Upgrade of the BATMAN Test Facility for H^- Source Development

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Abstract. The development of a radio frequency (RF) driven source for negative hydrogen ions for the neutral beam heating devices of fusion experiments has been successfully carried out at IPP since 1996 on the test facility BATMAN. The required ITER parameters have been achieved with the prototype source consisting of a cylindrical driver on the back side of a racetrack like expansion chamber. The extraction system, called "Large Area Grid" (LAG) was derived from a positive ion accelerator from ASDEX Upgrade (AUG) using its aperture size (ø 8 mm) and pattern but replacing the first two electrodes and masking down the extraction area to 70 cm^2. BATMAN is a well diagnosed and highly flexible test facility which will be kept operational in parallel to the half size ITER source test facility ELISE for further developments to improve the RF efficiency and the beam properties. It is therefore planned to upgrade BATMAN with a new ITER-like grid system (ILG) representing almost one ITER beamlet group, namely 5 x 14 apertures (ø 14 mm). Additionally to the standard three grid extraction system a repeller electrode upstream of the grounded grid can optionally be installed which is positively charged against it by 2 kV. This is designated to affect the onset of the space charge compensation downstream of the grounded grid and to reduce the backstreaming of positive ions from the drift space backwards into the ion source. For magnetic filter field studies a plasma grid current up to 3 kA will be available as well as permanent magnets embedded into a diagnostic flange or in an external magnet frame. Furthermore different source vessels and source configurations are under discussion for BATMAN, e.g. using the AUG type racetrack RF source as driver instead of the circular one or modifying the expansion chamber for a more flexible position of the external magnet frame.

INTRODUCTION

High power radio frequency (RF) driven ion sources for positive hydrogen ion extraction have been successfully developed for the neutral beam heating systems of ASDEX-Upgrade and Wendelstein 7-AS at IPP, Garching [1], [2] and proved very reliable operation over more than 15 years without regular maintenance. Due to their simple design and the basically maintenance-free operation they were also considered beneficial for the negative hydrogen ion sources of the fusion experiment ITER. In addition the caesium conditioning, which is needed to enhance the negative ion source performance, is expected to be easier in RF sources as there is no tungsten evaporated from filaments which buries the Cs layer. Therefore a negative ion RF source development program was started at IPP in 1996 with the small test facility \`BATMAN\` (**Ba**varian **T**est **Ma**chine for **N**egative Ions), on which the prototype source (1/8 of ITER size) is installed with the so-called “Large Area Grid System” (LAG) [3].

The experimental setup is essentially still the same as started with, using many spare components of the positive ion sources and extraction system for budget reasons. In this configuration BATMAN could demonstrate together with the long pulse test facility MANITU [3] which is equipped with the same prototype source and the same LAG extraction system the required ITER parameters [4] and the RF source was selected as the ITER reference source in 2007 [5]. As next step towards the full ITER source the test facility ELISE was built at IPP Garching using a half size ITER source which started operation at the end of 2012 [6], with the first plasma in February 2013. While MANITU was closed, BATMAN will be kept operational in parallel to ELISE, as it is a well diagnosed and highly flexible test facility. It will be used to further improve the physics understanding of the formation and extraction of negative ions and to test new concepts. The main interest is devoted to the enhancement of the RF efficiency and to the characterization of beam properties in order to further benchmark the beam codes for negative ions. Therefore a BATMAN upgrade is planned for 2015 in order to implement the knowledge gained over the years. It comprises several modifications, mainly a new extraction system, which is also closer to the present ITER design, called "Iter Like Grid System" (ILG). Furthermore source and driver modifications are under consideration to increase the RF efficiency. The paper presents briefly the present status of BATMAN with its limitations and describes the main modifications.

PRESENT STATUS OF THE TEST FACILITY

- The vacuum tank consists of two spherical chambers, each ø 1.3 m, connected together and pumped via two turbo pumps with 2200 l/s each and two titanium evaporation pumps with about 120 000 l/s total.
- The high voltage power supply can deliver 50 A at a total voltage of 35 kV, with a maximum extraction voltage of 10 kV and the acceleration voltage up to 25 kV. However, the feedthroughs for the extraction grid are the same as for the positive ion extraction system and limit the acceleration voltage to 20 kV. Depending on the conditioning status the total voltage is usually below 22 kV.
- The RF generator is the first self-excited oscillator bought at IPP from the company OCEM [7] in the 1980´s for the development of the positive ion RF sources delivering 100 kW at 1 MHz. It is placed on ground potential and the RF power is transferred to high potential via a HV insulating ferrite transformer with a transformation ratio of 1:3.
- The extraction system is derived from a PINI-type positive ion extraction system as used on JET or ASDEX Upgrade [8]. The main insulator, the grid support structure and the grounded grid are being kept, while the extraction grid and the plasma grid have been replaced, called the "large area grid system" (LAG) [9]. Grooves in the extraction grid (EG) between each row of apertures are filled with electron deflection magnets, either in a quadrupole configuration (so that the field does not penetrate into the source upstream the plasma grid) or in a dipole configuration (the field penetrates into the source). Initial experiments with the quadrupole arrangement have shown very high electron leakage and high power loads on the grid. Hence, all further experiments have been performed with the dipole magnetic field.
  The plasma grid (PG) was changed several times, the major campaigns were carried out and ITER relevant parameters were achieved with a 2 mm thick plasma grid and a 2 mm thick cover plate on top with chamfered holes, edge heated up to 200°C with a heating wire clamped onto it [10]. The PG can be biased against the source body and an additional bias plate is installed in front of the plasma grid which is on source potential. As the LAG makes partially use of positive ion grids, the aperture size (ø 8 mm at PG) and aperture position had to be kept to the existing grids. The overall extraction area of 776 holes (0.039 m^2) was reduced by a PG cover plate down to 126 holes (63 cm^2) due to the low pumping speed of the test bed.
- The ion source used on BATMAN is the IPP prototype source, called type 6 source [11]. A 245 mm id alumina cylinder is mounted as driver (plasma volume 8 l) on the back side of the source body (310 mm x 580 mm). A water cooled copper faraday screen protects it from the plasma on the inside. In order to reduce copper sputtering by the plasma, in particular self-sputtering of copper, this shield is additionally coated by a 3 µm thick molybdenum layer. The source vessel is racetrack shaped, 212 mm long (plasma volume is 37 l) with deep drilled cooling channels inside the side walls to control the wall temperature and to improve by that the caesium distribution and conditioning of the source. For a homogeneous temperature distribution the inner side of the source wall is coated by a 1 mm thick copper layer.
- A diagnostic and filter field flange is installed between the source body and the extraction system which provides access in front of the PG for probes and spectroscopy [12]. This flange also houses the permanent magnets creating the filter field. The magnet configuration can only be changed by opening the source and deteriorating the Cs-condition. Therefore for filter field studies an external magnet frame was added which is placed outside of the source vessel side walls and can be slide in axial source direction over a wide range. However, it cannot get as close to the PG as the inner magnets and the field topology is different for the two magnet configurations. Results of experiments with different filter field configurations are described in [13].

UPGRADE OF TEST FACILITY

The operating parameters of BATMAN upgrade are summarized in Table 1. The HV power supply will be upgraded by using the former MANITU supply which is able to deliver 50 kV, 15 A. Furthermore a solid state RF generator is already installed and will be further upgraded with an improved power regulation and will then replace the old self excited oscillator [14]. The main modifications, however, will be a new extraction system and different source and driver geometries, which are described in the following.

TABLE 1. Parameters of the BATMAN upgrade

Isotope	H, D
Extraction area	108 cm^2
Apertures	70, ø14 mm
Total voltage	≤ 50 kV
Extr. voltage	≤ 15 kV
Total current	≤ 15 A
RF power	75 kW, solid state gen.
Pulse length	10 s

EXTRACTION SYSTEM

The entire extraction system of BATMAN will be replaced by a new one except the porcelain main insulator, the neutralizer and the ground support tube. Figure 1 shows an overview of the new extraction system of BATMAN.

The main insulator (820 mm outer diameter, 555 mm length) separates the high voltage potential of the source from the ground potential of the test facility. The ground support tube as well as the water cooled copper neutralizer is taken over from the original BATMAN extraction system. On the source side a high voltage ring (HVR) will be introduced which forms an extension of the main insulator and allows radial access to the grid stack for all different water and current supplies on high potential via insulated feedthroughs. The grid stack itself is also mechanically supported from the HVR and is presented in exploded view in Fig. 2. The end plate of the HVR is designed to be compatible with the existing source vessels and diagnostic flanges.

So far the accelerator structure of BATMAN was based on the structure used for the AUG Upgrade positive ion system which consists of a plasma electrode at +100 kV, an electron repeller electrode at -1.5 kV and a ground grid. This means that in the positive ion systems the large potential drop is between plasma and repeller grid. If used for negative ions the voltage drop between the first and the second electrode is being kept below 10 kV to keep the power loading from the co-extracted electrons onto the second grid at a tolerable level while the main acceleration takes place between second and third electrode. Hence, using a positive system for negative ions changes the voltage holding requirements of the structure and has limited the acceleration voltage for the LAG to less than 20 kV due to the gaps between structural components and due to the design of the feedthroughs at the ground support tube. Furthermore the LAG was designed for a perveance optimum, e.g. a good beamlet divergence, at 5 kV extraction voltage (U_{ex}) while it was shown meanwhile that 9 – 10 kV are needed to achieve the ITER requirements on the extracted negative ion current [10]. At this U_{ex} and the low ratio between U_{acc} and U_{ex} the beam becomes highly divergent (>3.5°) and is partially hitting the EG [10]. Additionally the beamlets are very sensitive to space charge repulsion at the low acceleration voltage.

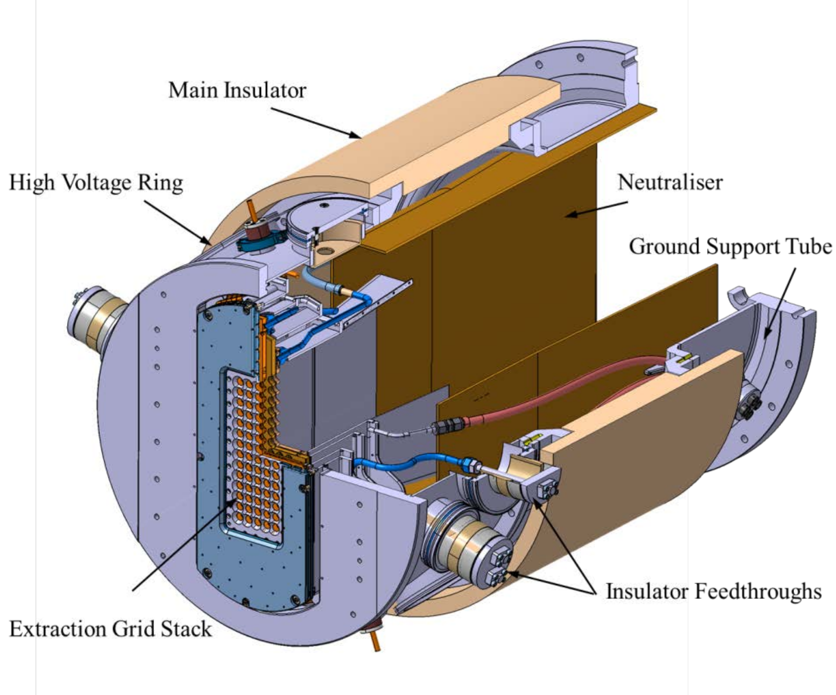


FIGURE 1. New extraction system of BATMAN.

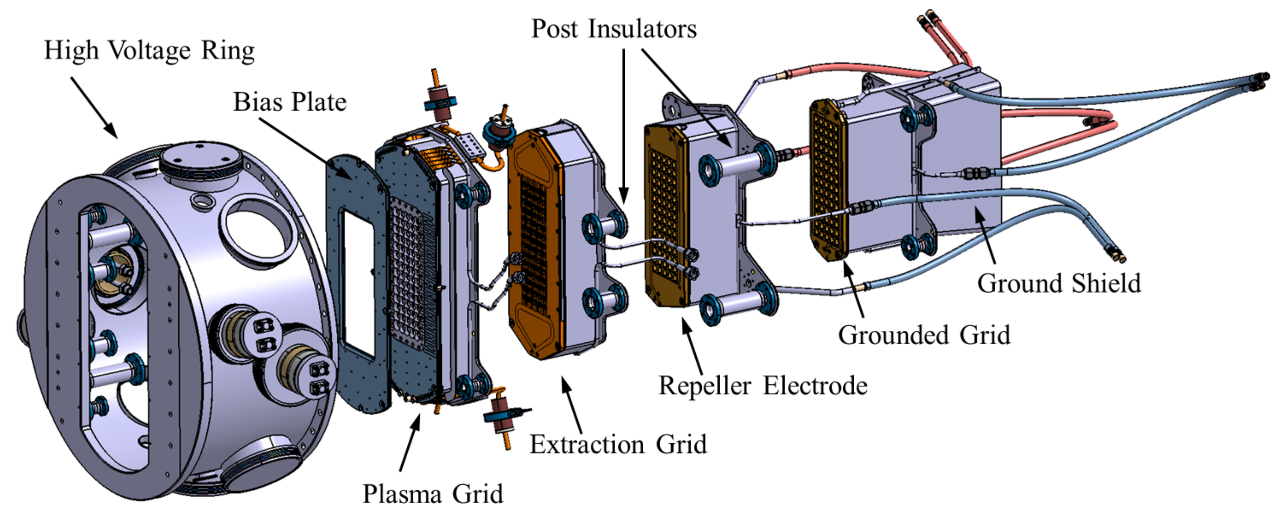


FIGURE 2. Explosion view of the extraction grid stack.

Consequently the measurement and evaluation of the beam homogeneity is difficult to perform. By introducing the HVR which incorporates all feedthroughs at high potential and by a new geometry between the grid holder boxes the total voltage can now be increased to 50 kV, the maximum available from the power supply of this test facility. As this is still very limited for good beam optics it was decided to install optionally a fourth electrode, the "repeller electrode (RE)", between EG and GG which is kept at around +2 kV wrt GG.
In this way a positive potential well is set up stopping positive ions from the drift space downstream of the GG to be extracted towards the source. It is expected that this will bring the space charge compensated drift space closer to the accelerator and thus reduce the space charge blow up. Evidence is provided from experiments at MANITU [15] by comparing the measured divergence (using line integrated beam emission spectroscopy) with calculated beamlet divergence (using KOBRA3, [16]). While the perveance dependency of the divergence fits well between calculations and measurements the absolute value depends on the assumed space charge drift length. For a tank pressure of 10^{-5} mbar the divergence measured along two central lines of sight is far above the calculated divergence under the assumption that the space charge compensation onset is at 0 cm, and still slightly above an onset assumption at 12 cm (Fig. 3).

Furthermore recent experiments at BATMAN with an elevated tank pressure by a gas inlet into the tank have also shown a clear effect on the divergence [17].

Additionally the potential of the RE can be varied in order to benchmark beam optic codes by measuring the currents on the grids and to validate assumptions for the space charge compensation. A minor benefit of the RE is expected for the reduction of the power load on the source back plate caused by backstreaming positive ions. The major contribution of those (several percent of the extracted current) is generated upstream the RE by backstreaming H^+ while only a minority of H_2^+ is created downstream.

All grids are mounted on grid holder boxes which are nested inside each other and supported from the HVR by post insulators. The grids are insulated against the grid holder boxes to measure the currents to the grids independently from the current to the grid holder boxes. The grid spacing can be adjusted with washers underneath the post insulators. In case the benefit from using the RE is negligible, the system can easily be used as a three grid system by grounding the RE or removing the GG and using the RE as GG. Downstream of the GG grid holder box a ground shield is installed to bridge the gap to the

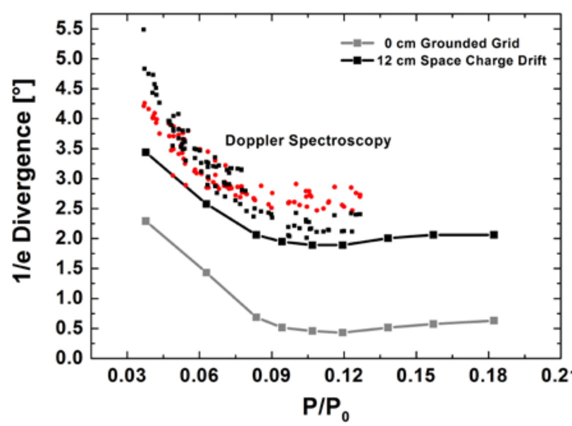
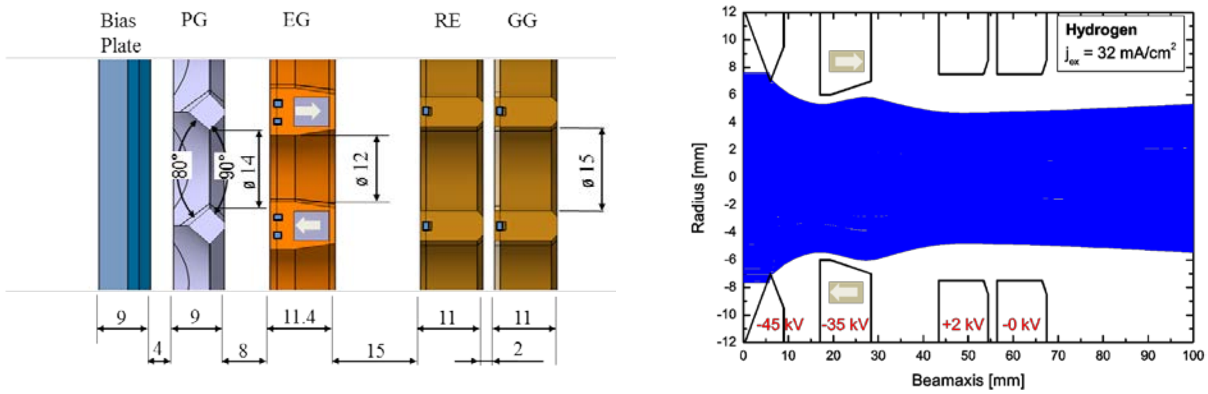


FIGURE 3. Calculated (lines) and measured (dots) beam divergence at MANITU for two central LoS.



(a) (b)

FIGURE 4. Cross section through one beamlet of the BATMAN upgrade extraction grids, (a) geometry, (b) beam optic calculation for H^- current density of 32 mA/ cm^2.

neutralizer and to prevent beamlet deflection by electric fields of the grid support structures. A bias plate (BP) is mounted on top of the PG with a window like opening around the apertures. The potential of the BP can be controlled separately from outside.

The aperture pattern of the grids is identical to the ELISE pattern and very similar to one beamlet group of the ITER extraction [5]. Only the number of apertures has to be reduced to 5 x 14 (spacing 20 mm x 20 mm) while it is 5 x 16 for one beamlet group of ELISE/ITER. This is caused by the geometrical boundary conditions of the stacked grid holder boxes. The total extraction area is 108 cm^2. An aperture cross section through all grids indicating the aperture sizes and spacing as well as its beam optic calculation is shown in Fig. 4. The calculations have been performed with KOBRA3[16] for a current density of 32 mA/cm^2 in Hydrogen for a total voltage of 45 kV, extraction voltage of 10 kV and +2 kV for the repeller electrode. The required current density for ITER of 27 mA/cm^2 in D^- shows similar trajectories due to the broad perveance optimum. Putting the RE on ground potential has almost no influence on the beam optics.

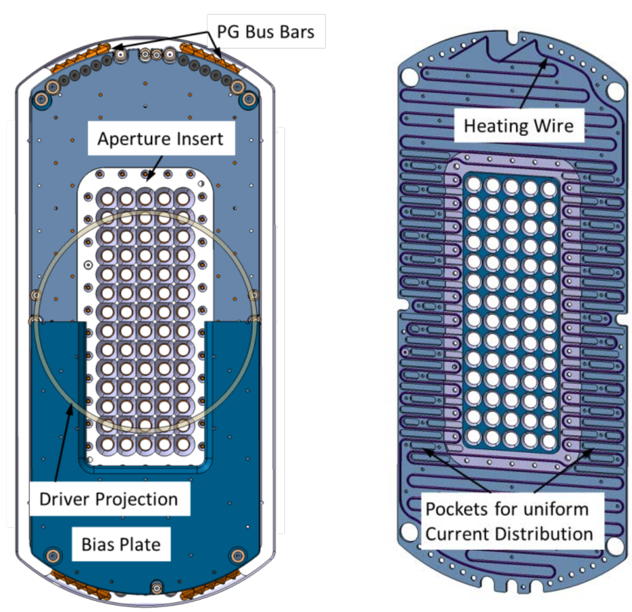
All grids can be accessed for modifications from the source side and can be dis-assembled sequentially, without taking apart the entire grid structure as all water connections are screwed from the plasma side. The alignment of the grids wrt each other is done via two dowel pins which can be inserted through all grids and allow positioning within ± 0.02 mm.

The grids are under construction and will be delivered by end 2014.

Plasma Grid and Bias Plate

In RF sources the PG heating by the plasma is relatively low with 10 - 20 kW/m^2 and therefore it has to be heated actively, while cooling is not required for short pulses at BATMAN. The nominal operating temperature for a well-conditioned caesiated source is 150°C – 200°C [2][3].

The PG is composed of two molybdenum plates (4 mm & 5 mm thick) screwed together to clamp a heating wire between them. This wire is meandered inside grooves of the downstream plate. The aperture group is an independent insert of the PG which allows easier modification of the aperture shape or grid material by only machining the central part and not the entire grid (Fig. 5). The ø 2 mm heating wire is 8 m long with a heating power of 2 kW. This allows to increase the PG temperature by

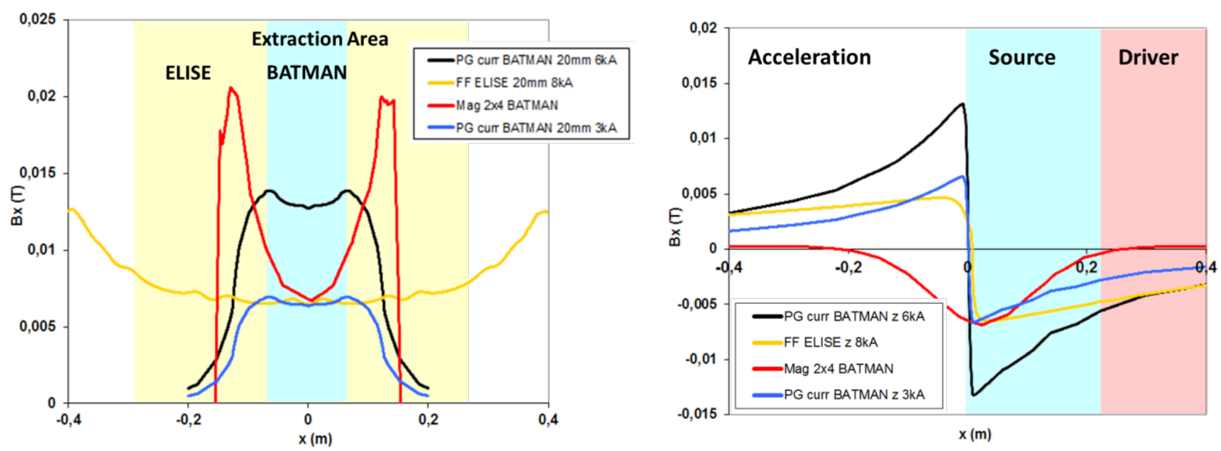


(a) (b)

FIGURE 5. Plasma grid, (a) assembled configuration with aperture insert and bias plate shown on lower half, (b) open configuration, showing the heating wire.

several hundred °C and to study which effect this has on negative ion production. The temperature is measured via thermocouples and controlled from outside.

The BATMAN source has obtained ITER parameters with a magnetic filter field created by permanent magnets which are embedded in the diagnostic flange 3 cm upstream the [13]. For large sources like ELISE and ITER this configuration is not possible because of the source width. Instead the filter field is created by an electric current driven vertically through the PG. In order to compare the different 3D field topologies of both types – the PG filter field shows reversed direction on the downstream side compared to the upstream side of the PG – the new BATMAN setup will include both possibilities. Therefore flexible connectors are foreseen at the top and bottom side of the PG to drive a vertical PG current through the grid (see Fig. 2). In order to make the field across the apertures as uniform as possible pockets are machined across the side wings of the PG (between the heating wire meanders) to reduce the electrically conductive cross section along the sides. FEM calculations for the magnetic field distribution have been performed for the PG current in comparison to the standard permanent magnet configuration as well as in comparison to the ELISE filter field (Fig. 6) assuming the same horizontal field strength in the center of the extraction area. For these calculations the position of the return conductor has not been taken into account, the graphs are showing an infinite long grid. With the position of the return conductor the far ranging tail of the PG current field can be shaped, e.g. compressed into the extraction region and thus providing a low-field zone at the exit of the driver for the plasma flow out.



(a) (b)

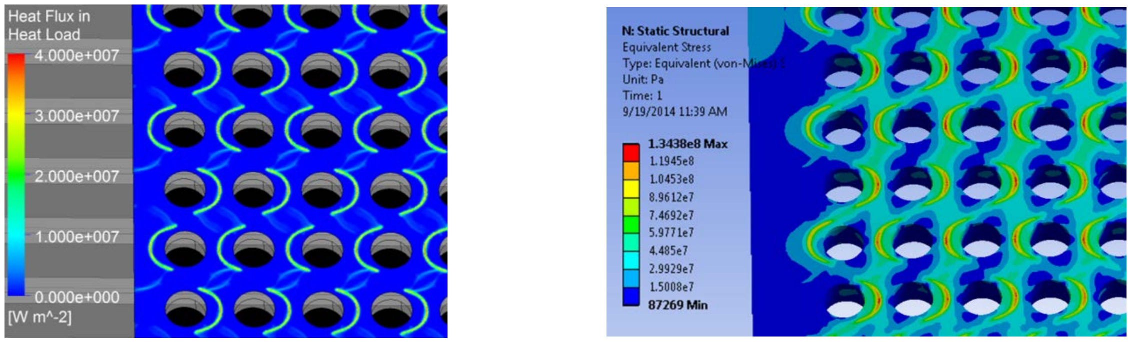
FIGURE 6. Comparison of the horizontal magnetic filter field for the standard permanent magnets (red), PG field with 3 kA (blue), PG field with 6 kA (black) and ELISE PG field with 8 kA (yellow), (a) horizontal profile across the grid , (b) profile along the source axis.

The bias plate can be operated at the PG temperature but is controlled independently; therefore the design is similar to the PG with two Mo-plate layers clamping a heating wire in between. It is screwed on top of the PG via insulators and its potential can be controlled externally.

Extraction Grid

The EG is thermally loaded by impinging co-extracted electrons, which are deflected out of the beam onto the grid surface by embedded electron suppression magnets. The power is deposited in crescent-shaped profiles around the apertures (Fig. 7), changing side each row due to the alternating dipole magnetic field (Fig. 8c). As the new EG for BATMAN is similar to the ELISE grid and operating with the same parameters, the same load conditions and design solutions have been adopted for cooling optimization [18]: For 30 mA/cm^2 extracted electron current density and 10 kV extraction voltage, the localized power density is of the order of 39 MW/m^2 and the total heat load is around 33 kW for the BATMAN grid.

The cooling concept follows the ELISE design with three channels between each aperture row, two wound channels and a central straight channel (Fig. 8). Due to geometrical boundary conditions the channels at BATMAN are arranged vertically, which is in fact favorable as they follow the crescent shaped power deposition profiles. For a uniform water flow distribution between all channels the pressure drop is adjusted by different channel cross



(a) (b)

FIGURE 7. FEM calculations, (a) power density distribution (max 39 MW/m2), (b) resulting mechanical stresses (< 135 MPa).

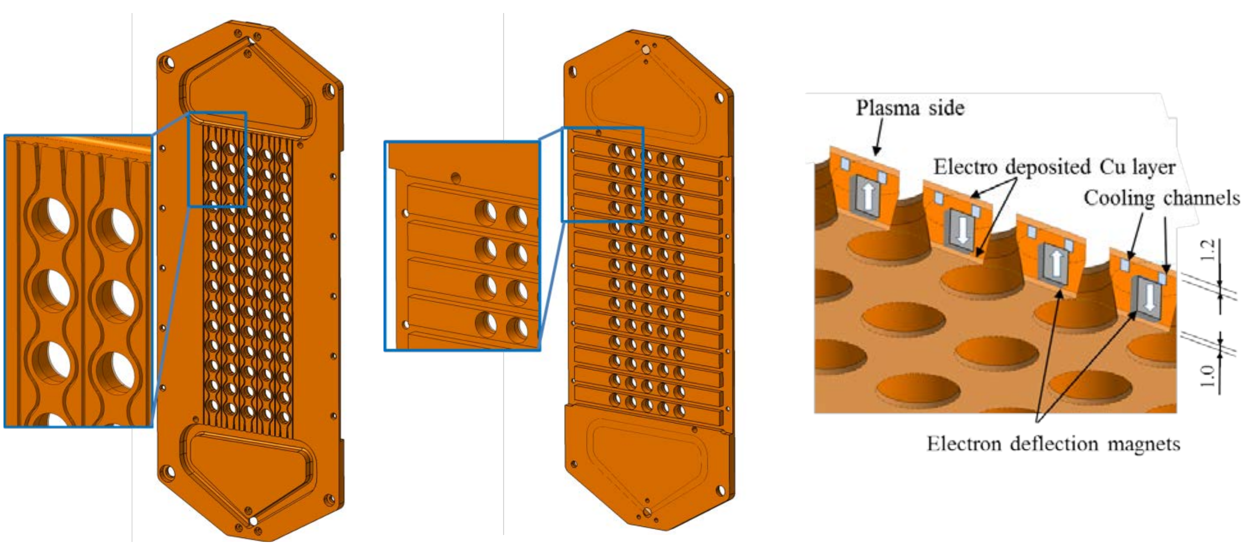
sections, 1 mm width x 2 mm depth for the wound channels, but 1 mm width x 1.2 mm depth for the straight channels. The total pressure drop across the grid is 5.2 bar; the total flow is 0.3 l/s with a maximum flow velocity of 12 m/s. By CFD calculations it was shown that the maximum water temperature increase between mean inlet temperature and maximum local exit temperature stays below 65 °C, with an overall water temperature increase of 30°C between inlet and outlet. According to the estimations given in [18] the calculated critical heat flux is more than a factor 3 above the maximum heat flux for the BATMAN grid. This margin is very beneficial especially during source conditioning and in Deuterium operation, where the co-extracted electron to ion current ratio can easily exceed the ITER design value of one [4].

Figure 7 shows the power density distribution to the EG and the resulting mechanical stresses (< 135 MPa). The maximum out of plane bending of the grid is negligible <0.1 mm.

The EG is manufactured by a two-step electro deposition process of copper onto a pre-machined copper base plate: cooling manifolds and cooling channels are machined on the upstream side between the vertical columns of apertures, while on the downstream side the magnet grooves are embedded horizontally between the aperture rows (see Fig. 8). The latter side is closed by a 1 mm thick electro deposited copper layer, while the upstream side is closed by 1.2 mm in order to keep the internal mechanical stresses at a tolerable level. The magnets (cross section 5 x 6 mm^2) can be inserted and modified via windows on either side of the grid. The standard set up will be the dipole configuration.

Repeller Electrode and Grounded grid

Repeller electrode and grounded grid have identical aperture geometry and cooling channels (1.5 mm wide x



(a) (b) (c)

FIGURE 8. Extraction grid, (a) cooling channels on upstream side, (b) magnet grooves downstream, (c) cross section showing cooling channels and electron deflection magnets, arrows indicate magnetization direction.

1 mm deep, machined horizontally between the aperture rows), they differ only in their outer geometry to fit on different grid holder boxes. The power load on the GG is estimated from ELISE to be about 10% of the extracted beam current, e.g. 11 kW (2 mA/cm^2, 50 kV, 108 cm^2). The cooling channels have a cross section of 1.5 x 1 mm^2 (width x depth) and a total pressure drop of 1.5 bar, the water flow is 0.2 l/s.

Both grids are also made from copper by closing the pre-machined cooling channels with a 1mm thick electro deposited layer.

ALTERNATIVE SOURCE GEOMETRIES

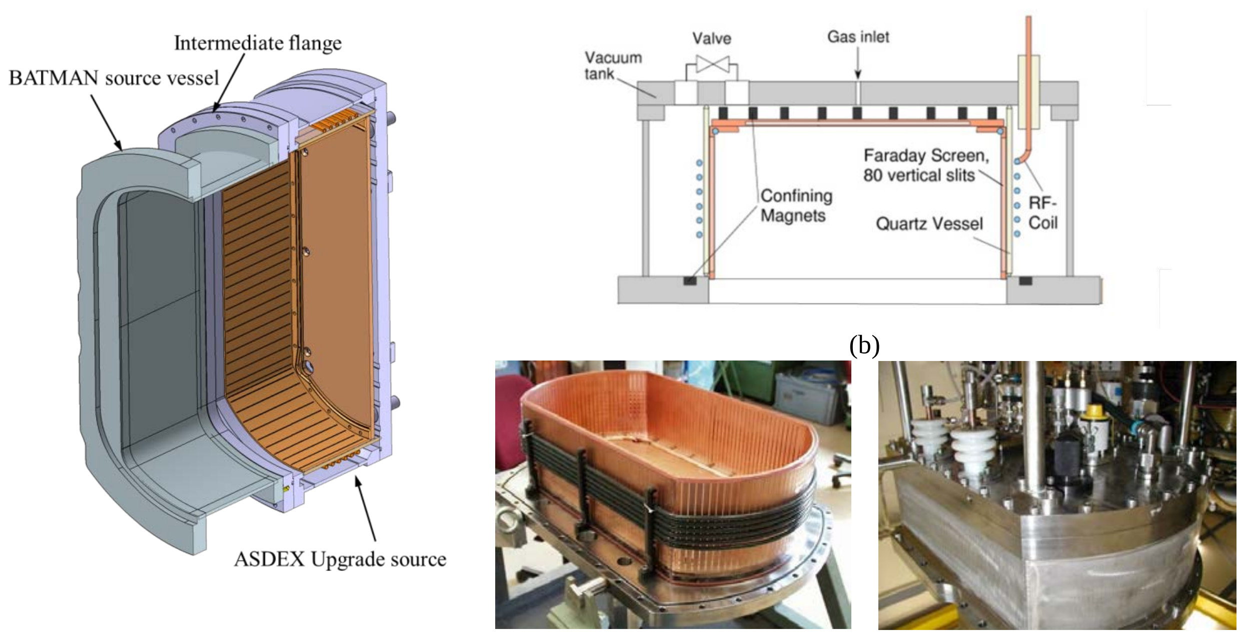
The present BATMAN source offers a large amount of flexibility. The cylindrical driver concept has been extrapolated in a modular way for ELISE with four drivers (slightly increased to ø 284 mm id) and for ITER with eight drivers. So far no optimization of the driver shape has been performed. For large sources other driver geometries might be advantageous which illuminate the large extraction area directly. E.g. for ITER it could be preferable to use four racetrack type drivers aligned horizontally on top of each other with one driver covering one grid segment over the whole width of the extraction area. By combining two circular drivers to one racetrack driver the volume to surface ratio and therefore the efficiency of the source increases as the loss area is reduced for the same plasma volume. Furthermore the dissociation degree is expected to be higher due to the reduced recombination surface enhancing therefore the negative ion production by neutral atoms [19].

Additionally previous experiments at IPP with two drivers being operated by two RF-generator showed a mutual inductive influence of the drivers among each other. An additional RF-shield (copper cylinder around each driver assembly) was installed on ELISE to avoid this behavior. This was assumed – but not proved yet – to be one of the reasons for local damages on the internal faraday shields. Those RF shields have to be water cooled for long pulse source operation in vacuum. Using one single racetrack driver only could make the RF shield needless and therefore simplify the design substantially.

For BATMAN upgrade two source configurations are planned: a racetrack driver on the existing source vessel and a new source vessel with integrated diagnostic access and filter field along its sides. Other options with planar coils or helicon discharges are under investigation for the future.

Racetrack Driver

For a first simple test it is intended to replace the circular driver of the prototype source by a standard ASDEX-



(a) (c) (d)

FIGURE 9. BATMAN source with racetrack driver, (a) assembly (b) schematic of AUG racetrack driver, (c) assembly of quartz vessel, faraday shield and coil, (d) fully assembled AUG racetrack source.

Upgrade (AUG) RF ion source for positive ions [20] via an adapter flange. This source has a racetrack shape with a plasma volume of 35 l (31 cm width x 60 cm length x 19 cm depth) and fits with its shape quite well onto the present BATMAN expansion vessel (Fig. 9). The plasma is confined in a quartz vessel which is internally protected from the plasma by an edge cooled faraday shield with 80 slits. A 6 turn RF coil (PTFE insulated copper tube, water cooled) is wound around the quartz vessel. The entire unit is placed inside a stainless steel vacuum tank as the quartz cannot withstand the air pressure in this shape. The outer volume is pumped via a bypass valve which is opened between the pulses and connects the inner source volume with the outer containment volume. During the pulse this valve is closed. Confinement magnets in chequerboard configuration are placed between the cooled source back plate and the steel back plate. All inner copper surfaces will be coated with a 3 µm thick Mo-layer by a PVD process in order to avoid Cu sputtering.

In this configuration the BATMAN source vessel has no longer the function of an expansion vessel (like for the present prototype source) – as it has almost the same cross section as the racetrack driver – but it is needed as drift region for the electrons to be cooled down and for a homogeneous plasma distribution. As the overall source volume (source vessel + driver) increases from 44 l (prototype) to 72 l (≈ factor 1.6) a shorter vessel length may be favorable. Therefore three different vessel lengths are available: 146 mm (62 l), 180 mm (68 l), 212 mm (standard prototype source length, 72 l). It is furthermore possible to mount the AUG racetrack driver directly onto the BATMAN extraction system (35 l) or just using the standard diagnostic flange in between.

New BATMAN Source Vessel with Diagnostic Access

Figure 10 shows a horizontal cross section comparing the present source vessel (lower half) with the new source vessel concept (upper half) mounted on the HVR. The present BATMAN prototype source has no direct diagnostic access from the side; therefore, an additional diagnostic flange is mounted between the source and the extraction system which houses the filter magnets along the vertical sides and provides access for probes and spectroscopy between the magnets (Fig. 10, lower half). Due to the very limited space available, these magnets can only be changed in strength or direction by opening the source and destroying the caesium conditioning. Additionally an external magnet frame is available which is mounted outside the source vessel and can be slide in axial source direction. In this way the 3D-filter field configuration can me modified to identify the leading parameters for electron suppression and negative ion formation. The experiments are described in [13]. Unfortunately this frame cannot reach the position of the internal magnets (about 3 cm upstream the PG, for which the best results were achieved), as it cannot be shifted above the diagnostic flange. Therefore a concept for a new source body has been developed with lateral contractions along the side walls, which would allow to slide the magnet frame up to the PG level and still have room underneath for some flexible diagnostics, like pin probe cables or light fibers for spectroscopy. The envelope of the inner surface would remain the same as the existing geometry of the diagnostic flange.

The construction of this new source vessel is under discussion now, as it would, together with the PG current, further increase the filter field flexibility.

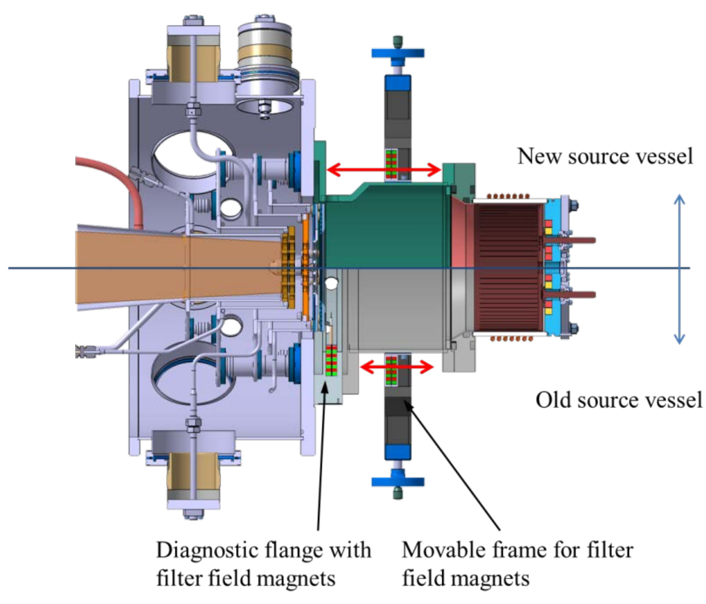


FIGURE 10. Horizontal cross section through BATMAN ion source, lower half: old (present) source configuration with diagnostic flange, upper half: new source vessel concept with lateral contractions and enlarged movement for the magnet frame.

CONCLUSION

After many years of successful operation of BATMAN an extensive upgrade of the test facility is planned as BATMAN will stay in operation as an accompanying experiment to the other test facilities to further improve the physics understanding of the formation and extraction of negative hydrogen ions. The upgrade will integrate the meanwhile gained knowledge and make the experimental setup more ITER relevant. A new extraction system with ITER like aperture geometry (ILG) is under construction with an additional repeller electrode to enhance the space charge compensation. The new system includes the possibility to generate the filter field by a PG current and to compare plasma and beam behavior with the permanent magnet filter field. The total voltage will be increased to 50 kV. In order to increase the RF efficiency an alternative racetrack shaped driver geometry is also under construction using an existing RF ion source from ASDEX Upgrade as driver. As a further upgrade a new source vessel is under discussion which would allow using the external movable magnetic filter frame over the whole source length and incorporates diagnostic access from the side of the source vessel.

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