Karlsruher Institut für Technologie

Integrierte Intelligente Sensoren Sommersemester 2012 27.06.2012

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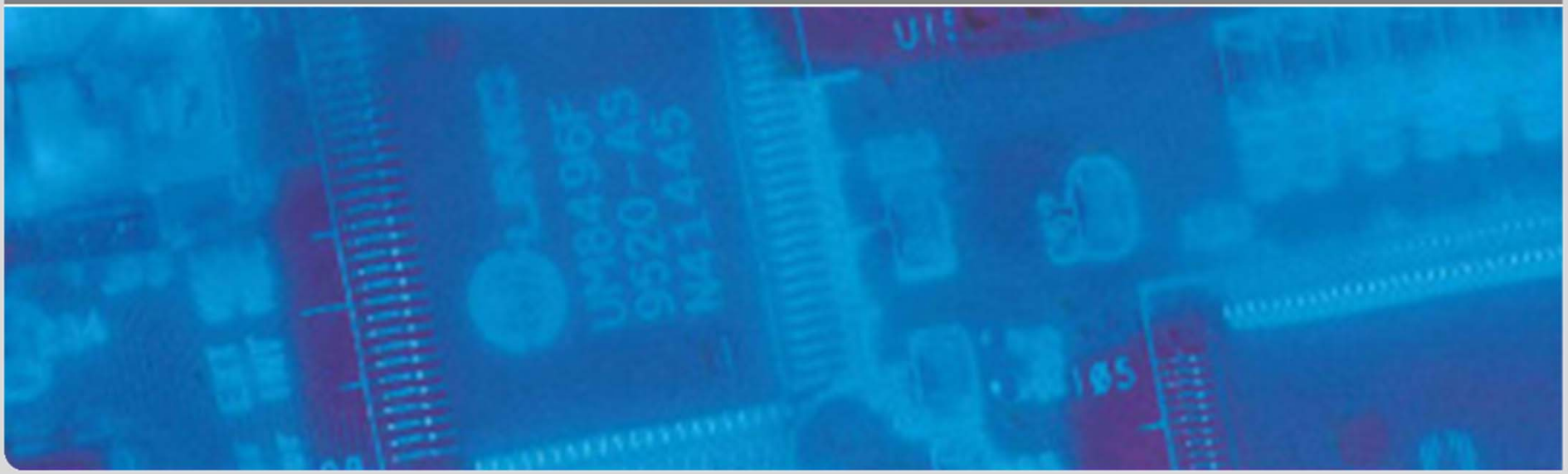
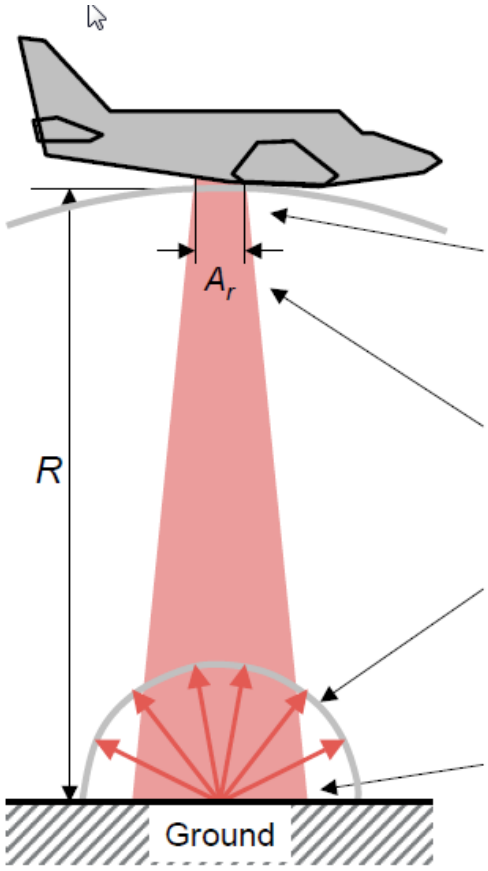
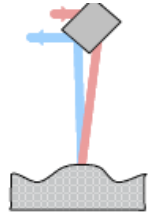


Leistungsparameter



Power balance



4 - Power received:

$$P_r = \frac{A_r}{2\pi R^2} \cdot M \cdot \rho \cdot M \cdot P_T = \rho \frac{M^2 A_r}{2\pi R^2} \cdot P_T$$

1 - Power transmitted:

P_T

3 - Power reflected, assuming Lambertian surface:

$$\frac{\psi}{2\pi} \cdot \rho \cdot M \cdot P_T$$

2 - Power received:

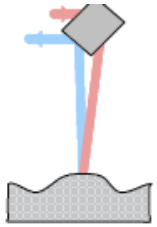
$M \cdot P_T$

- P_T = 2000 W
- Atmospheric transmission M = 0.8
- A_r = 80 cm^2 (D_r = 10 cm)
- R = 1 km
- Reflectivity ρ = 0.5

→ $P_r = 4 \cdot 10^{-10} P_T$ = 800 nW

Reflektivität des Bodens

Reflectivity



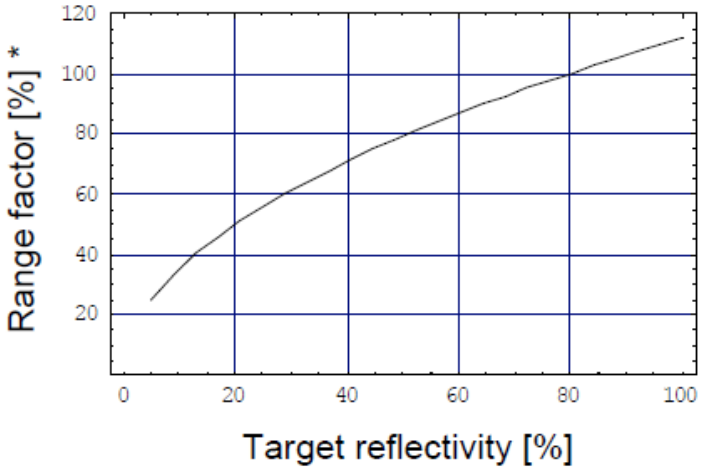
Reflectivity vs. material

MATERIAL	REFLECTIVITY @ λ = 900 nm
Dimension lumber (pine, clean, dry)	94%
Snow	80-90%
White masonry	85%
Limestone, clay	up to 75%
Deciduous trees	typ. 60%
Coniferous trees	typ. 30%
Carbonate sand (dry)	57%
Carbonate sand (wet)	41%
Beach sands, bare areas in desert	typ. 50%
Rough wood pallet (clean)	25%
Concrete, smooth	24%
Asphalt with pebbles	17%
Lava	8%
Black rubber tire wall	2%

Source: www.riegl.co.at

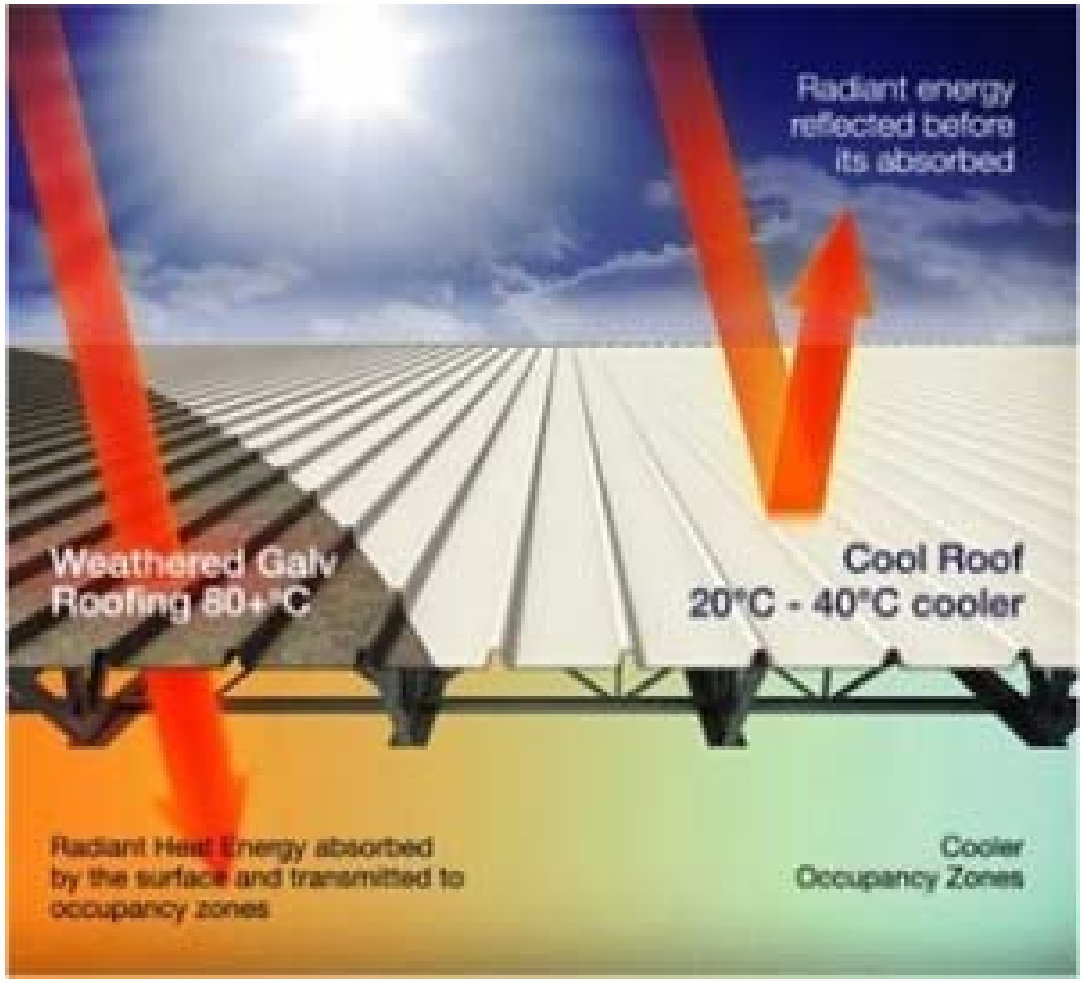
Range vs. reflectivity

$$P_r = \rho \frac{M^2 A_r}{2\pi R^2} \cdot P_T \quad \Rightarrow \quad R \propto \sqrt{\rho}$$



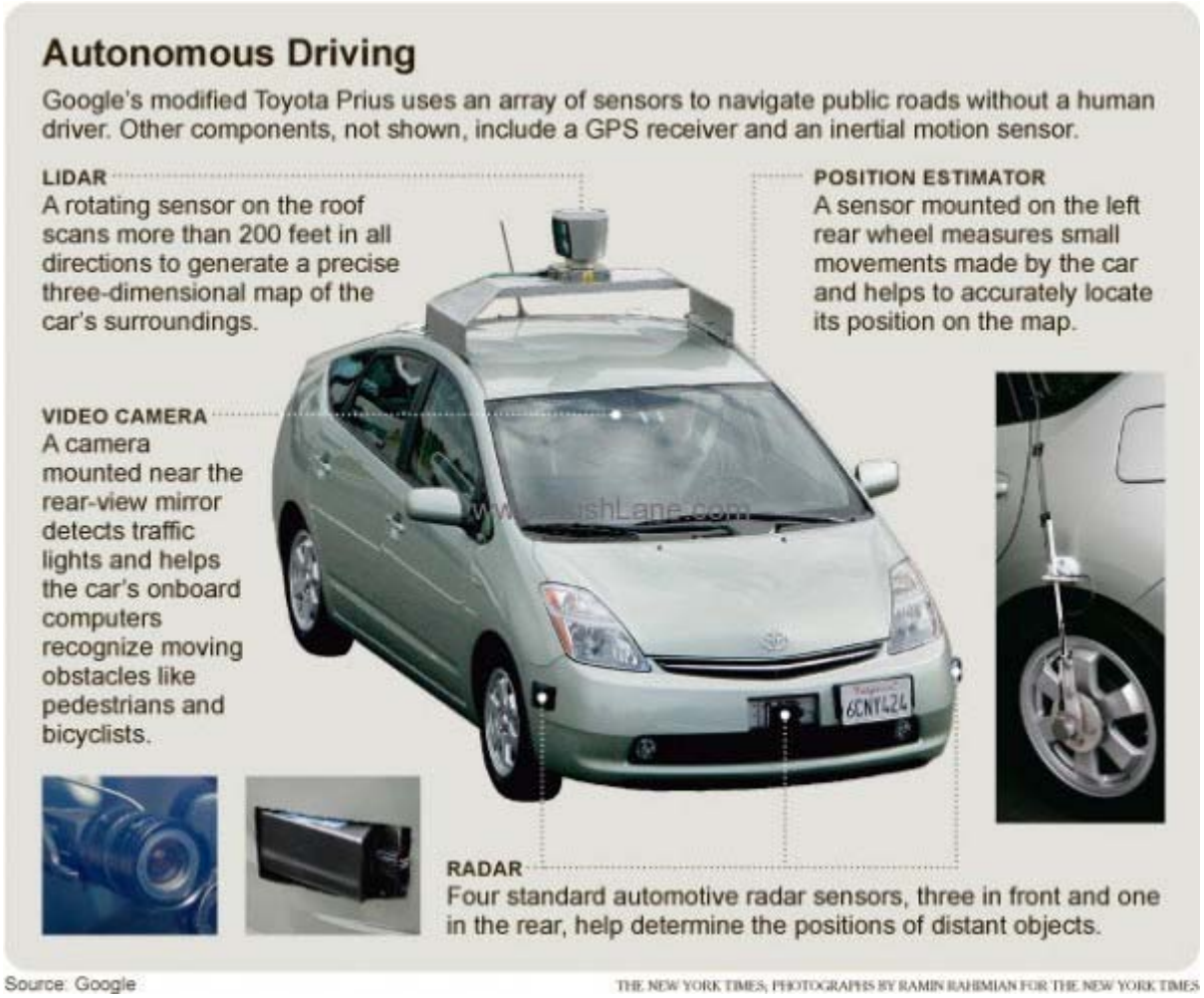
* Normalized to 100% @ 80% reflectivity

Kühlung durch reflektierende Flächen

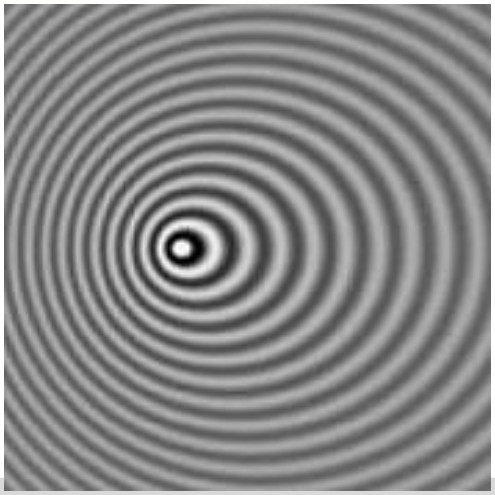


Ist Das bekannt?

Das auch?


Autonomous Driving
Google's modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.
LIDAR
A rotating sensor on the roof scans more than 200 feet in all directions to generate a precise three-dimensional map of the car's surroundings.
POSITION ESTIMATOR
A sensor mounted on the left rear wheel measures small movements made by the car and helps to accurately locate its position on the map.
VIDEO CAMERA
A camera mounted near the rear-view mirror detects traffic lights and helps the car's onboard computers recognize moving obstacles like pedestrians and bicyclists.
RADAR
Four standard automotive radar sensors, three in front and one in the rear, help determine the positions of distant objects.
Source: Google
THE NEW YORK TIMES; PHOTOGRAPHS BY RAMIN RAHIMIAN FOR THE NEW YORK TIMES

Laserradar Laser-Doppler



Technische Daten

Geschwindigkeitsmessung:	
Messbereich	0 ... 320 km/h*
Distanzbereich	30 m ... 350 m**
Messgenauigkeit (nach Eichordnung EO 18-11)	± 3 km/h (Geschwindigkeit < 100 km/h) ± 3% (Geschwindigkeit > 100 km/h)*
Messzeit	
Geschwindigkeit	0.36 ... 1 s
Distanz	0.1 s
Laser- und Zieloptik	
Vergrößerung	7 fach
Sehfeld	5,5° (entspricht 9,5 m auf 100 m)
Dioptrienverstellbereich	± 4 Dioptrien
Zielmarke	Strichplatte mit Fadenkreuz
Messstrahl Ø	35 cm (in 100 m Entfernung)
Laser	Impulslaserdiode, infrarot, Laserklasse 1 nach DIN EN 60825-1:1997-03 augensicher
Stromversorgung	12 V DC, NC-Akku intern, bis zu 1000 Messungen pro Akku-Ladung
Interface	RS 232 (parametrierbar)
Einsatztemperaturbereich	- 10°C ... + 50°C
Gewicht	ca. 2.4 kg

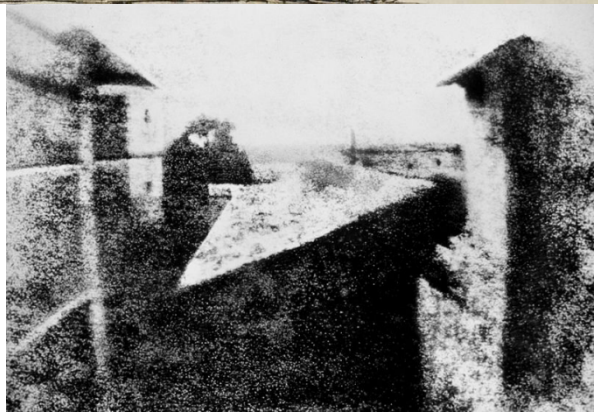
Laserradar

Technische Daten	
Geschwindigkeitsmessbereich	0 ... 250 km/h
Genauigkeit	± 2 km/h bis 100 km/h, ± 2 % über 100 km/h
Messbereich	30 m bis 500 m
Kennzeichenerkennbarkeit	70 m bis 120 m
Laserklasse	Klasse 1

Photographie

- Camera Obscura

(Projektion in einen dunklen Raum und abzeichnen)

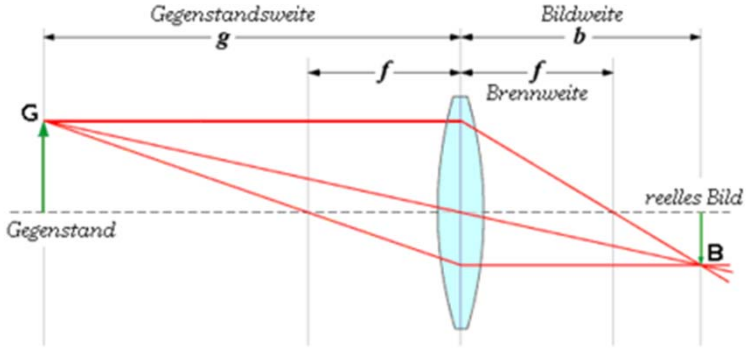


- Photochemischer Prozess
  - Erfunden durch Joseph Niepce 1826 in Frankreich

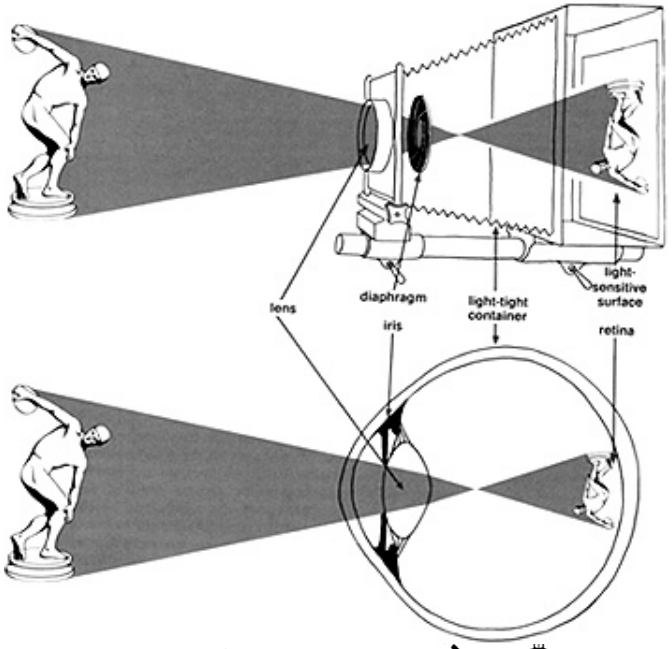
- Kameras Ende 19th Jhr.

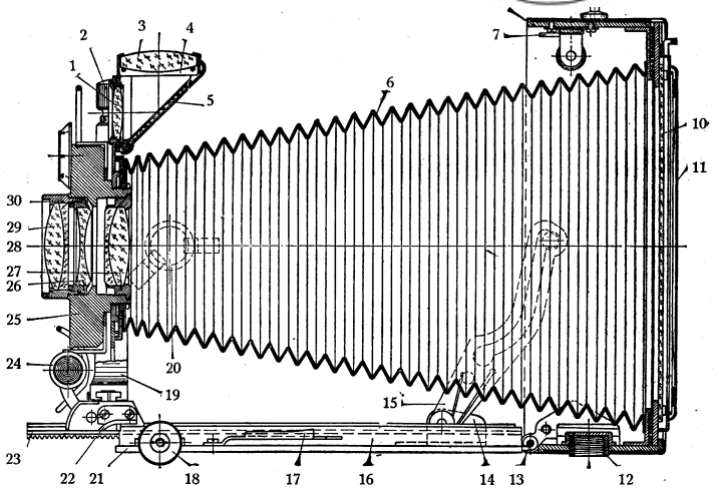
Alte Kameras mit Faltenbalg

- Kameas mit Objektiv und Faltenbalg zur Abstandsänderung des Objektivs von der photographischen Platte



$$\frac{1}{b} + \frac{1}{g} = \frac{1}{f}.$$





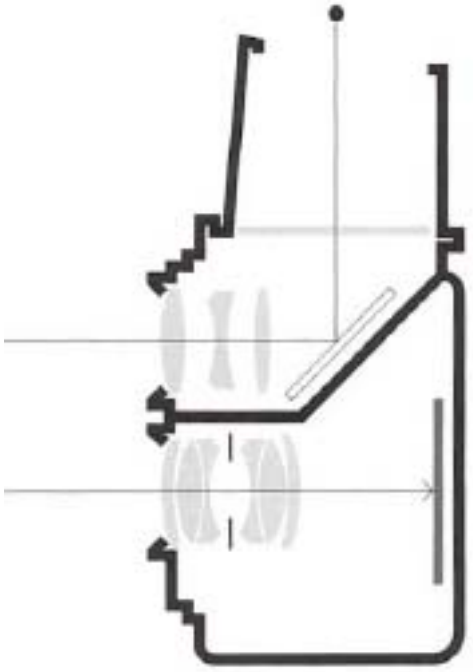
Photographische Kameras

- Erste Photokamera mit Film unter dem Namen Kodak „Kodak“ by George Eastman 1888 in Rochester, USA

- Erste 35 mm Film (Kleinbild) Kamera „Leica“ Leitz Camera 1925, Ernst Leitz in Wetzlar, Germany,
  Beginn des Photojournalismus (Time Magazine,..)

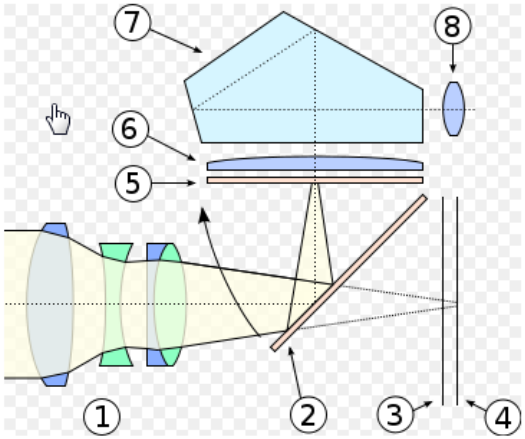
Twin lens reflex cameras

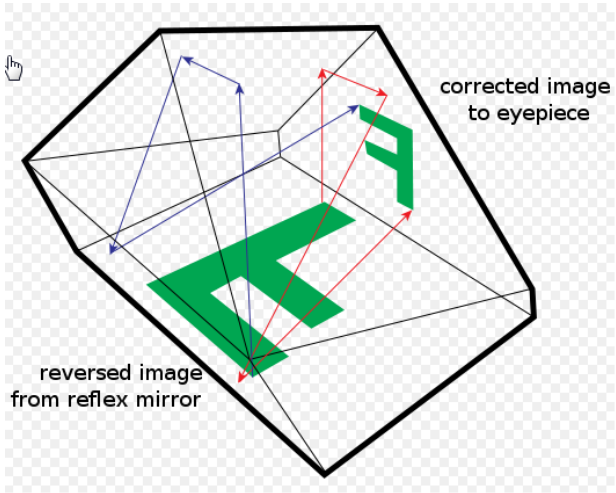
- Doppel-Linse Reflex mit Streuscheibe zur Fokussierung (Rollei 1928, Braunschweig)
- Unterschiedliche Perspektiven für Auge und Hauptobjektiv



Spiegelreflex Kamera

- Erste SLR (Single Lens Reflex Kamera) bzw. Spiegelreflex Kamera durch Carl Zeiss 1949 (Marke Contax)
- Nur ein Objektiv, Sucher durchs gleiche Objektiv über beweglichen Spiegel zeigt das reale Bild
- Für aufrecht stehende Bilder wird ein Pentaprisma benutzt.





Cross-section view of SLR system: 1: Front-mount lens (four-element Tessar design) 2: Reflex mirror at 45-degree angle 3: Focal plane shutter 4: Film or sensor 5: Focusing screen 6: Condenser lens 7: Optical glass pentaprism (or pentamirror) 8: Eyepiece (can have diopter correction ability)
Source: Wikipedia

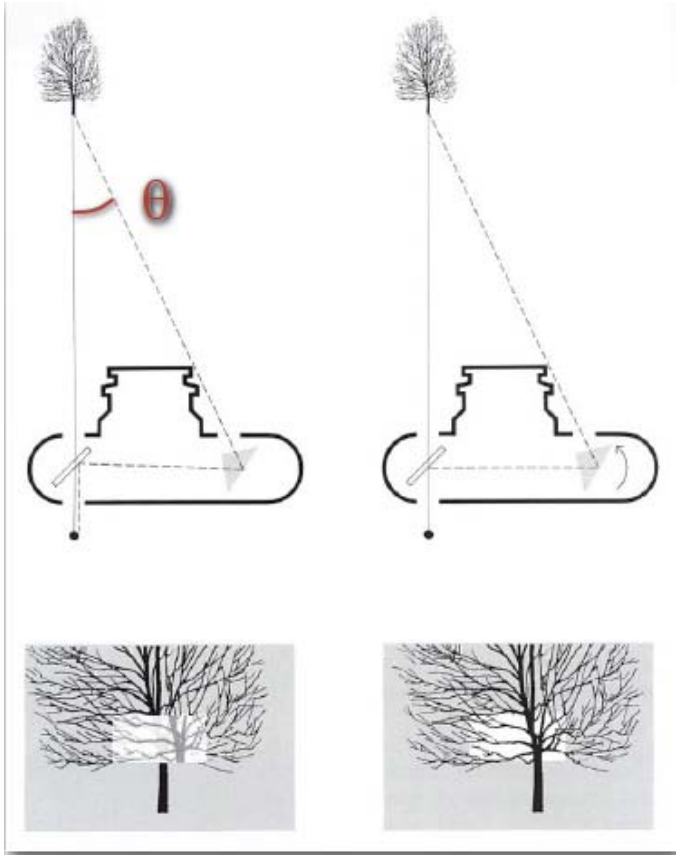
Berühmte Kameras

- Erste Autofokus Kamera
  Leica Correfot (1978)

- Erste Kamera mit integrierter
  Lichtmessung Minolta 1981

Manuelle Abstandseinstellung

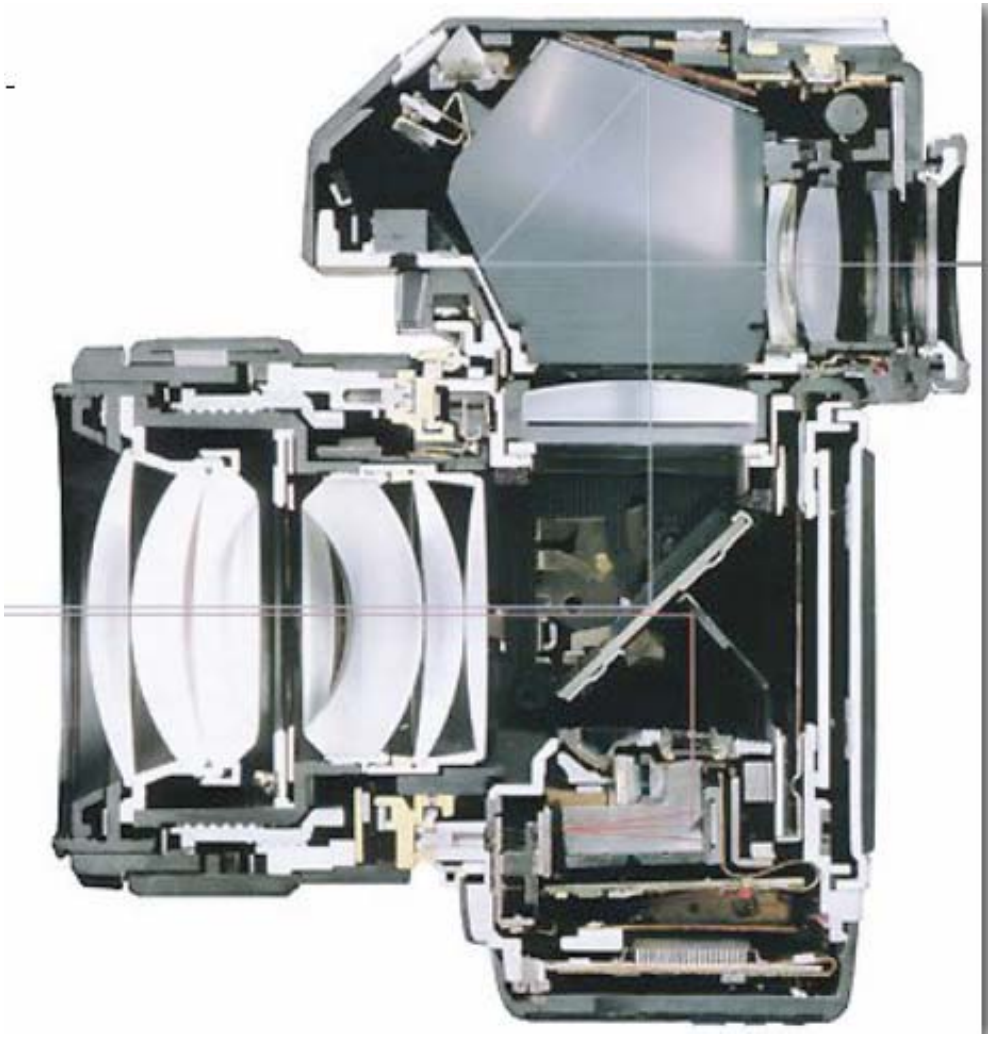
- Triangulations Konzept: Sucher mit halbdurch-lässigem Spiegel plus drehbarem Prisma prism -> Überlappung beider Bilder, wenn das Prisma gedreht wird



Source:Marc Levoy

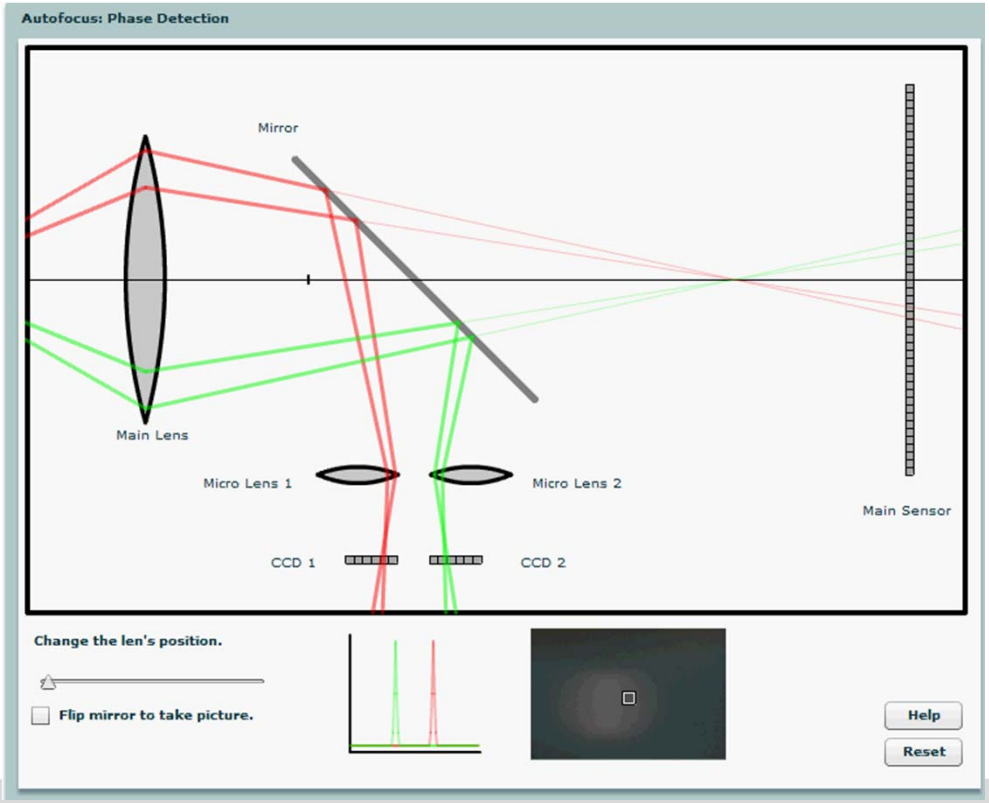
Autofokus SLR Kamera

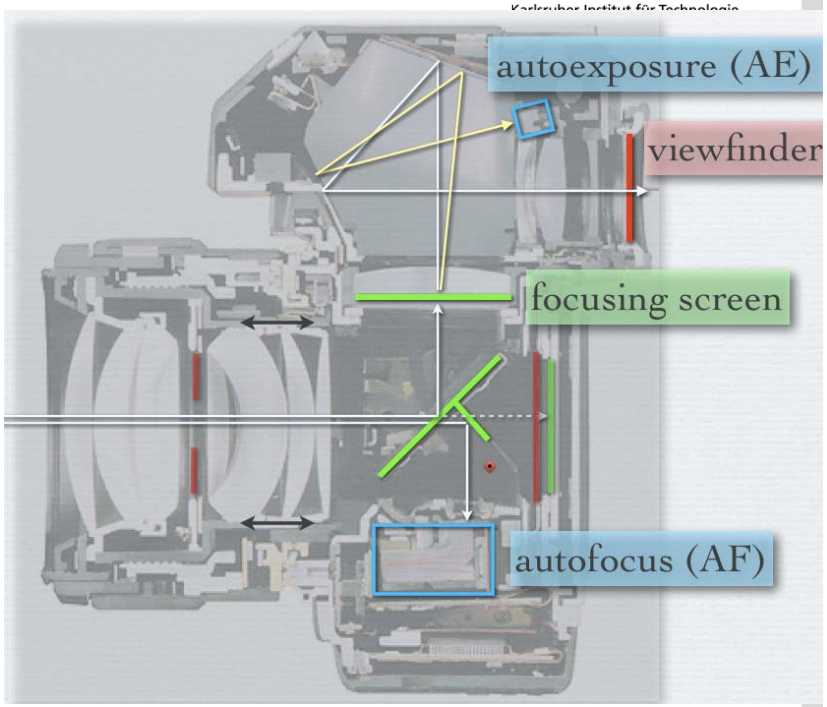
- Nikon F4



Autofokus (Phasen Messung)

- Querschnit einer SLR Kamera
- Ein Teil des Lichts geht durch den Spiegel durch, wird umgelenkt und mit zwei Linsen auf eine CCD Zeile abgebildet – liegt das Lichtbündel zentral ist das Bild im Fokus

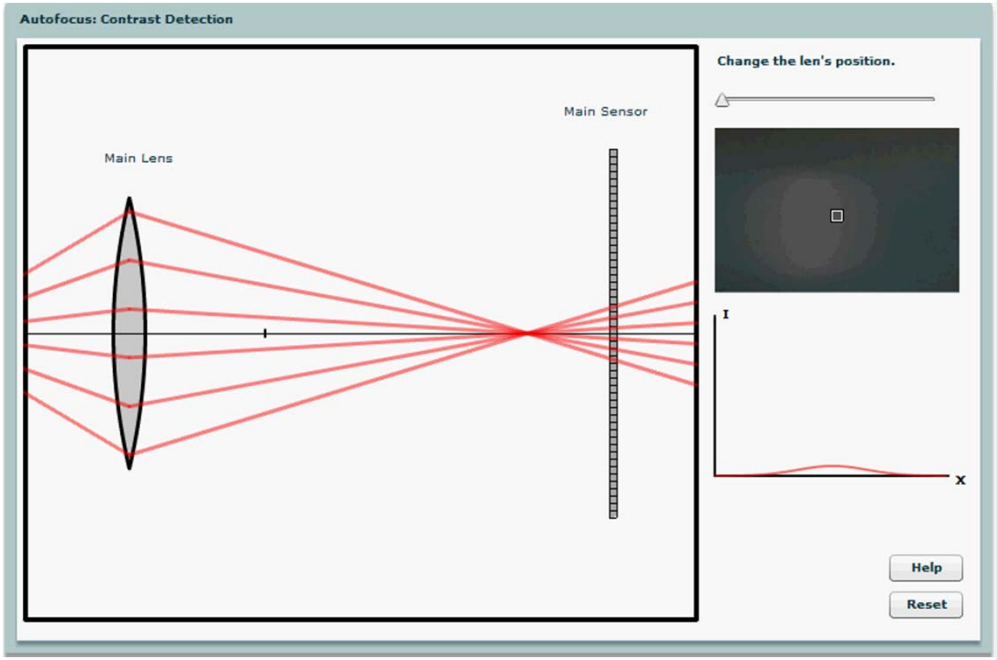


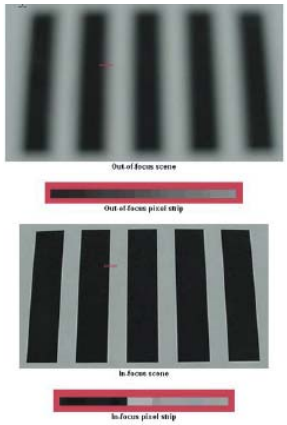


Auto Focus über Kontrast Detektion

- Intensitätsmessung auf dem zentralen CCD oder CMOS Sensor und Maximierung von Helligkeitsunterschieden in der Nachbarschaft (Fokus Kriterium)

- Die meisten DSC (Digital Still Camera) Kameras nutzen das Prinzip (langsamer als Phasenautofocus)





Live View

- Live view in DSC cameras shows the image which is focused with contrast measuerement

- For Live in DSLR the mirror has to be in the up position -> no phase detection -> bad and slow autofocus for movies

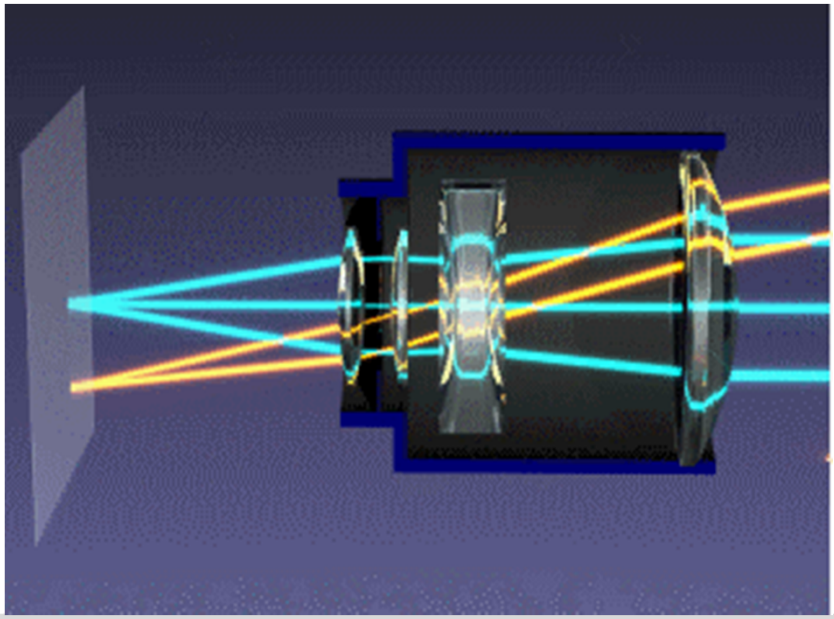
- New SLT camera from Sony with semi transparent mirror -> no reflex mirror-> phase autofocus also for movies

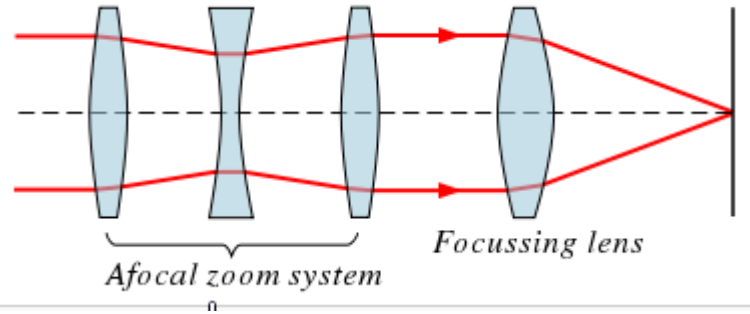
Zoom Objektive

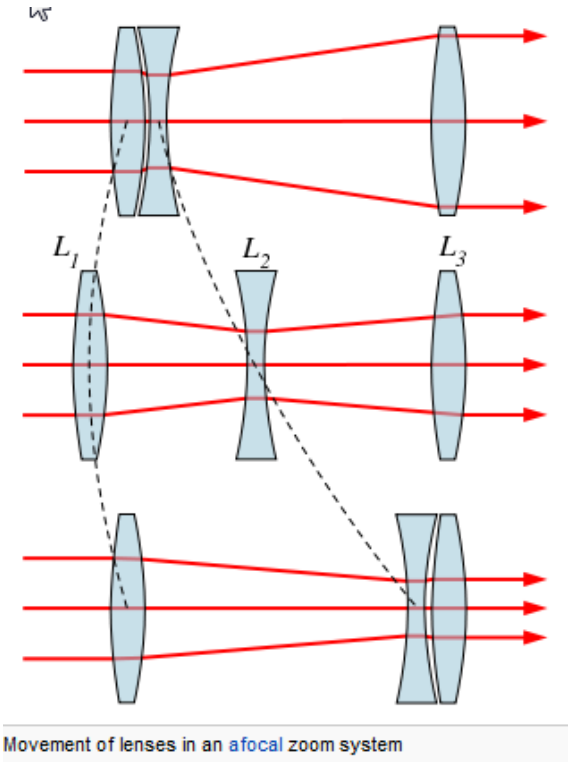
- Ein Zoomobjektiv bleibt im Fokus, wenn die Vergrößerung / Brennweite verändert wird.
- Zum ersten mal 1834 in astronomischen Teleskopen in England benutzt.
- Erstes Zoomobjektiv für die Photographie 1902 durch C. Allen (US patent)
- Erste kommerzielle Nutzung für 35mm Filme 1932 in USA
- Erstes Zoomobjektiv für die Photographie durch Voigtländer Zoomar 1959 (Germany)
- Heute sind Zoomobjektive in einem Bereich bis 15x in der Photographie und 30x für Camcorder erhältlich.
- Warum haben FilmKameras mehr Zoom?

Zoomobjektiv

- Die rsten drei Linsen formen ein afokales System – parallel Strahl in und out – nur der Strahldurchmesser ändert sich und damit die Vergrößerung







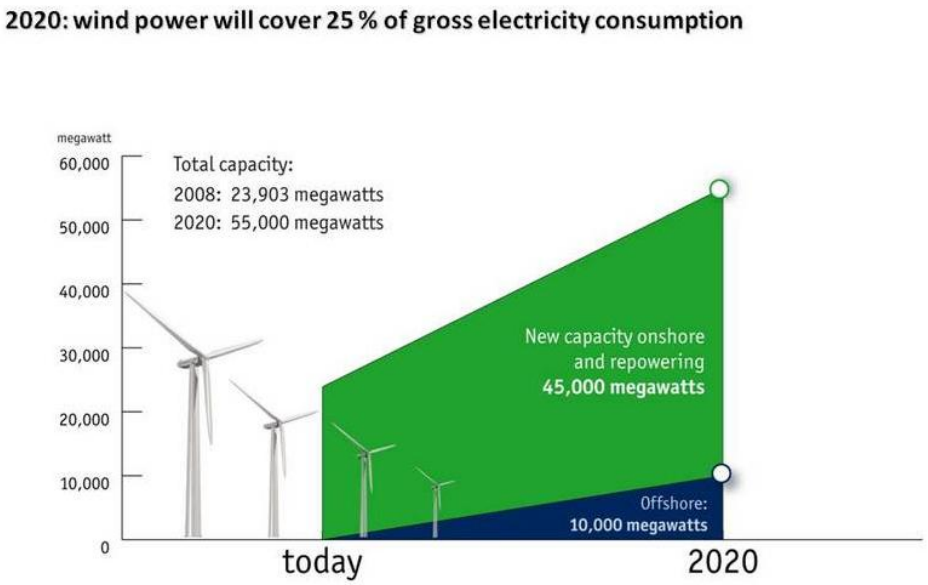
Movement of lenses in an afocal zoom system

• Wind Energy

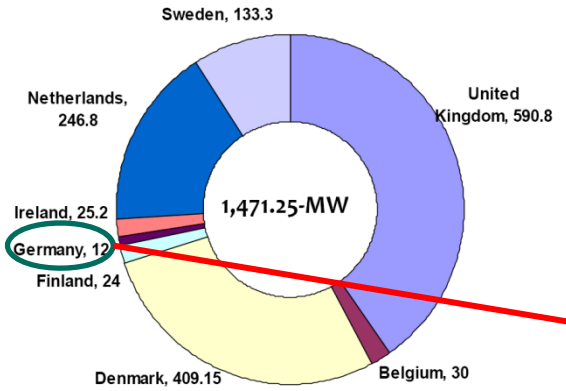
Brief history of wind turbine

- The First Wind Energy Systems
  - Ancient Civilization in the Near East /Persia
  - Vertical-Axis Wind-Mill: for grinding
- Wind in the Middle Ages
  - Post Mill Introduced in Northern Europe
  - Horizontal-Axis Wind-Mill
- Wind in 19th century US
  - Wind-rose horizontal-axis wind mills
  - 1920s-1950s: Propeller-type 2 & 3-blade horizontal-axis wind electricity conversion systems (WECS)
- Second Era of WECS Development (1970s – 1980s):
  - Emphasis on Experimentation & Variety
  - Horizontal-Axis: 1 to many blades
  - Vertical-Axis
    - Darrieus / Egg-Beater (liftdriven)
    - Savonius (drag-driven)

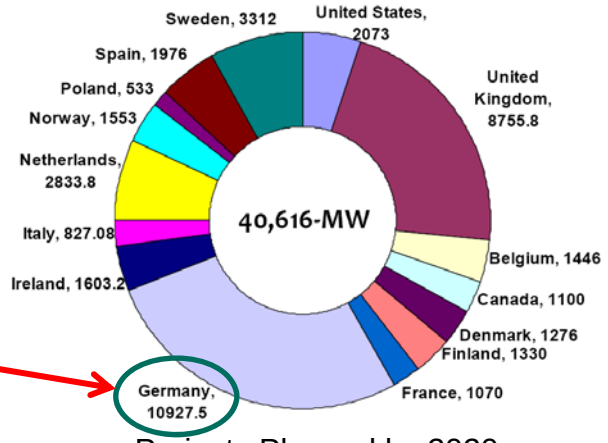
Wind Energy in Germany



- **Today**
  - 20,301 wind turbines
  - 23,903 MW installation power
  - 7.5 % of Germany's net electricity consumption
- **Target**
  - By 2020
    - onshore capacity at 45,000 MW
    - 10,000 MW offshore wind
    - 150 TWh/year wind energy
    - 25 % of the German electricity consumption
  - By 2030
    - 20,000 – 25,000 MW installed offshore capacity



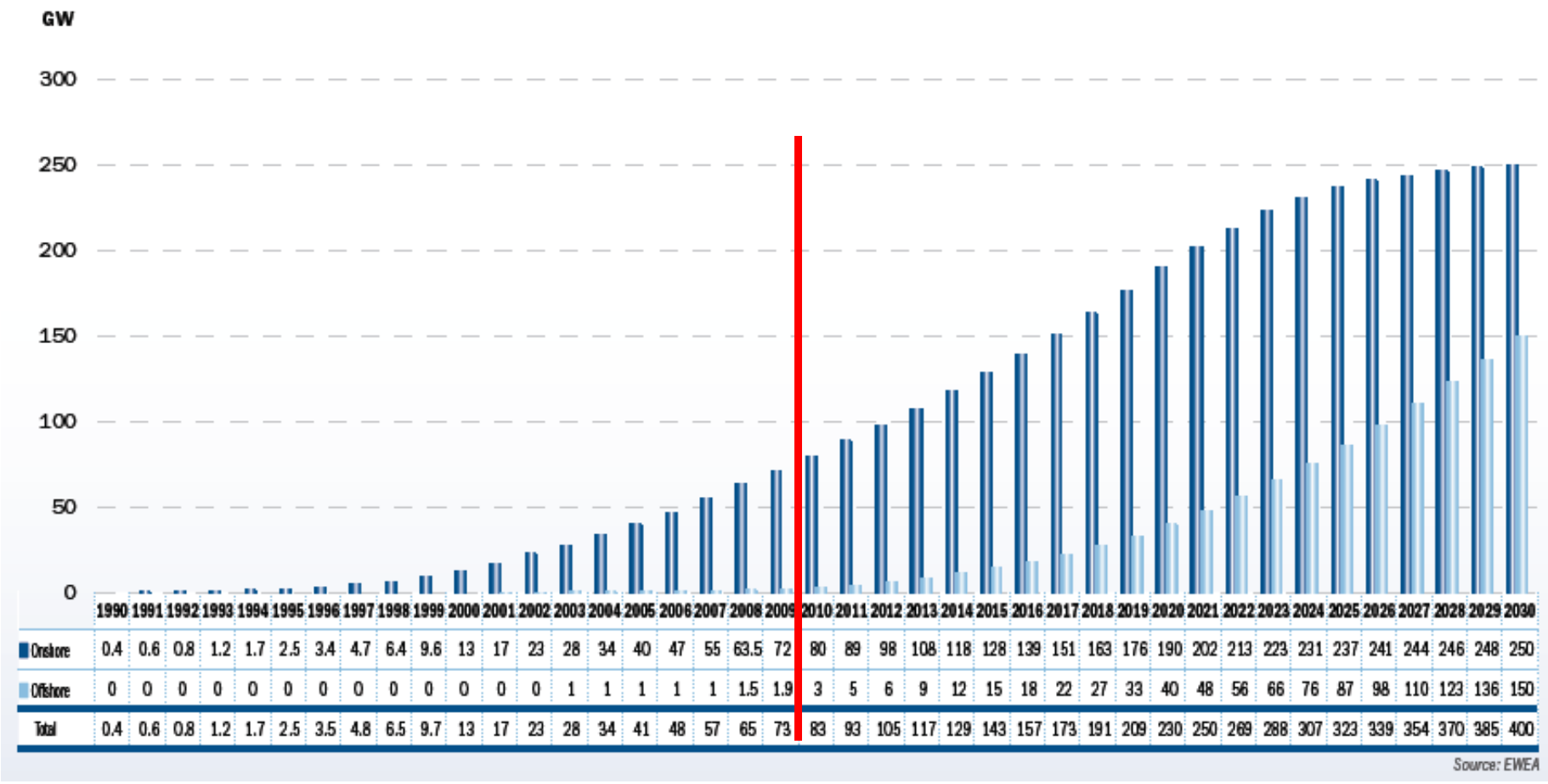
Current Installed Offshore Capacity



Projects Planned by 2020

*Source: The European Wind Energy Association (EWEA)
German Energy Association (BWE)

Cumulative onshore and offshore wind in the EU



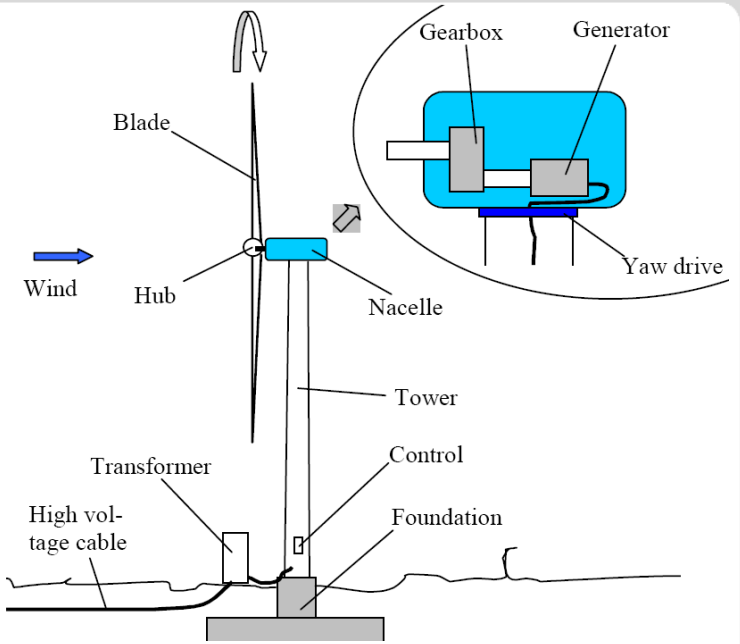
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Onshore	0.4	0.6	0.8	1.2	1.7	2.5	3.4	4.7	6.4	9.6	13	17	23	28	34	40	47	55	63.5	72	80	89	98	108	118	128	139	151	163	176	190	202	213	223	231	237	241	244	246	248	250
Offshore	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1.5	1.9	3	5	6	9	12	15	18	22	27	33	40	48	56	66	76	87	98	110	123	136	150
Total	0.4	0.6	0.8	1.2	1.7	2.5	3.5	4.8	6.5	9.7	13	17	23	28	34	41	48	57	65	73	83	93	105	117	129	143	157	173	191	209	230	250	269	288	307	323	339	354	370	385	400

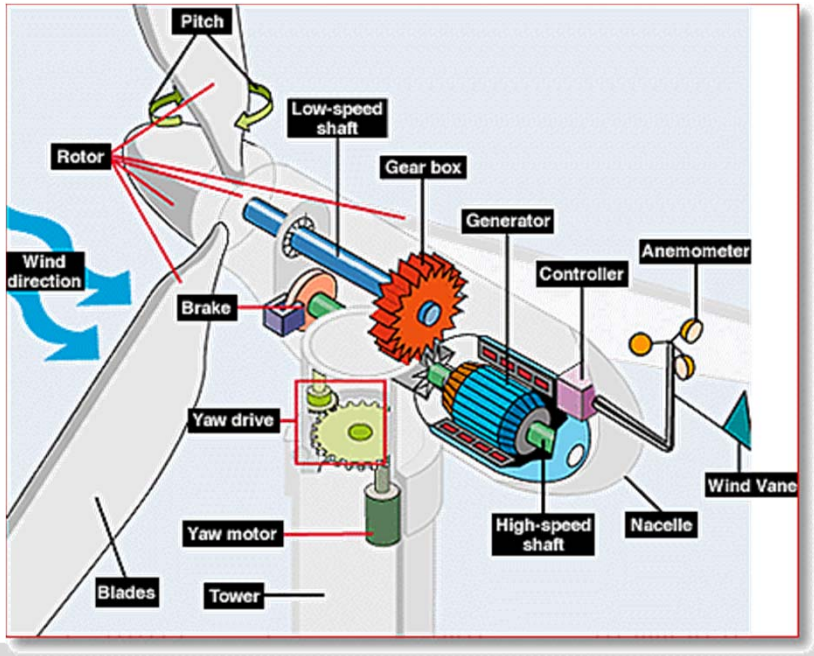
Annual wind power installations EU (1990-2030)

*Source: The European Wind Energy Association (EWEA)

• Modern Wind Turbine
Overview

- Basic Turbine Subsystems Include
  - Foundation
  - Nacelle
  - Hub & Rotor
  - Drivetrain
    - Gearbox
    - Generator
  - Electronics & Controls
    - Yaw
    - Pitch
    - Braking
    - Power Electronics
    - Cooling
    - Diagnostics





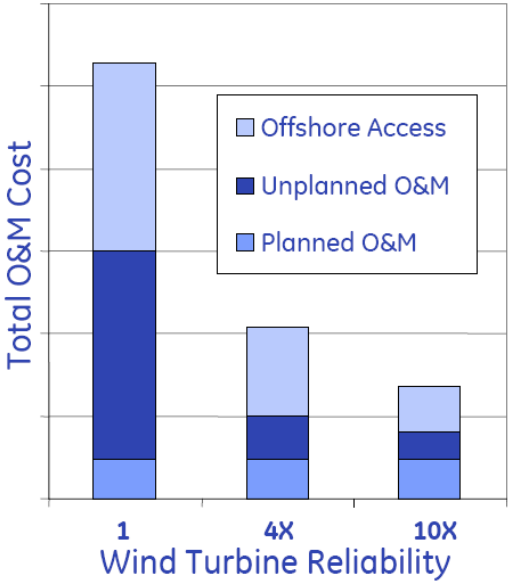
- **Back Ground**

  Offshore wind farms

- Pros
  - Lack of locations and public acceptance for onshore projects
  - Larger energy resources
  - Potentially less complicated planning process
  - Larger projects – economy of scale
- Cons
  - Larger investment (foundations, cables, substations)
  - More expensive O&M (Operation and Maintenance)

Life-cycle Reliability Has Large Impact on O&M Costs

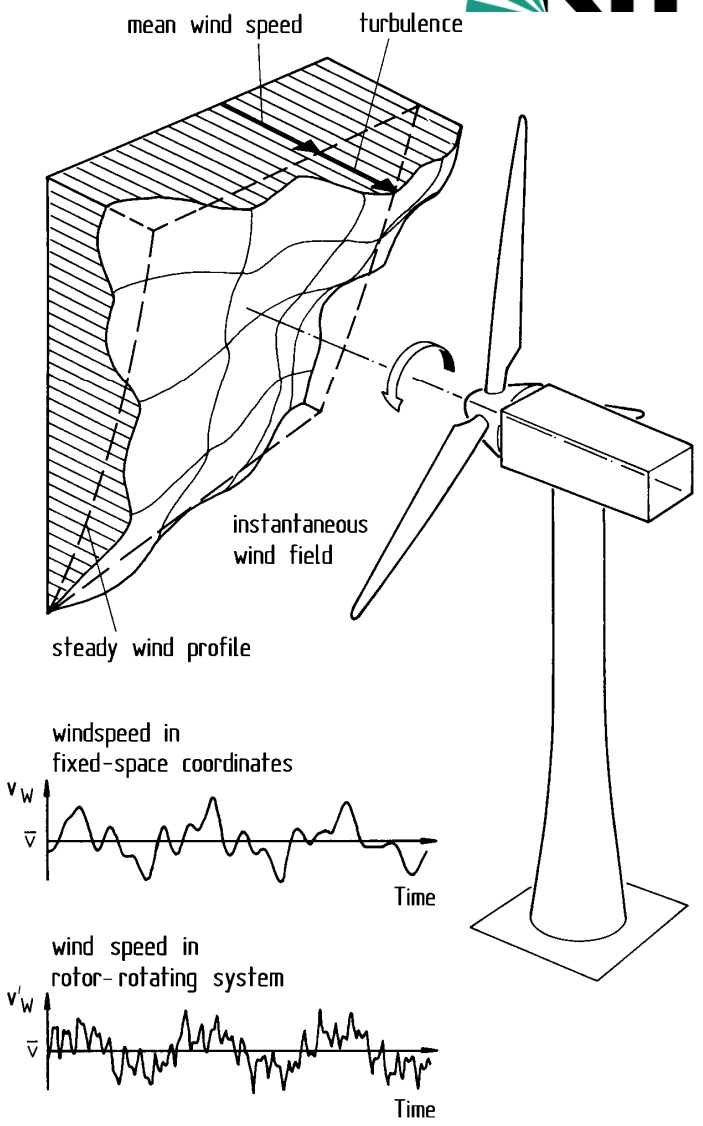
- Product Reliability (Prevention)
  - Enhanced Offshore Equipment Designs
  - Design for Serviceability
  - Advanced Controls for Load Mgmt & Performance



• Modern Wind Turbine

Problem statement for offshore wind turbine

- **Wind Loading**
  - Wind conditions are complex and site specific
  - Large spatial and temporal variations
  - Rotational sampling effect increases effective wind fluctuations
- Wind Sensing
  - Limitation of current turbine wind sensor
    - Wind cup anemometer
    - Ground based wind LIDAR
    - Wind LADAR, SODAR, LDV, …
- Other issue
  - Difficulty for construction
  - Difficulty for access
  - Damage from wave, hurricane, seaweed
  - ect …



Effect of an uneven wind-speed distribution over the swept rotor area on the upwind velocity of the rotating rotor blades*

*Figure Source: E. Hau, Wind Turbine, 2006

Motivation

- Reduce O&M cost
  - Extensions of life-cycle time and Improving the turbine reliability
    - Reducing the damage of mechanics
    - Predictive control of blade pitch
    - Reducing influence from wind fluctuations
  - Improving the efficiency of turbine
    - Destructive dynamic loads, excited by turbulent inflow & rotation
    - Greater potential dynamic coupling
    - Extend the working wind speed range
- Smart turbine design
  - Optimal control to get highest output
- Larger scale turbine design

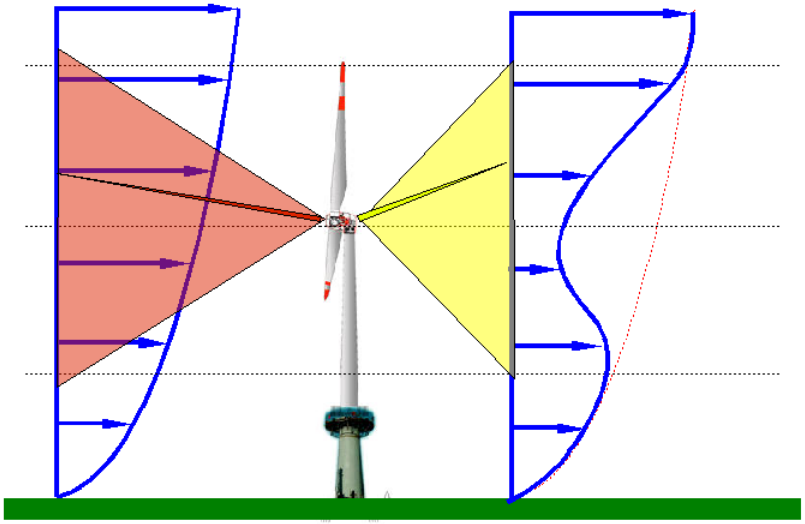
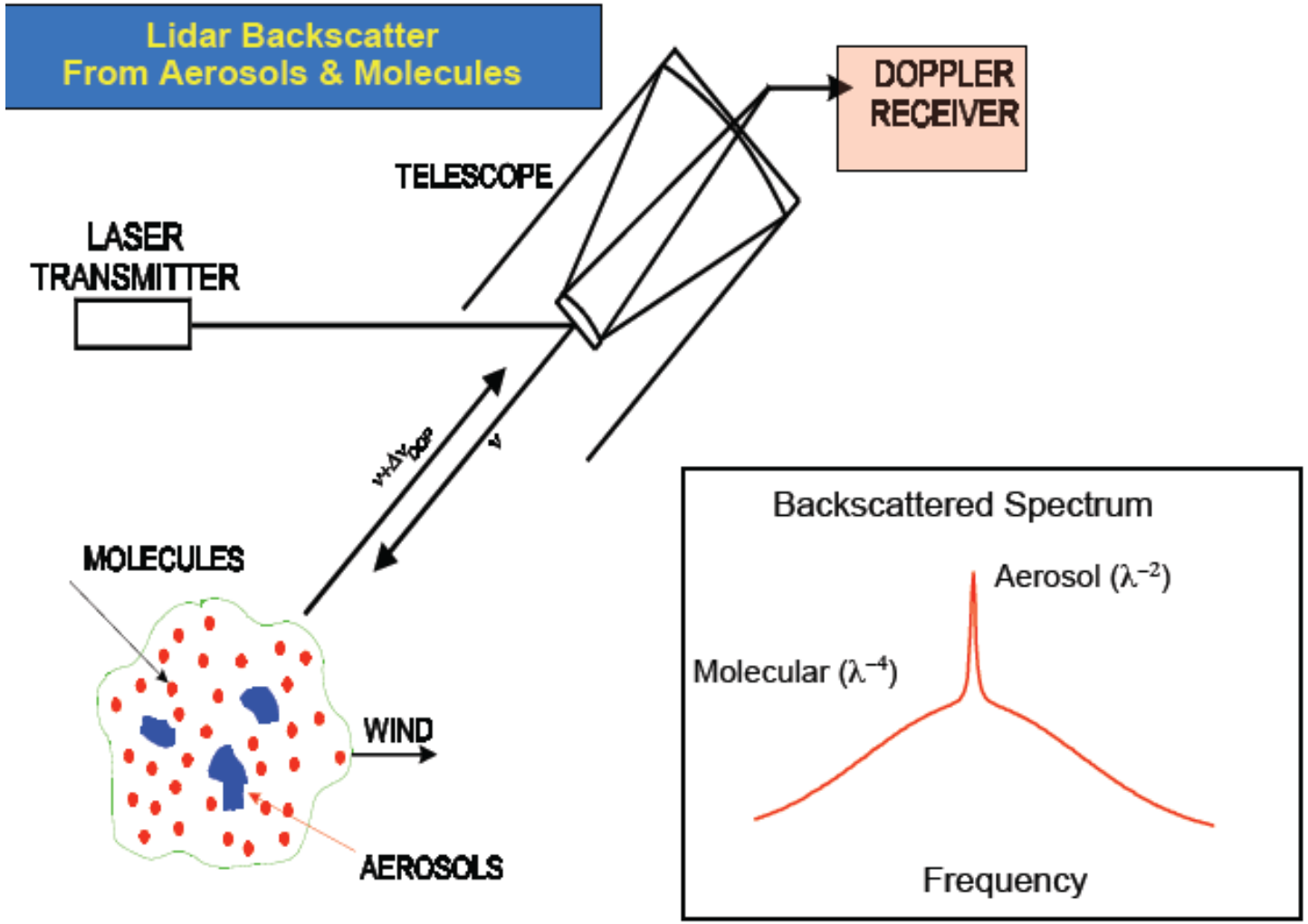
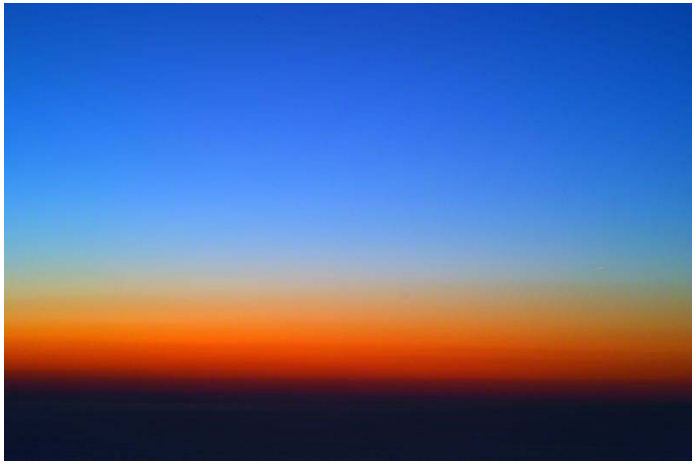


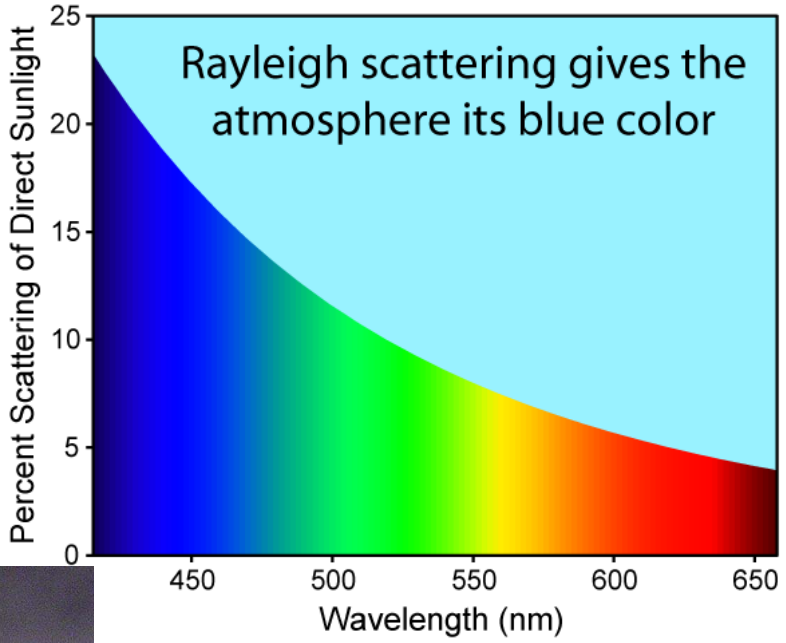
*Figure Source: SWE, Stuttgart

- **Introduction to LIDAR**
  Doppler Wind LIDAR



Rayleigh Streuung

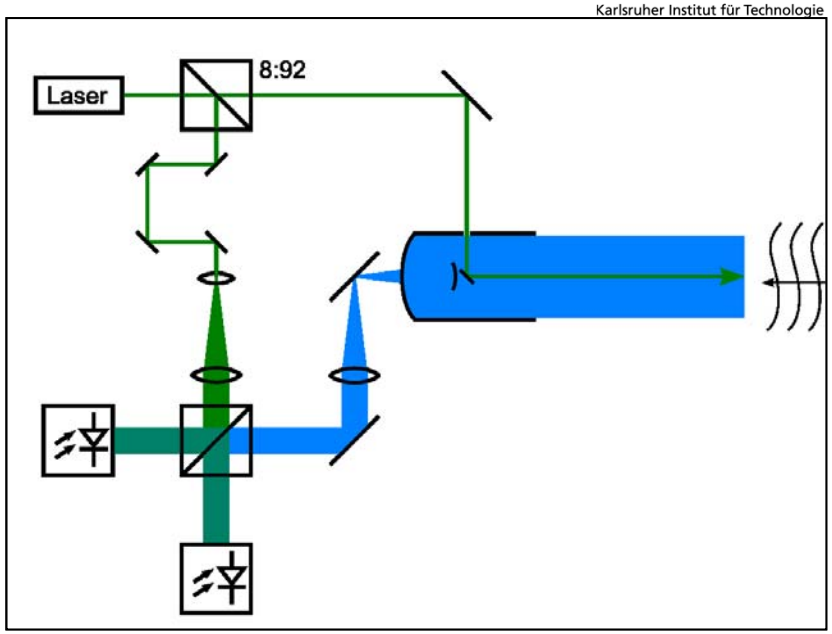


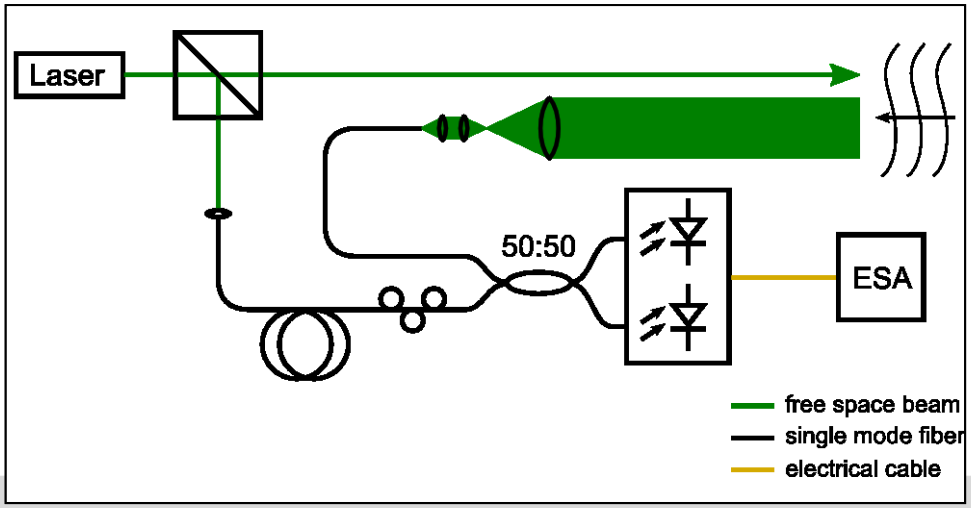


• Introduction to LIDAR

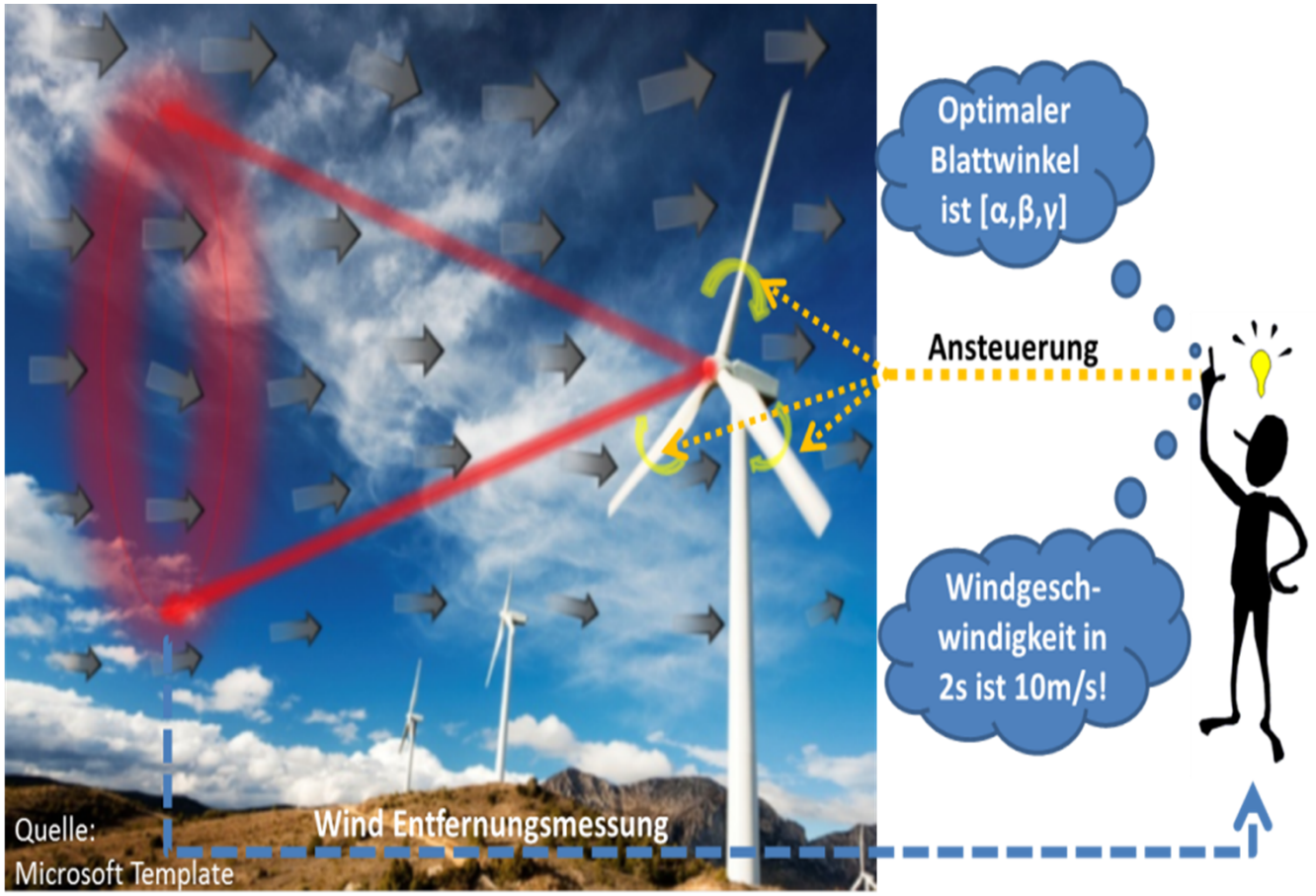
Layout of a LIDAR system

- Transmitter
  - Laser
    - Focusing setup
    - Collimating setup
- Receiver
  - Receiver optics: telescope
  - 50:50 beam splitter
  - Detector
    - APD
    - PMT
    - Pin photo-diode
- Signal processing
  - Spectrum analyzer





Neues Projekt am ITIV



Windprojekt – Lastregelung durch Laser-Doppler Messtechnik