Programme for BB MDs of 25-26 August 2008

August 20, 2008

MD request sent on 22nd February 2008

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0.1 Motivations

The long range beam beam interaction (LRBB) will be a primary performance limitation of the nominal LHC and imposes severe constraints for an LHC upgrade. Beam lifetime limitations may require an installation of wire compensators after a few years of LHC operation. Space in IR1 and IR5 has been reserved for this purpose. Also any future LHC upgrade scheme is strongly affected by the constraints from the long-range beam-beam interactions. It is therefore fundamental to test the simulated effectiveness of the two proposed remedies (wire compensation and early separation) in an experiment in order to validate the proposed cures and upgrade paths. The SPS experiments are designed to verify/identify/examine both the strengths and the weaknesses of either scheme. They will also allow us to benchmark beam-beam simulation codes by quantifying the accuracy of our prediction, thus enabling a better interpretation of LHC simulation results. More generally, the SPS BBLR experiments will also further our understanding of unstable particle dynamics caused by the beam-beam effect.

0.2 Participants

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0.3 Beam

Beam energy: 37 GeV (for several seconds), beam intensity: $1 - 12$ LHC-type bunches with $\approx 2\ 10^{10}$ protons each.

0.4 Requirements

BBLRs, orbit measurement, emittance measurement, on line visualization of lifetime, possibly scraper, beam loss monitor, tune measurements...

1 Program in details

We split the MD program in two: parts 1-2 on the 25th August, parts 3-4 on the 26th August. In SPS there are 4 wire box installed [1]. They are grouped in two families: the BBLR1 (**BBLR.51760** and **BBLR.51771**) is a 60 cm x 2 wire (installed in 2002), the BBLR2 (**BBLR.51772** and **BBLR.51774**) consists of a set of 3 wires (60 cm x 2) in on the vertical, horizontal and diagonal plane (installed in 2004). Only the vertical wires are powered. Each family is powered, independently, in series (I1 and I2).

In March 2008 the BBLR1 was rotated to be on the vertical plane below the beam. The vertical wire of the BBLR2 is (by definition) on the vertical plane below the beam too. There are set up to make possible the compensation. When I1 has the same sign of I2 compensation is active, that is to say that BBLR1 and BBLR2 have opposite polarity. When the I1 is negative the BBLR1 mimics a counterrotating proton beam (for compensation I2 has to be negative too).

For the previous BB MDs the following orbit corrector were used: MDV.51507, MDV.51707, MDV.51907, MDV.52307, MDV.52707 [2].

To mimic the effect of 1 BBLR at the nominal LHC bunch current (assuming the 3.75 mrad mm normalized emittance) it is necessary 5.59 Am (8.26 Am for the ultimate): this means 4.66 A (and 6.88 A) on the 1.2 m BBLR (BBLR1 or BBLR2). Last MDs, in SPS we have an emittance of 1.5 mm mrad [2]: the values above therefore become 1.86 A (and 2.75 A). The goal is to reproduce 60 parasitic encounters. We summarize the quantities in table

	Nominal Current		Ultimate current	
	$\epsilon_n = 3.75\ \ \mu$m	$\epsilon_n = 1.5\ \ \mu$m	$\epsilon_n = 3.75\ \ \mu$m	$\epsilon_n = 1.5\ \ \mu$m
1 BBLR	4.66 A	1.86 A	6.88 A	2.75 A
60 BBLRs	279.6 A	111.6 A	412.8 A	165 A

It is very important to measure and record during each fill the tunes, the closed orbit (x an y), the chromaticity, the current and the emittance of each bunch, the current of the wires (I1 and I2) and the position of BBLR2(1) and BBLR2(2). We assume that the only quantity that has to be recorded manually is the the BBLR2 positions.

1.1 Preparation and check

- We will work at 37 GeV/c.
- Prepare the BBQ and set up the synchronization of the Q kick, wire scan for measuring the vertical emittance (should we consder the horizontal emittance too?), the BBLR1 and BBLR2 power supplies (they should be triggered not too near to the ramp), set up LHC working tunes, no collimation, closed orbit on the reference orbit, Q'≈ 2, transversal planes decoupled.
- Powering the BBLR1 with I1=-300 A (it should be at $-19 - 1.27 =$ 20.27 mm from the wire's center (the minus stands for 'below' the beam) from reference orbit). Check if the ΔQ and Δy are correct. Set I1=0.
- Powering the BBLR2 with I2=-300 A (it should be at $-19 - 1.27 =$ 20.27 mm from the wire's center (the minus stands for 'below' the beam) from reference orbit). Check if the ΔQ and Δy are correct. Set I2=0.

1.2 DETERMINE THE PARAMETERS OF AN EARLY-SEPARATION UPGRADE (25th August)

1.2.1 Measure beam loss as a function of wire excitation for 4, 5, 6 and 7 σ effective separation, and Q'≈ 2

- We use only BBLR1 (I2=0)
- We put the beams ad 9.5 SPS vertical σ with I1< 0 to mimic 0, 15 (nom and ult), 30 (nom ad ult), 45 (nom and ult) 60 (nom and ult) BBLRs (for each step we take 3 stores) (calibration and check if we need orbit and/or tune compensation)
- We put the beams ad 4 SPS vertical σ with I1< 0 to mimic 0, 5, 10, 15, 30, 45, 60 BBLRs (for each step we take 3 stores). We compensate Q an CO if necessary.
- We put the beams ad 5 SPS vertical σ with I1< 0 to mimic 0, 2, 4, 8, 12, 16 nominal BBLRs (for each step we take 3 stores).
- We put the beams ad 6 SPS vertical σ with I1< 0 to mimic 0, 2, 4, 8, 12, 16 nominal BBLRs (for each step we take 3 stores).
- We put the beams ad 7 SPS vertical σ with I1< 0 to mimic 0, 2, 4, 8, 12, 16 nominal nom BBLRs (for each step we take 3 stores).

WARNING:
1. displacing the beams so much ($4 - 5\sigma$ case) can require complex bumps with several orbit correctors. 2. at 37 GeV/c (1.5 mrad mm) the radius ot the wire (1.27 mm) is almost 1 σ_y to for reduced distance it acts as a collimator.

1.3 DEMONSTRATE FEASIBILITY OF COMPENSATION (25th August)

1.3.1 optimize distance and strength of the second wire for optimum compensation at one working point

- BBLR1 at 9.5σ with I1<0 60 BBLRs. Move BBLR2 at 9.5σ and make a current scan (I2<0) to find optimum.
- If there are problem in the compensatio, optimize it changing the BBLR2 position and current.

1.3.2 Then redo wire-wire compensation experiment at different tunes; vertical tune scan between 0.2 and 0.33 without wire, with one wire and two compensating wires

- Choose the best compensation setup for BBLR2. Switch off the wires and make a Q_y scan (0.2-0.33).
- BBLR1 at 9.5σ with I1<0 60 BBLRs. Make a Q_y scan (0.2-0.33).
- BBLR1 at 9.5σ with I1<0 60 BBLRs and BBLR2 in optimum compensation. Make a Q_y scan (0.2-0.33).

1.3.3 Use both wires as exciters at different beam-wire separation to mimic LRBB at different beam-beam separation

- BBLR1 at 9.5 σ with I1$=0$.
- BBLR2 at 7 σ with I2$=0$. Take data (we expect to find again the previous result (BBLR1 at 7 σ).)
- I1<0 to mimic 60 BBLRs, I2>0 to mimic 2, 4, 6, 8, 12, 14 BBLRs.
- Move BBLR2 at 6 σ, I2>0 to mimic 2, 4, 6, 8, 12, 14 BBLRs.
- Move BBLR2 at 5 σ, I2>0 to mimic 2, 4, 6, 8, 12, 14 BBLRs.

1.3.4 study compromise between nominal and PACMAN bunches by partial compensation

- Back to LHC tunes.Choose the best compensation setup for BBLR2 (BBLR1 at 9.5σ with I1<0 60 BBLRs).
- Scan I1 for 58, 55, 50, 45 BBLRs.

1.4 UNDERSTAND DEPENDENCE OF BEAM LIFETIME ON BEAM-BEAM DISTANCE AND SENSITIVITY TO TUNE (26th August)

1.4.1 measure beam lifetime vs. beam-wire distance for different tunes to see (understand) whether different power laws seen at SPS (5th power), Tevatron (3rd power) and RHIC (2nd power) and (4th power) are tune related; study variation of lifetime and final emittance on tune with and without BBLR

1.5 NOISE SENSITIVITY (26th August)

1.5.1 experimentally verify the simulated precision requirements on a pulsed device; inject noise with transverse damper or on BBLR from BA5m introduce tune spread with BBLR

1.5.2 Verify the compensation with an higher chromaticity: repeat the vertical tune scan with 0, 1 and 2 wires for a larger value of Q'

- Move Q' from 2 to 4.
- Choose the best compensation setup for BBLR2. Switch off the wires and make a Q_y scan (0.2-0.33).
- BBLR1 at 9.5σ with I1< 0 60 BBLRs. Make a Q_y scan (0.2-0.33).
- BBLR1 at 9.5σ with I1< 0 60 BBLRs and BBLR2 in optimum compensation. Make a Q_y scan (0.2-0.33).

2 Question...

1. Who will be in CCC to setup the bumps and the instrumentation? Jorg will NOT be available.
2. Who will be in BA5 to move BBLR2(1) and BBLR2(2)? Gerard will be available.

3 Appendix

References

[1] http://cern-ab-bblr.web.cern.ch/cern-ab-bblr/documentation.htm

[2] Ulrich Dorda's private communication.

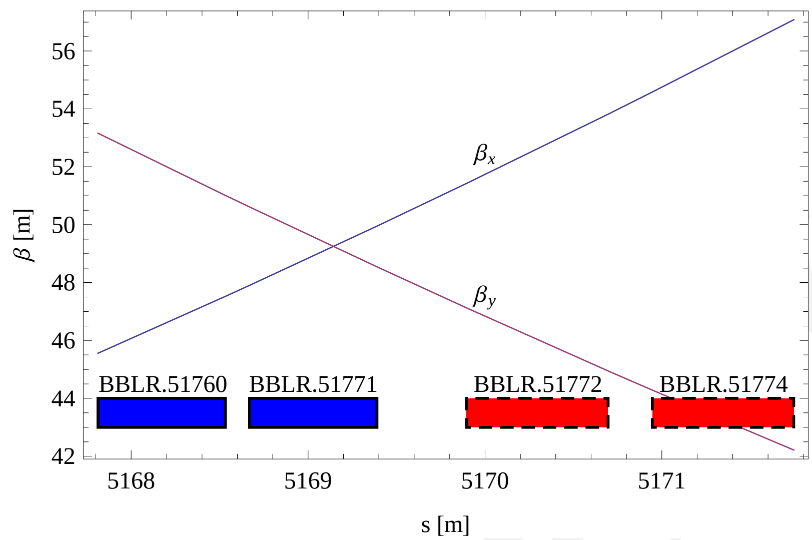

Figure 1: The betatronic functions in the SPS BBLR wires region.

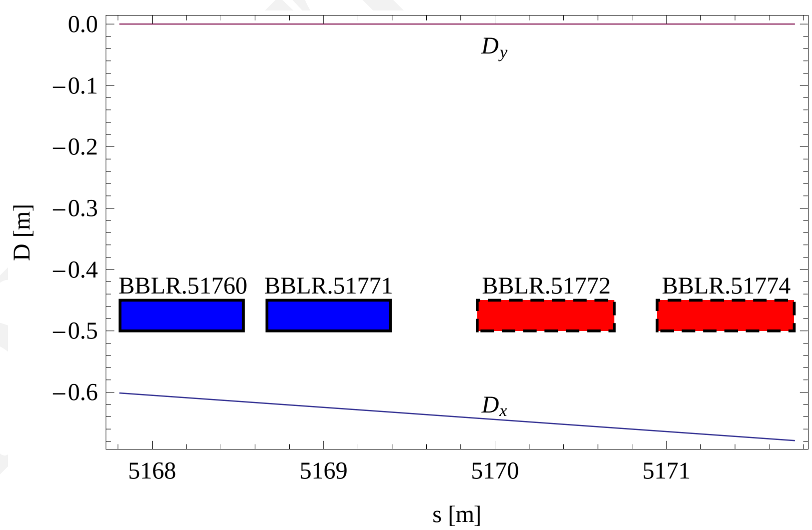

Figure 2: The dispersion functions in the SPS BBLR wires region.

NAME	S	L	BETX	BETY	ALFX	ALFY	MUX	MUY	DX	DPX
MDPH.51754	5164.05	0.25	36.32	65.43	-1.11	1.75	19.55	19.55	-0.53	-0.02
DRIFT_242	5167.81	3.77	45.56	53.16	-1.34	1.51	19.56	19.56	-0.6	-0.02
BBLR.51760	5168.53	0.72	47.53	51.01	-1.39	1.47	19.56	19.56	-0.62	-0.02
DRIFT_39	5168.67	0.14	47.91	50.61	-1.4	1.46	19.56	19.56	-0.62	-0.02
BBLR.51771	5169.39	0.72	49.95	48.54	-1.44	1.42	19.57	19.56	-0.63	-0.02
DRIFT_243	5169.9	0.51	51.42	47.12	-1.47	1.38	19.57	19.56	-0.64	-0.02
BBLR.51772	5170.7	0.8	53.82	44.95	-1.52	1.33	19.57	19.57	-0.66	-0.02
DRIFT_244	5170.95	0.25	54.58	44.29	-1.54	1.32	19.57	19.57	-0.66	-0.02
BBLR.51774	5171.75	0.8	57.08	42.21	-1.58	1.27	19.57	19.57	-0.68	-0.02

Table 1: Optical functions in the SPS BBLR wires region

	BBLR1	BBLR2
s [m]	5168.6	5170.82
β_x [m]	47.73	54.22
β_y [m]	50.83	44.64
D_x [m]	-0.62	-0.66
D_y [m]	0	0
$\Delta\mu_x$ [deg]	2.50058	
$\Delta\mu_y$ [deg]	2.67948	

Table 2: Averaged values at BBLR1 and BBLR2.

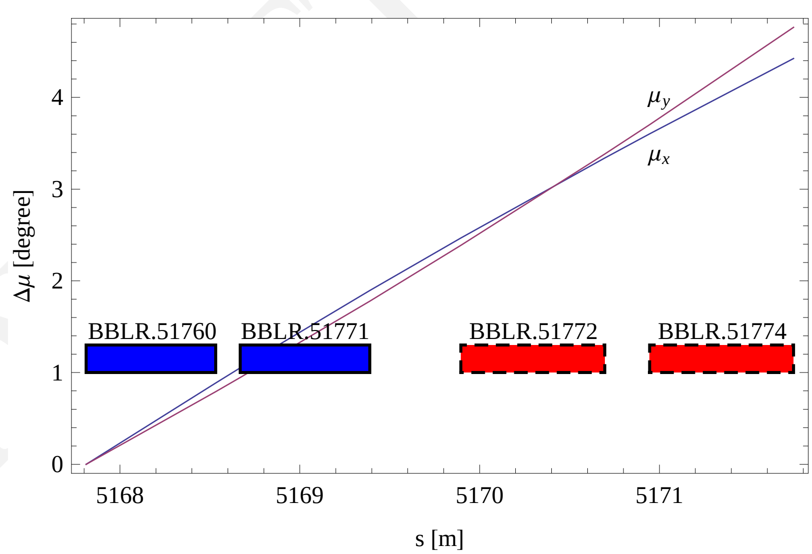

Figure 3: The phase advances in the SPS BBLR wires region.