Central Instrumentation and Controls - WBS6

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ITD & CODAC Staff

and the NSTX Upgrade Team

NSTX Center Stack Upgrade Peer Review
LSB B318
May 18, 2011

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CompX
General Atomics
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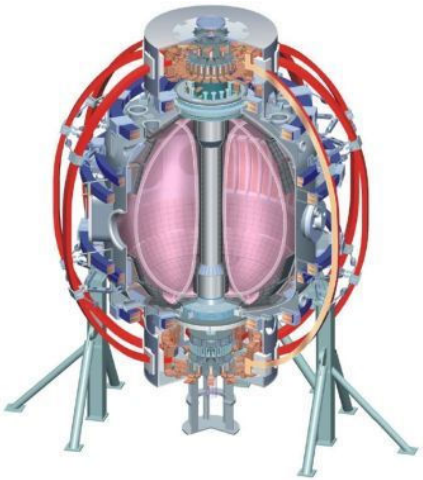

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
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NIFS
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TRINITI
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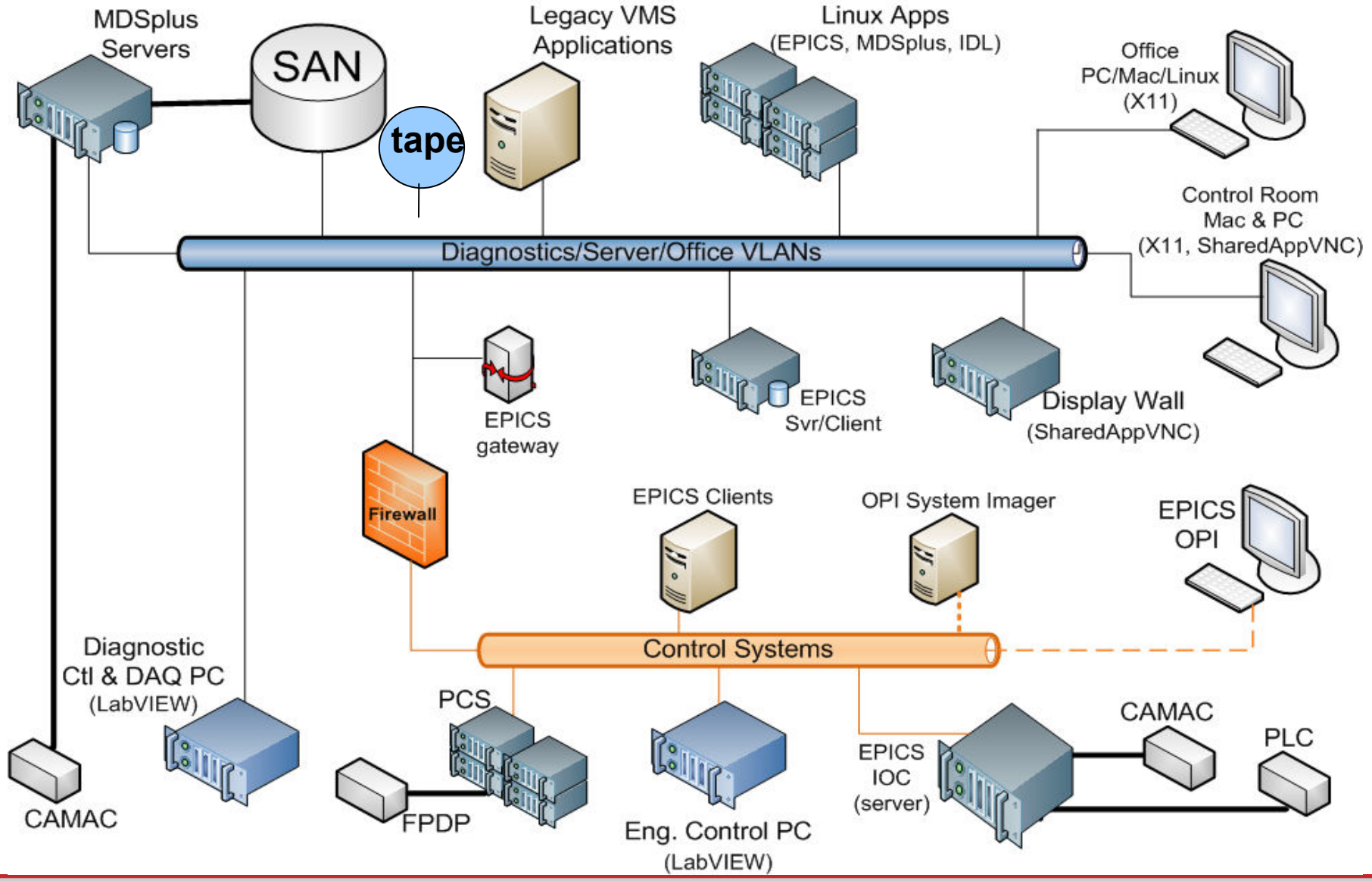
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

NSTX Computing & Data Acquisition



Overarching Requirements

- Pulse Length: The pulse length drives real-time control, data acquisition, analysis, networking, and storage.
  - Currently, a 'long' plasma lasts ~1.8 seconds.
  - GRD Design Requirement: **6.5 second plasma**.
- Quality of Service: The *timeliness* of data acquisition, analysis, and visualization should not degrade from the pre-upgrade experience.

Central I&C (WBS6) Work Breakdown

- Real-Time plasma control system.
- Data acquisition systems (mostly CAMAC).
- Networking & data management.
- Re-commission relocated racks (per 2491).
  - Communications, Controls, Timing

Real-time Control

- The current 8-core real-time system (circa 2006) is at-capacity for processing.
- The longer pulse length, additional algorithms, and I/O will overwhelm the current system.

  - Procure RT computers
  - Migrate software infrastructure to 64-bit Operating System
  - Revise software for NSTX-U specific requirements
  - Support additional Input/Output equipment

Data Acquisition: Reduce Role of CAMAC

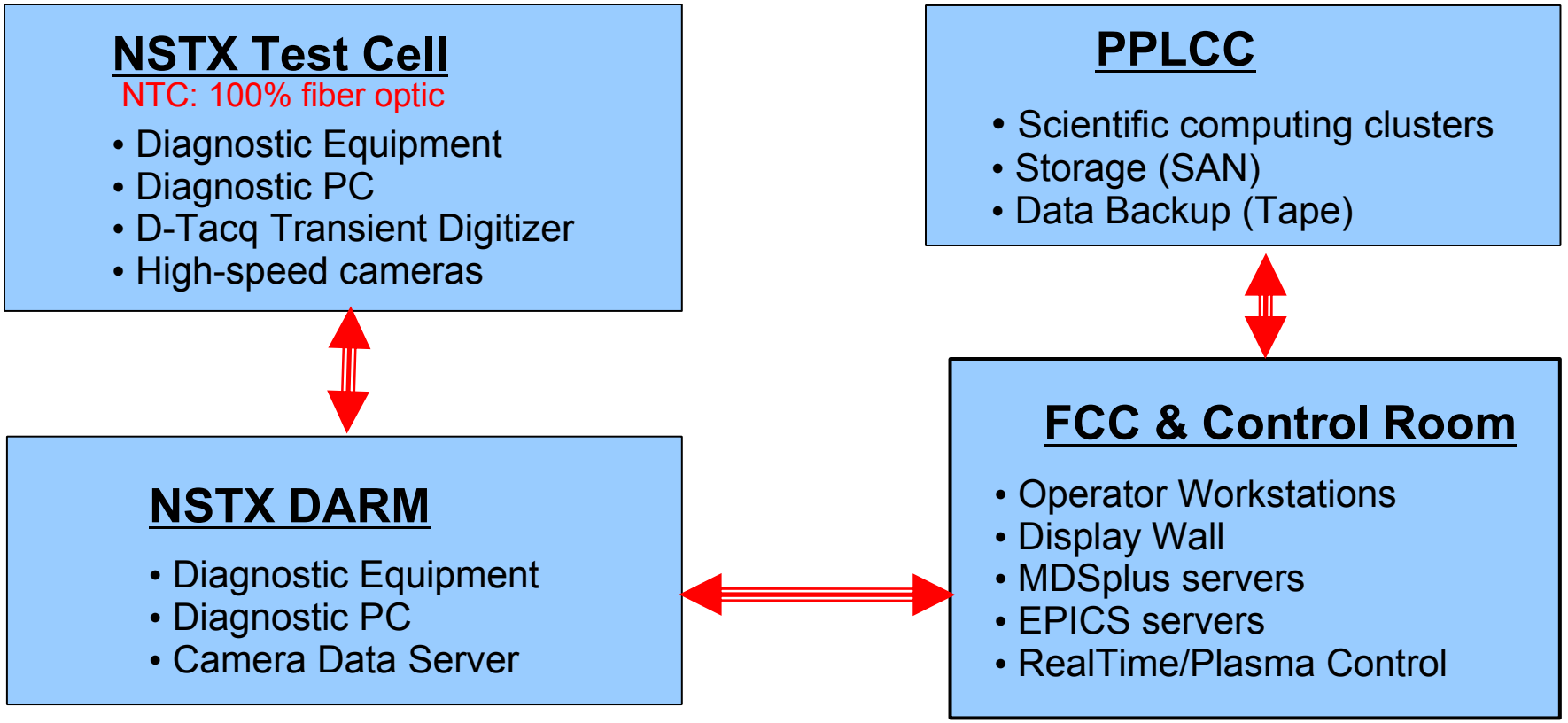
Pre-upgrade (Oct. 2010)	Post-Upgrade (Sept. 2014)
(**100**) 908/3232, (**43**) 907, (9)6810, (9) TR612	(**34**) 908/3232, (**25**) 907, (9) 6810, (9) TR612
1500 channels, 77 MB	**860** channels, 70 MB
•MDSplus ACQ: 2.5 minutes •EPIC ACQ: 7.5 minutes	•MDSplus ACQ: 2.5 minutes •EPIC ACQ: 5 minutes
	•(11) D-Tacq Networked Digitizers. •(3) PXI-based systems • (24) One Mega-sample memory boards (CAMAC)

CAMAC Transient Digitizer Replacement

- CAMAC digitizer migrations
  - (11) D-Tacq @ ~$16K each
  - (3) PXI (for NB) @ ~$20K each
  - (12) FCPC Fault Detector solution - free
- Systems designated for CAMAC upgrade
  - FCPC at Junction Area (1)
  - Magnetics (7)
  - TF Joint data (2)
  - EIES (Edge Impurity Emission Spect.) (1)
  - NBI (existing beamline) (3)

Network & Data Storage

- October 2010 baseline: 1 Gbit/sec “uplinks”.
- NSTX-U will need 10 Gbit to support 5-10x data/shot
  - 4x fewer shots/day (full power shots).
- SAN Storage and data backup infrastructure adequate.



Update Since PDR

- WAF: Labor and M&S swapped.
  - WBS **cost remains unchanged** at $836 K.
- Test Cell rack-relocation effort for *drafting* was over-estimated. This work is funded by WBS2 (2490,2491).
- CAMAC data acquisition upgrade more extensive than preliminary design.
  - Design based on detailed analysis.
  - More aggressive in response to recommendations/chits.
  - Retired risk 6100c, “Data acquisition takes too long”.
  - The final design choice (from numerous candidate systems) fell towards the more expensive end (technically superior).
  - (25) one-mega-sample CAMAC memory boards are required (prelim count was 10).

Recommendation Log

Date Ref	Item/Concern	Comment/Action	Status
200908-02	NSTX-U pulse length will increase 5x. Increasing memory of CAMAC likely does not increase speed of data read-out and archiving. Should consider options that can return data as fast as we presently archive instead of 5x longer.	Additional CAMAC replacements have been included in baseline estimate	CLOSED
200908-24	Evaluate eliminating CICADA with state of the art equipment	Eliminating all CAMAC is out of scope for the NSTXU work-scope describe in the GRD. Some CAMAC systems will be converted to modern technology in order to maintain present data acquisition performance.	CLOSED
200911-24	Consider alternate solutions to the I&C system other than CAMAC. It is old and frought with problems and difficult to debug failures. Now may be the time to replace	The GRD has been revised to specify that the post-shot data acquisition and analysis time should be the same as before the upgrade. The design presented at the PDR will consider this.	CLOSED
200911-32	Consider replacing data acquisition and I&C CAMAC systems with something more modern and reliable.	See 200911-24	CLOSED
201004-10	Is the 10Gbit/sec network required as part of the GRD?	Yes. The 10 Gbit is an implementation to satisfy the requirement that data acquisition, analysis, and visualization should not be degraded (in light of 4x data load).	CLOSED
201004-15	Resolve I&C requirements. Paul should estimate scope as presented and resolve during a WAF review meeting.	WAF updated and reviewed prior to PDR.	CLOSED

Risk Registry

Updated	Number	Risk Description	Mitigation Plan/Impact	Deadline to retire risk	Cost incurred plan	Status	likely hood	Cost impact ($K)
12/08/09	6100a	Volume of data from diagnostic camera systems exceed capability of network, storage, and backup systems	Install 10 Gb networks and enhance storage and backup systems	FY10 PDR	FY13	RETIRED	U	30 to 200
12/08/09	6100b	EPICS data acquisition takes too long	Include in the base job the upgrade of some data acquisition systems (CAMAC)	FY10 PDR	FY13	RETIRED	VL	10 to 100
12/08/09	6100c	Data acquisition takes too long	Upgrade additional data acq systems and/or networks, revise software	FY11 FDR	FY11	RETIRED – *pending 5/17/2011*	VU	5 to 25
07/25/10	6100d	Loss of key personnel	Assure project **schedule has free float to absorb potential schedule impact**. Hire replacement and assess schedule impact	CD-4	FY14	open	U	10 to 50
07/25/10	6100e	NSTX operations does not fund work scope as listed in WBS6100 PDR	Continued diligence to assure the program office funds req'd infrastructure improvements. Additional work scope for upgrade	CD-4	FY14	open	U	50 to 300

WBS6 Cost & Schedule

- Cost: $836K
  - Additional $450K *required workscope* in 'Operations‘ (detail in Supplemental section)
- WBS6 Schedule
  - Final Design Review June 2011
  - Work on-hold until Summer 2013
    - WBS6 post-hold Peer Review May 2013
  - WBS6 ready for ISTP Aug. 2014
    - ISTP sched Sept. 2014
    - Only ~1 month sched. Contingency.

Summary

- The Central Computing and Controls WAF is complete and integrated into the upgrade project's Resource Loaded Schedule.
- The estimate was developed by an experienced engineering staff with specialized knowledge in Plasma Control, EPICS, and MDSplus software.
- NSTX Operations has committed to fund computing and control upgrades that are required for a successful NSTX-U project.

Supplemental

Basis of Estimate

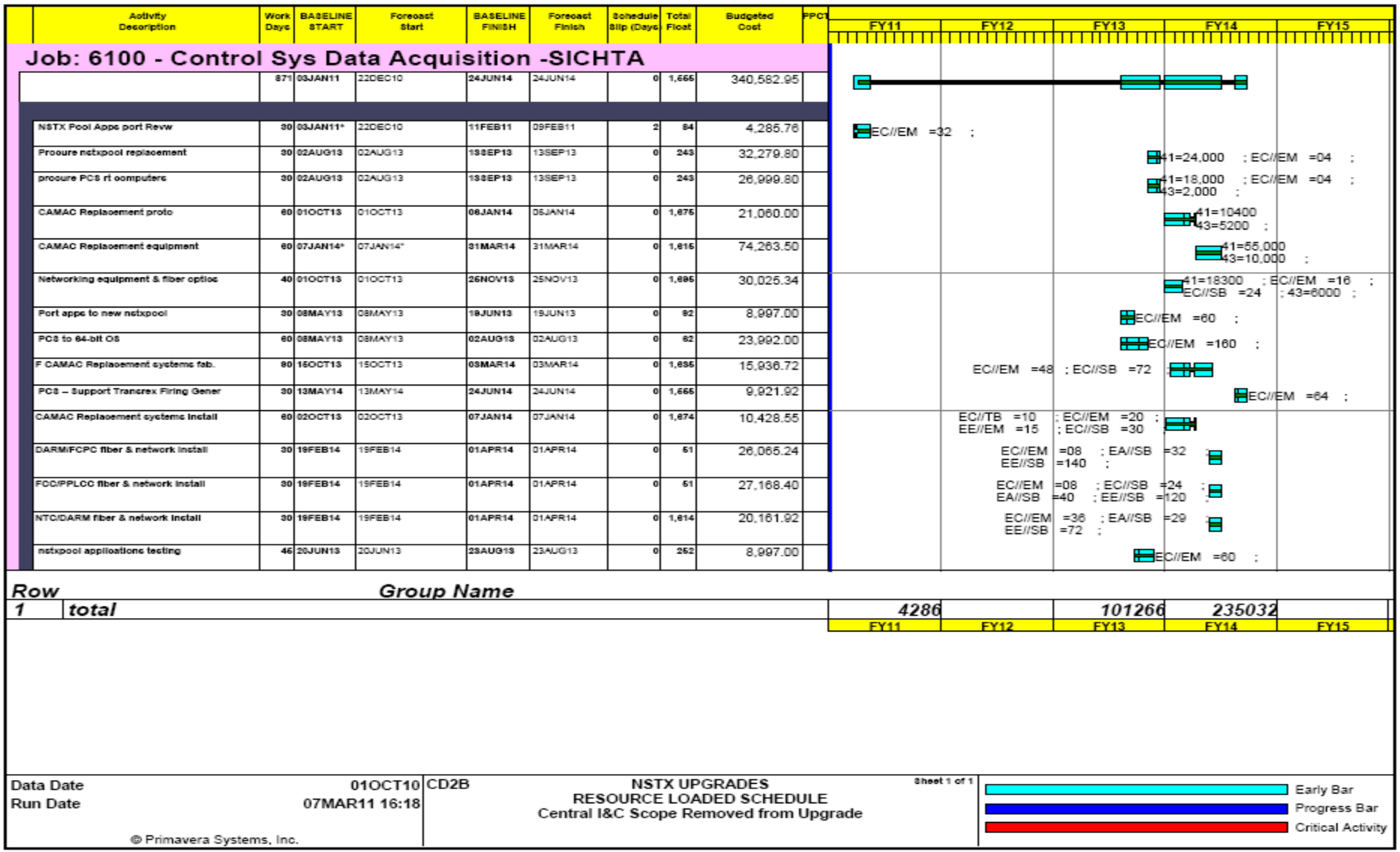
- Follow established NSTX-U project methods
  - Detailed Work Approval Form (WAF) developed including task descriptions, labor estimate by demographic, M&S detail, key risks and uncertainty.
  - WAF incorporated into project Resource Loaded Schedule (RLS).
- Catalog prices and prior purchases
- Similar tasks previously executed
- Engineering judgment

Required NSTX-U Workscope funded by Operations

These would likely occur regardless of NSTX-U. Total ~$400 K

- PCS real-time computer upgrade (more CPU/cores)
- PCS real-time software port to 64-bit OS (memory > 4 GB)
- FPDP_IO support for digital (Transrex) Firing Generator
- Diagnostic CAMAC replacements
- EPICS CAMAC acquisition speedup
- 10 Gbit networking
- Upgrade nstxpool computers

Required NSTX-U Workscope provided by Operations



Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT
Job: 6100 - Control Sys Data Acquisition -SICHTA									
	871	03JAN11	22DEC10	24JUN14	24JUN14	0	1,665	340,582.95	
NSTX Pool Apps port Revw	30	03JAN11*	22DEC10	11FEB11	09FEB11	2	84	4,285.76	
Procure nstxpool replacement	30	02AUG13	02AUG13	13SEP13	13SEP13	0	243	32,279.80	
procure PCS rt computers	30	02AUG13	02AUG13	13SEP13	13SEP13	0	243	26,999.80	
CAMAC Replacement proto	60	01OCT13	01OCT13	06JAN14	06JAN14	0	1,675	21,060.00	
CAMAC Replacement equipment	60	07JAN14*	07JAN14*	31MAR14	31MAR14	0	1,615	74,263.50	
Networking equipment & fiber optics	40	01OCT13	01OCT13	26NOV13	25NOV13	0	1,695	30,025.34	
Port apps to new nstxpool	30	08MAY13	08MAY13	19JUN13	19JUN13	0	82	8,997.00	
PCS to 64-bit OS	60	08MAY13	08MAY13	02AUG13	02AUG13	0	82	23,992.00	
F CAMAC Replacement systems fab.	80	15OCT13	15OCT13	03MAR14	03MAR14	0	1,695	15,936.72	
PCS – Support Transrex Firing Gener	30	13MAY14	13MAY14	24JUN14	24JUN14	0	1,665	9,921.92	
CAMAC Replacement systems install	60	02OCT13	02OCT13	07JAN14	07JAN14	0	1,674	10,428.55	
DARM/FCPC fiber & network install	30	19FEB14	19FEB14	01APR14	01APR14	0	51	26,065.24	
FCC/PPLCC fiber & network install	30	19FEB14	19FEB14	01APR14	01APR14	0	51	27,168.40	
NTC/DARM fiber & network install	30	19FEB14	19FEB14	01APR14	01APR14	0	1,614	20,161.92	
nstxpool applications testing	46	20JUN13	20JUN13	23AUG13	23AUG13	0	252	8,997.00	

Row	Group Name	FY11	FY12	FY13	FY14	FY15
1	total	4286		101266	235032	

Data Date 01OCT10
Run Date 07MAR11 16:18

CD2B

NSTX UPGRADES
RESOURCE LOADED SCHEDULE
Central I&C Scope Removed from Upgrade

Sheet 1 of 1

Early Bar
Progress Bar
Critical Activity

GRD Excerpt

3.6 Central Instrumentation & Control (I&C) System (WBS 6)

a. The Central I&C system shall provide the same functionality as existing except for the change in pulse length and repetition period. To accommodate the full interval of coil current rise and fall the time interval of real time control of the plasma and power suppliesshall be extended to 10s. Nominal repetition period in this mode of operation shall be 2400s, upgradeable to 1200s as described in section 2.4.

b. The baseline set of individually controlled power supply circuits is the same as the existing NSTX device. However, feedback control of individual branches of the TF converter will be necessary, adding to the number of measurements and feedback loops to be managed by the real time control. The details of this requirement will be determined during the design process.

c. With the future addition of the PF1BU, PF1CU, and PF1CL circuits, the real time power supply control shall be expandable to include these three additional measurement and feedback loops.

d. Other control, monitoring, and data recording-analysis-management services provided by Central I&C, which includes some diagnostics, shall be upgraded to accommodate a 5 second plasma.

e. The time required for post-shot data acquisition and the presentation of between-shots analysis shall be comparable to the pre-upgrade time.

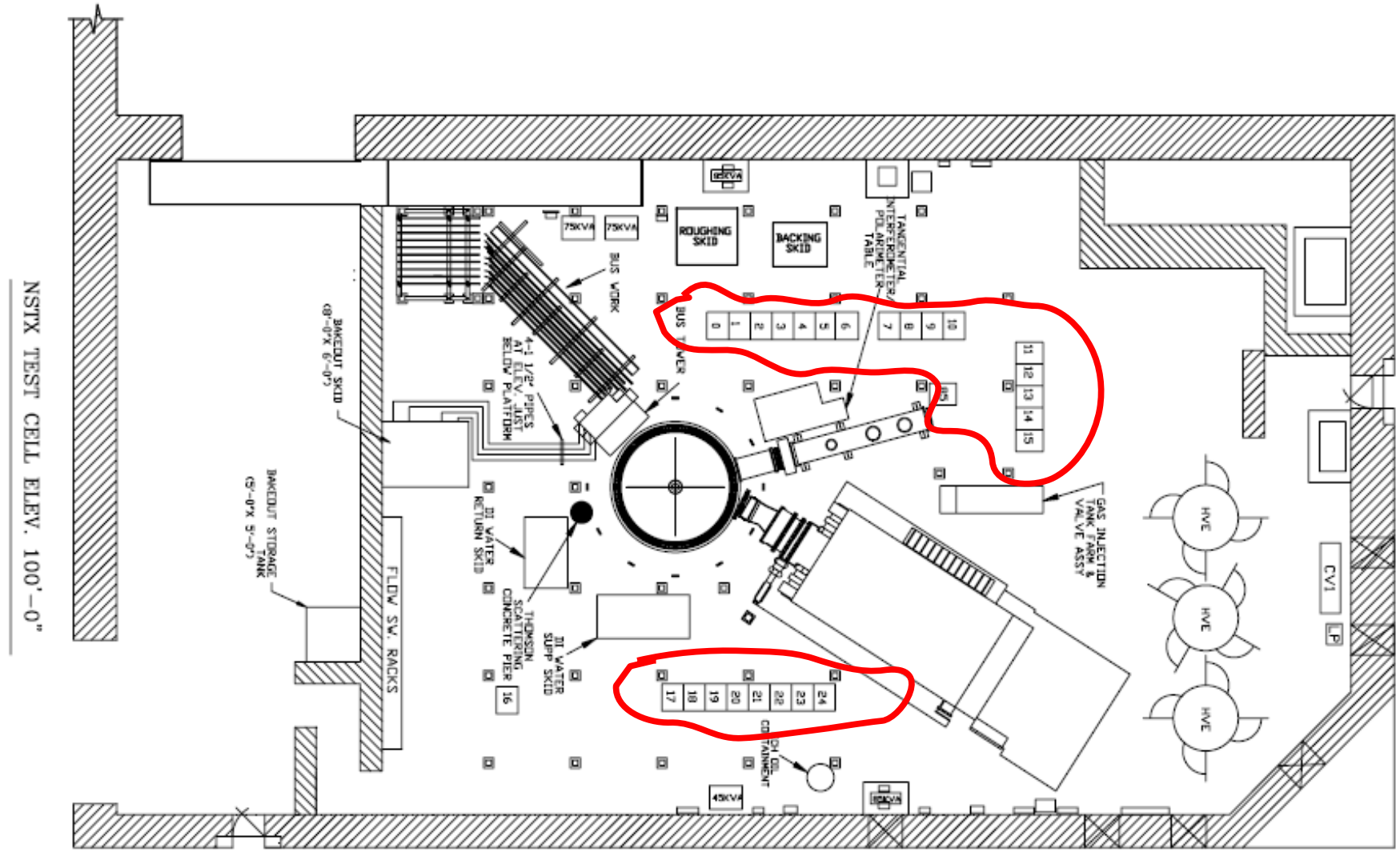
Central Computing Tasks in support of longer plasma pulse

Real time plasma control	•Longer control period. •Additional algorithms and I/O (2nd NB).
CAMAC data acquisition	•Migrate selected systems to newer technology. •Develop 1 MegaSample Memory board. •Improve CAMAC data acquisition performance. •Deploy UNT Clock Receivers.
Data acquisition and management (currently <10 GB/shot)	•Data load up 5-10x •Buy more disks •Improve networking •Upgrade nstxpool & MDSplus services
NSTX networking	•Deploy 10 Gbit/sec networks
NTC Rack Moves	•Rack moves covered in WBS2 "No engineering required". •Support designers.
Center Stack Thermocouples	16 additional Class 3 TC's

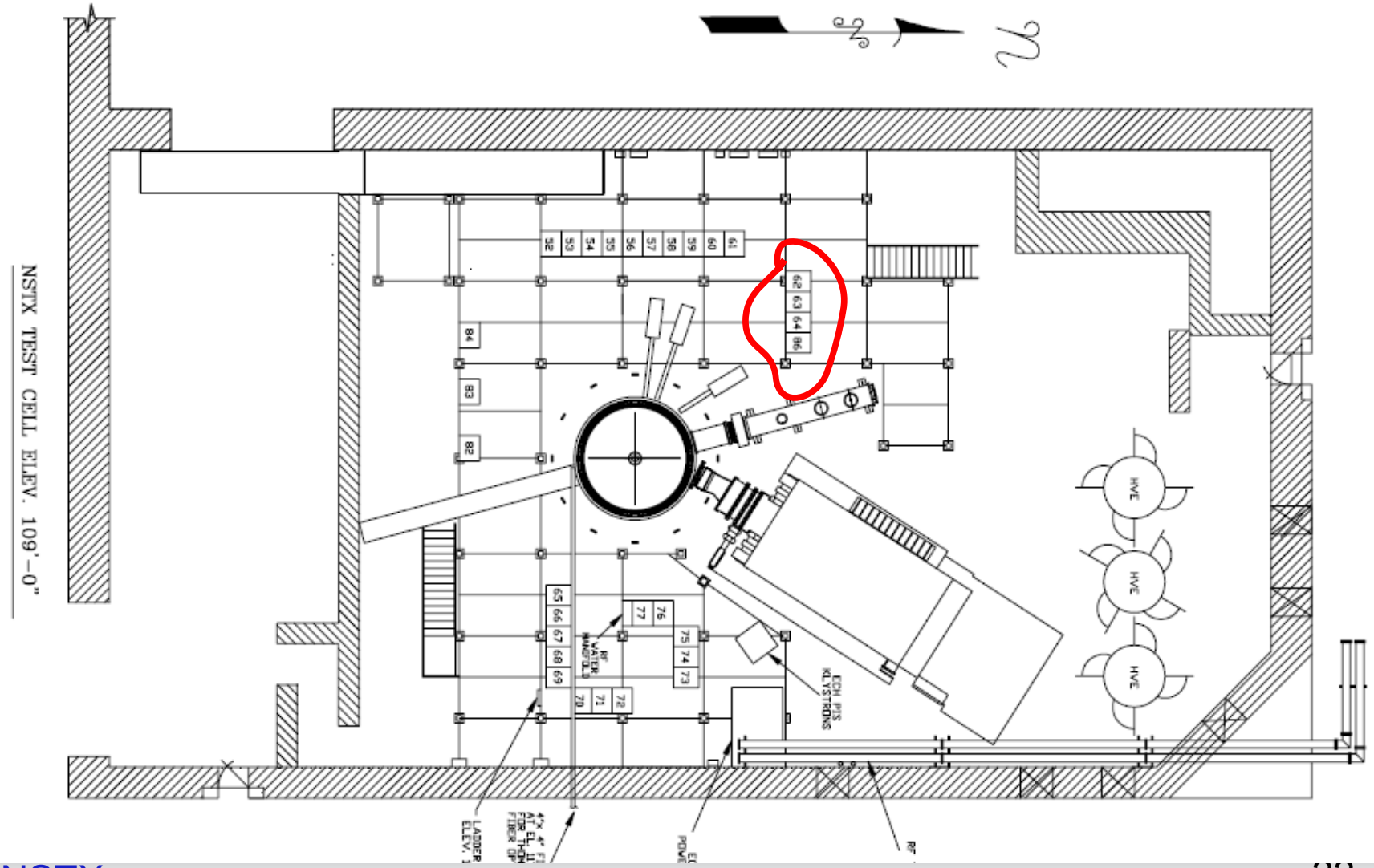
Data Acquisition, Data Storage and Management

Issue	Approach
CAMAC Memory - The CAMAC crates do not have room for more memory modules.	Develop a (high-density) 1 megasample CAMAC memory module
CAMAC serial Highway - The throughput is too low.	Reduce the amount of CAMAC data by migrating selected CAMAC-based systems to current technology-based data acquisition systems.
Camera-based diagnostics' data acquisition and file transfer timeliness exceeds the present capability.	Upgrade the networking and computing capability of the present systems.
Post-shot data analysis and visualization timeliness exceeds the present capability.	Upgrade the networking and computing capability of the present systems.
EPICS CAMAC acquisition slow	Reduce CAMAC data load, improve software, upgrade IOC servers.
5-10x data per shot will place additional burden on IT Division infrastructure for data storage (SAN) and data backup systems	•Issue somewhat mitigated because of 4-5x fewer shots (45 min. between full power shots). •For operations: consider adding intteligence to data acquisition to acquire limited data for shorter shots.

NTC Rack Moves - 100' level

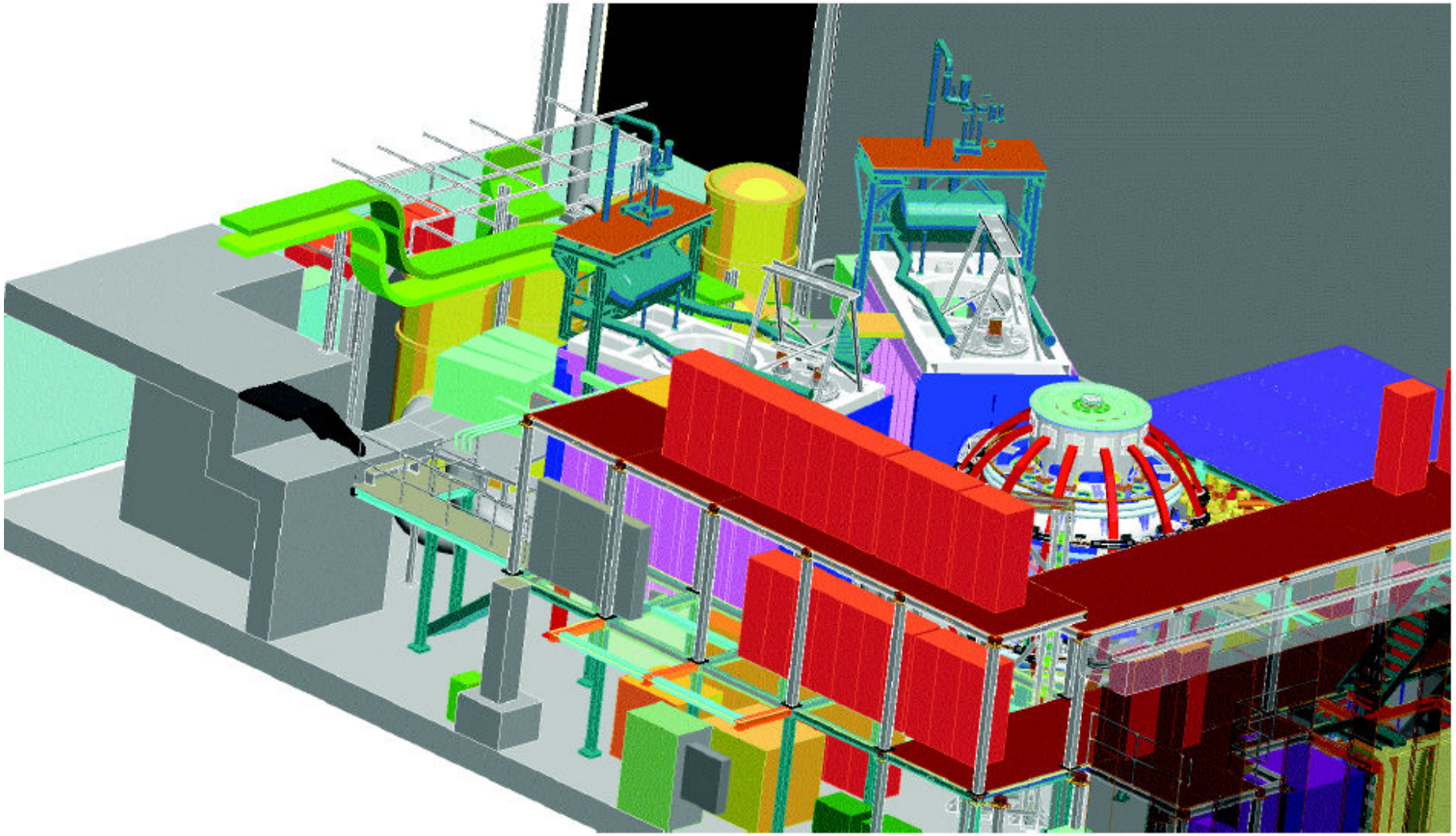


NTC Rack Moves - 109' level



NSTX with BL 1&2 in NTC

Job 2450



Center Stack Thermocouples

- In addition to the former CS thermocouples (TC)
  - (16) new Type “E” TC
  - CWD's forthcoming from Kaita/Tresemer
- I&C workscope:
  - Add H359 Instr. Ampl. module to class3 TC CAMAC crate
  - Revise CAMAC dwg A-AE1026
  - Revise EPICS databases, displays, SNC program, trending/archiving.