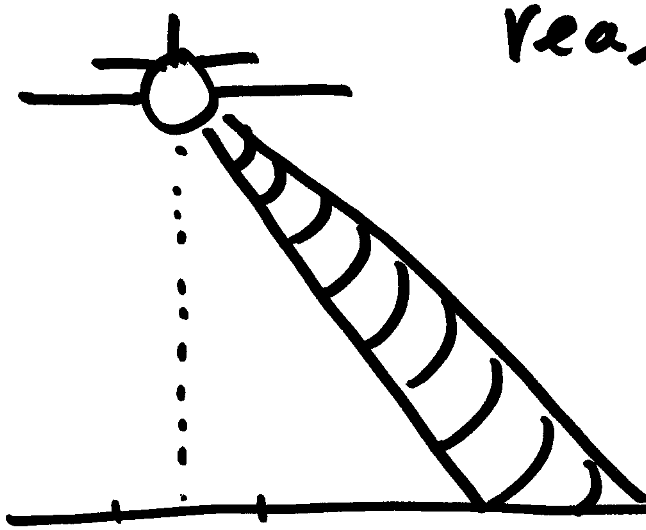
SLAR: side-looking airborne radar



real mode: coarse spatial resolution

1957 Carl Wiley

Goodyear Aerospace

dopplerbeam sharpening

SAR: synthetic aperture radar (always side-looking)

return signal, backscatter

analog signal

→ recorded on film

using optical processing : image formed
image exists only in <u>hardcopy</u>

NASA – SeaSat 1978
- first completely digital SAR
- excellent quality imagery
- 100 days
- S.I.R A, B, C 80's + 90's
- Feb 2000 SRTM

shuttle radar topography
mission NASA + NGA

11 days mapped ~ 80% earth's land area

Europeans : ERS 1,2

Envisat

TerraSAR-X

Japanese , PALSAR

fully polarimetric instrument

HH, VV, HV, VH

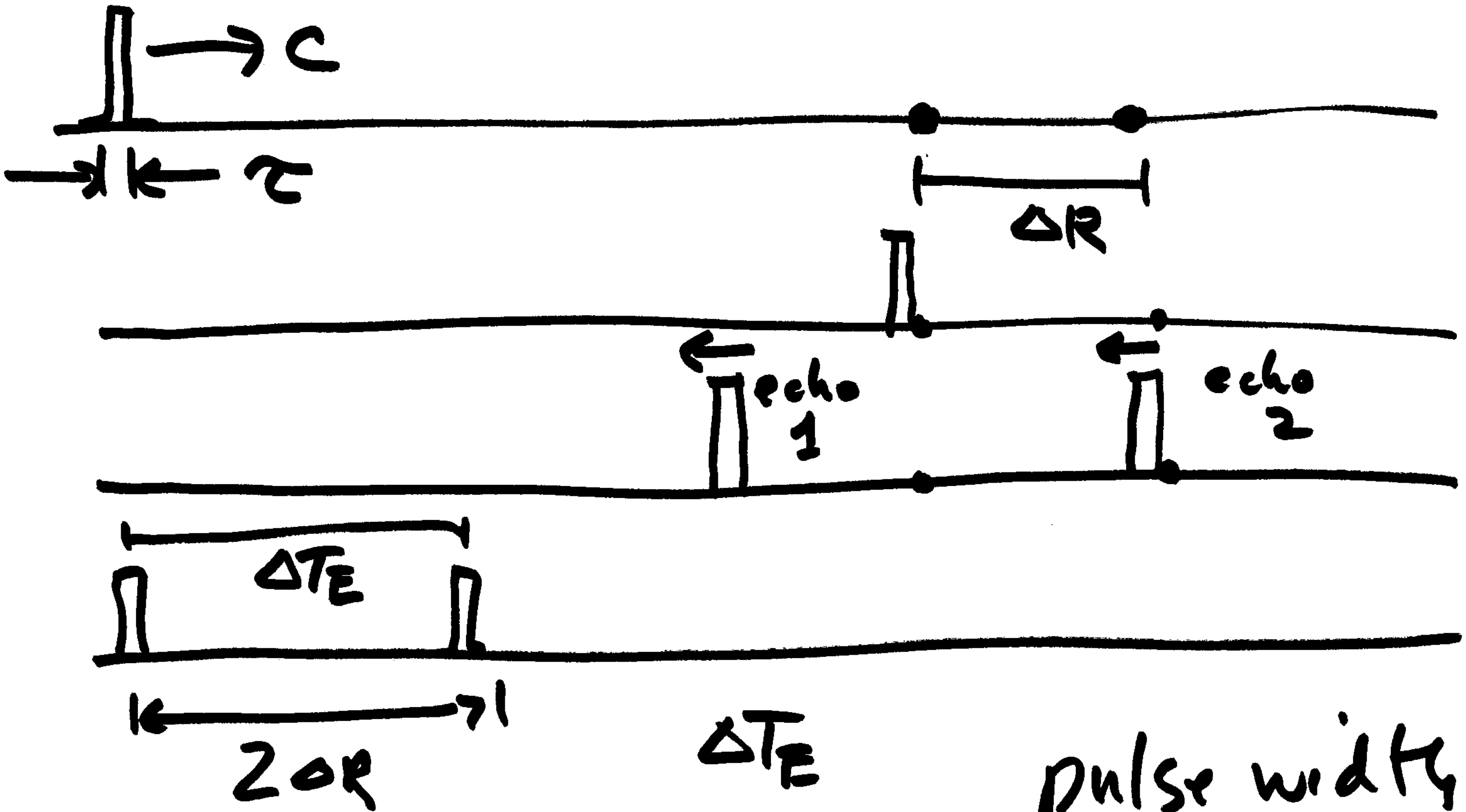
remote sensing applications

Canadians

Radarsat 1+2

<u>echo</u> <u>ranging</u>

Pulse Echo Ranging - 1D -



pulse width & resolving power

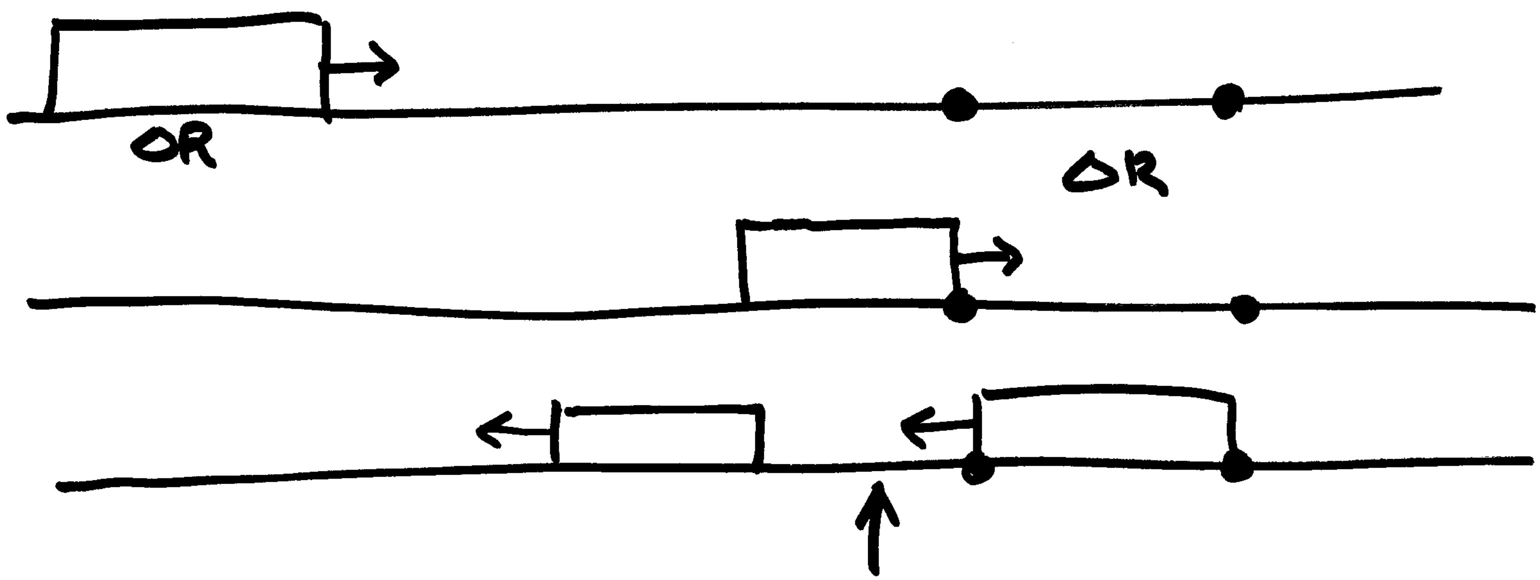
$$2\Delta R = c\,\Delta T_E$$

$$\Delta R = \frac{c\,\Delta T_E}{2}$$

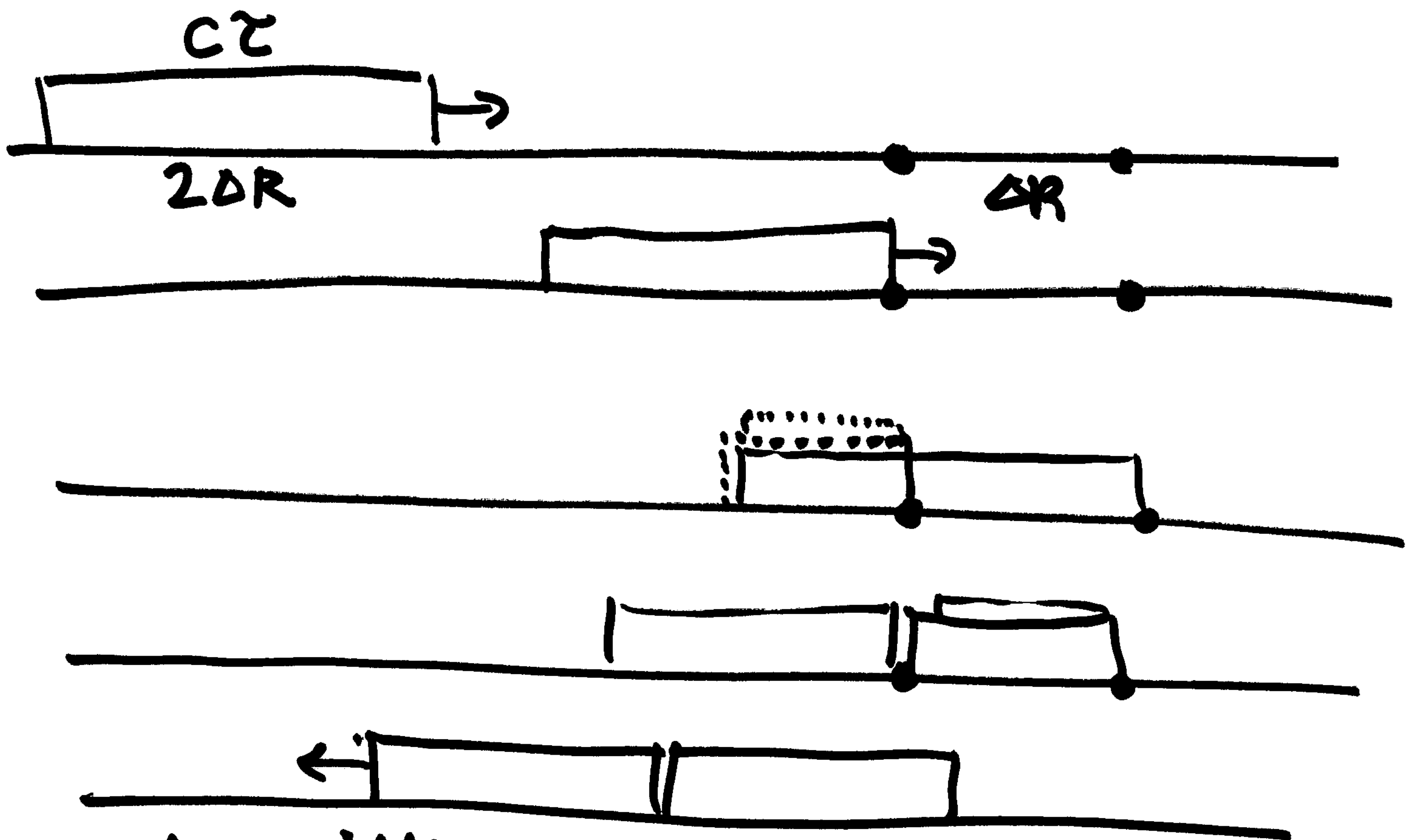
fine resolution : want narrow pulse width

detectability ~ Energy = Power × τ

Power limited



⇒ can resolve ΔR ✓



pulse width = 2ΔR = cτ
just able to resolve 2 scatterers @ ΔR

pulse width τ min. resolvable distance

$$\boxed{c\tau/2}$$

if you need finer spatial resolution with fixed power, can only reduce τ so much, <u>what to do</u> ?

---

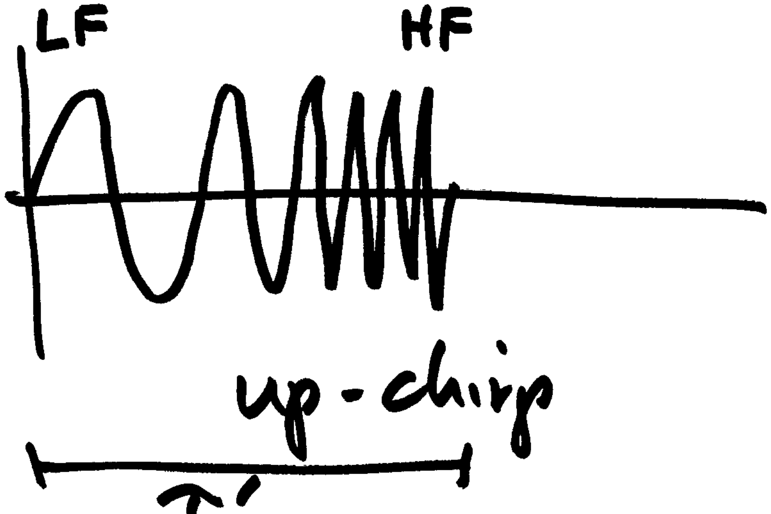
signal processing: 

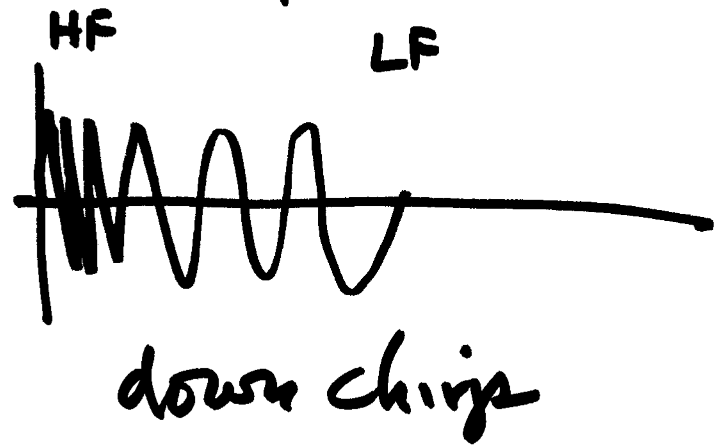
coded waveform:

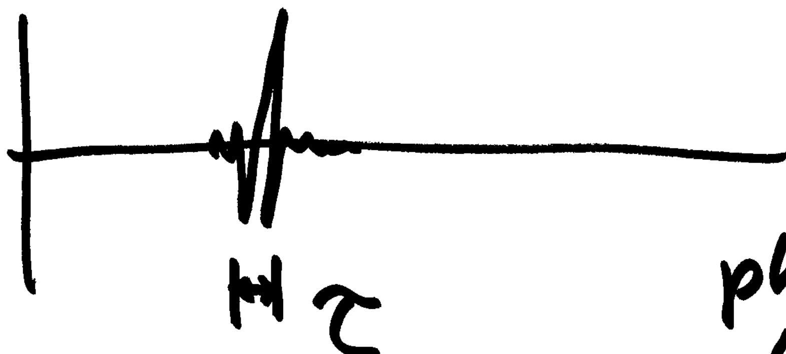
long time τ' } match filter

effective width τ } autocorrelation

coded waveform : chirp pulse







phase = quadratic

$$A(t) = A\cos\big(\underbrace{\omega_0 t + \alpha t^2}_{\text{phase}}\big)$$

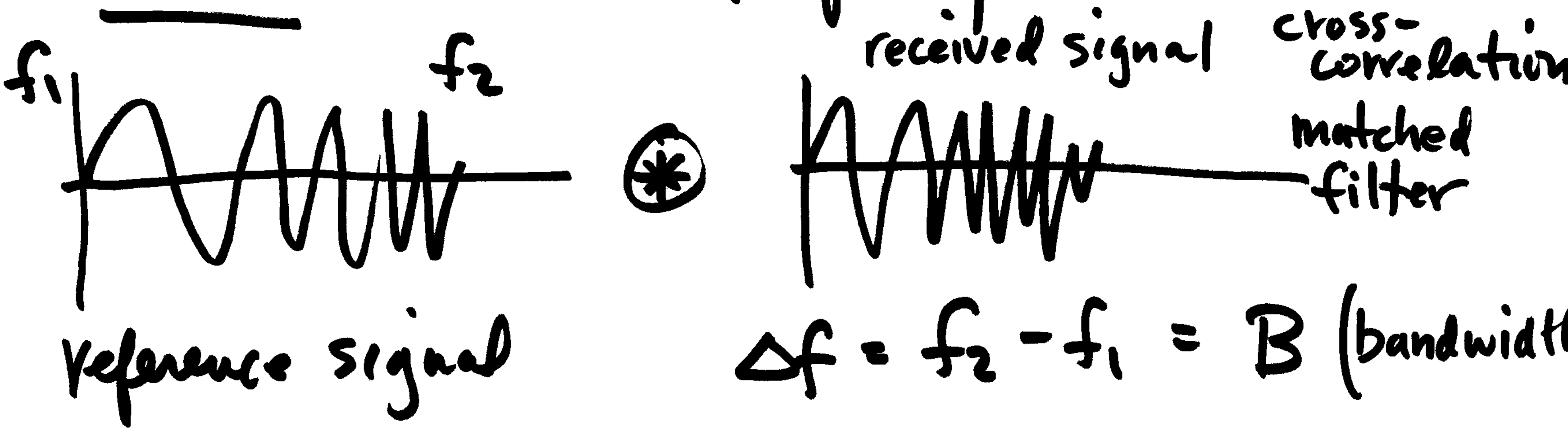
quadratic phase

frequency = $\frac{d}{dt}$(phase)

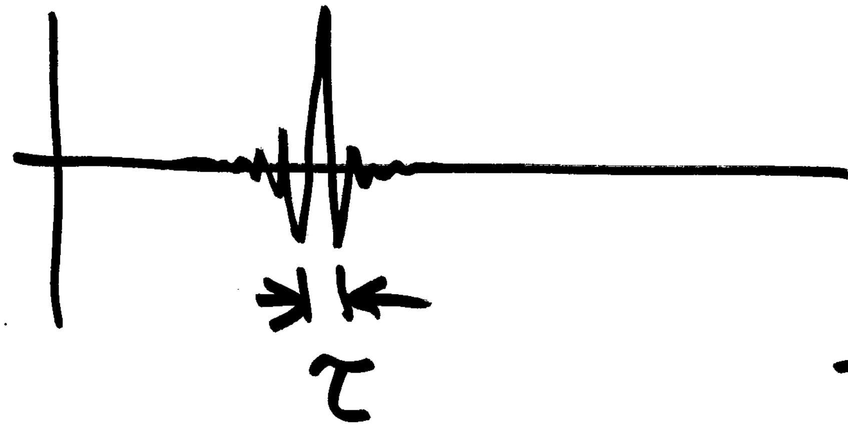
$= \underline{\omega_0 + 2\alpha t}$

instantaneous frequency **linear** with time

LFM : linear frequency modulated



$\Delta f = f_2 - f_1 = B$ (bandwidth)



$0 \rightarrow F$

$f_0 \rightarrow f_0 + F$

$f_0 - \frac{F}{2} \rightarrow f_0 + \frac{F}{2}$

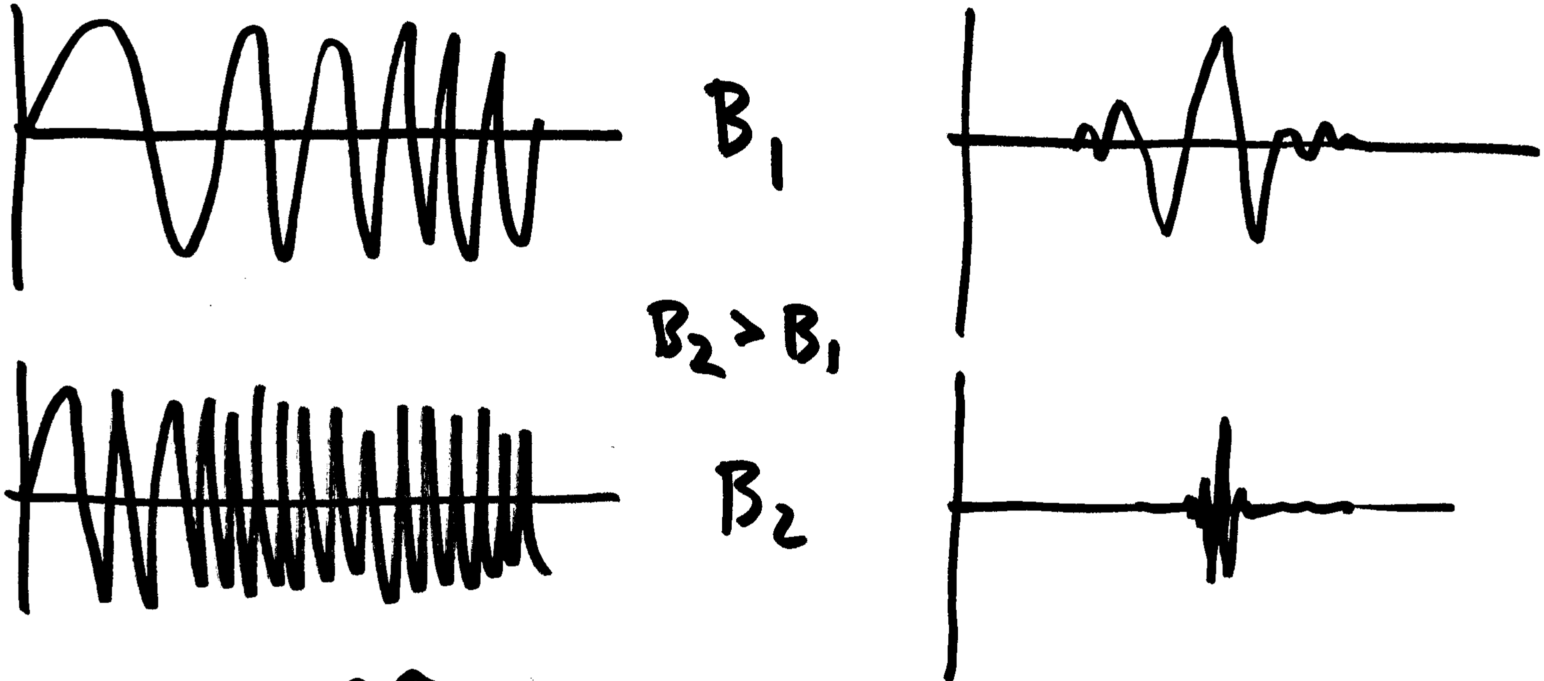
f_0 : center frequency

$B = \frac{1}{\tau}$, $\tau = \frac{1}{B}$

B: bandwidth

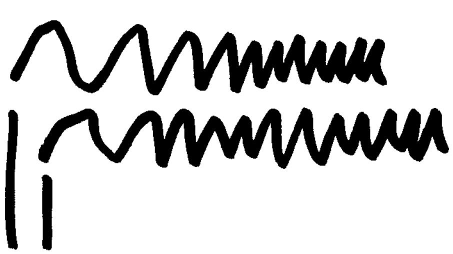
to increase spatial resolution

$\Rightarrow$ increase bandwidth.

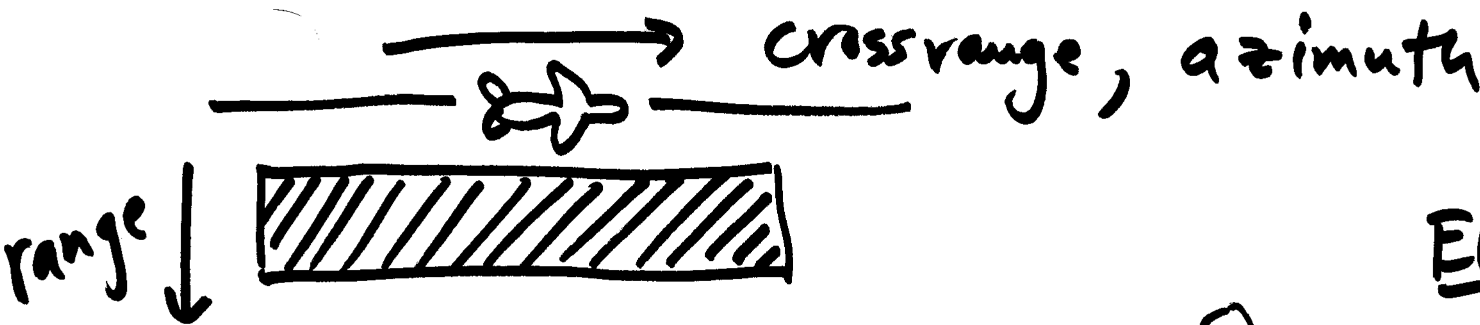


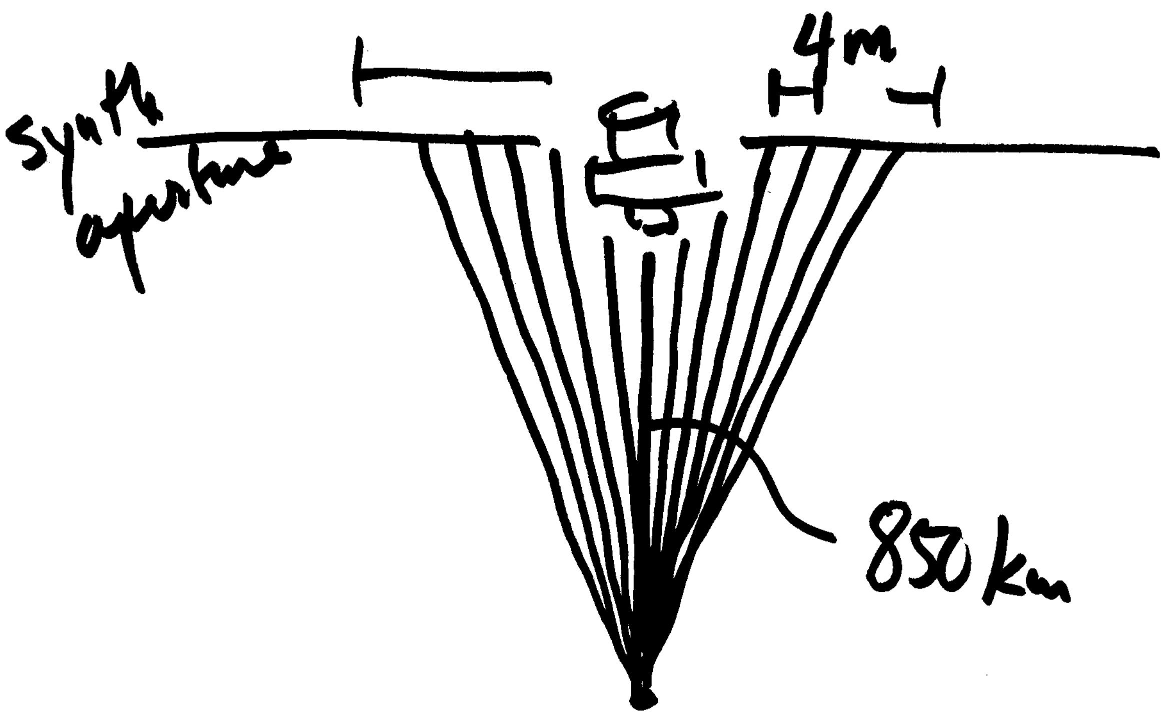
$$\Delta R = \frac{c\tau}{2} \qquad \tau = \frac{1}{B}$$

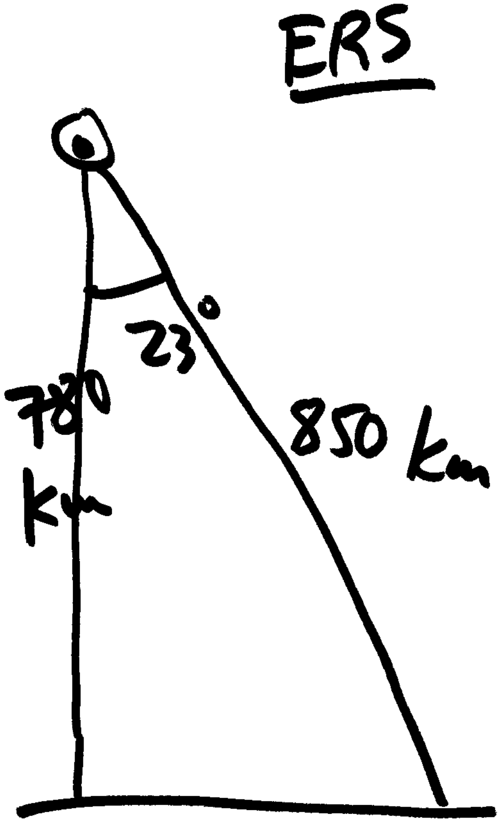
$$= \frac{c}{2B}$$



<u>pulse compression</u>, to resolve scatterers with overlapping signal

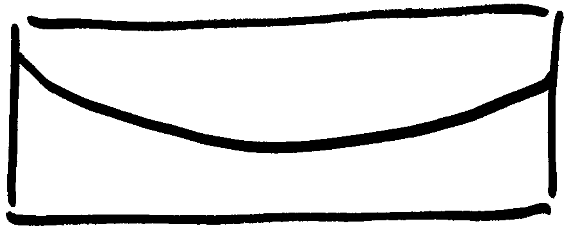




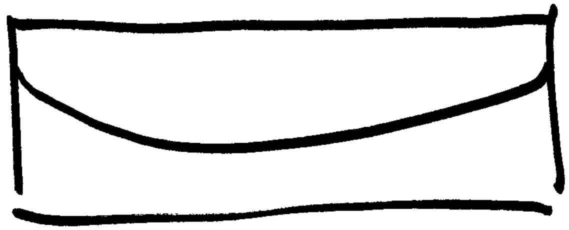


PRF : pulse repitition freq.

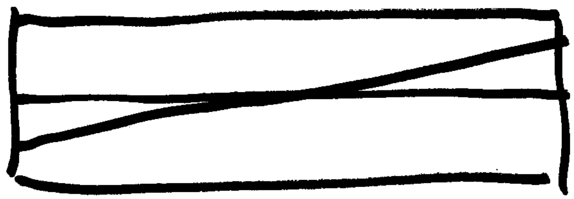
4m



distance, quadratic range

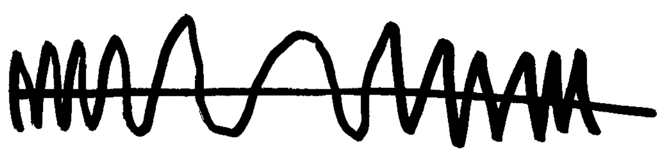


phase = # wavelengths (modulo 2π) ($\lambda \approx 5.6$ cm)



freq. = $\frac{d}{dt}$(phase), linear!

cos (phase)

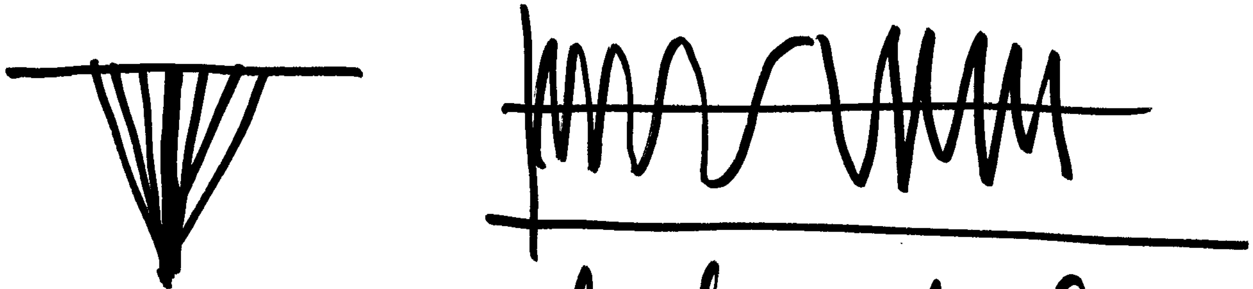


chirp

Quite unexpected

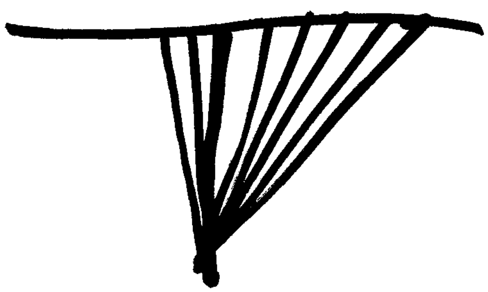
doppler frequency

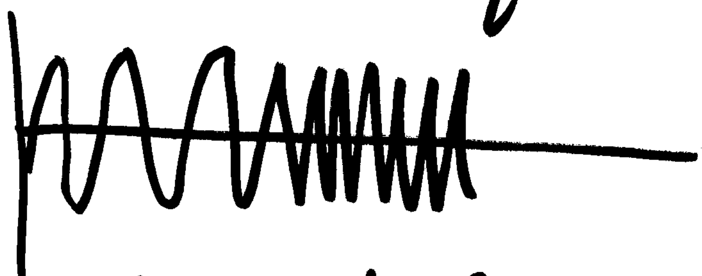
Azimuth signal: looks similar to range sign.



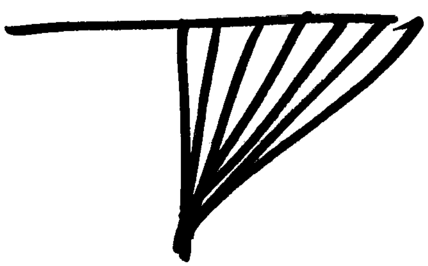
doppler center freq = 0

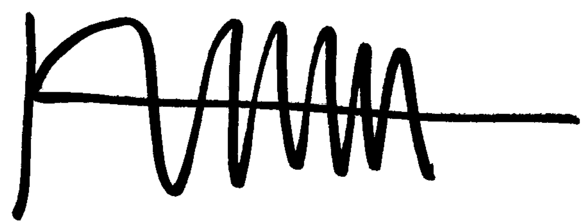
skewed / squinted





doppler center freq. ≠ 0





[See slides in next lecture for better graphics]