

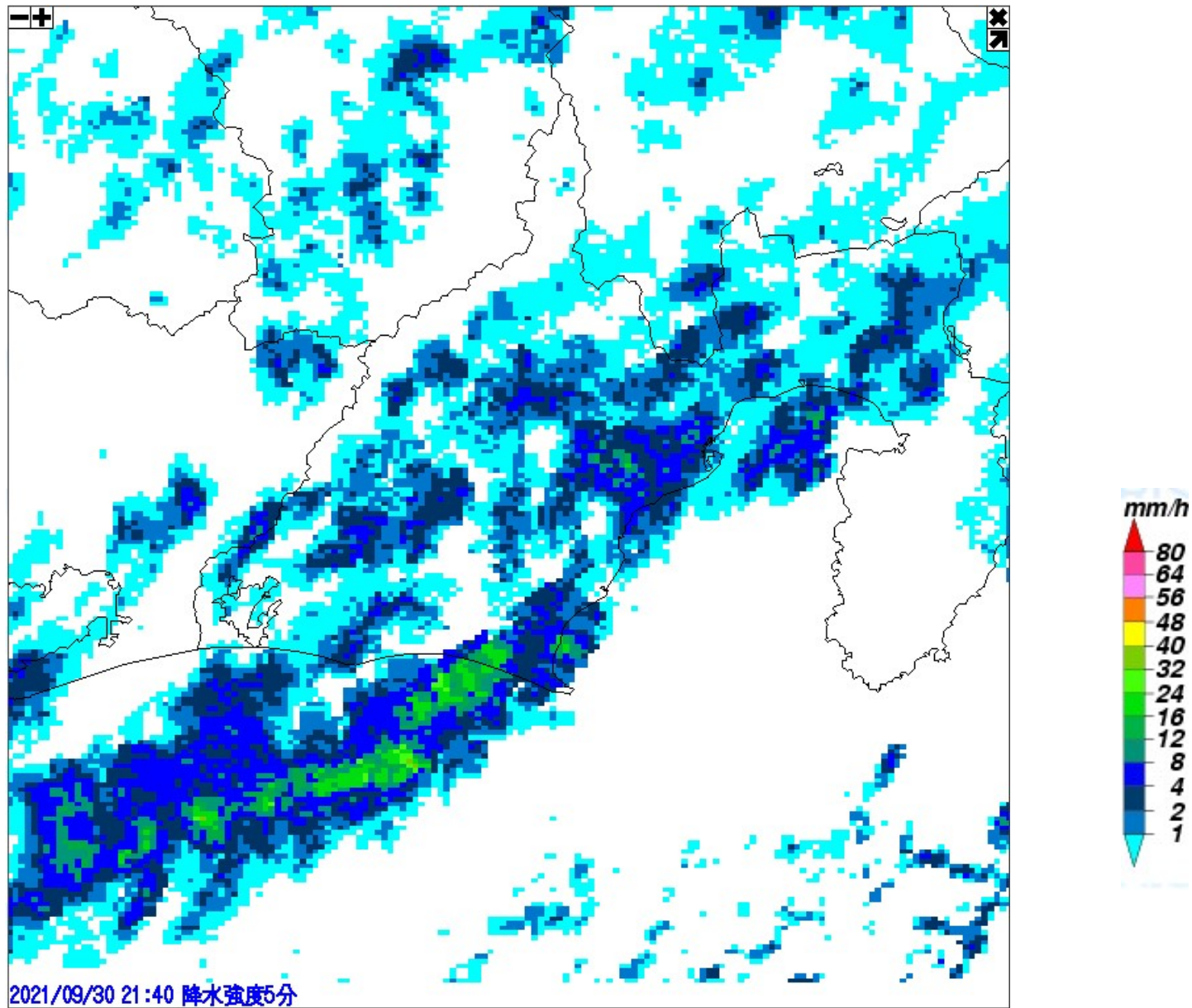
Overview of solid-state weather radar and Related operational experience

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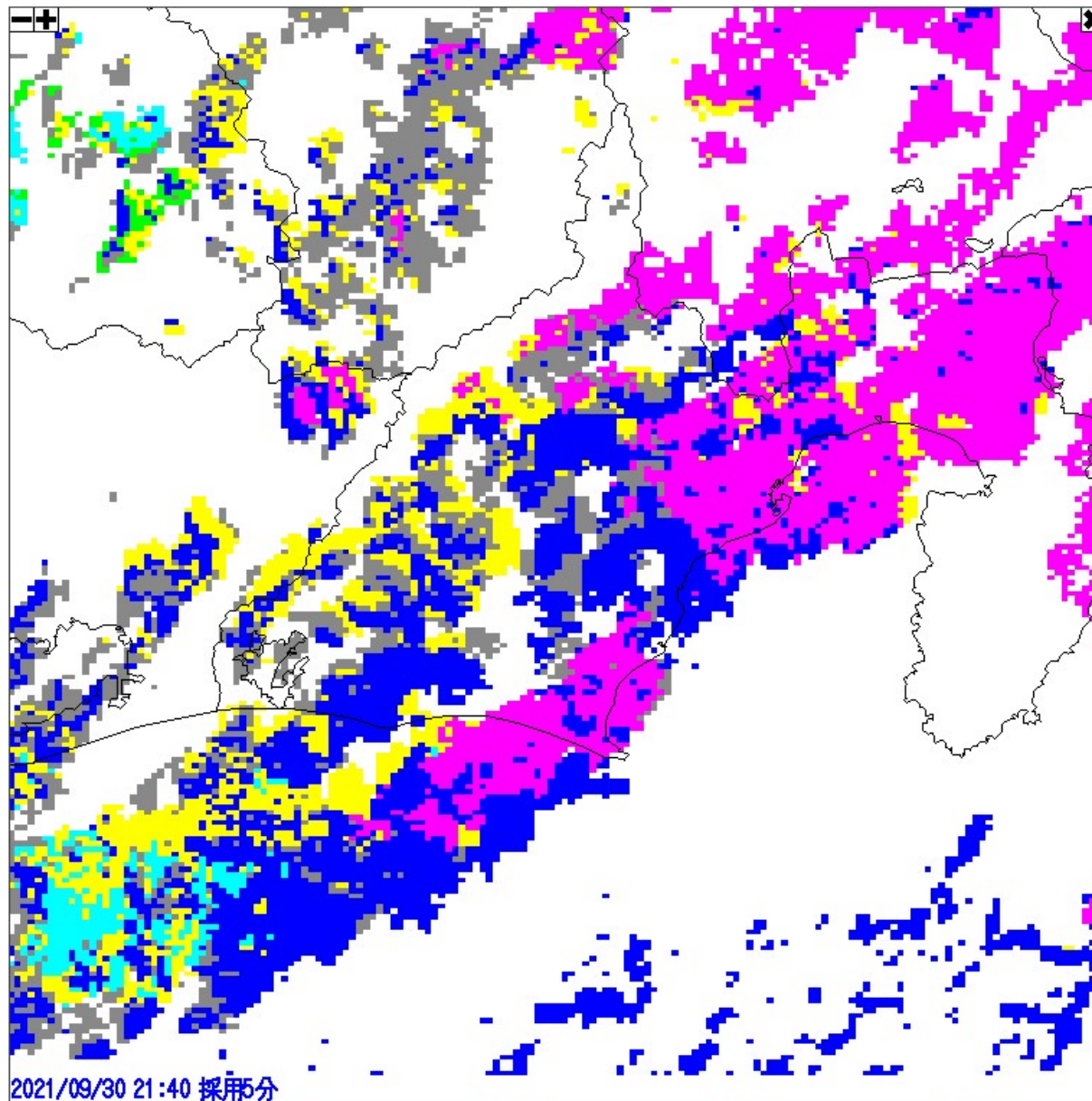
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A composite picture of radars



A composite picture of radars



dual-pol SSPA

■ Tokyo

■ Nagoya

■ Osaka

■ Fukui

single klystron

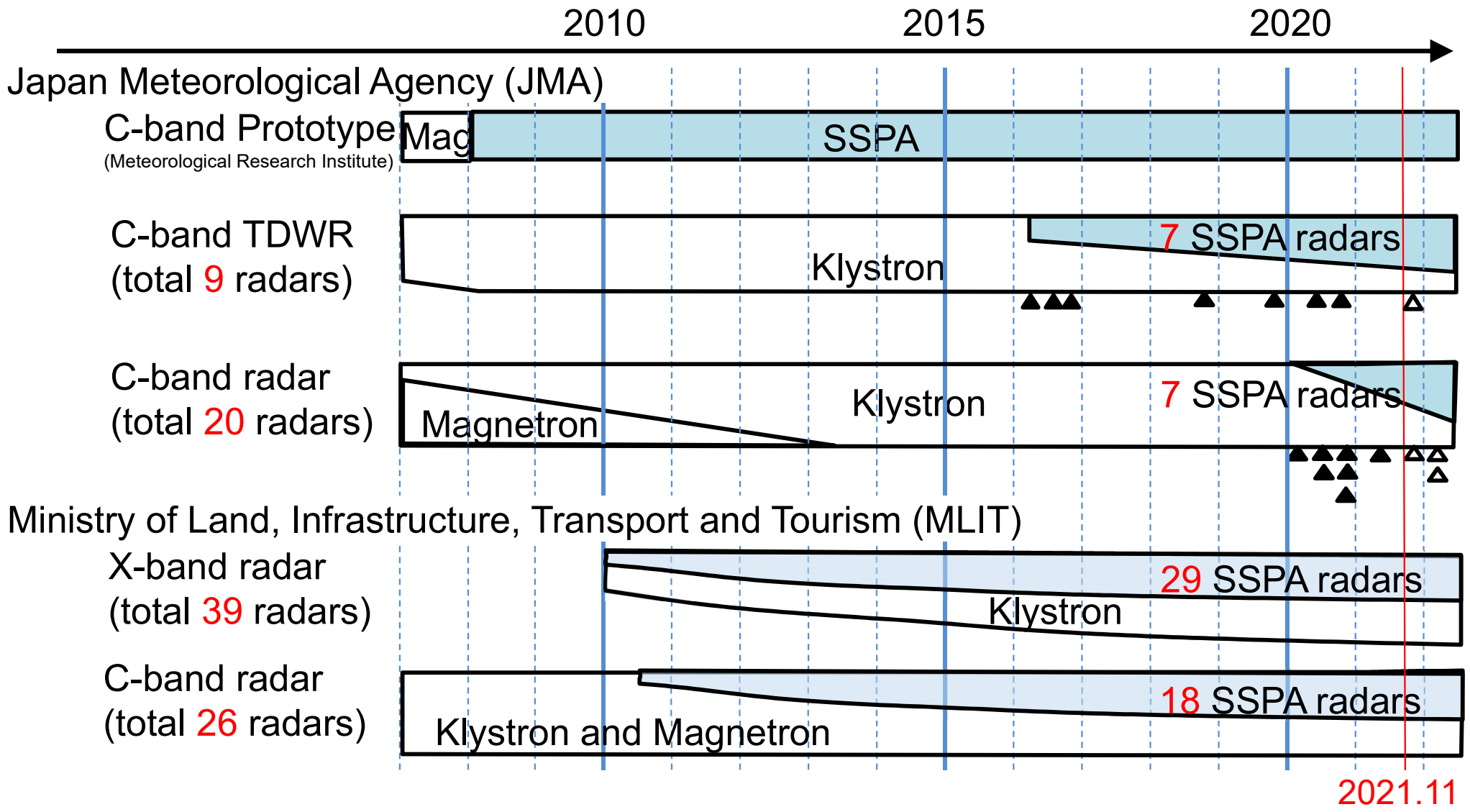
■ Shizuoka

■ Nagano

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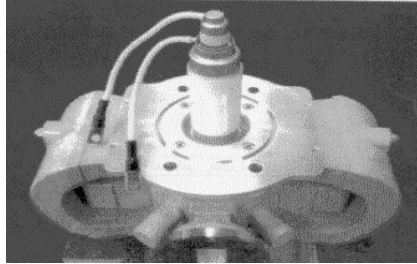
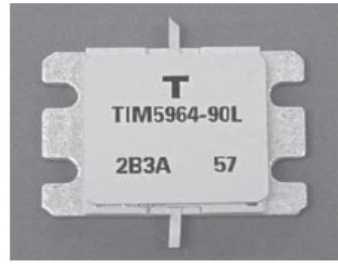
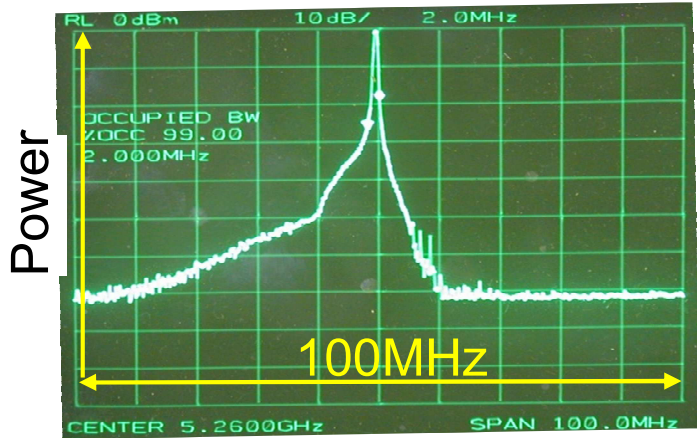
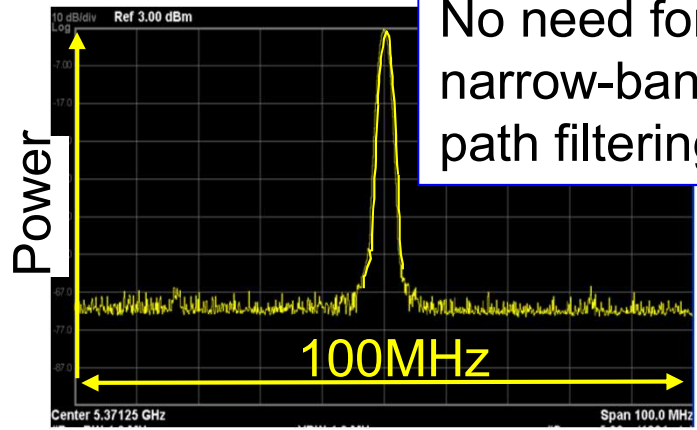
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Chronology of SSPA weather radar in Japan



61 of 94 the operational weather radars in Japan are **the solid-state radars.**

SSPA transmitter feature

	Conventional Transmitter	SSPA Transmitter
Transmitter element	<p>Electron tube (Magnetron /Klystron)</p> 	<p>Transistor (power HEMT)</p> 
Spectrum of transmitting wave		
Peak power	250 kW	3.5 kW (to 6 kW)
Pulse width	1 us	Short pulse: 1us Long pulse: 10 – 400 us

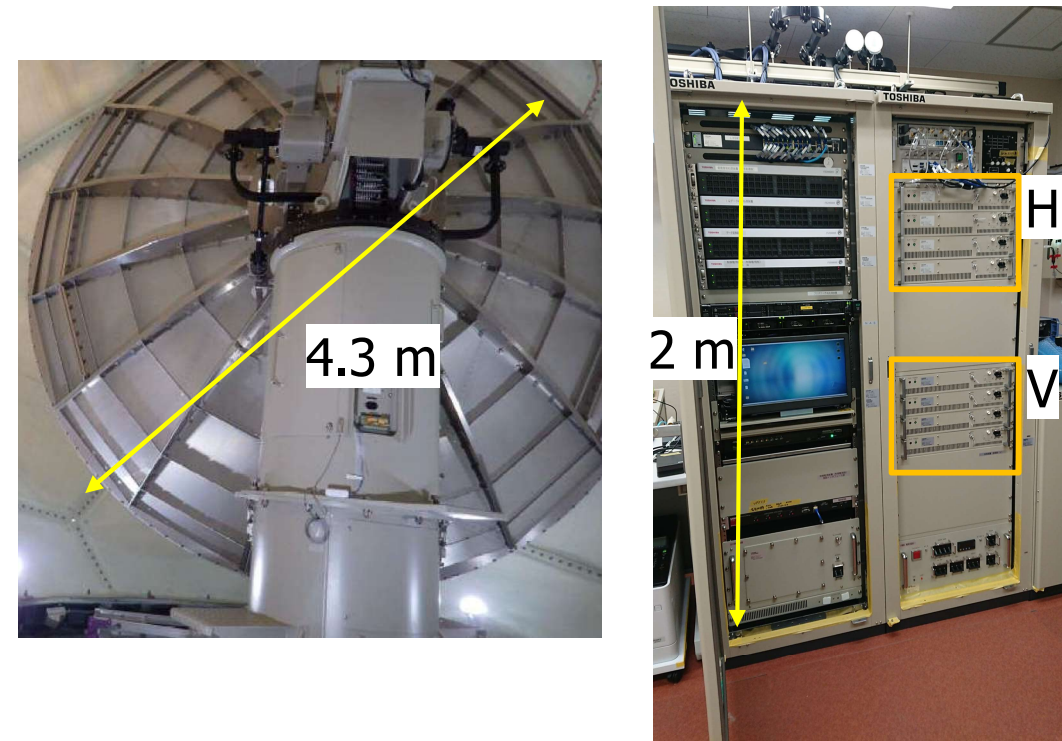
1/100

x100

No need for narrow-band path filtering

C-band radar with SSPA transmitters

- C-band dual-pol radar with SSPA transmitters.
- Operation started in 2020.



Transmitting frequency	5350.0 MHz (Osaka, Fukui) 5357.5 MHz (Tokyo) 5360.0 MHz (Hiroshima, Nagoya) 5365.0 MHz (Sendai, Fukuoka)
Antenna	Parabola, Diameter 4.3 m
Beam width	0.95 degree
Transmitter	Gallium / Nitride HEMT
Peak transmitting power	Horizontal 3 or 4 kW Vertical 3 or 4 kW
Pulse width	Short Pulse: 1 us Long Pulse: 30 – 200 us

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Advantages

- High reliability
 - Low failure rate (no high voltage, no arcing)
 - Tolerance to failure
- Low operational cost
 - High energy efficiency for overall radar system
 - Long life span
 - Compactness
- Rapid observation
 - High phase stability
 - High range resolution
- Less radio interference with radar
 - Narrow band width

Low transmitter failure rate

- The HPA (High Power Amplifier) failure rate of SSPA radars is lower than that of electron tube radars in JMA.
- The SSPA total operation time in Japan is 30.4 years, with **zero** SSPA transmitter failure.

	Number of sites	Total operation time (year × sites)	Total number of transmitter failure (including electron tube failure)	Transmitter failure rate (per year, per site)
Electron tube	20	200	38	0.19
SSPA	14	30.4	0	0

Tolerance to failure

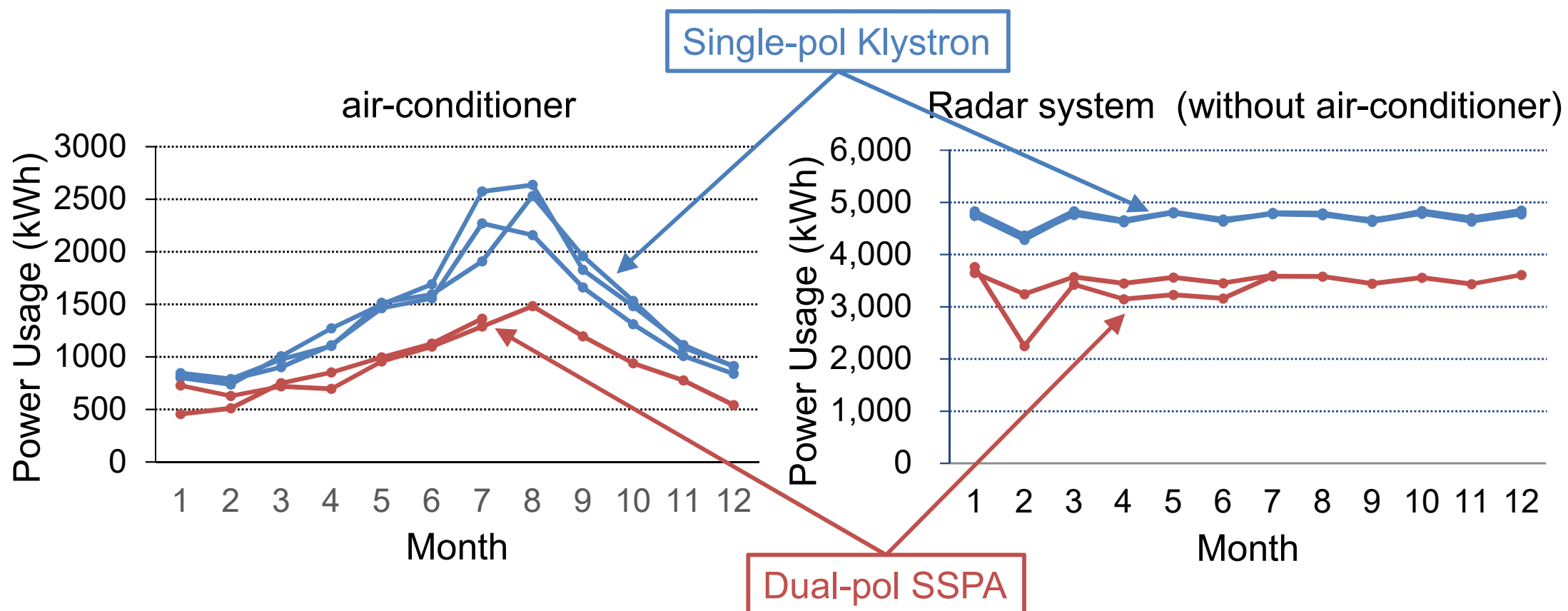
- As power transmission power involves synthesis for the output power of multiple SSPA modules, failure in a single module has little influence on radar observation.
- Failed modules can also easily be changed with a spare. (Hot-swap)



Courtesy of OKUMURA Hidehiro

Low operating costs

- SSPA has a long life span, while the klystron requires periodic replacement.
- SSPA provides high energy efficiency for the radar system as a whole.

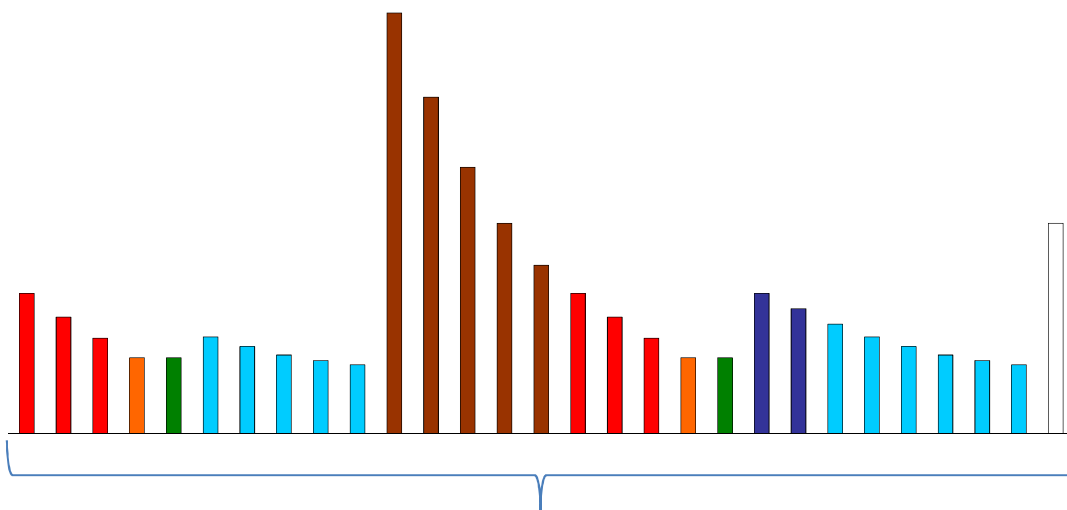


Rapid observation

- SSPA has high phase stability.
- Pulse compression leads to high range resolution.
- Even small number of beams can get enough range resolution.

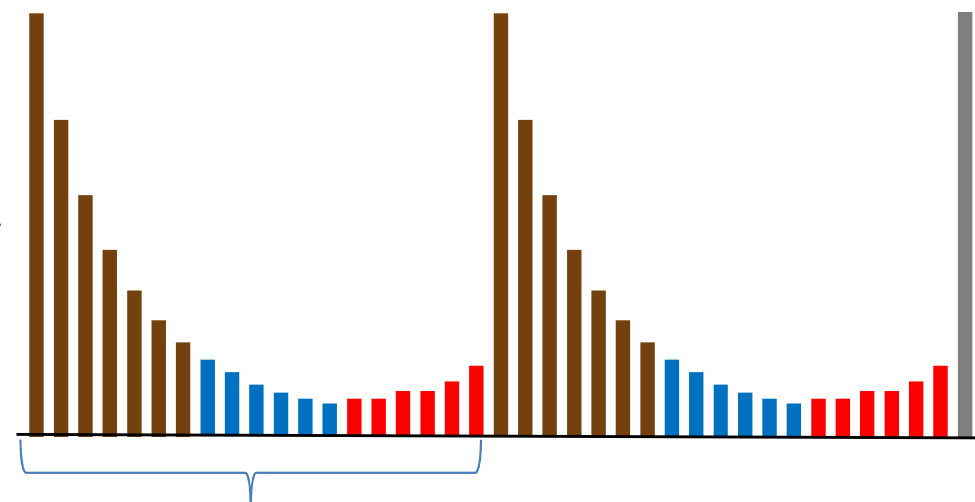
The scan sequence of SSPA dual-pol updated to 5-min from 10-min cycle.

Single-pol Klystron



One cycle = 10 min

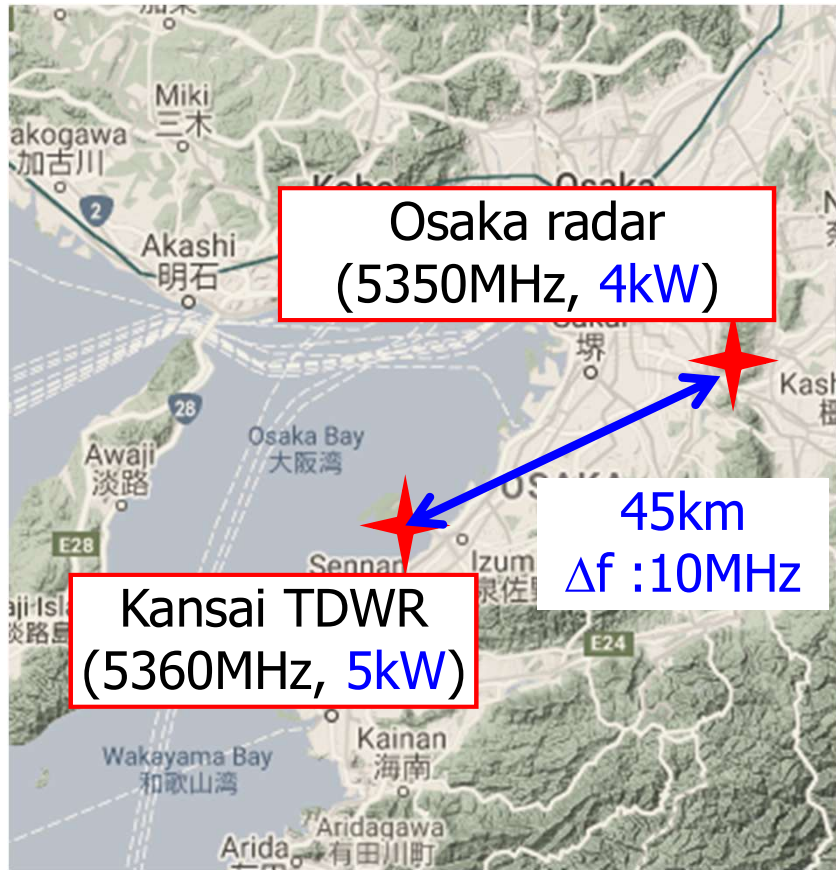
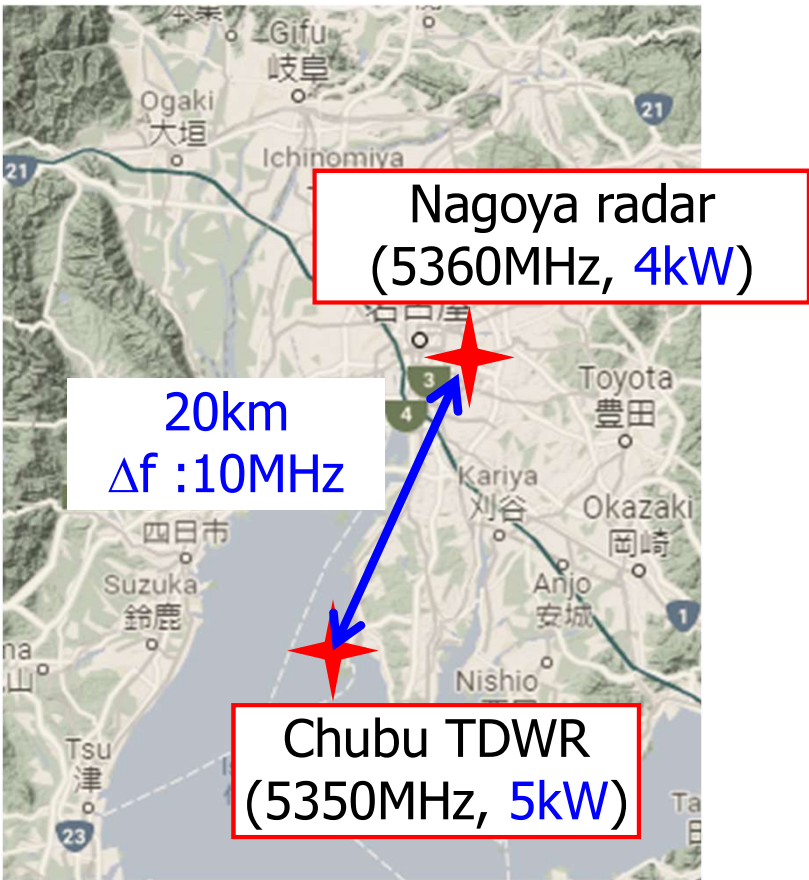
Dual-pol SSPA



One cycle = 5 min

Less radio interference with radar

- SSPA radars is characterized by low peak power.
- The band width is narrow.

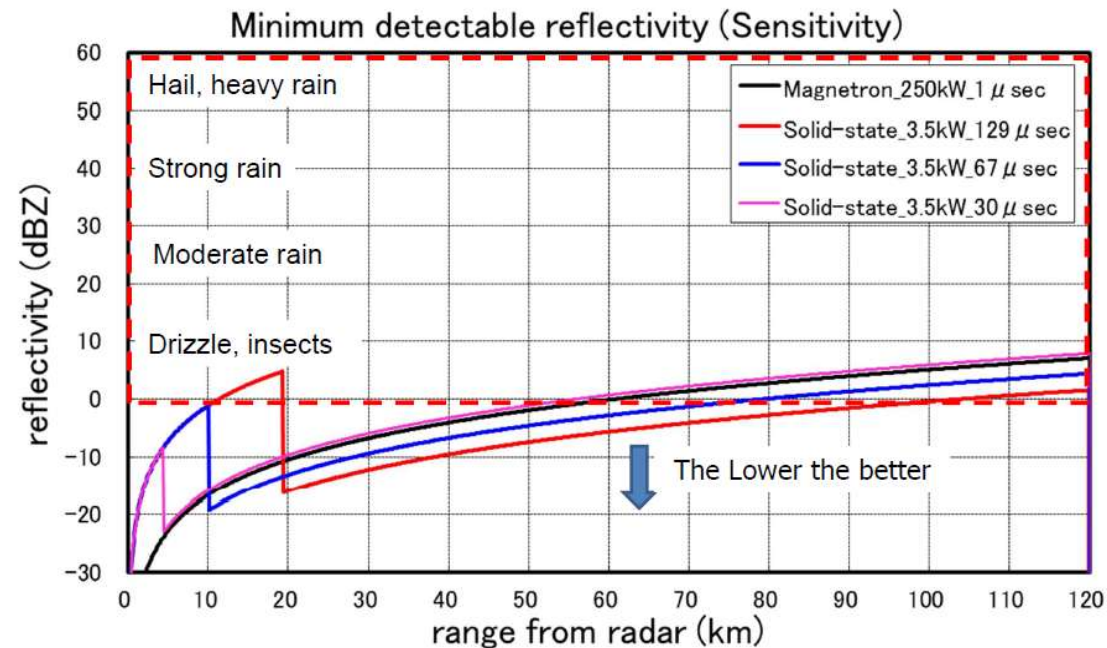
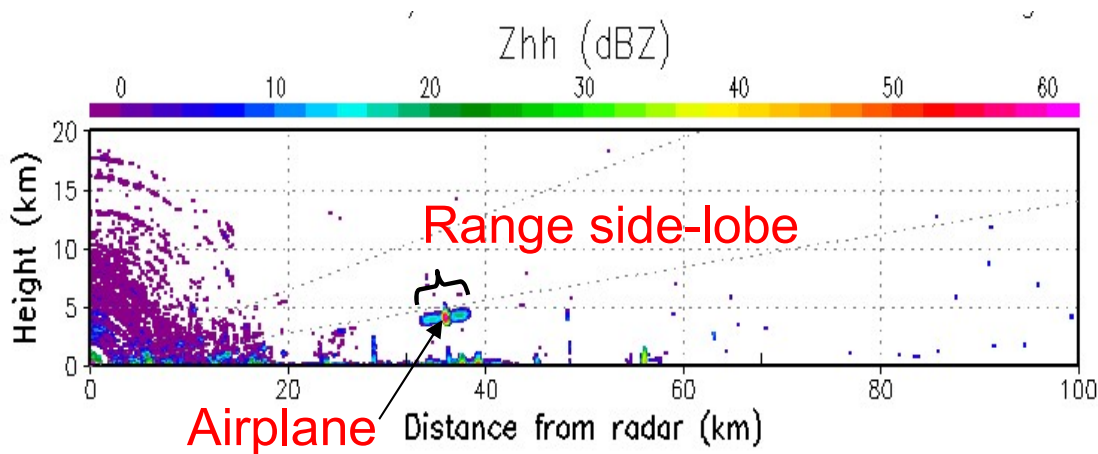


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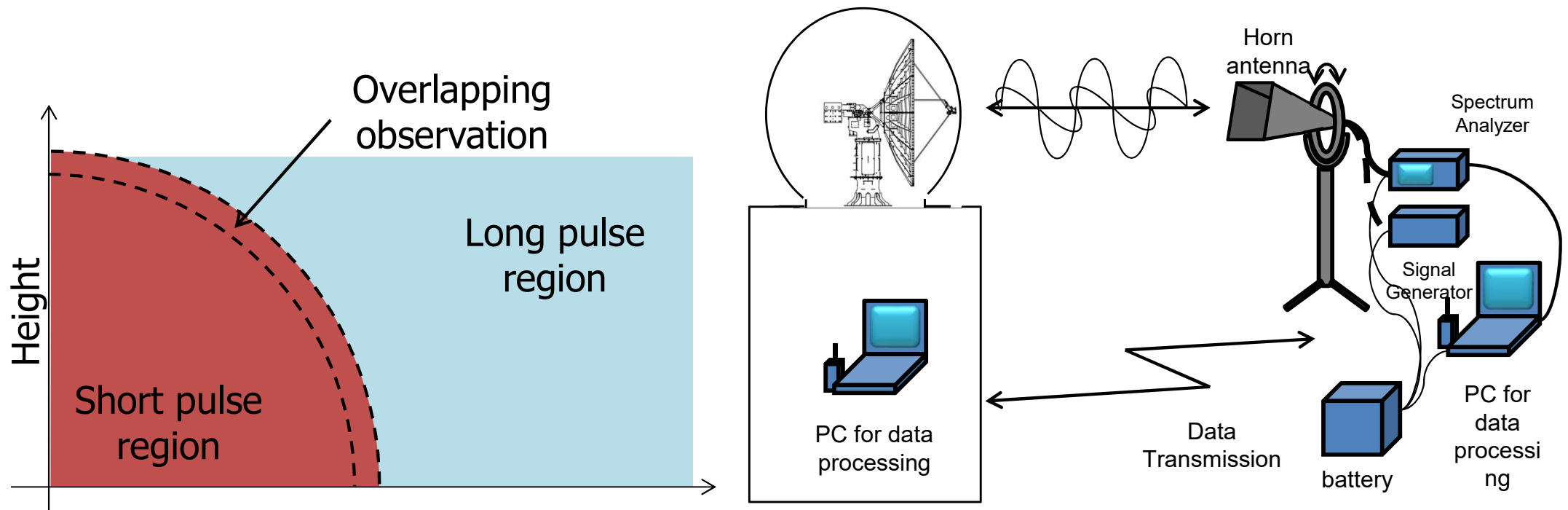
SSPA radar considerations (1/3)

- Suppression of range side-lobe
 - Using longer pulse width
 - Using nonlinear frequency modulation (NLFM)
- Improvement of sensitivity of short pulse region
 - Using shorter pulse width



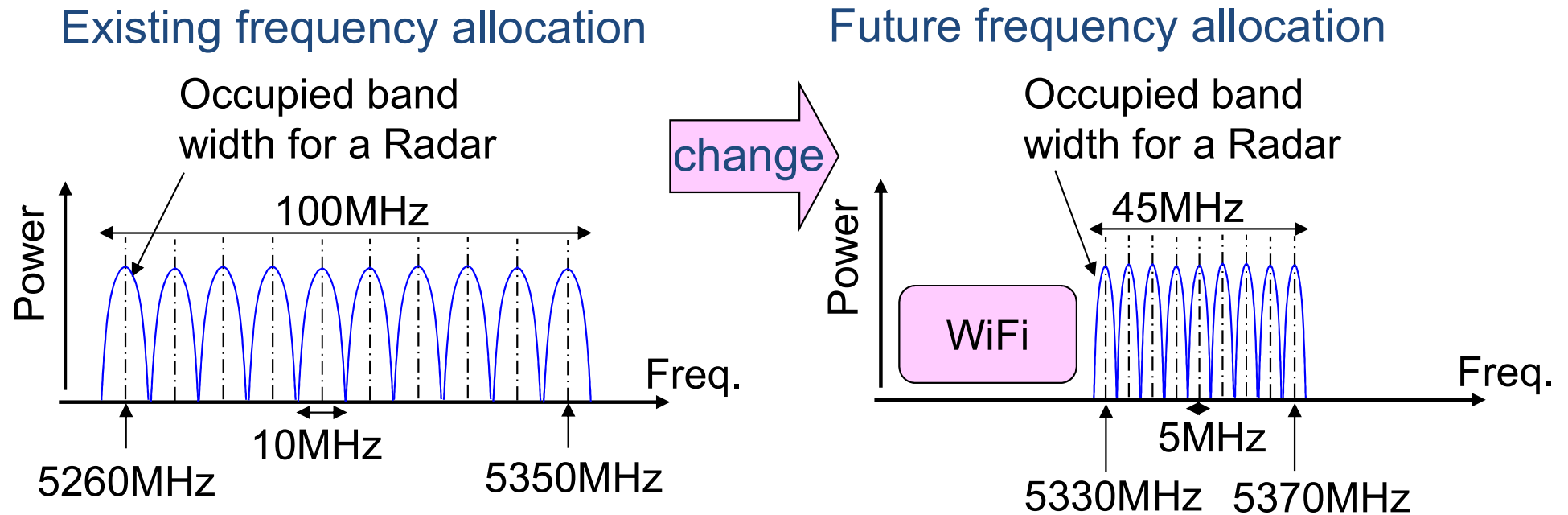
SSPA radar considerations (2/3)

- Additional calibrations
 - Calibration gap between short/long pulse areas
 - Adjustment of dual-pol parameters



SSPA radar considerations (3/3)

- Interference with RLAN
 - Reduced meteorological radar band width



Summary

- JMA has 12 years of operational experience with SSPA weather radar, and operates 14 SSPA dual-pol radars.
 - More and more radars are planned to be renewed to SSPA radars.
- Although there are some additional points to be considered, SSPA radar has significant advantages.
 - High reliability and low operation costs.
 - We satisfied the performance of SSPA radar.
 - We may not be able to go back to use electron tube radar.

Thank you for your attention !