

Status of CEPC RF Power Delivery Systems

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On behalf of CEPC RF power source team

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Outline

- ◆ **Collider**
- ◆ **Booster**
- ◆ **Damping ring**
- ◆ **Linac**

Design consideration

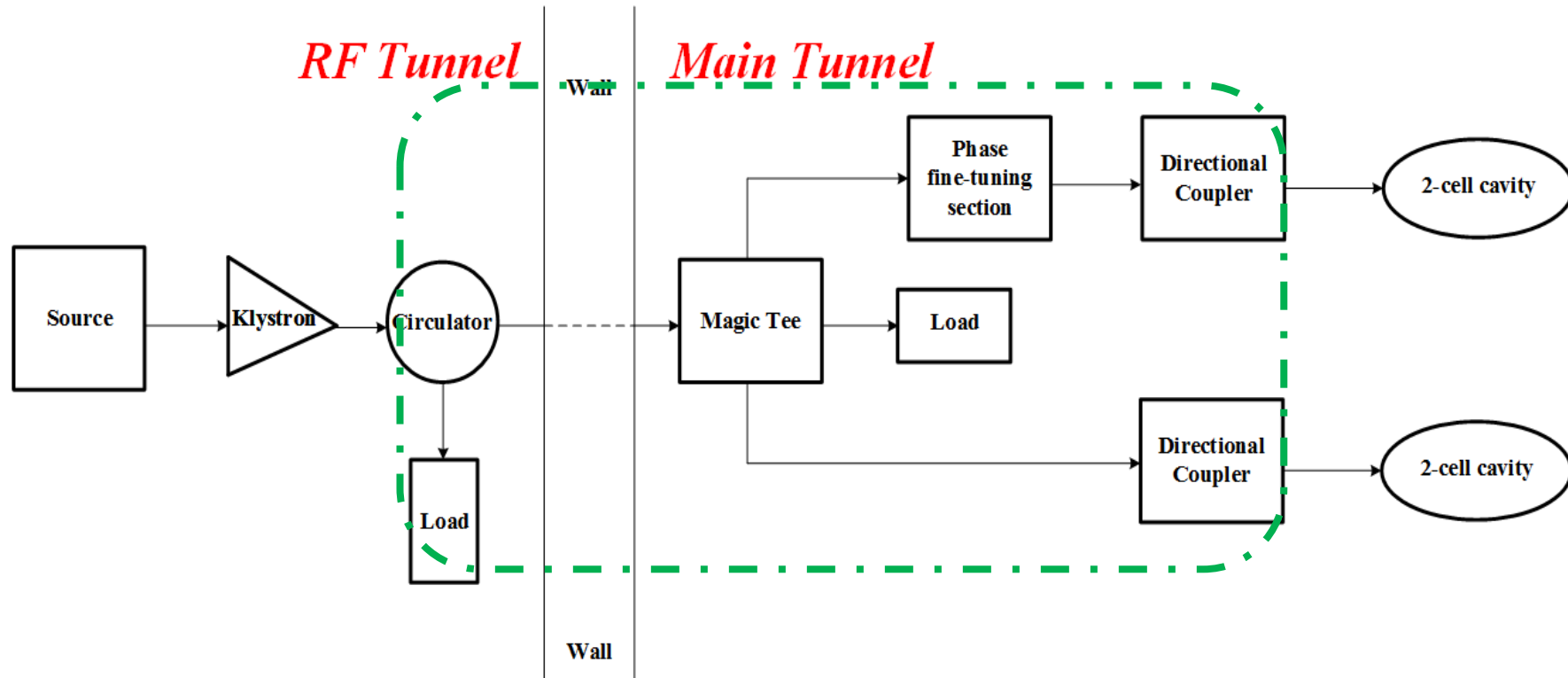
Superconducting Cavity power demands

Parameters	Value
Freq.(MHz)	650+/-0.5
Cavity No.	240
Coupler input power(kW)	300

- *Considering klystron lifetime, power redundancy and cost, the **2 cavities will be powered with one CW klystron** capable to deliver more than 800 kW.*
- *Distribution of RF power (800kW) to the cavities (300kW), including **waveguide, power divider, phase shifter, circulator and load.***
- *Other Auxiliary PS, Interlock and Controls, LLRF, Pre-amplifier.*

Transmission system

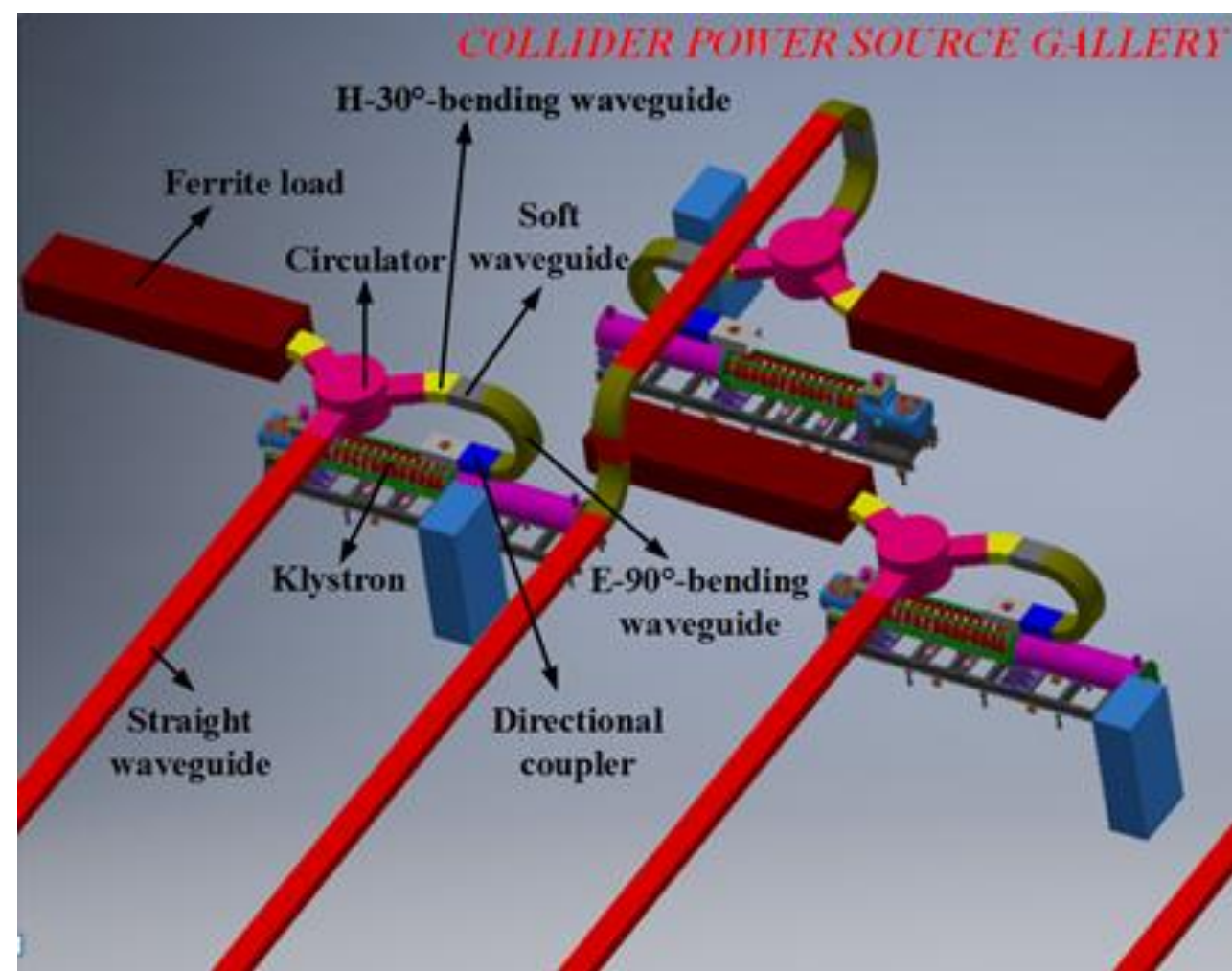
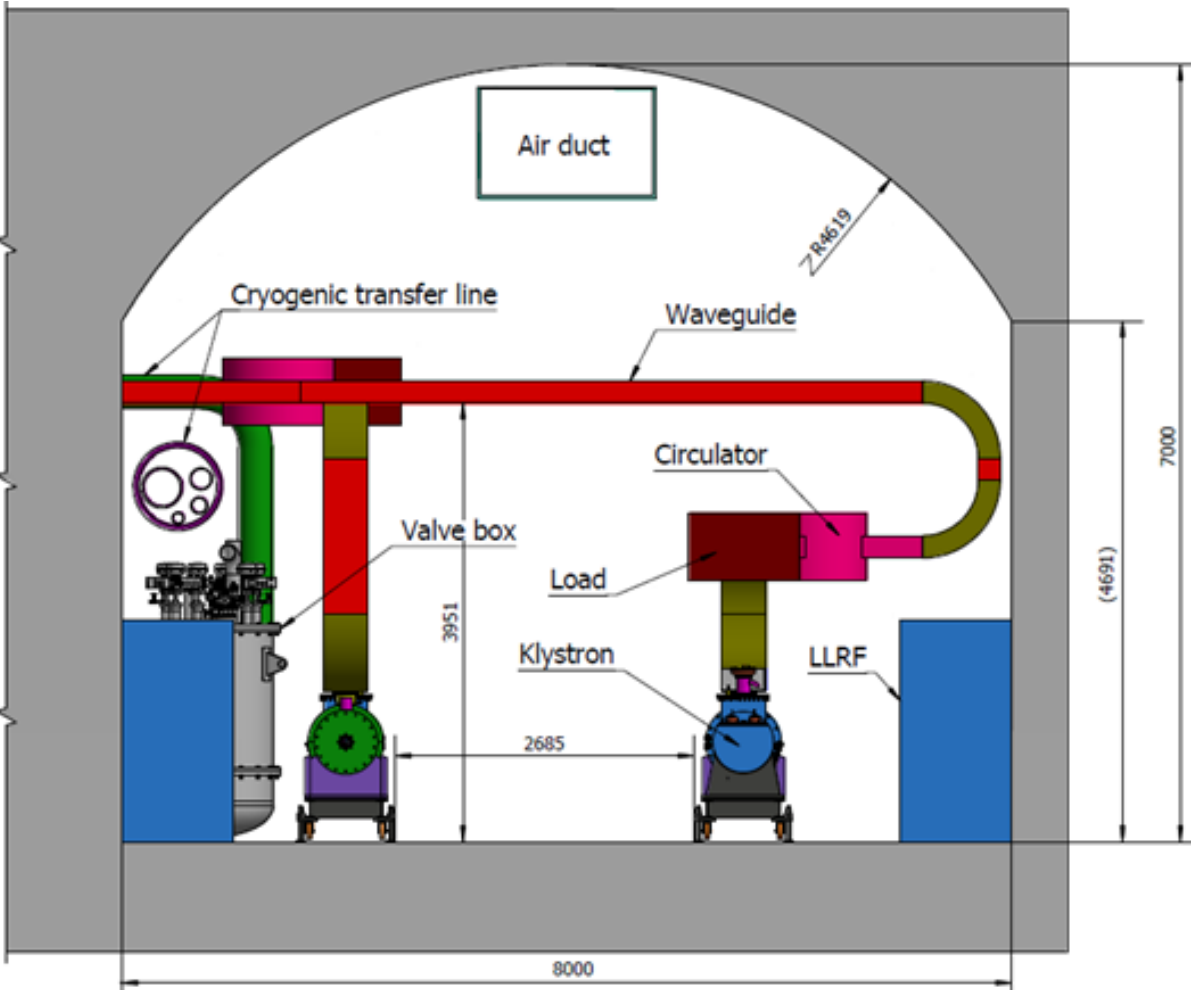
Schematic of the RF Transmission System (RFTS)



Collider

Infrastructure

Collider Power Source Gallery



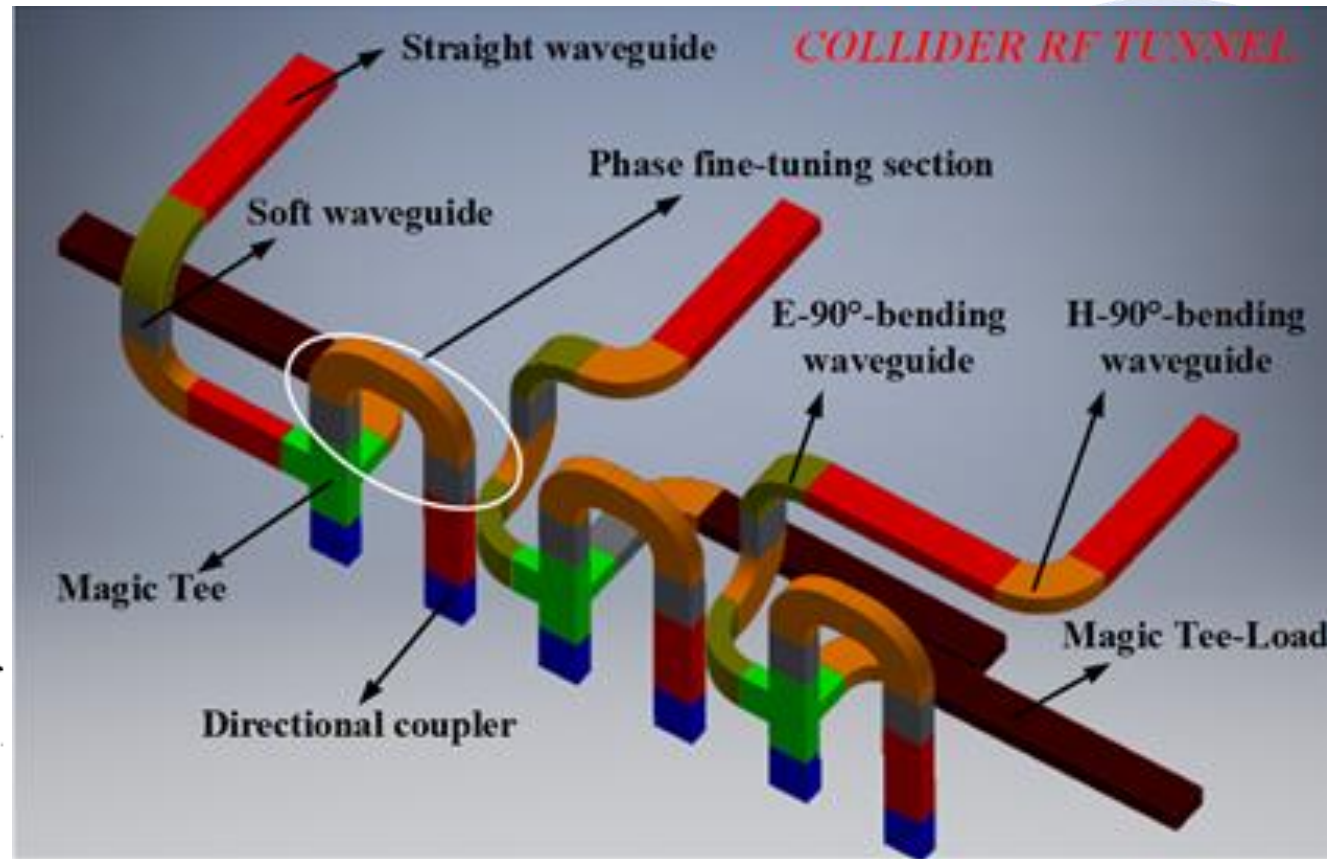
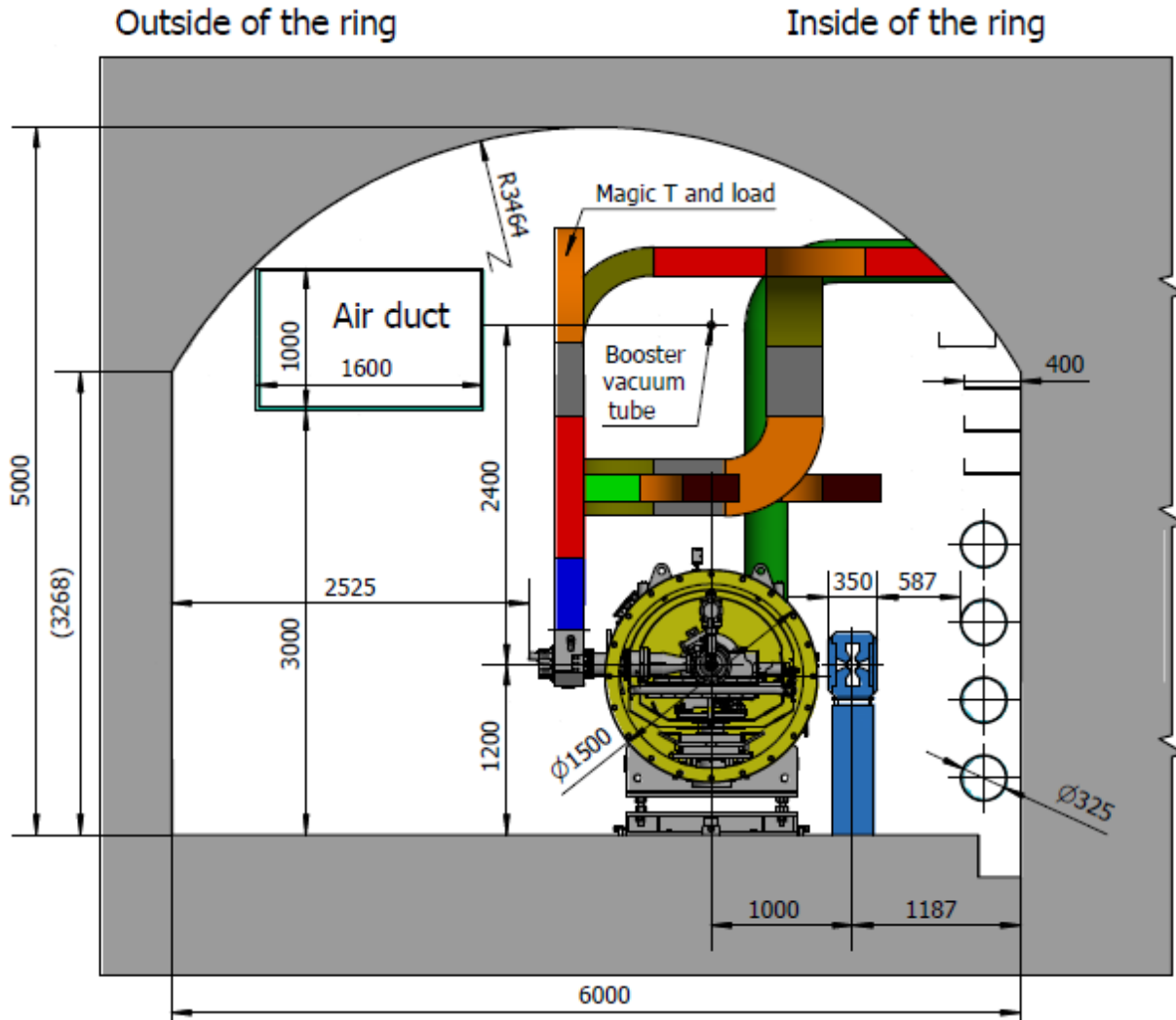
Klystron and transmission system are placed underground.



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Chinese Academy of Sciences

Collider

Infrastructure



For space savings, **transmission system** in part are placed in **RF tunnel**.

PSM Power supply



*PSM high voltage power supply and related auxiliary power supply are **on the ground.***

Design consideration

- *The Booster RF system consists of 1.3 GHz superconducting RF cavities. There are 12 cryo-modules for Higgs operation, each containing eight 9-cell superconducting cavities.*
- *These cavities need **96** set **1300 MHz** power sources.*

Power source choice-SSA

- *Their capabilities extend from **a few kW to several hundred kW**, reasonable efficiency (~50%), high gain, and modular design provide high reliability.*
- *High **reliability** for redundancy design, high **flexibility** for module design, high **stability**, low maintenance requirements, absence of warm-up time and low voltage operation.*
- *So the SSA has been chosen for the Booster RF power source system.*

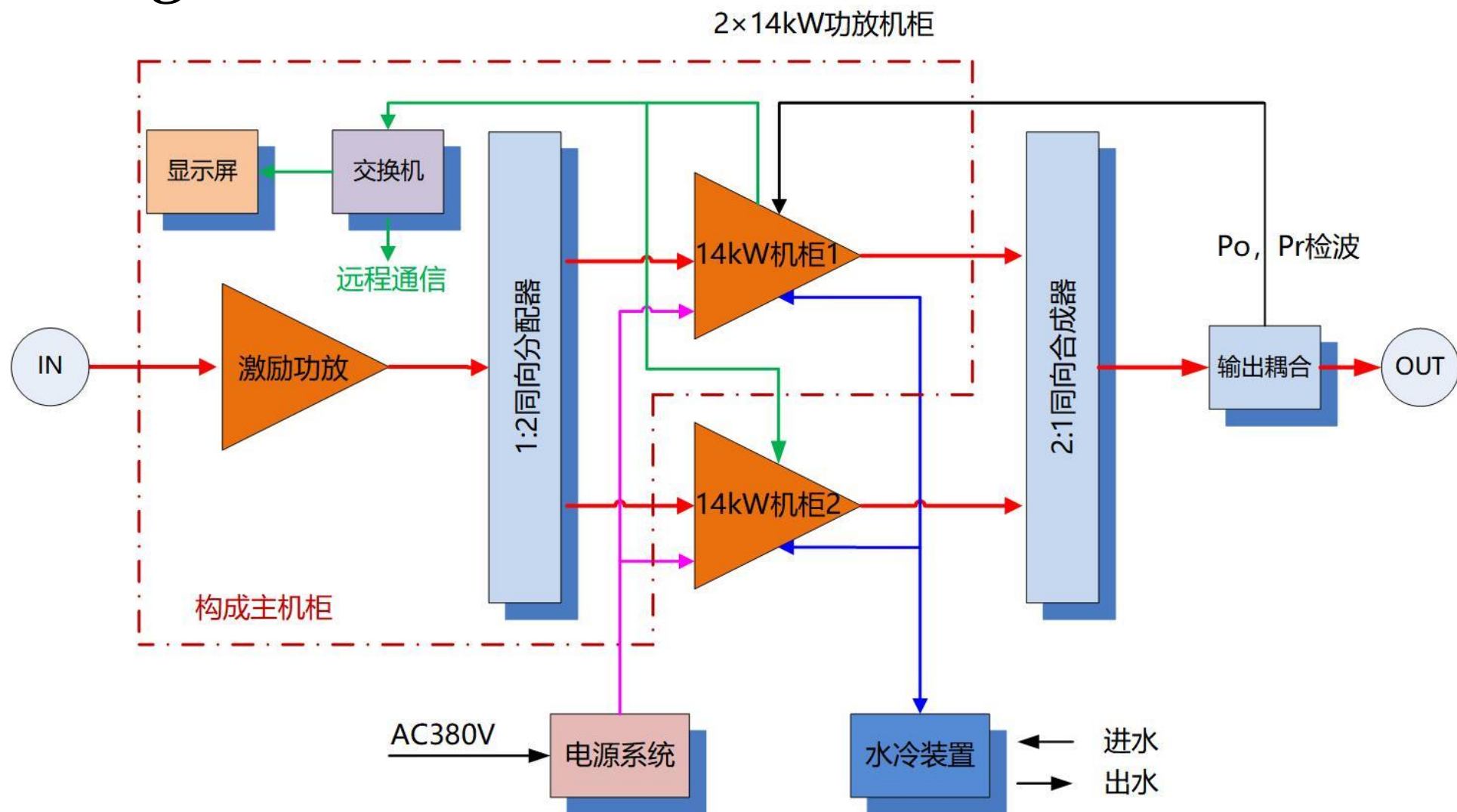
Solid state amplifier

1.3 GHz/25kW SSA Specifications

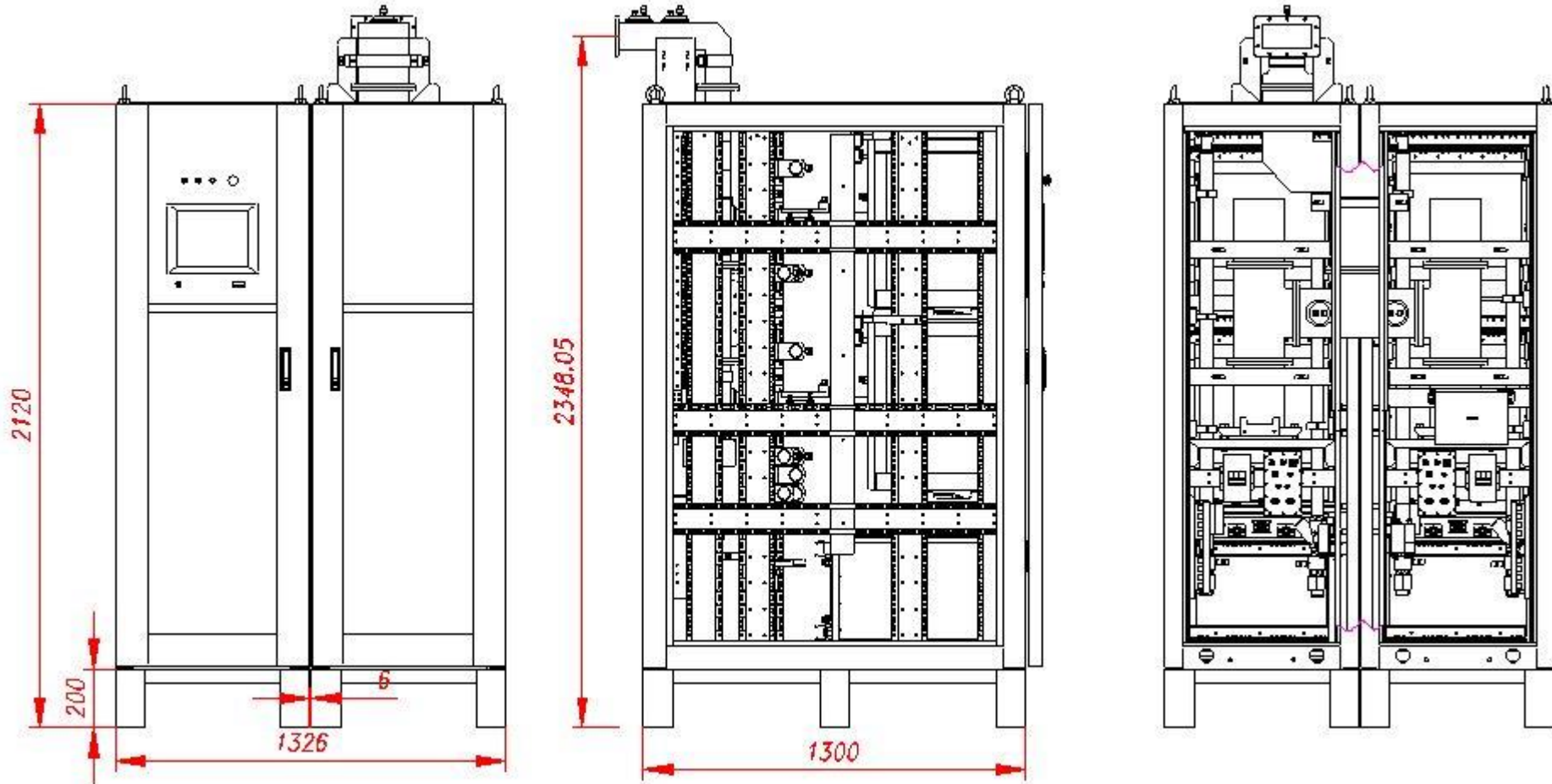
Parameters	Values
Frequency	1.3 GHz
Power	25 kW
Gain	≥ 65 dB
Bandwidth (1dB)	≥ 1 MHz
Amplitude stability	$\leq 0.1\%$ RMS
Phase stability	$\leq 0.1^\circ$ RMS
Phase Variation	$\leq 10^\circ$
Harmonic	< -30 dBc
Spurious	< -60 dBc
Efficiency at 25kW	$\geq 45\%$
MTBF	≥ 30000 h
Redundancy	1 power module failure

Booster

Schematic drawing



Cabinet dimension



2120mm (H) × 1326mm (W) × 1300mm (L)

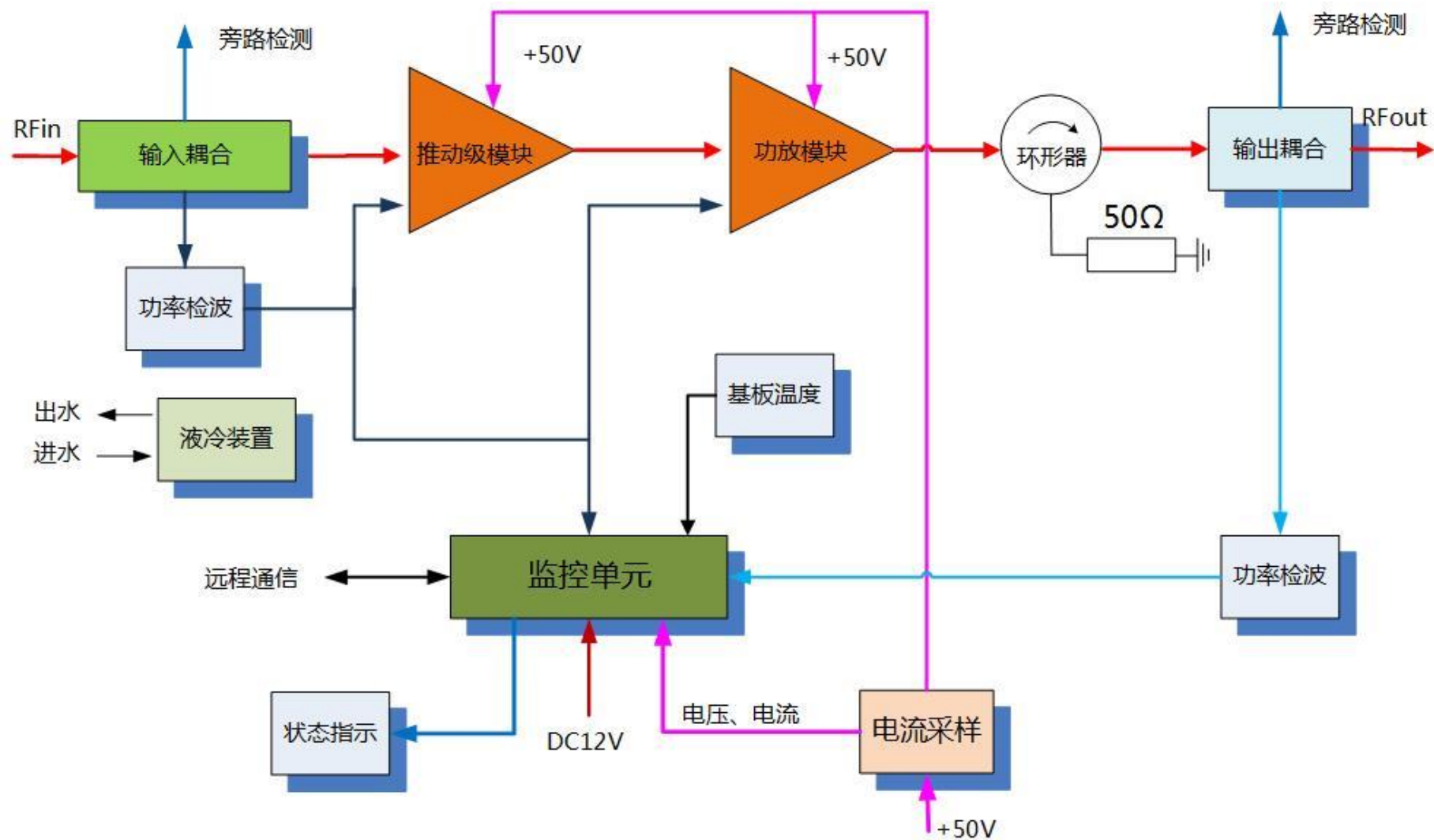
Booster

SSA Parts

No.	Name	QTY.
1	Driver unit	1
2	1:2 power divider	1
3	14kW amplifier cabinet	2
4	2:1 power combiner	1
5	Directional coupler	3
6	LED	1
7	Switch	1

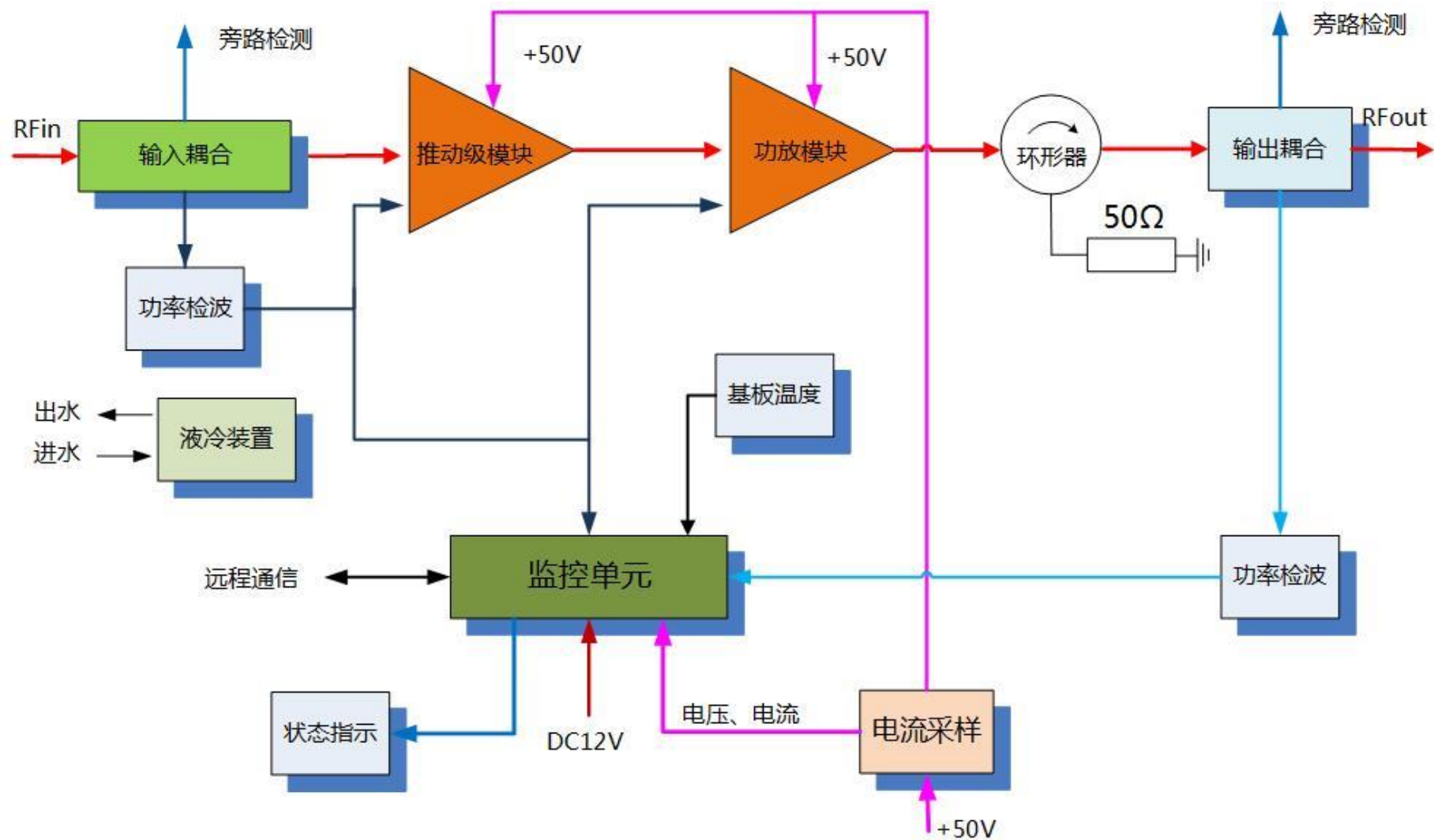
Booster

SSA Parts-driver unit



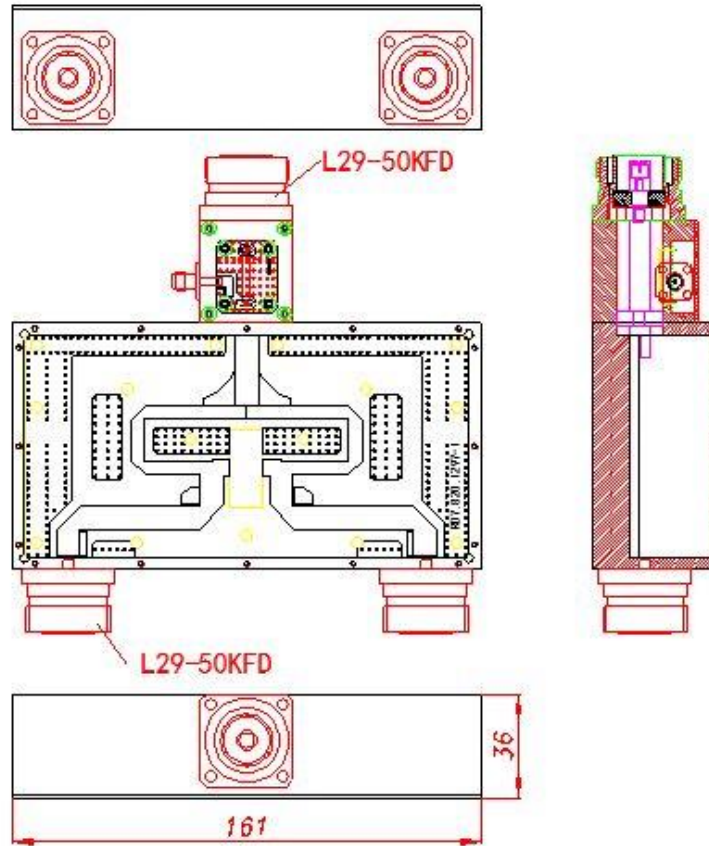
Booster

SSA Parts-driver unit

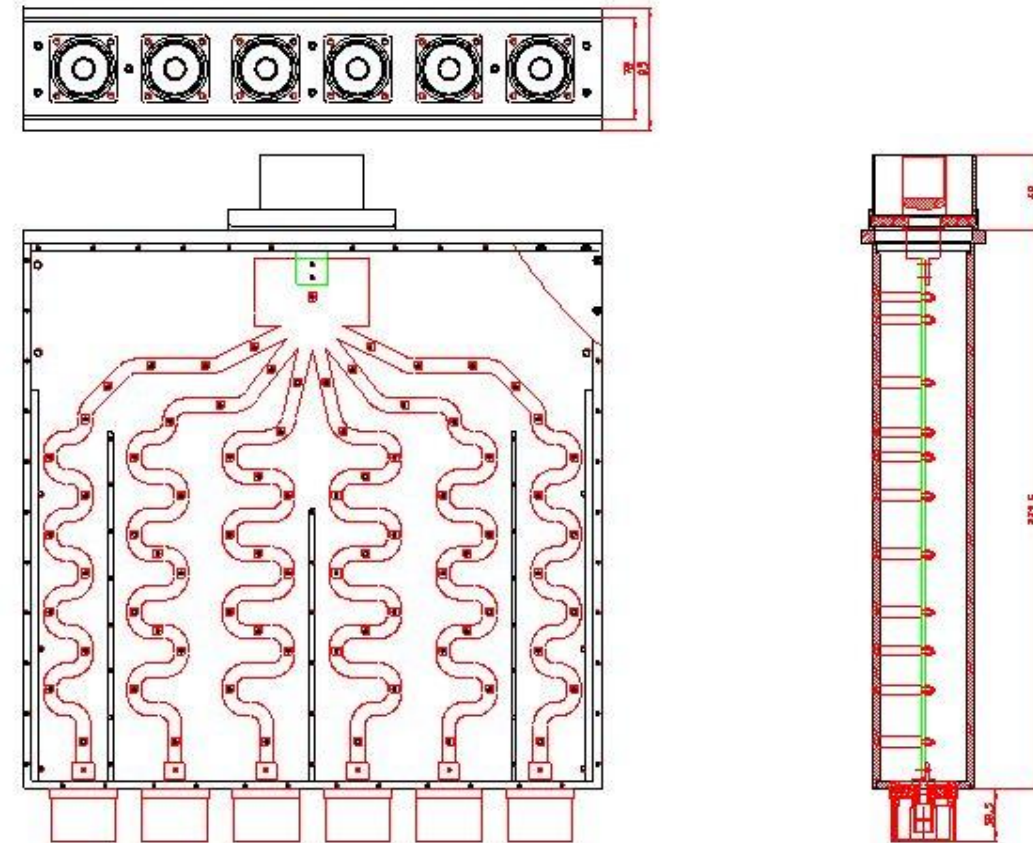


Booster

SSA Parts-power divider and combiner

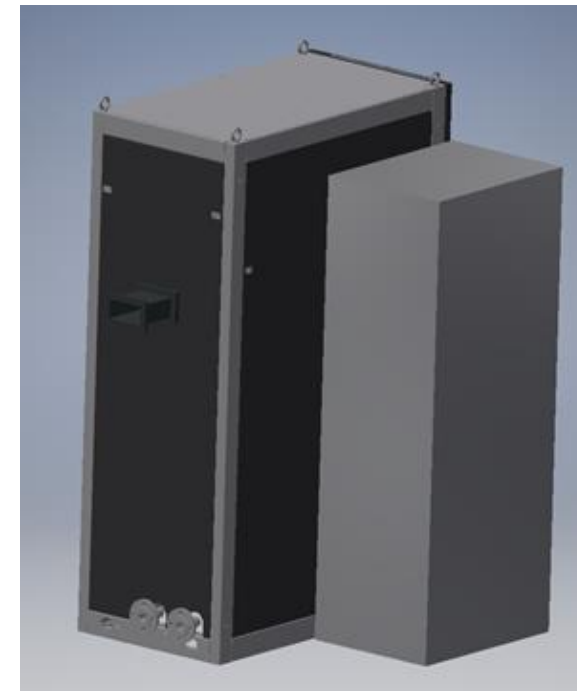
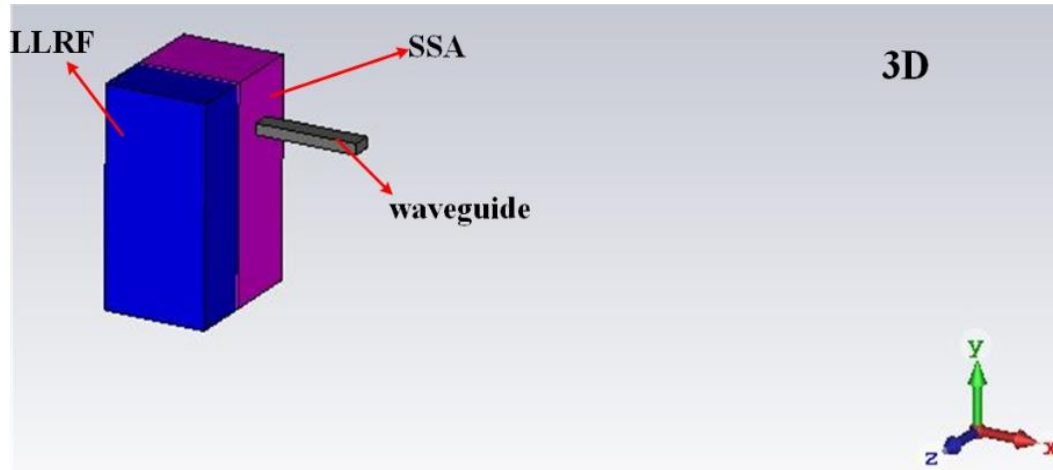
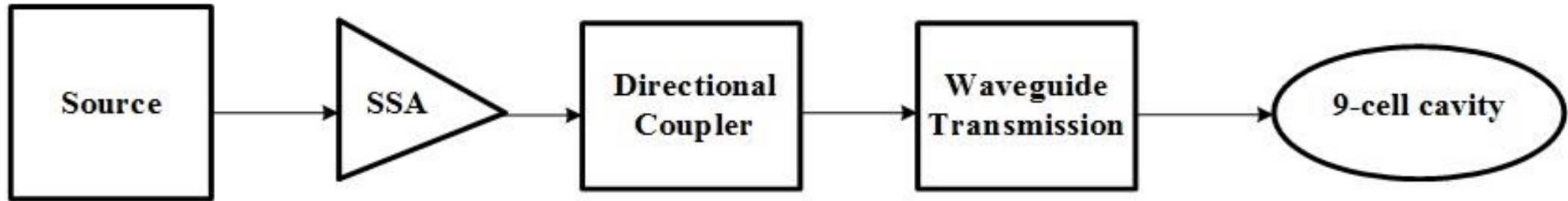


1:2 power divider



6:1 power combiner

RF Transmission system

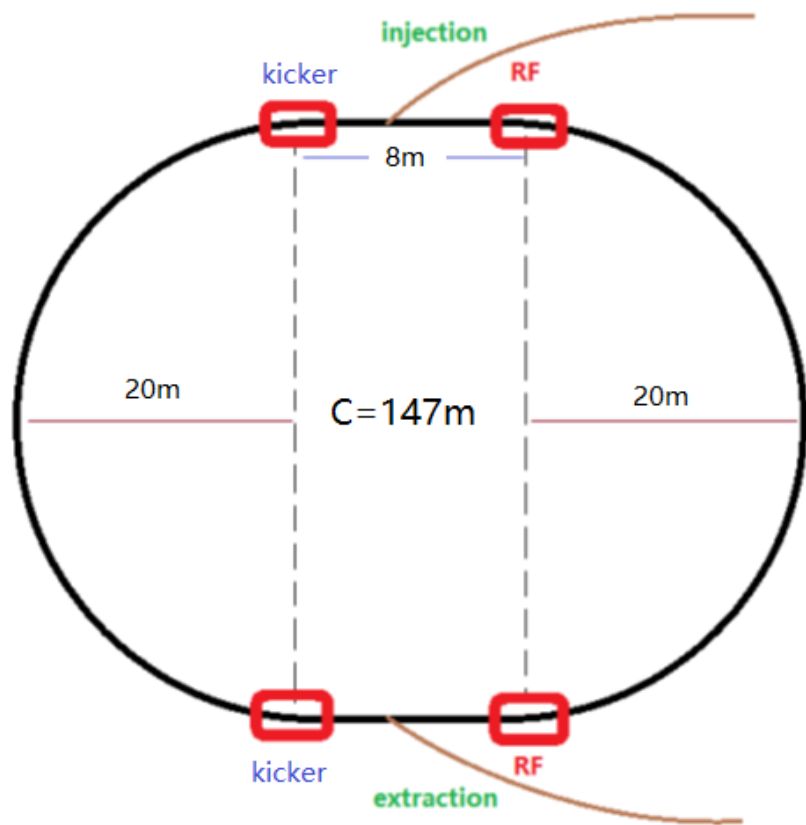


Damping ring

Introduction

- There are 2 RF station, RF power is **650MHz/100kW** per station.

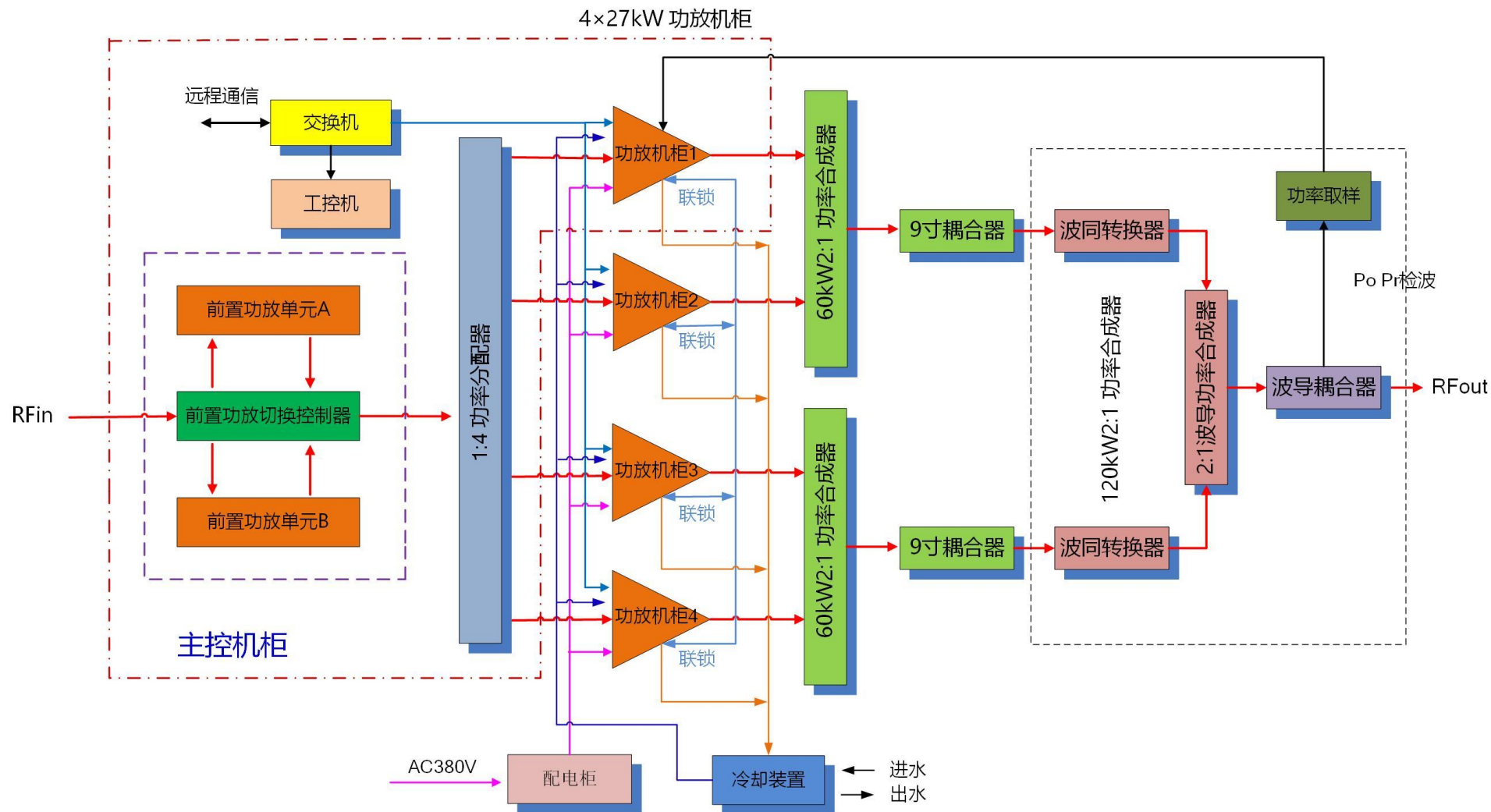
650MHz/100kW SSA Specifications



Parameters	Values
Frequency	650MHz
Power	100 kW
Gain	≥ 65 dB
Bandwidth (1dB)	≥ 1 MHz
Amplitude stability	$\leq 0.1\%$ RMS
Phase stability	$\leq 0.1^\circ$ RMS
Phase Variation	$\leq 10^\circ$
Harmonic	< -30 dBc
Spurious	< -60 dBc

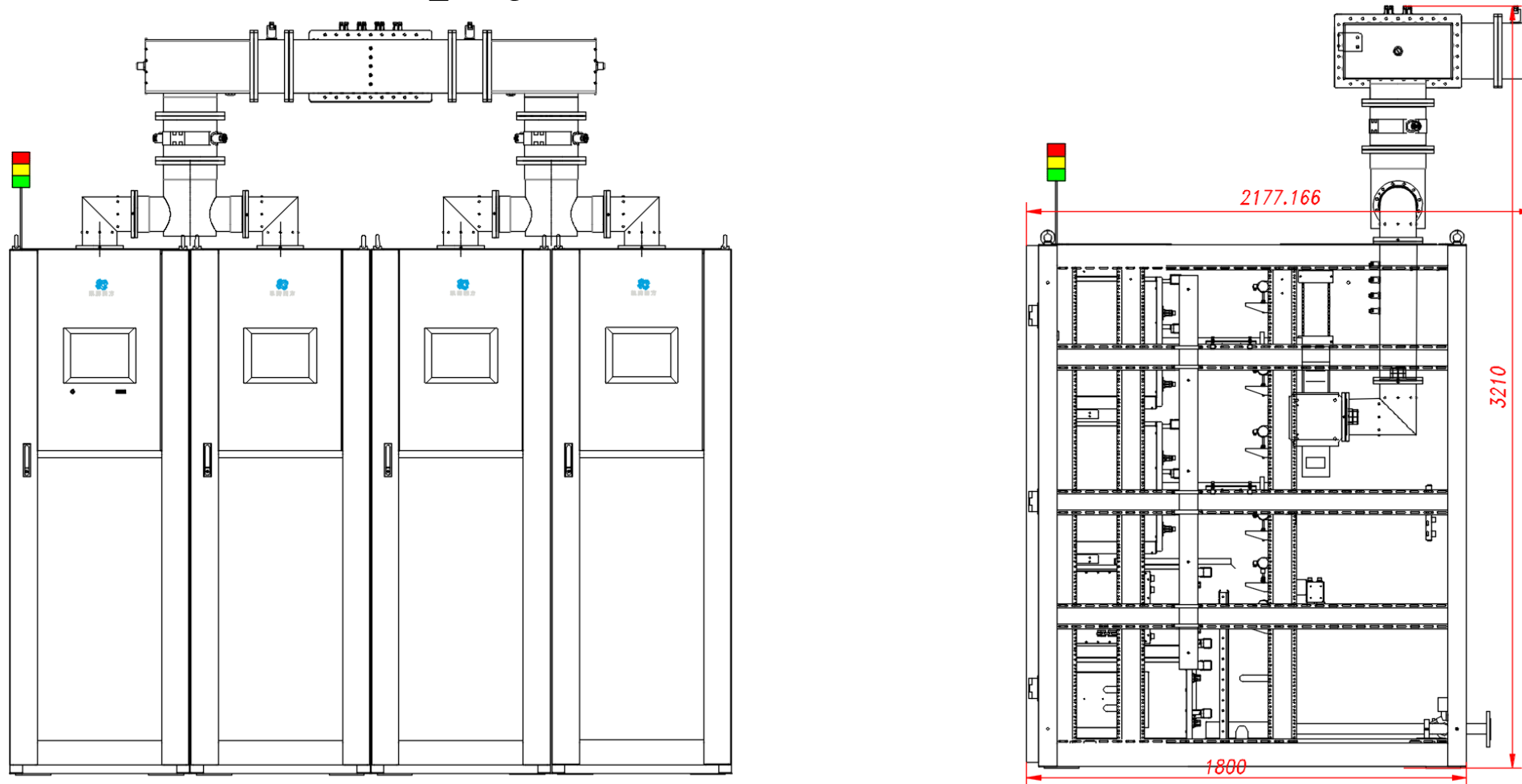
Damping ring

Solid state amplifier- Schematic drawing



Damping ring

Solid state amplifier- Cabinet dimension



3210mm (H) × 3220mm (W) × 1800mm (L)

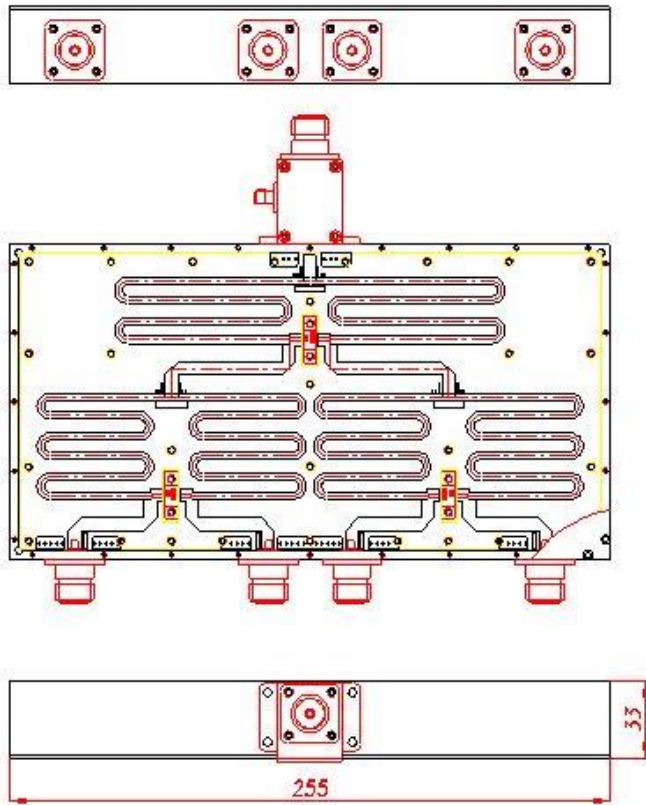
Damping ring

Solid state amplifier- Parts list

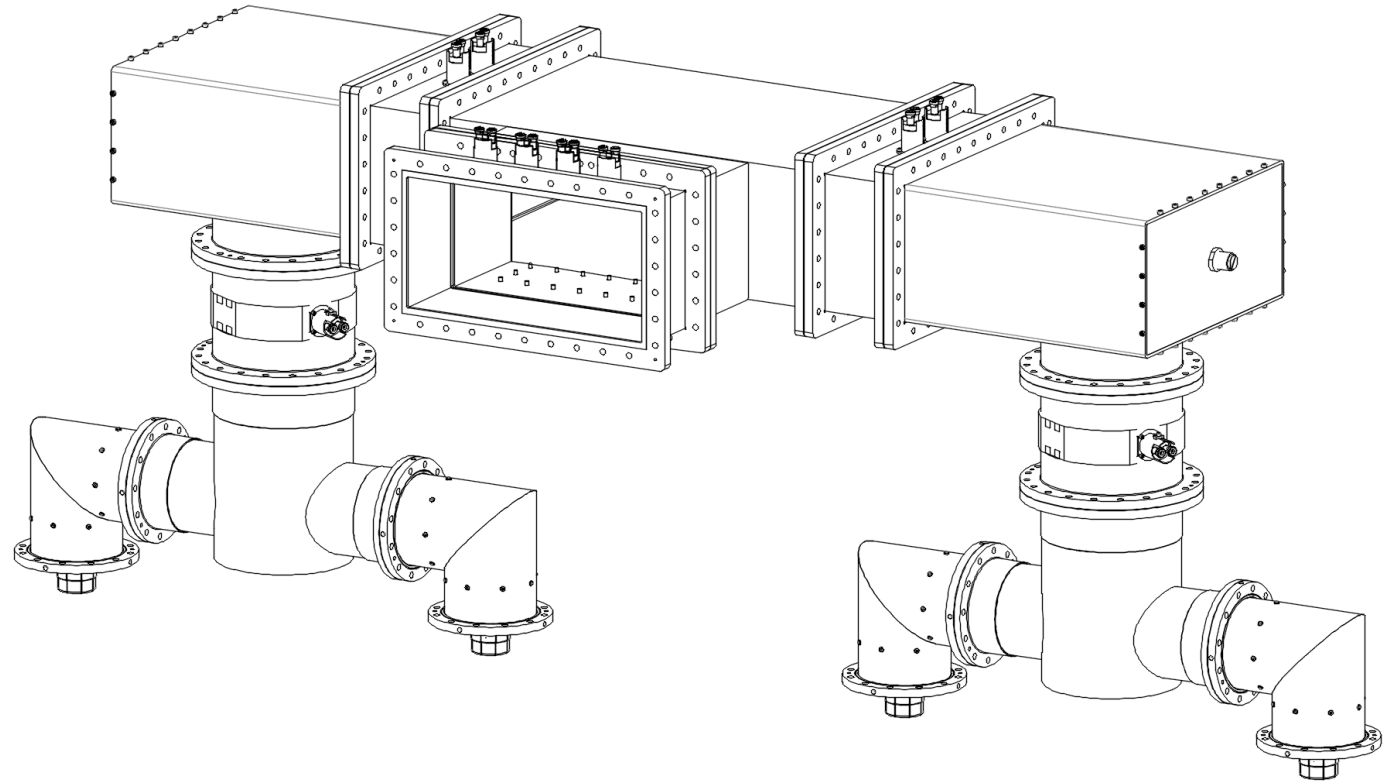
No.	Name	QTY.
1	Pre-amplifier unit	1
2	1:4 power divider	1
3	27kW amplifier cabinet	4
4	60kW 2:1 power combiner	2
5	120kW 2:1 power combiner	1
5	Directional coupler	1
6	LED	1
7	Switch	1

Damping ring

Solid state amplifier- *Key components*



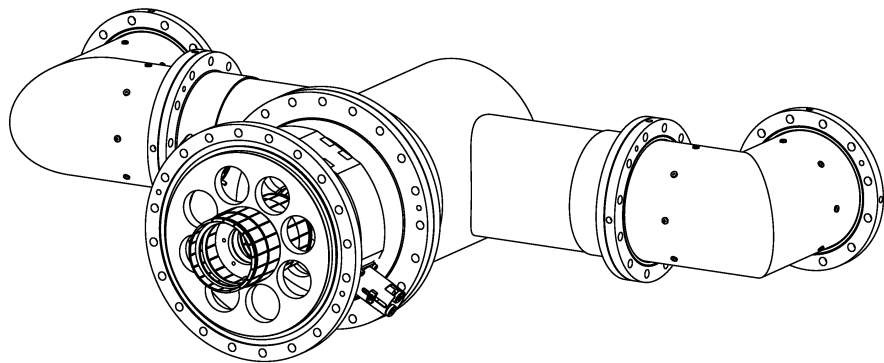
1:4 power divider



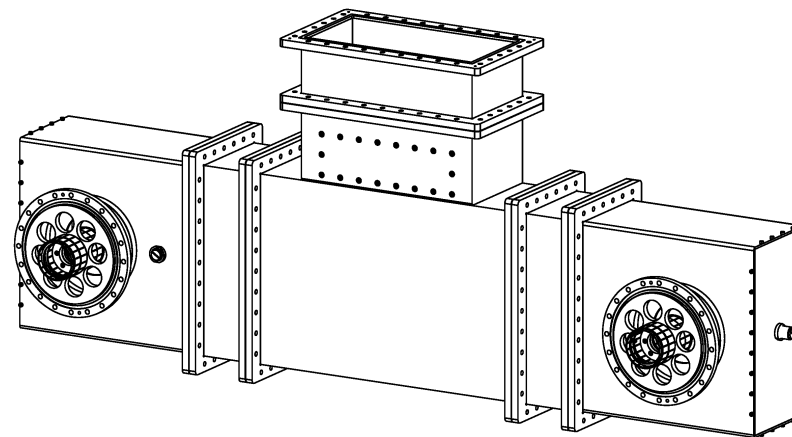
60kW 1:2 power divider

Damping ring

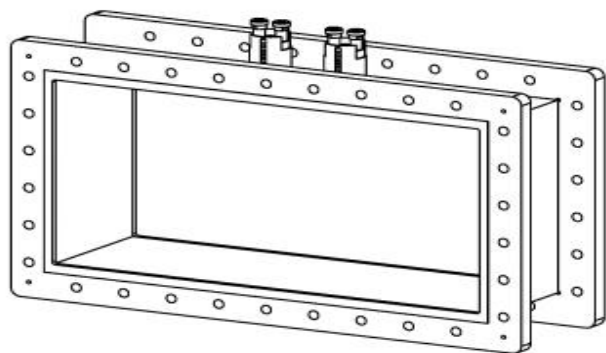
Solid state amplifier- *Key components*



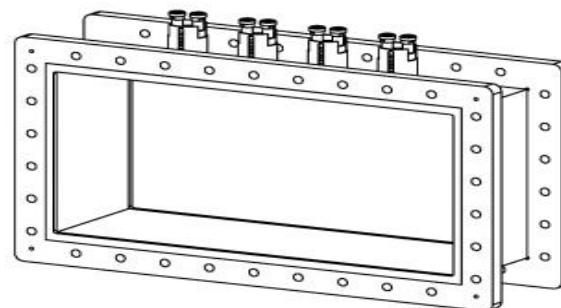
30kW 2:1 power combiner



60kW 2:1 power combiner



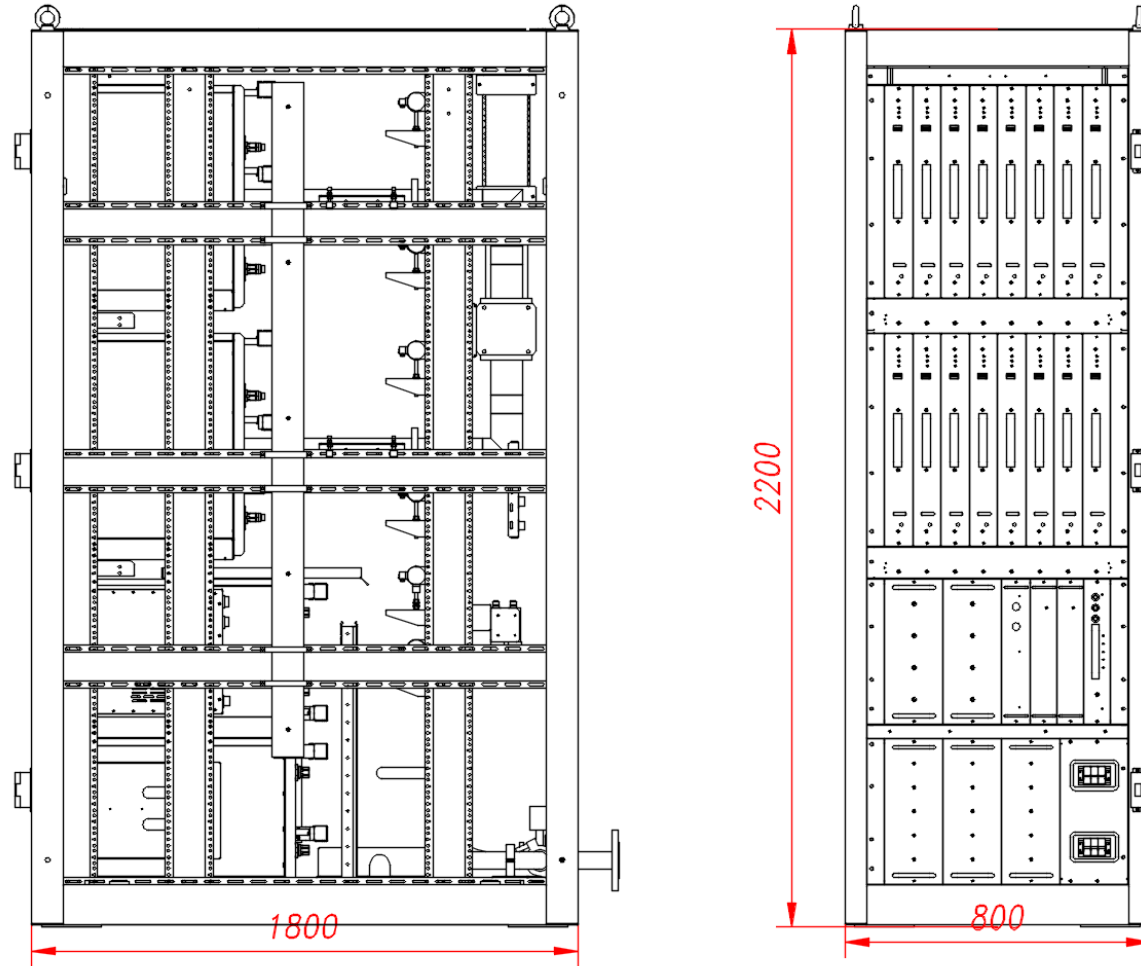
2 port directional coupler



4 port directional coupler

Damping ring

Solid state amplifier- 30kW Cabinet dimension



2200mm (H) × 800mm (W) × 1800mm (L)

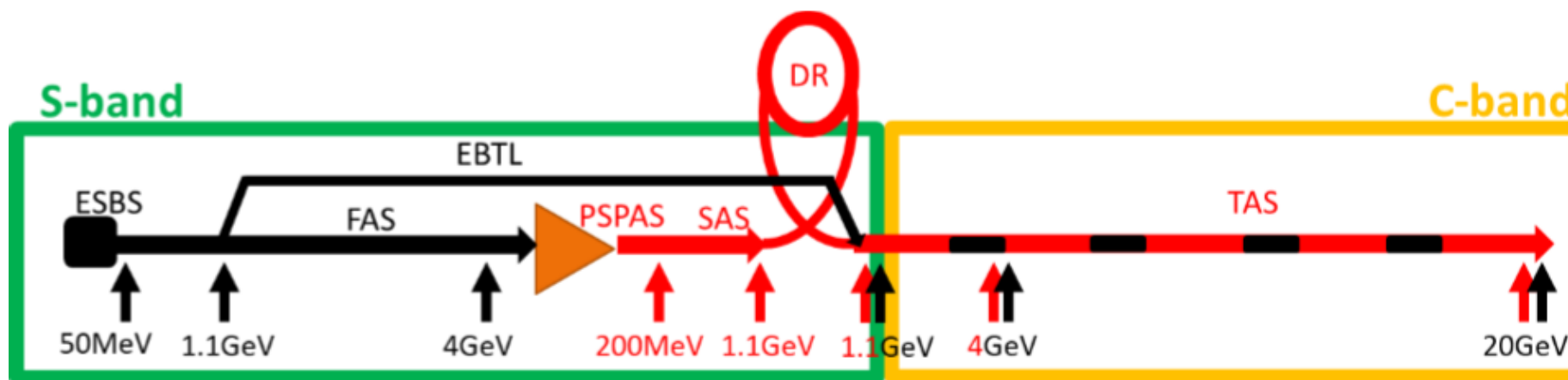
Linac injector

Introduction

- *The main high power RF components are **35 units of 80 MW S-band klystrons**, **146 units of 50MW C-band klystrons** and conventional solid state modulators.*
- *A waveguide system is used for power transmission from the klystrons to the accelerating structures, **181 klystrons** are used to provide power for **401 accelerating structures**.*

Linac injector

Power distribution



Type	Numbers	Value	Accelerator structure
Repetition rate [Hz]	/	100	
S-band KLY	35	2860MHz 80 MW 4us	1-set 1-to-1 14-set 1-to-2 20 set 1-to-4
C-band KLY	146	5720MHz 50 MW 3us	1-to-2

Summary

- *Design of RF power sources system for collider, booster, damping ring and linac injector is showed.*
- *Engineering design of 650MHz 100kW and 1.3GHz 25kW solid state amplifier is also showed.*
- *650MHz 800kW klystron is being developed in Chinese company.*
- *2860MHz 80MW, 5720MHz 50MW and 80MW klystron are also under consideration in IHEP.*

Thanks for your attention!