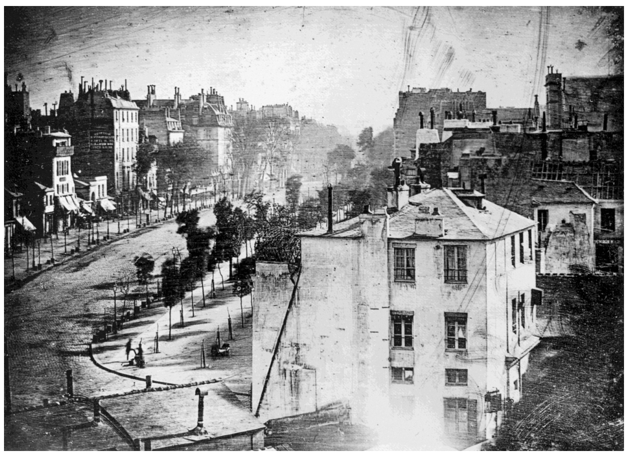
Detecting light

- How do we detect light?

Detecting light

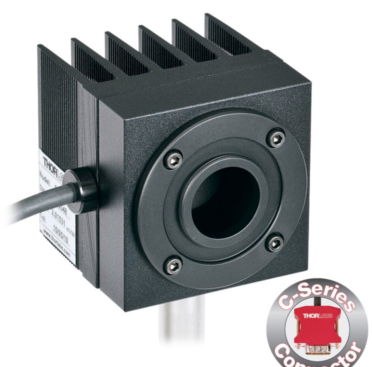
Eyes

Chemical change



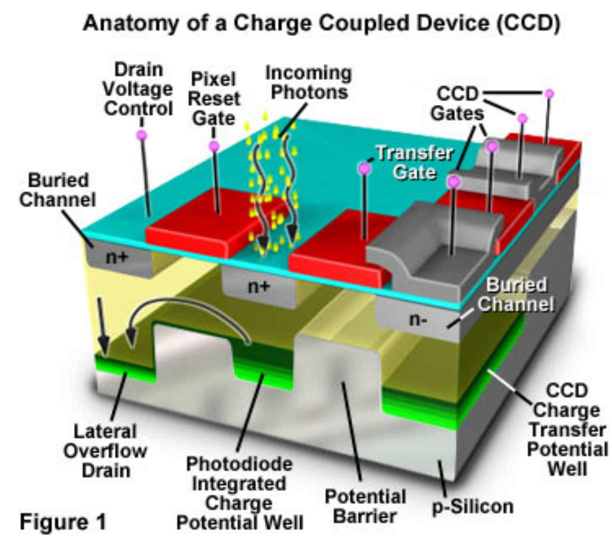
Daguerre

Thermal sensor

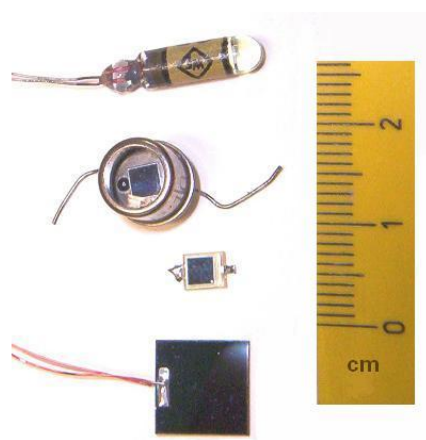


Thorlabs

Photoelectric effect



National high magnetic field lab



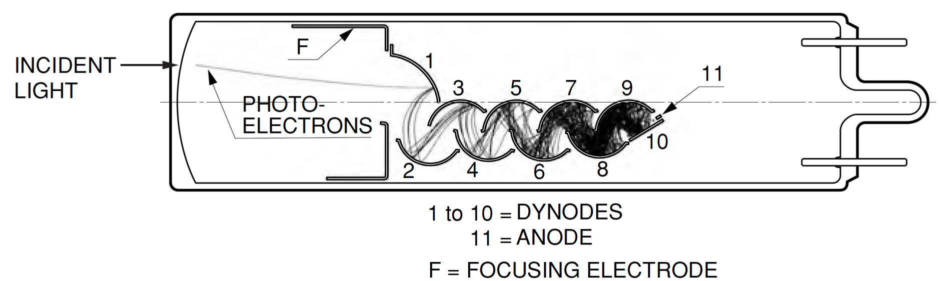
Photodiodes - Wikipedia

What do we care about in a detector?

- Quantum efficiency
- Gain
- Noise amplitude
- Noise spectrum
- Dark current
- Response time
- Linearity
- Spectral response

Photomultiplier tubes

1 photoelectron multiplied in a cascading series of dynodes

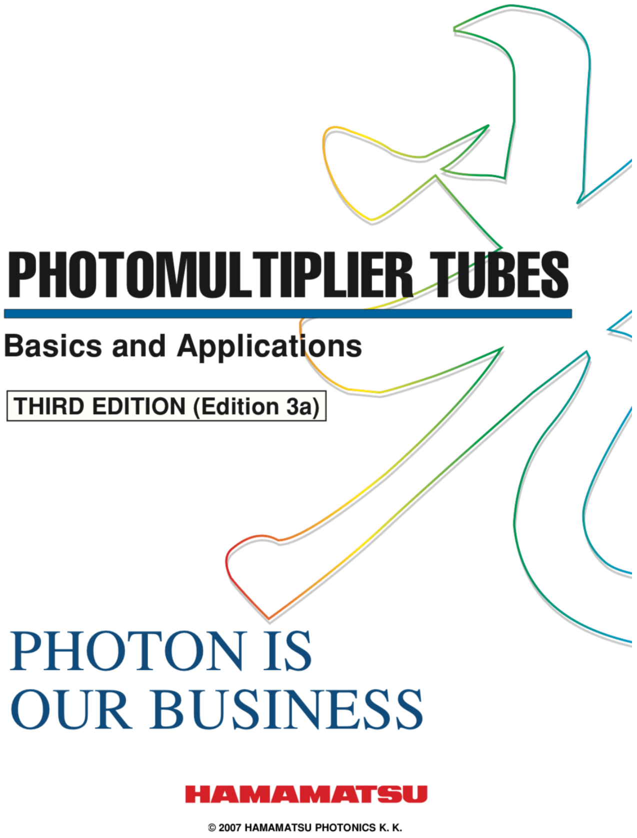


Large amplification of signal
High temporal resolution

Pictures from Hamamatsu website/PMT guide

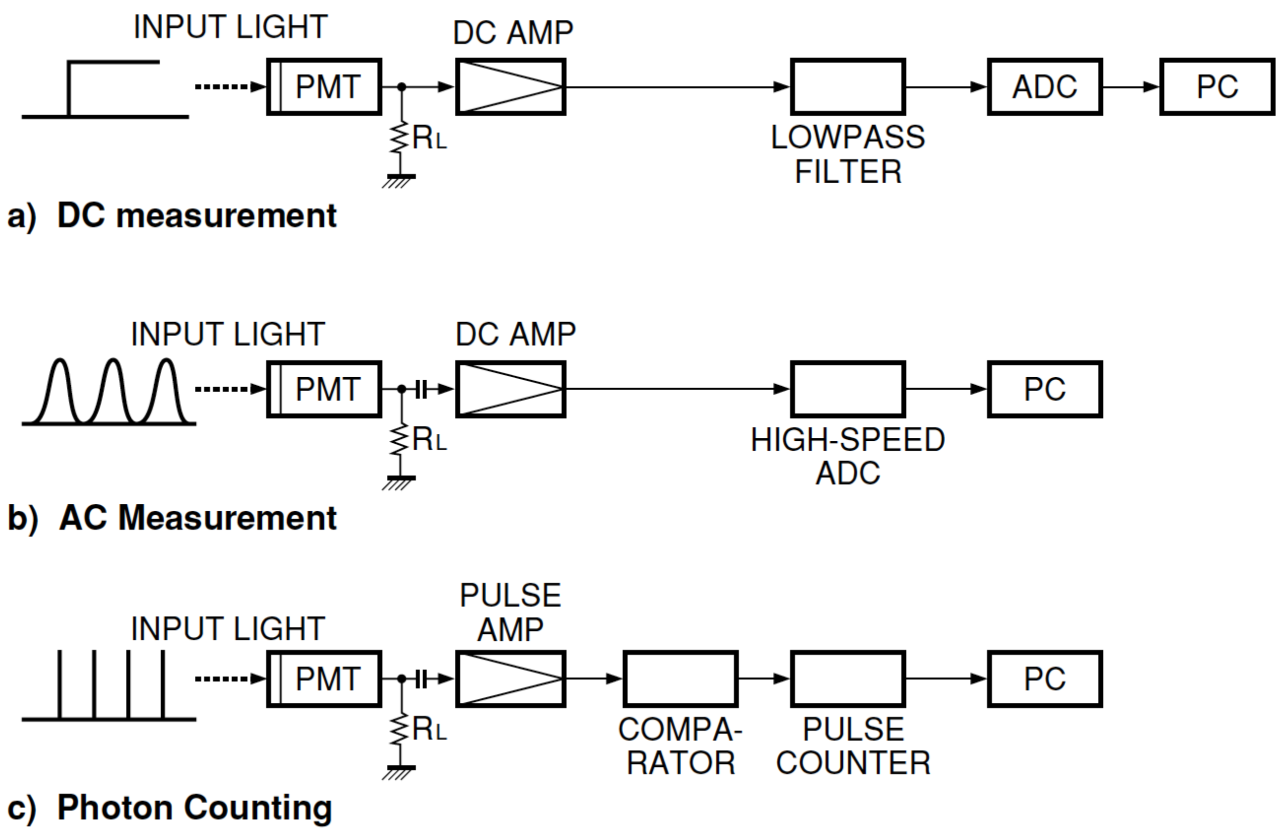
PMT characteristics

High signal to noise (allows for photon counting)
Fast
Large active area

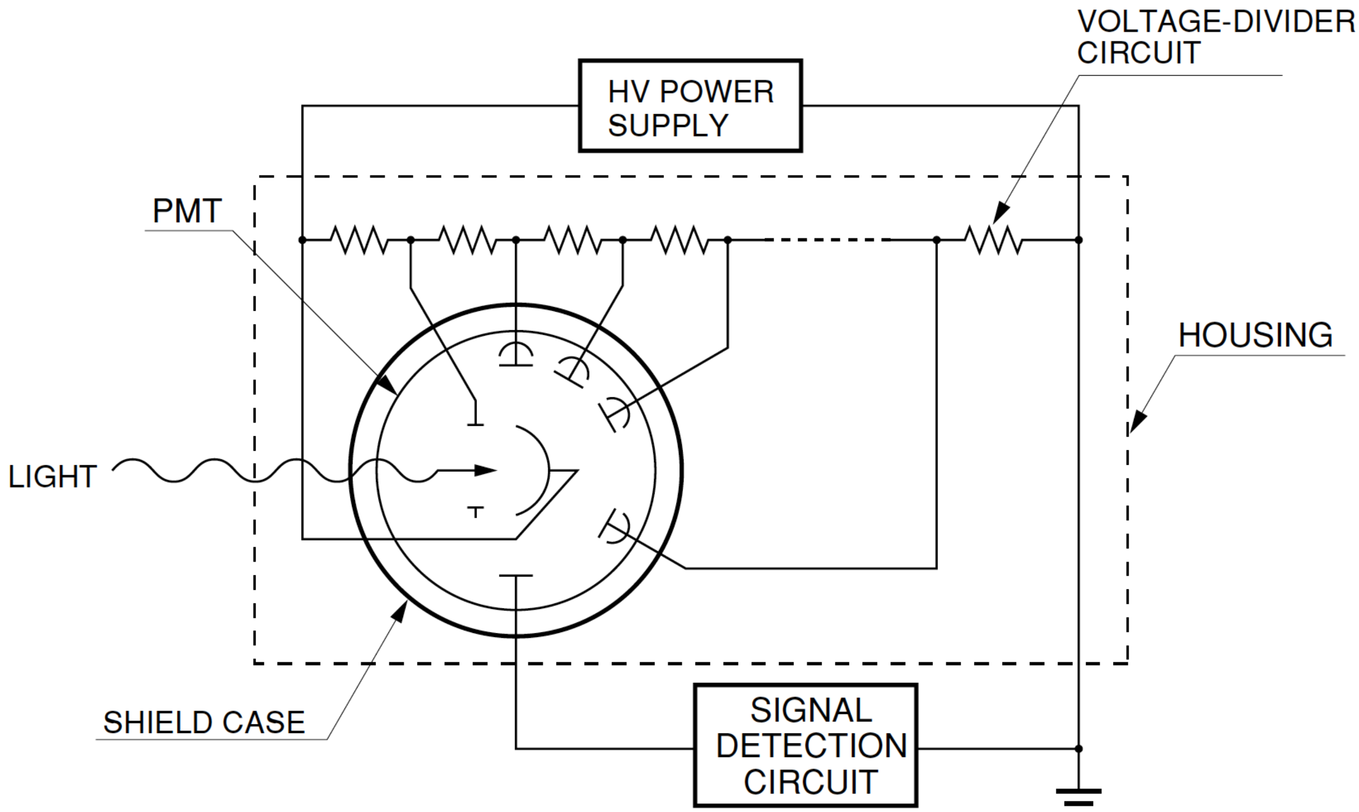


Picutres from Hamamatsu PMT guide

Different output configurations

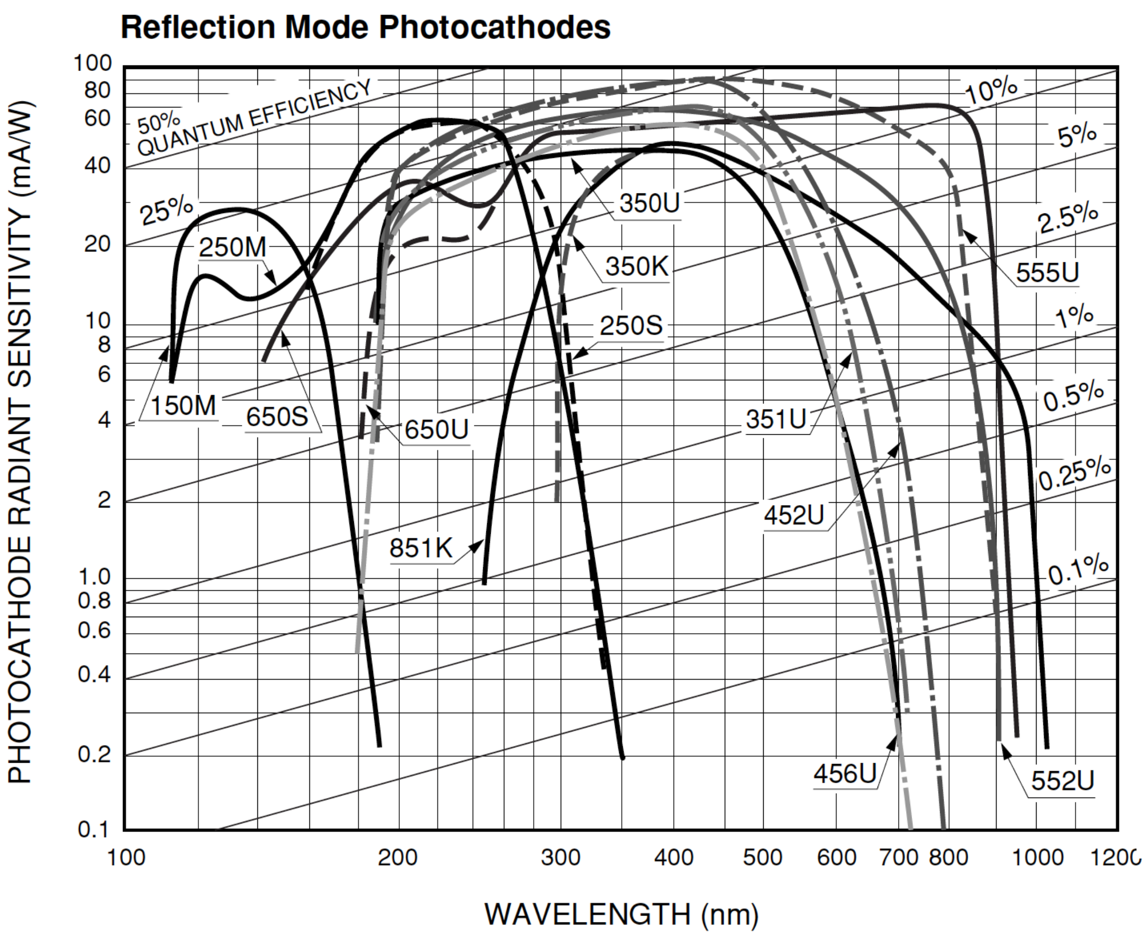


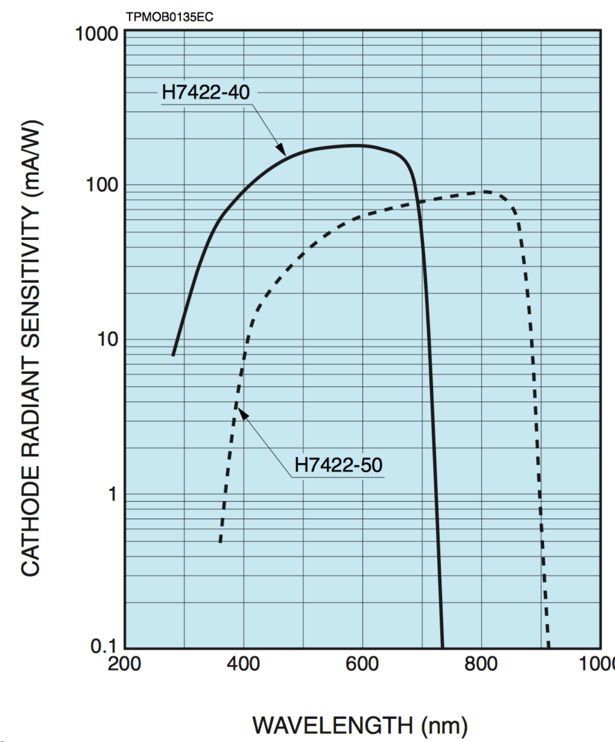
Configuring your PMT



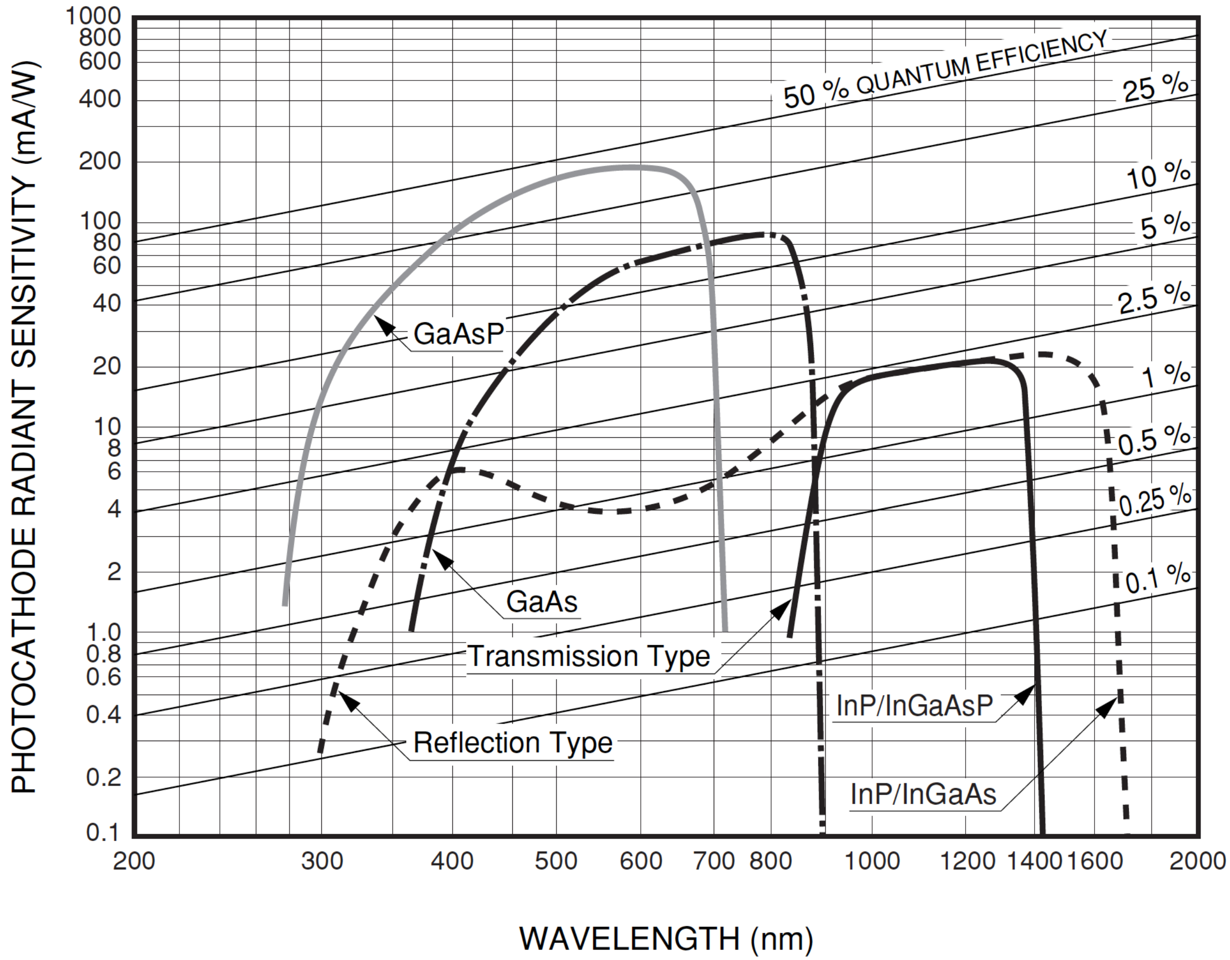
Set the voltage drop ‘gain’ with a voltage divider.
Amplify the output with a current to voltage amplifier.
Record the output with an analog to digital converter.

PMT efficiency

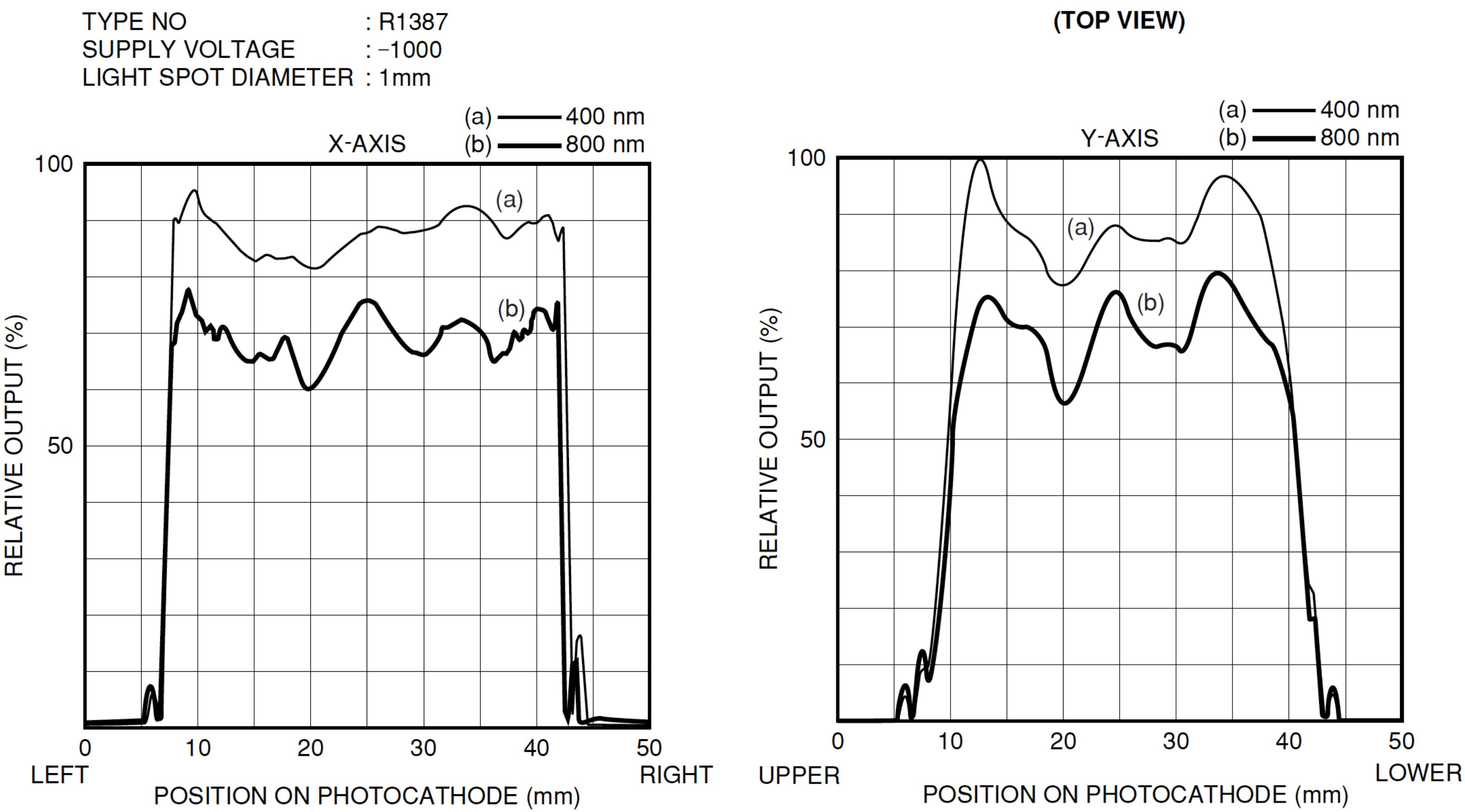




PMT efficiency



Spatial uniformity



Dark current

- Thermionic emission
- Leakage
- Noise from cosmic rays

Dark current vs supply voltage

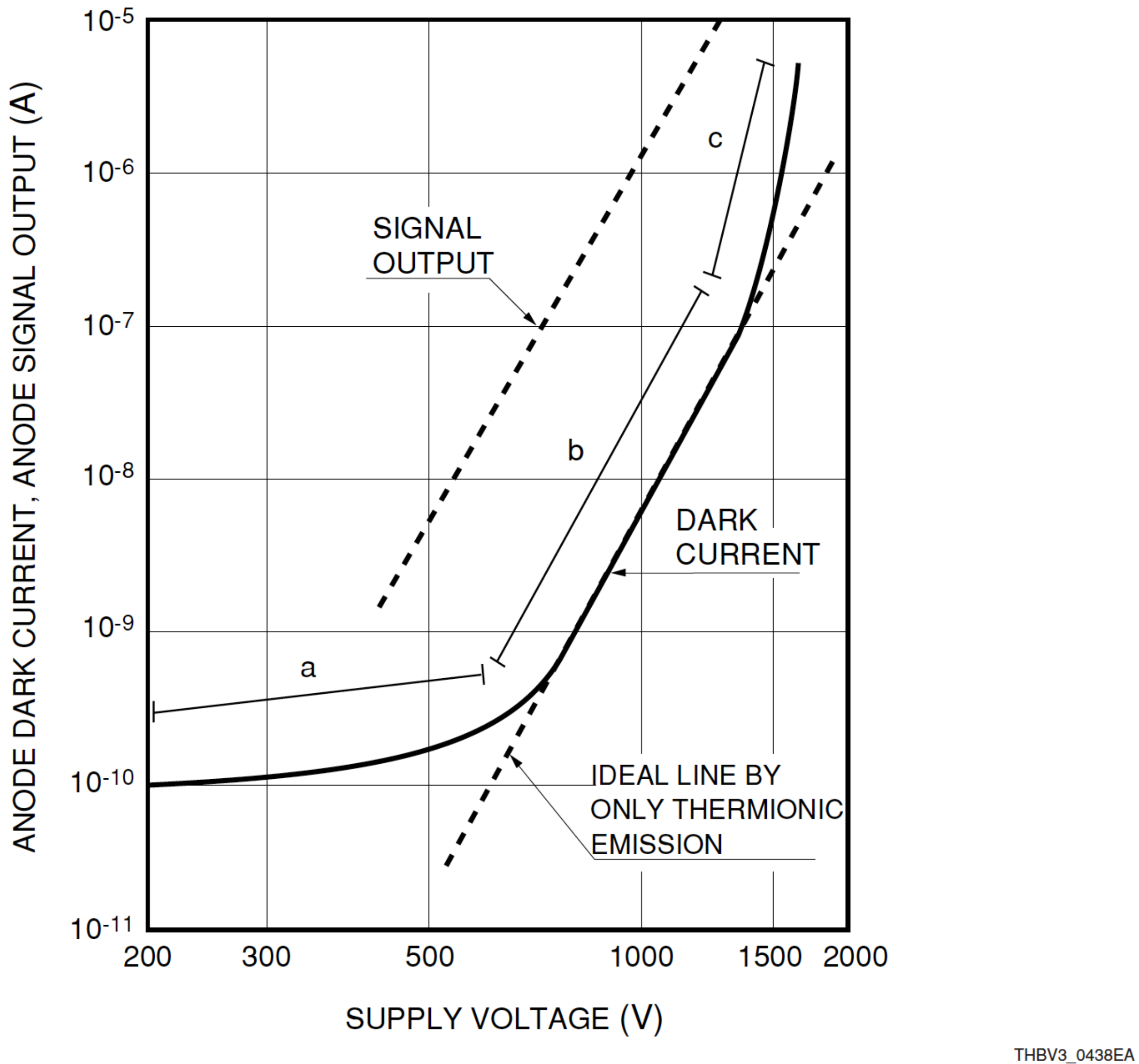
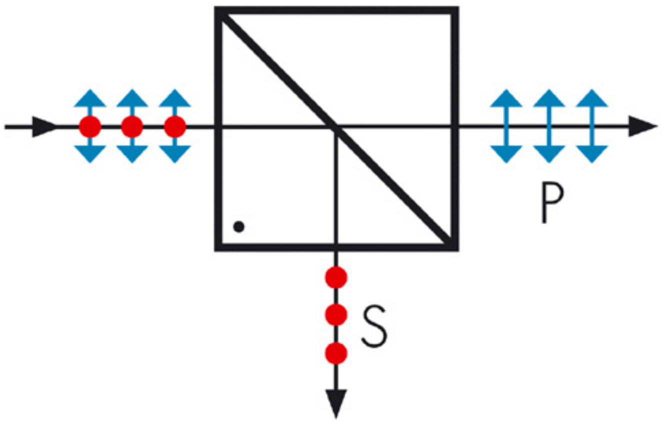


Figure 4-38: Typical dark current vs. supply voltage characteristic

Control of laser intensity

Control of laser light intensity using a beamsplitter

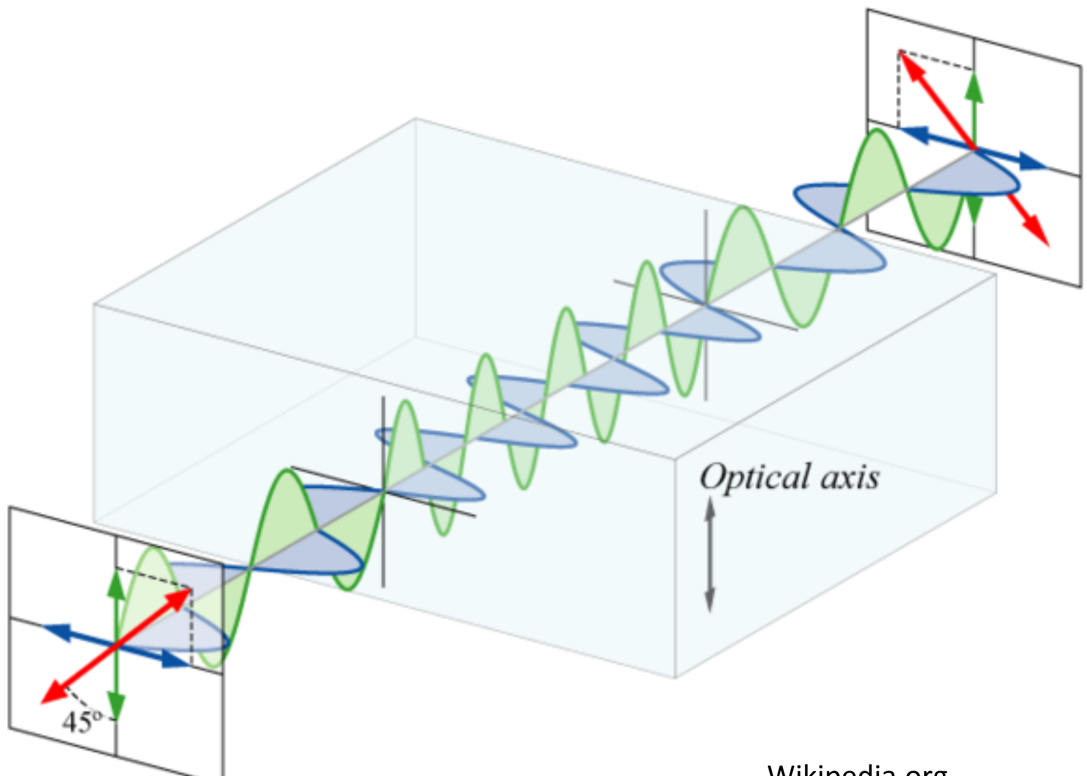
Thorlabs polarizing beamsplitter



Half-wave (λ/2) plate

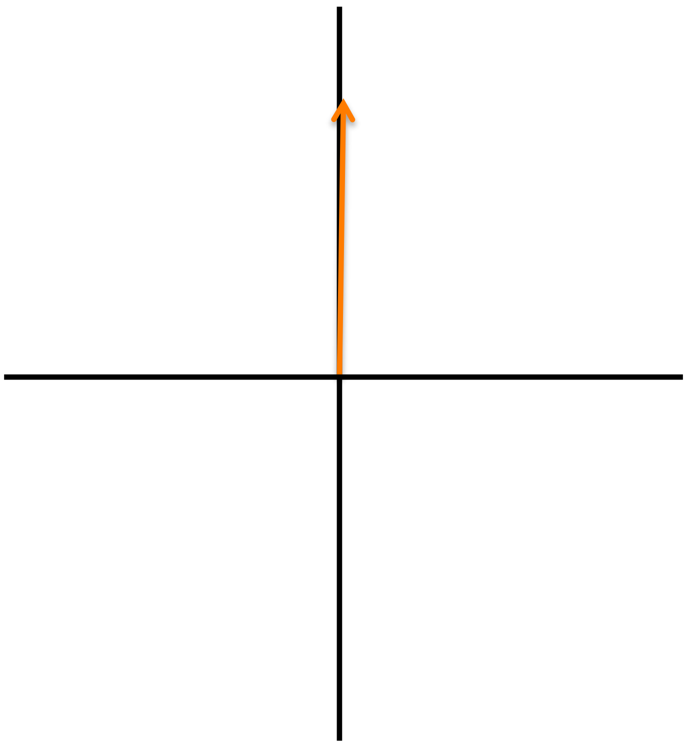
Birefringence: dependence of refractive index on polarization angle

thorlabs.org

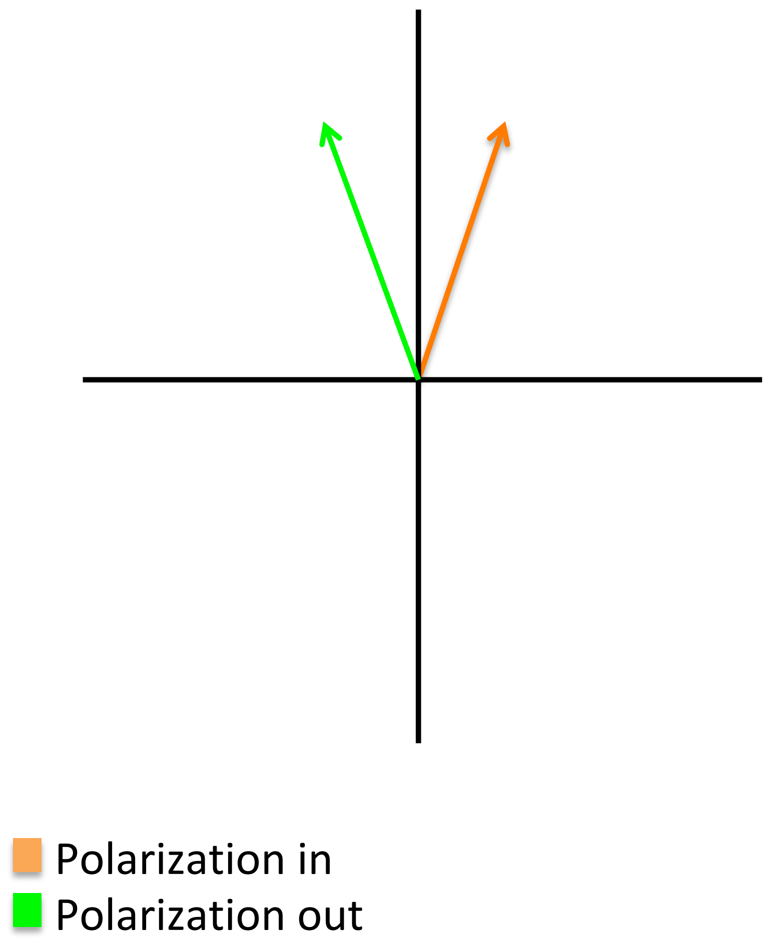


Wikipedia.org

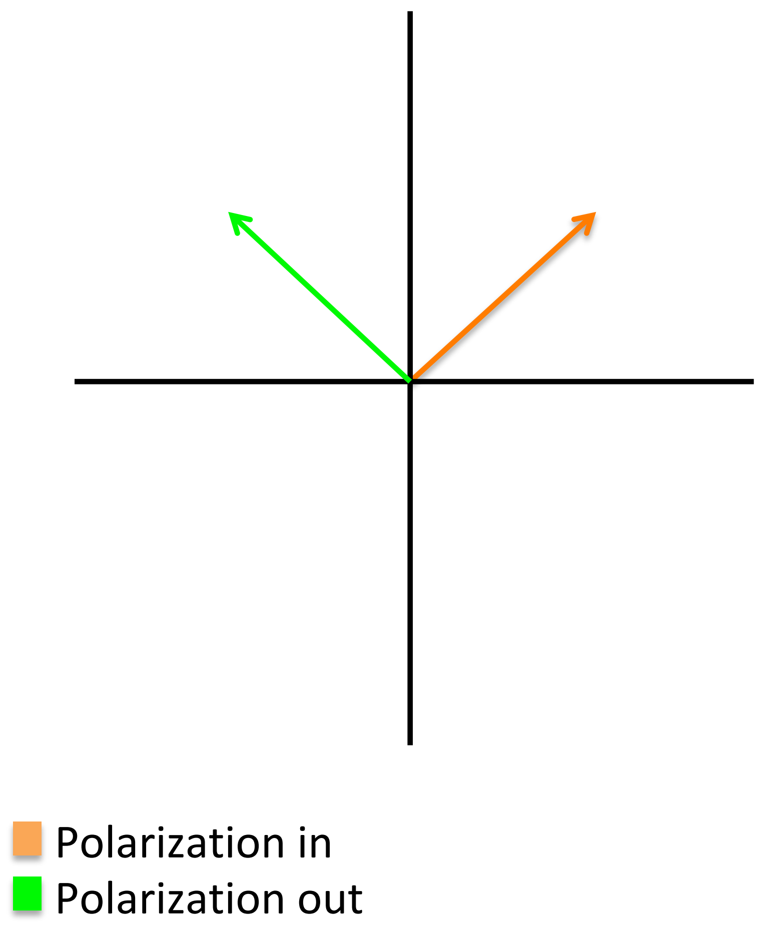
A half wave plate reflects the polarization direction in a plane



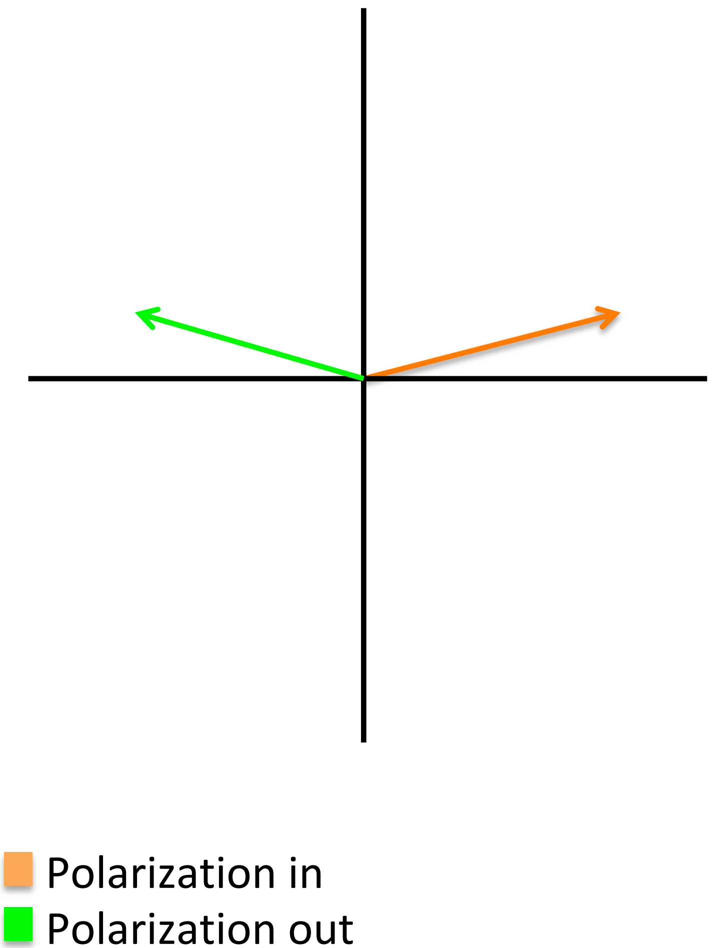
A half wave plate reflects the polarization direction in a plane



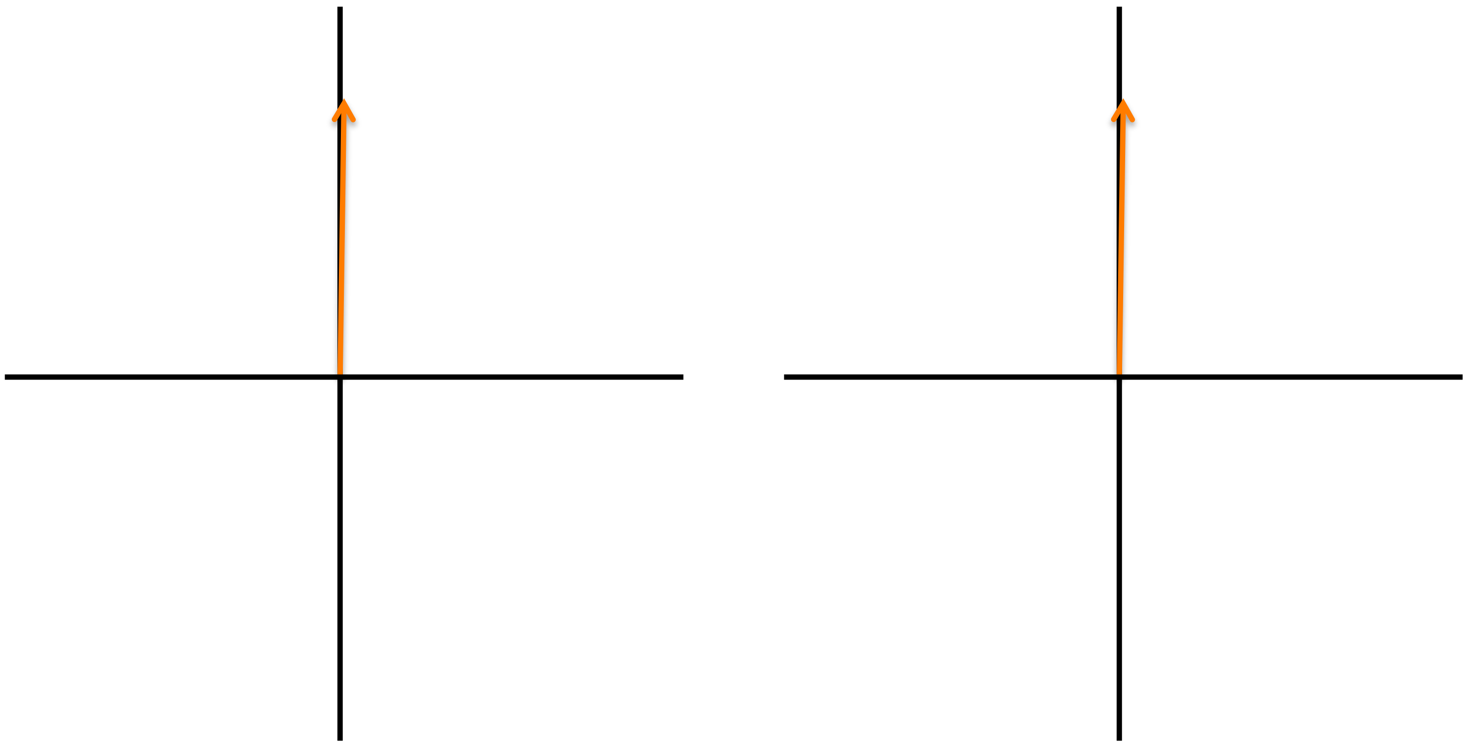
A half wave plate reflects the polarization direction in a plane



A half wave plate reflects the polarization direction in a plane

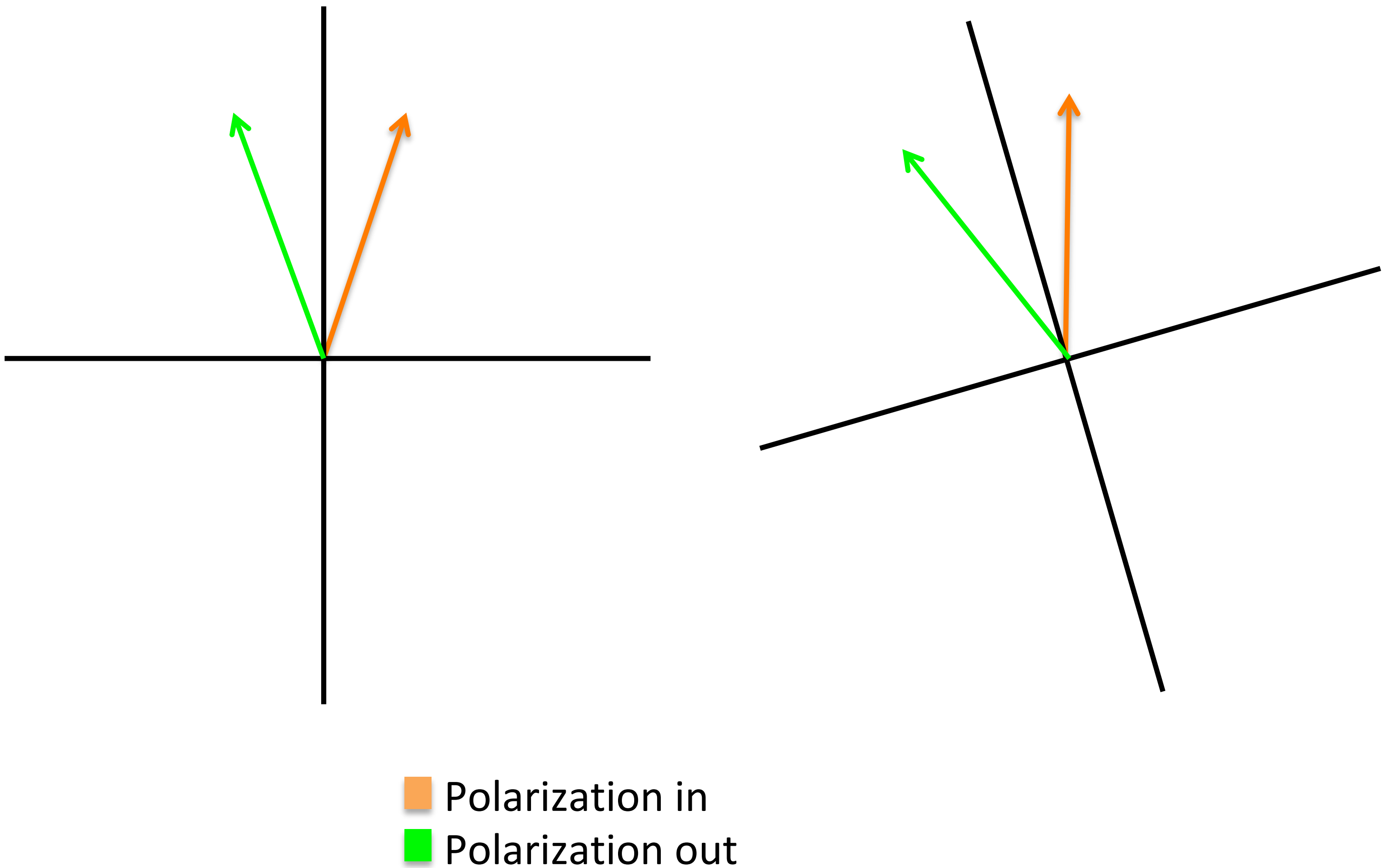


If the half wave plate is rotated, the polarization angle rotates twice as far.

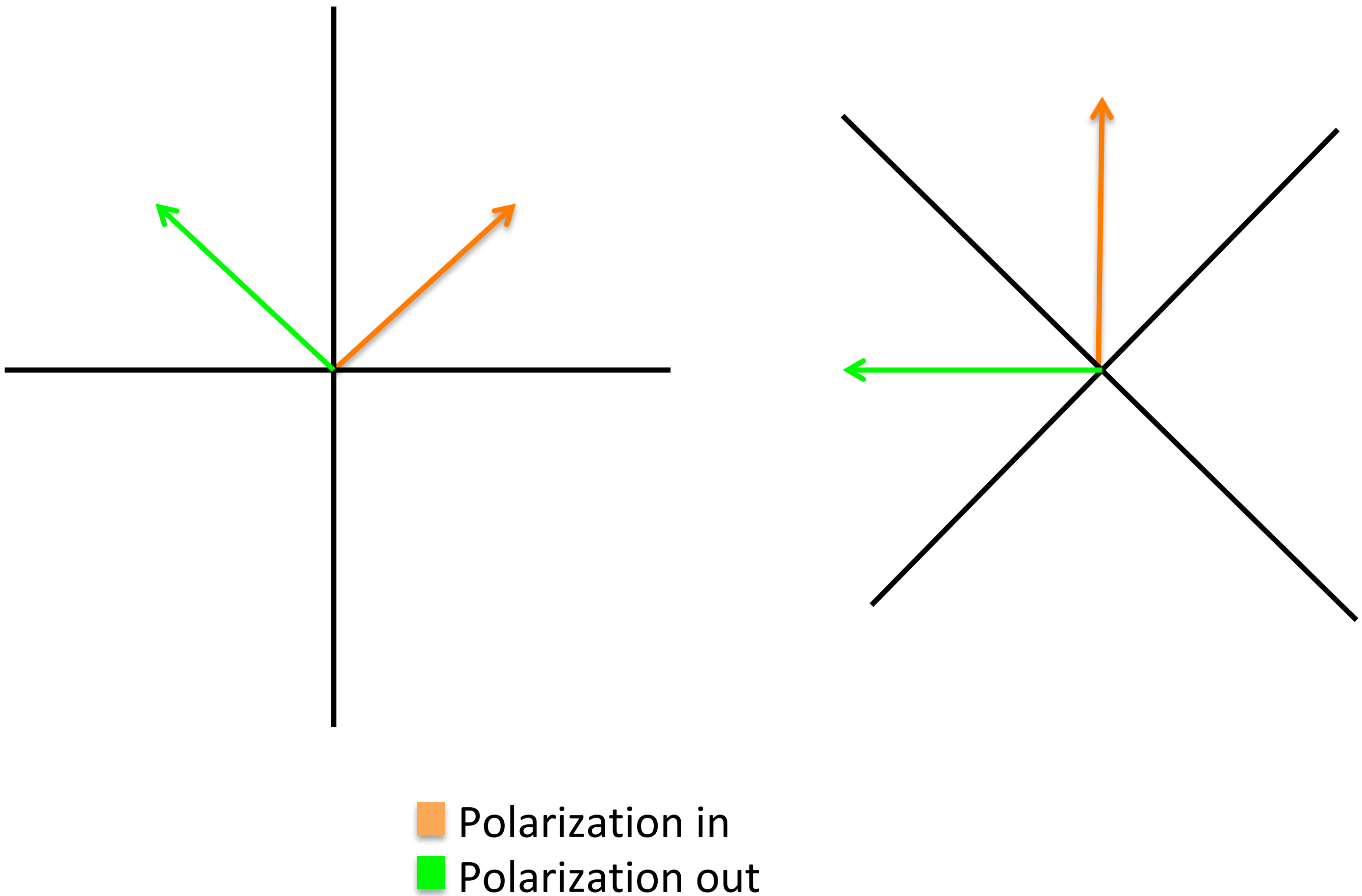


Polarization in
Polarization out

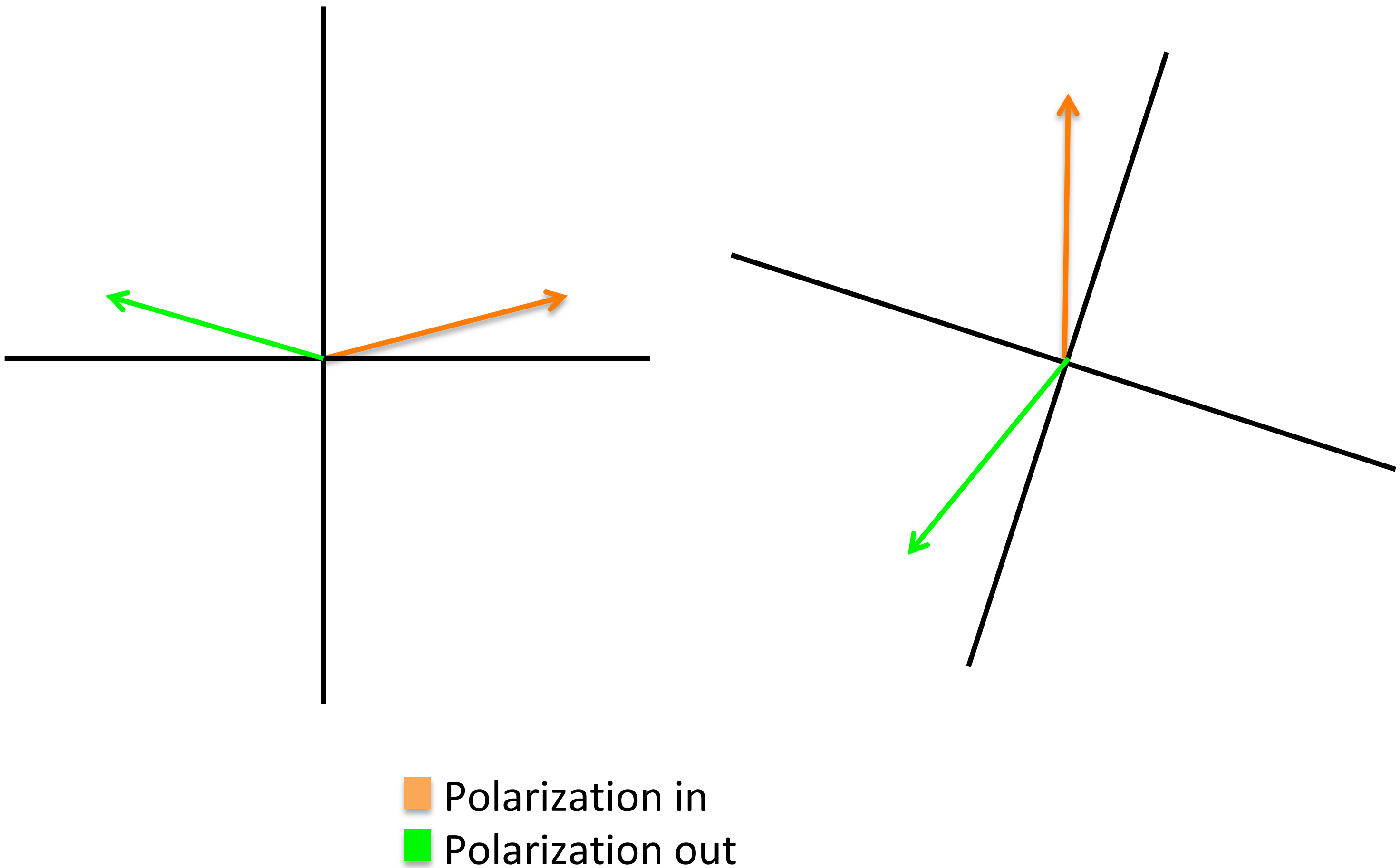
If the half wave plate is rotated, the polarization angle rotates twice as far.



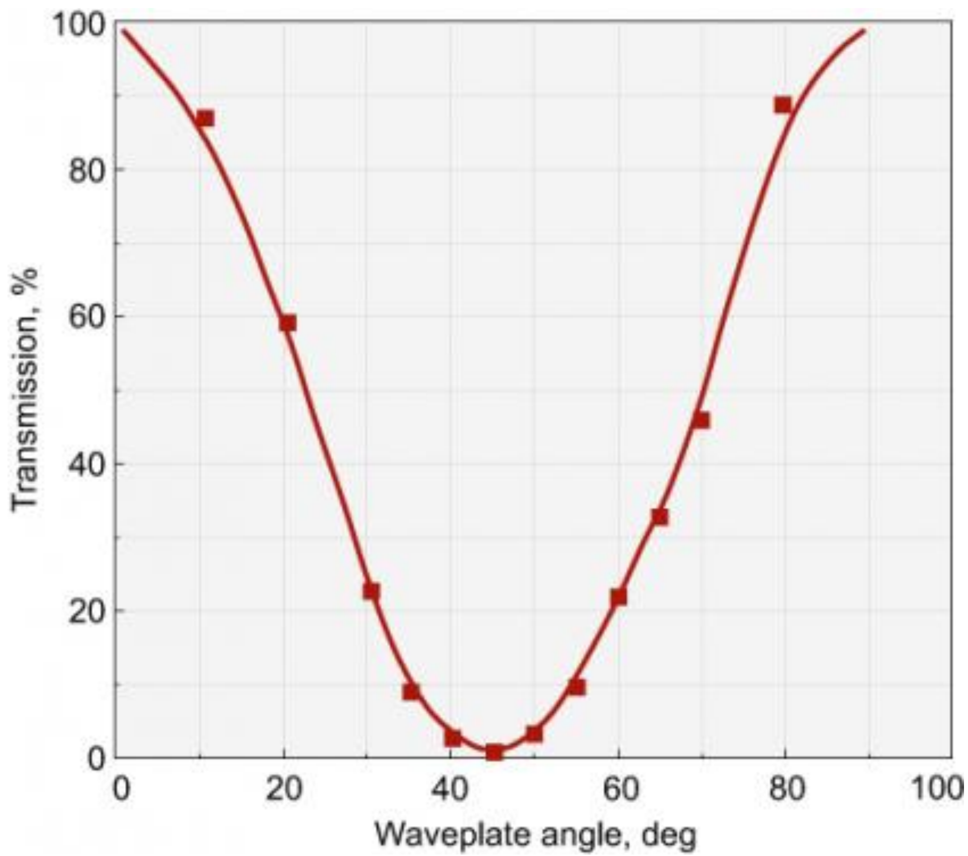
If the half wave plate is rotated, the polarization angle rotates twice as far.



If the half wave plate is rotated, the polarization angle rotates twice as far.



Power cycles every quarter rotation of the half wave plate.



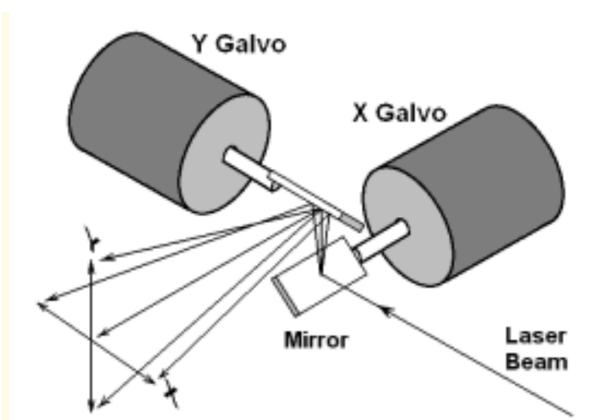
Pockels cells operate on similar principles

Light passes through a crystal whose birefringence is modulated by an applied electric field.

Allows fast switching down to <1 microsecond

Galvanometer scanners

- Tilt mirror to different positions
- Closed loop control
- Fast, arbitrary positioning
- XY configuration



www.elm-chan.org

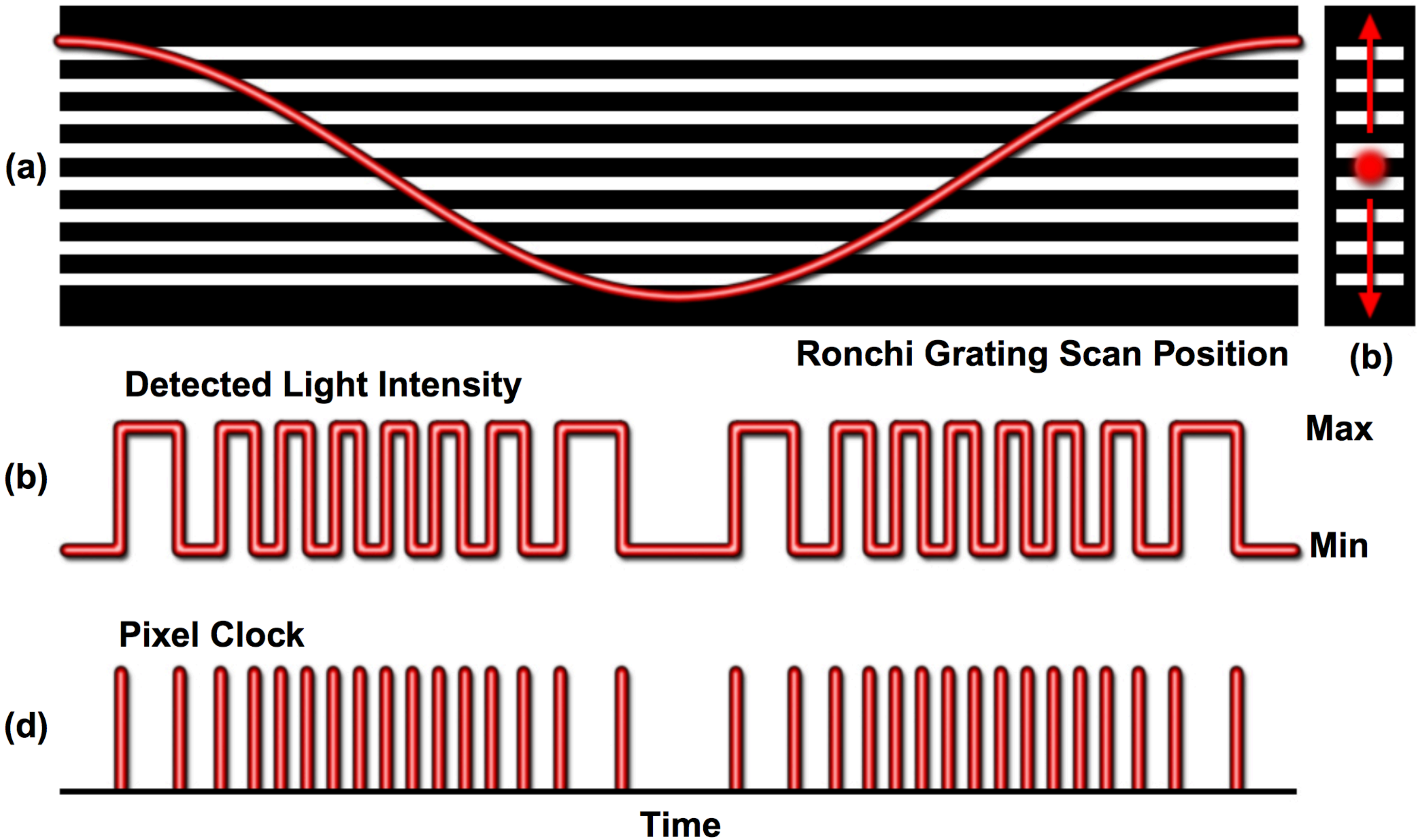
Resonant scanners

Pros:
Low power
Fast (3000-12000 Hz)

Cons:
Fixed frequency
No control over position
Non linear scan

Cambridge Technology

Uneven pixel dwell times

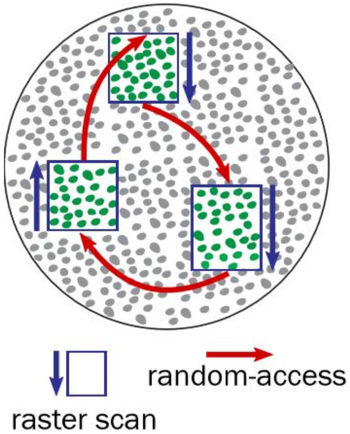


microscopyu.com

Other configurations

Resonance-galvo-galvo

- Combines fast scanning and arbitrary positioning

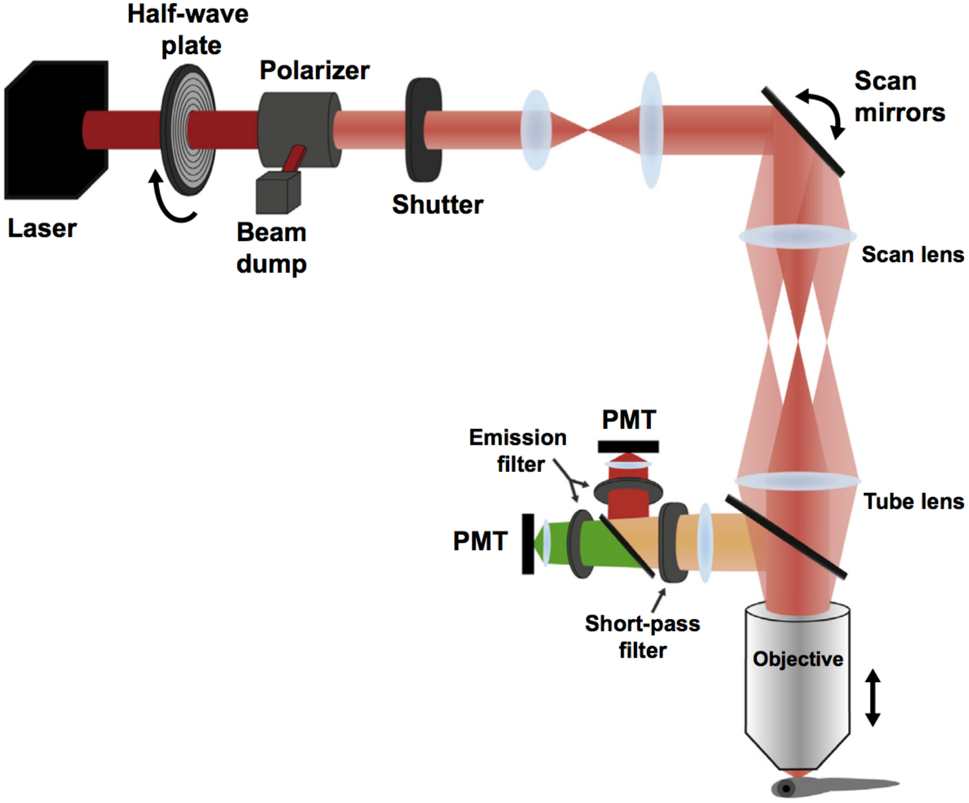


Labrigger.com

AOD-based scanning

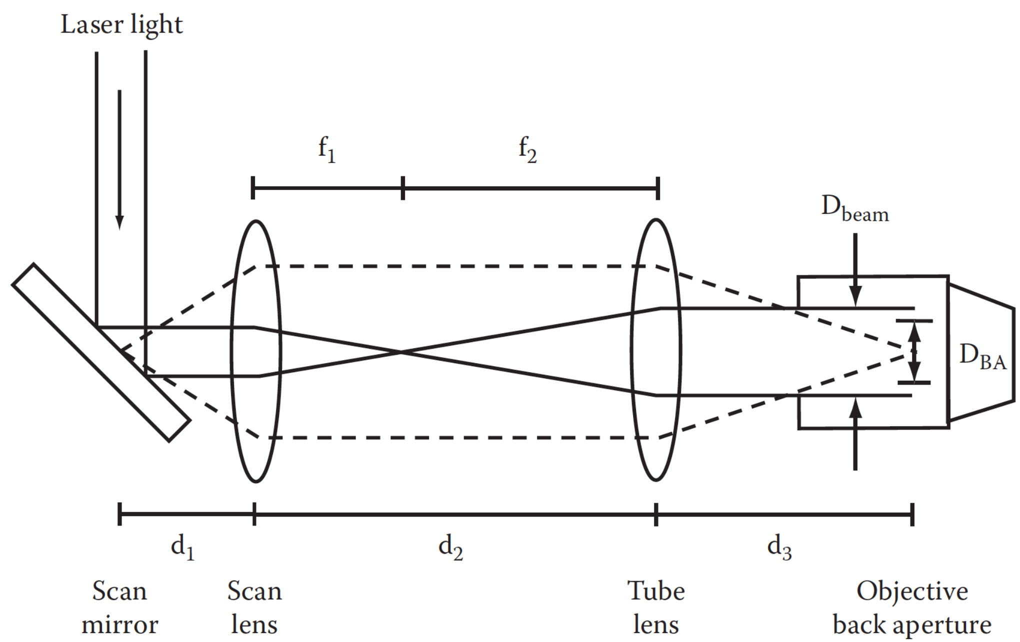
- Ultrafast positioning of beam (see Stephane's lecture)

Basics of a scanning microscope



Renninger, Methods, 2013

Scanning optics



3 In Vivo Two-Photon Laser Scanning Microscopy with Concurrent Plasma-Mediated Ablation

Principles and Hardware Realization

Philbert S. Tsai and David Kleinfeld