32nd Meeting of the Machine Availability and Reliability Panel (MARP)

Present: A. Apollonio [TE/MPE], E. Benedetto [ATS/DO], T. Cartier-Michaud [TE/MPE], M. Cirilli [IPT/KT], A. Di Meglio [IT/DI], Y. Donon [IT/DI], Y. Foka [EP/UAI], E. Hatziangeli [ATS/DO], A. Raimondo [IPT/KT], M. Sapinski. [ATS/DO], L. Serio [EN/ARP], B. Todd [TE/EPC], M. Vretenar [ATS/DO], M. Zerlauth [ATS/DO]

Excused: R. Steerenberg [BE/OP], J. Uythoven [TE/MPE]

Indico link: https://indico.cern.ch/event/1001473/

Discussion on predictive maintenance for medical accelerators (M. Vretenar)

M. Vretenar presented the Next Ion Medical Machine Study (NIMMS), a Knowledge Transfer (KT) based initiative to apply HEP technologies to the next generation of medical accelerators. While proton accelerators are already commercial, ion therapy is still in early development, in particular due to the size and cost of such accelerators. CERN could have a strong impact on those two points by sharing its knowledge and technology, allowing for more research on ion therapy.

The CERN management is very supportive for this activity. M. Vretenar has the mandate to start a large collaboration, with in particular SEEIST (South East Europe International Institute for Sustainable Technologies) as a key partner and reference user.

For now, NIMMS has defined the following four work packages: 1) Superconducting magnet; 2) High frequency hadron linacs; 3) Gantries; 4) Synchrotron design. Three alternative designs of the machine hosted by SEEIIST are under evaluation: a normal conducting synchrotron, a superconducting synchrotron and a linear accelerator. The normal conducting option is considered the baseline today, but the second and third options could decrease the cost of the facility, while in turn requiring an increased development time.

M. Vretenar expressed interest in having a fifth work package dedicated to Machine Learning / Artificial Intelligence to support the design and operation of an ion accelerator with the objectives of

1) design optimization for reliability of ion therapy synchrotrons (structural dependencies learned from other machines, supporting the choice of one of the three developed designs; the superconducting synchrotron appears as the most reliable option prior to any detailed study);
2) predictive maintenance and operation plans;
3) Procedures for dose delivery (stabilization of the beam intensity).

The time frame of NIMMS is to converge to a final design in the next 4/5 years. SEEIIST is targeting a facility operating in 2029.

Discussions extended the presentation of M. Vretenar, while giving the opportunity to MARP members of presenting their current activities in ML for reliability and availability.

A. Apollonio presented the different application of ML developed in the MPE group: 1) prediction of RF breakdowns in CLIC accelerating structures, 2) fault prediction using the PSB alarm system, 3) quench prediction for FRESCA2 magnet using vibration data. Each project uses 'Explainable Artificial Intelligence' to get the most out of each prediction, especially when studying very complex systems.
L. Serio reported on the studies he has been supervising on the CERN technical infrastructure, working on the development of a platform (with several building blocks already operational) in order to predict failures and dependencies of complex systems.
B. Todd exposed the important contribution ML can do to in the context of Power Converters, in particular following the work of L. Felsberger, a PhD student who worked on failure prediction using alarms of PSB and definition of load balance between redundant power supplies [1].

A. Di Meglio reported on the availability of the IT Department through the OpenLab initiative to support studies in the field of Machine Learning for Accelerators. Y. Donon briefly explained his work on anomaly detection using LINAC3 and LINAC4 data.

A. Apollonio explained that the coordination of ML activities is under definition following the restructuring of the AT Sector. A. Di Meglio explained that the role of IT is to provide resources (CPU cluster, a few tens of GPU) and a software layer for anyone interested, but not to provide human resources working on the case studies. Support on the case studies should be provided by the involved groups and technical experts. M. Zerlauth underlined the importance of working on a common framework to give access in a consistent and intuitive way to all available CERN data sources (NxCALS, Post-Mortem, Alarms, etc.).

M. Vretenar concluded that there seems to be an interest from the MARP to be involved in the NIIMS project. He proposed having a link person within the MARP for the additional work package. After this is clarified, a more formal plan or project proposal can be developed, and the involved resources discussed.

MARP members further discussed the role the MARP could have in the project. Further discussions are needed, possibly involving C. Roderick to discuss the plans for support on data extraction and synchronization.

Outcome of discussions on reliable electronics design in ATS (A. Apollonio, B. Todd)

Postponed.

[1] Putting ML into Practice: Data-Driven Reliability Optimization for Particle Accelerators Systems https://indico.cern.ch/event/974740/