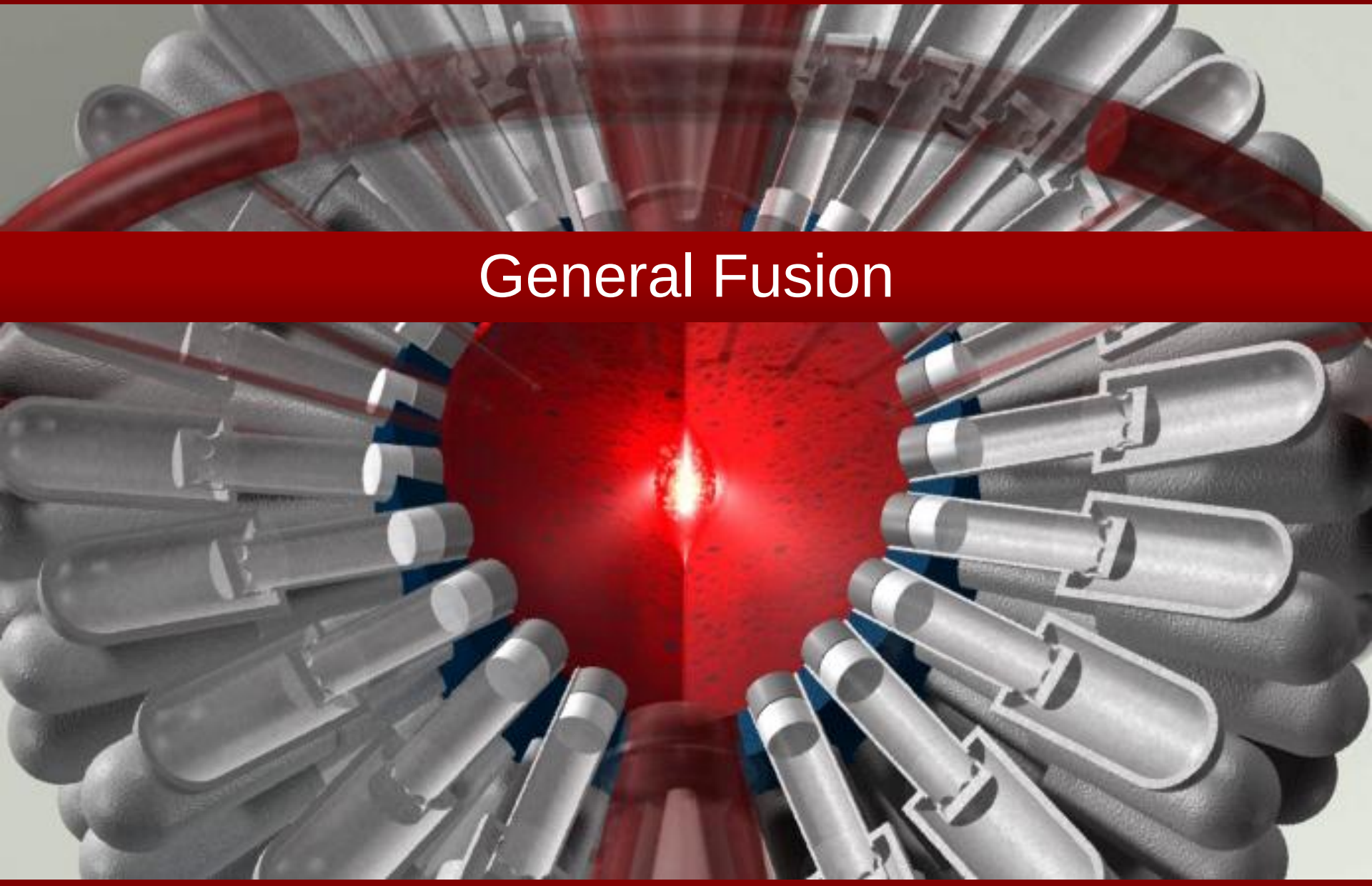
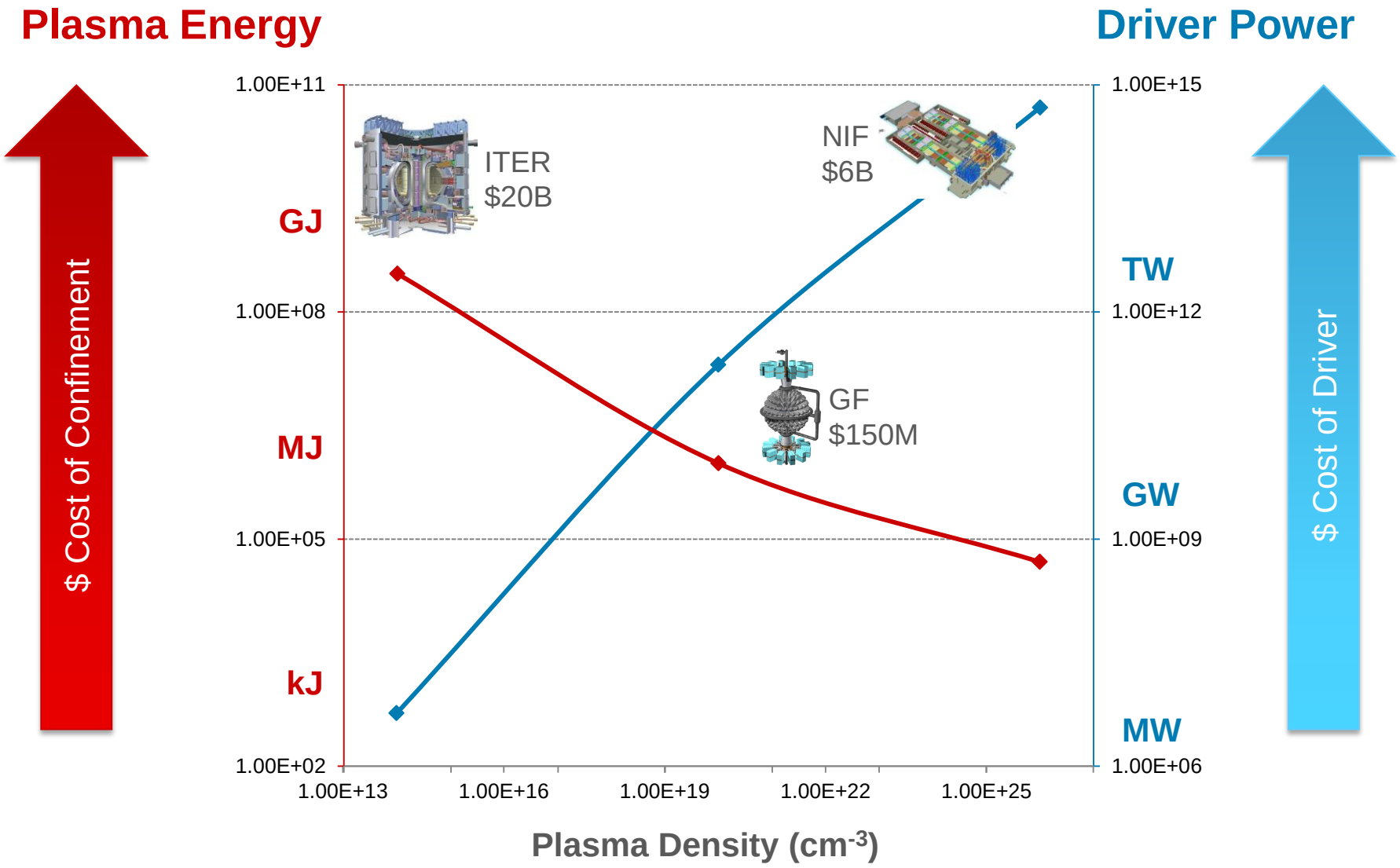


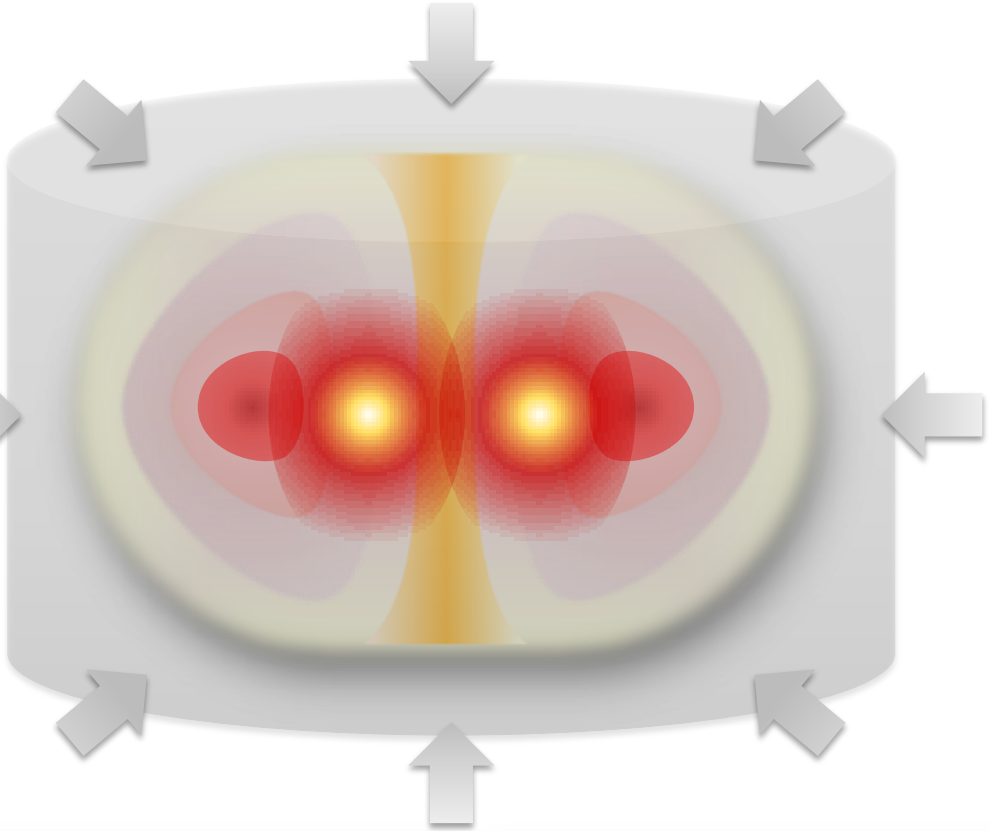
General Fusion

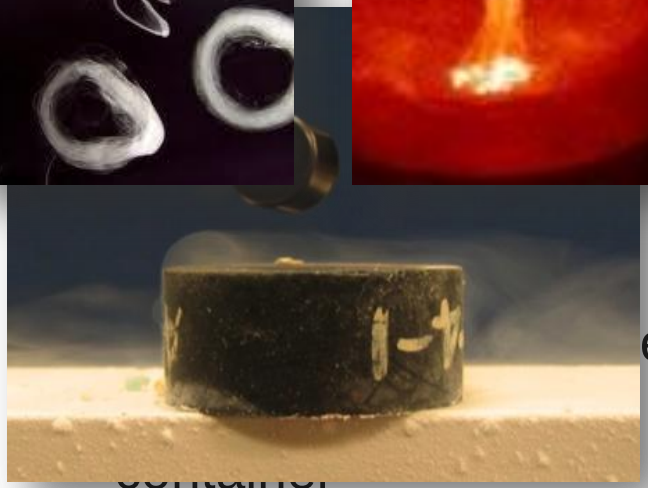
Fusion Technologies



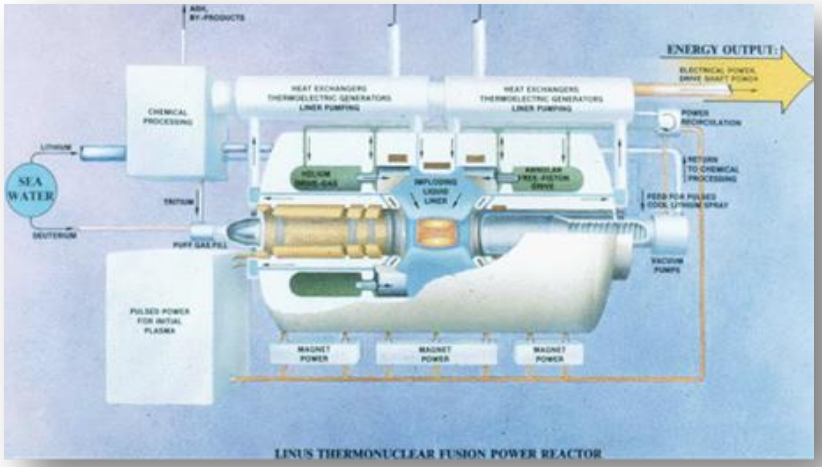
Magnetized Target Fusion

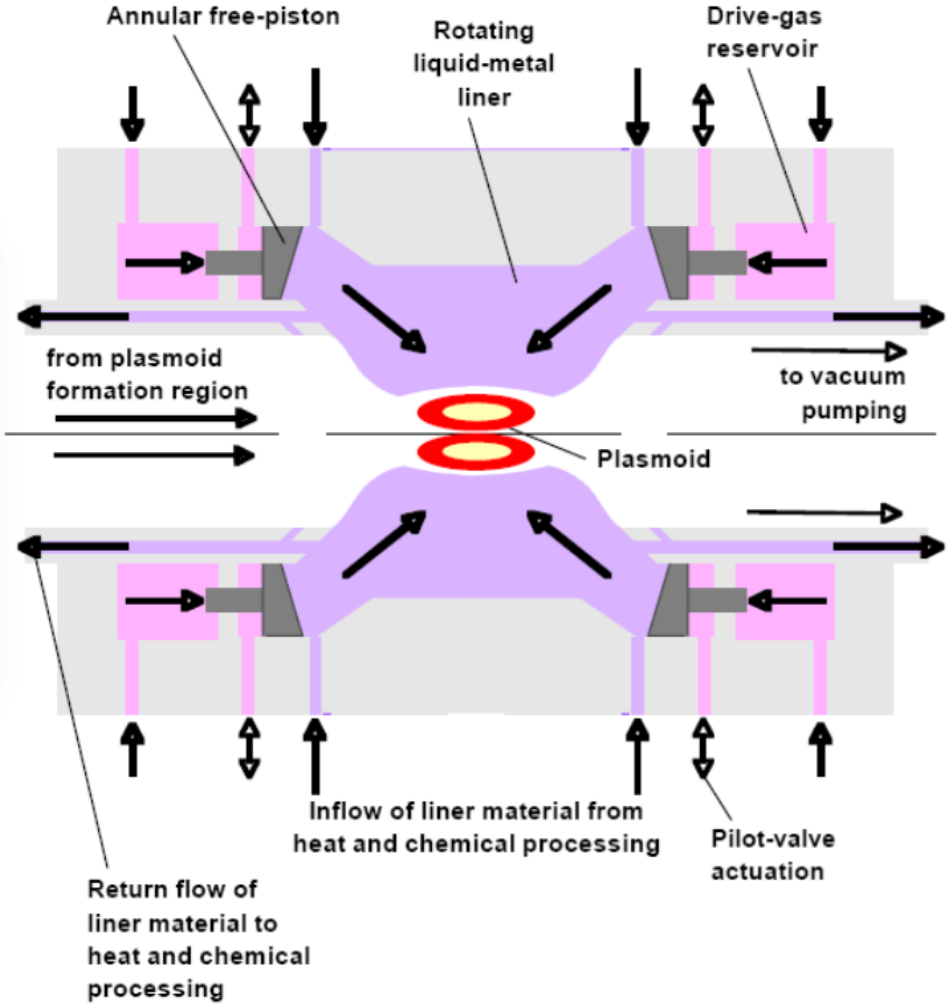
1. Form a compact torus of plasma



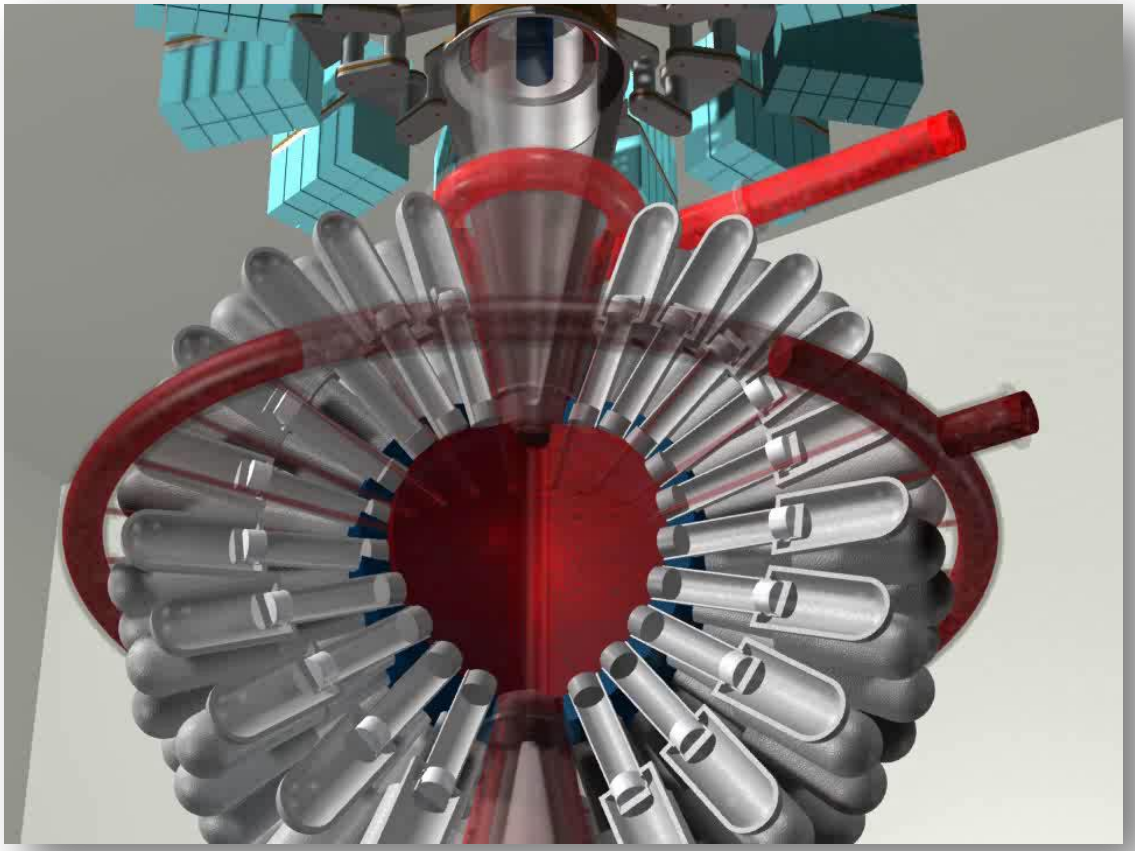


LINUS – Naval Research Laboratory, 1976





General Fusion's Acoustically Driven MTF

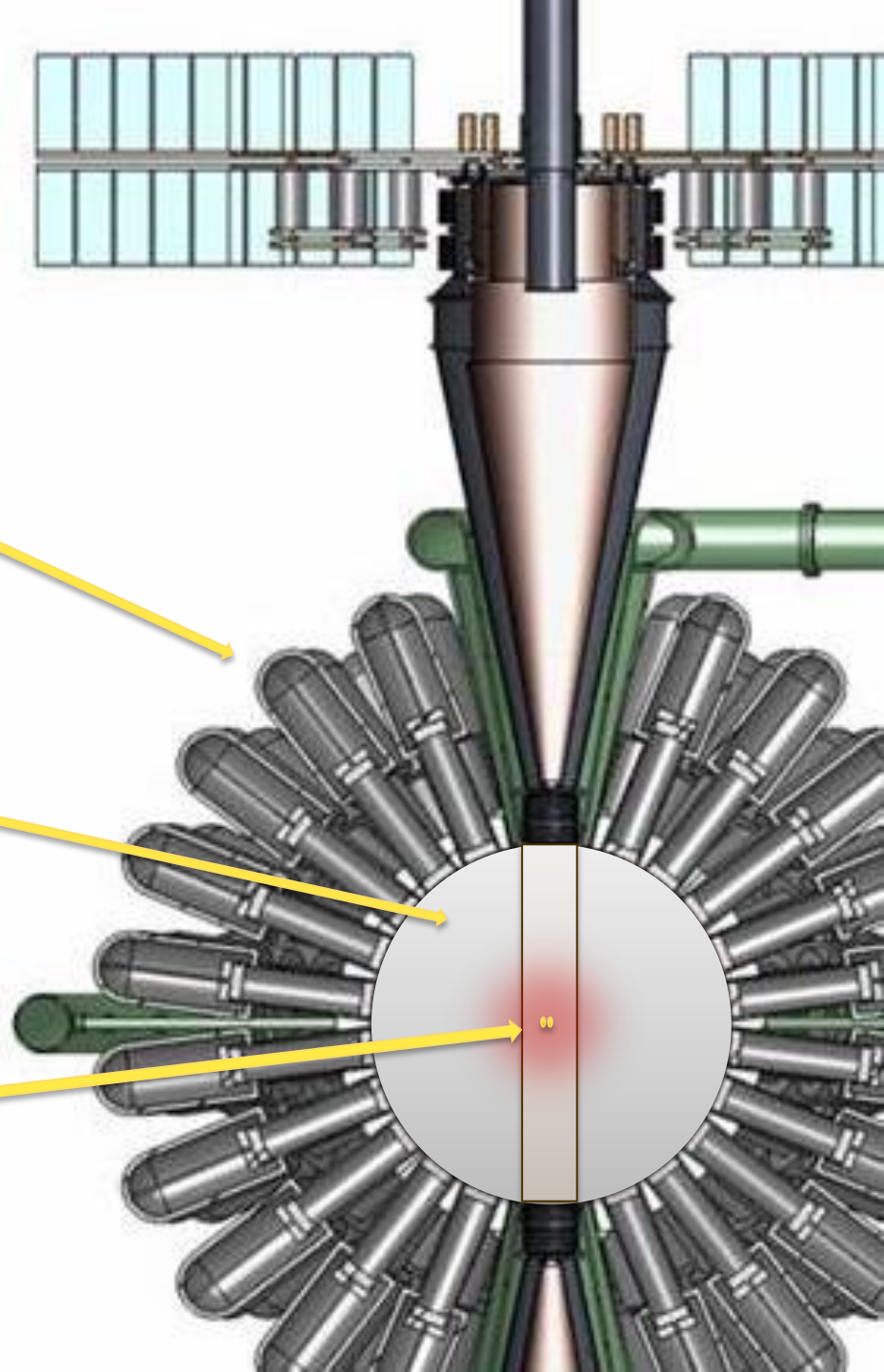


Practical

Compressed gas driver
- Uses power plant working fluid
- Low cost

Thick Lead-Lithium blanket
- Extracts heat
- Shields structure
- Breeds tritium

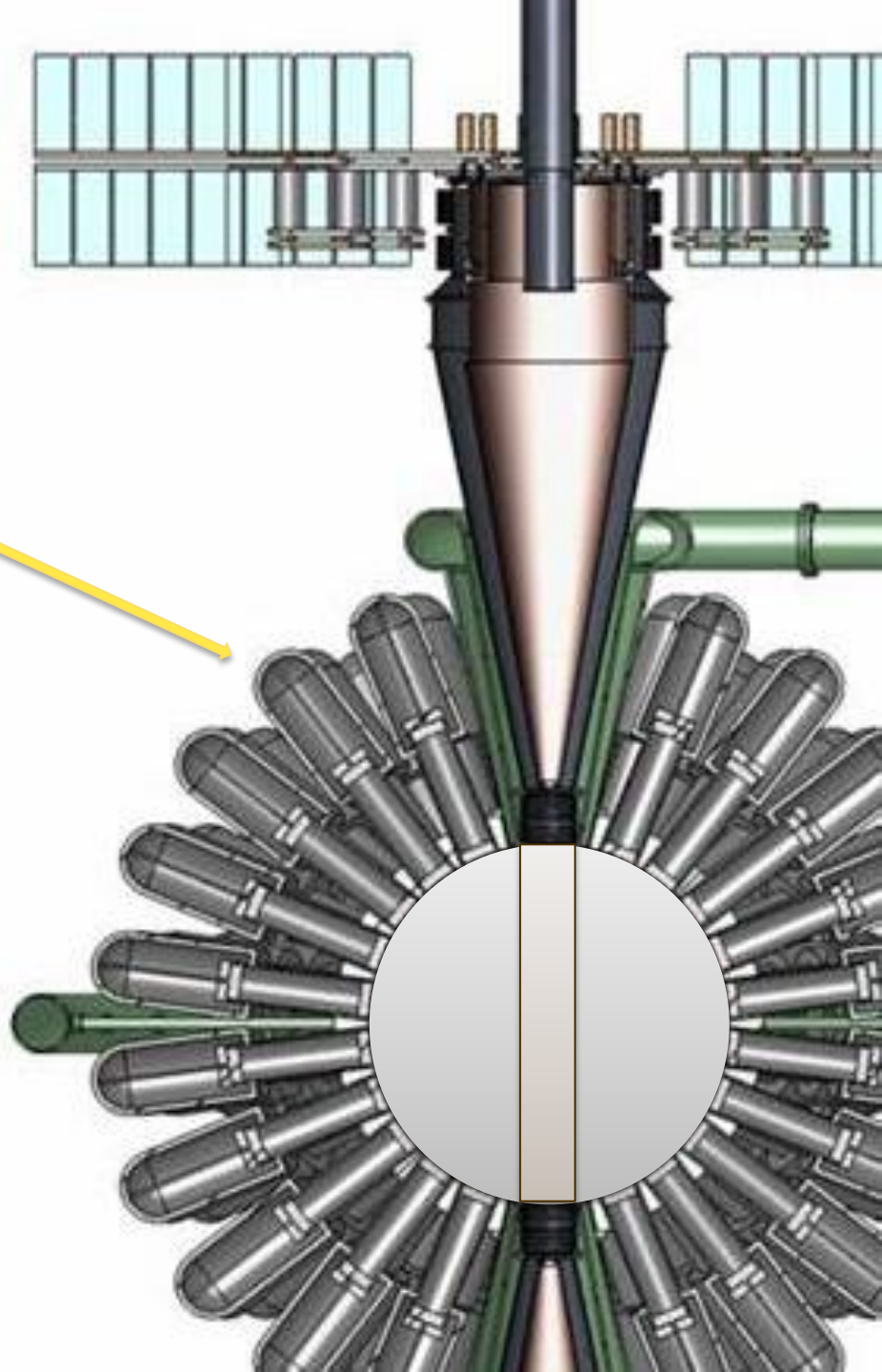
Plasma target
- Pulsed system with no consumables



Practical

Compressed gas driver

- Uses power plant working fluid
- Baseline steam, could be CO2 or Helium
- Low cost for high energy: <$0.2/J compared to >$2/J for pulsed power



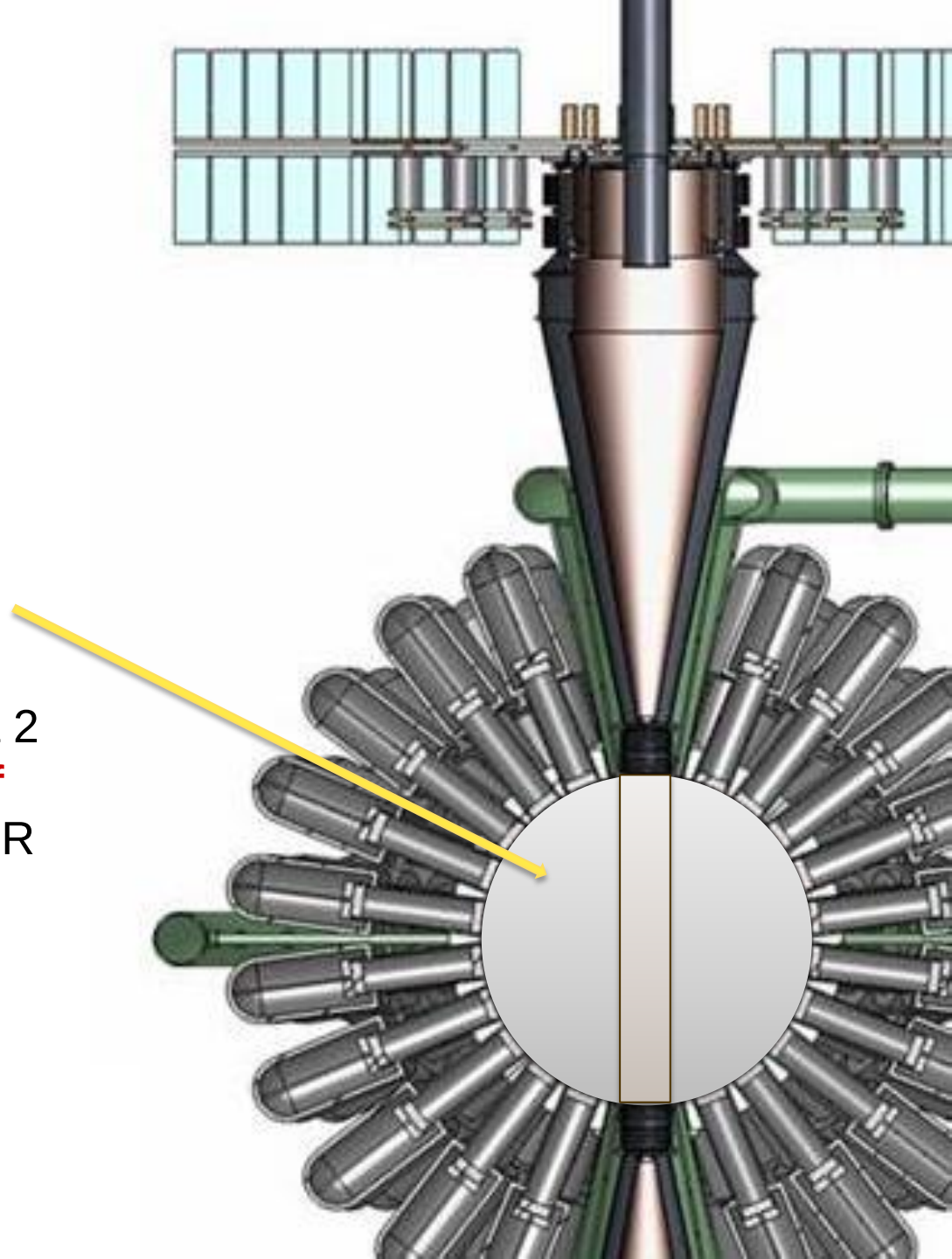
Practical

Thick Lead-Lithium blanket

- 300 °C inlet temperature
- 550 °C outlet temperature
- 2 m^3/s flow rate

- Neutron flux to structure at 2 MeV and up is **5 orders of magnitude** lower than ITER

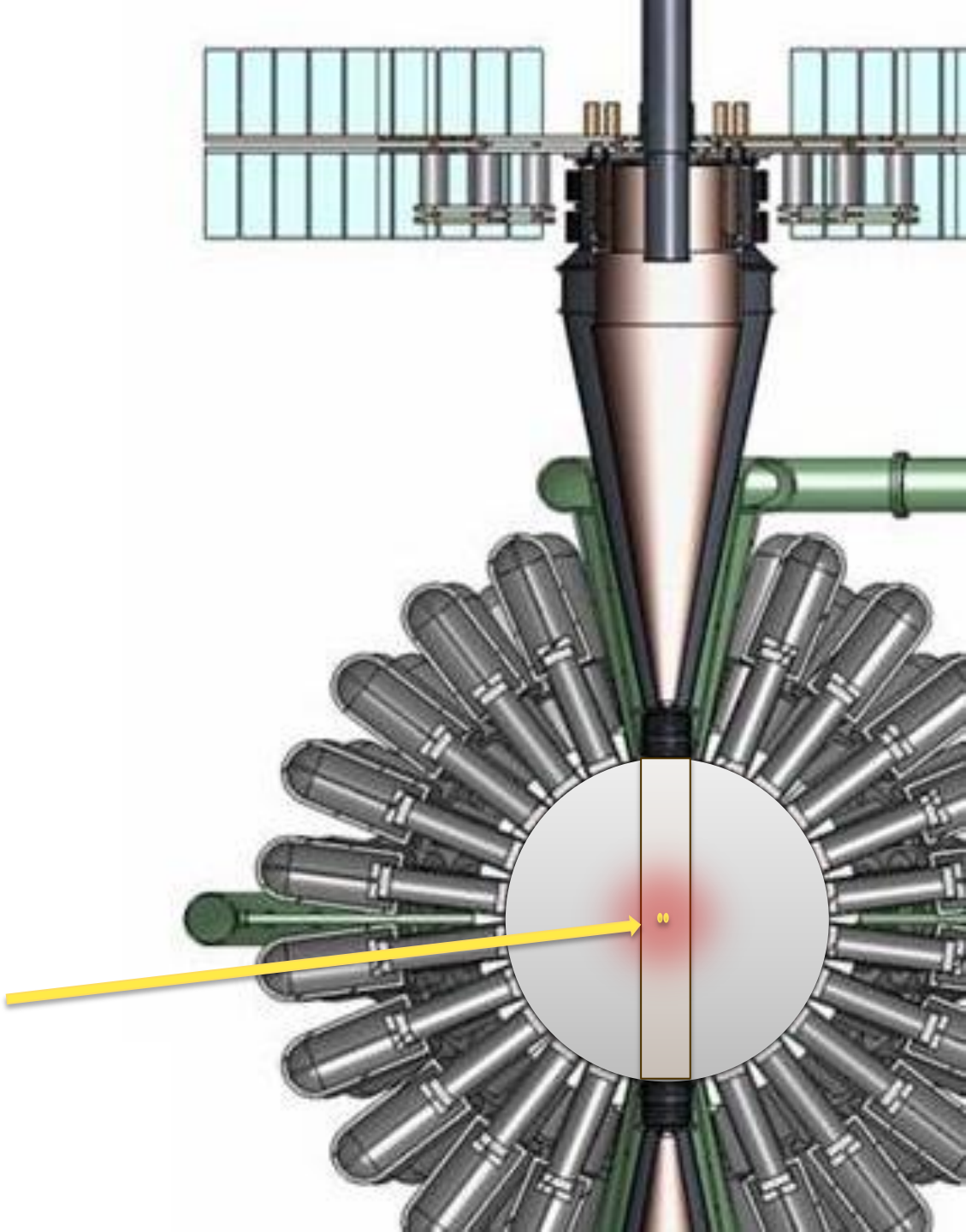
- 4π coverage, n,2n Pb reaction provides tritium breeding ratio of **1.5**



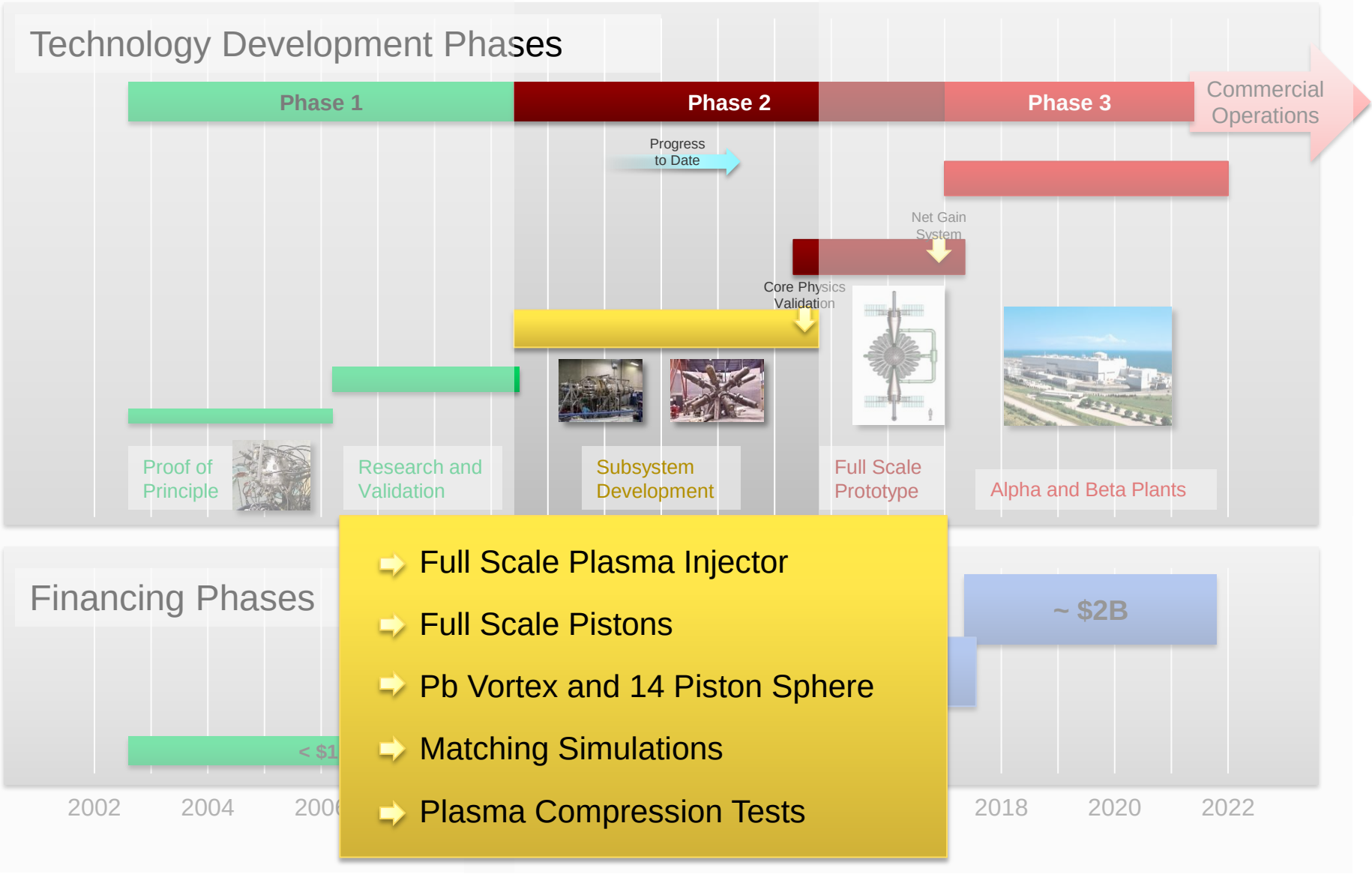
Practical

Plasma target

- Liquid wall cannot be destroyed
- Target is plasma only
- Provides a pulsed system with no consumables

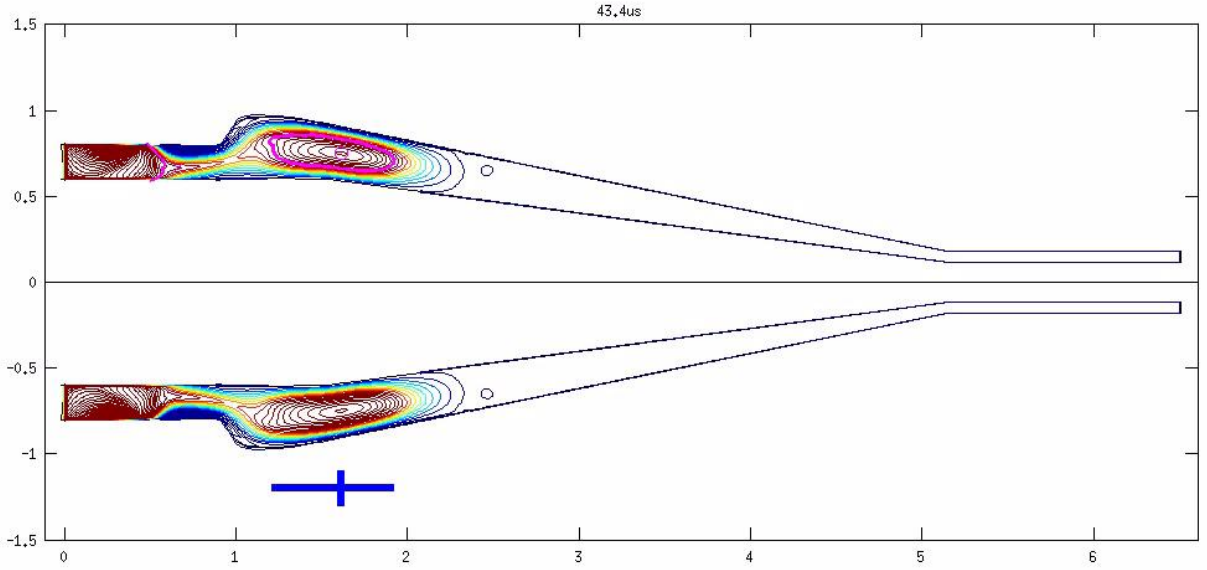


Development and Commercialization



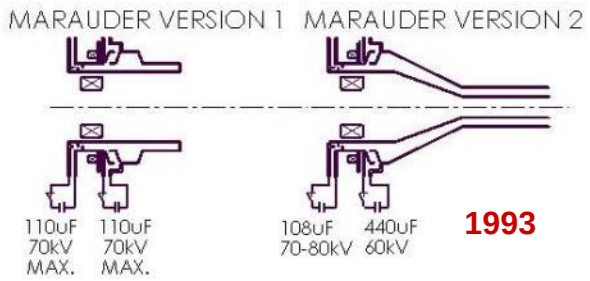
- Full Scale Plasma Injector
- Full Scale Pistons
- Pb Vortex and 14 Piston Sphere
- Matching Simulations
- Plasma Compression Tests

Plasma Injector Simulation

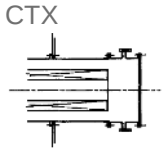


Plasma Injector Heritage

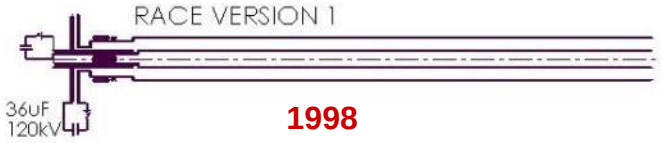
Scale comparison of previously constructed CT accelerators
With GF's plasma injector design



1993

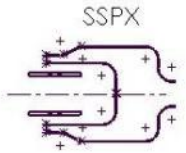


1990



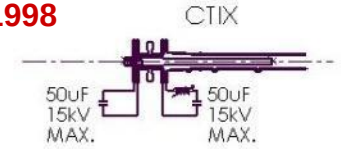
1998

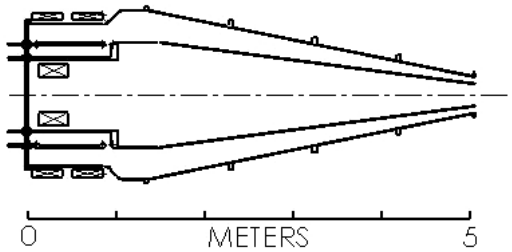
1997



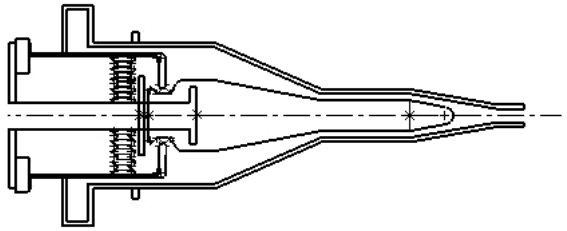
1993

1998



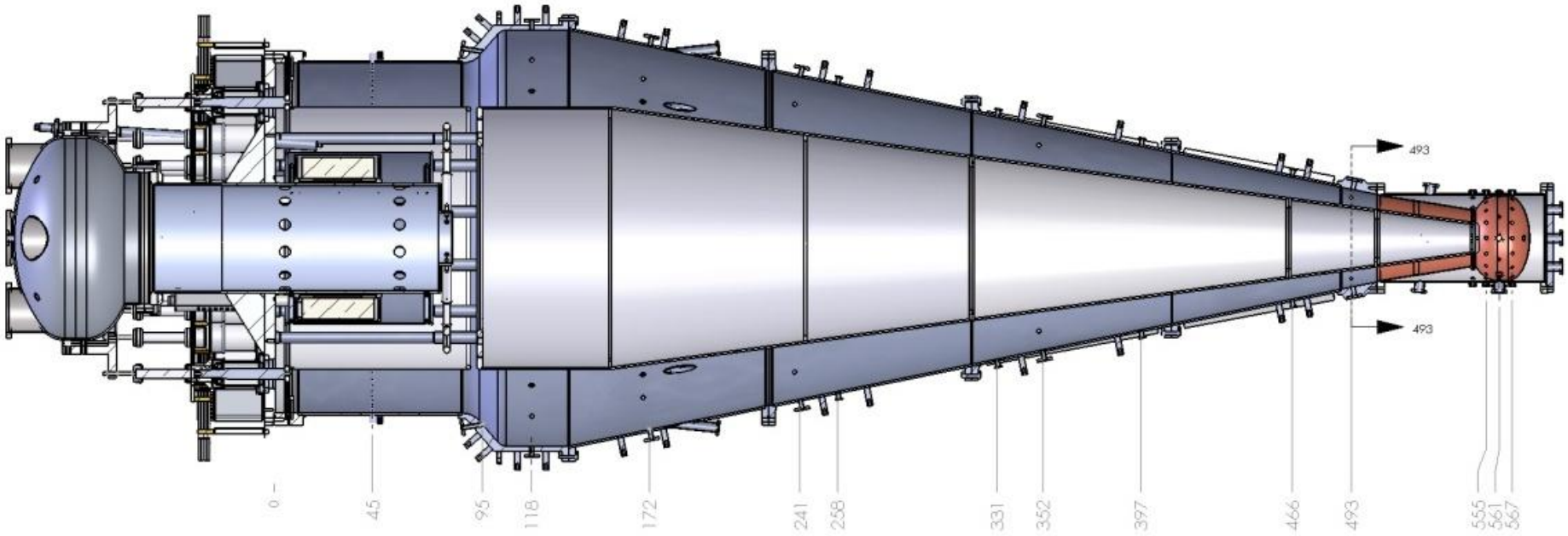


GENERAL FUSION INJECTOR VERSION 1



ITER INJECTOR

Plasma Injector Design



Power Supply

- 2.4 MJ pulse power supply (22 kV formation, 44 kV acceleration)
- programmable pulse shaping control
- 1 MW DC stuffing flux power supply

Diagnostics

- Thomson scattering
- X-ray photo diodes
- triple Langmuir probe
- 5 interferometer chords
- >12 Rogowski coils
- >50 B-dot probes with in-situ integration
- high resolution time resolved spectroscopy
- 1 million frame/second video camera

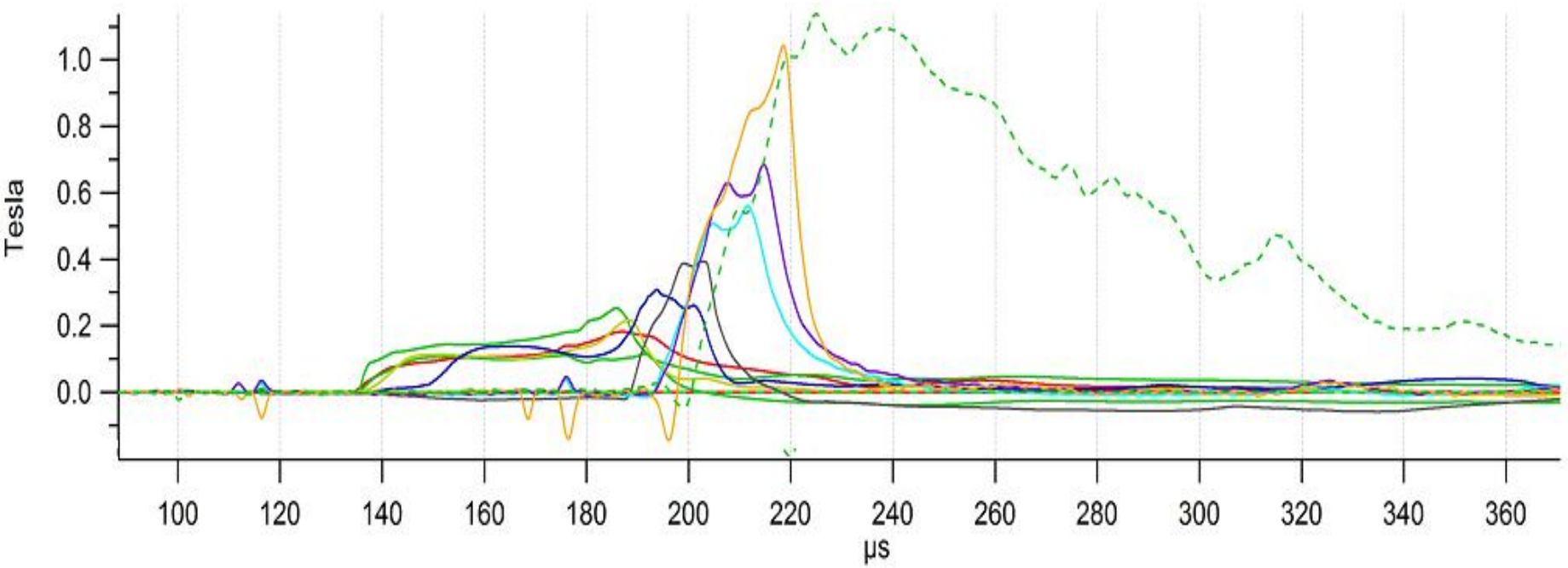
Largest Plasma Injectors ever built

Record spheromak plasma energy (~100 kJ)

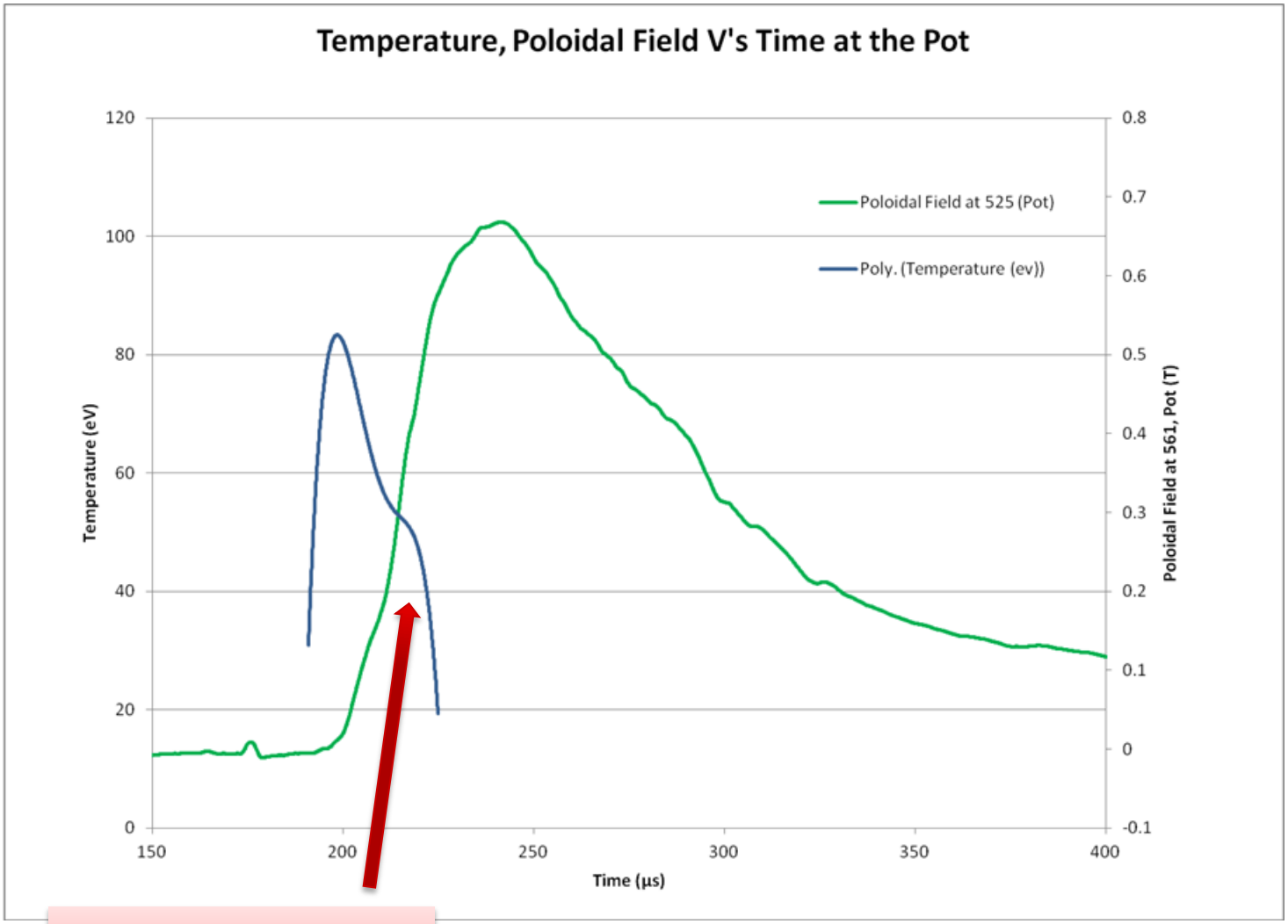
Plasma temperatures over 200 eV (>2.3M °C)

Density of 10^{16} cm^{-3}

Plasma Acceleration

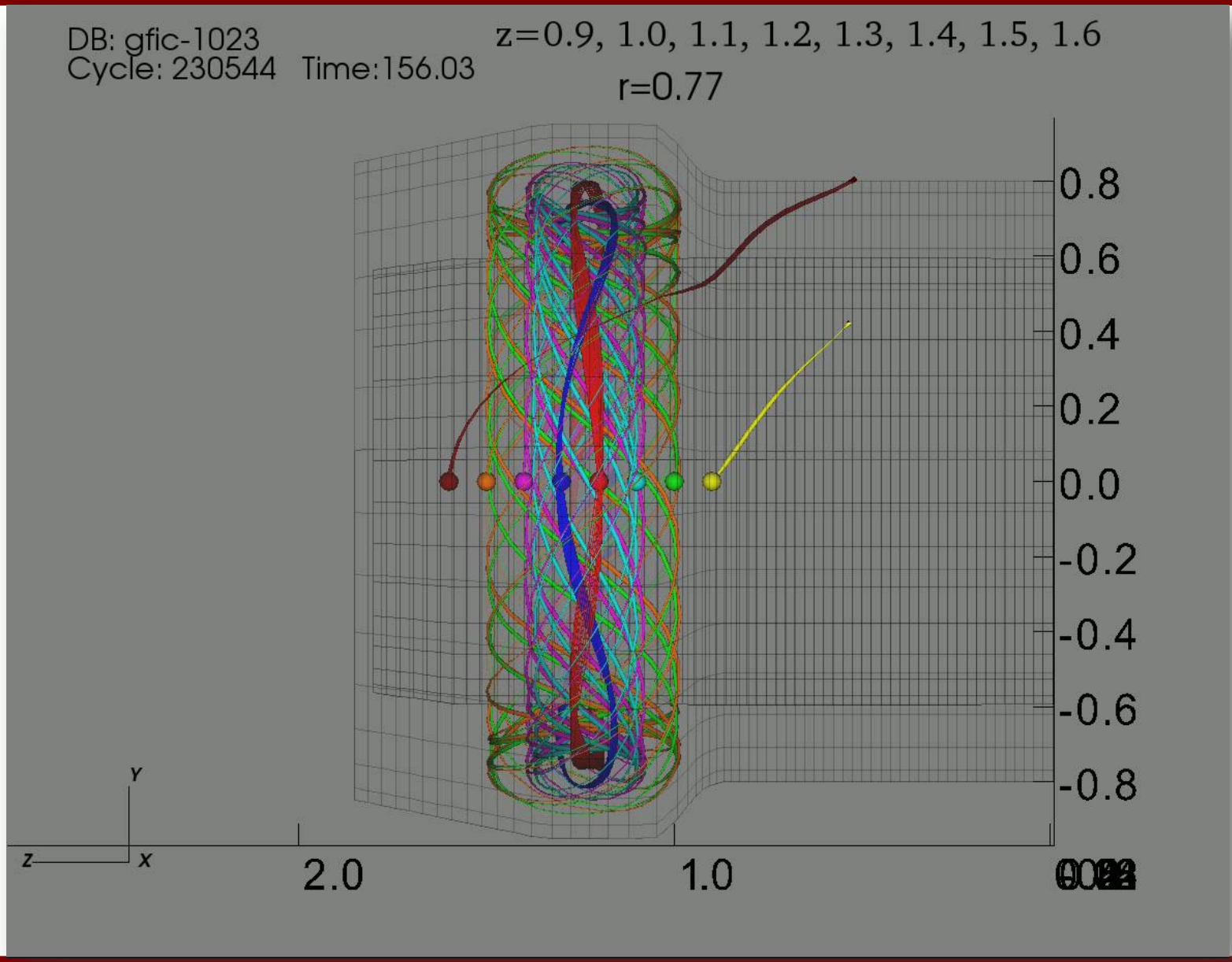


Plasma Cools Quickly

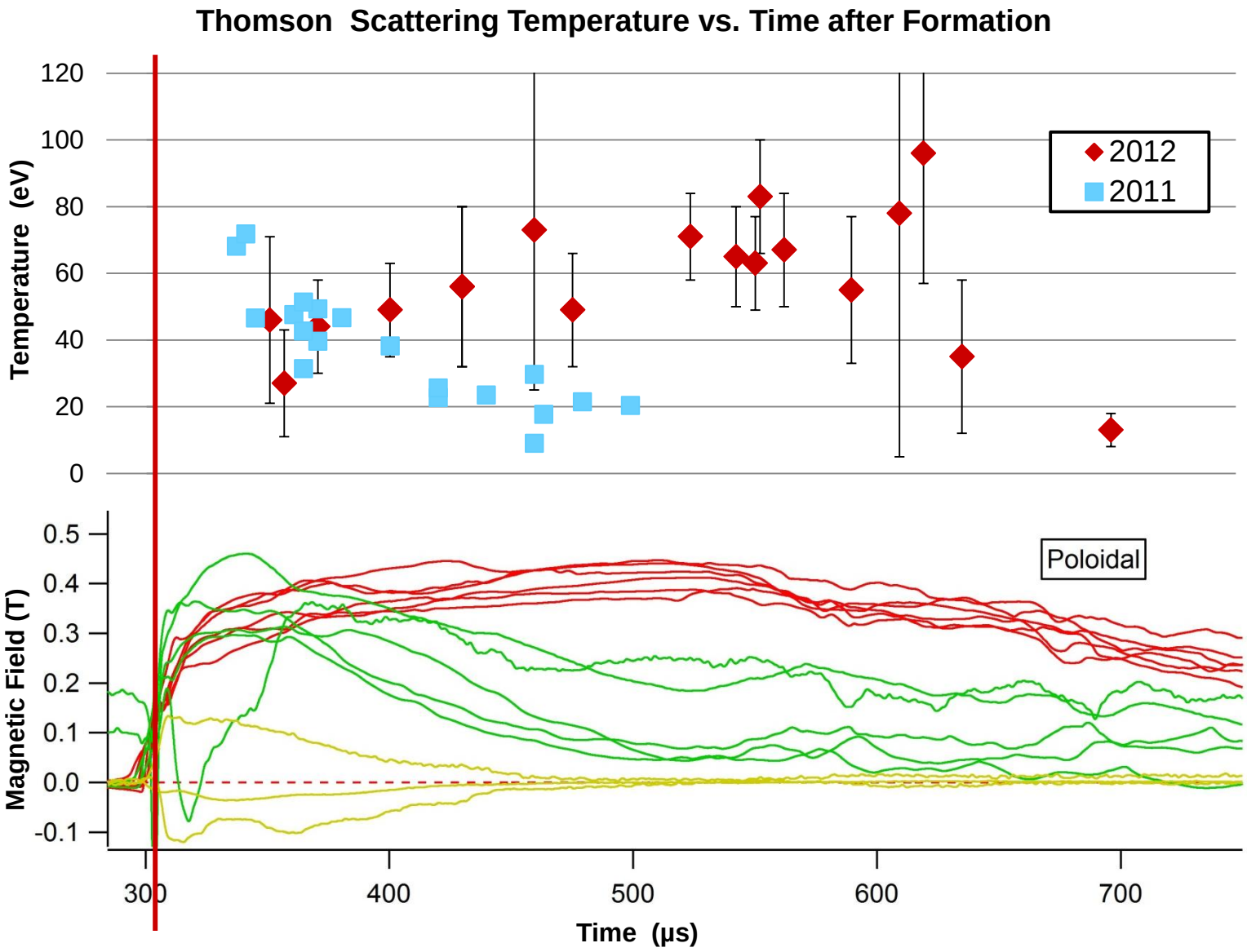


Plasma rapidly cools when entering pot

Plasma Injector: Confinement



Plasma Formation



Plasma Compression

- 10^{14} cm^{-3}
- 40 eV
- 0.2 T

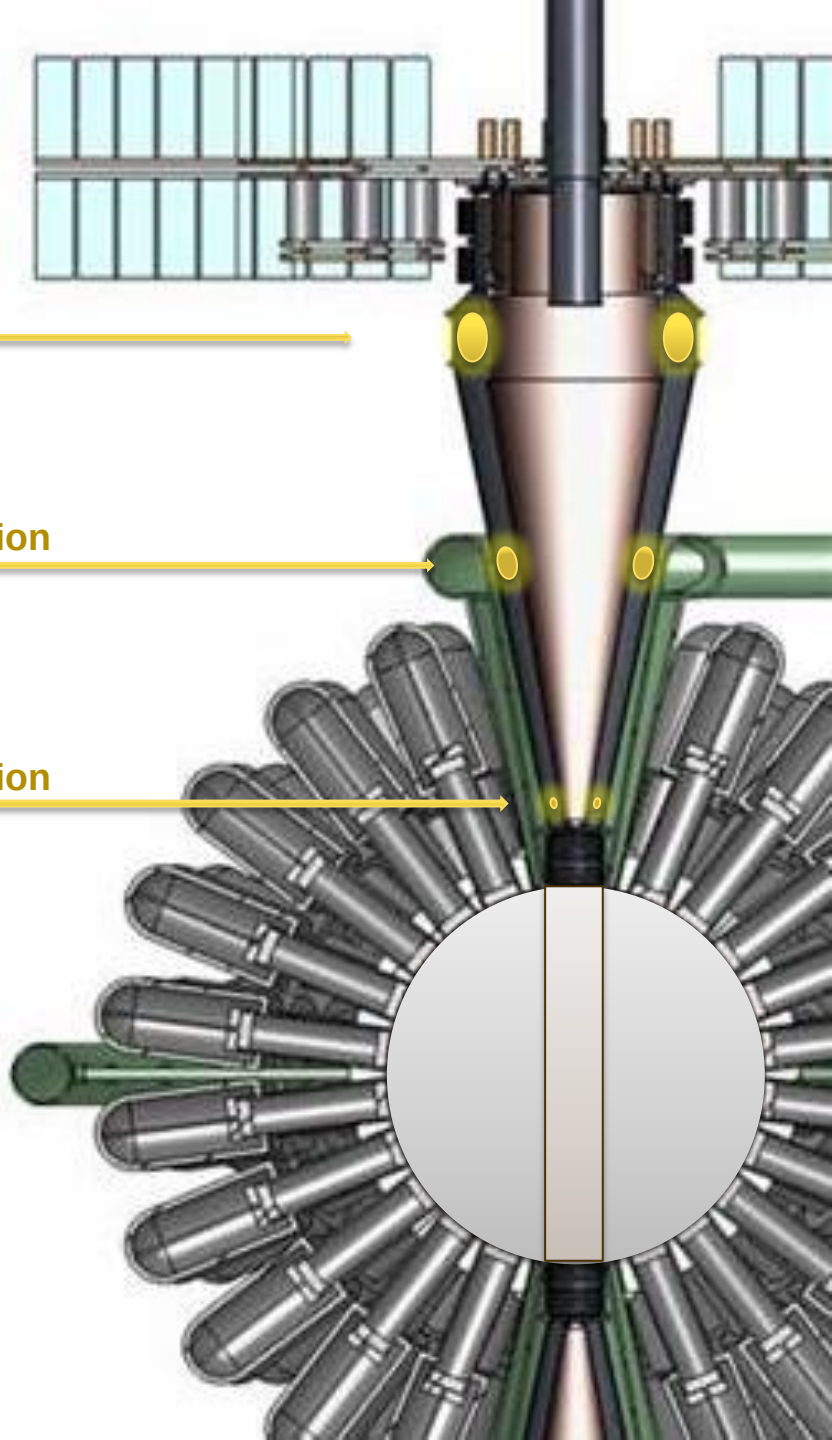
Formation

- $8x10^{14}$ cm^{-3}
- 160 eV
- 0.8 T
- **Adiabatic!**

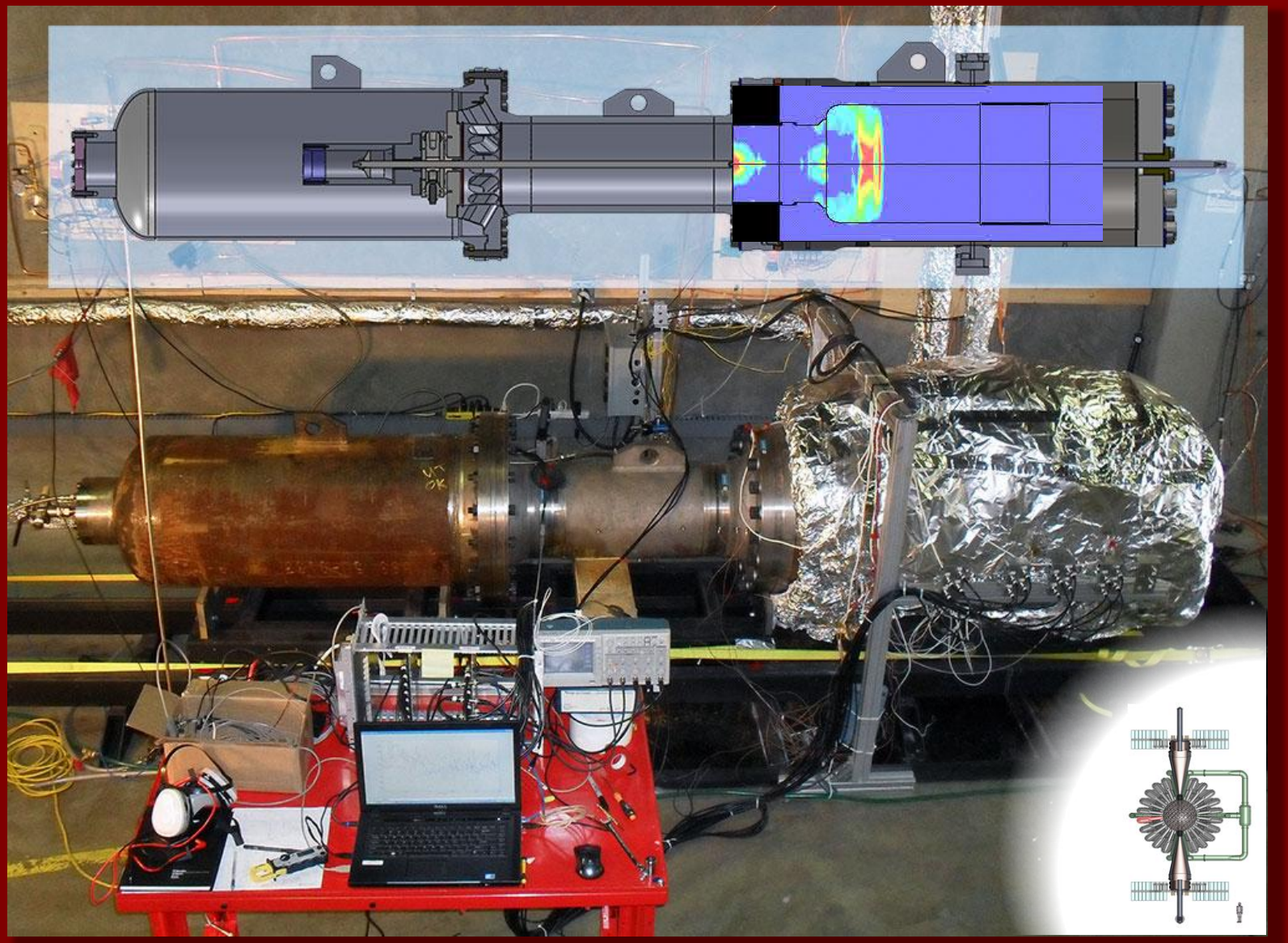
2X Radial Compression

4X Radial Compression

- $6x10^{15}$ cm^{-3}
- 3.2 T
- 200 eV
- Expect >600 eV, not adiabatic

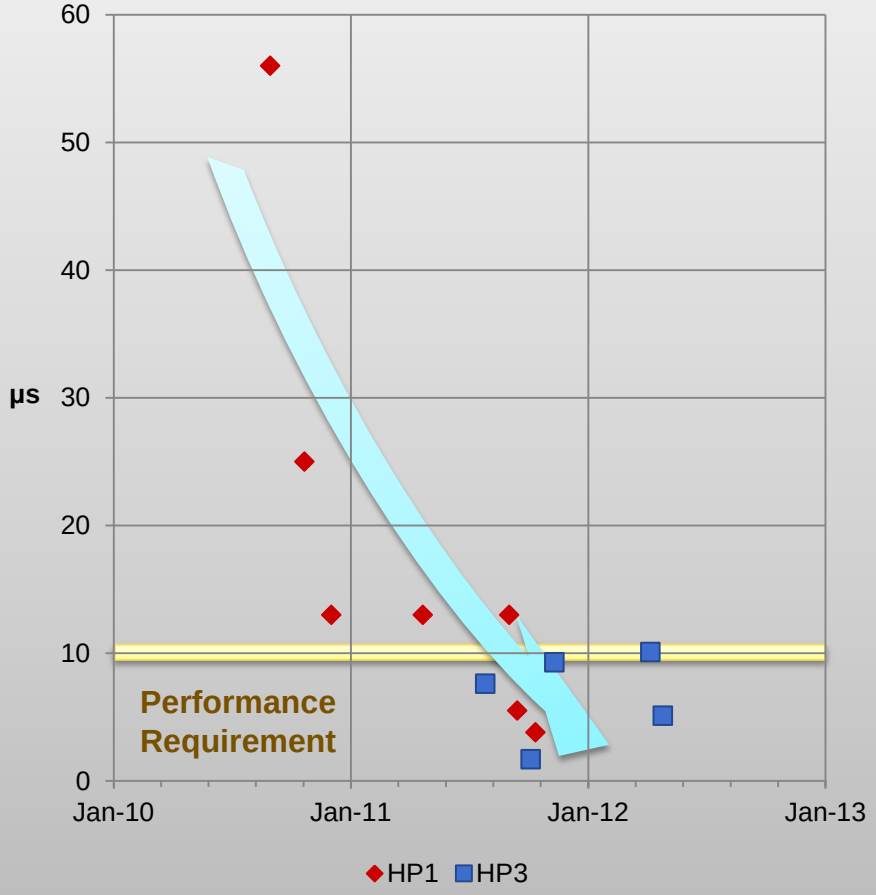


Acoustic Driver

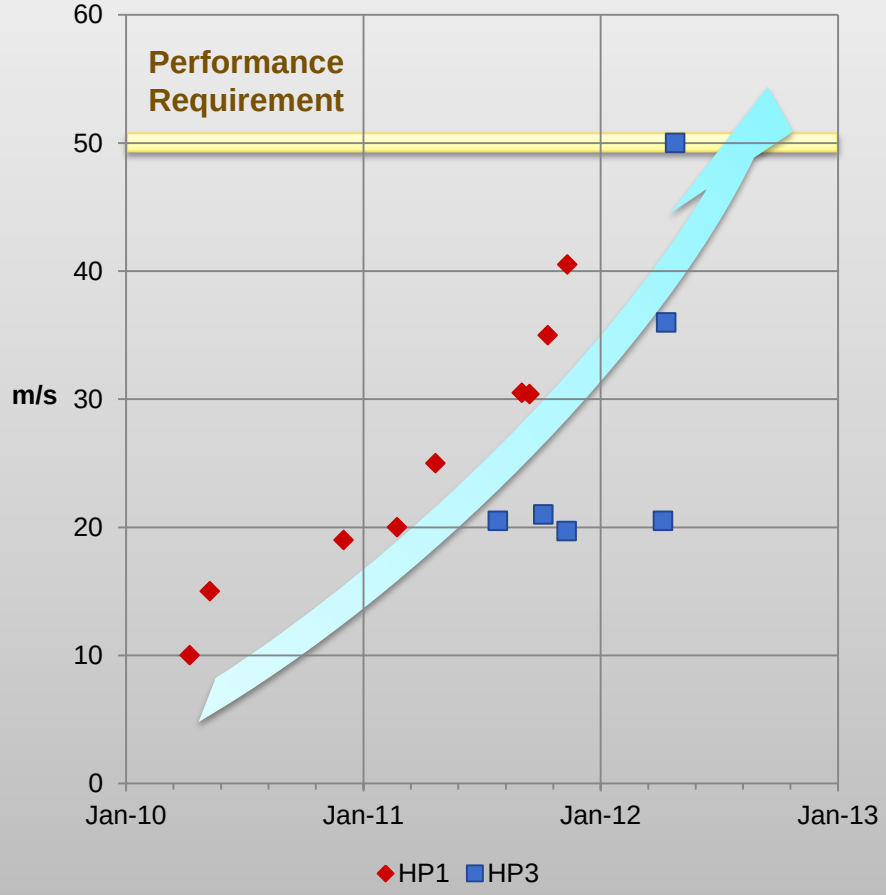


Acoustic Driver Milestones Met ✓

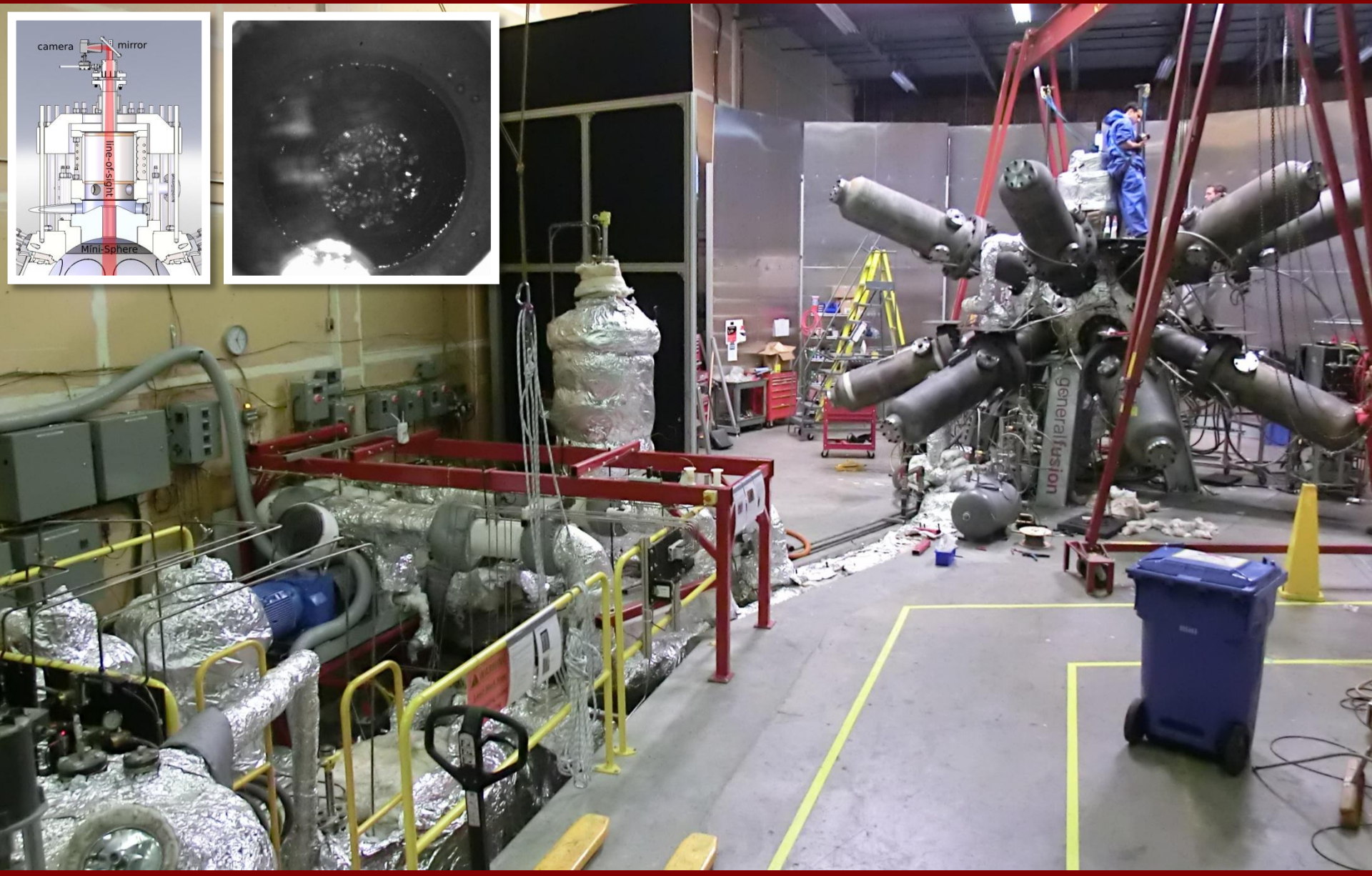
Piston Impact Timing Control (5 sequential shots)



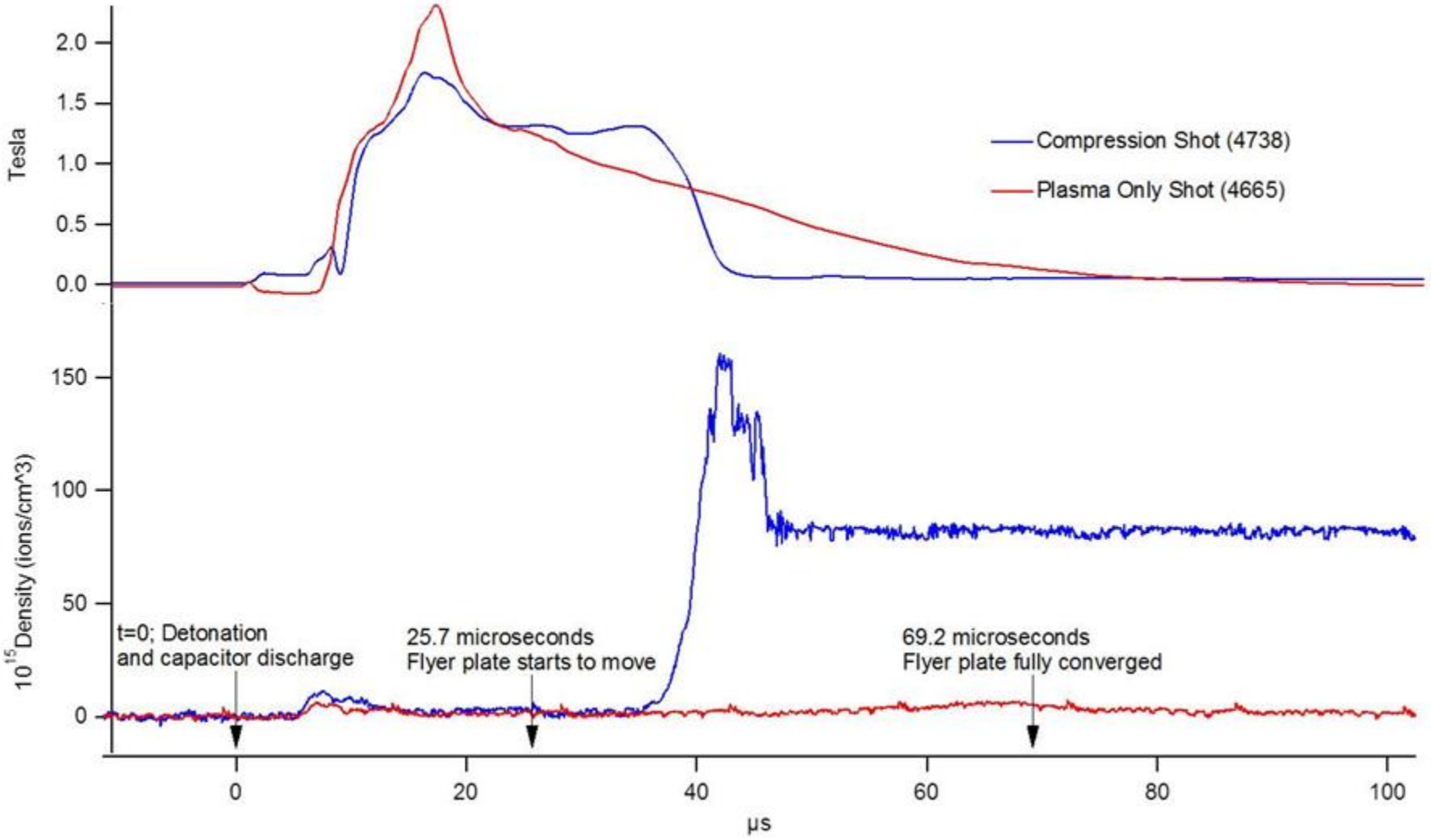
Piston Impact Velocity



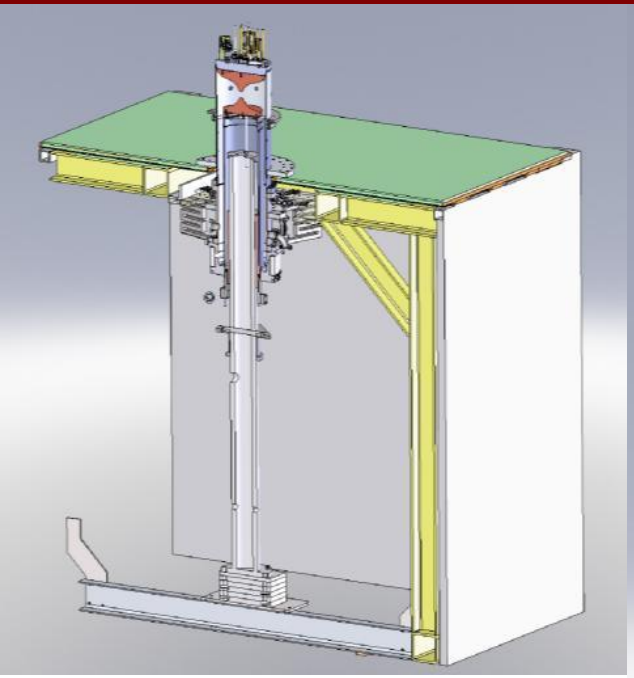
Mini-sphere – 14 full scale pistons, liquid metal vortex

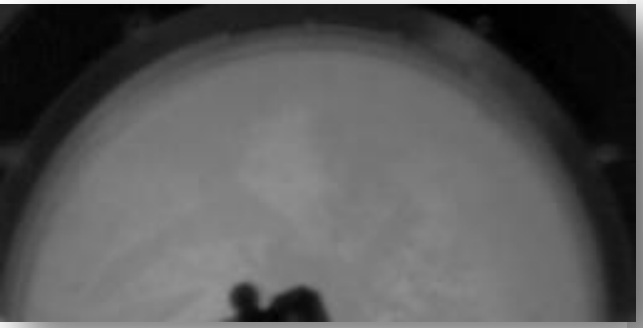


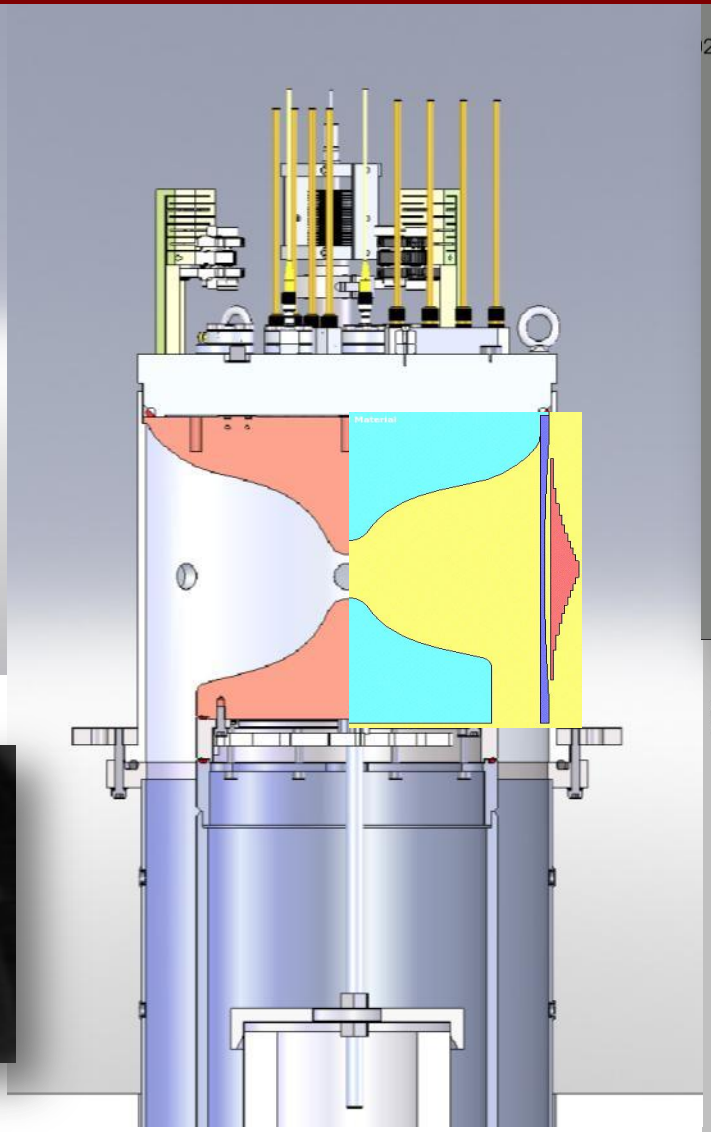
Plasma Compression May 2012

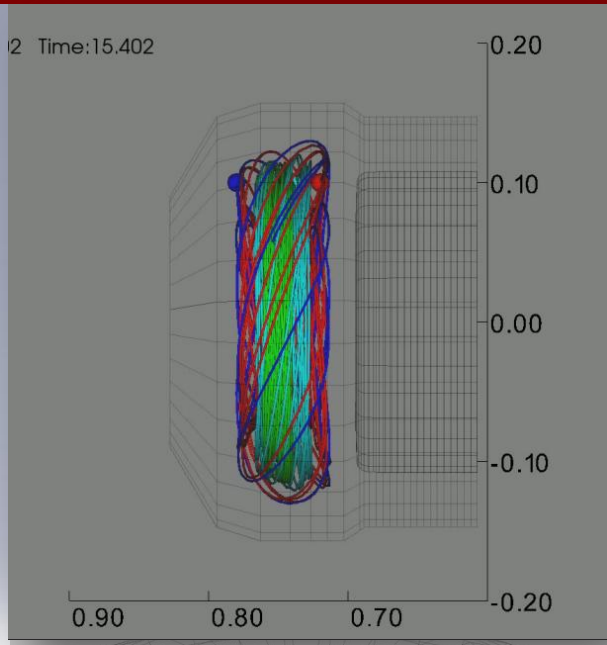


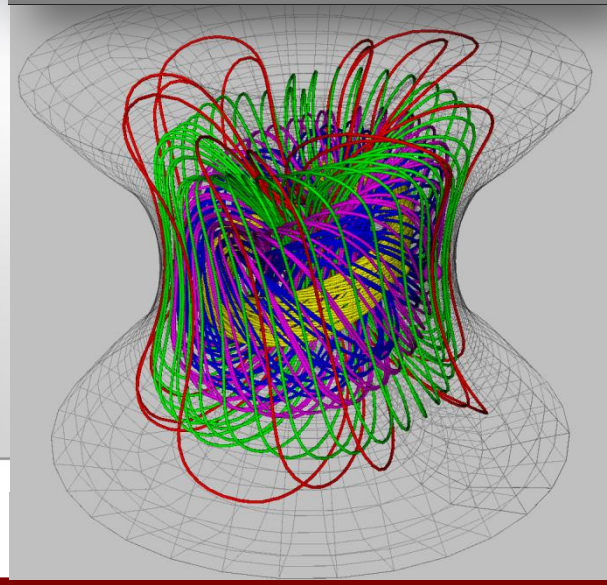
PC Small Experiment





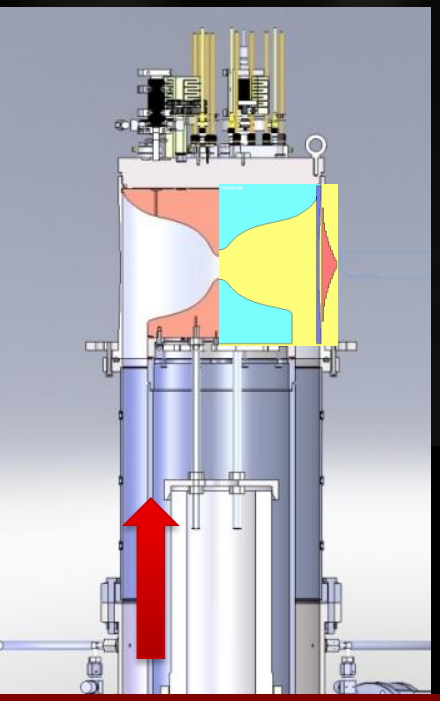




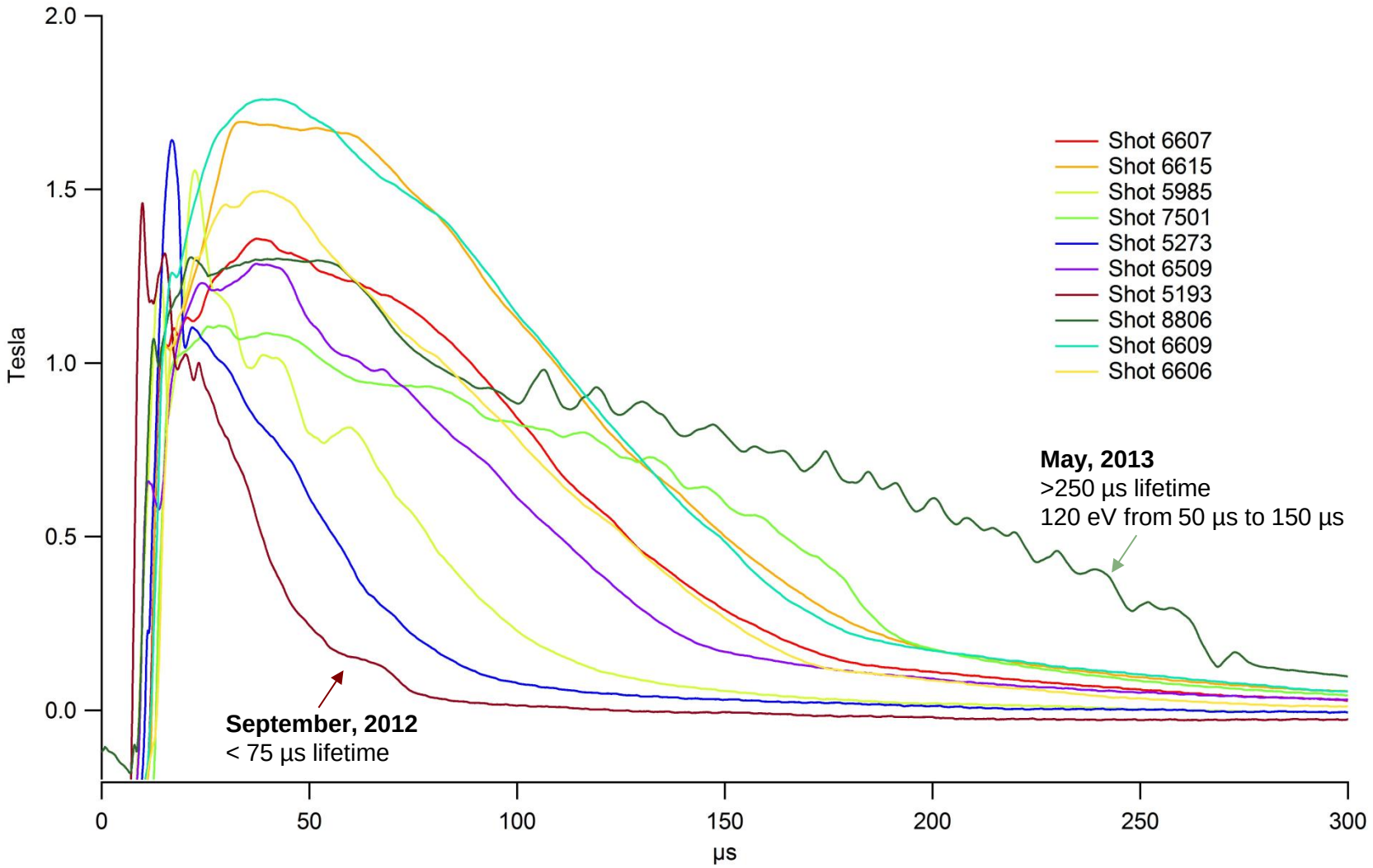


Compression time: 65 µs

Redesigned PC Compression Chamber



PC Small Plasma Data



PC Small Experiment #2

Objectives for Phase II – Subsystem Development

Full Scale Component Development

Plasma Injector

Temperature	Density	Lifetime
✓	✓	*50 µs* *Target is 100 µs*

Acoustic Driver

Impact Velocity	Impact Timing	Vortex Collapse
✓	✓	*Spallation issue*

Plasma Compression Tests

Small Tests	*Ongoing*	
Large Tests	*Starting end of 2013*	*Net Gain Possible*

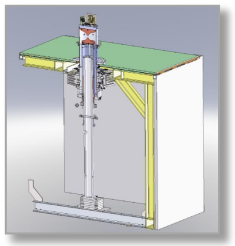
Build Strategic Relationships

Customer / Partner	Cenovus Energy - Invested 2011	✓

The Path Forward

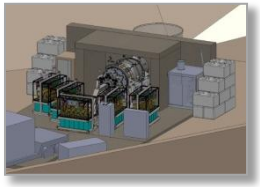
Plasma Injector

- Confinement improvement
- Power increase
- Increase in magnetic compression
- Geometry upgrade: efficiency improvement
- ➢ Demonstrate heating beyond 500 eV



Plasma Compression – Small Test

- Experimental campaign of 10 or more tests
- Power increase
- ➢ Target 10X radial compression, 10 keV



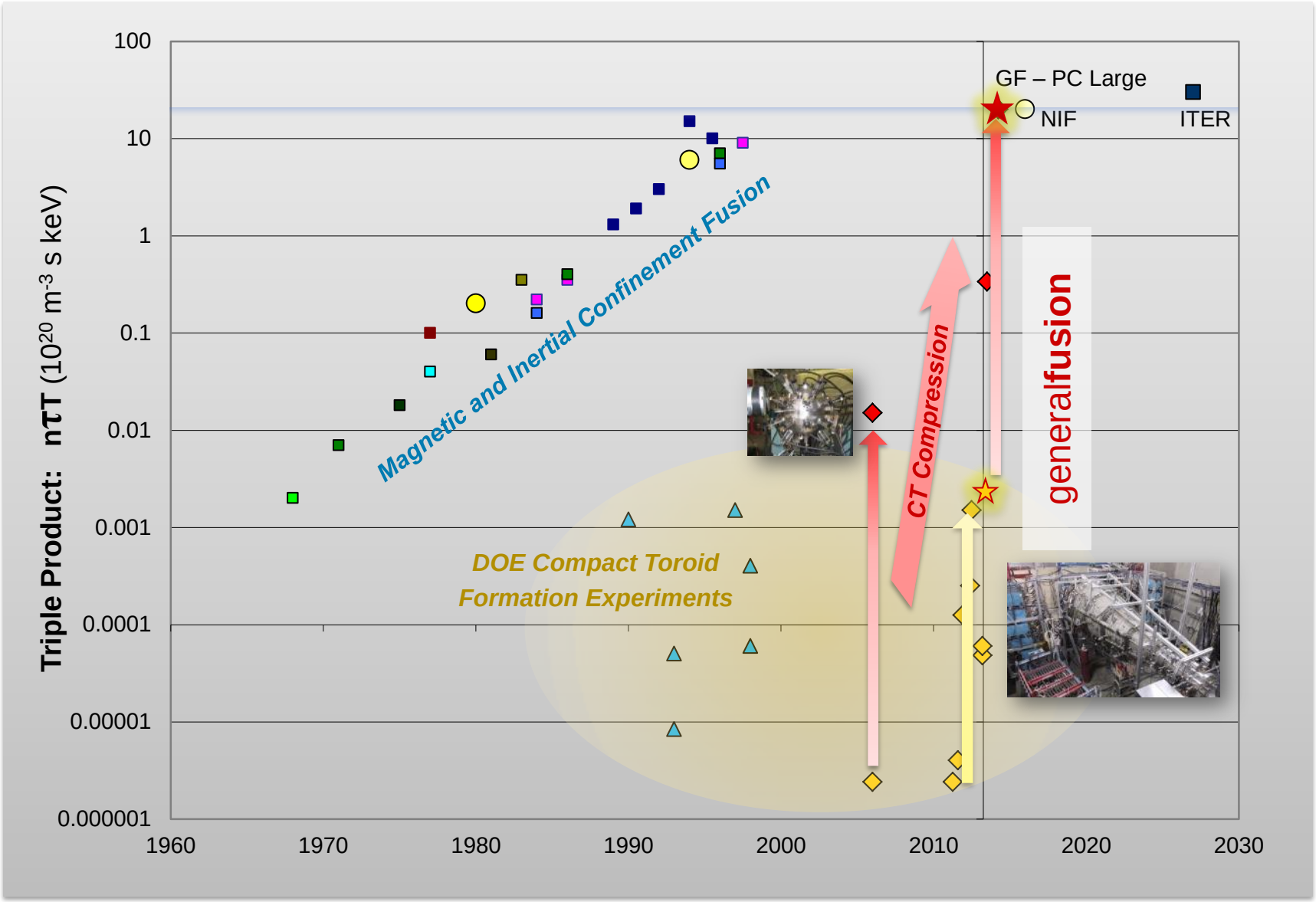
Plasma Compression – Large Test

- Experimental campaign of 10 or more tests
- ➢ Validate reactor-scale plasma behavior

Reactor Development

- Vortex stability improvements
- ➢ Demonstrate smooth radial compression

Pursuing a Compressible Plasma, towards Net Gain




Clean energy.
Everywhere.
Forever.
generalfusion