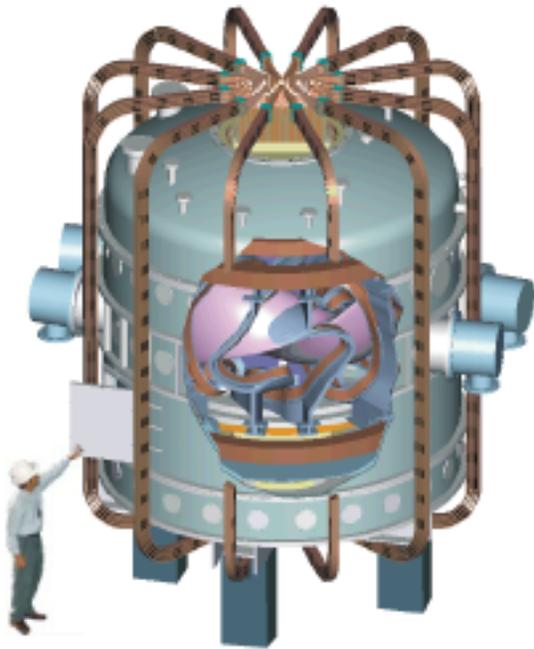


# ORNL Perspective on the Compact Stellarator Program

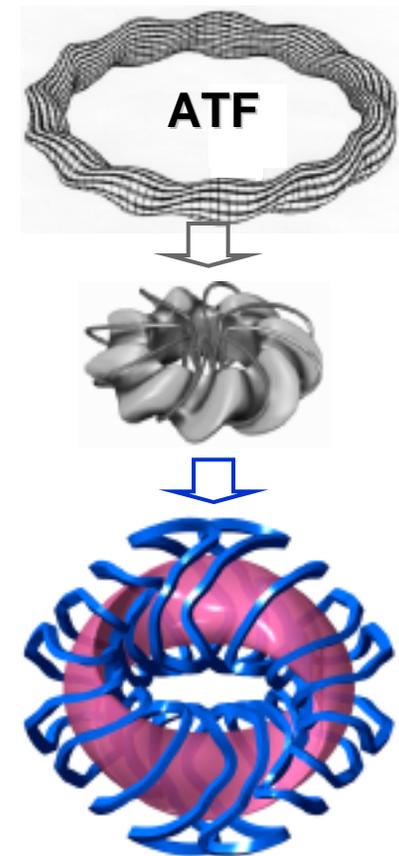
Stan Milora  
ORNL



End view looking eastward

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

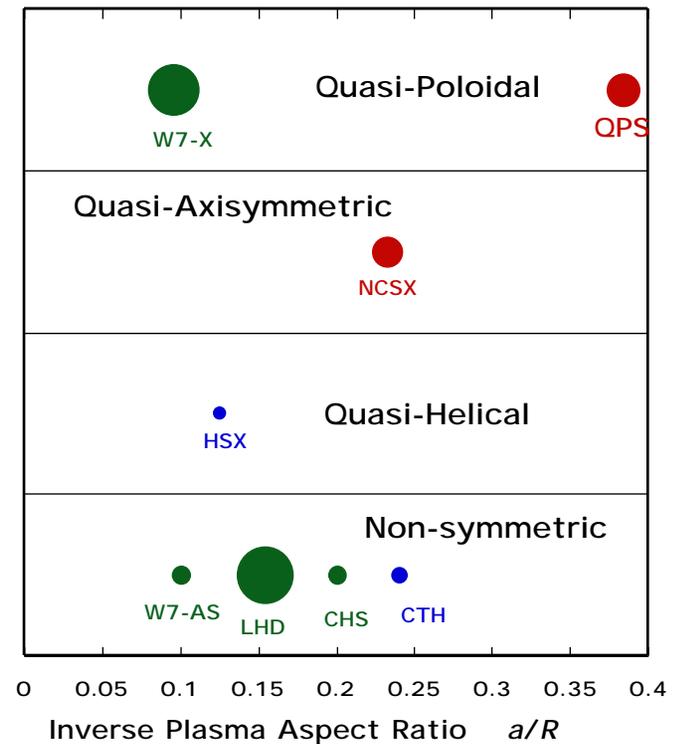
- Has developed and continues to evolve the design and analysis tools that serve as the world standard
  - DKES, VMEC, STELLOPT, COILOPT, PROCTR
- Designed, built and operated ATF
- Over the past 6 years ORNL has worked on development of a low-aspect-ratio stellarator that incorporates the bootstrap current in its optimization
  - ⇒ QPS—very low aspect ratio, excellent neoclassical confinement, good MHD properties, and a high- $\beta$  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- $\beta$  and high- $\beta$  quasi-poloidal configurations**
  - scaling of the bootstrap current with  $\beta$
  - reduction of neoclassical transport
  - reduction of H-mode power threshold
  - flux surface robustness as  $\beta$  increases due to reduced parallel bootstrap current
  - ballooning instability character and limits

Type of Symmetry



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

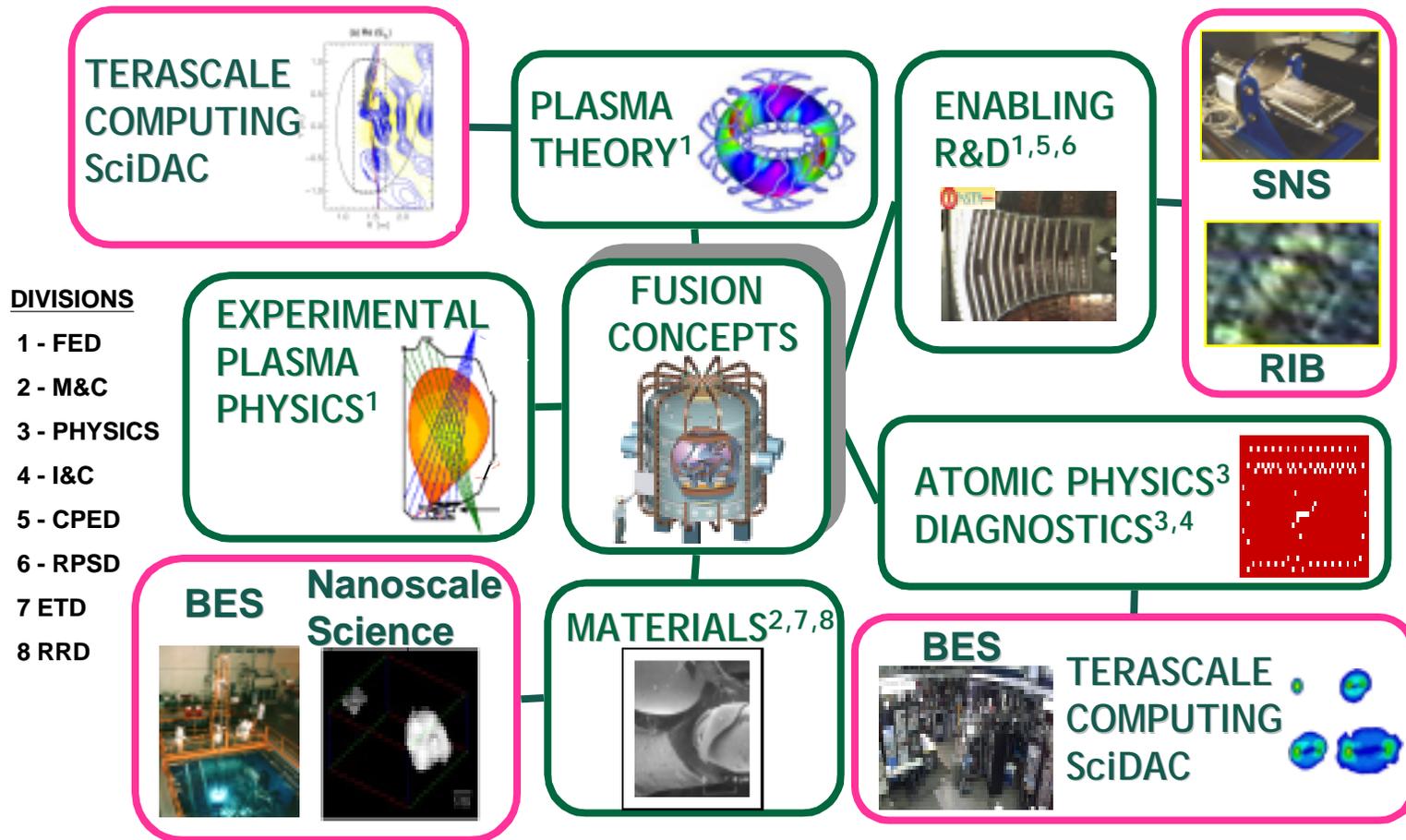
## **QPS is needed now.**

- **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

### Building a National Energy Policy

Presented to the  
**Tennessee Valley Corridor Summit**

**Dr. William J. Madia**  
Director  
Oak Ridge National Laboratory

May 30, 2001  
Washington, DC

OAK RIDGE NATIONAL LABORATORY  
U. S. DEPARTMENT OF ENERGY

### Fusion is an attractive long-term energy option

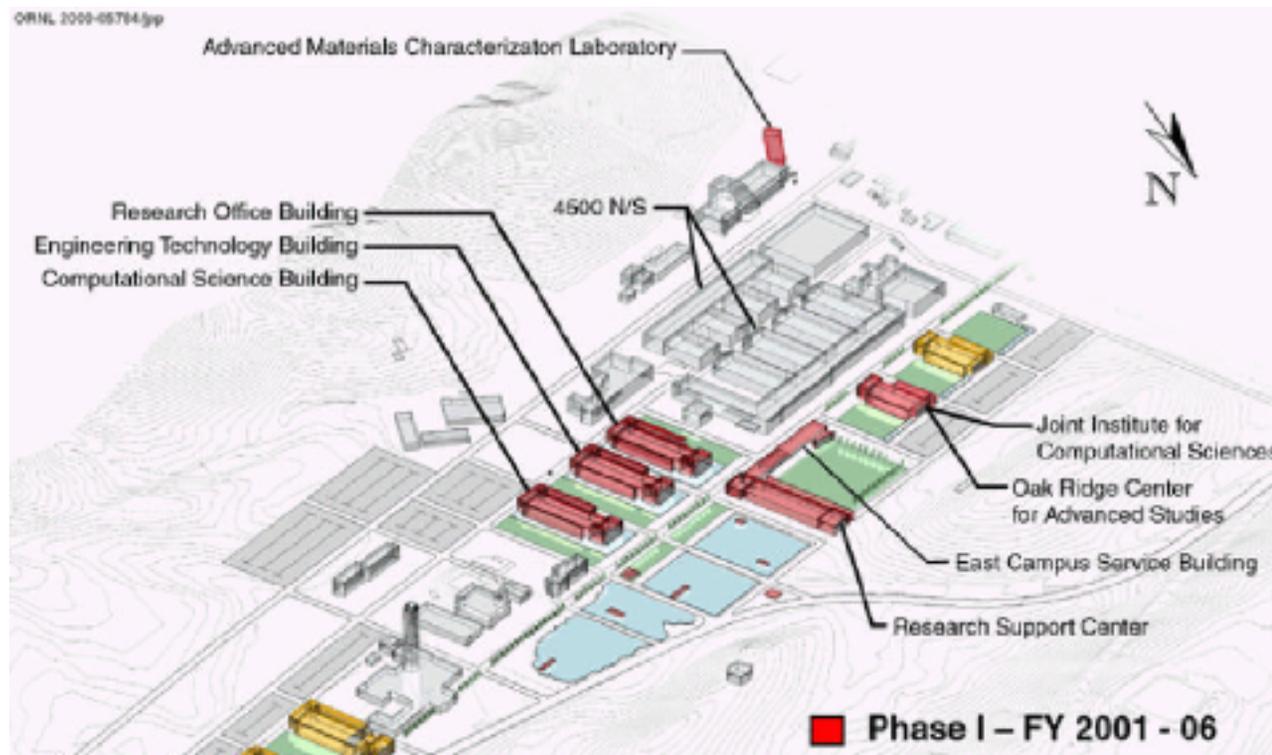


- Creating the sun's power in a magnetic bottle could provide clean energy for thousands of years
- Fuel from 50 cups of seawater equals 2 tons of coal
- Progress has been steady—power increased by 8 orders of magnitude and sustained plasma time increased by 100 fold

OAK RIDGE NATIONAL LABORATORY  
U. S. DEPARTMENT OF ENERGY

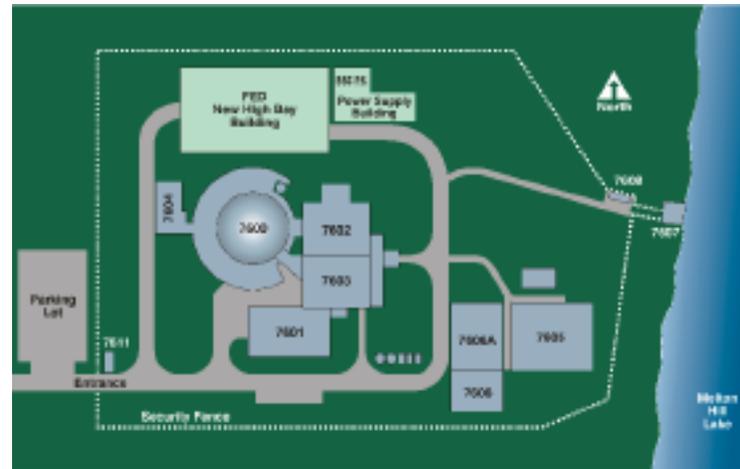


**A new fusion home with QPS as it's centerpiece is part of ORNL's \$200M program to modernize research facilities.**



**+ 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.**



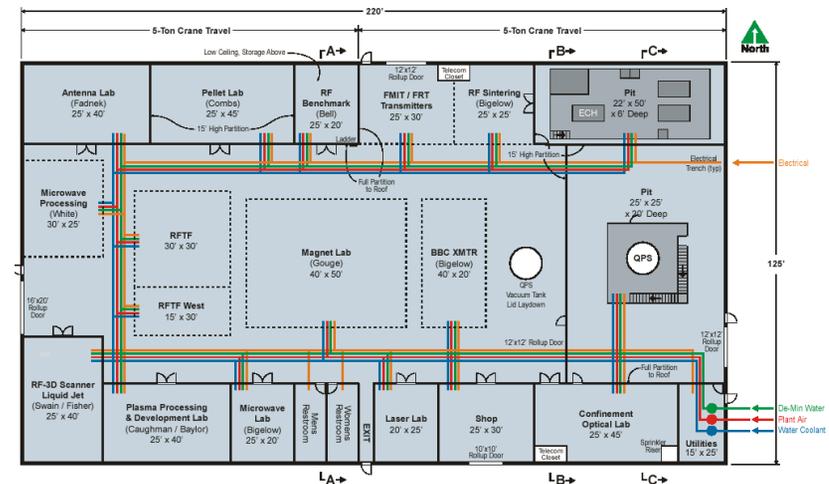
- **Experimental facilities are 2 mi. from main ORNL campus**

# 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**