SUMMARY OF INVENTION

[027]Embodiments provided herein are directed to systems and methods for a negative ion-based neutral beam injector. According to a first aspect of the invention, a negative ion-based neutral beam injector comprises an ion source, an accelerator wherein the accelerator is in spaced relation with and indirectly coupled to the ion source and a neutralizer coupled to the ion source~~to produce about a 5 MW neutral beam~~. The ion source is adapted to produce a negative ion beam. According to a second aspect of the invention, the negative ion-based neutral beam injector ~~comprises~~

an ion source adapted to produce a negative ion beam, wherein the ion source includes a plasma box and plasma drivers, and wherein internal walls of the plasma box and plasma drivers are maintainable at elevated temperatures of about 150-200° C to prevent cesium accumulation on their surfaces,

an accelerator coupled to the ion source, and

a neutralizer coupled to the ion source~~according to the first aspect is adapted to produce about a 5 MW neutral beam with energy of about 0.50 to 1.0 MeV~~. The ion source is located inside a vacuum tank and produces a 9 A negative ion beam. The ions produced by the ion source are pre-accelerated to 120 keV before injection into a high energy accelerator by an electrostatic multi aperture grid pre-accelerator in the ion source, which is used to extract ion beams from the plasma and accelerate to some fraction of the required beam energy. The 120 keV beam from the ion source passes through a pair of deflecting magnets, which enable the beam to shift off axis before entering the high energy accelerator. After acceleration to full energy, the beam enters the neutralizer where it is partially converted into a neutral beam. The remaining ion species are separated by a magnet and directed into electrostatic energy converters. The neutral beam passes through a gate valve and enters a plasma chamber.

[028] The plasma drivers and the internal walls of a plasma box of the ion source are maintained at elevated temperature (150-200° C) to prevent cesium accumulation on their surfaces. A distributing manifold is provided to supply cesium directly onto the

surface of the plasma grids and not to the plasma. This is in contrast to existing ion sources which supply cesium directly into a plasma discharge chamber.

[029] A magnetic field used to deflect co-extracted electrons in ion extraction and pre-acceleration regions is produced by external magnets, not by magnets embedded

WHAT IS CLAIMED IS:

1. A negative ion-based neutral beam injector comprises

an ion source adapted to produce a negative ion beam,

an ~~accelerator~~ accelerator, wherein the accelerator is in spaced relation with and indirectly coupled to the ion source, and

a neutralizer coupled to the ion source~~, wherein the ion source, accelerator and neutralizer are adapted to produce a neutral beam with power of about 5 MW~~.

2. A negative ion-based neutral beam injector comprises

an ion source adapted to produce a negative ion beam, wherein the ion source includes a plasma box and plasma drivers, and wherein internal walls of the plasma box and plasma drivers are maintainable at elevated temperatures of about 150-200° C to prevent cesium accumulation on their surfaces,

an accelerator coupled to the ion source, and

a neutralizer coupled to the ion source~~, wherein the ion source, accelerator and neutralizer are adapted to produce a neutral beam with energy of about 0.50 to 1.0 MeV~~.

3. The injection of claim 1, wherein the ion source includes a plasma box and plasma drivers, and wherein internal walls of the plasma box and plasma drivers, are maintainable at elevated temperatures of about 150-200° C to prevent cesium accumulation on their surfaces.

4. The injector of claim 2, wherein the accelerator is in spaced relation with the ion source.

5~~3~~. The injection of claims 1 through 4, wherein the ion source, accelerator and neutralizer are adapted to produce a neutral beam with energy of about 0.50 to 1.0 MeV.

6~~4~~. The injector of claims 1 through 4 ~~2~~, wherein the ion source, accelerator and neutralizer are adapted to produce a neutral beam with power of about 5 MW.

75. The injector of claims 1 through 4, wherein the ion source is adapted to produce about a 9 A negative ion beam.

~~6. The injector of claims 1 through 4, the accelerator is in spaced relation with the ion source.~~

87. The injector of claims 1 through 4 ~~6~~ wherein the accelerator is a high energy accelerator, and wherein the injector further includes a pre-accelerator ~~and a high energy accelerator~~.

98. The injector of claim 87 wherein the pre-accelerator is an electrostatic multi aperture grid in the ion source.

109. The injector of claim 87 wherein ions from the ion source are pre-accelerated by the pre-accelerator to 120 kV before injection into the high energy accelerator.

1110. The injector of claim 87 further comprising a pair of deflecting magnets, interposing the pre-accelerator and high energy accelerator, wherein the pair of

deflecting magnets enables a beam from the pre-accelerator to shift off axis before entering the high energy accelerator.

~~11. The injector of claim 7 wherein the ion source includes a plasma box and plasma drivers.~~

~~12. The injector of claim 11 wherein the internal walls of the plasma box and plasma drivers are maintainable at elevated temperatures of about 150-200° C to prevent cesium accumulation on their surfaces~~.

12~~13~~. The injector of claims 2 and 3 ~~12~~ wherein the plasma box and drivers include fluid manifolds and passageways to circulate high temperature fluid.

13~~14~~. The injector of claim 8~~7~~ further comprising a distributing manifold for directly supplying cesium on plasma grids of the pre-accelerator.

14~~15~~. The injector of claim 8~~7~~ wherein the pre-accelerator includes external magnets to deflect co-extracted electrons in an ion extraction and pre-acceleration regions.

15~~16~~. The injector of claim 8~~7~~ further comprising a pumping system to pump gas out from a pre-acceleration gap.

16~~17~~. The injector of claim 13~~14~~ wherein the plasma grids are positively biased to repel back streaming positive ions.

17~~18~~. The injector of claim 8~~7~~ wherein the high energy accelerator is spaced apart from the ion source by a transition zone comprising a low energy beam transport line.

18~~19~~. The injector of claim 18~~17~~ wherein the transition zone includes bending magnets, vacuum pumps and cesium traps.

19~~20~~. The injector of claim ~~19~~18 wherein the bending magnets deflect and focus the beam onto the axis of the high energy accelerator.

2021. The injector of claim 87 further comprising magnetic lenses following the high energy accelerator to compensate for over focusing in the high energy accelerator and to form a quasi-parallel beam.

2122. The injector of claim 87 wherein the neutralizer includes a plasma neutralizer based on a multi-cusp plasma confinement system with high field permanent magnets at the walls.

2223. The injector of claim 87 wherein the neutralizer includes photon neutralizer based on a cylindrical cavity with highly reflective walls and pumping with ~~high efficiency~~ lasers.

2324. The injector of claim 2122 wherein the neutralizer includes photon neutralizer based on a cylindrical cavity with highly reflective walls and pumping with ~~high efficiency~~ lasers.

2425. The injector of claims 1 through 4 ~~and 2~~ further comprising a residual ion energy recuperator.

~~2726. The injector of claim 6 further comprising a residual ion energy recuperator.~~

2627. The injector of claim 87 further comprising a residual ion energy recuperator.