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Steady-state charge-exchange ion source of 10 mA H^- beam

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Outline

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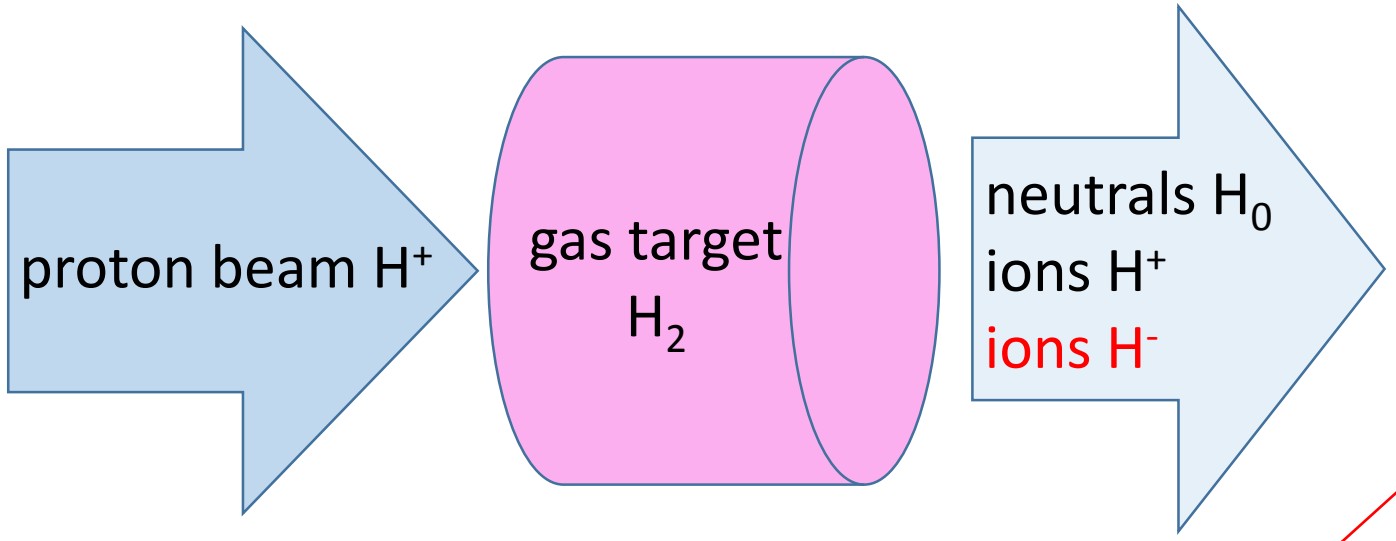
- Introduction
- Pulsed charge-exchange negative ion source at BINP
- Ion species composition in the ion source
- RF charge-exchange negative ion source design
- Simulation of the beam transport
- Transport of the negative ion beam
- Power supplies
- Conclusion

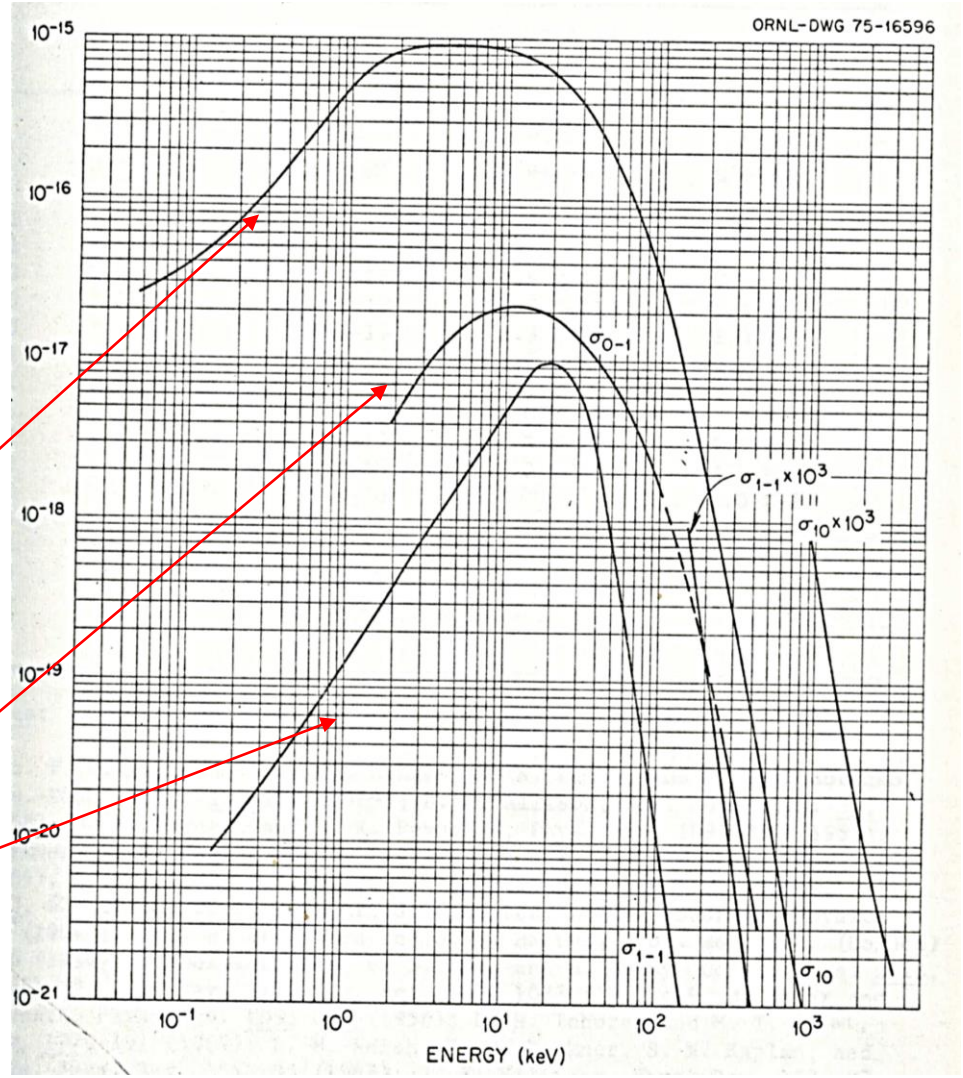
Charge-exchange negative ion source principle (1)



$H^+ + H_2 \rightarrow H^0$

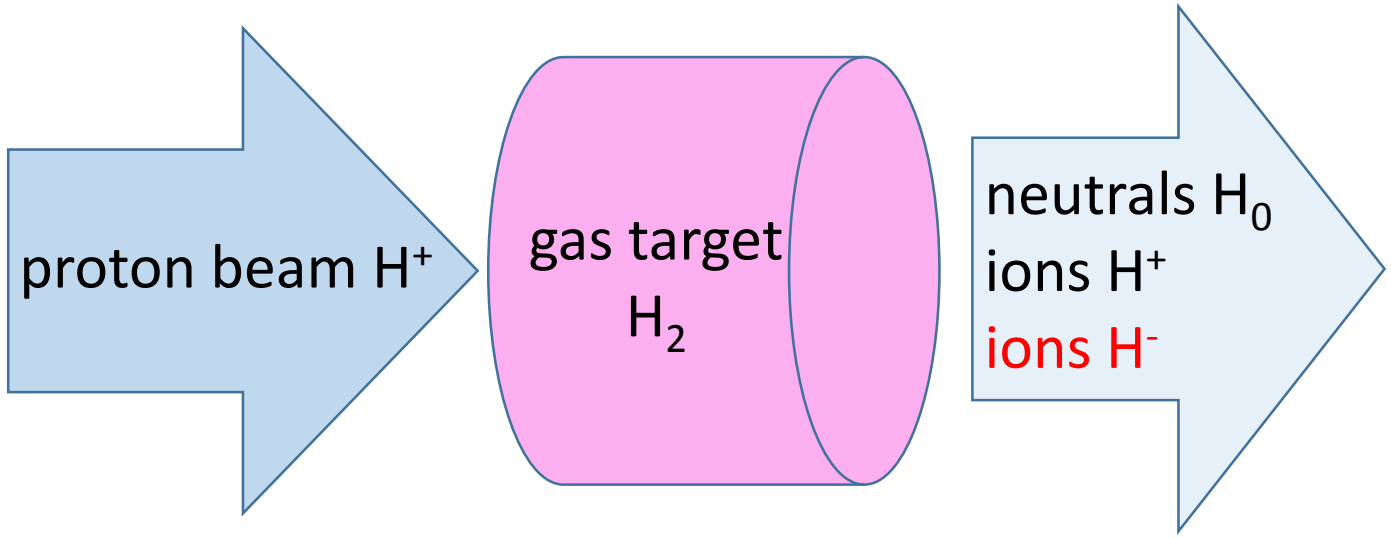
$H^0 + H_2 \rightarrow H^-$

$H^+ + H_2 \rightarrow H^-$

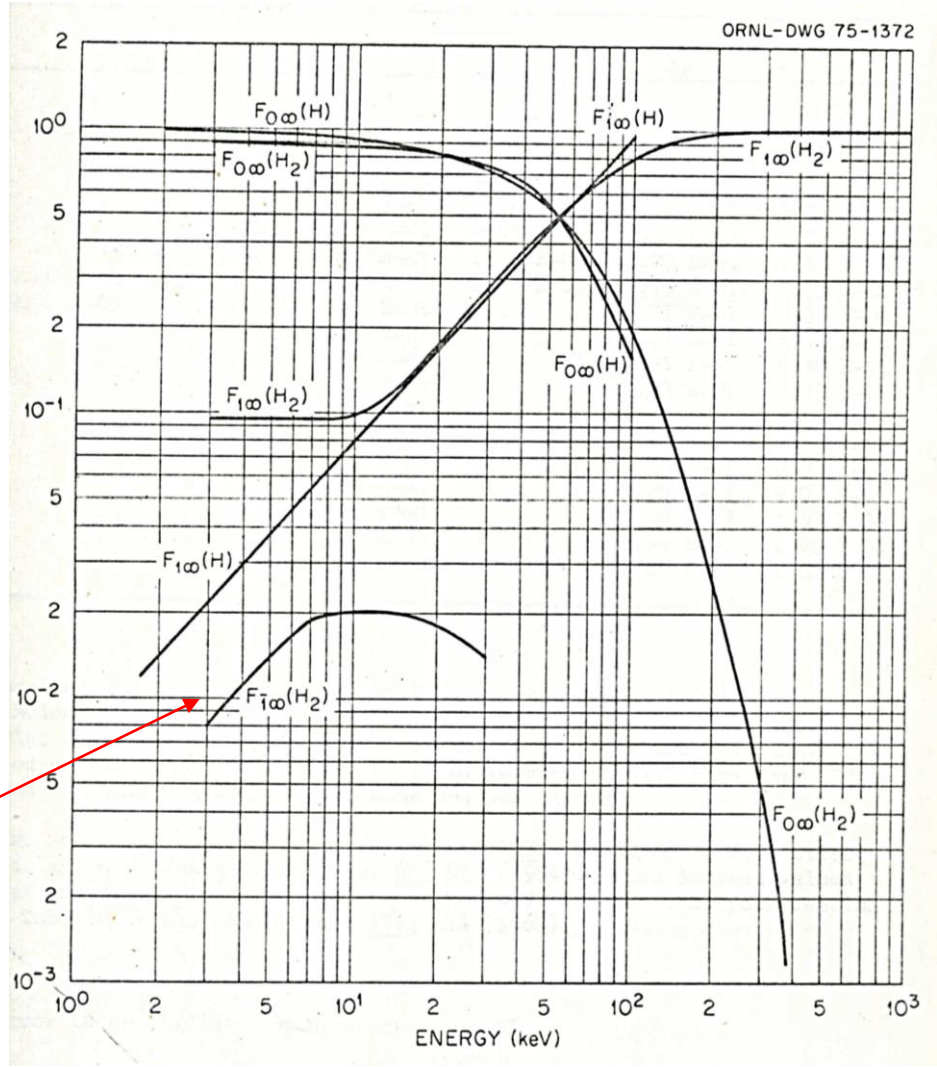


Electron capture cross section H^+ and H^0 passing through H_2 gas target

Charge-exchange negative ion source principle (2)

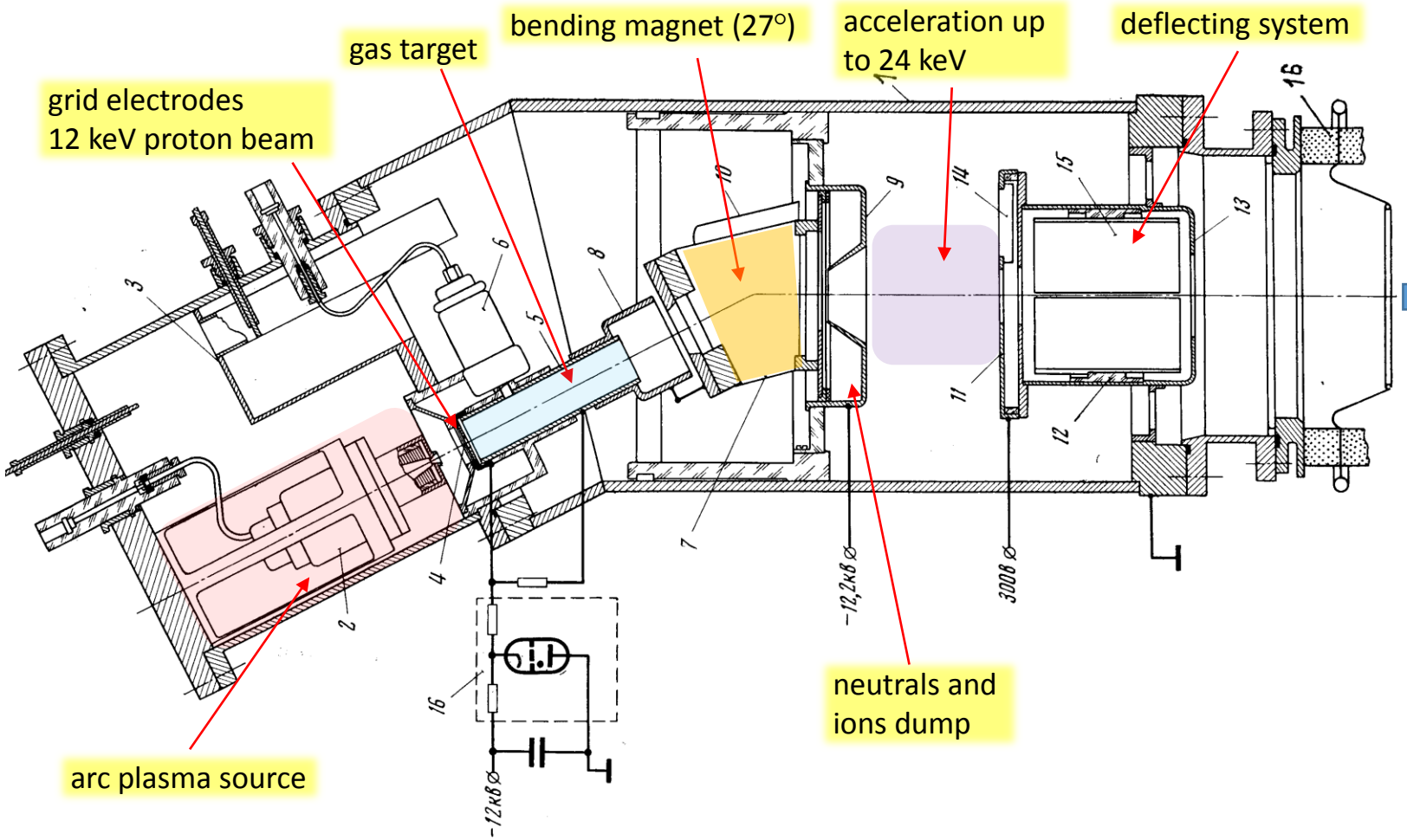


For beam with energy of 10÷15 kV, after gas target beam has 2% content of negative ions



Equilibrium fraction of H^- ions from the H_2 gas target

1973: Pulsed charge-exchange negative ion source at BINP



I_{H^-} =20 mA

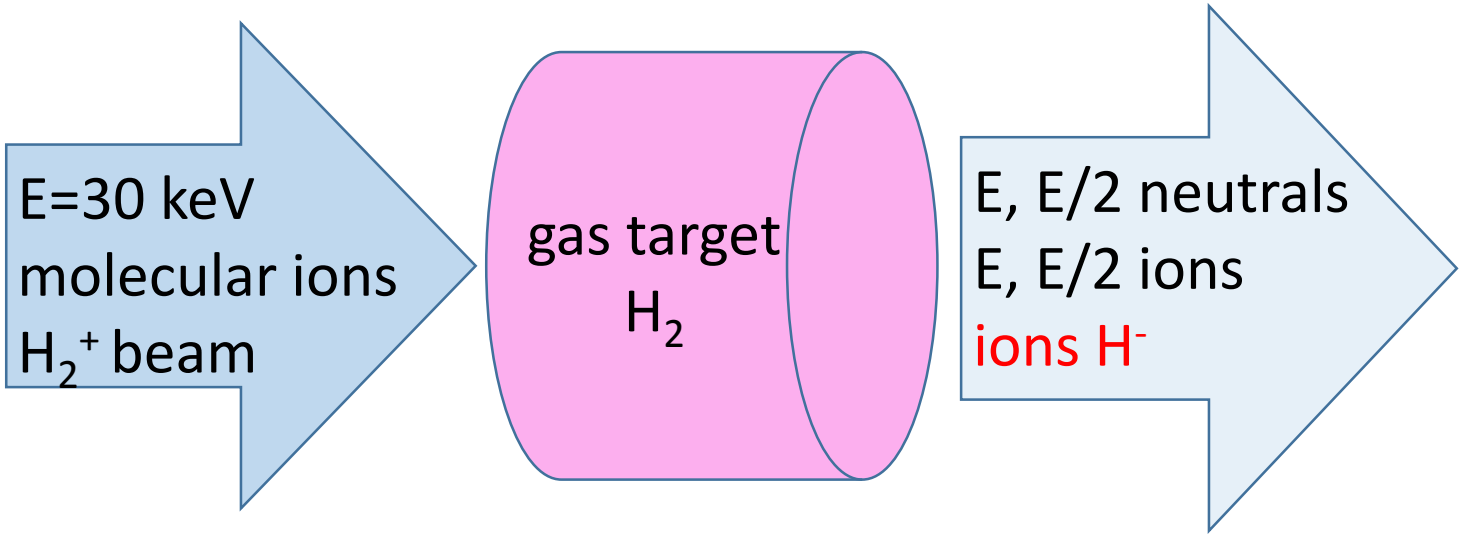
T= 100 mks

ε_{nx} = 0.2 mm·mrad

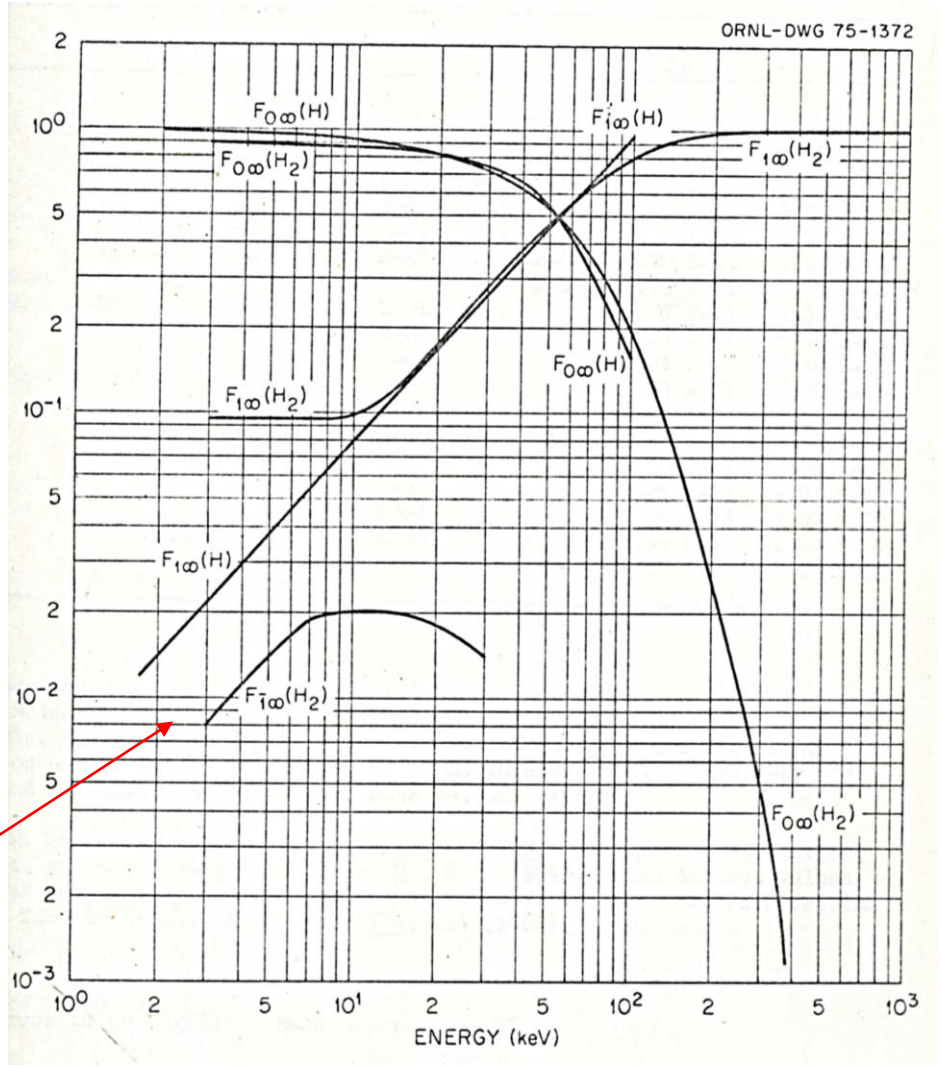
ε_{ny} = 1.7 mm·mrad

G.I.Dimov, G.V.Roslyakov, Instruments and Experimental Techniques, No 2, pp. 33-35 (1974).

Dissociation and charge-exchange negative IS principle

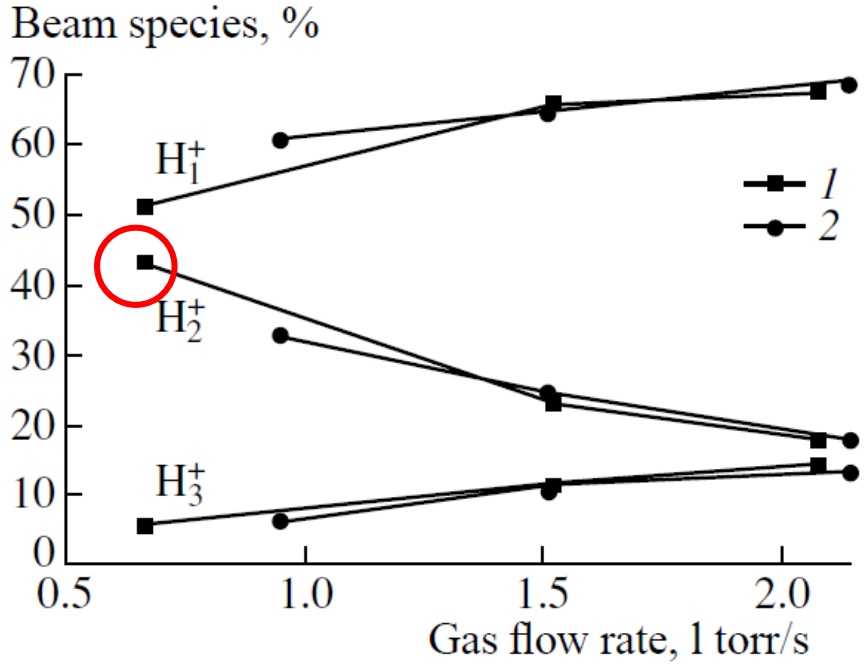


For primary beam (30 keV energy, 1A current),
after gas target (dissociation and charge-exchange)
beam has 40 mA of negative ions with 15 keV energy.

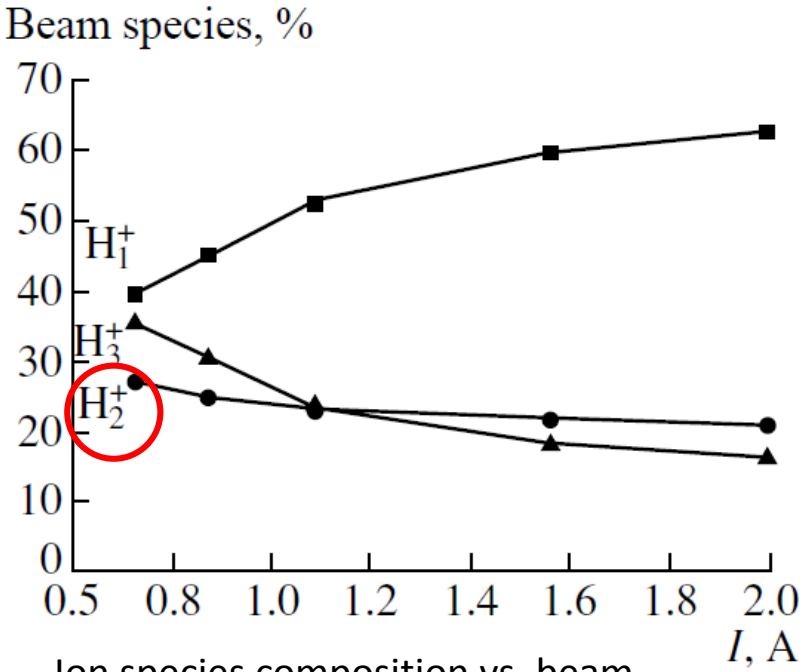


Equilibrium fraction of H^- ions from the H_2 gas target

Ion species composition in the RF ion source



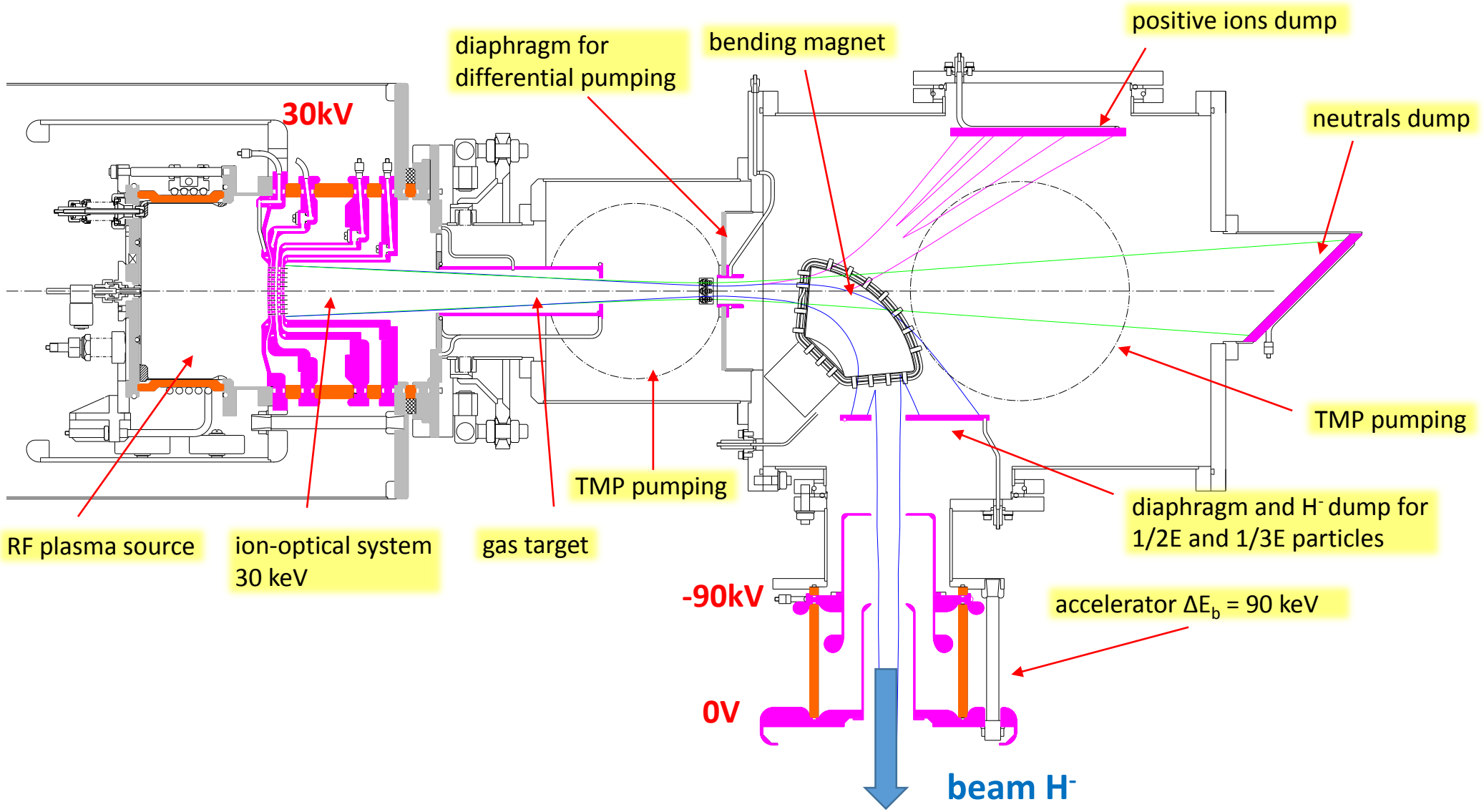
Ion species composition vs. gas flow rate for an ion beam current of (1) 2 A and (2) 1.7 A.



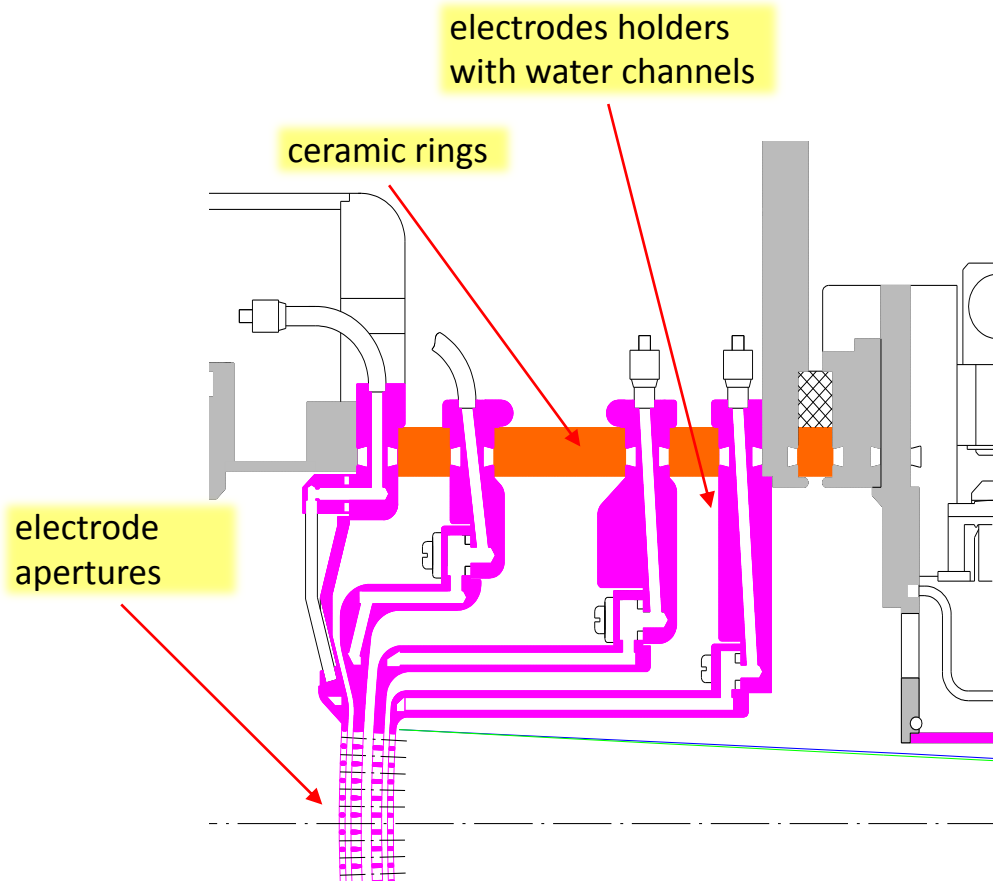
Ion species composition vs. beam current at 2·I torr/s a gas flow rate .

1. A.A.Ivanov et al, Radio frequency ion source for plasma diagnostic in magnetic fusion experiments, Rev. Sci. Instruments **71**, 3728-3735 (2000).
2. Plasma Physics Reports, Vol. 28, No. 3, 2002, pp. 196–203. Translated from Fizika Plazmy, Vol. 28, No. 3, 2002, pp. 221–228.

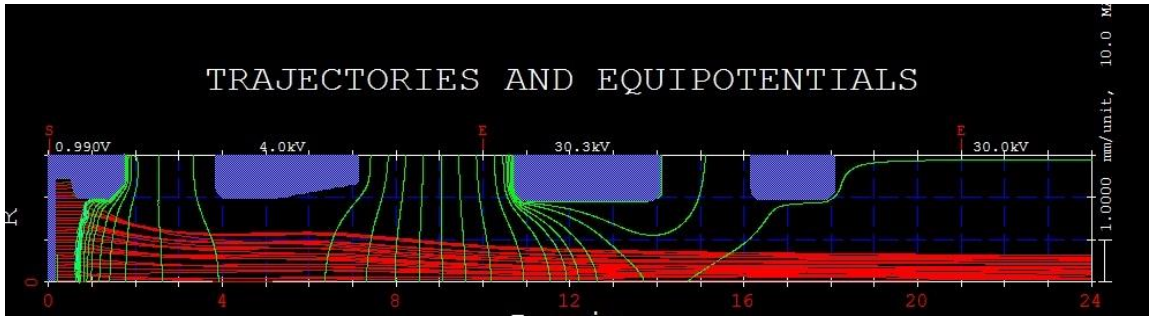
RF charge-exchange negative ion source design



Ion optical system. Cell geometry and particle trajectories.



Ion optical system with geometrical focusing (F=0.5m)
109 apertures with 4 mm diameter in round 60 mm
50% transparency



Cell geometry with equipotentials and particle trajectories for 30kV accelerating voltages (PBGUNS code)
4 mm holes diameter
2, 3.5, 3.5, 2 mm thickness

Calculated trajectories of the hydrogen beam components

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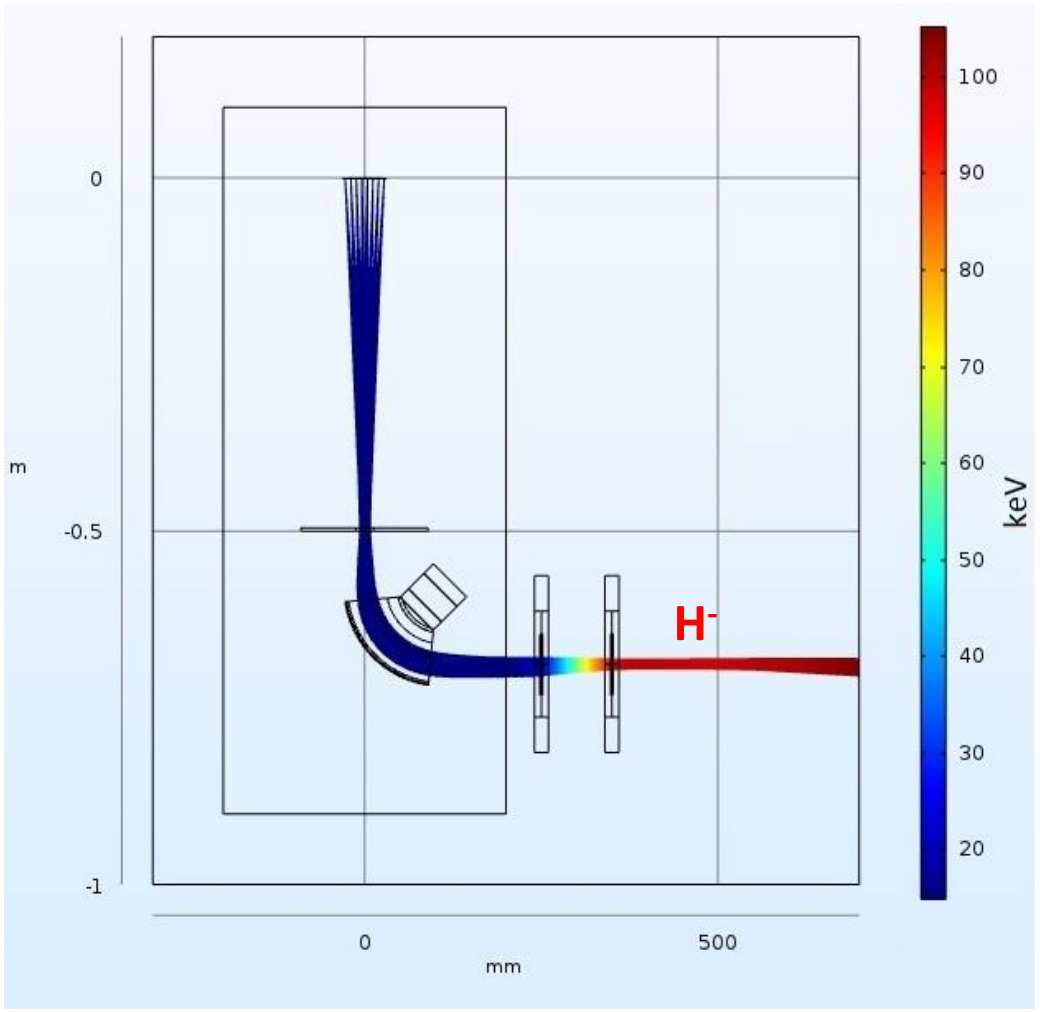
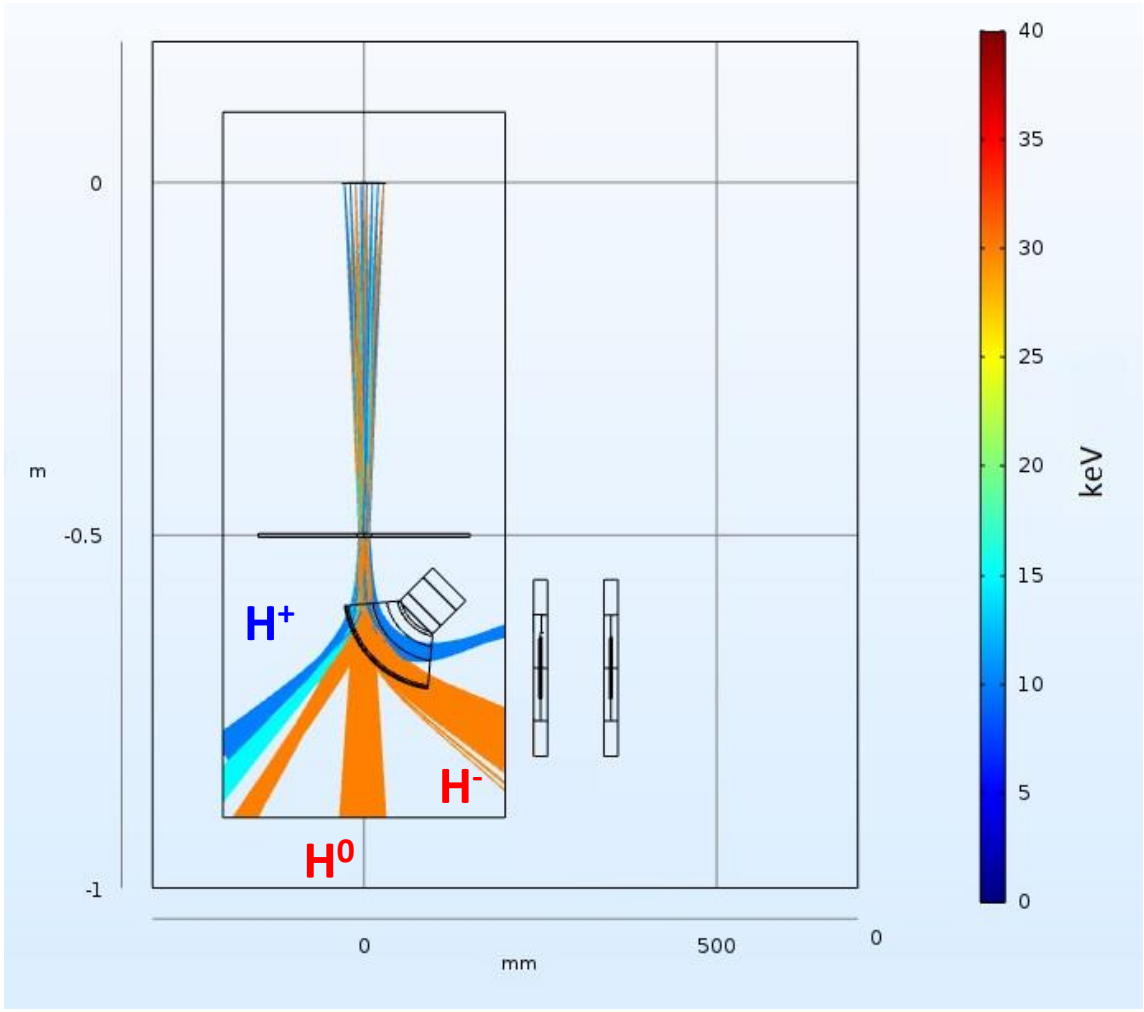
Trajectories of H- ions with 15 keV energy



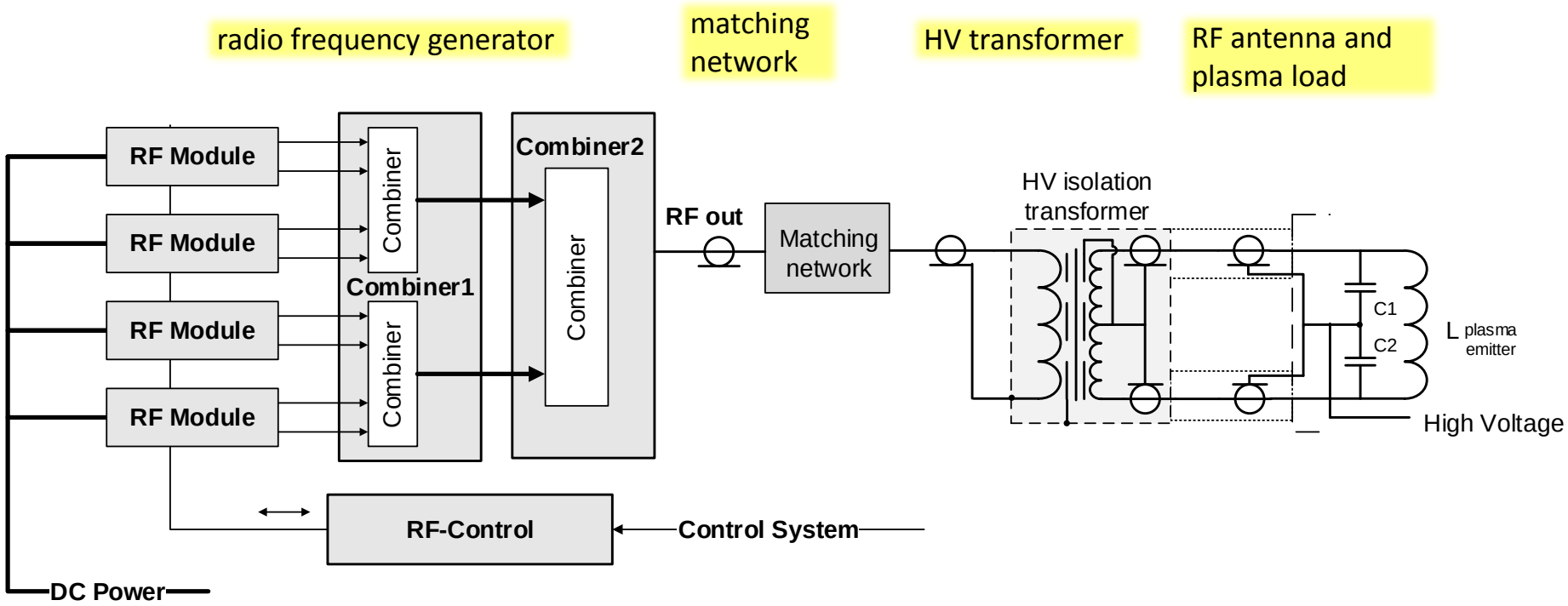
Trajectories of neutrals and hydrogen ions



RF power supply system

RF generator

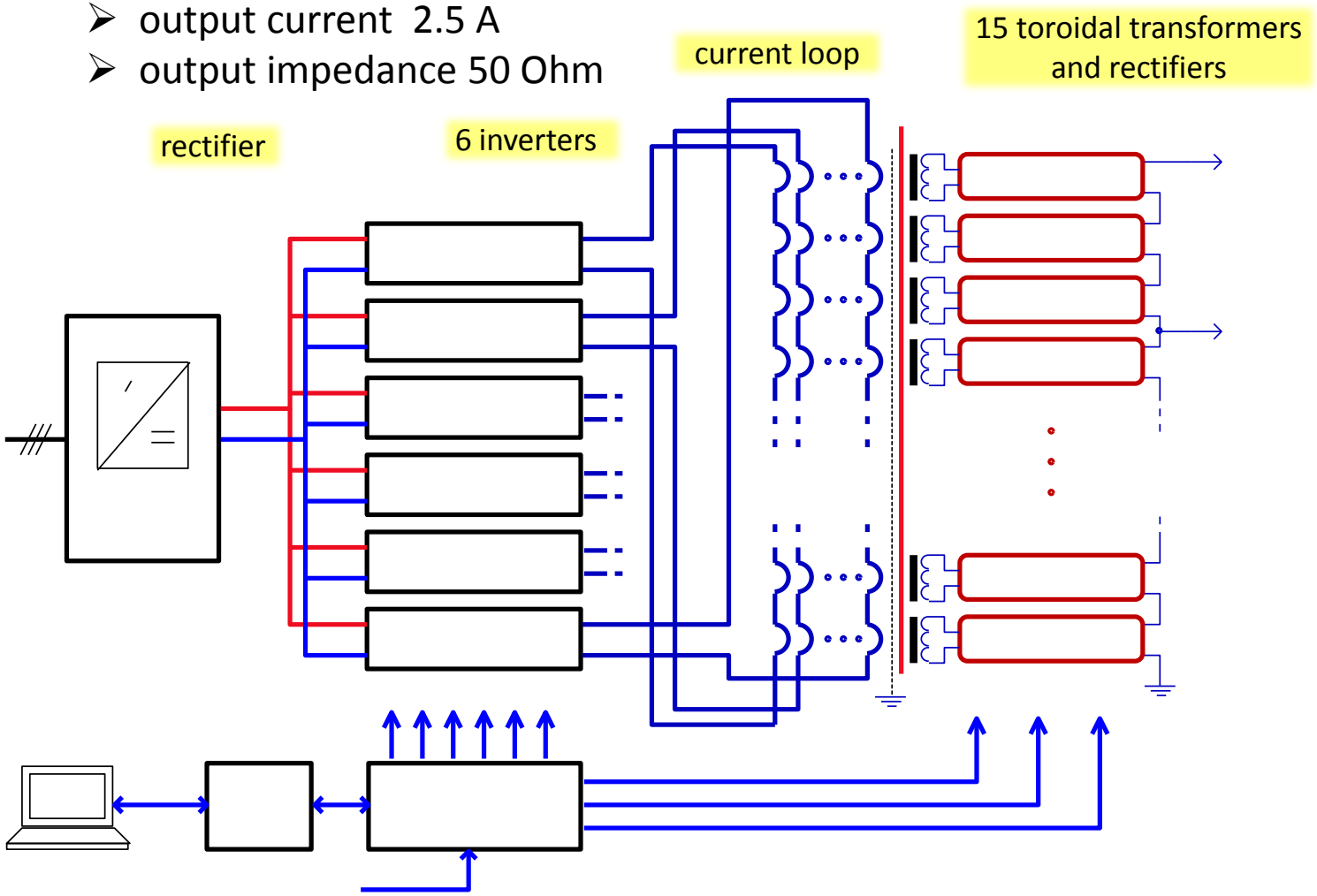
- power 9 kW
- frequency 4 MHz
- output impedance 50 Ohm



High voltage power supply

HVPS

- output voltage 3 ... 30 kV
- output current 2.5 A
- output impedance 50 Ohm



Conclusion

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- RF charge-exchange negative ion source is designed.
- Calculations of beam transportation and acceleration is performed.
- Manufacturing of the power supplies are completed.
- The ion source is being assembled.
- Additional experiments are planned to study the composition of hydrogen ions in the primary ion beam.
- The experiments should begin soon.

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Thank you for your attention !