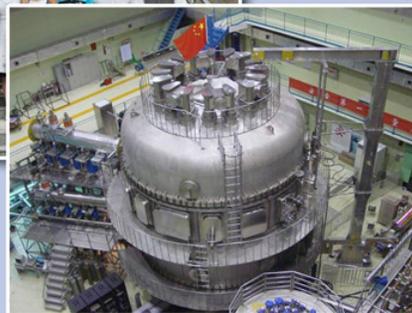




FDS Team

Institute of Plasma Physics, Chinese Academy of Sciences
School of Nuclear Sci. & Tech., University of Sci. & Tech. of China



www.fds.org.cn



INEST · ASIPP · USTC

Overview of Research Activities in FDS Team for Advanced Nuclear Energy Technologies

Presented by Qunying HUANG

Contributed by FDS Team

Institute of Nuclear Energy Science and Technology (INEST)

Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP)

School of Nuclear Science and Technology

University of Science and Technology of China (USTC)

www.fds.org.cn



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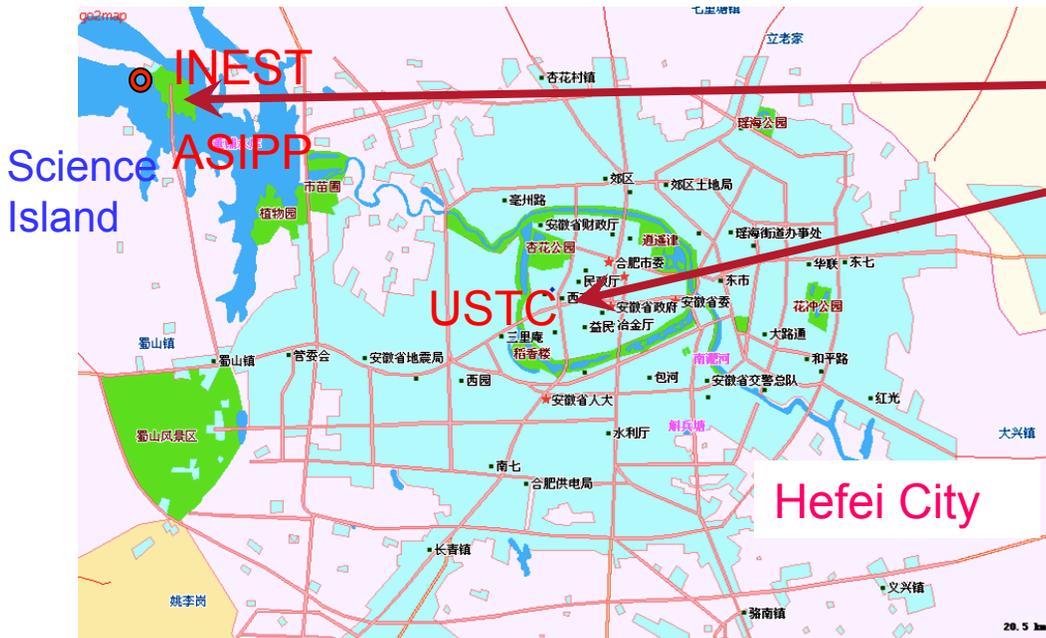
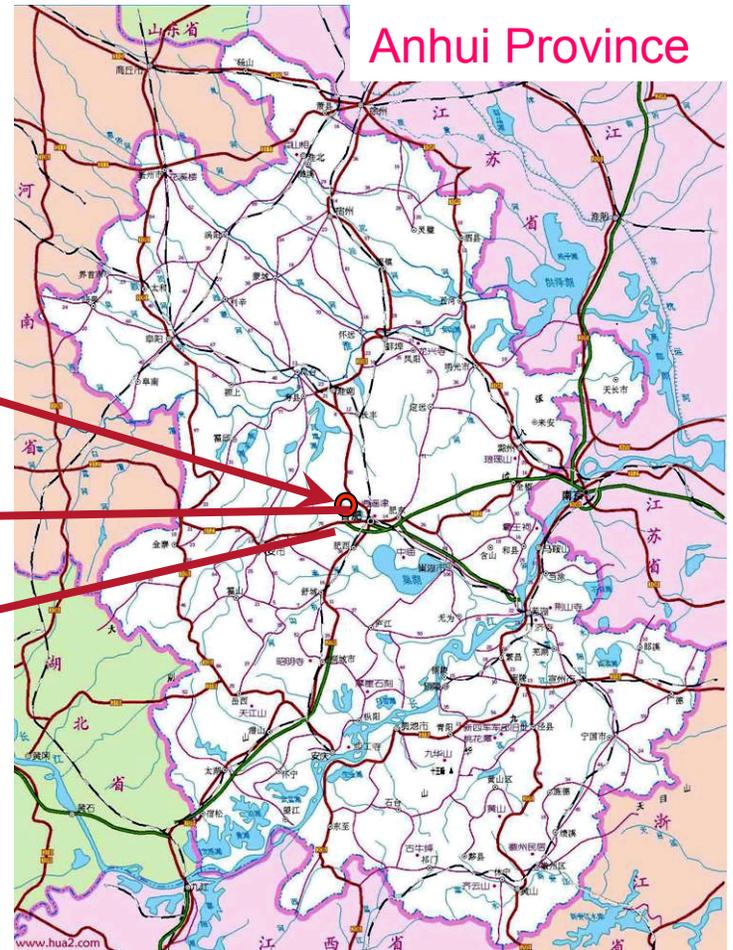
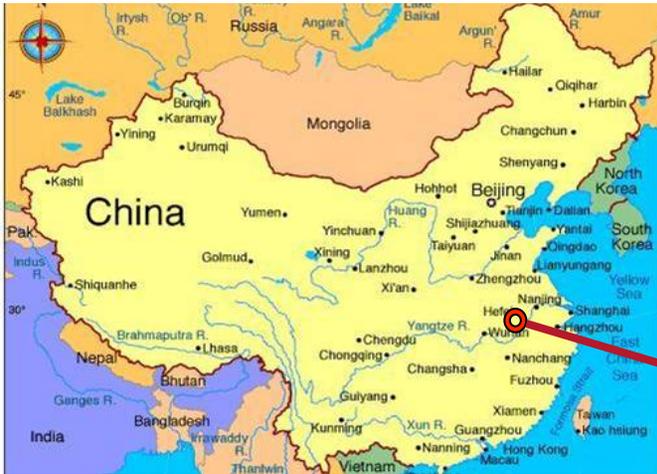


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Where is INEST/ASIPP/USTC located?





INEST

Institute of Nuclear Energy Safety Technology (INEST) Chinese Academy of Sciences (CAS)

**One of the main institutes of nuclear safety research in China
to promote the efficient and safe application of nuclear energy**

➤ **Jointly affiliated with:**

- Hefei Institutes of Physical Science, CAS (HIPS CAS)
- University of Science and Technology of China (USTC)

- **6 Research Divisions**
- **Staff: > 450**
(~200 scientists, ~250 engineers)
- **Students: >300**
- **Site Area:~ 26000m²**

➤ **Research Areas :**

- Nuclear safety and environmental impact analysis
- Neutronics physics and radiation safety
- Thermal hydraulics and transient security
- Advanced nuclear reactor materials and technology
- Nuclear chemical and radioactive waste management
- Advanced nuclear reactor design and numerical simulation



ASIPP

Institute of Plasma Physics, CAS (ASIPP)

One of the main institutes of fusion research in China

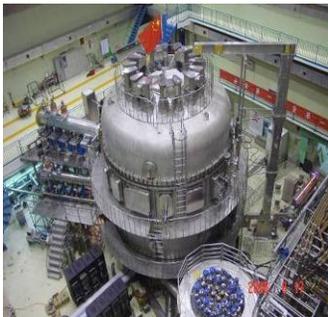
Hefei Institutes of Physical Science, CAS

- **Institute of Plasma physics (IPP)**
- **Institute of Optics and Fine Mechanics (IOFM)**
- **Institute of Solid State Physics (ISSP)**
- **Institute of Intelligent Machines (IIM)**
- **High Magnetic Field Laboratory (HMFL)**

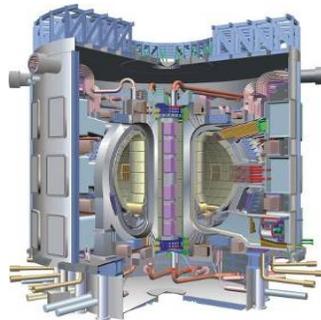
ASIPP

- **Excellent Research Center in the 3rd World**
- **In charge of >75% ITER project of China**
- **Division: 13**
- **R&D company: 6**
- **Staff: ~ 660 (200 Scientists, 400 Engineering)**
- **Students: ~ 380**

The 1st Class Special Progress Prize of National Science and Technology (2008)



EAST (1998-2006-.....)



ITER



President Jiang Zemin (1998)



President Hu Jintao (2008)



USTC

School of Nuclear Science and Technology (SNST)
of **University of Science and Technology of China (USTC)**

Jointly affiliated with

**National Synchrotron Radiation
Laboratory , USTC
Institute of Plasma Physics, CAS**

USTC (Top10 Universities in China)

Academicians:37

Prof.: 332; Asso. Prof.: 616

Graduate: ~8200; Undergraduate: ~7400

SNST:

Academicians: 4

Prof.: 70; Asso. Prof.: 65

Graduate:400; Undergraduate:400

Six Research Areas :

- **Nuclear science and engineering**
- **Nuclear technology and application**
- **Radiation protection and
Environmental protection**
- **Nuclear fuel cycle and material**
- **Synchrotron radiation and application**
- **Radiation medical physics**

10 Laboratories

2 Facilities

1 International Video Meeting Center



CNIT

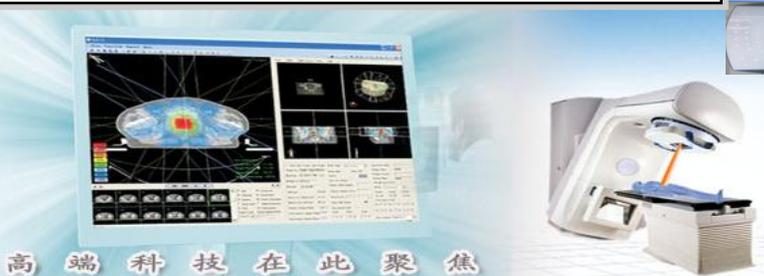
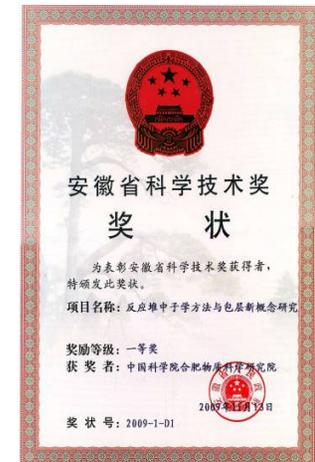
Research Center for Nuclear Information Technology

Advanced Features

- **Digital Simulation & Visualization** : > 100 international users of professional software
- **System engineering & safety** : Application of Risk monitor in Qinshan nuclear power plant
- **Medical Physics (TPS)** : Passed clinical validation, submitted to SFDA

Key Techniques

- **Human modeling & visualization**
- **Particle transportation calculation & optimization**
- **Real time dose validation**





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History



Research Team on Advanced Nuclear Energy

Involved in
ADS, 2010

Involved in
ITER, 2006

FDS History

Fusion/Fission Design Study
(聚变和裂变设计研究)

Fusion Design Study
(聚变设计研究)

Fusion Driven-subcritical System
(聚变次临界系统)

Fusion Digital Simulation
(深度集成数字仿真)

Deep integration
(Advantage)



Scientific Research

6 Main Areas, 9 Key Topics, ~30 Projects

Main Areas:

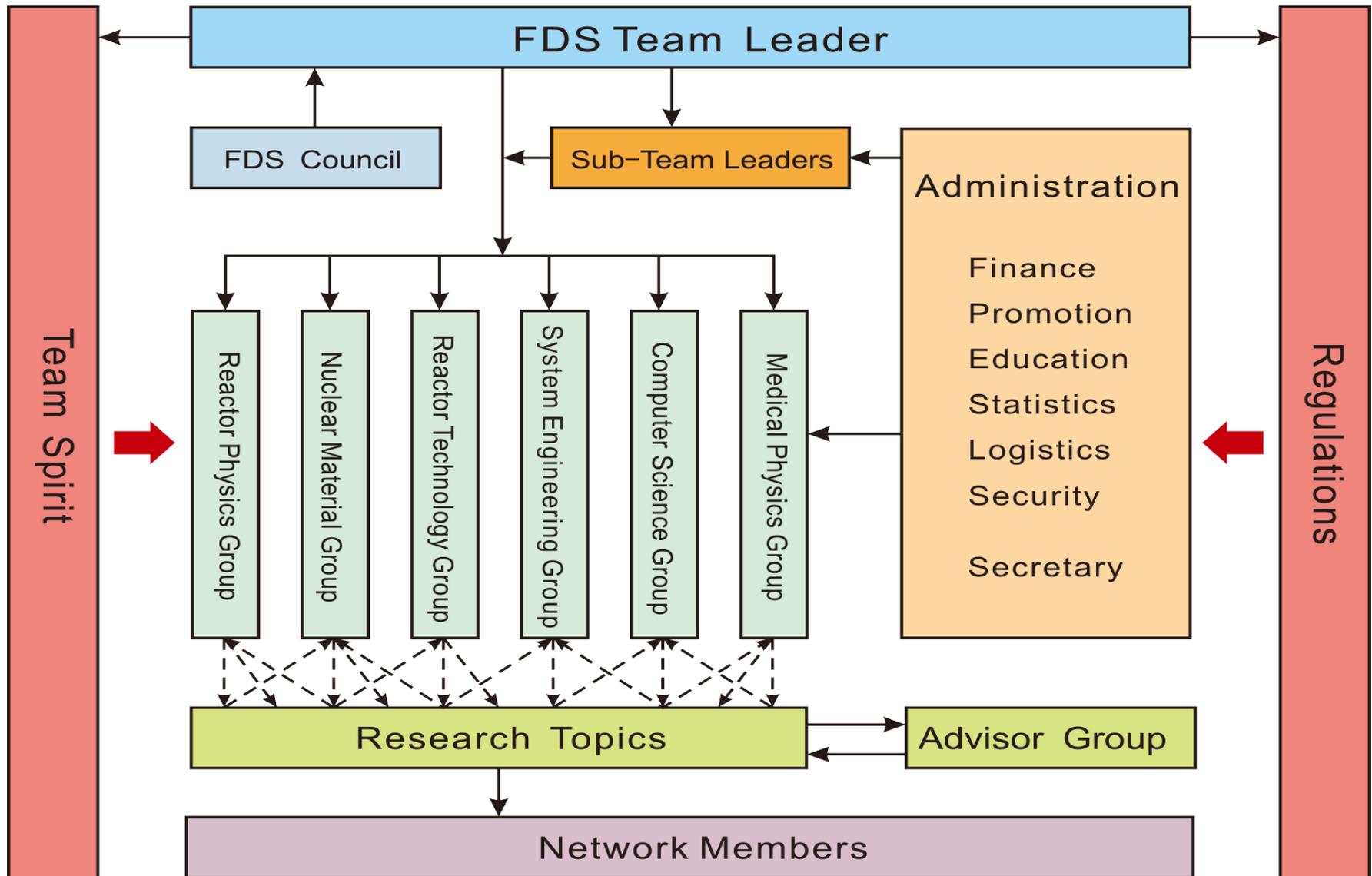
- 1. Nuclear Reactor Physics**
- 2. Nuclear Reactor Material**
- 3. Nuclear Reactor Technology**
- 4. System Engineering & Safety**
- 5. Numerical Simulation & Visualization**
- 6. Medical Physics & Environ. Protection**

Topics:

1. FDS Series Reactors & Blankets Conceptual Design
2. Accelerator Driven Subcritical System
3. Fusion Neutronics
4. China Low Activation Structural Steel
5. Series Liquid Alloy Loops in China
6. Test Blanket Module
7. RiskA/RiskAngel/TQRM
8. 4-Dimensional System for Integrated Design and Simulation of Advanced Reactors
9. Accurate/Advanced Radiotherapy Planning System



Management Structure





Official Organization

- **Three Centers jointly affiliated with different official entities:**
 - Research Center for Reactor Physics and Technology
Located in **INEST & ASIPP (CAS)**
 - Education Center for Nuclear Science and Technology
Located in **USTC (University of Science and Technology of China)**
 - Research Center for Nuclear Information Technology Industrialization
Located in **CNIT (Anhui Nuclear Information Companies/Institutes)**
- **Man Power (~150 in Hefei + 50 on network) and Budget:**
 - Professor & Associate Professors ~15
 - Research Associates ~25
 - Ph.D & postgraduate students ~100
 - Other management staff ~10
 - Network members ~50
 - **Approved budget: ~0.7Billion RMB for 2011-2015**





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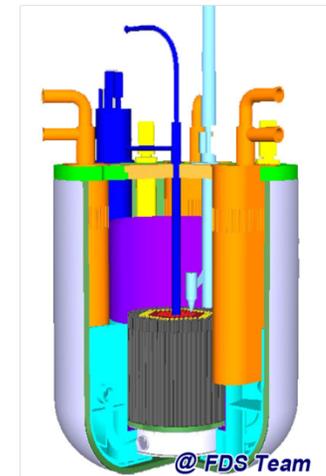
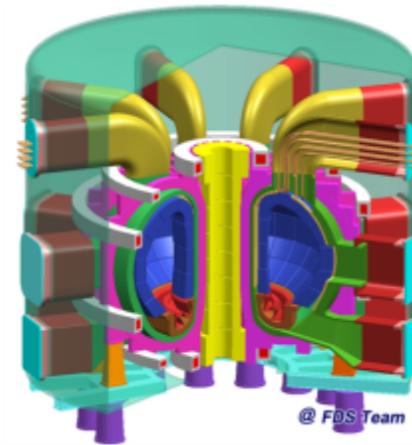
AREA-I

INEST · ASIPP · USTC

Nuclear Reactor Physics

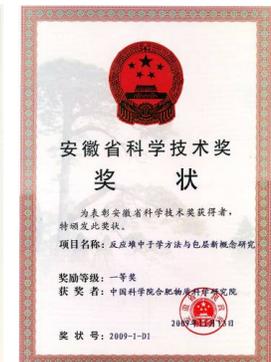
Main Topics :

- Advanced conceptual design and research
- Neutronics analyses and experiments
- Neutronics-Thermohydraulics coupled
- Plasma physics
- Nuclear source and fuel recycling
- Software and nuclear database development



Key Achievements :

- FDS Series Reactors Conceptual Design
- CN-ITER Tasks
- **1st** class prize of Science and Technology of Anhui Province (2009)
- **1st** class prize of Science and Technology Award of China Nuclear Energy Association (2010)





FDS Series Reactor Concept Design

Pure Fusion Reactor

- FDS-II(SLL/DLL) : Fusion power reactor, (Advanced electricity generation)
- FDS-III(HTL) : High temperature fusion reactor (Hydrogen production)

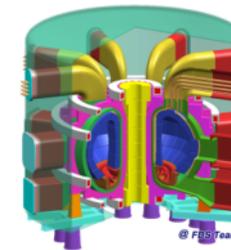
Hybrid Reactor

- FDS-SFB(DCB/WCB/HCB): Fusion-driven sub-critical system (Early application of fusion)
- FDS-ST(CCP) : Spherical tokamak-based reactor (Better economics)
- CLEAR-III: Accelerator driven system (Nuclear waste transmutation)

Experimental Reactor

- FDS-MFX : Multi-functional experimental reactor (Viable engineering)
- CLEAR-I : PbBi-cooled experimental reactor (Viable engineering)

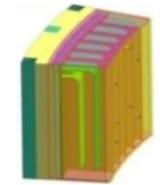
- "Neutronics software and sub-critical reactor concept design" 1st class prize of Science and Technology Award of China Nuclear Energy Association (2010)
- "Neutronics methods and innovation blanket concept design" 1st class prize of Science and Technology of Anhui Province
- "Fusion power reactor conceptual design study" for three consecutive years was named "China's one hundred most influential domestic academic excellence."



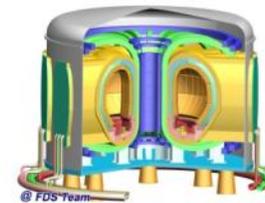
FDS-II



700°C



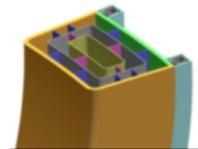
DLL/SLL



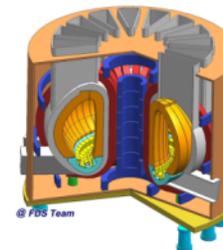
FDS-III



1000°C



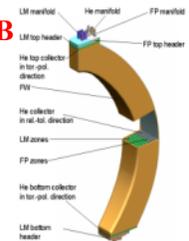
HTL



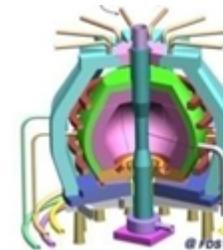
FDS-SFB



450°C



DCB



FDS-ST



450°C

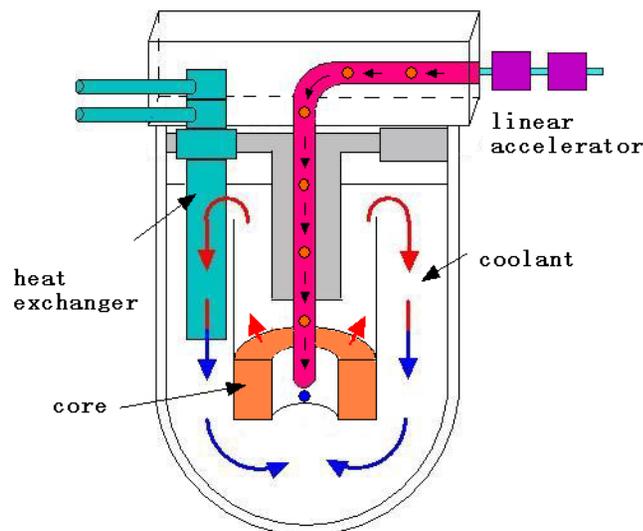


CCP

Accelerator Driven Subcritical System (ADS)

ADS Reactor Physics and Technology

- ADS reactor conceptual design
- Neutronics and thermohydraulics coupling code development
- Nuclear database development
- Lead-Bismuth (Pb-Bi) experimental loops construction
- Thermal-hydraulics experiment research
- Compatibility of LBE and materials research



Principle of ADS system



Pb-Bi experimental loop



Fusion Neutronics

ITER neutronics tasks:

- ITA 73-01-CN :Upper port shielding analysis
- ITA 73-03-CN :Update of basic MCNP model for ITER and extension of data library
- ITA 73-08-CN :Testing and application of a CAD/MCNP interface program for ITER neutronics design calculations
- ITER/CT/09/4100001055: Analysis of radiation outside bio-shield

EAST neutronics tasks:

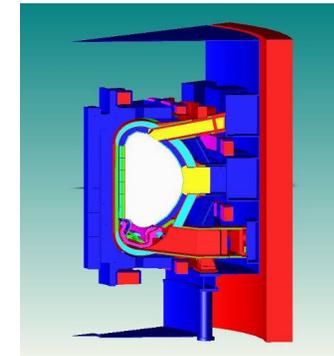
- Shielding design and analysis for EAST
- EAST irradiation monitor

Neutronics experimental platform:

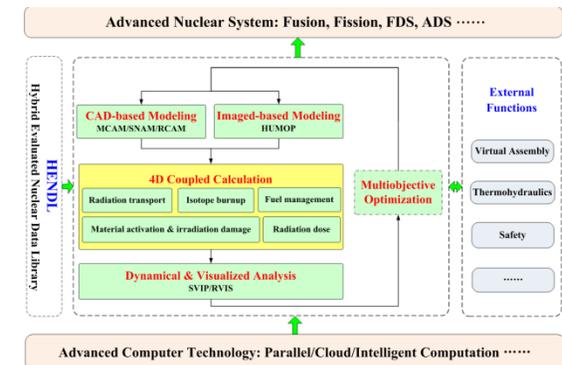
- HINEG D-T neutron generator
- A series of neutronics measurement equipments

Software and nuclear database development

- MCAM → 1) ITER reference neutronics model
2) > 100 institutes in the world
- The highest current intensity D-T neutron generator (~10¹³n/s) in China.



ITER reference neutronics model Alite-4



VisualBUS: Multi-Functional 4D Neutronics Simulation System



Bonner neutron spectrum instrument



High purity germanium gamma spectrum instrument



Nuclear Reactor Material

Main Topics

⊕ Structural material (CLAM)

- Composition optimization
- Fabrication & Processing
- Performance evaluation
- TBM development
- Irradiation effect
- Synthesis service performance

⊕ Functional material

- Multifunctional coating
- SiC_f/SiC composite
- Reactor coolant
- Tritium breeders
- High-temperature alloy



Key Achievements

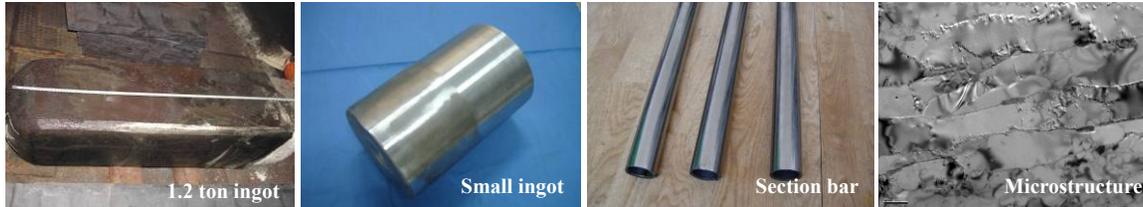
- In charge of the R&D on China low activation structural steel (CLAM)
- Chief of working group of national reactor physics and materials
- International conference presentation invited (ICFRM / ISFNT)
- Leading R&D of CAS Knowledge Innovation Program “R&D on materials under intense irradiation”





China Low Activation Structural Steel (CLAM)

- In charge of the R&D on CLAM steel
- Invention of CLAM steel and optimization of its composition
- Smelting of CLAM steel reached ton scale (4.5ton), the basic component is stable and controllable
- CLAM steel shows similar properties with other RAFM steel, some properties even better



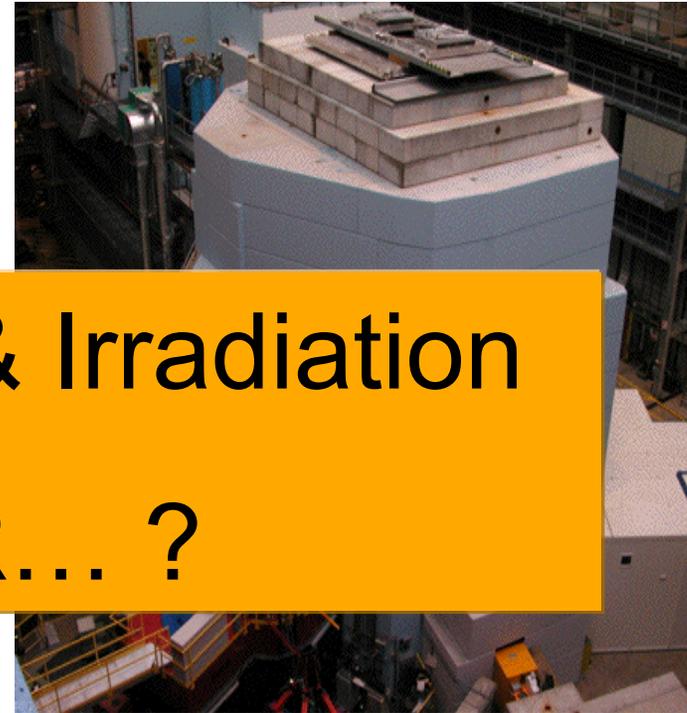
- High-dose neutron irradiation experiments on CLAM steel
(Spallation source ~ 15dpa)
(High Fluence Engineering Test Reactor ~1dpa)
- Fabrication of test blanket module (TBM)



Leading R&D of CAS Knowledge Innovation Program
“R&D on materials under intense irradiation”



Irradiation plan of CLAM steel (2007~2013)



Collaboration & Irradiation in HFIR... ?

High Flux Engineering Test Reactor (HFETR) in China

Neutron Irradiation test
(~1dpa, ~300°C)
finished

PIE is underway (2010-2011).

Spallation Neutron Source, SINQ, PSI, Switzerland

Spallation neutron irradiation tests
(STIP-V, 10~20 dpa, 100~500°C)
finished

PIE is underway (2012-2013).



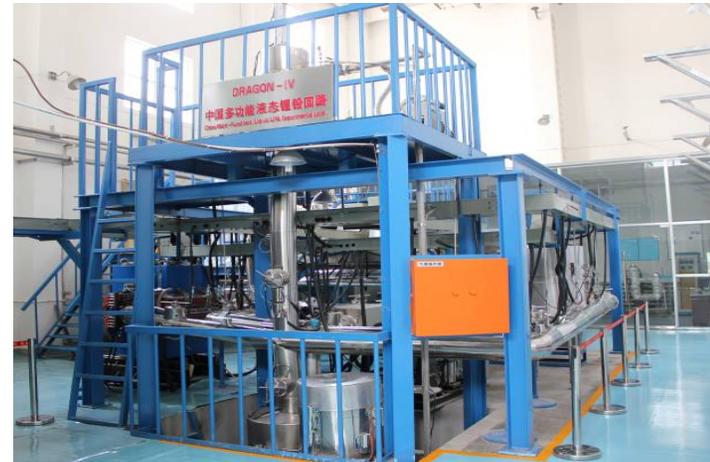
Nuclear Reactor Technology

Main Topics :

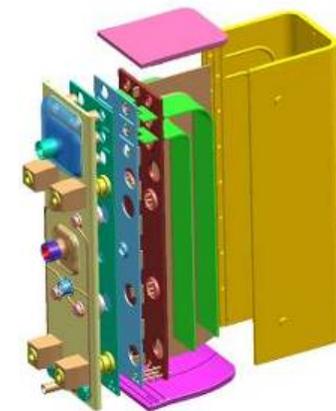
- Liquid LiPb Loop
- Liquid PbBi Loop
- Water/Helium Loop
- Test Blanket Module (TBM) & Tritium Technology
- Thermal hydraulics for Reactor

Key Achievements :

- **Leading level on multi-functional LiPb blanket experimental platform**
- Series of experimental liquid alloy loop
 - Series of DRAGON LiPb alloy loops
 - Series of KYLIN PbBi alloy loops
- Innovative Design on the Dual Functional Lithium-Lead TBM (DFLL-TBM) for ITER



Multi-Functional LiPb Blanket Experimental Platform DRAGON-IV



DFLL-TBM for ITER



Series Liquid Alloy Loops in FDS

Loop Name	Type	Function	Temperature	Period
DRAGON-I	TC	Compatibility	420~480°C	2001-2005
DRAGON-II	TC	Compatibility	550~700°C	2004-2006
DRAGON-III	TC	Compatibility	800~1000°C	2007-2010
DRAGON-IV	FC	Compatibility, Thermal-hydraulics, TBM mockup, MHD effect test, etc.	480~800°C	2007-2010
DRAGON-V	FC	TBM test, MHD test for the complex ducts	300~700°C	2010-2013
DRAGON-VI	FC	Auxiliary system for EAST-TBM	300-700°C	2011-2022
DRAGON-VII	FC	Auxiliary system for ITER-TBM	300-700°C	2015-2029
DRAGON-VIII	FC	Auxiliary system for DEMO blanket	-	2019-
KYLIN-I	TC	Compatibility	480°C	2009-2010
KYLIN-II	FC	Compatibility, Thermal-hydraulics, etc.	~600°C	2010-2012
KYLIN-III	FC	Thermal-hydraulics experiment for ADS	-	2012-2014
PHOENIX-I	FC	He Thermal Hydraulics Experiment	~300°C, 8MPa	2010-2011
H ₂ O Loop	FC	H ₂ O Thermal Hydraulics Experiment	~300°C, 6MPa	2010-2011



DRAGON-I



DRAGON-II



DRAGON-IV



KYLIN-I



ITER Test Blanket Module (TBM)

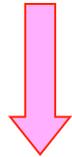
Out of Pile Test
(2006-2014)



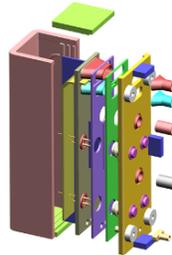
1/3 scale DFLL-TBM



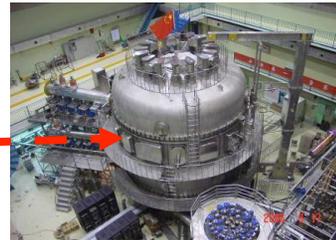
- 1/3 size DFLL-TBM
- Thermal convection, Forced convection
- Thermal-hydraulics, MHD test
- Material R&D (RAFM, Coating, FCI)



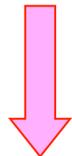
Test In EAST
(2014-2022)



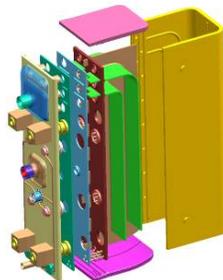
EAST-TBM



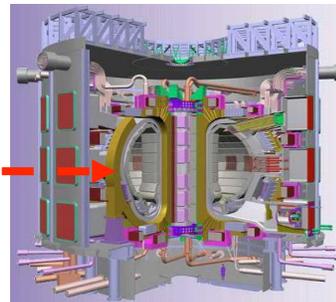
- EAST-TBM (1/2 size DFLL-TBM)
- LiPb loop, He loop for EAST
- Thermal-hydraulics, MHD, Neutron test
- Effect of ferrite material on plasma



Test In ITER
(2019-2029)



DFLL-TBM



- Full size DFLL-TBM
- LiPb loop, He loop for ITER
- Validating the technology of getting energy and tritium
- Validating design tools, nuclear data
- Integrated performance test of TBM

National Magnetic Confinement Fusion Special Project
Study on Design and Technology Feasibility for Liquid Breeder TBM



System Engineering and Safety

❖ Main Topics:

- Probability safety assessment
- Risk Informed decision / risk monitor
- Reliability analysis of complex system
- Transient safety and severe accident management
- Economical analysis on nuclear engineering
- Development of related software and database

❖ Key Achievements:

- RiskA: Probabilistic Safety Assessment Program
- Risk Angel: Risk Monitor for Nuclear Power Plants
- TQRM: Third Qinshan NPP Risk Monitor
- Risk Base: Database Management System for Reliability Analysis
- SYSCODE: System Analysis Program for Parameter Optimization and Economical Assessment of Fusion Reactor



RiskA/RiskAngel/TQRM

- ❖ Qinshan nuclear power plant Risk Monitor
- ❖ Qinshan NPP: Pressurized Heavy Water Reactors, 2×728MW CANDU-6
- ❖ **First safety analysis software applied in nuclear power plants with fully intellectual property right in China**





Numerical Simulation and Visualization

Main Topics

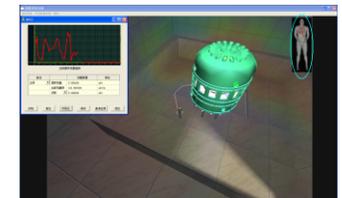
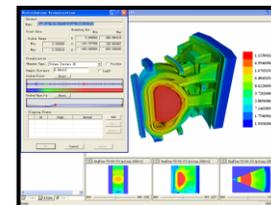
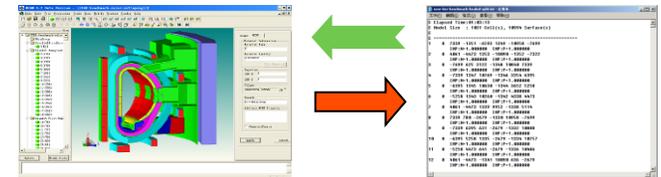
- Automatic modeling (*for system / human*)
- Scientific visualization
- Virtual reality (*assembly, simulation, etc.*)
- Integrated simulation (*digital reactor*)
- Cloud computing & Collaborative work
- Integrated design and simulation system for nuclear analysis

Key Achievements

- Large multi-projection based surround-screen stereoscopic simulation system
- > 20 programs

MCAM: Monte Carlo Automatic Modeling Program

- Passed **ITER QA** verification & validation
- Selected as “**ITER reference code**”
- Created the 3D “**ITER reference neutronics model**”
- Applications: > **100** institutes/companies





INEST · ASIPP · USTC

FDS Software

◎ Physics and Engineering Calculation

- **VisualBUS** **Multi-functional Integrated 4D Neutronics Simulation System**
- **NTC** **Neutronics-Thermohydraulics Coupled Simulation Program**
- **MTC** **Magnetic-Thermohydraulics Coupled Simulation Program**
- **TAS** **Tritium Analysis Program for Fusion System**
- **RiskA** **Probabilistic Safety Assessment Program**
- **RiskAngel** **Risk Monitor for Nuclear Power Plants**
- **SYSCODE** **System Analysis Program for Parameter Optimization and Economical Assessment of Fusion Reactor**
- **ARTS** **Advanced/Accurate Radiotherapy System**

◎ Database Management System

- **FusionDB** **Database Management System for Fusion**
- **HENDL** **Hybrid Evaluated Nuclear Data Library**
- **RiskBase** **Database Management System for Reliability Analysis**

◎ Computer Modeling and Simulation

- **MCAM** **Monte Carlo Automatic Modeling Program for Particle Transport Simulation**
- **SNAM** **SN Automatic Modeling program for Particle Transport Simulation**
- **RCAM** **MC-SN Coupled Automatic Modeling Program for Radiation Transport Simulation**
- **SVIP** **Scientific Visualization Program**
- **FVAS** **Fusion Virtual Assembly System**
- **RVIS** **Radiation Virtual Simulation System**
- **HUMOP** **Human Automatic Modeling Program**
- **4DS** **4-Dimensional System for Integrated Design and Simulation of Advanced Reactors**



VisualBUS

CAD-Based Multi-Functional 4D Neutronics Simulation System

Main Functions:

CAD-based/Imaged-based Modeling

- Monte Carlo (MC) geometries
- Discrete Ordinates (SN) geometries
- MC-SN coupled geometries
- CT/MRI/Color images

4D Coupled Multi-Process Calculation

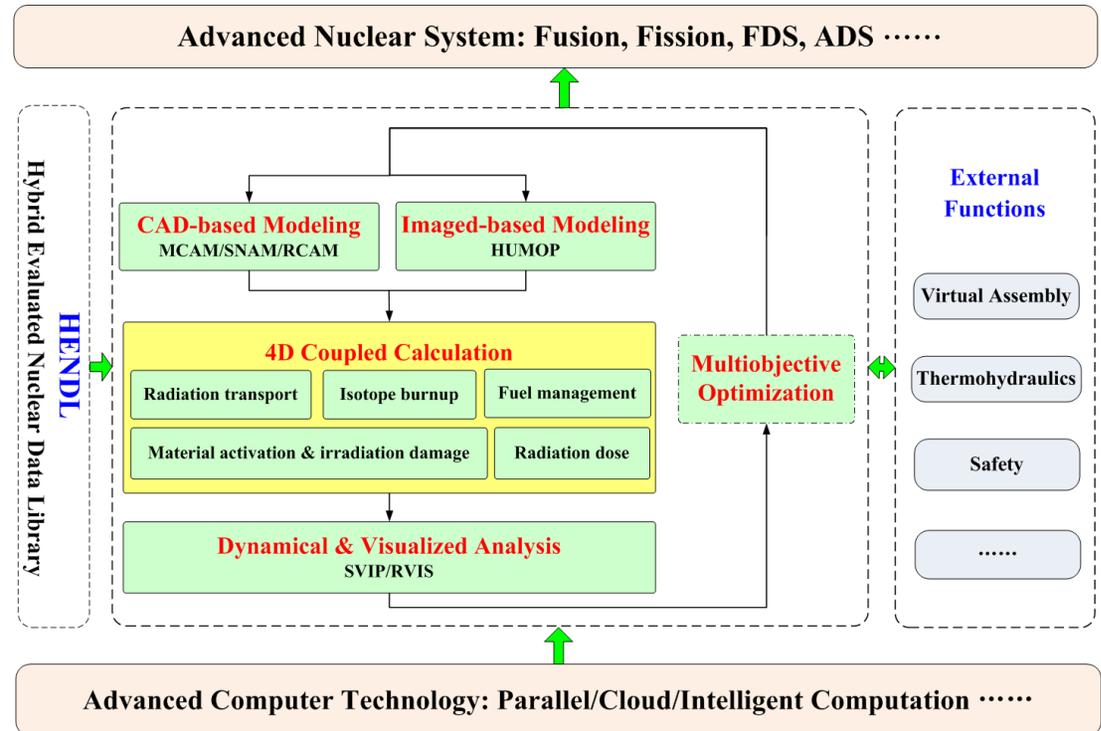
- Radiation Transport
- Isotope Burnup
- Material Activation & Irradiation Damage
- Radiation Dose
- Fuel management

Dynamical & Visualized Analysis

- Static / dynamic physical data fields
- Human virtual roaming & dosimetry assessment

Multi-objective Optimization

- Artificially intelligent algorithms
- Space optimization of irregular complex solutions



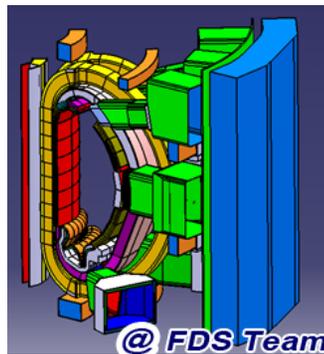
- Hybrid Evaluated Nuclear Data Library for fusion/fission/hybrid systems
- External functions for other physics process simulations such as virtual assembly, thermal-hydraulics, safety, environmental impact and economics etc.



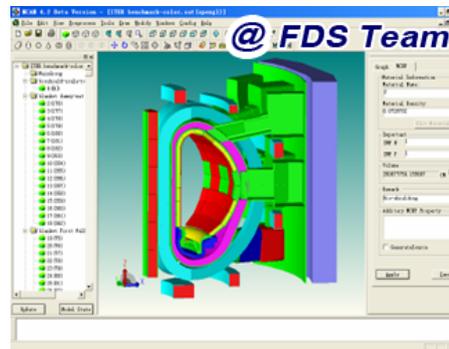
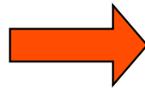
CAD-based Automatic Modeling Programs for Neutronics

Example: MCAM Monte Carlo Automatic Modeling Program

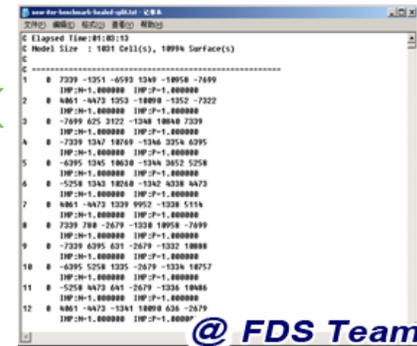
CAD ↔ MC (MCNP / TRIPOLI / GIANT...)



ITER CAD model



Model in MCAM



ITER MCNP model

- Adopted as ITER reference code
- Created the 3D “ITER reference neutronics model”
- Users: > 100 international institutes/companies

SNAM: SN Automatic Modeling Program (CAD ↔ SN)

RCAM: MC-SN Coupled Automatic Modeling Program (CAD ↔ MC-SN)

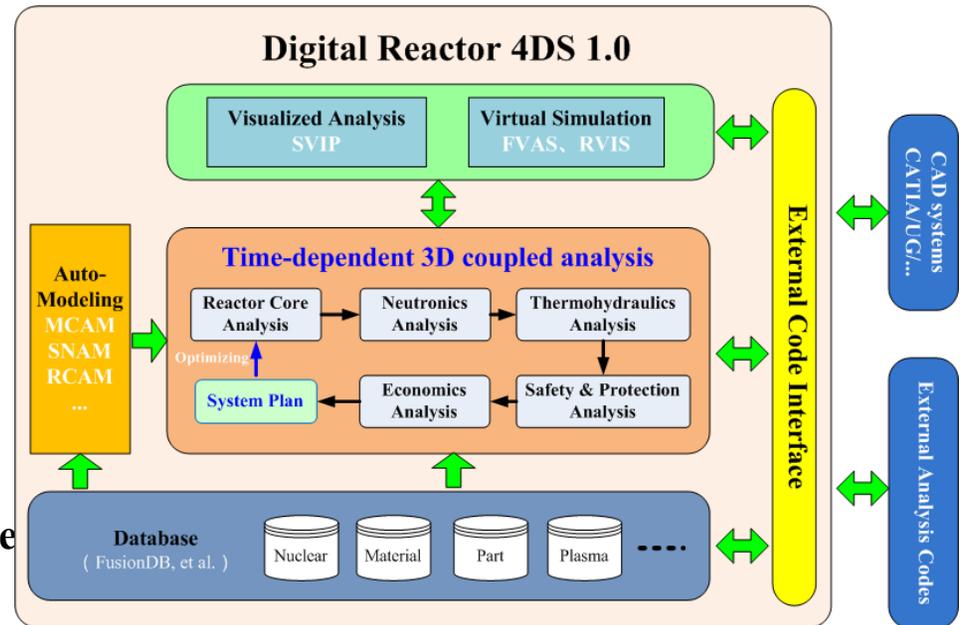
HUMOP: Human Automatic Modeling Program



4DS: 4-Dimensional System

for Integrated Design and Simulation of Advanced Reactors

- Time-dependent 3D accurate calculation based on multi-physics coupling concept
- Auto-modeling & visualized analysis
- Virtual roaming & assembly
- Integration with design & simulation
- Auto coupling each process
- Easy to integrate new-developed codes, due to hierarchical design



Ideal design & simulation platform for advanced nuclear energy systems (fusion/fission reactors, FDS/ADS sub-critical systems, etc.)



Medical Physics and Environmental Protection

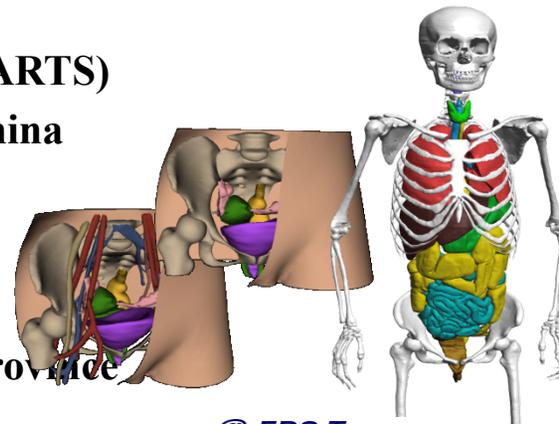
Main Topics:

- Digital human modeling
- Radiation dose calculation
- Inverse planning optimization
- Intelligent positioning
- Radiation biological effect
- Radiation protection



Key Achievements :

- Accurate/Advanced Radiotherapy System (ARTS)
- National Key Basic Research Program of China (“973” Project)
- Engineering Technology Research Center of Accurate Radiotherapy, Anhui Province
- The 1st Prize of Natural Science of Anhui Province



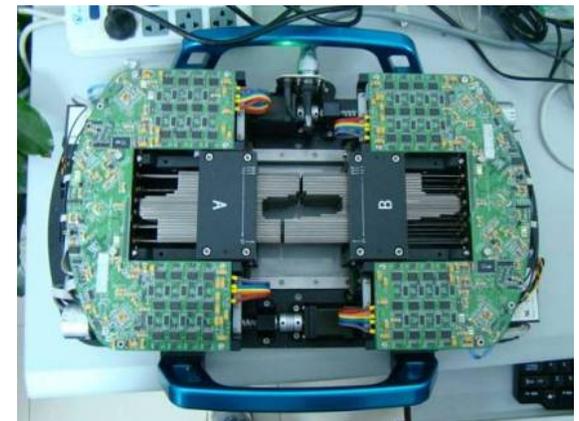
@ FDS Team





Accurate/Advanced Radiotherapy System (ARTS)

- **Treatment Planning System (TPS)**
5D Human modeling, Hybrid dose calculation
Multi-objective optimization inverse planning
Multi-dimensional dynamic visualization
- **Plan Verification and Quality Assurance**
Real-time dose reconstruction; Accurate positioning
- **Dynamic Multi-Leaf Collimator (DMLC)**



IMRT, IGRT and DGRT are supported.

The phantom and clinical test showed the system was effective



Contents

- 1. Introduction**
- 2. FDS Organization**
- 3. Research Areas & Topics**
- 4. Facilities & Achievements**



INEST · ASIPP · USTC

Four Laboratories

- ◆ **Advanced Reactor Design & Numerical Simulation Laboratory**
- ◆ **Advanced Nuclear Material & Reactor Technology Laboratory**
- ◆ **Neutronics & Radiation Safety Laboratory**
- ◆ **Medical Physics & Environmental Protection Laboratory**



Nuclear Material



Reactor Technology



Simulation and Visualization



Medical Physics



Advanced Reactor Design and Numerical Simulation Lab.

Main Facilities	Featured Projects
<ul style="list-style-type: none"> ◆ Large-scale multi-pipe visual simulation system ◆ High-performance parallel blade server ◆ Analysis codes for nuclear systems: ~20 ◆ 4DS: 4D System for Integrated Design and Simulation of Advanced Reactors 	<ul style="list-style-type: none"> ◆ <i>Strategic Priority Program</i> : Pb-Bi cooled Reactor ◆ <i>Key Project of NSFC</i>: Transient safety process & effect of accelerator-driven subcritical system ◆ <i>ITER Project of MOST</i>: Design of TBM with liquid breeder and its technological feasibility



Vice minister (Jianlin Cao) of MOST & vice head (Fuke Ni) of Anhui came to visit (2011.03)



- First Prize of Sci. & Tech. Award of China Nuclear Energy Association
- First Prize of Anhui Sci. & Tech. Award



Advanced Nuclear Material and Reactor Technology Laboratory

□ Main experimental platforms

– Fabrication & Processing System

CLAM steel/PbLi/PbBi/TBM development
(Vacuum induction melting furnace / HIP system / ...)

– Property Testing & Analysis System

Basic performance/Welding/Irradiation/Database
(Universal material testing machine / Heat treatment furnace / ...)

– Service Performance Testing Platform

Key component/Loop construction/Loop operation/corrosion
(High-temperature liquid alloy loops / DRAGON-IV / KYLIN-I / ...)

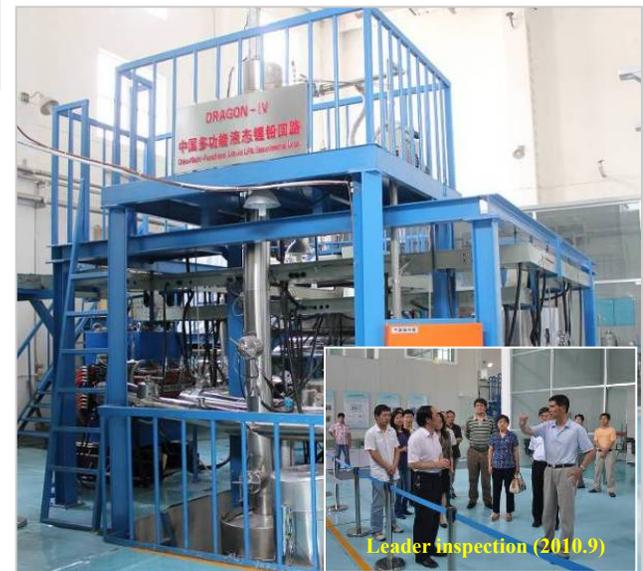


□ Key research projects

– **MOST-ITER Project** “Study on the liquid-metal-breeder TBM design and technical feasibility” (Chief research institution)

– **Knowledge Innovation Program of CAS** “Research on materials by high level irradiation” (Chief research institution)

– **Technology Projects of Strategic Leader of CAS** “Lead-bismuth cooled Experimental Reactor” (Head of projects)





Neutronics and Radiation Safety Laboratory

Main experimental platforms

- ◆ **Intensified D-T neutron generator ($10^8 \sim 10^{13} \text{n/s}$)**
(Neutronics, material activation and irradiation, etc)
- ◆ **Medical physics and health physics**
(Accurate radiotherapy, surgical navigation, digital human, etc)
- ◆ **Radiation safety and environmental protection**
(Radiation monitoring, protection optimization, etc)

Key research projects

- ◆ **Key equipment research project of CAS**
Rotating tritium target development of neutron generator
- ◆ **Strategic leader special project of CAS**
Radiation influence on the environment study
- ◆ **National major scientific project**
Radiation protection research project of EAST tokamak



D-T neutron generator



Bonner sphere spectrometer



He-3 neutron intensity monitor



HpGe spectrometer



NaI photon spectrometer



Tritium monitor



Portable neutron detector



Portable photon detector



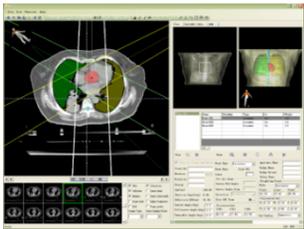
Radiation Medical Physics and Environmental Protection Laboratory (Accurate Radiotherapy Engineering Research Center of Anhui Province)

Main experimental platforms

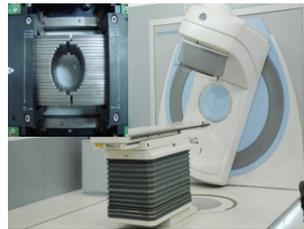
- ◆ **TPS of Accurate/Advanced Radiotherapy System**
(Treatment Planning System, Clinical Electron Linear Accelerator, Dynamic Multi-leaf Collimator, etc)
- ◆ **Accurate Positioning System**
(Radiotherapy Simulator, X-Ray Generator, Imaging Panel, Infrared Location System)
- ◆ **Dose Measurement and Validation System**
(Multi-channel Dosimeter, Film and Scanner, etc)

Key research projects

- ◆ **Special Purchasing Project of CAS**
---Accurate Radiotherapy Experimental Study
- ◆ **Engineering Technology Research Center of Accurate Radiotherapy, Anhui Province**
- ◆ **Significant Industrialized Project of Accurate Radiotherapy System**



Treatment Planning System



Clinical Linear Accelerator



X-Ray Generator



Infrared Positioning System



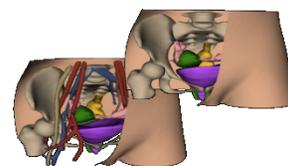
Awarded the First Prize of Natural Science by Anhui Province Government In 2006



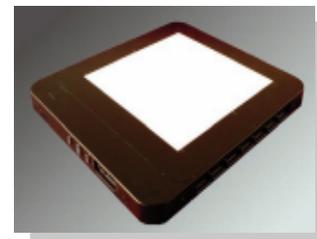
Multi-channel Dosimeter



Human Dose Phantom



Digital Simulation Phantom

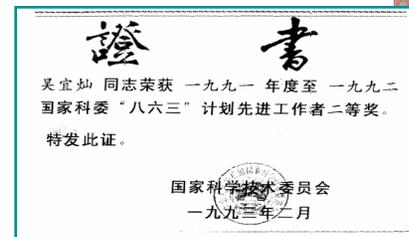
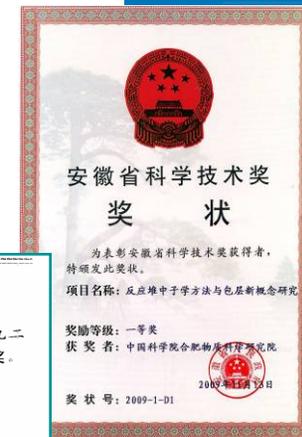
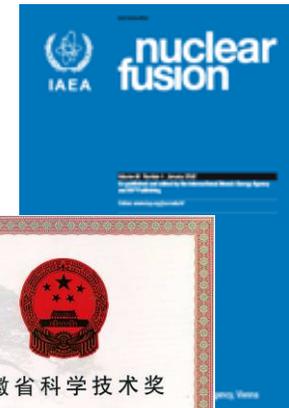


Imaging Panel



Achievements

- ◆ International / Domestic projects : >50
- ◆ Publications : >600
- ◆ Patents : >20
- ◆ Professional software : >20
- ◆ Invited presentations : >20
- ◆ The first prize of province-level science and technology awards : 3





Better Nuclear Energy Technology, Better Life.



**发展先进核能科技
让人类生活更美好**



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The End

Thanks for your attention !

FDS Website: www.fds.org.cn