Premium German Quality in Light & Display Measurement.

Global Sales Network and Service Teams.
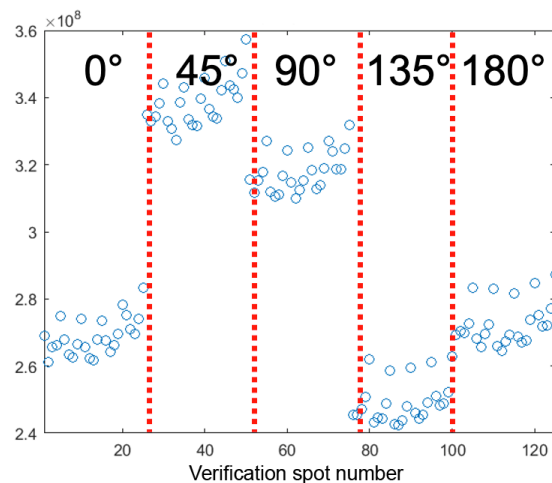
One-Shot Single Emitter Characterization

on a VCSEL Array including polarization properties
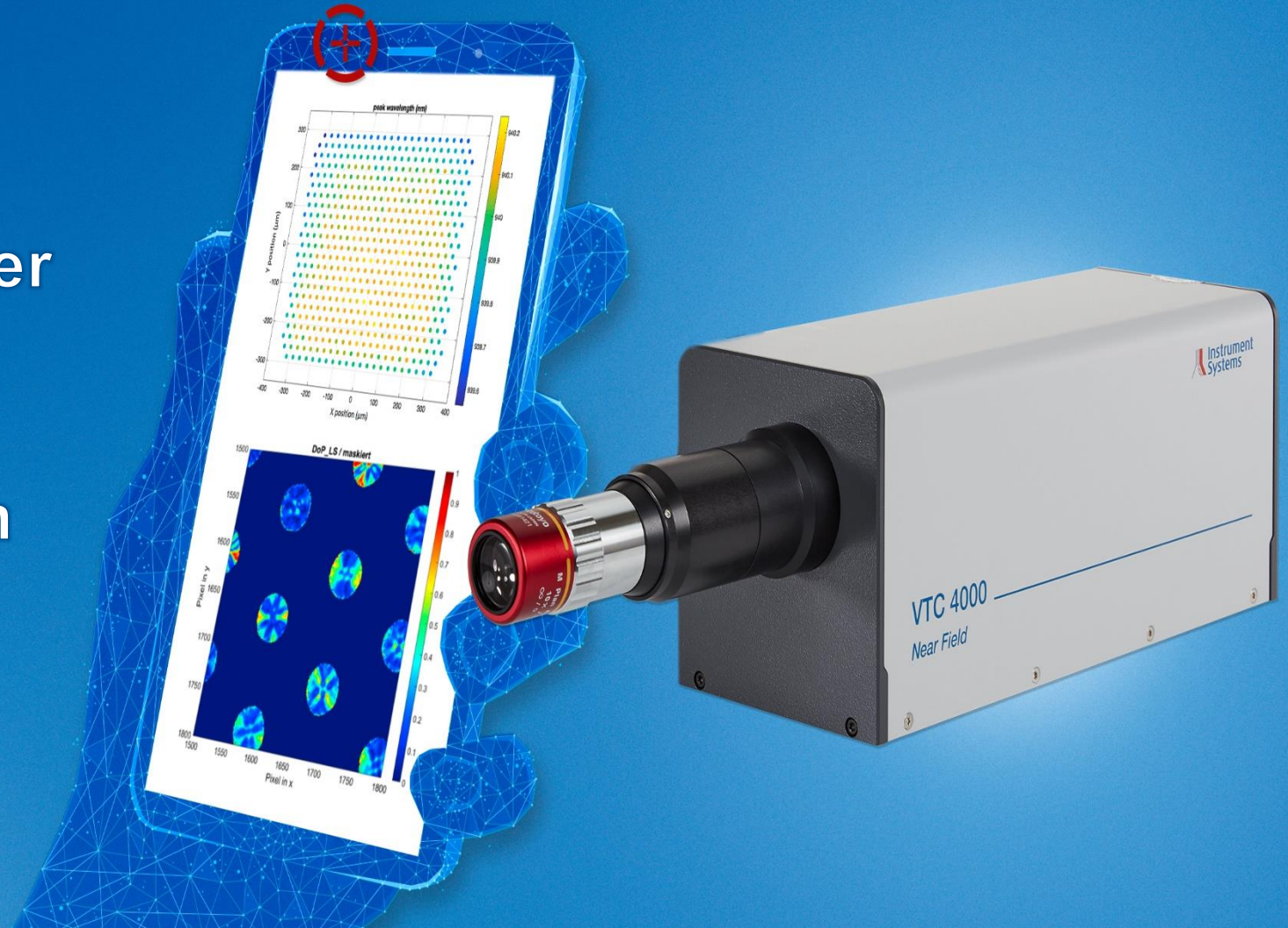
Importance of characterizing polarization dependency

- For absolute power measurements of the emitter power of the VCSEL, e.g. for eye safety, it is important to take these effects into account, otherwise the read-out value is incorrect.

Comparison of total power measurement with different polarizations, each dot represents one measurement position. Measurement done with rotating the source in 45° steps
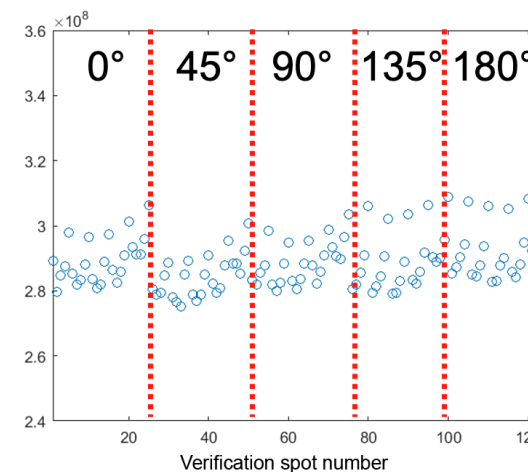
The same measurement as shown in the left, but corrected for polarization effects. The intensity does not show any polarization effects anymore and can be calculated back to Watt independent of the polarization of the incoming light.

Polarization Analysis with VTC 4000

Degree *of polarization*

Angle *of polarization*

Polarisation unstable
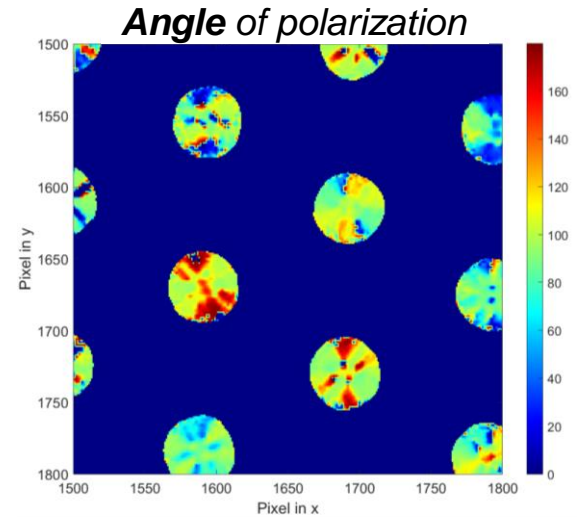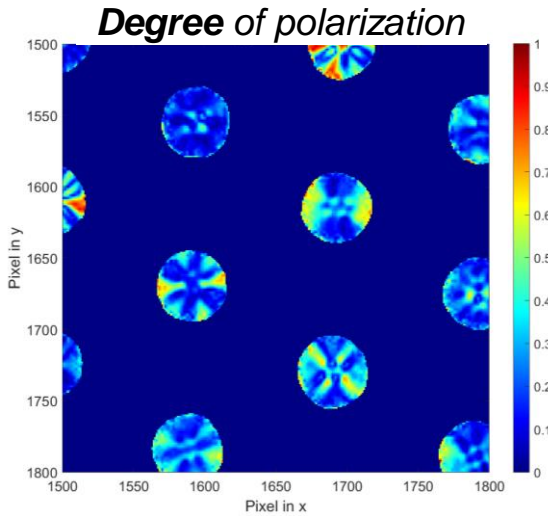
Polarisation stable
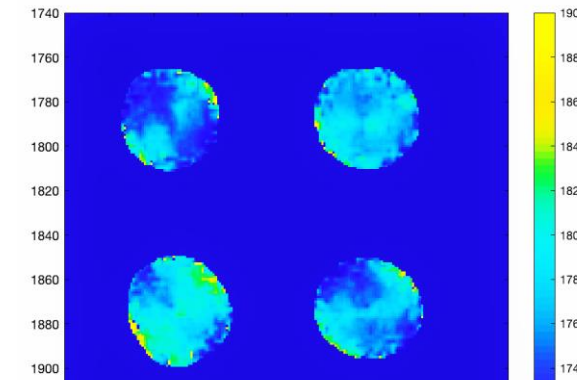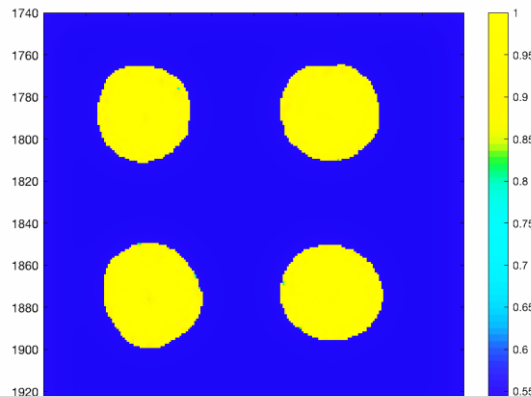
This solution can be very helpful for the researchers as well as for VCSEL manufacturers to characterize/analyze polarization controlling techniques

Results

◢ Polarization Angle
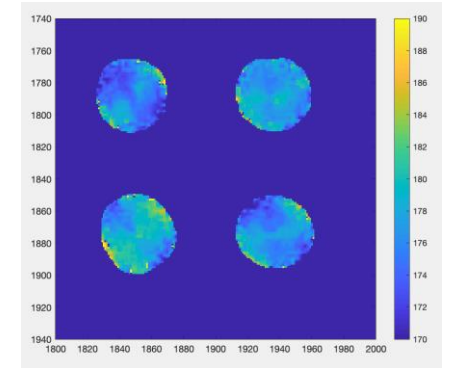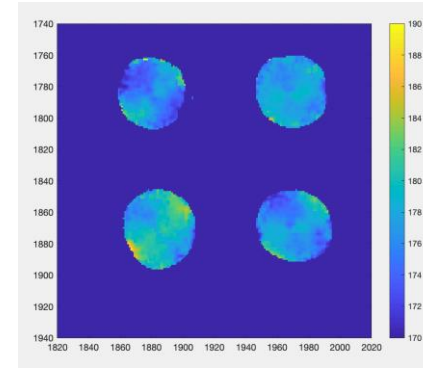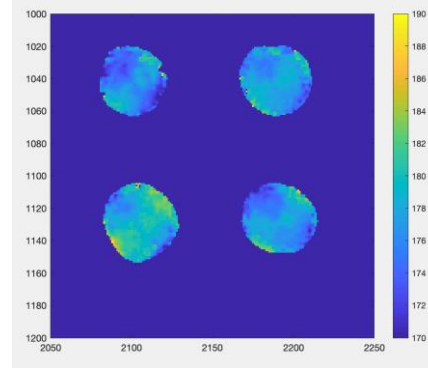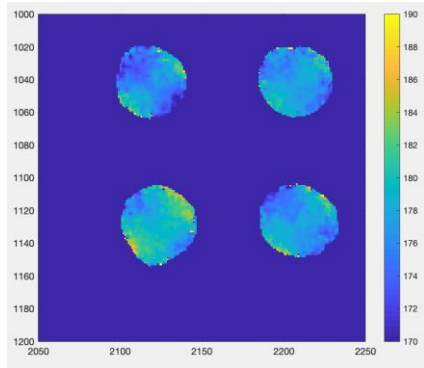
◢ Polarization Degree
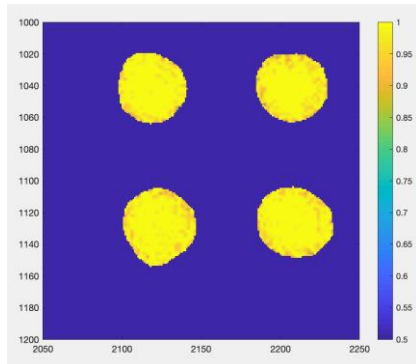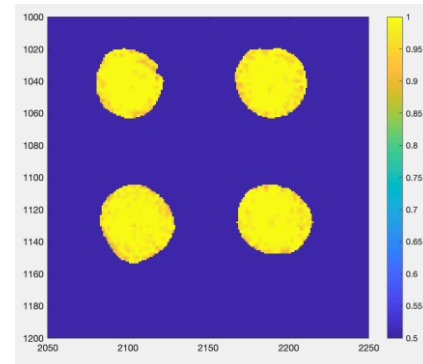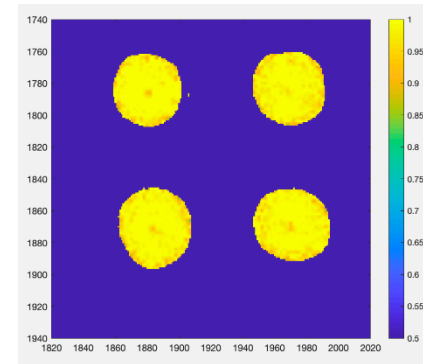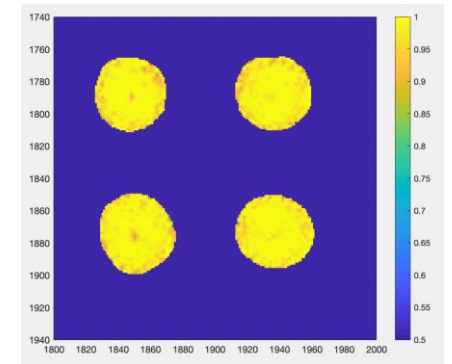
| 15mA | 20mA | 25mA | 30mA |

Laser light

Coherent and strongly directed, great potential to destroy retina, lens or cornea

Eye-Safety

Laser Eye Safety

Determine the fraction of laser light absorbed in the eye ball or imaged onto the retina

Laser Class Assessment: Flowchart

```
Laser pulsed or          YES      λ, P/E, PW,          YES      Choose class to                Determine
scanned?                          PRF known?                    evaluate                       time base
                                                                (start with class 1)
     │ NO                              │ NO
     ▼                                 ▼
Refer to CW                       Determine λ, P,                                          Angular subtense &
classification                    PW, PRF                                       YES        acceptance angle known?
                                                                                                │ NO
                                                                                                ▼
                                               Determine AEL measurement          Determine angular subtense &
                                               conditions and limits and          acceptance angle or assume small
                                               evaluate                           source

Classification      YES    Single fault       YES    Accessible
DONE!                      condition                 emission less than
                           satisfied?                AEL?
                                                          │ NO
                                                          ▼
                                                                                  Repeat for a higher
                                                                                  class
```

[Eye safety assesment](#) ←Youtube Video

Data acquisition and measurement device

Eye safety --IEC60825-1 standard

Values to be collected from measurements:

1. **Wavelength**
2. **DUT array size, emitter, pitch (for Alpha)**
3. **Average power**
4. **Beam profile**
5. **Divergence angle (for spot area)**
6. **Highest Intensity Spot**
7. **Repetition frequency, pulse with, pulse train**

VTC2400

VTC4000

PVT

NIR Light source from a commercial IPhone 12 pro

Example : Iphone12pro front light source

Far-Field: VTC2400

Technology:
2D camera with transparent screen

Parameters:
- Beam Profile
- Divergence Angle
- Hot Spot detection (Max Power)
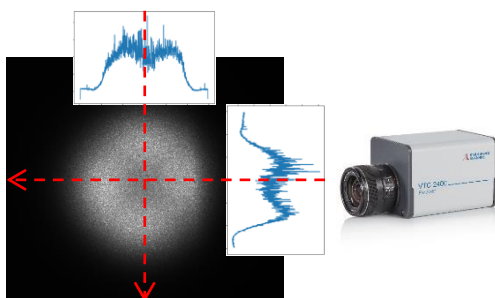
Pulse Analysis: PVT

Technology:
Spectrometer with integrating sphere, driving electronics and fast photodiode

Parameters:
- Pulse width, Pulse train, DC
- Power, Wavelength
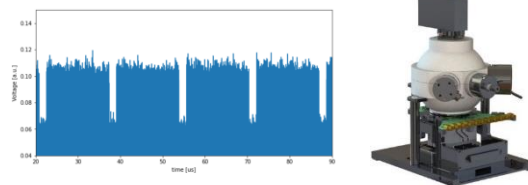
Spectral Analysis: HR-CAS

Technology:
Spectrometer with integrating sphere and optional photodiode

Parameters:
- Wavelength
- Peak Power
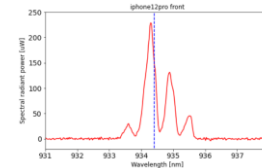
Near-Field: VTC4000

Technology:
2D camera with microscopic optics

Paramters:
- Emmiter and Array size
- Pitch
- Beam quality
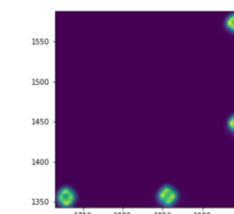
PLUS NIST or PTB traceable calibration with known error budget

Hot Spot Detection in Lumisuite Software with VTC2400
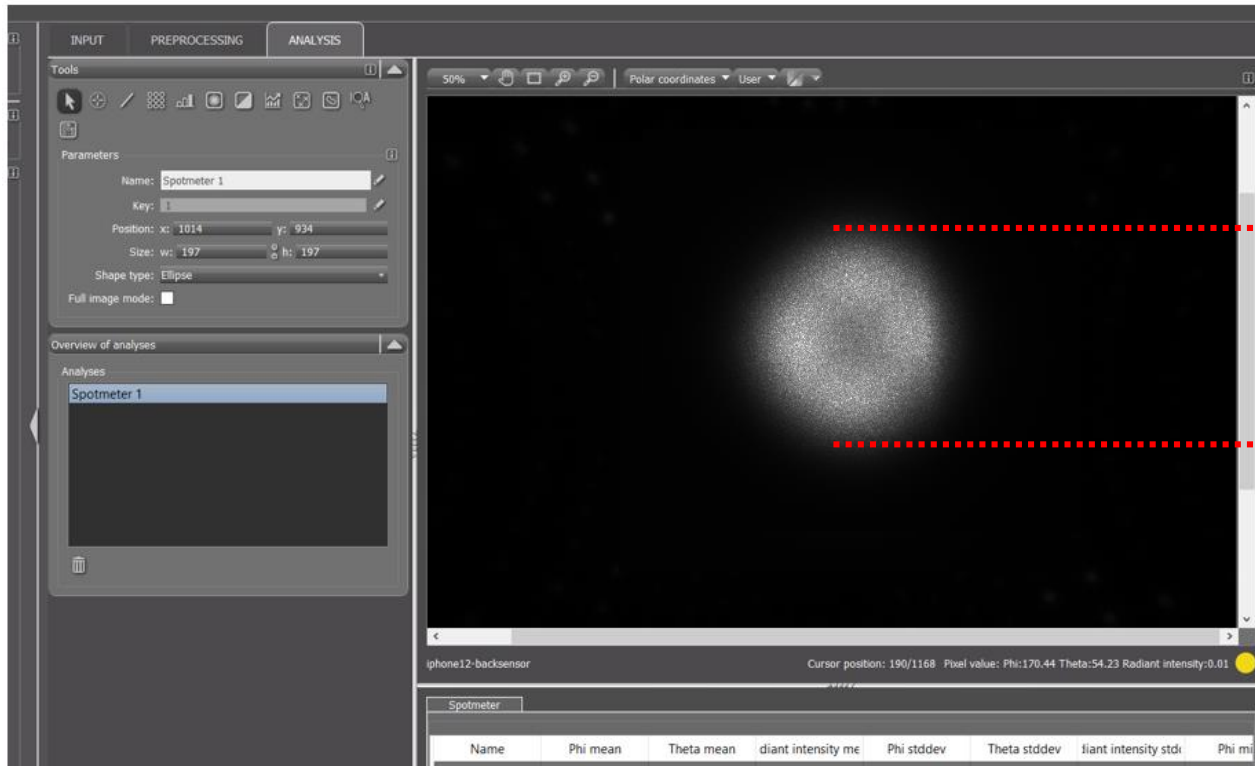
Auto detection for highest intensity within area
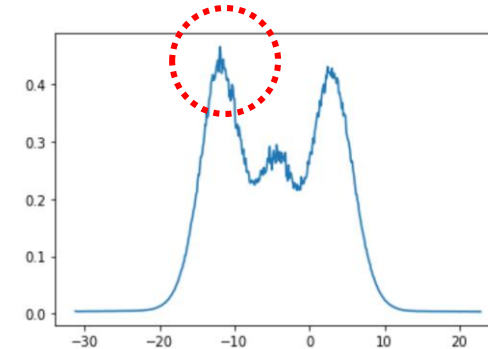
▲ In reality, the radiant intensity is not homogeneously distributed

▲ Hot Spot Detection is necessary

▲ Relevant for eye safety considerations

Calculations

Parameter

Messung mit PVT, VTC2400, VTC4000		Geometrische Berechnungen		Konstanten und Korekturfaktoren lt. Norm	
lambda	934.400000000 nm	D_eye(940nm)	0.007000000 m	Timebase(940mn)	10 s
t_pulse	0.000015000000 s	=> A_eye	0.000038485 m²	C4	2.94306599
p_peak	0.006003493 W	D_min	0.100000000 m	C6	0.277149984
t_burst	0.010000000 s	A_spot (D_min)	0.000347049 m^2	T_i	0.000005 s
DC_pulse	0.882352941	A_spot/A_eye	9.017877772		
=> T	0.00001700000				
DC_burst	0.029411765	**P_eff**	**0.000665732**		
		Ausgedehnte Quelle			
Divergence	24.000000000 °	alpha_x	0.000415725 rad		
=>Div_rad	0.209439510	alpha_y	0.000422625 rad		
=>DUT X	0.000083145 m	alpha_min	0.001500000 rad		
=> DUT Y	0.000084525 m	(beachte für alpha < alpha min: C6=1)			

| 1. Single Pulse Kriterium (S.27)		2. Mittlere Leistung nach 5µs, 2ms und 10s (S.27)		3. Reduziertes Einzelpulskriterium (S.27)	
E_pulse	**9.98599E-09**	N(T_i)	0.294117647	C5(T_i)	1 (N<600,Tpulse<Ti)
E_SP_MPE	6.28066E-08	**P_avg(T_i)**	**0.000587411**	C5(t_burst)	86.660938 (N<600,Tpulse<Ti)
		P_avg_MPE	0.012561329	C5(Timebase)	624.8475007
		N(t_burst)	588.235294118	**E_pulse_Ti**	**9.98599E-09**
		P_avg(t_burst)	**0.000587411**	**E_pulse_Tburst**	**9.98599E-09**
		P_avg_MPE	0.001805564	**E_pulse_Timaba**	**9.98599E-09**
		N(Timebase)	17301.038062284	E_SP_MPE_Ti	6.28066E-08
		P_avg(t_Timeba	**0.000017277**	E_SP_MPE_tburst	5.44288E-06
		P_avg_MPE	0.000321080	E_SP_MPE_Timba	3.92446E-05
		PLR		PLR	
		T_i	0.046763440	T_i	0.158995695
		t_burst	0.325333757	t_burst	0.001834687
		t_Timebase	0.053808416	t_Timebase	0.000254455

Manual Calculation

Classified as Class 1 Laser

LaserEyeSafety Tool

Take Home Message

▲ VCSELs are lasers and must comply with the IEC60825-1 standard

▲ As compared to „normal" lasers they are
  – Multimode / Irregular
  – Divergent
  – Often Extended
  – Often Pulsed

▲ Worst case assumptions can reduce effort (complex measurements and analytics), however, may lead to restricted AELs

▲ **Choose calibrated and traceable measurement equipment that satisfies IEC 61040 !**

Thank you for your attention

Custom Solutions

Modular system approach

VCSEL testing solutions for complete characterization

Production Know-how

German Engineering

High-end HW & SW

VCSEL characterization adapted to your needs

The Solution Provider

Application Know-how

Service & Support

Certified calibration processes and error budget analysis

Metrology Know-how

World-wide service and calibration partners

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