

Report of the FESAC Proof of Principle Subpanel

May 2001



Jeff Freidberg

Panel Members

Jeff Freidberg (Chair)

Tom Jarboe

Joseph Johnson

Jerry Navratil

David Newman

Tony Peebles

Don Steiner

Tony Taylor

Harold Weitzner

Background Information and Summary of Charge



- | The PoP subpanel met in Knoxville in August 1999**
- | Our job was to determine whether or not the RFP, MTF, and CS were ready for PoP status**
- | We concluded that the RFP was ready for PoP status and should move ahead**
- | We concluded that MTF was not ready and recommended continuation as a CE level experiment**
- | We concluded that the main component of the CS program, the NCSX experiment, was not ready for PoP status**

Stellarators 101



Stellarators are toroidal helical devices

Advantages:

- | Inherently steady state**
- | Low or no problems with disruptions**
- | Reasonably high beta possible**

Disadvantages Opportunities:

- | Complicated and expensive**
- | Scale to large reactors**
- | Bad neoclassical losses**

The Quasi-Axisymmetric Stellarator (QAS)



- | NCSX is a QAS configuration**
- | QAS solves two of the problems**
- | QAS is compact**
- | QAS has low neoclassical losses**

How does QAS do this?

- | QAS is a stellarator that thinks it's a tokamak**
- | QAS is designed so that single particles see a mod-B field very similar to what they would see in a tokamak**
- | QAS has a substantial bootstrap current**
- | However, high bootstrap fraction is not necessary or desired for success**

What Was the Issue with NCSX?



- | The panel felt that the NCSX was an interesting idea with a lot of potential promise**
- | The issue was a technical one.**
- | We were not convinced that it was possible to evolve stably from a cold initial state to a high β final state.**
- | This was tricky because of the uncertain behavior of the self-consistent bootstrap current**
- | At the time of Knoxville, the NCSX team had not demonstrated such a stable evolution**

What Was Our Recommendation?



- **The NCSX team should carry out a more detailed design**
- **They should demonstrate that a stable evolution exists**
- **They should demonstrate that the evolutionary path is robust – not sensitive to small perturbations**
- **When the design was ready for a Physics Validation Review the PoP panel wanted to be present**
- **We would then re-evaluate whether NCSX was ready for PoP status**

The Physics Validation Review



- | The Physics Validation Review took place in March 2001**
- | The PoP subpanel was present**
- | Our charge was to determine whether or not NCSX was ready for PoP status**

What We Did and Did Not Do


- | We answered our charge in the narrow sense – was the NCSX design sufficiently robust to warrant PoP status?**
- | We did not raise any additional scientific questions.**
- | We wanted to avoid setting up a moving target for the NCSX team**
- | These issues were left for the Physics Validation Review**
- | We reviewed only the NCSX proposal**
- | We did not review the entire US stellarator PoP program**

What Were Our Conclusions and Recommendations?

- | The NCSX team has made substantial progress validating the robustness of QAS equilibria**
- | They have investigated a broad range of pressure and current profiles, beta values and start-up scenarios**
- | While there is more that can and should be done, the NCSX team convinced the panel of the robustness of the design**
- | We concluded that the NCSX design is ready for PoP status as the lead element in a stellarator PoP program**
- | The panel also noted that NCSX was a relatively costly investment for the fusion community lasting many years (\$55M for construction)**
- | We recommended that FESAC and OFES address the larger programmatic issues to see how, when and whether to proceed with construction**
- | Basically, we were asking for an update of the Knoxville Priorities and Balance Report**

Why Did We Raise This Issue?

- | The money counts**
- | There are other pressing needs in the program**
- | The Priorities and Balance Report sends mixed messages as to how we should proceed**
- | Some examples:**
 - 1. Aggressively pursue CE and PoP concepts**
 - 2. Prepare for a Burning Plasma experiment**
 - 3. Revitalize the technology program**
 - 4. Assess attractiveness of the CS in 10 years**
 - 5. Join international collaboration for a BPX**
 - 6. \$220M – seriously delay new PoP experiments**
 - 7. \$260M – initiate ICC expt's on a limited scale**
 - 8. \$260M – more fully utilize existing large expt's**
 - 9. \$300M – study promising ICC on a larger scale**

- 
- **Conclusion: If there is enough money we can do it all**

 - **My opinion: NCSX is a promising idea. It's future should not be determined by 3 year old mixed messages**

 - **The PoP subpanel wants FESAC to update and clarify the Knoxville recommendations**

 - **The PoP subpanel wants FESAC to lay out a detailed spending profile based on the current budget to show how NCSX can be built and operated**

 - **The PoP subpanel wants FESAC to make sure that other programmatic needs are kept in balance if NCSX is built**

 - **My opinion: Let's find a way to build this experiment**

 - **An open issue: FESAC needs examine and approve an overall stellarator PoP program consistent with budget constraints**