1st XLINAC Topical Workshop

28 April 2014

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This work is part of EuCARD-2 Work Package 5: Extreme Beams (XBEAM).
Abstract:
The milestone report summarizes the first workshop organized by EuCARD-2 Task 5.4 “Extreme Linacs” (XLINAC) in April 2014. The workshop was organized at Lund in Sweden. The purpose of the workshop was to bring together and enhance the knowledge and the communications in the community of beam physicists, beam diagnostic experts and operators for the improved and efficient commissioning of the proton linacs.
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<th>Name</th>
<th>Partner</th>
<th>Date</th>
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1. INTRODUCTION

The task 5.4 “extreme linacs” of EuCARD-2 looks at the challenges involved in the high power, high energy, in other words the Extreme Linacs. One of the challenges of these accelerators is how to commission them efficiently and timely considering the delicacy of the components and the high power of beam or RF power. The commissioning is an important in the life of an accelerator that could significantly affect its performance over the coming years of operation. The increased number of linear accelerators under design or at the verge of commissioning, especially in Europe, demands for increased collaboration on commissioning on proton linacs.

The first EuCARD-2 XBEAM-XLINAC workshop on beam commissioning was held aiming to bring together and enhance the shared knowledge as well as the communications among and within the beam physicists, beam diagnostic experts and operators for the improved and efficient commissioning of the future high power proton linacs.

This XBEAM-XLINAC workshop took place at the European Spallation Source, ESS, in Lund, Sweden, on 2018 April 8th and 9th. The workshop was sponsored and supported by EuCARD-2 and ESS.

2. BASIC DETAILS ABOUT THE WORKSHOP

<table>
<thead>
<tr>
<th>Type of activity</th>
<th>Workshop</th>
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<tr>
<td>Title</td>
<td>EuCARD-2 workshop on beam commissioning of the proton linacs</td>
</tr>
<tr>
<td>Date</td>
<td>2014 April 8-9</td>
</tr>
<tr>
<td>Place</td>
<td>Tänkarkanken, European Spallation Source, Lund, Sweden</td>
</tr>
<tr>
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<td>Scientific community</td>
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<td>31</td>
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<td>International</td>
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<td>Partners involved</td>
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3. WORKSHOP SUMMARY

The presentations and intense discussions at the workshop yielded the following insights and conclusions.

A commissioning plan is needed few years in advance, since such a plan will define the number, type and location of the required beam diagnostics needed for setting up an accelerator.

One should be careful while defining the required diagnostics for the purpose of beam commissioning and, in particular, not rely on diagnostic devices which themselves need major beam times to debug and commission. In case of discrepancies with simulation data it would otherwise be hard to judge whether the problem lies in the diagnostic and its corresponding electronic, or the diagnostic is measuring the right value, but the beam parameters differ from expectation. This concern is especially true for the diagnostics that directly follows the source, and for which there is no other source of information to confirm or reject the findings.

For the selection of the set of diagnostics, depending on the type of accelerator, one should find the optimum ratio between the longitudinal and transverse diagnostic devices. One should also consider the diagnostics which are needed for daily operation.

Another point in favour of formulating a commissioning plan long ahead of the actual commissioning is the definition of the different types of beam modes that the accelerator should provide. These beams should have enough charged particles to provide a signal at diagnostic devices higher than those caused by the background noise, while at the same time the charge population should be small enough not to cause any damage to equipment or people while the accelerator is being tuned up.

One example, for the case of the ESS linac, is the detection by beam loss monitors (BLMs) for which a beam pulse of length between 50 and 100 µs is needed to induce a BLM signal above the background noise. Also possible use cases for low current/emittance beam(s) should be identified for the commissioning, if required.

Eventually the achievement goals should be precisely quantified for a particular commissioning objective or measured parameter, including specific criteria for considering an objective to be achieved, with dedicated-time limits and a decision path for passing on to the next phase.

To confidently measure the beam properties out of the source one should use a set of beam diagnostics that have already been tested and commissioned. As mentioned, commissioning the source and beam diagnostics at the same time one does not allow a distinction if one or the other part is the faulty component. Additional diagnostic elements in the linac are advised as back up for broken or faulty diagnostic elements. Redundant beam diagnostics and/or measurement techniques should be considered to avoid potential issues in case of diagnostics or measurement failure. Redundancy does not mean two monitors of the same type but rather complementary diagnostics or measurement techniques.
Though the main workhorses of a diagnostic system are the BPM, BCT and BLM devices, in high power accelerators one should consider measuring the beam profile and halo before the latter is lost on some structure. This is especially important since the budget constraints usually limit the number of relevant diagnostic devices.

Using the 3-profile method instead of quadrupole scans for emittance measurement is recommended, as the latter could cause beam defocusing and consequent beam loss downstream of the measurement point.

The commissioning objectivesbeam measurements which could not be fulfilled with existing in-line diagnostics should be identified and mitigation measures be proposed (e.g. additional in-line diagnostics or a temporary diagnostics bench).

Diagnostic benches, the components of which could later be used for in-line measurements, are valuable tools to gain useful information about the beam or the accelerator structure.

Dual applications of the same device as well as the sharing of devices among labs would reduce the cost and design efforts. This requires an early identification of synergies in terms of diagnostics needs for different parts of the linac.

Components of a common temporary diagnostics line may later be installed in the actual downstream linac (with potentially no extra diagnostics required).

With increased collaboration among laboratories the community should consider reusing some unused components, e.g. dipole magnets, from other labs. Similar beam energies out of RFQs and DTL tanks increase the possibilities of using shared devices at different labs.
4. FUTURE PLANS

At the end of the workshop a strong interest was expressed to have another similar beam commissioning workshop in the future.

It is also planned to organize a workshop on the high power coupler needs of extreme linear accelerators. The preliminary time frame is the academic year of 2014-2015.

ANNEX: GLOSSARY

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ESS</td>
<td>European Spallation Source, Lund, Sweden</td>
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<tr>
<td>CERN</td>
<td>European Organization for Nuclear Research, Geneva, Switzerland</td>
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<td>CEA</td>
<td>Centre Energie Atomique, Saclay, France</td>
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<tr>
<td>DESY</td>
<td>Deutsches Elektronen-Synchrotron, Hamburg, Germany</td>
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<tr>
<td>GANIL</td>
<td>Grand Accélérateur National d'Ions Lourds, Caen, France</td>
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<tr>
<td>INFN LNL</td>
<td>Laboratori Nazionali di Legnaro, Legnaro, Italy</td>
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<tr>
<td>INFN LNS</td>
<td>Laboratori Nazionali del Sud, Catania, Italy</td>
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<tr>
<td>ISA / Aarhus Uni.</td>
<td>Aarhus University, Aarhus, Denmark</td>
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<tr>
<td>Max IV</td>
<td>Max IV Laboratory, Lund, Sweden</td>
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<tr>
<td>ORNL</td>
<td>Oak Ridge National Laboratory, Oak Ridge, US.</td>
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<tr>
<td>SNS</td>
<td>Spallation Neutron Source, Oak Ridge, US.</td>
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<tr>
<td>PSI</td>
<td>Paul Scherrer Institute, Zurich, Switzerland</td>
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<td>RAL</td>
<td>Rutherford Appleton Laboratory, Oxford, UK.</td>
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<tr>
<td>BLM</td>
<td>Beam Loss monitor</td>
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<td>BPM</td>
<td>Beam Position/Profile Monitor</td>
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<td>BCT</td>
<td>Beam Current Transformer</td>
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<td>RFQ</td>
<td>Radio Frequency Quadrupole</td>
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<td>DTL</td>
<td>Drift Tube Linac</td>
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