

Power RF Klystrons and Modulators

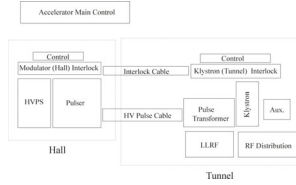
TESLA



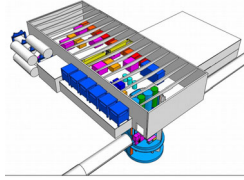
RF System Parameter

Number of cavities:	936
Peak power per cavity:	122kW
Number of RF stations:	26
Peak power per RF station:	5.2MW
RF pulse duration:	1.37ms
Repetition rate:	10Hz
Average AC power per station:	180kW

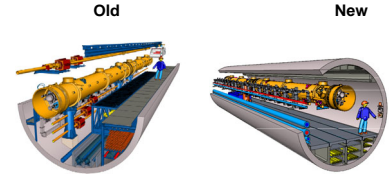
RF Station



Modulatorhall



Tunnel



Klystrons

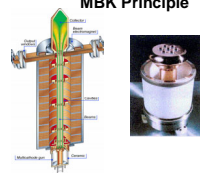
THALES TH2104C Klystron at TTF

RF Output Power	5MW (4MW org.)
RF Pulse Duration	1.5ms
Repetition Rate	10Hz
Cathode Voltage	128kV
Cathode Current	90A

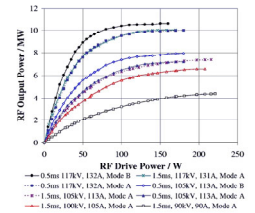


The Multi Beam Klystron THALES TH1801

MBK Principle



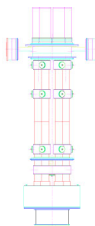
Design	Measurement
Operation Frequency:	1300MHz
RF Pulse Duration:	1.3ms
Repetition Rate:	10Hz
Cathode Voltage:	110kV
Beam Current:	130A
HV Pulse Duration:	1.7ms
No. of Beams:	7
mPervance:	3.5
No. of Cavities:	6
Max. RF Peak Power:	10MW
RF Average Power:	150kW
Efficiency:	70% goal
Gain:	48dB
Solenoid Power:	4kW



The Multi Beam Klystron CPI VKL-8301

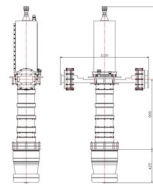
Typical Operating Parameters

Peak Power Output	10 MW (min)
Ave. Power Output	150 kW (min)
Beam Voltage	114 kV (typ)
Beam Current	131 A (typ)
Efficiency	65 - 67 % (typ-goal)
Frequency	1.3 GHz
Pulse Duration	1.5 ms (min)
Saturated Gain	47 dB (min)
Number of Beams	6
Number of Cavities	2+3+1 HOM, fund., harmonic
Focusing	CFF
Cathode loading	2.5 A/cm ² (typ)
Solenoid Power	4 kW (typ)
Length	2300 mm (typ)
Diameter	560 mm (typ, gun)

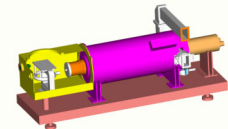


The Multi Beam Klystron TOSHIBA E3736 in cooperation with KEK

Peak Output Power	10 MW
Average Output Power	150 kW
Cathode Voltage	115 kV
Beam Current	132 A
Efficiency	> 65 %
Saturated Gain	47 dB
Number of Beams	6
Number of Cavities	6
Cathode Loading	< 3 A/cm ²
Solenoid Power	< 4 kW
Operation Frequency	1300 MHz
RF Pulse Duration	1.5 ms
Repetition Rate	10 Hz



Horizontal MBK for Tunnel Installation



Work for XFEL RF Tunnel Installation

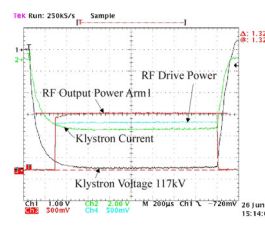
- Horizontal MBK for the tunnel
- Interface pulse transformer to klystron
- FPGA based RF interlock system
- Layout for auxiliary power supply tunnel installation
- Layout of interfaces

Modulators

Modulator Requirements

	Typical	Maximum
Klystron Gun Voltage:	115kV	130kV
Klystron Gun Current:	130A	150A
High Voltage Pulse Length:	<1.7ms	1.7ms
High Voltage Rise and Fall Time (0-99%):	<0.20ms	0.2ms
High Voltage Flat Top (99%-99%):	1.37ms	1.5ms
Pulse Flatness During 1.4ms Flat Top:	±0.5%	±0.5%
Pulse-to-Pulse Voltage fluctuation:	±0.5%	±0.5%
Energy Deposit in Klystron in Case of Gun Spark:	<20J	20J
Pulse Repetition Rate:	10Hz	10Hz
Transformer-Ratio:	1:12	1:12

Fermilab Modulator at TTF



New Modulator at TTF

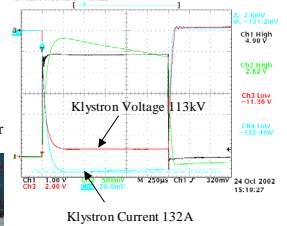
HVPS and Pulse Forming Unit



IGCT Stack



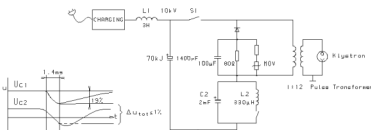
Pulse Transformer



Work for XFEL Modulator

- Modular modulator layout
- FPGA based interlock
- Pulse cable test
- Layout for hall and tunnel installation
- Investigation of alternatives (direct switch, SNS)

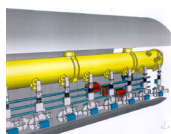
Circuit Diagram



HV Pulse Cable



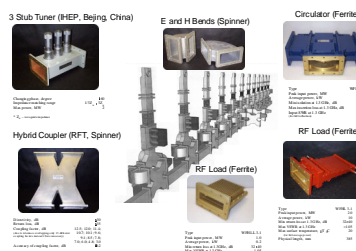
RF Waveguide Distribution



Waveguide Distribution Parameter

Waveguide type	WR650
Dimensions, mm	165.1 - 82.25
Material	A1
Flange type	PDR14
Max pulse power (max. for 500ns)	56 MW
Max pulse power (max. for 100ns)	> 5 MW
Losses at 1.3 GHz (measured)	0.22%/m
Max waveguide losses (see 2.1.1.1)	150 W/m
Waveguide temperature (see 2.1.1.1)	40 °C-Tolerance
Max thermal waveguide expansion	0.8 mm/m
Max phase-shift (over waveguide length due to increasing waveguide width)	12.5
Total RF power _{ave} for the XFEL	1.8 MW
Total waveguide losses _{ave}	73 kW
Total circulator losses _{ave}	36 kW
Total length of waveguide system	5 km
Total length of circulator structure	550 m

RF Waveguide Components



Work for Waveguide Distribution

- Layout for tunnel installation
- Integrated units, e.g. circulators with loads
- Investigation of alternative components

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