BWA/cg

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3 February 1994

MINUTES OF PS TECHNICAL MEETING N°51
HELD ON 2th February 1994

Proton Injector Performance and Outlook

Present : *B.W. Allardyce, R. Barthelemy, J. Boucheron, M. Bouthéon, R. Cappi, G. Daems, J.P. Delahaye, R. Garoby, J. Gruber, H. Haseroth, C. Hill, I. Kamber, H. Koziol, S. Maury, F. Perriollat, W. Pirkl, U. Raich, J.-.P. Riunaud, K. Schindl, D.J. Simon, E. Tanke.*

CC: *Present + J. Boillot, K. Langbein, K.Hübner.*

A. Source and pre-acceleration

1. H. Haseroth gave a short historical introduction on RFQ's (annex 1), then C. Hill showed the statistics of fault rates observed (annex 2) during 1993 where sparking caused serious problems from April through to July. The various problems and their solutions were presented (annex 3). Extensive work on reconfiguring the earths, with invaluable assistance by I. Kamber, resulted in a dramatic reduction in the consequences of sparking. Work on the software (see later, U. Raich), on shielding of CAMAC supplies, and the installation of forced cooling in the cage further reduced the bad effects caused by sparks. There was excessive sparking in October which seems to have been due to earlier damage to the "expansion cap" of the source, and work is continuing on improving this region.

2. During the present shutdown the 80nF capacitor is being replaced by a 10nF one in order to reduced the stored energy, together with a "bouncer" to compensate for the energy taken by the beam. Cabling is being tidied up and certain connections (Lemo 00) are being eliminated. The intention is to replace old CAMAC ADC's by the new standard of CO group, but G. Daems warred that this is perhaps not a good idea since we have plenty of spares and it is not obvious the new ones would be less sensitive.

B RFQ2

3. M. Vretenar explained that the breakdown rate increases with rf level. Since the transmission of the RFQ can be improved by increased RF levels, the request of high intensity leads indirectly to larger sparking rates. Another effect not yet completely understood, leads to increased sparking for longer beam durations, i.e. for higher integrated beam currents. Although we have had 200 mA out of RFQ2B, the highest level is now slightly lower (193 mA for LHC test in December, but ~ 180 mA normally). The spark rate is about 2/hour usually, but there are "crisis periods" following which it takes up to 30 minutes to recover, followed by gradual increase of the r.f. level over several days (see annex 5).

4. The causes of the degradation from 200 mA are probably the pollution of the vacuum by the "oil-free" pumps which are not completely oil-free, and bombardment by ions or electrons originating in the source and linked to changes of focusing or steering. M Vretenar proposes several immediate actions such as to limit the harm (i.e. use high level rf only when strictly necessary), improve and monitor the vacuum conditions, (including gas analysis), endoscopic inspection, study beam position at RFQ entrance, develop a better RF conditioning program for the RFQ. J.P. Delahaye notes that the structure has such a high Kilpatrick value (~ 2.4) that excellent surface smoothness is needed, coupled with impeccable cleanliness.

C Controls

5. U. Raich explained the functioning of the linac 2 source equipment module (see annex 6) to show how the recent problems had arisen. The best approach is to read the values each cycle into the shared memory area outside the HV area so there is a systematic refreshing of data in the hardware exposed to the transients; however this requires careful handling at start-up when "reasonable" values must be given beforehand. CO group has also disabled the spike detection system wherely some supplies went into standby after a spark.

D Required performances

6. K. Schindl presented a table (annex 7) of wanted versus obtained values, where it can be seen that we have achieved the desired conditions. He also showed (annex 8) that the density of the beam now is higher than in the days of the Cockcroft-Walton pre-injector. No further development is needed for LHC type beams in 1994, but some work is needed on the high intensity beams (neutrino and Isolde)

7. The time profile of the beam at Booster entrance was also discussed. This is the well-known problem of the first 50μs of the beam pulse whose characteristics are unstable, which results in position movements at the entrance to the Booster. The origin of the problem seems to be the source and more study is required to minimise the phenomenon.

E. RFQ test stand

8. E. Tanke showed the test set-up (annex 9) and explained that its controls are being made identical with the new control system. The cabling is as close as possible to that on the linac 2 pre-injectors so as to simplify the search for weak points. Tests are under way with a proton source to investigate the expansion cup problems mentioned earlier, asymmetries, etc.

9. It was explained that RFQ2A is stored and is ready for installation as a replacement for RFQ2B should this be necessary. The unit will be kept under high vacuum with 3 ion pumps (without connection to any mechanical forepumps with their inherent risk of oil pollution). From time to time RF is applied in order to maintain the conditioning and to ascertain field symmetry. W. Pirkl believes there is no need to do tests with proton beam, and this was accepted.

10. The test set-up will soon receive RFQ1 in order for tests of the "folded dipole" mode (which simulates a 4-rod RFQ) with proton beam. These tests will be useful in conjunction with the new RFQ from Legnaro for Pb. Tests of BLVD will also be done. The fact that all these tests are done with RFQI means that we run no risk of damaging RFW2A.

11. Finally W. Pirkl mentioned possible alignment problems in front of linac 2 as a reason for the slightly lower beam current. A way of making changes to the alignment without affecting normal operation is under study.

B.W. Allardyce

The complete set of transparencies is available with B.W.A. for anyone who would like to have a copy.

ANNEX 1

Short History: Installations, Start-up, Problemes of Run 2 and 3

Invention of RFQ by Kapchinsky in 1970.

Proof of Principle and presentation by Los Alamos at the 1980 Acc. Conf.

Originally: "Cheap replacement" of Cockcroft Walton (Sames) in Linac 1.
Design and fabrication of RFQ1 (in collab. with LANL), installation in Linac1 (1984).

(necessary for pulling back Linac1 and hence for the oxygen and sulfur program)

Design and fabrication (in 1990) of RFQ2(a) and (in 1992, after oil pollution of version a) of RFQ2b and installation in 1993.

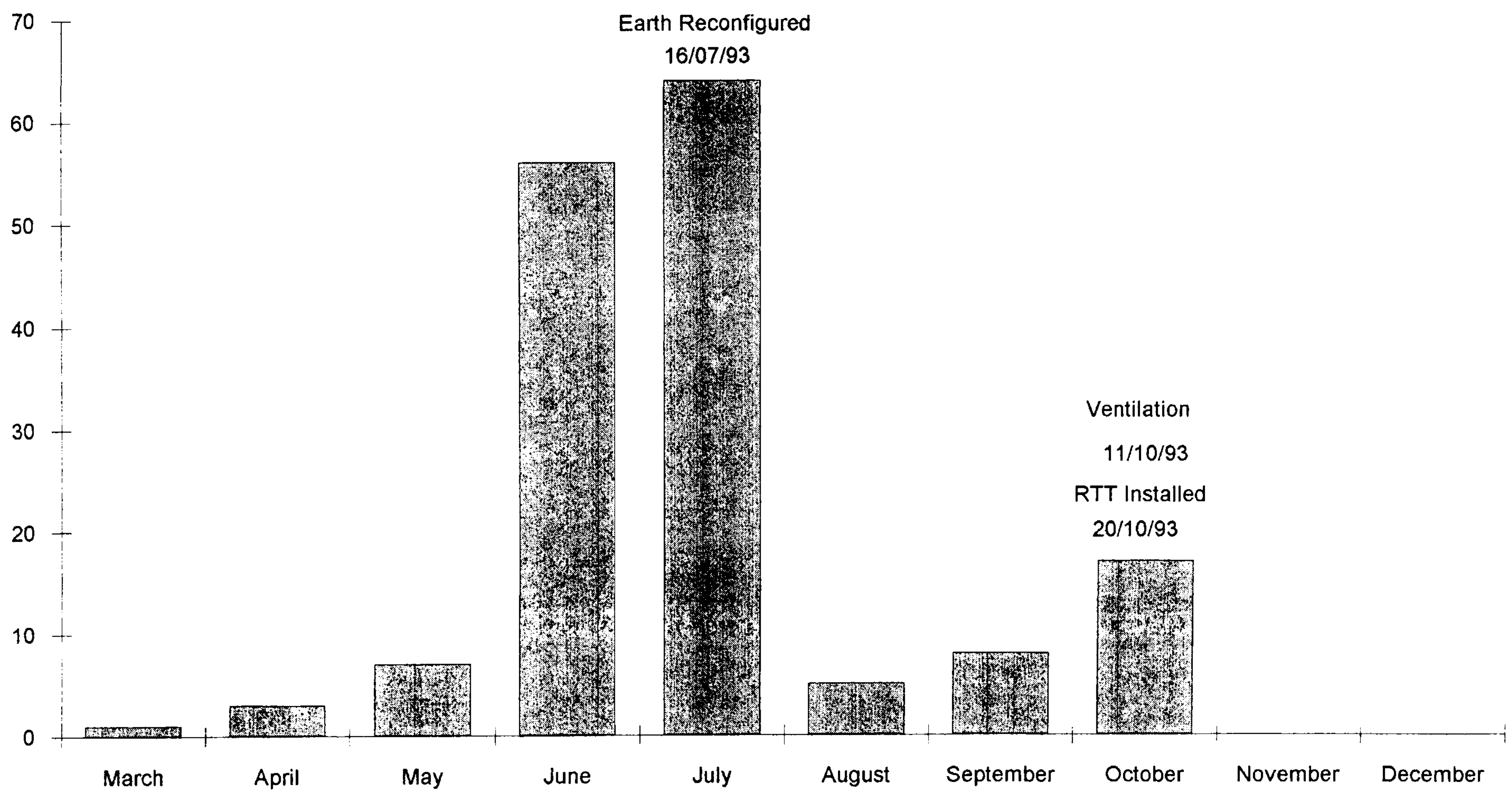
Originally intended as a cheap replacement of the 750 kV Cockcroft on Linac2, later intended to produce better beams for LHC.

H. HASEROTH

Annex 2

C. Hill

Pannes Attributable to HT Problems



ANNEX 3

HT problems in 1993 Linac2

Main parameters of HT system

HT 92kV, Focus potential-3kV, Acceleration gap 16.5mm. Maximum voltage seen by source extraction 95Kv, eqivalent to 58kV/cm (5.8Mv/m). Energy storage capacitor (100)80nF, equivalent to 400J.

Problems and solutions for 1993

1) Knock out of Magnetic bearing vacuum pumps (packed with μ-processors)
Fuses in the Solenoid power supplies

Repair electrostatic shielding mesh on cage doors (corona problems)
Multiple reconfigurations of masses and source of 380V for cage and HT system (including vacuum earth). No positive results until major reconfiguration of mass on the advice of Kamber.
Change of 220/220 120kV isolation transformer and addition of mains filter.

2) Knock out of source magnet and Camac power supplies.

Better ground connections at 100kV level.
Modified power supplies with slower protection circuits

3) Loss of source parameters after flashover

A problem which has existed for years on the 750kV system, and cured by the same method. Re-installation of the real time task to refresh source parameters.

4) Damage to ADC (Elliot/Fischer)

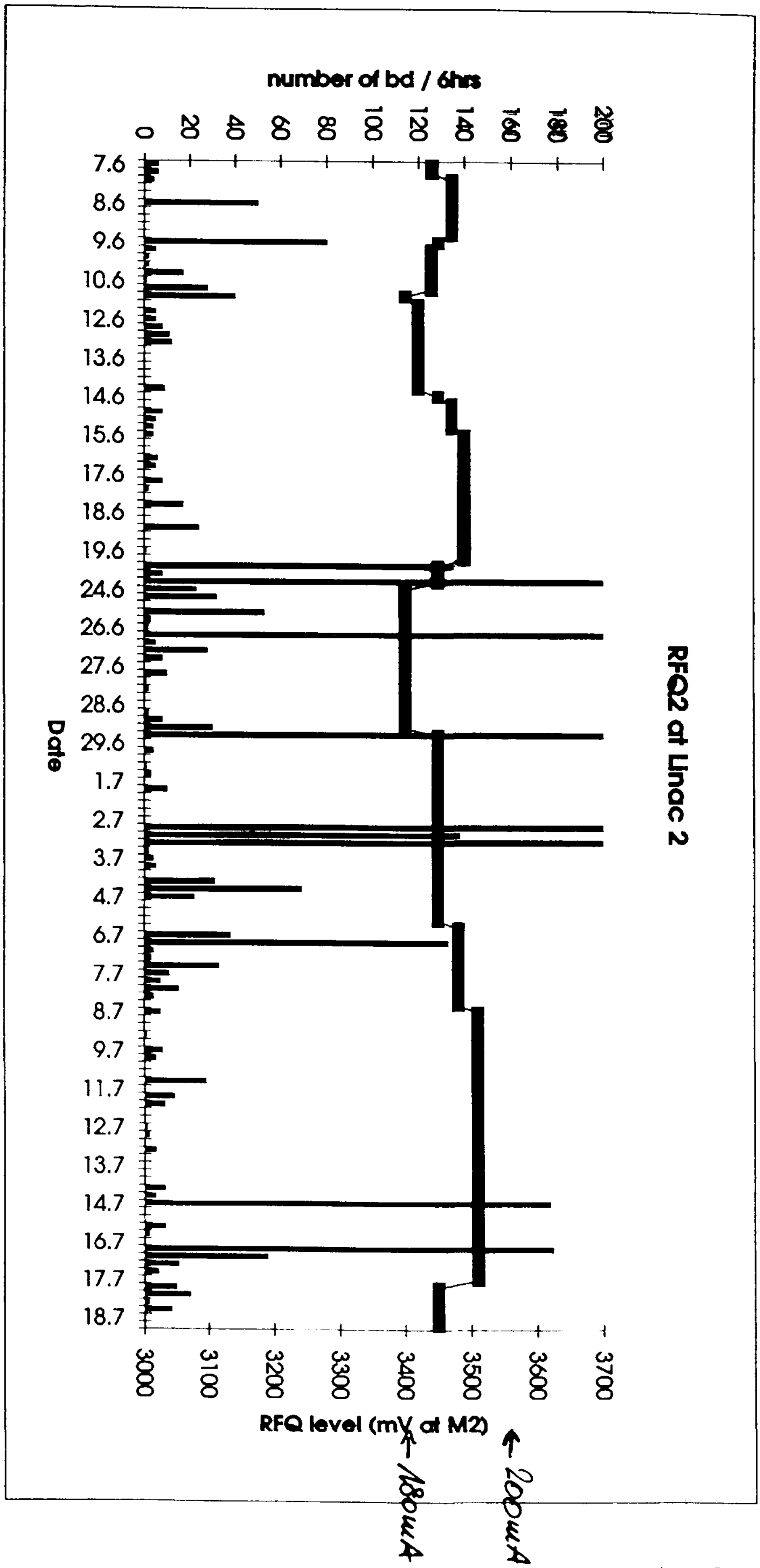
Extensive filtering of input cables
Add magnetic shielding below camac crate

5) Excessive sparking 8/9/93 (end of run 3)

Change expansion cup for repolished unit (mark on electrodes) and during stop new expansion cup and tapered focus installed.
Forced ventilation of cage 11/10/93

C. HILL

ANNEX 5

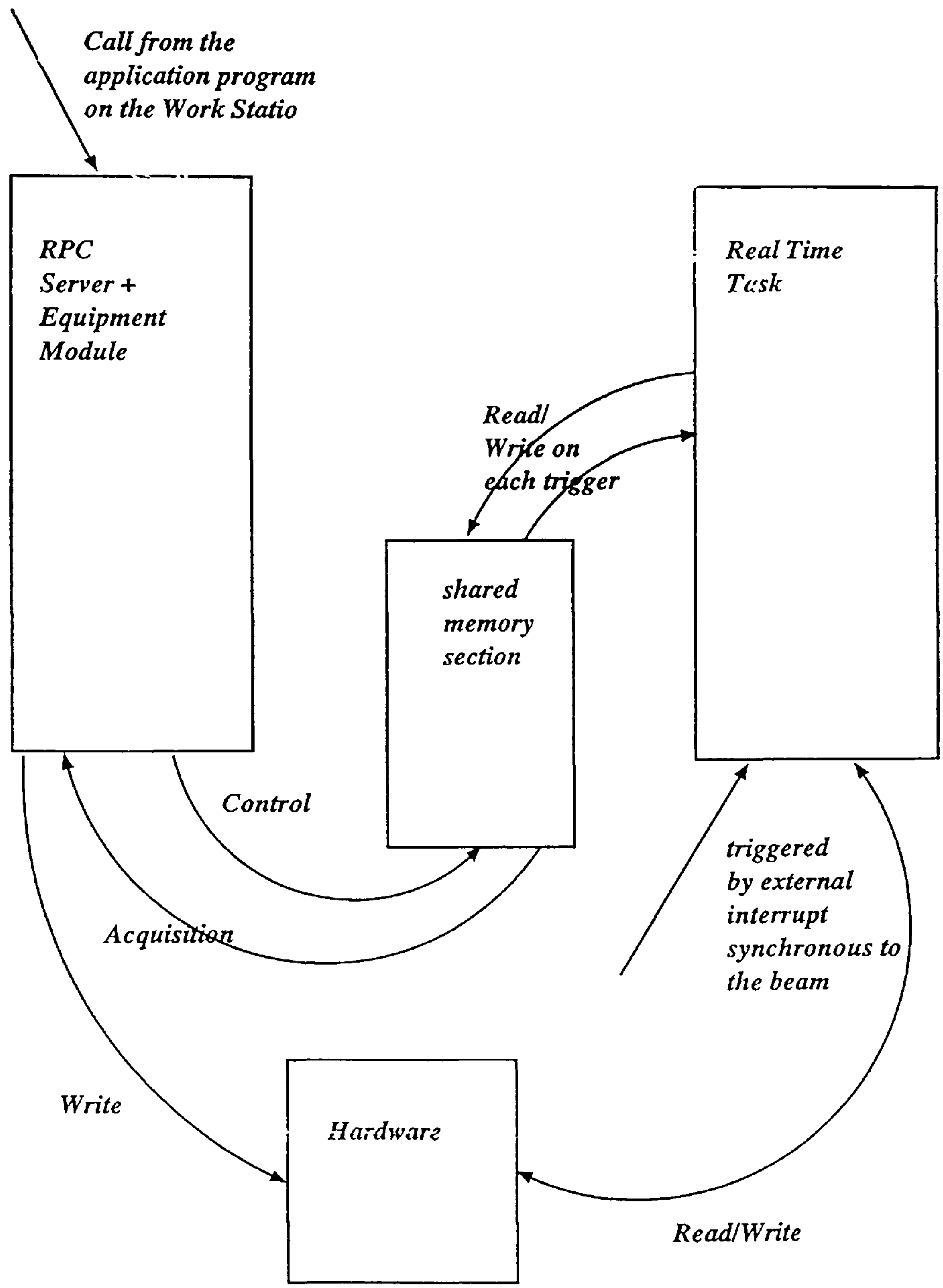


M. VRETENAR

U. RAICH

ANNEX 6

Linac 2 Source Equipment Module



U. RAICH

ANNEX 7

LINAC 2 PERFORMANCE: "CONTRACT" VS. REALITY

PARAMETER	SPS (ν), ISOLDE, AA WANTED	SPS (ν), ISOLDE, AA OBTAINED	LHC WANTED	LHC OBTAINED	
I [mA] LTB.TRA60	140	**[130]**	180	**[160]**	PSB ENTRY
ε_0 [π mm mrad]	9	≤ 9	7.5	7.5	BETTER THAN 1992 !
⇓ ε^*_{rms} $\left[=\frac{1}{4}(\beta\gamma)\varepsilon_0\right]$ [μm]	1.5	≤ 1.5	1.2	~1.2	BETTER THAN 1992 !
MISMATCH [SURFACE INCREASE, %]	<35	<35	<35	10–30	
USEFUL PULSE LENGTH [μs]	>100	>100	>20	25	
HOR. POSITION CHANGE DURING USEFUL PULSE [mm]	≤ 2	**[≥ 2]**	≤ 2	≤ 2	ON "WORST" PU
DISTRIB. EFFICIENCY $\frac{BITRA20}{BITRA10}$ [%]	>95	97	>95	97	92% IN 1992

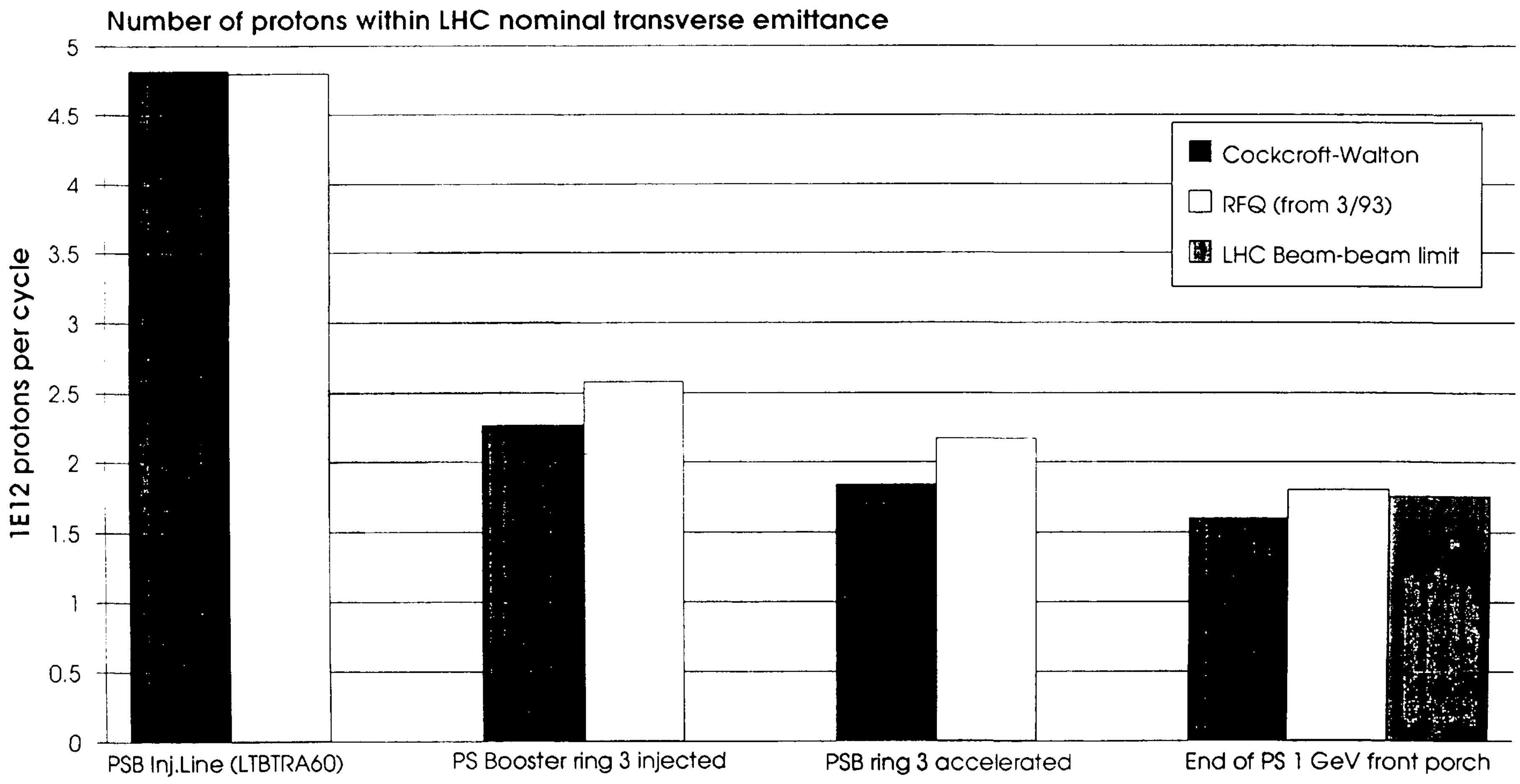
PPM WISHES: 130 mA * 100 μsec, ± 150 keV (op)
160 mA * 25 μsec, ± 250 keV (LHC)

[ ] INSUFFICIENT PERFORMANCE

KS 2/2/94

K. Schindl

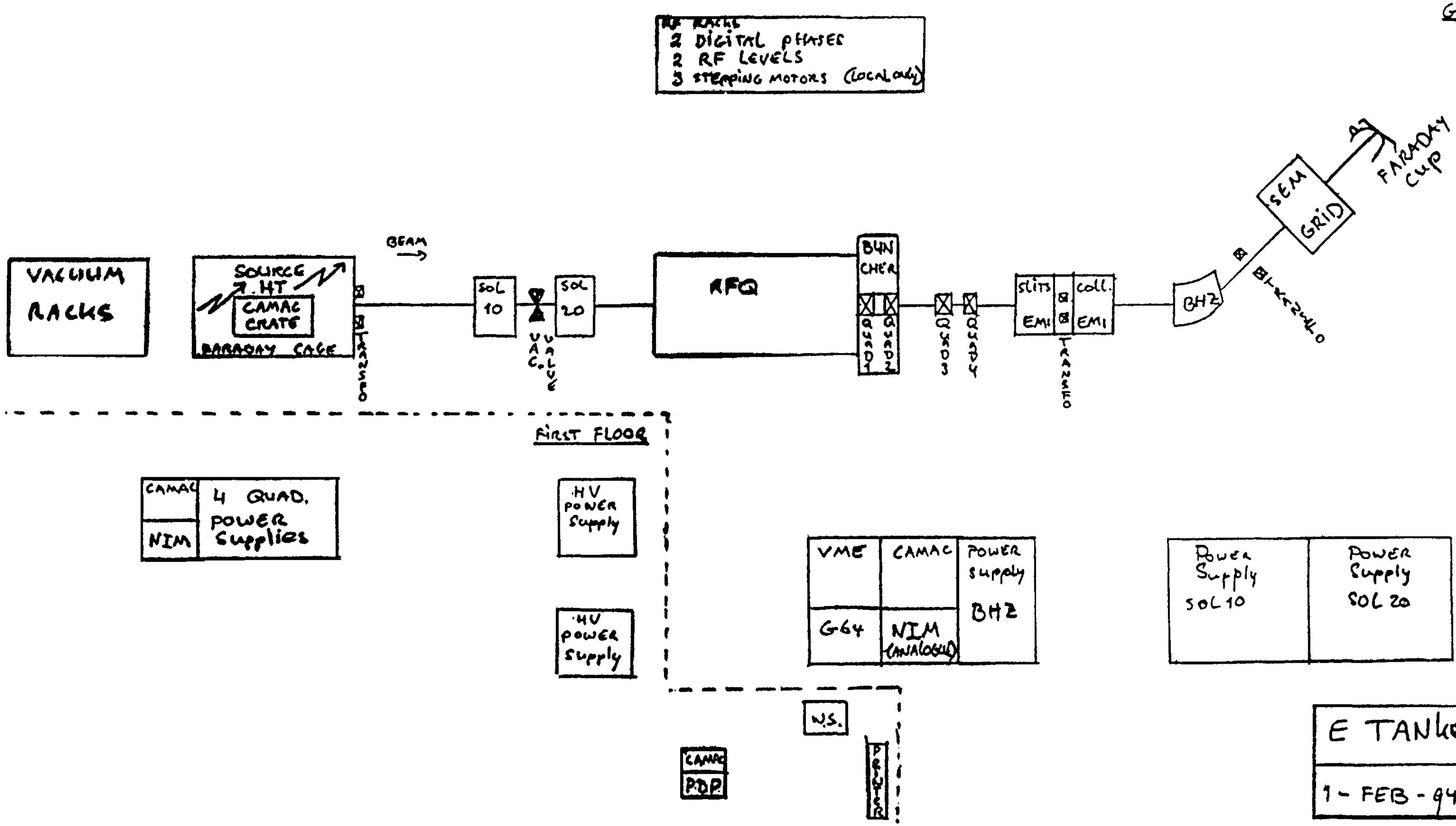
HIGH BRILLIANCE PROTON BEAM FOR THE LHC: IMPROVED WITH THE RFQ AS LINAC2 PRE-INJECTOR



K.SCHINDL

Annex 9

GROUND FLOOR



E TANKE	LAYOUT FO RFQ IN SOU
1 - FEB - 94	HALL EXTEN