A Green CEPC using the power of nuclear waste

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CEPC and IHEP

- CEPC: the development in energy frontier of particle physics.
  - The next step for BEPC and BEPCII.
  - Research on the Higgs particle of standard model.
- CEPC: will be a huge machine that ever built in china in fundamental research
  - Non profit
  - High construction cost(much more than BEPC)
  - High operation cost
  - Huge energy consuming (several hundreds MW)

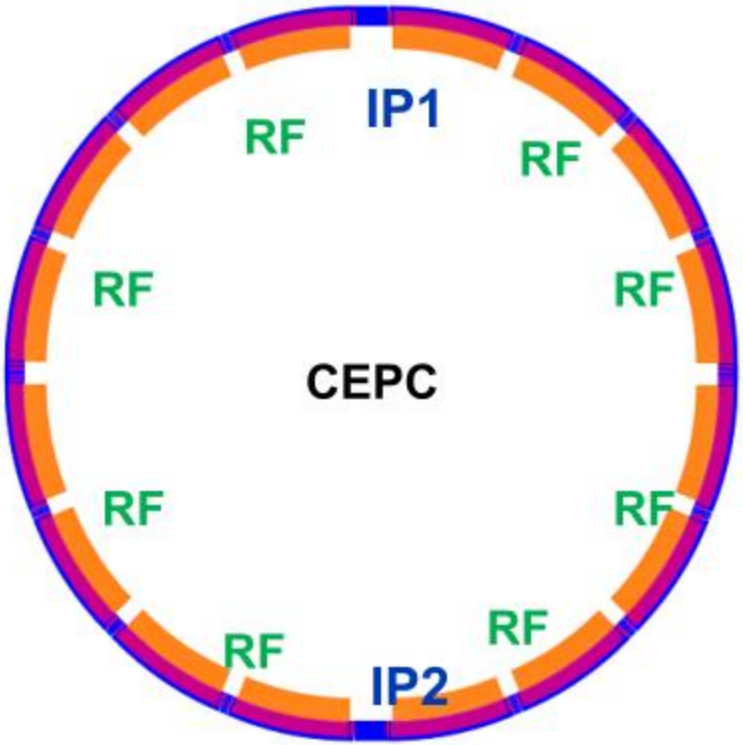
Main parameters of CEPC ring

Parameter	Unit	Value	Parameter	Unit	Value
Energy	GeV	120	Circumference	km	53.6
Number of IP		2	SR loss	(GeV/turn)	3.01
N_e/bunch	1E11	3.71	N_b/beam		50
Beam current	mA	16.6	SR power/beam	MW	50
Partition Je		2	Long. damp. time	ms	6.7
Dipole field	Tesla	0.0658	Bending radius	km	6.094
Emittance (x/y)	nm	6.8/0.0204	β_{IP} (x/y)	mm	800/1.2
Trans. size (x/y)	μm	73.70/0.16	Mom. compaction	1E-4	0.415
$\xi_{x,y}$ /IP		0.104/0.074	Bunch length	mm	2.26
RF voltage V_{rf}	GV	6.87	RF frequency f_{rf}	GHz	0.7
Long. Tune v_s		0.206	Harmonic number		125208
Hourglass factor		0.687	Energy acceptance	%	2
Lifetime (simu.)	hr	1.5	L/IP (10^{34})	$cm^{-2}s^{-1}$	1.82

Accelerator studies in China, Qing Qin

Critical Parameters

- Circumference: 53.6 km
- SR power: 50 MW/beam
- 16 arcs
- 2 IPs
- 8 RF cavity sections (distributed)
- 6 straight sections (for injection and beam dump)
- Filling factor of the ring: ~80%



High power consuming

- Synchrotron radiation:
  - One beam 50MW, two beams 100MW
- Total: ~300MW
  - including power source, cryogenic system (LHe,LN_2) and so on.
- Compare with LHC and ILC
  - CERN at peak 180MW, ~140MW average (24/7), one year 1.2TWh, 50-60M€/year(40-50 €/MWh)
  - ILC: 300MW for 500GeV and 500MW for 1TeV, 160M€/year for 500GeV (135 €/MWh)

Energy problem in China

- China population is >1.3billion, average energy consumption per person is <1/2 of the world level, <1/10 of the developed country's level.
- Fast development of economy at annual rate of 7-10% has been kept for >20 years.
- China has been the 2nd largest energy producing and consumption country

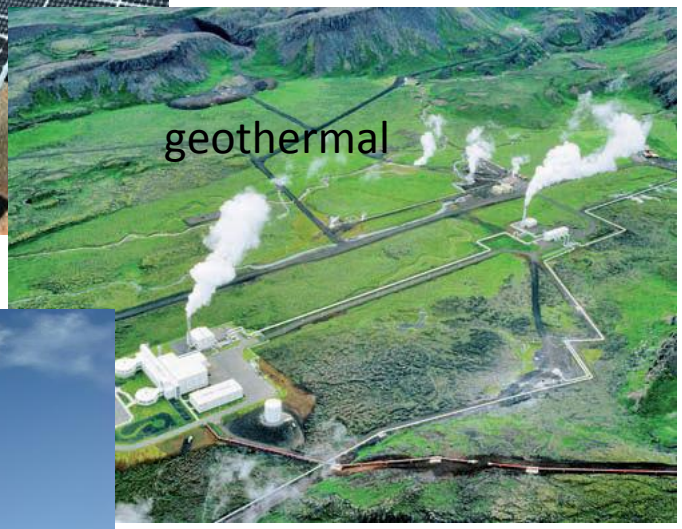
Energy problem in China

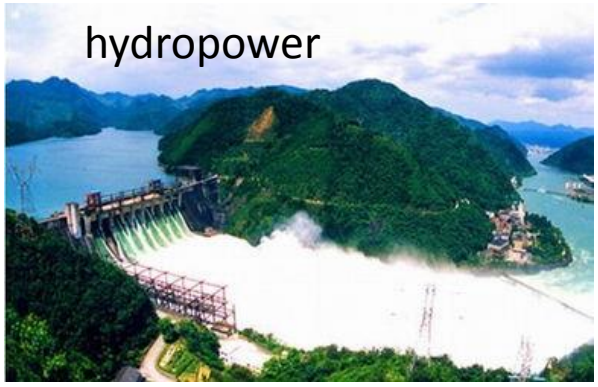
- Population will be 1.5 billion at 2050, conservatively predicted capacity of electricity will be 1200~1500GWe
- China will probably be the 1st largest CO_2 producer at 2025

Serious pollution &Energy shortage

Renewable/sustainable energy, Nuclear Energy

Renewable Energy in China





All kinds of electric capacity in China

- by the end of 2012, Installed power generation capacity 1144910MW, hydropower 248900MW, thermal power 819170MW(71.5%), nuclear power 12570MW, wind 60830MW, solar power3280MW.
- by the end of Aug. 2013,wind 68450MW,solar 8980MW, nuclear power 14780MW,biomass energy 8000MW. (8.5% of total)

来源：全国人大常委会执法检查组在关于检查 《中华人民共和国可再生能源法》实施情况报告

2015 forecast for renewable energy

- hydropower 2900000MW, wind 100000MW, nuclear 40000MW, solar 35000MW, biomass 13000MW.
- ~32% of the total electricity power

Investment on renewable energy in 2013

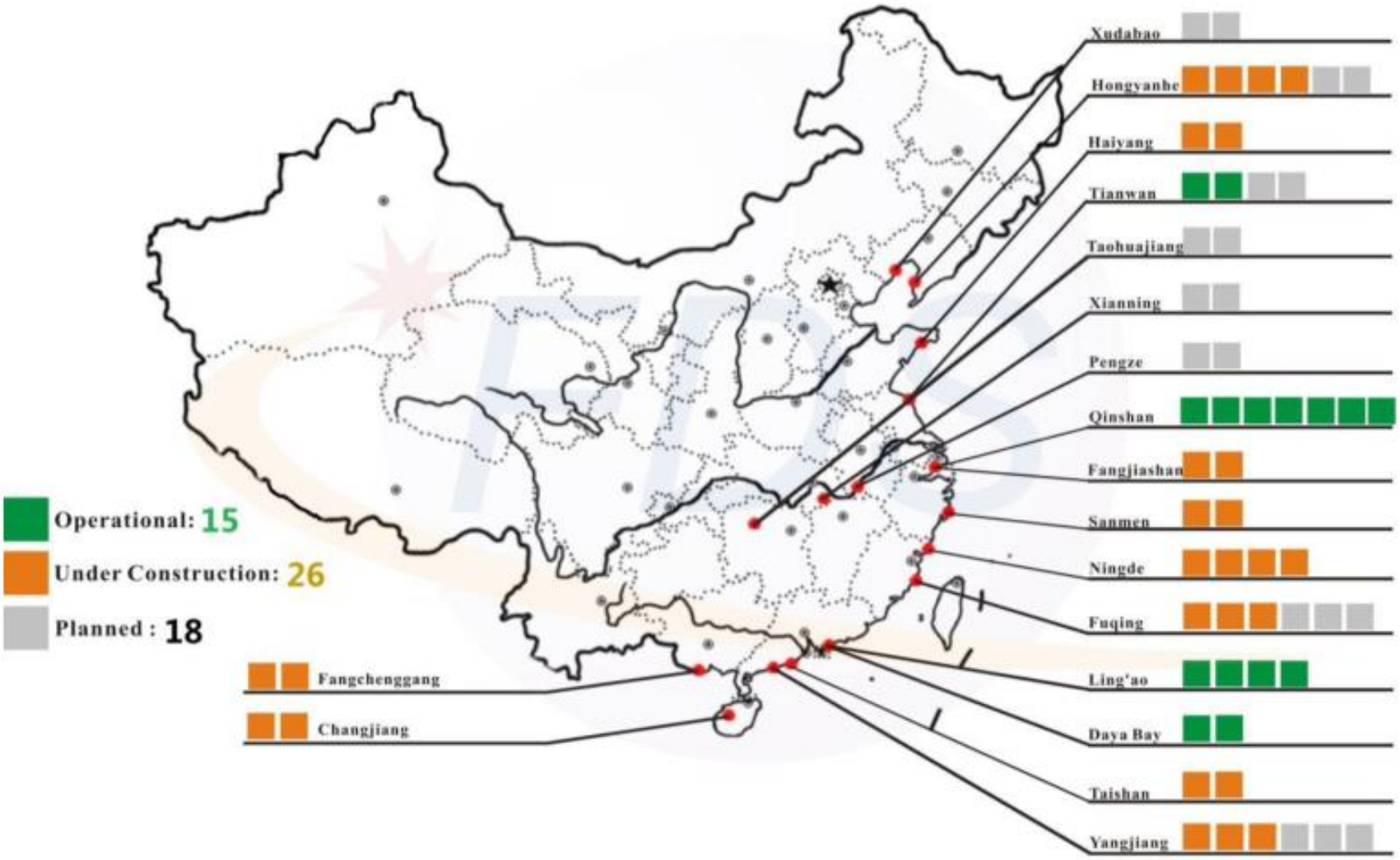
- China 56 billion U.S. dollar, for the first time more than Europe
- Europe 48 billion U.S. dollar
- USA 36 billion U.S. dollar
- India 6 billion U.S. dollar
- Brazil 3 billion U.S. dollar

Nuclear Power

- Electric energy production: 14780MW(2013.8)
- 1.23% of total electric energy production (~1200000MW)

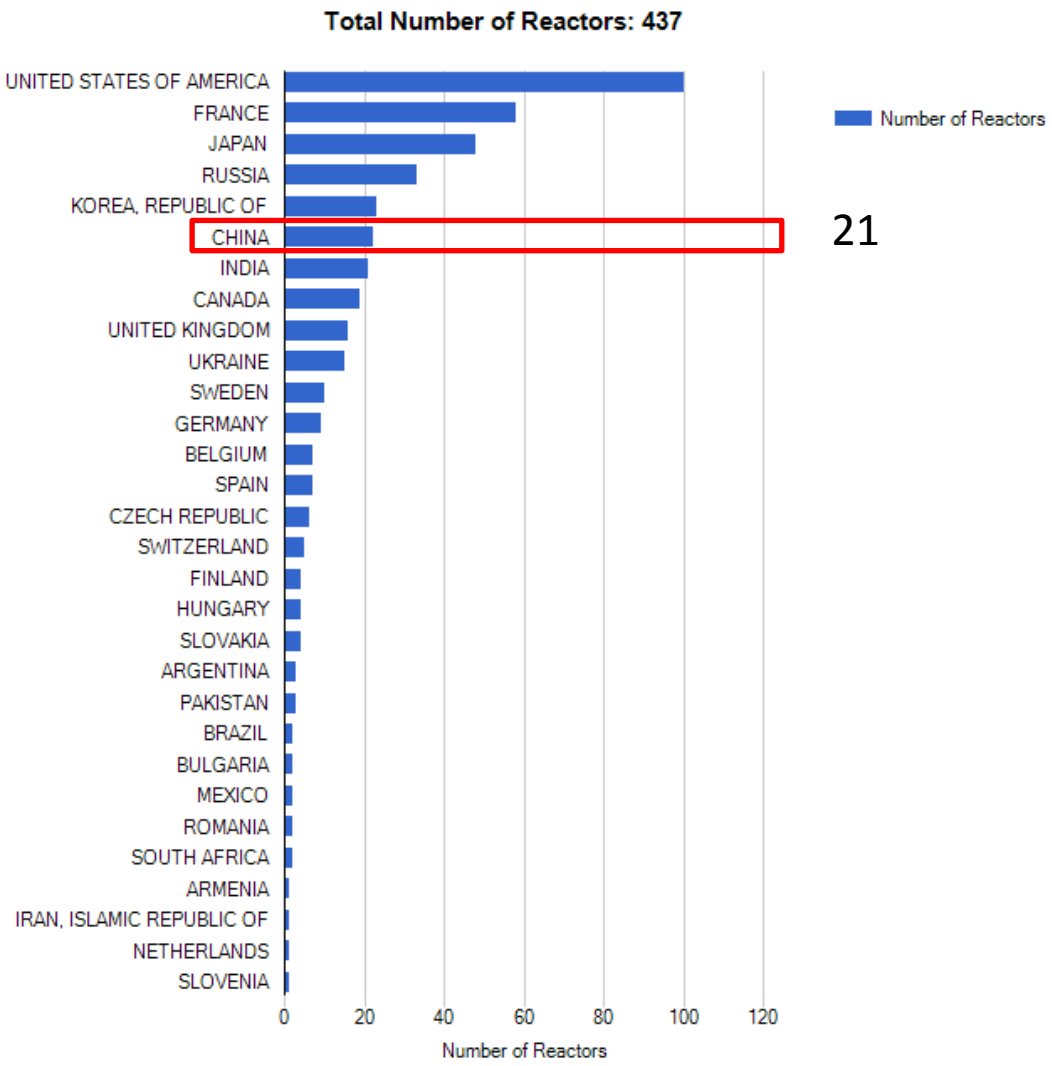
China's Nuclear Power Reactors

Before Fukushima Daiichi Accident



Yican Wu, ICENES talk

Number of reactors in operation



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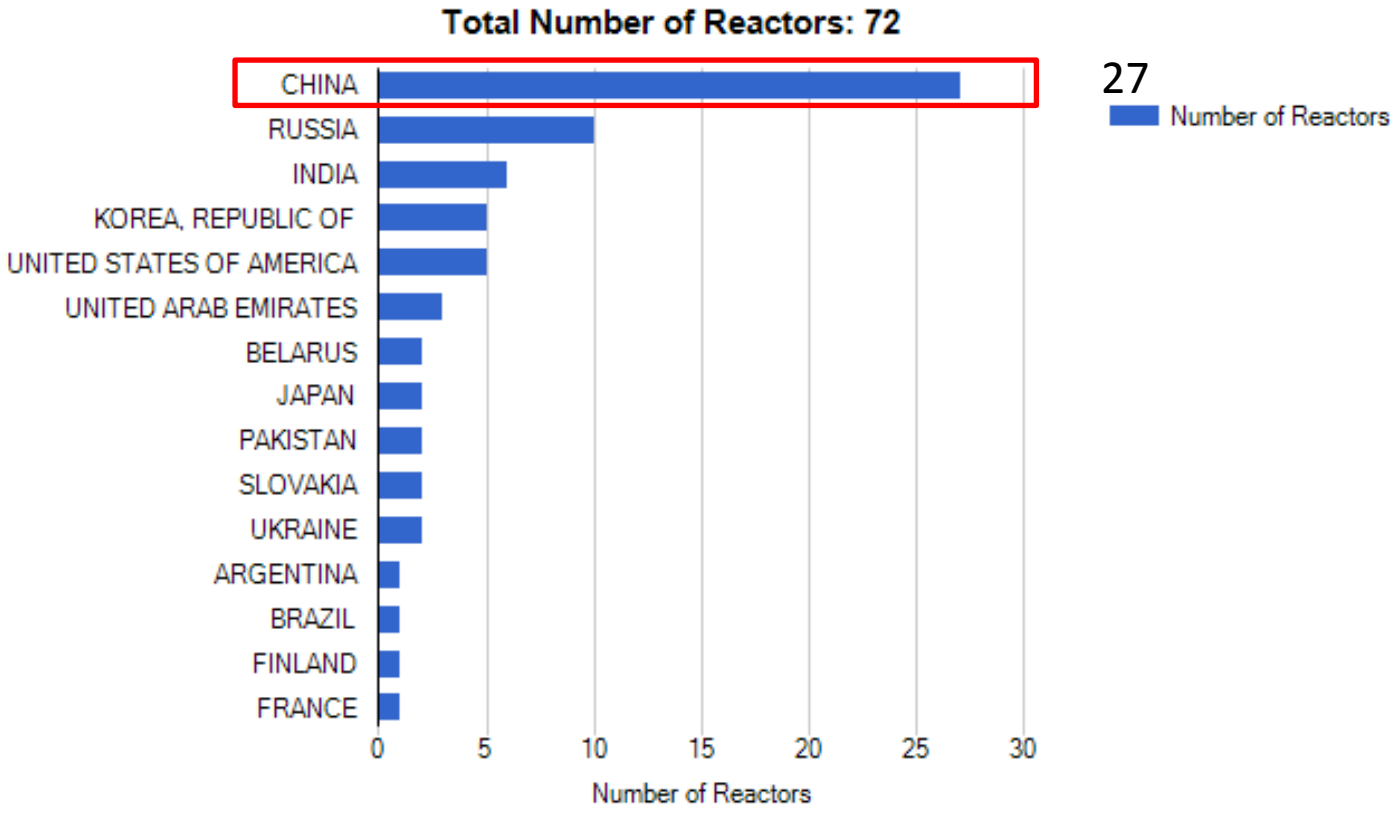
Data from IAEA/PRIS

Number of reactors under construction



Data from IAEA/PRIS

Current Plan on Fission

- 2020: 58GW (in operation, 4% of total electricity capacity)+30GWe (under construction, ~2%)

  ~7 new units to be constructed per year from now to 2020
- ~2050: 240GW

Yican Wu, ICENES talk

Nuclear waste

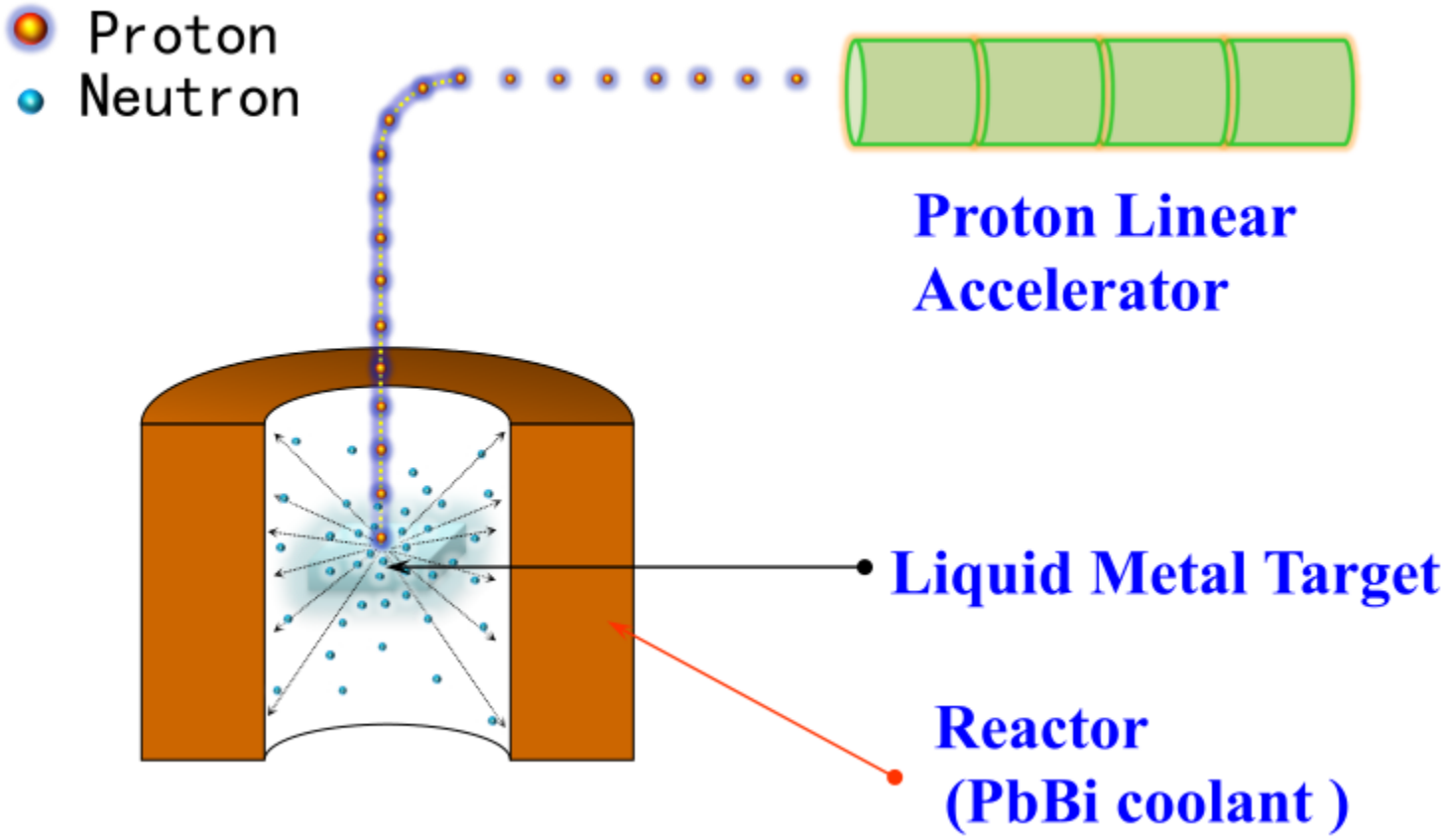
- 1000MW nuclear power plant:
  - 10s of tons nuclear waste per year
  - After processing, it becomes 4m^3 high radiation nuclear waste, 20m^3 medium radiation nuclear waste, 140m^3 low radiation nuclear waste, 200m^3 non-radiation nuclear waste.
- 150 tons of high radiation nuclear waste per year in China (2008 data)
  - 3200 tons per year in 2030

中国核废料处置库

ADS program

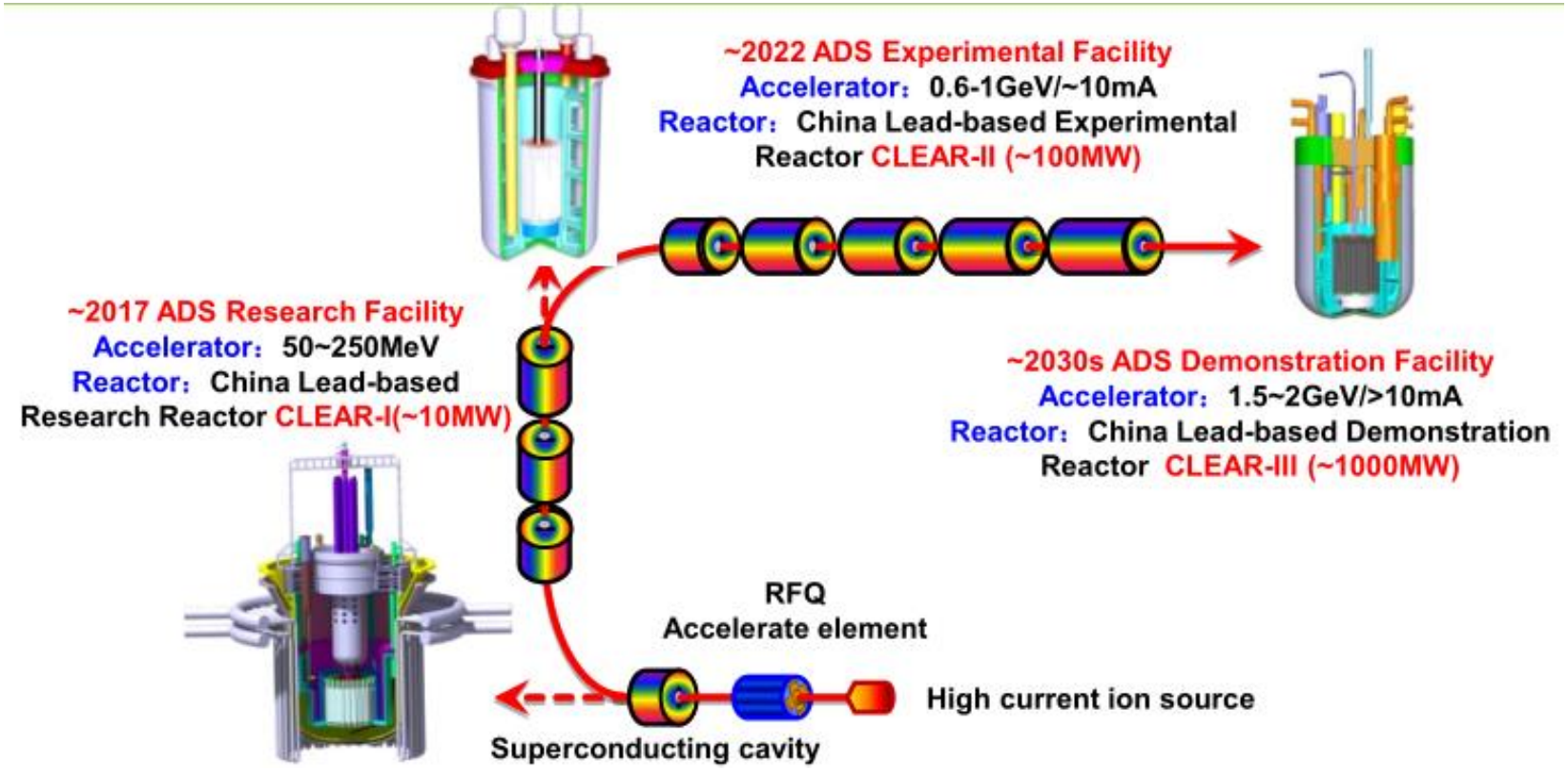
- Nuclear waste is a bottle neck for nuclear power development in China
- ADS has been recognized as a good option for nuclear waste transmutation.
- ADS has been supported by CAS as a long-term program.
- Many accelerator technologies have been developed by the ADS R&D, such as SC technology, RF power source, SC magnet…
- ADS can provide electric power to the society as a nuclear plant. The fuel can be nuclear waste or thorium (Th-232) since it is three times as abundant in the earth‘s crust as uranium.

Principle of ADS

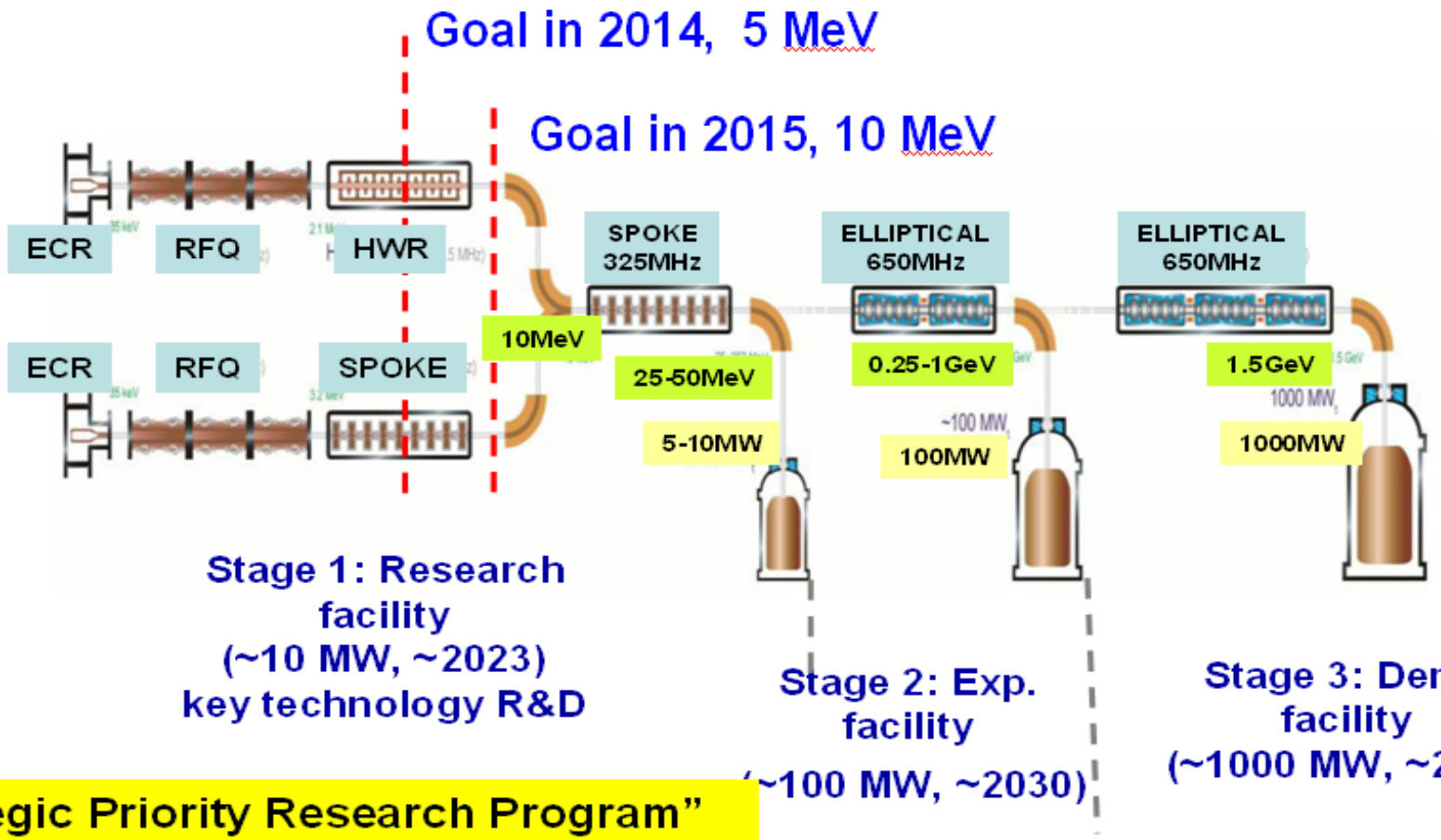


ADS program

- Launched in 2011 and plan to construct demonstration ADS transmutation system ~2030s through three stages



China-ADS Roadmap



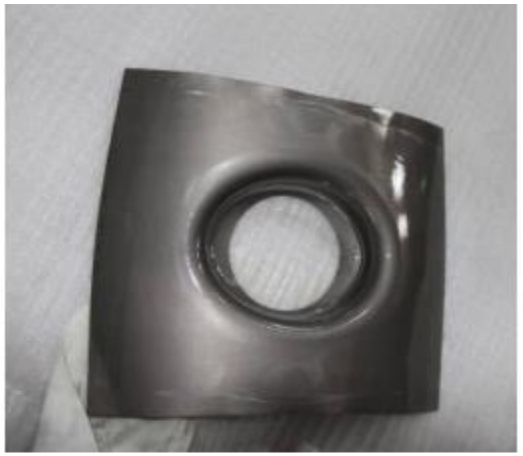
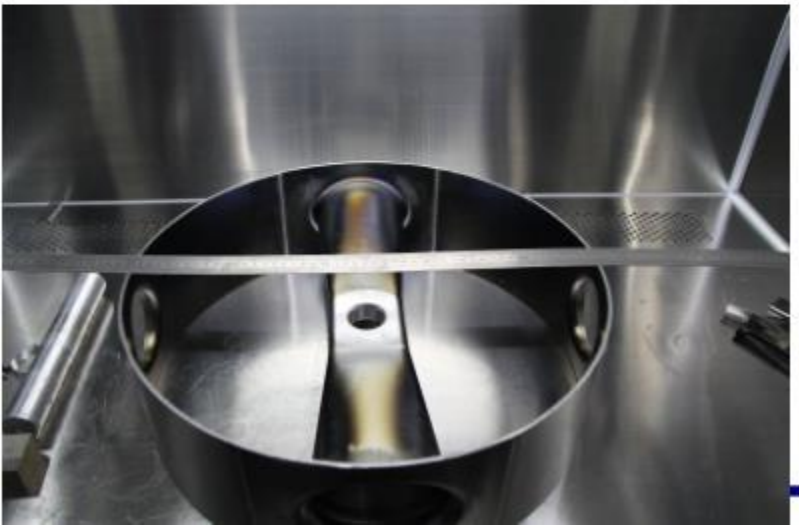
"Strategic Priority Research Program" of the Chinese Academy of Sciences

Technology shared by CEPC and ADS

Shared Tech.	CEPC	ADS
Superconducting technology	✓	✓
RF system	✓	✓
Power source	✓	✓
Cryogenic system	✓	✓
SC Magnet	✓	✓
Vacuum	✓	✓

SC Technology



SC Technology

Power Source

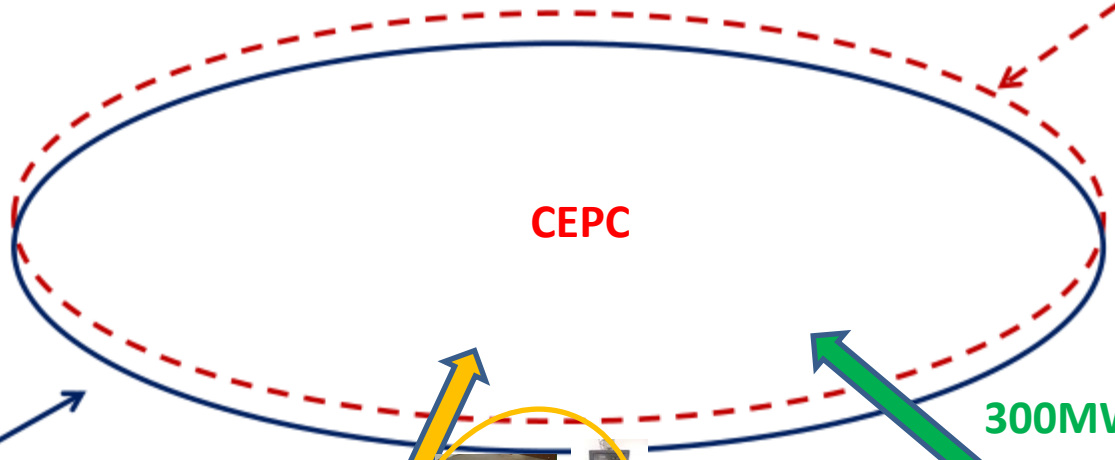
Cryogenic system

- Superconducting cavity cryomodule
- 2K cryogenic LHe system

12 meters long cryomodule for Euro-XFEL

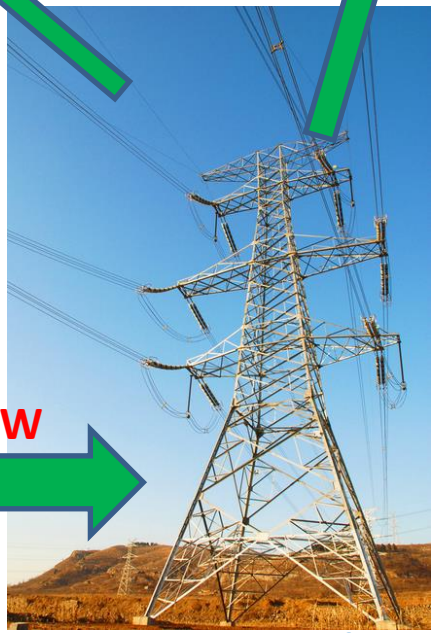
2K helium system

Green CEPC in the future



300MW

1000MW



Summary

- CEPC is a large machine and need huge power of 300MW, ~ 2 times of LHC
- China is developing nuclear power, but the bottle neck of nuclear power development is the nuclear waste, ADS can safely solve this problem and provide electric power.
- ADS is under development by CAS.
- CEPC and ADS based on a lot of same technology, such as superconducting technology and so on. The CEPC construction can be motivated by the ADS technology improvement.

Thanks!