Beams Department

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The next issue will be published beginning of August 2016. Contributions for that issue should be received end of July 2016.

Suggestions for contributions are always most welcome: simply contact your Correspondent (see last page).

Editorial

Dear Readers,

The enlargement of the BEAMS Department with the creation of the Industrial Controls & Safety Systems Group has a significant impact on many of us. We are now the second largest CERN Department in terms of personnel, but BE has also gained a substantial variety of activities, responsibilities and infrastructure. In order to get to know them, the group has proposed to present their activities in a series of articles in this newsletter. I can only welcome this initiative and encourage you to read their contributions.

Speaking about newsletter contributions… I'm the first one to acknowledge that we all have other, more important priorities, especially those related to the start-up and commissioning of the machines. Nevertheless, this time it turned out to be particularly difficult to get the input from all groups. As a consequence, the current issue is published quite late and is unusually thin. Don't be shy to take initiative and propose an article to your correspondent!

As far as our primary goal is concerned – and in spite of several serious electrical perturbations – the acceleration complex is getting up and running. The injectors are fully ready and the LHC has produced the first beams for physics since the year-end technical stop. Also ISOLDE and AD users are getting their exotic beams.

The Department – and especially the Controls group – was again saddened by the loss of two colleagues and friends: Pierre Charrue and Sylvestre Catin. Many of us have known both of them since numerous years and they are greatly missed.

Ronny Billen
Editor, BE Newsletter

SCADA and Distributed Systems

In January 2016 a new group joined the BE department. The Industrial Controls and Safety systems group lead by Peter Sollander was formed by combining three sections from the EN-ICE group with three sections from GS-ASE. The group serves the accelerator domain and the experiment users with support and services in the industrial controls and technical infrastructure monitoring domain, including PLC solutions and SCADA systems. The group also designs, installs and maintains CERN's access control systems for accelerators and sites and its fire detection, gas detection and other safety systems.
The BE-ICS group is organized in six sections which we will present in this and the future issues of the BE newsletter in order to introduce our activities to the rest of the department. We are starting in this issue with the SCADA and Distributed Systems section.

The SCADA and Distributed Systems section (SDS) is composed of about 20 members with mixed backgrounds (physicists, engineers in telecommunications, automation, software) mostly involved in software development. The work of the section revolves around WinCC Open Architecture (OA), a commercial tool to build industrial control systems [1]. WinCC OA, originally named PVSS, was selected more than 15 years ago after an extensive evaluation to homogenize initially the LHC experiments control systems. The main reasons for the choice were its scalability, openness, multiplatform and the relations with the vendor. The initial successful use of WinCC OA lead to much wider adoption at CERN.

The work of the section is organized around four main axes: (a) support to the CERN community; (b) development and maintenance of the JCOP and UNICOS frameworks; (c) development and maintenance of WinCC OA applications; and (d) research activity related to SCADA systems.

The WinCC OA community at CERN is made of more than 700 developers located either on site or at their home institutes. The SDS section is responsible for the validation, packaging and distribution of the different versions and patches of WinCC OA, but also acts as first line support for all developers and application users. Another important aspect is training for which about 80 courses have been given over the past 15 years. CERN, through the section, has a long term collaboration with ETM [2] (company owned by Siemens) as the manufacturer of WinCC OA. Since the beginning of the collaboration, there is work on common developments, with access to the source code of the product. At the same time ETM has developed specific features on CERN requests. In some cases, developments done at CERN have been transferred to the company through Knowledge Transfer.

More than 600 systems based on WinCC OA are currently in production at CERN. These cover the domains of the experiments (e.g. Detector Control System of the LHC experiments), the accelerators (e.g. LHC Cryogenics) and the technical infrastructure (e.g. Radiation Monitoring). All of these systems rely on the JCOP or UNICOS frameworks. The SDS section plays the role of CERN wide coordinator for both frameworks. The section is the main contributor to the development and maintenance, but also integrates external developments.
The JCOP framework provides the basic tools for the supervision applications such as trending tools, alarm and event screens, the interfaces to the CERN computing and controls environment (e.g. DIP, DIM, LHC Logging, LDAP) and others. In addition, for the experiments, it provides out-of-the-box integration of the commonly used devices (e.g. High Voltage systems, Acquisition Crates, Electrical Distribution, etc.)
The UNICOS framework is built on top of the JCOP framework and targets applications in which typically PLCs are involved (e.g. Cryogenics, Cooling and Ventilation, Vacuum)

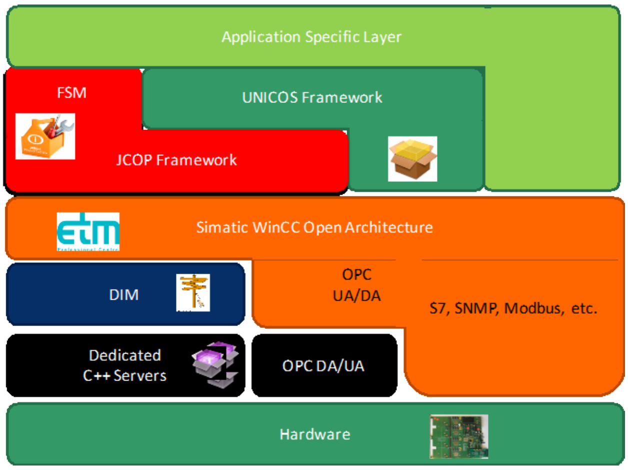


Figure 1 - Software architecture of CERN WinCC OA based system.

Out of the all the CERN WinCC OA based systems, the SDS section has direct involvement in the development and maintenance of about 200 of them in collaboration with several equipment groups. Such applications include PSEN for the supervision of the electrical network, the Detector Safety System (DSS) for the LHC experiments, machine protection applications (Quench Protection System, LHC Power Interlock and the Warm Interlock applications), as well as the NA62 DCS and Run Control and the Technical Infrastructure Portal providing a single entry point to different supervision systems to the BE-OP-TI operators.

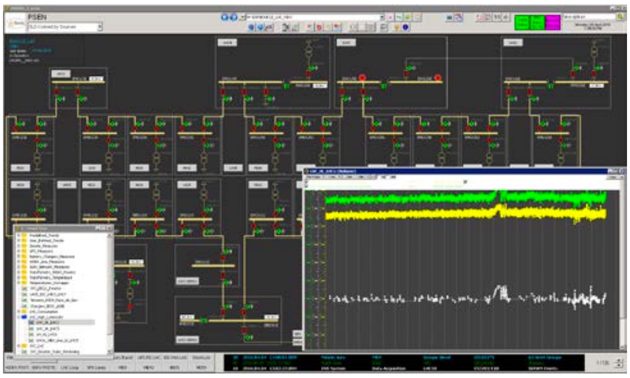


Figure 2 - Screenshot of the CERN Electrical Network Supervision

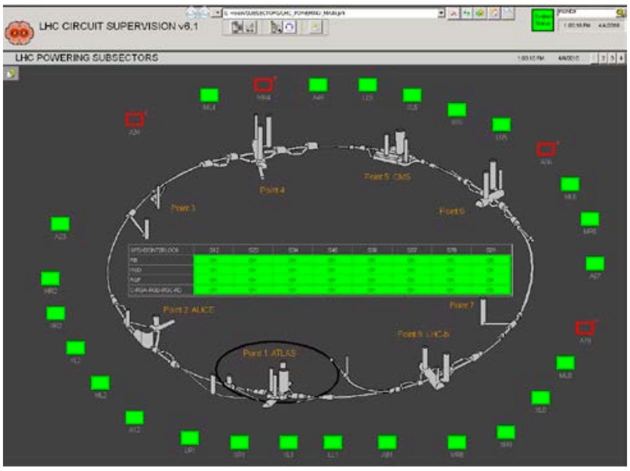


Figure 3 - Screenshot of the LHC Circuit Supervision

In order to continuously improve its service, the section pursues some research activities with external universities as well as through the openlab program with Siemens and ETM. These cutting edge activities are bringing short term benefits such as the optimization of the archiving of the QPS data (100,000 signals at an overall rate of 150 kHz) and the analysis of control systems data to detect abnormal situations. There are also longer-term activities taking place such as automatic test case generation of WinCC OA code, usage of the cloud computing for SCADA development, and enhanced SCADA monitoring and analytical capabilities through the integration of external data analytics frameworks.

Figure 4 - Overview of the data analytics for control systems activity conducted in collaboration with BE-ICS-CIC.

Manuel Gonzalez on behalf of the BE-ICS-SDS section

[1] SCADA System SIMATIC WinCC Open Architecture

[2] ETM

Update on the status of the HIE-ISOLDE project

ISOLDE is one of the world leading research facilities in the field of nuclear physics. Radioactive Ion Beams (RIBs) are produced when high energy protons from the PS Booster are sent to the facility and hit one of the two targets in the facility. The RIBs can be sent to different experimental stations for study either directly or after being accelerated in the REX/HIE-ISOLDE linear post-accelerator. Phase 1A of the High Intensity and Energy ISOLDE (HIE-ISOLDE) project was completed in 2015. The first cryomodule (CM1) equipped with five superconducting quarter-wave resonators and a solenoid together with two High Energy Beam Transfer (HEBT) lines have been installed. In addition, many of the subsystems of the REX normal conducting post-accelerator have been renovated or refurbished.

The beam commissioning of the post-accelerator started in June 2015, after the hardware commissioning of the refurbished REX normal conducting linac, and after the newly-installed CM1 and HEBT lines were completed. Three different pilot beams produced in the REX-EBIS charge breeder, were used during this time ($^{12}C^{4+}$ with an A/Q = 3.0, $^{14}N^{4+}$ with an A/Q = 3.5 and a mixture of $^{20}Ne^{5+}$, $^{16}O^{4+}$ and $^{12}C^{3+}$ with A/Q = 4.0).

The beam commissioning was divided into different stages. First, beam accelerated to 0.3 MeV/u was used to re-commission the components of the REX diagnostics box after the operational settings of the RFQ were determined (Fig. 1). Second, beam with that same energy (ie. all other RF structures were turned off) was drifted along the linac to the first HIE-ISOLDE diagnostics box and used to commission its components (a Faraday cup, a silicon detector and the scanning and collimator slits).

Fig. 1 Layout of the REX normal conducting linac. The seven RF structures are labeled in red.

Third, this silicon detector was used to set up the rest of the accelerating structures (i.e. determine the amplitude and the phase for each amplifier). The velocity at the exit of each normal conducting cavity is the same for every A/Q. Therefore, the relative phases for the cavities do not change when the beam is changed and it is normally not necessary to re-phase the cavities. However, the RF reference line was replaced during the refurbishment of the RF systems of the linac making it necessary to re-phase all the cavities at this time.

Fourth, beam with the REX nominal energy (2.85 MeV/u) was drifted through the cryomodule while the superconducting cavities were off. This beam was used to commission the diagnostics and the optical elements of the linac and the first HEBT line (Fig. 2). Fifth, the superconducting cavities were commissioned and phased using a Si detector in a diagnostics box at the end of the tunnel. Beam was transported along the second HEBT line and the different elements of the line were tested during the last stage of the beam commissioning.

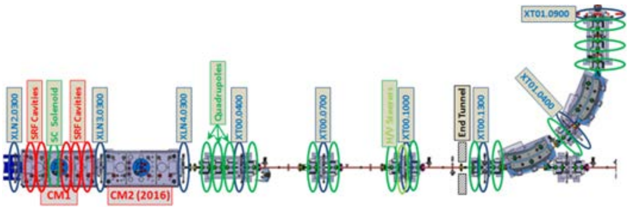


Fig. 2 Layout of Phase 1 of the HIE-ISOLDE linac and the first experimental line. The nine diagnostics boxes are labeled in blue.

Operations started in mid-October with preparations for the delivery of beam to users. Before the physics campaign started and in order to test the accelerator chain, a beam of stable ^{87}Rb was produced in the GPS target, accumulated and cooled in the REX-TRAP, charge-bred to $^{87}Rb^{28+}$ in the REX-EBIS and accelerated to its nominal final energy in the REX normal conducting linac. In addition, stable $^{12}C^{4+}$ produced in the EBIS, was used as a pilot beam to phase the superconducting cavities and to set up the HEBT lines.

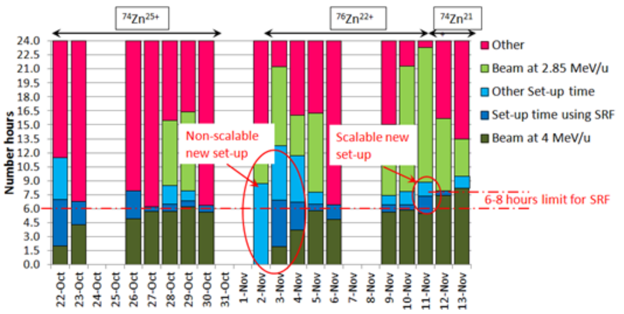


Fig. 3 Beam time available to users during the first HIE-ISOLDE physics experiment in green. Time spent setting up the machine in blue

On October 19th, the Physics campaign started with the delivery of stable $^{22}Ne^{7+}$ with an energy of 2.85

MeV/u to the Miniball experimental station. The first 4 MeV/u Radioactive Ion Beam (RIB) was delivered a few days later on October 22nd. Over the following weeks, different charge states of two zinc isotopes ($^{74}Zn^{25+}$, $^{76}Zn^{22+}$ and $^{74}Zn^{21+}$) and energies of 2.85 and 4 MeV/u were sent to the experimental station (Fig. 3). The 4 MeV/u beam time was limited to 6-8 hours per day due to the overheating problem of the couplers of the superconducting cavities. Beam with the final energy of the normal conducting linac was used during the rest of the time.

In addition to the radioactive Zn to the Miniball experimental station, several stable beams were delivered to the scattering chamber (a few hours of $^{14}N^{4+}$ and $^{12}C^{4+}$ beams) and to the SPEDE detector (4.5 days of $^{133}Cs^{39+}$ beam) for commissioning purposes.

Fig. 4 Final verifications on cryomodule 2 in the cleanroom in SM18 before closure and transport to the ISOLDE facility.

During the shutdown of 2016, as part of Phase 1b, the second cryomodule (Fig. 4) has been added to the superconducting linac which will increase the final energy of the beam to 5.5 MeV/u. Earlier this year, the first cryomodule (CM1) was disconnected in the shielding tunnel from all its services (vacuum, RF and cryogenics) and has been shipped back to the cleanroom in SM18 for retro-fitting of the RF couplers (Fig. 5).

CM1 will be installed back in the HIE-ISOLDE shielding tunnel by mid-April. As far as the installation is concerned, we are on track with regard to the schedule. The second cryomodule (CM2) has been installed and aligned inside the tunnel. The downstream vacuum chambers are connected, as well as the intertank sector, which holds a corrector magnet and a beam instrumentation diagnostic box. A high tech BCAM camera observation system is installed at the intertank position on both sides of each cryomodule. They look into the vessel to measure and verify at all times the exact position of the cavities and solenoid with respect to the beam axis.

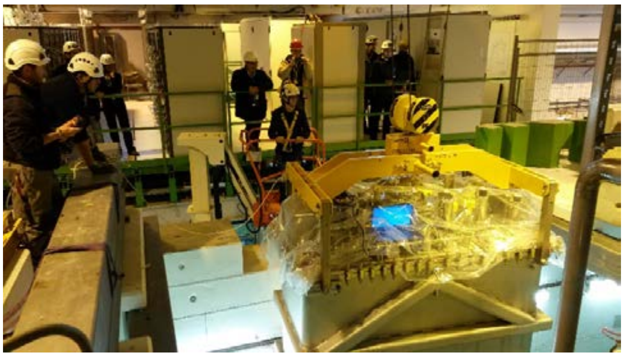


Fig. 5 Dismounting cryomodule 1 in the HIE shielding tunnel for retro fitting of the RF couplers in SM18

The vacuum system for CM2 has been connected, as well as all the top plate services: RF cabling, motor control, instrumentation cabling and cryogenic connections from the cryomodule to the cryo jumper box outside the tunnel (Fig. 6). The cryo system feeds the module with liquid helium and cools the Nb sputtered superconducting cavities and the solenoid down to an operational temperature of 4.5 K.

Fig. 6 Cryomodule 2 being connected to its services in the HIE-ISOLDE tunnel

The cryogenic plant maintenance and connections to the two cryomodules will finish end of April, in time to start the cooldown of both cryomodules for the hardware and beam commissioning at the beginning of May 2016. Physics with 5.5MeV/u Radioactive Ion Beams is expected to start this summer serving both the Miniball and Scattering Chamber experiments, which are installed on the XT01 and XT02 HEBT lines respectively.


Erwin Siesling,
Jose Alberto Rodriguez,
BE-OP-ISO

PSB brightness curve for LHC beams in the Linac4 era

The High Luminosity LHC (HL-LHC) will require beams with twice the intensity and brightness of today. To fulfil this requirement, the LHC Injector Upgrade (LIU) Project is putting in place an upgrade program for all the injector chain and, in particular, it relies on the important assumption that the PS Booster (PSB) can successfully produce these beams after the implementation of the 160 MeV H- injection from Linac4.
Complete tracking simulations including the detrimental effect of space charge have been carried out to confirm that the PSB can indeed perform as needed for the future HL-LHC runs.

First of the synchrotrons in the proton injector chain, the PSB defines the transverse emittance of the LHC beams. This quantity is related to the transverse size and to the brightness (intensity vs. emittance) and it can only be preserved or deteriorated during the beam's long way till the LHC.

Presently, the maximum brightness that can be achieved for the LHC beams is limited by the space-charge effects at low energy in the PSB.
The Coulomb forces between the charged particles create a self-field acting on the particles themselves, with a defocusing effect that depends on their position inside the bunch. As a consequence the tune, i.e. the number of transverse oscillations performed in one turn along the ring, will be different for each of the particles and will be smaller than the programmed one.
Figure 1 shows a typical tune spread, in the (Qx,Qy) diagram, together with resonance lines. In the PS Booster, the space-charge tune spread at injection is $|\Delta Q|>0.5$. This is a high value for a synchrotron, since the aim is to avoid as much as possible the resonance lines, which cause emittance degradation and/or beam losses.

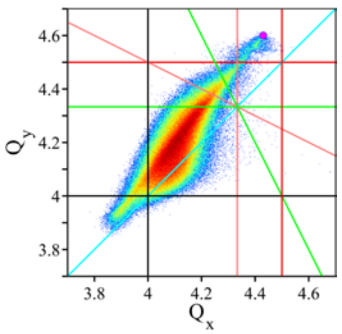


Fig.1 Space-charge tune spread at injection energy in the PSB and resonance lines in the tune diagram

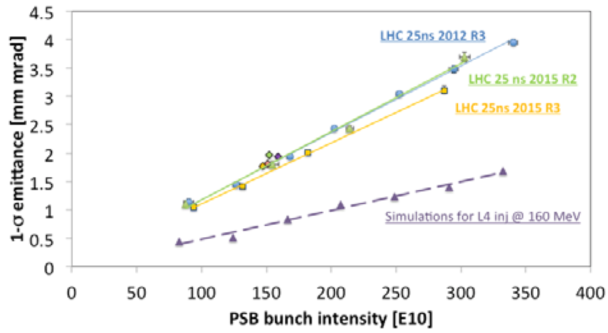


Fig.2 The measured optimized beam brightness and the simulated curve after the 160 MeV upgrade

The space-charge effects can be drastically mitigated by increasing the energy. The LIU project aims at producing twice brighter beams by increasing the PSB injection energy from 50 MeV to 160 MeV.
In addition to that, the new multi-turn H- charge-exchange injection will allow to reduce the losses, which today are dominated by the interaction with the injection septum, and will give more flexibility and a better control of the transverse phase-space filling.

Figure 2 shows the measured brightness curve in terms of semi-sum of the transverse emittances as a function of the bunch intensity, for the current LHC-type beam in Ring 2, Ring 3 and the present LHC-25ns beam performances in all the rings (single points), as of October 2015. Results are comparable with those obtained in the first measurement and optimization campaign in 2012 on Ring 3. Measurements have been done at the extraction flat-top, and the intensity has been varied by injecting 1 to 4 PSB turns.
Each point is the result of a careful optimization of tune, kickers timing and position/angle offsets at injection. Additional measurements at the time of the first campaign showed that the transverse emittance is constant during acceleration, indicating that the final emittance is indeed determined at injection energy, where space-charge is dominant.

The dashed line on the same plot is the result of simulations during the first 10 ms after injection, to predict the PSB beams brightness with the 160 MeV H- injection Upgrade.
Simulations confirmed both the linear behaviour of the brightness curve and the rough factor-2 scaling with respect to the present situation: they are indeed more optimistic by about 20%.

The multi-particle space-charge tracking simulations have been done with the PTC-Orbit code, which has been extensively benchmarked with a dedicated set of measurements at 160 MeV.

The model includes misalignments and quadrupolar errors from measurements. In addition, we have modelled the chicane magnets (see Fig. 3) that create a bump, which is maximum at injection and then decays in 5 ms, to bring the orbit close to the injection stripping foil.
To compensate for the quadrupolar perturbations at the chicane magnets, additional trims on two defocusing main quadrupoles are envisaged.

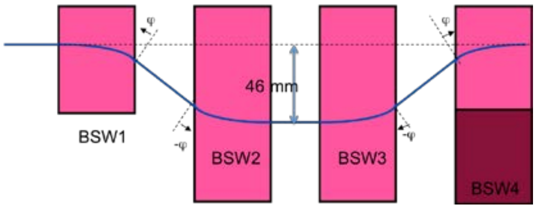


Fig. 3 Sketch of the injection chicane bump.

These magnets (with the associated perturbations) and the trims are now modelled in time-varying tables, acquired as input in PTC-Orbit, and the model has been used in the specification of functions and tolerances for the injection hardware power supplies. The simulations optionally include the H- multi-turn injection painting with scattering at the injection stripping foil and have proven to be independent of the details of the injection process itself, which is a big advantage with respect to the current proton injection with the septum.
In addition to that, a scan on the injection working point has shown an even larger improvement in the beam brightness if the horizontal tune is increased from the baseline value of 4.28 up to 4.43. As in the present machine, the simulations have demonstrated for the future machine that the integer line at Qx=4.0 is responsible for the blow-up. An increase of the working point therefore helps to accommodate a larger tune spread at injection.

To summarize, in the PS Booster the emittance is determined by the space-charge effects at injection energy. Simulations of the PSB Upgrade, which include the best available model of the machine, predict a factor 2 improvement in beam brightness, in agreement with the LIU requirement, and indicate that the choice of the injection tune might give additional margin.

Stay tuned on the subject, as our plan for 2016 is to reproduce the measured brightness curve via simulations, which is not trivial due to uncertainties in the injection parameters. In addition, following in medium-long term, we will continue to improve the PSB optics model to better understand and cure beam losses and tail formation.

Further readings

- B. Mikulec, in the LIU Beam Study Review event http://indico.cern.ch/event/200692/ (2012)
- E. Benedetto, et al., Proc. HB2014, TH04LR05 (2014)
- E. Benedetto, et al., Proc. IPAC15, THPF088 (2015)
- V. Forte, et al., PhD Thesis, to be published soon (2016)
- V. Forte, et al., will appear in Proc. IPAC16 (2016)

Elena Benedetto, V. Forte BE-ABP-HSI
G.P. Di Giovanni, B. Mikulec, BE-OP-PSB
G. Rumolo, BE-ABP-HSC
The LIU-PSB Injection and the ABP Space Charge WGs

Organiser une visite professionnelle dans une installation faisceau

Vous recevez une entreprise dans le cadre d'un appel d'offre, des candidats pour un poste ? Vous devez leur présenter les installations du CERN ? Alors vous serez certainement guide d'une visite professionnelle.

Une visite professionnelle est toute visite accompagnée dans le cadre d'une mission professionnelle réalisée dans l'intérêt du CERN.

Quand elle a lieu dans une installation faisceau, le DSO de BE autorise la tenue de la visite. Il doit être contacté au préalable, et ce, au moins 2 jours ouvrés avant la date de visite. Les étapes-clés pour préparer la visite sont décrites dans la procédure EDMS 1281098.

Les visiteurs professionnels n'ont pas d'obligation de suivre les cours de sécurité et recevront des informations relatives à leur sécurité par leur guide sur les risques potentiels. Ils doivent respecter les consignes de sécurité qui leur sont communiquées.

Pour être guide, vous devez être une personne majeure et titulaire d'une carte d'accès CERN valide. Il est possible, sous conditions, que le guide soit un contractant. Vous devez :

- être autorisé à accéder aux zones visitées et traversées,
- connaitre les risques potentiels rencontrés,
- connaître les consignes de sécurité relatives aux zones visitées et traversées,
- pouvoir faire face à toute situation d'urgence, par ex. faire appliquer les consignes d'évacuation.

Vous serez responsable de la sécurité des visiteurs lors de la visite. Vous devrez vous assurer du respect de toutes les consignes, en particulier au port des EPI et à la limitation du nombre de visiteurs par guide (max. 12).

Si la visite se déroule dans des installations équipées d'un système d'accès avec authentification biométrique, les visiteurs doivent enregistrer leurs données biométriques au bât.55. Prévoyez suffisamment de temps au moment de l'enregistrement pour les formalités.

Depuis le LS1, la Safety Unit de BE a traité plus de 200 demandes de visites professionnelles dans près de 30 zones. En période d'arrêt technique, les demandes sont plus nombreuses : anticipez donc vos demandes pour faciliter leur traitement.

BE-Safety Unit Envoyer un message

Plus d'infos sur : Instruction générale de sécurité GSI-SH-1 – Visites sur le domaine du CERN – EDMS 1137263

Organising a professional visit in a beam facility

You receive a company within the framework of a call for tenders, or candidates for a position? You have to show them CERN facilities? Then you will certainly be guiding a professional visit.

A professional visit is any escorted visit organised in the framework of a professional assignment in the interest of CERN.

When the visit takes place in a beam facility, the BE DSO shall authorise it. He should be contacted with at least a 2 working day notice. The key steps for the preparation of the visit are described in procedure EDMS 1281098.

Professional visitors are not required to attend safety courses. They will receive a safety briefing by their guide about potential hazards. They should follow the safety instructions given by the guide.

To be guide, you should be major of age and have a valid CERN access card. Guides may be, under conditions, contractors.

As a guide, you must:

- be authorised to access the visited and passed through areas,
- be aware of the potential risks,
- know the safety instructions specific to the areas visited and passed through,
- be able to react when facing an emergency situation, e.g. by applying the evacuation policy.

You will be responsible for the safety of your visitors during the visit. You should ensure that the safety rules are followed, in particular relating to wearing the appropriate PPEs, and respecting the maximum number of visitors per guide (12).

If the visit is in a facility with the biometric identification system, the visitors shall record their biometric data in building 55. Please allow enough time for this.

Since the beginning of LS1, the BE Safety Unit has processed more than 200 requests for professional visits in more than 30 different areas. During machine stops, the requests are numerous: please anticipate your requests to ease their treatment.

BE-Safety Unit Send a message

Read more on: General Safety Instruction GSI-SH-1 – Visits on the CERN Site – EDMS 1137263

Restructuration of OP Group @ 1.4.2016

New Section : ISOLDE (ISO)
Section Leader : José Alberto Rodriguez Rodriguez

Newsletter Contacts

ABP Correspondent
Elena Benedetto

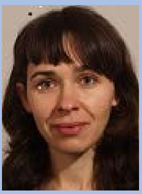
BI Correspondent
Barbara Holzer

ICS Correspondent
Jean-Charles Tournier

RF Correspondent
Wolfgang Höfle

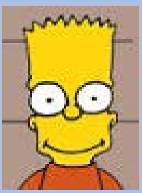
Copy Editor
Laurence Van Cauter-Tanner

ASR Correspondent
Lisa Kobzeva



CO Correspondent
Mick Draper

OP Correspondent
To be confirmed



Editor-In-Chief
Ronny Billen