Inertial Electrostatic Confinement (IEC) Fusion

IEC Fusion utilizes negatively charged electrodes to electrostatically accelerate positively charged ions to fusion relevant energies.

All experiments discussed herein were conducted on the UW-Madison IEC Device known as HOMER using deuterium fuel.

HOMER utilizes concentric, highly transparent spherical grids as the electrodes.

Majority of ion source species created are D₂⁺, with lesser fractions of D⁺ and D⁻ also created.

Typical Operating Parameters:
- Cathode Voltage: -40 to -120 kV
- Anode Voltage: Ground
- Ion Current: 30 – 75 mA
- Feed Gas: Deuterium
- Pressure: 1.5 – 2.5 mTorr

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Fusion Ion Doppler (FIDO) Diagnostic

Purpose - Measure the Doppler shift of the products of D-D fusion reactions in order to back out the center-of-mass energy of the fusion reaction.
- In high background pressure (>0.1 mtorr), Doppler shift results from center of mass energy of beam background fusion reactions.
- Challenge - Reduce x-ray noise sufficiently to accurately discern Doppler shifted peaks of products.
- High levels of x-ray noise from bremsstrahlung radiation produced when electrons impact the wall of the device overwhelm the triton signal (1.01 MeV) and distort the proton signal (3.02 MeV).
- Solution - Move the charged particle detectors out of the line-of-sight of the IEC chamber.

Method - Detector placed at end of arm with 20 degree bend at the elbow. Fusion products are bent around the elbow and into the detector using a 1.5T electromagnet.

Result - Energy spectra of fusion reactions measured with resolution on the order of 50 keV.

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High concentration of fusion events seen in Core and Source regions.

TOF uses FIDO diagnostic to determine fusion reactant energy, but is currently unable to determine reactant species (positive ion, high energy neutral, negative ion).

TOF is also unable to detect embedded fusion reactions because they do not allow both products to be captured, so above profiles show only beam-background and beam-beam fusion.

Spatial and Energy Profiling of D-D Fusion Reactions in an Inertial Electrostatic Confinement Fusion Device

Spatial & Energy Profiling with Time-of-Flight (TOF) Method

The TOF diagnostic offers far greater spatial and energy resolution than any other diagnostic system previously implemented on an IEC device.

Initial results indicate a high concentration of fusion inside the cathode and outside the anode, with an unexpected lower concentration between electrodes.

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Future goals include increasing rate of data collection in order to obtain more complete fusion reaction energy profiles in each radial bin.

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Conclusions

When anode radius was reduced from 25 cm to 15 cm, the center of the peak in concentration in the Source region contracted radially by ~6-10 cm.

Since negative ions reach max energy at the anode, the question still remains why the peak in source region counts is ~15 cm beyond the anode in both cases.

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