Introduction to Incoherent Scatter Radar – Part 2: Scattter

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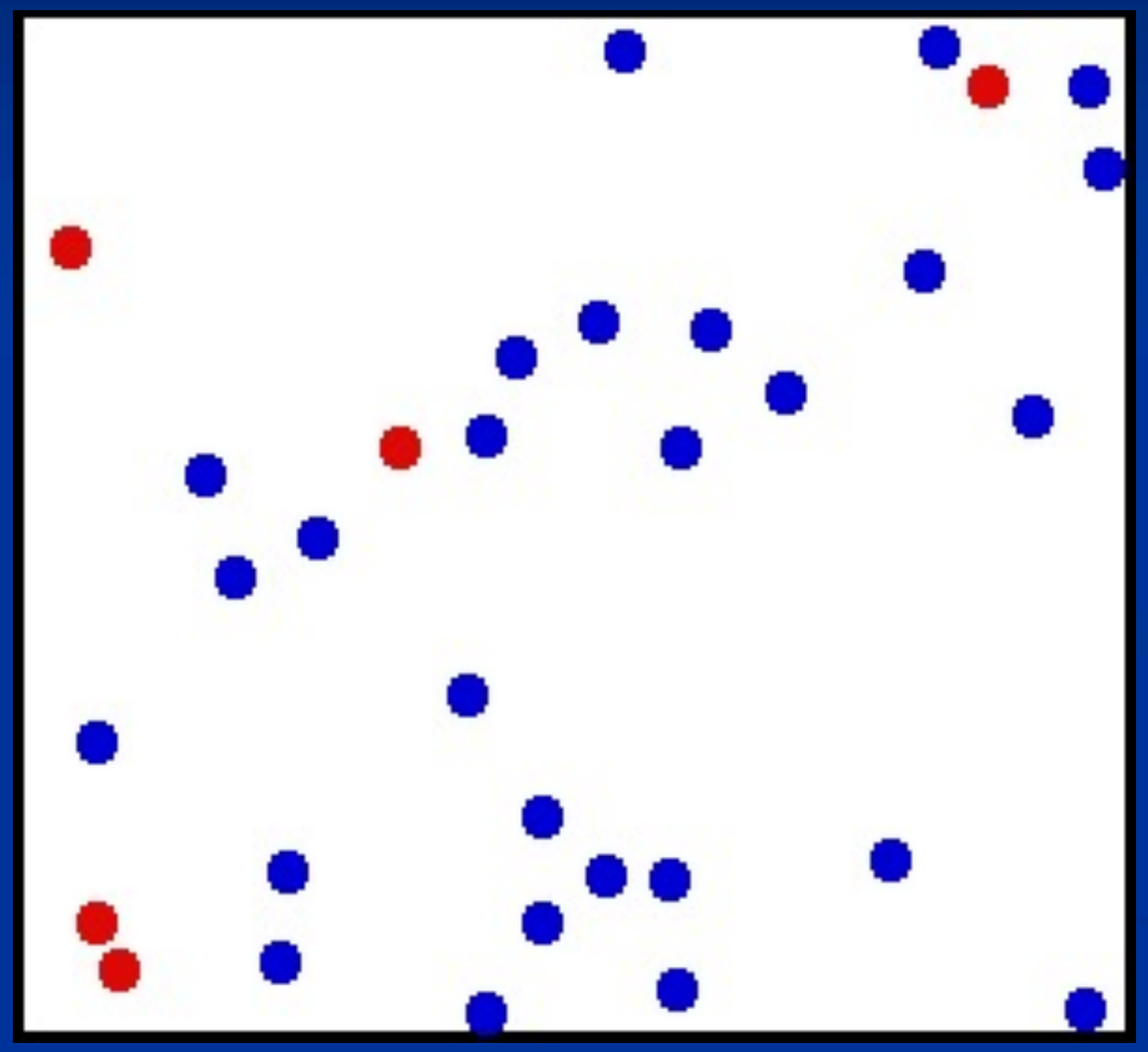
With credit and thanks to **Anja Strømme**, Craig Heinselmann, Phil Erickson, Bill Rideout, Josh Semeter, Juha Vierinen

And my advisor: William E. Gordon

Incoherent Scatter Radar

- Radar
- Scatter
- Incoherent

Thermal fluctuating electrons



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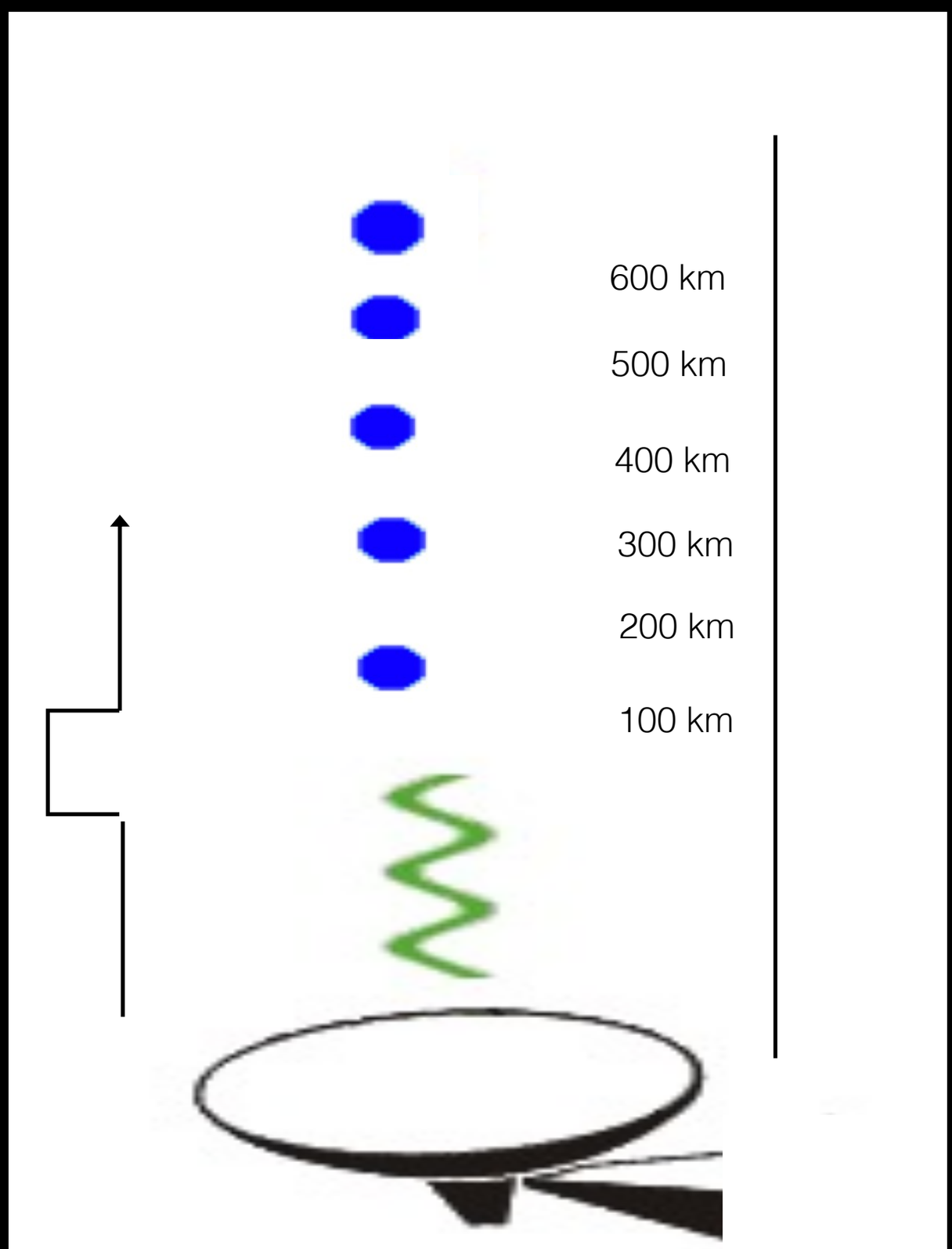
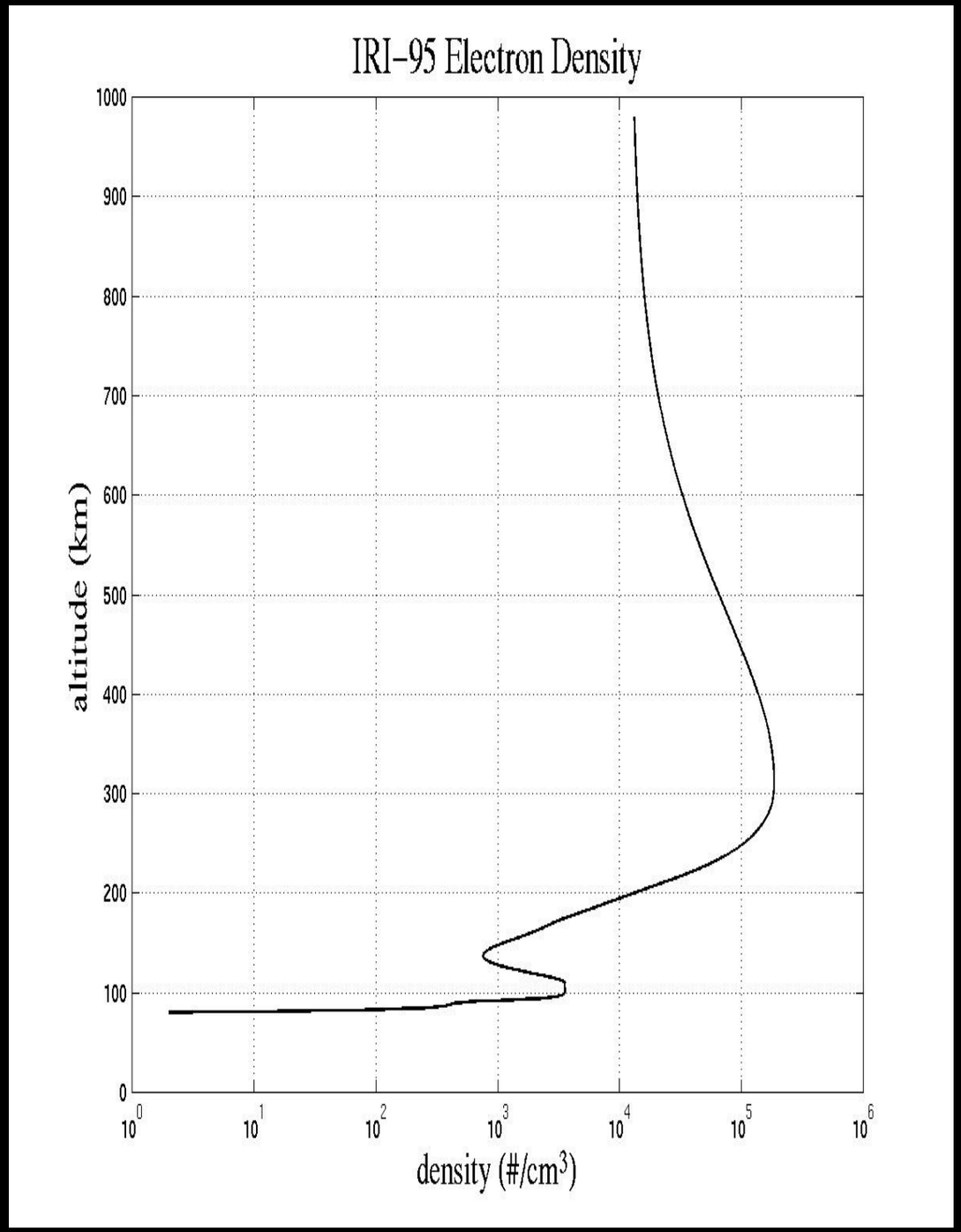
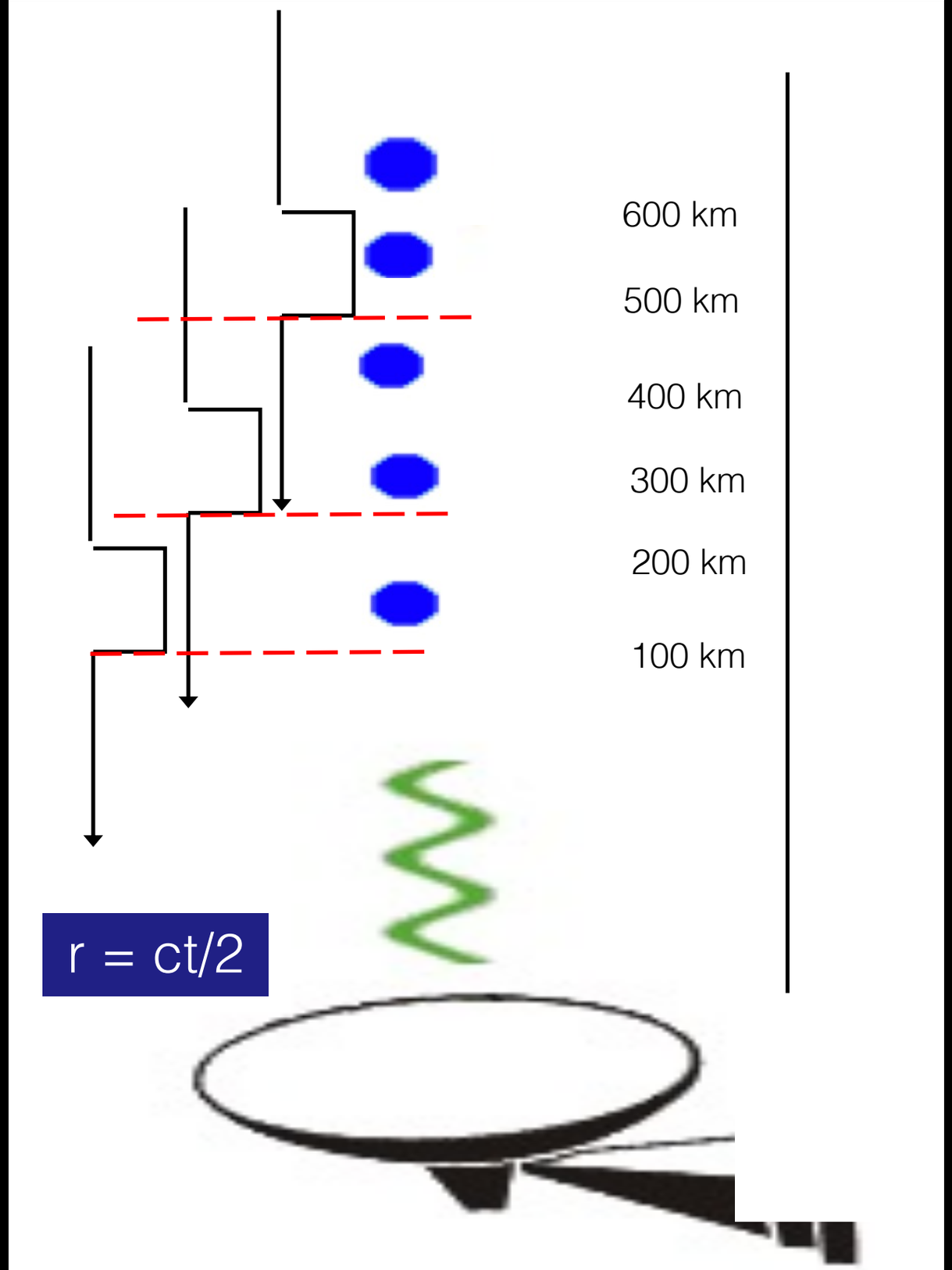
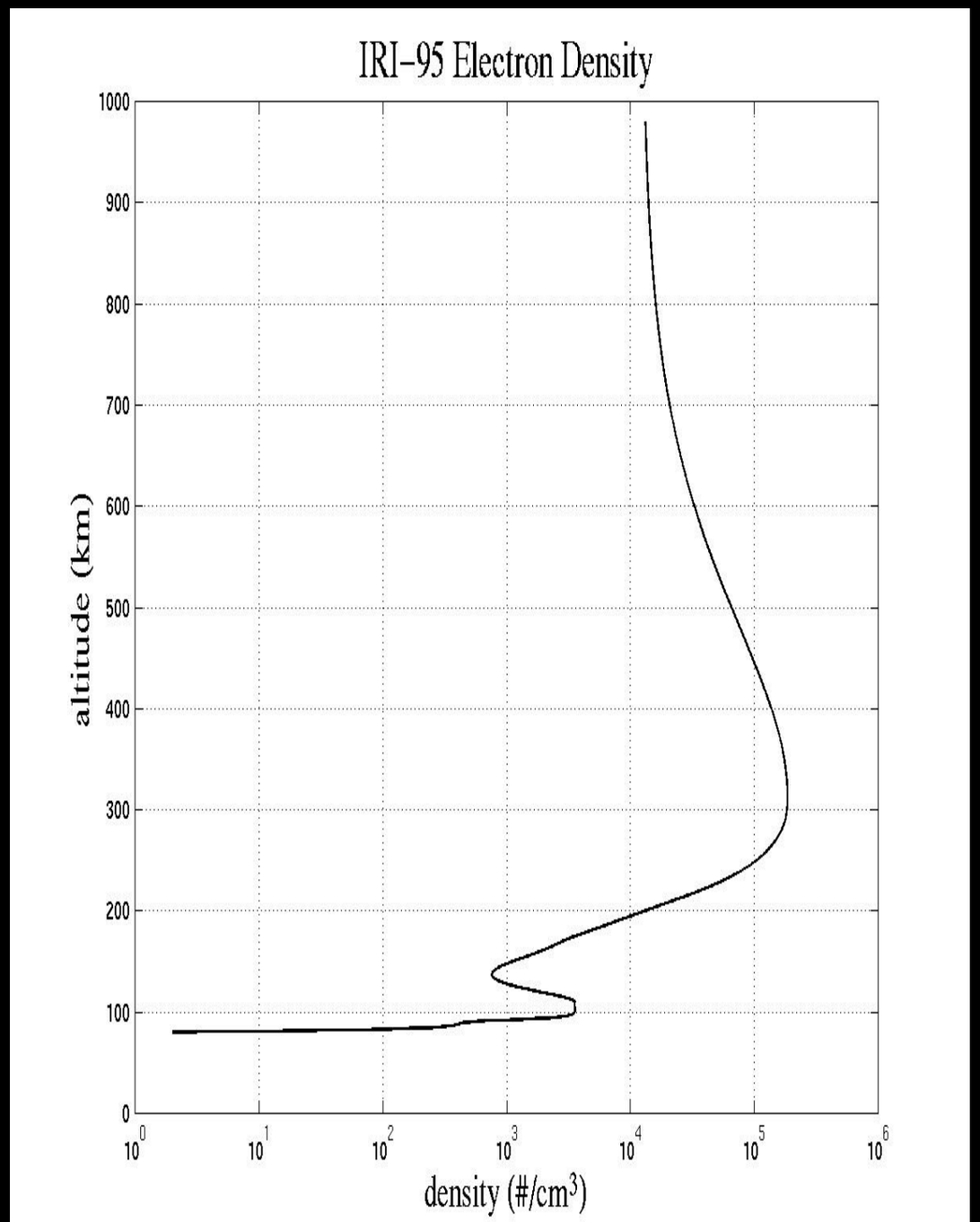

600 km
500 km
400 km
300 km
200 km
100 km


IRI-95 Electron Density
altitude (km)
density (#/cm3)
1000
900
800
700
600
500
400
300
200
100
0
10^0
10^1
10^2
10^3
10^4
10^5
10^6


600 km
500 km
400 km
300 km
200 km
100 km
r = ct/2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10^0
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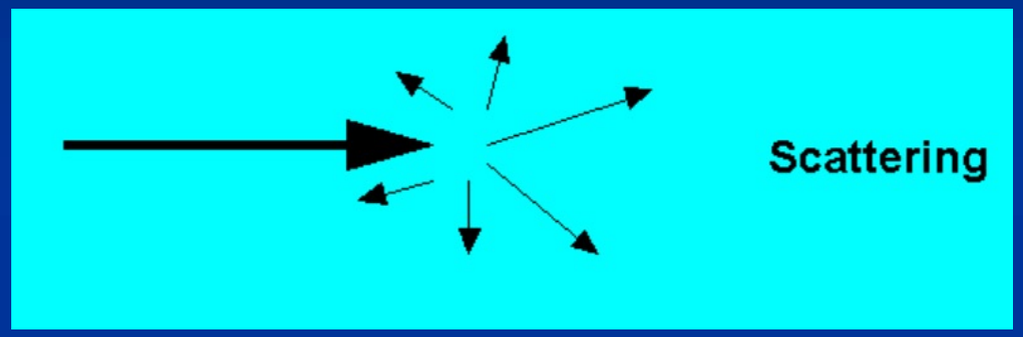
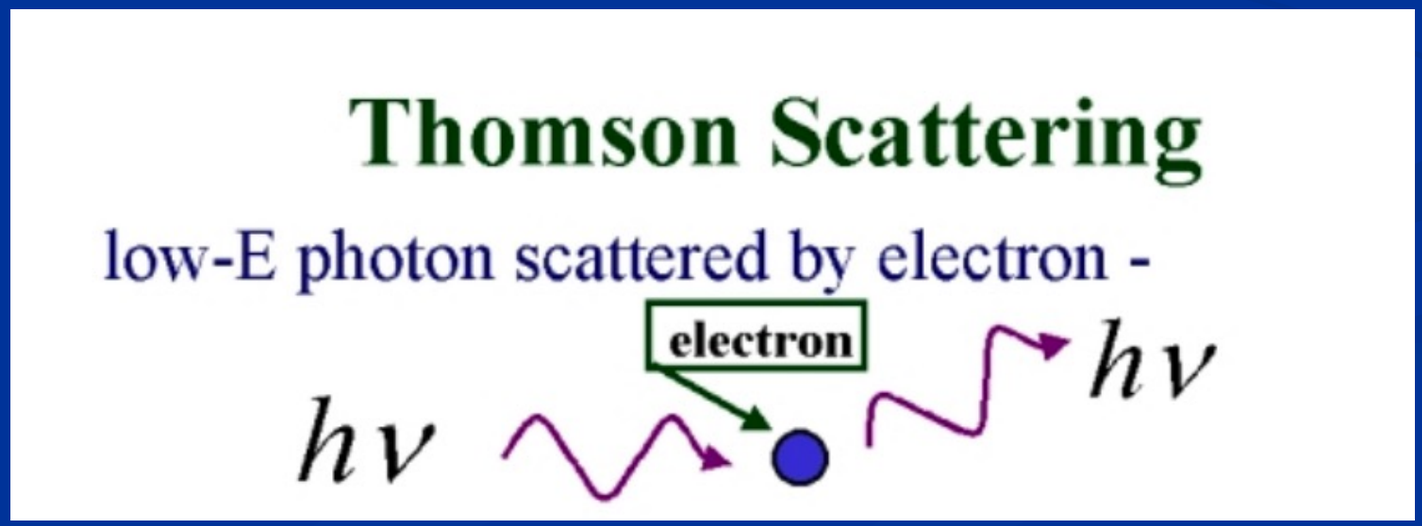
10^2
10^3
10^4
10^5
10^6

Thomson scattering

- Thomson scattering is the elastic scattering of electromagnetic radiation by a free charged particle, as described by classical electromagnetism.

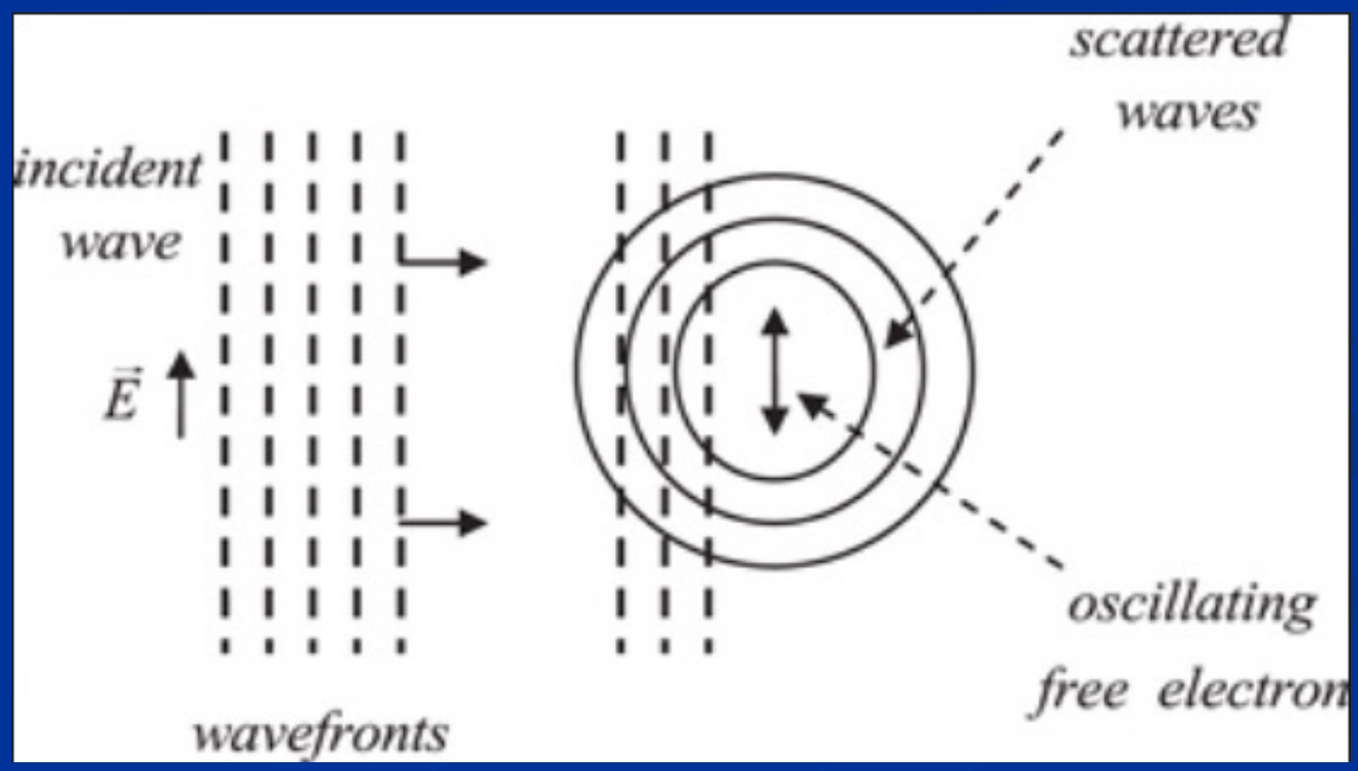


- In the low-energy limit, the electric field of the incident wave (radar wave) accelerates the charged particle, causing it, in turn, to emit radiation at the same frequency as the incident wave, and thus the wave is scattered.



Thomson scattering (con.)

- As long as the motion of the particle is non-relativistic (i.e. its speed is much less than the speed of light), the main cause of the acceleration of the particle will be due to the electric field component of the incident wave, and the magnetic field can be neglected. The particle will move in the direction of the oscillating electric field, resulting in electromagnetic dipole radiation



Thomson Scattering

$$E_x = E_0 e^{j(\omega t - kx)}$$

$$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$$

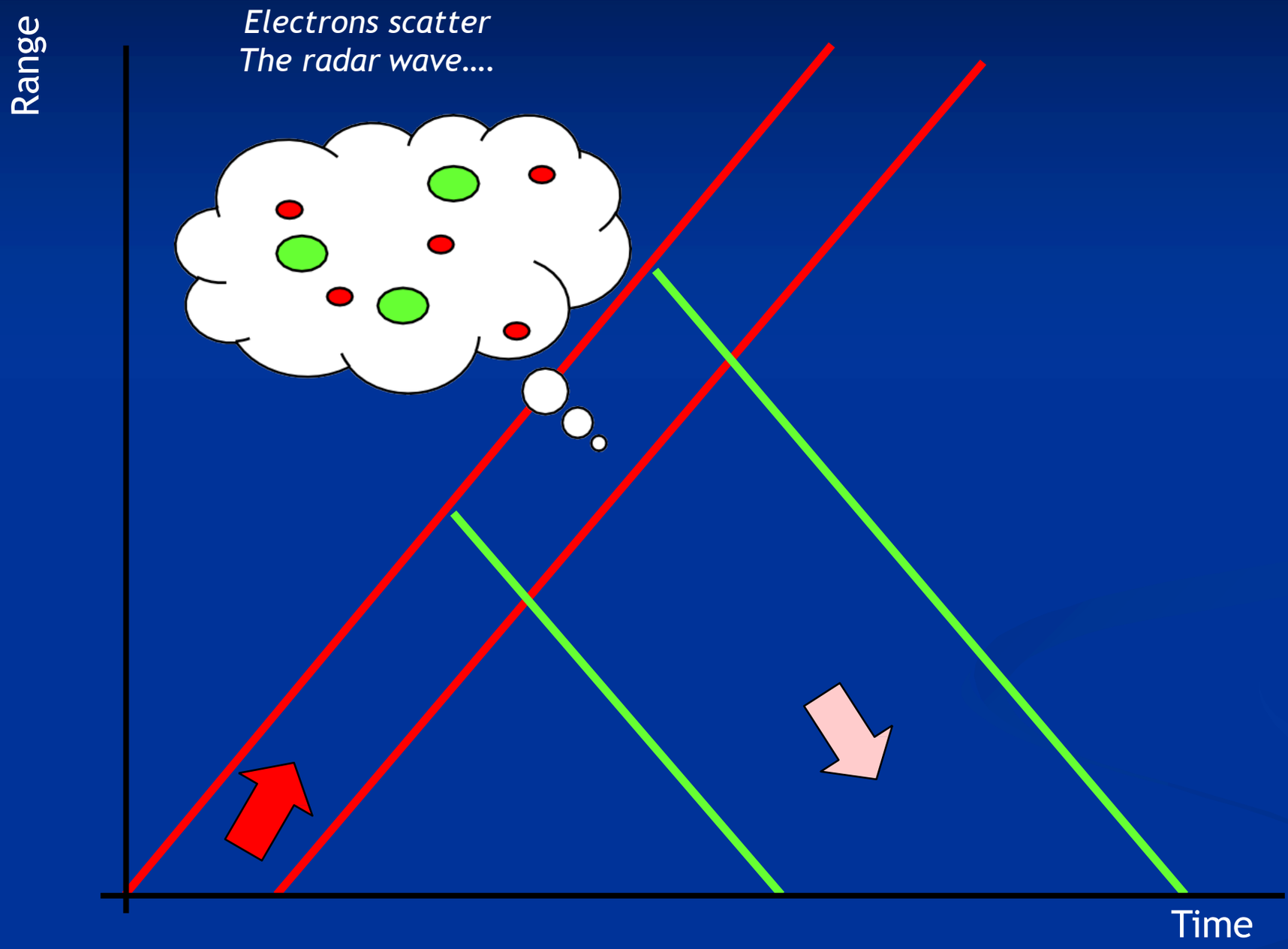
$$v_x = -j\frac{q_e E_0}{m_e \omega} e^{j\omega t}$$

$$E_\phi = \frac{\mu_0 q_e^2}{4\pi m_e}\frac{\sin\phi}{r} e^{-jkr} E_0$$

$$\sigma_e = 4\pi\left(\frac{\mu_0 q_e^2}{4\pi m_e}\right)^2 \sin^2\phi = 4\pi r_e^2 \sin^2\phi$$

$$\approx 10^{-28}\sin^2\phi \quad (\mathrm{m}^2)$$

How ISRs work

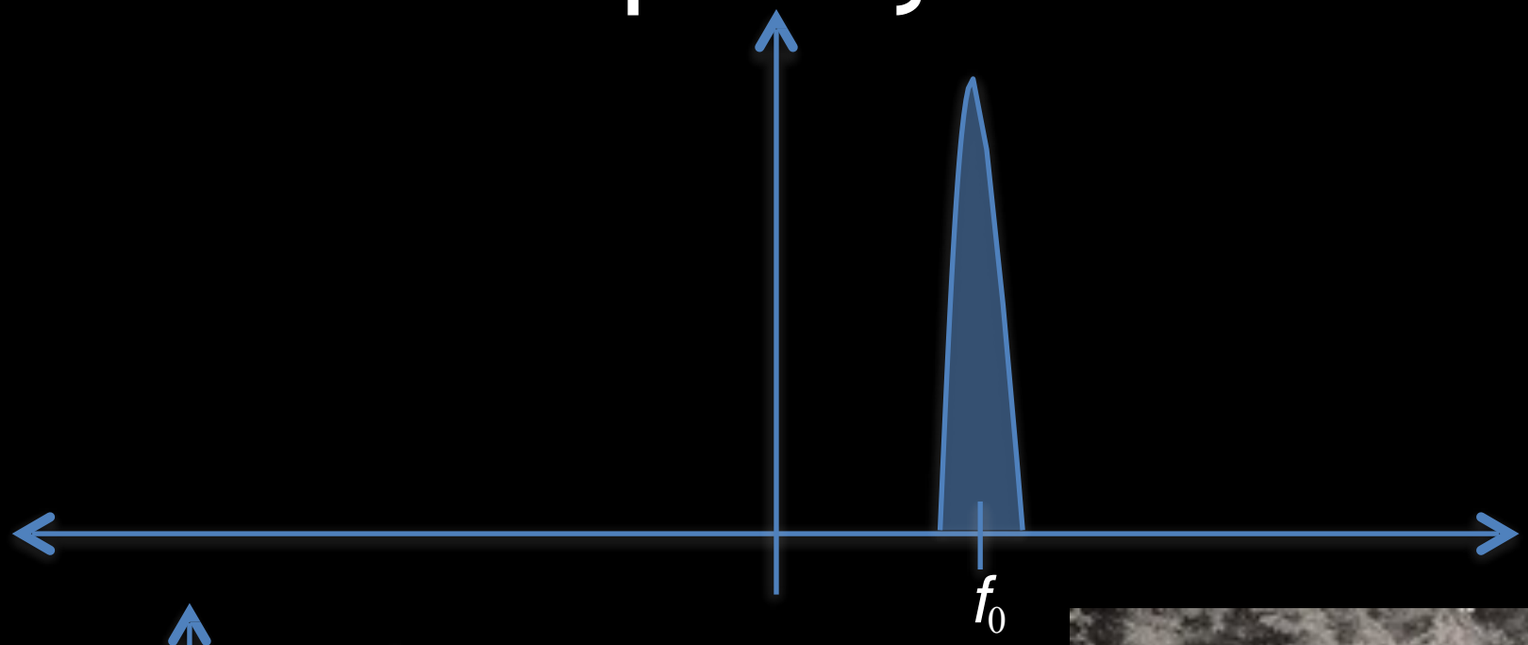


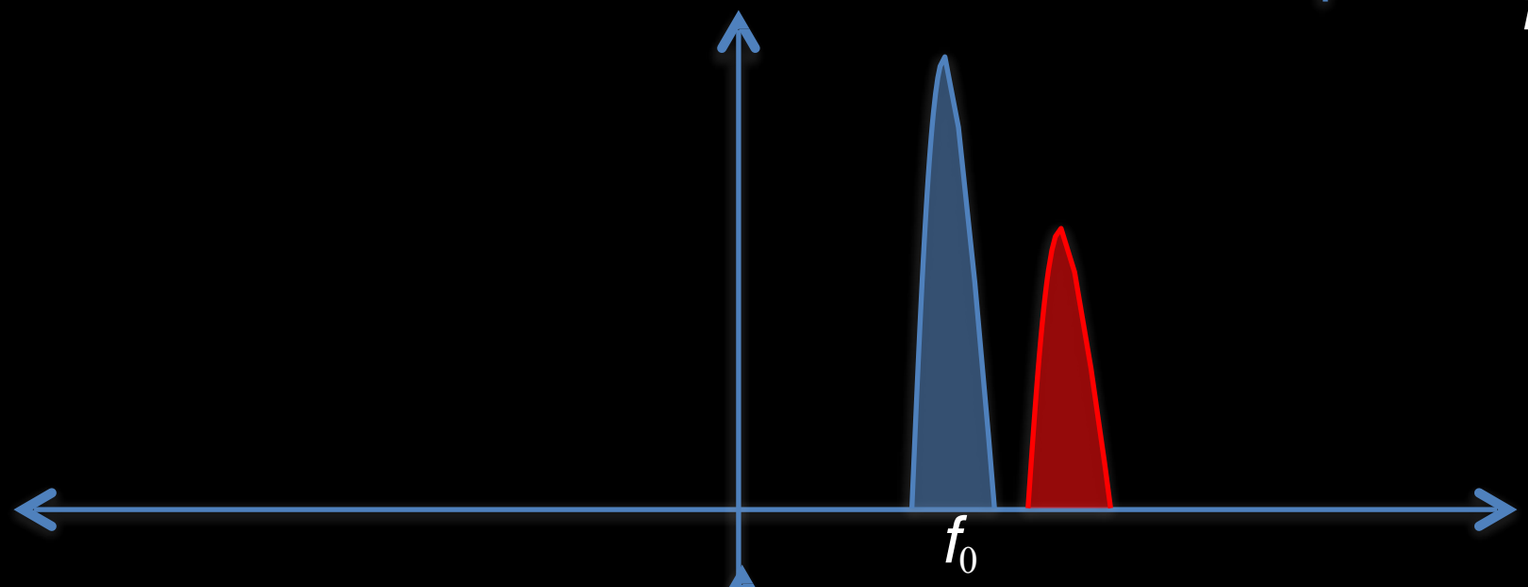
High power transmitter

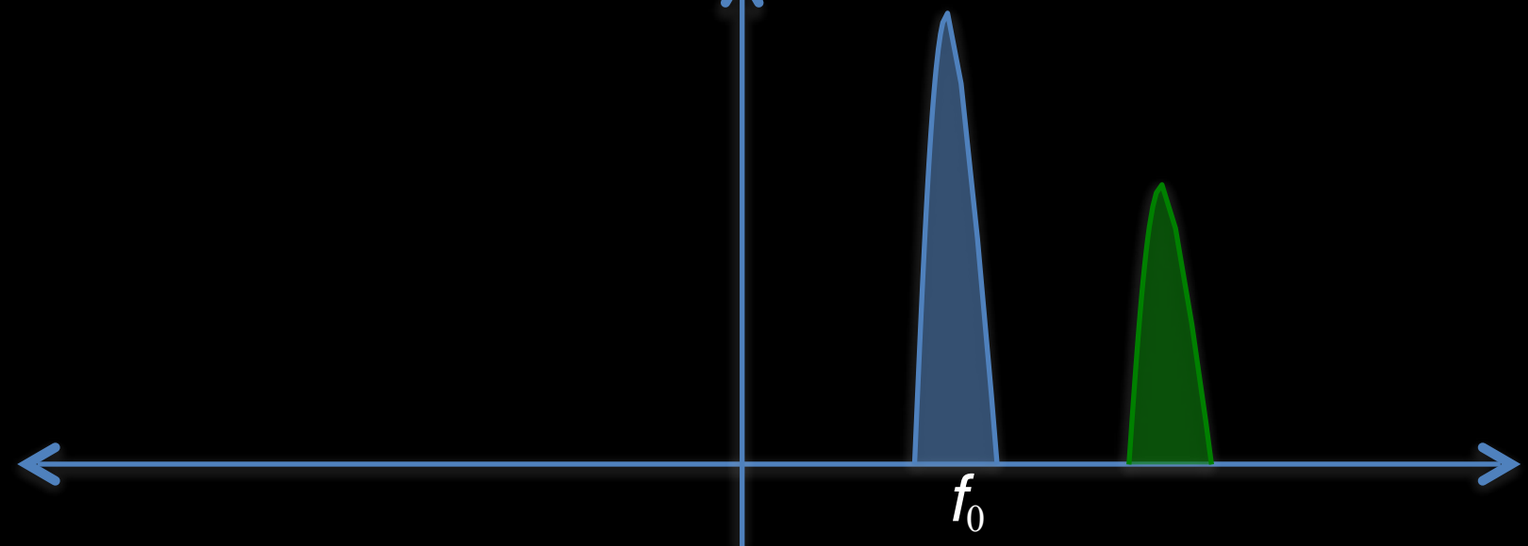
Very sensitive receiver

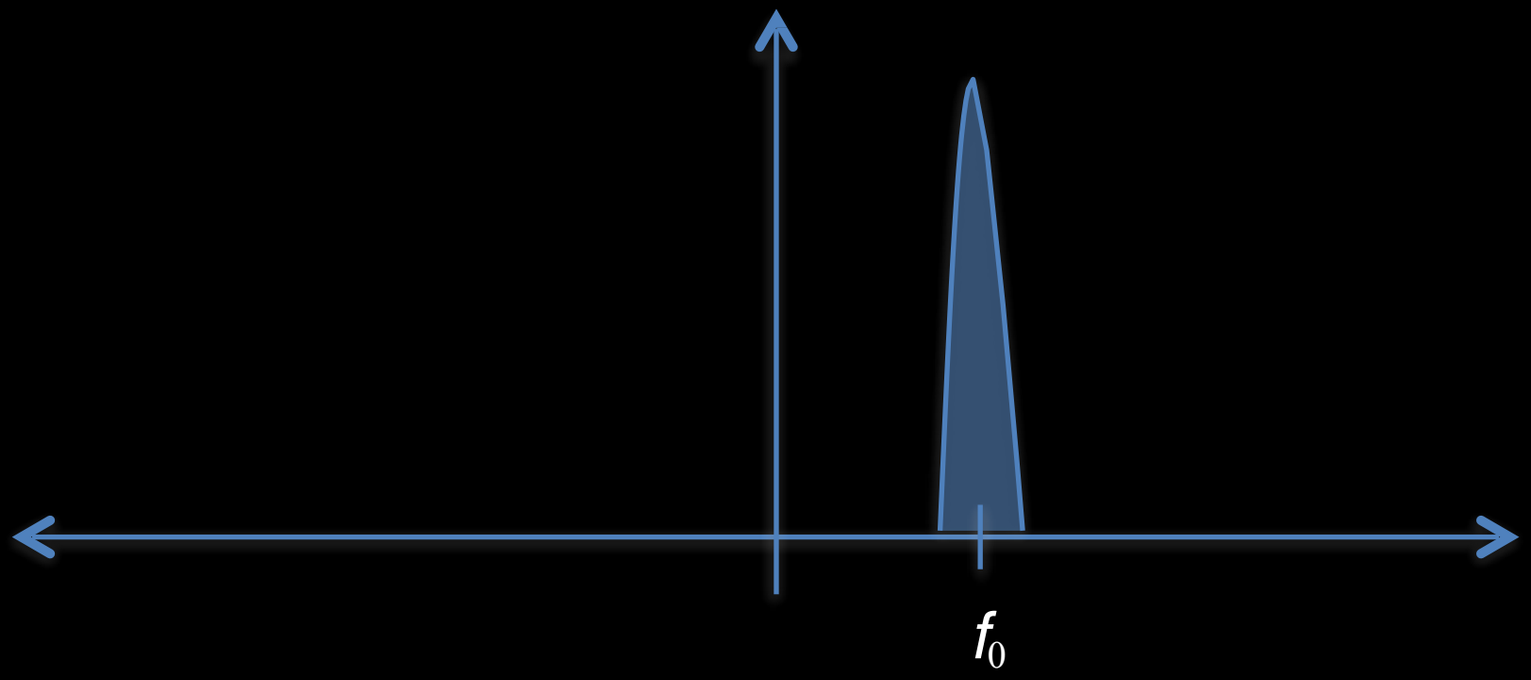
Only ~0.00000000000000000001% of the transmitted power is returned!

Doppler Radar – frequency domain





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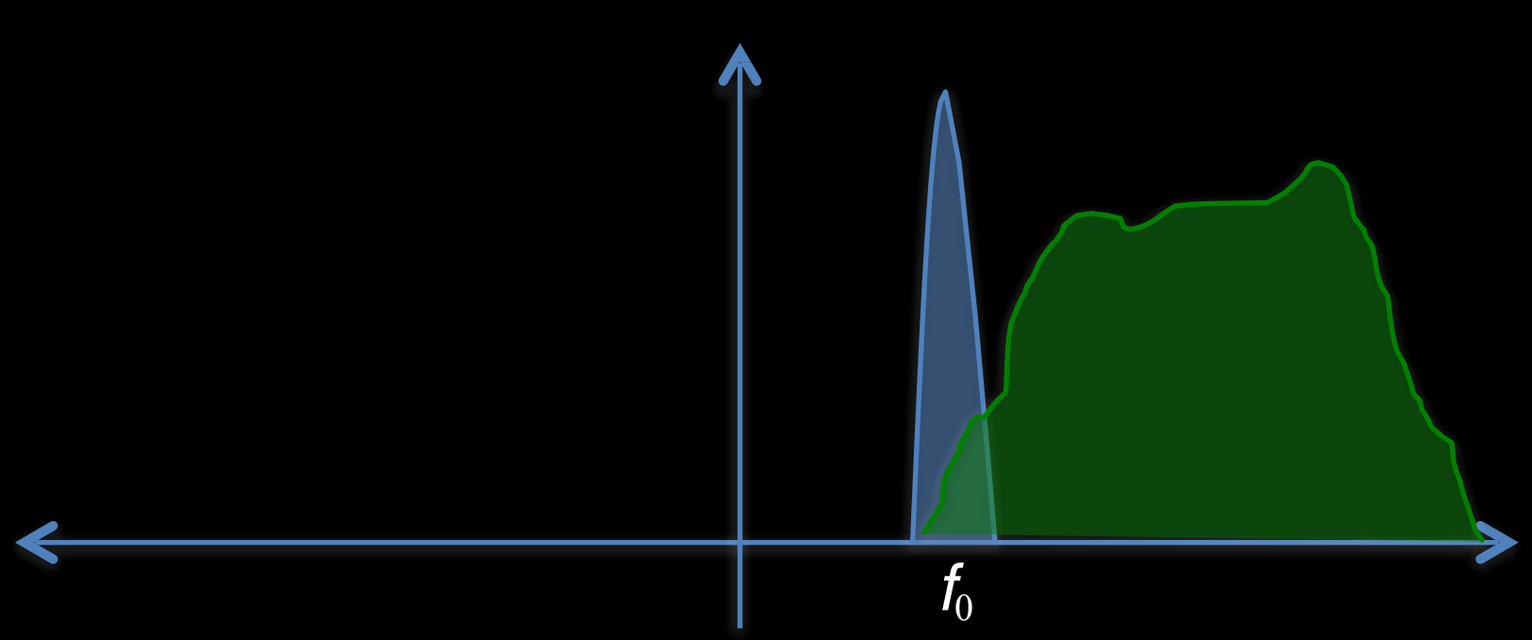
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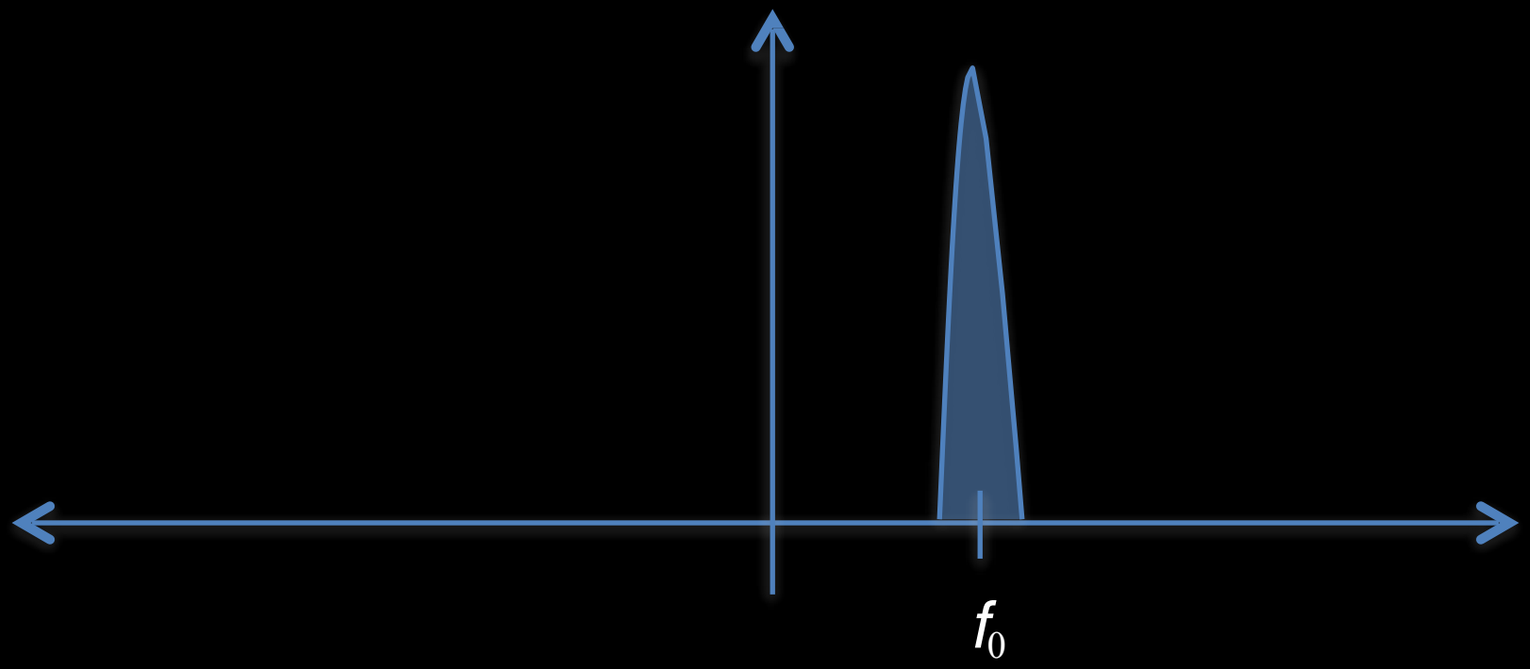
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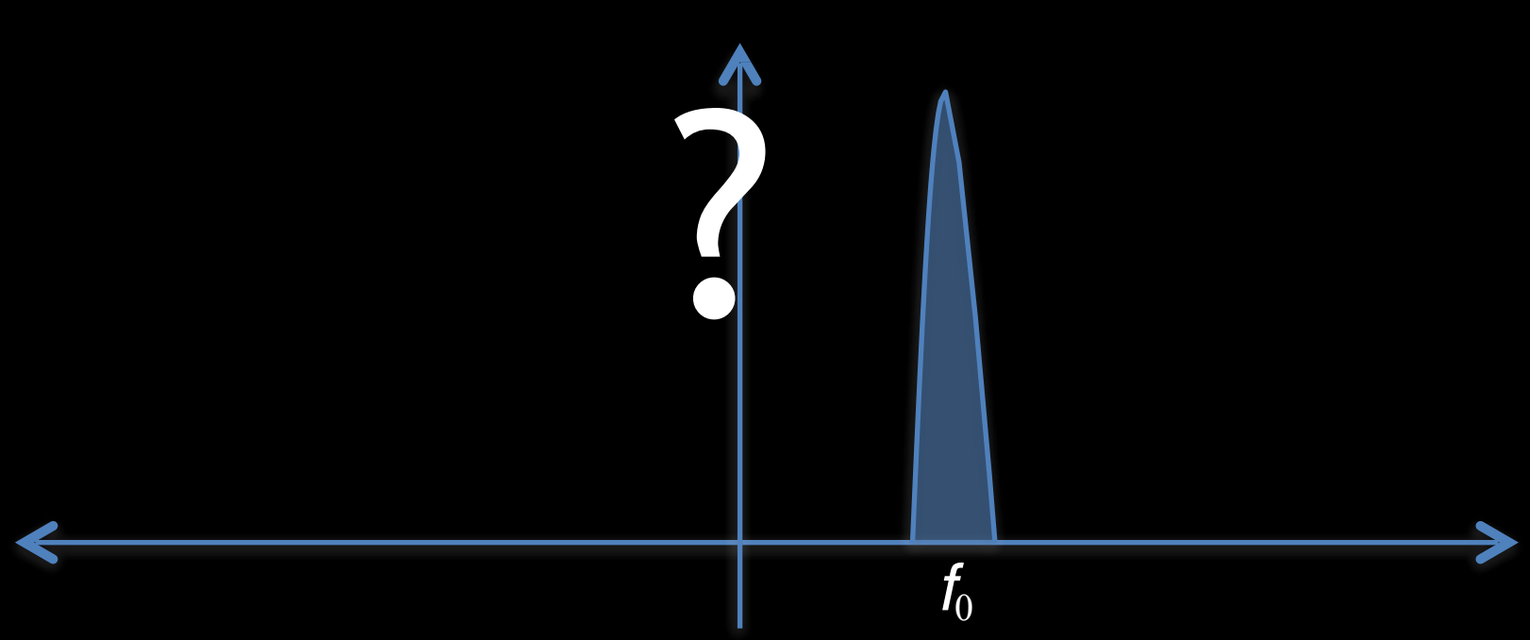
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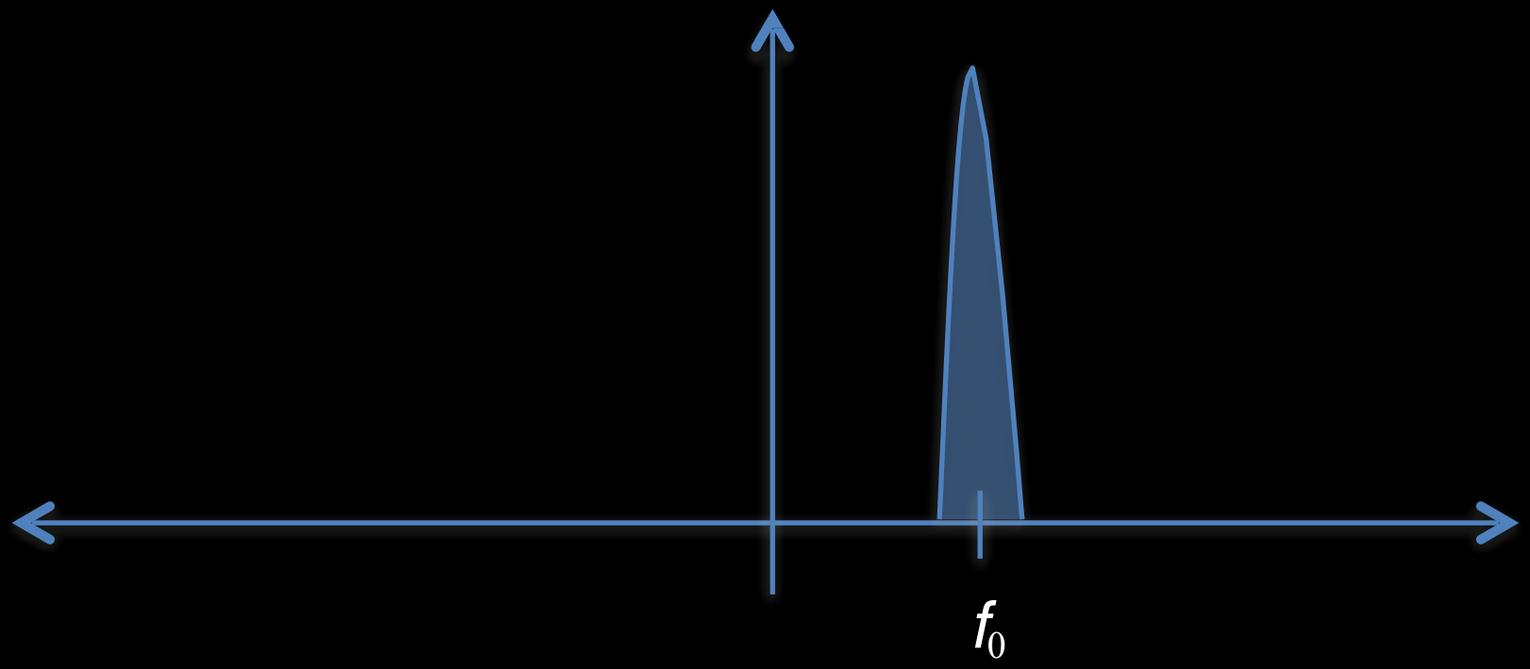
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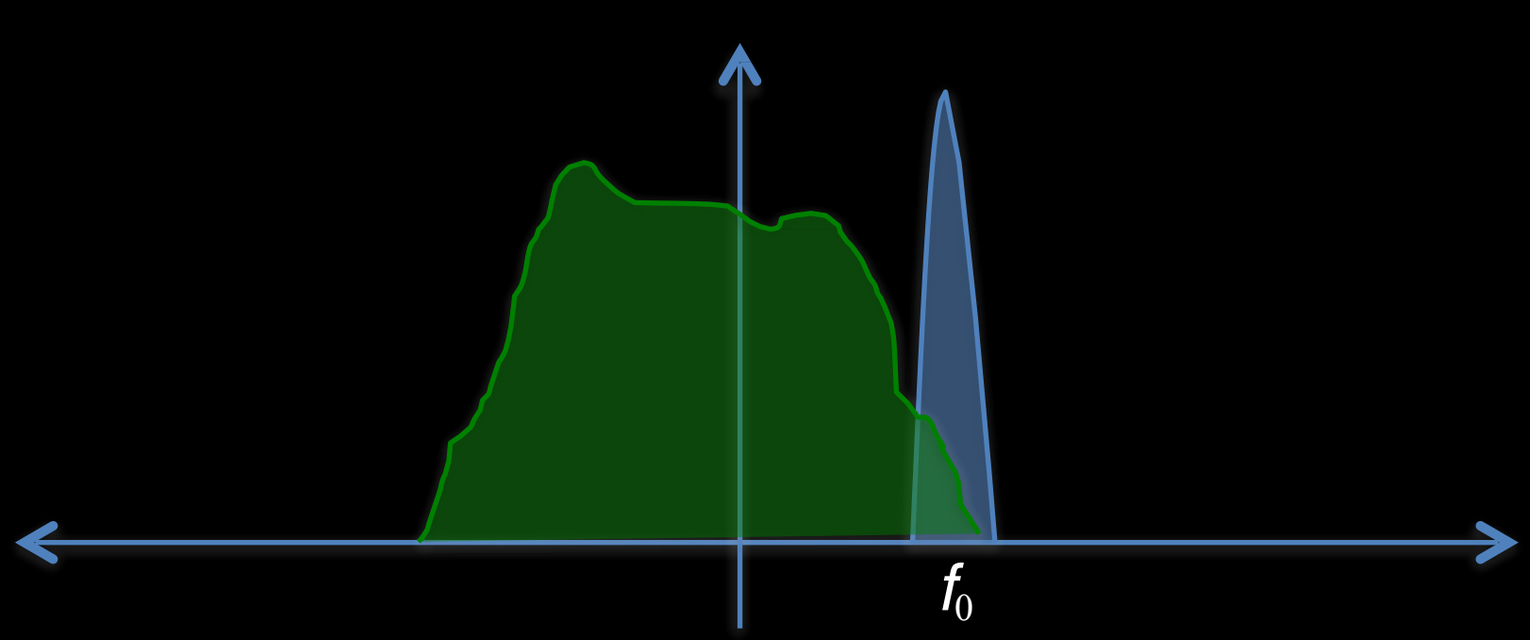
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