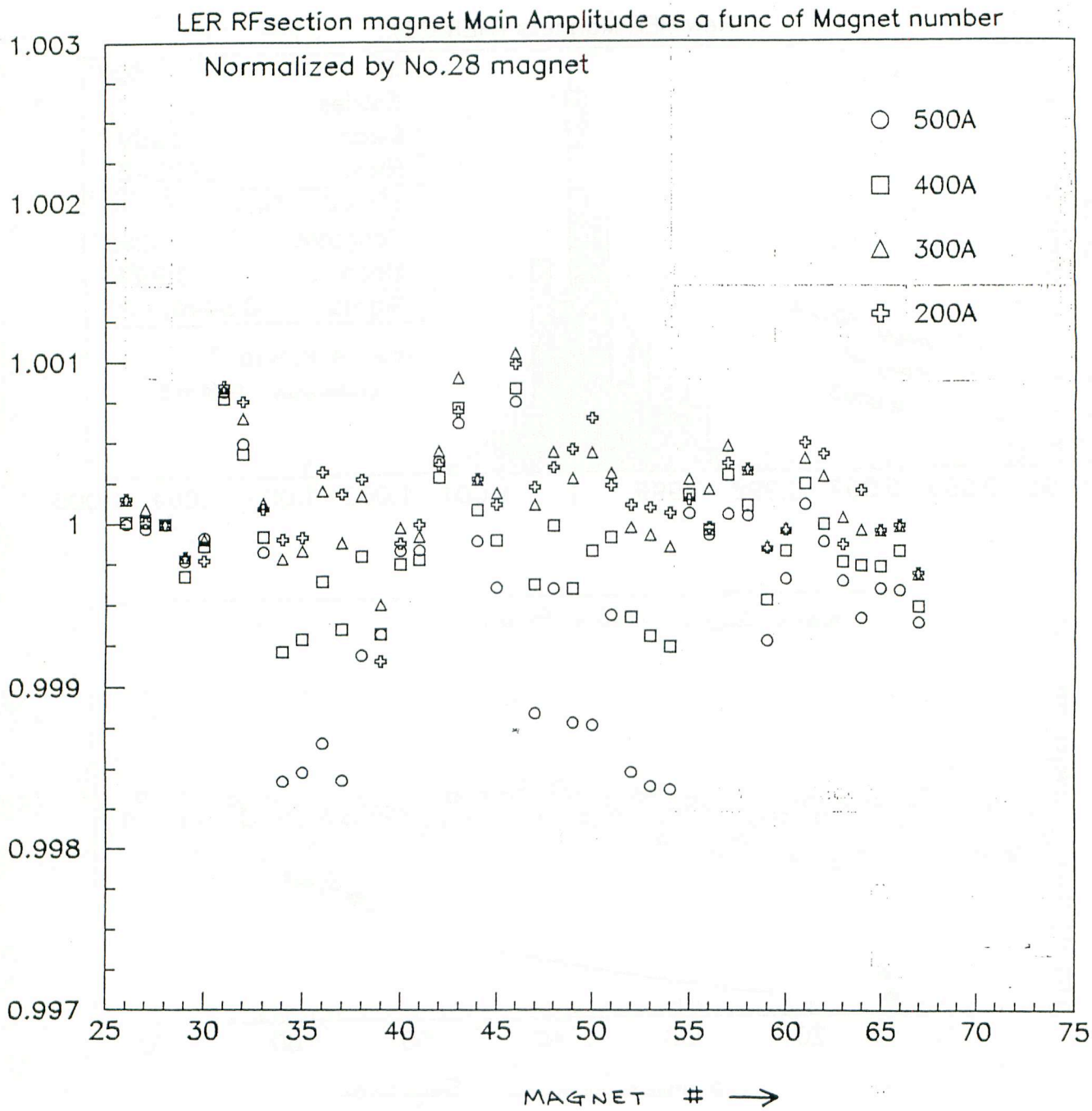
98/02/28 03.12


New HER Magnets (HER QS)
ID 800
Entries 75
Mean 0.9997
RMS 0.6962E−03
χ²/ndf 14.17 / 10
Constant 9.295
Mean 0.9998
Sigma 0.5449E−03
σ = 4.8 × 10⁻⁴
without #8003
"Longer Short" magnet #8003
0 2 4 6 8 10 12 14 16 18 20
0.995 0.996 0.997 0.998 0.999 1 1.001 1.002 1.003 1.004 1.005


Normalized Main Amp.
Fixed
0.995 0.996 0.997 0.998 0.999 1 1.001 1.002 1.003 1.004 1.005
10 20 30 40 50 60 70
→ Measurement Sequence

# Example of Finding a problem

98/02/28 03.58



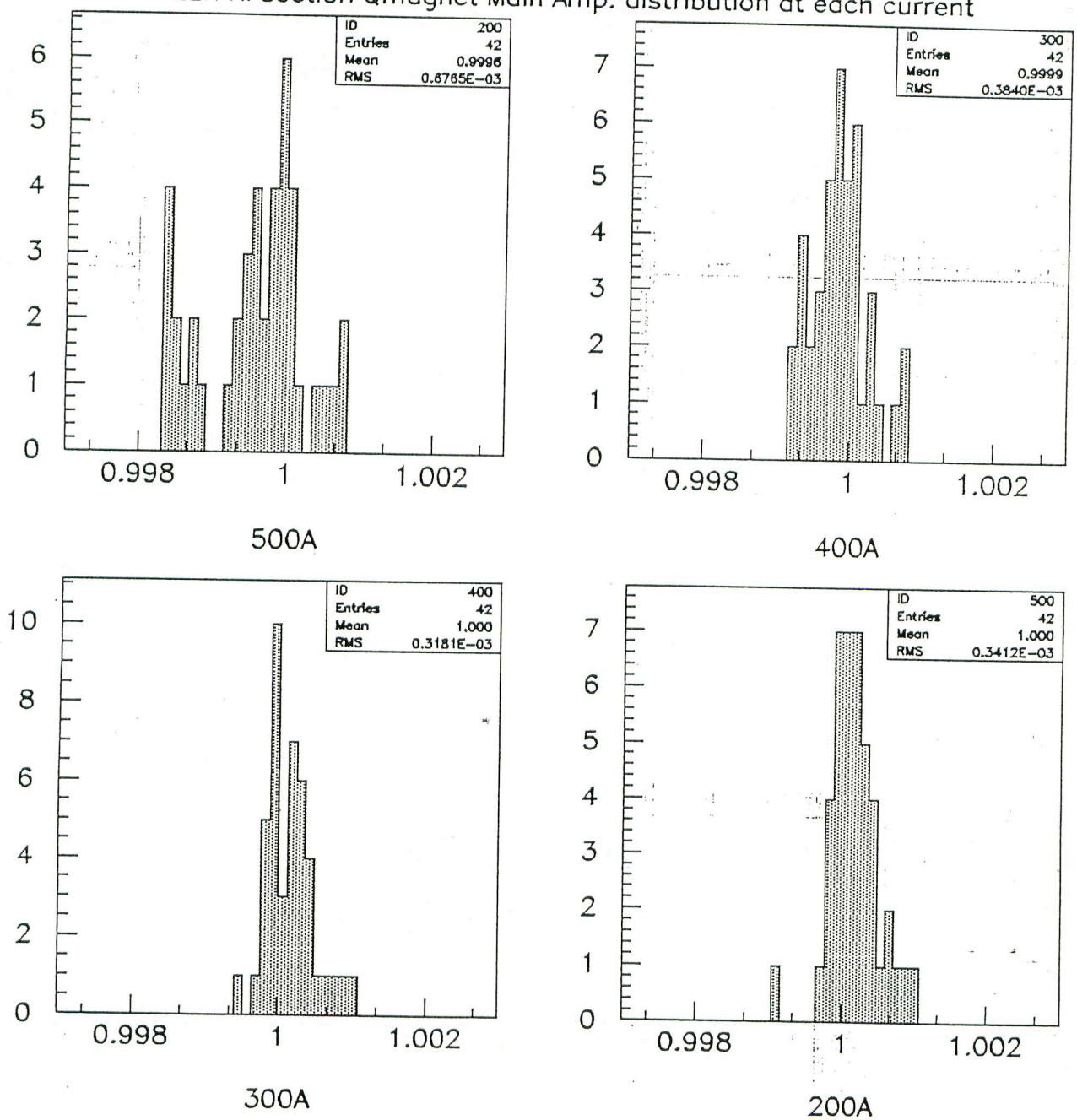

$\sigma < 4 \times 10^{-4}$ @ 100A, 200A, 300A, 400A

However $\sigma = 6.8 \times 10^{-4}$ @ 500A [ three peaks ]

B50
1.73
1.74
1.75

98/02/28 04.14

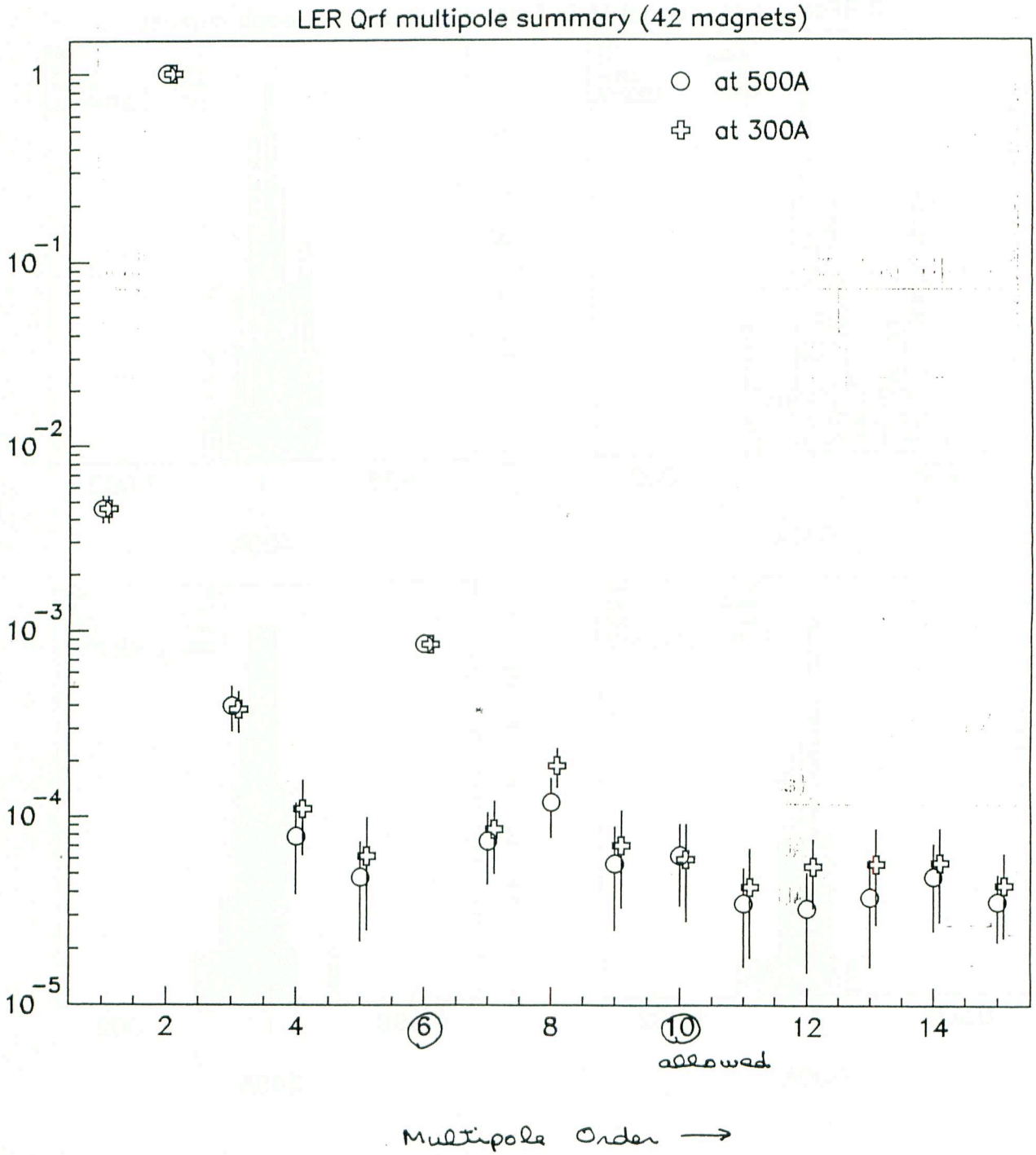
LER RFsection Qmagnet Main Amp. distribution at each current




Do not mix magnets with different strength
( different peaks ) @ 500A

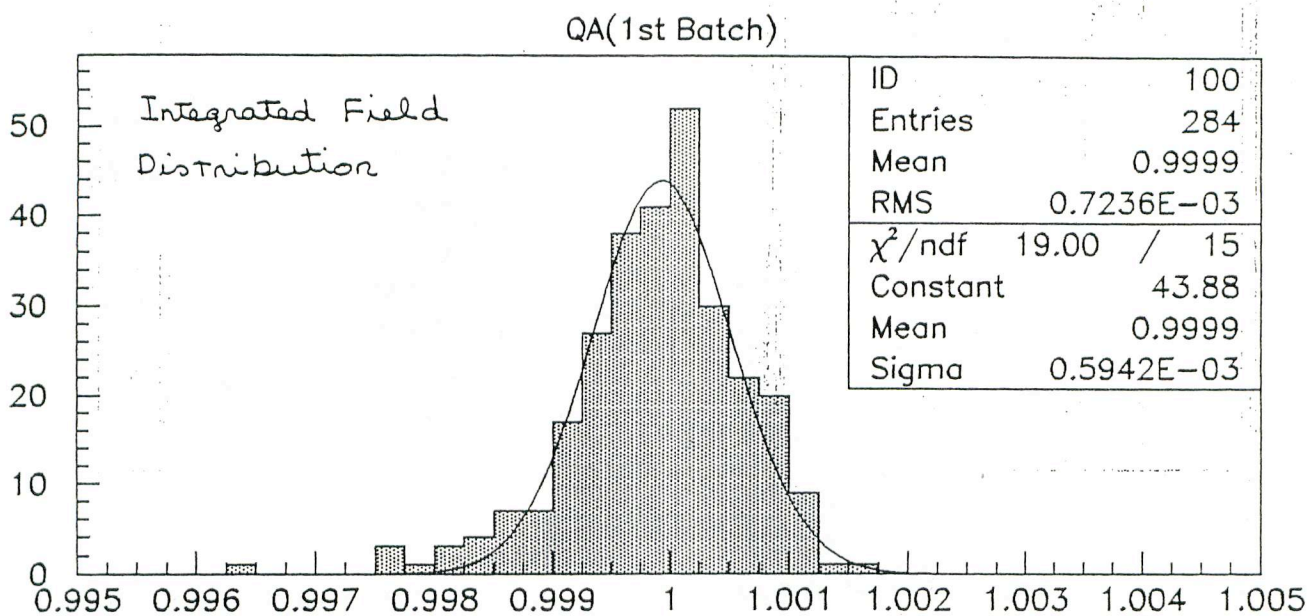
→ Seperate power supplies

98/01/18 13.01


LER Qrf multipole summary (42 magnets)
at 500A
at 300A
1
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
2
4
6
8
10
12
14
allowed
Multipole Order →

Another Example of spotting a bad magnet

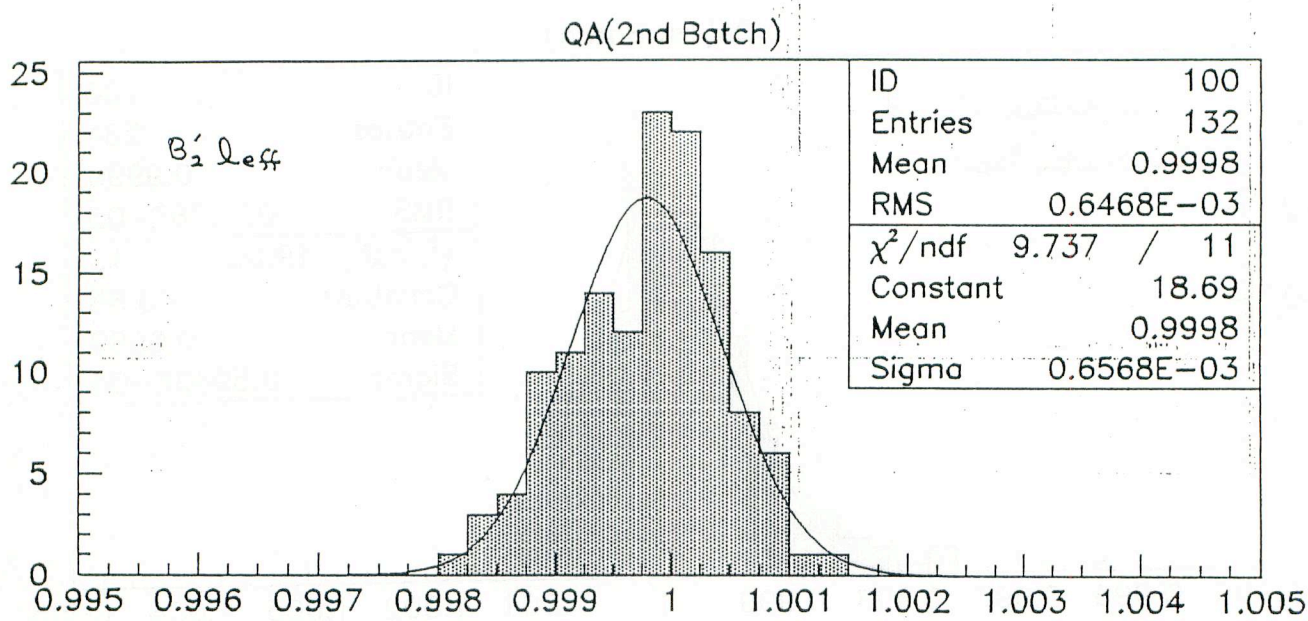
$B_2' L_{eff}$

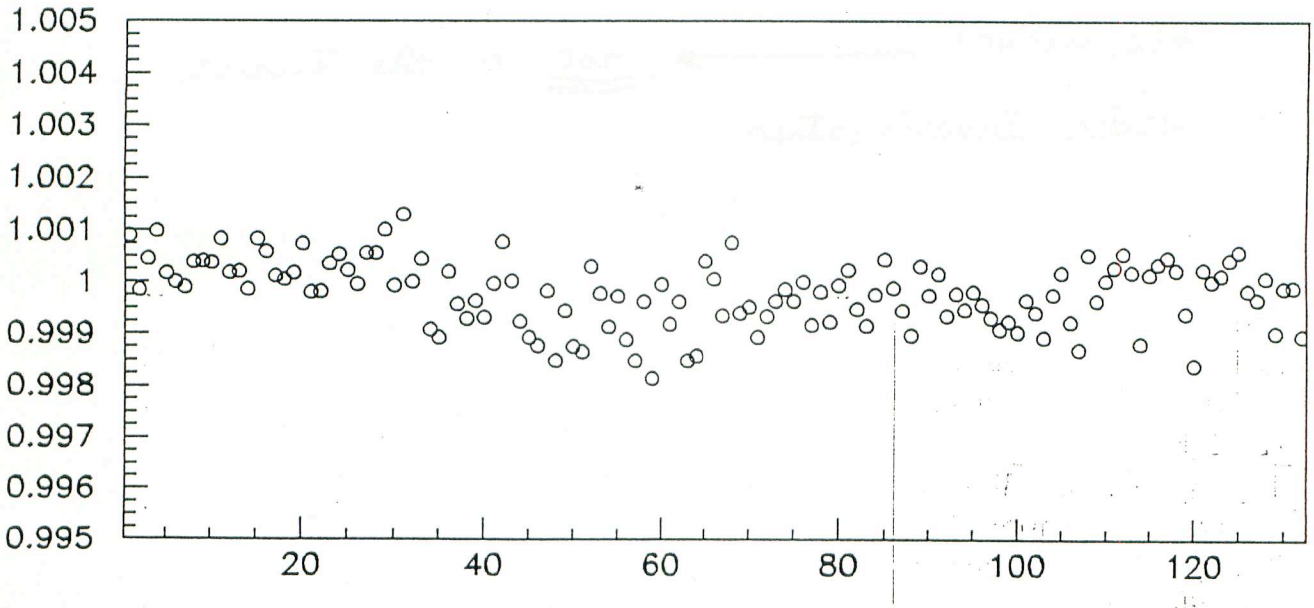



#32 MAGNET → not to the Tunnel

Under Investigation

"Sorting" needed for QA (II)



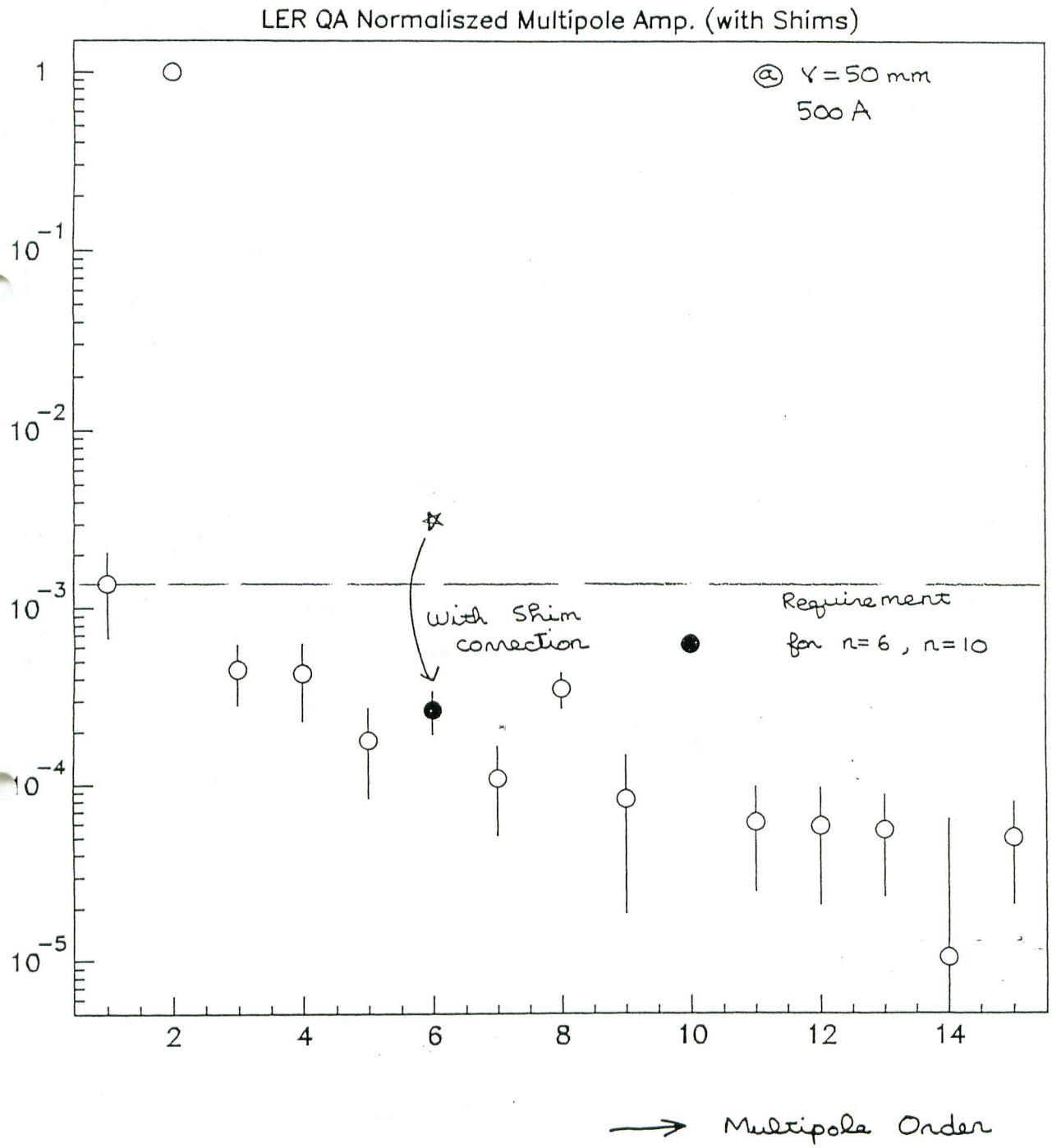

→ MAGNET PRODUCTION SEQUENCE

[Actually measurement sequence]

Careful sorting depending on B'z leff

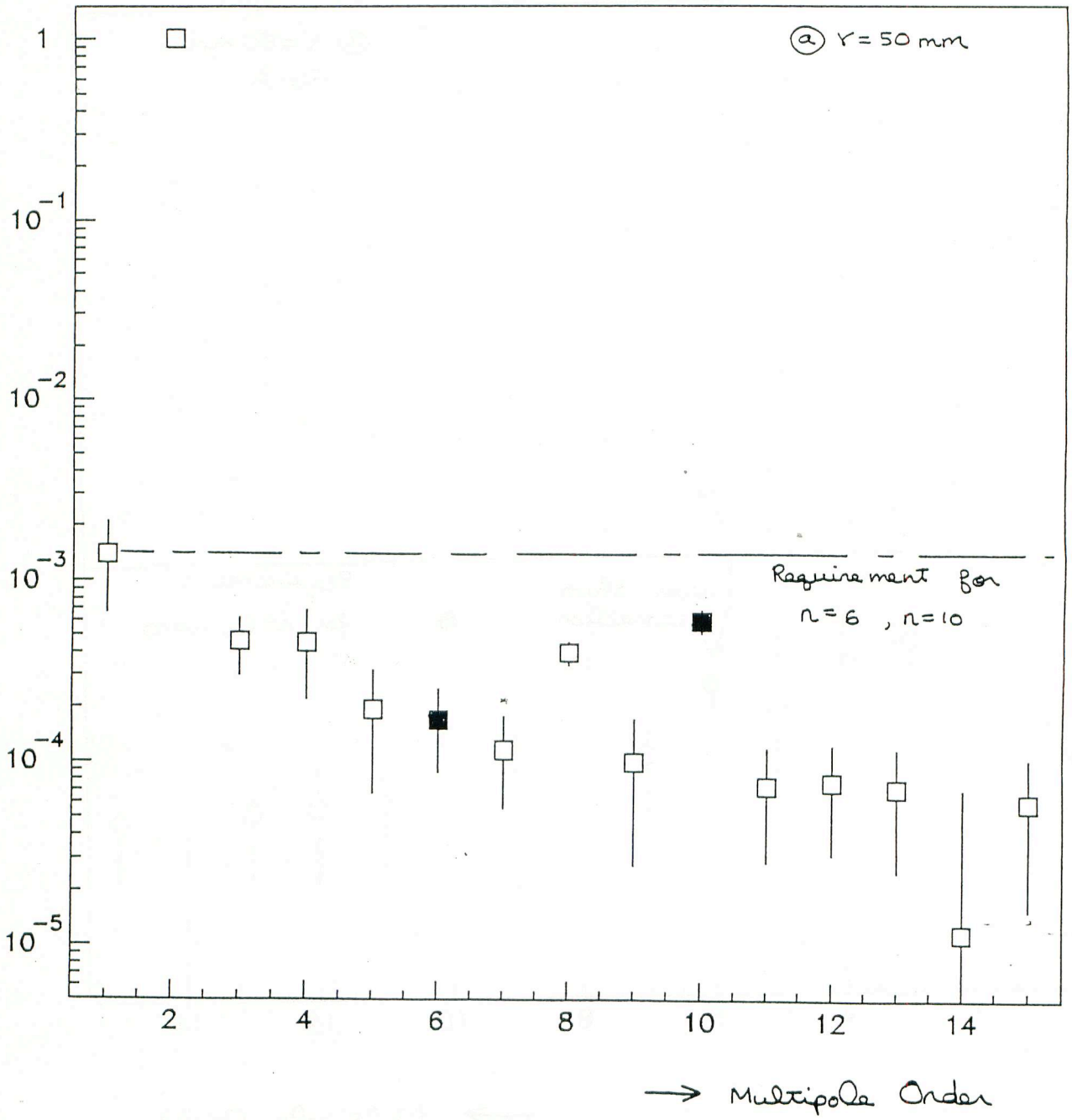
Check
Multipoles

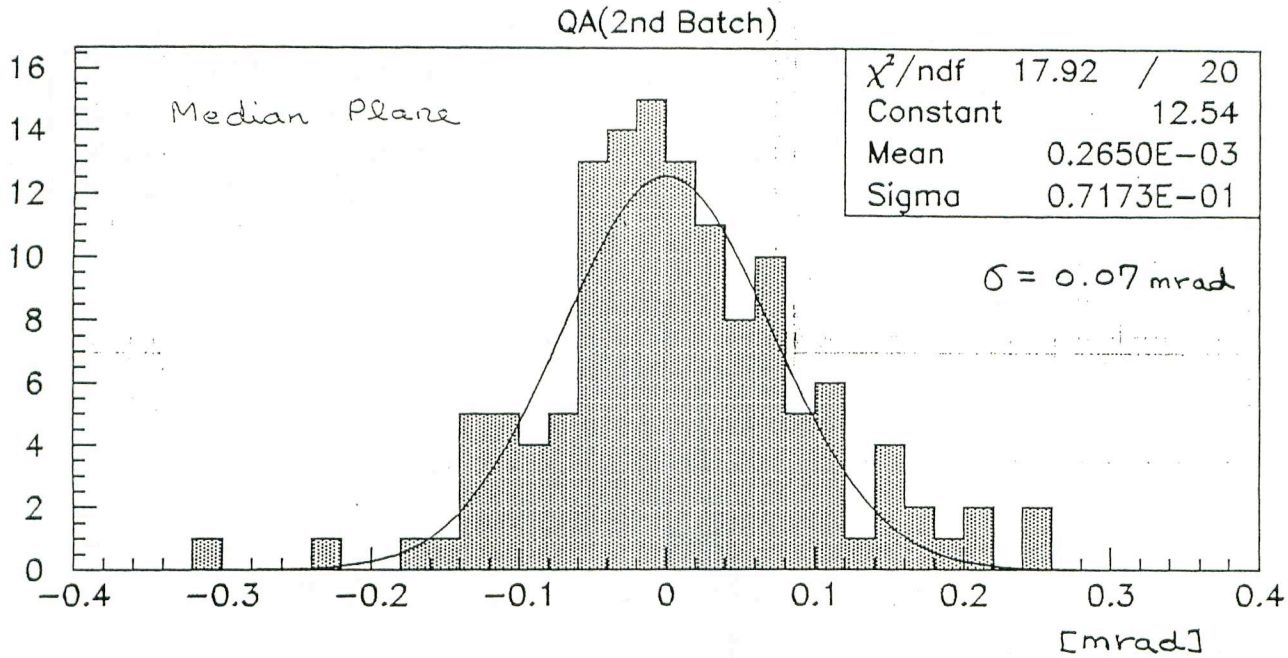
97/06/12 06.07

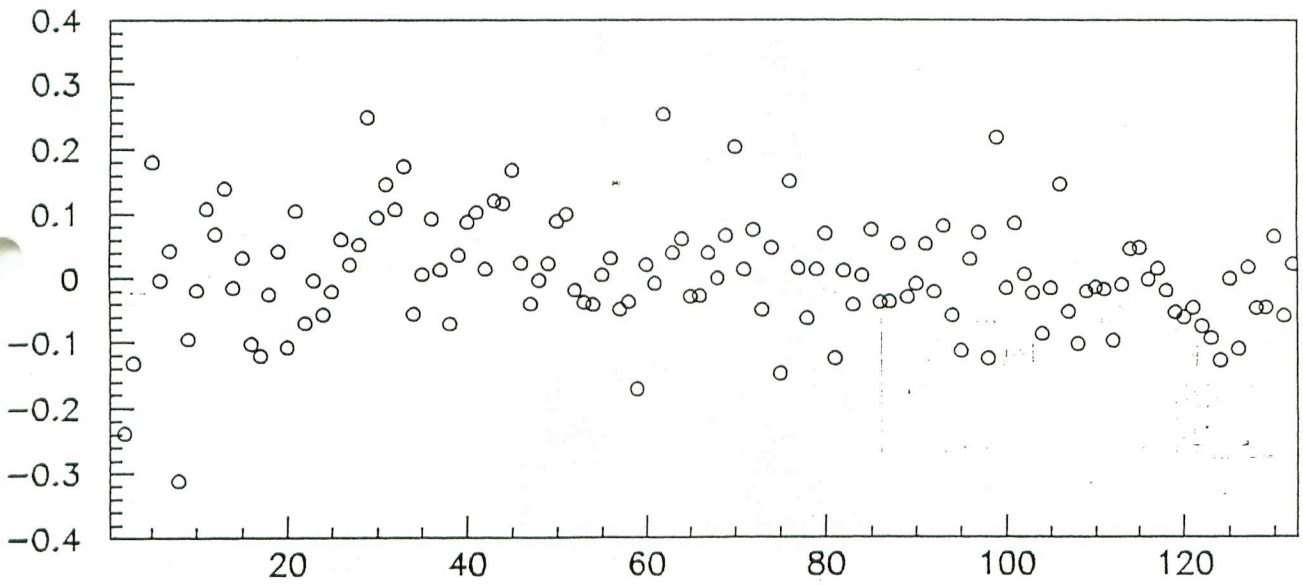


97/06/12 06.33

LER QA Normaliszed Multipole Amp. (with Shims) at 300A



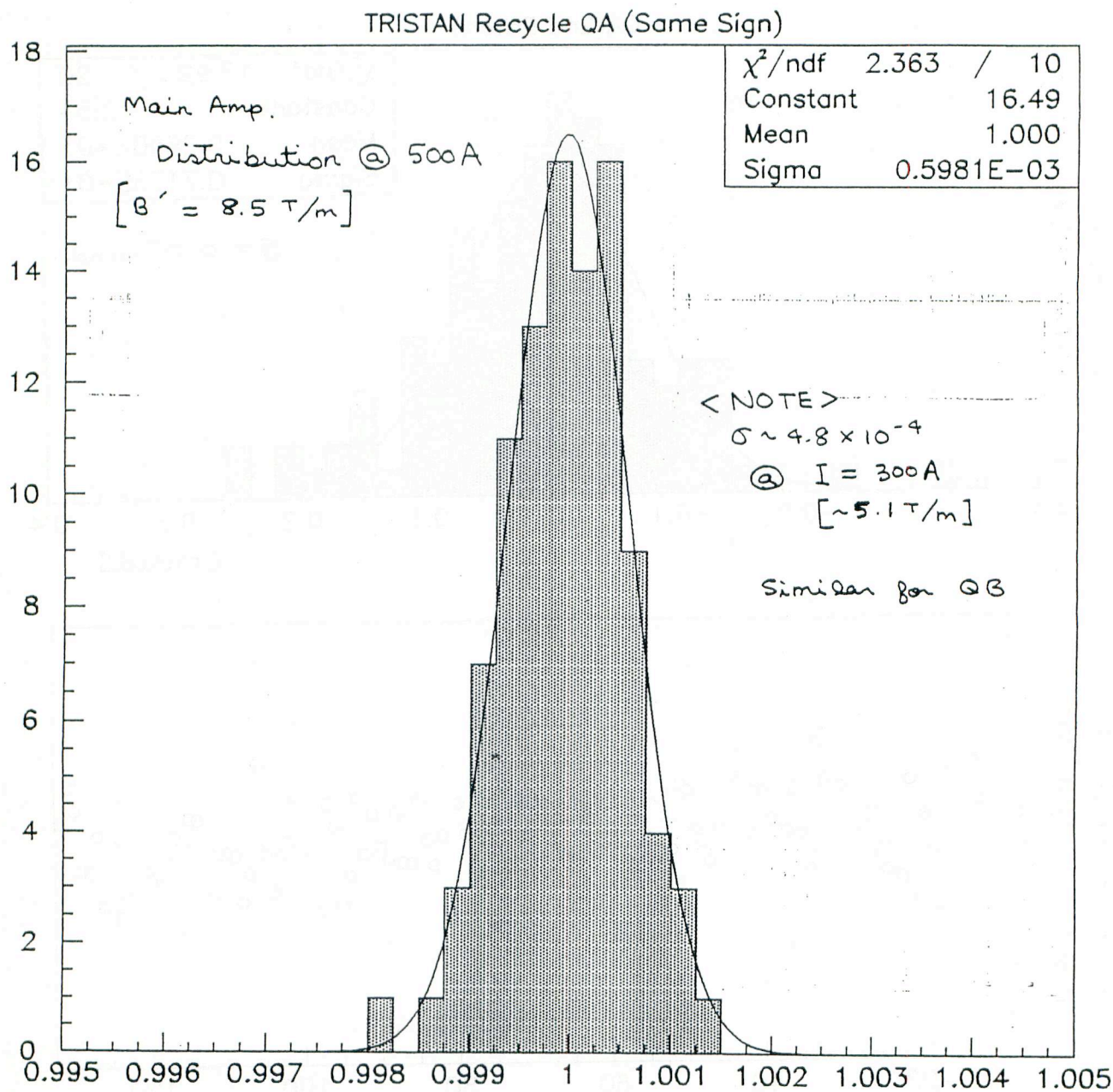


→ MAGNET PRODUCTION SEQUENCE

[ Measurement sequence ]

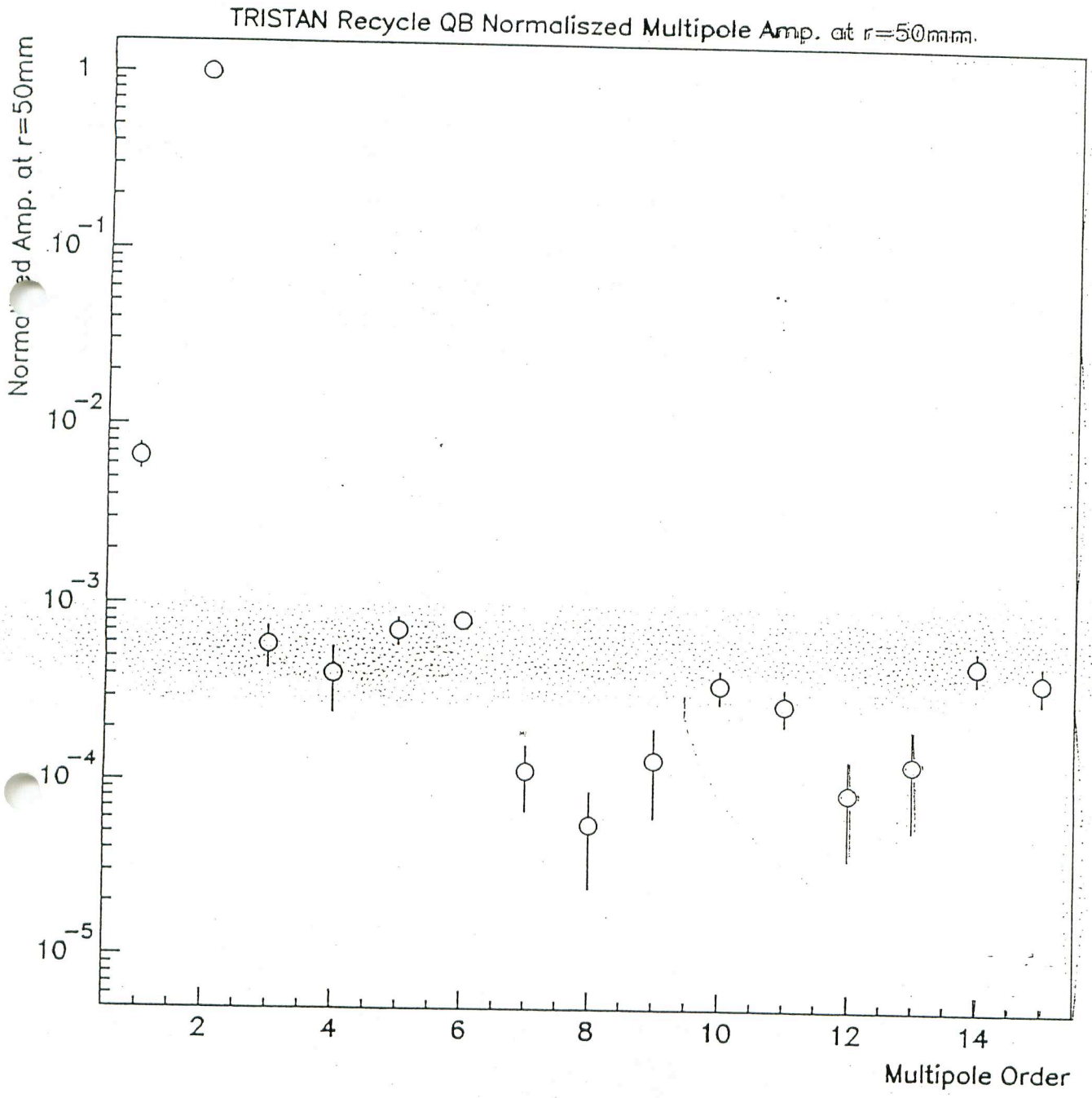
98/02/27 07.36

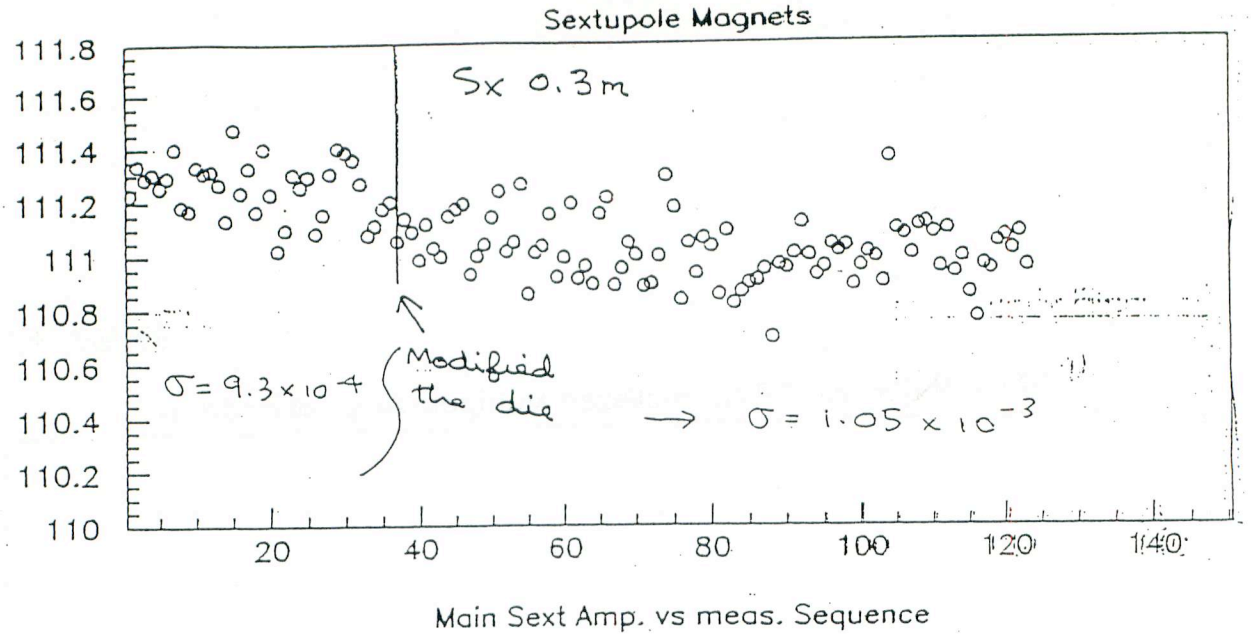


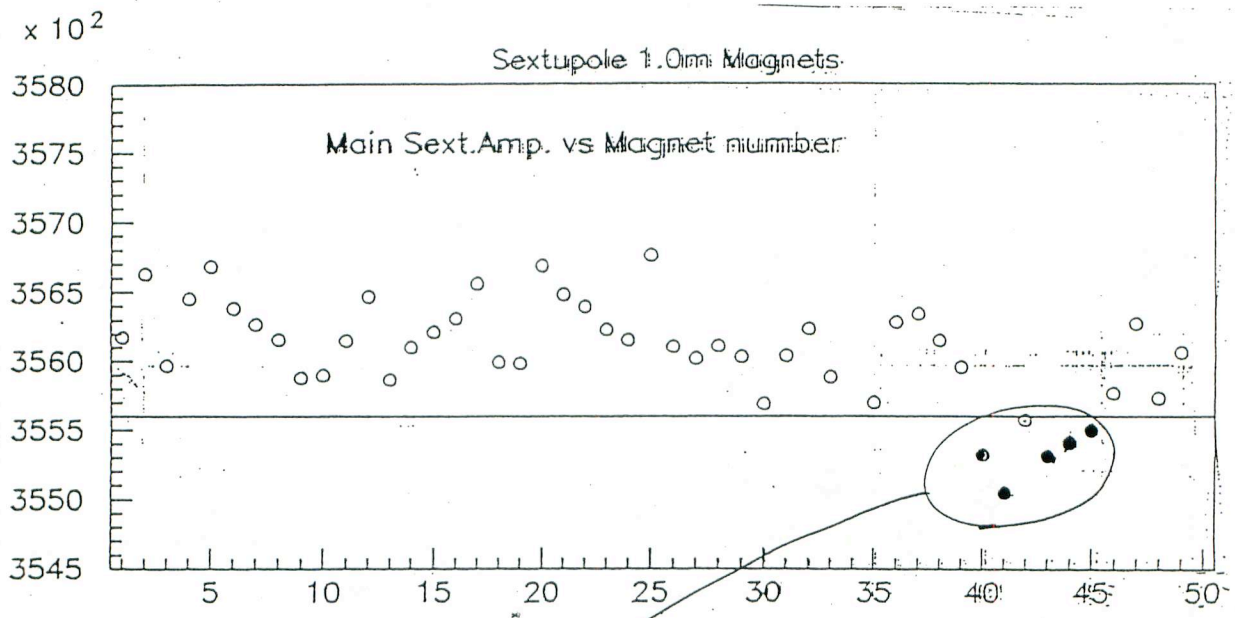

Ref

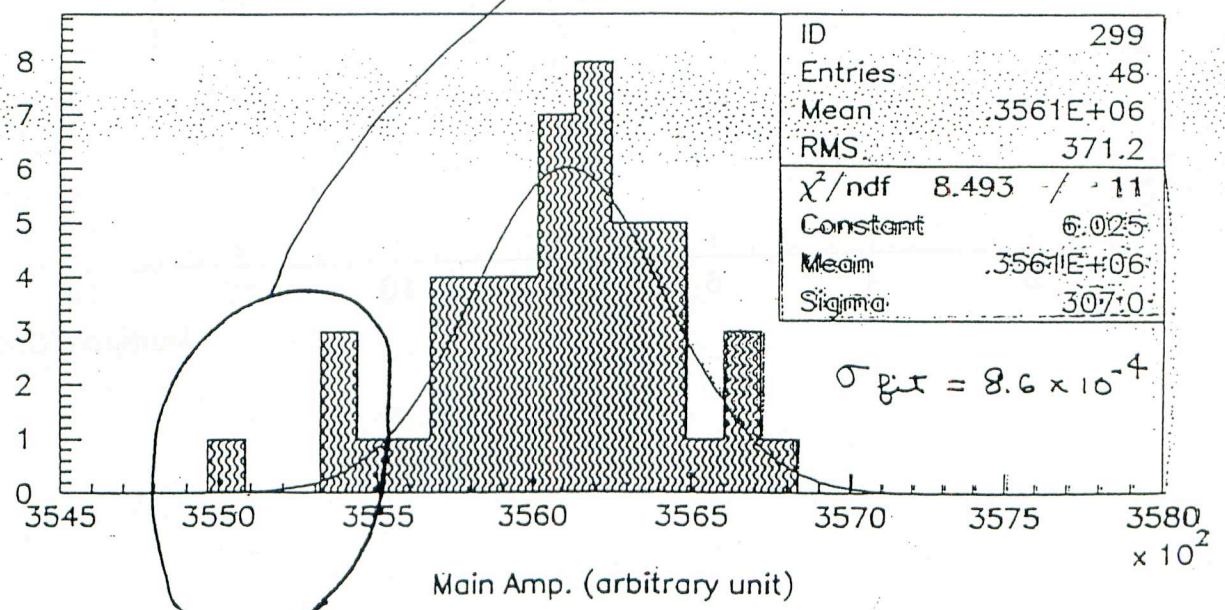
$\sigma = 4.2 \times 10^{-4}$ @ 4.7 T/m
$\sigma = 7.9 \times 10^{-4}$ @ 18.2 T/m
] AT TRISTAN

97/07/18 11:54

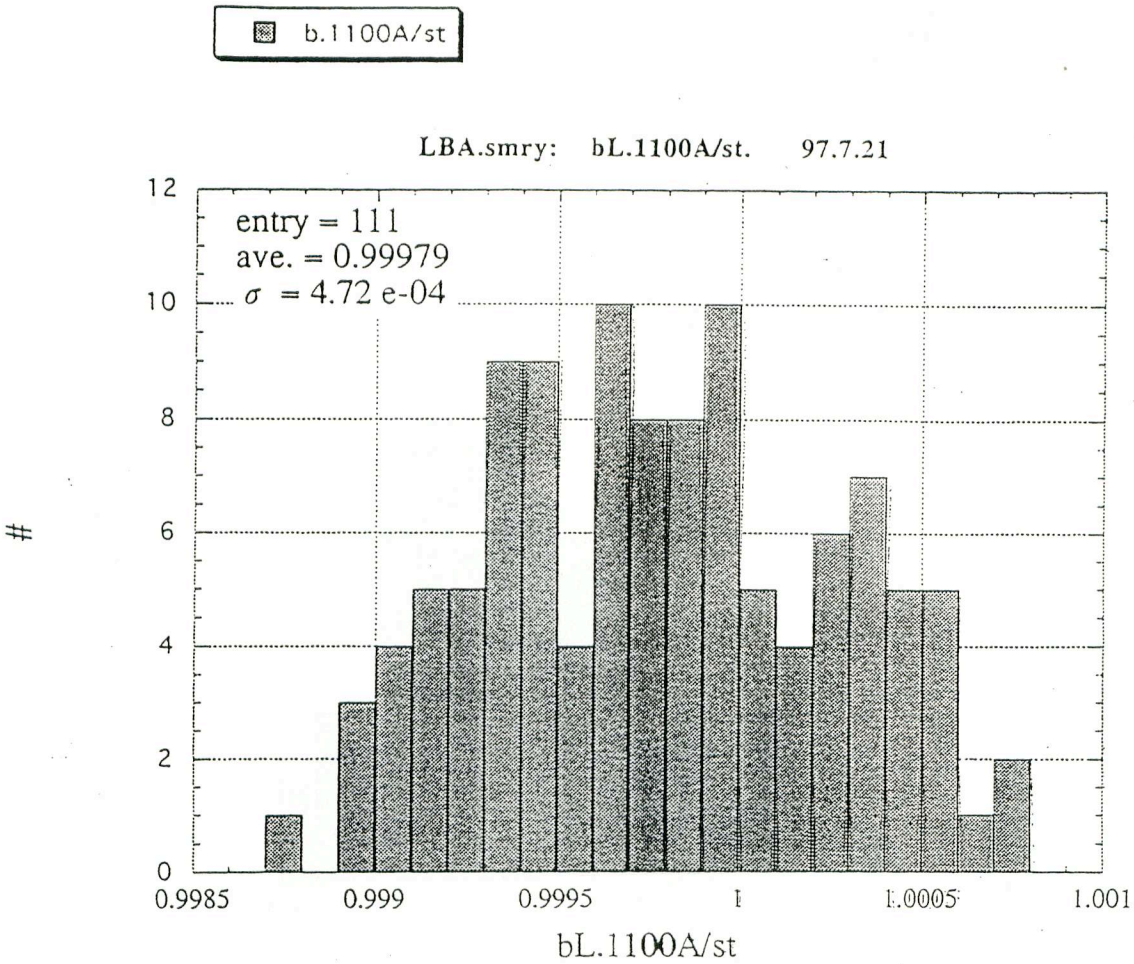

TRISTAN Recycle QB Normaliszed Multipole Amp. at r=50mm.
Normalized Amp. at r=50mm
1
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
2
4
6
8
10
12
14
Multipole Order

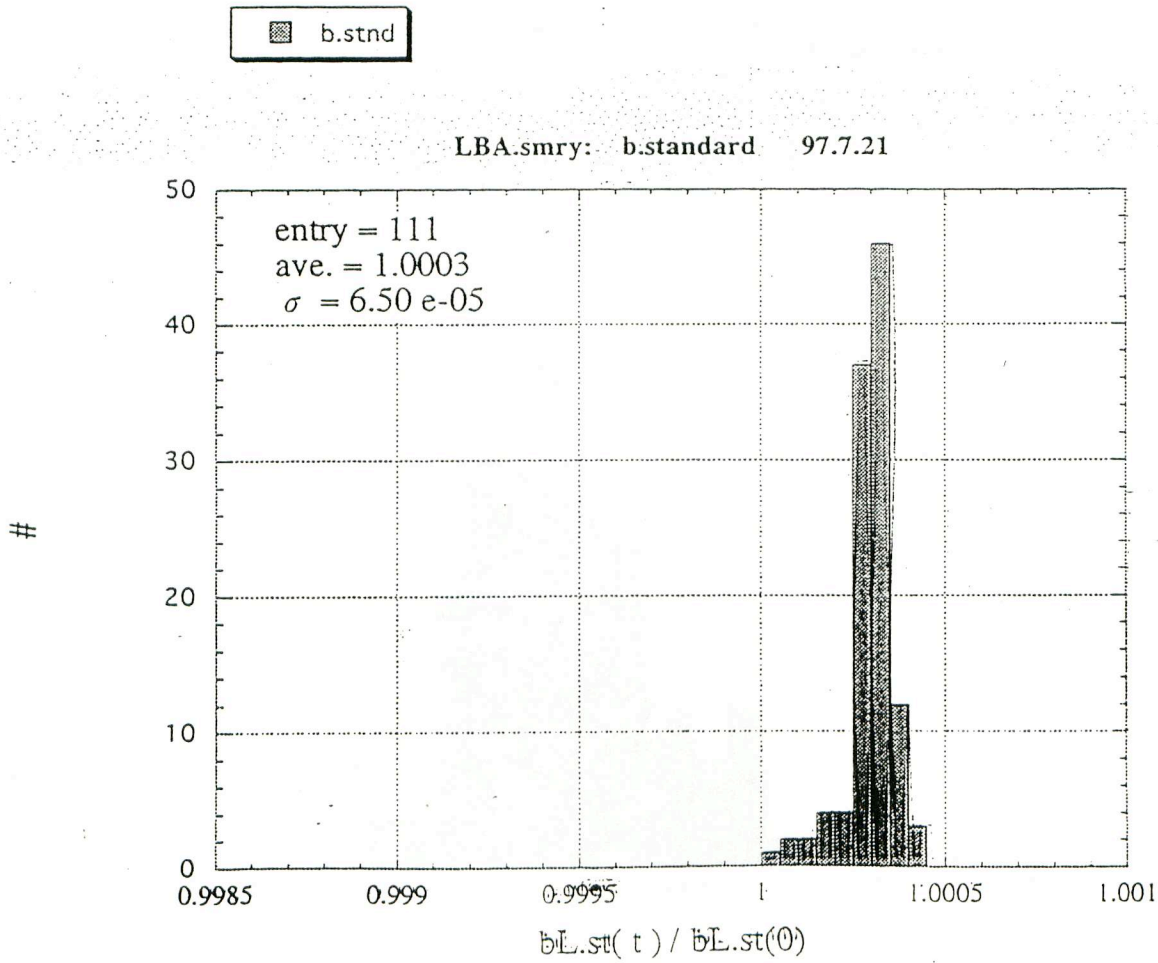


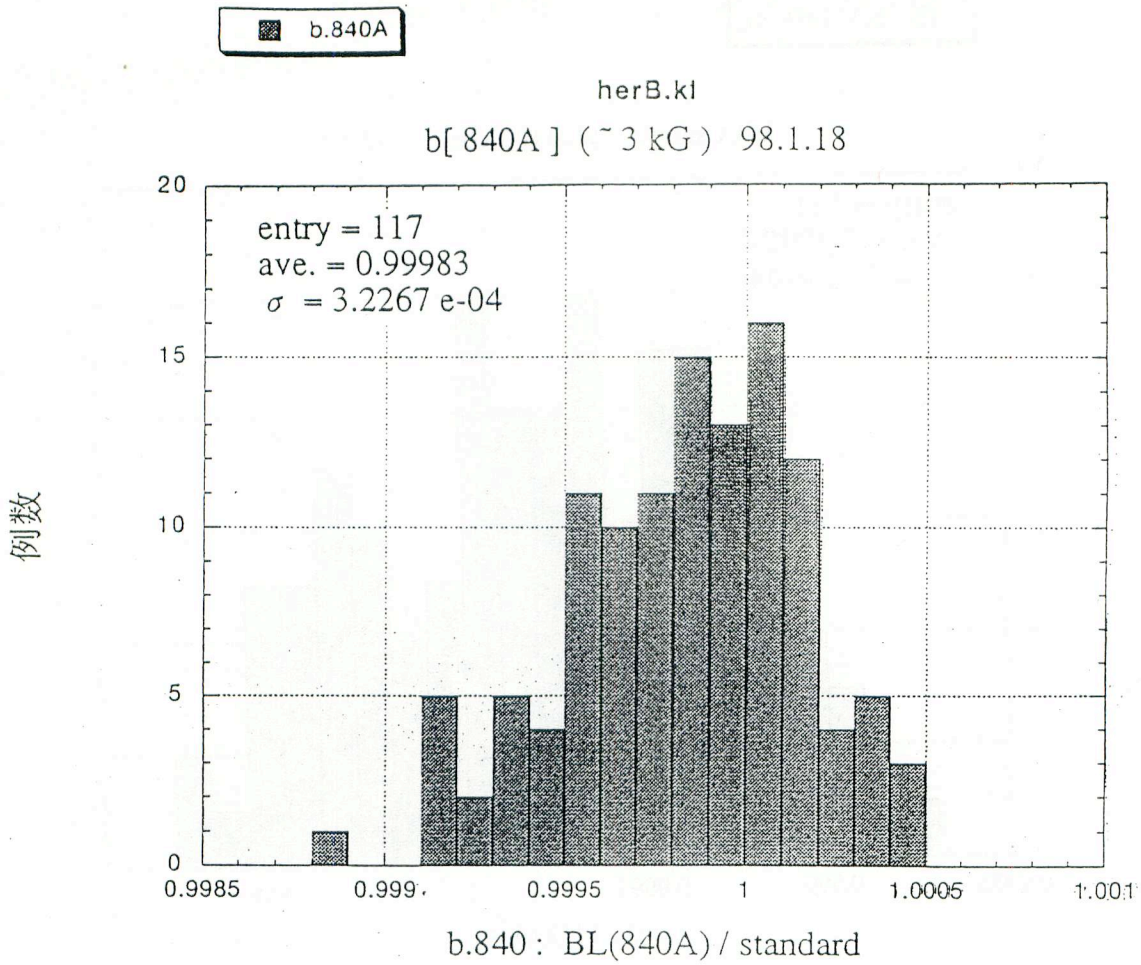



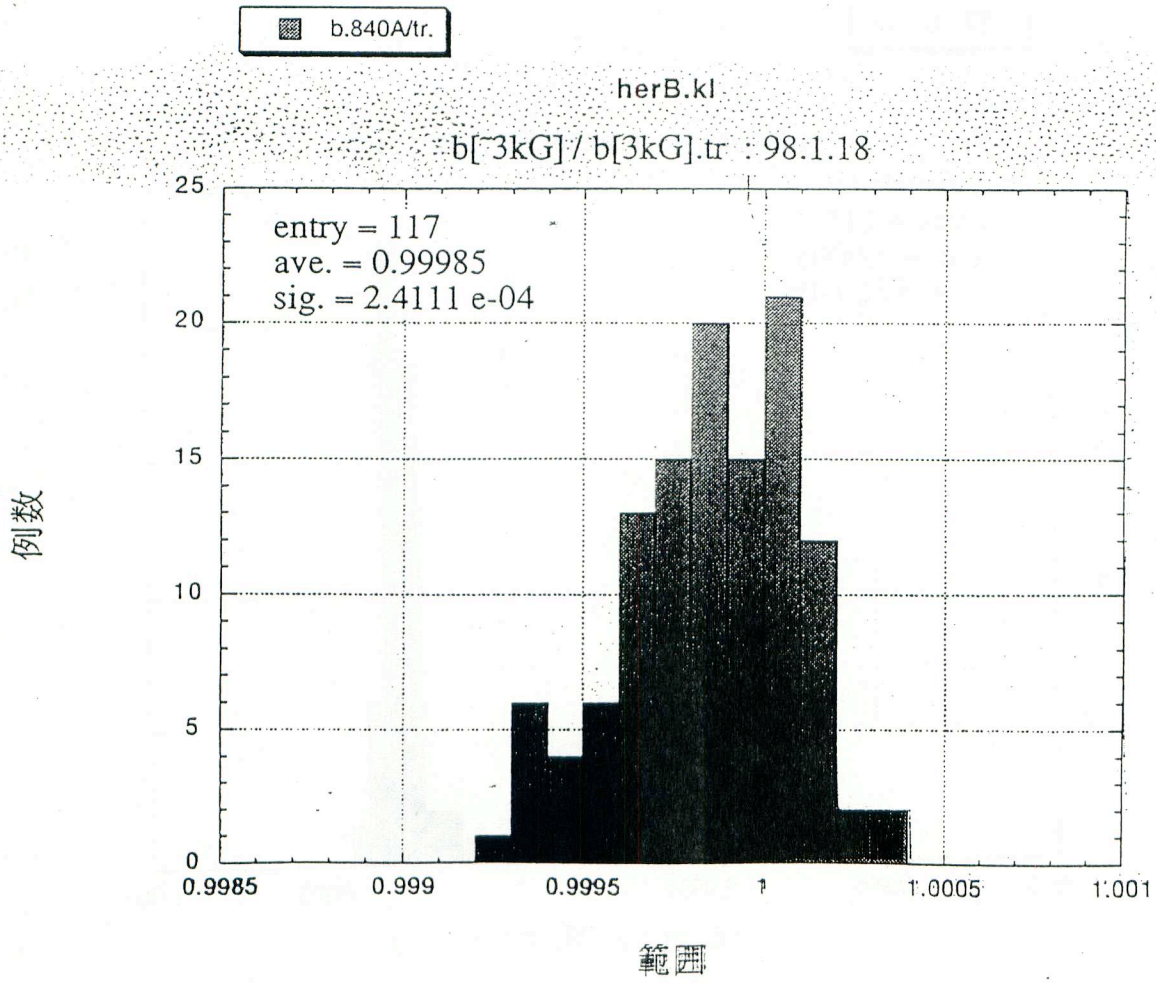



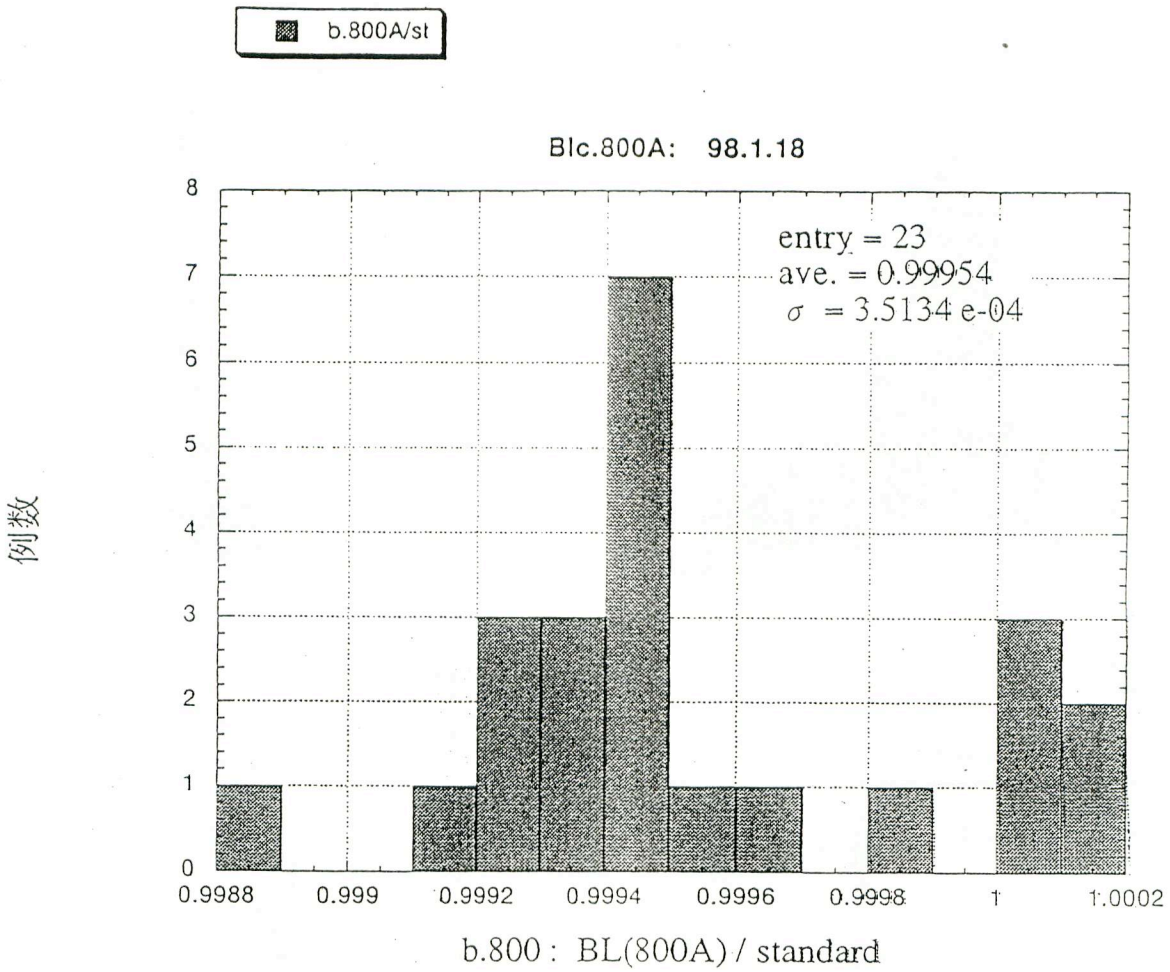

→ under investigation

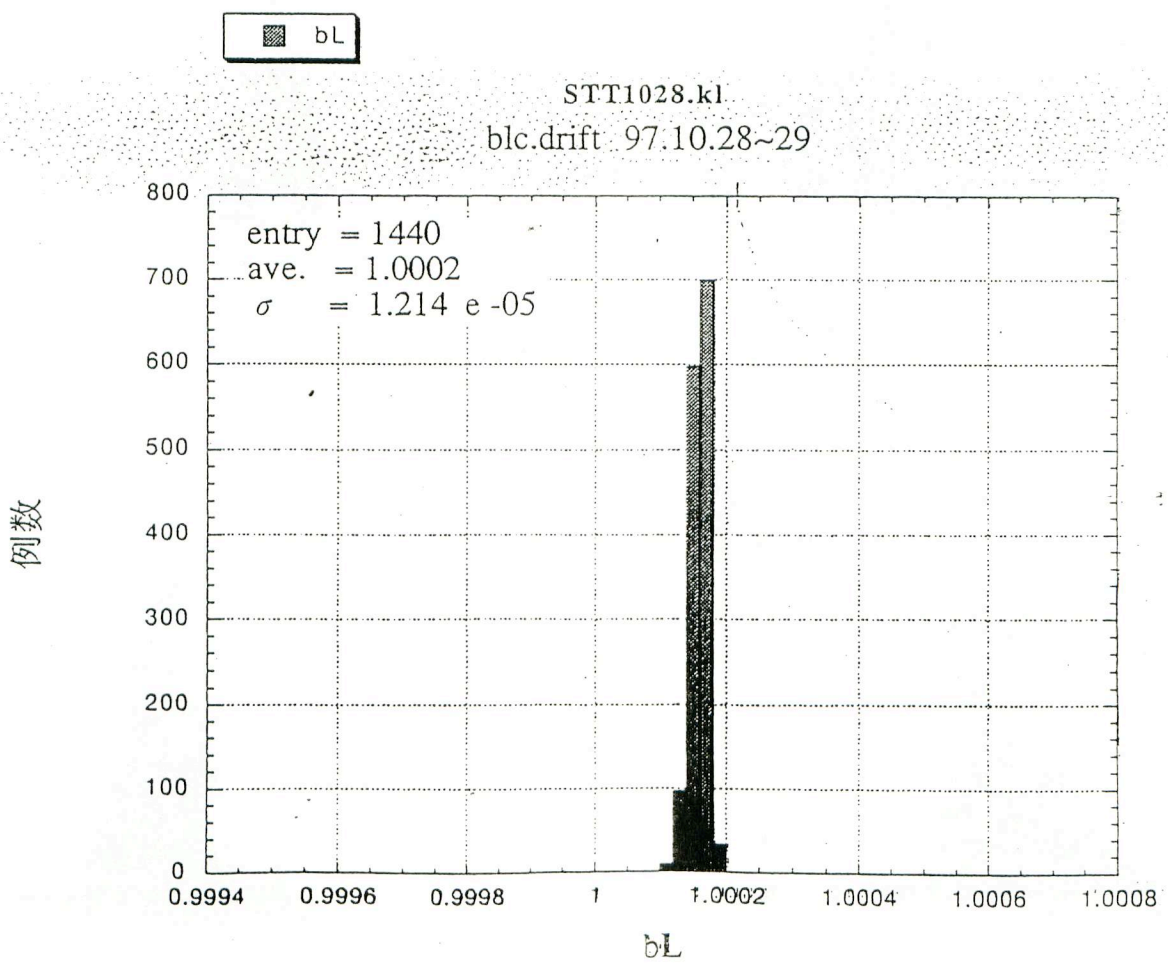

b.1100A/st
LBA.smry: bL.1100A/st. 97.7.21
entry = 111
ave. = 0.99979
σ = 4.72 e-04
#
0
2
4
6
8
10
12
0.9985
0.999
0.9995
1
1.0005
1.001
bL.1100A/st


b.stnd
LBA.smry: b.standard 97.7.21
entry = 111
ave. = 1.0003
σ = 6.50 e-05
#
0
10
20
30
40
50
0.9985
0.999
0.9995
1
1.0005
1.001
bL.st( t ) / bL.st(0)

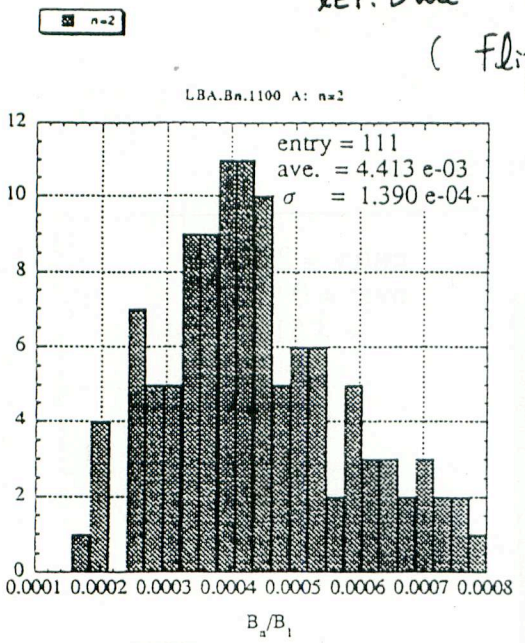

b.840A
herB.kl
b[ 840A ] ( ~3 kG ) 98.1.18
entry = 117
ave. = 0.99983
σ = 3.2267 e-04
例数
0
5
10
15
20
0.9985
0.999
0.9995
1
1.0005
1.001
b.840 : BL(840A) / standard

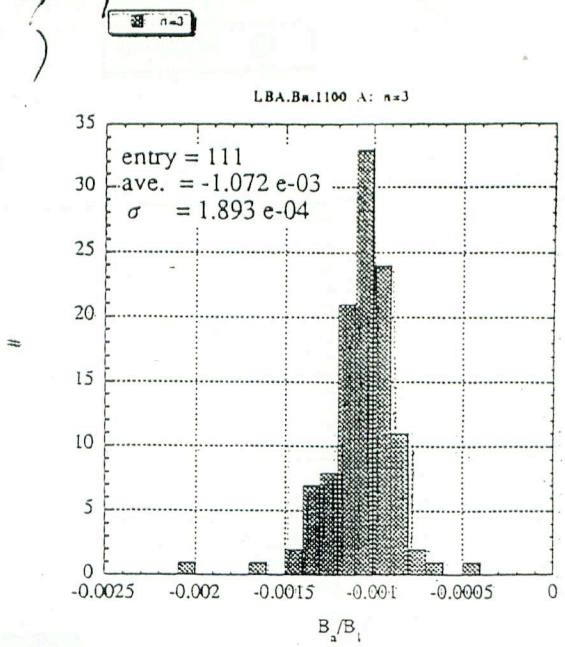

b.840A/tr.
herB.kl
b[~3kG] / b[3kG].tr : 98.1.18
entry = 117
ave. = 0.99985
sig. = 2.4111 e-04
例数
0
5
10
15
20
25
0.9985
0.999
0.9995
1
1.0005
1.001
範囲

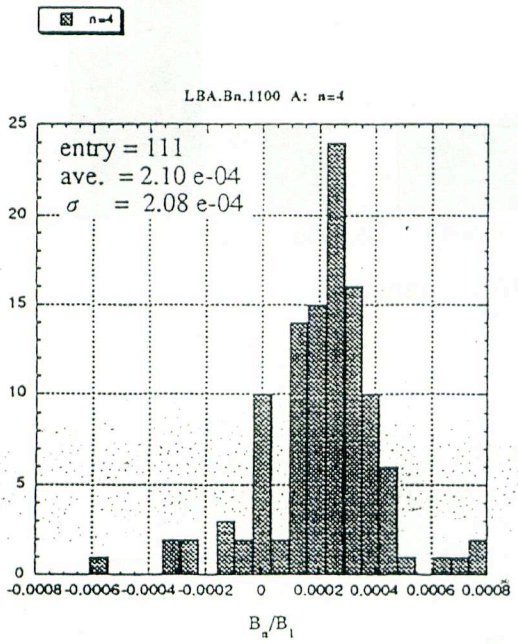

b.800A/st
Blc.800A: 98.1.18
entry = 23
ave. = 0.99954
σ = 3.5134 e-04
例数
0
1
2
3
4
5
6
7
8
0.9988
0.999
0.9992
0.9994
0.9996
0.9998
1
1.0002
b.800 : BL(800A) / standard

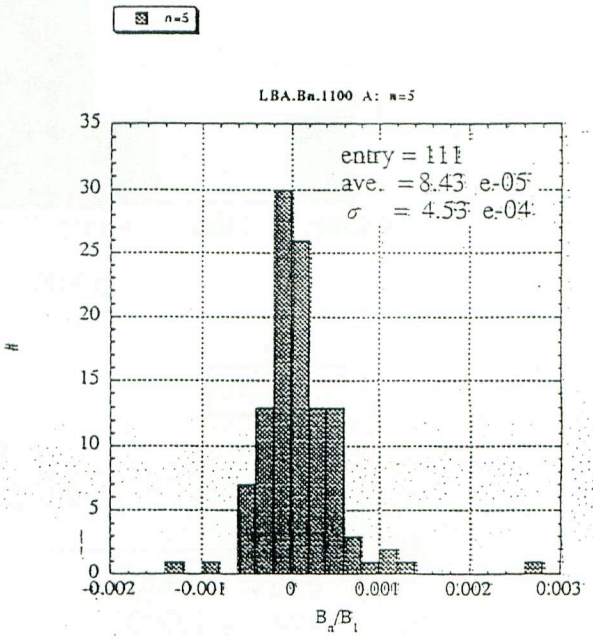

bL
STT1028.kl
blc.drift 97.10.28~29
entry = 1440
ave. = 1.0002
σ = 1.214 e -05
例数
0
100
200
300
400
500
600
700
800
0.9994
0.9996
0.9998
1
1.0002
1.0004
1.0006
1.0008
bL

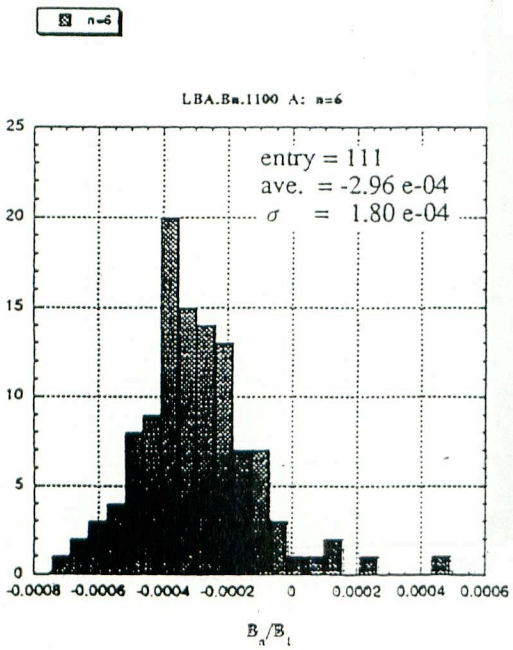
ler. Barc Bn by pol. fit
( flip. coil )

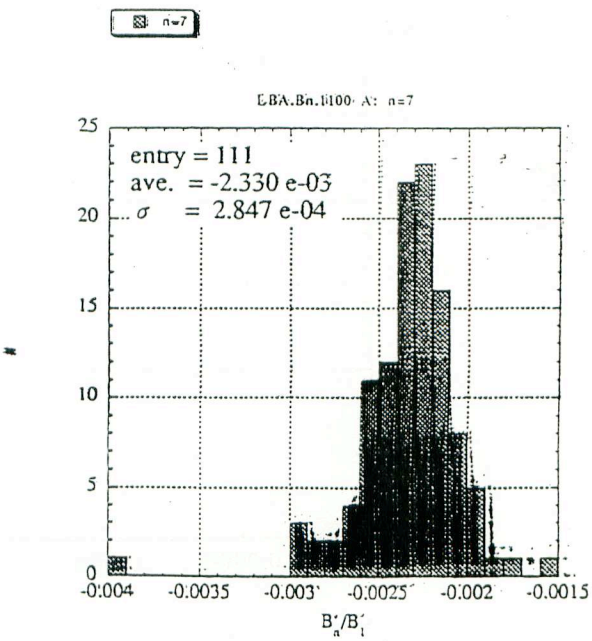


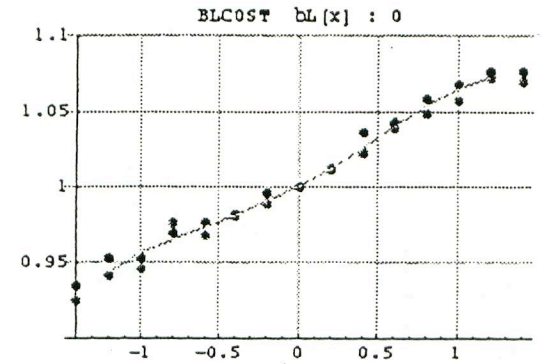



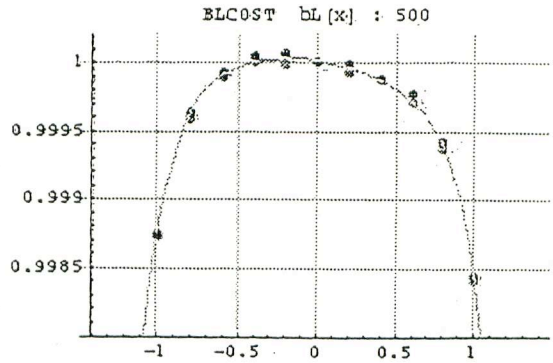



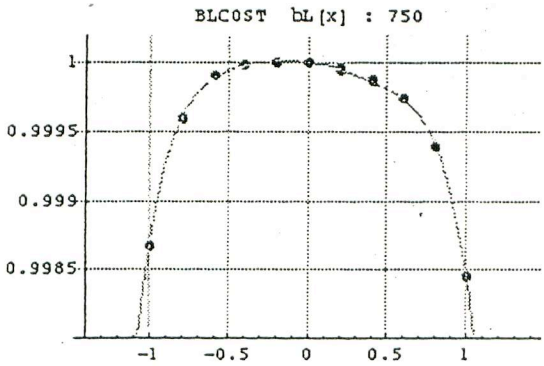
ler.Blc.Magnet BL[x] exam. #14 ( standard ) 1000 A excitation

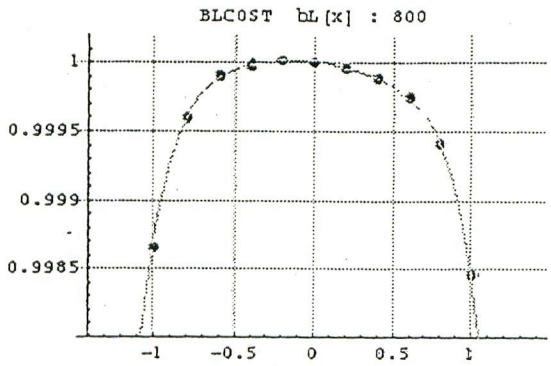
Xn = 1 means X = 50 mm

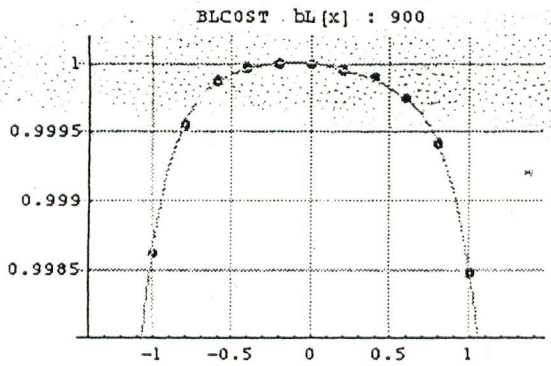
Each is normalized by the center value.

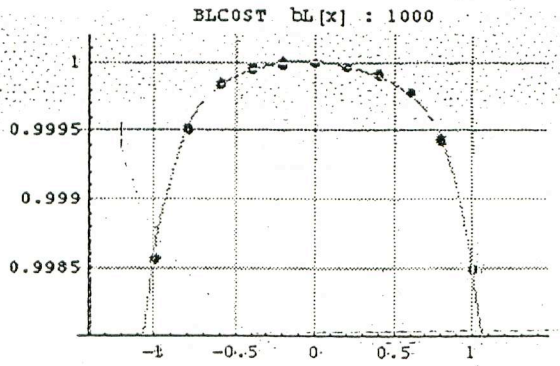


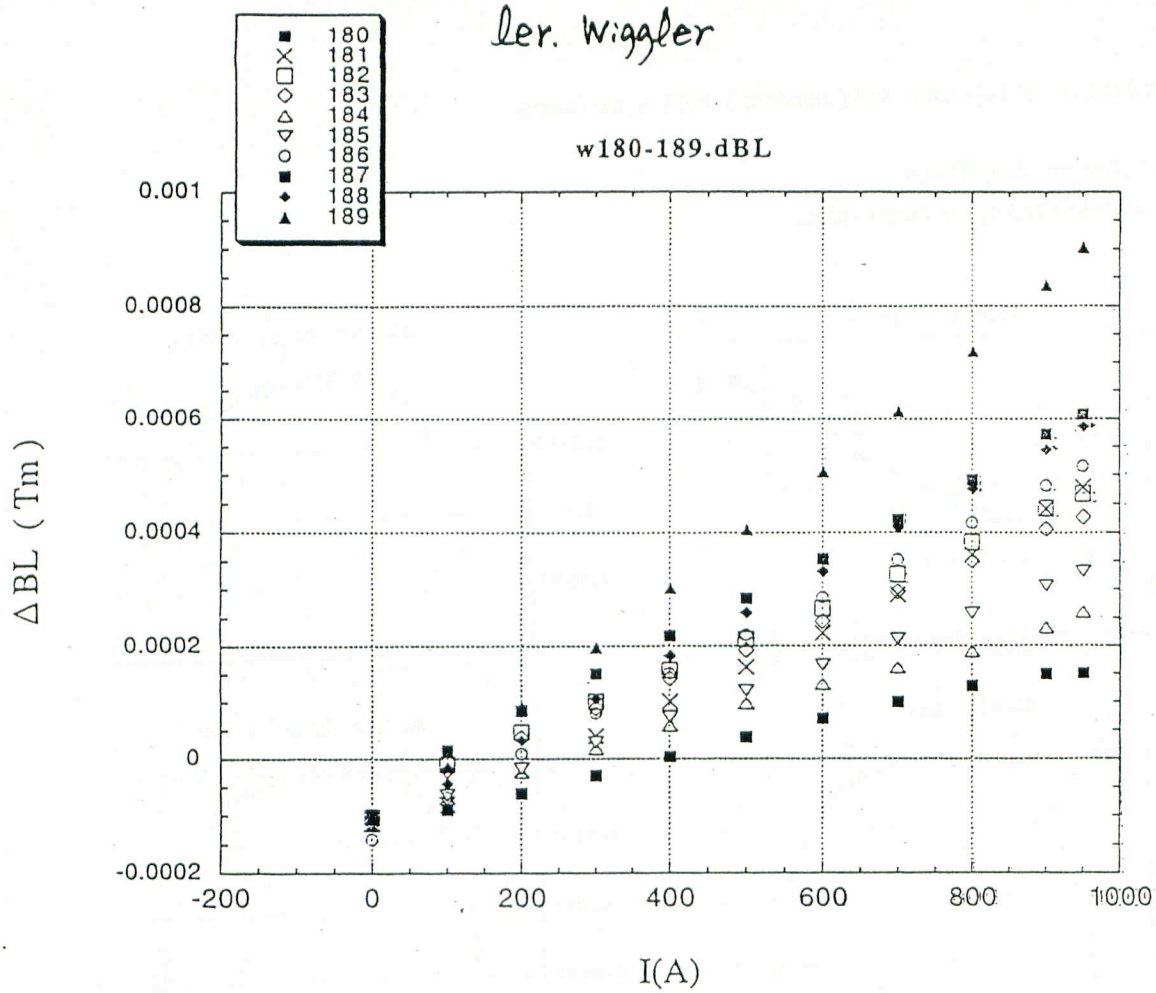



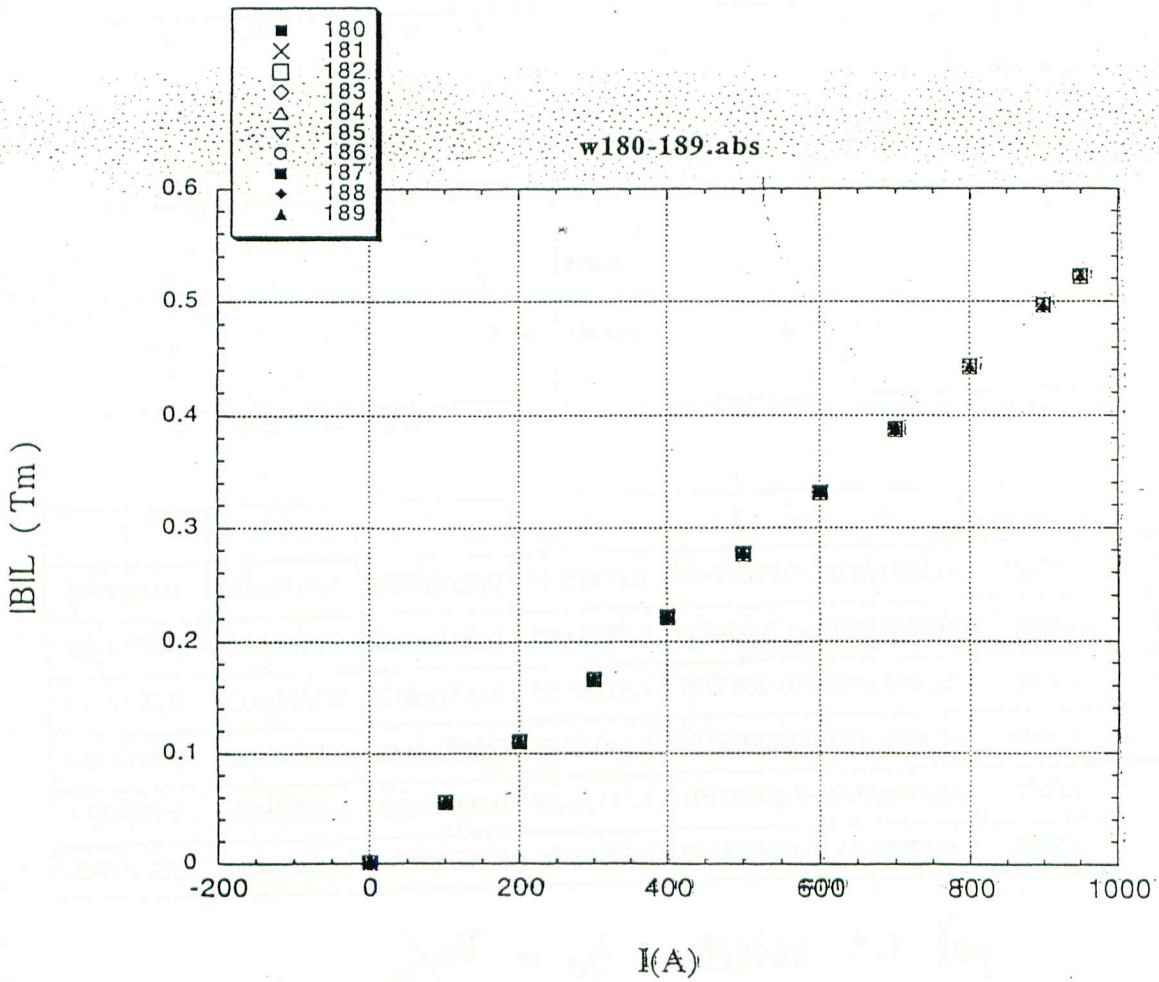



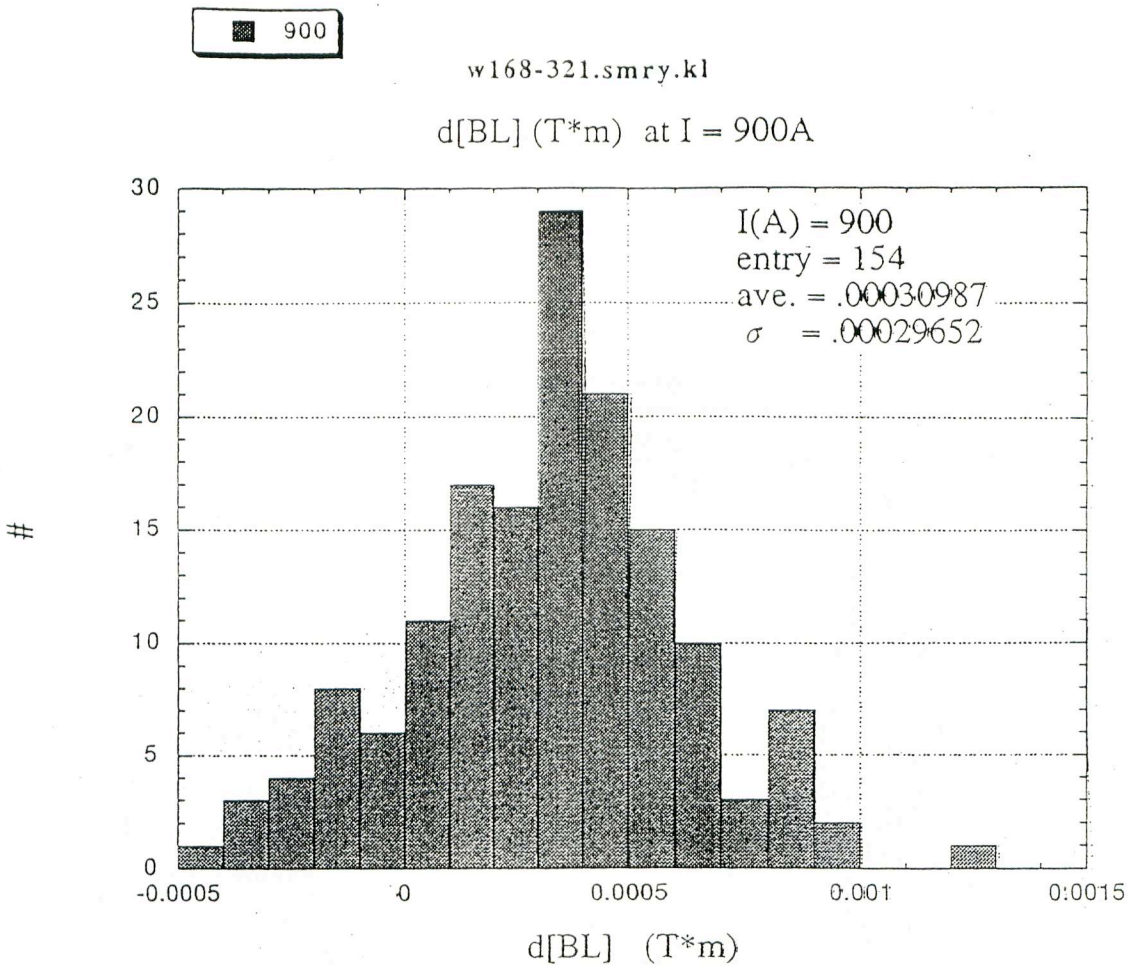

| I(A) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 500.00 | 1.0000 | -0.00015828 | -0.00057454 | 2.3747e-07 | 0.00060986 | 1.4679e-05 | -0.0014705 |
| 750.00 | 1.0000 | -0.00014870 | -0.00054754 | 3.0349e-05 | 0.00056100 | 5.8601e-06 | -0.0014527 |
| 800.00 | 1.0000 | -0.00013049 | -0.00055301 | 1.8108e-05 | 0.00056913 | 9.3304e-06 | -0.0014560 |
| 850.00 | 1.0000 | -0.00011187 | -0.00053259 | 2.1402e-05 | 0.00054485 | 9.1304e-06 | -0.0014489 |
| 900.00 | 1.0000 | -0.00010529 | -0.00057191 | 1.7411e-05 | 0.00057838 | 1.1223e-05 | -0.0014599 |
| 1000.0 | 1.0000 | -6.7706e-05 | -0.00058102 | 2.2088e-05 | 0.00056274 | 1.0346e-05 | -0.0014542 |

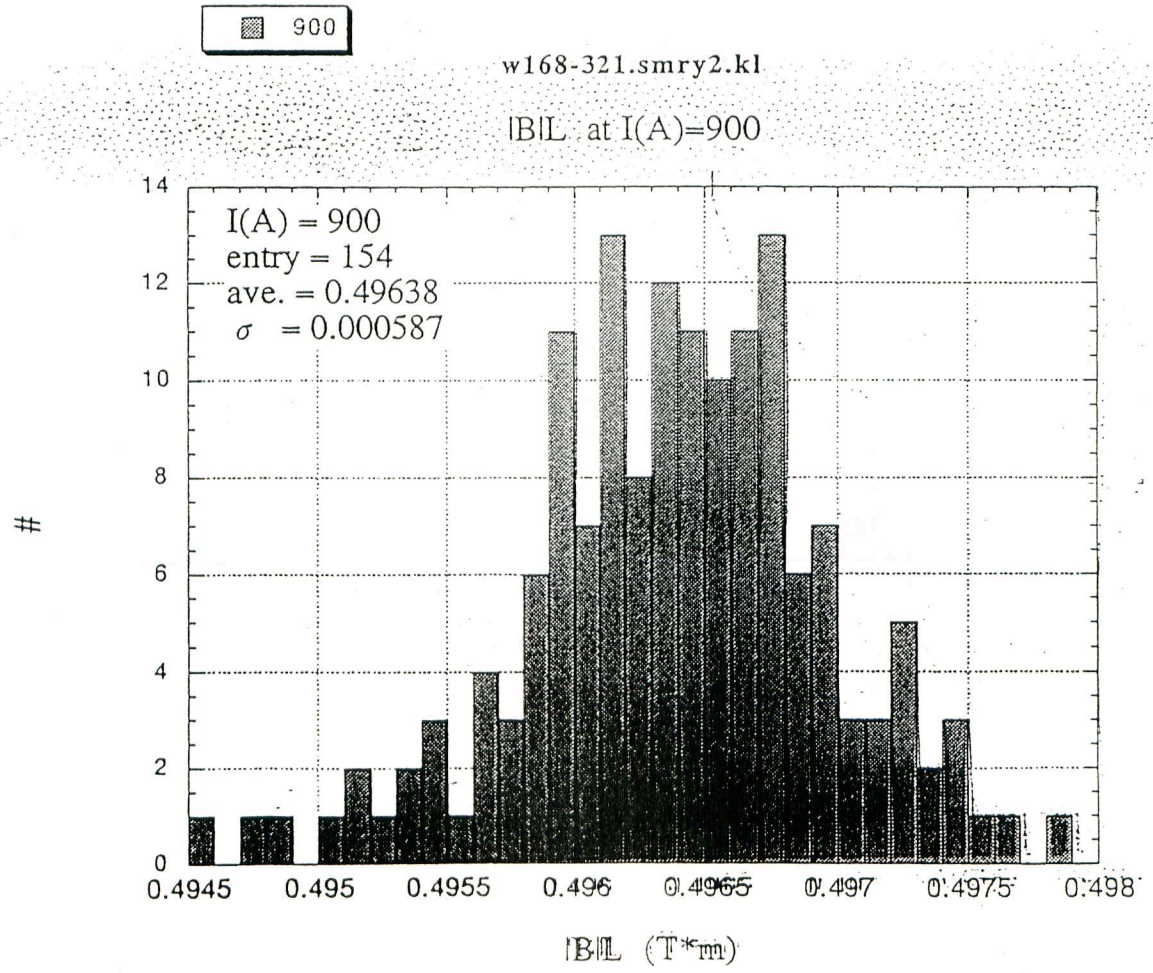
pol. fit. result $b_n \equiv B_n / B_1$

ler. Wiggler


w180-189.dBL
180
181
182
183
184
185
186
187
188
189
0.001
0.0008
0.0006
0.0004
0.0002
0
-0.0002
-200
0
200
400
600
800
1000
ΔBL ( Tm )
I(A)

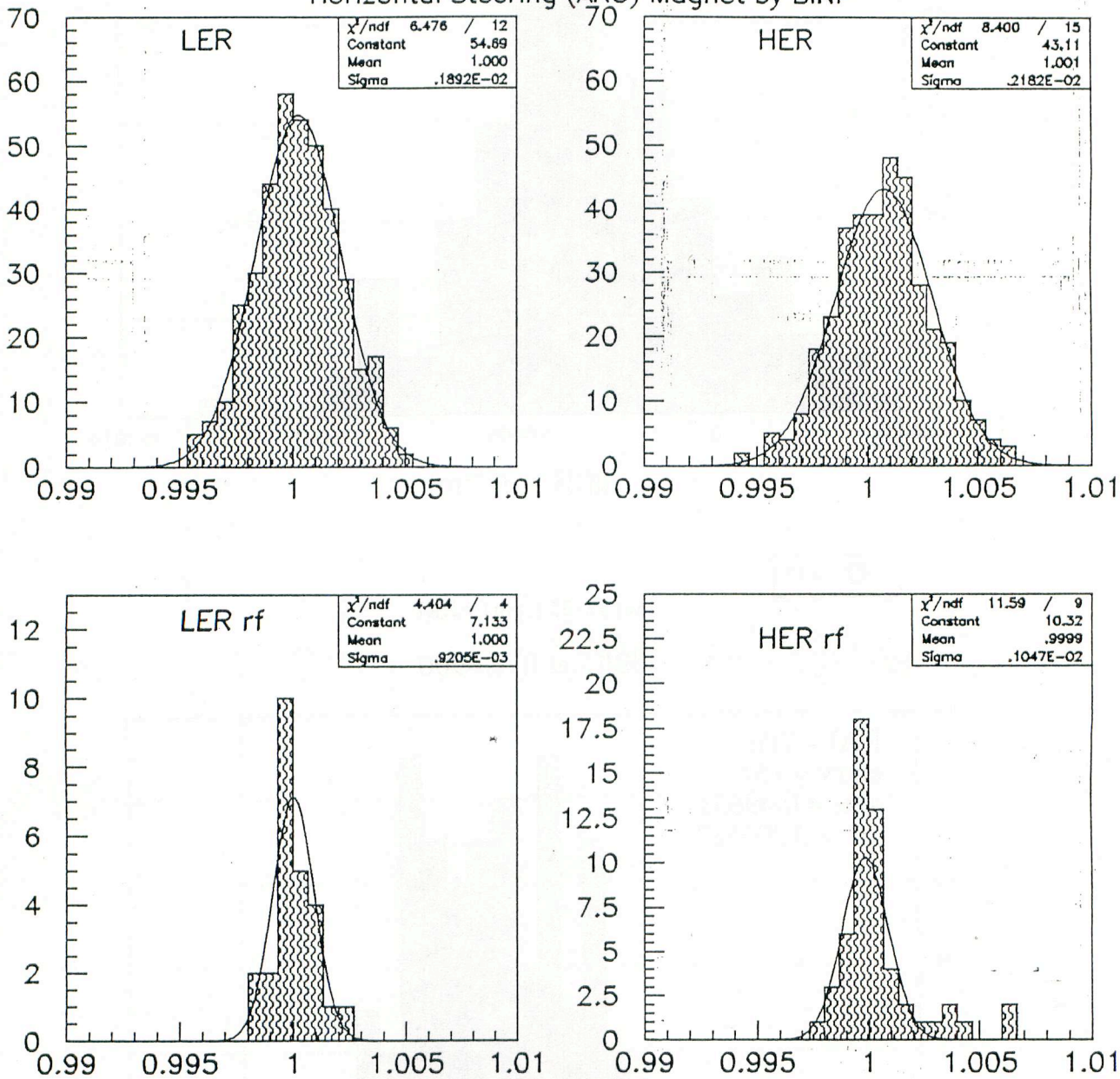

w180-189.abs
180
181
182
183
184
185
186
187
188
189
0.6
0.5
0.4
0.3
0.2
0.1
0
-200
0
200
400
600
800
1000
|BL| ( Tm )
I(A)

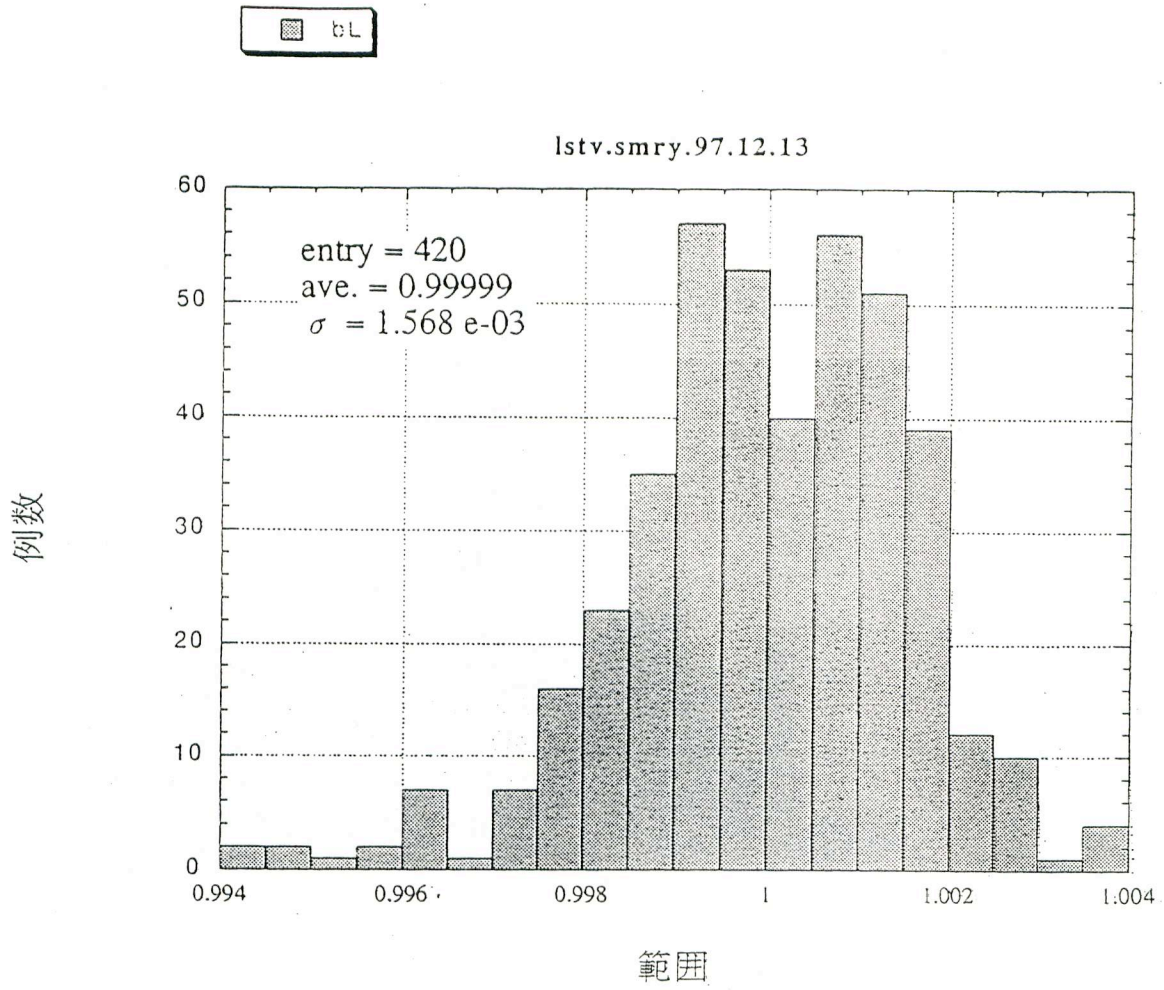

900
w168-321.smry.kl
d[BL] (T*m) at I = 900A
I(A) = 900
entry = 154
ave. = .00030987
σ = .00029652
#
30
25
20
15
10
5
0
-0.0005
0
0.0005
0.001
0.0015
d[BL] (T*m)

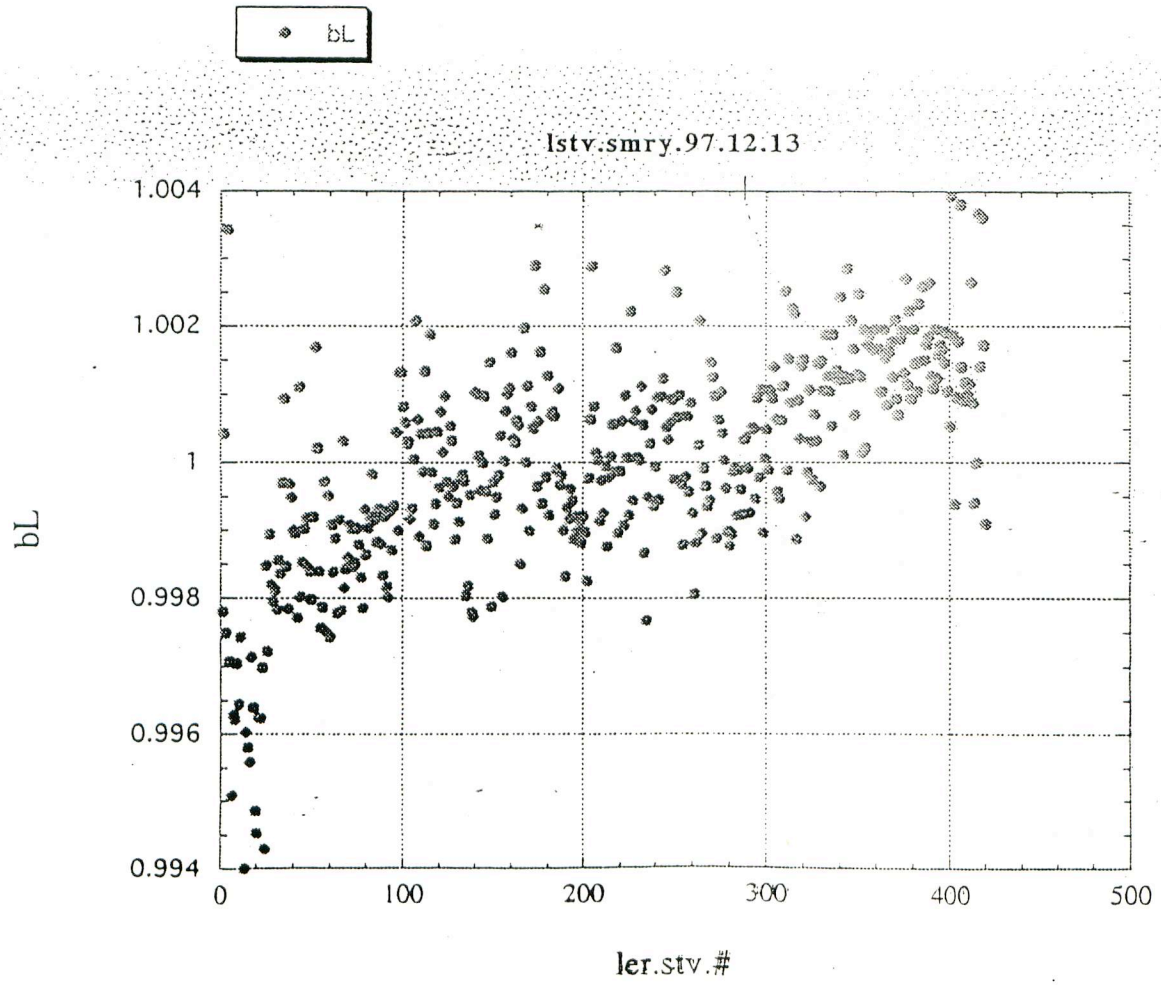

900
w168-321.smry2.kl
|B|L at I(A)=900
I(A) = 900
entry = 154
ave. = 0.49638
σ = 0.000587
#
14
12
10
8
6
4
2
0
0.4945
0.495
0.4955
0.496
0.4965
0.497
0.4975
0.498
|B|L (T*m)

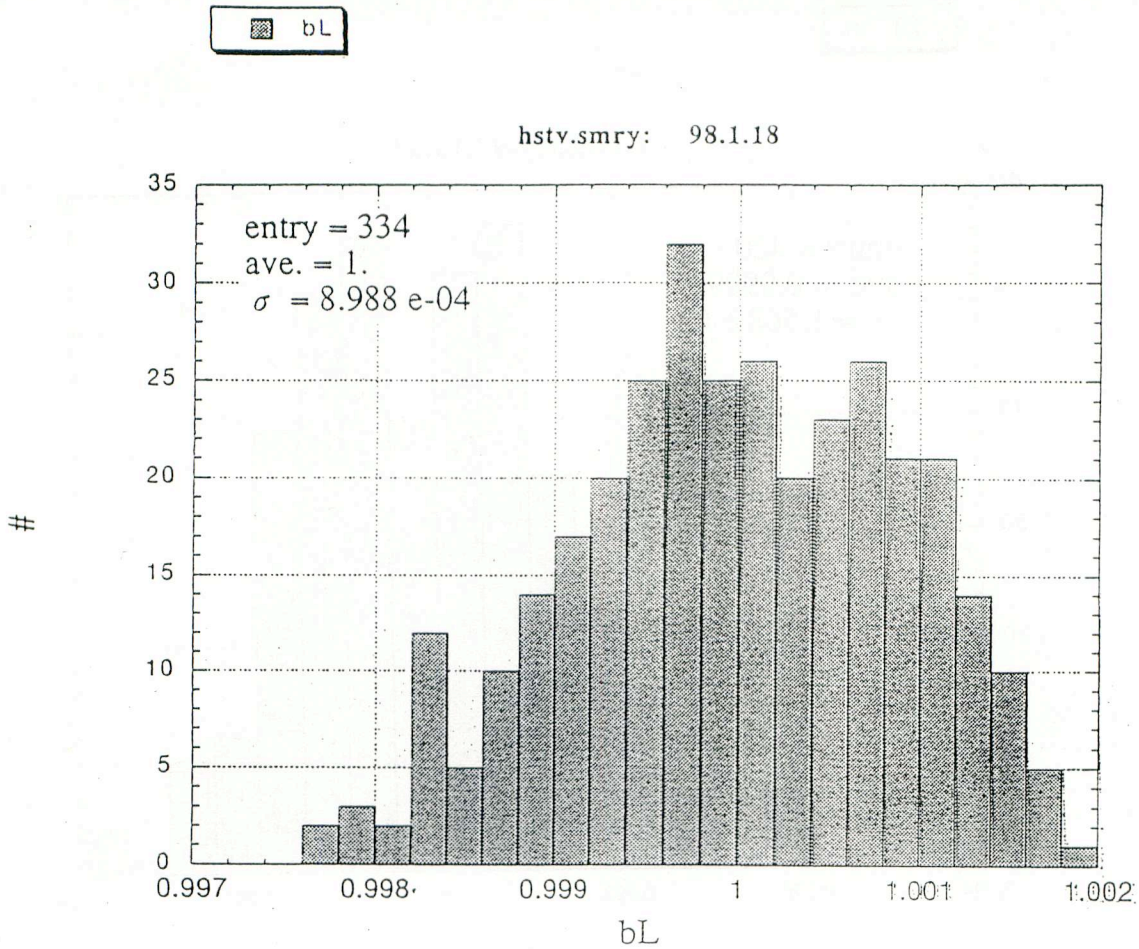
98/01/19 07.58

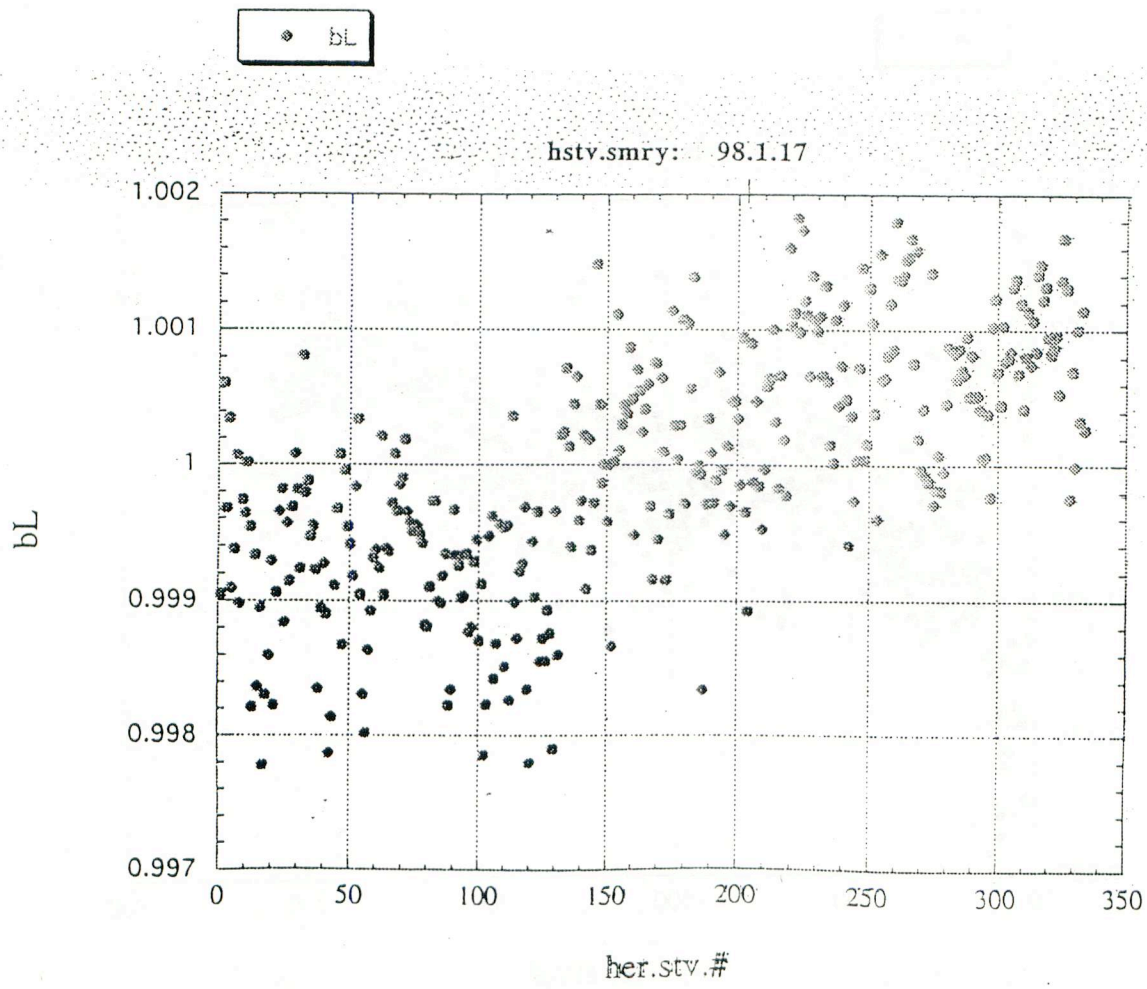
Horizontal Steering (ARC) Magnet by BINP




bL
lstv.smry.97.12.13
entry = 420
ave. = 0.99999
σ = 1.568 e-03
例数
範囲
0
10
20
30
40
50
60
0.994
0.996
0.998
1
1.002
1.004


bL
lstv.smry.97.12.13
bL
ler.stv.#
0.994
0.996
0.998
1
1.002
1.004
0
100
200
300
400
500


bL
hstv.smry: 98.1.18
entry = 334
ave. = 1.
σ = 8.988 e-04
#
35
30
25
20
15
10
5
0
0.997
0.998
0.999
1
1.001
1.002
bL


bL
hstv.smry: 98.1.17
bL
1.002
1.001
1
0.999
0.998
0.997
0
50
100
150
200
250
300
350
her.stv.#

# **Correction Coil (Backleg) Issue
# some concern shown at MAC97

We are aware of the potential problems.

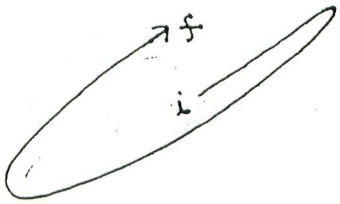
-->> Steps we took (and are going to take):

(1)Take data and understand the effect of the hysteresis left by the correction coil.

(2)Discuss scenario with the operation group.

Data show that the effect is

5-6 x 1.e-04 depending on the current of the main coil (and the magnet types).




$\Delta k$ = final − initial

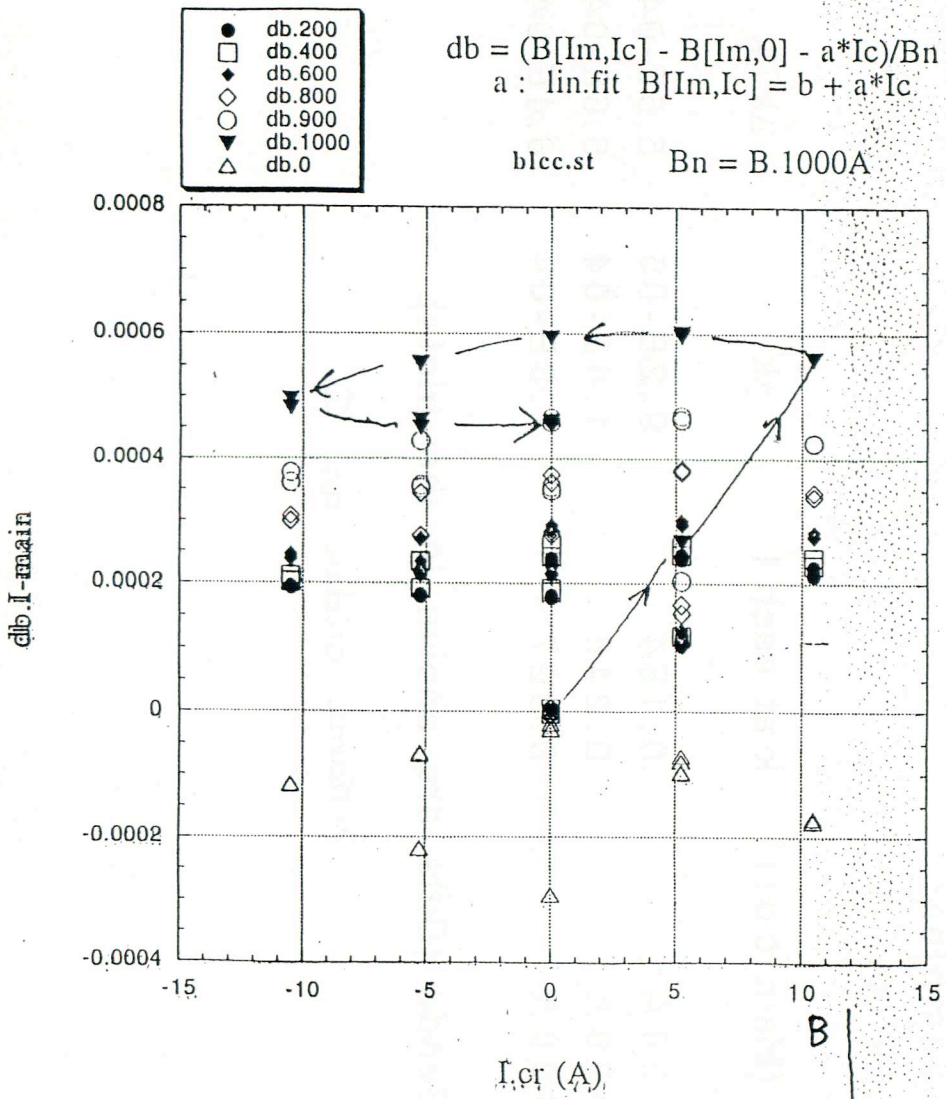
Examples:
LER QA

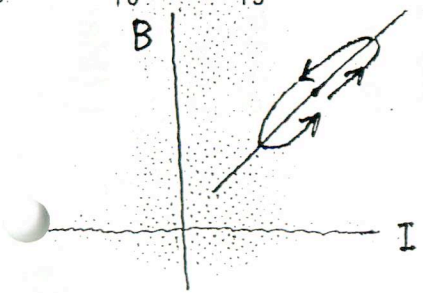
| I (Main coil) | k at each I | $\Delta k$ | $\Delta k / k$ |
|---|---|---|---|
| 200A | 0.164 | 9.2E-05 | 5.6E-04 |
| 300A | 0.246 | 1.4E-04 | 5.6E-04 |
| 400A | 0.327 | 1.6E-04 | 6.4E-04 |

Bends (Data are shown in the plots).

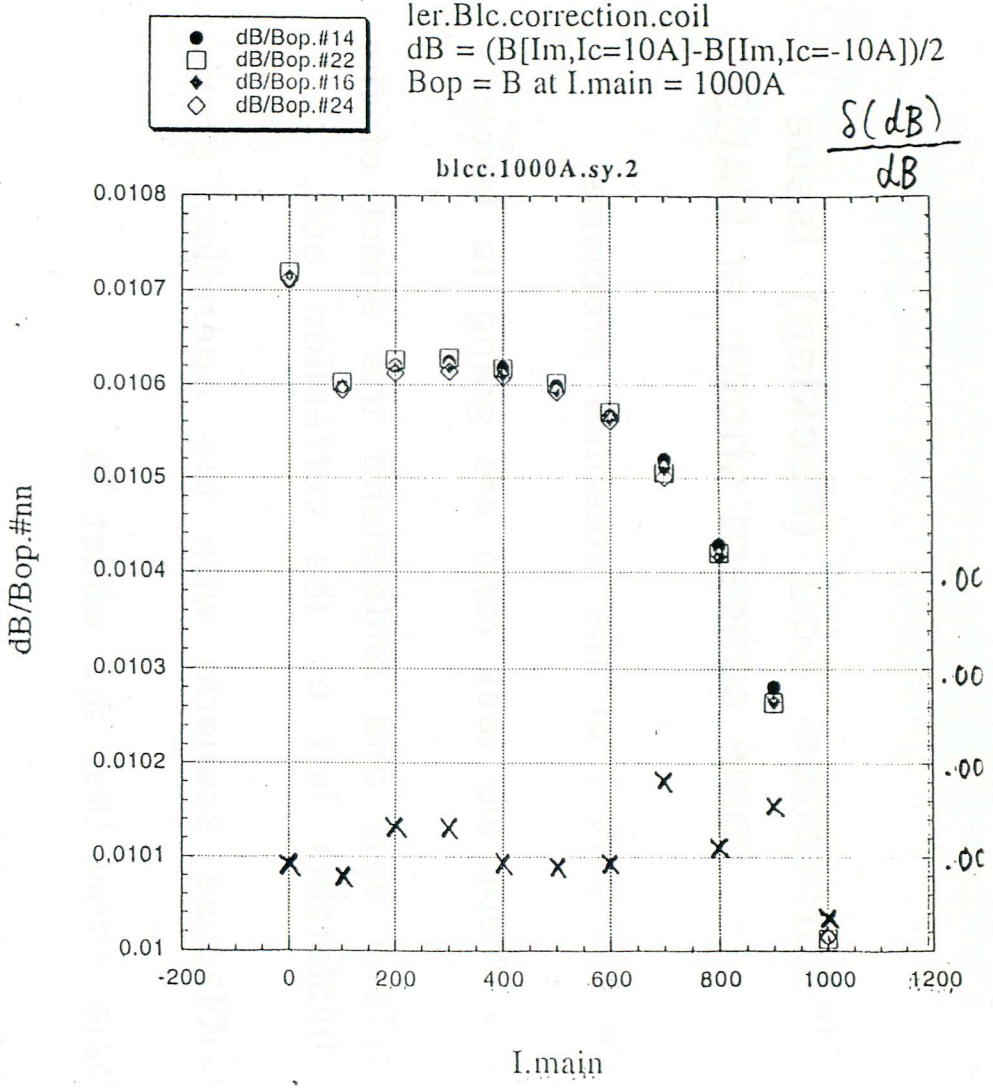
~ same order as Q

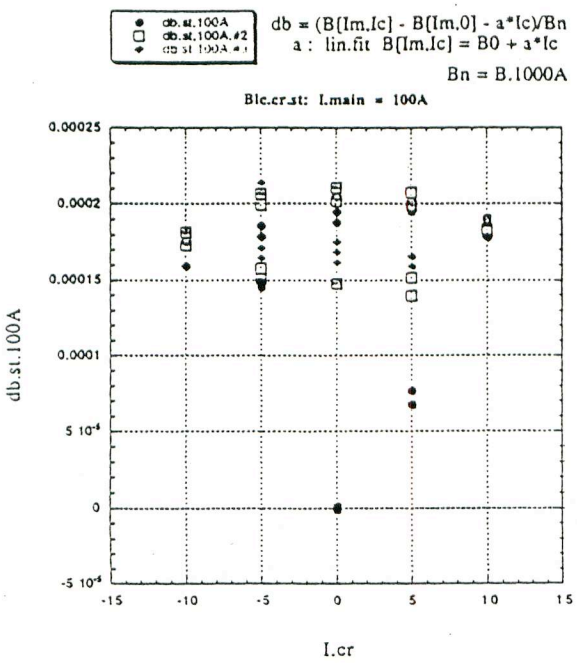
I cor. hysteresys loop

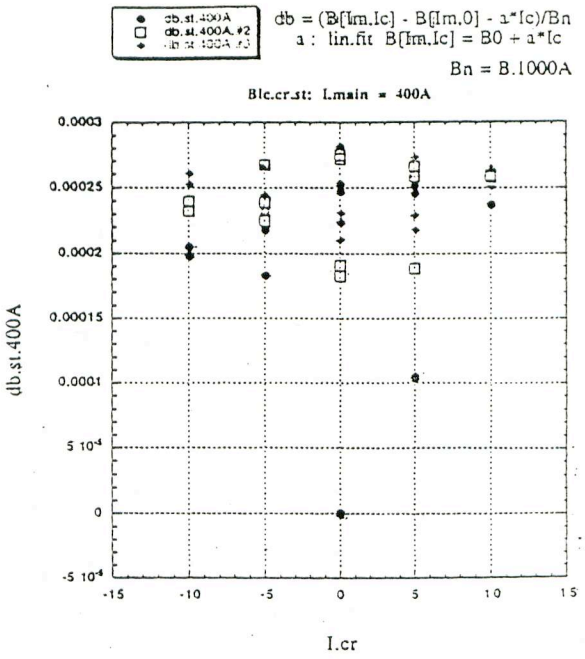


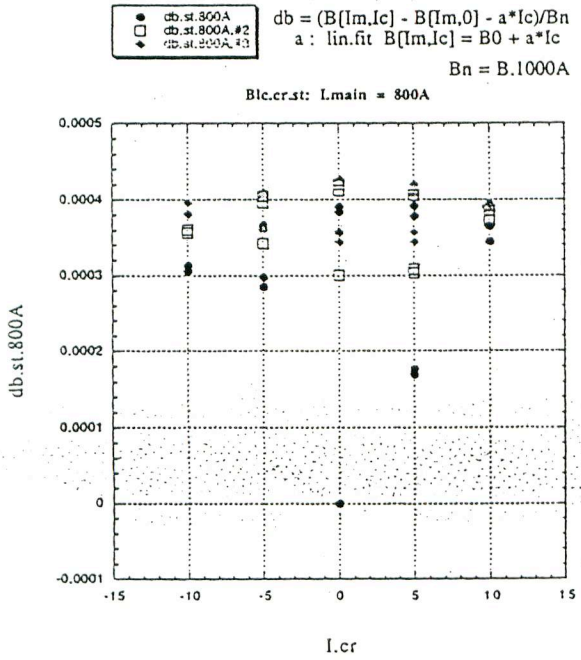



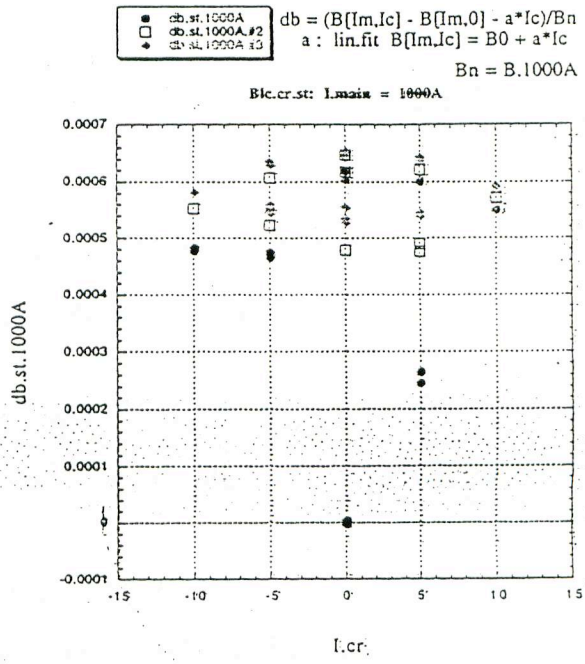

Correction hop. for 4 Blc's

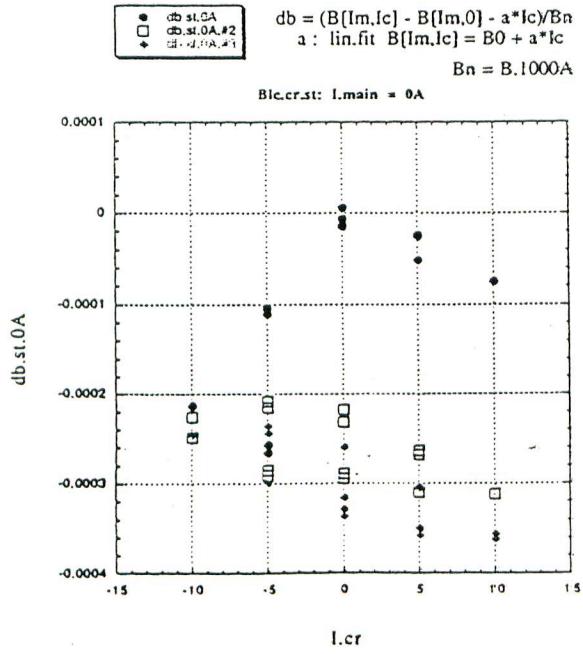


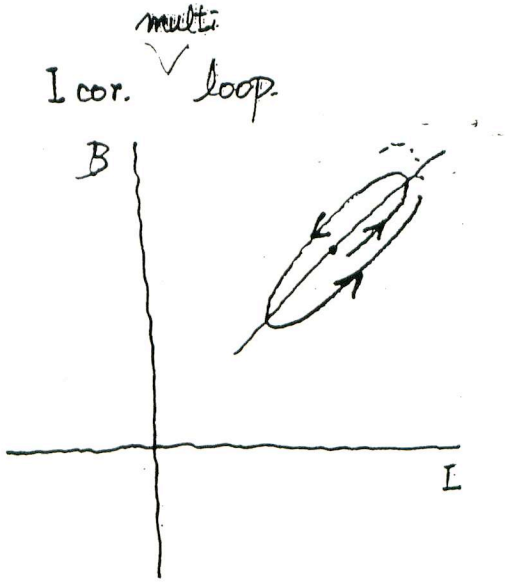

db.st.100A
db.st.100A.#2
db = (B[Im,Ic] - B[Im,0] - a*Ic)/Bn
a : lin.fit B[Im,Ic] = B0 + a*Ic
Bn = B.1000A
Blc.cr.st: I.main = 100A
db.st.100A
I.cr


db.st.400A
db.st.400A.#2
db = (B[Im,Ic] - B[Im,0] - a*Ic)/Bn
a : lin.fit B[Im,Ic] = B0 + a*Ic
Bn = B.1000A
Blc.cr.st: I.main = 400A
db.st.400A
I.cr


db.st.800A
db.st.800A.#2
db = (B[Im,Ic] - B[Im,0] - a*Ic)/Bn
a : lin.fit B[Im,Ic] = B0 + a*Ic
Bn = B.1000A
Blc.cr.st: I.main = 800A
db.st.800A
I.cr


db.st.1000A
db.st.1000A.#2
db = (B[Im,Ic] - B[Im,0] - a*Ic)/Bn
a : lin.fit B[Im,Ic] = B0 + a*Ic
Bn = B.1000A
Blc.cr.st: I.main = 1000A
db.st.1000A
I.cr


db.st.0A
db.st.0A.#2
db = (B[Im,Ic] - B[Im,0] - a*Ic)/Bn
a : lin.fit B[Im,Ic] = B0 + a*Ic
Bn = B.1000A
Blc.cr.st: I.main = 0A
db.st.0A
I.cr


multi
I cor.
loop
B
I

## Bends:

When initializing the magnets
(with Main Coils)
loop over the correction coils
at the same time.

Important to take as many data sets as possible with various current loops (both directions) at various current points (of the main coil).

## Quads:

In principle, do not use correction coils during the normal operation.

Correction coils will be used at "k-modulatin" study, which is an independent run.

Initialize the magnets AFTER the study (BEFORE the normal operation).

Preliminary Results

| Magnet type | Comment | Offset(r.m.s) X | Y | Amplitude(r.m.s.) |
|---|---|---|---|---|
| Quadrupoles | | | | |
| LER QA(I) | H | 40 | 30 | 5.90E-04 |
| LER QA(II) | H | 40 | 40 | 6.60E-04 |
| LER QRF | T | 30 | 30 | 3.80E-04<br>But 6.8E-04 at 500A |
| HER QA | TRISTAN | 40 | 70 | 4.80E-04 |
| HER QB | TRISTAN | 50 | 60 | 4.80E-04 |
| HER QS | H | 60 | 50 | 4.80E-04 |
| | | | | |
| Sextupoles | | | | |
| Sx(0.3m) | H | 30 | 40 | 1.40E-03 |
| Sx(1.0m) | H | 40 | 40 | 1.00E-03 |
| | | | | |
| Wiggler | T | | | 3.00E-04 |
| | | | | |
| Bends | | | | |
| LER B | H | | | 4.70E-04 |
| Blc | T | | | 3.50E-04 |
| | | | | |
| HER B | TRISTAN | | | 3.20E-04 |
| | | | | |
| Steering | | | | |
| | | | | |
| LER STV | IHEP | | | 1.60E-03 |
| HER STV | IHEP | | | 9.00E-04 |
| | | | | |
| LER STH | BINP | | | 1.90E-03 |
| HER STH | BINP | | | 2.20E-03 |
| LER wide | BINP | | | 9.00E-04 |
| HER wide | BINP | | | 1.00E-03 |

Offset: Transverse Offset between the physical and magnetic center

Other requirements:

B3/B1 < 0.12% B6/B2 < 0.12%

B5/b1 < 0.45% B10/B1 < 0.14%

for Bends for Quads

are satisfied

## Thigs to do:

Finish up the series measrements

Mapping (beam direction)
Precise measurements of the absolute value

Prepare database for the actual accelerator operation.