FAIR Commissioning & Control Working Group

Notes from the meeting held on 2nd December 2015

e-mail distribution: <u>FAIR-C2WG-ALL at GSI.de</u>, <u>participants list</u>

Agenda:

- BLM Integration for Commissioning, Controls & Machine Protection, R.J. Steinhagen

1. BLM Integration for Commissioning, Controls & Machine Protection, R. J. Steinhagen

In his presentation (see <u>slides</u>), Ralph briefly summarized the study about FAIR BLMs from previous meeting and presented a proposal of integration of the BLM system in the SIS-100 control system. This presentation aims to be a base for the SIS-100 BLM system functional specification.

The two main use cases for the BLM system were stated: transmission monitoring and machine protection. The argument behind the first case is mainly a larger sensitivity of the BLMs to beam loss than the beam transformers to intensity loss. Assuming a good coverage of the SIS-100 circumference with BLMs, they can altogether provide complementary measurement and control of beam transmission. Concerning the second case it is concluded that quench prevention function – critical for the LHC BLM system – is not required for SIS-100, however the damage protection, especially of septa wires, is mandatory. Also, similar to LHC, the BLMs can be used for collimator alignment.

The studies performed up to now (mainly FLUKA simulations) indicate an independence of the critical BLM signals on ion species, small dependence on lost ions impact angle and sensitivity and dynamic range of the system (including electronics chain) relevance to the investigated SIS-100 beam loss scenarios (stripping losses, injection losses, septa wire losses).

It was stressed that, because of machine protection criticality, the reliability of the components of the BLM system should be assured, probably in a similar way as for LHC system, performing regular connectivity tests which imply 'as good as new' status of the system.

An important aspect is time resolution of the system. With LHC-type ionisation chamber a 1-turn resolution (3.6 us) is not possible to achieve therefore, for diagnostic of injection losses, a system based on semiconductor detector could be envisaged.

Discussion:

Calibration/connectivity test

R. Bär: Is it enforced by the system or is it just an organizational procedure? (slide 8)

R. Steinhagen: It's procedural but the 'sequence service'(?) enforces that you always do this before injecting a beam. So it's enforced once a day.

M. Sapinski: It doesn't stop the system. It checks when the last check had been performed.

(clarification: in LHC connectivity check requires no beam in the machine – no losses)

R. Steinhagen: We could force a software protection procedure. BLMs haven't been checked for three days --> do calibration test now. Not really complicated, documentation exists. Modulate the high voltage and look at the response. First choose how to modulate it and then monitor the response of all BLMs.

Data reduction for threshold tables (slide 14)

R. Bär: It's rather simple to fit. Defining a reduced table

R. Steinhagen: Is 330kb too much?

M. Thieme: 330kb is not that much. We have 1 GB

C. Omet: it's for just one channel (one BLM)!

R. Steinhagen: What would you prefer? Handle the full data or reduced data? If you prefer reduced data we'll think about it.

R. Bär: You have to consider 15 channels.

Physics for threshold

M. Sapinski: Quench tests with collimation never been done before. Would be great to confirm that thresholds don't depend whether it's ions or protons.

(recent development: two successful ion quench test have been performed at LHC in December, results should be useful for SIS-100.)

Machine aperture (slide 21)

4. : Is this for normal operation?

R. Steinhagen: Test pilot beam.

Management of critical settings / specification

M. Sapinski: The problem with the system on LHC was when not masking a channel and it reaches maximum, it dumps. You cannot set the threshold to maximum and then it never dumps. So we need to check if you need to have some kind of sunglasses for injection or extraction. At LHC they had to develop an additional system to mask BLMs at injection (as problem wasn't considered during design).

R. Steinhagen: If we set threshold table to the maximum value... *(not fully understood)*

(clarification: setting the threshold to electronic maximum would mask the channel. In LHC this solution was considered not safe, but for SIS-100 that is not critical)

M. Sapinski: That could be another solution. It should be discussed at the design phase (not later)

R. Steinhagen: We could code something like: if 0, than ignore the beam loss data.

M. Sapinski: At some point you have millions of numbers and you want to check if they make sense. You'll probably run some statistical tests. So when you set something to 0 (it could cause trouble for those tests). It's still possible but it may complicate these kind of tests.

R. Steinhagen: We have to add some sort of masking...

M. Sapinski: E.g. some kind of flag that masks BLMs at a given time of the cycle.

R. Bär: 2^{30} is the maximum count rate

R. Steinhagen: I don't want to add another field. If you want to store it somehow that would be at least a byte. That would be 500-600 kB (instead of 330kB). We won't reach the 32 bit value.

R. Bär: What is the maximum count rate?

R. Steinhagen: 2 Mhz

M. Sapinski: The issue with 4 bytes per threshold is that the comparison in electronics is performed with count (not numbers). For very long integration times – 10 seconds - we have a lot of counts.

R. Steinhagen: Let's say one second

R. Bär: 10^7 is the maximum frequency (10MHz), in 10 seconds it's 10^8. So if we use 32 bit register, so it should be no problem to check the count

C. Omet: We haven't specified what the longest extraction could be. 10 seconds seems to be a practical consideration but we are currently not limited to 10 seconds. It could be also 100 seconds

D. Ondreka: It's even in the range of the specification in the parameter table for CBM

R. Bär: Maximum is $4*10^9$. So even 100 seconds would work.

R. Steinhagen: We have a fast-cycling machine, we have a lot of cooling power – the difference of whatever threshold this is – one, 10 or 100 seconds is probably negligible

M. Sapinski: 4 bytes is okay for fast losses, for very long cycles it's optimistic

R. Bär: We should consider much higher cycle periods than we consider in the definition of the threshold band

C. Omet: It's not a real issue. When there is an extraction time of 100 seconds and is a technical restriction we'll just produce another cycle with less intensity to get the same rate on the detectors. So there is no reason to make it much longer.

P. Schuett: In storage ring beams are there for a longer time

R. Steinhagen: When it's okay for some time it's okay for 100 or more seconds. Use 4 bytes everywhere in order to simplify FPGA design...

D. Ondreka: You have to decide many of these *(not fully understood)*. Operators must be able to

handle this. You have manage several time scales when you actually need just two. You don't have to do a comparison on all of them. It must be defined.

R. Bär: It's absolutely impossible to handle all those 7 channels. Automatisms are needed.

R. Steinhagen: The operator would never set the threshold table by hand. The system would give the number of losses.

C. Omet: It has to be robust. When the BLM measures e.g. 0 count and you are imposed to save 30% on it. When it measures one count you'll get an interlock. This shouldn't happen!

R. Steinhagen: That's the purpose of injecting 10 pA like at CERN. It's ensures that you always get counts.

C. Omet: It's possible to check if the device still responds – isn't it? Check for broken cables is a must.

R. Steinhagen: This is mainly an additional exploitation on how to use the BLMs and how to incorporate them over the control system.

C: Omet: There are some scenarios in SIS100 were we don't have anything to measure directly – unknown losses, beam instabilities. We can easily produce a SIS 18 beam that has energies and intensities which lead to damage. The system is essential. This is the situation on day one. We don't have to wait ten years until we get these intensities. We just inject 4 beams of SIS18 and we are there. Somehow the system should be capable of dealing with it.

R. Bär: Next step – we need to produce a functional requirement

A. Reiter: You have to interlock that anyone has access to the BLMs. Anyone could log into a step motor...

R. Steinhagen: This is management of critical settings. It's done in LSA and RBAC. Must be done in top down approach.

A. Reiter: You don't know all the available software that that has access to the hardware

R. Steinhagen: Not a good idea to introduce backdoors without telling operators

R. Bär: Presently full of back doors unless there are no front doors...

A. Reiter: All kind of problematic devices could be put into the beam line

C. Omet: Setting a power converter to local mode is also a no-go for high intensity operation. Cannot be done anymore.

R. Bär: When you physical access, you can always change settings but there is a security mechanism.
There is a consensus. We have accelerator mode, beam modes which can be used to ensure that only allowed actions are performed. Implementation hasn't been done so far but should be doable.

R. Steinhagen: It's a critical setting that must be monitored. It must be defined who is allowed to change it and when. Change must be communicated to the control system. LSA must be the only place where it can be changed.

R. Bär: We need to implement RBAC into our systems. The range may set in high-intensity depends on the user and the mode. In high-intensity mode certain settings may not be set by the operator at all.

R. Steinhagen: LSA and FESA are already aware of these mechanisms – disabled for the time being.

A. Reiter: It's similar to Heidelberg. When the therapy control system takes over you are an observer. Already done in the past, must be done again.

R. Bär: Issues must be considered in upcoming functional specification. Before 2020 there are opportunities to test if before in existing machines; e.g. SIS18

A: Reiter: To perform these tests many things like scintillators can be used

C. Omet: Various equipment could be used for such tests

R. Steinhagen: Range factors must be the same for a measurement across the facility

C. Omet: Factor can be changed in between as long as its transparent to the underlying algorithm and the factor is known

R. Bär: Next step is to write a functional specification, define interfaces, define way system is to be used. Who'll write it?

R: Steinhagen: Use CERN spec as a base for a quick spec. Includes low level definitions for the hardware, then software on top

R. Bär: Software handles thresholds, must be defined early

R. Steinhagen: Software was actually referring to 'Management of critical settings' and other stuff which can be done later

System sensitivity and dynamic range

M. Sapinski: *(no fully understood)*

(if I remember well I was worried about the maximum current which can be measured using GSI CFC, which is about 20x less than in case of LHC .)

A. Reiter: There are three ranges. Big problem is move from a system that observes losses to a system that is supposed to fulfill some safety features.

Who is now in charge of switching ranges? When you go from 100 nA to 10μA in range – you count nothing. Direct implication on using the system. This is a lot more critical. This has to be waterproof otherwise you can have the best automated system to deliver the thresholds but fool yourself.

C. Omet: Similar problem also for other devices like beam transformer or BPMs. There can be parts where we set the gain that satisfies injection but not extraction.

A: Reiter: We have to break it down to the hardware scenario and to the operational scenario. This is the main effort.

R. Steinhagen: It's not that complicated. There might be different ranges and different location where we expect low and high losses... *(not fully understood)*

M. Sapinski: Do we need to monitor injection losses?

R. Steinhagen: It's not critical but it's useful to monitor them. If we know that we have 3% losses at injection but cycle gets 10%. I want to get a warning or even a dump to tell the operator that something is severely different which we didn't understand.

R. Bär: There is a limit that's around 20 Mhz. Would require different hardware.

A. Reiter: 5hz when there is no signal *(not fully understood)*.. enough to see it's alive

C. Omet: Could that happen when disconnecting a cable (dark current)?

A. Reiter: Design for sensitivity...must be installed properly

Funds

R. Bear: All BLMs funded?

C. Omet: Yes, but only the detectors

R. Steinhagen: Current to frequency converter not funded?

R. Bär: How much is it?

A. Reiter: 2000€ per piece (200x)

C. Omet: Part of SIS100 budget -> fine. 200 BLMs means 200 readouts. Decision by P. Spiller

D. Ondreka: Aware that costs are doubled?

R. Steinhagen: Budget available for threshold comparison

R. Bear: Everything directly related to machine protection --> there is a budget. Cross-funding possible in limited way.

A: Reiter: Applies to transformer hardware?

R. Bear: If it's directly related to machine protection is worth discussing. Project-leader decision.

Redundant systems?

D: Ondreka: Are BLMs only electronic for counting or is there a separate electronics (directed to LOBI)?

A. Reiter: Counting all detectors – same as now in SIS18

C. Omet: Shouldn't do it two times

A. Reiter: Current system does standard things, not a safety system. Various things can be integrated into the system, can do all kind of conversions. Advantage is that frequencies can be transported over long distance

D. Ondreka: Only one big scalar system for whole FAIR?

R. Steinhagen: Magnet/current supervision done by SCU

R. Bear: background data acquisition, for post mortem, …

D. Ondreka: Easiest to use system to record frequencies along with BLM signals

R. Bear: There were no other systems available

C. Omet: LSA can get data from different sources

A: Reiter: Intended as general system where people can host their things

R. Bear: Multi-purpose measurement system. Monitor all systems that we interfere (power supplies, RF systems. …). SCU is doing continuous background data acquisition on all these systems

C. Omet: When data can be combined done similar to the way in ATLAS no second system

required.

R. Bear: Automatically integrated in all power supplies. Signal directly taken from source. Inherent in system design.

D. Ondreka: It will be timestamped and time-correlatable with other values

R. Bear: Yes, really high-precision time stamp. Makes data available to clients. Any client like an oscilloscope or an application can subscribe to any signal like any dipole or frequency. Like some kind of distributed oscilloscope. Overlap should be discussed.

A. Reiter: Measurements has nothing do with each other

D. Ondreka: Should be discussed. Operator will ask which system to use

R. Bear: Should we benchmark the two systems? (--> no)

C. Omet: No time and money for redundant systems

D. Ondreka: True that you can transfer frequencies over long distances but cables are still required. Acquiring them at the source and digitize them --> can be send anywhere. For the scalar systems you would need a lot of cables.

R. Bear: Systems should work complimentary. All devices must be monitored anyway. Most instrumentation systems are not interfaced. Combining both system and providing harmonized view when publishing the data.

Availability of BLM data is a by-product. Could be used for operation.

D. Ondreka: Ensure there is no separate program acquiring BLM signals where you can arbitrary switching the gains while the system is being used in machine protection

R. Steinhagen: Other cross-links exist

R. Bär: There is system done by CSCO. BI system basically does the same at the end of the cycle. Makes sense to do both?

C. Omet: Doesn't make sense to build both. Make sure we are not losing an essentially needed functionality when not doing both. Must be discussed. At the end data acquisition should be done in one system. One sensor, one system. Saves time.

Other subjects:

S. Petri: *Question not understood*

R. Steinhagen: For the timing ionization chambers only used in SIS18 (less critical)/SIS100. Losses at the extraction septa/electrostatic wire, interesting to have BLMs/similar at the target

When lost rate deviates from programmed, you'll get a feedback

S. Petri: Issue with intensity, trying to put it outside. That means radiation, target is activated *(not fully understood)*

C. Omet: 10% beam loss for slow extraction, BLMs have to cope with it, quite high activation

D. Ondreka: Motion of the beam dangerous at primary target.

S. Petri: *Question not understood*

R. Steinhagen: Part of machine experiment interface – to tell there is dangerously more intensity than acceptable

The next meeting is planned for: Wednesday 27th January 2016, 15:00-17:00 (SE 1.124c)

Reported by Ch. Hilbricht & M. Sapinski