generalfusion

Experimental Results from Initial Operation of Plasma Injector 1

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Background

Assembly of Plasma Injector





Engineering R&D of full scale high speed synchronized piston (100 kg) firing into liquid PbLi (2 prototypes have been built)

3m diam. Spherical chamber is filled with circulating liquid PbLi, spun up to open a vortex in the center, which is evacuated. High density compact toroids are injected into the vortex, merging to form the target plasma.

eneral Fusion MTF reactor prototype Energy budget for each burn pulse:

ut: 100 MJ of piston KE creates a erically focusing compression wave,

put: DT Fusion yield of ~600 MJ, then with 30% conversion eff. that becomes 105 MJ for the next pulse, plus ~100 MJ as

F is in the process of finalizing the sign of this prototype reactor, using ata from injector experiments, ulation of plasma dynamics as well s fluid and structural dynamics, and by

set of other engineering tests.



Sub-scale 1 m diam. Water Vortex experiment demonstrates stable laminar vortex cavity, and benchmark data for OpenFOAM simulations.

120 mWb

Comparison of previous coaxial CT devices







Early test assembly of first components, Feb 2010





Self-supporting center electrodes being installed



lves are fast solenoid lunger type Parker 900 eries, Qty = 100Only 50 have been used

Outer formation bias co and support frame



Inner surface of feedthrough flange before center electrode, bus rods and bias coil.

Pulsed Power





Vacuum system and pulsed power feedthrough



Bank of car batteries switched with IGBTs and thermal fuses, rated for 1 MW DC, 2 sec pulses for formation bias coils.



Thyratron Switch rated for 35 kV, 100 kA



nternal magnetic probe array measures toroidal and radial components at 5 axial locations during formation and acceleration discharges. Made with a closed end alumina tube, cantilevered off a double Wilson seal flange on the back plate. Positioned at R = 70 cm, coils positioned at z = 0 cm, 44 cm, 64 cm, 84 cm, 104 cm. Data shows bubble out and reconnection of back surface of CT.



Formation poloidal fields at z = 118 cm Bz Odeg 0.4 -0.3 -0.2 -0.1 -600 800 400



Formation

ements of toroidal

bubble pushing past

of internal probe coils g formation pulse at

us, followed by an

elerator pulse at 160 us

t injects flux uniformly

oidal field of external

leading edge of the

be shows sustained

e integration error.

ving front of toroidal bble matches closely

 $(\mathbf{V}, \mathbf{V}(t))$ at input electrodes

th formation circuit uctance measure by

nation bubble. 44 cm

pression of outer wall

eld, 64, 84 cm probes show

earing out of bias field. Late me signal at 104cm may

fing flux is compressed a

nd CT



Steady state B of formation bias coils is calculated to give Ψ_{mn}







High flux formation is possible with existing bank, yielding a relatively stable spheromak configuration in expansion region. Peak formation currents can exceed 1.2 MA, with more than 100 mWb of net injected toroidal flux. The external current drops from peak as circuit inductance rapidly increases during bubble out. Rebound in current is due to reconnection, and subsequent backward slingshot of wall pinned bias poloidal field lines that bring a fraction of toroidal flux back into external circuit. Light emission peaks during the bubble out phase, then subsides to an even level for about 500 us, with spikes likely corresponding to current filaments passing in and out of the collection cone angle of the fiber optics. These high flux spheromaks, however, are not possible to accelerate given that the existing bank has insufficient energy to compress such a strong field. Optimum total system efficiency will require making a lower flux CT with less caps in formation, and more caps in the accelerator bank.









Surface B field measurements show a very long CT structure, extending past 352 cm, produced by a high current formation pulse, V_{form} =15 kV, V_{acc} =33 kV. Gun flux = 63 mWb. Accelerator bank fires at 209 us and drives back end of CT down the injector with v = 61 km/s.



Time resolved spectroscopy shows impurities present in target chamber, only while poloidal field structure is present. When Bp goes away, impurity light goes out, while H light and plasma density continue for another 300 us.



Close up of Target Chamber Flux Conserver geometry



Very long CTs fit well with GS equilibrium model of a hollow λ -profile CT. Using linear model $\lambda = \lambda_{ave} [1 + \alpha^* (2\Psi - 1)]$ we find that $\alpha = -0.7$ gives a result similar to experimental data. Formation region values are: $\lambda_{ave} = 10$, $\lambda_{edge} = 16$, $\lambda_{core} = 4 \text{ m}^{-1}$



Interferometer and visible light emission signals from CT acceleration that yielded an oscillatory CT structure partially injected into target chamber



n=1 rotating mode at 29 kHz, similar to that seen on Sphex. Mode is driven by poloidal edge currents that flow around both the new small CT in bell of FC, and the main part of CT that is stagnated at muzzle of accelerator. When mode stops, the stagnated plasma at muzzle finally pushes in.