



Gyroklystron Update:

Review of K-band (20GHz to 40GHz), Gyrotron Klystron Experiments

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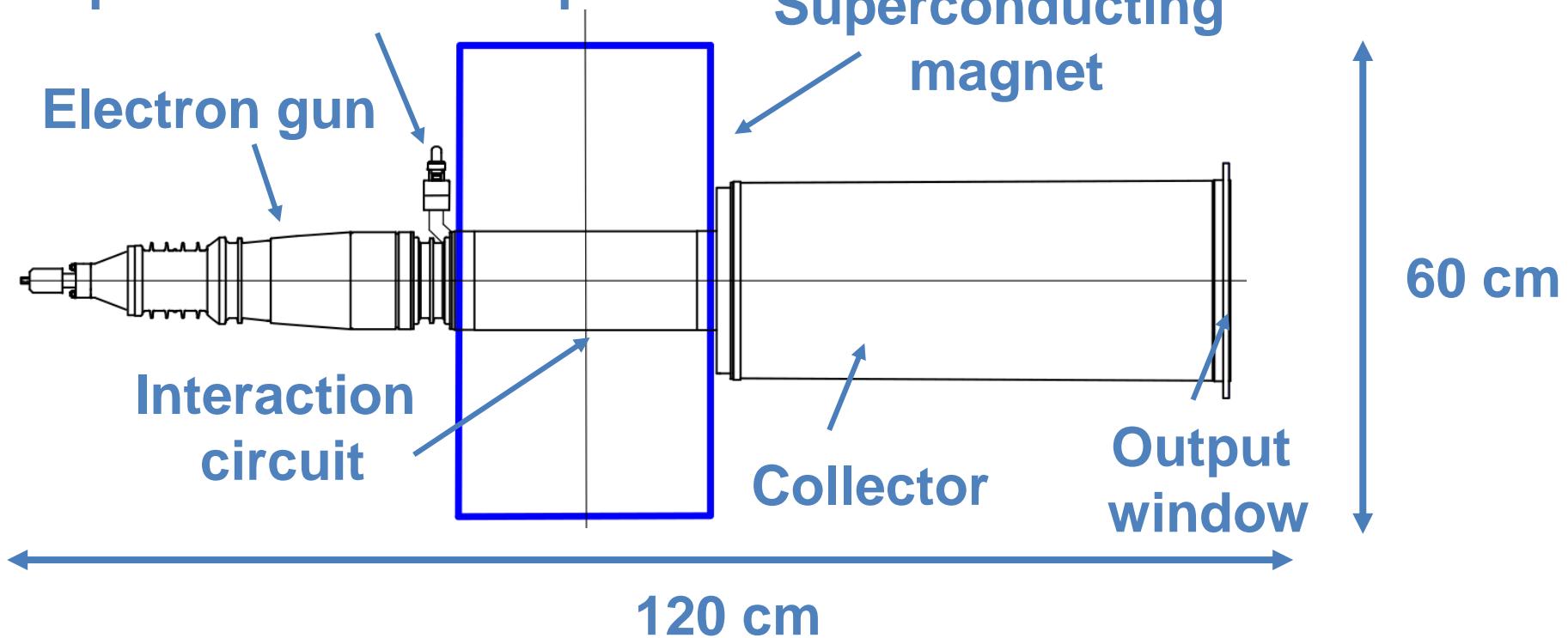
Recap: 36GHz Gyroklystron can meet specification

Beam voltage / Beam current	150 kV / 50 A
Output power / 2nd harmonic power	3.2 MW / 2.3%
Output power stability	0.4% @0.5% variation of the modulator voltage
Output frequency / 3dB bandwidth	36 GHz / 108 MHz (0.3%)
Magnetic field and frequency drift	1.46 T and < 1 MHz frequency drift due to the drift of magnetic field
Frequency drift due to beam voltage	24 MHz @0.5% / 4.8MHz @0.1% variation of the modulator voltage
Pulse repetition rate / Duration	1000 Hz / 1.5 us
Drive power / Gain	410 W / 39 dB
Input / output waveguide mode	Input TE10 (Rectangular) mode, output TE02 (Circular) mode
Efficiency	43% (without energy recovery), 58.0% (with single stage depressed collector)
Average spent beam power	6.5 kW (mm-waves on), 11.3kW (mm-waves off)
Dimensions	60 cm (W) * 60 cm (L) * 1200 cm (H)
Phase stability	17.0 degree @ 0.5% variation in modulator voltage 3.4 degree @ 0.1% variation in modulator voltage 0.34 degree @ 0.01% variation in modulator voltage



Harm- onic	Cavities (Output mode)	Interaction	Freq (GHz)	Power (MW)	Effic (%)	Gain (dB)	Institute	PRF (Hz) (duty)	τ [μ s]
2	2 (TE _{0,2})	Gyro-klystron (Cylindrical)	19.8	32	29	27	Univ of Maryland	>0.1	1.5
3	2 (TE _{0,3})	Gyro-klystron (Cylindrical)	29.6	1	1	12	Univ of Maryland	>0.1	1.5
1	4 (TE _{0,1})	Gyro-klystron (Cylindrical)	34.9	0.2	25%	56	NRL, USA	5	2
1	2 (TE _{0,1})	Gyro-klystron (Cylindrical)	28.0	0.08	9	30	CPI, USA	>0.1	1.5
2	4 (TE _{0,2})	Gyro-klystron (Cylindrical)	34.9	0.25 (5 av)	24	36	UESTC, China	250 (2%)	80
1	2 (TE _{7,3})	Gyro-klystron (Cylindrical)	37.5	1.5	7	-	Saratov Univ, Rus	>0.1	1
1	2 (TE _{0,2})	Gyro-klystron (Cylindrical)	35	0.75	24	25	IAP, Gycom	>0.1	1
1	3 (TE _{5,3})	Gyro-klystron (Cylindrical)	30.0	15	40	35	IAP, Gycom	>0.1	0.5
1	1 (TE _{0,3})	Gyrotron Oscillator	36.0	4	10	-	Strath- clyde, UK	330 .003%	0.1

Input window & coupler



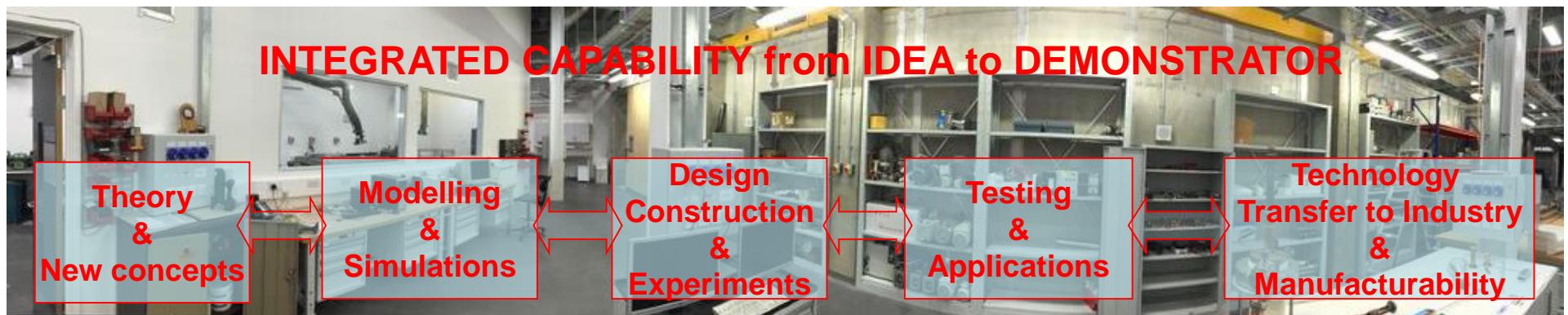
- Power, 3.2MW
- Frequency, 36GHz
- Efficiency, 43%
- Gain, 39dB
- Output mode, $TE_{0,2}$
- Phase stability, 0.34 degrees @ 0.01% variation in voltage
- Pulse Repetition Frequency, 100Hz to 1kHz
 - to be experimentally confirmed
- Modulator, Scandinova, K200
- Cryo-cooled superconducting magnet, 1.46T



Specification	Gyro-klystron	
Power, (3.2MW)	✓	
Frequency, (36GHz)	✓	
Efficiency, (43%)	✓	
Phase stability, (0.34 degrees)	✓	
PRF (100Hz), Hard X-rays	✓	
PRF (1kHz), Soft X-rays	?	
Hardware		Suppliers
Modulator, (150kV, 50A, 1kHz)	✓	ScandiNova Diversified Technologies Inc
Magnetic field (1.46T)	✓	Cryogenics Ltd Oxford Instruments Ltd
Driver, (<500W)	✓	Mission Microwave Technologies Inc, (GaN)
Gyro-klystron	✓	CPI Inc, UESTC, Gycom



- Group of ~20 staff + postgrad students
 - 36GHz, 3MW, gyro-klystrons to drive harmonic lineariser
 - Theory, modelling and simulation
 - Dedicated workshop with skilled technician operates CNC Lathe, CNC Mill, welding bay and electrochemical copper deposition
 - Magnetron Injection Gun, design, simulation, construction with industry and testing
 - Electron beam diagnostics, current, voltage, beam position, etc
 - Suite of high power microwave measurement techniques, frequency, power, phase, mode
 - Vector Network Analysers, spectrum analysers, power meters etc
 - Modulator experience and design / commissioning of superconducting magnets with cryogenic coolers
 - 750m² laboratory with five 50cm concrete shielded experimental bays with 7mm lead doors and roof equipped with power, cooling, gas, vacuum and safety systems





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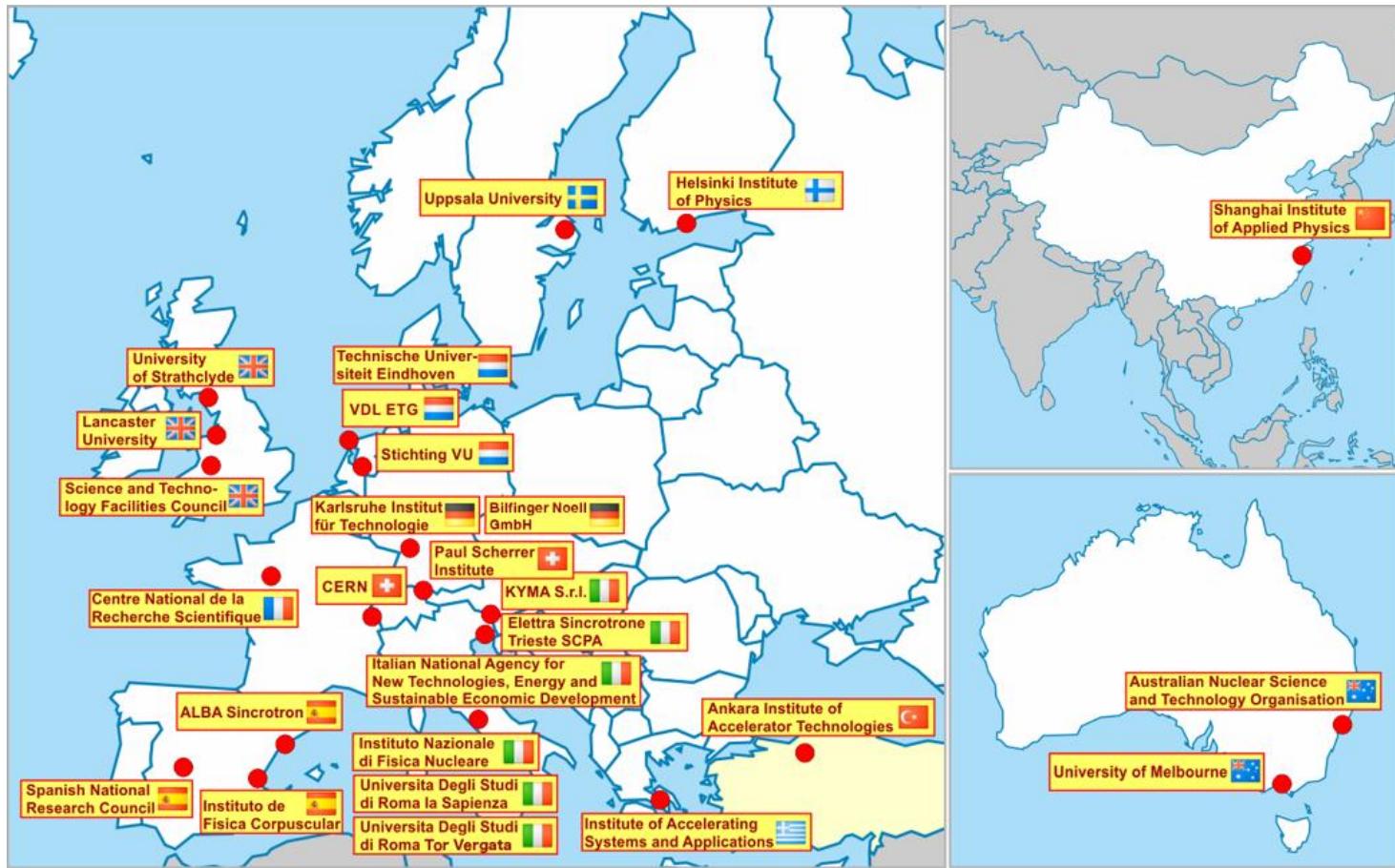


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