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OPERATION OF THE PS COMPLEX IN 1994

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Abstract

Starting a new year of operation, we traditionally review the general running of the PS Complex during the previous year in order to recall the essential results for our users, the performance of each beam and the main problems concerning machine equipment.

This note relates the three operational periods of 1994 and presents the evolution of the beam performance and also a comparative analysis of machine reliability over the last years.

Geneva, Switzerland
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1. INTRODUCTION

This note reviews the running of the PS Complex in 1994 and recalls the essential features of the beams delivered to our users, the performance of each machine and the main problems concerning equipment. The statistics of the PS operation are detailed in Ref. 1. After the review of the different operational periods, this note also presents the evolution of the beam performance in 1994 and a comparative analysis of machine reliability over the last years.

After a long shutdown of 10 weeks until 14 March, the year 1994 for the PS Complex was divided into 3 Operation periods (Fig. 1). The first and second operational periods respectively lasting 14 and 18 weeks were devoted to LEP physics, SPS fixed target physics with protons, experiments in the South Hall with antiprotons supplied by LEAR, ISOLDE served by proton beams from the Booster and test experiments in the East Hall. The same users were scheduled during the last period but Pb ion beams replaced protons for SPS fixed target physics. The year ended with one week devoted to the first study of Pb ions in LEAR and to control tests on the PS.

The running time of the PS Complex exceeded 6400 hours with 5411 hours for proton beams used by SPS (fixed target physics and machine studies), 5136 hours for lepton beams used by LEP and SPS and 4646 for LEAR physics (Fig. 2). The overall availability was of the order of 88% for LEP, SPS and the South Hall experiments. This relative low performance is mainly due to the difficulties encountered during the general start-up in March and April.

Figure 3 gives a summary of the different users supplied by the PS Complex in 1994 and of the main beam characteristics.

2. ANNUAL SHUTDOWN

As usual, during the long Winter shutdown, extensive maintenance work was carried out in all machines of the PS Complex. In 1994, the main installation work again concerned the hadron injectors:

1) Three machines were involved in the Lead ion project: the installation of Linac3, the Booster with the modification of vacuum equipment and the PS with the installation of two new septum magnets for the ejections in the TT2 and TT70 lines.

2) Two other major improvements were realised on the Booster: the replacing of the cables and ferrites of all the kicker magnets and the renovation of the control system (third slice of the control project).

Among the other tasks, let us mention: the complete realignment of TT2 and TTL2 elements, the replacing of the temperature detection circuits on the PS magnets, the protection of Linac2 source against the consequences of HT breakdown, the regulation of waterflow on LPI, the completion of several beam diagnostic devices for the Lead ion project and various improvements on the LEAR electron cooling system.

3. FIRST OPERATIONAL PERIOD (14 MARCH - 19 JUNE)

After numerous equipment tests carried out on the different machines during the first two weeks of March, the PS Complex officially started up on the 14th. Due to the major installations or modifications in the Booster, the first proton beam was only foreseen in this machine on 24 March in order to test the new control system during one week before Easter. For this reason, the general start up of the PS was planned with leptons.

The lepton beams were sent on time, on 25 March, to SPS for its own start-up. At first, as during the major part of 1993, four cycles of the supercycle were used for this operation. Then on 31 March we switched to the 8 bunch mode with about $2{\cdot}10^{11}$ particles per cycle in order to only use 2 cycles for the normal operation in 1994 (1e+ cycle and 1e- cycle). See fig. 4 (examples of supercycles used in 1994).

On the proton side, the Linac2 started up on 15 March and 2 days later delivered its beam to LEAR for several weeks of machine development mainly devoted to electron cooling studies. During the last eight days of March, just before Easter stop, numerous tests with proton beam were carried out on the new PSB control system. Unfortunately these tests were disturbed by two long interventions on the Booster vacuum system.

After Easter, in spite of major problems due to a general electricity cut and a long Booster stop for the installation of new beam scapers and the new distributor for lead ions, SPS took protons on schedule at 14 GeV/c. AAC started well with the proton test beam and then switched to the inverse polarity for a one week proton machine development session mainly devoted to careful adjustments of the different AC or AA beam cooling systems and acceptance studies in the AA and AC rings.

Unfortunately the three remaining weeks of April were seriously disturbed by numerous major problems which affected all the machines and mainly concerned two categories of equipment: 1) new devices installed during the winter shutdown and presenting initial unreliability, 2) old elements needing renovation and very often equipped with insufficient diagnostics.

Among the long list of faults let us mention :

- a vacuum leak on the high current connection of the new septum magnet in the PS straight section 16. After three long interruptions for temporary repairs, the defective piece was finally changed on the 21 April (total stop of about 4 days).

- technical problems and pollution on the new PS water station (10 hours lost)
- leak on the new Booster vacuum installation (change of an ion pump).
- serious problems in setting-up the pbar deceleration in the PS.
- numerous interruptions due to general timing or sequencing problems.
- several breakdowns of two septum magnet power supplies (Booster and PS) caused by defective interlocks circuits (old electronics).

In addition to the above problems the South Hall users suffered from other major faults during the first 2 weeks of May: 1) the AA antiproton stack was lost several times due to breakdowns of the main AA focusing quadrupole power supply finally needing the change of the DC current transformer; 2) a similar problem occurred on the LEAR defocusing quadrupole power supply and the same remedy was carried out.

Mainly due to this excessive number of failures, the availability of the PS Complex beams during this first operational run was lower than usual: 85% for SPS proton beams, 86.1% for leptons, 91.8% for ISOLDE and only 76.6% for antiprotons for South Hall users.

In May and June, the intensity of the proton beam for SPS was regularly increased on SPS request from $1.5 \cdot 10^{13}$ to $2.2 \cdot 10^{13}$ protons per cycles. For this and for the other proton beams, the RF specialists worked hard on the Booster beam control and on the fine adjustments of the PSB harmonic-10 cavities. Careful adjustments were also carried out at 1 GeV in order to optimise the transmission between the Booster and the PS and minimise the beam losses to around $2. \cdot 10^{12}$ protons per cycle.

Due to the numerous problems mentioned above, the first antiproton beams were only ejected to the South Hall pbar users on May 1st (6 days later than scheduled). For 3 weeks, LEAR worked at 200 MeV/c for CP LEAR with in parallel Xbarrel then Obelix. Then during 10 days Obelix ran alone working at 415 MeV/c. Finally in June LEAR again switched to 200 MeV/c for CP-LEAR, X-Barrel and Hot Nuclei. PS196 (Trap) and PS200T (GRAV) were also supplied with the fast extraction at 105 MeV/c. Figure 5 gives the main characteristics of the beams used by the LEAR users.

ISOLDE experiments took their first beams ($4 \cdot 10^{12}$ protons per cycle) on the 20th April using a liquid target (Sn plasma). At the end of the month the intensity was increased between to $2 \cdot 10^{13}$ and $2.5 \cdot 10^{13}$ protons per cycle for new experiments using a solid target (SiC).

The East Hall test experiments worked during 7 weeks and received, as usual, spills of $3 \cdot 10^{11}$ protons.

Most of the PS and PSB machine development sessions were devoted to the preparation with protons of the PS and PSB for the acceleration of Lead ions. As planned, on the 15 June, a 13 μA beam of Pb^{53+} ions was provided by the LINAC3 and injected into BOOSTER ring 3. About 4.10^{9} charges were kept during 30 ms on a 1412 gauss flat magnetic cycle.

4. SECOND OPERATIONAL PERIOD (22 JUNE - 23 OCTOBER)

This second operational period of 1994, with a duration of 18 weeks, was the longest in the history of the PS Complex. For this run, the global beam availabilities for the main CPS users were comprised between 88 and 92%. After a fast setting-up, the improvement of the performances, especially on the proton beams for SPS and ISOLDE, took time and needed a strong effort from all the specialists concerned.

In Summer, the main work concerned the Booster on which many adjustments were successfully carried out in the longitudinal and transverse planes (RF capture, injection steering, transverse tune adjustment). Improvements were also made in the PS (fine adjustment of the continuous transfer process, optimisation of the transmission) and in the Linac2 (source control, change of a broken 5 KV preamplifier, realignment of the RFQ). SPS benefited from these improvements and was finally able to deliver up to $3.5 \cdot 10^{13}$ protons per cycle at 450 GeV/c to its different experiments.

ISOLDE worked for various experiments using two levels of proton beam intensities ($6 \cdot 10^{12}$ and $2.5 \cdot 10^{13}$ protons per cycle) and with various numbers of cycles per Booster supercycle.

The lepton beams continued to be delivered to SPS on two PS cycles ($2 \cdot 10^{11}$ particles per cycle) but were seriously perturbed in September and October due to many breakdowns of the LIL modulator 13. After having changed several pieces of hardware (including the klystron twice), the situation dramatically improved.

For all the beams, many interruptions were caused by:

1) electricity cuts due to thunderstorms (numerous AA stack losses, problems with the connection of the LPI back-up power supply, serious power failure on LEAR on the 28 and 29 July);

2) vacuum leaks on the PS (change the septum magnet in straight section 57), on the Booster (long interventions and temporary repairs in the injection area and in the extraction section) and on the Linac2 (pre-injector);

3) water problems (leak on a PS power converter, cooling of the PSB septum magnets).

After one week devoted to machine studies with protons (measurement of the cooling time at low energy and tests of the slow extraction), LEAR worked for a single experiment HYPERONS running at different moments around 1440 MeV/c. End of July LEAR switched to 1940 MeV/c for X-Barrel and HOT Nuclei. In August the experiment JETSET benefited from a good performance: a record beam intensity of $7.54 \cdot 10^{10}$ antiprotons was injected into LEAR and $7.34 \cdot 10^{10}$ particles reached 1315 MeV/c. On 5 September LEAR again served CP and HELIUM-TRAP working in parallel. Unfortunately at 200 MeV/c, about 10% of the extracted spills were again lost for an unknown reason ("LEAR ghost"); these losses are still under investigation. LEAR finished this second operational run at 105 MeV/c for OBELIX and IONIZATION. During the period the experiments TRAP and GRAV continued to receive beam at 105 GeV/c in fast extraction. Figure 5 gives the main beam characteristics for each experiment.

The transfer efficiencies from AAC to LEAR were continuously improved and became very stable and reproducible around 80%. AAC worked well with good stacking rates (2 to $3{\cdot}10^{10}$ pbars/h) and the stack reached a maximum of $1.07{\cdot}10^{12}$ antiprotons. Unfortunately the antiproton stack was lost 9 times, mostly due to general power cuts (thunderstorms, EDF network).

From the 19th September the East Hall worked alternatively with two types of beams :

- the classical slow extraction at 24 GeV/c for the test experiments in t9, t10 and t11 lines.

- A fast extracted beam used by the energy amplifier test in the t7 line. This experiment was successfully supplied with a beam of variable intensities between $2{\cdot}10^{8}$ and $2{\cdot}10^{9}$ protons per cycle at different energies during 4 half-weeks, at 2.7 GeV, 2 GeV, 1.5 GeV, 1.2 GeV, 1 GeV, 900 MeV, 800 MeV, 700 MeV and 600 MeV.

On 13 July, an important milestone was reached with the acceleration of lead ions in the Booster. For the first time a beam of $2.7{\cdot}10^{9}$ charges of Pb^{53+} was accelerated in the PSB ring 3 to 95.4 MeV/u and then extracted in the transfer line towards the PS. In Summer, several machine developments were carried out in parallel with physics in order to continue to adjust the PSB and PS with beams of Pb^{53+} ions. On 28 September, Pb ions were sent to SPS for the first time on 4 successive PS cycles with 6 to $7{\cdot}10^{9}$ charges of Pb^{53+}/cycle. Finally on the 21th October, regular lead ions beams were sent to SPS (about $1.4{\cdot}10^{10}$ charges of Pb^{82+} per cycle after the TT2 stripper). A new record was achieved in the Booster with $2{\cdot}10^{10}$ charges of Pb^{53+} accelerated.

5. THIRD OPERATIONAL PERIOD (31 OCTOBER - 20 DECEMBER)

This third operational period ended on 14 December for physics and was followed by one week devoted to machine developments and to a first test of the new controls of the PS. As far as the beam availability is concerned this 2-month run was the best of the year with availabilities comprised between 90% and 96%. The performance of the high intensity proton beams for ISOLDE and of the antiproton transfers from AAC to LEAR continued to stay at the good level reached in October. The pbar transfer efficiencies very often reached 90% with shots of about 3.10^{9} antiprotons.

This run was also successful for the beams of Pb ions, serving SPS fixed target physics for the first time. After the replacement of the Al stripper device at the end of TT2 line (0.5 mm thickness in place of 2 mm), a good performance was achieved in the SPS due to better transverse emittances of the Pb^{82+} beams received by this machine.

LEAR was affected by a vacuum leak occurring on a bellows at the end of the October shutdown; this incident delayed by 5 days the machine development session foreseen for the first week of the run. Then LEAR worked successfully at 105 MeV/c for Obelix and XBarrel and finally for LEX (see Fig. 5 for details).

ISOLDE used alternately high and low proton intensities (2.8 and $0.6 \cdot 10^{13}$ protons per cycle) depending on the experiments and the type of target. An improvement was achieved in the losses in the transfer line after the discovery of an incorrect current value in a quadrupole. After the intervention, the losses disappeared completely and the intensity received on the target was increased by about 5%.

The East Hall users very often benefited from two 24 GeV/c cycles in the 19.2s supercycle. A long stop happened on the 24th and 25th November on the slow extraction due to an important water leak in the power supply of the PS septum magnet 57.

Several machine studies were carried out after the physics run on the PS (test with SPS of a 1mm stripper for Pb ions, PSB-PS transfer) and on the Booster (adjustments and measurements with Pb^{53+}, transfer steering and losses at extraction). After the LEP shutdown on 5 December, LPI ran during 2 1/2 weeks for irradiation tests of LHC vacuum chambers and for several machine studies on LIL and EPA.

The LEAR machine development was devoted to the injection and the accumulation of Pb^{53+} ions (up to $5 \cdot 10^{8}$ charges accumulated). The electron cooling system worked well (a reduction of 10 in $\Delta p/p$) and numerous measurements were carried out.

In parallel with the LEAR MD, the last week before Christmas was successfully used to test the renovated control system on the PS (first slice). This preliminary test concerned the proton injection, the ring power supplies (low and high energy corrections), the acceleration systems and the pulse-to-pulse modulation.

6. PERFORMANCE IN OPERATION

6.1 Lepton beams

The lepton beams ran well with a good regularity and continued to use two successive cycles of the PS supercycle. The mean intensity per PS cycle (e+ or e-) was of the order of $2.1 \cdot 10^{11}$ leptons.

6.2 Proton beams

Figure 6 illustrates the progressive evolution of the average proton intensity delivered per Booster cycle for SPS fixed target physics during the second period. In October, after the numerous optimizations mentioned before, a very good performance was obtained with about $2.7 \cdot 10^{13}$ protons per PSB cycle producing 2.4 to $2.5 \cdot 10^{13}$ protons per PS cycle.

The other proton beams benefited from these improvements, especially the proton beam for ISOLDE (Fig. 7) and the antiproton production beam for AAC. Nevertheless ISOLDE beams reached intensities of $3 \cdot 10^{13}$ protons per cycle only during the last period.

6.3 Pb ion beam

During the SPS physics run, 1.0 to $1.7 \cdot 10^{10}$ charges of Pb^{82+} were delivered after the TT2 stripper on each of the first 4 cycles of the 19.2s supercycle. The average Pb^{53+} ion intensity produced per day by the Booster is represented on Fig. 8. The ion intensity suffered from the presence of high intensity proton beams in the Booster and of the leptons in the PS. When these events happen simultaneously, the ion intensity delivered by the PS can decrease by more than 30% due to the degradation of the vacuum. A delicate program of sublimation was carried out on the Booster in order to improve the vacuum. Due to this, the ion intensity accelerated in this machine was varying between 1.2 and $1.6 \cdot 10^{10}$ charges of Pb^{53+}. In 1995 we will try to avoid high intensity proton runs for ISOLDE in parallel with ion beams for SPS.

6.4 Antiproton beam

LEAR ran for 9 different experiments with a record of 2687 spills delivered for physics (Fig. 9). The transfer efficiency from AAC to LEAR was maintained at an high level between 70% and 95%.

A constant surveillance and re-adjustment of the pbar transfer efficiencies from AAC to LEAR were undertaken in 1994 and consequently the average value went up to about 80% and was maintained stabilized around this value up to the end of the year. Figure 10 shows the evolution of this parameter during 6 years and also the pbar stacking efficiency.

Unfortunately more than 10% of the spills extracted at 200 MeV/c were destroyed by a unexplained phenomenon (called "ghost") which is still under investigation. Figure 11 represents the LEAR operation efficiency (ratio between the number of spills delivered to the users and the number of machine fills) which recorded a slight decrease (85%) in 1993 and 1994 mainly due to these extraction instabilities with higher intensities.

7. RELIABILITY ANALYSIS

7.1 Beam availabilities in 1994

Figure 12 represents the evolution of the beam availability for the main users supplied by the PS Complex: leptons for SPS/LEP, protons for SPS fixed target physics and antiprotons for South Hall experiments.

7.2 Comparison with the previous years

As far as the fault rates for SPS and LEP are concerned (Fig. 13), we have noticed a significant degradation from 1988 to 1991 but in 1992 and 1993 we have seen a stabilisation and even a slight improvement [2]. In 1994, the degradation of the fault rates is mainly due to start-up problems especially affecting Booster and PS (25% of 1994 downtime occurred in this start-up).

For the antiproton beam fault rates we can only compare 1994 with 1993 and 1992 because the corresponding statistics were not recorded during the previous years. Figure 14 shows the evolution of the fault rates of the 3 machines involved in the pbar operation (AAC, PS, LEAR).

The evolution of the distribution of the fault rates of each individual machine during the last four years is represented in Fig.15. In 1994, if we except the start-up problems on PS and PSB, the total machine time lost due to equipment faults is comparable to the previous three years; we must also notice that AAC records a very few number of days lost as a result of fast recovering times after antiproton stack loss.

7.3 Detailed analysis (number of faults and fault time)

Figure 16 compares the years 1992, 1993 and 1994 for 6 categories of fault duration (0 to 10 minutes, 10 to 20 minutes, 20 minutes to 1 hour, 1 to 3 hours, 3 to 6 hours and more than 6 hours). The total number of faults concerning all the PS Complex is increasing : 2882 in 1994 and only 1942 in 1993; this is mainly due to LPI whose number of faults went up from 422 to 845 (510 short interruptions due to modulator problems) and to Booster/Linacs with a total of 942 faults in 1994 (586 short interruptions of less than 20 min).

Over this total of 2822 faults concerning all the PS Complex and representing in average 11.4 faults per operational day, 61% of these faults lasted less than 20 minutes: they represent about 7% of the time lost and, therefore, are not very significant. The long faults lasting for more than one hour which much more hampered the PS users represent 20.7% of the total number but they account for 81.1% of the time lost.

Nevertheless the total fault time in 1994 (all machines added) was lower than in 1993: 111 days lost in place of 126.6. This is mainly due to the category of faults longer than 6h for which the average duration was 13h in place of 25h. In particular, we recorded faster recovering time after general power cuts especially on AAC side.

8. CONCLUSIONS

In 1994 a good performance was achieved for the operation of the PS Complex. In particular, the benefits of the improvements in operation launched in 1992 and 1993 begin to be significant: 1) on equipment reliability; 2) on the antiproton transfer efficiency; 3) on the lepton operation. Nevertheless a degradation of the global beam availability was recorded due to major problems occurring during and just after the start-up. For this, new actions were discussed

[Ref. 4] and proposed in order to improve the general start-up of the PS Complex [Ref. 5].

The actions in order to improve the quality of the operation of the PS Complex and the reliability of our machines will be pursued in 1995. During this new operational year we will continue to lay emphasis on the improvement of high intensity proton beams for ISOLDE and SPS (including emittance studies), on the reduction of the beam losses in PSB and PS and on the antiproton operation which needs a constant surveillance.

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REFERENCES

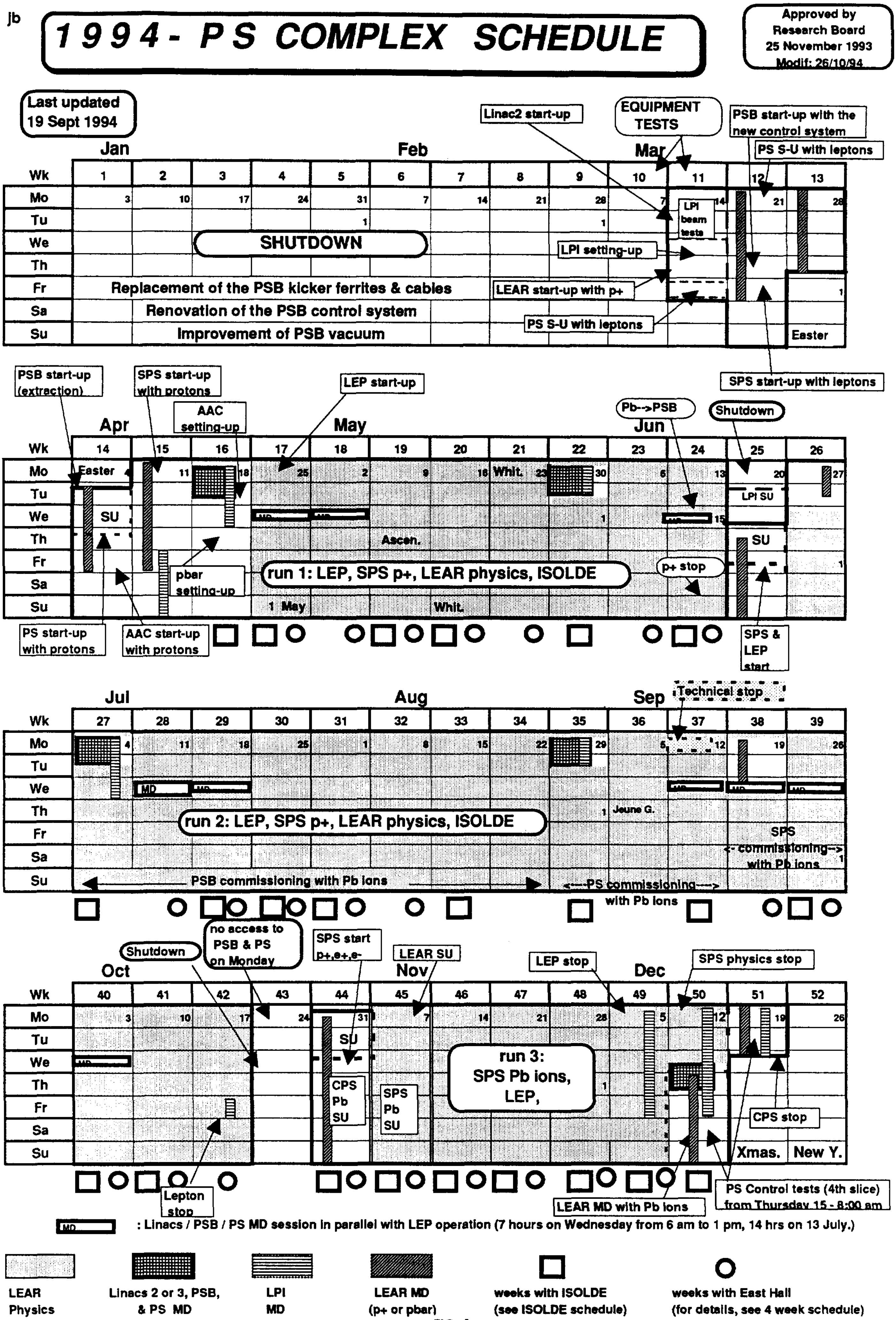
[1] G. Azzoni, D. Dagan, PS Complex operation statistics, PS/OP/Note 95-06.

[2] J. Boillot, Operation of the PS Complex in 1992, CERN/PS 93-14, March 1993,- Operation of the PS Complex in 1993, CERN/PS 94-07, March 1994.

[3] Proceedings of the second PS Performance Day, edited by D. Manglunki, PS/PA Note 95-03 (PPC).

[4] B.W. Allardyce. PS Technical meeting nb. 59 - Démarrage des machines en 1994 - PS/DI/Note 94-18 (Min.).

[5] D.J. Simon, Améliorations des démarrages du complexe PS, PS/DI/Memo 94-55.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1994 - PS COMPLEX SCHEDULE
Approved by Research Board 25 November 1993 Modif: 26/10/94
Last updated 19 Sept 1994
Jan
Feb
Mar
Linac2 start-up
EQUIPMENT TESTS
PSB start-up with the new control system
PS S-U with leptons
SHUTDOWN
Replacement of the PSB kicker ferrites & cables
Renovation of the PSB control system
Improvement of PSB vacuum
LPI beam tests
LPI setting-up
LEAR start-up with p+
PS S-U with leptons
Easter
SPS start-up with leptons
PSB start-up (extraction)
SPS start-up with protons
AAC setting-up
LEP start-up
Apr
May
Jun
Pb-->PSB
Shutdown
Whit.
LPI SU
SU
Ascen.
pbar setting-up
run 1: LEP, SPS p+, LEAR physics, ISOLDE
p+ stop
1 May
PS start-up with protons
AAC start-up with protons
SPS & LEP start
Jul
Aug
Sep
Technical stop
MD
Jeune G.
run 2: LEP, SPS p+, LEAR physics, ISOLDE
SPS <-commissioning--> with Pb ions
PSB commissioning with Pb ions
<---PS commissioning---> with Pb ions
Shutdown
no access to PSB & PS on Monday
SPS start p+,e+,e-
LEAR SU
LEP stop
SPS physics stop
Oct
Nov
Dec
run 3: SPS Pb ions, LEP,
CPS Pb SU
SPS Pb SU
CPS stop
Xmas.
New Y.
Lepton stop
LEAR MD with Pb ions
PS Control tests (4th slice) from Thursday 15 - 8:00 am
: Linacs / PSB / PS MD session in parallel with LEP operation (7 hours on Wednesday from 6 am to 1 pm, 14 hrs on 13 July.)
LEAR Physics
Linacs 2 or 3, PSB, & PS MD
LPI MD
LEAR MD (p+ or pbar)
weeks with ISOLDE (see ISOLDE schedule)
weeks with East Hall (for details, see 4 week schedule)

FIG. 1

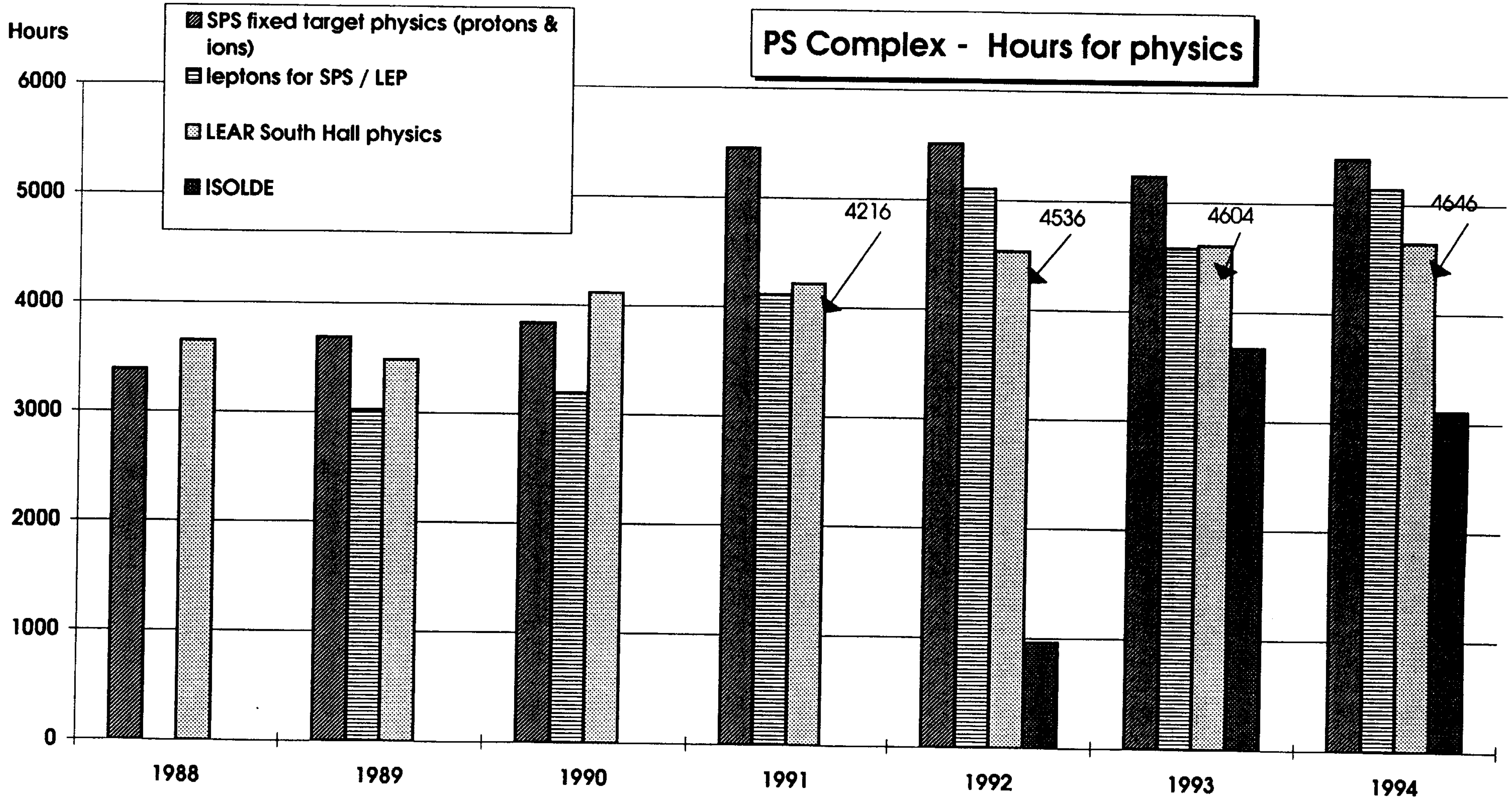

PS Complex - Hours for physics
Hours
6000
5000
4000
3000
2000
1000
0
SPS fixed target physics (protons & ions)
leptons for SPS / LEP
LEAR South Hall physics
ISOLDE
4216
4536
4604
4646
1988
1989
1990
1991
1992
1993
1994

Fig.2

BEAMS produced by the PS COMPLEX in 1994

Beam	av. intensity/cycle	Records or performance	availability
Leptons			
e+e- --->SPS - LEP	1.8 E11 *(2cycles: 1 e+, 1 e-)*		88.3%
Protons			
SPS	1.5 to 2.5 E13		88%
ISOLDE 71 experiments	.6 & 2.5 E13	3 E13 / PSB cycle	93.6%
EAST HALL (slow extr.) 43 experiments	3 E11		
EAST HALL (energy amplifier)	5 E8 to 5 E9	9 energies	
Pb ions			
Pb53+ (charges)	1.33 E10 (Booster)	2 E10 / cycle (Booster)	
Pb82+ (charges) ---> **SPS**	1.2 E10 (TT2)	1.7 E10 / cycle (TT2)	92.3%
Antiprotons			
AAC	*stacking rate: 1.9 E10 pbar/h*	*Max. Stack.: **1.07 E12** pbars*	
		AAC-LEAR transfer effic ---> **90%**	
LEAR & SOUTH HALL		7.34 E10 pbars at 1315 MeV/c	87.3%
11 experiments		2687 spills	

Fig. 3

1994 typical SUPERCYCLES

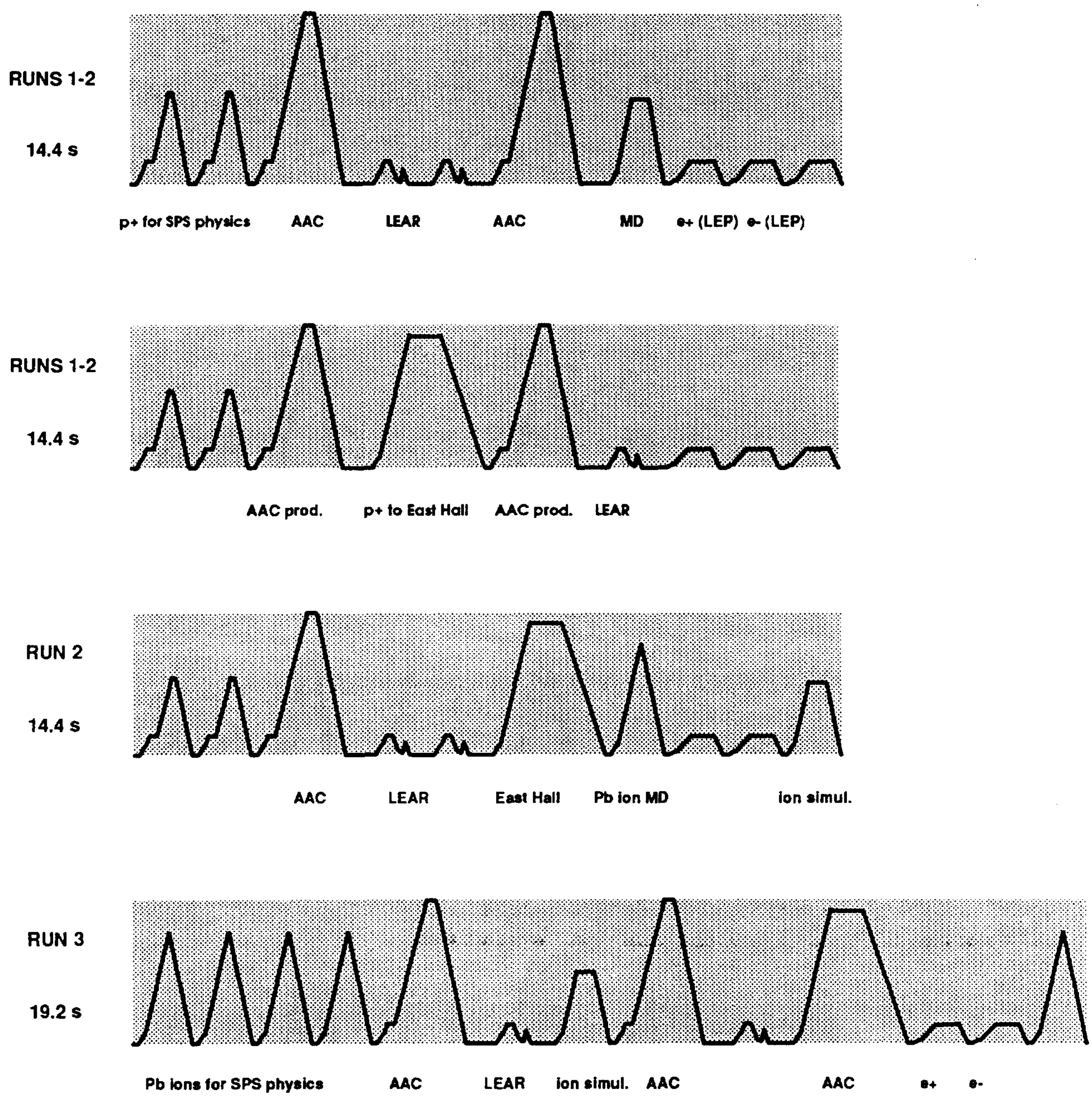


Fig. 4

1994 - PS Complex - Physics experiments supplied by LEAR

Period	Experiments	Momentum	pbars/s *(average)*	beam availability	AAC-->LEAR transfer eficiency
26/4 to 17/5	PS195 (CP Lear) in parallel with PS197 (XBarrel) then PS201 (Obelix)	200 MeV/c	7 E5	63%	70%
18/5 to 29/5	PS201 (Obelix)	415 Mev/c	2.5 E6	85%	72%
1/6 to 19/6	PS195 (CP Lear) in parallel with PS197 (XBarrel) & PS208 (Hot Nuclei)	200 MeV/c	6.5 E5	86%	75%
29/6 to 24/7	PS185 (Hyperons)	1440 MeV/c *(average)*	8 E5	86%	75%
25/7 to 15/8	PS197 (XBarrel) & PS208 (Hot Nuclei)	1940 MeV/c	1.5 E5 3 E5	93%	70%
16/8 to 4/9	PS202 (Jetset)	1000 to 2000 Mev/c		91%	61%
5/9 to 9/10	PS195 (CP Lear) & PS205 (Helium-Trap)	200 Mev/c	7 E5 2 E4	91%	79%
10/10 to 23/10	PS201 (Obelix) & PS194 (Ionization)	105 MeV/c	5 E4 1 E5	93%	87%
9/11 to 25/11	PS201 (Obelix) & PS197 (XBarrel)	105 MeV/c	5 E4 5 E4	97%	85%
25/11 to 14/12	PS207 (LEX)	105 MeV/c	5 E5	88%	82%
18 weeks	PS196 (Penning Trap) & PS200T (GRAV)	105 MeV/c *(fast extraction)*			

Fig. 5

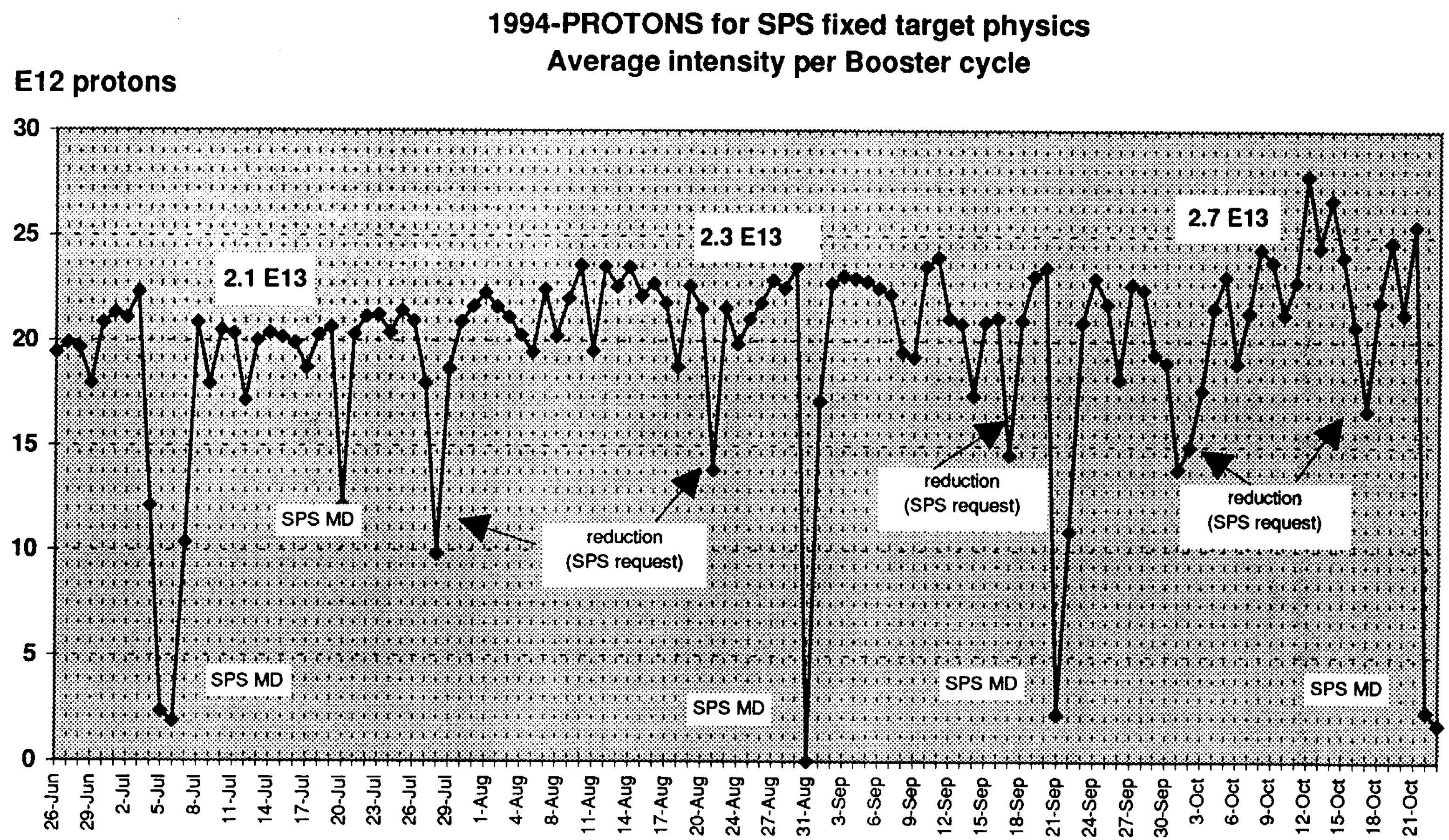


Fig. 6

SFTPRO.XLS

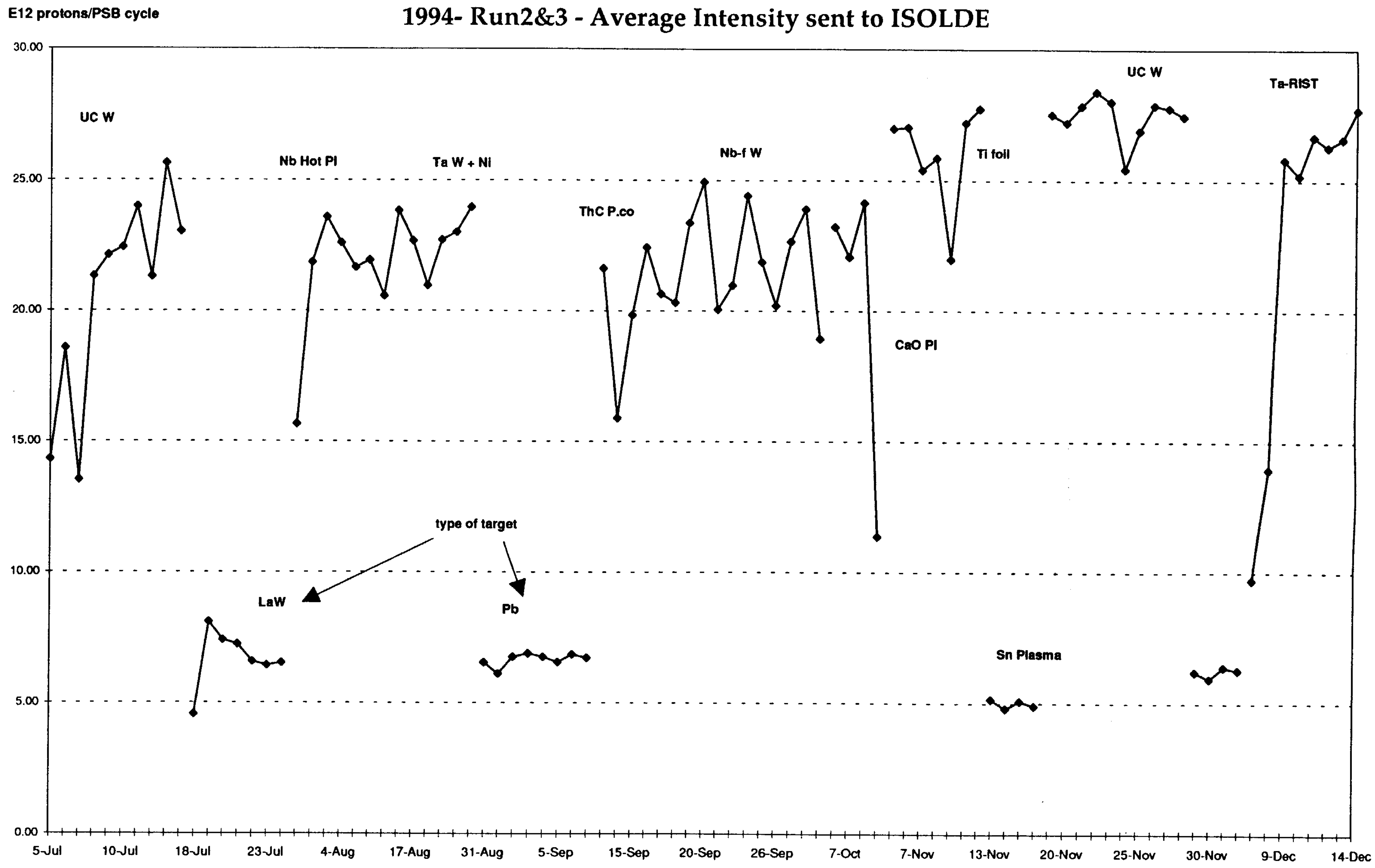


Fig. 7

RUN2&3.XLS

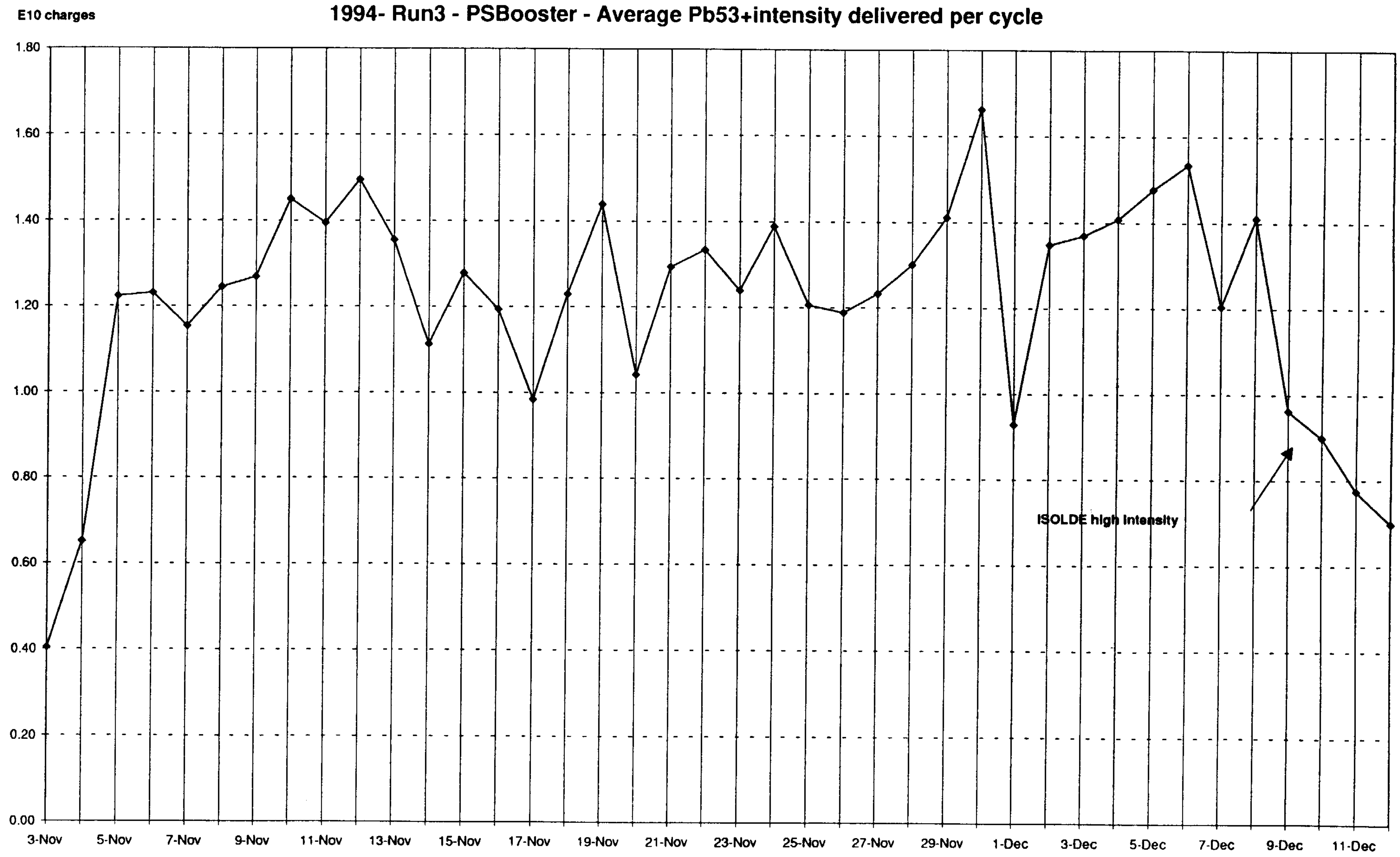


Fig. 8

ION94.XLS

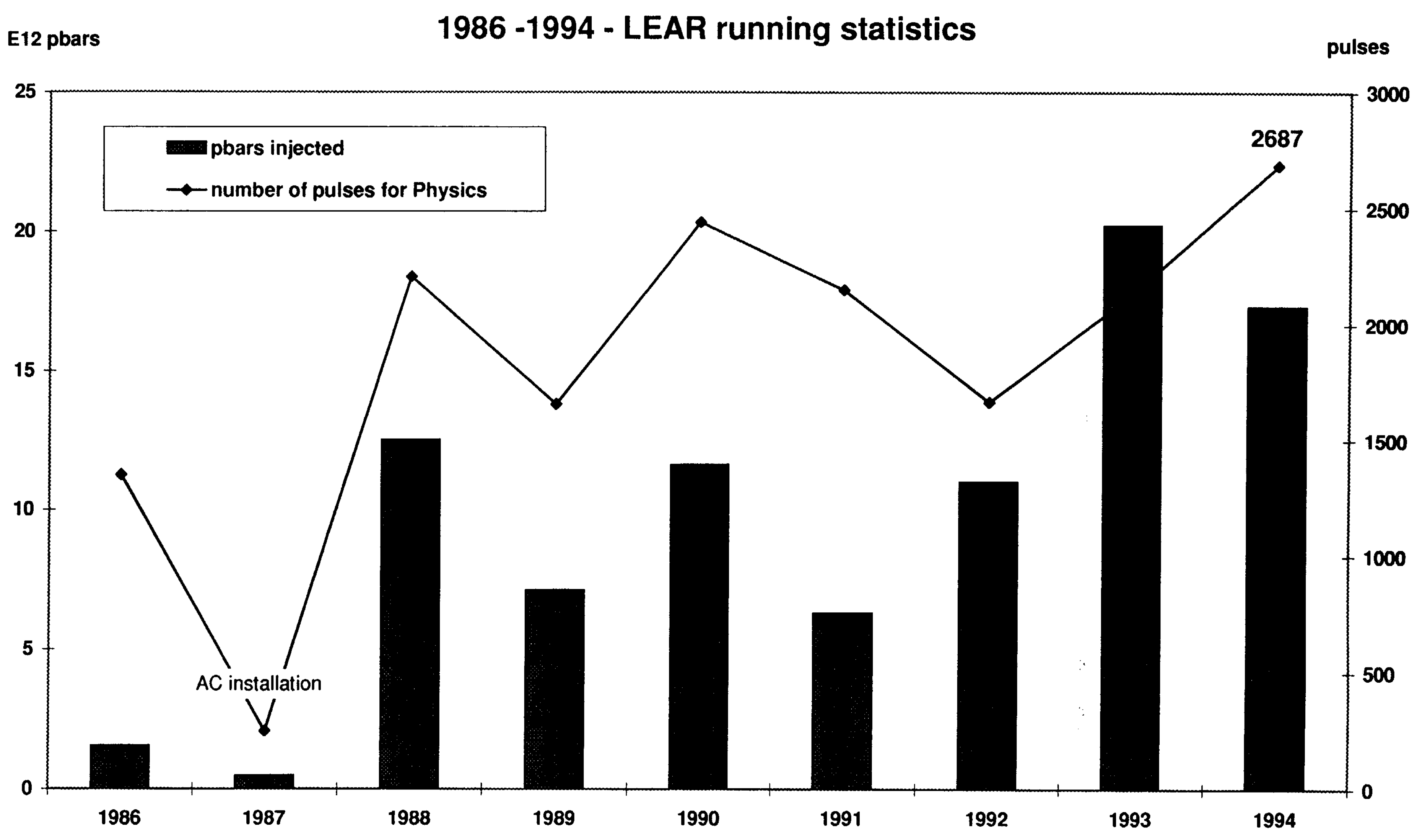
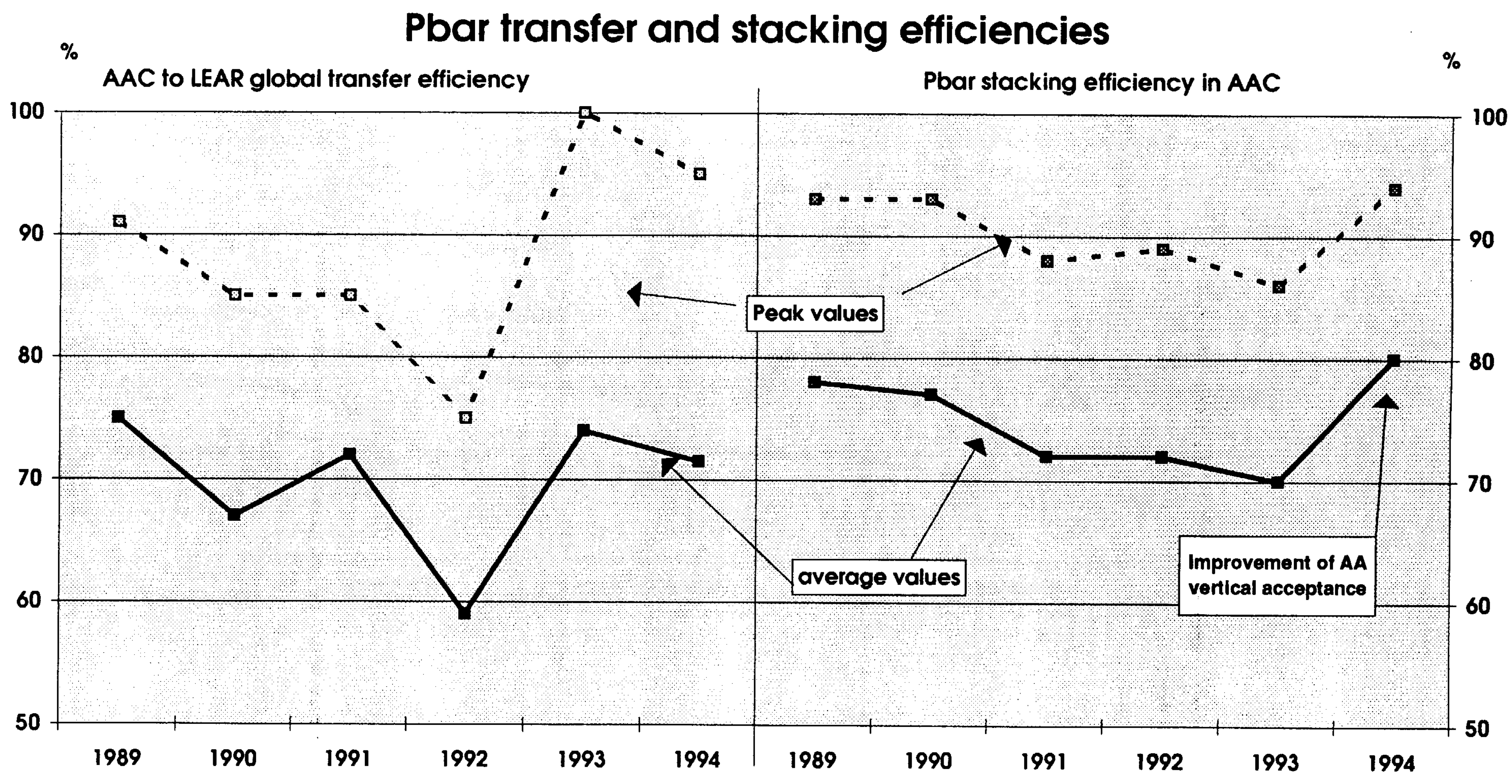


Fig. 9

pbareff.xls|Lear stat



Pbar transfer and stacking efficiencies
%
AAC to LEAR global transfer efficiency
Pbar stacking efficiency in AAC
%
100
90
80
70
60
50
1989
1990
1991
1992
1993
1994
Peak values
average values
Improvement of AA
vertical acceptance

Fig. 10

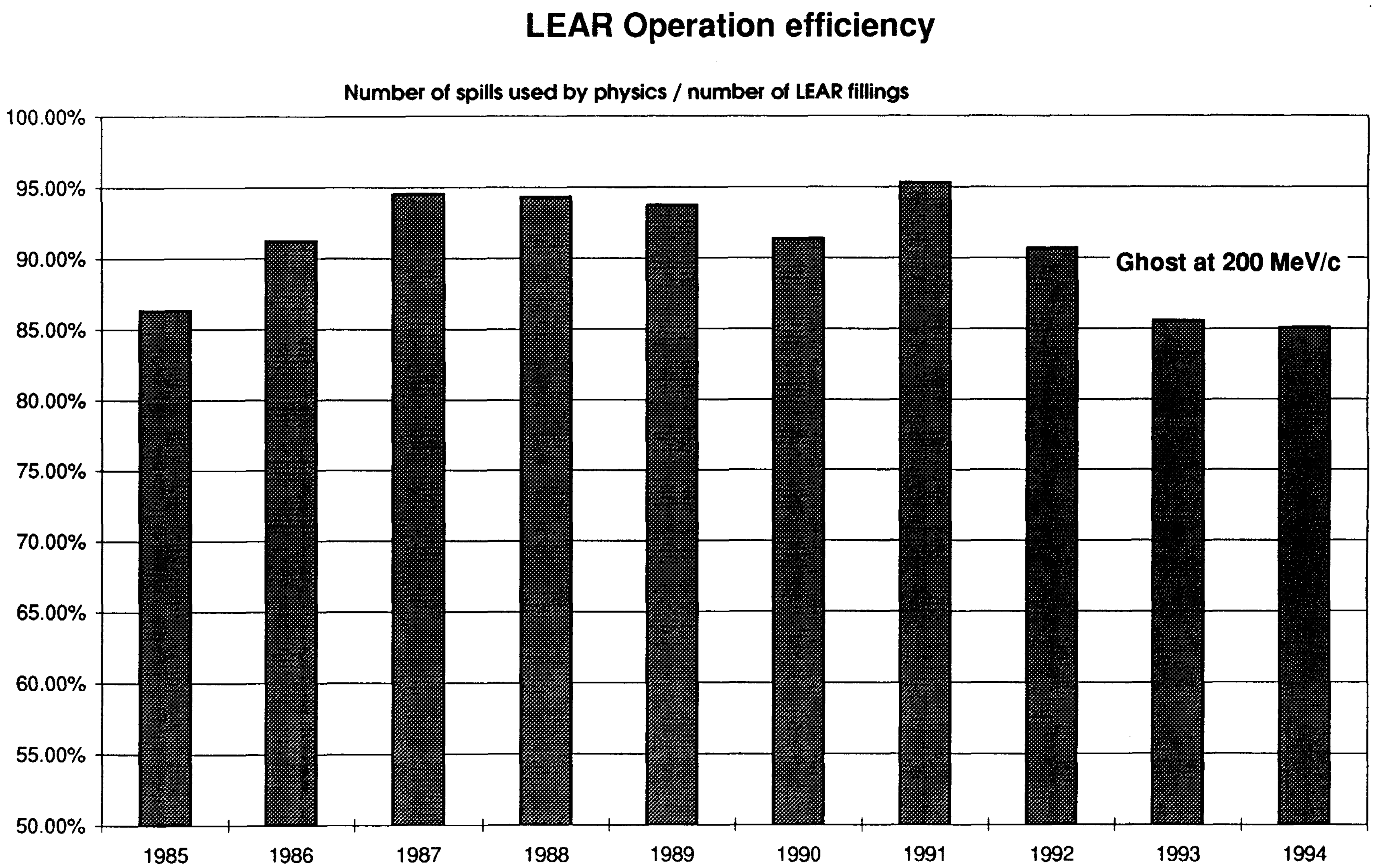
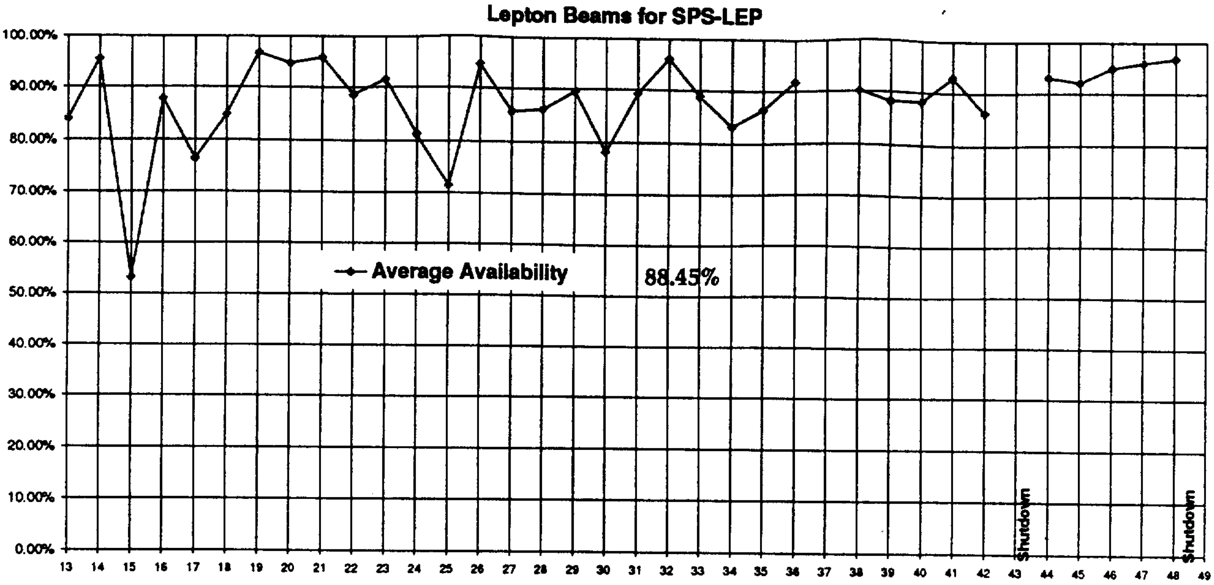
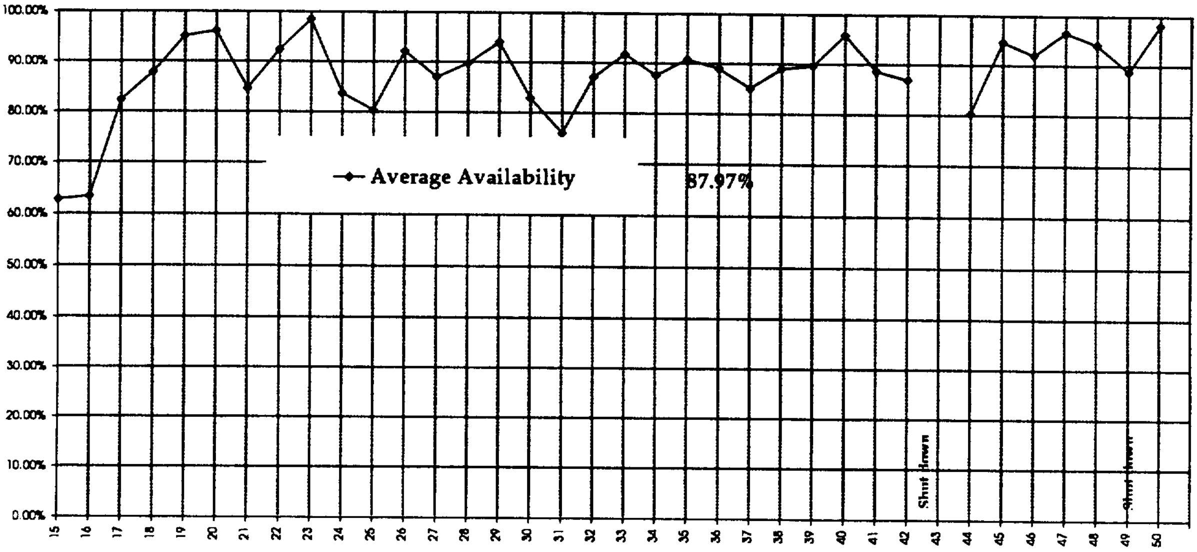

LEAR Operation efficiency
Number of spills used by physics / number of LEAR fillings
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
Ghost at 200 MeV/c
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994

Fig. 11

Lepton Beams for SPS-LEP



Proton and Pb ion beams for SFS fixed target physics



Antiproton Beams fort South Hall Users

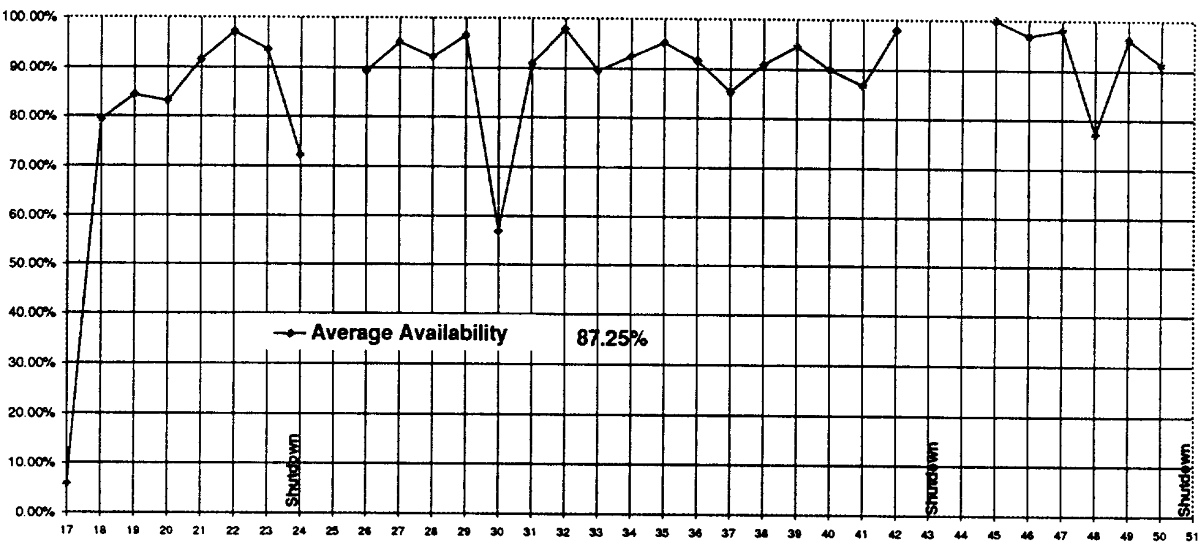
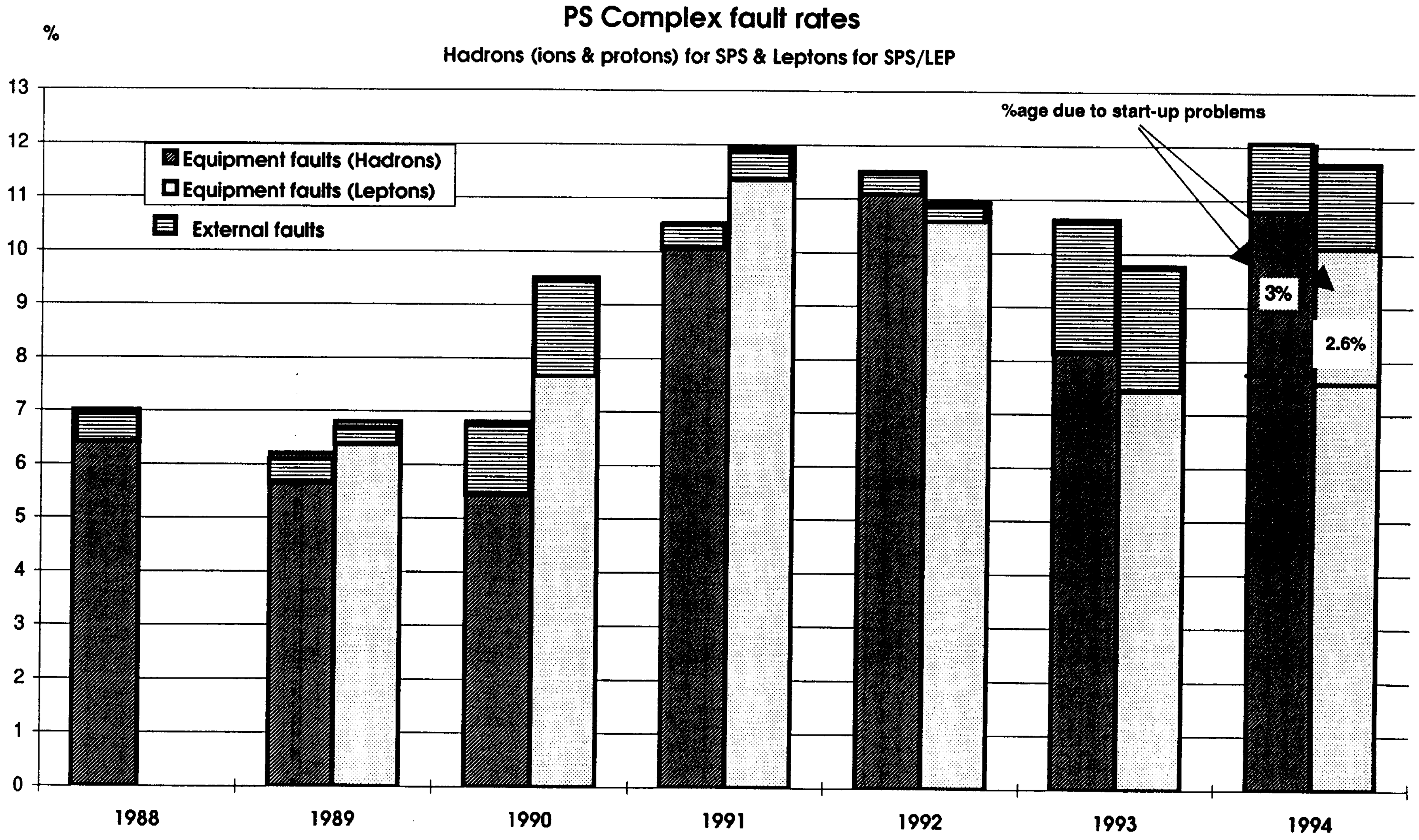


Fig. 12 - Beam availabilities in 1994

LEPAVAIL.XLC



PS Complex fault rates
Hadrons (ions & protons) for SPS & Leptons for SPS/LEP
%
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Equipment faults (Hadrons)
Equipment faults (Leptons)
External faults
%age due to start-up problems
3%
2.6%
1988
1989
1990
1991
1992
1993
1994

Fig. 13

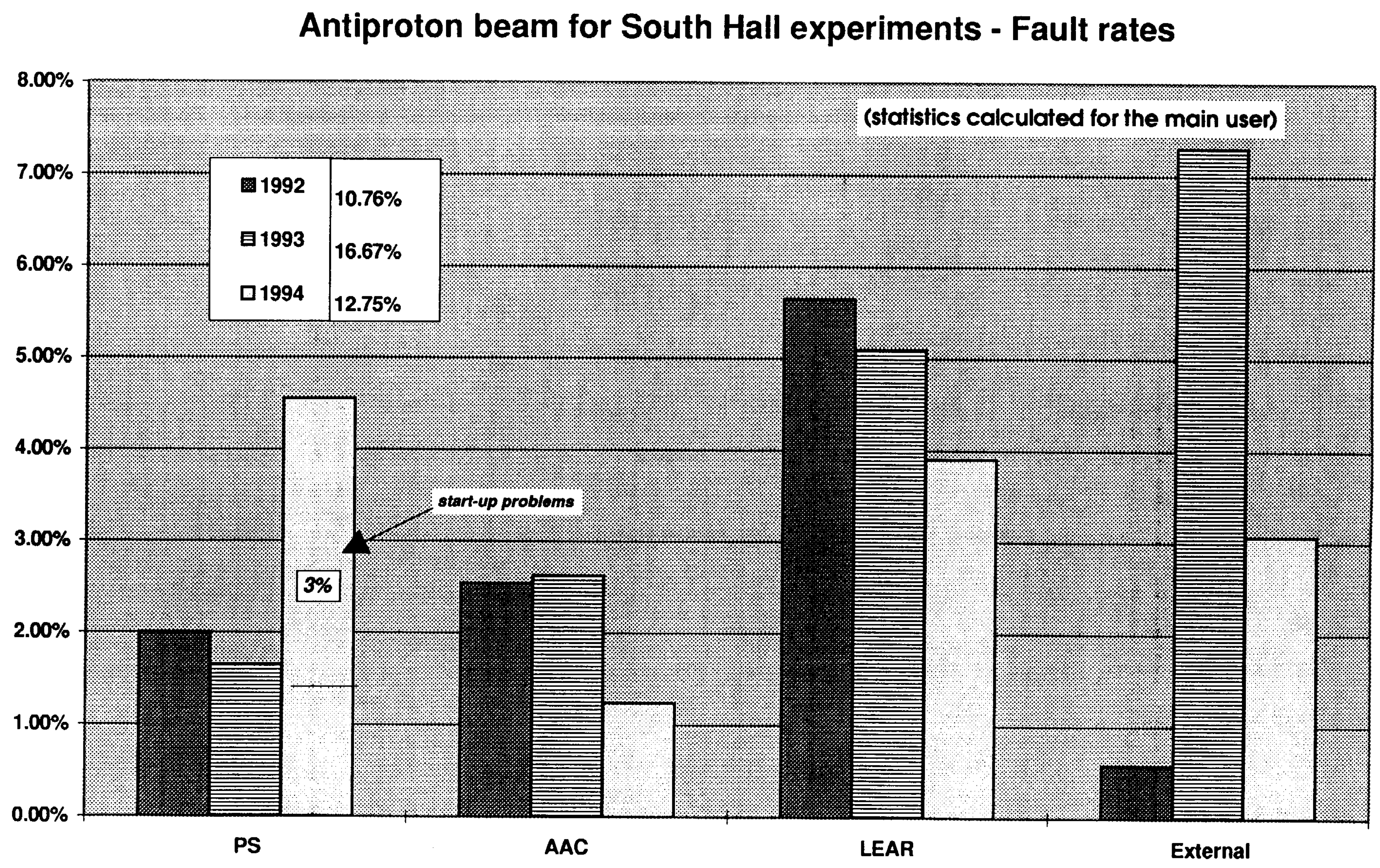
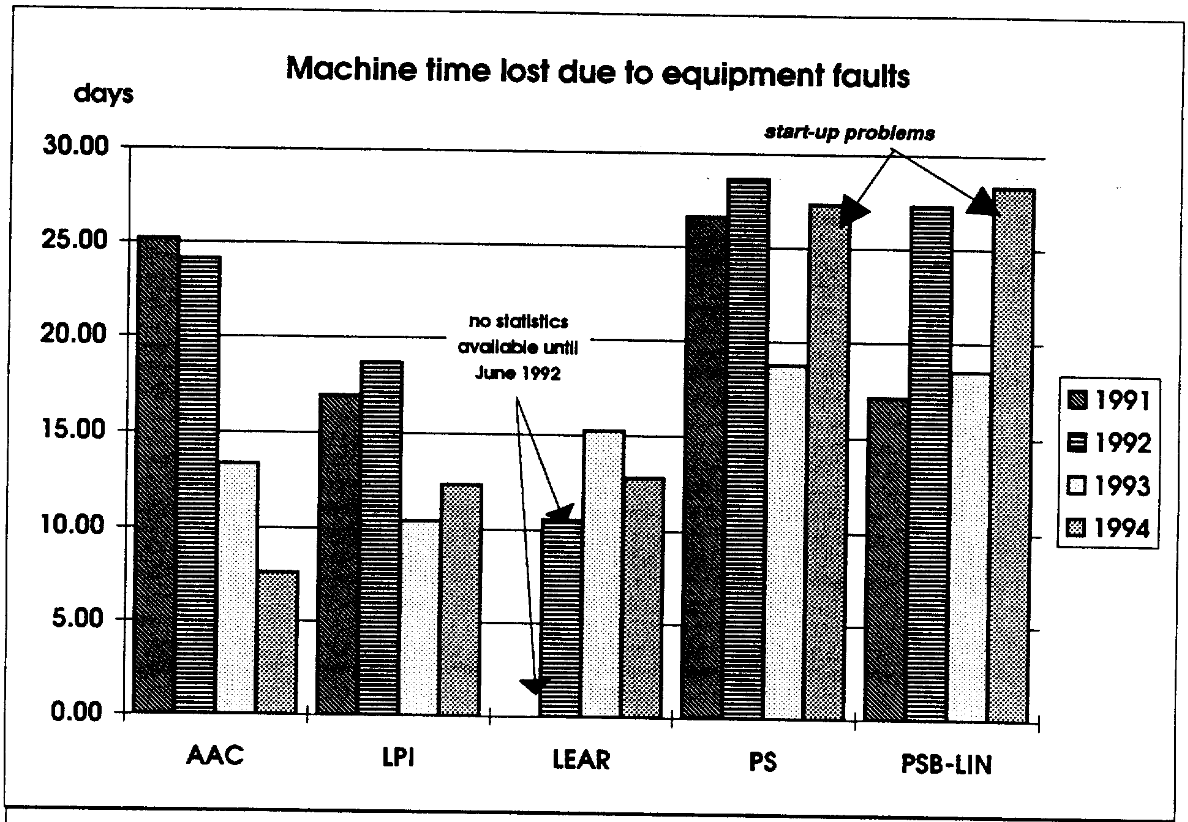

Antiproton beam for South Hall experiments - Fault rates
(statistics calculated for the main user)
1992
10.76%
1993
16.67%
1994
12.75%
start-up problems
3%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
PS
AAC
LEAR
External

Fig. 14

Evolution of the fault time per machine (equipment and external faults)



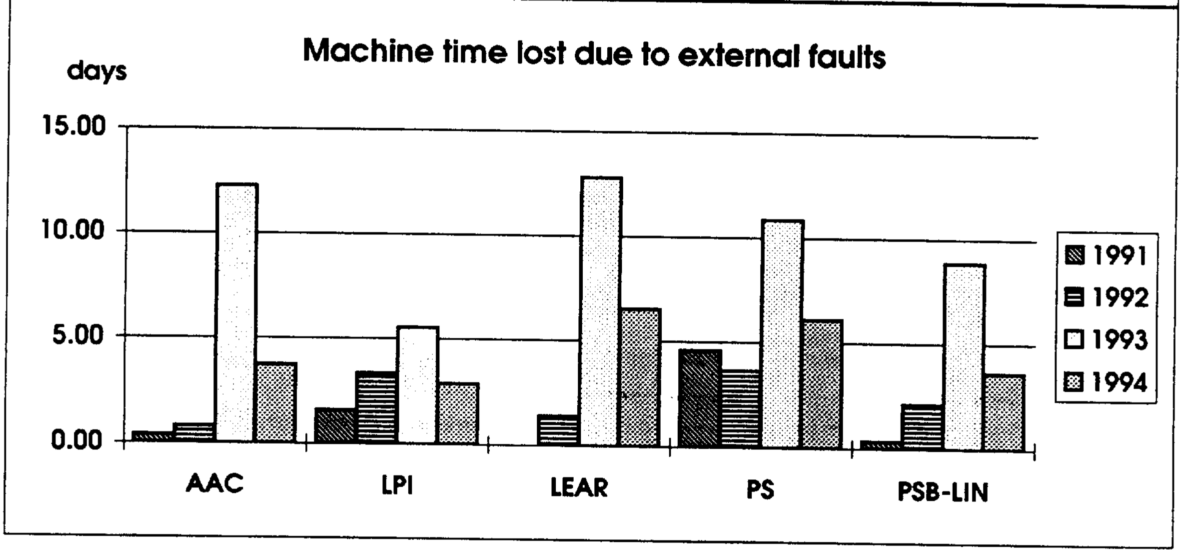


Fig. 15

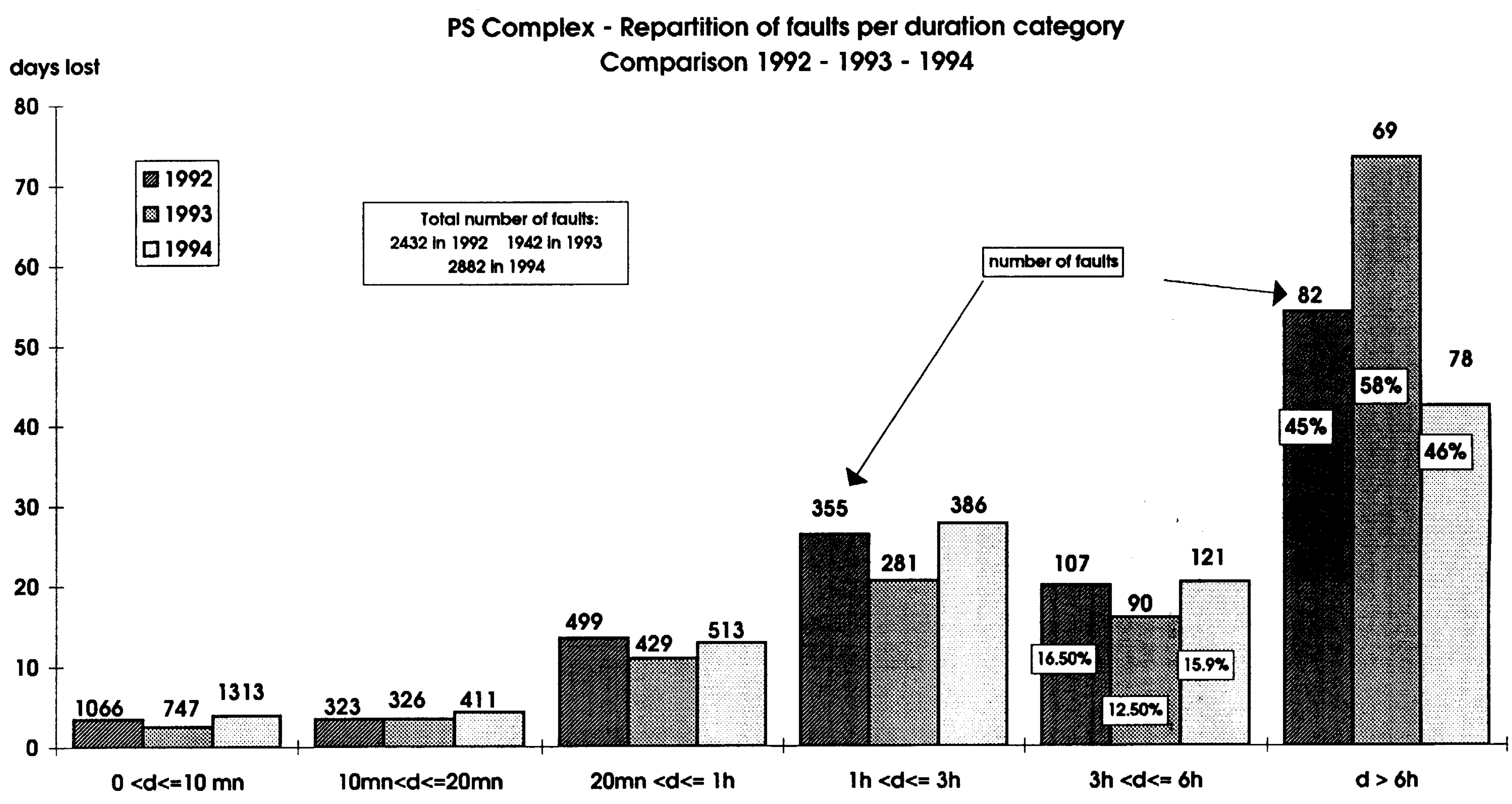

PS Complex - Repartition of faults per duration category
Comparison 1992 - 1993 - 1994
days lost
80
70
60
50
40
30
20
10
0
1992
1993
1994
Total number of faults:
2432 in 1992 1942 in 1993
2882 in 1994
number of faults
1066
747
1313
323
326
411
499
429
513
355
281
386
107
90
121
16.50%
12.50%
15.9%
82
69
78
45%
58%
46%
0 <d<=10 mn
10mn<d<=20mn
20mn <d<= 1h
1h <d<= 3h
3h <d<= 6h
d > 6h

Fig. 16

Distribution

D.J. Simon
M. Bouthéon
B.W. Allardyce

J. Boillot
J.P. Delahaye
R. Garoby
J. Gruber
H. Haseroth
H. Koziol
S. Maury
F. Perriollat
J.P. Riunaud

S. Baird
R. Cappi
T. Camporesi/PPE
D. Dagan
D. Dekkers
M. Doser/PPE
L. Evans/DG
A. Faugier/SL
B. Frammery
J-Y. Hemery
K. Hübner/DG
K. Schindl
A. Schopper/PPE
Ch. Steinbach
O. Tengblad/PPE
E. Wildner