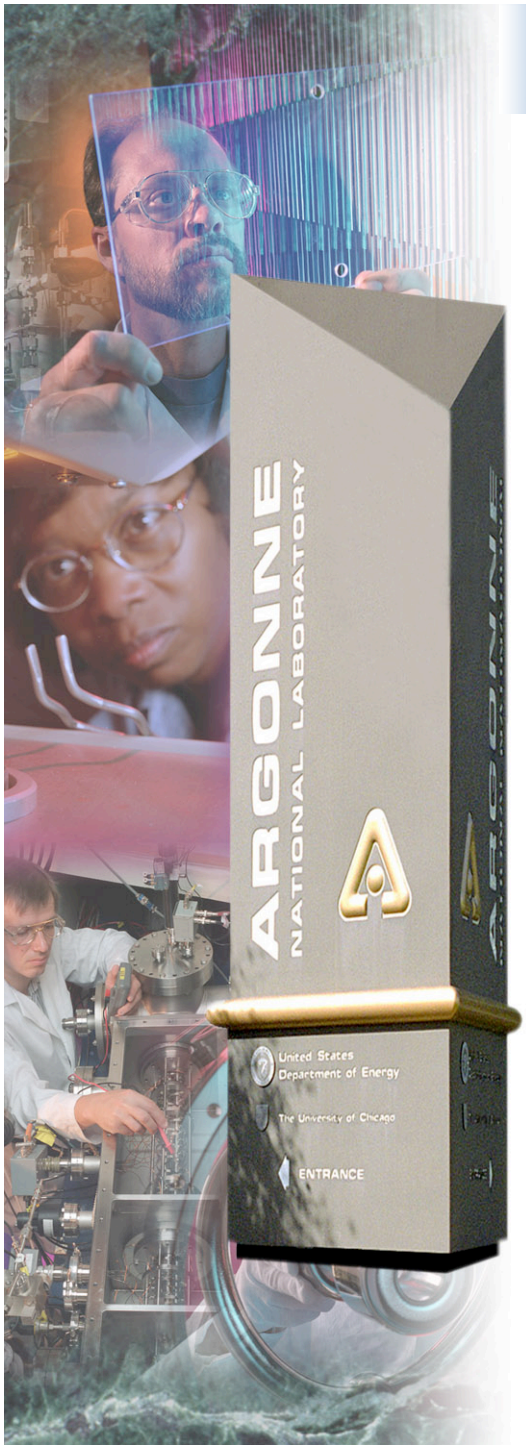

Introductory Remarks on Gen IV Activities

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Findings and Conclusions from Previous Workshops

- **Existing tools (codes and data) can be adapted for pre-conceptual design and viability phase analyses**
- **Some modeling improvement are needed, e.g.,**
  - Representation of double heterogeneity of coated-particle fuel in neutronic calculations
  - Uncertainty propagation in Monte Carlo depletion analysis
  - Re-evaluation of minor actinide data for high burnup and closed fuel cycle evaluations
  - Better representation of coupled phenomena
- **Need to preserve specifications and measured results of past experiments**
- **Need for systematic approach to prioritize future efforts**
  - International standard problems
  - Use of sensitivity and uncertainty analysis tools

Physics Work Focused on Improved VHTR Design Methods

- **Rationale**
  - VHTR is targeting a high level of performance (e.g., coolant outlet temperature, fuel burnup, highly passive safety)
  - Accurate modeling tools are needed to characterize performance relative to achievable limits
- **Approach**
  - Take advantage of past investments in analysis tools (codes and databases) and their foundation in experimental measurements
  - Assess adequacy of tools and experiments for Gen IV system design and safety confirmation
  - Plan, implement and qualify needed improvements
    - *Collaborate with universities, to develop innovative methods*
    - *Use international collaborations to share costs*
- **Analysis needs for fast reactors will be further specified as fast reactor development program is defined**

Sources of Funding for Physics Work

Two Gen IV Program Elements

- **VHTR/NGNP**
  - Gas-cooled designs
  - Liquid-salt cooled designs
- **Gen IV Design and Evaluation Methods (D&EM)**

U-NERI Projects

- **U.S. University-based projects**

I-NERI Projects with France and ROK

- **No additional funding – leverage Gen IV activities**

FY 2005 Physics Activities

- **Reactor physics benchmarks**
  - Perform sensitivity studies for high-priority VHTR benchmarks to confirm relevance and potential for uncertainty reduction
  - Document benchmark problem specifications (HTTR, HTR-10, and CNPS) and measured results for use in validation and quality assurance of VHTR physics analysis tools
    - *Develop a detailed benchmark evaluation for the HTR-10 Pebble Bed Reactor in OECD/IRPhEP format*
  - Organize and chair the first meeting of the OECD International Reactor Physics Benchmark Evaluation Program (IRPhEP)
  - Participate in peer review of other VHTR-relevant benchmarks submitted during the year to IRPhEP
- **Integral neutronic measurements**
  - Perform reactor modeling and pre-analysis for OSMOSE, support OSMOSE measurements in MINERVE (CEA-Cadarache), inter-compare code results for the purpose of code validation
  - Define GFR integral measurements and participate in analysis of ENIGMA GFR experiments in MASURCA

FY 2005 Physics Activities (Cont'd)

- **Sensitivity and Uncertainty evaluations for prismatic block-type VHTR**
  - Quantify need for additional cross section measurements and evaluations by determining impact of data uncertainty on accuracy of core parameters
- **Core Simulator development, coupling and assessment, and validation**
  - PEBBED code Development
- **Cross-section generation code development**
  - Focus on COMBINE for directed integration in PEBBED calculations
  - Collect information on the DRAGON lattice capability pertinent to NGNP design and analysis, and perform limited evaluation
- **Development of method for generating temperature-dependent displacement threshold energies (E_d) for various substances**

I-NERI Physics Projects

- Assessment of Existing Physics Experiments Relevant to VHTR Design (US/France)
- GFR Physics Experiments in the CEA-Cadarache MASURCA Facility (US/France)
- OSMOSE—An Experimental Program for Improving Neutronic Predictions of Advanced Nuclear Fuels (US/France)
- Development of Advanced Suite of Deterministic Codes for VHTR Physics Analysis (US/ROK)

University NERI Physics Projects – Advanced Systems

- **Utilization of Minor Actinides as a Fuel Component for Ultra-Long Life VHTR Configurations: Designs, Advantages, and Limitations (**Texas A&M**)**
- **Uncertainty Analyses of Advanced Fuel Cycles (**University of Tennessee**)**
- **Flexible Conversion Ratio Fast Reactor Systems Evaluation (**MIT**)**
- **Development and Utilization of Mathematical Optimization in Advanced Fuel Cycle Systems Analysis (**North Carolina State University**)**
- **Feasibility of Recycling Plutonium and Minor Actinides in Light Water Reactors Using Hydride Fuel (**University of California- Berkeley**)**
- **Managing Model Data Introduced Uncertainties in Simulator Predictions for Generation IV Systems via Optimum Experimental Design (**North Carolina State University**)**
- **An Advanced Neutronic Analysis Toolkit with Inline Monte Carlo Capability for VHTR Analysis (**University of Michigan**)**

FY 2006 Physics Modeling Improvement Scope

- **OSMOSE program measurements and analysis**
  - Participate in measurement and analysis of configurations with thermal spectra
  - Determine relevance of OSMOSE configurations to VHTR and other Gen IV systems
  - Evaluate use of OSMOSE samples for Doppler measurements and model validation
  - Contribute to chemical analysis of actinide samples
- **Participate in definition and analysis of ENIGMA experiments for GFR systems**
  - Contribute to safety case for facility refurbishment and core conversion
- **Enhance REBUS-3/DIF3D model for neutronic analysis of prismatic block VHTR**
  - Implement algorithms for T-H feedback and pin/compact power reconstruction
  - Improve algorithms for nuclide evolution and axial neutron streaming
- **Develop a cross-section functionalization scheme linking DRAGON or WIMS9 assembly calculations to DIF3D/REBUS-3 whole-core analysis**
- **PEBBED code development**
- **Temperature-dependent displacement threshold studies**

FY 2006 Physics Modeling Improvement Scope (Cont'd)

- **Evaluate and document additional high-priority HTGR benchmarks**
  - Focus on HTR-PROTEUS pebble-bed tests
  - Evaluate VHTRC integral measurements and develop benchmark problem
- **Organize and chair OECD/NEA IRPhE project meeting on benchmarks**
  - Review Gen IV relevant benchmarks contributed to IRPhE project
- **Participate in international efforts directed to assessment, validation and qualification of codes and data for VHTR analysis**
- **Cross-section integral experiment evaluations**

LS-VHTR Neutronic Studies (ORNL/INL/ANL)

- **Perform neutronic evaluations of design options for a liquid-salt-cooled reactor, including analysis of coolant void and temperature coefficients of reactivity, fuel burnup, fuel cycle length, etc.**
- **Evaluate neutronic implications of alternative coolant salts other than Li_2BeF_4 with respect to reactivity feedback effects, fuel cycle length, enrichment, etc.**
- **Develop initial design for control rod and reserve shutdown systems including rod worths and shutdown margins**

- **Program re-direction focusing on evaluation of impact of hot refueling to the overall LS-VHTR design**