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EPR 2016

General Fusion's Acoustically Driven MTF

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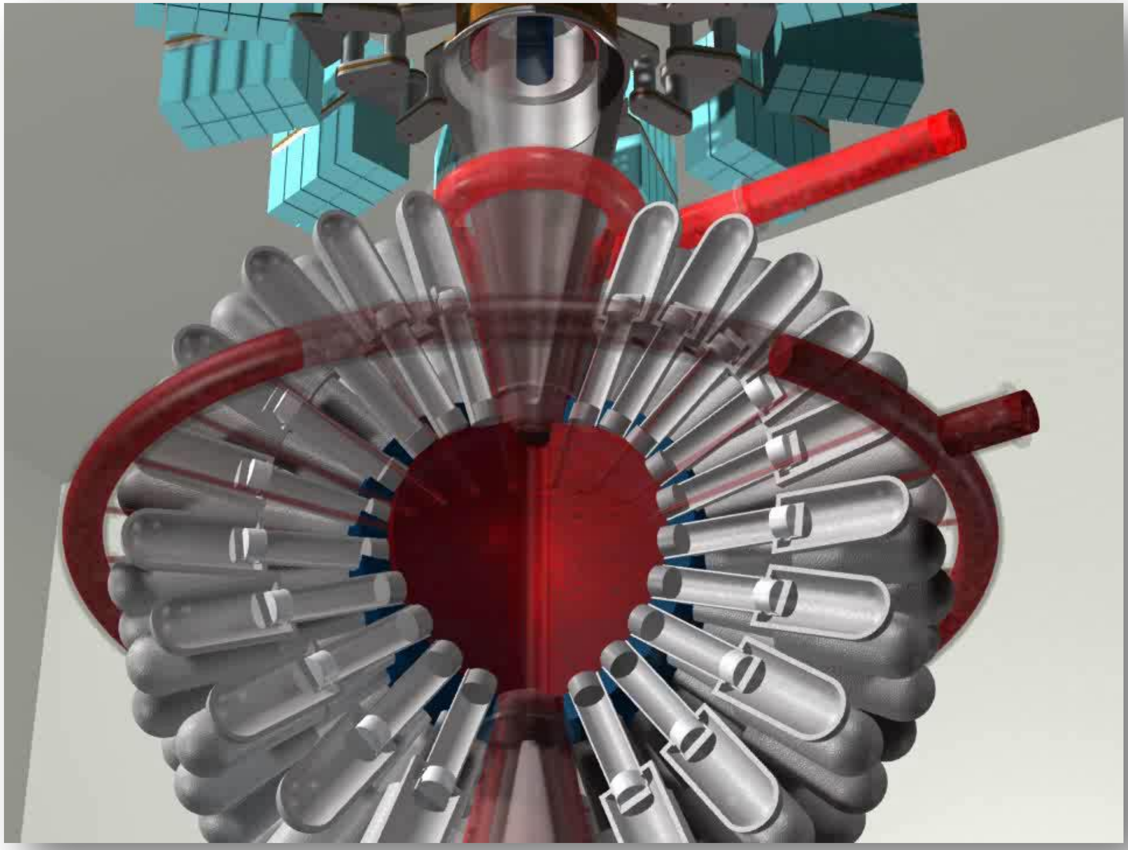


Example Parameters

Initial Conditions

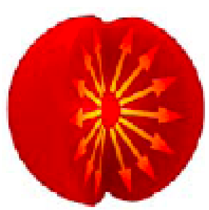
Pistons kinetic energy	120	MJ
Initial plasma density	1.25×10^{17}	cm^{-3}
Initial plasma temperature	100	eV
Initial magnetic field	7	Tesla
Initial plasma radius	20	cm

Compression

Radial compression	10	
Maximum fluid-plasma surface velocity	-2600	m/s
Energy transfer to plasma	14	MJ

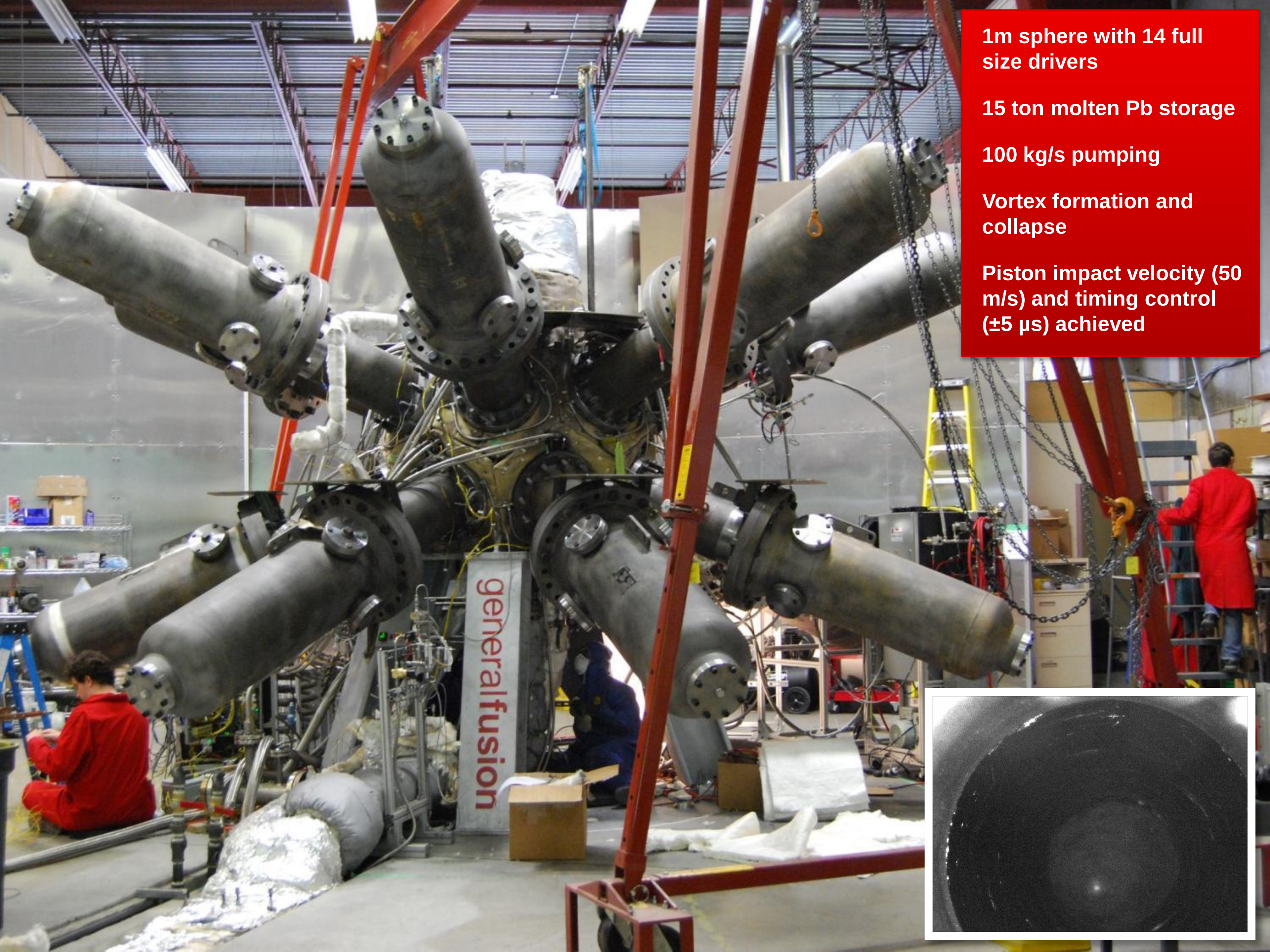
Ignition

Peak plasma density	1.16×10^{20}	cm^{-3}
Peak plasma temperature	25	keV
Peak plasma pressure	5	Mbar
Peak magnetic field	670	Tesla
Confinement time (FWHM of plasma density):	7	μs



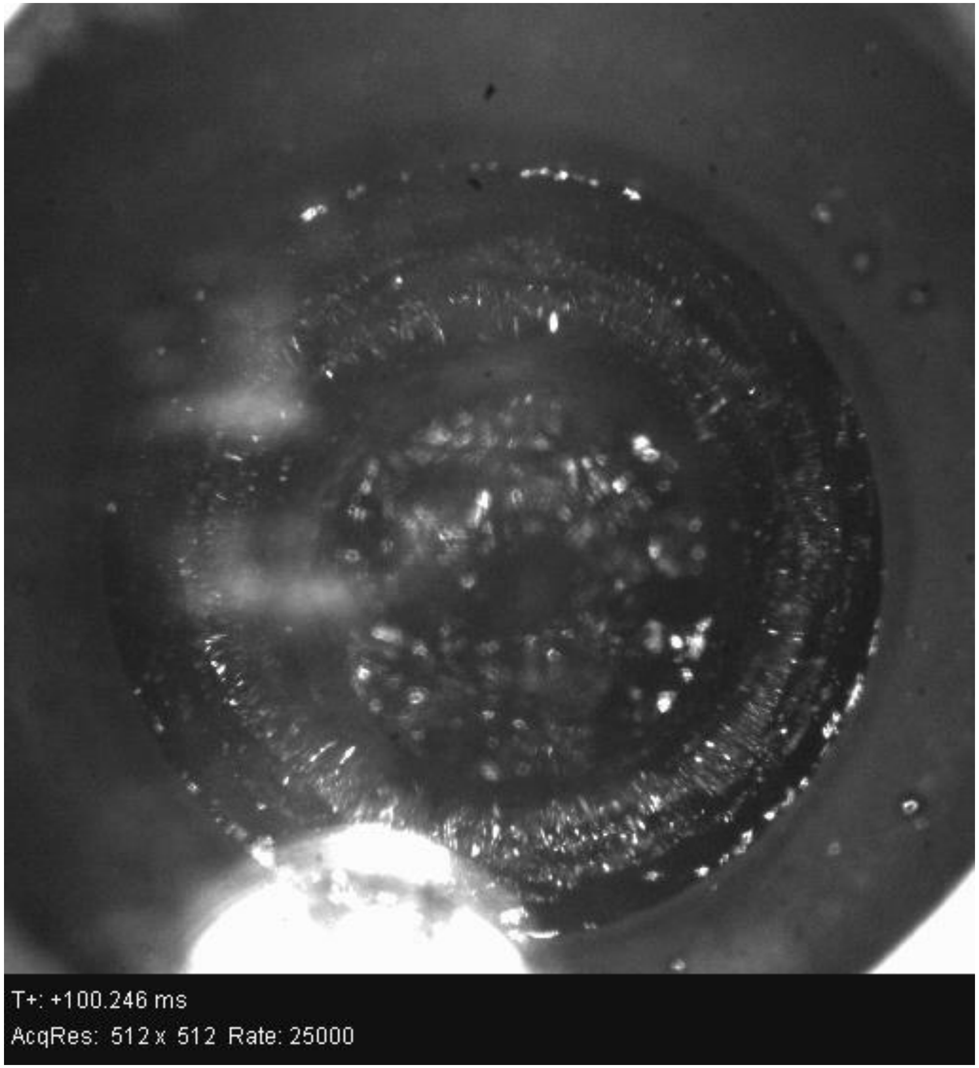
Energy Output

Fusion energy produced	700	MJ
Energy gain	6	

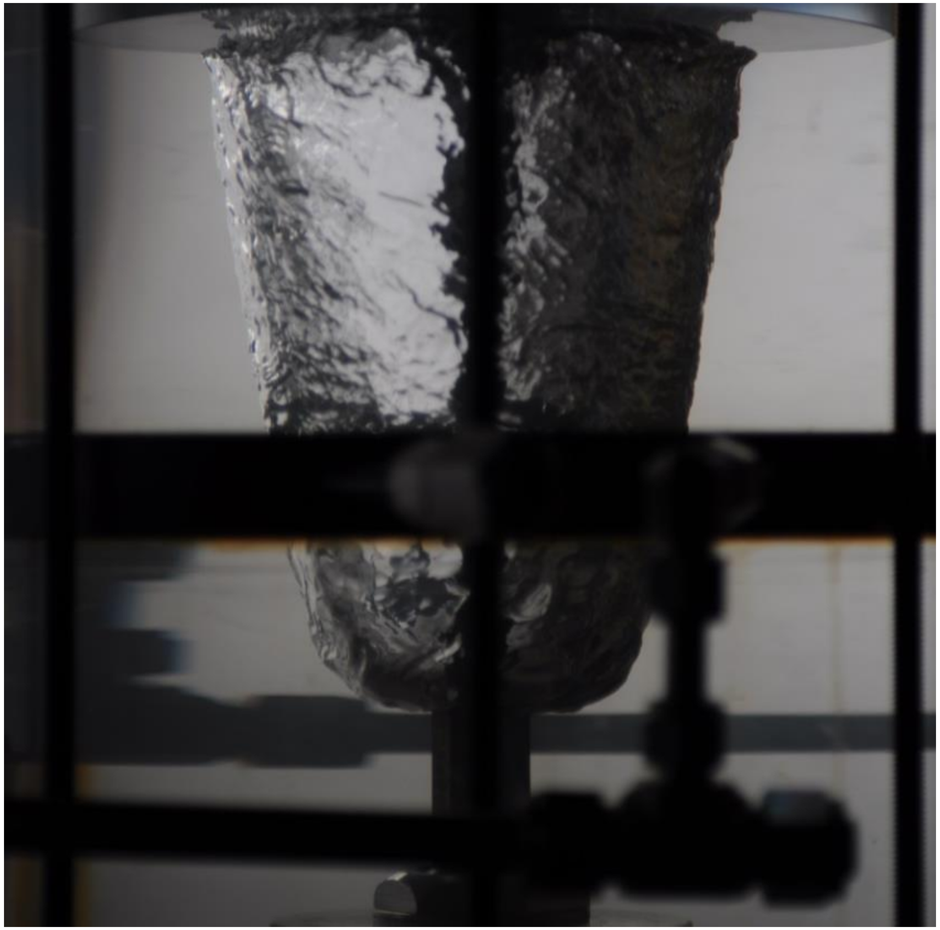


- **1m sphere with 14 full size drivers**
- **15 ton molten Pb storage**
- **100 kg/s pumping**
- **Vortex formation and collapse**
- **Piston impact velocity (50 m/s) and timing control (±5 μs) achieved**

Liquid Pb Vortex Collapse

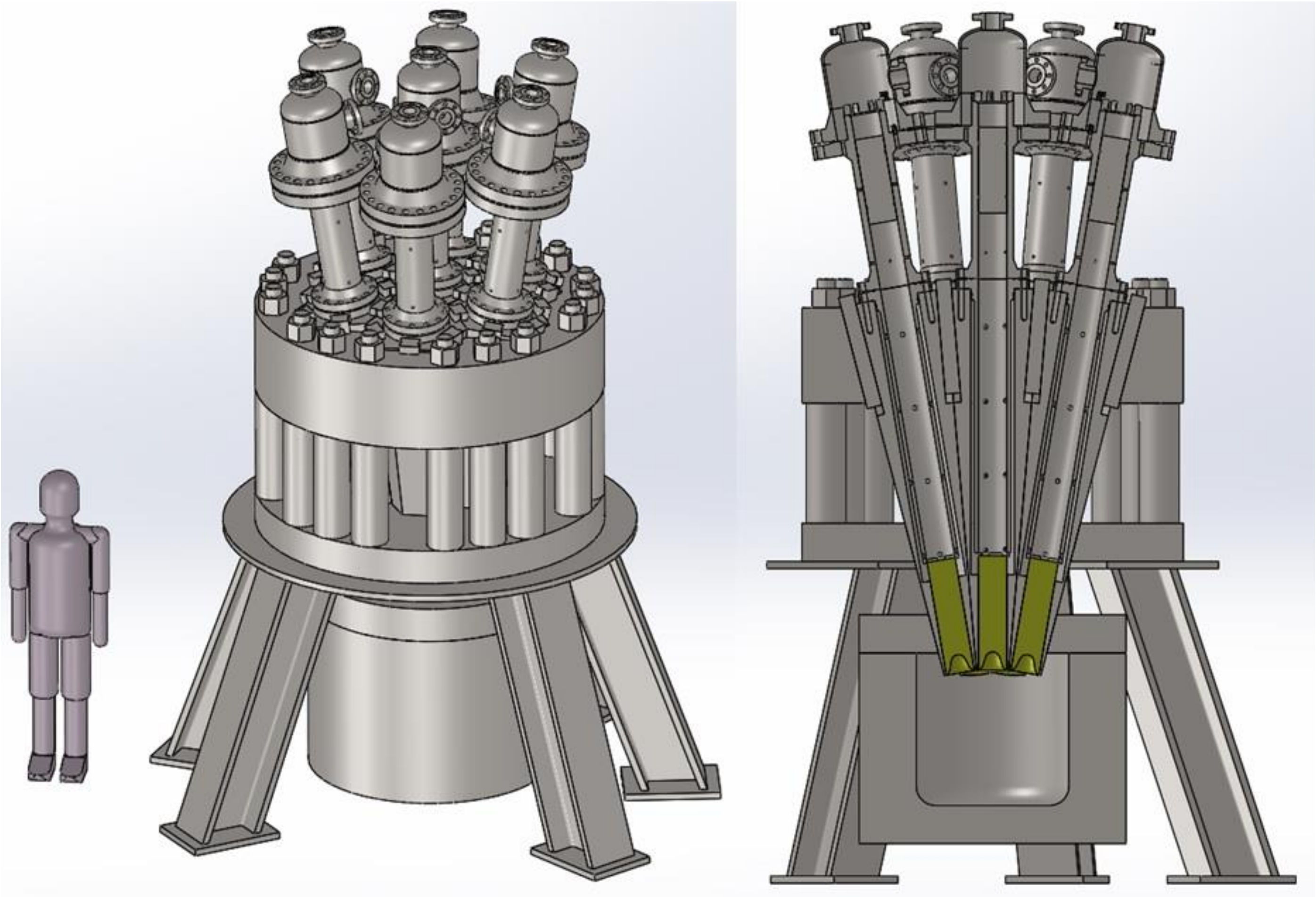


Vortex Progress



Anvil test rig 2016:

- Test pistons, seals, anvils under power plant conditions
- Compare and validate pressure pulses and acoustics vs. simulation
- Complete build in 2016



Plasma Injector Simulation

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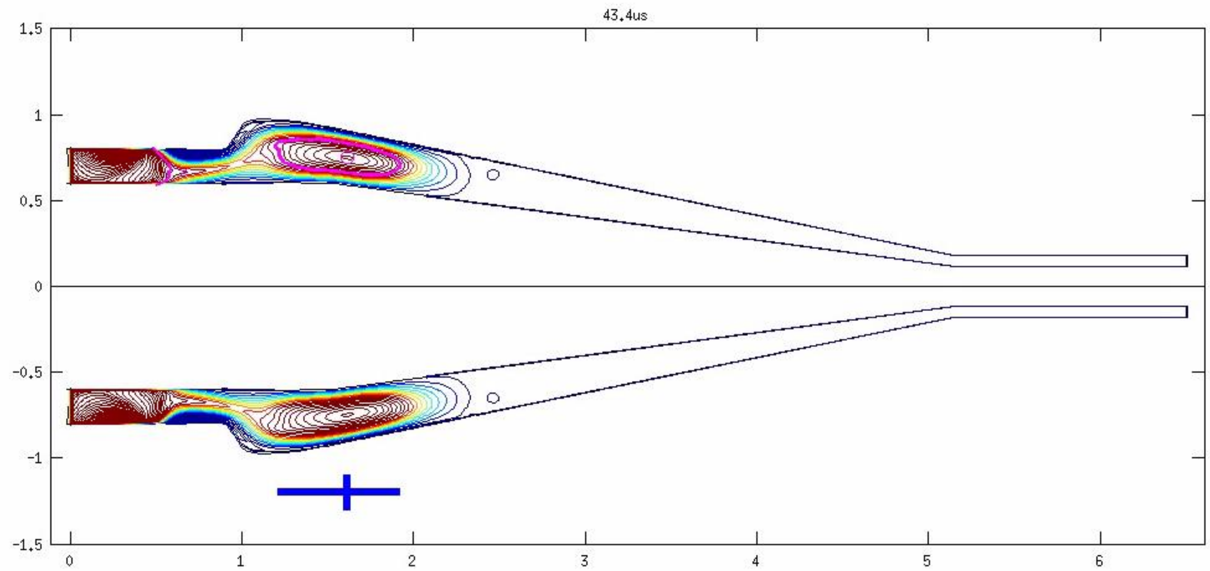
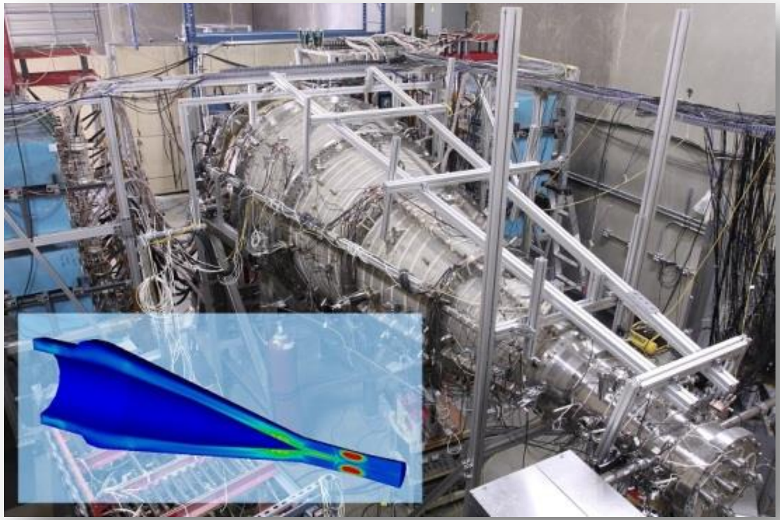




Plasma Injector

5×10^{16} cm^{-3}

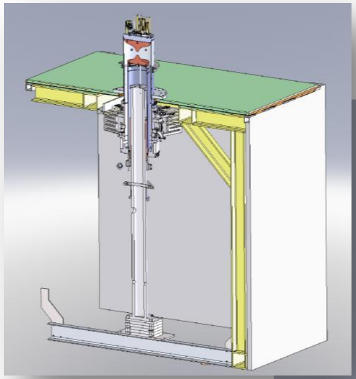
300 eV

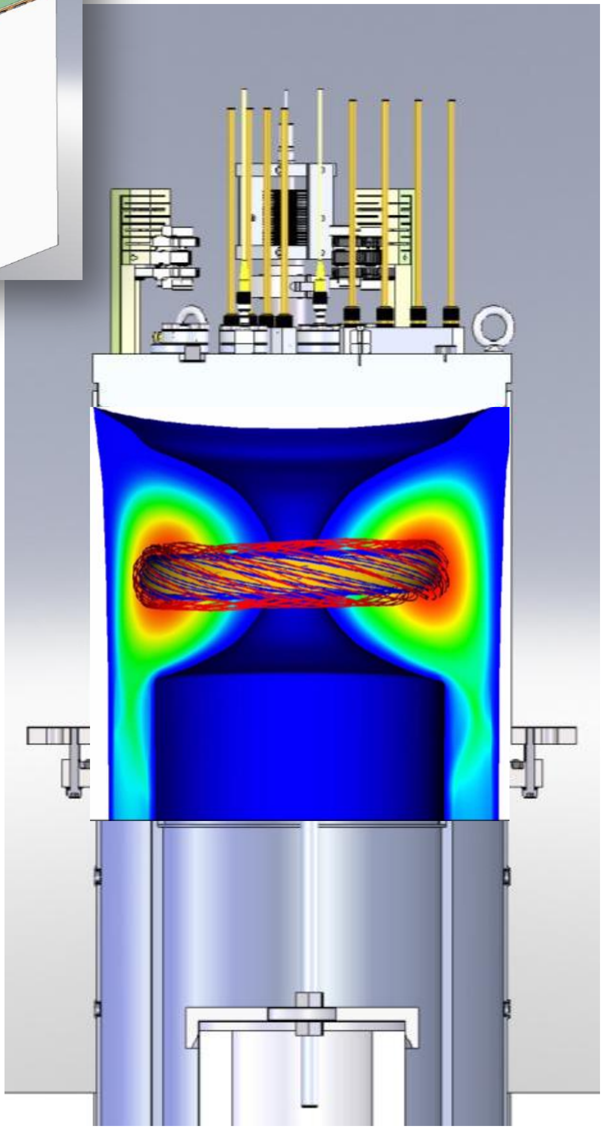
20 μs

3 T

Accelerator current damages plasma magnetic structure

Small Plasma Injector





Direct formation: no acceleration stage.

Comparable to CTX and SSPX designs

Lower maximum plasma density than large injectors

1e15 cm^{-3}, 300 eV

800 μs magnetic life,

80 μs energy confinement time

1.5 T

Faster design iteration

Designed for use in plasma compression experiments

Plasma Lifetime Progress

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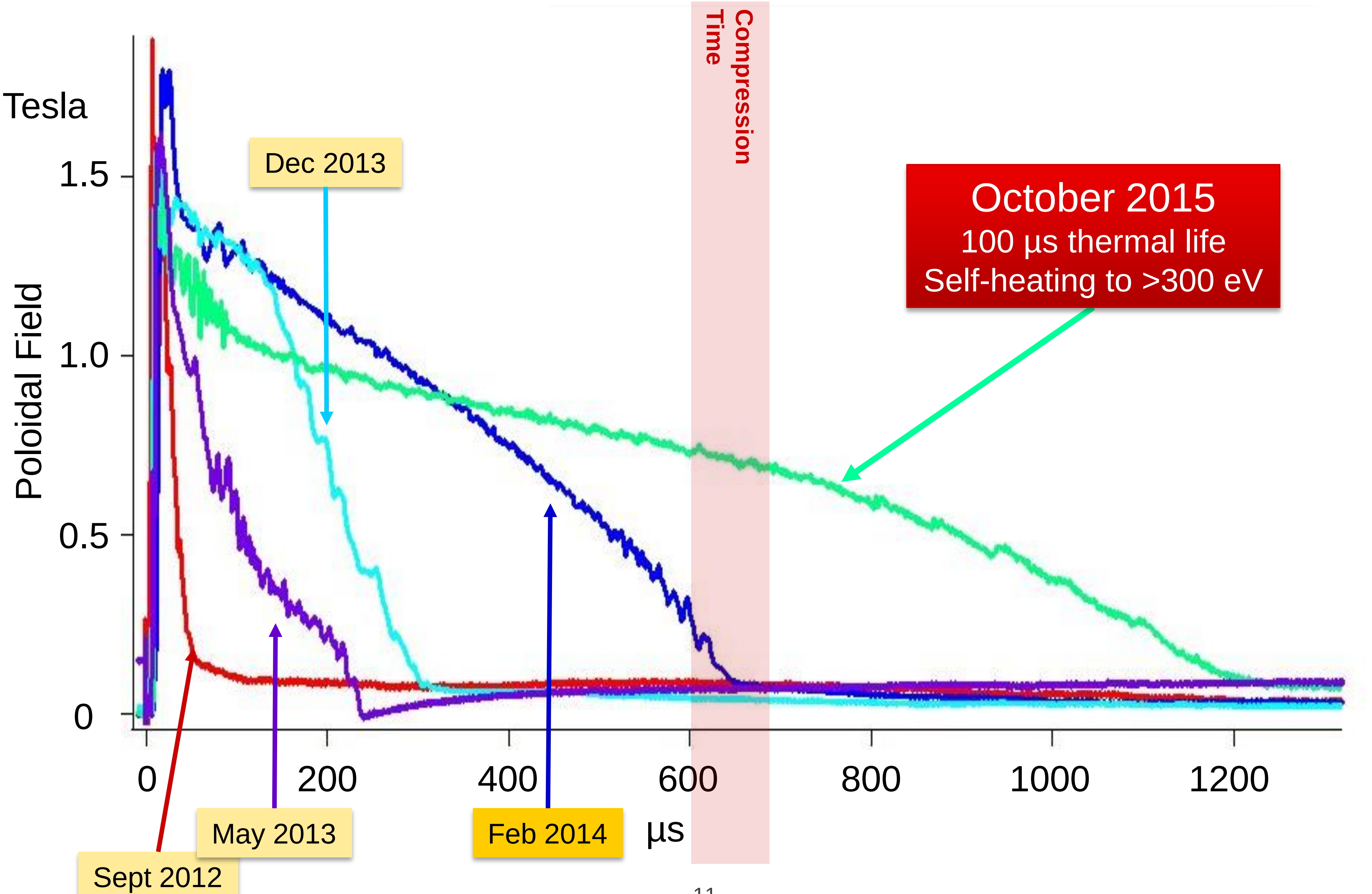
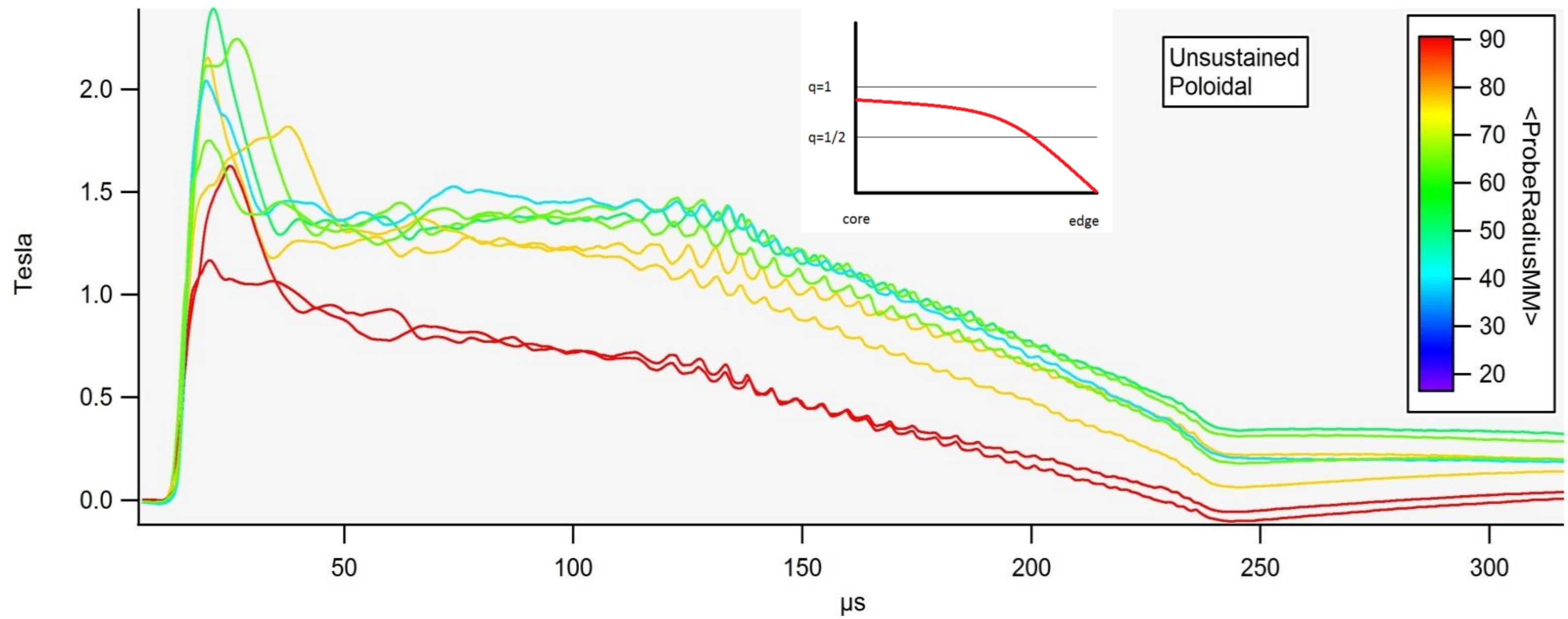
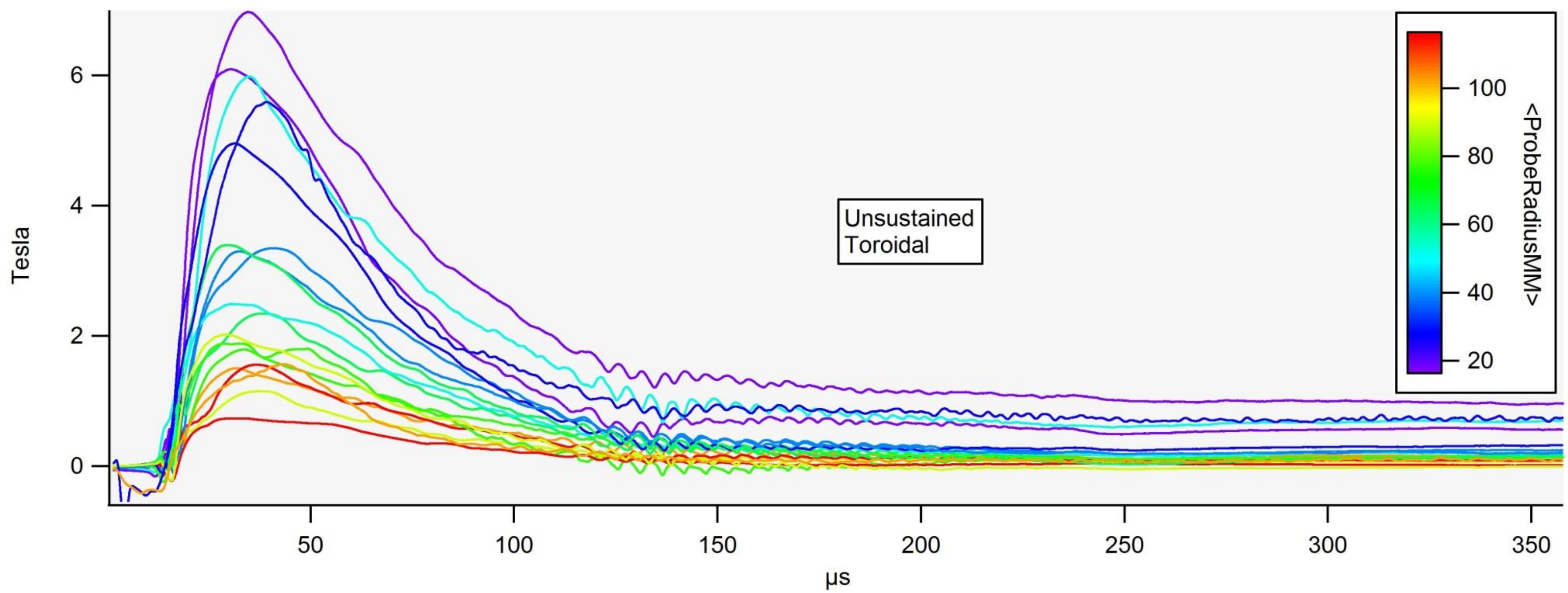
GF has created a long-lived plasma that we believe is good enough to compress. In 2016 we are not targeting creating a longer-lived plasma



Poloidal and toroidal field unsustained





Sustained Poloidal and Toroidal field

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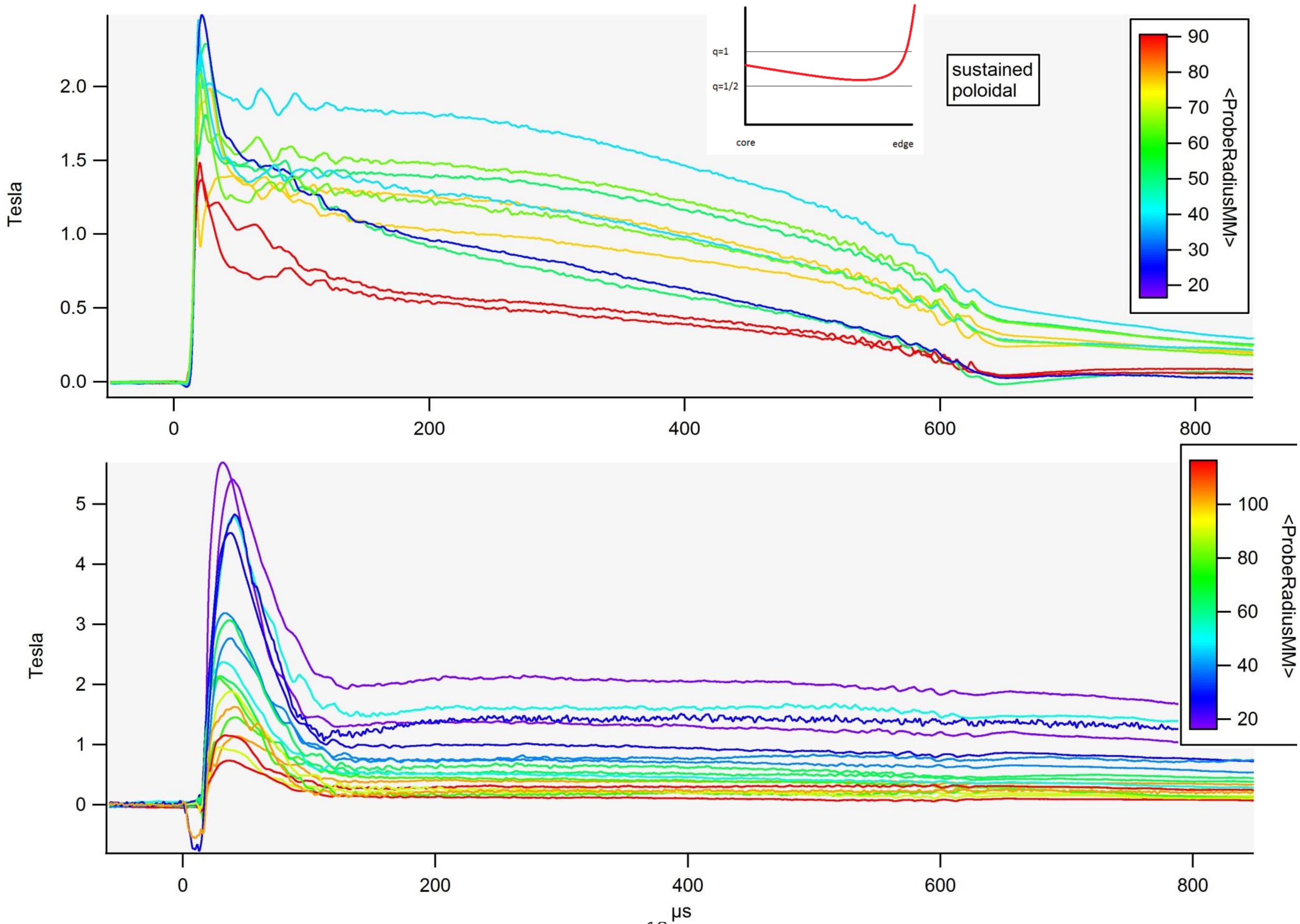
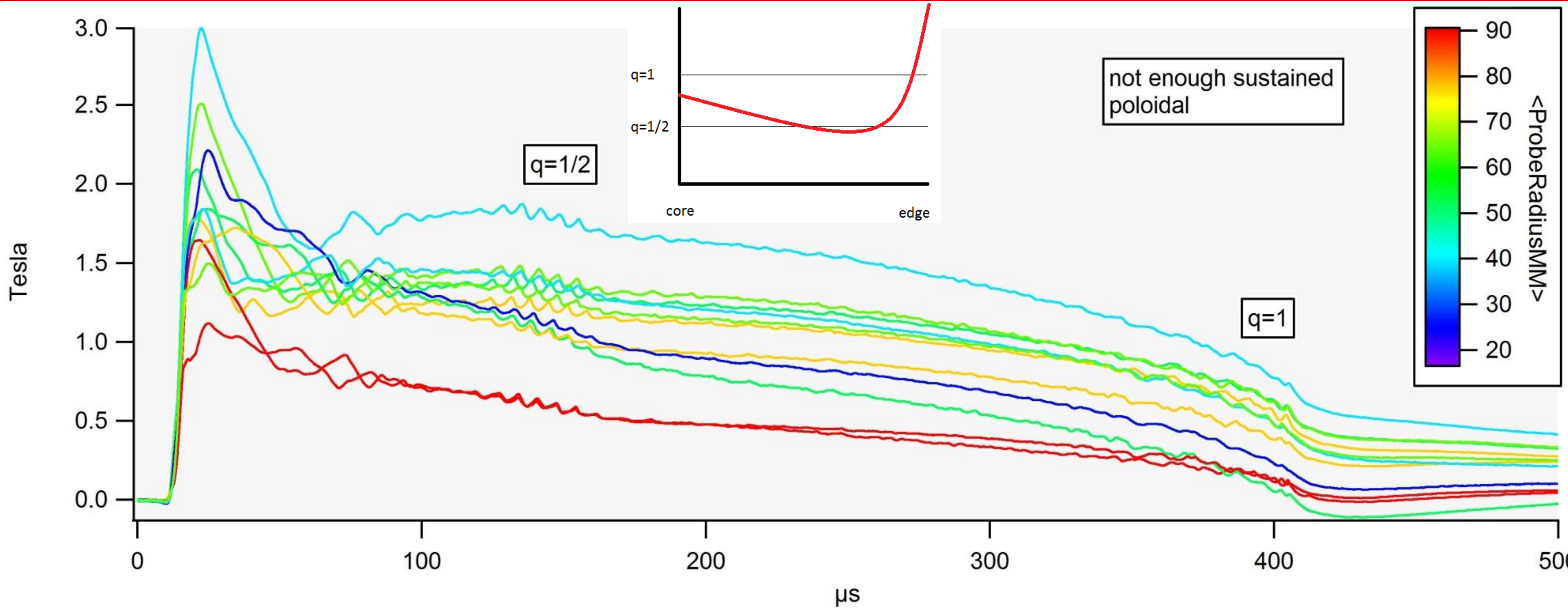
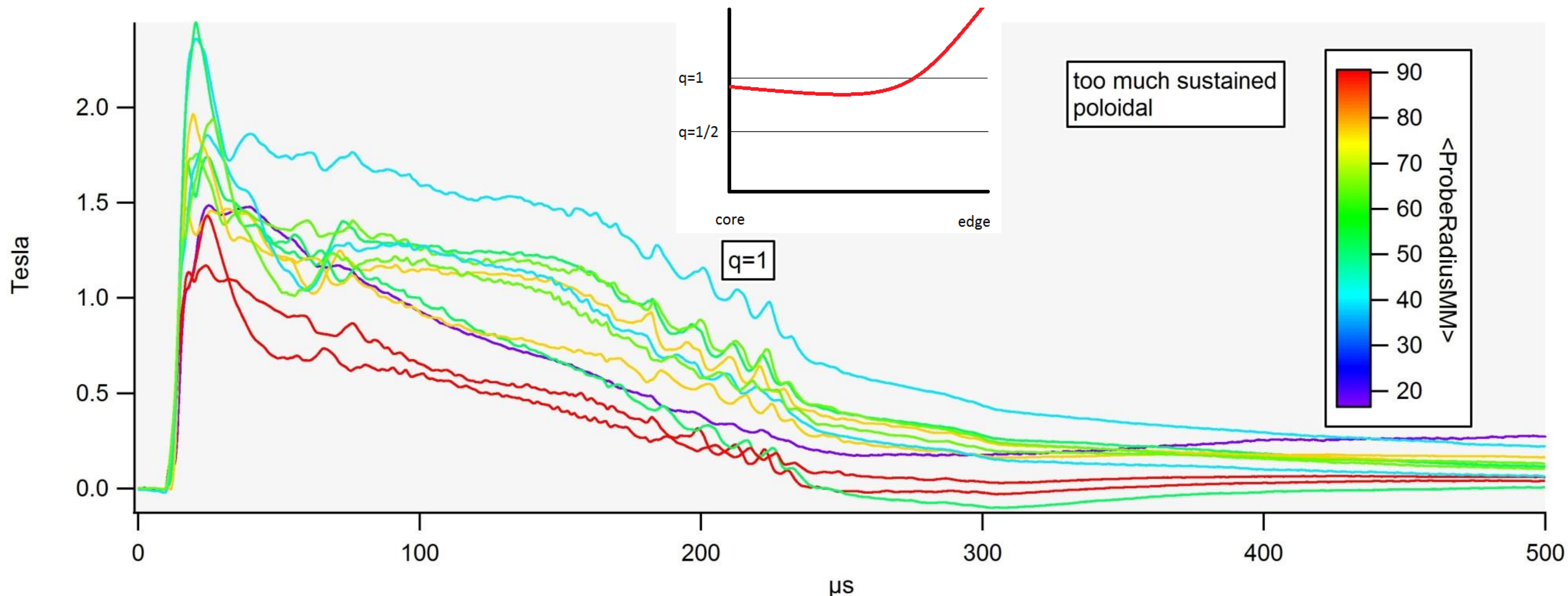


Under and Over Sustained Poloidal Field





Temperature Rises With Time

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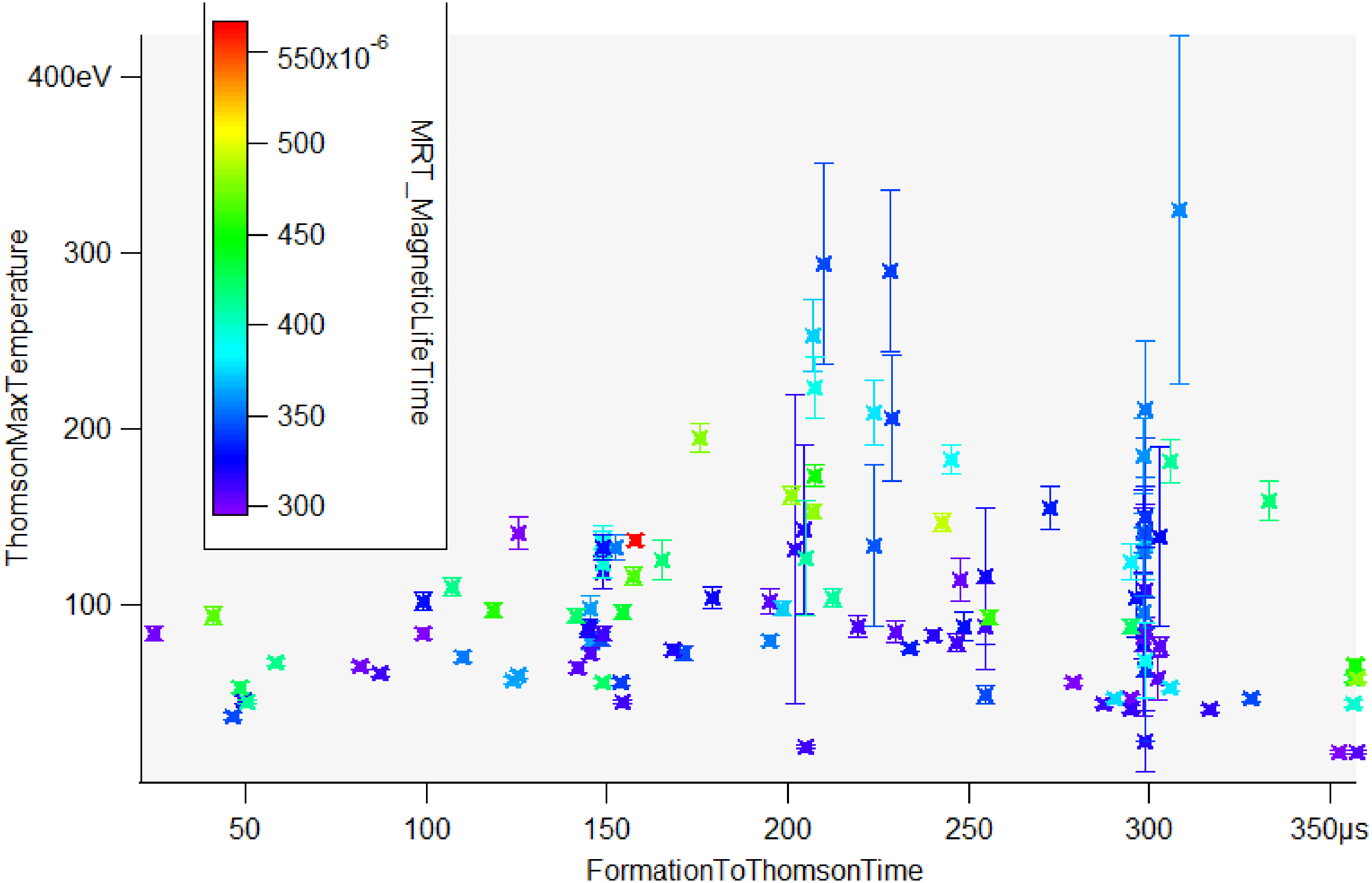
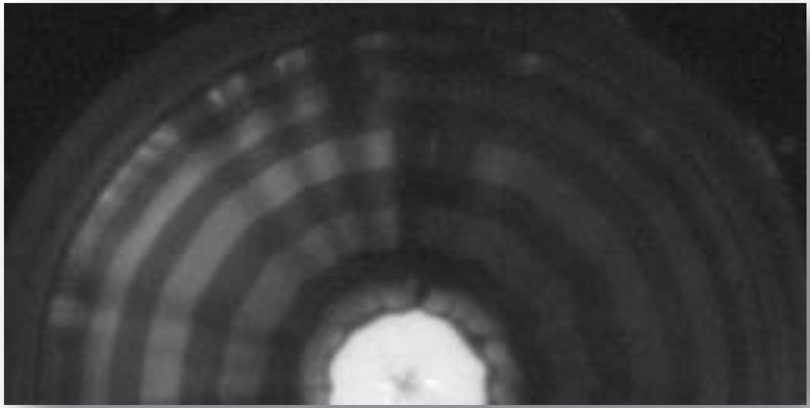
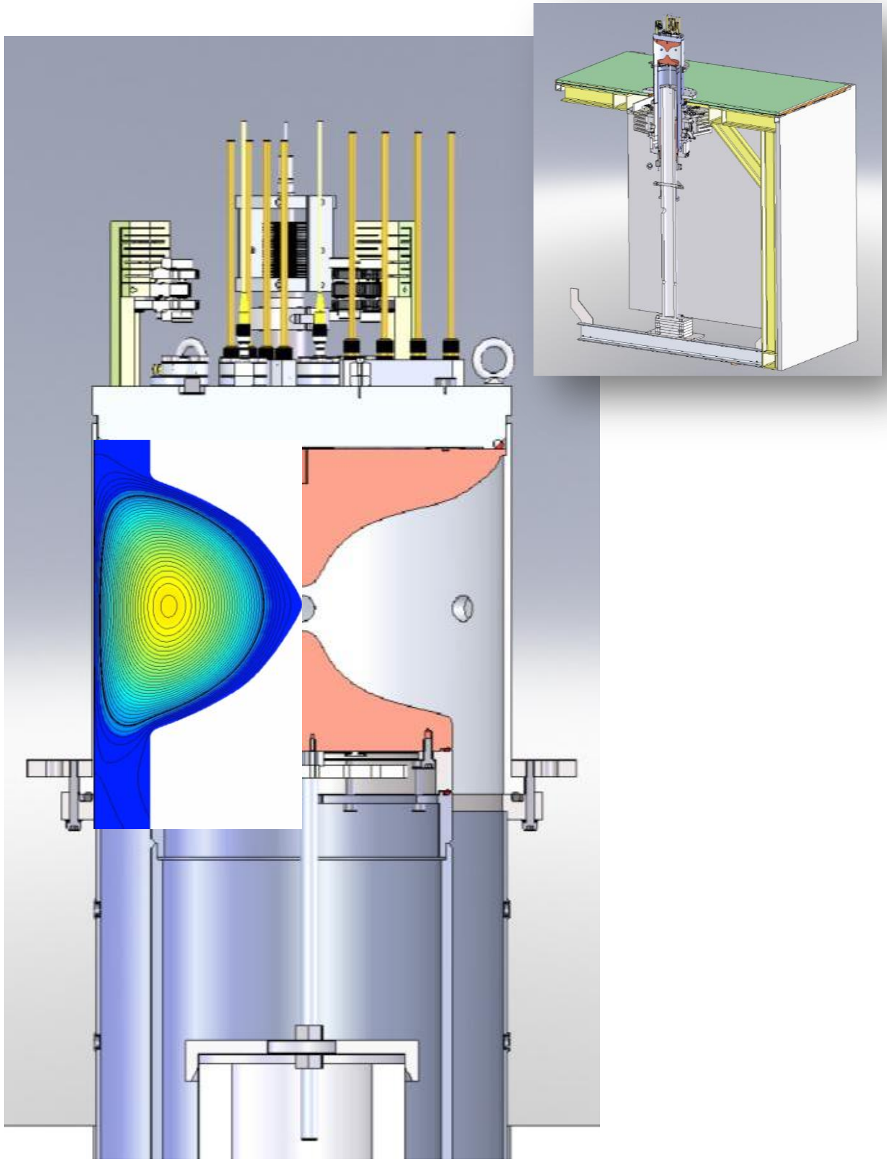


Plasma Compression Testing





Diagnostics

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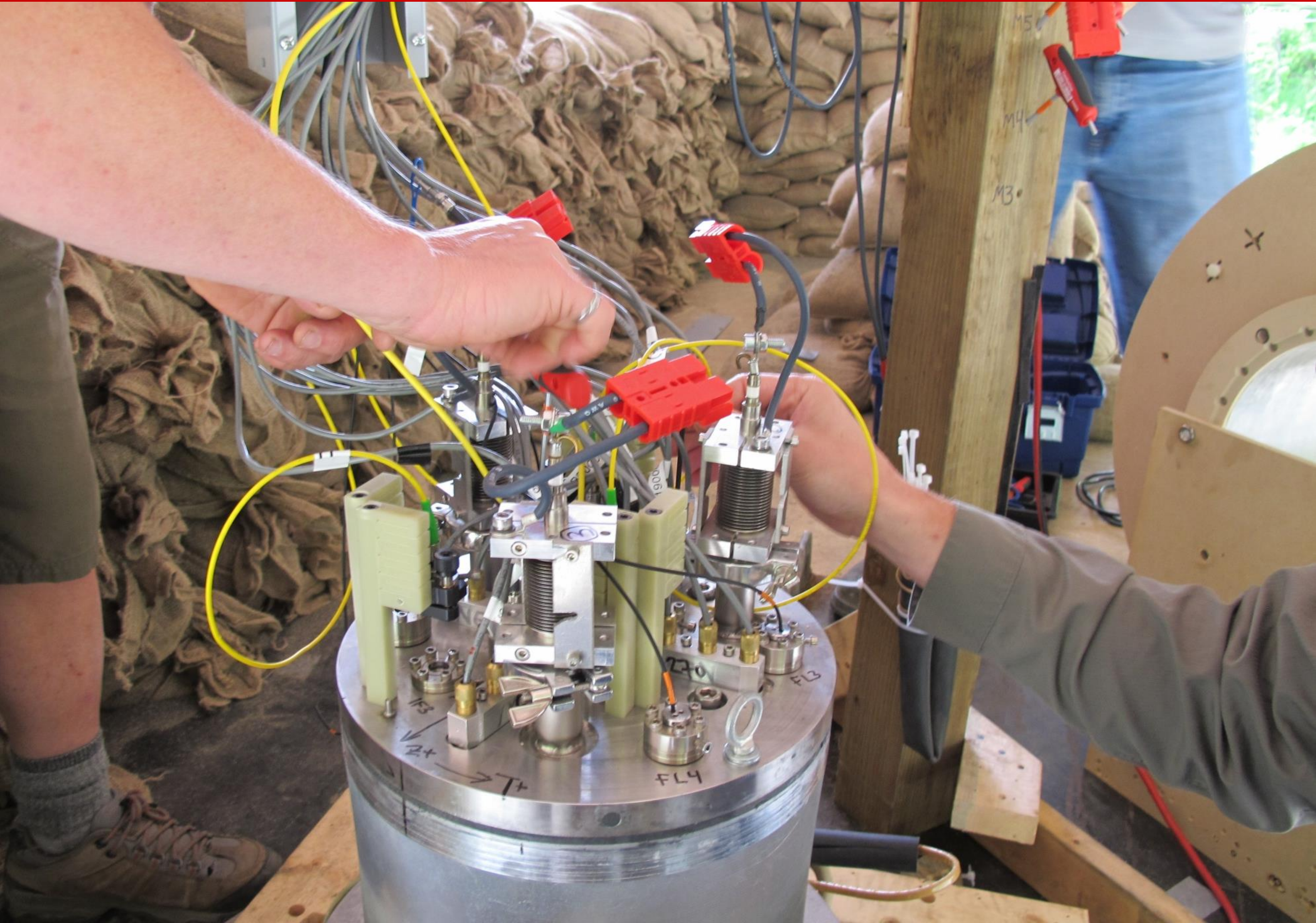
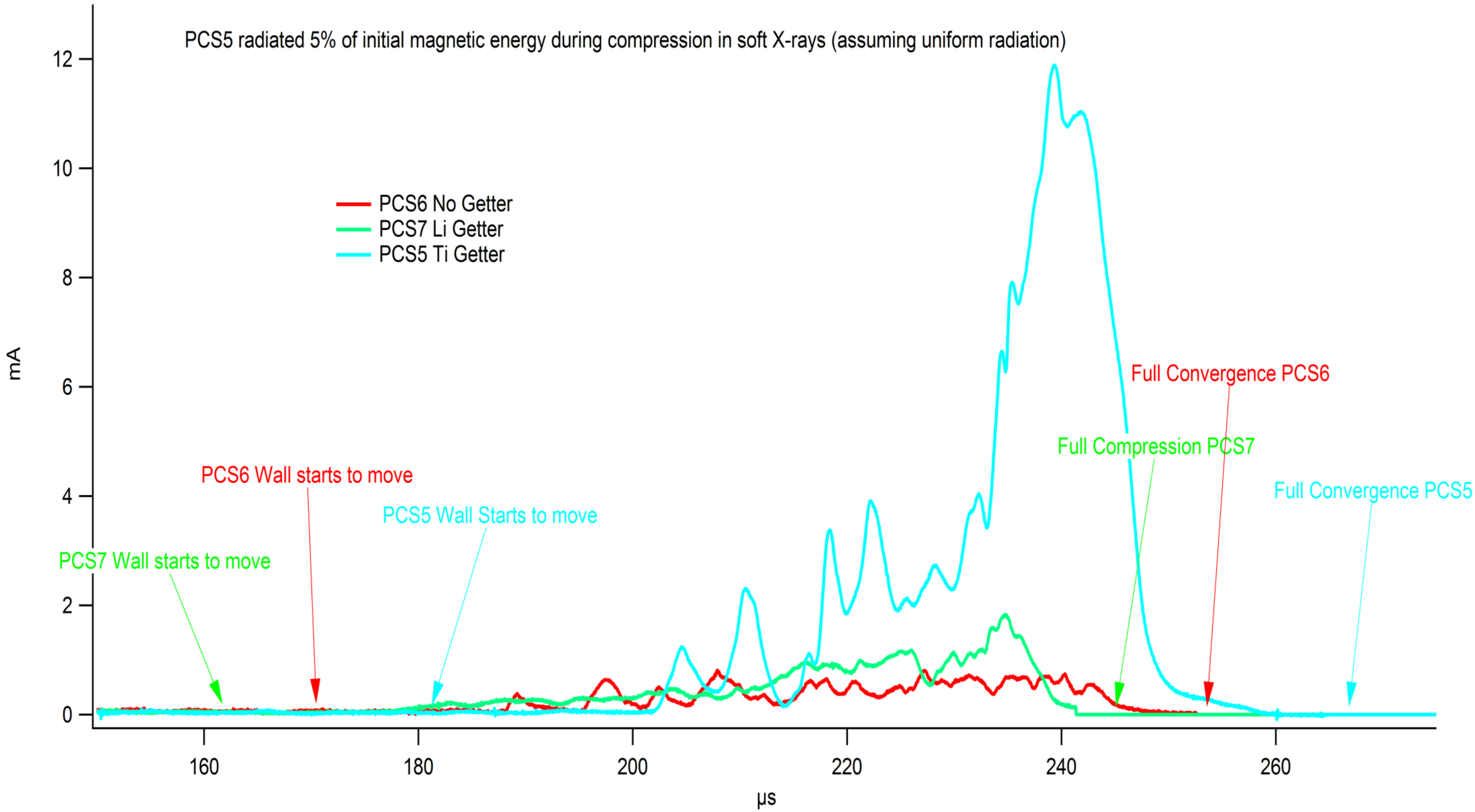
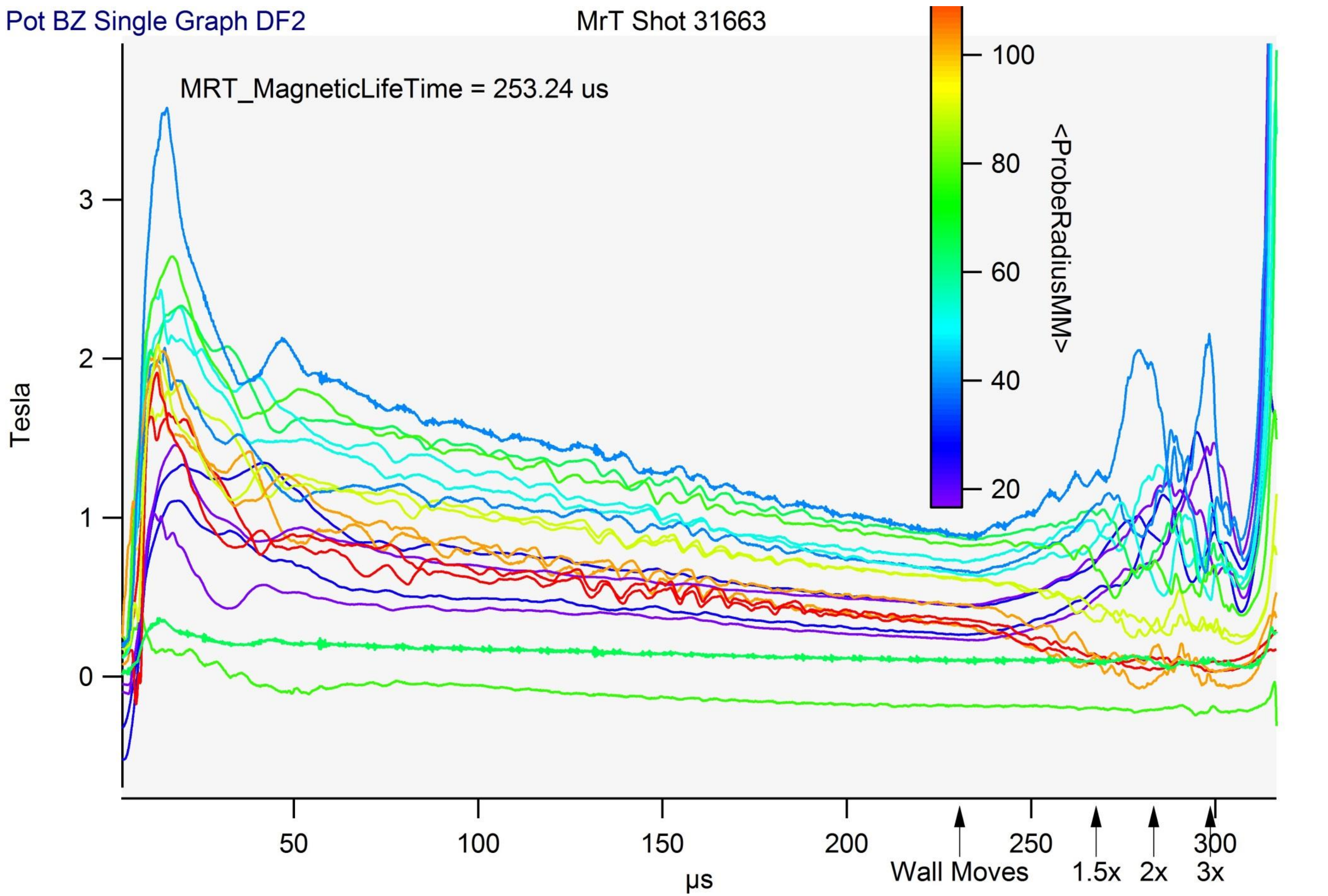


Fix radiation death

- Changed from Ti coating to Li coating. Lower Z. Less brittle coating
- Put a vacuum gap between the explosive and the liner. Shockless acceleration of the liner

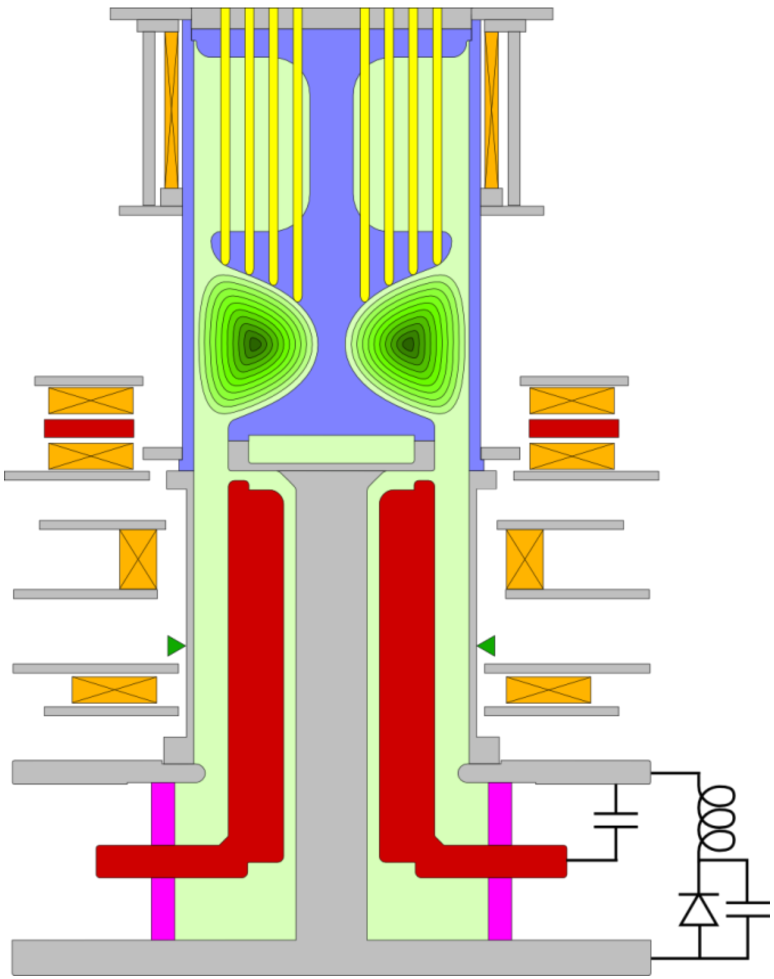


Spheromak compression



Built to allow more systematic/deliberate control of:

- 'Sustainment' current path:
- Overall safety factor: Stuffing Flux has Toroidal component



- Can drive up to 800 kA through central shaft (separate electrical circuit)
- Formation current of up to 1 MA
- No gap below Center electrode

Prospector

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Scan of Shaft Current in PROSPECTOR

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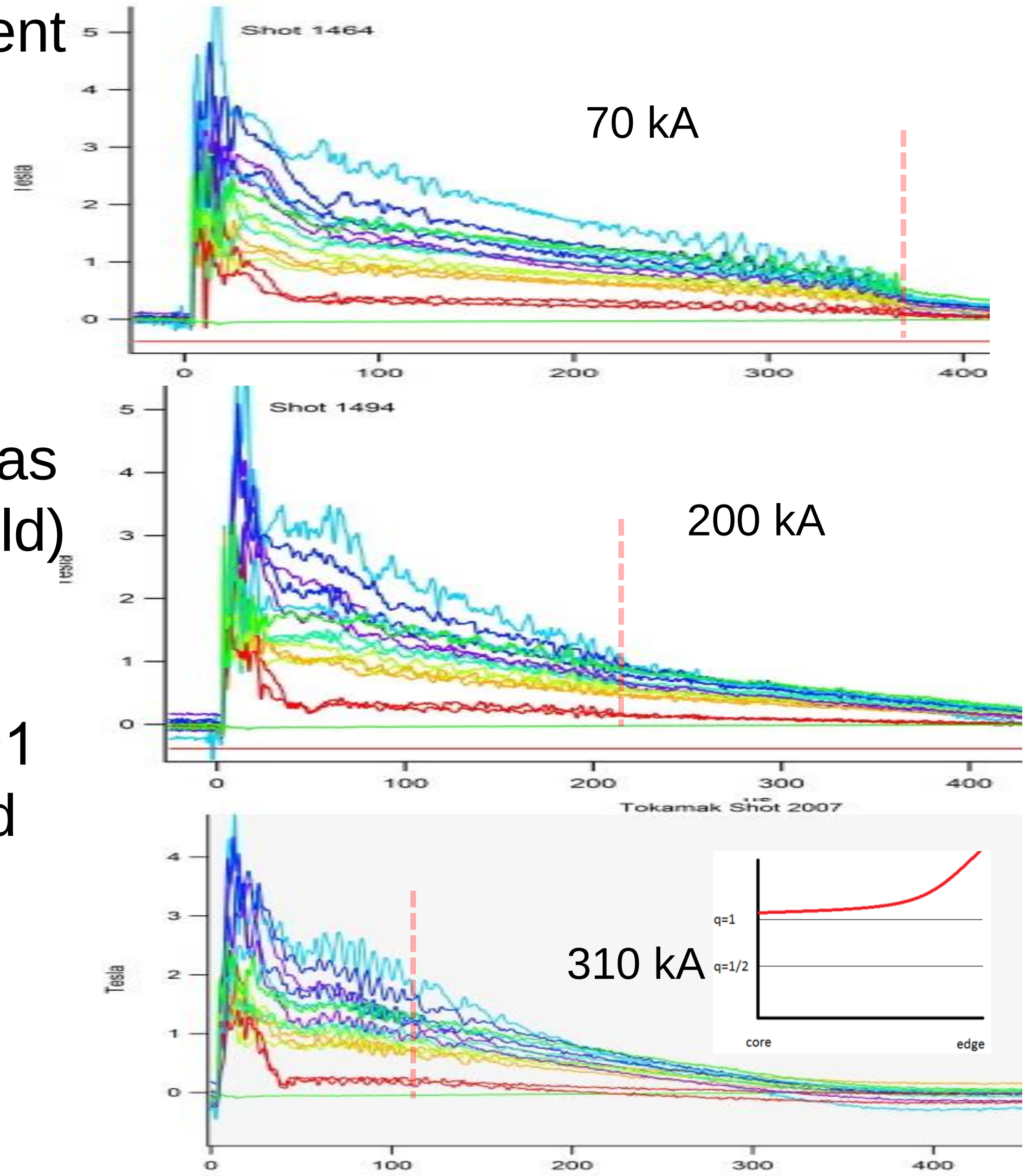
- Early scans of shaft current showed transition from familiar spheromak behavior to tokomak-like behavior (dashed line)

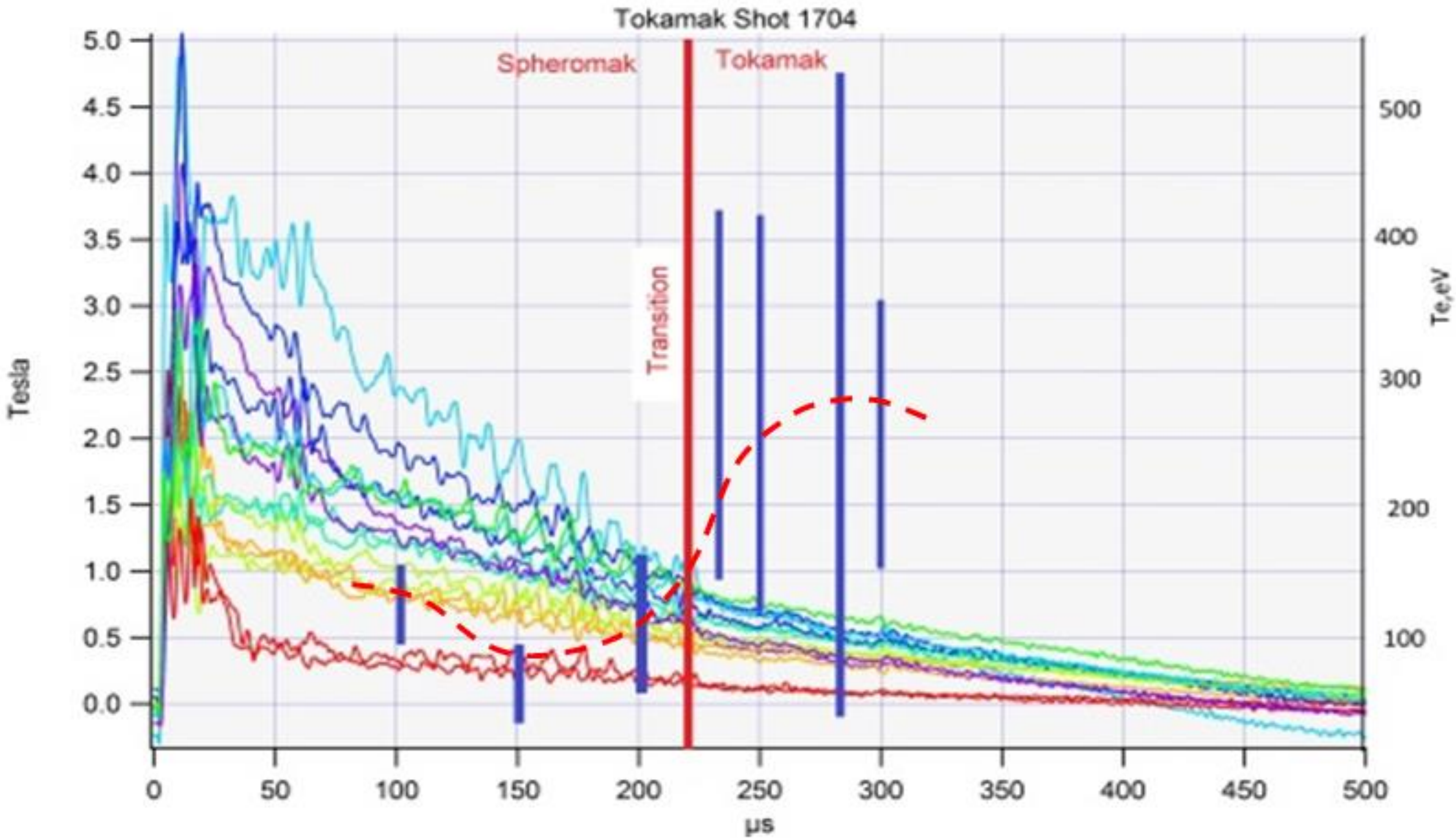
- Transition occurs earlier as shaft current (Toroidal field) increased

- ‘Tokamak’ discharge (q >1 everywhere) has reduced magnetic turbulence



Plasma Characteristics after Transition

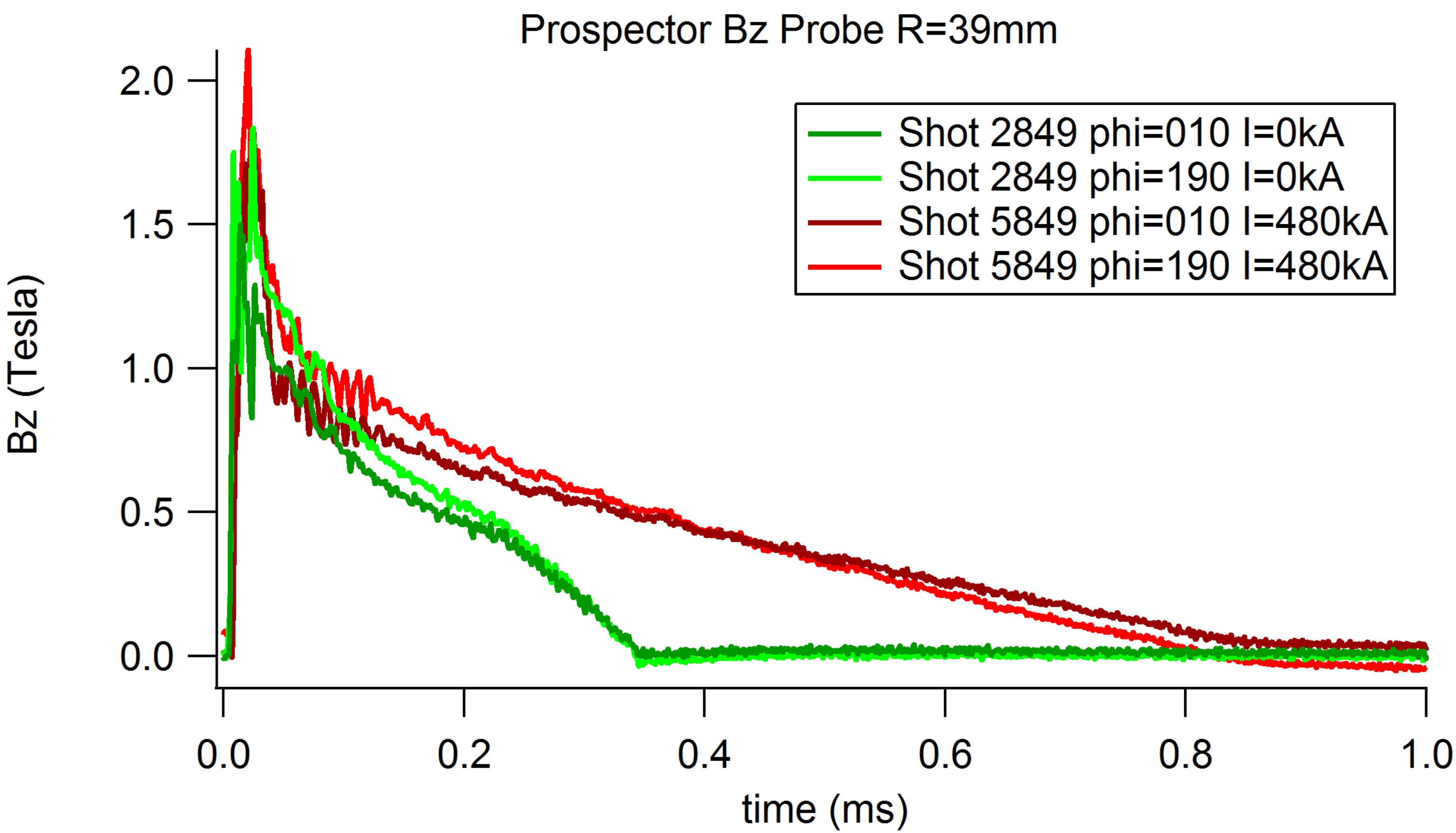
- Increased electron temperature (from Thomson scattering)



- PROSPECTOR data

Optimized PROSPECTOR Plasmas

- By scanning magnetic configuration, gas puff timing and shaft current we have achieved lifetimes up to 1 msec
  - lower densities (~ $3 \times 10^{20}\ m^{-3}$) than our Spheromaks



Poloidal Field Compression: Field Test #12

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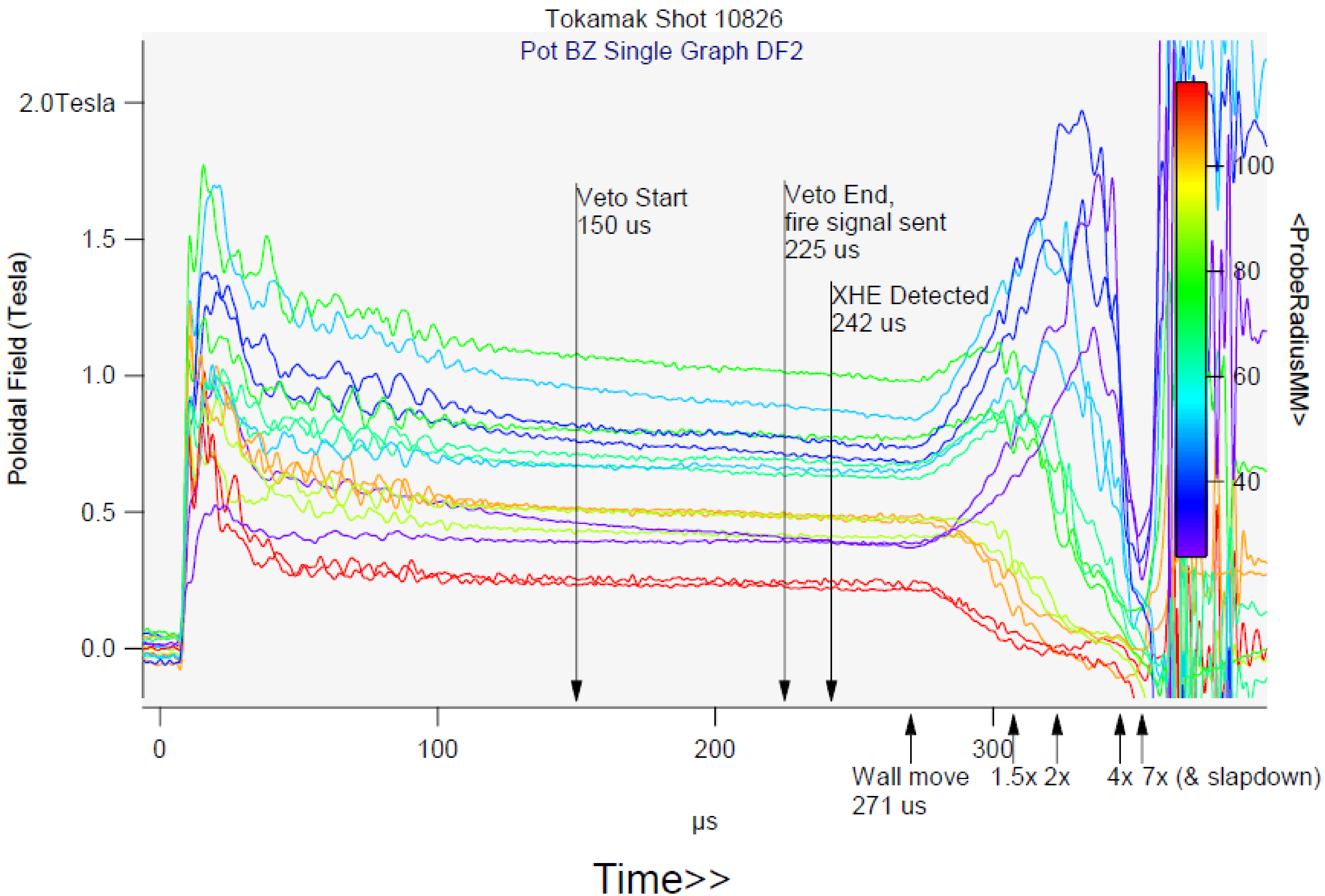
Chart of increase in magnetic field during compression…for field test #12



Uncompressed (blue) compared to compressed (red)

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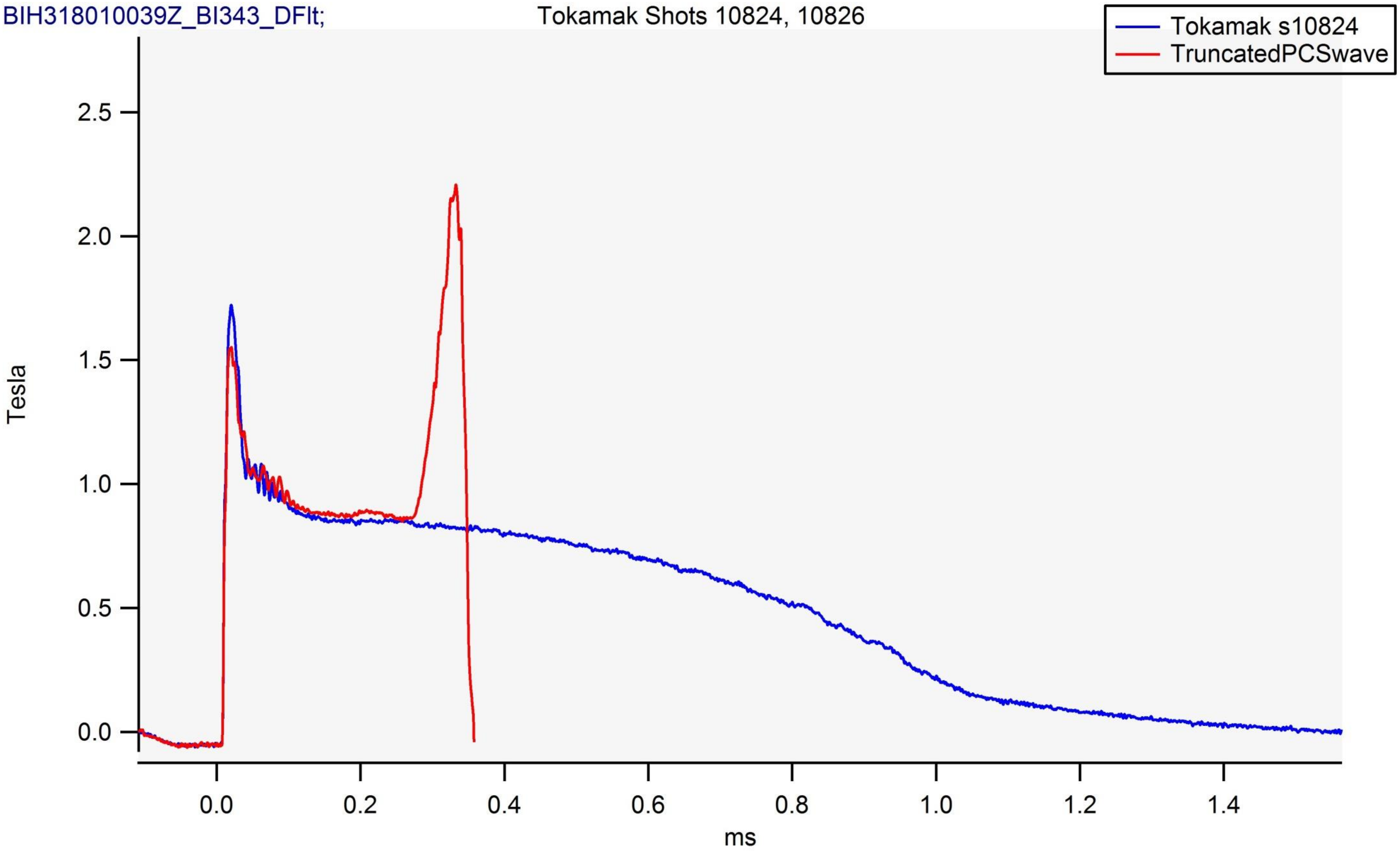
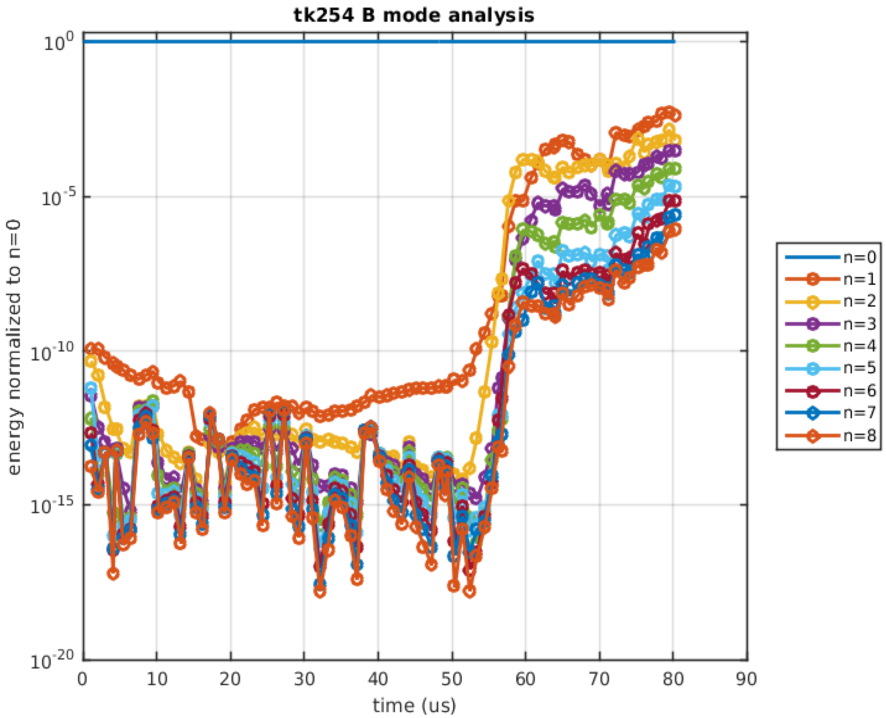
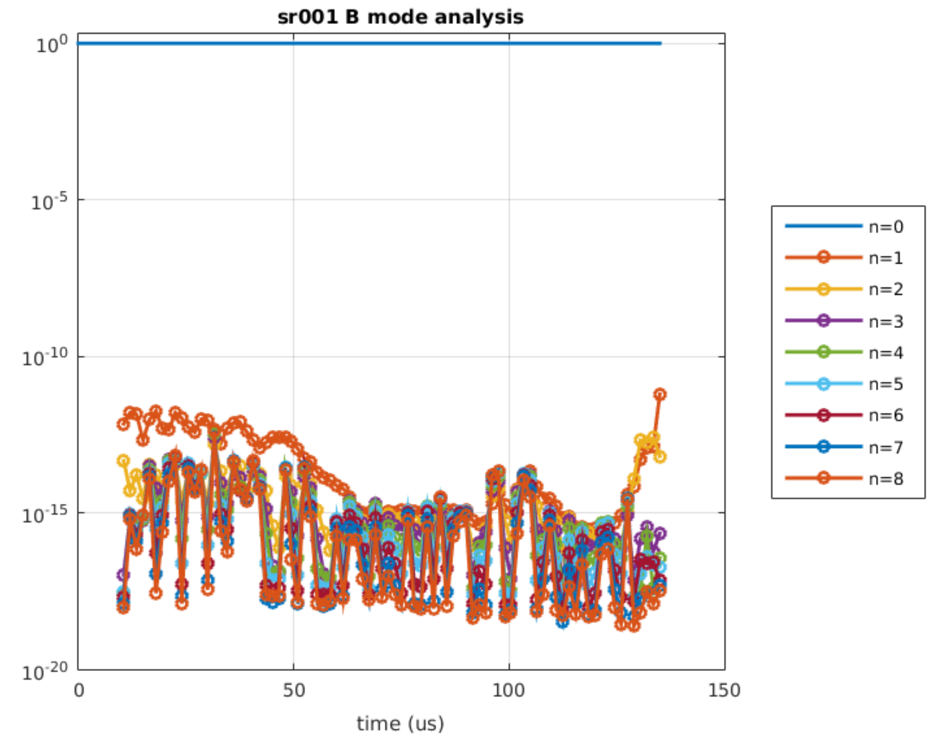
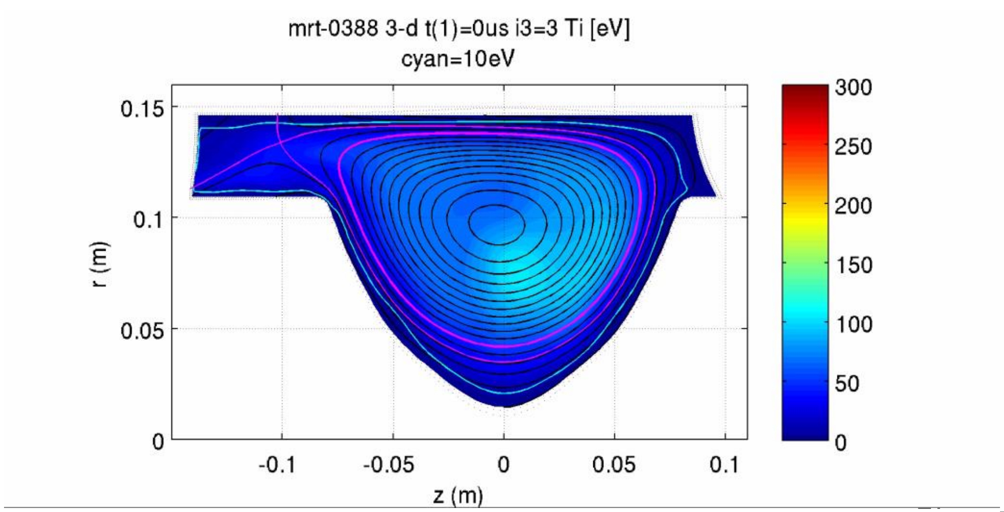
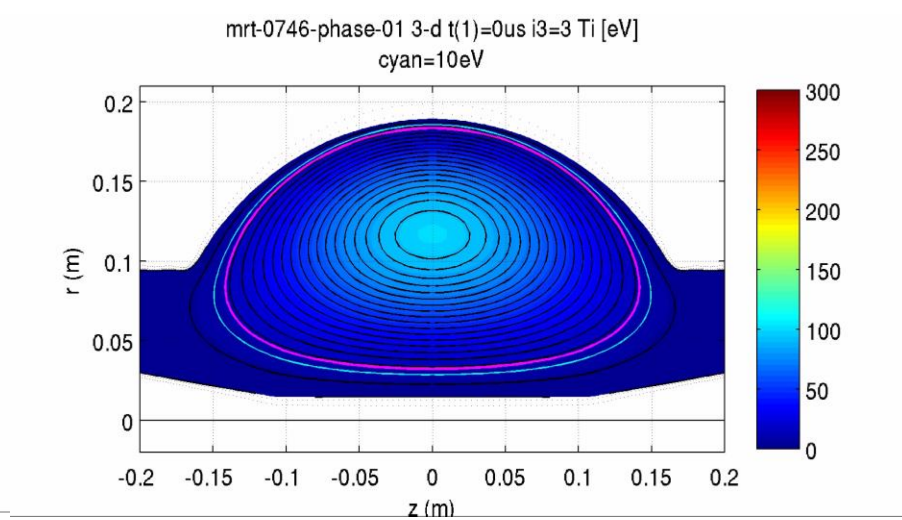


Change in compression geometry



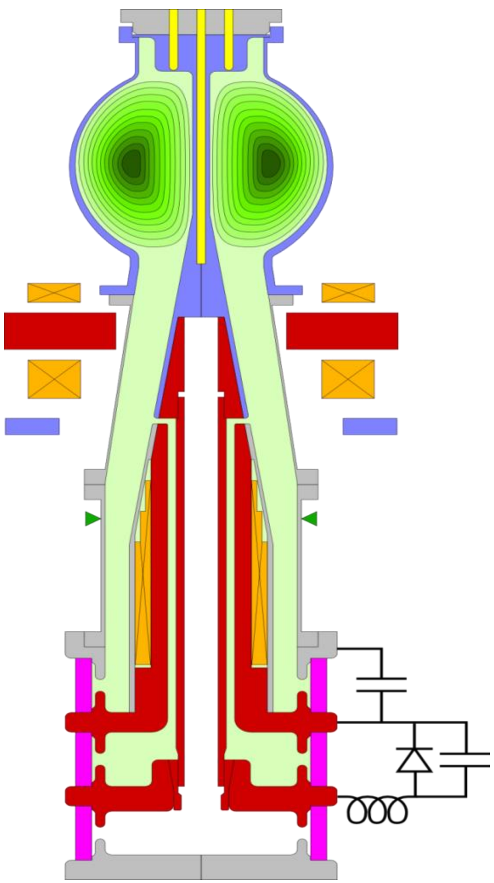




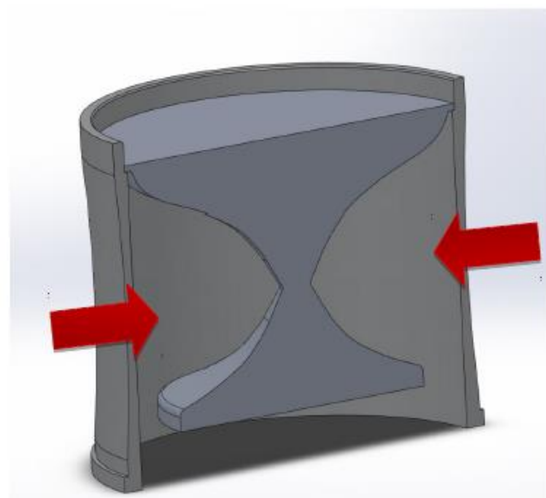


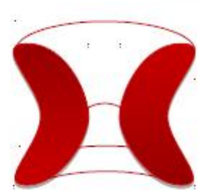
Near Future (Plasma Development) Work

- Commissioning and lab tests of advanced shape, variable-q device: *SPECTOR*
  - “3D” compression tests of **SP**h**E**rical **C**ompact **TOR**oid



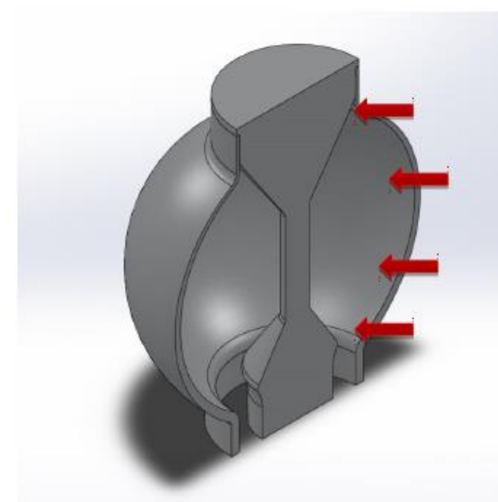
Current Geometry
Cylindrical Compression

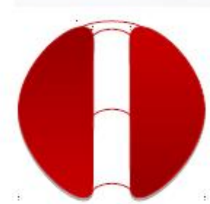




Compressed plasma shape is reverse-D, quite unstable; technique was easier to implement

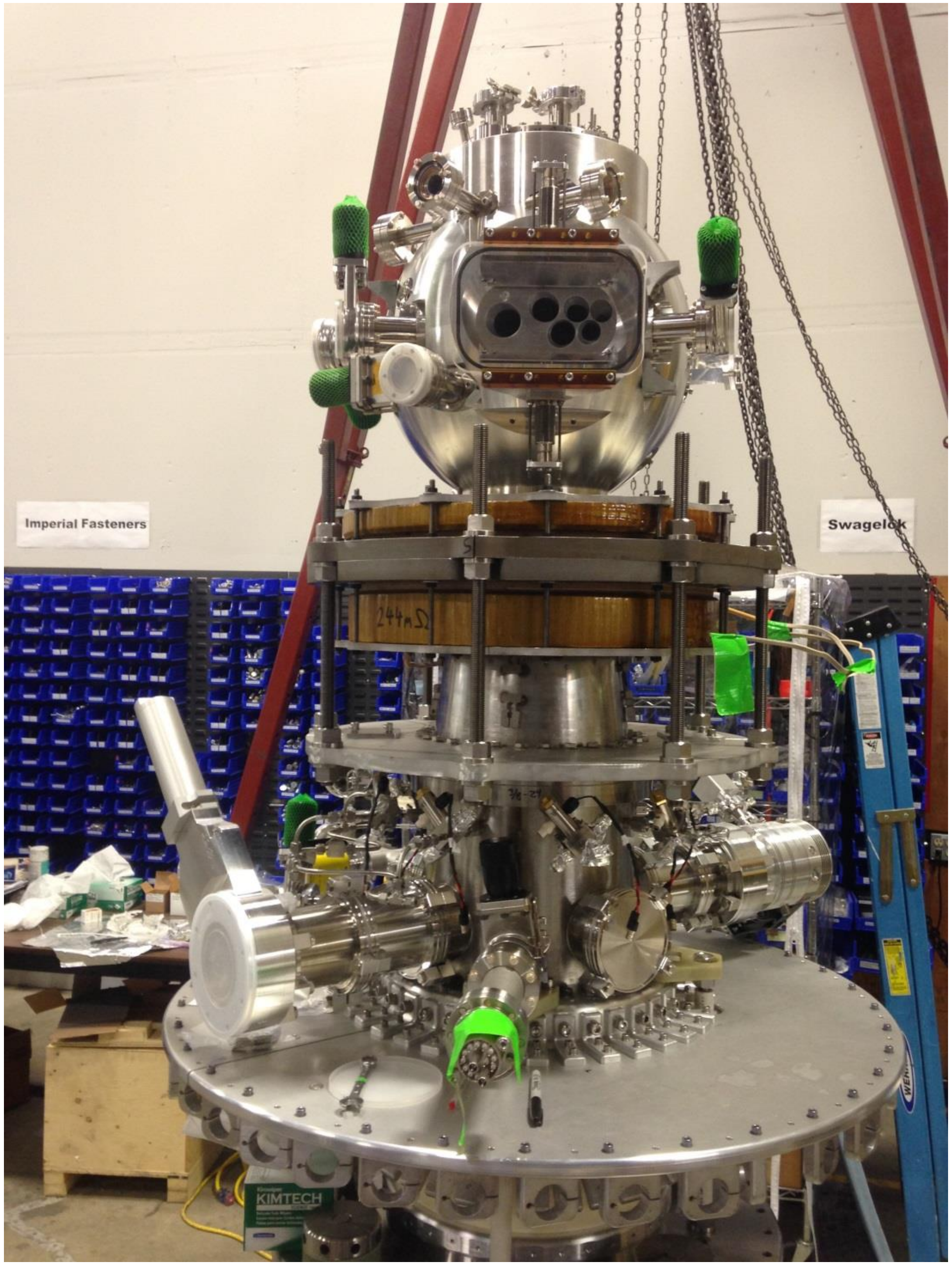
New Geometry
Spherical Compression





Compression maintains D-shape of plasma.

Spector, first plasma april 2016



Explosive compression work in progress

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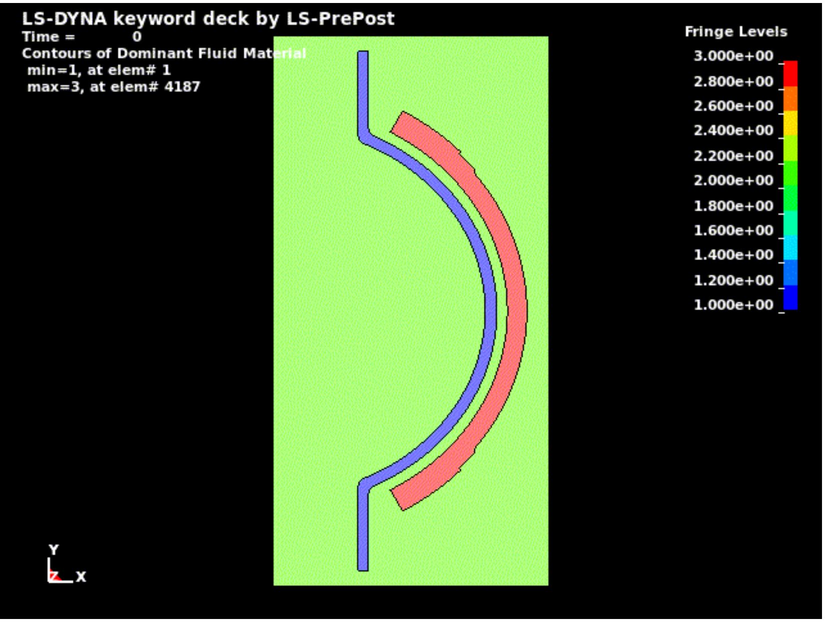

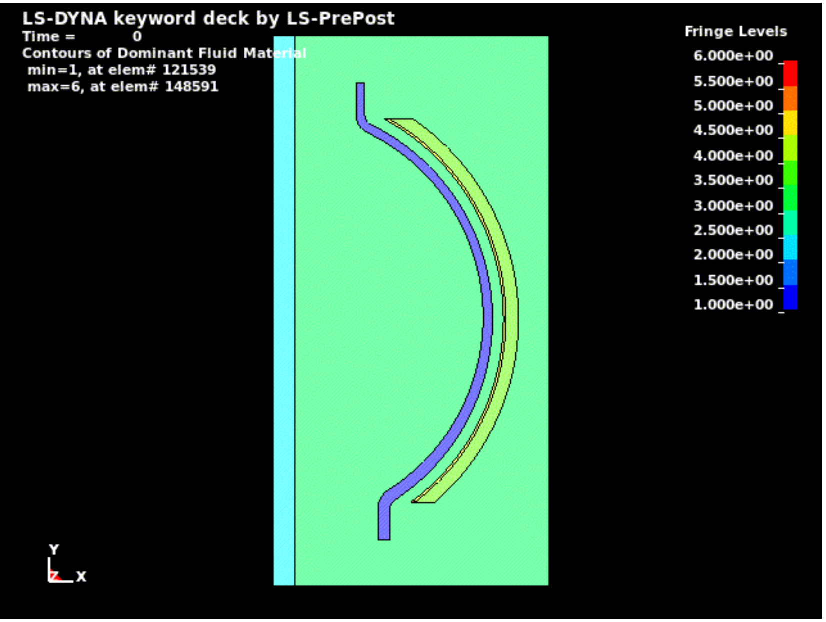

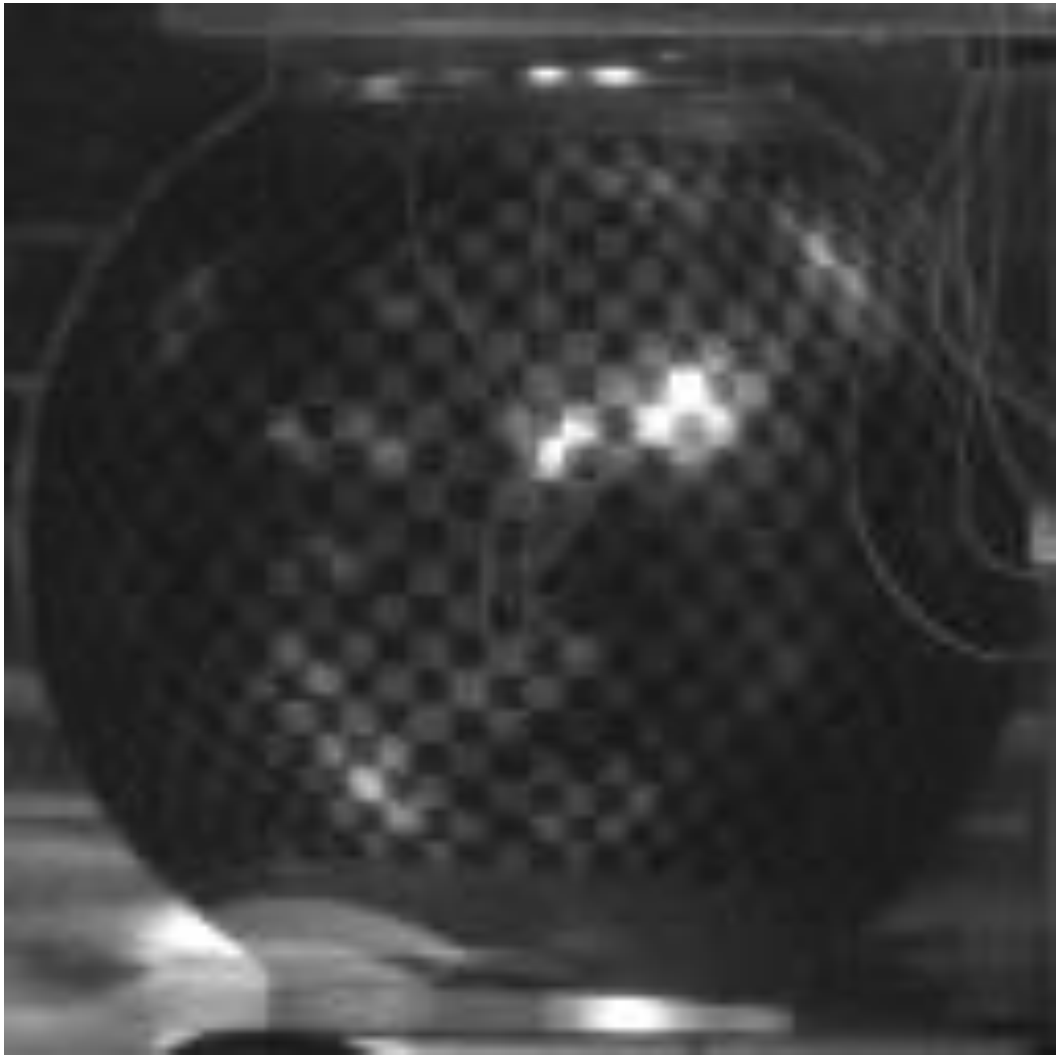

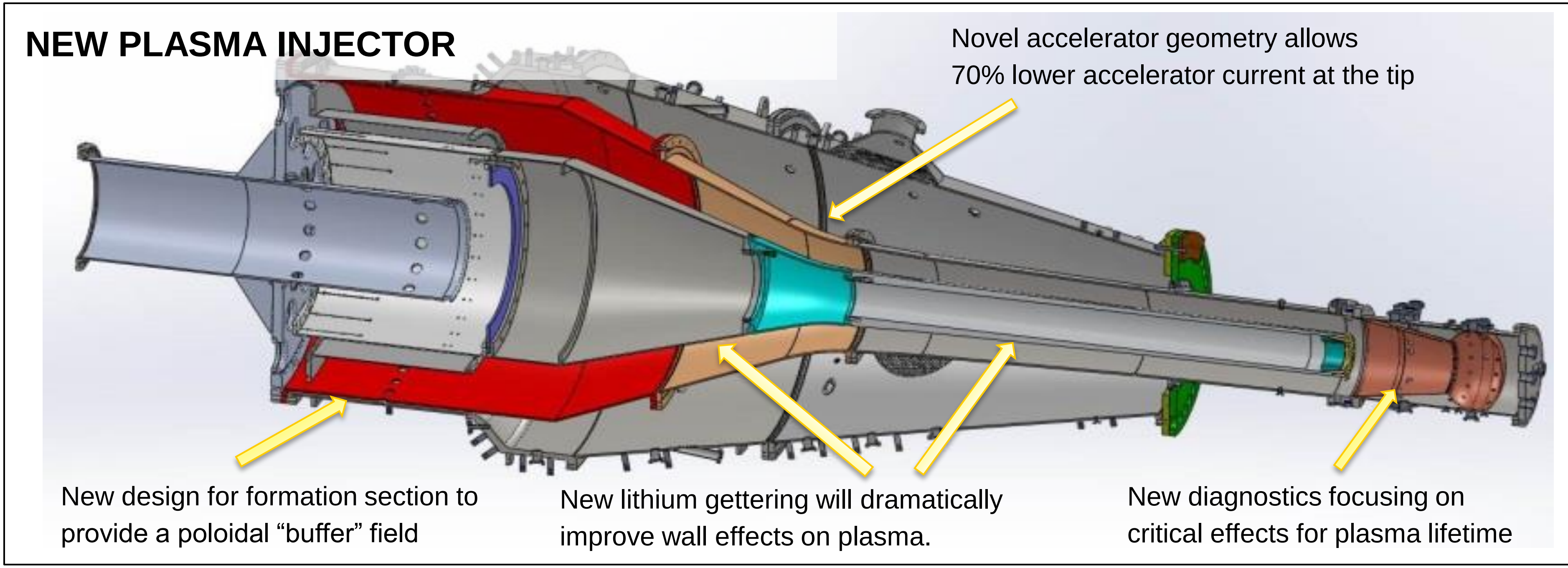

Current left in accelerator when CT arrives at the tip will be just the amount required to stabilize the CT

Conclusion

- We can make pre-compression plasma with sufficient confinement
- We solved death by radiation from impurities
- We now go MHD unstable under compression both with spheromak and tokamak
- We have some tokamak configurations that on the computer compress 13:1 and remain MHD stable
- Presently building a more self similar compression machine
- Designing PI3, more density and magnetic field
- Will implode PI3 with new more self similar compression to high DD yield