NSTX

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"Enhancement to LLD Capability for Divertor Pumping to Control Edge Collisionality for the FY11 Joint Research Milestone"

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ARRA Projects Discussion
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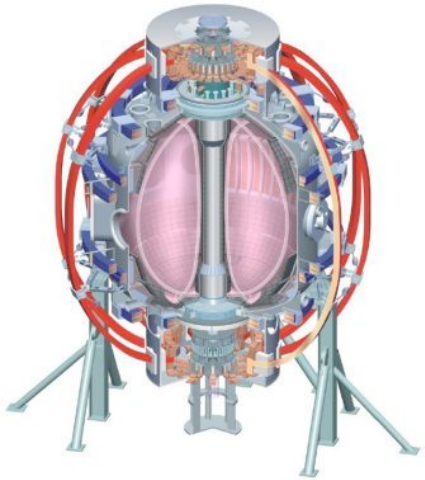

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An Enhancement of the LLD that Includes the Inner Divertor Needs to Resolve Existing Programmatic Concerns and Design Limitations

- PROGRAM: Outer Divertor was chosen for LLD-1 as the lowest risk location to XP's requiring high performance, high-δ discharges.

RADIUS & WIDTH	PROGRAM RISK LEVEL	Consequence
Inner-half, Inner Divertor	*Highest*	This is the high performance, high-δ region. If LLD malfunctions, stop the run, vent, and fix malfunction.
Outer-half, Inner Divertor	*Medium*	If LLD malfunctions could run inboard, but flux expansion would overlap LLD.
Inner-half, Outer Divertor	*Lowest*	If LLD malfunctions could run in high performance, high-δ region almost unchanged.

- DESIGN: To meet the program schedule, it was necessary to adopt readily available and affordable lithium handling technologies. This limits the LLD-1, (baseline case), to low fill rates, thin coverage, short pulses, and low powers (200-400 ms, 1-4 MW).

Enhancements to LLD Prior to LLD-1 Results

Candidate Enhancements

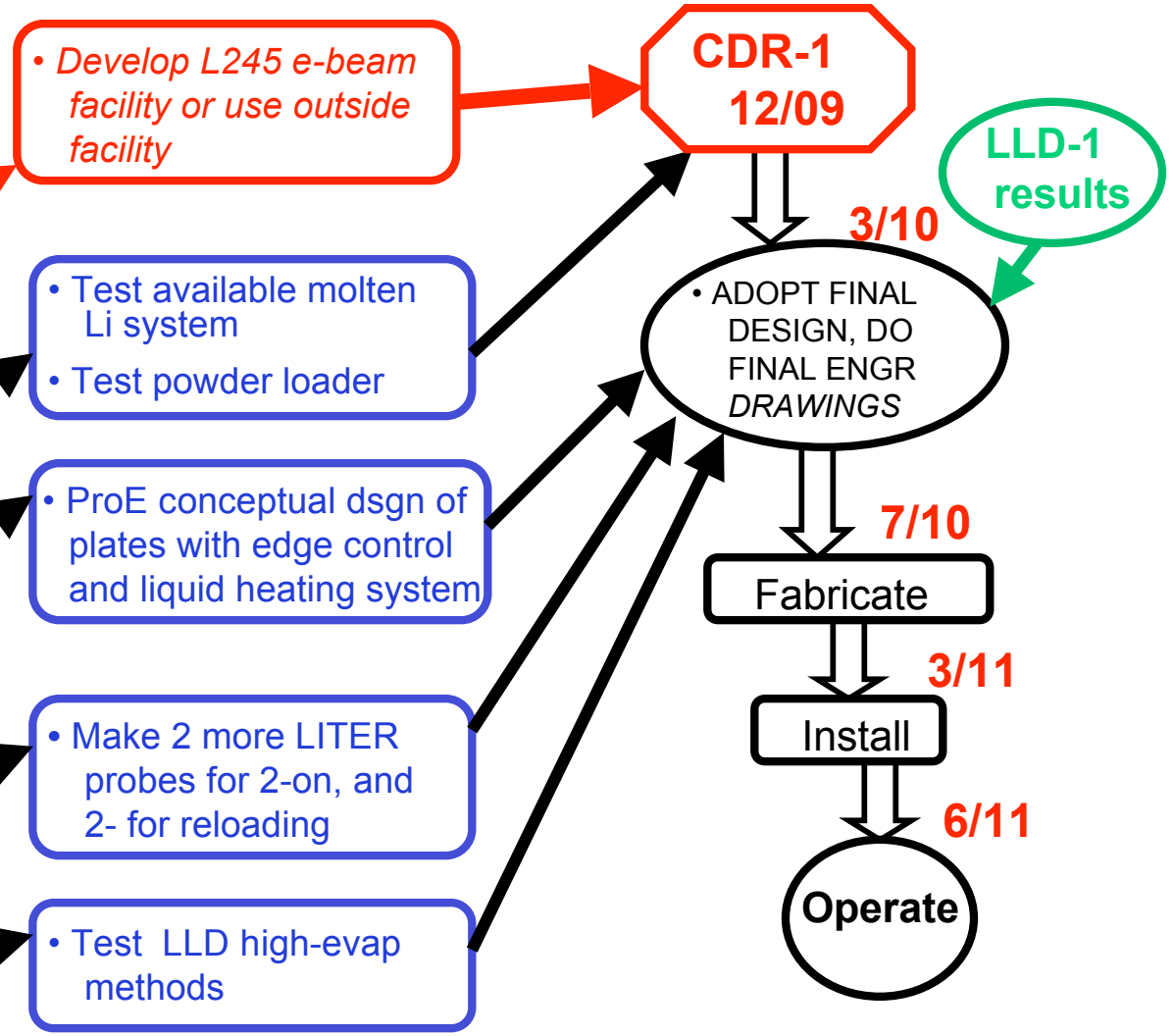
1) Characterize power density limits for long pulses: e-beam testing of a) LLD-1 samples, b) Other candidate surfaces.

2) Improve Li loading: test liquid and powder Li feed systems.

3) Design Inner Divertor LLD plates.

4) Increase LITER reloading capability from 2 to 4 probes.

5) Develop global Li coverage: coat all exposed graphite/metal.



Enhancement-1: Characterize Power Density Limits for Long Pulses via e-beam Testing of LLD-1 Samples, and Candidate Surfaces

- Existing LLD-1 power-handling information is based on PPPL and SNL simulations. Benchmarking these simulations to remove uncertainties involving heat transfer coefficients (Li/Mo, Li/SS, Mo/SS, SS/Cu) and 3D effects would allow for enhancement and operation planning.
- Experimental e-beam studies were intended but never performed.
- The L-245 e-beam facility is complete. This option requires NSTX labor support, plus $2K for M&S.
- An e-beam facility at UIUC is a possible alternative facility. This option is less flexible. It requires moving personnel, IR camera, IR window and other equipment to UIUC for scheduled experiments.
- *e-beam testing is a critical path need for planning:*
  - *FY 10 XPs*
  - *FY10 LLD-1 operations*
  - *Achieving an Inner Divertor LLD concept and specifications*
  - *Next-step enhancements*

Enhancement-2: Improve Lithium Loading- Test Liquid Lithium and Lithium Powder Feed Systems

- A prototype Molten Liquid Lithium Extractor has been fabricated and is in the queue for testing after present work is completed.
- Lithium powder dropping will be tested after other LLD work is completed.
- *Testing Liquid Lithium and Lithium Powder Feed Systems is needed to determine how an Inner Divertor or improved Outer Divertor LLD design needs be changed to accommodate the selected system(s).*
  - A capillary liquid lithium fill system would enter at one spatial location, and exit at one spatial location, and depend on stable wetting behavior to transport Li from input to output.
  - A high capacity evaporator and/or powder fill system would need special equipment installed elsewhere on the vessel but would make a plate design simpler.

Enhancement-3: Design Inner Divertor LLD Plates

- To be acceptable to the NSTX program, a design for Inner Divertor LLD plates requires:
  - 1-2 sec, power handling capability for +6MW NBI (+RF?, + upgrade?)
  - High lithium fill rates with adequate area and depth coverage
  - If the LLD can be operated $\leq$ 350°C, a fluid heating system would be a simpler design than an electrical heating system.
  - Recoverable following vents
- *e-beam testing is a critical path need for planning:*
  - *Achieving an Inner Divertor LLD concept and specifications*
- *Testing Liquid Lithium and Lithium Powder Feed Systems is needed to determine how an Inner Divertor or improved Outer Divertor LLD design needs be changed to accommodate the selected system(s).*
- *Experienced testing and design engineering support to do this work has not been available.*

Enhancement-4: Increase LITER Reloading Capability From 2 to 4 Probes

- An Work Authorization Form (WAF) has been drafted for ARRA funding of:
- Two additional LITER probe systems for:
  - 2 on the vessel, and 2 off the vessel for reloading
  - 2 additional LITER support stands
  - 2 pumpcarts
- Work to be completed by ~3/10

Enhancement-5: Develop Global Lithium Coverage: Coat All Exposed Graphite and Metal

- For NSTX to reach the theoretical limit of recycling (~0.15) and achieve near-maximum possible impurity control is would be useful to have the capability to lithium coat all plasma facing graphite and metal.
- A simple high rate evaporating system for global coverage is required.
- A candidate high rate lithium evaporating system for CS, upper divertor, passive plate, and outer wall coverage would use LITER, or LITER-U, and LLD:
  - Re-evaporating lithium coatings from the LLD requires:
    - a fast Li fill system or faster LITER reloading
    - not stressing LLD heater system (<400°C)

Schedule and Costs

- Enhancements to LLD-1 have been identified
  1) Characterize power density limits for using e-beam testing
  2) Improve Li loading: test liquid and powder Li feed systems.
  3) Design Inner Divertor LLD plates.
  4) Increase LITER reloading capability from 2 to 4 probes.
  5) Develop global Li coverage: coat all exposed graphite/metal.

- Some tasks can be completed or initiated with existing Li R&D support. Rate of progress will depend on available support. Detailed Job Estimates have not been completed.