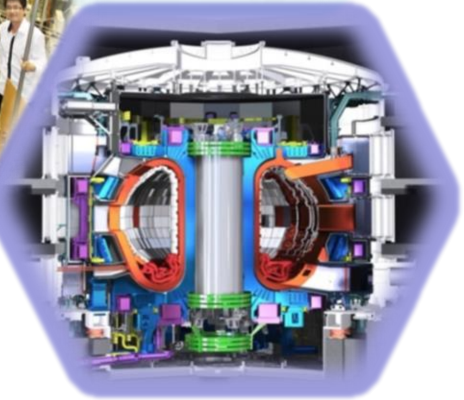


ITER School 2015, Hefei China

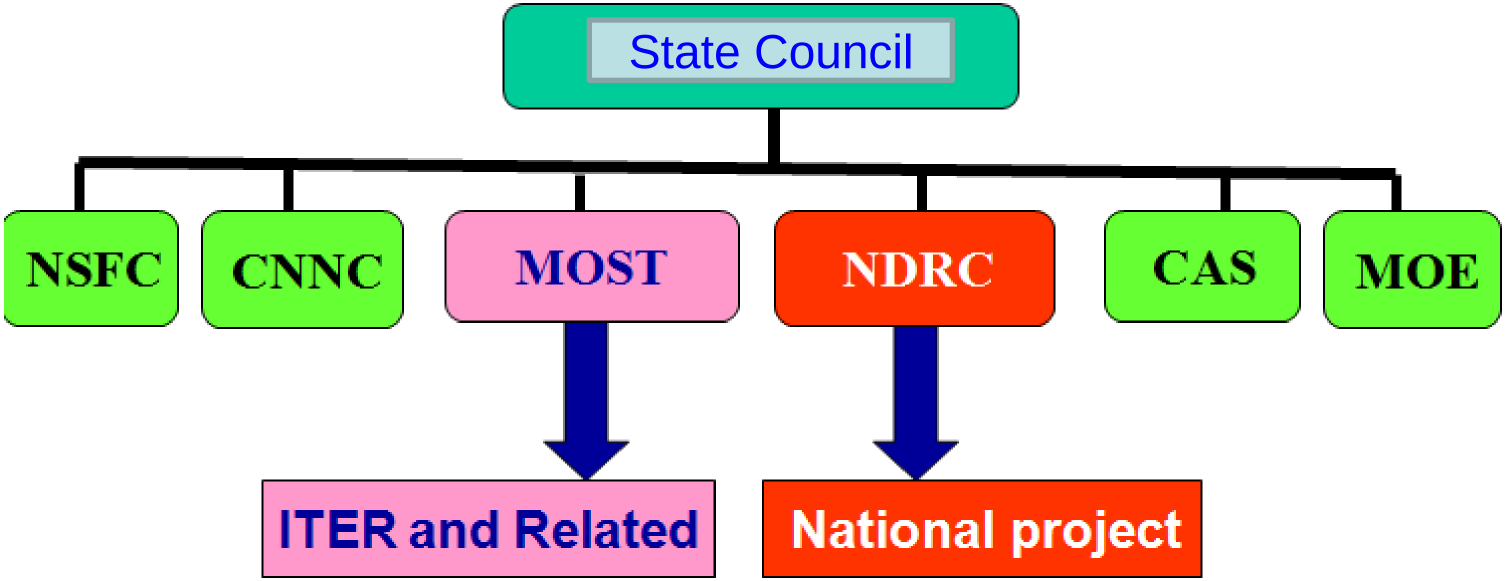
CN MCF Program and CFETR

Jiangang Li (j_li@ipp.ac.cn)

Outline

- Present State of MCF in China
- EAST Progress
- CN-ITER Activities
- Next Step-CFETR
- Summary

Support system for fusion research in China



State Council

NSFC

CNNC

MOST

NDRC

CAS

MOE

ITER and Related

National project

Fusion supported by

National Development and Reform Commission – NDRC
Ministry of Science and Technology – MOST
Ministry of Education – MOE
Chinese Academy of Sciences – CAS ;
China National Nuclear Corporation – CNNC
Natural Science Foundation of China – NSFC

CN-MCF Near Term Plan (2020)

ITER construction

- ASIPP: Feeders (100%), Correction Coils (100%), TF Conductors (7%) , PF Conductors (69%), Transfer Cask System(50%), HV Substation Materials (100%), AC-DC Converter (62%)
- SWIP: Blanket FW (10%) &Shield (40%), Gas Injection Valve Boxes+ GDC Conditioning System (88%), Magnetic Supports (100%),
- Diagnostics (3.3%)

Enhance Domestic MCF

Upgrade EAST, HL-2M

ITER technology

TBM (solid, DCLL, water)

University program

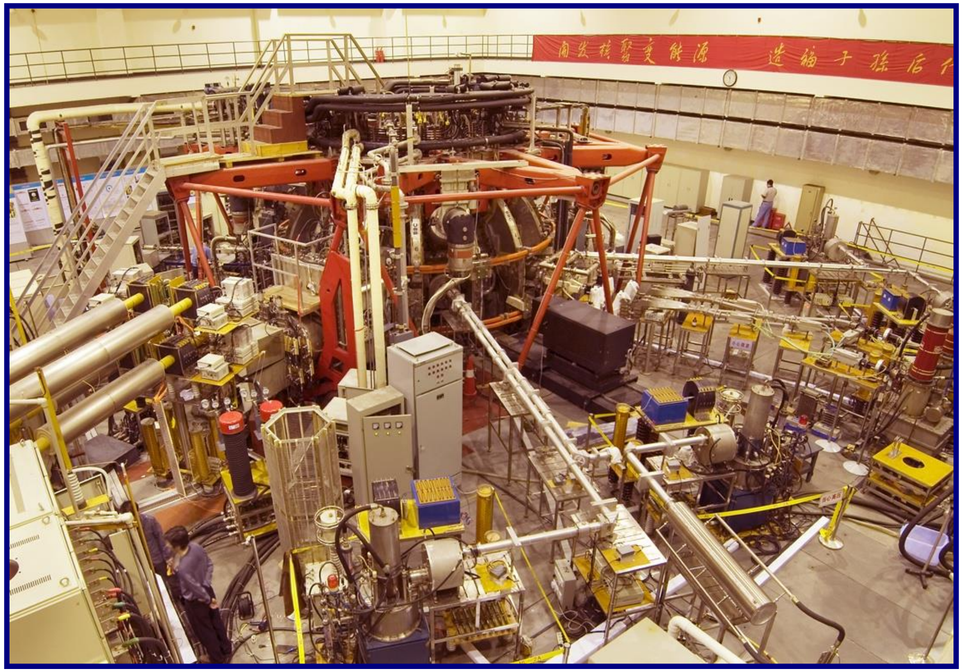
CFETR design (Wan)

CFETR R&D

Education program(2000)

Can start construct CFETR power plant @ 2020

HL-2A in SWIP



- *R:* 1.65 m
- *a:* 0.40 m
- *Bt:* 1.2~2.8 T
- *Configuration:*
  Limiter, LSN divertor
- *Ip:* 150 ~ 480 kA
- *ne:* 1.0 ~ 6.0 x 10^{19} m^{-3}
- *Te:* 1.5 ~ 5.0 keV
- *Ti:* 0.5 ~ 1.5 keV

Auxiliary heating:

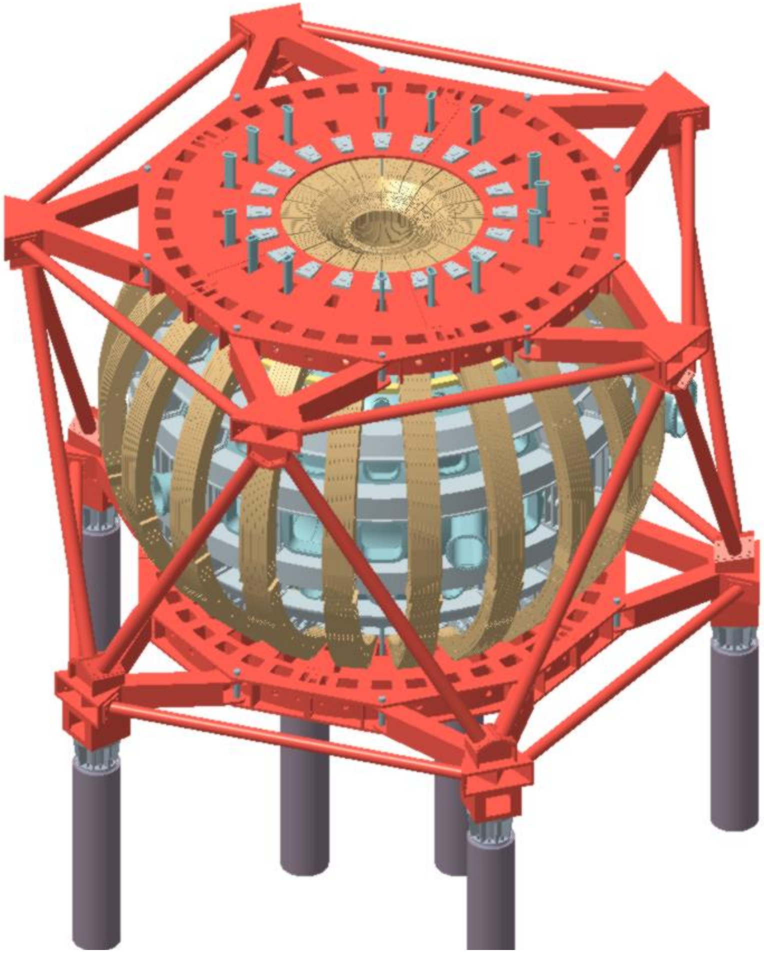
ECRH/ECCD: (3+4)MW
(6/68 GHz/500 kW/1 s)
modulation: 10~30 Hz; 10~100 %
NBI(tangential): 4MW
LHCD: 2 MW
(2/2.45 GHz/500 kW/1 s)

Fueling system (H_2/D_2):

Gas puffing (LFS, HFS, divertor)
Pellet injection (LFS, HFS)
SMBI (LFS, HFS)
LFS: f =1~80 Hz, pulse duration > 0.5 ms
gas pressure < 3 MPa

Next Step: HL-2M (2016)

Major radius, R	1.78m
Minor radius, a	0.65m
Aspect ratio	<2.8
Flux-swing (one side OH current)	7 Wb @ maximum I_{OH}.
Ip	2 MA (3MA)
Bt	2.2 T (3T)
δ	>0.5
κ	2
Plasma pulse	3s, extendable (depending on the discharge needs)
Divertor configurations	Usually LSN but flexible. DN, USN and elongated limiter shapes are achievable.



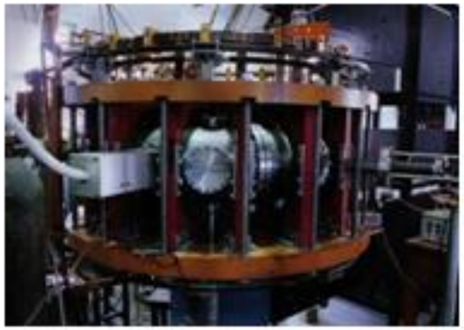
University Program

- More than 10 universities are involved in 10-15 tasks (40-60M$/per year) with 200 Staff 200 students in MCF project;
- 3 theoretical research centers (Hefei, Zhejiang, Beijing)
- School of NST in USTC has been created:

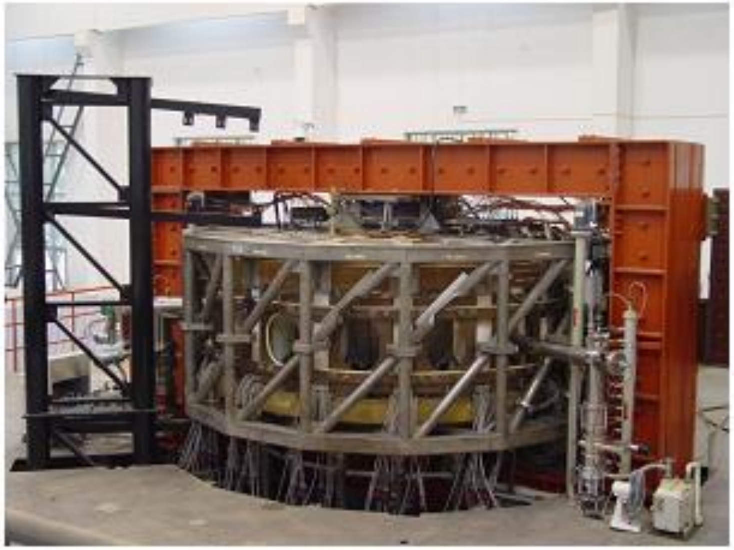
  100 undergraduate/year

  100-150 (MS+Ph.D)/year

SUNIST in Tsinghua Univ.

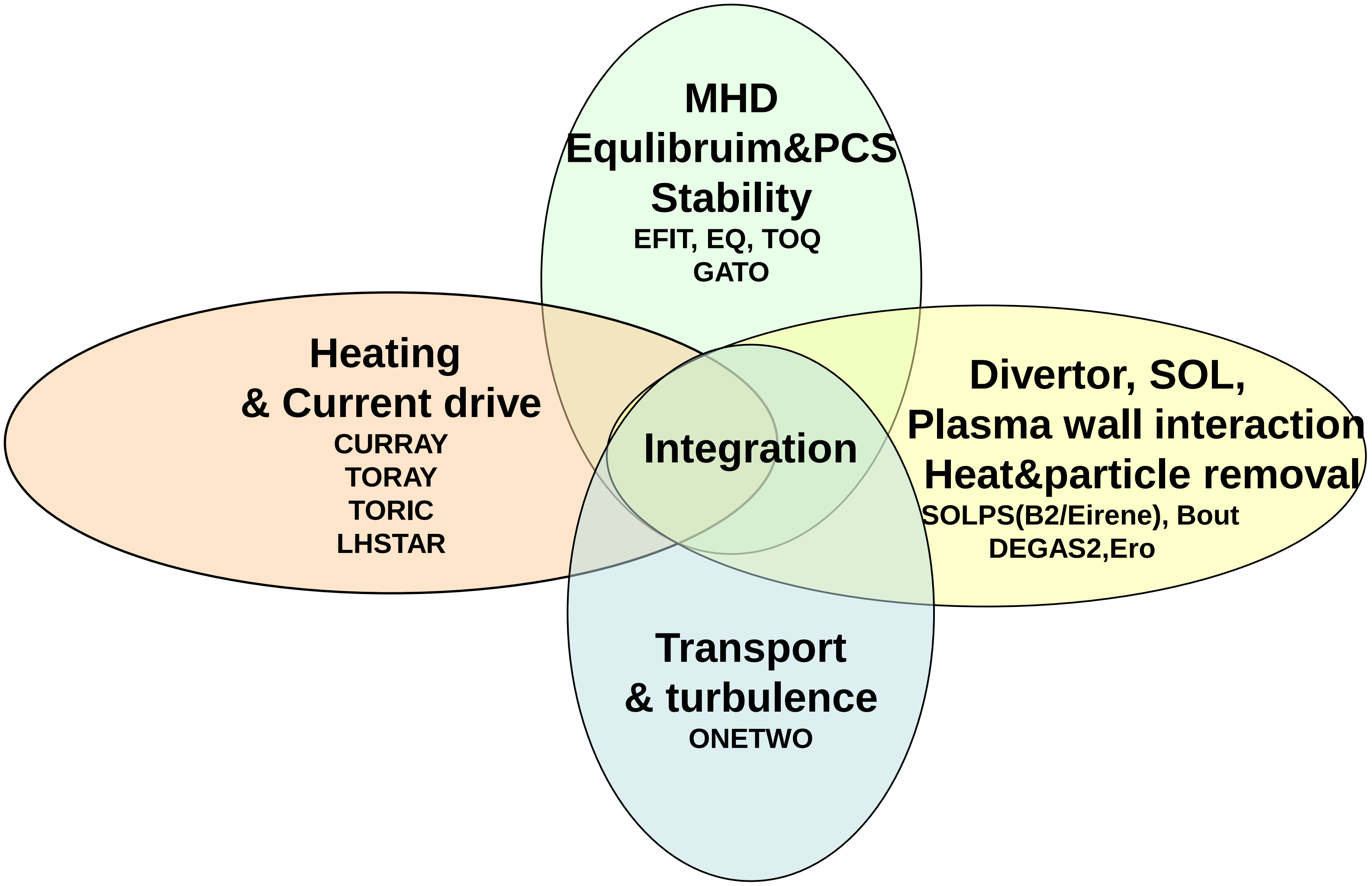


KT-5 in USTC



J-TEXT in Huazhong Univ.

Try to Build a Close Coupling between Theory and Experiments



MHD
Equlibruim&PCS
Stability
EFIT, EQ, TOQ
GATO

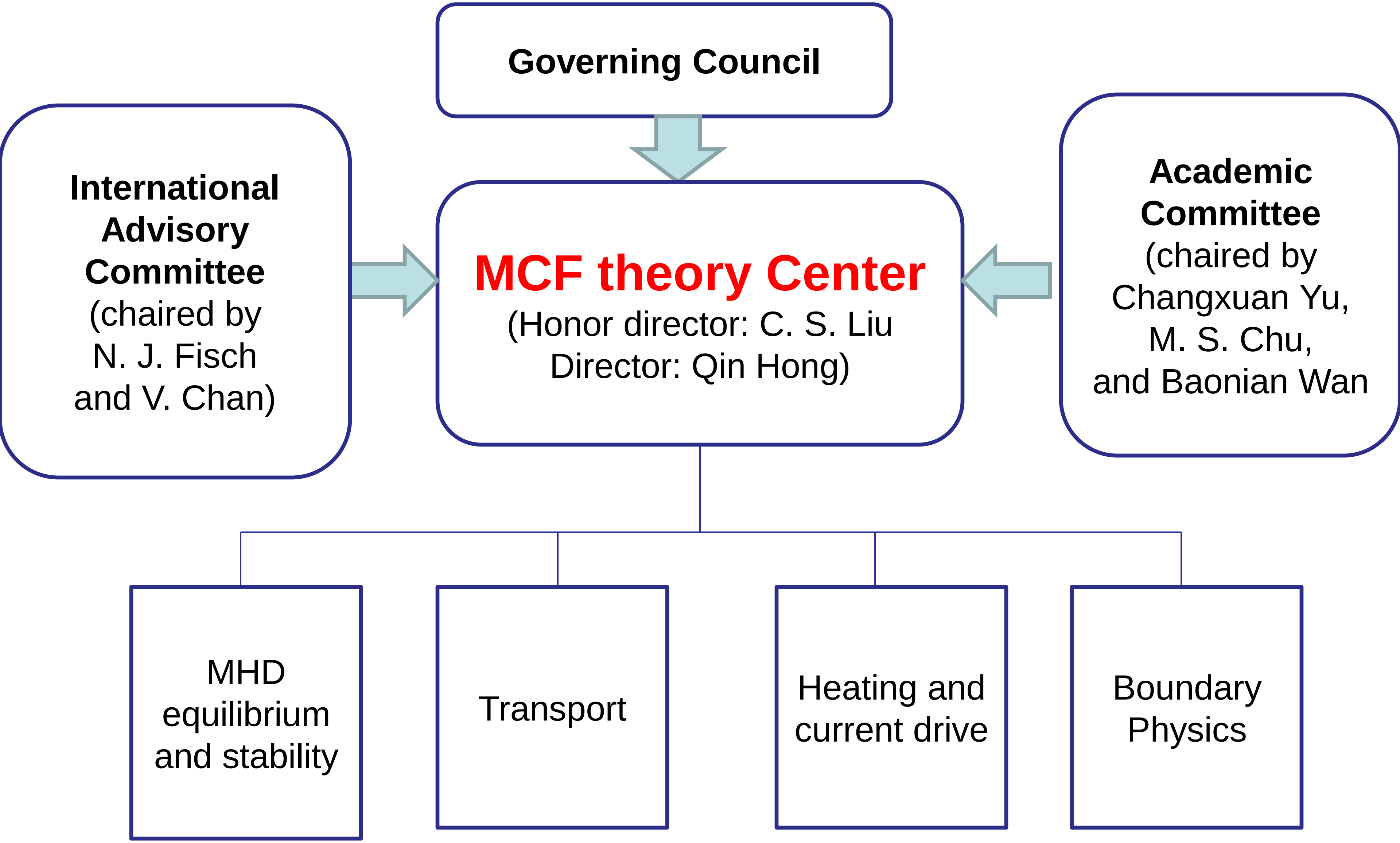
Heating
& Current drive
CURRAY
TORAY
TORIC
LHSTAR

Integration

Divertor, SOL,
Plasma wall interaction
Heat&particle removal
SOLPS(B2/Eirene), Bout
DEGAS2,Ero

Transport
& turbulence
ONETWO

CAS-MCF-Theory Center



Governing Council

International Advisory Committee
(chaired by
N. J. Fisch
and V. Chan)

MCF theory Center
(Honor director: C. S. Liu
Director: Qin Hong)

Academic Committee
(chaired by
Changxuan Yu,
M. S. Chu,
and Baonian Wan

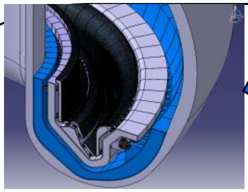
MHD equilibrium and stability

Transport

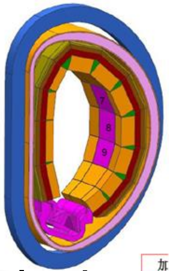
Heating and current drive

Boundary Physics

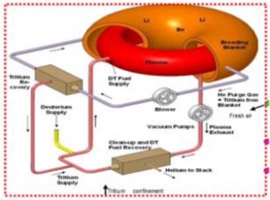
Integrated Concept design team for CFETR



Divertor

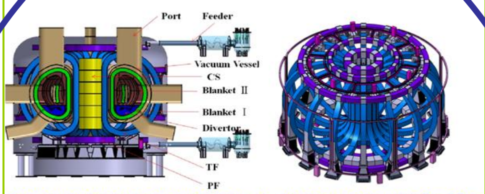


Blanket



Fuel cycle

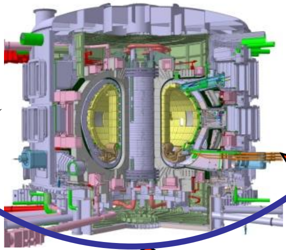
CFETR

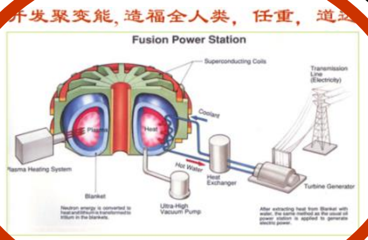


On the basis of matching the machine size, i.e., the plasma major radius R = 5.7m and minor radius r = 1.6m, considering as well the plasma design scheme, if the device will be further upgraded in the future that VV should be large enough to satisfy of R = 5.9m and r = 1.6m.

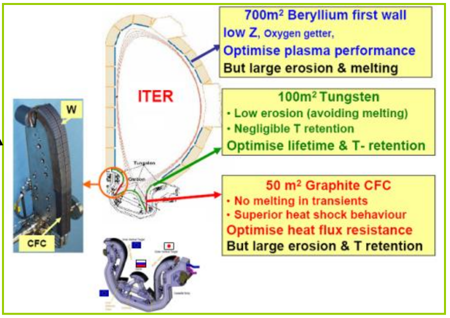
The magnets and VV systems design scheme should satisfy the three divertor configurations simultaneously.

Can realize both of the balance configurations of **R = 5.7m and R = 5.9m, under the same magnets system**.





Target



700m² Beryllium first wall
low Z, Oxygen getter,
Optimise plasma performance
But large erosion & melting

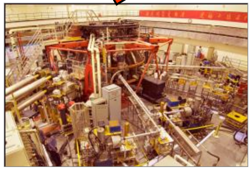
100m² Tungsten
- Low erosion (avoiding melting)
- Negligible T retention

Optimise lifetime & T- retention

50 m² Graphite CFC
- No melting in transients
- Superior heat shock behaviour

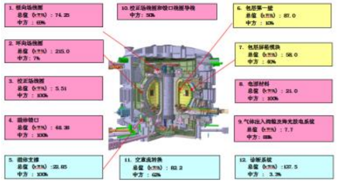
Optimise heat flux resistance
But large erosion & T retention

PWI& FWmaterail



HL-2A

EAST



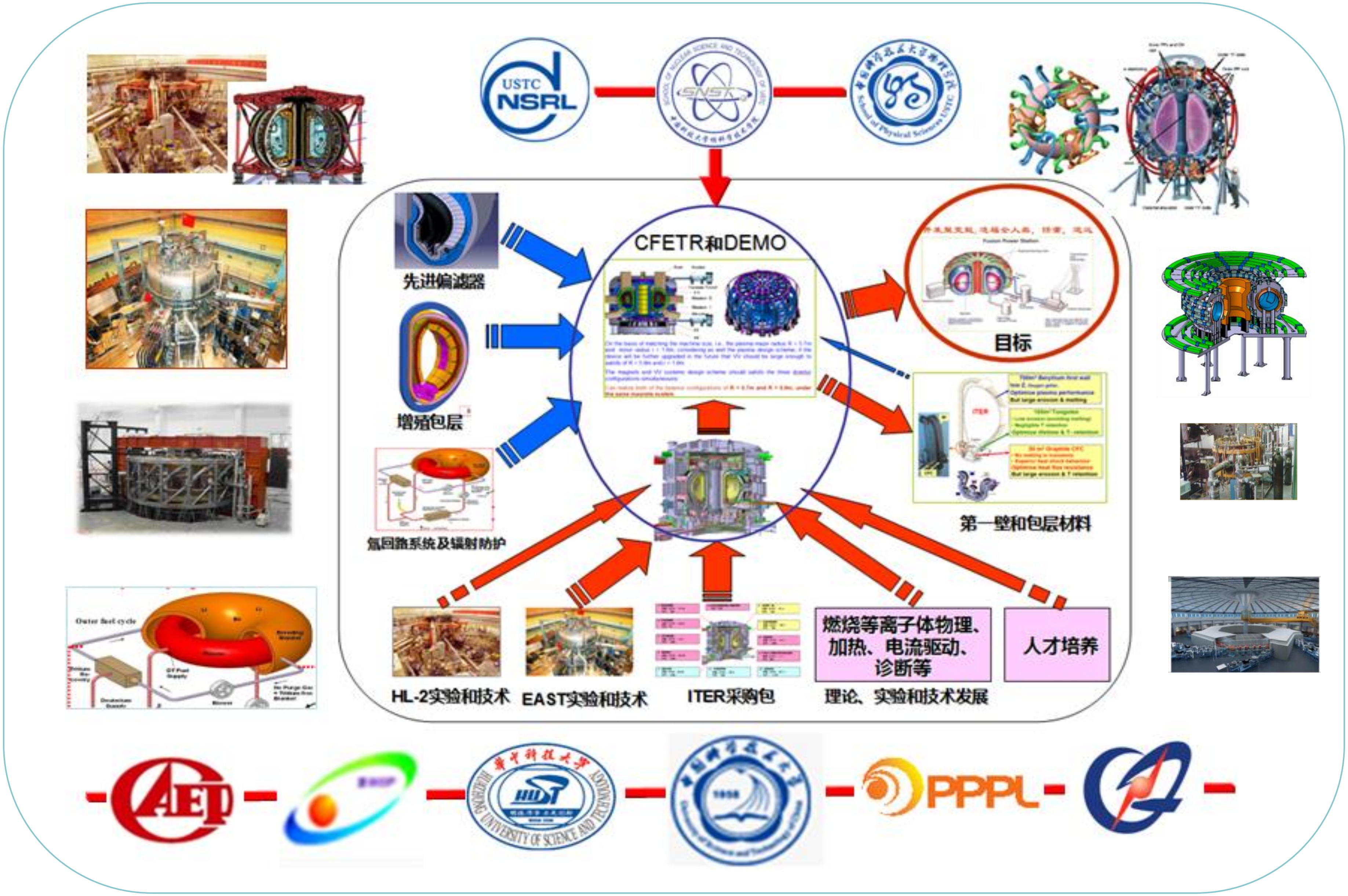
ITER-CN

Burning Plasma,
H&CD, H-mode
Transport, Edge

CFETR **Physics**

Education

Innovation Center for Plasma physics and Fusion energy



Education Program

- ASIPP: EAST (220 students), ITER (70 students),Fusion Tec(150)
- School of Physics (USTC, 35)
- School of Nuclear Science (USTC-ASIPP, 40)
- CN-MCF center (10 top universities) 200
- ITER operation (>100/year)

- ➢HT-7 training machine: 1/3 operators, 80% proposal assign to young person.
- ➢EAST 10young person (<45) take task force leader.
- ➢20-30 (EAST)+ 30(ITER) PhD, post.Dr, young staff to foreign lab for further education.
- ➢Training courses and summary school (20-250)
- ➢Teaching in top universities.

Outline

Present state of MCF in China

EAST Progress

CN-ITER Activities

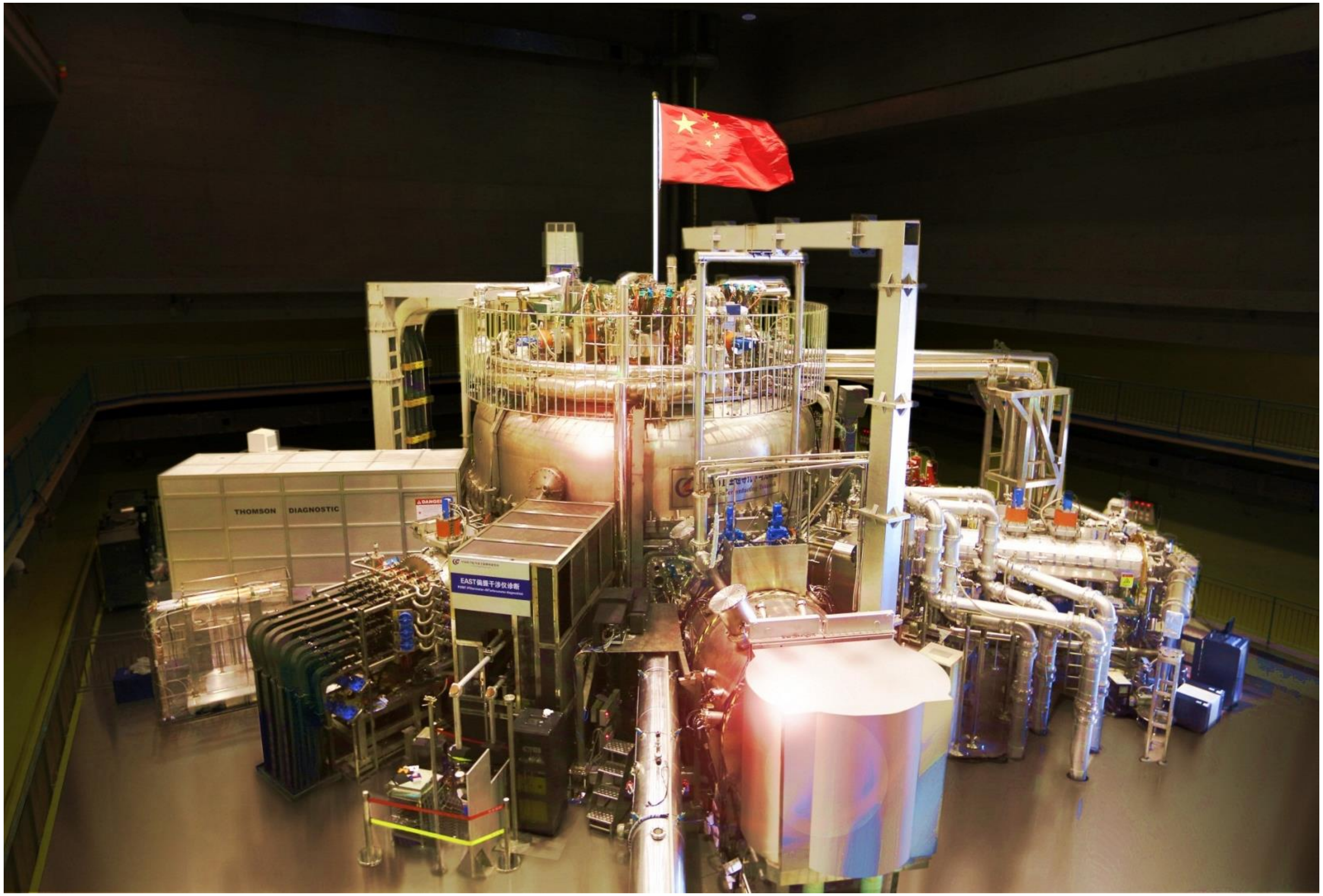
Next Step-CFETR

Summary

Mission of EAST

Play a key role for understanding advanced SS plasma physics.

Provide valuable data bases for ITER &CFETR



Milestones of EAST

1996.8 first proposal to CN Gover.

1998.6: accepted by CN Gover.

1998.7-2000.9 Design， R&D

2000.10: Start construction

2006.9: 1st plasma

2007.3-2012.7 Experiments,

45600 shots

2012.9-2014.4 Upgrade

2014.5-2020.12 2nd Phase of exp

B_T= 3.5 T (4T)

Ip = 1.0MA (1.5MA)

R =1.85m, a = 0.45m

K =1.6-2.0, Delta = 0.4-0.6

ICRF: 25-70MHZ, 6MW (12MW)

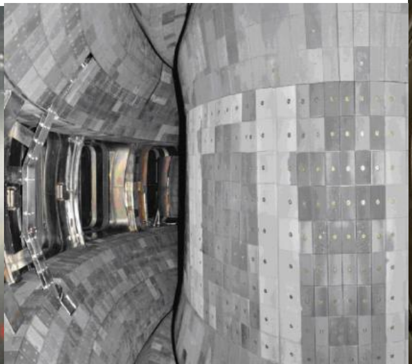
LHCD: 2.45GHz, 2MW (4MW)

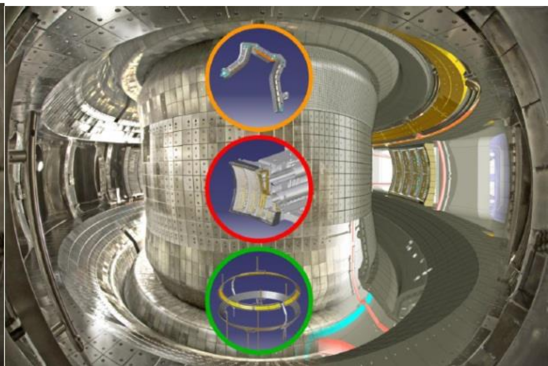
4.6GHz, (6MW)

NBI: 40-90keV (8MW)

ECRH: 140GHz 4MW, 170GHz, 6MW

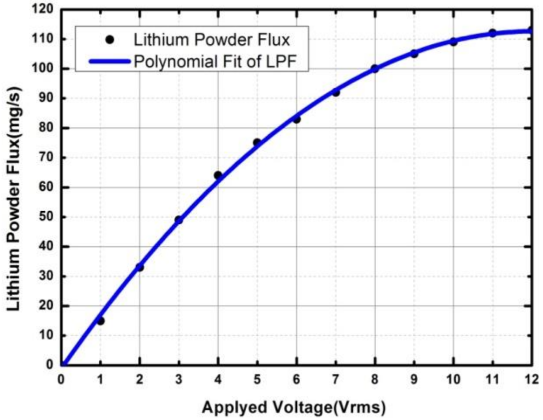
Diagnostics:30 (80)

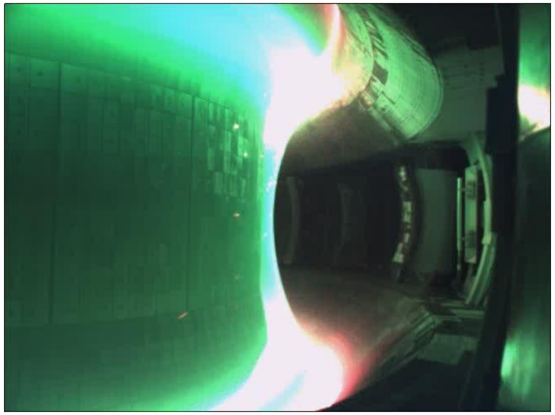


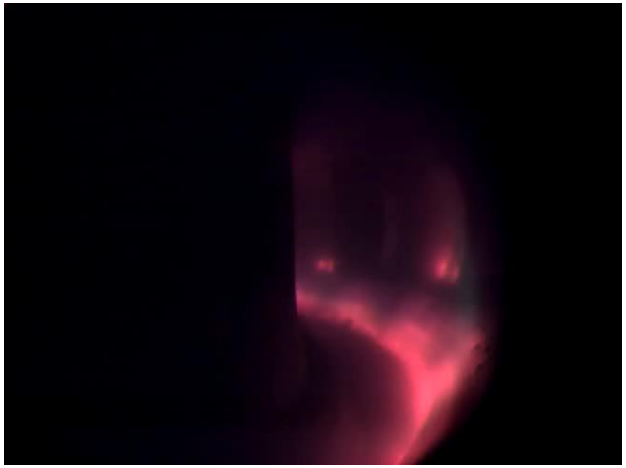


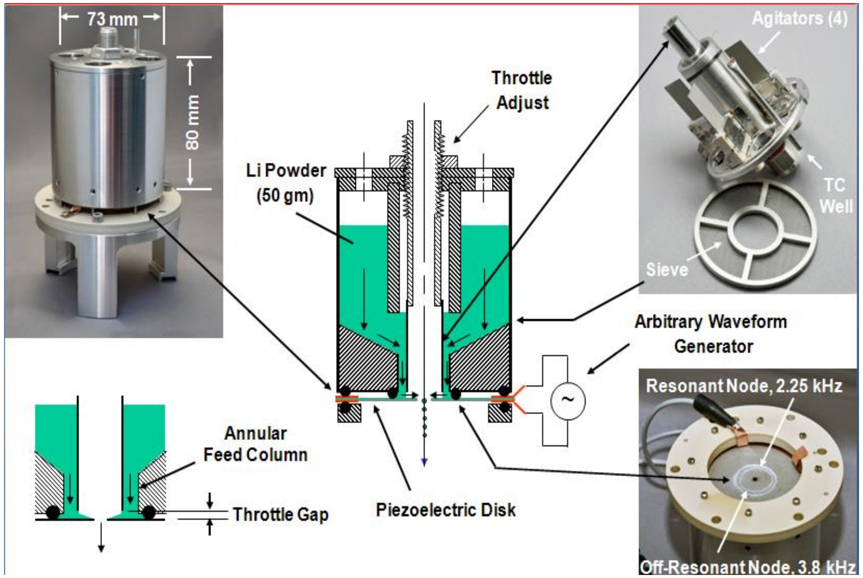
Wall Conditioning: For H-mode

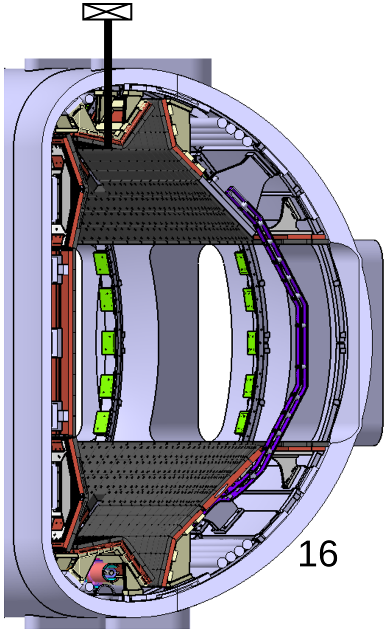
- Two Li droppers





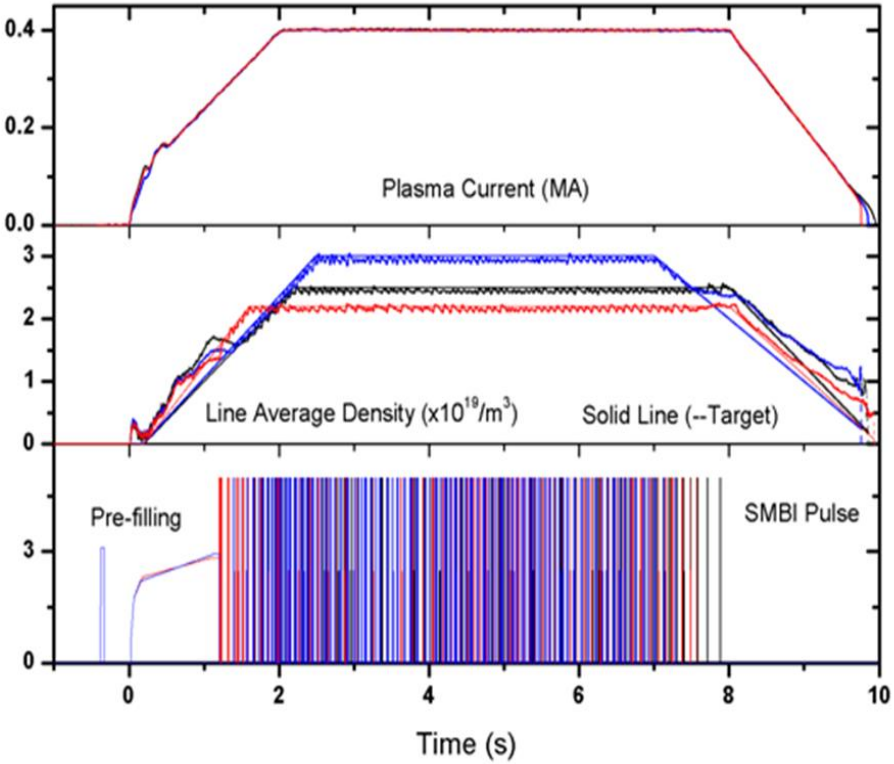




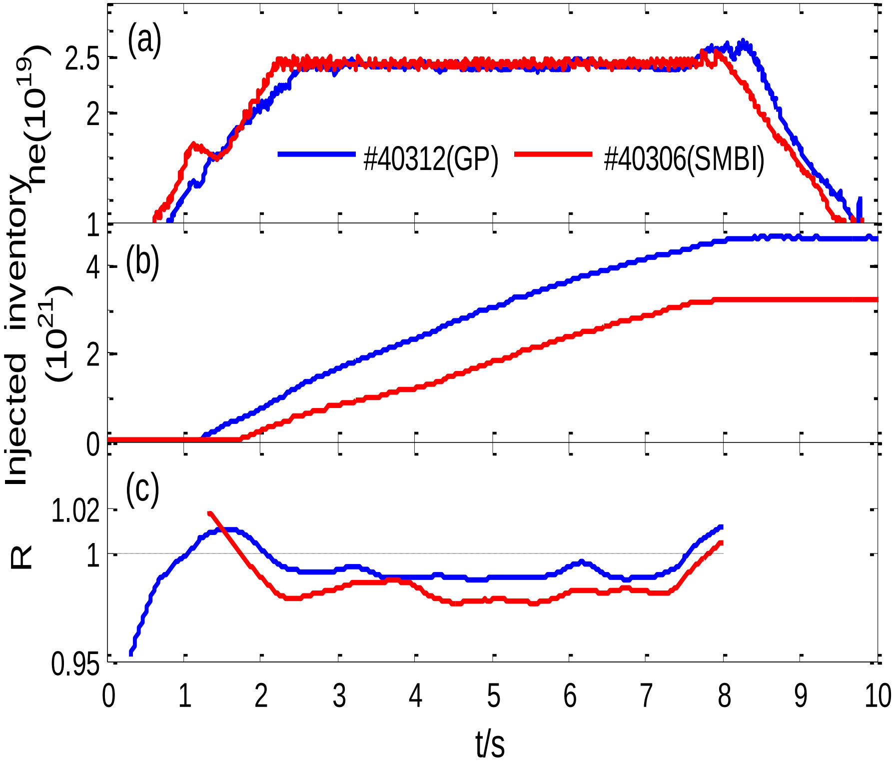


SMBI- better fueling method

- ➢Better ne FB control, ， 25 -35% lower retention, lower recycling

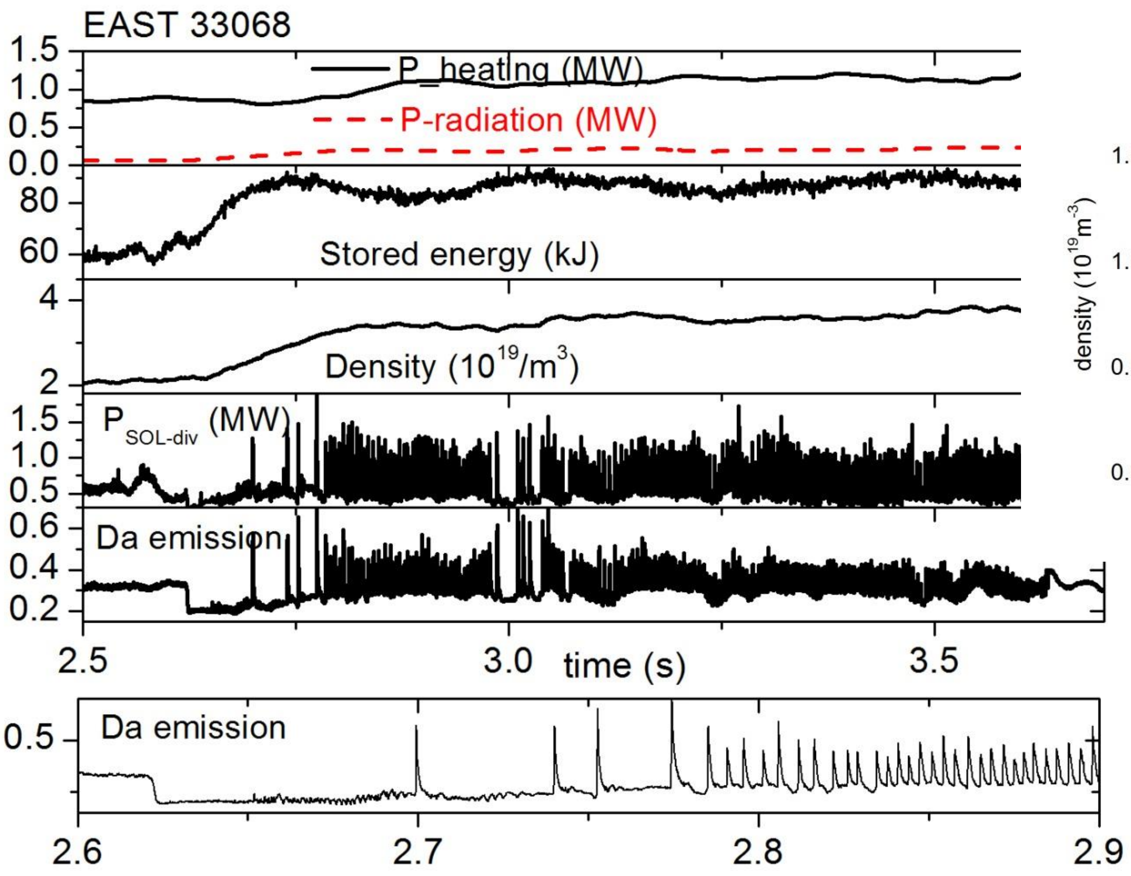


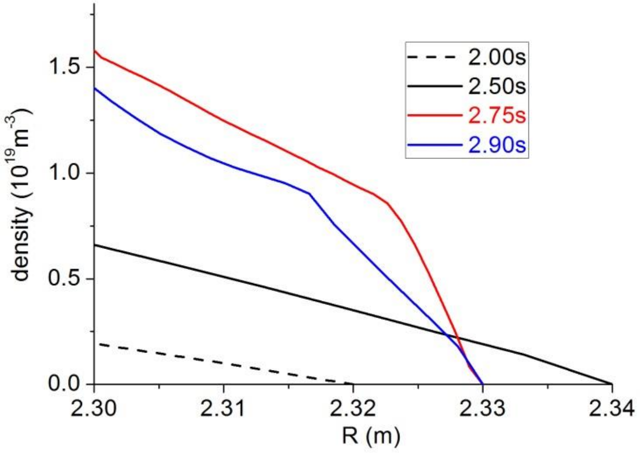
Higher ne under Li wall



Comparison with GP

LH driven H-mode





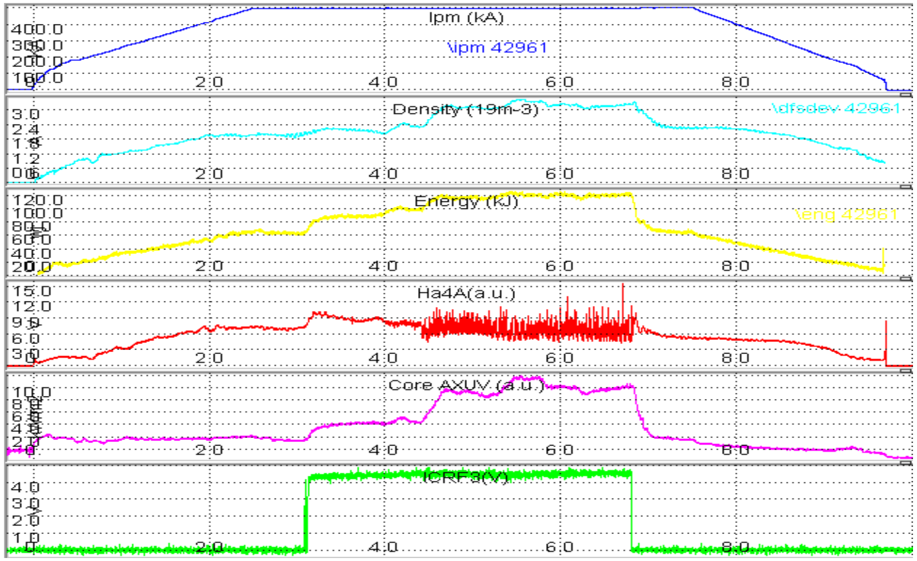
Density pedstal formed after L-H transition

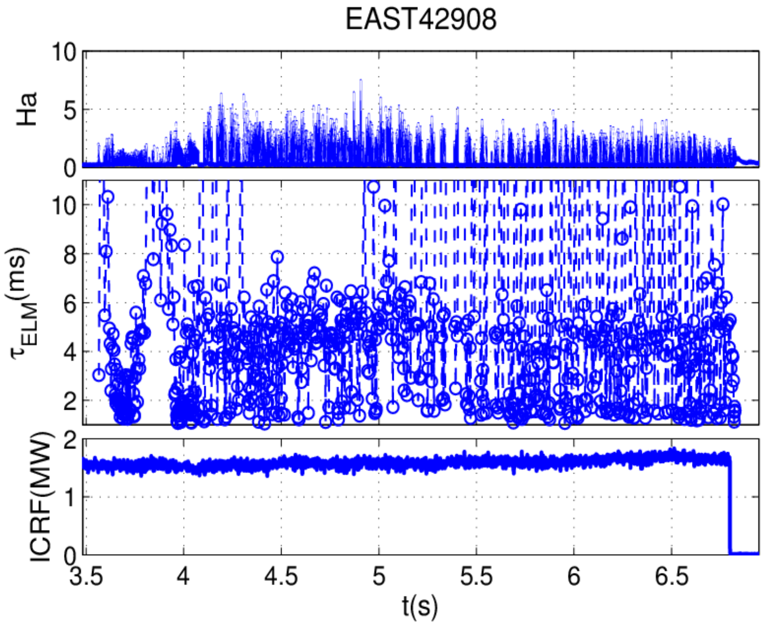
Type I-like phase had more steep gradient than in type III phase

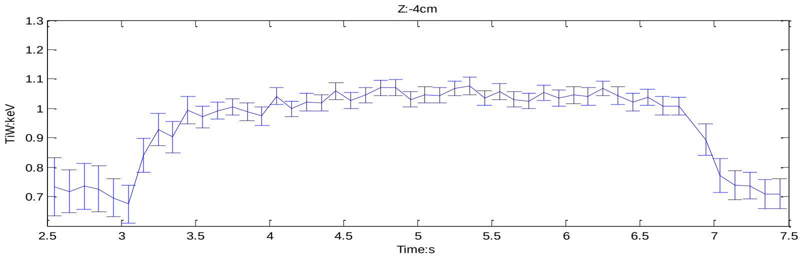
Along accumulation of Lithium in vessel, stationary H-mode has been achieved

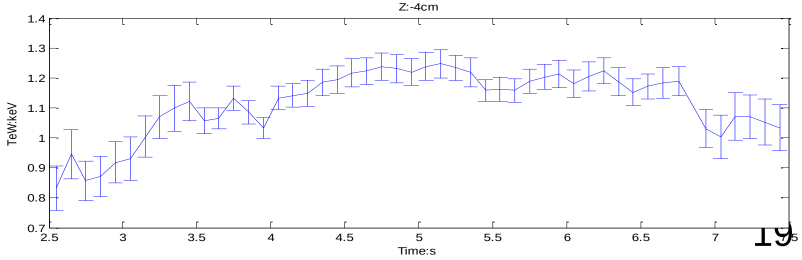
Ip~500kA, Bt~1.54T, n_H/n_{GW}~70%

ICRF Driven H Mode









Ip=400-500kA, Bt = 2T,

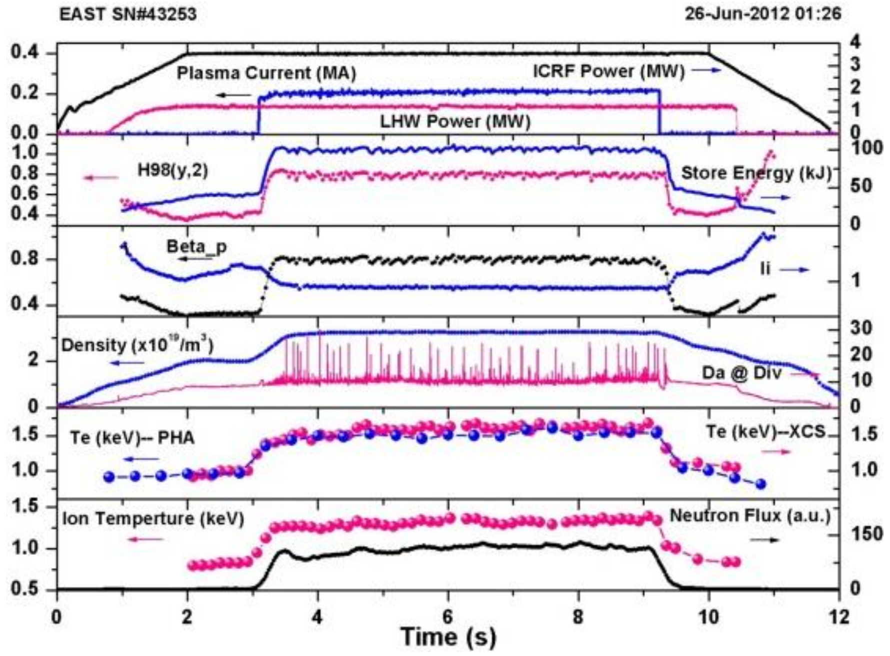
f_{RF} = 27MHz,

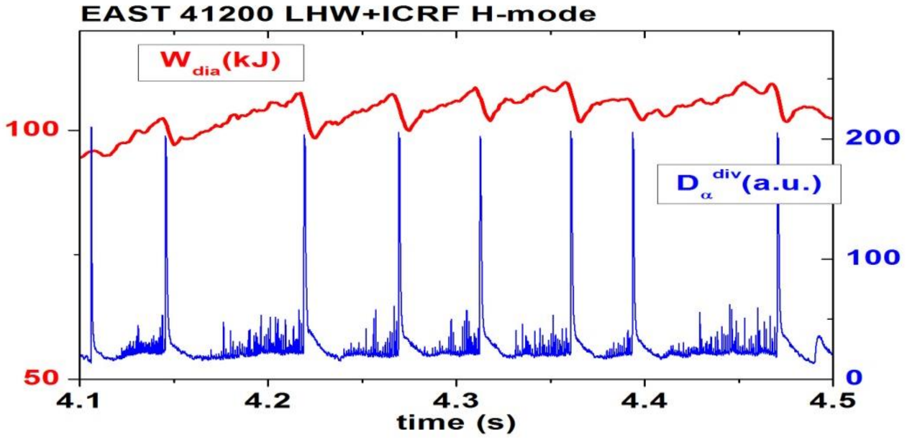
two antennae, P ~ 2.0MW

ELMy Frequency: 200-500Hz,

ΔTe 500eV , ΔTi 500eV

Type-I ELM+ Type-III ELM





$n_e/n_{GW} < 0.5$,

$n_e \sim 3\times10^{19}/m^3$

I_p~0.4MA, B_t~1.85T, δ ~ 0.4

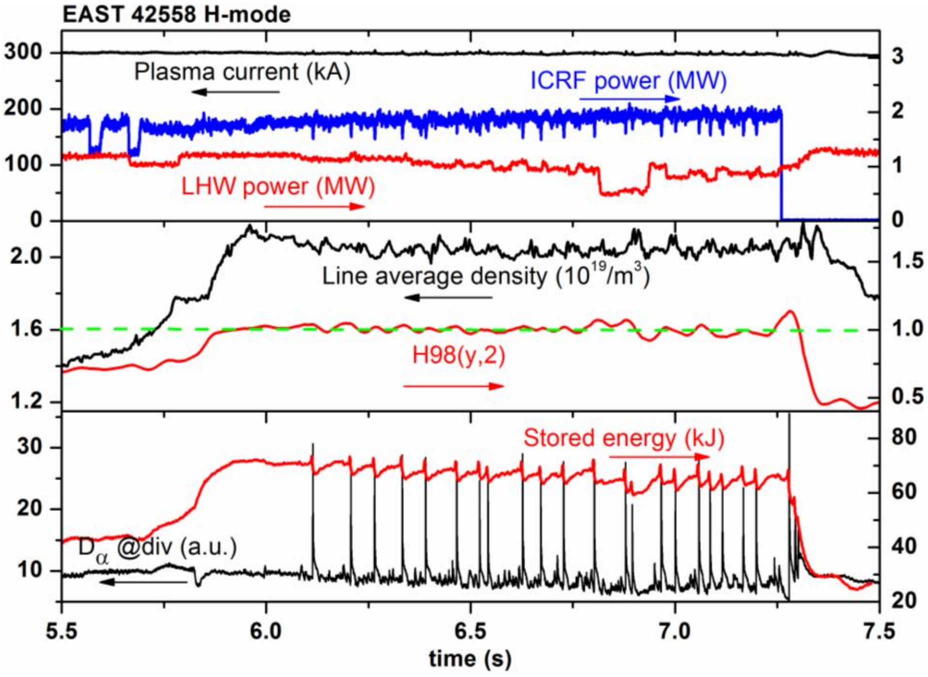
P_{LH}~1.6MW, P_{RF}~0.8MW,

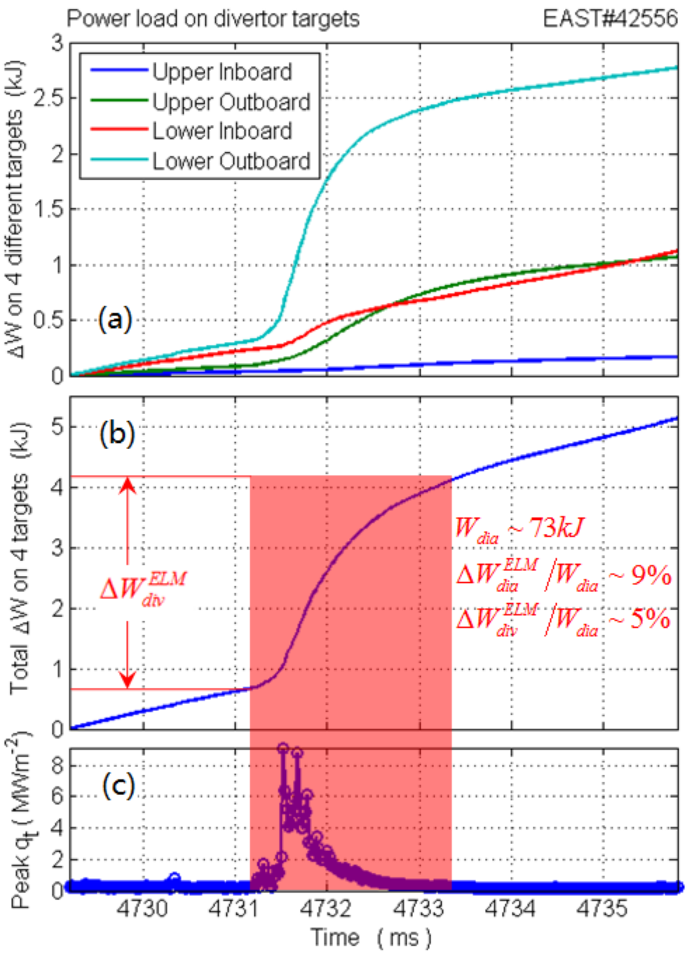
$0.8 \leq H_{98} < 1$

$f_{Large\ ELM}$~20-50Hz

ΔW/W~5-10% depends on inter-ELM time

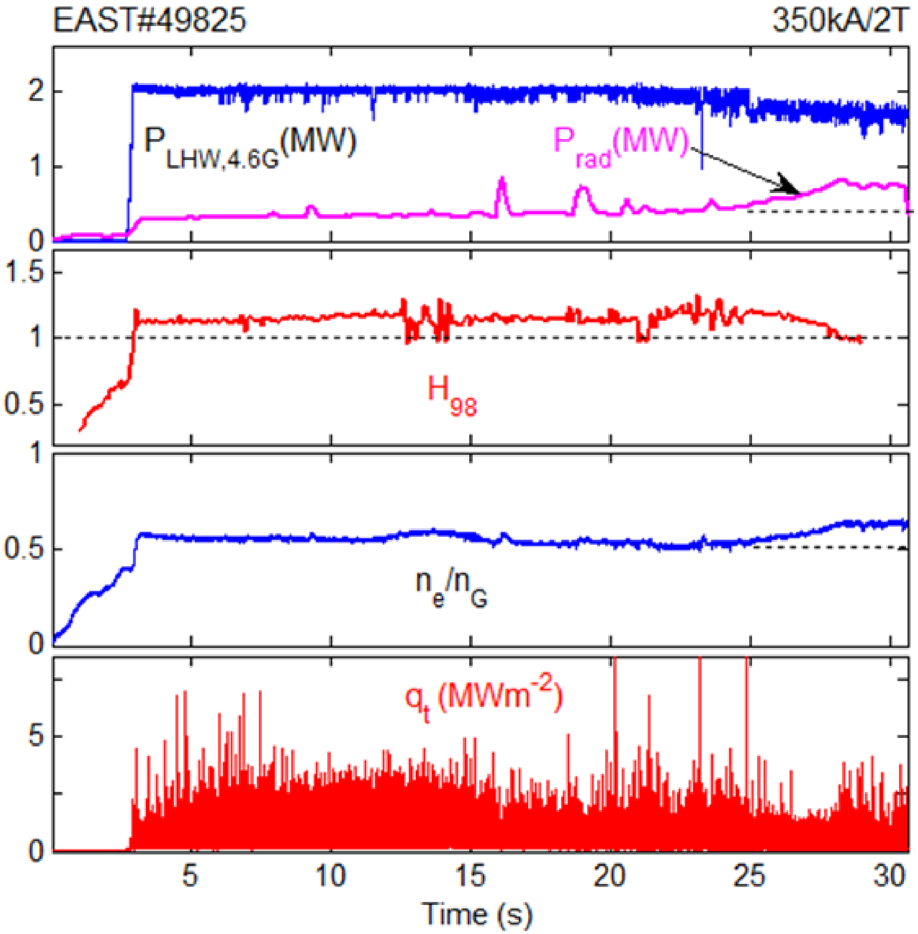
Low density Type-I H mode $H_{IPB98(y,2)}$ ~ 1



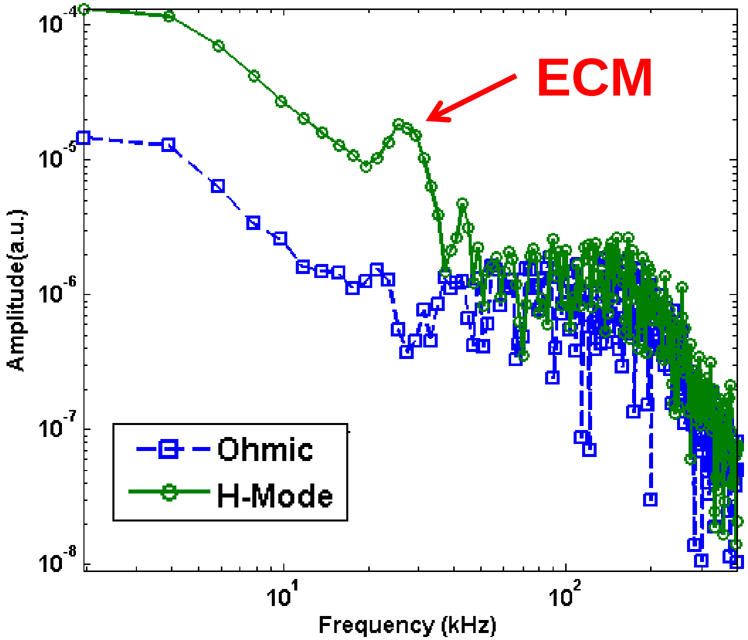


ELM10 F~10-20Hz
energy loss~10%
Heat load on target > 10MW/m^2

Newly 4.6GHz-LHCD System Facilitates much Better Performance → Long Pulse H-mode

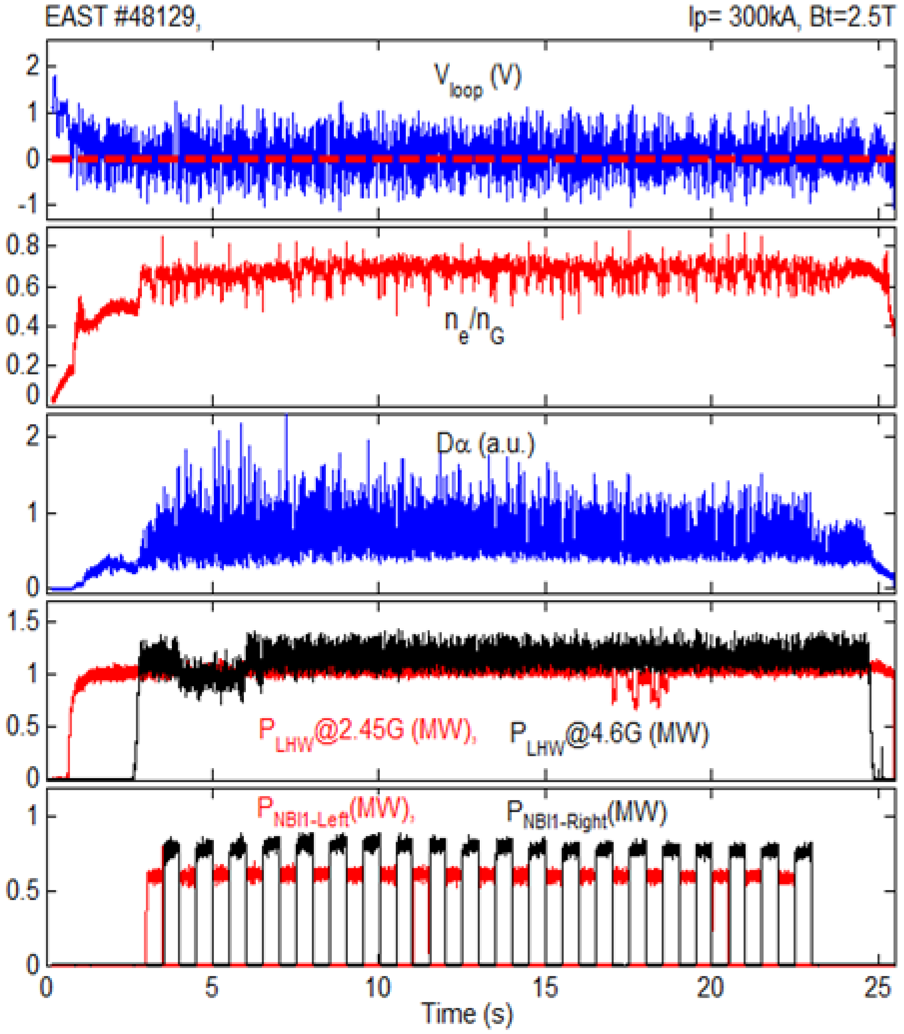


Confinement is much better than the record 32 s H-mode in 2012 campaign.



- ☐ LHCD & Li-Coating
- ☐ High δ ~ 0.55, q_{95} ~ 6.5, n_e/n_G ~ 0.55
- ☐ Presence of an ECM ~ 30kHz
- ☐ Peak heat flux: < 3MW/m^2

Long Pulse H-mode with LHCD+NBI

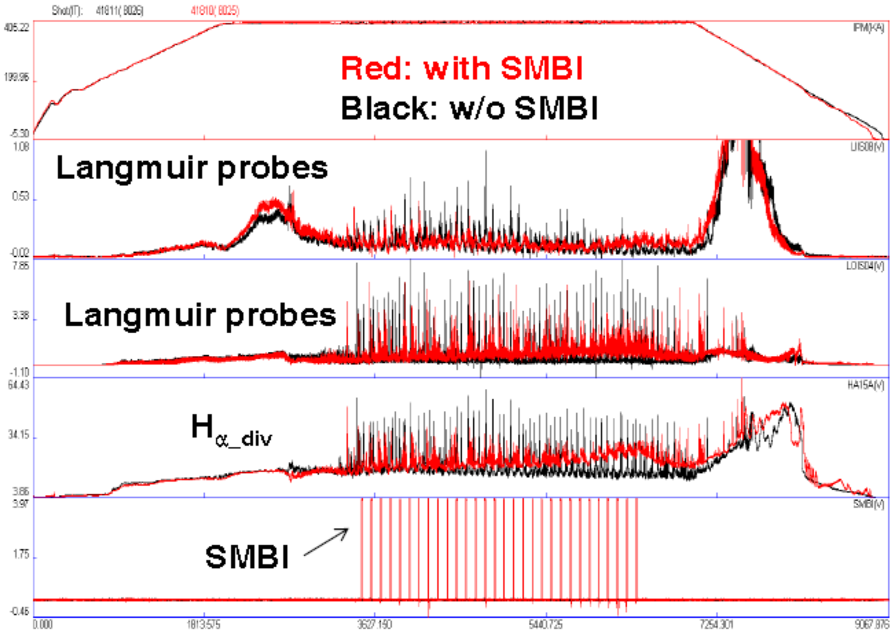


- ☐LHCD+NBI modulation
- ☐P_{NBI}=1.2 MW
- ☐$P_{LHW,2.45G}$=1.0MW
- ☐$P_{LHW, 4.6G}$=1.2MW
- ☐n_e/n_G ~0.7
- ☐V_{Loop}<0.04V
- ☐T_d>20S, Small ELM
- ☐Controllable density

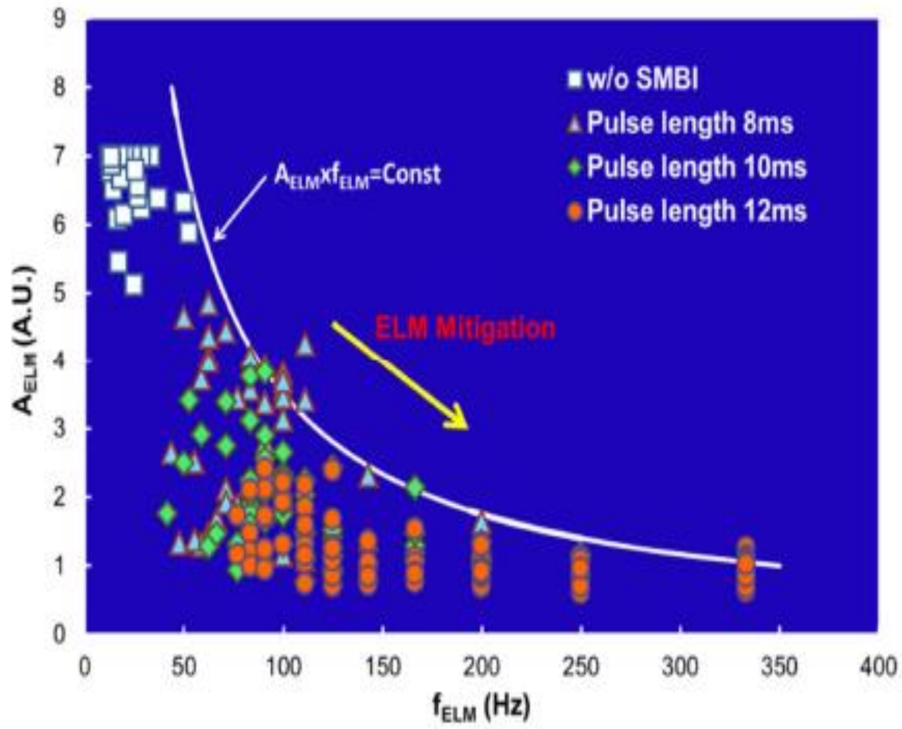
ELM Control（p, j)

- SMBI
- Impurity gas puffing
- LHCD
- Li pellet injector
- D2 Pellet
- LHCD+SMBI
- RMP Coils
- ECRH, ICRH

ELM control by SMBI



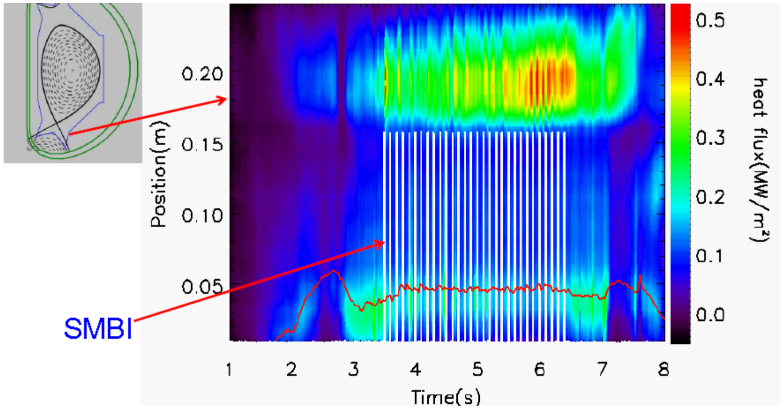
400kA/LSN/LHW-1.5MW/ICRF-1.1MW



ELM amplitude reduce by a factor of 3

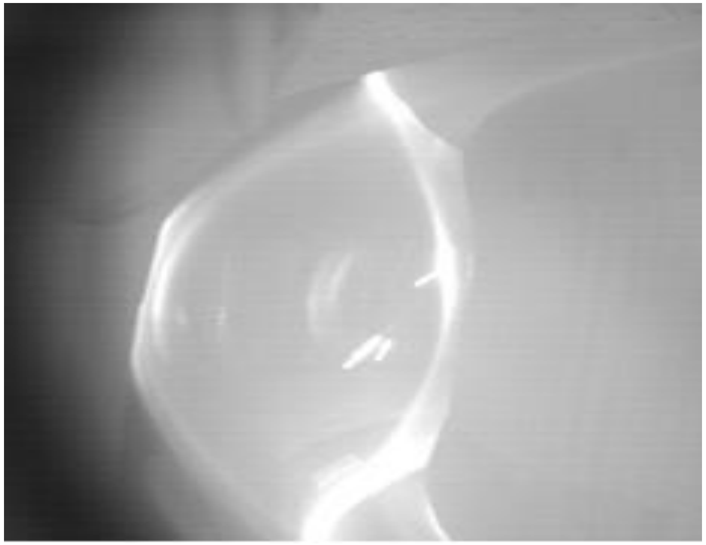
ELM frequency increase by a factor of 6

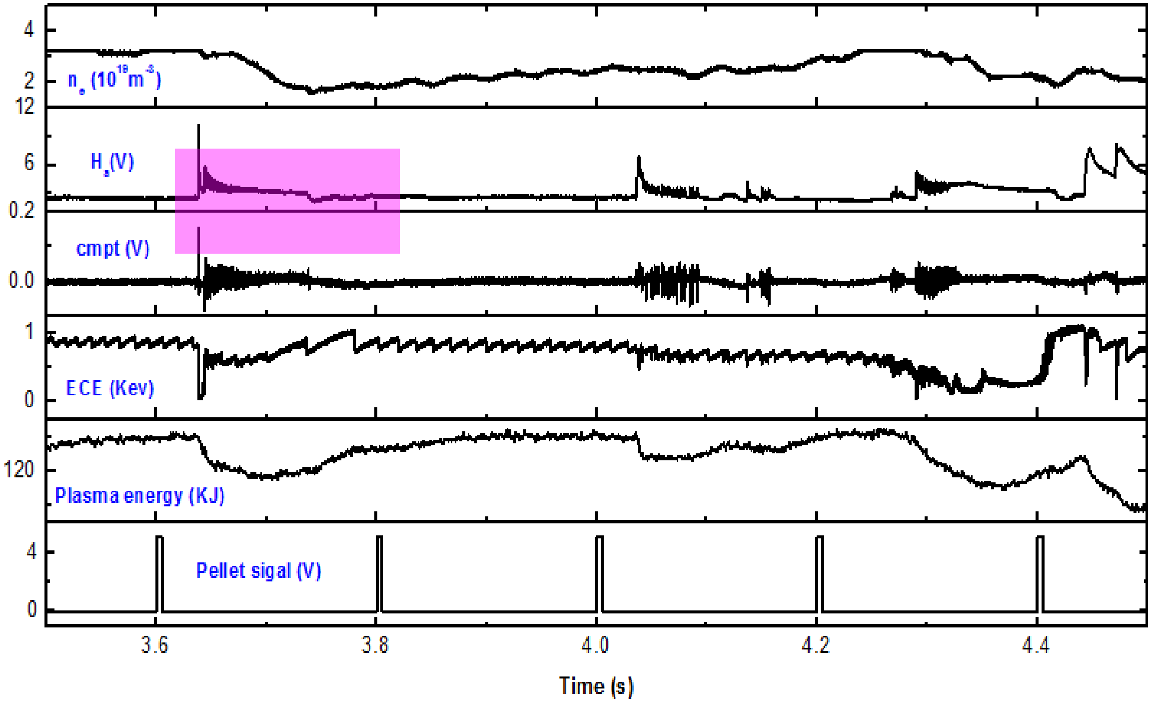
Higher frequency of SMBI, smaller ELM

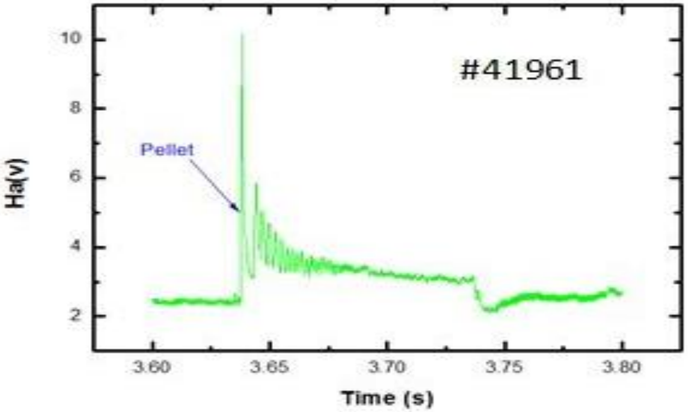


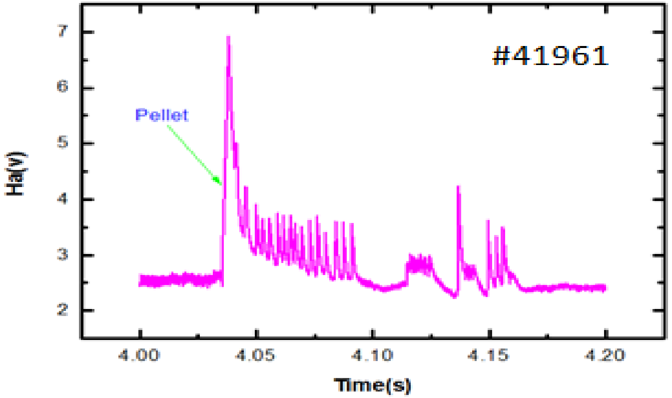
The SMBI increase the striated heat flux and decrease the heat flux at OSP region

ELM control by pellets

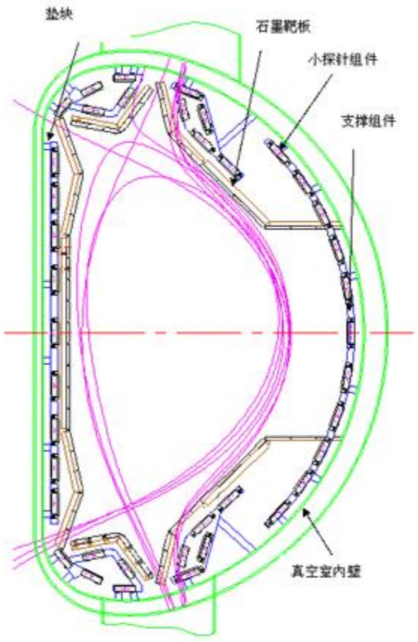




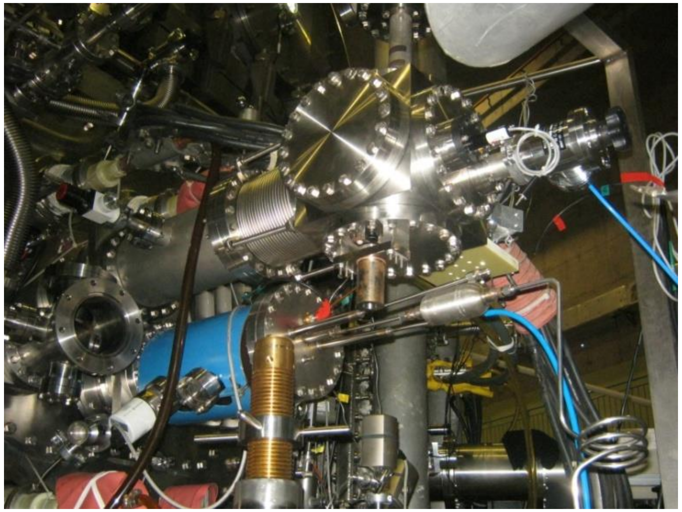


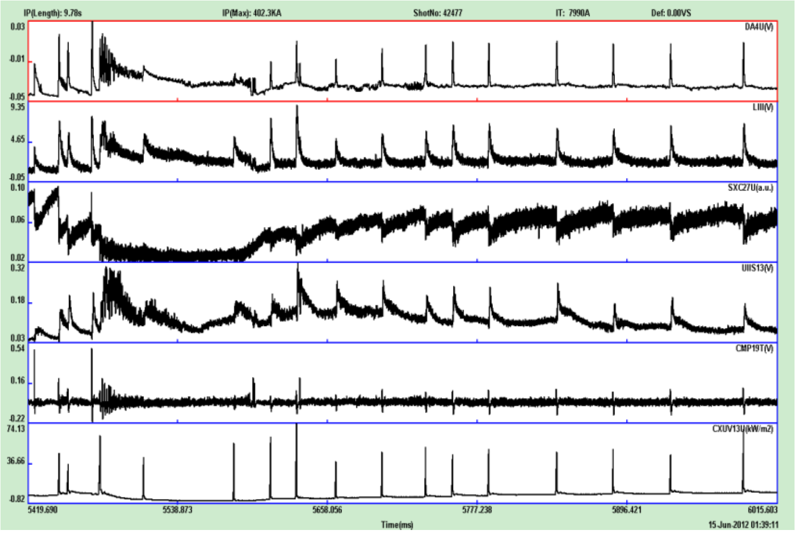


ELM control by Low Velocity Li Granule Injection



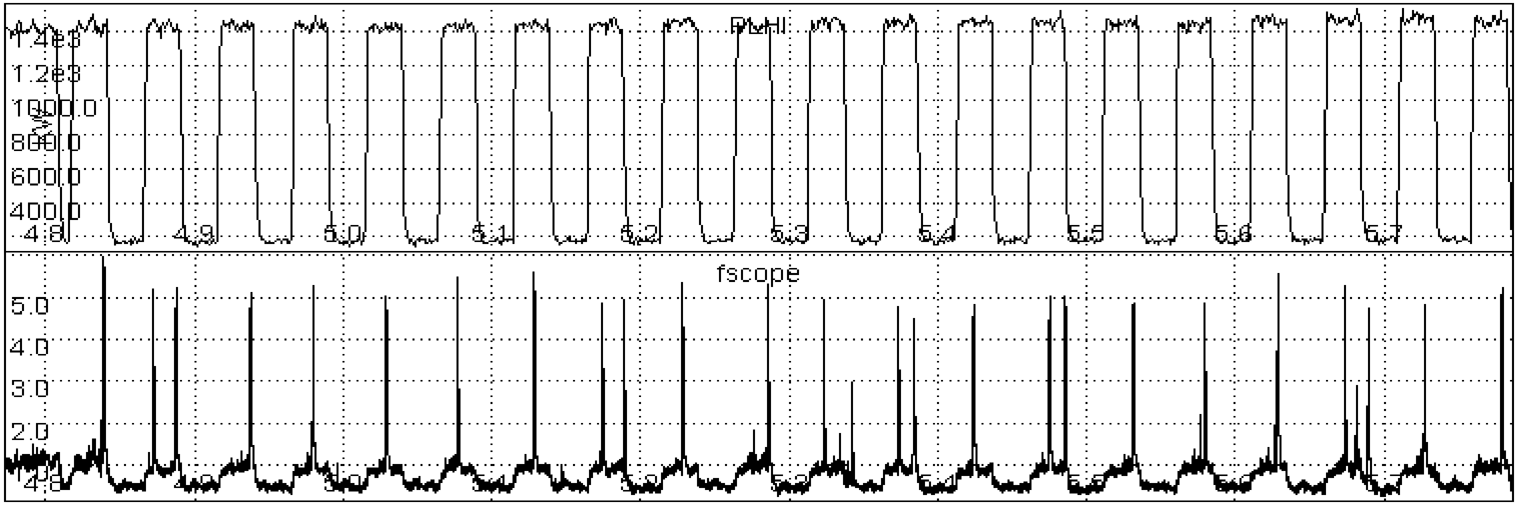
小探针在真空室内截面安装位置



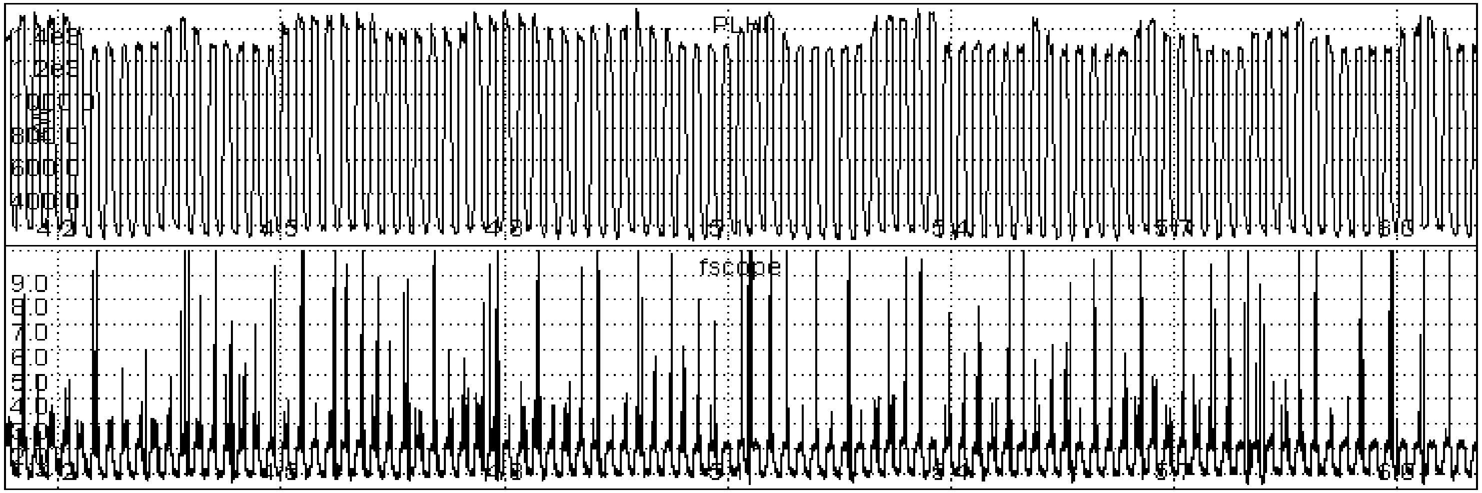


Li Granule
Size:0.2,0.4,0.6,0.7mm
Velocity:20-200m/s

ELM Pacing by LH modulation

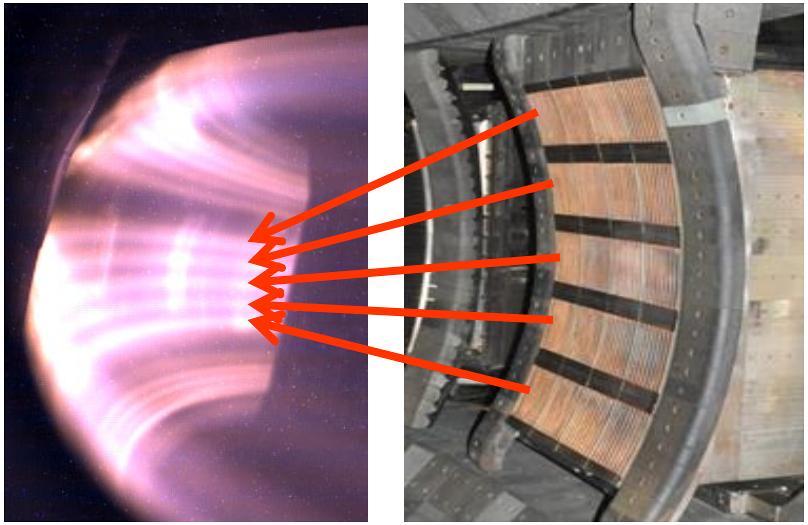


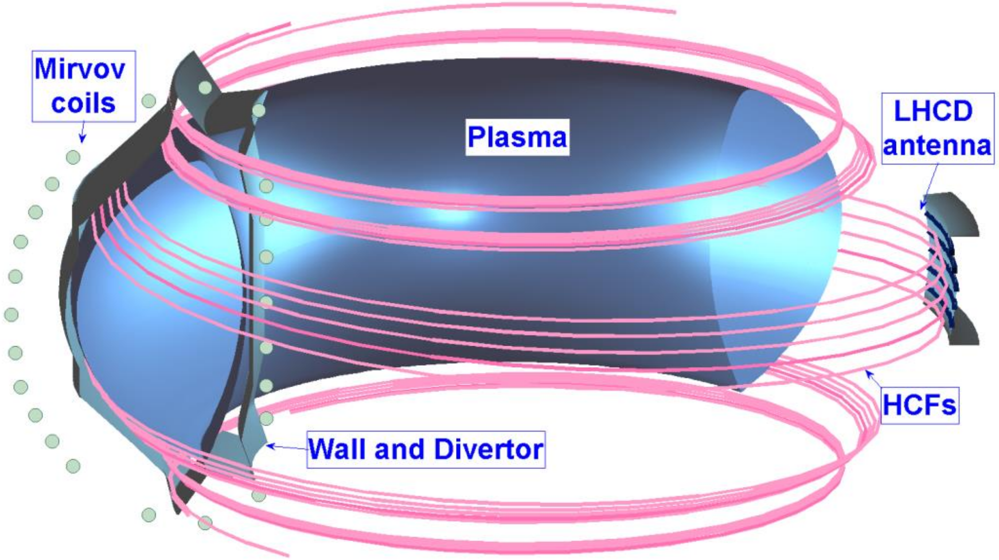
20 Hz

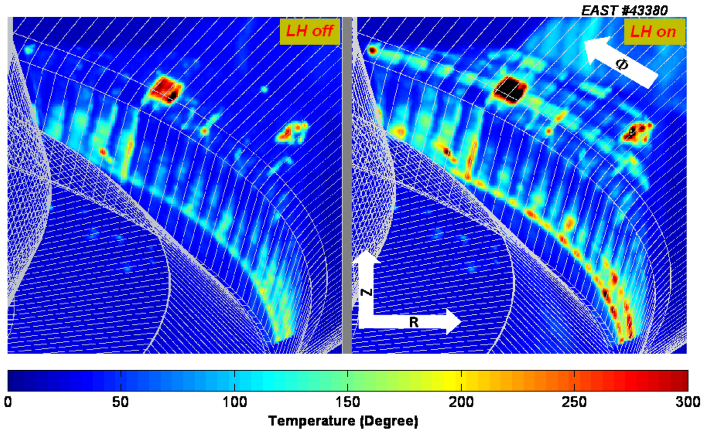


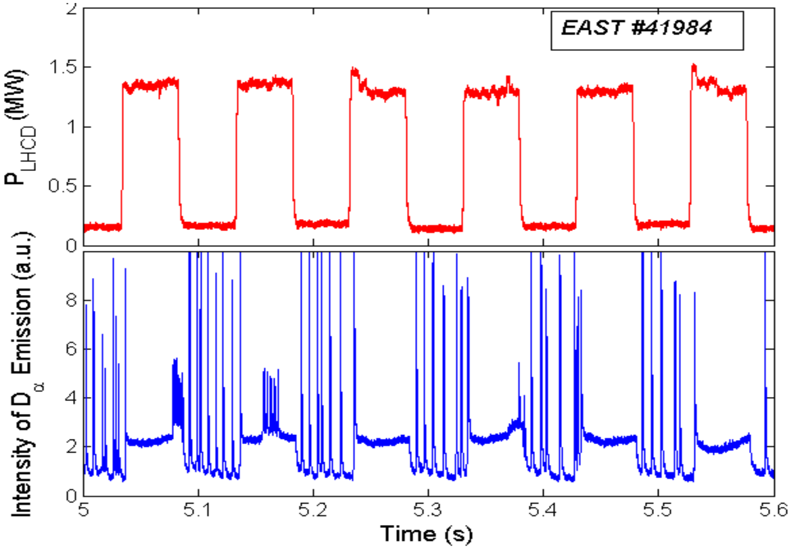
50 Hz

RMP-like features by LHCD+ SMBI



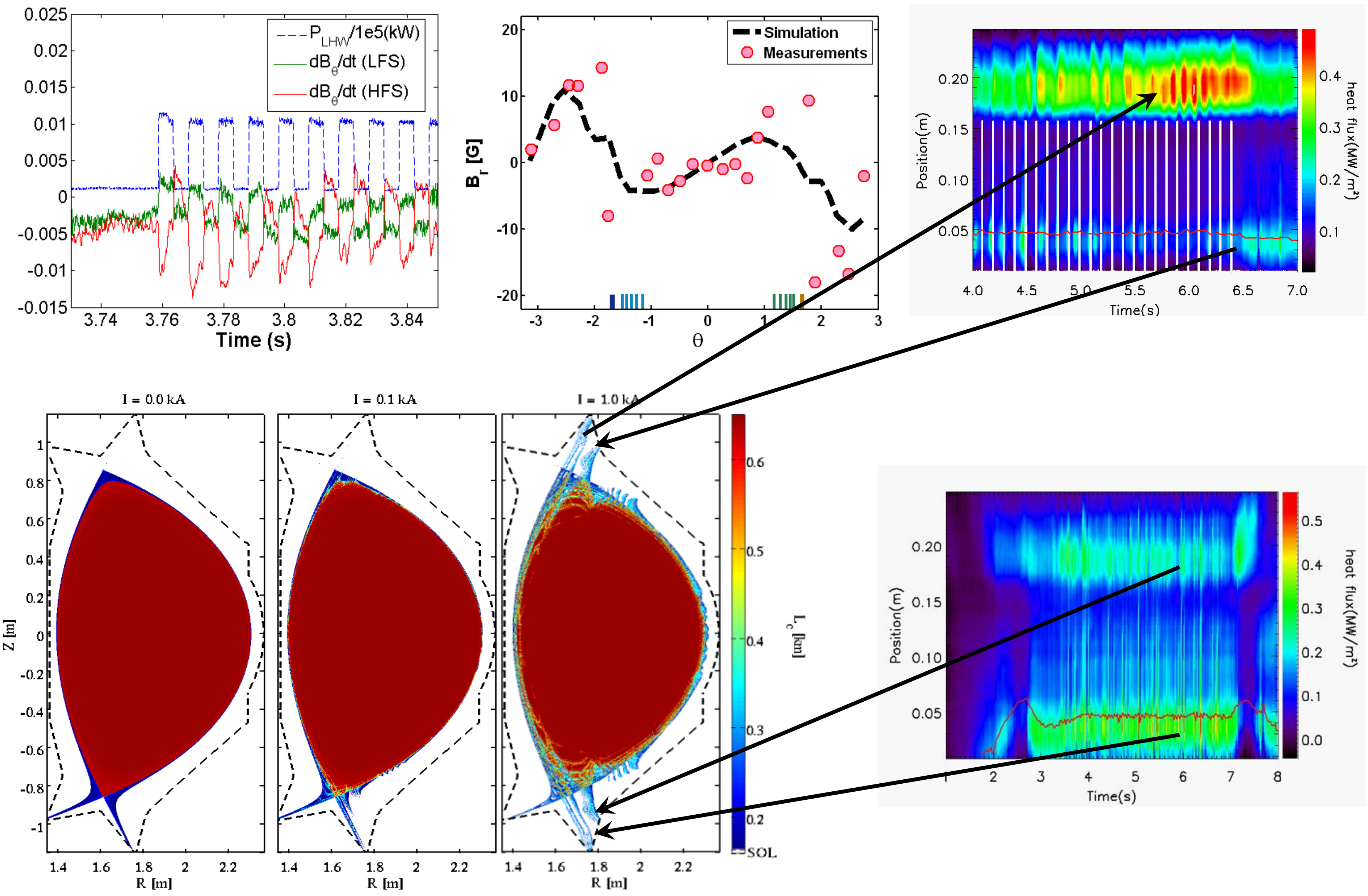




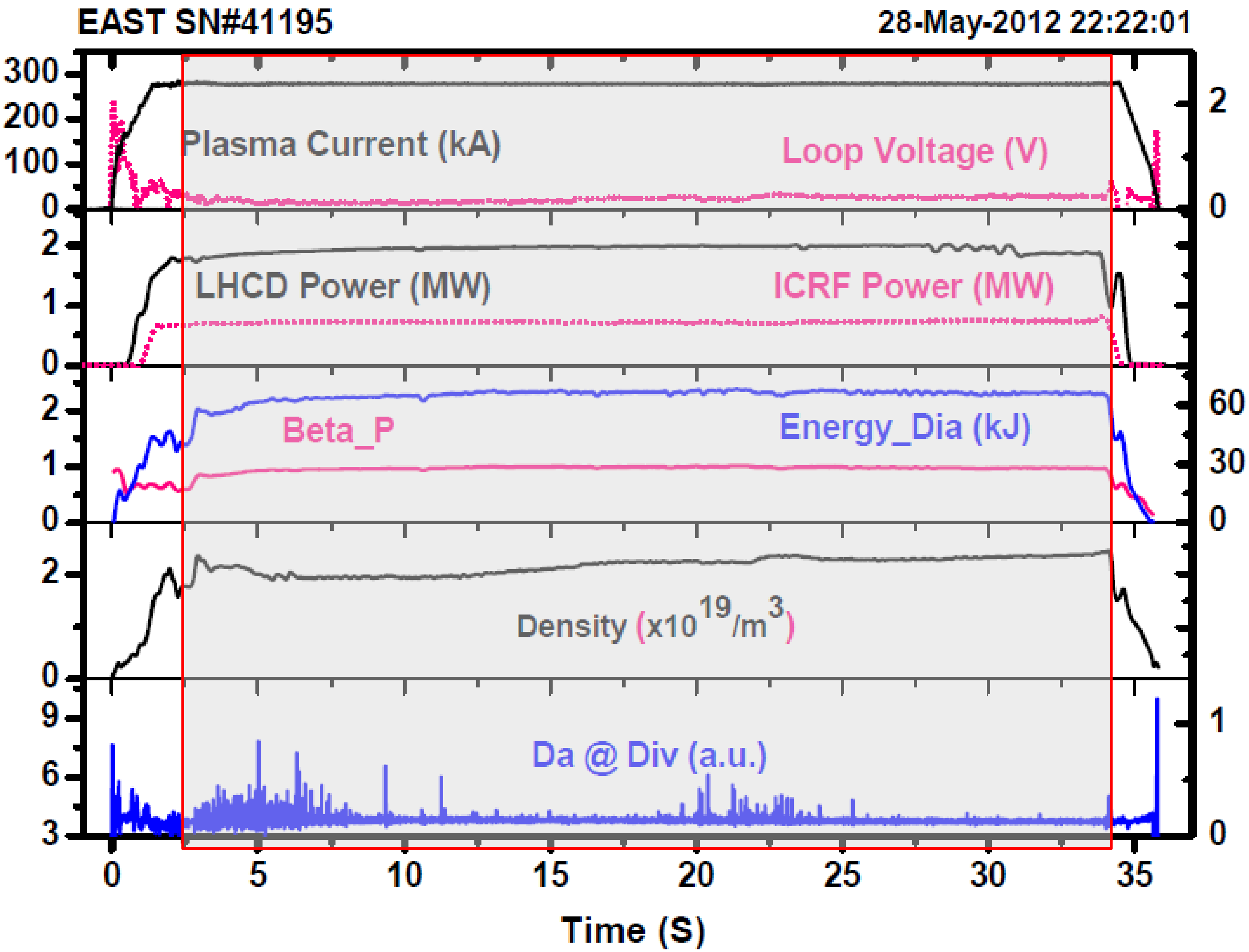


Y. F. Liang, et al., IAEA FEC 2012

Two strike points on the targets: reduce heat loads



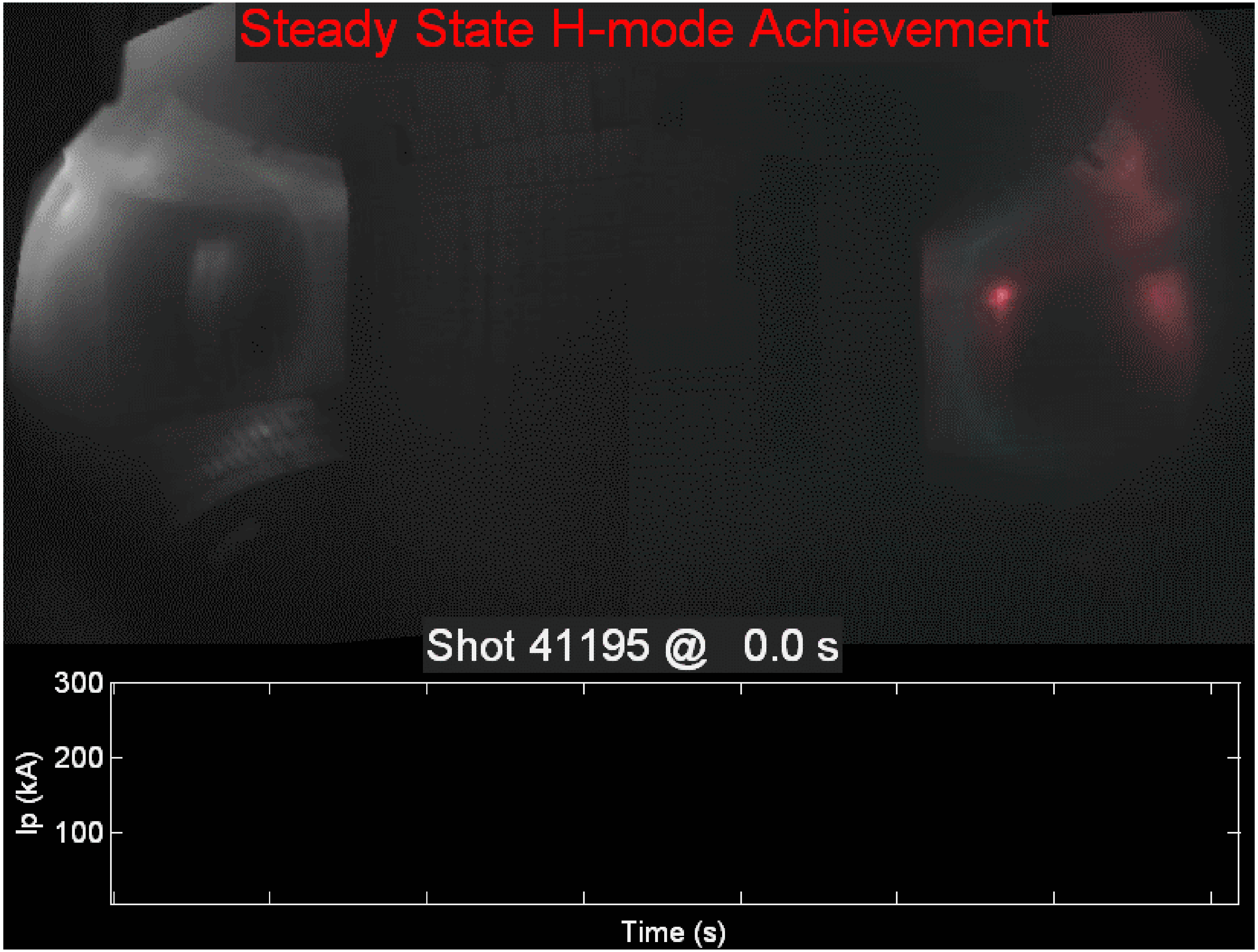
Stationary H-mode up to 32s achieved



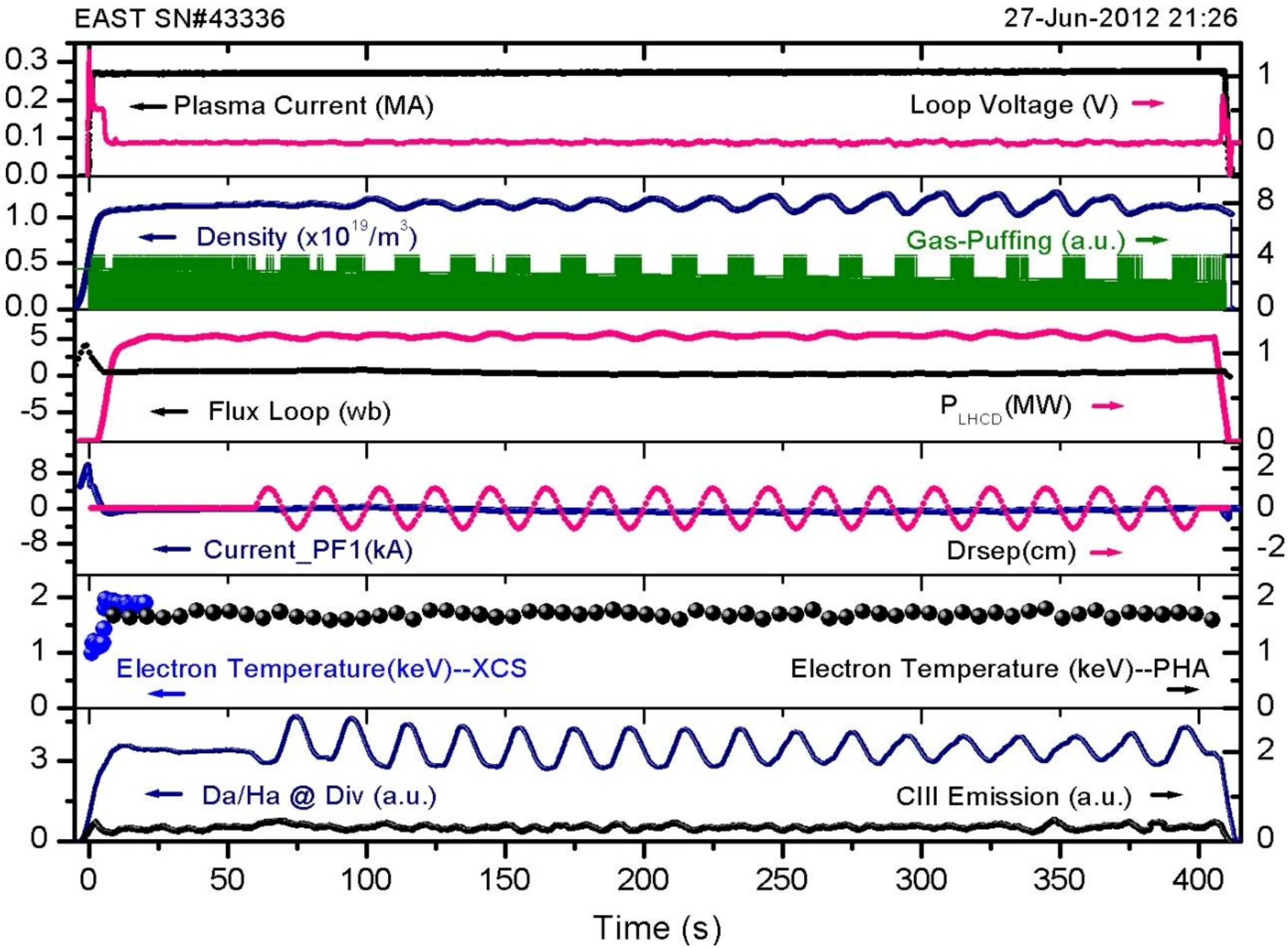
Ip ~0.28MA, Bt~1.85T, P_{LH} ~2.0 MW, P_{RF}~0.75MW, f=27MHz, Beta_P~1.0, H_{98}~0.8

Similai shots: 41181,41182,41183

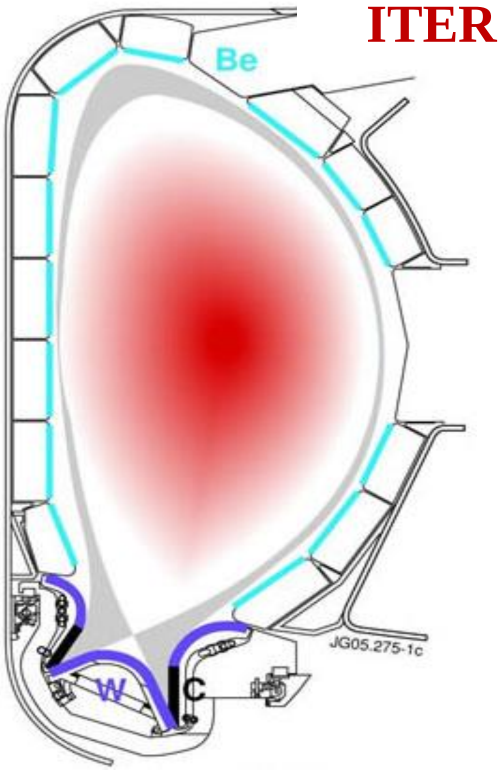
30s H-mode

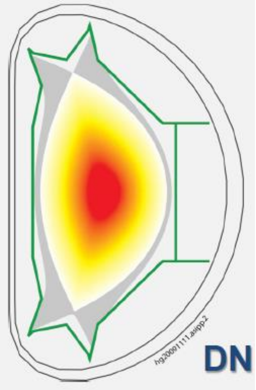

Steady State H-mode Achievement
Shot 41195 @ 0.0 s
300
200
100
Ip (kA)
Time (s)

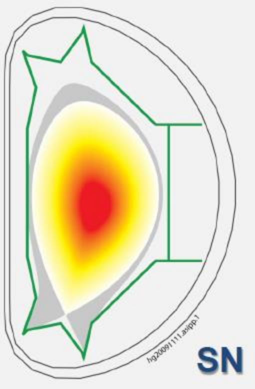
411s steady-state discharge



PFC Strategy for ATSSO







- Initial phase (2006-2007)

  PFM ⇨ SS plates bolted directly to the support without active cooling
- First phase (2008-2012)

  PFM ⇨ SiC-coated doped C tiles bolted to Cu heat sink ~2MW/m^2
- Second phase (2013-2016)

  Full W, Actively-cooled ITER W/Cu divertor , 10MW/m$^{2.}$
- Last phase (2017---)

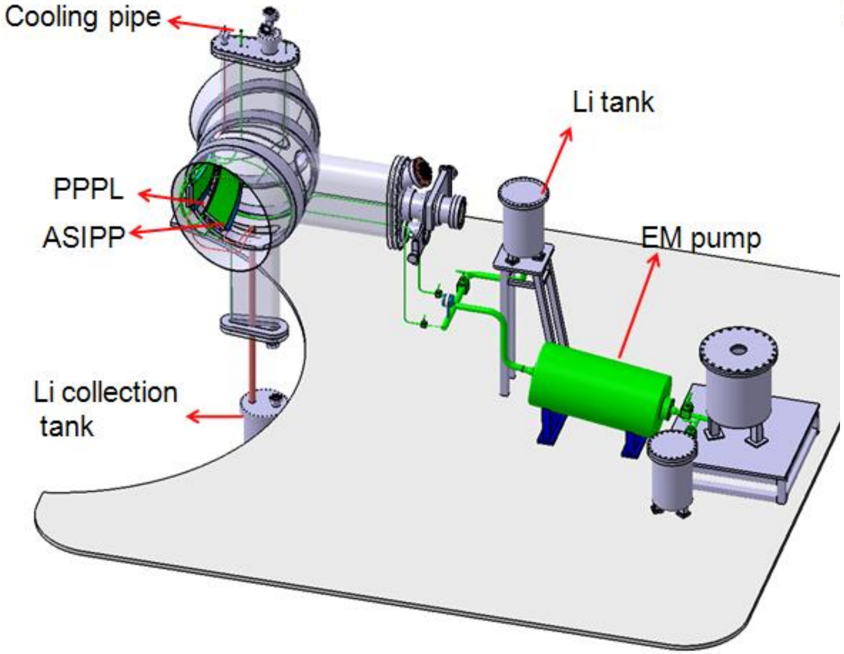
  High Tw operation（>400C) by hot He Gas 15MW/m$^{2.}$

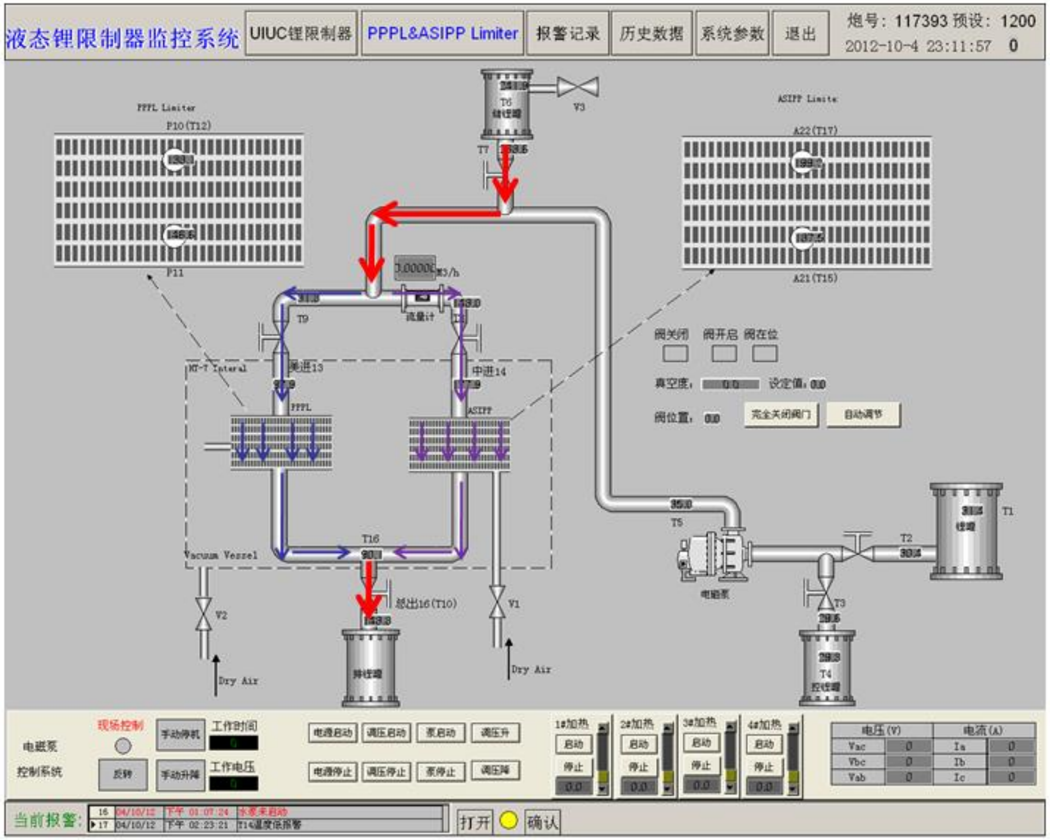
  \+ Flow LSN Li divertor（2014-2018, a national team has been built, 6M$）

Edge Simulation under H-mode

With LLNL, ENEA, TS, ITER-IO

System introduction of flowing Li limiter of ASIPP and PPPL

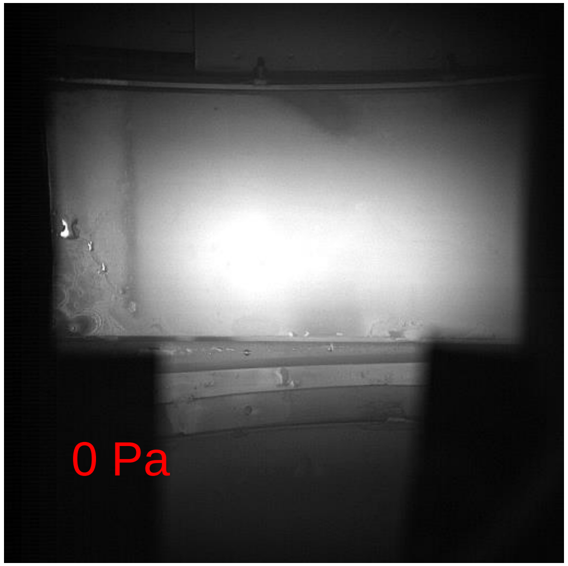


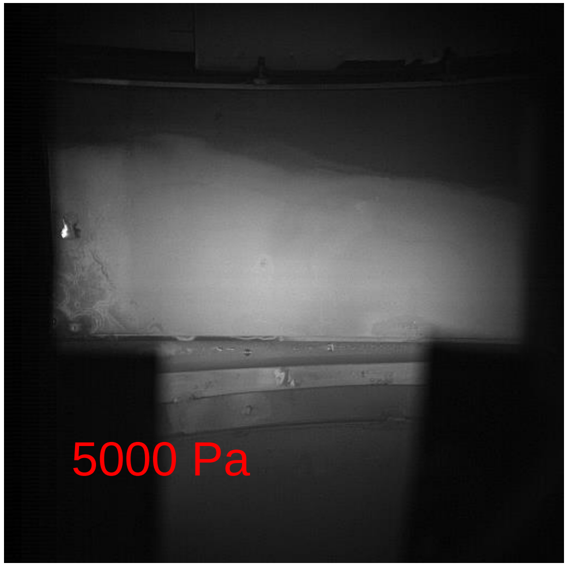


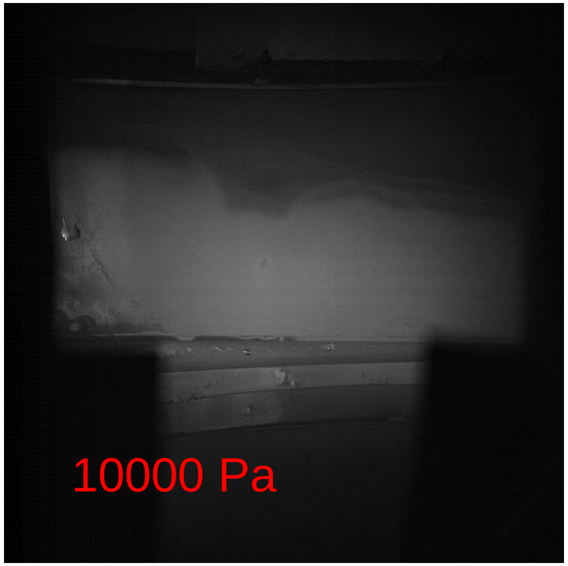
电压(V)		电流(A)	
Vac	0	Ia	0
Vbc	0	Ib	0
Vab	0	Ic	0

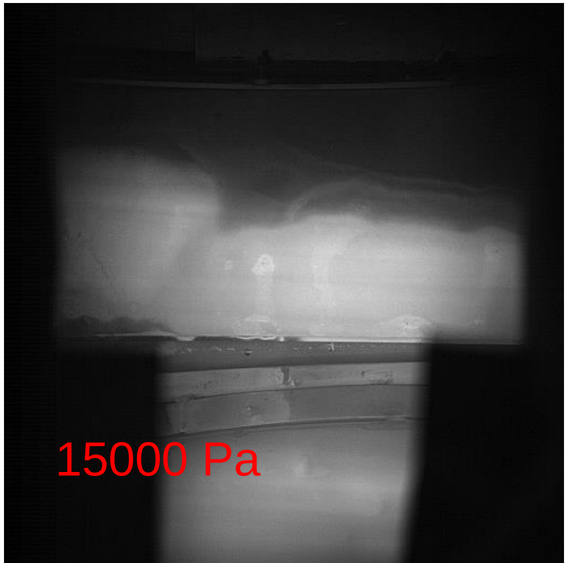
```
16  04/10/12  下午 01:07:24  水泵未启动
17  04/10/12  下午 02:23:21  T14温度低报警
```

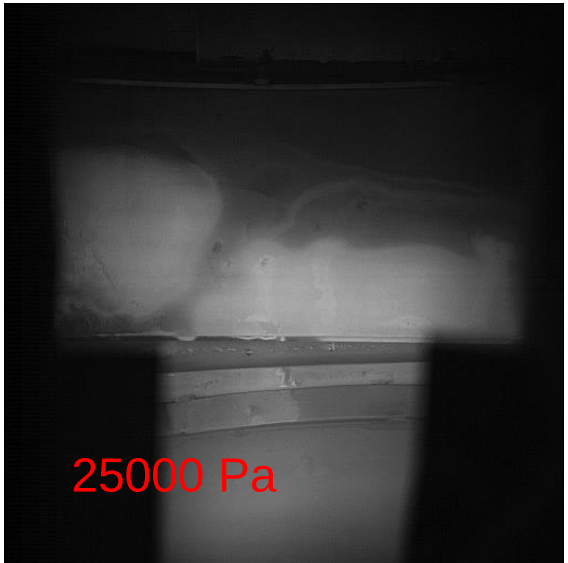
Lithium slowly moving on the surface

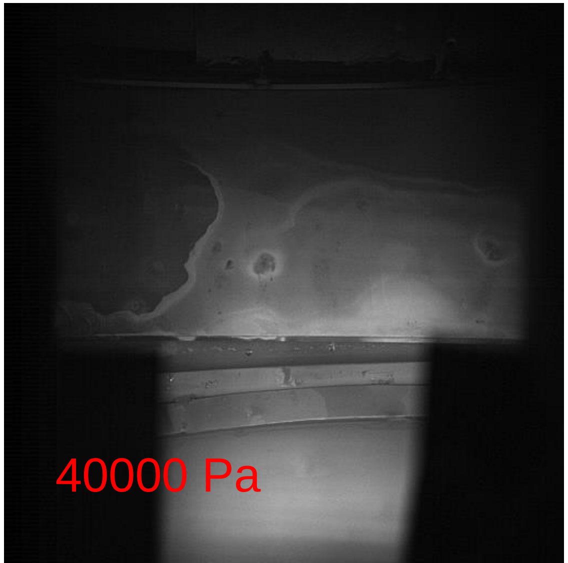




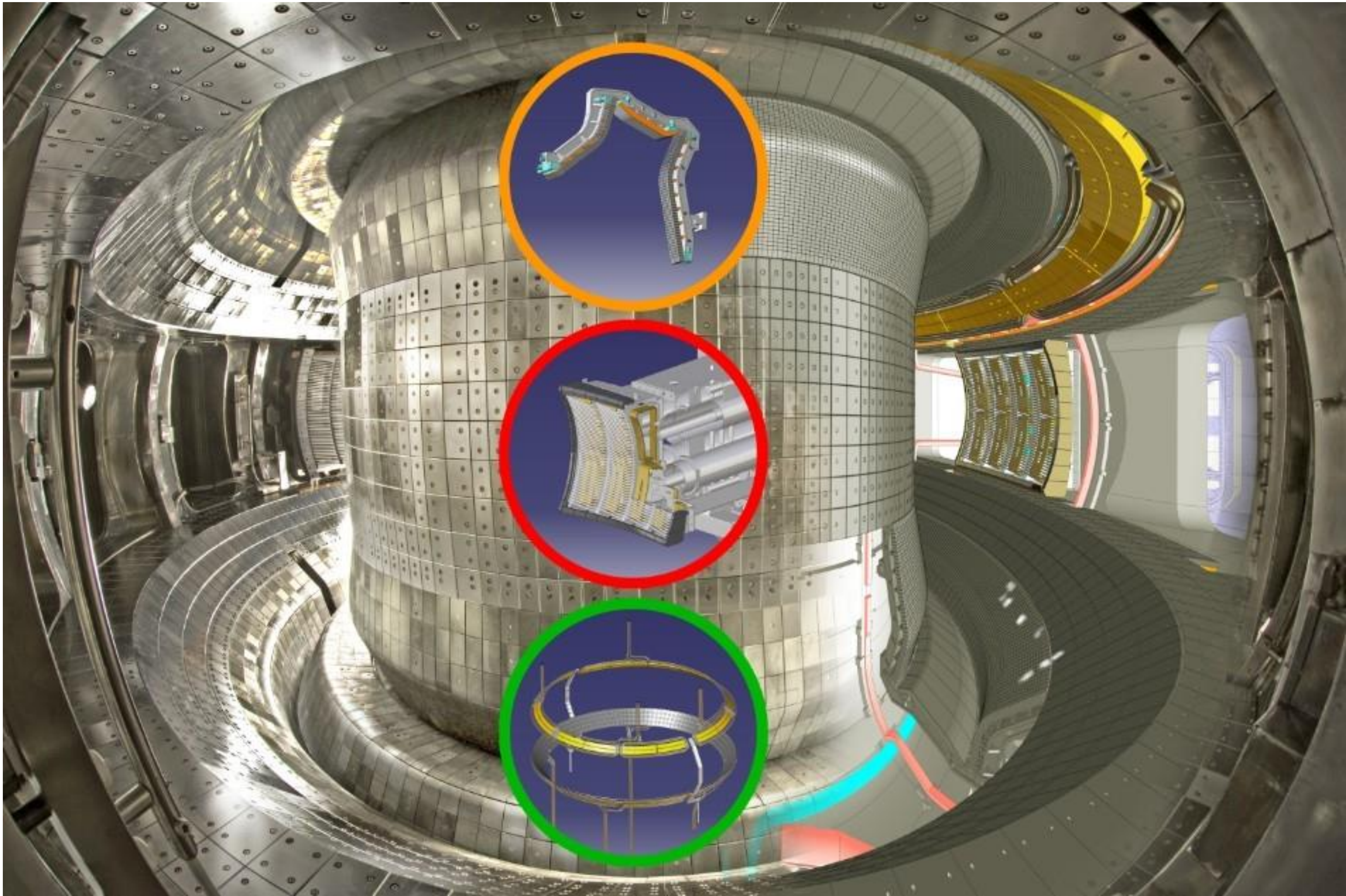




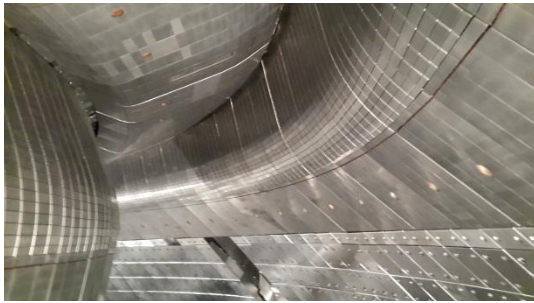


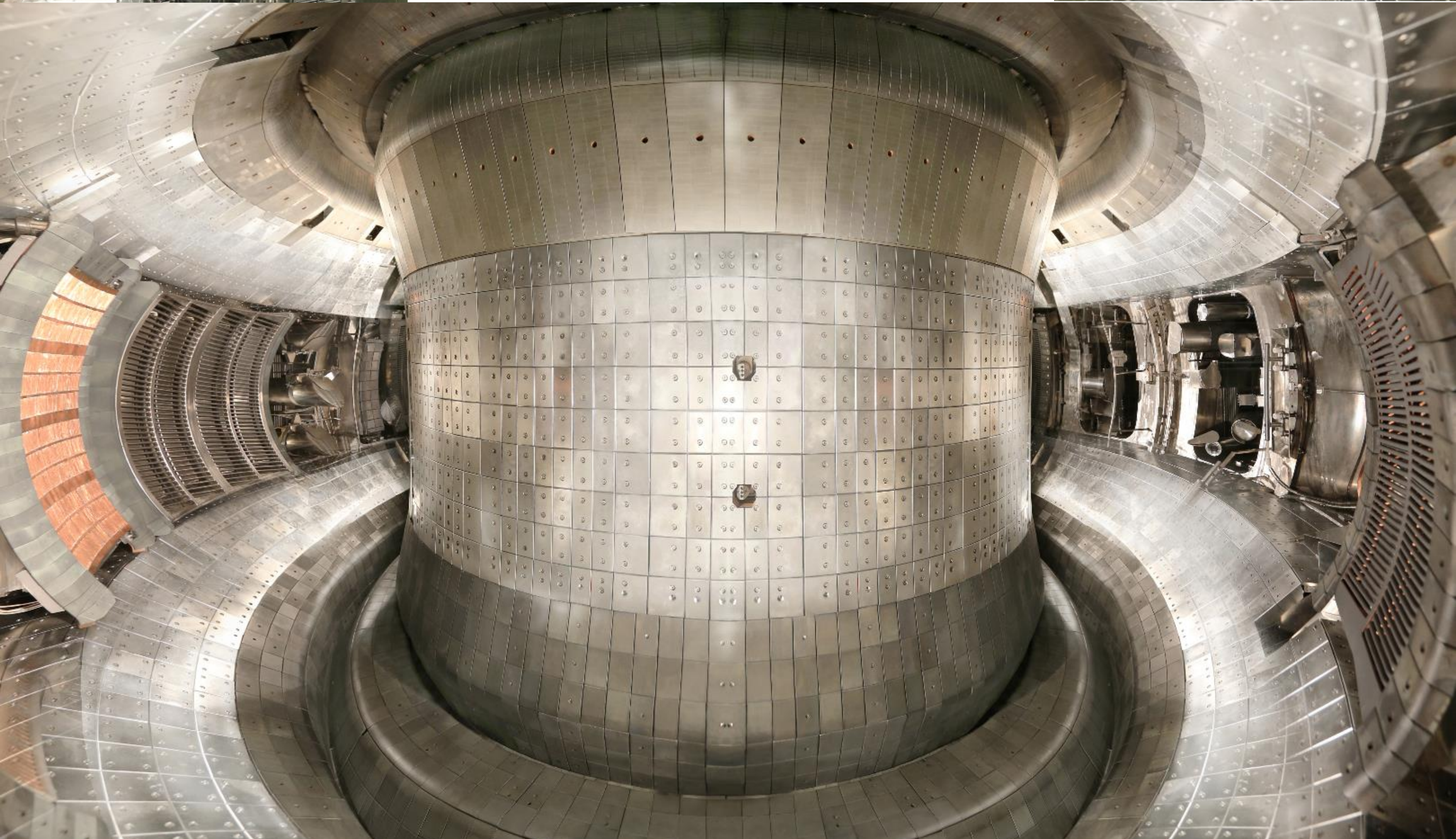


Upgrade of EAST (>98,000)



EAST 2014 PFC



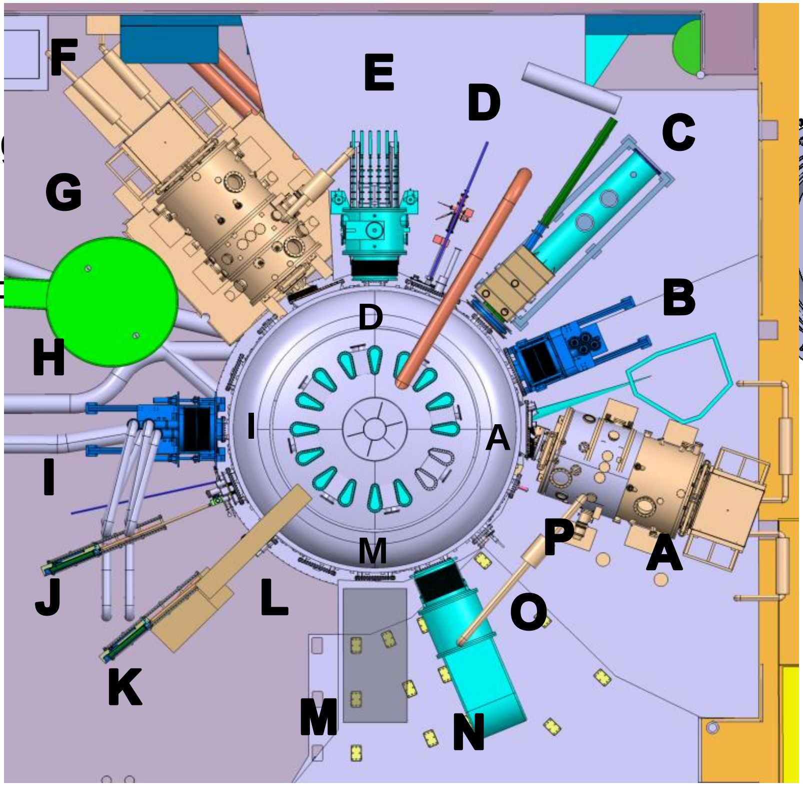


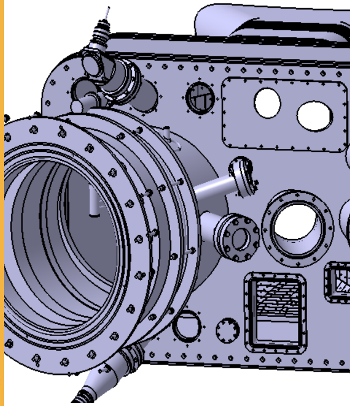
Distribution of the EAST Diagnostics

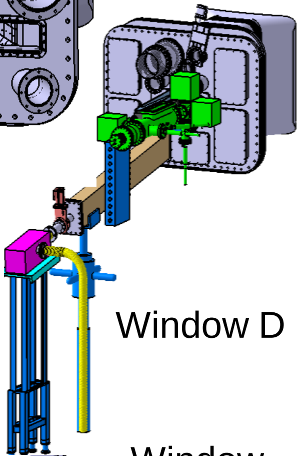
A. NBI+Diag.
B. ICRF
C. Inner Pump+Dia
D. Diag.
E. LHCD
F. NBI（ITER ICRF
G. Diag.
H. MAPES+Diag.
I. ICRF
J. IC+Diag.
K. IC+Diag.
L. TS+Baking pipe
M. ECRH+edge TS
N. LHCD
O. Diag.
P. Diag.

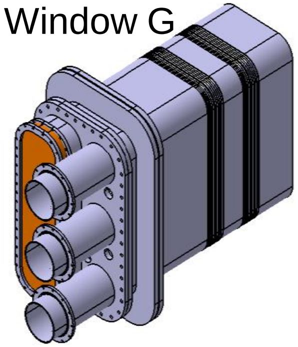
Horizontal：

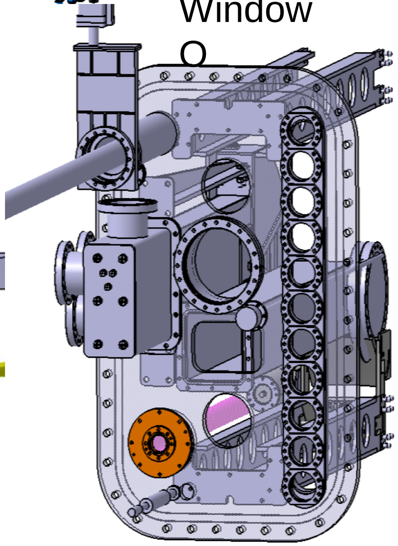
C, D, G, H, J, K, O and P

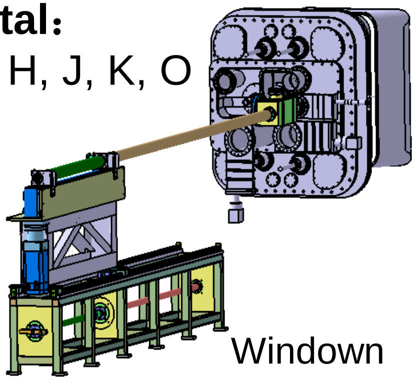


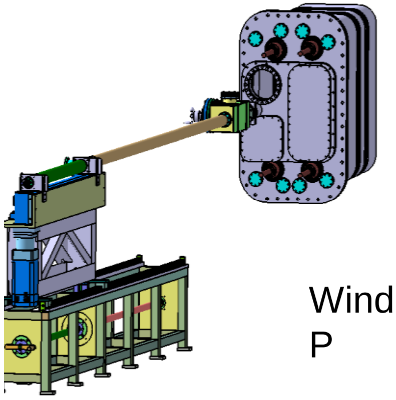

WindowA

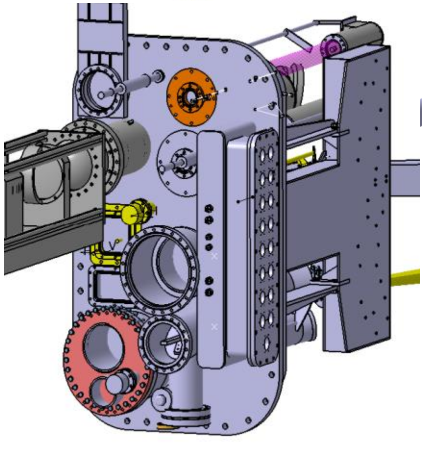

Window D


Window G


Window O


Window J

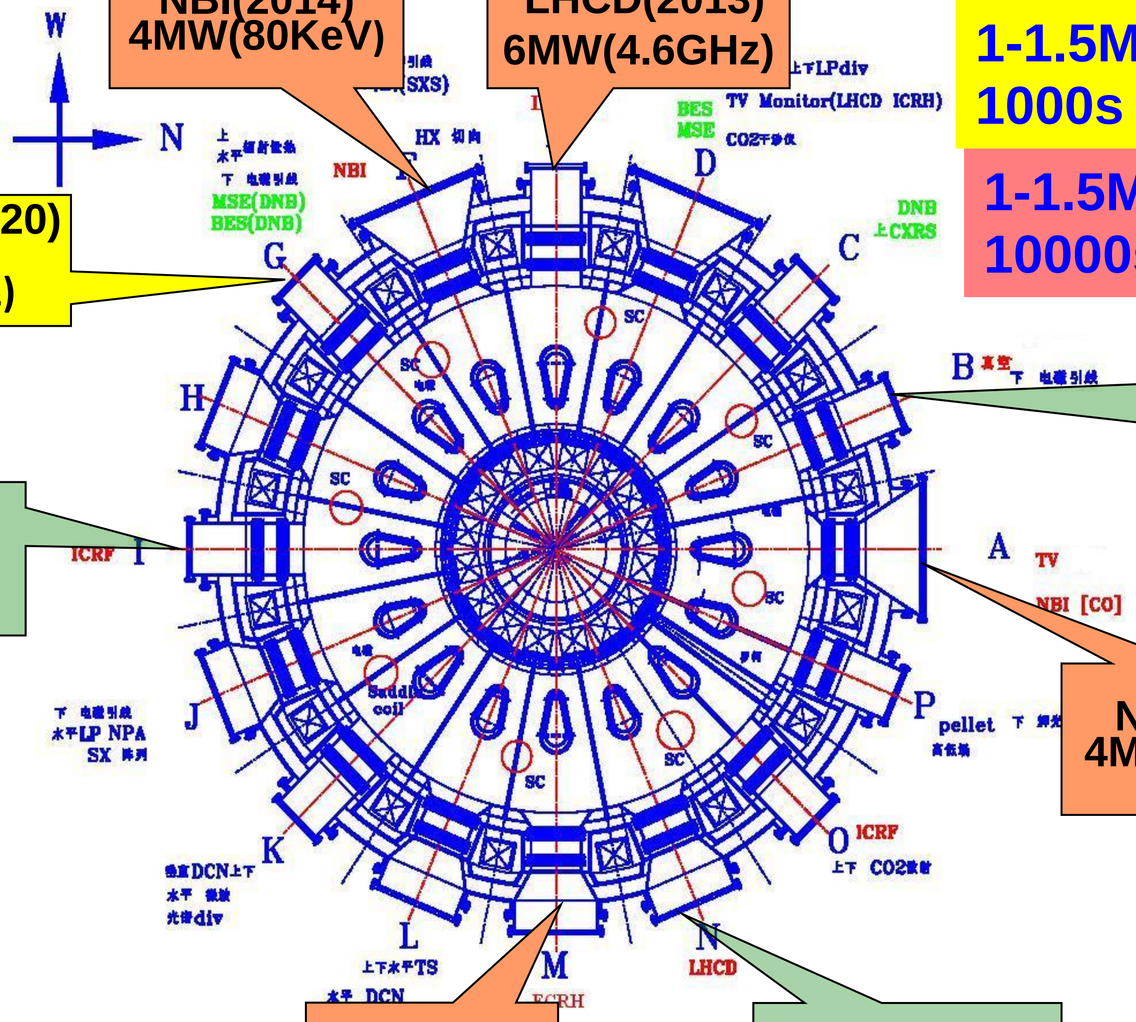

Windown K


Windown P

Future(2015-2020)

1-1.5MA, 1000s, 3.5-4T, 1000s H, 34MW@2016

1-1.5MA, 10000s, 3.5-4T, 10000s H, 40MW@2018



NBI(2014)
4MW(80KeV)

LHCD(2013)
6MW(4.6GHz)

ECH(2016-20)
6MW
(170GHz)

RF(2013)
6 MW
30-100MHz

RF(2013)
6 MW
20-70MHz

NBI(2013)
4MW(80KeV)

ECR(2015)
4MW

LHCD
4MW(2.45)

Outline

Present state of MCF in China

EAST Progress

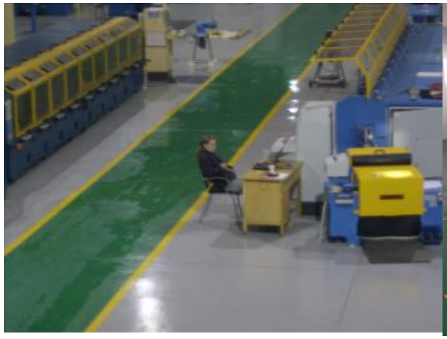
CN-ITER Activities

Next Step-CFETR

Summary

ITER-Conductor

TF finished -Early than schedule!



Wire: NICNC,Oxford

Coating:Shenghai Ltd

Wire testing:ASIPP

Central tube: Tai Steel,

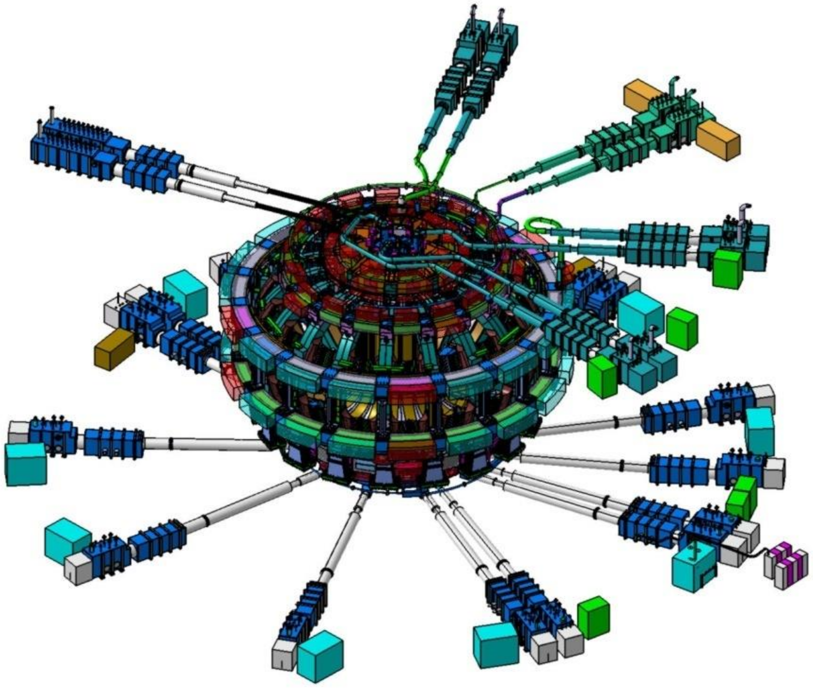
Cabling: Basheng Ltd,

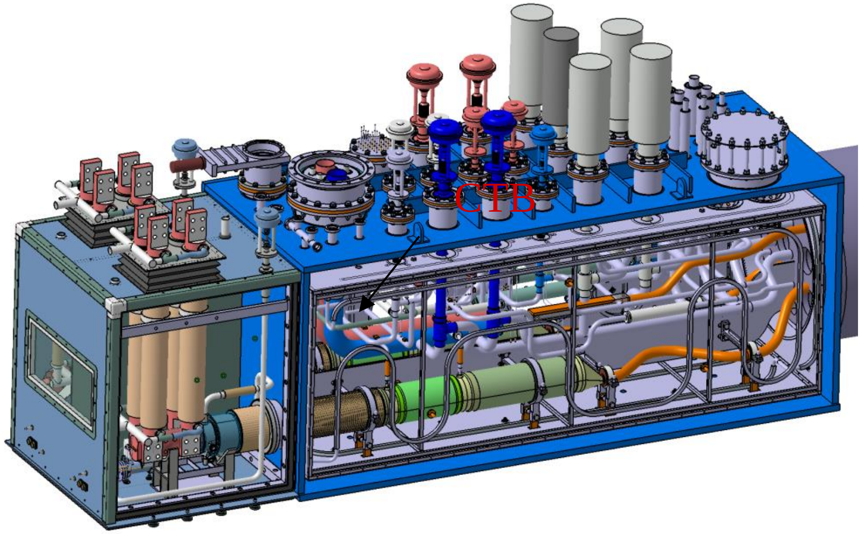
316LN Tube:

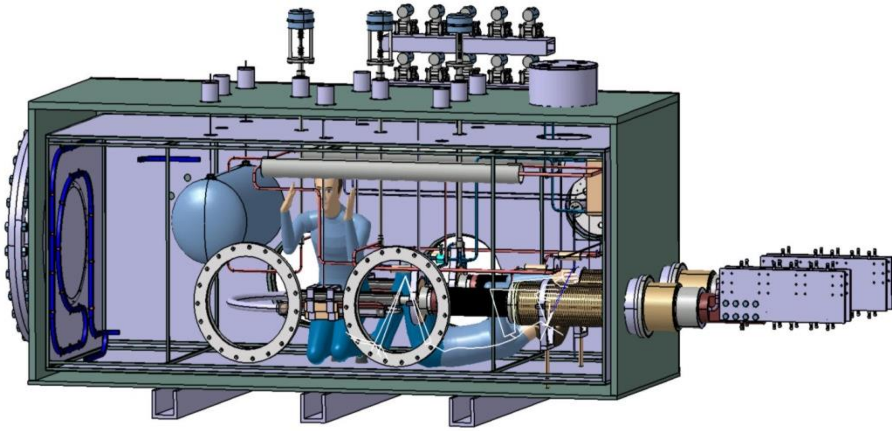
Integration:ASIPP

1000m jacketing line
In ASIPP

Feeder: Starting construction

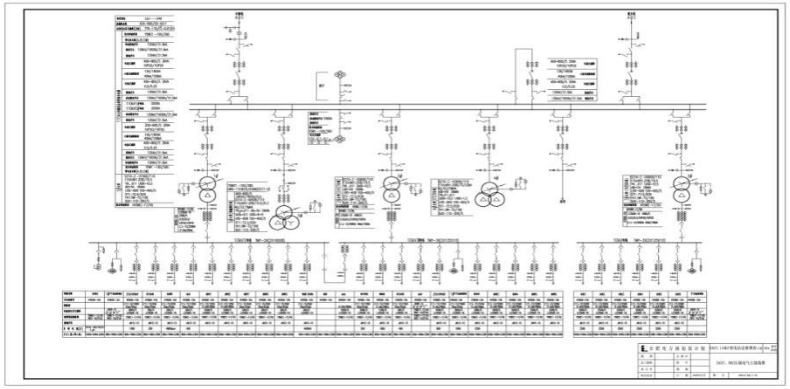






DC/AC：PS Test Facility

300 MVA HV Substation completed

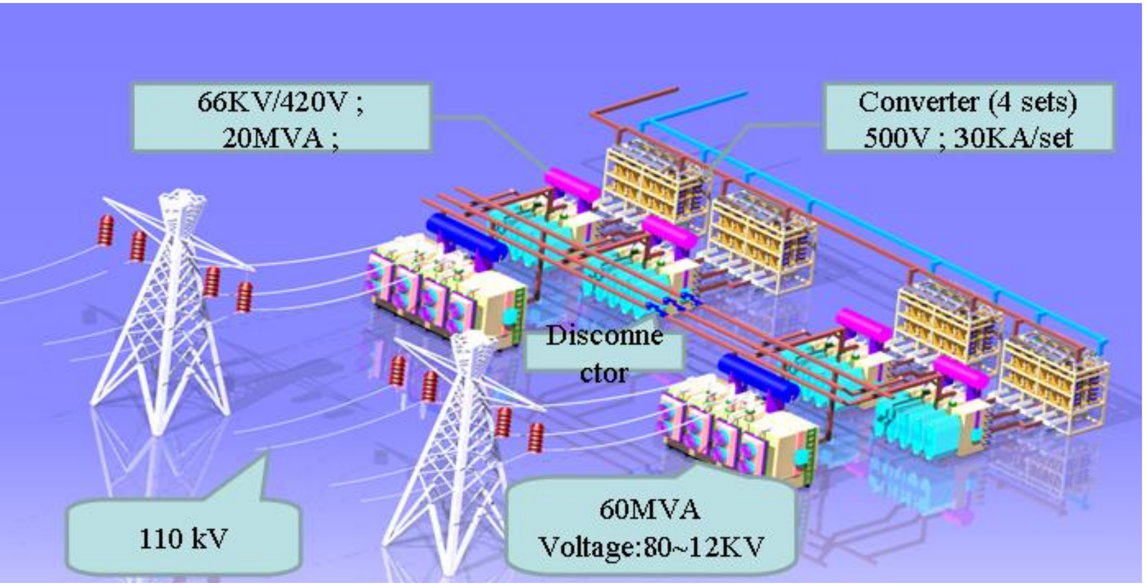


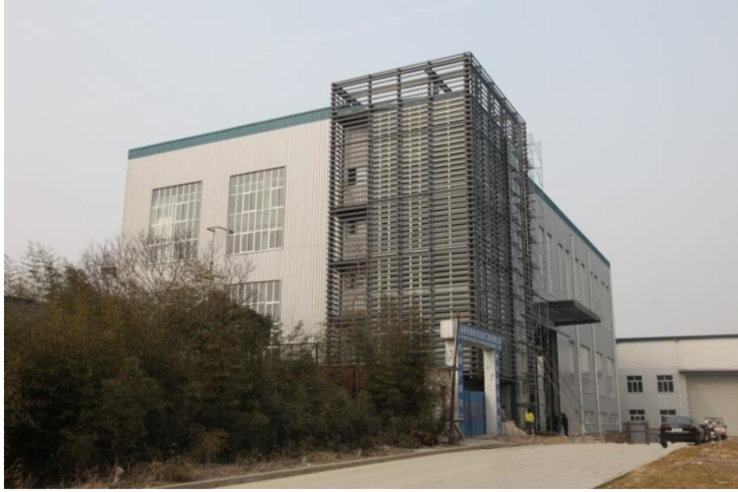
110 kV, 80 MW substation

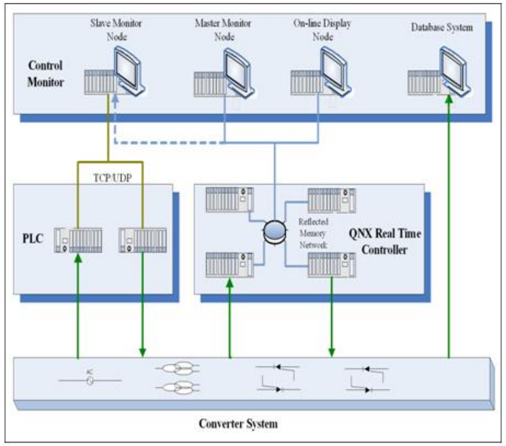
Upgrade

110 kV, 350 MW substation (6000m2)

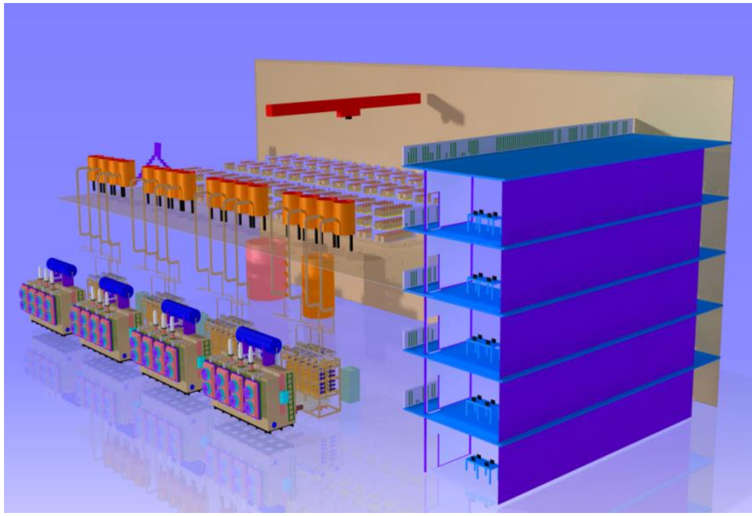
R&D：PS Test Facility







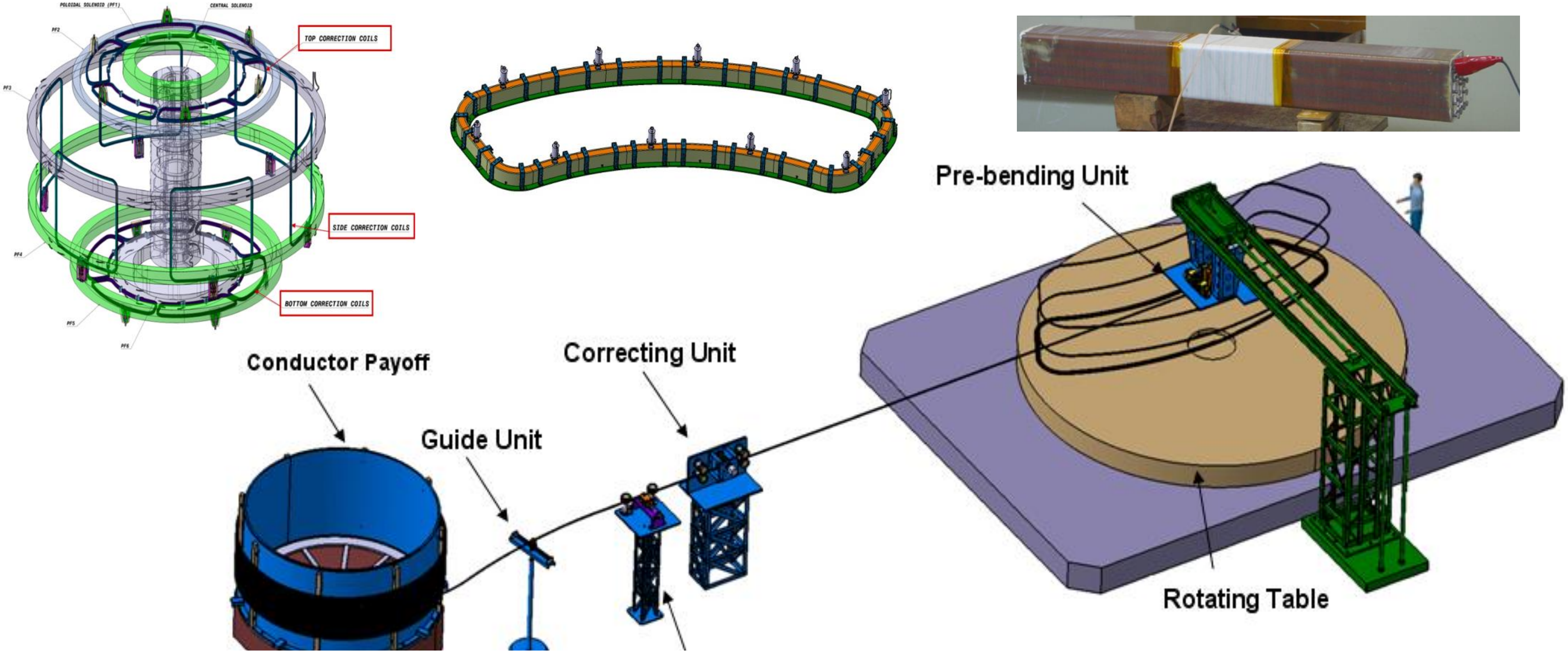
Control System for data display and monitor

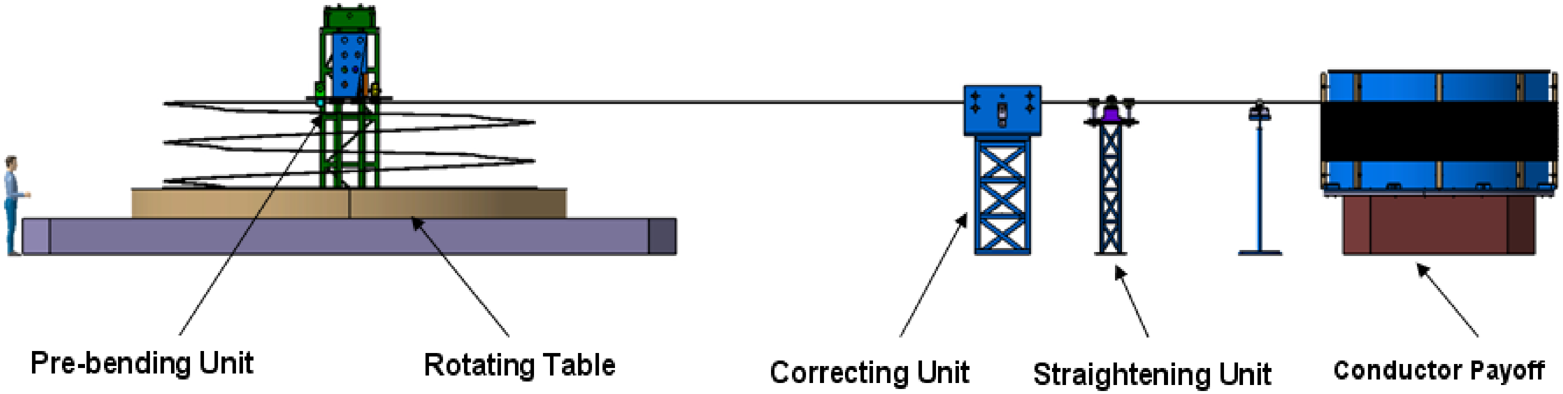


350kA,10min has been tested

CC: R&D Finished

proto-type was finished





CC: Start Construction

There are three main manufacture procedures in CC workshop:

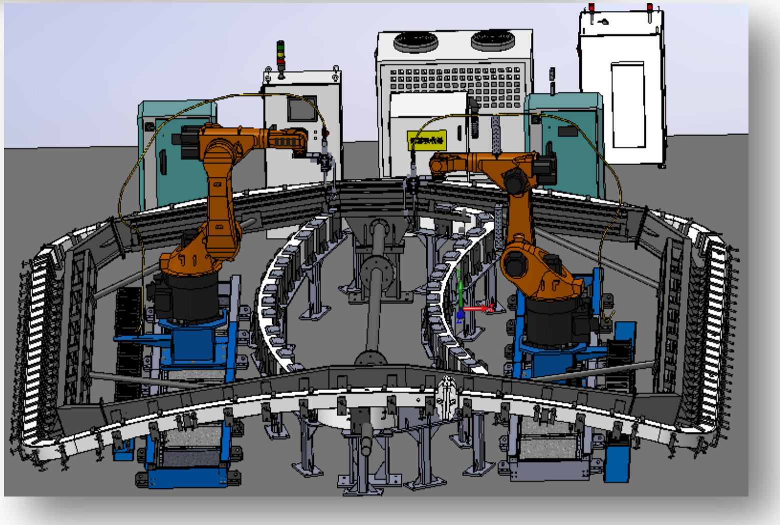
1. All equipments for Bending & Winding the CICC is on assembly;
2. VPI equipments used on insulation procedure are ready;
3. The Laser Beam Welding system for case enclosure is on factory test.

1

2

3rd VPI test

3

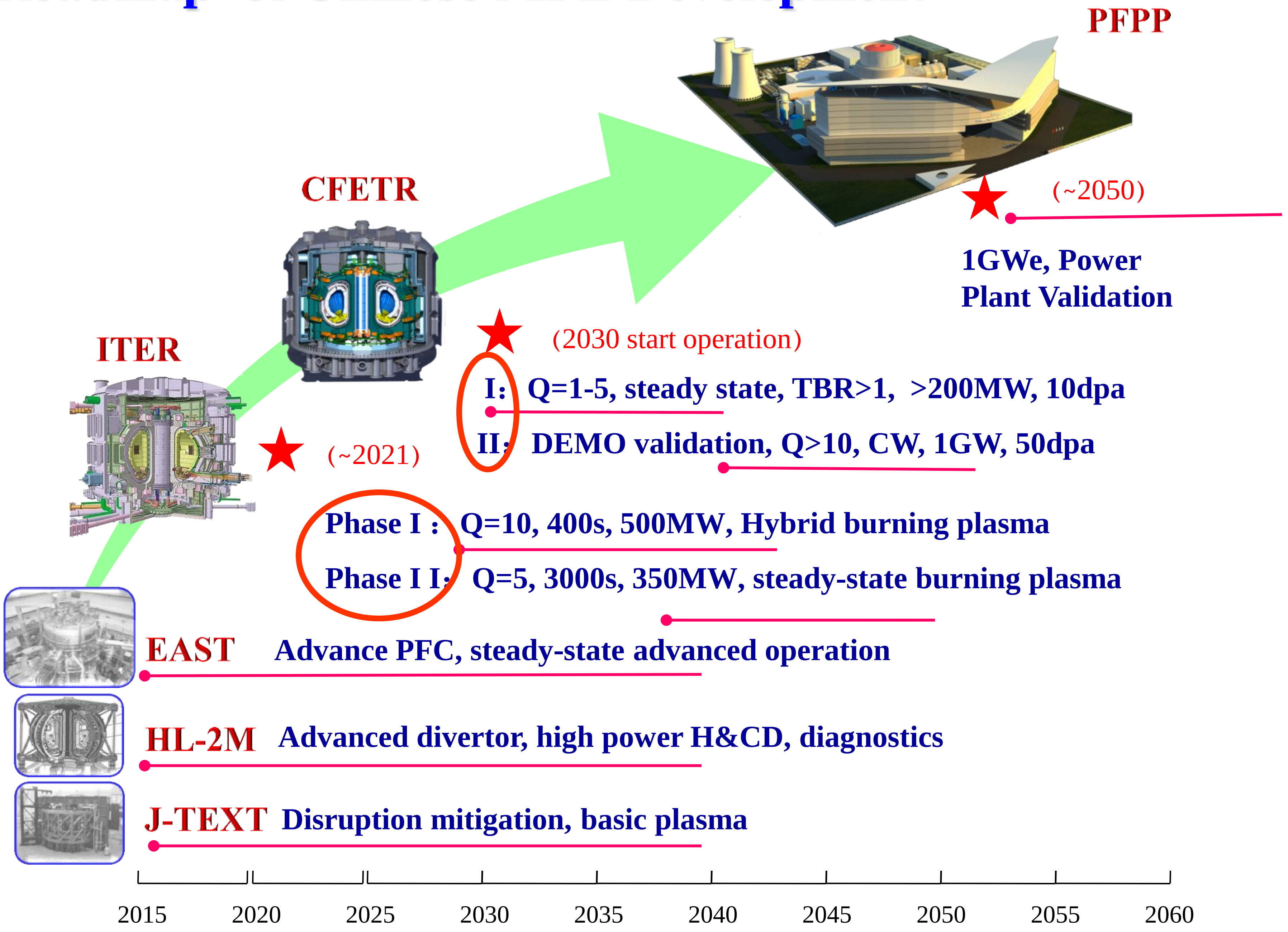


Outline

- Present state of MCF in China
- EAST Progress
- CN-ITER Activities
- **Next Step-CFETR**
- Summary

Chinese Fusion Engineering Test Reactor

Roadmap of Chinese MFE Development



PFPP

(~2050)

1GWe, Power Plant Validation

CFETR

(2030 start operation)

I: Q=1-5, steady state, TBR>1, >200MW, 10dpa

II: DEMO validation, Q>10, CW, 1GW, 50dpa

ITER

(~2021)

Phase I : Q=10, 400s, 500MW, Hybrid burning plasma

Phase I I: Q=5, 3000s, 350MW, steady-state burning plasma

EAST **Advance PFC, steady-state advanced operation**

HL-2M **Advanced divertor, high power H&CD, diagnostics**

J-TEXT **Disruption mitigation, basic plasma**

CFETR Mission & Objectives

Mission: Bridge gaps between ITER and DEMO, realization of fusion energy application in China

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

Core Plasma Performance-Phase I

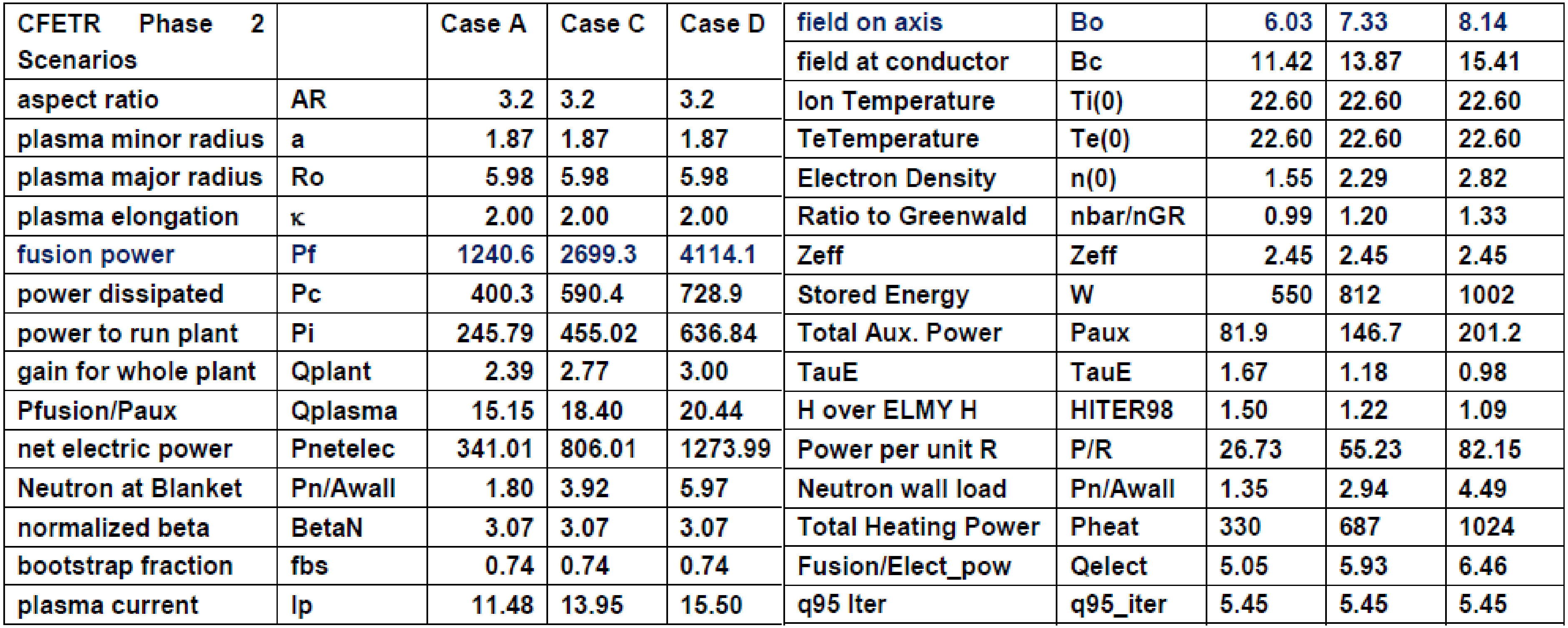
E(MJ)	141	159	178	196	206	183
P_Fus(MW)	155	193	234	276	298	226
Q	2.4	3.0	3.7	4.	4.6	3. 53
Ti0	13.2	14.8	16.6	18.4	19.3	20. 8
nel	0.79	0.79	0.79	0.79	0.79	0. 65
nGR	0.85	0.85	0.85	0.85	0.85	0. 7
betaN	1.59	1.79	2.00	2.22	2.33	2. 07
betaP	1.03	1.16	1.29	1.43	1.50	1. 33
fbs	41.4	46.7	52.2	57.8	60.7	54
taoE98Y2	1.65	1.56	1.48	1.41	1.38	1. 38
Pn/Awall	0.27	0.33	0.40	0.47	0.51	0. 39
Res	9.72E-09	8.13E-09	6.89E-09	5.90E-09	5.49E-09	4. 88E-09
Pthre	63.6	63.6	63.6	63.6	63.6	55. 3
ICD(MA)	2.03	2.29	2.56	2.83	2.97	3. 9
H98	1	1.1	1.2	1.3	1.35	1. 35
T_burn(s)	1933	3075	5714	15693	margin ss	ss

Ip~8MA, Bt=5T, q95=5.2, Zeff~1.76， P~80*0.8MW， γ_{CD} = 0.15~0.22 (ITER target 0.4)

start up needs 100V*s,break down 10V*S, 50V*s for burning

Operation parameters with high B_T Phase II

A: B=6T, Ip=11.5MA, betaN=3， q_{95}=5.5, Q=15, P_{fusion}=1.24GW, Pnet =340MW

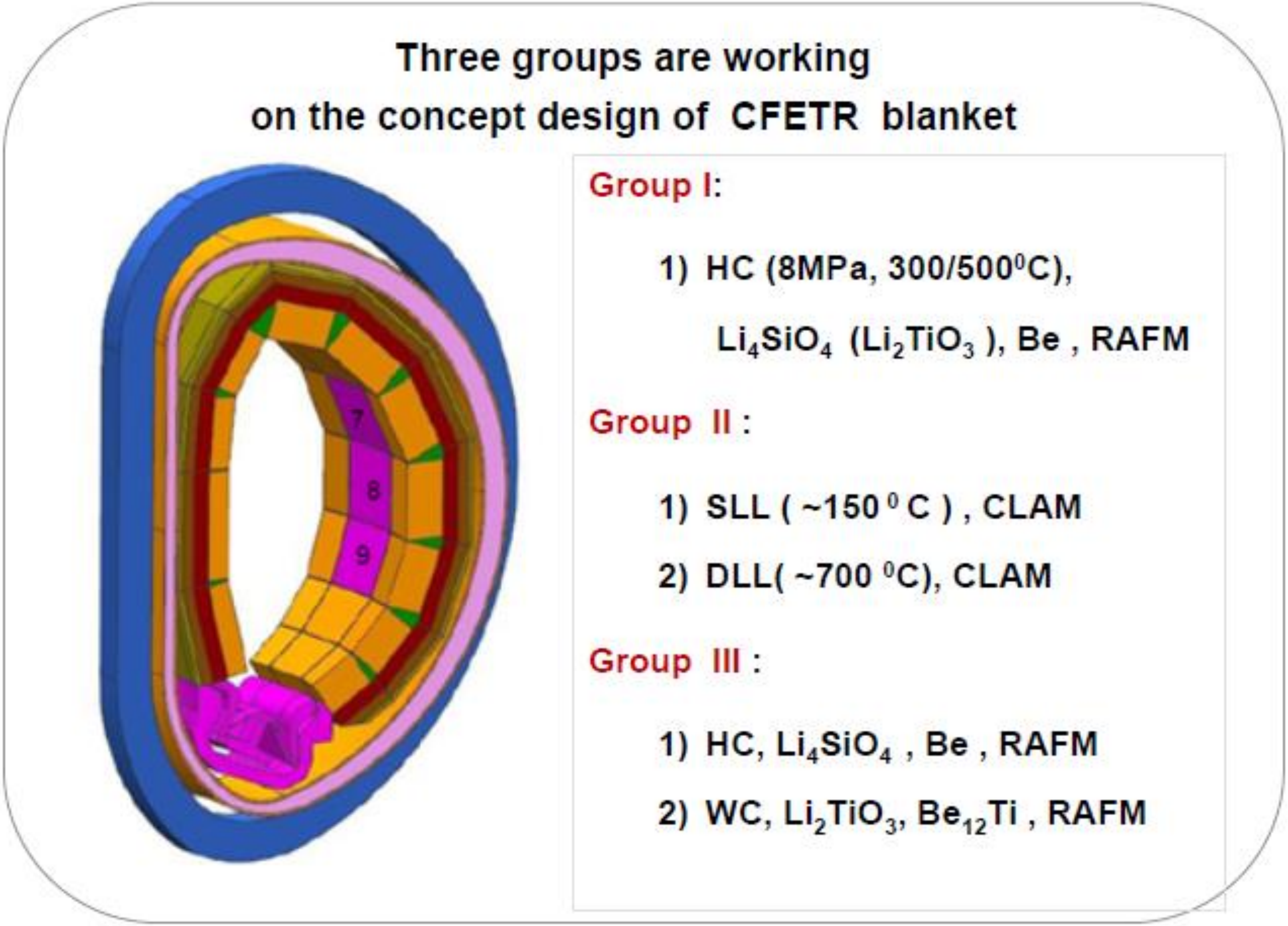


CFETR Phase 2 Scenarios		Case A	Case C	Case D
aspect ratio	AR	3.2	3.2	3.2
plasma minor radius	a	1.87	1.87	1.87
plasma major radius	Ro	5.98	5.98	5.98
plasma elongation	κ	2.00	2.00	2.00
fusion power	Pf	1240.6	2699.3	4114.1
power dissipated	Pc	400.3	590.4	728.9
power to run plant	Pi	245.79	455.02	636.84
gain for whole plant	Qplant	2.39	2.77	3.00
Pfusion/Paux	Qplasma	15.15	18.40	20.44
net electric power	Pnetelec	341.01	806.01	1273.99
Neutron at Blanket	Pn/Awall	1.80	3.92	5.97
normalized beta	BetaN	3.07	3.07	3.07
bootstrap fraction	fbs	0.74	0.74	0.74
plasma current	Ip	11.48	13.95	15.50

field on axis	Bo	6.03	7.33	8.14
field at conductor	Bc	11.42	13.87	15.41
Ion Temperature	Ti(0)	22.60	22.60	22.60
TeTemperature	Te(0)	22.60	22.60	22.60
Electron Density	n(0)	1.55	2.29	2.82
Ratio to Greenwald	nbar/nGR	0.99	1.20	1.33
Zeff	Zeff	2.45	2.45	2.45
Stored Energy	W	550	812	1002
Total Aux. Power	Paux	81.9	146.7	201.2
TauE	TauE	1.67	1.18	0.98
H over ELMY H	HITER98	1.50	1.22	1.09
Power per unit R	P/R	26.73	55.23	82.15
Neutron wall load	Pn/Awall	1.35	2.94	4.49
Total Heating Power	Pheat	330	687	1024
Fusion/Elect_pow	Qelect	5.05	5.93	6.46
q95 Iter	q95_iter	5.45	5.45	5.45

B: B=7.3T, Ip=14MA, betaN=3， q_{95}=5.5, Q=18.4, P_{fusion}=2.7GW, Pnet =800MW

Key Components: Blanket



Three groups are working
on the concept design of CFETR blanket

Group I:

1) HC (8MPa, 300/500⁰C),
   Li_4SiO_4 (Li_2TiO_3), Be , RAFM

Group II :

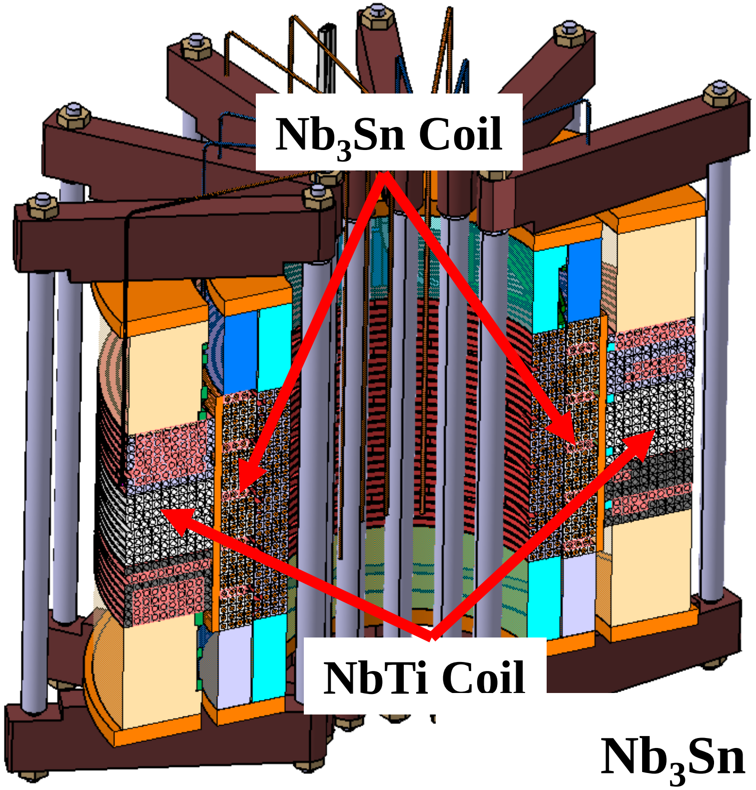
1) SLL (~150 ⁰ C) , CLAM
2) DLL(~700 ⁰C), CLAM

Group III :

1) HC, Li_4SiO_4 , Be , RAFM
2) WC, Li_2TiO_3, $Be_{12}Ti$, RAFM

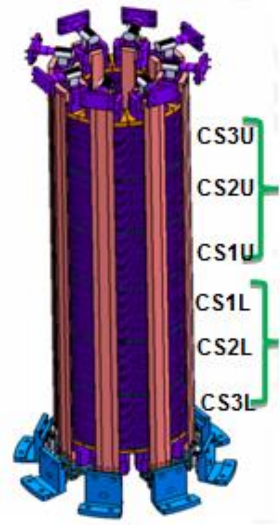
1/32 section mock up of the VV

One Section(1/6) of CFETR CS Model Coil

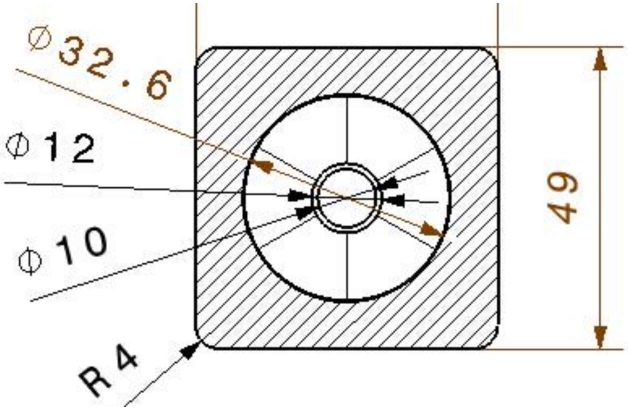


Coil Parameters

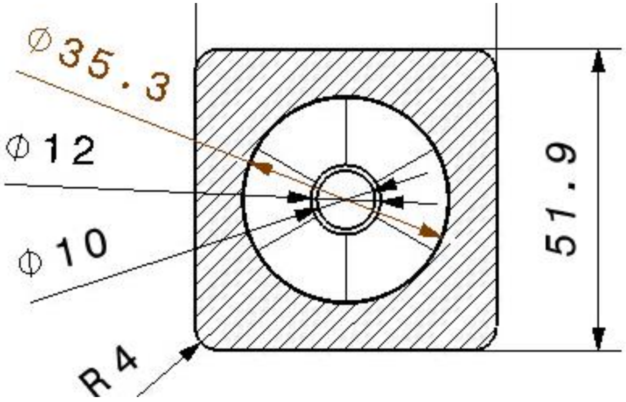
Design Parameters of CFETR CS Model Coil	
Max. field	12 T
Max. field rate	1.5 T/s
Inner radius	750 mm
Coil structure	Hybrid magnet **Inner：Nb_3Sn coil** **Outer：NbTi coil**
Conductor type	Nb_3Sn CICC NbTi CICC



Nb_3Sn Conductor

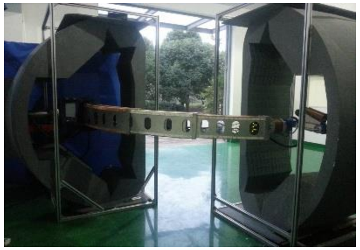


NbTi Conductor

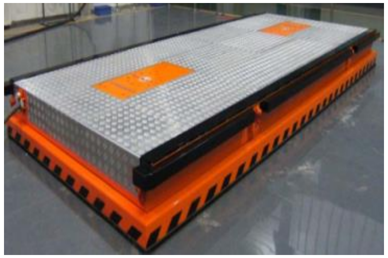


Some Achievements of RH project

1. Tokmak RH flexible In-Vessel Viewing System



2. ITER parts Transfer Cask

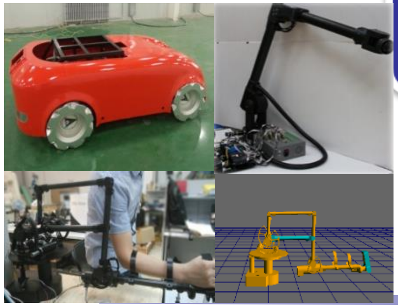


3. Blanket RH maintenance system

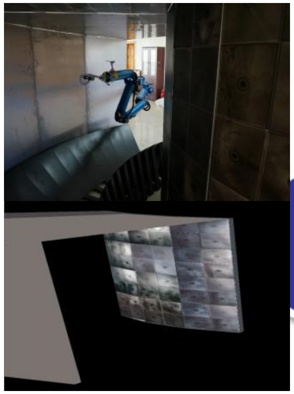
4. large scale heavy load maintenance robot arm system

5. RH master-slave robot and man-machine interactive control system

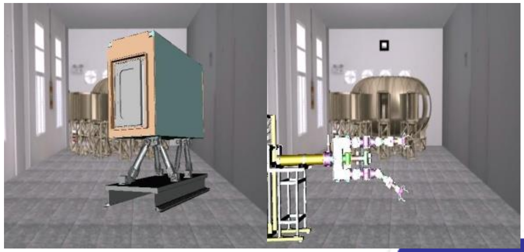
6. multifunction inspection and rescue robot



7. vision grabbing and scene modeling

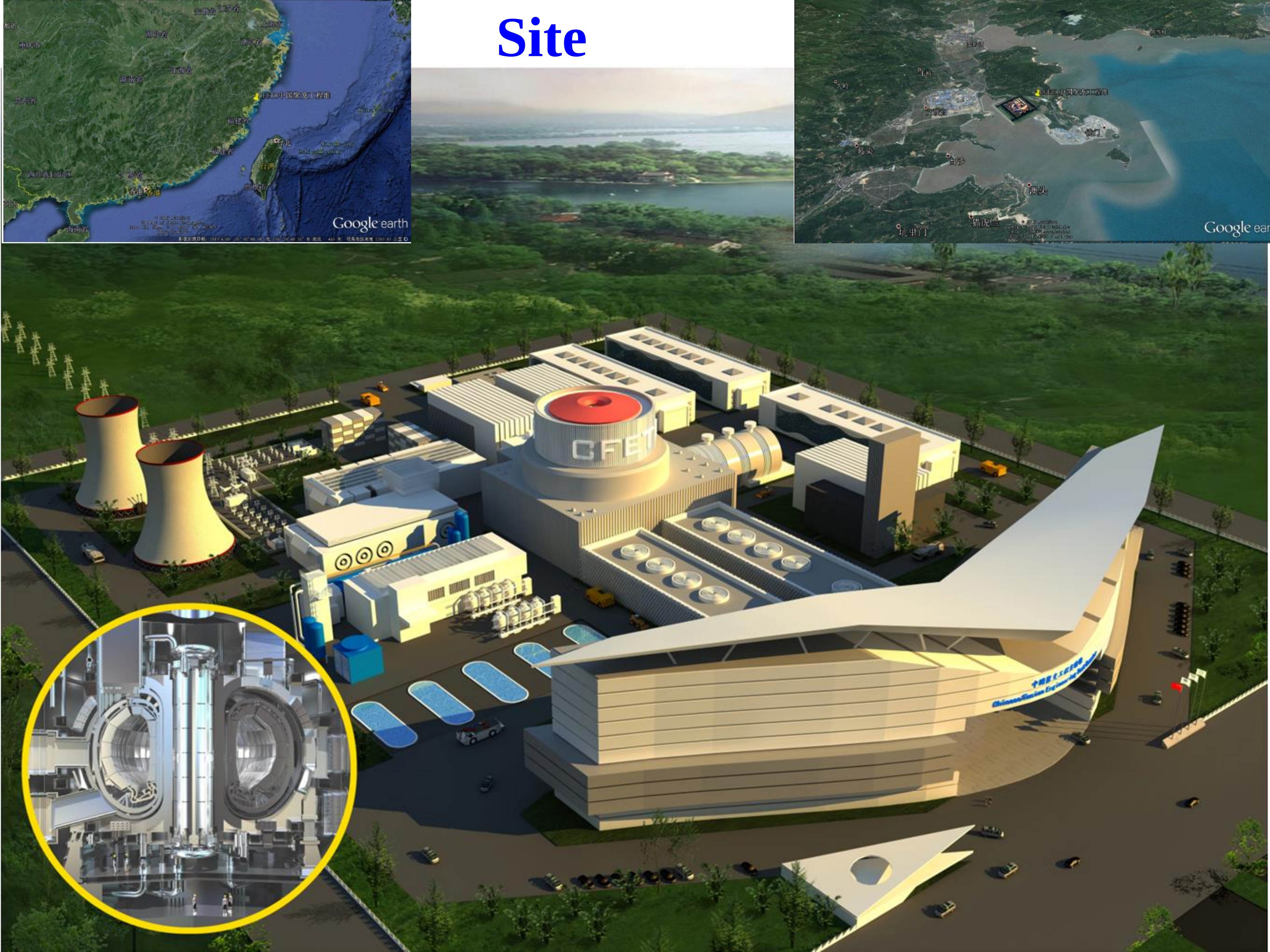


8. system integrating and testing



~ 80%

Site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安徽省
上海市
湖北省
重庆市
浙江省
江西省
湖南省
贵州省
CFETR中国聚变工程堆
福建省
台北
台湾
广东省
香港
海南省
Google earth
大岭
白沙
澳头
坑里门
Google earth
CFETR

CFETR Present Activities

- H&CD:

off-aix NBI (0.5MeV) + ECRH(top， 170-230GHz）

LHCD（HF， 4.6、8.2GHz）+ECRH(top， 230GHz）

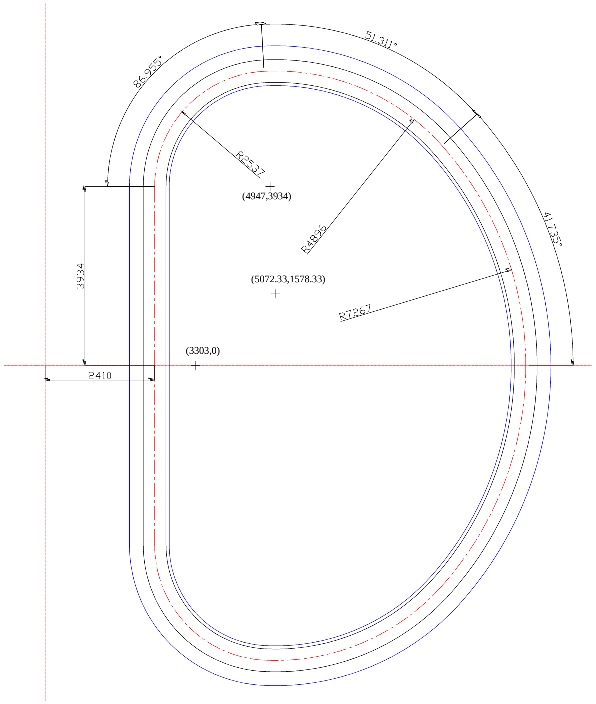
- High B_T （7.5-8 T）

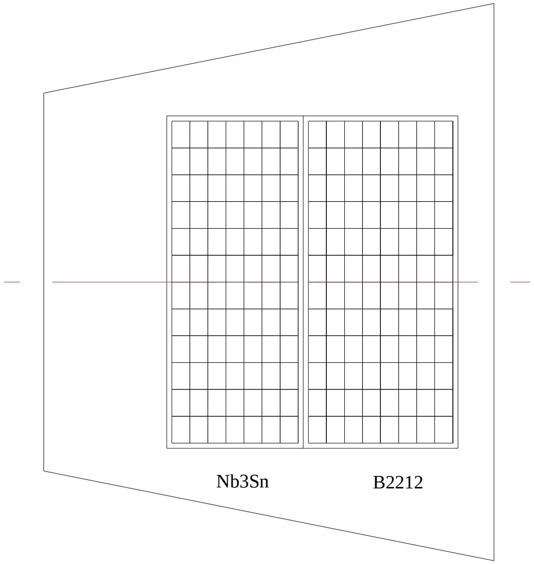
CS （2212 CICC， YBCO tape， Nb3Al)

Hybrid TF (2212 CICC+Nb3Sb)

- Heat exhaust (Divertor)
- Advanced Blanket
- T-Plant
- DEMO Materials

High B_T – Hybrid (Nb_3Sn+2212) TF





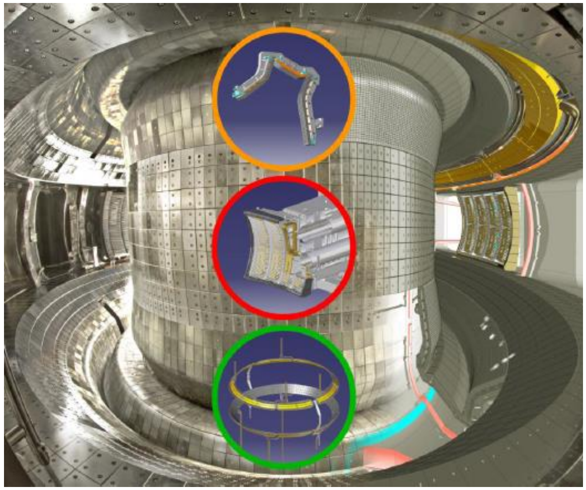
wire：ϕ=1.0mm
Cable：3×4×6×6=432
Porosity：30%
Cable size：15mm×32mm
Jacket thickness：8mm
conductor：31mm×48mm
Isolation thickness：2mm
Full size：35mm×52mm

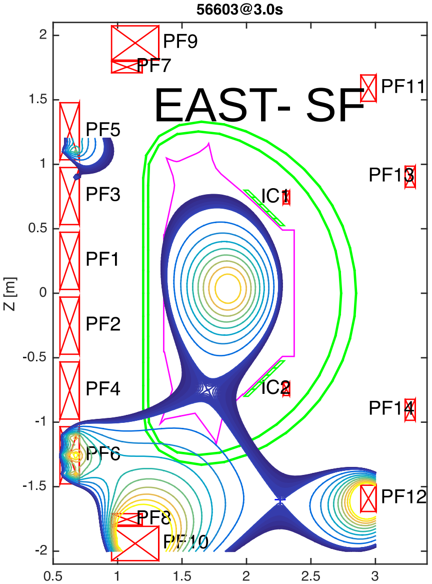
Nb_3Sn or Nb_3Al :
Jce>1200A/mm² (Ic>942A)
Conductor I =190×432=82kA
245mm×624mm
Turn：7×12
Bmax=8.2T

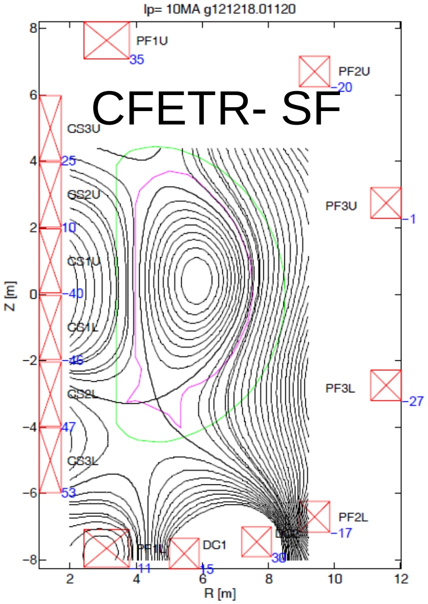
Bi2212:
Jce>380A/mm² (Ic>300A)
Conductor I =190×432=82kA
280mm×624mm
Turn： 8×12
Bmax=19.1

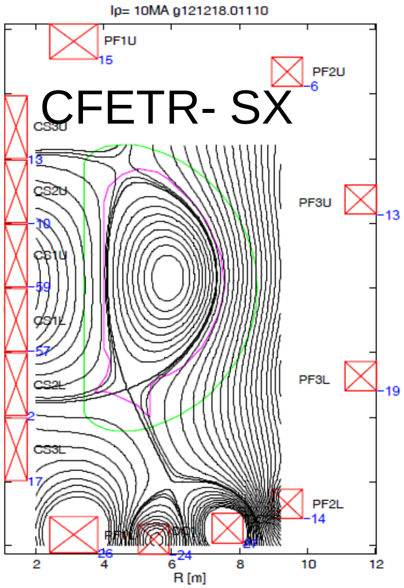
Maybe possible

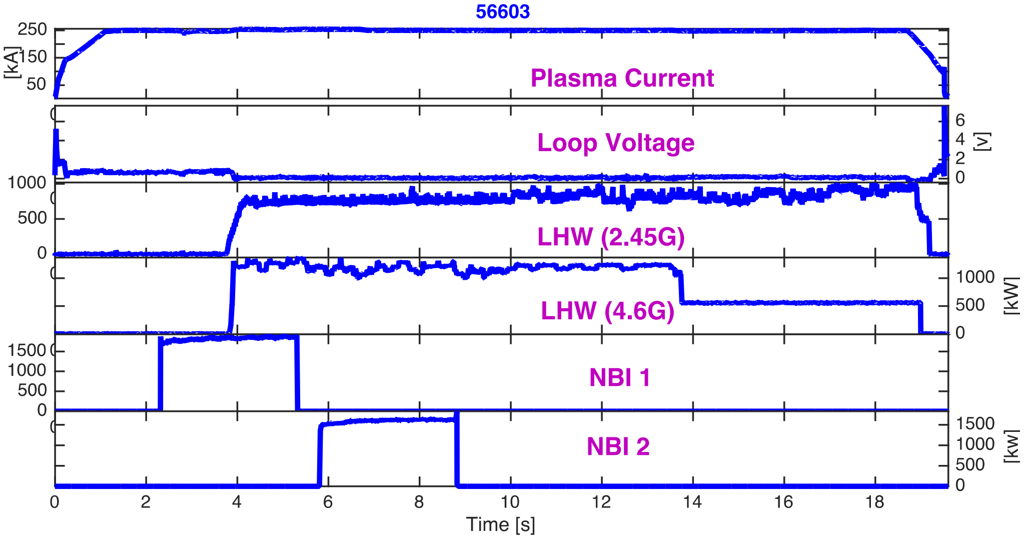
Advanced Divertor concept validation









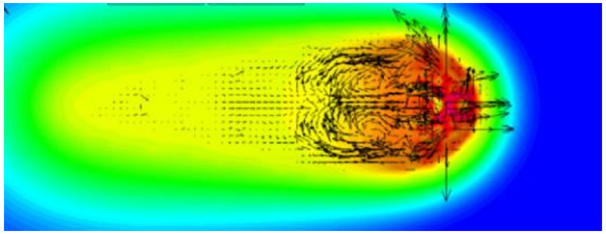


Connection Length [m]	**189.91**	**144.38**
Magnetic flux expansion at outer SP $f_{m,out}$	**8.22**	**2.01**
Magnetic flux expansion at inner SP $f_{m,in}$	**4.71**	**2.34**
Peak heat flux [MW/m^2]	**0.10**	**0.81**

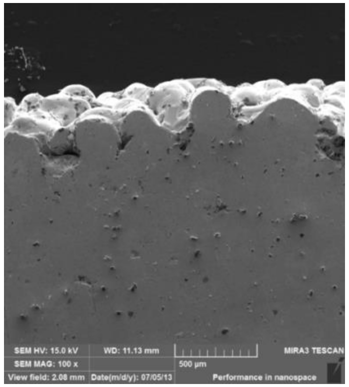
EAST: snowflake experiments Vs EFIT+TSC+B2, Radiation+detache

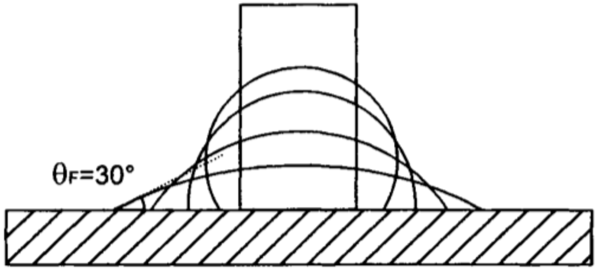
CFETR: D1+D2 coils Snowflake, Super-x, Snowflake+X , XD

Selective Laser Melting of Pure Tungsten

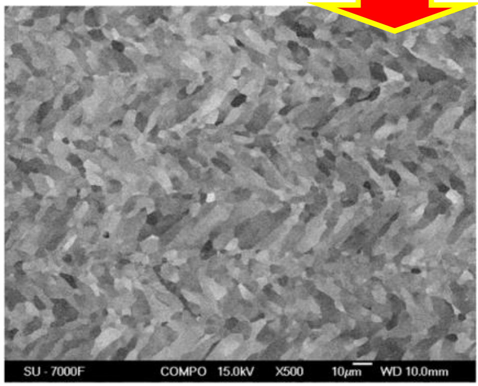


Heat,mass and momentum transfer in turbulence melt flow, homogenization

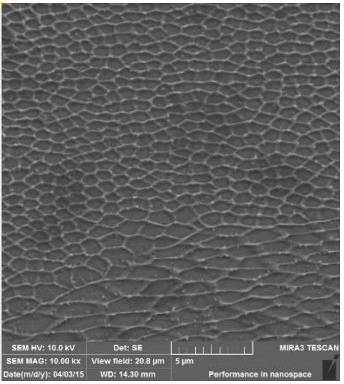




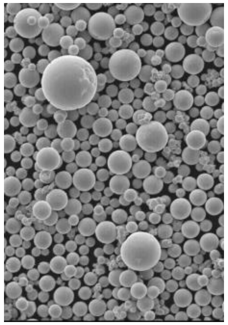
balling mechanism: the competitive processes of spreading and solidification

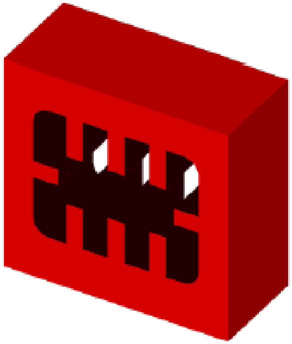


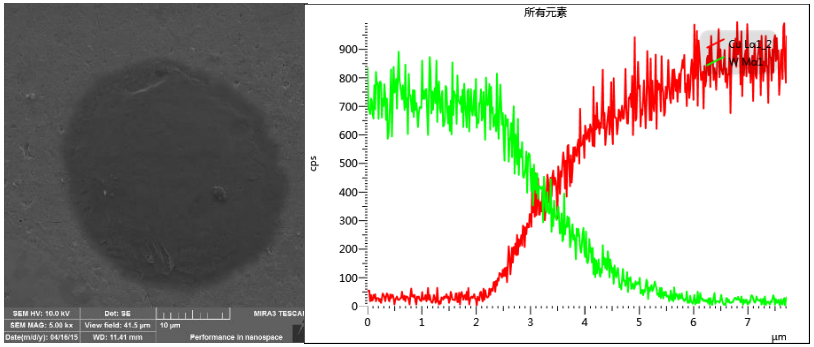
Surface texture



Sub-grain Cel







W-Cu dissimilar welding
Inter-diffusion

Target: 4-5 years DEMO full W block

30MW/m²Tmax: 1700C

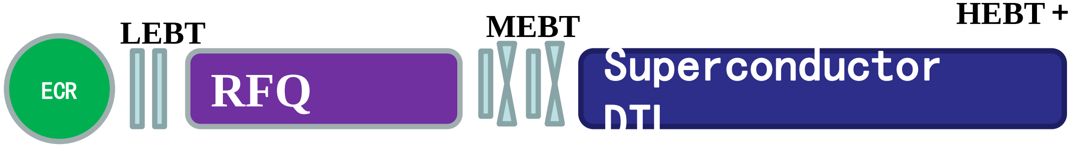
水流速 m/s	20MW/m²	30MW/m²
8	1130℃	1680℃
10	1070℃	1600℃
12	1040℃	1540℃

CMIF: Compact Neutron Source

The Materials Irradiation Facility in China(CMIF)	
Target	**High Neutron Flux** **Low Neutron Yield** **Small Sample Size** **~1MW granular Be/C Target**
Beam	**50~100MeV@(5~30)mA (CW)**
Cost	**Low**

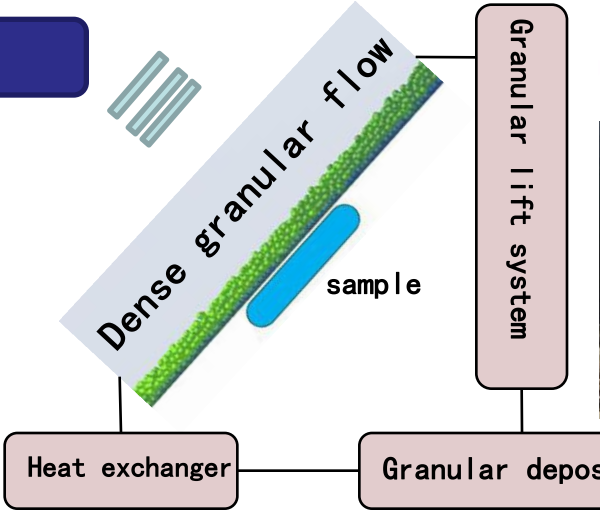
	energy（MeV）	**20**	**50**
I	Flux(D+Be) Y (n cm^{-2} mA^{-1} s^{-1})	**3.6*10^{13}** *5 mA	**2*10^{14}** *10 mA
II	Flux(D+Be) Y (n cm^{-2} mA^{-1} s^{-1})	**9.81*10^{14}** *20mA	**2*10^{15}** *30 mA

Superconductor LINPAC



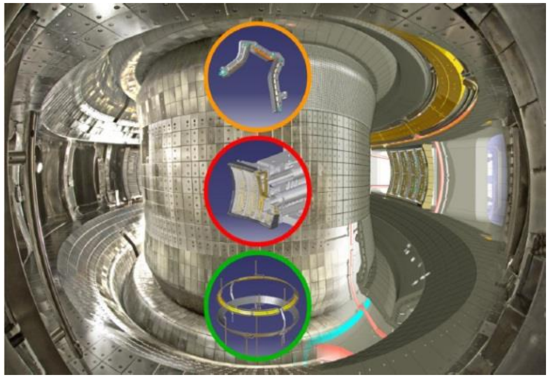
Granular Target

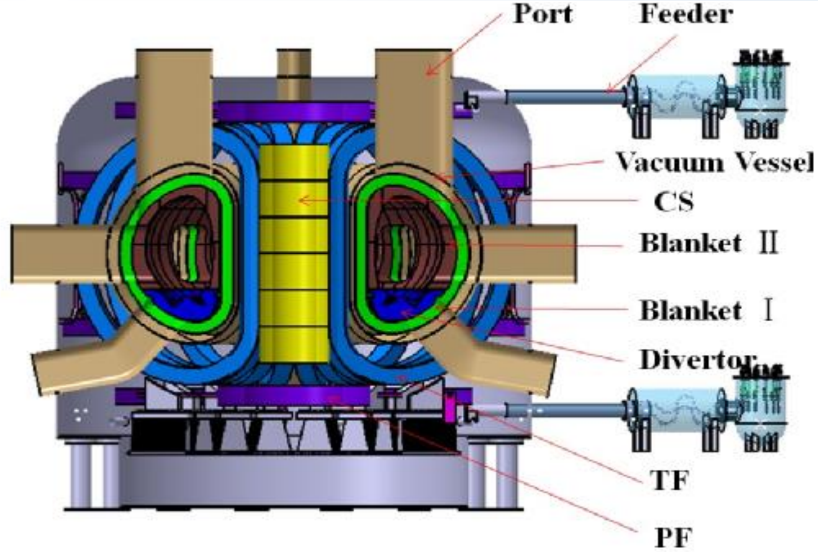
HEBT + scanning + Vacuum differential

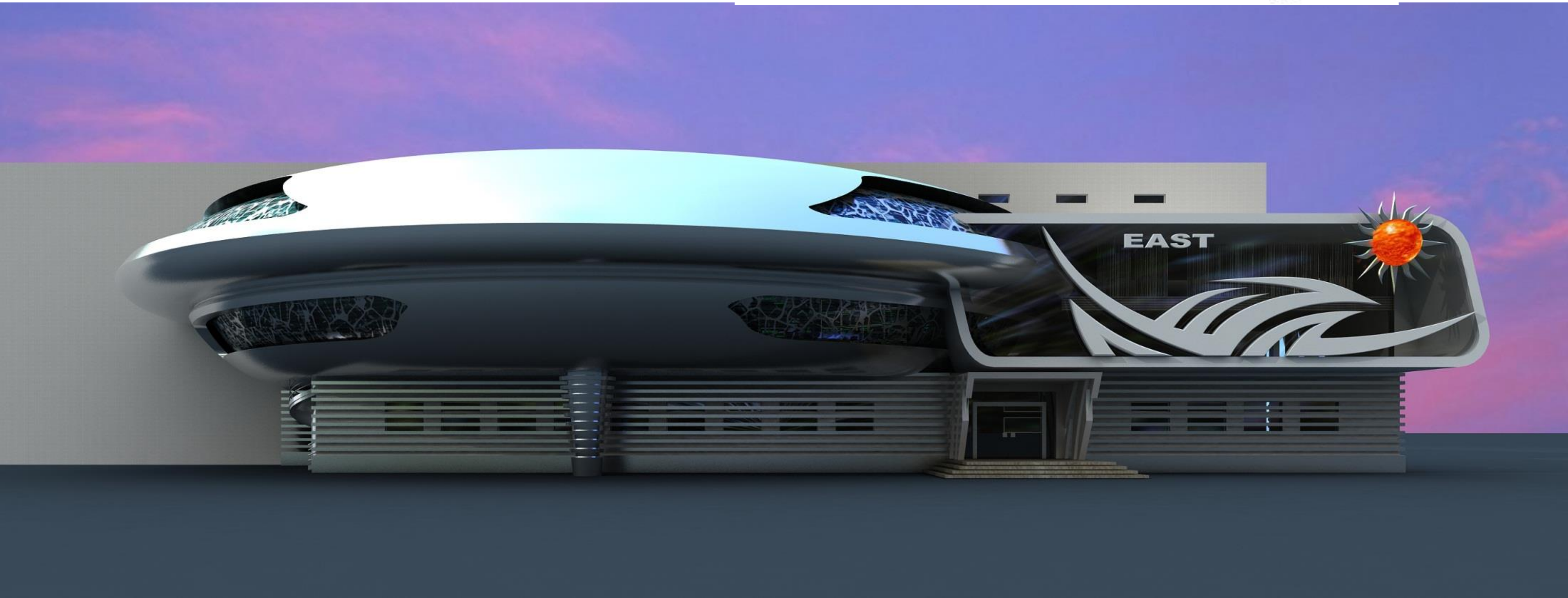


ASIPP-Huainan R&D Center

Looking for an exciting future







Strengthen international cooperation

France, CEA,CADERACHE
UK, UKAEA, CULHAM
EU, JET, EFDA
Germany: IPP, Garching
KFA, Julich
Italy, Frascati: ENEA
India, IPR
Korea, NFRI,KAERI
Russia: Kurchchatov institute
Swiss: DRCP, PSI
ITER-IO, 6-DA

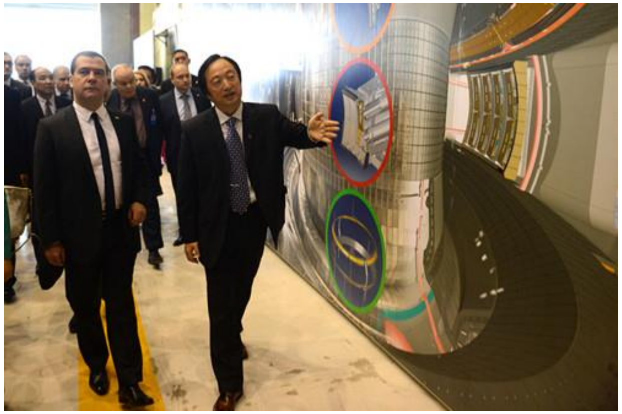
Japan: NIFS, Toki
JAEA, Naka
JSPS, CUP

USA: GA, San Diego
FRC, Texas
PPPL, Princeton
MIT, UCSD
UCLA, LLNL
ORNL,
ITPA: 20 person/year and invite topic meeting in China

Build international task forces

EAST is Fully open to fusion community as valuable test bench for advanced steady-state plasma for ITER

Fusion is very important for China



Summary

- Significant progress has been made since China joint ITER.
- EAST starts high performance long pulse physics experiments and stationary H-mode was obtained.
- Next 5 year will be a key step which could focus on several key issues with ITER urgent needs on experiments, such as ELM control, high heat load and advanced SS H-mode.
- CFETR will benefit from ITER and make joint efforts towards DEMO.
- Young talent is our future, we are looking forward for your contribution.