PS/AR/ME Note 88
SM/afm

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AAC ME SUMMARY, 4TH DECEMBER - 10TH DECEMBER 1989

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Introduction

30 hours of the PS MD took place during the last AAC ME week of the year, before starting $\bar{p}$ accumulation for LEAR. During the PS MD time, the band II cryogenic pump was repaired. Here is the list of MEs we carried out during that week.

ME1 Ion tune shifts vs barrier pocket length and shaking
(J. Galayda, F. Pedersen, L. Soby, D. Williams)

ME2 Vertical stack tail (G. Carron, L. Thorndahl)

ME3 New coherent oscillations with filtered signals (S. van der Meer)

ME4 Quadrupole oscillations (S. van der Meer)

ME5 Vertical AC acceptance (S. Maury, S. van der Meer)

ME6 PS/AA and AA/AC rf matching
(F. Pedersen, S. van der Meer, D. Williams)

ME7 AC dampers (D. Williams)

ME8 Russian ejection (J. Kuczerowski, F. Pedersen)

ME9 Improved AA and AC coefficients (S. van der Meer)

ME10 Study of the TFA 7044 noise (C. Carter, F. Caspers, V. Chohan)

ME11 Software test "Fermeture" or "Démarrage" (G. Adrian)

ME12 AC cooling with different PU/K movement function (X. Brunel, S. Maury)

ME13 Study of the dog-leg optics (G. Adrian, S. Maury)

ME14 Study of AA rf heating during $\bar{p}$ stacking (G. Adrian, F. Pedersen)

ME1: ION TUNE SHIFTS VERSUS BARRIER POCKET LENGTH AND SHAKING

(J. Galayda, F. Pedersen, L. Soby, D. Williams)

The positive voltage capability of the clearing system was used to create ion barriers at 2 points in the AA ring.

When the barrier was extended between electrodes VEC 1300 and VEC 500, a moderate tune shift was observed with shaking ON, but the quadrupolar instability appeared with shaking OFF (Fig. 1). We also observed quadrupolar instabilities (Fig. 2) by blocking the ions pockets with a barrier between electrodes UHV 600 and VEC 500 with shaking OFF.

A vertical or horizontal instability signal was looked for, but not observed because the signals are a bit closer to the horizontal tune while the vertical emittance blows up. To create it, the operation should be repeated with a bigger separation in the tune settings. The frequencies observed seem to correspond to the horizontal ones, but shifted 2.5 kHz towards a higher horizontal tune.

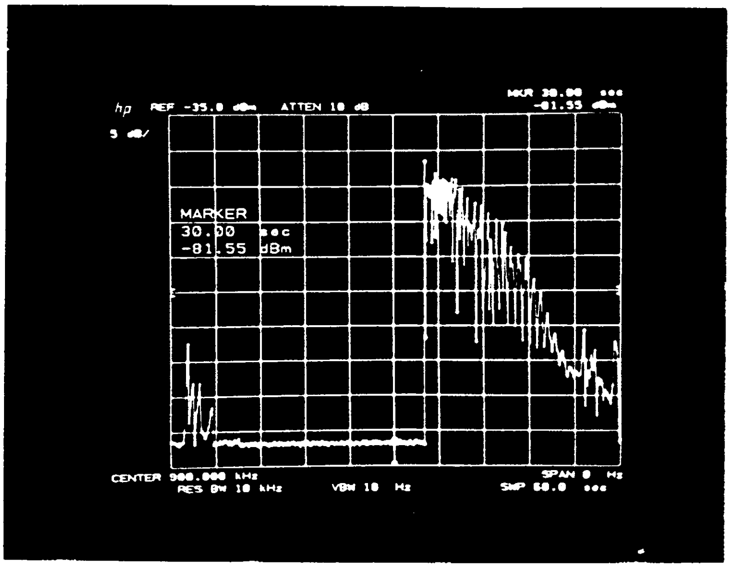


Figure 1

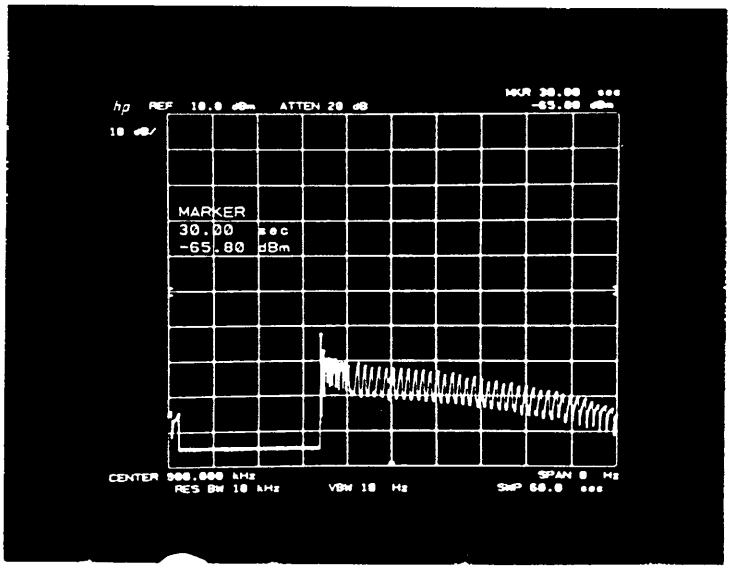


Figure 2

ME2: VERTICAL STACK TAIL

(G. Carron, L. Thorndahl)

The stack-tail hardware works well (Fig. 3), but the cooling speed is rather slow and the effect was not observed on the vertical emittance nor on the stacking rate at low stack intensity. At high stack intensity (~4.5 E11) the vertical stack-tail system provoked a longitudinal instability on the right hand side of the core.

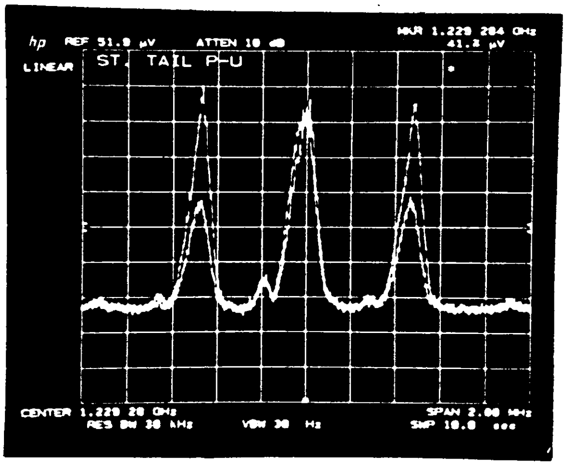


Figure 3

This longitudinal instability widened the stack which gave a high loss rate and saturated the longitudinal stack-tail system, giving a longitudinal phase displacement loss rate.

ME3: NEW COHERENT OSCILLATIONS WITH FILTERED SIGNALS

(S. van der Meer)

A new coherent oscillation program was tried. This program is more sensitive, so lower beam intensity can be used, in particular with inverted polarity. The program uses:

- for AA: the dipole outputs from the quadrupolar pick-up filtered,
- for AC: the same pick-ups as before (ss 26/27) but signals treated to give equivalent signals to the AA one before filtering.

Signals are good and the digitization works. The correction of the program also works but the jitter observed last time remains the same. This jitter is probably real and some tests should be done with inverted polarity.

ME4: QUADRUPOLE OSCILLATIONS

(S. van der Meer)

To improve the PS/AA matching, the quadrupolar frequency measurements were improved, but the analysis is slightly different from what it was before. Frequencies are measured using a time record 400μs long, but only the first quarter of this is used to determine the phase. The cosine and sine components are fluctuating but the fluctuations do not seem correlated with the intensity or the frequency. However, the quadrupolar correction program works well. In Fig. 4, the horizontal and vertical quadrupolar frequencies are measured before the corrections, and in Fig. 5 they are measured after corrections. The amplitudes seem to be reduced a lot but it corresponds to tenths of mm. The PS/AA matching seems quite good. This program should be extended on AC/AA transfer line, this year.

ME5: VERTICAL AC ACCEPTANCE

(S. Maury, S. van der Meer)

With all AC cooling pick-ups and kickers open at 240π mm.mrad (theoretical maximum acceptance), we ran the vertical SEARCH OBSTACLE program to find where the vertical acceptance limitation is. We found it in section 44. After a vertical bump with 4 quadrupoles, the vertical acceptance obtained was 208π mm.mrad. Then, we found the cooling PU 43 and cooling K1 limited the acceptance. With 3 new quadrupole bumps, the limitation was removed. Finally, we found a new limitation due to the kicker cooling K4, but a bump was not possible because a quadrupole QDN05 was not motorised. Another bump could be tried. However, to remove this limitation we decided to open the K4 at 215π mm.mrad instead of 200π mm.mrad.

All PU/K opened at 240, A_v = 208π mm.mrad
All PU/K closed at 200, A_v = 206π mm.mrad (except K4 at 215).

ME6: PS/AA AND AA/AC RF MATCHING

(F. Pedersen, S. van der Meer, D. Williams)

1. PS/AA rf Matching (p via loop - mode 2)

   Coherent quadrupolar longitudinal oscillations were observed with a passive peak detector applied to the bunch signal.

   With the current rf voltage setting in the PS, significant quadrupolar oscillations were observed in the AA with voltages varying from 5 kV_p to 12 kV_p. The minimum corresponding to a pure sine component was found for V_{RF} = 8 kV_p. This means that the bunch is tilted in the phase plane, probably due to a non-adiabatic voltage decay in the PS, which induces a quadrupolar oscillation in the PS prior to extraction (to be investigated in the PS).

2. AA/AC rf Matching (p via loop - mode 3)

   With V_{AA} = 12 kV_p a sharp minimum in coherent quadrupolar oscillations in AA was observed for V_{AC} = 2.25 kV_p corresponding to a good longitudinal matching. This ratio:

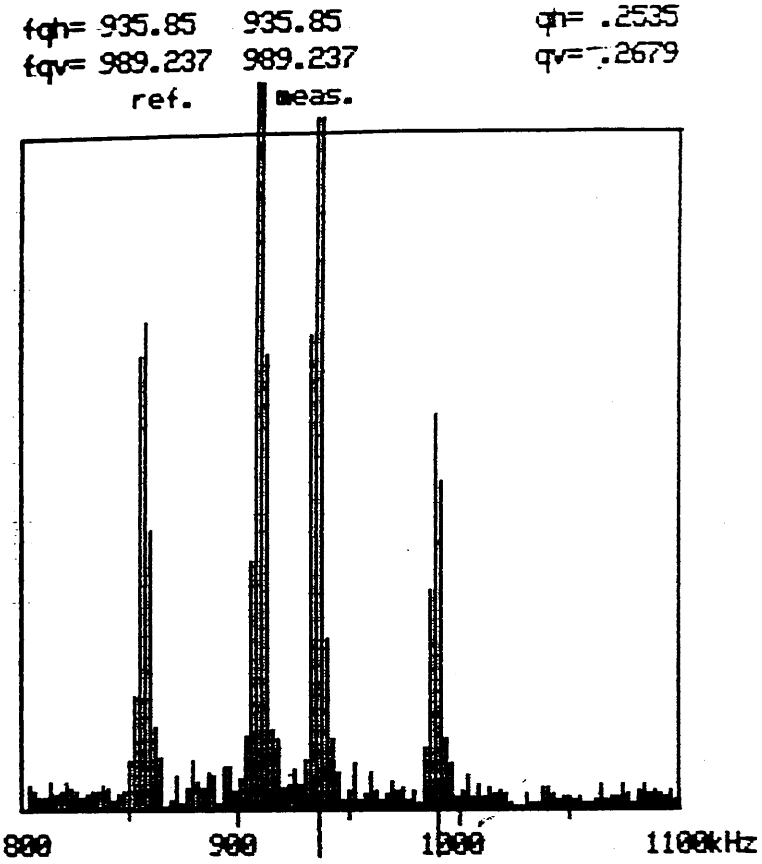


Figure 4

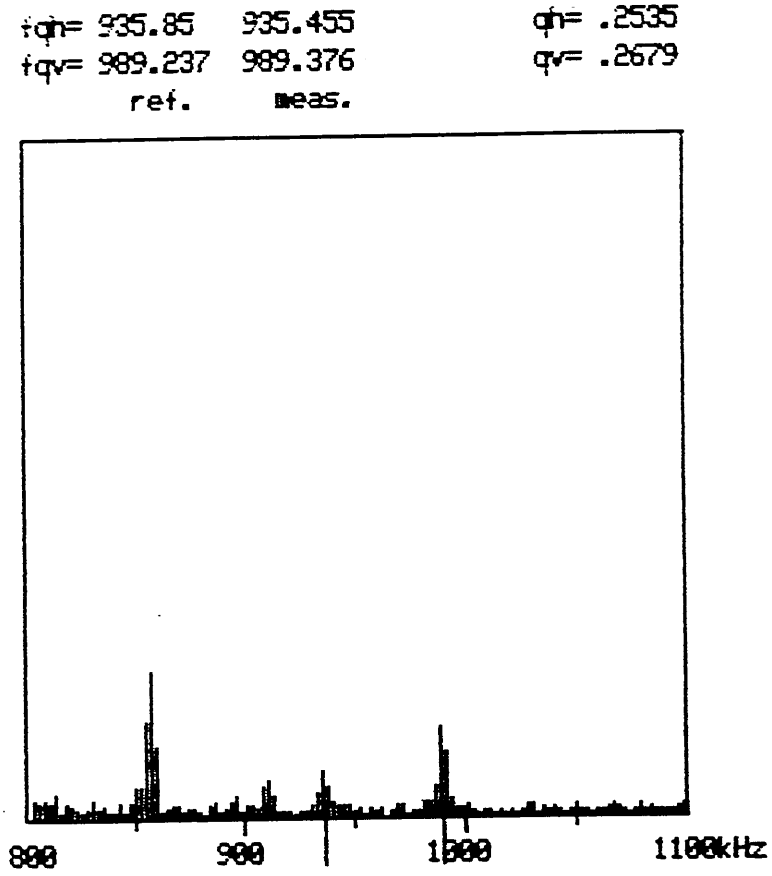


Figure 5

$$V_{AA}/V_{AC} = 12/2.25 = 5.33$$

is in reasonable agreement with the theoretical value of:

$$V_{AA}/V_{AC} = \eta_{AA}f_{AC}/\eta_{AC}f_{AA} = (0.111 \times 1589)/(0.0187 \times 1846) = 5.11$$

The new ratio is applied in the AC and AA rf files used for $\bar{p}$ stacking to reduce the blow-up during transfer.

ME7: AC DAMPERS

(D. Williams)

After the previous attempt to measure the AC horizontal and vertical dampers open-loop phase response, it was decided to try again using the FFT. This technique had been successfully used in the AA. The open loop measurements of amplitude and phase of AA horizontal damper are shown in Figs. 6 and 7.

To make a clean measurement, it was necessary to have a very narrow beam and this was created with a special rf file. It was also necessary to inject a new beam for each measurement because the process of making the BTF measurement using the noise source of the FFT increased the beam emittance. The intensity used was typically 3 x 10^{10} protons. The $(n+q_H)f_0$ for n = 1 to 17 in odd steps (869 kHz to 26.301 MHz).

The vertical damper was similarly examined for n between 0 and 19.

The open loop measurements of amplitude and phase of AC horizontal and vertical damper are shown in Figs. 8, 9 and 10.

The phase of the horizontal damper is correct but the vertical damper has a phase inversion of 180°.

ME8: RUSSIAN EJECTION

(J. Kuczerowski, F. Pedersen)

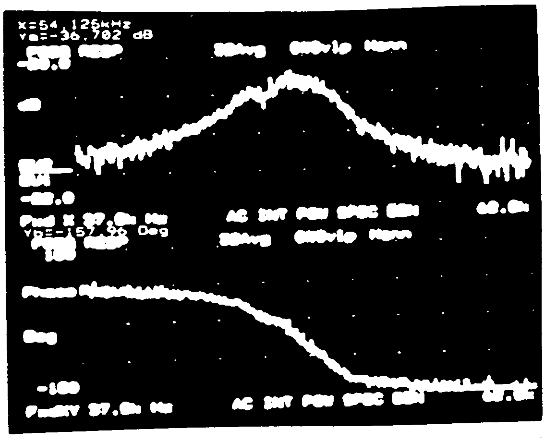
During the last ME week, we tried the Russian ejection with a proton stack built with protons via the loop. There were mainly 2 disadvantages:

- no cooling was available,
- the equalizing did not work.

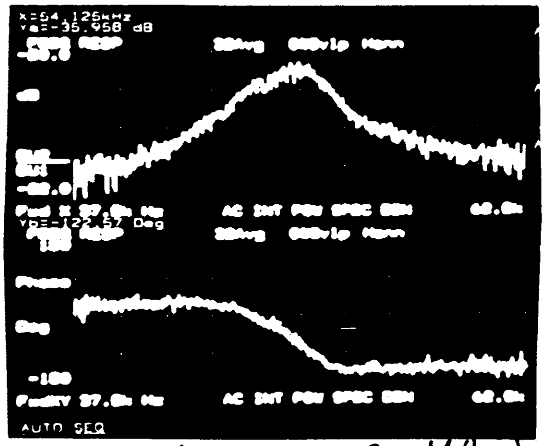
But the advantage was that different rf settings could be tried because new proton stack could be made quickly.

Now, with these rf adjustments, the Russian ejection on the $\bar{p}$ stack was tried. The shape of the stack after unstacking, interrupted every 10 shots, is shown in Fig. 11.

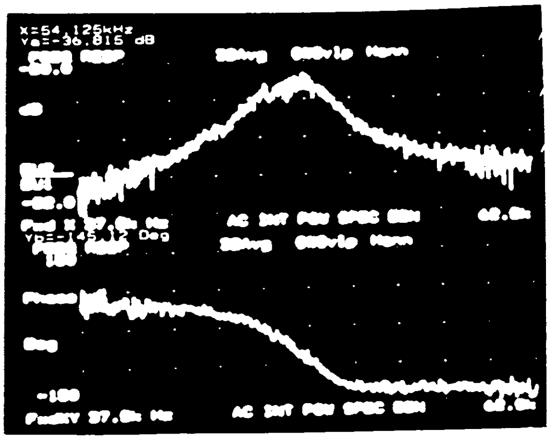
The first 60 shots are quite good. The ejected intensity is more or less equal, but after the 70th shot, the ejected intensity drops very rapidly. Some bad ejected shots were observed, maybe hardware problems?



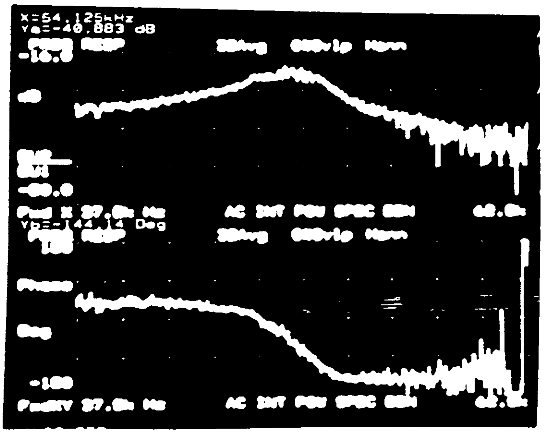
n = 4 (c.F. 11·6395 MHz)



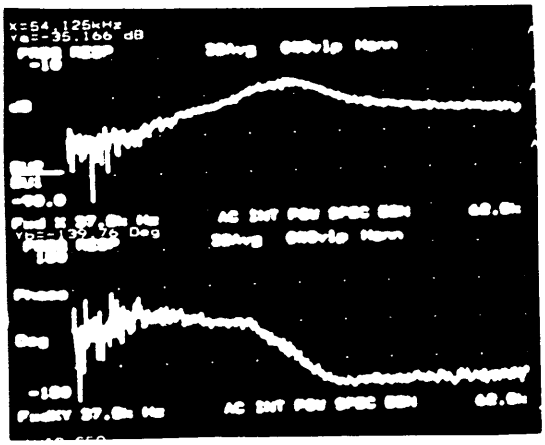
n = 5 (c.F. 13·494 MHz)



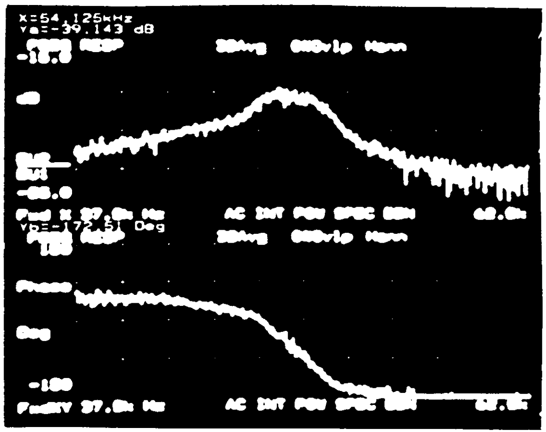
n = 6 (c.F. 15·349 MHz)



n = 7 (c.F. 17.204 MHz)

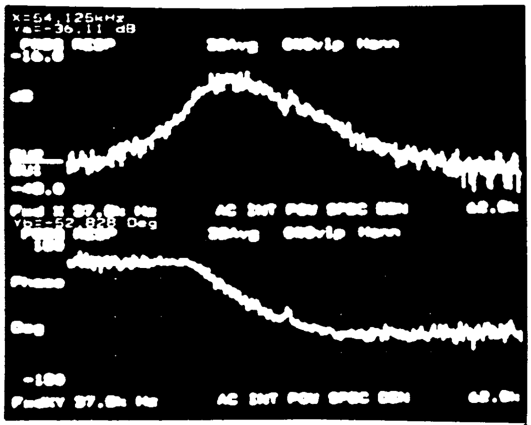


n = 8 (c.F. 19·06 MHz)

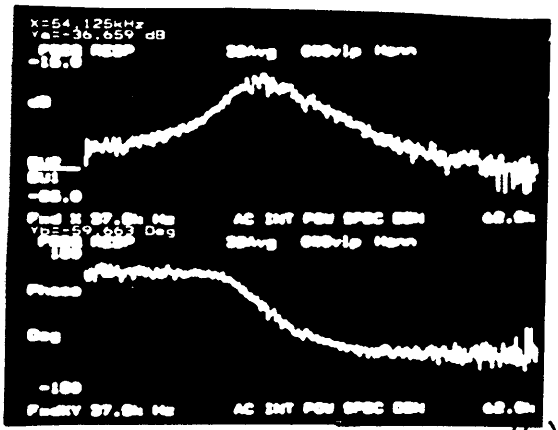


n = 9 (c.F. · 20·915 MHz)

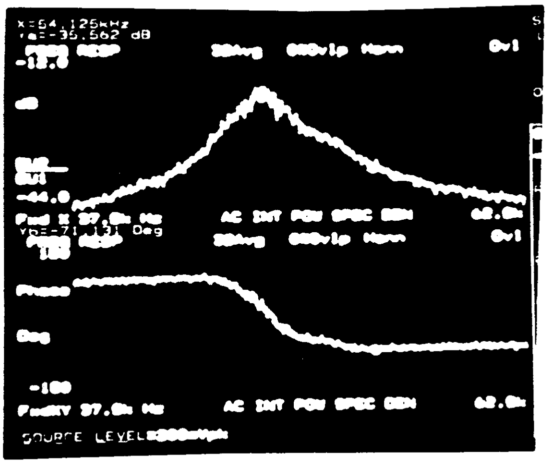
<u>Figure 6</u>



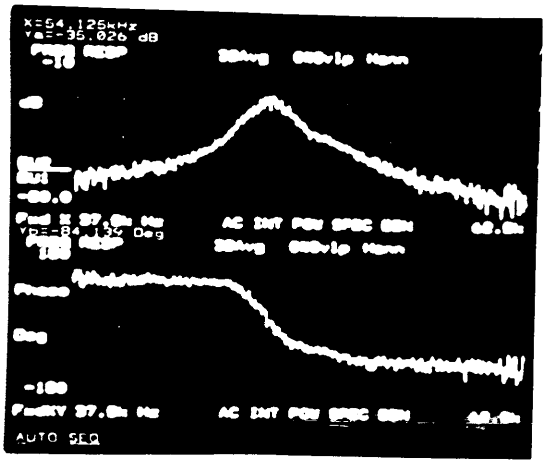
n = 3 (c.f. = 1.3499 MHz)



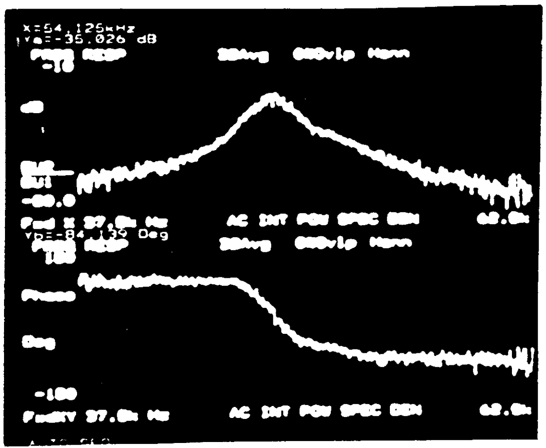
n = 4 (c.f. = 3.205 MHz)



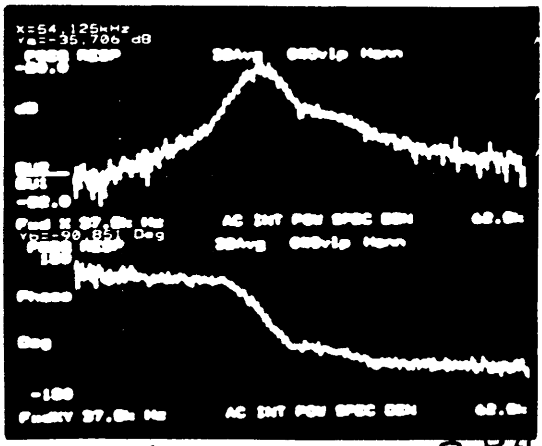
n = 5 (c.f. = 5.06 MHz)



n = 6 (c.F. = 6.9152 MHz)



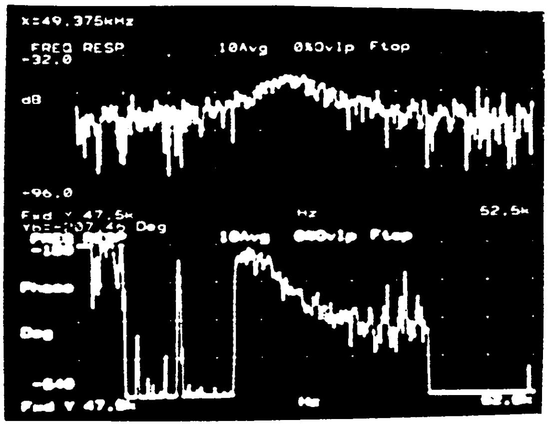
n = 7 (c.f. = 8.7703 MHz)



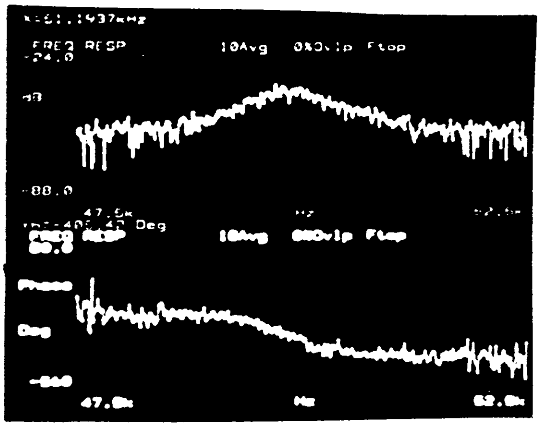
n = 8 (c.f. = 10.6254 MHz)

Figure 7

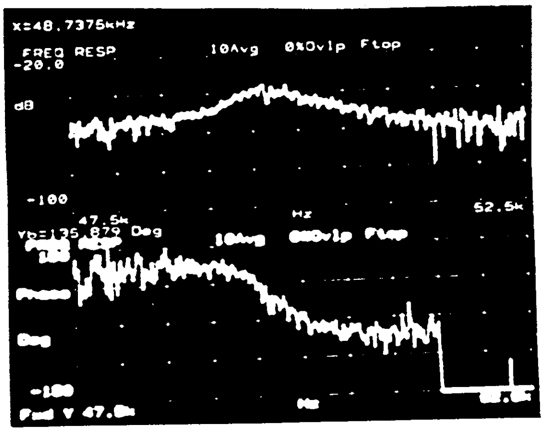
Horizontal (n + 9) f_0 is in centre of display.



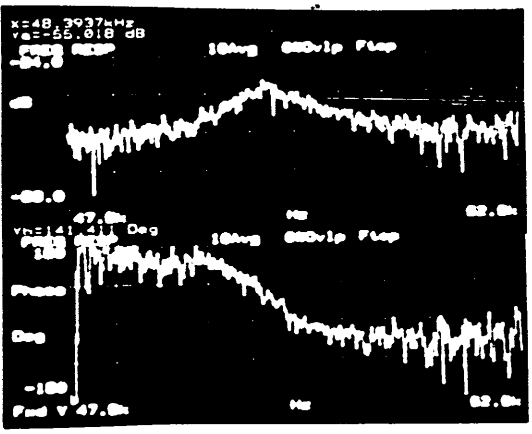
$n = 0$ c.f. = 721 kHz



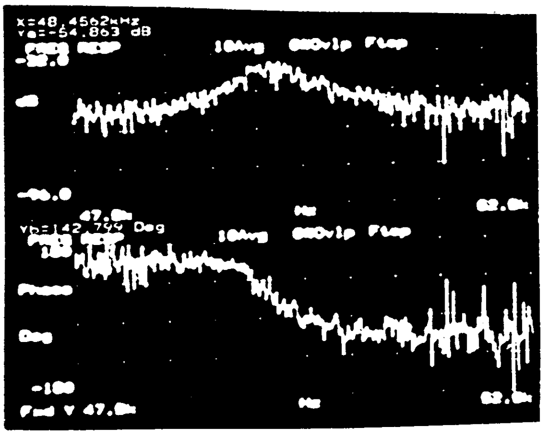
$n = 2$ c.f. = 3.900 MHz



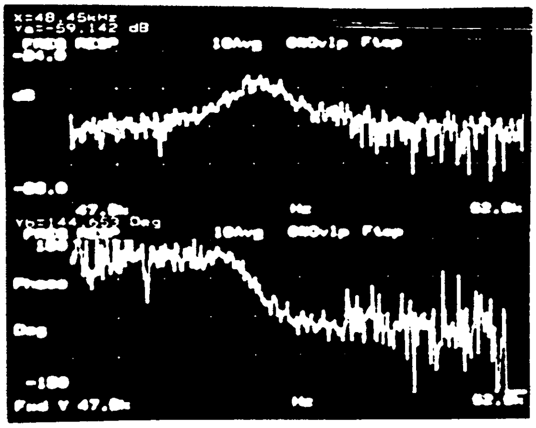
$n = 4$ c.f. = 7.079 MHz



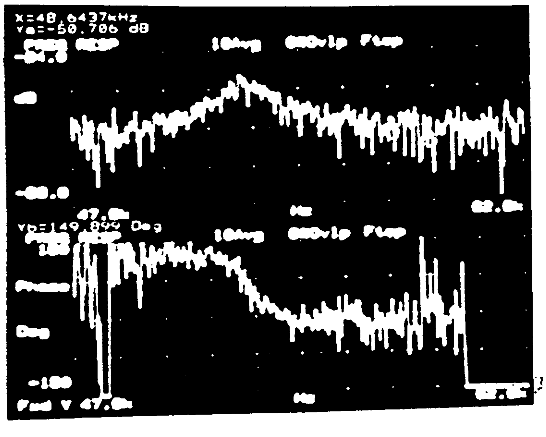
$n = 6$ c.f. = 10.258 MHz



$n = 8$ c.f. = 13.437 MHz

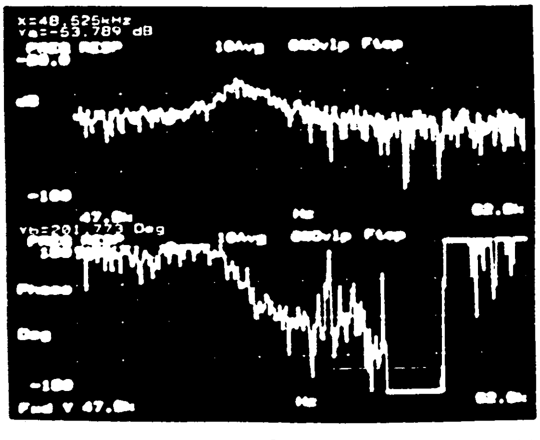


$n = 12$ c.f. = 19.795 MHz.



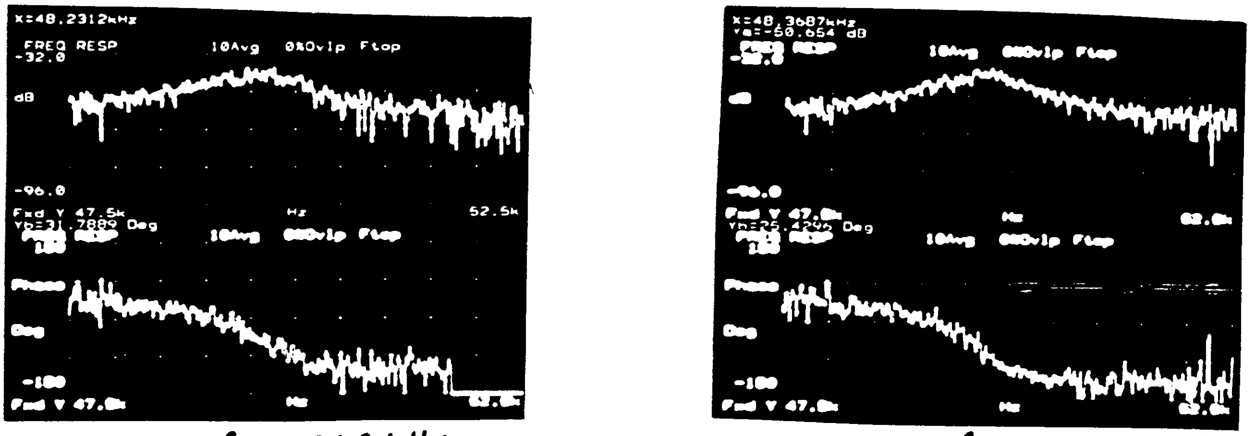
$n = 16$ c.f. = 26.153 MHz

Figure 8



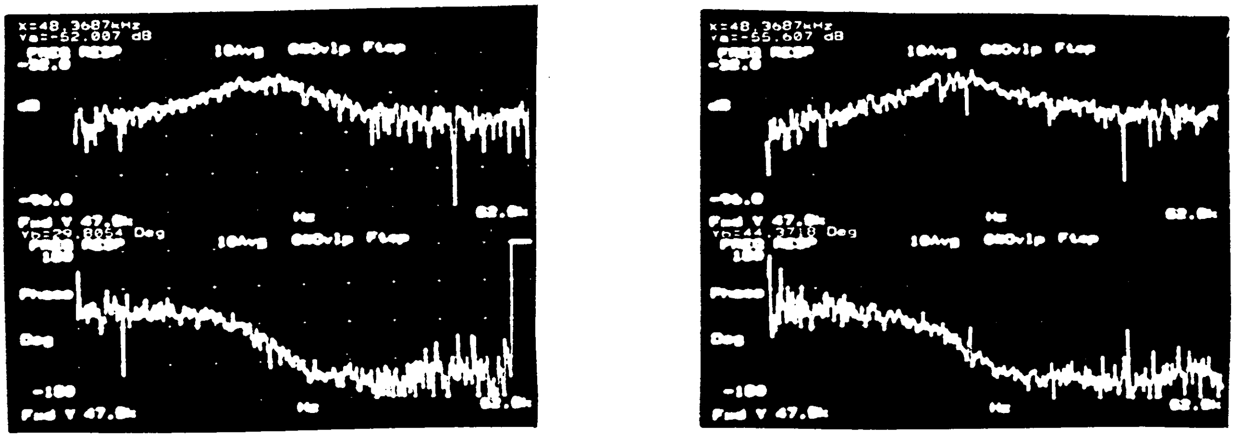
$n = 20$ c.f. = 32.511 MHz

AC Horizontal (n - qH) fo measurement



n = 1 c.f. = 869 kHz

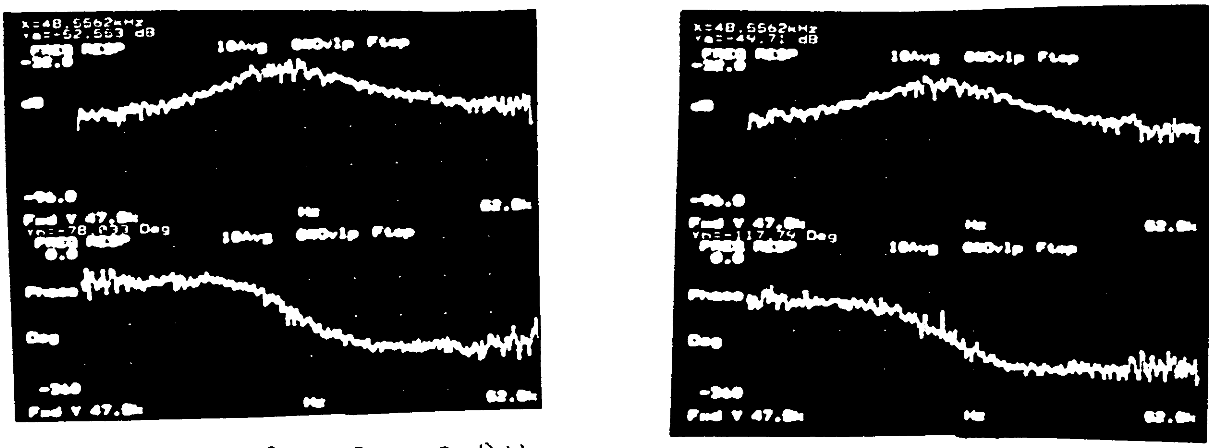
n = 3 c.f. = 4.048 MHz



n = 5 c.f. = 7.227 MHz

n = 7 c.f. = 10.405 MHz

Vertical (n - qv) fo.

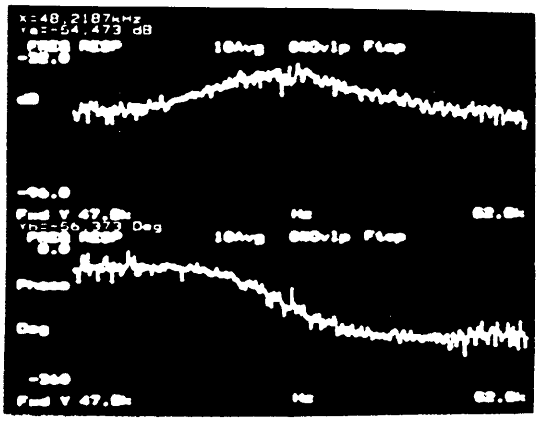


n = 1 c.f. = 897 kHz

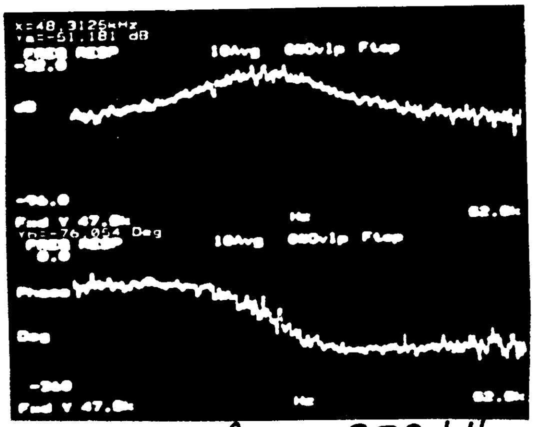
n = 3 c.f. 4.076 MHz

Figure 9

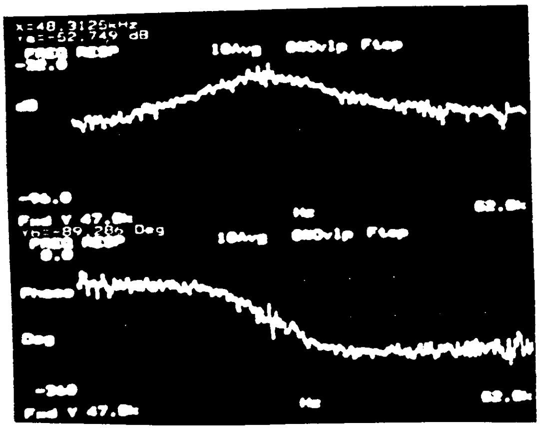
AC Vertical (n + 9v) fo measurement



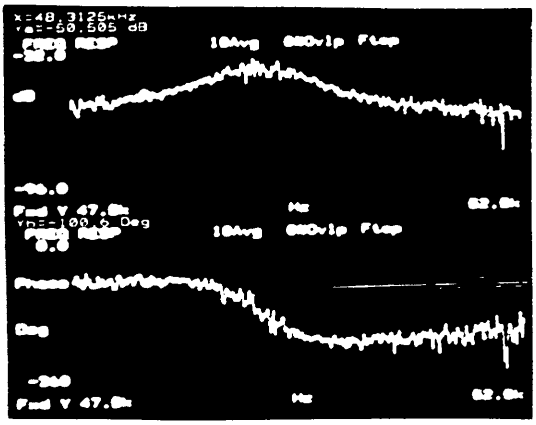
n = 0 c.f. =693 kHz



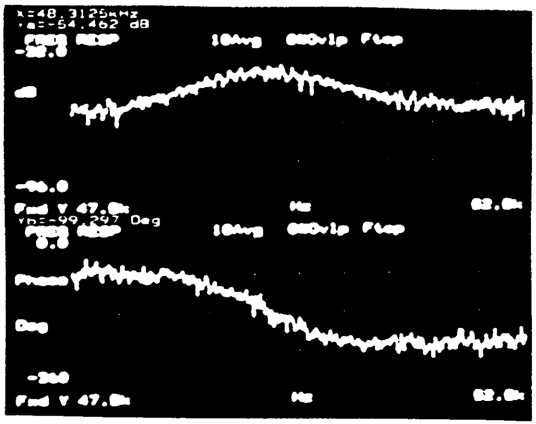
n = 2 c.f. = 3872 kHz



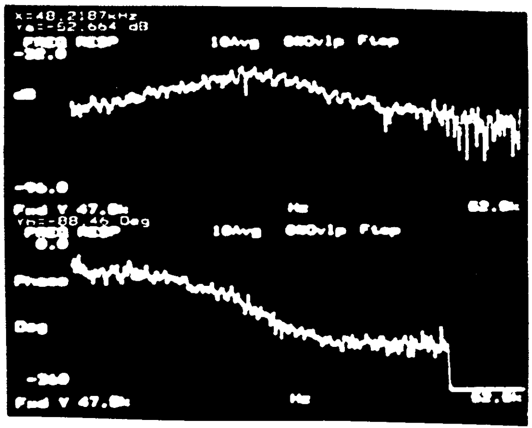
n = 4 c.f. = 7.051 MHz



n = 6 c.f. = 10.230 MHz

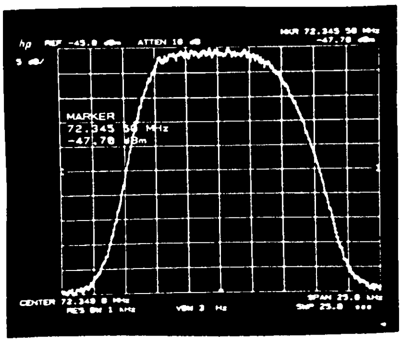


n = 8 c.f. = 13.409 MHz

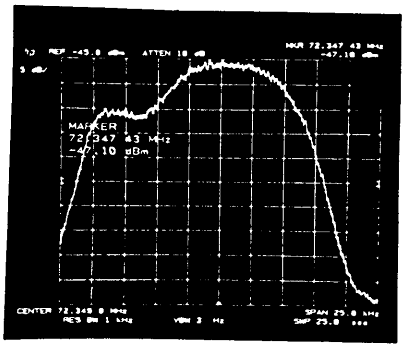


n = 10 c.f. = 16.588 MHz

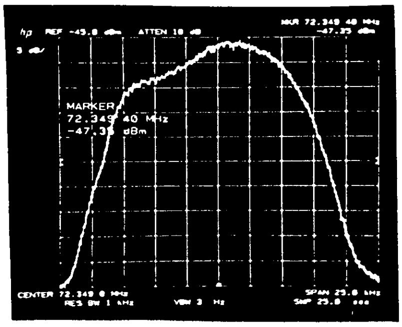
Figure 10



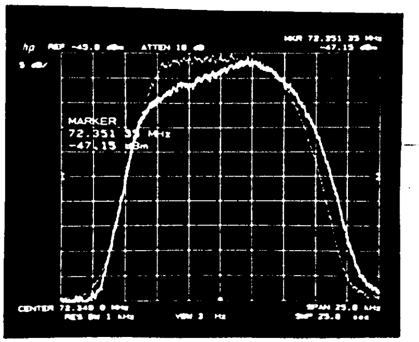
init.



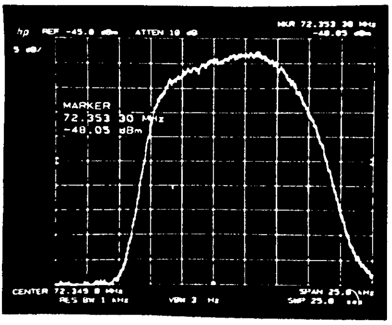
10 Shots



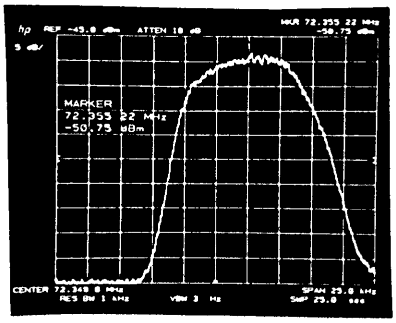
20 Shots



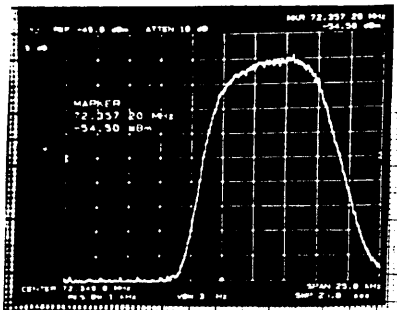
30 shots



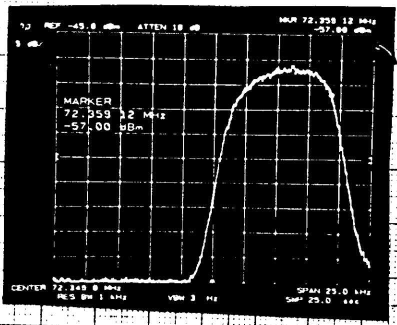
40 Shots



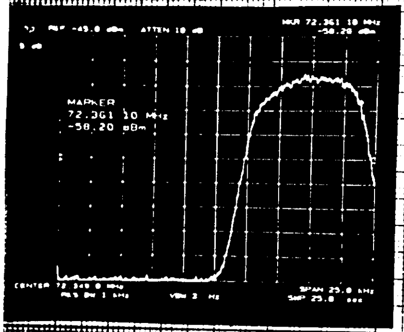
50 Shots



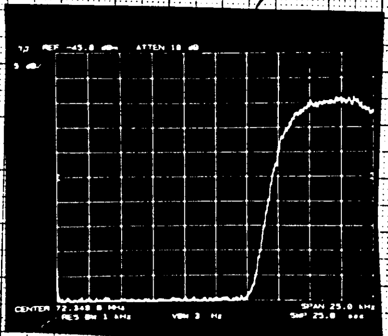
60 Shots



70 shots



80 shots



90 shots

Figure 11

ME9: IMPROVED AA AND AC COEFFICIENTS

(S. van der Meer)

In AC, new coefficients were introduced for adjusting Q_H, Q_V, Trim, α_p independently. The same work was done for AA where new coefficients were also introduced for adjusting Q_H, Q_V and Trim independently.

ME10: STUDY OF THE TFA 7044 NOISE

(C. Carter, F. Caspers, V. Chohan)

The transformer TFA 7044 is in the AC/AA transfer line to measure the number of transmitted $\bar{p}$. It was not possible to measure anything because the signal was (completely) lost in the noise. The main cause of the noise in this transformer is the AC ejection kickers in sections 35 and 50. It was not yet well defined whether the problem comes from the transformer itself or from the transmission line. It was proposed first to produce a copper shielding for the transformer and for the signal transmission a symmetric line. It is expected that such a modification would help in making measurements with the beam.

ME11: SOFTWARE TEST "FERMETURE"OR "DEMARRAGE

(G. Adrian)

A new program is developed to prepare the machine for controlled access and for closing the AAC for a shutdown. This software was tested but not implemented yet.

ME12: AC COOLING WITH DIFFERENT PU/K MOVEMENT FUNCTIONS

(X. Brunel, S. Maury)

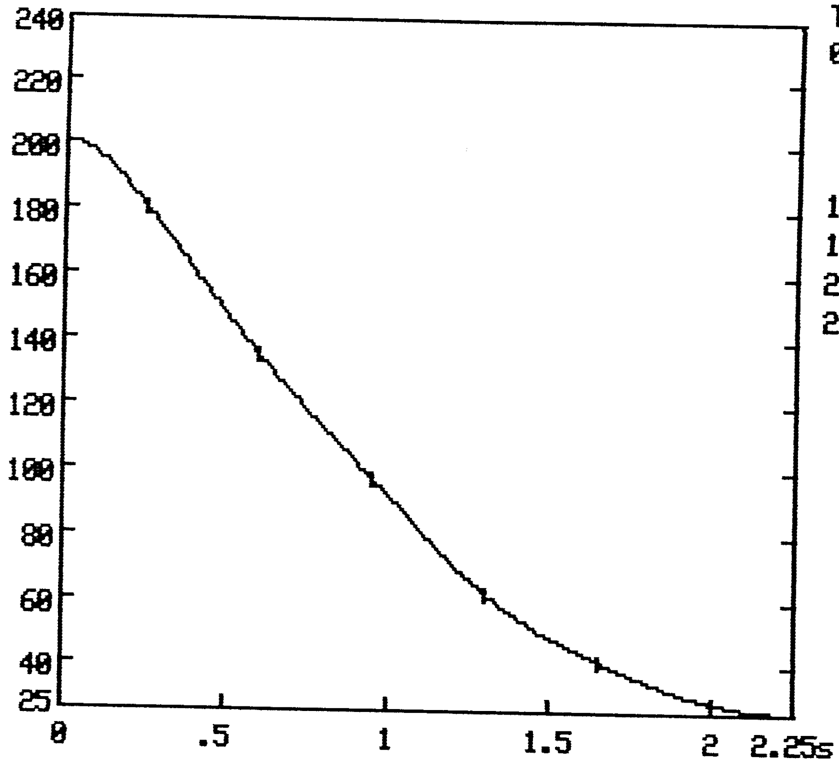
It is mentionned in CERN PS/AA/82-20 "Fast Betatron Cooling in an Antiproton Accumulator" by B. Autin, that the emittance can be reduced further if the pick-up gap only is varied during the momentum cooling, because the thermal noise has a weaker influence in this case. The experiment was made to verify that.

First, we put function 1 on PU and kicker movement, and measured the transverse emittances and the transmission to the AA followed by function 2 (Fig. 12) on the kickers only and the same measurements were made.

Function	ε_H (π.mm.mrad)	ε_V (π.mm.mrad)	Transmission (%)
1 on PU/K	5	4	73, 71
1 on PU 2 on K	5	4	74, 73

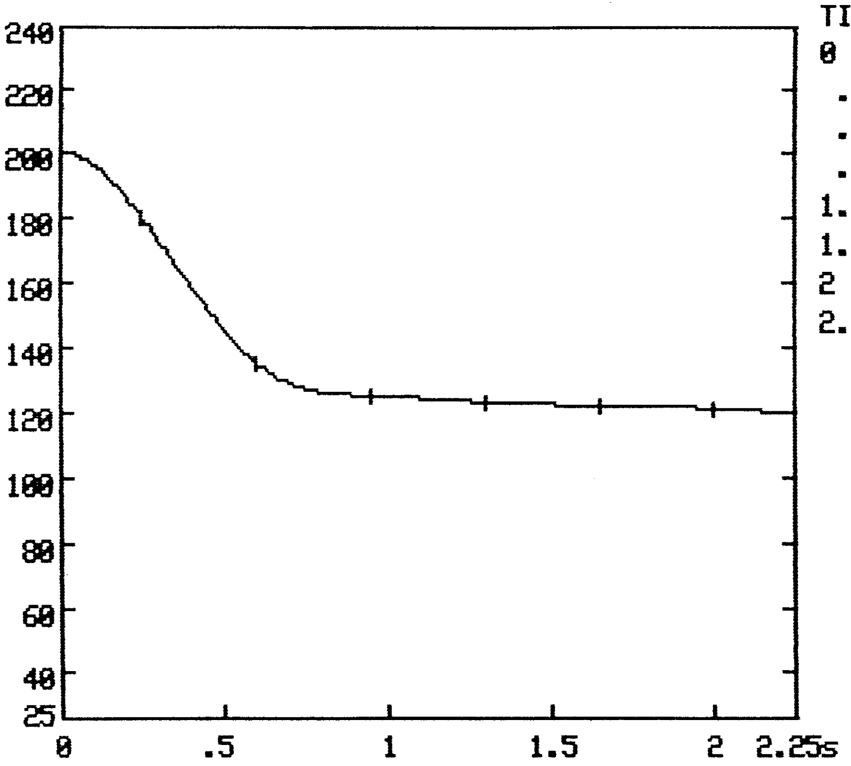
We varied also the final position of the function 2 on the kickers. It seems that there is no influence between the 2 machines.

FUNCTION 1 200-25 PI



TIME	POS
0	200
.25	180
.6	135
.95	97
1.3	62
1.65	41
2	28
2.25	25

FUNCTION 2 POUR ME



TIME	OLD
0	200
.25	180
.6	135
.95	125
1.3	123
1.65	122
2	121
2.25	120

Figure 12

ME13: STUDY OF THE DOG-LEG OPTICS

(G. Adrian, S. Maury)

To match the AC injection line (dog-leg) to the AC, we need to know 6 parameters: β_H, α_H, β_V, α_V, D, D' (D is the dispersion term). Theoretically these parameters are well known but practically they are perhaps different. To adjust them, we calculate with the TRANSPORT program the variation of one parameter with the others with 6 quadrupoles fixed. For each parameter we calculate all the coefficients of the quadrupole variations and put them in the computer.

The variation of each parameter and the yield is recorded in Table 1. No better dog-leg optics were found.

Table 1

$\Delta\beta_H$	100	200	300	400	500	600	700	0	-100	-200	-300	-400	-500	-600
Yield	69,9	61,9	60	60,7	59.7	58,9	58,4	62,6	62,5	62,4	62,6	61,2	62,7	60,5

$\Delta\alpha_H$	40	80	120	160	200	240	280	-40	-80	-120	-160	-240
Yield	62,6	62,1	62,0	63,2	60,8	60,2	58,1	63,6	63,8	62,0	62,1	59,8

$\Delta\beta_V$	1000	2000	3000	4000	0	-1000	-2000	-3000	-4000	-5000	-1000	0
Yield	63,3	62,8	61,4	58,4	63,7	64,5	63,6	61,9	62,7	52,7	61,5	63,5

$\Delta\alpha_V$	+40	80	120	160	200	240	-80	-120	-160	-200	0
Yield	62,3	62,1	59,1	58,3	55	61,5	60,1	60	59,7	57,7	62,1

ΔD	5	10	15	20	25	30	35	-5	-10	-15	-20	-25	-30	-35
Yield	62,5	62,5	61,4	62,2	60,1	60,6	60	61,9	62,2	61,4	63,3	61,2	61,8	62,5

$\Delta D'$	4	8	12	16	20	24	-4	-8	-12	-16	-20	-24	-28	-32	-36
Yield	63	64	63,4	64	63,9	63,5	62,5	64,6	64	62,1	62,7	62,1	61	60,1	58,2

ME14: STUDY OF TRANSVERSE HEATING OF $\bar{p}$ STACK DURING $\bar{p}$ ACCUMULATION

(G. Adrian, F. Pedersen)

Of several candidates potentially capable of causing transverse heating of the core:

- AA injection kicker,
- stack tail kicker (0.8 - 1.6 GHz),
- AA h = 1 rf,

only the AA h = 1 rf produces a measurable heating rate. The transverse heating has the following characteristics:

- It is independent of whether there are $\bar{p}$ in the bucket or not (no rf overlap knock-out).
- It is independent of whether the frequency is fixed or following the stacking program.
- It becomes insignificant if the maximum voltage requested is below 1 kV_p
- If the stack tail is filled, there is a loss rate from the tail of about 15% of the stacking rate (stack = $5.7 \cdot 10^{11}$). This loss may or may not be enhanced by the transverse heating due to AA rf.

During the normal stacking cycle 12 kV_p is applied for ~10 ms (debunching) and 3 kV_p for ~200 ms (transfer to tail).

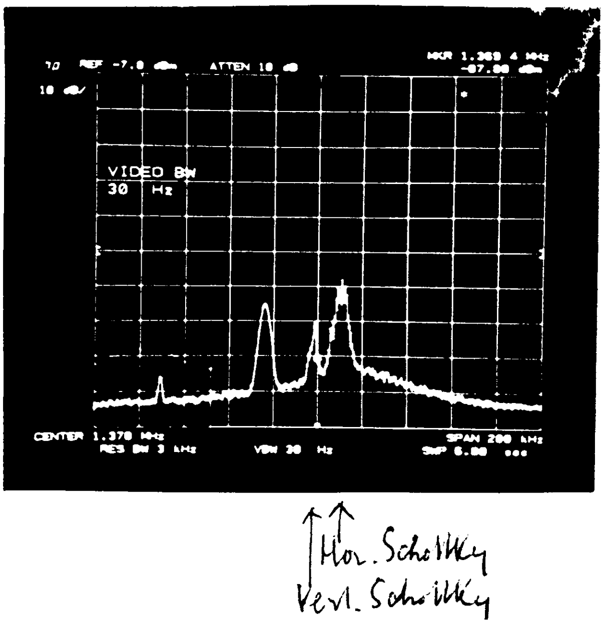
Further Studies: Measure rf gap noise density at betatron sidebands as function of voltage and rf amplifier feedback gain (during shutdown).

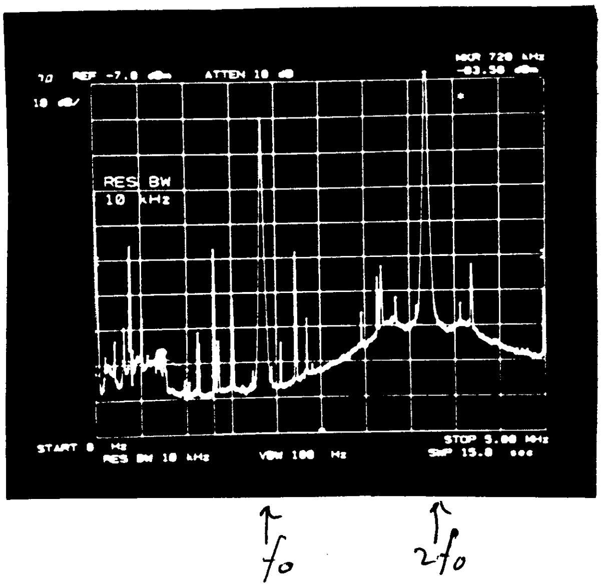
What Was not Done

- $\bar{p}$ transverse blow-up due to p via the loop.

What Was Observed

It was observed that the low-frequency resonant pick-up in the AA (vertical plane) produces many coherent lines with a bunched beam. They disappear when the beam is debunched and reappear when it is rebunched.





CONCLUSION

After the unsuccessful ejected $\bar{p}$ shots to the PS during Sunday night, it was possible to diagnose the PS faults and to fix them early on Monday morning. The first $\bar{p}$ were ready and taken by LEAR on Monday morning at 9.00 am, December 11th.

S. Maury

PS/AA/FP/afm

12 December 1989

PS/4 LIST

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