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PS/AR/ME Note 84
PS/OP/Note (ME-AA)89-1
14.11.1989

AAC ME SUMMARY FROM 27TH SEPTEMBER UNTIL 7TH OCTOBER 1989

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At the end of the period 2, two weeks have been devoted for AAC ME's. Some ME's have been started a week before during $\bar{p}$ transfer for LEAR. I would like to give a short résumé of each ME, to comment on what was done and to record what was not done.

ME1 : TIMING ON THE AC AND AA COOLING PEAK FILTERS
(G. Carron, S. Maury)

The filter method is used in AC and AA for the momentum cooling. Two filters are used and are superimposed: the notch filter and the active filter. It has been observed during the period I that the active filter pushes some $\bar{p}$'s out of the notch filter. It was decided to switch off these filters and to give them a different timing.

During this ME, new timing for the peak filters has been optimized and was found to begin at 200 ms after the start of all cooling

Δp/p		Active filter Off	Notch/active filter ON
L1 only	4.8s	0.54%	0.36%
L2 only		0.50%	0.33%
L1+L2+L3		0.19%	0.16%

This table shows the Δp/p after the AC cooling band I (L1) after band II, and after the AC cooling (L1+L2+L3) with and without the active filters. The design value for the Δp/p after AC cooling is 0.18%.

The same work has been done in AA on the precooling. Then, we tried to compare the Δp/p on the AA injection orbit for 4.8 s and 2.4 s cycle rates.

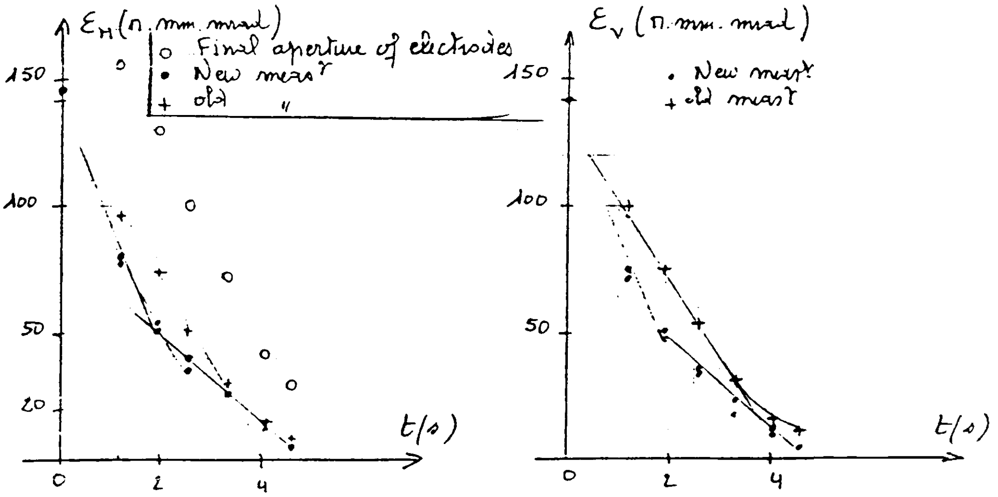
Δp/p	AC	AA
4.8 s	0.16%	0.061%
2.4 s	0.23%	0.123%

It is interesting to compare these values, particularly in the AA because the installation of the cryogenic on the precooling pick-up should reduce the noise by 6 dB and this corresponds to a factor 2 in cooling speed.

ME2 : AC EMITTANCE VERSUS COOLING TIME

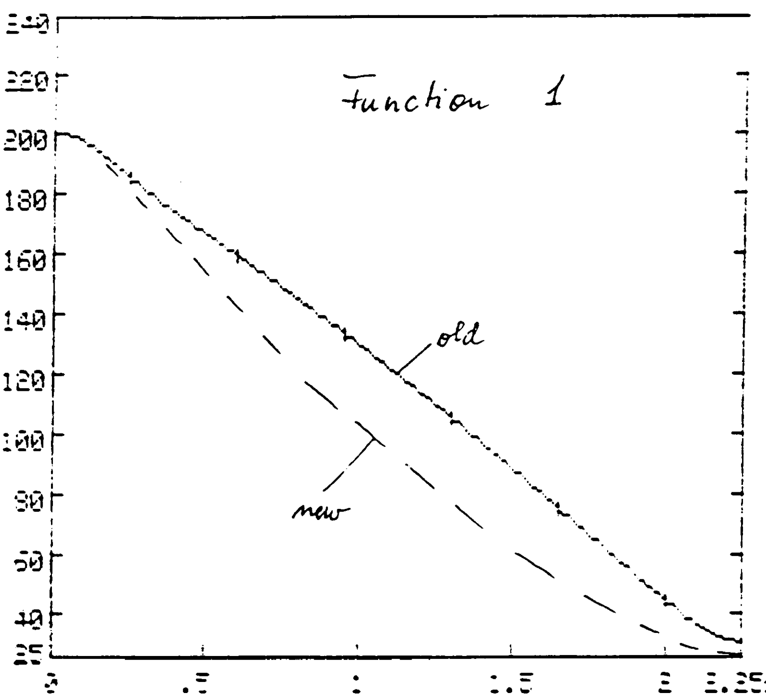
(G. Carron, S. Maury, L. Thorndahl)

We varied the cooling time between 0 and 4.8 s and each time the pick-up/K movement function has been adapted.



Last year, the cooling was linear with time. Now, the kink point at 2 s for horizontal and vertical emittances is probably due to the additional AC cryogenics installed in January.

From these measurements, the PU/K movement function, originally from 200 π to 30 π was modified to 200 π to 25 π. 25 π were put as a minimum because it is a hardware minimum limit. Lower than 200 π is not interesting because we lose antiprotons. Then we decided to change the function as well. The curve is no longer linear but convex; this increases the loop gain during the cycle without reducing the initial acceptance of 200 π. No loss was measured during the movement. The emittances measured were 4 π in both planes.



TIME	OLD	NEW
0	200	200
.25	185	180
.5	159	140
.75	133	107
1.0	105	77
1.65	75	51
2	44	31
2.25	30	25

4.8 s $\varepsilon_H = \varepsilon_V = 4\ \pi$ mm.mrad

$\Delta p/p = 0.12\%$

2.4 s $\varepsilon_H = 13\ \pi$ mm.mrad

$\varepsilon_V = 12\ \pi$ mm.mrad

$\Delta p/p = 0.19\%$

A longitudinal instability was sometimes observed at the end of AC cooling, mainly due to the L2 (band 2) in AC. This instability is more pronounced when L active filters are used. However, the particles stay well within 0.18% in $\Delta p/p$.

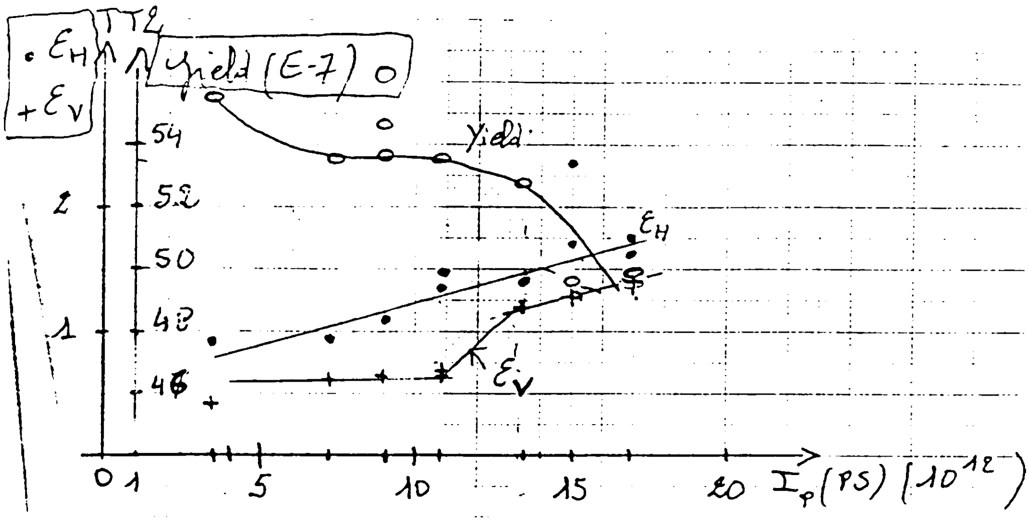
Then, by changing the coupling on the AA injection orbit, 70% of the $\bar{p}$'s produced are injected into the AA at 2.4 s. And, simulating the cryogenic on AA precooling and stack tail, we reached 19.10^9 $\bar{p}$/h in stacking rate. This corresponds to 3.80 10^7 $\bar{p}$'s/shot. Normalizing the number of antiprotons injected into AC with the lepton supercycle, we should obtain 3.26 10^{10} $\bar{p}$/h in stacking rate with 2.4 s repetition rate compared to 3.2 10^{10} $\bar{p}$/h at 4.8 s repetition rate. With $Sp\bar{p}S$ supercycle, we should reach 5.40 10^{10} $\bar{p}$/h; we got 5.0 10^{10} $\bar{p}$/h during period I.

Of course, this cryogenic simulation supposes to improve by a factor 2 on the AA precooling and on the stack tail. The cryogenics on precooling would reduce the noise by 6 dB and this reduction corresponds to a factor 2 in cooling speed. The cryogenics on the stack tail reduces the noise by only 3 dB which is equivalent to $\sqrt{2}$ in cooling speed. The missing factor can be compensated by increasing the power in the transmission line in order to get this factor 2 in speed. But too much power on the stack tail causes trouble on the transverse core cooling and to solve that, we should increase the 4-8 GHz bandwidth at lower frequencies. In conclusion, with the AA cryogenics we should be able to accumulate about 10% more at 2.4 s than at 4.8 s with the $Sp\bar{p}S$ supercycle. And if we keep the 4.8 s repetition rate, we would be able to keep the good stacking rate right up to the high stack intensities.

ME3 : EFFECT OF THE PRODUCTION BEAM EMITTANCE ON THE YIELD

(S. Maury, N. Rasmussen, T. Risselada, J.P. Riunaud)

It is very difficult to modify the emittances of the beam, but in the Booster, the intensity is directly related to the horizontal emittance due to the increasing of the number of turns, the vertical emittance should stay more or less constant. But we clearly see a break point on vertical emittance at I = 1.2 10^{13} p probably due to the coupling in the Booster. Anyway the yield goes down by about 7% after 1.3 10^{13} p or after the vertical emittance break point and between 0.7 10^{13} and 1.3 10^{13} p, the yield stays constant.



<u>ME4: DO WE NEED SHUTTERS IN AA ?</u> (Figure 1)
(G. Carron)

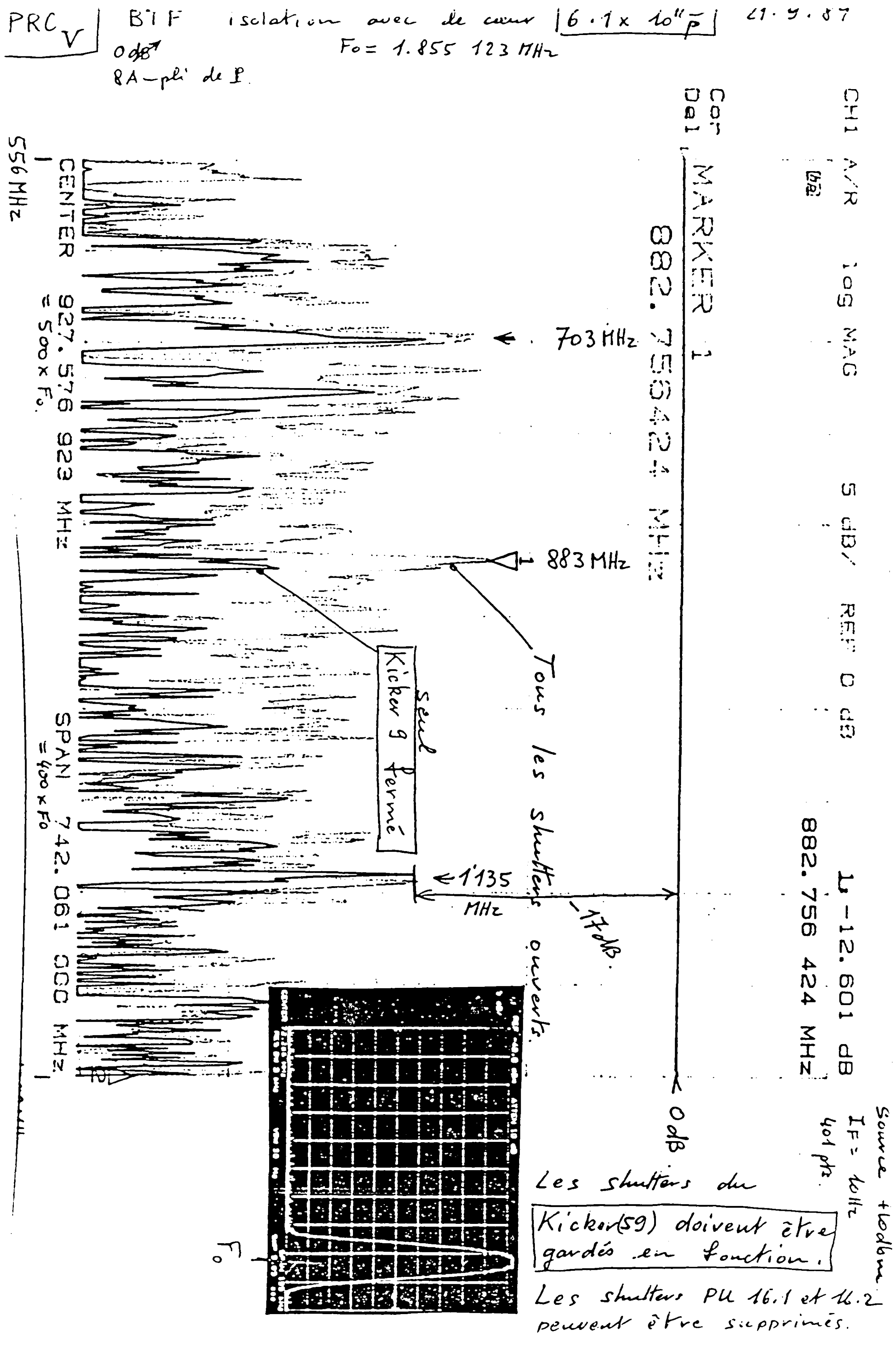
We had 6.1 10^{11} $\bar{p}$ in the AA core. We did a beam transfer function (BTF) with the vertical precooling system, where each point represents a stack core harmonic - the thin trace is a BTF measurement with all the shutters open and the thick trace with the shutter (S9) only closed, the others did not give any difference. We see clearly 3 spikes:

- at 703 MHz, there is no change with or without shutters, but if this spike disturbs the stack, it could be attenuate by reducing the gain on the edge of the bandwidth;
- at 1135 MHz, there is no change with or without shutters and the signal is 17 dB lower;
- at 883 MHz, we see a big difference with and without shutters; without shutters, this spike is only -13 dB and with shutters S9 closed the signal at 15dB lower. This spike could give some trouble.

Therefore, shutter S9 is needed.

This experiment has been done because to install the AA cryogenics it is easier to build thermal screens in the PU without the shutters in the AA.

Figure No. 1


PRC V
BTF isolation avec de coeur 6.1 x 10[11] p
21.9.87
Fo = 1.855 123 MHz
CH1 A/R log MAG 5 dB/ REF 0 dB
MARKER 1
882.756424 MHz
-12.601 dB
882.756 424 MHz
703 MHz
883 MHz
Tous les shutters ouverts
Seul Kicker 9 fermé
1'135 MHz
-17 dB
0 dB
CENTER 927.576 923 MHz
= 500 x Fo
SPAN 742.061 000 MHz
= 400 x Fo
556 MHz
Fo
Les shutters du Kicker (59) doivent être gardés en fonction.
Les shutters PU 16.1 et 16.2 peuvent être supprimés.

ME5 : VERTICAL AC ACCEPTANCE STUDY
(S. Maury, J.P. Quesnel)

We noticed in the past that the vertical AC acceptance were limited by the PU/K cooling. We closed one by one the PU/K with the others completely open and then the vertical acceptance has been measured. When the PU/K has been found to be a limitation, we did a bump with 3 quadrupoles to increase the vertical acceptance. All the defocusing quadrupoles are vertically motorized except QDN05 which is sitting just above the AA ejection line. Finally, with all the PU/K closed at 200 π mm.mrad, we measured a vertical acceptance of 201 π mm.mrad and all PU/K fully open, 212 π mm.mrad has been measured. We noticed that the quadrupole QDN05 is tilted with an angle of about 0.2 mrad.

ME6 : HORIZONTAL AC ACCEPTANCE STUDY
(S. Maury, J.P. Quesnel, S. van der Meer)

By using the horizontal obstacle search program, we found an obstacle in section 44 (outside) and another one in section 41 (inside). After using a bump (4 quadrupoles) we got 217 n mm.mrad for the horizontal acceptance. It was necessary to readjust the Trim and then we got 223 π mm.mrad with all PU/K fully open.
Finally, with all the PU/K closed at 200, we found that the PU30 limits the acceptance. After a new local bump (3 quadrupoles) we got

$$A_H = 211\ \pi\ \text{mm.mrad}$$

and with all PU/K closed at 25 π, we got

$$A_H = 31\ \pi\ \text{mm.mrad}$$

It is important to note that when we are working only in AC the AA should be ON because the AA bending affects the AC closed orbit.

ME7 : QUADRUPOLAR PU AND QUADRUPOLAR COHERENT OSCILLATIONS
(V. Chohan, G. Carron, S. van der Meer, D. Williams)

After seeing the first signals from the quadrupolar PU, a lot of hardware work has been done to get good signals for analyses by computer. Preliminary software has been tested, however more time is needed to make the system operational.

ME8 : INFLUENCE OF AA TUNE AND SKEW QUADRUPOLES ON AC/AA TRANSFER EFFICIENCY (S. Maury, R. Sherwood, L. Soby)

It has been observed that the transfer efficiency between AC and AA increases by about 8% when we put the skew quadrupole off. We would like to find a new AA tune on the injection orbit to get effective this gain. We increased the transfer efficiency by 6% when we changed

$$\Delta Q_V = +1.0\ 10^{-3}$$

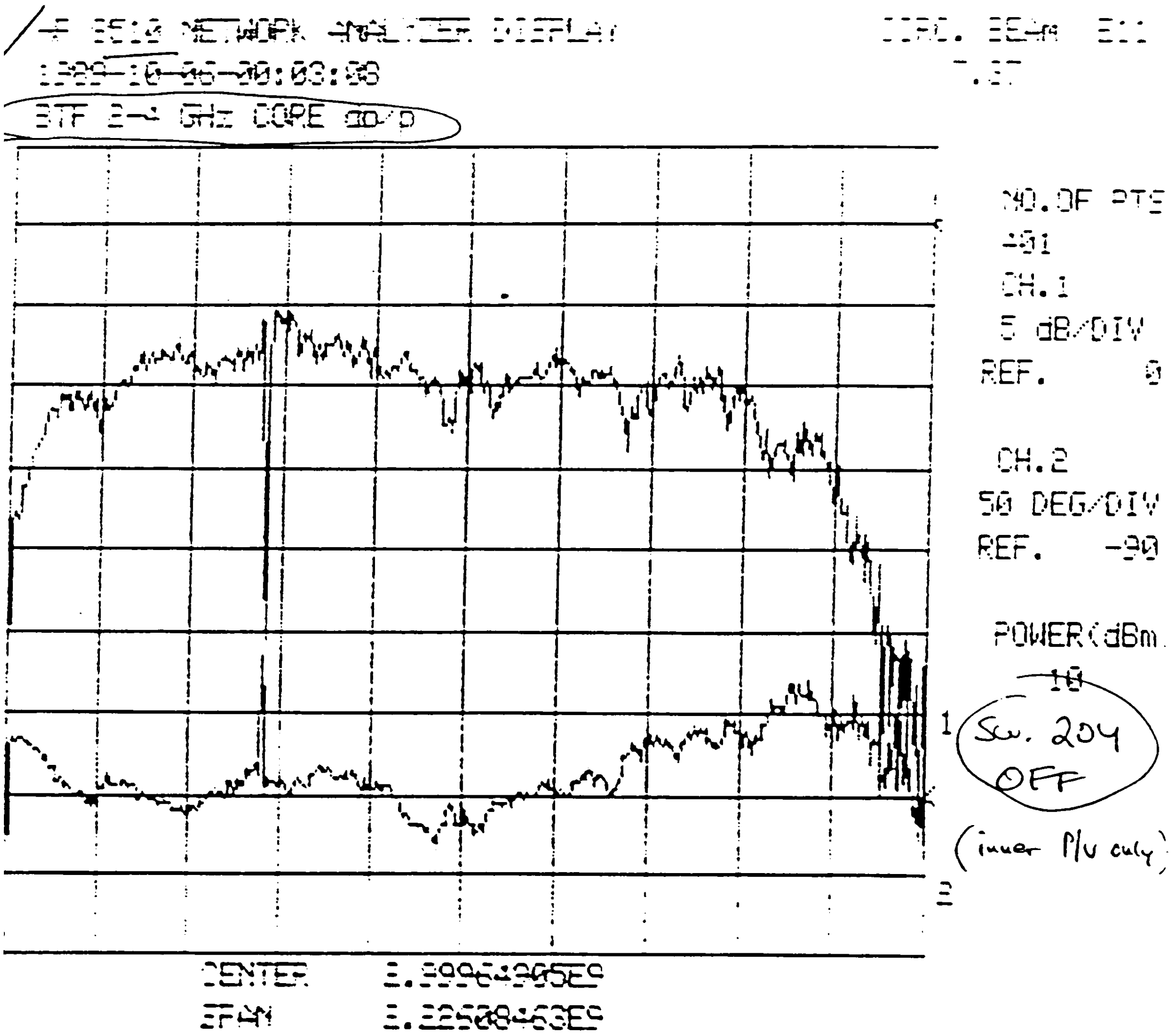
but, at this time, we got problem with the AA defocusing quadrupole power supply and the measurements were not very stable. This experiment should be repeated again.

ME9 : DIGITIZER "NO Q-RESPONSE"
(V. Chohan, J. Ottaviani, S. van der Meer)

Several software and hardware tests have been made. The preliminary conclusion points to an equipment module "TIM" problem in using a property "TRIG"; this had been suspected of unusual behaviour since several years but no systematic tests had been done till now. Further tests are in progress.

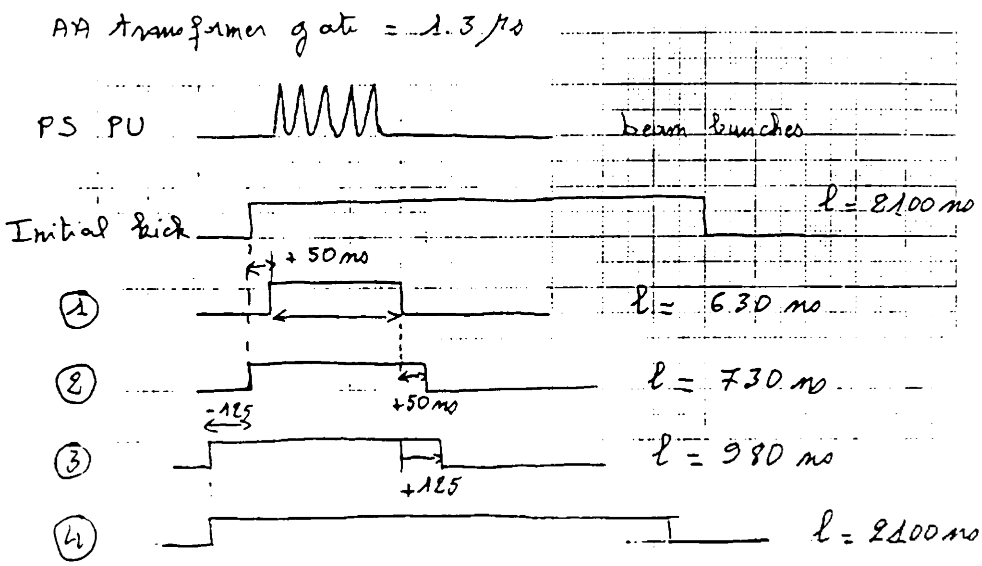
ME10: BTF MEASUREMENT OF THE 2-4 GHZ COOLING SYSTEM ON THE COMPUTER
(T. Eriksson, C.S. Taylor)

A beam transfer function can be measured on the 2-4 GHz cooling system via the computer;



ME11 : EFFECT OF THE PS KICKER LENGTH ON THE PRODUCTION BEAM AND ON YIELD IN AC (S. Maury, J.P. Riunaud)

Different length of the PS ejection kicker have been tried (l = 630 ns, 730, 980 and 2100 ns) and PS intensity and AC yield have been recorded.



Case 1 : the PS kicker too close to the beam, reduces the PS intensity by about 7%.
Case 2 : about 5% of the beam is lost in the PS (protons outside the kicker) but the yield remains the same.

In the cases 3 and 4, the total intensity is on the target without any losses in PS, the yield remains the same (55 10^{-6}).

We can conclude that the different PS ejection kicker length show that the protons outside the 5 bunches do not affect the yield.

ME12 : NEUTRALISATION EXPERIMENT WITH A 10^{12} PROTON STACK (A. Poncet, L. Soby)

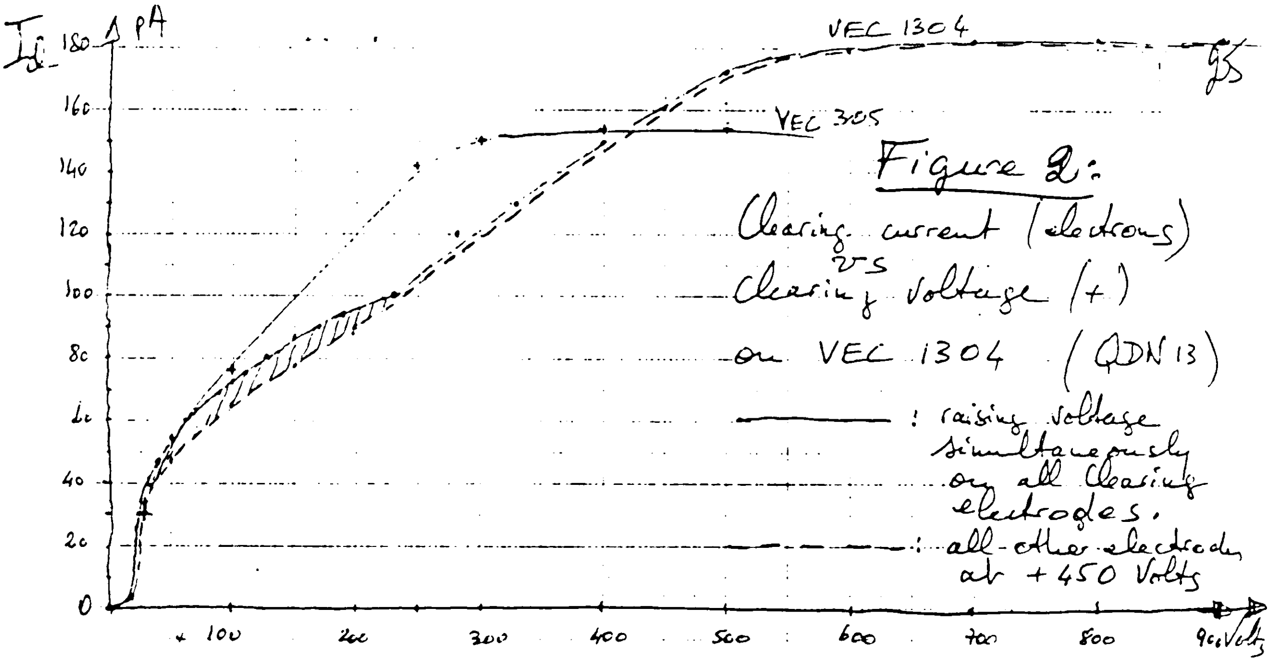
a) Lifetime measurement
The lifetime was measured with a cool 10^{12} proton stack, the average pressure in the machine being 4.10^{-11} Torr (90% H_2, 10% Co):

+400 Volts on Electrodes(correct polarity): 2498 hours (after 6 hours of cooling and no blow-up
-400 Volts (wrong polarity): 1893 hours

This confirms that electron pockets exist if the polarity is not correct. What is not yet understood is the limiting mechanism (single scattering?). The lifetime of a 10^{12} proton cool stack of 2500 hours is twice the one measured with an equivalent antiproton stack in June 89 (11.6.89), for the same average pressure of 4.10^{-11} Torr. This shows that we are still neutralization limited with pbars, even with shaking.

b) Measurements of clearing currents versus clearing voltage
These measurements are interesting, in so far that the saturation voltage may be easier to detect with protons, since there is no risk of parasitic secondary electron emission currents on electrodes with positive voltage. These measurements confirmed this feature on most

electrodes, showing that a voltage of 200 to 800 Volts is necessary on electrodes, depending on their location (large to small dispersion regions). See figures 2 and 3.



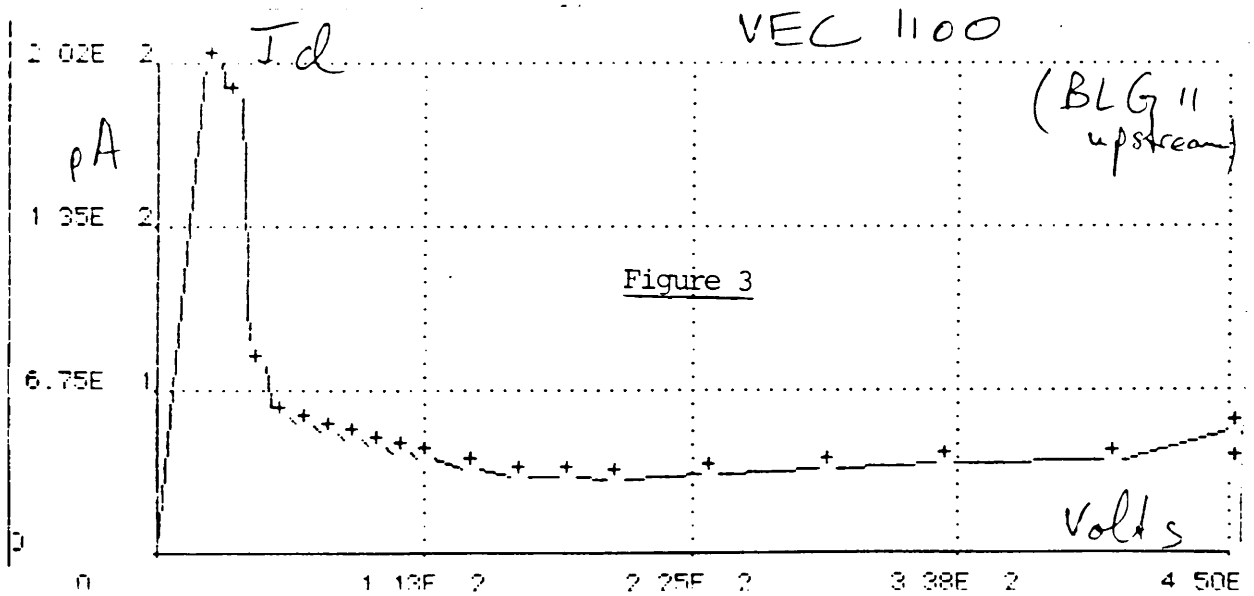
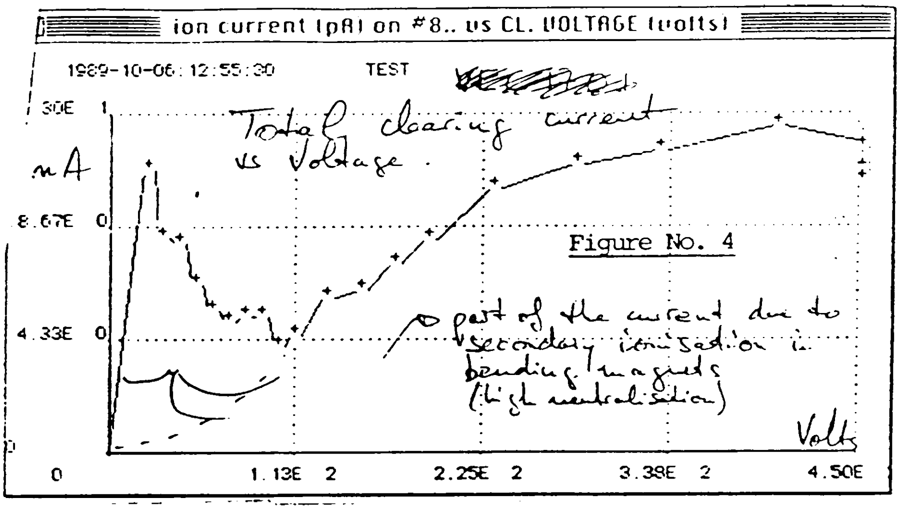
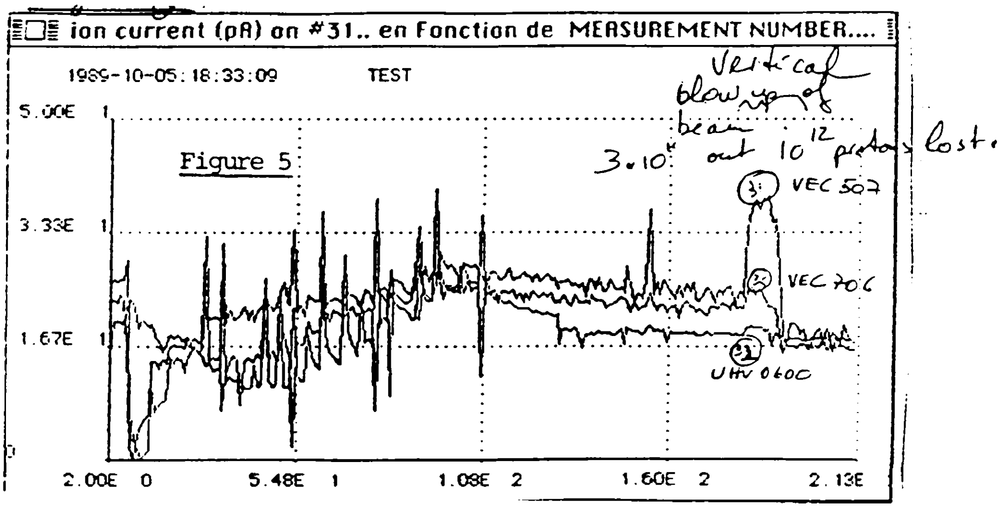


Figure 3

They revealed also secondary ionisation (from electrons trapped) in bending magnets, at low voltage, where neutralisation is high (see Figure 4).



c) Search for obstacles with clearing current measurements
We very clearly identified the known obstacle in s.s. 5 in AA, from enhanced clearing currents due to secondaries from high proton losses, blowing up the beam vertically for a few minutes ($3x10^{11}$ lost), Electrode VEC507, upstream of stack tail pick-up 5, showed a strong signal as seen on Figure 5.



The suspicion is that the pick-up electrodes are not correctly aligned with respect to mid plane. This should be solved by moving the tank.

ME13 : SHAKING DURING STACKING AND COOLING
(X. Brunel, T. Eriksson, S. Maury, D. Möhl, L. Soby)

a) During cooling (I_p=8.3 10^{11} $\bar{p}$)
We measured the loss rate for shaking frequencies in the range of 500 kHz to 800 kHz using the "new" shaking system. Loss rate was read from the TV screen and the average over 20 min was taken for each setting. All measurements were done with a setting of +3dBm on the synthetizer except at 500 kHz where -7dBm had to be used to avoid beam heating due to the proximity of the (0+q)f_0 band at 476 kHz. Voltages read on the shaking amplifier are included in the curve (Figure 6).

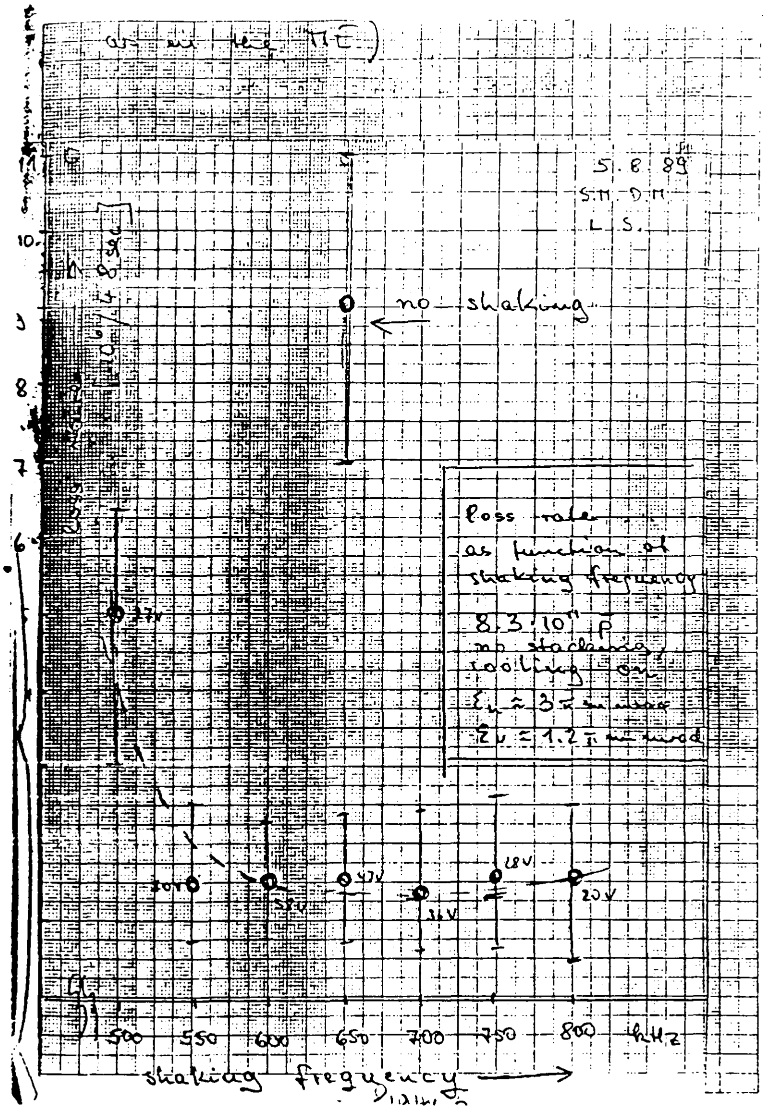
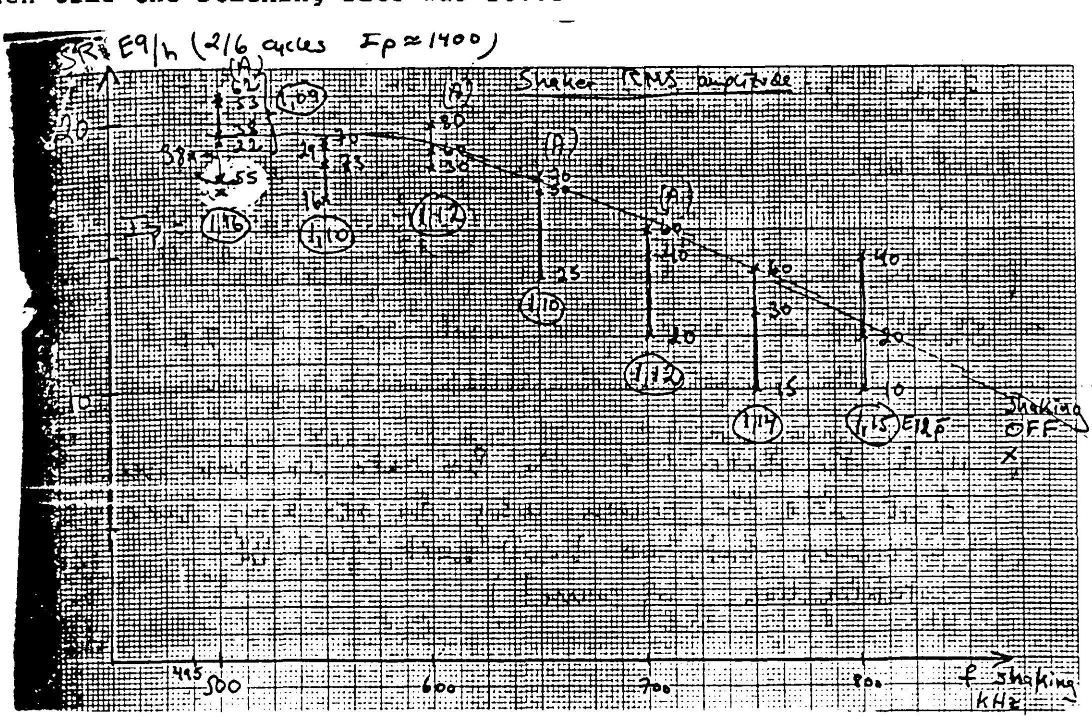


Figure 6

A frequency near the unstable band $(1-q)f_0$ were also tried but without any success.
We see from the curve, there is a broad minimum of the losses at 600-800 kHz shaking frequency.

b) During stacking
All these shaking frequencies with different amplitudes were tried. Each time the stacking rate was recorded.



We see from the curve a maximum of the stacking rate at 500-600 kHz shaking frequency.

ME14: RUSSIAN EJECTION
(S. van der Meer)

A Russian ejection consists to eject all the beam from AA in 66 shots. The program that stabilizes the ejected intensity by changing the bucket area was tried. The system was unstable. Next time, we should either use constant bucket area or reduce the feedback gain a lot.

LOST	UNST	BUCKT	LOST	UNST	BUCKT	LOST	UNST	BUCKT	LOST	UNST	BUCKT	LOST	UNST	BUCKT
1	6	.25	0	9	.3067	1	9	.3239	0	8	.3420	0	9	.3768
0	10	.3979	-2	10	.4050	0	13	.4123	0	16	.3767	-1	16	.3285
0	15	.2726	0	15	.2395	0	16	.2105	0	10	.1791	-1	11	.1765
0	8	.1692	0	16	.1864	-1	6	.1585	0	21	.1945	0	0	.1543
0	75	.0	0	22	.5250	0	16	.4126	0	17	.3510	0	21	.2944
0	11	.2357	0	16	.2259	0	16	.1922	0	5	.1635	0	23	.2153
-1	7	.1677	0	14	.1941	1	10	.1737	3	10	.1713	4	10	.1688
0	12	.1665	0	3	.1555	0	38	.2884	1	21	.2052	1	7	.1643
0	14	.1901	0	11	.1702	0	8	.1631	0	21	.1796	-1	0	.1424
1	103	.0	0	32	.5126	0	21	.3752	0	16	.2975	0	20	.2531
-1	20	.2047	0	10	.1656	0	7	.1633	0	14	.1890	0	10	.1691
0	7	.1722	0	10	.1993	0	10	.2029	0	7	.2065	0	5	.2390
1	8	.3433	0	6	.3782	0	11	.4640	0	8	.4446	0	6	.4898
1	8	.6010	1	6	.6621	0	6	.0	0	6	.0	0	5	.0
-2	3	.0	0	1	.0	0	2	.0	0	0	.0	0	0	.0
0	0	.0	0	0	.0									

ME15 : TO FACILITATE THE OPERATION, WE HAVE

- a new AC setting-up program,
- on each screen in the transfer lines, the beam can be steered in mm in all modes.

What was not done but scheduled
- dogleg optics
- AC dampers
- horizontal AA acceptance

What should be done again
- influence of AA tune on AC/AA transfer efficiency.

S. Maury

Distribution

PS/4

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PS/OP/Note 89-1
6.1.1989

PROGRAMME DES ACCELERATEURS PS EN 1989

M. Bouthéon

Le programme du complexe PS pour l'année 1989, agréé après la séance de novembre du Comité de la Recherche, est décrit brièvement ci-dessous. Le schéma annexé résume également ce programme. Comme toujours, des modifications et des précisions sur les horaires sont élaborées en cours d'année à l'échelle du mois environ. Les réunions hebdomadaires avec les coordinateurs de physique permettent aussi des ajustements plus fins.

ARRET DES MACHINES

Arrêt annuel destiné à la maintenance générale et aux installations pendant les semaines 1 à 8 incluses. Parmi les travaux importants, citons au PS : la rénovation des octants 3 et 4, l'installation expérimentale de la nouvelle éjection lente, l'installation pour la mesure de la lumière synchrotronique, et la rénovation de la climatisation de l'anneau. Linac et Booster recevront une maintenance générale complete. Le démontage au Booster de certains éléments en vue de trouver la cause d'instabilités de faisceau dans l'anneau 4 est reporté à l'arrêt de la semaine 26 (voir plus loin). LEAR verra des améliorations apportées à l'instrumentation (moniteur spécial à jet de carbone), aux modes de fonctionnement à basses énergies, ainsi qu'à la preparation de la cible à jet gazeux. Les machines LPI seront en arrêt jusqu'à la semaine 20. En dehors des améliorations destinées à rendre cet ensemble totalement opérationnel, il faut procéder aux travaux nécessités par des fuites au niveau des plaques d'embout des cavités accélératrices des Linacs V et W. Quant aux machines AAC, l'essentiel des travaux consiste en l'amélioration du refroidissement stochastique dans AC (ensemble des PU et leur cryogénie). De plus, l'installation d'une lentille à lithium collectrice d'antiprotons à grand diamètre et son système de pulseur de courant est un point important des améliorations de la zone de production.

Les halls verront la suite de l'installation des expérimentateurs de deuxième génération pour le Hall Sud, et les modifications destinées à servir un nombre toujours plus grand de tests pour le Hall Est.

Enfin, le projet de renovation des systèmes d'accès contrôlé se poursuit : les chaînes Linac 2, Booster et LEAR seront ainsi traitées.

PERIODE 1

Semaine 8 : la fin de la semaine sera consacrée aux tests (dans les soirées) de la generatrice principale, mais aussi des divers aimants, ainsi que des tests de contrôle par ordinateurs.

Semaine 9 : démarrage le 27 février. Cette semaine dite technique est la semaine de "setting-up" des faisceaux utilisés pour la période 1. Setting-up du LI2-PSB-PS le 28.2 et 1.3.1989. Démarrage de AAC le 2 mars pour quelques jours d'études et mises au point. Rappelons que le but de cette semaine est d'arriver à retrouver l'ensemble des paramètres machine correspondant aux bonnes performances de la période $p\bar{p}$ de fin 1988. En même temps, LEAR démarre avec des protons du Linac 1 dès le 28 février.

Semaine 10-15 : c'est donc la suite de la période 88-4 : $p\bar{p}$ pour collisionneur SPS + LEAR, avec en parasite (2 bursts/43,2 s) le Hall Est avec un cadencement général identique à 1988. Cependant, des essais de production d'antiprotons à répétition plus élevée auront lieu. Cette très longue période en est le prolongement. Notons que les accelerateurs fonctionneront sans interruption pendant Pâques. L'ensemble PS fournira des protons du SPS des le 6 mars; setting-up du Hall Est le 7; la production d'antiprotons pour utilisateurs devrait commencer le 9. Quelques impulsions (pilotes) devraient pouvoir être fournies à partir du 10 mars, si tout fonctionne bien. Pendant ce temps, LEAR recevra toujours des protons depuis le Linac 1. Ensuite, LEAR recevra des pbars de l'ensemble PS à partir du 20 mars. Cependant, cette date pourrait être repoussée de quelques jours, selon les problèmes rencontrés avec le collisionneur.

Semaine 16 : un court arrêt technique destiné à la maintenance essentielle (génératrice, refroidissement, etc...). Cette annee, afin de perturber au minimum les utilisateurs, cet arrêt sera fait en conservant le stack d'antiprotons dans AA (sauf incident bien entendu). Les utilisateurs $Sp\bar{p}S$ devraient donc recevoir à nouveau des antiprotons dès le jeudi 20 au soir. Pendant cette semaine, LEAR fonctionne en mode protons avec Linac 1, jusqu'au 25 mars.

Semaines 17-25 : reprise régulière de la période avec $Sp\bar{p}S$ collisionneur, LEAR et HAll Est, jusqu'au 25 juin (arrêt de la production d'antiprotons le 24 au soir, pour permettre une diminution de l'activité avant intervention). Le Hall Est sera interrompu les semaines 19 et 20 pour procéder aux essais du nouveau schéma de l'éjection lente. Les machines LPI démarreront à partir de la semaine 20. Il est probable que pendant les deux dernières semaines de la periode, des essais en leptons avec le PS auront lieu afin de préparer ce mode de fonctionnement, tout au moins partiellement.

PERIODE 2

La <u>semaine d'arrêt 26</u> entre autres travaux verra la ré-installation de la cavité RF 114 MHz nécessaire au fonctionnement opérationnel du PS en leptons. D'autre part, pendant cet arrêt, certains éléments du Booster seront démontés temporairement, ceci afin d'analyser les causes possibles d'instabilités propres à l'anneau 4.

<u>Semaine 27</u> : le Booster démarrera donc avec l'anneau 4 seul, puis après études, on procèdera au remontage complet des éléments. Ceci implique un retard d'environ 24 à 30 heures pour la disponibilité des protons. Le faisceau avec les 4 anneaux Booster pourra être délivré le vendredi 7 juillet au SPS. Les machines LPI auront demarre des le 3, pour un fonctionnement opérationnel "non-stop" de plusieurs mois, pour la première fois de leur histoire. Les ajustements en leptons avec le PS devraient commencer aussi dans le courant de la semaine 27.

<u>Semaines 28-29</u> : periode consacrée au SPS en mode cibles fixes, au demarrage du LEP, à LEAR en antiprotons. LEAR fonctionne cependant en protons les semaines 27-28-29, ainsi que 34 et 37, semaines dediées aux ameliorations, installations et études dans les machines AAC. Tout comme en 1988, les semaines où la combinaison Etudes AAC + LEAR protons sera en operation, le Hall Est pourra recevoir des déversements à 24 GeV/c. Trois séances d'études en temps propre (sans utilisateurs) auront lieu le 31 juillet, 21 août et 11 septembre.

PERIODE 3

Semaines 41-51 : démarrage des machines LPI le 9 octobre. L'ensemble PS aura les mêmes utilisateurs que pour la periode précédente. LEAR démarrera en protons pendant les études AAC, et le Hall Est sera en opération les semaines 41 et 42. Le 26, les antiprotons seront disponibles pour les utilisateurs du Hall Sud jusqu'en fin d'année, à l'exception de la semaine 46 (Hall Est + LEAR protons) et de l'interruption pour études de la semaine 49.

Rappelons, au titre de remarques générales, que le Booster fonctionnera de manière permanente à 1 GeV et par conséquent cette énergie sera le standard pour l'injection dans le PS. D'autre part, il est évident que le fonctionnement en leptons au cours de la seconde moitié de l'année aura la première priorité opérationnelle, et que la planification fine en sera tributaire.

<u>Annexe</u> : 1989 Accelerator Schedule

Une version simplifiee peut être obtenue via VM selon la procedure suivante :

1) pour les utilisateurs de la Division PS :

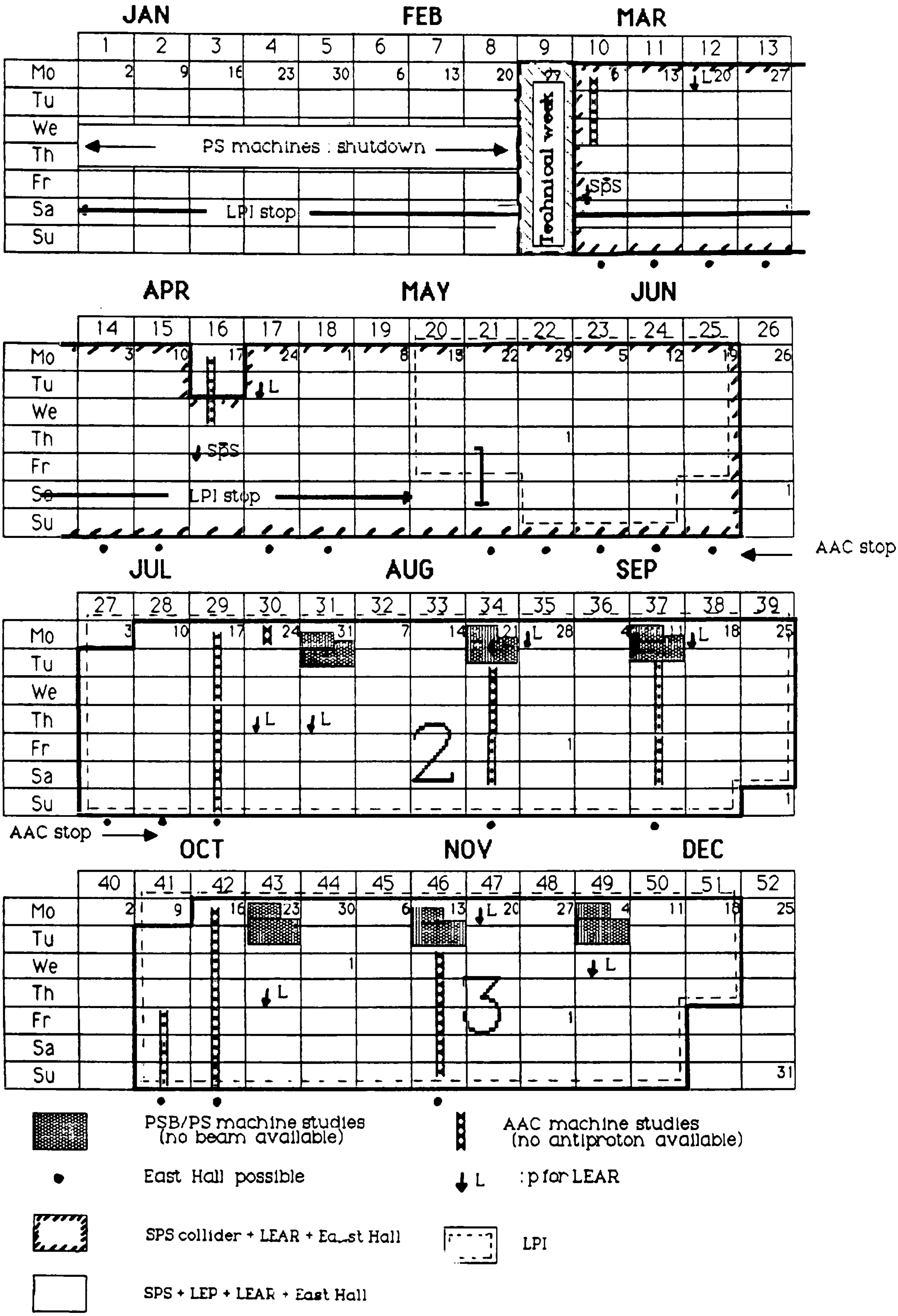
taper HELP PSPLAN89

2) pour les autres utilisateurs :

taper GIME PUBPZ 197
HELP PSPLAN89

18.12.1988

1989 PS SCHEDULE



Distribution

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