NSTX-U

Supported by U.S. DEPARTMENT OF ENERGY | Office of Science

MGI and EPI experimental activity during FY16

College W&M
Colorado Sch Mines
Columbia U
Comp-X
General Atomics
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
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U Colorado
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U Washington
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R. Raman[1], W-S. Lay[1], F. Hoffmann[2], D. Westover[2], T.R. Jarboe[1], S.P. Gerhardt[2], S.C. Jardin[2], J.E. Menard[2], B.A. Nelson[1], M. Ono[2], J. Schmitt[2]

[1]University of Washington
[2]PPPL

This work is supported by US DOE contract numbers DE-SC0006757, DE-FD02-99ER54519, and DE-AC02-09CH11466

FY16 Results Review
September 21 – 22, 2016
PPPL, Princeton, NJ USA

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Disruption Mitigation (DM) Studies on NSTX-U

- Massive Gas Injection (MGI) Studies
  - Established MGI capability on NSTX-U

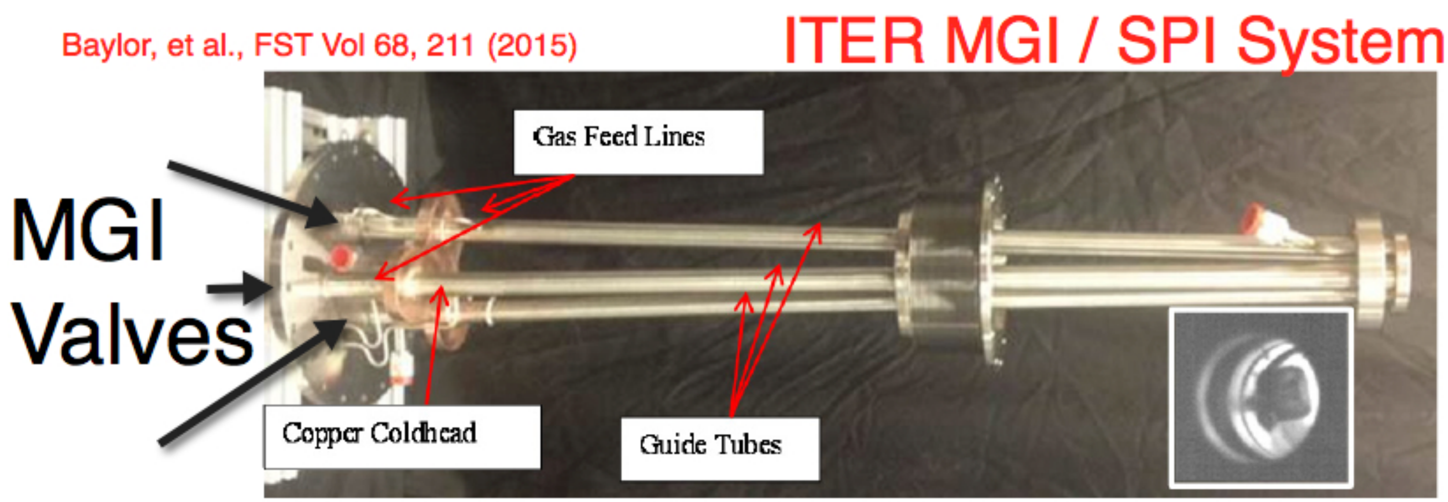
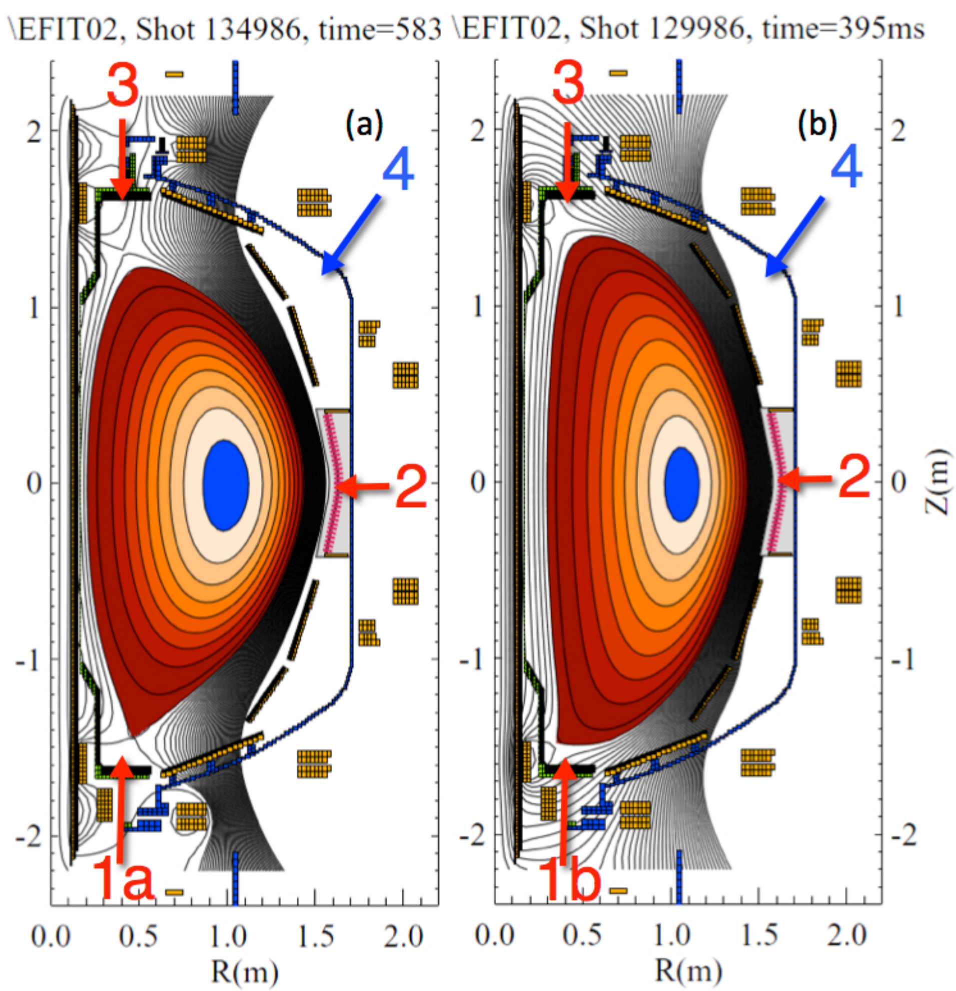


Fig. 2. A 3-barrel shattered pellet injector prototype before installation in a guard vacuum chamber. Inset shows a 16 mm D_2 pellet accelerated to 500 ms using this injector.

- Electromagnetic Particle Injection (EPI) Studies
  - Designed, fabricated and assembled an EPI system for testing and verifying key parameters for NSTX-U EPI system

NSTX-U MGI will study poloidal injection location variation using nearly identical MGI valves and gas transit piping



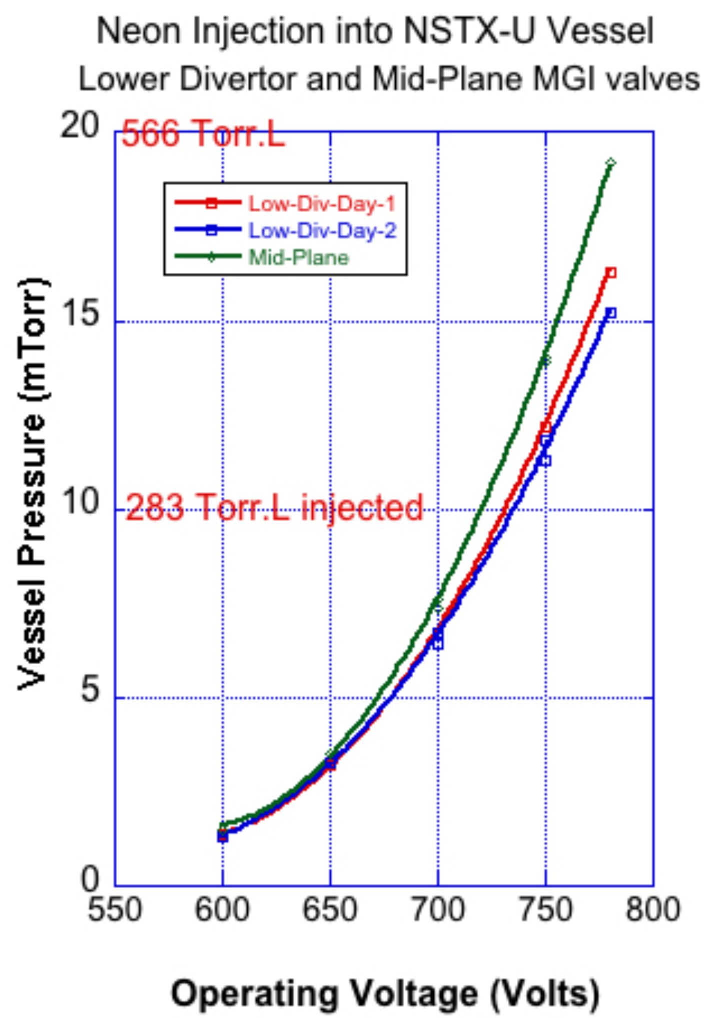
FY16 Goal:
Assess benefits of injection into the private flux region & the high-field side region vs. LFS mid-plane

In support of this goal two MGI valves (at locations 1 and 2) were made fully functional on NSTX-U

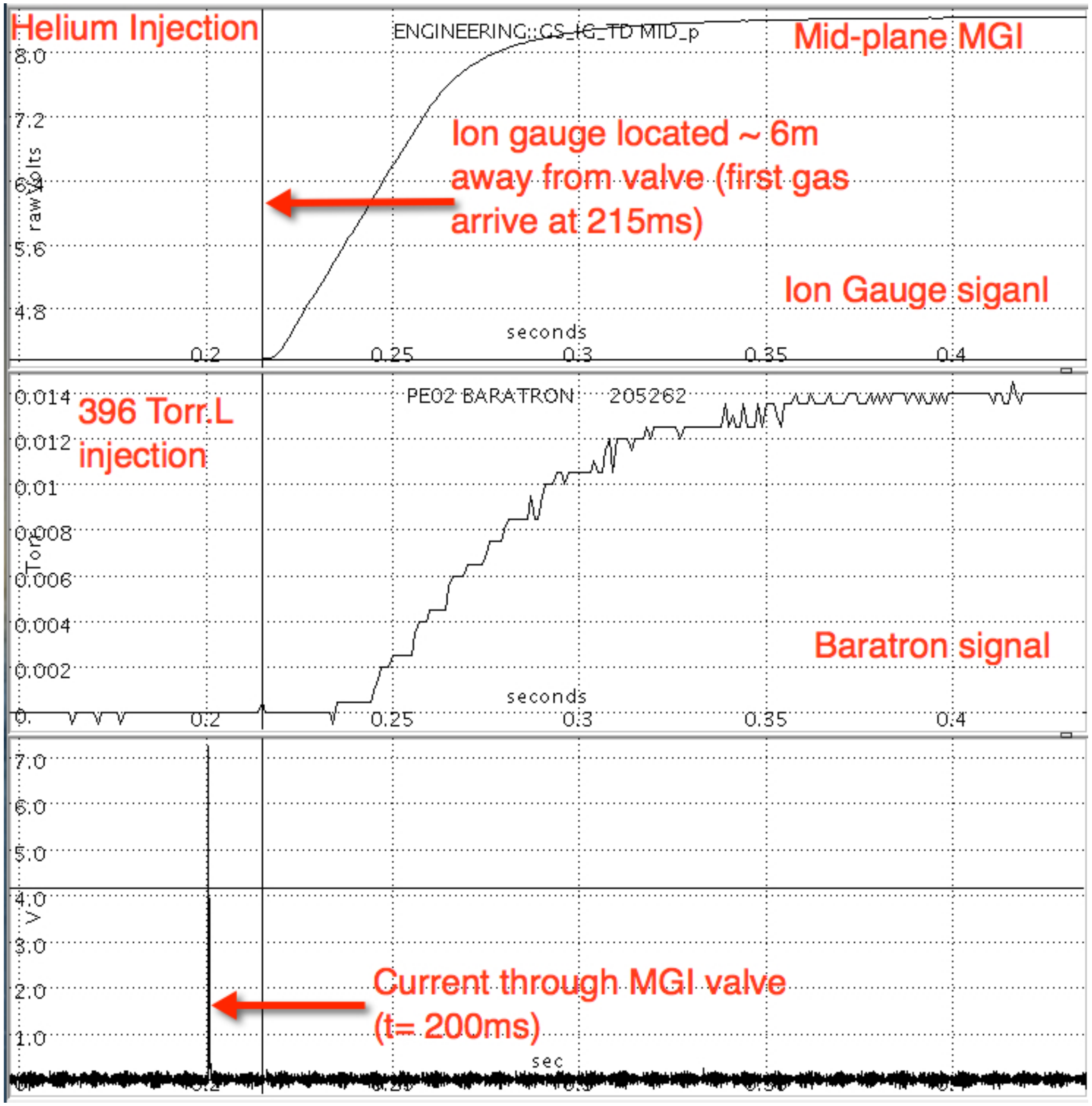
1a: Private flux region
1b: Lower SOL, Lower Divertor
2: Conventional mid-plane
3: Upper divertor
4: Future installation

Mid-Plane & Divertor MGI Valves ready to support Plasma Operations

- The Pre-operational Test Procedure (PTP) for both MGI valves were completed
- Valve power supplies operated at 1kV during PTP
- Both valves were calibrated in Nitrogen, Helium and Neon at the full operating pressure (200 Psig)
- During these tests 400Torr.L of neon was injected into the NSTX-U vessel, this is about twice the amount of neon injection planned for the first MGI experiments to be conducted on NSTX-U



Gas Arrival Times as Measured by Slow Pressure Gauges Roughly Consistent with Sound Speed of Gas



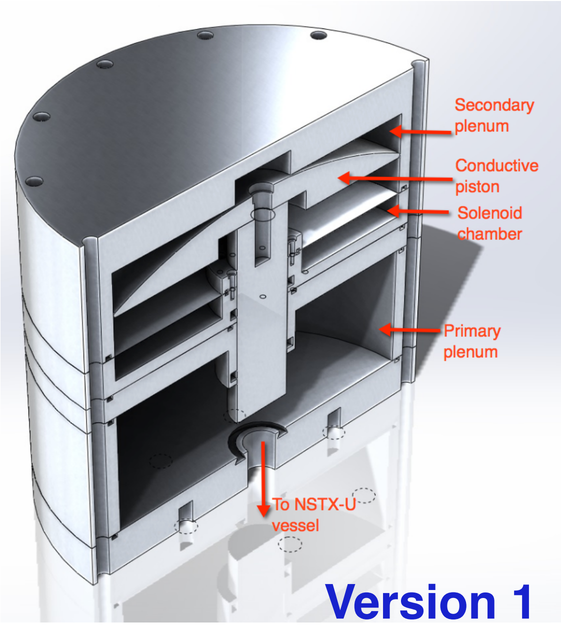
200 Psig Plenum pressure

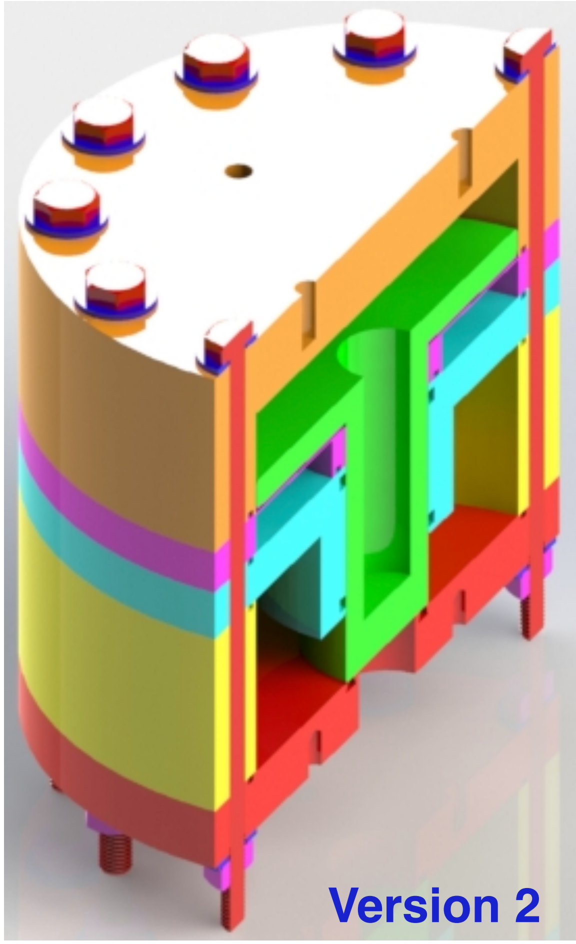
MGI gas travels through 2m long tube with bends.

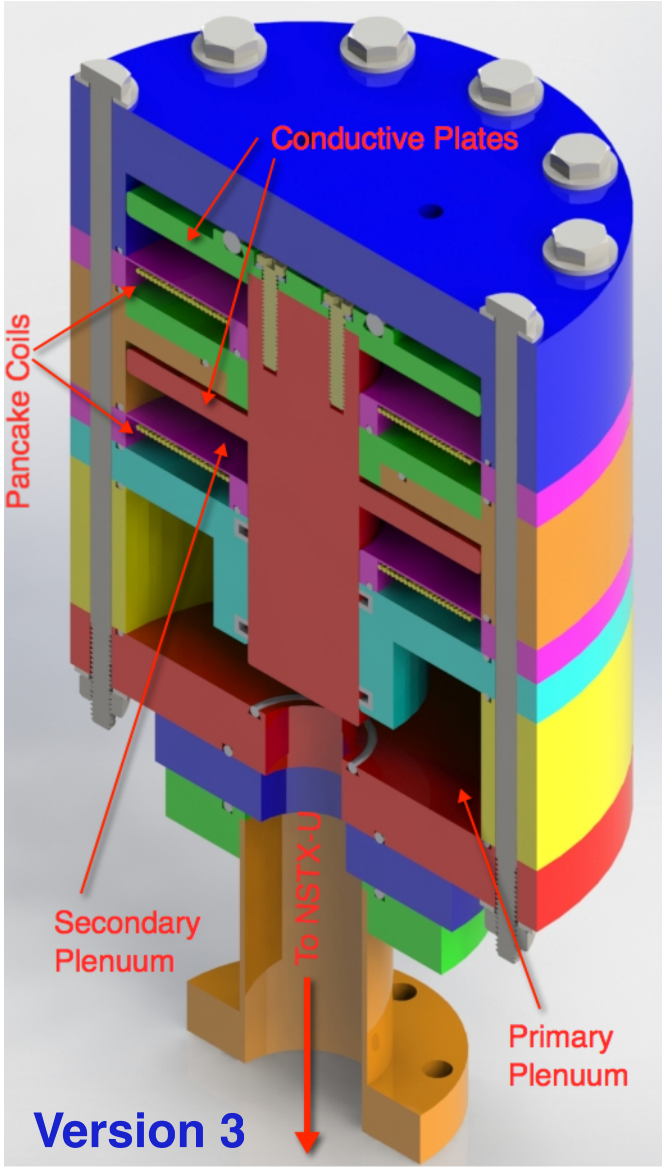
Future experiments will inject gas using a short connecting tube (to compare to Upper Divertor MGI configuration)

Sound speed:
He : ~972 m/s
Neon: ~461 m/s
Nitrogen: ~354 m/s

Off-line MGI Studies will Contribute to MGI Valve Development in support of NSTX-U and ITER







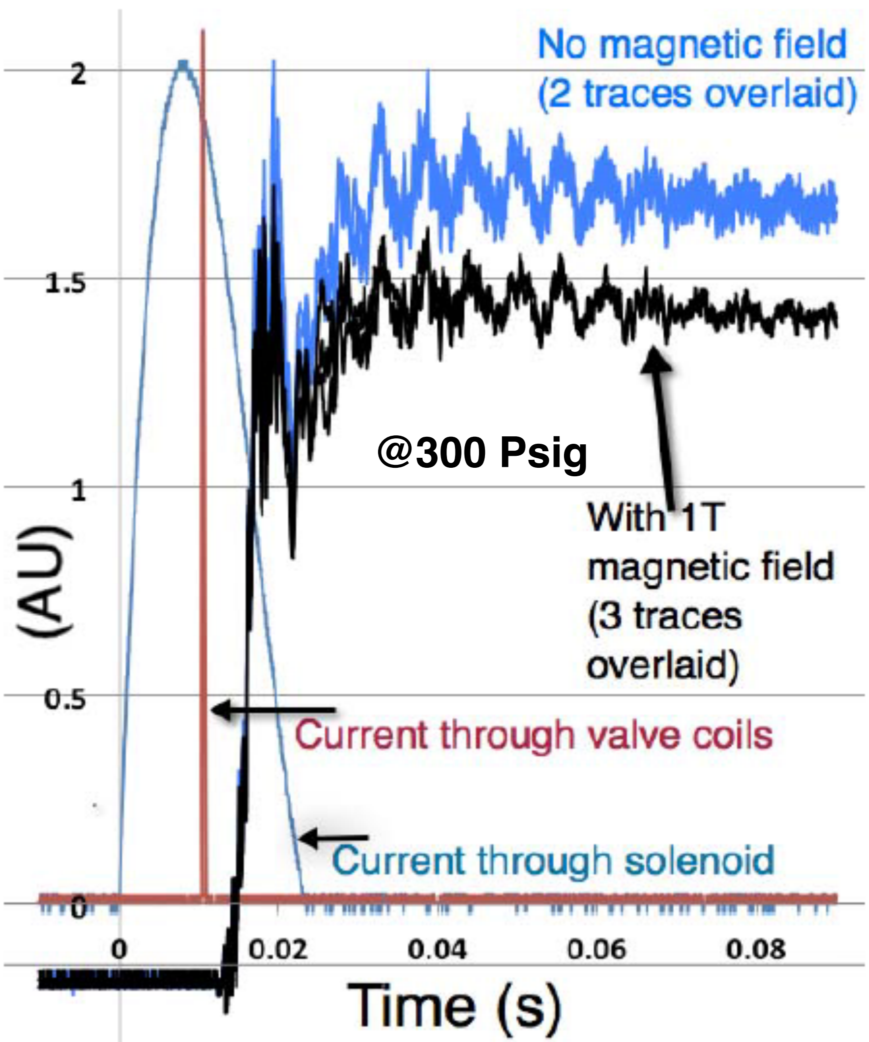
MGI valve design based on TEXTOR / JET MGI concept

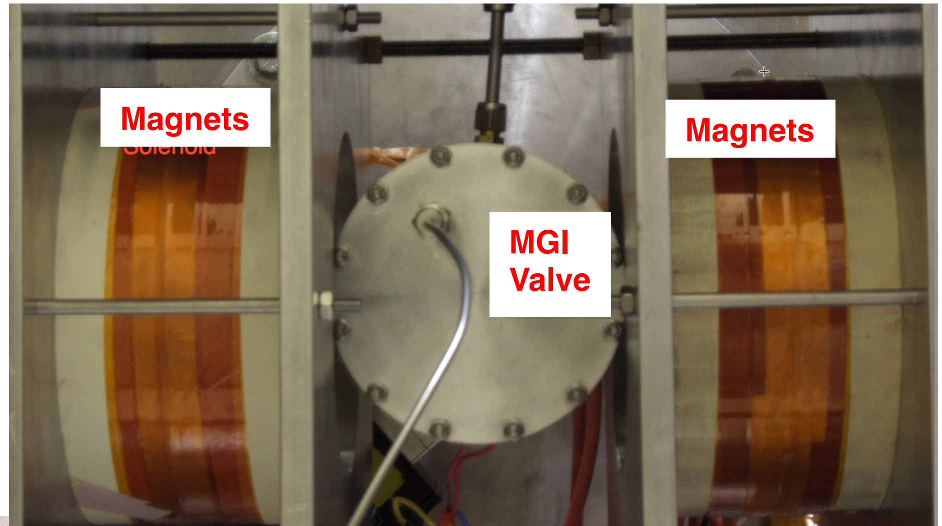
New double solenoid MGI design – V3 (zero net J x B torque) based on ORNL ITER MGI concept

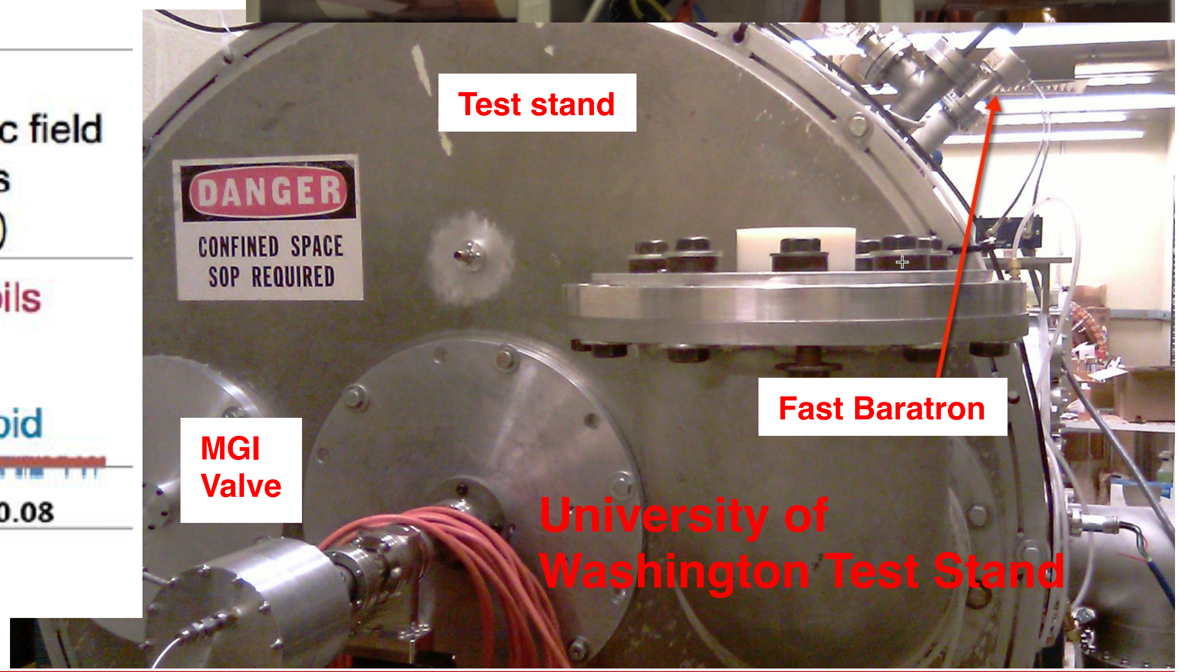
R. Raman, et al., RSI, 85, 11E801 (2014)

Understand Reliability and Magnetic Field Limits on Valve Operation

Baratron traces with and without magnetic field

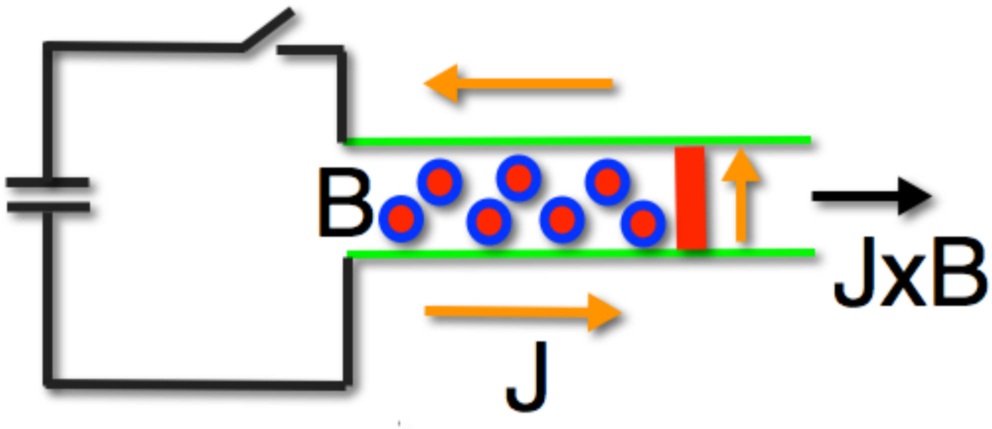




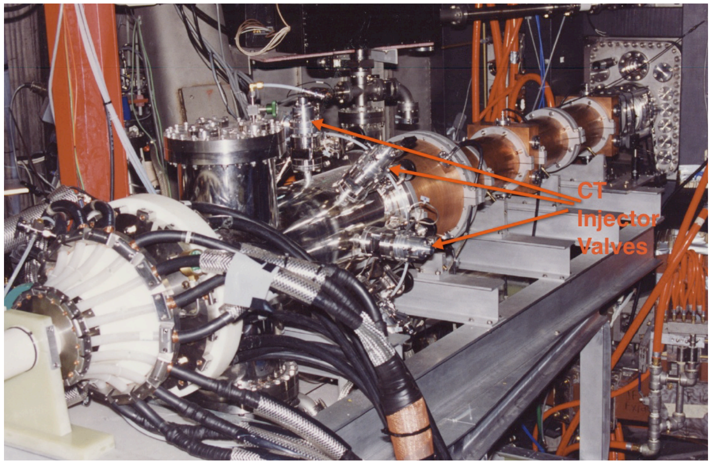


R. Raman, et al., IEEE-PS 44, 1547 (2016)

Linear Rail Gun is Especially Well Suited for Operation in High-Ambient Magnetic Fields

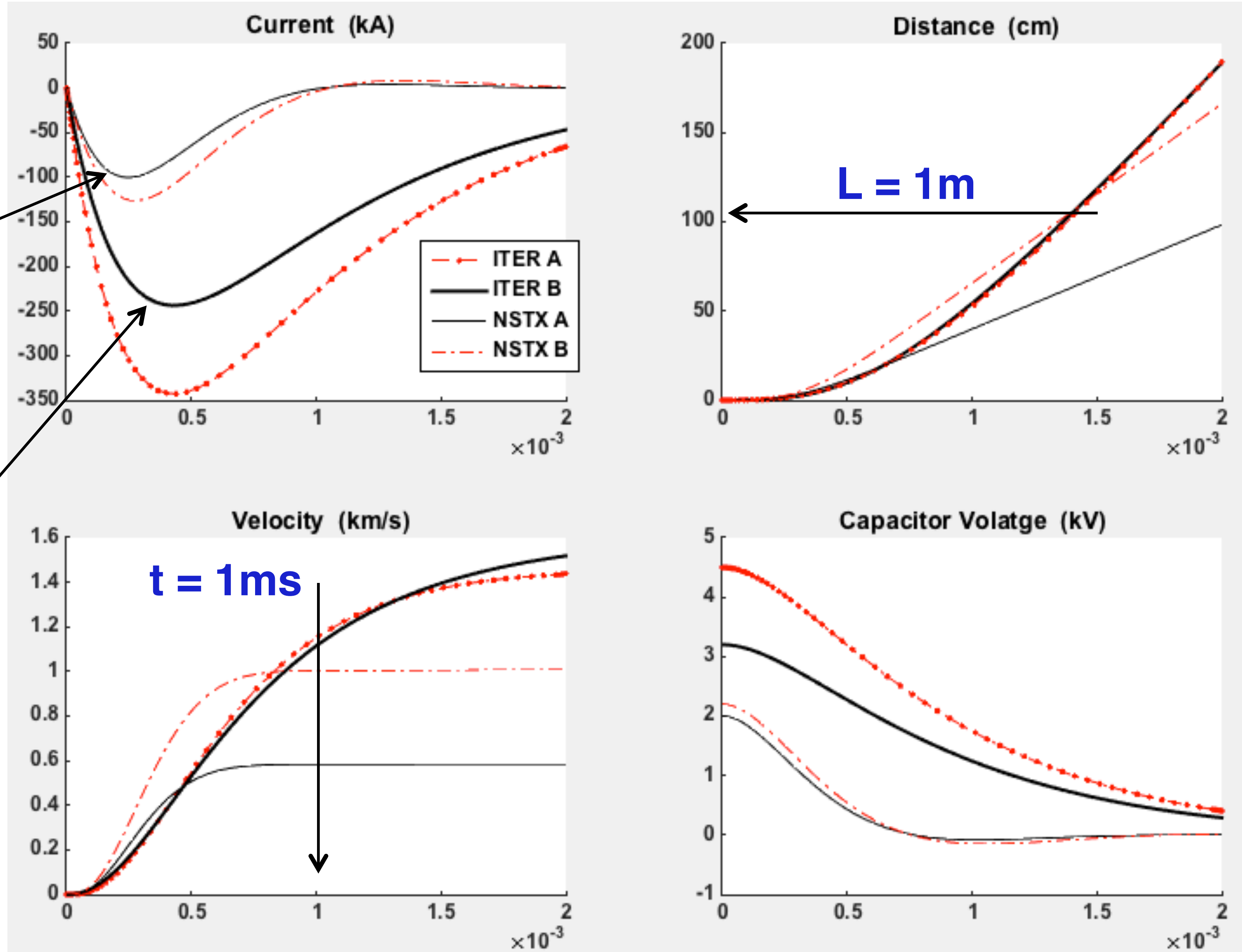


CT Injector on TdeV



- In a simple rail gun, the magnetic field is produced by the current flowing along the rails
- To increase the JxB force accelerating the projectile, the current along the rails needs to be increased
- An important advantage of a linear rail gun is that the ambient magnetic field in ITER can be used to increase the gun efficiency
- Injector can to be positioned very close to the vessel, which further improves the system response time and efficiency

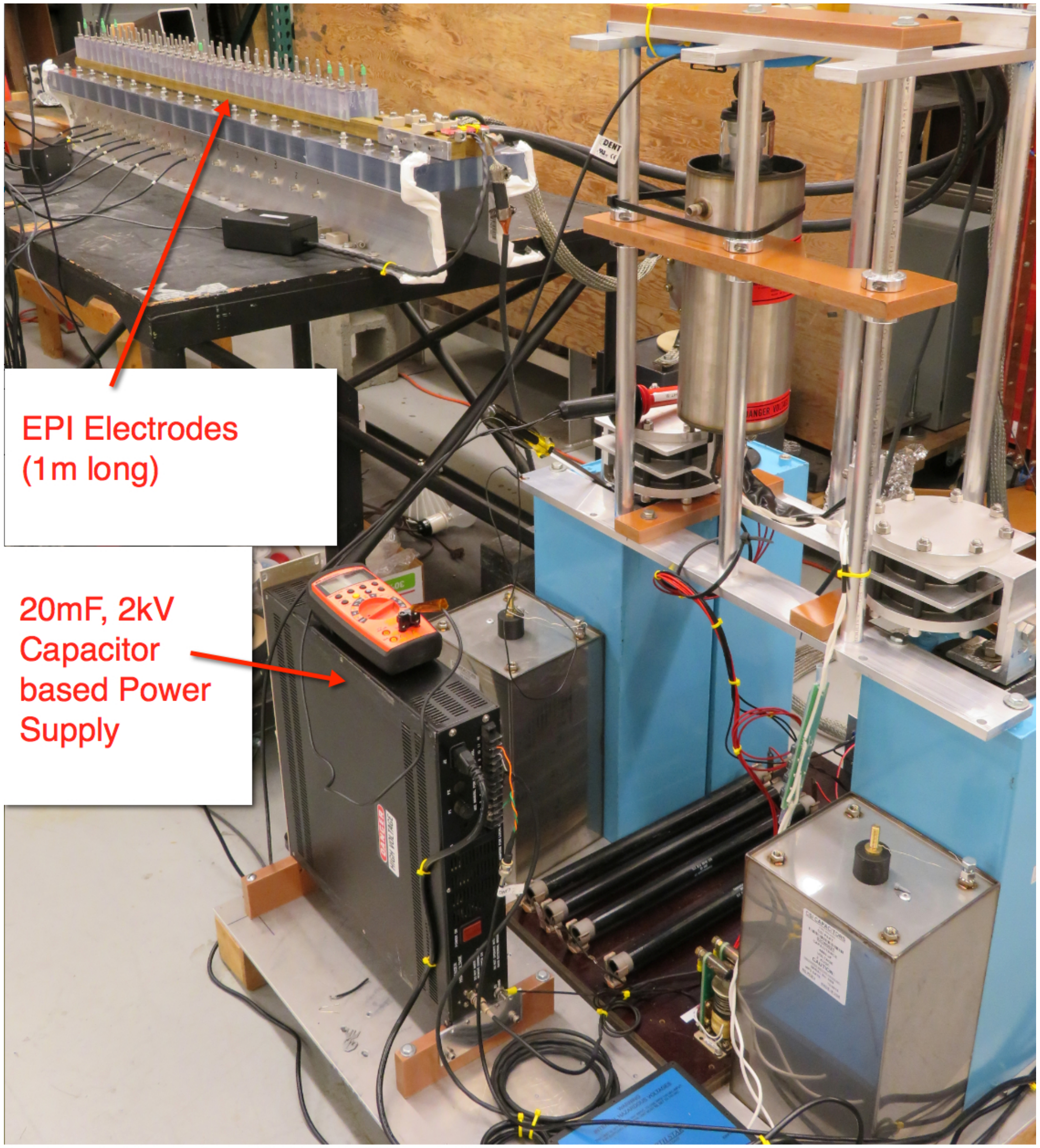
External Magnetic Field Augmentation Substantially Reduces Electrode Current and PS Requirements



NSTX-U
20 mF, 2kV

ITER
2T external magnetic field augmentation, 100mF, 3.2kV

EPI-V1 Designed, Fabricated, and Assembled



MGI Valves Ready to Support Plasma Operations on NSTX-U

- ITER-type MGI valve will be used on NSTX-U in a configuration to do exact comparison experiments
  - Same valve & piping configuration at each poloidal location
- Two MGI valves commissioned on NSTX-U, and are ready to support plasma experiments
- MGI valve has been tested in 1T ambient magnetic fields in off-line tests
- Something like the EPI system will be eventually needed for ITER and ST/ Tokamak based next-step devices
  - Key capabilities of these systems are:
    - Rapid delivery of impurities deeper into plasma with fast time-response
    - Reliable operation, and capability for close positioning to the vacuum vessel
  - NSTX-U sized EPI system (V1) designed and built (results to be reported in IAEA meeting)