ALIST Liquid Surface Module and FY03 NSTX Research

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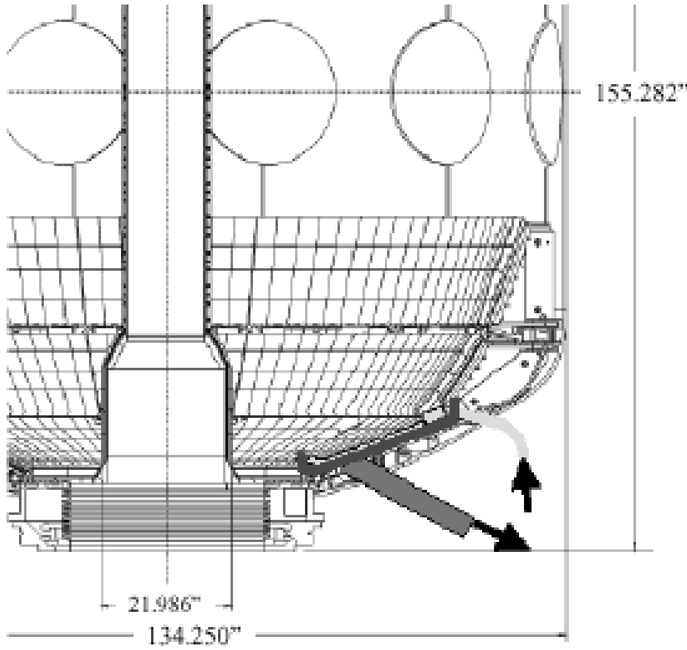
ALIST Liquid Surface Module (LSM) Concept

NSTX



Concept courtesy of B. Nelson of ORNL:

- Liquid surface module designed to remove 10^{23} particles/ shot
  - Can also help with power handling capability
- Lithium surface area ~ 1 m^2, 10 m/s flow velocity
- ≈3.3 m^2 outboard divertor means only ≈1/3 coverage may be needed

LSM Addresses NSTX Program Needs in Boundary Physics

NSTX

- Heat flux, particle influx scalings
- **Baseline Milestone:**

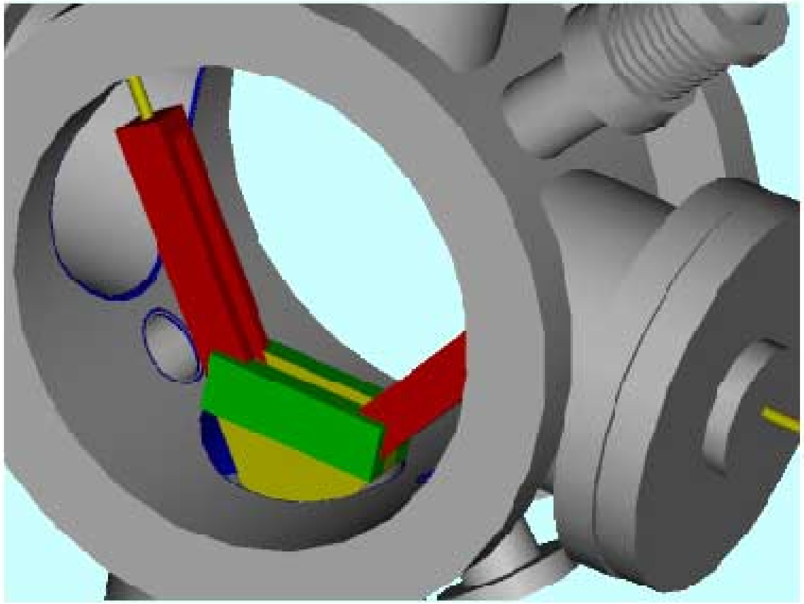
  1. Measure and analyze the dispersion of edge heat flux and assess the impact on plasma facing component requirements under high heating power in NSTX.
- - LSM offers potential solution to heat load in divertor
- Li pellets
- - LSM is logical “next step” in assessing lithium as PFC
- Particle control needs assessment
- - LSM for particle control based on known ability of lithium to reduce recycling

NSTX Advanced Power and Particle Handling Decision Point Occurs in FY03

- LSM accepted in Five Year Plan Ideas Forum as possible solution for particle control but work is needed in following areas.
  - Effectiveness for helium pumping (cf IPPA Goal 3.1.4.3).
  - Effect of ELM's on LSM.
  - MHD effects on liquid lithium
  - Requirements for major machine modifications.
- Results from NSTX and other experiments in FY03 contribute to decision point.
- ALIST resources contribute to analysis of NSTX experiments in FY03.

Non-NSTX Experiments Addressing LSM Issues

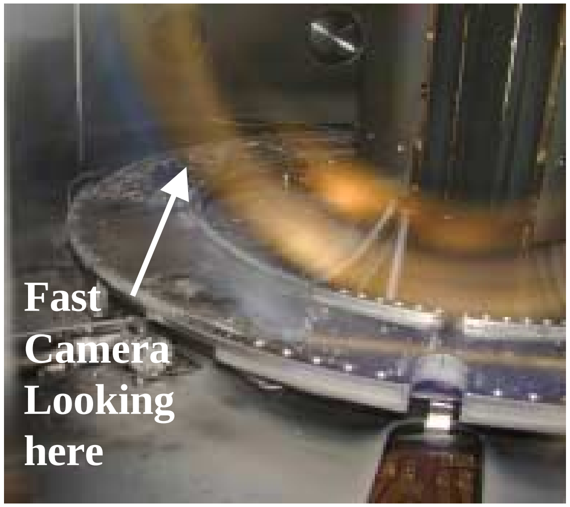
- Effectiveness for helium pumping: FLiRe at U. of Illinois and PISCES and UCSD



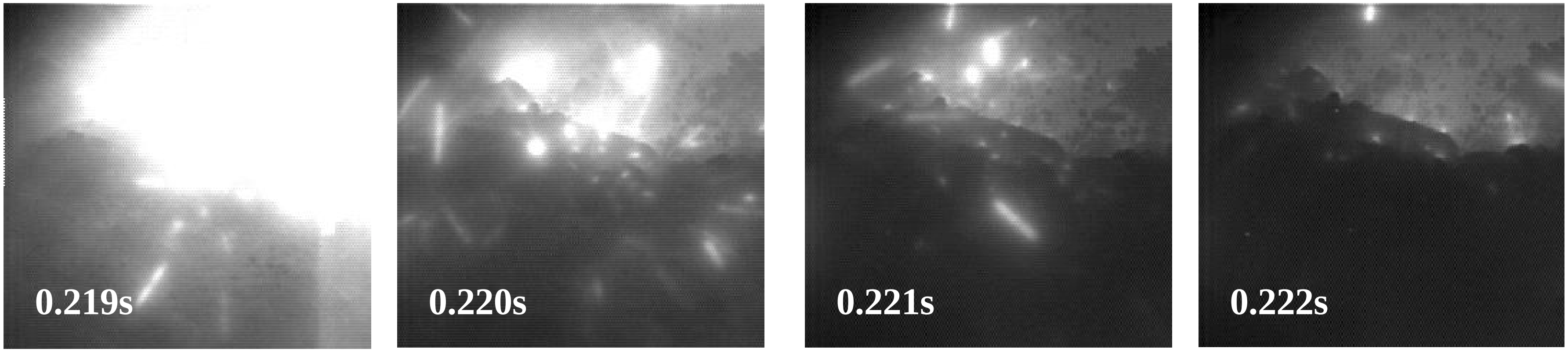
Layout of internal ramps with stainless steel bracket and inlet tubes in the upper vacuum chamber of FLIRE.

Non-NSTX Experiments Addressing LSM Issues

• Effect of ELM's on LSM: Simulated on CDX-U at PPPL

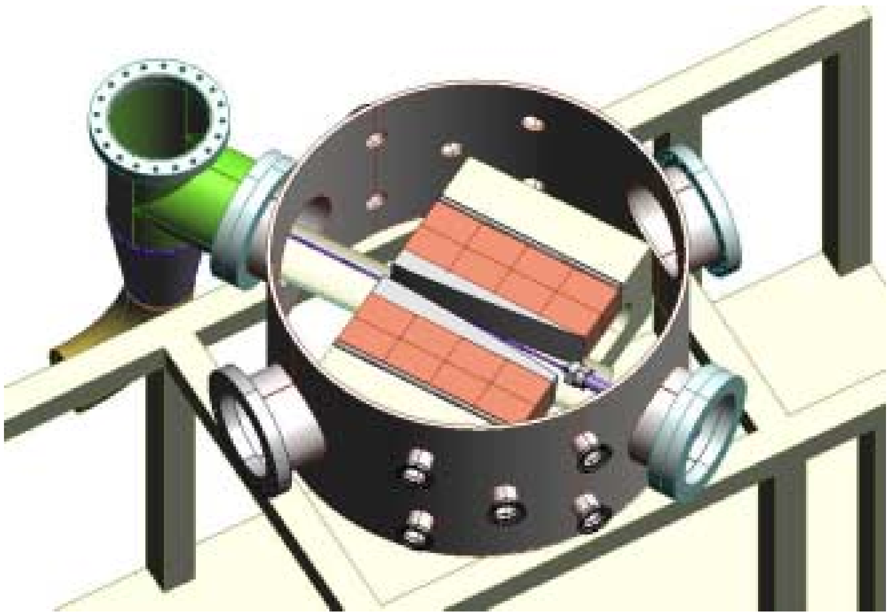


• Stills of plasma-lithium interactions in Li I light at 6708 Å; 1000 fps, 1/5000 s shutter speed
• Some evidence of macroscopic lithium ejection but plasmas did not disrupt



Non-NSTX Experiments Addressing LSM Issues

- MHD effects on liquid lithium: CDX-U at PPPL, LIMITS at SNL, and MTOR at UCLA



LIMITS

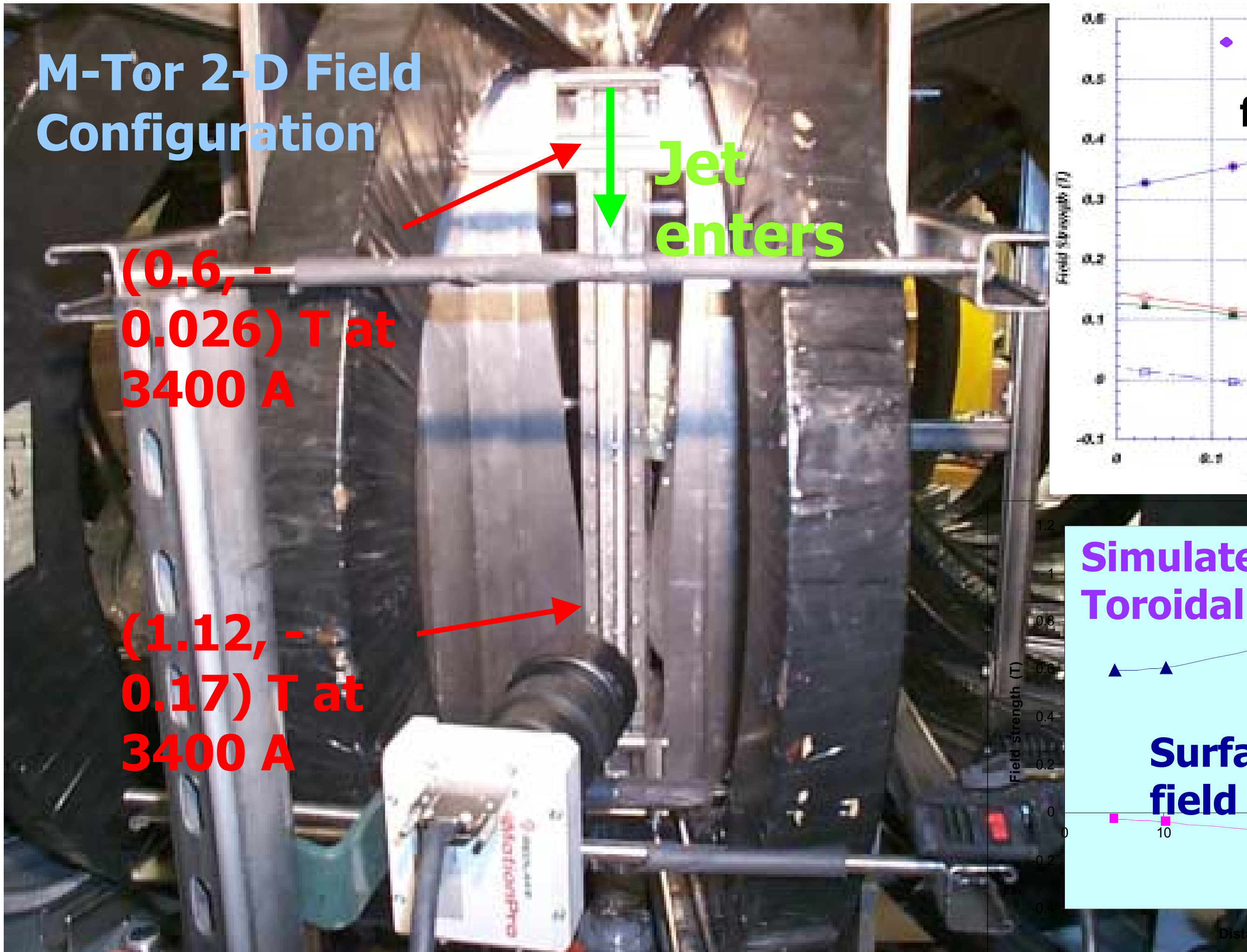
- Measure liquid lithium flow parameters with NSTX equivalent fields and gradients (deflection, shape changes, etc.)
- Test each of 5 magnetic field configurations

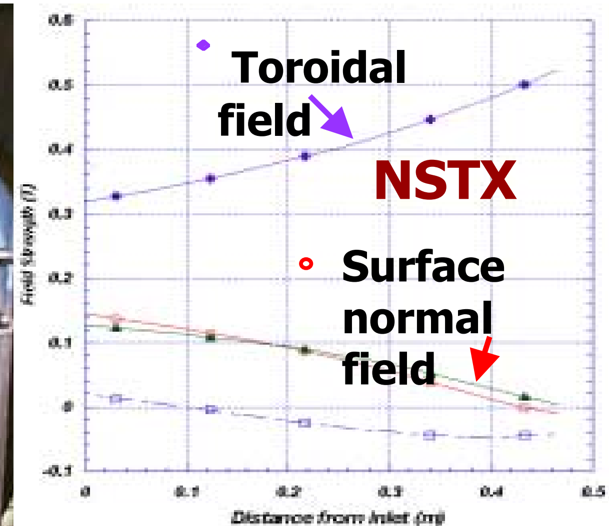
Non-NSTX Experiments Addressing LSM Issues

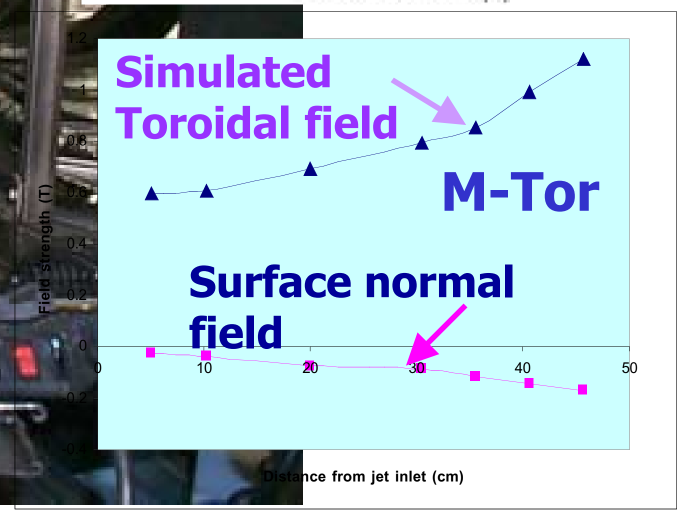
Initial LIMITS tests with water jet:

- 5 mm diameter jet 300 mm long (figure shows 200 mm)
- Flow velocity = 10 m/s
- Evidence of small flutes on surface
- No droplet formation or break-up
- High speed camera video (2000 fps) shows stream

Non-NSTX Experiments Addressing LSM Issues





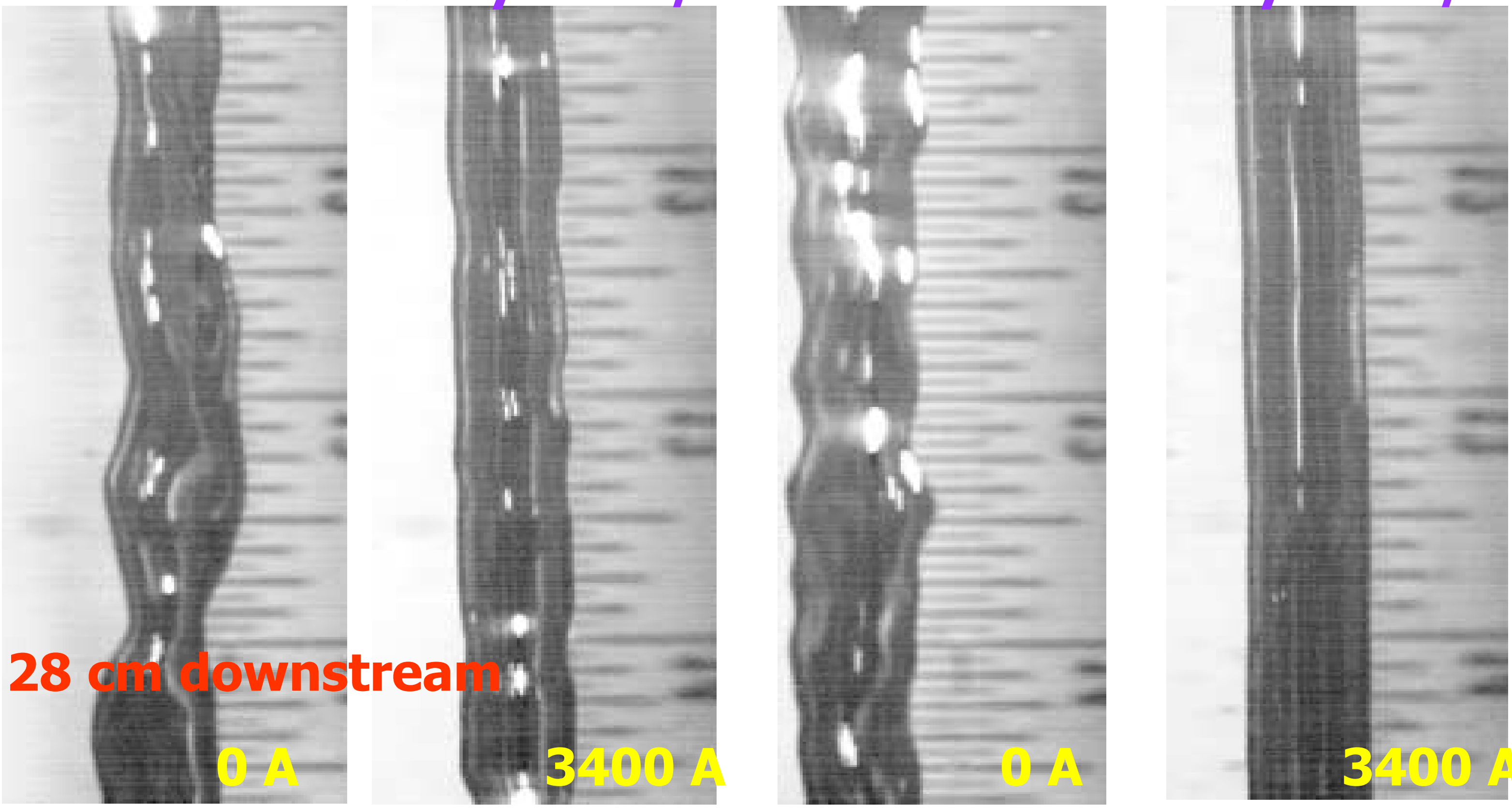


Non-NSTX Experiments Addressing LSM Issues

NSTX

NSTX like magnetic field strength has significantly stabilized GaInSn jet by suppressing velocity perturbations

Inlet velocity =3 m/s **Inlet velocity= 5 m/s**



LSM and FY03 NSTX Experiments

1) Lithium and Boron Injection for Particle Control

- ALIST to obtain data on effect of lithium on recycling in NSTX for LSM modeling.
- ALIST to support NSTX data analysis by providing UEDGE 2-D multi-fluid edge modeling (LANL).
  - Lithium contamination of core from NSTX module modeled by coupling UEDGE (LANL) and WBC impurity transport code (ANL)
  - Extend to analysis of core penetration dependence on injection velocity

LSM and FY03 NSTX Experiments

2) H-Mode Studies:

- Wall heat load (divertor heat load) measurements.
    - o Needed to check LSM fluid thickness and flow rate assumptions made to keep evaporation rates acceptable.
    - o Compare with UEDGE modeling (LANL).
- Extrapolations for long-pulse outboard divertor heat loads.
    - o Determine feasibility of LSM to “prototype” divertor as well as provide particle control.

LSM and FY03 NSTX Experiments

2) H-Mode Studies (continued):

- Recycling data for refining anticipated particle control needs.
    - ALIST modeling with UEDGE and WBC.
    - Note: Necessity for thermal shielding puts limitation on cryopumping.
- Estimate edge power deposition associated with ELM's.
    - Need IR camera data for divertor region.
    - HEIGHTS (ANL) high energy interaction modeling for vapor and shielding effects with UEDGE.
        - SOL energy deposition and currents evaluated for ITER: need to consider for NSTX.

LSM and FY03 NSTX Experiments

NSTX

3) XP: Resistive Wall Mode (RWM) Studies:

- Get data with new magnetic sensors for eddy current information.
    - Require measurements with magnetic sensor on UCSD fast reciprocating probe as well as new RWM detection coils.
- Determine effects of actual eddy currents on LSM.
    - Check against assumptions and predictions in LSM simulations at UCLA.
        - Model using ESC with ASTRA (UCSD) plasma and neutral transport code interface and liquid metal wall model.

Summary of LSM Relationship to NSTX Boundary Physics Research

Near-term (FY03):

- Modeling of LSM behavior improves understanding of edge plasma conditions

Long-term:

- Particle control: LSM predicted to reduce recycling significantly
- Power handling: LSM unique in combining particle and heat removal