Fusion Technology Update

Presentation at the Emerging Technologies Meeting

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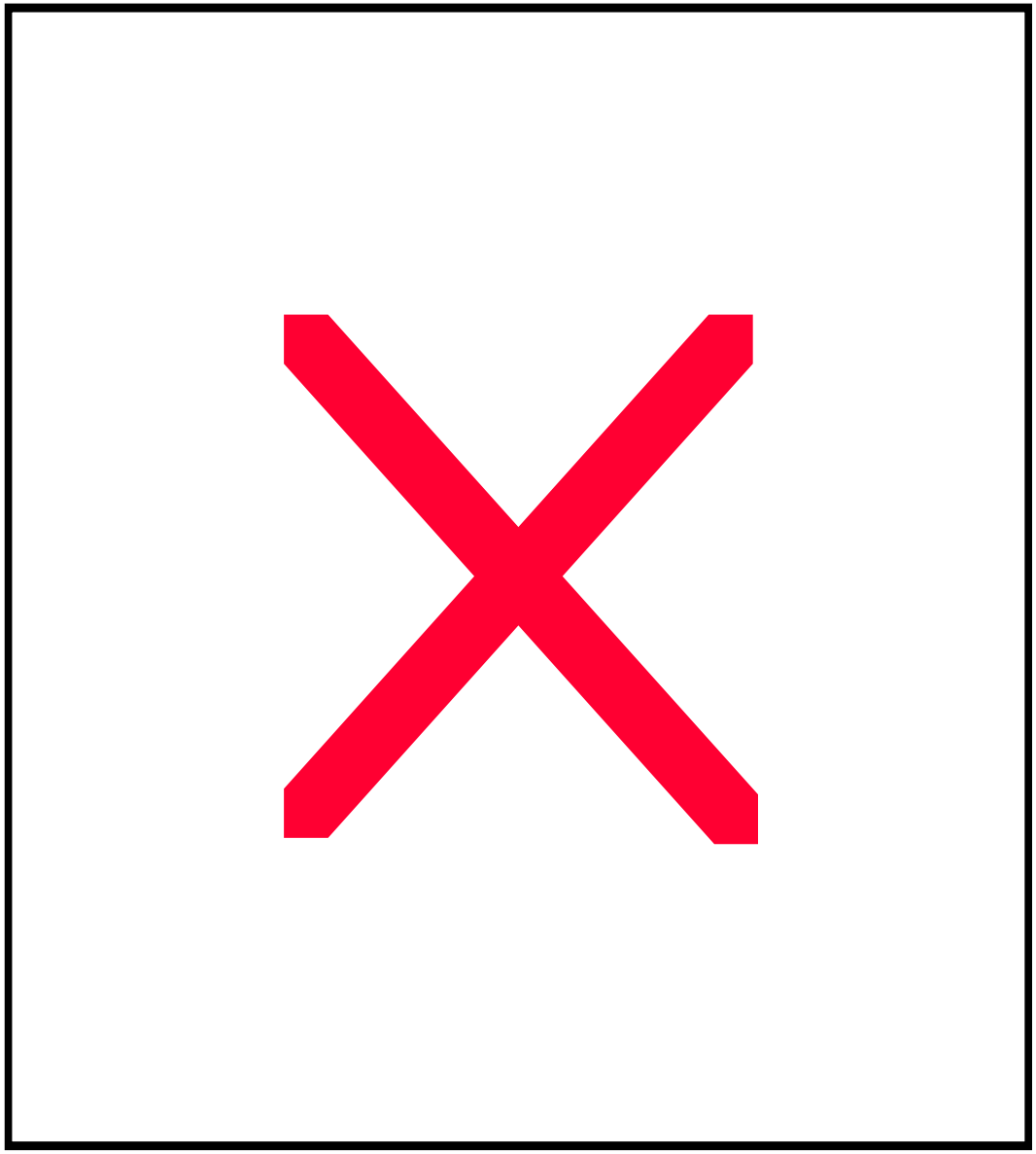
Fusion Technology Update

- Fusion is a scientific and technological grand challenge
  - Developing entire field of high-temperature plasma physics
  - Cross-cutting insights in nonlinear mechanics, atomic physics, and fluid turbulence
  - Needing advanced technologies and materials for magnetic and inertial fusion
- Fusion is an international activity at over $1 b/year
  - Collaboration in science, technology, experiments, and materials
  - A variety of approaches to magnetic and inertial fusion energy
  - ITER (EEC, Japan, Russia, Canada, …)
  - NIF (U.S.) and Laser MegaJoule (France)
  - Advanced computational simulation is a major component

  - Opportunities in the Fusion Energy Science Program FESAC http://wwwofe.er.doe.gov

Roadmap for Fusion Energy



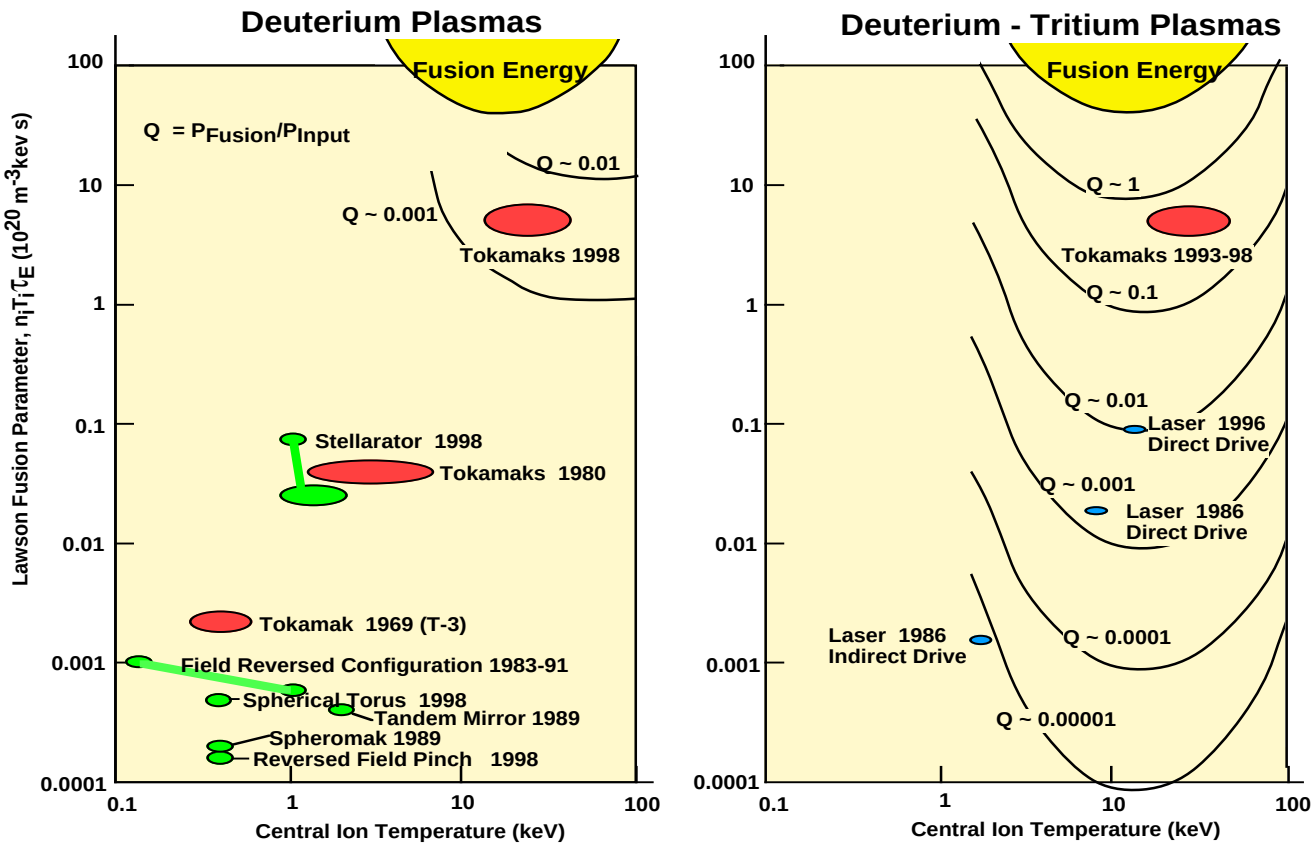
Reaction rates (Maxwellian plasmas)

Neutron power production (Maxwellian plasmas)

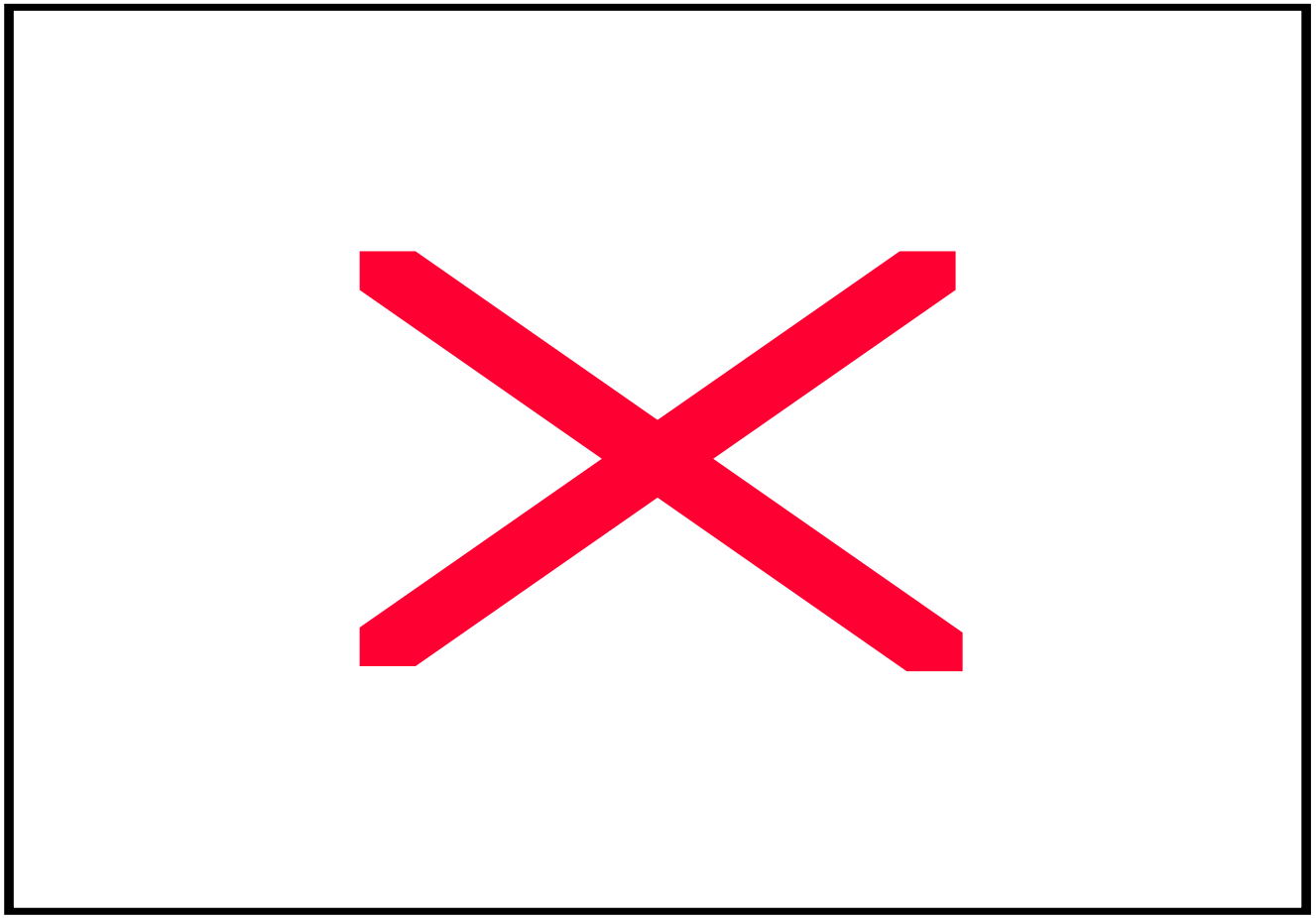
Ignition temperatures and confinement requirements

Characteristics of Fusion Reactions

Summary of Progress in Fusion Energy Gain Achieved in Experiments

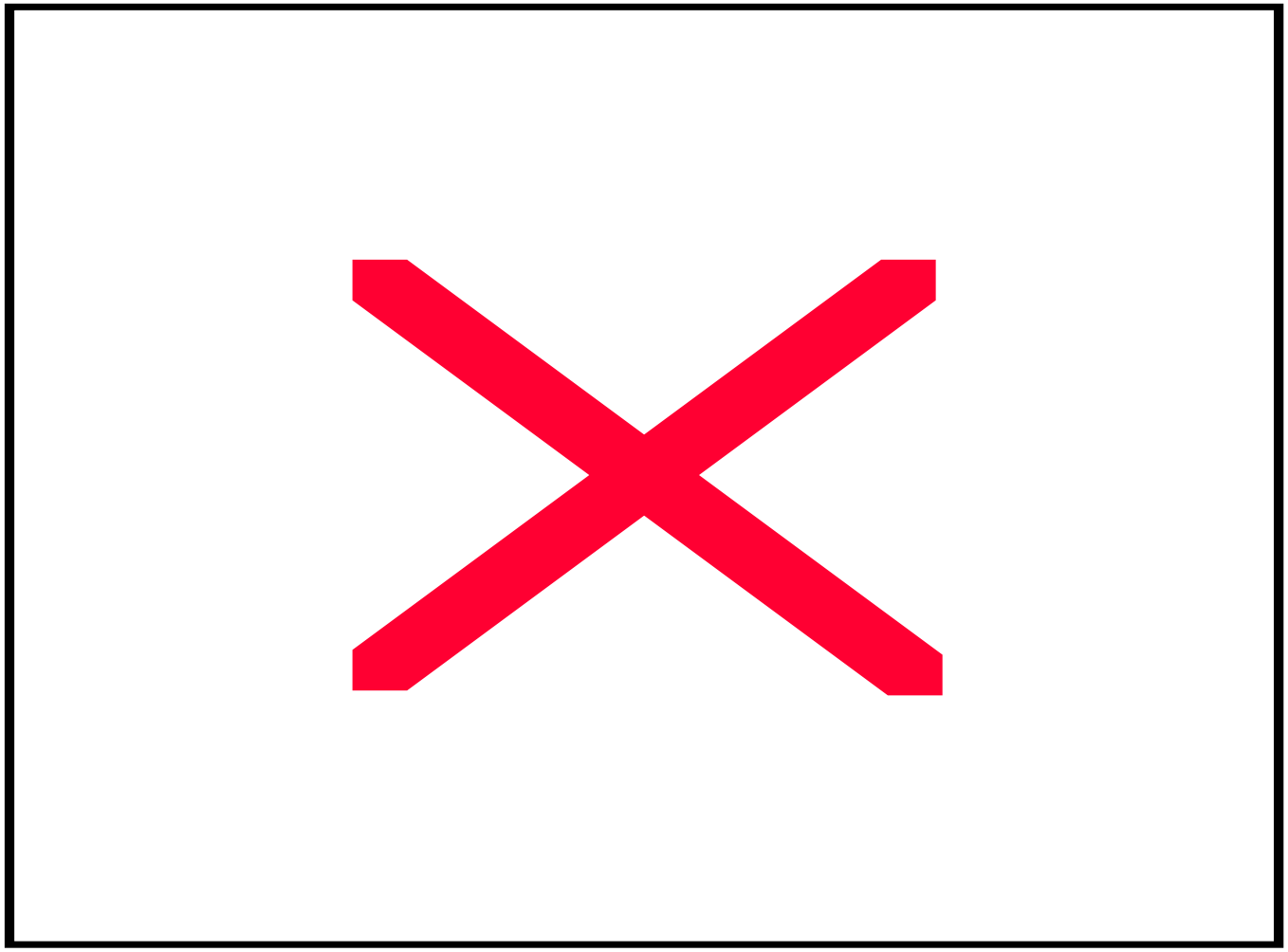


Comparison of Fission and Fusion Radioactivity After Shutdown

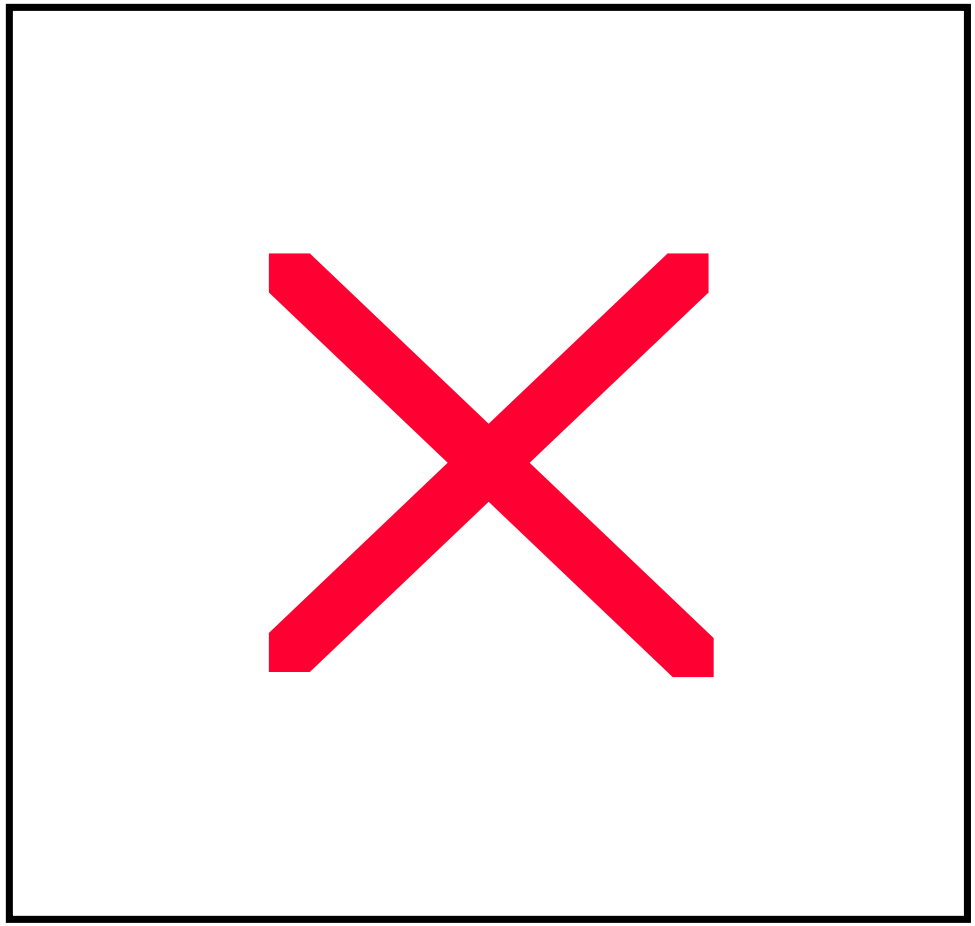


Schematic Diagram of an MFE Power Plant

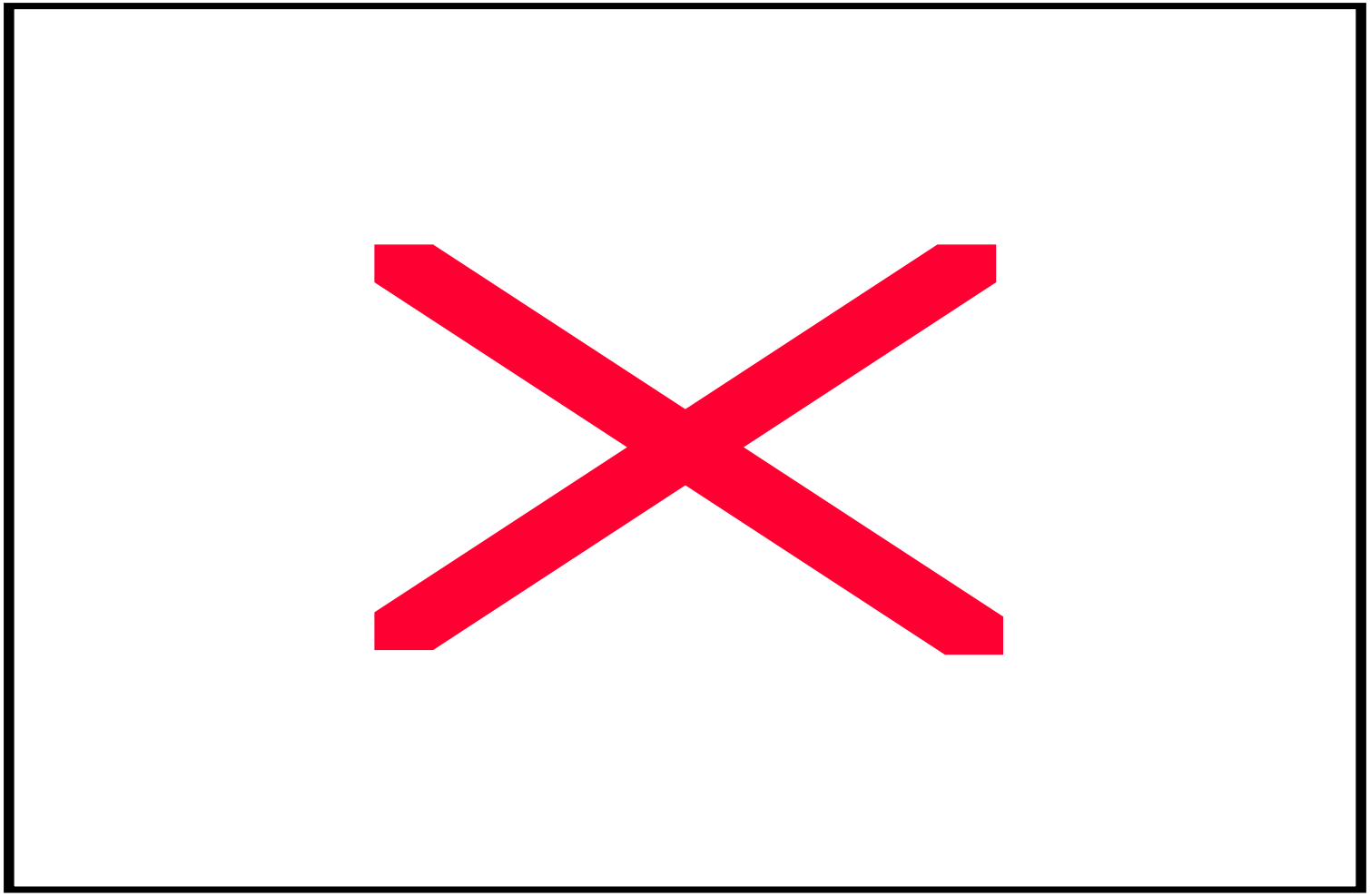
Schematic of the Fusion Power Core of the ARIES-RS Advanced Tokamak Power Plant Design



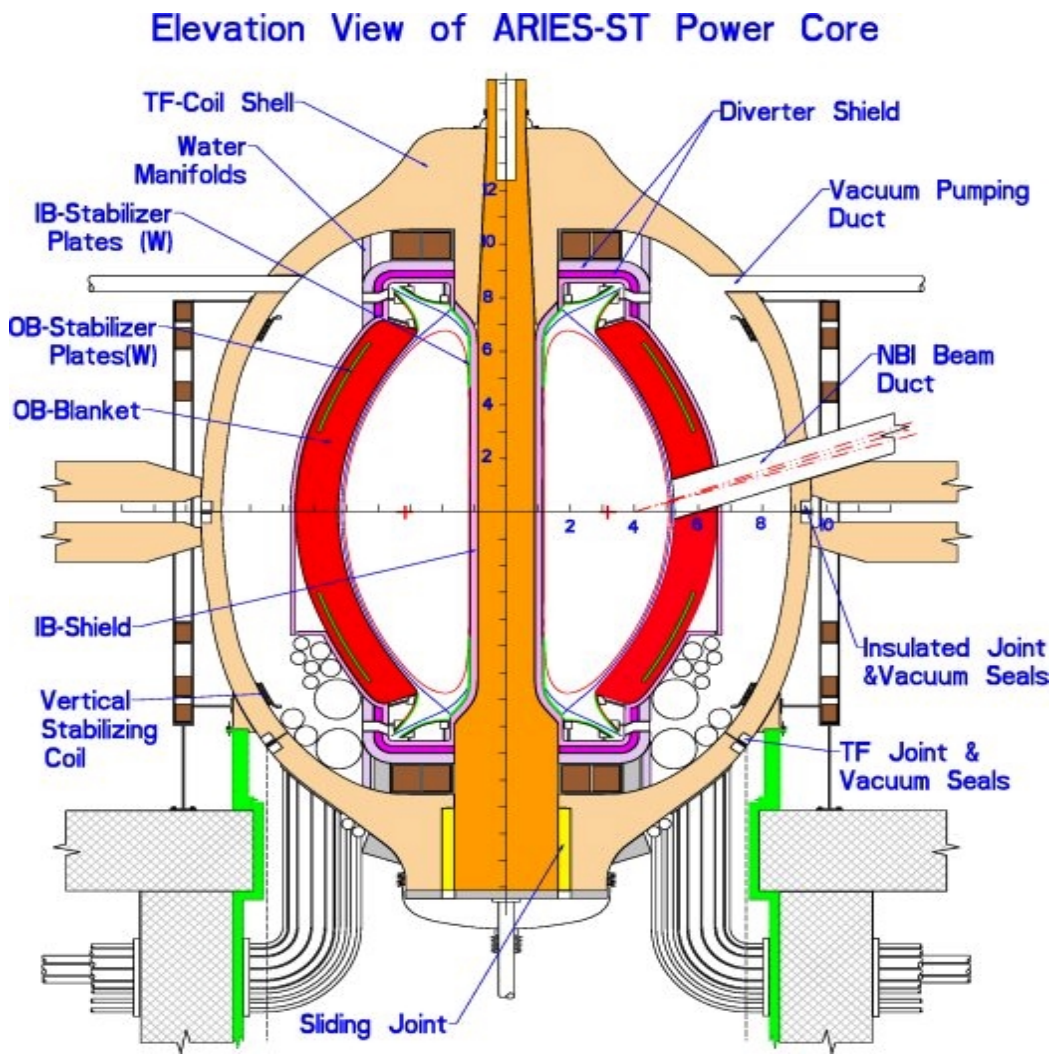
Database for Confinement Scaling in Tokamaks
Points for ITER and reduced-cost variants



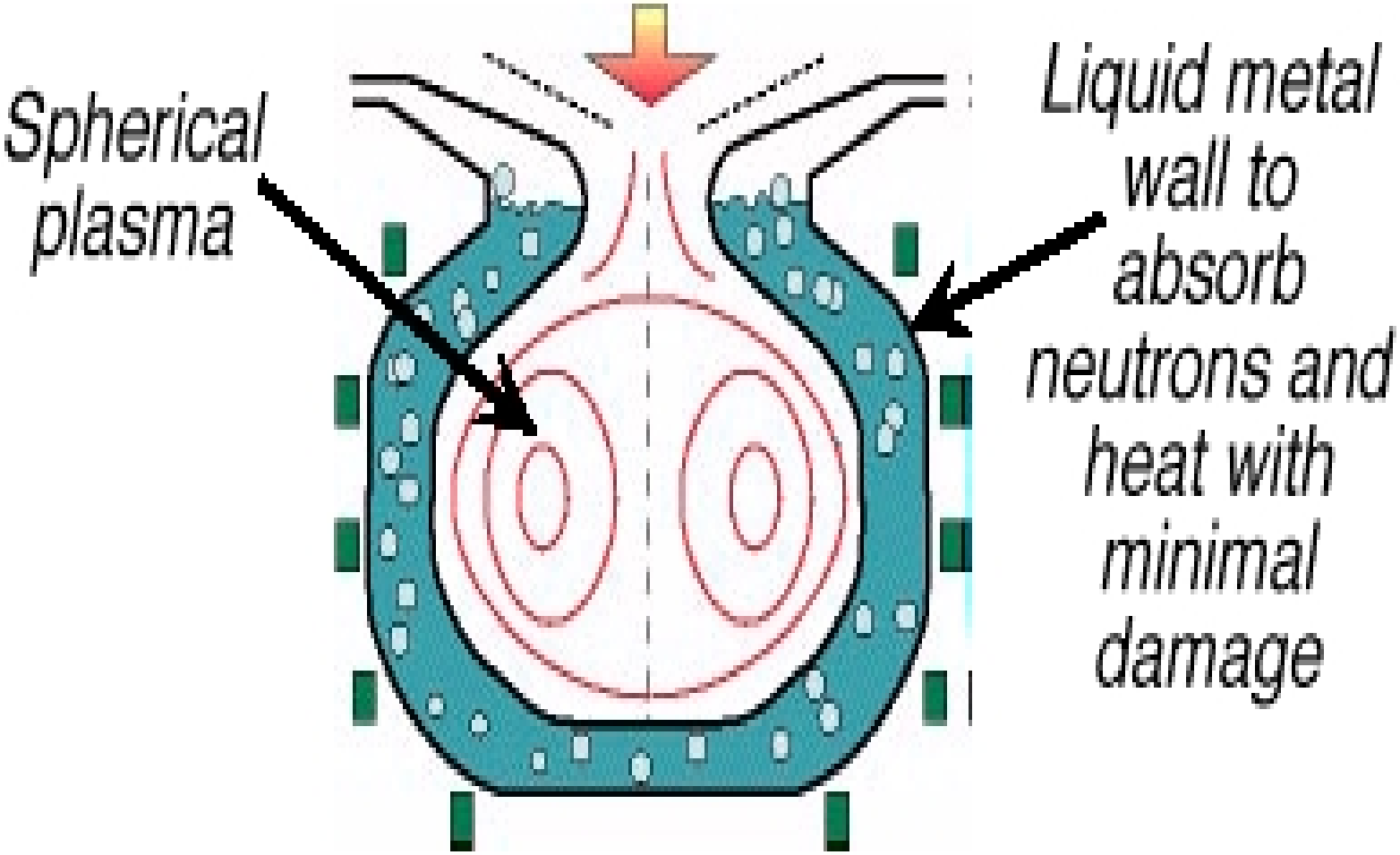
Levels of Development and World Distribution of Major Facilities in MFE



Schematic of Fusion Power Core of an ARIES Spherical Torus power Plant

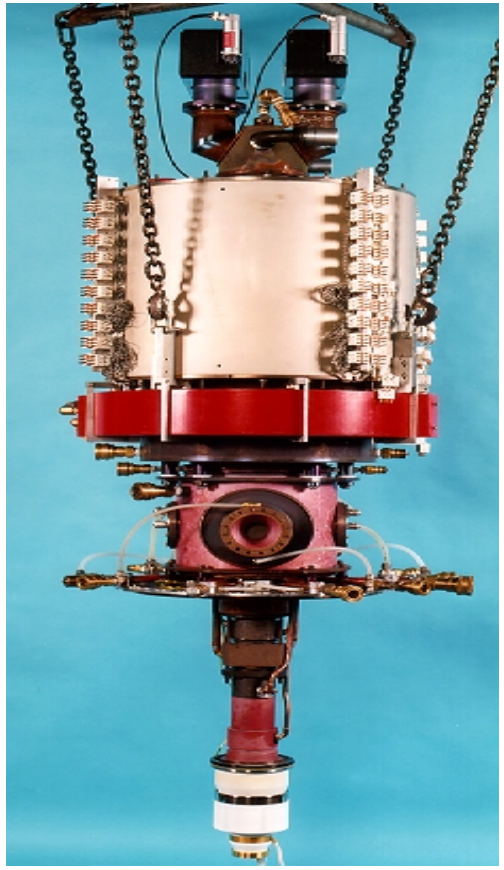


Schematic of a Self-ordered Spheromak Configuration Using a Liquid Metal Wall

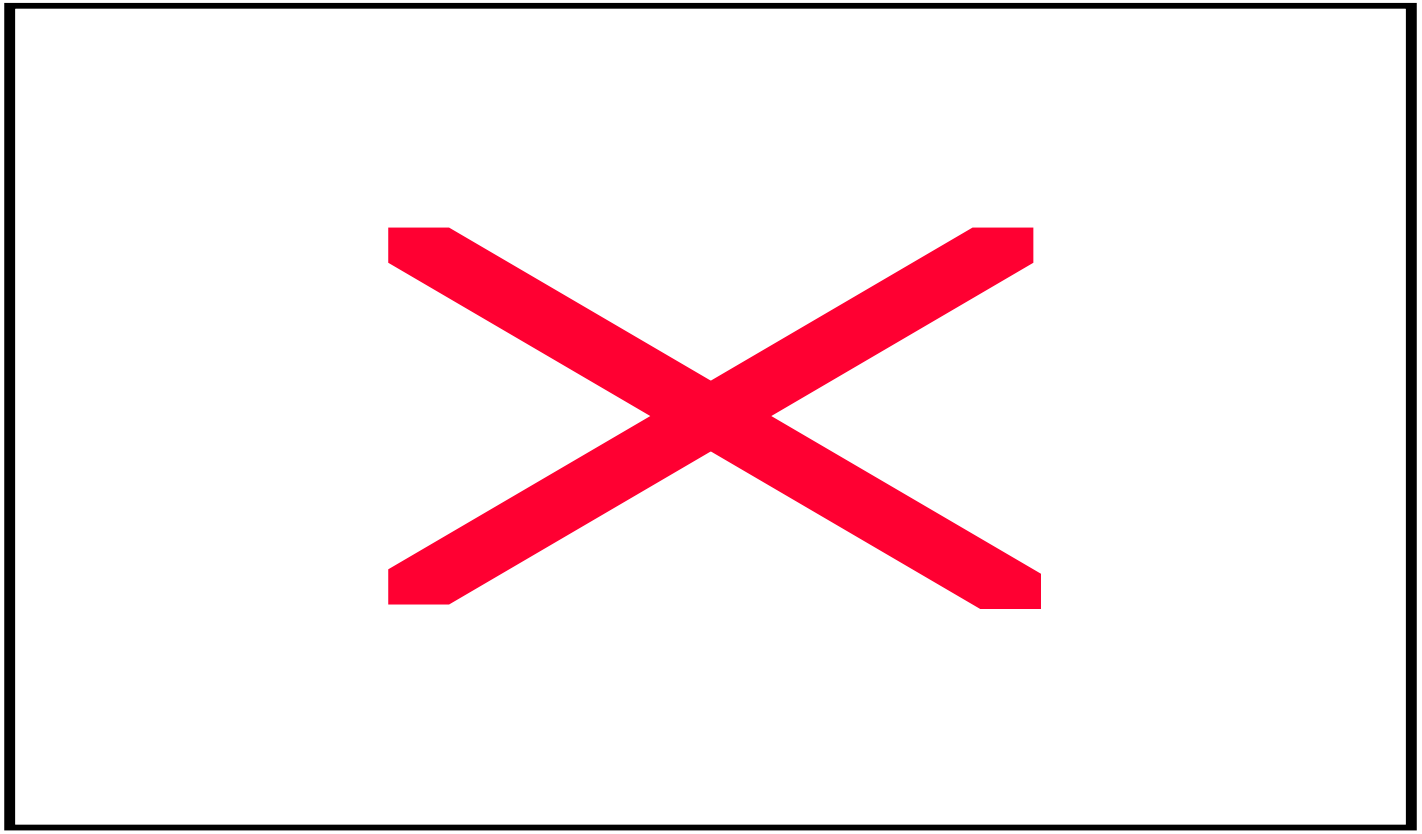


Prototype 1-MW Gyrotron

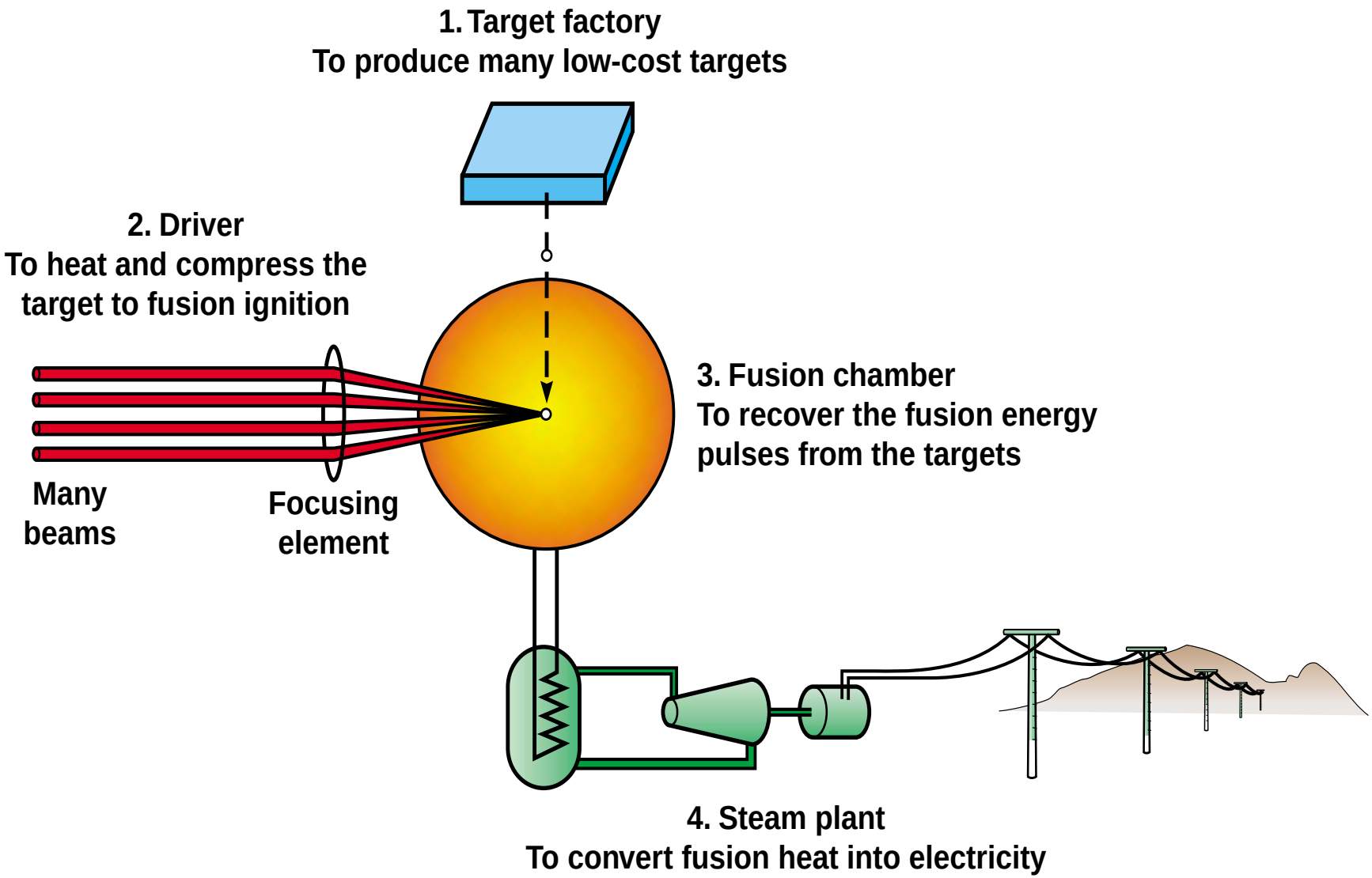
- 1-MW CW gyrotron
- 170-GHz
- Heating plasmas
- Driving plasma currents



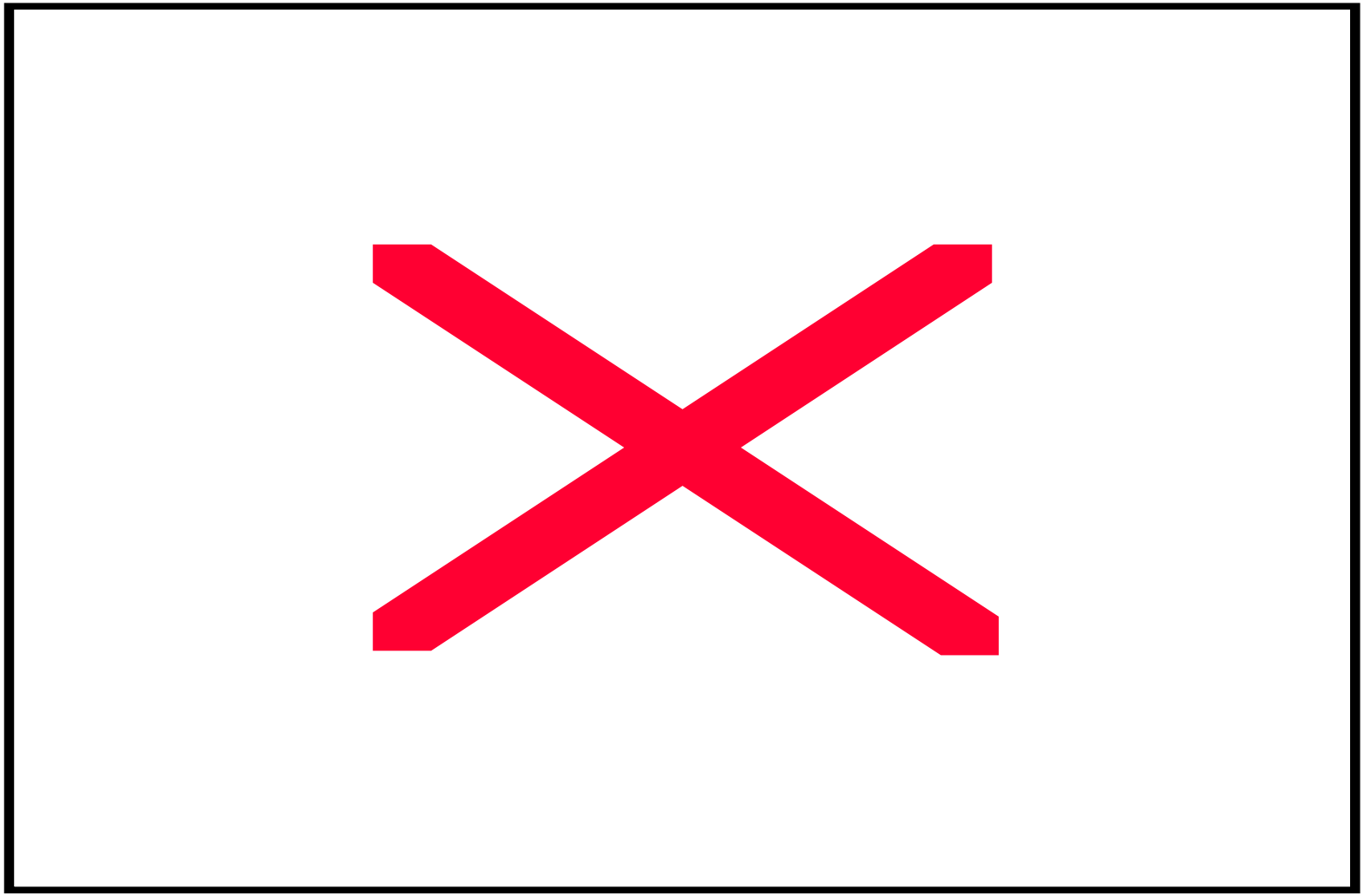
Central Solenoid Test for ITER
13 Tesla Pulsed Coil



Schematic of an Inertial Fusion Power Plant



The Principal Approaches to Inertial Confinement Fusion are Direct Drive and Indirect Drive

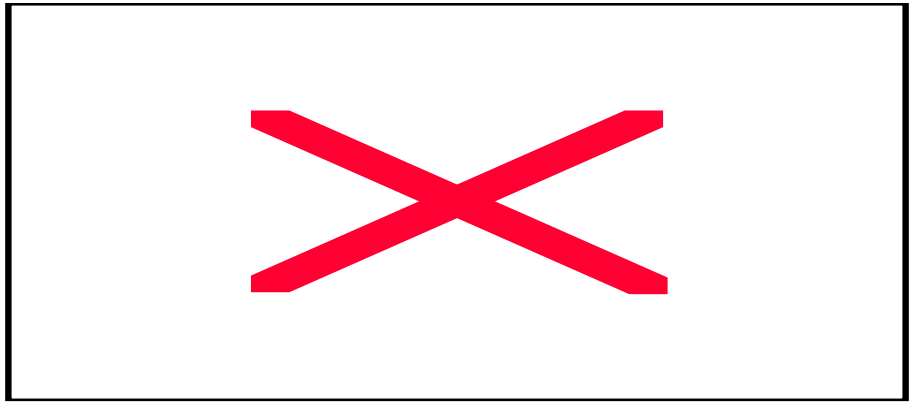


The NIF will map ignition thresholds and regions of the gain curve for various targets

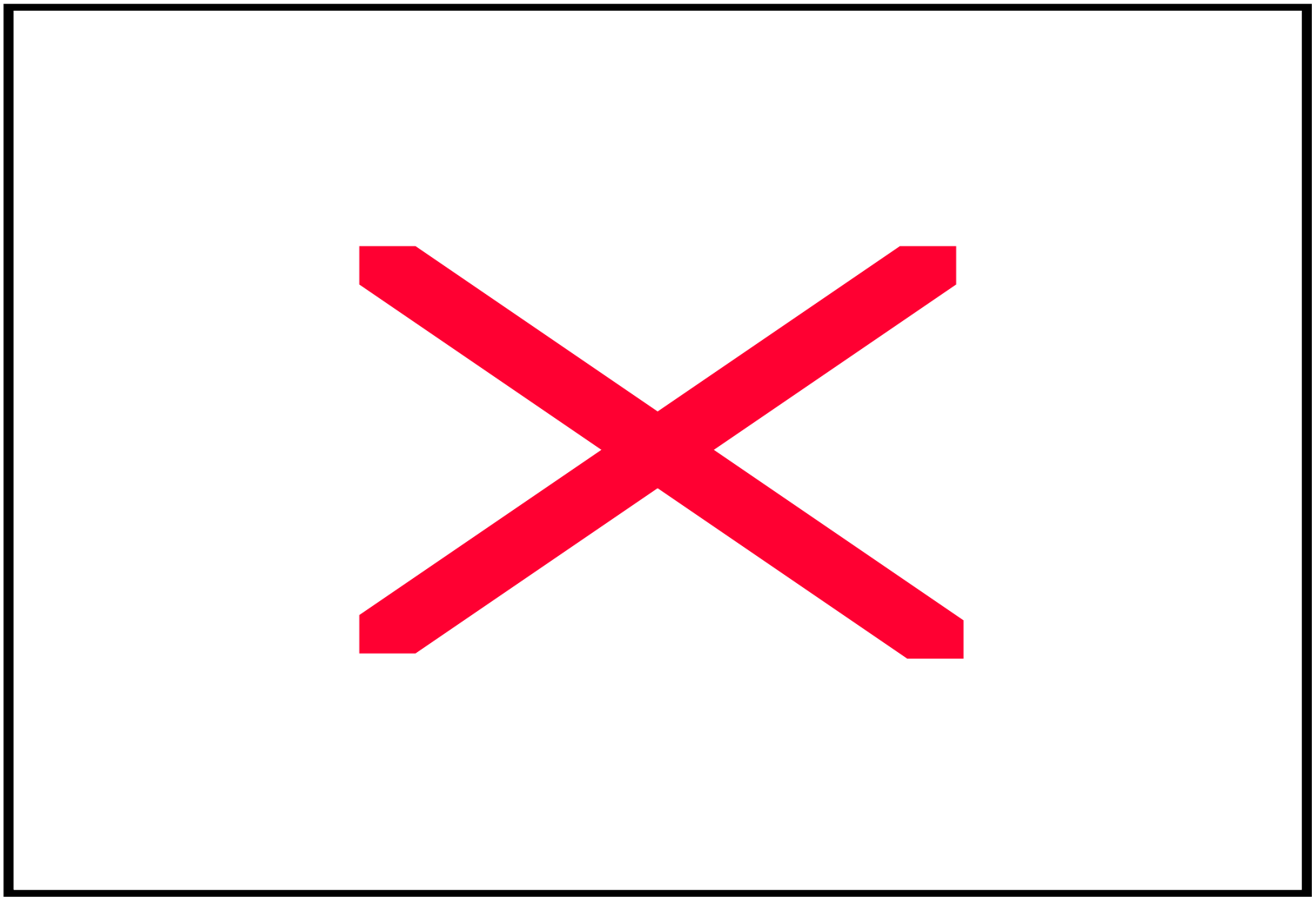
A Phased Criteria-driven IFE Development Pathway

Indirect-drive target for ion beam fusion energy using a distributed radiator foam radiation case

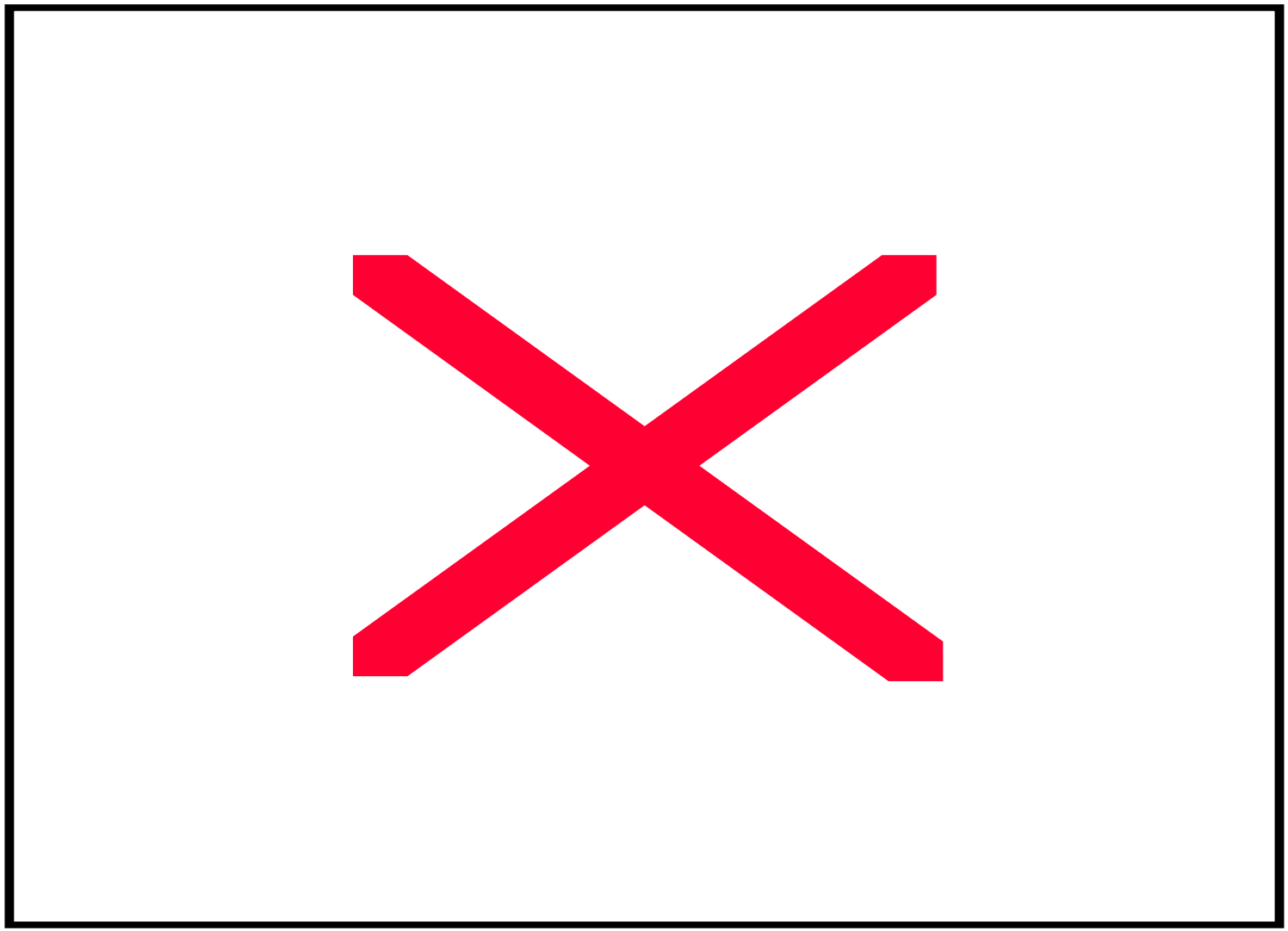
- Heavy ion beams are considered for IFE
- Greater efficiency than lasers
- Similar indirect targets

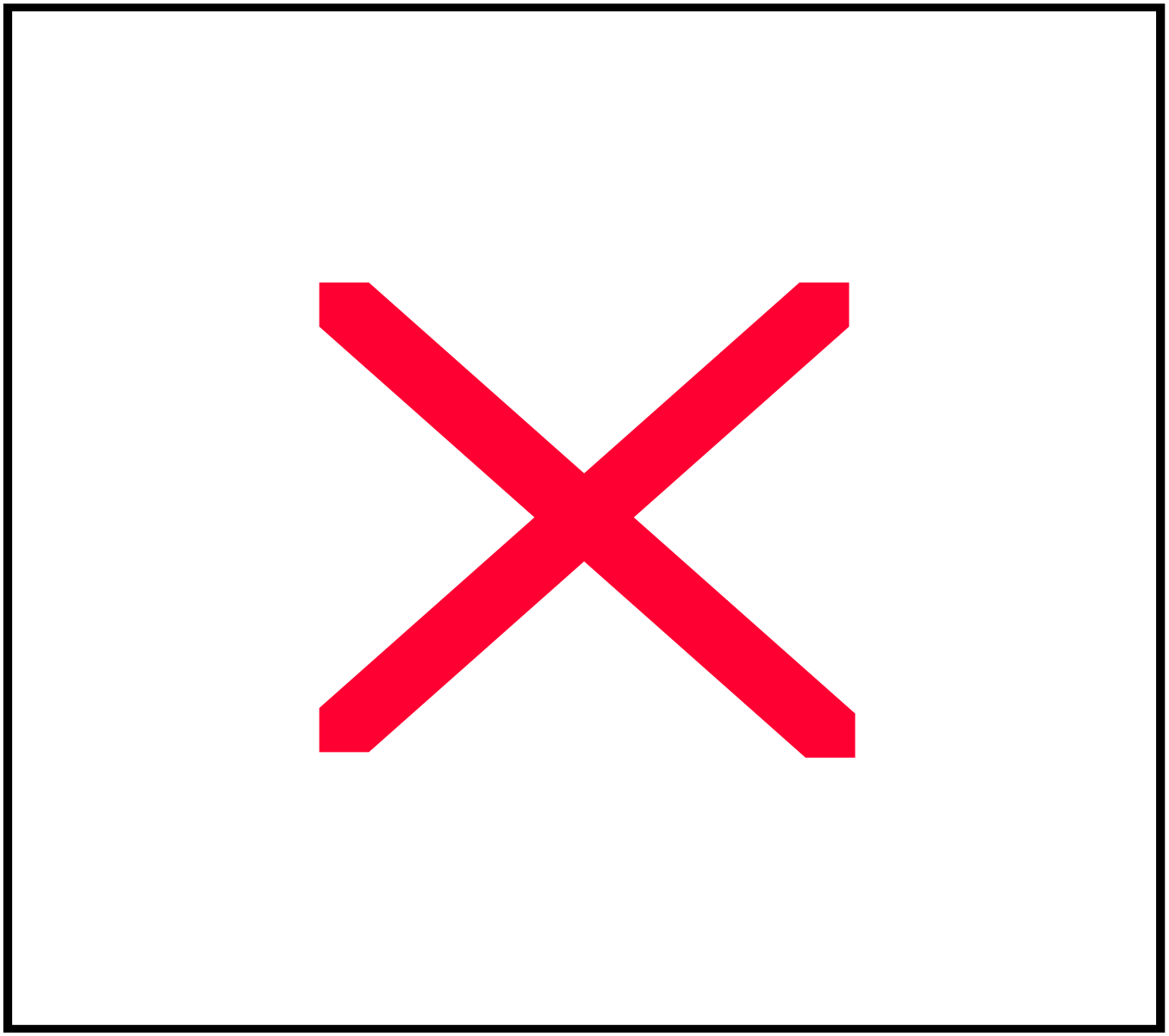


HYLIFE-II Liquid-jet Protected chamber



Projected Range of COEs for ≤ 1 GWe Power Plants without Carbon sequestration

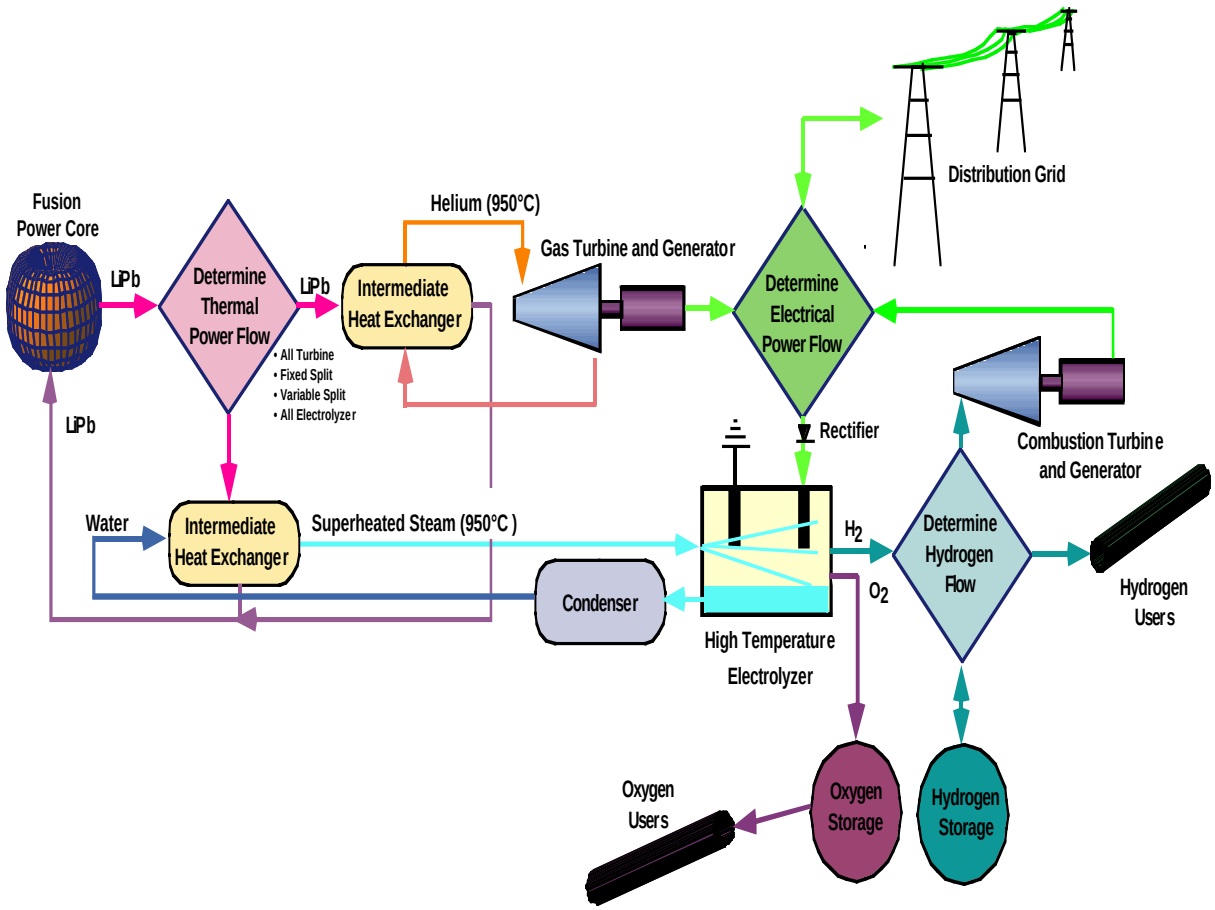




Potential Fusion Products

Neutrons	*Charged Particles*	*Radiation*
Hydrogen	Hydrogen	Hydrogen
Process Heat	Waste Processing	Waste Sterilization
Rocket Propulsion	Rocket Propulsion	Rocket Propulsion
Electricity + Space Power	Electricity + Space Power	
Potable Water	Potable Water	
Fissile Fuel	Ore Reduction	
Transmuted Waste	Transmuted Waste	
Tritium	Destruction of Chemical Warfare Agents	
Radioisotopes	Radioisotopes	
Detection and Remote Sensing	Detection and Remote Sensing	Detection and Remote Sensing
Neutron Radiography + Tomography	Radiography + Tomography	
Radiotherapy	Radiotherapy	Radiotherapy
Neutron Activation Analyses/Testing	Proton Activation Analyses/Testing	Radiation Testing
Altered Material Properties	Altered Material Properties	

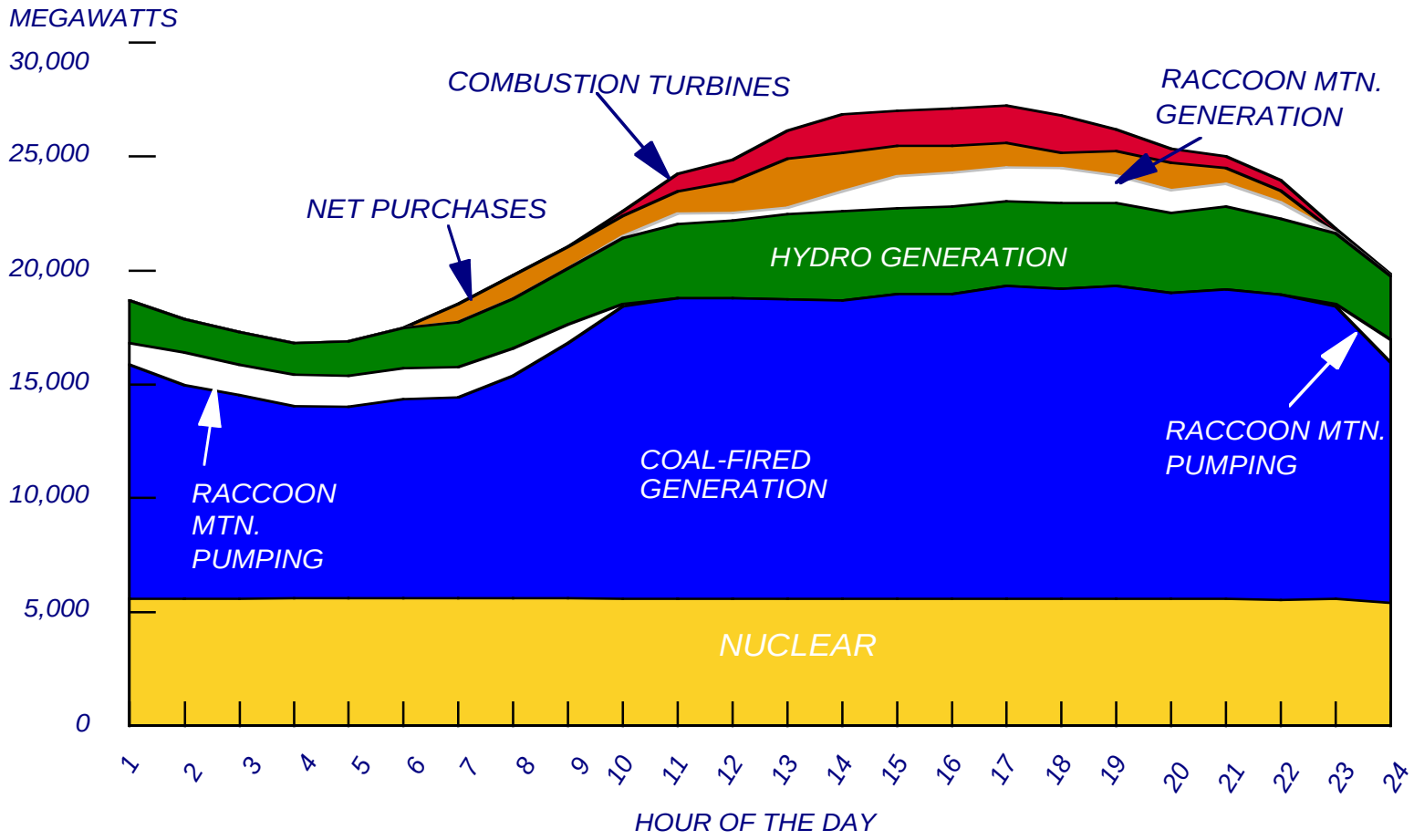
Fusion Power Plant with Electrolyzer



TVA LOAD AND SUPPLY

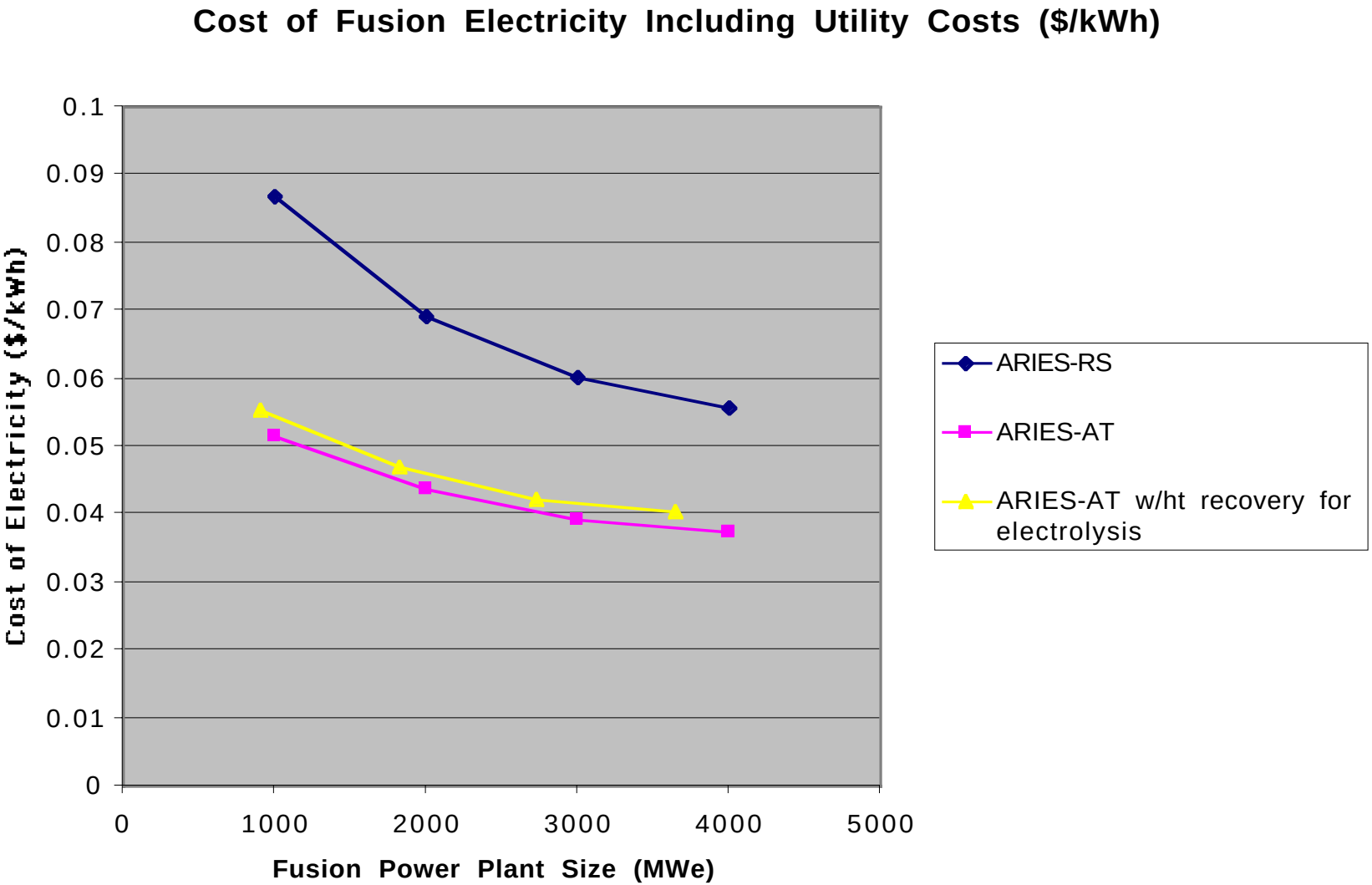
JUNE 24, 1998

NET SYSTEM LOAD 27,253 MW
HOUR: 1700
TEMPERATURE:94 DEGREES F.

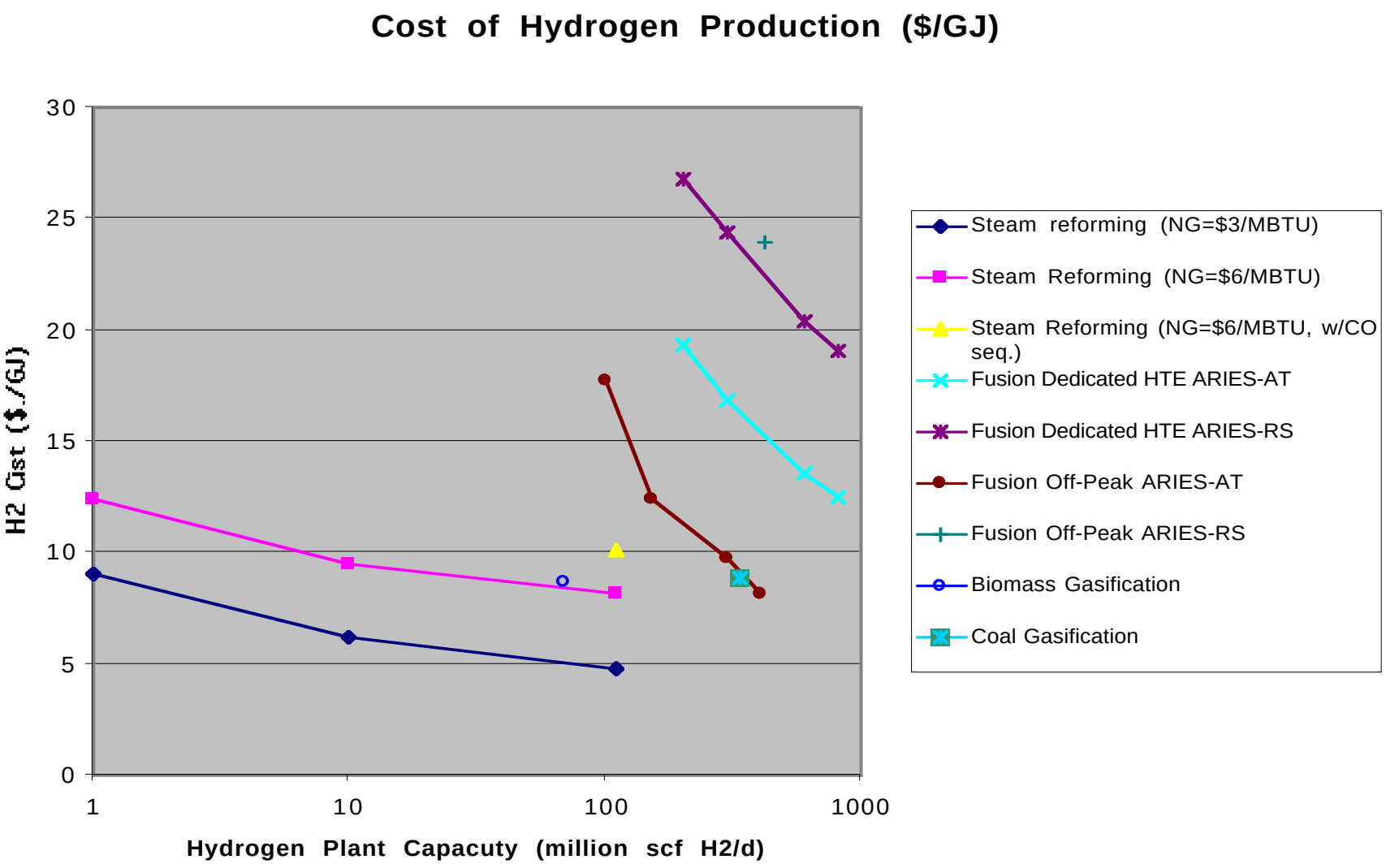


TPS:ESO:SA 10/13/98

Cost of Electricity w/wo Heat to Electrolyzer



Comparison of Hydrogen Costs from Various Sources



CONCLUSIONS

- Fusion energy could be available in the middle of the 21st century if ITER and NIF work and other technologies and radiation resistant materials are developed.

- Today's fusion power plant designs and the expected economies of scale for fusion plants indicate one route for fusion power to be competitive – going to large power plants e.g., 3 to 4 Gwe.

- Studies show that even with the additional utility costs for such plants, about 5 mills/kWh, they should remain competitive. Co-produced hydrogen could be priced competitively, reduce the power going to the grid, and could allow load following while running at full power.