EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE

CERN - PS DIVISION

PS/ PA/ Note 96-06 (PPC)

PROCEEDINGS OF THE PS PERFORMANCE DAY (PPD '96)

Edited by D. Manglunki

Abstract

The PS Performance Day, organised by the PS Performance Committee, was held in Chavannes-de-Bogis, Vaud, Switzerland on 16 February 1996. The first two sessions covered the beam performance of all the machines of the PS complex in 1995, their expected performance and their required machine study periods in 1996. The third session was devoted to the new developments and projects under way in the PS division, in view of the short- (generalisation of the ABS, new antiproton deceleration dedicated facility), medium- (LHC beams, laser ion source), and long- (CLIC) term future. The last session consisted of short summaries underlining, for each group of machines, the current issues facing the specialists in charge.

PS Performance Day (PPD '96) held in Chavannes-de-Bogis (Vaud, Switzerland), on February 16th 1996

Geneva, Switzerland
15 March 1996

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PS Performance Day 1996

PS Complex performance in 1995

Jean BOILLOT

Abstract

In 1995, the running time of the PS Complex exceeded 6680 hours with an overall beam availability better than during the previous years: about 92% for the different beams delivered to SPS and LEP, 94% for the ISOLDE beam and 87% for the antiproton beams serving the LEAR experiments.

The lepton beams ran well with a good regularity. The 2 lepton cycles were advanced to the 9th and 10th slots of the PS supercycle. This interesting improvement allowed better flexibility for machine developments and operations.

After various optimisations carried out on the Linac2, Booster and PS, good results were obtained with the intensity delivered to SPS fixed target physics reaching 2.3 to 2.5 10^{13} protons per PS cycle, intensity which was maintained during the 2 physics runs.

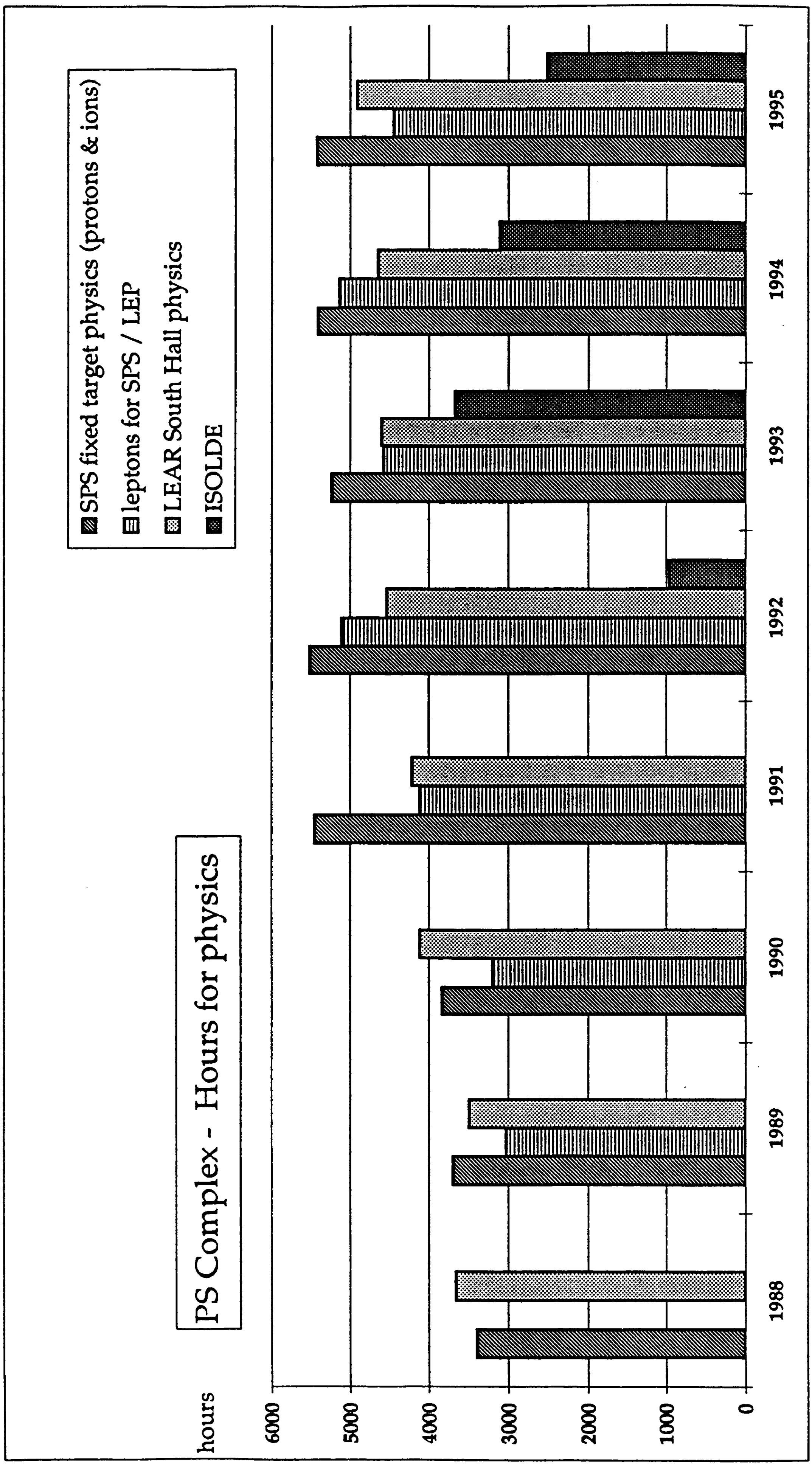
The proton intensity for ISOLDE very often reached 2.9 to 3 10^{13} protons per pulse. ISOLDE also worked at low intensity for several experiments and used for the first time the staggered extraction of 3 Booster rings.

The East Hall test experiments ran during 25 weeks with the classical PS slow extraction of protons at 24 GeV/c.(about 1.1 10^{6} spills shared between 40 physics groups)

After a careful commissioning with Pb ions of Linac3, PSB and PS the operational run was very successful for these beams serving SPS fixed target physics for the second year. An average of 1.7 10^{10} charges of Pb^{82+} per cycle was currently provided for SPS.

AAC worked well over this year with an average stacking efficiency of 79% and a good availability for physics (97.5%).

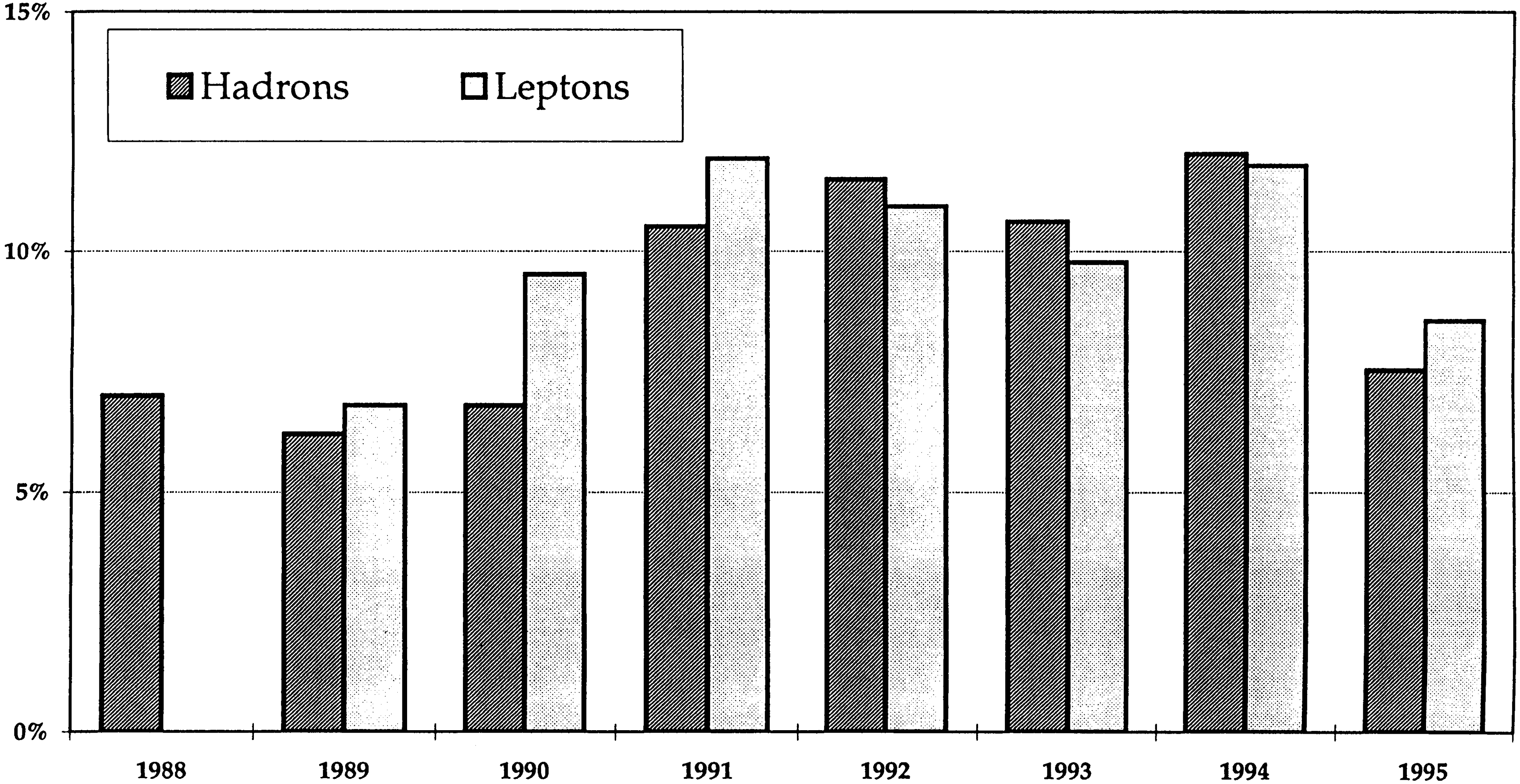
LEAR ran for 11 different experiments with a record of 4196 spills delivered for physics and a total intensity of 2.2 10^{13} antiprotons injected in the machine. Unfortunately, the average transfer efficiency from AAC to LEAR went down to 61% due to numerous problems affecting AAC, PS and LEAR Nevertheless a very effective improvement was carried out in order to compensate the non-understood instabilities at 200 MeV/c. Another good performance was achieved in LEAR with a spill duration of 14 hours at 310 MeV/c.



HOURS.XLSChart

PS Complex fault rates

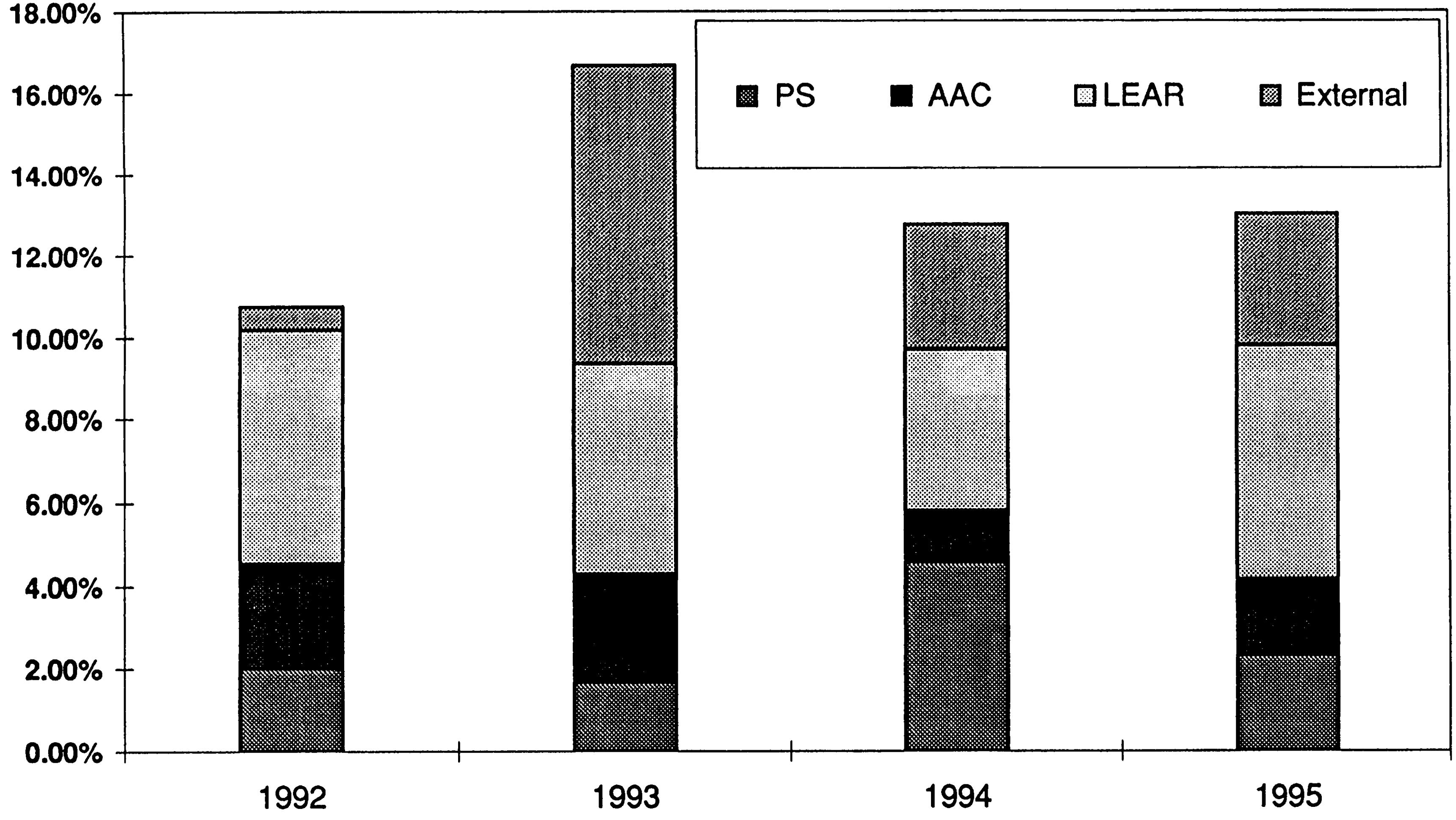
Hadrons (ions & protons) for SPS & Leptons for SPS/LEP



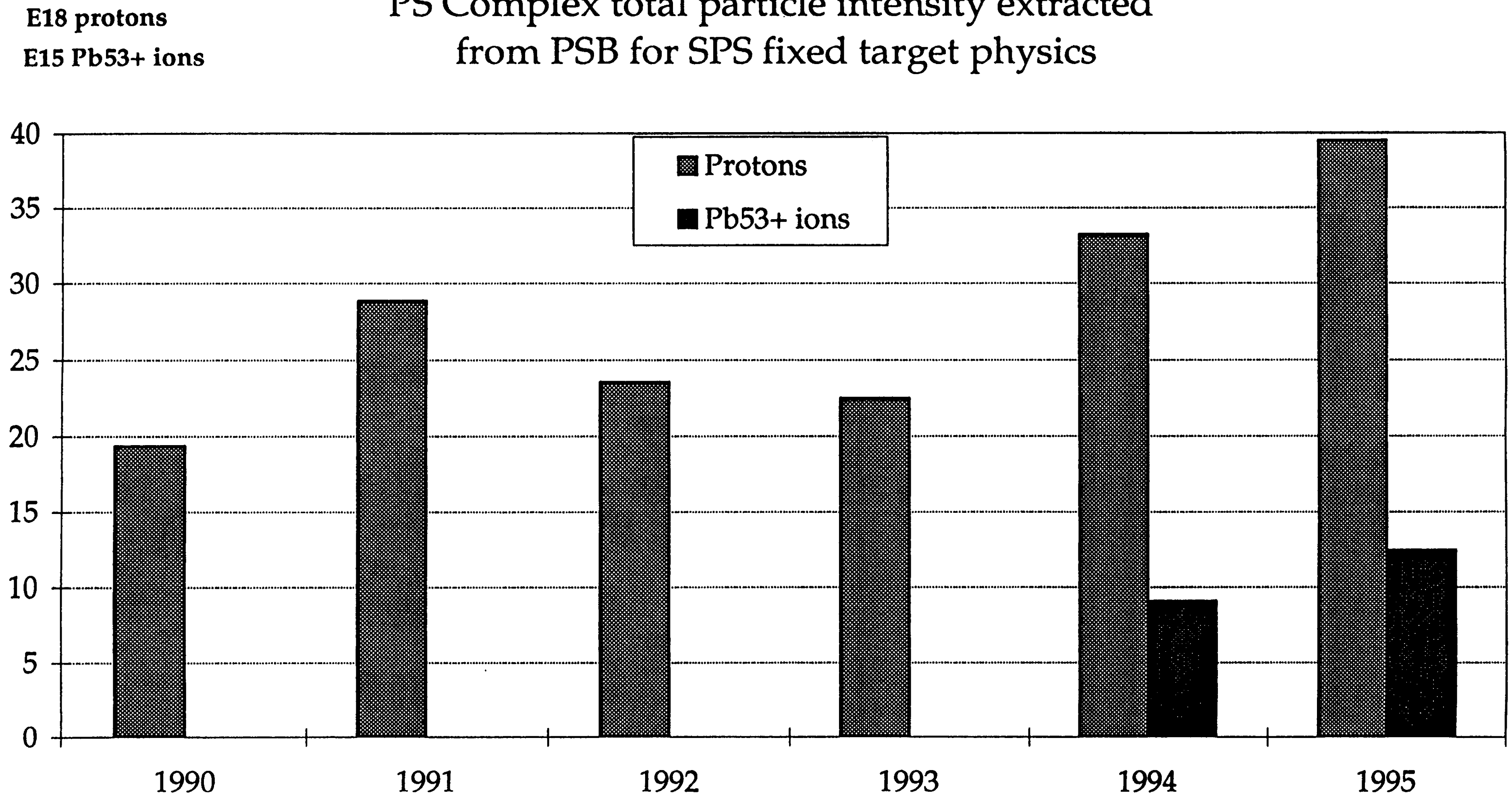
HOUR_INT.XLSfault rates

Antiproton beam for South hall Experiments - Fault rates

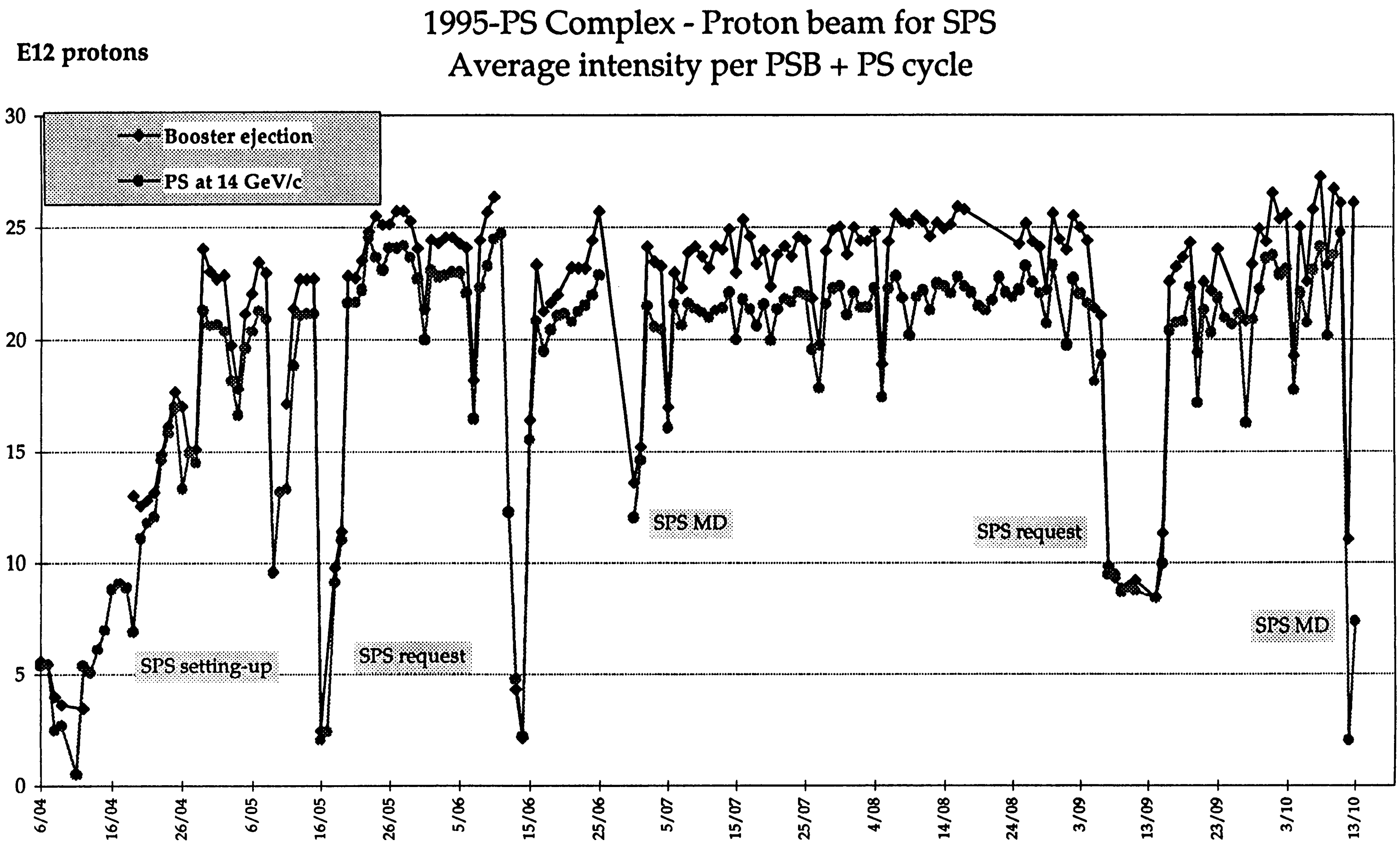
(statistics calculated for the main user)



PS Complex total particle intensity extracted from PSB for SPS fixed target physics

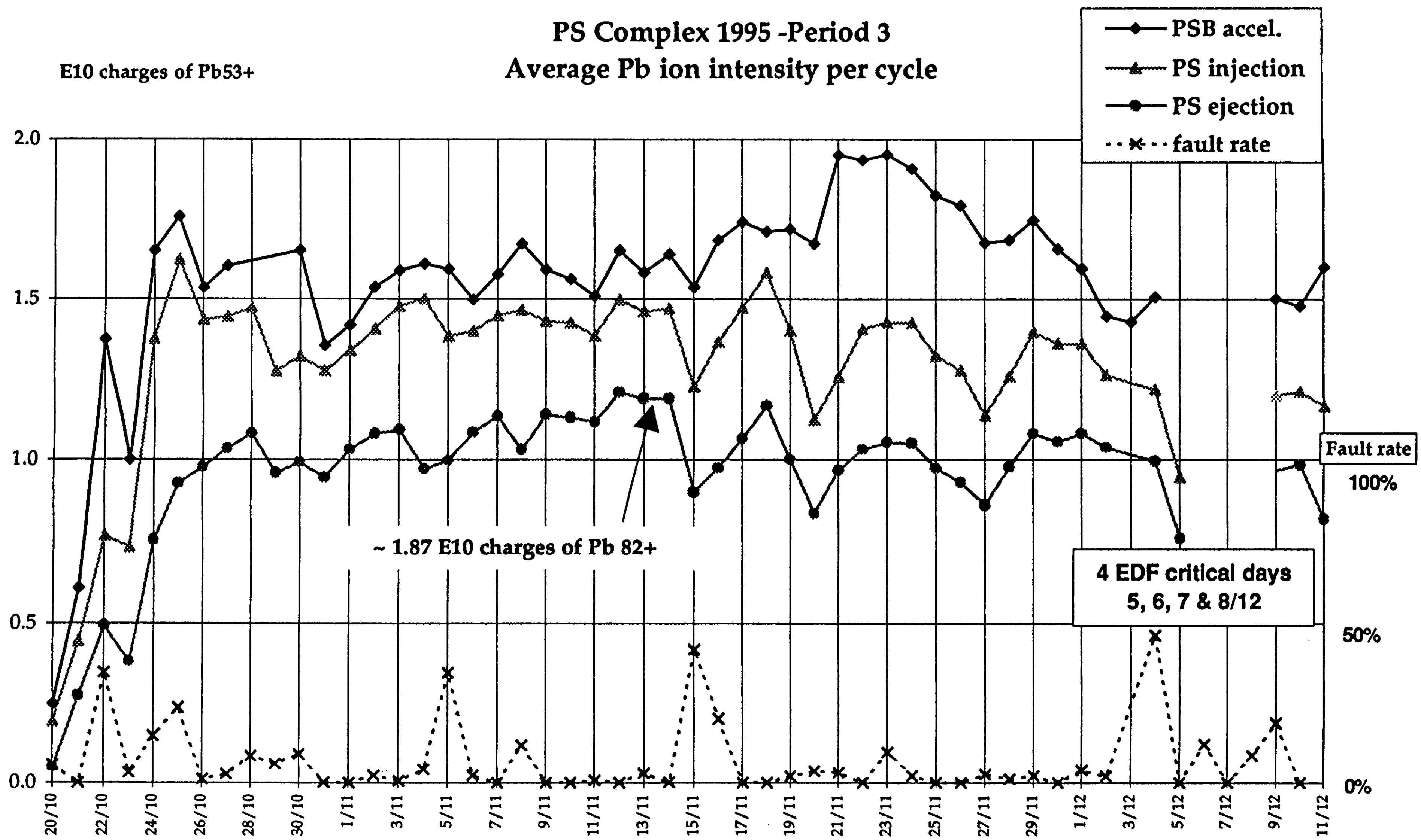


HOUR_INT.XLStotal intensity (p+ & Pb ions)



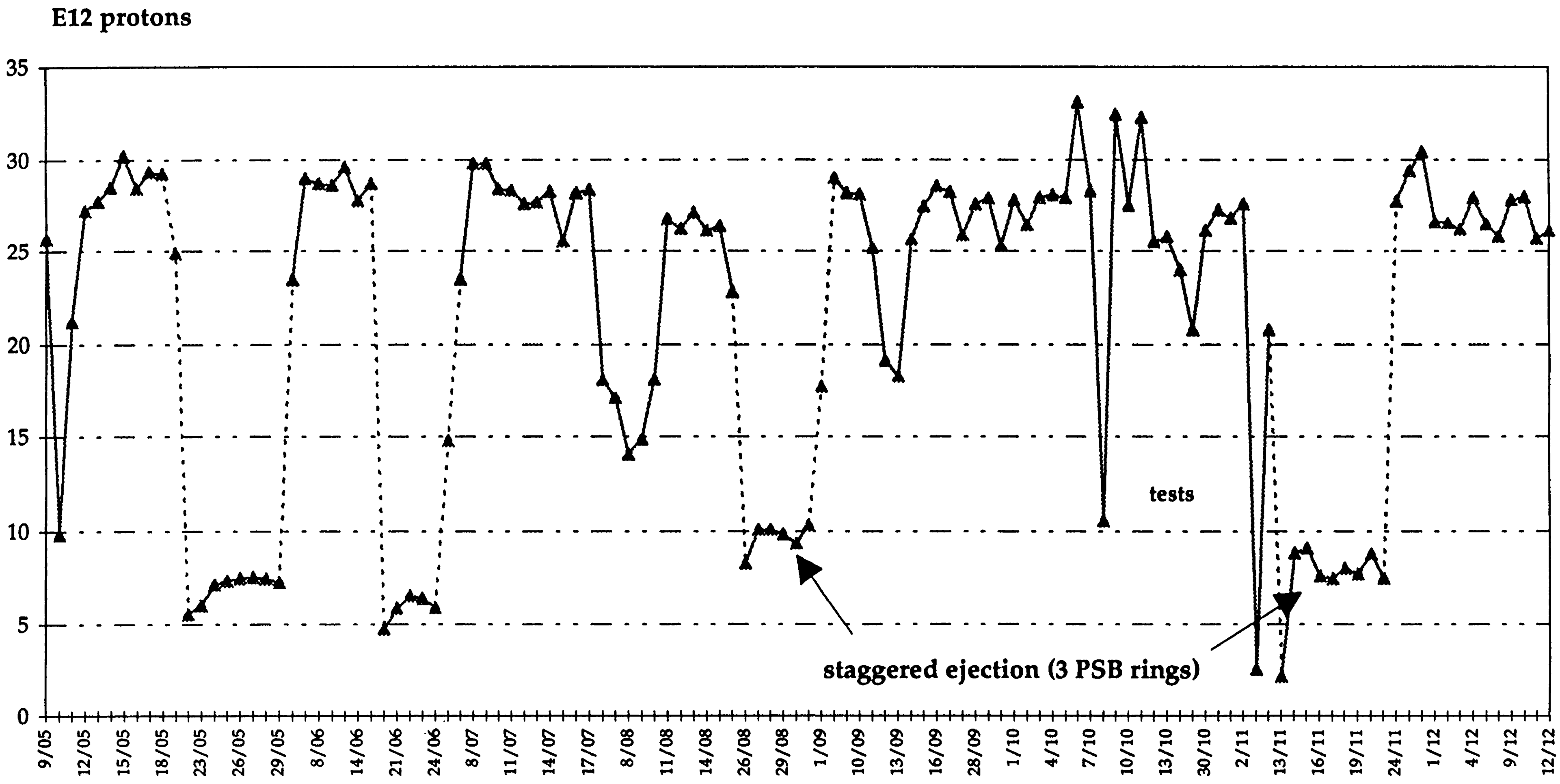
E12 protons
1995-PS Complex - Proton beam for SPS
Average intensity per PSB + PS cycle
Booster ejection
PS at 14 GeV/c
30
25
20
15
10
5
0
6/04
16/04
26/04
6/05
16/05
26/05
5/06
15/06
25/06
5/07
15/07
25/07
4/08
14/08
24/08
3/09
13/09
23/09
3/10
13/10
SPS setting-up
SPS request
SPS MD
SPS request
SPS MD

SFTPRO.XLS

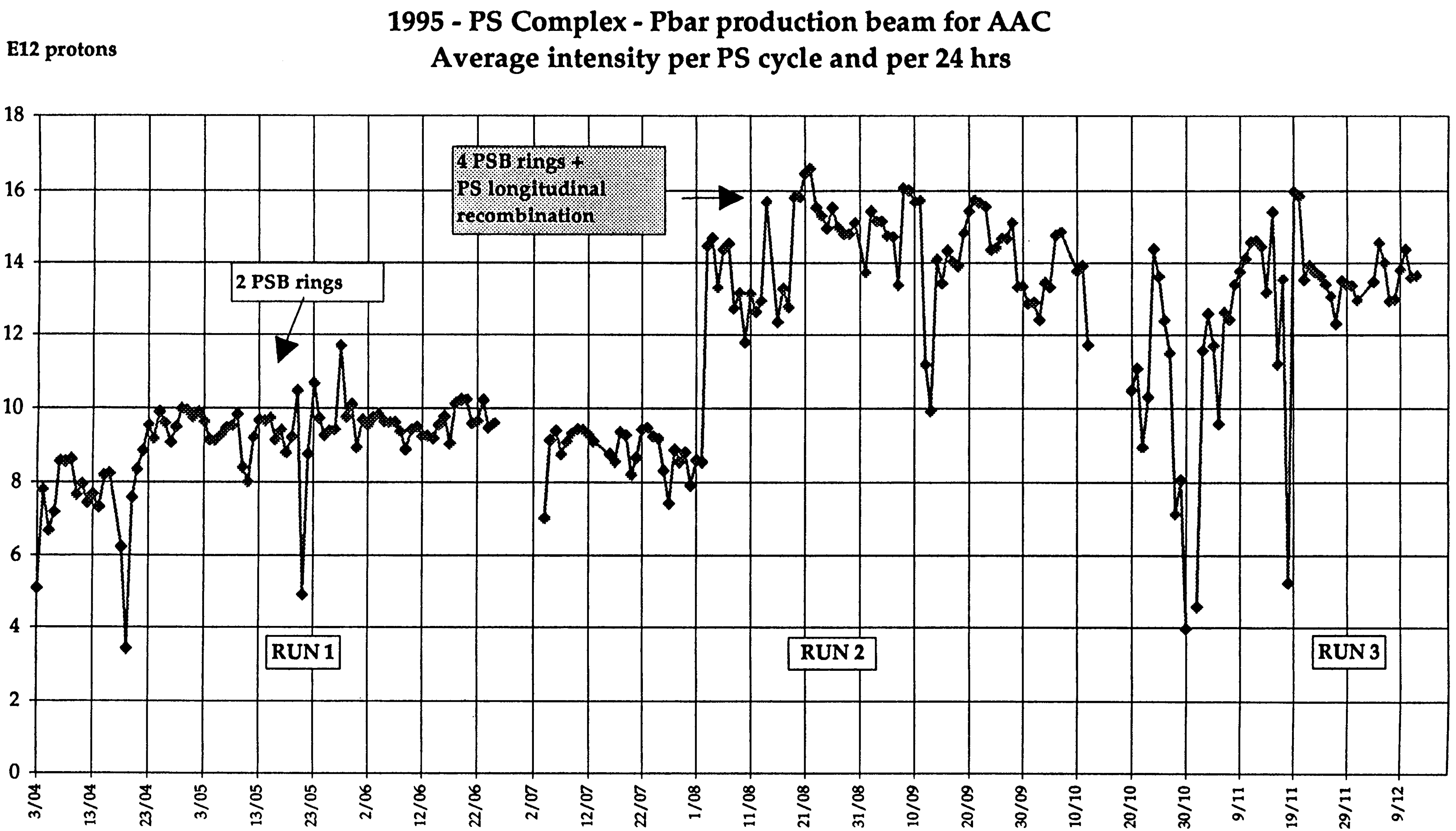

PS Complex 1995 -Period 3
Average Pb ion intensity per cycle
E10 charges of Pb53+
PSB accel.
PS injection
PS ejection
fault rate
~ 1.87 E10 charges of Pb 82+
4 EDF critical days
5, 6, 7 & 8/12
Fault rate
100%
50%
0%
2.0
1.5
1.0
0.5
0.0
20/10
22/10
24/10
26/10
28/10
30/10
1/11
3/11
5/11
7/11
9/11
11/11
13/11
15/11
17/11
19/11
21/11
23/11
25/11
27/11
29/11
1/12
3/12
5/12
7/12
9/12
11/12

SFTION.XLS

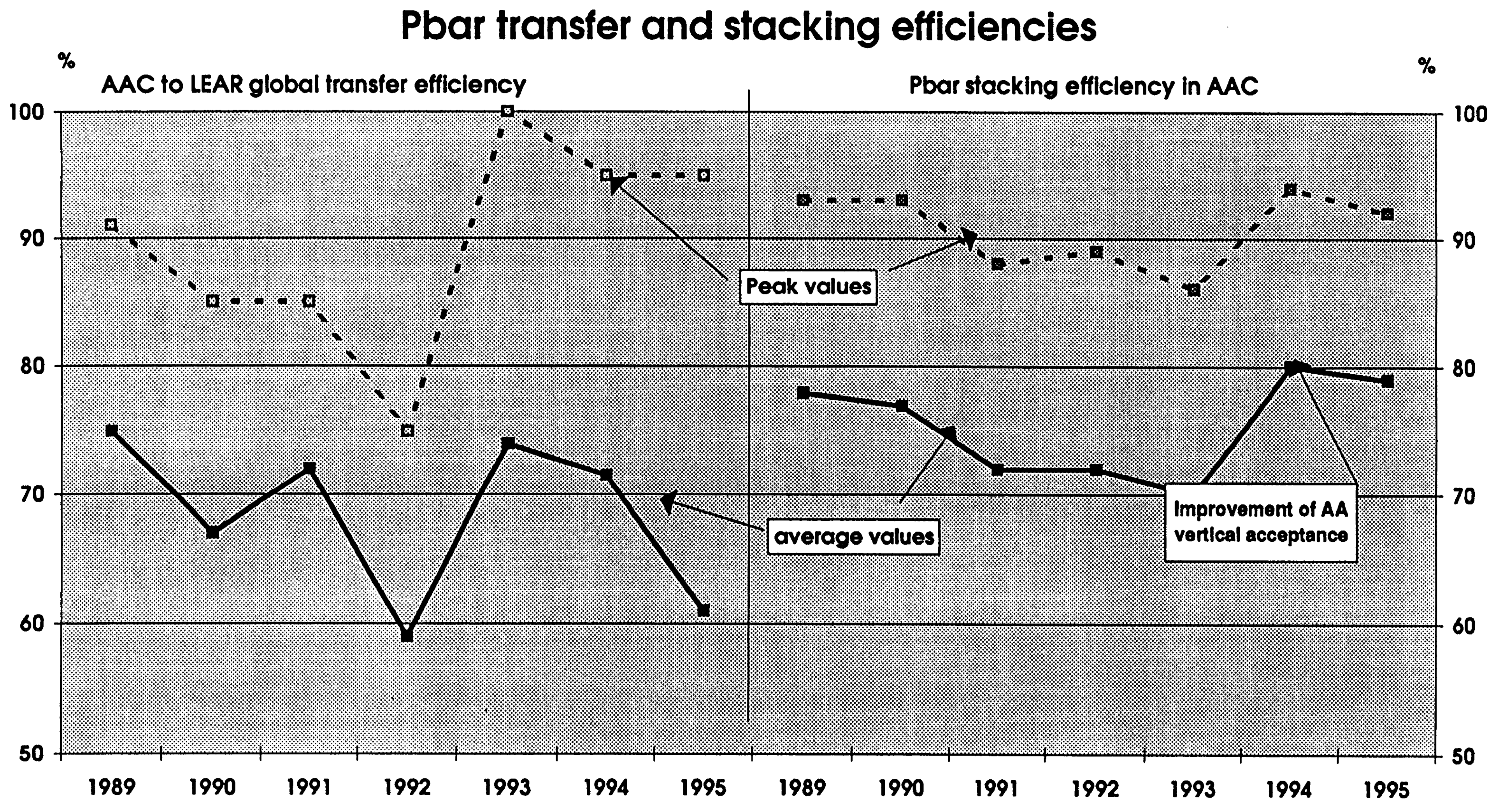
1995 - Proton Beam for ISOLDE - Average intensity per PSB cycle and per 24 hrs



ISOPRO.XLS

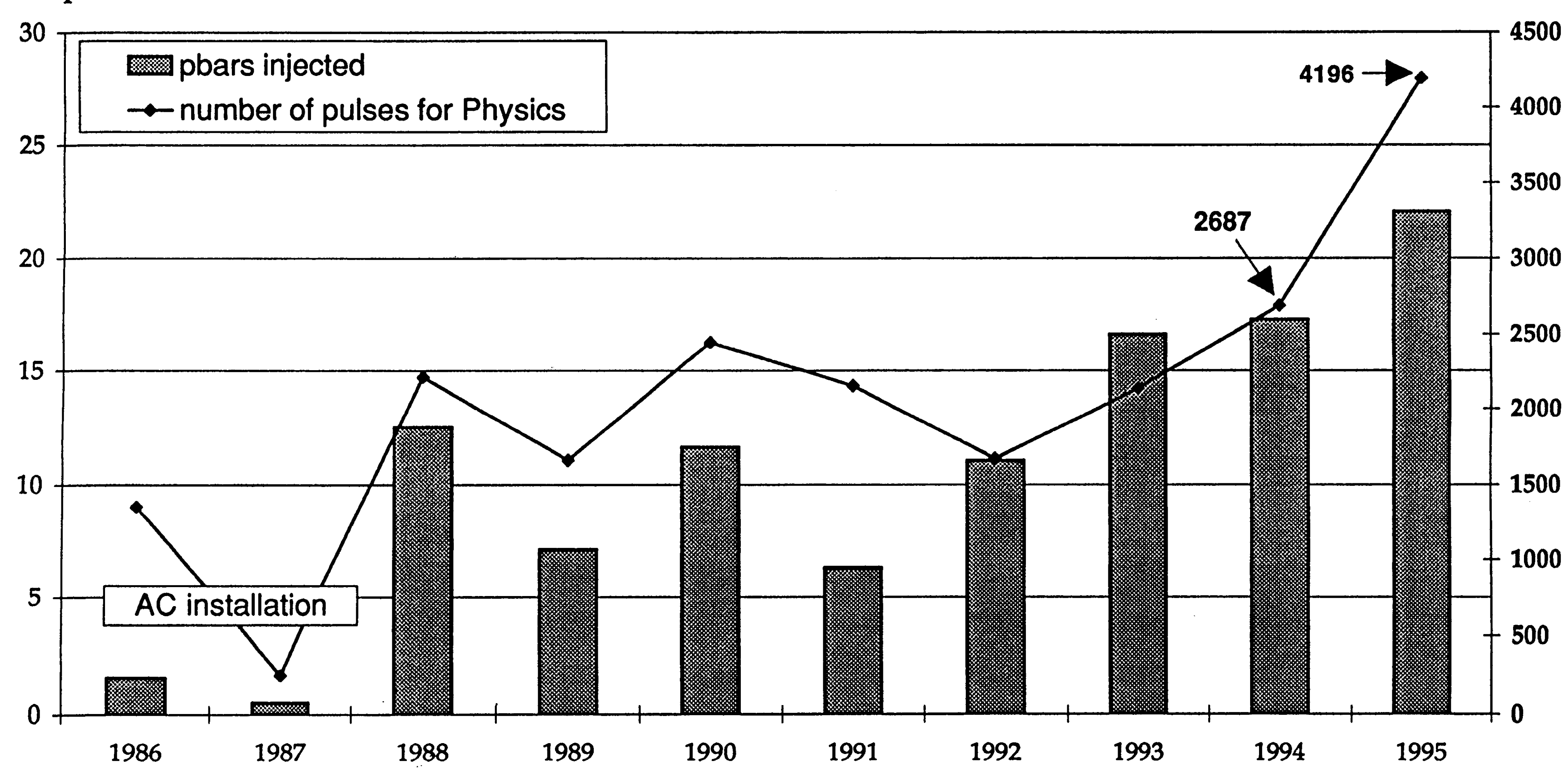

1995 - PS Complex - Pbar production beam for AAC
Average intensity per PS cycle and per 24 hrs
E12 protons
0
2
4
6
8
10
12
14
16
18
2 PSB rings
4 PSB rings +
PS longitudinal
recombination
RUN 1
RUN 2
RUN 3
3/04
13/04
23/04
3/05
13/05
23/05
2/06
12/06
22/06
2/07
12/07
22/07
1/08
11/08
21/08
31/08
10/09
20/09
30/09
10/10
20/10
30/10
9/11
19/11
29/11
9/12

AA_PSPSB.XLS



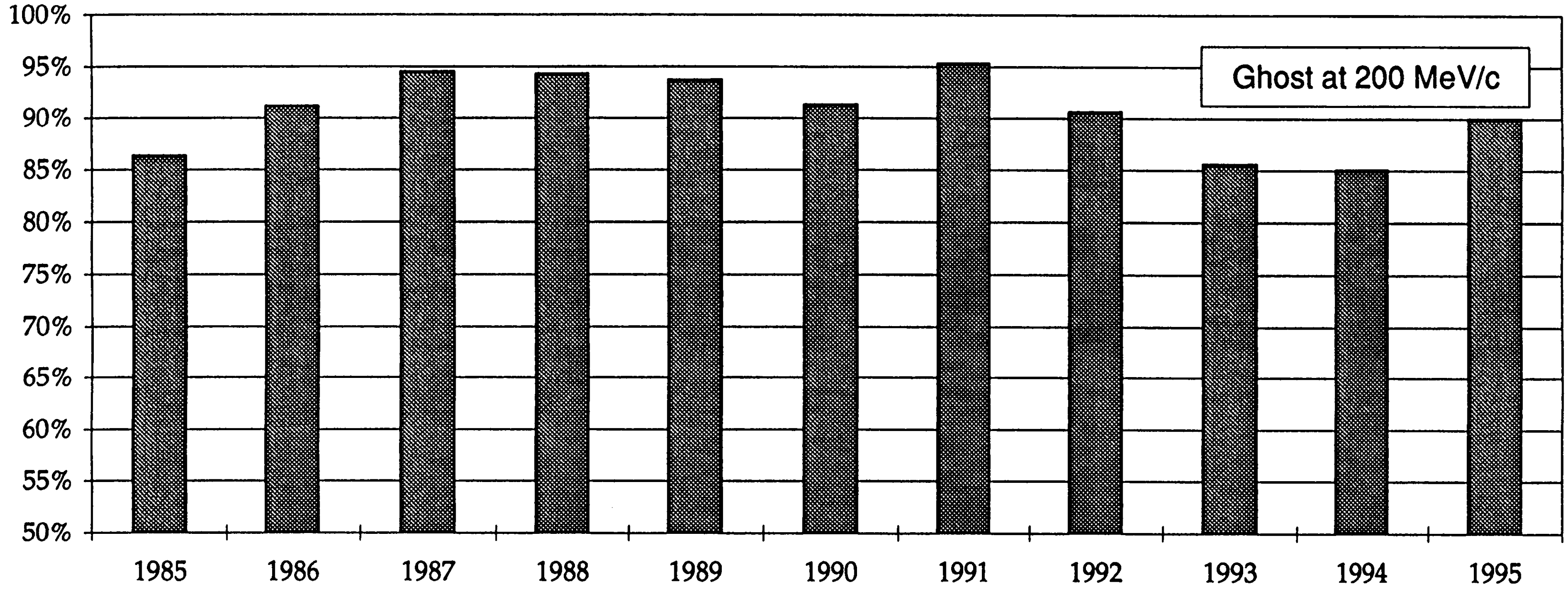
PBAREFF.XLSAAC-transfer-efficiency

1986 -1995 - LEAR running statistics



LEAR Operation efficiency

Number of spills used by physics / number of LEAR fillings



PBAREFF.XLS

BEAMS produced by the PS COMPLEX in 1995

Beam	av. intensity/cycle	improvements & records	availability
Leptons			
e+e- —>SPS - LEP	2 E11	2 lepton cycles on 9th & 10th basic periods	91.5%
Protons			
SPS	2 to 2.5 E13	high intensity	92.5%
ISOLDE 44 experiments	.6 & 3 E13	high intensity, staggered extraction	93.6%
EAST HALL (slow extr.) 40 experiments	2 to 3 E11 1114100 spills		
Pb Ions			
Pb53+ (charges) *Booster:* *PS:*	1.7 E10 1.1 E10	1.2 E16 charges of Pb 53+ for physics	
Pb82+ (charges) ---> **SPS**	1.75 E10 (TT2)		92.7%
Antiprotons			
AA stack	*total pbars: 4.5 E13* *80% used by LEAR*		
LEAR & SOUTH HALL	1 E4 to 2 E6 pbars/s	ghost at 200 MeV/c compensated	87.0%
11 experiments	4196 spills	*spill of 14h duration at 310 MeV/c*	

ppd 16-02-96

PS Performance Day 1996

LPI evolution and MDs

Jean-Pierre POTIER

Abstract

The LEP Injector Linac (LIL) produced its first beam 10 years ago. Since then it has had a large evolution aimed at reducing its complexity and improving its reliability. The LIL beam is also used as an LHC beam simulator, as it has the same characteristics as the latter, for what concerns synchrotron radiation.

February 16, 96

LPI PPDAY96

J.Clendenin, J.P.Potier

Summary of the contribution, complementary information to the attached transparencies.

The LPI 10 years after its first beam

LIL (LEP Injector Linacs) part of the LPI (LEP Pre Injector, i.e. the lepton source for LEP) produced its first beam 10 years ago (November 22, 1985). Since that time, it has had a large evolution aimed at reducing, its complexity and improving its reliability. In figure 1, these changes as well as the design, achieved and operational performances are summarised.

LPI fault rate over the last five years

Since 1991 the LPI fault rate has dropped monotonically from 7.9 % to 3.3 % , if we exclude 1994 where the klystron modulator 13 gave a lot of stops, during the LEP production runs (see figure 2 top graph). In parallel, the overall number of stops dropped from 800 per year to 470 (figure 2 middle graph). If we remove the stops < 10 min (fixed without specialist intervention) the MTBF rises to an annual average of 22h(figure 2 bottom) and as high as 72h during the last run thanks to the efforts of the different systems responsible.

Simplifications of LIL RF powering

MDK03 withdraw

In figure 3 top, where the LIL RF network is shown, it can be seen that KLY-03 which powers the bunching system, is run at a very low level, 3.0 MW for a 35 MW klystron, and could be replaced by a power derivation from KLY-13.

As the buncher is a resonant cavity, its behavior, when it is powered by a LIPS (power pulse compressor), which produces an RF wave with a sharp peak, was not known. An experiment (figure 3 bottom left) was setup. It was found that its behavior was satisfactory and a power coupler was installed during December 95 for tests (figure 3 bottom right) to connect the buncher to klystron 13. The results which are satisfactory, are summarised in table 1, top. In 96, LIL will be run in these conditions.

Towards MDK35 withdraw ?

Pushing further the considerations above, it can be seen that increasing the power of klystrons 25, 27 and 31 (from 15.4 MW to 21.8 MW) allows one to stop klystron 35. This situation was tested during December 95, showed a lower positron production rate. Then some tuning work will have to be done on the positron production in order to recover to the usual production rates.

LHC Irradiations

(LHC vacuum team, information provided by V.Baglin)

In LHC the pressure inside the beam pipe will be essentially dominated by photo-desorption since thermal desorption of all gases except He will be very small at the beam screen temperature (between 5 to 20 dg K). At 308 MeV with leptons, the critical energy of the synchrotron light emitted in EPA is the same as in LHC with protons at flat top energy. In order to test the behavior of the future beam screen of LHC, at 2K, a cryostat, with a test sample, has been installed in the EPA tunnel at the output of HR.BHZ91,on a light port. At this momentum, the LPI can be run with 45E10 electrons in 8 bunches circulating.

The phenomena to be evaluated are mainly:

Primary photo-desorption: photo-desorption due to tightly bounded gas molecules which are desorbed by the photons from the near oxide surface. It constitutes a source of gas
Recycling photo-desorption: photo-desorption of weakly bound gas molecules phisisorbed (cryopumped) on the cold surface. This coefficient could be much larger than the primary one.

Apparatus
It is shown in figure 4.

1995 experiments

- Calibrations
- Long irradiations run at 4.2 K (figure 5 top): The rapid increase is followed by a slow increase due to the recycling effect and partially by a vapor pressure change. The increase of the base pressure when the irradiation is off may be due to the increase of the H2 surface coverage and hence vapor pressure on the cold non-irradiated areas of the sample.
- Primary photo-desorption yields (see figure 5 bottom) versus temperature.

This work is the subject of a thesis (V.Baglin)

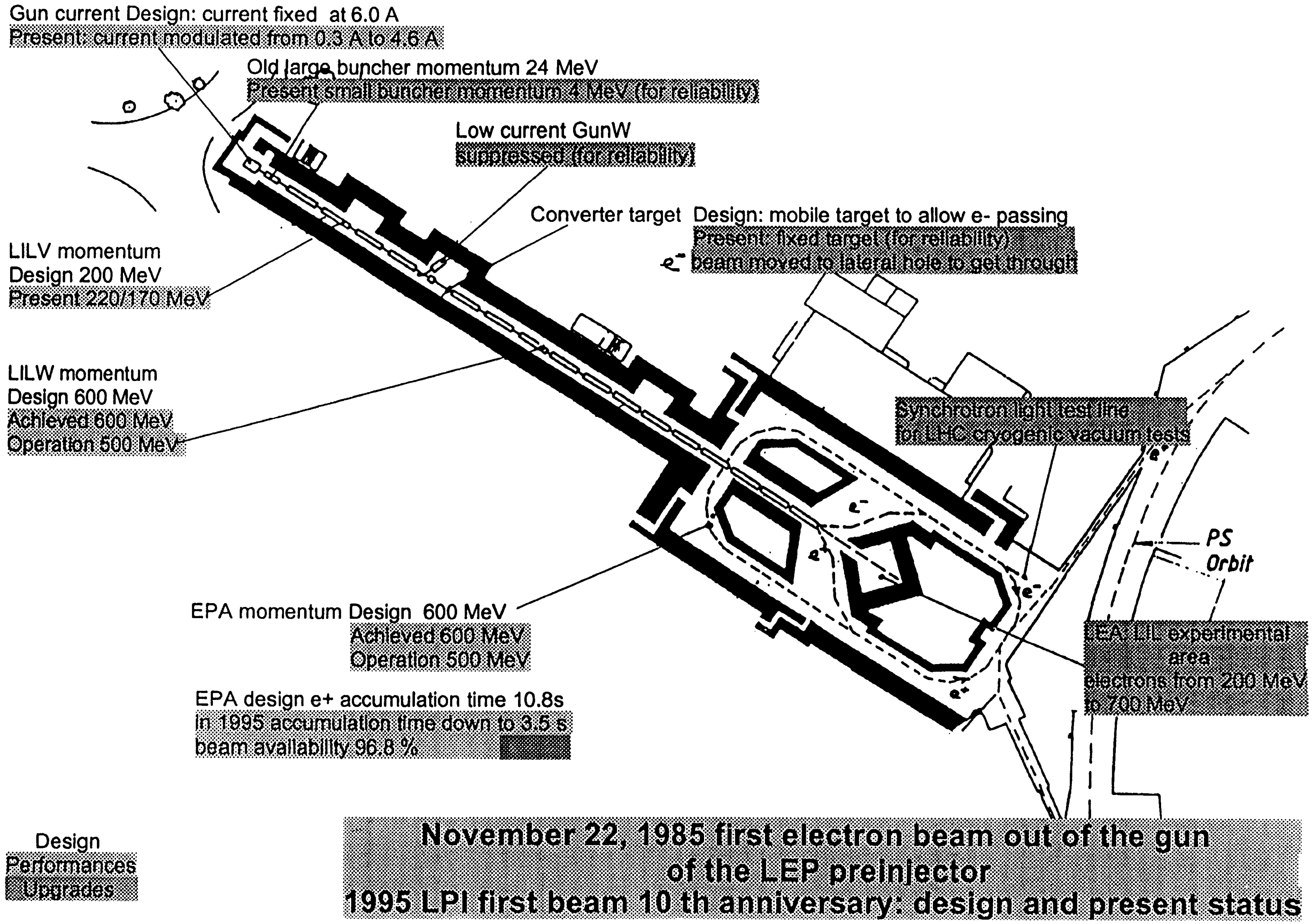
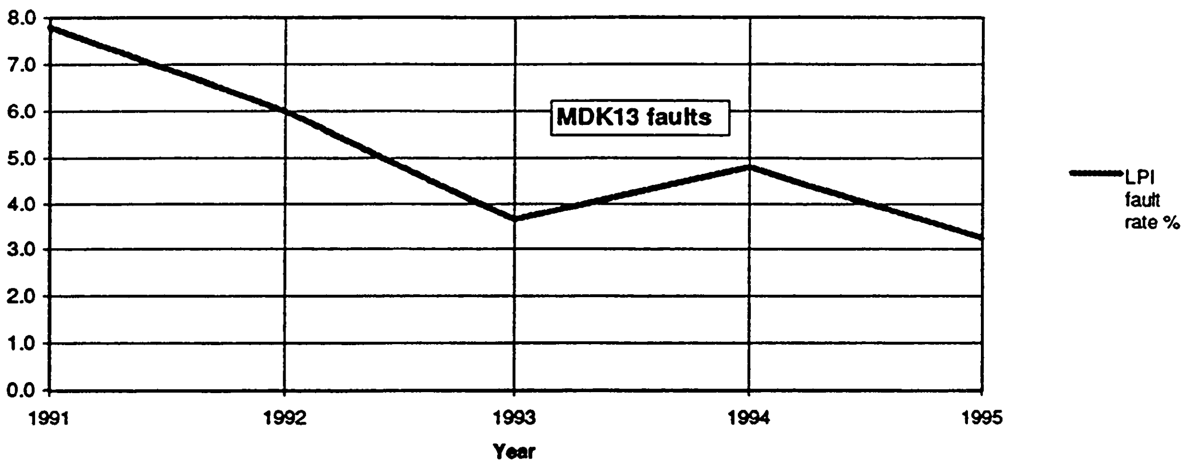

Gun current Design: current fixed at 6.0 A
Present: current modulated from 0.3 A to 4.6 A
Old large buncher momentum 24 MeV
Present small buncher momentum 4 MeV (for reliability)
Low current GunW
suppressed (for reliability)
Converter target
Design: mobile target to allow e- passing
Present: fixed target (for reliability)
e⁻ beam moved to lateral hole to get througt
LILV momentum
Design 200 MeV
Present 220/170 MeV
LILW momentum
Design 600 MeV
Achieved 600 MeV
Operation 500 MeV
Synchrotron light test line
for LHC cryogenic vacuum tests
PS
Orbit
EPA momentum Design 600 MeV
Achieved 600 MeV
Operation 500 MeV
LEA: LIL experimental
area
electrons from 200 MeV
to 700 MeV
EPA design e+ accumulation time 10.8s
in 1995 accumulation time down to 3.5 s
beam availability 96.8 %
Design
Performances
Upgrades
November 22, 1985 first electron beam out of the gun
of the LEP preinjector
1995 LPI first beam 10 th anniversary: design and present status

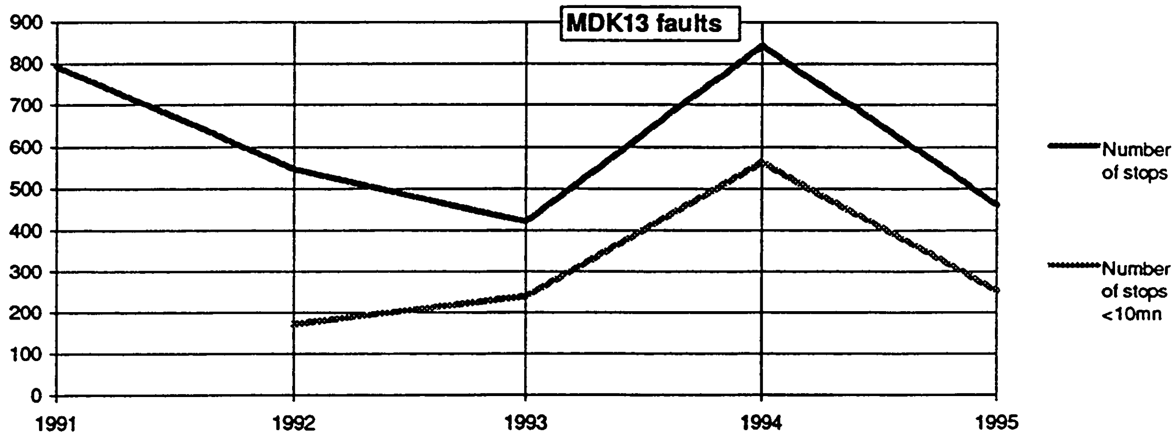
Figure 1

Evolution of the LPI fault rate since 91

Evolution of LPI fault rate in %



Evolution of the number of stops in the LPI > 10 mn or < 10 mn
(in 1991 classification of stops length not available)



Yearly values of the evolution of the mean time between stops and of the mean time between interventions (>10 mn) on the LPI in hours

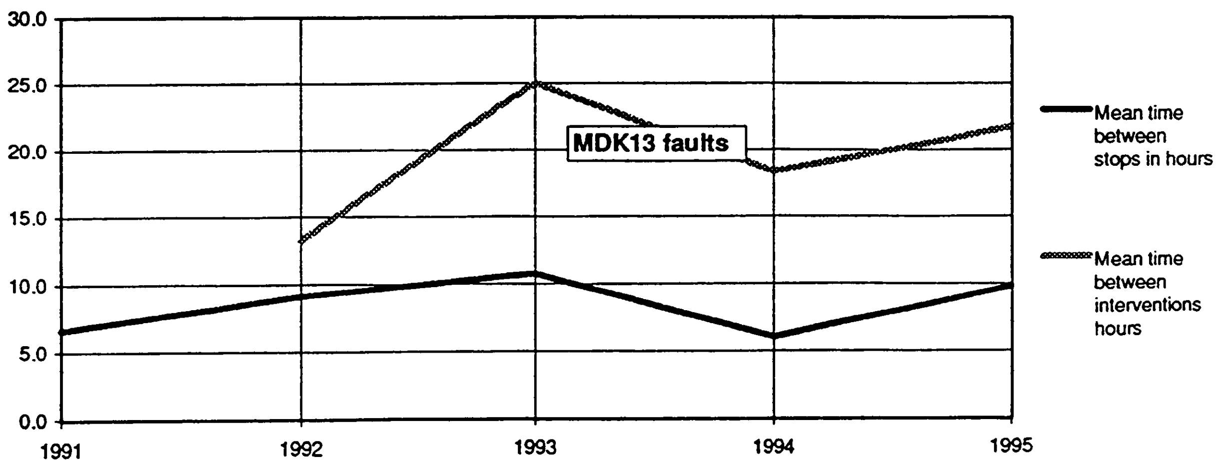
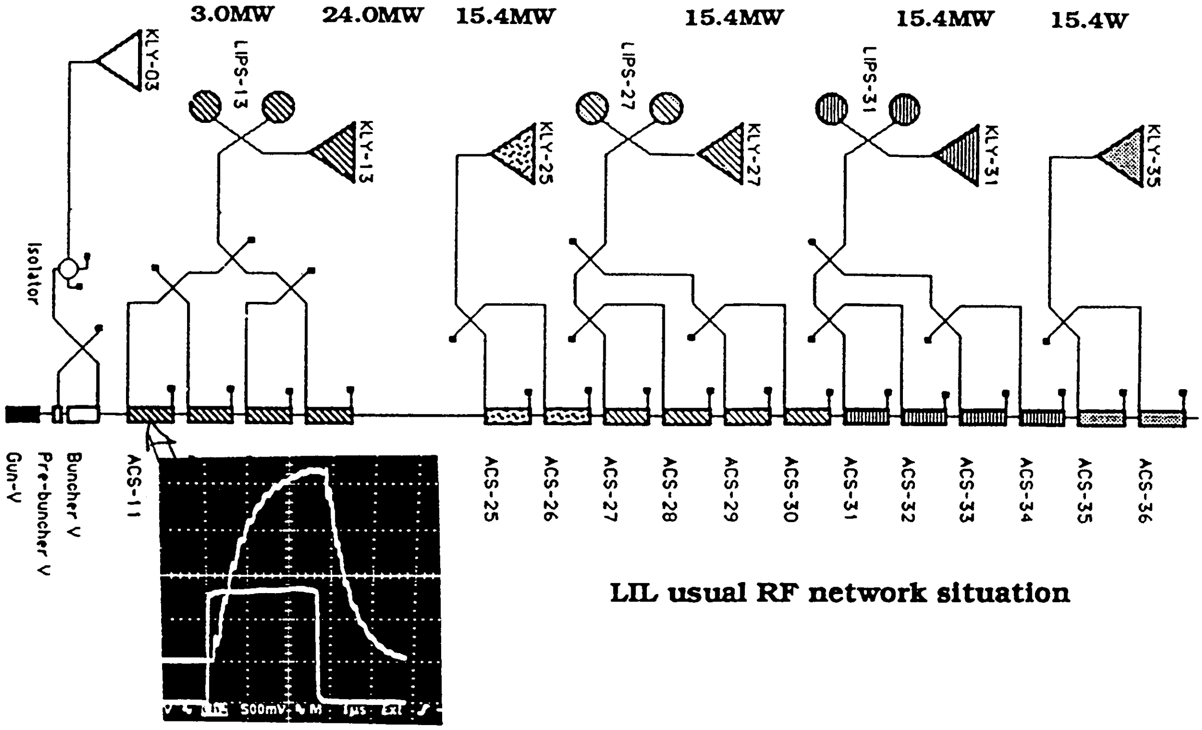


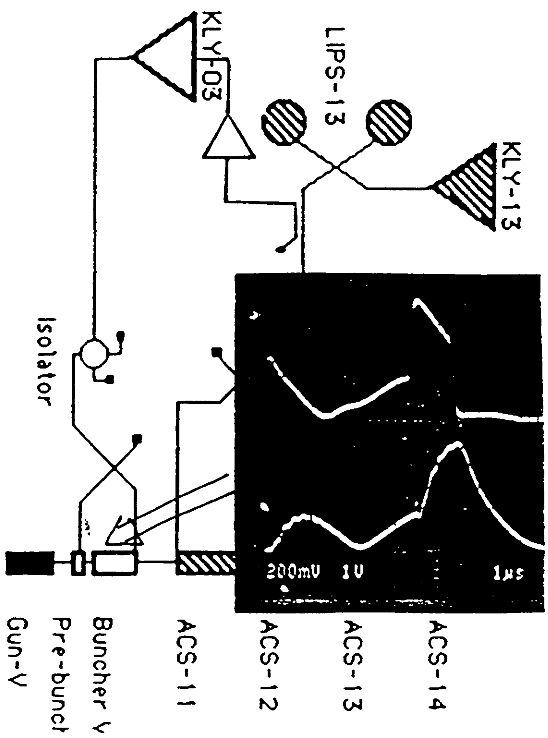
Figure 2

LIL with the buncher powered from LIPS13

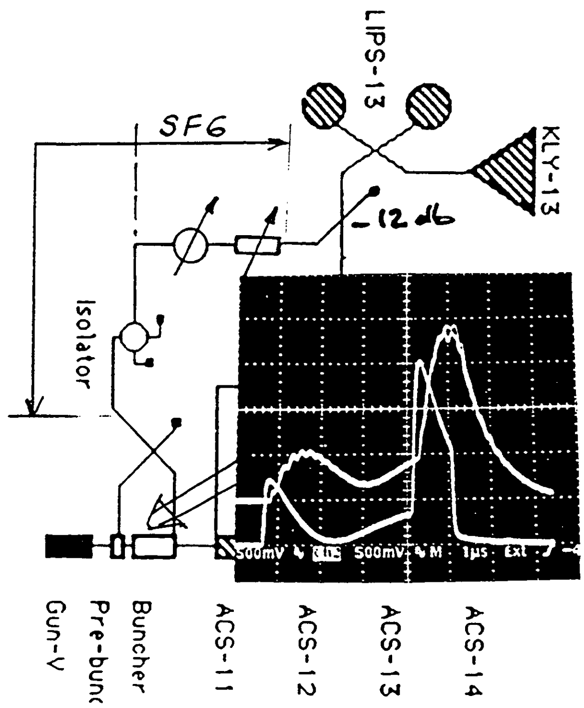
/J.Clendenin, J.P.Potier, G.Rossat



LIL usual RF network situation



End 94 and early 95 tests Buncher fed by LIPS13 through an amplifier and MDK03



December 95 setup and planned 96 startup: Buncher fed by LIPS13

MDK03 Suppression from the LIL RF Network

Figure 3

LIL with the buncher powered from LIPS13

/J.Clendenin, J.P.Potier, G.Rossat

Beam momentum at buncher exit

No absolute measurements done (no spectrometer available). Relative measurements have been done using a vertical dipole in the front end showing an energy gain in the LIPS13 configuration equivalent to 3 MW applied from MDK03 => OK.

Transmission and conversion efficiencies

Buncher powered by MDK03 or from LIPS13

	Operational values in 95	24 MW end 95 tests	18 MW end 95 tests
Bunching %	50 to 60	55 to 57	52
LIL transmission in %	75 to 85	70 to 78	75
Number of e- on the converter target	1.75 E11	1.75 E11	1.46 E11
LILV momentum MeV	**205**	**200**	**171**
Conversion e+/e- in %	**0.45 to 0.52**	**0.47 to 0.51**	**0.41**
Normalised yield e+/(e-*GeV) in %	2.2 to 2.5	2.3 to 2.5	2..4

Conclusion:

Powering of the bunching system from LIPS13 gives results similar to the usual MDK03 powering, future tests will be done with EPA accumulation

Towards MDK 35 stop ?

1996 planned setting

PB and Buncher fed from LIPS13 with 180 dg phase inversion, No LIPS 25
9.3 MV/m e+ trapping field in ACS 25 (same as 95 runs)
High power in MDK27, e+ production reduced by 5%

Planned 96 operation	*Unit*	MDK13	*MDK25*	*MDK27*	*MDK31*	*MDK35*	*Sum*
MDK in production/ dummy				*Yes*			
Calibration	*Mev/ MW^0.5*	42.75	21.24	45.00	45.00	21.24	
Energy gain	*MeV*	*209.43*	*83.35*	*209.43*	*154.36*	*72.86*	*520.00*
Klystron power	*MW*	**24.00**	**15.40**	**21.66**	**11.77**	**11.77**	

Possible setting with MDK35 OFF

PB +B fed from LIPS13 with 180 dg phase inversion No LIPS 25
Av gain and e+ trapping in ACS 25 = 11.3 MV/m (in 95 9.3 MV/m)

Stop of MDK35 ?	*Unit*	MDK13	*MDK25*	*MDK27*	*MDK31*	*Sum*
MDK in production/ dummy				*Yes*		
Calibration	*Mev /MW^0.5*	41.85	21:24	45.00	45.00	
Energy gain	*MeV*	*210.36*	*99.29*	*210.36*	*210.36*	*520.00*
Klystron power	*MW*	**25.26**	**21.85**	**21.85**	**21.85**	

First tests without MDK35 (and MDK03) performed end December 95:

Low production of e+ which needs to be optimised (perturbations by the field imperfections of the solenoid following the converter target).

Studies planned in 96 on positron production and beam optics consequences of the faster acceleration

Table 1

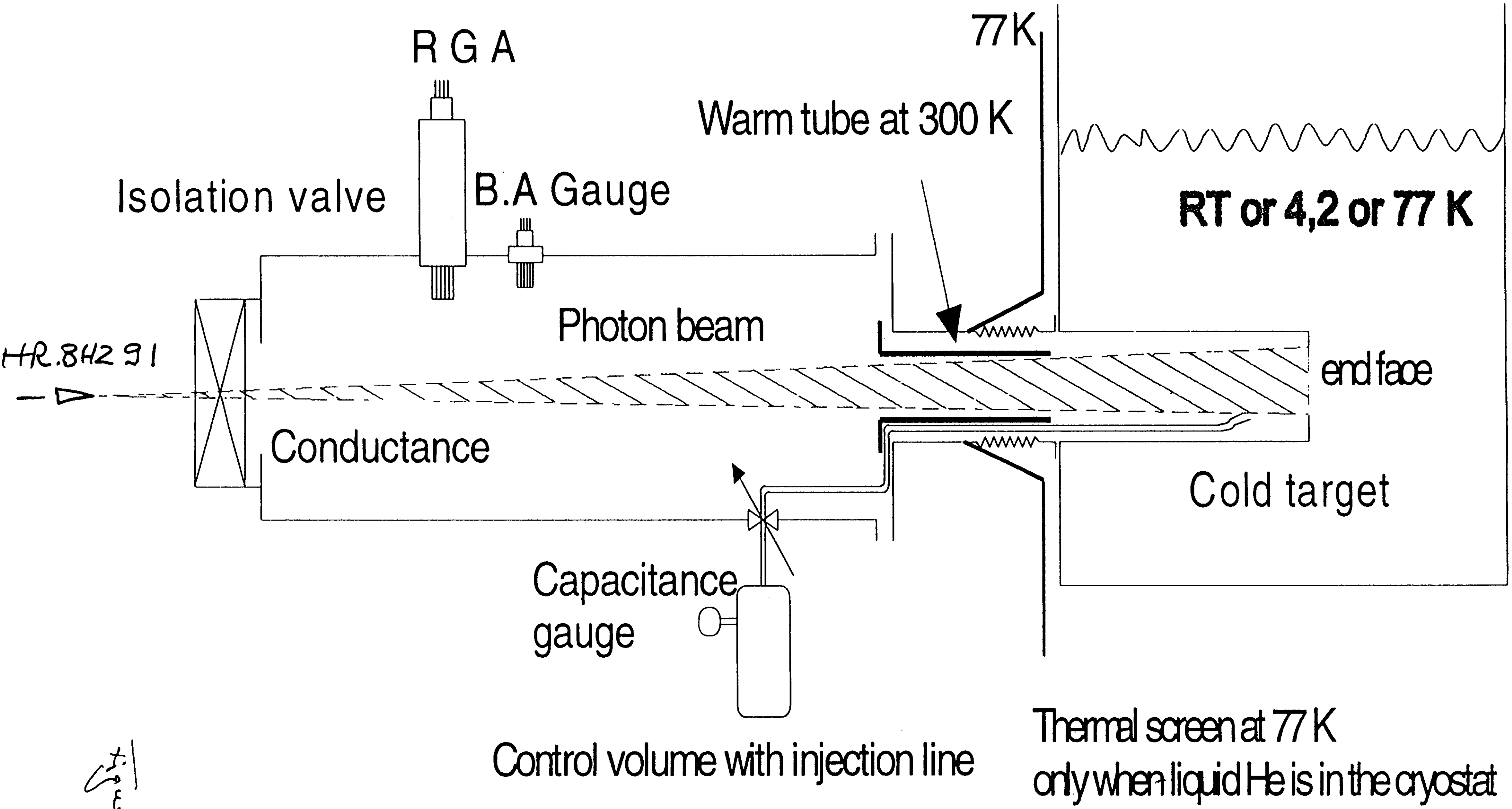
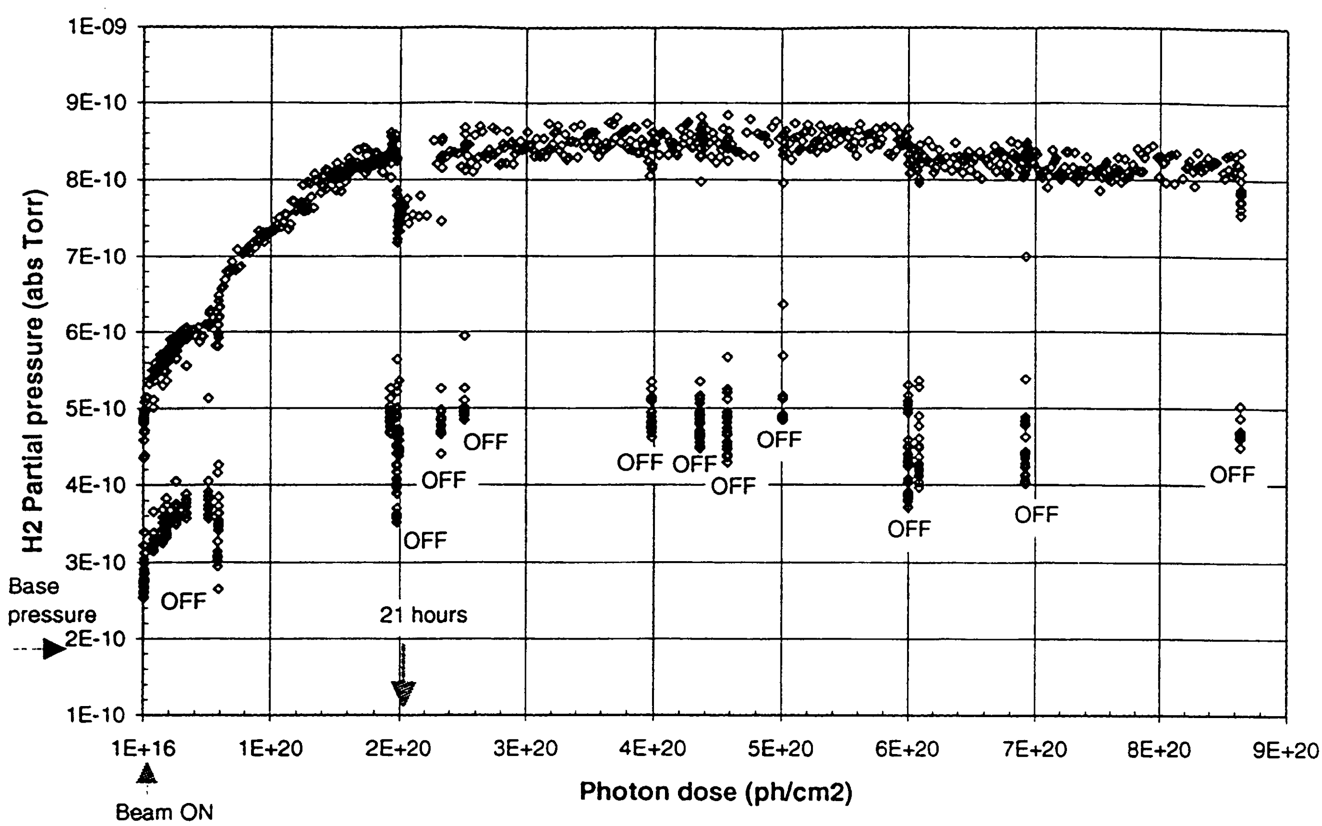

R G A
77 K
Warm tube at 300 K
Isolation valve
B.A Gauge
RT or 4,2 or 77 K
Photon beam
HR.842 91
end face
Conductance
Cold target
Capacitance
gauge
Thermal screen at 77 K
only when liquid He is in the cryostat
Control volume with injection line

Figure 4



15:46

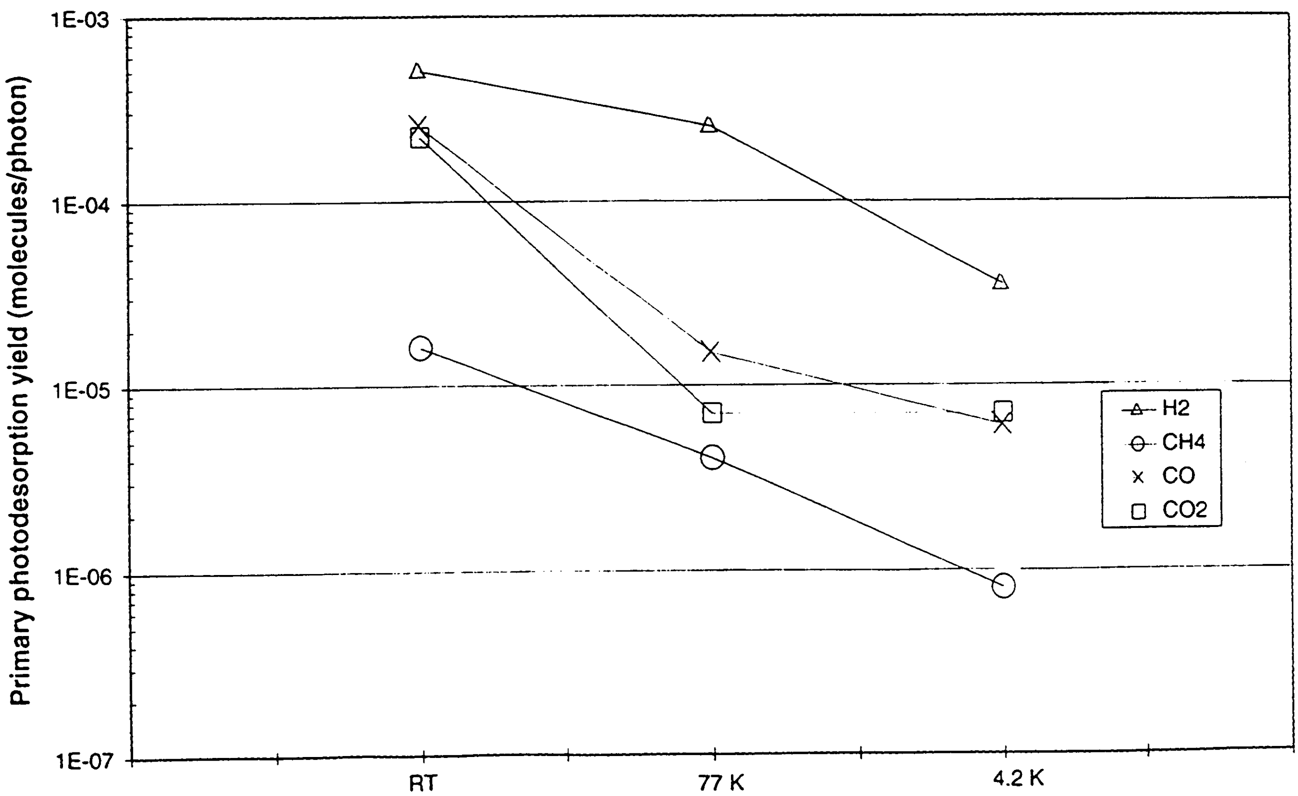


Figure 5

PS Performance Day 1996

Ion source and Linac 3 evolution and MDs

Charles HILL

Abstract

Following the 1994 lead ion run, time was available during the first part of 1995 to consolidate the new heavy ion linac. Apart from hardware improvements, studies were carried out not only on the ion source but also on the machine itself. The results of these tests are presented together with an initial idea of the tests that would be of interest in the near future. Some of the results presented were beneficial to the machine performance during the 1995 ion run and others indicated where limits to the present performance exist.

Naturally, certain experiments were focused on the future when the heavy ion injector will be coupled to the LEAR machine for LHC.

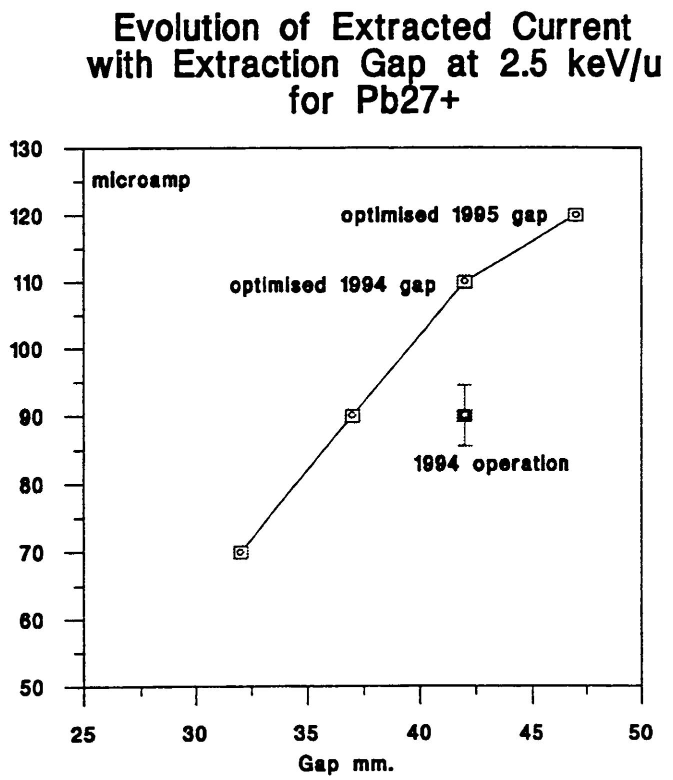
SOURCE

Extraction Gap

Following the 1994 period, the source was reoptimised on Pb 27+ to see what were the limits for analysed current at the Faraday cup. A special optic with extra secondary electron suppression is needed in the LEBT which is not compatible with operation.

Tests were performed with some optimisation on a small number of extraction gaps to see the influence on the beam. Computer simulations of the extraction will be needed to continue these tests a) to see the effect on the emittance, b) to reduce the number of vacuum breaks, and c) to set limits for a variable extraction.

There were indications that for a short (LEAR) beam more could be gained than for a long (PSB) beam but stability needs checking.



Other Ions

Ion	Extraction kV	keV/u	I μA	Notes
40 A 8+	13.8	2.76	210	optimised for 8+
40 A 9+	12.3	2.76	120	optimised for 8+
40 A 9+	12.3	2.76	150	optimised for 9+
40 A 8+	13.8	2.76	175	optimised for 9+
40 A 9+	20	4.5	220	not optimised
84 Kr 18+	12.5	2.68	20 (equ 40)	Source failure *
16 O 4+	20	5	520	
16 O 6+	20	7.5	530	
16 O 8+	20	10	15	
4 He 2+	20	10	1300	100 μs flat top
4 He 1+	20	5	1000 - 1200	Quasi CW

* Test failed before full optimisation due to HT failure - Metalisation of extraction insulator.

Lower Limit for extraction HT 13 kV unless extraction mechanically optimised for new species. This requires a vacuum break. Source has space charge limited diode characteristics (at least in operating range), i.e. extracted current increases with voltage. (Maximum HT 25 kV)

Gas Mixing

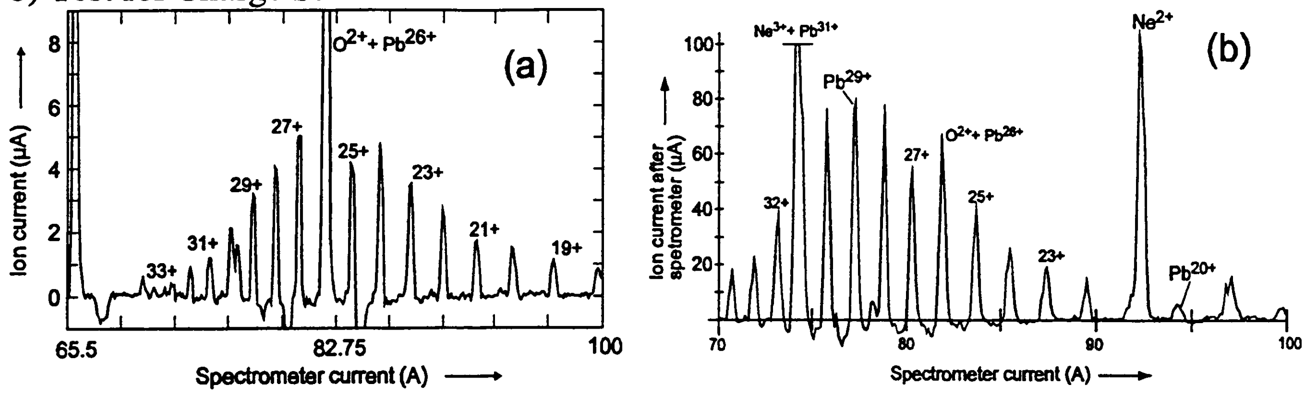
Follow up ideas of Shirkov that the addition of Neon to discharge should increase yield of Lead 27+.

a) Tests for Pb 27+

A test in 1994 indicated that the replacement of oxygen by neon led to a steady reduction of the extracted lead current as the oxygen was eliminated from the source. In 1995, this test was repeated with an oxygen/neon mixture.

As compared to 120 μA in normal operation, with neon the current fell to 70 μA. Increasing the percentage of oxygen increased the Pb current until full current was attained without neon.

b) Test for Charge State



Charge state distributions during the afterglow for:-a) Normal oxygen operation and b) Oxygen and neon as plasma gas

In this test the source was tuned for maximum charge state with neon. Spectra were obtained for peak charge states up to Pb 32+ seeming to confirm theory. However, it proved possible to obtain similar performance without neon!

Future Tests

The following tests are envisaged to increase the yield of the source:-

a) Biased electrode in plasma chamber (RF co-axial feed).
b) Higher magnetic fields for axial confinement.
c) Plasma chamber coatings or liners.
d) Other extraction gaps derived from computer simulations (variable extraction ?)
e) Other ions (feedback from physics needed)
f) Optimisation of short (LEAR) beams

LINAC 3

Linac Structure Tests

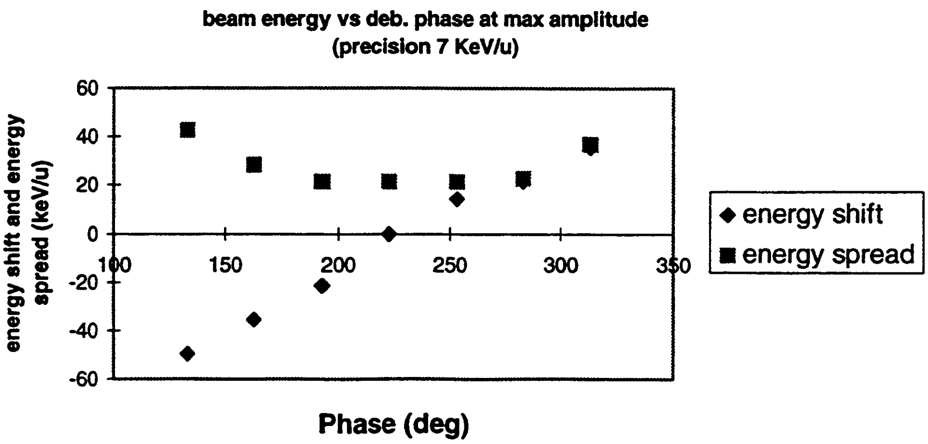
Installation and setting up of definitive 101 MHz amplifier for Tank 1 with full measurement of beam characteristics at 1.86 MeV/u using the Bunch Length and Velocity Detector. This, and the repetition of BLVD measurements on the output of the two remaining tanks, resulted in the establishment of a new RF working point for Tank 3 which allowed a reduction of RF power by 10% (and less X-rays).

At the request of GSI, a test was performed to examine the acceleration field limits of Tank 2. Up to 550 kW (limited by amplifier) was injected into the tank which would correspond to an average accelerating gradient of 7.7 MV/m (6.1 MV/m nominal at 346 kW).

Energy Variations

MD1. Investigation of the working point in Tank 3 showed that it was possible to vary the output energy by 140 keV/u (3%) by the correct choice of RF levels and tuner positions. This should be of help in adapting the linac energy for stripper foil thickness variations (and also for optimising Pb 54+).

MD2. In anticipation of LEAR demands for a ramped energy of ± 25 keV/u over 50 µs the effects of debuncher amplitude and phase on beam energy and energy spread were studied. These indicated that, in the present static case, varying the debuncher phase by ± 60° with respect to the nominal setting would provide the requested change.



Beams

Development continued on the Pb 53+ beam for PSB in collaboration with colleagues from PSB. This was mainly limited to fine tuning of Linac and transfer parameters for operation.

With colleagues from LEAR, set up and provided beams of Pb 52+. 53+, 54+, 55+ for their cooling experiments.

Future Plans

a) Continue power tests for GSI in Tank 2 up to 1 MW.
b) Repeat fine tuning tests on the RFQ with its final 101 MHz amplifier.
c) Is it possible to modify the optic around the stripper to gain in horizontal emittance at the expense of vertical? Does this help the stripper?
d) Recommence the testing of the Phase Probes.
e) Accelerate Pb 25+ in the machine (design particle).
f) Accelerate O 2+ in the machine to simulate beam loading.
g) Emittance studies.
h) Continue studies on energy ramping.

PS Performance Day 1996

Ion MDs in the PS

Django MANGLUNKI

Abstract

Many hours of MD were devoted in 1995 to the preparation of the autumn ion run, in collaboration with the SPS teams. Several "test beams" or protons and ions - fully or partially stripped - at various energies, emittances and intensities were set up to perform measurements, cross-checks and instrumentation calibrations in both rings and in the transfer lines. A special session was devoted to the measurement of energy straggling, stripping efficiency and emittance blow-up in the stripper foil, in order to determine the optimum stripper thickness.

Lead Ion MDs in the PS

D.Manglunki, 16/2/96

- GL.Arduini/SL, H.Burkhardt/SL, R.Cappi/PS, M.Martini/PS ...
- PS machine modifications
- Test beams
- Bunch rotation
- Scraping
- Stripping
- Performances in 1995
- Prospects for 1996

PS Machine modifications

- Recabling of beam control
  - Transparent to OP (not to RF)
- Control system
  - 24 users
  - NAOS
  - Too few access points made parasitic MDs very difficult
- Bdot regulation of Main Power Supply
  - Better energy reproducibility
  - No PFWs for ions
- Temperature tests
  - $\frac{\Delta p}{p} = \frac{1}{\alpha}\frac{\Delta R}{R}$

Test beams

- P+ 20 Gev/c for PS (simulate Pb^{53+})
- P+ 13 GeV/c for SPS (simulate Pb^{82+})
  - Good agreement in PS/TT2/TT10/SPS for ε_H and ε_V
  - PS-TRA379 97% ; TRA379-SPS 94% ; PS-SPS 91%
- Unstripped Pb53+
  - No Blow-up PS-SPS
  - PS-SPS transmission 93%
- Small longitudinal emittance at low intensity
  - longitudinal acceptance reduction

Bunch rotation

- Longer bunches for smaller $\Delta p/p$
- Voltage reduction (200 kV -> 20 kV)
- Bunch length = 6 ns -> 18 ns
- $\Delta p/p$ = 0.8 E-3 ->0.3 E-3
- Kept in operation

Scraping

- Use of "measurement targets" before extraction
- Reduce emittances
  - for PS/SPS transmission tests
  - Down to $\varepsilon_H = 0.8\ \pi$ mm.mrad ; $\varepsilon_H = 0.9\ \pi$ mm.mrad
- Not used for operation

Stripping

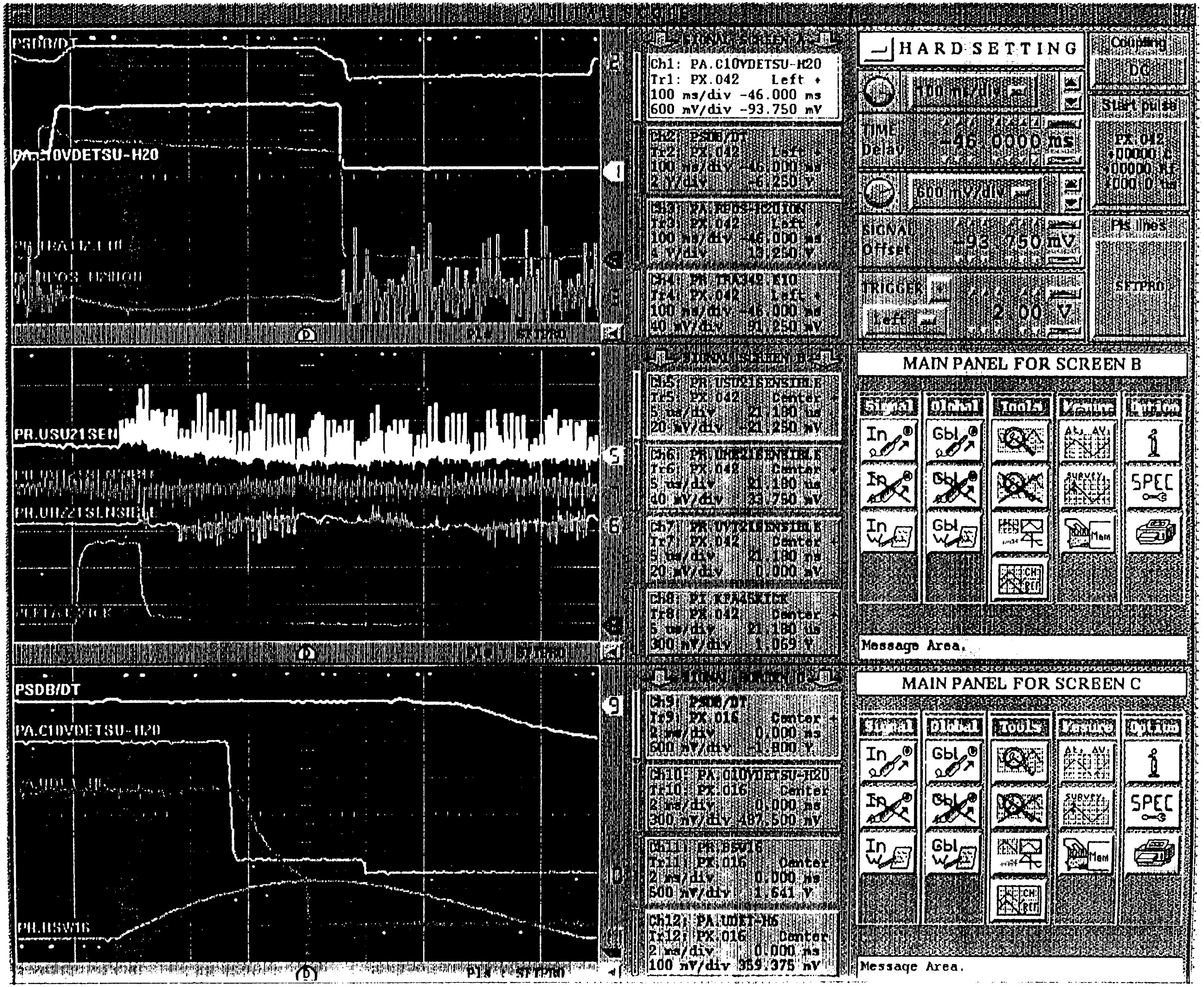
- Energy loss
  - 0.35% / mm
- Emittance blow-up
  - 0.75 π mm mrad / mm in Horizontal plane
  - 0.6 π mm mrad / mm in Vertical plane
- Stripping "efficiency" (ratio of Pb^{82+})
  - 95% for 0.8mm
  - 100% for 1mm
- 0.8 mm
  - "Best compromise"
  - will be kept for operation in 1996 (or shall we keep 1mm?)

Performances in 1995

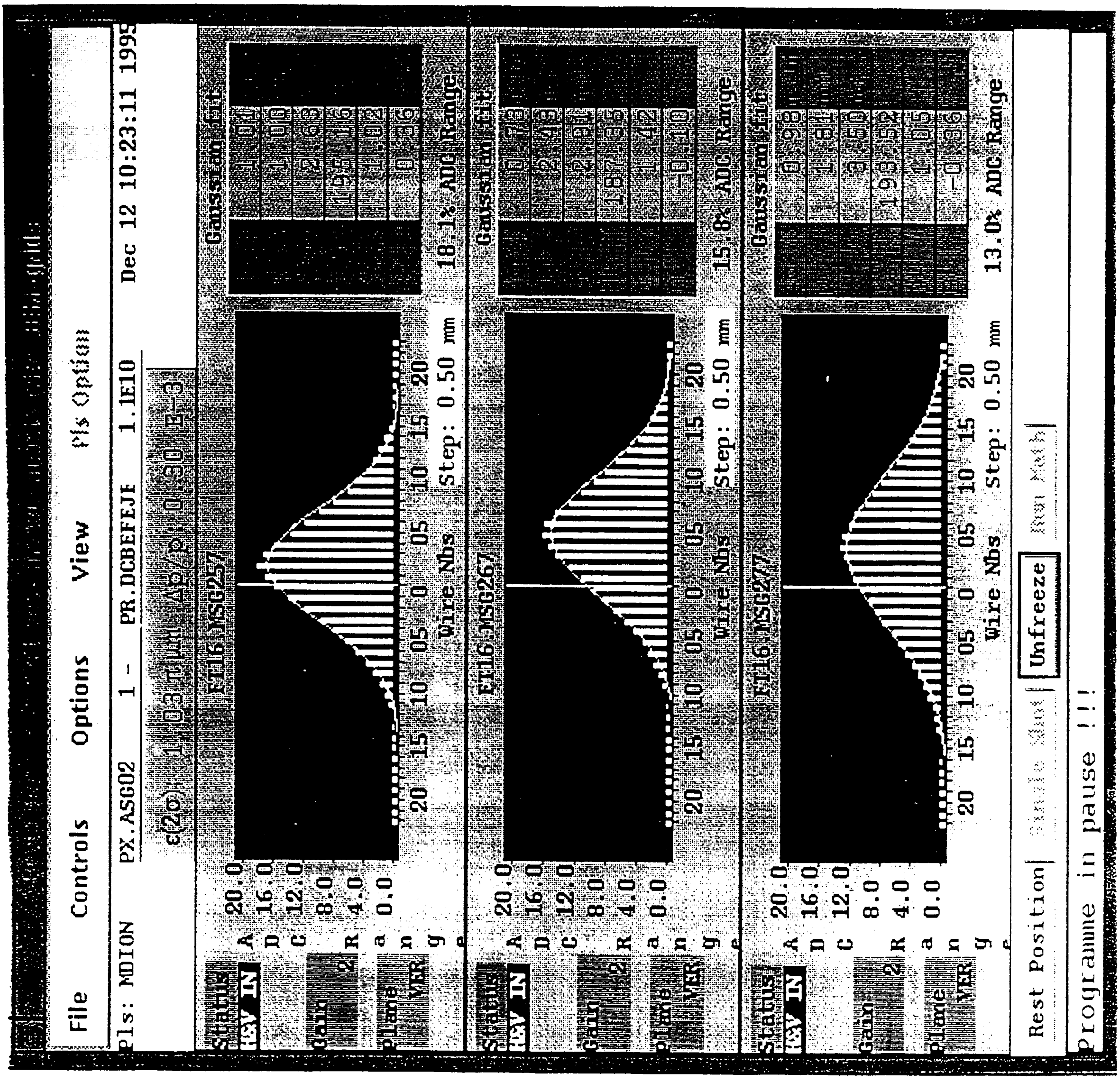
- $N > 1.5 \times 10^{10}$ charges of Pb^{82+}/PS pulse
- $\varepsilon_H = 1.8\ \pi$ mm.mrad
- $\varepsilon_V = 1.5\ \pi$ mm.mrad
- $\tau_B = 18$ns
- $\Delta p/p = 0.3 \times 10^{-3}$

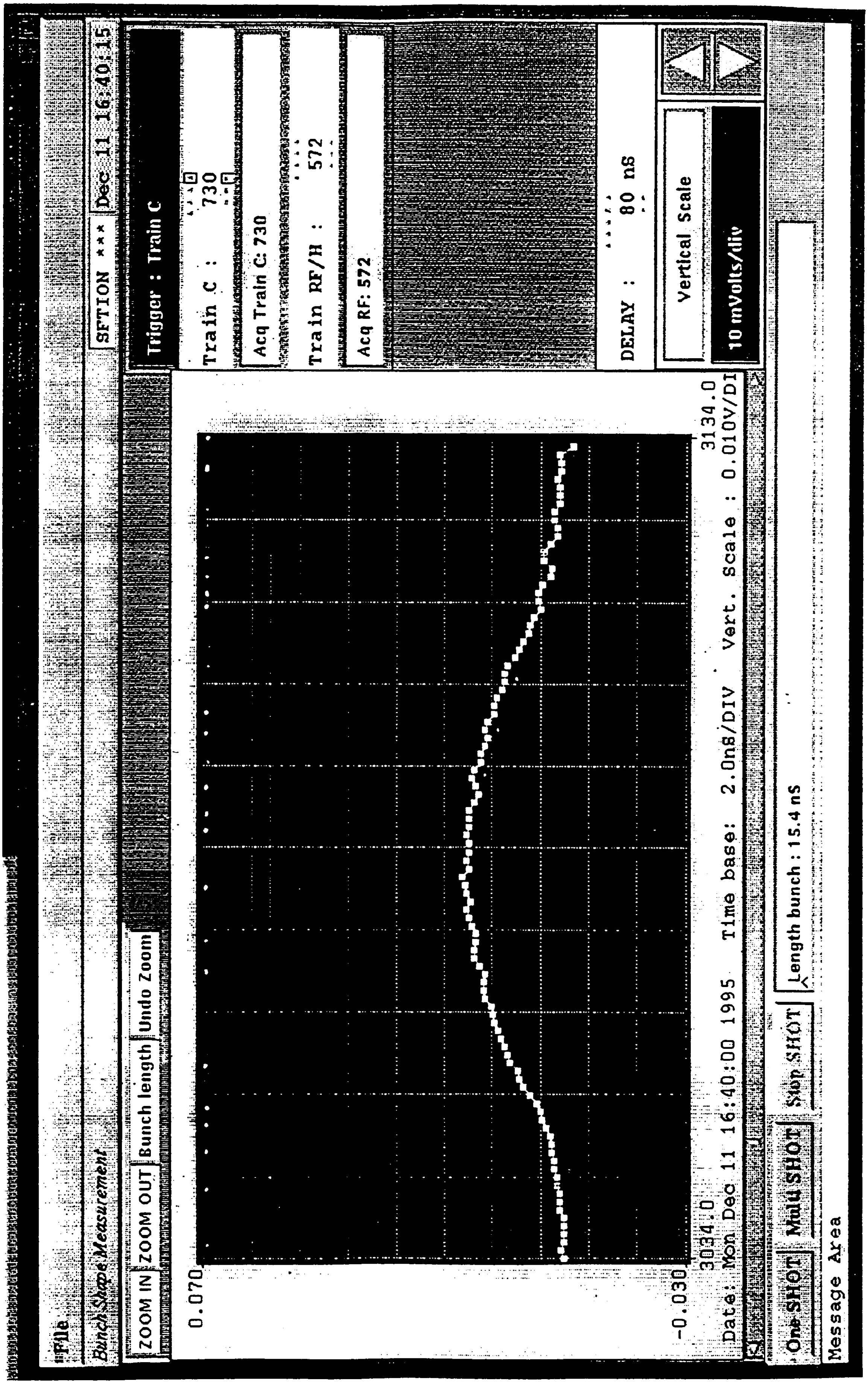
Prospects for 1996

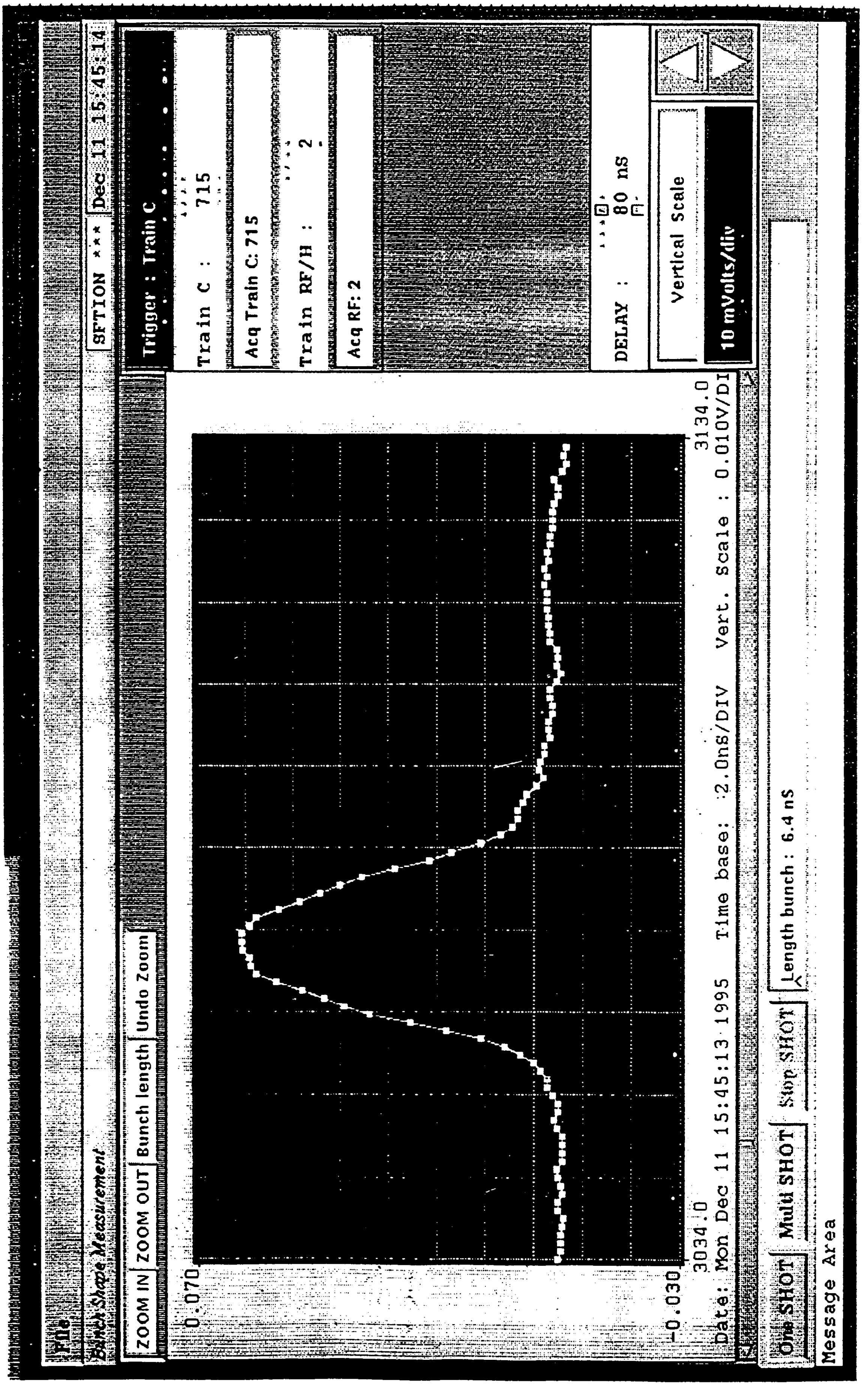
- Instrumentation upgrade in 1996
  - MRP
- SMH42 in ppm in 1996
  - will allow better injection -> smaller H emittances
- Control system
  - Extraction will be part of control system
  - SPS ion request
  - NAOS
  - Varilog fully in operation



PSDB/DT
PA.C10VDETSU-H20
Ch1: PA.C10VDETSU-H20
Tr1: PX.042 Left +
100 ms/div -46.000 ms
600 mV/div -93.750 mV
HARD SETTING
Coupling
DC
Start pulse
TIME Delay
-46.0000 ms
SIGNAL Offset
-93.750 mV
TRIGGER
Left
2.00 V
SETPRO
MAIN PANEL FOR SCREEN B
PR.USU21SEN
Message Area.
MAIN PANEL FOR SCREEN C
Signal
Global
Tools
Option
SPEC
Ch10: PA.C10VDETSU-H20
Ch12: PA.UDET-H6
Tr12: PX.016 Center
2 ms/div 0.000 ms
100 mV/div 359.375 mV
PR.USV16
Message Area.

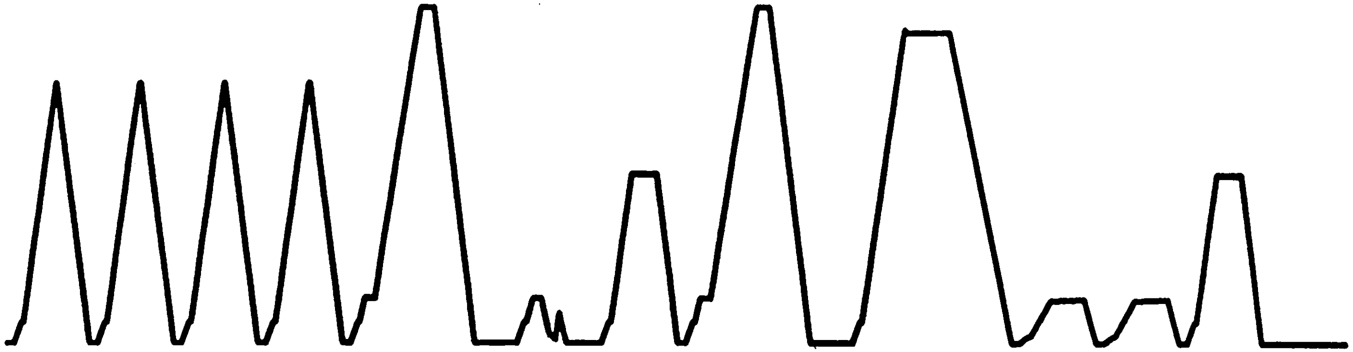

File
Controls
Options
View
Pls Option
Pls: MDION
PX.ASG02
PR.DCBEFEJE
1.1E10
Dec 12 10:23:11 1995
Status
H&V IN
Gain
Plane
VER
FT16.MSG257
Gaussian Fit
Wire Nbs
Step: 0.50 mm
18.1% ADC Range
FT16.MSG267
15.8% ADC Range
FT16.MSG277
13.0% ADC Range
Rest Position
Unfreeze
Programme in pause !!!


File
Bunch Shape Measurement
SFTION ***
Dec 11 16:40:15
ZOOM IN
ZOOM OUT
Bunch length
Undo Zoom
0.070
-0.030
3034.0
3134.0
Date: Mon Dec 11 16:40:00 1995 Time base: 2.0nS/DIV Vert. Scale : 0.010V/DI
Trigger : Train C
Train C : 730
Acq Train C: 730
Train RF/H : 572
Acq RF: 572
DELAY : 80 nS
Vertical Scale
10 mVolts/div
One SHOT
Multi SHOT
Stop SHOT
Length bunch : 15.4 nS
Message Area



File
Bunch Shape Measurement
SFTION ***
Dec 11 15:45:14
ZOOM IN
ZOOM OUT
Bunch length
Undo Zoom
Trigger : Train C
Train C : 715
Acq Train C: 715
Train RF/H : 2
Acq RF: 2
DELAY : 80 nS
Vertical Scale
10 mVolts/div
0.070
-0.030
3034.0
3134.0
Date: Mon Dec 11 15:45:13 1995
Time base: 2.0nS/DIV
Vert. Scale : 0.010V/DI
One SHOT
Multi SHOT
Stop SHOT
Length bunch : 6.4 nS
Message Area

19.2 sec. duration - PS SUPERCYCLE



particle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	pbar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
PS Energy (GeV/c)	20	20	20	20	26	3.5 0.6	13	26	24	3.5	3.5	13	
user	SPS	SPS	SPS	SPS	AAC	LEAR	Pb simul	AAC	EAST HALL	SPS LEP	SPS LEP	Pb simul	ZERO
intensity	1.1E+10	1.1E+10	1.1E+10	1.1E+10	1.6E+13	2.E+09 to 6.E+10	1E+12	1.6E+13	3.E+11	2.E+11	2.E+11	1E+12	
PSB user & intensity					ISOLDE 2.9E+13	ISOLDE 2.9E+13		ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13		ISOLDE 2.9E+13

PS Performance Day 1996

PSB evolution and MDs

Karlheinz SCHINDL

Abstract

The most demanding PSB beam is the one for ISOLDE who are regularly requesting proton intensities of up to 3 10^{13} p/pulse. While these levels have been often attained, the concomitant beam losses at high energy remain a major issue, as they are causing increased machine irradiation and personnel doses. These losses are mainly due to longitudinal coupled-bunch modes and possibly microwave instabilities (ring 4) which are being investigated.

The Pb beam intensity produced by the PSB (1.5 - 2 10^{10} charges per cycle) exceeds the design figure (1.2 10^{10} charges). Nevertheless, MD's to analyse performance limitations, as well as close monitoring of the very critical vacuum system, were performed. It was found that loss rates for Pb^{53+} and Pb^{54+} do not differ, whereas the beam is lost much faster in ring 3 than in the others.

The ISOLDE line transports ~10^{13} p/sec, but beam diagnostics is far from adapted to this level. A crash programme for adding monitors (PU, current transformers, SEMs, also in view of using ABS) and more work on the optics is required. The staggered beam extraction, seemingly the only way to enable liquid targets to stand the shock wave generated by >10^{13} p/pulse, was further studied and should be rendered operational as soon as possible.

PSB High Intensity Proton Beams 1995 (ISOLDE, SFT, AA)

Problem	MD results and/or actions	Comments
Beam loss - low energy (multiturn, capture, stopbands)	Frequent readjustments of injection, frequent readjustment of beam control h=5,10	not very relevant for machine irradiation, but limits performance
Beam loss - high energy (coherent instabilities, extraction losses)	Repeated readjustments of long. coupled-bunch mode damping system, Frequent readjustment of voltage/phase of h=5 and h=10 cavities, Increase of ejection kicker by 10% to 36 kV Main contributor to loss (on BLM's): **ring 4.** • instability 1 (at 320 ms): long. µ-wave, spill-out of bucket • instability 2 (at 360 ms): almost disappears with $\xi_v \sim 0$ (vertical high-frequency?)	**Main reason for machine irradiation** irradiation around ejection septum down by factor 3 lost vertically because of ξ_v -1.8
Annual collective doses1995	Still increasing	frequent ring interventions
"Sabotage" of PS (and PSB) RF, beam control	Production beam with 2 rings until 8/95, four rings with funnelling (RF dipole) afterwards	marked increase of intensity with 4 rings

nevertheless, PSB intensity regularly between 2.7 and 3 10^{13} p/p (ISOLDE)

PPD 16.2.96, K.Schindl

PSB - General Issues 1995 (and '96)

Problem	**Actions, MD results**	**Comments**
Linac LBS spectrometer: measurement of mean momentum <p>	spectrometer magnet equipped with NMR => to monitor changes in <p>	marked improvement
$\Delta p/p$ measurement of injected beam by long. BTFM	compares rather well to $\Delta p/p$ measured in LBS	soon operational?
PS stray field deflects beams from both linacs	improve shielding	*PS subvention '96*
B-train: jitter several G, resolution 1 G, insufficient for digital beam control (ions, future h=1, h=2)	2 NMR installed in ref. magnet, new B-train envisaged (1 G jitter, 0.1 G resolution)	*PS subvention '96*
Shaver dipoles: pulsed power supplies unreliable (used for PHY, MD, TST, maybe LHC)	new supplies to be built	*PS subvention '96*
Deviation control/acquisition of Q-tuning supplies	supplies improved during 1995	new supplies (LHC)

PSB for LHC 1995

Problem	**Action and/or MD**	**Comments**
Beam profile measurement device (for LHC beam)	spare wire scanner being installed in ring 1	lowest energy?
Increase of PSB energy 1 to 1.4 GeV (Bdl +26%)	longer 20^0 magnet BTM.BHZ10 being installed (beam to measuring line and ISOLDE)	modified optics for ML, ISOLDE
Q-measurement by kicking the beam	hopefully available soon (not only for LHC!)	
PSB-PS recombination + transfer beam steering	ABS helps pinning down inconsistencies	analysis of geometry

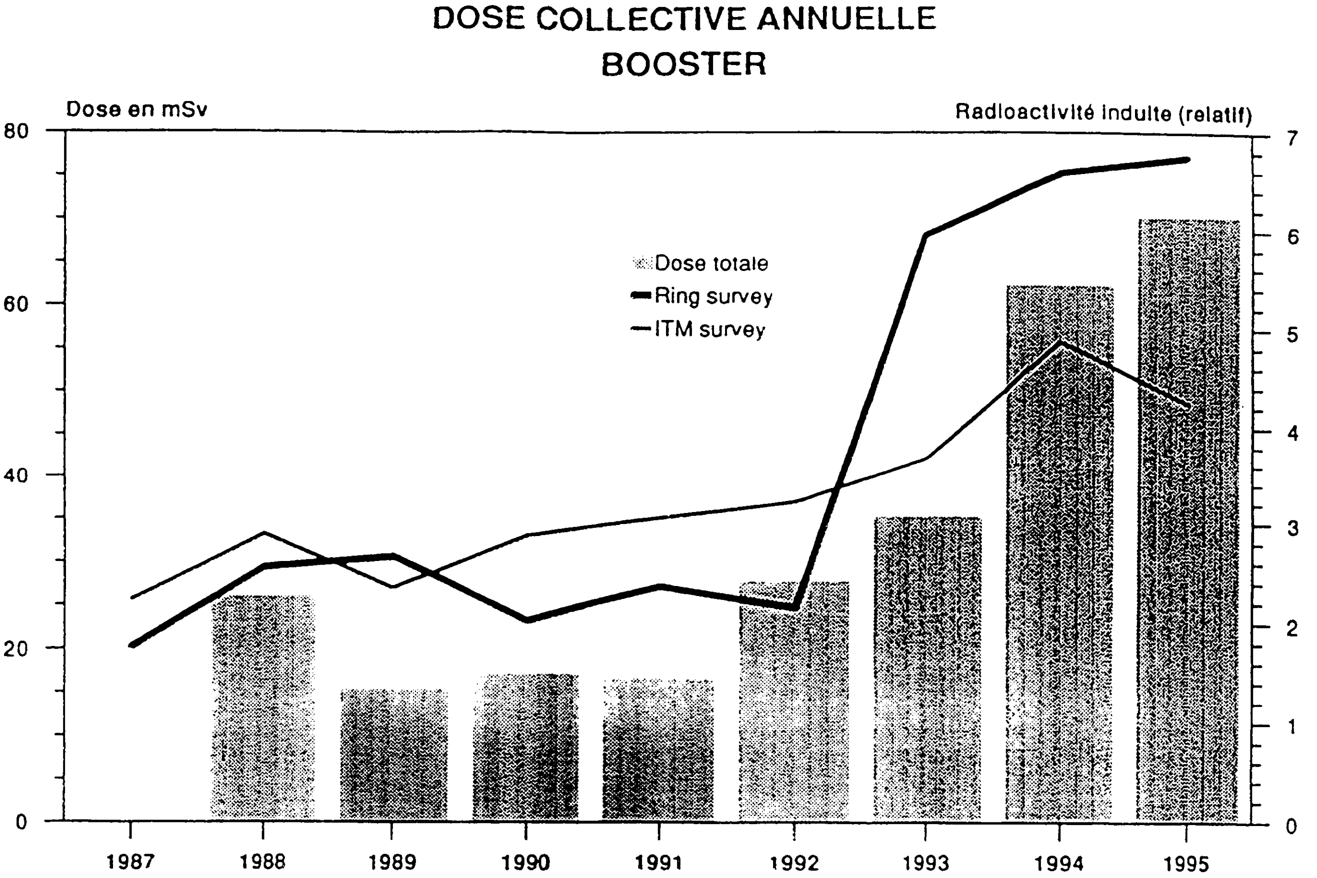
PPD 16.2.96 K.Schindl

PSB - Pb Ions 1995

Problem	MD results and/or actions	Comments
Intensity per PSB cycle	Max. 2 10^{10} charges Pb^{53+} achieved, although linac3 22...25 μA	not really better than 94
Injection line steering (with scintill. screens) (alignment different under vacuum?)	attempts to invert experimental steering matrices with limited success	SEM upstream Pb distrib. required
Setting-up of RF trapping tedious	control code to be written	
Pb ion - rest gas interaction	• continuous battle for better vacuum • lifetime (at injection energy 4.2 MeV/u) 2x worse in ring 3 than in the others • lifetime (at injection) of Pb^{53+} same as Pb^{54+}	many interventions vacuum leak ring 3? chamber 15RB2 ring 3 changed
Synchronisation (of the four rings before transfer to PS) failures	fewer than 1994 - hardware improved? less jitter on PSB flat top?	NMR marker for new B-train generator useful
Pb^{53+} emittance measurement at 95.4 MeV/u in ML	3 SEM's give good signals, but optics to be improved	

PSB - ISOLDE 1995

Problem	MD results and/or actions	Comments
10^{13} p/second, with diagnostics for 10^{10} p/second	Crash programme to install **basic** instruments: • beam transformers near GPS and HRS targets • two electrostatic PU (~10 needed) • a SEM near each target	Do we lose beam?? Only route to ABS to understand optics
Significant discrepancies between computed and real optics	not clearly understood; more analysis; more dedicated MD's in ISOLDE line	Render HRS operational (almost no diagnostics)
Vertical settling of ISOLDE building (~10 mm)	special trajectory worked out	doesn't ease steering
Beam spot on target - steering and shaping	Low-β doublet moved upstream	stronger dipoles needed; automated optics setting?
Staggered extraction - only way to use liquid targets with > 10^{13} p/burst and to match isotope yield at SC	Test runs with ring-to-ring distance 10 μs: liquid targets work up to 2 10^{13}! But beam transformers cannot digitize the extended beam length unless 100 kfr invested	Further test 1996 foreseen Routine operation (1997?): beam current measurement indispensible for watchdog



Graph. 2

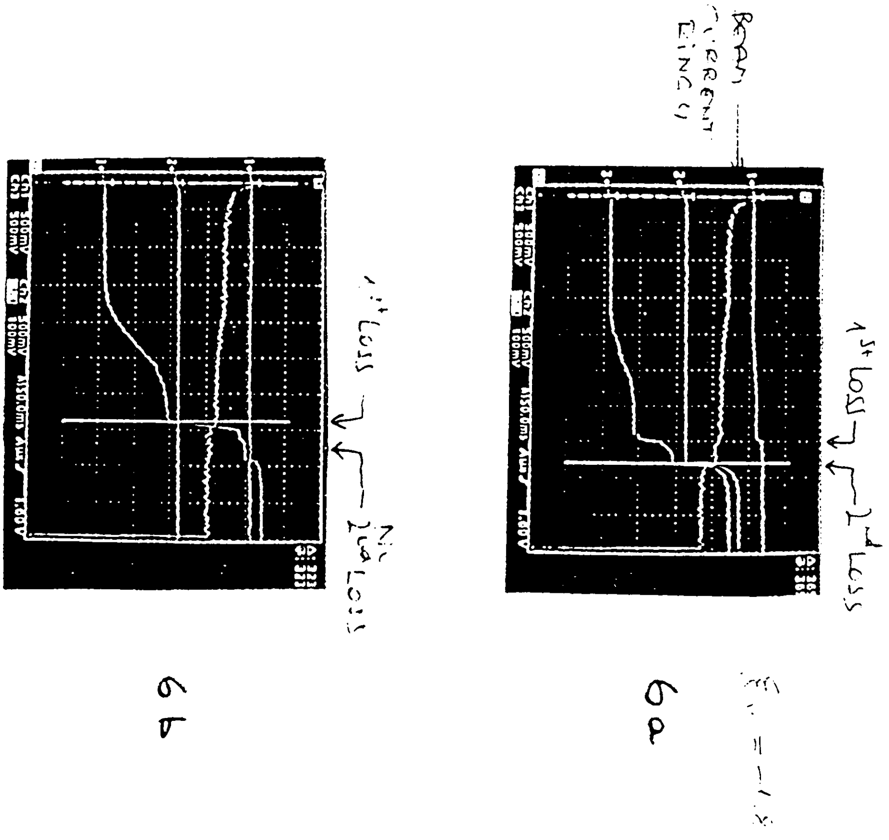
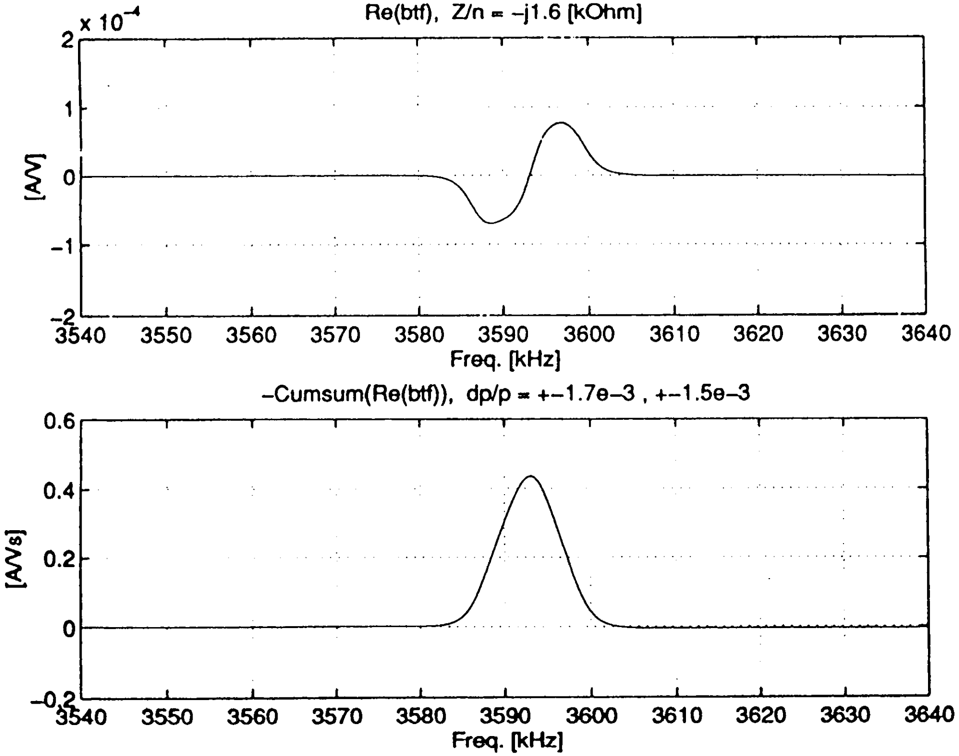
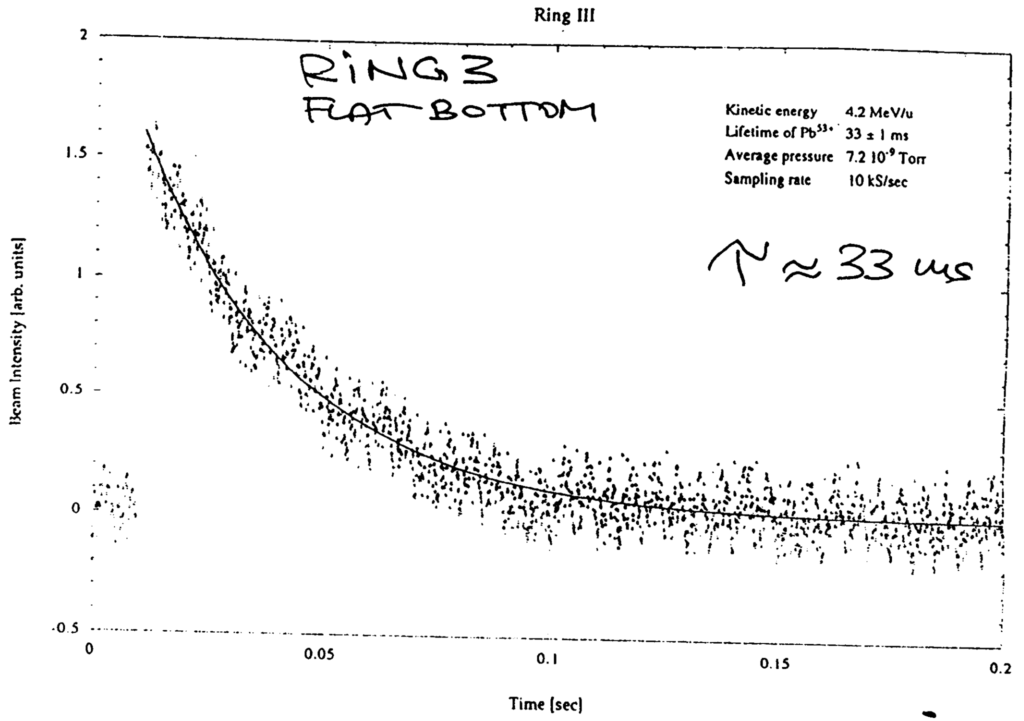


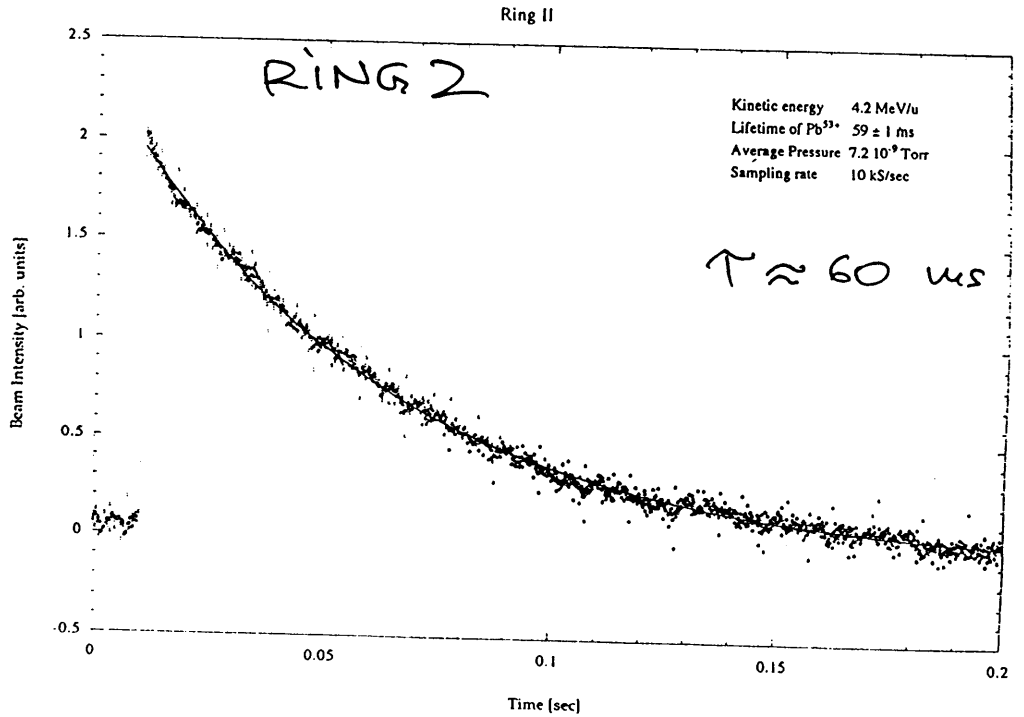
Fig. 6. SOS signals of the BLM's 7L2, 8L2, 9L2 sup. together with the beam current of Ring 4. 6a without and 6b with excitation of the zero-harmonic sextupoles such as to compensate vertical chromaticity.

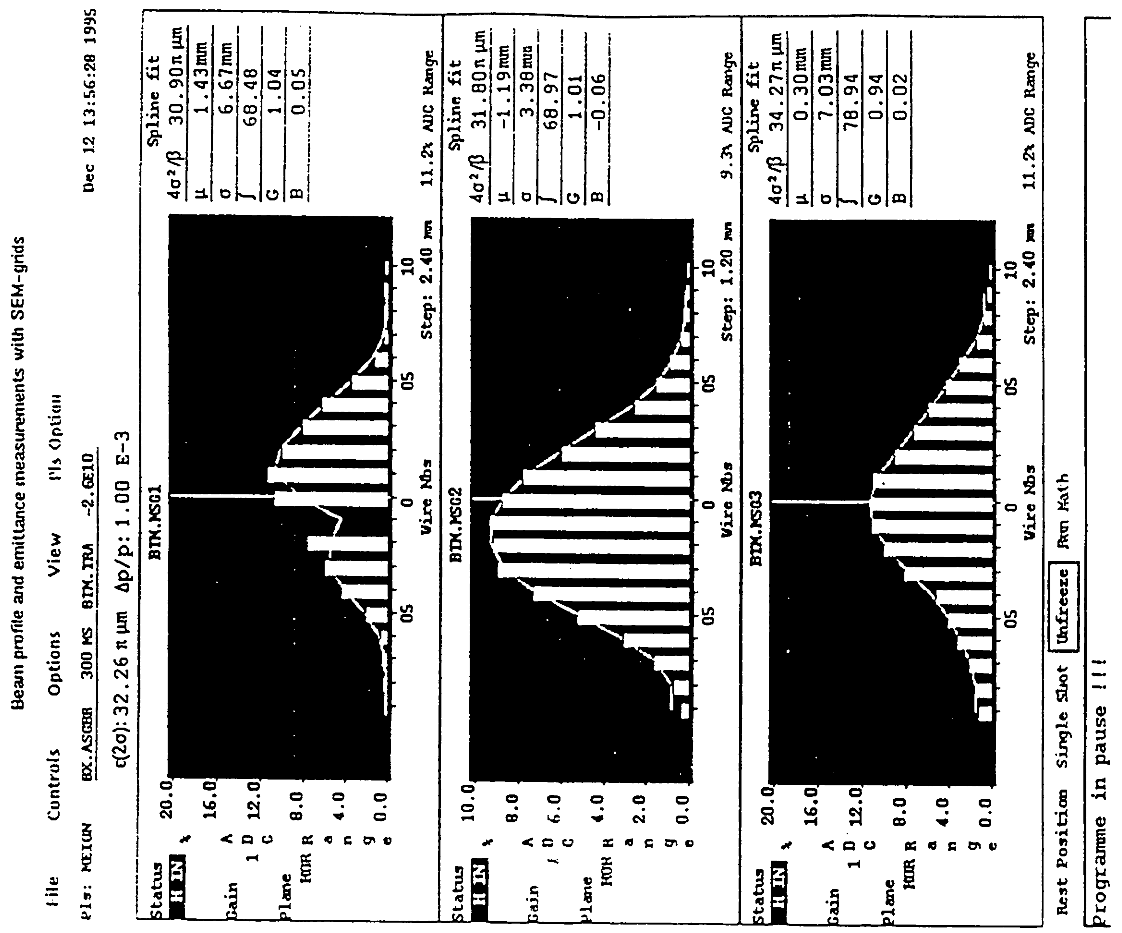


$\frac{\Delta p}{p}$ MEASUREMENT OF THE BEAM COASTING AT 50 MeV IN THE BOOSTER BY BEAM TRANSFER FUNCTION MEASUREMENT

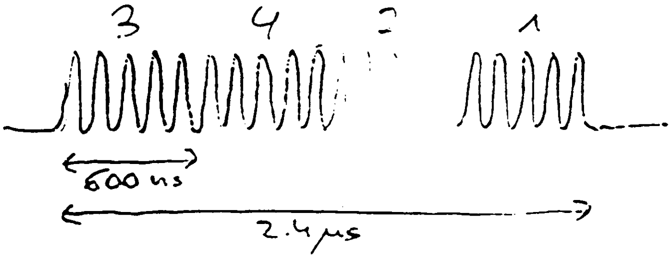


LOSS OF Pb IONS

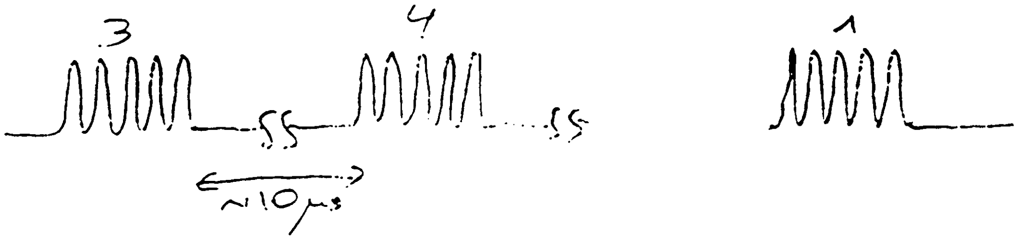




Pb^{53+} IONS IN THE 1 GeV MEASUREMENT LINE (ML)



NORMAL EXTRACTION (SOLID TARGETS)



STAGGERED EXTRACTION (LIQUID TARGETS)

NORMAL AND "STAGGERED" EXTRACTION FOR ISOLDE

PS Performance Day 1996

Status of ABS in the PS Complex

Bruno AUTIN

Abstract

Automatic beam steering has been introduced in the PS complex in 1994 for the correction of the proton coherent oscillations in the PS and the transfer of particles between booster and PS. The two tests were successful and, beyond the obvious simplification of the operation, improved the reliability of the machine by imposing a better quality of the instrumentation and revealing hidden hardware bugs. In 1995, the automation has been consolidated in the PSB-PS line and the correction of injection errors in the PS has been extended to leptons. The adjustment of the Linac-PSB line has been simulated and shows an anomalous sensitivity in the horizontal plane especially, a concern reported by the operation crew in the past years. A revision of this line is thus under study and dedicated experimental tests will be performed this year.

Motivation

Operation

- Simplicity and reliability for fast setting-up and corrections

Performances

- Lower beam losses due to a precise beam steering

Long term

- Emittance preservation for LHC and eventually CLIC.

Cast

M. Arruat, B. Autin, F. Di Maio, V. Ducas,

G.H. Hemelsoet, A. Kazymov, O. Jensen, M. Lindroos,

A. Lombardi, M. Martini, H. Schonauer, O. Tungesvik,

V. Vicente, E. Wildner.

Fields of activity

System Architecture

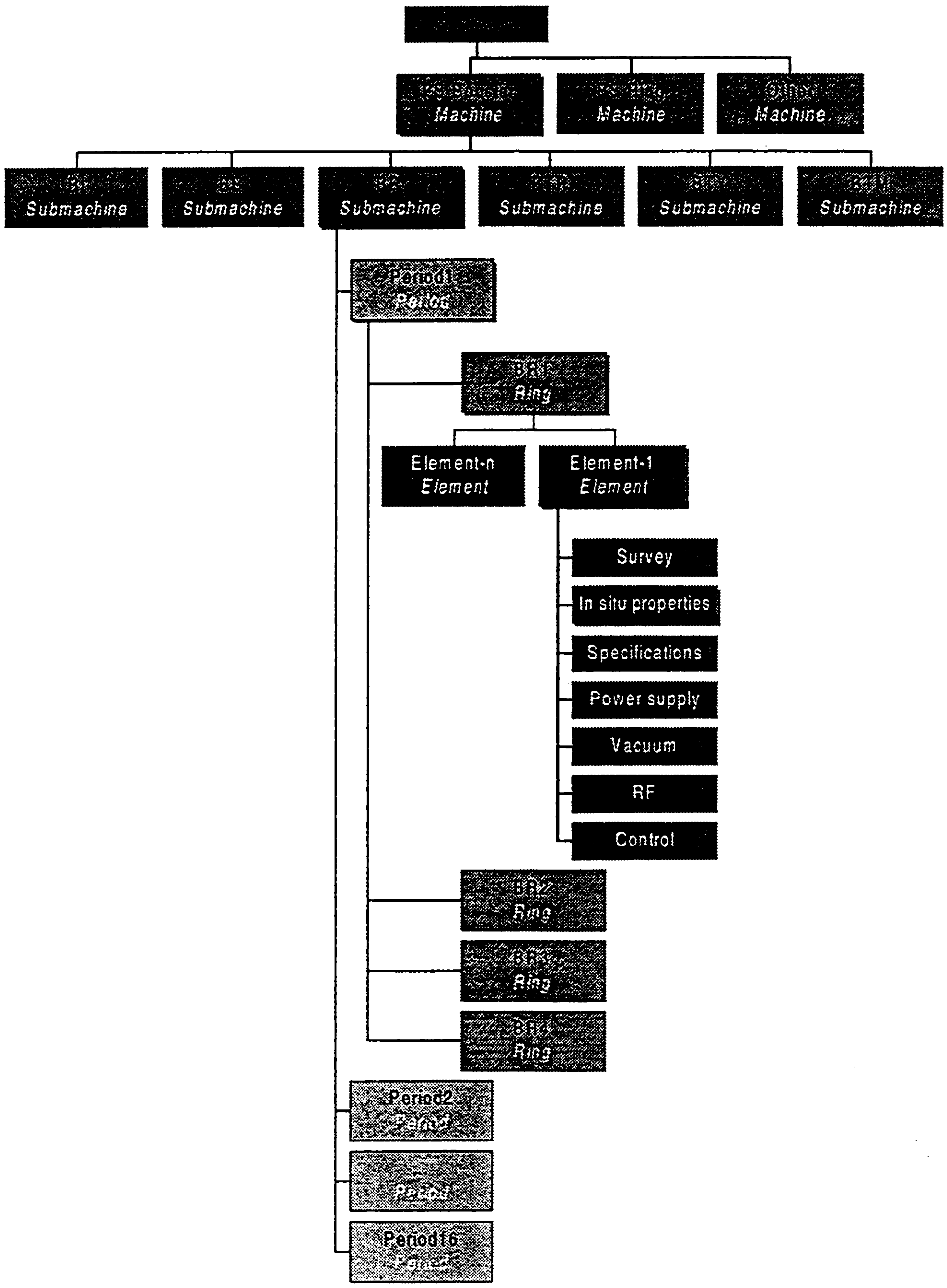
PS Booster-PS line

Linac-Booster line

System architecture

- Access to data base (*ACCIS*)
- Data base
- Selector
- Programs
  - BeamOptics
  - CorrectionMatrix
  - Micado
- User interface

Data base


Machine
Machine
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Period1
Period
Ring
Element-n
Element
Element-1
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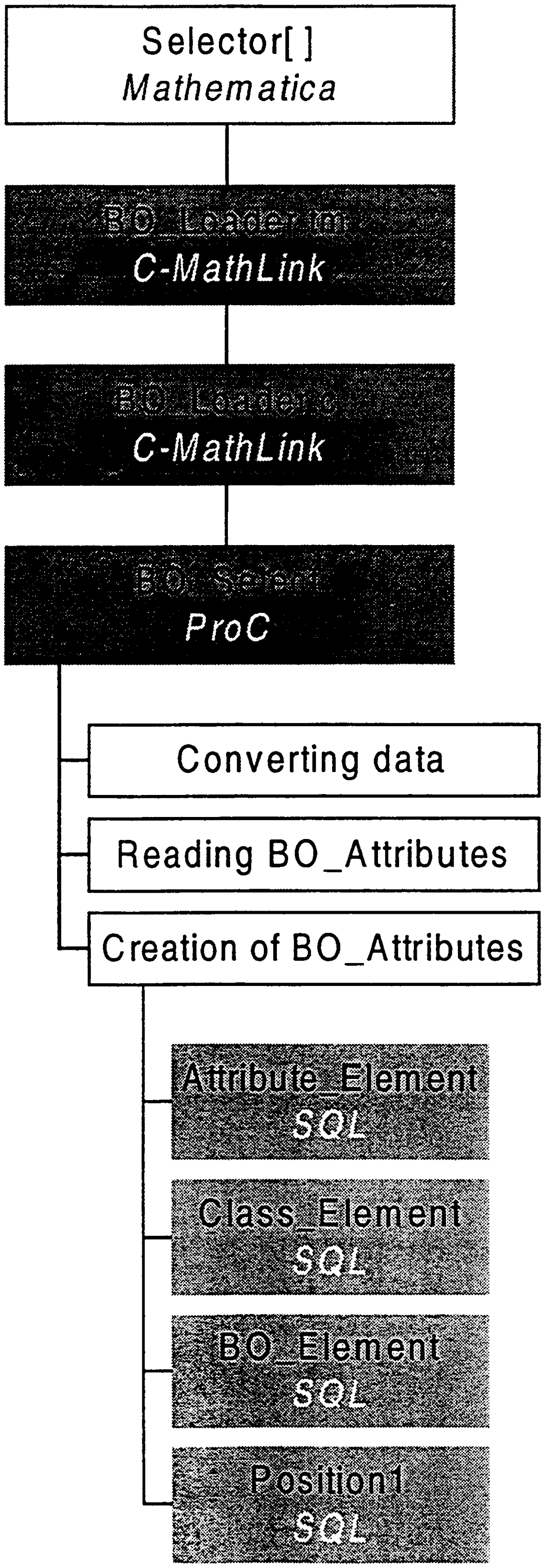
Specifications
Power supply
Vacuum
RF
Control
Ring
Ring
Ring
Period2
Period
Period
Period16
Period

Selector


Selector[ ]
Mathematica
BO_Loader.tm
C-MathLink
BO_Loader.c
C-MathLink
BO_Select
ProC
Converting data
Reading BO_Attributes
Creation of BO_Attributes
Attribute_Element
SQL
Class_Element
SQL
BO_Element
SQL
Position1
SQL

Automatic Beam Control

Example

In[1]:= Install["/mcr/math/Packages/SAP/BO_Loader"]

Out[1]= LinkObject[/mcr/math/Packages/SAP/BO_Loader, 1, 1]

In[2]:= <<SAP`BeamOptics

In[3]:=

db = Selector["BOOSTER","BTY","BeamOptics"];

In[4]:= Short[db]

Out[4]//Short=

{{BTY.QFO304, Q, 0.564, 0, 0.9493, 0, 0, 0, 0, 0},

<<80>>}

In[5]:= ch=ToChannel[db];

In[6]:= Short[ch]

Out[6]//Short=

```
Channel[ Q[0.564, 0.9493],
          SS[0.5],
          <<78>>,
          Q[0.564, 0.5209]]
```

Programs

- **BeamOptics**

General paraxial optics program with symbolic, numeric and graphics facilities.

- **CorrectionMatrix**

Builds the correction matrix A of a machine m for a given correction type and stores the result in an operation file *file*.

Example:

m=Selector["Booster","BR1","Steering"];

a=CorrectionMatrix[m,Steering,file]

It returns the correction matrix, the list of monitors, the list of correctors

- **Micado**

Solves the correction system

$$A x + b = r$$

by finding the corrections x which minimize the norm of the residual vector r for initial measurements b. Note the **generality of the process**: b may denote the positions of a trajectory or of a closed orbit, the tunes at different momenta, etc. The correction is iterative up to an order n. It needs the monitors *mv* and correctors *cv* validated by the operator.

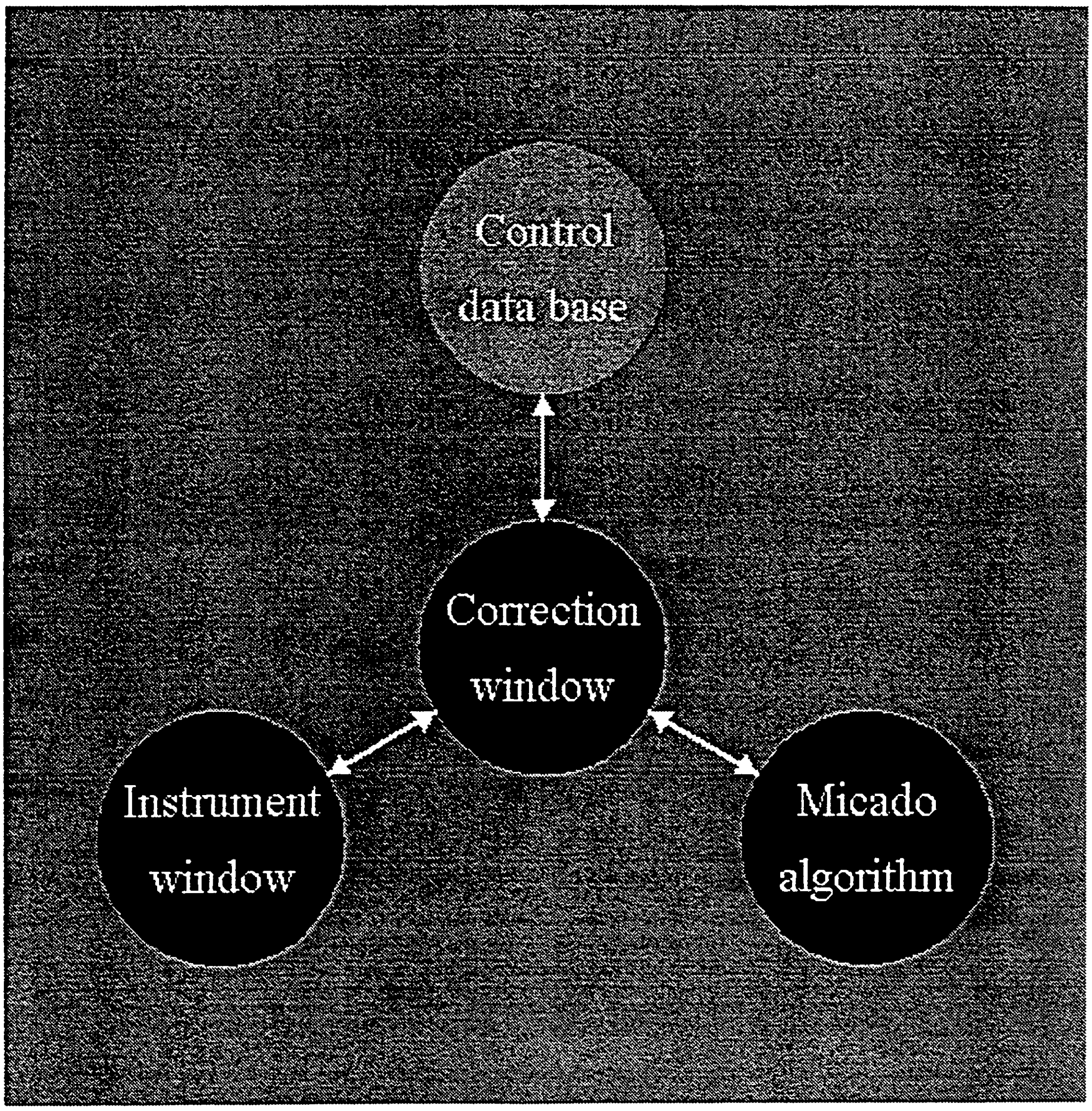
Example:

Micado[file,b,n,mv,cv]

returns: the r.m.s. values of r_1, r_2, ... , r_n , the corrections $\{\{c_1,x_1\},...,\{c_n,x_n\}\}$, the residual vector r_n.

User interface

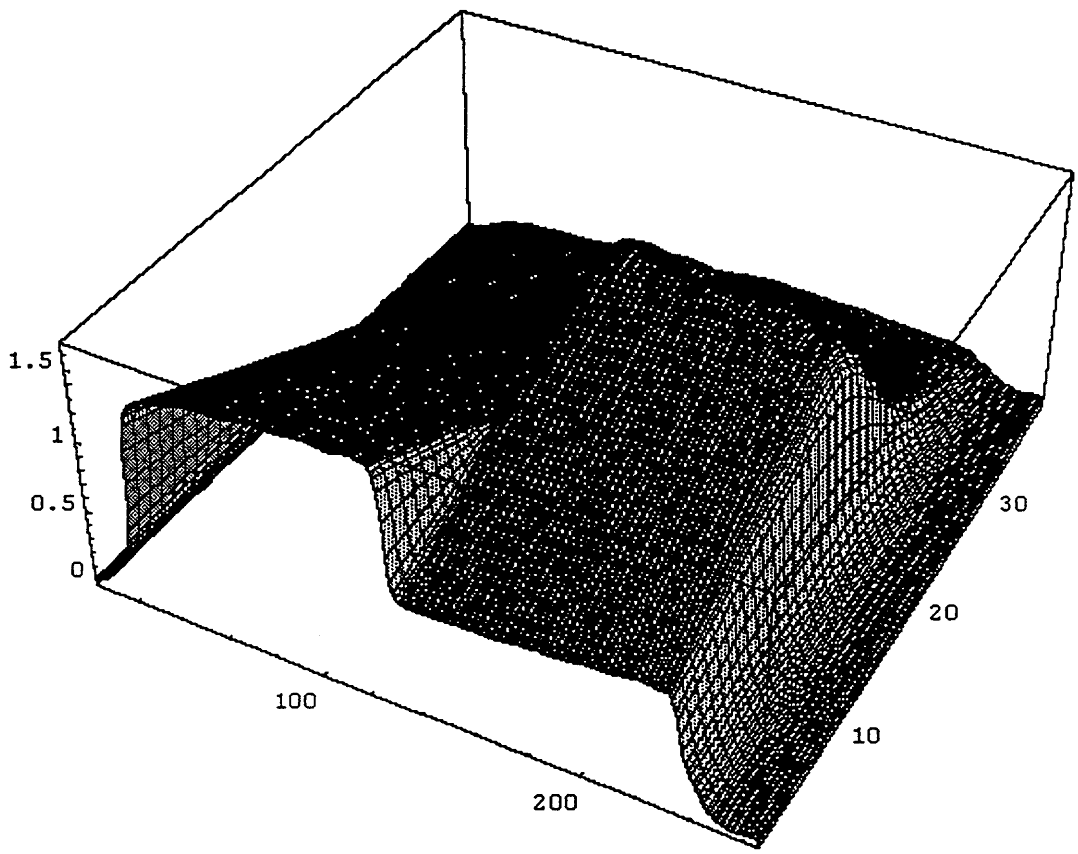
- The Correction window is generic.
- The Instrument window depends on the instrument.



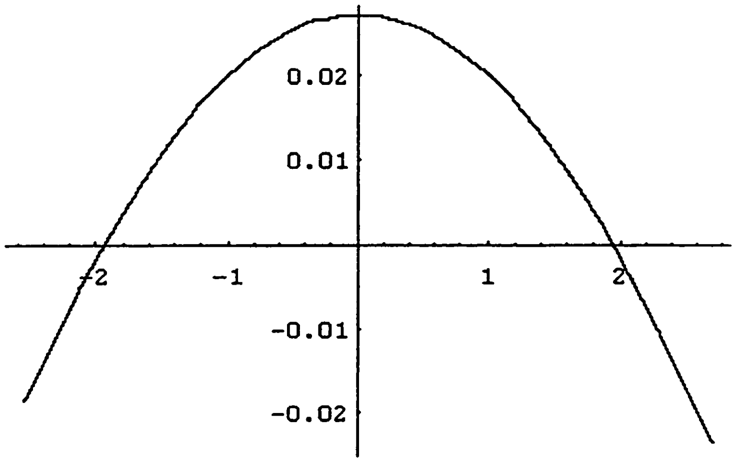
PS

- Preparation of lepton injection.
- Test of positron injection.
- Preparation of optics model for the PS magnet stray field at ejection.

Functional field map



Trajectory



Particle coordinates near the central orbit:

In	Out	
-2550	2730	mm z
-18.46	-23.8324	mm x
31.41	-31.0825	mrad phi

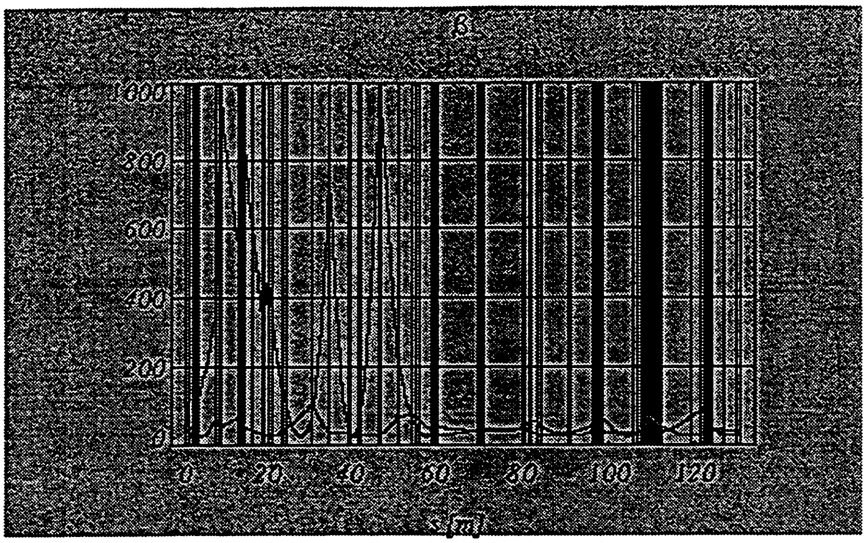
Horizontal transfer matrix:

$$\begin{pmatrix} 1.26475 & 5.26483 \\ -.0116791 & .74206 \end{pmatrix}$$

Booster

- **Booster to PS transfer**
    - Available in operation for four rings.
    - New system for simultaneous acquisition of the four beams.
    - Need for PPM in BTP line.
- **Linac to Booster transfer**
    - Very sensitive beam steering (see β-functions, dispersion and matrix coefficients).
    - Revised optics to concile beam envelope and centroid motion.

The problem of the Linac line



Explosion of horizontal β-function resulting from reverse tracking in the linac-booster line.

-0.17	0	0	0	0	0	0	0	0	0	0	0	0
-0.71	-1.5	0	0	0	0	0	0	0	0	0	0	0
-0.36	-2.6	-0.17	0	0	0	0	0	0	0	0	0	0
2.	-5.5	-6.8	-0.35	0	0	0	0	0	0	0	0	0
-0.9	2.6	3.1	0.066	-0.42	0	0	0	0	0	0	0	0
1.2	-6.4	-5.4	4.	-2.8	-1.4	0	0	0	0	0	0	0
-0.75	5.6	4.	-4.9	3.7	1.1	-1.9	0	0	0	0	0	0
-2.8	17.	13.	-13.	9.8	3.6	-3.8	-2.2	-0.15	0	0	0	0
-2.	12.	9.3	-8.2	5.9	2.5	-1.7	-2.4	-2.8	-0.15	0	0	0
-1.8	9.1	7.8	-5.7	4.	2.1	-0.52	-3.	-5.3	-2.1	0	0	0
2.5	-16.	-12.	12.	-9.1	-3.3	3.7	1.7	-0.82	-2.8	-4.3	0	0
3.1	-19.	-15.	15.	-11.	-4.	4.2	2.4	0.13	-2.7	-4.8	-0.64	0
6.5	-39.	-31.	29.	-21.	-8.3	7.5	6.3	4.1	-3.	-8.3	-4.4	-2.1

Horizontal matrix coefficients in mm/A: the adjustment of beam position within 1 mm at the end of the line requires a precision in current setting of .01 Ampère!

Conclusions

- **α-version of ABC**

Data base, selector, algorithms and user interface exist.

To be done: data entry, running-in of the full system, polishing.

- **PS and PSB**

Improved operation already clear for steering.

The number of automatic tasks will be increased.

Experimental study of the linac-booster line with a probable re-design of the focusing.

- **Think of an automatic correction of orbit dispersion and emittance blow-up.**

PS Performance Day 1996

PS dynamic aperture for the LHC beam

Roberto CAPPI

Abstract

The LHC beam at PS 26 GeV/c extraction has a large momentum spread. Foreseen at the beginning as $dp/p=\pm2x10^{-3}$ it was then "raised" to $\pm4x10^{-3}$ to eventually gain stability in the SPS.

Studies were made in the first part of 95 to check if it was possible to extract and transfer to the SPS such a beam without destroying its transv. emittances.
Some preliminary results concerning measurements done in 1995 are presented. They show that we can expect a PS to SPS transmission of ~100% for beams with dp/p<±4x10-3. Possible transverse mismatch has not been yet investigated.

Instrumentation calibrations and TT2 optics verifications done for these measurements have also improved the performance of operational beams (e.g. ions).

RC / PPD96

PS (DYNAMIC) APERTURE FOR LHC BEAM

Instrumentation: C. Dutriat,U. Raich, J. Olsfors, M.Arruat
Operation: G. Azzoni, B. Vandorpe
Beam Studies: R.Cappi, D. Manglunki, M. Martini, J-P. Riunaud

The problem:

The LHC beam at PS 26 GeV/c extraction has a large momentum spread. Foreseen at the beginning as dp/p=+-2 10^{-3} it was than "raised" to +-4 10^{-3} to eventually gain stability in the SPS.
Studies were made in the first part of 95 to check if it was possible to extract and transfer to the SPS such a beam without destroying its transv. emittances.

1st PART:

DA measurements of the circulating beam at 26 GeV/c

Transv. emittance measurements (H & V) were done with WS's before and after extraction bumps (Δt ~ 30ms), keeping the extraction kicker OFF and changing the beam momentum with a radial perturbation

$$I_p \sim 10^{12} \text{ ppp}, \; k_b = 20, \; \varepsilon_l = 0.5 \text{ eVs}, \; dp/p = \pm 0.3\ 10^{-3},$$
$$\varepsilon^*_x \sim \varepsilon^*_y \sim 4\ \mu m\ (1\sigma)$$

RESULTS:

a) no significant $\varepsilon_{x,y}$ blow-up (< few %) for
$-5\ 10^{-3} < dp/p < 5\ 10^{-3}$

b) at these positions only few % of beam losses were measured (SS16).

2nd PART:

Extracted beam

Transv. emittances measured on TT2 SEMgrids and SEMfils. Transmission measured with transformers up to SPS injection.

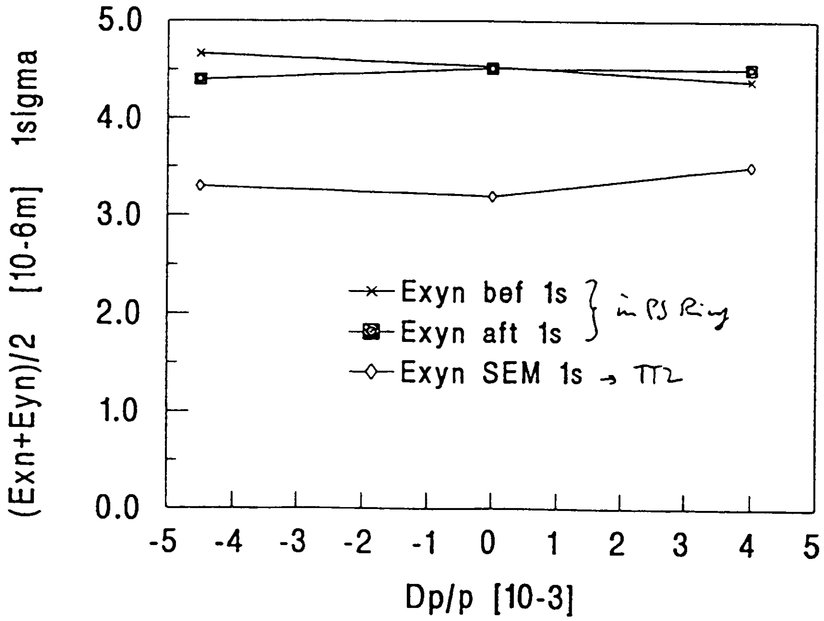
RESULTS:

a) $\varepsilon_{x,y}$ values consistent (+-20%) with those measured in the machine with WS's.

b) Transmission close to 100% for

$-4\ 10^{-3} < dp/p < 4\ 10^{-3}$

including SPS injection



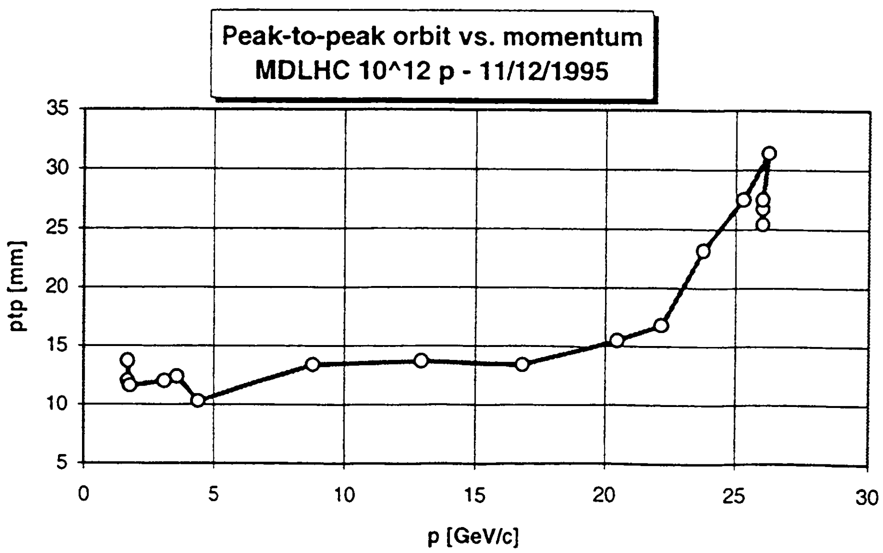
REMARKS:

☞ Mismatch factors of 20 - 100 % were measured...but uncertainties exist on the consistency of these data...*A SUIVRE...VERY IMPORTANT !*

☞A lot of time was devoted to check and calibrate the instrumentation (WS's, SEM's, etc.)...and many problems were detected and cured. *Some improvements are still missing in the signal and data processing and WS measurements.*

☞Many efforts were also dedicated in carefully tuning the machine working point (e.g. chromaticity) taking advantage of the new GFA's, Q-meas., the PC "passerelle" etc. *We don't need HE octupoles any more!*

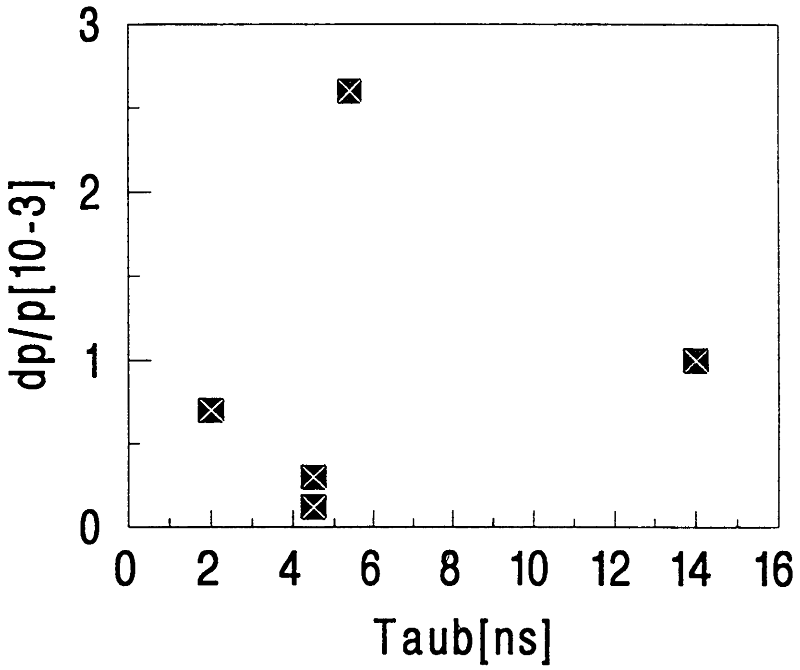
☞The horizontal orbit was found to deteriorate at high energy. Why? *This will have to be investigated in the future.*



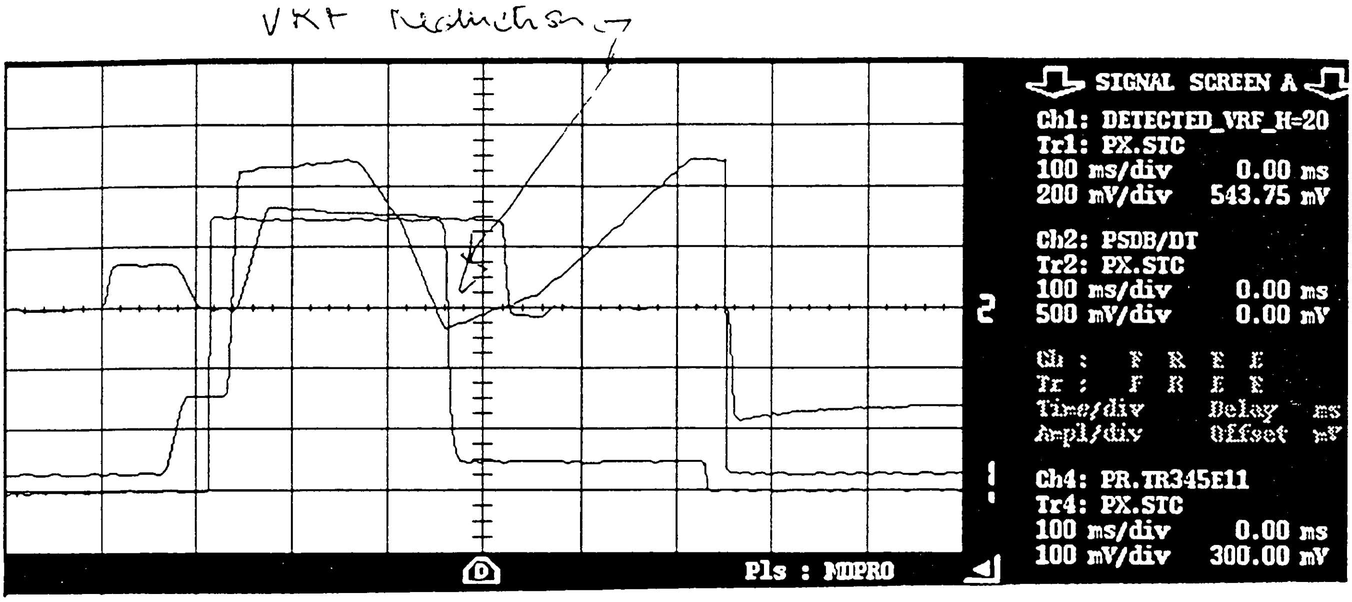
☞ TT2 optics was also examined (for ex. by measuring the dispersion SEM positions). The measured values were in agreement with the theoretical ones...but not exactly (+- 20%).

☞ We profited of the many special beams we had to prepare, in parallel, for the μW SPS instability studies.

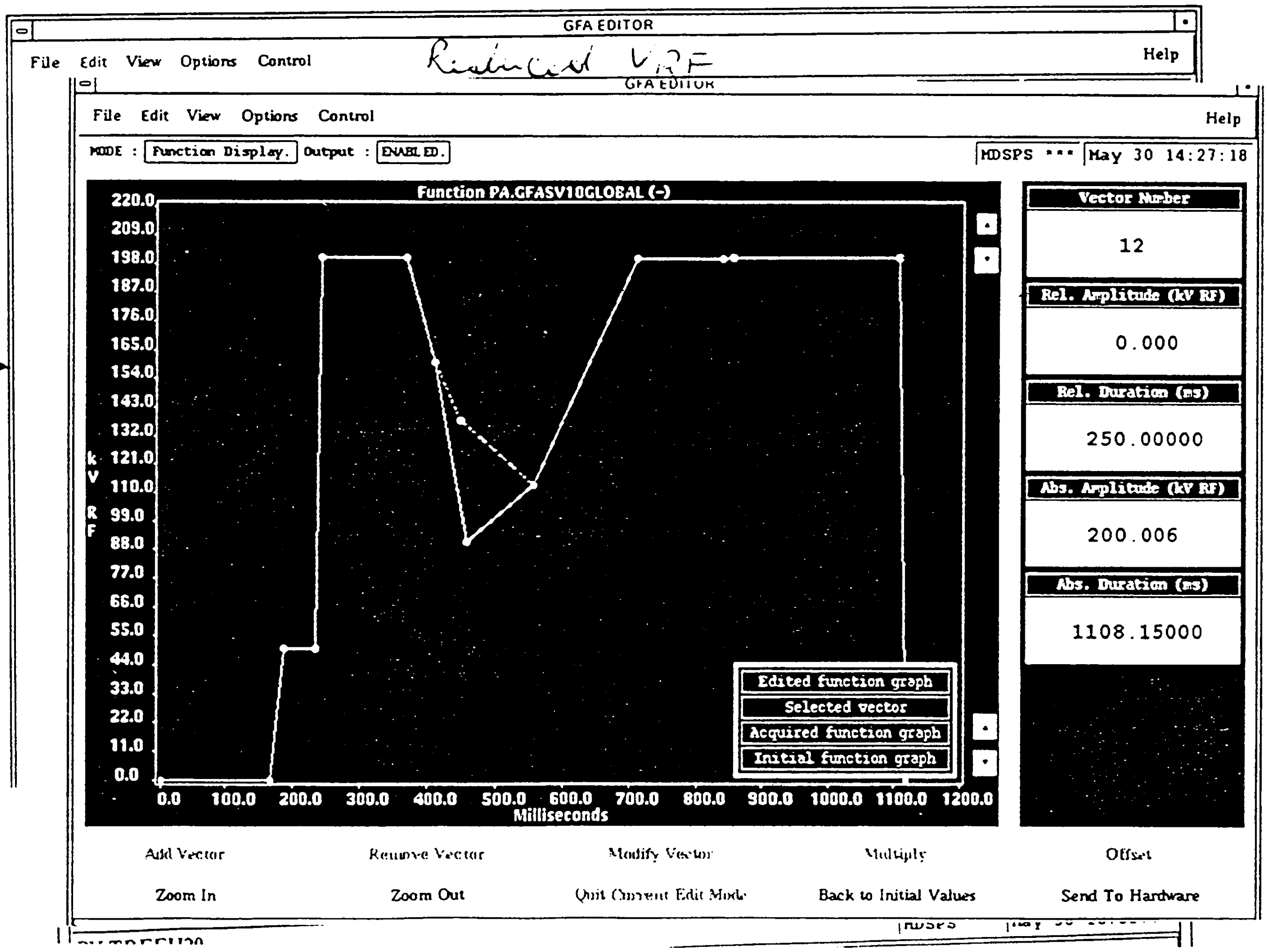
These beams, of various long. dimensions and densities, were obtained by combining RF scraping and bunch rotation gymnastics.



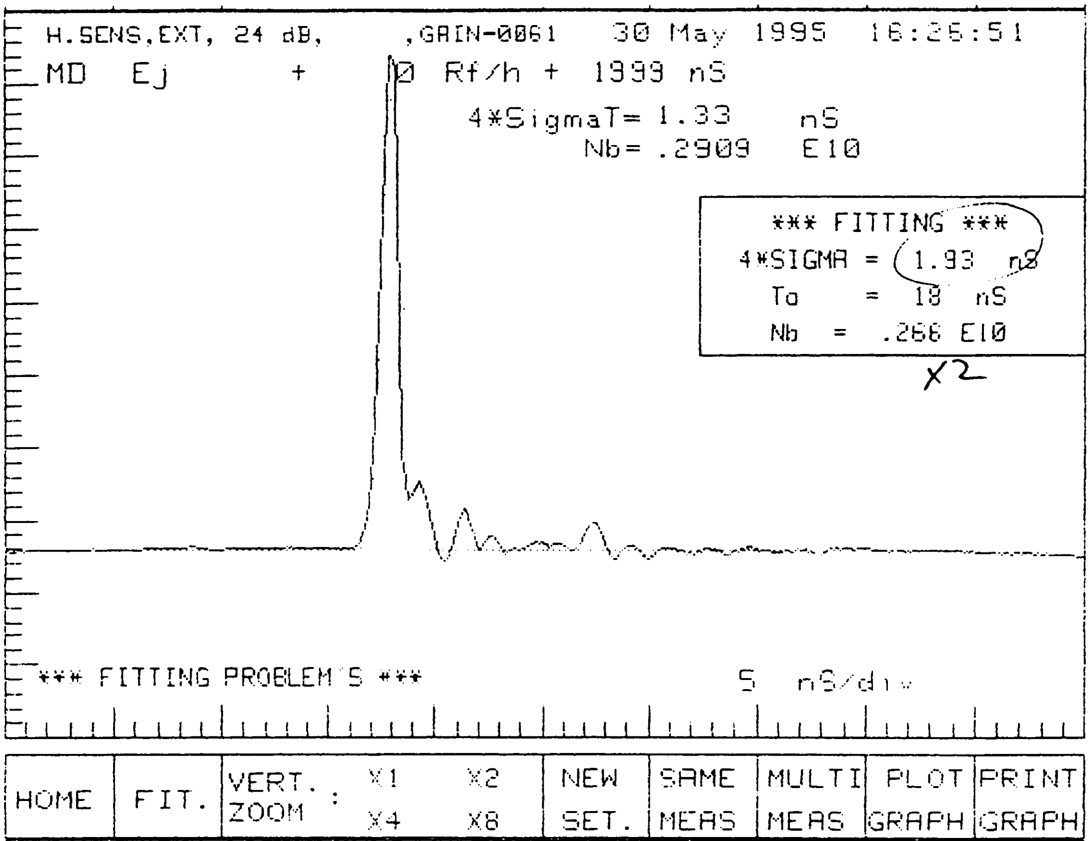
4a



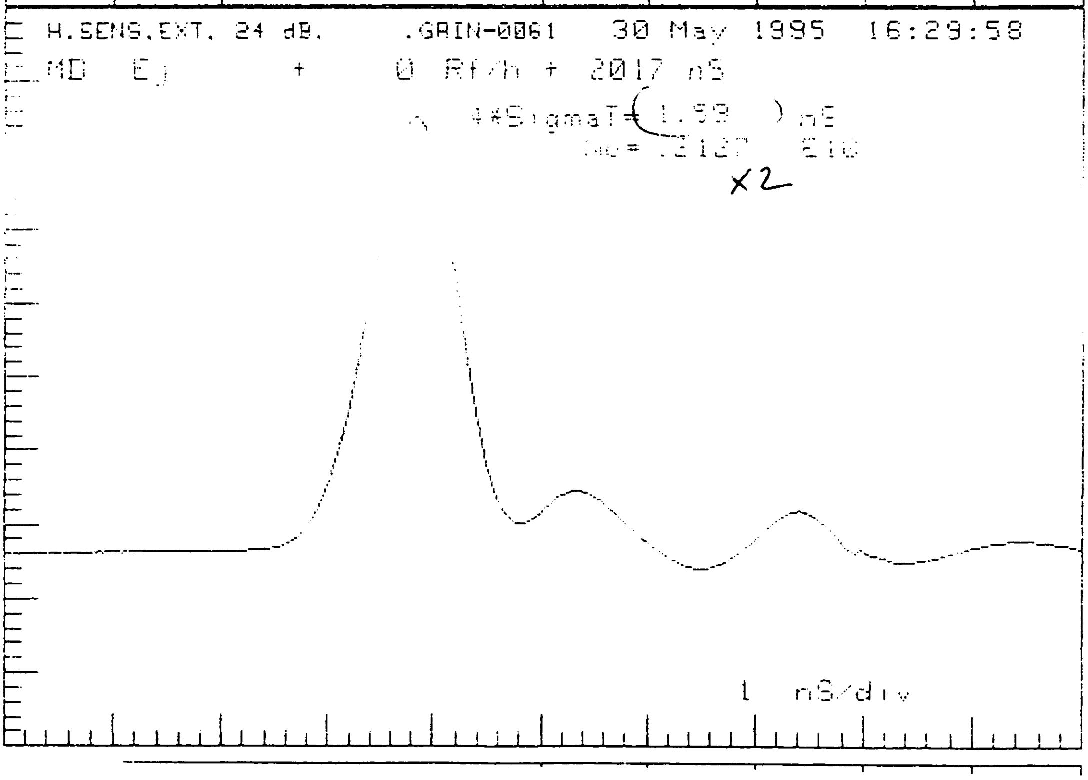
VRF Reduction
SIGNAL SCREEN A
Ch1: DETECTED_VRF_H=20
Tr1: PX.STC
100 ms/div 0.00 ms
200 mV/div 543.75 mV
Ch2: PSDB/DT
Tr2: PX.STC
100 ms/div 0.00 ms
500 mV/div 0.00 mV
Ch : F R E E
Tr : F R E E
Time/div Delay ms
Ampl/div Offset mV
Ch4: PR.TR345E11
Tr4: PX.STC
100 ms/div 0.00 ms
100 mV/div 300.00 mV
Pls : MDPRO



GFA EDITOR
File Edit View Options Control
Reduced VRF
Help
MODE : Function Display. Output : ENABLED.
MDSPS *** May 30 14:27:18
Function PA.GFASV10GLOBAL (-)
kV RF
220.0
209.0
198.0
187.0
176.0
165.0
154.0
143.0
132.0
121.0
110.0
99.0
88.0
77.0
66.0
55.0
44.0
33.0
22.0
11.0
0.0
0.0 100.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0 900.0 1000.0 1100.0 1200.0
Milliseconds
Edited function graph
Selected vector
Acquired function graph
Initial function graph
Vector Number
12
Rel. Amplitude (kV RF)
0.000
Rel. Duration (ms)
250.00000
Abs. Amplitude (kV RF)
200.006
Abs. Duration (ms)
1108.15000
Add Vector
Remove Vector
Modify Vector
Multiply
Offset
Zoom In
Zoom Out
Quit Current Edit Mode
Back to Initial Values
Send To Hardware


H.SENS,EXT, 24 dB, ,GAIN-0061 30 May 1995 16:26:51
MD Ej + 0 Rf/h + 1999 nS
4*SigmaT= 1.33 nS
Nb= .2909 E10
*** FITTING ***
4*SIGMA = 1.93 nS
To = 18 nS
Nb = .266 E10
x2
*** FITTING PROBLEM'S ***
5 nS/div
HOME
FIT.
VERT. ZOOM :
X1 X2 X4 X8
NEW SET.
SAME MEAS
MULTI MEAS
PLOT GRAPH
PRINT GRAPH

③


H.SENS,EXT, 24 dB, ,GAIN-0061 30 May 1995 16:29:58
MD Ej + 0 Rf/h + 2017 nS
4*SigmaT= 1.59 nS
x2
1 nS/div

④

THE GOOD NEWS (T. Linnecar, E. Shaposhnikova)

Preliminary results indicate that bunches of $N_b = 10^{11}$ p/b $\varepsilon_l \sim$ 0.35 eVs, $\tau_b \sim$ 3.5ns, **dp/p ~ +- 2.5 10^{-3}** will be stable in the SPS.

CONCLUSIONS

☺ The PS_{extr} - TT2 - TT10 - SPS_{inj} transmission is ~100% if

$$-4\ 10^{-3} < dp/p < 4\ 10^{-3}$$

😐 Transverse matching is for the time being unexplored

☺ All these studies have definitely profited to the performance of the normal operational beams (e.g. ions)

1996 PROGRAM (concerning the LHC beam)

We will concentrate on

transverse matching

collective effects during the acceleration and debunching *(1st prototype of 40MHz cavity in the PS at the end of the year!).*

<u>a last remark</u>

With the SPS //MD cycle we are entering in a new phase of operation:

one more user
many more and "difficult" beams

this demands good

coordination,
communication,
flexibility,
<u>collaboration</u>

PS Performance Day 1996

CT 5 turn improvement

Michel MARTINI

Abstract

Two split foils in TT10 have been equipped with a wide band readout electronics to measure the proton intensity and beam centroid position profiles during the continuous transfer from CPS to SPS. Vertical excursions have been observed during the spill with a maximum peak-to-peak amplitude of about 20 mm. No relevant horizontal displacement has been observed. An almost complete cancellation of the vertical beam position excursion along the spill has been achieved in two steps:

- Adjustment of the timing and strength of the kick provided by the *Emittance Reduction Dipole* (ERD1) in TT2 acting on the last (5th) PS turn.
- Addition of a second kick provided by a spare *Emittance Reduction Dipole* (ERD2) to adjust independently the 4th and 5th PS turns.

A reduction of the mean vertical emittance of the injected beam up to 21% and an improvement of the injection efficiency in the SPS up to 3% have been achieved.

Continuous Transfer (CT) Improvements

GOAL: Provide high intensity proton beams for SPS Fixed Target Physics (SFT)

Outline

- SFT Beam Process
- CT System
- CT Improvements

SFT Beam Process

SFT beam characteristics

p [GeV/c]	I_b [p/batch]	h	ε^*_x [µm]	ε^*_y [µm]	ε_l [eVs]	$\Delta p/p$	τ_b [ns]
14	$2.5\ 10^{13}$	420	11	7	0.1	10^{-3}	5

PROCESS

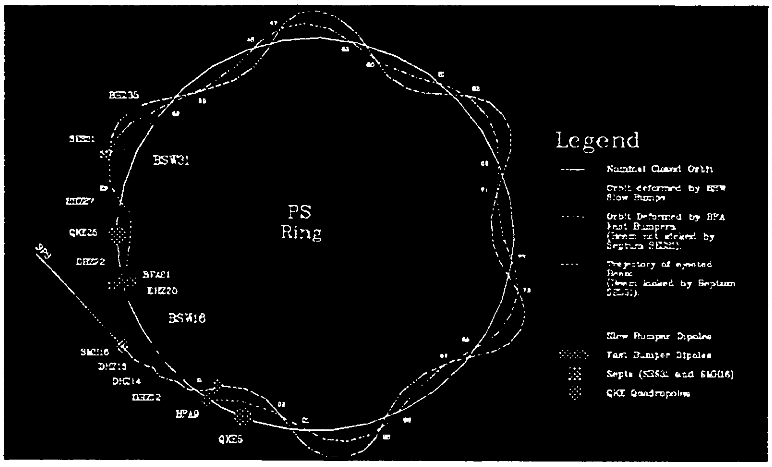
- 20 bunches PS injection at 1 GeV
- Acceleration on h=20 beam (9.5 MHz) up to 14 GeV/c
- Debunching and rebunching on h=420 (200 MHz)
- Continuous transfer to SPS (5 turn shaving ejection):
  - 420 bunches/turn: 1 SPS batch of 2100 bunches (5/11 of SPS)
  - 4200 SPS bunches in 2-batch ejection (4620 SPS buckets)

CT System (1)

ELEMENTS FOR CT

- *1 PS electrostatic septum* (*SES*): 5 turn beam shaving
- *1 PS electromagnetic septum* (*SMH*): beam slice ejection **(the shaved slices are kicked out of the PS)**
- *2 PS slow bumpers* (*BSW*): place the beam near *SES* and *SMH*
- *2 PS fast bumpers* (*BFA*): shift the beam progressively into *SES*
- *2 PS quadrupoles* (*QKE*): kick enhancement, *SES* high β-function, zero dispersion function **(avoid losses and momentum drift)**
- *PS pole face windings, figure-in-eight-loop*: Q_x=6.25 ($\xi_{x,y}$>0)
- *1 TT2 electromagnetic kicker* (*ERD* - ***Emittance Reduction Dipole***): 5*th* slice angle correction **(reduce integrated 5 turns ε_x)**

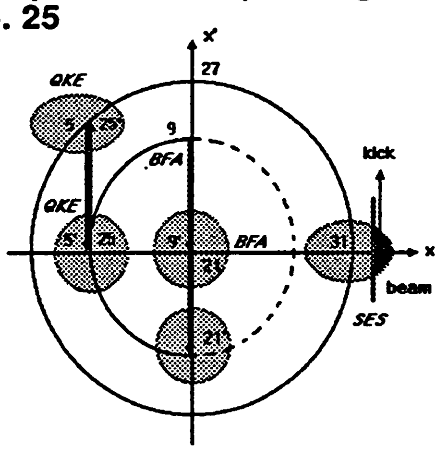
CT System (2)



PPD 16 Feb 1996

CT System (3)

Phase plane beam peeling: Q=6.25



Michel Martini — CT 5 turn improvements — 5

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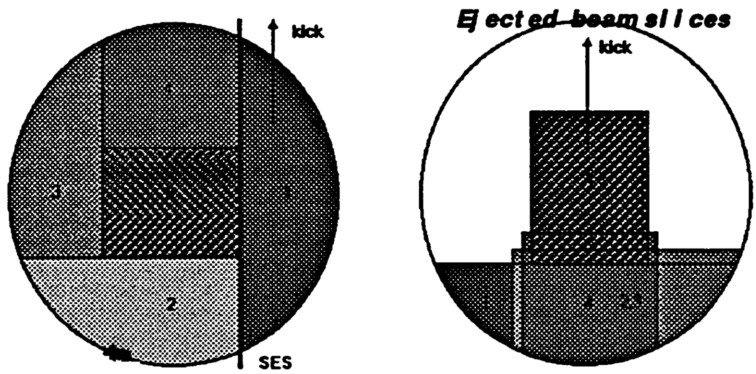
CT System (4)

5 turn shaving ejection : Q=6.25

Horizontal phase plane at *SES* — Horizontal phase plane at *SMH*



Michel Martini — CT 5 turn improvements — 6

CT Improvements (1)

PROBLEM

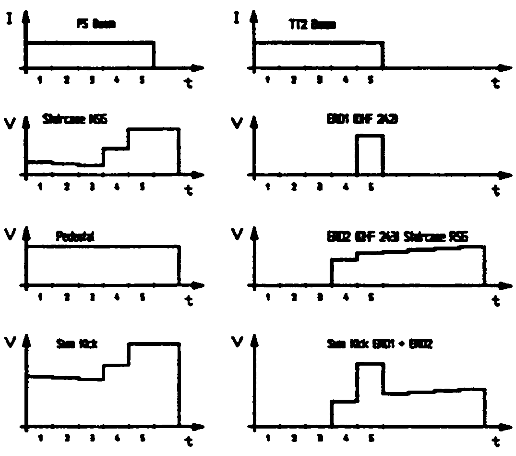
- Adequate TT2 horizontal alignment of the 5 beam slice centroids cannot be achieved with a single *ERD*
  - » **Variable beam slice ejection trajectories due to a *BFA* (*5th* turn -*4th*?- angle at *SMH* different from the other)**
  - » **Vertical emittance blow-up at SPS injection (TT10 emittance exchange to cope with SPS vertical acceptance limitation)**

SOLUTION

- Installation of 2 *SPLIT FOILS* in TT10:
  - » **Measure beam centroid position profiles and intensity**
- Additional *ERD* in TT2:
  - » **2nd kick to better align the ejected turns:**
    - *1st ERD* (*5th* turn), *2nd ERD* (other turns)

CT Improvements (2)

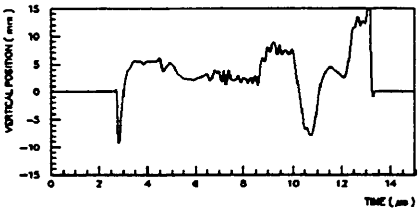
BFA PS function | ***ERD*** TT 2 function

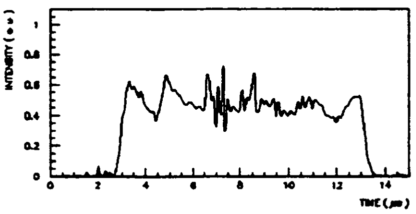


CT Improvements (3)

TT10 beam <u>before</u> *ERD* tuning

- **Vertical beam centroid position**
  - *BFA*'s rise/fall times yield peaks at spill beginning/end
  - 20 mm peak-to-peak oscillation between the *4th*-*5th* turns
  - No horizontal oscillation observed between turns
- **Spill intensity profile**
  - Adjusted with the *BFAs*

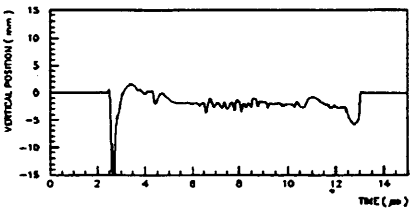


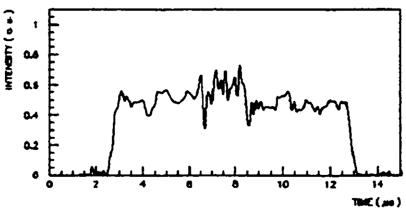


CT Improvements (4)

TT10 beam <u>after</u> *ERD* tuning

- **Vertical beam centroid position**
  - ***1st ERD*** timing and kick strength adjustments (*5th* turns)
  - ***2nd ERD*** timing and kick strength adjustments (*4th* and *5th* turns)
  - 4 mm peak-to-peak displacement between *4th* and *5th* turns
- **Spill intensity profile**





CT Improvements (5)

New performance

Mean beam parameters

TT10 horizontal emittance reduction $\Delta\varepsilon^*_x/\varepsilon^*_{x0}$	0 %
TT10 vertical emittance reduction $\Delta\varepsilon^*_y/\varepsilon^*_{y0}$	21 %
SPS injection efficiency increase	3 %
SPS 440 GeV transmission efficiency increase	3 %

Fast ejection of positrons in straight section 61

Jean-Pierre RIUNAUD

Abstract

A short MD session was devoted to the Fast Extraction of e^+ beams to the East Area (FE61). The purpose of the experiment was to take advantage of the fast extraction to the East Area of p^+ beam at low energy (<3.5 GeV/c), already achieved in 1994 for the Energy Amplifier Test, to send e^+ to this area via the same process. The final aim being to check whether the PS can provide a pure and high flux (10^9) e^+ beam to East Area users, who presently get these leptons as secondaries at low fluxes ($<10^5$) and mixed with other secondaries.

Fast extraction of e^+ (or p^+) to the East Area makes use of the PS general purpose full aperture kicker KFA71-79 and elements of the slow extraction, namely 4 dipoles for the orbit bump and 2 magnetic septa. For positron extraction, the Pole Face Windings at low current, normally powered during the lepton acceleration cycle, were used to tune machine parameters such as chromaticities, transverse tunes and (partially) damping.

An e^+ beam was successfully extracted and observed on the first TV scintillator screen of the area.

Fast Extraction of e^+ to the East Area

Aim:

- Make use of the low energy p^+ Fast Extraction (FE61) achieved for the Energy Amplifier Test
- Add the possibility of providing "pure" and "high flux" e^+ beams to the users of the East Area

MD session : 19/10/95

R. Cappi, L. Durieu, J.-Y. Hémery, M. Martini, G. Métral, B. Vandorpe, J.-P. Riunaud

PPD Chavannes de Bogis, 16 Feb. 1996

Proportion of e^+ in Secondary Beams

(2. 10^{11} p^+ hitting the target at 24 GeV/c)

© PS/PA/Note 93-21
L. Durieu, D.J. Simon

Beam t7

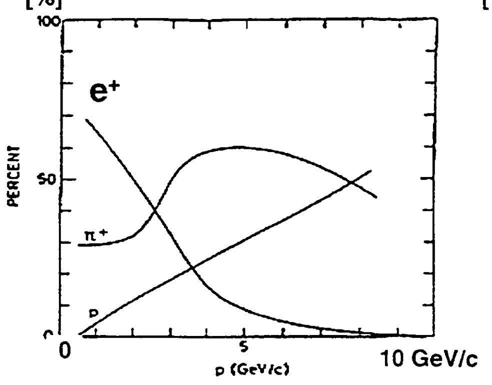


Fig. 14 Relative distribution of protons, pions and positrons in the t7-beam, as measured by PS188 (Ref. 6,7)

Beam t11

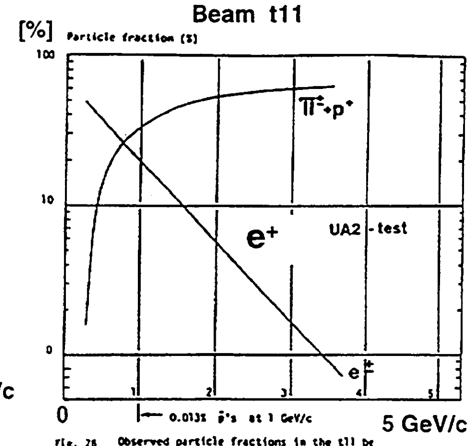
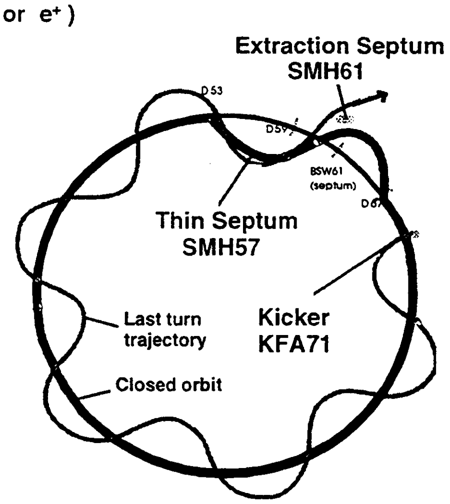


Fig. 28 Observed particle fractions in the t11 be (particle identification by 2 Čerenkov counters + 1 pre-shower detector) UA2-test (1987)

Fast Extraction FE61

(p^+ or e^+)

- **Elements**
  - Fast kicker KFA71/79
  - Some dipolar elements of Slow Extraction 61
- **Adjustments**
  - Qx = 6.10 for proper phase advance & Horiz. Dispersion



Fast Extraction of e^+ compared to p^+

- Smaller beam size of e^+
  - Radiation damping
  - Vertical emittance only due to coupling
- Use of Pole Face Windings to control
  - Chromaticity
  - Damping (partially)
  - Focusing
- Tool to control ξ_x, ξ_v, J_x, Q_x, Q_y with 3 PFW and a Wiggler

Tuning ξ_h, ξ_v, Q_h with PFW currents I_F, I_D, I_B

- PS natural chromaticities: $\xi_{x,v} = -1$
- Use of $PFW_{F,D}$ to change chromaticities
  - Requirements: $\Delta \xi_{x,v} > 1$ to get $\xi_{x,v} > o$ for e^+ stability
    - Produced by $PFW_{F,D}$: $I_F > 0$ & $I_D < 0$
    - Consequence: $\Delta Q_x > 0$ & $\Delta Q_v < 0$
- Use of PFW_B to reduce Q_x to 6.1
  - $\Delta Q_v > 0$ and no effects on $\xi_{x,v}$
  - Produces a favourable Damping change ($\Delta J_x = .6$)
- Final results: ξ_x=.80; ξ_v=.35; Q_x=6.11; Q_v=6.39

PPD Chavannes de Bogis, 16 Feb. 1996

Results and Next Steps

Achieved

- Operational changes:
  - Slow Extraction / Fast Extraction / Lepton cycle
- Beam on first TV screen at entrance of East Area (TV2)

Next step

- Transport e^+ down to secondary line

Possible Positron Beams in the East Area

	Slow Extraction Primary $p^+ >> e^+$	Fast Extraction Primary e^+
User (s)	Beam sharing	Single user
Beam composition	e^+, p^+, π^+, ...	e^+
Energy	0 - 5 GeV	3.5 GeV or lower, fixed
Flux [e^+/ pulse]	10^3 - 10^5	10^7 -10^9
Burst duration	350 ms	5 ns bunches, within 2 μs
PS cycle	2.4 s, High energy	1.2 s, Low energy

PS Performance Day 1996

LEAR MDs with ions

Gérard TRANQUILLE

Abstract

In the framework of the LHC project, LEAR is expected to be used as a lead ion accumulator where electron cooling plays an important role in the stacking process.

Development time has been devoted to improving the transport of the ions from the Linac 3 to LEAR, the understanding of the mechanisms that limit the beam lifetime under electron cooling, and also the reduction in the cooling time constant through the variation of various cooling and machine parameters.

LEAR MD with ions

- Motivation for the studies
  - LEAR to be used as a Pb ion accumulator for LHC
  - Stack 1×10^{9} ions in 2 secs.
  - Cooling times <100ms for multiturn injection

Studies made

- Transfer line : beam transport
  injection matching
- Beam lifetime measurements
- Cooling time measurements

Machine parameters

Ion energy	4.2	MeV/u
Proton eq. momentum	341	MeV/c
Velocity	0.094c	ms^{-1}
Ring circumférence	78.54	m
Cooling length	1.50.02	m
Electron beam radius	0.025	m
Electron beam current	0.02-0.5	A
Electron density	$2.2\times10^{8}I$	cm^{-3}
Longitudinal B field	628	G
Machine I		
D	3.6	m
β_H	1.7	m
β_V	6.5	m
Machine IV		
D (SS1 & SS3)	0	m
β_H (SS1 & SS3)	11	m
β_V (SS1 & SS3)	7	m

Allocated MD time

- December 1994 - Pb^{53+}, injection & lifetime
- June 1995 - $Pb^{52+,53+,54+}$, lifetime
- December 1995 - $Pb^{53+,54+,55+}$, lifetime & cooling time

Transfer Line

- Problem taking the beam around the E0 loop
- Poor instrumentation - 1 SEM grid & 5 TV screens
- Injection matching still difficult
- 1..2x10^8 charges/injection
- All charge states transported and injected

Lifetime measurements

- Power density of Schottky signal is directly proportional to the intensity
- Lifetime τ (1/e) obtained from an exponential fit of the Schottky power density evolution recorded on a spectrum analyzer
- The decay rate $1/\tau = \Sigma_r 1/\tau_r$ where r = machine vacuum
  electron recombination
  other losses (I.B. stripping)
- Plotting $1/\tau$ vs. I_e the slope of the curve gives us information on recombination processes

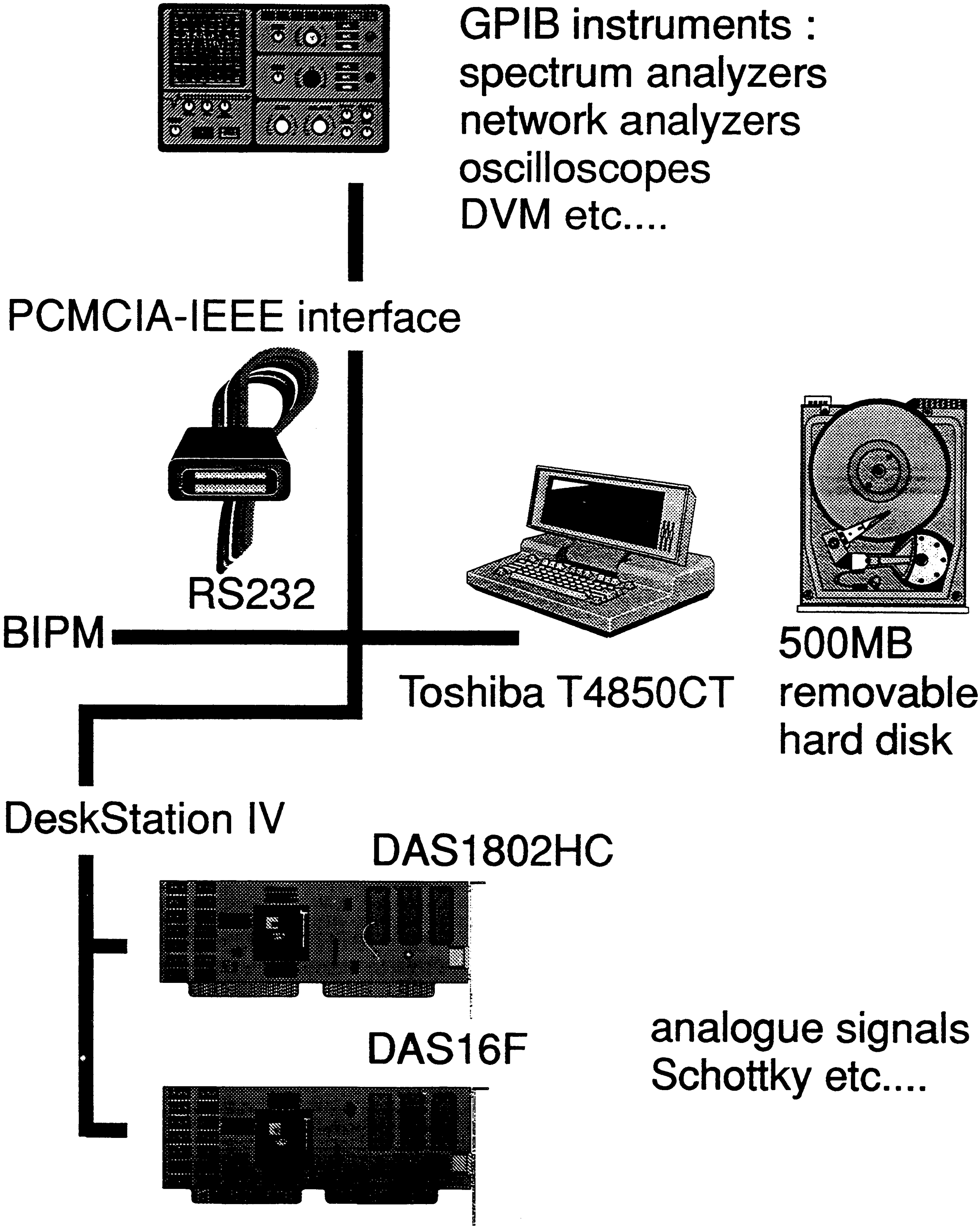
$$\alpha = (1/\tau)/(2.25\text{x}10^6\, I_e)$$

Cooling time measurements

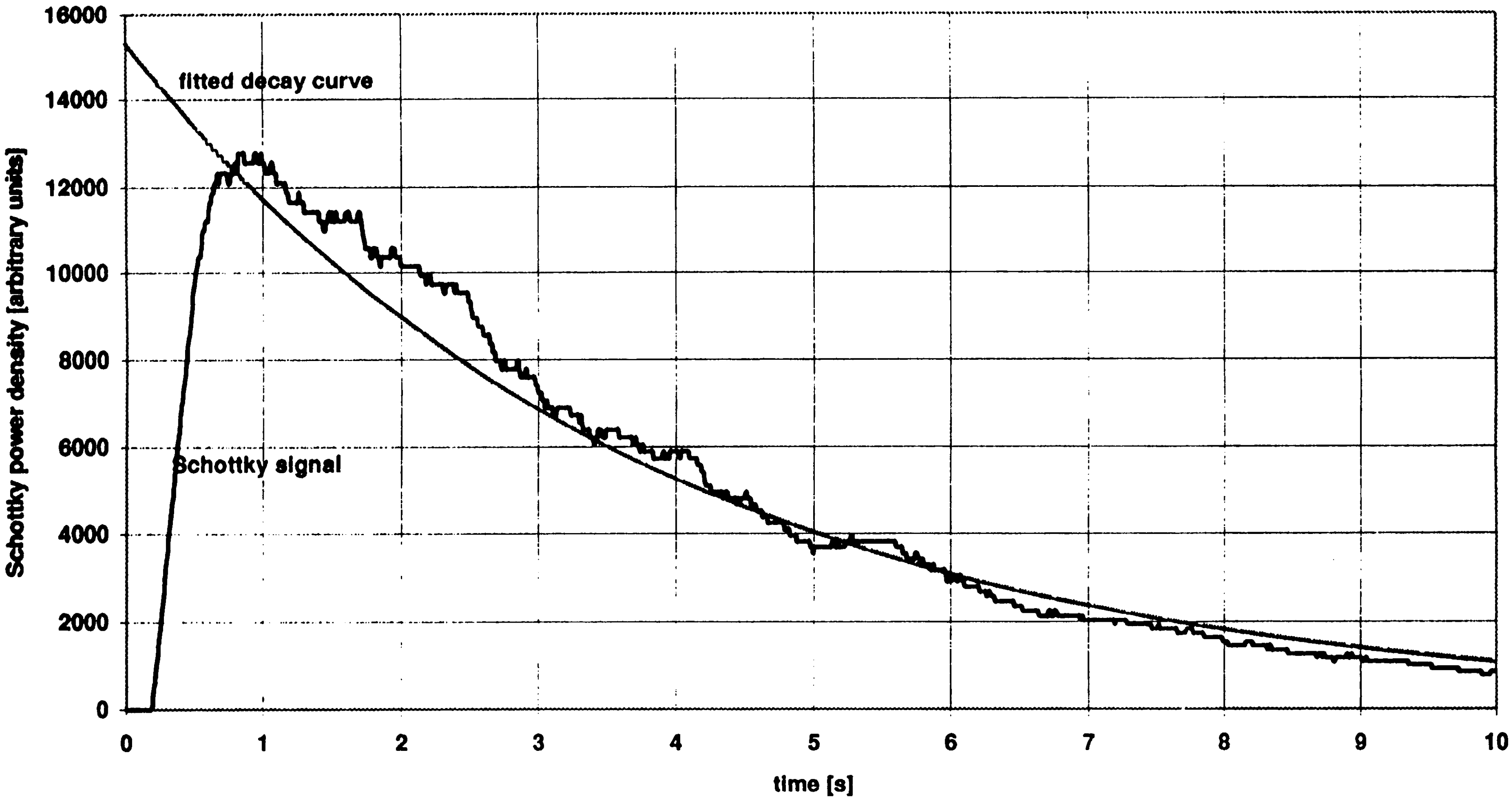
- Measured the total cooling time, i.e. the time to reach a certain equilibrium !!!! (approximately 2-3 times the cooling time constant)
- Schottky signals
  100 kHz bw for ....sec, all 3 planes simultaneously
- Ionisation profile monitors (BIPM)
  spatial resolution of 1mm, maximum beam dimension 32mm
  temporal resolution of about100ms
- Measurements at injection or by kicking part of the beam
- Cooling time constant $\tau_{cool} \propto \theta^3/(I_e \, \eta_{cool})$,$\eta_{cool}=L_{cool}/L_{machine}$,$\theta=(\varepsilon/\beta)^{1/2}$
  therefore to reduce the cooling time can :
  increase I_e and/or η_{cool}
  reduce θ i.e. increase the β function in the cooler

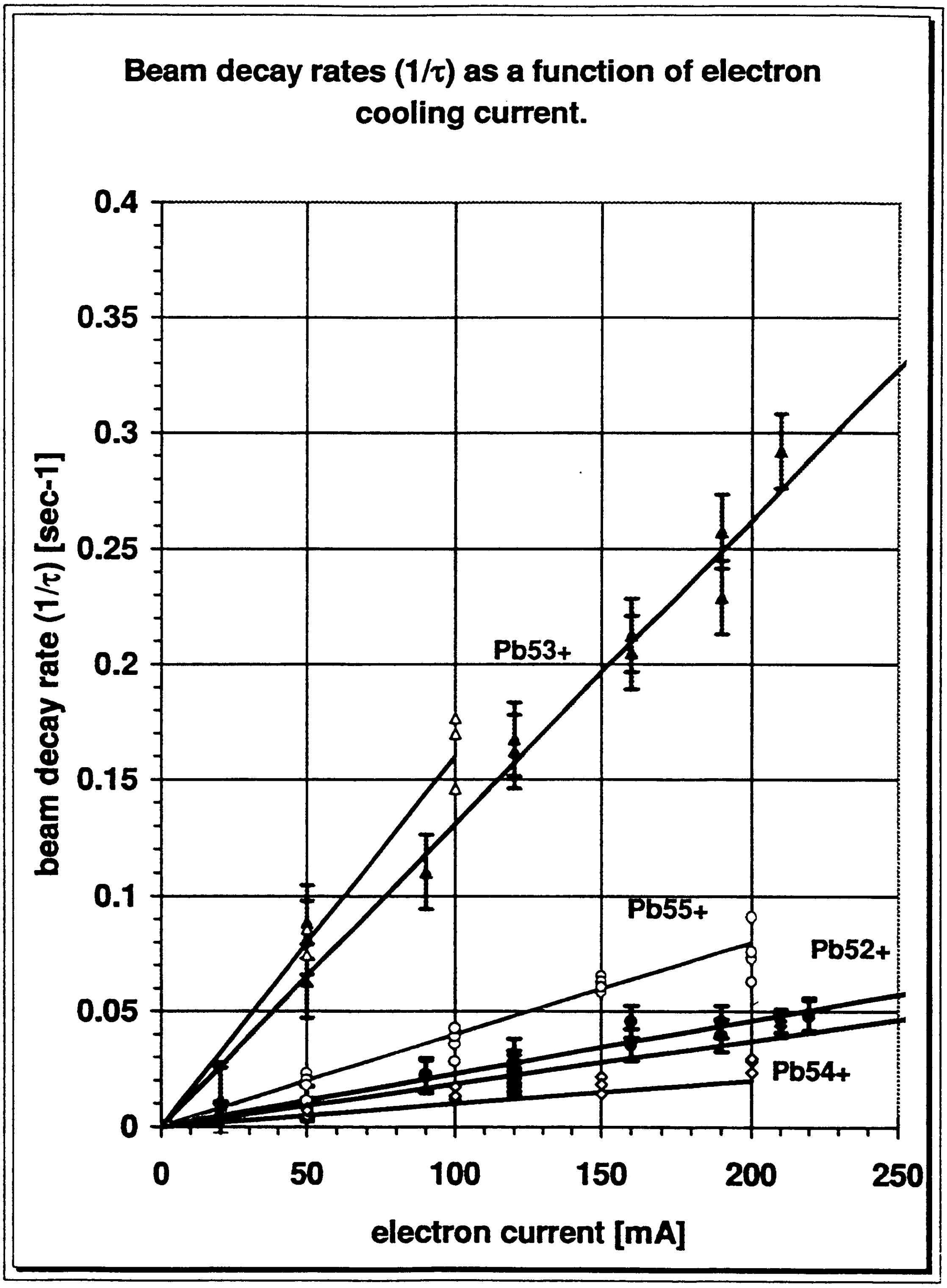
Conclusions & things to do

- Use Pb54+
- Improve instrumentation in the transfer lines
- Vacuum quality influences the lifetime => need to improve the vacuum by a significant factor
- Need stable high intensity electron beam. Up to now 200 mA obtained, above the beam is unstable
- Investigate the effect of electron beam neutralisation
- Increase of the β function did not give any appreciable gain in the cooling time. Why ??
- Test multiturn injection with energy ramping
- Study doubling the cooler length


GPIB instruments :
spectrum analyzers
network analyzers
oscilloscopes
DVM etc....
PCMCIA-IEEE interface
RS232
BIPM
Toshiba T4850CT
500MB
removable
hard disk
DeskStation IV
DAS1802HC
DAS16F
analogue signals
Schottky etc....

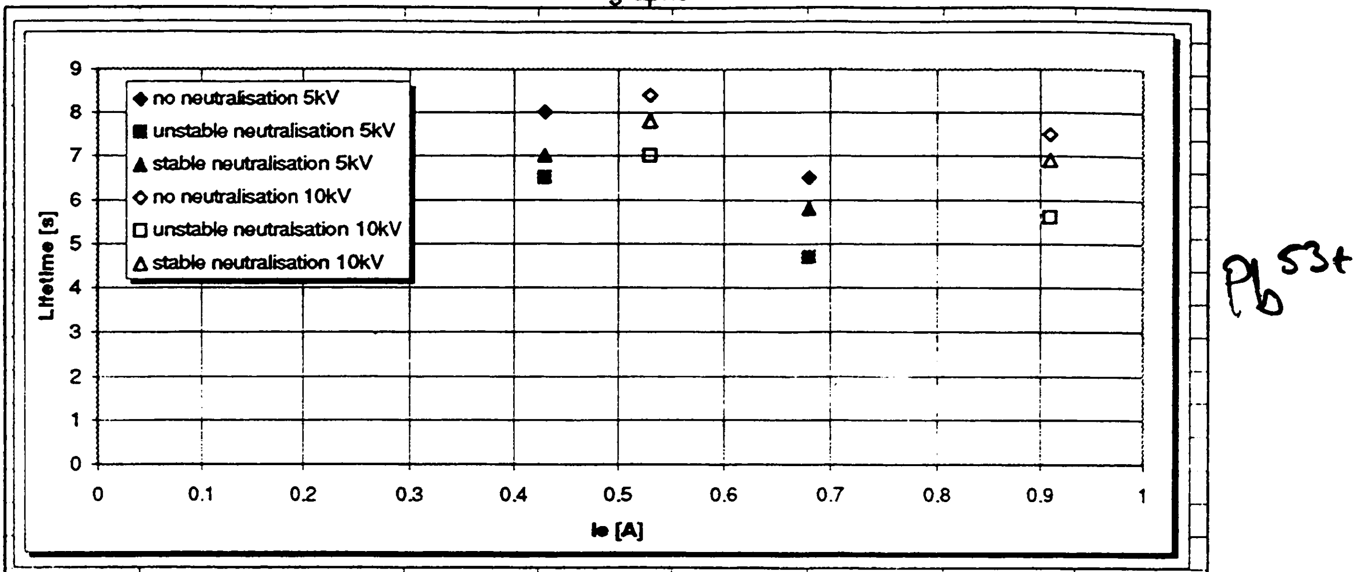
Variation of the Schottky power density at 36 .097MHz as a function of time



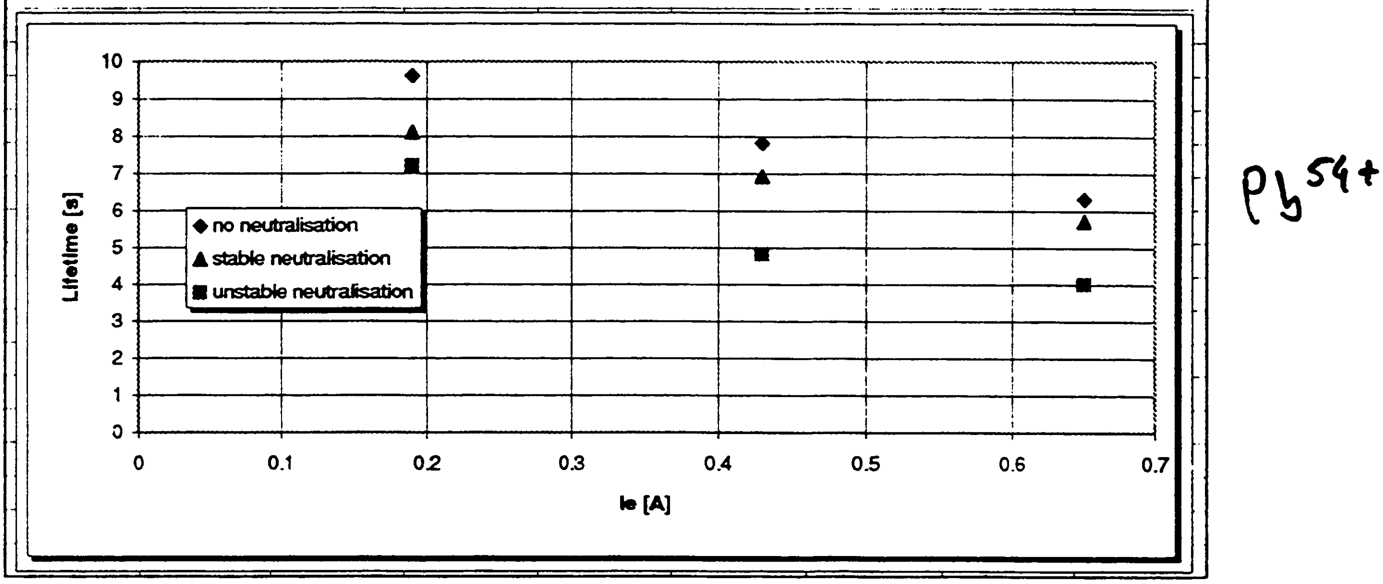


Charge state	α theory
52+	2.25
53+	2.29
54+	2.32
55+	2.36

graphs



9
8
7
6
5
4
3
2
1
0
Lifetime [s]
no neutralisation 5kV
unstable neutralisation 5kV
stable neutralisation 5kV
no neutralisation 10kV
unstable neutralsation 10kV
stable neutralisation 10kV
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Ie [A]
Pb53+



10
9
8
7
6
5
4
3
2
1
0
Lifetime [s]
no neutralisation
stable neutralisation
unstable neutralisation
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Ie [A]
Pb54+

For 1e-12 Torr/atom

H	1210
He	603
C	205
N	178
O	157
Ar	79
Xe	37.8

Following Franske's formulae and D. Moehl's excel progs.

decembre 1995

		RGA	103		202		303		402		[redacted]	rel <P>	1/tlife	tlife
	For 1e-12 pp*	length[m]	27	<P>***	16	<P>	16	<P>	19.7	<P>	[redacted]			
H2	605.00		18	6.19	12	2.44	15	3.06	12	3.01	[redacted]	0.706	0.024295	41.161
He	603.00		0.4	0.13	0.16	0.03	1.7	0.35	0.16	0.04	[redacted]	0.026	0.000906	1103.902
CH4	122.19		6	2.06	2.6	0.53	0.7	0.14	2.6	0.65	[redacted]	0.163	0.027719	36.076
H2O	124.65		0.9	0.31	1.4	0.29	0	0.00	1.4	0.35	[redacted]	0.046	0.007615	131.324
N2	89.00		0	0.00	0	0.00	0	0.00	0	0.00	[redacted]	0.000	0	#DIV/0!
CO	88.91		1.1	0.38	0.1	0.02	0	0.00	0.1	0.03	[redacted]	0.020	0.004764	209.886
Ar	79.00		1.6	0.55	0	0.00	0.11	0.02	0	0.00	[redacted]	0.028	0.007246	138.004
CO2	56.76		0.4	0.14	0.2	0.04	0	0.00	0.2	0.05	[redacted]	0.011	0.004024	248.507
Xe	37.80		0	0.00	0	0.00	0	0.00	0	0.00	[redacted]	0.000	0	#DIV/0!
											[redacted]			

Meas. Taulife = 10..11 s | **calc. Taulife[s] 13.06**

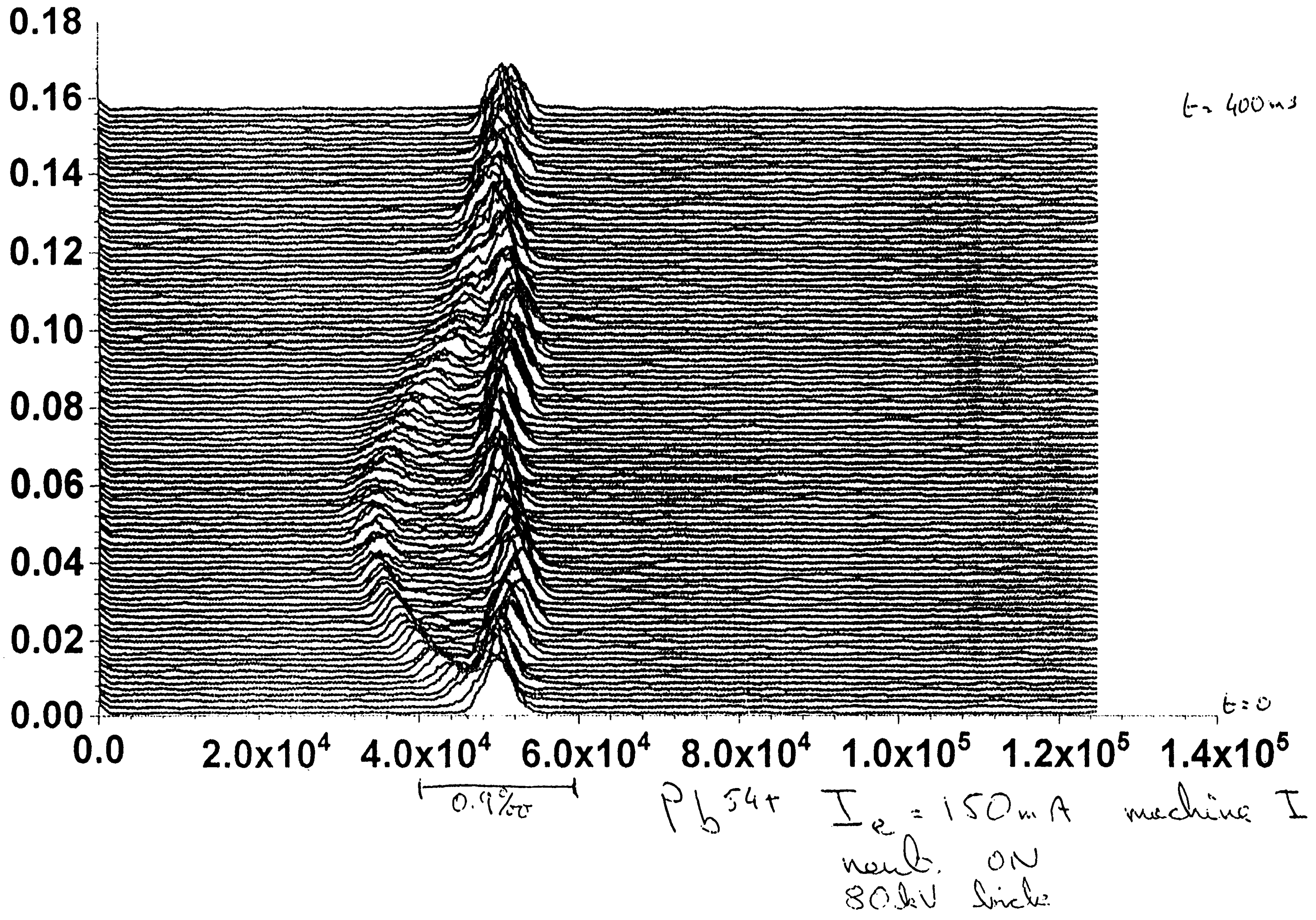
* pp=Partial physical pressure in pTorr

*** <P>= contribution of this section to the average pressure of the ring

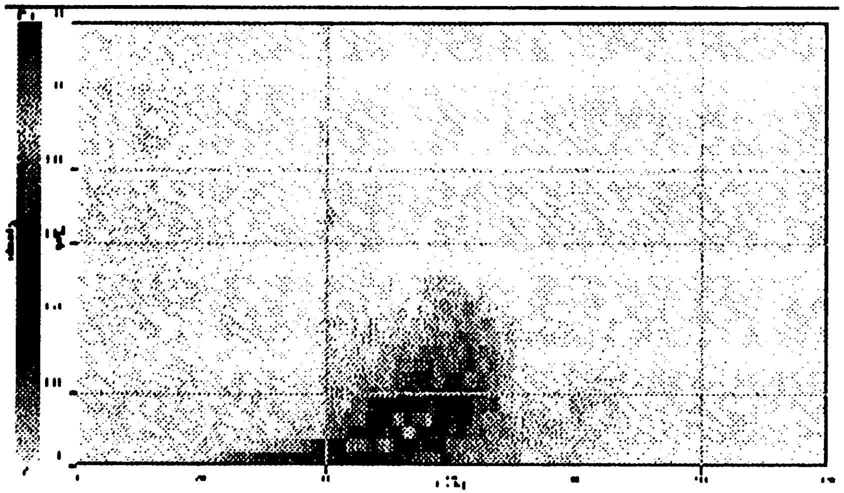
JUIN 1995

		RGA	103		204**		303		304		[redacted]	rel <P>	1/tlife	tlife
	For 1e-12 pp*	length[m]	50	<P>***	50	<P>	4	<P>	4	<P>	[redacted]			
H2	605.00		16	5.50	5.1	1.04	16	3.26	6.1	1.53	[redacted]	0.647	0.018725	53.403
He	603.00		0.6	0.21	1.3	0.26	3.1	0.63	9.4	2.36	[redacted]	0.198	0.005739	174.257
CH4	122.19		0.4	0.14	1.6	0.33	1.1	0.22	1.1	0.28	[redacted]	0.055	0.007885	126.827
H2O	124.65		0.7	0.25	1.4	0.29	0	0.00	1.1	0.28	[redacted]	0.046	0.006487	154.152
N2	89.00		0	0.00	0	0.00	0	0.00	2	0.50	[redacted]	0.029	0.005637	177.413
CO	88.91		0.2	0.07	0.28	0.06	0.85	0.17	0	0.00	[redacted]	0.017	0.003362	297.398
Ar	79.00		0	0.00	0.21	0.04	0	0.00	0.17	0.04	[redacted]	0.005	0.001081	924.826
CO2	56.76		0	0.00	0.16	0.03	0	0.00	0.13	0.03	[redacted]	0.004	0.001149	870.576
											17.51			

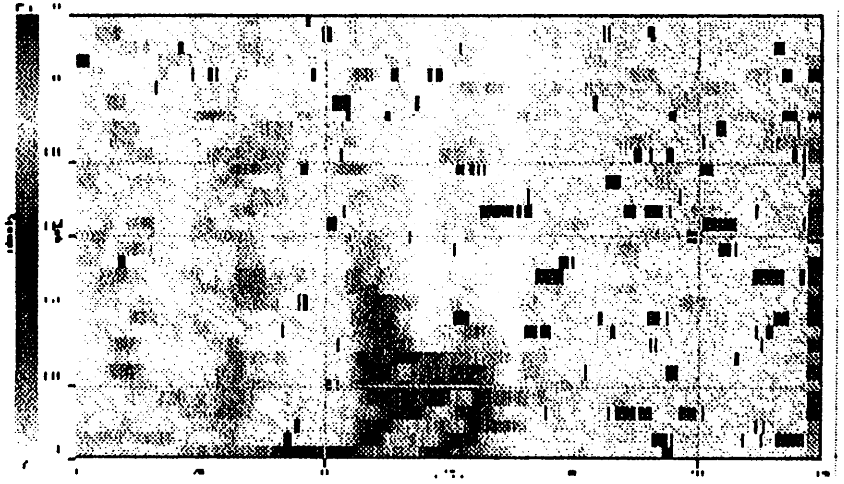
Meas. Taulife = 16..20 s | **calc.Taulife[s] 19.974**



0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.0
2.0x10⁴
4.0x10⁴
6.0x10⁴
8.0x10⁴
1.0x10⁵
1.2x10⁵
1.4x10⁵
t = 0

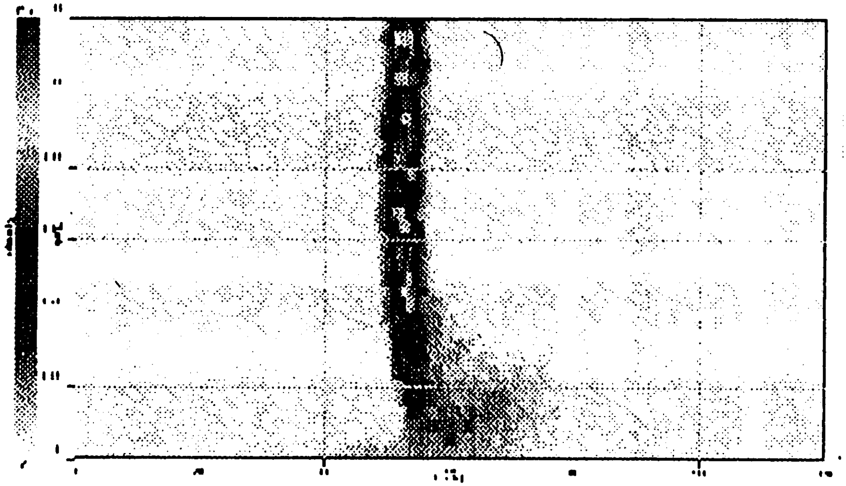


horizontal



vertical

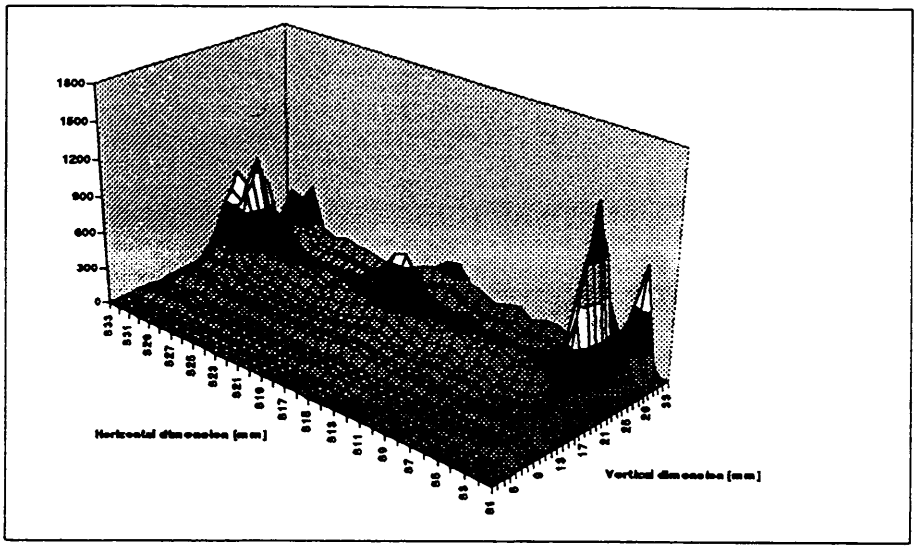
Ie=100mA
machine 1
injection



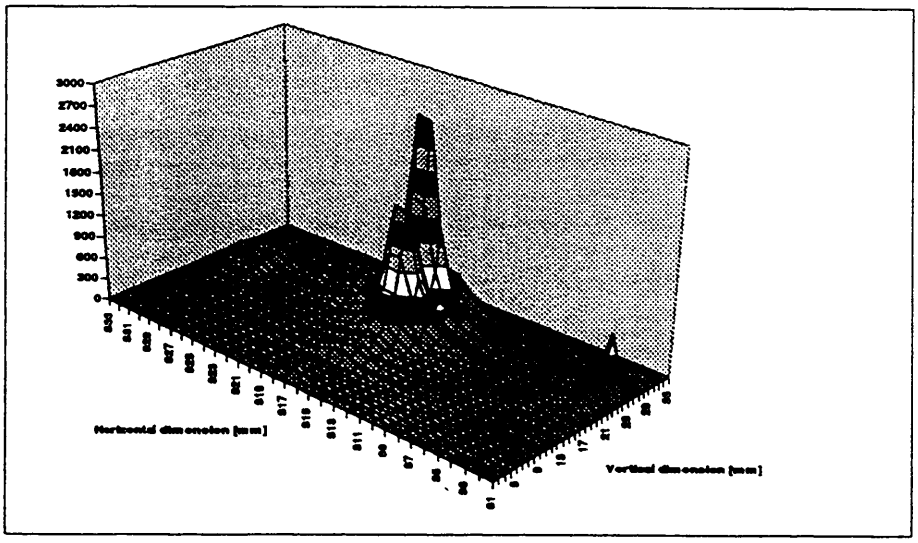
longitudinal

3DPROF.XLS

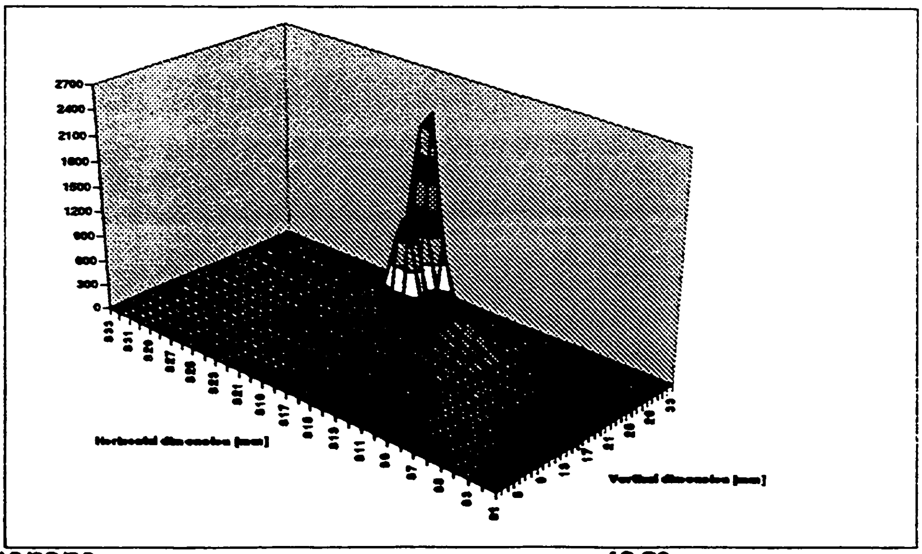
Electron cooling of Pb54+ ions in LEAR observed on the ionisation profile monitor (BIPM)
Ie=120mA



at injection



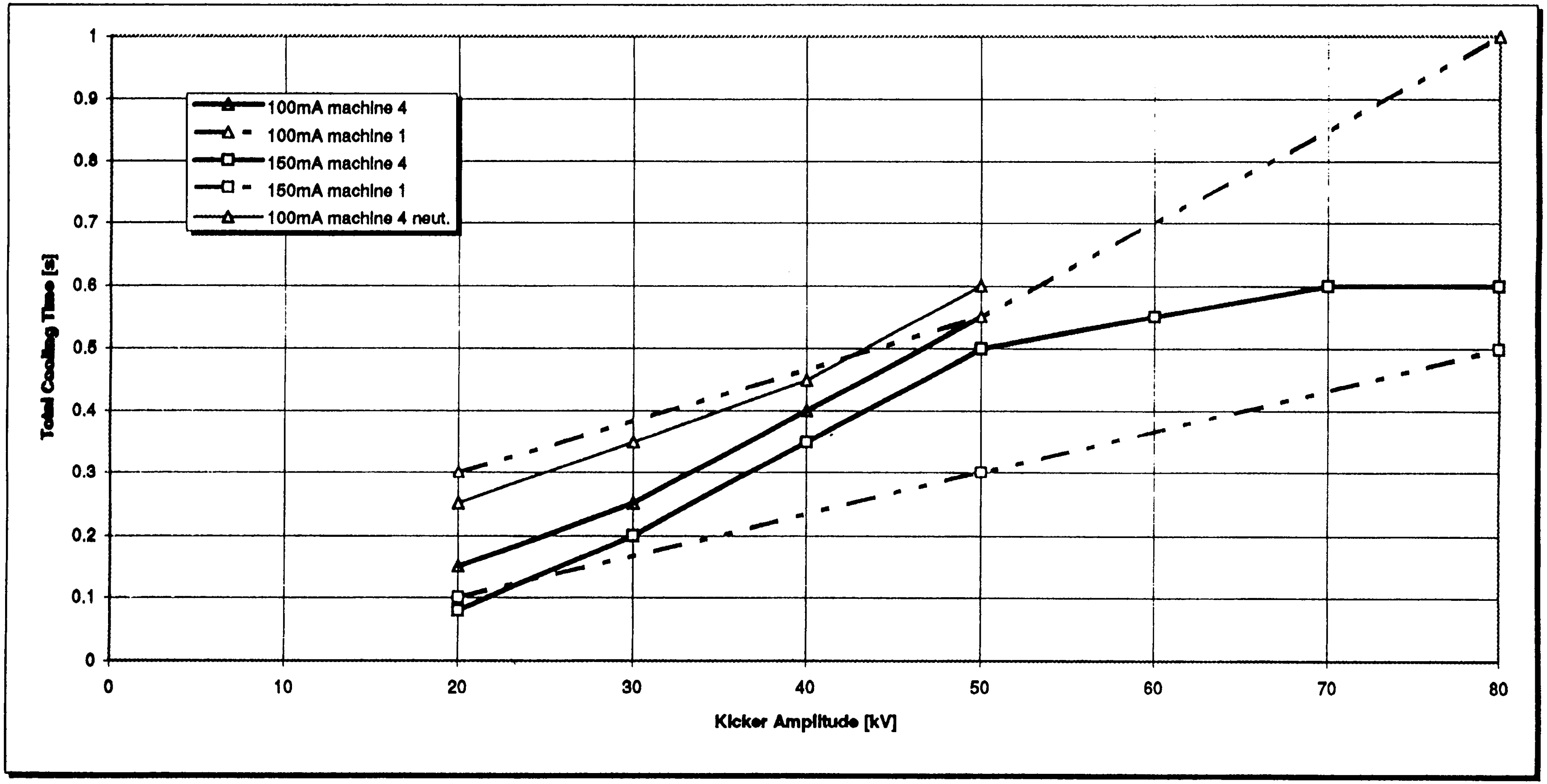
t=300ms



t=600ms

13/02/96 16:20

13/02/96 17:14


100mA machine 4
100mA machine 1
150mA machine 4
150mA machine 1
100mA machine 4 neut.
Total Cooling Time [s]
Kicker Amplitude [kV]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
10
20
30
40
50
60
70
80

PS Performance Day 1996

Antiproton deceleration tests in AC

Flemming PEDERSEN

Abstract

To enable continued low energy antiproton trap experiments, the AD project has been proposed. It consists of replacing the presently used four rings (AC, AA, PS, and LEAR) with a single ring (AC->AD). It requires slow deceleration of low intensity antiprotons and medium intensity protons (for diagnostics) in the AC ring. The addition of ramping software for synchronous ramping of RF and magnets, as well of the addition of a new digital beam control system for MD's is described. Results and problems identified during MD's in 1995 and outlook for MD's in 1996 are presented.

Deceleration Tests in AC

PPD 96 - February 16

F. Pedersen

Outline

The AD proposal

Why decelerate protons and antiprotons in AC?

How did we do it?

AC Low Level RF System

What has been achieved in 95? Problems?

What should be done in 96?

The AD proposal

There is a physics community who has a strong interest in antihydrogen spectroscopy

The present antiproton complex (AC, AA, PS, LEAR) is very costly to operate and will stop end 96

A single ring 'antiproton trap filler' based on pulsed operation of a single ring (AC -> AD) has been proposed: single shot - no accumulation (almost)

Decision expected some time late spring / summer 96

Why decelerate protons and antiprotons in AC?

The AC was not designed for ramping, magnets only measured at fixed field, ring optics < 3.5 GeV/c? Power supply ripple at low momentum?

The proposal requires deceleration of very low intensities: $5*10^7$ pbars to 100 MeV/c. Beam phase loop OK?

Single coulomb scattering lifetime and multiple coulomb emittance heating rates scales as $1/\beta p^2$ (factor 10^4; do we need a bakeable vacuum system?)

How did we do it?

NODAL Program written for synchronous ramping of magnets and rf frequency program, tune correction tables (Tommy Eriksson). Orbit & tune diagnostics.

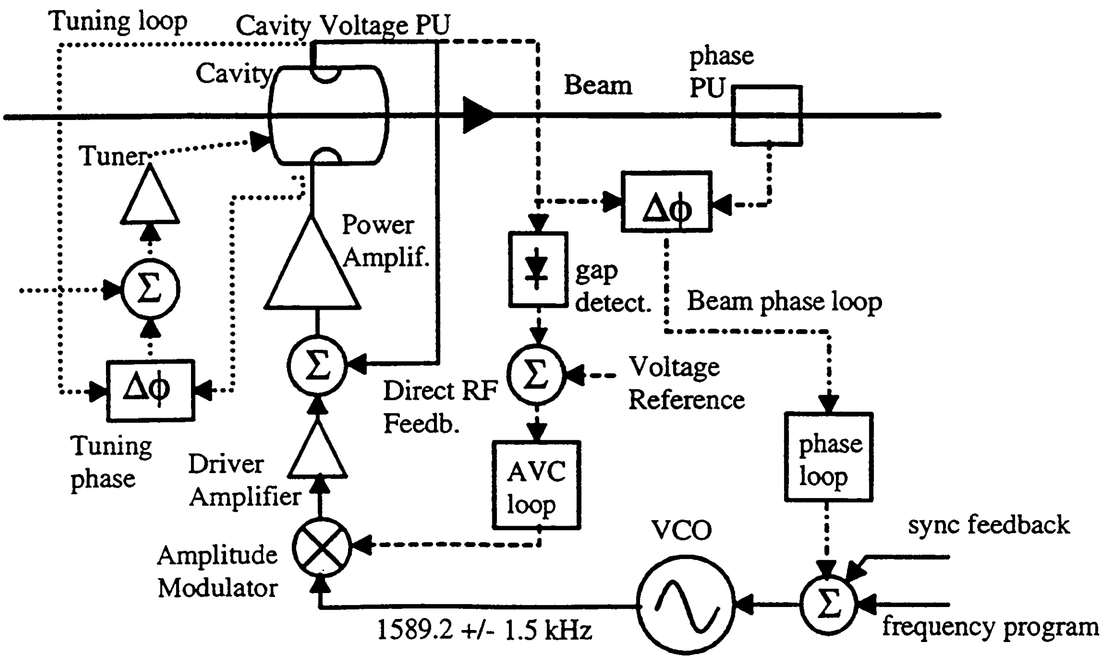
New digital beam control added to existing analog beam control; harmonic number change; fixed filter -> superheterodyne (10.7 MHz IF) (René Barthelemy)

Cavity (1.6 MHz) tuning range extended to 1 - 2 MHz, 3 kV_p

Beam phase PU sensitivity (Z_L incr.), lower noise (pbars)

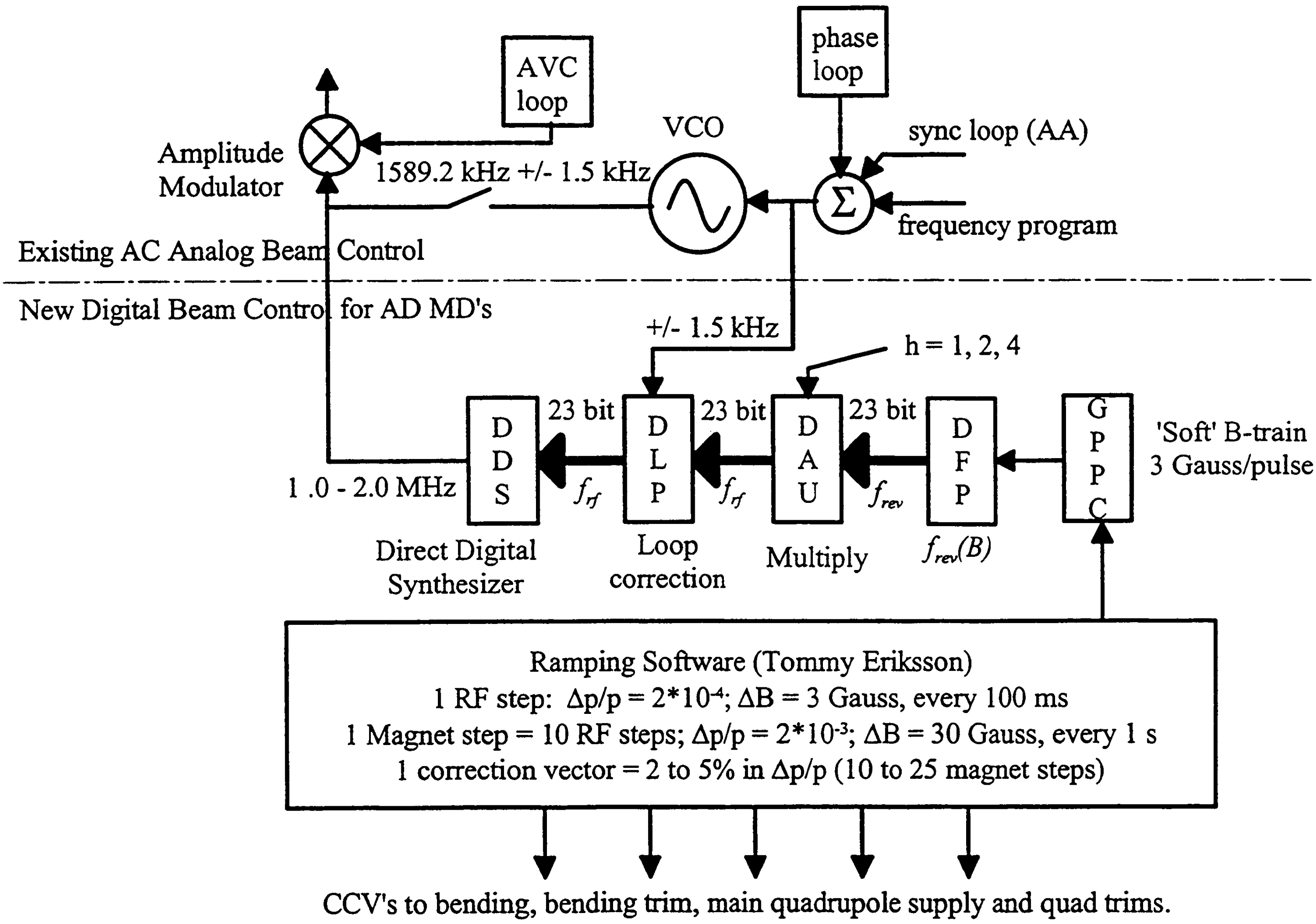
Band I intermediate cooling at 2 GeV/c required for pbars (RF acceptance). (Fritz Caspers)

AC Low Level RF System



AC Low Level RF System, modified

Deceleration Tests in AC | Slide 6



What has been achieved in 95?

In parasite with operation for LEAR:

Test protons decelerated to 1.61 MeV/c, 46% of nominal momentum of 3.5 GeV/c (via loop and AA)

Mixers and IF electronics installed but not yet tested with beam (needed below 1.4 MHz)

Deceleration of a few 10^7 pbars (from target area direct) to 2 GeV/c (Longit. cooling needed at 2 GeV/c), 10^5 pbars seems possible

No problems with eddy currents so far (very slow ramp, 9 min., limited by soft B-train)

Problems?

Main problem: Intermittent but frequent trips of main power supplies during ramping. Identified to be 'bug' in power supply microprocessor (Berlin et al.)

Occasional complete loss of beam for unknown reasons (power supplies?)

What should be done in 96?

Fix the power supply intermittent trips

Test Superheterodyne Beam Control with beam

Measure ring optics (orbits, chromaticities, dispersion etc.) at low and intermediate energies

Measure vacuum related beam behaviour (life time vs. $A_{H,V}$, heating rate $dE_{H,V}/dt$) at low and intermediate energies. Gas analysis, sublimation pumps.

If AD approved, tests of accumulation scheme (few shots) at 3.5 GeV/c

Conclusion

Very modest effort MD program, much can be done in parasite with normal operation

Modification of AC low level RF system transparent to normal operation

Deceleration of very low intensities (sensitive beam phase loop) easier than expected, pbars almost as easy as p's

The main worry is vacuum related: to bake or not to bake... => MD's at low energy needed

PS Performance Day 1996

East Hall New Look

Jean-Yves HEMERY

Abstract

The EHNL project has been triggered by the requests we received from the potential 5 new-comers to run in the EAST HALL of PS. The list of elements required for re-configuring and expanding such a facility is given. As a first step, a more detailed inventory list is being compiled. The design studies should lead to a proposal which matches the requests from the physicists and the best use of the parts presently in stock. The major milestone is fixed at July this year. By this date, it will be possible to validate the first cost estimate and the time scale of the project for completion.

MOTIVATIONS EHNL

At Present

Test of detectors	**40 groups** for a total of	
	200 physicists per year	

New-comers

Experiment	**DIRAC**	
Test of detectors	**ALICE**	**ATLAS**
	CMS	**LHCB**

FIRST STEP & DESIGN STUDIES EHNL

Inventory of current stock

⇒ Available volume

⇒ Iron, concrete, magnets, power supplies, monitors, stoppers, access doors, water cooling, vacuum parts, collimators, controls, survey

⇒ Available particles, intensities, B cycles (primaries p^+, e^+ and secondaries)

⇒ "Budget"

Optimization

⇒ Sharing of the volume and location (areas, counting rooms, corridors)

⇒ Momentum range

⇒ Quality of the momentum analyzers

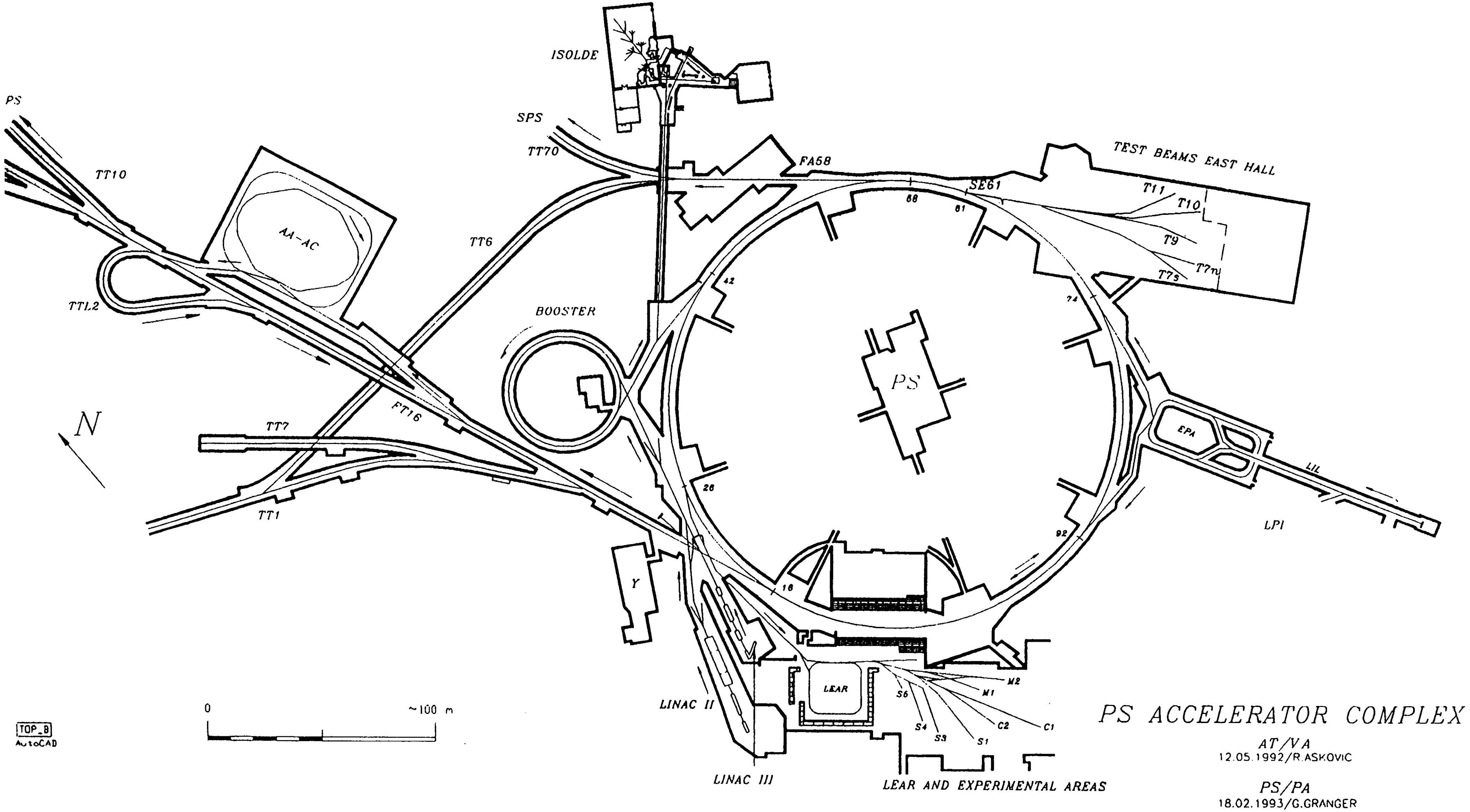
⇒ Beam optics

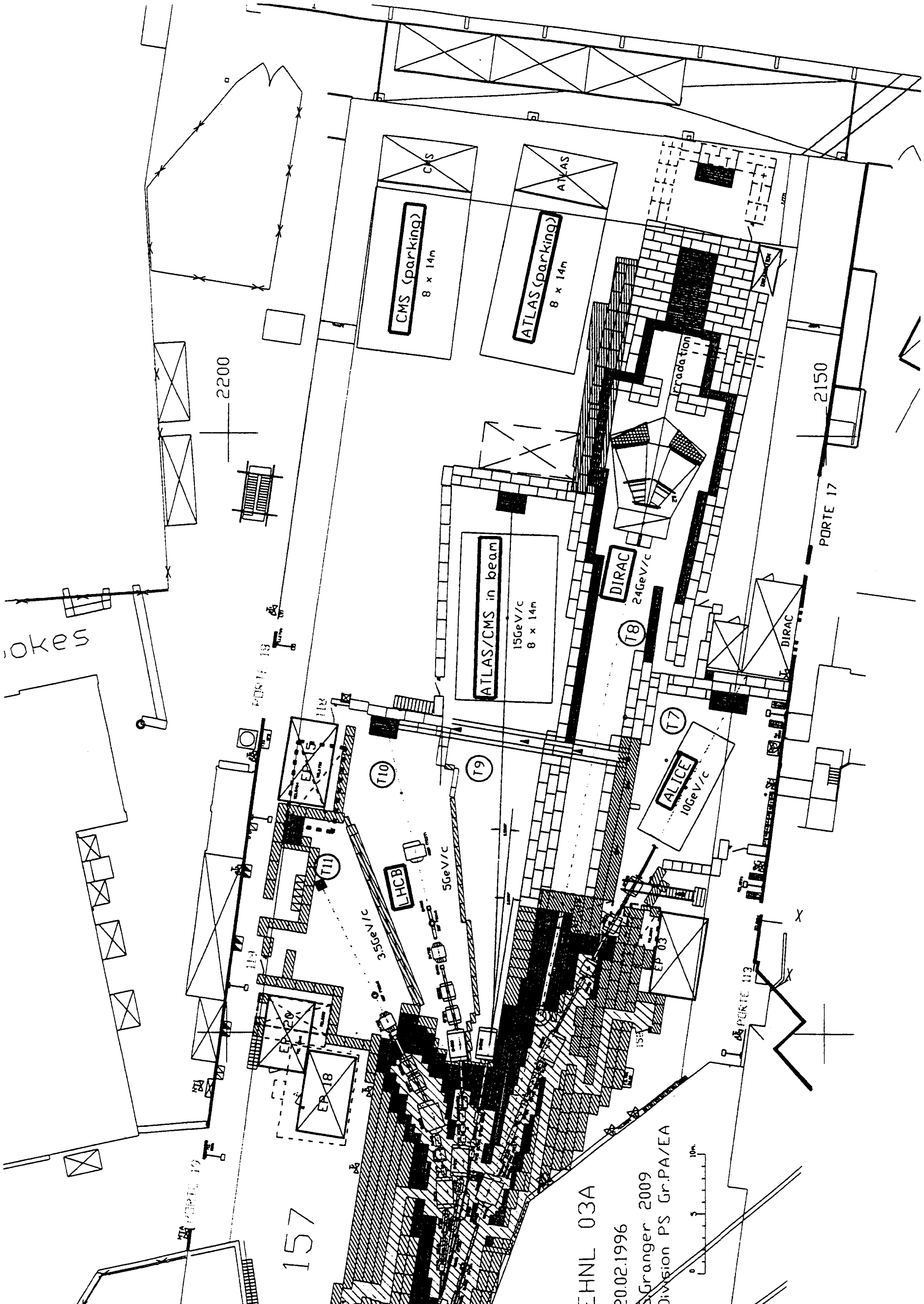
⇒ Collimators, correctors and monitors

⇒ Scattering (air gaps, vacuum windows)

⇒ Beam line pulsed switching (ALICE/DIRAC)

⇒ Personnel protection (concrete, iron shielding, stoppers)


PS ACCELERATOR COMPLEX
AT/VA
12.05.1992/R.ASKOVIC
PS/PA
18.02.1993/G.GRANGER
PS
ISOLDE
SPS
TT70
FA58
TEST BEAMS EAST HALL
SE61
T11
T10
T9
T7n
T75
TT10
AA-AC
TT6
TTL2
BOOSTER
N
TT7
FT16
TT1
Y
LINAC II
LINAC III
LEAR
LEAR AND EXPERIMENTAL AREAS
S6
S4
S3
S1
C2
C1
M1
M2
EPA
LIL
LPI
68
61
42
74
26
92
16
0
~100 m
TOP_B
AutoCAD

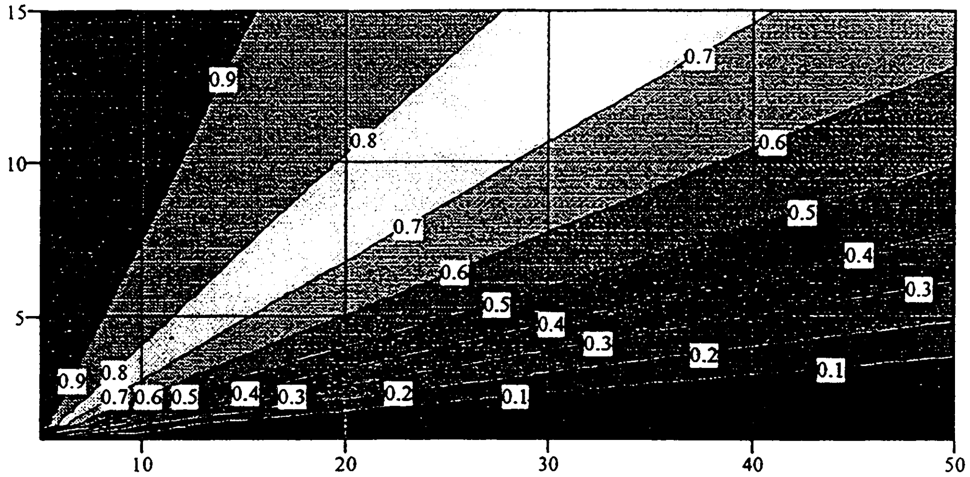

CMS (parking)
8 × 14m
ATLAS (parking)
8 × 14m
ATLAS/CMS in beam
15GeV/c
8 × 14m
DIRAC
24GeV/c
T8
T7
ALICE
10GeV/c
T9
T10
T11
LHCB
5GeV/c
3,5GeV/c
EP 03
EP 18
DIRAC
PORTE 17
2150
2200
157
HS
151
EHNL 03A
20.02.1996
G.Granger 2009
Division PS Gr.PA/EA

Remaining amounts in % as a function of P (Gev/c) and distance (m)

distance index	maxi := 25	i := 0 .. maxi	$d_i := i \cdot 2$	$d_{maxi} = 50$ m
momentum index	maxj := 30	j := 1 .. maxj	$Pc_j := j \cdot 0.5$	$Pc_{maxj} = 15$ GeV/c
k	m0 := .4937 GeV	$\tau s := 1.237 \cdot 10^{-8}$ s	$c \cdot \tau s = 3.708$ m	

$$K_{i,j} := e^{\left[-d_i \cdot \left(c \cdot \tau s \cdot \frac{Pc_j}{m0}\right)^{-1}\right]}$$

GeV/c



K

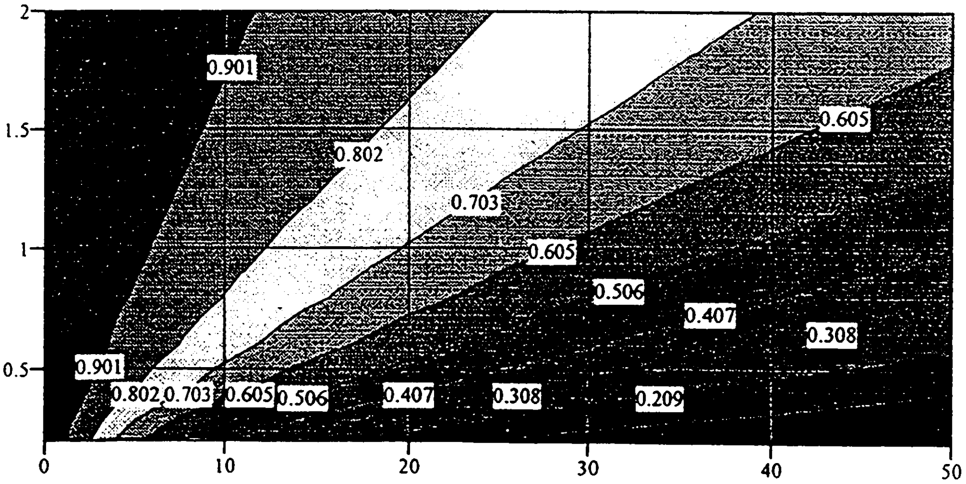
m

K^+ --> $\mu^+\nu_\mu$ (63.5%), $\pi^+\pi^0$ (21.2%)

distance index	maxi := 25	i := 0 .. maxi	$d_i := i \cdot 2$	$d_{maxi} = 50$ m
momentum index	maxj := 9	j := 0 .. maxj	$Pc_j := j \cdot 0.2 + .2$	$Pc_{maxj} = 2$ GeV/c
π	m0 := .1396 GeV	$\tau s := 2.603 \cdot 10^{-8}$ s	$c \cdot \tau s = 7.804$ m	

$$Pi_{i,j} := e^{\left[-d_i \cdot \left(c \cdot \tau s \cdot \frac{Pc_j}{m0}\right)^{-1}\right]}$$

GeV/c

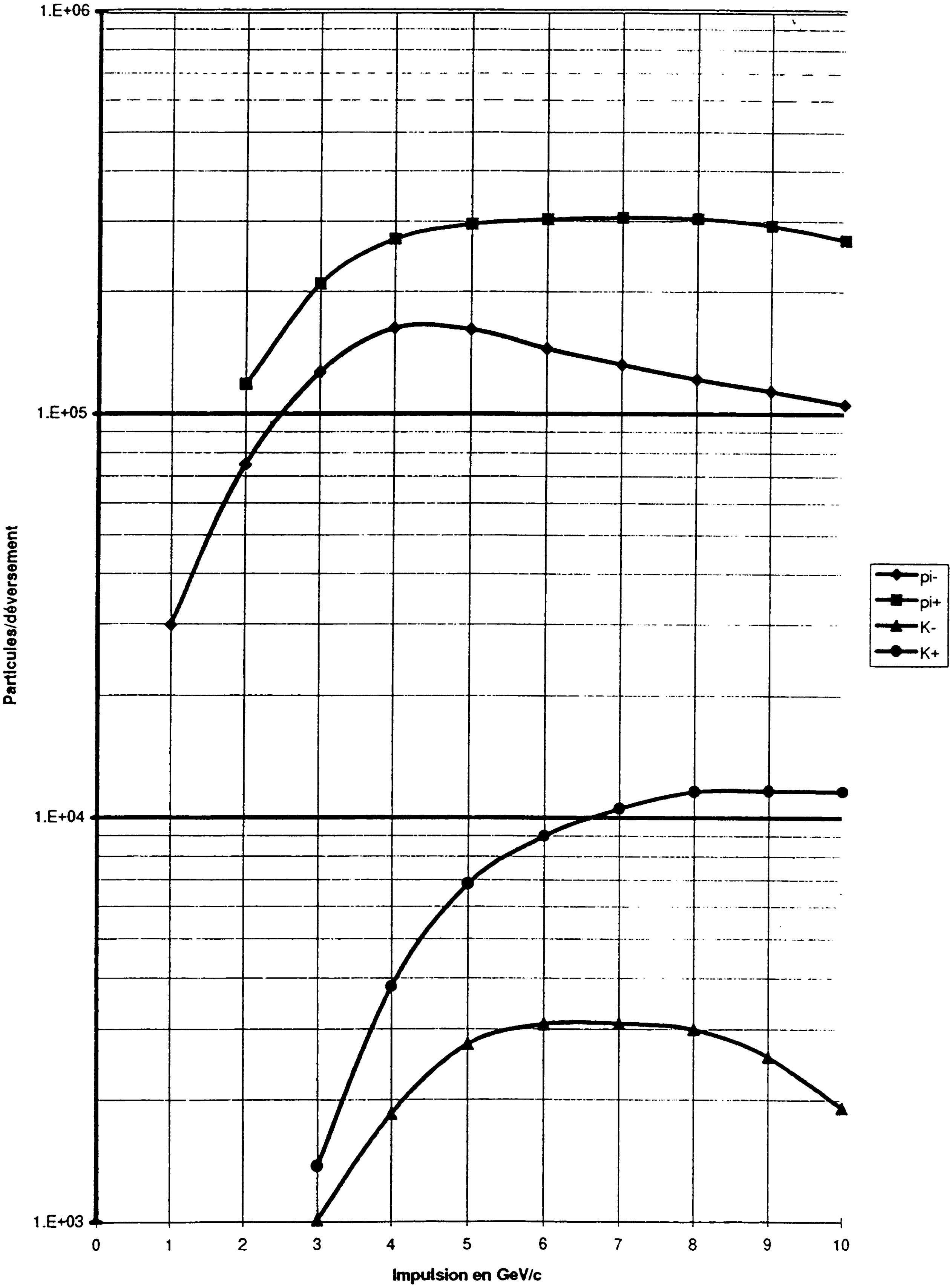


Pi

m

π^+ --> $\mu^+\nu_\mu$ (99.99%)

Intensité des exotiques (Atlas et CMS)
23 m en aval du foyer nominal de T9.



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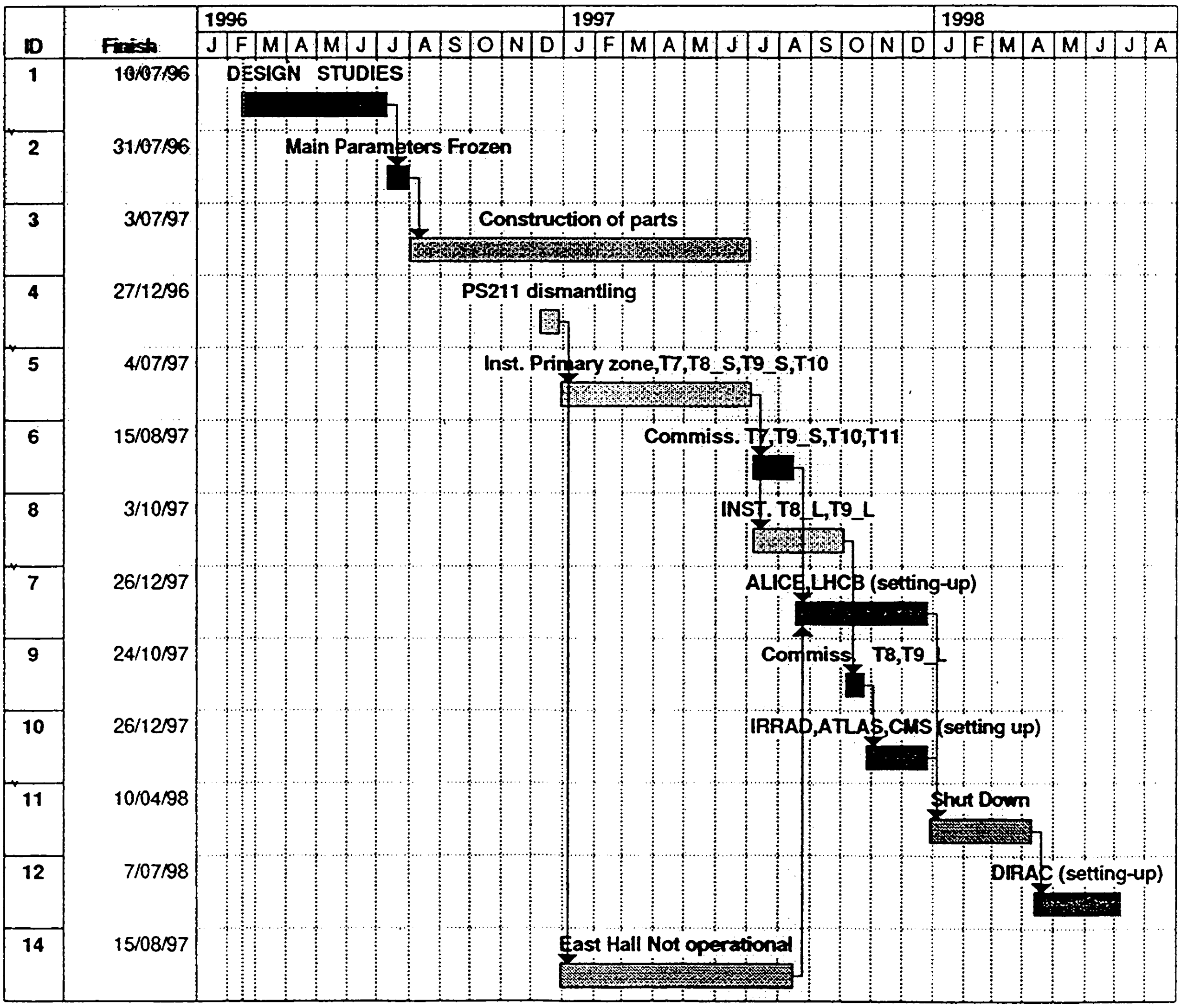
copie sur g:\home\d\durieu\eastzone

14 février 1996.

TIME SCALE EHNL



TIME SCALE EHNL

- MAJOR MILESTONE

July 96 : End of DESIGN STUDIES relative to MAIN PARAMETERS (frozen).

By this date, the list of required elements will be published. It should allow to **validate** the :

first step cost estimate
proposed time scale

PS Performance Day 1996

Laser ion source developments

Hartmut KUGLER

Abstract

In the HI group we experiment on Laser Ion Sources. The successful generation and acceleration of light ions has us encouraged to aim at a source of heavy ions, suitable for the LHC. The system we aim at is shown in figure 1. The realization of this source (Pb^{25+}, 10 mA, 6μsec, 1 Hz) can be divided in 4 phases. In this context the present (1996/97) set - up can be considered as phase 2.

This experiment consists of a free running CO_2 laser, a target (Ta, Pb), an ion extraction system (80 kV), a low energy (6.9 keV/u) transfer system (LEBT), an RFQ (acceleration of Ta^{16+}/Pb^{18+} to 100 keV/u) and a measuring line (ML). We expect some mA of the desired ions at the outlet of the RFQ.

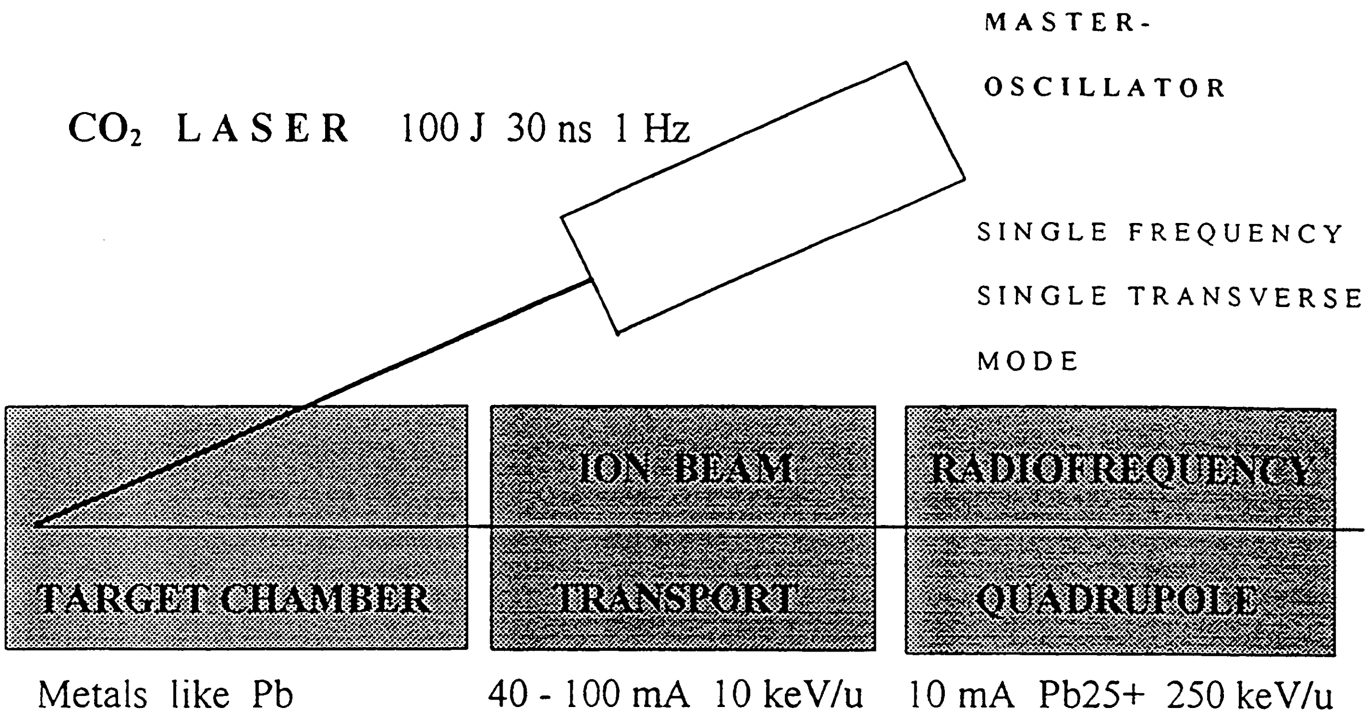
Problems to face: adaptation of extracted ion beam to LEBT, beam transfer (100 mA) and acceleration of a current (50 mA), consisting of 8-10 different charge-states, only one of interest to us. Strongly varying beam loading due to (the present) laser instabilities.

In this presentation one finds:

- an ion injection scheme with a rough estimation of the performance of a "final" source,
- target and extraction area, as in use at present,
- a Ta charge-state distribution with the highest yield at Ta^{17+}, as obtained daily,
- simulation of beam dynamics for LEBT, RFQ and ML for the present setup,
- characteristics of the RFQ,
- technical drawings of the outfit of the experiment and its housing.

PPD 96
16/2.96

HEAVY ION PRE - INJECTOR with
a **LASER ION SOURCE** for HIGH CURRENTS



One can define 4 main phases :

1) The " light ion " experiment

2) Ta16+ / Pb18+ some mAe at 100 keV/u

3) The " Ta16+ / Pb18+ " experiment with (partially) new Laser equipment

4) Assembly and running in of system with final laser, RFQ and new target chamber

The LHC Ion Injector Chain (Laser Ion Source)

LHC	**T [TeV/u] Pb^{82+}**	**2.76**	
	$\mathcal{L}$ [$cm^{-2} s^{-1}$]	**$1.9\ 10^{27}$**	one low-β experiment
12	Ions/bunch	$9.4\ 10^{7}$	bunch spacing 125 ns
- - - -	bunches/ring	608	712.8 bunch places
pulses	bunch spacing [ns]	125	filling per ring ~4 **min**
	ε^* (=$(\beta\gamma)\sigma^2/\beta$) [$\mu m$]	1.5	***$\varepsilon^* = 1.0\ \mu m$ useful?***
177 GeV/u	Pb^{82+}		
SPS	Ions/bunch	$1.2\ 10^{8}$	bunch compr. 2 ns
cycle ~25 s	bunches	52	Fixed-frequency
13	ε^* [μm]	1.2	acceleration with
- - - -			200 MHz t.w. cavities
pulses			Inj.kicker rise 115 ns
	Pb^{54+} => Pb^{82+}		Al stripper
6.15 GeV/c/u	Pb^{54+}		
PS	ions/bunch	$1.6\ 10^{8}$	bunch compr. 4 ns
cycle **1.2** s	bunches	4	125 ns bunch spacing:
	ε^* [μm]	1.0	h=16=>17 @ 258MeV/u
			Vacuum: η = 0.8
1 pulse			
148.1 MeV/u	Pb^{54+}		
PSB 1 ring	ions/bunch	$2\ 10^{8}$	24.3 MeV/u: 4 bunches
	ions/bunch (inj)	$3\ 10^{8}$	from h=1 to h=2 RF syst.
cycle 1.2 s	bunches	4	better vacuum (η = 0.67)
	ε_x^*, ε_y^* [μm]	**0.5**, 0.5	Monoturn injection
1 pulse			
4.2 MeV/u	Pb^{54+} ions/pulse	$1.2\ 10^{9}$	1.9 mA for 5.5 μs
	ε^* [μm]	0.25	~ ε_0 = 5 π mm.mrad
	Pb^{25+} => Pb^{54+}		C stripper (η=0.2)
LINAC3	Pb^{25+} ions/pulse	$6\ 10^{9}$	4.4 mA for 5.5 μs
			η=0.8 *
1 pulse			
LIS	Pb^{25+} ions/pulse	$7.5\ 10^{9}$	**5.5 mA for 5.5 μs**

modifications

K.Schindl 19/11/95

* the η of 0.8 is based on recent Linac3 performance

Our needs (particles from the source)

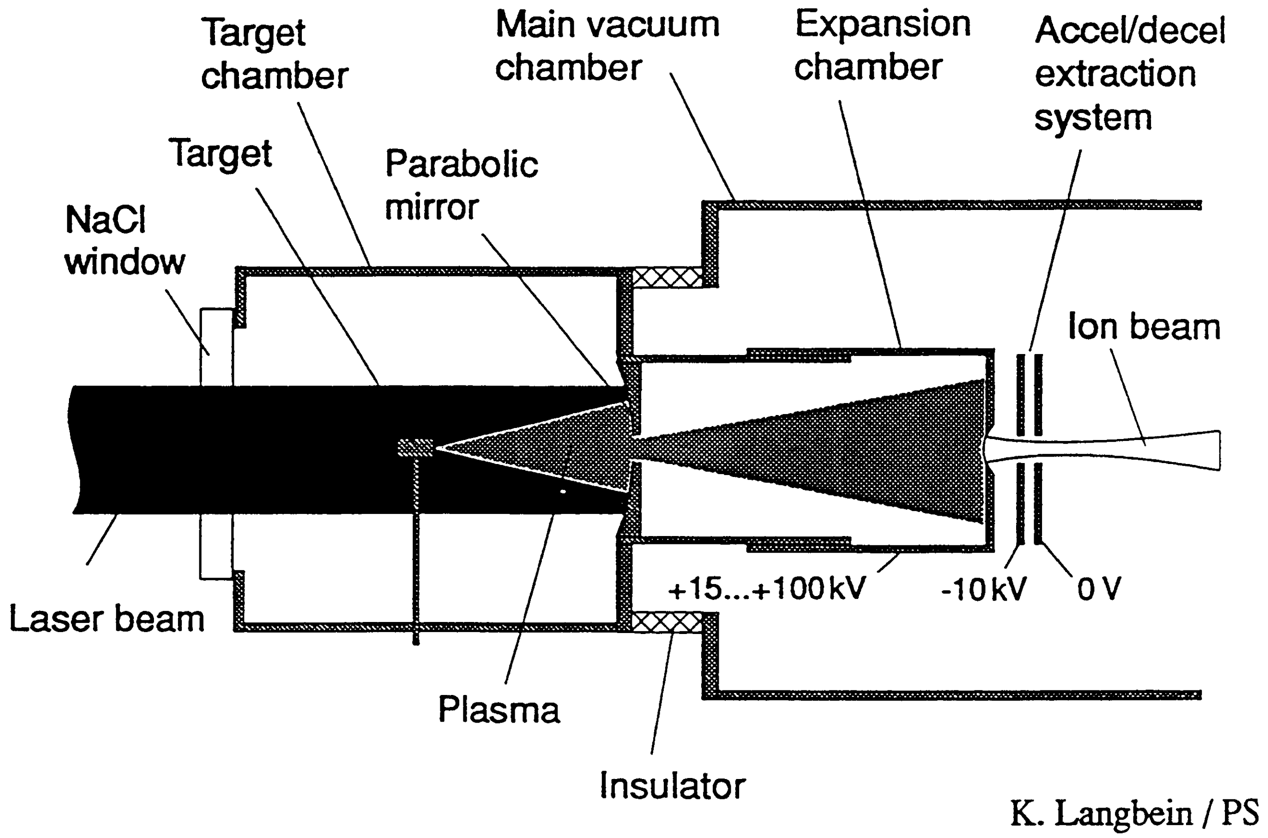
ref: CERN/PS 94-34 (HI)

Source out (= 1st solenoid in), 80 kV extraction voltage:

10 mAe @ 6 microsec of Pb25+ (= 1.5*10exp10 ions) at 9.6 keV/u,
4 rms emittance (about 86% of particles) normalized: 0.2*10exp-6 m*rad.

With beta*gamma = 0.045 for Pb25+ at 9.6 keV, this demands a un-normalized emittance of 44 mm*mrad.

Current and emittance are scaled from 1.9 mAe of Pb54+ at 4.2 MeV/u, expected at the entry of the PSB (see K.S. The LHC Ion Injector Chain (Laser Ion Source)).



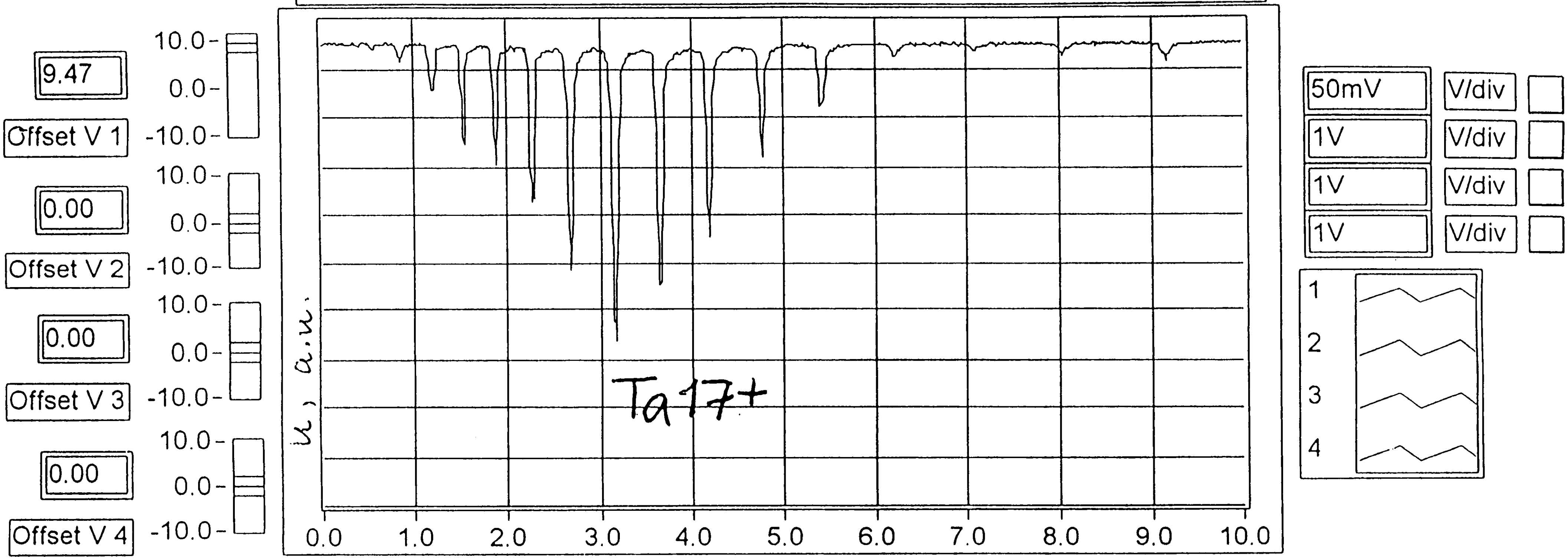
Target and extraction area for LIS

Single virtual scope (for printing) ver 0.1.vi
10/09/95 11:47 AM

Page 1

Ta-ions out of LIS, no acc.

Scope 1



0 2500 5000

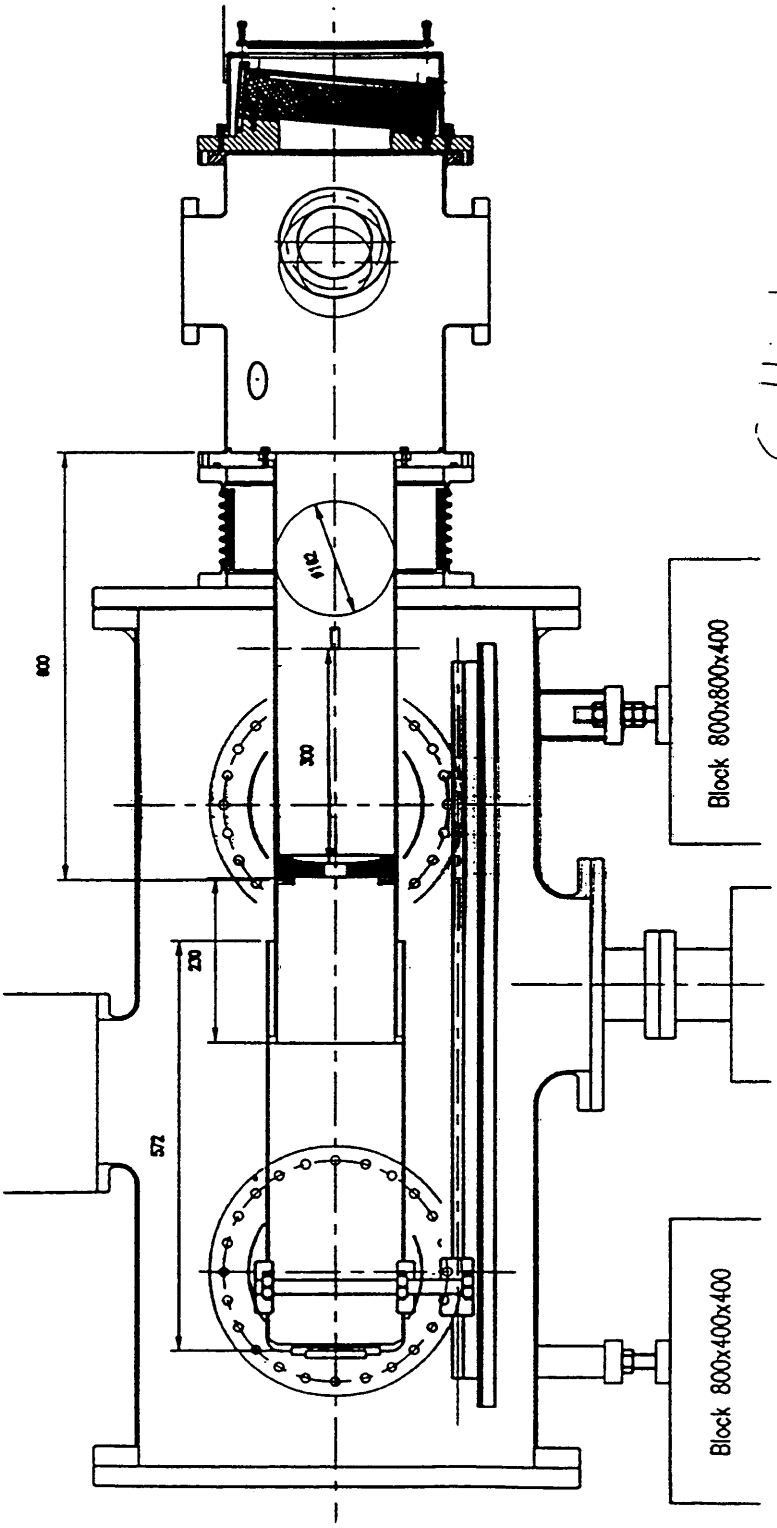
1600 Points/div 100 time/div 0.000800 ms Tzero 0.013

Ta^{16+}_{181} , Pb^{18+}_{208} $\frac{q}{m} = 0.088, 0.087$

$\varepsilon_0 : 200\,(-300)\ mm \times mrad \rightarrow \varepsilon_n = 0.75\ mm \times mrad$

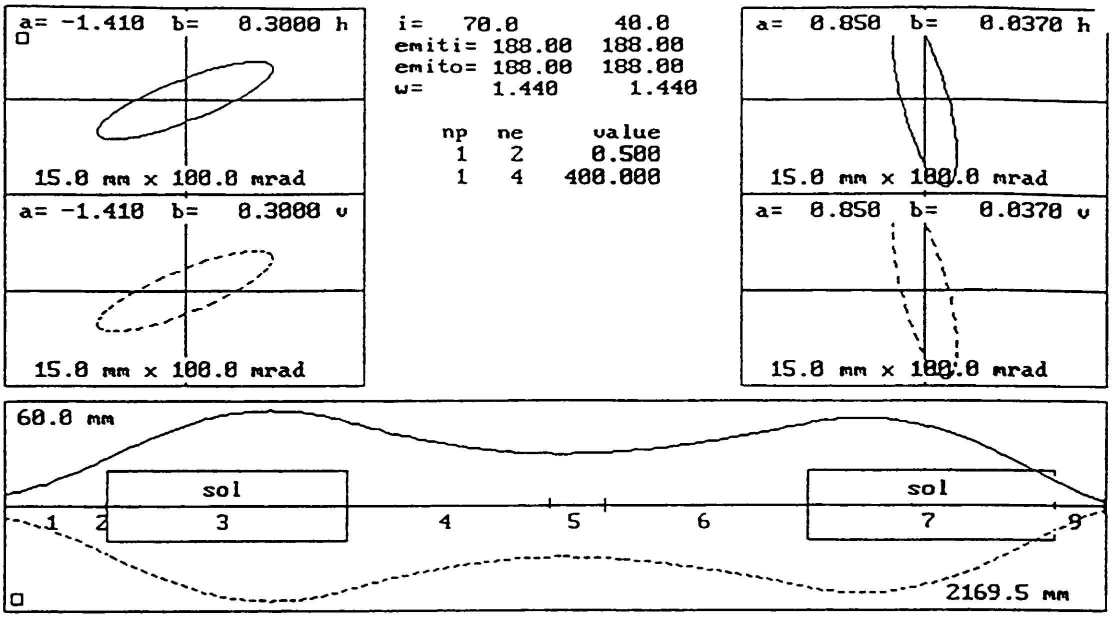
$\left(\begin{array}{l} E_{Kin}(80kV) = 7.07, 6.92\ keV/u \\ \beta = , 3.8 \times 10^{-3} \end{array} \right)$

12/2.96



G. Himbury

TRACE 14/2.96



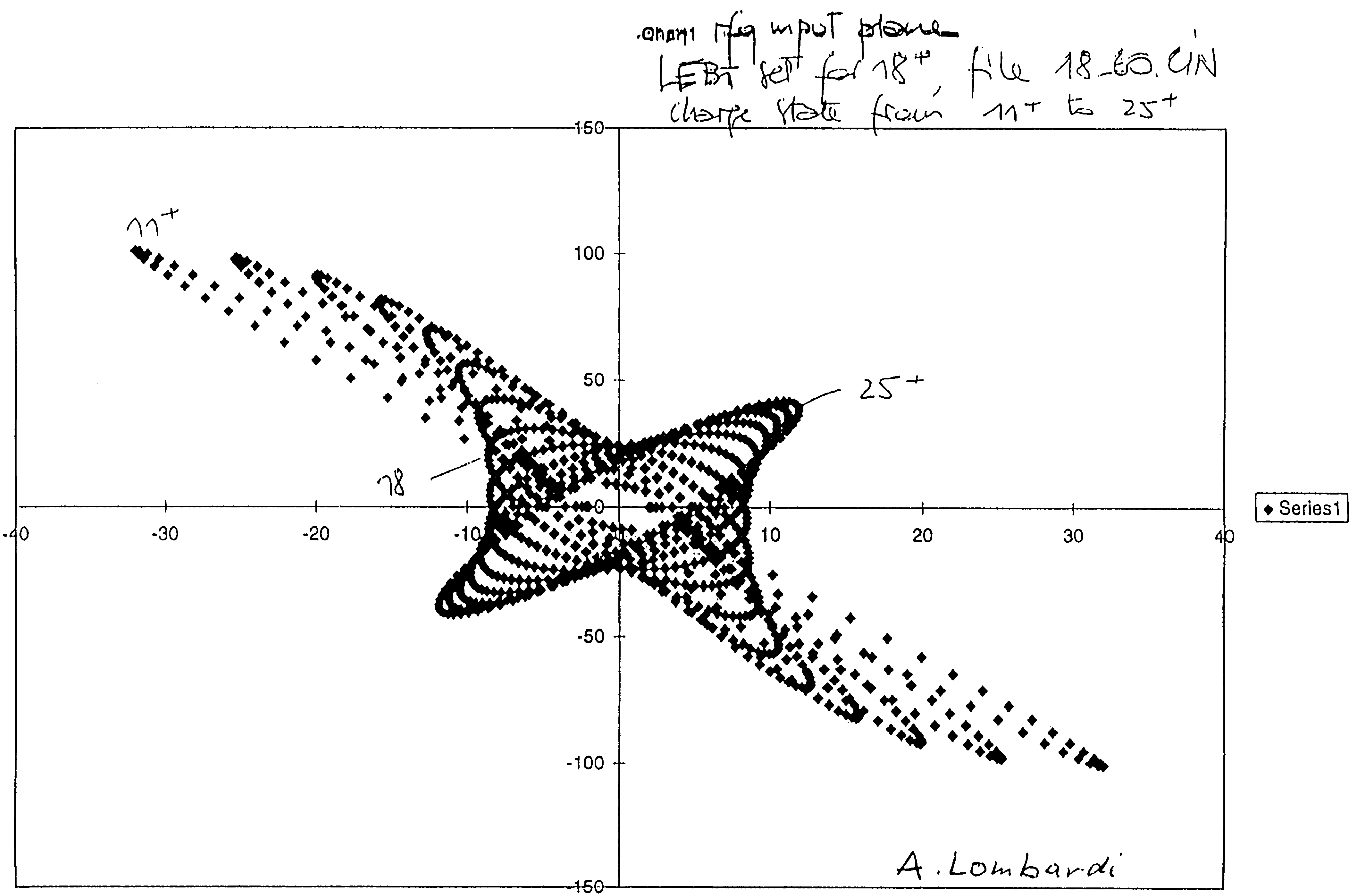
R. Scrivens
A. Lombardi

```
&data
 er=195158.100, q=18., w=     1.440, xi=  40.0    ,
 emiti(1)=     188.00,     188.00, dpop=25.0000,
 beami(1)=  0.85, 0.0370, 0.85, 0.0370
 beamf(1)=  -3.128, 5.0334, -3.128, 5.0334,
 mt=3,nc=2,mp=1,3,1,5
 freq=      0.000, pqext=  0.00, ichrom= 0,
 xm= 15.00, xpm= 100.0, ym=  60.0,
 n1= 1, n2=  5, smax=  10.0, pqsmax=   2.0,
 nprin= 2, ijprin(1,1)=1, 2,1, 4
 nt( 1)=  1, a(1, 1)= 200.0
 nt( 2)=  1, a(1, 2)=   0.5
 nt( 3)=  5, a(1, 3)= 9946.5    , 480.0     ,0.0000     ,0.0000
,0.0000
 nt( 4)=  1, a(1, 4)= 400.0
 nt( 5)=  1, a(1, 5)= 108.502
 nt( 6)=  1, a(1, 6)= 400.0
 nt( 7)=  5, a(1, 7)=10233.1    , 480.0     ,0.0000     ,0.0000
,0.0000
 nt( 8)=  1, a(1, 8)= 0.507
 nt( 9)=  1, a(1, 9)= 100.00
 &end
```

Matching achieved with a minimum 200mm from extraction to the first solenoid field, with at least 100mm before the RFQ. Trace file 18_70.t01 . Extracted current is 70mA, reduced to 40mA after element 5.

LIS LEBT 70-100 mA, Ta^{11+}, 7keV/u

Soon: PATH up-graded



.onam1 rfq input plane
LEBT set for 18+, file 18_60.CIN
charge state from 11+ to 25+
11+
18
25+
A. Lombardi
150
100
50
0
-50
-100
-150
-40
-30
-20
-10
0
10
20
30
40
◆ Series1

Page 1

100 keV/u Pb^{18+}

11.12.95

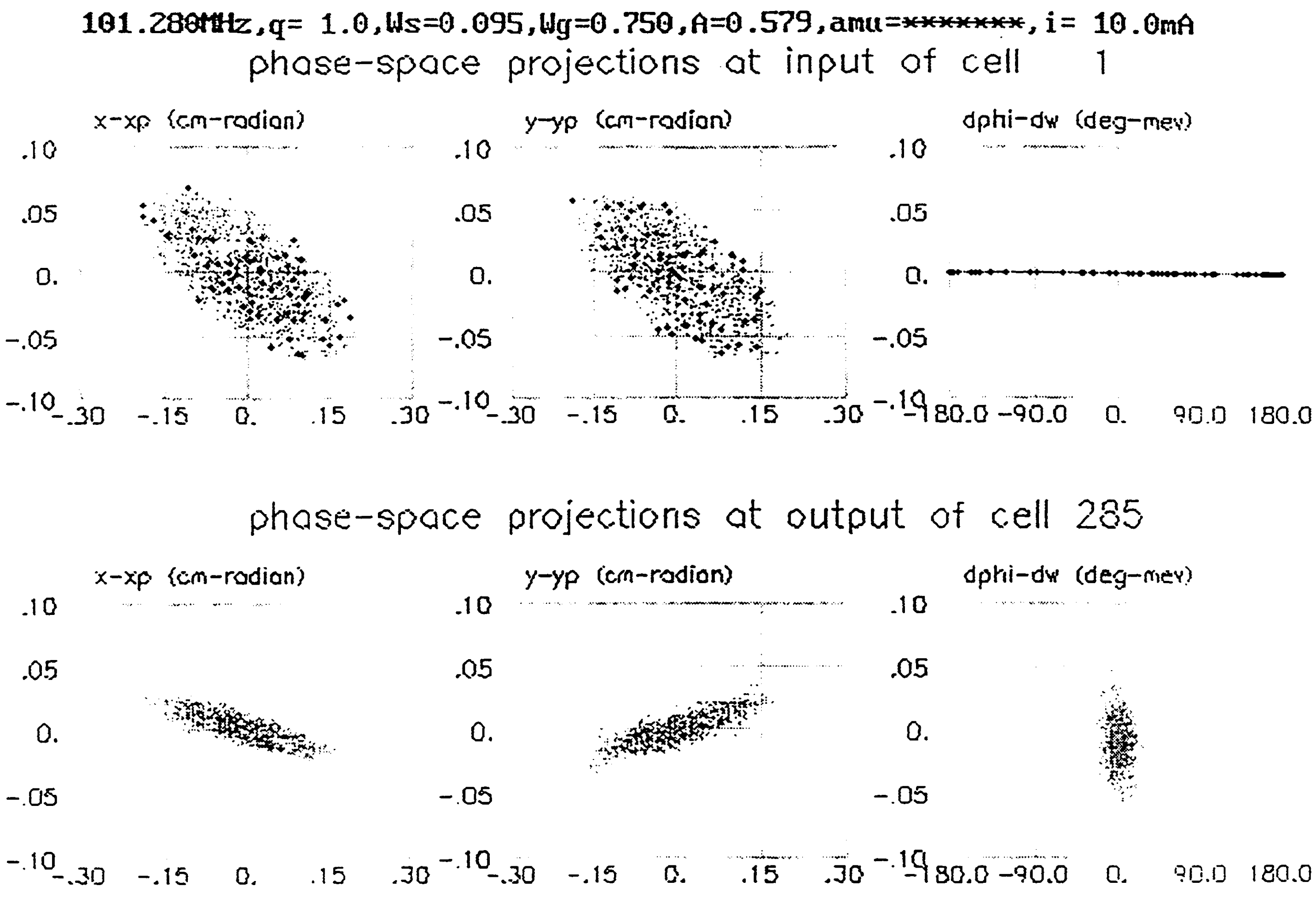
1_ Operation with 18+ , tank length equal to the Legnaro one, output energy limited to 100 keV/u

RFQ Characteristics
(file: rfq18_6b.in)

Design Ion : Charge 18+, Mass 208 a.m.u
Frequency : 101.28 MHz
Vane voltage : 73 kV (1.9 Kilp)
Power losses (at 90 kOhm-m) : 75 kW (*)
Maximum electric field : 27 MV/m (rho/ro=0.75)
Vane Length : 253.18 cm
Number of cells : 307
Minimum aperture : 0.2 cm
Modulation factor (max) : 1.8
Transmission : 96 %
Current : 10 mA (Ieff=30mA)
Input energy : 6.9 keV/u (extrac. voltage 80 kV)
Output energy : 100 keV/u
Input emittance : 100 π mm mrad (tot,un)
Input acceptance : 200 π mm mrad (tot,un)
Transv. emittance growth : 0
Output long. emittance : 12 π deg keV/u
Maximum tool bit diameter : 4.5 cm
Transverse radius of curvature : 0.26 cm
Vane width : 0.52 cm

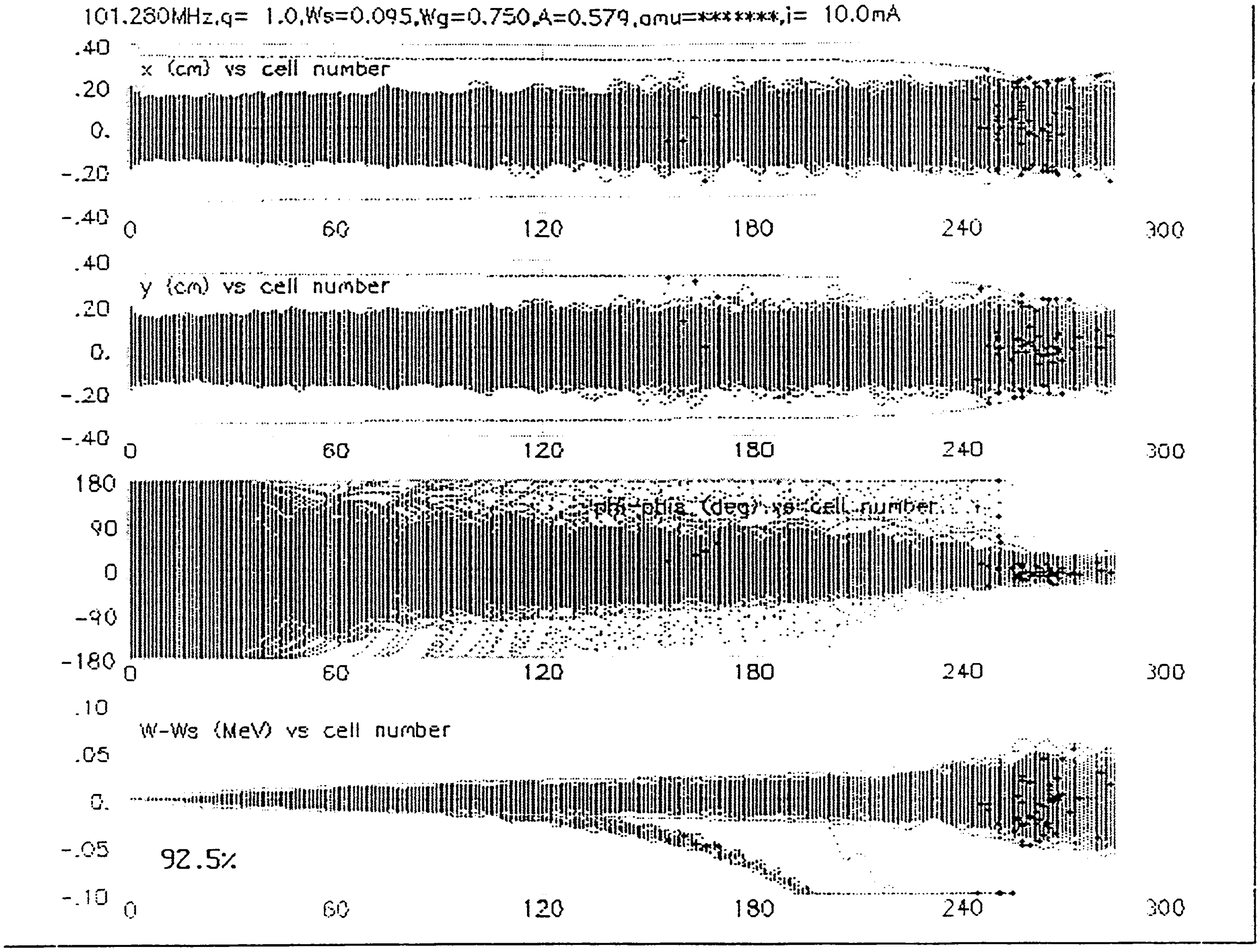
(*) The value of the assumed shunt impedance is theoretical, the estimate of the power losses is probably optimistic

Beam loading ~5 kW at 50 mA
Filling Time ~50 μs

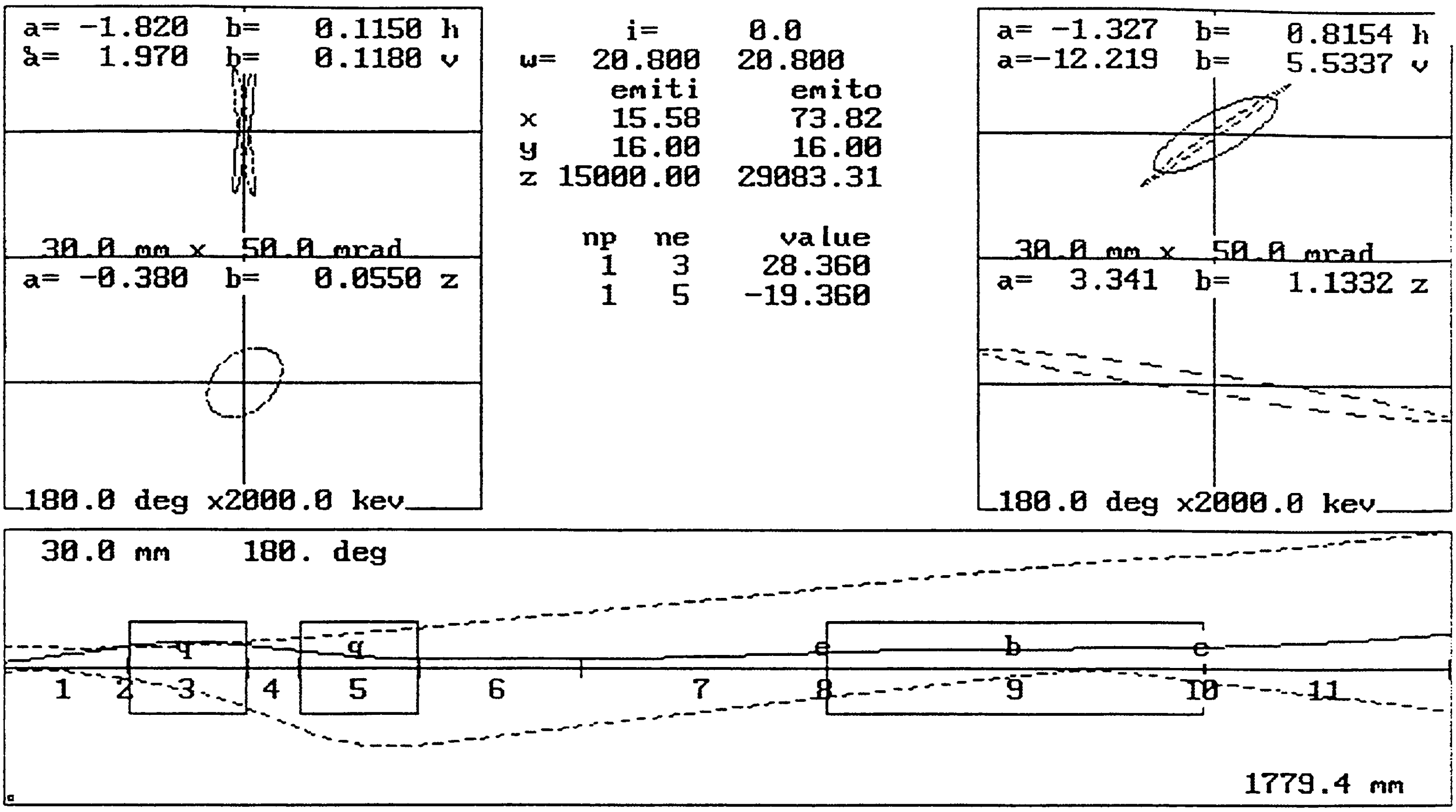


A. Lombardi

RFQ 7 → 100 keV/u Pb^{18+}

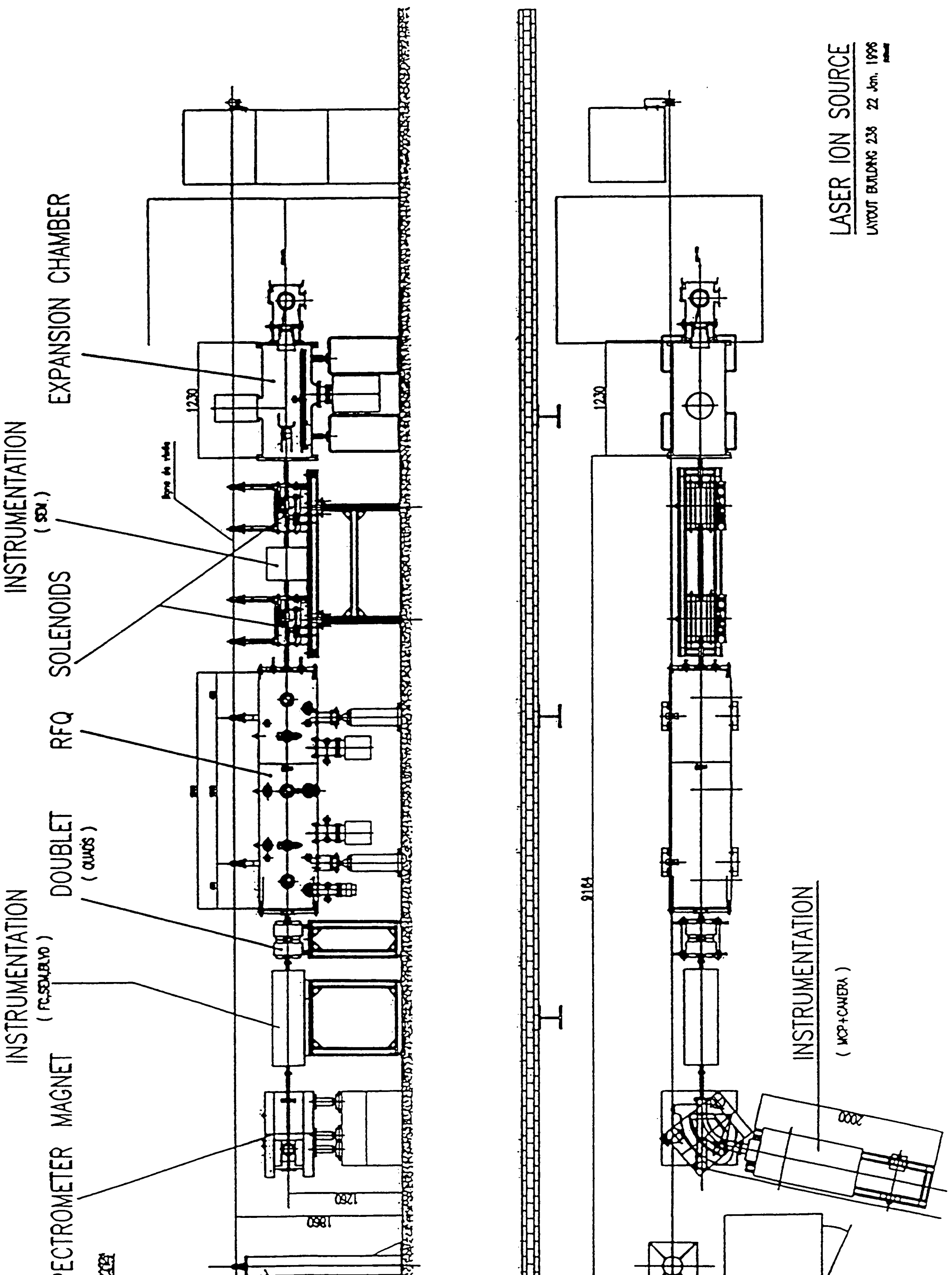


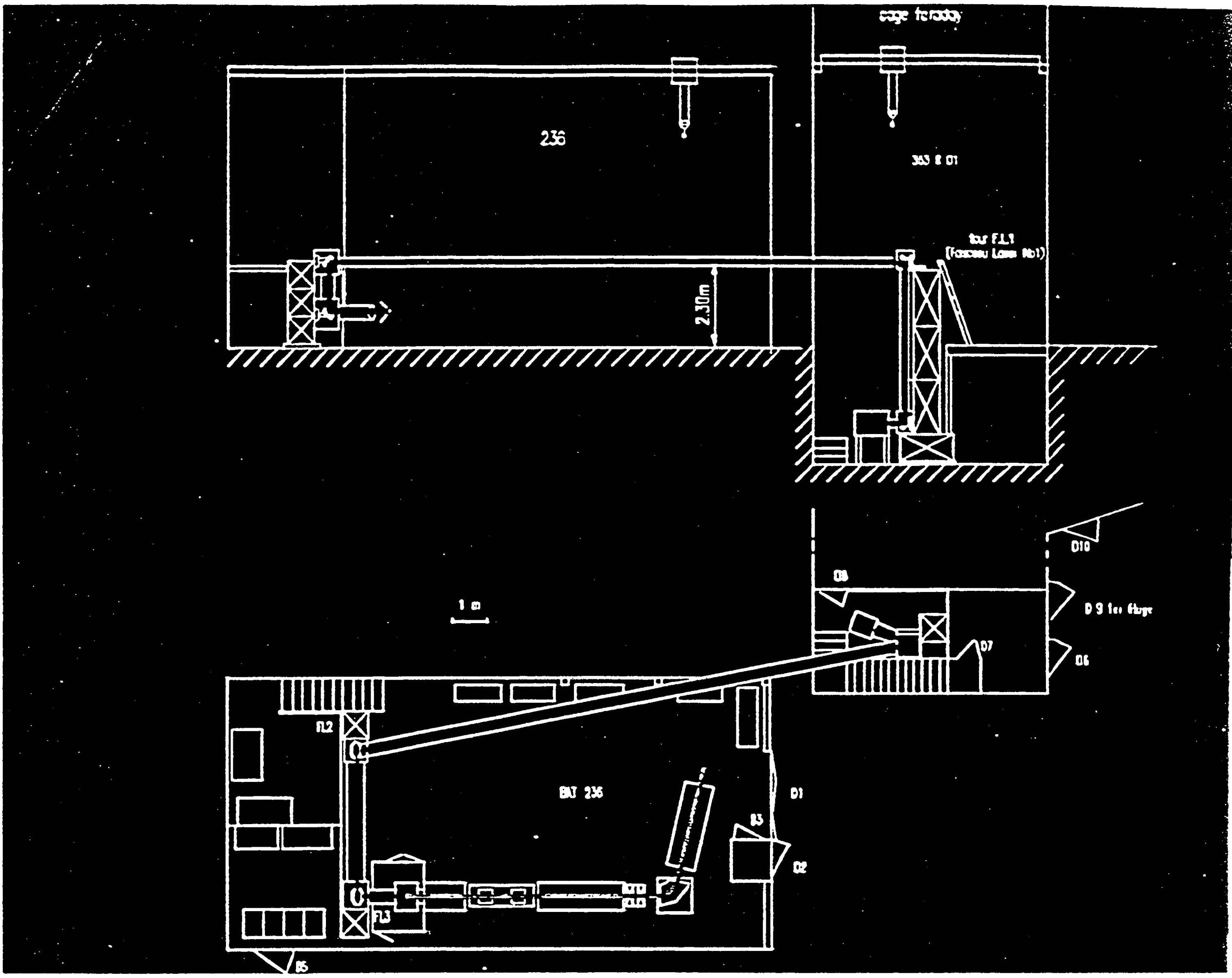
RFQ 7 → 100 keV/u Pb^{28+} A. Lombardi



A. Lombardi, A. Ster
R. Scrivens

100 KeV/u Measuring Line


LASER ION SOURCE
LAYOUT BUILDING 238 22 Jan. 1996
EXPANSION CHAMBER
INSTRUMENTATION
(SEM)
SOLENOIDS
RFQ
DOUBLET
(QUADS)
INSTRUMENTATION
SPECTROMETER MAGNET
INSTRUMENTATION
(MCP+CAMERA)
SAS
1230
1230
9184
2000
1260
1860



M. Bourgeois / PS

New Lab of LASER ION SOURCE

CTF95 and CTF2

Hans BRAUN

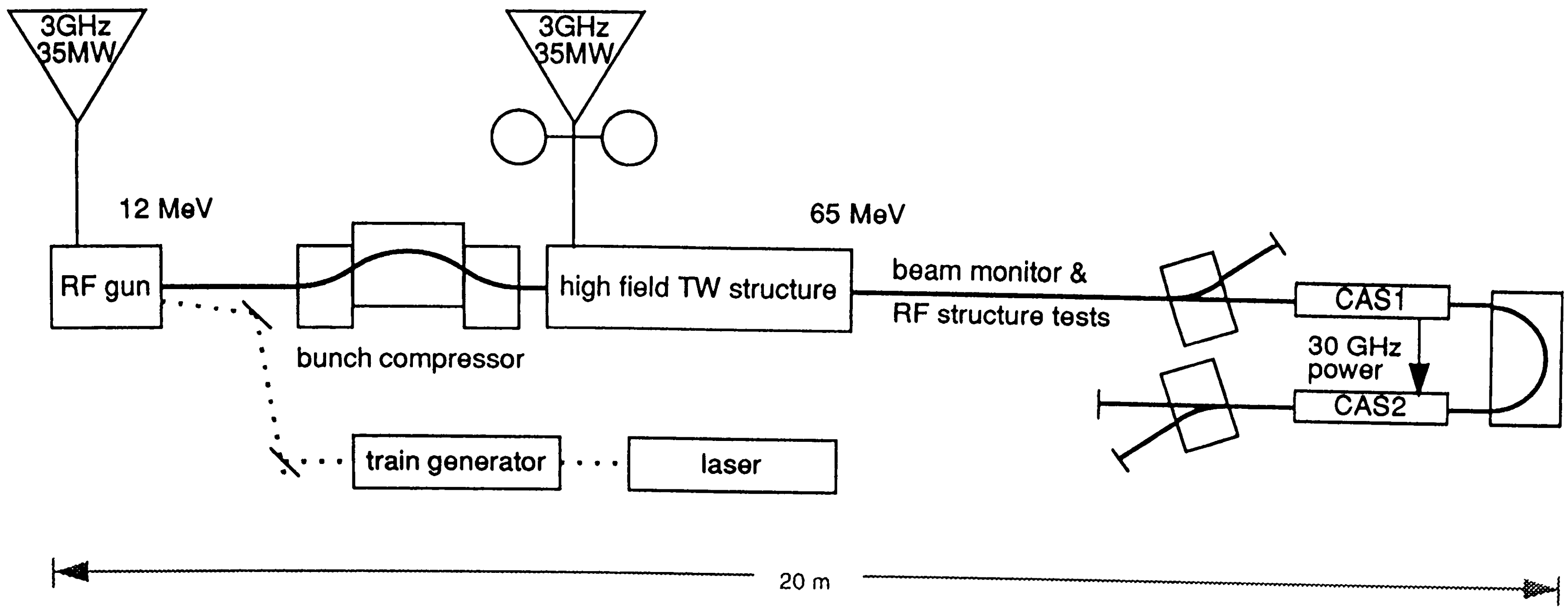
Abstract

In 1995 experiments in the CLIC Test Facility (CTF) were performed on high charge bunch compression, high power behaviour of 30 GHz components, impedance measurements of 30 GHz RF transfer structures, beam tests of a variety of beam monitor prototypes, and photo cathodes. A considerable part of these experiments was done with respect to CTF2, an accelerator experiment presently under construction with the aim to demonstrate the two beam acceleration scheme with 30 GHz technology as foreseen for CLIC. The construction of the CTF 2 experiment is progressing well and first 30 GHz acceleration is expected for end of this year.

CTF I

Objectives:

- Act as a 30GHz high power source with P>60MW to test CLIC RF components
- Study production of high charge bunches with σ_t<2ps with respect to CLIC drive beam source
- Test of beam monitors and RF structures with single bunches and bunch trains



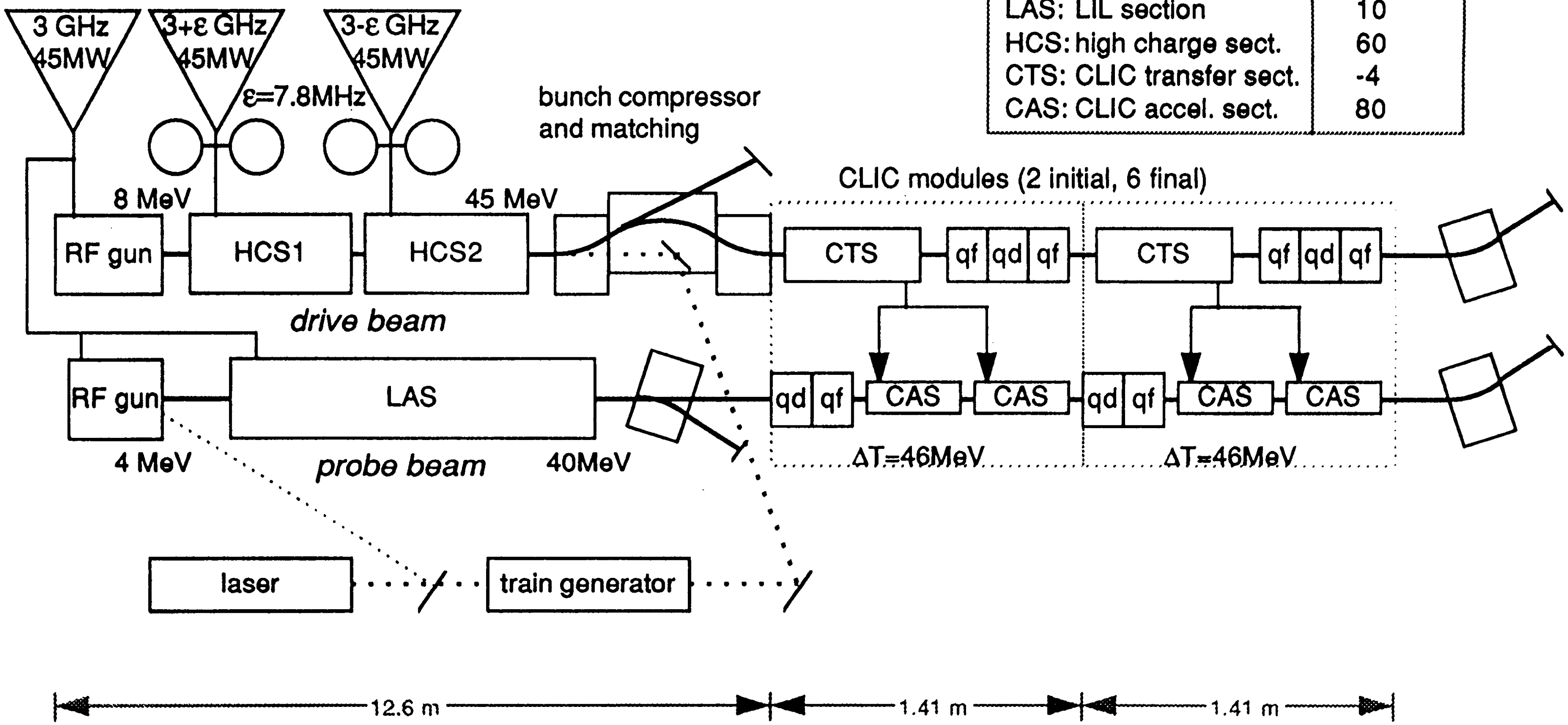
CTF II

Objectives:

- Test two beam acceleration in 30GHz technology
- Build and test prototypes of CLIC modules
- Study drive beam dynamics
- Test active alignment system
- Test CLIC beam monitoring

	Drive beam	probe beam (initial)
n_b	48	1
q_b [nC]	21	1.3
σ_t [ps]	<2	<3

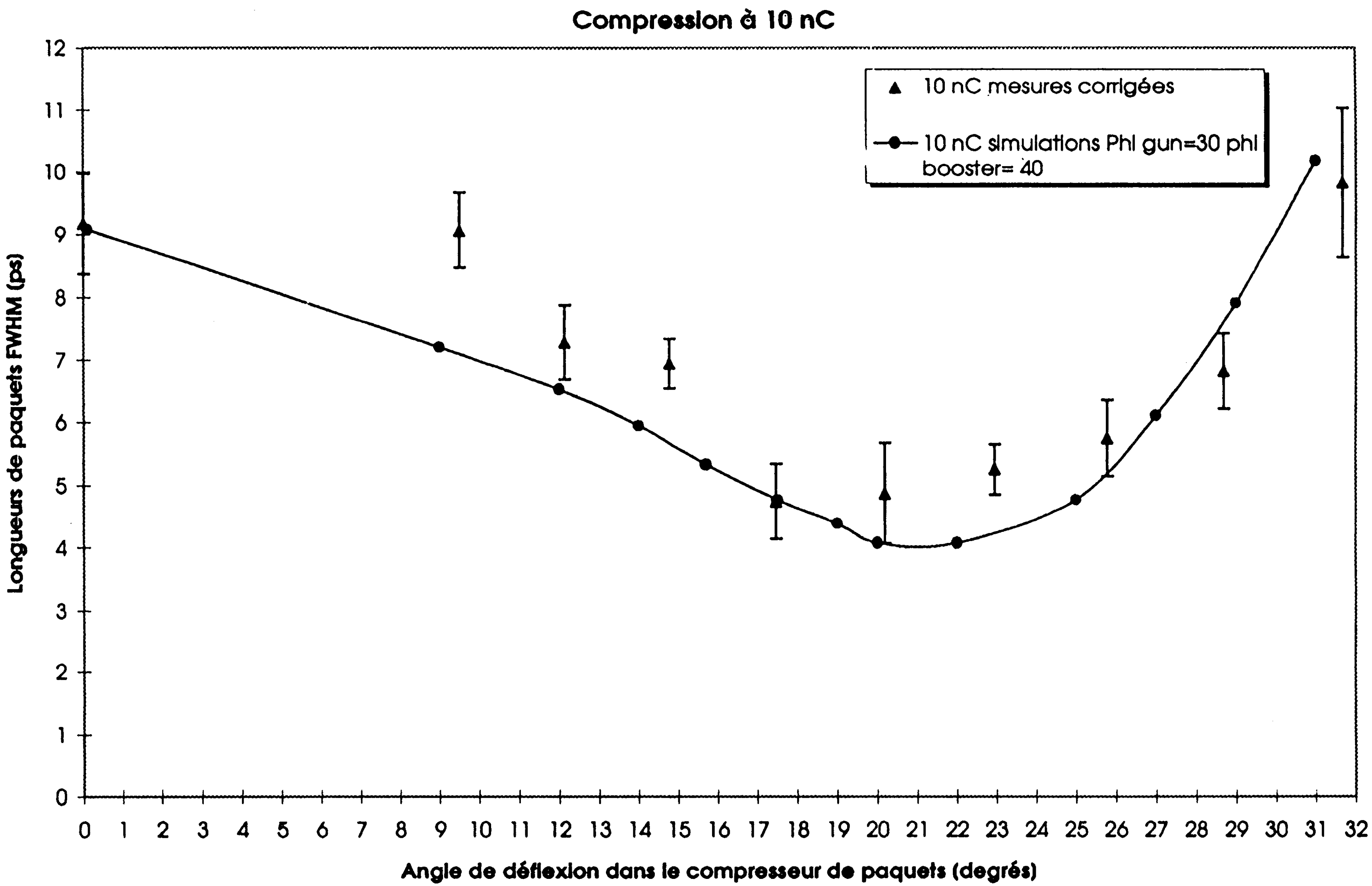
RF structure	E_z [MV/m]
LAS: LIL section	10
HCS: high charge sect.	60
CTS: CLIC transfer sect.	-4
CAS: CLIC accel. sect.	80



CTF'95 experiments

(compressed version)

experiment	result
bunch compression studies	I_{peak}>2 kA
30 GHz high power tests (60-75 MW) of CLIC/CTF2 components • flexible waveguide • stainless steel w.g. power load • ceramic w.g. power load • phase shifter • waveguide with silver lining • waveguide with nail	no sparks
tests of CTF2 30 GHz transfer structures	Version 1 showed to strong beam position sensitivty. Version 2, built in crash program of ≈ 1 month, works satisfactory
30 GHz BPM tests with beam	resolution better than ±5 µm
test of new button BPM's for CTF2 drive beam and its acquisition system with beam	works, resolution better than ±100 µm, BW BPM ≈4 GHz, BW acquisition ≈500 MHz
high BW WCM for CTF2	works, BW≈10 GHz, sufficient to measure charge of individual bunches
bunch length measurement with coherent transition radiation (DESY & THD)	seems to work
Test of CsI+Ge photocathodes for CTF2 probe beam (exposable to air))	QE is sufficient
Test of GaAS photocathode in RF gun. (for polarized beams in linear colliders)	kept cathode voltages of up to 85 MV/m, (DC guns typ. 1-2 MV/m)


Compression à 10 nC
Longueurs de paquets FWHM (ps)
Angle de déflexion dans le compresseur de paquets (degrés)
10 nC mesures corrigées
10 nC simulations Phi gun=30 phi booster= 40
0 1 2 3 4 5 6 7 8 9 10 11 12
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

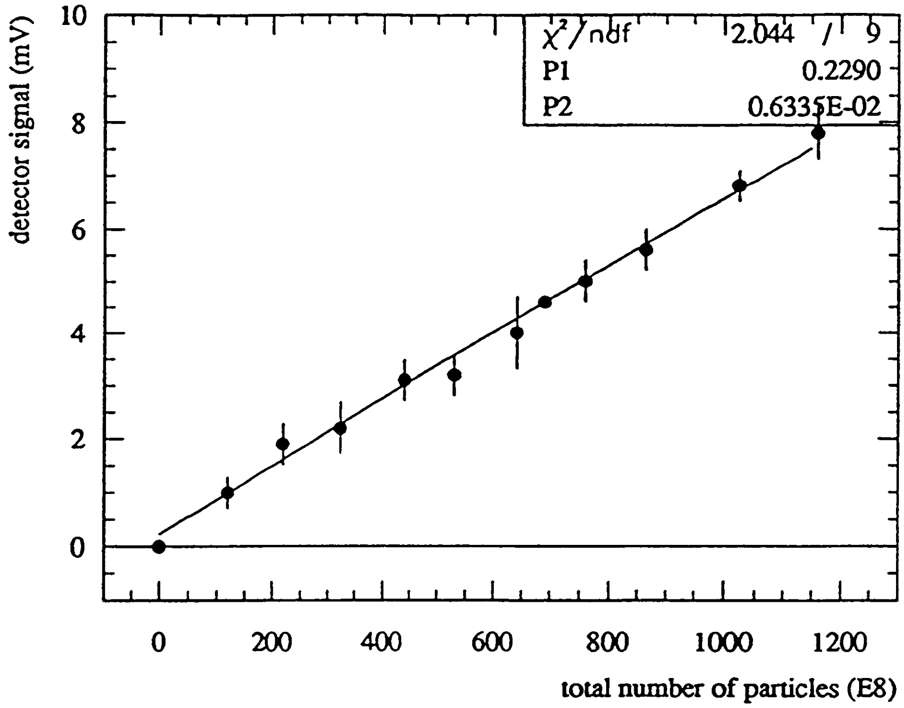


Figure 4: Signal for different numbers of bunches in a train. The first value is taken with one single bunch, then bunches are added successively until the train consists of 12 bunches.

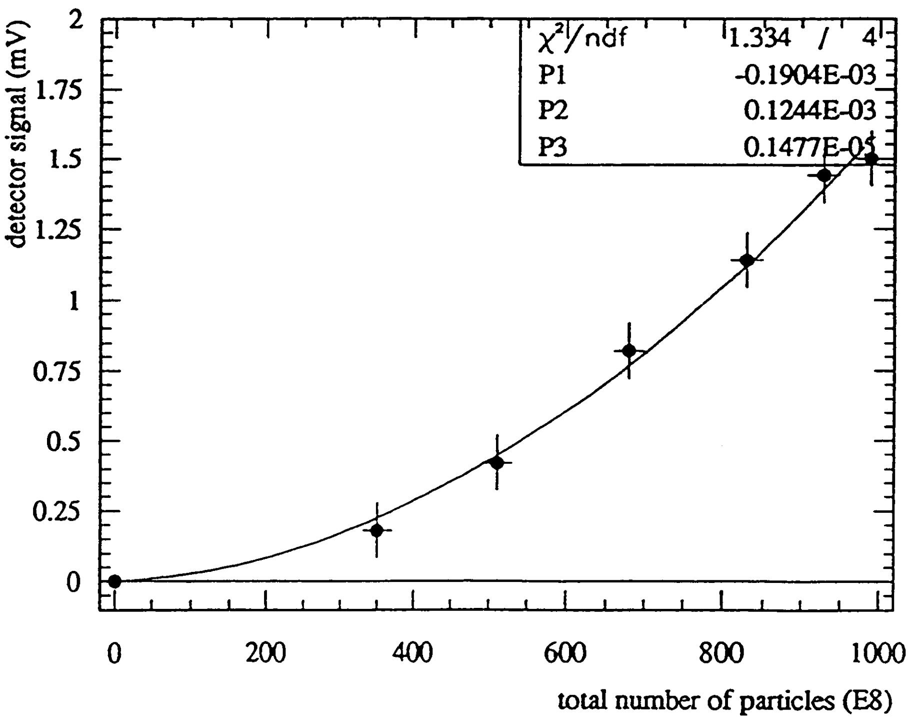
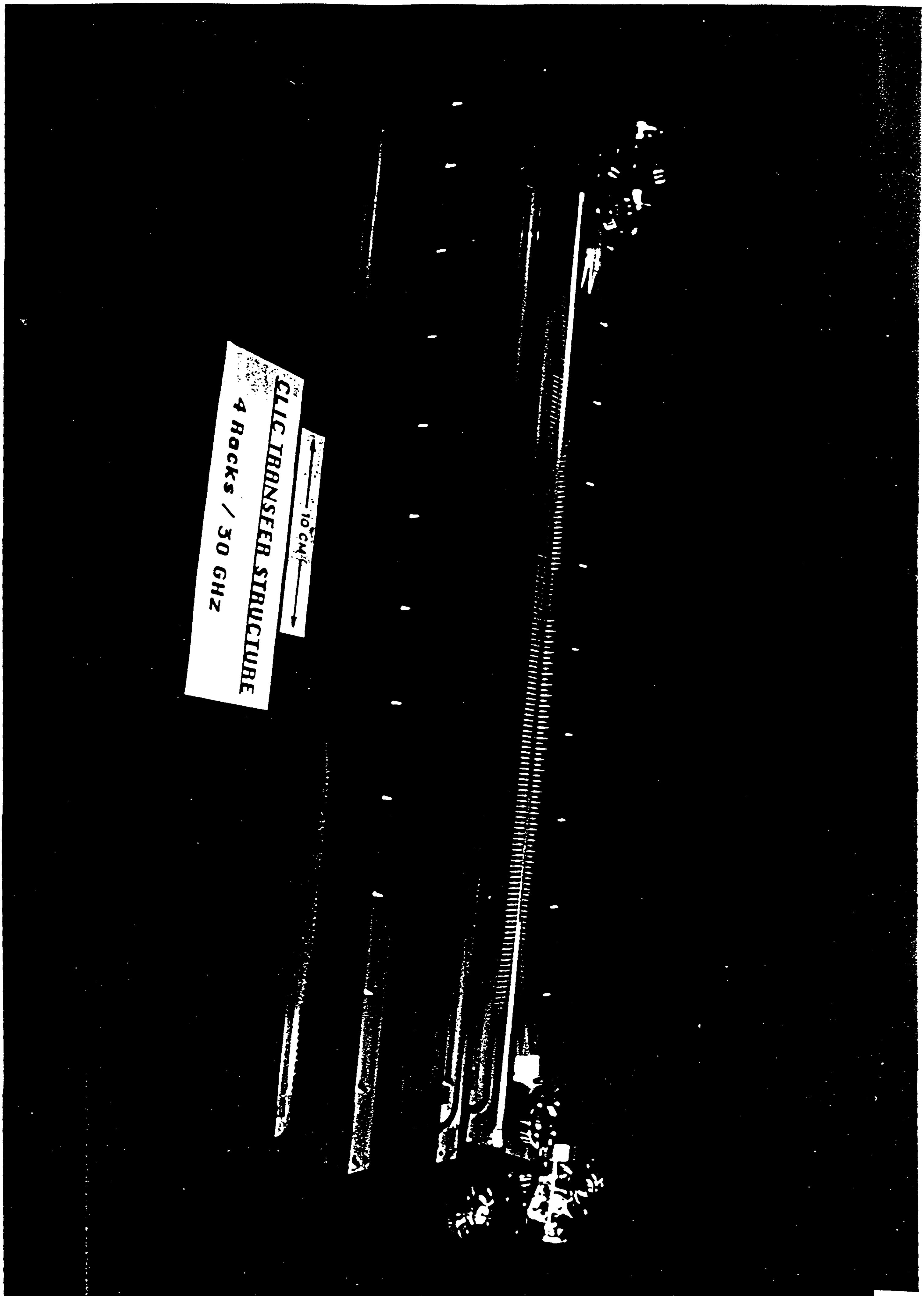
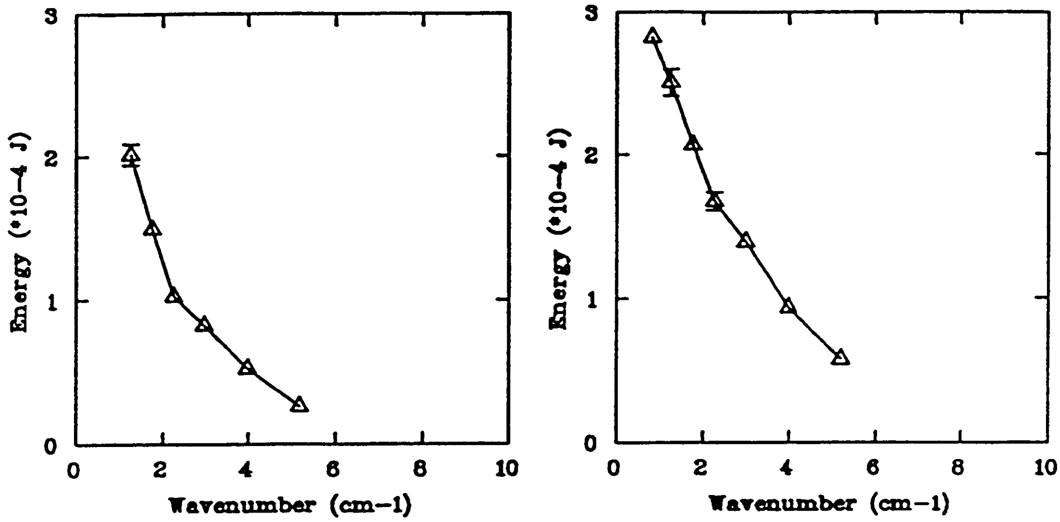


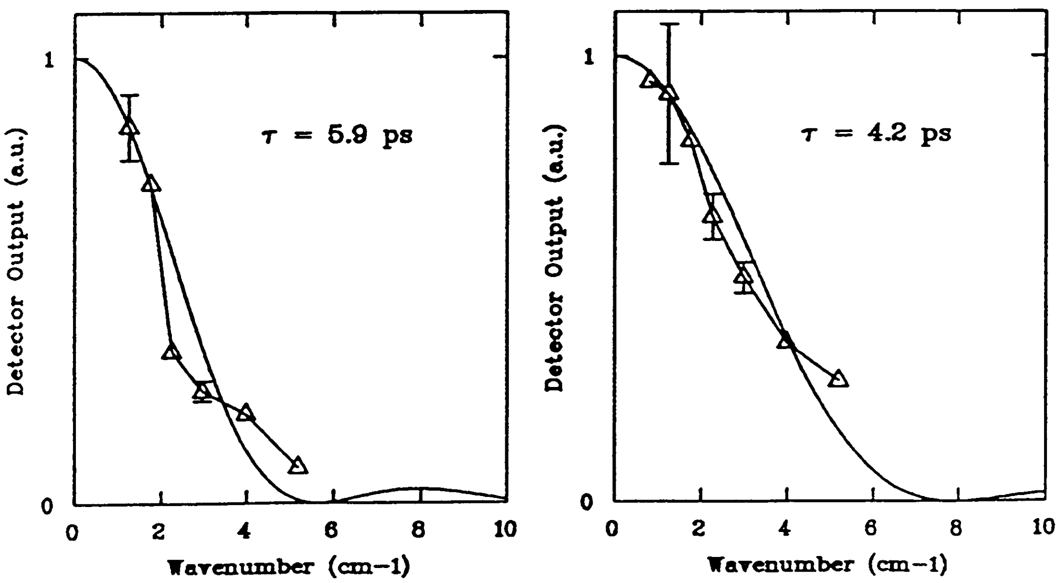
Figure 5: Detector signal for increasing single bunch charge. The number of bunches in the train is kept constant to 12.

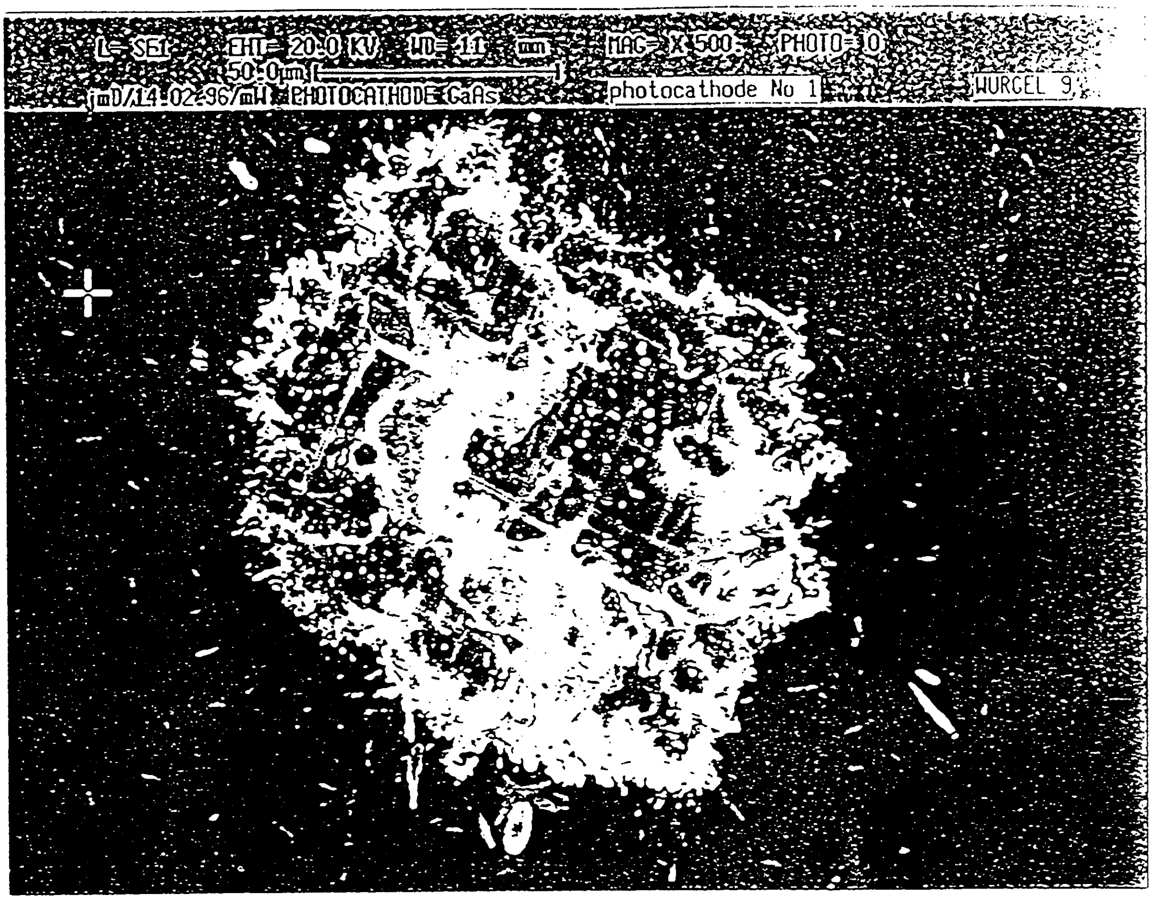

10 CM
CLIC TRANSFER STRUCTURE
4 Racks / 30 GHz

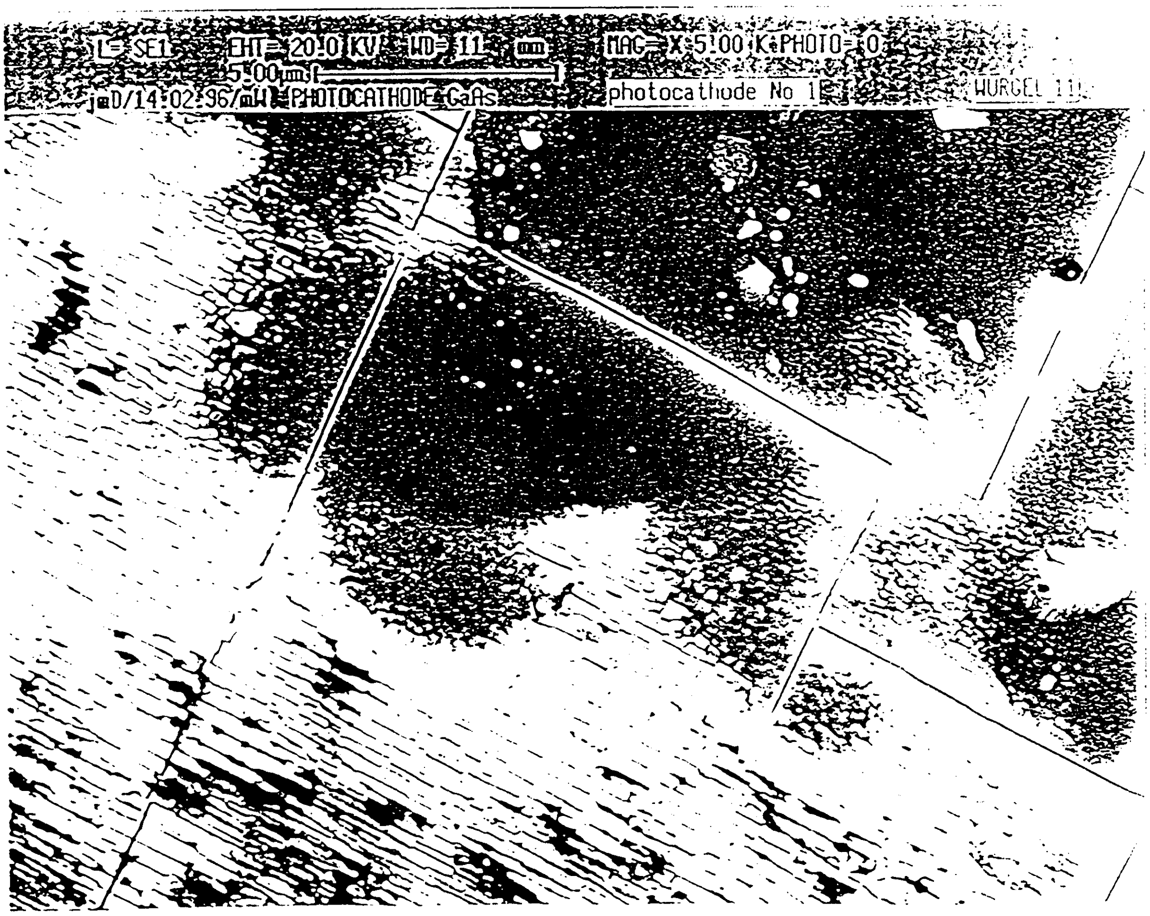
Integrated Spectral Intensity



Formfactor




L= SE1
EHT= 20.0 KV
WD= 11 mm
MAG= X 500
PHOTO= 0
50.0µm
jmD/14.02.96/mW PHOTOCATHODE GaAs
photocathode No 1
WURGEL 9


L= SE1
EHT= 20.0 KV
WD= 11 mm
MAG= X 5.00 K
PHOTO= 0
5.00µm
jmD/14.02.96/mW PHOTOCATHODE GaAs
photocathode No 1
WURGEL 11

Status of CTF2

General

- Extension of building in progress
- Layout of beamlines ready
- Magnets of 3 GHz region reused from CTF1

3 GHz RF cavities

- Probe beam RF gun reused from CTF1
- Probe beam 3 GHz accelerating structure is spare of LIL
- New drive beam RF Gun (type 4) almost ready. Type 5 already developped
- HCS construction by LAL Orsay & Philips. Delivery HCS 1 foreseen for July, HCS2 for October

3 GHz RF generation

- Timing system built, under test now
- Upgrade RF Phasing system in progress
- Modulator upgrade from 35 MW to 45 MW in progres

Laser and Photocathodes

- Upgrade Laser System in progress
- Photo Cathodes for drive beam (Cs_2Te) and probe beam (CsI+Ge) tested and ready for production

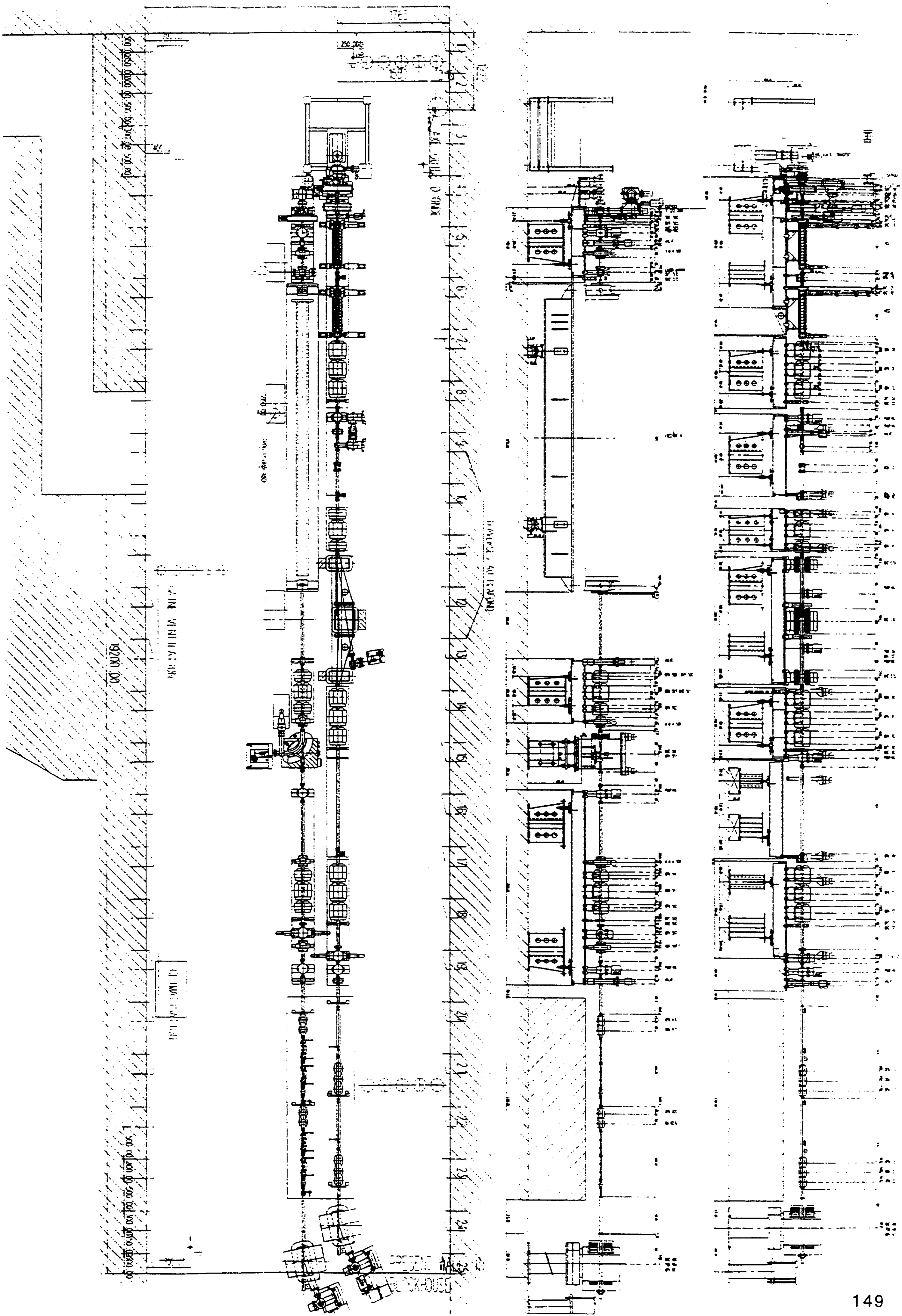
Beam Diagnostics

- Drive beam BPM's built, prototypes of acquisition electronic tested, components ordered
- Drive beam WCM build and tested
- Probe beam UMA's reused from CTF1
- New TCM optical beamlines in progress, streak camera upgrade ordered
- Construction of 3 GHz part (except of HCS's) will (hopefully) be finished in May

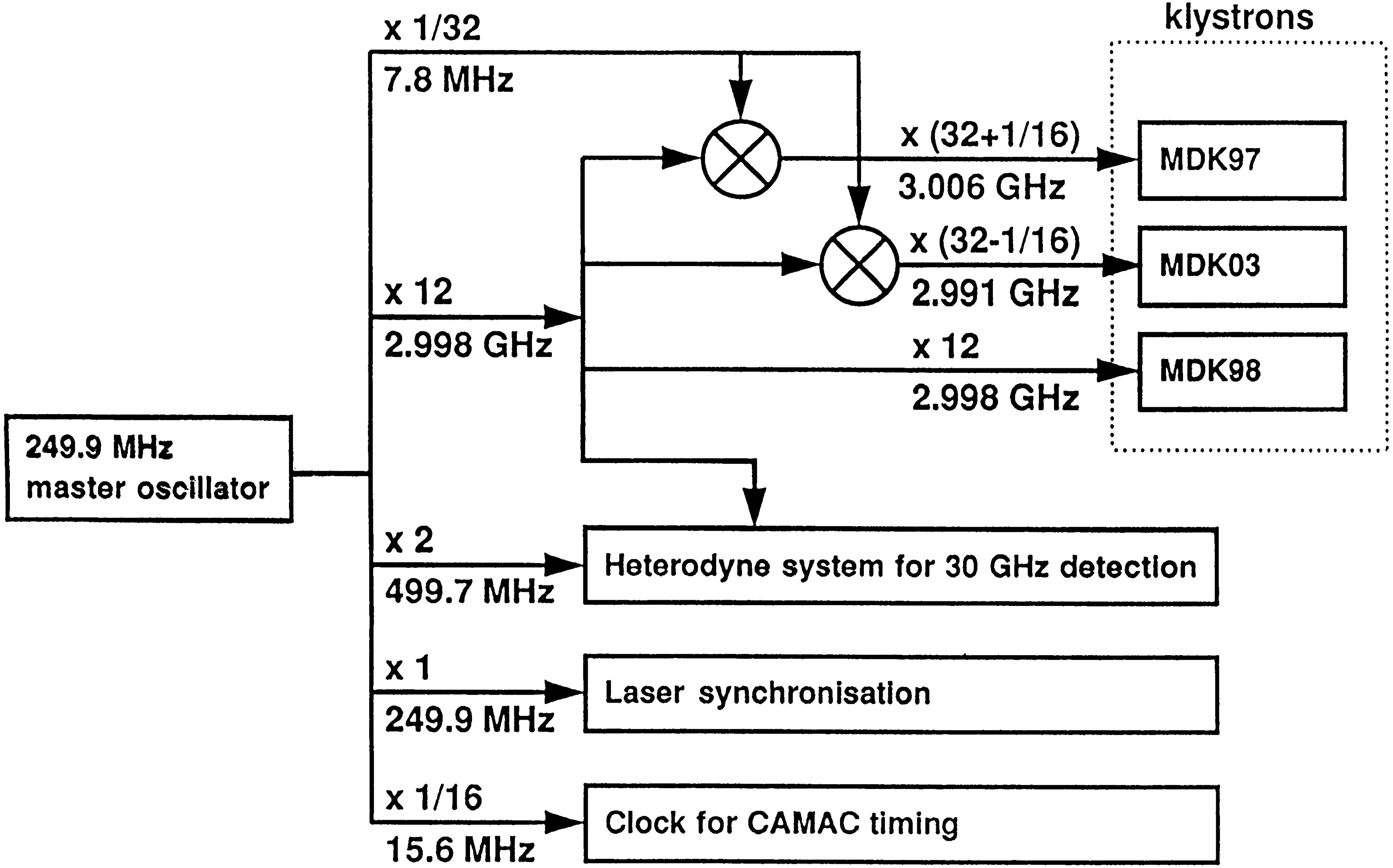
30 GHz Modules

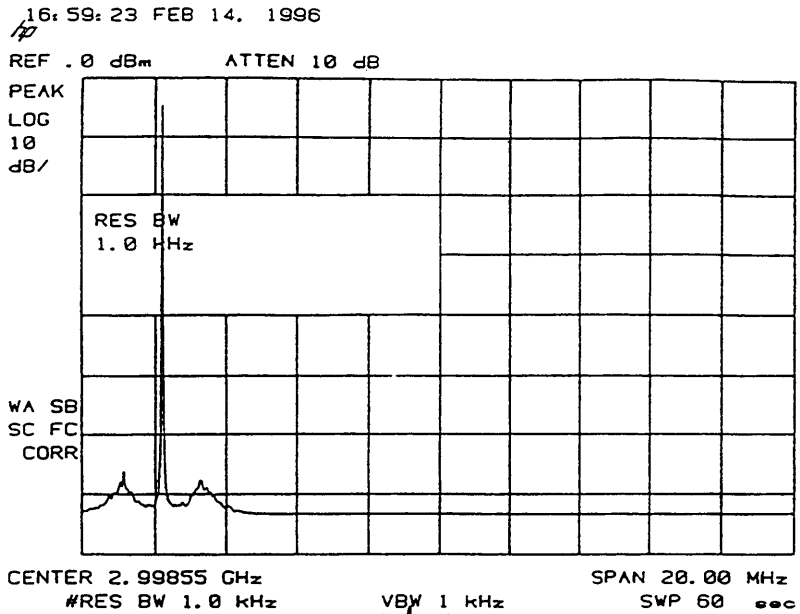
- Installation of first and second 30 GHz module foreseen for October.

With some luck we may manage to get some 30 GHz acceleration end of this year !

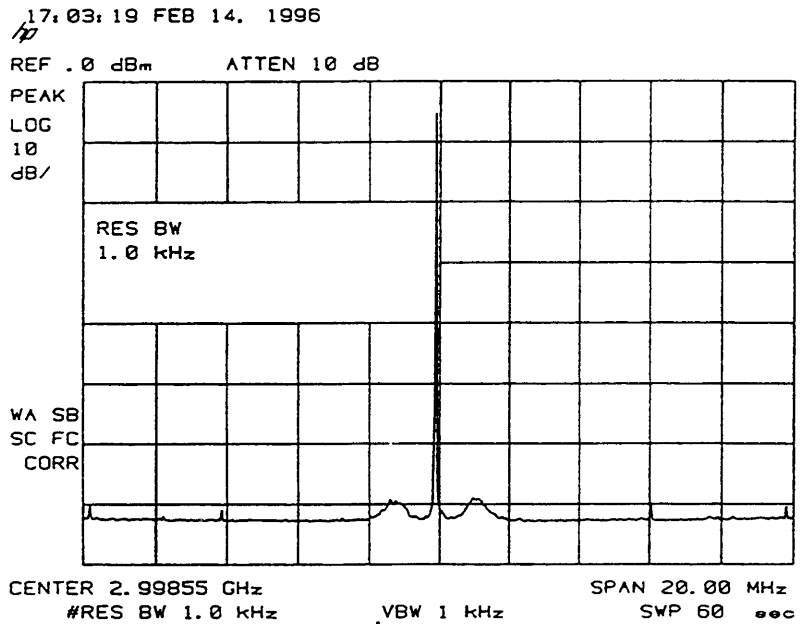


Scheme of CTF2 timing system

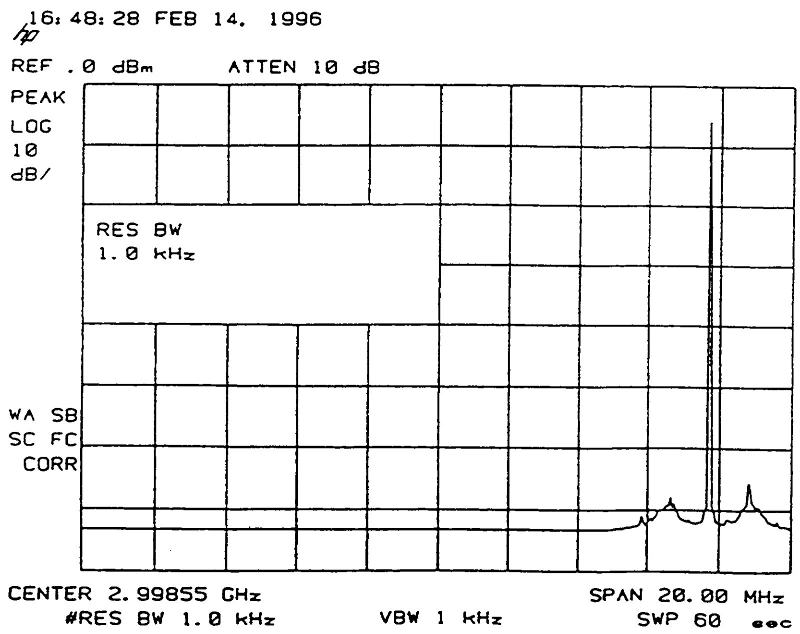




lower sideband



carrier



upper sideband

PS Performance Day 1996

Linac 2 and Linac 3 Summaries

Maurizio VRETENAR

LINAC 2 AND 3 SUMMARIES

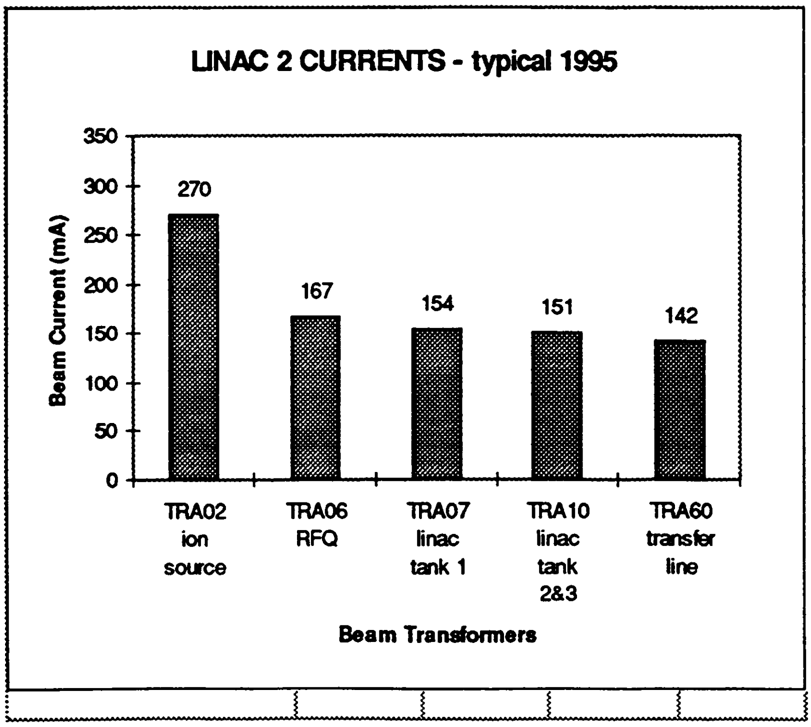
M. Vretenar

Abstract:

The performance of the two Hadron Linacs in terms of typical accelerated currents and emittances during the physics runs is presented. For both machines 1995 has been a positive year, with a substantial increase in beam brightness, together with a better overall stability of the machines. The improvements are mainly due to the studies done on the ion source and to the re-alignment of the IH tanks for Linac3, and to the re-alignment of the proton source and RFQ done at Linac2 during the shut-down. Nevertheless, some worries about misalignment of elements inside Linac2 tanks arose after a vacuum leak that appeared in October, pushing high on the 1996 MD priority list the study of quadrupoles alignment using the beam as a probe, in order to identify misaligned elements. Another important MD topic for Linac2 will be the reproduction of the high intensity LHC-type beam with a more stable RFQ.

LINAC 2 PERFORMANCE IN 1995

CURRENTS:



TRANSMISSIONS:

RFQ	~ 94 %
Linac Tank 1	92 %
Linac Tanks	90 %
Transfer line	94 %

EMITTANCES:

				1994
Horizontal	**1.0-1.3**	*π mm mrad*	*1σ, normalised*	**1.7**
Vertical	**0.6-0.9**	*π mm mrad*	*1σ, normalised*	**1.2**
Longitudinal	**~ 6.0**	*deg MeV*	*1σ*	**6.1**
Energy Spread	**±140-160**	*keV*	*2σ*	**170**

STABILITY:

* *no complains of instabilities in beam position at PSB input*
* *very low fault rate* (until a bad leak...)

LINAC 3 PERFORMANCE IN 1995

Currents:

	Ion	1995	1994
Source	Pb27+	110-120 μA	80 μA
RFQ	Pb27+	85-90 μA	70 μA
Linac	Pb27+	80-85 μA	60 μA
after stripping	all	160-170 μA	130 μA
to PSB	Pb53+	25-30 μA	22 μA

Emittances & Energy Spread at PSB:

	1995	1994	
Horizontal emittance	0.4	0.6	mm mrad (1σ, normalised)
Vertical Emittance	0.4	0.6	mm mrad (1σ, normalised)
Energy Spread	± 2.5	± 2.5	keV/u (2σ)

LINAC2 MD PRIORITIES

(Linac3 priorities were presented by Ch.Hill during his morning talk)

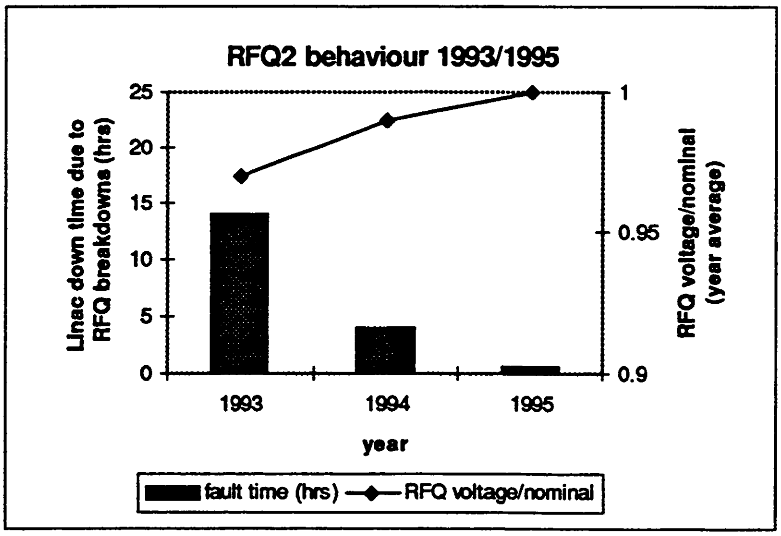
HIGH INTENSITY

1. REALIGNMENT OF SOURCE AND RFQ

done at beginning of 1995, *but* the 2 weeks of beam measurements foreseen in February-March 1995 have been totally eaten up by a difficult start-up (hardware and software problems on different equipment).

⇒ the work has been done, but we have still to analyse the consequences!

2. RFQ PERFORMANCE AND STABILITY (critical issue for the high intensity beam):



⇒ NEED MD time in 1996 !

NEW & UNEXPECTED PROBLEMS

The important vacuum leak between Tank 1 and Tank 2 of October 1995 (now repaired) was due to the impact of a misfocused/misaligned beam on the beam pipe.

Question: Was the damage due to an accidental event or was it due to 18 years of operation ?

⇒ <u>NEED</u> MD time to study the problem and analyse the alignment of linac elements (mainly quads)

MD PRIORITIES FOR 1996

1.	Assess the performance of the linac after the (heavy!) repair of the vacuum leak.	*1 week at start-up*
2.	Analyse the alignment of linac elements by studying their effect on the beam, in order to reduce losses (at the same time avoid other accidents and improve the high intensity beam).	*1 dedicated period + some time during the year, ev. in ppm*
3.	Reproduce the high intensity beam and study the effect of the RFQ and source re-alignment	*1 or 2 periods of >6 hours dedicated*

<u>Note</u>: New measurement equipment (Bunch Shape Monitor from INR-Moscow) to be commissioned this year.

OLD AND NEW PROBLEMS (LINAC2)

	1993	1995	1996	
RFQ alignment	X			↘↘
Instabilities in the horizontal trajectory, injection into PSB	X	X		↘
Alignment and beam trajectory in the linac		X	X	↗↗
Linac mechanics			X	↗

PS Performance Day 1996

PSB summary

Karlheinz SCHINDL

PSB Summary

PSB Performances 1995

User Name	Beam Type Destination	Nr of Rings	Nr of p tot.	Nr of p/ring	(2-sigma) Norm. H	Emitt V	Comments	Limits
SFTPRO	SPS Neutrino Ph.	4	2.7E+13	7.0E+12	45 pi	25 pi	even intensity in all rings	Limit 1 capture
AA	pbar production	4	1.8E+13	4.6E+12	30 pi	15 pi	RF dipole recomb h=10 phase inv.	
ISOGPS	ISOLDE	4	3.0E+13	8.0E+12	55 pi	30 pi		LIMIT 1 (2) capture (?)
MDION	Pb 53+	4	2 E+10 (charges)					Ion Source Vacuum

LIMIT 1 : Longitudinal stability is marginal at higher intensities due to
- coupling between rf beam control loops of dual RF system (11 per ring): difficult to control, lack of understanding
- Coupled-Bunch Long. Feedback not designed for acceleration to 1 GeV (requires frequent readjusting at very high intensities)
- Instability of unknown type (GHz signals ?) in Ring 4, causing blowup and loss of a few % beam (main reason for machine activation)
- Recently octupole in-phase modes seen

LIMIT 2 : "Classical" transverse space charge limit.
At high intensity also the longitudinal space charge drastically reduces bucket area

H.Schönauer, 15.2.96, PPD

PSB MD's 1996

Topic	Client	Remarks/Requirements/ Contribution	Prime Time	1996 hrs
h=5/h=10 Dual RF System: - study of basic properties: gap-derived or beam-derived h=10 phase; - new HW: Synchr. Detector for quadr./octup. modes; new mode analyzer	ISOLDE, SFT	relevant also for future h=1, h=2 systems maybe feedback on in-phase modes	P [1]	30
h=1 / h=10 RF Systems	LHC	Controlled bunch flattening with h=10	Y	10
h=1 / h=2 Dual RF System	PSB	for intensities > 2 10^{12} p/pulse	P	20
Loss Analysis	PSB	High-energy loss ring 4, with BLM's etc	P	10
Steering and Focusing inTransfer Lines *(dedicated ISOLDE line MD's needed)*	LHC,SPS, ISOLDE	ABS + analysis of geometry (recomb.) ISOLDE line optics, use of SEM's, BLM Staggered extraction	Y P	10 20 8
Beam Transfer Function Measurement	PSB	Momentum distribution of injected beam measured in the ring		20
Comparison Wire Scanner / Beamscope	LHC	before ordering 8 wire scanners from TRIUMF		10
1 GeV Measurement line	LHC	Render operational, in particular for Pb		20
"Initial" Beam for LHC	LHC	ε^* = 0.75 μm at 26 GeV/c; shavers?	P	10
Scintillator Screens Inj. Line, CCD cameras	Pb Ions	Test of new SW developments	Y	8
Transverse Stability with New Kicker Cables Damper Tuning	PSB, LHC	Unknowns in acceleration to 1.4 GeV	 P	20 10
Ion Injection Steering, improved Focusing	Pb Ions	Correction from Screen Position (Matrix Inversion)	P	8
Multiturn Injection Study	Pb Ions, LHC	(PhD Thesis)	P	10
B-Train Generation (with new NMR markers)	Pb Ions	System tests, integration into control system		8
Ion lifetime measurements	Pb Ions	At varying energy, with AT (PhD thesis)	Y	20
Integer Stopband Compensation	PSB	Successful at ISIS - against theory! Waiting for Q-Measurement..		10
Total				260
1) P = Partially during prime time				

3 PSB PROBLEMS:

i) Marginal stability of dual RF system: limit to highest intensities, tedious operation, losses ==> relevant also for future h=1/h=2 systems; longitudinal coupled-bunch instabilities for present h=5,10

ii) Loss management (mainly related to (i) and in ring 4 - to be further analysed; study of collimators and cleaning septum)

iii) Lack of diagnostics in ISOLDE beam line: crash programme
- Beam transformers in GPS, HRS *(needed for Watchdog!)*
- 2 SEM grids and 2 PUs

(iv) Left with 5 BS!)

PS Performance Day 1996

LPI summary

Jean-Pierre POTIER

LPI 95 summary

J.Clendenin, J.P.Potier

Beam performances in 95 (same as 93)

	Max present Users requests**	Operational values	Max. values
LPI accumulation rate in E09 $e^+/(s^*$ bunch)	3.5	5.4	8.0
LPI accumulation rate in E09 $e^-/(s^*$bunch)	32.0	49.0	120.

** Corresponding to 2.8 E11 leptons in 8 bunches on the usual 14.4 s supercycle

Faults statistics = 3.3 % (external faults removed).

Remark

Present users' requests: In fact the LPI is tuned approximately for the operational values shown above, but the accumulation is stopped before the end of the total time available by an intensity limiter.

=> Possibilities of parasitic studies

Conclusions (same as PPDAY 95 and 94)

Performances OK . As they are high enough in respect to users requests... **But one must remember** that increasing the positron production, our closest LPI bottle-neck, will need time and money to develop and implement.

1995 Studies

In 95 the study time was devoted mainly to:

LPI

- e+ tuning, after the exchange of the positron trapping section and focusing solenoids (ACS25). RF conditioning OK now. operational conversion factor back to 5 E-03 at 1.8 E10 on the converter target.
- RF conditioning on ACS27 now OK up to 22 MW (11.6 MV/m average, 18.3 MV/m peak), found limited in 94 by the higher order modes sent to the cavity by a worn out klystron producing a lot of 6 and 9 GHz.
- Experiments on LILV to feed the Pre-Buncher and Buncher from MDK13 avoiding the use of MDK03 and setting up tests with the last MDK (MDK35) OFF.
- Electron beam emittance measurements in WL.WBS25 (end LILV at 200 MeV) and HIM.WBS00 (end LILW at 500 MeV) and comparison with the optical model.

LHC

Irradiation of LHC vacuum chamber samples at a critical energy of 45.3 eV (308 MeV in EPA, 7 TeV in LHC), at room temperature and in a cryostat at about 2 dg K after LEP stop. Stable 4.5 E11 / 8 bunches beam circulating during one week with a good life time.

LEA

After the running-in of the pulsed BSH00, it has been possible to share the beam between LEA (LIL Experimental Area) and LEP, enabling one to perform more easily irradiations' for OPAL and ECAL/CMS collaborations on detectors.

Hall 174

Tests on strengthened pulsed solenoids have been pursued and burn-in tests have been performed on regular solenoids which will be installed with the new converter tank in 96.

LPI 96 study program

LPI studies

At 96 startup the stability of LPI with the LIL Buncher powered from LIPS13 will be checked. Then, as usual, beam machine parameters and performances will be measured, then tests on 4 bunches and 8 bunches transfer mode performed with the CPS.

Our main subjects will be:

- Optimization of the WL.SNL25 imperfections compensations using an electron beam.
- Electron and positron beam emittance and matching in LIL to the EPA transfer line.
- Beam production without MDK35
- Test of ABS in LIL and possibly at EPA injection with the PS-ABS team ?
- Training of the LPI Operation technicians in order to prepare them forthe new LPI supervision scheme (LPI running without a technician during shifts 3X8h/24h).

LHC irradiation

Making profit of the long LEP stops, the cold bore experiment will continue in the synchrotron light line during 2 periods of 2 weeks and one 3 weeks period, end 96. Momentum will be 308 MeV e- beams . The main subjects will be:

- CO_2 primary photo-desorption coefficients at 77 dg K
- Observe evidence of residual gas cracking using molecules with isotopes markers.
- Recycling coefficient measurement etc....

LEA activities

Measurement for the evaluation of the explosion risks in cryogenic liquids exposed to radiation (TIS and British Institute of cryogenic/ Southampton). Irradiation's for ECAL/CMS.

Hall 174

Tests on strengthened pulsed solenoids will continue as well as the development of a conical solenoid (for positron capture improvement).

Major problems 1995 and nowadays

The **performances** of the LPI are safely above the requests of the users and apart from studies aiming at improving the availability (our major hardware effort) and the operation of LPI, there is no pressure and consequently no priority.

Controls

In 95 as in 94 and 93, the instrumentation reliability remains the weak point during studies. It should improve in 96 due to the planned upgrade of the instrumentation software.

Man Power for studies

In 93 and 94: *"In the present operation scheme, MD periods of 60 to 70 h are allocated every 1 to 4 months. The use of such a long study period, with only 2 to 3 people involved in LPI studies, is completely inefficient."*

In 95 the situation was still the same and is expected to continue in 96.

PS Performance Day 1996

AAC summary

Claude METZGER

AAC Summary (C.Metzger)

Performances

Comparaison des stastistiques des années 1992 à 1995

	1992	1993	1994	1995	1996
Nb. heures programmées	5897 h.	5563 h.	5657 h.	5920 h.	(6168 h.)
Disponibilité du "stack" en heures	5599 h.	4963 h.	5359 h.	5774 h.	
Disponibilité du "stack"en %	94.95 %	89.22 %	94.72 %	97.53 %	
Nb. heures en mode économique	2399 h.	1438 h.	2235 h.	1860 h.	
Temps de pannes	12j.10h.05m.	25j.14h.53m.	11j.07h.57m.	18j. 00h. 08m.	
Intensité maximun	>9 10^{11}	8.61 10^{11}	1.116 10^{12}	1.036 10^{12}	
Taux de production	1.29 10^{10}/h.	1.79 10^{10}/h.	1.909 10^{10}/h.	1.703 10^{10}/h.	
Nb. heures de production	1986 h.	2305 h.	1931 h.	2673 h.	
Nb. antiprotons produits	25610 10^9	41251 10^9	36879 10^9	45526 10^9	
Nb. antiprotons extraits	18347 10^9	27320 10^9	24767 10^9	36134 10^9	

Les points marquants de l'exploitation en 95:

En général:

- Très bonne disponibilité du "stack" (97.5% du temps programmé).
- Nombre record d'antiprotons produits et extraits pour LEAR.

Production d'antiprotons:

- Lentille Lithiun détruite à la fin du démarrage d'avril - remplacée par une corne - diminution du taux de production de 11% en moyenne.
- Jusqu'à fin juillet, limitation de l'intensité du faisceau de production à 1.10^{13} protons/pulse (dernière conséquence du sabotage).
- Remplacement préventif de la corne (rupture d'un boulon de fixation) pendant l'arrêt technique de septembre.
- Corne brulée par un survoltage accidentel du pulseur.

Accumulation:

- Globalement, bonnes performances d'ensemble avec une efficacité d'accumulation de 79%.
- A signaler:
  - ⇒ Problème de refroidissement cryogénique de plusieurs terminaisons des pick-ups du "cooling AC" ayant entrainé une limitation des performances pendant quelques mois.
  - ⇒ Novembre Noir: Cinq pertes de "stack" dues à:
    - ◊ une fuite d'eau,
    - ◊ deux coupures du réseau EOS,
    - ◊ deux pannes RF.

Ejection et Transfert:

- Faible taux de pannes
- Performances fluctuantes, moyennement bonnes.
- A signaler:
  - ⇒ Instabilité de l'alimentation de BTI 8025.
  - ⇒ Modification des trajectoires due à:
    - ◊ Tests d'échauffement du tunnel du PS
    - ◊ Variation du train B (lié au test d'échauffement)
  - ⇒ Oscillations des pbars dans le PS à l'injection. Amélioration dès que le système de mesure OSC-pbar est devenu opérationnel.

Améliorations et Développements en 1966.

Accumulateur:
Avec la décision d'arrêter l'exploitation du complexe AAC actuel à la fin de 1966, aucun développement ou programme d'amélioration n'est prévu.

D'autre part, le programme de physique à LEAR est prioritaire et le temps disponible pour les Mds ne permet de faire que la maintenance et le réglage des installations.

Collecteur: (en vue de l'éventuelle conversion du AC en AD)
En sessions parasites, pendant les périodes d'exploitation en mode économique, il est prévu de poursuivre, autant qu'il se peut, les études sur:

1. la décélération de protons.
2. la décélération d'antiprotons.
3. le refroidissement stochastique d'un faisceau d'antiprotons sur le palier de 2 GeV/c.
4. le refroidissement de faisceaux bunchés.

Problèmes antérieurs et leurs solutions.

1. Baisse du taux de production:

La cause de cette atténuation n'a pas encore était identifiée:

⇒ lentille lithium?
⇒ cible?
⇒ optique?

Après vérification de l'optique avant la cible et de celle de l'injection dans le AC, on a retrouvé le taux de production habituel. Malheureusement quelques jours après, le transformateur de la lentille lithium a grillé. Avec le remplacement de la lentille par une corne, le taux de production a baissé définitivement de 11% en moyenne.

2. Démarrage du complexe AAC:

Le personnel travaillant actuellement sur les machines de production d'antiprotons et ayant une connaissance globale de ces machines diminue d'année en année. Ceci se fait sentir en particulier lors des démarrages par des pertes de temps dues à la méconnaissance des systèmes.

Ce point perd de son importance puisque c'est la dernière année d'exploitation du complexe.

3. Organisation des mesures d'acceptance dynamique:

Dans le programme actuel nous ne disposons pas suffisament de temps pour effectuer ces mesures lors des démarrages.
Est-il possible de les faire en parasite sans perturber l'exploitation?

Une réunion du PPC a eu lieu pour débattre ce sujet. Il n'y a pas eu de suite.

Problèmes actuels.

Dernière année d'exploitation du complexe AAC.
Arrêt définitif: le 19 décembre 1996.

$$\text{Etude AD} \overset{?}{\Rightarrow} \text{Projet AD}$$

PS Performance Day 1996

LEAR summary

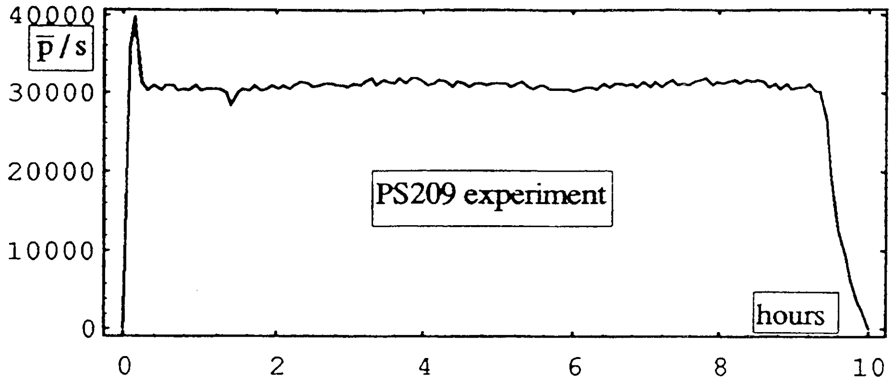
Michel CHANEL

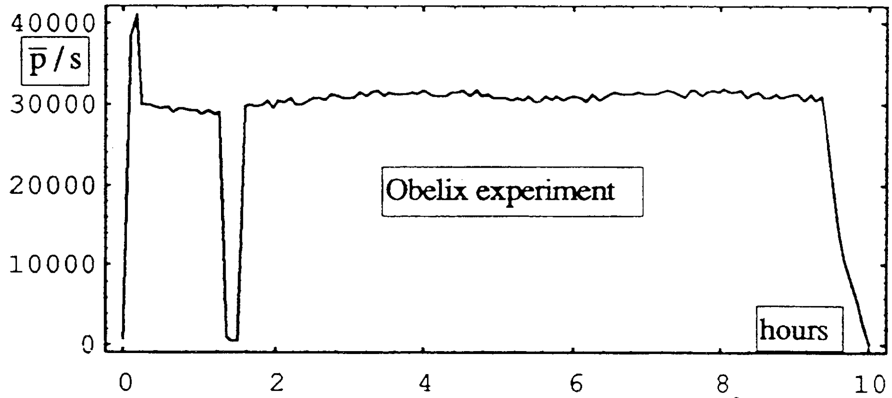
LEAR D'AVANT

1995

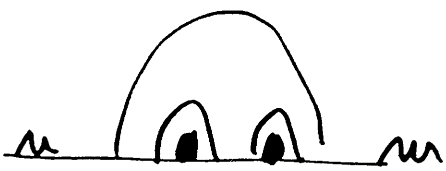
P MeV/c	Exp.	Flux $\times 10^3 s^{-1}$	Extime h	Stack 10^9	Limit.
1940	X Barrel PS208	100 200	>2h	5	Extime
310	PS201 PS209	>2000(30k) 30k	~1h → 10h	>10	stack
200	PS195 PS197 PS205	600-800 30-50 → 10 FAST	1,2	4-5	stack
105	PS201 PS197 PS207	100-200 10 300	0,8 " 0,5	2-3	Stack Lifetime VACUUM?
FE65	PS196 PS200T	1-2 shots 10 shots	– –	2-3	→ 10^6 in trap.
PS $\bar{H}$ 210	Jetset on Xe	–	Storage ~10^{-7}	~$2 \cdot 10^{10}$	g $\bar{H}_0$

- If $p \leq 36$ MeV/c ecool ok.

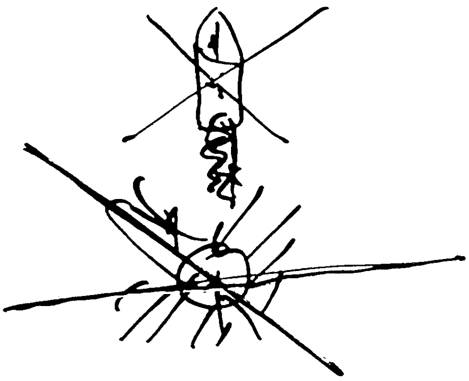




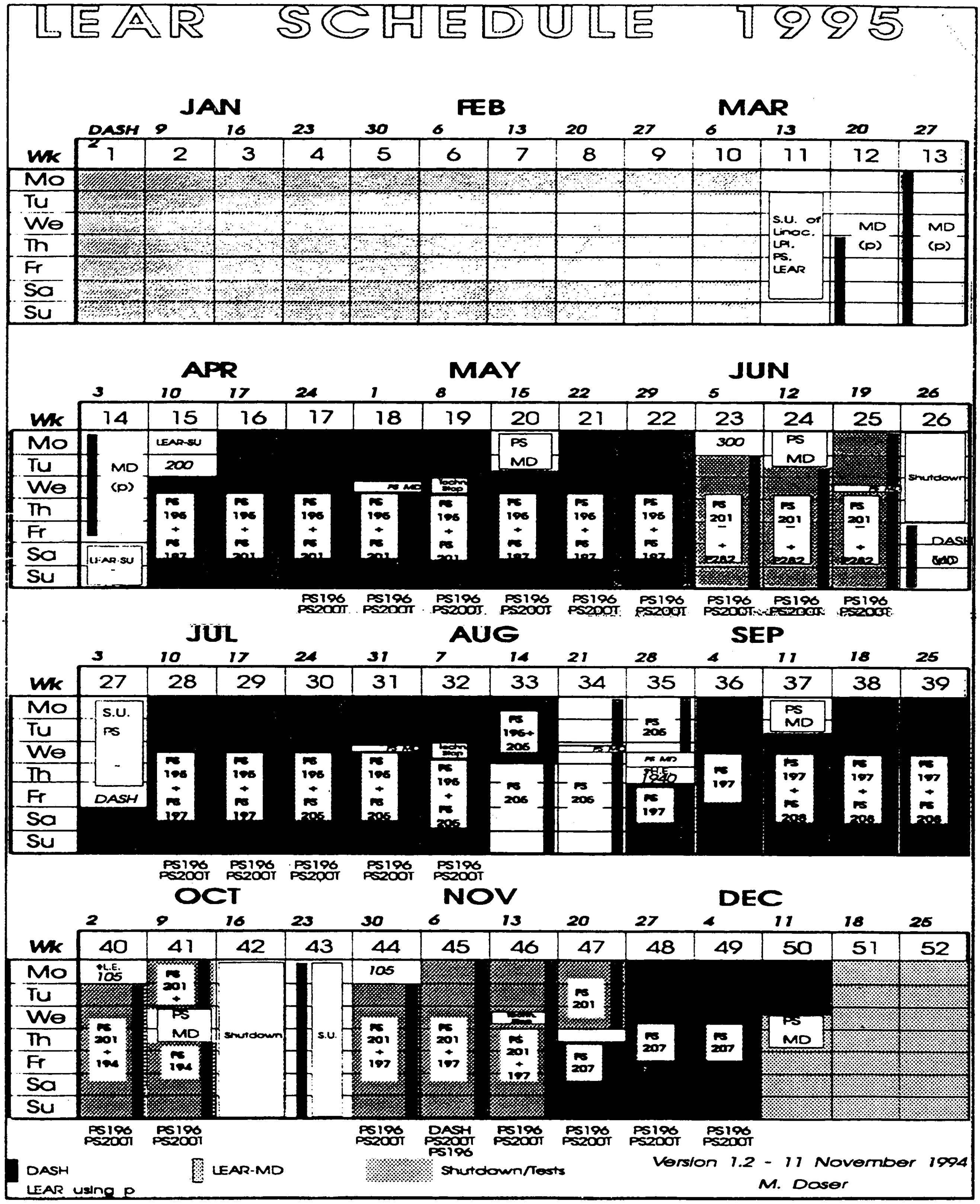
- Feedback ⇒ $\bar{p}$ constant
  → $\bar{p}$ effects of 200 MeV/c Ghost.

- 
  - less often
  - not strong.

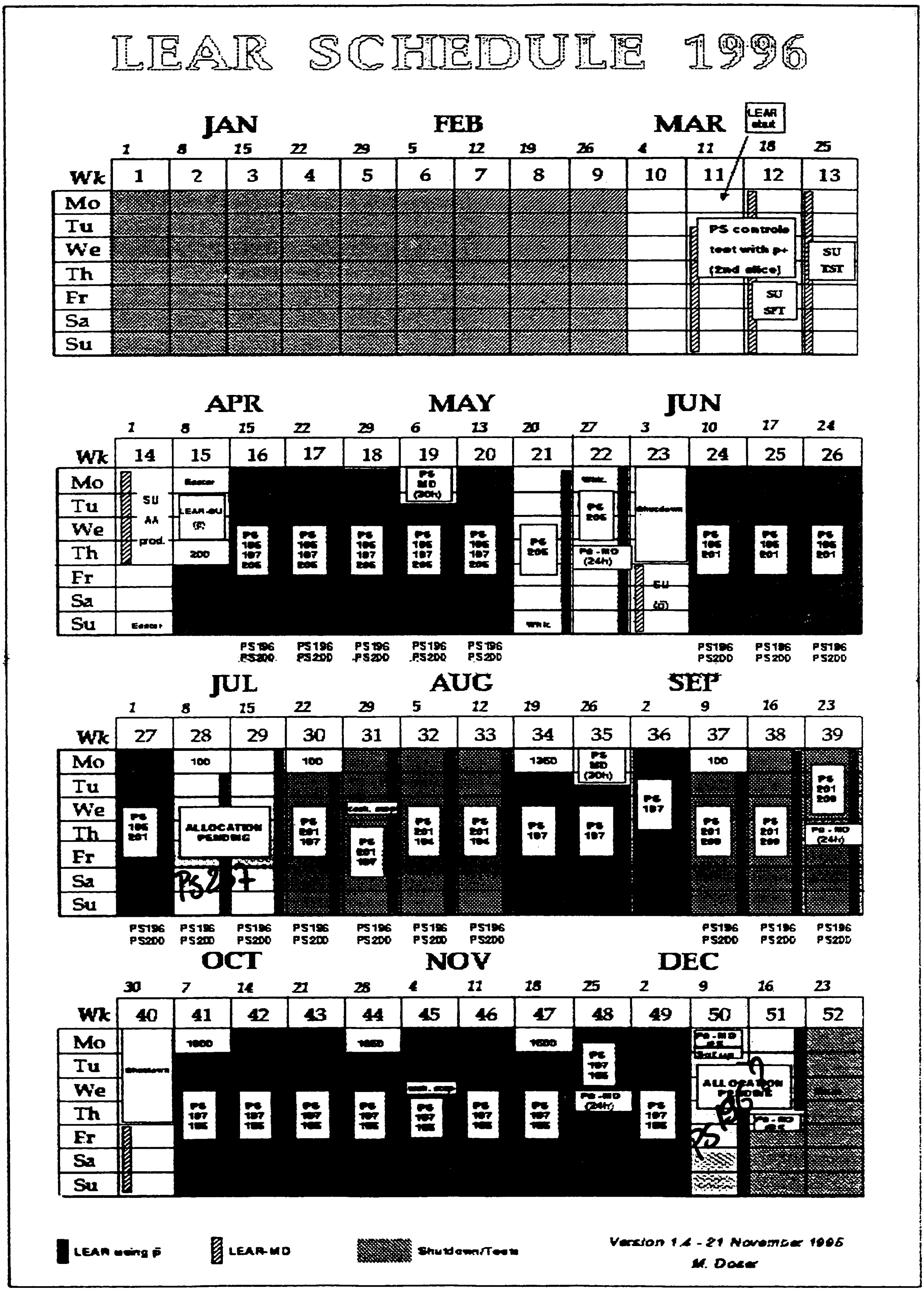
- $\overline{H_0}$



for physic. (oh yes!)

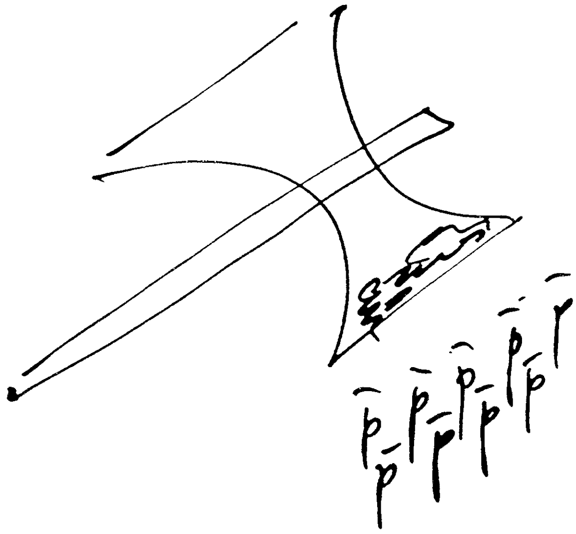


LEAR SCHEDULE 1995
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Wk
Mo
Tu
We
Th
Fr
Sa
Su
S.U. of Linac, LPI, PS, LEAR
MD (p)
LEAR-SU
Shutdown
S.U.
DASH
LEAR-MD
Shutdown/Tests
LEAR using p
Version 1.2 - 11 November 1994
M. Doser


LEAR SCHEDULE 1996
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Wk
Mo
Tu
We
Th
Fr
Sa
Su
LEAR start
PS controls test with p+ (2nd slice)
SU SFT
SU TST
SU AA prod.
Easter
LEAR-MD
200
PS MD (30h)
Shutdown
PS-MD (24h)
ALLOCATION PENDING
100
1350
1600
PS196 PS200
LEAR using p̄
LEAR-MD
Shutdown/Tests
Version 1.4 - 21 November 1995
M. Doser

1996

1- Motivation. malgré



to maintain high performances

2 _ beg. year MD ions
_ Prepare 1997 ions M.D.

LEAR.

- finish year, p̄ story.

by am

END STORY FEST.

Boss - budget !

PS Performance Day 1996

PS summary

Roberto CAPPI

PS summary - R.Cappi

1996 PS MD forecasts

LHC beam

- 26 GeV/c optics (PS & TT10)
- Transverse & Long. instabilities during acceleration without...and with 40Mhz cavity
- Debunching at 26 GeV/c
- W.P. and resonance compensation at low energy
- PSB-PS matching
- HE orbit investigations
- Various "calibrated" beams for common PS-SPS studies

Others

- ABS: inj. and orbit optimisation
- FE61 (& SE61) with calibrated intensities for TARC
- SFT beam optimisation (eventually making use of the new TT2WB pu's)
- Long. & transv. "echo" phenomena

RC/PPD95/2.02.95

PS Beams in 1995

16.02.96

user	part.	cp [GeV]	I_b [part./p]	k_b	ε^*_x [μm]	ε^*_y [μm]	ε_l [eVs]	dp/p [10^{-3}]	t_b [ns]	peculiarities	problems
SFT	p	14	2.5 10^{13}	420	11	7	0.1	1	5	5t.CT, very high Ip, ad.deb., h=420 recapt.	coll.effects., lossy extraction
SPP/SPN	e+e-	3.5	10^{11}	4 or 8	0.05 x βγ	0.01 x βγ	0.01	1 (1σ)	1.1 (1σ)	h=8+240, J_B var. (Rob.wiggler)	trapped. ions, TMCI
AA	p	26	1.6 10^{13}	5	13	9	2	2.5	20	funn./merg. h=20,10, 12, ...20, b. compress.	coll.effects.,lossy inj., large ε_v
TST	p	3.5	2 10^{10}	1	4	1.5	0.5	1.3	70	h=20,6	
LEAR	pbars	0.6	10^{10}	1	2	2	.2	2.4	160	decel. to low energy, h=10	A_l lim., transf.eff. 80%
PHY	p	24	3 10^{10}	deb.	3	2		1-3	(0.4s)	ES in int.pos.	
Pb IONS	Pb53+	5.1	1.6$10^{8}$	20	1.4	1	0.03	0.23	17	b. stretching, stripped to 82+in TT2	30% vacuum losses
MD beams											
MD/ionsim	p	13	2 10^{10}	20	4	1	.013	.2	3.5	bunch rotation	
MD/ionsim	p	20	10^{12}	20	4	4	0.5	0.6	25		
MD/spsμw	p	26	.1-1 10^{12}	20	4	4	.03-3	.3-2.6	2-14	w or w/o b. rot., low ε_l	
MD/spsμw	p	14	1 10^{12}	20	4	4	.15	.66	10	w or w/o b. rot., low ε_l	
MD/lhcdam	p	26	10^{12}	20	4	4	0.5	0.3	35	low dp/p	
MD/FE61e+	e+	3.5	10^{11}	4 or 8	0.05 x βγ	0.01 x βγ	0.01	1 (1σ)	1.1 (1σ)	h=8+240, J_B var. (Rob.wiggler)	

NB: $\varepsilon^* = \beta\gamma\,\sigma^2 / \beta_c$

For ion beams: cp[GeV/u] and ε_l [eVs/u]

PROBLEMS IN PS PERFORMANCE ('94)

Integrated performance

☞no daily follow up of the main beam parameters

☞one techn. supervisor is not enough

Peak performance (MD's)

☞2.5 consoles are not enough (interference)

☞no archiving (yet)

Instrumentation

☞ meas. targets are still not in an operational status while WS software needs improvements

PROBLEMS IN PS PERFORMANCE ('95)

Integrated performance

☞no daily follow up of the main beam parameters

☞one techn. supervisor is not enough

Peak performance (MD's)

☞2.5 consoles are not enough (interference)

☞SOS in a very poor status

☞no archiving (yet)

Instrumentation

☞essential instruments are not in an operational status (e.g. meas. targets, WS, ..)

RC/PPD96/16.02.96

a last remark

With the SPS //MD cycle we are entering in a new phase of operation:

one more user
many more and “difficult” beams

this demands good

coordination,
communication,
flexibility,
collaboration

PS Performance Day 1996

Conclusions

Daniel SIMON

OPERATION : FIRST PRIORITY!

A good start-up is vital (see 1995).

"First priorities in 1996"

⟶ Protons for SPS (neutrino experiments :
⟶ end 1997 - 2 years only)

CHALLENGE : run as good as 1995 !

	1993	1994	1995
Fault rate	10,6%	12%	7.5%

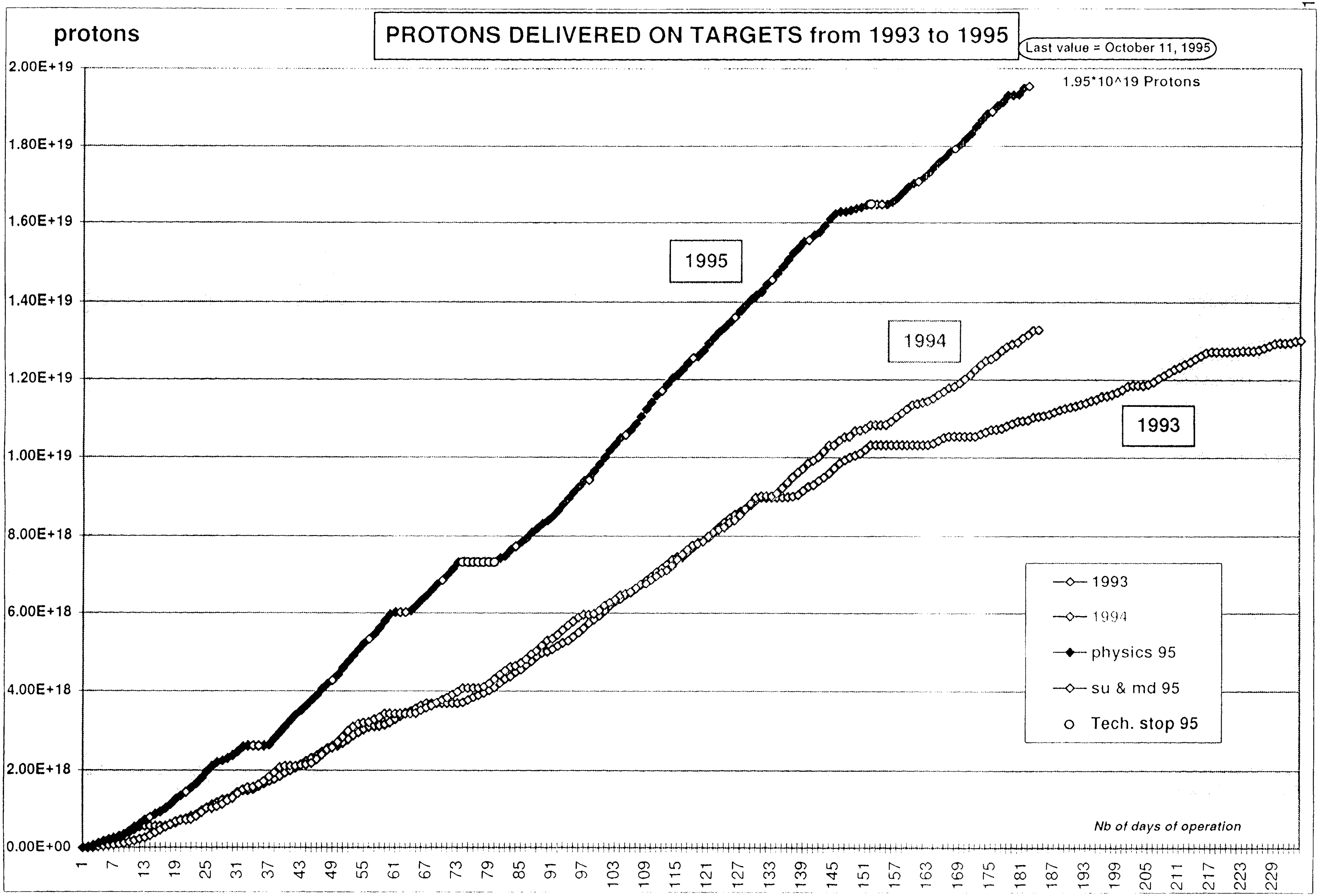
⟶ Antiprotons in LEAR (last year/5500 hours)

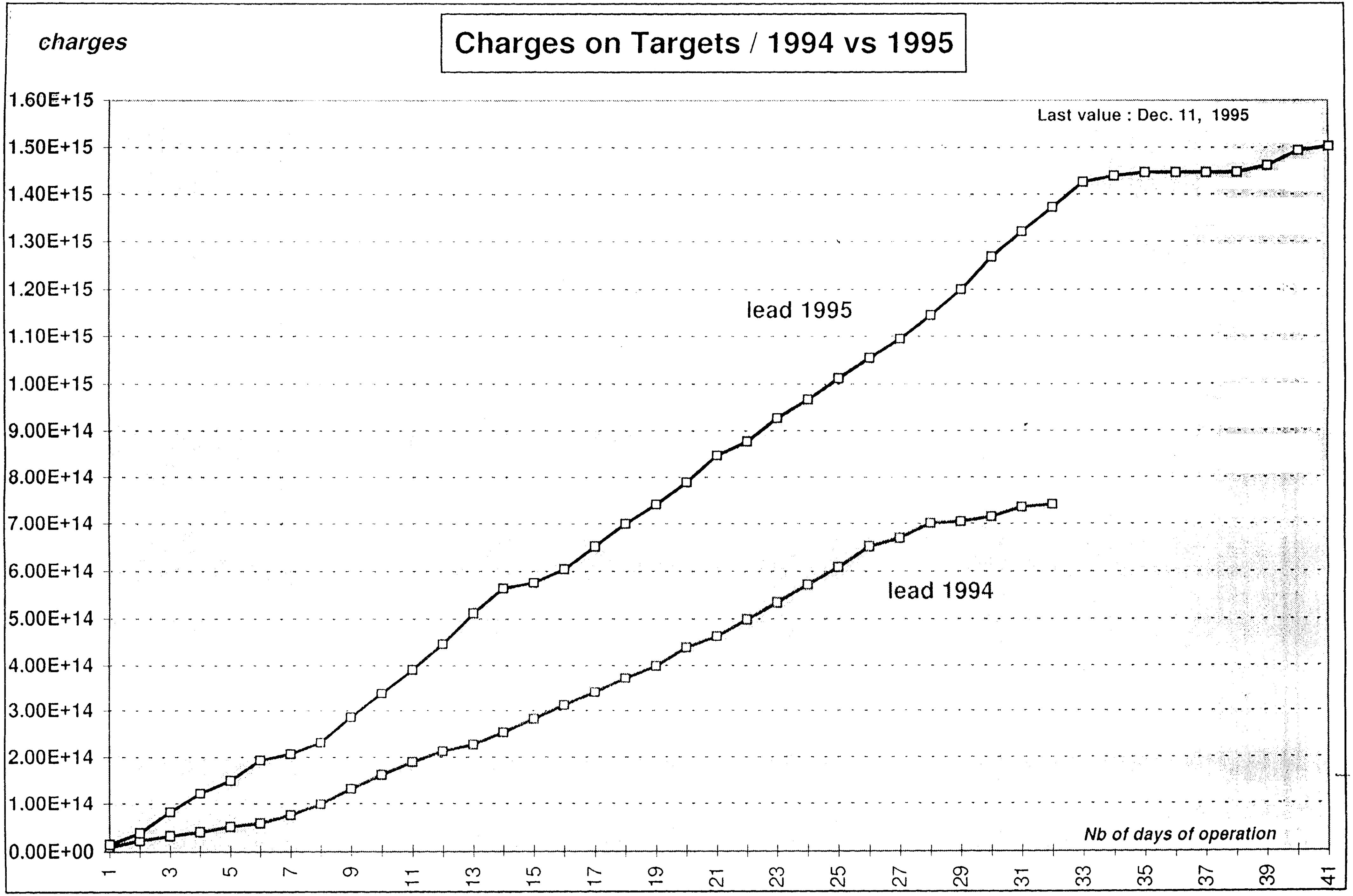
	1993	1994	1995
Fault rate	16,7%	12.7%	13%

"High priorities"

... all other beams !

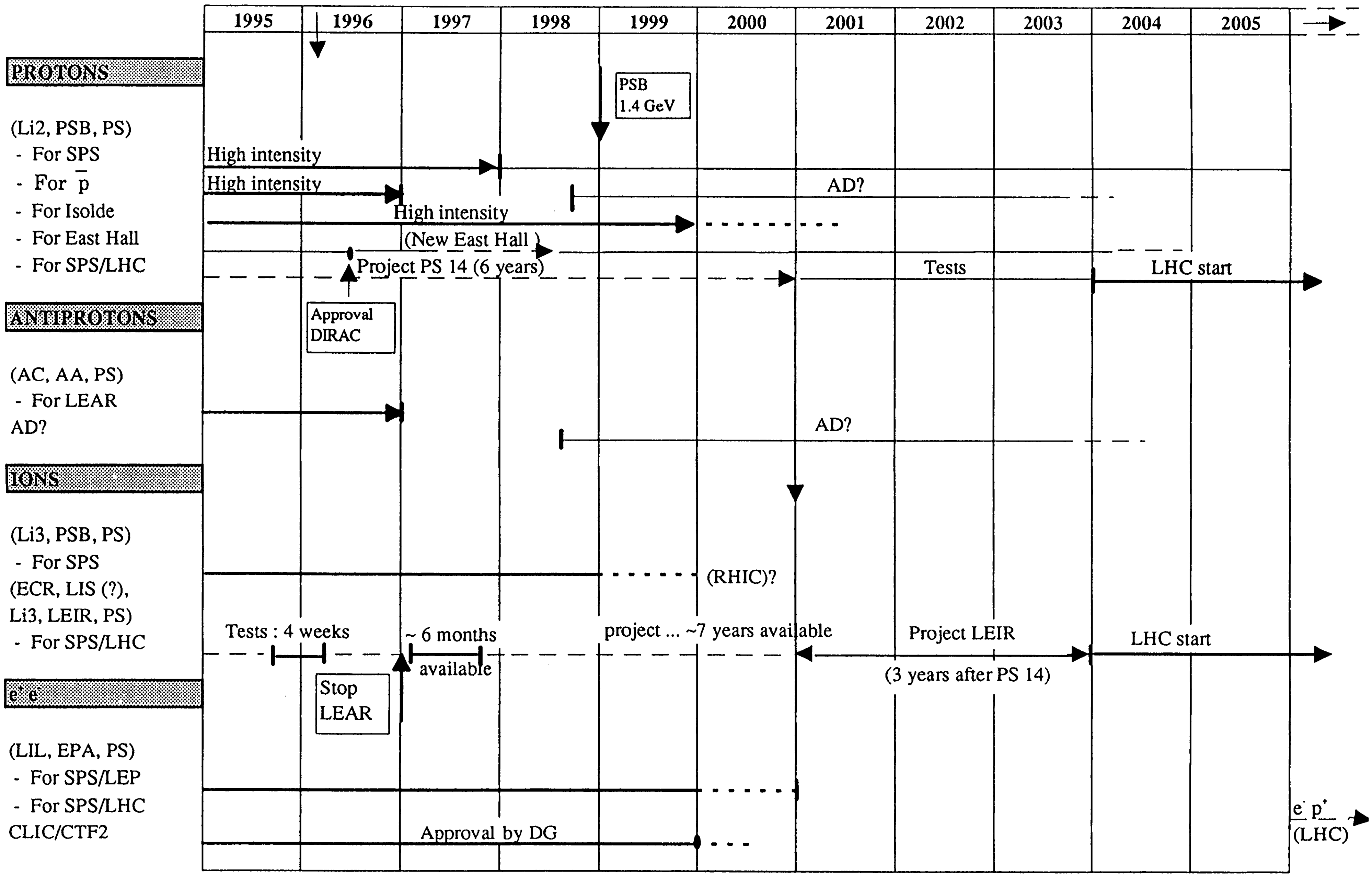
... and do not forget : tests (important) in LEAR (p^+, Pb^{54+}) before Easter.


protons
PROTONS DELIVERED ON TARGETS from 1993 to 1995
Last value = October 11, 1995
1.95*10^19 Protons
2.00E+19
1.80E+19
1.60E+19
1.40E+19
1.20E+19
1.00E+19
8.00E+18
6.00E+18
4.00E+18
2.00E+18
0.00E+00
1995
1994
1993
1993
1994
physics 95
su & md 95
Tech. stop 95
Nb of days of operation
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175 181 187 193 199 205 211 217 223 229



LEAD9495.XLC

MODEL FOR THE PS WORK PLAN (If AD, Antiproton Decelerator)



Participants:

ALLARDYCE Brian	PS
ARDUINI Gianluigi	SL
AUTIN Bruno	PS
AZZONI Guerino	PS
BOILLOT Jean	PS
BOUCHERON Jean	PS
BOUTHEON Marcel	PS
BRAUN Hans-Heinrich	PS
BRYANT Philip	PS
CAPPI Roberto	PS
CASPERS Friedhelm	PS
CHANEL Michel	PS
CHAPOCHNIKOVA Elena	SL
CHOHAN Vinod	PS
CLENDENIN James	PS
CORNELIS Karel	SL
CORSINI Roberto	PS
D'AMICO Tomaso	PS
DAEMS Gilbert	PS
DEKKERS Daniel	PS
DELAHAYE Jean-Pierre	PS
DUCAS Vincent	PS
DURIEU Luc	PS
ERIKSSON Tommy	PS
FAUGIER André	SL
FRAMMERY Bertrand	PS
GAROBY Roland	PS
GELATO Giovanni	PS
GIANNINI Roberto	PS
GIOVANNOZZI Massimo	PS
GRUBER Jacques	PS
GUIGNARD Gilbert	SL
HANCOCK Steven	PS
HASEROTH Helmut	PS
HEMERY Jean-Yves	PS
HILL Charles	PS
HUBNER Kurt	AC
JENSEN Erk	PS
KISSLER Karl-Heinz	SL
KOZIOL Heribert	PS
KUGLER Hartmut	PS
LEY Rudolf	PS
LINDROOS Mats	PS
LINNECAR Trevor	SL
LOMBARDI Alessandra	PS
MANGLUNKI Django	PS
MARTINI Michel	PS
METRAL Gabriel	PS
METZGER Claude	PS
MOHL Dieter	PS
MULDER Hendrik	PS
O'NEIL Michael William	PS
PEDERSEN Flemming	PS
POTIER Jean-Pierre	PS
RIUNAUD Jean-Pierre	PS
SCHINDL Karlheinz	PS
SCHNEIDER Gerhard	PS
SIMON Daniel Jean	PS
SJOSTROM Mårten	PS
STEERENBERG Rende	PS
STEINBACH Charles	PS
TANKE Eugenius	PS
TRANQUILLE Gérard	PS
ULLRICH Hanns	PS
UMSTATTER Hans-Horst	PS
VRETENAR Maurizio	PS
WARNER David	PS
WILDNER Elena	PS
WILSON Ian	SL