

Sensori ottici e laser nelle applicazioni industriali

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Outline

- ❑ **Optical sensors in industry: why?**
- ❑ **Types of optical sensors**
 - ❑ optical barriers
 - ❑ distance measurement / ranging
 - ❑ vibration measurements
- ❑ **Julight series and custom products for industry**

Optical sensors in industry: WHY ?

❑ **contactless**



❑ **precise**



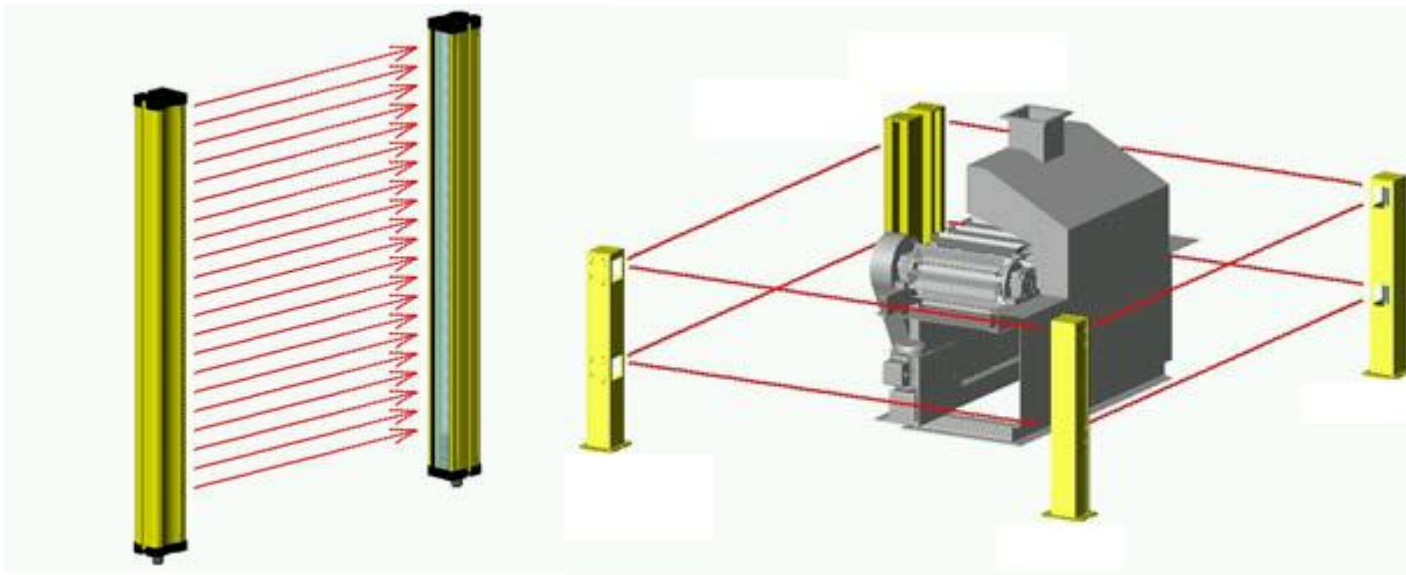
❑ **small-sized**



❑ **versatile**



Optical barriers



- **Application:** presence ; safety ; intrusion ; shape, ...

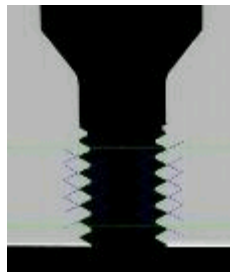
Optical barriers

- ❑ Technology

- ❑ LED / laser + photodetector

- ❑ Precision

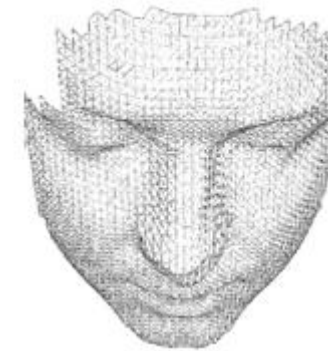
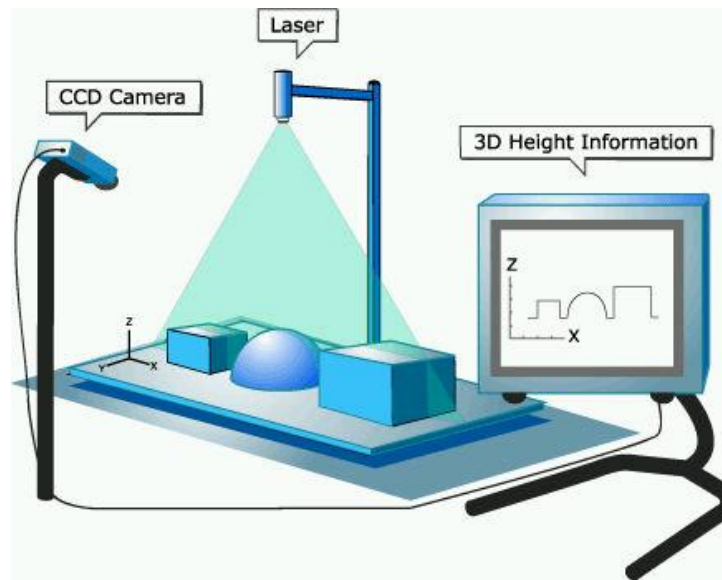
- ❑ low / high



- ❑ Evolution

- ❑ from presence to detailed shape measurements
 - ❑ tomorrow: lower cost ; higher resolution

Distance / Ranging

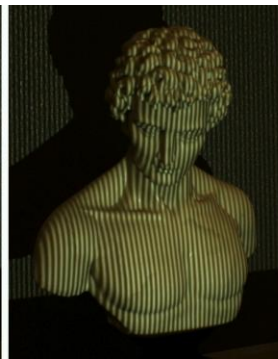
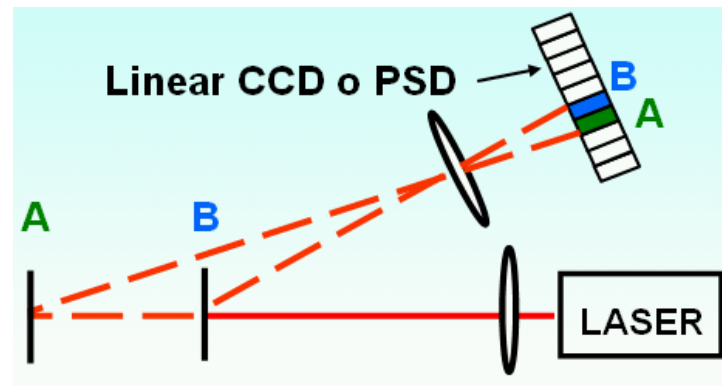


- ❑ **Application:** control ; size/shape ; 3D imaging ; ...
- ❑ **Technology:** triangulation ; time-of-flight ; confocal ; coherence radar

Distance / Ranging → Triangulation

□ Technology

- laser / LED / white light + 1D/2D photodetector (PSD, CCD, CMOS)
- pure triangulation / structured light projection



Distance / Ranging → Triangulation

□ Precision

- mm / μm

□ Advantages ☺

- (relatively) low cost ; operates on all surfaces ; versatility

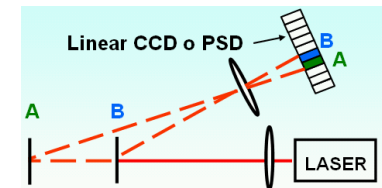
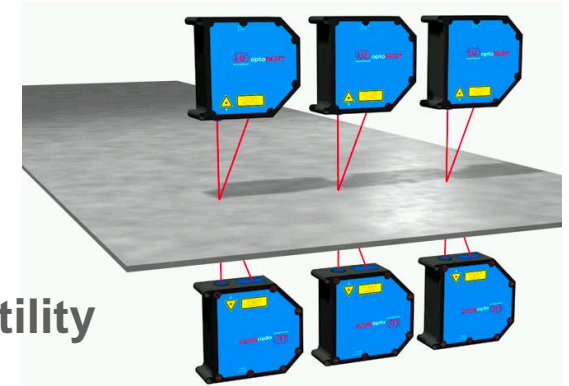
□ Drawbacks ☹

- not a collinear technique → requires an “angle of view”
→ not suited for sharp edges, holes, etc.

- precision scales with stand-off distance → long distance = poor resolution

□ Evolution

- from single-point to 2D (laser line) and 3D (structured light)
- tomorrow: miniaturization ; integration with other sensors



Distance / Ranging → Time-of-flight

❑ Technology

- ❑ laser + (fast) photodetector

❑ Precision

- ❑ a few mm

❑ Advantages 😊

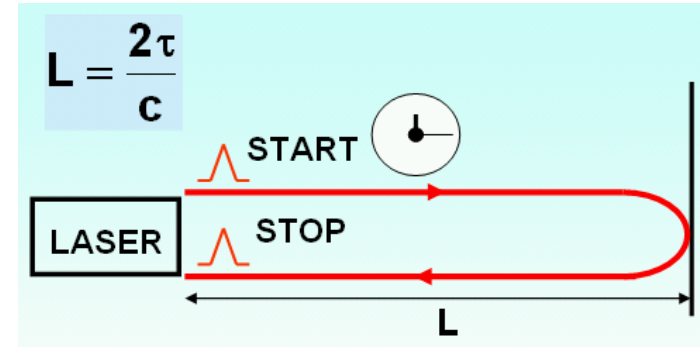
- ❑ very long range (0.2÷100m) ; operates on all surfaces ; collinear

❑ Drawbacks 😞

- ❑ not a high resolution technique

❑ Evolution

- ❑ from industrial sensor to portable devices
- ❑ tomorrow: no further improvements



Distance / Ranging → Confocal

❑ Technology

- ❑ white light + optical fiber + spectral measurement

❑ Precision

- ❑ nm !!

❑ Advantages ☺

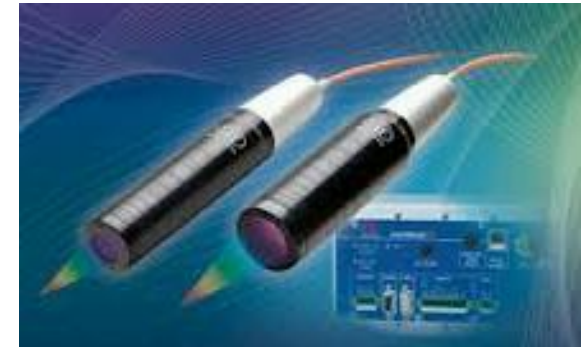
- ❑ very high resolution (10nm) ; collinear

❑ Drawbacks ☹

- ❑ very limited distance range (10-30mm) ; high cost

❑ Evolution

- ❑ from laboratory to industrial sensor
- ❑ tomorrow: extended range?





❑ Technology (**Julight**)

- ❑ diode laser + wavelength modulation + interferometry

❑ Precision

- ❑ μm

❑ Advantages ☺

- ❑ good resolution/range ratio (stand-off 10-500mm) ; collinear ; small size

❑ Drawbacks ☹

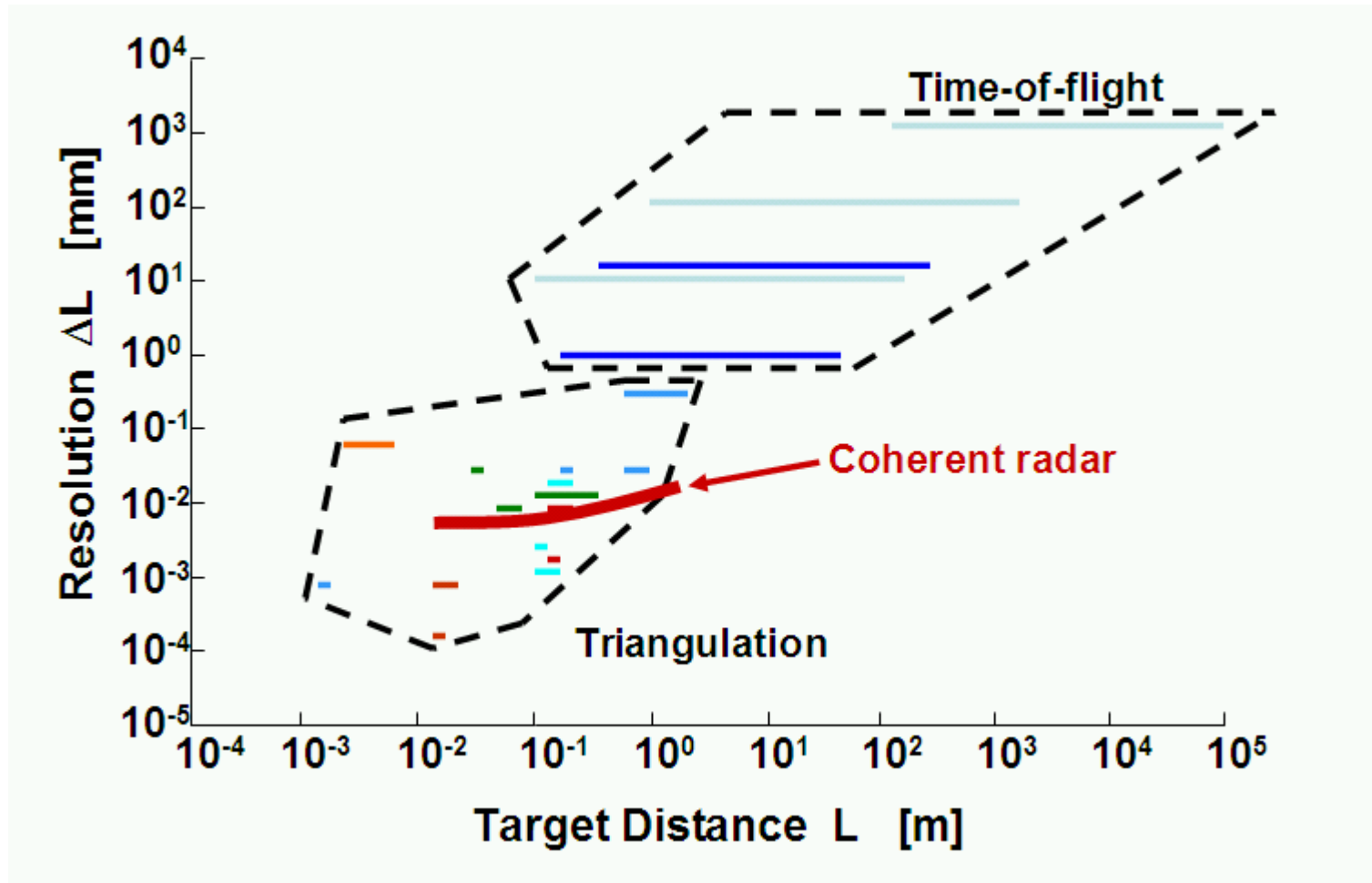
- ❑ requires steady target ; new technology

❑ Evolution

- ❑ from laboratory to industrial sensor
- ❑ tomorrow: miniaturized sensor



Distance / Ranging Comparison



Vibration measurements

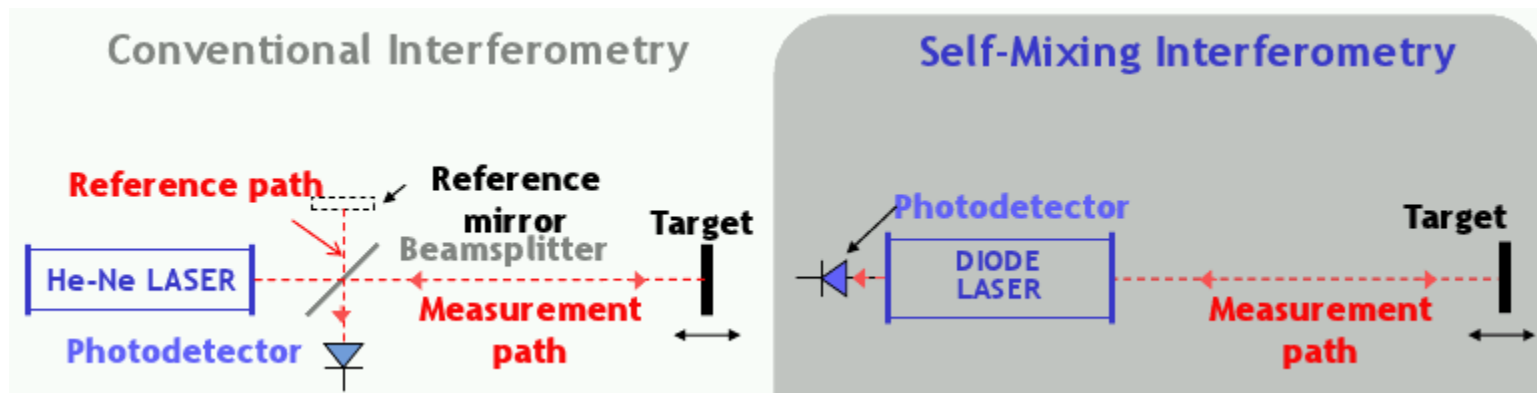


□ Application: quality control ; modal analysis ; machine supervision

Vibration measurements

❑ Technology



- ❑ (trivial) use time-domain response of distance sensors
- ❑ laser interferometry



❑ Precision

- ❑ nm

Vibration measurements

- ❑ **Advantages** 
 - ❑ extremely high resolution ; collinear ; small size (Self-Mixing)
- ❑ **Drawbacks** 
 - ❑ large size (conventional technology) ; high cost ; intrinsically single-point
- ❑ **Evolution**
 - ❑ from conventional to Self-Mixing technology
 - ❑ tomorrow: miniaturized sensor for in-line applications



Julight

when light takes the measure



COMPANY

- Julight Srl: a start-up company, spin-off of the **University of Pavia**



Instruments and sensors based on lasers and photonic technologies

- **Julight staff**
 - Founding partners have 15+ years international experience in photonics
 - Management: expertise in finance, human resources and business
- **GOAL:**
 - Exploit **laser light** for novel **control & measurements** applications
 - Fields: **Industry** • **Laboratories** • **Biomedical**

Julight Technologies

- ❑ **Laser triangulation**
 - ❑ distance / ranging
 - ❑ vibrations
 - ❑ small sized

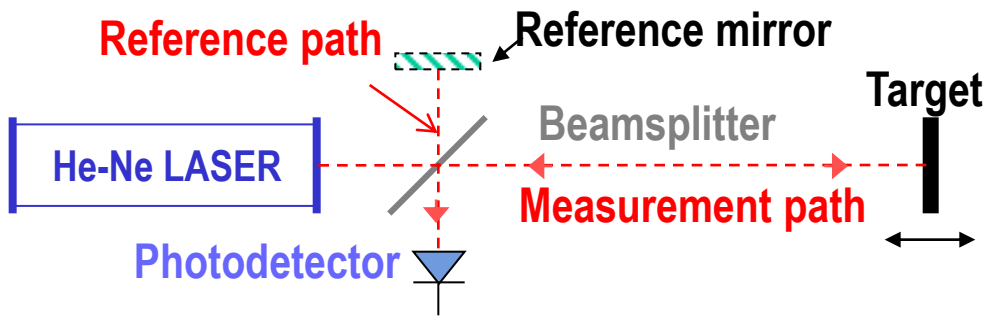
- ❑ **Self-Mixing interferometry**
 - ❑ vibrations
 - ❑ distance: coherent laser radar (collinear beam)

- ❑ Any other laser measuring technique

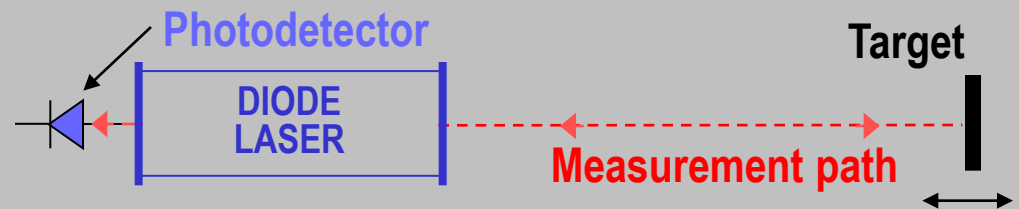
- ❑ Integration of **optics, photonics, electronics**

TECHNOLOGY: Julight'S SELF-MIXING INTERFEROMETRY

Conventional Interferometry



Self-Mixing Interferometry



ADVANTAGES

- Reduced optical components count
 - **simple** and **reliable**
 - **small optical head** (*the smallest on the market!*)
- Automatic alignment** system
- Operation on **rough surfaces**
(no need for mirrors or retroreflective paper)

Julight LASER VIBROMETERS

CONTACTLESS MEASUREMENT

VSM100

Single-Head Laser Vibrometer



**SMALL-SIZE
optical head**

25 mm x 60 mm x 100 mm

VSM400

Multiple-Head Laser Vibrometer



**...up to 4
optical
heads!!!**

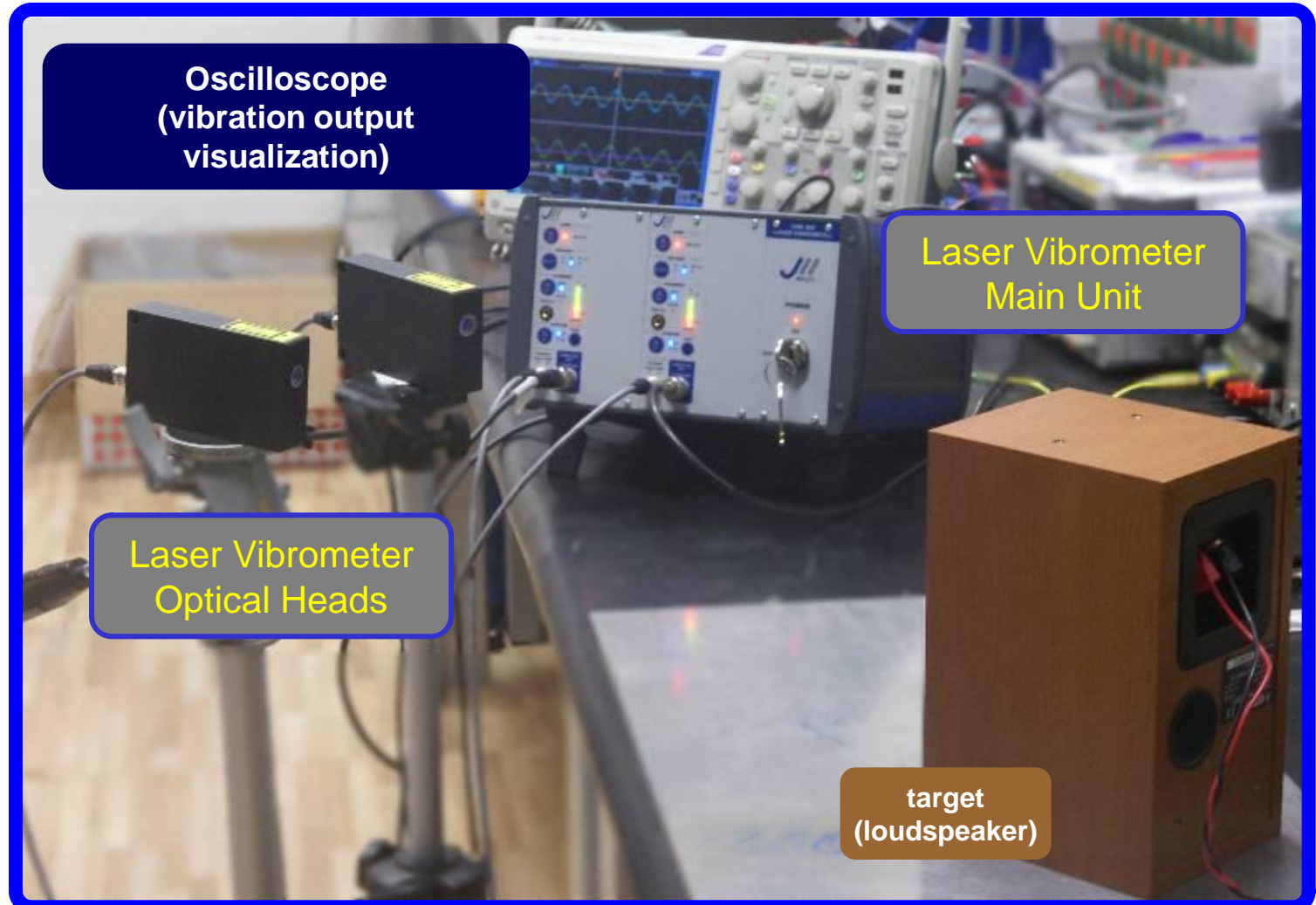
**also
available as
OEM
module**

**modular
architecture**



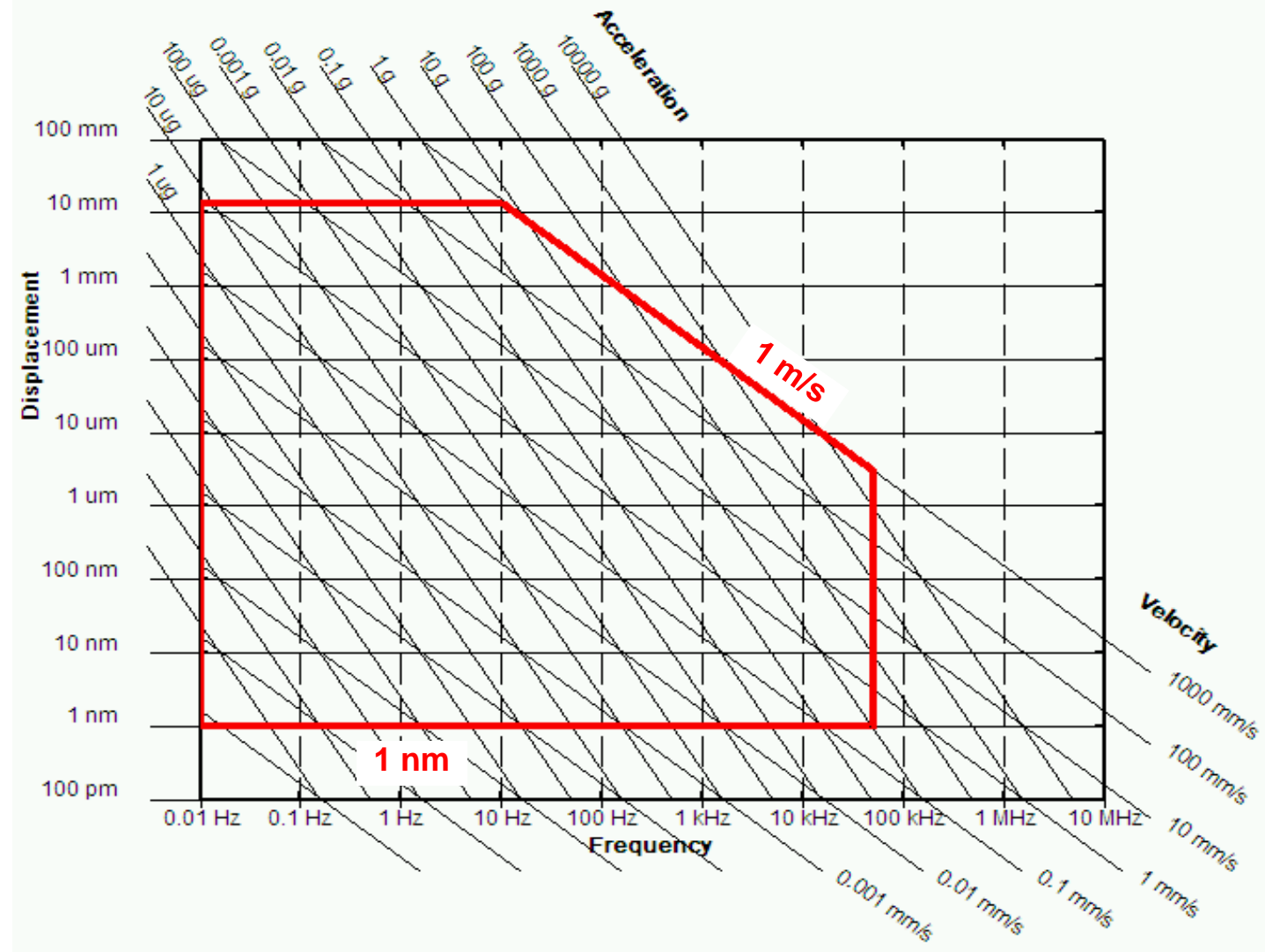
VIBRATION MEASUREMENTS by **Julight**

- ❑ operating distance
20 – 40 – 100 cm
- ❑ Automatic alignment
- ❑ LED bar indicator for optical signal quality



Julight LASER VIBROMETER CHARACTERISTICS

- ❑ **Displacement** vibration output (1 mV/ μm \Leftrightarrow 1000 $\mu\text{m}/\text{V}$)
- ❑ Frequency range: DC to 50 kHz (works as DC interferometer)
- ❑ 1 nm sensitivity



Julight PRODUCTS vs. MAIN COMPETITOR



34 cm
vs.
10 cm

**SIZE DOES
MATTER!**



Further miniaturization possible
(limit is laser diode size!)

Julight *CUSTOMIZED SERVICES*

Julight's proven expertise in photonic systems and measuring techniques enables to offer state-of-the-art customized services

- **Consultancy and solutions** for the development/exploitation of laser and photonic technologies
- **Design and realization** of *prototype and small-series* systems (distance, displacement, speed, flow, roughness, thickness, material composition, etc.).
- **On-site measuring campaigns**