Fusion Drivers for the Fusion-Fission Hybrid

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Sub-Panel Participants:

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Questions Posed for Proponents

1. **Describe the main application or applications for the proposed hybrid concept.**

2. **What is the present status of scientific progress for each concept with respect to the final goal?**

3. **How many intermediate experiments are needed before demo?**

4. **What is the approximate time scale to demo?**

5. **What are scientific research needs for each concept?**

   a. **What are possible off-normal events, i.e. instabilities, misfires,...?**

      How does the system recover?

   b. **How is the configuration maintained? Heating, current drive, attainment of needed rep rate for pulsed systems ... ?**

6. **What are the plasma engineering and fusion technology research needs for each concept?**

   a. **What is the expected neutron flux? What is the duty cycle?**

   b. **What is the "true Q" of the system? That is, what is the ratio of neutron energy produced divided by the power taken from the wall plug?**

Claims of Sub-Panel

- **There are a number of credible candidates for fusion drivers for:**
- **Pure fusion energy systems;**
- **Fusion-fission energy production systems with closed fuel cycles and little radioactive waste;**
- **Fusion-fission systems for the reduction of the mass of spent fission fuel, plus modest energy production;**
- **Fusion-fission systems primarily for the production of fissile fuel and reduction of the mass of spent nuclear fuel.**

The time scale the development of such systems ranges from an optimistic (my opinion) early 2020's through 2040, or shortly thereafter. The earliest estimates are for LIFE and other laser-based systems to the longest estimates for systems dependent on results from ITER, or others requiring substantial new science or technology. Pure magnetic fusion systems have the longest development times.

The issues requiring resolution are primarily technical developments for inertial confinement, and a mixture of scientific and technical issues for magnetic confinement. The electrostatic driver proposal sees primarily major technical issues in massive scale-up from existing facilities.

So What is Being Proposed?

MAGNETIC CONFINEMENT

A. Pulsed

- **Field Reversed Configuration (FRC) (University of Washington)**

Based on new experimental results in which two translating plasmoids collide, are heated, further compressed and become the neutron source.

Separation of plasma production region and neutron production region.

Relatively simple axisymmetric geometry. Need additional facility(ies)? to validate ideas and demonstrate scale-up, modest cost testing (?)

B. Quasi-Steady State System

(1) Georgia Tech

Built on ITER results.

Hybrid requires no enhancement over ITER plasma performance.

Allows a smaller machine than ITER.

(2) Proposed U.S.-China collaboration.

Based on ITER design studies, but accelerates schedule over ITER by means of enhanced plasma performance to be obtained by the use of wetted Lithium walls . Proposed exponent validates ideas.

(L. Zakharov, PPPL).

(3) Improvement over ITER schedule and performance by means of low aspect ratio tokamak, advanced divertor design, and modular construction. Needs validation of ideas.

(University of Texas)

(4) Reversed Field Pinch (RFP) (University of Wisconsin)

A tokamak-like system with smaller magnets and with a toroidal magnetic field which reverses direction in the plasma. Science and technology need development.

(5) Axisymmetric Mirror (LLNL)

Based on good results from the Gas Dynamic Trap (GDT), Russia and Gamma 10, Japan.

Requires validation of scientific results and technological developments.

(6) Stellarator (ORNL)

Non-axisymmetric toroidal configuration without net toroidal currents results. Good results from LHD (Japan) and previous experiment W7AS (German) demonstrate potential. Wait for W7X (Germany) results, starting 2013 – 2014?

C. Inertial Confinement

(1) KrF Laser Fusion (NRL)

Development path based step-by-step technological advances.

Proposed pilot plant, early 2030's.

(2) NIF-LIFE

Based on assumed NIF success, and major technological advances in laser design and for system configuration requirements. System has many incarnations running the full gamut of possible uses for the hybrid. Proposed demo in 2020's.

(3) Z-Pinch (Sandia)

Indirect drive inertial fusion arising from x-rays produced by electrical discharge into grid of tungsten wires containing target pellet. Less developed than other inertial concepts.