FAIR Commissioning & Control Working Group

Notes from the meeting held on 9th March 2016

e-mail distribution: FAIR-C2WG-ALL at GSI.de, participants list

Agenda:

- FAIR Machine-Experiment Interface – First Iteration & Proposals (jump below), Ralph J. Steinhagen

1. FAIR Machine-Experiment Interface – First Iteration & Proposals, Ralph J. Steinhagen

The presentation's main aim (see slides) was to provide an overview of the new FAIR accelerator controls infrastructure and facility operation concepts[1] to the present and future FAIR experiment community, and to motivate these to provide their detector data also to the accelerator control system via one of the standard CSCO interfaces. The latter focuses at those detector information related to the machine-experiment interface (e.g. spill-structure, target steering, beam spot size, etc.) and that could be used within semi-automated beam-based feedbacks to (continuously) improve or stabilise the beam quality for the experiments.

The existing accelerator controls infrastructure is undergoing substantial improvements and upgrades that – in its initial version – will be deployed at CRYRING and retrofitted to SIS18, ESR, and other future accelerator by and starting from 2018. The new control system is necessary to provide the required flexibility for FAIR and alleviates many of the shortcomings of the existing one. In contrast to the old system, the new control system is not monolithic but based on a variety of distributed open maintainable technologies and systems shared with CERN (i.e. being used operationally there for years). Some of the core systems are the settings management (LSA), 'White Rabbit' Timing System, common Communication Middle-Ware (CMW), Front-End Software Architecture (FESA), Machine Protection and Interlock System (MASP, FBAS), Transmission Monitoring System, Post-Mortem and Archiving System. The systems are grouped into a three tier architecture that separates the industrial device control (front-end level, 3rd tier) from the business layer (background server, 2nd tier), from the application/presentation/monitoring layer (tier 1).

The new control system is designed to facilitate a continuous gradual improvement and evolution of the system to the actual accelerators' and experiments' needs and thus provides much more control and new functionality. Individual systems or even core-components can be improved or exchanged more gradually (a big advantage to the previous monolithic approach) while limiting the impact on the rest of the infrastructure.

1Notably the 'Accelerator- & Beam-Mode' oncept (see FC2WG meeting #3 & draft specification for details), and interfaces to the machine protection (beam aborts, see FC2WG meeting #7 for details).

Further more detailed information is available via the following list of links:

- **Good entry point:** https://www-acc.gsi.de/wiki/
- Specific details regarding:
  - **Glossary:** https://www-acc.gsi.de/wiki/FAIR/FAIRGlossar
  - **Timing:** https://www-acc.gsi.de/wiki/Timing/
  - **FESA:** https://www-acc.gsi.de/wiki/FESA
    - https://www-acc.gsi.de/wiki/FESA/WhatIsFESA
  - **LSA:** https://www-acc.gsi.de/wiki/Applications/LsaMainPage
    - https://www-acc.gsi.de/wiki/Applications/LsaPresentationsAndPublications
    - https://www-acc.gsi.de/wiki/Applications/LsaFrequentlyAskedQuestions
    - https://edms.cern.ch/ui/#!master/navigator/document?D:1935804008:1935804008:subDocs
  - **Applications:** https://www-acc.gsi.de/wiki/Applications/

Ralph provided some examples of how the new control system functionality can and will be used to improve FAIR accelerator operation. He provided a list (including tentative priorities) of the planned new beam-based cycle-to-cycle feedback applications that will be common across all FAIR accelerators: i.e. transmission monitoring, control of orbit, tune & chromaticity, optics measurement, etc. (see slide #8 for details). Two noteworthy new functionalities that address in particular to improve the machine-experiment interface are the trajectory control application (injection/extraction/target steering) as well as tools related semi-automated steering of the (slow) spill-structure. Examples of existing LSA-based applications as used at the CERN-SPS were shown and which a priori could be equally implemented and deployed for the existing and future FAIR accelerators.

Target Steering, Beam Performance Indicators & (Micro-) Spill-Structure:

Since any feedback is only as good as the sensor input it is based on, emphasis was put on particularly that the target steering and control of the slow extraction spill-structure would benefit from a direct (digital/controls) input from also the experiment's detectors as many of the information required for re-steering may not available during regular physics runs using the – in many cases – intercepting accelerator-side detectors in front of targets).

Ralph compiled a 'wish-list' of detector information that would be beneficial from an accelerator operation point-of-view. He stressed the tentative nature of the list, that it is not yet finalised not finalised, and that it may require further detailed discussion:

- Target Steering – FESA integration of Exp. Specific Detectors
  (if not already based on BI standard, N.B. FESA being a front-end server architecture wrapped around whichever experiment control system)
  - x(t), y(t), Δp/p(t) + r.m.s. & status bits → cycle-to-cycle feedbacks (ms-level binning)
  - target temperature, BLMs & radiation (interlock) levels (if not part of accelerator infrastucture), ...
  - for setup (& online, if available): $<\sigma_x>$,$<\sigma_y>$ or if available: $\sigma_x(t)$, $\sigma_y(t)$, 2D distribution
    - at target and directly after last final-focus magnet

- Beam Performance Indicators & (Micro-) Spill-Structure
  - General Parameters:
    - (avg.) bunch length [ns], bunch profile [ns scale] + r.m.s. & status bits
    - total numbers of particles extracted on target (transmission efficiency)
    - particles recorded by experiments (accelerator/experiment efficiency), in relation to expected rates (model assumptions: cross-sections, detector efficiencies) → the real performance indicator 'integrated "useful" luminosity'
    - beam-induced background information (signal-to-background from an experiment point-of-view → input/discussion required)
      - primary beam, secondary beams (up-stream/down-stream generated
  - Slow spill structure → cycle-to-cycle feedbacks (binning: 1 ms or 100 us, tbd.)
    - Binned particle rate dN/dt – total & 'by bunch' (→ bunched beam extraction)
    - pile-up histogram, spectrum (2D array: 1 FFT per 10% of the spill duration), integrated r.m.s. (from 0 → detector bandwidth), detector bandwidth
  - Fast spill structure → fast in-cycle feedbacks (future option, priority tbd. → disclaimer)
    - proposal: digital optical Gigabit-link (cables pulled to SIS18/SIS100 K.O. exciter, SW protocol to be defined)

CO Interface to the Machine Protection – Beam Aborts:

In the last part of his presentation Ralph gave a brief summary and overview of the planned machine protection and beam abort concepts. Four types of aborts are distinguished: programmed slow-aborts, faster beam aborts (within-cycle) via the timing system (ms-scale), fast beam aborts (FBAS, within cycle) via digital optical link (us-scale), and non-machine-protection related spill-aborts (medial-type-operation, integrated dose control).

It was stressed that the specified machine protection system is a 'safety system' which should not be unnecessarily stressed. Spill-aborts have been previously routinely used as part of SIS18's 'therapy' mode of operation for bio-medical applications. Re-purposing the FBAS for SIS100 may not be a viable option for regular operation, since the related internal beam dump may not be able to repeatedly absorb near-nominal intensities due to potential heating and activation issues (i.e. dump should be used max. ~5 times a day [info: C. Omet]). Such a request is a new machine design criteria from an accelerator point of view, and as such need to be evaluated and discussed with the concerned experimental community in more detail (e.g. detailed requirements, constraints, procedure, reliability, activation of components, where to dump the remained of the beam, etc.).

Similarly, due to the design of the internal SIS100 extraction beam dump (and also radiation permit of the corresponding tunnel segment) the number of false-positive dumps at nominal intensities and energies per day may need to be limited (N.B. 'false-positive dumps' being dumps related to non-preprogrammed or non-machine-protection-incidents). In line with ALARA, one should thus limit the number of false-positive triggers 'by design'. One of such design analysis tools is the Failure-Mode-Effects-And-Criticality-Analysis (FMECA, IEC 61508, MIL–STD–1629A, or similar) which has been already carried out for the SIS100 (C. Omet et al.), related extraction devices, and is planned to be done for HEBT (F. Hagenbuck et al.). Since the experiments requested to be able to feed into the same FBAS system is would prudent to perform a similar FMECA for the systems beyond what is already covered by the accelerator side, and that feed into the FBAS signal (i.e. false-positive rates of diamond detector, beam condition monitors, other experiment specific machine-protection equipment, etc.).

Discussion:

Q: what happens, if detector or experimental-data-acquisition fails? Would it potentially destroy the machine or even the detector via the feedback?

A: Limits for feedback trims in place. Reduced trim limits in high intensity mode.

Inti Lehmann et. al.: The experiments are OK with this request, but they actually may not know, how to implement this FESA-classes in particular into their different data acquisition systems. A guideline (or 'how to') is needed and a contact person in controls department.

R. Bär: CSCO will provide an initial template frame-work for the FESA class definition. Further discussions for the specific implementations are required (i.e. some experiments already use standard CSCO/BI infrastructure, others may need just a 'FESA wrapper' within their existing detector data acquisition system).

M. Schwickert: BI had the similar problems as the experiments → now already solved for many type of BI systems. There are many detailed specifications for BI DAQ systems from BI, for example, see: https://edms.cern.ch/document/1179740/4

General feedback: experiments love the idea of using a gateway which should be provided. Help from CSCO is needed for the specific implementation.

The next meeting is planned for: Wednesday 20th April 2016, 15:00-17:00 (SE 1.124c)

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