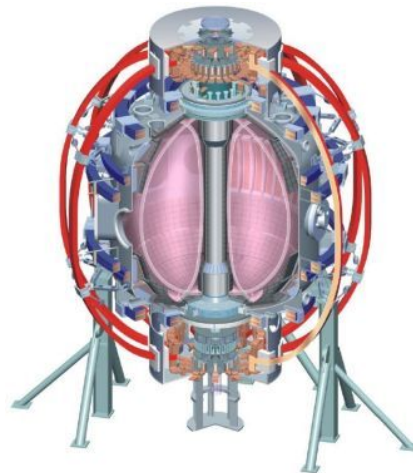


NBI Upgrade Power & Control Systems

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**



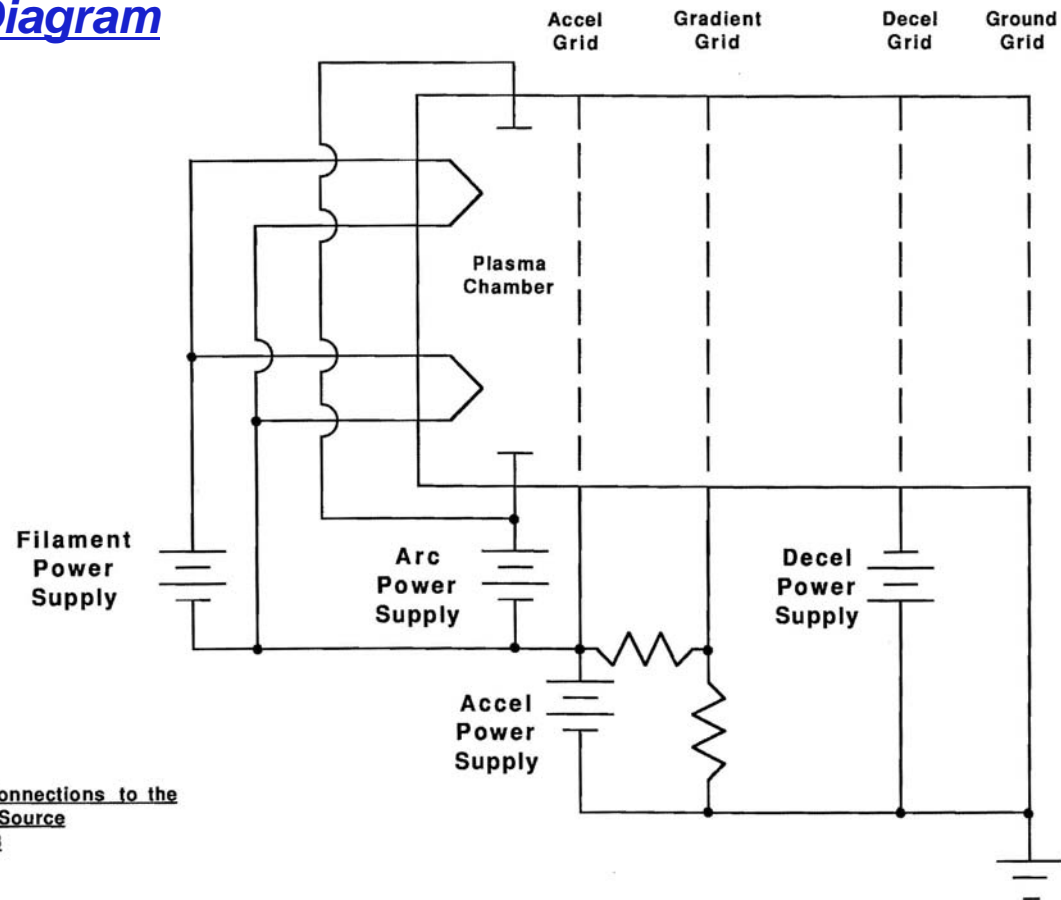
Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

NBI BL2 Upgrade Power & Controls - Introduction

- *Introduction to the NBI Power System*
- *Work Scope to connect N4 NBPS ABC to BL2 ion sources*
- *Procurements*
- *Routing and Installation*
- *Grounding*
- *Introduction to the NBI Controls*
- *Work Scope to control NBI BL2 and inject NBI into NSTX plasma*
- *Conclusion*

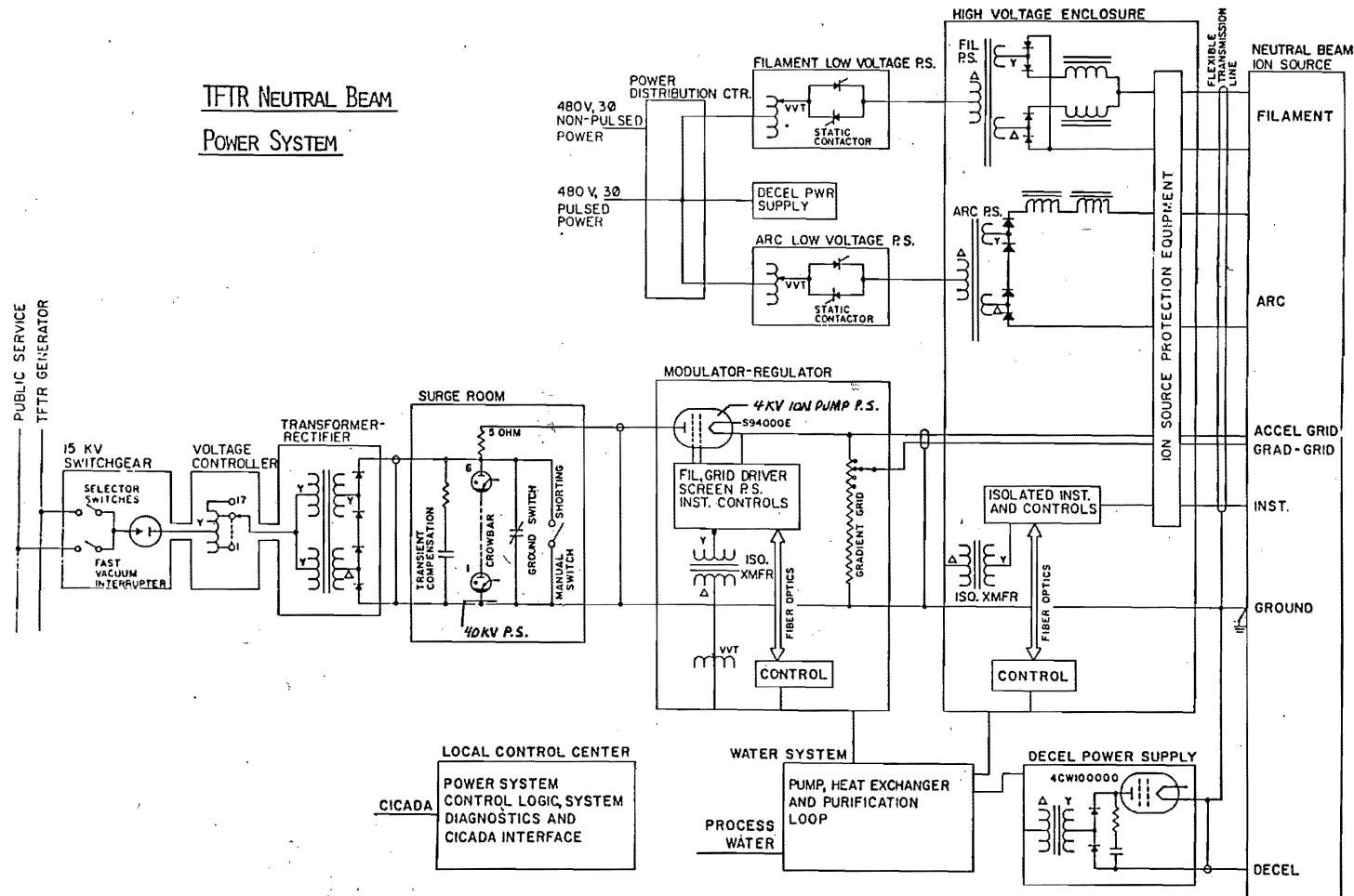
NBI BL2 Upgrade Power & Controls - Battery Diagram

NBI Source Battery Diagram



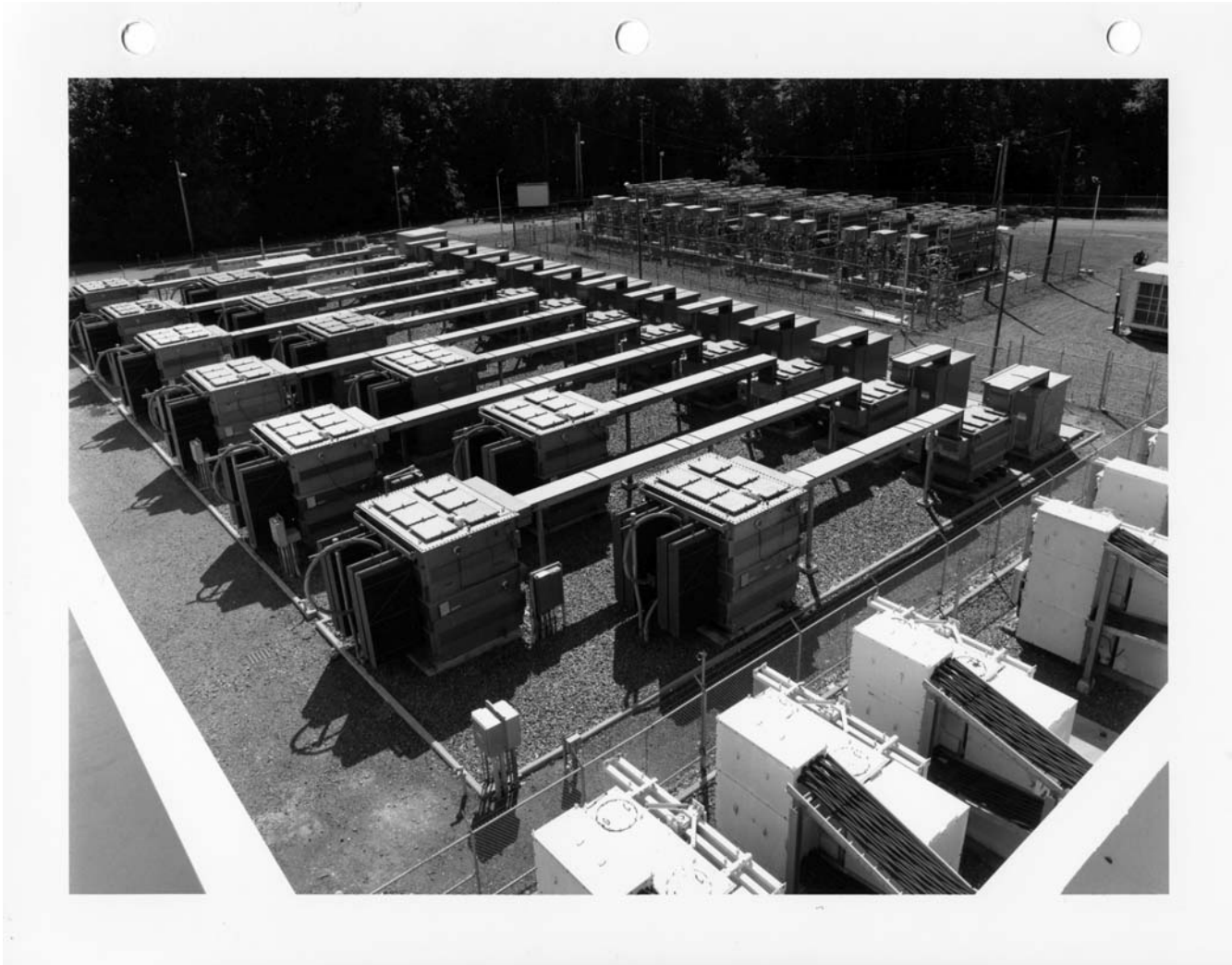
Power Supply Connections to the
Long Pulse Ion Source
TNS-11/03/88

NBI BL2 Upgrade Power & Controls - One Line Diagram



NBI NBPS One Line Diagram

NBI BL2 Upgrade Power & Controls - NBPS N4 available



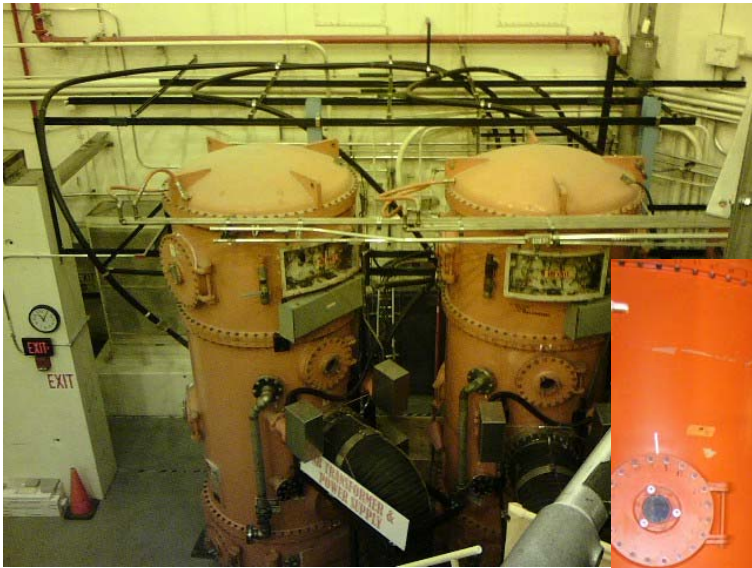
NBI NBPS Switchgear and Transformers

NBI BL2 Upgrade Power & Controls - NBPS

Neutral Beam Power System Work Scope

- Same design as original power systems but updated to present BL1 configuration
- Recommission N4 power systems A,B, & C (all still available):
 - ✓ Accel (with some new electronics in Surge Room & Mod/Reg)
 - ✓ Grad Grid (build new air cooled resistive dividers per BL1 design)
 - ✓ Decel (with new tube control and regulator electronics)
 - ✓ Arc
 - ✓ Filament
 - ✓ Bending Magnet
- Run both beamlines from MG set for 13.8 kV feed (same as we did on TFTR)
- Reuse existing N4 Arc and Filament low voltage 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 in NTC (like BL1)
- Reuse existing telemetry and fiber optic cables salvaged from TFTR
- Reuse existing NBPS Deionized Water Skids in the pump room (still attached)

NBI BL2 Upgrade Power & Controls - HVEs & Xmsn Lines



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 Power & Controls - Power feeds are OK

Turn some breakers back ON for NBPS N4 A,B, & C systems...

NBPS Power Requirement

	Volts	Amps	kWdc	Eff	kW	Pulse sec	Cycle sec	Duty Factor	kVA ave
Filament	10	4000	40	0.5	80	10	300	0.033	3
Arc	100	1000	100	0.5	200	6	300	0.020	4
Decel	2500	15	37.5	0.9	42	5	300	0.017	1
Accel	110000	65	7150	0.9	7944	5	300	0.017	132
Water skid	480	50	24	0.8	30	CW	CW	1.000	30
Magnet	20	700	14	0.8	18	CW	CW	1.000	18
Total power per source									187
									x3
Total power per BL									562

Note: BL Mechanical Systems not included

NBI BL2 Upgrade Power & Controls - New Cable

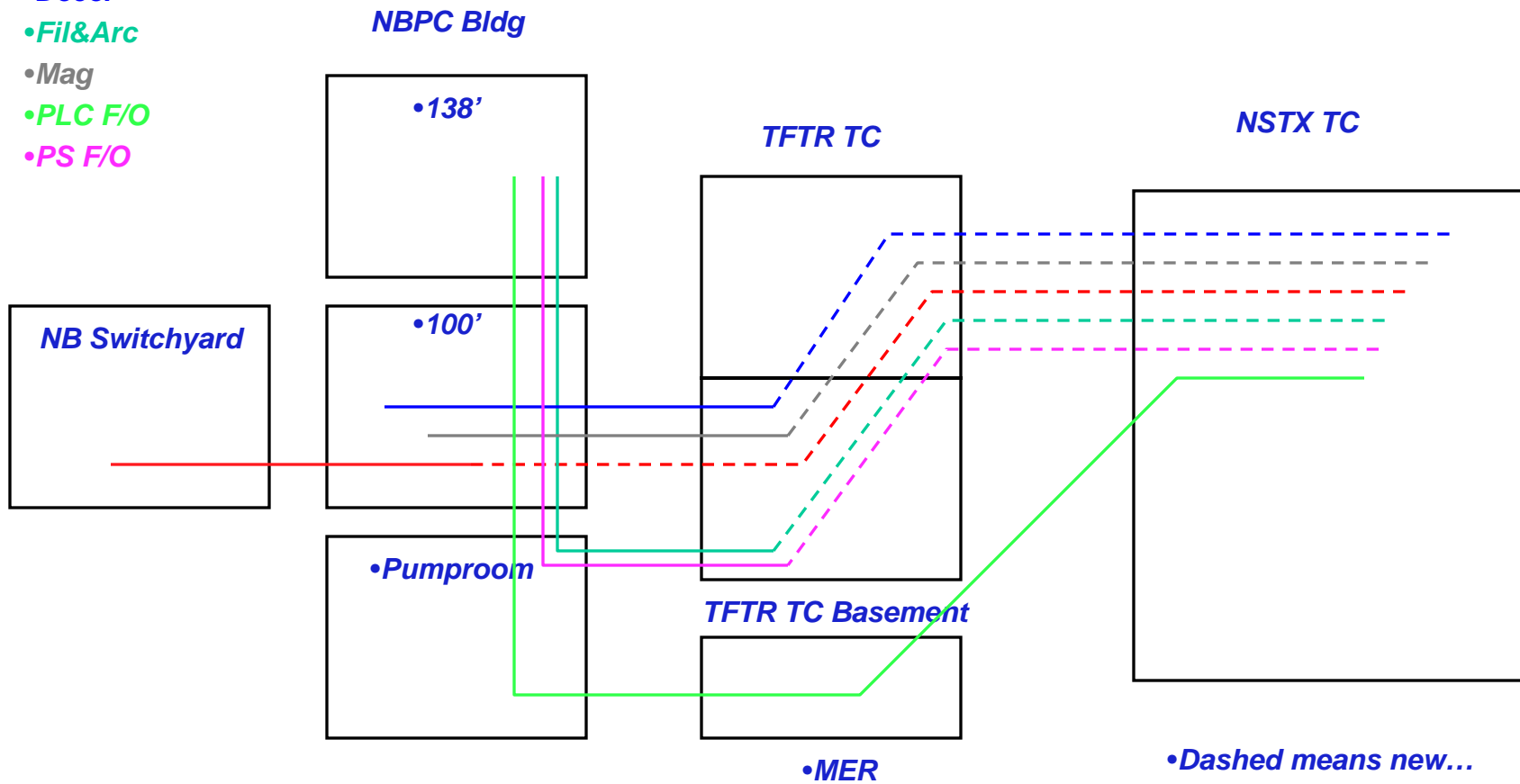
Procurements required are standard items for NBPS Operations and Maintenance

- **NEW TRIAX CABLE TO BE PROCURED FOR ACCEL - long lead item**
 - **SOW TO BE ISSUED FOR PROCUREMENT**
 - SUPPLYING THE CABLE
 - TERMINATING AND TESTING THE CABLE
- **NEW 600V 4/C-500 MCM CABLES TO BE PROCURED FOR ARC/FILAMENT/MAGNET**
- **COAXIAL CABLE RG218U FOR DECEL TO BE PROCURED**
- **PARTS FOR GRADIENT GRID RESISTORS & HARDWARE TO BE ORDERED**
- **CABLE TRAY**

NBI BL2 Upgrade Power & Controls - Road Map

Routing and Installation

- **Accel**
- **Decel**
- **Fil&Arc**
- **Mag**
- **PLC F/O**
- **PS F/O**



NBI BL2 Upgrade Power & Controls

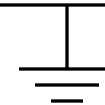
Routing and Installation

- **TOTAL CABLES TO BE INSTALLED**
 - THREE TRIAX CABLES – PROJECTED LENGTHS 300*3 FEET
 - THREE CABLES 600V 4C/500MCM & GRD WIRE - ARC
 - THREE CABLES 600V 4C/500MCM & GRD WIRE - FILAMENT
 - THREE CABLES 600V 4C/500MCM & GRD WIRE – MAGNET*
 - *STANDARDIZE THE CABLES FOR EASE OF PROCUREMENT
 - THREE CABLES 600V 4C/#8 & GRD WIRE – 208V FEED
 - THREE COAXIAL CABLES RG218U FOR DECEL
 - ALL POWER CABLES OF ARMORED CONSTRUCTION
 - FIBER-OPTIC CABLES
 - 6 CABLES WITH 8 FIBERS FOR EACH HVE – TOTAL 18 FOR HVEs
- **ROUTING PROPOSED**
 - ROUTE ALL CABLES VIA TFTR TEST CELL BASEMENT, TFTR TEST CELL AND ON TO NSTX TEST CELL VIA PENETRATIONS
- **INSTALL THE TRANSMISSION LINES**
- **INSTALL AUXILLIARY POWER CIRCUITS**

NBI BL2 Upgrade Power & Controls

NBI Grounding scheme will conform to TFTR and NSTX design and operating experience

- **GROUNDING BASED ON SINGLE POINT PRINCIPLE**
- **PROVIDE 24"X18"X3/8" CU PLATE ON INSULATORS IN WEST WALL NTC**
- **CONNECT THE 500 KCMIL GROUND WIRES (FROM 2 TRAYS) TO PLATE**
- **CONNECT PLATE TO BUILDING STEEL VIA THE EXISTING TFTR TEST CELL GROUND.**
- **BEAMBOX WITH STAND TO BE INSULATED FROM FLOOR – DOUBLE BREAK**
- **TRIAx RETURN (HVE) TO BE CONNECTED TO THE SOURCE BOX PER EXISTING SCHEME**
- **PROVIDE GROUND WIRE AROUND TRANSMISSION LINE – CONNECT THIS TO THE PLATE**
- **CONNECT SOURCE BOX TO GROUND VIA THE GROUND WIRE AROUND THE TRANSMISSION LINE**
- **RUN GROUND WIRE FROM EACH HVE TO THE GROUND PLATE**
- **CONNECT THE ARMOR OF EACH TRIAX TO THE HVE IN NTC**
- **CONNECT THE ARMOR OF EACH TRIAX TO MODREG GROUND IN NBPC**
- **CONNECT HVE SEGMENTS WITH GROUND JUMPERS**
- **FOR TESTING THE GROUND WIRE CAN BE DISCONNECTED FROM GROUND PLATE AND THEN TESTED**



NBI BL2 Upgrade Power & Controls - Controls

Neutral Beam Injection Control System Work Scope

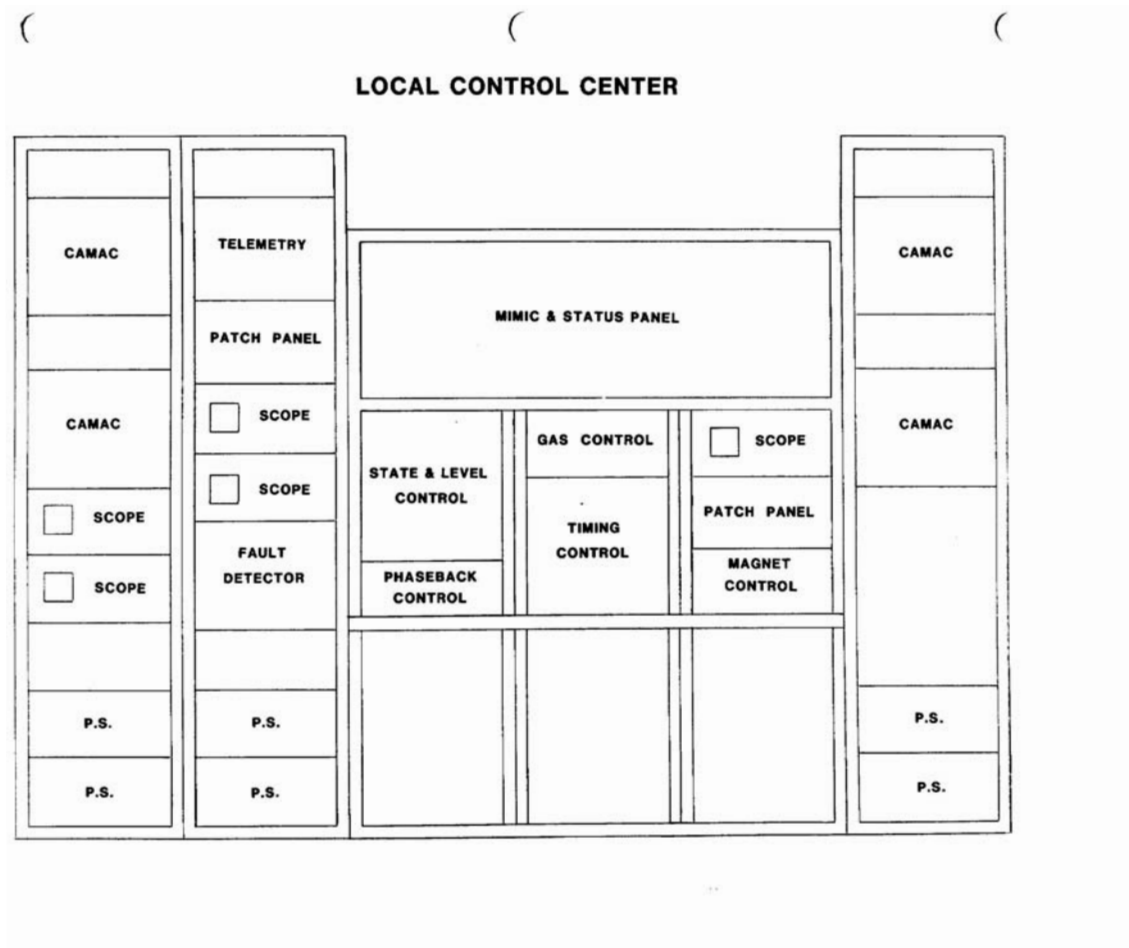


NBI BL2 Upgrade Power & Controls - NBI Operations x 2

Neutral Beam Injection Control System Work Scope very similar to BL1 with updates to current status

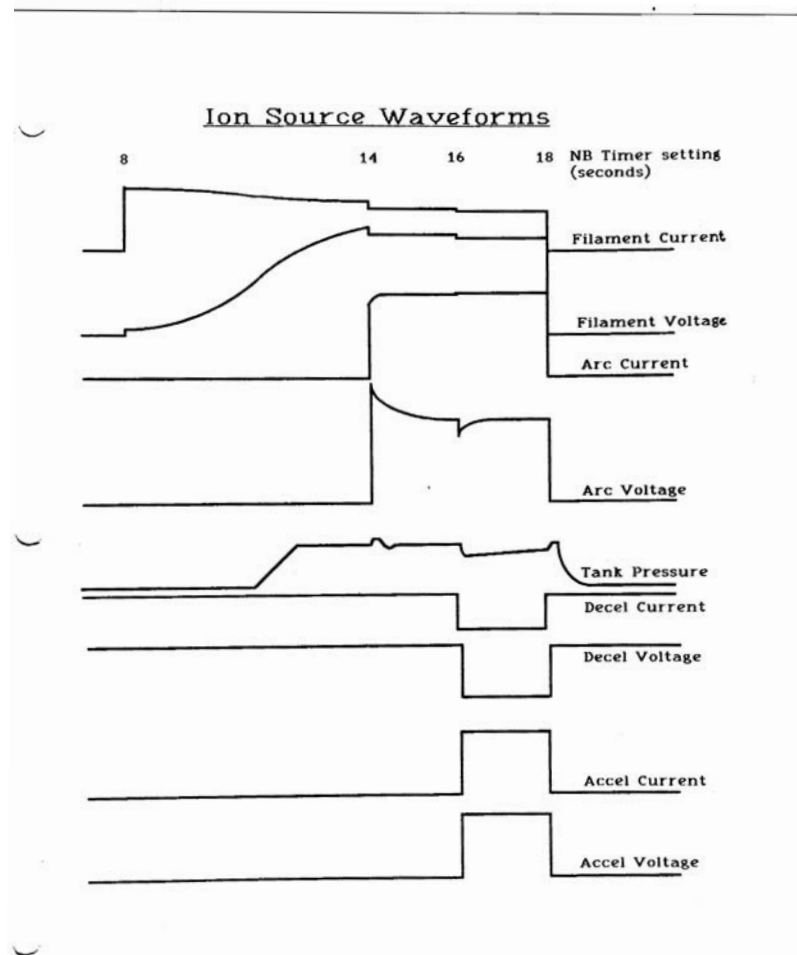
- Mimic existing NSTX BL1 Control scheme for BL2
- Reactivate N4 Local Control Centers, CAMAC, Hardwired Interlock System
- Turn BL2 Plasma Current Interlocks on (PDM chassis still in use for BL1)
- Add additional plasma interlock to prevent long pulse into armor
- Expand I/O for PLC control of BL and Services but use existing PLC
- PLC program logic similar to present BL1 control
- Add BL2 to PLC RSVIEW software pages for operator interface
- 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...

NBI BL2 Upgrade Power & Controls - NBI Operator Station



Manual control requiring operator input to manage source behavior

NBI BL2 Upgrade Power & Controls - Typical pulse

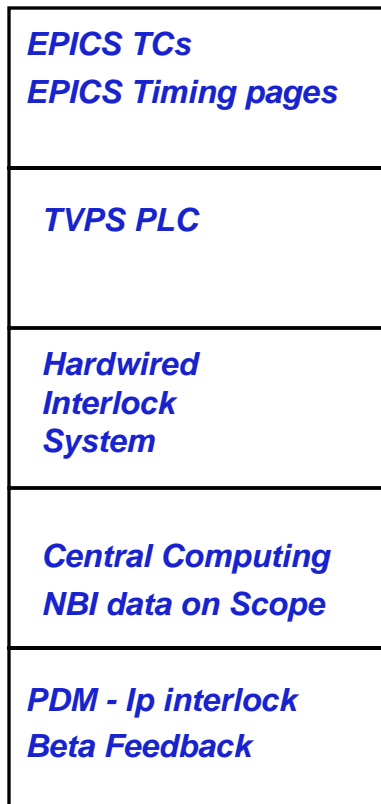
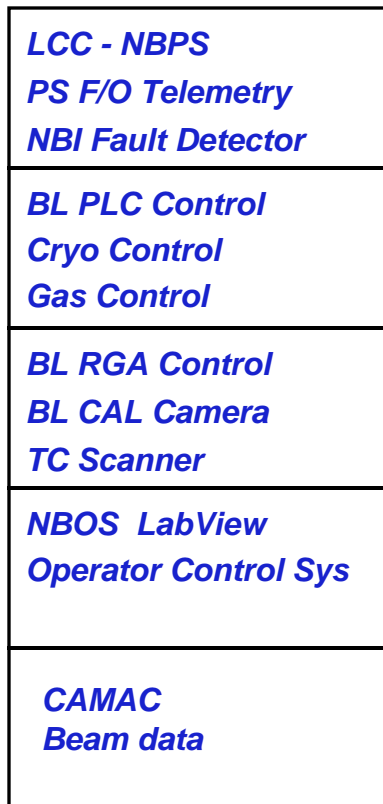


Typical NBI source waveforms for one ion source monitored and adjusted as required every source every shot by NBI Operations staff due to unregulated arc and filament supplies and emission limited ion source design

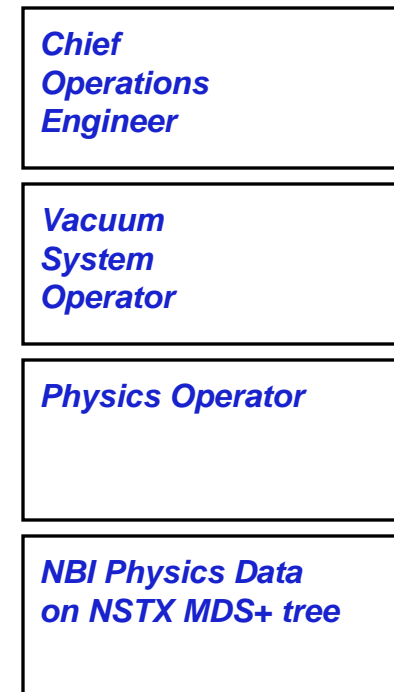
NBI BL2 Upgrade Power & Controls - Handshakes

Neutral Beam Control System & Interfaces to NSTX

NBI Ops Supervisor



NSTX Ops

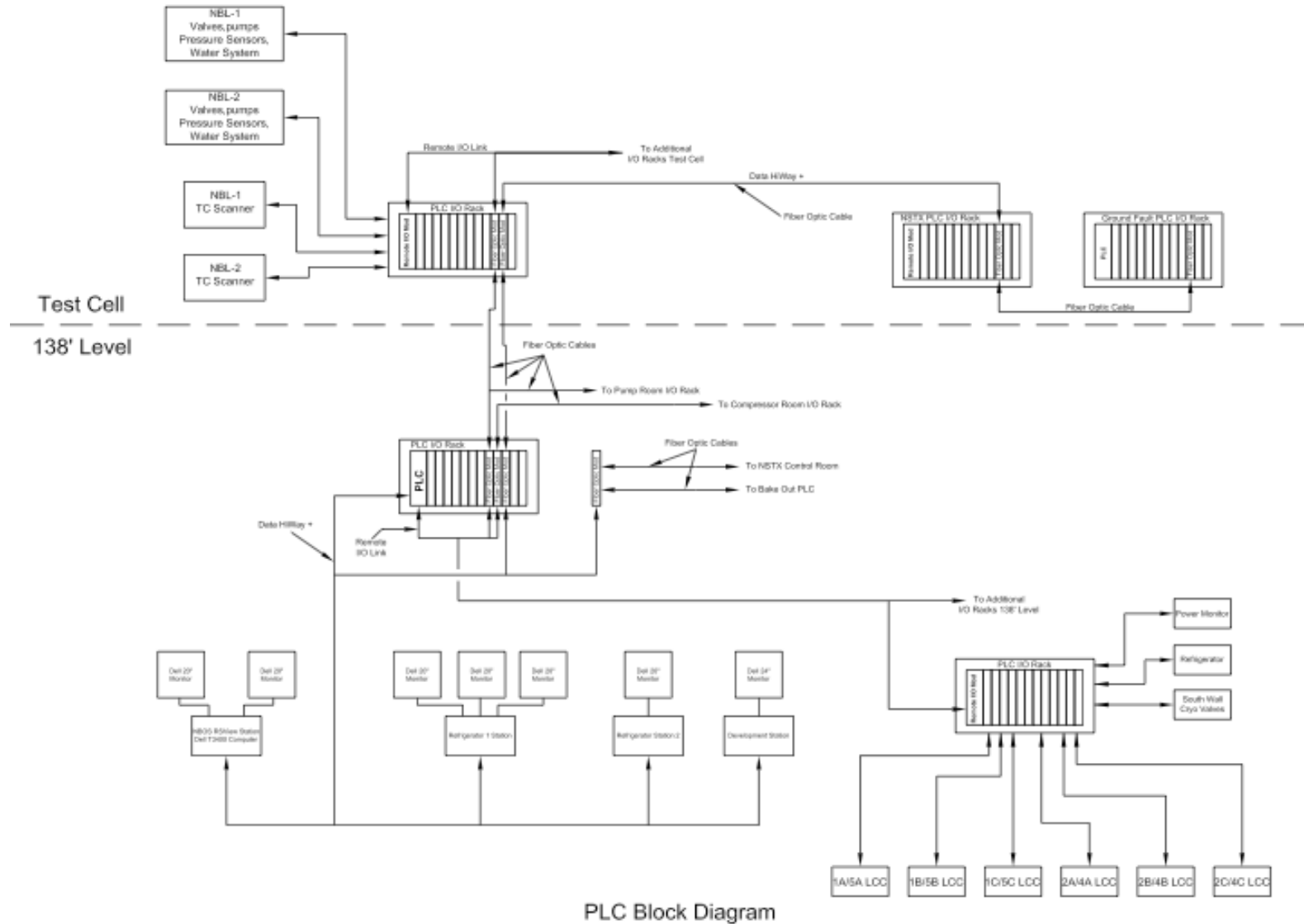


NBI BL2 Upgrade Power & Controls - Progress

- *Block Diagrams of each segment of the control scheme presented at NBI Peer Review 6/24/09*
- *Signal lists have been prepared to determine I/O requirements*
- *Drawing lists have been prepared to determine requirements for new drawings and P&IDs*
- *Rack contents and layouts have been evaluated to determine new space requirements*
- *NBOS LabView Controls will be updated to current technology like BL1*
- *Interfaces are well understood and can be replicated for BL2 control*

Controls design is under control...

NBI BL2 Upgrade Power & Controls - Many block diagrams



NBI BL2 Upgrade Power & Controls - Conclusion

- *Introduction to the NBI Power System -*
 - *Reuse major portions of N4 power supply with updates*
- *Work Scope to connect N4 NBPS ABC to BL2 ion sources - known*
- *Procurements - similar to TFTR and NSTX BL1*
- *Routing and Installation - a clear path forward identified*
- *Grounding - same or similar*
- *Introduction to the NBI Controls - repeat for BL2*
- *Work Scope to control NBI BL2 - known*

Conclusion - BL2 Power and Control design is well known and tested

And ready to run another BL again...