PS/OP/Info 92-11
20.2.1992

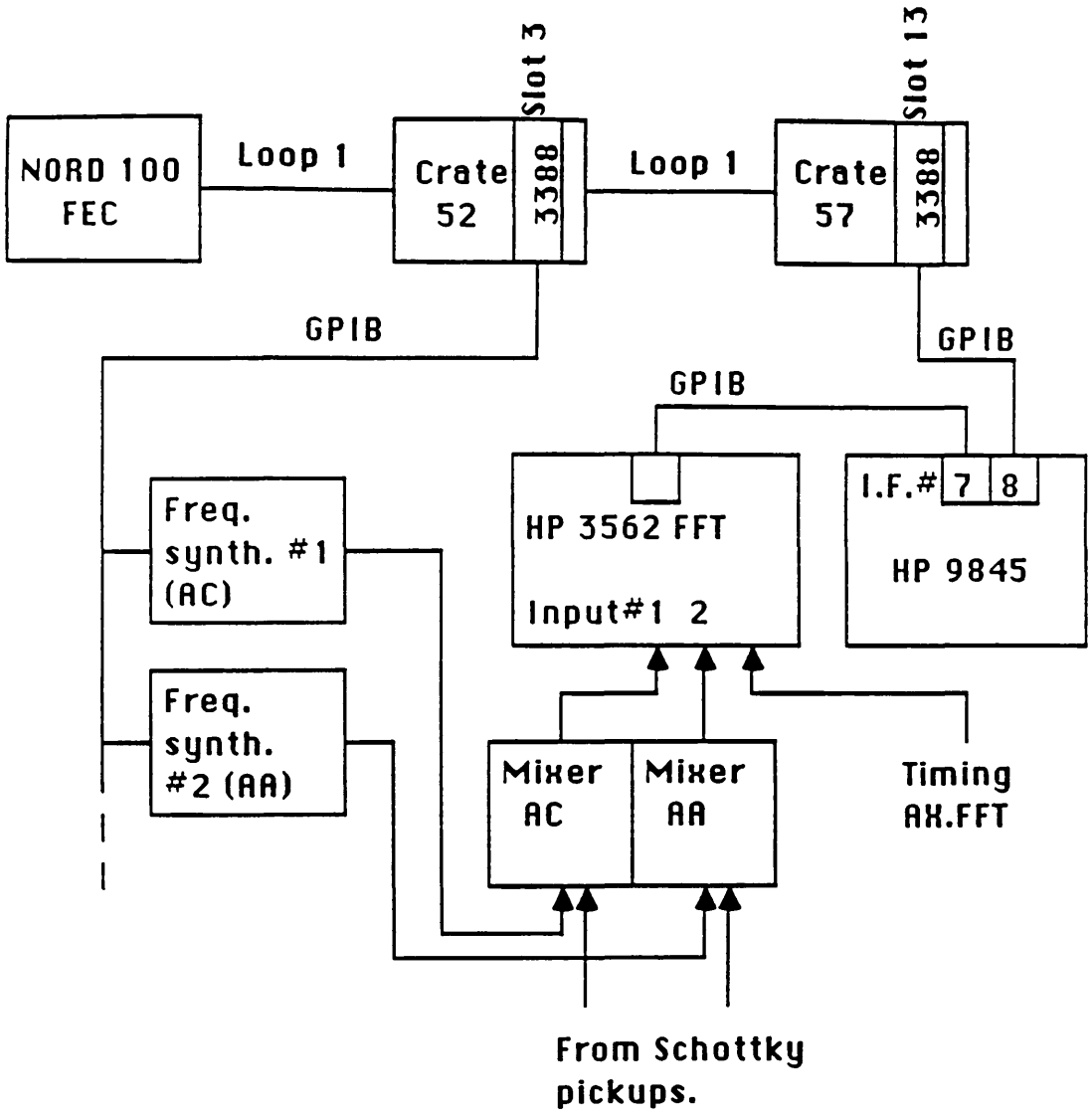
AAC MONITORING AND OPTIMIZATION OF PBAR ACCUMULATION

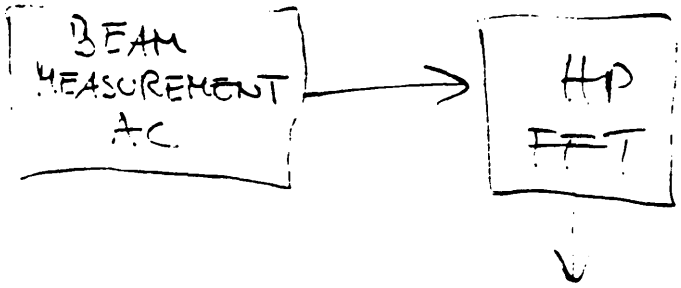
Copie des transparents
du cours donné aux techniciens d'opération AAC/LEAR
le 21.2.1992
par T. Eriksson

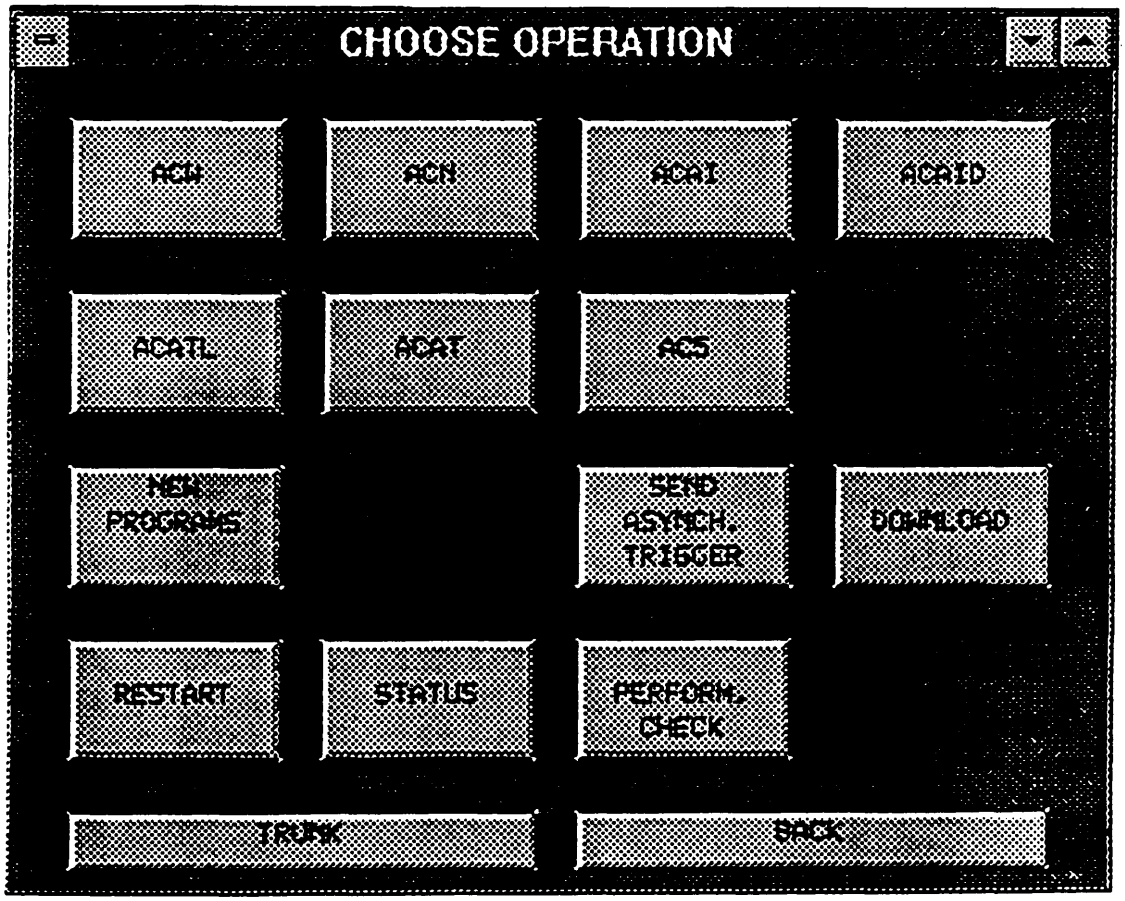
Distribution

Section OP/AAC/LEAR
AAS
LEAS

Fig. 1 HARDWARE LAYOUT




BEAM
MEASUREMENT
AC
HP
FFT


CHOOSE OPERATION
ACW
ACN
ACRI
ACRID
ACATL
ACAT
ACS
NEW PROGRAMS
SEND ASYNCH. TRIGGER
DOWNLOAD
RESTART
STATUS
PERFORM. CHECK
TRUNK
BACK

Description of each button of "HP FFT": (Fig. 2)

-"ACW" - AC Wide. This measurement takes place just after the bunch rotation after injection into the AC. The program does not change any parameters in AAC, so ACW can be used during accumulation without affecting the accumulation rate.It can also be run with single shots.A choice of "START AVERAGING IN HP9845" or "READ BACK EACH CYCLE" has to be made before the measurement starts (Fig. 3). With 4.8 sec. production rate, the program will measure 1 out of 2 cycles. The measurement will generate results as follows :

- "AC 5.3" : Beam intensity in AC within 5.3 % momentum spread. To simplify the use of the FFT analyzer, 5.3 % was chosen instead of 6 % (nominal AC acceptance).

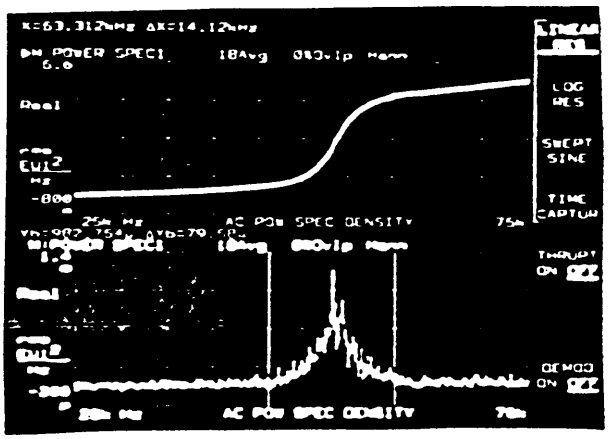
- "AC 1.5" : Beam intensity in AC within 1.5 % momentum spread.

- "Eff." : AC 1.5 / AC 5.3 , corresponds to the efficiency of the bunch rotation system.

- "Yield" : "AC 5.3" value divided by beam intensity acquired from a fast beam transformer in the inj. line (TFA 9053). "Yield" appears only when the program is running in "READ BACK EACH CYCLE" mode.

Note: this is not the "real" yield since the bunch rotation, RF etc. is operational. The result may be different from those of yield measurements made with other programs.

Display on HP 3562 after measurement:



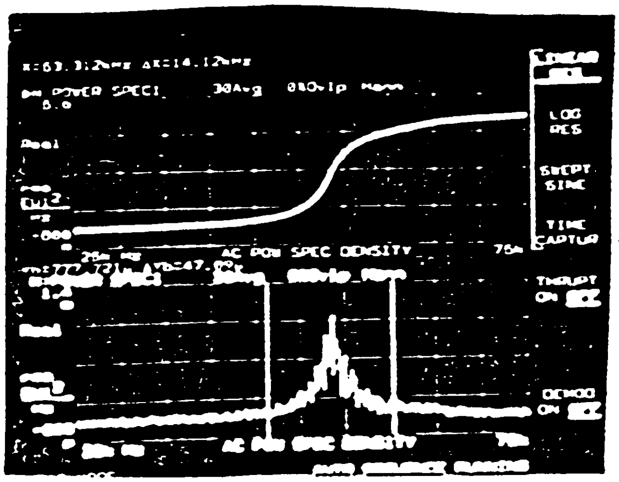
Top trace shows the integral of the lower trace.

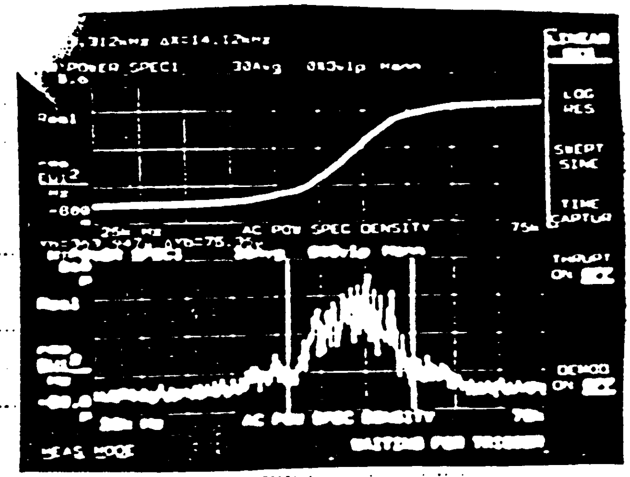
Bottom trace shows the momentum distribution in AC with markers to indicate 1.5 % dp/p.The whole width of the display is 5.3 % dp/p.

Results displayed on terminal:

```
ACWX: AVERAGE VALUES FOR LAST 10 SHOTS:
      4.74      3.63      .76       51.96
```

AC 5.3 AC 1.5 eff. "Yield" E-7

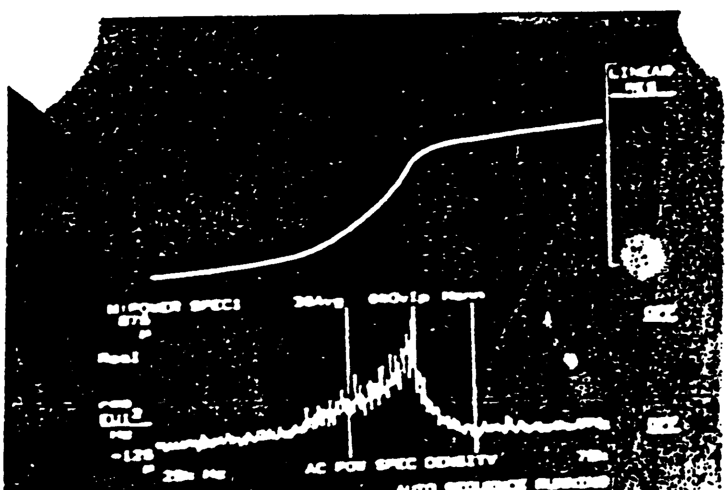




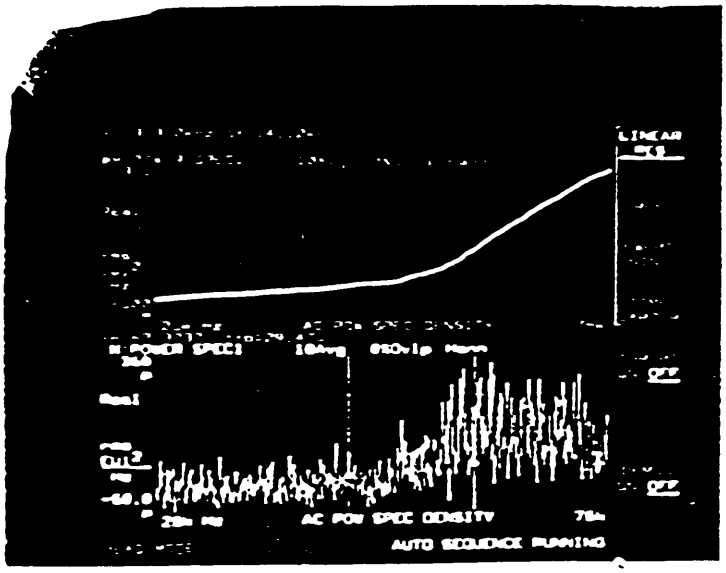
ACW measured with AC cooling ON ⇓

ACW, AC cooling Off Eff ≃ 75%

	AC 5.3	AC 1.5 (E7)	EFF	PS.IP	TF9012	TF9053 (E12)	TF5309	YIELD E-7
121	4.68	3.92	.83	8.87	9.13	8.93	1555	52.4
122	4.46	3.69	.82	9.11	9.39	9.19	1590	48.5
123	4.81	4.04	.84	9.13	9.40	9.21	1571	52.2
124	4.47	3.77	.84	9.01	9.29	9.08	1519	49.2
125	4.45	3.69	.82	9.11	9.35	9.17	1555	48.5
126	4.55	3.71	.81	9.21	9.51	9.31	1640	48.8
127	4.68	3.89	.83	9.13	9.38	9.20	1566	50.8
128	[illegible]	3.77	.82	9.18	9.44	9.24	1636	[illegible]
129	[illegible]	3.84	.82	8.99	9.25	[illegible]	[illegible]	[illegible]
130	[illegible]	4.14	.83	9.11	9.33	[illegible]	[illegible]	[illegible]
AVERAGE VALUES FOR LAST 10 SHOTS:								
	[illegible]	3.85	.83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



conv.2 H=6
(de temps en temps (1/10))



h=6

Cavity 2 only

-150 off

Sync. ϕ offset = -100° (max)

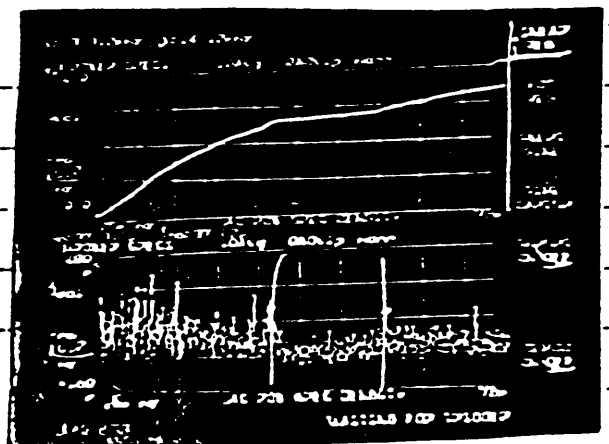
-we need to change the offset more! -

(Cavity 1 3 OK with -55°)

ACW

Optimized Dog-Leg BHZ-s vs. Yield. There is a problem in PS-RF system — no synchronization between PS 53.7 MHz synthesizer and RF — The bunches are captured in the h=6 RF buckets with random phase;

	AC 5.3	AC 1.5	EFF	PS.IP	TF9012•	TF9053	TF5309	YIELD E-7
130	6.15	2.98	.48	11.77	11.92	11.63	2005	52.9
131	6.53	5.29	.81	11.59	11.68	11.39	2078	57.3
132	6.22	5.09	.81	12.10	11.99	11.52	2104	53.9
133	2.58	.29	.00	11.89	11.93	11.61	2128	21.5
134	5.98	3.57	.60	11.99	12.02	11.67	2068	50.6
135	1.59	.06	.04	11.94	12.12	11.69	2102	13.6
136	6.15	4.52	.73	12.28	12.19	11.81	2107	52.1
137	6.84	5.03	.73	12.06	12.22	11.88	2135	57.6
138	6.27	5.10	.81	12.10	12.13	11.76	2138	53.2
139	6.89	5.60	.81	12.40	12.52	12.14	2235	56.7
ACMM: AVERAGE VALUES FOR LAST 10 SHOTS:								
	5.50	3.75	.68	12.03	12.07	11.71	2109	46.9



Large phase error

ACW display for shot with large phase error.

Optimization ACW + Yield

PS: beam intensity
bunch length – B.rot sensitive
timing – fine inj. kicker adjustments / RF period jumps

TT inj.: Steering before + after target
injection using coherent oscillations pgm. (H) => correct.

Collector: timing
(current)
(z-position)

TT RF B.rot.: Synch phase offset
match level
timing (affects duration of rotation)

- "ACN" - AC Narrow. Like ACW, only one measurement per cycle is performed. The ACN measurement has only the "READ BACK EACH CYCLE" possibility (Fig. 4). The program will automatically reset the beam request, disable AC h=1 RF timing, disable AC ej.kicker timing and set the timing for the HP 3562 to a later value in order to measure after the AC cooling sequence. Single shots will be asked for by the program until the operator stops it. When it is stopped, all the timings will be re-enabled, reset to initial values and the beam request restored to its initial state. During the measurement, the accumulation will be completely stopped. The measurement rate will be approx. 1 out of 3 cycles with 4.8 sec. accumulation rate. Results generated will be as follows (intensities after the AC cooling sequence) :

  - "AC 5.3" : Beam intensity in AC within 5.3 % momentum spread (remaining beam after bunch rot. + AC cooling).

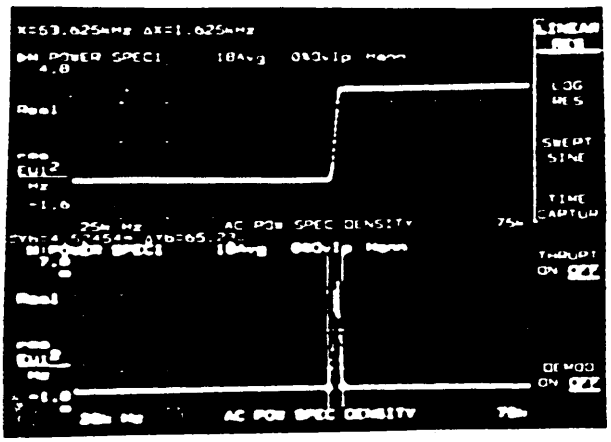
  - "AC .18" : As above but within 0.18 % momentum spread (4 eVs).

  - "Eff" : AC .18 / AC 5.3 , corresponds approx. to AC cooling efficiency.

Normally, more than 1.5 % dp/p can be taken care of by the AC cooling systems. This explains why the "AC 1.5" value using ACW is sometimes smaller than the values measured using ACN.

To calculate the overall AC efficiency, one can compare the ACN "AC .18" and the ACW "AC 5.3" values.

Display on HP 3562 after measurement :



Top trace shows the integral of the lower trace.

Bottom trace shows the momentum distribution in AC with markers at 0.18 % dp/p. Total width = 5.3 %.

Results displayed on terminal:

```
ACNX: AVERAGE VALUES FOR LAST 10 SHOTS:
      3.78     3.78      .97
```

- "ACAI" : AC to AA Injection. ACAI has the choice between "READ BACK EACH CYCLE" and "START AVERAGING IN HP 9845" (Fig. 5).It measures exactly like "ACW", but with the addition of a second measurement that acquires the beam intensity at the injection orbit just after injection into AA. The AA precooling timing will be changed slightly in order to start cooling 1 sec. later (total cooling time will be 3370 instead of 4370 ms). This has proved to cause only a slight deterioration of the stacking rate when used during accumulation. Measurement rate will be 1 cycle out of 3 with 4.8 sec. production rate.

Results:

- "AC 5.3" : Like "ACW".

- "AC 1.5" : Like "ACW".

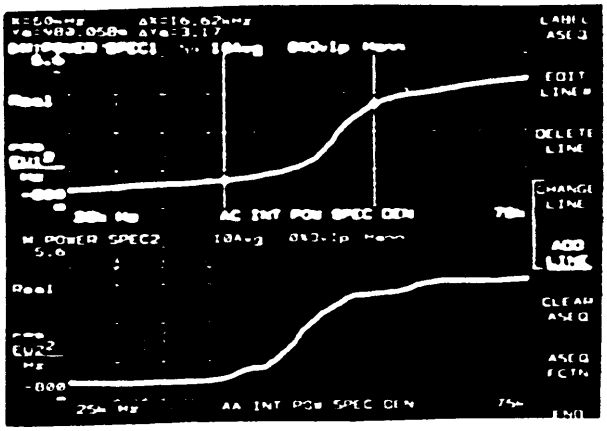
- "Eff." : Like "ACW".

- "AA .21" : Beam intensity on AA inj. orbit just after injection. dp/p = 0.21 % which corresponds to 4 eVs.

- "Eff." : AA .21 / AC 5.3 , Total efficiency of AC + rebunching and transfer into AA.

- "Yield" : Like "ACW" Yield.

Display of HP 3562 after measurement:



Integral of AC measurement. Markers belong to lower trace.

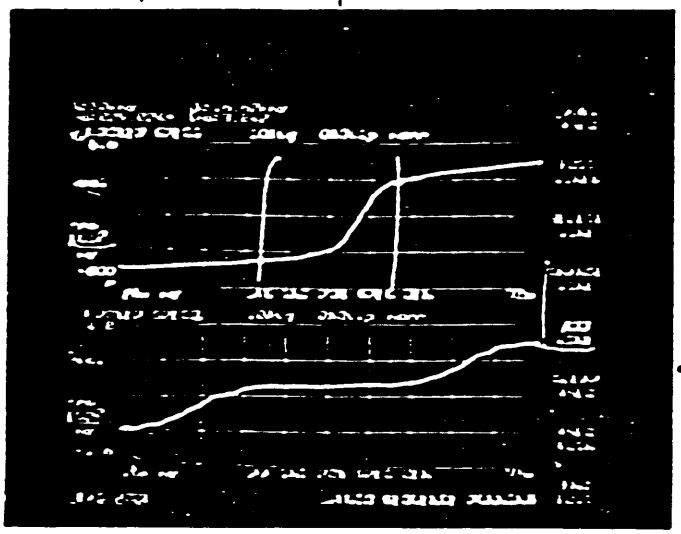
Integral of AA Inj. beam measurement. Markers of top trace indicates 0.21 % dp/p on lower trace.

Results displayed on terminal:

```
ACAIX: AVERAGE VALUES FOR LAST 10 SHOTS:
       4.78     3.54      74     3.50      73      52.19
```

29/4/90

22:30 The stacking problems of today (and yesterday) was caused by a malfunctioning synchronization of the AA RF to the AC h=1 RF, some shots were OK, but others very bad:



ACAI

← AA inj. orbit, completely out of synch.

— Found a bad GFPC in Loop 1 cr. 53 slot 11/0 (AX.SIRI-SYNC)

- "ACAID" - AC to AA Injection Delayed. This measurement is identical to ACAI with the exception of a longer internal delay in the HP 3562 autosequence. This will give us the AA intensity after AA precooling and before RF-displacement into the stack tail. The AA precooling timing will also be slightly different with the end of the cooling sequence 1 sec. earlier. (Total cooling time 3370 instead of 4370 ms.) Measurement rate is 1 cycle out of 4 with 4.8 sec. production rate.

Results:

- "AC 5.3" : Like "ACW".

- "AC 1.5" : Like "ACW".

- "Eff." : Like "ACW".

- "AA .21" : Intensity of beam on AA injection orbit within 0.21 % dp/p (4 eVs) after precooling.

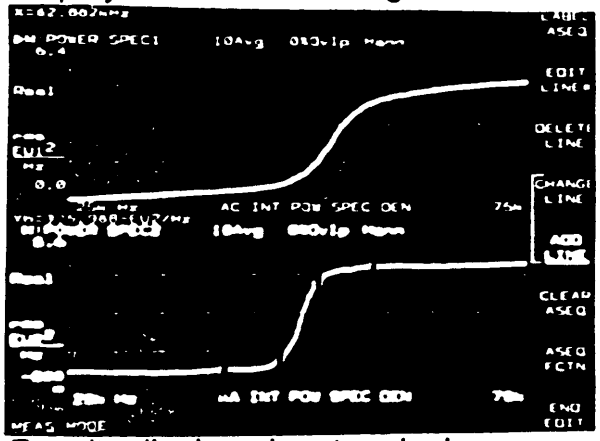
- "Eff." : AA .21 / AC 5.3 .

- "AA .052" : Like "AA .21" but within 0.052 % dp/p (1 eVs).

- "Yield" : Like "ACW" Yield.

This measurement will show the efficiency of the AA precooling.Although 4 eVs will be displaced by RF into the stack tail region, it is favourable to have a smaller momentum distribution since the central part of the distribution will be deposited closer to the stack core.

Display of HP 3562 during measurement (to show a typical distribution):



Top trace shows the integral of the AC measurement.

Bottom trace shows the integral of the AA measurement. The inner markers correspond to 1 eVs and the outer to 4 eVs.

Results displayed on terminal:

```
ACAIDX: AVERAGE VALUES FOR LAST 10 SHOTS:
      4.51     3.37      74     3.88      86     2.83      .62      48.7
```

Optimization ACN

AC cooling: delays
attenuators
filters - check/adjust using 1 band at a time (only "dd" ACN)

ACA1

transfer AC/AA: steering through xfer line (AC quadrupoles + dipoles)

injection to AA: use coherent oscillations pgm (L,H,V) - will correct AC field + phase offset for AA RF (L)

ACA10

precooling L: delay
attenuator
filter

- "ACATL" - AC to AA Tail Losses. Measures beam intensities in the AC plus the losses at the high energy side of the stack tail in the AA, i.e. the particles "pushed" out by the RF system if the stack tail or the core cooling systems are too slow. High loss rates can also be caused by malfunctioning of cooling systems used previously in the pbar production sequence (in AC or AA). No parameters such as cooling timing etc. will be altered during the measurement. "READ BACK EACH CYCLE" or "START AVERAGING IN HP9845" are possible (Fig. 3). Repetition rate will be 1 out of 4 cycles with 4.8 sec. production rate.

Results :

- "AC 5.3" : Like "ACW".

- "AC 1.5" : Like "ACW".

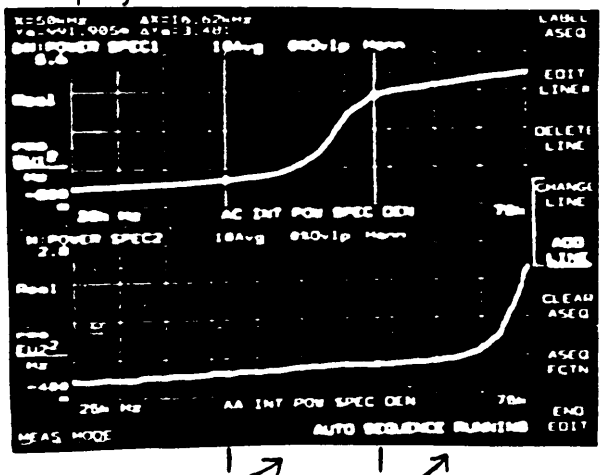
- "Eff." : Like "ACW".

- "AA .21" : Intensity within 0.21 % momentum spread just outside the RF deposit area on the high energy (low frequency) side of the stack tail. The RF deposit area corresponds to 0.21 % dp/p, so the "AA .21" value will represent the number of lost particles for one shot.

- "Eff." : AA .21 / AC 5.3 , corresponds to loss rate during one cycle.

- "Yield" : Like "ACW" Yield.

Display of HP 3562 after measurement:



"Loss area" RF deposit area

Top trace shows the integral of AC measurement.Markers belong to bottom trace.

Bottom trace shows momentum distr. in the AA just to the left of the RF-deposit area. Markers from upper trace indicates 0.21 % (4 eVs) dp/p.

Results displayed on terminal:

```
ACATLX: AVERAGE VALUES FOR LAST 10 SHOTS:
      3.87     2.88      .74      .08      .02      41.92
```

- "ACAT" - AC to AA Tail. Measures the AC efficiencies like "ACW" plus the intensity of the freshly deposited beam in the stack tail area. Only "READ BACK EACH CYCLE" is possible (Fig. 4). Beam requests will be handled automatically like in "ACN". The stack tail cooling will be started 1 sec. later in order to give the HP 3562 enough time to measure before the particles are pulled into the stack tail. Measuring rate is 1 cycle out of 4 with 4.8 sec. production rate. Accumulation will be completely stopped.

Results :

- "AC 5.3" : Like "ACW".

- "AC 1.5" : Like "ACW".

- "Eff." : Like "ACW".

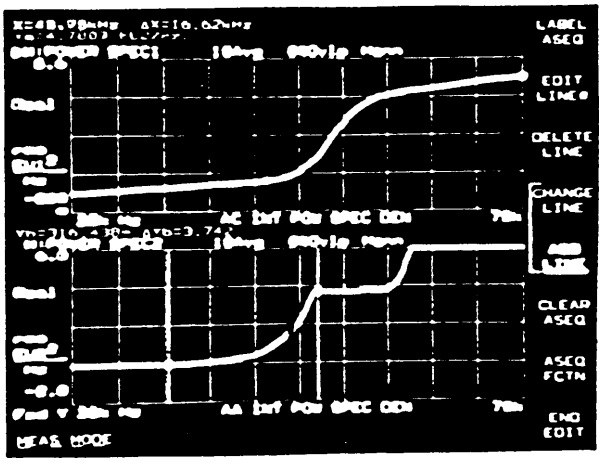
- "AA .21" : Intensity of beam just deposited in stack tail region within 0.21 % dp/p (4 eVs).

- "Eff." : AA .21 / AC 5.3 . Corresponds to the global AC + Transfer + AA cooling + RF-deposit efficiency.

- "AA .052" : Like "AA .21" but within 0.052 % dp/p (1 eVs).

- "Eff." : AA .052 / AC 5.3 .

Display of HP 3562 after measurement:



Top trace shows the integral of the AC measurement.

Bottom trace shows the distribution of the RF-deposited beam in the AA. Markers are at 0.21 % (4 eVs) dp/p. On the right side one can see the outer edge of the stack tail.

Results displayed on terminal:

```
ACATX: AVERAGE VALUES FOR LAST 10 SHOTS:
      4.74     3.61      .76     3.33      .70     2.29      .48       52.07
```

- "AC5" - Measures AC intensity within 5 % dp/p divided into 5 slices. using this, one can more exactly measure the dp/p distribution just after injection and bunch rotation.

Results :

- "-2%" : Intensity in the -2,5 to -1,5 % range.
- "-1%" : Intensity in the -1,5 to -0,5 % range.
- "0 %" : Intensity in the -0,5 to +0,5 % range.
- "+1%" : Intensity in the +0,5 to +1,5 % range.
- "+2%" : Intensity in the +1,5 to +2,5 % range.

Results displayed on terminal:

```
AC5%: AVERAGE VALUES OVER     10      SHOTS
      .34      .87     1.55     1.02      .44     58.32

     -2%      -1%       0%      +1%      +2%    YIELD E-7
```

Optimization ACATL

(losses from St. tail area during stacking)

Stack core: tunes

core cooling (L, H, V) delays, attenuators

Stack tail cooling (L) —"—

ACAT

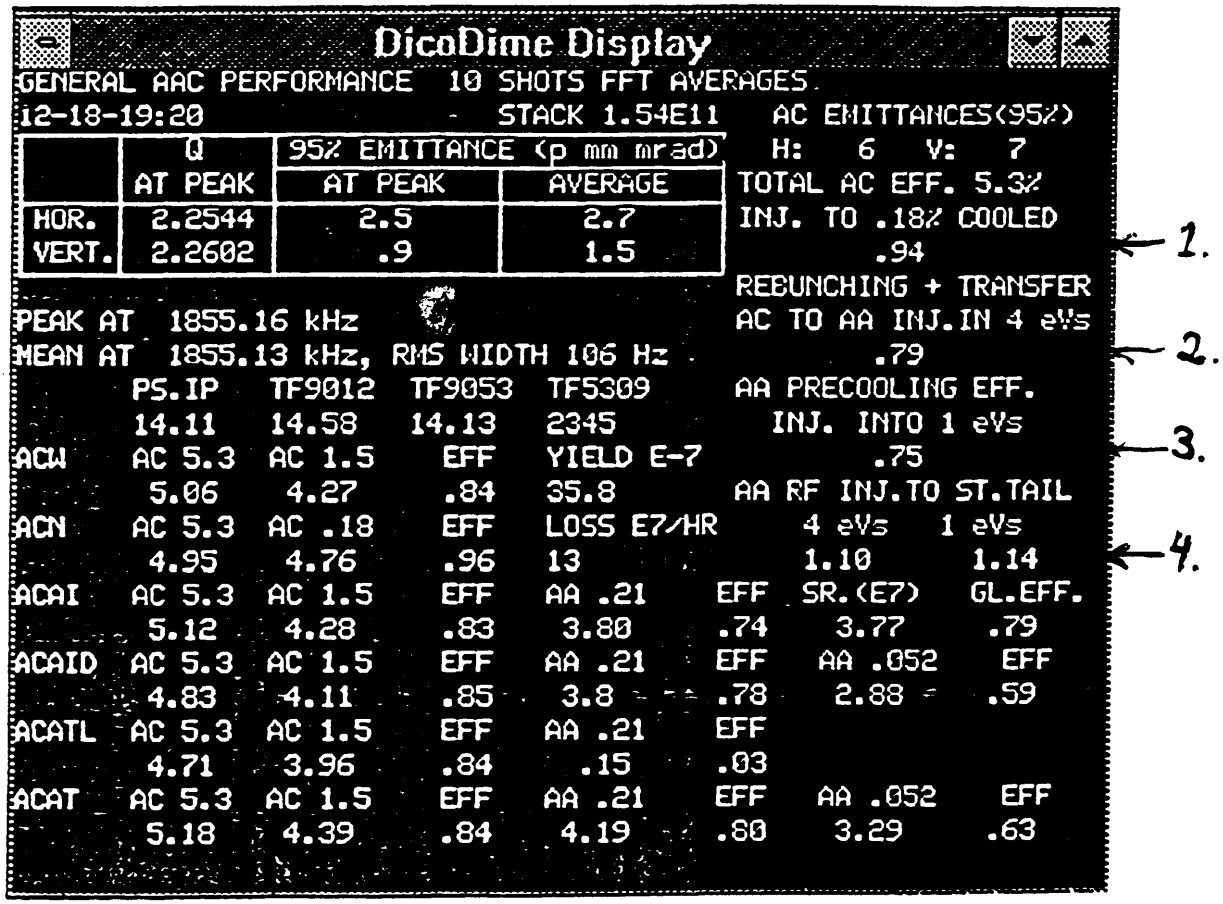
M RF: function

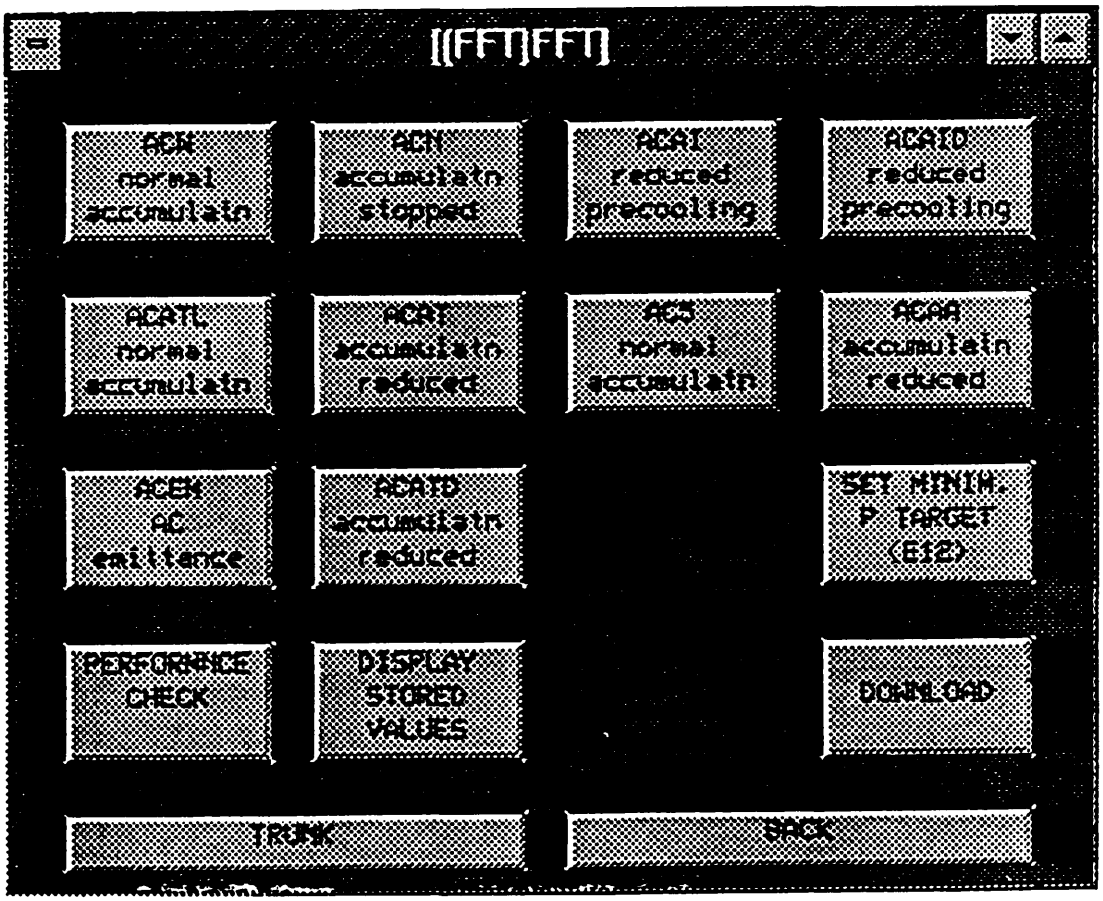
precooling L, V delays, attenuators

Fig. 10 Results on monitor after a complete "PERFORM. CHECK" measurement.

Comments:

1. Equal to "ACN" AC .18 value divided by "ACW" AC 5.3 value.
2. Equal to "ACAI" AA .21 value divided by "ACN" AC .18 value.
3. Equal to "ACAID" AA .052 value divided by "ACAI" AA .21 value.
4. Equal to "ACAT" AA .21/AA .052 values divided by "ACAID" AA .21/ AA .052 values.




[[FFT]FFT]
ACH normal accumulatn
ACH accumulatn stopped
ACAI reduced precooling
ACAID reduced precooling
ACATL normal accumulatn
ACRT accumulatn reduced
ACS normal accumulatn
ACAA accumulatn reduced
ACEK AC emittence
ACAID accumulatn reduced
SET MINIM. P TARGET (Ei2)
PERFORMANCE CHECK
DISPLAY STORED VALUES
DOWNLOAD
TRUNK
BACK

Differences old — new versions

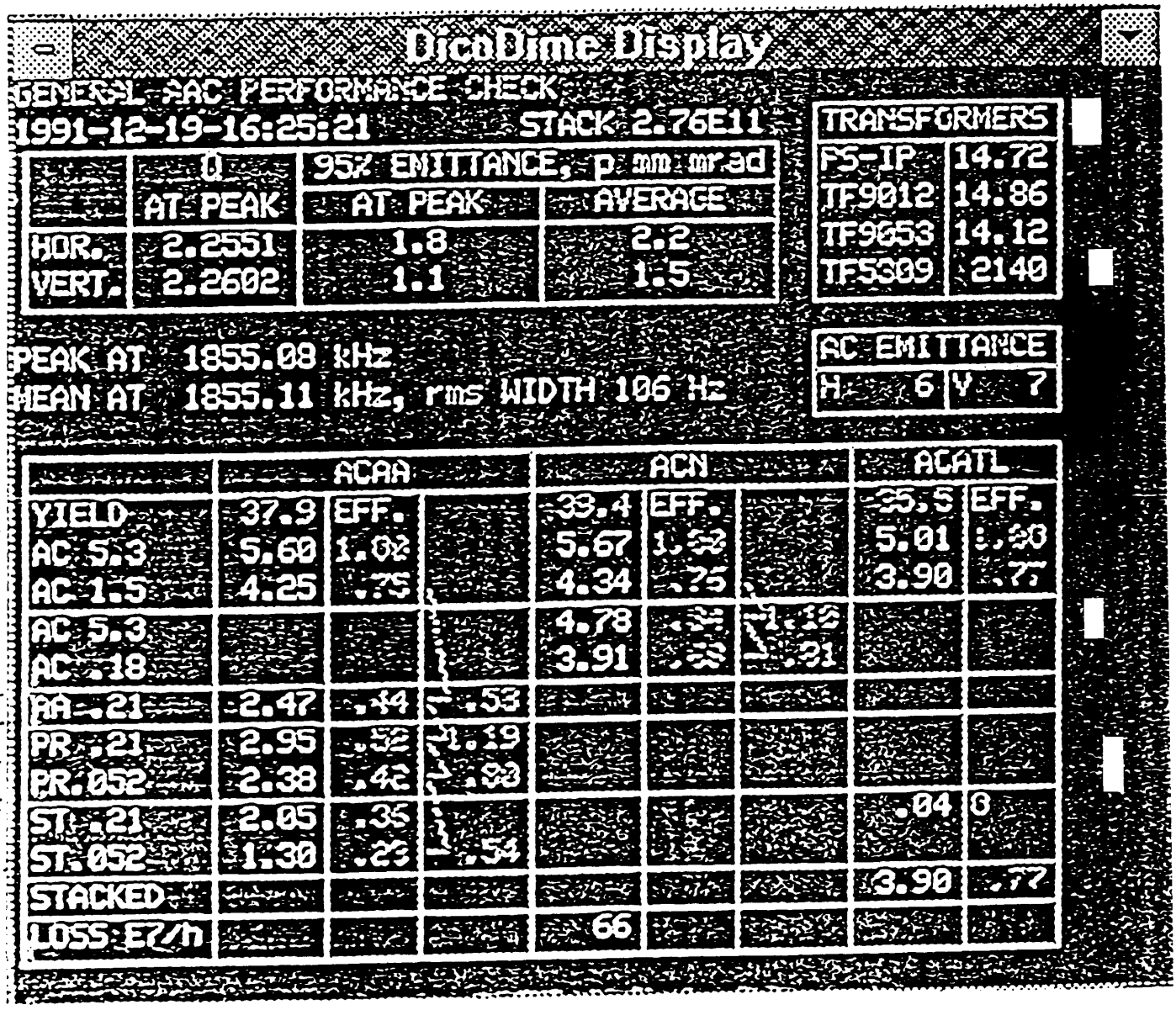
— No HP-computer used, a 2nd 3562 is directly connected to NORD via GPIB-3388.

— Each slot is displayed..

— Faster, ACW measures every 4,8s cycle

— ACAA new mixmit, uses the same beam all the way through. Delays are introduced in the accumulation sequence to give enough time to measure. Does: ACW + ACAA + AEAIO + AEAT gives lower numbers due to losses during the extended sequence.

— FFT-device is not using the trig input. Synchronization is dependent on the NORD. Some cycles can be skipped.


DicoDime Display
GENERAL AC PERFORMANCE CHECK
1991-12-19-16:25:21
STACK 2.76E11
TRANSFORMERS
FS-IP 14.72
TF9012 14.86
TF9053 14.12
TF5309 2140
95% EMITTANCE, p mm mrad
AT PEAK
AT PEAK
AVERAGE
HOR. 2.2551
VERT. 2.2602
1.8
1.1
2.2
1.5
PEAK AT 1855.08 kHz
MEAN AT 1855.11 kHz, rms WIDTH 106 Hz
AC EMITTANCE
H 6
V 7
ACAA
ACN
ACATL
YIELD 37.9
EFF.
AC 5.3 5.60
AC 1.5 4.25
AC 5.3
AC .18
AA .21 2.47
PR .21 2.95
PR.052 2.38
ST .21 2.05
ST.052 1.30
STACKED
LOSS E7/h
33.4
5.67
4.34
4.78
3.91
66
35.5
5.01
3.90
.04
3.90