NSTX-U

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Control and Data Acquisition Upgrades for NSTX-U

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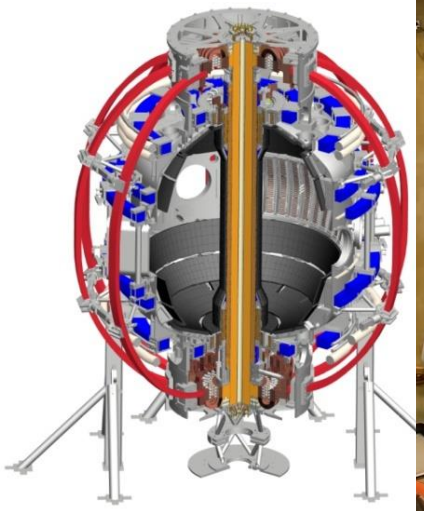
and the NSTX-U Research Team



Tenth IAEA Technical Meeting on
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Abstract Number 146

Abstract

The NSTX Upgrade (NSTX-U) Project consists of major components which allow a **doubling of the toroidal field** strength (to 1T), a **doubling of the Neutral Beam heating power** (to 12MW), and substantial structural enhancements to withstand the increased electromagnetic loads. The larger forces on the coils will be protected by a **Digital Coil Protection System**, which requires demanding real-time data input rates, calculations and responses.

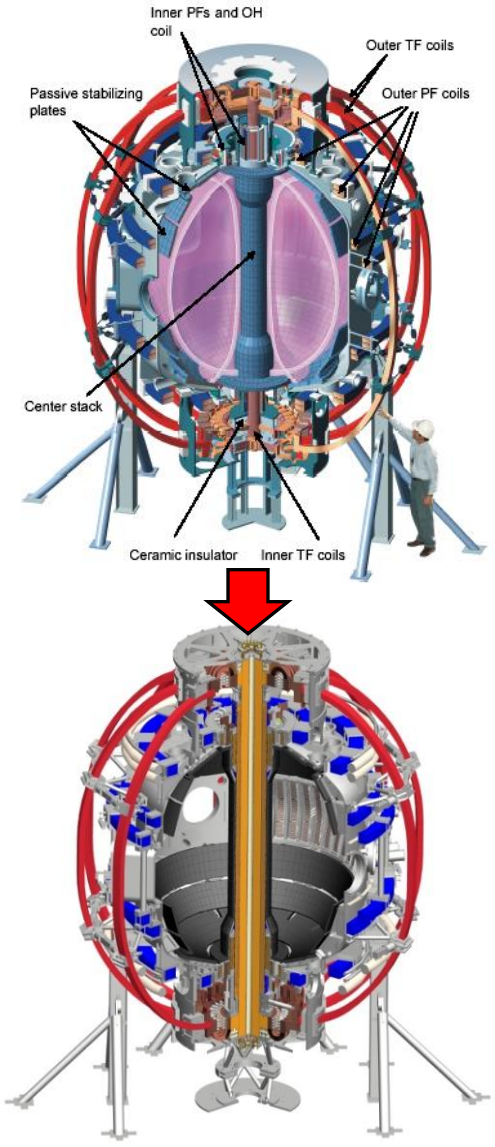
The maximum **pulse length will increase from 1.5 s to 5 s**. The amount of fluctuation data will increase from 2.5 to 5 GB per second. 2-D Fast Camera data is expected to go from 2.5 GB/shot to 10, and another 2 GB/shot is expected from new IR cameras. The **total amount of data acquired per shot will increase by an order of magnitude**, at least.

Our network capacity been increased by a factor of 10, with **10 Gb/s fi**bers used for the major trunks.

The number of **cores in Linux computers** used for between-shot data processing **will increase from 58 to 194**. We will be able to finish TRANSP runs between-shot for better analysis of the plasma performance..

Our **single MDSplus server will be expanded into a multiple node system** that will provide failover and performance benefits. The incorporation of a faster SAN disk array as well as other architectural changes will make acquired data available more rapidly and increase the number of simultaneous connections that can be supported. Improvements to the **MDSplus events subsystem** will be made through the use of **both UDP and TCP/IP based methods** and the addition of a dedicated “event server” to better compartmentalize this functionality.

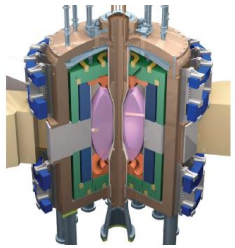
NSTX upgraded to NSTX-U



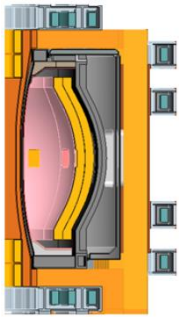
- NSTX, a medium sized Spherical Tokamak, ran from 1999 to 2010.
- US$94M upgrade over 3 years just about complete
- Toroidal field strength will go from 0.55 T to 1 T
- Neutral Beam heating power will go from 6 MW to 12 MW (HHFW remains at 6 MW)
- The maximum pulse length will increase from 1.5 s to 5 s.
- The maximum plasma current will increase from 1 MA to 2 MA

NSTX-U research targets predictive physics understanding needed for fusion energy development facilities

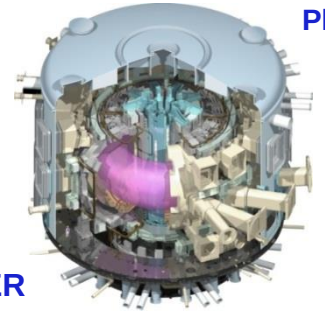
- Enable key ST applications
  - Move toward steady-state ST FNSF, pilot plant
  - Close key gaps to DEMO
- Extend understanding to tokamak / ITER
  - Leverage ST to develop predictive capability



Fusion Nuclear Science Facility (FNSF)



ST Pilot Plant



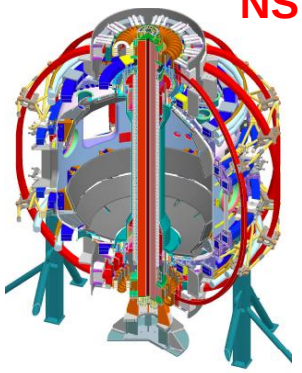
ITER

Present Research

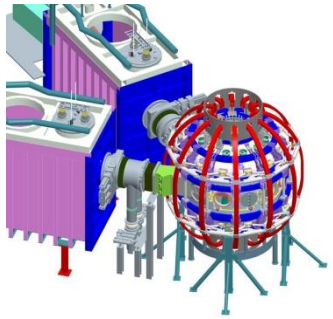
- Develop key physics understanding to be tested in unexplored, hotter ST plasmas
  - Study high beta plasma transport and stability at reduced collisionality, extended pulse
  - Prototype methods to mitigate very high heat/particle flux
  - Move toward fully non-inductive operation

Menard, IAEA FEC Meeting, 2012

NSTX-U

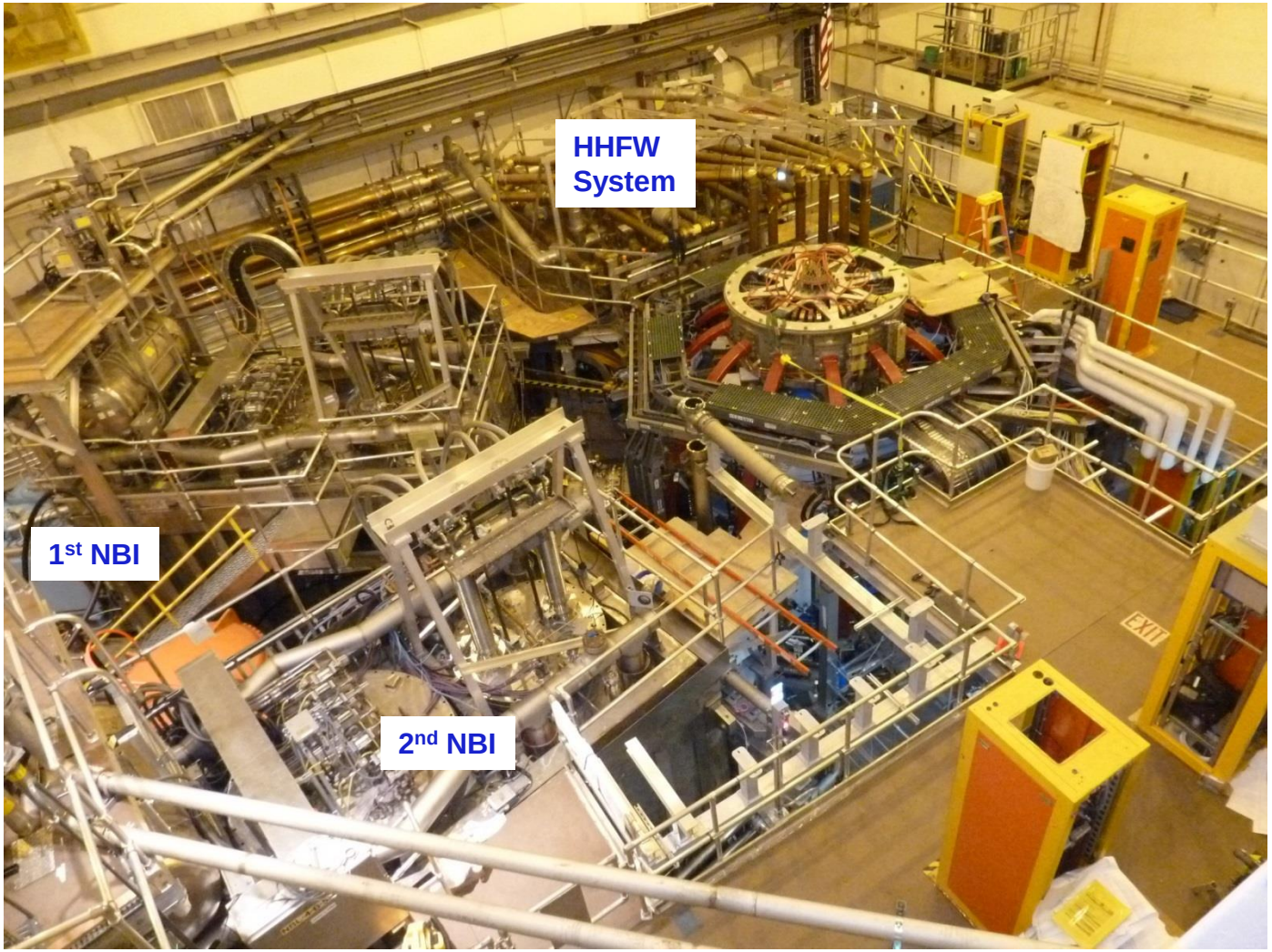


New center-stack

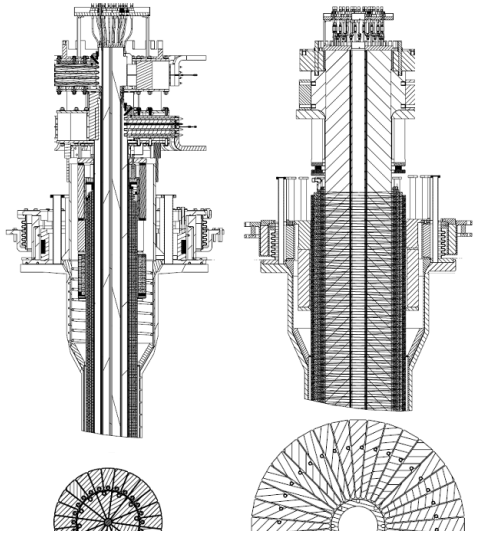


2nd Neutral Beam

NSTX-U Heating Systems

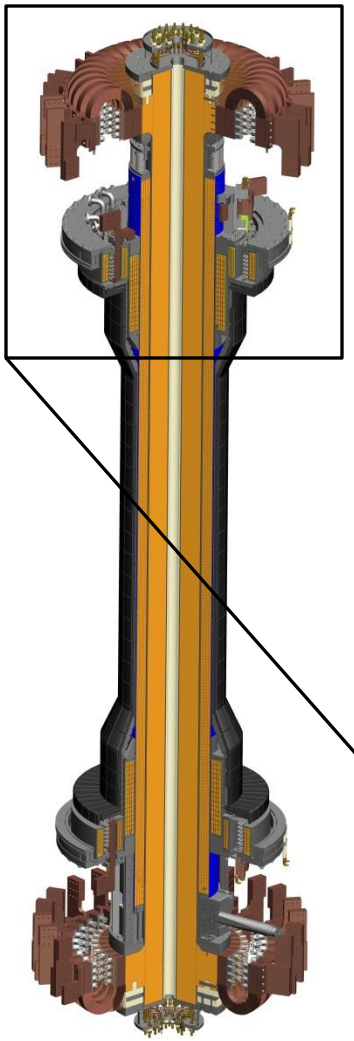


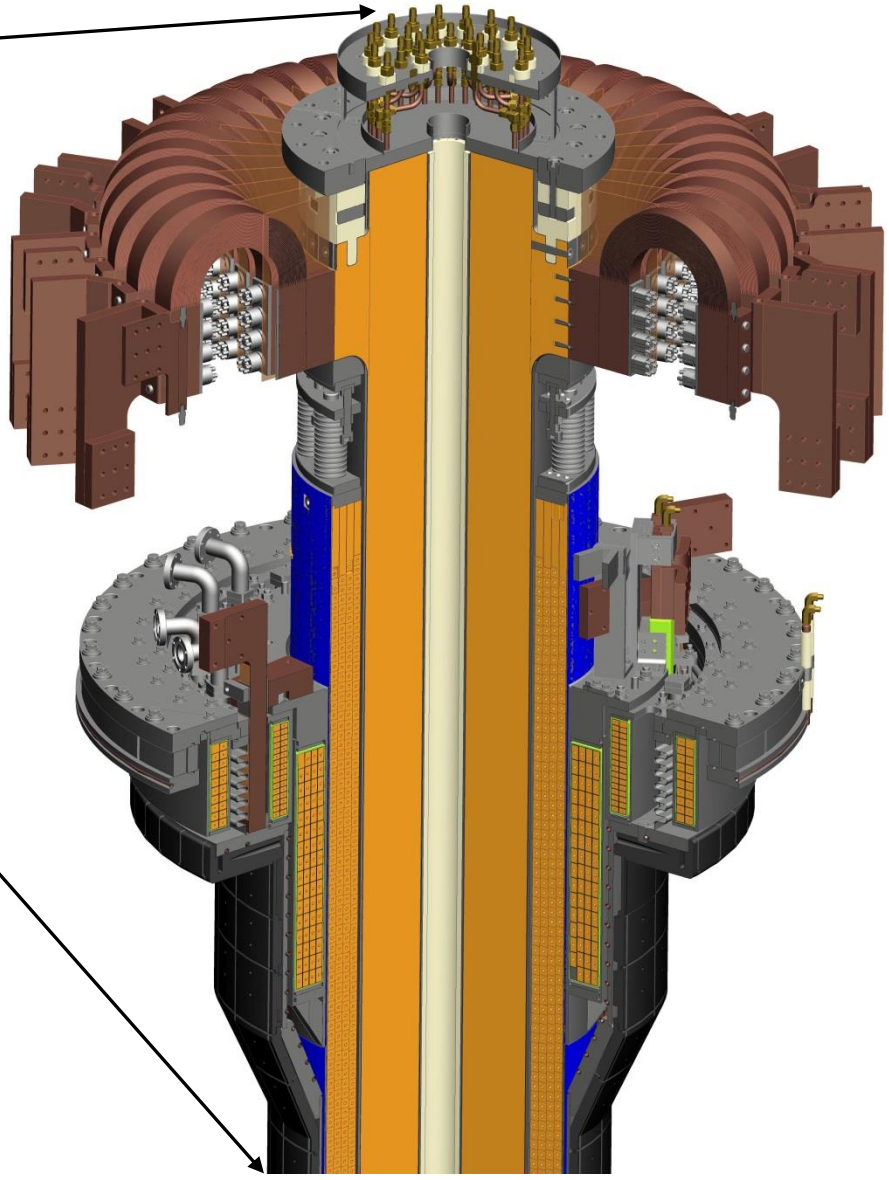
Center Stack Upgrade



Old Center Stack

New Center Stack





Major computer-related upgrades for NSTX-U

- Digital Coil Protection System[1], a new real-time system
- Network trunks increased from 1 Gb/s to 10 Gb/s.
- 300 TB added to our Hitachi SAN array
  - Expecting a 2x increase in fluctuation data
  - Expecting a 4x increase in Fast 2-D and IR Camera data
- 4x increase in between-shot processing power, plus the ability to get results from TRANSP code between shots

After the construction phase is certified (DoE Critical Decision 4):

- Upgrade to version 6 of MDSplus
- Upgrade to RHEL 6
- Upgrade MDSplus server host
- Reconfigure internal VLANs to avoid Internal Firewall

1 – see K. Erickson presentation, abstract 157

Increasing quantities of data, users, and computer resources from NSTX to NSTX-U

	NSTX 2010 run	NSTX-U 2015 est.	2018 est.
Max pulse length (sec)	1.5	3.5	5
Fast Camera data/sec (GB)	2.5	10	40
IR Camera data/sec (GB)	0.1	2	8
Fluctuation data/sec (GB)	2.5	5	20
Total GB for typical pulse	5	17	68
Total GB for max pulse	8	60	340
run days/year	100	75	75
pulses of interest	4000	3000	2025
Concurrent users	50	60	80
Diagnostic systems	45	52	65
Linux CPU cores for between shot processing	58	194	776
Cores for Real-time processing	8	64	

Camera-based diagnostics are increasing

- Fast 2-D Camera data is an important source of understanding the plasma behaviour
  - macroscopically (full vessel view)
  - edge turbulence
  - Divertor studies
- IR camera data is increasing on NSTX-U
  - Understanding heat transport is critical for confinement and plasma-material interface (PMI) issues in ITER and beyond
  - The ST is well suited for these studies
  - NSTX-U plans new lithium studies and divertor technology

Camera types contributing the most data

Camera Type	Typical MB/pulse	Max MB/pulse	Mega Pix/sec	Max. Resol.	Bits/ pixel
Phantom 7.3 (2@)	1000	4000	3000	800x600	14
Phantom 710 (2@)	1000	10000	7000	1280x800	12
Phantom v1211	2000	12000	12000	1280x800	12
Miro 4	350	1000	600	800x600	12
Miro 2	50	2000	300	640x480	12
SBF 161 (2@)	500	750	26	128x128	14
FLIR Tau 2 (2@)	110	110	20	640x512	14
IDS UI-5240CP-NIR	43	43	60	1280x1024	10
Dalsa GigE Vision Spyder 3 (8@)	75	75	40	1024	12
Princeton Instruments ProEM GigE 1600x400	28	28	380	1600x400	16
Princeton Instruments ProEM GigE 1600x200	20	20	370	1600x200	16
Princeton Instruments CCD w/PCI Spec-10	27	27	130	1340x100	16

Camera Types used by NSTX-U Diagnostic

DIAGNOSTIC	CAMERA	ACQUISITION SOFTWARE
lower divertor fast IR	Santa Barbara Focalplane SBF 161	
upper divertor fast IR	Santa Barbara Focalplane SBF 161	
wide-angle, lower divertor IRTV	FLIR Tau 2	
Tangential RF Antenna IRTV	FLIR Tau 2	
Bay F - lower divertor tangential camera	Phantom73-8032	LabView
Multi-Point Thomson Scattering	IDS UI-5240CP-NIR GigE Camera	Visual Basic
Bay E - top divertor camera	Vision Research Phantom 710	LabView
Bay J - top divertor camera	Vision Research Phantom 7.3	LabView
Bay H - bottom divertor camera	Vision Research Miro 4	LabView
Bay I - top TWICE camera	ThermoScientific CID Camera	Python, already developed and tested on LTX
Bay L / Bay I- midplane camera - TBD	ThermoScientific CID Camera	Python, already developed and tested on LTX
Bay G - midplane ENDD camera	DALSA Camera	LabView
New LLNL Phantom camera	Vision Research Phantom v1211	LabView
1D CCD arrays	Dalsa GigE Vision Spyder 3 camera	Need to develop, Python + ActiveGigE
Divertor SPRED (VUV spectrometer)	Princeton Instruments ProEM GigE 1600x200	Winspec+LabView, need to modify, consider Python
Divertor Control Spectrometer	Princeton Instruments ProEM GigE 1600x400	Winspec+LabView, need to modify, consider Python
DIMS (Divertor UV-VIS imaging spectrometer)	Princeton Instruments ProEM GigE 512x512	Winspec+LabView, need to modify, consider Python
VIPS2 (Survey UV-VIS spectrometer)	Princeton Instruments CCD w/PCI Spec-10	Winspec+LabView, need to modify, consider Python
Loweus EUV spectrometer	Princeeton Instruments CCD w/USB2 Pixis XO 100B	Winspec+LabView, need to modify, consider Python
Xeus EUV spectrometer	Princeeton Instruments CCD w/USB2 Pixis XO 100B	Winspec+LabView, need to modify, consider Python
MonaLisa EUV spectrometer	Princeeton Instruments CCD w/USB2 Pixis XO 100B	Winspec+LabView, need to modify, consider Python
Upper Divertor UV-VIS-NIR (survey spectrometer)	Princeton Instruments ProEM CCD	
Gas Puff Imaging	Vision Research Phantom 710	LabView
Plasma TV (full vessel)	Phantom Miro 2	LabView

Computer enhancements

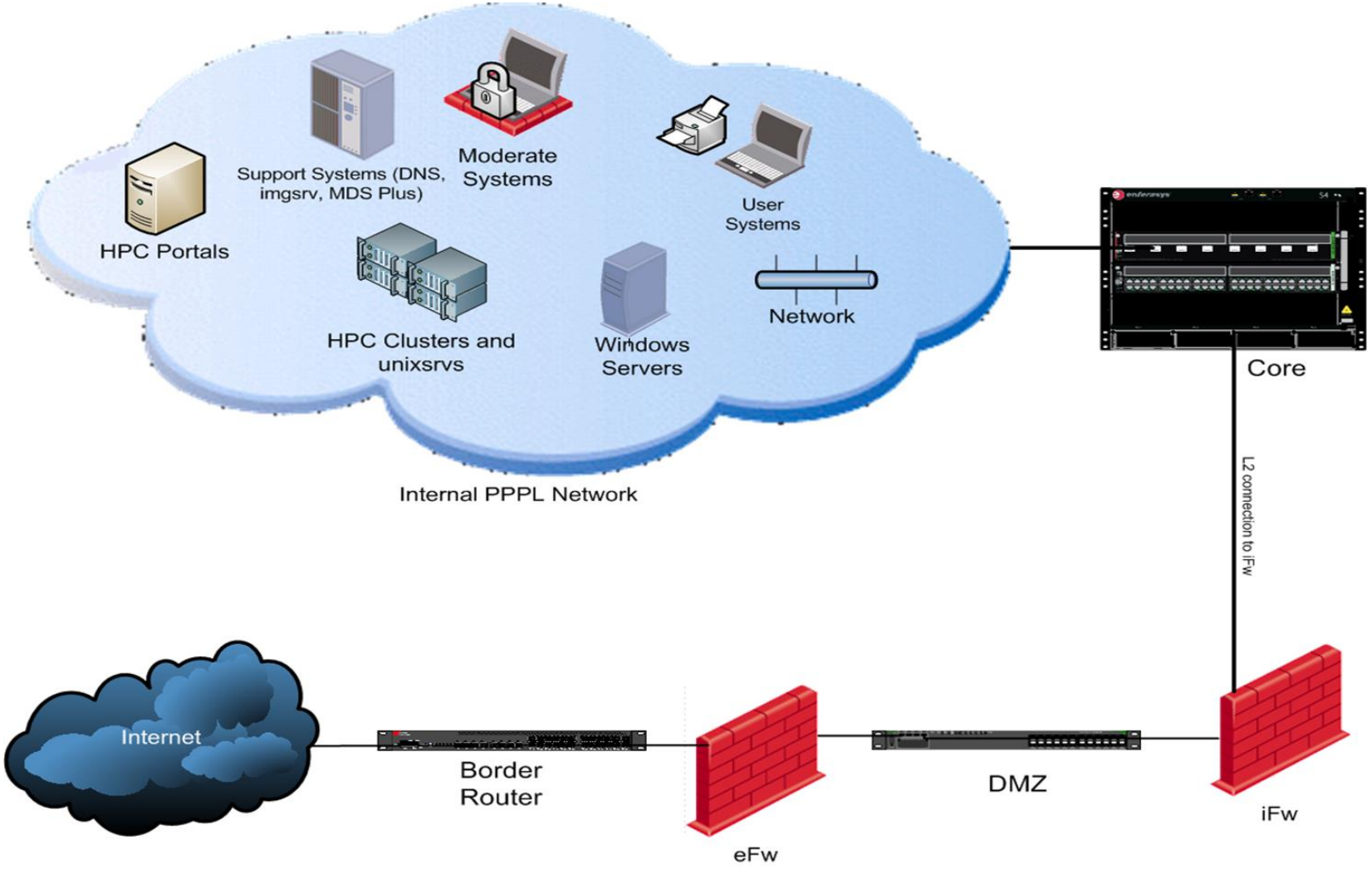
- # of cores for between-shot processing doubles every 2 years
- Real-time processing power increasing even faster
- 32-core system added for between-shot TRANSP
- MDSplus data server upgrade planned:
  - Dell PowerEdge R520 (considering the R530)
  - Dual Intel® Xeon® E5-2450 2.10 GHz, 20M Cache, 8.0GT/s QPI, Turbo, 8C
  - 2 200 GB SSD RAID0 System disks.
  - 32 GB RAM
  - X6 1 GB Ethernet ports
  - QLogic 2562, Dual Port 8Gb Optical Fibre Channel HBA
  - 4 PCIe x16 ports on riser

Configuration changes planned

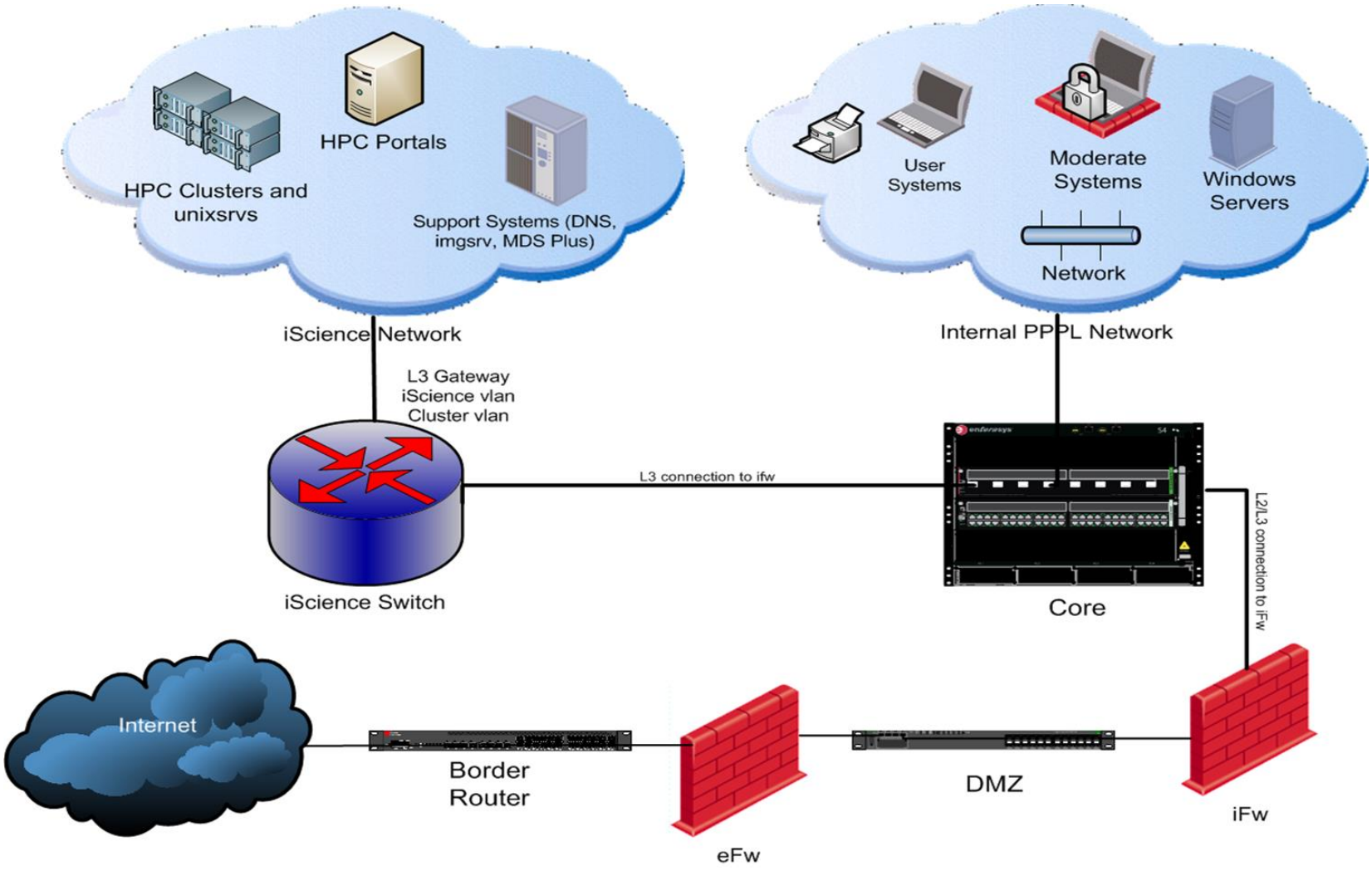
- Change from a single 10 gigabit connection to pass all inter-VLAN traffic to grouping “safe” VLANs in an iScience enclave

- Offload MDSplus serving to a separate server and use both UDP and TCP/IP events

In the current PPPL network all inter-VLAN traffic goes through the iFw



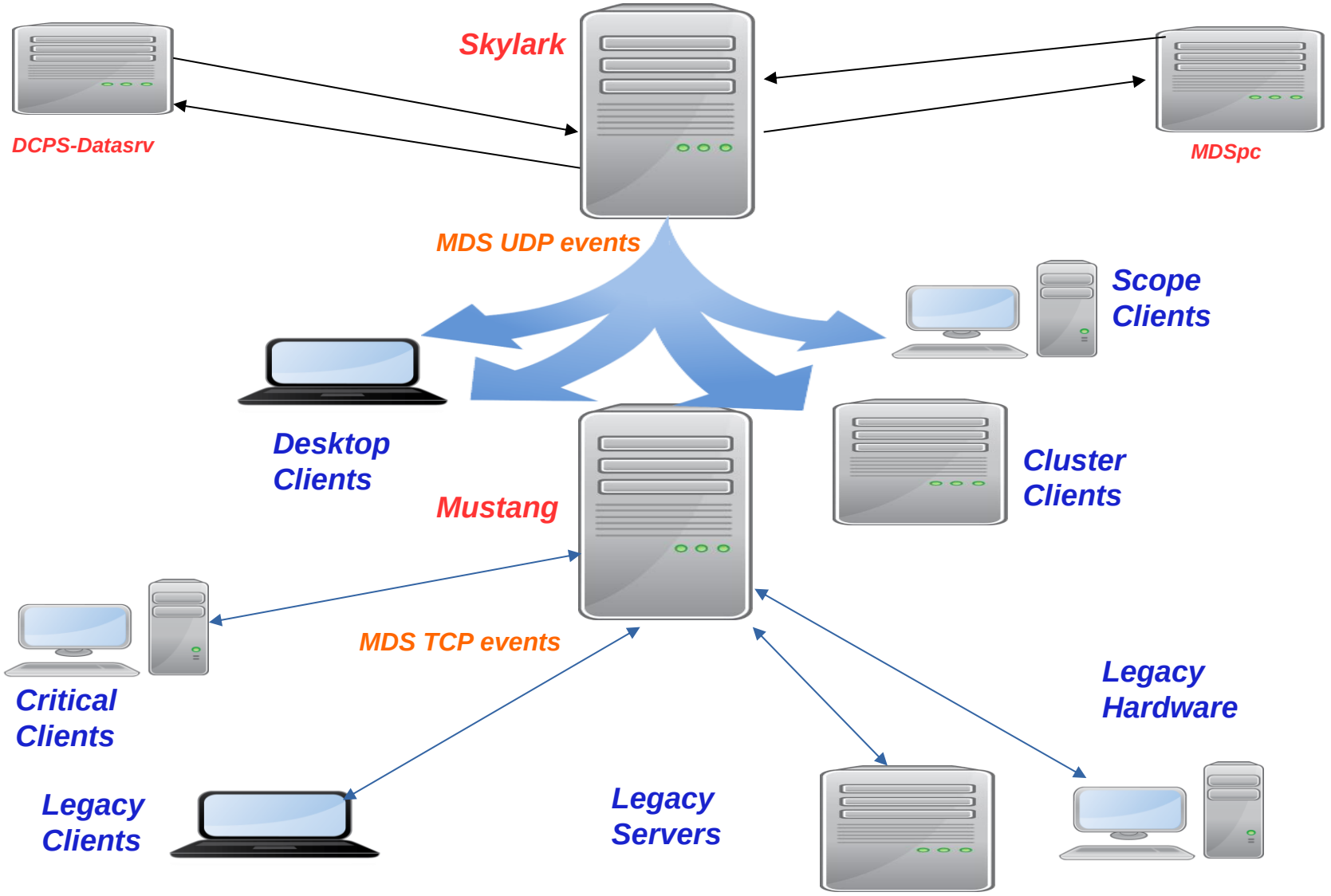
An iScience Network avoids the iFw



MDSplus Event Serving enhancements

- NSTX-U uses events heavily; perhaps beyond design goals
  - To synchronize post-processing steps
  - To pass small amounts of data, like shot numbers
  - To provide information to monitoring tools
- During NSTX operations, event handling could become unreliable after many days of heavy use, requiring a reboot of our MDSplus event (and data) server.
- We will distribute our event serving for NSTX-U
  - Will use UDP events for common, non-critical signaling
  - Will use the more mature, “guaranteed” TCP/IP events for others, including “legacy” systems that cannot use UDP
  - Some relaying of events between UDP and TCP/IP may be necessary

Plan to offload MDSplus serving and use both UDP and TCP/IP events



15 new desk locations identified in the NSXT-U Control Room

Orders for stations using Macintoshes

#		cost @	Total
4	2.6 GHz Mac mini (no monitor)	$700	$2,800
8	27" iMac 3.2 GHz	$1,800	$14,400
3	27" iMac 3.4 GHz	$2,000	$6,000
1	21.5" iMac 2.9 GHz + 1GB Vid memory	$1,500	$1,500
5	27" Thunderbolt display	$1,000	$5,000
		SubTotal:	**$29,700**
#			
5	Dell 27" Ultrasharp monitor	$650	$3,250
3	Dell Dual 24" Ultrasharp monitors	$700	$2,100
		SubTotal:	**$5,350**
		Grand Total:	**$35,890**

Future possibilities

- Red Hat High Availability (HA) cluster
- Incrementally adding Linux servers to distribute data- and event-serving, and between-shot processing.

Summary

- NSTX Upgrade (NSTX-U) Project
  - 3-years and US$94M
  - Doubling the toroidal field strength (to 1T) and the Neutral Beam heating power (to 12MW), and increasing the maximum pulse length from 1.5 s to 5 s
- Most data loads and computing requirements increasing with Moore's Law
  - fluctuation data will increase from 2.5 to 5 GB per second
  - 2-D Fast Camera data is expected to go from 2.5 GB/shot to 10, and
  - another 2 GB/shot is expected from new IR cameras
  - New processing power required
    - DCPS
    - Between-shot TRANSP

Questions?

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