KSTAR ACTUATORS STATUS AND PLANS FOR 2009-2010

Apr. 15 2009

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GA, SanDiago
April 15-16, 2009

NFRI 국가핵융합연구소
National Fusion Research Institute

Outline

- **Near Term KSTAR Operation & Upgrade Plan**
- **Status & Upgrade Plan of the KSTAR Actuators**
  - **MPS & Electric Power System**
  - **Heating & Current Drive System**
  - **In-Vessel Components**
  - **Diagnostics**
- **Other Systems**
- **Summary**

Near Term KSTAR Operation & Upgrade Plan

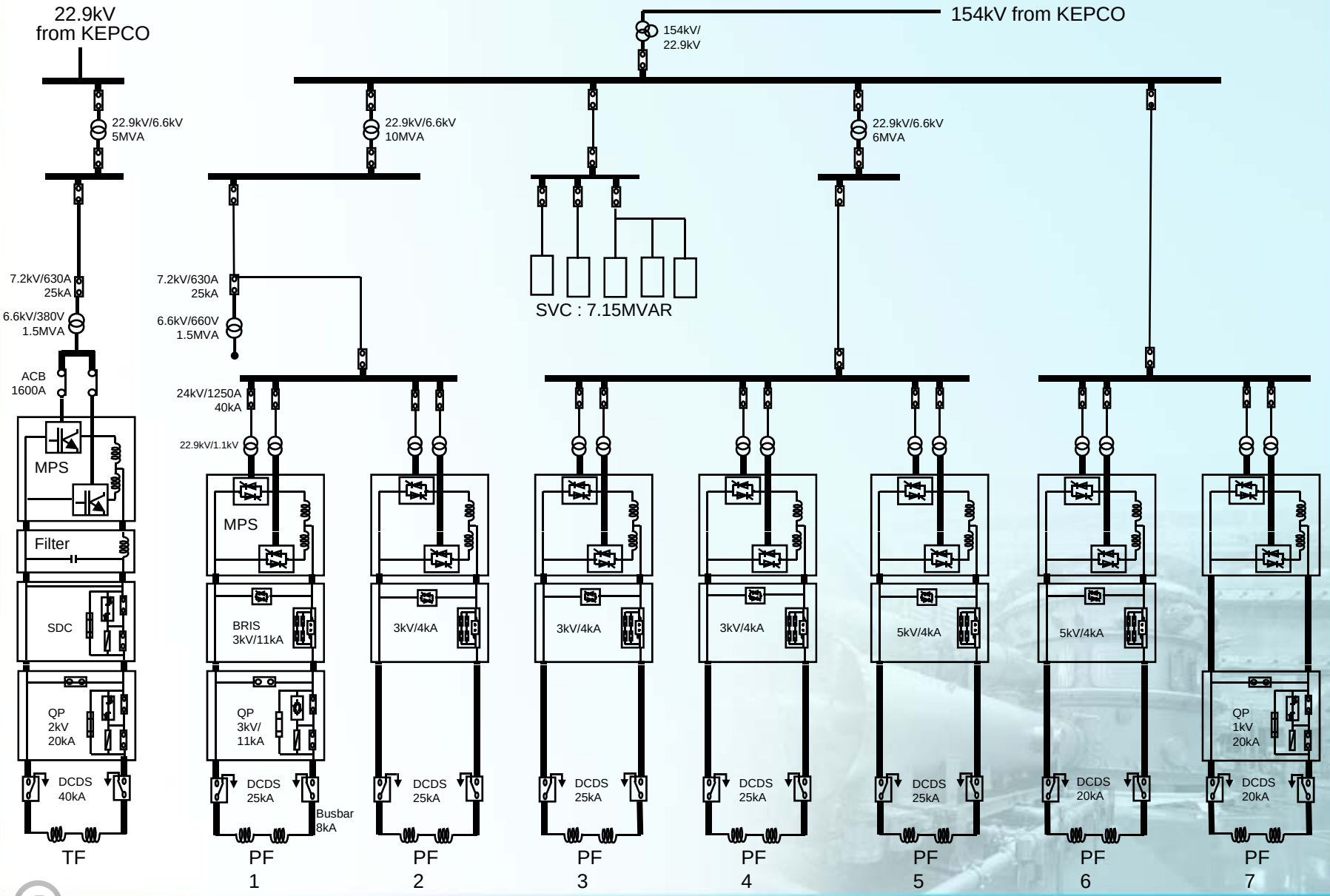
Last updated : Feb. 4, 2009

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Operation (Vac,CD & WU)	'08. 3 ~ '08. 8 (6 mon.)	'09. 8 ~ '09.12 (5 mon.)	'10.6 ~ '10. 11 (6 mon.)	'11. 4~ '11. 9 (6 mon.)	'12. 2 ~ '12. 7 (6 mon.)
Experimental Goals	• First plasma startup • 2nd Harmonic ECH pre-ionization	• 1st Harmonic ECH Pre-ionization • Startup stabilization	• Shaping control & vertical stabilization • Heating	• Confinement (L-H) • Stabilization • Heating	• Plasma–Wall Interaction • Profile control • RWM, ELM control • Off-axis current drive
Target Operation Parameters	• B_T ~ 1.5 T • I_P > 0.1 MA • t_P > 0.1 s • Te > 0.3 keV • Ti ~ 0 keV • Flux ~ 1 Wb • Shape ~ Circular • Gas : H_2	• B_T ~ 3 T • I_P > 0.3 MA • t_P > 2 s • Te > 0.3 keV • Ti ~ 0.3 keV • Flux ~ 2 Wb • Shape ~ Circular • Gas : H_2, D_2	• B_T ~ 3 T • I_P < 1 MA • t_P ~ 10 s • Te ~ 1 keV • Ti ~ 1 keV • Flux ~ 4 Wb • Shape ~ DN(double null) • Gas : H_2, D_2	• B_T ~ 3 T • I_P < 1.5 MA • t_P ~ 10 s • Te ~ 1 keV • Ti ~ 3 keV • Flux ~ 6 Wb • Shape ~ DN & SN • Gas : D_2	• B_T ~ 3 T • I_P < 2 MA • t_P > 100 s (0.5 MA) • Te ~ 1 keV • Ti ~ 5 keV • Flux ~ 8 Wb • Shape ~ DN & SN • Gas : D_2
PFC & Wall conditioning	• Inboard limiter (belt) • Gas puff	• Inboard limiter (w/o cooling) • Boronization	• Divertor / Passive plate • PFC baking • In-vessel coil	• Cryopump operation • PFC cooling	• PFC cooling • *Pellet*
Magnetic control	• TF : 1.5 T • PF : 4 kA unipolar	• TF : up to 3.5 T • PF : +/-4 kA	• TF : up to 3.5 T • PF : +/-10 kA • IVCC : VS, RS	• TF : up to 3.5 T • PF : +/-15 kA • IVCC : FEC. RMP	• TF : up to 3.5 T • PF : +/-20 kA • IVCC : RMP, RWM
Heating operation	• ECH(84G): 0.5MW, 0.4s	• ECH(84GHz): 0.5MW, 2s • ICRH(45MHz): 0.3MW, 10 s	• ECH(84/110GHz): 0.5MW • ICRH(45MHz): 1MW, 10 s • NBI: 1.0MW, 10s • LHCD: 0.5MW, 2s	• ECH(84/110GHz): 0.5MW • ICRH(45MHz): 2MW, 10 s • NBI: 2.5MW, 10s • LHCD: 0.5MW, 2s • ECCD(170GHz): 1MW, 10s	• ECH(84/110GHz): 0.5MW • ICRH(45MHz): 2MW, 300 s • NBI :5MW, 300s • LHCD : 1MW, 2s • ECCD(170GHz): 1MW, 300s
Diagnostics	• MD (77 Ch)/ MMWI / ECE / Hα / filterscope / VS / TV	• MD/ MMWI / ECE / Hα / filterscope / VS / TV • PD / XCS (1 set) / Bolometer (resistive) / Reflect. / Soft X-ray	• MD / MMWI / ECE / Hα / filterscope / VS / TV • PD / XCS / Bolometer / Reflect. / Soft X-ray • Thomson Spectroscopy / Hard X-ray / Fast neutral / IR TV / ECEI	• MD / MMWI / ECE / Hα / filterscope / VS / TV • PD / XCS / Bolometer / Reflect. / Soft X-ray • TS / Hard X-ray / Fast neutral / IR TV / ECEI • MSE / FIR / CES / neutron	• MD / MMWI / ECE / Hα / filterscope / VS / TV • PD / XCS / Bolometer / Reflect. / Soft X-ray • TS / Hard X-ray / Fast neutral / IR TV / ECEI • MSE / FIR / CES / neutron / VUV • MIR / BES / CI /

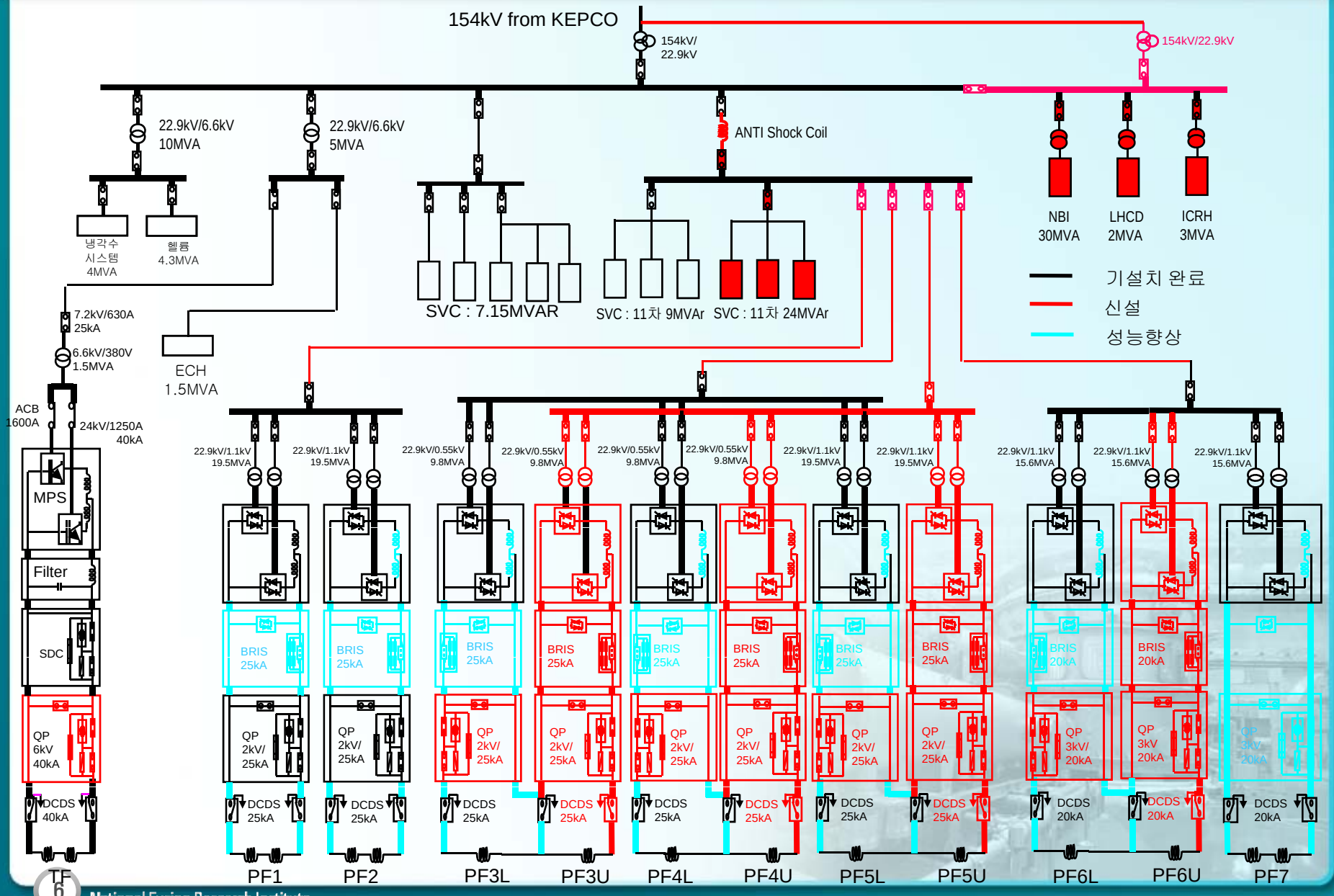
Status & Upgrade Plan of the KSTAR Actuators

- MPS & Electric Power System -

KSTAR MPS Layout (2008)



KSTAR MPS Layout (2009-2010)



KSTAR MPS Upgrade Plan

Upgrade FY 2009

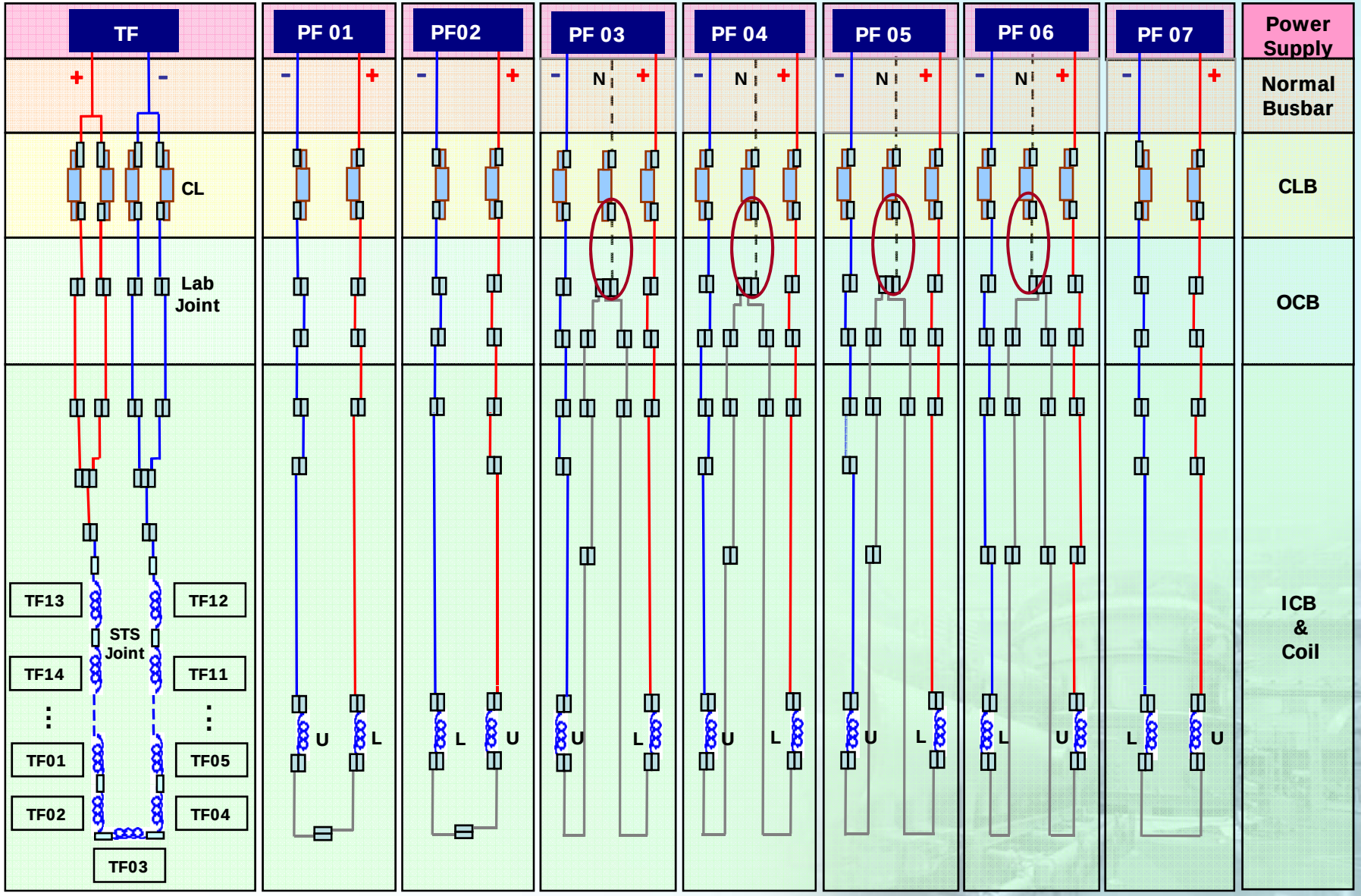
Upgrade FY 2010

NFRI
http://www.nfri.re.kr

Item	Specification						
	Inverter	QP	SDC	QPR	SDR	DCDS	DC Busbar
TF MPS	25V/40kA	3kV/20kA (6kV/40kA)	1kV/40kA	114 mΩ/6kV	2.2 mΩ/6kV	40kA	32kA/+25℃

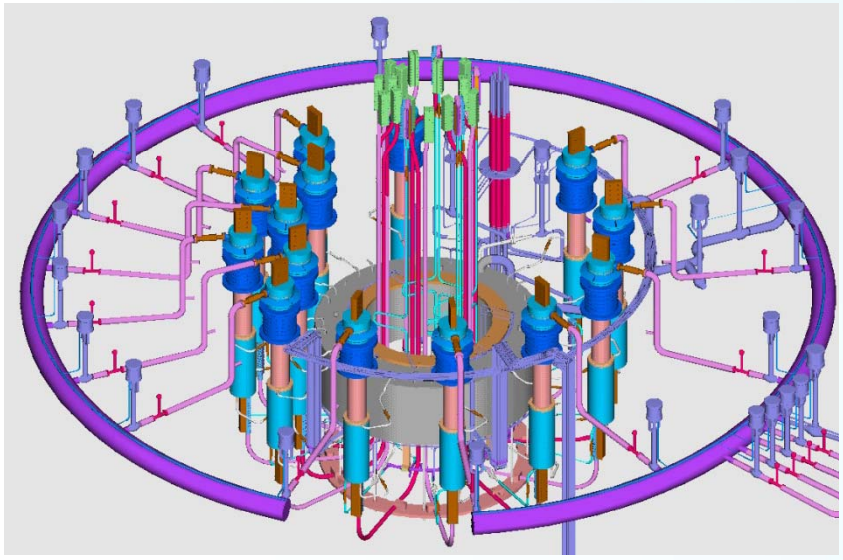
Item	Specification					
	Convertor	DCL	BRIS	QP	DCDS	DC Busbar
PF1 MPS	1kV/25kA	0.4mH/25kA	3kA (25kA)	2kV/25kA	25kA	8 kA (25kA)
PF2 MPS	1kV/25kA	0.4mH/25kA	3kA (25kA)	2kV/25kA	25kA	8 kA (25kA)
PF3L MPS	500V/25kA	0.4mH/25kA	3kA (25kA)	2kV/25 kA	25kA	8 kA (25kA)
PF4L MPS	500V/25kA	0.4mH/25kA	3kA (25kA)	2kV/25 kA	25kA	8 kA (25kA)
PF5L MPS	1kV/25kA	0.4mH/25kA	3kA (25kA)	3kV/25 kA	25kA	8 kA (25kA)
PF6L MPS	1kV/20kA	0.4mH/20kA	3kA (20kA)	5kV/20 kA	20kA	8 kA (20kA)
PF7 MPS	1kV/20kA	0.4mH/20kA	No BRIS	3kV/20kA	20kA	8 kA (20kA)
PF3U MPS	500V/25kA	0.4mH/25kA	25kA	2kV/25 kA	25kA	25kA
PF4U MPS	500V/25kA	0.4mH/25kA	25kA	2kV/25 kA	25kA	25kA
PF5U MPS	1kV/25kA	0.4mH/25kA	25kA	3kV/25 kA	25kA	25kA
PF6U MPS	1kV/20kA	0.4mH/20kA	20kA	5kV/20 kA	20kA	20kA

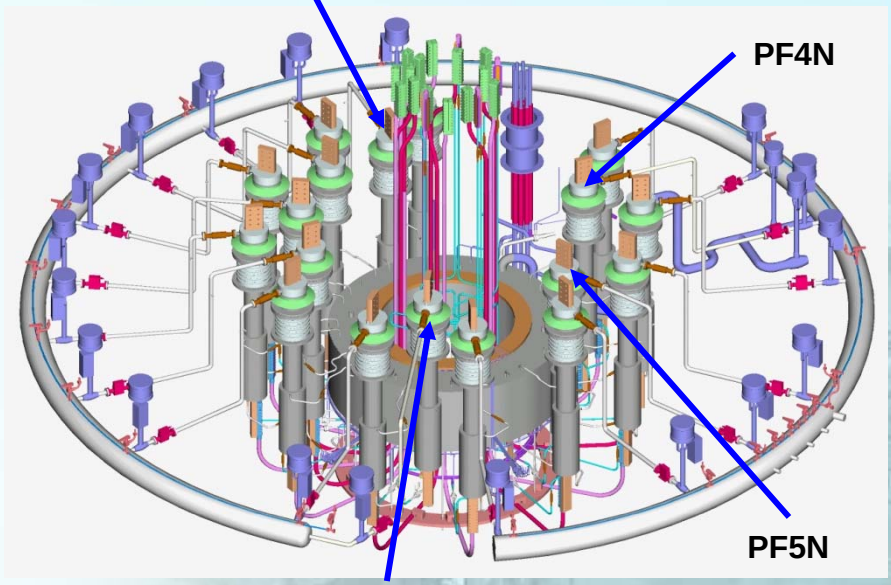
Electrical Configuration of CFS



CFS Upgrade Schedule

	2009										2010				
	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
CL Manufacturing															
CL & He Line Assembly															
SC Bus-line Manufacturing															
SC Bus-line Assembly															
Commissioning															





Electric Power System Upgrade Plan

NFRI
http://www.nfri.re.kr

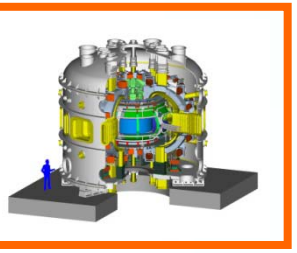
2008 ~ 2009

1st Step : First Plasma
Grid Power (50MVA)

Grid Power : 50MVA

154kV line

22.9kV line

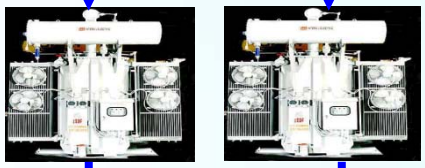


2009 ~ 2011

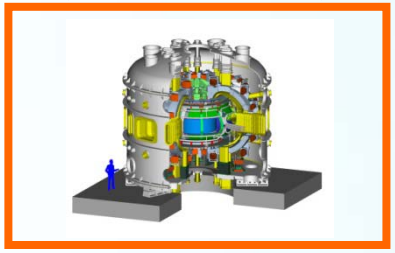
2nd Step : Base line
Grid Power(100MVA)

Grid Power : 100MVA

154kV line



22.9kV line

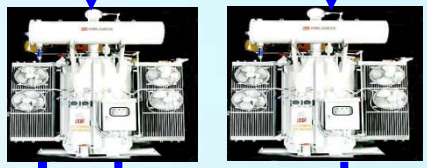


2012 ~ 2025

3rd Step : Upgrade
Grid Power (100MVA) + MG(200MVA)

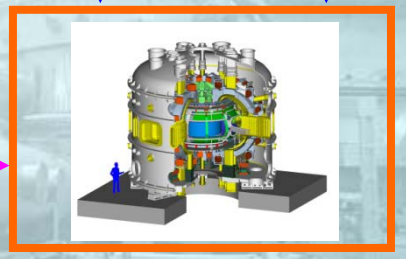
Grid Power : 100MVA

154kV line



MG

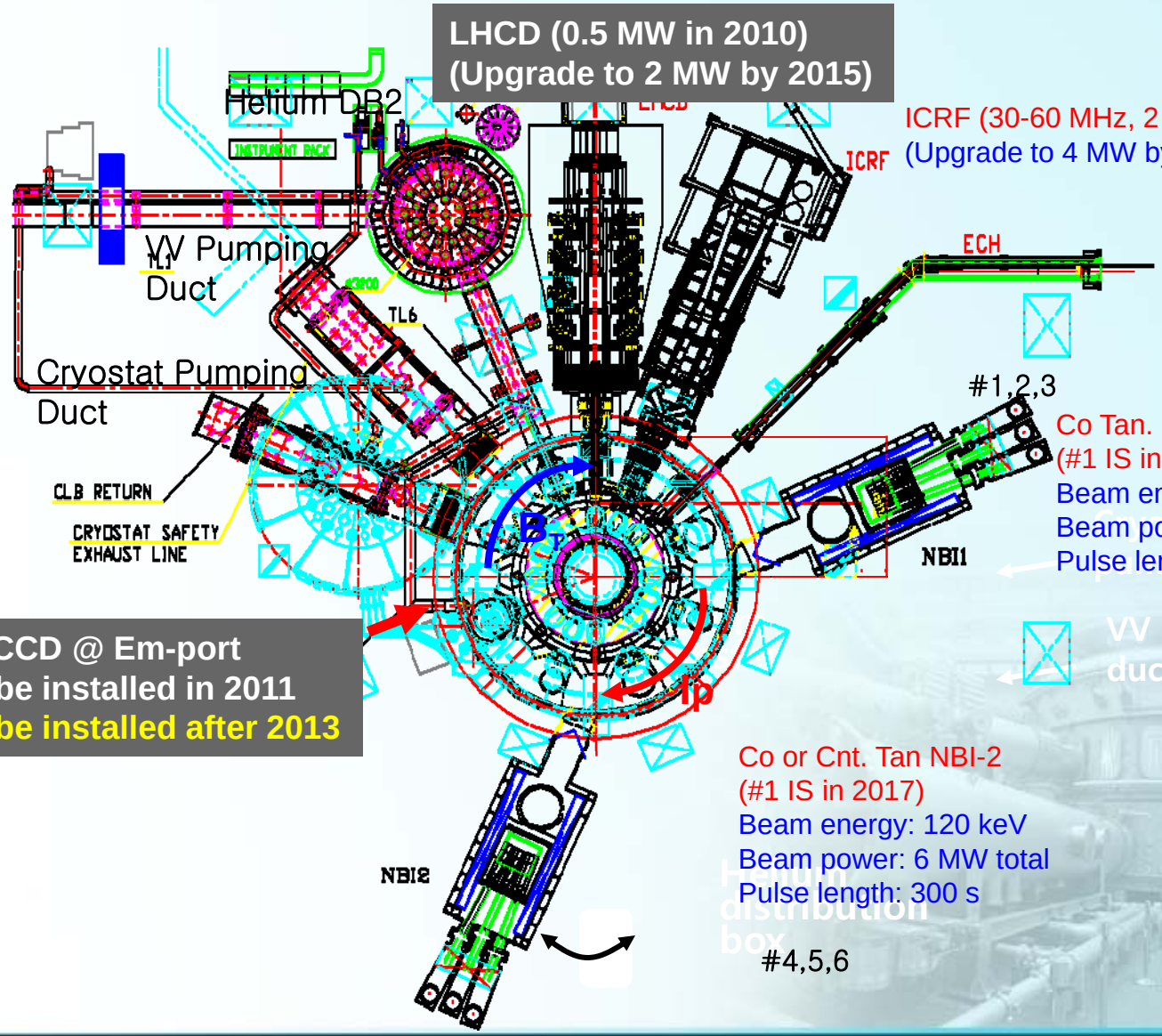
22.9kV line



Status & Upgrade Plan of the KSTAR Actuators

- Heating & Current Drive System-

Overview of the H&CD System - Layout

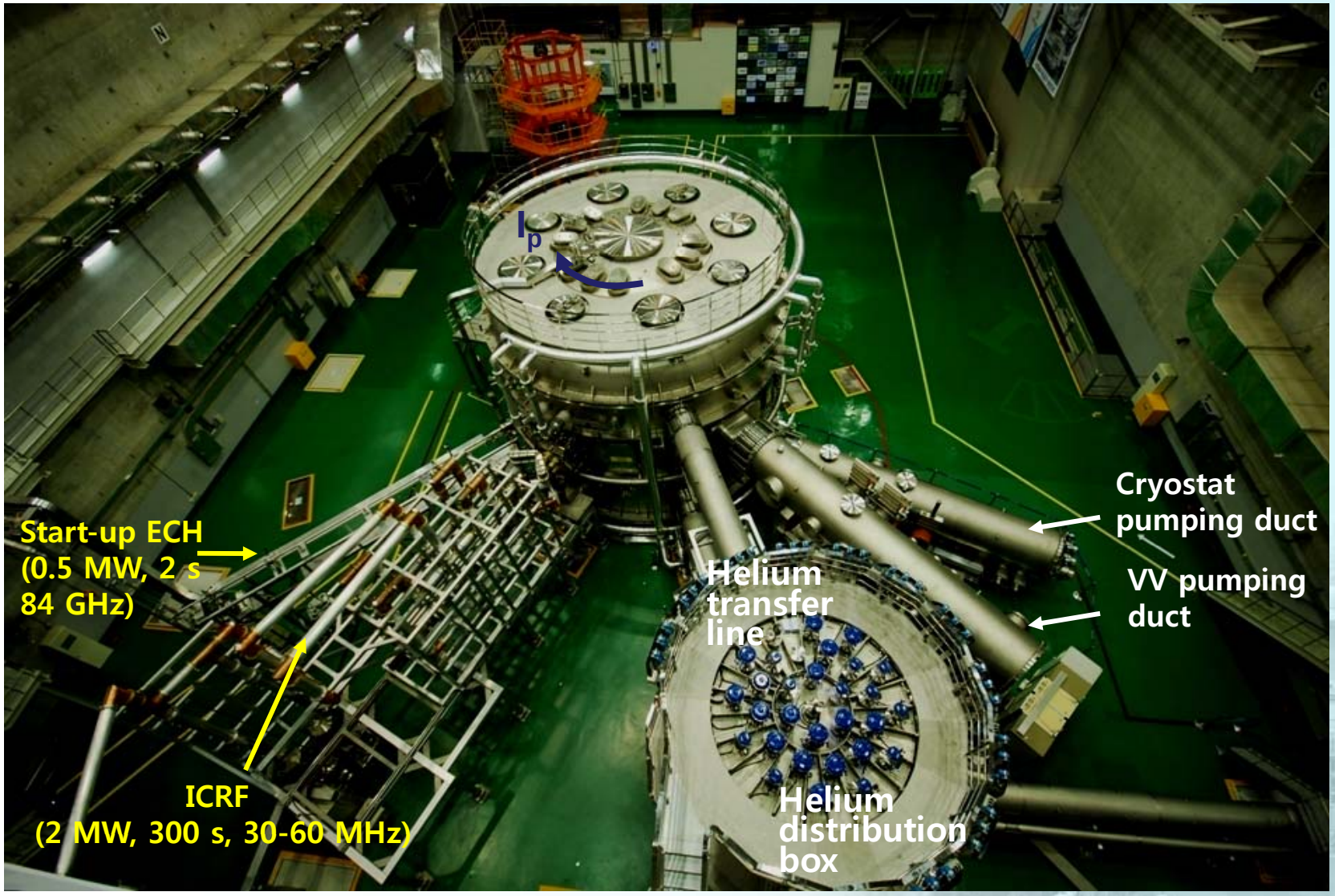


Overview of the H&CD System – Spec.

NFRI
http://www.nfri.re.kr

KSTAR	Specification	Role	ITER
NBI	14 MW, 300 s D0/H0 -Two beam lines -Three ion sources per each beam line -Positive based ion source at 120 keV	-Ion heating & CD -H-mode in initial phase	33 MW D0 -Two beam lines -1 MeV D- ion source
ICRF	30 – 60 MHz, 8 MW, 300 s -Sources: Four 2MW transmitter	-Ion & electron heating in high density -On- and off-axis CD -Wall cleaning by RF discharge between shot	35–60MHz, 25 MW CW - 10 x 2.5 MW CW transmitters
LHCD	5 GHz, 2 MW, 300 s - 4 x 500 kW CW klystrons	-Electron heating -Off-axis CD for plasma current profile control -RS-mode	5 GHz (or 3.7 GHz), 25 MW CW (50 x 500 kW CW klystrons)
ECH/CD	84(or 110)GHz, 0.5 MW, 2 s -84 GHz, 0.5 MW gyrotron 170 GHz, 3 MW, 300 s - 3 x 1 MW CW gyrotrons	• 84 (or 110) GHz ECH Startup system -Assisted startup using pre-ionization •170 GHz ECCD system -2nd harmonic heating & CD -NTM stabilization leading to high beta -Sawteeth mode control (heating around q=1 surface)	170 GHz, 24 MW CW - 24 x 1 MW CW gyrotrons

Status of the H&CD

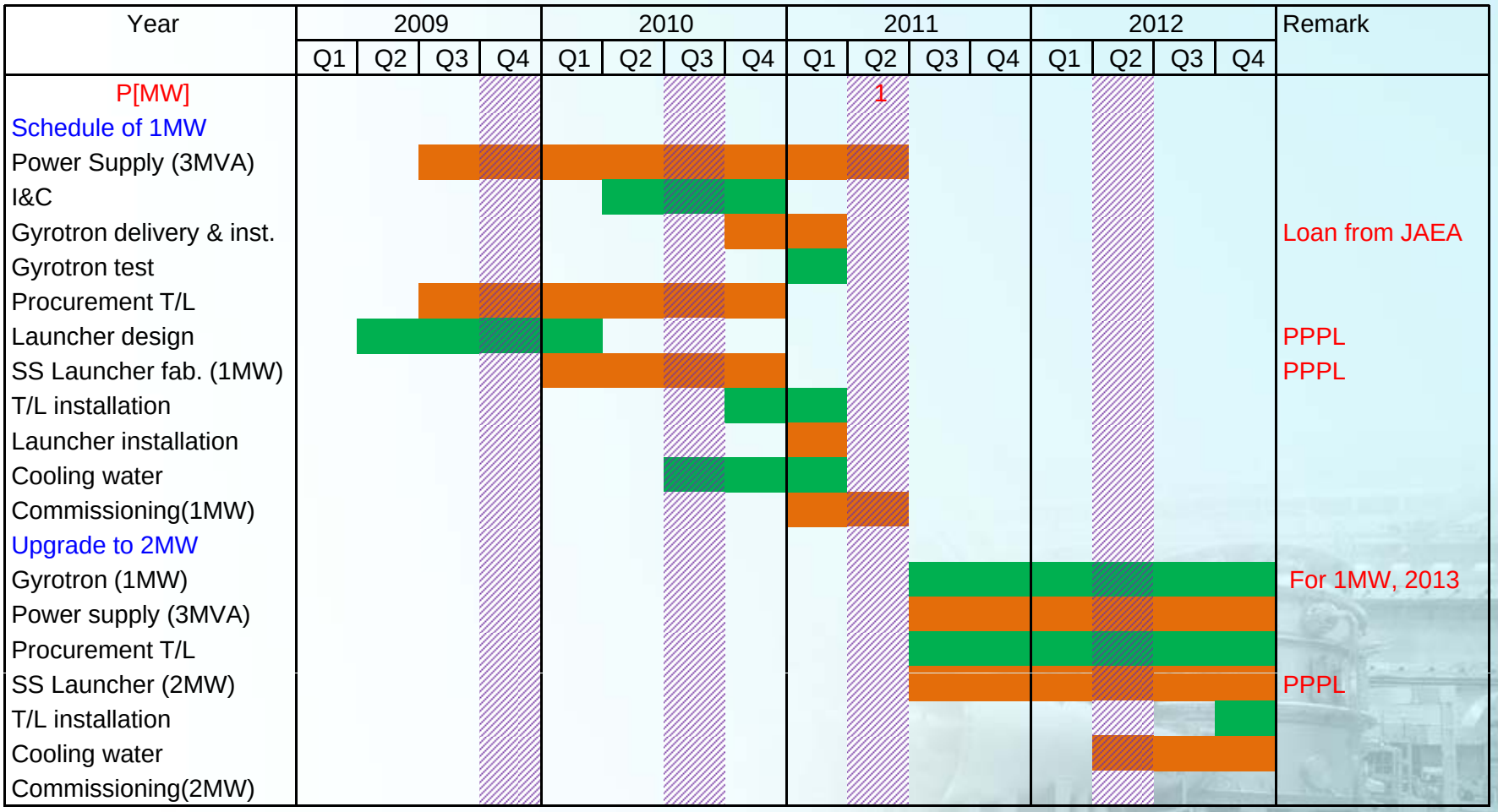


Key Milestones of the H&CD Upgrade

NFRI
http://www.nfri.re.kr

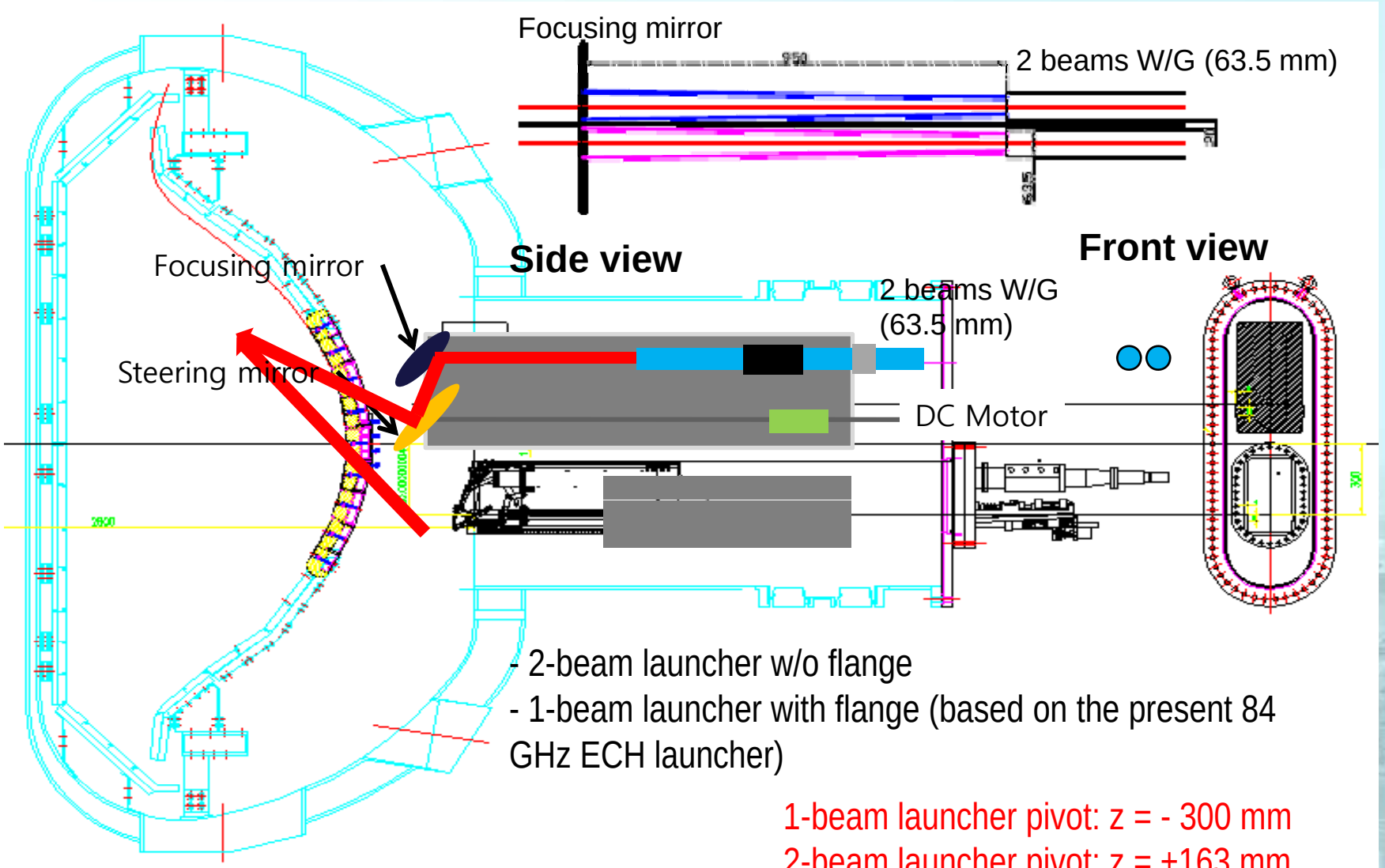
Device	2008	2009	2010	2011	2012
ECH/CD					
- 84 GHz	0.5MW/0.4s	0.5MW/2s	0.5MW/2s	0.5MW/2s	0.5MW/2s
- 110 GHz (under collaboration)			0.5MW/2s	0.5MW/2s	0.5MW/2s
- 170 GHz				1MW/10s	1MW/300s
LHCD				0.5MW/2s	1MW/2s
ICRF	30MHz 50kW/10s	45MHz 300kW/10s	45MHz 1MW/10s	45MHz 1MW/10s	45MHz 2MW/300s
NBI			100keV D0 1.5MW/10s	120keV D0 2.5MW/10s	120keV D0 5MW/300s

Schedule of 170 GHz ECCD System



Pre-conceptual Design of 3(1+2) MW ECCD Launcher

Top view of 2 MW launcher



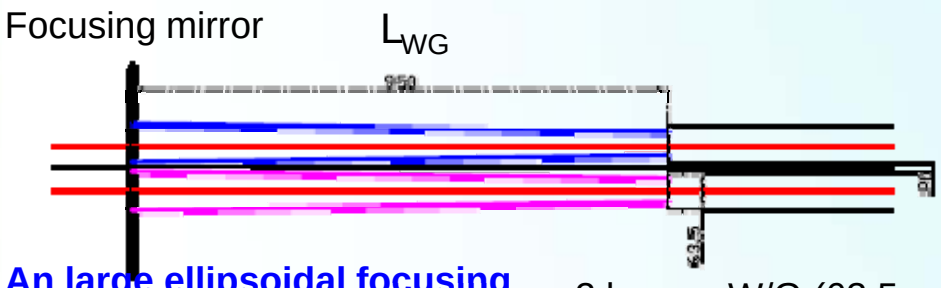
- 2-beam launcher w/o flange
- 1-beam launcher with flange (based on the present 84 GHz ECH launcher)

1-beam launcher pivot: z = - 300 mm
2-beam launcher pivot: z = +163 mm

Beam Focusing of 170 GHz EC Wave

NFRI
http://www.nfri.re.kr

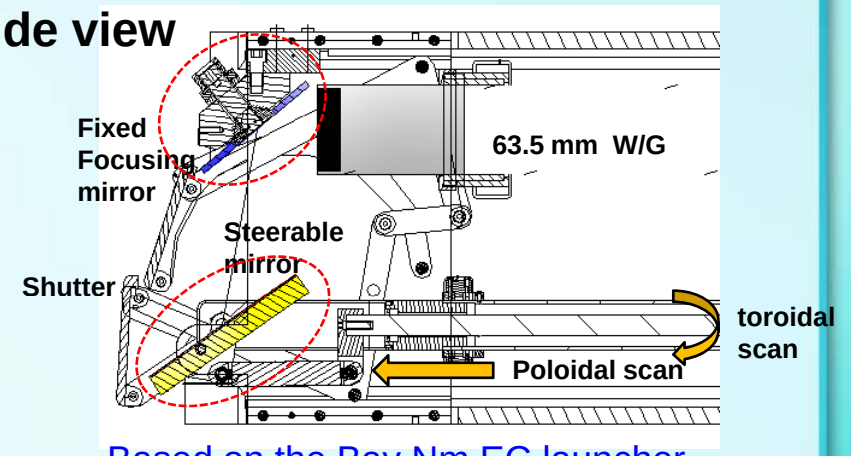
Top view of 2 MW launcher



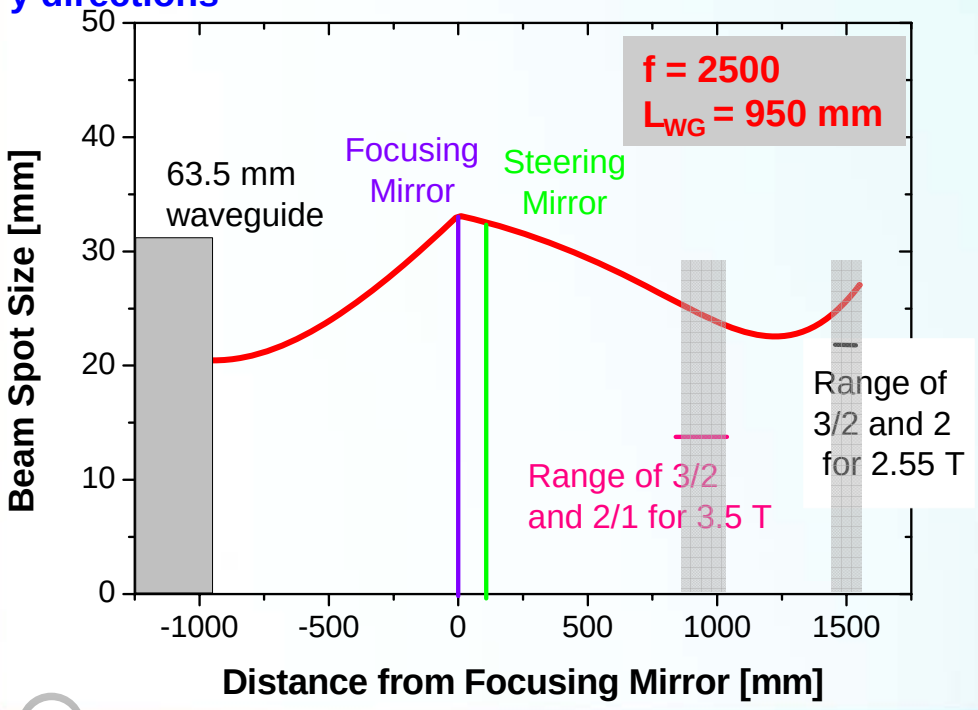
2 beams W/G (63.5 mm)

An large ellipsoidal focusing mirror for simultaneously focusing two beams in x and y directions

Side view



Based on the Bay Nm EC launcher



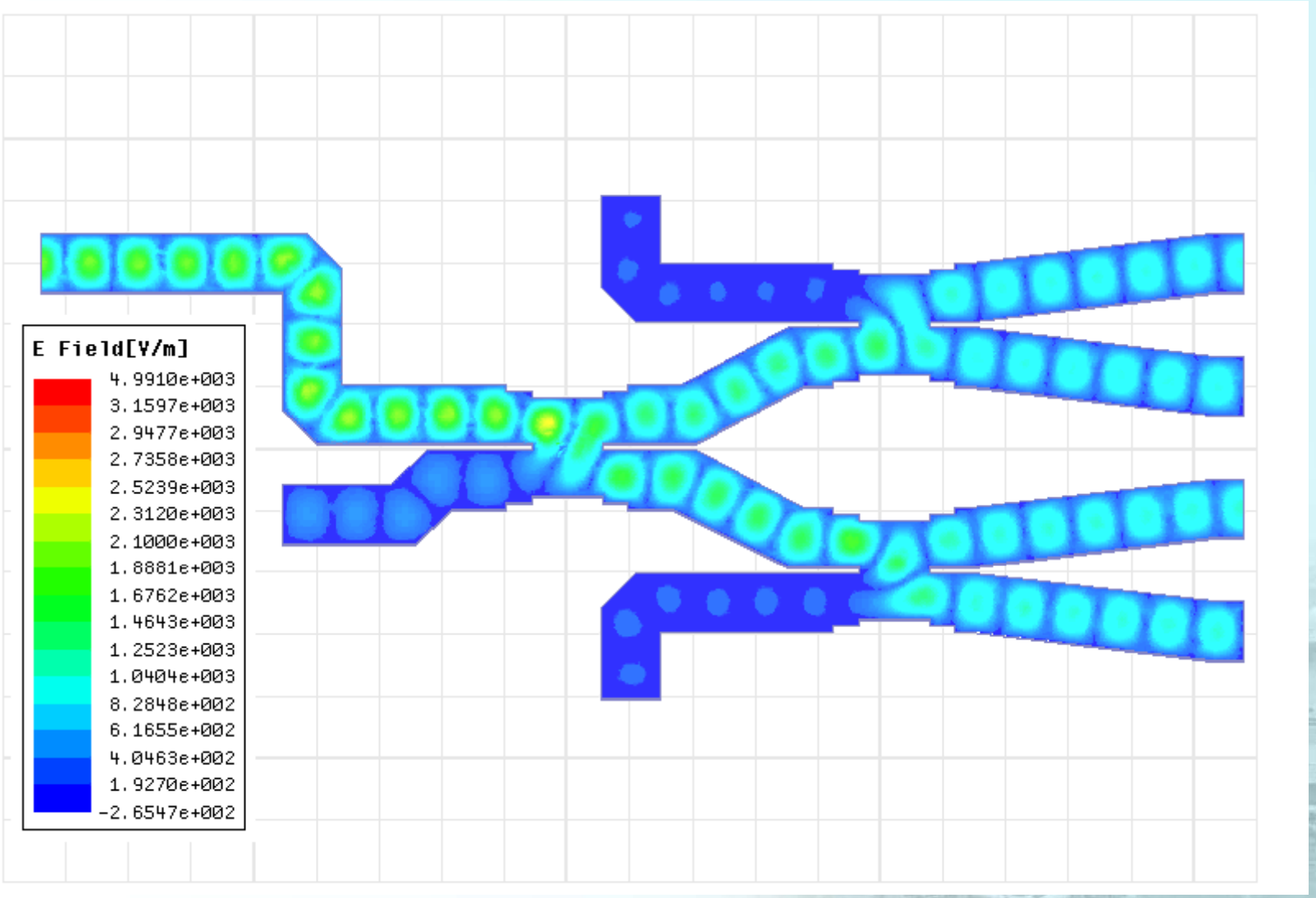
Beam Size (r_B) Calculation

f	L_{WG}	r_B (z0=L_{WG})	r_B (z0+1000)	r_B (z0+1500)
flat	950	33.16	57.35	70.35
3000	950	33.16	25.83	25.52
2500	**950**	**33.16**	**23.84**	**25.71**
2000	950	33.16	21.15	28.6
1000	950	33.16	18.66	64.57

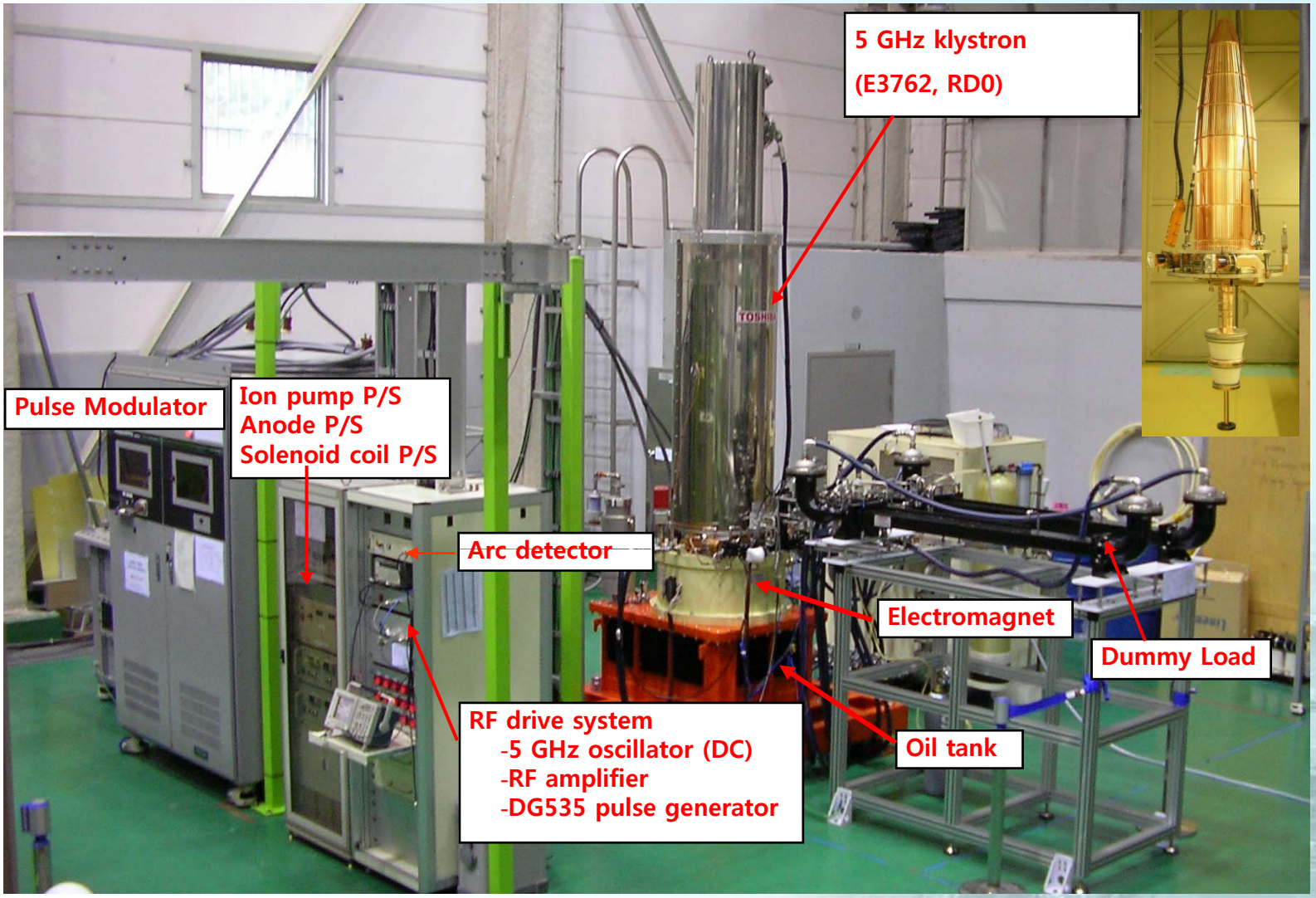
Schedule of 5 GHz LHCD System

Year	2009				2010				2011				2012				Remark
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
P[MW]								0.5						1			
Schedule of 0.5 MW																	
Power supply (2MVA)																	Loan from PEFP
I&C																	
Klystron test																	klystron proto-type
Procurement T/L																	
Launcher design																	PPPL
Launcher fab. (1MW)																	Korea
Installation of T/L																	
Installation of Launcher																	
Cooling water																	
Commissioning																	
Upgrade to 1 MW																	
Procurement of 5GHz, 500 kW (cw) Klystron																	
Power supply (2MVA)																	
Procurement & installation of T/L																	
Cooling water																	
Commissioning (1MW)																	

4-way Splitter Design of 5 GHz LHCD Launcher



Test Lab of 5GHz Klystoron



KSTAR ICRF System - Status

NFRI
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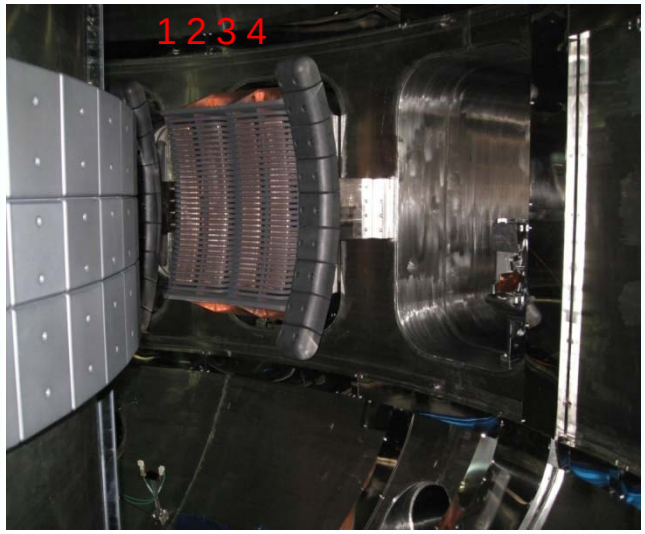
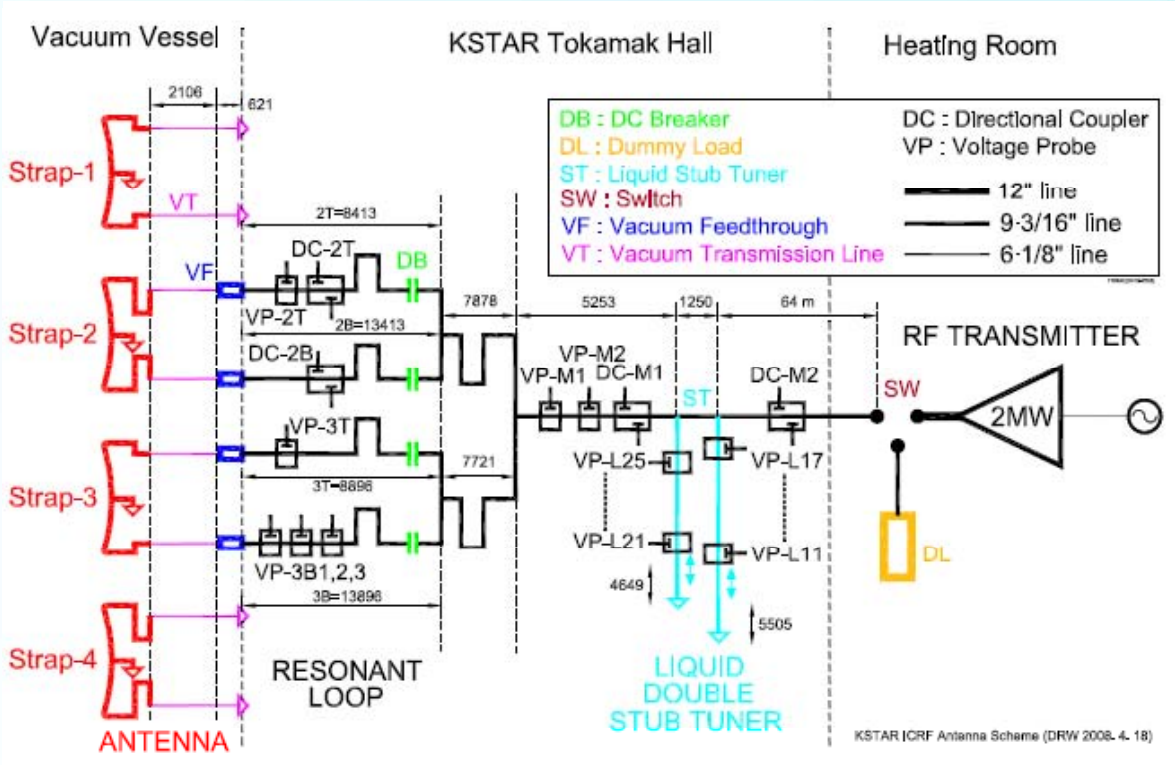
- **Transmitter specifications**
- **Frequency: 33 MHz (30, 37, 45, 50, 60MHz)**
- **Anode V/I: 22.2 kV/ 122 A**
- **Screen grid V/I: 980 V/ 2.4 A**
- **Control grid V/I: -470 V/ 9.2 A**
- **Input RF power: 86.2 kW**
- **Efficiency of FPA: 64.7 %**
- **VSWR (Driver/FPA): 1.22**
- **VSWR (FPA/Dummy load): 1.51**
- **Ion pump current: 0.6 μA**



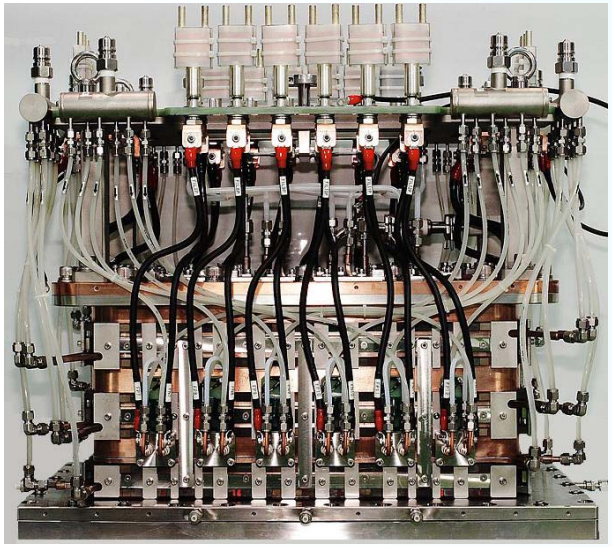


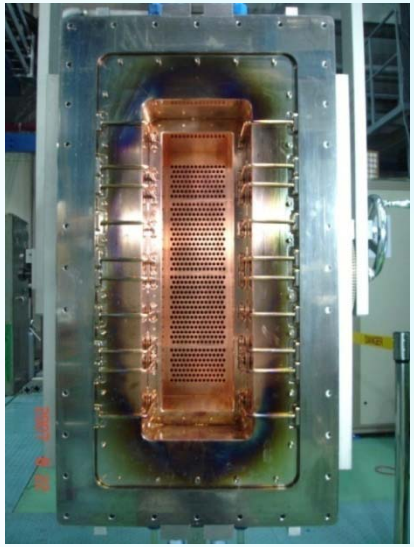
Schematic of KSTAR 2 MW ICRF system

Development Plan of NBI System

- We are aiming at the injection of 1-1.5 MW deuterium neutral beam power for the 2010 KSTAR campaign with a maximum pulse length of 10 seconds.
- For this, the first NBI beam line is presently under design and the fabrication will begin very soon.
- The design and capability of the ion source is based on those of prototype ion sources developed by the Korea Atomic Energy Research Institute (KAERI).
- A 1-MW, 300-s long hydrogen neutral beam has been recently extracted with a beam energy of 90 keV in the KAERI test-stand. For the higher beam energy of 100 keV, only 2-s long neutral beam extraction was possible.
- The ion source is under development in collaboration with KAERI and JAEA
  - A source chamber (plasma generator) of 120 kV, 65 A, 300 s has been developed by JAEA and it was delivered to KAERI. Now it is being tested.

Status of Ion Source Development





JAEA plasma generator of ion source

- Delivered to NFRI in July, 2008 and moved to KAERI for test.
- This will be used for KSTAR NBI-1 # ion source

KSTAR accelerator grid system

- 4 lens system
- Designed energy and current : 120 keV, 65 A (D+)
- Pulse length : 300 s
- Extraction hole size: 7.6 mm
- Number of extraction holes: 568

Collaboration Issues for KSTAR H&CD

NFRI
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- 5 GHz, 1 MW LHCD launcher prototype development (concerning the power upgrade to 1 MW in 2012)
  - 16 x 4 front coupler (grill) with 16 power inputs from two 500 kW klystrons (one klystron feeds 8 inputs)
  - Maximum 2 s pulse duration (no active cooling needed!)
- 170 GHz, 1 MW ECCD launcher development
  - 1 beam, 1 MW (300 s) two mirror antenna (similar launcher as Bay N launcher, the laminated mirror, active water cooling channels)
  - Design and fabrication in with PPPL
- Gyrotron conditioning support from GA
  - 84 GHz gyrotron is now under repair at CPI
  - Initial conditioning support from GA
- Loan of 110 GHz gyrotron from GA
  - 500 kW Gycom gyrotron tube, magnet system, MOU
  - 110 GHz polarizer system, dummy load, collector coil PS, filament ISO transformer, etc…
- Application of DIII-D ECH setup tools (ECHRES, Toray code, EFIT viewer for EC launcher mirror settings) to KSTAR

Status & Upgrade Plan of the KSTAR Actuators

- In-Vessel Components-

In-Vessel Components for Next Campaign

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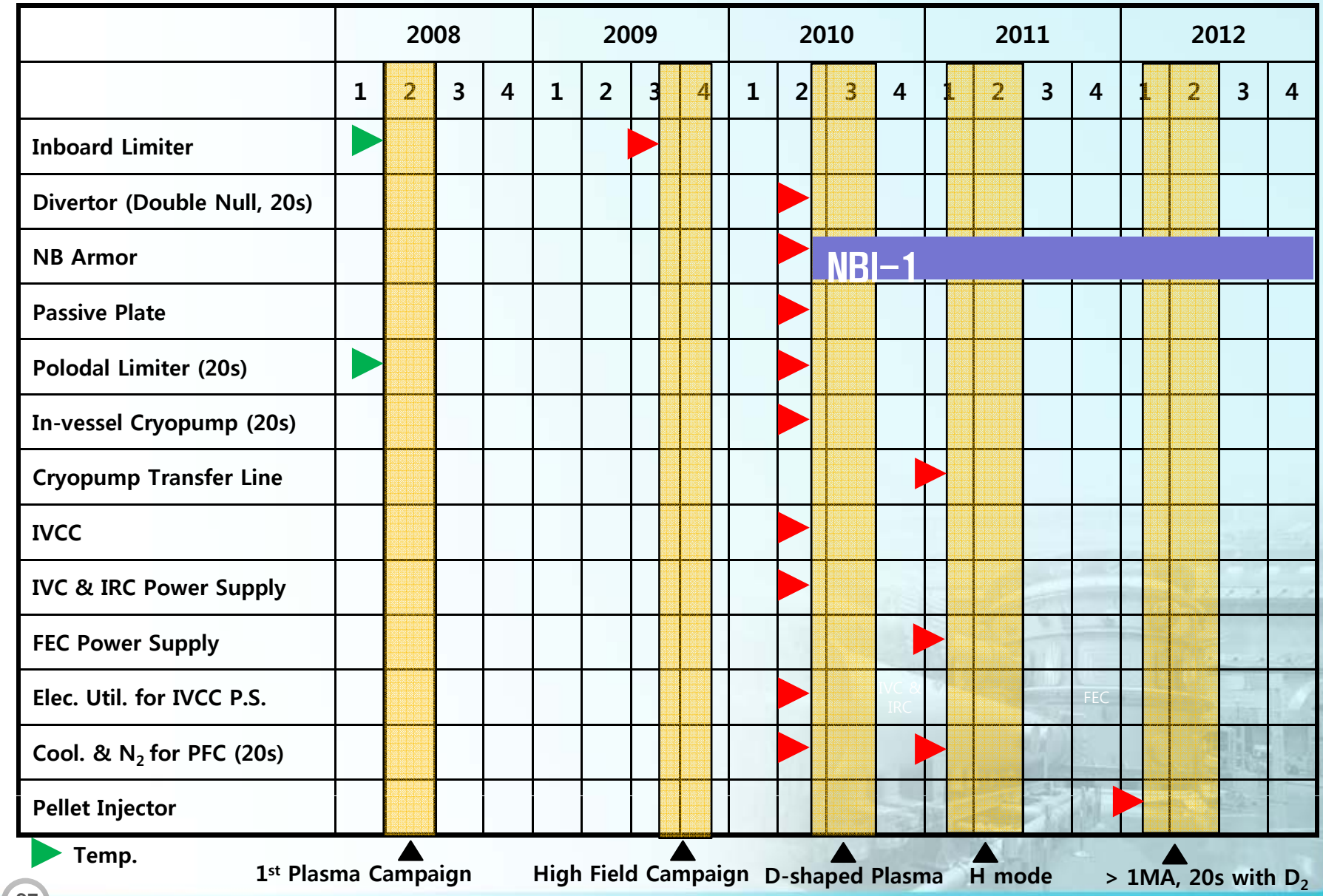
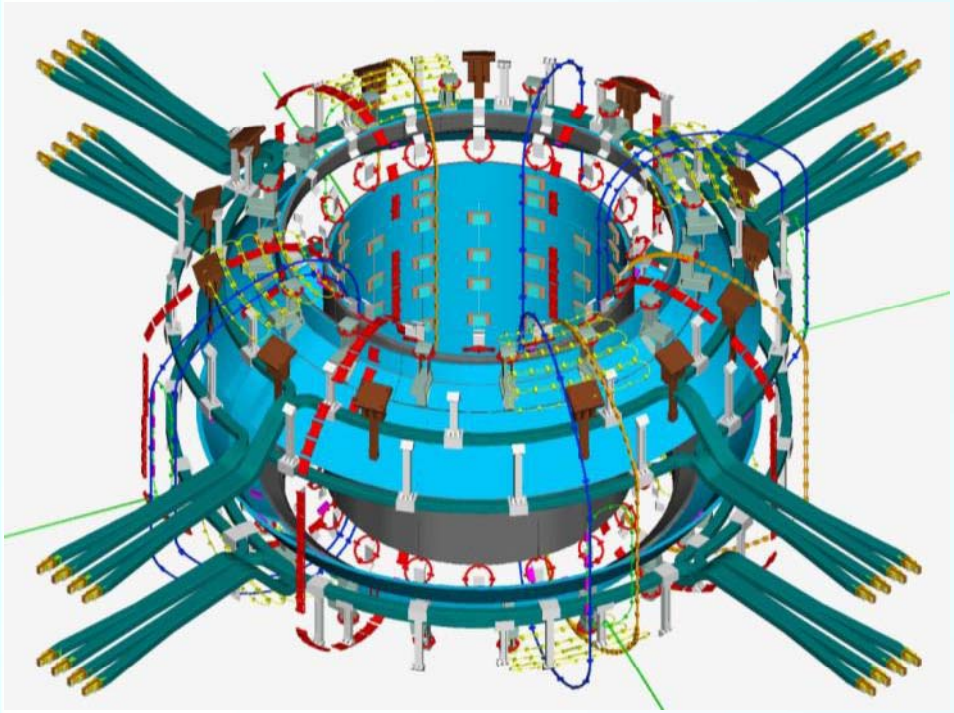
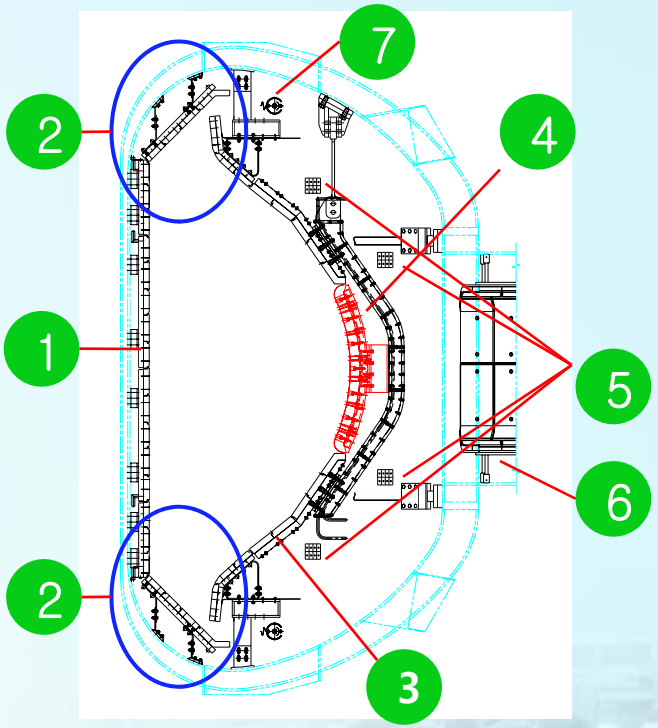


In-Vessel Component



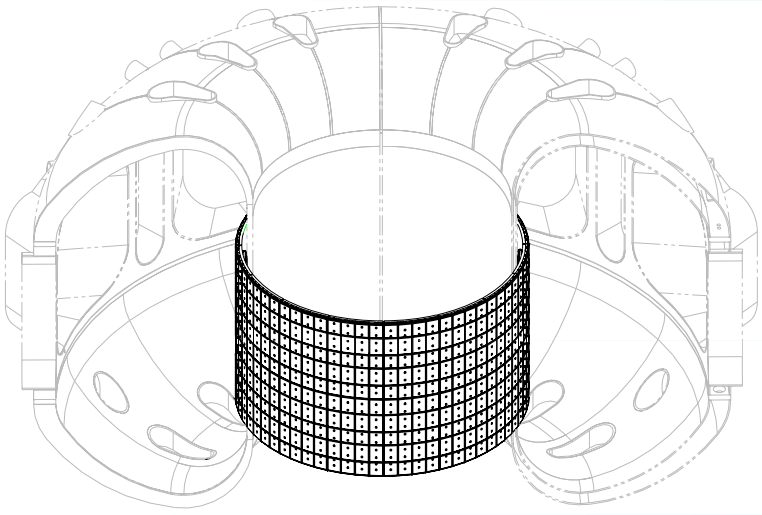


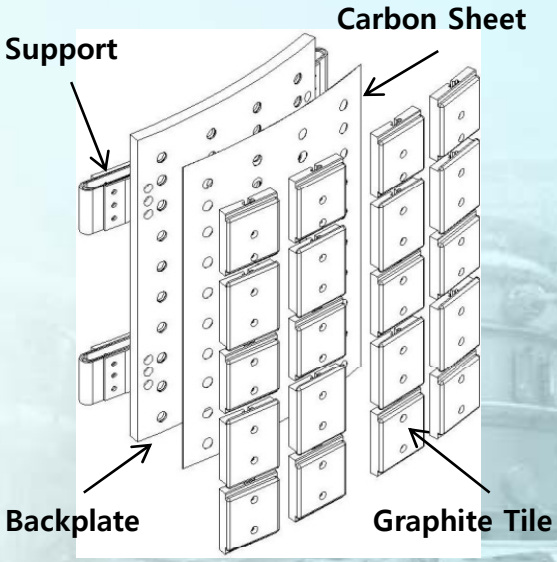
1. Inboard Limiter (**2009**)
2. Divertor (for double null, 20 sec, **2010**)
3. Passive Stabilizer (**2010**)
4. Poloidal Limiter (**2010**)
5. In-vessel control coil (**2010**)
6. NB armor (NBI-1, Port L, **2010**)
7. In-vessel Cryopump (**2010 ~ 2011**)

In-Vessel Component – Inboard Limiter

- To protect inboard wall of vacuum vessel and to define inner boundary of operating plasma
- Design
  - Total 32 sectors (16 x 2) – back plate
  - Graphite tile for normal sector
  - CFC tile for NB hitting sector (: need to be upgraded)
  - Back plate : STS316LN, Water cooling channel

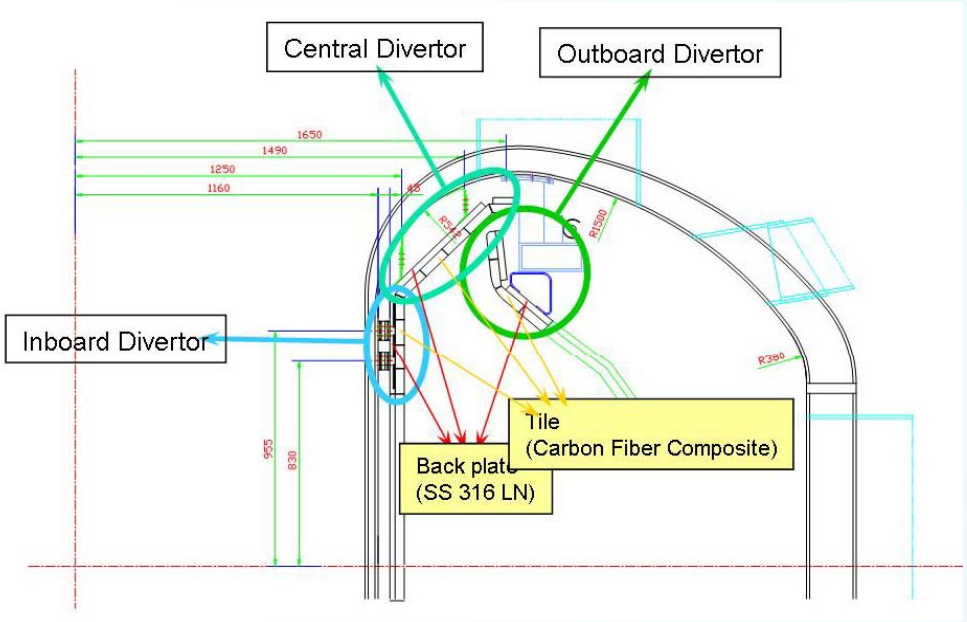
- **Under Fabrication**

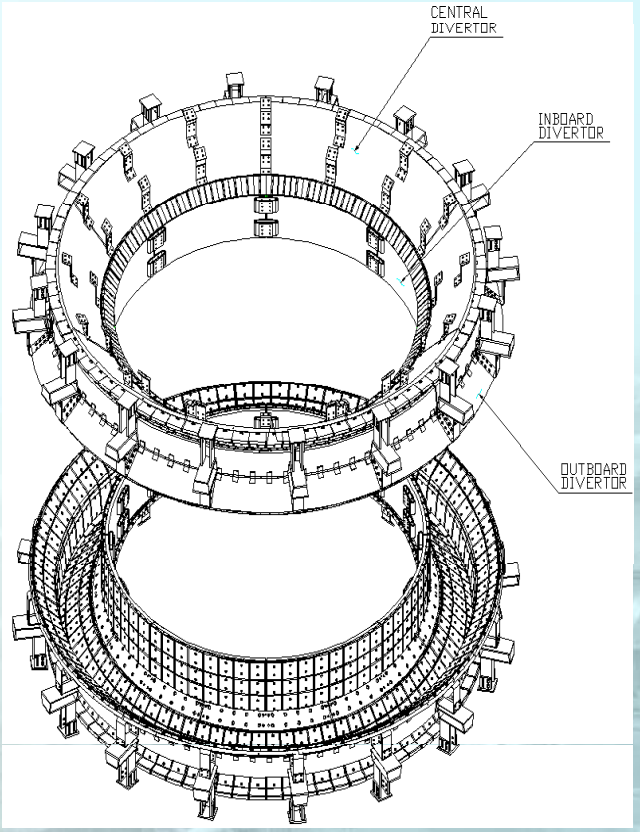




In-Vessel Component - Divertor

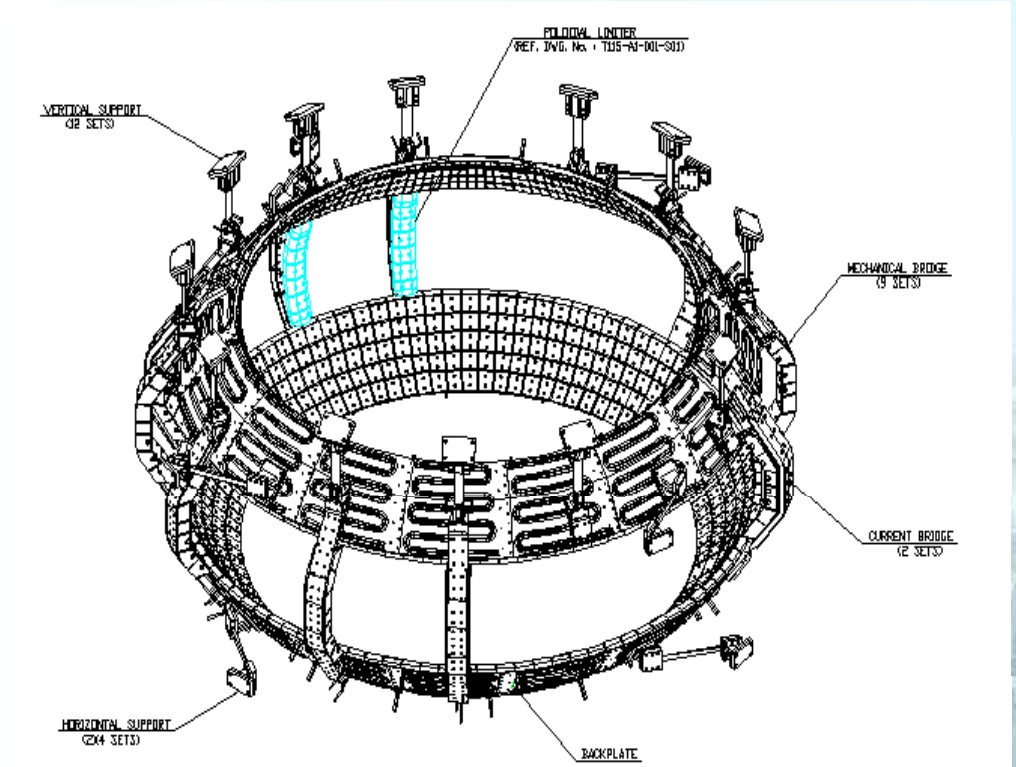
- To control effective particle to keep high quality plasma with enough shaping flexibility accommodating wide range of plasma operation
- Design
  - Three parts : Inboard, Central and Outboard divertor
  - Total 48 sectors (3 x 8 sector x 2)
  - Symmetry upper and lower parts
  - CFC tile (carbon fiber composite)
  - Backplate : STS316LN, Water cooling channel
  - Need to be upgraded for 300 sec. operation





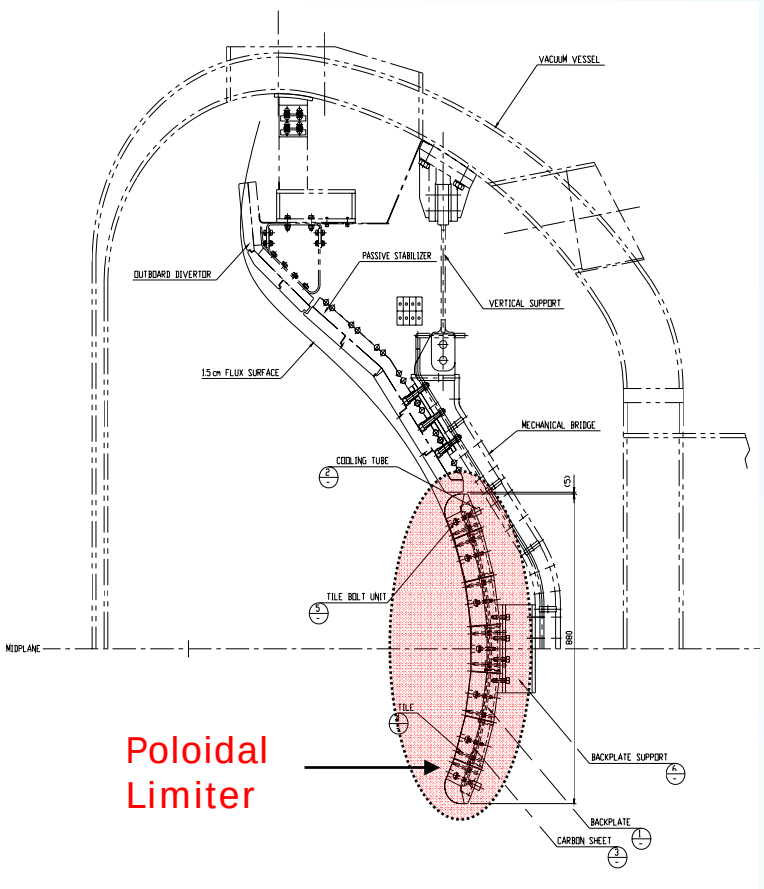
In-Vessel Component – Passive Stabilizer

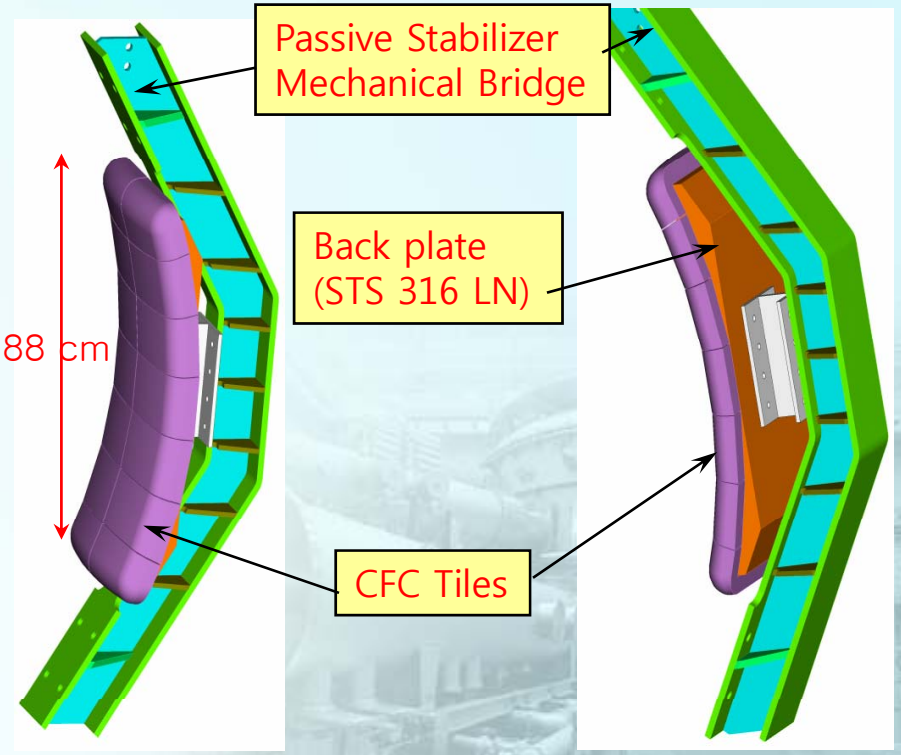
- **Design**
  - Two toroidal rings shape, 9 Mechanical bridges , 2 Current bridges (under consideration)
  - Total 32 sectors (16 x 2)
  - 12 vertical supports(at upper TR), 4 horizontal supports(at upper/lower TR)
  - Upper parts support lower parts with 9 mechanical bridges
  - Graphite tile (impurity < 10ppm)
  - Back plate : CuCrZrMg, Water cooling tube



In-Vessel Component – Poloidal Limiter

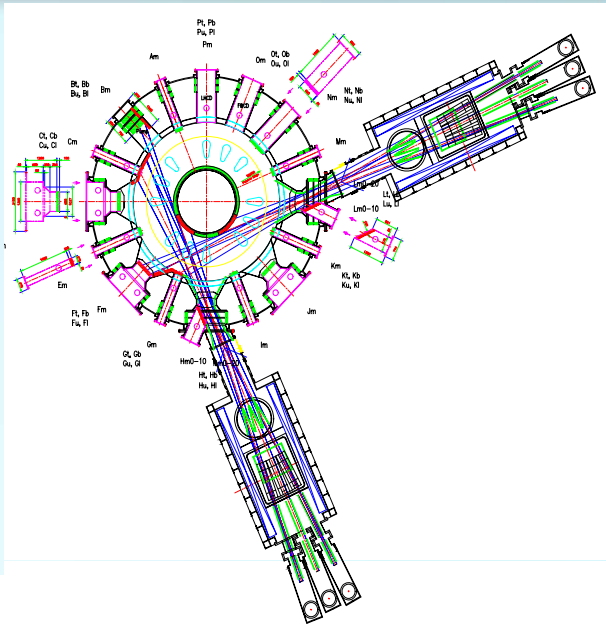
- To protect ICRH and LHCD antennas from the operating plasma
- Design
  - 3 parts on mechanical bridge
  - saddle loop shape with CFC tile
  - Needed to be upgraded for 300 sec operation

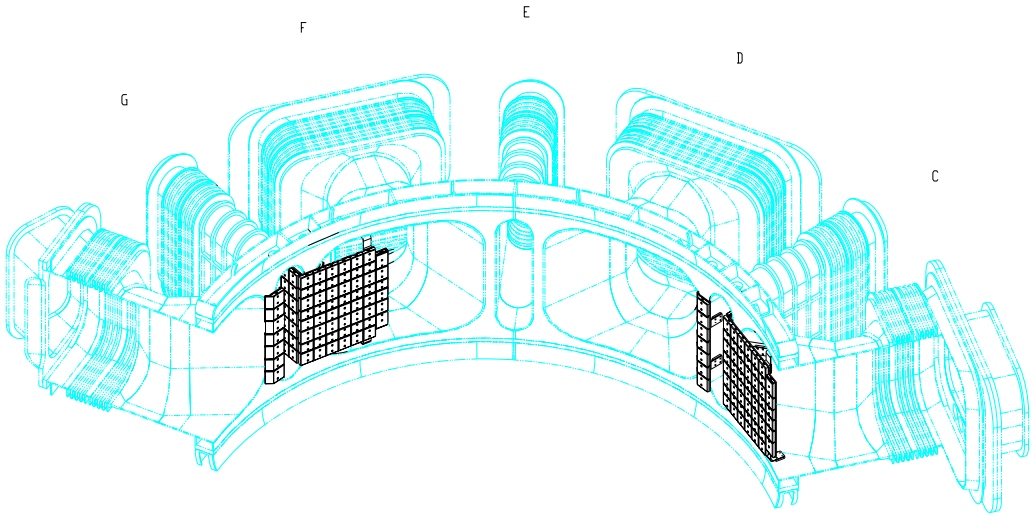




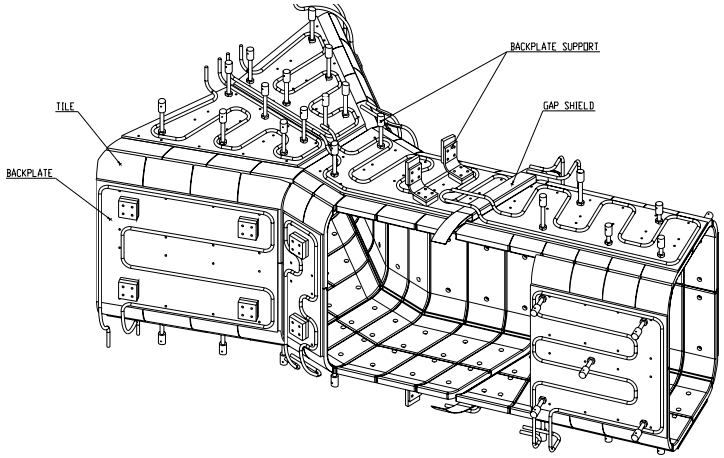
In-Vessel Component – NB Armor

- To protect vacuum vessel port from particles occurring by collision and to prohibit opposite side surface from damage by neutral beam penetrating the plasma area
- Design
  - Two parts : Neutral beam entrance port protector (H, L port), neutral beam shinethrough armor (B-C, F-G port)
  - Graphite tile
  - Need to be upgraded for 300 sec operation



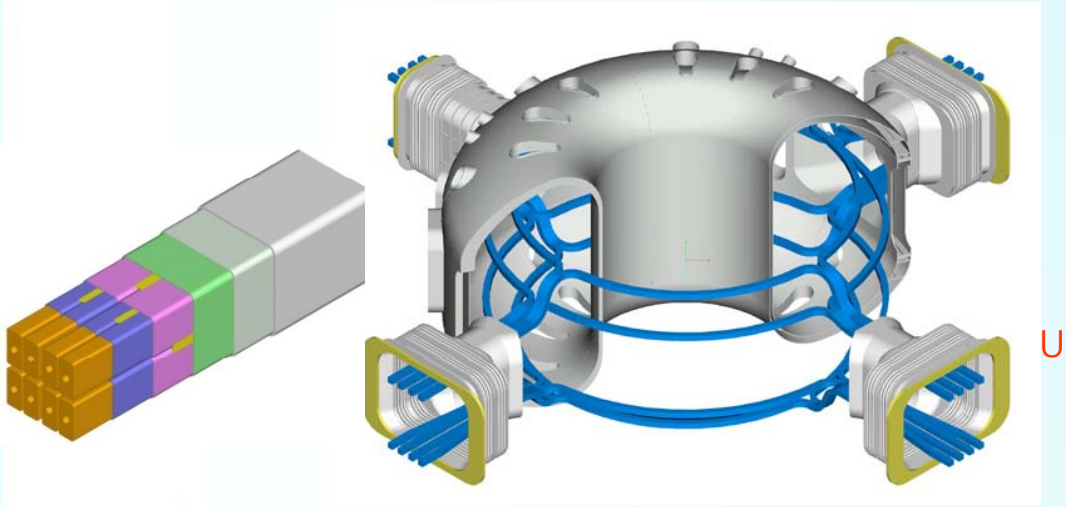


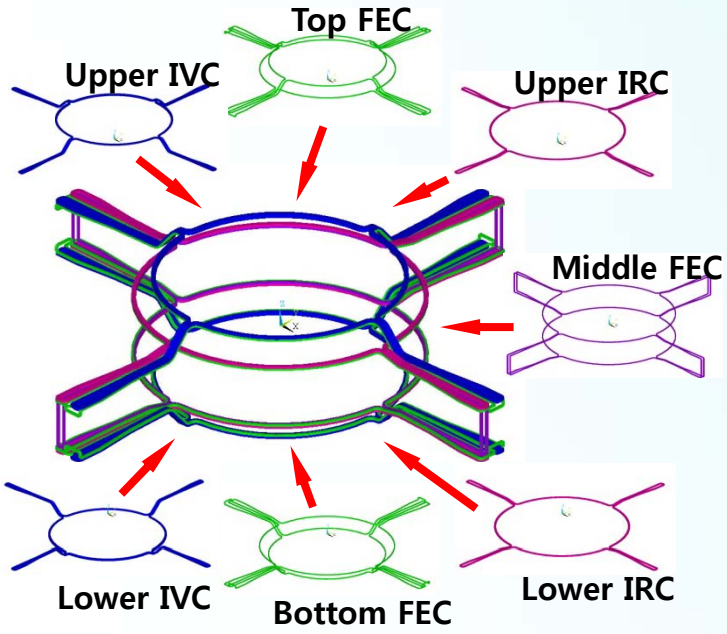
NB Shinethrough Protection Armor

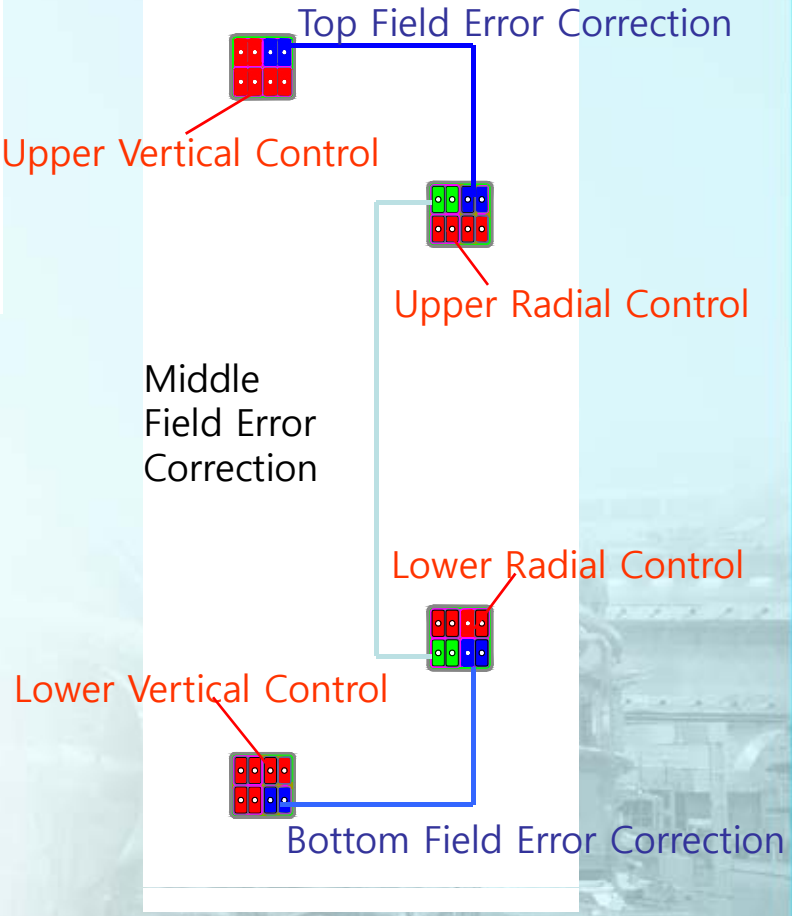


NB Entrance Port Protector

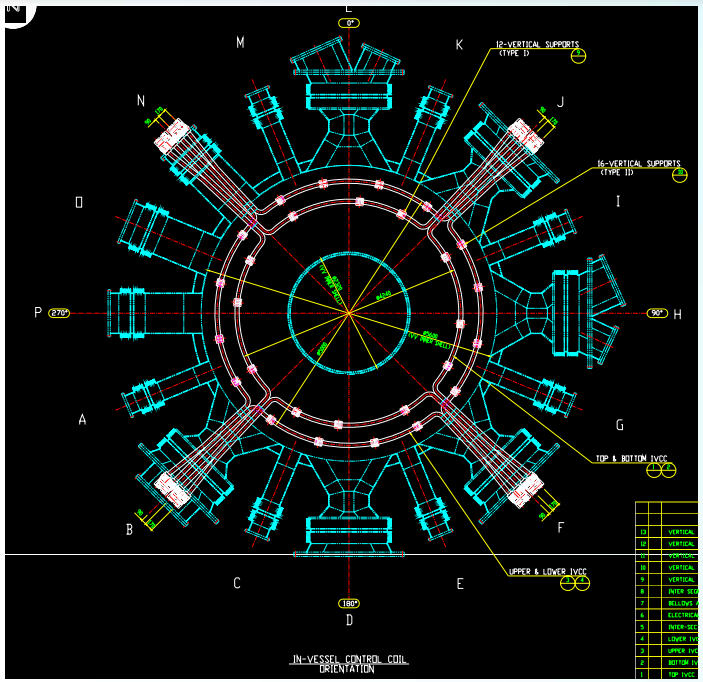
In-Vessel Component – IVCC



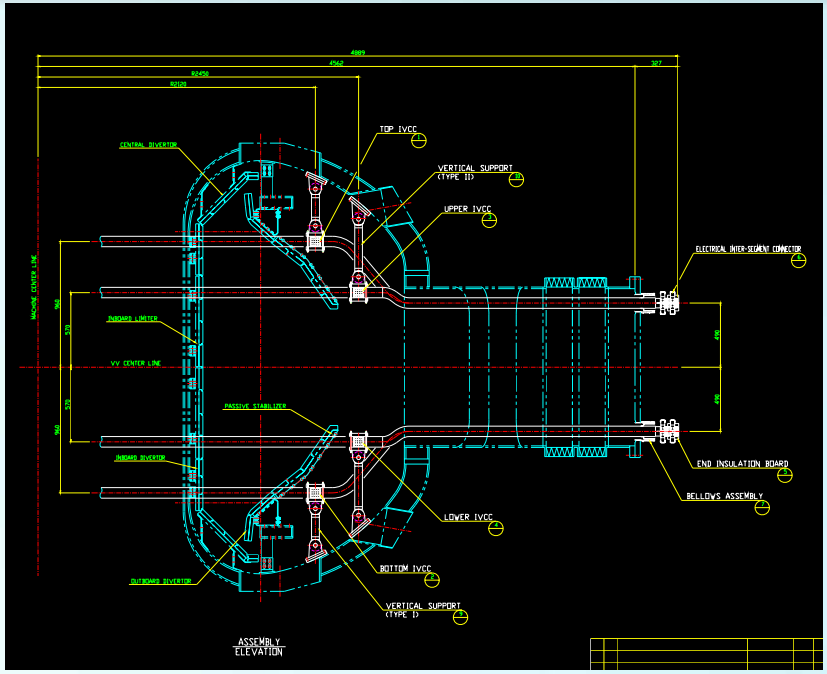




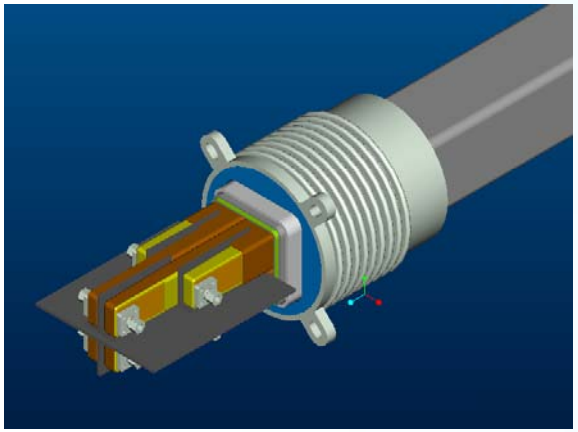
In-Vessel Component – IVCC



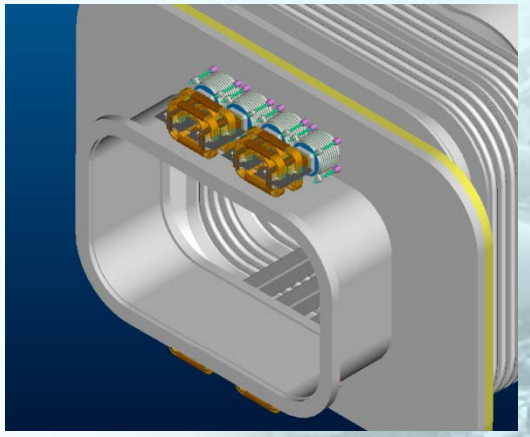
Vacuum Vessel & IVCC – Top View



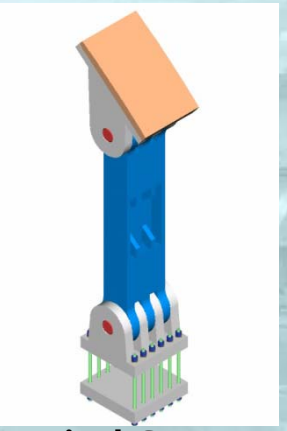
Vacuum Vessel & IVCC – Elevation View



End Part of Coil Segment



Electrical Connection



Vertical Support

In-Vessel Component - Cryo-pump

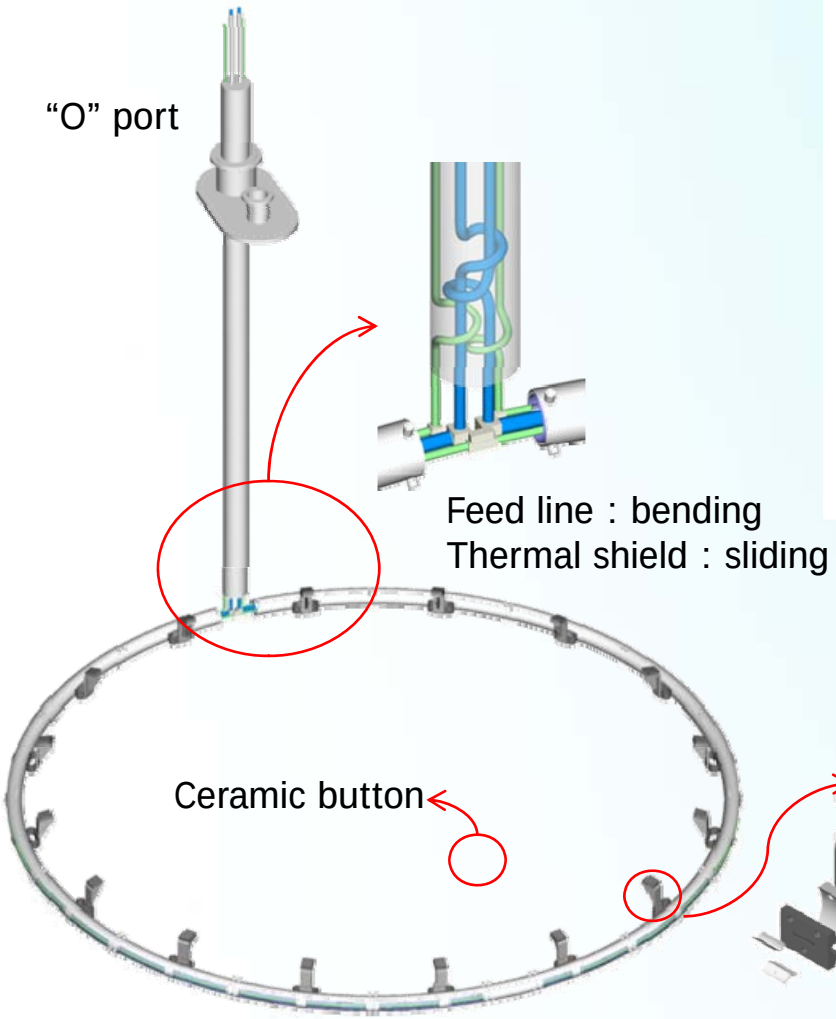
- **Requirement**

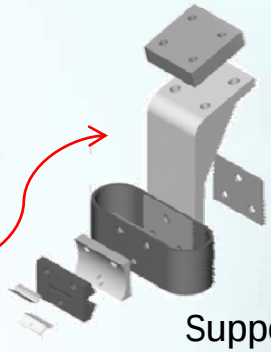
KSTAR in-vessel Cryo-pump requirement			
Characteristics	Number	**2**	ea
	Pumping speed	**25,000**	l/s
	Pulse Length	**20/300**	s
	Perimeter of the pump	**12.65**	m
	Pumping area	**1.01**	m^2
Helium coolant condition	Inlet temperature	**4.7**	K
	Inlet pressure	**1.52**	bar
	Outlet temperature	**4.7**	K
	Outlet pressure	**1.2**	bar
Thermal shield coolant condition	Inlet mass flow	**15.7**	g/s
	Inlet temperature	**55**	K
	Inlet pressure	**16**	Bar
	Outlet temperature	**70**	K
	Outlet pressure	**14**	bar
	Inlet mass flow	**15.7**	g/s
Heat Load	Helium Panel	**32**	W
	Thermal Shield	**1325**	W

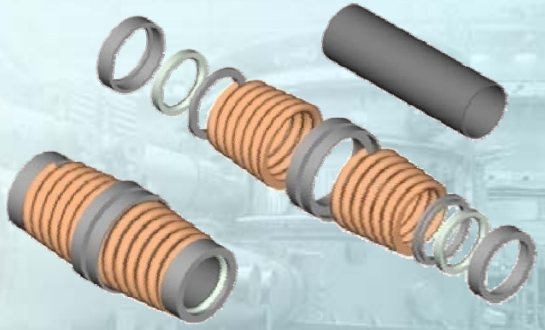
In-Vessel Component - Cryo-pump

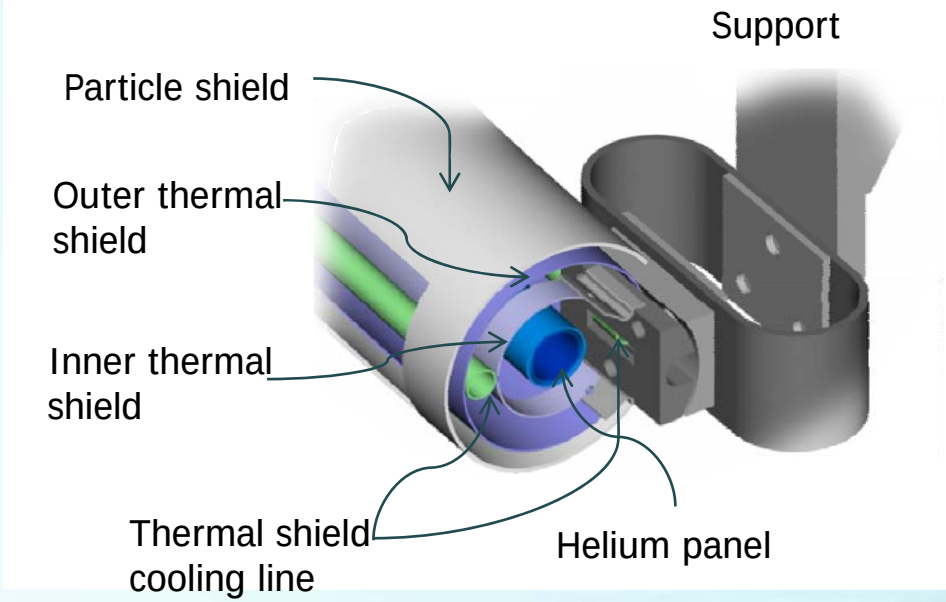
NFRI
http://www.nfri.re.kr

- **Designed Feature (under Eng. Design)**

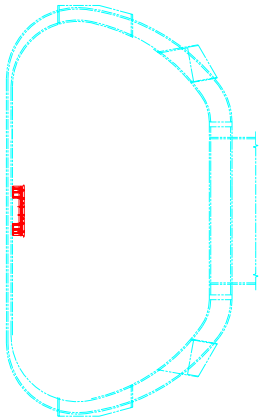



Support : 16

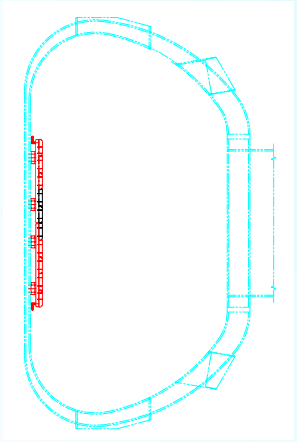

Conical spring : 16



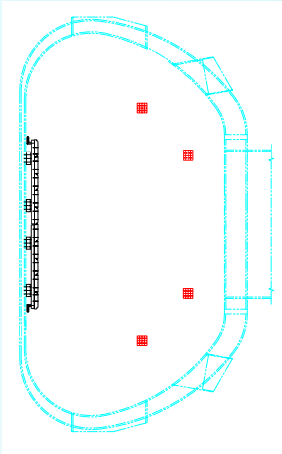
Upgrade Sequence of In-Vessel Component



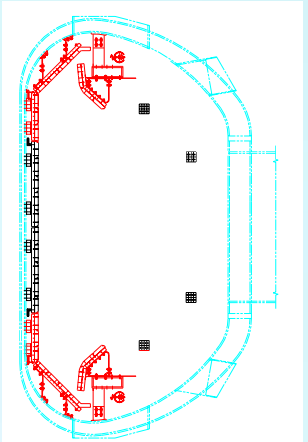
1 Partial Installation of the Inboard Limiter



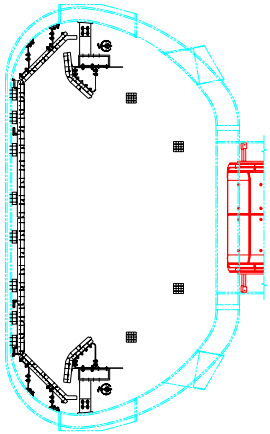
2 Full Installation of the Inboard Limiter



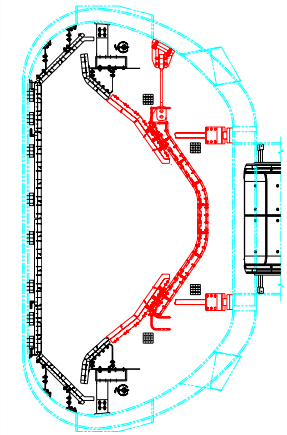
3 Installation of the IVCC



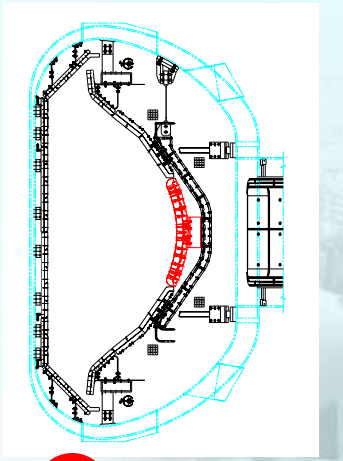
4 Installation of the Divertor System



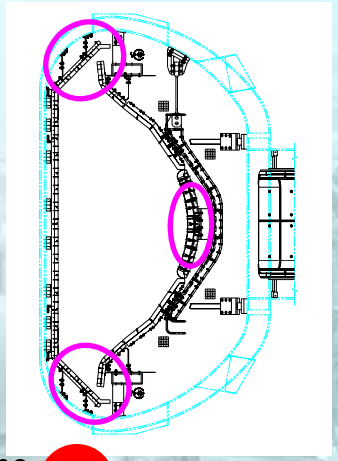
5 Installation of the NB Armor



6 Installation of the Passive Stabilizer



7 Installation of the Poloidal Limiter



8 Upgrade for 300s

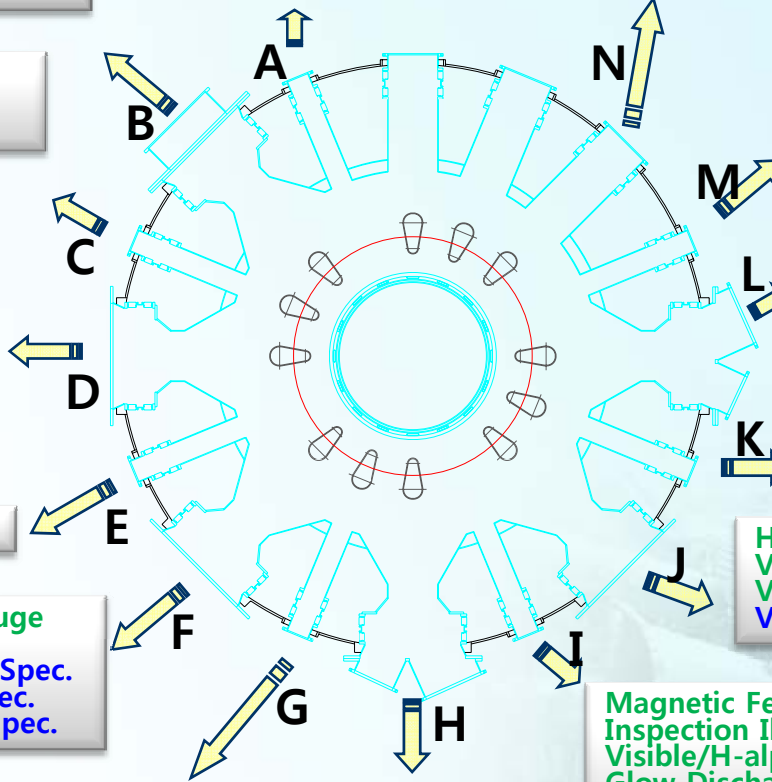
Status & Upgrade Plan of the KSTAR Actuators

- Diagnostics-

Status and Plan KSTAR Diagnostics

NFRI
http://www.nfri.re.kr

Basic Diagnostics (2008)
2009 New Diagnostics
Next Diagnostics



Torus Ion Gauge
RGA
X-ray Crystal Spec.
Fast Neutral Pressure Gauge
Thomson S.(Beam Dump)

Magnetic Feedthrough
Inspection Illuminator
Visible/H-alpha TV
Glow Discharge Probe
Survey IR TV
CES (Background)

Thomson Optics
Div. Thomson Optics

Magnetic Feedthrough
Inspection Illuminator
MSE
CES
BES

Reciprocating Langmuir Probe
Bolometer Array
X-ray Pinhole Camera

Soft X-ray Array
Survey IR TV
Visible/H-alpha TV
X-ray PHA
Multichord Vis. Spec.
X-ray Pulse Height Anal.
Impurity Pellet Injector

Bolometer Array
Fast Neutral Pressure Gauge
Thomson S. (Laser Input)
CX-NPA

ECE Radiometer(110~162GHz)
ECE GPC
Diagnostic Neutral Beam
LIF (Optics)

Magnetic Feedthrough

H-alpha Monitor
Visible Survey Spec.
Visible Filterscope
Visible Brems. Array

Torus Ion Gauge
RGA
X-ray Crystal Spec.
Soft X-ray Spec.
VUV Survey Spec.

Magnetic Feedthrough
Inspection Illuminator
Visible/H-alpha TV
Glow Discharge Probe
Survey IR TV
MSE(II)

mm-Wave
Interferometer
Reflectometer
MIR
ECEI

Fast Neutral
Pressure Gauge
Tan. FIR Int.
(Laser Input)

Revised Version: Dec. 2008

Upgrade Plan of Diagnostics System

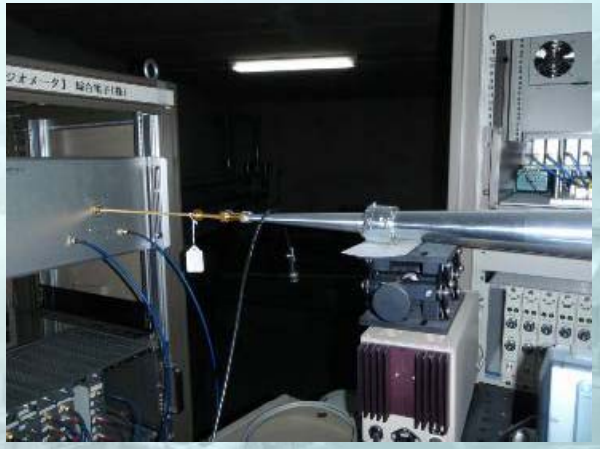
NFRI
http://www.nfri.re.kr

- **Resistive Bolometer (Collaborate with NIFS)**

- Time Resolution : < 0.1 ms (> 10 kHz)
- Spatial Resolution : 4.5 cm
  (toral 12 channel)
- Detection limit : 10^{-6} W/㎠
- Thermal drift (dU/dt) : < 10^{-4} V/K
- Sensitivity : 10.02 V/W
- Position : L-middle port

- **ECE(110~162GHz) (Collaborate with NIFS)**

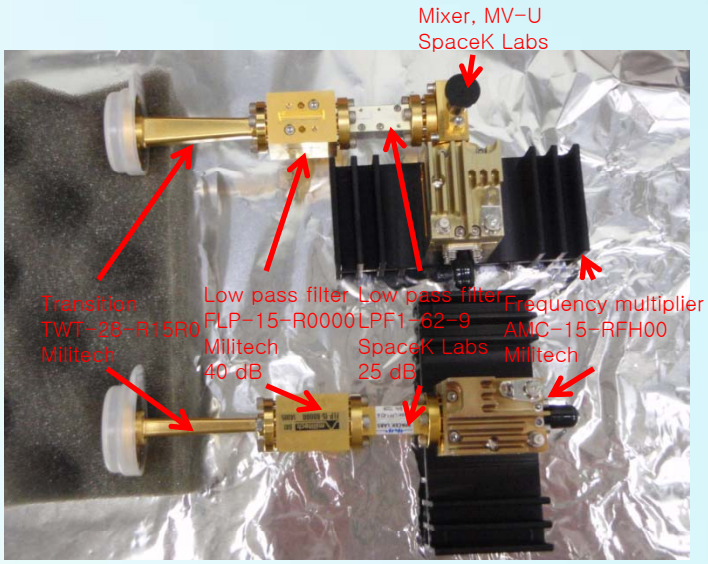
- Measurement parameter : electron temperature profiles
- Temperature measurement range: 500 eV – 2 keV
- Accuracy : <10%
- Time resolution : 100 kHz
- Spatial resolution : 20-25 mm
- Installation position : K-port



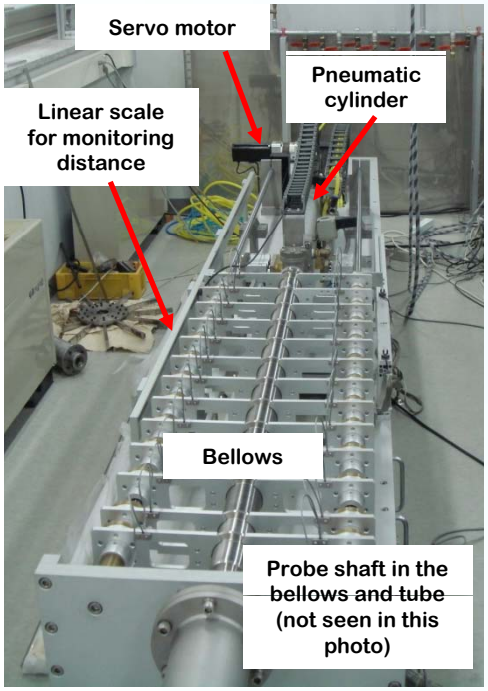
Upgrade Plan of Diagnostics System

• Microwave Reflectometer

- Channel : 2ch
- Time Resolution: **200 us (5 kHz)**
- Magnetic Field Range: **0-2.5 T**
- Density Range: **0-2 x 10^{13} cm^{-3}**
- Position: G port



• PD (fast reciprocating probe)

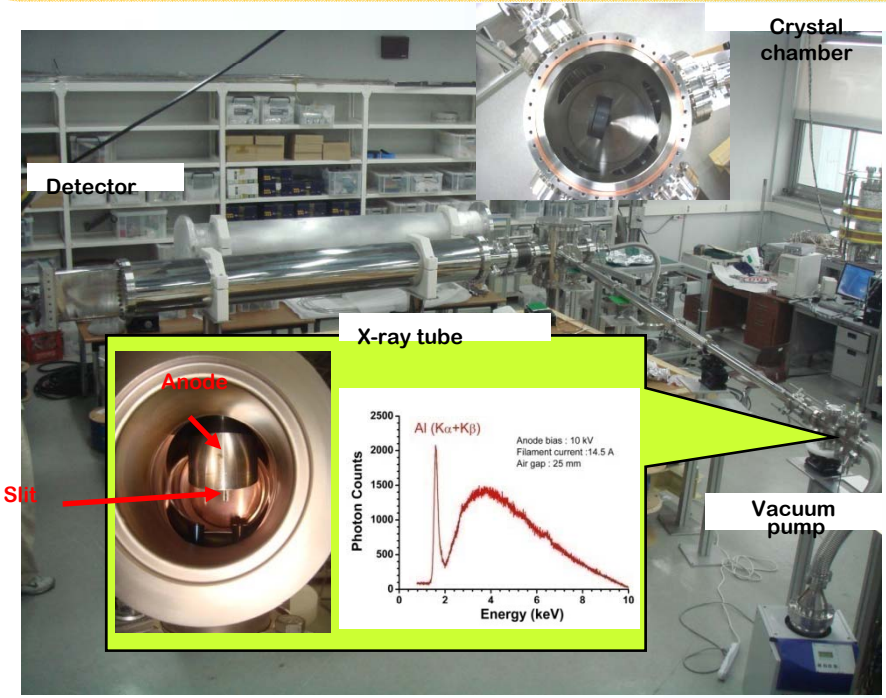


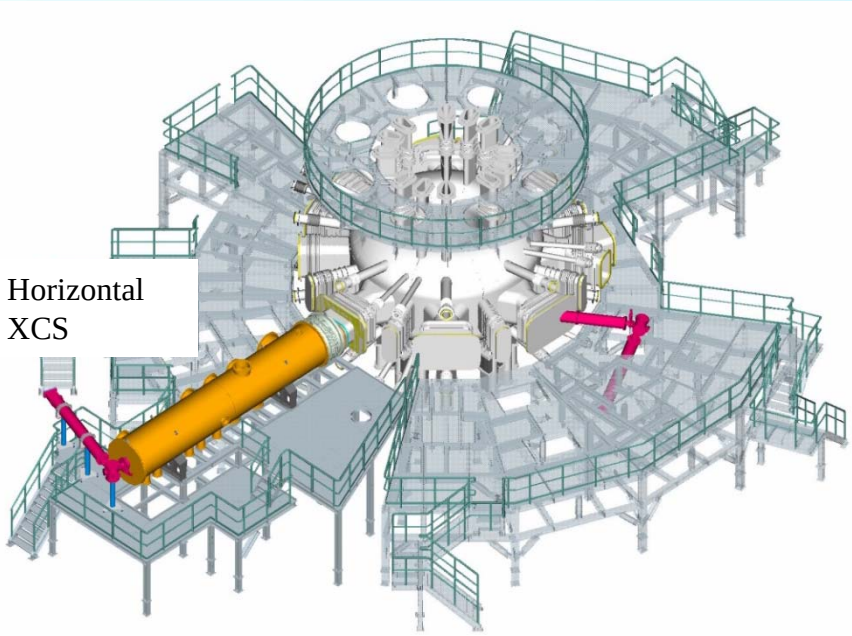
- **Scan speed : 1 m/s**
- **Measurement parameter: electron temperature and density profiles at edge region**
- **Measurement range: less than 200 eV at edge region**
- **Density range : less than 10^{18} m^{-3} at edge region**
- **Accuracy: < 10 %**
- **Spatial resolution: 5 mm**
- **Installation position: C port**

Upgrade Plan of Diagnostics System

• X-ray Crystal Spectroscopy XCS (1 set)

- Measurement parameter: **Ion and electron temperature profiles**
- Temperature measurement range: **500 eV – 2 keV**
- Accuracy: **<5%**
- Time resolution: **100 ms**
- Spatial resolution: **20 mm**
- Installation position: **B port for Horizontal XCS**



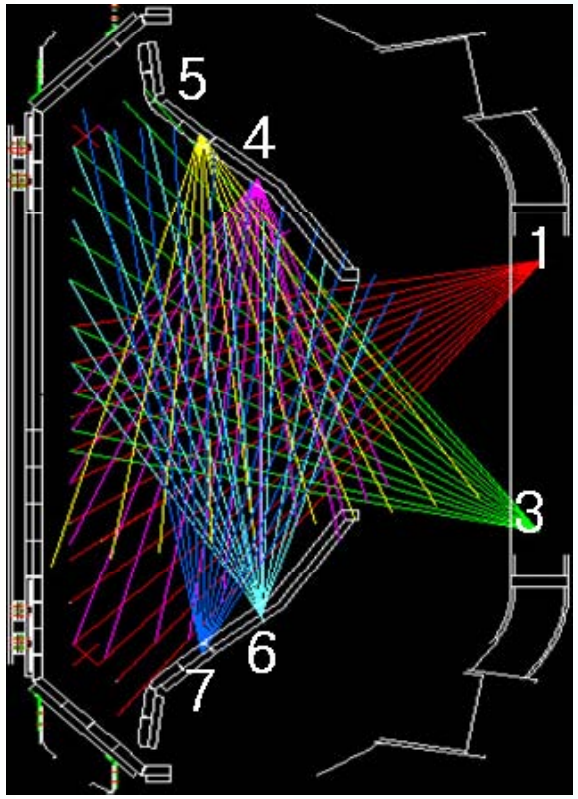


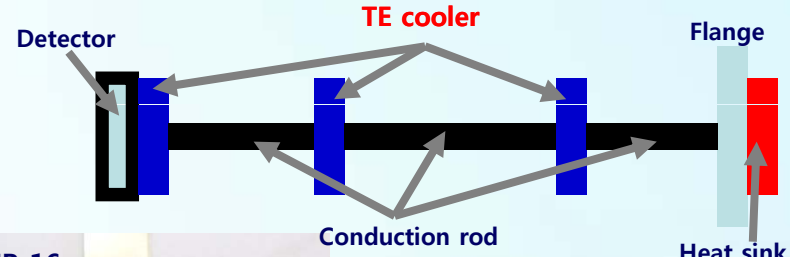
Upgrade Plan of Diagnostics System

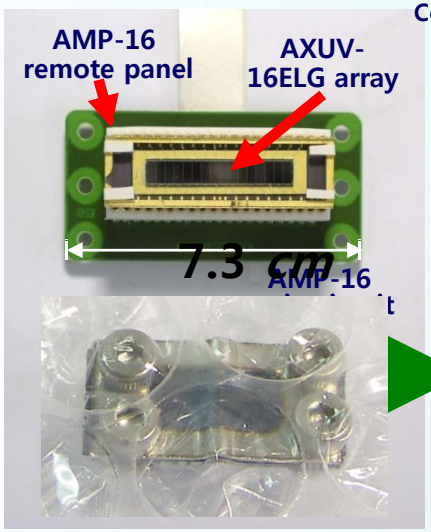
• Soft X-ray system

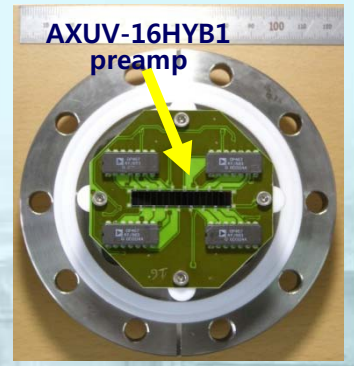
- 6 arrays, max. 240 ch (total system)
- Bandwidth of preamp : 500 kHz (for fast MHD such as TAE)
- T_e range: 1-10 keV
- inter-shot and post-shot analysis
- Developed tomographic reconstruction codes will be used.
- MHD phenomena and thermal heat transport will be studied.
- FY2009 : HU and HD will be installed.

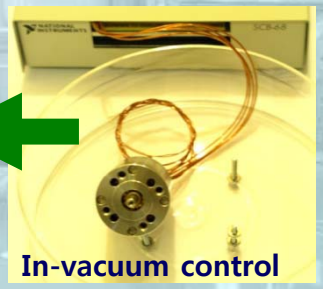
6 arrays, 240 ch
KSTAR soft x-ray array











Other Systems to Be Upgrade

- Boronization System (Under Collaboration)
- HFS Pellet Injection (Urgent Item for Collaboration)
- Baking System for VV Pumping Duct
- Upgrade Gas Fueling system
- Access Floor
- Cooling System
- Data Acquisition System
- QDS
- Control System
- HRS & HDS
- Sensors
-
-

Summary

- The KSTAR operation plan requires rapid upgrade schedule for the in-vessel components and ancillary systems
- Most of MPS and in-vessel component will be upgraded by 2010
- Preparation for the 2010 campaign is very tight and important!
- Because every main systems for 2010 operation requires lead time for manufacturing & installation, every MPS and In-vessel components are under manufacturing
- But most of the in-vessel components have to be upgraded for 300 s operation from Phase II
- It needs strong relationship between KSTAR Research Center and domestic & international collaboration partners for machine upgrade. Especially, heating and diagnostic systems