Role of Multiple Effects in Fusion Nuclear Technology R&D

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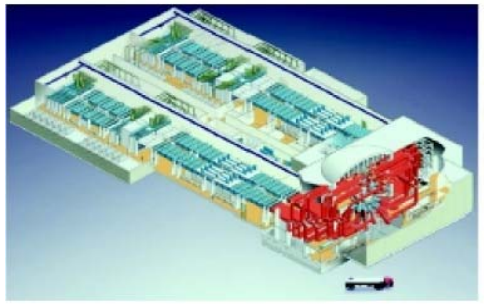
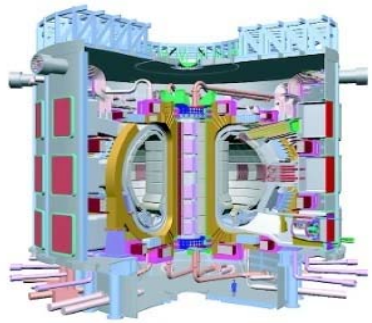
Fusion Research is about to transition from Plasma Physics to Fusion Nuclear Science and Technology

- 1950-2015
  - The Physics of Plasmas
- 2015-2035
  - The Physics of Fusion
  - Fusion Plasmas-heated and sustained
    - $Q = (E_f / E_{input}) \sim 10$
    - ITER (MFE) and NIF (inertial fusion)



National Ignition Facility



ITER

- ITER is a major step forward for fusion research. It will demonstrate:
  1. Reactor-grade plasma
  2. Plasma-support systems (S.C. magnets, fueling, heating)

But the most challenging phase of fusion development still lies ahead:
The Development of Fusion Nuclear Science and Technology

The cost of R&D and the time to DEMO and commercialization of fusion energy will be determined largely by FNST.

Key Technical Challenges beyond ITER

FNST: Fusion Nuclear Components (In-Vessel Components: Blanket/FW, Exhaust/Divertor) and associated technical disciplines (Materials, RAMI, Tritium)

Blanket / FW

- Most important/challenging part of DEMO
- Strict conditions for T self-sufficiency with many physics & technology requirements
- Multiple field environment, multiple functions, many interfaces
- Serious challenges in defining facilities and pathway for R&D

Exhaust / Divertor

- High heat and particle fluxes and technological limits: challenge to define a practical solution
- Both solid and liquid walls have issues
- Huge T inventory in Exhaust for low T burn fraction

Materials

- Structural, breeding, multiplier, coolant, insulator, T barrier Exposed to steep gradients of heating, temperature, stresses
- Many material interfaces e.g. liquid/structure
- Many joints, welds where failures occur, irradiation

Reliability / Availability / Maintainability / Inspect. (RAMI)

- FNCs inside vacuum vessel in complex configuration lead to fault intolerance and complex lengthy remote maintenance
- Estimated MTBF << required MTBF
- Estimated MTTR >> required MTTR
- No practical solutions yet
- How to do RAMI R&D?

- **Serious Challenges that require aggressive FNST R&D and a well thought out technically Credible Pathway to DEMO**