Logbook For BBLR Wire Compensation Installation and Studies

August 16, 2002

INSTALLATION

1 Installation 24th July 2002

1.1 Alignment

1.2 Water Cooling Interlock

Difficulties were encountered with this interlock which is not sensitive enough and would always go on. To overcome this difficulty, the operation pressure was increased from 7 to 11 bar to enhance the water flow. The present value are:

- water pressure at inlet: 11 bar (as a reminder, the service pressure in the thin Cu tube is 40 bar and the max. pressure 60 bar, i.e. a large safety margin is respected)
- water pressure at outlet: 4 bar
- pressure drop: 7 bar
- calculated temperature increase at 300 A: 21 degrees
- calculated water flow: 0.65 l/mn

As a result of this increased pressure drop, the safety valve and the pressure adjustment system become unnecessary and were removed. After successful operation of the cooling circuit and check that there are no beam losses either on the BBLR or on the protection collimator, it was decided to LEAVE THE COOLING ON PERMANENTLY. This has the further advantage of protecting the BBLR against heating if ever a situation of heating arises.

1.3 Water Temperature

The water temperature is continuously monitored at the exit of the BBLR. In the absence of beam and excitation, the observed temperature is about 23 degrees (to be verified with Jacky).

1.4 Check of Interlocks

The whole interlock chain was checked in two steps:

- Passive: the PC cannot be switched on if the water flow is not established.
- Active: the PC, switched on at zero current, trips if the water flow stops or if the exit water temperature (heated by a foehn in the tunnel) exceeds 66 degrees.

After these tests, the interlock chain was deemed to be operational and the whole system safe for operation.

1.5 Check of the Beam Losses

The BBLR is in the shadow of the TIDV (far away) and of the MB vacuum chamber which efficiently close the phase space. Losses on the BBLR would only occur in case of a large local misalignment (more than 2 mm). To further increase the confidence level in the protection, the vertical collimator BRCV51699, a quarter of a cell upstream of the BBLR, is left PERMANENTLY at -25 mm, about 1 mm deeper than the BBLR.

When the SPS beam for physics was established, we observed no losses on the machine BLM's in the section 517 or nearby, even in the event of non negligible injection losses.

1.6 Conclusion after Installation

At this stage, the BBLR was demonstrated not to interfere with normal operation and no further testing is required besides following up possible beam losses in 517 that would be detected during operations. Further testing of the aperture may however be required to carry out the experiments in a well controlled fashion.

The following tests are still required to declare the BBLR operational for MD studies:

- Tuning and excitation of the power supply; measurement of the ripple.
- Check of the BBLR BPM.
- Check of the BBLR BLM.

HARDWARE CHECKS ALREADY CARRIED OUT

2 Tuning of the Power Supply, 9/8/2002, parasitic

This test, carried out by M. Royer, revealed the following:

- we realized that the coil, anticipated to reach 200 mHenry, had actually be measured to only 4 mHenry. The expected ripple would reach 0.005%. This is large but does not prevent first experiments.
- the inductance actually seen by the power supply was even lower, due to the saturation of the magnetic material by the nominal dc component of the excitation current. This makes the coil unsuitable for the experiment. The coil was thus moved to the lab for modification (creation of a gap).
- in the course of this study, the power supply was excited up to 40 A without any consequence for the physics beam nor on the wire outlet temperature.
- the cable needed to connect the PC to the MUGEV is missing. The can only be controlled locally. If needed, a temporary cable can be installed.

  15th August/M Royer: a cable now connects the power supply to the MUGEV. Testing is necessary to ensure that all is OK
- the beam signal picked up by the wire perturbed the power supply interlock loops. J. Camas noted as well that the reading of the temperature disappears at each beam passage, in spite of the 10 nF capacitor (calculated with L. Vos) installed between the wire and the ground (support). M. Royer added a 10 μF capacitor on the PC side and all perturbations disappeared, including those to the temperature measurement device.

The conclusion of this test is that the coil need to be modified to reach a minimum inductance compatible with our experiment, at least 4 mH in year 2002. If the coil cannot be modified satisfactorily, M. Royer offers to lend us a 25 mH coil temporarily. It weights more than 1000 kg, i.e. requires organization for the relocation, the rigidity of the floor in BA5,... I propose not to use this option for the first MD.

3 Check of the BBLR BLM's

This test was carried out by G. Ferioli. The BBLR is equipped with a DOUBLE BLM incorporating a standard ionization chamber and a photomultiplier for increased sensitivity. Their signals were checked OK. The Bloss does not detect any significant counting. The PMT shows counting in the kHz range. LSS5 is luckily equipped with 4 such double BLM's, two upstream of the BBLR (51459 and 51699) and one downstream (51931/2). The rate at the BBLR PMT is equivalent or lower that the rates recorded upstream or downstream, showing no specific losses on the BBLR.

The software for the PMT's is specific and accessible from the control room:

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Operation->New pgms->SPS collimator monitors
Verify that the extraction is done in BA5, otherwise
File->Extraction... select BA5
The sampling interval of 44 means 1 ms.
The loss is observed over 11 sec from the start event which needs to
be shifted by 7000 to observe P2.
To save a measurement:
File-> Save acquisition
Auto: acquisiation at each cycle, otherwise on request
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The software for the Bloss is only meant for use by the expert. GianFranco will ask Lars on his return whether the Bloss cannot be incorporated in the standard OP software.

4 Check of the BBLR BPM 14,15/8/2002, parasitic

These tests were carried out by C. Boccard, R. Jones,... This new BPM looks perfectly OK when it is calibrated. However, when it measures beam, it seems to show a large offset. After analysis, the data are consistent with a perturbation of the beam signal by the metallic support of the wire. The observed offset is larger than 10 mm. This leaves the impression that the linearity may as well be significantly perturbed. Rhodri proposes that e-m calculations be done to identify the transfer function and to carry out measurements during the AC dipole MD.

CHECKS TO BE CARRIED OUT

5 Check of the orbit bumps at the BBLR

We anticipate the use of a superposition of a π-bump, sufficient at 26 GeV, a 3π-bump and even a 5π-bump at higher energies. The bumpers and their excitations for the SPS optics 2001 are listed in the table:

Bump	Correctors	kicks (μrad)
π-bump	MDV.51507	14.43255
	MDV.51707	-0.7557320
	MDV.51907	14.42629
3π-bump	MDV.51107	-14.63510
	MDV.51707	-2.173442
	MDV.52307	-14.63124
5π-bump	MDV.50707	14.87106
	MDV.51707	-3.619378
	MDV.52707	14.87002

Table 1: Vertical bumps for use in the BBLR experiment. The kicks are calculated for a +1 mm displacements in the middle of the BBLR

16 August, 4:27 am J. Wenninger: ... has just implemented the capability of superposition of 1, 3 and 5 πbumps and checked that the table 1 is still valid for the SPS optics 2002.

6 Check of Aperture and Alignment

TO BE REWORKED: The aim is to verify that the wire is indeed in the shadow of the aperture limits with a beam which does not risk to damage it. Several weeks of observation showed no losses on the BBLR, consistent with expectations. This check will therefore be done more for the excat understanding of the aperture at 55 GeV....

26 GeV, beam intensity of the order of one LHC bunch or a bit more (the safety margin should be large).

Make successively two vertical kicks and increase their amplitude until the aperture is reached as shown by the loss monitors. Verify that the loss monitor at the BBLR does not react.

7 Check of the BPM

7.1 Measurement of the offset

This will require iterations. First interpolate the beam position from the near-by BPM's and evaluate the offset. A more accurate measurement will be done by measuring the kick due to the wire later on.

7.2 Measurement of the transfer function

Move the beam with the bump and record the readings.

8 ‘Calibration’ of the Losses

TO BE REWORKED

This experiment shall be made in a MD period, using a single LHC bunch or a few of them (max intensity to be checked with Bernard Jeanneret). The aim is to get a feeling for the losses as recorded by the BLM.

Measure emittance and beam position at the BBLR. Using a closed bump, move the beam closer to the wire and record losses versus position. Stop at 4 sigma from the wire.

BBLR EXPERIMENTAL PROGRAMME

9 MD 1 22/08/2002 8:00 to 14:00

The aim of this MD is to check the basic toolkit, learn how to handle the closed orbit and get a first feeling on the strength of the BBLR perturbation on the beam.

9.1 Beam and Machine Conditions

- Beam intensity: to minimize any risk, we start with only 12 bunches of the LHC type (easy to get/ GianLuigi)
- Beam energy: for the same reason, we will let the beam coast at 26 GeV/c. We have no choice anyway since we have to use the cycle P2 of duration about 4 s.

9.2 Experiment the Basic Toolkit

- M. Royer: adjust the BBLR power supply to its load (the inductive coil will have been installed only Monday evening). Check that the power supply can be controlled from the control room thru the MUGEV. If the current increases above 16A (5A/mm2), the water temperature in BA5 should be watched.
- increase the current in the BBLR in steps of 10% and verify that the cooling is effective.
- Define the excitation strategy of the wire in the P2 cycle and check it works: some time for the wire scan; then the wire should go to xx Amps in yy ms. then coast for zz s. then wire back to zero?
- start a repetitive monitoring of the machine losses.
- start a repetitive measurement of the beam lifetime.
- start the monitoring of the PMT’s in BA5 in automatic mode
- start the monitoring of the Bloss at the BBLR if not included in the machine losses by Lars.
- start the repetitive measurement of the beam position with the BBLR BPM. If Christian is around, a calibration without beam would be valuable to give the zero of the system.
- ensure someone is in BA5 to locally monitor the cooling water temperature.

9.3 Set-up

- Carry out the usual set-up necessary to obtain a clean machine with a long beam lifetime, whatever this means. At this stage, any working point is acceptable. This wont eventually be true.
- Correct the closed orbit around the BBLR’s with the following goals:
    1. move the orbit to the zero of the BBLR BPM, whatever the zero is. Ensure with the near-by vertical BPM’s that all the positions are consistent. minimize any oscillation in this area.
    2. . Unload as much as possible the following vertical orbit correctors, which will be needed for other purposes: MDV.51707, MDV.51507, MDV.51907 at 26 GeV/c. For higher energies, consult the table for 3 pi and 5 pi bumps.

9.4 Handling of the dipole kick due to the BBLR

(–> for me: please rewrite the scaling laws to make it clean in the other note!!!)

The closed orbit distortion, directly expressed in mm's is the only quantity of the beam dynamics which scales with energy in the usual way. This means that the orbit perturbation by the BBLR at the SPS energies will be very large as compared to the LHC situation. This requires a compensation. We will try using the machine correctors and investigate whether such a correction can be done easily and somehow later automated. If this is not the case, we must plan the installation of an additional orbit corrector at the azimuth of the BBLR. By the same token, we verify that the BBLR indeed works and perturbs the closed orbit. If we believe the current and active length of the BBLR, we can derive the distance between the beam and the BBLR from the closed orbit perturbation.

The kick given by the BBLR excited by a current of 267 A is given in figure 1 versus beam separation and energy.

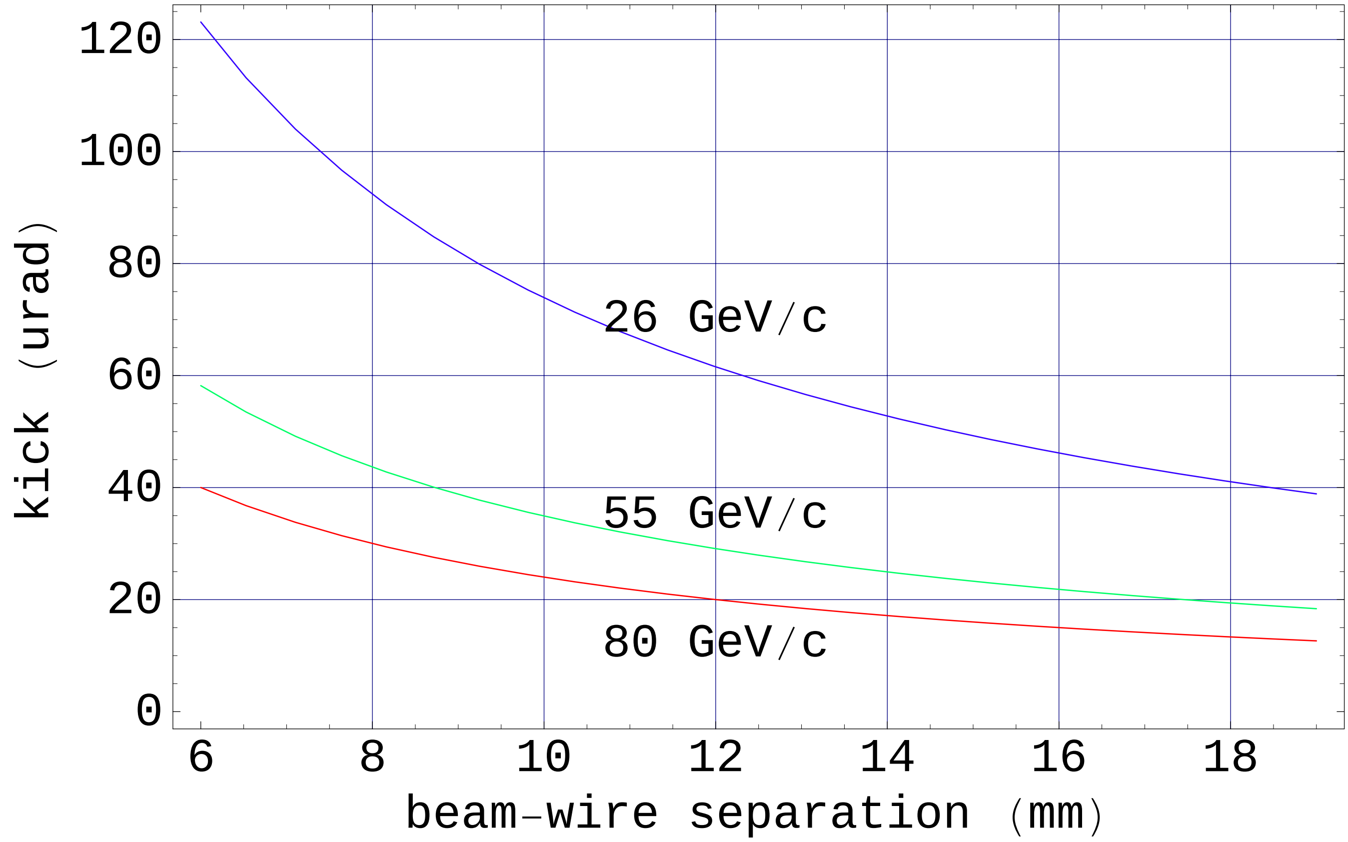

Figure 1: Kick by the BBLR at nominal excitation

The resulting perturbation of the closed orbit is given in table 2.

Kick μrad	y_{peak} mm	y_{rms} mm	y_{BBLR} mm
+ 15	0.56	0.29	-0.1
+ 40	1.50	0.77	-0.26
+80	3.0	1.55	-0.51
+120	4.5	2.3	-0.77

Table 2: Orbit perturbation by a kick at the BBLR

- measure the beam profile with the wire scanner to get a reference profile.
- Increase the wire PC in steps of 10% and follow all observables: wire outlet temperature, beam losses , beam lifetime, SPS orbit distortion at all BPM's and beam position at BBLR. After each step, record the closed orbit and the beam position at the BBLR. According to the calculations, it should be possible to reach 267 A. If this is no so, go to next step when necessary.

- Correct the orbit distortion with the corrector MDV.51707 (quasi-local correction) and the residuals with other correctors. Does the beam move towards the wire or away? Is the non-linearity a difficulty? what should be the proper strategy?
- At this stage, either the BBLR is at nominal excitation and the beam lifetime is unperturbed or the beam has been significantly pertubed at some excitation level. If this is the case, skip the next item.
- Reduce in steps of 1 mm the beam-wire separation and follow carefully the losses, temperature and lifetime. Correct the orbit every few mm's. At some stage, one of the observables will go crazzy!
- If the temperature goes too high, we have probably excessive beam losses on the wire and must investigate the situation.
- If the beam loss pattern indicates large losses on the TIDV or if the lifetime drops, the BBLR must be at work.
- Measure the beam profile with the wire scanner. Any blow-up or tails?
- Measure the ripple (amplitude, frequencies) on the BBLR current which could enhance the BB effect beyond what is expected in LHC.

The aperture limit being between 6 and 7 σ at 26 GeV/c, this is perhaps all what can be done at this energy.

If there is time left (?!), prepare the strategy of the next experiment:

- measurement of the diffusion with the collimator
- widden the beam distribution (kicks + wire scan)

10 MD 2

- check with Gianluigi for beam time and SPS cycle

11 Set Up

- use single bunch (preferred) or LHC batch
- install & commission special cycle (?); inject and accelerate beam to desired energy 55 GeV (help from Gianluigi)
- measure and correct closed orbit (overall and near the wire)
- measure the horizontal and vertical physical aperture by exciting pairs of steering correctors until beam is lost; alternatively: blow up beam and measure beam profile, or kick beam to determine physical aperture
- measure the transverse beam emittances with wire scanners in non-dispersive locations
- (possibly measure and monitor emittance using other diagnostics such as IPM or luminiscence monitor if available).
- measure the beam lifetime using BCT, *i.e.*, current and time (?)
- adjust new SPS collimators to produce beam of desired emittance and/or to remove unwanted initial halo
- record informations from beam loss monitors (?)
- adjust orbit locally to desired distance from wire (how do we determine this?); prior calibration of BPMs would be desirable (help from BI)

12 Effect of Wire

- store beam
- retract collimators
- excite wire & monitor the orbit change induced by wire current (from this we could also infer the distance to the beam); orbit may need to be re-adjusted.

a) at various times close the collimators slowly (is this possible?) and record the beam loss rate as a function of collimator position (detected how?); for each collimator setting retract the collimator jaws in small steps and observe time evolution of beam loss near the collimator; save data from (all) beam loss monitors (?)

b) kick the beam by 1 or 2 mm using Q meter and let it filament; detect the beam profile (wire scanner) after filamentation - diffusive aperture should show up as a region of depletion; repeat this study for different wire currents; and perhaps different distances

c) measure beam lifetime with and without wire excitation as a function of time.

d) vary the emittance & distance wire-beam; and repeat studies a), b), and/or c).