Preparations for NCSX Physics Validation Review

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Preparation for NCSX PVR

- Dates
- Reference Plasma Configuration
  - Confinement and transport
  - MHD equilibrium and bootstrap current
  - MHD stability and disruptions
- Reference Coil Configuration
- Physics Program, Requirements
- Engineering Plausibility
- Cost and Schedule
- Reactor Extrapolation

- NSTX experience

Dates of Interest

- Yokohama IAEA Conference (Oct. 19–24)
  - 2 IAEA posters, IEA meeting, seminar at Toki
- APS Div. Plasma Physics (Nov. 16–20)
  - invited paper, poster session, NSPPC meeting
- NCSX PAC Meeting (December 2–3)
- PVR Documentation (December)
- Physics Validation Review (January)
- FY 2001 Budget Review (March)
- FESAC Program Review (Spring)
- Conceptual Design Review (May)

Charge for NSTX PVR Panel

- **What is the overall scientific and technical merit of the proposed research program? What are its strengths? What are its weaknesses?**
- **If the goals of the program are achieved, how will they be of value to the US fusion program or the world program?**
- **Is the physics design adequate to meet the program goals? Are there any improvements that you think the design team should consider?**
- **Are the proposed costs and schedule reasonable and appropriate?**
- **Are the proposed research personnel competent to carry out the proposed program? Is the institutional support adequate?**

NSTX Review

- **Overview**
- **Motivation**
- **Physics Capabilities**
- **Design**
- **MHD Stability**
  - **ideal MHD stability;** *resistive wall stabilization*
- **Discharge Formation and Sustainment**
  - *helicity injection;* **non-inductive (RF) current drive; startup and vertical stability; discharge scenario development**
- **Diagnostics; Power and Particle Handling**
  - **diagnostics; power and particle handling;** *neutron budget;* **long-pulse upgrade**
- **Cost and Schedule for Construction and Operation**

Confinement and Transport

- Monte Carlo calculations: GC3, STELL
  - ICRF orbit confinement
  - electric field effect
- Neoclassical transport adequate??
- Orbit impacts on wall, divertor
- Parameter projections
  - from ISS95 scaling
  - from transport code

MHD Equilibrium, I_{BS} Consistency

- **Bootstrap current & consistency**
  - **ARIES-RS or stellarator profiles?**
  - **uncertainty, flattened *p* profile, seed *I***
  - **range of profiles**
- **Startup from vacuum and *j*(*r*) control**
  - **time dependent scenario (WHIST)**
  - **boundary sensitivity, robustness**
- **Vertical stability (CAS3D), stabilization?**
- **Islands and variation with β**
  - **need to avoid ι = 1/2?** – **PIES & I_{BS}**

MHD Stability, Disruptions

- Mercier stability
- Ballooning stability
- External kink stability, control
  - benchmark TERPSICHORE vs CAS3D, PEST for 3-D stellarator configuration
  - effect of bootstrap current on stability
  - integrate with ballooning, QA, coils
  - systematic optimization of boundary
- Calculations with stellarator profiles
- Disruptions

A. Reiman's List for PVR

Physics Calculations for the Reference Configuration

- Convergence studies to verify equilibrium and stability calculations: Ku
- Flux surface integrity in free-boundary equilibrium (PIES): Monticello, Hughes, Oliver
- vertical stability (CAS3D): Redi, Monticello
- self-consistent bootstrap currents: Monticello, Hughes, White
- bootstrap current effect on magnetic islands (PIES): Monticello, Hughes
- energetic particle confinement: Redi, White
- benchmark Terpsichore external kink calculations against CAS3D: Redi, Fu
- high n global ideal modes (CAS3D): Redi
- gyrokinetic calculations: Mynick, Lin
- kinetic stability calculations for electrostatic modes of potential importance for anomalous transport: Rewoldt

A. Reiman's List for PVR (cont.)

Robustness - perturb profiles and boundary, look at:

- **free-boundary VMEC equilibrium.**
- **flux surfaces (PIES): Monticello, Hughes, Oliver**
- **ballooning: Ku**
- **confinement: Mynick**
- **kink stability: Fu**
- **vertical stability: Redi**
- **energetic particle confinement: Redi**
- **bootstrap currents: Monticello, Hughes**

Startup - generate sequence of free-boundary equilibria, evaluate above physics properties

Flexibility - generate free-boundary equilibria accessible with given coil set, evaluate physics properties

Coil Configuration

- **Reference coil configuration**
  - **saddles, helices, F-H coils??**
  - **flux surface reconstruction, δB_{res}, PIES**
  - **I_{BS} consistency, stability & transport OK?**
- **Backup configuration**
  - **2, 4 or 2 + 4 periods?**
- **Configuration flexibility**
  - **poloidal coils, TF, add'l saddles**
  - **vacuum vessel constraint**
- **Sensitivity to field errors**
  - **misalignments, coil feeds, fat coils**

Physics Program, Requirements

- **Program goals and research plan**
  - topical research areas, campaign task forces
- **Device capability and diagnostics**
  - configuration flexibility
  - diagnostics, schedule needed
- **Plasma heating**
  - co and counter NBI
  - ICRF staging
  - long-pulse capability, I_{BS} evolution
- **Particle and power handling**
  - diverted flux patterns

M. Zarnstorff's List for PVR

- **Reference plasma configuration**
  - required poloidal flux, <a>
- **Device capability and diagnostics**
  - evaluation of candidate coil designs
  - configuration flexibility
  - diagnostics, schedule needed
- **Plasma heating**
  - NBI aiming angles
  - ICRF staging
  - long pulse prospects

M. Zarnstorff's List for PVR (cont.)

- **Plasma evolution**
  - **OH-CD target plasma scenarios**
  - **non-CD target plasma scenario**
  - **evolution during heating**
  - ***disruption requirements***
- **Plasma/Boundary Studies: requirements**
  - **baking; wall coating**
  - **limiter; divertor**
  - **localized power handling**
  - **ergodic edge**
- ***Reactor Projections***
  - ***candidiate configurations***
  - ***upgrade SPPS projections***

Engineering Plausibility

- **Coil fabrication and installation**
  - **high inboard current density in saddle coils**
  - **outboard helices and F-Hcoils**
- **2-T operation, pulse length**
- **Vacuum liner and installation**
  - **low conductance and baking needed?**
  - **limits boundary flexibility, plasma size**
  - **graphite tiles**

Cost and Schedule

- Key issue for DOE & community!
- Candidates for cost reduction
  - 2-T, 350°C bakeout, liner
- Relative costs of 2, 3, 4 field periods
- Options for schedule acceleration
  - staging?

Reactor Extrapolation

- **Coil-plasma spacing: reactor size**
  - **N_{fp} = 2 modular coils?**
- **Relative cost of electricity too high?**
  - **redo SPPS costing?**
- **Alpha-particle confinement adequate?**
- **Beta limits too low?**
- **Optimum aspect ratio vs β?**
- **Advantages as reactor**