EQUIPMENT OF EXPERIMENTS DIRECTLY INTERFERING WITH THE BEAM OPERATION

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Abstract

All four experimental insertions will be equipped with movable devices which, in some cases, have to be located very close to the beam. In addition, both ALICE and LHCb use spectrometer magnets which distort the beam trajectories.

The location of this experimental equipment and the signals used for its positioning will be presented. The various operation scenarios will be discussed together with the experiments' proposals for who will be responsible for these operations.

INTRODUCTION

Both ALICE and LHCb use spectrometer magnets which distort the beam trajectories in the vicinity of the interaction point and around the machine and their effect has to be compensated locally with dedicated compensation magnets. In addition the ALICE central detector is completed by a set of zero-degree calorimeters (ZDCs) [1] located far downstream in the machine tunnel. The ZDCs are movable devices and, even though they are not located inside the primary vacuum, a false manoeuvre may damage the vacuum pipe and cause a major machine downtime. The LHCb detector is equipped with a movable vertex locator (VELO) [2] which has its nominal position during data taking at 5 mm from the beam axis. With a false manoeuvre, the VELO detector is capable of touching the beam with important consequences for the LHC machine. The same is valid for the TOTEM Roman Pots [3] located in the IR5 which are supposed to go as close as 1 mm to the beam axis. It should be noted that the project of placing Roman Pot in IR1 [4] has been recently submitted to the LHCC and encouraged by the Committee.

EXPERIMENTAL SPECTROMETER MAGNETS

The ALICE and LHCb dipole magnets have to be compensated placing 2 compensator magnets at about 20 m from the respective IPs. However, it turns out that the compensator magnets fully compensate the effects outside the bump, but create an angle and an offset at the interaction point. The solution adopted to solve this problem is to add a third compensation magnet preferably symmetric to the spectrometer magnet on the other side of the interaction point [5]. The magnet positions and strengths, according to the LHC optics version 6.5, can be found in Table 1. It should be noted that the magnet strengths of the ALICE and LHCb dipoles correspond to the design values. The real values are presently under measurement and the first results confirm the design values reported in Table 1.

Table 1: Magnets parameters

IP	Name	L (m)	Angle (μrad)	∫Bdl (Tm)
2	MBXWT.1L2	-20.490	-77.3	1.804
2	MBWMD.1L2	-10.750	+147.3	3.437
2	ALICE	+9.750	-133.6	3.117
2	MBXWT.1R2	+20.490	+63.6	1.484
8	MBXWS1L8	-20.765	-45.7	1.066
8	MBXWH.1L8	-5.250	+180.7	4.216
8	LHCB	+5.250	-180.7	4.216
8	MBXWS.1R8	+20.765	+45.7	1.066

The controls and safety of all magnets belonging to the experiments is in charge of the PH/DT1 group. The same group is also responsible for the magnet commissioning together with the experiments. However, it has been decided that the magnets will be controlled by the Cern Control Center (CCC). The experiments will log the current values and measure the field via probes located in the magnets: the experiments may ask the operator to change the current values if the measured field is not nominal. The safety issues affecting the beam, and so the operation, are going to be discussed with the Machine Protection Working Group. A special attention should be paid to the dipole magnets since they have to be ramped always together with the compensator magnets and in step with the beam energy. The operational scenarios of these magnets according to physics programme of the experiments can be found in [6].

ALICE ZDC

One set of two calorimeters (ZN and ZP) will be installed in the LSS2 on both sides of the interaction point at 115 m from IP2. The ZN is positioned between the two beam pipes of the recombination chamber to intercept the spectator neutrons while the ZP is positioned external to the outgoing beam to collect the spectator protons. Both calorimeters make use of highly radiation hard quartz fibres as active material embedded in a W alloy matrix in the case of the ZN (see Figure 1) and in a brass matrix in the case of the ZP. The Cherenkov light produced by the

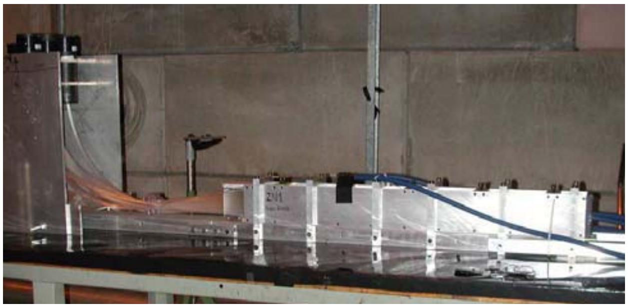

Figure 1: The ALICE ZN

passing particles in the quartz fibres is optically guided by the same fibres to photomultipliers (PMTs). Both calorimeters are placed on a movable support table which will be lowered by ~ 20 cm during injection to minimize the absorbed dose and to protect the calorimeters from possible beam losses at injection. The ZDCs' transverse positions are fixed and therefore they can only move along the vertical plane. The ZDC data taking position is at the beam plane which is defined during the commissioning of the ZDC together with the support table. According to the actual planning, the ZN will be put in the data taking position only during the heavy ion runs while the ZP is supposed to take data also during the pp runs. Therefore, the support table provides independent vertical movements for the ZN and ZP. The ZDCs will be located at few mm from the beam pipes. Hence, end switches are needed to avoid collisions with the beam pipes during the movements of the support table. In addition, machine interlocks will disable the movement during injection until beams are ready to collide (the ZDCs are in the garage position during injection). Once the interlock is disabled, the ZDCs will be put into their nominal data taking positions. Then the crossing angle will be measured detecting the signals from the 4 towers on the ZN and the centroid of the spectator neutrons can be calculated (preliminary studies indicate that the centroid can be reconstructed with an uncertainty of ~ 0.5-1.4 mm depending on the number of spectator neutrons). Once the value of the crossing angle is known, the vertical position of the platform can be optimized until the vertical coordinate of the centroid of the spectator neutrons is zero.

Taking into account that:

- the ZDCs are located far away from the ALICE experimental cavern in a zone which hosts mainly machine equipments
- a false maneuver of the mobile support table could have serious consequences for the machine, given the small clearance between the beam pipe and the ZDCs,

ALICE proposes that the ZDCs are operated from the CCC on ALICE's request. This would allow consistent operation procedures, no change in procedure in case the ZN will be used as machine luminosity monitor and a better control of the search procedures like "forgotten tools" on the ZDC mobile support table.

LHCB VELO

The VErtex LOcator has to provide precise measurements of track coordinates close to the interaction region. For this, the VELO features a series of silicon stations placed along the beam direction. They are placed at a radial distance from the beam which is smaller than the aperture required by the LHC during injection and must therefore be retractable. Figure 2 is a schematic of the VELO design. The two main mechanical features of the VELO are the separation into two halves and the encapsulation of the silicon sensors in a secondary vacuum container. In order to leave enough aperture (~ 3 cm) for the LHC injection and ramping, each station is divided in half; each half station consists of an *R* and a φ

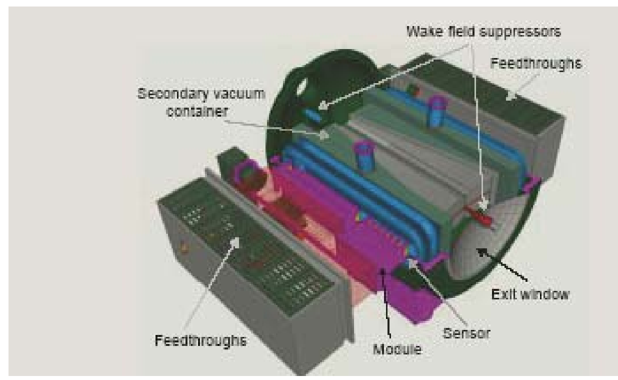

Figure 2: A schematic of the VELO design

measuring sensor. The sensors and secondary vacuum box are retracted using a rectangular bellows during LHC injection and acceleration. All moving parts are outside the secondary vacuum. The secondary vacuum box is designed to limit material before the first measurement. The silicon sensors are operated in a secondary vacuum, with only a thin wall separating them from the primary (LHC) vacuum. An RF-foil, consisting of 250 μm aluminum, surrounds each half of the VELO. In fact, operation within the primary vacuum is precluded due to contamination by VELO components via out-gassing, and RF-frequency pick-up from the beams leading to large correlated noise in the sensors. Finally, VELO gives a vital input to the L1-trigger to enrich the b-decay content of the data via a fast and stand-alone pattern recognition which is also the main tool used for the VELO positioning close to the beam.

The VELO operation foresees machine interlocks to forbid the VELO positioning during injection and ramping and to forbid unsafe beam operations when VELO is in the data taking position. As already mentioned, VELO has a fast precise standalone tracking system and it is able to locate vertices with a precision of ~ 10 μm in the transverse plane in a fraction of a second (this is due to the fact that during nominal operation VELO provides input to the L1 trigger whose output rate is 40 kHz). This procedure allows a precise gradual positioning of the VELO detector into the final position which corresponds, for nominal optics, to ~ 50 σ from beam axis. Therefore, LHCb plans to operate VELO from the LHCb Control Room.

TOTEM ROMAN POTS

Three stations of Roman Pots (RP) will be mounted on each side along LSS at IR5. The first station is placed at 148 m from IP5, the second at about 180 m between Q4 and Q5 and the third between 216 m and 220 m behind Q5. The second station will not be installed at start-up. Each station is composed of two units, separated by a distance of ~ 4 m, with each unit consisting of two pots that move vertically and one that moves horizontally (see Figure 3).

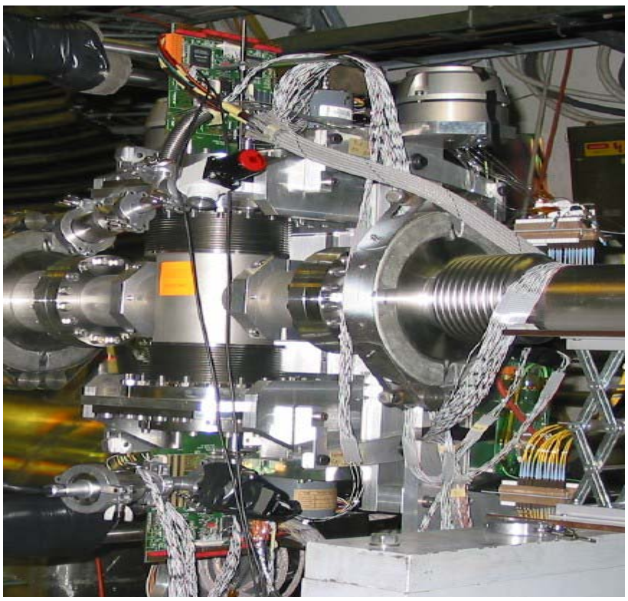

Figure 3: RP prototype mounted on the SPS ring. Only the vertical unit is present.

Like in the VELO case, the TOTEM detectors and electronics are physically separated from the primary (LHC) vacuum to prevent an unacceptable outgassing and RF-pick up from the beams. They are therefore placed in a pot equipped with a 200 μm window and kept in secondary vacuum. The pots are retracted using bellows during LHC injection and acceleration (4 cm from beam axis).

The RP operation foresees machine interlocks to forbid the RP positioning during injection and ramping and to forbid unsafe beam operations when RP is in the data taking position. The RP nominal position during data taking is 10 σ from the beam axis. The initial information on the beam position is given by the BPMs located close to the RP stations (TOTEM is presently studying the possibility of additional BPMs). BLM information is also very useful as demonstrated during the SPS test in 2004. BLMs have been already foreseen at each RP station. The vertical pots are centered around the beam axis using the on-line data from the detectors located inside the pots and equalizing the data-rate. The distance between the two vertical pots is measured with LVDT sensors with a precision of few microns. Then the horizontal pot is moved in using the data rates on its detector. TOTEM would be in favour of operating the RP from the CMS/TOTEM Control Room.

ATLAS ROMAN POTS

ATLAS has submitted a proposal to install one RP station on each side of IP1. Each station, located at ~ 240 m from IP1, is composed of two units, separated by a distance of ~ 4 m, with each unit consisting of two pots that move vertically. The project is still at the level of Letter of Intent and therefore the details of the RP operation have not been discussed yet. However ATLAS would be in favour of operating the RP from the CCC. The RP may not be operational at start-up.

CONCLUSIONS

Equipment which could interfere with the beam operation is located in all experimental insertions. The operation of the magnets belonging to the experiments is done from the CCC and the project looks very well advanced.

For what concerns the movable detectors, follow up is needed for setting up a safe procedure for their operation like dedicated interlocks and signal exchange between the machine and the experiments. In addition, the responsibilities for their operation need to be finalized. It should be noted that if the interlock system and the signal exchange is very well designed, the choice of Control Room to operate the movable detectors is most probably not an issue.

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