SPring-8 Storage Ring RF system

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SPring-8

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- Storage ring RF system
- RF components
- Operation

SPring-8


XFEL under construction
New Subaru
8GeV Sy
1GeV Linac
8GeV SR

SPring-8 storage ring parameter

Energy	8GeV
Circumference	1436 m
Stored current	100 mA
Emittance	3.4 nm rad
Momentum compaction	1.7×10^{-4}
Energy spread	0.1%
Energy loss	8.9 MeV/turn (Bmag)
Harmonic number	2436
Cell configuration	36 normal DBA cell + 8 match. cell
Straight section	40 x 7 m + 4 x 30 m

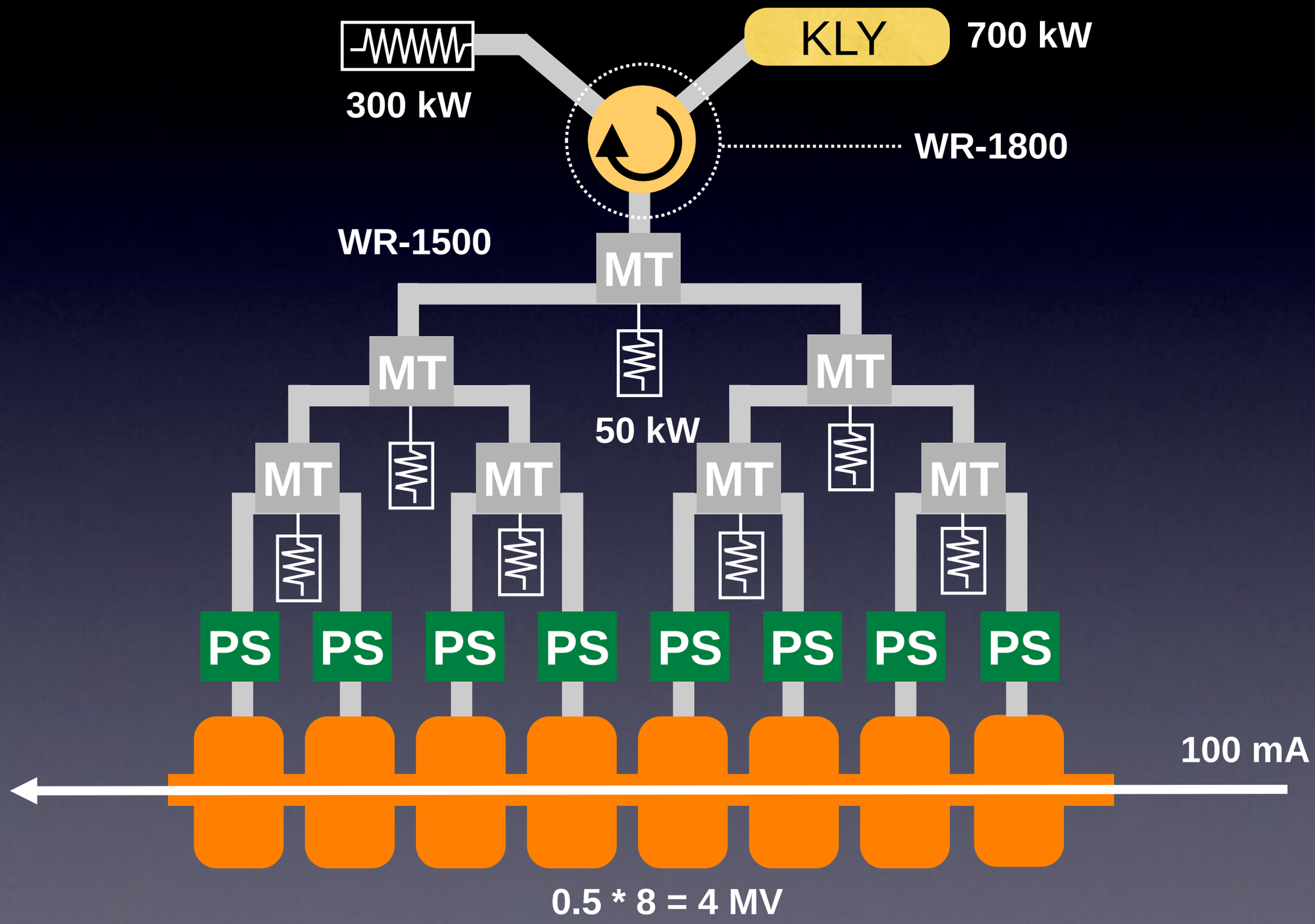
RF stations

Four RF systems in storage ring named A-, B-, C- and D-station

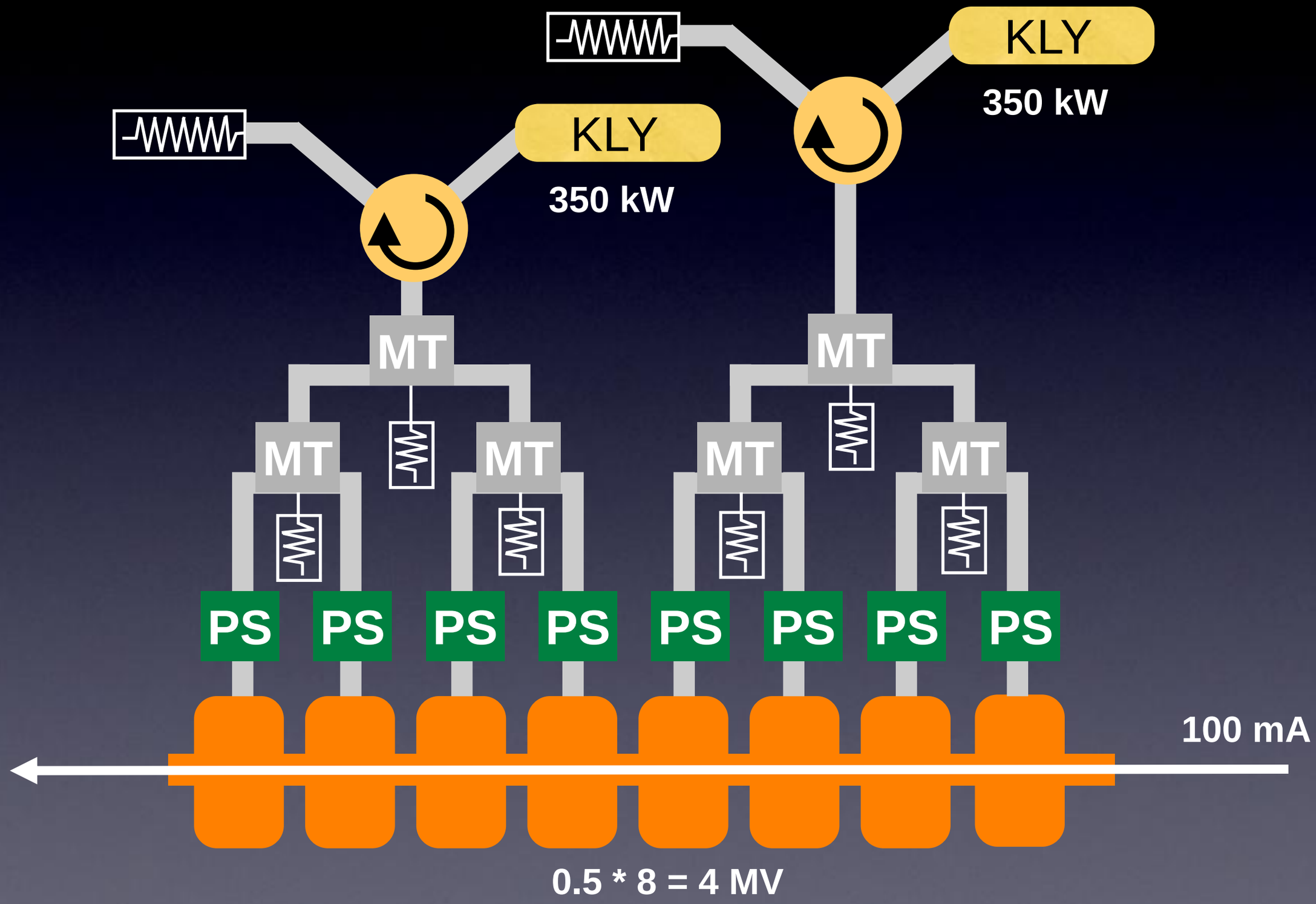
RF parameters

	Storage Ring	Booster
Beam current	100 mA	10 mA
Loss [MeV/turn]	8.9(B), 13.4 (B+ID)	12.3 (@8GeV)
RF stations	4	1
klystrons	5 x 1.2 MW	2 x 1.2 MW
frequency [MHz]	508.58 MHz	508.58 MHz
RF cavities	Single cell x 32	5 cell x 8
Va [MV]	16	18
Harmonic number	2436	672

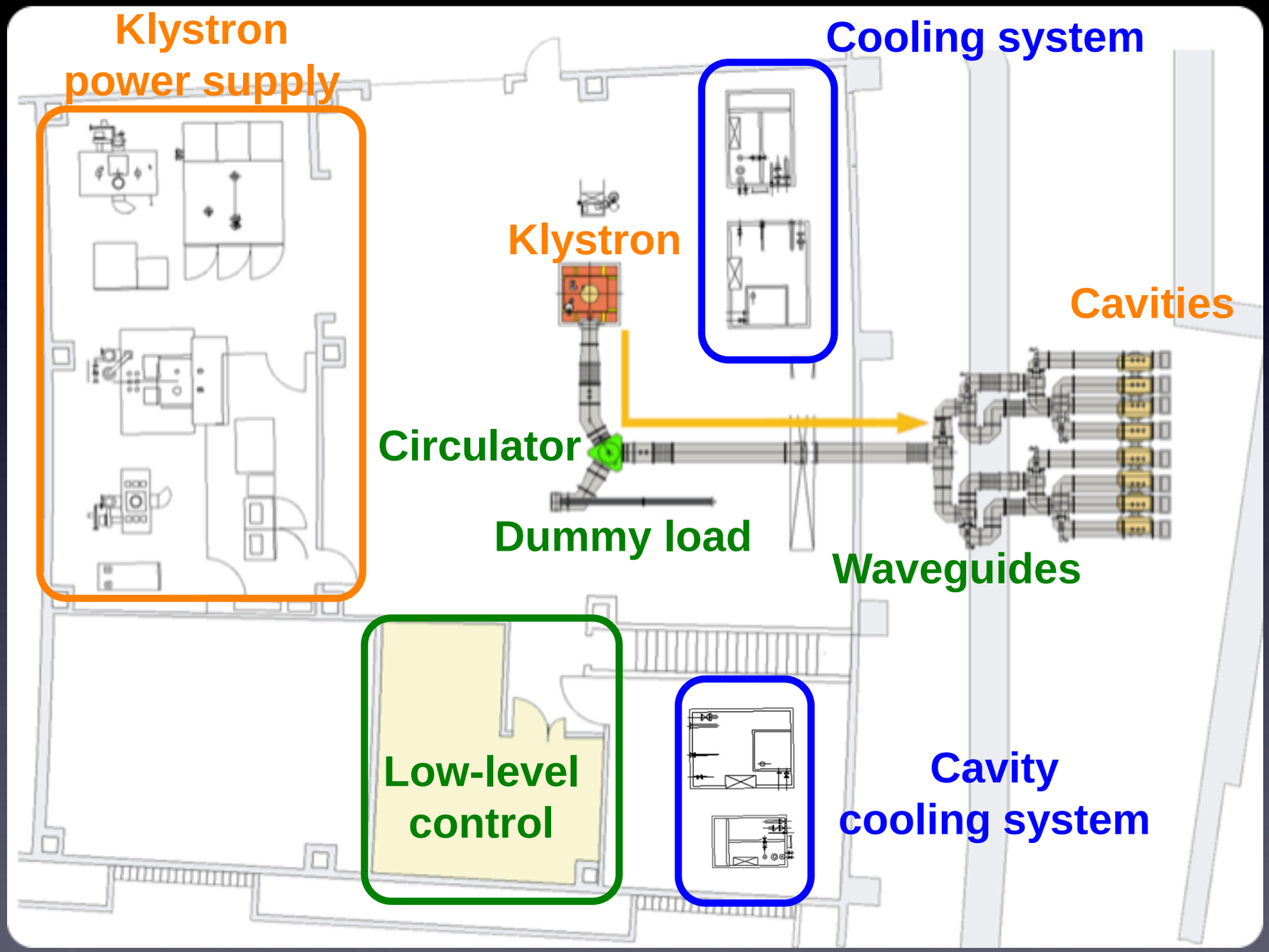
RF accelerating system 1



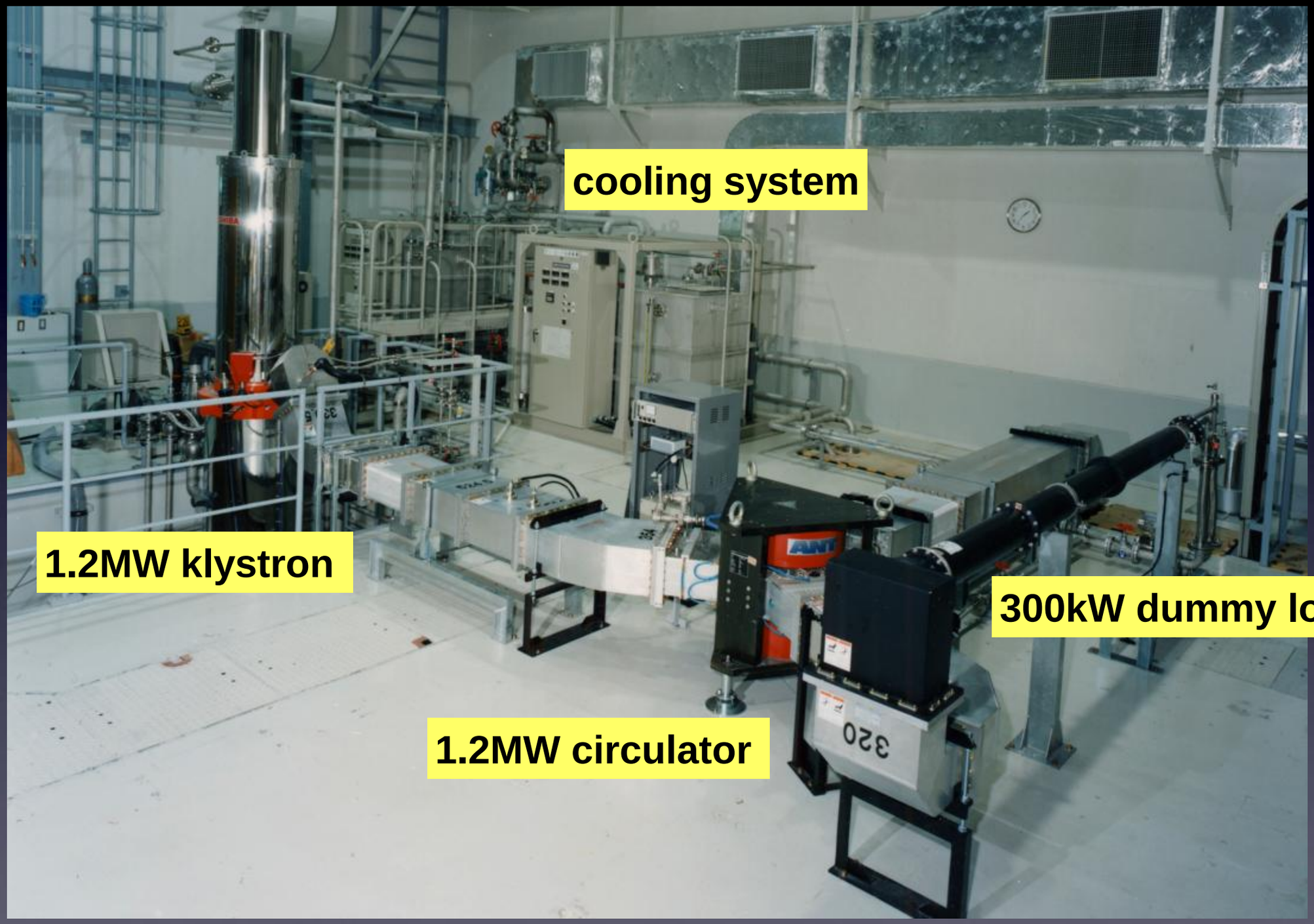
RF accelerating system 2



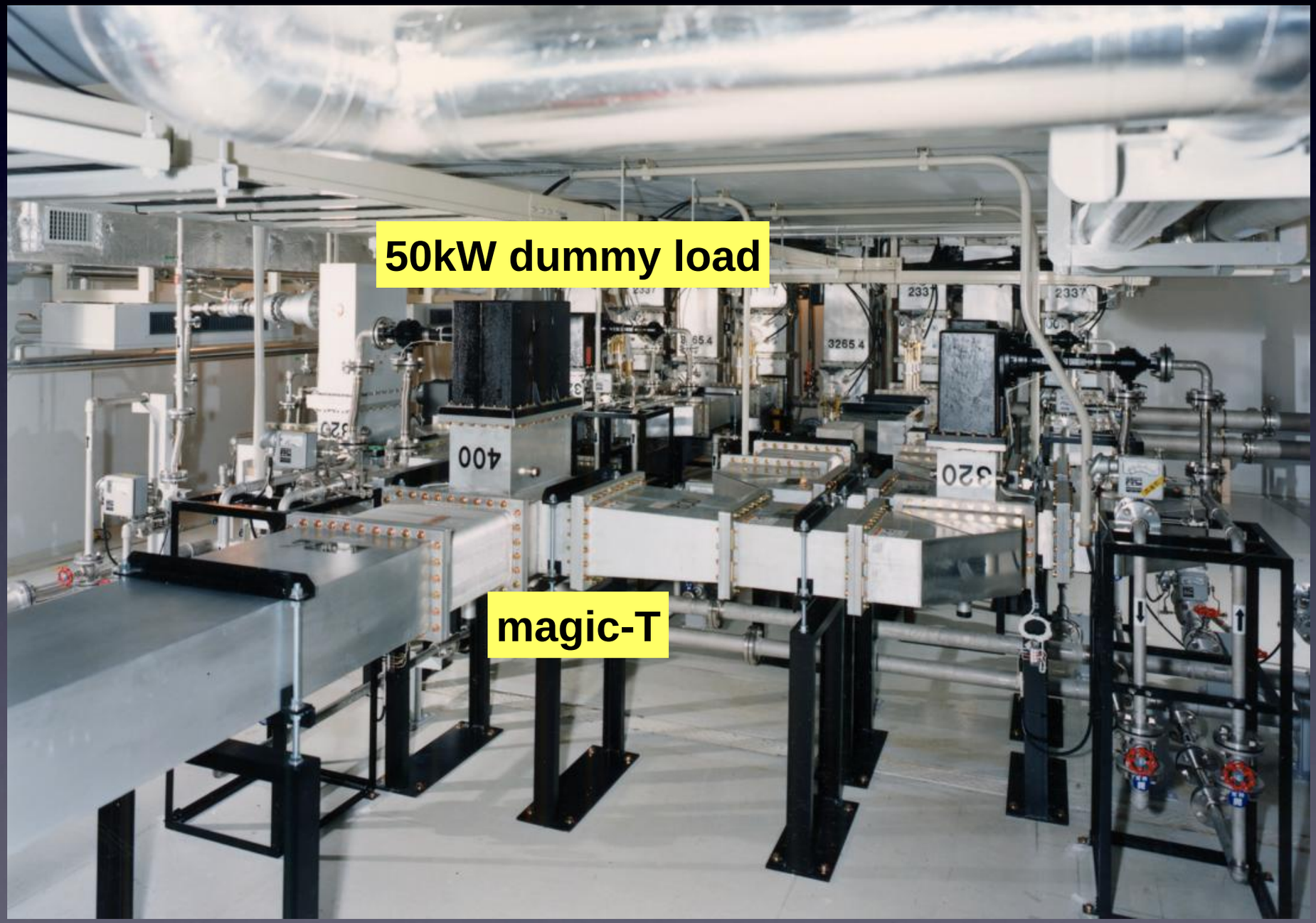
Layout of RF components



RF power source

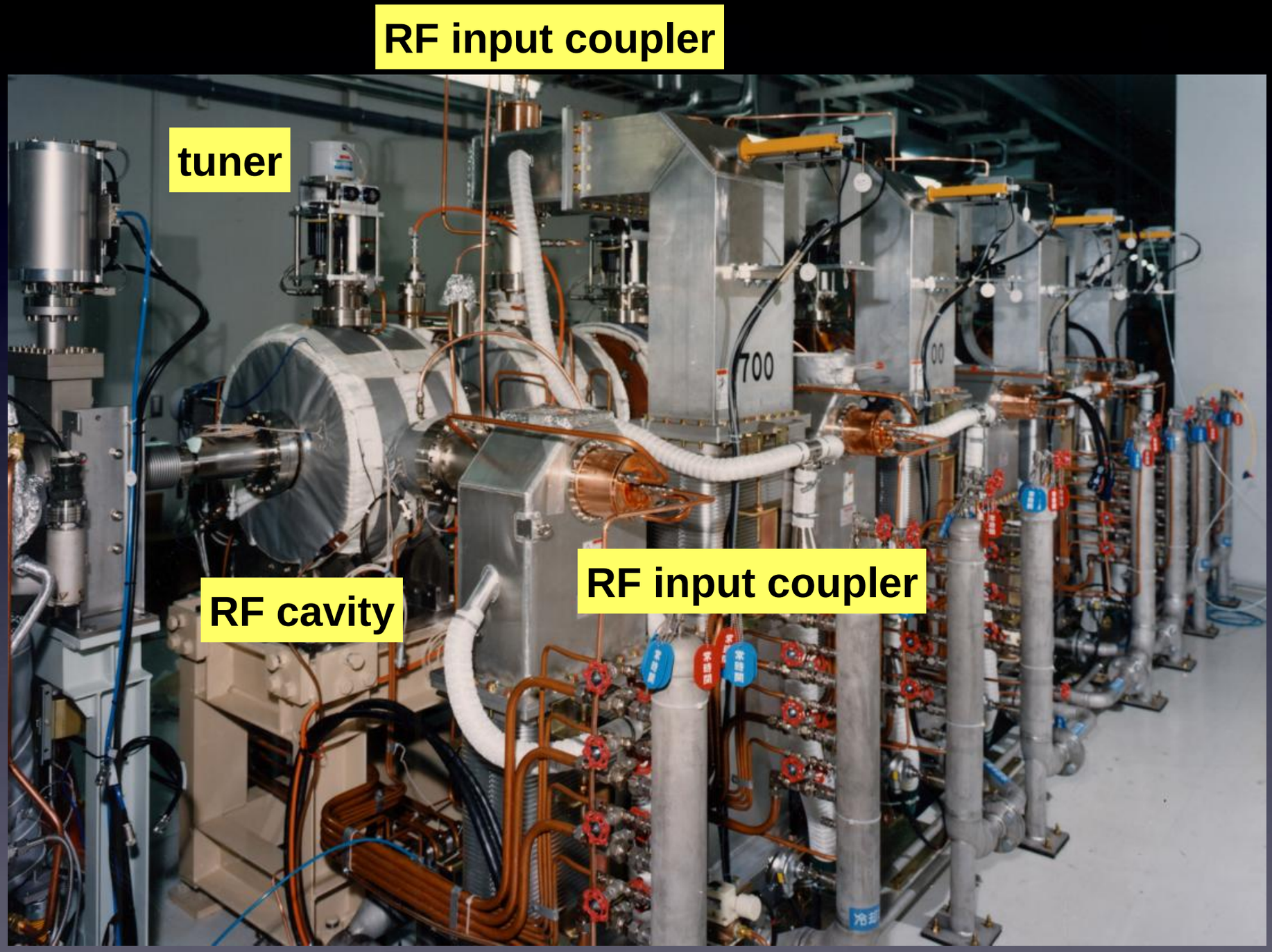


Junctions of waveguide system

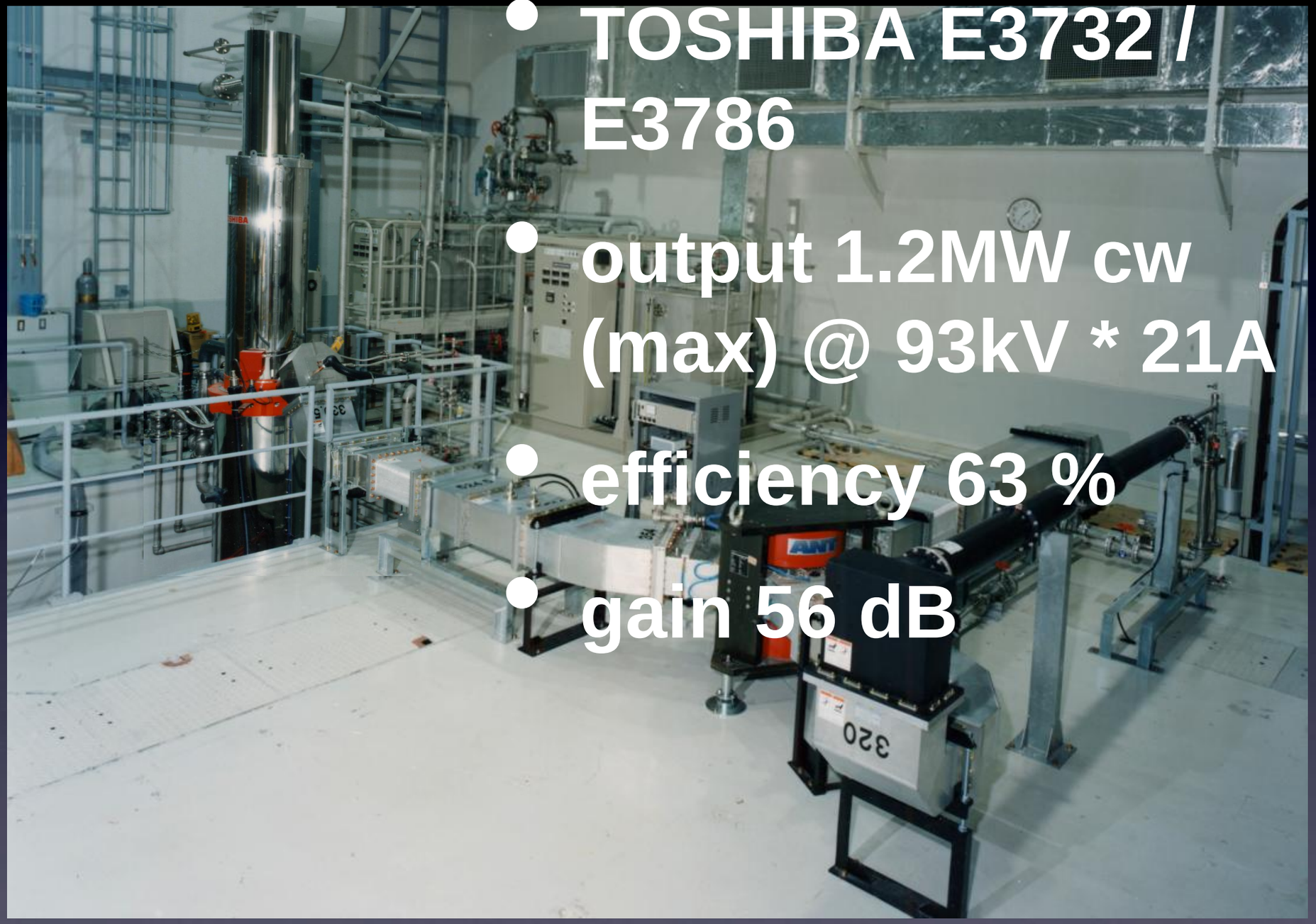


Downstream waveguides

RF cavities in SR tunnel



Klystron



- TOSHIBA E3732 / E3786
- output 1.2MW cw (max) @ 93kV * 21A
- efficiency 63 %
- gain 56 dB

Operation : 300 ~ 700 kW / klystron

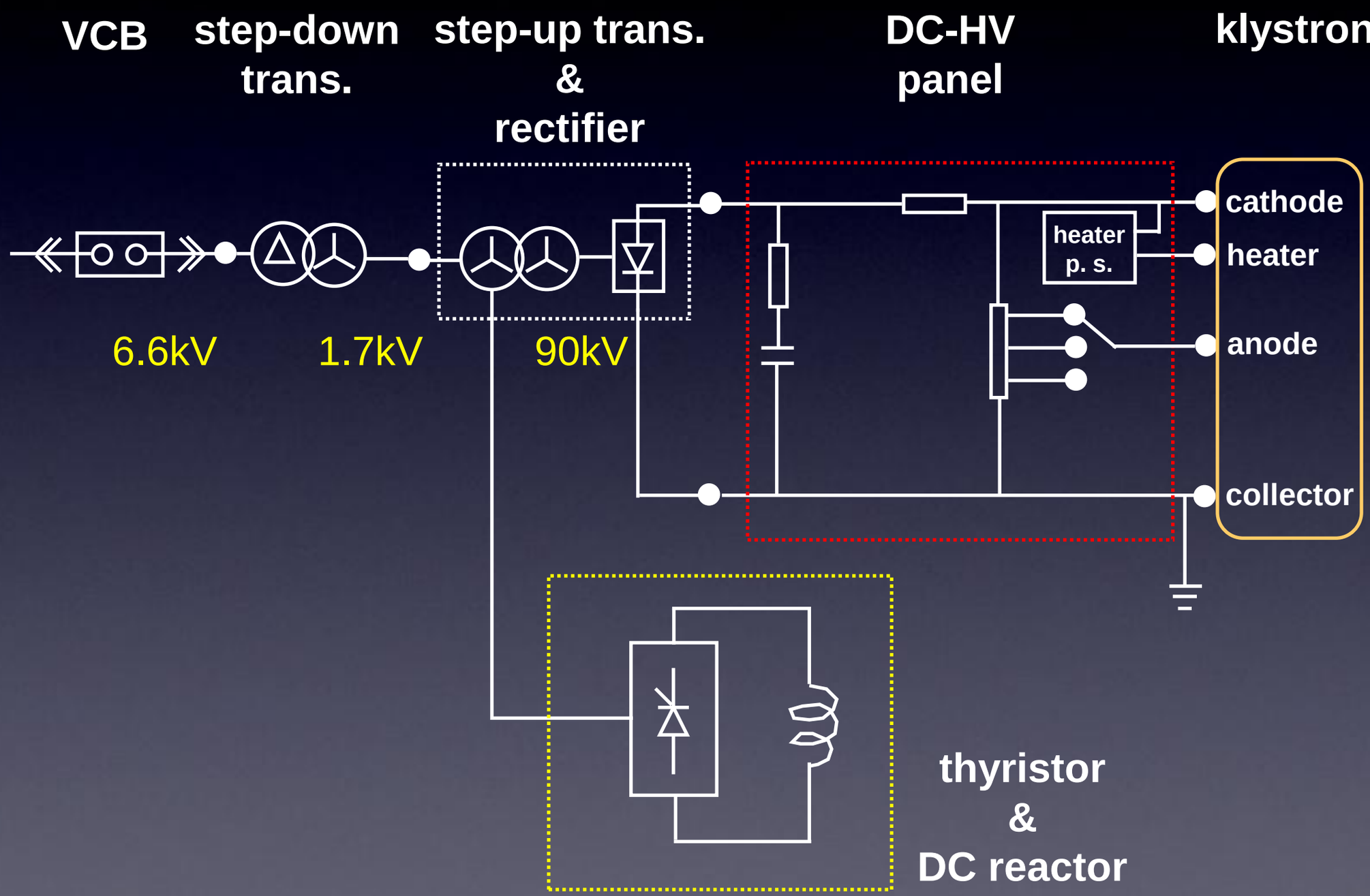
klystron issues

- Two klystrons have been operated stably over **65,000 hours.**
- Two klystrons were exchanged by vacuum leakage.
- Water leakage of cooling pipes by erosion and corrosion happened in three times at the output coupler part.
- Klystron E3786 was exchanged by discharge problems.

klystron power supply

- Thyristor-regulated type
- No crowbar circuit
- Six-phase rectifier circuit
- Ripples at multiples of 360 Hz : $\delta V/V \sim 10^{-3}$

Klystron power supply



klystron power supply issues

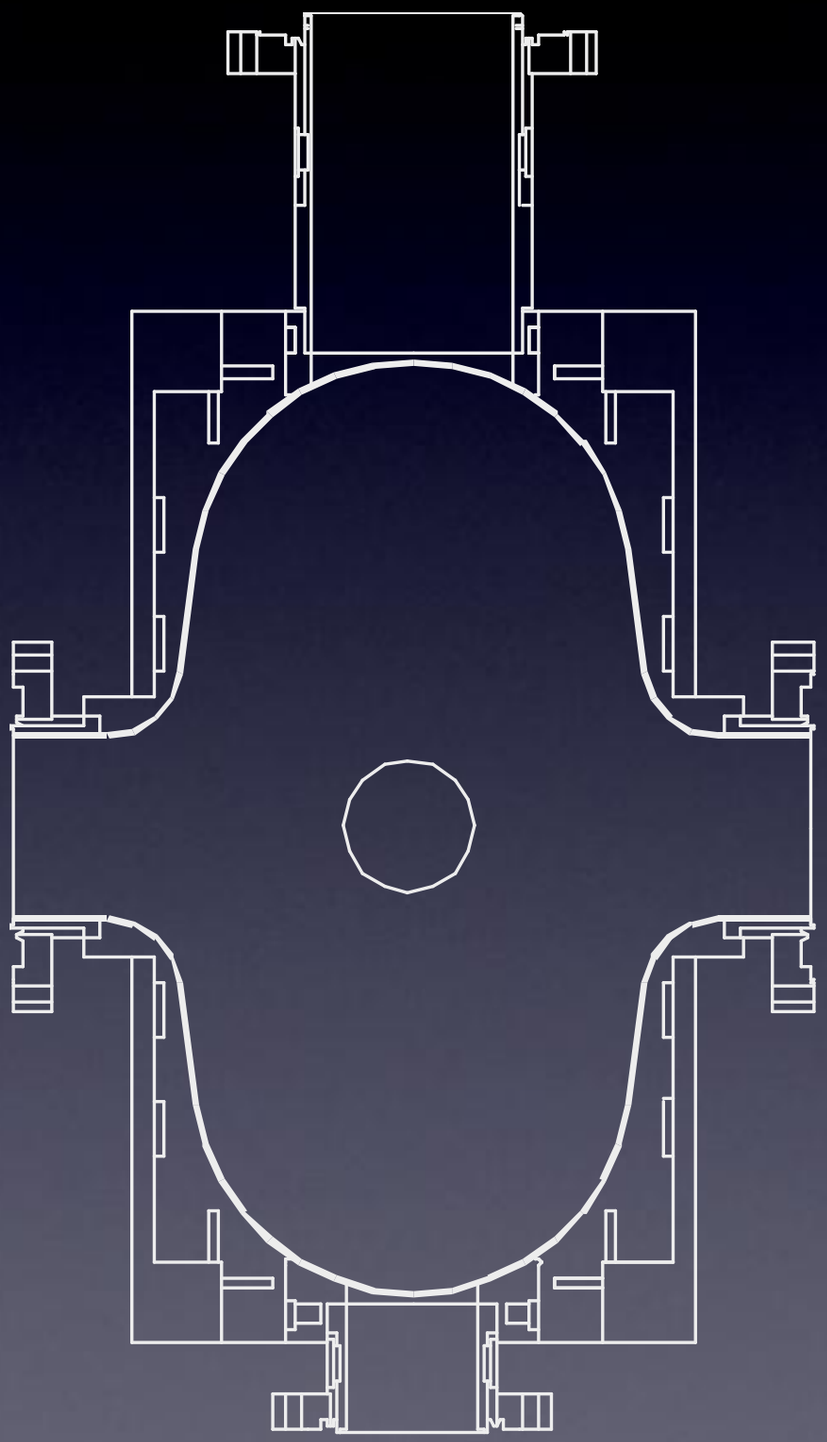
- Coherent synchrotron oscillations due to the ripples were reduced to 1/10 by feedback circuits such as ALC and PLL.
- Components such as chemical condensers, mechanical switches and control boards recently became out of order by excess of their life.

Y-junction circulator

- AFT CIRC 508/1200
- forward power 1.2 MW cw
- reverse power 600 kW cw

- Arc detection
- Water leakage at cooling pipes

RF cavities



Bell-shaped single-cell RF cavity

- Resonant frequency : 508.58 MHz
- Unloaded Q-value : 40000
- Effective shunt impedance : 6 MΩ
  V_a = 0.5 MV

- Body : OFHC copper
- RF input Coupler : TOSHIBA E4263
- 2 movable tuners + length-fixed tuner

Suppression of coupled-bunch instabilities

Precise Control of HOM frequencies

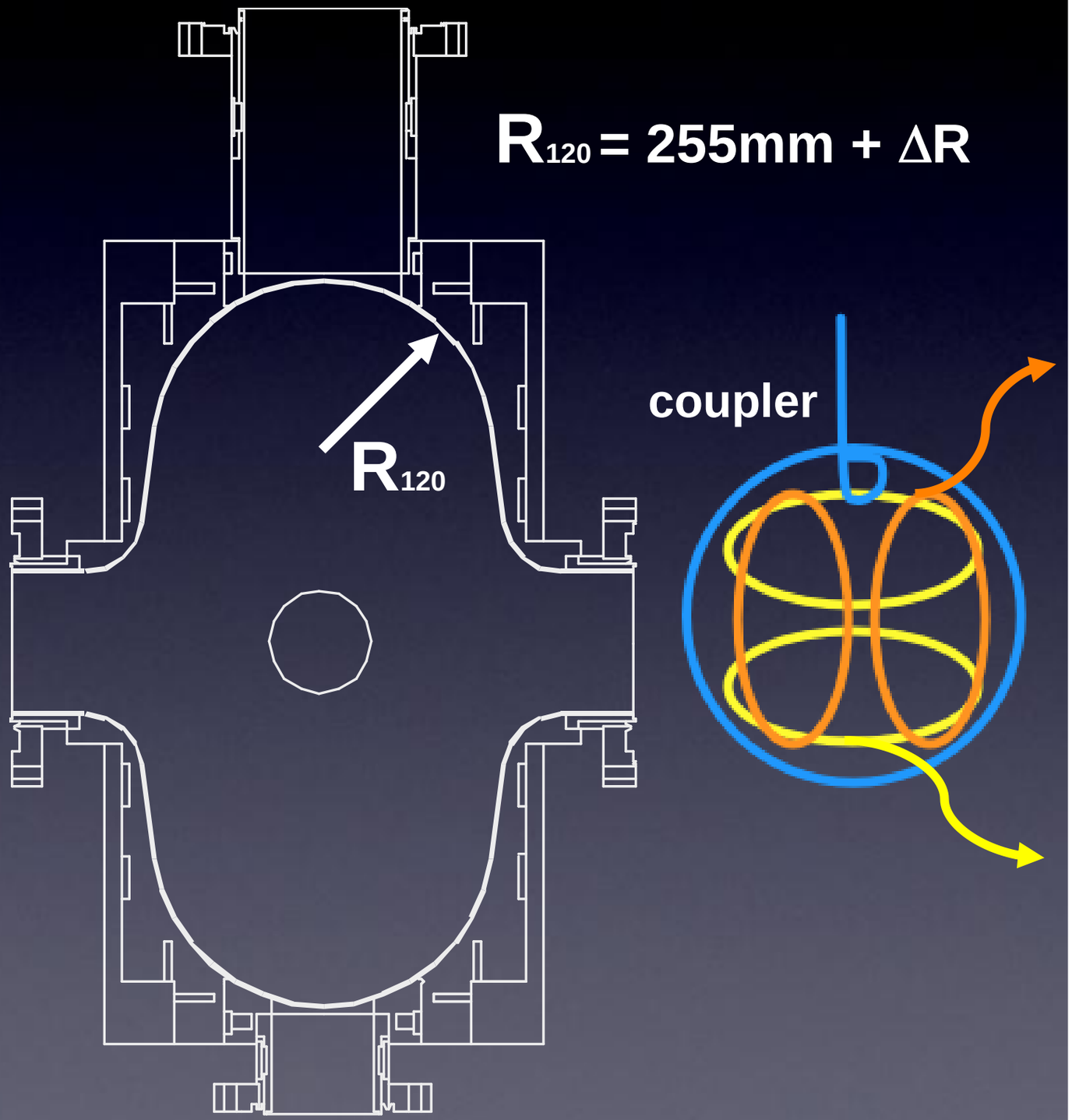
Optimization of the cavity inner shape

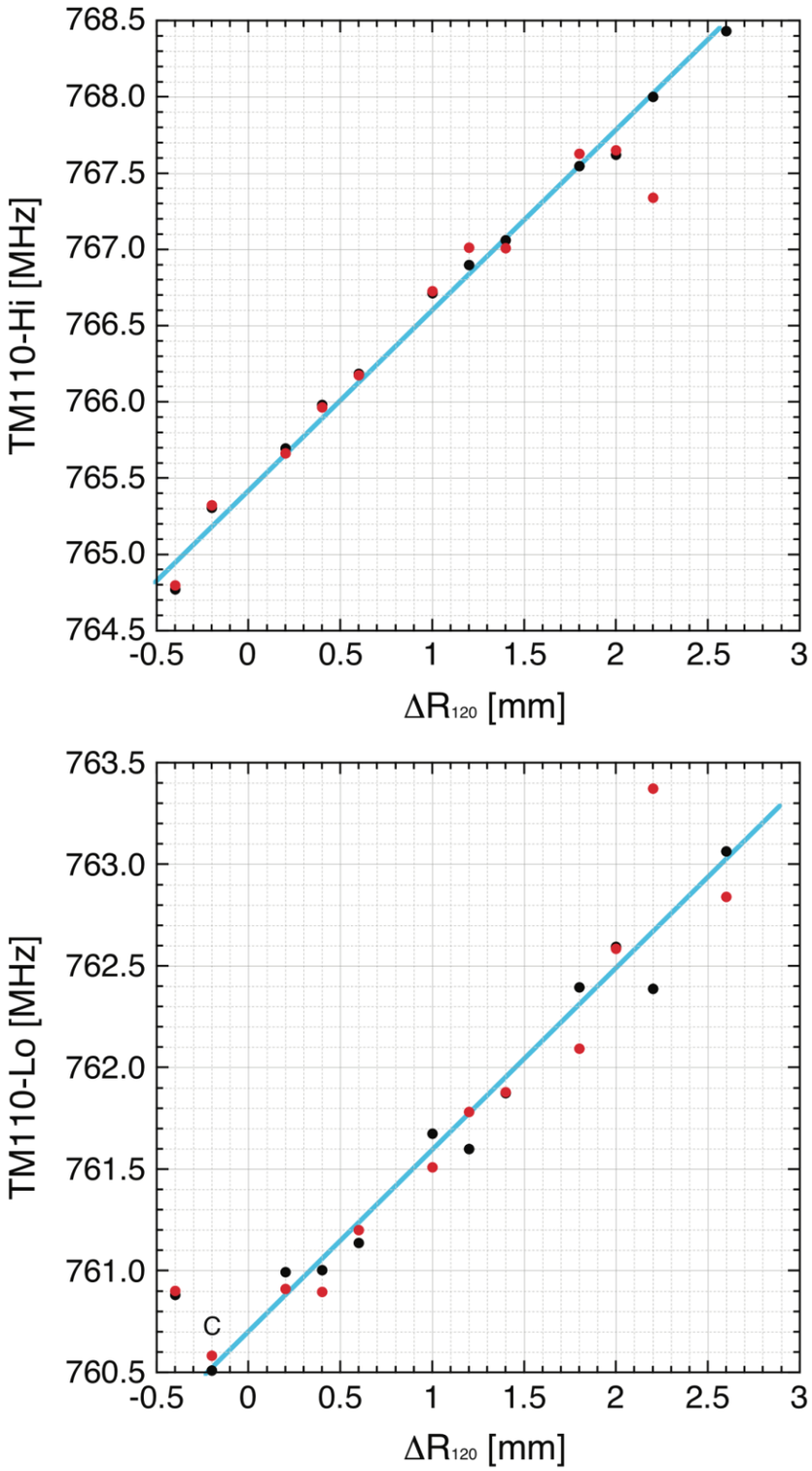
- low HOM coupling impedance
- slightly and systematically different inner shapes

HOM frequency tuner

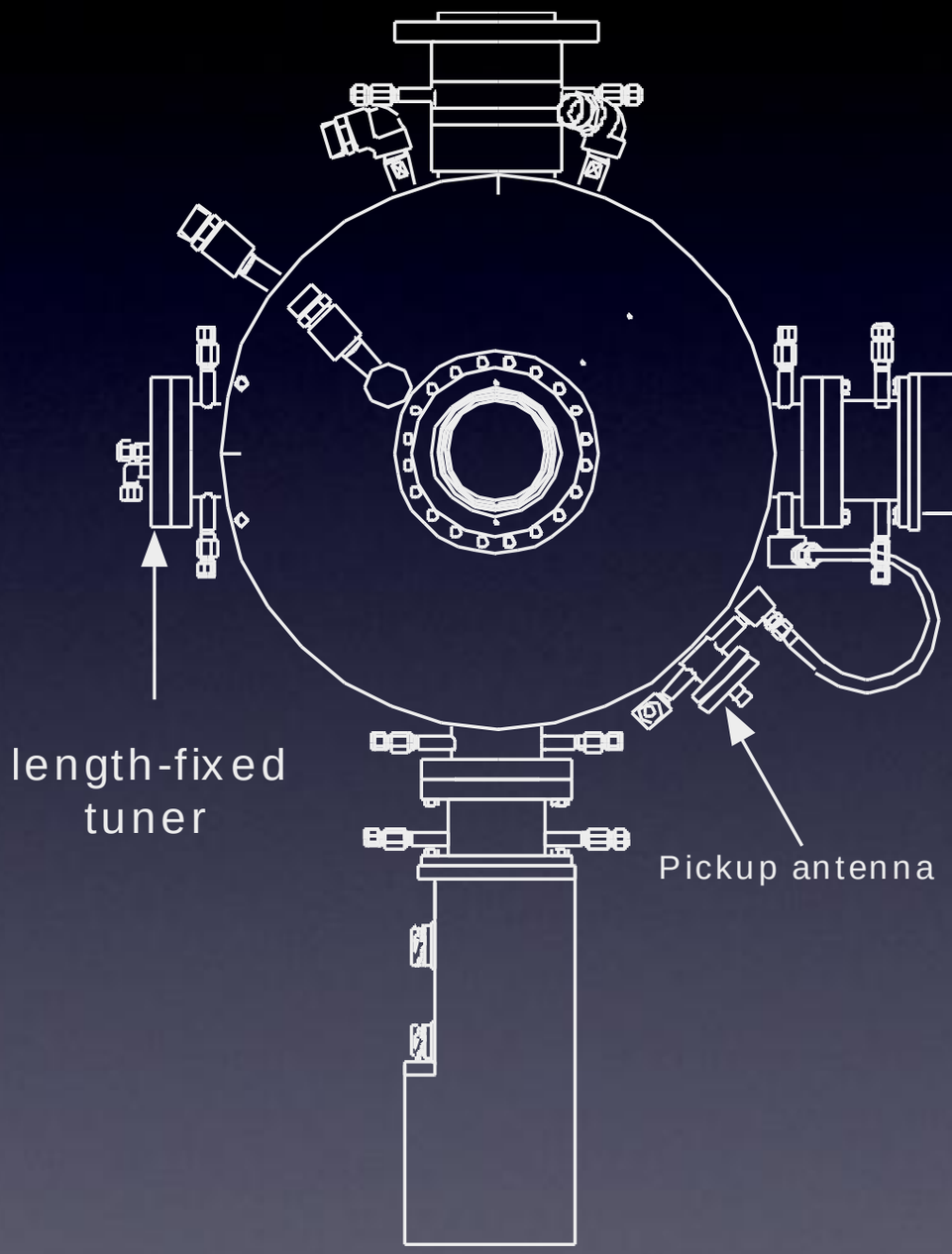
Precise temperature control of cooling water (< Delta 0.1℃)

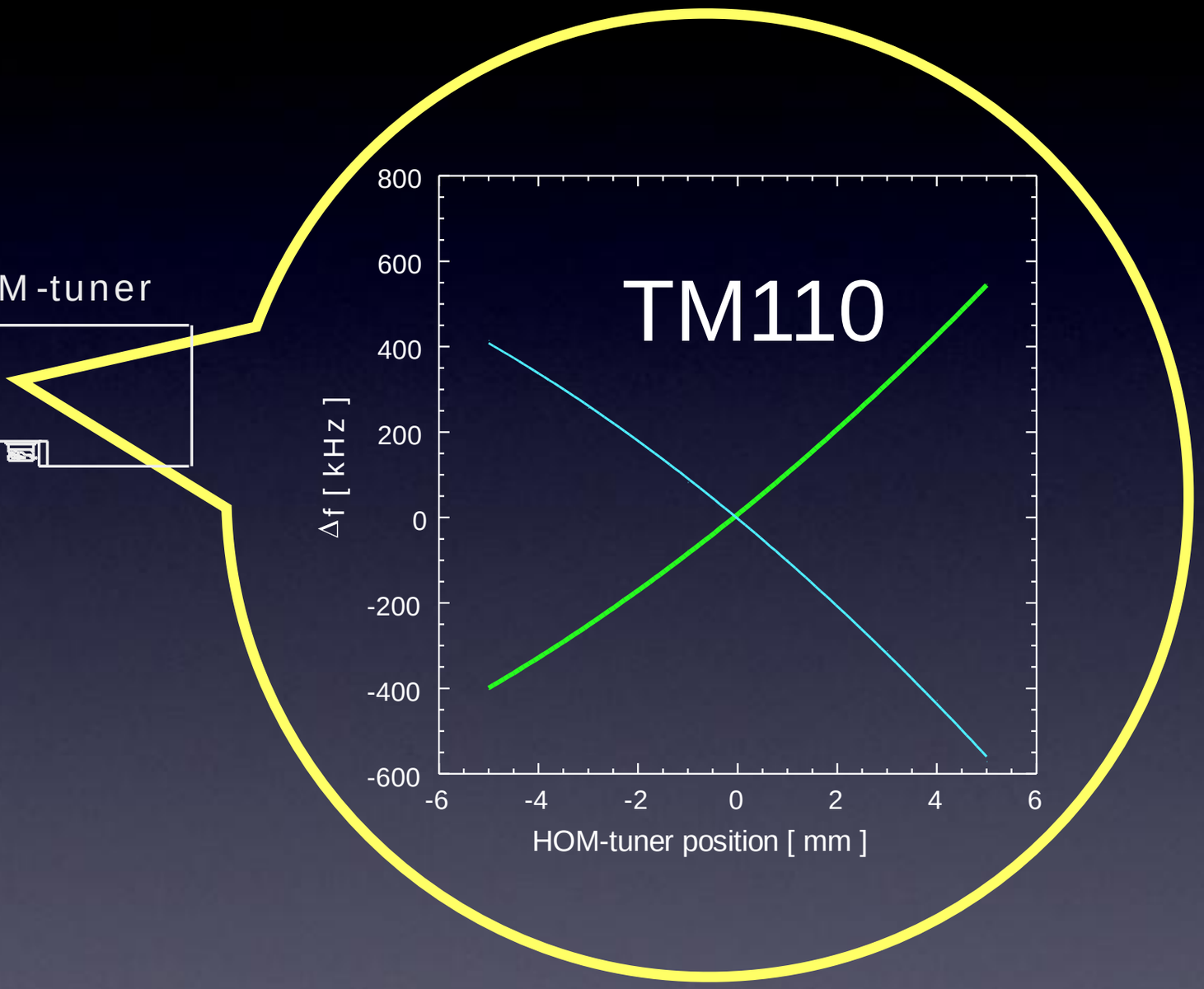
Systematically inner-shape modification dispersing HOM frequencies





HOM frequency tuner
avoiding the CBI conditions





keeping the TM010 frequency 508.58 MHz

Cavity issues

- Vacuum leakage of some cavities
  fabricated by Electron-beam welding (2002)

→ **Replacement with cavities fabricated by diffusion bonding (2003)**

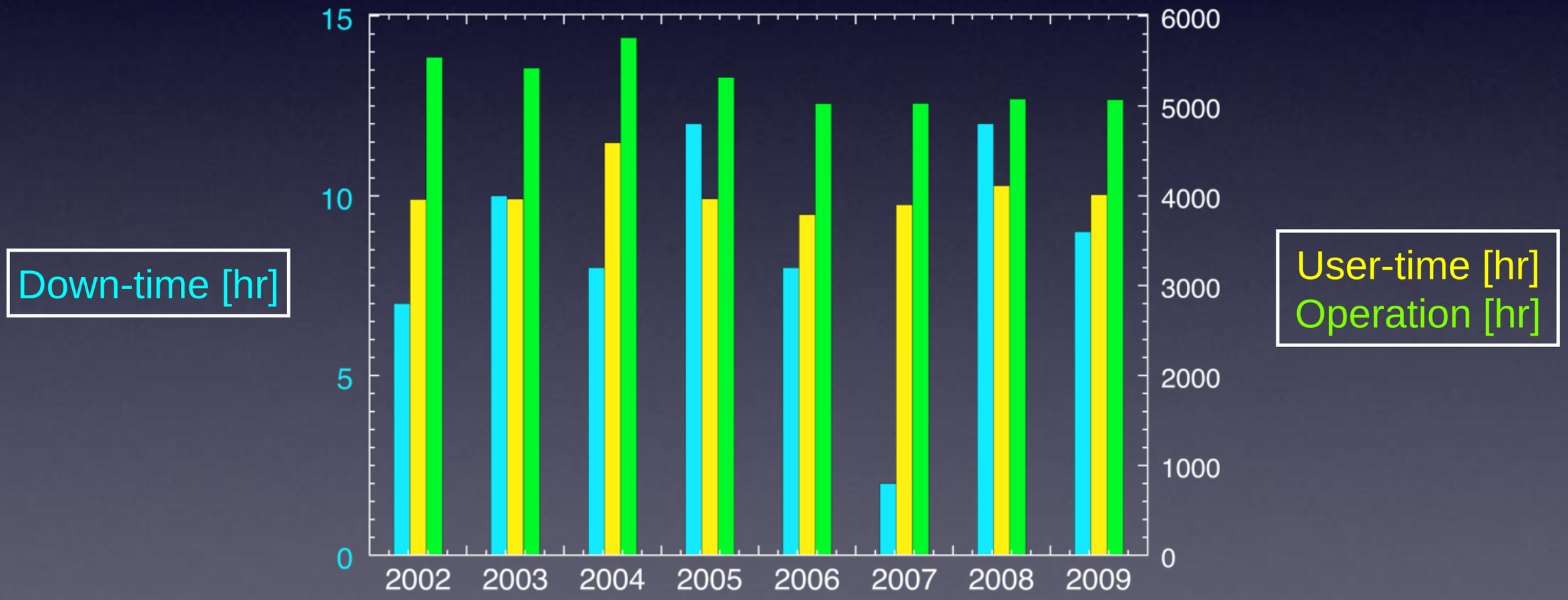
- Water leakage of the tuner at a welding point

RF operation

Mean annual down-time by the troubles of RF system

8 hours (2002-2009)

user-time 4000 hours / operation 5300 hours



Main troubles of RF system

(2002-2009)

trouble	number of times
cooling system error	15
cavity power reflection	15
circulator arc	14
klystron power supply	6
low-power instruments	4

Recently faults by the RF components exceeding their life increase.

Thank you for your attention!