High-Temperature Teaching & Test Reactor (HT^{3}R)

Project Objectives

Presentation to NRC

May 11, 2006

Rockville, MD

James F. Wright, PhD
HT^{3}R Program Manager
University of Texas of the Permian Basin

Introduction

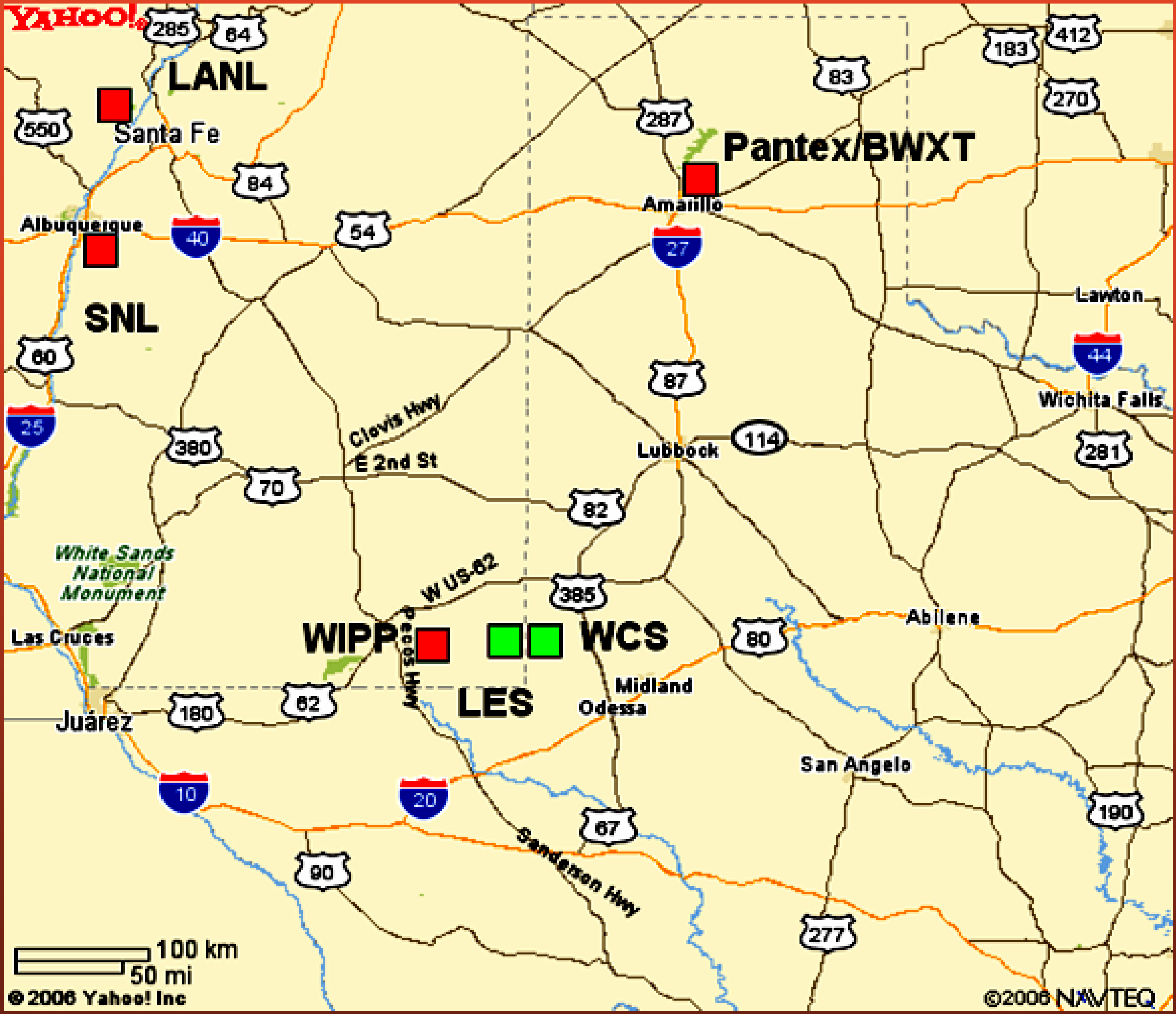
The University, People & Region

University of Texas of the Permian Basin

- Component of the University of Texas System
  - 9 Academic Campuses
  - 6 Medical Campuses
  - ~$8+ Billion Annual Operating Budget
  - ~180,000 Students
- 3600 Students (>14%/yr Growth 3 yrs)
- Hispanic Serving Institution

University of Texas of the Permian Basin

- At least 300 miles from Most Everywhere Else
- ~250,000 people within 30 miles of Campus
- Largest Oil & Gas Producing Region in US
- Largest Petrochemical Complex in the World ***not*** on a Body of Water.
- Regional Commercial Nuclear Industry Development



YAHOO!
LANL
Santa Fe
Albuquerque
SNL
Pantex/BWXT
Amarillo
Lawton
Wichita Falls
Clovis Hwy
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Lubbock
White Sands National Monument
Las Cruces
WIPP
Pecos Hwy
W US-62
WCS
LES
Midland
Odessa
Abilene
San Angelo
Juárez
Sanderson Hwy
100 km
50 mi
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Project Objective

High-Temperature Teaching & Test Reactor
(HT^3R)

Develop Teaching and Research Capabilities to Address Urgent <u>Energy</u> & <u>Environmental</u> Issues Facing US and World

Urgent US Energy Problems

Transportation – Imported Oil

Fixed - Electricity Generation

Urgent US Energy Problems

- The World's Petroleum Reserves are Decreasing! Peak U.S. Production: 1973
  - US Imports ~65% Today
  - US Projected Imports >85% by 2020

Fixed - Electricity Generation

Urgent US Energy Problems

- The World's Petroleum Reserves are Decreasing! Peak U.S. Production: 1973
  - US Imports ~65% Today
  - US Projected Imports >85% by 2020

- By 2045 - >46% of current US electricity generating capacity must be replaced
  - 20% nuclear
  - >26% non-nuclear (Coal, Nat. Gas, etc.)

Urgent US Environmental Problems

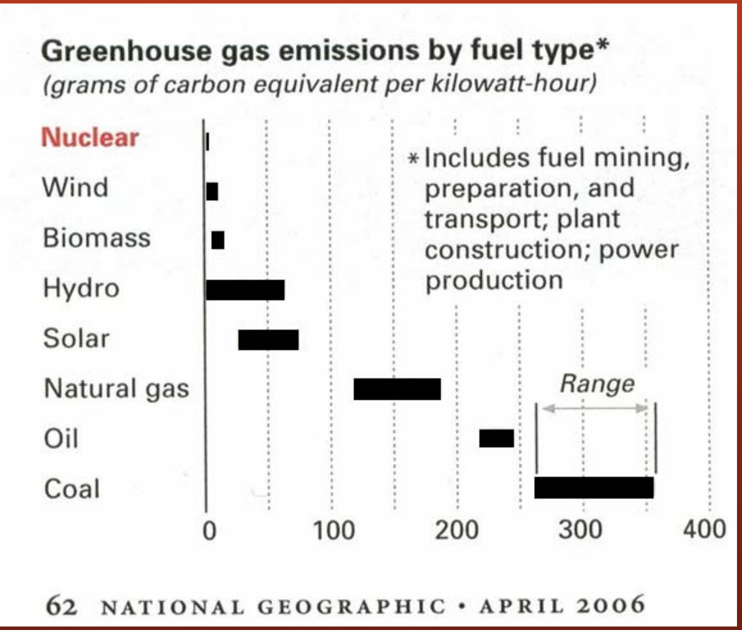
Air Quality

Water Supply

Urgent US **Environmental** Problems

- Decreased Air Quality
- Greenhouse Effect (Carbon Footprint)

Water Sup



Urgent US Environmental Problems

- Decreased Air Quality
- Greenhouse Effect (Carbon Footprint)

- Increased Resource Demand and Aquifer Drawdown
- Aquifer Pollution from Agriculture and Industry
- Lack of Aquifer Restoration Projects

Real Solutions are Complex!

- Allow Developing and Undeveloped Nations to Rise to our Standard of Living
- Protect the Environment
- Utilize Existing Infrastructures
- Multifaceted (Fixed, Mobile & Resource)
- “Deployment Transition” Plan
- Deployable Within 20 to 30 Years

UTPB’s Project Objective

Develop Teaching and Research Capabilities to Address Urgent <u>Energy</u> & <u>Environmental</u> Issues Facing US and World

UTPB's Project Objective

Support the Development of the ***US Gen IV High-Temperature Gas Reactor Program***

UTPB's Project Objective

Supports the Development of the ***US Gen IV High-Temperature Gas Reactor Program***

- **HT^{3}R** – Re-Create Educational Infrastructure; Support Timely Development of the NGNP; Develop Energy/Environmental Technologies
- **NGNP** – Provide a Technology Demonstration for Utility & Energy Companies
- ***Timely Commercialization*** – Address Critical US Environmental & Energy Problems that Have Become Security Problems!

US Needs High-Temperature Gas Reactor Program

- Develop New Mobile Energy Sources
  - Synthetic Hydrocarbons for Transition from Petroleum to Hydrogen Economy
  - Hydrogen for Future
- Replace the Projected 46% of Electrical Generating Capacity with High-Efficiency "Green" Nuclear Methods
- Provide Economic Water Desalinization
- Aim for Long-term future use of Hydrocarbons as a Base Chemical only

High-Temperature Teaching & Test Reactor (HT^{3}R)

Programmatic Information

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UTPB's Technical Solution

High-Temperature Gas Reactor Technology

UTPB's Technical Solution

High-Temperature
Teaching & Test
Reactor Facility

Basis for Technology Selection

- Andrews County
- Gen IV Technology
- Multifaceted Research Capability
  - Rad Lab (Fuel Cycle, Nuclear Structure, Hot Cells, “Rabbits,” etc.)
  - HTMP Lab (New High-Temperature Materials & Processes)
  - ETS Lab (Brayton Cycle & Other Energy Transfer Processes)

Strong Public Support!

The ***Texas Department of Environmental Quality*** Ordered an Independent Survey of the Residents of Andrews County, plus parts of Gaines and Ector Counties, Regarding the Siting of Nuclear Facilities.

Baselice & Assoc. Survey

How do you feel about using a nuclear reactor to generate heat, electricity, and hydrogen in Andrews County?

	Favor	Oppose	Unsure
Andrews	70%	17%	13%
Region	56%	26%	19%

Baselice & Assoc. Survey

How do you feel about enriching Uranium at the NEF in nearby Lea County New Mexico?

	Favor	Oppose	Unsure
Andrews	50%	19%	31%
Region	53%	24%	23%

Baselice & Assoc. Survey

How do you feel about processing low-level radioactive waste at the WCS facility in Andrews County?

	Favor	Oppose	Unsure
Andrews	66%	27%	8%
Region	53%	34%	13%

Baselice & Assoc. Survey

How do you feel about storing low-level radioactive waste at the WCS facility in Andrews County?

	Favor	Oppose	Unsure
Andrews	67%	26%	7%
Region	53%	35%	12%

Baselice & Assoc. Survey

How do you feel about disposing low-level radioactive waste at the WCS facility in Andrews County?

	Favor	Oppose	Unsure
Andrews	65%	26%	9%
Region	52%	35%	14%

Pre-Conceptual Design
The Team

- "Major Partners" – UT-Permian Basin, General Atomics, & UT System
- "Regional Partners" – Andrews City & County, Midland, & Odessa
- "Collaborators" – UT-Arlington, UT-Austin, UT-Dallas, UT-El Paso, Sandia National Laboratory, & Thorium Power

Pre-Conceptual Design
The Money

- >$3 Million in ~6 Weeks
  - >$250,000 – Individuals & Companies in West Texas
  - $1,250,000 – Pledged by Thorium Power
  - $500,000 – Andrews City & County EDC
  - $500,000 – Midland EDC
  - $500,000 – Odessa EDC

Pre-Conceptual Design
The Components

- **Technical** – Develop Design as Basis for Reasonable Estimates for total Project Cost and Schedule
- **Academic** – Determine how New Facility will be Used to create "World-Class" College of Engineering and Physics Department
- **Business** – Determine how New Facility Engineering, Licensing, Construction & Operations will be financed

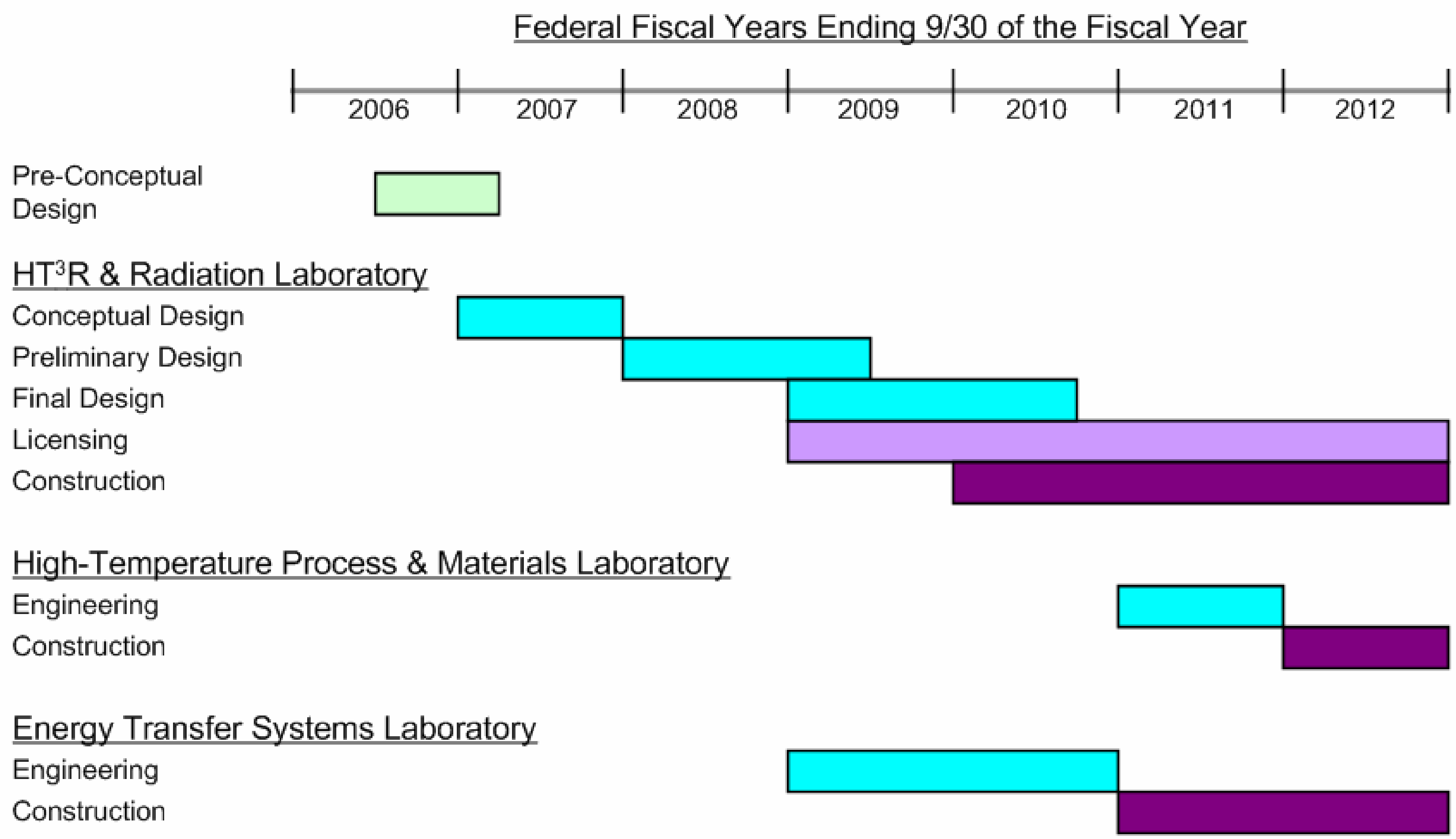
Pre-Conceptual Design
Purpose of Technical Component

- Generate a Reference Design
- Develop Engineering and Licensing Cost plus Schedule
- Develop Construction Cost plus Schedule

Pre-Conceptual Design Technical Milestones

- Feb 2006 – Started PCD
- Mar 2006 – First Two Years Engineering Estimates
- Aug 2006 – Technical Analysis Complete
- Dec 2006– Final Report With All Components

Project Gantt



HT^3R Technical Information

Malcolm P. LaBar
General Atomics

April 20, 2006

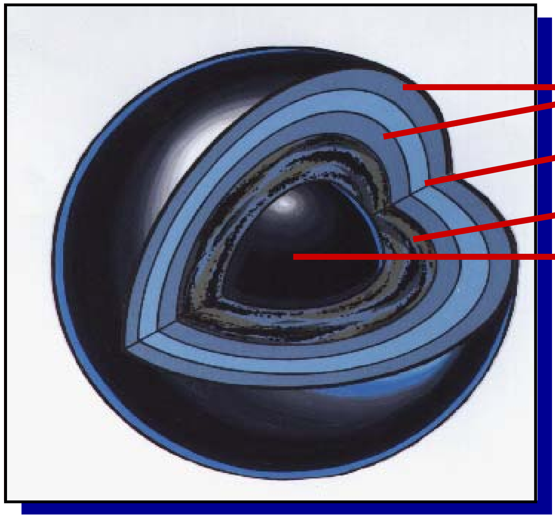
Outline

- General description of overall HT3R system
- Proposed reactor size, rating and operating conditions
- Passive safety features
- Use of existing technology
- Overall schedule goal

Overall System Characteristics Selected for HT^{3}R

- High temperature gas-cooled reactor (HTGR) key characteristics (Helium coolant, graphite moderator, coated particle fuel)
- Use of hexagonal graphite fuel blocks with coated particle fuel in compacts; 10% enriched UO_2 fuel
- Incorporation of same passive safety characteristics as the MHTGR and GT-MHR
- Coolant circulator and heat exchanger in primary loop. (Reactor heat transfer through heat exchanger to secondary loop for rejection to atmosphere)
- Provisions for add-on heat utilization systems in secondary loop

Coated Particle Fuel Ceramic Coatings Retain Their Integrity Under High Temperature Conditions



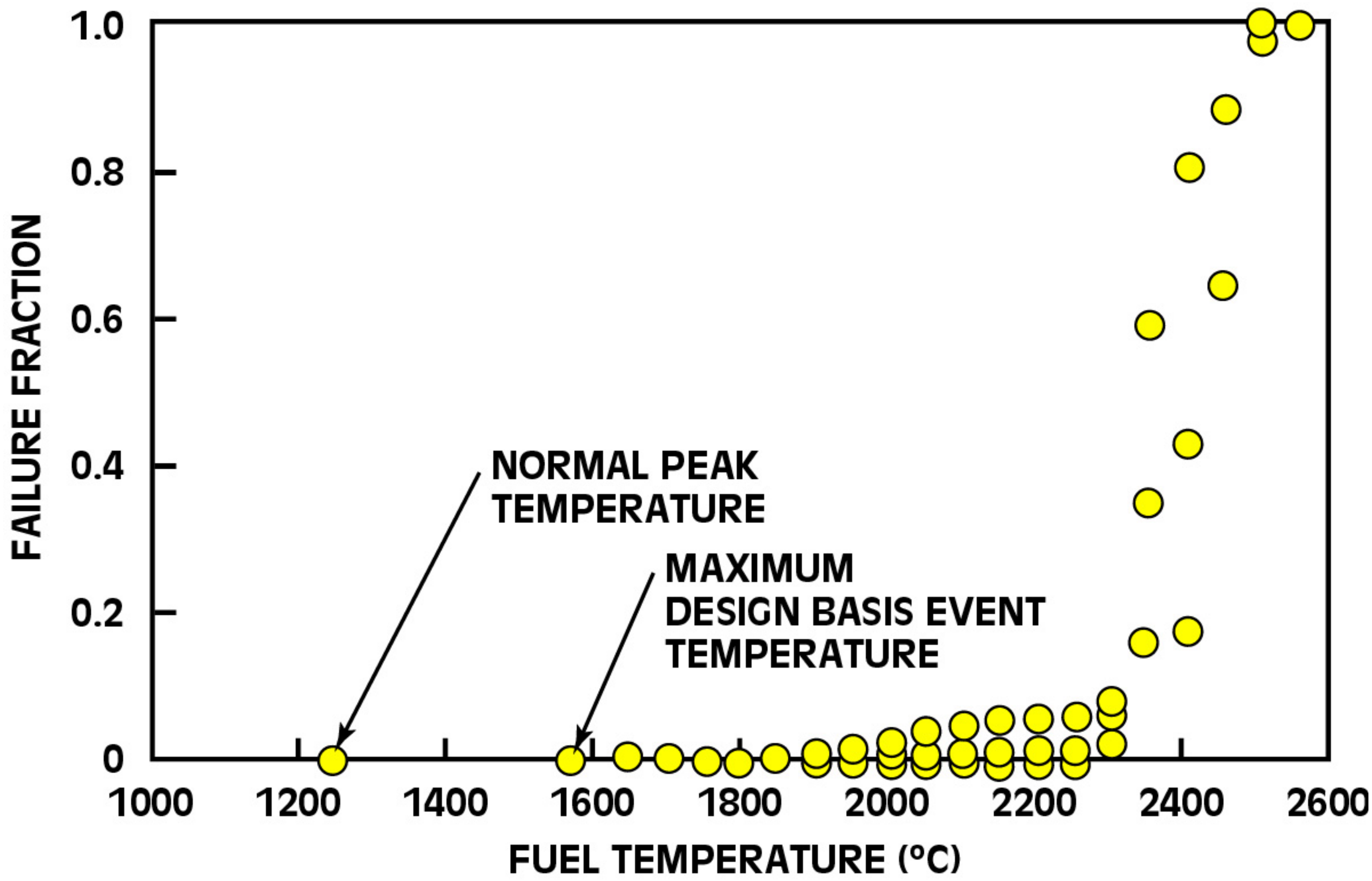
TRISO Coated fuel particles (left) are formed into fuel rods (center) and inserted into graphite fuel elements (right).

PARTICLES

COMPACTS

FUEL ELEMENTS

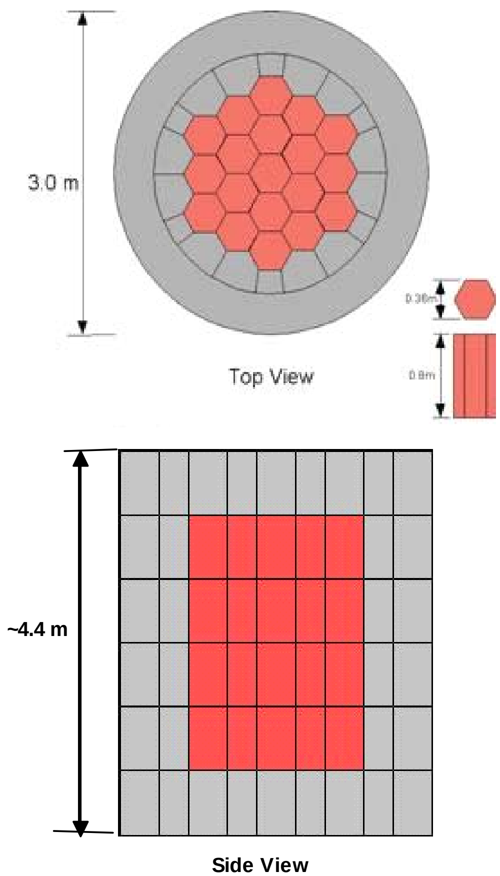
Coated Particles Stable To Beyond Maximum Accident Temperatures



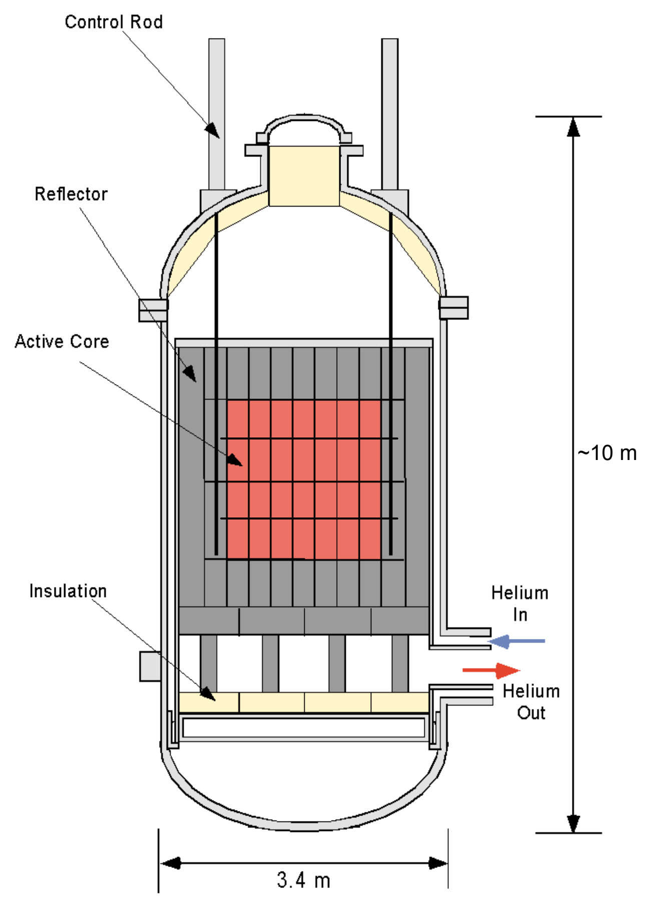
Proposed HT³R Core Size, Rating and Operating Conditions

- **Tentative core selections:**
  - **19 fuel element block columns**
  - **4 fuel element block rows high**
  - **25 MWt power**
- **Key selection criteria include:**
  - **Thermal power level sufficient for generating 10 MWe *(with suitable power conversion system)***
  - **Fuel performance within proven limits**
- **Key operating parameters include:**
  - **Outlet temperature ~850°**
  - **Power density ~3.5 w/cc**
  - **Max fuel temp <1250°C**
  - **Primary system pressure ~3MPa**

General Arrangement of HT³R Reactor System



HT³R Core Arrangement

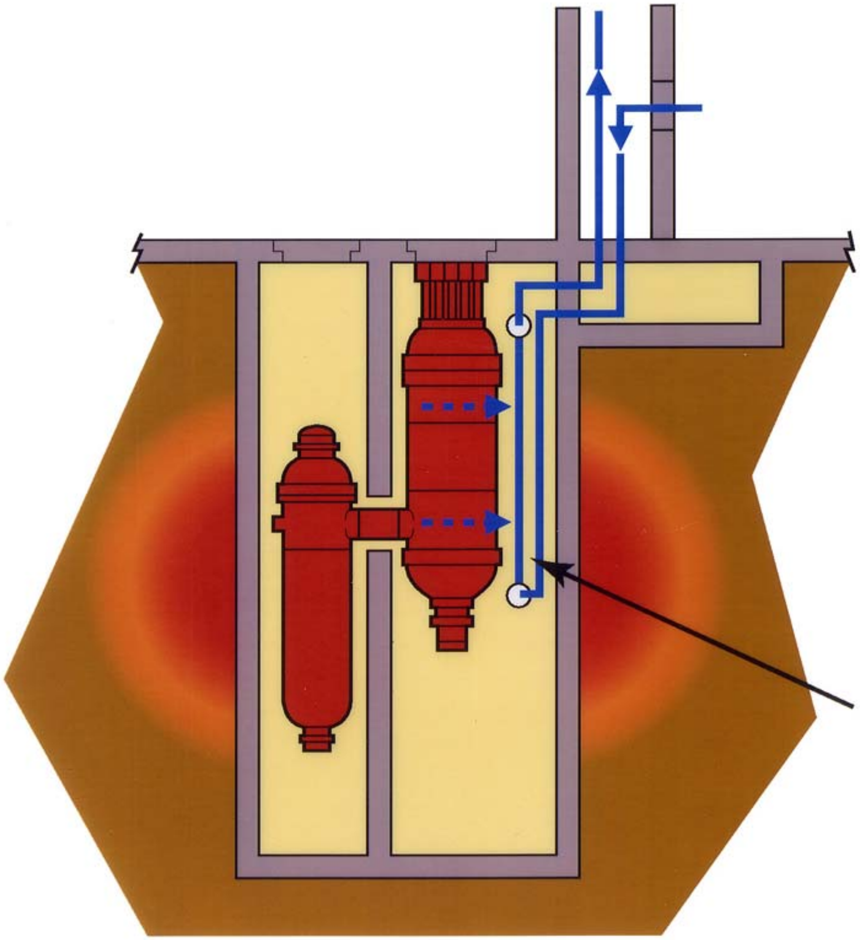


HT³R Reactor Arrangement

HT^{3}R Passive Safety by Design

- **Fission Products Retained in Coated Particles**
  - *High temperature stability materials*
  - *Refractory coated fuel*
  - *Graphite moderator*
- **Worst case fuel temperature limited by design features**
  - *Low power density*
  - *Passive heat removal*
- **Core Shuts Down Without Rod Motion**

HT^{3}R Design to Include Passive Reactor Cavity Cooling System for Removal of Core Decay Heat

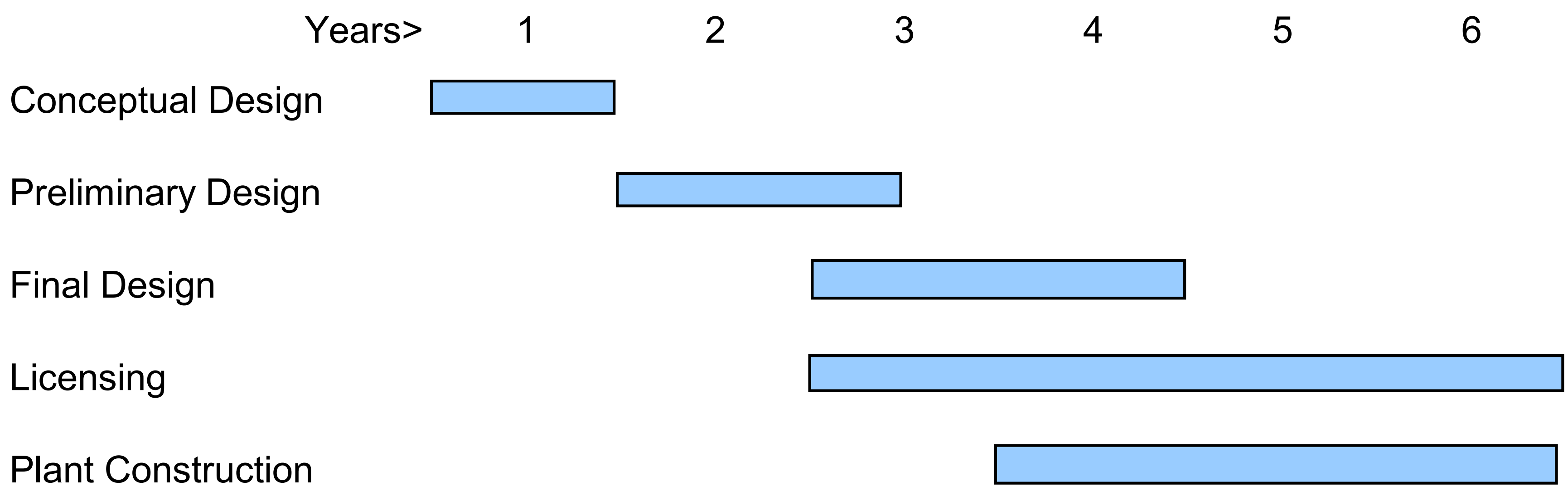


- **Decay heat radiates from vessel to natural draft air cooling system**
- **No pumps or fans required**
- **Heat vsm also conduct into ground**

HT^{3}R Being Designed to Use Existing Technology

- **Design objective: Use of proven technology to maximum possible extent (little or no need for new R&D)**
- **Design approaches and principles:**
  - Use of proven fuel element and fuel particle designs
  - Fuel designed to operate within proven performance parameters
  - Use of materials qualified for the intended service conditions
  - Use of previously proven service and auxiliary systems
  - Design characteristics having test reactor licensing precedence

HT3R Schedule Goal is Complete Deployment in 6 Years



Licensing plan proposed to be completed by end of conceptual design

Summary of HT^3R Technical Information

- Employs key HTGR characteristics (He coolant, graphite moderator, coated particle fuel)
- Tentative core size, rating and operating conditions identified
- Passive safety capability
- Use of existing technology to maximum practical extent
- Overall deployment schedule projected to be ~6 years.

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Research Facility Requirements

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UTPB Energy, Security & Environment Research Institute

- Train Scientist & Engineers to Develop and Improve Gen IV VHTR Technologies
  - High-Temperature Gas Reactors
  - High-Temperature Processes (H_2, Syn-Fuels, Water Desalinization, Refractories, etc)
  - Brayton Cycle Electricity Generation
- Support NGNP at INL
- Train Operators and Technical Staff to work at Future Gas Reactor Facilities

HT^3R is The Keystone (It's Multifaceted!)

Supports Many Research Disciplines

- Radiation Research Laboratory
- High-Temperature Materials and Process Development Laboratory
- High-Temperature Energy Transfer Laboratory.

Radiation Research Laboratory Design Objectives

- Hot Cell & Remote Handling Capabilities
- One or Two Line-of Sight Beam Ports. One will have an On-Line Mass Spectrometer with Moving Tape Collection System

Radiation Research Laboratory Design Objectives

- Two Automatic Sample Irradiation tubes ("Rabbits"). One to Hot Cell, One to Remote Counting Station.
- Positions in Reactor Core to Test Fuel

High-Temperature Materials & Process Development Laboratory Design Objectives

- Develop New Refractory Materials that can be machined and molded into “usable” shapes and sizes.
- Develop economic processes to:
  - Generate non-petroleum sources of hydrocarbons to be used in transportation
  - Generate Hydrogen from Water
  - Generate desalinated potable water from brines like sea water.

High-Temperature Energy Conversion Laboratory Design Objectives

- R&D on Advanced Brayton Cycles
- R&D on Advanced Gas Turbine Components: bearings, seals, recuperators, etc.

Wanted From the NRC

- Input on Licensing Process for Estimation of Cost & Schedule for PCD (2006)
- Review of Licensing Plan Developed During Conceptual Design (2007)
- HT^3R Licensing Complete by 2012