Consideration of the Missions of CFETR

(and charge of this workshop)

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CFETR-DG

The scientific goals of ITER

A burning plasma device can be design and constructed based on the significant progress on tokamak. ITER is the burning plasma device and it's scientific goals are:

- to produce a plasma dominated by α-particle heating
- produce a significant fusion power amplification factor ($Q \geq 10$) in long-pulse operation (300 - 500s)
- aim to achieve steady-state operation of a tokamak ($Q=5$)
- retain the possibility of exploring 'controlled ignition' ($Q \geq 30$)
- demonstrate integrated operation of technologies for a fusion power plant
- test components required for a fusion power plant
- test concepts for a tritium breeding module

Gaps between ITER and DEMO (1)

Even if ITER can make great contribution to long pulse or SSO burning plasma but it is mainly on physics and not on real fusion energy because of the real burning time during it's 14 years D-T operation is only about 4 %, which results:

1. There is no enough fusion energy produced for utilization.
2. As the consequent the total neutron flux are not enough to demonstrate the real tritium breeding for self sustainable of tritium by blanket.
3. No enough neutrons to do the material tests in high fast neutron radioactive environments.

Gaps between ITER and DEMO (2)

4. Therefore there only are shielding blankets for ITER.
5. Even if adding the TBM with addition budget but it is only concept testing for tritium breeding and not real self sustainable blanket tests and material tests.

Conclusion: the engineering test reactor is necessary to be constructed parallel with or after ITER but before the DEMO and fusion power plant.

Common understanding

- The CFETR must be built before the fusion power plant in China
- ITER can be a good basis for CFETR both on SSO burning plasma physics and some technologies;
- The goals of CFETR should be different with ITER and aimed to the problems related with fusion energy;
- Both physic and technical basis of the CFETR should be more realistic when it is designed.

The Mission and Design goal of the first option of CFETR

- A good compliment with ITER
- Demonstration of full cycle of fusion energy with a minim
  P_f = 50 ~ 200MW；
- Long pulse or steady-state operation with
  duty cycle time ≥ 0.3 ~ 0.5；
- Demonstration of full cycle of T self-sustained with
  TBR ≥ 1.2
- Relay on the existing ITER physical （k<1.8, q>3, H~1) and technical bases (higher B_T , diagnostic, H&CD);
- Exploring options for DEMO blanket & diverter with a easy changeable core by RH；

For instance

Tritium self-sufficiency will be one of the most important issues for CFETR

Data related the consumption and Inventory of T

Fusion Power	Neutron source intensity	Neutron fluency (assuming 180 EFPD) EFPD: Effective Full-Power Day	Consumptions of Tritium per year (180 EFPD)	Inventory required
50 MW	**1.7781E+19 n/s**	**2.7650 E+26**	**1.89 kg**	
100 MW	**3.5562 E+19 n/s**	**5.5306 E+26**	**2.78 kg**	
150 MW	**5.3343 E+19 n/s**	**8.2959 E+26**	**4.67 kg**	
200 MW	**7.1124 E+19 n/s**	**1.1061 E+27**	**5.56kg (~30g/day)**	**~ 1.6 kg /online if assuming f_b~ 0.3 % and t_p~ 4h)**

Tritium self-sufficiency must be emphasized as top level fusion Goal

- D-T fuel cycle in a practical system (very complex topic)
- Tritium generation, extraction & inventory, actual operating conditions
- Tritium implantation, permeation & control in blanket and PFCs

(1 GW fusion power plane will burn up 55.6 kg T)

Working target

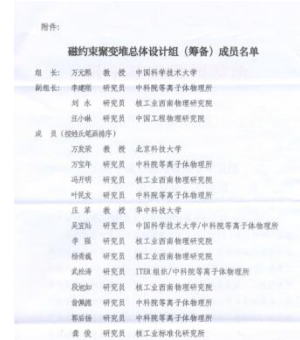
Mission	Sub-missions	Results	Required answer by design groups		Remarks
CW or long pulse burning plasm	**P_f = 50 -200 MW** (with H mode and duty cycle time ≧0.3-0.5 , no requirement on Q)	• Suitable size of device; • Require enough addition P_H and P_{CD}; • Require large amount of T consumptions;	What are the key required parameters of CFETR ?	**B_t = ?**	With SC or Cu coils ?
				R_0 = ?	
				b/a ~ 1.8 ?	
				a ?	
				I_P = ?	
				β_N = ?	
				P_H= ?	
				P_{CD} = ?	
	Duty time ≧ 0.3- 0.5	CW P_{CD} and P_H	What kind of and how high of P_{CD} and P_H are required ? What kind of diverter and material could be used?		
		T consumptions per year:≧6 Kg	Is it right and possible?		Assuming P_f = 200MW
	TBR ≧ 1.2	Produce T ≧ 6 Kg/year	Is it right and possible? What kind of blanket and the dimension are required?		Assuming P_f = 200MW
	Q_{eng} ≧ 1 ?	With hybrid blanket ?	What kind of blanket and the dimension are required ? Is it right and possible?		Should be discussed further!

Working task and schedule

- **Now- 2014:** provide **two** options of engineering concept design of CFETR which should include in:
  - Missions
  - Type
  - Main physics basis
  - Main techniques basis to be taken
  - **The concept engineering design for all sub-systems**
  - Budget & Schedule
  - Location
  - Management system
  - List of the key R&D items
  - The plan for 200 PhD students / year

- **2015:** will make the proposal to government to try to get permission for CFETR construction;

Organization (members) of National MFR integration design group


附件:

磁约束聚变堆总体设计组（筹备）成员名单

组 长:	万元熙	教 授	中国科学技术大学
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	万发荣	教 授	北京科技大学
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	冯开明	研究员	核工业西南物理研究院
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Wang, Xiaolin	CAEP
Ye, Minyou	USTC
Wan, Baonan	ASIPP
Duan, Xuerun	SWIP
Yu, Qin quang	Germany
Zhuang, Ge	HUST
Yang, Qinwei	SWIP

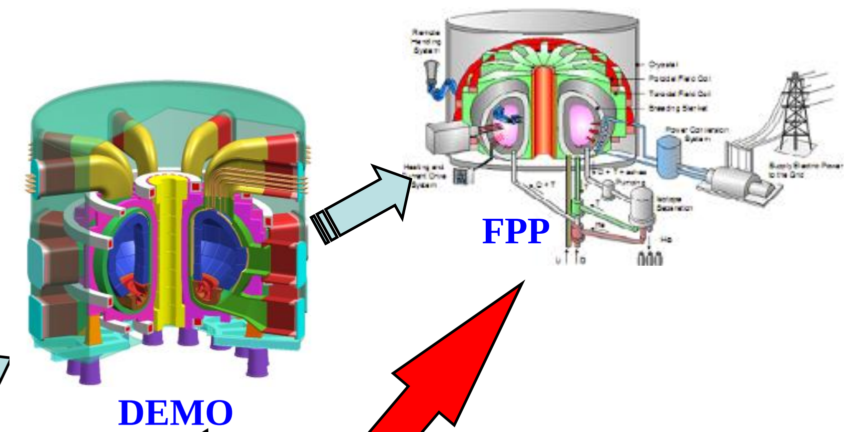
Wu, Songtao	ITER
Li, Qiang	SWIP
Weng, Pede	ITER, ASIPP
Guo, Huoyang	USA
Feng, Kaiming	SWIP
Wan, Farong	BUST
Fu, Pen	ASIPP
Wu,Yican	USTC, ASIPP
Gong, Jun	INS

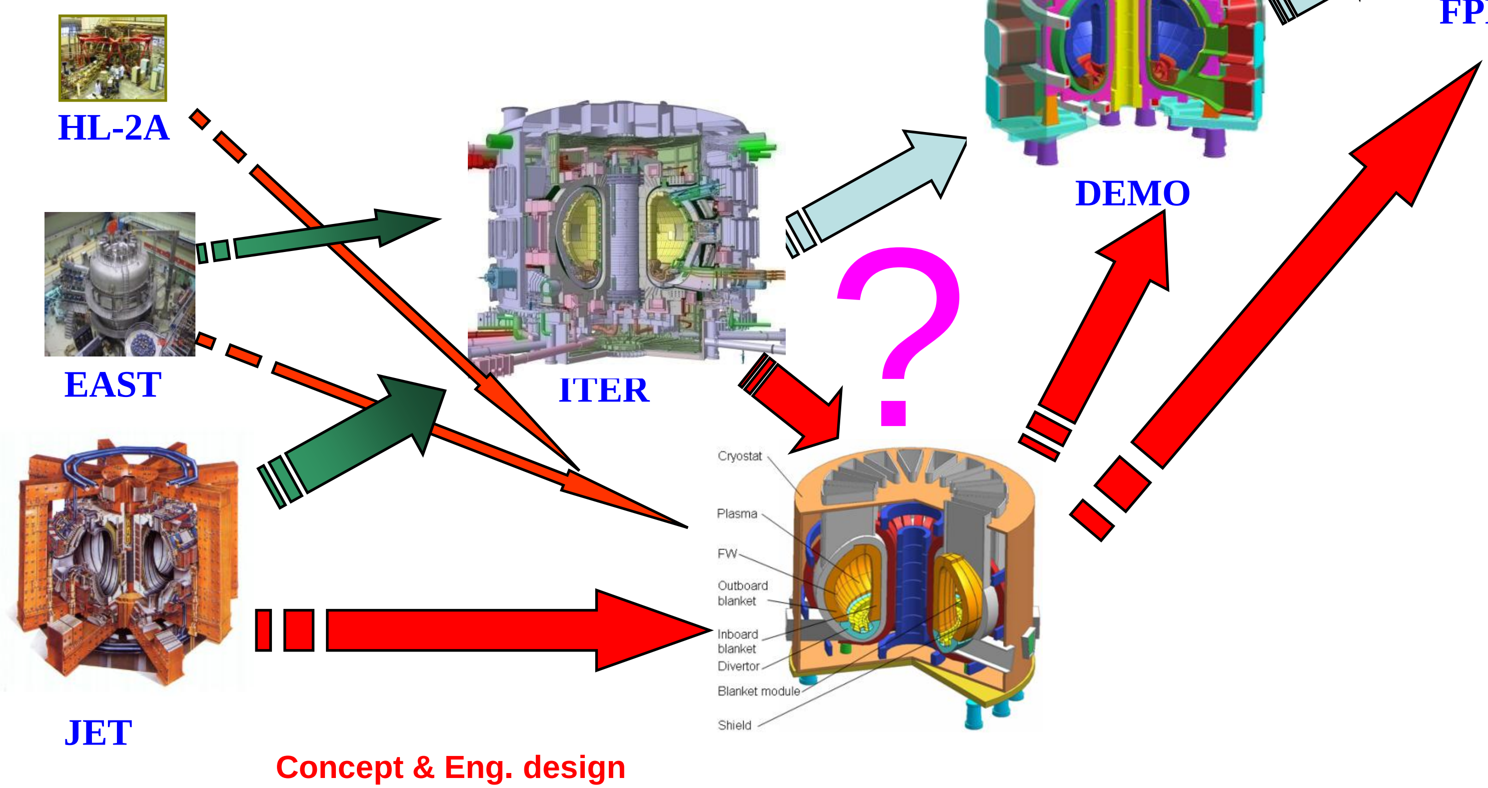
Sub-design groups of the national integration design group for CFETR

1. **Layout Design and System Integration**
2. **Plasma Physics and Technology**
3. **Superconducting Magnet and Cryostat System**
4. **Vacuum Vessel & Vacuum System**
5. **In-vessel Components & Blanket System**
6. **Heating & Current Drive System**
7. **Diagnosis & CODAC**
8. **Electrical Power & Control System**
9. **Fuel Circulation System & Waste Disposal**
10. **Radiation Protection & Safety**
11. **Remote Control and Maintenance System**
12. **Auxiliary Supporting System**
13. **Project Management**

Under discussion → *final option*

What is Possible Road map of Fusion to DEMO in China





Now~2015 | 2015~2025 | 2030~2040 | 2050

Recall: suggestions of the first workshop

- Make advisory suggestion, comments, proposals on the mission, type of the next device for MFE development in China;

- If the first option is tokamak:

  types (AT, ST, Hybrid) ?

  the basis of physics and technologies can or should be taken?

  challenges and risks?

- What is the alternative options?

  stellarator or any other attractive options?

  the basis of physics and technologies can or should be taken?

  challenges and risks ?

Charge for this workshop

- **Does the mission of CFETR fit the urgent needs and gaps between ITER and DEMO, is this realistic and feasible?**
- **What is the possible cost effective solution to meet the requirement of CFTER's mission (machine size, top priorities)**
- **What are the most important challenges and risks on physics and technologies for the approach chosen?**
- **Comments and suggestions on key issues of CFETR which should start R&D within next 3-10 years**

End and Thanks!