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Wall Current Monitors for CTF3

Introduction

The CTF3 requires beam current measurements over a wide range of parameters. Moreover, monitors to measure field emitted current from 30 GHz structures are needed. To allow for good comparison of the signals in different parts of the machine and to simplify data acquisition it would be desirable to have a common type of current monitor all over the machine. Table 1 summarises beam current parameters at different locations of CTF 3.

	beam current (averaged over bunch spacing)	micro bunch repetition frequency	macro pulse length
drive beam gun	8 A	-	1540 ns
drive beam linac	3.5 A	1.5 or 3 GHz	1540 ns
drive beam at combiner ring extraction	35 A	15 GHz	140 ns
probe beam	1.5 A	1.5 GHz	0-33 ns
dark current from 30 GHz structures	0.001-10 mA	30 GHz	1-140ns

Table 1 Beam parameters at different locations in CTF3.

Modification of CTF II WCM design for CTF3

Here we discuss the use of a modified design of the CTF II drive beam wall current monitors (WCM) [1] for current measurements in CTF3. These WCM's have demonstrated in CTF II and in the photo-cathode laboratory good and reliable performance for a very wide range of currents (up to beam currents of more than 50 A averaged over one RF period). Figure 1 shows one of the WCM's installed in CTF II and figure 2 shows the signal of one of these WCM's as induced by a single microbunch. The rise and fall times are in this case probably dominated by the very long cable (≈100m) used to transport the signal to the control room, thus the performance would be even better with a remote controlled oscilloscope close to the monitor. The high frequency capability of these monitors allows to capture the temporal structure of a current pulse with the highest real time bandwidth available with modern oscilloscopes (≈4GHz). This permits for example to measure in detail the reaction of the beam to the fast phase switch of the sub harmonic bunching system in CTF3. However, a drawback of the present design is the relatively high value of the low frequency cut-off ν_L. Without modifications this would lead to a non acceptable droop of the signal during the pulse. This is in particular true for the drive beam linac, where the pulse length is longest. This frequency could be lowered by increasing the inductance of the WCM. A high inductance WCM has been built for the SPS with ν_L=22 kHz [2]. However, the total length of this WCM design is prohibitive for use in CTF 3. To avoid this kind of problem we consider a design with a ν_L of about 100 kHz and an active integrator to compensate for the still considerable signal droop.

The raw signal, before the integrator, expected from this WCM for a 1.54 μs long linac pulse is shown in figure 3. The increase of inductance could be achieved by combining ferrite's of microwave absorber type with ferrite's of high magnetic permeability, and a moderate increase of the device length (the present CTF II WCM's use only ferrite's of microwave absorber type). The active integrator would of course reduce the high frequency capability, however, either by switching or splitting of the signal the integrator could be bypassed for applications like the fast phase switch measurement.

Vacuum issues

An important feature is the capability to bake-out the monitor. This is because a large part of these monitors will have to be installed close to equipment which stringent vacuum requirements like the thermionic drive beam electron gun, the RF photo-injector of the probe beam, 30 GHz decelerating and accelerating structures, and 3 GHz accelerating structures. The present CTF II WCM design fulfils this requirement.

WCM's for dark current measurements in CTF II

On top of the CTF3 requirements it would be desirable to make within a short delay (<6 month) a set of 2 ultra high vacuum compatible wall current monitors for the measurement of dark current from the 30 GHz structures in CTF II. Since the development of a prototype for CTF 3 will not be possible within this delay we propose to make a slightly simplified copy of the CTF II drive beam WCM with only 4 feedthroughs instead of 8. This increases the sensitivity but also ν_L by a factor 2 and reduces the high frequency cut-off by the same amount. For the application foreseen this doesn't cause a problem.
The parameters of the existing WCM's and those proposed are summarised in table 2.

Number of WCM's needed

The number and tentative locations of WCM's are summarised in table 3.

Costs

The production cost of the WCM's is estimated from the CTF II monitors to be about 7 kSFr a piece. For those to be installed in and downstream of the combiner ring, special 50 Ω loads and attenuators have to be foreseen to withstand the high instantaneous currents. These elements are actually more expensive than the WCM itself. However, for two WCM's we can reuse CTF II equipment, therefore we will only need new equipment of this kind for another two WCM's. The total costs are estimated to be around 150 kSFr for CTF 3 and 14 kSFr for CTF II. The costs for data acquisition and cables are not included.

References

[1] Jacques Durand, T. Tardy, M.Wurgel, "A 10 GHz Wall Current Monitor," PS/LP/Note 95-09 (Tech)
[2] Jean-François Malo CERN/SL, private communication

	CTF II WCM	CTF II WCM for 30 GHz dark current	CTF3 WCM (tentative)
Type	A	B	C
impedance	4 Ω	8 Ω	4 Ω
low frequency limit ν_L	1.33 MHz	2.66 MHz	0.1 MHz
high frequency limit ν_H	10 GHz	5 GHz	10 GHz
number of feed-throughs	8	4	8
gap length	2 mm	2 mm	2 mm
beam aperture diameter	40 mm	40 mm	40 mm
length	108 mm	108 mm	<150 mm
flange type	DN63CF	DN63CF	DN63CF
max. temperature for bake-out	200^0 C	200^0 C	200^0 C

Table 2 Parameters of existing CTF II and proposed CTF 3 WCM's.

accelerator	WCM locations	type	status	number
CTF3 drive beam	gun/end of injector/end of linac/after delay loop/ before injection into combiner ring/ combiner ring/ after extraction from combiner ring/ before decelerating structures/before beam dump	C	needed for 2003	9
CTF3 probe beam	after RF gun/ after x before 30 GHz structures/2x after 30 GHz structures	C	needed for 2003	6
reserve		C		4
total				19
CTF II drive beam	after 3 GHz accelerator/after 30 GHz decelerator (existing)	A	exists	2
photo cath. lab.	after DC gun	A	exists	1
CTF II probe beam	1x before 30 GHz structure, 1x after 30 GHz structure	B	needed for 2001	2

Table 3 Number and distribution of WCM's.

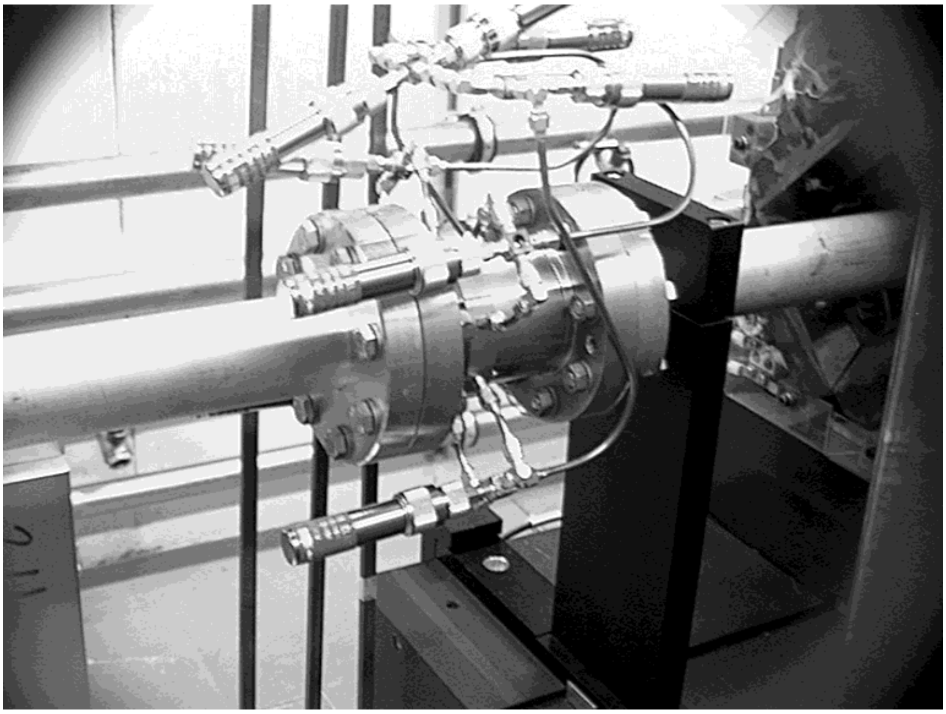

Figure 1 10 GHz WCM with signal combiner network in CTF II

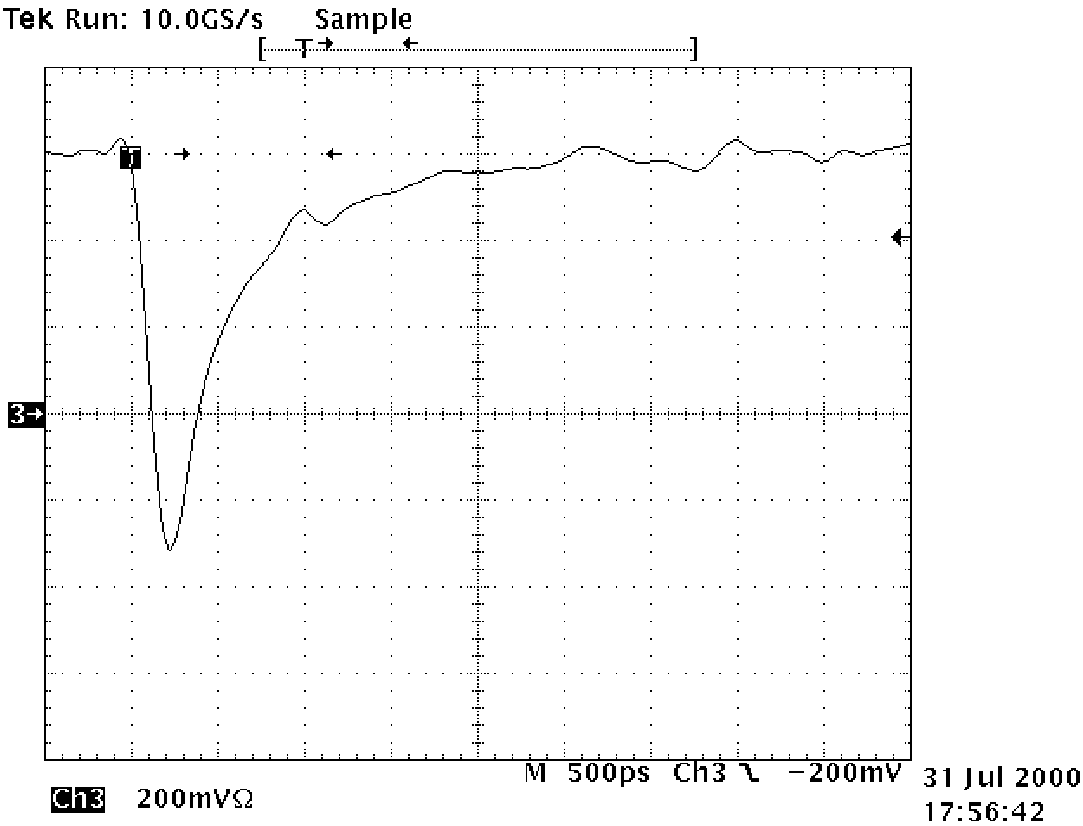

Figure 2. Control room signal from a CTF II drive beam WCM excited by a single bunch of 6.3 nC and 10 ps fwhm. The response is probably dominated by the approximately 100 m of cable between the WCM and the oscilloscope.

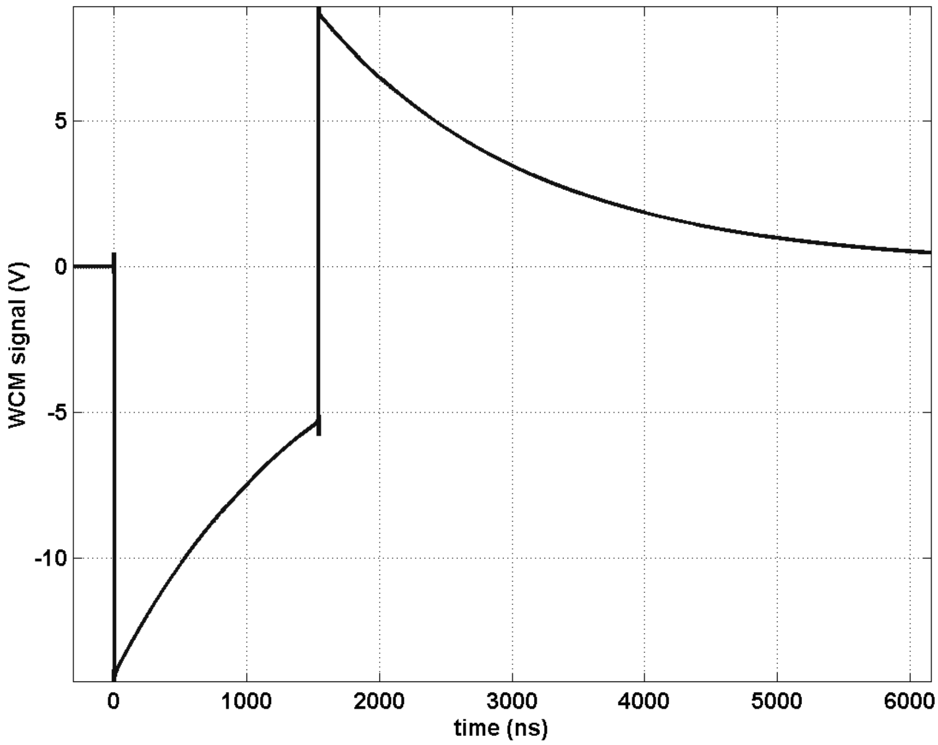

Figure 3. Expected raw signal (before active integrator) for C-type WCM in CTF3 drive beam linac running with nominal parameters.