Minutes PSB Upgrade WG Meeting 5th April 2016

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Agenda (https://indico.cern.ch/event/514686/):

- 1. Approval of Minutes
- 2. Communications
- 3. Follow-up of Open Actions
- 4. PSB RF System Upgrade Availability Studies
- 5. AOB

1. Approval of Minutes

- The minutes of the last LIU-PSB WG meeting #170, available here, have been approved.

2. Communications

- **LIU-PT Meeting:**
  - In the last meeting, S. Mataguez presented the updated schedule for the activities in LS2, available here.
  - The minutes of the meetings with EN-CV and EN-STI have been released:
    - Concerning EN-CV, the missing input about how much work is budgeted in consolidation have to be clarified.
    - There was a worry about possible delays caused by the presence of asbestos in the ventilation units in the tunnel, but, finally, the units can be dismounted without touching the asbestos.
  - The file with the requests for fellows within the LIU-PSB project has been updated.

- **LIU and BE-BI Activities:**
  - A dedicated meeting was held between the LIU management and the BE-BI representatives, see https://indico.cern.ch/event/496749/.
  - A series of actions have been derived and the minutes will be published soon.

- **Status of LIU-PSB Spending Profiles:**
  - K. Hanke presented the status of the spending profiles in Q1 of 2016, see here.
  - Following a linear extrapolation, about 25% of the allocated money should have been spent, **while only 6% of the budget has been currently spent (excluding the pipeline).**
  - It is difficult to expect linear progression in the spending profiles, nevertheless the message should be clear: **It is crucial that the requested money are spent this year, otherwise the CERN management will take control of the LIU-PSB budget and cut away the money not spent.**
  - Several work packages are under spending: **Every work-package holder is requested to have a look at their budget profile and organize the work to make sure that their requested money are spent by the end of the year.**
  - K. Hanke will regularly review the budget status during the year.

- J. Tan commented that about 36% of the budget of BI is allocated to cabling for an early Linac4 connection. If the connection is not performed, this budget may not be spent. K. Hanke acknowledged that similar issues are present in many work-packages, nevertheless the **procurement has to be done independently of the connection happening or not.**

3. Follow-up of Open Actions

- C. Zamantzas/J. Tan on "Make sure that the SRR or ECR for BLM for the PSB and transfer lines is submitted. The SRR or ECR should include FLAT ionization chambers and ionization chambers to replace ACEMs." → J. Tan reported that C. Zamantzas would need an additional month to finalize the ECR. **Action postoponed**

- J.Tan/J.Belleman/L.Soby on "Demonstrate 200 µm resolution for low intensity beam for the turn-by-turn measurement system. Demonstrate reliable operation with new firmware/software. Electronics to be ready for deployment in EYETS 16-17." → J. Tan reported that the work is ongoing and weekly MD sessions are dedicated to the BTMS commissioning. **B. Mikulec mentioned that the deadline for decision should be set at the end of April, as the input is needed for the cabling activities.**

- B. Holzer on "Provide specifications for the wire-scanners." → J. Tan reported that additional time would be needed. K. Hanke added that, according to the last review of the BE-BI activities, the deadline is set to end June and it should be reflected in the LIU-PSB open actions list. **Action postoponed**

- M. Calviani on "Verify the need for new cables in case of an upgrade of the beam stoppers in BTP line for the 2 GeV operation." → K. Hanke reported that the input has been received: the current cables will be re-used and an additional cable of type NE18 has been requested for each beam stopper. A DIC should be prepared. **Action closed.**

- K. Hanke on "Clarify with all the relevant experts the need for new support for the equipment in the BTP line." → B. Riffaud prepared some options. The cost is comparable for the proposed options and a meeting will be organized to finalize the technical decision.

- G. Rumolo on "Clarify the value of Δp/p which should be used in the LIU-PSB related simulations." → K. Hanke reported that G. Rumolo provided the value of Δp/p for the LHC-type beam to be 1.5e-3. W. Bartmann was using a value of 1.07e-3 for his simulation, but, according to W. Bartmann, this modification should marginally impact the specifications of the magnets in the PSB-PS transfer line presented last week. **Action closed.**

4. PSB RF System Upgrade Availability Studies

- O. Rey Orozco presented slides about studies of the availability of the Finemet RF system, see here.

SUMMARY:

- The main scope of the study is to **assess the achieved availability and reliability of the upgrade PSB RF system.**
- Two approaches have been investigated:
  - By using the **commercial software Isograph.**

    - By employing **analytical calculations based on Boolean system probability theory.**
- Isograph offers a reliable and detailed software but, because of the large number of components and redundancy, the simulation is slow, of the order of a day.
- The analytical calculation offers a quick turn-around, of the order of few minutes. One of the aim of the study is to validate the analytical model with the Isograph simulation.

- **The elements are assumed to follow an exponential failure distribution.**
- **The simulation uses realistic models of the PSB RF components and their failure rate, but it does not include failures due to the vacuum chambers.**
- **The yearly operational period was assumed to be 9 months, split in blocks of 3 months. At the end of each block a planned maintenance of 48 hours was assumed.**
- **Planned maintenance phases are not modeled in the analytical calculations, so the validation was performed assuming an operational time lasting 3 months.**
- The analytical model allows for a **sensitivity analysis:** Moving one component failure rate while keeping the others at their nominal values and check the effect on the availability/reliability of the RF System.

- **RESULTS:**
    - Both Isograph simulations and analytical calculations show compatible results, validating the analytical model.
    - **The system is expected to fail 1 time during the 9 months operational time with a maximum total downtime of about 7 hours, of which about 6 will be need to repair the failing equipment.**
    - **The availability, defined as the ratio between the operational time and total time, is estimated to be 99.9%.**
    - **DC supply, ancillary electronics and PLC interlocks are the major components contributing to RF system downtime.**
    - Mosfets failures have a very small impact.
    - **The impact of components failures on the PSB RF system is minor due to the implemented redundancy.**

Detailed Description

- The main scope of the study is to assess the achieved availability and reliability of the upgrade PSB RF system.
- Two approaches have been investigated:
    - By using the **commercial software Isograph.**
    - By employing **analytical calculations based on boolean system probability theory.**
- Isograph offers a reliable and detailed software but, because of the large number of components and redundancy, the simulation is slow, of the order of a day.
- The analytical calculation offers a quick turn-around, of the order of few minutes. One of the scope of this talk is to show the validation of the analytical model.

- **Isograph Availability Workbench:**
    - A modular Monte Carlo simulation code used to optimize maintenance and spares policies, as well as predict system availability.
    - The simulation is composed of so-called Reliability Block Diagrams (RBD) which are used to model system dependencies and behaviour in case of failures.
    - The RBD is made of blocks and nodes which can be connected in parallel or series. A failure mode is assigned to each block. A voting strategy is defined in case of redundant components (blocks).

- **Assumptions for the PSB RF system, based on Finemet:**
  - Four PSB rings. All must be functional. In the RBD blocks they are connected in series
  - Each ring is composed of 36 Finemet cells in parallel. The system to be functional requires 30/36 operational cells.
    - Every 6 cells there is a dedicated PLC interlock and water cooling connected in series.
    - Each cell is composed by DC supply, ancillary electronics and the RF cell, connected in series.
      - A RF cell is composed of its cooling, a Finemet Core and and RF power amplifier, connected in series.
      - The RF power amplifiers is made of 32 Mosfets paired in block 16. Only 7 pairs need to be operational.
  - **The 36 cells are connected with a ceramic gap in series, because a failure of the ceramic gap implies that the entire ring will be compromised.**
  - **The simulation does not include failures due to the vacuum chambers.**
  - **The elements are assumed to follow an exponential failure distribution.** The input data for the mean time to failure (MTTF) and the maintenance time to repair was taken from manufacturer data or expert experience.
  - **The yearly operational period was assumed to be 9 months, split in blocks of 3 months. At the end of each block a planned maintenance of 48 hours was assumed.** This to realistically reflect the current operation cycle where regular technical stops are planned to prevent and fix problems with the accelerator equipment.
  - Two kind of maintenance assumed:
    - **Corrective maintenance** done when the RF system is not available any more due to components failures.
    - **Planned maintenance** scheduled at predefined time. This time is not taken as RF system downtime.
  - **Results:**
    - **The system is expected to fail 1 time during the 9 months operational time with a maximum total downtime of about 7 hours, of which about 6 will be need to repair the failing equipment.**
    - **The availability, defined as the ratio between the operational time and total time, is estimated to be 99.9%.**
    - **DC supply and ancillary electronics are the major components contributing to RF system downtime.**
    - *PLC interlocks failures also contributes to RF system downtime.*
    - **The impact of components failures on the PSB RF System is minor due to the implemented redundancy.**
    - The expected number of spares needed in one operational year:
      - Ancillary electronics: 18 boards.
      - DC Supply: 18 supplies.
      - PLC Interlocks: 1 board.

- **Analytical model:**
  - The system dependencies are model with **Boolean system probability theory.**
  - **Components failures follow an exponential distribution.**
  - **Planned maintenance phases is not modeled**

- **Assuming that the system is as good as new after each planned maintenance, one has to consider and validate the analytical results obtained after 3 months operations.**
- The analytical model allow for a sensitivity analysis: Moving one component failure rate while keeping the others at their nominal values and check the effect on the availability/reliability of the RF System.
- **Results:**
  - The reliability, or probability that no intervention has to be done, is 61%, which agrees with the estimated 64% from Isograph, in particular taking into account of the several approximations done in Isograph modeling as well.
  - The sensitivity to components failure rates, shows that
    - **Ancillary electronics, DC supply and PLC interlocks are the components with more impact in system reliability.**
    - Mosfets have very small impact.
  - The system will probably fail almost each 102 days, which is after the 3 months operations before the planned maintenance.
  - Special attention must be given to ancillary electronics, DC supply and PLC interlock. For instance if their mean time to failure is 10 times smaller, the system will probably fail before entering planned maintenance period.
  - The availability, or fraction of time that can be used for production is calculated to be 99,92%, which is in line with results from Isograph simulations which is estimated to be 99,89%.

- **M. Paoluzzi commented that the key to the excellent predictions is the redundancy of the system.**
- S. Albright asked if aging is taking into account in the model. O. Rey Orozco replied that the aging is not directly accounted in the Isograph model. The system is assumed to be as new after each planned maintenance. On the other hand with the analytical model one can study the sensitivity to an increasing deterioration rate, e.g. because of aging. The results showed which elements are more sensitive as well as how reliable will be the system.

5. AOB

- G.M. Georgiev presented an updated list of the cabling request for the LIU-PSB, available here:
  - The green color code indicates work already done.
  - The orange color code indicates work needed for the 2 GeV upgrade and it is not urgent for the end of this year.
  - The remaining rows summarize the work needed for Linac4 connection. The column highlighted in red indicates which is the missing information for a given request. The typical information missing is a reference in PLAN, an incorrect naming convention, an incorrect cable type, etc, etc.
  - **K. Hanke asked G.M. Georgiev to contact the responsible of each system which did not provide the exact information to make sure their request is completed.**

- M. Buzio presented few proposal for the field control of the switching dipole BT.BHZ10, see here:
  - The extensive measurement campaign carried last year on the main dipole spares showed that the expected issues could be:
    - An history-dependence (order 1e-3 at low field).

        - Symmetric field profile, resulting in complex hysteresis and eddy currents patterns.
        - Difficulties in measuring and simulating the magnet performances.
    - The proposed solutions could be:
        - **A feed-forward current control:** Test on the bench, then apply a ΔI taken in real-time from a table. This will rely on the current of the previous cycle or even better from 2 previous cycles. Complicated solution as the new energy levels would require new measurements.
        - **Measure the field in a single point:**
            - **Using an Hall-probe**, whose resolution is expected to be of the order of few 1e-4. Still to be tested.
            - **Using a NMR-teslameter.** The current control in Java (used for ISOHRS) is considered too slow, but an FGC3 controller is now available on the market. Still to be tested.
            - **Implement a full fledged B-train measurement**. This is the **recommended solution, but it requires new PCB integral coils (2x1 mm thick) and one field marker to be installed in the magnet.**
                - A. Newborough commented that the installation would be possible as the vacuum chamber is currently about 122 mm and the gap is designed to be 128 mm.
                - **The additional cost should be between 50 and 100 kCHF.**
        - **K. Hanke and B. Mikulec recommended to study the feasibility of implementing a measurement of the full fledge B-Train as well as the other possible fallback options and come back with a more precise answer by the end of the year.** → **Open Action**

- B. Mikulec mentioned that RP simulations of the LBE dump shielding requires to remove the un-used CV pipes in the tunnel wall between PSB and PS. The reason is to implement a better shielding, in particular on the top of the wall where the pipes are passing over. The work is indeed planned for EYETS 2016/2017, see here.

- The next meeting is planned for the 19th April 2016.

Assigned to	Due date	Description
M.Buzio	2016-10-31	Investigate and report the options for implementing an online field measurement in the switching dipole BT.BHZ10.