Protection systems for high intensity beams

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Abstract

A summary of the existing facilities for beam interlocks to protect the SPS machine. Beam current transformer (BCT), beam loss monitors (BLD, BLRING) and the 30 [mm] excursion interlock in the horizontal plane will be presented. Special emphasis will be given to the new design of the "large excursion" interlock, which is presently under conception for both transverse planes.

1 DIFFERENT BEAM INCIDENTS

The following table 1, which is reproduced from the 1998 BI day [1], shows the different systems for which the interlock systems have to protect against their failures.

System	Delay	Direct	BI prot.
MPS	15 [ms]	6 [ms]	BLD
RF	50 [ms]	Supra only	BLD, SBCT, BLRING
Transv. Damper	100 turns	NO	30[mm] interlock

Table 1: Time scales of beam incidents after equipment failures and protection systems

Delay: time between equipment failure and beam hitting vacuum chamber
Direct: delay between failure and beam dump
BI prot: the system that the SL/BI group suggests as indirect protection system.

In the following text, each of the 4 systems mentioned in table 1 will be described in more detail.

2 BEAM-LOSS DUMP (BLD)

The BLD system is installed in 3 regions around the SPS ring, namely:

BA1: to protect against large injection losses
BA2: to protect against large losses during the extraction towards the North area
BA6: to protect against large losses during the extraction towards the West area

It should be mentioned that since the BLD monitors are in the SPS ring, any losses that

occur in these regions, which are above the set limits, will trigger the beam dump. The users can change the gain, which is applied to the signals coming from the SPS tunnel, as well as the thresholds at which the system will react. The interlock is done in hardware to minimise the latency, and is working such that if any of the (maximum) 15 channels show beam losses above their set threshold, the beam dump is triggered. Presently the only access to the BLD gains is via a NODAL specialist program. The BLD system is based on the G64 standard, which is no longer supported at CERN. Ideas have come out to replace the present protection system with new hardware. One of two solutions will then have to be chosen:

1) Replace BLD by a standard BLRING system (described later in this document), which means that the latency between a beam loss arrives and the beam dump could be as high as 5[msec].

2) If the above mentioned latency cannot be tolerated, the BLRING ADC modules would be modified such that the interlock is done in hardware. This would also involve minor software modifications.

Both solutions 1) and 2) are considered to be possible, and could be installed in the SPS machine during the year 2000 should the request arise. By basing the system on BLRING, new possibilities would be added to this system.

3 BEAM-LOSS RING (BLRING)

The software for the system was completely redone during the year 1999, and involves several installations:

1) BA1->BA6 with beam dump interlock
2) TT20 and TT60 extraction channels
3) TT20 splitters

For the beam loss interlock a cable was pulled all around the SPS ring. This is connected to the SPS emergency beam dump. For each of the 6 BA's, the users can specify a number of monitors. If at any point in the current elementary cycle, the number of monitors which shows losses above their threshold is higher than the just mentioned figure, the beam dump is triggered. The main difference between BLD and BLRING is that the interlock is handled in software, which gives a latency that is (maximum) the time between acquisitions from the beam loss starts until it is detected by the system. Presently, all BLRING systems are working with a time between acquisitions, which is 20 [msec], but this could be lowered to a minimum of 5 [msec]. A Labview application allows the users to set the necessary parameters (gains and thresholds). A suite of fixed displays allows the surveillance of beam losses for each of the monitors around the SPS ring. A new logging system was put into operation during 1999. The integrated losses during one hour are read from the equipment and stored in a measurement database. During year 2000, a similar logging without beam in the SPS will be developed to follow the induced radiation.

4 SPS BCT SYSTEM

The SPS BCT systems are used to measure the intensity of beams in the ring and transfer lines. Several installations exist to measure with high precision, all the different types of beams. The operational range is from low intensity lead ions up to the very high intensity beams for fixed-target physics. In the future LHC injection and beams for the CNGS extraction will be supported as well. After a problem, which caused a hole in the vacuum chamber, a new beam current interlock was put into operation in 1998. This system uses the BCT for high intensity measurements in BA3. The principle is that if more than 2*10^12 charges are lost during the energy ramp for the P1 cycle, the beam is considered unstable and is subsequently dumped. The system checks the current loss every 5 [msec]. The low-level software for the SPS BCTs is presently being rewritten to be SPS2001 compatible. The system will work on elementary cycles, which means that no action is needed whenever the super-cycle is changed. The modified version will be ready for the start-up 2000 and will incorporate an interlock like the present for all elementary cycles, should the users request this.

5 LARGE BEAM EXCURSION INTERLOCK

This system, which is also called the 30 [mm] interlock, is presently an all-analogue system, which is only installed for the horizontal plane. It is meant to protect the machine elements from large excursions for high intensity beams. It has the fastest response times of all the interlock systems described here, as it allows dumping the beam within one SPS turn. If the local intensity is above 1*10^12 charges, the beam position above ±30 [mm] is integrated. If during one turn, this integrated value is above a threshold (set in hardware only), the beam dump is triggered. As the system is all-analogue, the post-mortem analysis is very difficult. Presently, the only way to check that the system works is going to BA1 with a digital scope, which is triggered by the beam dump signal. We propose to make this system work in both transverse planes using DSP techniques with fast ADCs to sample the beam position. The choice of logarithmic amplifiers for the beam position was taken. These allow the necessary dynamic range in position without the need for gain switching. The software specifications for the new system are presently being written for an external software company. The goal is to be able to dump the beam within 2 turns of the instability starting. The users will be given the possibility to set many operational parameters. The two high intensity beam types in the SPS require different time resolutions. The Fixed-target + CNGS beams will be sampled at 2 [Msamples/sec] whereas the LHC where the local intensity is much higher, will be sampled at 10 [MSamples/sec]. The first tests with beam will take place during the second half of 2000, and the system will be put into operation in 2001.

6 REFERENCES

[1] Summary of the 9th BI day 1998, edited by J.J.Gras, SL-Note-98-078 (BI)