TRITIUM WORKSHOP GOALS

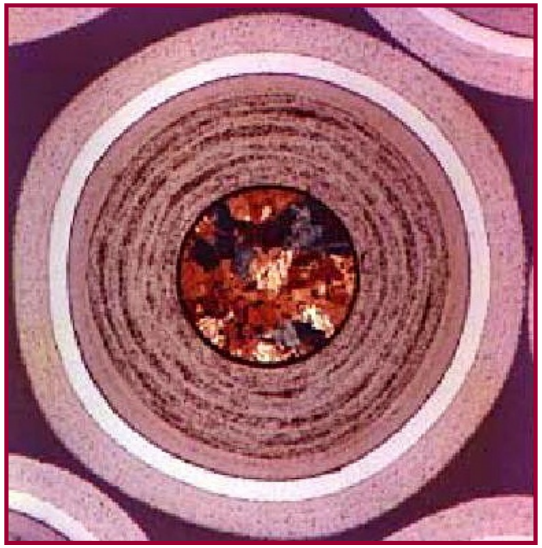
Charles Forsberg

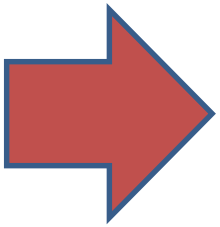
Department of Nuclear Science and Engineering; Massachusetts Institute of Technology
77 Massachusetts Ave; Bld. 42-207a; Cambridge, MA 02139; Tel: (617) 324-4010;
Email: cforsber@mit.edu; http://web.mit.edu/nse/people/research/forsberg.html

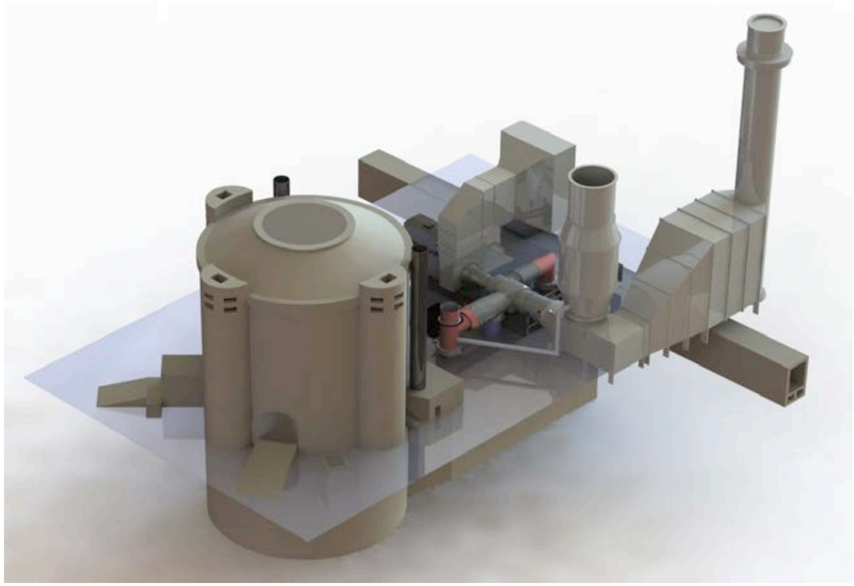
Workshop on Tritium Control and Capture in Salt-Cooled Fission and Fusion Reactors:
Experiments, Models, and Benchmarking
Salt Lake City
October 27, 2015

Three Technologies Depending Upon Liquid Salt Coolants & Control of Tritium

Fluoride-salt-cooled High Temperature Reactors: Solid Fuel & Clean Salt





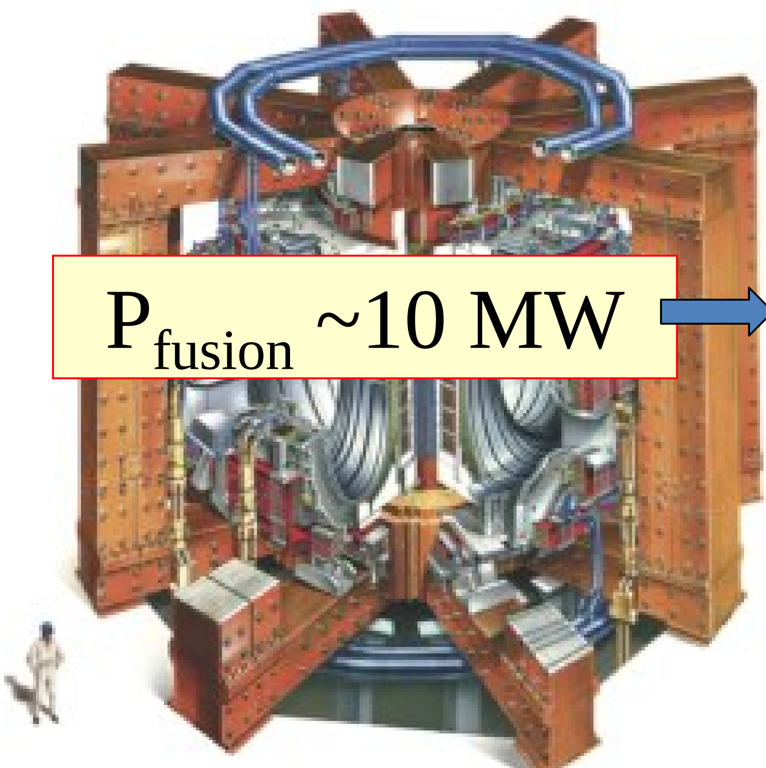


Enabled by Advances In Gas-cooled High-Graphite-Matrix Coated Particle Fuel

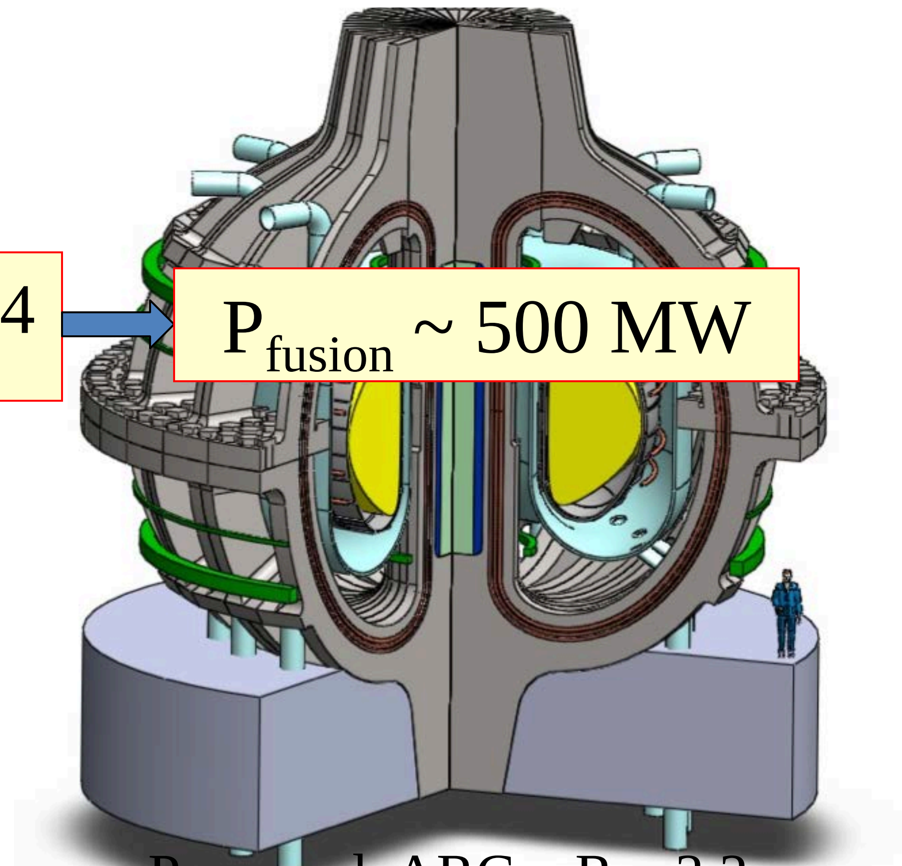
High-Magnetic Field Fusion

Copper, B = 3.5 T

REBCO superconductor, B = 9.2 T



P_{fusion} ~10 MW → x B^4 → P_{fusion} ~ 500 MW



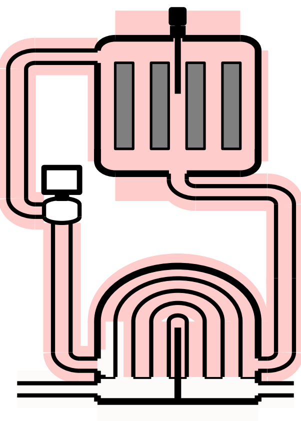
JET: R ~ 3 m
Operated in United Kingdom

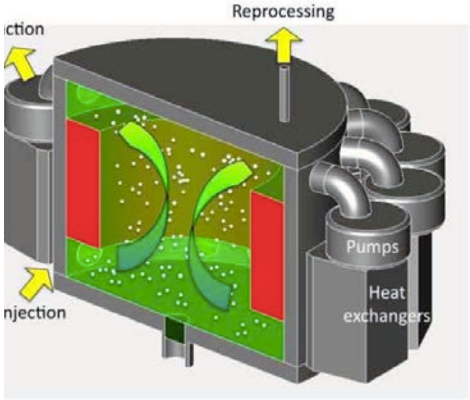
Proposed: ARC: R ~ 3.2 m

Enabled by REBCO Superconductors that Enable Doubling Magnetic Fields

Molten Salt Reactor

Fuel Dissolved in Salt





Many Options

Enabled By Multiple Technologies and Interest In Alternative Breeder Reactors and Fuel Cycles

Common and Different Salt Challenges for FHR, MSR, and Fusion

Property	FHR	MSR	Fusion
Salt	Fluoride	Fluoride or Chloride (fast spectrum only)	Fluoride
Impurities	Corrosion and possible fission product impurities	High concentrations of fission products and actinides	Corrosion impurities
Use lithium salts	Optional	Depends upon goals	Required
Tritium production	Small (^{7}Li in Coolant)	Small (^{7}Li in Coolant)	Very High (^{6}Li in Coolant)
Tritium value	Waste	Waste	Fuel
Carbon in system	Yes	Depends upon option	No
Redox control	Ce^{+2}/Ce^{+3}, other	U^{+3}/U^{+4}	Ce^{+2}/Ce^{+3}, Be, other

Common Technology Challenges for FHR, Fusion, and MSR

Common Challenges

- **Power Cycles**
- Themohydraulics
- Mechanical Equipment
- Instrumentation
- Lithium Isotopic Separation (^{6}Li or ^{7}Li)
- **Tritium Generation**
- **Corrosion Control**
- **Tritium Control**

Common Technology Challenges for FHR, Fusion, and MSR

Unique Capability of All Salt-Cooled Fission and Fusion Systems to Couple to Air or Helium Brayton Cycles

Salt Coolants Were Developed for the Aircraft Nuclear Propulsion Program

Salt Coolants Designed to Couple Reactors to Jet Engines

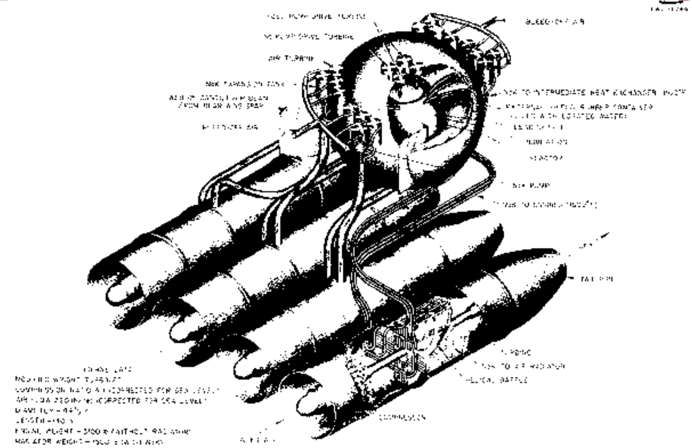
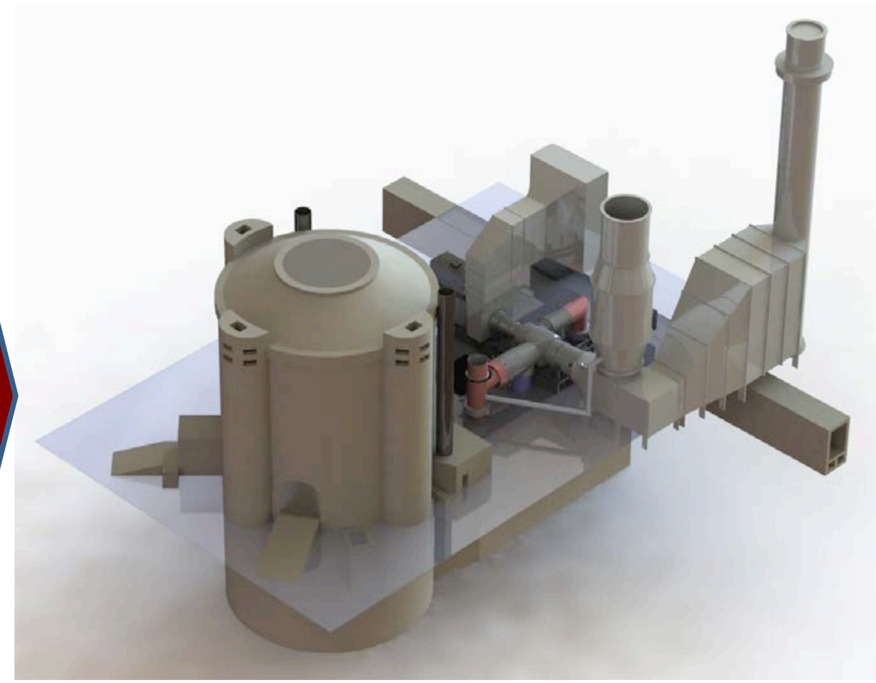


Fig. 4.33. Aircraft Power Plant (200 Megawatt).

It Has Taken 50 Years for Utility Gas Turbine Technology to Mature Sufficiently to Enable Coupling with an FHR

Coupling Reactors to Gas Turbines is Transformational

Advances In Natural Gas Combined Cycles Enable Coupling Reactors to Gas Turbines



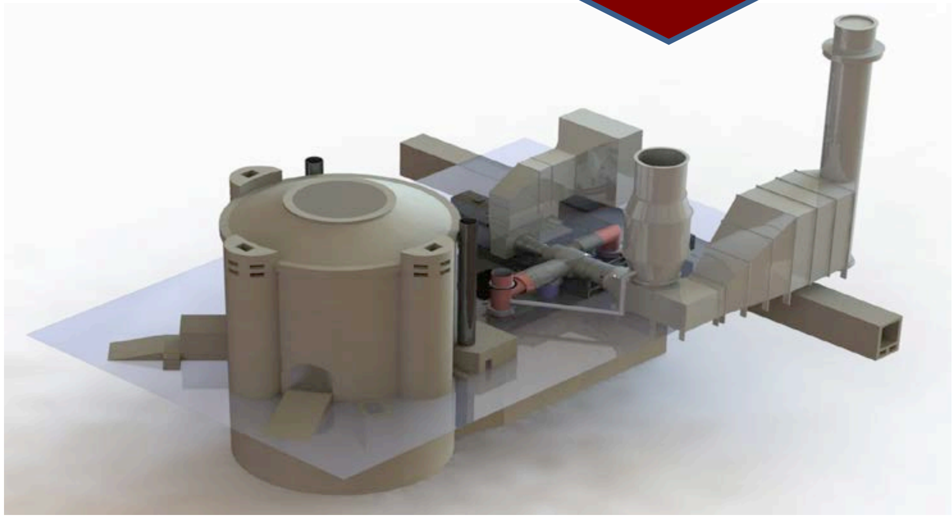
Gas-Turbine Technology Not Viable 15 Years Ago

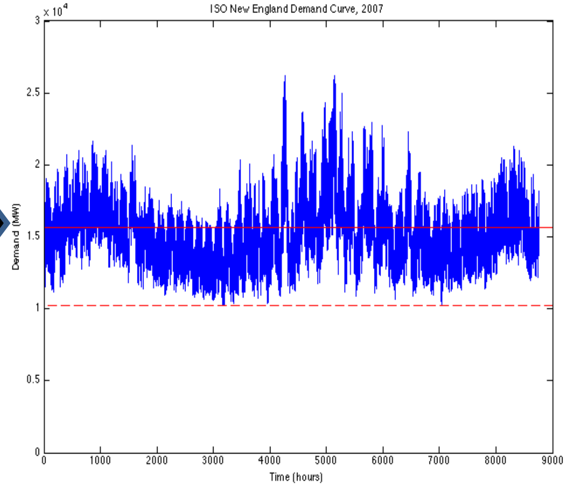
Only Salt-Cooled Reactors (Fission & Fusion) Couple Efficiently to Nuclear Air-Brayton Combined Cycles (NACC)

Commercial gas-turbine exit air compressor temperatures are between 400 and 500°C; thus, must deliver all heat above these temperatures

Coupling Salt Fission and Fusion Reactors Using NACC Enables Base-Load nuclear with Variable Electricity to the Grid

Stored Heat, Natural Gas, or Hydrogen





Base-Load Reactor

Gas Turbine

Variable Electricity

Boosts Revenue by 50 to 100% Relative to Base-load Nuclear Power Plants

Power Cycle Choices May Impact Tritium Control Strategies

- Can trap tritium in some power cycles because cold side of power cycle prevents tritium releases
  - Supercritical carbon dioxide
  - Helium Bryaton cycles
- Tritium major challenge if enters some power cycles
  - Steam cycles
  - Air-Brayton power cycles

Common Technology Challenges for FHR, Fusion, and MSR

The Coupled Challenges of Tritium Generation, Corrosion and Tritium Control

Tritium Generation, Corrosion and Control Are Coupled

Neutrons + $^{7}Li/^{6}Li/Be \rightarrow {}^{3}HF$

^{3}HF + Metal → Corrosion + $^{3}H_2$

Can't Separate Tritium Generation, Corrosion and Control

Workshop Goals

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- Exchange information and enable future exchange of information
- Initiate an effort for benchmarking of experiments and models
- Encourage cooperation between different groups working on the same challenges

Common Challenges for Multiple Power Systems