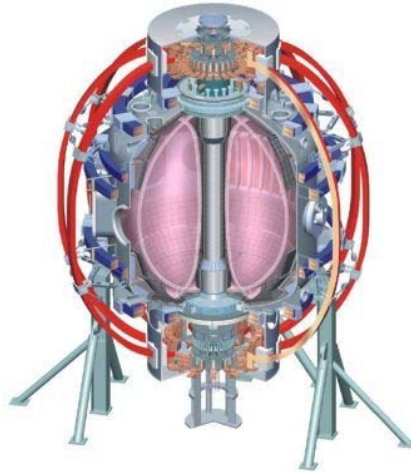


NSTXU NBI Peer Review Overview

Timothy N. Stevenson

**Princeton Plasma Physics Laboratory
NSTX Upgrade Project
LSB B318
April 19, 2011**

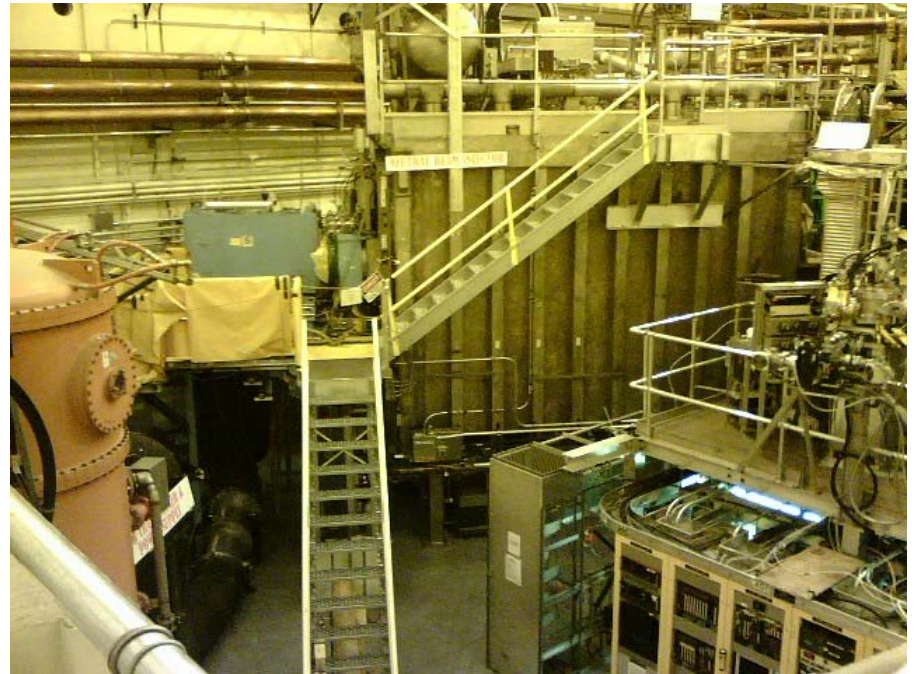


*College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Washington
U Wisconsin*

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

NSTXU NBI Overview - *Main Requirements*

- *Disassemble & evaluate a TFTR BL* ✓
- *Decon a TFTR DT BL* ✓
- *Refurbish BL for reuse: started*
- *Lift BL over wall*
- *Add second NBI & Services in NTC*
- *Connect Power & Controls*
- *Aim wider*
- *Rearrange NTC to fit* **
- *Capability to run either or both*
- *NBI Power x 2 for NSTX!*



SAME

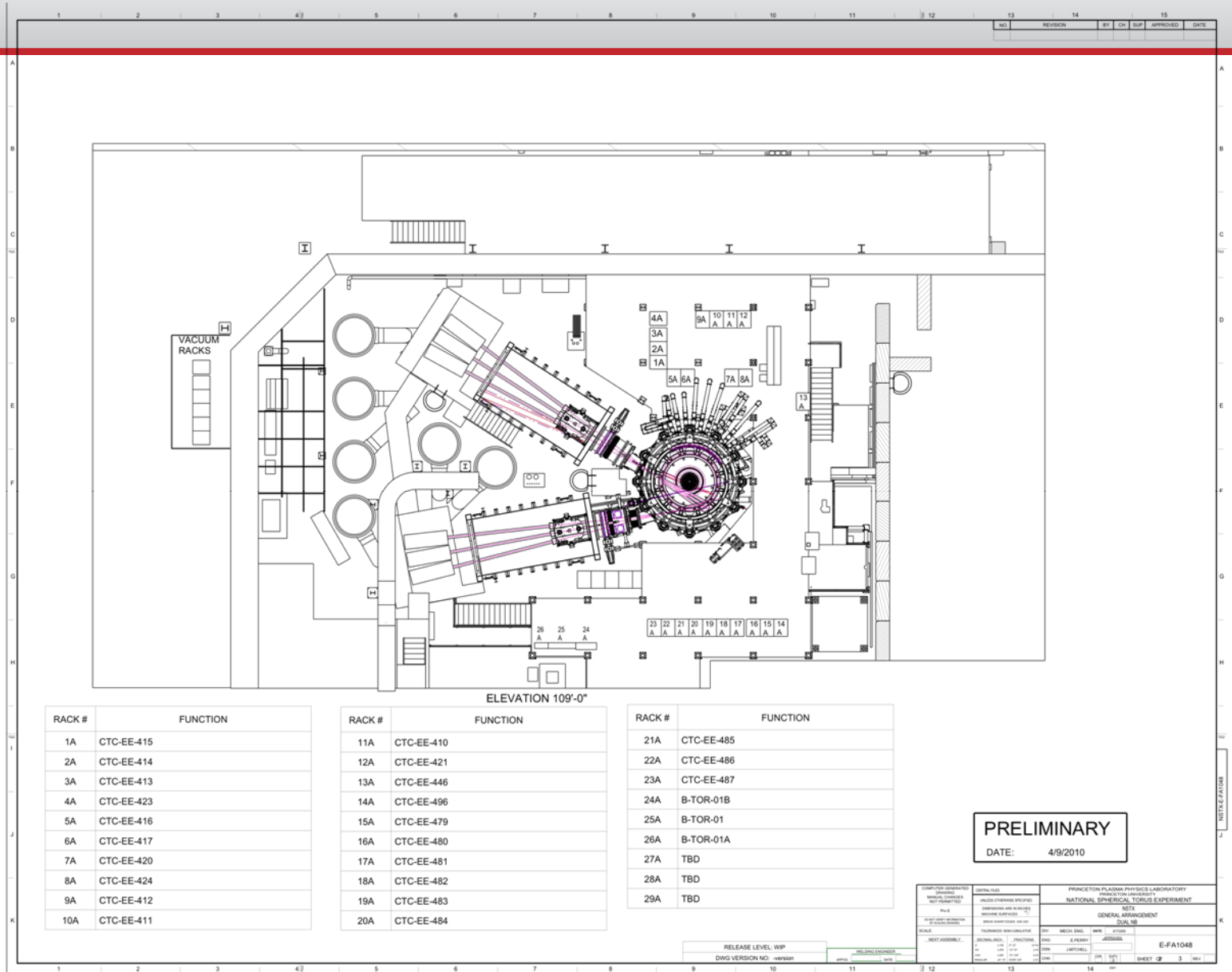
NSTX Beamline 1 operating since 2000

**** NTC Equipment relocations planned. Removal IPs written. Installation IPs in progress.**

NSTXU NBI Overview - Jobs

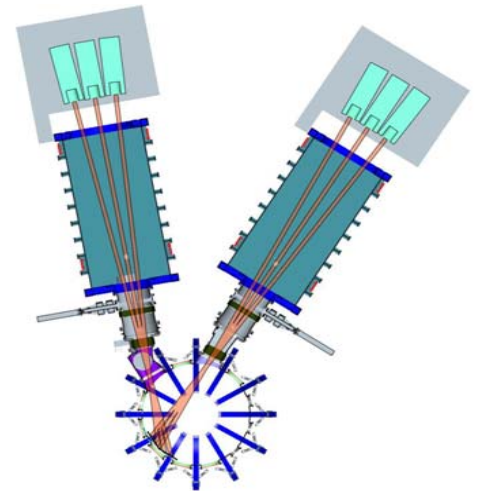
NSTXU NBI Project Cost (all k\$)		NBIU base budget	Total contingency	% contingency	Total budget	CPI	SPI
Job: 2420 - 2nd NBI Sources	Cropper	\$1,094	\$175	16	\$1,269	n/a	n/a
Job: 2425 - BL Relocation	Denault	\$1,859	\$257	14	\$2,116	1.19	0.74
Job: 2430 - 2nd NBI Decontamination	Stevenson	\$2,057	\$3	15	\$2,060	0.99	1.00
Job: 2440 - 2nd NBI Beamline	Denault	\$2,589	\$364	14	\$2,953	1.80	1.02
Job: 2450 - 2nd NBI Services	Denault	\$4,516	\$986	23	\$5,502	1.03	1.03
Job: 2460 - 2nd NBI Armor	Denault	\$700	\$104	20	\$804	0.96	1.02
Job: 2470 - 2nd NBI Power	Ramakrishnan	\$3,334	\$557	18	\$3,891	1.03	0.99
Job: 2475 - 2nd NBI Controls	Cropper	\$2,089	\$253	12	\$2,342	3.04	0.88
Job: 2480 - 2nd NBI/TVPS Duct	Denault	\$2,258	\$480	25	\$2,738	0.98	0.98
Job: 2485 - Vacuum Pumping System	Blanchard	\$388	\$54	16	\$442	0.97	0.93
Job: 2490 - NTC Equipt Relocations	Perry	\$3,618	\$575	17	\$4,193	1.00	1.00
Job: 7300 - NB2 Management	Stevenson	\$1,450	\$181	14	\$1,631	1.26	1.00
Job: 7400 - Health Physics Support	Stevenson	\$2,507	\$297	14	\$2,804	1.36	1.00
Job: 7700 - NSTX Upgrade HP Allocations	Strykowski	\$2,604	\$256	14	\$2,860	1.04	1.00
Total NBI Upgrade BL2		\$31,063	\$4,542	14.6%	\$35,605		

NSTXU NBI Overview - General Arrangement Drawing

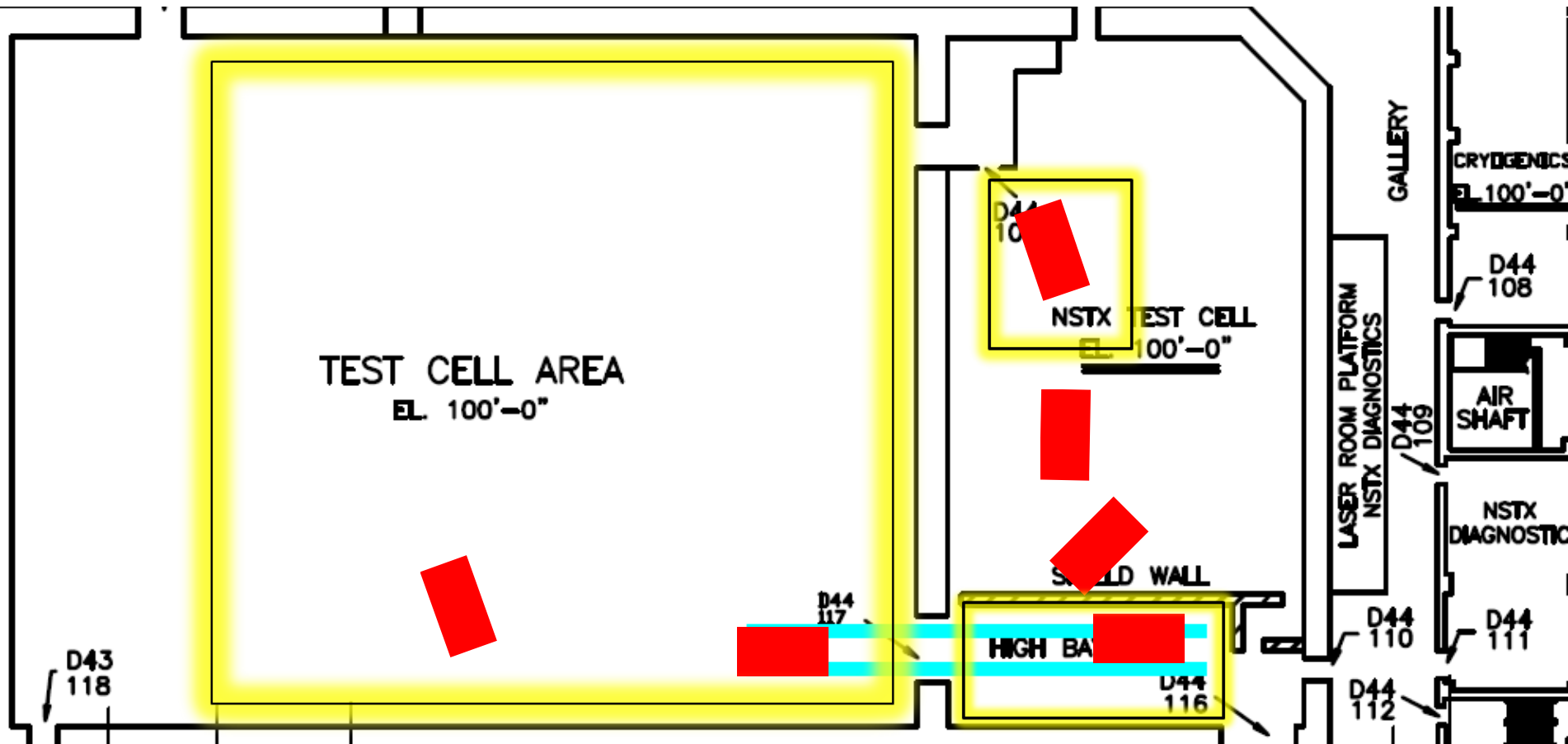


NSTXU NBI - *BL Relocation and Services*

- Beamline cleared for use on NSTX by successful Peer Review 4/21/10
- Refurbish Ion Dump (in progress) & update Calorimeter (next)
- Relocate beam box, lid, & components to NTC - everything goes over the shield wall
- Refurbish sources for BL2 - (normal NBI operations work)
- Reactivate stack vent connections in NTC
- Build BL support structure similar to existing NSTX NBI
- Align box, lid, components in NTC
- Salvage water rack and source platform
- Modify and connect DI ion source, ion dump, & HVE DI water
- Modify and connect vacuum, cryogenics LHe & LN, gas, SF6, pneumatic services
- Attach platforms
- Install refurbished sources



BL Relocation Path



RWP areas posted for contaminated work during installation

NSTXU NBI - BL2 Services

- ✓ High Voltage Enclosure Cooling Water
- ✓ Ion Dump Cooling Water
- ✓ Ion Source Cooling Water
- ✓ SF6
- ✓ Liquid Nitrogen
- ✓ Liquid Helium
- ✓ Vacuum Backing Lines
- ✓ Gas Injection System



•New pumps for BL IS & ID DI water



•Reuse NBPS DI Water skids

All services accounted for

All routes mapped

Heat and flow calculations performed for water systems

Pipes, pumps, and runs sized accordingly

Cryogenic loads minimized and acceptable (reuse same frig)

All penetrations identified and locations approved

Drawings in progress...

NSTXU NBI Overview - NBI Power

Neutral Beam Power System

- Same design as original power systems but **updated to present BL1 configuration**
- Recommission N4 power systems A,B, & C (all still available):
 - ✓ Accel
 - ✓ Gradient Grid (build new air cooled resistive dividers per BL1 design)
 - ✓ Decel
 - ✓ Arc
 - ✓ Filament
 - ✓ Bending Magnet

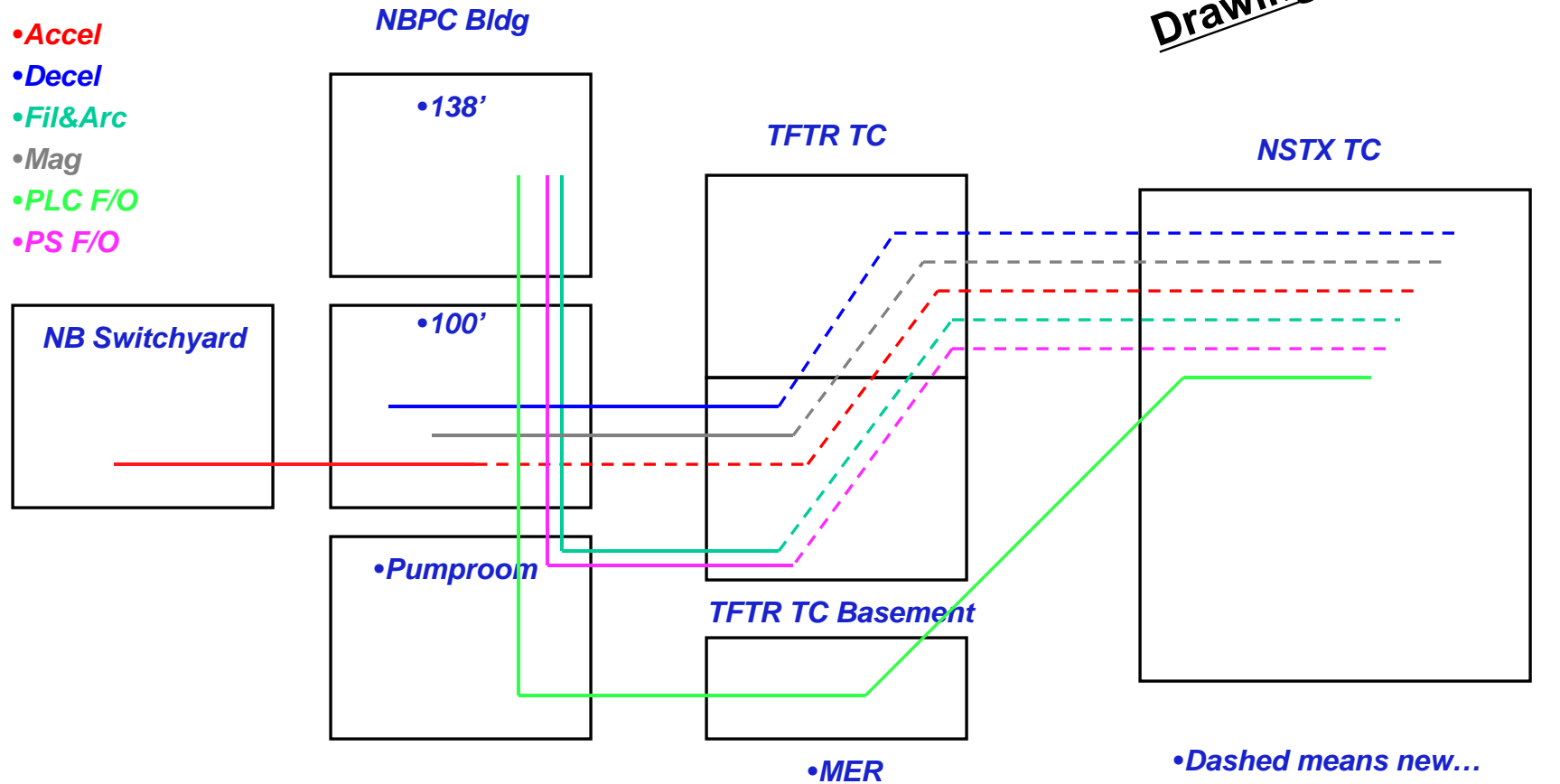
SAME

- Run both beamlines from MG set for 13.8 kV feed (same as we did on TFTR)
- Reuse existing N4 cabling to TFTR TC Basement as is
- Add junction boxes and route new cables from TCB through TC to NTC
- Move N4 HVEs from TCB to NTC – **ready to move**
- Reuse transmission lines with clamshell arrangement – **ready to move**
- Reuse existing telemetry and fiber optic cables salvaged from TFTR
- Reuse existing NBPS Deionized Water Skids in the pump room (still attached)

New wires...

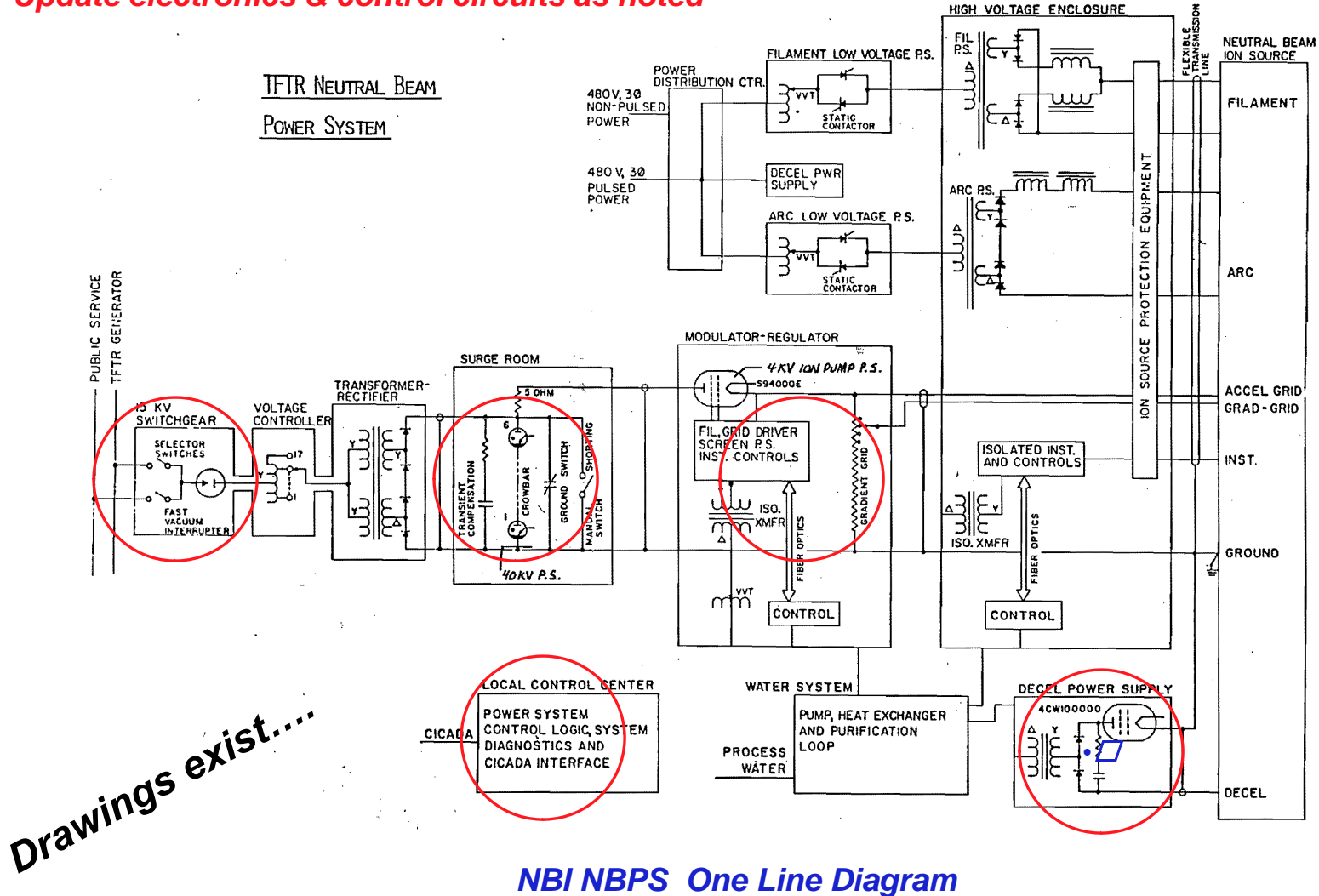
NSTXU NBI Power & Controls - Road Map

Routing, Penetrations, draft Installation Procedures done



NSTXU NBI Power & Controls - One Line Diagram

Update electronics & control circuits as noted



NSTXU NBI Controls

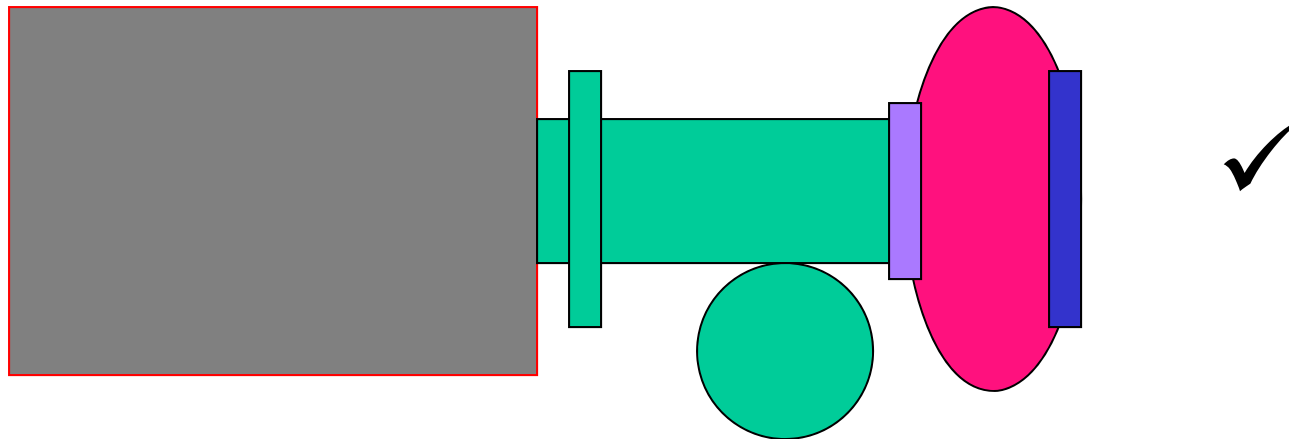
- Mimic existing NSTX BL1 Control scheme for BL2 **but move NTC racks**
- Reactivate N4 Local Control Centers, CAMAC, Hardwired Interlock System
- Turn BL2 Plasma Current Interlocks on (chassis still in use for BL1)
- **Add additional plasma interlock to prevent long pulse into armor- Ip & IpR**
- Expand I/O for PLC control of BL and Services but use existing PLC
- Expand Thermocouple Scanning System to include BL2 **& the ARMOR**
- Fold BL2 into EPICS & timing pages
- Update NBOS LabView Operator interface so existing staff can run 2 BLs
- **Pyrometer added per recommendation**

Drawings in progress.....

NSTXU NBI BL to VV

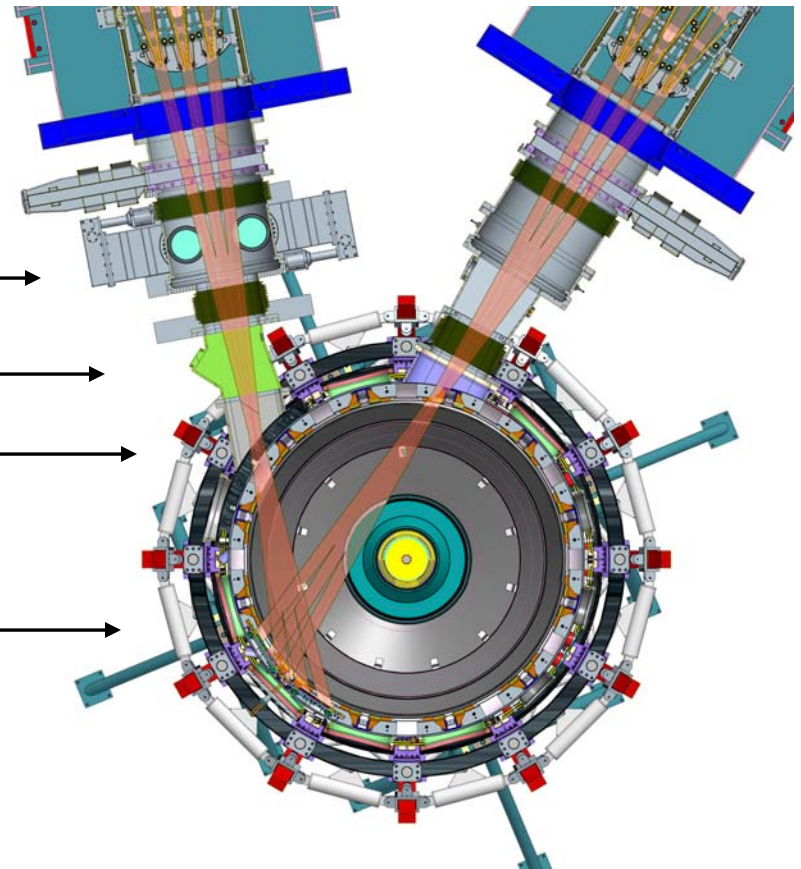
NBI Duct, TVPS, VV, Armor fully integrated into NBI & VV

- Duct, port extension, and Bay K cap design completed
- TVPS design completed with shielding and instrumentation
- VV modification prototype set up and ready for testing
- Gaining experience with the plasma cutting and welding techniques required
- Drawings in progress and well along or completed
- Reinforcements developed for areas on VV around these ports (ongoing)
- Interfaces have been discussed and included

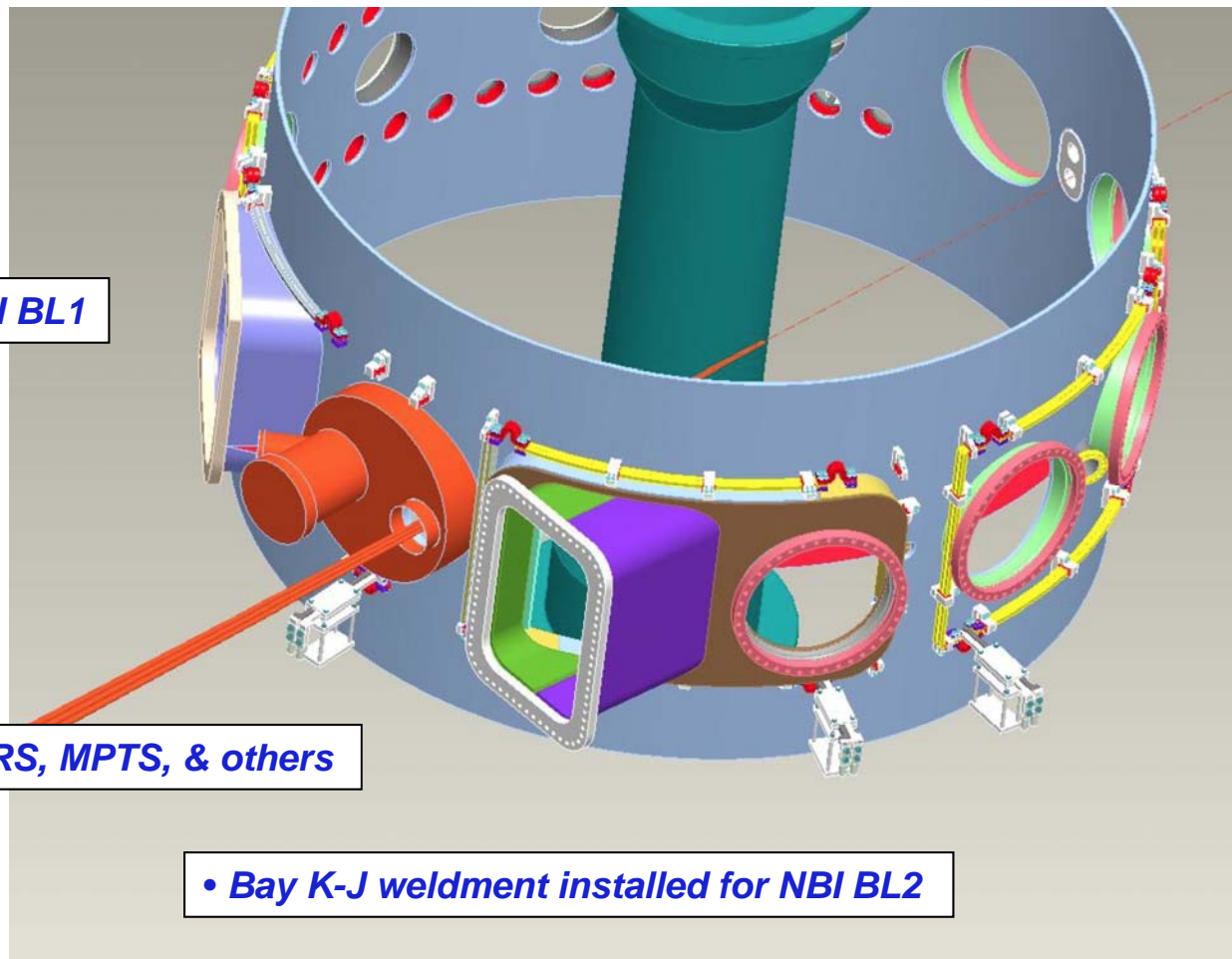


NSTXU NBI Duct Overview & Trajectories

- Aiming angles achieved per GRD
- NBL2 Duct w/ new TIV
- Torus Vessel Pump System Duct
- Port Extension
- Bay J-K Cap
- NSTX Vessel Modification
- NBI Armor relocation



NSTXU Bay L Diagnostics & NBI Bay K Weldment



• Bay A NBI BL1

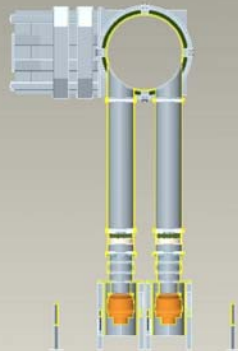
• Bay L *CHERS, MPTS, & others*

• Bay K-J weldment installed for NBI BL2

• *VV Reinforcements required for stresses per M. Smith*

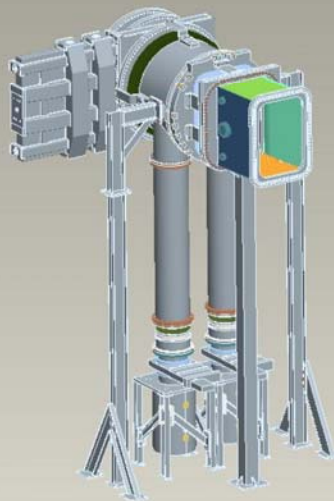
Torus Vessel Pumping System (TVPS) Design

• *Between NBI box and vessel*

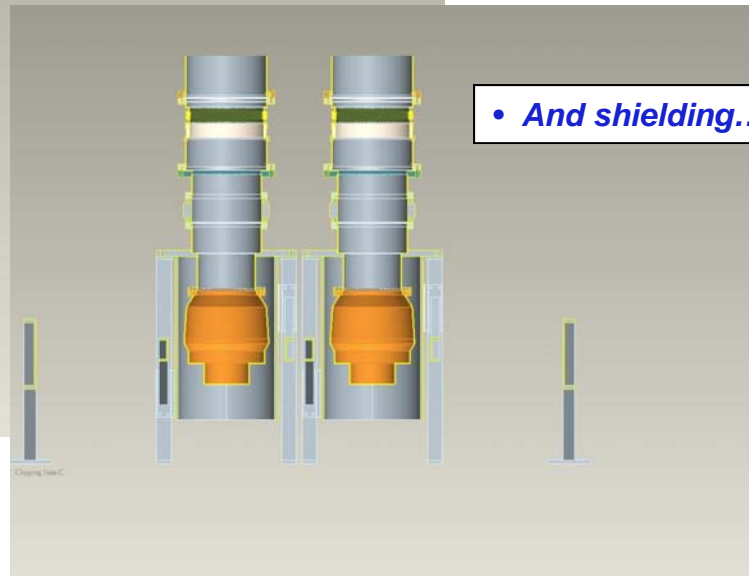


Clipping, Item C

• *With structural supports*



• *And shielding...*

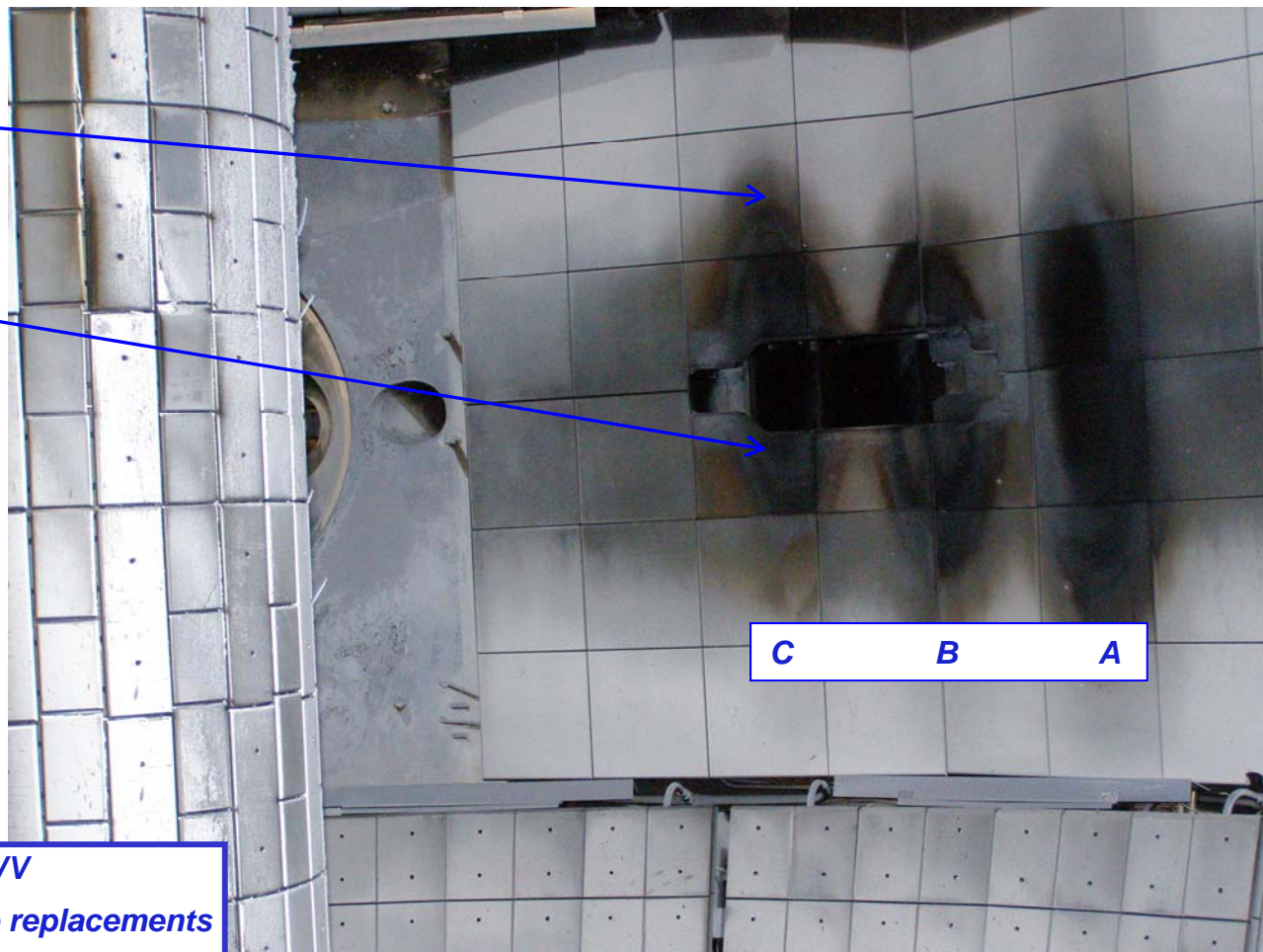


Clipping, Item C

Existing Armor Position - 3 Beams

Divergent Beam

Core Beam



*Takes a direct hit to protect VV
Sacrificial - might require tile replacements
Interlock with Ip and R Ip*

• *The Armor takes a direct hit now...*

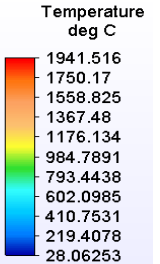
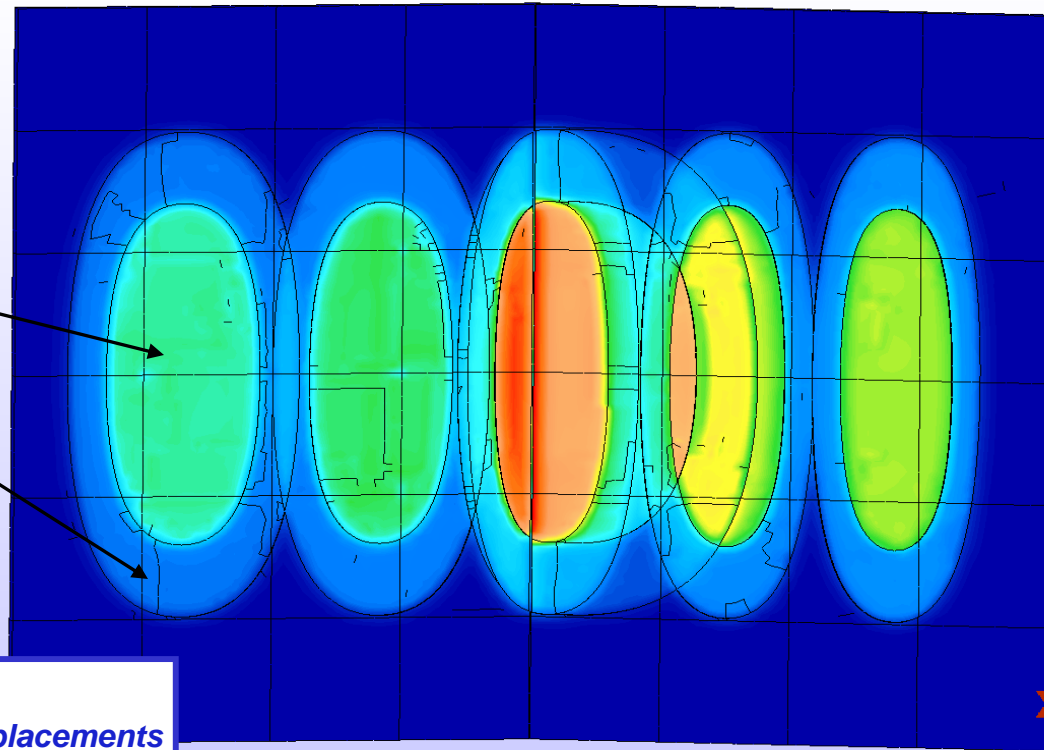
New Armor Position - 6 Beams



Core Beam

Divergent Beam

Takes a direct hit to protect VV
Sacrificial - might require tile replacements
Added true redundancy to Ip and R Ip
Added Thermocouple Scanner for Armor
Will add pyrometer



0.343 m 0.686 1.028

Analysis complete

Cost & Schedule

- *Decon complete*
- *BL Refurbishment started*
- *Design and Drafting nearing completion for FDR*
- *BCWS = 4010 K BCWP = 3979 K ACWP = 3819 K*
- *CPI = 1.04 SPI = .99 OK to date*
- *On track for FDR 6/22/11*
- *Preparing for EVMS certification, Lehman review, and CD3 (summer)*
- *Upgrade outage starting 4/03/12 (now less than 1 year away)*
- *Diagnostics and rack removals complete 12/03/12*
- *NBI BL2 flies over the wall 10/21/13 with lid & components following*
- *NB Bay K installed 1/3/14 (this should probably come before BL2 move)*
- *CS installed 4/09/14*
- *NSTXU pumpdown 6/18/14*

Let's run...

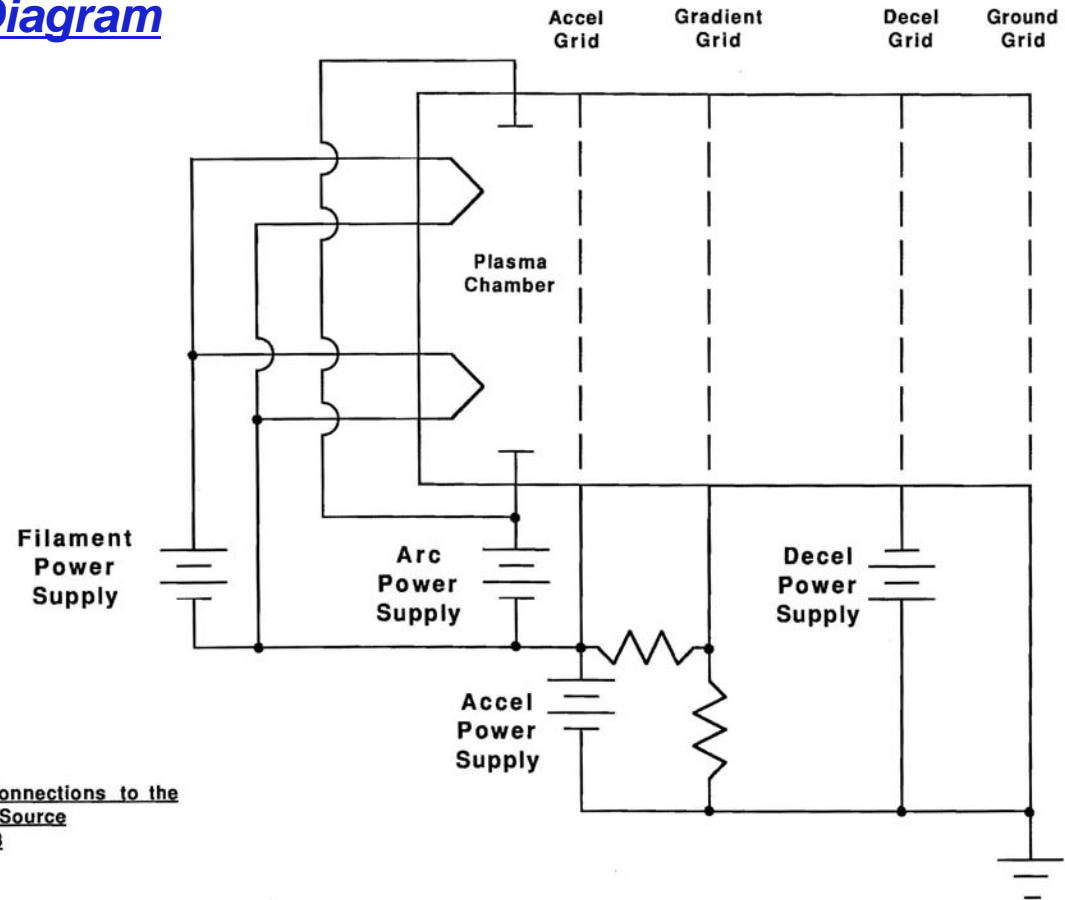
Conclusion

- **NBI BL2 Upgrade Requirements - GRD achieved**
- **NSTX Test Cell General Arrangement Drawing - maintained**
- **BL Decontamination: good enough...**
- **Project Overview: Overall design completed. Drawings done or in progress...**
 - **BL2 Relocation and Services and Platforms**
 - **Duct, Torus Vacuum Pumping System, Vacuum Vessel**
 - **NBI Armor - tough enough**
 - **NBI Power and Control Systems - steady progress**
- **NSTX Test Cell Equipment Relocations - no new issues**
- **Risks, Chits, Recommendations, and near term deliverables - OK**

Conclusion: Good to go... to FDR

NSTXU NBI Power & Controls - Battery Diagram

NBI Source Battery Diagram



Power Supply Connections to the
Long Pulse Ion Source
TNS-11/03/88