Energy Efficiency of Particle Accelerators: A Networking Effort within the EuCard2 Program

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**Abstract:**

EnEfficient is an Integrating Activity Project for coordinated Research and Development on Particle Accelerators, co-funded by the European Commission under the Capacities Programme. Within the networks EuCARD² we address topics around energy efficiency of research accelerators. The ambitious scientific research goals of modern accelerators produce huge requirements in beam power and beam quality for those research accelerators. In combination with the usual need for the power consumption and environmental impact of the research facilities becomes a major factor in the perception of both funding agencies and the general public. In this network we continue and focus the R&D done individually at different research centers into a series of workshops.

We cover the topics “energy recovery from cooling circuits”, “higher electronic efficiency RF power generation”, “short term energy storage systems”, “virtual power plants” and “beam transfer channels with low power consumption”. Our network activities are naturally open to external participants. With this work we will introduce our energy efficiency topics to interested participants and contributors from the whole community.

**EnEfficient**: A Networking Effort within the EuCARD² Program

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**Task 1: Energy recovery from cooling circuits**

Modern high power accelerators usually dissipate a lot of their consumed energy in cooling circuits of electronics, magnets and RF. Using the generated waste heat for the overall efficiency and helps in reducing operation costs. Within this subtask state-of-the-art methods for making use of waste heat are to be evaluated. Cost versus revenue scenarios are investigated. A collection of heat inventory data in all participating labs has already been conducted.

**Task 2: Higher electronic efficiency RF power generation**

One of the main power consumers in accelerators is the RF. At a recent EnERR workshop, 44 international experts were discussing new ideas of how better RF systems could be conceived and built. It should be noted that high efficiency in RF power conversion not only reduces the power consumption and thus running cost, but also reduces the power lost as heat and the carbon footprint. The power and cooling installations become smaller as well. Klystrons reach efficiencies of up to 65% today. Revolutionary new ideas implying “core oscillations” and the “BAC method” (bunch–align–collect) make the 90% efficiency range achievable.

**Task 3: Short term energy storage systems**

The overall high energy consumption of accelerator research facilities suggests to use them for energy grid stabilizing. Instead of increasing the energy production in times of high demand it is as effective to reduce the overall power consumption. The scheduled winter shut down at CERN is an example for this procedure on a long term basis. If a facility identifies enough power consumers which can be switched off on short notice, ideally without impact to the facility’s routine operation, they can form a virtual power plant. For identification of power using devices which are possible candidates to be part of a virtual power plant the power consumption of the entire facility has to be analyzed. A survey of the electrical energy use of the present GSI accelerator complex and science campus has been done.

**Task 4: Virtual power plants**

Electrical energy storage on time scales of seconds up to around a minute can contribute to the safe and efficient operation of accelerators. Short interruptions of the grid can already lead to unwanted beam aborts. During the often long recovery time the full grid power is needed leading to inefficiency. Energy storage at accelerators is even more important for pulsed operation of high power klystrons or ramped magnets. The negative feedback of a strongly fluctuating high power load on the electricity grid can be avoided by a short-term storage.