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SPS

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ENGINEERING CHANGE REQUEST

Modification of the magnetic bumps for safe operation of the BIPM in SPS LSS5

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

From the start of the beam physics run in 2014, the two Beam Ionization Profile Monitors (BIPM) installed in LSS5, which provide information on the beam profile, will be operated routinely. Each BIPM device uses the magnetic field from the dipole magnet in which it is installed. The magnetic kick generated by this field is presently compensated by two adjacent magnets with inversed polarity powered at half current by a separate power converter. In case of a failure of one of the converters, the resulting kick to the beam cannot be handled in all conditions by the Beam Interlock System. This could potentially result in losing the beam in the machine.

It is proposed to modify the magnetic bump layout both in half-cells 516 and 517 by using only two magnets in the same circuit, powered with opposite polarity at the same current. This will provide a passive safety against any converter failure. The increase of voltage of the circuit would be compensated by powering it with the two same converters of the previous layout, but in master/slave mode. This way, the hardware modifications would be mainly limited to creating the master/slave scheme of the converters, and modifying the cabling connections on the circuit.

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SUMMARY OF ACTIONS TO BE UNDERTAKEN:

List the main actions to be undertaken.

1. EXISTING SITUATION AND INTRODUCTION

The Beam Ionization Profile Monitors (BIPM, sometimes called also Beam Gas Ionisation Monitor - BGI) provide a measurement of the beam profile based on the registration of electrons from the rest gas ionized by the SPS beam [1]. Magnetic field allows confining electron movement and therefore obtaining undistorted beam profile. This field is provided by the magnets in the aperture of which the monitors are installed. There are two BIPM devices, both installed in LSS5: BIPMH, installed in the magnet MDHW 51634 for the measurement in the horizontal plane and BIPMV, installed in the magnet MDVW 51734 for the measurement in the vertical plane.

The MDHW/MDVW dipoles can generate a magnetic field of 0.22 T over 0.55 m magnetic length when they are powered at their maximum current (50 A) [2] by their power converters type NO7 (+/- 125 A; +/- 125 V). This field value, which is required to achieve a good resolution of the signal in the profile monitor, generates also an important kick to the beam. This is presently compensated by two adjacent magnets of the same type, powered at half of the field (with the same polarity, opposite to the magnet containing the detector) by a second power converter, also type NO7. On both circuits, most of the voltage capacity of the converter is required to follow the operation cycle ramps. The mechanical layouts of the two set-ups are shown in Figure 1, the bump schematic is shown in Figure 2 and the electrical diagrams are shown in Figure 3.

More details on the existing situation can be found in the document EDMS 1341086 [3].

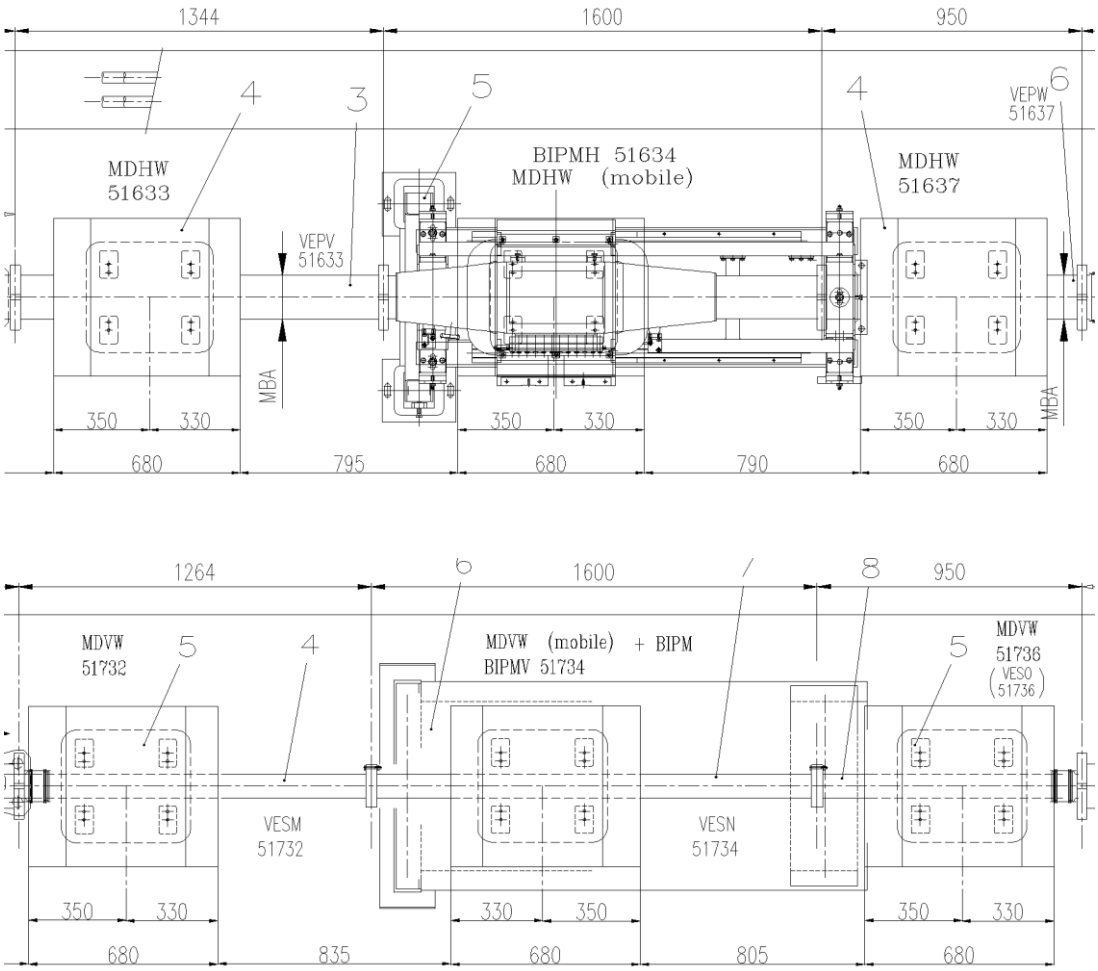


Figure 1. Mechanical layouts of BIPM set-ups in half-cells 516 (top) and 517 (bottom)

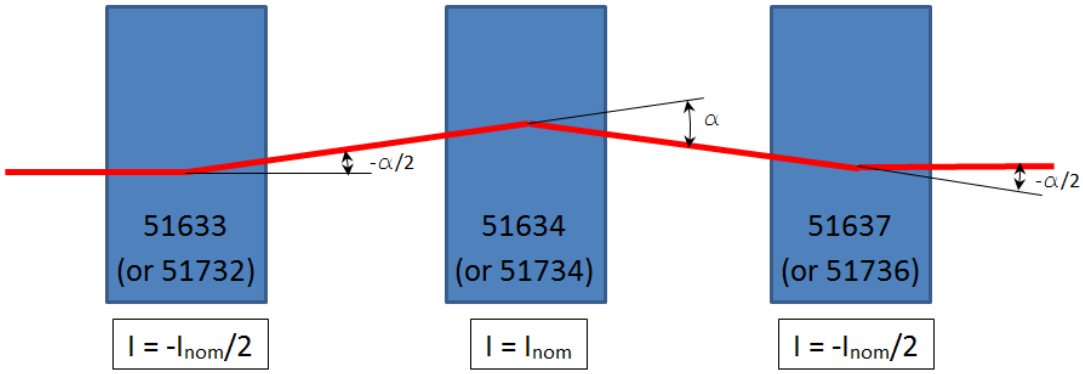


Figure 2. Bump compensation principle

Converter name	Magnet name
MDVW51732M	MDVW51732 MDVW51736
MDVW51734	MDVW51734
MDHW51633M	MDHW51633 MDHW51637
MDHW51634	MDHW51634

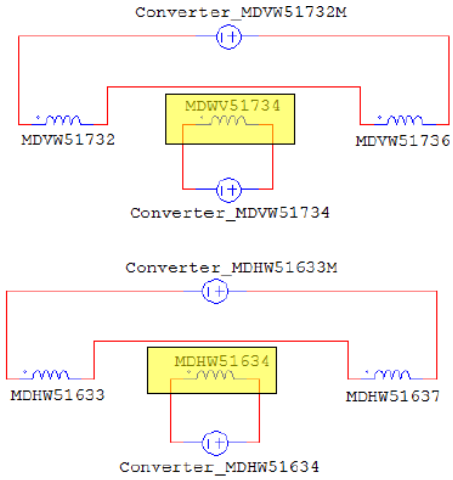


Figure 3. MDHW516 and MDVW517 electrical diagrams

During the winter TS 2012/2013 the electrical circuit of the vertical BIPM set-up magnets in 516 were reconfigured in order to test a single-compensator scheme. The magnets MDHW 51634 and MDHW 51637 were connected in series (with opposite polarities) to power converter MDHW51633M and the magnet MDHW 51633 was disconnected and power converter MDHW51634 consigned. The magnetic bump principle is illustrated in Figure 4.

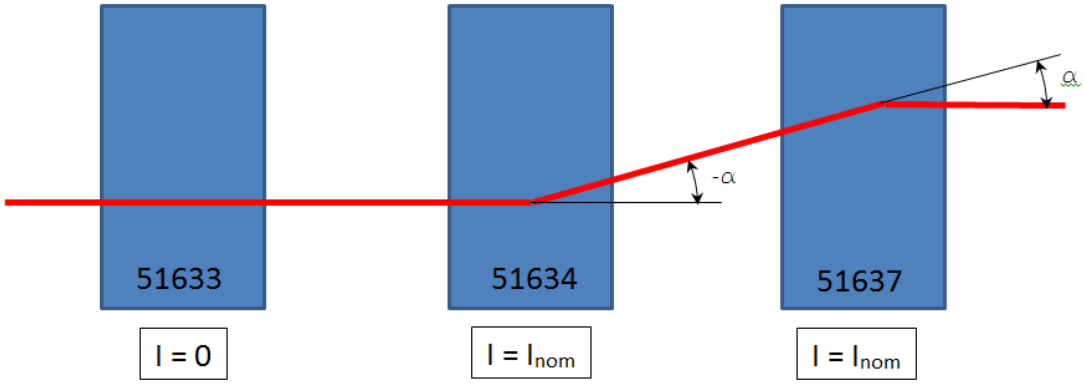


Figure 4. Modified bump compensation in half-cell 516

On January 21st, 2013 these magnets were powered during beam operation and it was found that:

- Impact on the orbit, even at 26 GeV beam energy, can be compensated by existing orbit correctors,
- A single power converter is able to ramp the current up to 50 A in two magnets within 1.4 seconds, while the time requested by operation is 625 ms.

2. REASON FOR CHANGE

The current powering scheme of BIPM magnets does not provide passive safety in case of failure in one power converter because the resulting kick to the beam cannot be covered in all conditions by the Beam Interlock System. This could potentially result in losing the beam in the machine.

The proposed modification assures this safety while keeping the monitor performance unchanged.

3. DETAILED DESCRIPTION

It is proposed to permanently modify the magnetic bump layouts both in half-cells 516 and 517 by using only two magnets powered in series with opposite polarity in a single circuit, instead of 3 powered with two independent circuits, as shown in Figure 5. This would provide a passive safety against any converter failure.

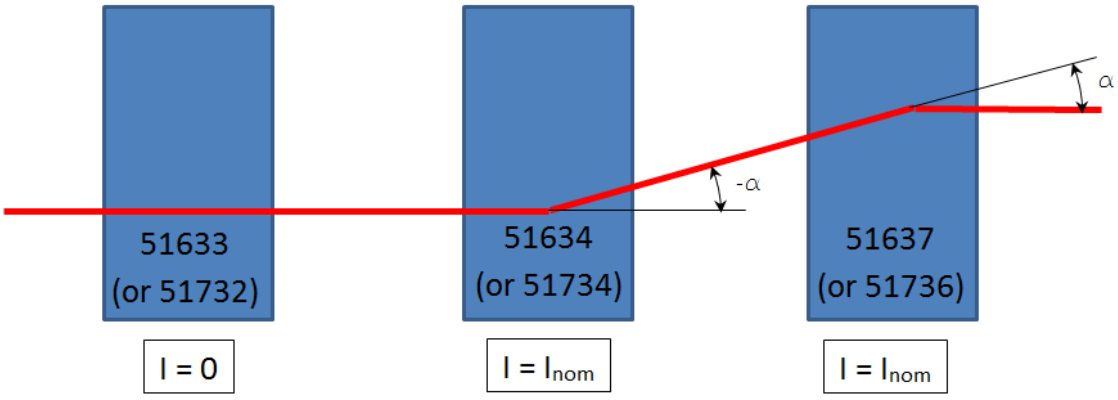


Figure 5. Modified bump compensation of both circuits

The new layout will not allow by itself to fully close the bump, but the offset generated is low due to the closeness of the two magnets (1.47 m between the magnetic centres), and can be recuperated by the adjacent orbit correctors, as could be verified during the test on January 21st, 2013. The resulting orbit distortion in case of failure is around 0.2mm. This is acceptable for extraction but the transfer lines will have to be re-steered. However the situation is much better than with 2 convertors where a failure would result in a destructive total beam loss.

To achieve the requested ramp time to nominal current, the voltage rating of one single power converter type NO7 is not sufficient as could be observed during the tests in January 2013. To avoid the replacement of the converter, it is proposed to assemble the two NO7 converters in series in each circuit in master/slave mode. The control electronics for this mode has already been developed and is available in TE/EPC. The DC cable links for the series connection of the converters - typically two 3 m long pieces of UCH1S (or equivalent) cable - between the adjacent master and slave converters for each set-up are needed, as well as a modification of the

cabling connections on the magnet (TE/MSC). The modification has to be implemented in both the horizontal (half-cell 516) and the vertical (half-cell 517) monitors. The principle is illustrated in Figure 6.

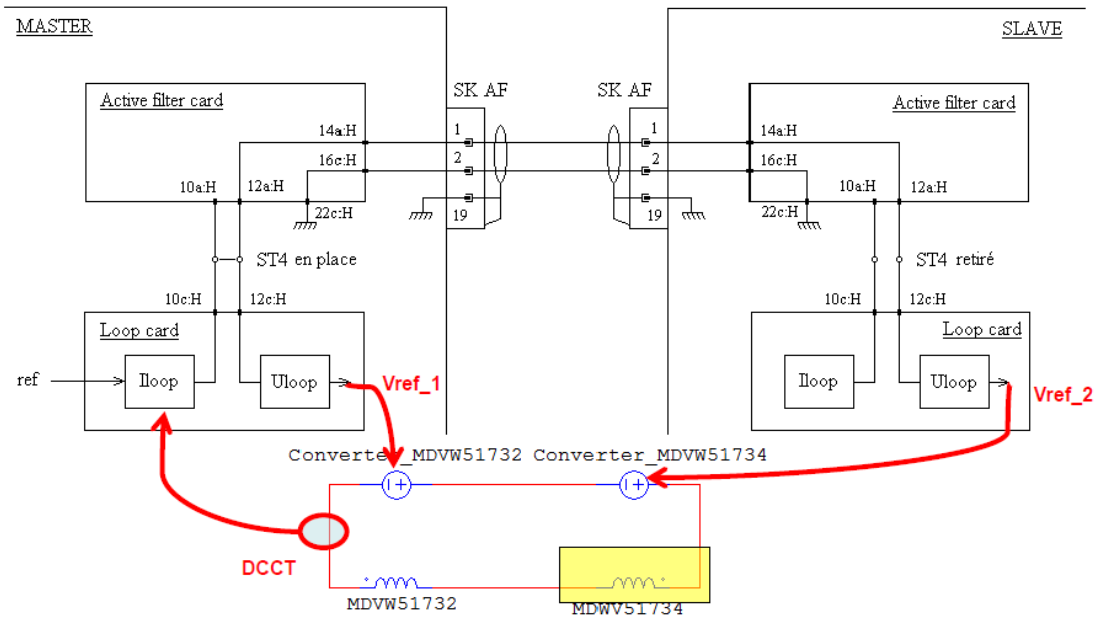
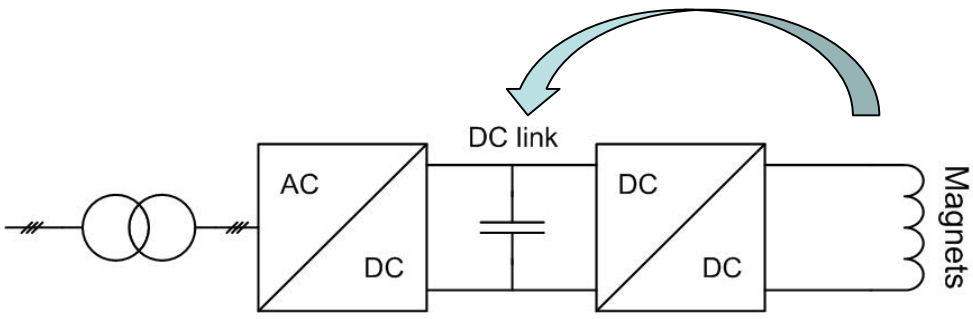


Figure 6. Modified MDVW517 electrical diagram. Modification of the MDHW516 circuit follows the same principle.

More details on the proposed change can be found in the document EDMS 1341086 [3], under "Scenario 5".

3.1 PERFORMANCES OF THE MASTER/SLAVE CONFIGURATION

- With this configuration, the time to ramp the current from 0 to 50 A will be ≈517 ms while the time requested by operation is 625 ms,
- Due to the topology of the converter (4 quadrant operation), the energy of the magnet (differential inductance of 1.74 H) has to be recovered locally in a capacitor bank when the current is decreased from 50 A to 0 A (fall time).



Given the limited space available in the converter to increase the energy storage, the minimum fall time, agreed with BE/OP during the technical study phase, shall be 1.75 s.

4. IMPACT ON OTHER ITEMS

4.1 IMPACT ON ITEMS/SYSTEMS

CCC databases and controls for magnet powering	The circuit modifications will need to be updated in all corresponding SPS magnet operation databases. Detailed information will be provided directly to BE/OP (separately from this ECR).
TE/EPC converters and database	The power converters MDHW51633M and MDHW51634 will need to be powered in master/slave mode for the set-up in 516, and their names changed accordingly to the new circuit configuration. Same goes for the power converters 51732M and 51734 of the set-up in 517.
EN/EL database (Cablothèque)	The cablothèque will need to be updated accordingly to the circuit layout changes. Detailed information will be provided directly to EN/EL (separately from this ECR).
TE/MPE warm magnet interlock system database	No hardware modification will be required (cable connection modification on magnet and power converters sides will be done by TE/MSC and TE/EPC, respectively). However, the labels on the interlock circuits (and associated databases) will need to be updated. Detailed information will be provided directly to TE/MPE (separately from this ECR).

4.2 IMPACT ON UTILITIES AND SERVICES

Raw water:	No.
Demineralized water:	No.
Compressed air:	No.
Electricity, cable pulling:	Yes. On the converter side, one 3 meter long DC cable type UCH1S (or equivalent) will need to be pulled between the two adjacent converters MDHW51633M and MDHW51634 in BA5. Same goes for the converters MDVW51732M and MDVW51734. It is already confirmed from EN/EL side that this workload (1 day) can be integrated with the resources of LS1. On the magnet side, no hardware modification will be required. The re-connection of the cables on the magnets according to the new layout will be done by TE/MSC.
Vacuum (bake outs, sectorisation…):	No.
Special transport/ handling:	No. The magnets disconnected (MDHW 51633 and MDVW 51732) will stay in place in the beam line at least for the next beam physics run. This would allow going back to the initial situation if needed. If some space would be required in these locations in the future, they would be removed at this time.
Temporary storage of conventional/radioactive components:	No.
Survey:	No.
Scaffolding:	No
Controls:	Yes. The various circuit modifications will need to be updated in the corresponding SPS magnet operation databases and controls. Detailed information will be provided directly to BE/OP (separately from this ECR), which will contact directly BE/CO if required.
Cryogenics:	No.

Contractor(s):	No.
Others:	No.

5. IMPACT ON COST, SCHEDULE AND PERFORMANCE

5.1 IMPACT ON COST

Detailed breakdown of the change cost:	TE/EPC: ~11 kCHF TE/MSC : ~1 kCHF
Budget code:	TE/EPC: 68371 TE/MSC: 99172

5.2 IMPACT ON SCHEDULE

Proposed installation schedule:	LS1.
Proposed test schedule (if applicable):	During SPS hardware re-commissioning, at the end of the LS1 period.
Estimated duration:	A few days to modify the magnet powering and interlock cabling. A few weeks to implement the master/slave configuration of the power converters.
Urgency:	Required to be operational after LS1.
Flexibility of scheduling:	None.

5.3 IMPACT ON PERFORMANCE

The beam operation safety will be improved against any failure of power converters because the serial connection of the magnets with opposite polarities will provide a fail-safe configuration of the set-up.

6. IMPACT ON OPERATIONAL SAFETY

6.1 ELÉMENT IMPORTANT DE SÉCURITÉ

Requirement	Yes	No	Comments
EIS-Access		X	This magnet circuit is not connected to any EIS circuit.
EIS-Beam		X	This magnet circuit is not connected to any EIS circuit.
EIS-Machine		X	This magnet circuit is not connected to any EIS circuit.

6.2 OTHER OPERATIONAL SAFETY ASPECTS

Have new hazards been created or changed?	No. The DC cables of the disconnected circuits will be put to ground by TE/MSC on the magnet side.

Could the change affect existing risk control measures?	No.
What risk controls have to be put in place?	None.
Safety documentation to update after the modification	No.
Define the need for training or information after the change	None.

7. WORKSITE SAFETY

Refer to EDMS document: 1155899 – "Contractors working on the CERN site".

Following the implementation of the change, the Safety File of the facility shall be updated. In the temporary absence of the Safety File, the hazards inventory and risk analysis of the concerned installation shall be established.

7.1 ORGANISATION

Requirement	Yes	No	Comments
IMPACT – VIC:	X		A specific IMPACT will be created for this activity. The necessity of a VIC shall be assessed by safety. It shall be noted that standard electrical consignation and radiation protection procedures will be used.
Operational radiation protection (surveys, DIMR…):	X		A radiation survey shall be done on the magnets. However, it is very unlikely that the ALARA level 1 is reached since the remnant radiation level in the area is usually quite low, and the work in the tunnel does not require long time exposure. To be checked by DGS/RP.
Radioactive storage of material:		X	
Radioactive waste:		X	
Fire risk/permit (IS41) (welding, grinding…):		X	
Alarms deactivation/activation (IS37):		X	
Others:		X	

7.2 REGULATORY TESTS

Requirement	Yes	No	Responsible Group	Comments
Pressure/leak tests:		X		
Electrical tests:	X		TE/MSC	Polarity tests.

Others:		X		

7.3 PARTICULAR RISKS

Requirement	Yes	No	Comments
Hazardous substances (chemicals, gas, asbestos…):		X	
Work at height:		X	
Confined space working:		X	
Noise:		X	
Cryogenic risks:		X	
Industrial X-ray (*tirs radio*):		X	
Ionizing radiation risks (radioactive components):	X		Magnet radiation dose rate to be measured by DGS/RP. Expected to be low in this area.
Others:		X	

8. FOLLOW-UP OF ACTIONS

BY THE TECHNICAL COORDINATION

Action	Done	Date	Comments
Carry out site activities:			
Carry out tests:			
Update layout drawings:			
Update equipment drawings:			
Update layout database:			
Update naming database:			
Update optics (MADX)			
Update procedures for maintenance and operations			
Update Safety File according to EDMS document 1177755:			
Others:			

9. REFERENCES

[1] C. Fischer et al., Design and Tests of a New Rest Gas Ionisation Profile Monitor Installed in the SPS as a Prototype for the LHC, CERN-AB-2004-031 BDI, proceedings of Beam Instrumentation Workshop BIW'04

[2] R. Chritin, Mesures magnétiques de 12 aimants correcteurs dipolaires de type IMHH, IMVH et IMHV, https://edms.cern.ch/document/697633/2

[3] G. Le Godec, SPS IPM, Proposals for different scenarios, https://edms.cern.ch/document/1341086/1