OVERVIEW OF THE DOE ADVANCED TURBINE SYSTEMS PROGRAM

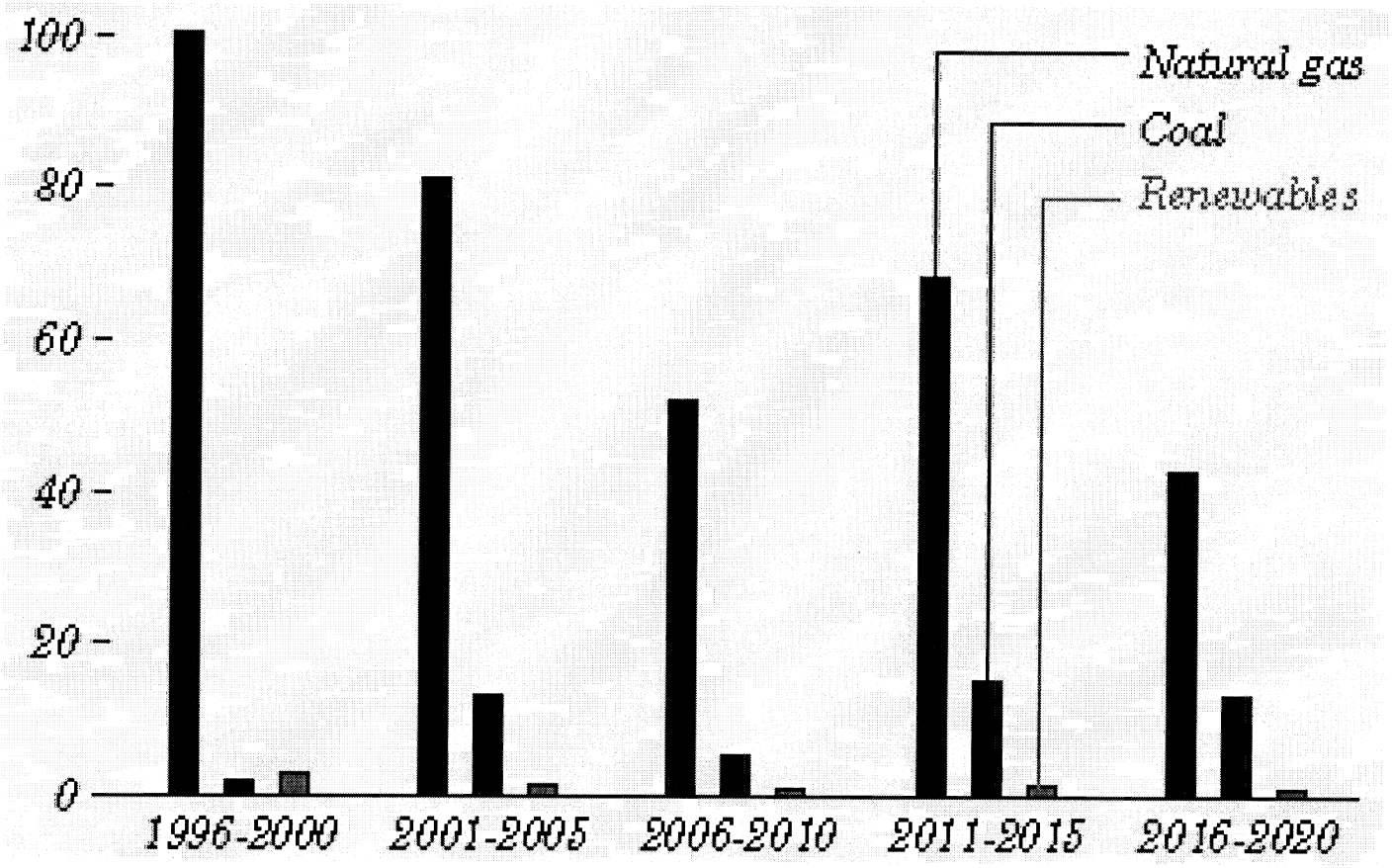
Abbie W. Layne
United Stated Department of Energy
Morgantown, West Virginia

Why develop advanced turbine systems?

- ***Market Demands*** **- Gas turbine power systems markets are rapidly growing to serve new demand, displacement or existing capacity and replacement of retired capacity**
- ***Climate Change*** **- Environmental regulations continue to require reduced levels of air pollutants from power generation facilities**
- ***DOE shares risk/accelerates public benefits***

THE NEED FOR ADVANCED GAS TURBINES WILL CONTINUE

U.S. Capacity additions by fuel type, GW



Source EIA 1998 report, fig. 57

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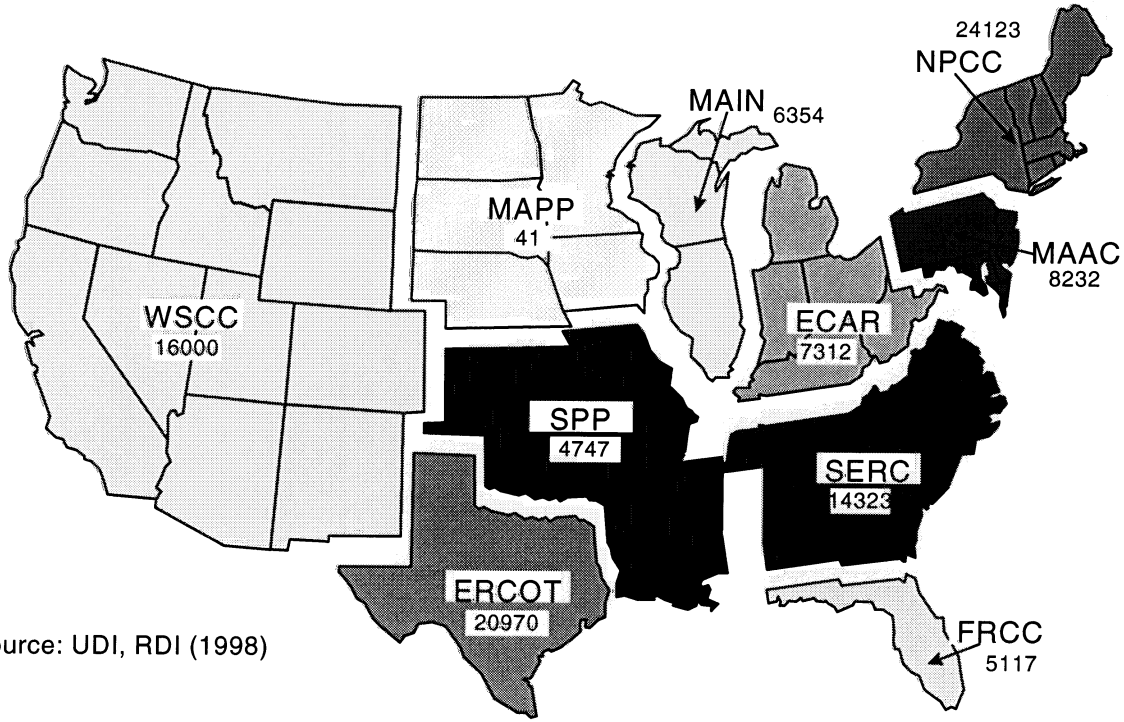
Announced Total Capacity (MW) Additions by NERC Region (as of 9/98)



Source: UDI, RDI (1998)

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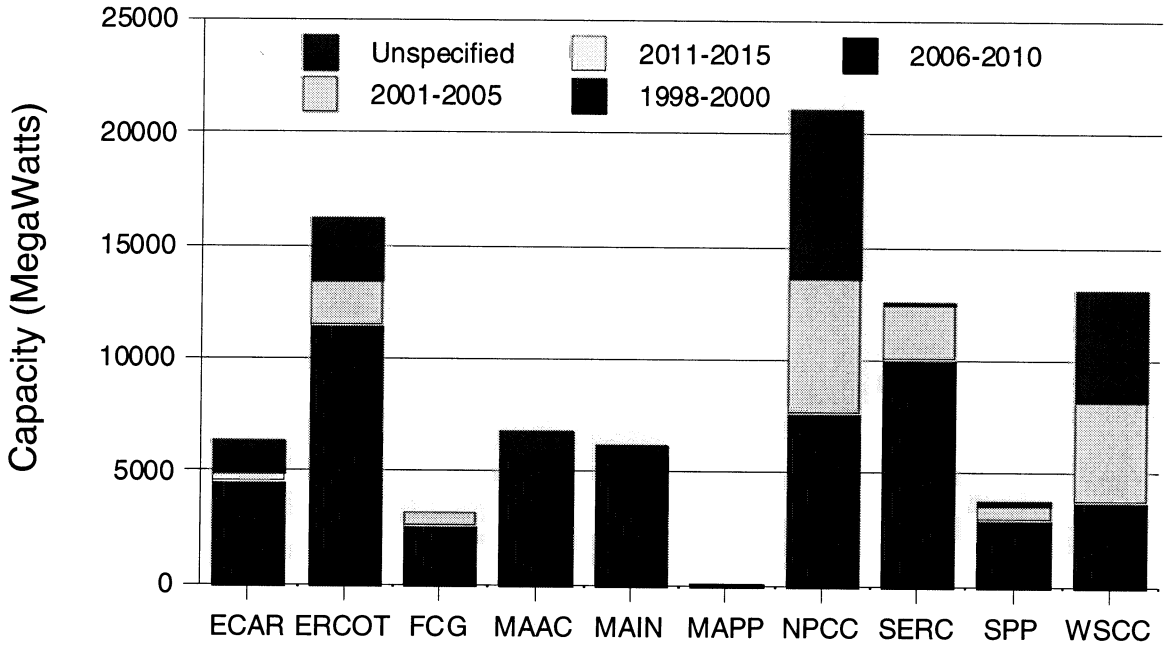
Proposed Installation Dates for Announced Gas-Fired Capacity Additions, by NERC Region (1998-2015)



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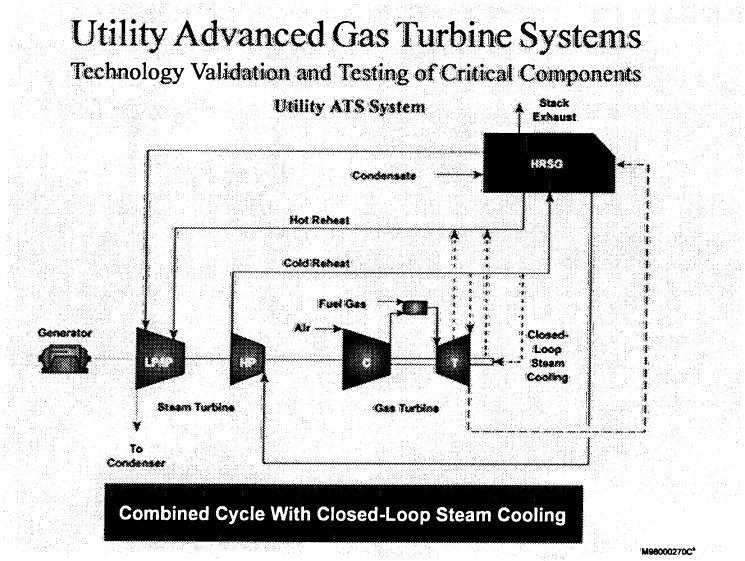
ATS-Scope of the Program

- Develop advanced turbine systems for utility-scale power generation
- Conduct supporting technology base research and development to advanced turbine systems
- 6 major projects:
  GE, Westinghouse, ORNL,
  SCIES, ABB, FETC, UTRC



Objective: ATS Program

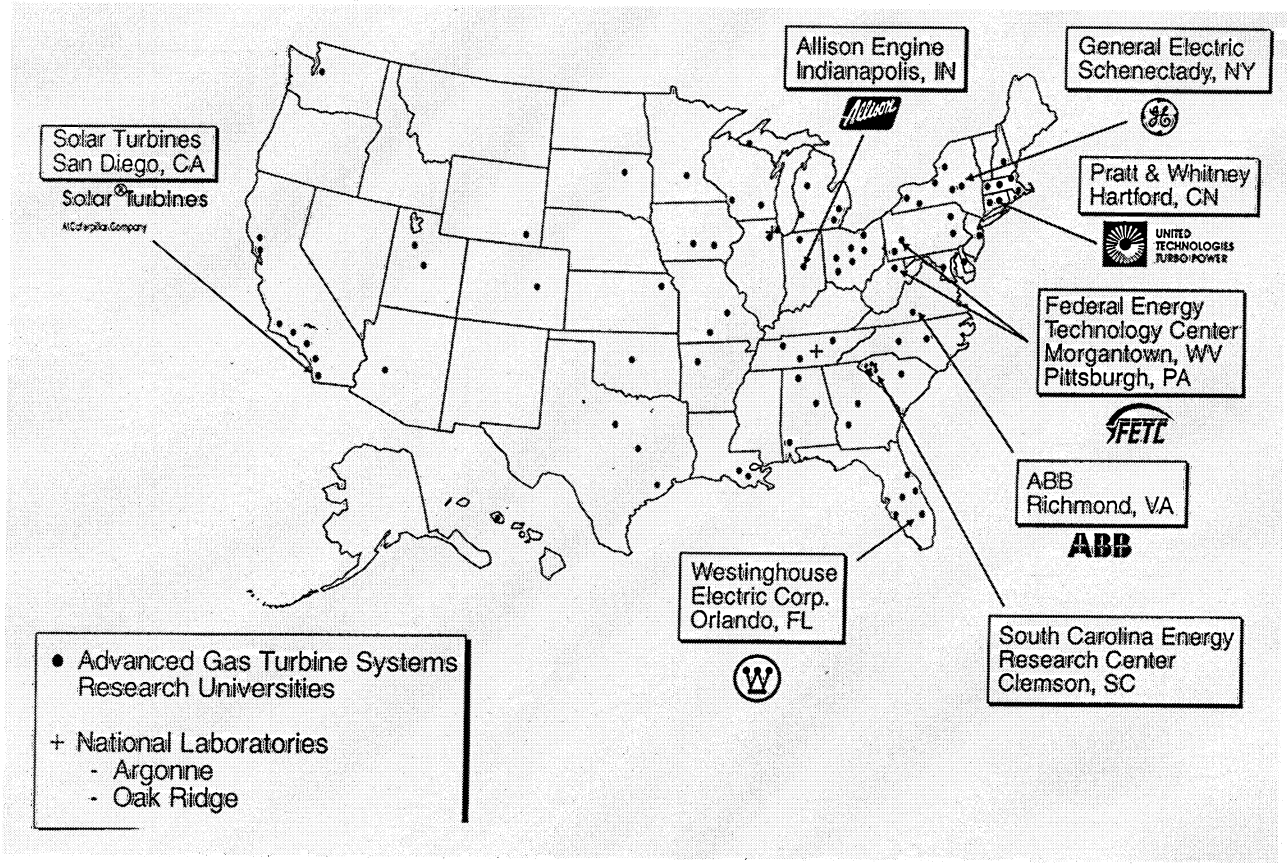
- **By 2000, develop ATS for utility and industrial applications that are:**

- Ultra-high efficiency:	> 60% for utility scale systems
	15% improvement for industrial system
- Super-clean:	NOx <8 ppm
- Cost of electricity	10% lower
- Fuel flexible:	Gas primary focus

Leapfrog in Turbine Performance

The Advanced Turbine System Program Participants

A Consortium of Universities, National Laboratories, U.S. Government, and Private Industry in 37 U.S. States



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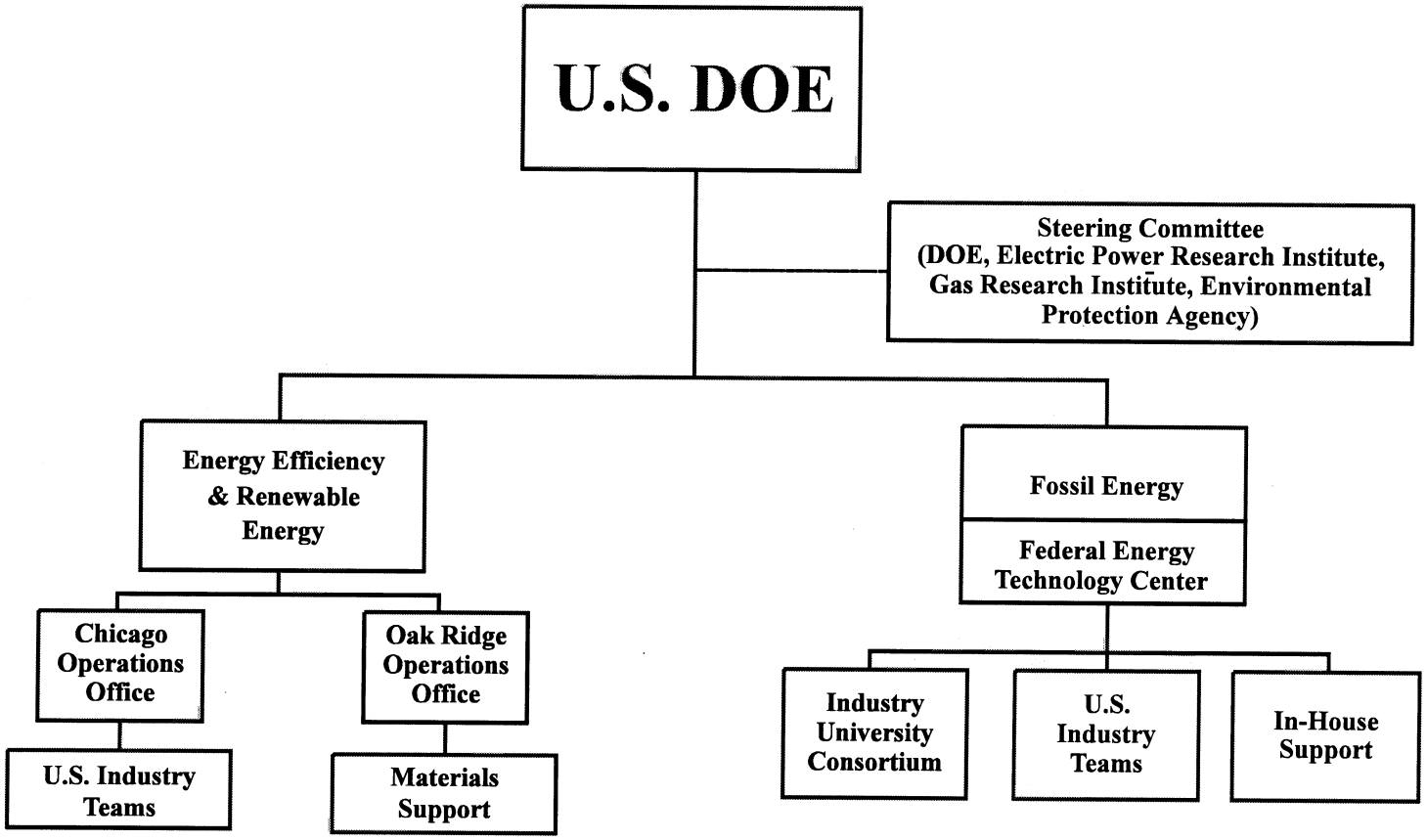
Management Structure for the ATS Program



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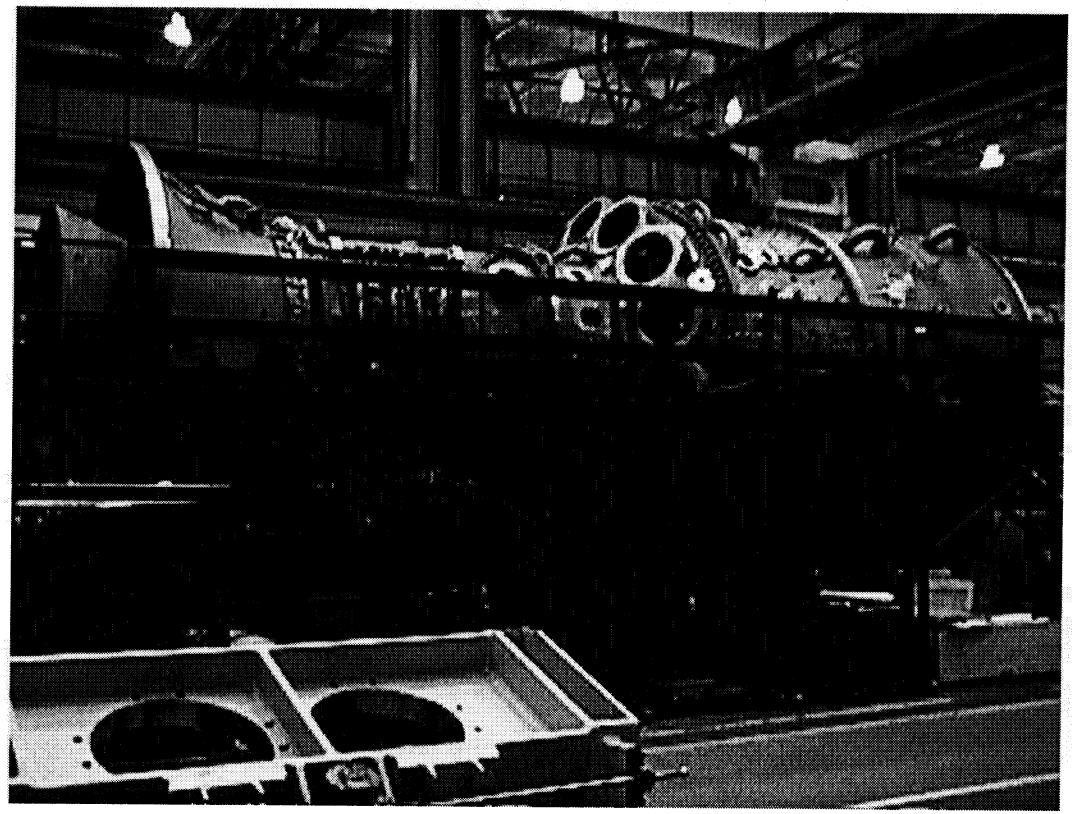
General Electric Company

- Completed full scale testing of 9H(50Hz)ATS at Greenville SC
- Complete 7H(60Hz) ATS in FY 2000-2001 at Greenville SC
- Conduct pre-commercial demonstration of 7H ATS in FY 2001-2002



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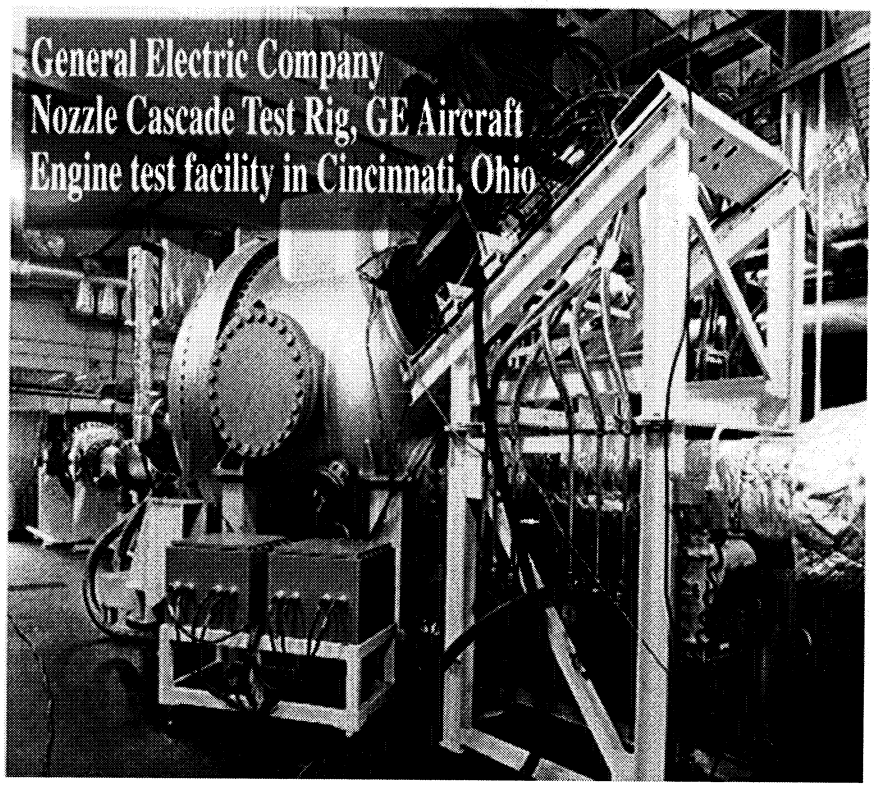
General Electric Company

Validation and Testing Program

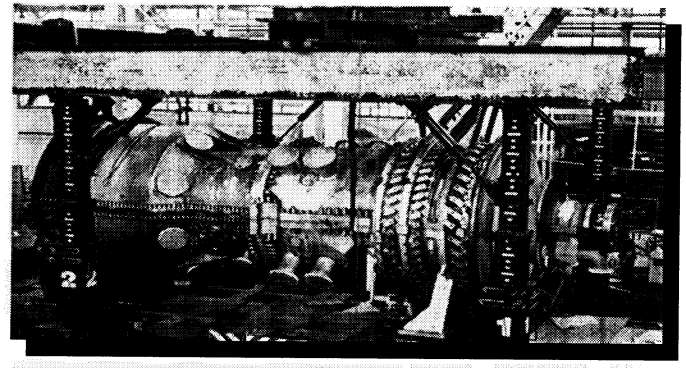
- **Full pressure combustion system at GE High Pressure Test Facility, Ohio**
- **Sub-scale compressor testing- GE Aircraft-, Lynn MA**
- **Steam cooled nozzle at GE High Pressure Test Facility, Ohio**

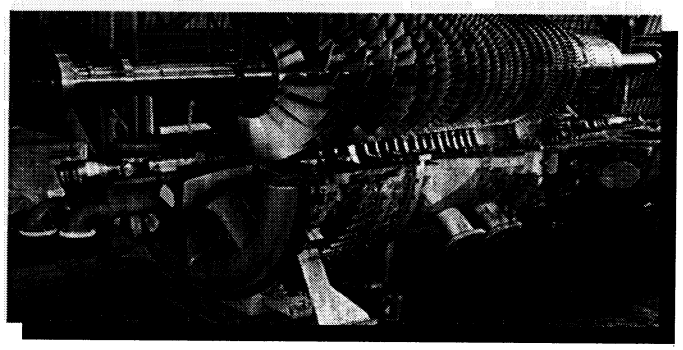


Siemens-Westinghouse Power Corporation

Turbine System Development and Testing

- Continue field testing of catalytic combustion and steam cooled systems on 501G
- Develop steam cooled vanes and test on 501GS power plant in FY 2001
- Manufacture 501 ATS and ship to customer site in FY 2002)
- Conduct pre-commercial demonstration on 501ATS in FY 2002

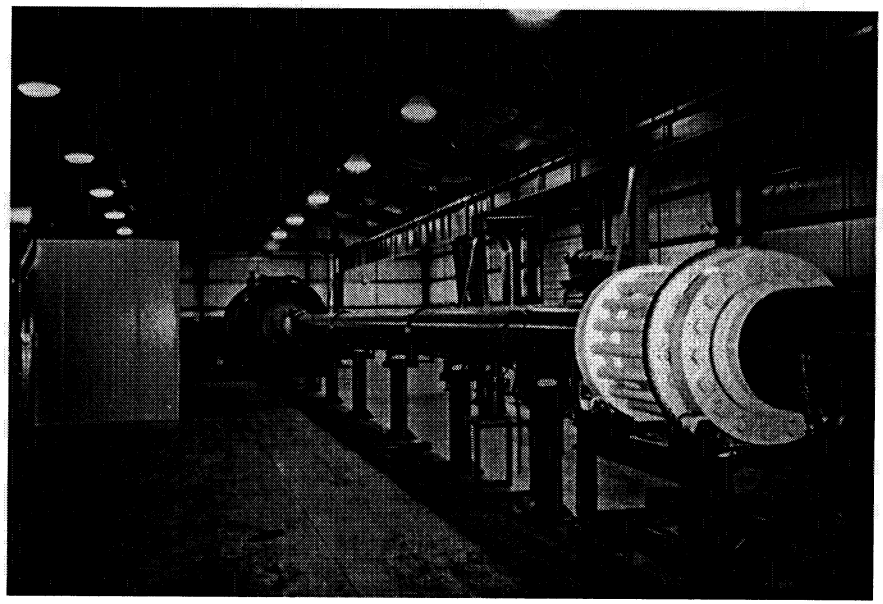




Siemens-Westinghouse Power Corporation

Validation and Testing Program

- Ohio State University Aerodynamic development testing on 1/3 scale model rig
- Catalytic combustion field testing on existing turbine
- Full scale steam cooled vane testing at Arnold Airforce Base



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Manufacturing Materials

Oak Ridge National Laboratory-FETC

Projects with: GE-PCC Airfoils, Siemens-Westinghouse, Howmet-GE-Solar

- Utility scale single crystal blades-reduced sulfur/no grain defects
- New core materials and processes, NDE
- Grain orientation control
- New projects - cost reduction, increased yield rates

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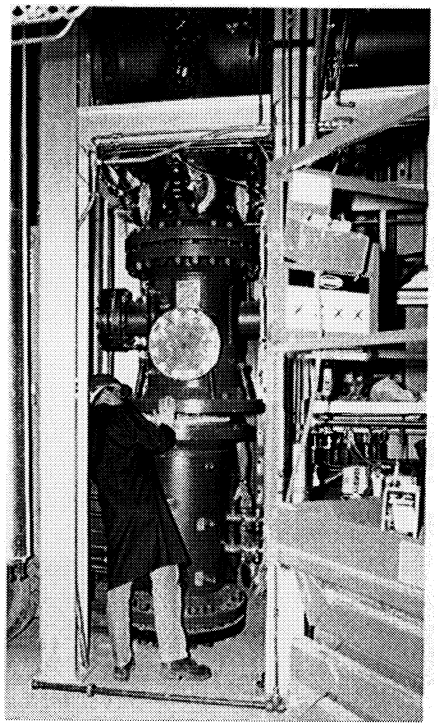
Federal Energy Technology Center
Combustion Division

Low Emissions Combustion Test Rig -

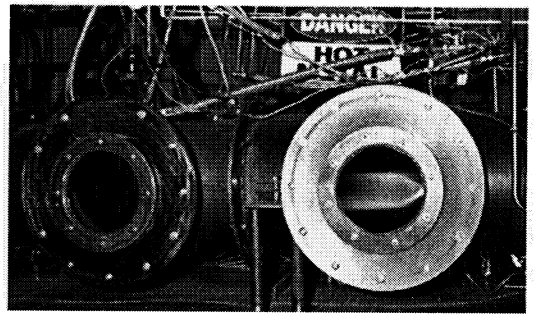
- Porous radiant burner
- Humidified cycle combustion
- Dynamic Gas Turbine Combustor
- Tested "active" and "passive" control techniques
- Emerging work aimed at reducing turbine fuel sensitivity, fuel premixing problems and flashback.

Atmospheric Pressure Test Rig

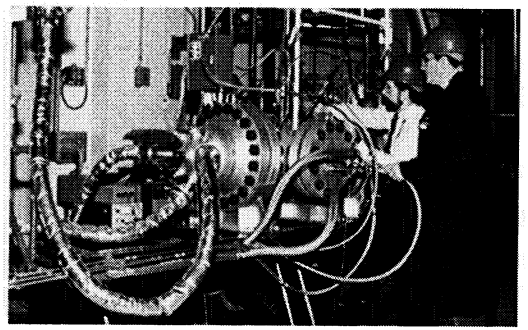
- Currently modifying for fuel flexibility studies



Low Emission Combustion Test Rig



Atmospheric Pressure Test Rig



Dynamic Gas Turbine Combustor

U.S. Department of Energy - ORNL & FETC

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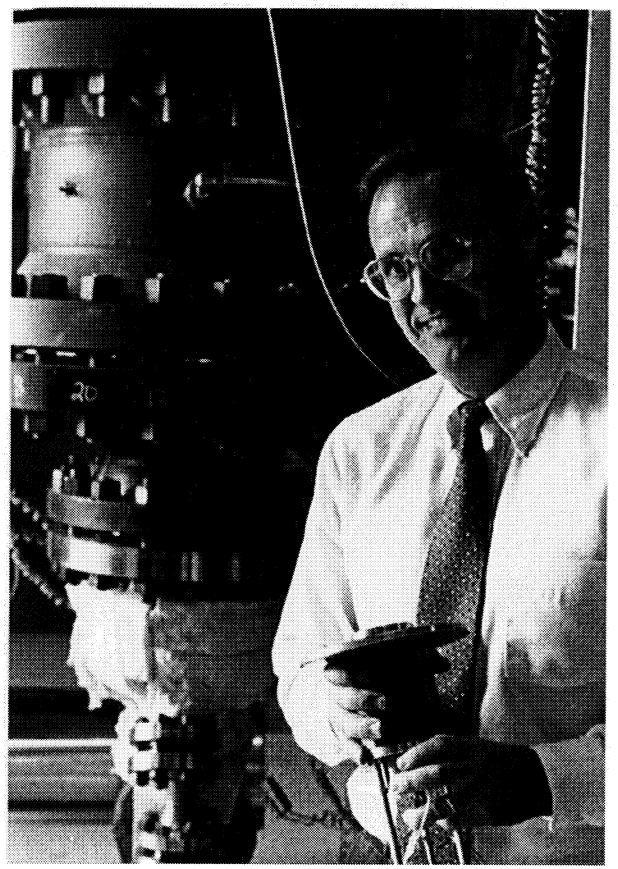
FETC - Low Emissions Combustion Testing

- Alzeta - outward fired, surface stabilized burner at 12 atm pressure
- United Technologies Research Center - low Nox/CO levels at high steam loadings(20%)



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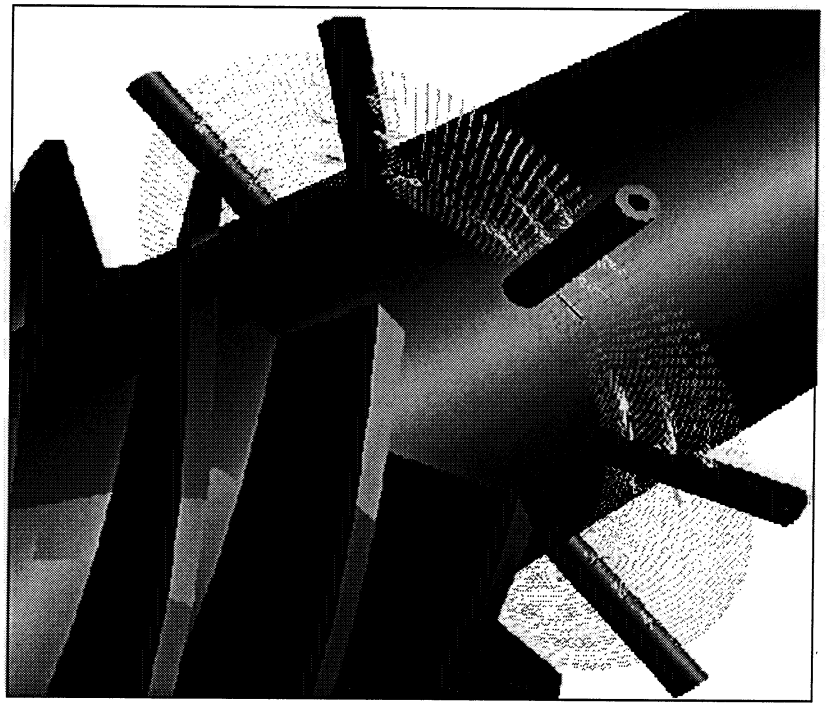
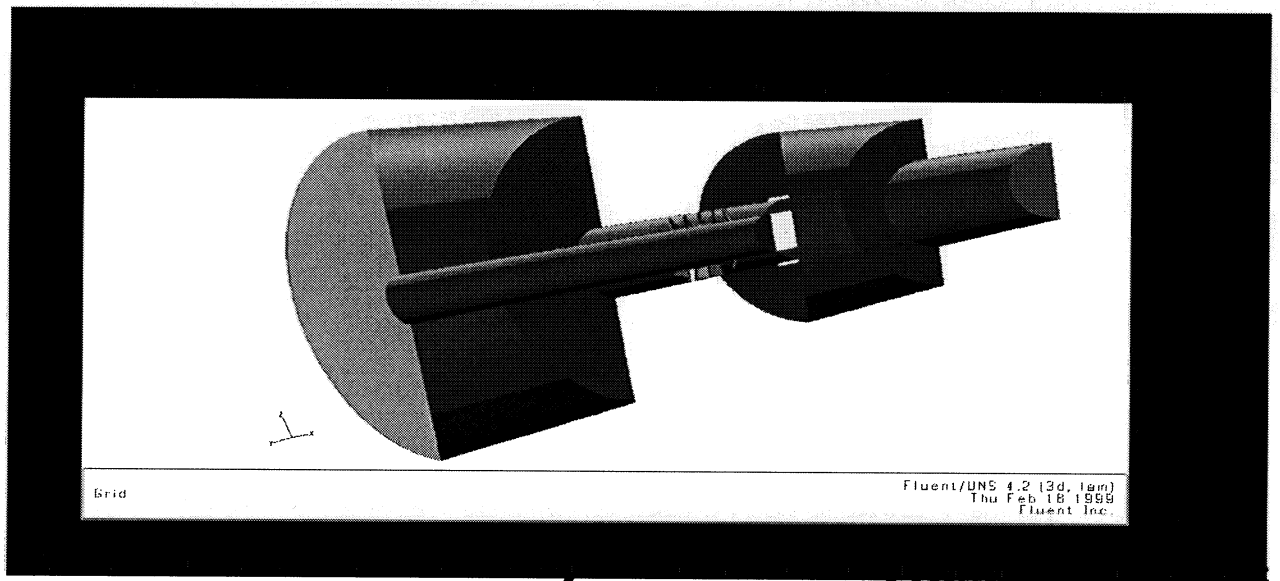
FETC - Combustion Dynamics Control

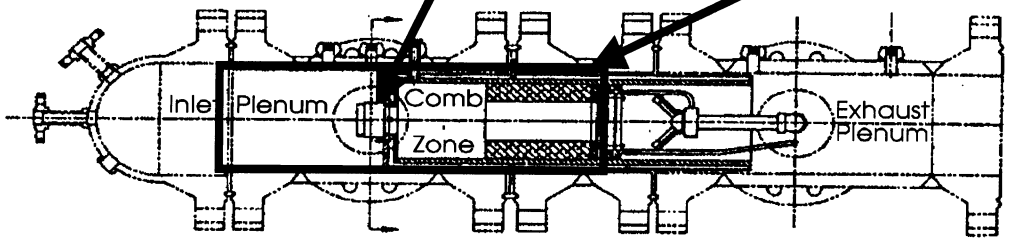
- Parker-Hannifan nozzle for dual fuel/ low emissions
- Effects of swirl vanes on stability-CFD and experimental validation
- Engine scale control of instabilities



Fluent Model of FETC Gas Turbine Nozzle



Simulate this region



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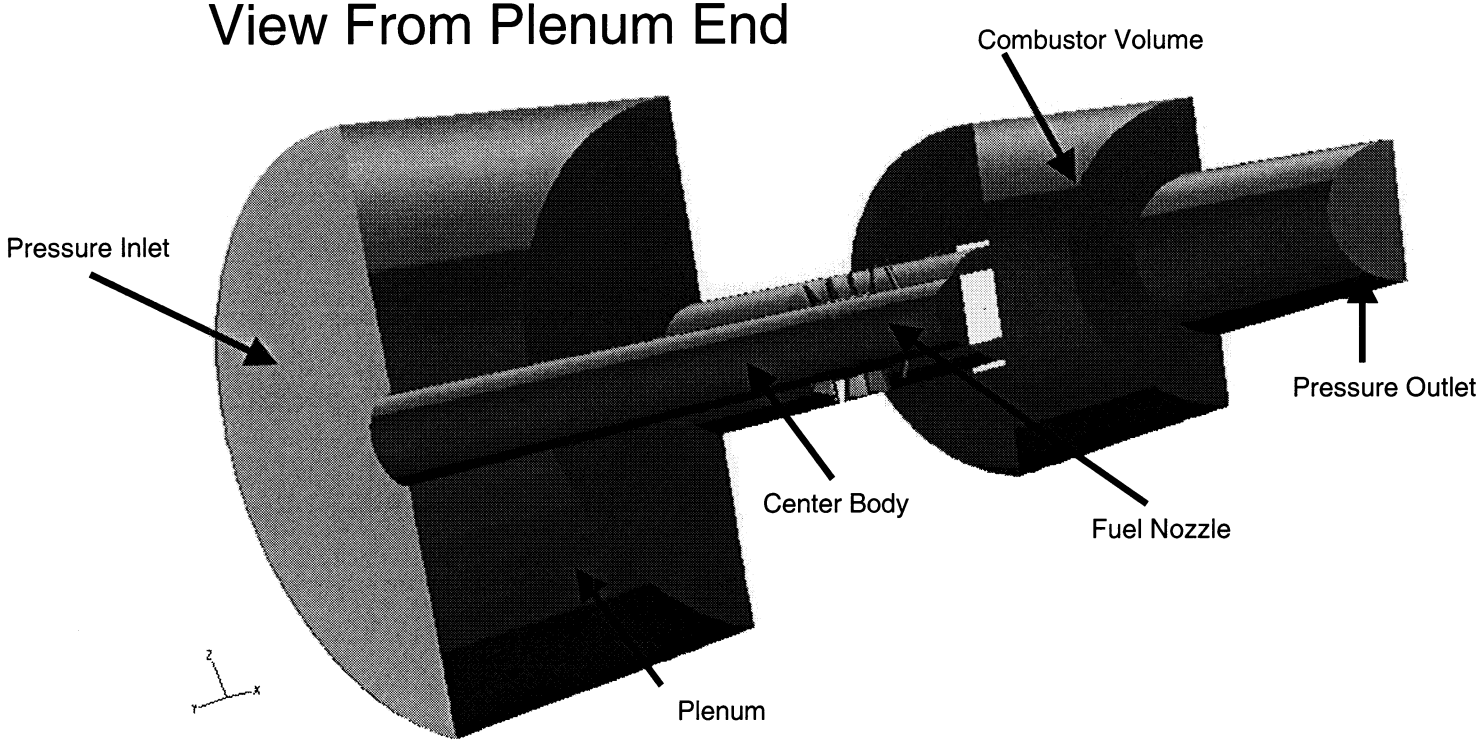
Computational Domain
View From Plenum End



Grid

Fluent/UNS 4.2 (3d, lam)
Thu Feb 18 1999
Fluent Inc.

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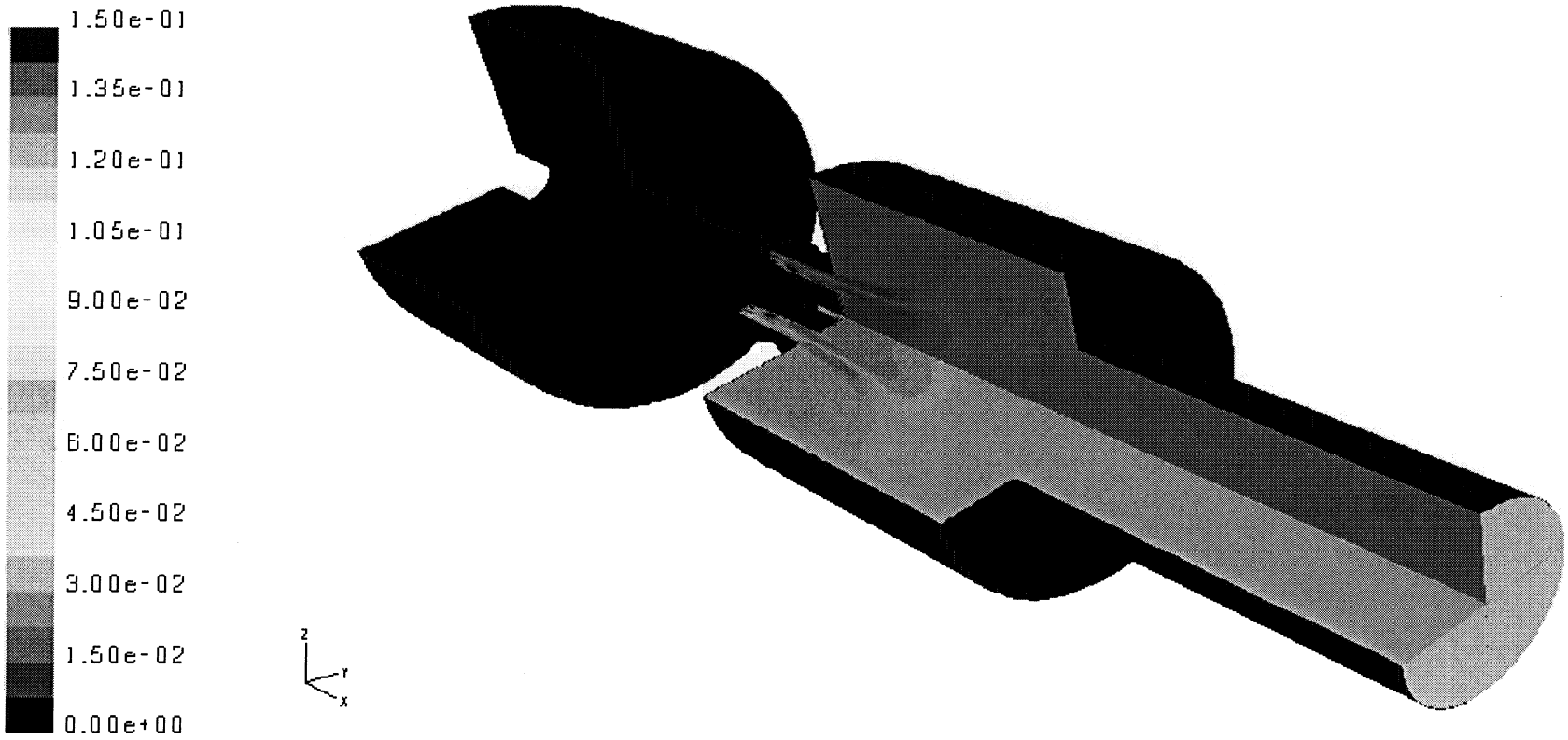

Contours of Mole fraction of ch4

Fluent/UNS 4.2 (3d, speB, react, ke)
Mon Mar 15 1999
Fluent Inc.

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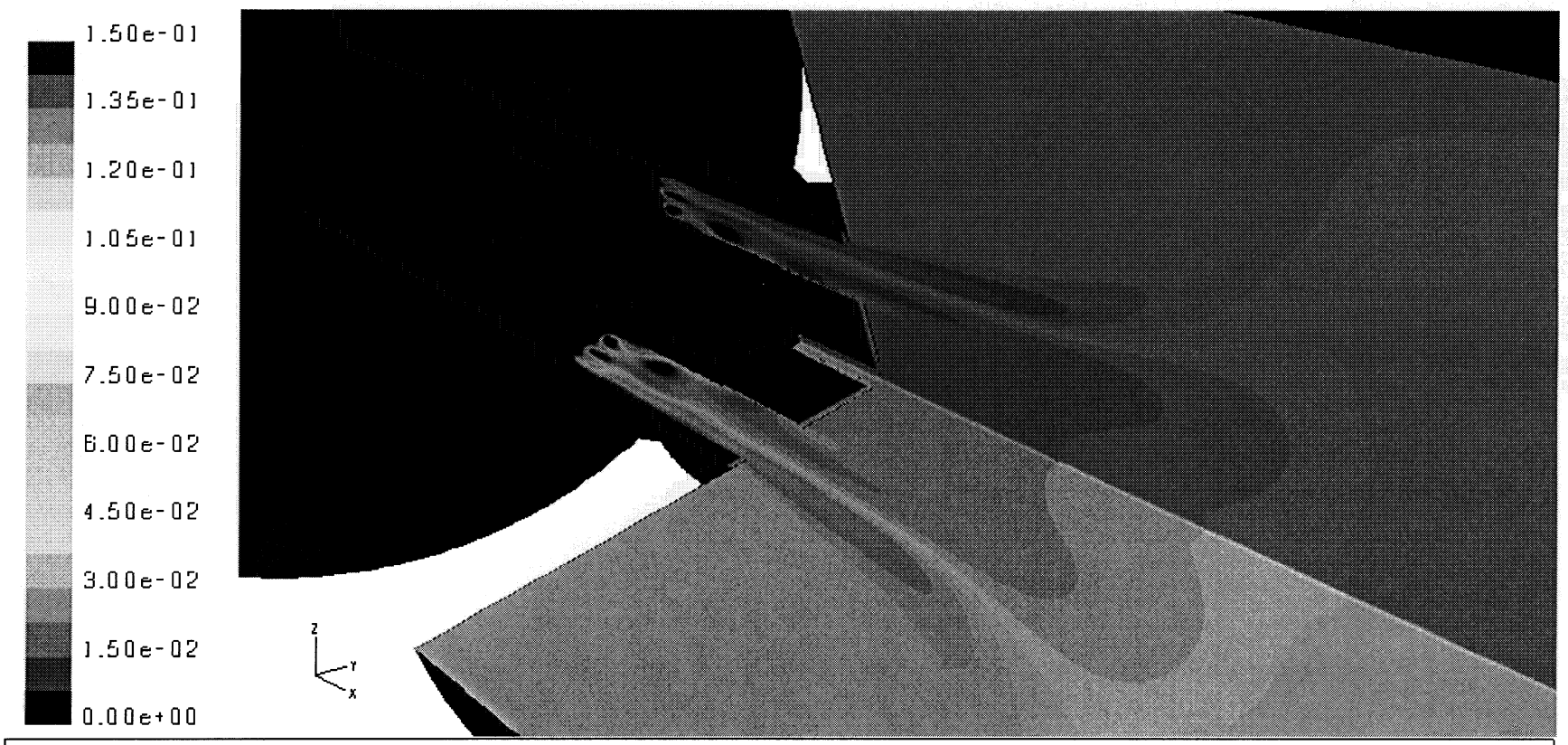

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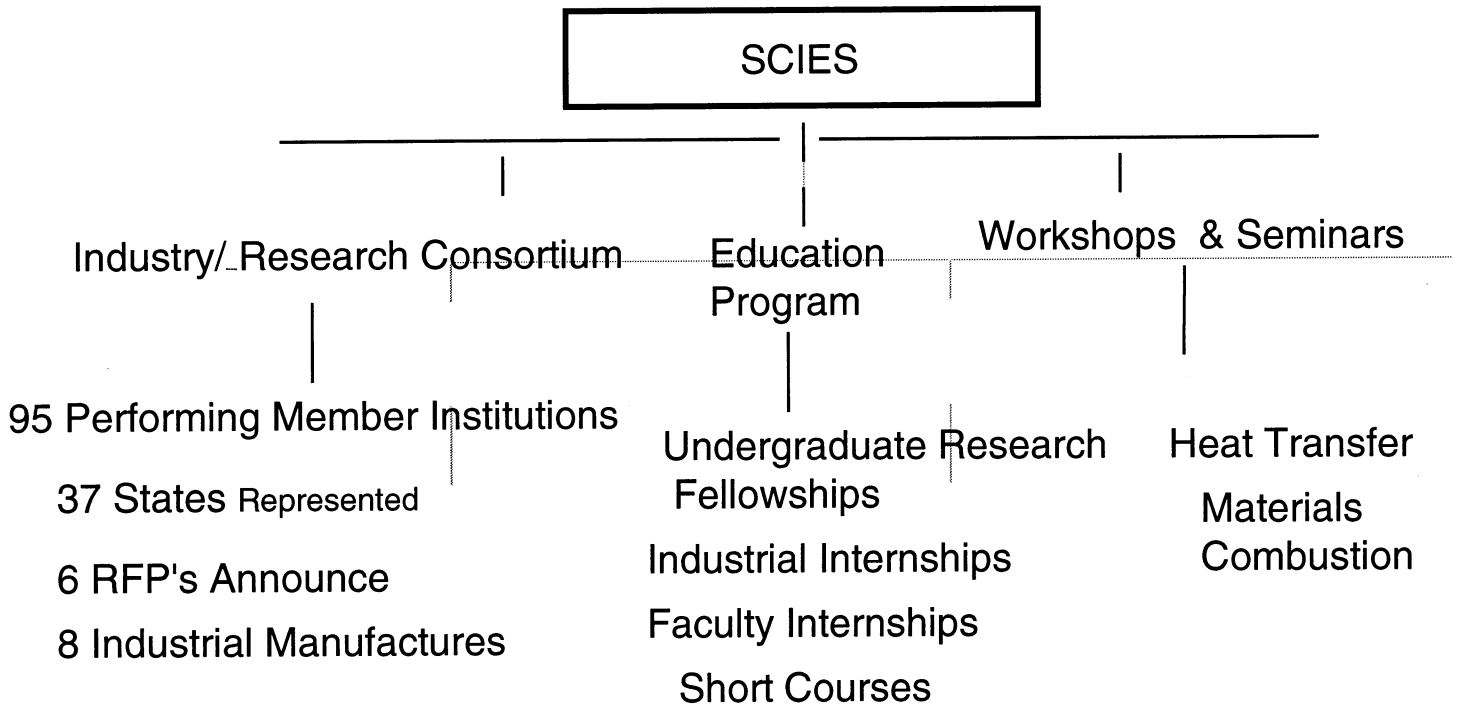
Industry/University Consortium



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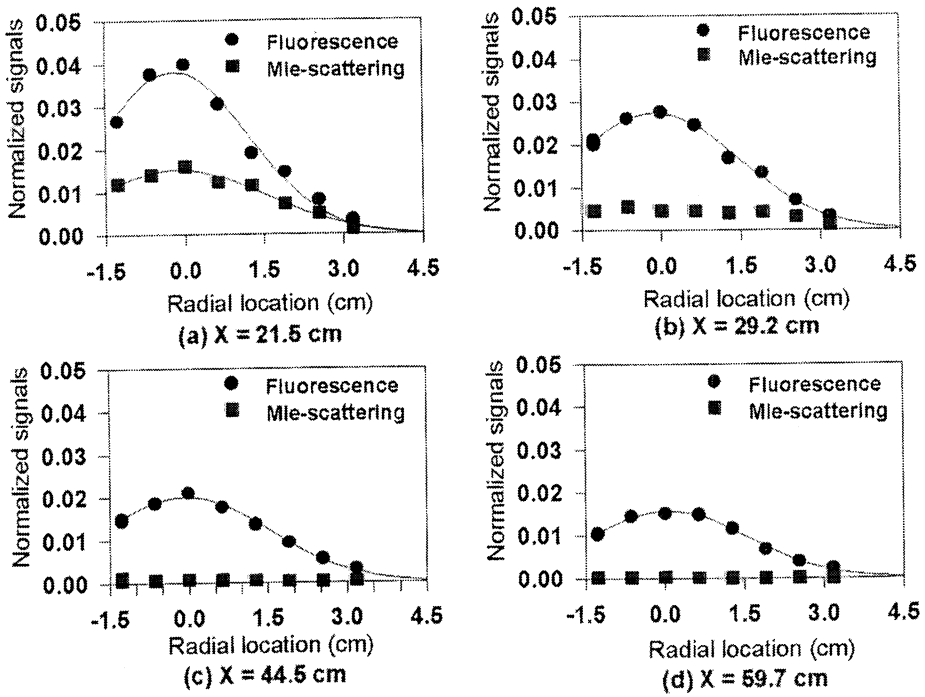
Combustion

Industry/University Consortium

- New equivalence ratio sensors(Penn State, Berkely, Georgia)
- Infrared sensor for temperature measurements(Purdue)
- Efficient chemistry algorithm(Cornell)
- 5 workshops



Next Generation Turbine and Engine Systems - DOE Office of Fossil Energy-FETC

- ***Fuel Cell Hybrid Systems(engines and turbines)***
  - High efficiency, low emissions
  - Distributed generation
  - Long Term Vision 21 systems
- ***Advanced Mid-size turbines***
  - Flexibility
  - Efficiency improvements for existing fleet of power plants(coal, gas, oil)

Next Generation Turbine and Engine Systems - DOE Office of Fossil Energy-FETC

- ***Vision 21-High Efficiency Engines and Turbines***
  - Advanced turbine cycles
  - Ultra high temperature, pressure
  - Reheat and/or inter-cooling
- ***Advanced Reciprocating Engine Systems***
  - Distributed Power
  - Ultra high efficiency
  - Lowest emissions technology
  - Natural Gas fueled

Next Generation Systems Will...

- Build on success of ATS program
- Result in significant air emissions reductions
- Accelerate the overall efficiency increase of the existing and new power generation fleets in the U.S.(coal,oil,gas)
- Develop an effective pathway to Vision 21 systems