UPGRADES OF S-BAND ACCELERATING STRUCTURES AND PULSE COMPRESSORS IN THE ELECTRON AND POSITRON INJECTOR LINAC OF KEK

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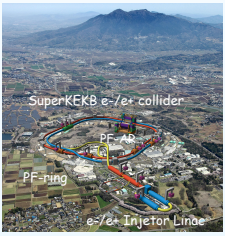
Abstract

New **S-band disc-loaded TM01-2π/3 traveling-wave structures** and **spherical-cavity-type pulse compressors** have been developed for upgrades of the injector linac for SuperKEKB and Photon-factory storage rings in KEK. The structures 2-m long have ingenious disk irises with oval fillets reducing discharge in high-power operation and modulations in radius suppressing beam break-up instabilities arising from HEM11 wake fields. The pulse compressors are of compact spherical-cavity-type resonating at the degenerate TE112 dipole mode with a high Q-value of 98,000 and yield a peak power gain of 6.2. The structures generate an acceleration gradient of 25.9 MV/m in power operation of 40 MW by using the pulse compressor and stably accelerate a two-bunch beam with a bunch charge of 4 nC

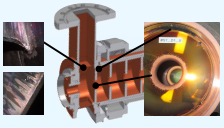
KEK electron/positron S-band Injector Linac



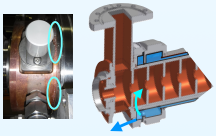
	Electron	Positron
Energy [GeV]	7	4
Number of S-band accelerating structures	226	
Operating frequency [MHz]	2,856	
Klystron	40 MW 4 μs 50 Hz	
Charge [nC]	4	4
Normalized emittance H/V [μm rad]	40/20	100/15
Energy spread [%]	0.07	0.16

What happen to the old structures?

Aging deteriorations of many old accelerating structures impossible to be repaired

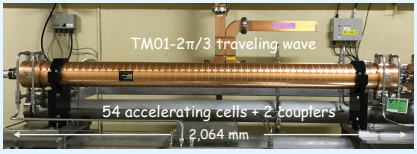


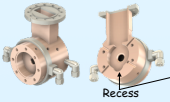
Discharge ・ Reflection



Water leakage

New S-band disc-loaded accelerating structure





RF coupler

- Single-feed type coupling to WR-284 waveguide
- Field symmetry corrected by a recess
- No sharp edge inside

Elliptical cross-section of iris edge reducing strength of surface E-fields

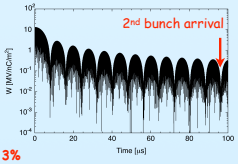
Tapered disc irises

Higher accelerating gradient + Suppression of HEM11-π BBU

RF properties

Operating frequency [MHz]	2,856
Accelerating mode	TM01 - 2π/3
Type of structure	Quasi-CG
Cell iris diameters [mm]	23.340 - 19.234
Mean group velocity / c	0.0117
Filling time [μs]	0.570
Unloaded-Q	14,000
Attenuation parameter [Neper]	0.366
Mean shunt impedance [MΩ/m]	61.7
Energy gain [MeV/MW$^{1/2}$]	7.87

Wake function of HEM11-π

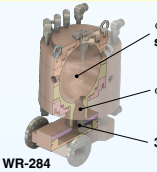


↓ 3%

HEM11-π wake fields Reduced to 1/1000 for 2-bunch beam operation with a time interval of 96.3 μs

Spherical-cavity-type pulse compressor: SCPC

Super compact body + low-cost

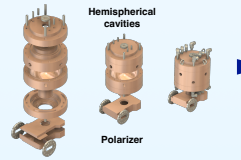


RF properties (design)

Operating frequency [MHz]	2,856
Resonant mode	Spherical TE112
Unloaded-Q	100,000 ↓ 2%
Coupling constant	6.4
Peak compression ratio	6.2
Input pulse length [μs]	4.0
Phase-reversed length [μs]	1.0
Input power [MW]	40

2-step silver-brazing fabrication

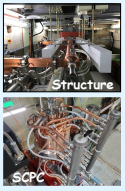
Components | STEP1 | STEP2

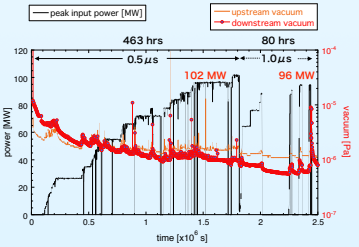


- Cooling-water channels formed inside the body
- frequency adjustment by correction machining after STEP1
- Fine frequency and degeneration adjustment by 8 detachable dimpling tuners after STEP2

High-power conditioning up to 100 MW

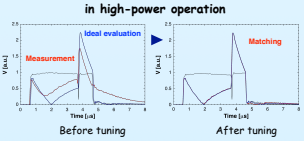
Setups for conditioning in the test stand





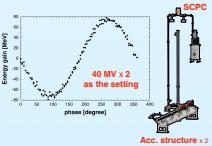
Beam acceleration by two structures with SCPC

Real time measurement and fine tuning of SCPC in high-power operation



Before tuning | After tuning

Measured beam energy gain



Summary

We have developed new S-band accelerating structures to replace with the malfunctional old ones suffering from aging deterioration. The four pilot structures have the RF characteristics as expected. The S-band spherical single-cell cavity-type pulse compressor was also developed and tuned adequately. The operations at an RF power of 80 MW or more were succeeded for both the structure and the SCPC. They were installed in the injector and are stably in beam acceleration of 20 MV/m. We have finished mass-produced 12 structures in the spring of 2023 and plan to install them in the injector after conditioning.