EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-EP/86-47
April 9th, 1986

**AN ALTERNATIVE CONCEPT FOR HIGH-VOLTAGE SYSTEMS
USED IN ELECTRON COOLING**

C. Habfast, H. Poth, B. Seligmann and A. Wolf

Institut für Kernphysik, Kernforschungszentrum, Karlsruhe, Fed. Rep. Germany,
and
CERN, Geneva, Switzerland

ABSTRACT

The present high-voltage systems of electron coolers with cathode and collector at high potential and a grounded drift tube require complicated electrical arrangements. An alternative concept to that of the standard design is discussed.

(Letter to the Editor of Nuclear Instruments and Methods in Physics Research)

In present-day electron coolers, the electrons are accelerated from a cathode at a negative high potential into a grounded drift tube. At the end of the cooler the electrons are decelerated and collected in an electron collector. Typical electron currents range between 1 A and about 20 A. The electrons are decelerated in the collector in order to achieve a high power-collection efficiency. This means that both the collector and the cathode are at almost the same potential, whilst the electrons on their way from the gun to the collector are surrounded by walls which are at ground potential.

A typical high-voltage (HV) block diagram for an electron cooler (fig. 1) shows the main drawbacks of this concept. The standard technique is to supply the cathode and the collector from a HV platform, which is biased with respect to ground potential via a highly stabilized power supply. The platform also houses other power supplies, which deliver, for instance, the cathode-collector voltage, or provide other electrodes with the required potential. The full electron current has to be handled at the HV level, although the precise stabilized power supply has to provide only the loss current of 10^{-4} to 10^{-3} of the primary electron current.

This implies major disadvantages with respect to the control of the system and the data-handling. Many key parameters have to be set from the HV platform. Also, the relevant currents and voltages have to be measured at high potential; the data then have to be transferred to ground potential. Moreover, the heating of the cathode, including its controls, has to be done from the platform. Since the collector usually has to be water-cooled, three cooling circuits are needed: one water circuit on high potential, an oil circuit between the high-tension platform and ground, and finally the water circuit at ground potential.

Nowadays electron coolers aim at voltages much above 100 kV. These coolers are operated in a vacuum environment of the order of 10^{-10} to 10^{-12} Torr. The vacuum system, including the big ceramic high-tension feedthroughs at the gun and at the collector, has to be capable of undergoing full bakeout. Owing to the compactness of the electron cooling devices, the high-voltage connections have to be kept in an SF_6 atmosphere in this voltage regime. The coincidence of these two conditions complicates the system even more.

Therefore we propose to have the drift tube at high potential, keeping the cathode at ground and the collector on a small positive potential. In this scheme the electrons are accelerated in the gun from the cathode, through an acceleration column with anodes increasing in potential to the desired final voltage. All along the drift region from the gun to the entrance of the collector, cylindrical electrodes at the desired potential are installed on ceramic supports, thus leaving the vacuum chamber at ground potential. The collector itself is at a small positive potential above ground so as to prevent the electrons from returning to the cathode. This scheme is illustrated in fig. 2. It has the following advantages: The flow of the full electron beam current from the collector supply back to the cathode is kept at ground level. The high-power collector supply as well as the cathode heating is operated and controlled from ground potential. The feedthroughs, which have to conduct high currents (cathode heating, gun, and collector), have to insulate only against moderate voltages. Only the potential for the drift tube—and, possibly, for the voltage dividers of the acceleration and deceleration columns—has to be provided by the stabilized high-voltage supply. The acceleration and deceleration columns may also be supplied by separate units. A further advantage is that in case of a supply failure, the electrons cannot hit grounded parts of the vacuum chamber. The HV feedthrough for the drift electrode can now be installed outside the guiding magnets of the electron cooler, where there is plenty of space. No big insulators are needed, neither on the gun nor on the collector side.

Further improvements may be considered. First, the collector vacuum chamber could be insulated from the rest of vacuum system by a short ceramic tube, thus making it possible to set up a collector-cathode voltage of a few kilovolts and to use that part of the vacuum chamber itself as the collecting surface. The cooling windings for the collector could then be mounted on the outside of the vacuum chamber and the heat could be directly transported to ground potential over a small potential difference only, without any load on the main supply. This would further simplify the mechanical structure of the collector and increase its robustness.

Finally, in the proposed scheme a feedback system could be installed, which would enable the remaining ripple of the drift tube voltage to be measured and then corrected for by making a further adjustment to the cathode potential. The cathode will then be not exactly at ground but regulated in the range of a few volts. However, this is also possible with present systems.

In summary we think that this concept is very promising since it simplifies electron cooling systems considerably and also reduces the cost of power supplies and controls, and the effort needed for their installation.

Figure captions

Fig. 1 : Schema of the HV electronics of an electron cooler with drift tube at ground potential.

Fig. 2 : Proposed schema for electron cooling high-voltage systems.