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Reactor Physics Studies for the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project

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Reactor Physics Studies for the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project

D. Beller

BACKGROUND

In the RACE Project of the U.S. Advanced Fuel Cycle Initiative (AFCI), a series of accelerator-driven subcritical systems (ADSS) experiments will be conducted at the Idaho State University's Idaho Accelerator Center (ISU-IAC), at the University of Texas (UT) at Austin, and at the Texas A&M University. In these experiments, we will use electron accelerators to induce bremsstrahlung photon-neutron reactions in heavy-metal targets. A beam power of 1 kW will produce a neutron source of 10^{12} n/s, which will then initiate fission reactions in the subcritical systems.

These systems will include a compact, transportable assembly at ISU and TRIGA reactors at UT-Austin and Texas A&M. A variety of fuel and assembly geometries will be studied: at ISU we will use 150 flat plates of 20%-enriched uranium-aluminum alloy plated with aluminum; at UT-Austin a 20%-enriched UZr-H fuel will be used; and at Texas A&M a 70%-enriched UZr-H "FLIP" fuel will be used as well as a used core of 20%-enriched UZr-H fuel. The use of compact accelerators and a small target will allow the placement of the target in various positions in or adjacent to these subcritical assemblies to "map" the coupling of driven neutron sources; measuring core coupling and mapping adjoint flux.

The RACE Project is an important intermediate step between

the recent European program MUSE and a future near full-scale demo like the TRADE project. For MUSE, which was conducted by the CEA at Cadarache, France, the driving neutron source was produced by D-D or D-T reactions which produce a mono-energetic source of 2.45 or 14.1 MeV and a maximum strength of $\sim 10^{10}$ n/s. For TRADE (ENEA, Casaccia, Italy), the source will be provided by spallation from a proton cyclotron, with an anisotropic source up to ~ 140 MeV and $\sim 10^{15}$ n/s. For design of full scale ADSS, a complete knowledge of the effects of the driving neutron source is essential. This will ultimately require spectral, temporal, directional, and intensity fidelity in prototype experiments. In the absence of this fidelity, simulated sources should match some of the characteristics of projected driving sources to build confidence in predicting performance of these systems, and codes and methods must be validated.

The RACE Project will provide experience in a higher energy range (above 14.1 MeV up to 40 MeV) and with a stronger and more isotropic source than the MUSE experiments. In addition, RACE will provide valuable information on thermal feedback effects in the TRIGA reactors. Finally, and possibly most important, because of the mobility of compact electron linacs connected to compact targets by easily fabricated vacuum tubes, RACE will permit source importance mapping and adjoint flux studies because of the ability to relocate the target between experiments. This combination of attributes of the



UNLV students Evgeny Stankovskiy (far left) and Timothy Beller (kneeling far right) with other participants in the RACE and ECATS projects after the joint RACE-ECATS.

RACE Project will provide highly valuable information in advance of the TRADE program.

RESEARCH OBJECTIVES AND METHODS

The specific research objective of this three-year project is to design and conduct an accelerator driven experiment at one of the Texas universities. This experiment will help demonstrate in the U.S. the ability to design, compute, and conduct ADSS experiments; and to predict and measure source importance, coupling efficiency, sub-critical reactor kinetics and source-driven transients. In addition, both steady state and transient ADSS benchmarks will be created for the nuclear community to develop and test new computational codes and methods, and the importance of a driving neutron source in various regions of different sub-critical assemblies will be mapped. Experiments will be conducted and compared to calculations with radiation transport and thermal-hydraulics codes such as MCNPX and RELAP.

RESEARCH ACCOMPLISHMENTS

Reactor Physics Studies

The Radiation Safety Information Computational Center (RSICC) at Oak Ridge National Laboratory granted Evgeny Stankovskiy access to a set of export-controlled codes and databases for reactor physics studies. Modeling with MCNPX was initiated in support of subcritical experiments at the Idaho Accelerator Center and of target design studies for Texas RACE. Electron beam/target interactions were studied for maximizing and characterizing photoneutron production from high-energy electrons. The newest beta test version of the MCNPX radiation transport code was acquired, installed, and used.

Preparations for Experiments

Collaborations began with Texas RACE Project participants to develop a plan to conduct an accelerator-driven subcritical experiment at UT-Austin or Texas A&M University. Principle Investigators and graduate students from the Texas universities visited UNLV in December and January to discuss preparations for experiments and MCNP modeling of the RACE Project configurations at ISU, UT, and TAMU.

ACADEMIC YEAR HIGHLIGHTS

- ◆ A large European ADS program has joined the RACE Project to participate in experiments at UT-Austin and Texas A&M.
- ◆ “Overview of the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project,” D. Beller, *Transactions of American Nuclear Society*, 90, Pittsburgh, PA, June 14-17, 2004.
- ◆ “Initial Results from the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project,” D. Beller, A. Hunt, J. Bennion, M. Garfield, K. Folkman, and M. Reda, *Transactions of American Nuclear Society*, 91, 446-447, Washington, DC, Nov. 14-18, 2004.
- ◆ “AFCI Reactor-Accelerator Coupling Experiments Program,” D. E. Beller, oral presentation, AFCI Semi-annual Technical Program Review, Salt Lake City, Utah, September 13, 2004.
- ◆ “Initial Results from the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project,” D. Beller, A. Hunt, M. Reda, and J. Bennion, poster presentation, to be published by OECD-NEA in the *Proceedings of the Eighth Information Exchange Meeting on Actinide and Fission Product Partitioning & Transmutation*, 9-11 November 2004, Las Vegas, Nevada.
- ◆ “Overview of the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project,” D. Beller, oral presentation, to be published by OECD-NEA in the *Proceedings of the Eighth Information Exchange Meeting on Actinide and Fission Product Partitioning & Transmutation*, 9-11 November 2004, Las Vegas, Nevada.
- ◆ “Overview of the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project,” D. Beller, GenIV/AFCI Nuclear Data Working Group and AFCI Physics Working Group Meetings, Las Vegas, Nevada, January 28, 2005.

FUTURE WORK

During the summer of 2005, an ADSS experiment is planned using an ISU-supplied 20- or 25-MeV electron linac accelerator and the TRIGA reactor at UT-Austin. This experiment will be planned in conjunction with participants from EUROTRANS ECATS. During the experiment we will measure actual fission energy production induced by accelerator-generated neutrons.

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