Suggested staging of PFC upgrades (Assuming high-Z conversion of divertors and cryo-pump are “givens”)

MA Jaworski

Dec 10, 2012

Baseline budget

Strawma… …ce by 2018 assuming base budget
(More … …and you to better define schedule)

First major outage

2014	2015	2016- 2018					
Upgrade Outage	1.5 → 2 MA, 1s → 5s						

New center-stack

Start-up and ramp-up

Upgraded CHI

ECH/EBW 1 MW

Boundary physics

Upper Cryo Pump

Materials and PFCs

U

L

Upper Mo divertor (lower later)

QDM + marker tiles + LP + MAPP + friends

Lithium

Upward Li deposition

2nd NBI

MHD

disruption mitigation tests

Enhanced RFA/RWM sensors

Transport & turbulence

High k_θ

Polarimetry and DBS

Waves and Energetic Particles

HHFW feedthru & limiter upgrade

Scenarios and control

Control: rotation, snowflake, divertor radiation, q_{min}

Staged upgrade logic (years 1&2)

- Expect limited outage between years 1 and 2
- Startup all carbon for years 1 and 2
  - High heat-flux capability on all surfaces to demonstrate full-power NSTX-U, minimum PFC risk
  - Establish material migration diagnostics and upward lithium application (and MAPP)
  - Notional MPTSG Milestone 1: determine role of coverage vs. deposition quantity in determining performance increase in NSTX-U
- Characterize B+C vs. Li+C operation in preparation for change to Li+TZM upgrade

Staged upgrade logic (year 3)

- Expect major outage in between years 2-3
- Install molybdenum tile divertor in upper divertor (IBDU-H/V)
- Validate new tile design for NSTX-U conditions
- Direct comparison between B+C, Li+C and Li+TZM with data from years 1&2
- Notional MPTSG Milestone 2: Determine local and global transport of high-Z material (uncoated experiments) and low-Z material in NSTX under standard divertor configurations (MAPP XPS for composition of redeposited material); determine Mo core contamination
- Begin vapor shielding studies with Li coatings on Mo tiles

Staged upgrade logic (year 4)

- Major machine outage to install cryo
  - Install in upper divertor
  - Install with high-Z PFCs to fully convert upper PFCs
- Key experimental comparison: high-Z+cryo (USN) vs. C+Li (LSN)
  - Also compare high-Z+Li+cryo in conventional vs. vapor shielded plasmas
- Avoid the potentially nasty surprise of attributing local retention via C+Li to cryo and *then* upgrading surrounding PFCs to high-Z
- Avoid double-sets of PFCs by upgrading straight to high-Z

Staged upgrade logic (year 5)

- Use data from year 3-4 on high-Z tile design to iterate design for lower divertor
- Notional MPTSG Milestone 3: Demonstrate high-performance, high-power plasmas with vapor-shielded PFCs
  - Example case: high-performance, high-power discharges with double-null geometry, vary flux expansion to really “cook” PFCs – push vapor-shielded regime to limits
  - Measure material migration in these plasmas to begin establishing liquid metal inventory control schemes
  - Length of duration to be determined by local transport of material (i.e. redeposition fractions)
- Provides basis for fully-flowing liquid metal module in lower divertor for long-pulse vapor-shielding