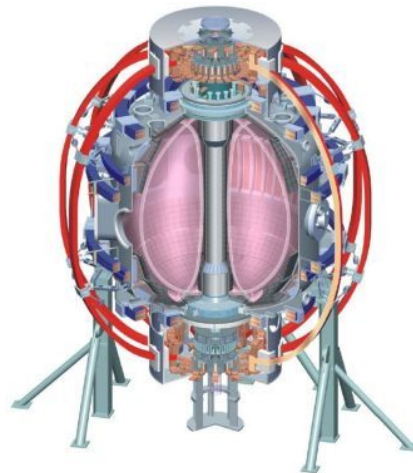


# NSTX NBI Upgrade Overview

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

**Timothy N. Stevenson**

**NSTX Upgrade Project  
Conceptual Design Review  
LSB B318  
October 28-29, 2009**



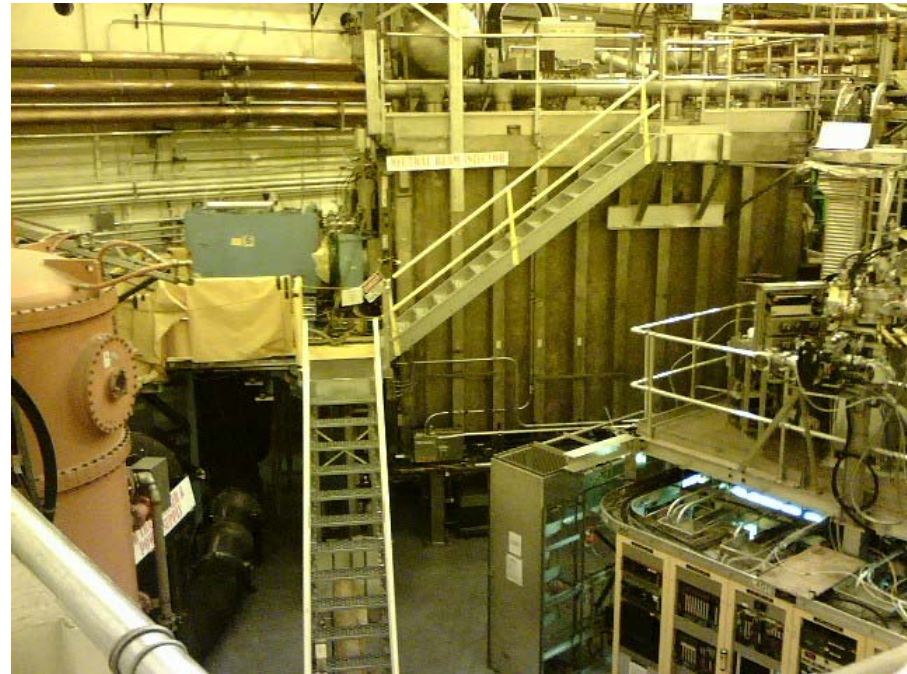
Culham Sci Ctr  
U St. Andrews  
York U  
Chubu U  
Fukui U  
Hiroshima U  
Hyogo U  
Kyoto U  
Kyushu U  
Kyushu Tokai U  
NIFS  
Niigata U  
U Tokyo  
JAEA  
Hebrew U  
Ioffe Inst  
RRC Kurchatov Inst  
TRINITI  
KBSI  
KAIST  
POSTECH  
ASIPP  
ENEA, Frascati  
CEA, Cadarache  
IPP, Jülich  
IPP,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

# NBI BL2 Upgrade Overview - Introduction

- *NBI BL2 Upgrade Requirements*
- *NSTX Test Cell General Arrangement Drawing*
- *NSTX Test Cell Equipment Relocations*
- *BL Decontamination Status and Progress*
- *NBI Project Overview:*
  - *BL2 Relocation and Mechanical Services .....Martin Denault*
  - *Duct, Torus Vacuum Pumping System, Vac Vessel Mod .....Craig Priniski*
  - *NBI Armor .....Kelsey Tresemer*
  - *Power & Control Systems .....Tim Stevenson*
- *Cost and Schedule comments*
- *Risks*
- *Conclusion*

# NBI BL2 Upgrade Overview - *Main Requirements*

- *Disassemble & evaluate a TFTR BL*
- *Decon a TFTR DT BL*
- *Refurbish BL for reuse*
- *Add second NBI & Services in NTC*
- *Connect Power & Controls*
- *Aim wider*
- *Rearrange NTC to fit*
- *NBI Power x 2 for NSTX!*



*NSTX Beamline 1 operating since 2000*

# NBI BL2 Upgrade Overview - GRD

## *NBI BL2 Operating Parameters in keeping with GRD*

- *TFTR 120 keV capability retained in design for NSTX BL1 and now BL2*
- *110 keV D service ceiling above which full energy power drops off so no real gain*
- *NSTX NBI typically operates up to 100 keV now @ approx. 2.5 MW per source*
- *Approx. 3 MW per source in deuterium at 110 keV available*
- *NSTX NBI original spec of 80 keV 5 MW for 5 seconds retained*
- *Ion dump operating limits retained based on TFTR operating experience...*

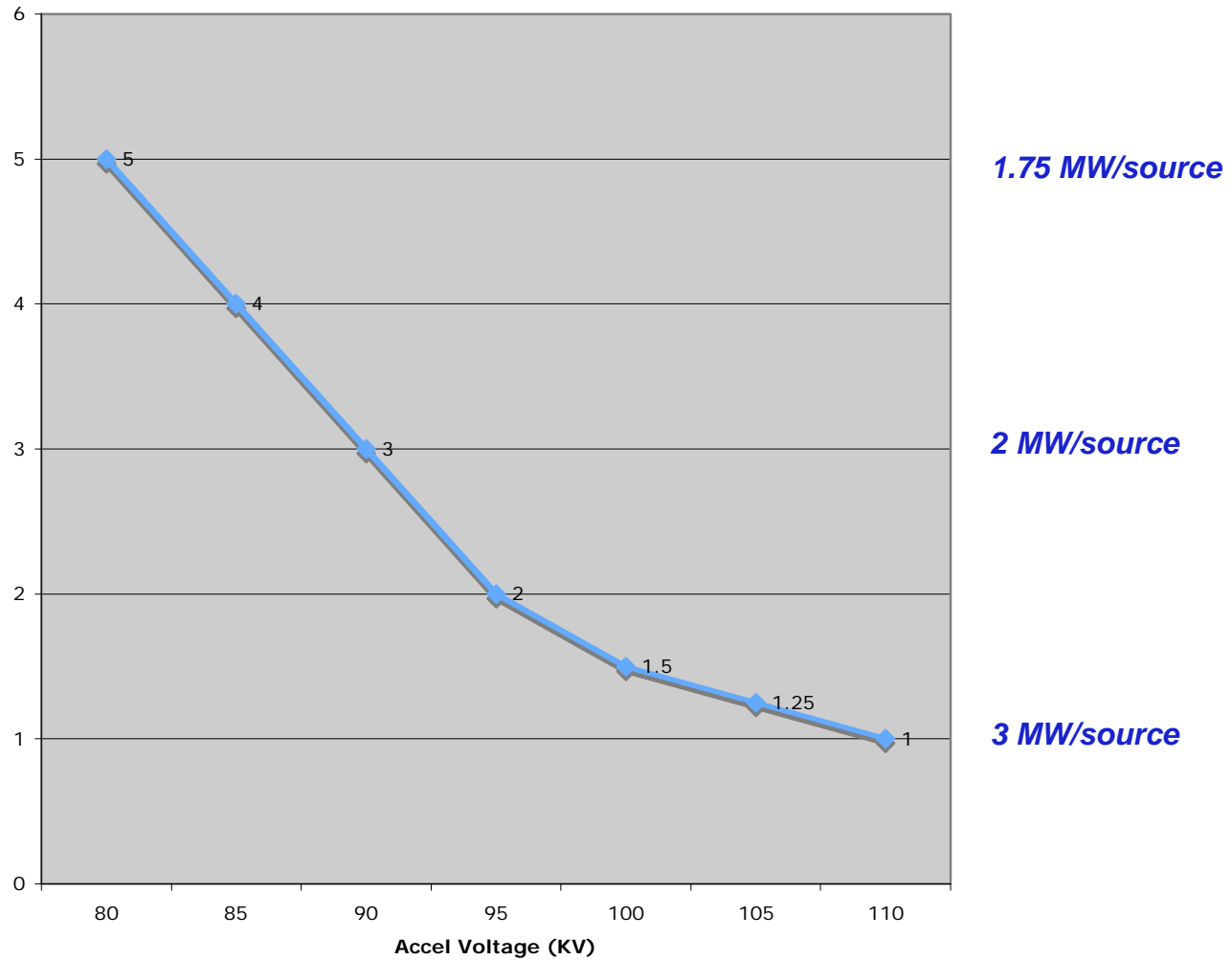
## *NBI Aiming*

- *Existing BL1 Tangency radii [C=50; B=60; A=70] cm unchanged*
- *BL2 Tangency radii designed to be [C=110; B=120; A=130] cm per GRD*

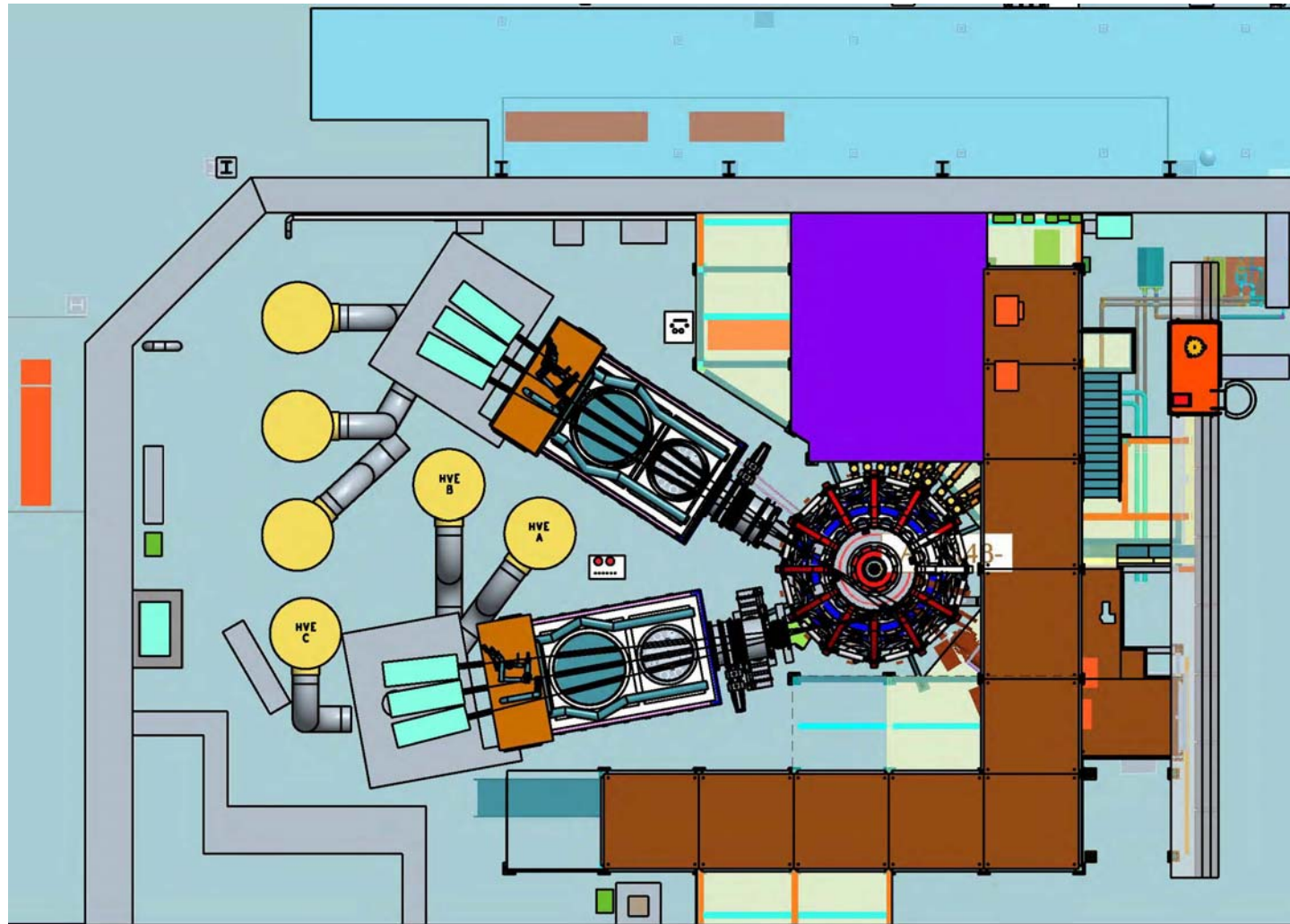
*2 BL 6 sources 18 MW  
possible...*

# NBI BL2 Upgrade Overview - *keV vs. t & MW*

Accel Voltage vs Pulse Length



# NBI BL2 Upgrade Overview - *General Arrangement Drawing*

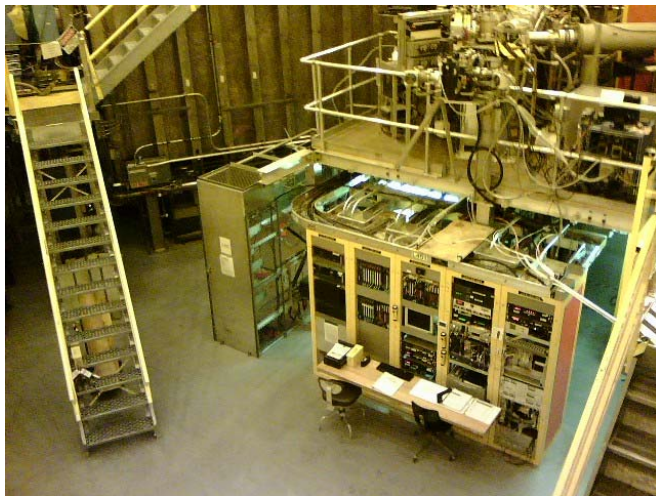
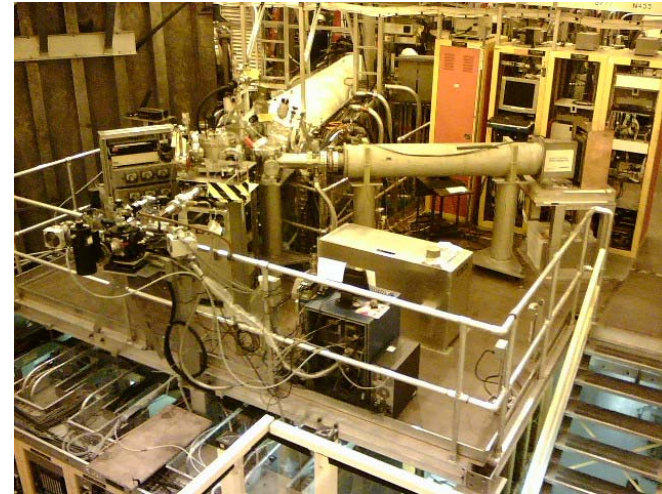


ELEVATION 118'-0"

# NBI BL2 Upgrade Overview - *Rearrange NTC for BL2*

## NTC Relocations

- Delete Pump Duct @ Bay L
- Move Diagnostics - many
- Change & add platforms
- Remove denizens of Bay K
- Move Diagnostic Racks
- Move Vacuum System Racks
- Move Gas Injection System bottles



# NBI BL2 Upgrade Overview - *Normal outage work*

*NTC Relocations are a major portion of the upgrade but constitute normal work for an NSTX outage...*

- *Diagnostics and Equipment Relocation considered on a case by case basis*
- *Project agreement for Diagnostics set installed Day 1 after the upgrade*
- *Bays G, J, K, L impacted and still others due to floor space*
- *Racks evaluated for contents and consolidation*
- *Procedures for removal and reinstallation drafted to contribute to cost estimates*
- *Platforms added at 118' elev. on West side for additional rack space*
- *TVPS racks go to North gallery outside NTC*
- *Beam racks go to East gallery outside NTC*
- *Removals slated to start after the NSTX 2011 run period has been completed...*



# NBI BL2 Upgrade Overview - *BL Recon and Decon*

## Evaluation, Decontamination, & Refurbishment of TFTR BL4

- Operating on TFTR DT campaign and shut down in 1997
- Operated in D2 for 1 week to remove tritium imbedded in impinged surfaces
- Air purged to stack for 10 years
- Sampled in 1997 and 1998 to determine feasibility of decon - *airborne and surface levels OK*
- Pump and purge BL - *done*
- Remove calorimeter, dump, magnet, and 90 inch flange - *done*
- Remove lid and panels and place in stand - *done*
- Evaluate for reuse - *BL and components are in very good shape*
- Decon calorimeter, dump, magnet, 90 inch flange, lid, box **<=== WE ARE HERE**
- Replace ion dump copper plate
- Refurbish seals and TCs
- Leakcheck
- Move each piece to NTC South High Bay

***Note: HP & ERWM required for duration of project and into future NSTX operations just as they are now...***

## NBI BL2 Upgrade Overview - *Decon in progress...*

- *BL has been fully disassembled*
- *HP Surveys done regularly*
- *Levels in range of PPPL experience*
- *Decon of components has commenced*
- *Progress has been steady - levels decreasing*
- *BL in good shape internally*
- *Ion dump needs replaced*
- *Uptakes have been detectable but very low.*



*Setting up new lid stand in TC*



*BL4 Magnet and 90 inch flange*



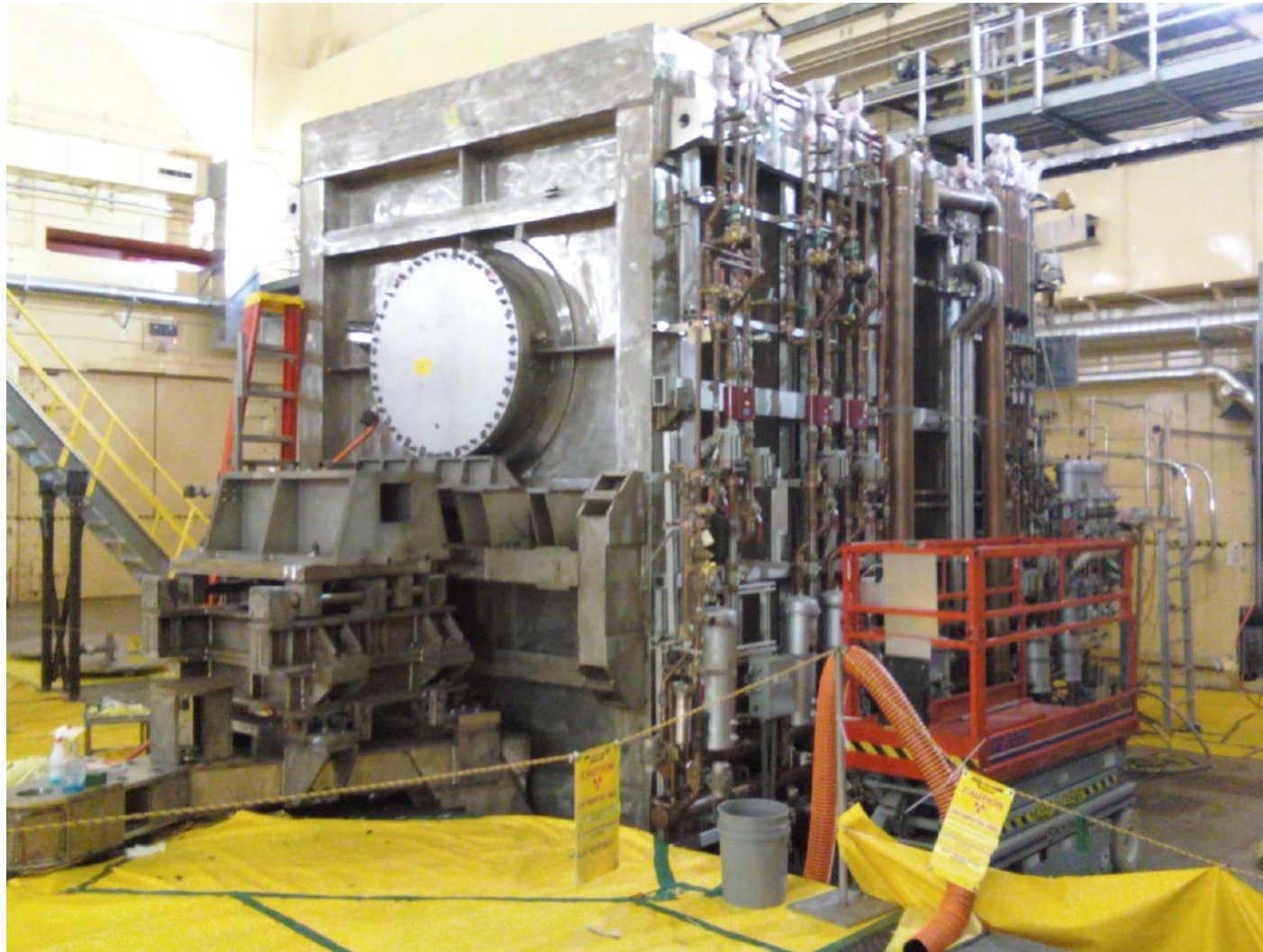
*Calorimeter decon in progress...*

## NBI BL2 Upgrade Overview - *Lid removal completed*



*Lid and cryo panels sitting in new stand... ready for decontamination phase*

## NBI BL2 Upgrade Overview - *BL4 Box*



*Box is open to air and ready for some internal decon...*

# NBI BL2 Upgrade Overview - *Decon Results*

- Initial surveys indicated BL airborne contamination well below DAC - 2 uCi/m<sup>3</sup>
- Linebreaks have gone as planned with no detectable stack releases
- Internal contamination levels have varied from .5 to 80 million dpm / 100 cm<sup>2</sup>
- Decon crew using double PC suits, triple gloves, and quadruple boots
- Uptakes @ 0.1-0.5% of daily allowable dose but always seeking continuous improvement
- Decon commenced on calorimeter, magnet, shield, and 90 inch flange & neutralizer
- Wipedowns with H<sub>2</sub>O<sub>2</sub>, Windex, Swiffer products, and rags
- Significant progress on areas that have received decon
- No detectable regrowth has been noticed

Decon by component - million dpm/100 cm<sup>2</sup>  
results have been generalized from detailed HP surveys

	Start - high	Recent - low	cycles
PrecCal Scraper	18	2	>20
Calorimeter Vee	20	1	>20
Exit Flange	45	8	>20
Heat Shield	3	0.3	>20
Magnet	40	<10	>5
90 inch flange	50	<10	>5
Cryo panels out	10	planned	tbd
Cryo panels in	70	planned	tbd

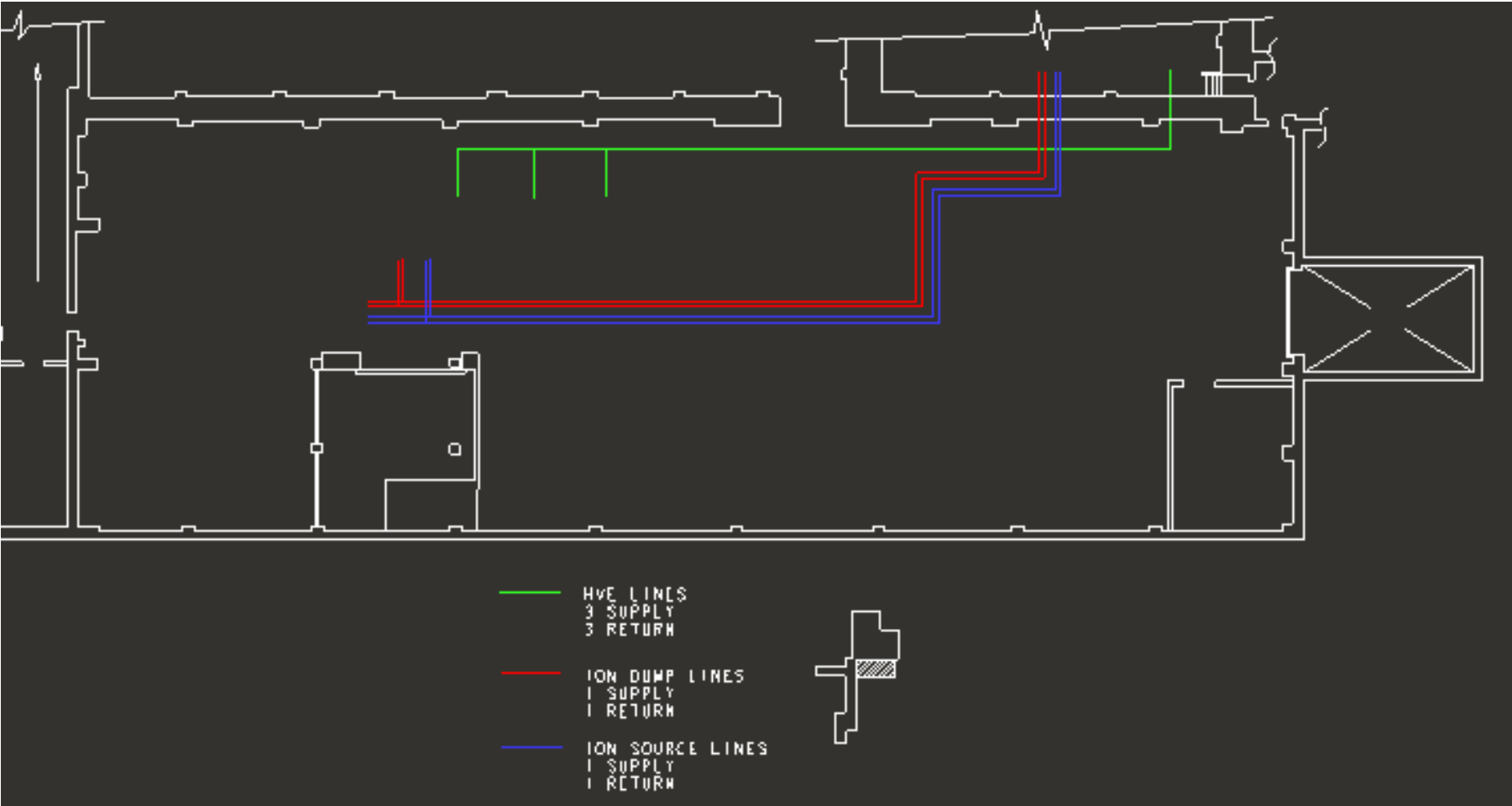
## NBI BL2 Upgrade Overview - *NBI Mechanical: Relocation and Services*

- Relocate beam box, lid, & components to NTC - everything goes over the shield wall
- Refurbish sources for BL2
- 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
- Shoot straight and don't miss...

*New pipes...*

# NBI BL2 Upgrade Overview

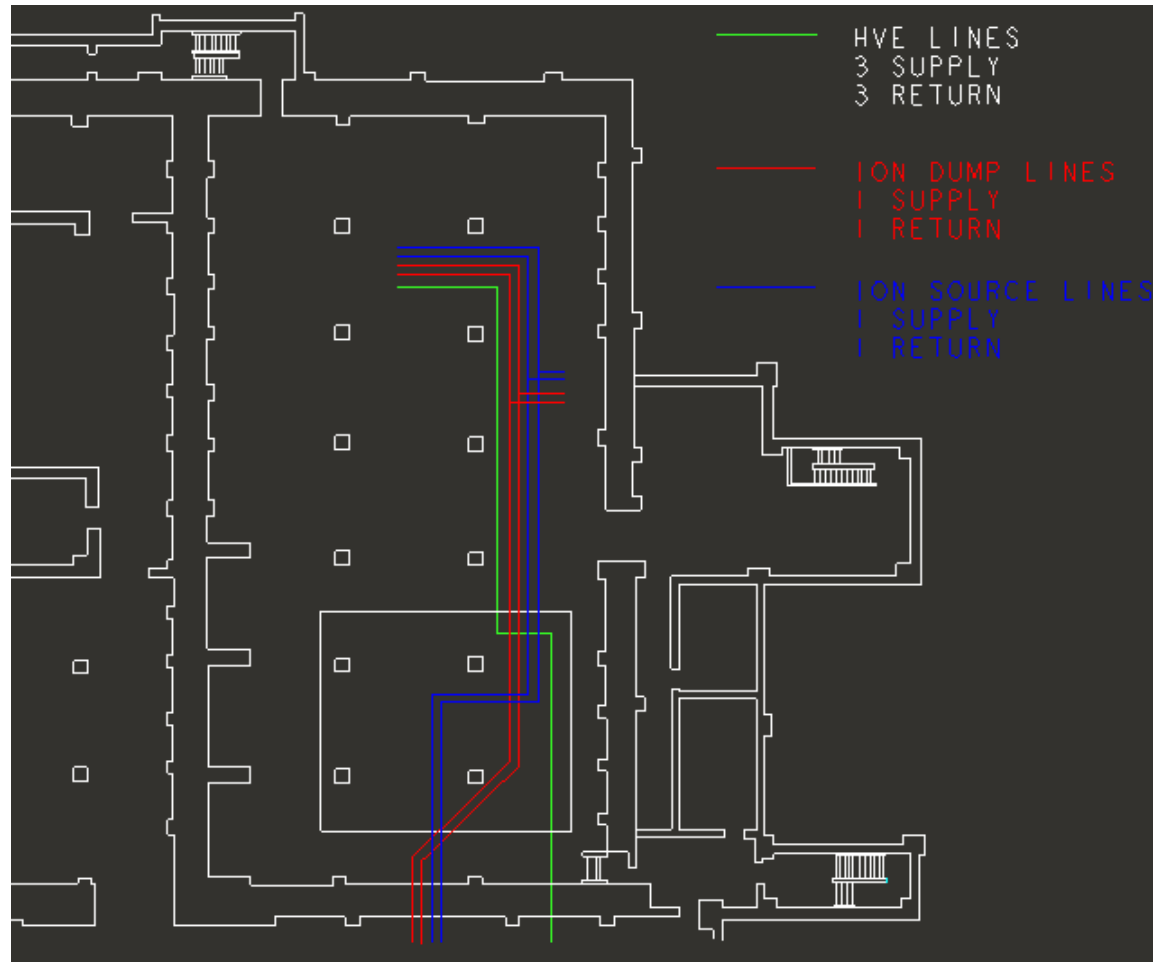
## NBI Mechanical: Relocation and Services



(M. Denault, NBI Peer Review 6/09)

# NBI BL2 Upgrade Overview

## NBI Mechanical: Relocation and Services

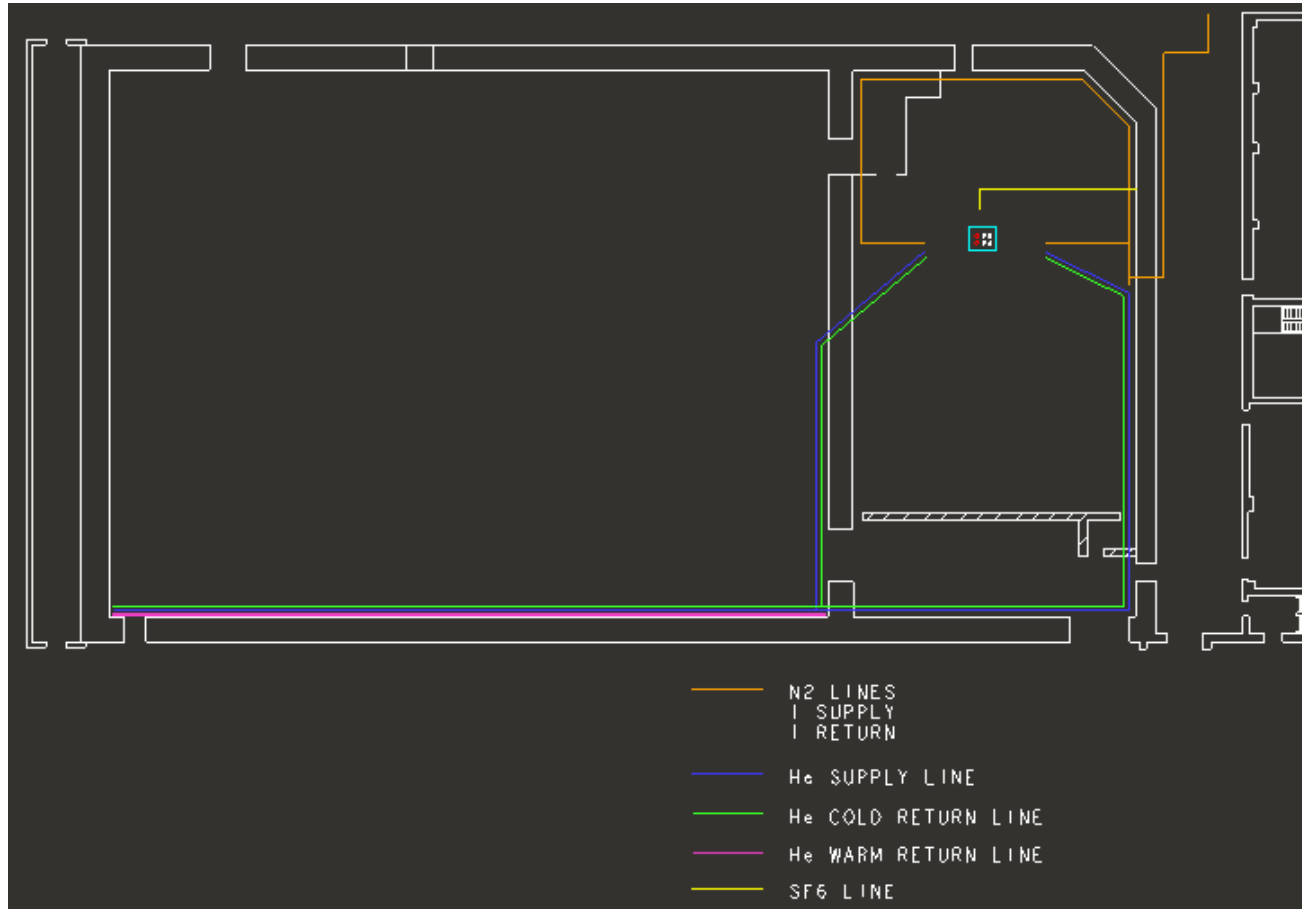


(M. Denault, NBI Peer Review 6/09)



# NBI BL2 Upgrade Overview

## NBI Mechanical: Relocation and Services

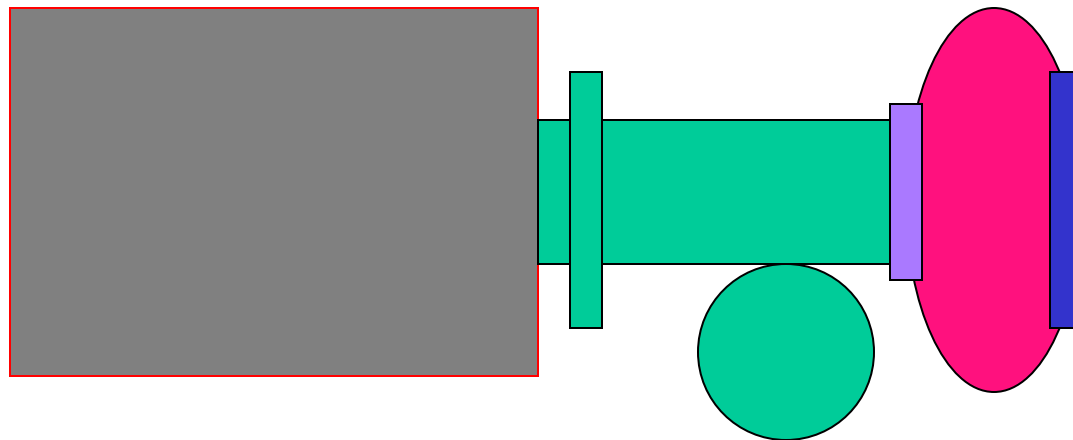


*(M. Denault, NBI Peer Review 6/09)*

# NBI BL2 Upgrade Overview - *BL to VV*

## *NBI Duct, TVPS, VV, Armor*

- Duct design significantly more involved than replicating original
- Larger tangency radii require vessel modification to Bay K port
  - New weldment for Bay J-K bay window required
- New circular and rectangular bellows and beam duct parts required
- Torus Vacuum Pump duct location now under and connected to beam duct
- Relocate NBI Armor in vessel to accept 6 source footprint and take a direct hit



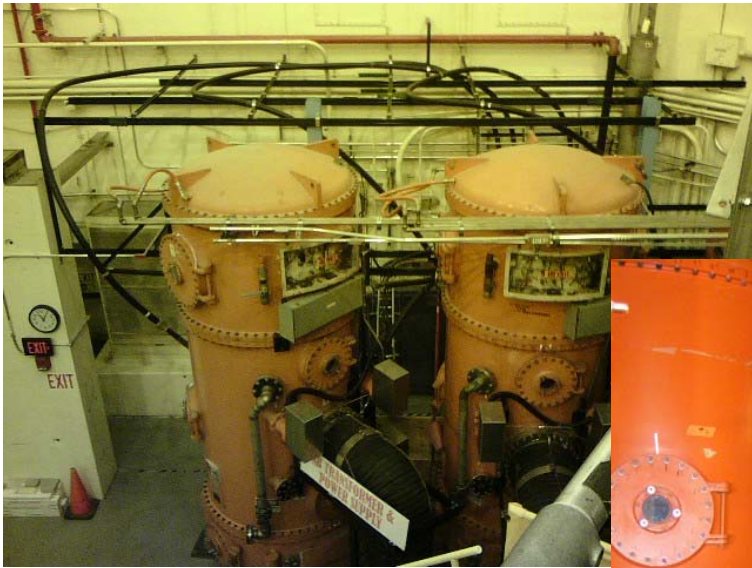
# NBI BL2 Upgrade Overview - *NBI Power & Control*

## ***NB POWER***

- 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
- 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
- Reuse transmission lines with clamshell arrangement
- Reuse existing telemetry and fiber optic cables salvaged from TFTR
- Reuse existing NBPS Deionized Water Skids in the pump room (still attached)

*New wires...*

# NBI BL2 Upgrade Overview



*BL1 HVEs and Triax*

Decon above in TC required lowering Xmsn lines to TCB for preservation and storage - completed prior to decon



*BL1 Xmsn lines*



*•Saving N4 Xmsn line for reuse*

Same type HVEs, Triax Accel cable, and Transmission lines for high voltage as on BL1

# NBI BL2 Upgrade Overview - *NBI Power & Control*

## *NB Control Room*



# NBI BL2 Upgrade Overview

## NBI Power & Control

- Mimic existing NSTX BL1 Control scheme for BL2
- 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
- Expand I/O for PLC control of BL and Services but use existing PLC
- Expand Thermocouple Scanning System to include BL2
- Fold BL2 into EPICS & timing pages
- Update NBOS LabView Operator interface so existing staff can run 2 BLs

*More sources, more buttons... but not more operators*

# NBI BL2 Upgrade Overview - Cost & Schedule

## *Cost & Schedule comments (detailed elsewhere)*

- *NBI BL2 Upgrade cost has direct similarities to original BL1 project for NBI work*
- *Added project components include NTC relocations, Decon, TVPS, and VV mods*
- *Added cost due to HP allocations*
- *Job Work Authorization Forms prepared and reviewed by job engineers*
- *On low end of CD0 cost range*

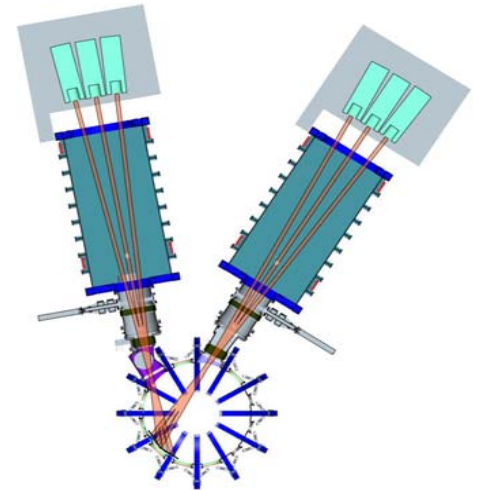
*& On schedule...*

- *PDR May 2010*
  - *FDR Jan 2011*
    - *Start NTC equipment removals after 2011 NSTX run period*
      - *NTC open for upgrade work 2012 and 2013*
        - *Resume NSTX Operations*

*•More field, more Ip, more NBI, more physics, more fusion, more fun...*

## Second Neutral Beam Technical Risks

- Risk: Uncertain of the level of effort required to decontaminate.
  - Decontamination has begun with pumps and purges of the beamline.
  - Decontamination techniques were well tested during the TFTR D&D project
  - Contamination levels in NB4 are similar to levels routinely encountered during the maintenance of TFTR NB sources (100,000 to 350,000 dpm).
  - Plan includes replacing all beam impinged copper surfaces to reduce schedule risk
- Risk: Uncertainty in the commercial availability of High Voltage Switch-Tubes, cabling and terminations for the 100kV Accelerator System.
  - There are sufficient High Voltage Switch Tubes available on site to support a second NB on NSTX
  - Contact with vendors has confirmed that the triax cables and connectors are still available.

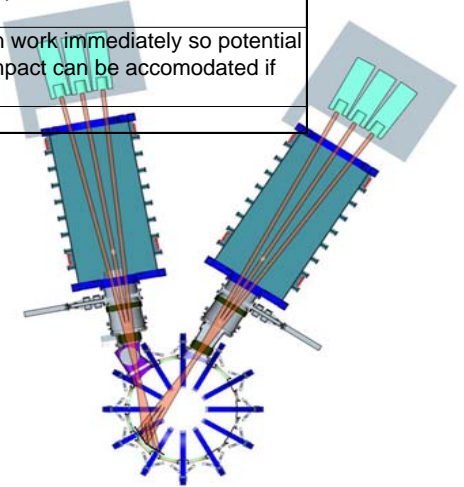




# Second Neutral Beam Technical Risks

<b>NSTX NB Upgrade Risk Registry</b>				
Number	Affected Job	Job Title	Risk Description	Mitigation Plan (& job where budgeted)
2440a	2440	Beamline Refurbishment	Further inspections may require additional parts and labor	BL OK.
2440b			Existing copper parts may be reusable (except for the dump)	Negative risk - reduce scope of job
2450c			Heat load may be too high	Remake He lines
2460b			May need to build new backing plates	Fabricate on site
2480a	2480	NB2 Duct and VV Mods	Beam too close to bellows/duct	Include molybdenum shielding in estimate
2480b			Difficulty machining vessel	Double estimate for this portion of the job
2480d			Previous fabricators of rectangular bellows not available	Locate alternate vendors
2490a	2490	Relocations to Support NB2 Installation	SPRED re-design and re-installation may require more effort than estimated due to the physical constraints in the area of bay L	Start design work immediately so potential schedule impact can be accomodated if necessary.
2490b			LOWEUS re-design and re-installation may require more effort than estimated due to the physical constraints in the area of bay L	Start design work immediately so potential schedule impact can be accomodated if necessary.
2490c			MPTS Beam Dump Window re-design and re-installation may require more effort than estimated due to the physical constraints in the area of bay L	Start design work immediately so potential schedule impact can be accomodated if necessary.
7400a	7400	Health Physics Support	Unplanned overtime	

- *Risks mitigated or work included in base estimate*



# NBI BL2 Upgrade Overview - Conclusion

- **NBI BL2 Upgrade Requirements - requirements met**
- **NSTX Test Cell General Arrangement Drawing - it fits**
- **NSTX Test Cell Equipment Relocations - moving day**
- **BL Decontamination Status and Progress - so far so good**
- **Project Overview: we have a plan...**
  - **BL2 Relocation and Services**
    - **Duct, Torus Vacuum Pumping System, Vacuum Vessel**
    - **NBI Armor**
    - **NBI Power and Control Systems**
- **Cost and Schedule comments - on track**
- **Risks - mitigated**
- **Conclusion: Good to go... to PDR in May and beyond**