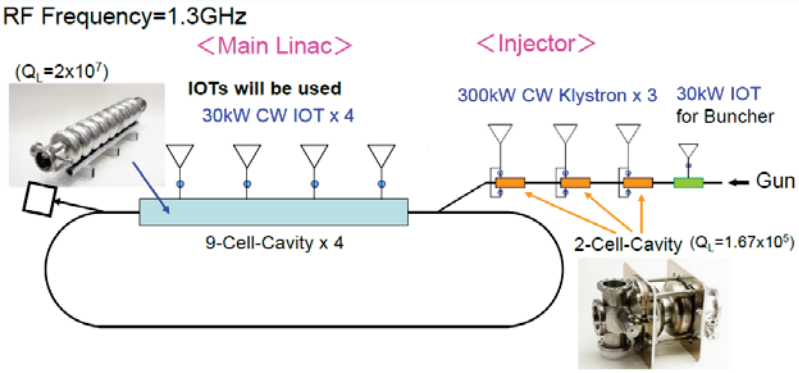
RF Source of cERL in KEK

S. Fukuda
KEK

Original Plan of cERL RF



Required stability : *0.1%rms (Amplitude), 0.1 degree rms (phase)*

Goal Stability of ERL :、*0.01%rms(Amplitude),0.01 degree rms(phase)*

Energy Reduced cERL Plan

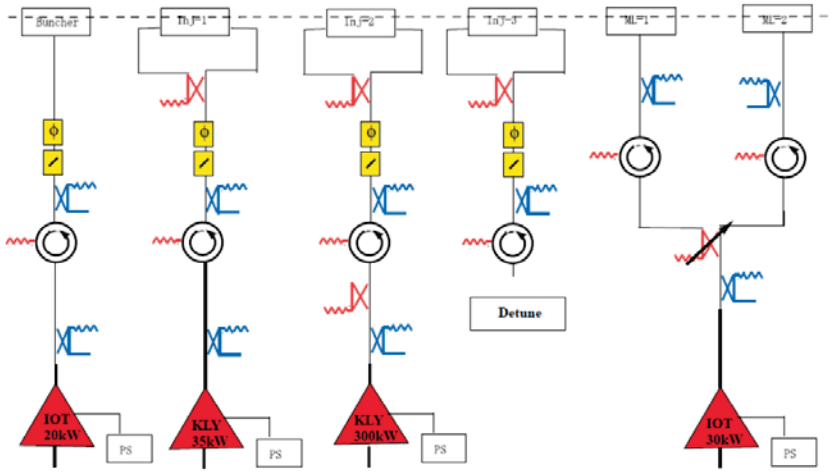
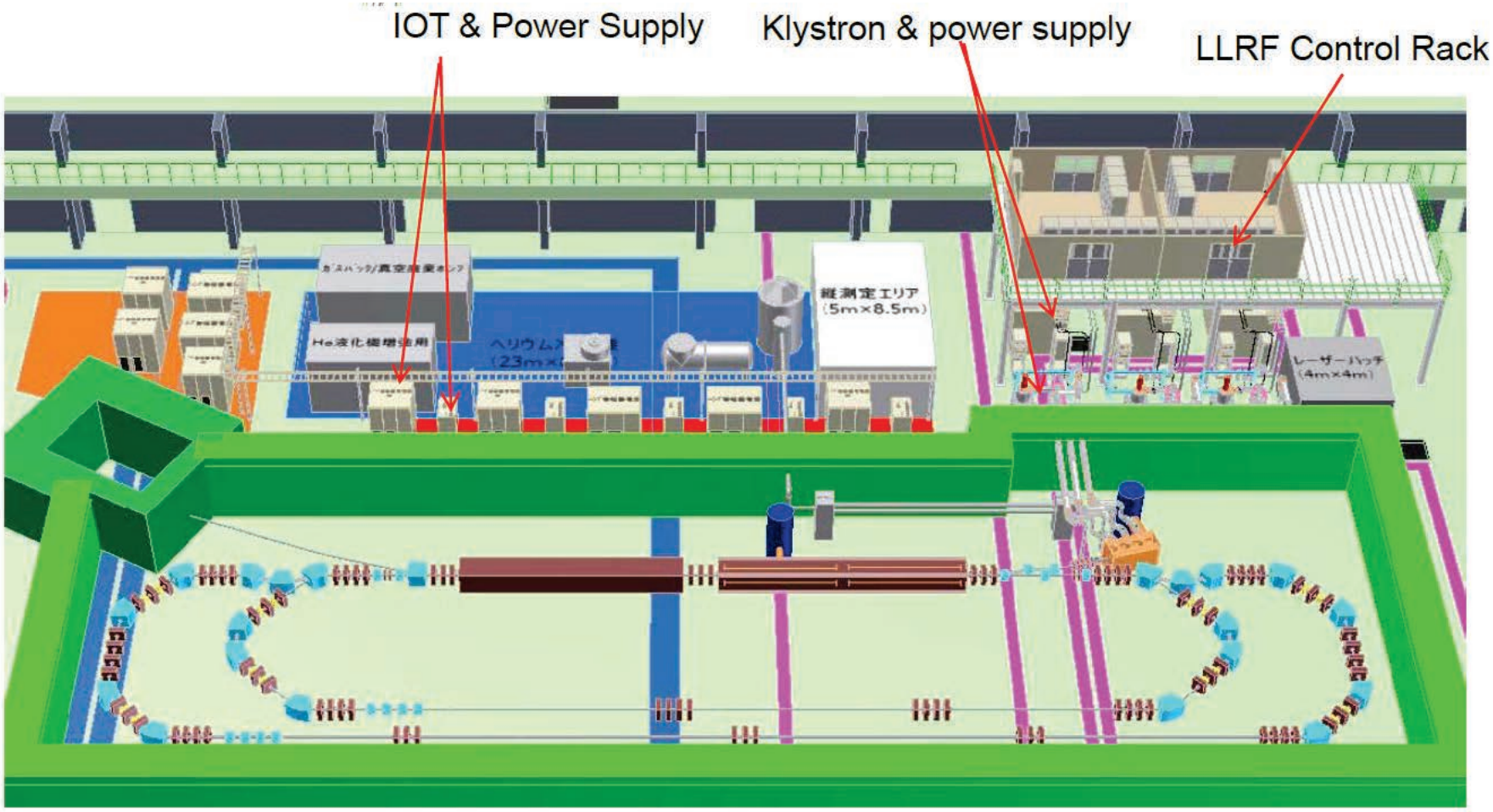


Table 1: RF parameters for the cERL of the reduced energy scheme

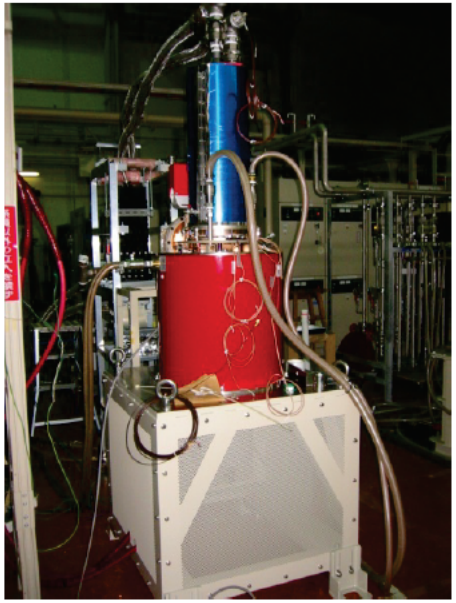
Item	Unit	Buncher	Inj-1	Inj-2	Inj-3	ML-1	ML-2
Structure		NC	SC	SC	SC	SC	SC
Gradient	MV	0.14	1.5	3.5		15	15
Ql			$8x10^5$	$2x10^6$	Detuned	$2x10^7$	$2x10^7$
Beam phase	degree	-90	-15 to -30	-10		0	0
Power Required	kW	4.5	20	55		11	11
Power Output	kW	6.2	27	76		30	
RF source		IOT	Klystron	klystron		IOT	
Power Available	kW	20	35	300			

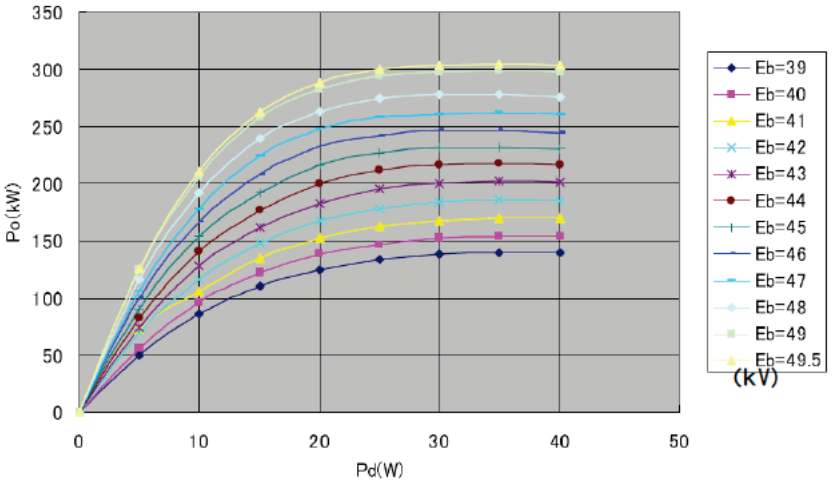
Layout of cERL and RF Source



300kW CW Klystron

Toshiba E37750 Klystron

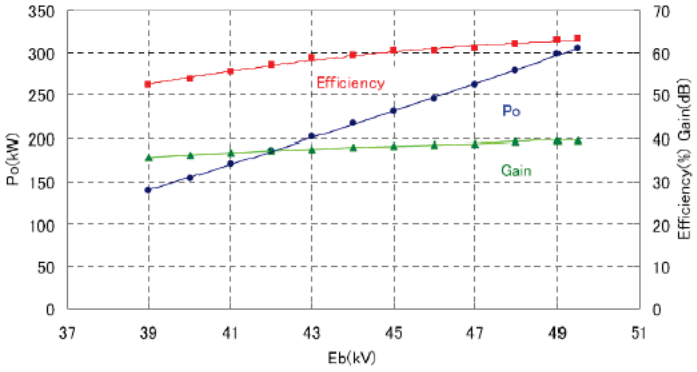




Input Power vs. Output Power

Table 2: Specifications of 300kW CW Klystron

Item	Unit	Specification
Perveance	$\mu A/V^{3/2}$	0.89+-0.9
Beam voltage	kV	52>
Beam Current	A	11>
Frequency	MHz	20
Klystron Type		Diode
Output Power	kW	>270 (Goal 300)
Efficiency at Sat.	%	>50 (Goal 60)
Gain at Saturation	dB	>37
Cavity Number		5
Cooling		Water Cooling

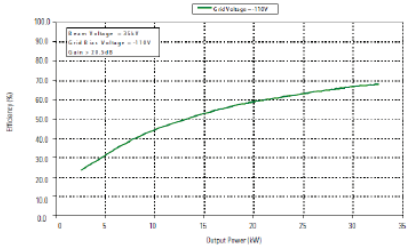


Applied Voltage vs. Output Power, Gain and Efficiency

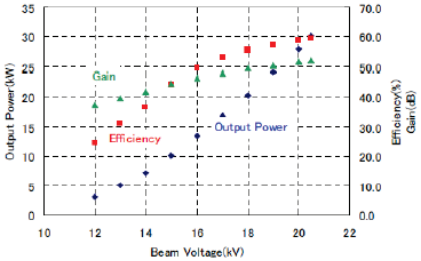
30kW RF Source

CPI VKL-9130 IOT

Frequency	1300 MHz
Output Power	30 kW
Beam Voltage	35 kV
Beam Current	1.4 A
Drive Power	< 500 W
-1dB Bandwidth	> 2 MHz
Gain	> 20 dB
Efficiency	> 60



Toshiba E3750 Klystron



For buncher section

20 kW CW 1.3 GHz IOT Amplifier

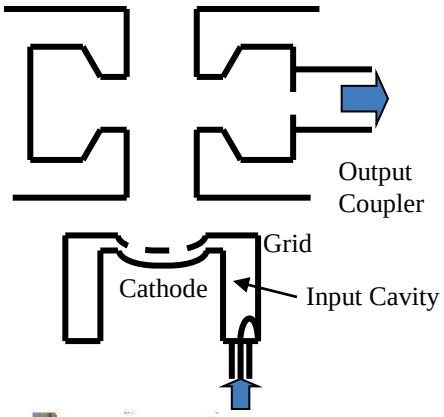
IOT Amplifier L-4445

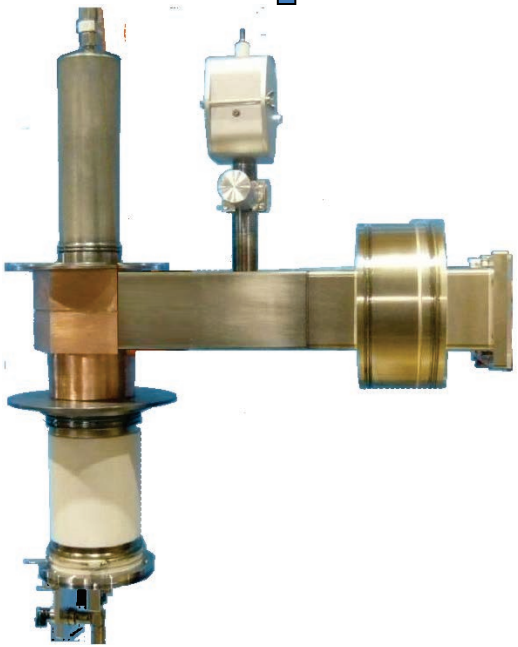
Ratings	Symbol	Min.	Max.
Heater Voltage	V	5	7
Heater Current (Operating)	A	20	30
Heater Current (Surge)	A	---	60
Heater Warm-up Time	Seconds	300	---
Beam Voltage	kV	28	36
Beam Current	A	---	2.0
Idle Current	A	0.0	0.5
Body Current	mA	---	60
Solenoid Current	A	20	30
Collector Dissipation	kW	---	55
Load VSWR	---	---	1.5:1
Bias Voltage (with respect to cathode)	V	-50	-150
Grid Current	mA	---	±150
Ion Pump Current (Beam On)	µA	---	20
Ion Pump to Cathode Voltage	kV	3	4
Bandwidth (-1 dB)	MHz	3.0	---
Bandwidth (-3 dB)	MHz	5.0	---
Gain with 150 mA of idle current	dB	20.0	---
Output Power	kW	---	25
Beam Efficiency @ 20 kW	%	43	--

Mechanical Specifications	
Mechanical Outline IOT	See Back
Mounting Position	Collector Down
Focusing	Electromagnet
Cooling	
Maximum Inlet Pressure	60 psi
Maximum Inlet Water Temp.	50°C
Maximum Outlet Water Temp.	70°C
Minimum Collector Flow RO or DI Water	10 gpm
Collector Pressure Drop	40 psi
Minimum Body Flow RO or DI Water	1.0 gpm
Minimum Window Flow RO or DI Water	.5 gpm
Air Flow to Input Cavity Mounted to Tube	70 cfm
Air Pressure at Intake	20"
Maximum Air Temp. @ Intake	60 °C
Weight (Approx.)	50 lbs.

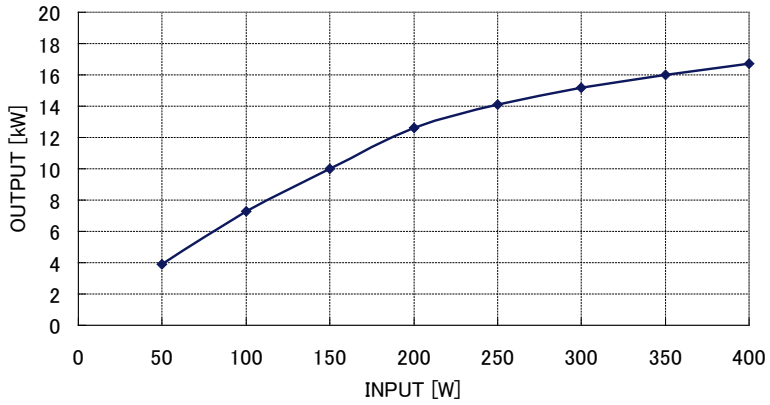
Development of IOT

Mitsubishi Electric Corporation Communication Systems





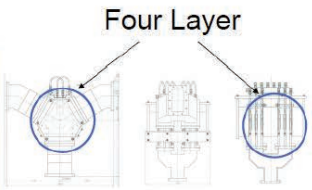
- Higher efficiency for input RF modulation.
- First domestic IOT product.
- Grid development.
- Development of beam simulation with grid.
- New dielectric waveguide realize higher applied voltage.



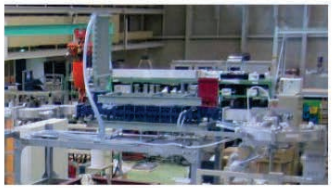
Power Distribution

150kW Circulator

Frequency	1300±5 MHz
Max. Power	150 kW CW
VSWR	<1.2 kV
Insertion Loss	<0.3 dB
Isolation	>20dB
Waveguide	WR-6f50
Cooling	Water Cooling
External Mag. Field	Permanent magnet



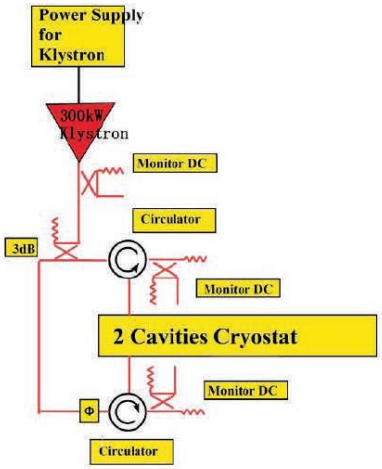
30kW Circulator

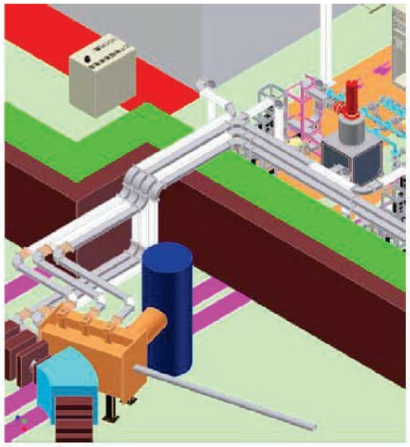


Technical Specification of the IsolatorWFHI3-2, 5MW
Order RT-791

Frequency ·	1.3GHz±5MHz;
Max. Pulse Power (forward) ·	5MW;
Max. Pulse Power (reflected) ·	5MW any phase;
Max. Average Power ·	85kW;
Pulse duration ·	<1,7ms;
Repetition Rate ·	<10Hz;
Insertion Loss ·	<0,15dB at 1,3GHz; <0,2dB at bandwidth;
Isolation ·	>30dB;
VSWR ·	<1,10 with full reflection at any phase;
Case ·	
Gas ·	gas tight up to 3 bar, leakage <5ml/hour; SF6 up to 1,5 bar;
Cooling ·	demineralized water, pressure <6 bar, test pressure 12 bar, flow rate <10 l/min for the circulator flow rate <60 l/min for the load
Magnet system ·	permanent magnets;

Power Distribution to Cryomodule





Future RF Source Candidate

- ***RF Source for Injector***

  CW 300kW or more higher RF source→klystron

  Power supply: need high efficiency power supply

- ***RF Source for Main Linac***

  Currently we use klystron and IOT for the cERL

  Cost of 20kW-class : 200k$(P/S)+75k$(IOT)

  cf. If L-band semiconductor power source is cheaper than this, it will be the candidate for RF source.

  There appears the high efficiency semiconductor power source. Price will be expected to be cheaper within there or four years later.