NSTX Liquid Lithium Divertor
Basic Scope of Sandia Effort

presentation at Princeton Plasma Physics Laboratory
on 27 February 2007

to the

NSTX TEAM

Richard E. Nygren

Manager Fusion Technology, Sandia Dept. 01658

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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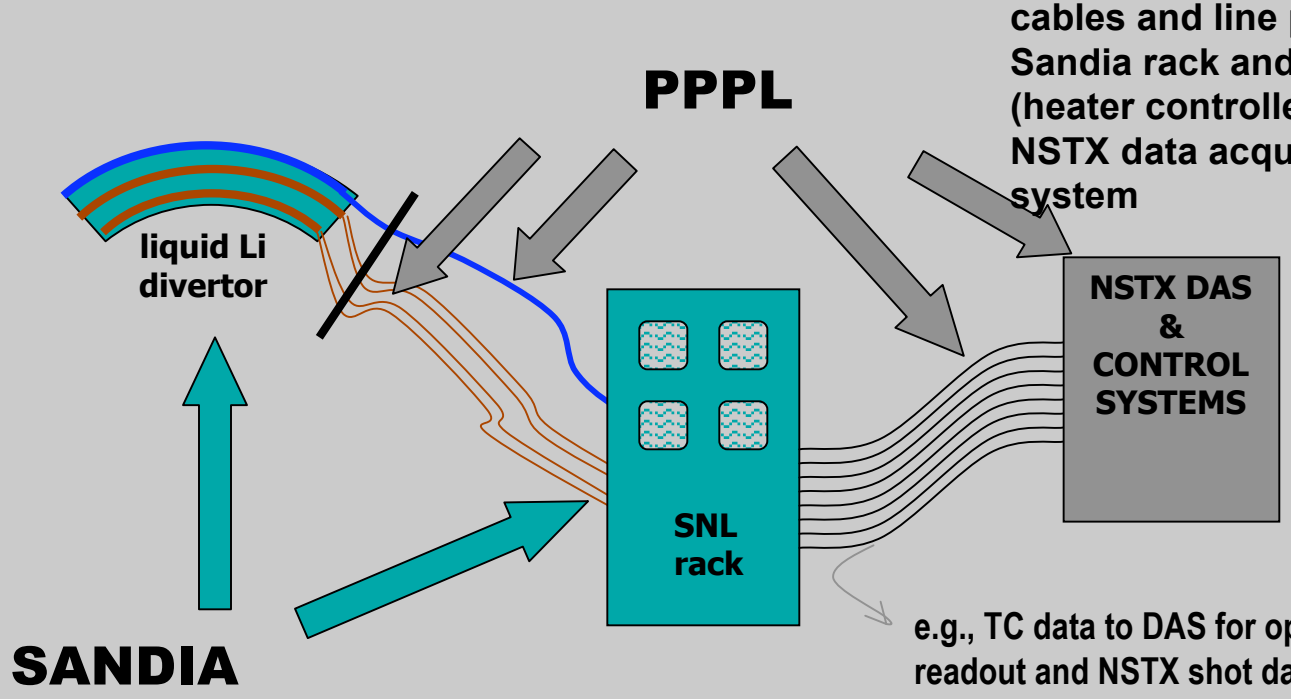
Introduction - Responsibilities

PPPL will provide:

- assistance in defining hardware interfaces
- labor during installation of the Li divertor
- feedthroughs and cabling
- visual, spectroscopic & IR views of LLD



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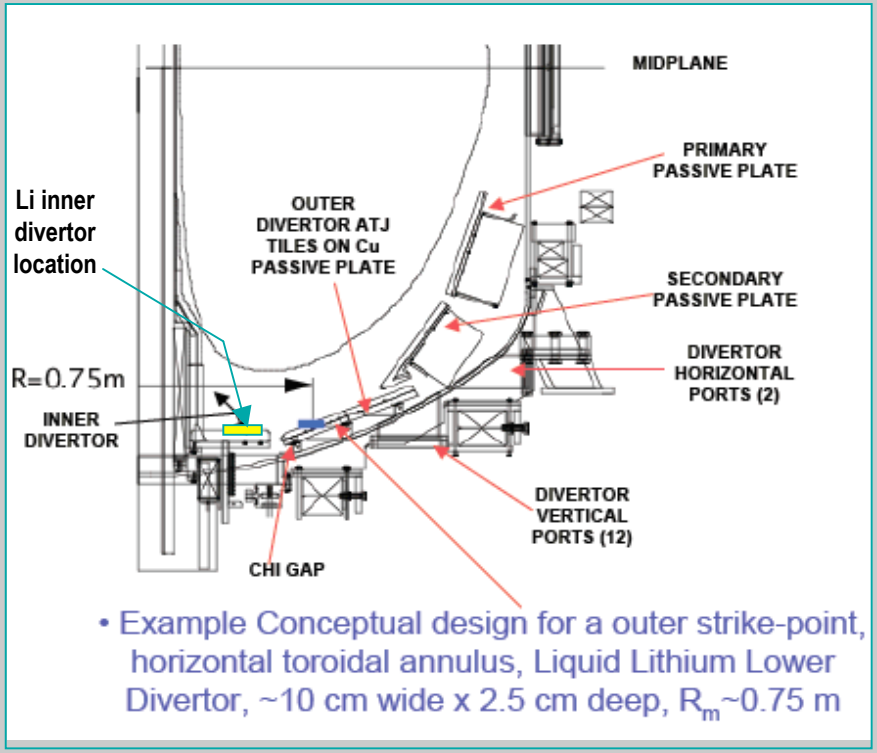
Issues

Sandia proposes a four-segment Li target and related hardware for NSTX (single null plasma) and replacements if the location is at the inner divertor.

Some Issues:

- LLD location/width, segments (2,4)
- port access for leads
- slant/level/armor (if outer divertor)
- heating system, long lead items
- schedule for tasks/vent
- Sandia structure/personnel
- burn-through failure
- diagnostics (data/control/safety)
- gas cooling



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LLD Shape

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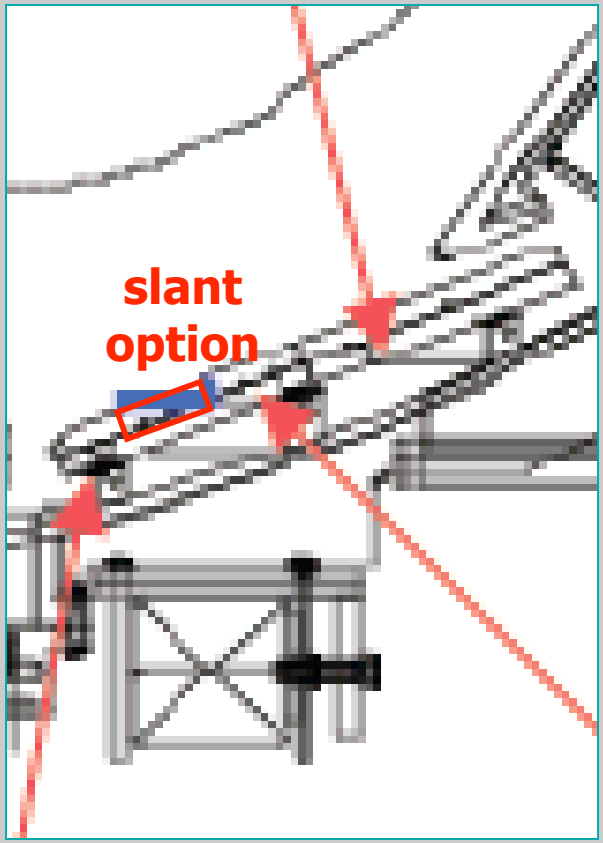

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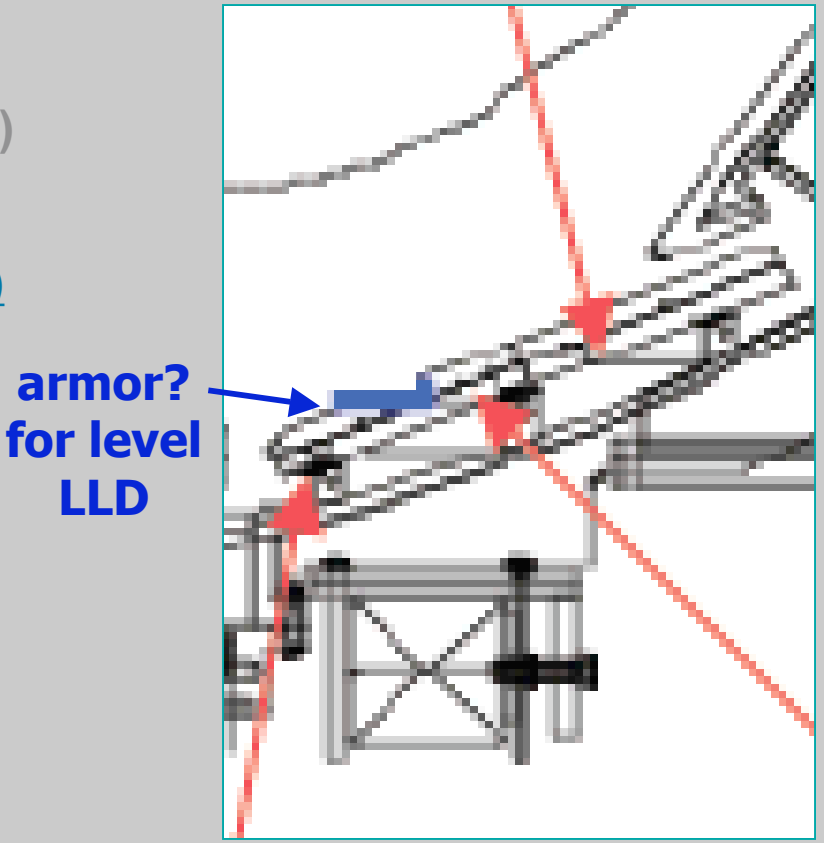

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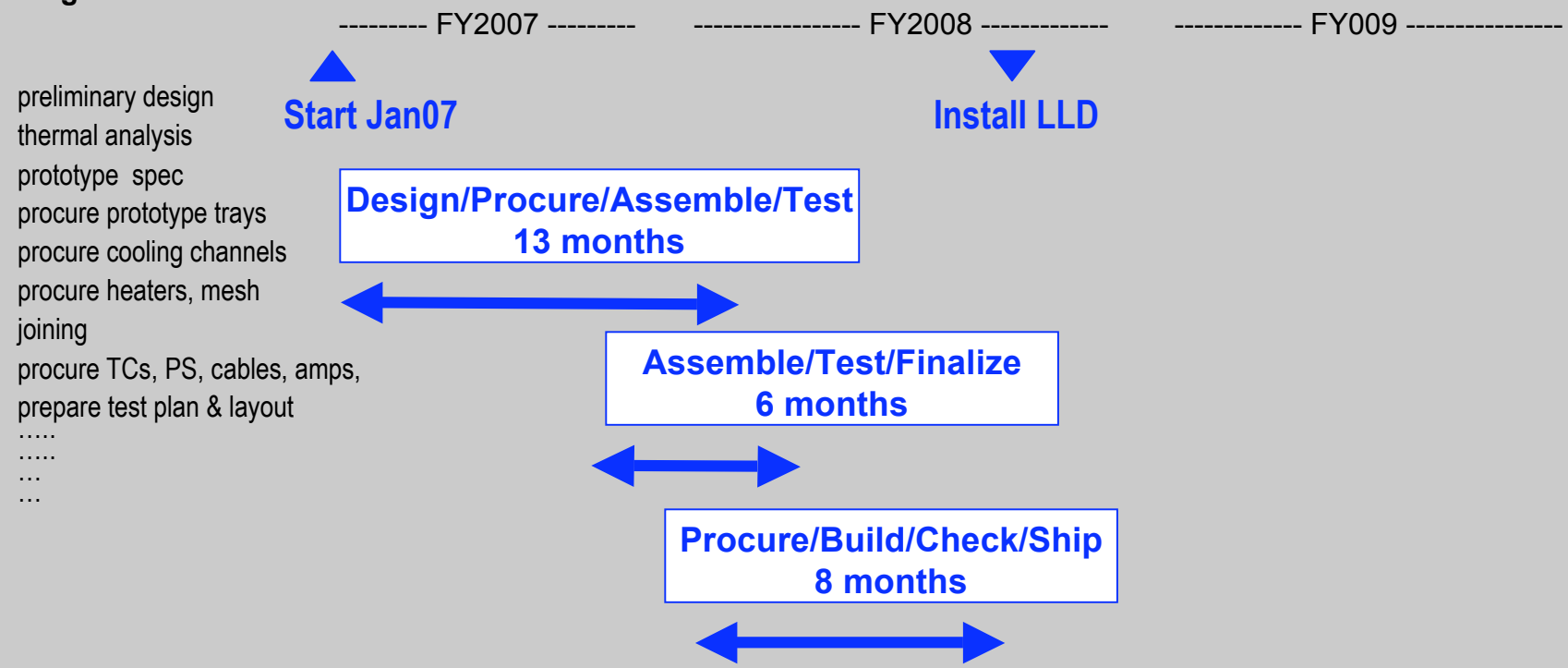
Schedule

Rough Draft Schedule



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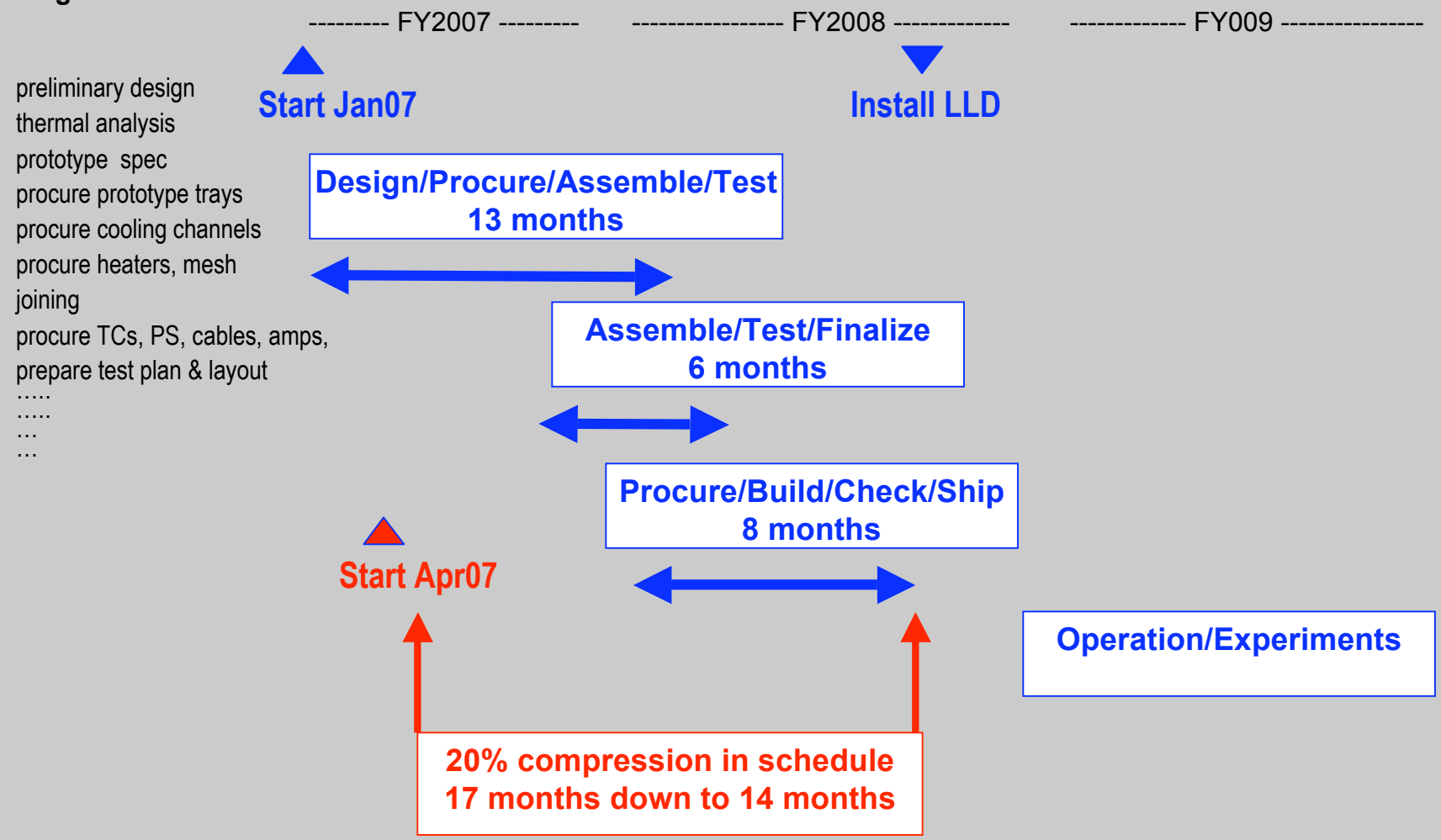

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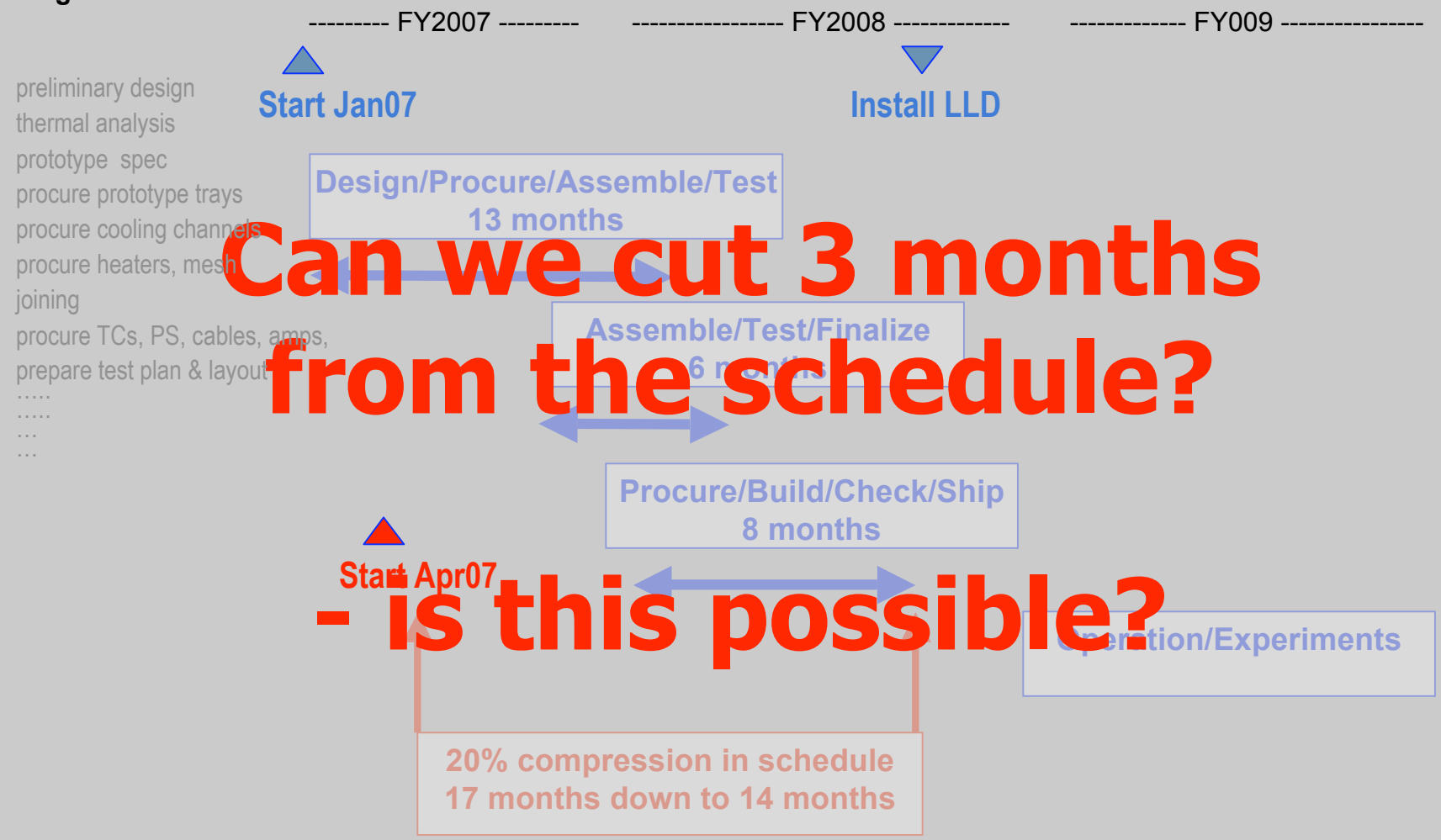

Can we cut 3 months from the schedule?

- is this possible?

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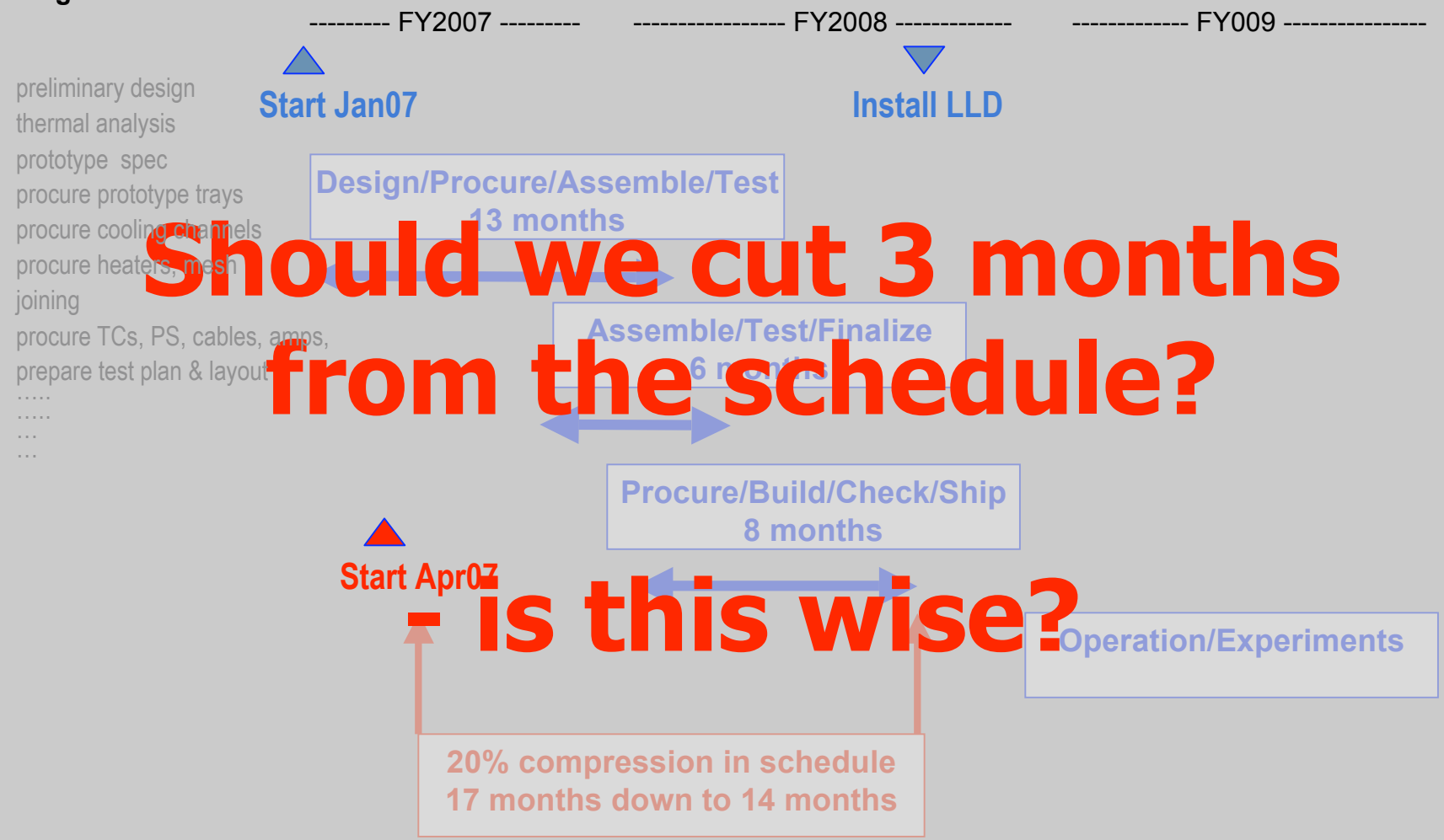

Should we cut 3 months from the schedule? - is this wise?

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Sandia Project Structure & Personnel

Fusion Technology
Sandia Dept 01658
RE Nygren, mgr

Mike Ulrickson	(ITER)
Tina Tanaka	(ITER +)
Dennis Youchison	(ITER +)
Tom Lutz	(diagnostics,LM)
Jimmie McDonald	(testing/facility
Fred Bauer	(tech/LIMITs)
Ken Troncosa	(tech/LIMITs)
Jim Bullock, Orion	(CAD, designer)

+ others

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Fusion Technology
Sandia Dept **01658**
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Pulsed Power
Center 01600

EM analysts	(ITER)
Thermal analysts	(ITER)
Stress analysts	(ITER)
Operator/tech	(ITER)

Nygren	(PI,LLD)
Tech	(LLD)
Designer	(LLD)

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Burn Through Failure of LLD

Is divertor armor needed under LLD to stop burn-thru failure mode?

Failure modes will need to be addressed for NSTX for the following:

- **Failure Modes and Effects Analysis (FMEA)**
- **Safety Assessment Document (SAD)**
- **Safety Review Committee (SRC)**
- **Activity Certification Committee (ACC)**

per Henry's presentation

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I do not yet understand all this.

per Henry's presentation

Sandia will work with the NSTX Team to satisfy design requirements.

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per Henry's presentation

Sandia will work with the NSTX Team to satisfy design requirements.

- **The design will prevent overheating of the ends and sides of the Li containers by shaping of the mesh that holds the Li.**
- **Three features will mitigate against burnout due to loss of Li.**
  1. **substantial volume of Li in "deep"mesh**
  2. **capillary replenishment of the heated surface**
  3. **heaters embedded in mesh mean the container is cooler**

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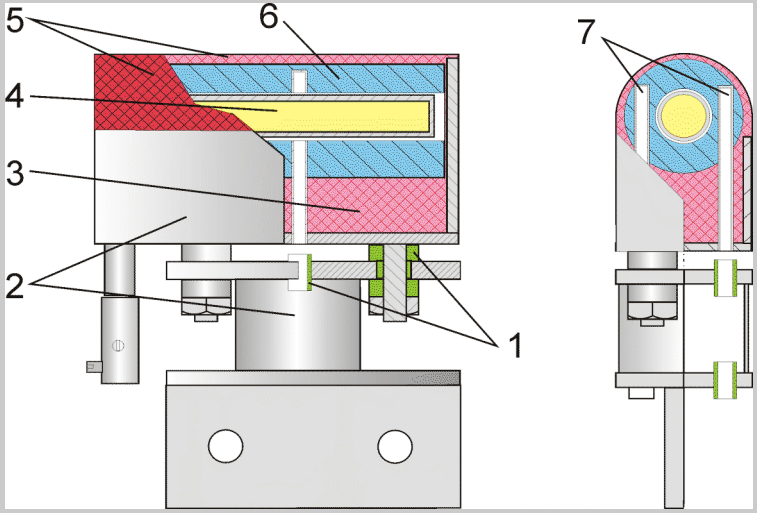
Basic Design Concept

- **Mesh holds Li surface.**

  This is based on Russian experience with various experiments on capillary systems and limiters in T-10 and in FTU as well as experience with the initial Li limiter in CDX-U.

- **Mesh can hold Li even during disruptions.**

  This is based on FTU experience published in SOFT and PSI and also presented in seminars here at PPPL.



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Basic Design Concept

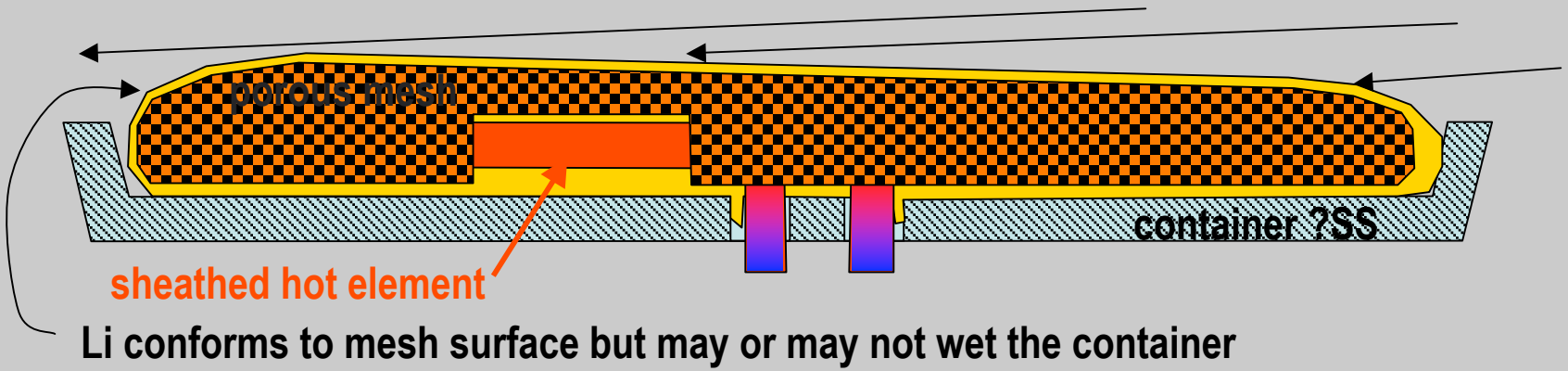
- **Proposed Sandia design includes the following features:**

  - **Shaped 3-D mesh - "proud" Li surface rises above container**
  - **Shaped 3-D mesh - deep mesh capture large Li volume**
  - **Embedded heaters – heat mesh and Li directly**

- **We have worked with a small business (Ultramet in CA) who produces porous meshes of refractory metals.**
- **We have tested W meshes for helium-cooled heat sinks.**
- **They also make various mesh products for bone implants, etc.**

Basic Design Concept

- Mesh holds Li surface above container to reduce heat at the sides.
- "Tiling" of LLD sections reduces heating at the ends.
- Embedded heaters in "deep" mesh improve thermal control because mesh and Li are heated directly. Container can be cooler.



Li conforms to mesh surface but may or may not wet the container

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Basic Design Concept

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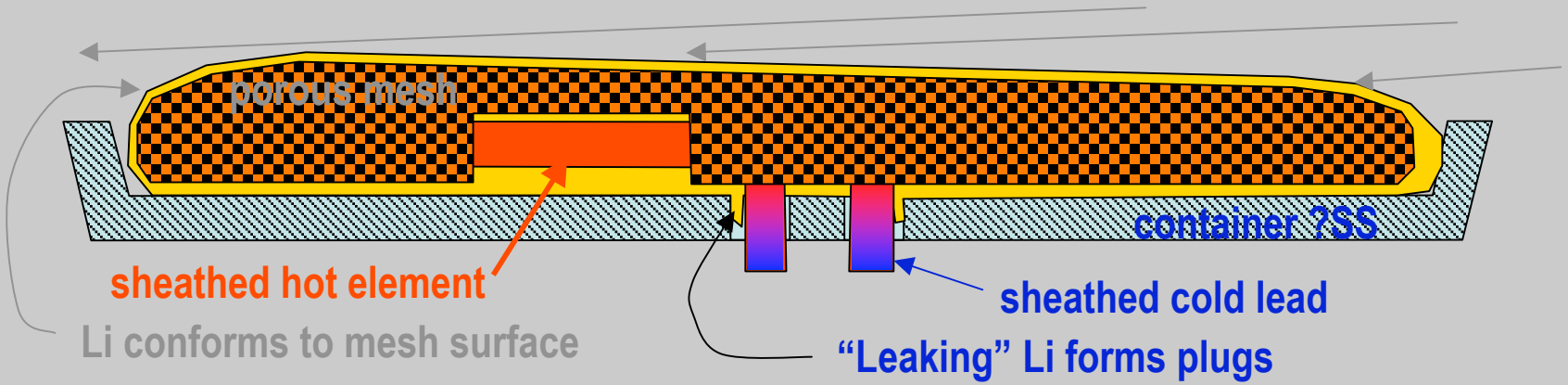

- **Embedded heaters in "deep" mesh improve thermal control because mesh and Li are heated directly. Container can be cooler.**
- **Sheathed heater contains both element and unheated leads.**

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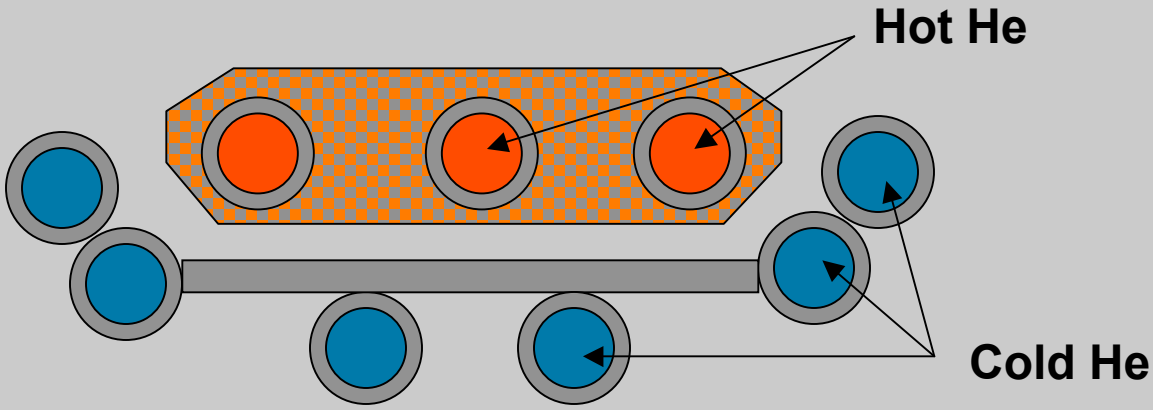
Gas Cooling

- **Sandia proposes to study gas heating and cooling with He of a LLD as a forward-looking application for steady state heat removal and thermal control for NHTX.**
- **This will utilize an upgrade to out He loop anticipated in 2008.**



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Conclusion

- **Sandia** has supported R&D on the applications of liquid metal surfaces for fusion through the ALPS and APEX Programs and their collaboration with CDXU.
- **Sandia** is excited about the opportunity to participate with the NSTX Team in this collaboration.
- We all what to make the LLD successful.

Thank you

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Introduction – last visit

Li target and related hardware for NSTX (single null, strike point TBD)
Important considerations:

- **Li inner divertor location (assumed) – still TBD**
- **heating system for the Li container(s) – ongoing design**
- **distribution/wetting of the surfaces by Li – basic demonstration**
- **mitigation as necessary of the spread of Li – good concept**
- **thermal management of Li and container(s) – good concept**
- **diagnostics for control, safe operation and experimental data - given**
- **design has electrical heaters & Li fill at startup - given**
- **UCSD (contractor) will provide a Li fill system. Sandia proposes a four segment LLD with replacements if LLD is at the inner divertor.**
- **GDC cleaning may be needed; excessive contamination will require removing the LLD. - given**