HYBRIS – an Hybrid Ion Source Aimed at Long-Life Production of Negative Hydrogen-Ion Beams

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Contributors

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Don Syversrud	LBNL	Mech. installation
Joe Wallig	LBNL	Mech. installation
John Staples	LBNL	2/13-MHz rf matching
Rob Welton	SNS	Discharge physics & technology
Richard Pardo	ANL	Microwave ion source
Bob Scott	ANL	Microwave ion source

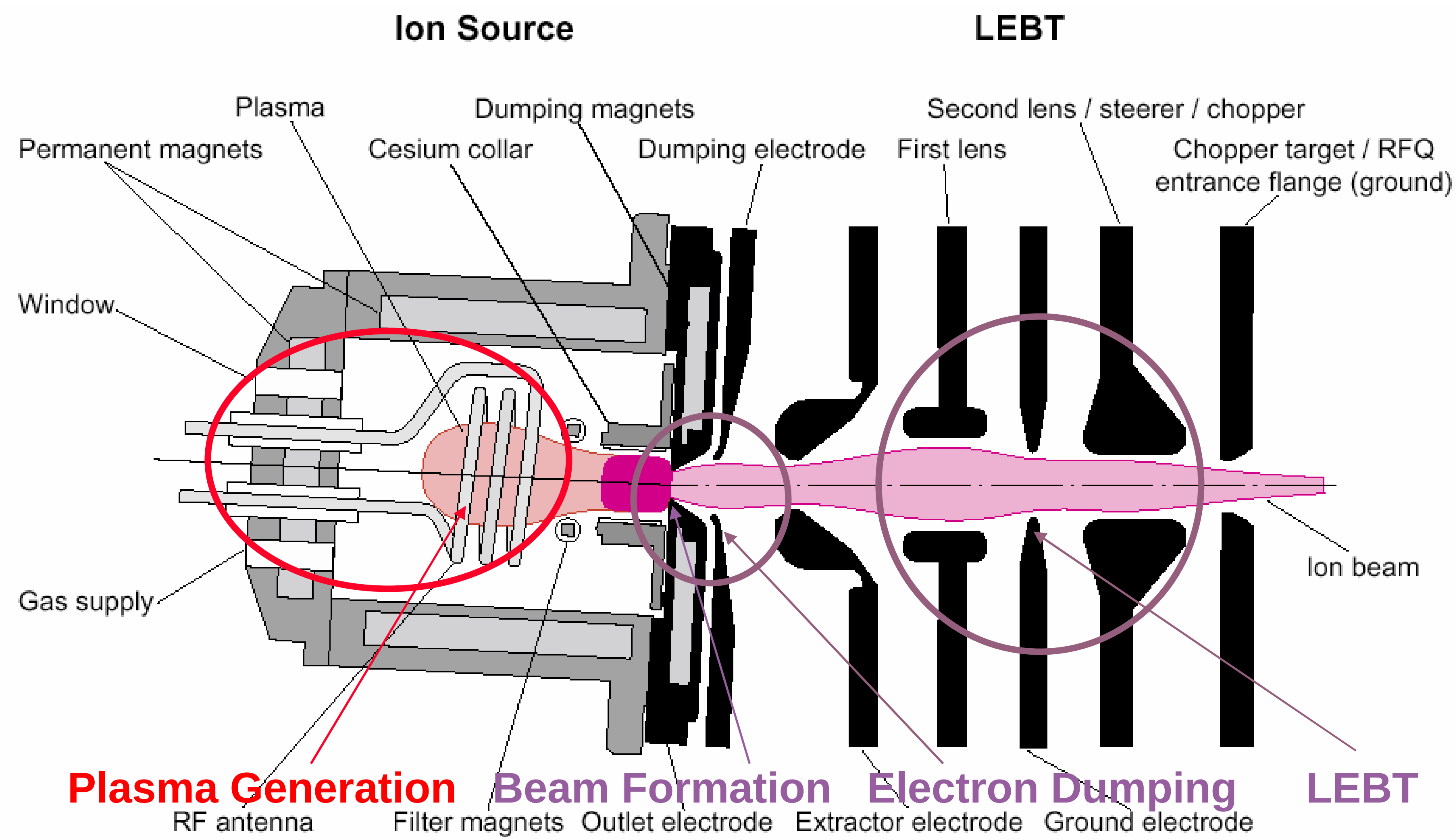
Total effort so far: 1 FTE average for 1 year

R&D Work on Intense H^- Ion Source

SNS needs to pursue cutting-edge technology in areas critical to accelerator operation

- Ensure adequate performance
  - Linac and Ring commissioning
  - **1.44-MW production beam**
  - **Future power upgrade**
- Ion source and beam-formation system constitute such an area
  - **H^- beam production is particularly complex and challenging**
- R&D investment in this area is highly cost effective
- **Create a development path to ensure availability of ion sources with highest levels of performance and reliability**
- **First phase aims at improving reliability and availability of the plasma generator (the "ion source proper")**

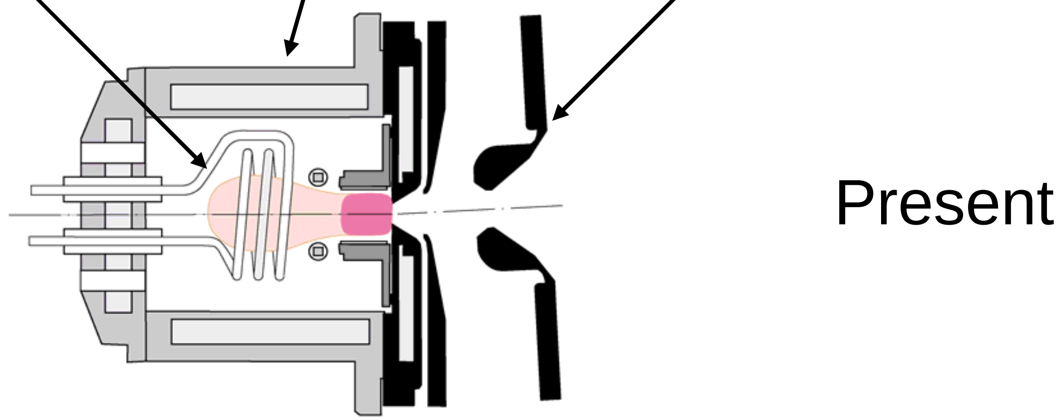
SNS Ion Source and LEBT
Areas for Improvement

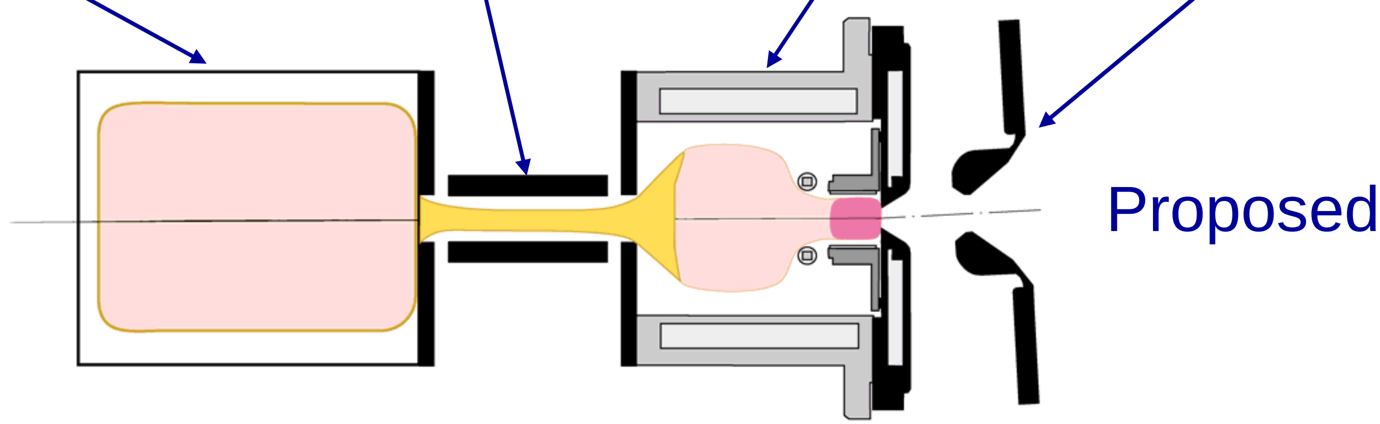


R&D Proposal
Highlights of First Phase

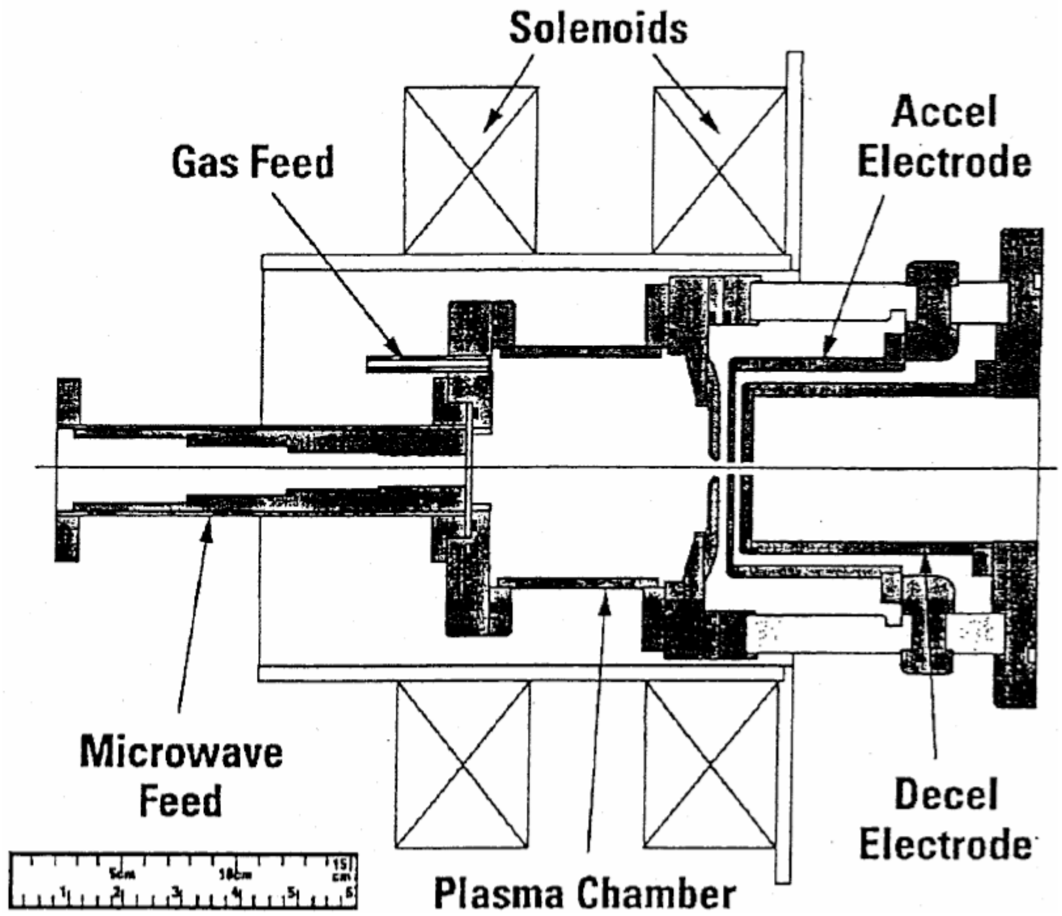
- Abandon 2 & 13-MHz rf technology, including
  - Internal, porcelain coated **antenna**
  - 2-MHz **amplifier** and **impedance matcher**
- **Plasma generation by pulsed d.c. discharge**
  - Proven to work for H^- production with filaments (KEK, JAERI)
- Sustain main discharge by **microwave-driven plasma cathode**
  - No need for thermionic filaments
    - No build-up of surface-poisoning deposits
  - 2.45-GHz ECR plasma generators have proven extremely long lifetime and reliability as **proton sources** (LANL-LEDA, CEA Saclay, others)
  - Attempts by CEA Saclay to **produce intense H^- beams directly** by ECR ion source were **not successful**
  - **Controlling electron energy in main vessel will be crucial**
- Ultimate performance goals
  - 75 mA peak H^- beam current
  - 10% duty factor
  - 2 months interval between services

HYBRIS Design Principle



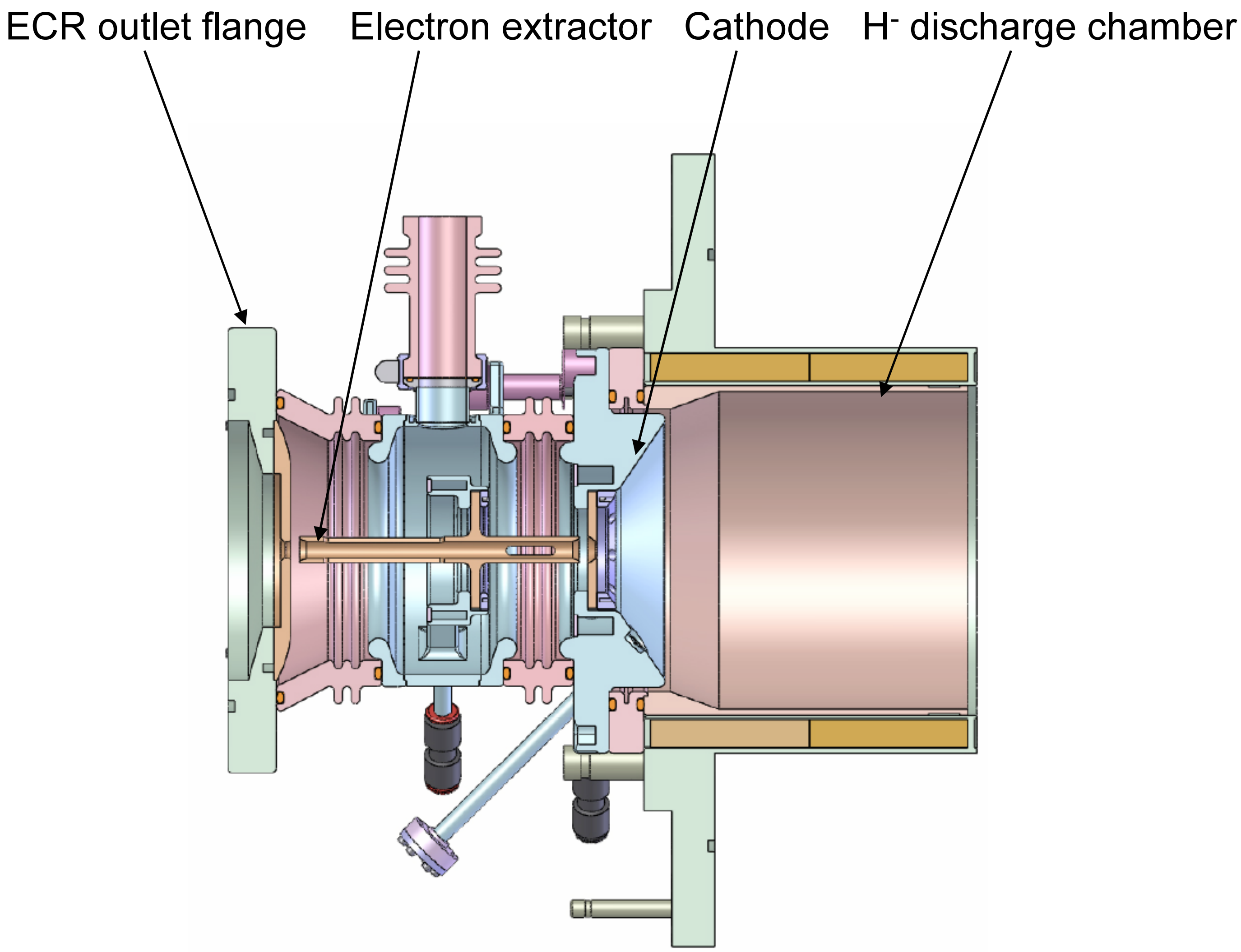


2.45-GHz ECR Proton Source Developed at Chalk River Nat. Lab

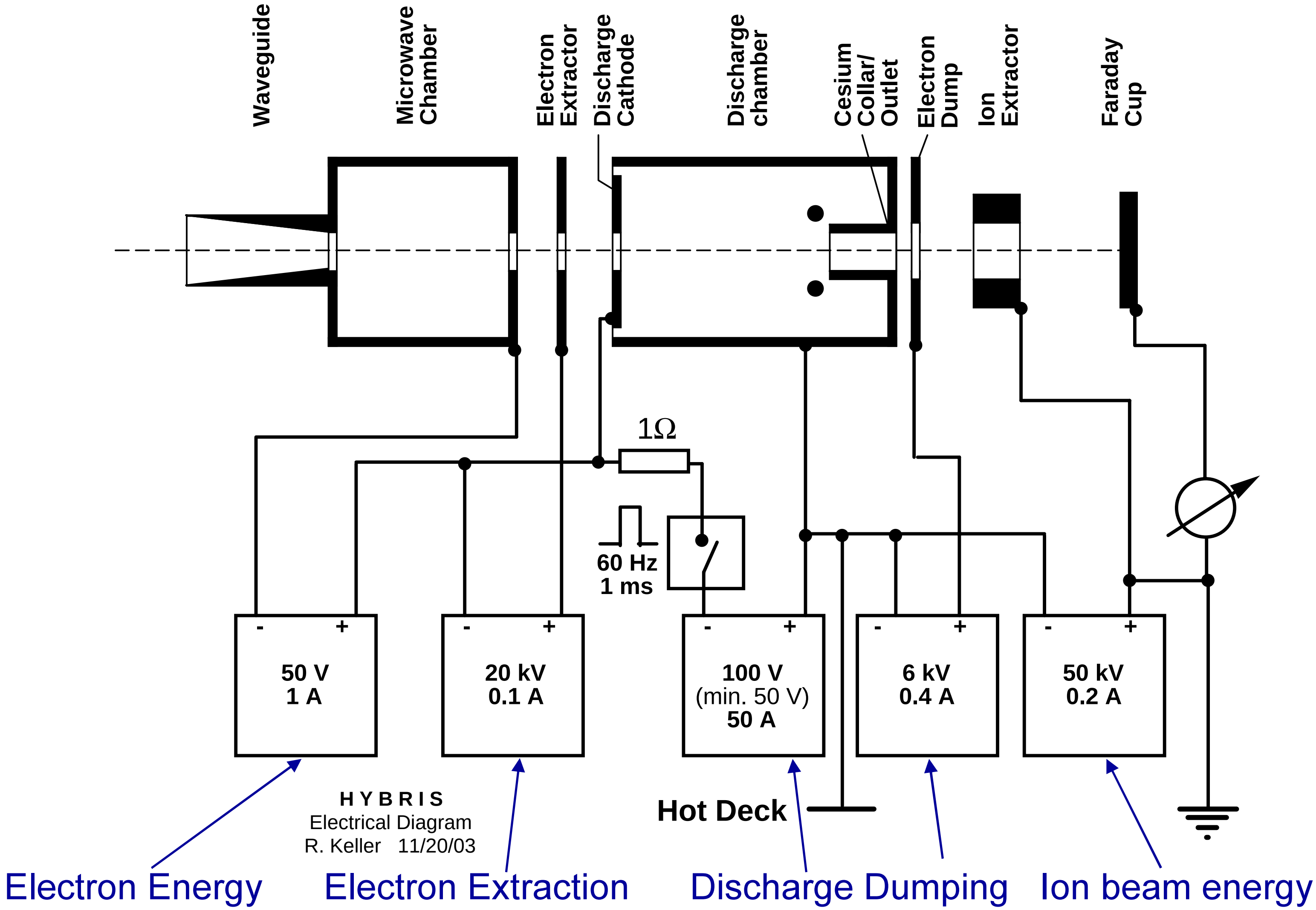


A copy of this ion source was received by Berkeley Lab as a loan from Argonne Nat. Lab

Electron Extractor



HYBRIS Electrical Circuit



Operational Parameters

H- collar			
H- beam currrent	mA	***50***	***Demonstration goal***
H- current density	mA cm^-2	130	*Derived*
H- flux	cm^-2	8.E+17	*Derived*
H- outlet diameter	mm	**7**	**Given**
Ion avg. energy	eV	2	Assumed
Ion avg. speed	cm/s	*2.E+06*	*Derived*
H- density	cm^-3	***4.E+11***	*Derived*
Main Discharge			
Electron plasma density	cm^-3	**4.E+12**	Assumed
2.45-GHz ECR Discharge			
Critical density w/o ECR	cm^-3	**7.00E+10**	**Given**
ECR magnetic field	mT	**87.5**	**Given**
Microwave power, max.	kW	**1.2**	**Given**
Hydrogen gas flow	sccm	**3**	Assumed
Ion current density	mA cm^-2	**300**	**Demonstrated**
Ion flux	cm^-2	*2.E+18*	*Derived*
Ion energy	eV	20	Assumed
Ion avg. speed	cm/s	6.E+06	*Derived*
Ion density	cm^-3	**3.E+11**	*Derived*
Electron energy	eV	20	Assumed
Electron density	cm^-3	***3.E+11***	*Derived*
Electron speed	cm/s	*2.7E+08*	*Derived*
Electron current density	mA cm^-2	*1.3E+04*	*Derived*
E-Outlet diameter	mm	**6**	**Given**
Electron current	A	***4***	*Derived*

Summary

- Hybrid Ion Source under development
- Aimed at very high reliability at very high duty factor and beam current
- Combining three well proven discharge concepts
  - D.c. main discharge
  - Microwave-driven plasma cathode
  - H^- production chamber of existing SNS ion source
- Principal uncertainty is the control of the electron temperature in the H^- production chamber
- Shoe-string budget
  - Research proposal to DOE-BES still pending