SPECTOR 1 Plasma as a Target for Adiabatic Compression

generalfusion

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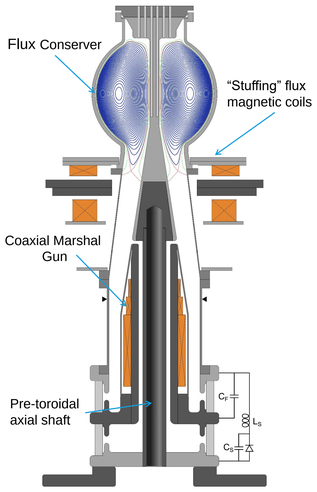
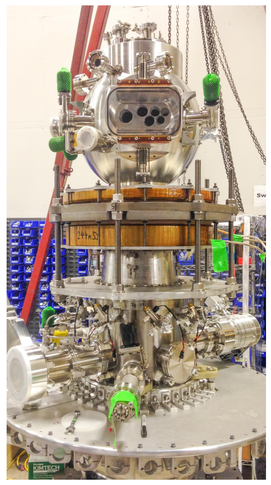
INTRODUCTION

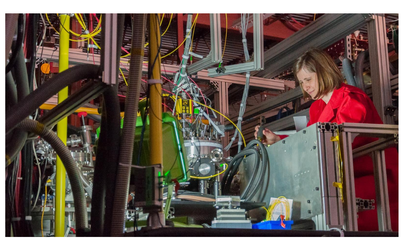
General Fusion is developing a Magnetized Target Fusion (MTF) concept, in which magnetized plasmas are brought to fusion conditions by an adiabatic compression of the plasma volume. The compression of plasma is to be reached by the concentric collapse of a liquid metal vortex. To imitate and study this type of plasma compression, General Fusion has a compression test (PCS) program in which plasmas are mechanically compressed by a chemically driven implosion of aluminum flux conservers. General Fusion has recently designed and built a new plasma injector SPECTOR (SphErical Compact TORoid) capable of generating and compressing plasmas with a more spherical form factor. SPECTOR 1 is a laboratory device aimed at generating plasmas that meet the requirements of the adiabatic compression.

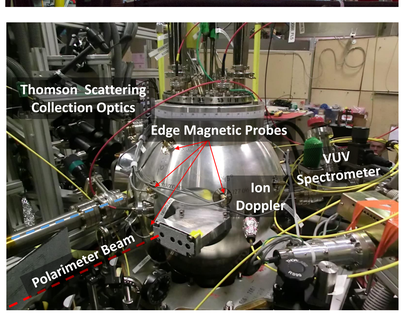
EXPERIMENTAL SET UP





- A spherical tokamak with Rinner = 3 cm, Router=19 cm
- The current through axial shaft is 0.5 MA
- Plasma density is $(1-2)x10^{14}cm^{-3}$
- T_e at the plasma center is 350 – 450 eV
- Toroidal Magnetic Field 0.5 T at the center of the plasma
- Plasma current of 300-800 kA is induced using coaxial helicity injection
- Coaxial Marshall Gun generates 80 µs long formation pulses of the current up to 850 kA
- The "stuffing" magnetic flux in the Gun is 10 - 20 mWb.
- The plasma current is not sustained and it resistively decays over 1.5 - 1.9 ms.
- The inner surfaces of the Gun and inner wall of the flux conserver are coated with plasma-sprayed Tungsten, the outer wall is pure Aluminum.



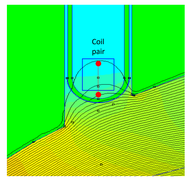


Flux conserving plasma vessel equipped with diagnostics

DIAGNOSTICS

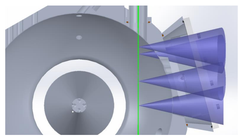
Surface Magnetic probes:

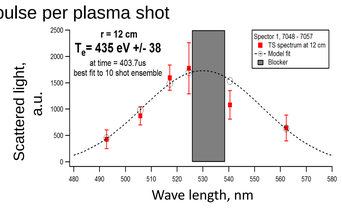
- 41 magnetic probes on the inner and outer walls of the plasma vessel and in the Marshall Gun.
- Each probe measures poloidal and the toroidal components of B



Thomson Scattering:

- A YAG laser generating 1 pulse per plasma shot

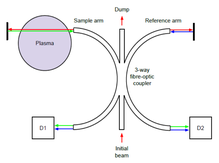




- λ=532 nm,10 ns pulse, with the energy of 1.5 J
- The scattered light was collected from 3 radially resolved points.

Fiber-based Infra-red Interferometers:

- Two IR interferometers. One is aligned horizontally and one nearly vertically
- λ=1.5 µm.
- The dual wave length technology is used

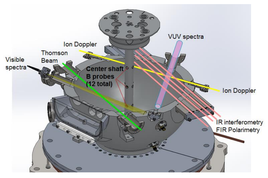


SXR Diagnostic:

- Two AXUV photodiodes with Al filters (5um and 10um thick).
- The ratio of signals generated by Bremsstrahlung radiation can be used to infer Te.

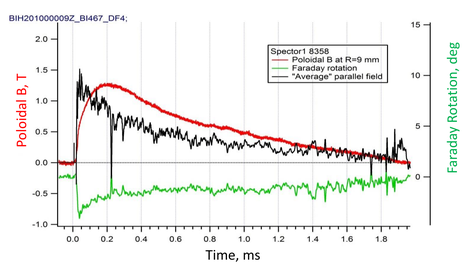
FIR Interferometer:

- A heterodyne interferometer
- Two 118.8um methanol cavities.
- The methanol cavities are pumped by a CO2 laser.
- The beams are combined and focussed onto a Schottky diode mixer.



FIR Polarimeter:

- Currently under development to constrain the q-profile of Grad Shafranov reconstructions.
- Four chords on the midplane sensitive to toroidal magnetic field.
- Faraday rotation is measured with the Dodel-Kunz heterodyne method using two counter rotating circularly polarized beams.



Visible Light Spectroscopy:

- Two Photon Control spectrometersSPM-002
- λ=200-850nm, exposure times down to 10us.

Time resolved total visible light.

- 4 vertical and horizontal chords
- Time resolution of < 1 µs.
- The system is absolutely calibrated

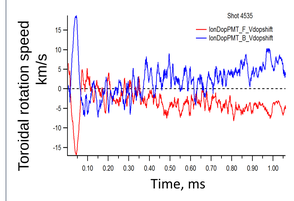
Two High Energy Scintillators

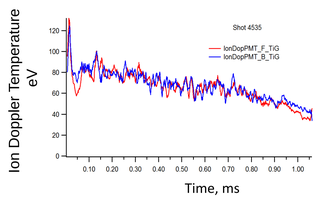
VUV Spectrometry:

- McPherson spectrometer (model 234-302 UHV) can measure light in the range of 50 – 200 nm
- Output plane is a sodium salicylate coated window acting as a VUV-visible scintillator.

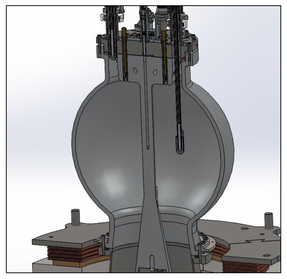
Ion-Doppler Spectroscopy:

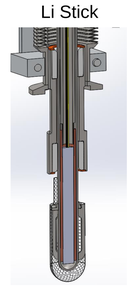
- Two high resolution Horiba iHR550 spectrometers with 16 channel PMT arrays
- Measurements of the line shape and Doppler shift of a single spectral line



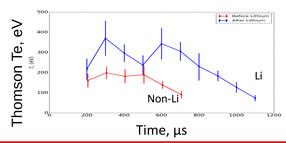


Li COATING

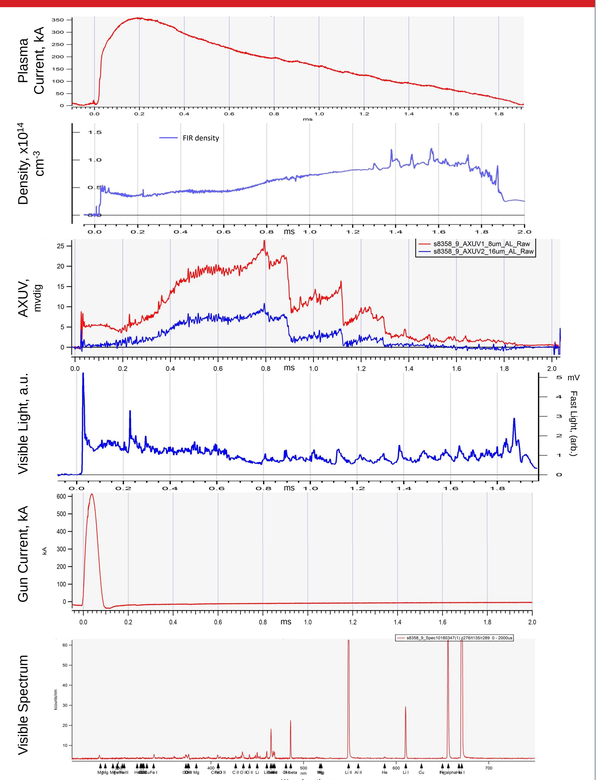




- The inner surfaces of the flux conserver are periodically coated by evaporated metallic Lithium.
- The original General Fusion "Li stick" technology was used.



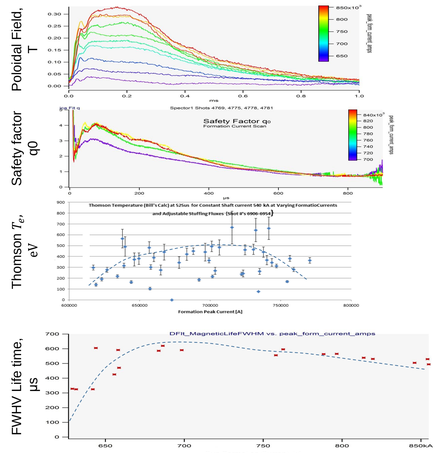
TYPICAL SPECTOR PLASMA



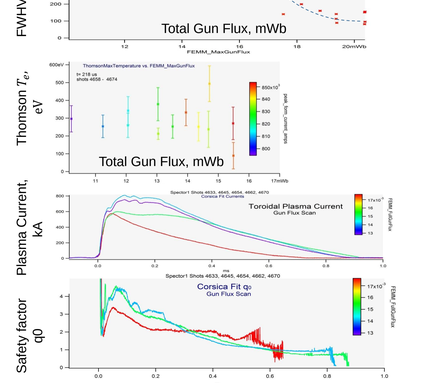
PLASMA OPTIMIZATION EXPERIMENTS

MHD stability and plasma lifetime was explored in different magnetic configurations, and with various safety factors q(a).

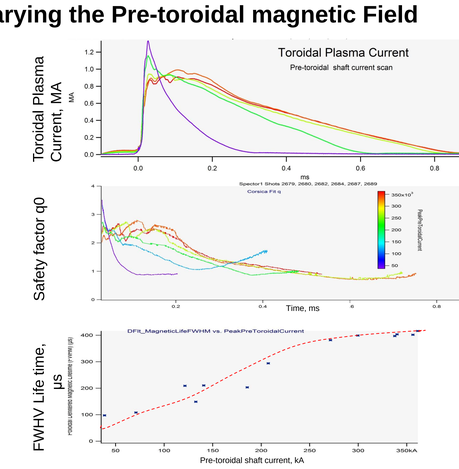
Varying the Marshall Gun Current:



Varying of the Magnetic Flux in the Gun



Varying the Pre-toroidal magnetic Field



SUMMARY

SPECTOR 1 generates plasmas with the major and minor radii of R=12.1 cm and a= 8 cm, having the inverse aspect ratio ε = 0.7 and elongation k=1.76.
The relatively hot ($T_e \geq 350$ eV) and dense (~ 2 x 10^{20} m^{-3}) plasma has achieved magnetic confinement time of τ_m~ 1- 2 ms.
With β ~ 0.04, the energy confinement time τ_E is to be estimated as ~100 µsec, which makes the SPECTOR devices suitable for compression tests.