The Researches of ADS and the Sustainable Development of the Nuclear Energy

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Introduction:

Prediction for future Energy Requirement

Need for Energy Source in China
Will be 4 billion tons Standard Coal in 2050
Need for Electricity will be 1200 GWe, 20%NP
Nuclear Waste Accumulated up to 2050 in China

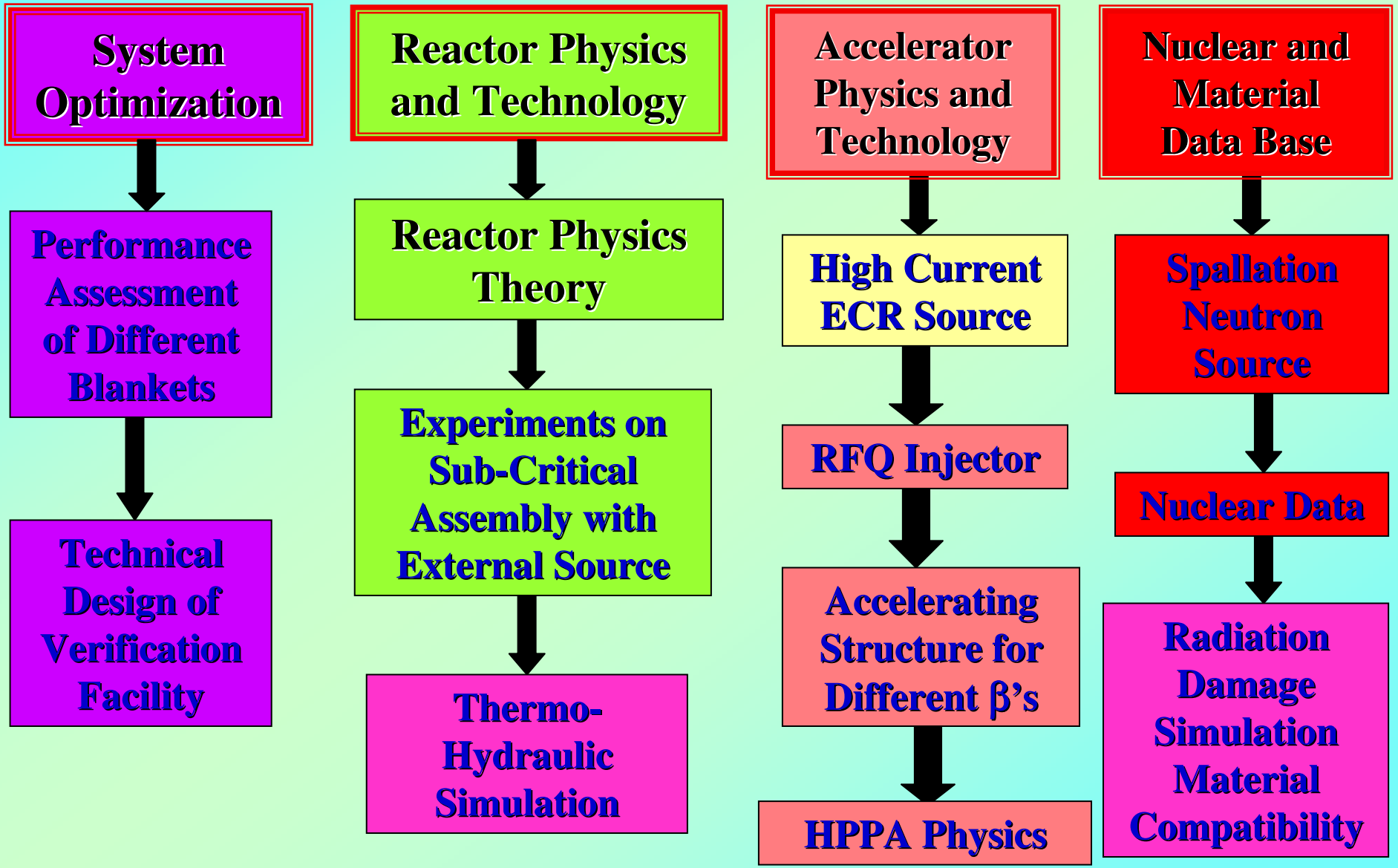
Year	2000	2010	2020	2050
Capacity, GW	6	20	40	(240)
Spent fuel, t			7200	[>50000]
MA, t			4	[>30]
LLFP, t			17	[>120]

Introduction:
ADS- A Good Candidate

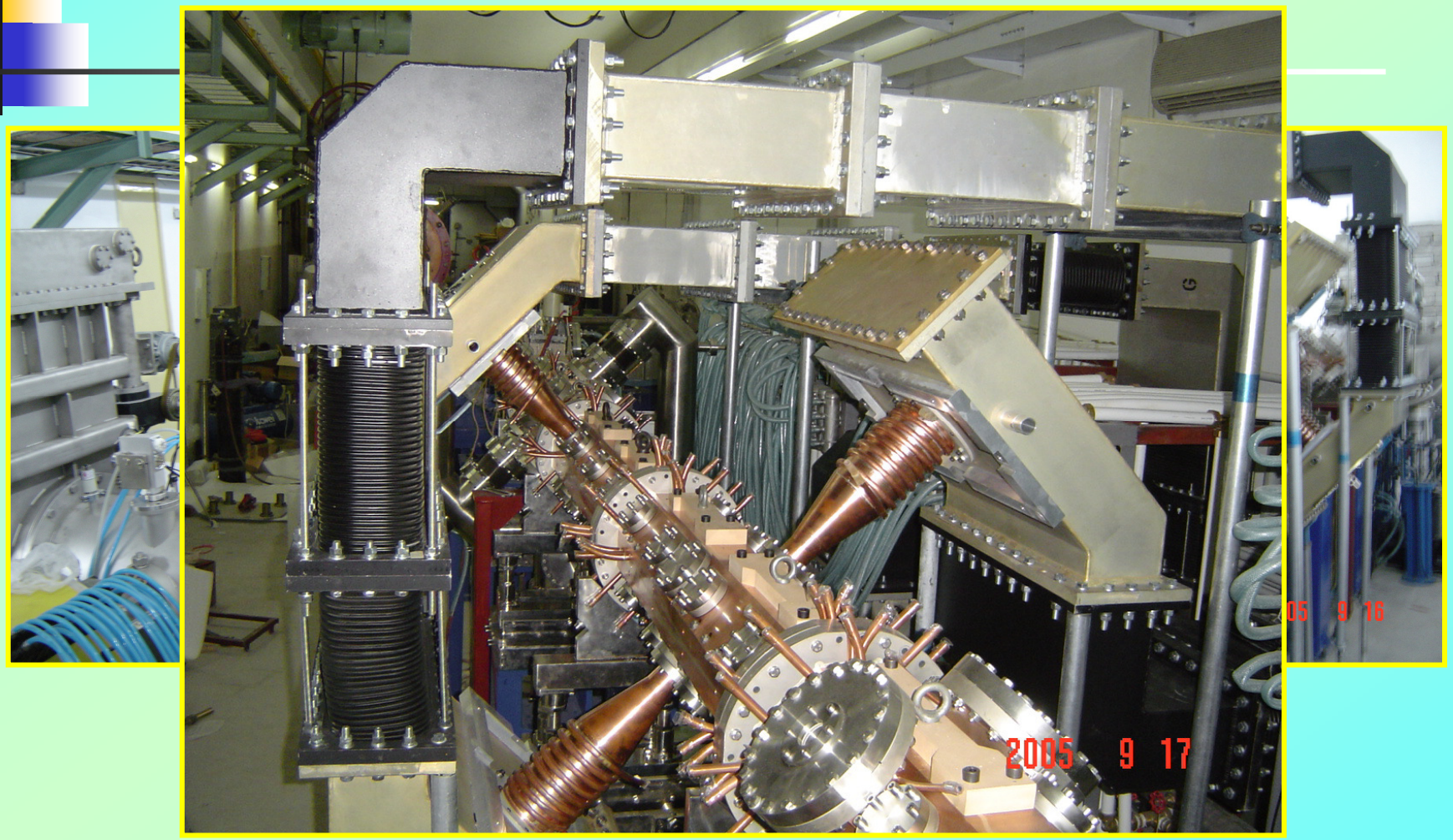
- **The conceptual study of ADS had lasted for about five years and ended in 1999 in China**
- **From 2000 a five years R&D program has been launched supported under National Basic Research Program, 973**
- ***After 5 years hard work,China ADS Project passed the national review successfully at the end of October, 2005.***
- ***In January,2009, ADS won 2nd class National Science and Technology Progress Prize***

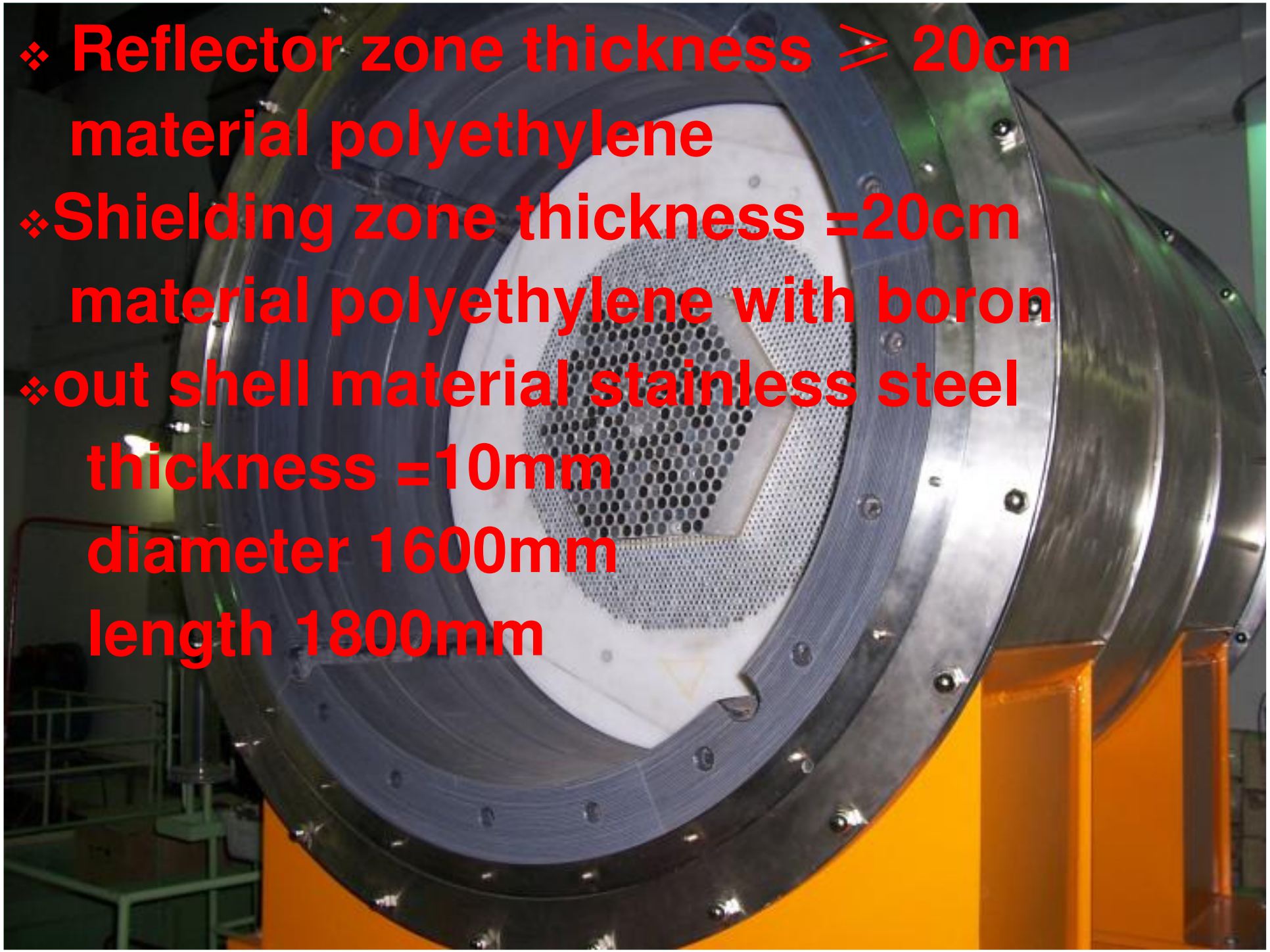
China ADS Study in Phase 1

ADS Work Packages

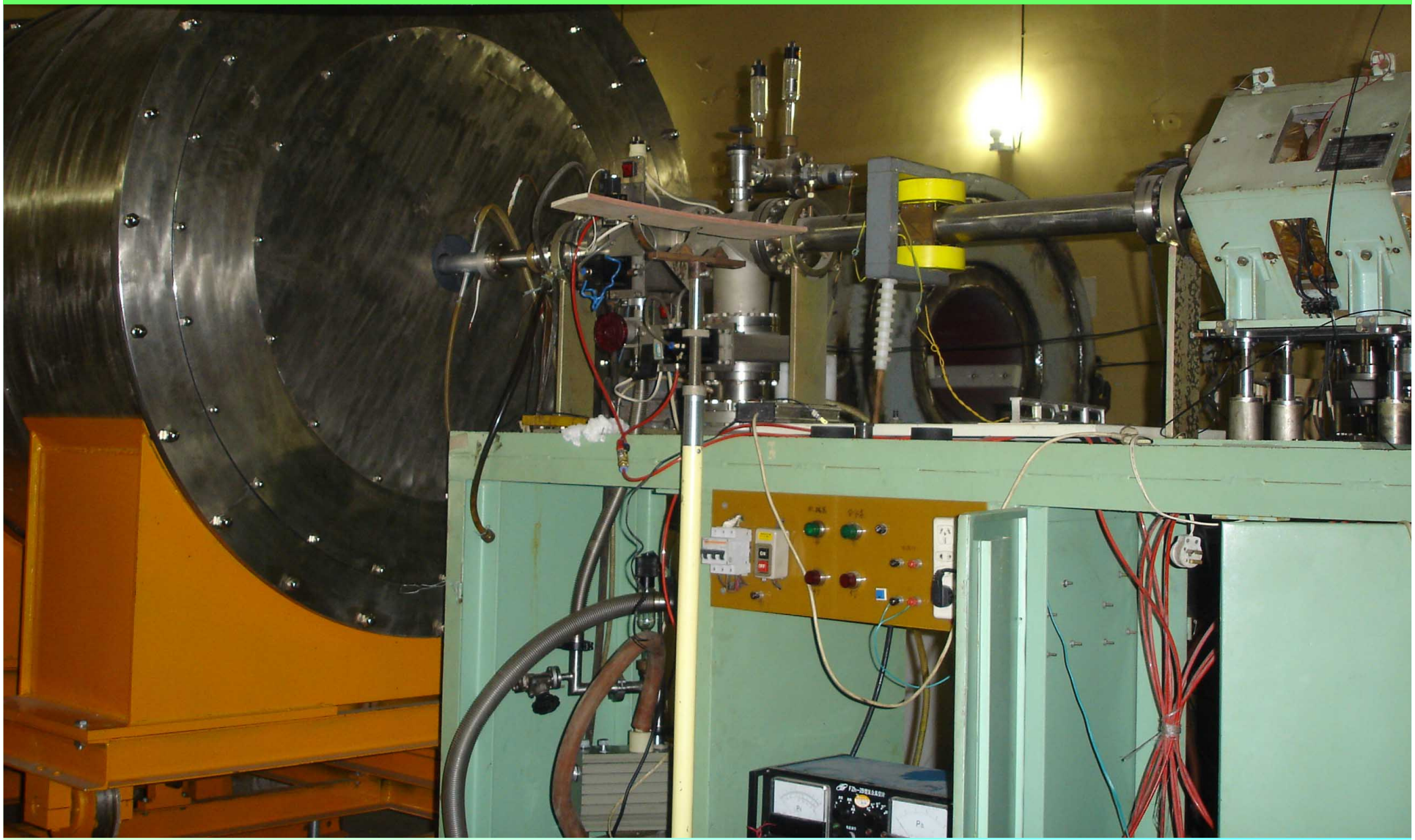


RFQ

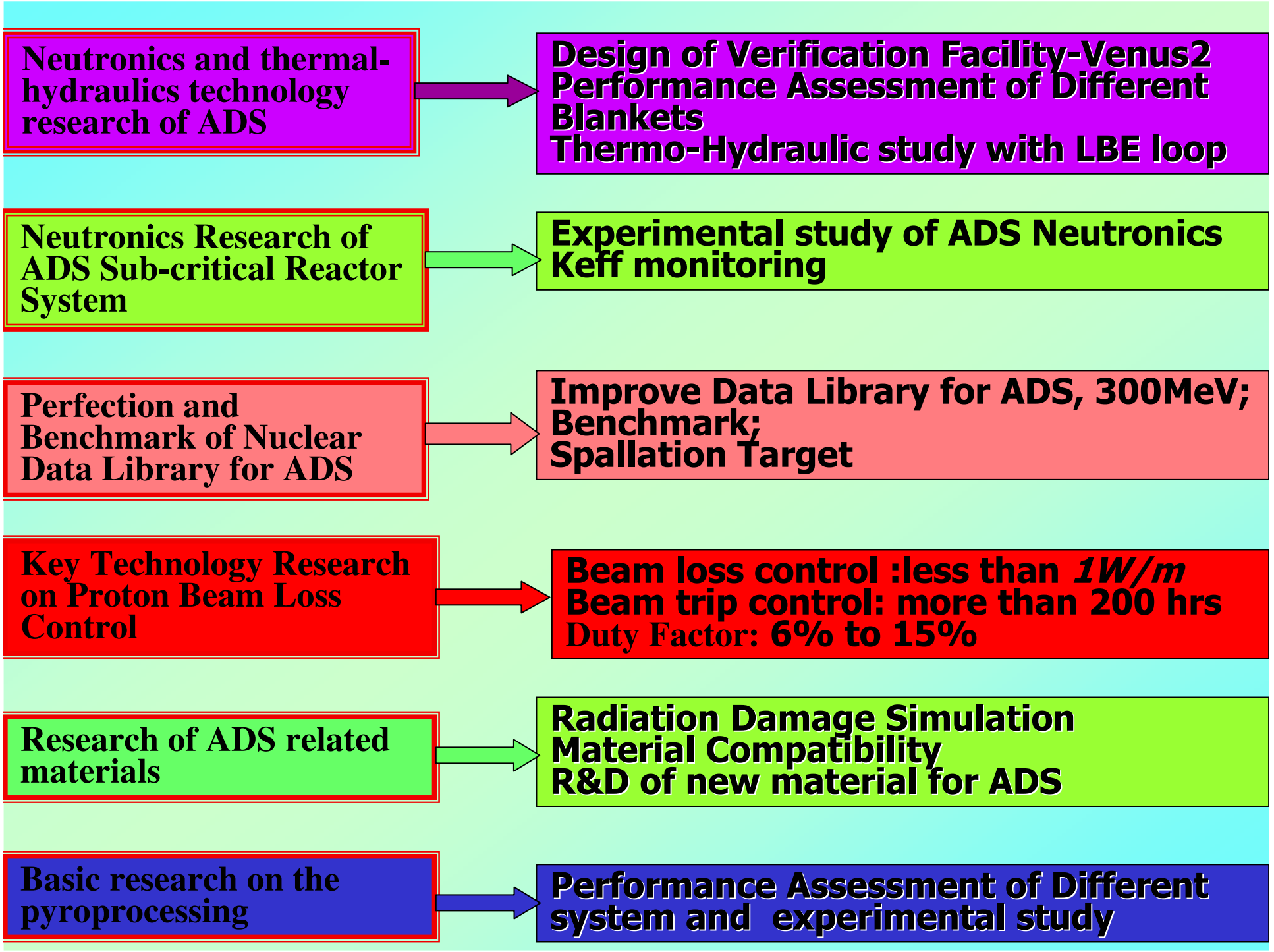



❖ Reflector zone thickness ≥ 20cm
material polyethylene
❖Shielding zone thickness =20cm
material polyethylene with boron
❖out shell material stainless steel
thickness =10mm
diameter 1600mm
length 1800mm

The Venus 1 coupled with 300 kV pulsed neutron generator

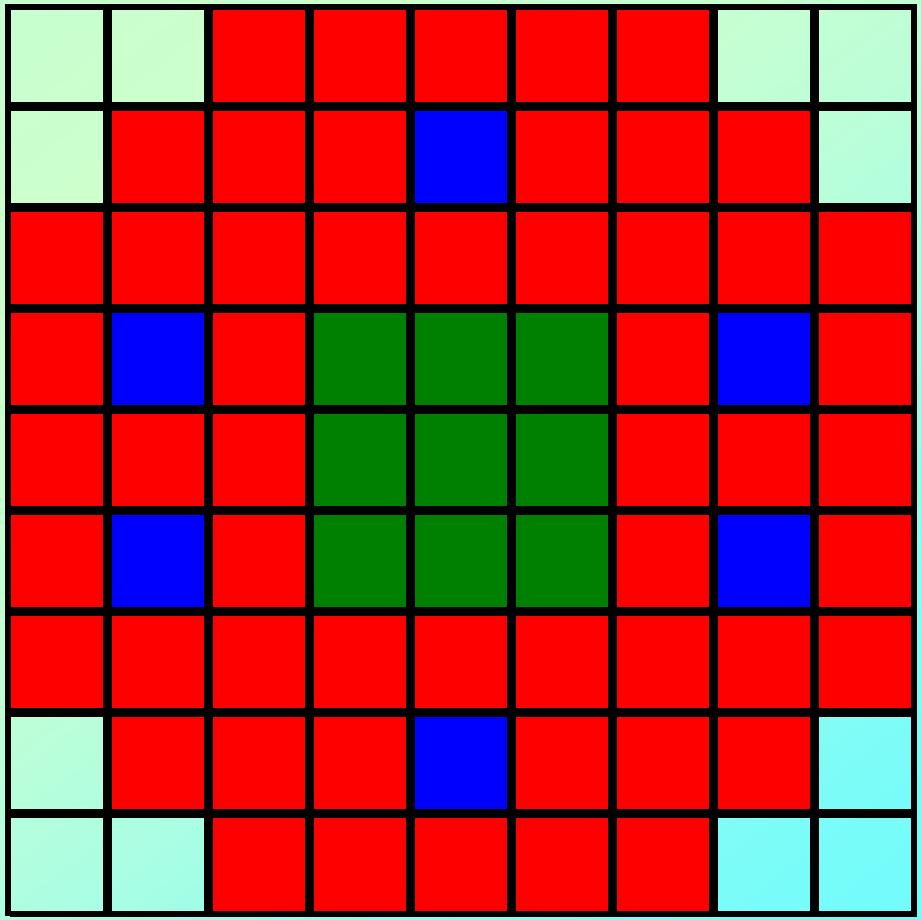


China ADS Study in Phase 2


Neutronics and thermal-hydraulics technology research of ADS
Design of Verification Facility-Venus2
Performance Assessment of Different Blankets
Thermo-Hydraulic study with LBE loop
Neutronics Research of ADS Sub-critical Reactor System
Experimental study of ADS Neutronics
Keff monitoring
Perfection and Benchmark of Nuclear Data Library for ADS
Improve Data Library for ADS, 300MeV;
Benchmark;
Spallation Target
Key Technology Research on Proton Beam Loss Control
Beam loss control :less than 1W/m
Beam trip control: more than 200 hrs
Duty Factor: 6% to 15%
Research of ADS related materials
Radiation Damage Simulation
Material Compatibility
R&D of new material for ADS
Basic research on the pyroprocessing
Performance Assessment of Different system and experimental study

Neutronics and thermal-hydraulics technology research of ADS –Venus 2

Fuel	**Spent fuel of CARR, U3Si2-Al , 149.3kg**
Keff	**0.982**
Spallation Target	**Solid W**
Energy of Proton Beam	**100MeV**
Yield of spallation neutron	**0.3 n/p**
Beam Intensity	**0.3 mA**
Beam Power	**30 kW**
Thermal Power of the Core	**200kW**



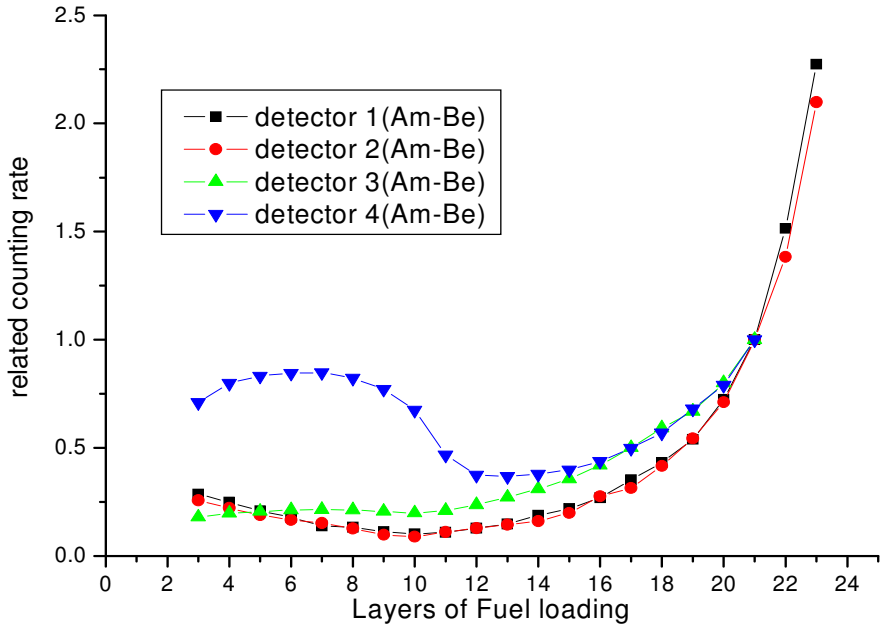
Primary Parameters for Our LBE loop

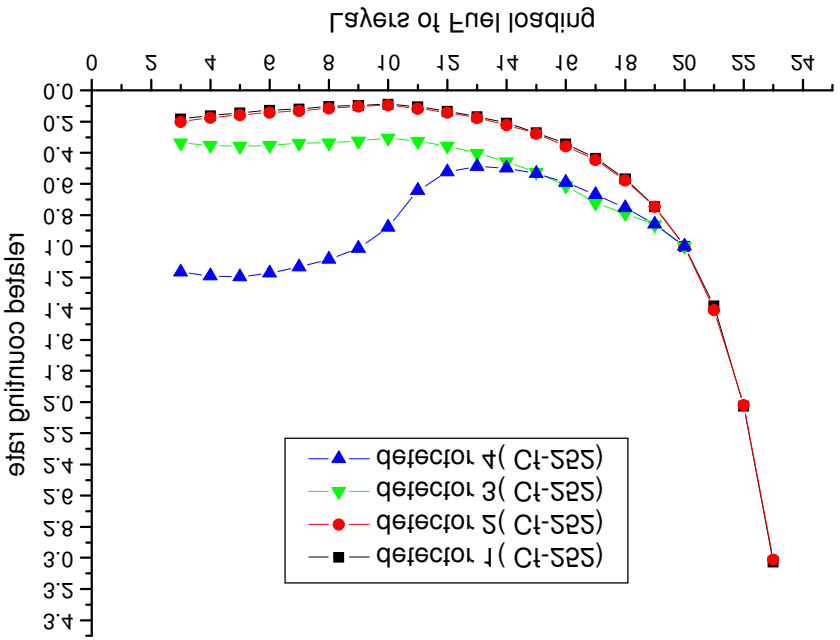
•Highest Temperature	550 ℃
•Maximum Flux	6 m^3/h,（velocity 3 m/s）
•Pressure	0.3 MPa
•Oxygen Control	Ar＋5%H_2/H_2O
•LBE capacity	100～150 l
•Height of Loop	5 m
•Experimental Segment	2
•Height of Segment	1.5～2 m
•Velocity of Flux	1 m/s
•Temperature Difference	100 ℃

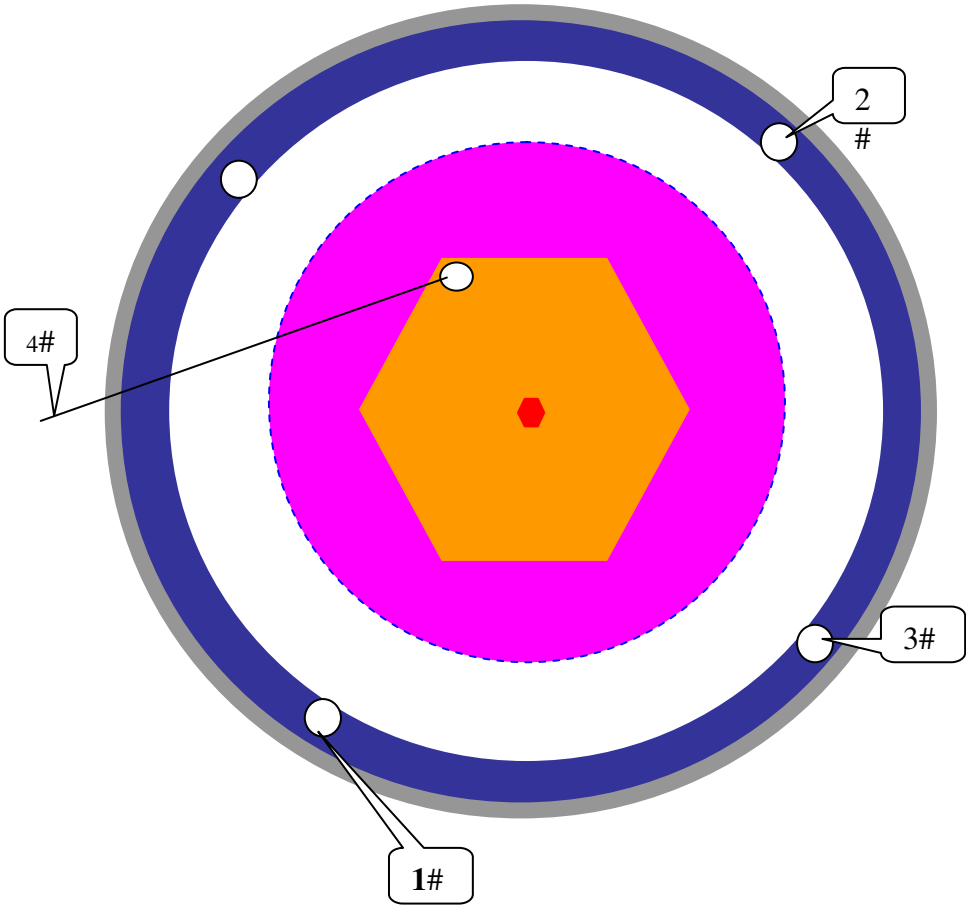
Neutronics Research of ADS Sub-critical Reactor System

- Analysis Primary experimental Results
- More measurements

Primary Results





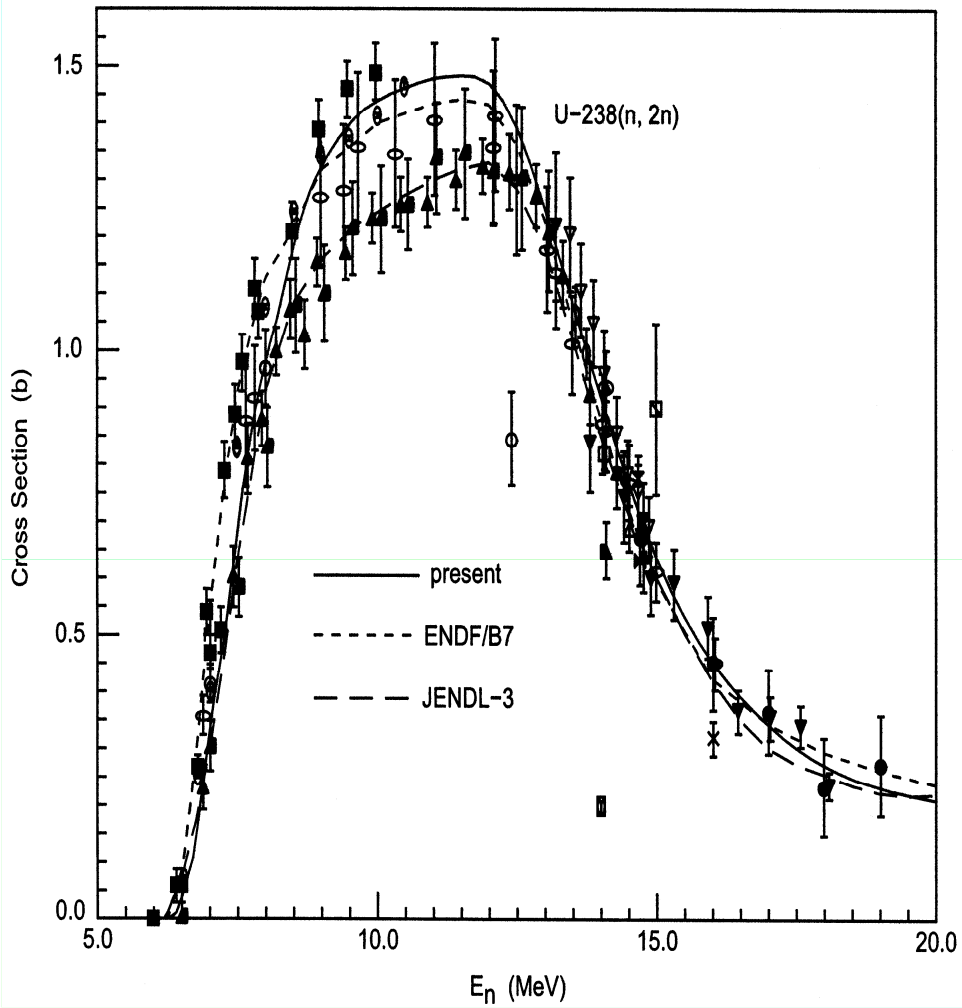


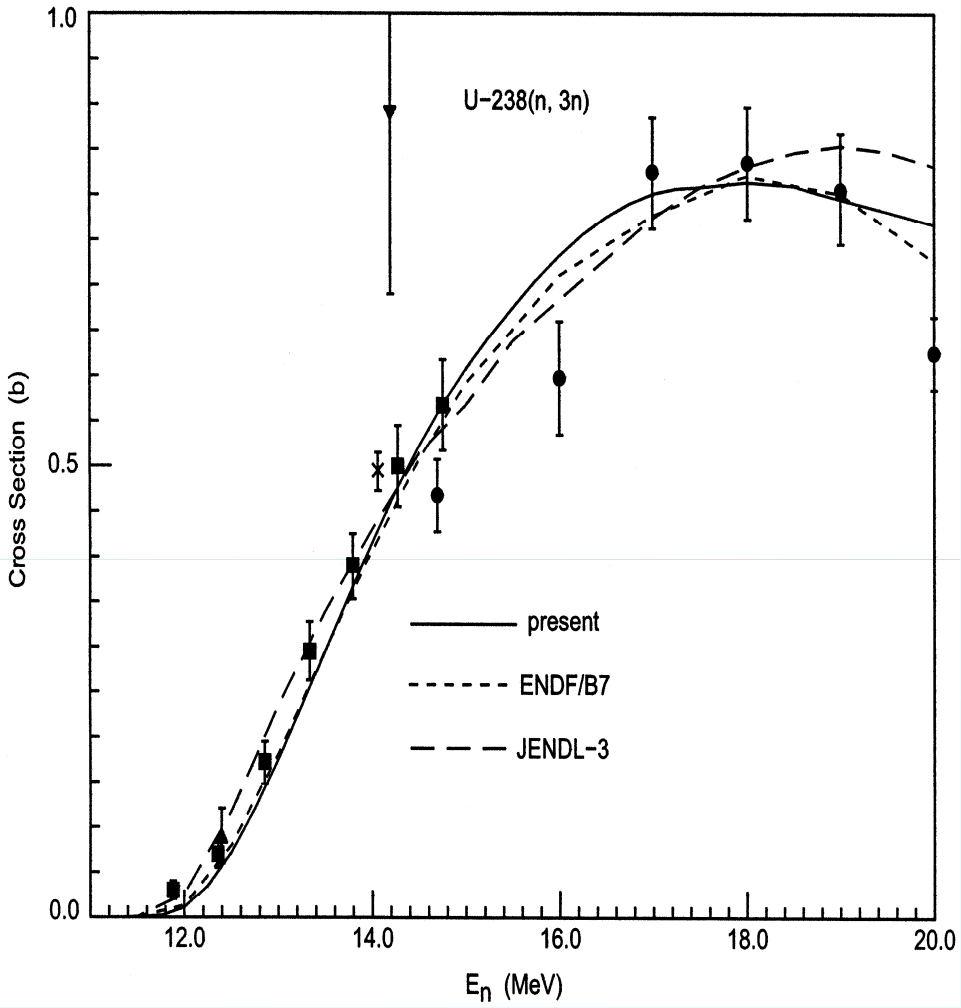
Perfection and Benchmark of Nuclear Data Library for ADS

Neutron induced reaction data for ^{28,29,30}Si, Cr, Fe, Ni, Cu, ^{93}Nb, ^{97}Mo, ^{129}I, ^{125}Sb, W , ^{209}Bi, Pb, Th, U, Pu etc.

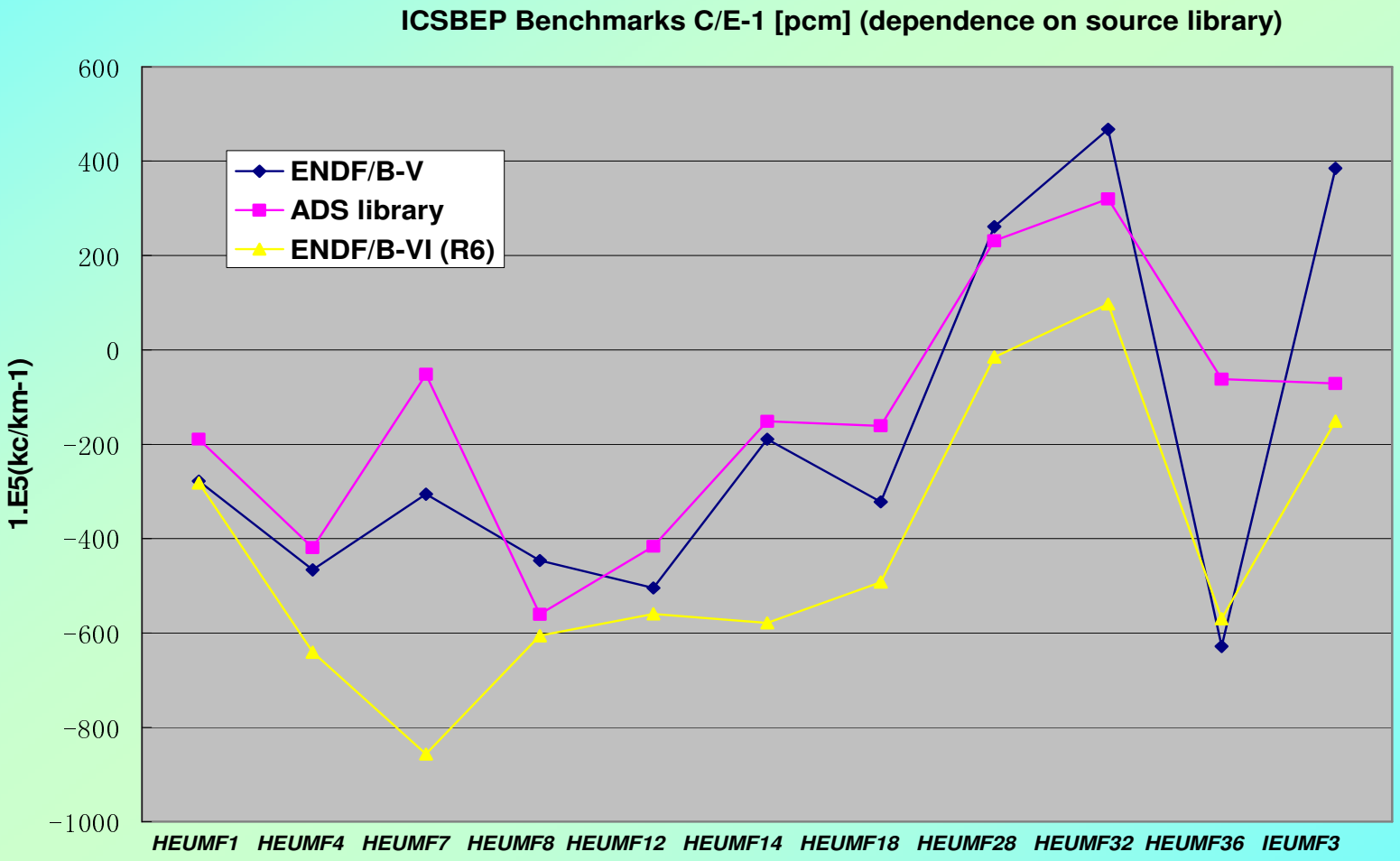
Proton induced reaction data for ^{27}Al, ^{30}Si, ^{54,65} Fe, ^{181}Ta, Hg, ^{208} Pb, ^{209} Bi etc.

The (n, 2n) and (n, 3n) cross sections for n+^{238}U reaction





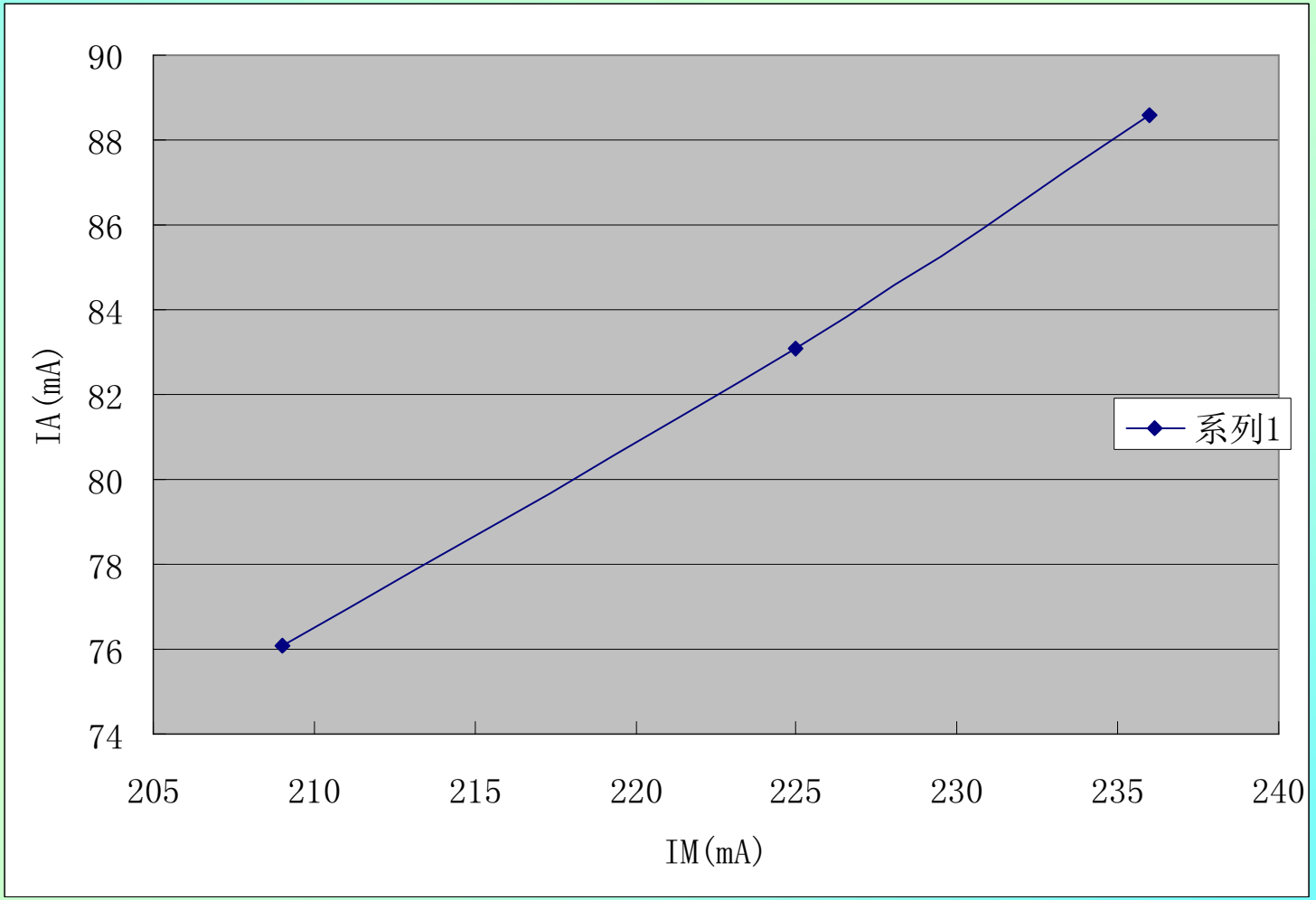
Results of calculations for the uranium critical benchmarks with different libraries



Key Technology Research on Proton Beam Loss Control

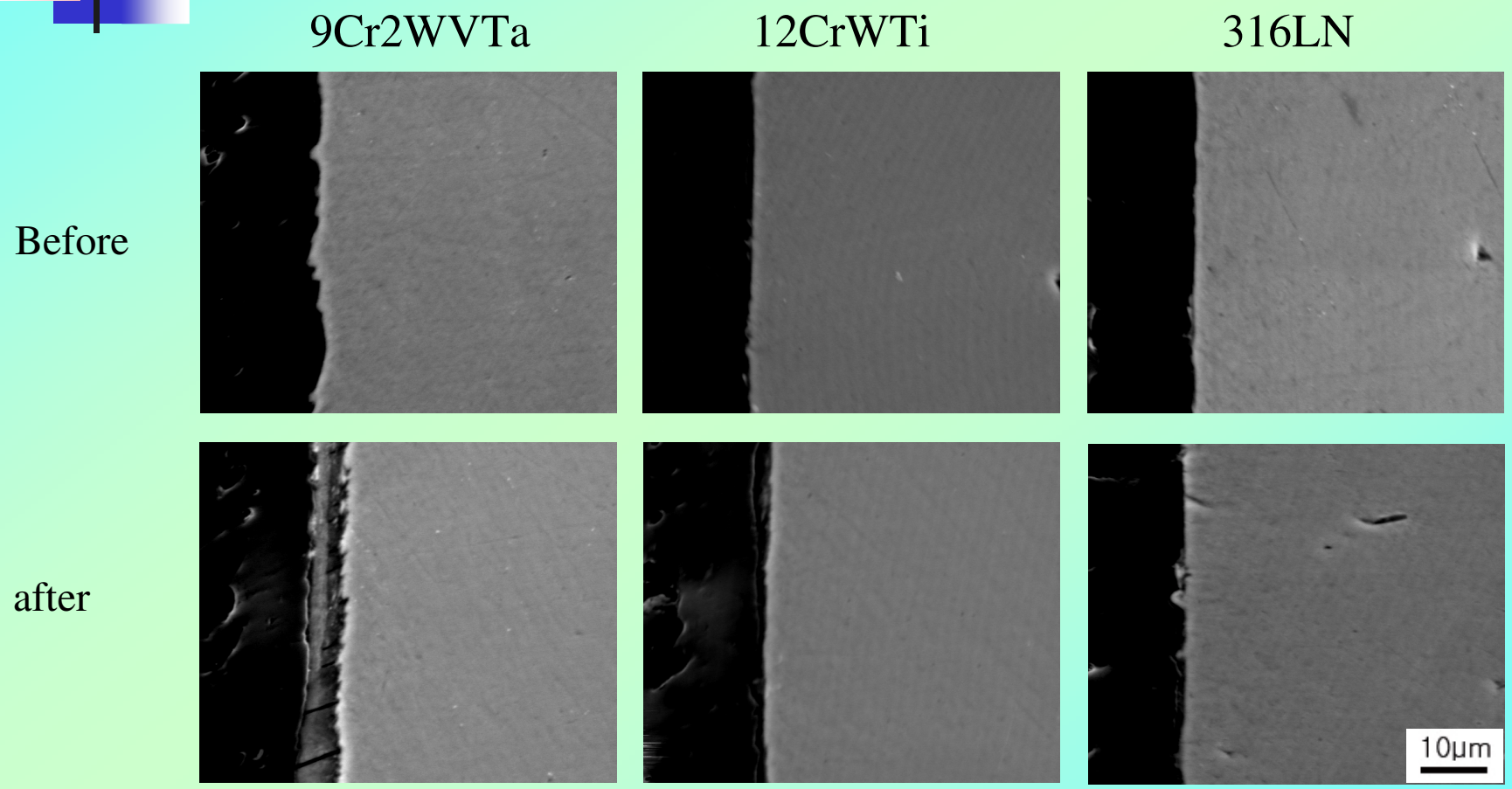
- Improvement of cooling system etc.
- Duty Factor: From 7% to 13.2%.
- Hydrogen beam extracted from the ECR source: From 65 mA to 89mA.

Key Technology Research on Proton Beam Loss Control- ECR source



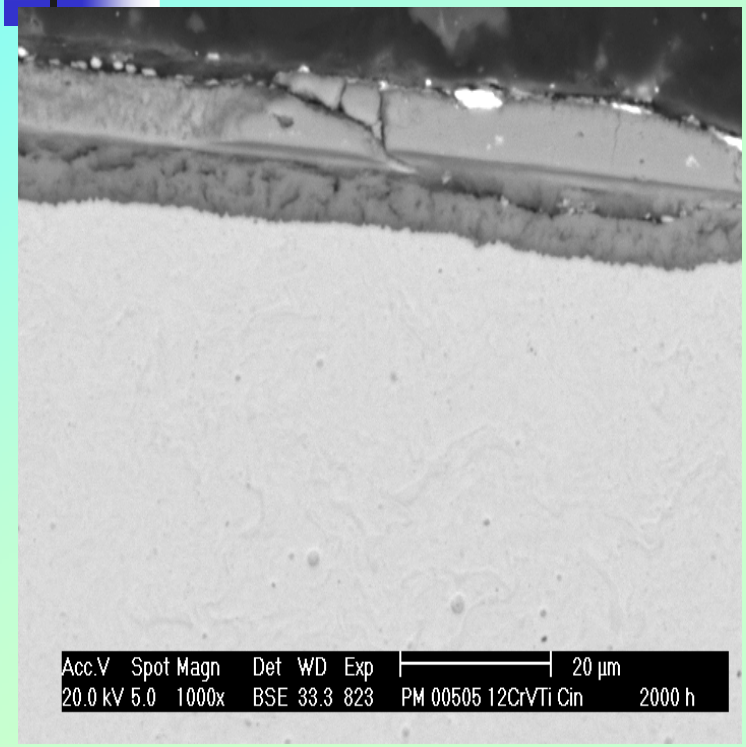
Research of ADS related materials

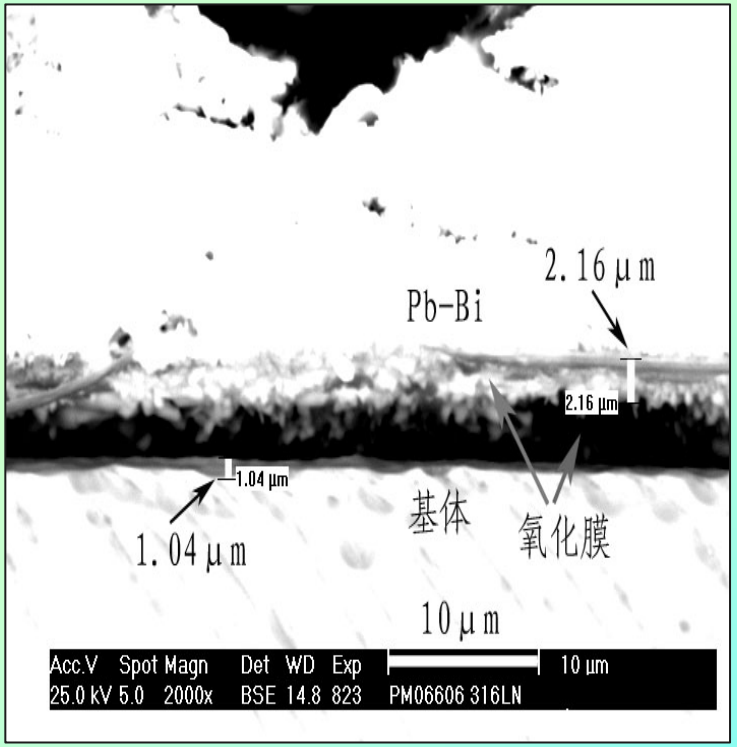
SCK：9Cr2WVTa,316LN and 12CrWTi in Pb-Bi pool



450°C, Pb-Bi, 3000h, Oxygen 5×10^{-7} （wt%）

Brasimone：12CrWTi in Pb loop
316LN in Pb-Bi loop



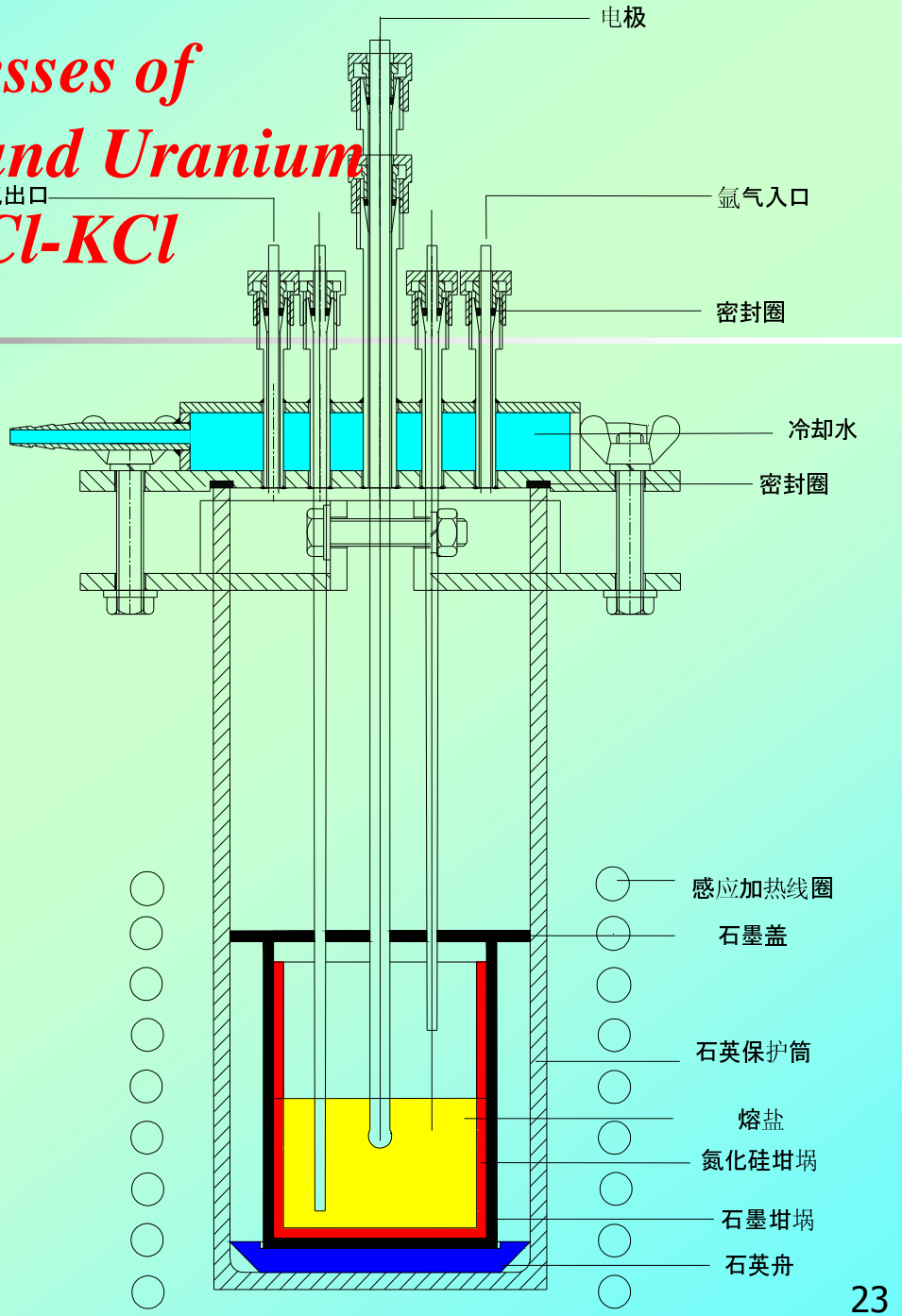


CHEOPE-III loop, T= 500° C, Oxygen 10^{-6} wt%, Pb velocity 1m/sec

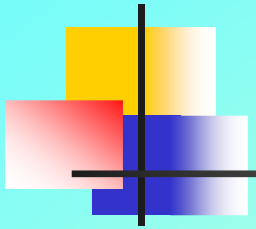
LECOR Pb-Bi loop, T= 450° C, Oxygen 7.3×10^{-8} wt%, Pb-Bi velocity 1m/sec

Electrochemical processes of Lanthanum chloride and Uranium chloride in Molten LiCl-KCl

A three-electrode measure system has been set up. The molten salt electrolytic cell is made up of a quartz chamber and a water-cooled lid sealed by flange structure.



Electrochemical processes of Lanthanum chloride and Uranium chloride in Molten LiCl-KCl

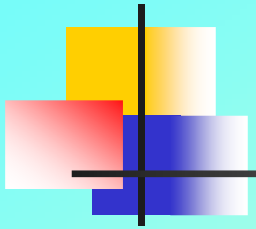


- **The electrochemical redox process of La(Ⅲ) in the molten LiCl-KCl eutectic in the temperature range 683-773K on molybdenum electrode was studied by cyclic voltammetry and chronopotentiometry. The reduction of La(Ⅲ) in the LiCl-KCl mixture occurs in a single step with an exchange of three electrons, the reversibility of this process was studied. LnDLa(Ⅲ)=7.742-1.441×10^4/T andwere obtained.**
- **The reduction of U(Ⅲ) occurs in a single step with an exchange of three electrons. It was determined that at a sweep rate of ≤0.2Vs^{-1},the electro reduction of U(Ⅲ)to U was reversible, but at >0.2Vs^{-1},mixed diffusion and electron-transfer control was observed. The formal potential of U(Ⅲ)/U was determined and the reduction process of U(Ⅳ)to U(Ⅲ) was also studied.**

Electrochemical processes of Lanthanum chloride and Uranium chloride in Molten LiCl-KCl

The dentritic uranium deposits were prepared by electrolysis in the molten LiCl-KCl eutectic, and the morphology of the deposits and cross-section of the 304 stainless steel cathode were investigated using SEM.

阴极沉积物照片



Consideration in near future

Consideration in near future

A moderate style multi-purpose verification system is under consideration. In the conceptual study, we consider:

- **Low energy accelerator**
- **MW swimming pool light water sub-critical reactor**

Development step

- **Develop ADS step by step**
- **Depend on budget**
- **Cooperation with other project**

  CSNS, BRIF…

Step by Step

1st，R&D of key technology：

ECR ion source、RFQ、

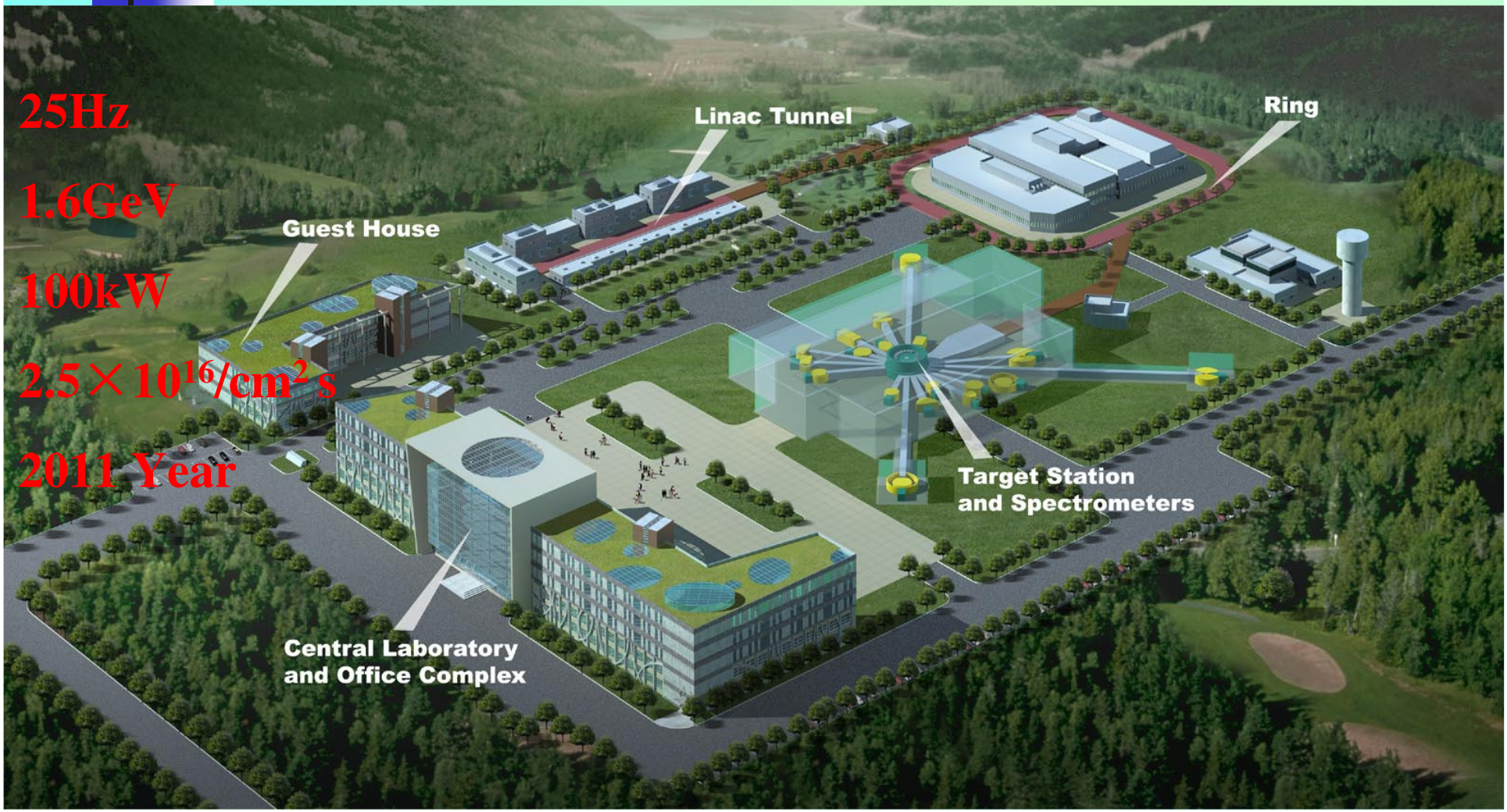
Super conducting cavity etc

2nd，Integral Test：150MeV, 50mA, 6%

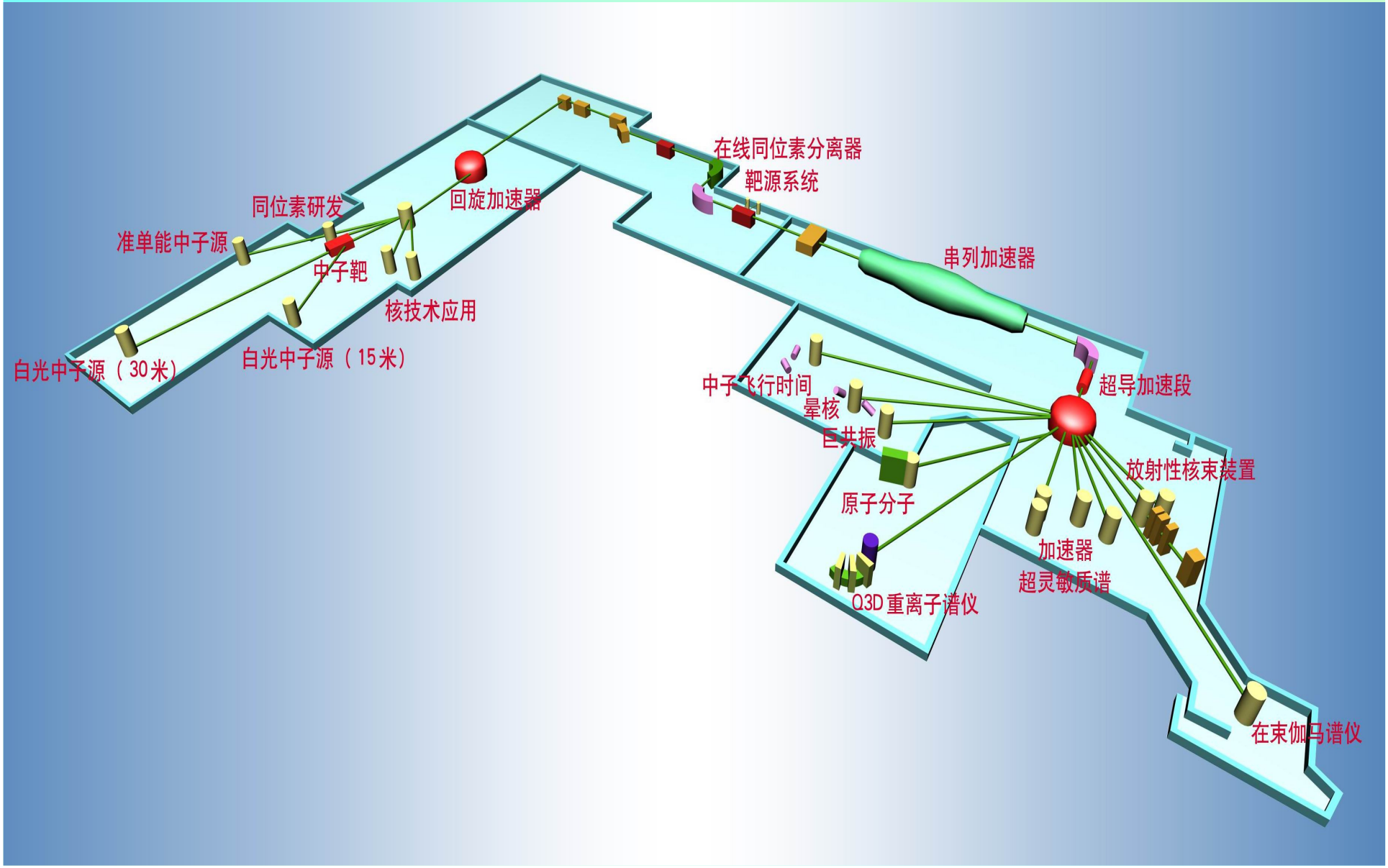
3rd，CW，300MeV，Sub-critical reactor。

4th，1GeV，ADS Demo

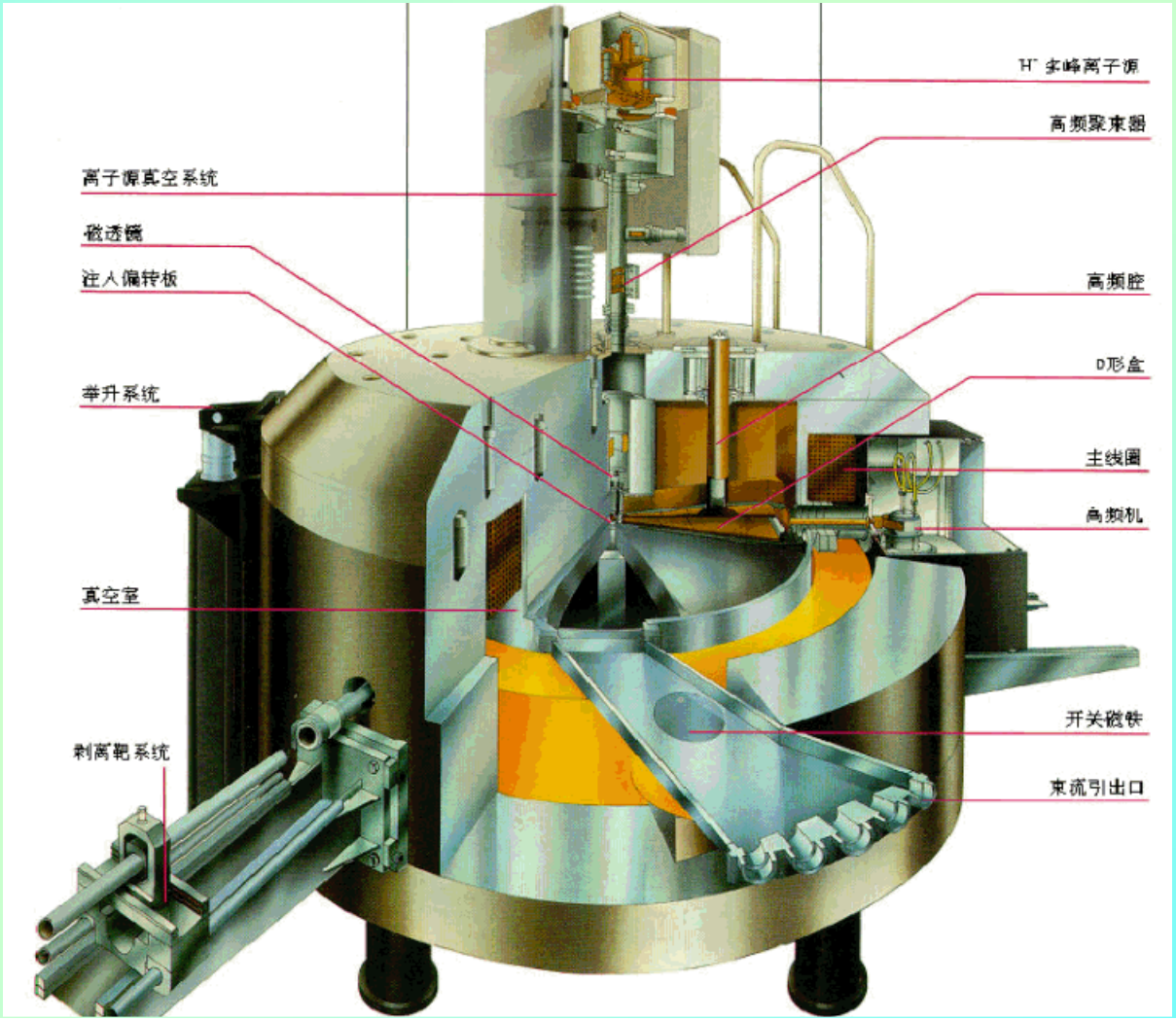
Artist View of the CSNS



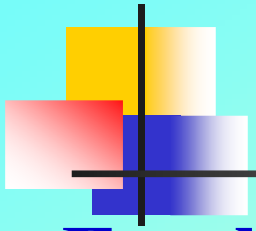
Tandem Upgrading Project
Beijing Radioactive beam Facility (BRIF)



100 MeV Cyclotron



SUMMARY



For long term and sustainable nuclear energy development, ADS is an option in fuel circulation. ADS has been started to develop with a rather moderate project in China and is still in the early stage. Different options have been taken into account to develop ADS in China. ADS should be developed step by step without stop.

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Thank you!