

# Accelerator Complex Status

## End week 26 (Tuesday 4 July 2022)

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### Technical Infrastructure (Ronan Ledru):

Statistics:

- About 4'200 alarms.
- 742 phone calls (497 incoming, 245 outgoing).
- 118 ODM created.

Events worth mentioning:

- Wed. 29.06, The Protection relay of the EMD203\*25 has rebooted by himself and tripped. Booster tripped, same event as the 12th of May 2022. The protection has been exchanged the 30th of May
- Thu. 30.06:
  - During the replacement of the protection relay for the EHT102\*59:
    - Electrical perturbation during the reconfiguration at 10:57.
    - Electrical blackout (10sec) after the replacement of the protection relay due to a wrong manipulation at 11h48
  - Fire detection in UX85 caused by some smoke from the ventilation UUV2-00380. EN-CV sent onsite
- Sun 03.07:
  - Few trips of the breaker EMD102\*25 (Booster) because of the ventilation UACW2-00166. The protection relay has been exchanged and the breaker repowered. Green light given to the booster at 20:04
  - Electrical perturbation on the 225kV line between Genissiat and Cornier n°2

Details: <https://wikis.cern.ch/display/TIOP/2022/07/04/TI+Week+summary%2C+Week+26>

### LINAC 4 (Eva Gousiou)

Last night's RP issue has not affected Linac4 so far. This has still been an eventful week with the availability at **90.8%**. The **~14h** downtime was mainly due to:

- [8h] **Electrical network intervention** as agreed in last week's FOM. In the shadow of this EN/EL intervention the main activity for Linac4 was the replacement of the oil in the **DTL1 klystron oil tank**, and the addition of an arc detector in the tank, by EPC/RF teams.
- [3h] The power loss during the electrical network intervention caused **difficulties to the start-up** for various equipment (Source, BTV, Ventilation) with inaccessible FECs and power supply issues giving this ~3h extra downtime.
- [1h30] An additional 1h30 was needed for the proper startup of the **RF cavities**
  - **All cavities** were at incorrect phase despite the fact that the LLRF in the Faraday cage is under UPS. Most probably the short power cut caused a brief dip in power that may have perturbed the electronics bringing them at an unknown state. The LLRF team reset the boards and this fixed all cavities but DTL3 and RFQ (see below). Further investigation into the UPC in the Faraday cage will follow.
  - **DTL3** instabilities in the cavity. Despite the reset described above, DTL3 LLRF was still giving random spikes that would cause beam dumps from time-to-time. Most probably this was also caused by the unknown state of the LLRF electronics. The team decided to replace the DTL3 LLRF module the day after.
  - **RFQ** was having several breakdowns at startup. The LLRF team changed the feedback control process from the Kalman to a slower PI control and like this the cavity stabilized

at nominal voltage and the cavity was operational; possibly during the restart the RFQ needed more time to warm up and be stable before enabling the feedback. The day after, the control was switched back to the original Kalman.

- [1h] The day after the electrical network intervention it was decided to stop the machine for 1h to finally exchange the **DTL3** LLRF module and reboot the crate; the intervention and retuning successfully finished within the scheduled period and DTL3 seems stable since.
- [15m] **DTL1** trip; this happened before the DTL1 klystron oil tank intervention. The issue seems to come from a spark in the klystron, as there was a small vacuum degradation. From now on the installed arc detector would help in distinguishing between issues in the klystron or the klystron oil tank.

### PS Booster (Gian Piero Di Giovanni):

An eventful week in the PSB which translated in ~80% availability including all stops, hence a longer-than-usual report.

On Monday late afternoon, we started experiencing issues with accelerating the parasitic TOF for intensity ~300e10 ppr. Then the same problem showed up for the nominal TOF and AD. Somehow not on MTE. The LLRF piquet was called and after some investigation until late at night, the expert intervention was required. The issue was tracked down a faulty card of the Beam Orbit Suppression System which was replaced the morning after, when the experts were available. Since ISOLDE was not taking beam, the intensity was reduced on TOF and the SC filled with TOF users to compensate for the lack of intensity until the fix was put in place.

An expected stop happened on Wednesday afternoon, when the communication with the cell EMD203\*25 was lost. As a consequence, several converters tripped requiring an EPC piquet intervention. It took ~1h50 minutes to recover beam for PS, and additional 25 minutes for ISOLDE because of the BTM.QNO20.

The planned EN-EL intervention to replace a protection relay in the Meyrin site took place from ~7h00 to ~15h00 on Thursday, as planned. Afterwards, it took ~3h30 minutes to restart the PSB from the end of the intervention, with all piquets and experts intervening as needed. Moreover, we had a short access after the intervention because of a false contact on the flowmeter of the B14.BSW. When the PSB was virtually ready, we had to wait for a bit longer before the Linac4 sorted out most of the issues with the cavities. Upon injecting beam at ~19h30, we started experiencing several worrisome interlocks from the H0/H- monitor. The foil looked fine after the inspection on camera and we could start the debugging. Most of the issues seemed to come from GPS beam in R2. The experiments (TOF, AD, EAST, MTE, ISOLDE) still required beam despite the degraded conditions and accepted the stops due to faults and debugging. In the end, we had two concurrent issues. The power converters responsible for the position/angle at injection in R2 randomly dropped to zero current causing all beam to get lost and an subsequent interlock from the H0/H- monitor. After identifying the issue, the EPC piquet promptly fixed it and we did not experience any of these interlocks after that. The identification of the problem took longer than desired as no warning appeared or persistently showed up in LASER. The issue is being closely followed up with EPC control. After fixing this problem, an issue with the LLRF in DTL3 caused the beam to arrive at the PSB injection with degraded conditions generating a watchdog interlock. We had to recurrently reset the WD until the issue was sorted out by the Linac4 RF experts on Friday at around 12h15.

Also to be mentioned that during the week we had some unusual watchdog interlocks at injection which were identified to come from the B-Train regulation loop in Ring 4 and affecting the beams at random. For the affected cycle, the marker was slightly higher than the expected marker value. In turn the power converter saw this jump and tried to regulate around it, and finally causing ring 1 to

regulate on a lower B field not only at injection but on the whole cycle. This would generate losses at injection triggering the WD. It was never understood the origin of the problem, e.g. the White-Rabbit transmission was suspected for a while but without real proof of it. All we can say is that after the stop on Thursday we did not have any occurrence of this issue which has been plaguing the PSB 3-4 times/day until then.

After all these events, Friday was mainly dedicated to recover performance, clean up the cycles to guarantee some stable beam for the downstream accelerators/facilities in the week-end and days to come.

Unfortunately, we were hit by another electrical glitch on the EMD102\*25 cell on Sunday afternoon at ~18h00 and we lost cooling, the electrical network and the vacuum pumps communication. The intervention of both EN-EL and EN-CV piquet was required on site. On the way to restart, the equipment powered by the EMD102\*25 tripped again. OP-TI informed the equipment behind both glitches was an air extraction ventilation located in 361/2-003 (ACW2-00166).

After the ventilation was locked-out, the operator restarted the machine. The EPC piquet was rather busy with the restarting the converters which could not be remotely reset. We got beam circulating in the PSB at around midnight and the debugging could start. Unfortunately, at around 1h40 in the morning, we lost communication with several RP monitors in the CPS complex. The RP piquet was contacted but could not restart the system and will need instrumentation experts from the HSE-RP-IL section, so we had no other option than stopping the beam until the issue is repaired. Hopefully tomorrow morning.

Despite the sub-optimal week in terms of availability, the experts maximized the opportunity to progress on a few fronts:

- A new version of the LHC standard 25ns beam with reduced transverse tails has been prepared in the PSB. It includes a change of the tune, adapted resonance compensation and transverse shaving. The beam is ready for the LHC with a bit losses of performance in terms of brightness, but still within the acceptable range. Also ABP and RF experts explored ways to recover the performance with an injection in triple harmonic. The results are promising, but more work is required on this front.
- A new MD cycle for LHC studies with longitudinal emittance up to 3.6 eVs has been prepared for the PS to explore the performance gain at different working points.
- An issue with the triggering timing of the LTB.BCT50 & 60 was identified when running lead ions in the LTB, which would cause the loss of BCT information for protons and would require a reboot of the FEC. A software patch was deployed to fix the issue.
- During the stop on Thursday, the new LLRF firmware, which has been successfully running in R4 for a few weeks, was deployed to the other 3 rings and now the PSB is back to have an homogeneous RF firmware. The upgrade worked well on Thursday when we got beam back and on Friday the experts spent some time to clean-up the settings.
- Last but not least, TE-MSX experts confirmed that the flow of the BTY.BVT101 and BTY.BVT116 is open to the maximum and that we can attempt to power the converters for the 1.7 GeV transfer. EPC will need a few hours to adjust the regulation at this working point. This will have to be coordinated with ISOLDE.

#### **ISOLDE (Emiliano Piselli):**

It has been a very quiet week on the low energy part of ISOLDE, and not good for REX/HIE-ISOLDE

#### **HRS**

Medicis irradiation on Tuesday and Wednesday. Everything worked properly.

## GPS

On Tuesday stable beam tuning with 39K and 64Zn (RILIS ionized) at 50kV to TAS experiment. Excellent transmission to the experiment.

Yield measurements on Wednesday and radioactive beam to users in the evening. Users have collected many isotopes: 78Zn, 79Zn, 80Zn,...,84Zn at 50kV.

On Friday we have prepared stable beam to IDS as well and users have collected the same isotopes listed above on this beamline.

## REX/HIE-ISOLDE

The REX linac was fully phased with beam  $A/q=2.8$  by Tuesday evening. We have commissioned beam energy measurement and we have started phasing HIE-ISOLDE SC cavities, but, unfortunately, on Friday we had a failure of the cooling system of the RFQ RF amplifier and had to stop. Further investigation and discussion ongoing within different experts.

## PS (Alex Huschauer):

Like the other accelerators, the PS had an extremely difficult week with an availability of only 86% considering AFT until now (PSB recovery from an electrical glitch still ongoing). Please find below a summary of the main events of the week:

### Monday 27.06.:

- Intensity of parasitic TOF beams degraded from the afternoon, and over night all TOF beams (dedicated and parasitic) were affected. Understood on Tuesday to be caused by a malfunctioning horizontal PSB TFB system.

### Tuesday 28.06.:

- Studies performed to improve T8 spill on BPM1 (horizontal tail visible)
- SPS SIS test-implementation to monitor the status of high-frequency cavities needed for LHC-type beams (to be further extended and more functionality included, but provides important information already considering this simple implementation)

### Wednesday 29.06.:

- issues with PA.C20-92 and therefore switched to PA.C20-80 awaiting expert intervention this week
- 20 mins due to issue with radial loop that required the front-end to be rebooted
- several bad shots occurred on HiRadMat cycles —> solved by adjusting the PS-to-SPS synchronisation via the radial position (earlier synchro-locking)
- PS inhibit button got stuck and required an intervention
- 10MHz cavity trips during the night

### Experience restarting on Thursday after the EN-EL intervention:

- multiple piquet and expert interventions required to get the machine back into an operational state
  - most of the issues could be resolved by Friday afternoon, as many systems were affected and help from many equipment groups was necessary
- multiple communications lost following the power cuts:
  - C10 cavities, EAST area magnets, diamond BLMs
- multiple elements down following the power cuts:
  - injection and extraction **kickers**
  - **PE.BSW22** electronic card needed replacement
  - **POPS** tripped on cooling water —> fixed by CV piquet
  - several **front ends** in bldg. 351

- **TFB V** needed piquet intervention to come back online
- **EC clearing solenoid** in TT2
- **BPMs** not available until Friday afternoon following a configuration problem after the power cut (problematic as injection trajectories couldn't be verified)
- **diamond BLMs** back online after expert intervention
- other issues:
  - significant **extraction losses** on all beams during restart
    - **PR.DHZ18** was all green in the working sets, but actually idle instead of cycling and hence **not pulsing** → solved by piquet intervention
  - once extraction losses were resolved, it was realised that also **injection losses were too high** → **BTP.DHZ20** down with similar symptoms as DHZ18 → piquet intervention
  - LHC-type beams:
    - 12b couldn't be delivered due to strong perturbation of the beam on flat top despite a synchronisation that looked ok
    - understood on Friday to be linked to one of the **PFW circuits (PR.WFNP)**, which had **lost its configuration** parameters and showed high ripple that perturbed the B-field → worst effect on 2BP cycles (LHCINDIV, LHCPILOT, AD), but also 3BP cycles affected
    - **C40-78** didn't follow the programme, 40 MHz cavities had to be swapped first, but since Friday evening only operating with one 40 MHz cavity

#### Saturday 02.07:

- several trips of 10 MHz cavities (full group due to coarse tuning or especially C10-36)
- several resets of KFA71 / module 6
- trip of BHZ378 causing downtime of beams towards SPS for more than 1h
- EAST SX significantly improved by reworking the settings
  - horizontal tail measured by IRRAD reduced and intensity to other targets increased

#### Sunday 03.07.:

- BCMS prepared at 1.9E11 ppb for SPS MD on Monday
- PSB / Linac4 still recovering from a power glitch at 18h.

#### PS - East Area ():

No report.

#### AD - ELENA (Pierre Freyermuth):

Besides some regular AD main quadrupole power supply trip, one of the main event of the week is indeed the major power cut on Thursday.

This black-out did not spare the powering of the AD and Elena electron-cooler filament. These delicate devices must have their current ramped up slowly, during 6 hours. Some main breakers had to be put back for several elements in ELENA, and more globally many devices needed the first-line or the specialist to restart. For example the vacuum valves, AD mains, kickers and septa.

This event also induced what we feared, namely an AD orbit change around the e-cooler. It took the all Friday for our accelerator physicists Laurette and Davide, and the all team, to recover around 90% of the AD performance. Fine tuning is still needed as the AD behavior changed.

Sunday evening another power cut happens. While I'm writing this, I'm waiting for the injectors to recover. A quick tour of the AD and ELENA elements let me think we might restart with less problems than Thursday.

### SPS (Arthur Spierer):

The week started with the follow-up of last week's issues with losses during SPS to LHC transfers. The orbit at extraction and steering in the transfer lines were (re)set up by Monday night. After this, the 144 bunch trains could be extracted for the LHC scrubbing. The HiRadMat program started on Tuesday only and was successfully completed by Wednesday afternoon with a good beam availability ranging from pilot to 288 nominal intensity bunches. In parallel the NA beam was steadily provided and no issues observed with the ZS. Several inspections and maintenances took place in the SPS during the EN-EL electrical intervention on Thursday from 7 to 15h that caused the injector complex to stop. Overall the SPS had a good week with 87% availability and faults mostly coming from the injectors.

Monday was dedicated to the setting up of extraction orbit and the LHC transfer line steering which finished around midnight. Problems were arising with 48 bunches while now 144 bunches can be extracted. The source of the losses has been identified as an aperture reduction in the SPS extraction area close to TPSC4, which became problematic with earlier changes of the orbit. To provide a maximum of beam time for the LHC beams, the parallel MD block was postponed. The NA beam was still provided but the HiRadMat startup postponed to Tuesday. The 50% amplitude modulation was set up on all the remaining cycle, saving on the average RF power and the economy mode now prevents the 200 MHz RF to pulse. A trip of one of the Mains power converter SMD5 occurred during the night that led to an investigation the day after.

Tuesday, the HiRadMat program went smoothly with the optics change for the new experiment and slow increase of beam intensity. Starting from 10.30 an electrical glitch powered down several crates in BA2, likely during SMD5/13 investigation. After the first line intervention the beam was back around 13h. The PS2SPS MD studies started around 15h and lasted up until the evening with up to  $2.4 \times 10^{11}$  ppb injected. With high intensities, glitches started to appear in the 200 MHz voltages (LLRF) and are being investigated. Emittance measurement of a series single bunch intensities were performed during the night. During day and night and for the rest of the week, the LHC was repeatedly filled with single bunch beams.

Wednesday, the HiRadMat run was successfully completed by 16h. We tried taking the AWAKE beam to investigate instabilities but the window was too short to advance. Several trips of the 200 MHz cavity 4 (Philips) started to occur on SFTPRO. The issue is closely monitored by the experts and the voltage setpoint of this cavity has been slightly reduced

Thursday was dominated by the EN-EL intervention on the 66kV relay in Meyrin, you can find the list of intervention performed in the shadow in the SPS below. All access were completed and the SPS was ready to restart a 15h, although the beam was only received from the injectors around midnight. The SMD5 power converter tripped again on false overtemp error, indicating the repair is not complete. Repeated problems with MAD in several BA (BA1,BA3,BA4) and with the PAD too in BA1 (the token was released but the door to access remained closed).

Friday and the weekend were dedicated to LHC single/multi-bunch, NA and the preparation of SPS MD beams for next week. A one hour stop for Linac 4 was requested in the morning and the phase pick-up frontend was changed in the shadow (improved robustness). Starting from Sunday evening the PSB suffered from an electrical glitch with no time estimate for beam return.

List of access performed:

- Single test for SMD13 power converter BA2 (Olivier) 7->10h
  - SMD13 repaired, resistor on divider bridge
  - SMD5 repaired, play on thermo-switch, maintenance
- TDC2 Vacuum interlock (Chiara)

- TPSC4/extraction area BA4 (Patrik, Chiara)
  - Measurements and intervention done, valve moved
- TPSC4 visual inspection BA4 (Louise)
- TT20/ZS Verify penning gauge cabling BA2 (Abel)
  - OK problème de mise à la terre /Résistance en fonction du type de jauge
- BSHV.11772 motor inspection (scrapper) BA2 (Jerome)
- Small water leak on TT66 magnet BA7 (Philip)
  - Repaired (will be improved @YETS)
- Robot maintenance BA3 (Luca)
- MBB inspection BA3-4 (Maxime)
  - Leak detected in BA4, repaired
- TT81 (Bastien)
- TT80

#### SPS North Area ( ):

No report.

#### AWAKE (Giovanni Zevi Della Porta):

Replaced laser beam dump and commissioned new streak camera.

Laser:

- Vacuum intervention to replace Laser Beam Dump 2 (LBDP2)
- Internal alignment lost at the beginning of the week (light on UV cathode was a factor of 3 low). Fixed after realignment of regen amplifier
- Investigated increased pulse length (up to 180fs) observed in the last proton run. Recovered the nominal 120fs after overall realignment of system upstream of the compressor, and realignment of autocorrelator

Streak cameras:

- New streak camera (brought to the tunnel last week) moved to the "upstream camera" position (previous one sent for repair)
- Realigned "upstream" optical line, from BTV350 to the streak room
- Observed OTR light from electrons focused on BTV350: ready to attempt single-shot and multi-shot measurements of bunch length
- Began installing cylindrical lenses on downstream streak (for high-density plasma measurements), but one of the lenses was delivered with incorrect specifications. New (correct) one arriving in ~2 weeks
- Vapor source visit in preparation for end-of-year interventions
- Elevator stopped working on Wednesday, then fixed. Stopped again briefly in the afternoon. Stopped again on Thursday afternoon. This becomes an issue.

**Next week:** electrons (bunch length measurements, orthogonal steering) on Tuesday. Access for down-to-up streak line, BI DAQ connections, and other preparations for the proton beam.

#### LINAC 3 (Giulia Bellodi):

Linac3 beam commissioning continued during week 26 (27 June – 4 July).

At the start of the week beam was transported through the LBS line for measurements and further down the LEIR injection transfer line.



Foil characterization measurements continued in order to establish a performance ranking. These revealed a problem with one of the foils installed the previous week, now appearing to be missing. A later inspection revealed the foil has been ripped off probably due to a mechanical problem with the stripper arm movement. A dedicated intervention to solve the issue will need to be planned in coordination with LEIR. This will require venting of the sector to clean up the foil debris. For the moment the arm movement has been constrained to avoid further damage and full retraction of the arm is interlocked.

On Thursday, in the shadow of the EN-EL intervention, the source moveable puller calibration was carried out and an access in the PS switchyard took place to repair the ITH.DVT21 steerer (the connections on the magnet were found to be not tightened up properly).

Several issues required attention at restart from the machine stop.

The persistent values of the min/max amplitude setting limits of the RF cavities were lost and values had to be manually retrieved by the expert from data history.

The debuncher cavity went in fault due to a discharge after 20 tuning attempts of the restart sequences – the expert was called for help.

A problem was also found with the ramping cavity tuner calibration range, which was not performed in a proper way. Once this was fixed the cavity could not be restarted and the SY-RF-FB expert had to be called for manual retuning of the cavity.

Beam was handed over to LEIR on Friday afternoon around 16h.

#### LEIR ():

No report .

#### CLEAR (R. Corsini and P. Korysko - CLEAR Weekly Supervisor):

Last week was dedicated to Cherenkov Diffraction Radiation Beam Position Monitor for AWAKE and to Electro Optical (EOS) pick-ups, both experiments in collaboration with SY-BI colleagues. On Monday the operation was delayed by a problem to the laser pulse picker trigger, which was fixed on Tuesday morning. Several scans were then taken, varying the bunch charge and number of bunches per train were taken recording signals from both AWAKE ChDR BPMs and EOS pick-up, eventually leading to the detection of some clear and consistent signals on the ChDR BPM.

Main issues: the programmed power cut on Thursday (replacement of the 66 kV EHC102\*59 protection relay on Meyrin's site) led to a long list of problems (laser, klystrons, magnets, BPMs, pumps, etc.). A big thanks to the RF engineers, laserists and CLEAR operating team, who helped to restart everything in a fast and efficient way. A really stable and high quality beam was obtained less than 20h after the power cut.

#### LHC (Jörg Wenninger & LHC Coordination webpage):

The 6.8 TeV machine aperture was (re)measured at 1.33m, 60 cm (separated beams) and 30 cm. The aperture at 30 cm is good, with a margin of 1 sigma between the TCTs and the IT aperture. At the other two points the apertures are of course largely sufficient with values close to expectations. The loss maps and asynchronous beam dump tests were executed over half a dozen of cycles at injection and at 6.8 TeV to validate the machine for physics and for the intensity ramp up. Abnormal losses were identified in the region of the TCLs-RPs, a verification fill on Sunday identified the TCL6 as the source of the issue. Strangely the abnormal losses appear in vertical loss maps while this collimator is horizontal. Opening the TCL6 by a few mm solves the issue.

The loss at injection for trains improved on Monday without a clear explanation. One TCDIL in TI2 was retracted by 1 mm as it had been found to be too close to the beam, the extraction of beam 2 was re-steered. With this change of conditions scrubbing with 144b per injection was performed Saturday (after the MD) and Sunday.

Floating MD from Friday afternoon to Saturday afternoon, quite successful despite the cancellation of one MD. This MD was replaced by the optics measurements along the ramp.