THE HERA VOLUME H^- SOURCE

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Abstract

The HERA RF-Volume Source is the only source that delivers routinely a H^- current of 40 mA without Cs. It has been running for years without interruption for maintenance. The production mechanism for H^- ions in this type of source is still under discussion. Laser photodetachment measurements have been done at DESY in order to measure the H^- distribution in the source. The measurements were done also under extraction conditions at high voltage. The dependency of the quality of the H^- beam on the frequency was investigated. A frequency range of 1.65 – 9 Mhz was scanned and the emittance was measured for several H^- currents up to 40 mA. The results of our investigations make further source improvements possible. Recently currents of 60 mA were reached. The design of the source is explained and alternatives are discussed.

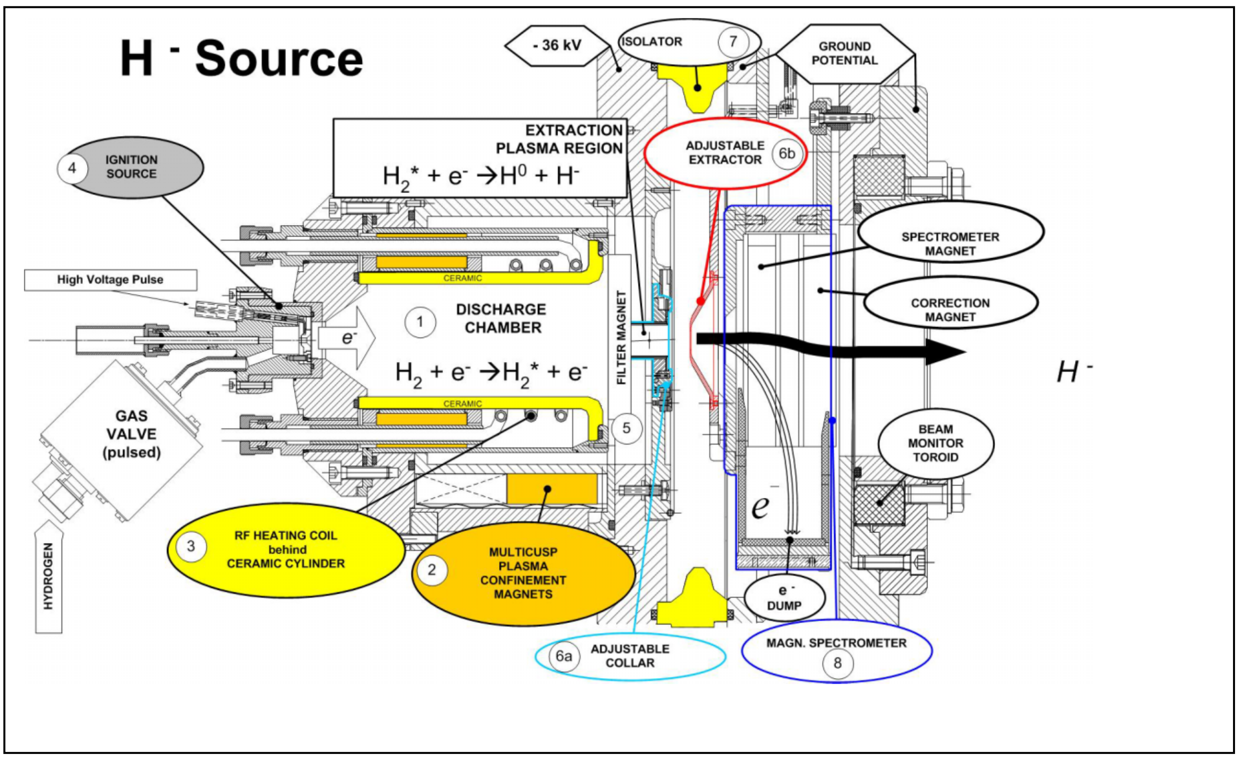

Figure 1: DESY HERA Volume H^- Source.

SOURCE DESIGN

Fig. 1 shows the DESY HERA Volume H^- source [1, 2]. The production part of the volume H^- source consists out of three parts: discharge chamber (1), filter field (5) and extraction plasma region. The plasma of the discharge chamber is confined by two sets of multicusp magnets. One behind the rf coil with 12 and one above with 20 magnets (2). The plasma heating is done with an rf coil (3) which is protected from the plasma by a ceramic cylinder. For ignition a small source (4) injects electrons into the plasma. It works with the high pressure of the gas valve pipe. In the discharge chamber (1) fast electrons are generated which produce vibrationally excited H_2* molecules. Slow electrons of the discharge chamber pass the dipole permanent magnet field (5) into the extraction plasma region. Fast electrons are rejected. In the extraction plasma region H^- are formed out of vibrationally excited H_2* and slow electrons. A 13 mm ∅ cylinder (6a) the so called collar forms the critical part of the extraction plasma region. It is closed by a thin metal sheet with an opening of 6.5 mm ∅. The direction of this collar can be adjusted. It is isolated and biased. The collar reduces the extracted electron current. A negative bias relative to the source body increases the H^- current and stabilizes the beam. Extraction is done at 36 kV with a diode system. The extractor electrode (6b) can be moved in x, y and z direction. It is on ground potential. The horizontal and vertical adjustment is done with eccentric rings (see Fig.2). A ceramic ring (7) isolates the source body. Transversal filter field components in the gap are compensated by the leaking spectrometer field. The field

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changes its sign and is almost zero. The magnetic spectrometer (8) which follows the extractor (6b)

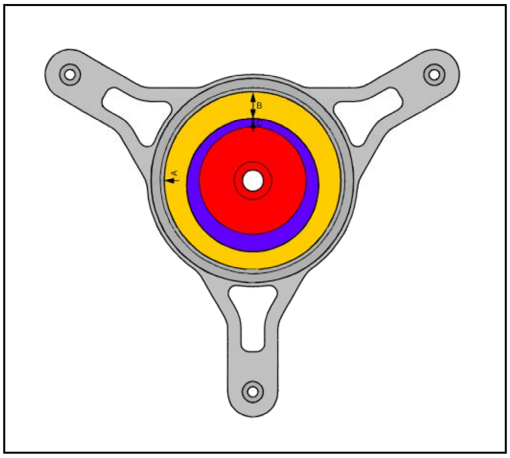

Figure 2 : Extractor electrode horizontal and vertical adjustable by eccentric rings.

is encapsulated in a box that is opened to the source exit side. A first pair of permanent magnets bends the electrons into a dump box with a wide gap and graphite walls. It can be isolated and biased in order to reduce the dumped electron power. This type of dumping makes sure that no secondary particles are transported back into the area of the H^- beam even when the source energy changes. A second dipole magnet bends the H^- back on a line parallel to the source axis. In table 1 the alternatives to the design of the HERA H^- source are compared with the solutions of other sources.

FREQUENCY DEPENDENCE OF THE H^- BEAM QUALITY

A cooperation between DESY and Frankfurt University made it possible to bring a transmitter tunable with four coils and a capacitor in the range between 1-13 MHz to DESY. A coupling box with a variable transformer and a tunable capacitor was built by DESY. The power delivered to the source is influenced by the skin effect, parasitic capacitances and the proximity effect. Power measurements were done with a dual directional coupler. Measurements directly at the coil turned out to be very difficult due to the nonlinear characteristic of the source load and the phase sensitivity of the parameters.

It turns out that with the set up used a frequency range between 2 MHz and less than 4 MHz demonstrates the best power efficiency. For higher frequencies the plasma penetration is reduced due to the skin effect, the voltage drop over the coil increases, parasitic capacitances and the proximity effect become more effective. In the low frequency range the voltage drop and the electrical field is reduced. These two effects can be compensated partly by a higher number of windings for the coupling coil.
current

Measurement of the Emittance vs. Frequency

Fig. 3. shows the frequency and H^- current dependence of the 90% rms emittance. The dependence on the H^- current was used for comparison because this is a parameter which can be measured easily. The curves demonstrate almost the same characteristics. This might be due to a slight change in the position of the beam. Only the 4 MHz curve seems to be different. Note that it is difficult to keep all parameters during the long emittance measurements constant. Especially the gas pressure and the tuning of the coupling series resonance seem to be very sensitive.

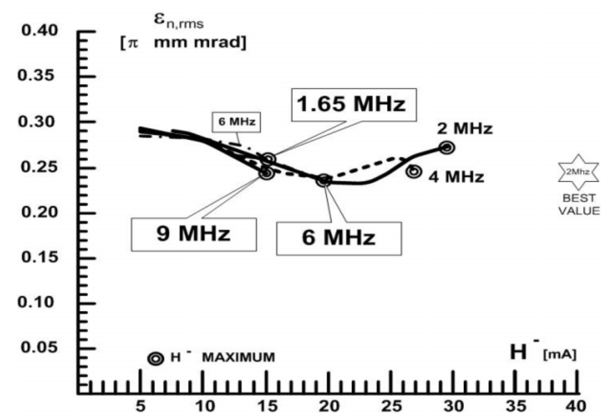

Figure 3 : Frequency and H^- current dependence of the rms emittance.

For comparison also the best emittance is given which was measured with the original DESY transmitter and couple box set up.

PHOTODETACHMENT MEASUREMENTS

In the HERA source a modification of a technique with a cylindrical metal probe (Langmuir probe) aligned parallel to a laser axis was used. The probe tip was moved step by step in rectangular planes perpendicular to the beam axis. The x and y movement is done by turning the probe in a joint the z motion by pulling the probe in and out. The movements in x, y and z are done with a three table system. A long bellow is used for transforming the movements into the vacuum.

The size of the planes over which measurements were done varied from 4mm x 4mm in the collar area to 10mm x 10mm in the RF coil range and had in the final part of the source a size of 6mm x 6mm. All measurements were done with a 0.5 mm step size. The z planes were measured in 5mm steps.

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Table 1: Comparison of design alternatives

ALTERNATIVES			
HERA H^- SOURCE		OTHER SOLUTIONS	
+	-	+	-
3 EXTERNAL ANTENNA		INTERNAL ANTENNA	
No deterioration			short lifetime, punctured
4 IGNITION SOURCE		FILAMENT, UV FLASH,[CONTINIOUS MODE]	
long lifetime		simpler	short lifetime,[vacuum load]
5 internal FILTERMAGNETS		external FILTERMAGNETS	
strong magnetic field in front of the collar	has to be vacuum tight	no vacuum necessary	lower magnetic field which is less homogenous
6a COLLAR		NO COLLAR	
highest currents are reached, improved e/H^- ratio		simpler	High electron currents
6a MOVEABLE INSULATED COLLAR		FIXED COLLAR no bias,(moving the source)	
higher current, adjustment of beam position bias stabilizes		simpler	less optimizing (complicated)
6b EXTRACTOR ADJUSTABLE in X,Y and Z		FIXED EXTRACTOR,(moving the source)	
higher current adjustment of beam position		simpler	less optimizing (complicated)
8 MAGN. SPECTROMETER with wide DUMP		MAGN. SPECTROMETER, with DUMP ELECTRODE.	
save, no H^+ or other secondary particles that interfere		simpler	not secure when the beam energy changes
8 MAGN. SPECTROMETER w. BEAM CORR.		MAGN. SPECTROMETER no BEAM CORR.	
simple			additional beam steering

Fig. 4 gives a 3D sample presentation of typical H^- intensities measured on selected rectangular areas along the source. It was possible to associate measurement patterns to different zones of the source. The H^- intensity (Nh-) is proportional to the additional electron current delivered due to the laser pulse . The Nh- are given in arbitrary units. Z is the distance in mm measured from the beginning of the source. Measurements were taken at 0 V and at 10 kV extractor gap voltage. For details see [2].

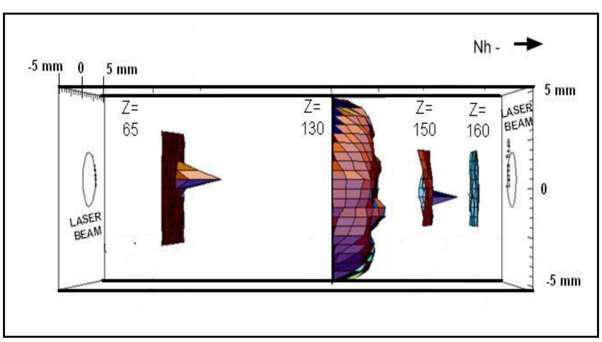

Figure 4: 3D H^- intensities measured with photodetachment.

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