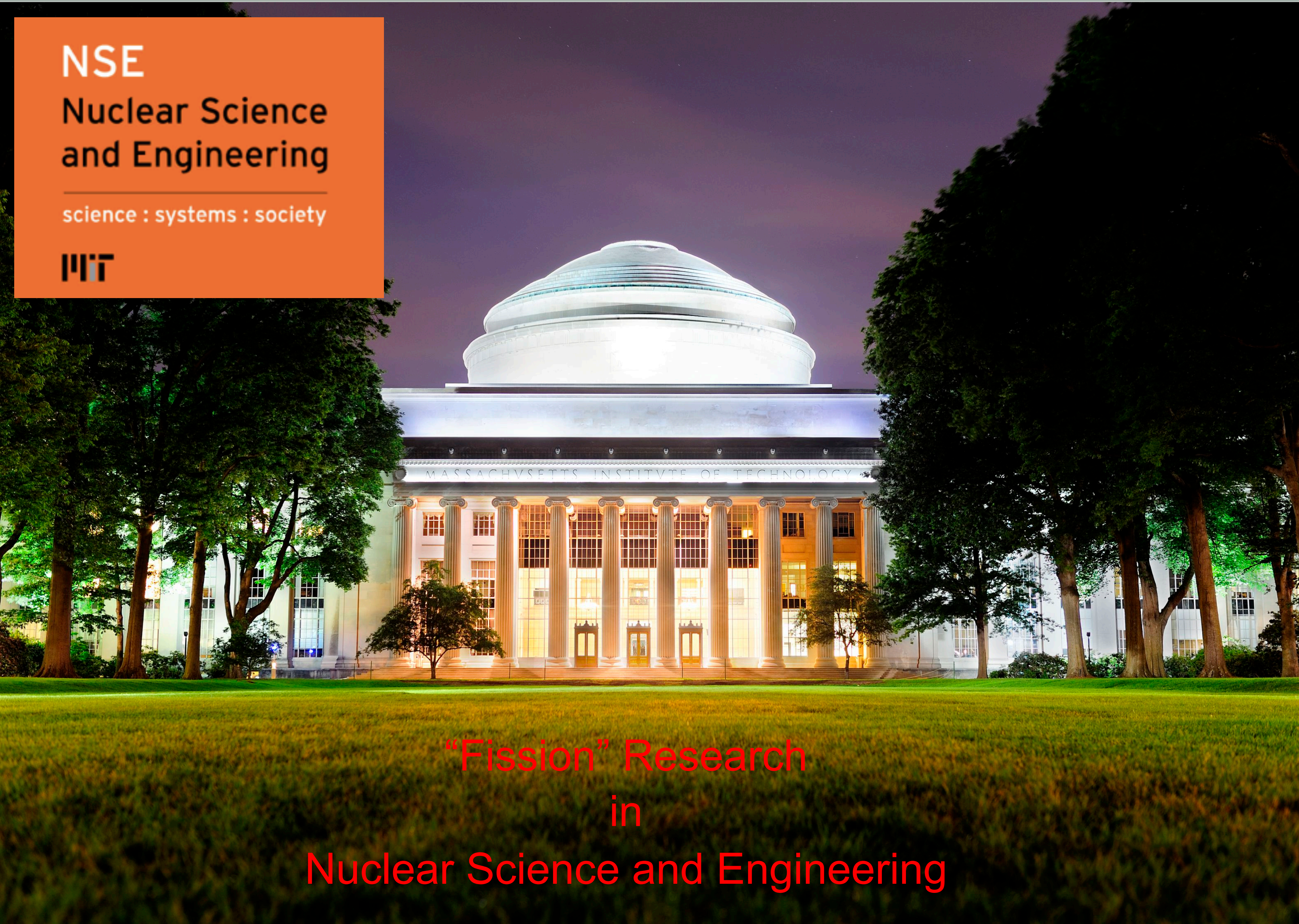
NSE
Nuclear Science and Engineering

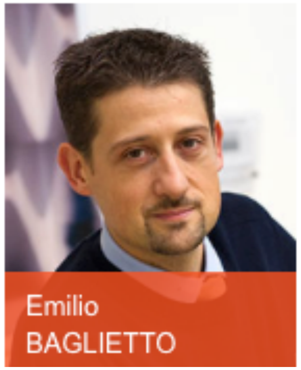
science : systems : society

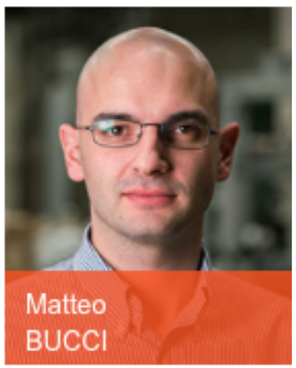
MIT



"Fission" Research
in
Nuclear Science and Engineering

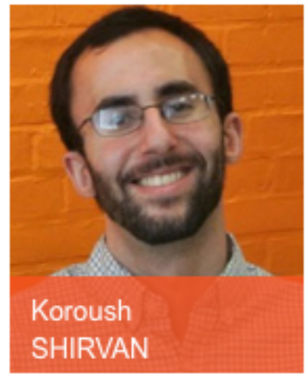
“Thermal-Hydraulics”

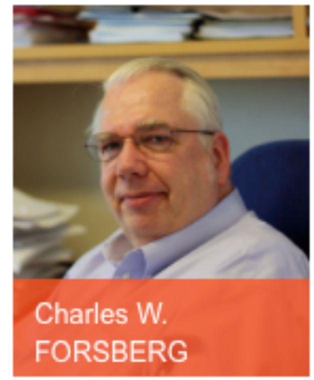




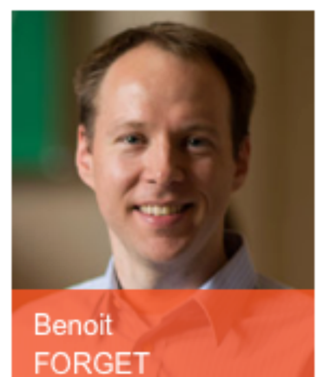
“Energy Studies”

“Nuclear Reactor & Systems Design”





“Reactor Physics and Advanced Computing”



Center for Advanced Nuclear Energy Systems (CANES)

** A MITEI Low-Carbon Energy Center **

MITei
MIT Energy Initiative

NSE
Nuclear Science and Engineering
science : systems : society

CANES Research Sponsors

EDF

Alfred P. Sloan Foundation 1934

مؤسسة الكويت للتقدم العلمي
Kuwait Foundation for the Advancement of Sciences
Established 1976

CEA – De la recherche à l'industrie

Sandia National Laboratories

SINAP

AREVA

HITACHI

KEPCO

Skoltech
Skolkovo Institute of Science and Technology

EPRI – Electric Power Research Institute

NASA

King Abdulaziz City for Science and Technology

Exelon

산업통상자원부
Ministry of Trade, Industry & Energy
MOTIE

General Atomics

U.S. Department of Energy

Masdar Institute

Statoil

Department of the Navy – United States of America

National Science Foundation – Where Discoveries Begin

IBC Advanced Alloys

CTP Ceramic Tubular Products, LLC

Lockheed Martin

U.S.NRC

Free Form Fibers – The Fiber of Innovation

ExxonMobil

INL Idaho National Laboratory

TEPCO

Westinghouse

Transatomic

KETEP
Korea Institute of Energy Technology Evaluation and Planning

GE

KAPL – Knolls Atomic Power Laboratory

bp

AFOSR – Air Force Office of Scientific Research

DCNS

TerraPower

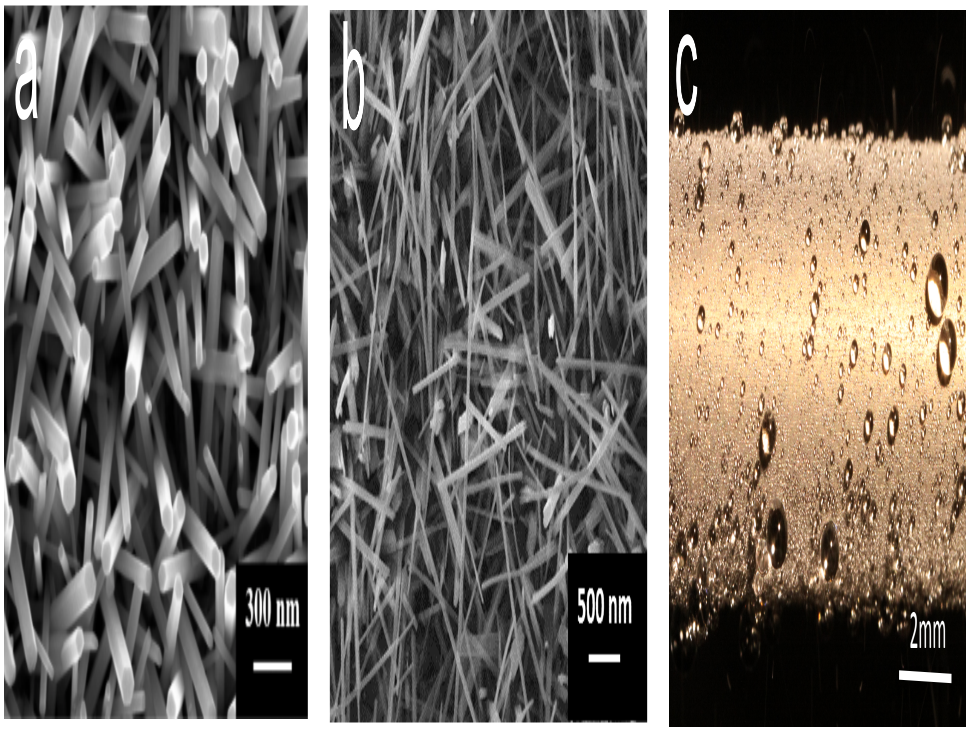
ABB

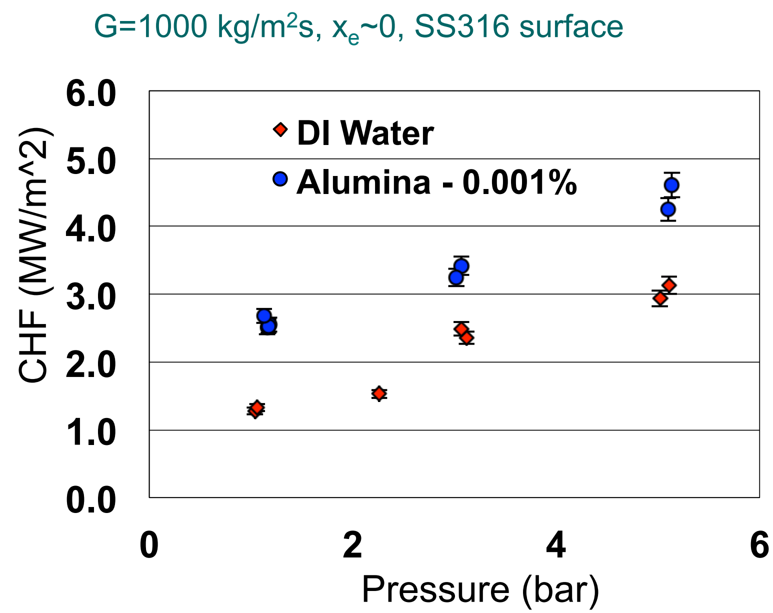
Bettis Laboratory

CASL – Consortium for Advanced Simulation of LWRs

SUTD-MIT International Design Centre

Engineered surface nano- and micro-scale features (coatings, pores, posts, patterns, …) enhance CHF





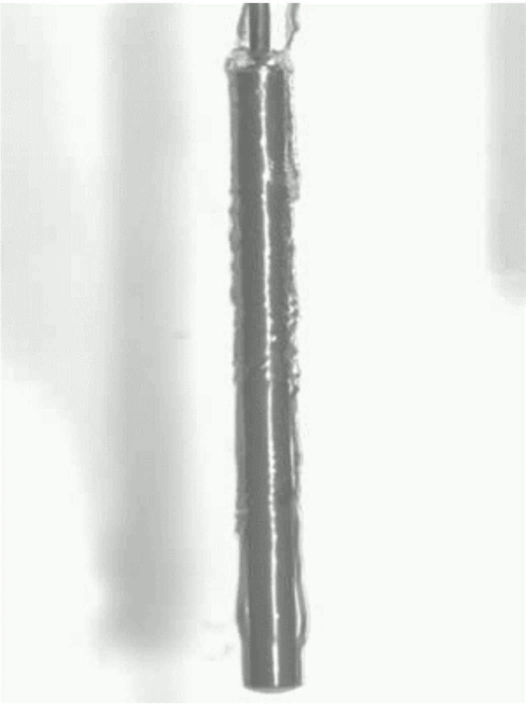
Increases design-basis and beyond-design-basis safety margins and/or enables power uprates in LWRs

Profs. Buongiorno and Bucci

Nano-engineered coating accelerates quenching in reactor - like rodlets

Stainless steel rodlets (4.8 mm x 40 mm), initial temperature 1000°C, quenched in wat er at atmospheric pressure and 80°C

Clean surface



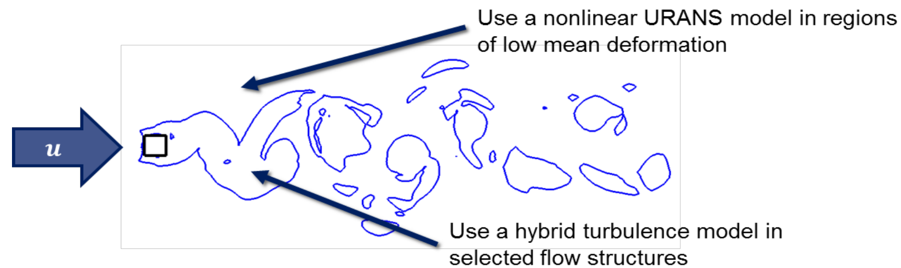
Thin porous layer of hydrophilic nanoparticles on surface

Reduction of Peak Cladding Temperature (PCT) by up to 150-200°C

Quench front speed: **~7 mm/sec** **~5000 mm/sec**

Profs. Buongiorno and Bucci

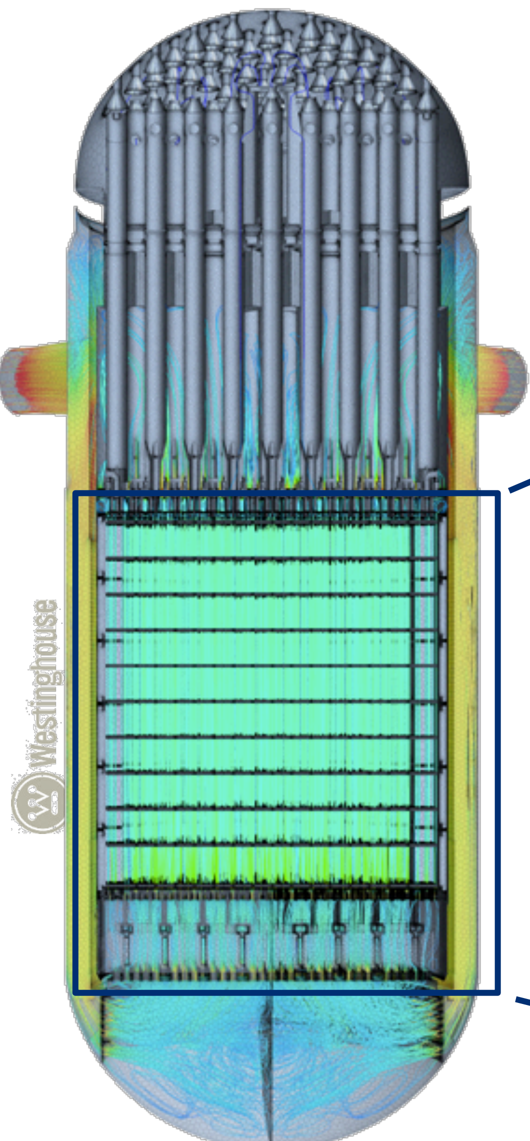
High-fidelity simulations of coolant flow in reactor core

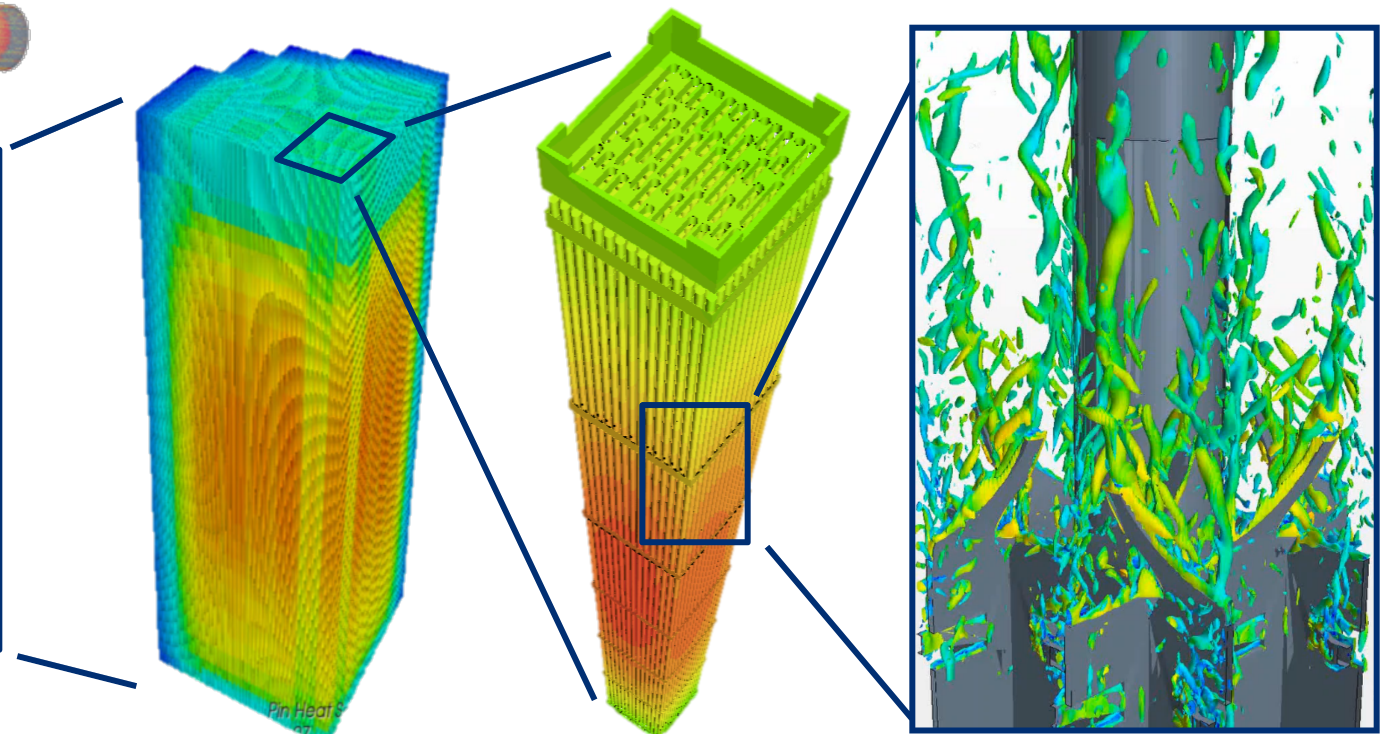


Objective: *High fidelity flow-thermal simulations of reactor cores*

Challenge: *Complex turbulence / computational requirements*

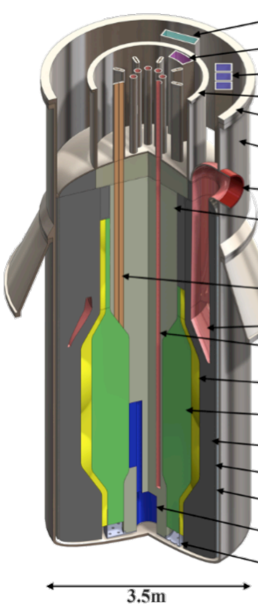
Approach: *STRUCTure-based hybrid turbulence modeling*



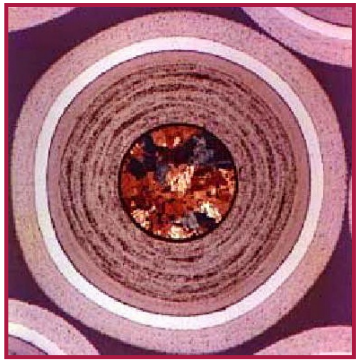


Profs. Baglietto and Bucci

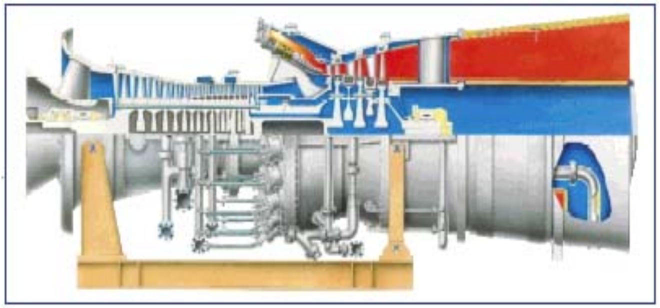
Fluoride-Salt-Cooled High-Temperature Reactor (FHR)



Fuel: TRISO particle fuel, no failure up to ~1650°C, strongly negative Doppler feedback



Coolant: FLiBe liquid salt, low-pressure, chemically inert, large margin to boiling (1430°C), high heat capacity, enables power density up to 10x gas-cooled reactors



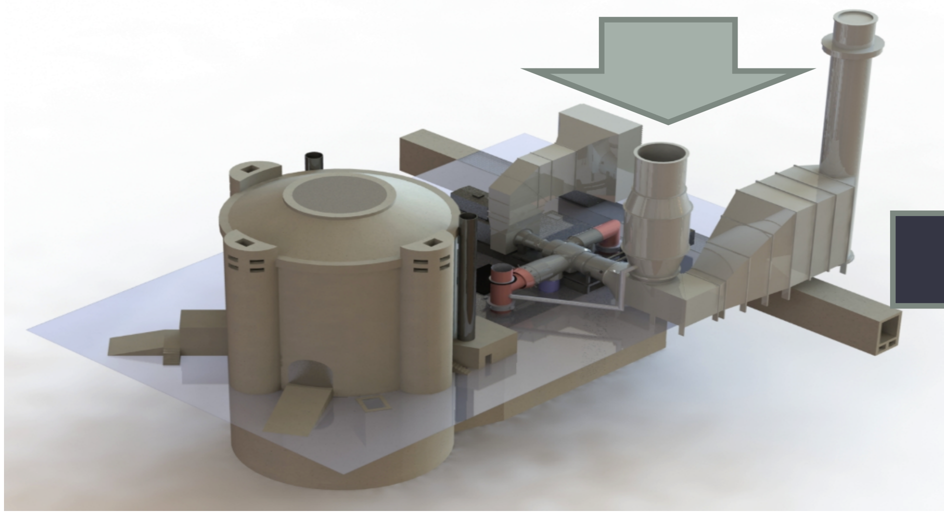
Power Cycle: Modified natural-gas air

GE Power Systems
MS7001FB

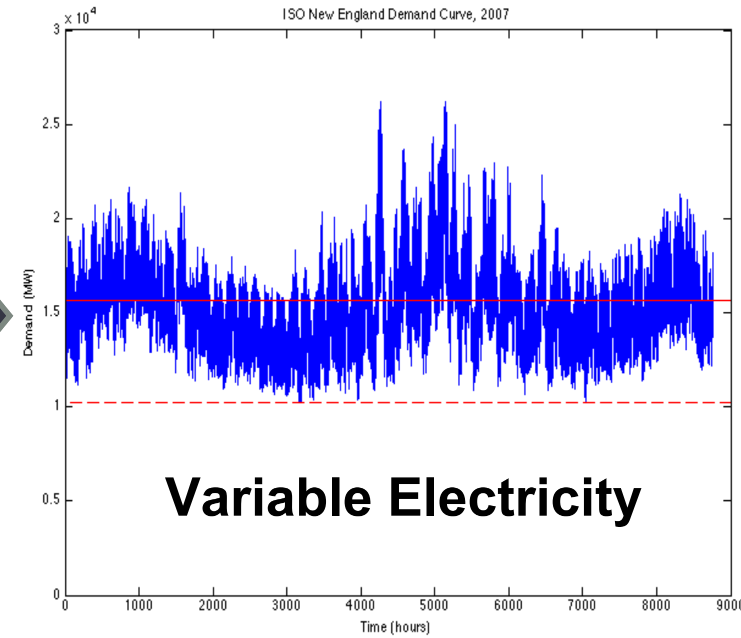
Drs. Forsberg and Hu

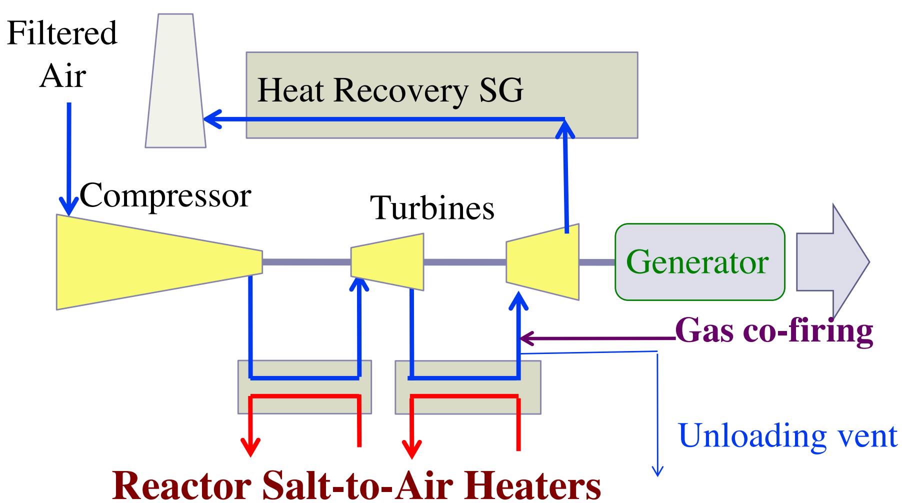
FHR with Nuclear Air-Brayton Combined Cycle (NACC)

Stored Heat and/or Natural Gas



Base-Load Reactor **Gas Turbine**

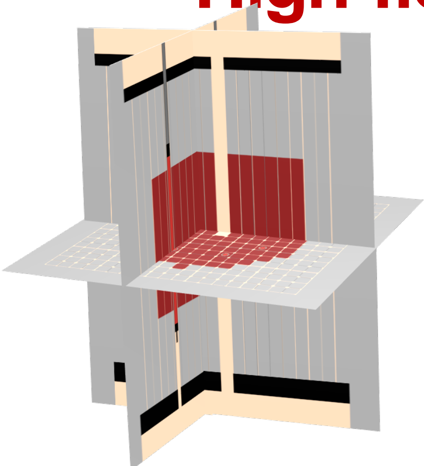


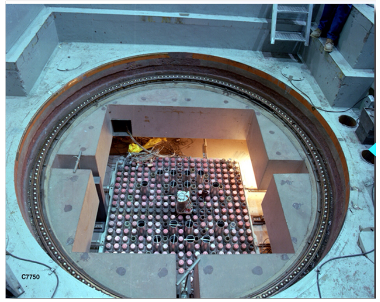


- Peak electricity with natural gas
- Highest efficiency conversion of NG to electricity
- Very fast response because peak power off base load
- 50 to 100% greater revenues than base-load plant

Dr. Forsberg

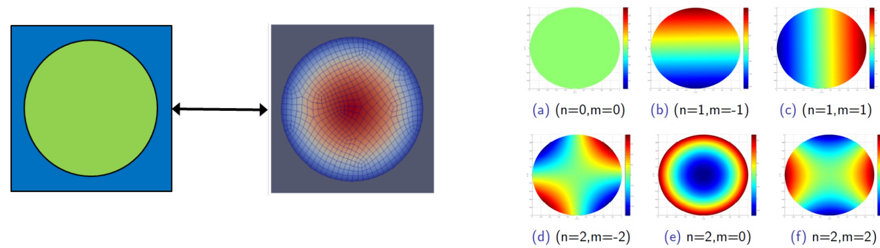
High-fidelity Reactor Neutronics Simulations



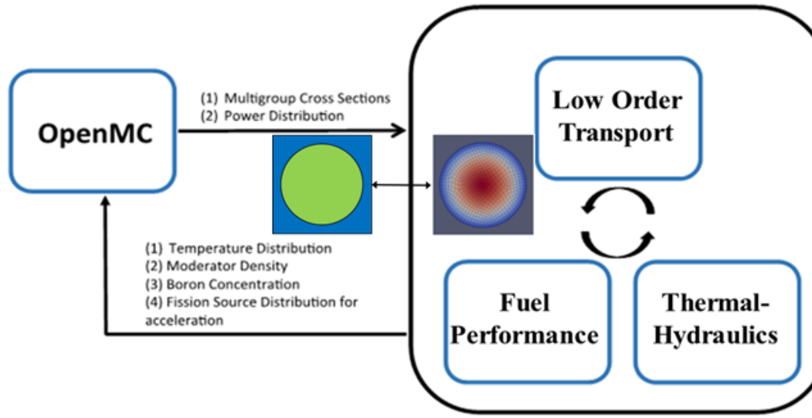


TREAT Reactor

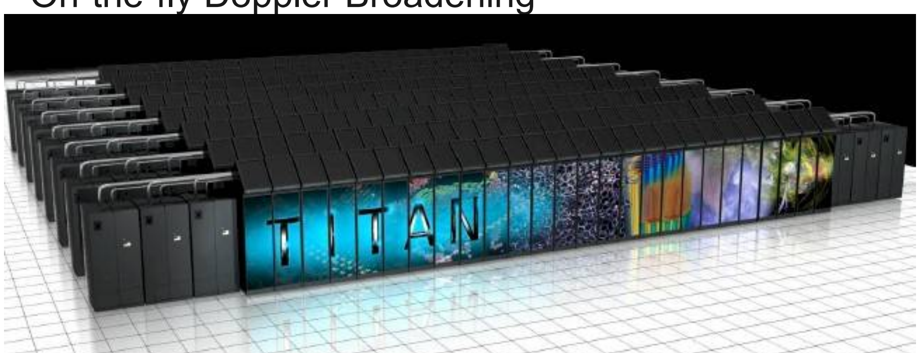
Coupling from MC mesh to FEM using orthogonal basis

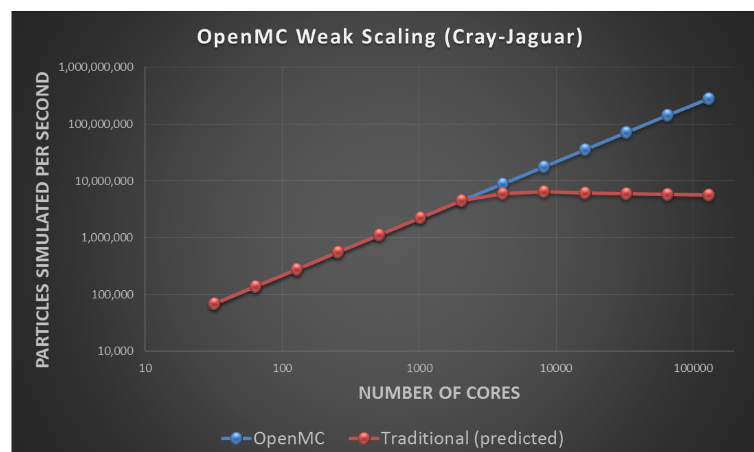


Integration in multi-physics environment



- High performance computing in particle transport, improved physical models, and open source software:
  - Time-dependent Monte Carlo
  - Multi-physics coupling
  - Acceleration and convergence analysis
  - Efficient parallelization algorithms
  - On-the-fly Doppler Broadening





Profs. Forget and Smith

MIT Graphite Exponential Pile: “Hands-on” Reactor Physics

25. MT of Reactor Grade Graphite

2.5 MT of Natural Uranium Metal Fuel

Reactor Physics Labs Experiments

- Measure approach-to-critical fuel loadings
- Measure neutron flux spatial distributions
- Measure fuel rod spatial self-shielding
- Measure control rod worths

Reactor Physics Research

- Testing of graphite thermal scattering kernels
- Measure neutron streaming in voids
- Validate high-fidelity neutron physics codes

Profs. Forget and Smith

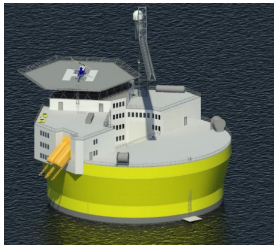
Offshore floating nuclear power plant (OFNP)

Floating rig

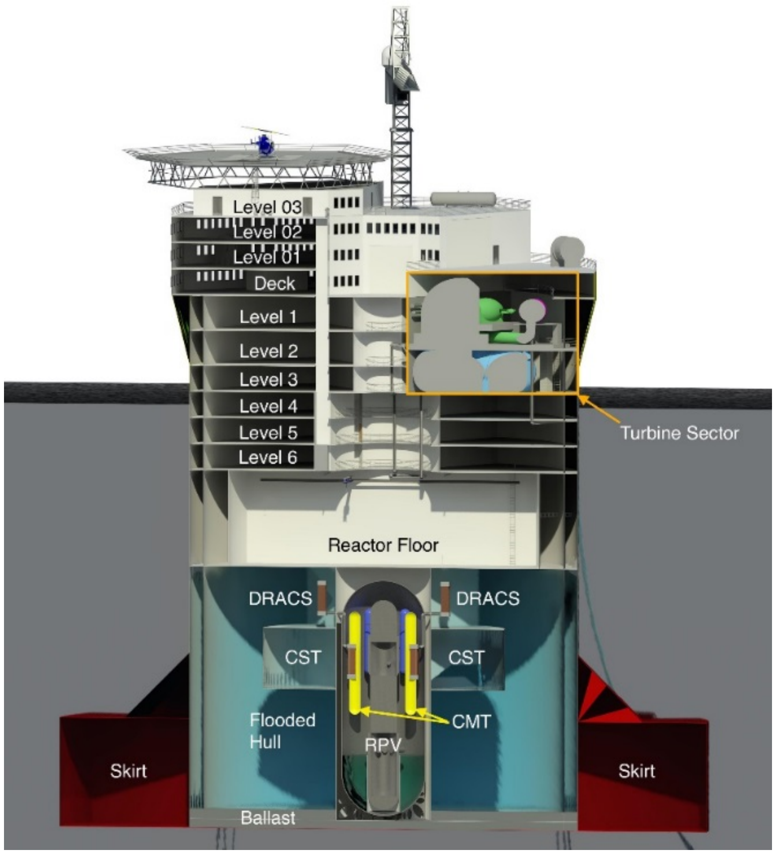
+

Nuclear reactor

=



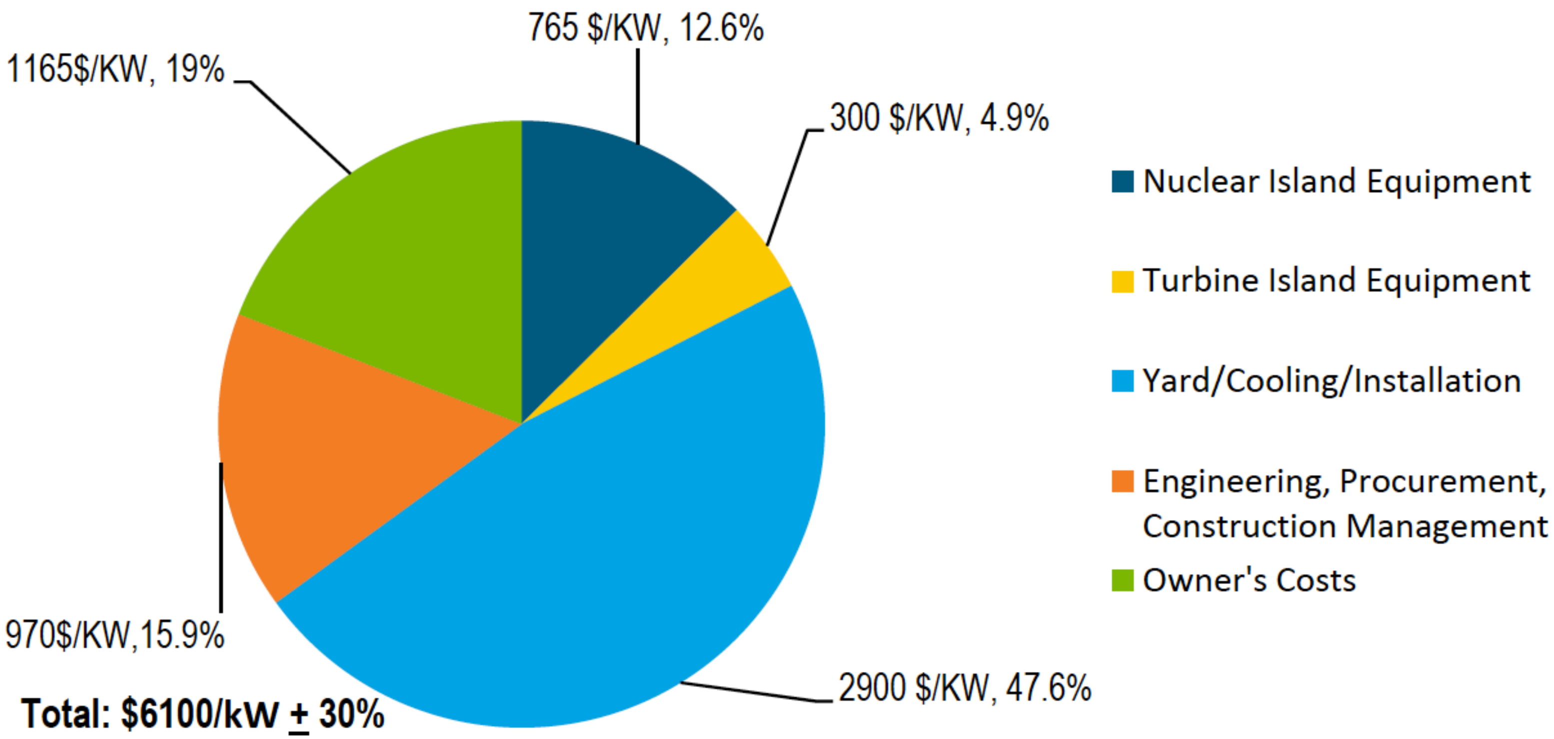
OFNP



- Entirely built and decommissioned in a shipyard: faster and cost-effective plant construction (<36 months)
- Reduced capital cost (>90% cut in reinforced concrete)
- Transported to the site, moored 5-12 miles offshore, in relatively deep water (~100 m): insensitive to earthquakes and tsunamis
- Submarine AC cable connects to grid
- Reactor could be large LWR (1100 MWe), SMR (300 MWe) or other designa
- Nuclear island underwater: ocean heat sink ensures indefinite passive decay heat removal (no Fukushima scenario)

Profs. Buongiorno, Golay, Todreas

How to Reduce NPP Capital Cost

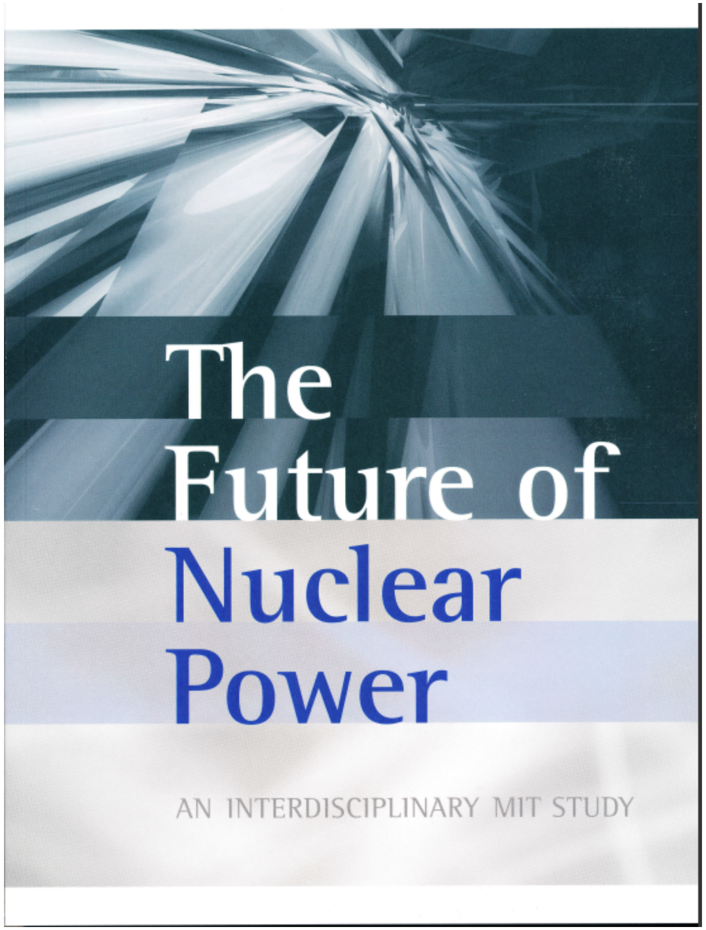


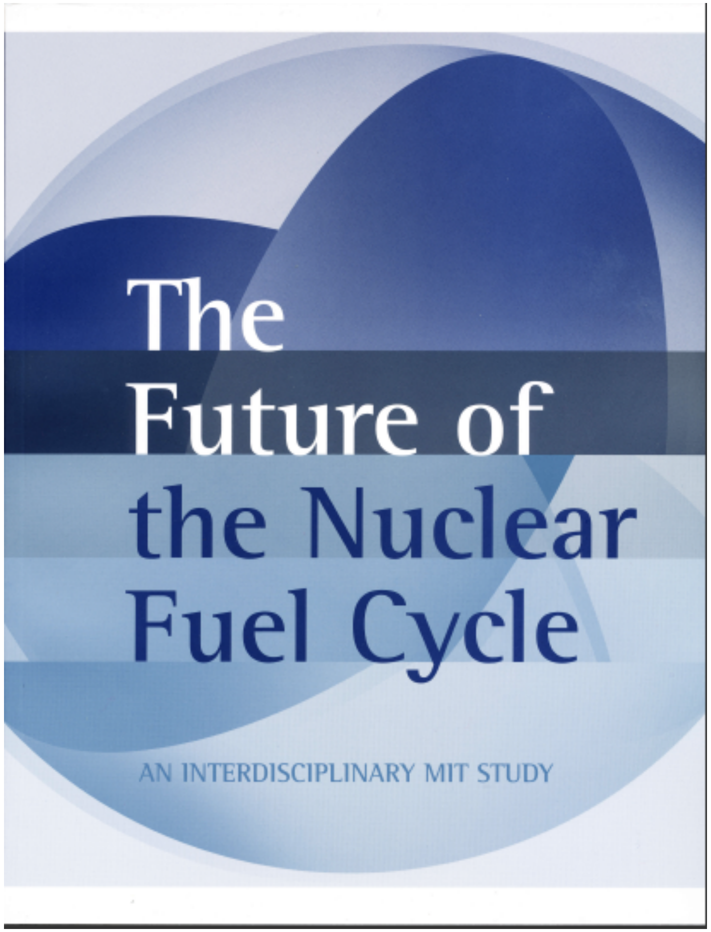
Total: $6100/kW ± 30%

Most of the cost is installation and financing, not equipment

Drs. Buongiorno and Forsberg

Educating the Community and Informing Public Policy





Profs . Buongiorno, Lester, Golay, Forsberg, ...