

Operational Test of 84 GHz Gyrotron for KSTAR ECH System

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POSTECH

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Abstract

KSTAR ECH System의 Microwave source로 84 GHz, 500 kW, 2 sec 급 Gyrotron (VGB-8084)을 사용할 예정이다.

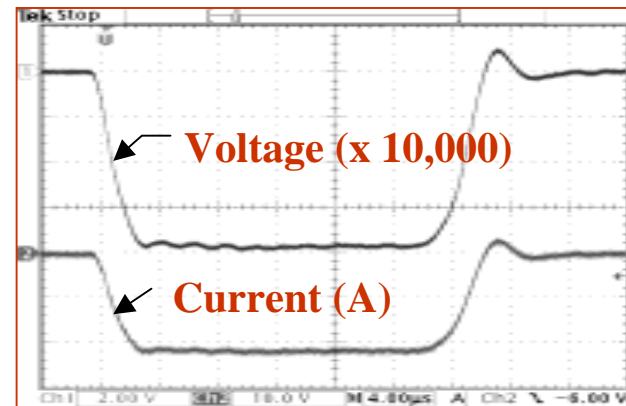
이 Gyrotron은 CPI에서 제작되어 포항에 설치하여 기본적인 시운전을 수행하였다. 시운전을 위한 전원은 PFN방식의 Modulator로써 80 kV, 20 A, 20 micro-sec이다. RF output power 측정은 WR10 Horn antenna와 Crystal Detector를 사용하였으며, 80 kV 운전에서 최대 출력 500 kW를 얻었다. RF Output Frequency 측정은 Frequency Meter와 spectrum Analyzer를 사용하여 84.14 GHz를 확인하였으며, Operation mode의 확인을 위하여 IR-Camera를 이용하였다. 직경이 1.25 인치인 corrugated 도파관에 전파하는 RF Power 분포가 Gaussian 분포임을 확인하였다.

* Work supported by MOST-Korea and KBSI-KSTAR project.

Gyrotron Test Pulse Modulator



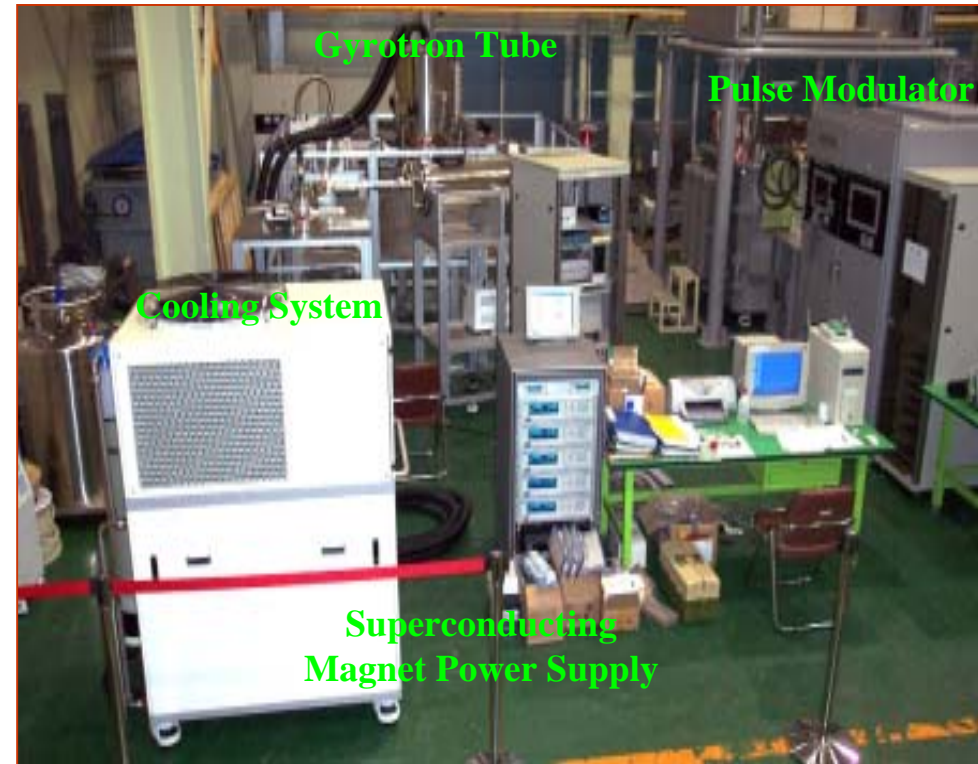
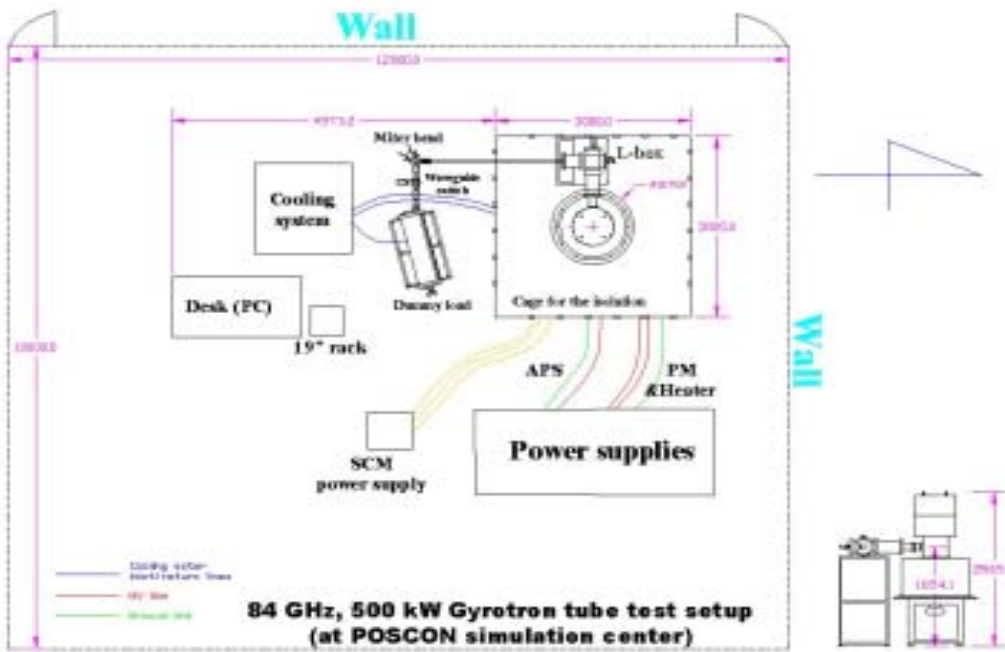
- 80 kV, 20 A 20 μ s, 60 Hz Pulse
- Rising time : \sim 3 μ s
- Pulse Forming Network



80 kV, 20 μ s Pulse Waveform

Gyrotron test setup layout

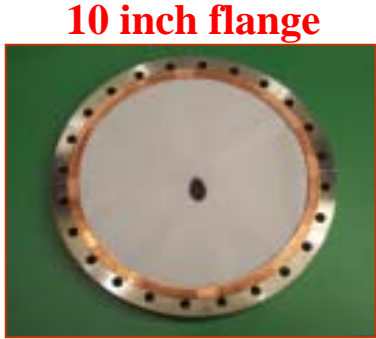
Gyrotron Test Setup



POSCON Simulation Center

Gyrotron Superconducting Magnet Cool-down

RF Beam Alignment Using L-box Mirror & IR-camera



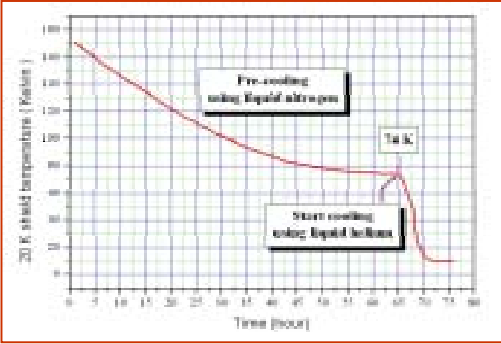
**Filling of LN2
Compressor & Cryo-cooler on
Pre-cooling with LN2**

Blowing out LN2

**L-box
IR-camera**

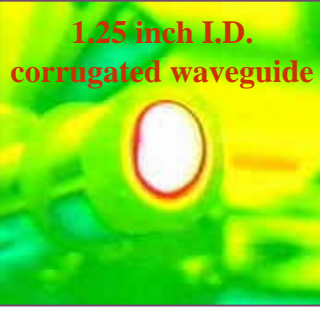
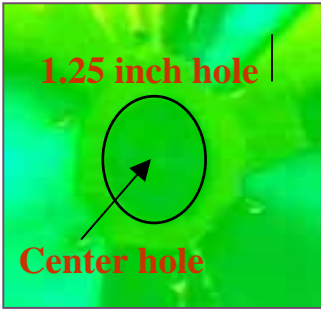
10 inch flange

**Paper Burning
(20 μs, 10 Hz, 10 sec shots)**



Filling of LHe

Cool-down temperature history



**1.25 inch hole
Center hole**

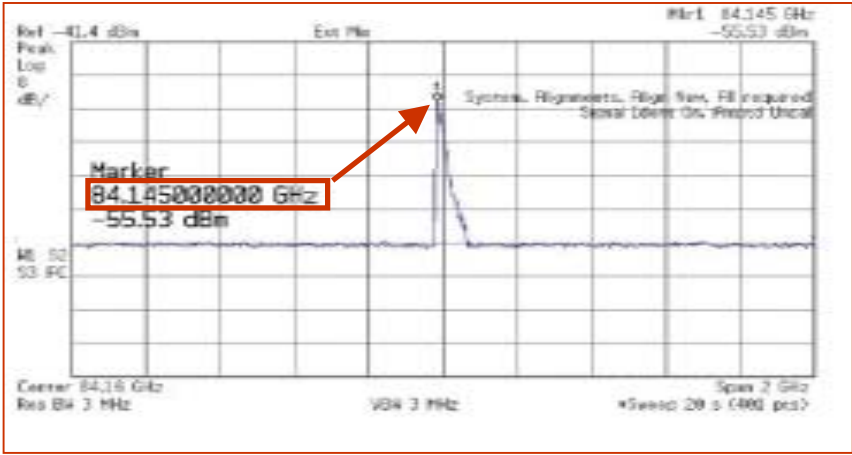
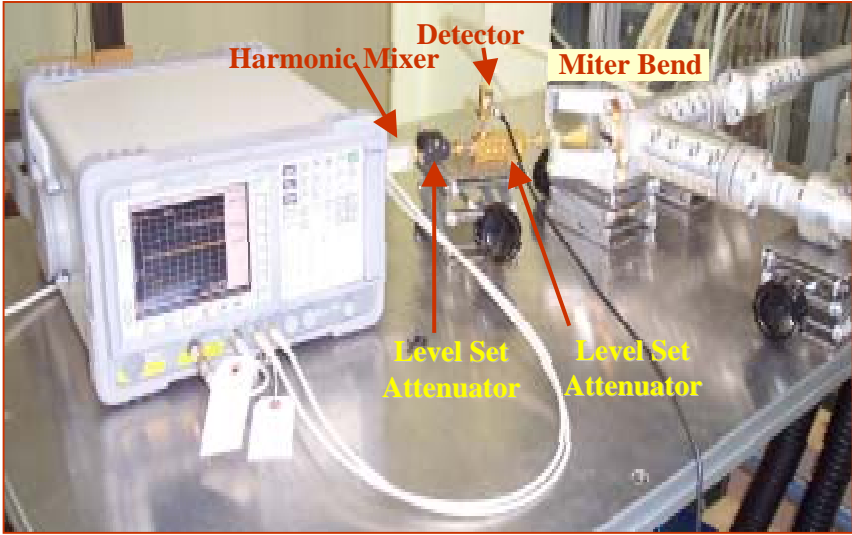
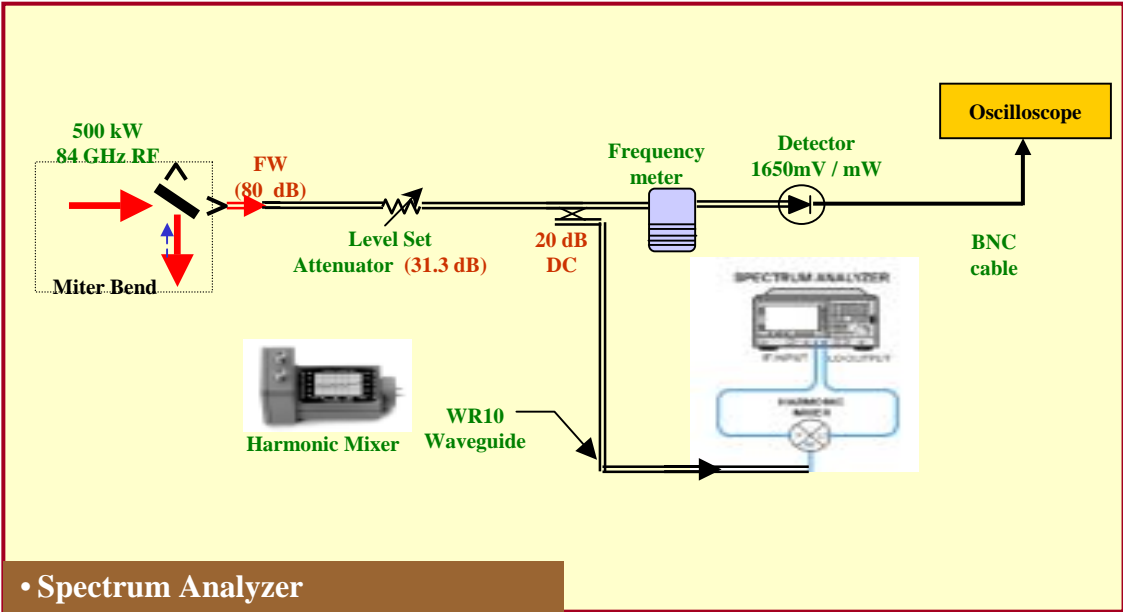
Centering RF beam

**1.25 inch I.D.
corrugated waveguide**

**Beam Matching
(10 Hz operation)**

RF Frequency & Power Measurement Setup

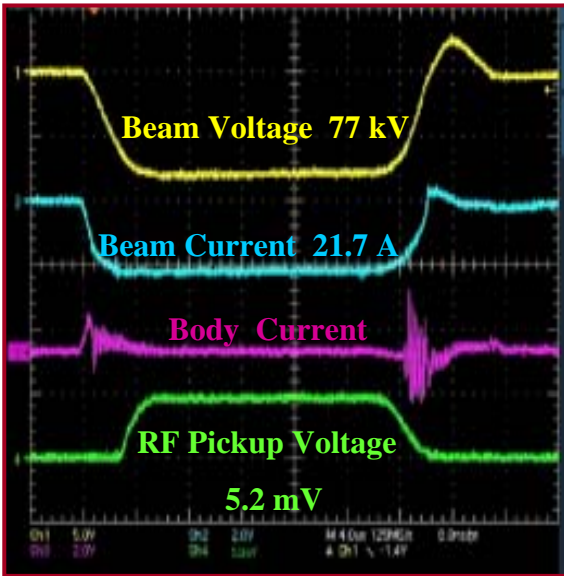
Frequency Measurement



- Spectrum Analyzer (Agilent E4407B model)
- Frequency range: 9 kHz – 26.5 GHz
- RBW: 10 Hz – 5.0 MHz (with option)

- Harmonic Mixer (Agilent 11970W)
- 75 GHz – 110 GHz
- Harmonic number: 18
- Typical RF input SWR: < 2.6:1

Power Measurement



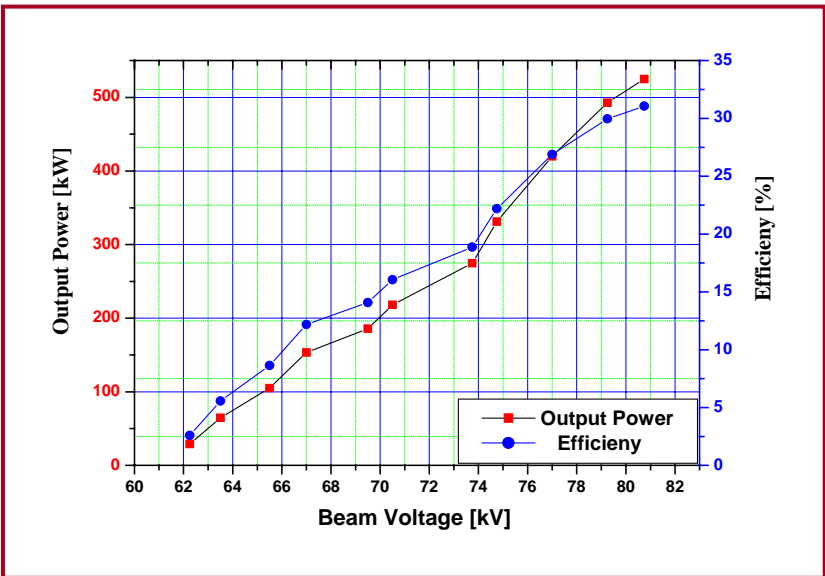
Power Calculation Example

RF Power

$$= \frac{V_{RF\ Pickup}}{Sensitivity} \times 10^{Total\ Attenuation/10} \quad [mW]$$

$$= \frac{V_{RF\ Pickup}}{1670} \times 10^{11.13} = 81 \times V_{RF\ Pickup} \quad [kW]$$

$$= 80.77 \times 5.2 \text{ kW} = 420 \text{ kW}$$



Conclusion

1. Corrugated 도파관에서 전파하는 RF Power 분포가 Gaussian 분포 임을 확인하였다.
2. RF output power 측정은 WR10 Horn antenna와 Crystal Detector를 사용하였으며 81 kV 운전에서 최대출력 525 kW를 얻었고, 이때 효율은 31 % 였다.
3. RF Output Frequency 측정은 Spectrum Analyzer를 사용하여 84.14 GHz를 확인하였다.