Development of an Experimental Method to Investigate ^3He-^3He Fusion with Inertial Electrostatic Confinement Techniques

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Purpose

Nuclear Physics

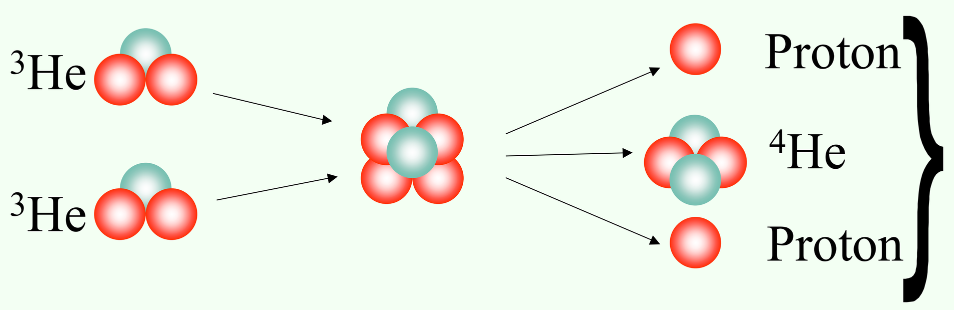
•The $^3He(^3He,2p)^4He$ fusion reaction is interesting to nuclear physicists because it is poorly characterized at energies less than 200 keV

Solar Physics

•A long proposed resonance in the $^3He(^3He,2p)^4He$ fusion cross section could help explain a discrepancy between theoretical predictions and measurements of neutrino emanations from the sun

Fusion Energy

•^3He-^3He fusion offers the potential of nuclear fusion without nuclear waste



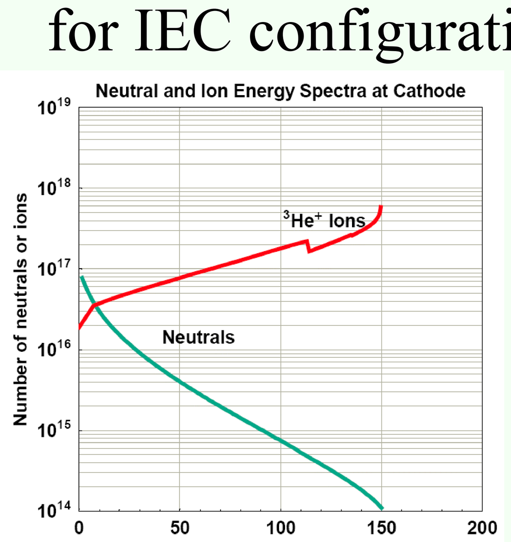
Inertial Electrostatic Confinement(IEC)

•IEC technology provides a method to achieve high ion currents through recirculation at energies of up to a few hundred keV

IEC Theory

•See poster JP1.104 in this session for details: G.A. Emmert and J.F. Santarius, "Multiple Ion Species Effects in IEC Modeling"

•Model shows little attenuation of ion energy for IEC configuration at low pressure



Simulation Conditions:

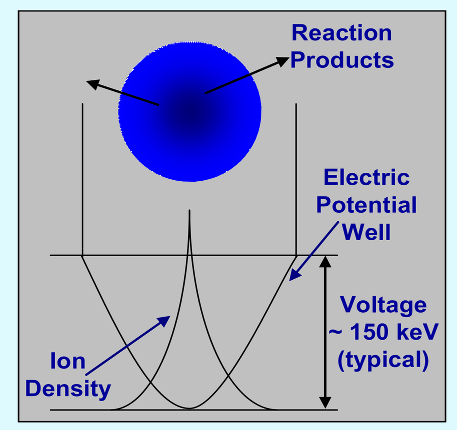
$V_{cathode}$=150 kV

$I_{cathode}$=35mA

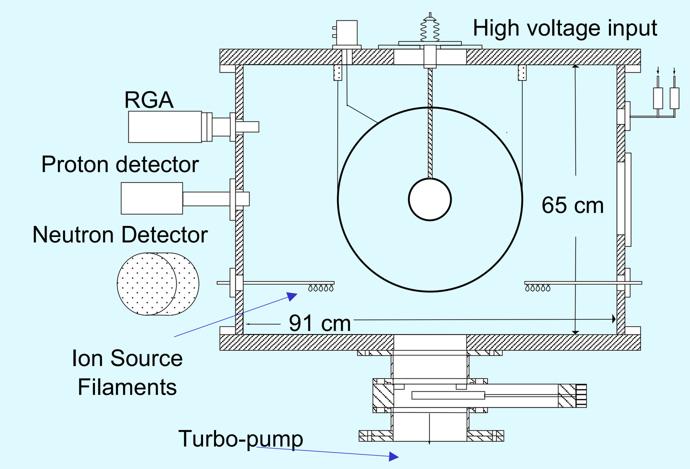
P=30mPa

Cathode trans=0.95

IEC Experiment

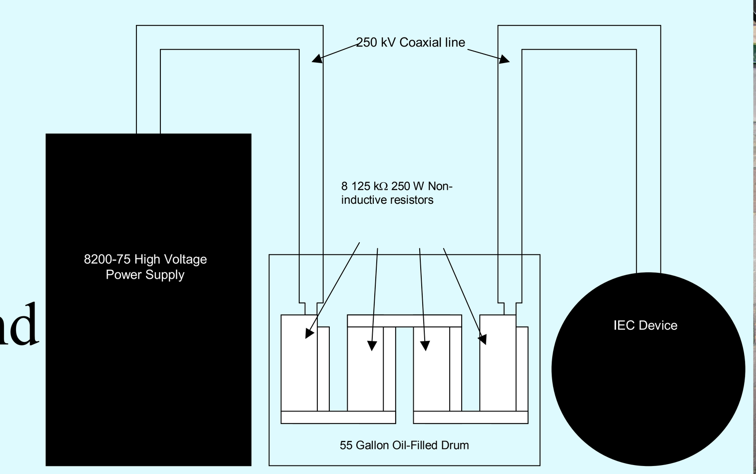


•IEC technology confines ions in an electrostatic potential well

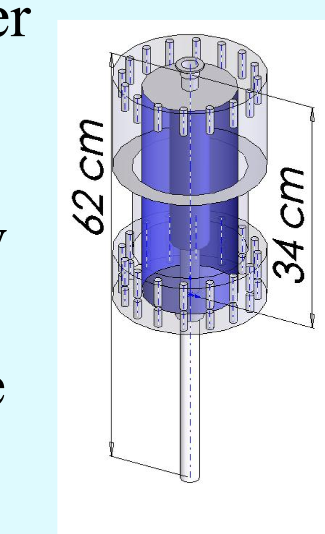


•The potential well is typically created by concentric, transparent grids, which allows ions to make many passes before colliding

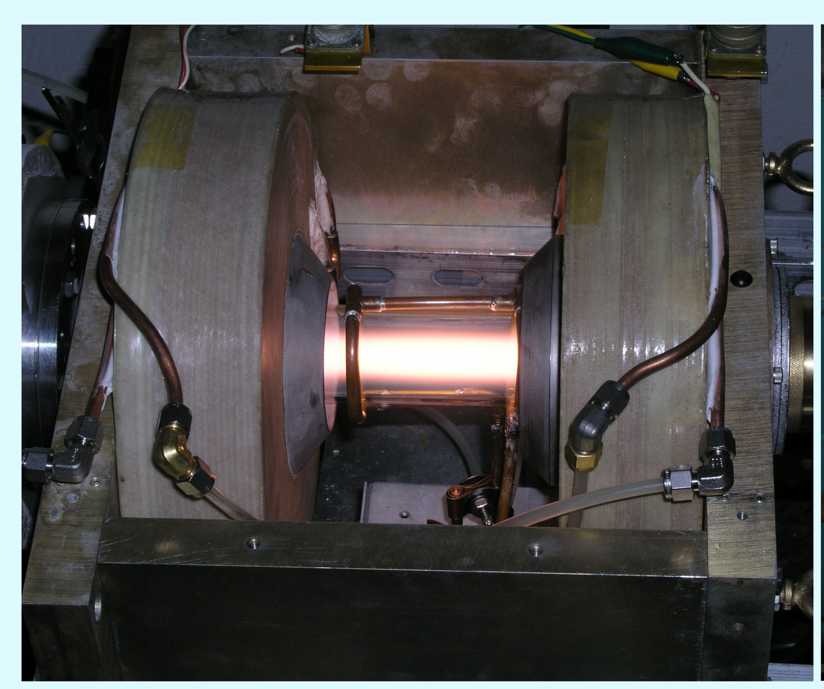
•^3He-^3He fusion requires high ion energies, which necessitates high cathode voltages and low neutral gas pressure

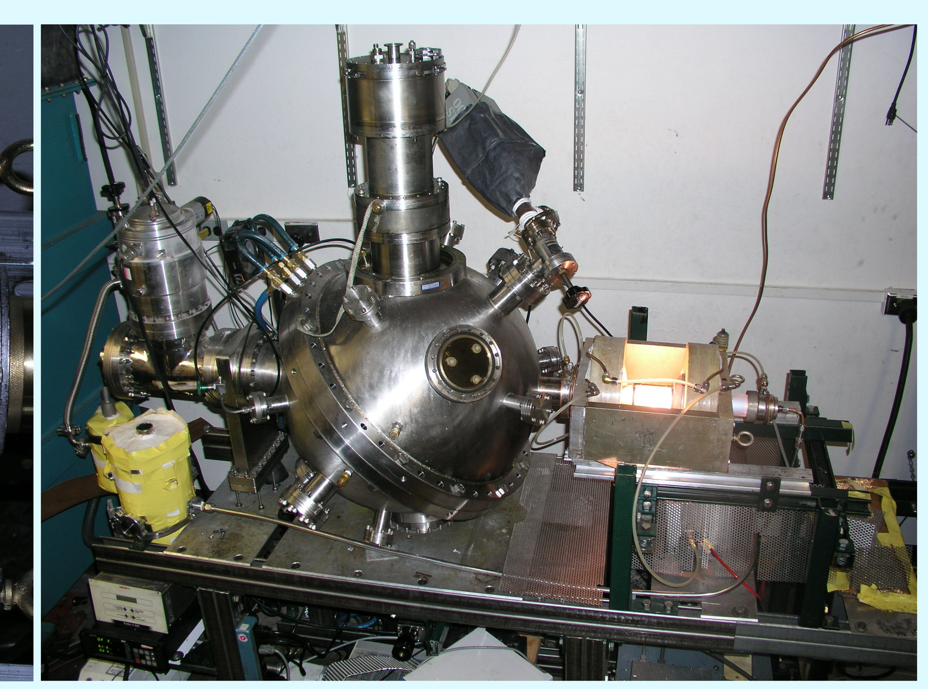


•High voltage buffer circuit (shown left) decreases instability, and new insulators (right) enable high voltage connection in plasma



•Helicon ion source has been developed to enable low pressure operation



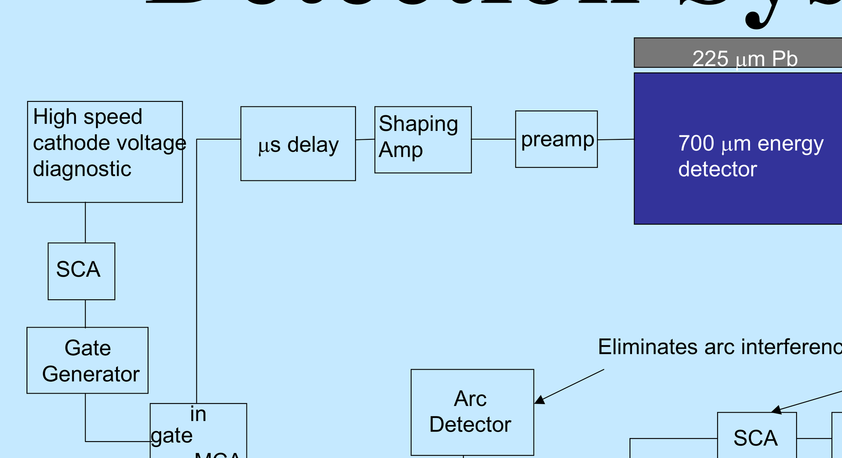


•Combined system has been operated up to 170 kV, up to 75 mA, and at pressures as low as 3 mPa

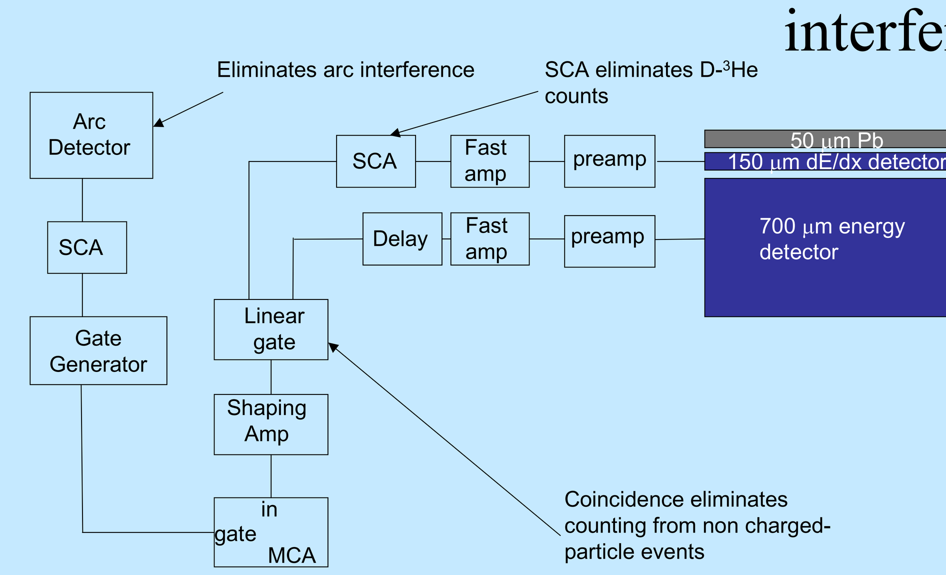
Detection System

•Detection of protons from 3He-3He reactions requires a low noise detection system to suppress electrical noise

•High speed electronics enables detection and suppression of electrical noise (top left). This system has been used so far



•Next generation detection system (bottom right) will eliminate counts due to background radiation as well as electronic interference



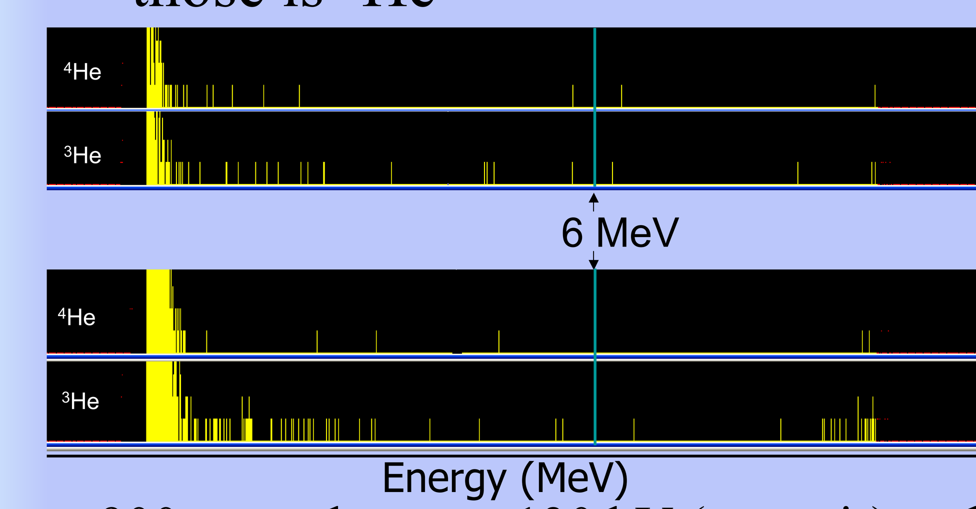
•Next generation system installed and ready for experiments

Results

• IEC device has been operated at 150 kV, 60 mA, 30mPa in ^3He and ^4He gasses

• Helicon source allows reliable steady state operation at currents up to 75 mA. Source can operate at up to 3kW, and as low as 600 W

• Experiments with ^3He gas show many more proton counts than those is ^4He



900 second runs at 130 kV (top pair) and 140 kV (bottom pair), 25 mA—Top in each set:^4He, Bottom:^3He

Summary

- ^3He-^3He reactions detected in an IEC device (see ANS TOFE 2006 paper for details)
- Low noise detection system has allowed low count rates to exceed background noise
- Helicon source technology has enabled high (~75 mA) currents at low (30 mPa=0.2 mtorr) pressures in an IEC device
- Next generation detection system should eliminate remaining background and allow measurements at lower energy

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