Discharge fueling with lithium wall operation of LTX

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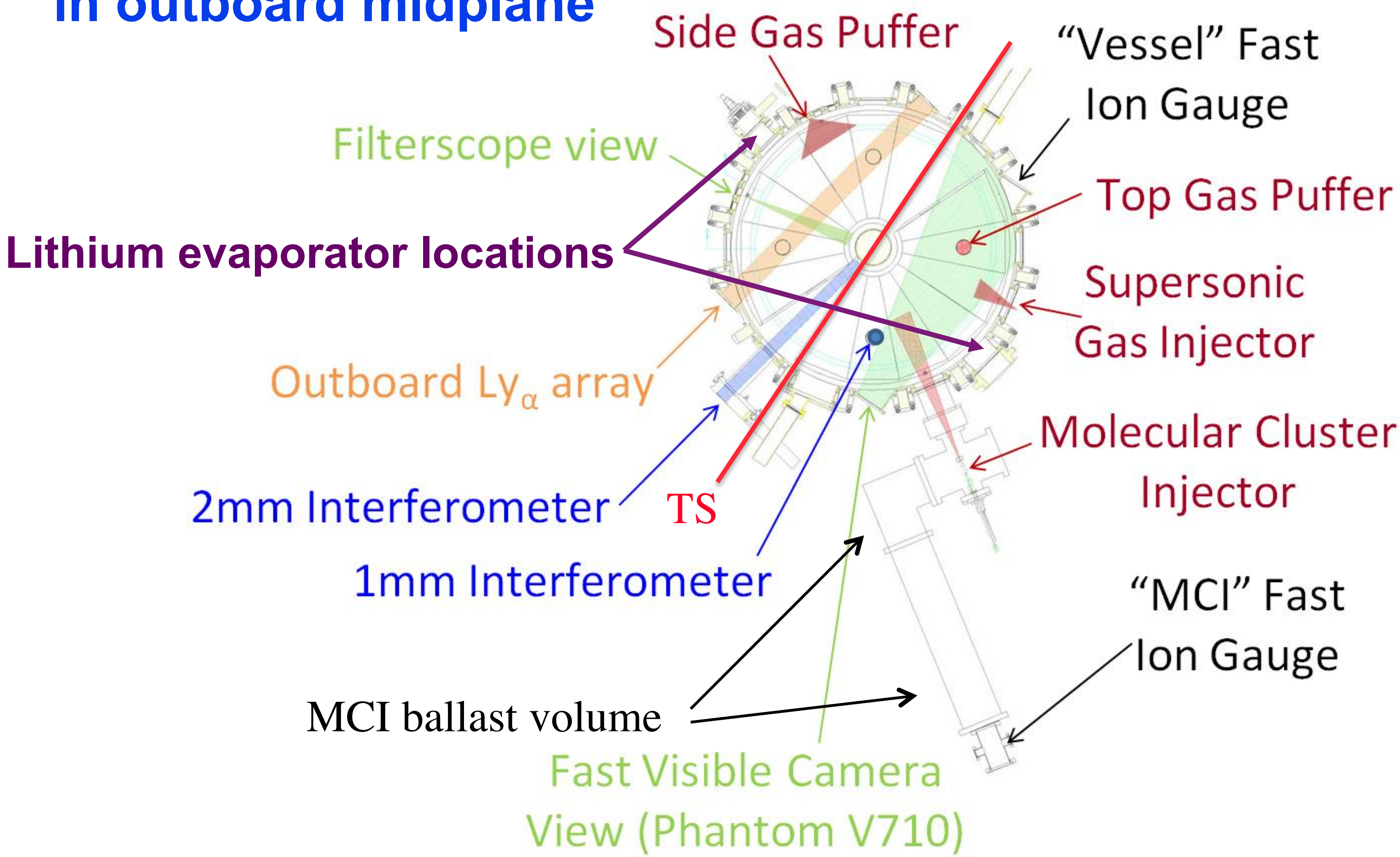
Outline

- Lithium deposition systems
- Wall pumping with lithium coatings in LTX
- Gas injection systems
  - Directed side puffer
  - Supersonic gas injector
  - Molecular cluster injector
- Fueling efficiency with directed jets
- Future plans

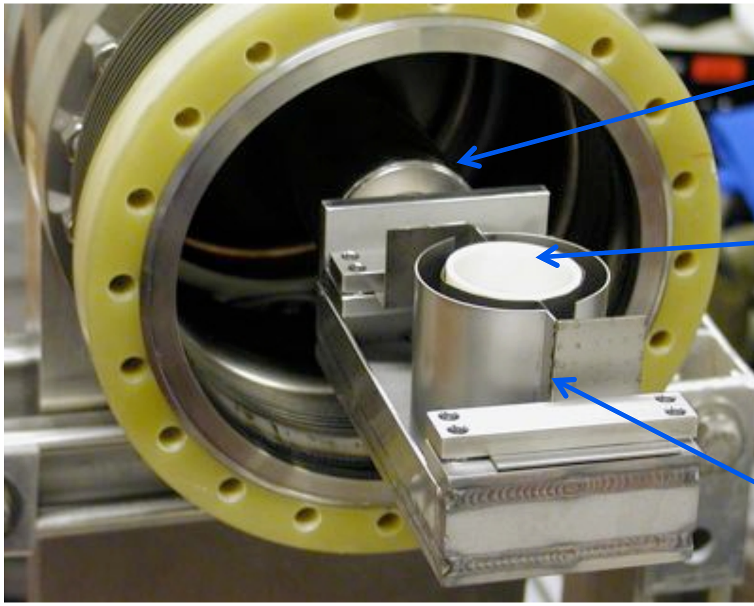
LTX fueling systems and associated diagnostics

- **Fueling systems all in outboard midplane**



Lithium coatings are applied via evaporation into helium gas

LTX



Mounted on long-stroke bellows to bring evaporator into shell volume

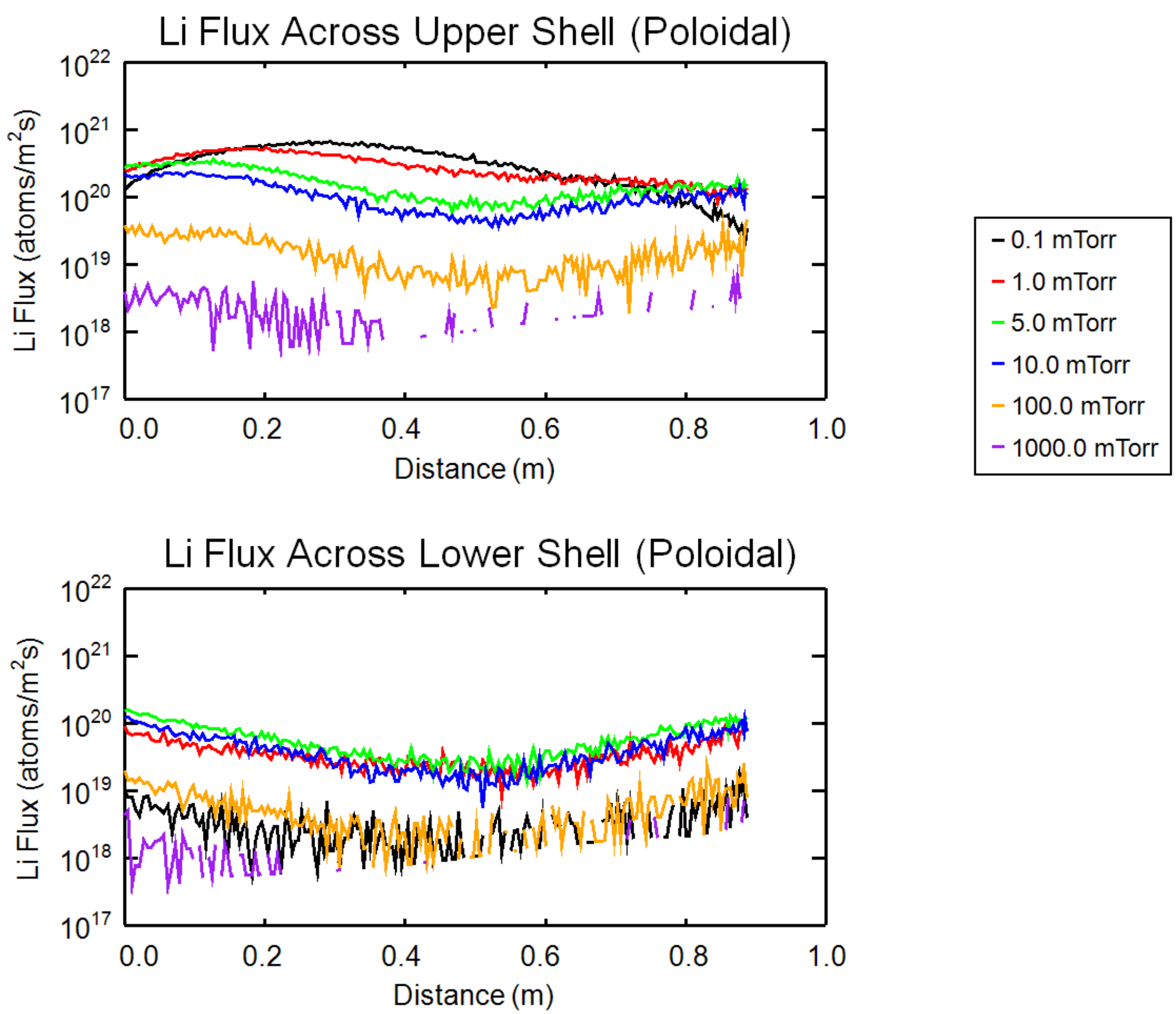
Yttria crucible transfers heat, lithium does not wet surface

Tantalum heater brings crucible to ~550-600°C → evaporates up to 1 gram per hour

- Helium pressure of 5 mtorr, which yields coatings with acceptable uniformity.

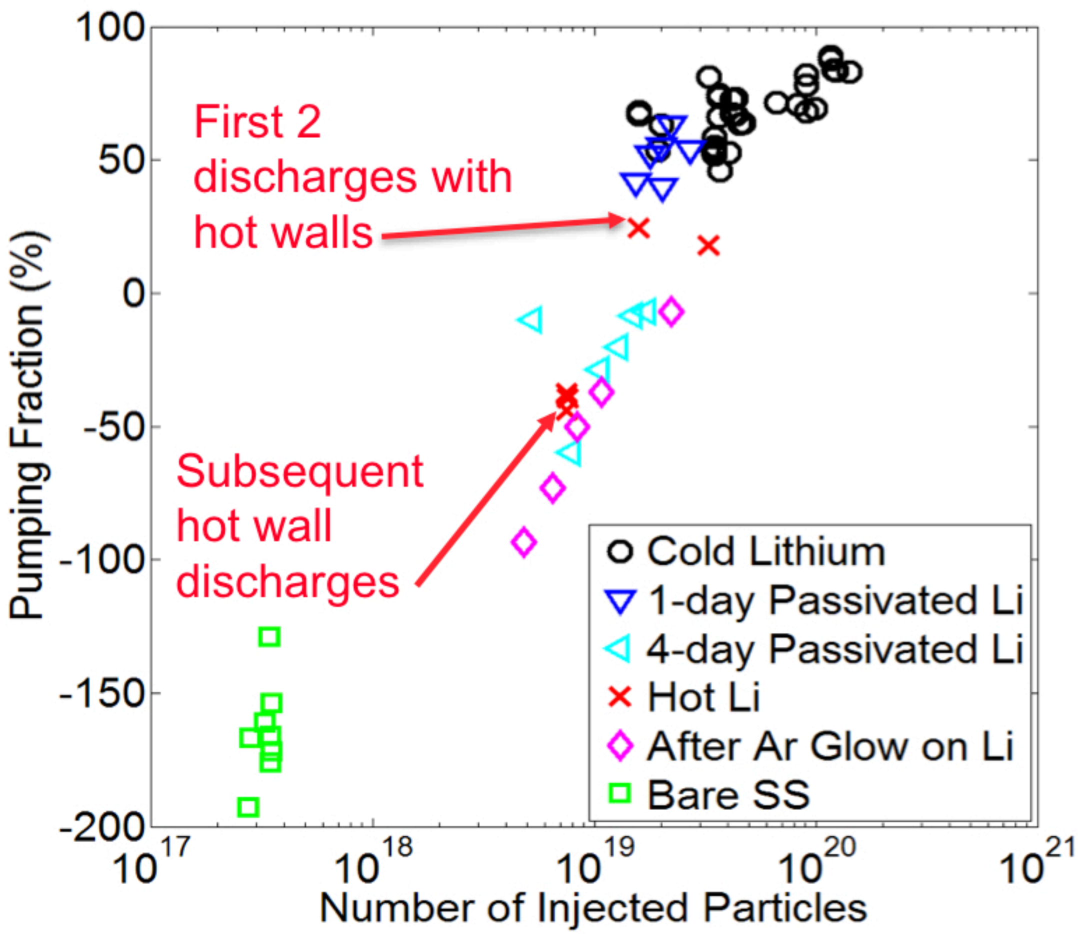
- Abrams & Stotler performed DEGAS 2 modeling of evaporation, concluded that 1-10 mtorr fill pressure produced the most uniform toroidal/poloidal distribution

Poloidal distribution of lithium coating in LTX



~5 mTorr helium backfill used in LTX experiments

Wall pumping most effective with cold lithium coatings

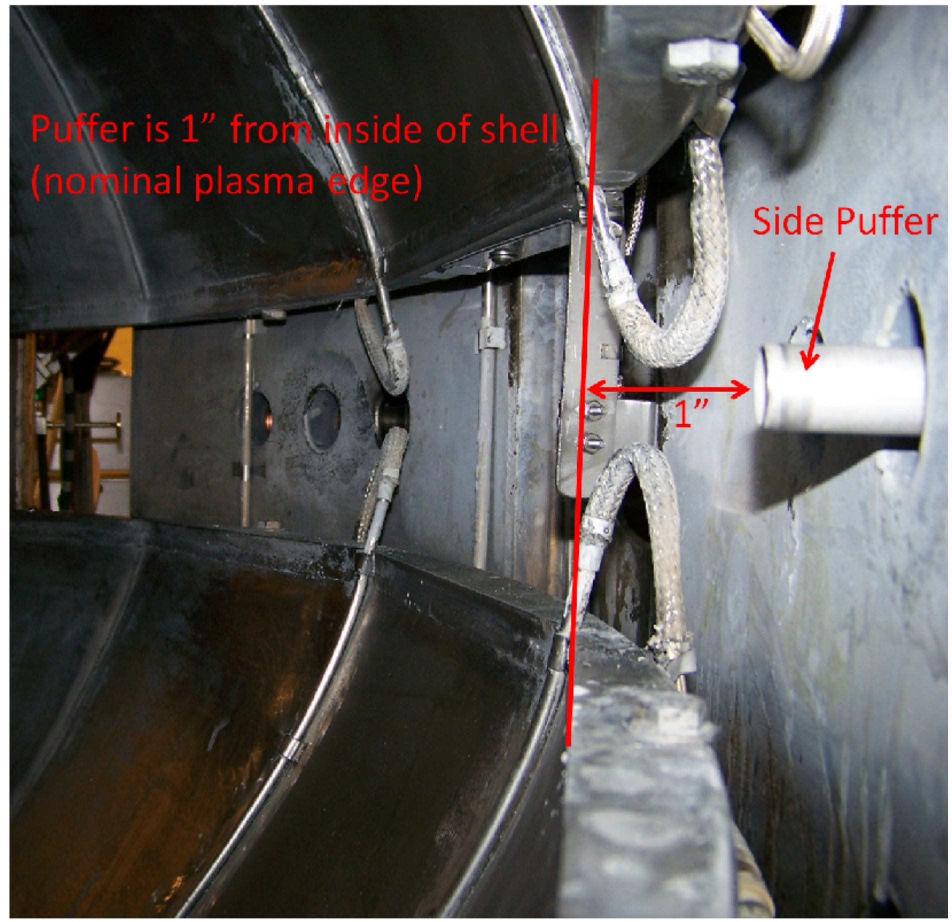


- So far lithium coatings on hot (300 C) walls only show a transient reduction in recycling

- Effective liquid lithium wall operation will require better control over the lithium surface conditions

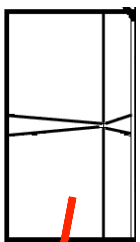
Gas injection systems

- Side puffer employs a piezoelectric valve
- Fast valve is mounted just outside the vacuum envelope
- A 0.5” tube ducts gas to within 2 cm of the last closed flux surface
  - Defined by the shells
- Used for prefill, to initiate discharge



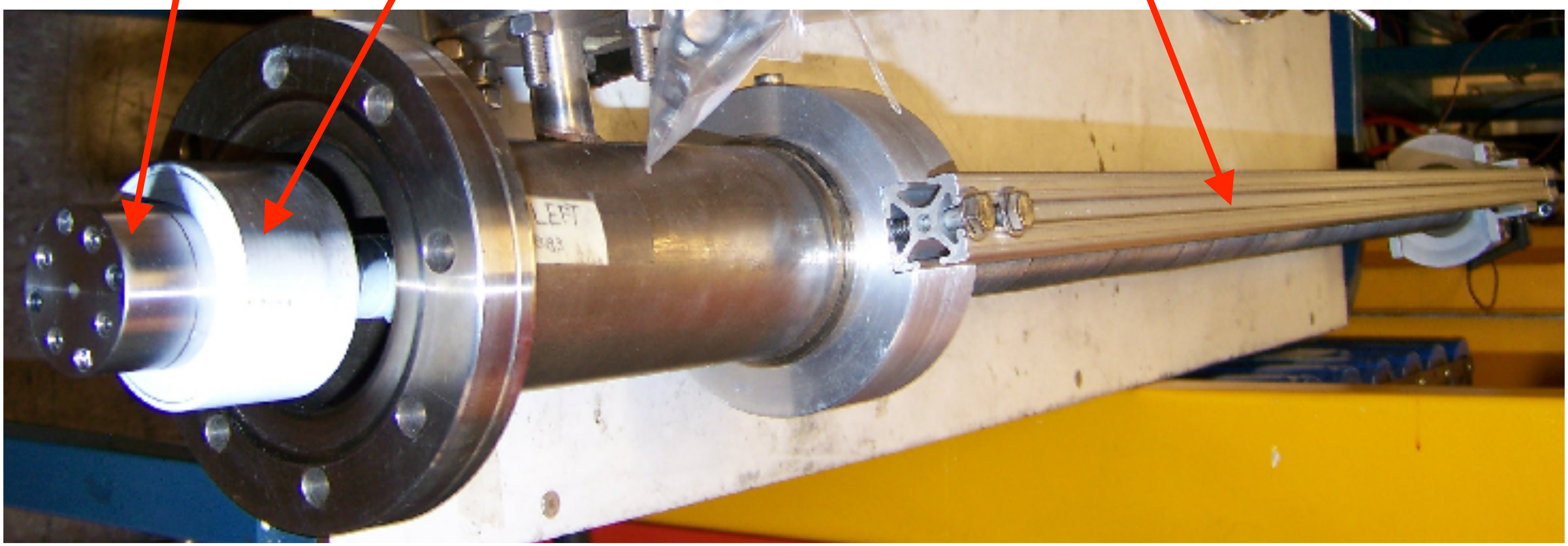
Gas injection systems – Supersonic Gas Injector (SGI)

- Mach 5.5 supersonic Laval nozzle
- Nozzle – LCFS distance can be varied



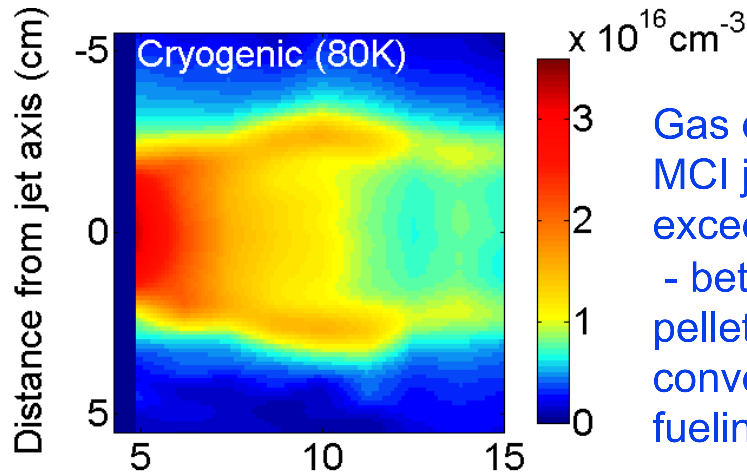
PV-10 piezoelectric pulse valve

Long-stroke bellows to position nozzle at LCFS

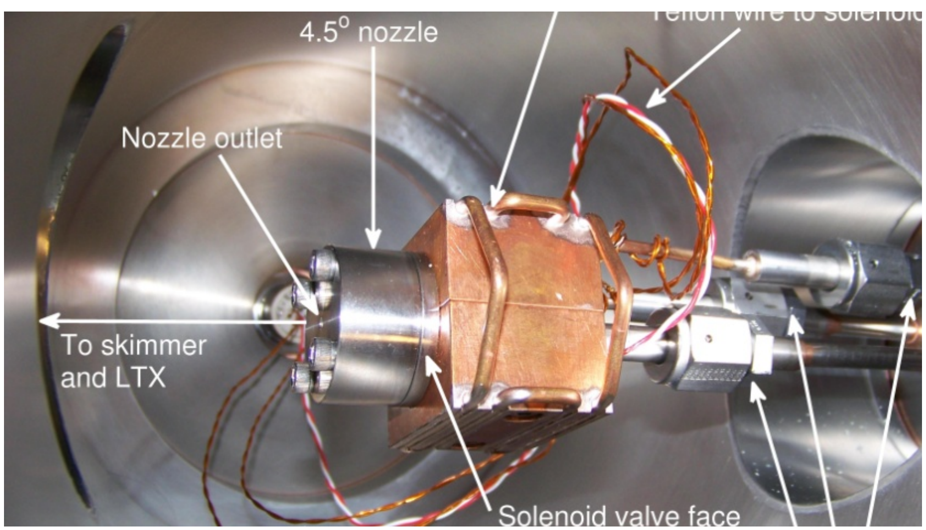


Molecular cluster injector

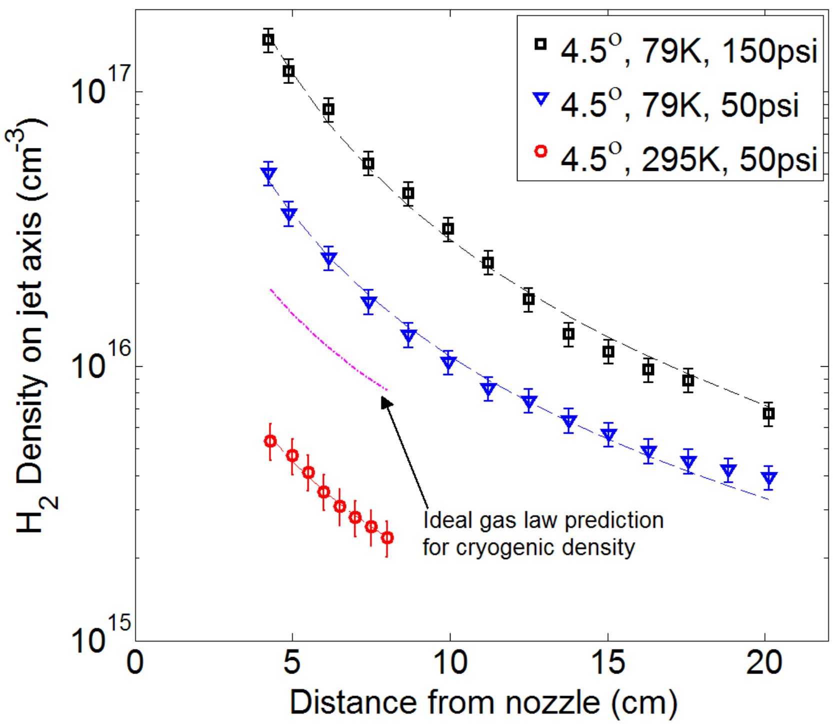
- Molecular cluster injector for LTX
  - Precooled (82K) gas condenses through nozzle exhaust
    - Forms clusters ~ 10^4 molecules
  - Less expansion of jet
  - High fueling capability
  - Millisecond response



Gas density in MCI jet exceeds 10^{22} m^{-3} - between a pellet and conventional gas fueling



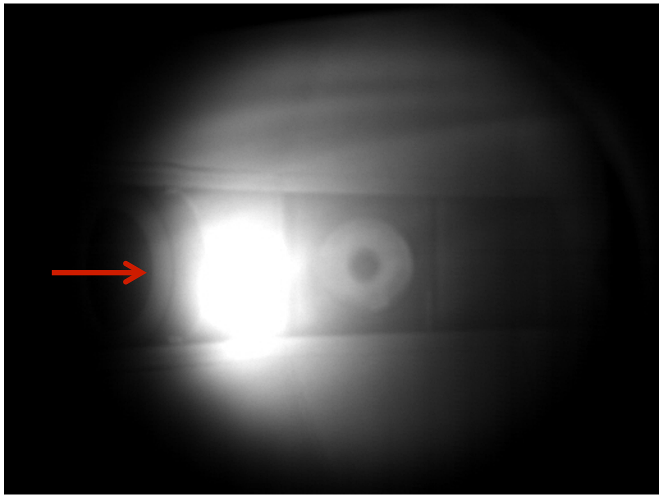
Nozzle is ~40 cm from plasma edge!



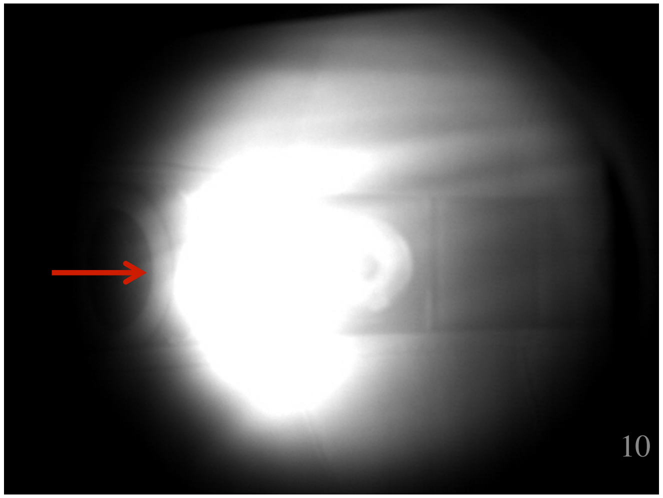
H_α measurements provide a diagnostic of neutral penetration into LTX plasmas

- Phantom V710 fast visible camera with an H_α filter to monitor hydrogen emission, block impurity emission
- These images are 5 μs exposures. Striations are inherent to LTX plasmas (field line structure), not caused by injector
- Qualitatively, cryogenic injector penetrates deeper, has brighter emission
- For quantitative measurements, need to correctly account for the angle of the injector relative to the camera and project emission on to target plane

Room-temperature injector

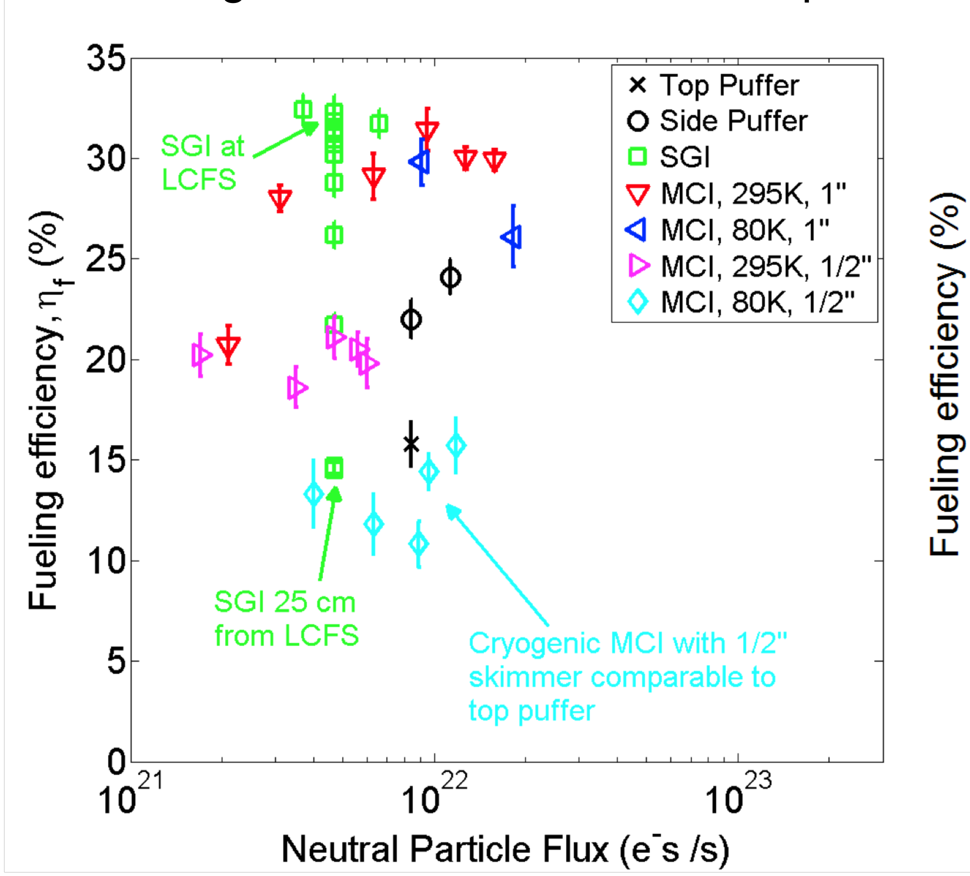


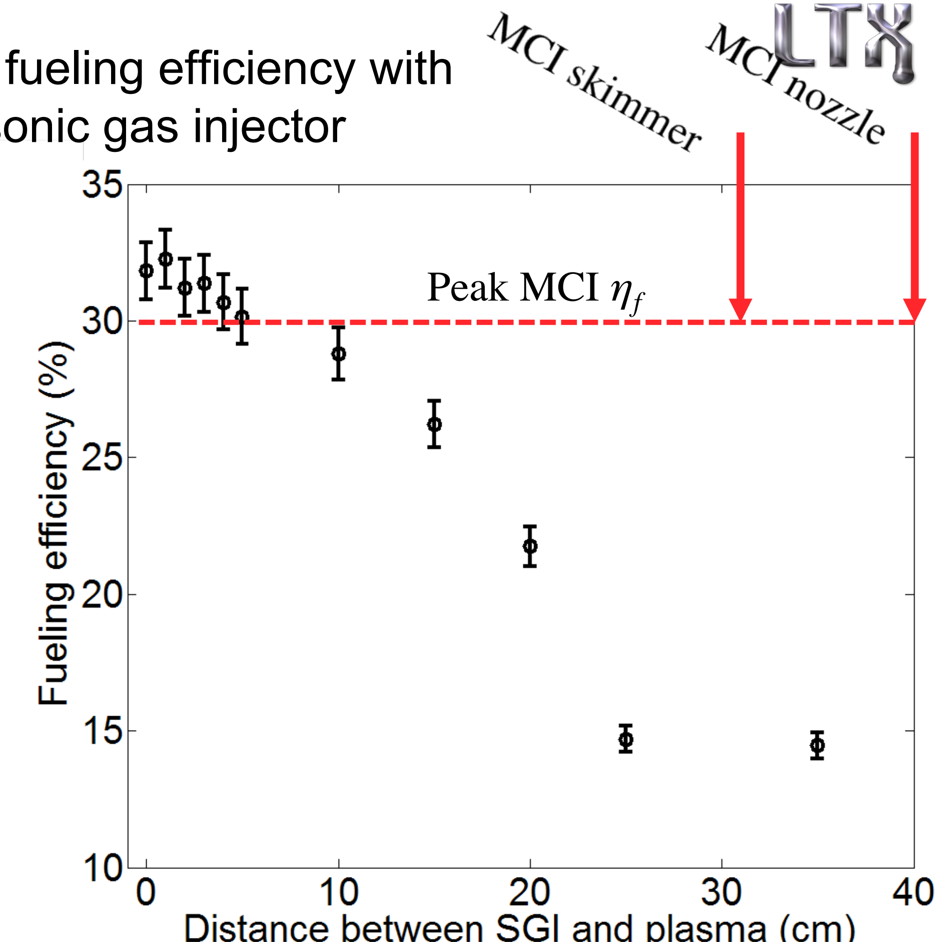
Cryogenic injector



Fueling efficiency highest with directed jets
➪Up to 30 – 35%

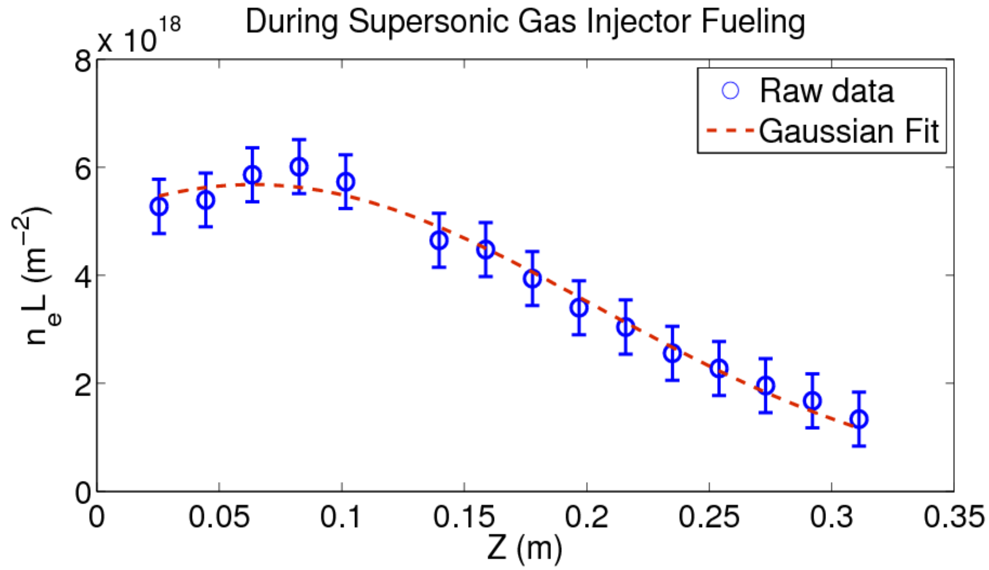
- Cluster injector system produces high fueling efficiency with much greater standoff than the supersonic gas injector

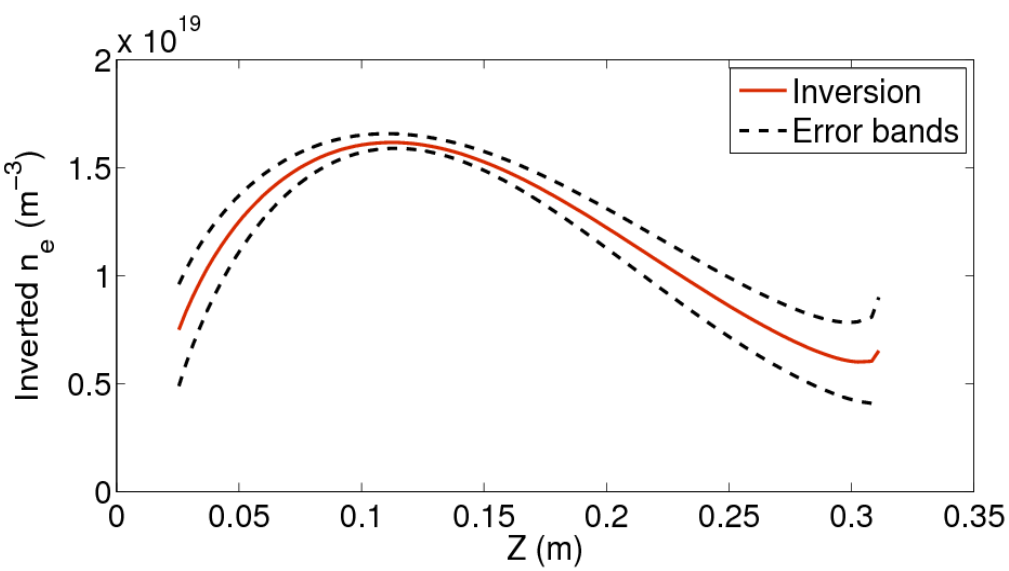


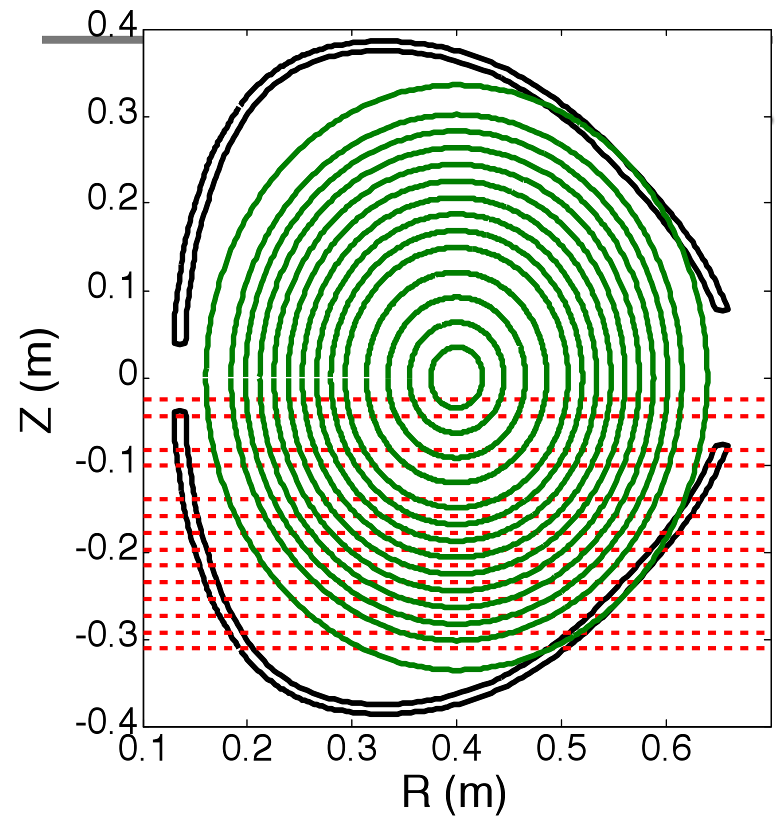


- Highest fueling rates with the MCI reduce the plasma current at present

LTX n_e profiles are hollow





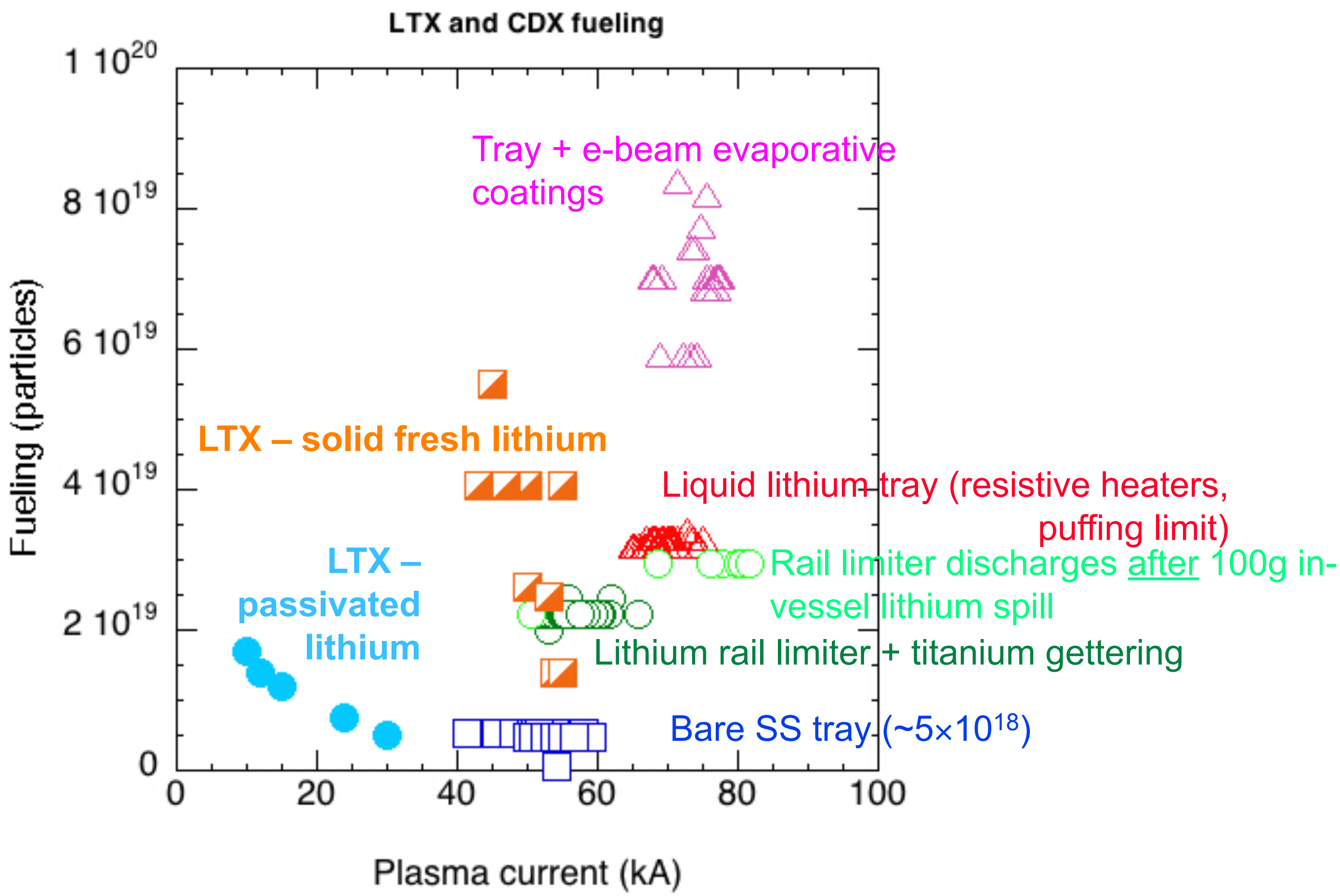


- This particular example is during SGI fueling.
- Resulting profile is hollow, with a peak ~11 cm below midplane.

LTX and CDX-U fueling comparison

- Fueling requirements for LTX are approaching CDX-U requirements for low recycling operation
  - LTX: similar shot duration
  - Lower plasma current, density

Total fueling
⇒including
prefill



Near term research program

- LTX is operating
- Continuing discharge development with thick bonded stainless steel/copper shells, and lithium wall coatings
  - Revisit hot wall experiments
    - » Better vacuum conditions, reduced helium fill for thicker, more localized coatings
  - Tests of lithium-filled dendritic tungsten limiter
    - » Poster by Matt Lucia on Thursday afternoon
- Move to operation with a liquid lithium pool in the lower shell
  - Electroformed tungsten filling system (Scott O'Dell and PPI) demonstrated (see Matt Lucia's poster)
  - Recycling characterization
- Electron temperature profile measurements
  - Core now, detailed edge profile later in 2012
- Confinement determination, as a function of global recycling