THE NEW HERA H$^-$ RF VOLUME SOURCE

J. Peters, Deutsches Elektronen-Synchrotron DESY,
Notkestraße 85, 22607 Hamburg, Germany

Abstract

The HERA H$^-$ RF volume source has been running for more than 25000 h without interruption for maintenance. The source delivers 40 mA pulses of H$^-$, 150 µsec in length with a repetition rate of 8 Hz (duty cycle 0.12%). The H$^-$ ions are produced without Cs. The status of the source design and new developments are presented.

1 SOURCE SET UP

Fig. 1 shows the source set up. Central is a ceramic chamber of Al_2O_3 with an external rf coupling. The chamber plasma is ignited by a small cell, the ignition source, in which a spark gap is installed. It is situated directly behind a piezo gas valve and operates with the high gas pressure of this area. H$^-$ ions are produced inside the plasma chamber and a small collar. This collar can be adjusted in horizontal and vertical direction together with the plasma aperture. With this device a beam steering of ±3° can be done. The extracted H$^-$ and electrons are accelerated to 36 keV and separated in a magnetic spectrometer. The electrons are dumped on a grooved graphite block. With the following four quadrant magnet the beam is steered horizontally and vertically on to the axis of the solenoids. Between the two solenoids there is a chopper system in order to vary the beam pulse length between 10 and 150µsec.

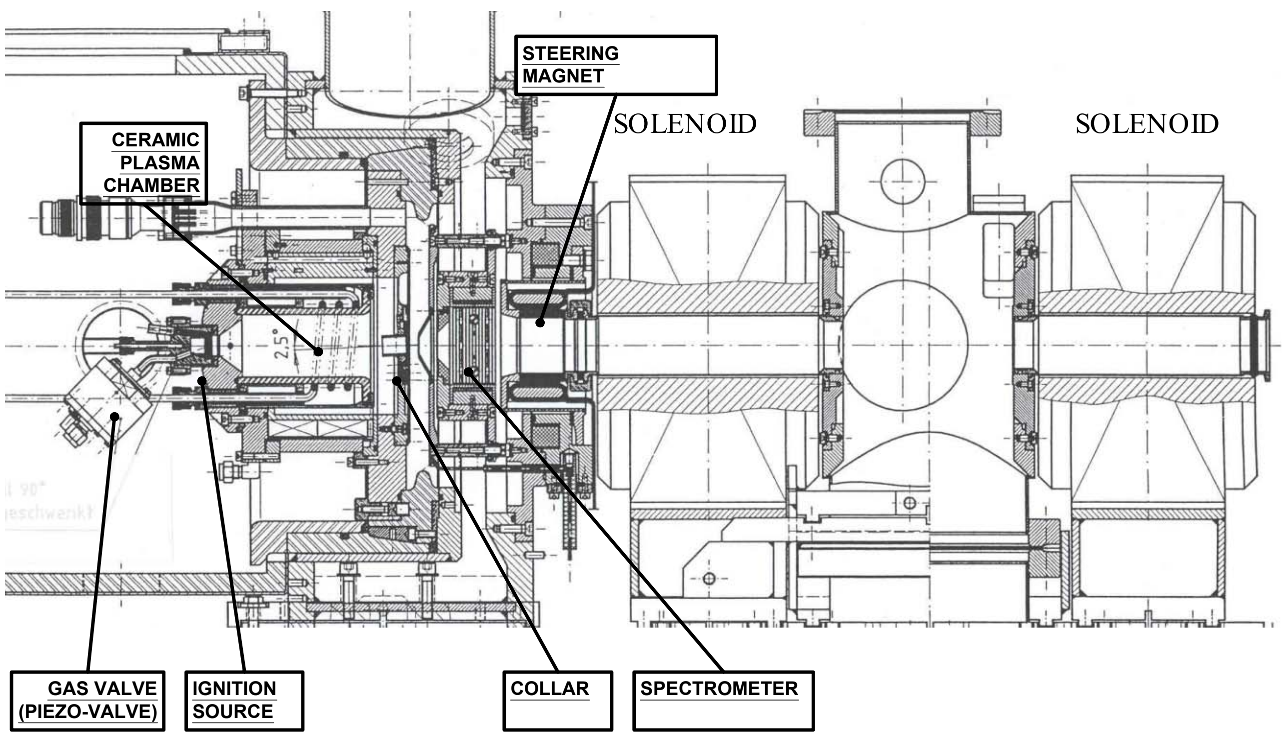

Figure 1: Source set up.

1.1 Gas Valve and Ignition Source

In an accelerator such as the HERA LINAC 3 it is important to have a good vacuum. For this reason and in order to reduce sparking and maintain high fields at the accelerating gap the gas flow is pulsed with a piezo gas valve. A spark gap is not feasible in the chamber of such sources due to the low gas pressure of about 5 mTorr for optimum operation. According to the Paschen law one would need either a long distance between the electrodes or a very high voltage under these conditions. This can be circumvented by introducing a tandem arrangement with an ignition source in the gas pipe connected to the source, using the higher pressure in the pipe for ignition. This small source then injects electrons into the main plasma chamber. For details see [1].

1.2 External RF Coupling and Plasma Chamber

The external rf coupling coil situated around a $Al_2 O_3$ ceramic chamber is shown in Fig.1. After extensive experiments with internal antennae which are immersed in the plasma this design was developed. It can be shown that there are six basic reasons why an external RF coupling is superior to internal coupling. Details are given in [2].

1.3 Collar

The collar is situated behind the plasma aperture which is opposite to the extraction electrode. A collar deneutralizes the plasma. It reduces the density of positive ions by producing H^-, H^0 and H* out of H^+ and H_3^+ on its surface. A negative collar voltage emphasises this effect as long as one can feed more electrons into the collar. For details see [3].

The H^- beam leaves the plasma at an angle of about 2°. The angle is dependent on the magnetic field in the collar extractor region. Several source designs [4], [5] correct this effect by tilting the source. There are also sources where the bucket is moveable during operation [5]. At DESY a different approach was used. The collar can be moved together with the plasma aperture in both horizontal and vertical directions (see Fig 2 and 3). Measurements and calculations show that the beam moves proportional to the collar angle. A coupling of collar and extractor movement does not improve the steering or the beam quality for these small angles.

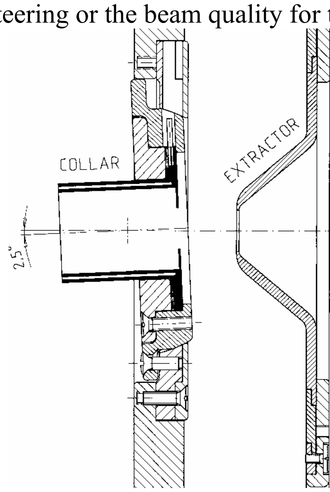

Figure 2: Collar steering and extractor

1.4 Extraction and e^- Dump

Collar and extractor can be moved 3.5 mm in any transversel direction. The aperture diameters are 6.5 mm. The beam is accelerated to 36 keV. There are several possibilities to dump the electrons, which are accelerated

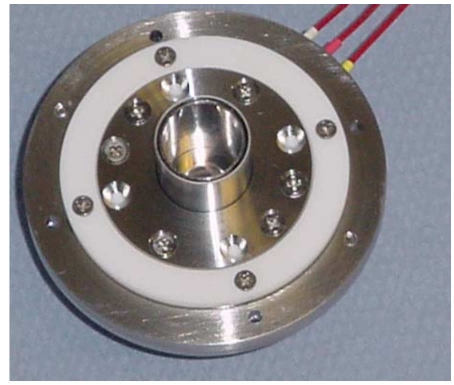

Figure 3: Insulated collar with steering

together with the H^- ions. The beam can be dumped behind (see Fig. 4 A 1,2,3) or in front of the extractor electrode (Fig. 4 B 1,2,3). Dumping after the extractor has the advantage that the space and fields between plasma aperture and extractor can be optimised for extraction in order to avoid space charge problems. The electrons are then dumped at high energy. This is no problem for low duty cycle sources like the HERA rf source. For high duty cycle sources it is possible to reduce the electron beam power by dumping at a lower potential.

Several solutions for e^- dumping have been reported. A simple spectrometer as shown in Fig.4 A1 was mainly used. For example at LBL [6], KEK [7], SSC [8], Grumman [4] and at DESY. Dumping the electrons on the extractor electrode itself (Fig.4 B2) was proposed by LBL [9] but there are no measurements reported. In such a design secondary electrons are more difficult to handle than in A1. LBL [10] also tried to dump the electrons on the plasma aperture plate (Fig.4 B3). It turned out that a clean dumping was not possible. For this reason they now use a dumping system where the electrons are dumped on an intermediate electrode as in Fig.4 B1. Such a system has been in use for some time at TRIUMF [11] and PMI [12].

Volume sources have a rather high total beam envelope divergence of about 250 mrad. For this reason a combination of focussing and dumping close to the extractor as shown in Fig.4 A3 is of special interest. At DESY a transport system consisting of two solenoids is used. Calculations show that it is possible to use these solenoids (or quadrupoles) for both electron dumping and H^- focussing. However such a system limits the possibilities for source investigations. For this reason a very short spectrometer was developed successfully at DESY for the first time, which dumps the electrons and delivers a H^- beam parallel to the axis as shown in Fig.4 A2.

1.5 Emittance

Emittances of $\varepsilon^N_{90\%RMS}$ =0.25 π mm mrad were measured at 38mA current out of the spectrometer (type: Fig. A1).

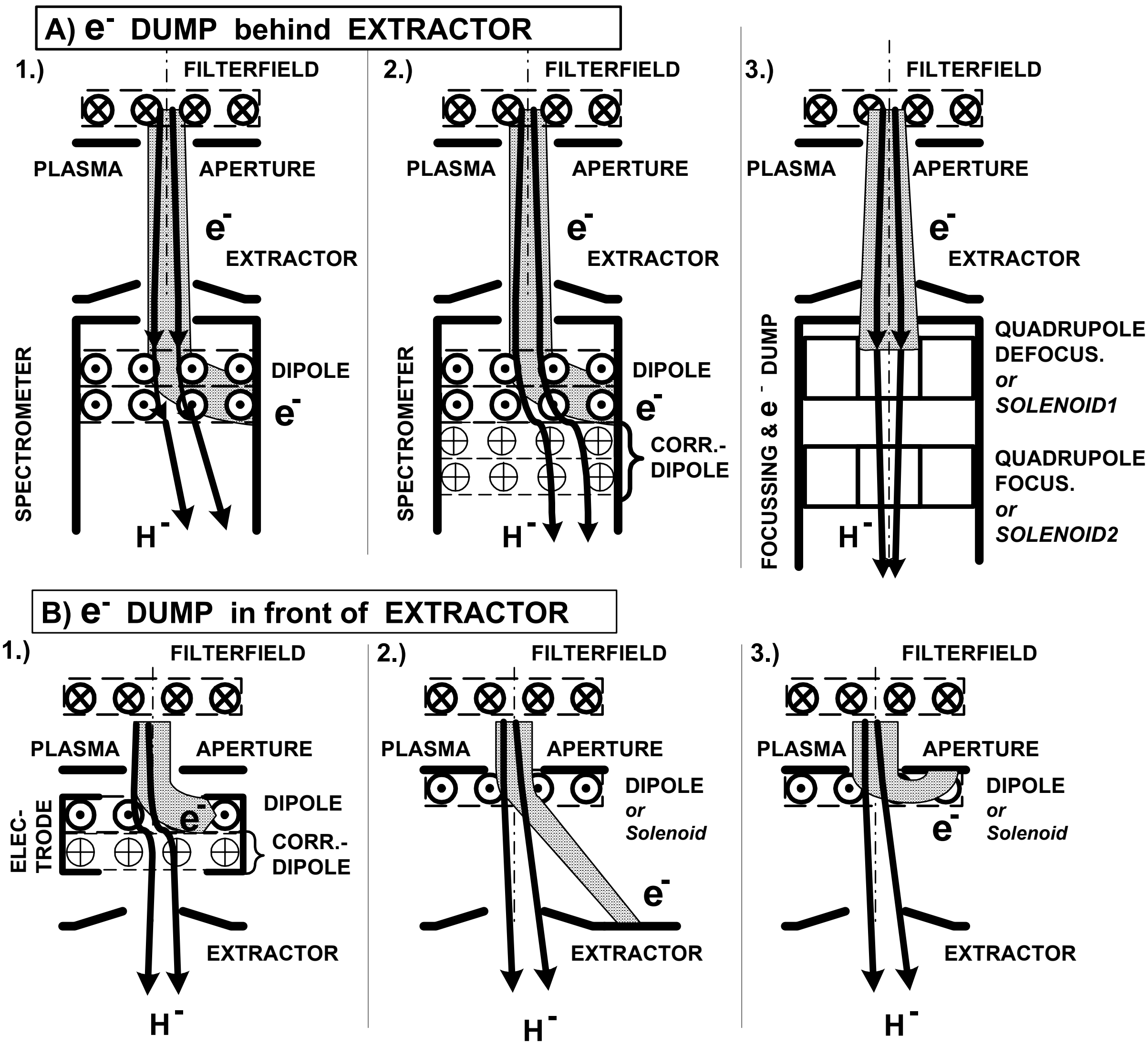

Figure 4: Configurations for dumping e^-

2 ACKNOWLEDGMENT

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