NCSX PVR Preparation

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NCSX Project Meeting

Timeline

√ Updated outline – 16 Nov.
- √ Required task-list – 22 Nov.
- √ PVR.doc, ½draft covering completed research – 20 Dec.

→ Initial-drafts of 6.3 sections received, 3 more in progress

- PVR.doc completion of first draft – end of January *expect ~ 2 weeks late*
  - Aim early to allow completion of engineering by March
  - Identify holes, fill in after January

- PVR-document sent out – mid-March (2 wks before review)
  - Purpose: document design and basis to convince reviewers and community that NCSX should be constructed and invested in
  - Draft outline, w/ identified authors

- PVR/CSR (physics and engineering) –March 26 – 28 ?

NCSX PVR Draft Outline

This is intended as a list of topics to be presented and is an approximate outline for the PVR Document. It may also be close to the expected schedule of talks. Suggested primary authors are indicated. Volunteers are welcome. The order of sub-sections is not intended to be final.

1. Overview and Introduction *(Neilson, Lyon)*
2. Motivation and Goals *(Zarnstorff, Lyon, Neilson)*
   - 2.1. CS opportunity, FESAC goals
   - 2.2. NCSX mission, physics program goals, and unique contributions to science and fusion energy. Role in the US FES program.
   - 2.3. NCSX in the AT context *(Zarnstorff, Neilson)*
   - 2.4. NCSX in the Stellarator context *(Lyon, Zarnstorff)*
   - 2.5. Potential reactor vision impact *(Lyon,)*
3. NCSX Physics Capabilities Overview *(Zarnstorff, Hirshman, Pomphrey, Reiman)*

   Purpose: Introduce the design, overview characteristics and analysis, demonstrate ability to satisfy mission and goals, establish requirements. Subsequent chapters substantiate the physics basis and capabilities introduced here.
   - 3.1. Plasma design, overview of physics characteristics *(Reiman, Ku)*
   - 3.2. Coil design, overview of characteristics including flux surfaces, trim coils, required accuracy. *(Hirshman, Monticello, Reiersen, Brooks, et al)*
     - 3.2.1. Basic design selection procedure
     - 3.2.2. Comparison modulars vs saddles, reconstruction characteristics, surface quality, engineering aspects
     - 3.2.3. Coil designs, PF, trim coils, S1/2/3 states & characteristics
     - 3.2.4. Specific characteristics of current coil designs
   - 3.3. Time evolving reference scenario (s1, s2, s3, and time intervals) and time-dependent modeling *(Lazarus)*
   - 3.4. Device flexibility and robustness *(Pomphrey)*
   - *3.5.* Heating & CD *(Kugel, Majeski)*
   - 3.6. Power & particle handling, first wall. *(Mioduszewski, Schmidt)*
   - 3.7. Diagnostics *(Johnson)*
   - 3.8. EM requirements: wall time constants, disruption handling *(Fredrickson, Fu)*
   - 3.9. Unique capabilities, relative to other experiments.
   - 3.10. Research plan, operation requirements (e.g. rep. rate, neutron sheilding)

4. Equilibrium & flux surfaces *(Monticello, Hirshman, Hudson, Reiman, Rutherford)*
   Purpose: Show that the equilibria are sound and have a sound basis
   - 4.1. VMEC & PIES
   - 4.2. benchmarking vs. experiments & codes
   - 4.3. Bootstrap current calculations for QAS *(Monticello, Lin, White)*
   - 4.4. flux-surface quality, repair
   - 4.5. neoclassical healing
   - 4.6. trim-coils for suppressing/inducing islands (if needed)
5. Ideal MHD stability *(Fu, Reiman,Redi,Spong)*
   Purpose: soundness of physics basis…
   - 5.1. Overview (Intro)
   - 5.2. Numerical codes and Benchmarking studies
   - 5.3. Mercier & Ballooning stability
   - 5.4. Kink & 'vertical' mode stability
   - 5.5. Effect of wall and conducting structures on stability
   - 5.6. Alfvenic-mode stability
6. Resistive stability *(Fredrickson, Reiman)*
   Purpose: soundness of physics basis…
   - 6.1. Present understanding vs. experiments
   - 6.2. Δ' analysis
   - 6.3. comprehensive analysis (Pies? M3D? *if needed*)
   - 6.4. neoclassical tearing
7. Heating & CD methods
   Purpose: soundness of physics basis…
   - 7.1. OH
   - 7.2. NBI *(Spong, Kugel, Zarnstorff)*
     - 7.2.1. PBX Beam characteristics
     - 7.2.2. Orbit losses
     - 7.2.3. Injection angles & location
     - 7.2.4. Co & counter configuration(s)
   - 7.3. HHFW (*Majeski)*
   - ~~7.4. ECH startup (is this needed?) *(Bigelow)*~~

8. Transport (*Mikkelsen, Liewandowski/Lin, Zarnstorff, Mynick, Ross?)*
   Purpose: soundness of physics basis…
   - 8.1. Intro; Stellarator & tokamak confinement & transport context
   - 8.2. Neoclassical transport
     - 8.2.1. GTC, DKES, & analytic models
     - 8.2.2. Self-consistent Er & effects *(Mikkelsen, Liewandowski)*
     - 8.2.3. Comparison with experiments & between codes
     - 8.2.4. Flow damping
   - 8.3. Transport simulations of NCSX including neo. & anomalous models
   - 8.4. Microstability and turbulence simulations *Is this needed? (Lewandowski? Ross?)*
   - 8.5. Methods for obtaining enhanced confinement
   - 8.6. Summary: expected NCSX plasma characteristics & operating range
9. Configuration flexibility and robustness (*Pomphrey)*
   Purpose: soundness of physics basis. In particular, that the device is flexible enough to achieve the mission.
   - 9.1. Profile robustness
   - 9.2. Flexibility to address each physics mission element
   - 9.3. General flexibility (for unforseen experiments)
10. Discharge scenarios *Lazarus*
    Purpose: soundness of physics basis. In particular, that it is plausible that the reference scenarios can be accessed
    - 10.1. Startup
    - 10.2. Evolution modeling
    - 10.3. Modeled scenarios
      - 10.3.1. With OHCD
      - 10.3.2. Without OHCD (?)
      - 10.3.3. Short and Long pulse expected evolutions
      - 10.3.4. Plasma quality during evolution; eddy current effects & limits

11. Power and Particle Handling (*Mioduszewski et al.)*
    Purpose: soundness of physics basis…
    1.1. Introduction and general concepts *(Mioduszewski)*
    1.2. Flux topology outside the last closed magnetic surface *(Grosman, Fenstermacher)*
    1.3. Fast particles *(Spong, Mioduszewski)*
    1.4. Expected power and particle deposition pattern *(Mioduszewski, Fenstermacher)*
    1.5. First wall configuration and materials *(Schmidt, Nelson)*
    1.6. Initial power handling system *(Schmidt, Nelson, et al.)*
    1.7. Initial neutrals and impurity control *(Mioduszewski, Fenstermacher)*
    1.8. Vacuum requirements and wall conditioning *(Kugel)*
    1.9. Divertor upgrades *(Mioduszewski, Schmidt, Nelson)*
    1.10. Development of 3-D plasma boundary modeling *(Fenstermacher, Rognlien, Stotler)*
12. Diagnostics (*Johnson)*
    12.1. Baseline
    12.2. Discharge control strategy *(Lazarus?)*
    12.3. Diagnostics upgrades & strategy
    12.4. Adequacy of Access
    12.5. Data acquisition & analysis *(??)*
    12.6. Opportunities for reuse and synergy; collaboration
13. Cost & Schedule for Construction and Operation *(Neilson, Schmidt, Lyon)*
    13.1. Design completion, reviews, cost profiles, schedule
    13.2. Management, collaboration plans, Laboratory context, institutional commitments.

Outstanding Issues:

Many issues in progress: choice of day-0 heating systems, flexibility & startup, transport benchmarking, coil reconstruction of physics, operating range and beta-limits, flow damping,…

Major concerns on schedule for:

- Coil modifications for good flux surfaces (for 10_17 coils)

- Trim coil design for preservation of flux surface quality
  Demonstration of adequacy

And subsequent analysis…

All areas: Need to identify outstanding tasks