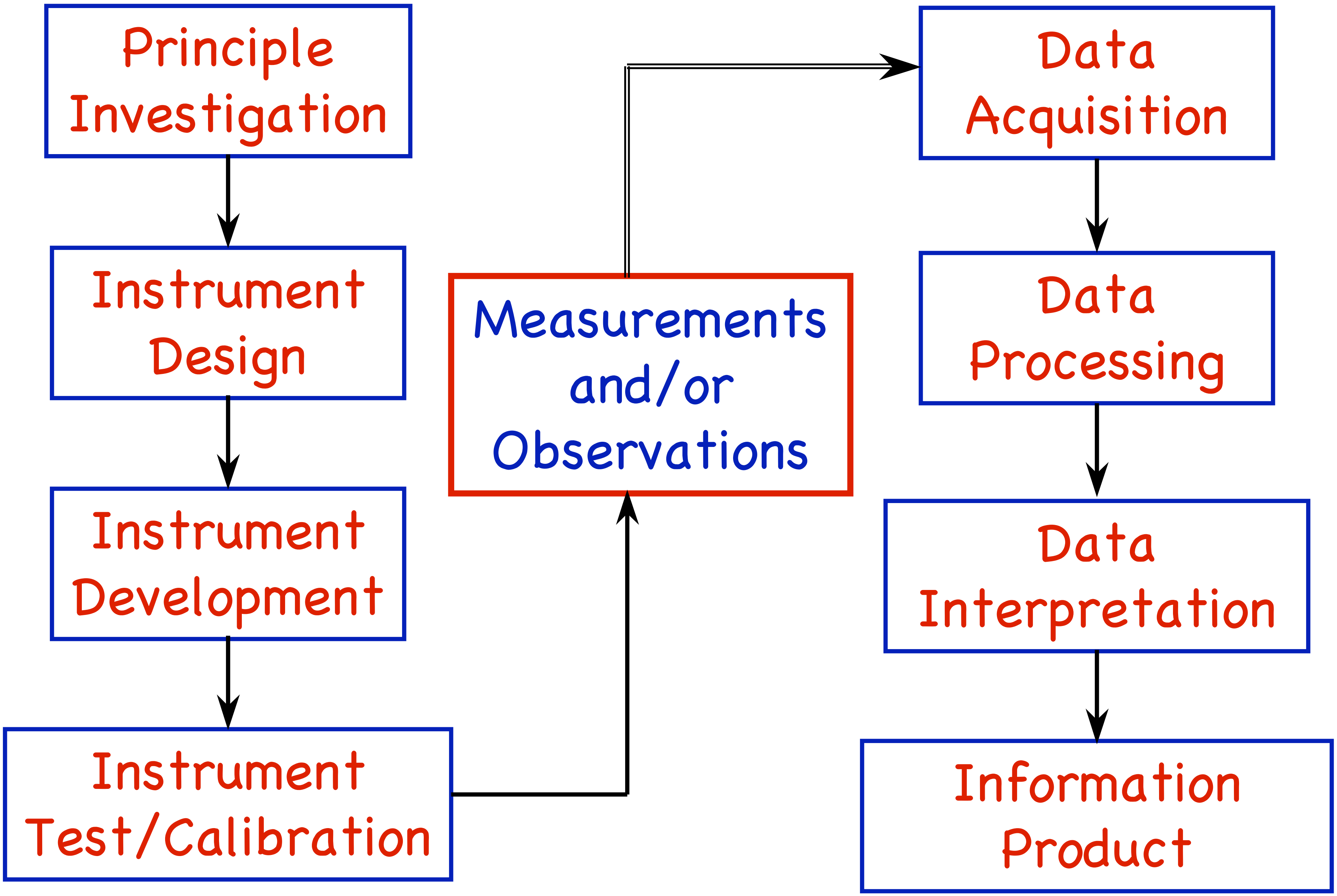
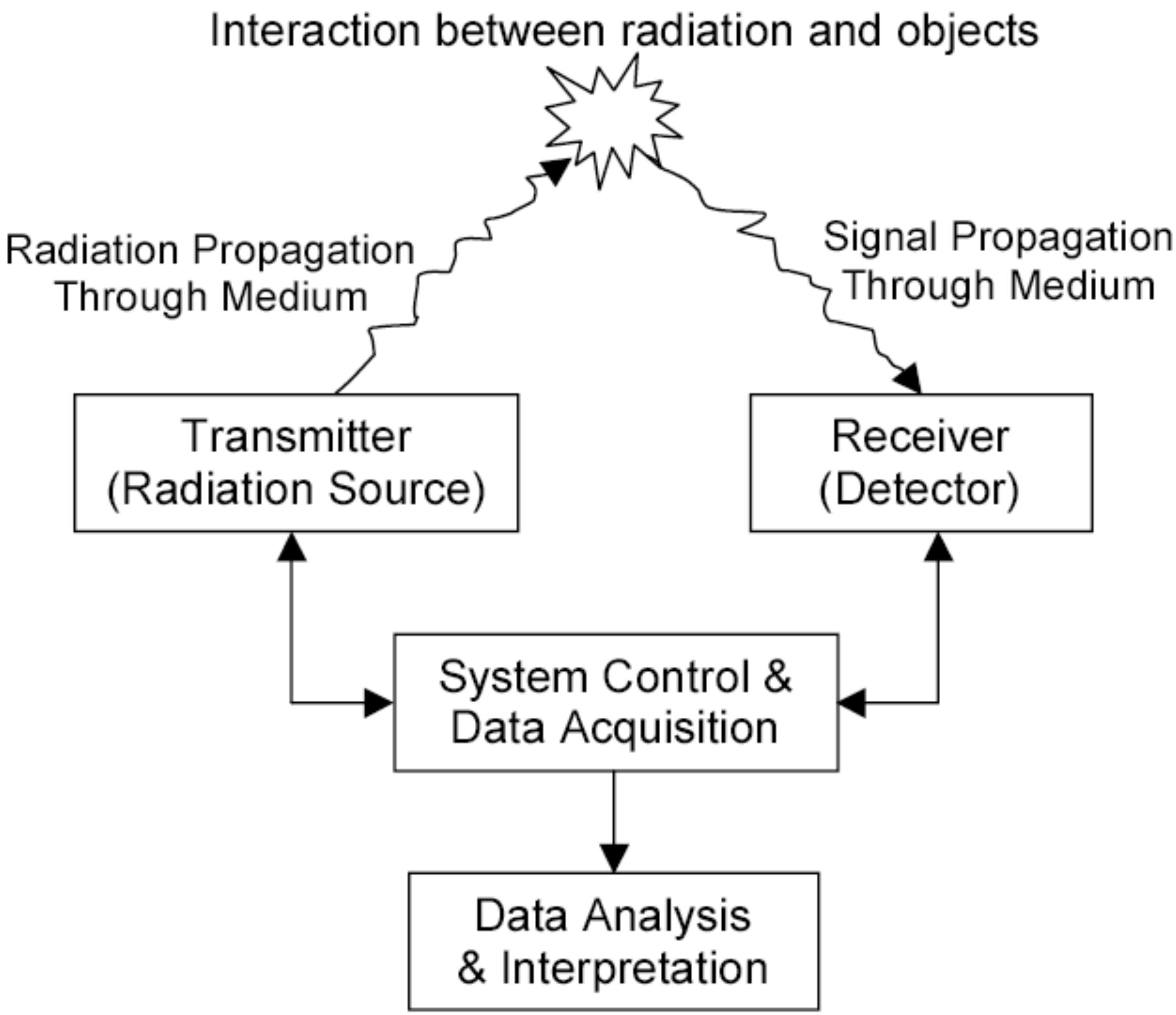
Lecture 16. Review of LIDAR Fundamentals

- Review of LIDAR principle and architecture
- Review of LIDAR data retrieval
- Review of QM, spectroscopy, and lasers
- Open Discussions

Content of Remote Sensing



Active Remote Sensing



General Form of LIDAR Equation

$$N_S(\lambda,R) = N_L(\lambda_L)\cdot\left[\beta(\lambda,\lambda_L,\theta,R)\Delta R\right]\cdot\frac{A}{R^2}\cdot\left[T(\lambda_L,R)T(\lambda,R)\right]\cdot\left[\eta(\lambda,\lambda_L)G(R)\right]+N_B$$

$$P_S(\lambda,R) = P_L(\lambda_L)\cdot\left[\beta(\lambda,\lambda_L,\theta,R)\Delta R\right]\cdot\frac{A}{R^2}\cdot\left[T(\lambda_L,R)T(\lambda,R)\right]\cdot\left[\eta(\lambda,\lambda_L)G(R)\right]+P_B$$

N_S (R) - expected received photon number from a distance R

N_L - number of transmitted laser photons,

β(R) - volume scatter coefficient at distance R for angle θ,

ΔR - thickness of the range bin

A - area of receiver,

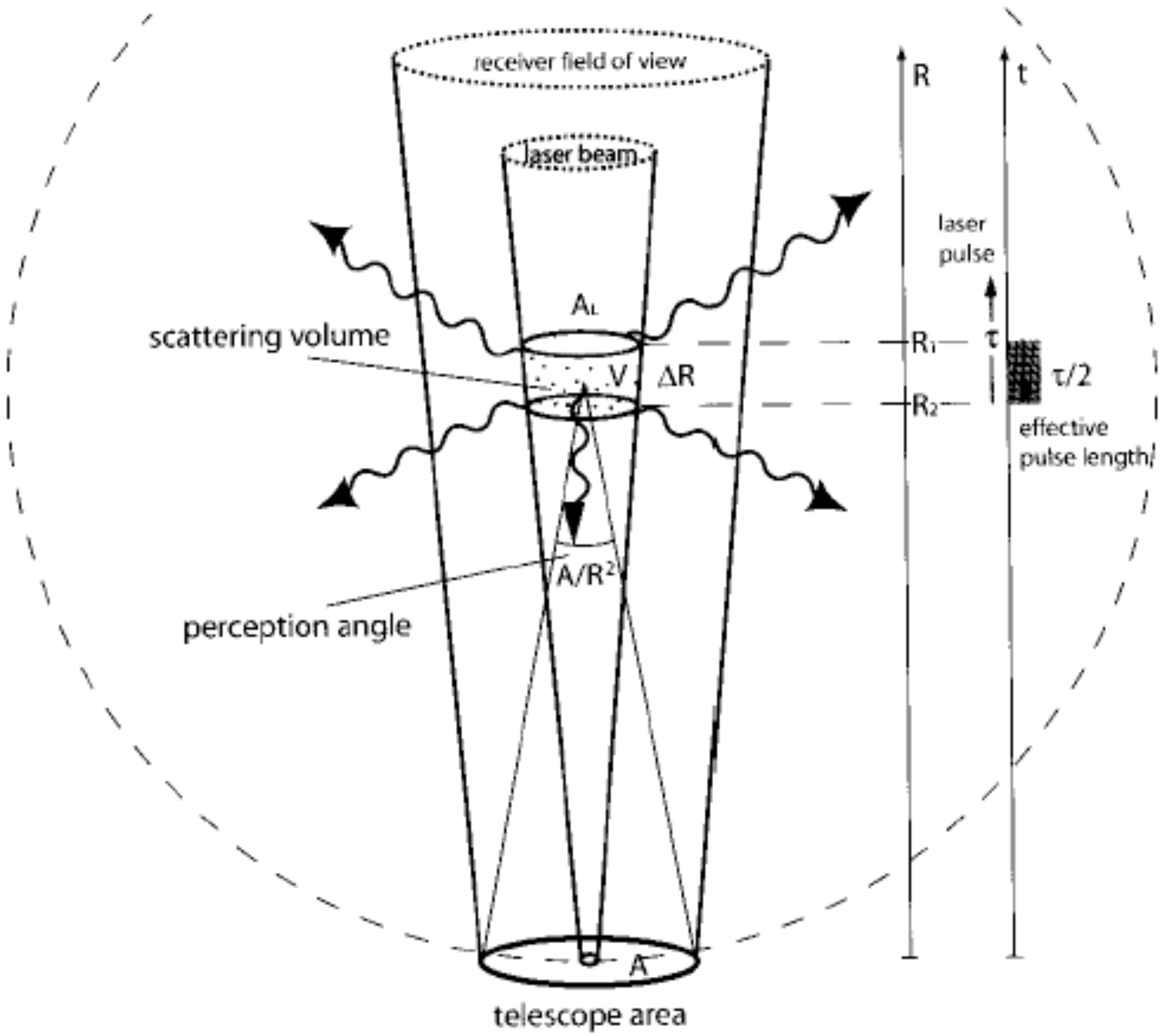
T(R) - one way transmission of the light from laser source to distance R or from distance R to the receiver,

η - system optical efficiency,

G(R) - geometrical factor of the system,

N_B - background photon counts.

Illustration for LIDAR Equation



Solutions of LiDAR Equation

- For resonance fluorescence lidar equation

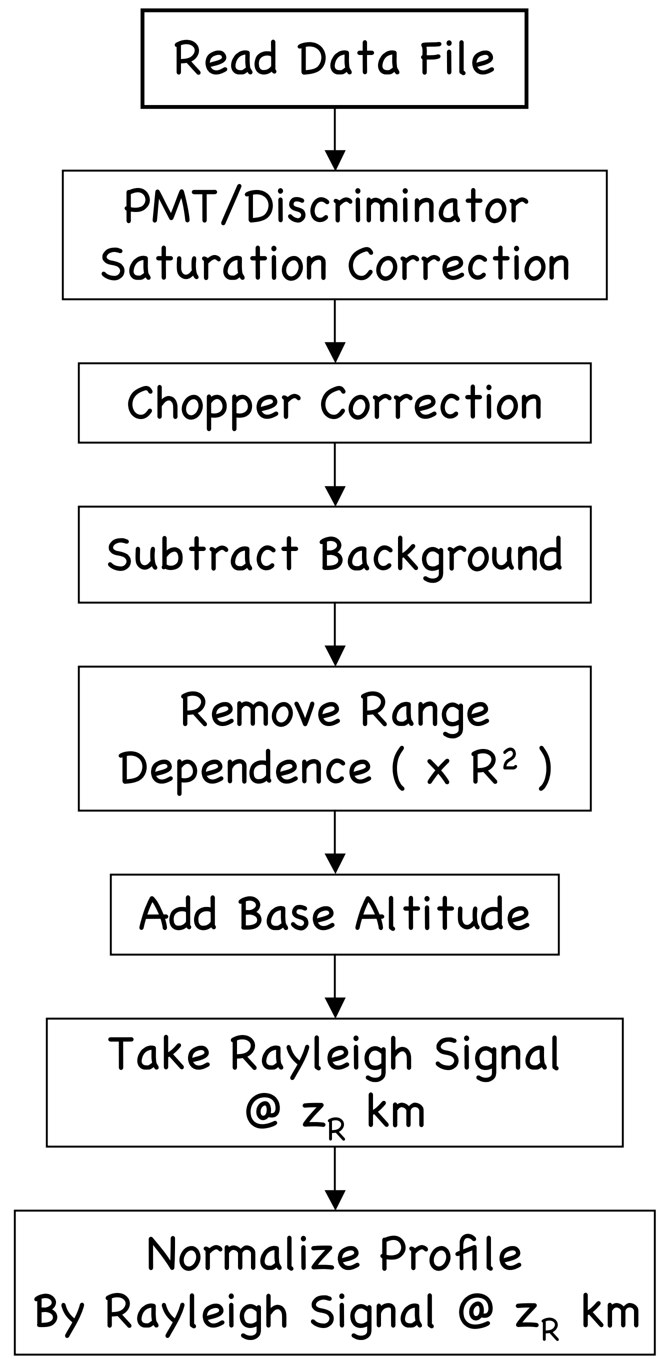
$$N_S(\lambda,z) = \left(\frac{P_L(\lambda)\Delta t}{hc/\lambda}\right)\left(\sigma_{eff}(\lambda)n_c(z)R_B(\lambda)\Delta z\right)\left(\frac{A}{4\pi z^2}\right)\left(T_a^{\ 2}(\lambda)E^2(\lambda,z)\right)\left(\eta(\lambda)G(z)\right) + N_B\Delta t$$

$$N_R(\lambda,z_R) = \left(\frac{P_L(\lambda)\Delta t}{hc/\lambda}\right)\left(\sigma_R(\pi,\lambda)n_R(z_R)\Delta z\right)\left(\frac{A}{z_R^{\ 2}}\right)T_a^{\ 2}(\lambda,z_R)\left(\eta(\lambda)G(z_R)\right) + N_B\Delta t$$

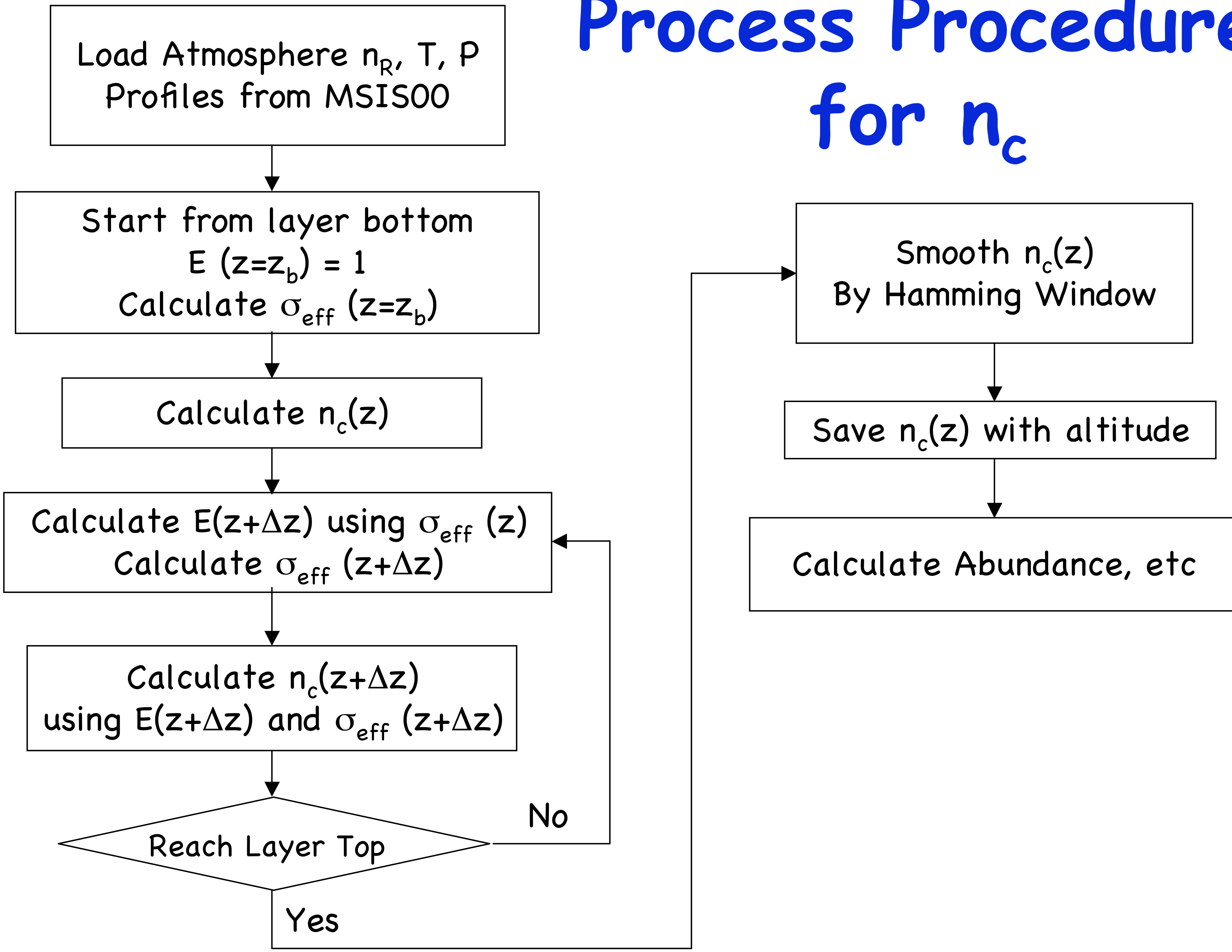
$$\frac{n_c(z)}{n_R(z_R)} = \frac{N_S(\lambda,z) - N_B\Delta t}{N_R(\lambda,z_R) - N_B\Delta t}\cdot\frac{z^2}{z_R^{\ 2}}\cdot\frac{4\pi\sigma_R(\pi,\lambda)}{\sigma_{eff}(\lambda)R_B(\lambda)}\cdot\frac{T_a^{\ 2}(\lambda,z_R)G(z_R)}{T_a^{\ 2}(\lambda,z)E^2(\lambda,z)G(z)}$$

$$n_c(z) = n_R(z_R)\frac{N_S(\lambda,z) - N_B\Delta t}{N_R(\lambda,z_R) - N_B\Delta t}\cdot\frac{z^2}{z_R^{\ 2}}\cdot\frac{4\pi\sigma_R(\pi,\lambda)}{\sigma_{eff}(\lambda)R_B(\lambda)}\cdot\frac{1}{E^2(\lambda,z)}$$

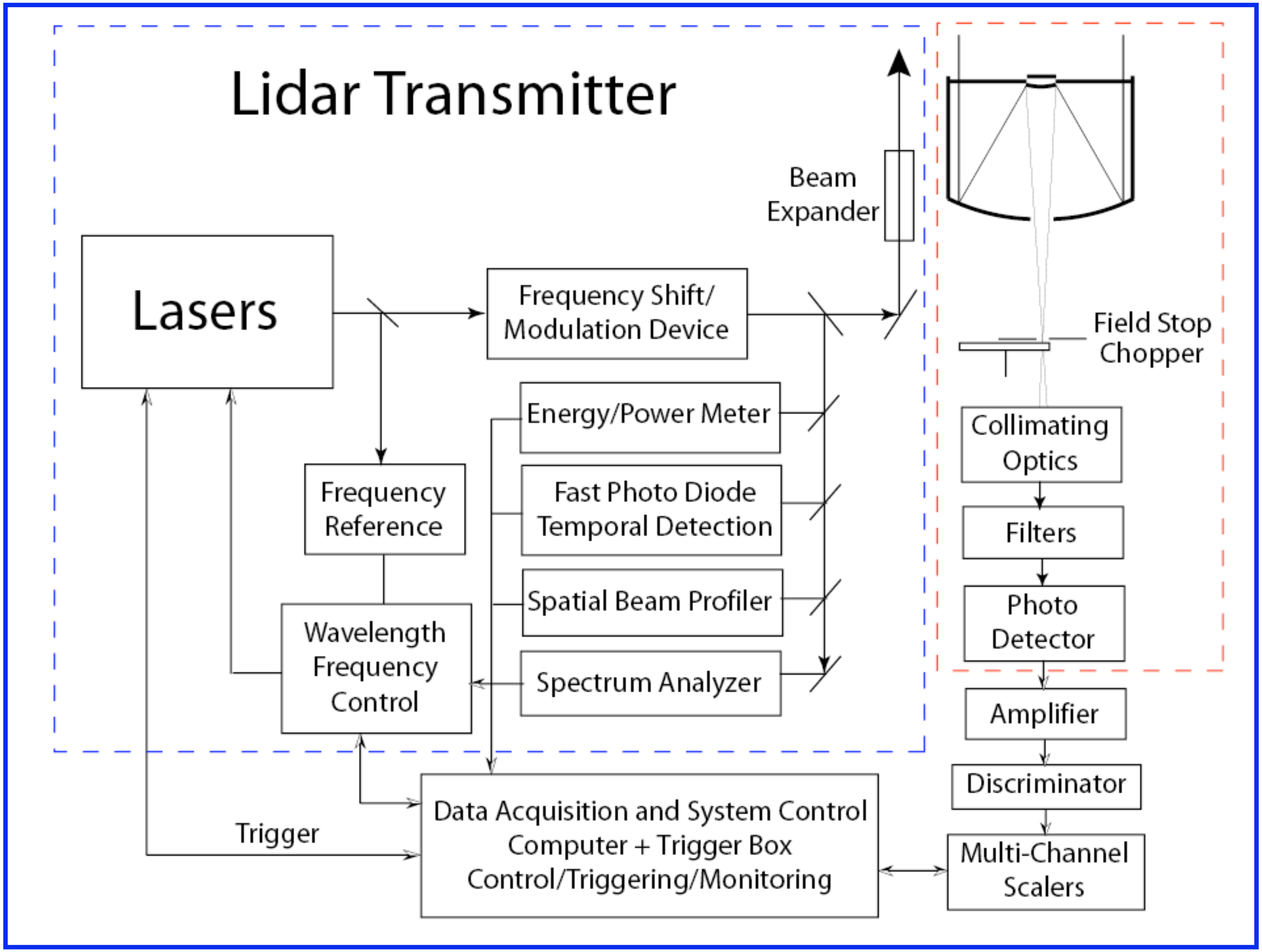
Preprocess Procedure Flow Chart



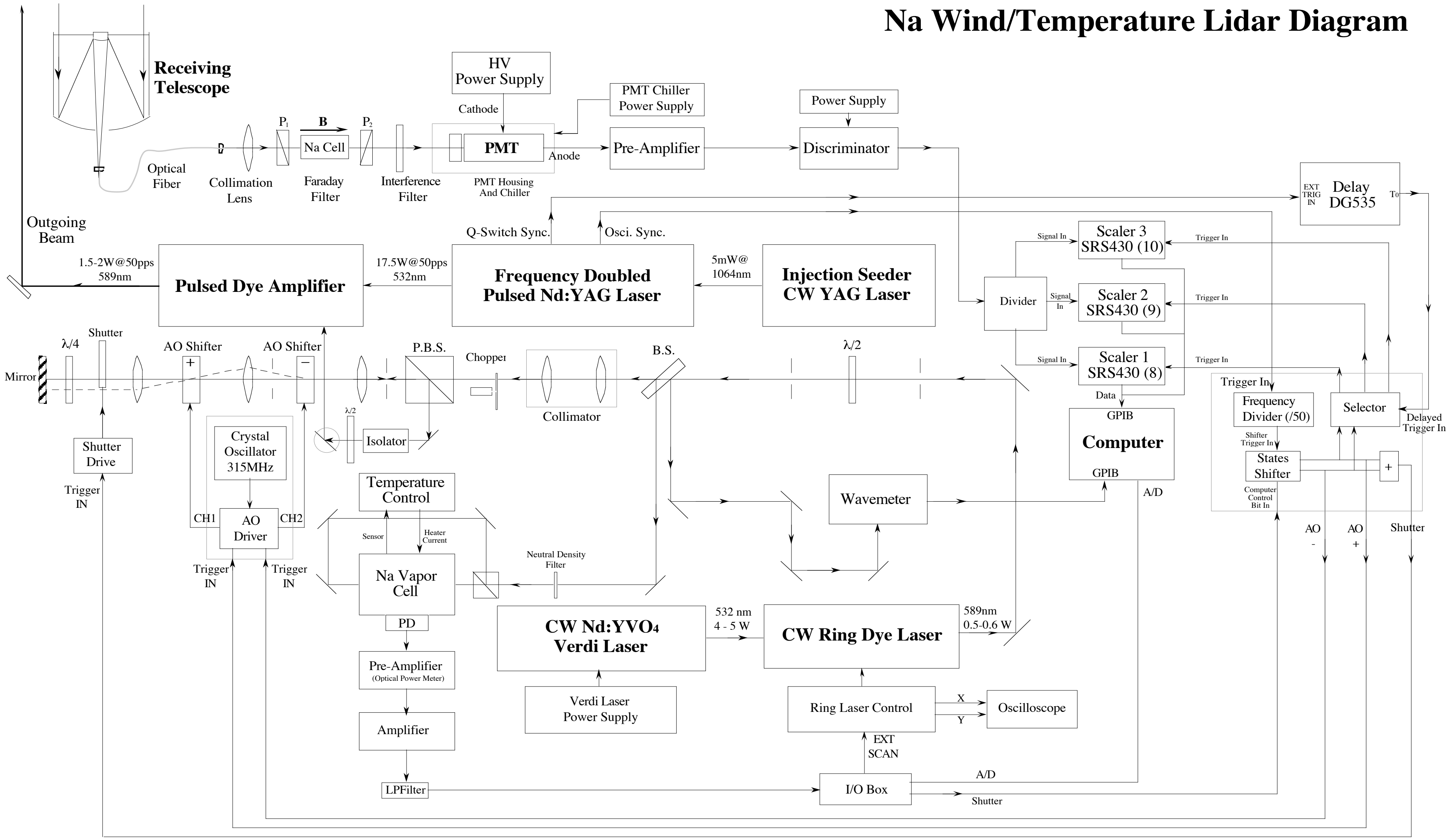
Process Procedure for n_c



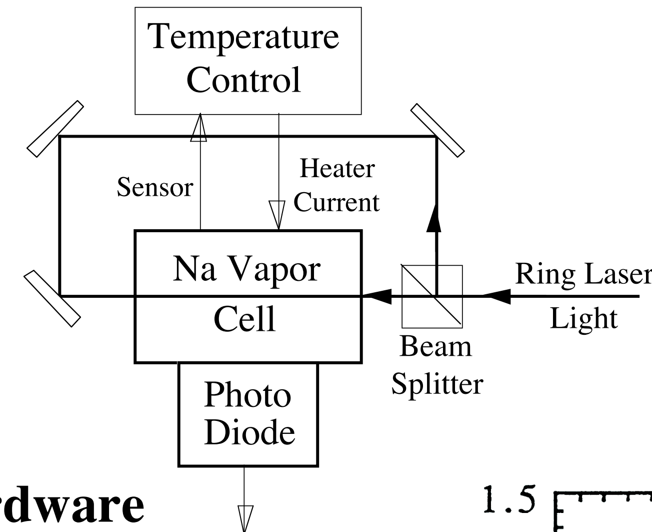
Basic Architecture of LIDAR



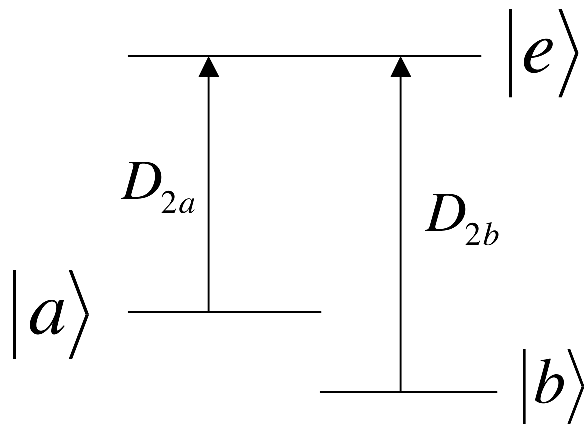
Na Doppler Lidar



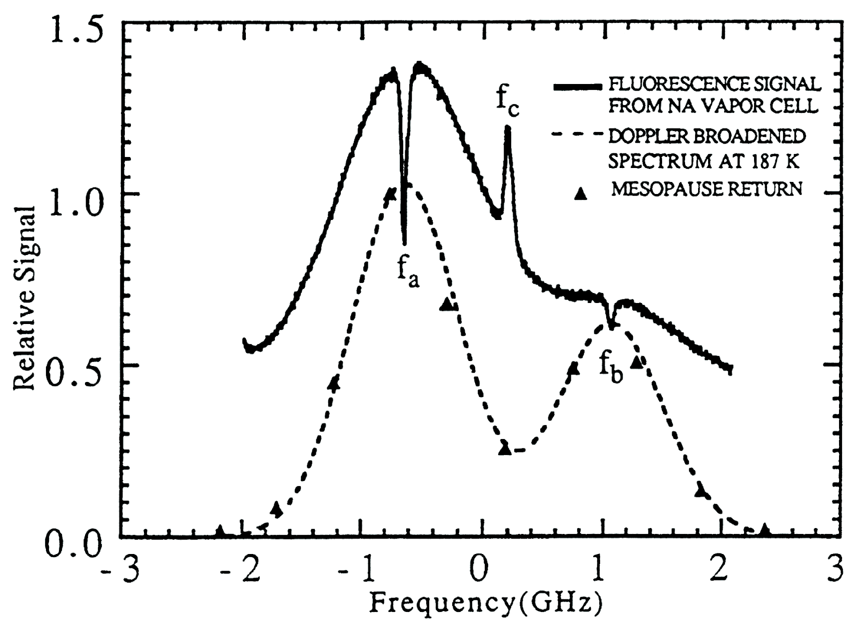
Na Saturation-Absorption Spectroscopy



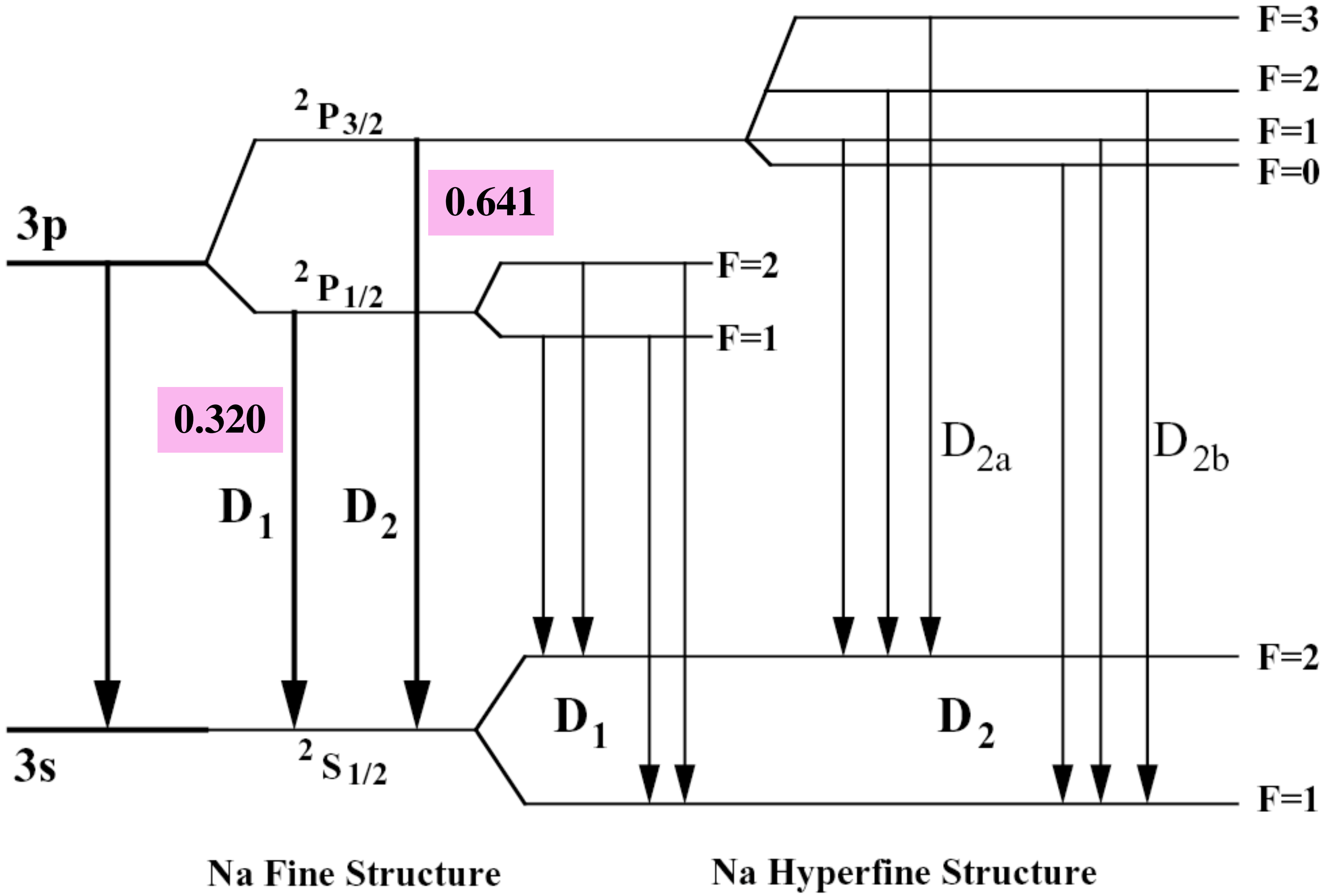
Hardware



3-Level Explanation



Example: Na Doppler Lidar Principle



Energy Level Diagram of Atomic Na

Open Discussions