# Lowering Peak Temperatures For Nuclear Thermochemical Production of Hydrogen

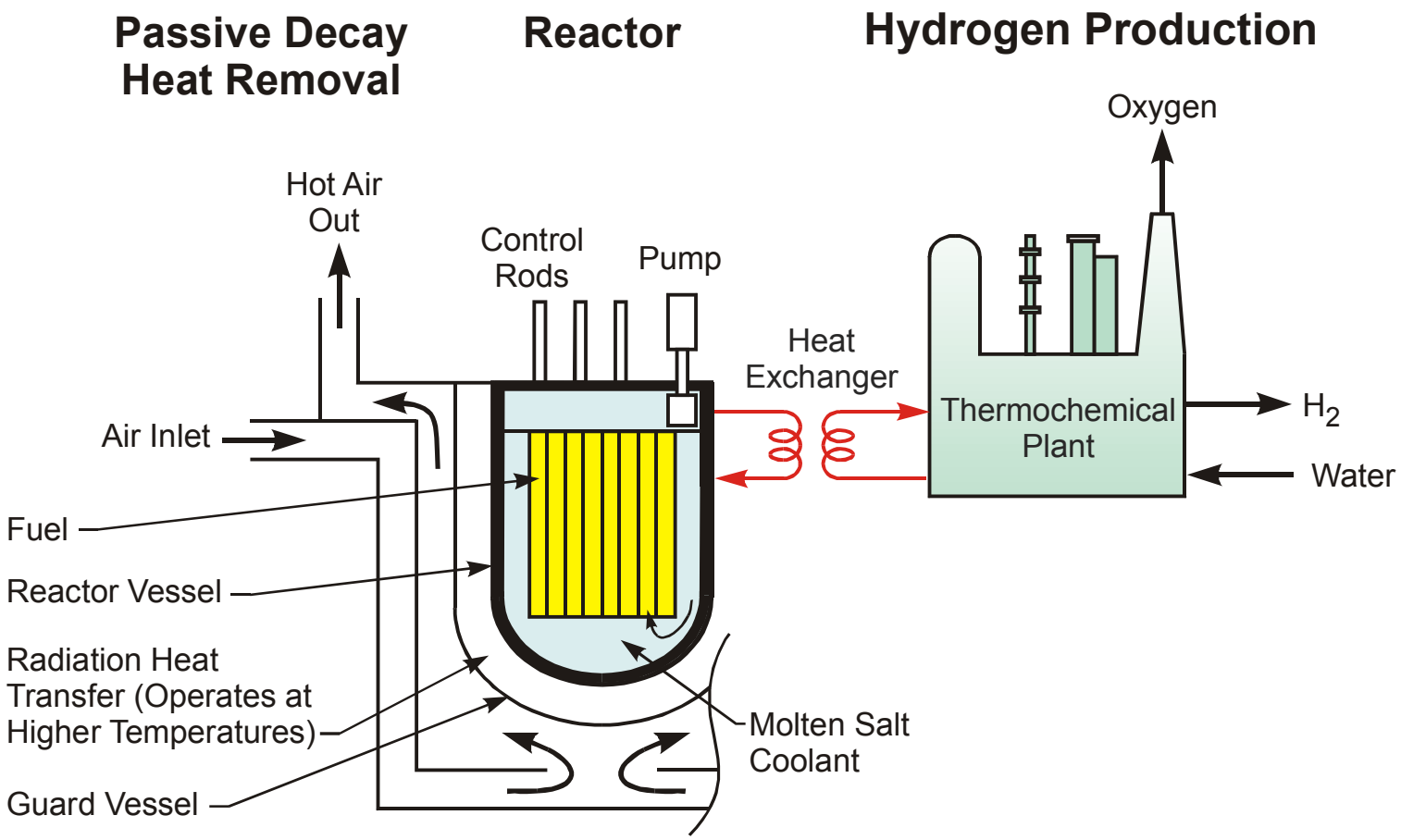
Dr. Charles Forsberg

Oak Ridge National Laboratory
P.O. Box 2008; Oak Ridge, TN 37831-6179
Tel: (865) 574-6783; E-mail: forsbergcw@ornl.gov

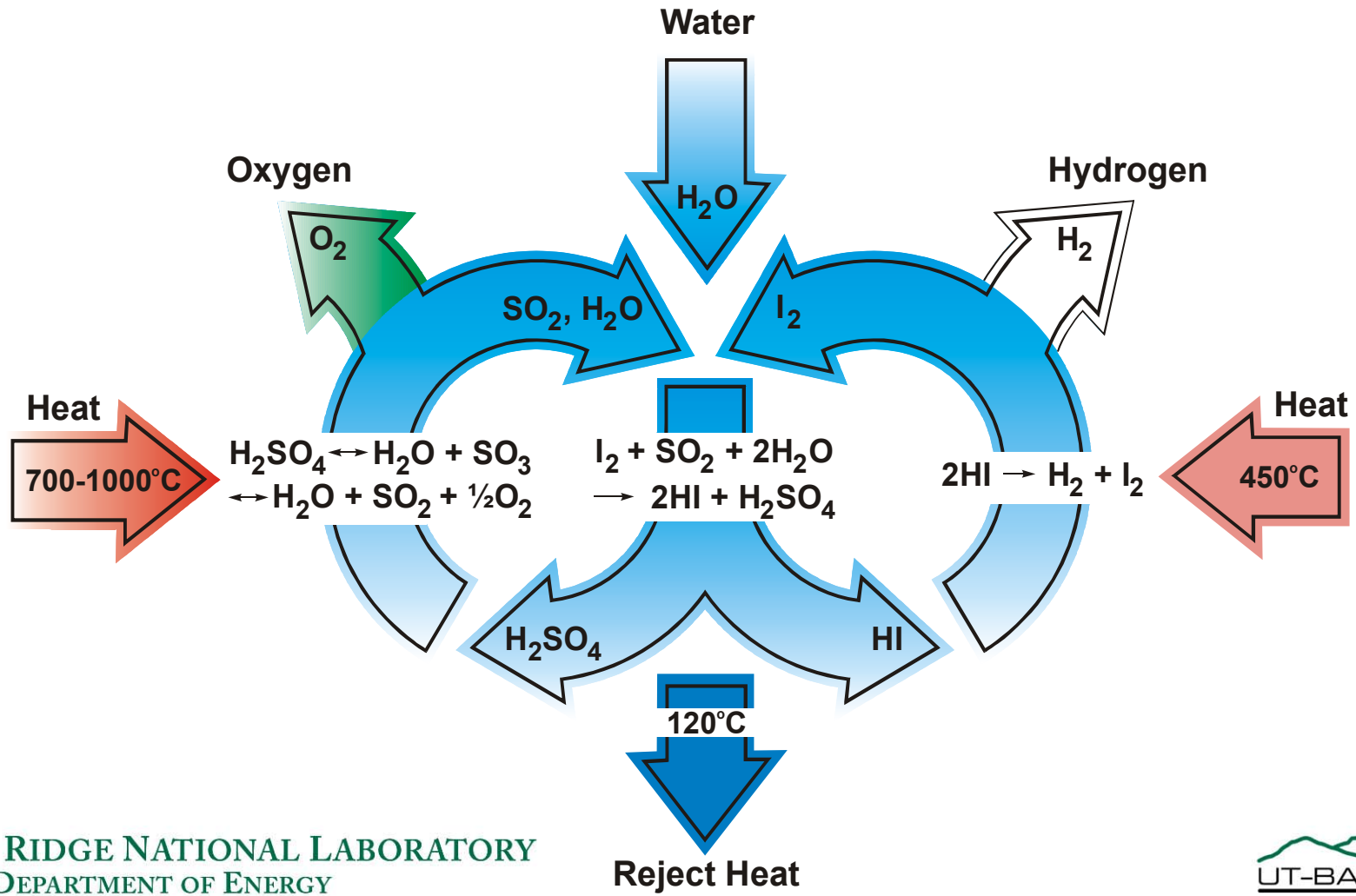
Safety and Economy of Hydrogen Transport: Second International Symposium
Town of Sarov, Nizhniy Novgorod Region, Russia.
18-21 August, 2003

**The submitted manuscript has been authored by a contractor of the U.S. Government under contract DE-AC05-00OR22725. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes. File name: AHTR:Russia.ORNL.AUG2003.Production**

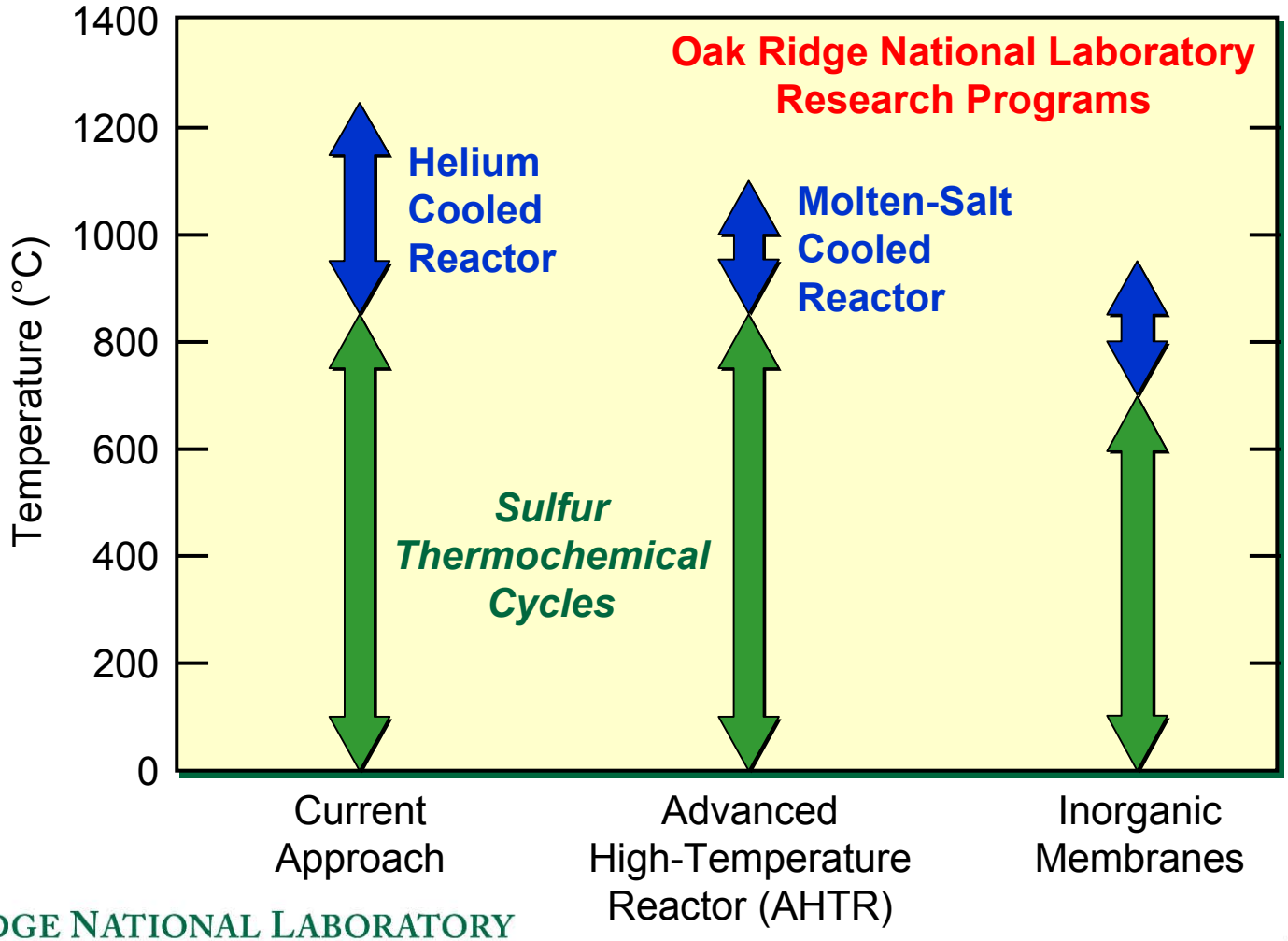
# Heat From Nuclear Reactors Can Be Used To Produce $H_2$



# Thermochemical Processes Use High-Temperature Heat and Water to Produce $H_2$



# The Challenge: High Temperatures Are Required

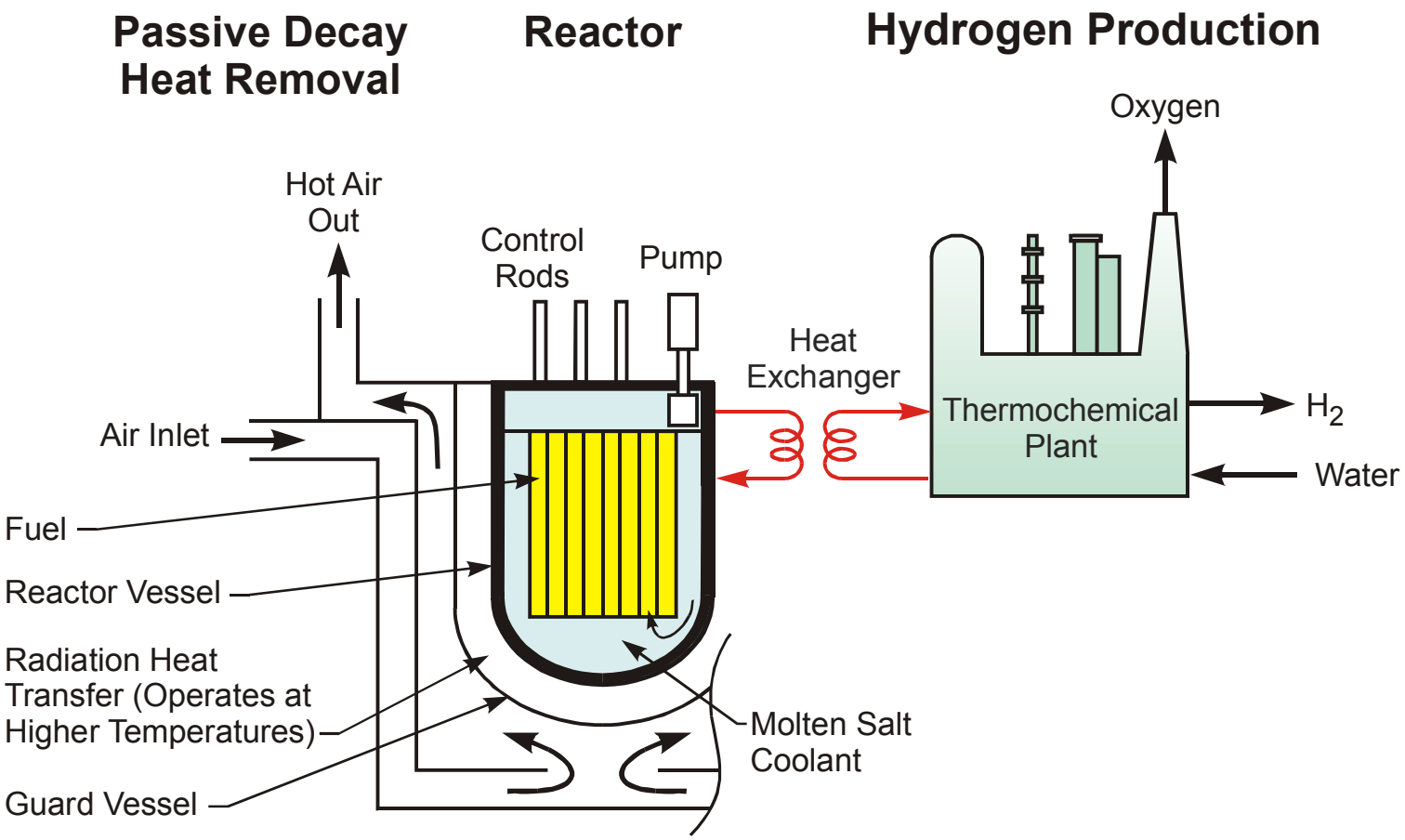


# Advanced High-Temperature Reactor

**Graphite Coated-Particle Fuel**

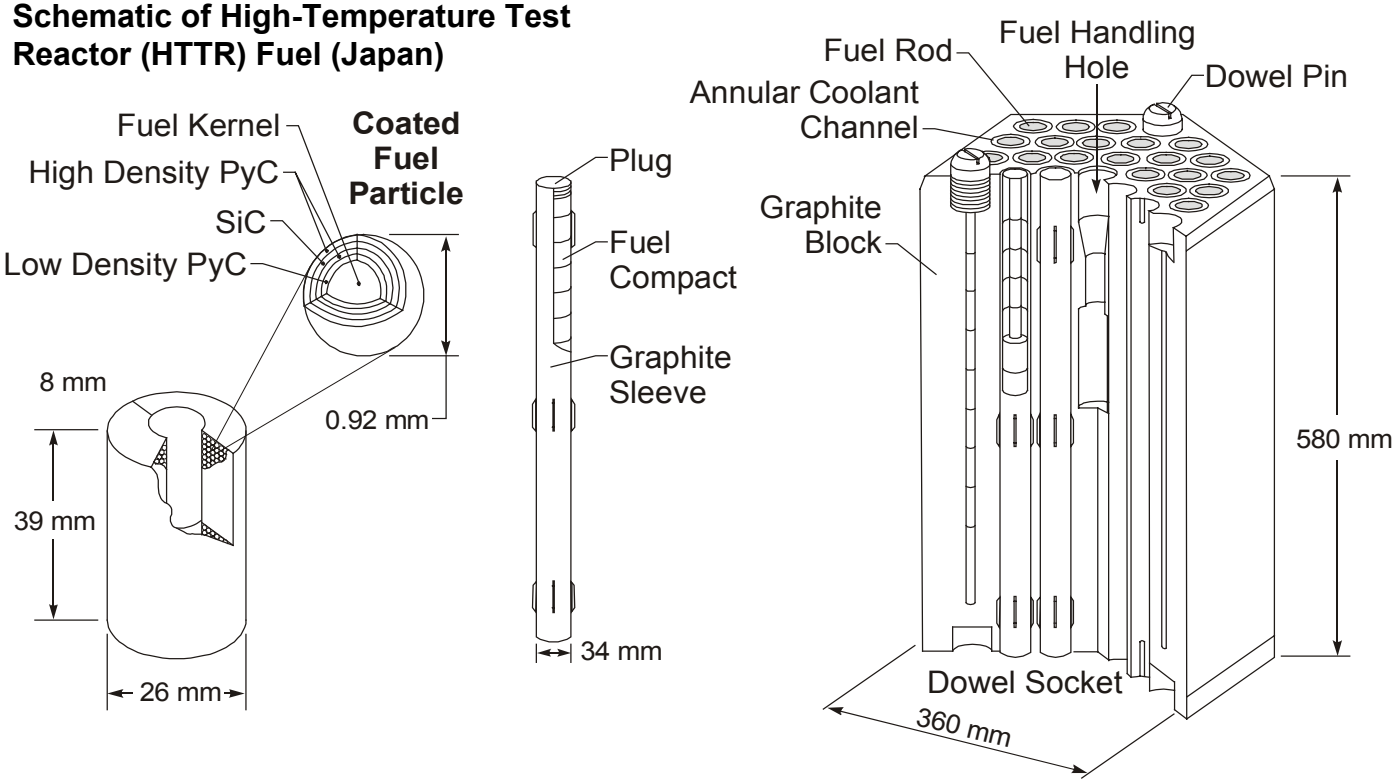
**Molten Salt Coolant (Fluoride Salts)**

# Advanced High-Temperature Reactor



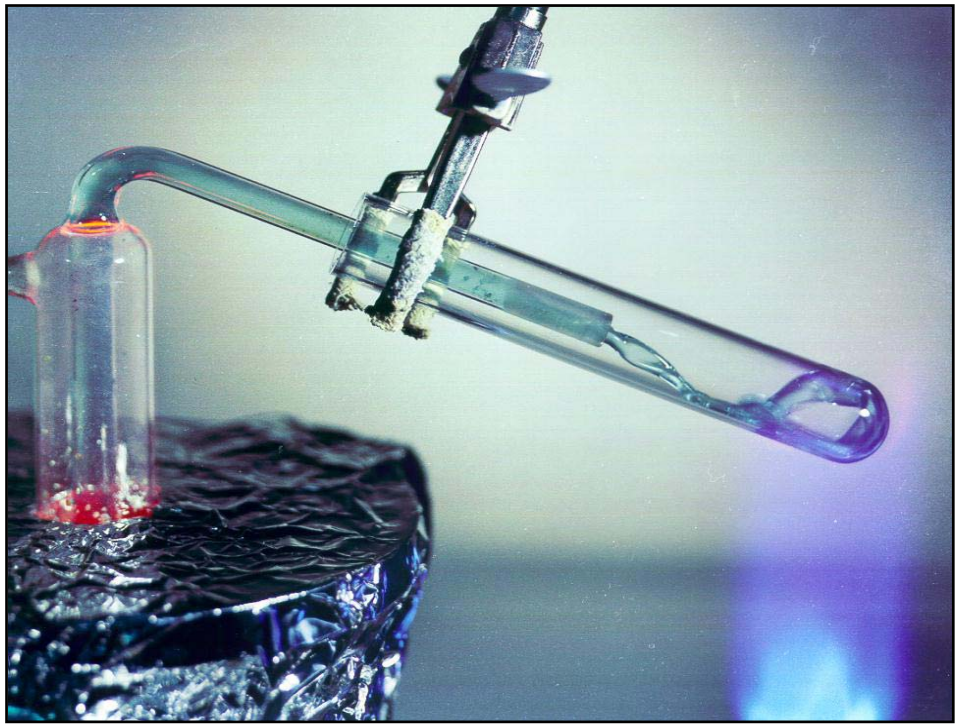
# High-Temperature Reactors Use One Fuel

**Schematic of High-Temperature Test Reactor (HTTR) Fuel (Japan)**

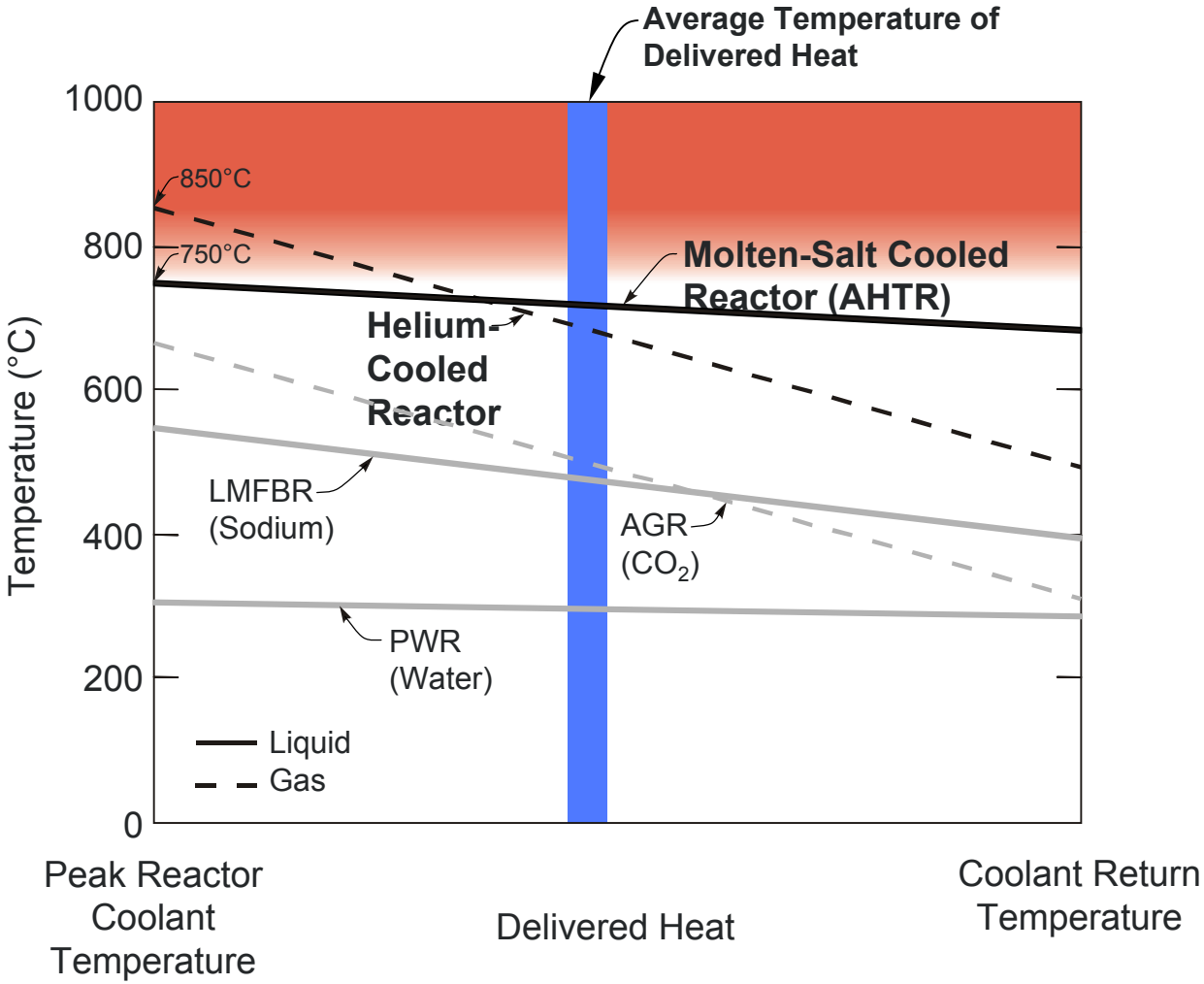



**Fuel Compact** **Fuel Rod** **Fuel Block**

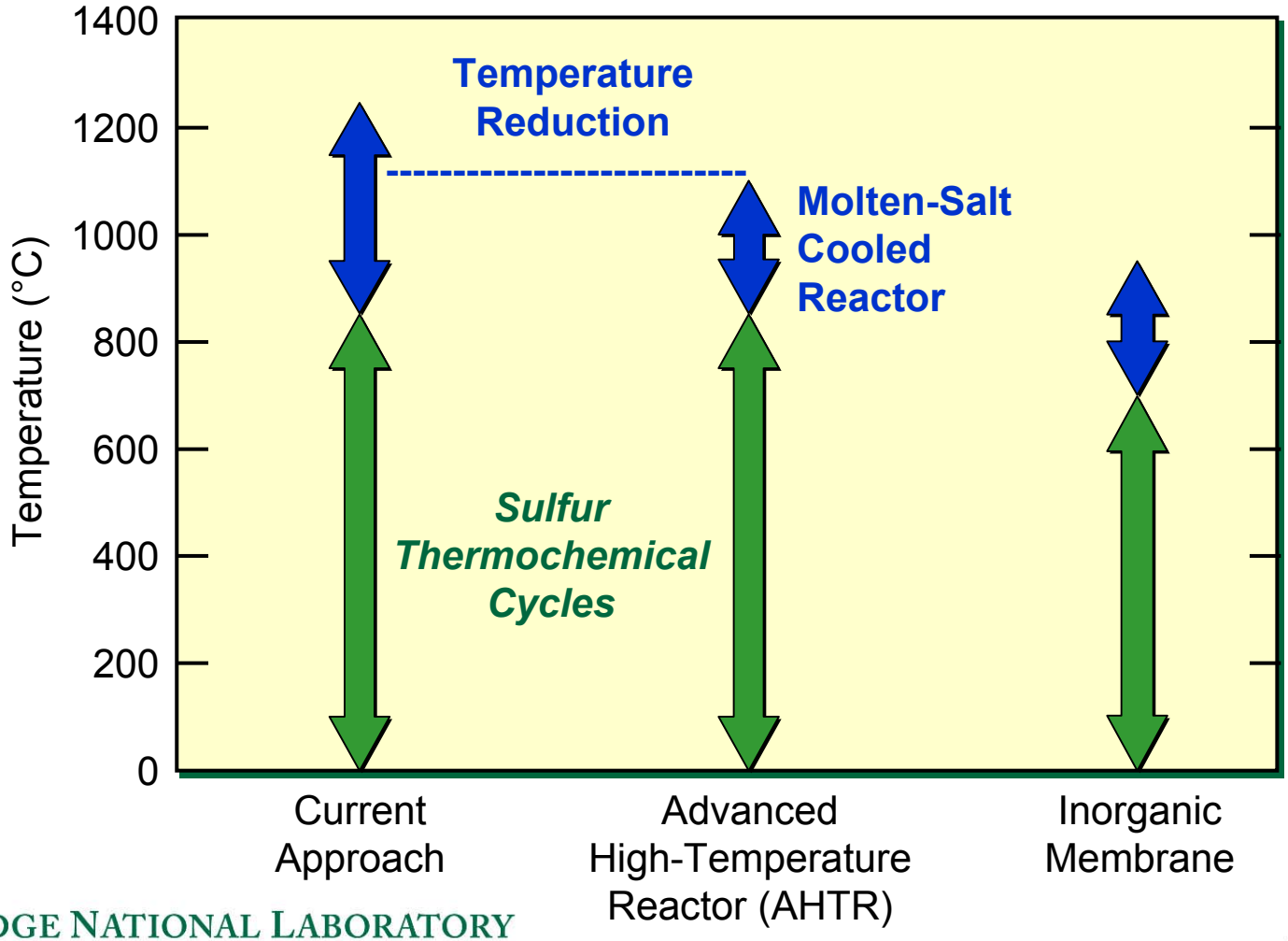
# Molten Salt Coolants Have Several Advantages: Good Heat Transfer, Low Pressure, and Transparent



# Liquid Coolants Lower Peak Reactor Temperatures



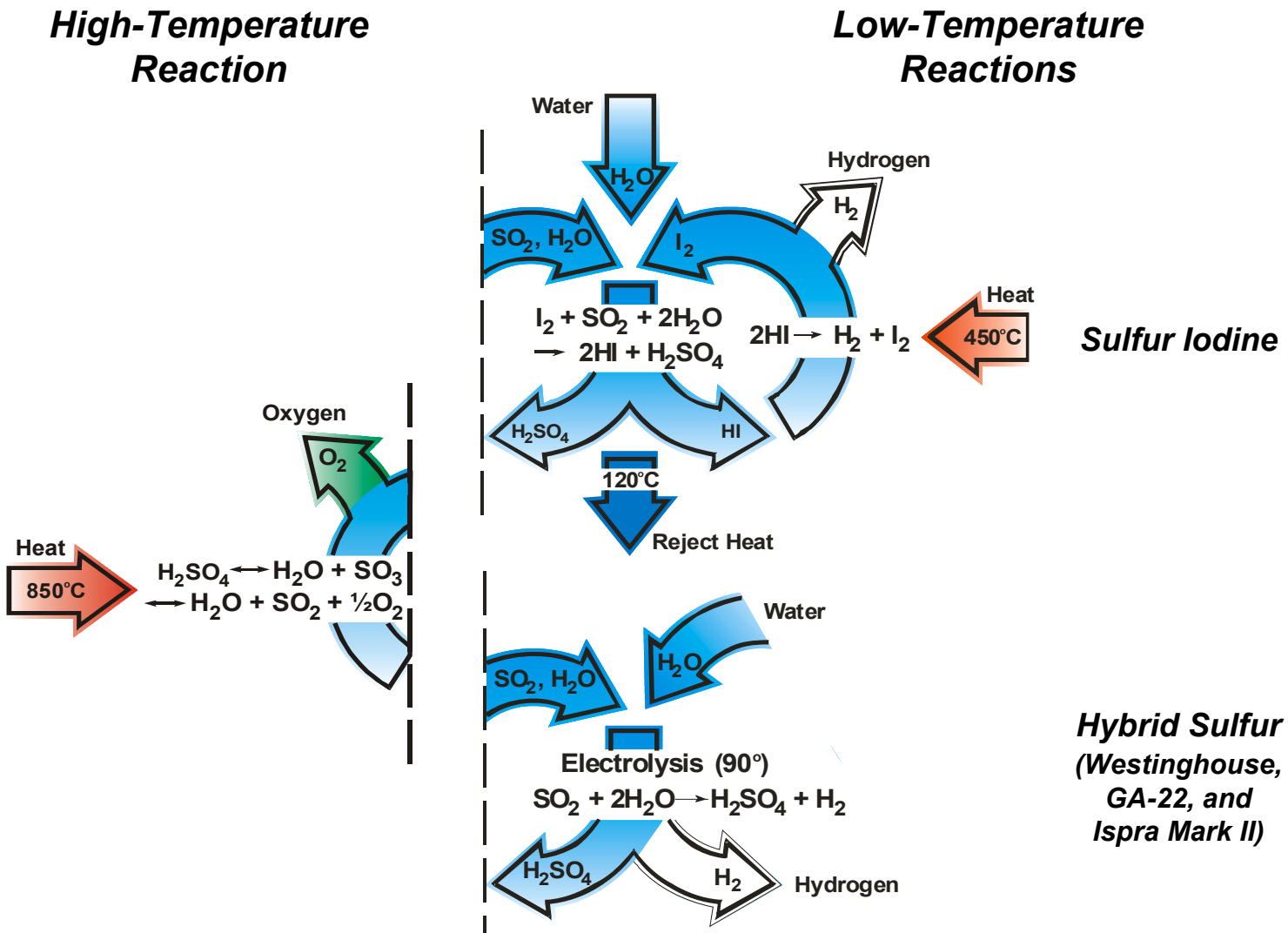
# Liquid Cooling Lowers Peak Temperatures



# Inorganic Separation Membranes

## Lowering Peak Thermochemical Cycle Temperatures

# Sulfur Family of Thermochemical Cycles



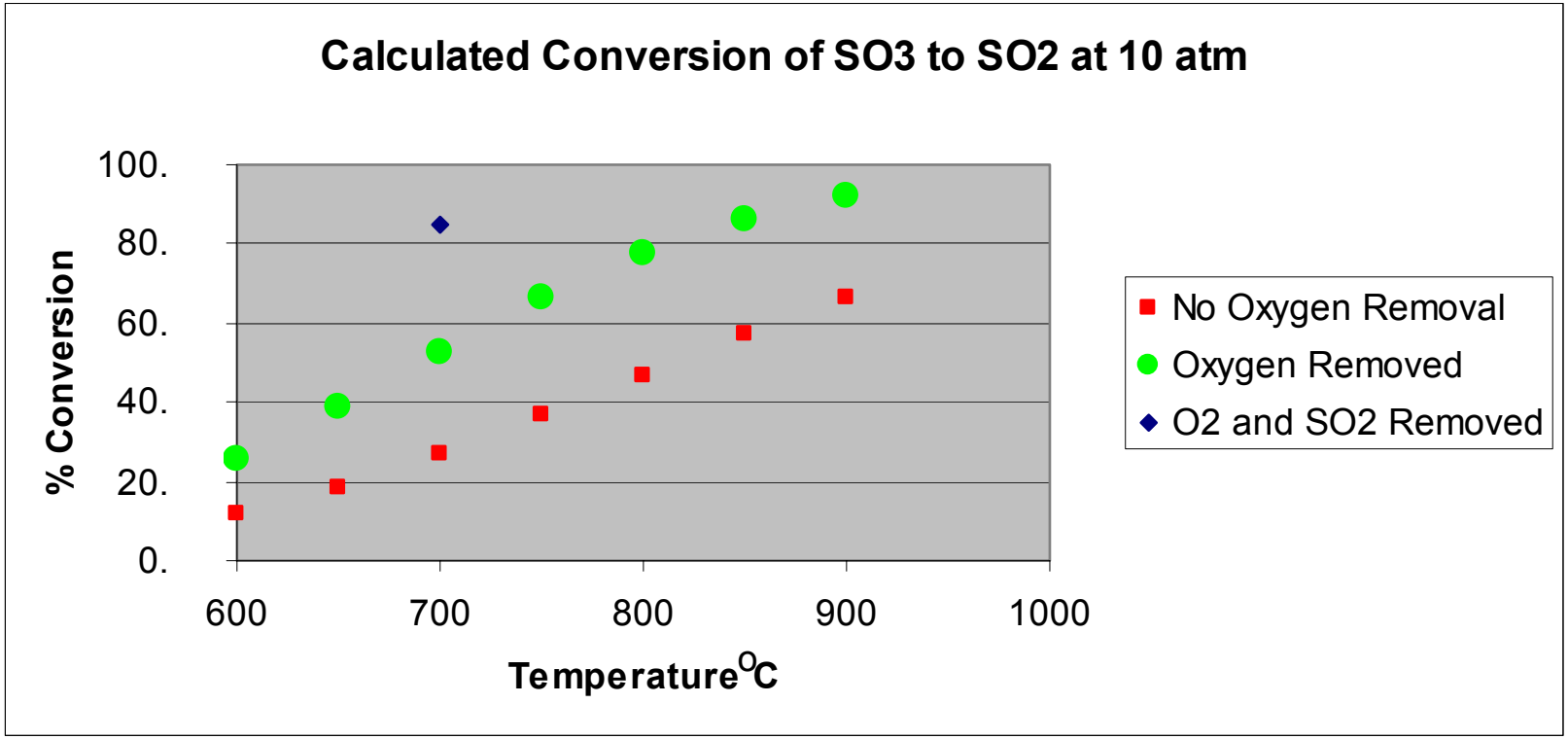
# High Temperatures Required By Sulfuric Acid Decomposition Step

- High-temperatures required to drive equilibrium reaction to completion

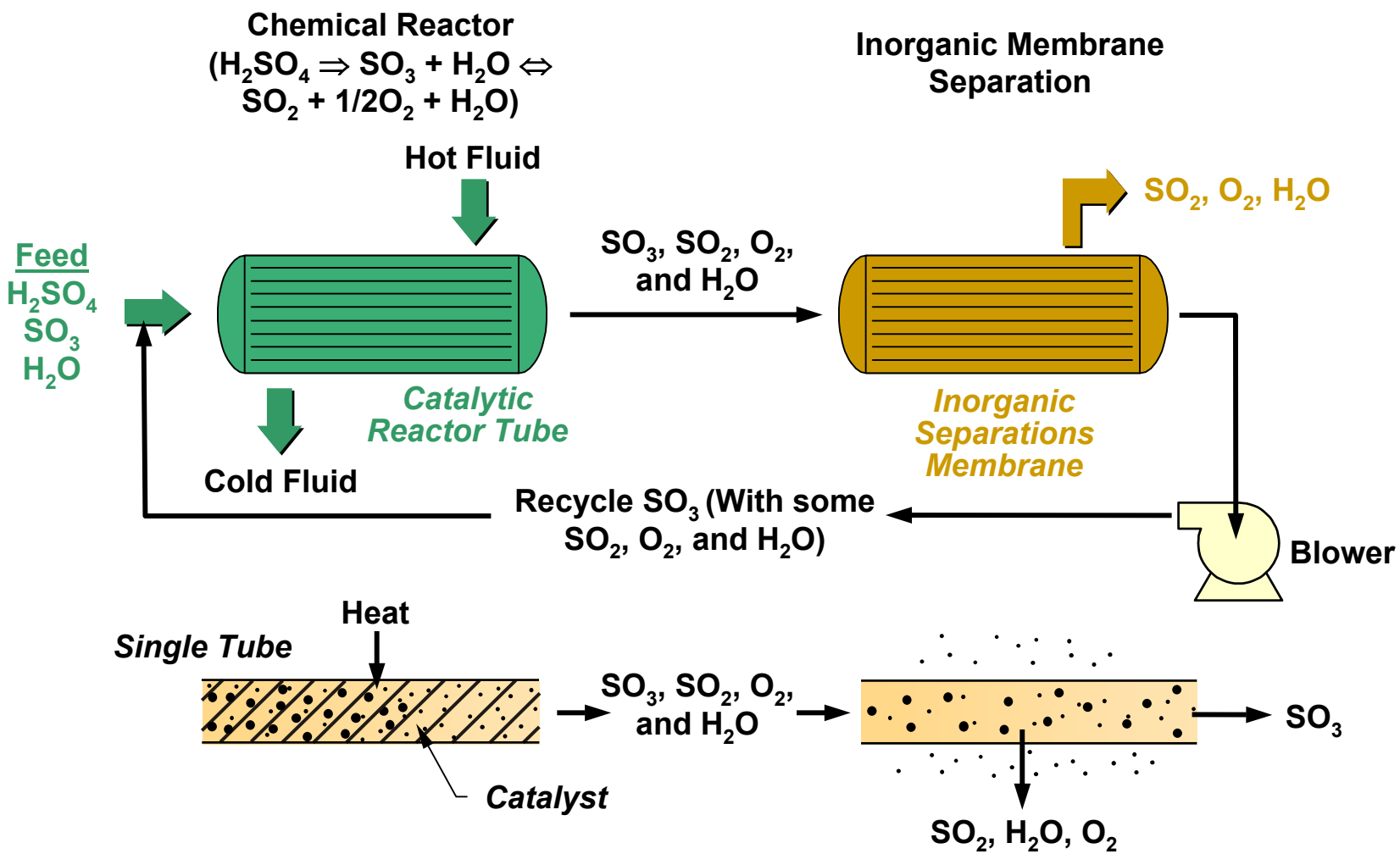
$$H_2SO_4 \Leftrightarrow SO_3 + H_2O \Leftrightarrow SO_2 + H_2O + 1/2\ O_2$$

- Membrane separation of $O_2$, $H_2O$, and $SO_2$ from $SO_3$ drives reaction to the right allowing high conversion at lower reaction temperatures

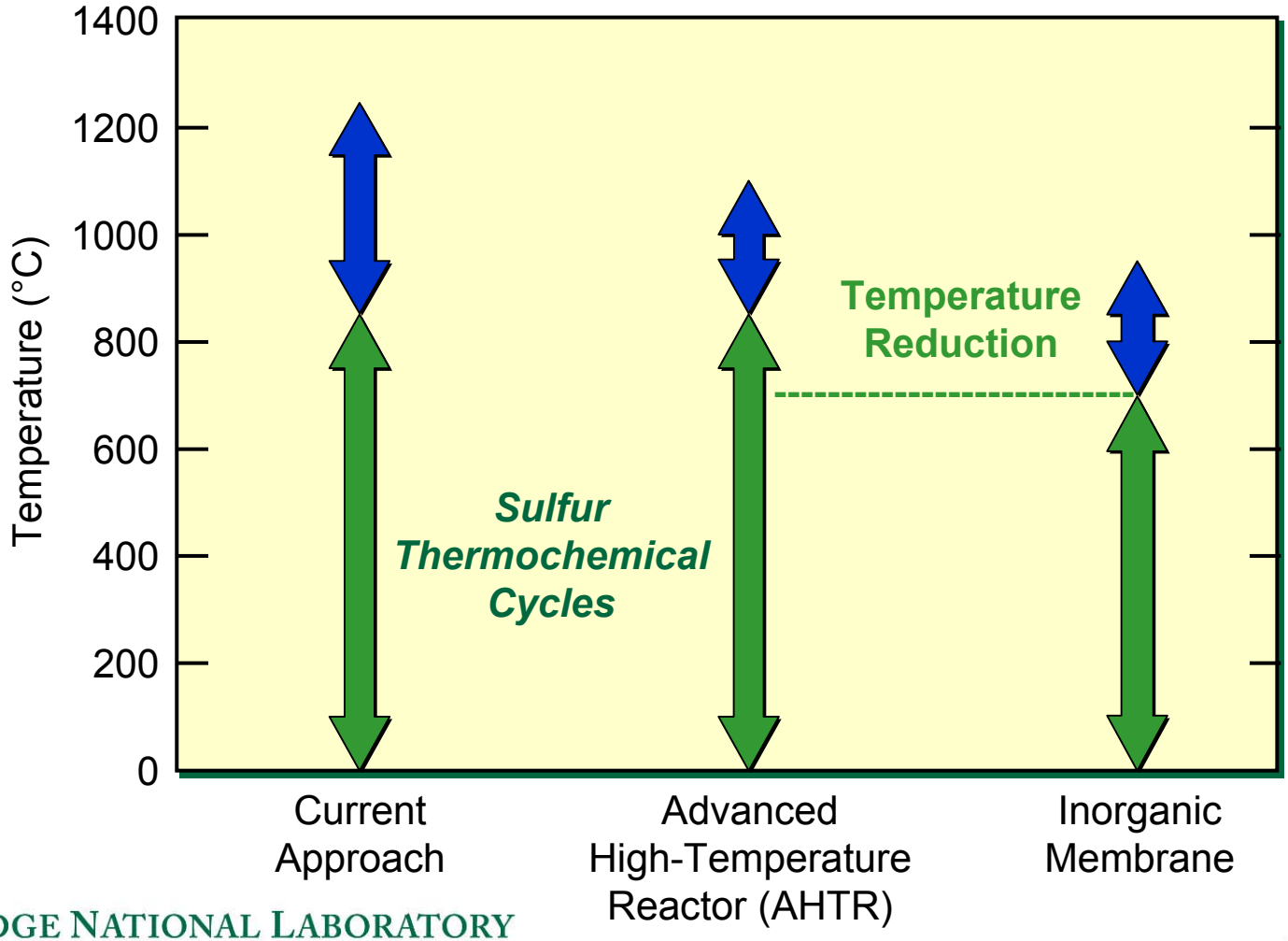
# Calculated Conversion of $SO_3$ to $SO_2$



# Sulfur-Trioxide Membrane Decomposition System



# Inorganic Membranes Lower Temperatures



# Methods to Lower Peak Temperatures for Thermochemical Hydrogen Production Are Being Developed

- Advanced High-Temperature Reactor
  - Low-pressure liquid cooled reactor
- Inorganic separation membranes
  - Complete chemical reactions at lower temperatures