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Applying MgB_2 Superconducting Magnet Technology for High Efficiency Klystrons in Particle Accelerator RF Systems

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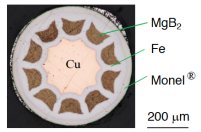
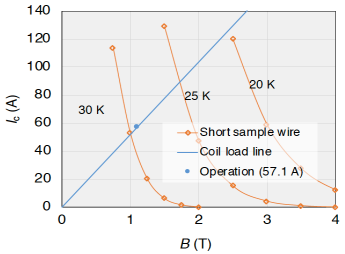
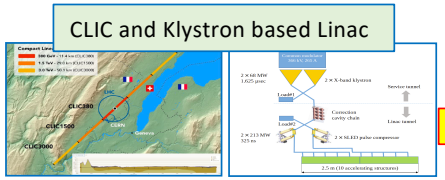
Abstract:

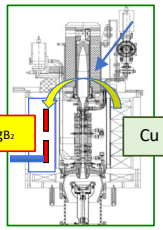
- An MgB_2 superconducting magnet has been developed for high-efficiency X-band (12 GHz) klystron and for electron beam focusing in particle accelerator RF systems, providing a solenoidal field of 0.8 T in a warm bore diameter of 0.25 m
- It has successfully demonstrated significant electric-power saving at an operation temperature of 20 K using a cryo-cooler with an AC-plug power consumption of 3 KW.

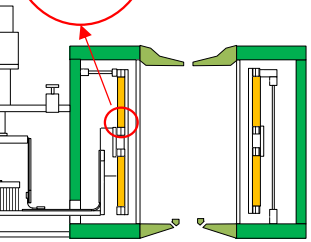




MgB_2 superconductor characteristics

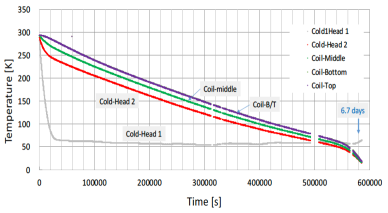




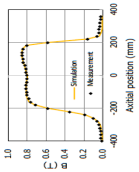


MgB2 Superc. Solenoid Parameter

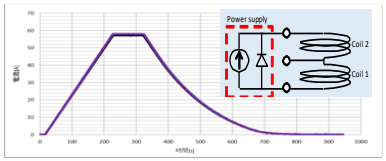
Parameters	Parameters
Superconductor	
Material	MgB_2/Cu /Fe/Monel ®
Strand Diameter, Length	0.67 mm, 5,600 m
Insulation	Glass-braid
Solenoid coil	
Inner Diameter, Length	0.34 m, 0.30 m
Central field, @ Current, Coil-turns	0.8 T @ 57.1 A, 4946 tuens
Stored energy	11.8 kJ
Cold mass (coil/Cu-insert/Bobbin)	71 (14/25/32) kg
Heat-treatment / Insulation	600 C x 6 h/ Epxy-Resin Impreg.
Cryostat	
Warm ID, Iron-yoke OD, and Hight	0.25, 0.63, and 0.52 m
Cryo-cooler (SHI-CH204)	
Cooling capacity (@ 20K / 65K)	6.7 / 13.5 @ 50 Hz
AC plug-power	< 3 kW



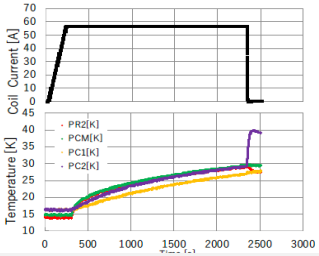
Initial Cooling in 7 days,



Axial Field profile



Excitation and discharge (< 4 min.)



Transition @ 29 K, B = 0.8 T (1 T in coil)

Summary:

- The MgB_2 superconducting solenoid for klystron beam focusing has been successfully demonstrated, B_c = 0.8 T at I = 57.1 A, and T_{cs} = 29 K
- It has realized the stable and easy operation at 20 ~ 25 K. and demonstrated significant AC-plug power saving down to < 3 kW, with one order of magnitude lower to that of a Cu solenoid (20 kW) .
- A large-scale application is anticipated in a future linear collider program, Compact Linear Collider (CLIC) proposed at CERN to realized significant energy saving and "Green Accelerators".

MgB2 SC magnet efficiency compared with Cu, NbTi, and HTS

Coil material	unit	Cu	NbTi	MgB_2	HTS (GdBCO)
Coil					
Central field	T	0.6	0.8	0.8	0.8
Current	A	~ 2 x 300	57	57	57
Voltage	V	35	0	0	0
Power	KW	20	0	0	0
Cooling					
Cooling		WC	CC	CC	CC
Temp	K	300	4.5	20	65
Capacity	W	tbd		4	3
AC-power	kW	tbd	~ 6	< 3	< ~ 2
Total Power		>20	~ 6	< 3	< ~ 2

References:

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3) H. Tanaka et al, : (SC), this conference, MT26, Wed-Af-Po3,.25-04.
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