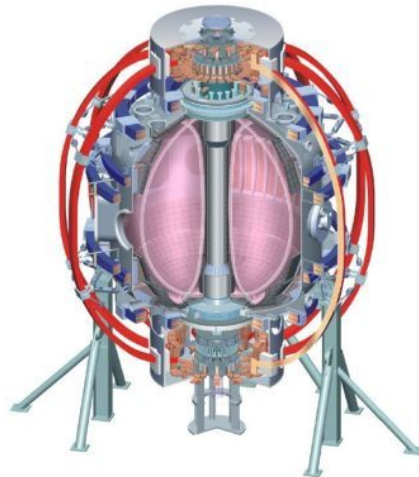


Liquid Lithium Divertor (LLD) Initial Inspection Following 2010 Experimental Campaign

H. W. Kugel / M. Ono

Jan. 10, 2011

*College W&M
 Colorado Sch Mines
 Columbia U
 CompX
 General Atomics
 INEL
 Johns Hopkins U
 LANL
 LLNL
 Lodestar
 MIT
 Nova Photonics
 New York U
 Old Dominion U
 ORNL
 PPPL
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 U Wisconsin*



*Culham Sci Ctr
 U St. Andrews
 York U
 Chubu U
 Fukui U
 Hiroshima U
 Hyogo U
 Kyoto U
 Kyushu U
 Kyushu Tokai U
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 Niigata U
 U Tokyo
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 Hebrew U
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 TRINITY
 KBSI
 KAIST
 POSTECH
 ASIPP
 ENEA, Frascati
 CEA, Cadarache
 IPP, Jülich
 IPP, Garching
 ASCR, Czech Rep
 U Quebec*

Liquid lithium divertor target system commissioned and utilized for particle pumping in four XPs

Unique capability in world program

- Only diverted H-mode experiment testing liquid Li

4 LLD plates form ~20 cm wide annulus in lower outboard divertor

- Heatable surface of porous molybdenum
- Loaded with lithium by LITER deposition

Liquid Lithium Divertor (LLD) Operated

Biased Electrodes

3x33 Langmuir Probe Array



IAEA: H.W. Kugel

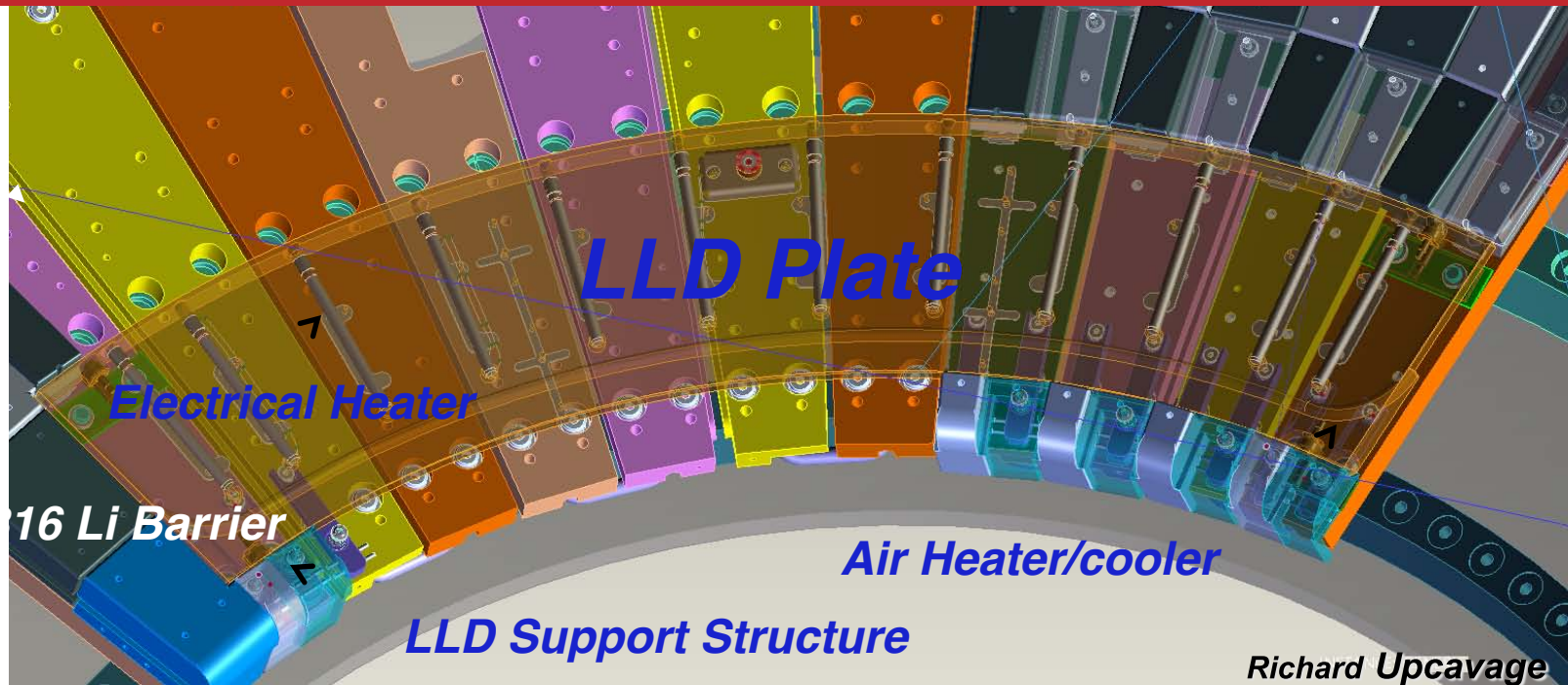
- During the 2010 experimental campaign, four different LLD specific experiments were performed as the net lithium deposition on the LLD increased.

- At the end of the 2010 experimental campaign, the total 1347 g lithium deposition resulted in a total estimated LLD lithium deposition of 67 g, or twice that needed to fill the LLD porosity.

- Plasma is found to be an effective way of heating the LLD surface to above the lithium melting point of 180°C.

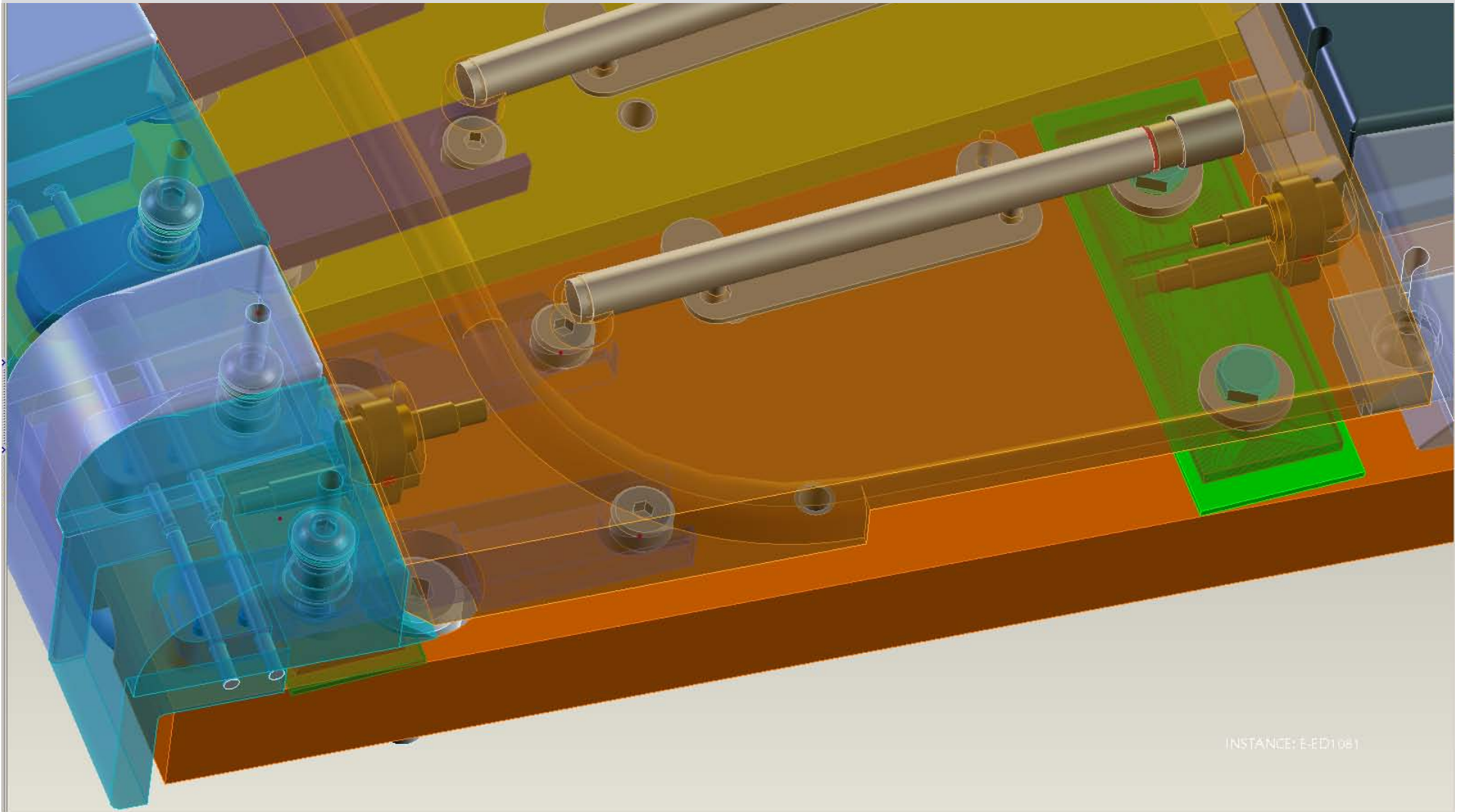
- No sign of moly impurity influx observed.

Liquid Lithium Divertor (LLD) with Porous Molybdenum Face to Hold Lithium

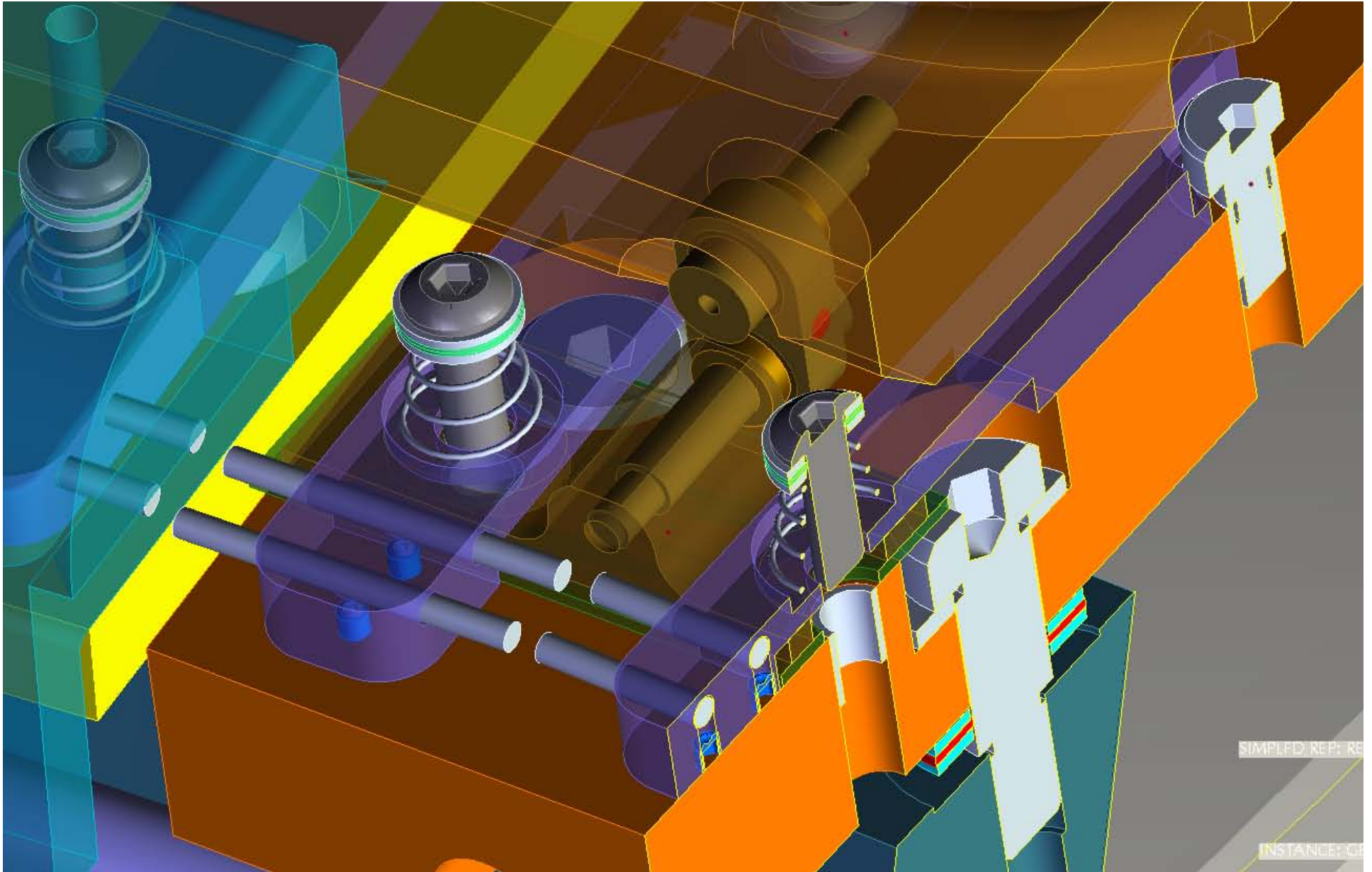


- 0.165 mm Mo plasma sprayed with 45% porosity on a 0.25 mm SS barrier brazed to 22.2 mm Cu.

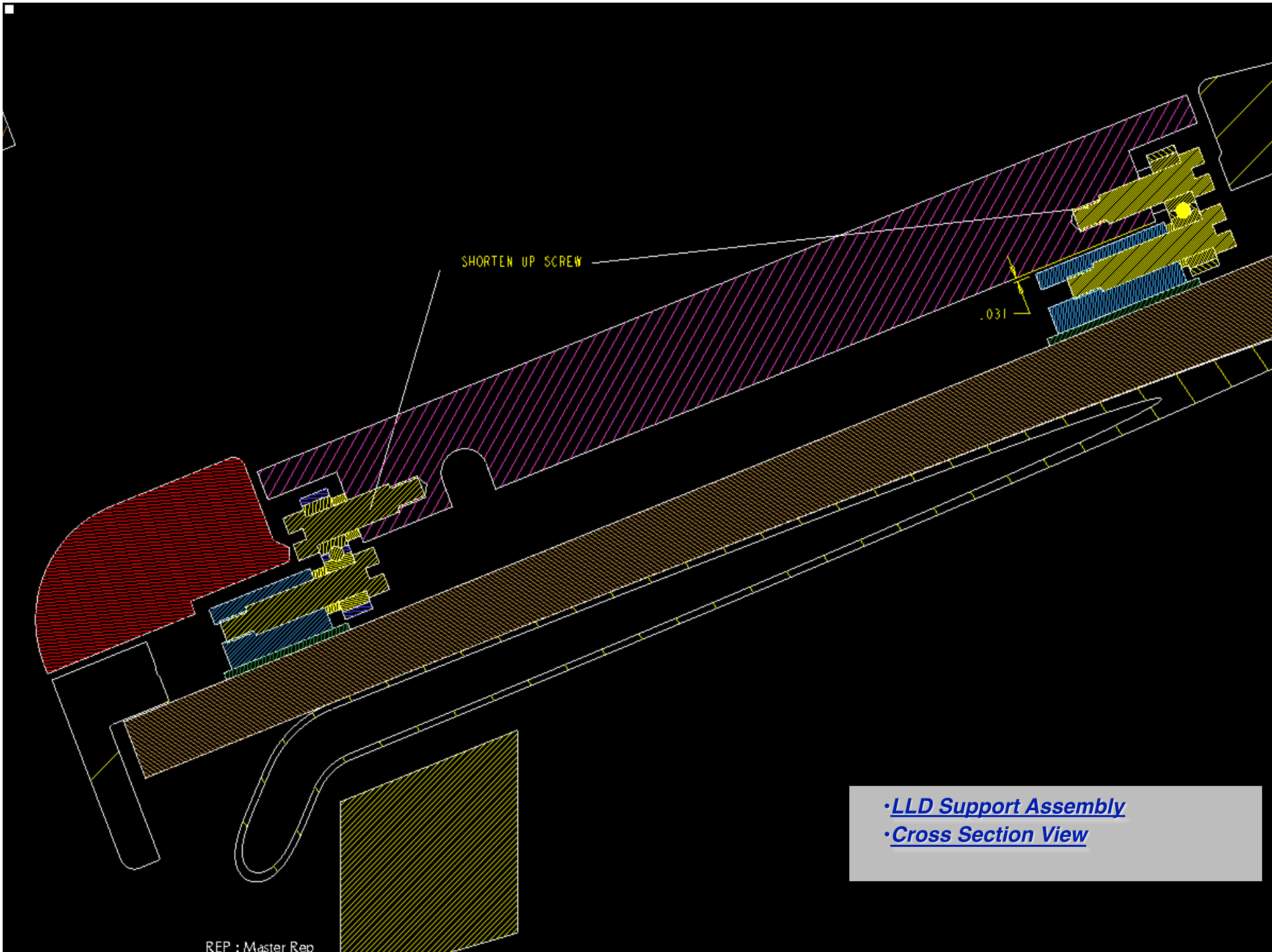
- 4 heated plates (80° each) separated by graphite diagnostic tiles.
- Each toroidal section electrically grounded to vessel at one mid-segment location to control eddy currents.



•LLD Assembly



•Front LLD Support Assembly w/o Tile



SHORTEN UP SCREW

.031

• [LLD Support Assembly](#)
• [Cross Section View](#)

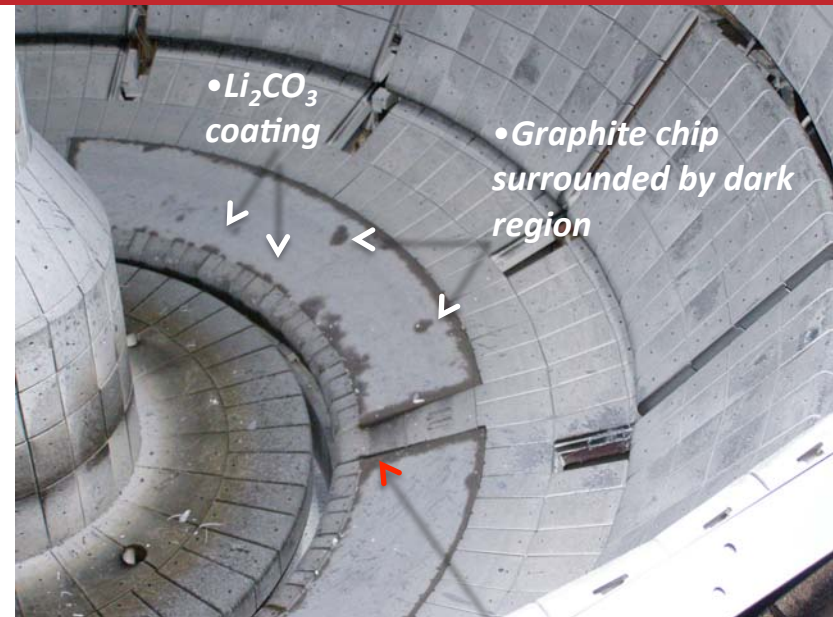
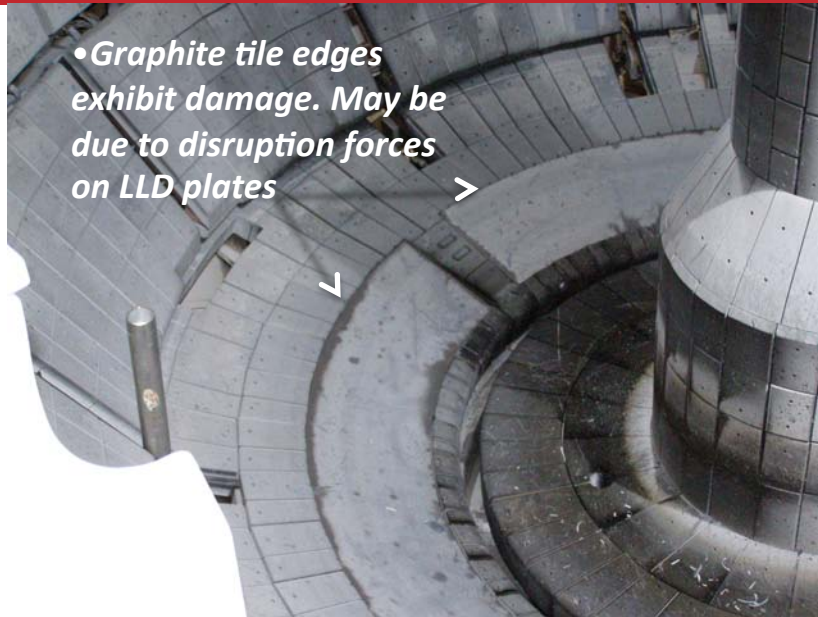
Photo of NSTX Interior Following 1.347 kg Lithium Deposition Applied During 2010 Experimental Campaign Indicates Extensive Lithium Coverage Due to Direct Evaporation and Plasma Transport



• Li_2CO_3 coating from conversion of Li and LiOH during air vent

• LL Porosity holds 37 g Li.
• Estimated LITER Li deposition on LLD is 67g

Photos of LLD Before Entry



• **Dark regions along most LLD edges are depleted of surface lithium and exhibit evidence of sputtered graphite from plate to graphite tile (vessel-ground) arcing.**

LLD Plate and Edge Graphite Tiles After 2010 Campaign With 1.347 Kg Li Deposition Over Lower Divertor



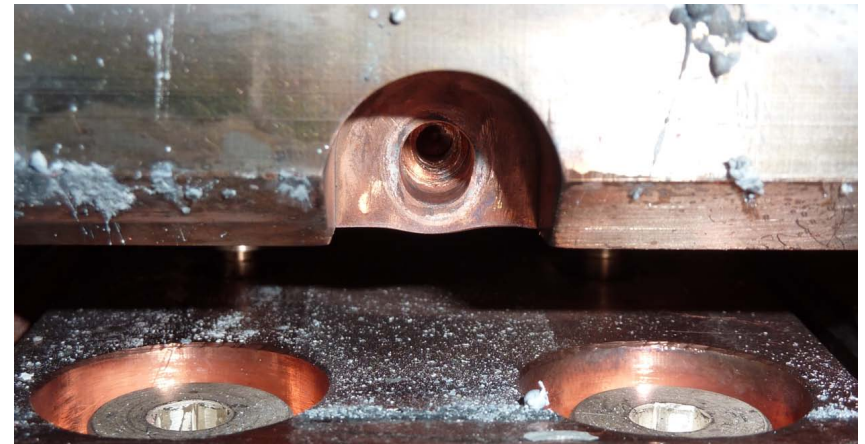
Post-run LLD Inspection Showed Issues

Liquid lithium overflow, disruption related damages

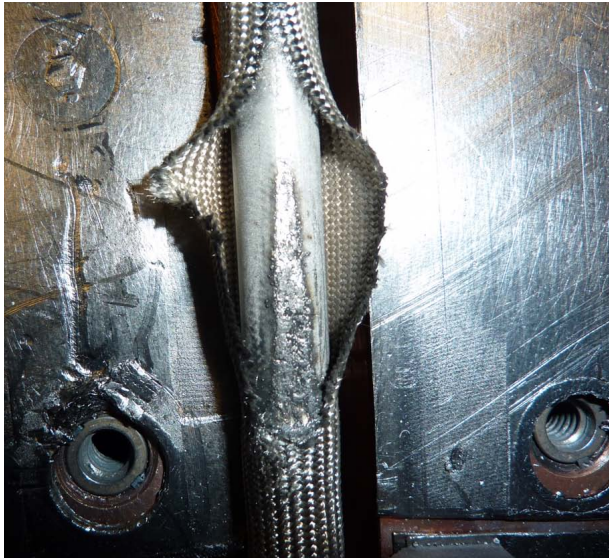
Liquid lithium overflow evident



LLD support hole elongated due to excessive stress



Arc damage in LLD heating tubes



LLD plate support structural damage



LLD Inboard edge with Bull Nose Tiles Removed Liquid Lithium Over-flow Evident



Bull Nose Tile and Inner Edge Support Bolting



Support hole into LLD elongated due to excessive stress



LLD Plate Support Bolt View (showing pulled out SS insert and copper material)



Cracked Row-3 Tile

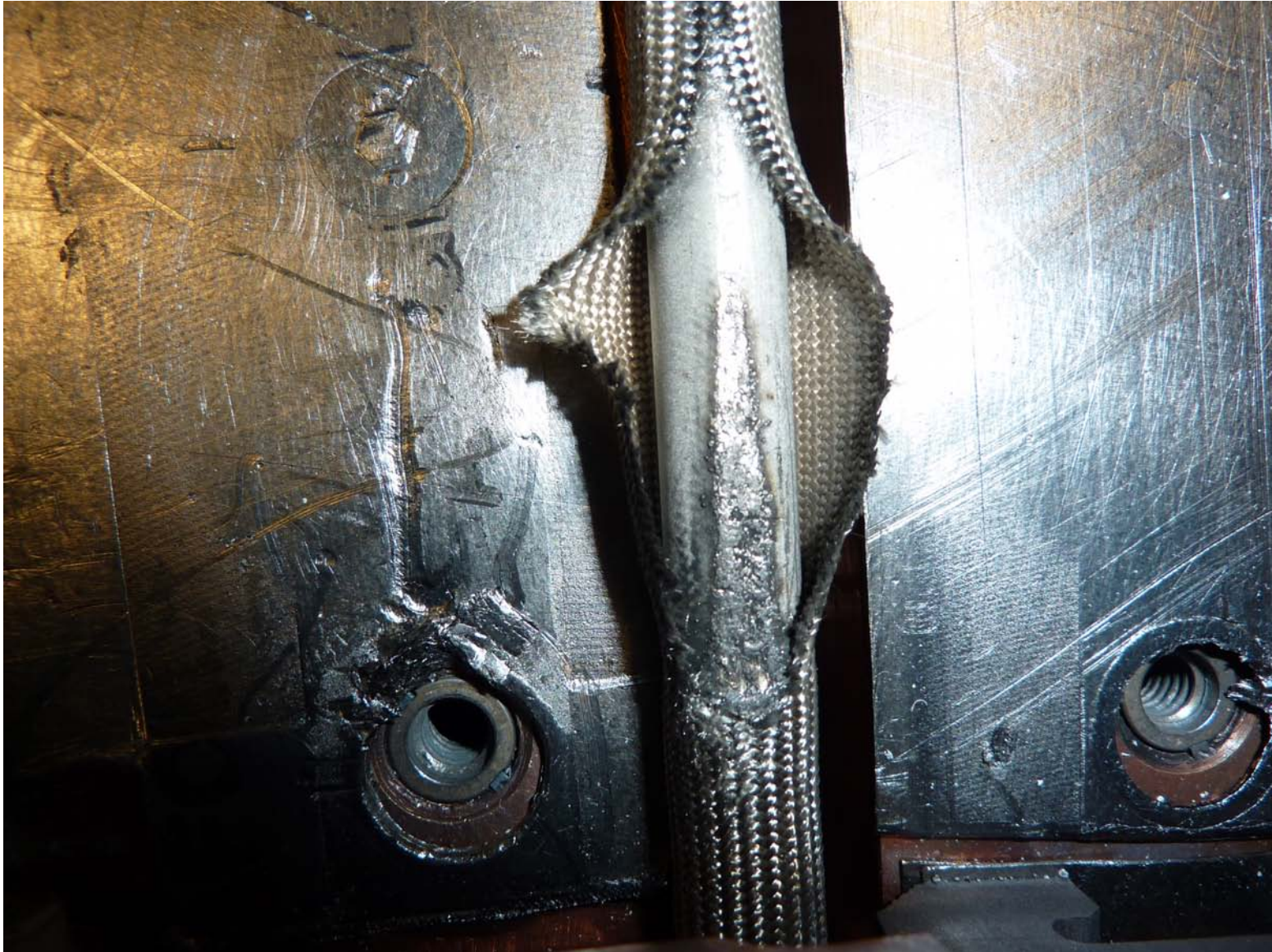


Lithium Beads Under LLD

Another evidence of liquid lithium over-flow



Abrasion and Arcing to Gas Cooling/heating Tube Considerable tube material erosion observed



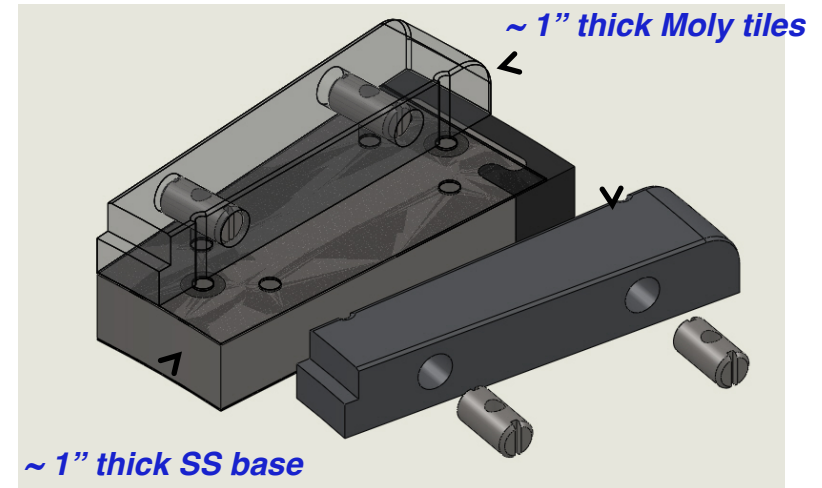
In-board Moly Divertor Tiles Pursued ***Robustly designed against disruption/thermal forces***



Molybdenum tiles on inboard divertor

- Facilitate high δ high performance discharges
- Reduce carbon influx
- Facilitate CHI to provide metal cathode surface
- Provide liquid lithium moly pumping surfaces

New moly tiles



Engineering effort ramped up

- Moly plate material secured (MIT)
- FDR scheduled on Jan 14
- Fabrication and installation schedule being formulated – quite tight
- Consult FES for the run schedule for FY 2011-2012

Present LLD Plan

- Remove LLD carefully (this week). The removal procedure is being readied today.
- Assess the damages and understand the causes of the damage.
- Assess if an acceptable support structure repair can be made. Need a reasonable assurance of the integrity of the support structure over the next campaign.
- The base plan is to re-install graphite tiles and save the dense packed probe tile.
- The in-board moly tile installation will be pursued with high priority.
- The LLD research will shift to the in-board moly tiles for the next run.