Dear Colleagues,

I am delighted to see that the BE Newsletter has been revived and will once again be a regular communication feature within the Department.

My thanks to Lars Jensen who has agreed to take over as Editor-in-Chief and to his supporting team, N. Biancacci (ABP), D. Carloni (ASR), S. Easton (OP), E. Fortescue (CO), T. Hakulinen (ICS), W. Höfle (RF), J. Kotzian (HDO) and J. Storey (BI).

To keep the Newsletter alive and engaging, we count on contributions from all members of the BE community, and I can only encourage you to contact the editorial team with topics you feel could be of interest to the BE Department. Communication is a key factor in helping us accomplish our goals and the Newsletter is one way of sharing our knowledge and experiences with fellow colleagues.

Another communication initiative introduced this year is the “BE Onboarding event” and you will find more details on page 9.

Please use the Newsletter as a forum for gaining awareness of the vast activities going on in the BE Department and for passing on your knowledge to others. As an avid reader, I am very proud to further my knowledge through the inspiring articles I read.

Paul Collier, BE department head
Editorial:

Dear readers of the BE Newsletter. It’s a pleasure to once again allow people a means to communicate to others what they are up to, at work or outside. We deliberately limit all contributions to 1.5 pages which is a challenge but being to the point in written and oral communication is a skill that we should all train and aim for. This first edition is still a ‘flat’ file however we are looking into using modern digital magazine technology in collaboration with the CERN library. I hope that you find the material interesting and it motivates you to contribute.

L. Jensen, BE Newsletter editor-in-chief

The HL-LHC Collimation System and the Impedance Challenge

The collimation system of the Large Hadron Collider (LHC) is essential to protect its superconducting magnets in case of beam losses. It intercepts the protons that would otherwise touch the machine aperture, potentially inducing quenches or even damage. The LHC collimation system is mainly located in two special Insertion Regions (IRs): IR7 is dedicated to betatron cleaning, whereas IR3 to momentum cleaning (see Fig. 1).

In order to optimise collimation efficiency, the collimation system was conceived in stages where each is located downstream of the previous one and sits transversally at larger apertures. In IR7, primary collimators (TCPs) are directly exposed to beam tails, absorbing most of the losses; secondary collimators (TCSGs) are meant to intercept beam particles out-scattered by the TCPs; finally, shower absorbers (TCLAs) catch most of the secondary particle showers started in the upstream collimators. IR3 follows the same working principle, but contrary to IR7 the collimator settings are optimised for cleaning protons with large energy offsets. Additional collimators are installed in other LHC IRs with specific roles: finalizing the cleaning upstream of the collision points (TCTs), protecting the arcs from collision debris (TCLs) from ALTAS and CMS collisions, and protecting the LHC cold aperture from badly injected beams or erroneous dumps.

The IR7 collimators are made of two parallel jaws, centred on the circulating beam. The jaws of the IR7 TCPs and TCSGs, being closest to the circulating beam, are made of a composite graphite material; this is done in order to enhance the robustness since they are subject to high loads in case of losses. Due to their number, to the relatively high electrical resistivity of this material, and to the proximity to the beam, the IR7 TCPs and TCSGs are responsible for a large fraction of the so-called LHC “beam coupling impedance”, a parameter quantifying the amount of beam self-induced electromagnetic fields potentially detrimental for the stability of the beam itself. The LHC machine is equipped with octupole magnets to fight the impedance. However their effect is limited and beams may eventually be lost.

The High Luminosity LHC (HL-LHC) project foresees boosting the yearly production of luminosity by a factor 10 and a series of upgrades will be carried out, both in LHC, and its injector-chain almost doubling the bunch population.

The LHC collimation system will undergo a substantial upgrade and in addition to impedance, the main driver of the upgrade is jaw robustness as the higher bunch population implies doubling the maximum loads for similar loss rates or accidental cases. The IR7 TCPs and TCSGs have been fully redesigned with the goal of improving the robustness of the collimator jaws while reducing their resistivity. The jaws of both TCPs and TCSGs will be made of Molybdenum-Graphite (MoGr); this composite material is chosen for its high electrical resistivity and its ability to absorb energy from beam loss events.

The HL-LHC project will also upgrade the IR3 collimation system with new collimators designed to handle the increased beam losses expected from the higher luminosity. These new collimators will be made of a composite graphite material that is optimized for handling protons with large energy offsets.

2 Each LHC ring is equipped with 3 TCPs and 11 TCSGs in IR7.

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1 A quench is the sudden transition of a magnet from its superconducting state to normal conducting.

2 Each LHC ring is equipped with 3 TCPs and 11 TCSGs in IR7.
material is developed in the EN department and is characterized by a resistivity a factor 5 lower than that of the present jaw material. The new TCSGs will be coated with a thin layer of low resistivity Mo. The coating effectively screens the bulk of the jaw at high frequencies thus further reducing the impedance of the collimator. The collimator upgrade will commence in stages, starting already in LS2, when four secondary TCSGs in IR7 per beam will be replaced with the novel TCSPM type. In order to probe the new collimator design and demonstrate the expected impedance improvement, a prototype collimator was built in the EN department and installed in LHC during the 2016-17 EYETS. This was possible thanks to a joint effort across the ATS sectors, in particular between the groups EN/MME, EN/STI, TE/VSC who worked together with BE teams to complete the construction in time for the installation in the EYETS. The prototype is unique in its genre, since its jaws, made of MoGr, have two coating stripes of Molybdenum (Mo) and Titanium-Nitride (TiN) (Fig. 2).

![FIG. 2. The prototype collimator has two 10 mm wide low resistivity (Mo and TiN) stripes on a MoGr substrate. Left - photo of the collimator assembly; right - schematic drawing of the collimator jaw.](image)

The jaws can move in the transverse plane, exposing the beam to one of the stripes at a time, thus selecting which coating to study. The prototype TCSPM was installed in a vertical configuration in the D4L7 slot, next to a standard secondary TCSG collimator. This allowed comparing the coatings with standard jaw material and the effect of each is quantified in terms of tune shift when the jaws are brought closer to the beam; the lower tune-shift, the better. The three materials are expected to produce tune-shifts 2 to 10 times lower and the measurements require a challenging precision level of $10^{-5}$. Years of continuous collaboration efforts between OP, RF, BI and ABP has made this possible.

Experimental results agree quite well with theoretical predictions of the current LHC impedance model, showing a clear reduction of the tune shift with the new materials with respect to the standard CFC (Fig. 3).

![FIG. 3. The usage of MoGr (red) reduces the resistive wall tune-shift compared to the uncoated CFC (blue); each type of coatings: TiN (green) and Mo (yellow) further improves the conductivity and can be clearly differentiated.](image)

The MoGr offers an impedance reduction of about a factor two, and each of the coatings lowers the tune shift further. The largest reduction, as expected, is found for the Mo coating, although the results do not perfectly match expectations as the measured resistive wall tune shift is a factor two larger than expected.

The present intensity threshold at top energy is around $3.4 \times 10^{13} p^+\text{ per bunch}$ and this threshold increases significantly for HL-LHC with the future low-impedance collimators. However, the quest for low-impedance collimators is not over: while Molybdenum has proven its superiority to other low-impedance options, the source of higher than expected measured tune shift remains unknown and studies are planned to investigate the possible influence of surface roughness, the micro-structure and thickness of the coating.

S. Antipov, N. Biancacci, A. Mereghetti (BE-ABP-HSC)

**Re-cabling campaign for injectors**

Since 2015, a highly ambitious overhaul of a critical piece of CERN’s infrastructure has been underway. The vital work is expected to last an entire decade and involves a staggering amount of meticulous labour, yet with so many amazing (and perhaps more glamorous…) projects happening all around us here, it is quite possible this seemingly mundane project
has slipped under the radar of many: the re-cabling of CERN’s injectors.

Although dwarfed by the LHC, the three proton-injector synchrotrons (PSB, PS and SPS) are all large and complex machines in their own right. They each contain a huge number of devices and each of those require many cables, which may in turn need connected to something hundreds of metres away. The quantity of cabling present in these three machines (and their transfer lines) is immense, totalling many hundreds of kilometres.

After LS3, the injectors must all be ready to play their part in providing high brilliance beams for HL-LHC and, as well as improving their performance, this means ensuring their reliability. The Injector Decabling Project, led by EN-EL with assistance from BE-OP, aims to audit all the myriad cables that line the PSB, PS and SPS infrastructure and replace/remove them as necessary. The sheer quantity of cabling, not to mention the labyrinthine routes it takes around the accelerator buildings, makes this a truly monumental task.

Preparations for the project began during the 2015 run, with surveys of cabling in the Booster and part of the SPS being performed during the YETS. During the EYETS 2016, the re-cabling identified in these surveys was performed. From the smallest injector alone - the PSB, which is 174m in circumference – some 4332 cables were removed with a total volume around that of a double decker bus (86m$^3$). At the same time, the central area of the PS ring was surveyed, in preparation for work being performed during the YETS just finishing now.

Re-cabling work can only be performed in technical stops or during shutdowns. This means that YETS or shutdowns are periods of furious intensity for the re-cabling teams, while the rest of the year can only be used to for planning and preparation for the next available work window. Figure 1 below shows the

situation before and after a re-cabling campaign in the PS.

Over the YETS 17/18, EN-EL teams worked hard removing ailing or obsolete cables for the PS ‘centre anneaux’, and also some that remain in a part of the PSB called “TP9”. Again the statistics are staggering, with 4313 cables totaling 185 km removed from the PS, and 698 cables totaling 117km being removed from TP9. The total volume of these cables is 224m$^3$, almost a quarter the volume of steel used in the Eiffel Tower! Indeed, the project removed some 622km of cable in the past 15 months. These number will increase over the remaining years of the project, when the two largest sectors (the PS ring and the SPS ring) are re-factoried from LS2 onwards.

Re-cabling work can only be performed in technical stops or during shutdowns. This means that YETS or shutdowns are periods of furious intensity for the re-cabling teams, while the rest of the year can only be used to for planning and preparation for the next available work window. Figure 1 below shows the.

Figure 1: ‘Before’ and “After” shots of ‘Ovoide 8’ – a 100m long tunnel in the center of the PS machine

The re-cabling project is a truly mammoth task that comes with great responsibility and very tight deadlines, and we thank the teams involved for their efforts in executing the task so effectively.

Sandy Easton (BE-OP-PS)
Teaching a semester in Africa

During my career at CERN, passing on the experience acquired during my work on the accelerators was always part of my job. For many years, I have been teaching micro-controller systems in developing countries in a collaboration of CERN and the Abdus Salam ICTP, Trieste, Italy, later also accelerator physics within the African school of physics.

During these schools, I made many friends from all around the world and I wanted to finish my CERN career with a teaching assignment at a university in the developing world.

When a long time ago a Ghanaian friend asked if I could imagine coming to help the University of Cape Coast (UCC), Ghana and teach a course on embedded systems, I did not hesitate and after some initial difficulties and with CERN’s permission I arrived in Ghana at the end of August.

In Ghana, I was received warmly, not only by the local climate with 32°C and 65% humidity, but also by my UCC colleagues who made me feel at home very quickly.

Unfortunately, the budget had not been released and laboratory material was not ordered so my work looked compromised. However, as is often the case in Africa, when everything seems to be lost, all of a sudden, things start moving and in the end, everything somehow works out. A week after my arrival the budget was available and 2 weeks later, we had all the material required. In any case, I needed 3 weeks of introductory lessons to prepare the students for work with the embedded computer systems and the sensors and actuators forming the laboratory, such that we managed to setup the lab “just in time”.

Four weeks after the start of the course, the university had its yearly Open Day, where all departments show their work to the interested public and I was asked to prepare the students such that they could present the course. We set up a number of experiments to be demonstrated: a weather station, an obstacle-avoiding robot, a traffic light simulator, etc.

On arrival I thought that four months were a very long time but with all the work that needed to be done, time flew by. I intended to do a bit of traveling to see the country but this simply did not work out. However, I had plenty of things to see even without moving: There was the Feta Afahye traditional festival, celebrated by the chiefs and people in Cape Coast, one of the biggest traditional festivals in the country. Then there was the WAFU cup of nations, the West African soccer championships that took place in the stadium just 200 m from my home and of course, there is the Cape Coast castle, one of the biggest and best-preserved European castles from where slaves were shipped to the Americas and the Caribbean.

The beach and Cape Coast castle

At the end of the semester, the UCC department of music and dance presented two shows with traditional dances and music which were simply fantastic in their authenticity.

End of semester dance show
Then the last lectures, the exams and my time at UCC was already over. We had a little good-bye celebration and I was asked more than once when I could return.

A last group photo and I had to return to Accra to catch my flight back home. I did this with very mixed feelings: on one hand the joy to see family again after such a long time and to be able to celebrate the end of the year festivities with them and on the other hand the regret to leave behind a large number of new friends I had made during my stay.

Goodbye photo

Ulrich Raich (BE-BI-PM)

Distributed I/O Tier and radiation-tolerant Fieldbus

The High Luminosity LHC project (HL-LHC) hopes to achieve much higher instantaneous luminosities. HL-LHC Work Package 18 (WP18) describes an upgrade of the CERN/BE control system designed to cope with new requirements. A centrally supported Distributed I/O Tier platform (DIOT) and new High-speed, radiation-tolerant fieldbus, together with a next-generation data logging system, are the three main tasks of WP18.

The CERN control system is comprised of multiple layers of hardware and software extending from hardware deployed close to the machine, up to the software running on application servers that operators use for control and monitoring. As figure 1 shows, one can distinguish the following three hardware layers:

- Front-end Tier – a PLC or powerful computer in various form factors (VME, PICMG 1.3, MTCA.4, etc.) running a set of user applications controlling Distributed I/O Tier over a fieldbus.
- Fieldbus Tier – communication link between the master in the Front-end Tier and a set of slaves in the Distributed I/O Tier
- Distributed I/O Tier – electronics modules that interface directly with the accelerator in radiation-exposed or radiation-free areas, controlled over the fieldbus. These are usually FPGA-based boards sampling digital and analog inputs, driving outputs and performing safety-critical operations.

Depending on the needs of a given application, equipment groups can use either COTS systems, design custom electronics, or a combination of the two. The specialised needs of CERN accelerators often demand the development of custom electronics. For these, the BE-CO group already provides a centralised service in the Front-end Tier that comes in the form of VME crates and PICMG1.3 computers. However, we miss a centrally supported service for modular and reusable electronics in the Distributed I/O Tier. Each equipment group (Power Converters, Cryogenics, Machine Protection, Beam Instrumentation, and others) has so far developed custom solutions. Whilst the devices may be different for each application, many of the needs are the same and we have identified that they could be handled centrally.

In the Fieldbus-Tier, the current BE-CO service for custom electronics is based on the radiation-tolerant WorldFIP bus. Its limited (2.5Mb/s) data bandwidth inflict prohibitive delays for some equipment groups as they transmit large amounts of data and BE-CO plan to expand the offering by developing a modern fieldbus communication based on 100Mb/s Ethernet.

In the scope of the project, we design a modular CERN-wide hardware kit that can be customized to suit various applications. Two important principles of
the project are 1) staying close to the standards used in industry and 2) designing the modules with future users – to benefit from the scrutiny and review of many developers. While the complete kit consists of modules for radiation-exposed and radiation-free areas, in the scope of WP18, we focus on radiation-tolerant components (Figure 2):

- The 3U crate with a fully passive, standard, off-the-shelf backplane and power supply that can be exposed to radiation
- The generic System Board that serves as the crate controller, implements crate diagnostics, interfaces with application-specific peripheral boards plugged into other slots of a 3U crate, and features an FPGA that can be programmed by each equipment group
- A set of communication mezzanines that implement various fieldbus protocols: WorldFIP (2.5Mbps), PowerLink (100 Mbps), LpGBTx (10 Gbps).

This modular approach will allow us to satisfy various needs of equipment groups. In particular, they can build their systems by either customising the whole kit, or using only some of its elements according to their needs. The customisation of the kit is done by developing application-specific add-in modules and implementing FPGA firmware for the System Board.

We have already designed the WorldFIP FMC and currently we are working together with the Radiation-2-Electronics task force on the PowerLink mezzanine. We are also preparing a first DIOT hardware-demonstrator which will feature an off-the-shelf crate. The System Board for this first prototype will be a modified GEFE board designed by the BE-BI group. This kit will be then used as a prototyping platform to work on a radiation-tolerant power supply and a set of FPGA cores for uniform diagnostics. We will also be able to provide these crates to equipment groups for evaluation and development of their application-specific add-in boards.

Grzegorz Daniluk (BE-CO-HT)
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<tr>
<th>Committee</th>
<th>Dates of Application</th>
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<td>ASSOCIATES AND FELLOWS COMMITTEE (AFC)</td>
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<td>22nd May 2018</td>
<td>Deadline for application – Fellows</td>
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<td>Deadline for application – Associates</td>
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<td>20th November 2018</td>
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<td>Deadline for application – Associates</td>
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<td>NB: Applications from Non-Member State theoretical physicists who seek a post-doctoral position at CERN will be considered at a meeting to be held on:</td>
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<td>22nd May 2018</td>
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<td>5th June 2018</td>
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<td>Deadline for application</td>
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Please note deadlines in bold and Selection dates underlined.
MERIT

Start of performance appraisal interviews: 27th November 2017

 Deadline for completing the interviews: 28th February 2018

 Deadline for signing the MERIT form: 6th March 2018

 MERIT notification letters to Staff members: by end April 2018

The Beams Department (BE) Welcome Event

On Monday, 19th March 2018, the Beams Department will launch a Welcome Event dedicated to our new arrivals. This event is scheduled to take place every 3 months. As this takes place from 9am to 5 pm, please grant your newcomers the opportunity to join this unique experience!

Here the preliminary agenda:

Morning Session

08:45 – 09:00 Registration
09:00 – 10:00 Presentation by Dr. Paul Collier, BE Department Head
10:00 – 11:00 Coffee Break and visit of CCC
11:00 – 12:00 “Accelerators Explained for Everyone without Maths”, Rende Steerenberg
12:00 – 13:30 Free Time

Afternoon

13:30 – 14:00 Visits Organisation
14:00 – 16:00 Guided visits of BE Installations: Linac2/LEIR by Richard Scrivens; SM18 by Erk Jensen
16:00 – 17:00 Welcome Cocktail – meeting with the BE Management
What is going on in BE Administration?

**Within the BE-BI (Beam Instrumentation Group)**

- **Closure of BE-BI-PI section (Position and Intensity) on 31.12.2017**
- **Opening of BE-BI-IQ section (Beam Intensity and Tune Measurement) on 01.01.2018**
- **Closure of BE-BI-QP section (Tune and Position) on 31.12.2017**
- **Opening of BE-BI-BP section (Beam Position Measurement) on 01.01.2018**

End of appointment as BI-PI Section Leader on 31.12.2017

*New BI-BP Section Leader from 01.01.2018*

*Manfred Wendt*

End of appointment as BI-QP Section Leader on 31.12.2017

*New BI-IQ Section Leader from 01.01.2018*

*Thibaut Lefevre*

**Within the BE-OP (Operation) Group**

End of appointment as OP-SPS Leader On 31.12.2017

*New OP-SPS Section Leader from 01.01.2018*

*Karel Cornelis*  
*Verena Kain*
Within the BE-ICS (Industrial Controls and Safety Systems) Group

Closure of BE-ICS-PCS (Process Control Systems) on 14.07.2017
Opening of BE-ICS-AP section (Applications) on 15.07.2017

Closure of BE-ICS-CIC section (Connections and Informatics for Control) on 14.07.2017
Opening of BE-ICS-FD section (Frameworks and Development) on 15.07.2017

Closure of BE-ICS-SDS section (SCADA and Distributed Systems) on 14.07.2017
Opening of BE-ICS-TI section (Tools and Infrastructure) on 15.07.2017

End of appointment as ICS-PCS Section Leader On 14.07.2017
Enrique Blanco Vinuela

New ICS-AP Section Leader as from 15.07.2017
Enrique Blanco Vinuela

End of appointment as ICS-CIC Section Leader On 14.07.2017
Fernando Varela Rodriguez

New ICS-FD Section Leader as from 15.07.2017
Fernando Varela Rodriguez

End of appointment as ICS-SDS Section Leader on 14.07.2017
Peter Sollander

New ICS-TI Section Leader As from 15.07.2017
Matthias Braeger

Within the BE-RF (Radio Frequency) Group

End of appointment as RF-SRF Leader On 31.12.2017
Karl Schirm

New RF-SRF Section Leader as from 01.01.2018
Frank Gerigk
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<td>Lars Jensen</td>
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