Radar Physics
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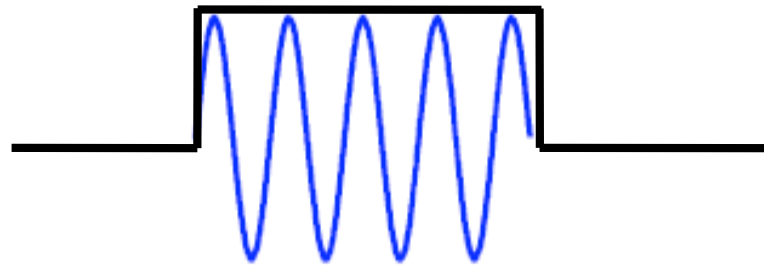
Outline

Radar fundamentals

Radar equation

Range resolution and pulsed radars
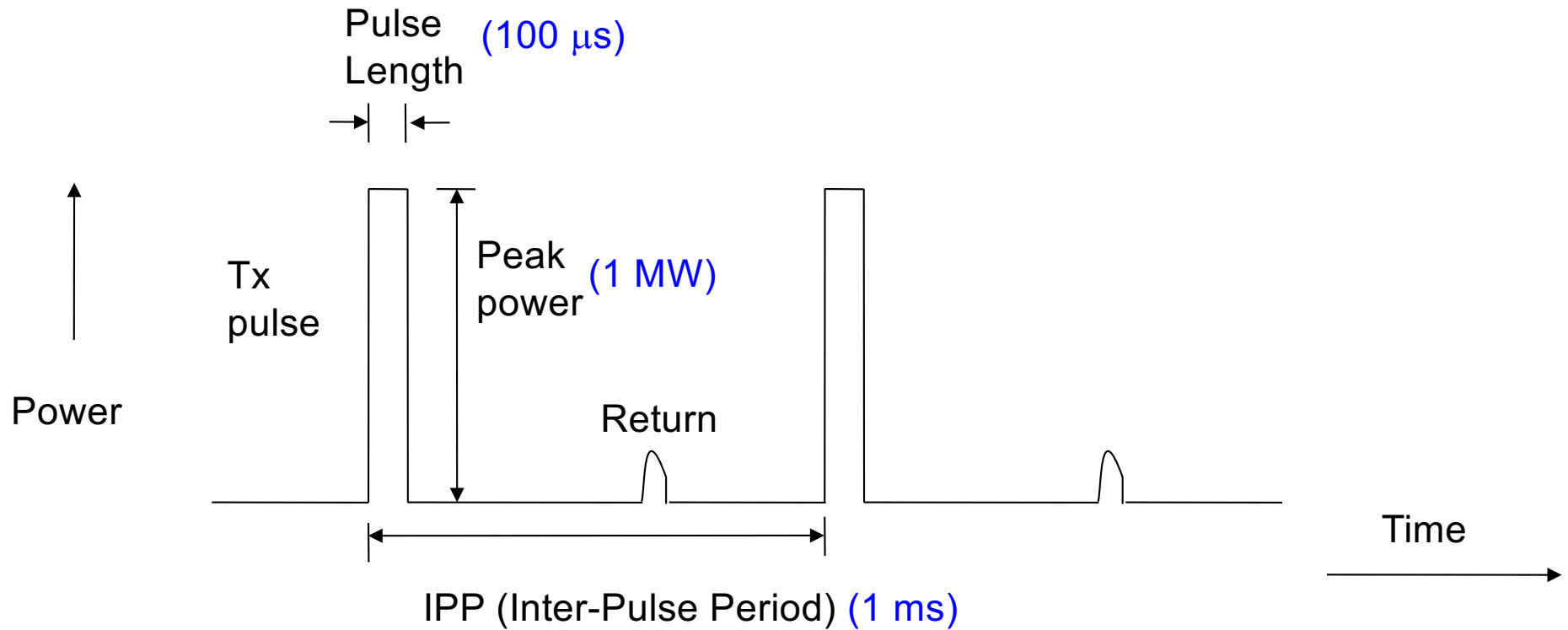
What the radar transmits: Pulses and waves

Cycles in a pulse.

PFISR frequency = 449 MHz
Long pulse length = 480 μs
# of cycles = 215520 !

Radar waveforms modulate the waves with on-off sequence

Pulsed Radar

Pulse Length (100 µs)

Peak power (1 MW)

Tx pulse

Power

Return

IPP (Inter-Pulse Period) (1 ms)

Time

Duty cycle = Pulse Length/IPP (10%)
Average power = Peak power x Duty cycle (100 kW)
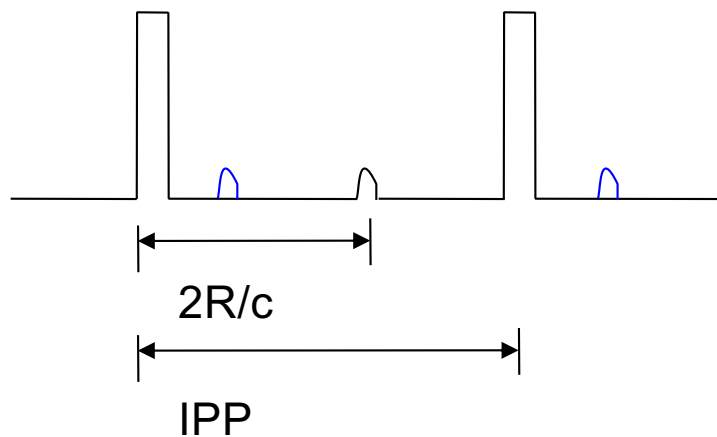PRF (Pulse Repetition Frequency) = 1/IPP (1kHz)

Duty cycle for a CW (continuous wave) radar 100%

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Range Resolution

Range resolution is set by pulse length

Pulse length = τ_p , Range resolution = $c\tau_p/2$ for a single target.

Maximum unambiguous range

MUR = c*IPP/2

2R/c

IPP

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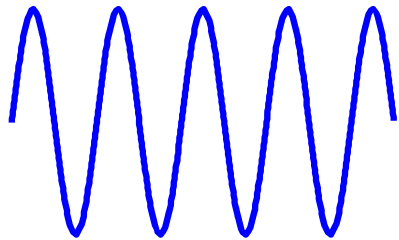# Pulse duration vs. Range resolution

Pulse Duration	Range Resolution
0.1 nsec	1.5 cm
1.0 nsec	15 cm
10 nsec	1.5 m
100 nsec	15 m
1 μsec	150 m
10 μsec	1.5 km
100 μsec	15 km
1 msec	150 km

What is a typical F region ISR pulselength?
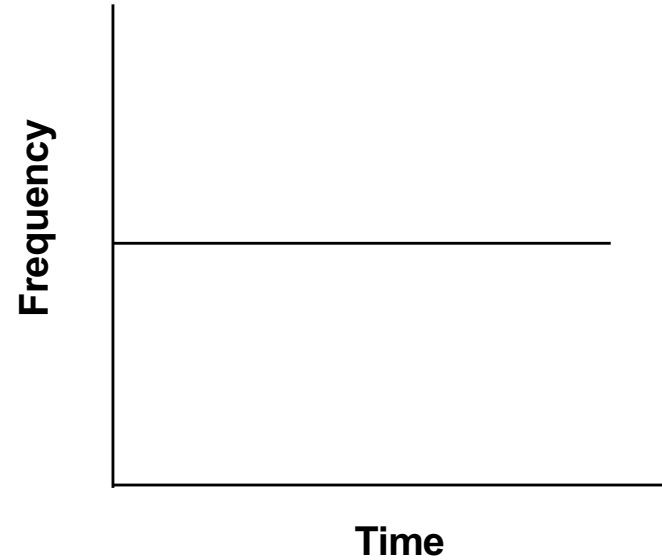
Radar Waveforms

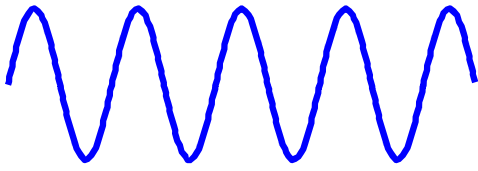**What do radars transmit?**

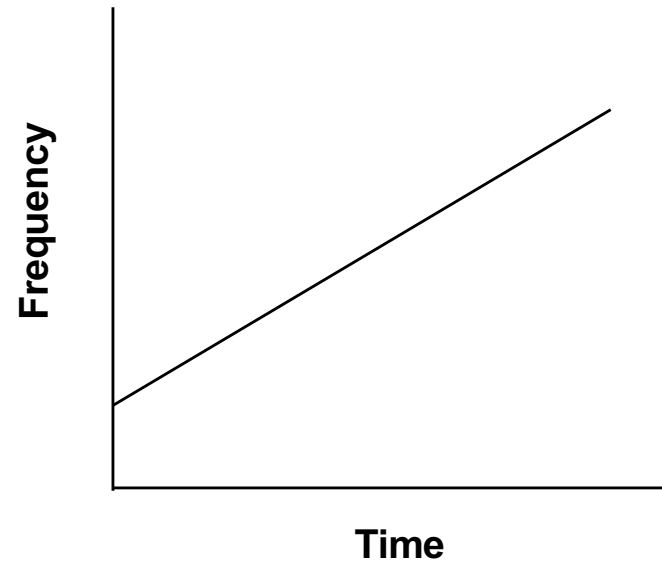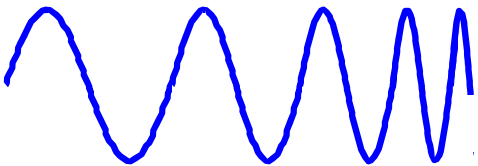**Waves?**

or Pulses?
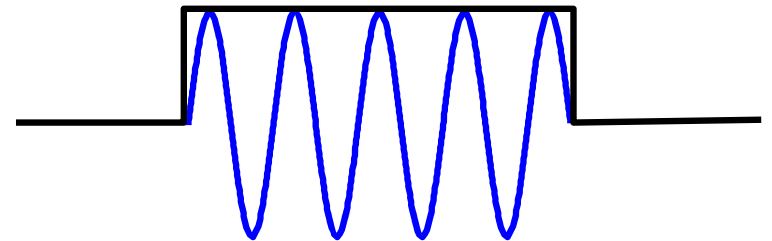
Waves, modulated by "on-off" action of pulse envelope

Radar Waveforms (cont'd.)

Pulse at single frequency

Pulse with changing frequency
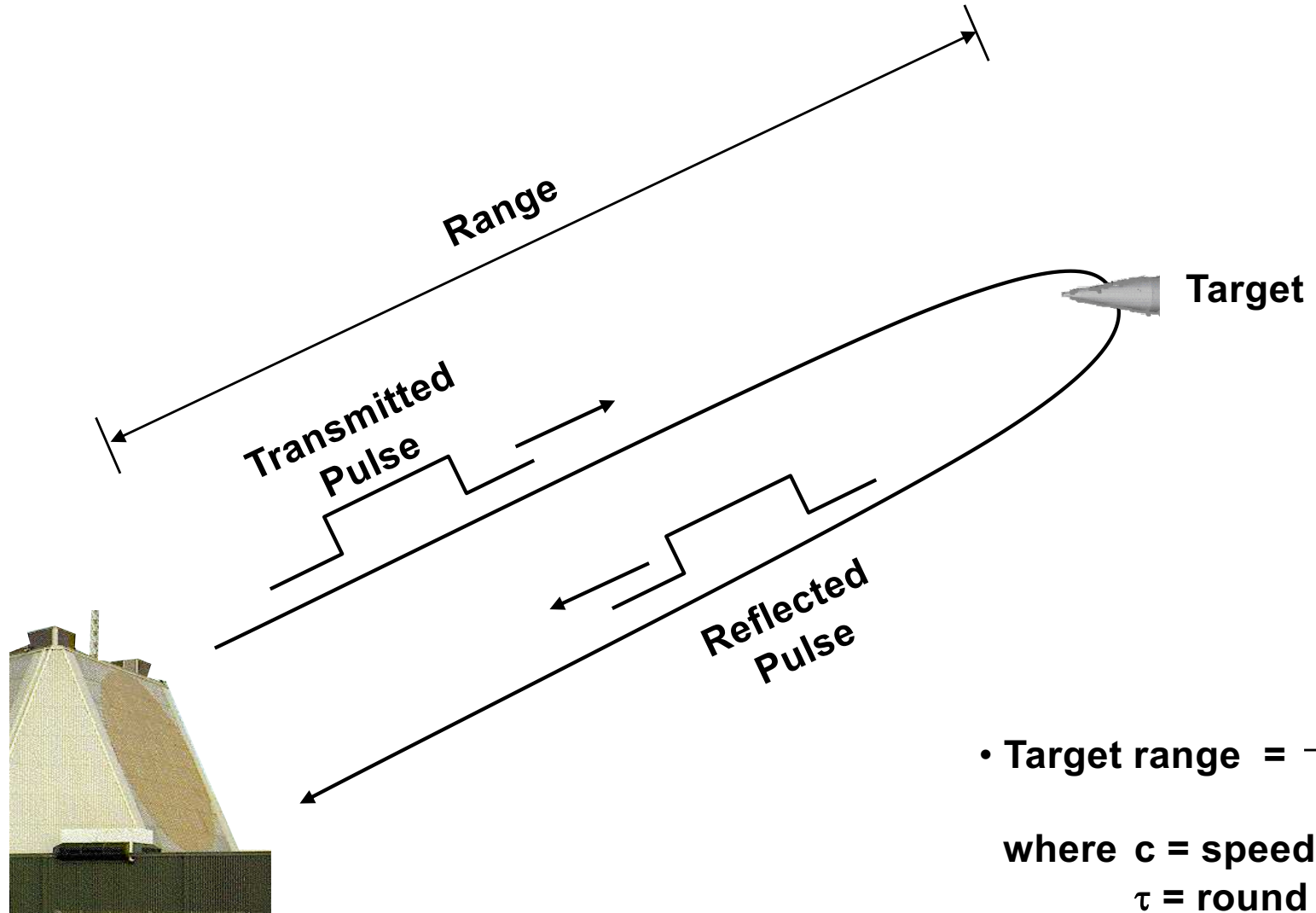
Frequency

Time

Frequency

Time

**Linear
Frequency-
Modulated
(LFM)
Waveform**

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Radar Range Measurement

Range

Target

Transmitted
Pulse

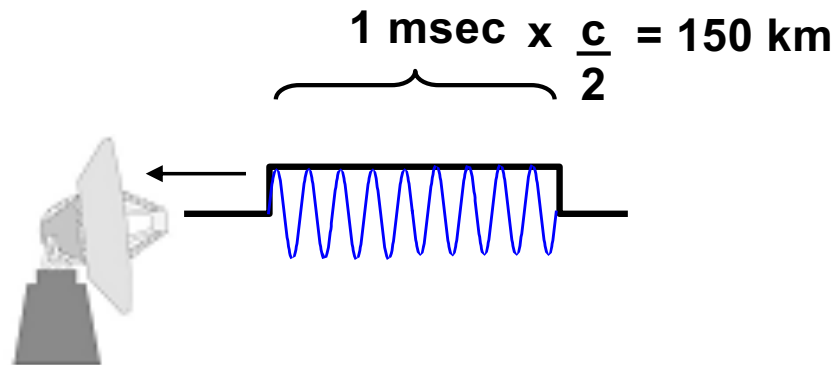Reflected
Pulse

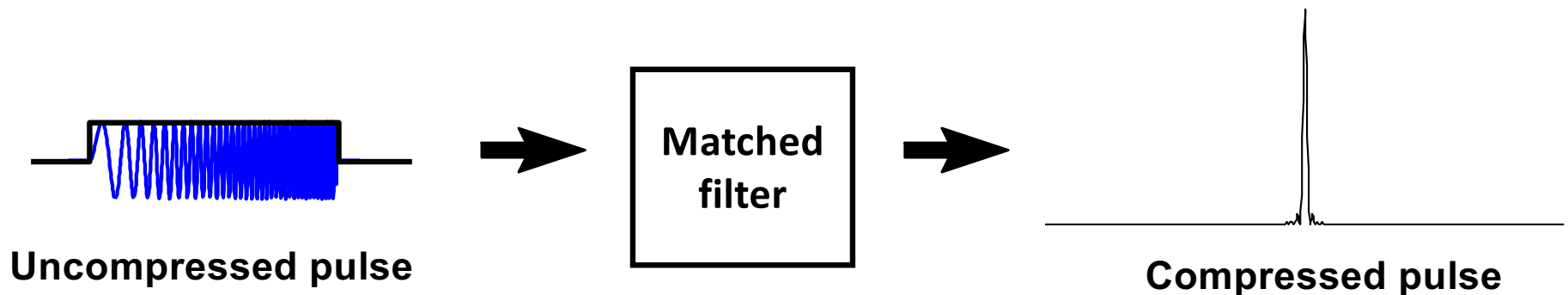- Target range $= \dfrac{c\tau}{2}$

  where c = speed of light

  τ = round trip time

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Signal Processing
Pulse Compression

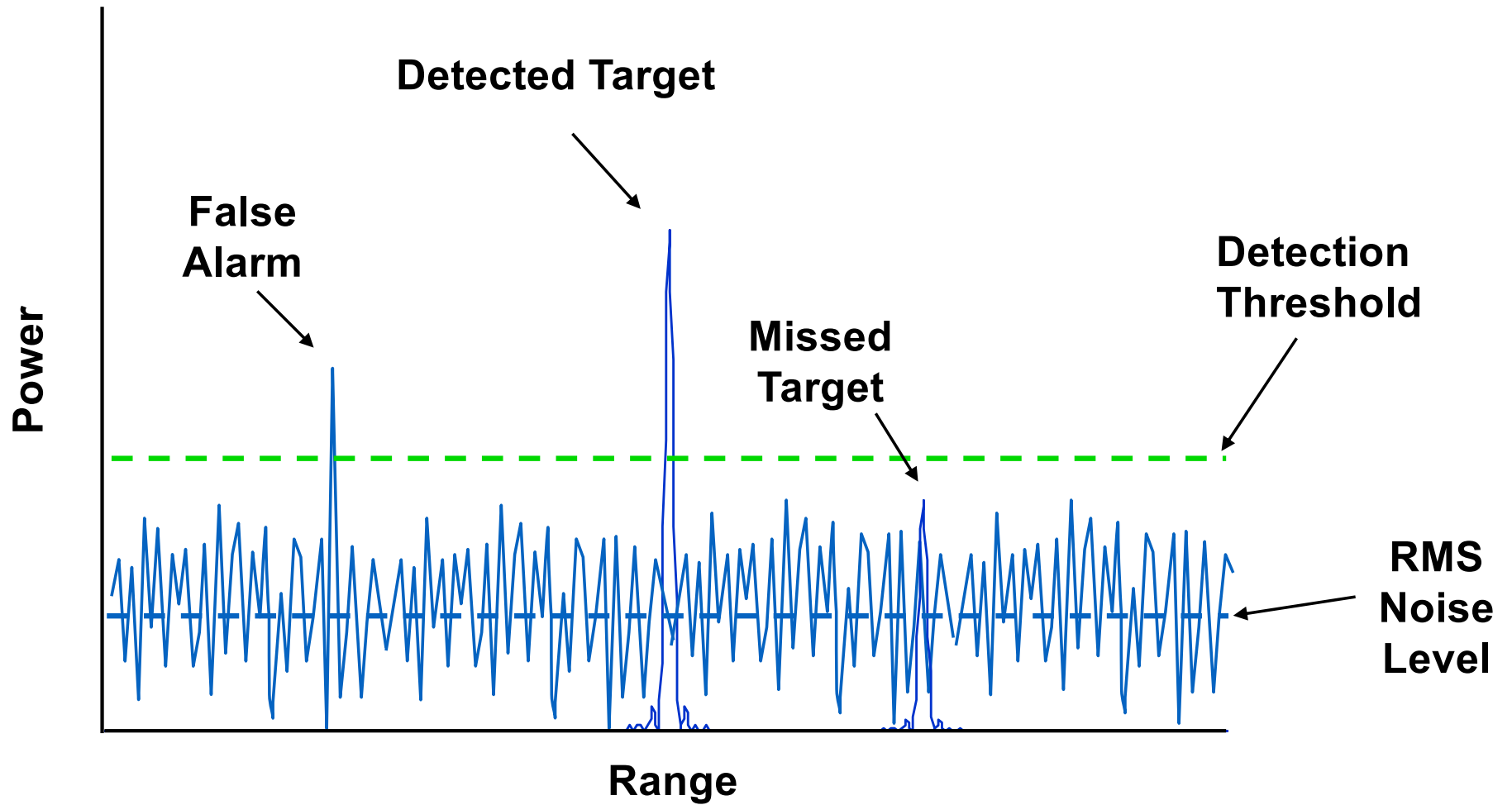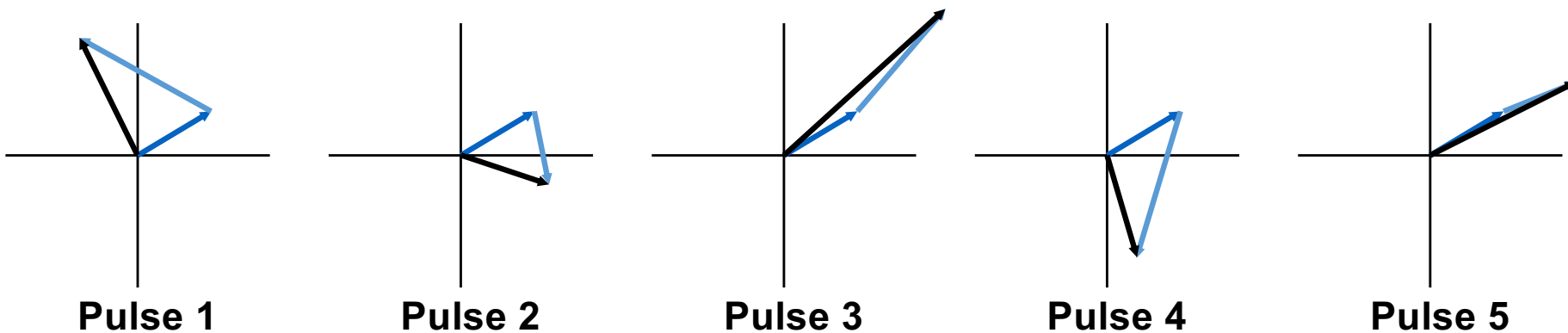**Problem: Pulse can be very long; does not allow accurate range measurement**

$$1 \text{ msec} \times \frac{c}{2} = 150 \text{ km}$$

Solution: Use pulse with changing frequency and signal process using "matched filter"

Uncompressed pulse → **Matched filter** → **Compressed pulse**

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Detection of Signals in Noise

Coherent Integration

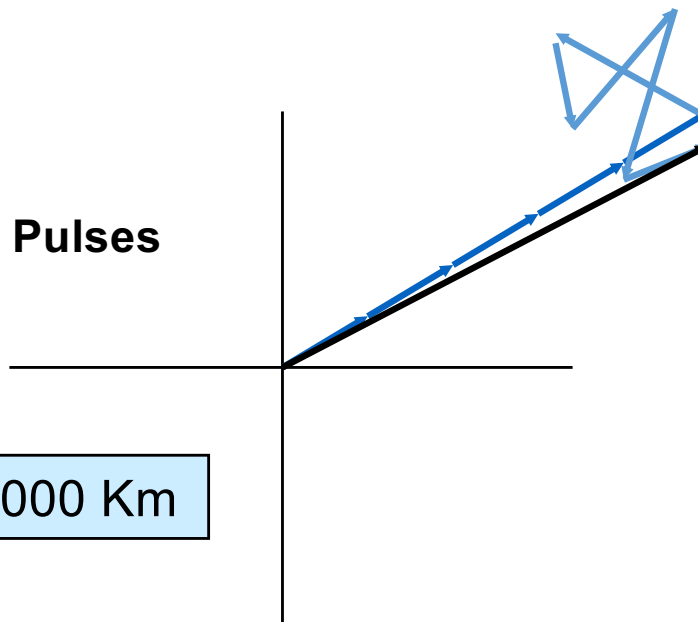Pulse 1   Pulse 2   Pulse 3   Pulse 4   Pulse 5

- **Coherent target returns**
- **Noise samples at low SNR**

- **Resultant signal**

Coherently Integrated Pulses

Deep space targets at 30,000 – 40,000 Km