Recent Progress and Applications Using Steady State D-D and D-3He Fusion

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**IEC Fusion Background**

**Inertial Electrostatic Confinement Theory of Operation**

The IEC fusion reactor is a closed chamber that acts as a gas gun with deuterium or tritium at low pressure. There are inner and outer spherical wire grids centered inside the chamber. The outer grid is held at nearly zero potential and the inner grid is held at a high negative potential, typically -100kV.

1. Positive ions are created from gas atoms inside the inner grid by photoemission or ionization
2. The ions can also subnuclearly decay, forming neutrons and gamma rays
3. Fast neutrons can collide with gas atoms, creating new ions
4. High energy ions deuterium and tritium ions are injected through an annular slot in the inner grid and accelerated toward the outer grid.
5. The ions collide, creating fusion reactions.

**Experimental Facility**

**Cylindrical Aluminum IEC Chamber**

- High voltage feedthrough
- Negative gas feedthrough
- High power diagnostic feedthroughs
- Inert gas feedthrough
- X-ray detector
- Neutron detector
- Plasma diagnostic feedthroughs
- High voltage feedthrough
- Solid state proton detector
- Electron emitting cathode
- Gas purging system
- Converged core of fusion reactions

**Steady State Fusion**

**Fusion Cross Sections**

**31N PET Medical Isotope Cross Section**

**Typical Runs**

**Solid State Proton Detector**

- Low fall 14.7 MeV D-D Protons
- High fall 18.5 MeV D-3He Protons
- X-ray
- 25µm thick silicon detector

**Proton Energy Spectrum from Detector**

**D-3He Proton Counts from Detector**

**Results and Applications**

**Key Results**

- Have achieved record steady state fusion rates of advanced fuels D and 3He
- 1st proof of principle creation of PET medical isotopes using fusion products
- Fusion reaction regimes identified using unique IEC diagnostics

Three Different Locations of Fusion Reactions in the IEC Chamber Have Been Identified

- Converged Core
- Volume
- Embankled

Eclipsing the Cathode from the Proton Detector Revealed the Areas of Fusion Reactions

**Medical Isotope Production Using a Water Cooled Cathode**

- HV cathode was thin wall 304 stainless steel
- Water served both as the cooling system and the material to be activated
- Primary water loop was kept pure and ion free
- Ion exchange resin removed the 31N ions

**13N Production Run**

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<th>Time (s)</th>
<th>Total Collected Activity (nCi)</th>
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**Helicon Source Ion Gun Installed on Spherical IEC Chamber**

**Experimental Facility**

**Fusion Reactions**

- D-D Fusion
- D-3He Fusion
- D-T Fusion

**Fusion Cross Sections**

**31N PET Medical Isotope Cross Section**

**13N PET Medical Isotope Cross Section**

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