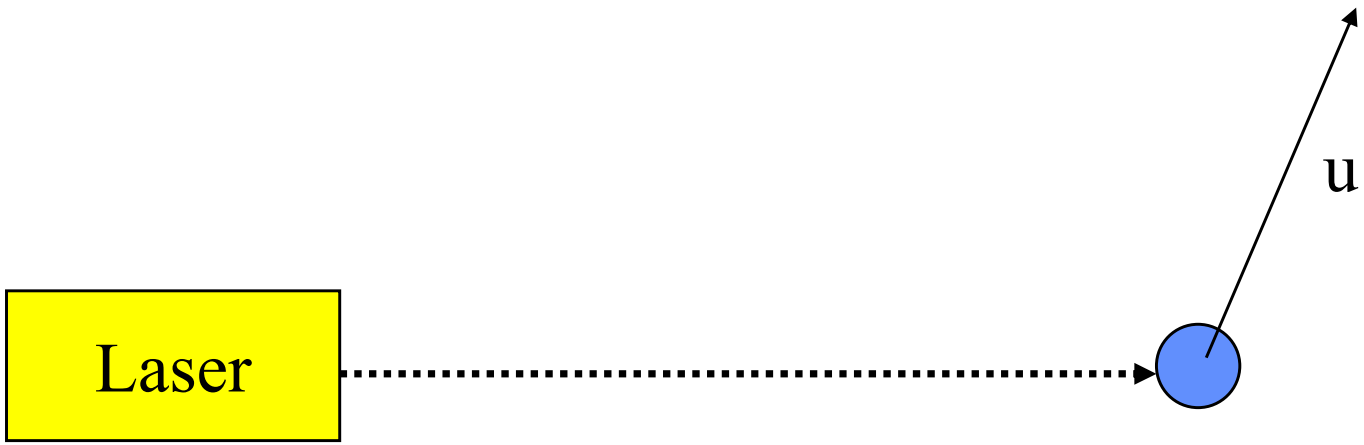
Laser Doppler velocimetry

Contents

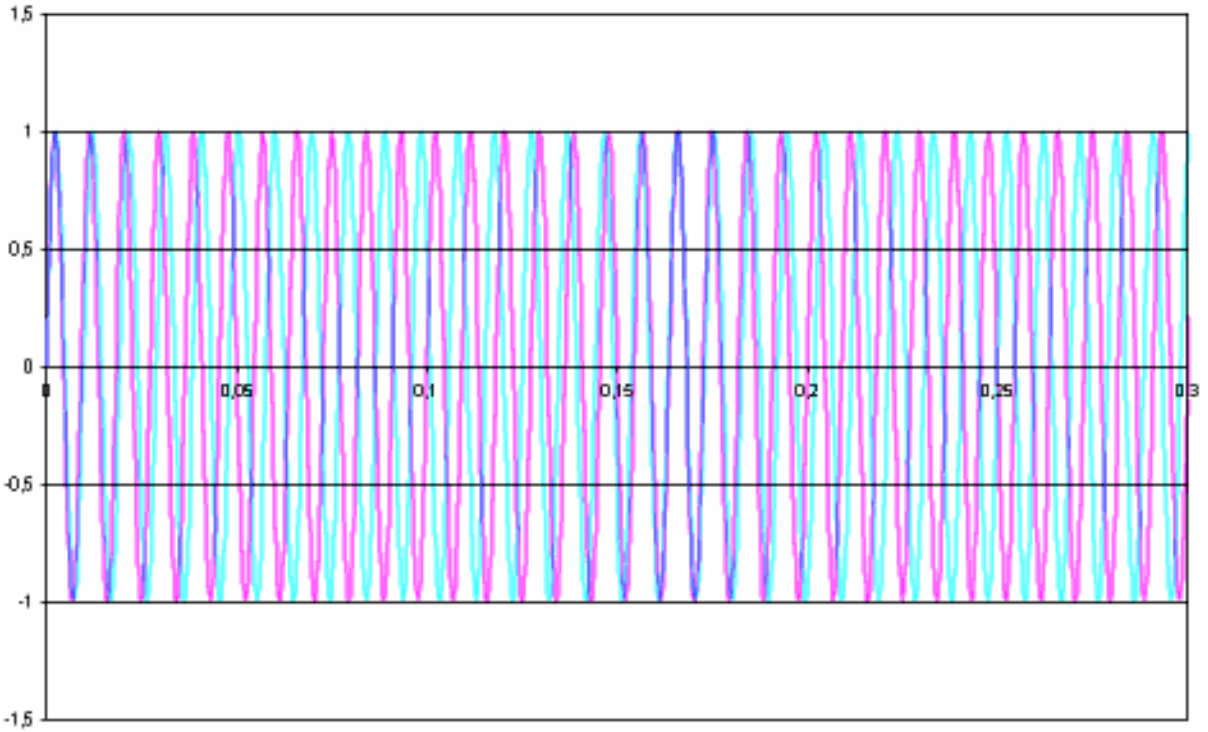

u
Laser

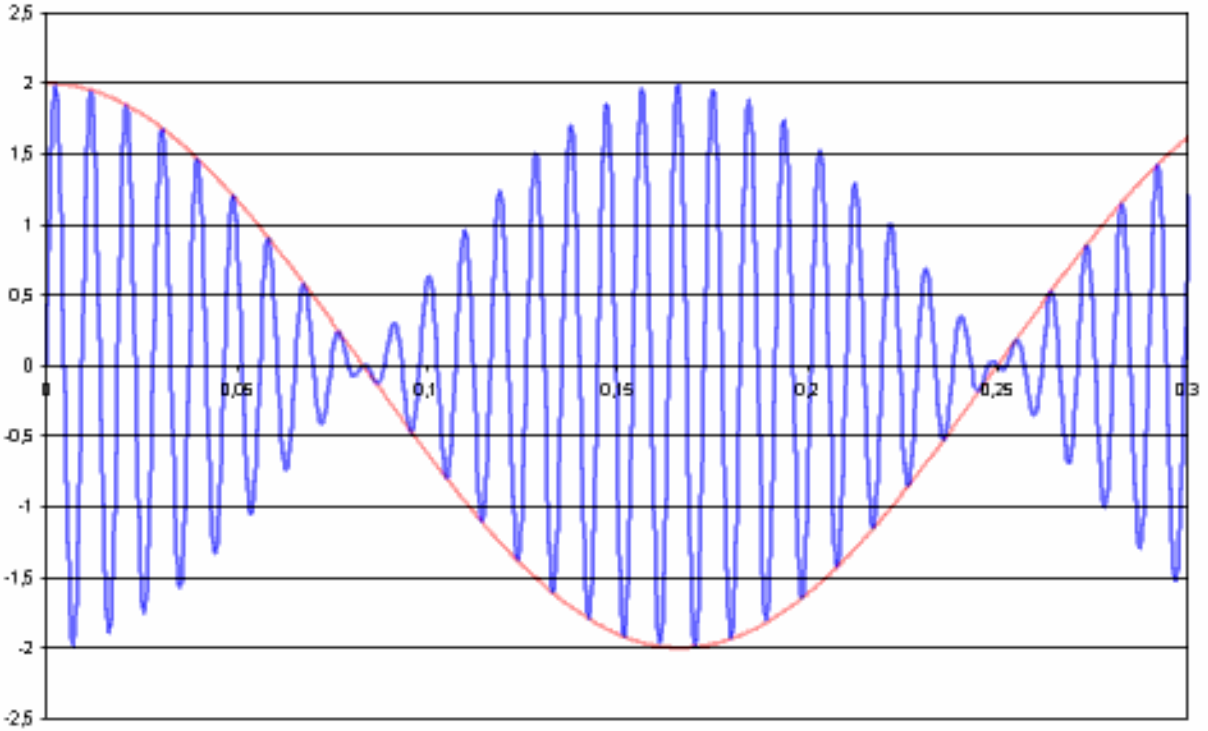
Beat frequency

$$f_{beat} = f_1 - f_2$$

Example:
Difference tone in music

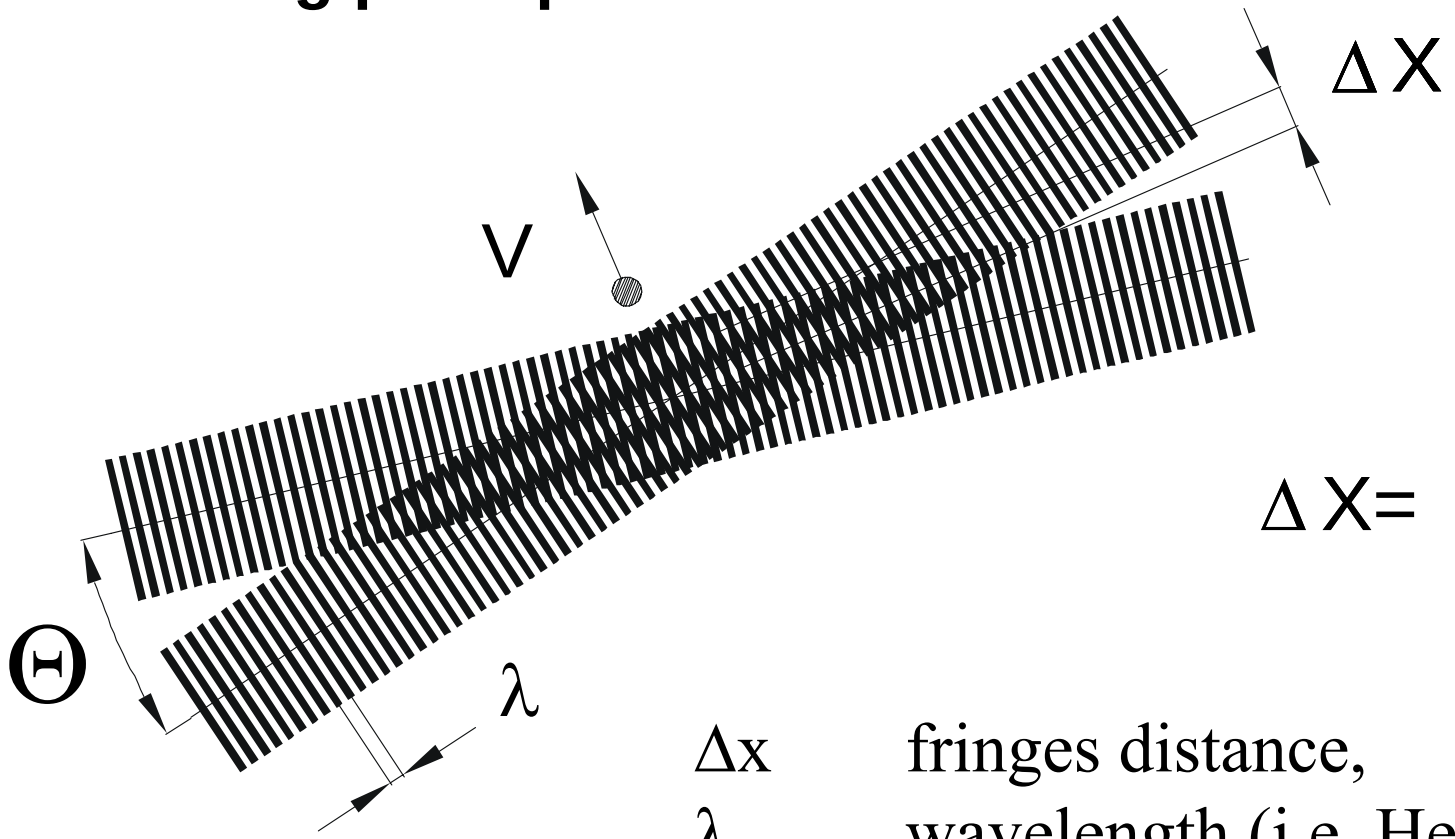
(show example)





Fringe model

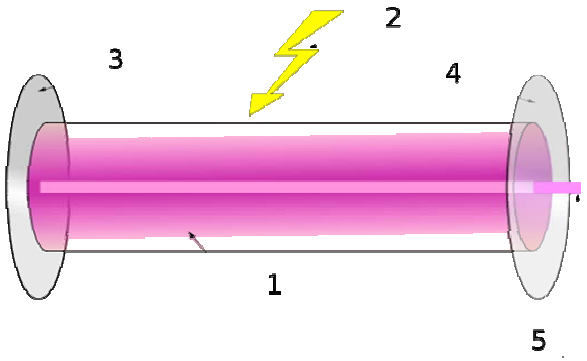
Measuring principle LDV



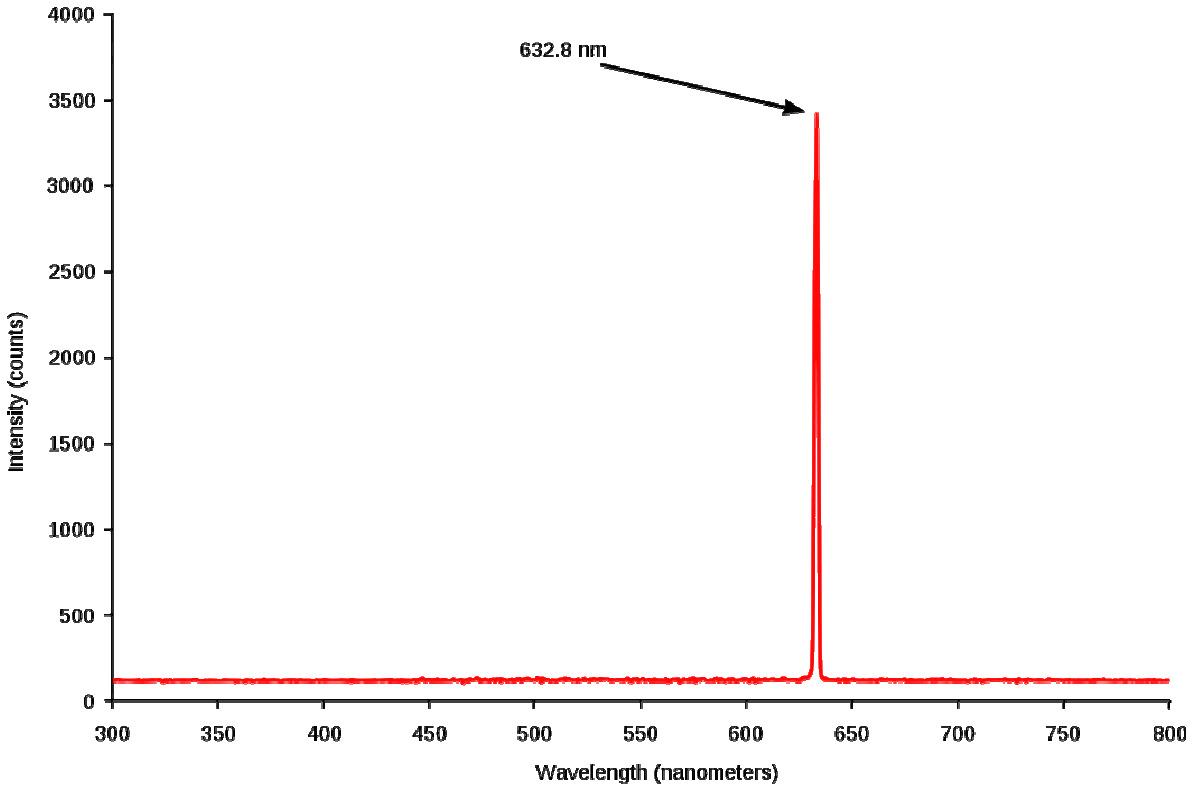
$$\Delta X = \frac{\lambda}{2 \sin(\Theta/2)}$$

Δx	fringes distance,
λ	wavelength (i.e. HeNe 632,8 nm),
α	crossing angle of the laser beams.

Lasers applied:
-continuous wave operation (CW)
-Mostly gas lasers: He-Ne (very high spectral purity)
- Argon-Ion one or more of these transitions can be lasing simultaneously; the most commonly used lines are 458 nm, 488 nm and 514.5 nm.

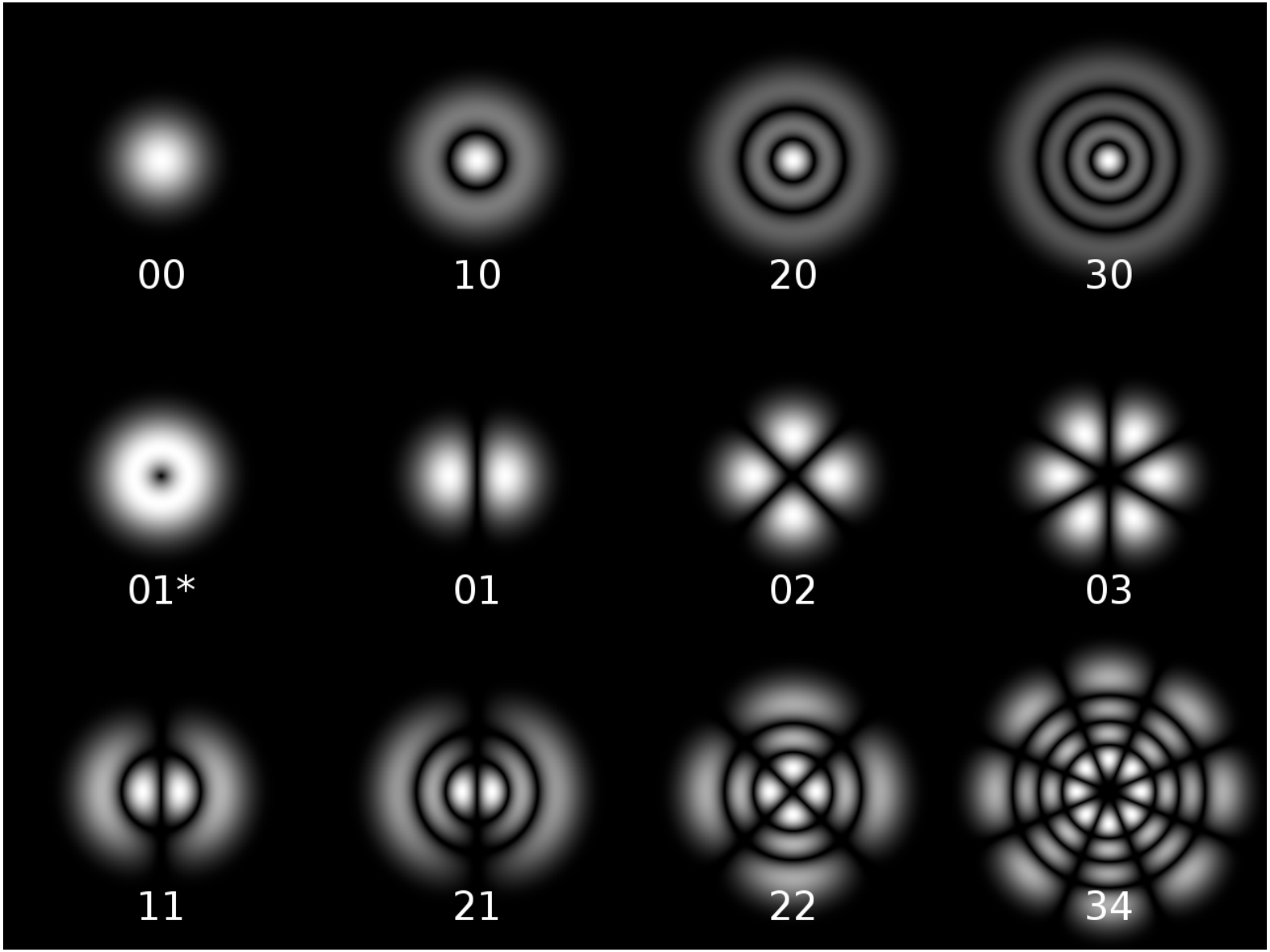


Principal components:
1. Gain medium
2. Laser pumping energy
3. High reflector
4. Output coupler
5. Laser beam

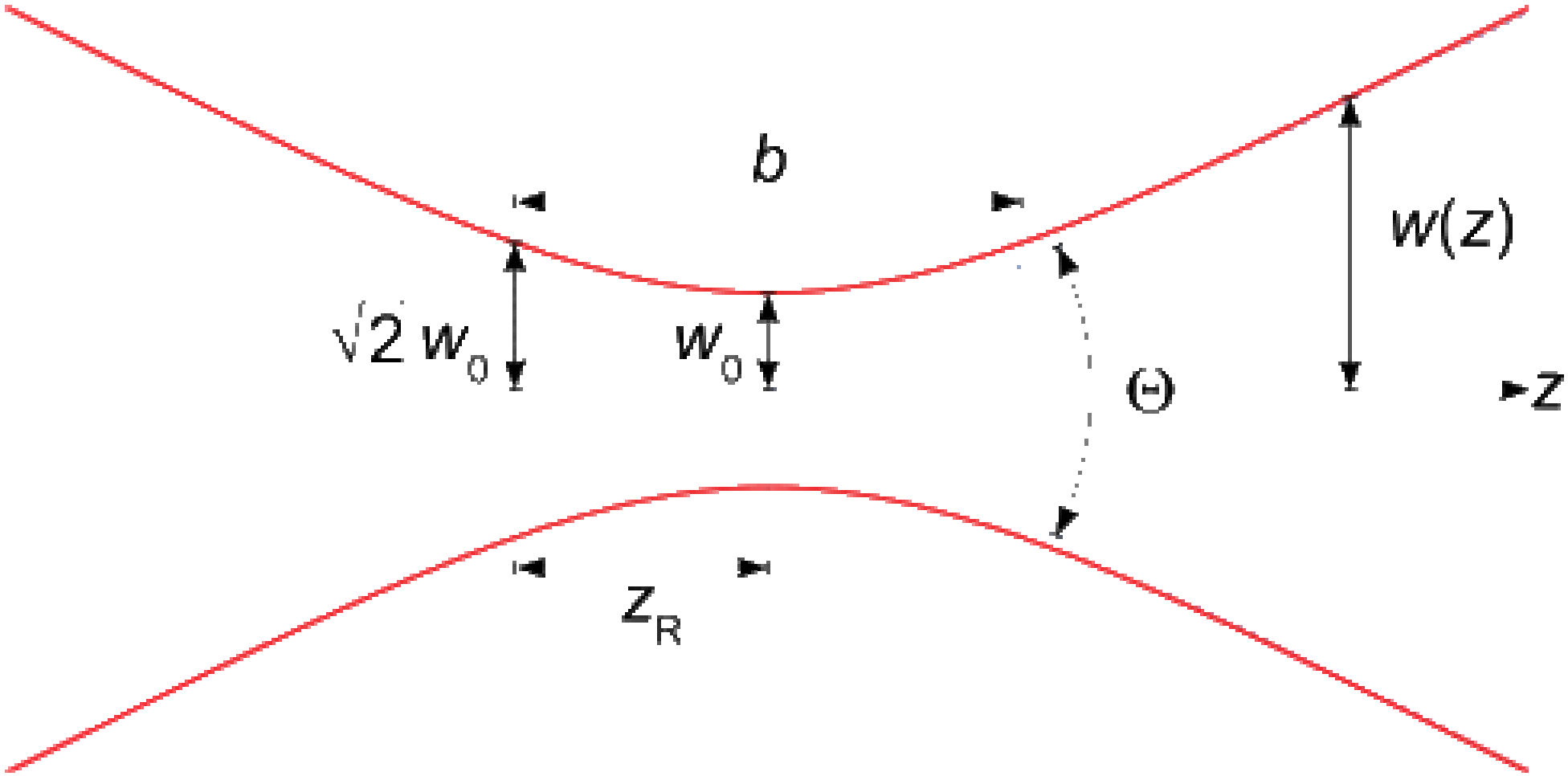


Laser beam properties:
-Intensity not homogenieous due to the construction of the optical resonator. Transverse modes occur

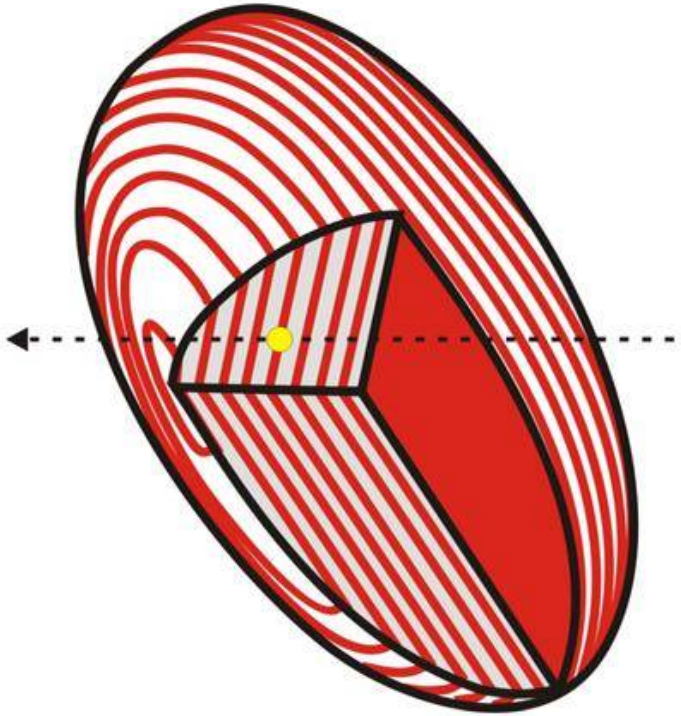
-TEM 00 : first mode: Gaussian

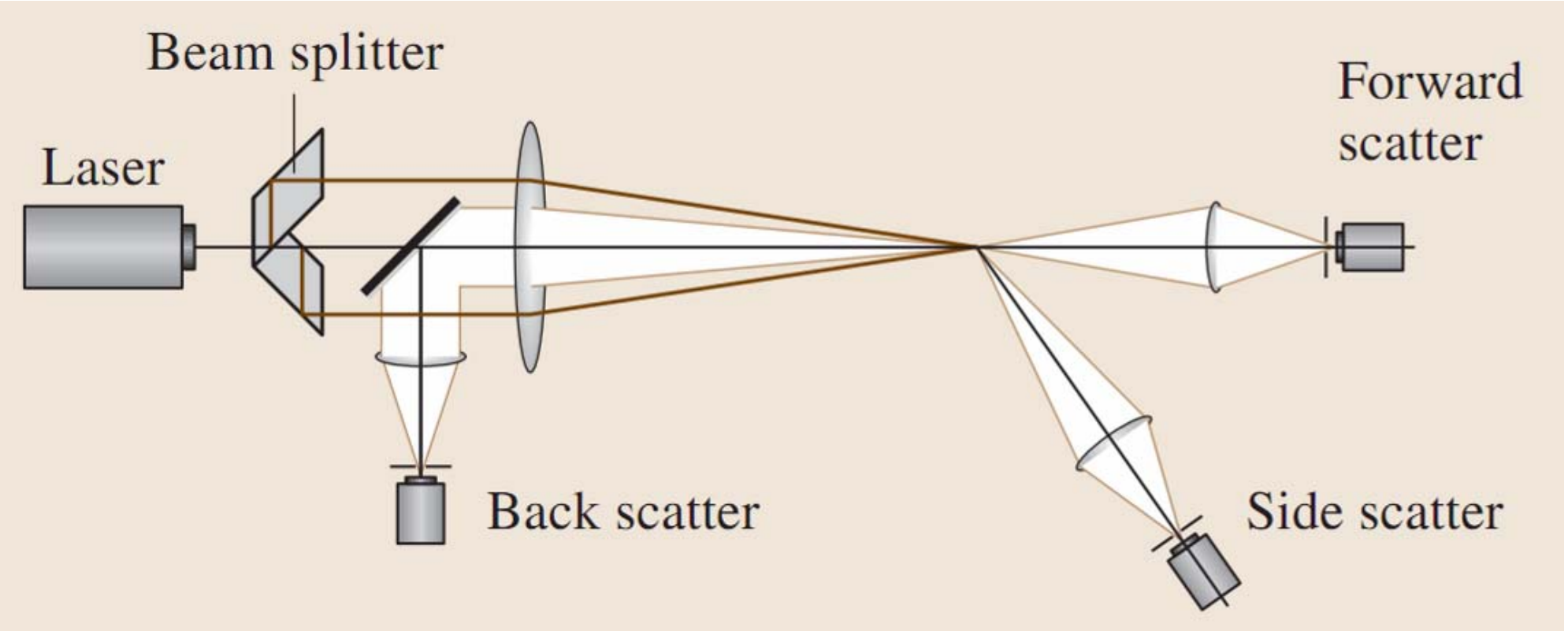


Laser beam properties:
-Diffraction
- needs focussing



Measurement volume:
Ellipsoid
Typical size : 40 – 200μm
Length : 1-3 mm
No. of fringes: about 50




Beam splitter
Laser
Forward
scatter
Back scatter
Side scatter

Mie-Lorenz szóródás

Wavelength and particle size are in same order of magnitude:

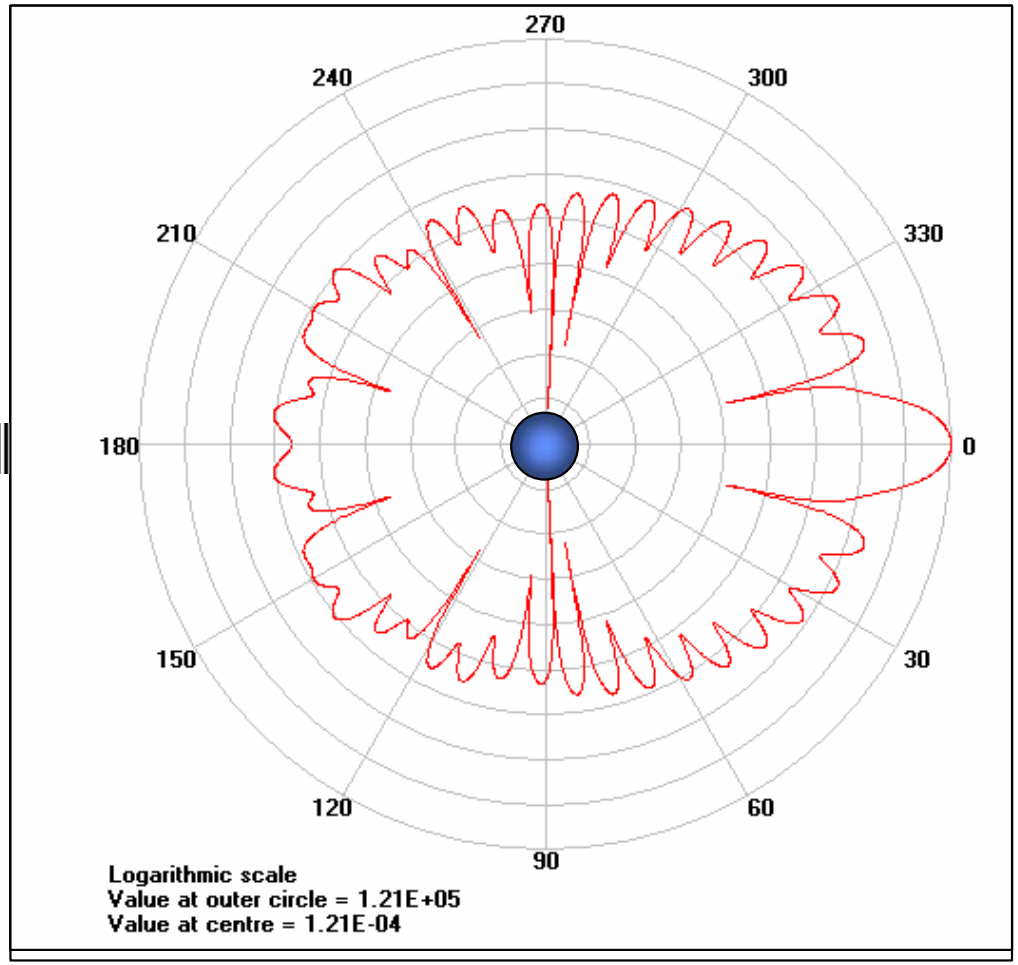
⇨ **Mie-Lorenz scattering**

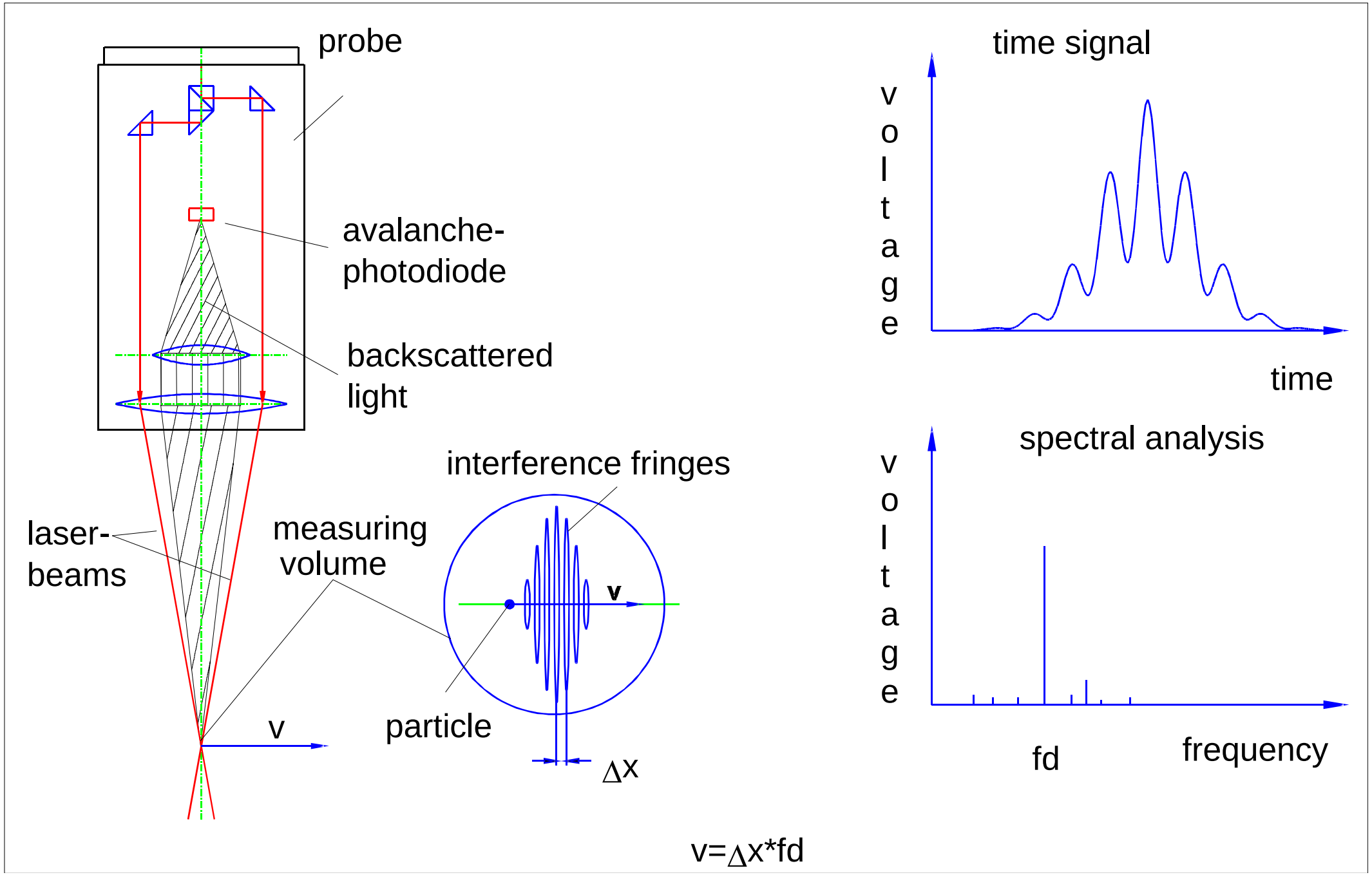
Direction dependent scattering

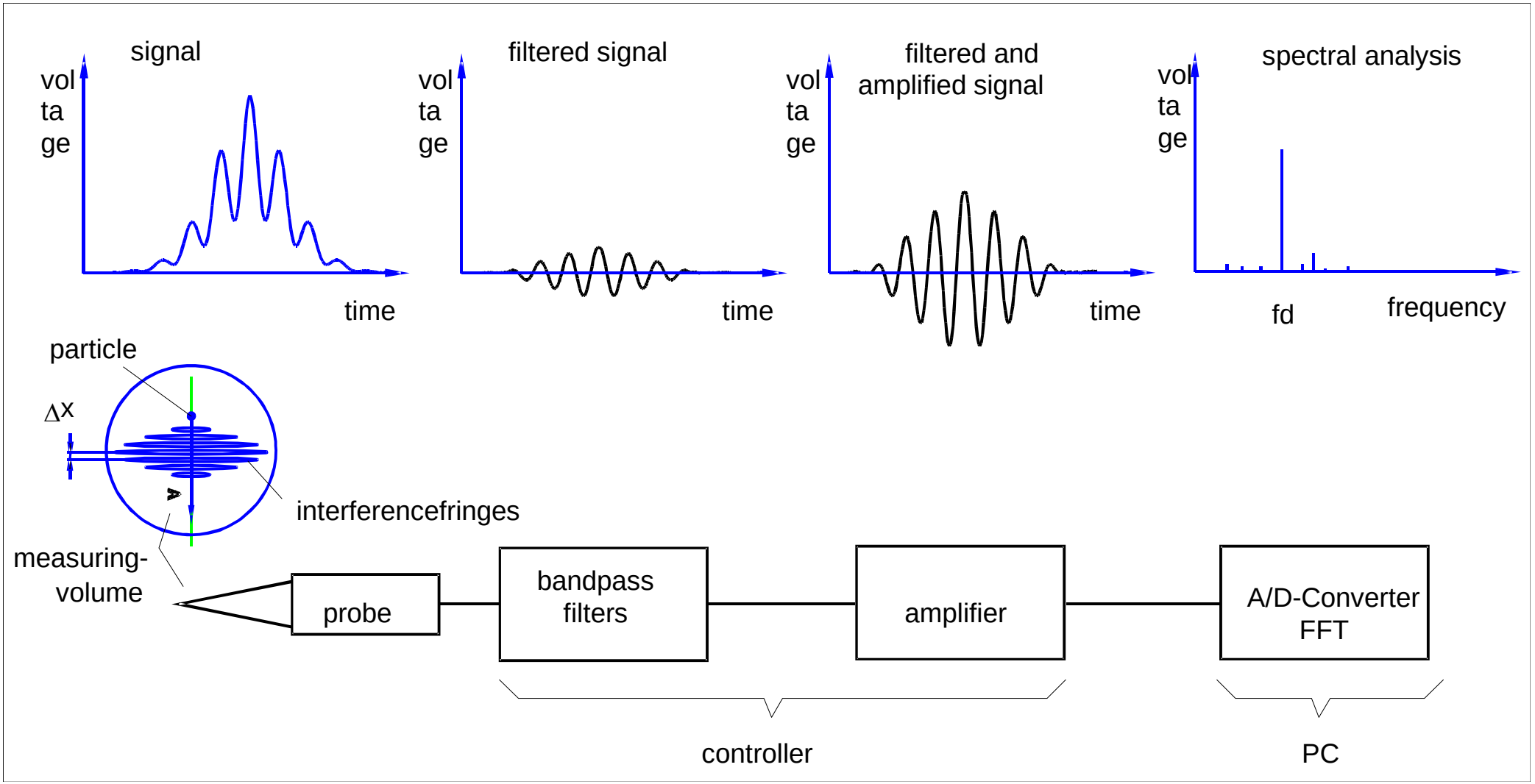
Colour	Wavelength [nm]
blue	420-490
green	490-575
red	650-750

Incoming light 650nm

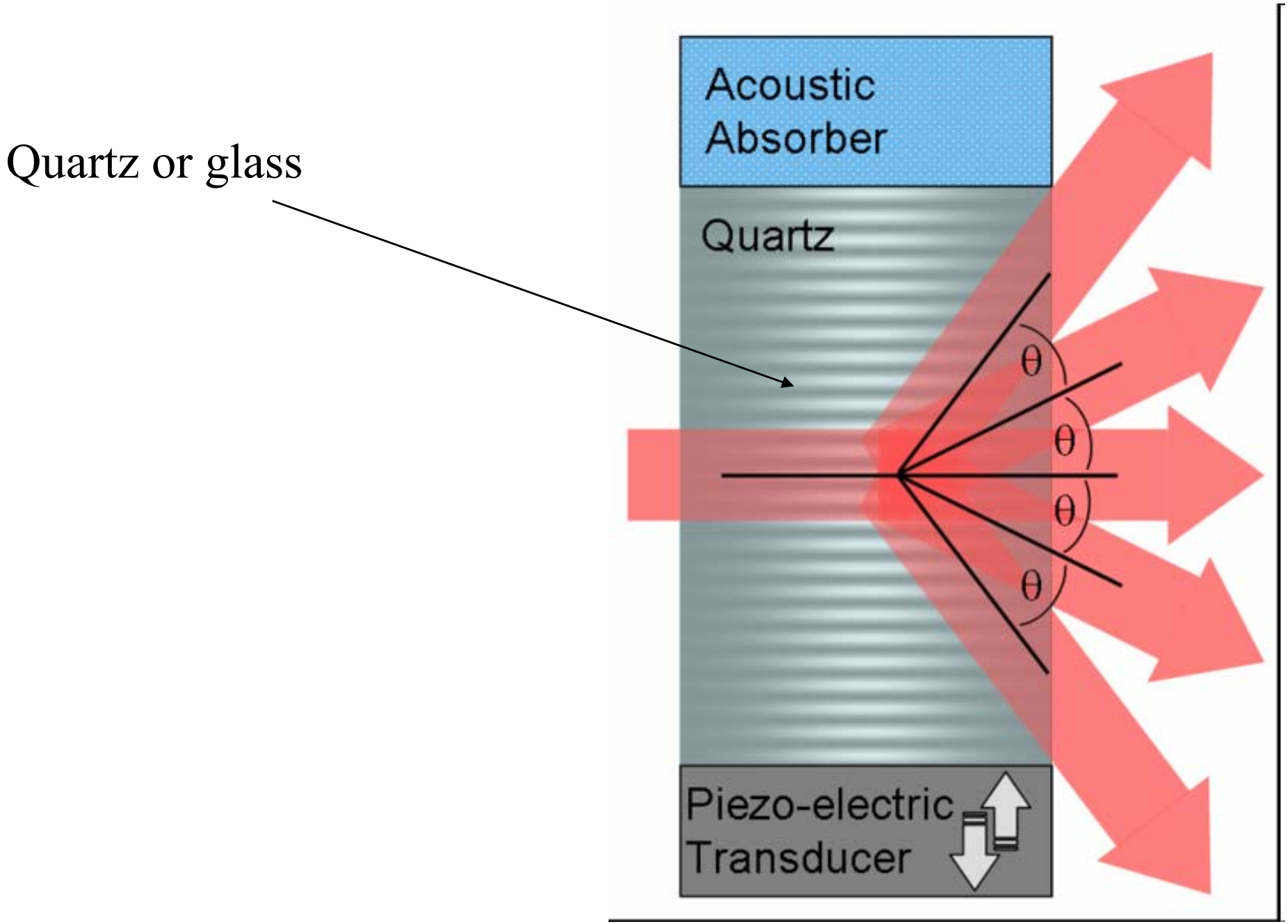
0.3 μm
1μm
5μm

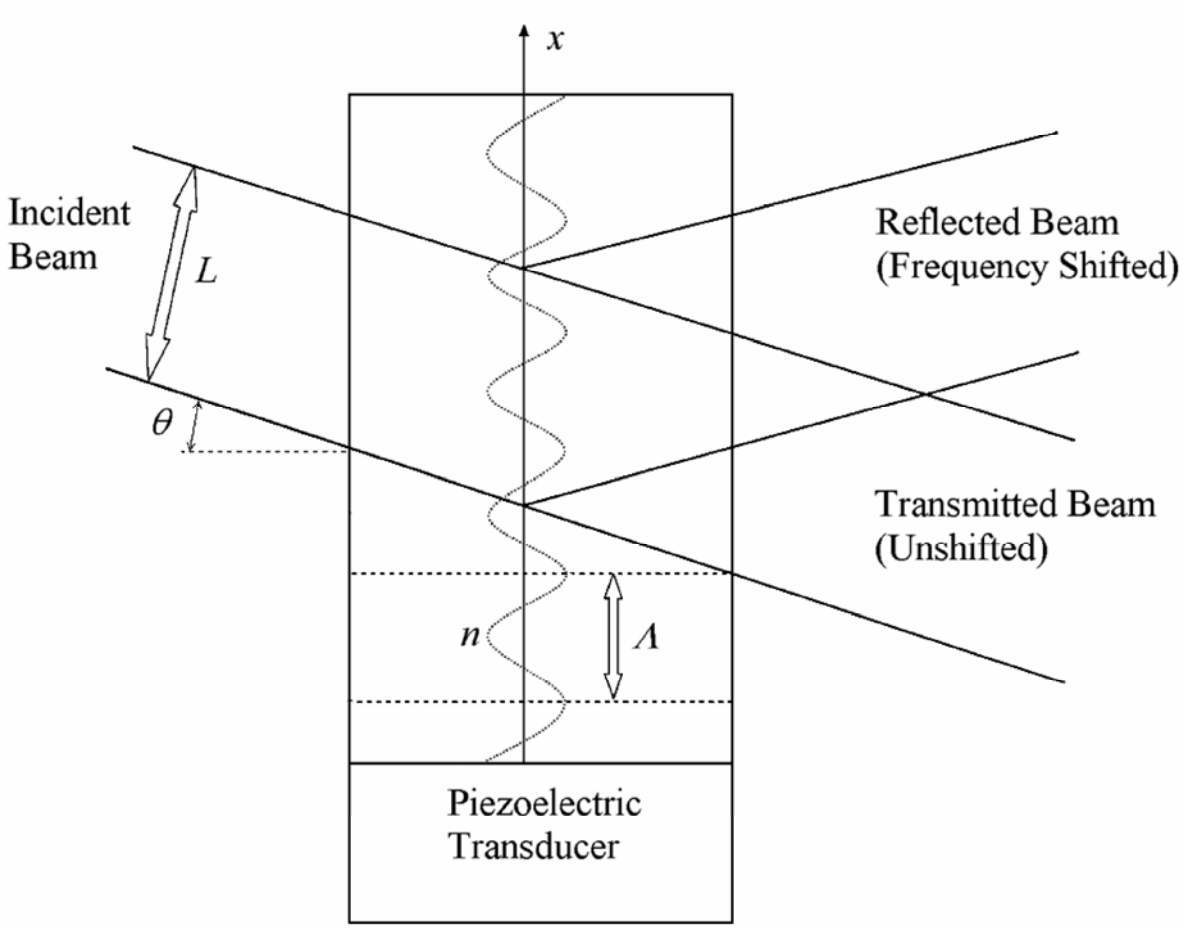



probe
avalanche-
photodiode
backscattered
light
laser-
beams
measuring
volume
interference fringes
v
particle
Δx
time signal
voltage
time
spectral analysis
voltage
fd
frequency
v=Δx*fd


signal
voltage
time
filtered signal
voltage
time
filtered and amplified signal
voltage
time
spectral analysis
voltage
fd
frequency
particle
Δx
interferencefringes
measuring-volume
probe
bandpass filters
amplifier
A/D-Converter FFT
controller
PC

acousto-optic modulator (AOM) / Bragg cell

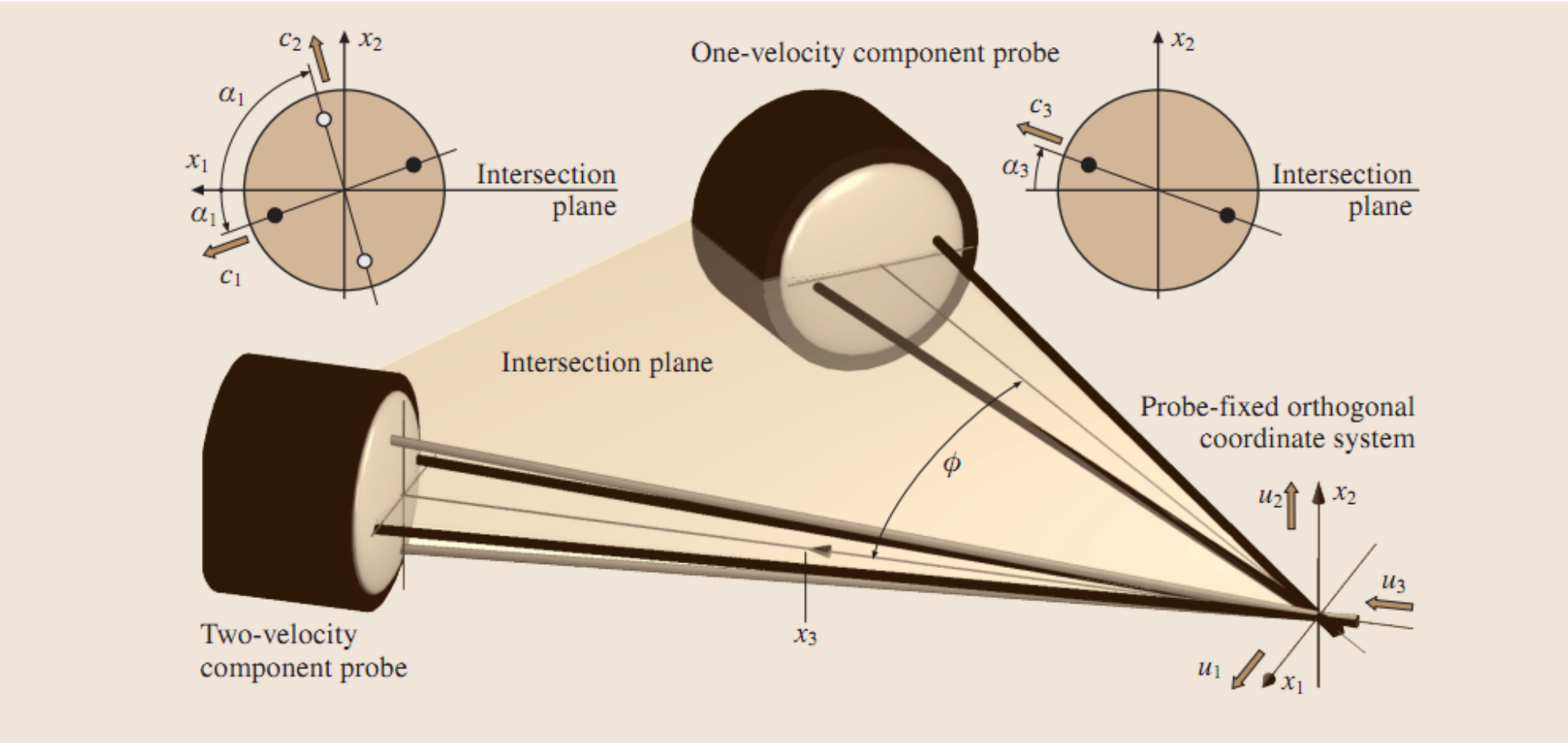


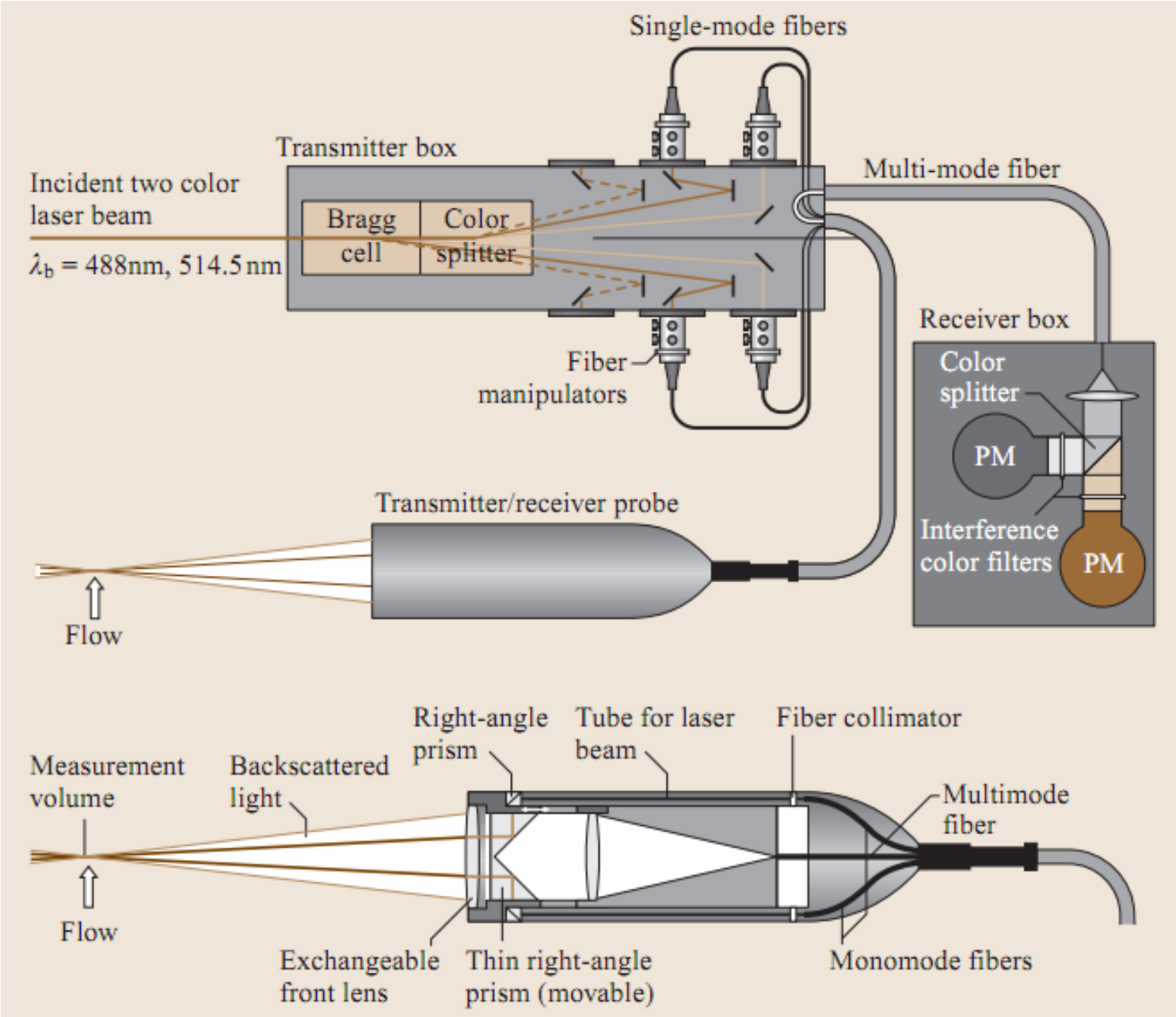


n (refractive index) is changing due to change of density in the wave.
Reflections occur on moving sound waves.

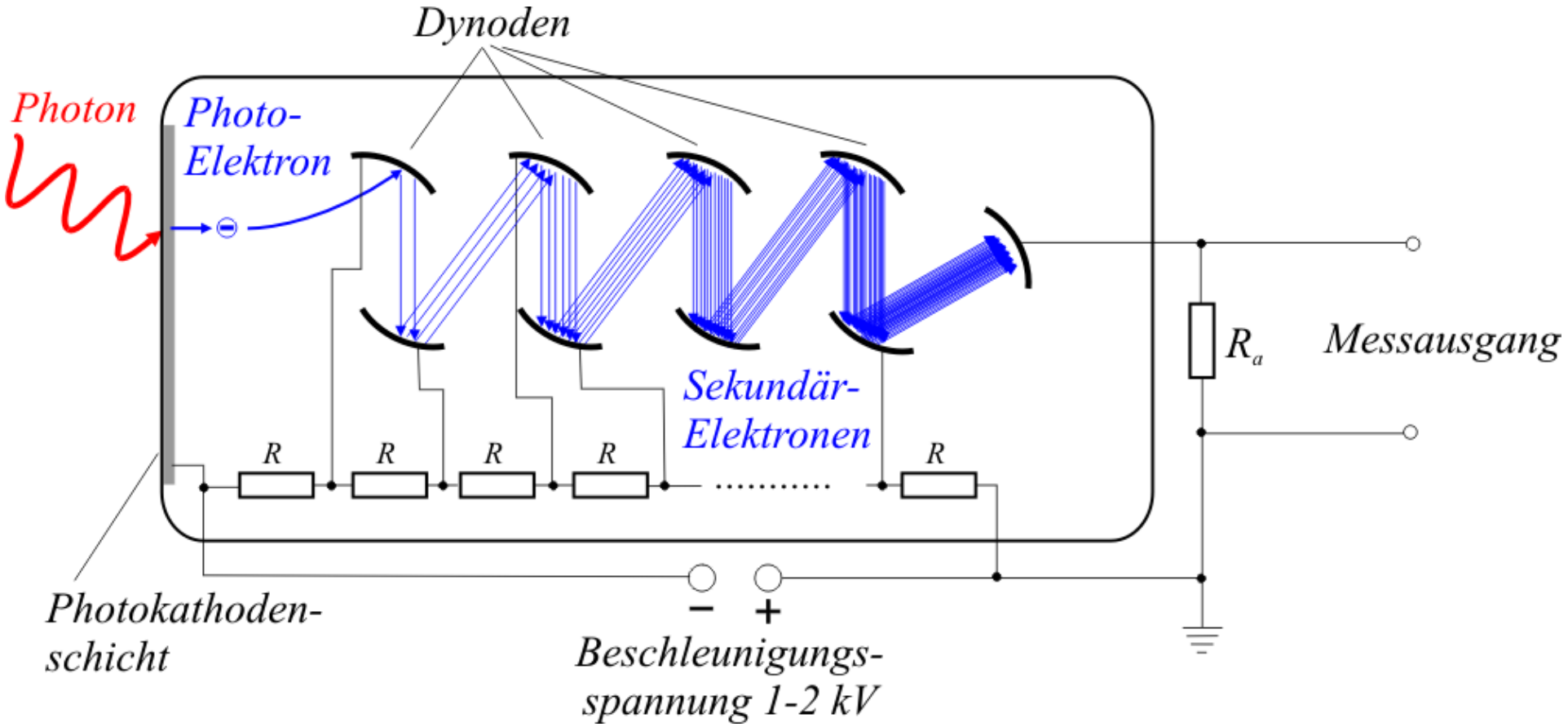
$f_n = f_0 + K f_e$
K : order of the beam

Multi component systems




Single-mode fibers
Transmitter box
Incident two color laser beam
λ_b = 488nm, 514.5 nm
Bragg cell
Color splitter
Multi-mode fiber
Receiver box
Color splitter
PM
Interference color filters
PM
Fiber manipulators
Transmitter/receiver probe
Flow
Right-angle prism
Tube for laser beam
Fiber collimator
Measurement volume
Backscattered light
Multimode fiber
Flow
Exchangeable front lens
Thin right-angle prism (movable)
Monomode fibers

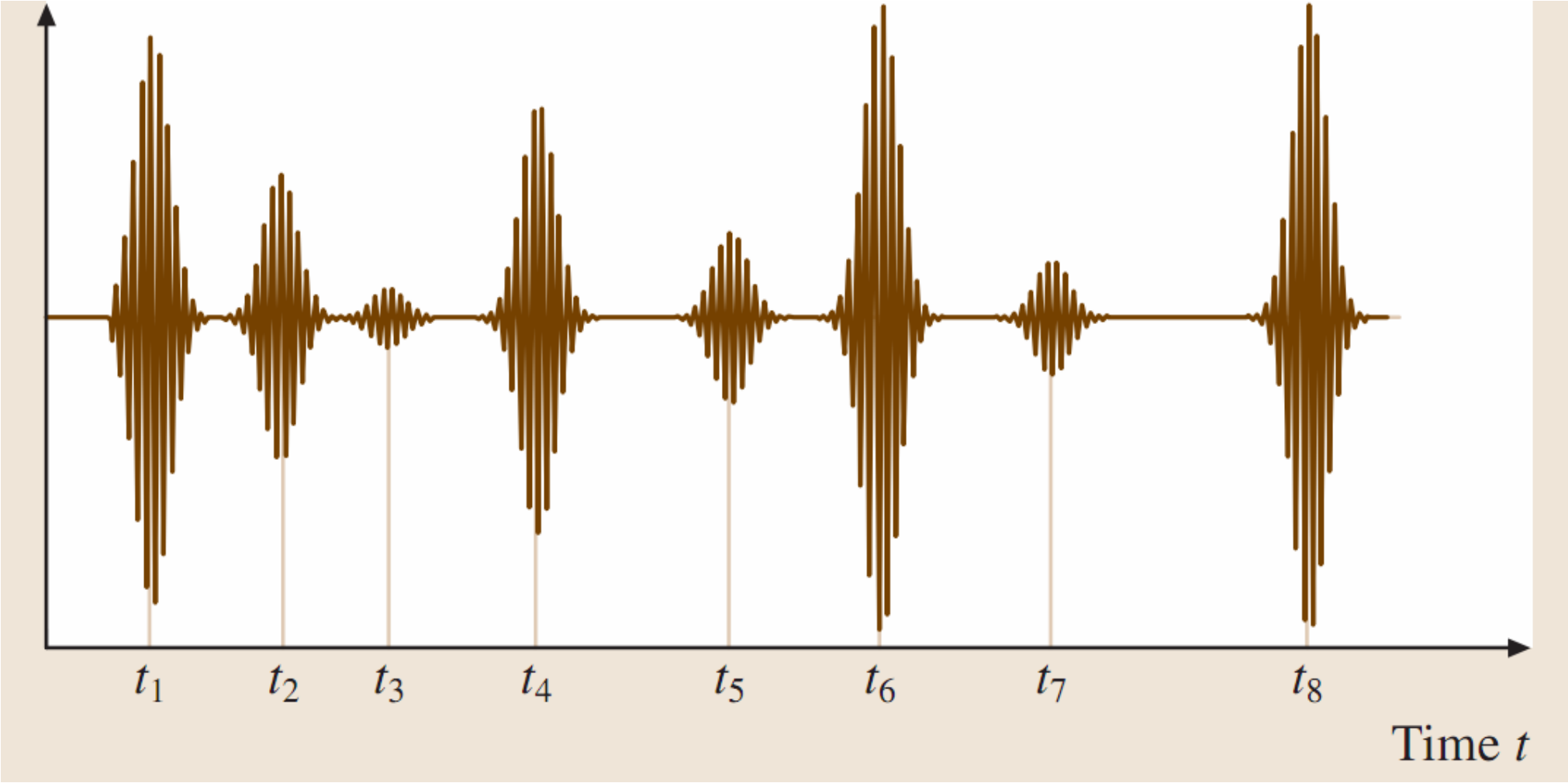
Photomultiplier



Vacuum tube with electrodes
-Photoelectric effect: electron released due to incident photon
- very high gain
multiply the current produced by incident light by as much as 100 million times (i.e., 160 dB),
in multiple dynode stages, enabling (for example) individual photons to be detected

Signal processing
-tracker
-counter
-transient recorder

Transient recorder



Continuous data acquisition would require huge amount of memory
Only burst should be recorded
-Triggering
-Sample length, digitization frequency, Shannon rule, resolution