Beams Department

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Editorial:

Dear readers of the BE Newsletter.

This edition will be the last before we break for the end-of-year closure and contains further evidence of wide ranging activities in the BE department. The first article presents statistics for work-related accidents during the year while the 2nd describes a novel technique to reduce the extraction losses in the PS. The final articles describe a new directory service for middle-ware and efforts to identify and remove sources of instabilities in PSB and LEIR.

I hope that you find the material interesting and it motivates you to contribute during 2019 with an article in French or English. In order to do so please contact your respective group contacts.

Lars Jensen, BE Newsletter editor-in-chief

Next issue

The next issue will be published in February 2019 and contributions for this should be received before the end of January 2018. Suggestions for contributions are always most welcome: simply contact your Correspondent (see last page of this newsletter).
Accidentologie dans BE (2018)

La fin de l’année approche, c’est l’occasion pour nous de faire le point sur l’accidentologie dans notre département. Cette analyse statistique est réalisée selon les données collectées par HSE-OHS.

Depuis Janvier 2018, au 26 Novembre, le département a été concerné par 48 événements dont 28 impliquent des accidents de personnes. Les autres événements correspondent principalement à des incidents matériels ou situations dites dangereuses1.

Les tendances sont constantes par rapport aux statistiques des années précédentes. (2017 : 30 ; 2016 : 29, Figure 1)

Les causes des accidents se répartissent comme suit (Figure 2) :

- 25% des accidents de personnes ont un lien avec les véhicules, une constante depuis les dernières années (Nov. 2018:7 ; 2017:7 ; 2016:6, Figure 3). Cela comprend les accidents sur les sites du CERN mais aussi les trajets domicile-travail.

- Une autre cause majeure d’accident demeure les chutes (tous types confondus) avec notamment 7 accidents déclarés en 2018, ce qui constitue une forte hausse par rapport aux années précédentes (2017 :4 ; 2016 : 4).

- Les cyclistes restent les plus touchés en 2018 avec 6 accidents sur 7 recensés.


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1 Selon la définition du code A2 : « un événement présentant d’importants facteurs de risque d’accident, même en l’absence de blessures et de dommages. »

2 Figure 2 - Causes² des accidents professionnels sur 2018

Parmi ces 28 accidents professionnels, les causes suivantes sont les plus fréquentes :

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Pour adopter les bonnes pratiques à vélo, nous vous invitons à vous rendre sur la page web : "Biking to work ? Stay safe" et suivre le cours CERN en ligne : "Road Traffic - Bike Riding".

Pensez à tenir la rampe dans les escaliers pour éviter les chutes. C’est important de signaler à votre TSO ou DSO tout problème de sécurité dans les locaux et les installations CERN.

Pendant le LS2, ne relâchons pas nos efforts, la sécurité doit rester une priorité. Soyez attentif à la signalisation de sécurité et à votre environnement. Anticiper vos actions et prenez le temps nécessaire à la préparation de votre activité avant de l’entreprendre.

Pour plus d’informations sur les thématiques de sécurité, vous pouvez consulter notre site web, ou nous écrire à l’adresse suivante :

be.dso@cern.ch

L.F. Andre on behalf of BE Safety Unit

**PS beam loss reduction by barrier buckets**

During the extraction of the de-bunched fixed-target beam from the PS delivered to the SPS for North Area physics, residual losses are occurring during the increasing field of the extraction kicker magnet. This process is illustrated in Figure 1 below.

Figure 4: Beam loss mechanism during the extraction of a de-bunched beam from the PS.

A project that started a year ago aims at reducing these losses by creating a controlled gap in the de-bunched beam by means of a so-called barrier bucket. Instead of driving an accelerating cavity with a continuous sinusoidal signal, single, isolated sine pulses can be used. The potential created by the isolated pulse makes a flat energy distribution around the energy of the “ideal” particle. This theoretical concept is called the barrier bucket. Figure 2 compares a non-accelerating bucket and a barrier bucket where particles can drift freely between two barriers.

Figure 5: Comparison of a single harmonic waveform and corresponding buckets (left) and a barrier bucket waveform and corresponding bucket (right).

To create such an RF signal at a gap of an accelerating structure in a synchrotron, requires a wide-band radiofrequency system and the existing “Finemet” cavity installed in the PS was chosen for the implementation. This cavity and supporting electronics were originally installed as a part of the PS longitudinal wide-band feedback system.

Most of the hardware ingredients to create the controlled gap in the de-bunched beam were therefore available, except for a beam synchronous source for the wide-band pulse. This was developed by modifying the programmable logic (FPGA) of existing RF electronics using software-defined radio techniques.

Once the prototype board was installed at the PS ring, tests with low intensity beams were performed at injection energy. Special cycles with carefully-defined timings were set up in order to control the newly created potential barriers in the PS. During the initial tests, two moving potential barriers were created to capture the injected beam from the PSB. At
injection, the barrier-bucket RF system mimicked a single RF system and by moving the barriers, the beam was stretched into a barrier bucket and vice versa.

The successful tests encouraged us to pursue barrier-bucket tests with the fixed-target beam at high energies and intensities close to the foreseen operational conditions.

The extensive effort during the last week of the proton run led to a quick and successful combination of the barrier-bucket system with the Multi-turn Extraction (MTE) at low and high beam intensity. The required gap in the beam was made at extraction, and a significant beam loss reduction was achieved at varying intensities from $-0.4 \cdot 10^{13}$ ppb to $-2.2 \cdot 10^{13}$ ppb, with $-1.5 \cdot 10^{13}$ ppb being the current operational value, see Figure 3.

![Figure 3: Re-bunching into a barrier bucket from 16 bunches per PS turn.](image)

Having seen that the scheme works very well with the MTE beam, green light was given to extracting the beam to the SPS. Synchronization remains a challenge however, using the normal extraction procedure, the beam made its way successfully to the SPS with the barrier-bucket RF system on, causing a few minutes of buzz in the CCC on the last Friday morning of the proton run.

M. Vadai (RF), H. Damerau (RF), S. Gilardoni (EN-STI), M. Giovannozzi (ABP), A. Huschauer (ABP)

Directory Service in the Controls Middleware (CMW) infrastructure

During technical stop 2 (TS2) the BECO CMW team deployed a new major version of the CMW Directory Service. This deployment marks an important milestone to eradicate the old, ADA-based version of the service.

The Directory Service is a core part of the BECO Controls Middleware (CMW). It is a naming service used to identify and locate all RDA (Remote Device Access) servers (e.g. FESA, FGCD) present in the Control System. Moreover, it is responsible for resolving the location of the physical server for a given logical device name. Additionally, based on the provided configuration, the service can route the client to an intermediate server that either provides high-level services or acts as a proxy; thus shielding the target server from a high load from multiple clients. The Directory Service must run with high availability (as every initial device access needs it) and serves approximately 220 requests per second.

The previous version of the service was implemented in ADA and deployed in 2009. Even though it was stable and functional for many years, it was neither extensible nor scalable. Scaling the service was impossible without significant source code changes and over the years, the service accumulated significant technical debt. Additionally, it was difficult to put in place a proper monitoring solution. In the second half of 2017, the CMW
team performed a market survey examining possible solutions for the next generation of the Directory Service. There are various products on the market, however, in addition to useful features, each one introduces many constraints. The Directory Service has many CERN domain-specific requirements and it is difficult to find a product that meets them all. Ultimately, the decision was made to develop a custom solution based on industry standards: Java, Spring Boot and REST API. Using this approach, the new service can be customised and extended, and deliver exactly what is needed.

The new architecture follows the micro-services approach. The new Java Directory client uses the Netflix open-source software stack: “Feign” for REST communication and “Ribbon” for client-side load-balancing. The new C++ Directory client uses the “libcurl” library for REST communication and provides custom load-balancing. The server-side is written in Java on top of Spring Boot and uses Netty as a TCP channel for old Directory clients. To provide the required scalability and availability the service is deployed as a cluster of three separate machines, as presented in the figure below.

All nodes in the cluster are connected via a distributed cache, based on the Red Hat “Infinispan” product. The cache provides a distributed, in-memory key/value data-store with automatic synchronisation between nodes, and it can scale horizontally to several hundred nodes. Additionally, each server instance has a local file backup containing the entire contents of the cache.

All nodes expose runtime metrics through JMX, which are acquired and analysed periodically by the monitoring system. According to the registered monitoring rules, warnings and alerts are sent to team members in case of abnormal behaviour or malfunction.

Key characteristics of the new service

- Contract and interoperability: the service is described through HTTP and REST and it is interoperable as it uses standard message exchange protocols.
- Loose coupling: As a micro-service, it is self-contained, independently deployable,
- Statelessness: It is stateless with no shared or conversational state. All business states are maintained in a database and in memory.
- Discoverability: When an instance of the service dies, the Directory client, equipped with load-balancing facilities, silently falls back to another server instance in a transparent way.
- Even when the database is unavailable, the service is able to serve and update the data on time. Additionally, each server instance provides a local data backup.
- Retro-compatibility: The new Directory Service is compatible with old Directory clients operating through the old TCP/ASCII protocol.

The new Directory Service has successfully passed many testing phases, including integration, performance and stability testing. Before the final deployment in production, the test setup ran continuously for several days without any problems, proving that the new service can reliably handle twice the expected production load. It was successfully commissioned and deployed during TS2 in September 2018.

K. Kaczkowski and W. Sliwinski (BE-CO)
Identification of instability sources in PSB and LEIR

Transverse beam instabilities can, if not suppressed, cause losses and as a consequence limit the maximum stored beam current in an accelerator. Studying such phenomena and understanding their origin are thus of great importance.

A horizontal instability, resulting in severe beam loss, has been observed for decades in the Proton Synchrotron Booster (PSB). In everyday machine operation, it is suppressed by the transverse feedback system (TFB). However, its origin has been a long-standing unknown.

A campaign of measurements at 160 MeV took place to further investigate its characteristics. A dependence of the beam loss on certain horizontal tunes became apparent when the TFB is off, as shown in Fig. 1.

![Figure 1: Beam loss at 160 MeV versus the horizontal tune. Red points correspond to measurements with TFB off and blue points with TFB on. Losses up to 100% are observed when the TFB is off for tunes between 4.21 and 4.30.](image)

After the second Long Shutdown (LS2), the new injection energy with Linac4 will be at 160 MeV, i.e. exactly where the instability develops for certain tunes. The TFB must be able to cope with this very fast instability from the very beginning of the cycle.

The PSB extraction kicker had previously been suspected as a possible source of the instability and similar equipment was already identified as issues in other laboratories like JPARC. Thanks to recent simulation studies and machine tests, several facts pointed further to this element. On Monday 12th November, the proton run for PSB was extended by a few hours to allow modifying temporarily the termination of the kicker: the characteristic impedance of the cable system was matched to a 6.25 Ω resistor, instead of the high impedance termination required for operation. The measurements in Fig. 2 proved that the long-standing unknown source of the instability was found: the instability is caused by the unmatched termination of the extraction kicker.

![Figure 2: Beam loss at 160 MeV versus tune with the modified termination. No sign of instability observed even when the TFB is off.](image)

It remains to be seen whether the new TFB system can cope with this instability at the new injection energy. In parallel, a possible permanent kicker modification, compatible with its performance in standard operation, is being considered.

The same type of instability was also observed in LEIR, where a vertical instability prevented the machine from operating without TFB. As the instability showed a typical “mismatch” pattern in the vertical plane (Fig. 3), mainly strip-line devices (like those used as beam exciters and beam position monitors) were considered as possible sources.
A detailed investigation was performed and obsolete devices identified. Among these, the ER.UQFHV41, an old LEIR pickup, was disconnected and matched after the second Technical Stop (TS2). This removed the instability as shown in Fig. 4.

From the PSB and LEIR experience, a significant improvement was achieved in the understanding of mismatch-induced beam instabilities: mismatching a single device can lead to severe instabilities. As a consequence, a systematic study in all machines of the CERN accelerator complex is now foreseen.

E. Koukovini-Platia, H. Bartosik, G. Rumolo, C. Zannini, N. Biancacci (BE-ABP), M. Barnes, L. Sermeus (TE-ABT) and T. Levens BE-BI.
Reminder of deadlines:

ASSOCIATES AND FELLOWS COMMITTEE (AFC)

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