General Requirements For NCSX

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General Requirements

- Handshake between Physics and Engineering on overall Device capability

- Finish Draft by 1 Feb. Finalize for CDR by 1 March.
  Currently in table form, will be turned into prose.

- Table posted on Web at
  http://www.pppl.gov/me/NCSX_Engineering/Requirements/index_requirements.htm

- Need to ensure requirements are consistent with Physics Mission

- Need to identify how to close out ‘TBD’s; identify which ‘TBD’s will continue through CDR

NCSX Mission

Understand…

- Beta limits and limiting mechanisms in a low-A current carrying stellarator
- Effect of 3D fields on disruptions
- Reduction of neoclassical transport by QA design.
- Confinement scaling; reduction of anomalous transport by flow shear control.
- Equilibrium islands and neoclassical tearing-mode stabilization by choice of magnetic shear.
- Compatibility between power and particle exhaust methods and good core performance in a compact stellarator.
- Explore Alfvenic-mode stability in reversed shear compact stellarator

Demonstrate…

- Conditions for high-beta, disruption-free operation

Acquire the physics data needed to assess the attractiveness of compact stellarators. (adopted as 10-year goal by FESAC-1999)

NCSX Reseach will Proceed in Phases

Phase	Topic	Heating Power
1. Initial Operation	initiate plasma; exercise coil set & supplies	Ohmic
	control plasma evolution	
	Initial wall conditioning	
2. Field Line Mapping	map flux surfaces	
	verify iota and QA	
3. Initial Ohmic	Improved plasma control, plasma evolution control	Ohmic
	global confinement & scaling, effect of 3D shaping	
	density limit & mechanisms	
	study of Te and ne profiles.	
	vertical stability	
	current-driven kink stability	
	effect of low-order rational surfaces on flux-surface topology	
	initial study of effect of trim coils, both signs	
	effect of contact location on plasma plasma performance	
	control of plasma contact location	
	Plasma edge and exhaust characterization	

Expected NCSX Reseach (2)

Phase	Topic	Aux. Power
4. Initial Aux. Heating	Plasma and shape control with NB heating, CD	3MW NBI
	test of kink & balooning stability at moderate beta	
	effect of shaping on MHD stability	
	initial study of Alfvenic modes w/ NB ions	
	confinement scaling w/ iota, B, …	
	local transport measurements, perturbative transport meas.	
	test of quasi-symmetry on confinement and transport	
	density limits and control with heating	
	use of trim coils to minimize rotation damping	
	blip measurements of fast ion confinement and slowing down	
	initial attempts to obtain enhanced confinement regimes	
	pressure effects on surface quality	
	controlled study of neoclassical tearing using trim coils	
	wall coatings with aux. Heating	
	Plasma edge and exhaust characterization, w/ aux. heating	
	Attempts to control wall neutral influx	
	wall biasing effects on edge and confinement	

Expected NCSX Reseach (3)

Phase	Topic	Upgrades
5. Confinement & beta push	Stability tests at beta >~ 4%	6 MW total
	detailed study of beta limit scaling	2nd gen. PFCs
	detailed studies of beta limiting mechanisms	More diags.
	disruption-free operating region at high beta	
	active mapping of Alfvenic mode stability (with antenna)	
	Enhanced Conf.: H-mode; Hot ion regimes; RI mode; pellets	
	Scaling of local transport and confinement	
	turbulence studies	
	scaling of power or other thresholds for enhanced confinement	
	ICRF wave propagation, damping, and heating (possible)	
	perturbative RF measurements of transport (possible)	
	Divertor operation optimized for power handling and neutral control	
	trace helium exhaust and confinement	
	scaling of power to divertor	
	control of high beta plasmas and their evolution	
6. Long Pulse	long pulse plasma evolution control	Long pulse
	equilibration of current profile	Divertor pumping
	beta limits with ~ equilibrated profiles	
	edge studies with 3rd generation PFC design, pumping	
	long-pulse power and particle exhaust handling with divertor pumping	
	compatibility of high confinement, high beta, and divertor operation	

Physics Requirements for CDR Engineering

Selected Highlights

Coils

- Produce reference plasma parameters and physics properties of li383.
- Provide flexibility in internal iota, external iota, shear, beta limit, quasi-symmetry, profile shapes.

Electromagnetics

- Vacuum vessel time constant <10 ms, far from plasma (LFS) to avoid kink-mode stabilization.
- Loop voltage and vertical field penetration time constants short enough to maintain adequate magnetic surface quality.
- Be able to withstand EM forces due to disruptions (plasma disappearance).
- Magnetic diagnostics for equilibrium reconstruction

NCSX Physics Requirements, continued

Plasma facing components

- Long connection lengths (≥120 m).
- Reconfigurable, with provision for future divertor hardware:
  - plates for heat removal (12 MW / 1 s) with minimum impurity generation.
  - baffles and pumps for neutrals control.
- Carbon-based materials bakable to 350 C.
- Coverage expandable to 100%.
- Can electrically isolate regions for edge biasing.
- Accommodate plasma shaping flexibility.

Vacuum and wall conditioning

- Glow discharge cleaning at bakeout temperatures or between shots.
- Boronization, lithiumization (upgrade).

NCSX Physics Requirements, continued

Heating

- Neutral Beam Injection: 6 MW (3 MW initially)
  - Balanced tangential injection: 2 co- / 2 counter (1 co- / 1 counter initially).
- Ion Cyclotron Heating: 6 MW upgrade.
  - Inboard-launch mode conversion scenario @ 20-30 MHz using available system.
- Port space for alternate NBI arrangements, high-frequency fast wave ICH, or ECH.

Fueling

- Gas injection: programmable, with density feedback.
- Pellet injection upgrade: pre-installed inside-launch guide tubes.

General Requirement issues for Physics

- Max current
  - 350 kA now
  - 174kA needed for S3 state at 1.7T
  - Extra current allows factor of ~2 variation, allows higher β, higher B (if possible), access to ι ~ 1
- Trim coil coverage and upgradability
  - Previous analysis used both inner and outer set, m=5 & 6
  - Engineering wants to only require Inner set for CDR
  - How many modes should the trim coils control?
- PFC specification & upgradability
  - Is it current?
  - Next week's meeting & discussion

- Plasma flexibility specification
  - What are correct parameters to emphasize? β, l_i, Iota, shear, beta-limit, QA? Coil-current limits?

- Eddy currents
  - Effect on stability
  - Effect on flux-surface quality -- coil structure and cold-mass
  - How to analyze or estimate ??

- Range of NBI injection angles
  - Do we need flexibility on this? PVR-rec.
  - Can we have any with the present device size?

- Pellet injection launch location
  - Inside launch, where?

- Coil/Field levels and upgradability
  - Maximum total field 1.7T in MC,   MC + TF of 2 T
  - Are present possible coil-current limits higher?
  - Can/should coil support structure be designed for possible upgrades to higher fields?

- Pulse rate
  - 15 min. maximum, currently
  - 5 min. minimum, currently

- wall conditioning
  - GDC between shots
  - boronization, lithiumization
  - how often/how fast to be able to bake?