ORNL Perspective on the Compact Stellarator Program

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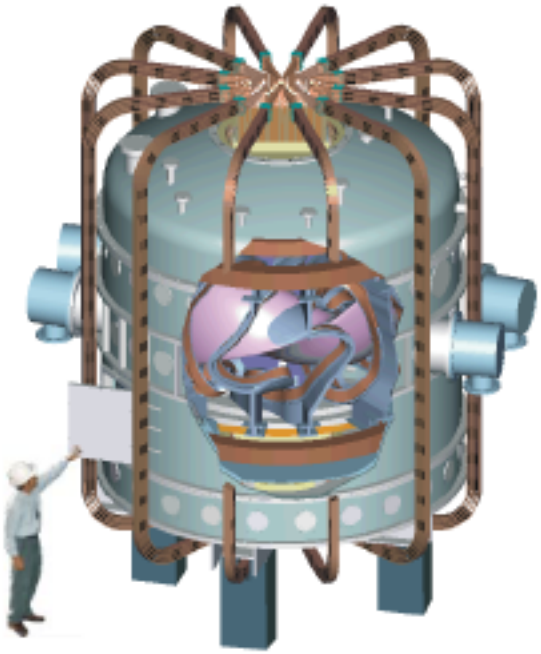
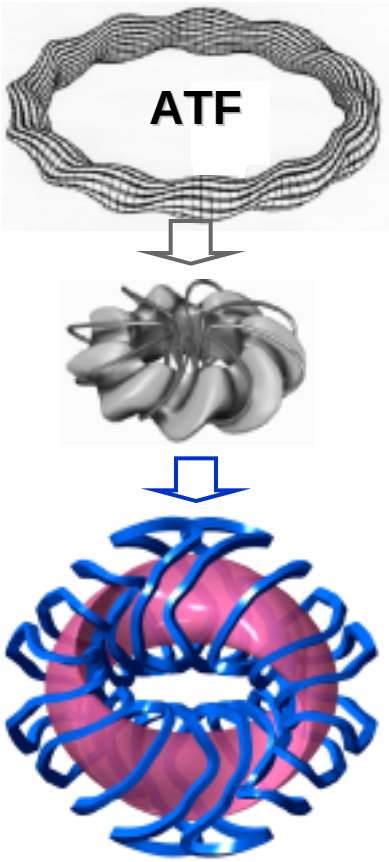
ORNL



End view looking eastward

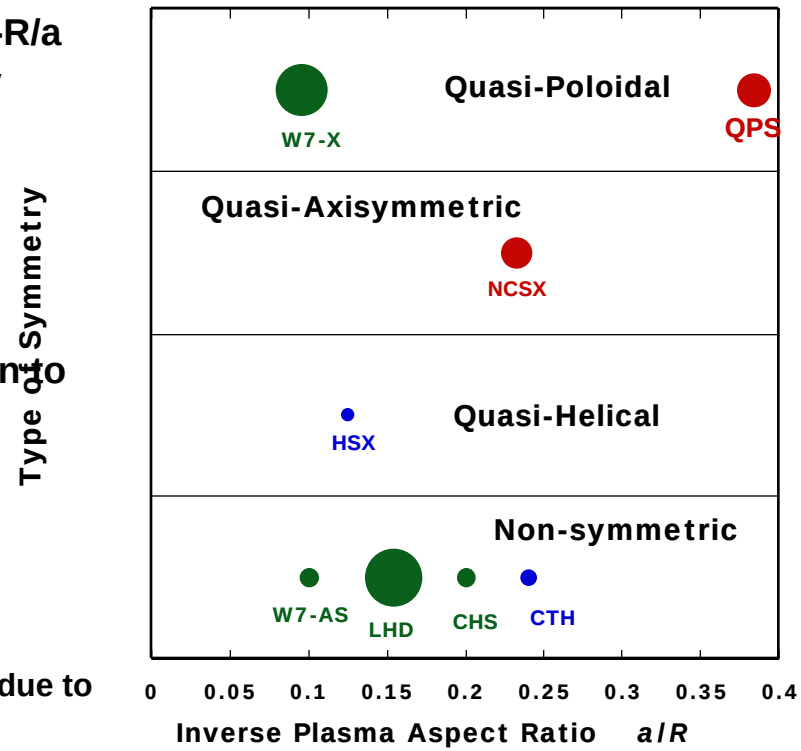
ORNL has a long-standing continuing commitment to stellarator research.

- Has developed and continues to evolve the design and analysis tools that serve as the world standard
  - DKES, VMEC, STELLOPT, COILOPT, PROCTR
- Designed, built and operated ATF
- Over the past 6 years ORNL has worked on development of a low-aspect-ratio stellarator that incorporates the bootstrap current in its optimization
  - ⇒ QPS—very low aspect ratio, excellent neoclassical confinement, good MHD properties, and a high-β reactor vision
- ORNL integrated into several elements of the compact stellarator PoP program
  - QPS development
  - leadership roles on NCSX
  - 3-D theory development
  - international collaboration



QPS pioneers an innovative direction in Compact Stellarator program—very low aspect ratio and quasi-poloidal symmetry.

- **Physics not obtainable from very-high-R/a W 7-X or other experiments and theory**
  - » **strong toroidal coupling**
  - » **significant bootstrap current**
  - » **different neoclassical transport reduction mechanism**
- **Can study fundamental issues common to low-β and high-β quasi-poloidal configurations**
  - – **scaling of the bootstrap current with β**
  - – **reduction of neoclassical transport**
  - – **reduction of H-mode power threshold**
  - – **flux surface robustness as β increases due to reduced parallel bootstrap current**
  - – **ballooning instability character and limits**



Radius of circles is proportional to average plasma radius

QPS Costs

- **Construction cost is moderate**
  - **$12M in 2001 dollars, $14M as spent**
  - **Maximize work done by outside contractors/partners**
    - » **Discussions with University of Tennessee to reduce costs and broaden participation, train students**
  - **to complete construction in ~ 4 years requires an increase of ~ $2M from present level in FY03 rising to a total annual budget of $5M by FY06 (as-spent $)**
- **QPS operating cost is $5M/year including collaborators**
  - **maximizing use of students and outside collaborators (universities, PPPL)**
  - **part of this redirection of existing funding**

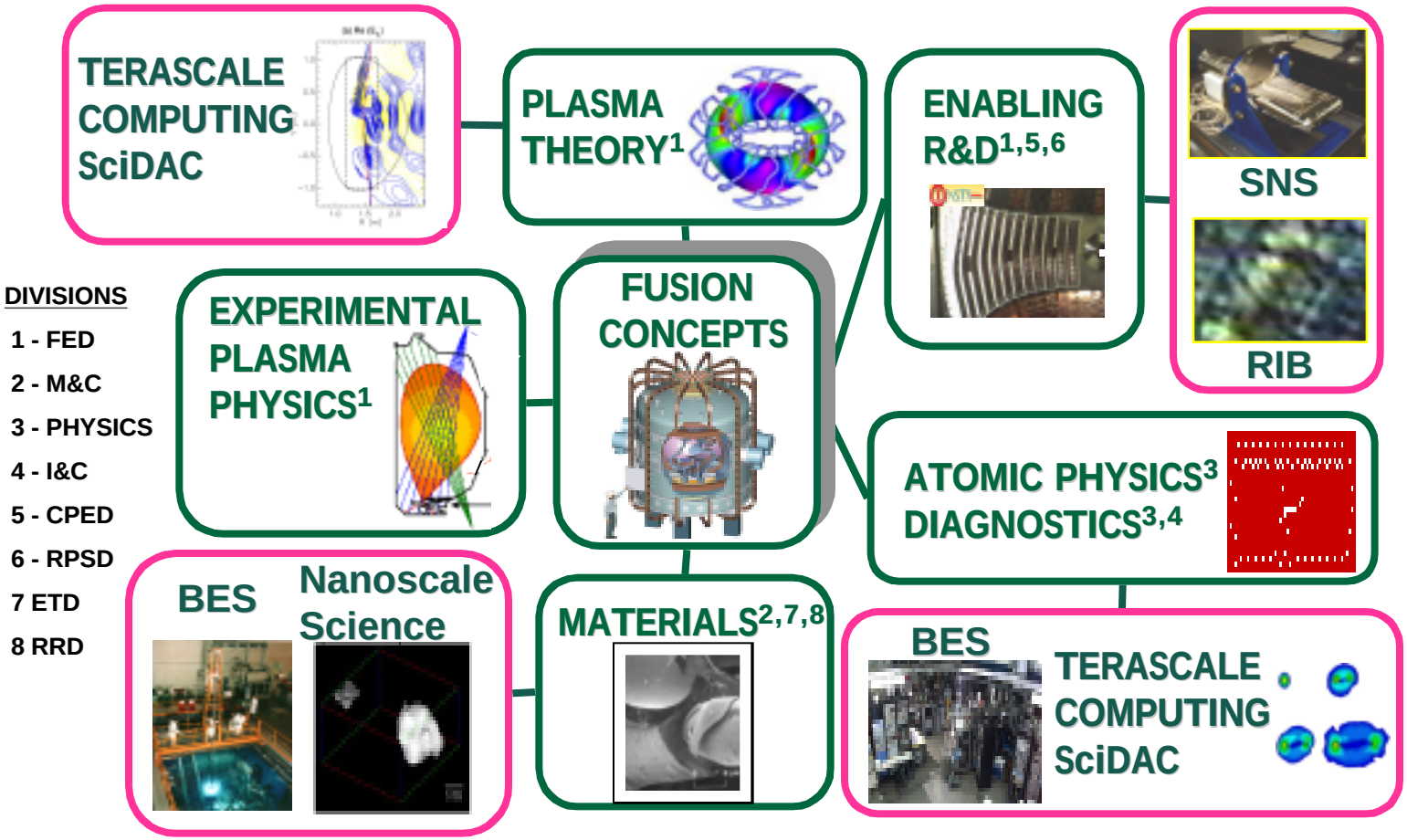
QPS is needed now.

- To complete the integrated compact stellarator PoP program
- To have an impact on
  - FESAC's 10-year goal for assessment of the compact stellarator approach
  - the direction of the post-LHD and post-W 7-X world stellarator program
- Theory needs benchmarking at low aspect ratio for validation and improvement

QPS is important to ORNL.

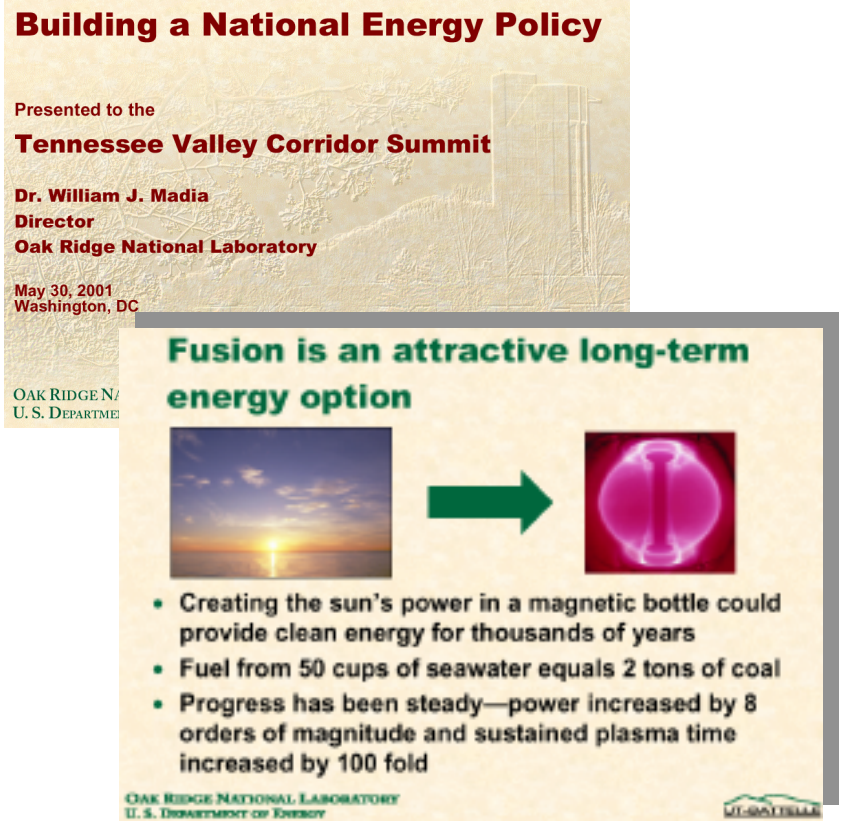
- **QPS strengthens other fusion activities at ORNL**
  - **confinement studies, 3-D theory, plasma technology development, advanced computing, materials, etc.**
  - **broadens ORNL support of university collaborations**
  - **educating new people for fusion research**
  - **international collaborations**
- **Broadens national participation in ORNL programs**
  - **~1/2 the QPS program conducted by university collaborations and PPPL**
  - **also reduces cost of construction and operation of QPS**

At ORNL fusion is integrated into the broader Science and Energy communities and leverages these huge capabilities.

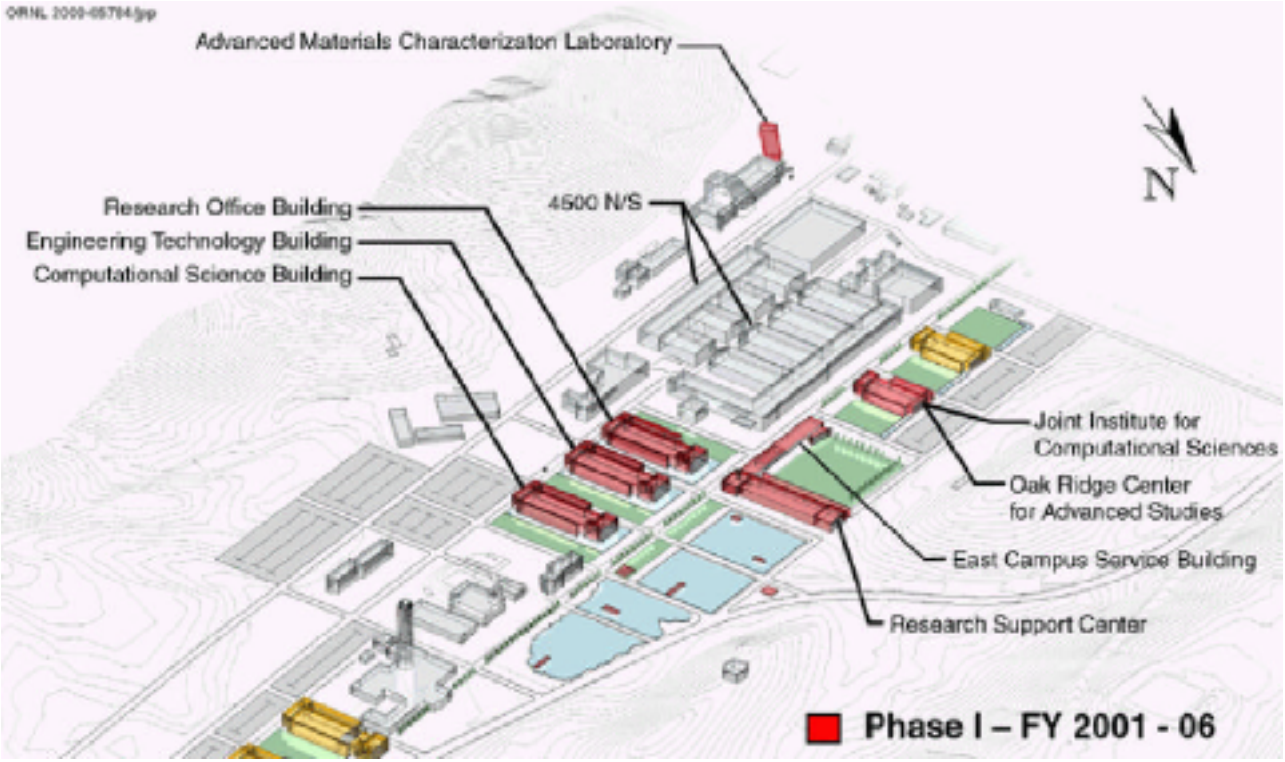


Fusion is also an important element of ORNL's Energy portfolio.

- **While QPS contributes strongly to our Science mission it is also a part of our Energy and Environmental Systems of the Future initiative**

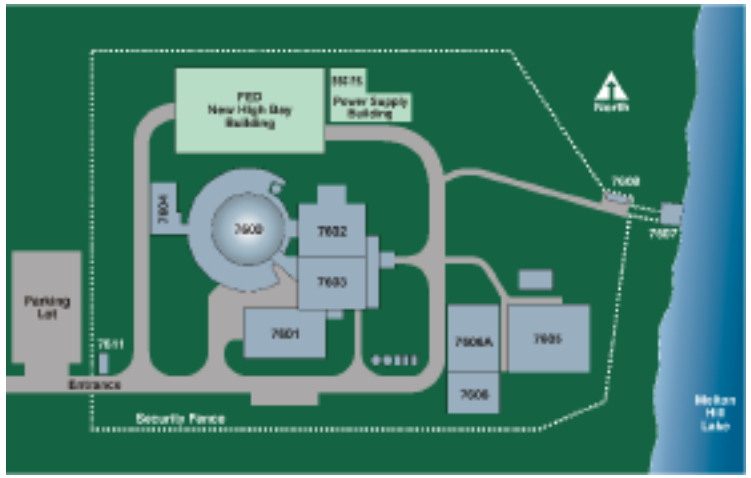


A new fusion home with QPS as it's centerpiece is part of ORNL's $200M program to modernize research facilities.



+ SNS, Center for Nanophase Materials Science, Joint Institute for Neutron Sciences, Joint Institute for Biological Sciences

As part of the laboratory modernization effort FED will move from the NNSA Y-12 complex to the ORNL site.

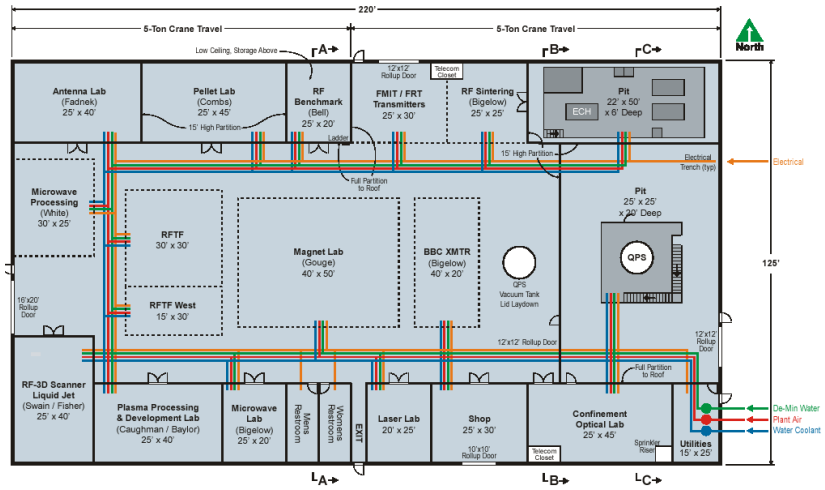


- **Experimental facilities are 2 mi. from main ORNL campus**

The Laboratory intends to invest substantially in the future of Fusion at ORNL.

- **27,500 sq. ft multi-purpose research facility (65% Fusion)**
- **Infrastructure configured for the QPS requirements**
  - **all coil power supplies; ECH & ICRF heating; bus work; cooling water; etc.**
- **60 office spaces in a new office complex in the main campus**
- **Additional offices at the QPS site**

End view looking eastward



Summary

- **QPS is an essential element of the compact stellarator program**
- **QPS extends toroidal confinement research in a new direction**
- **QPS is important to ORNL**
- **ORNL is important to the Fusion program**