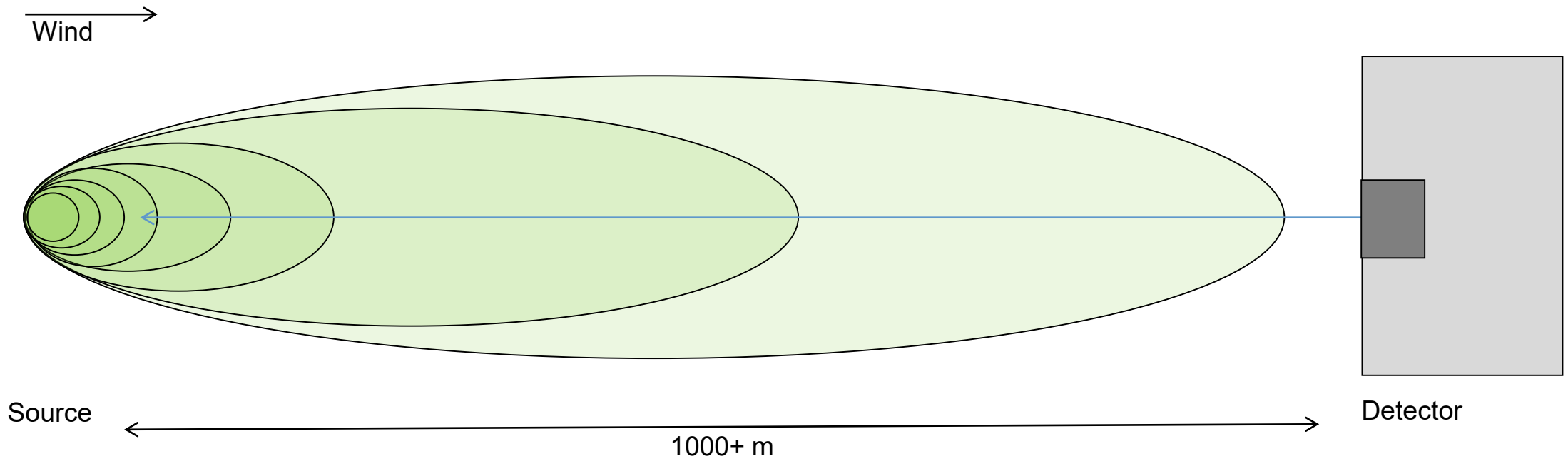


ADVANCES IN A STANDOFF RAMAN SYSTEM FOR CHLORINE GAS DETECTION

14th CBRNe Protection Symposium, Malmö



Scenario / Motivation



- **Wanted:** fast safe long range identification
- Point Sensor
- DIAL Laser System
- Raman

Halogens, Raman, Standoff Detection

Halogens (Chlorine)

- UV/Vis absorption (270 – 400 nm)
- Symmetry $D_{\infty h}$
 - IR inactive, Raman active

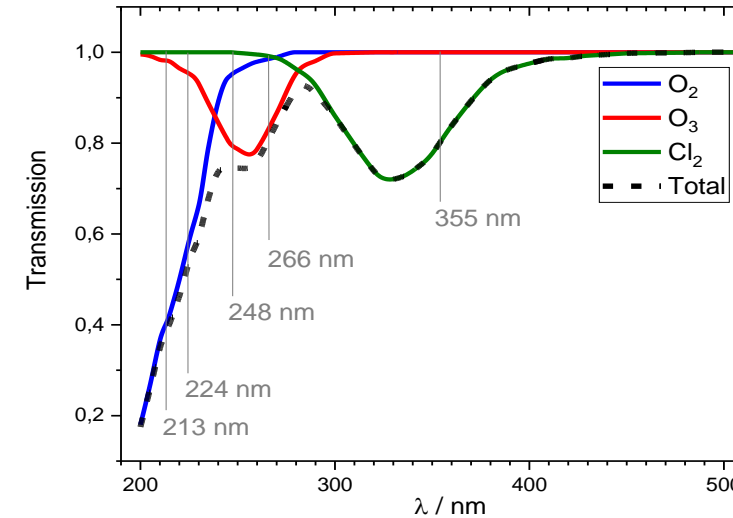
Raman effect

- Inelastic scattering
- Specific Line(s)
- Low signal intensity
- At every excitation wavelength

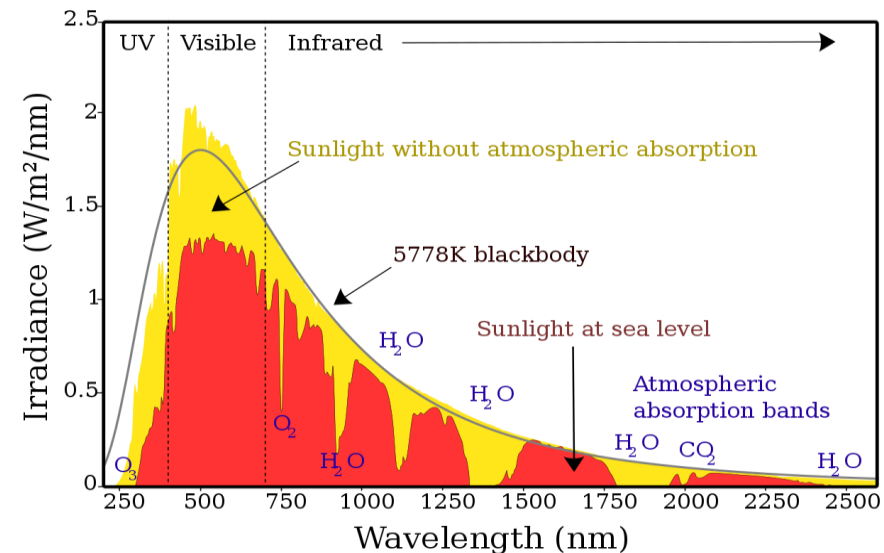
Standoff detection

- Atmospheric losses
 - O_2 , O_3 , Halogen (Cl_2), H_2O ...
 - Aerosol scattering
- Stray light
 - External Sources
 - Laser

Atmospheric Transmission of light



Solar Spectrum



Nick84/CC-BY-SA-3.0

Model – Wavelength and Range

Chlorine Cloud

- 10 m diameter / depth
- 1000 ppm Cl_2

Laser

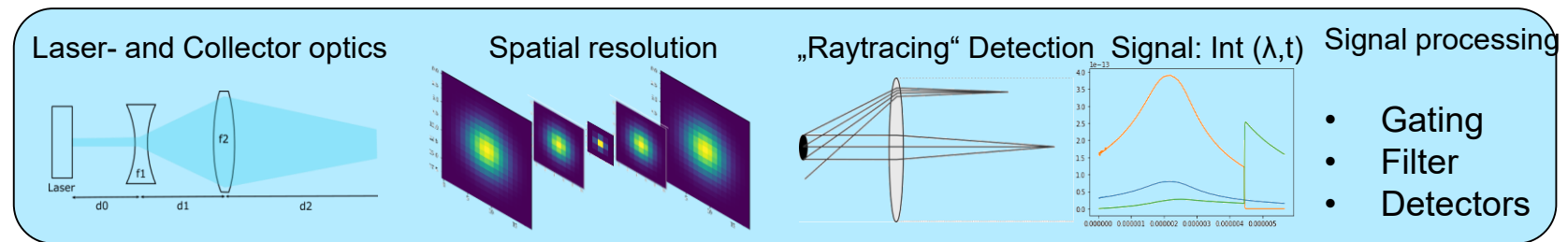
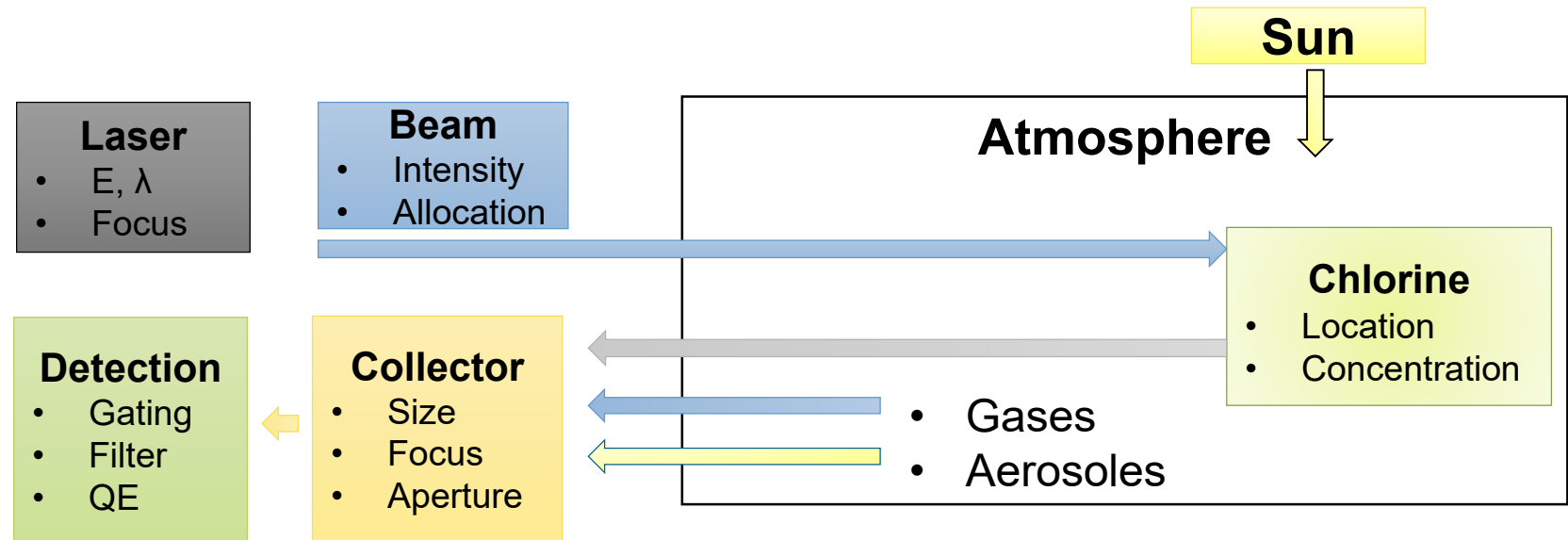
- Single pulse, 0.1 J
- Linewidth 0 (Deltafunction)

Detection

- Time-resolved
- UV: $0.1 < \text{QE} < 0.3$, IR: $\text{QE} = 0.3$

Filter

- Steep filter edge, 1 nm
- $T_{\text{pass}} = 0.95$, $T_{\text{block}} = 1 \cdot 10^{-6}$



Model – Wavelength and Range

Chlorine Cloud

- 10 m diameter / depth
- 1000 ppm Cl_2

Laser

- Single pulse, 0.1 J
- Linewidth 0 (Deltafunction)

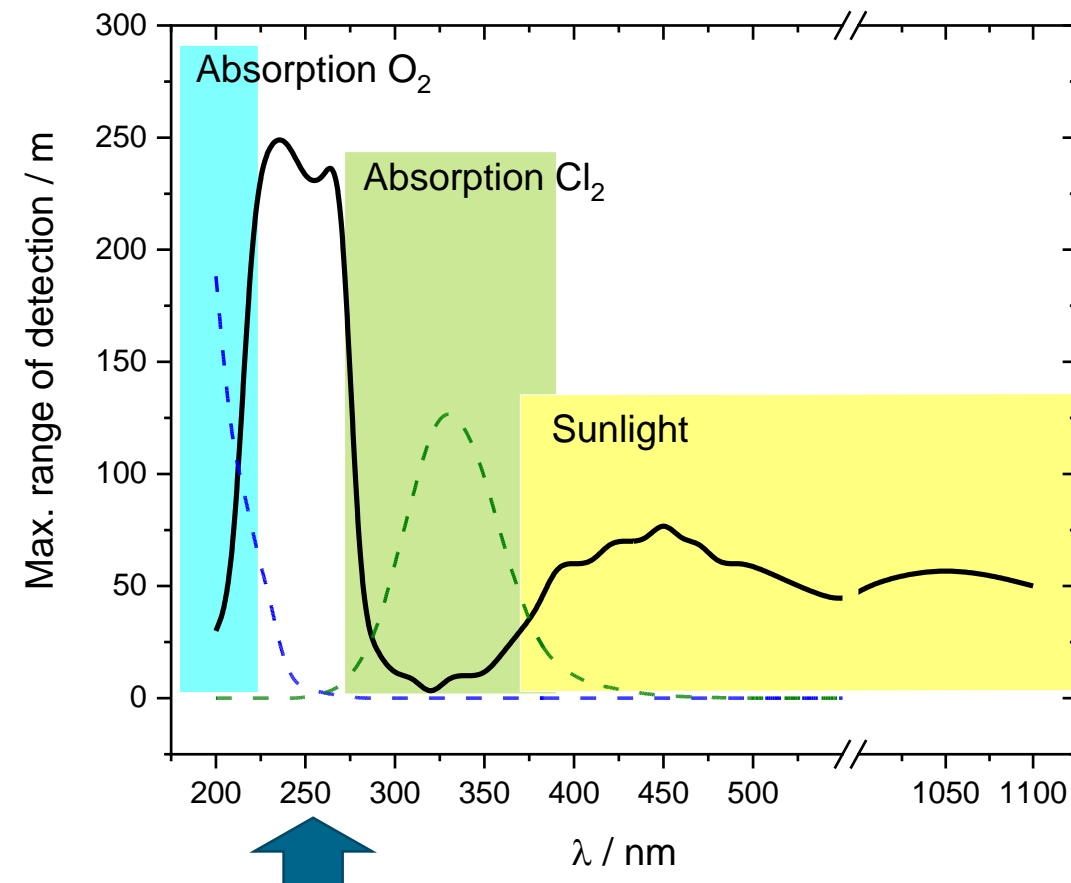
Detection

- Time-resolved
- UV: $0.1 < \text{QE} < 0.3$, IR: $\text{QE} = 0.3$

Filter

- Steep filter edge, 1 nm
- $T_{\text{pass}} = 0.95$, $T_{\text{block}} = 1 \cdot 10^{-6}$

- > 10 Signal photons detected
- Ratio Signal / Background > 2



From the model to the street - Setup



Chlorine Cloud

- 10 m diameter / depth
- 1000 ppm Cl₂

Laser

- Single pulse, 0.1 J
- Linewidth 0 (Deltafunction)

Detection

- Time-resolved
- UV: $0.1 < QE < 0.3$, IR: $QE = 0.3$

Filter

- Steep filter edge, 1 nm
- $T_{\text{pass}} = 0.95$, $T_{\text{block}} = 1 \cdot 10^{-6}$



Chlorine Cell

- 1 m length
- Variable partial pressure

NdYAG Laser

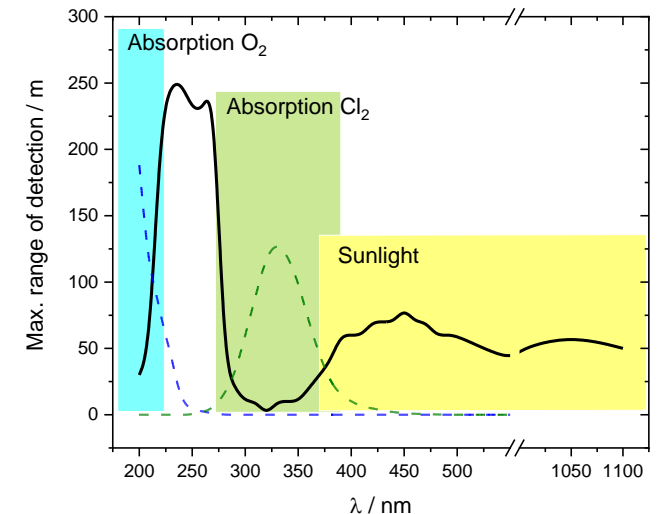
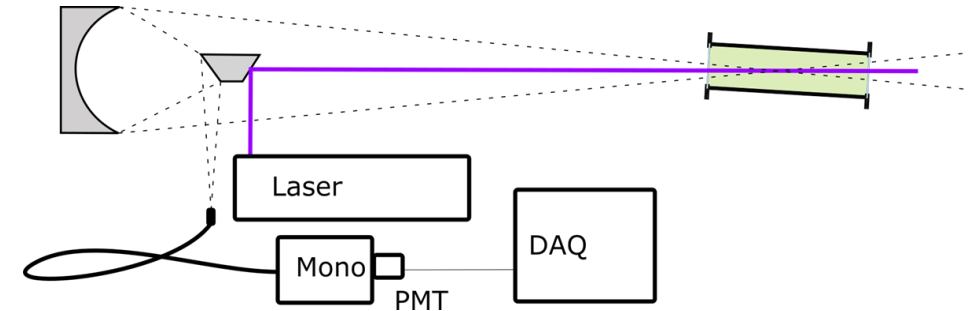
- 266 nm, 0.7 ns, 0.01 J, 100 Hz
- Linewidth < 1 nm

PMT

- Risetime 0.57 ns
- $QE_{266 \text{ nm}} = 0.25$

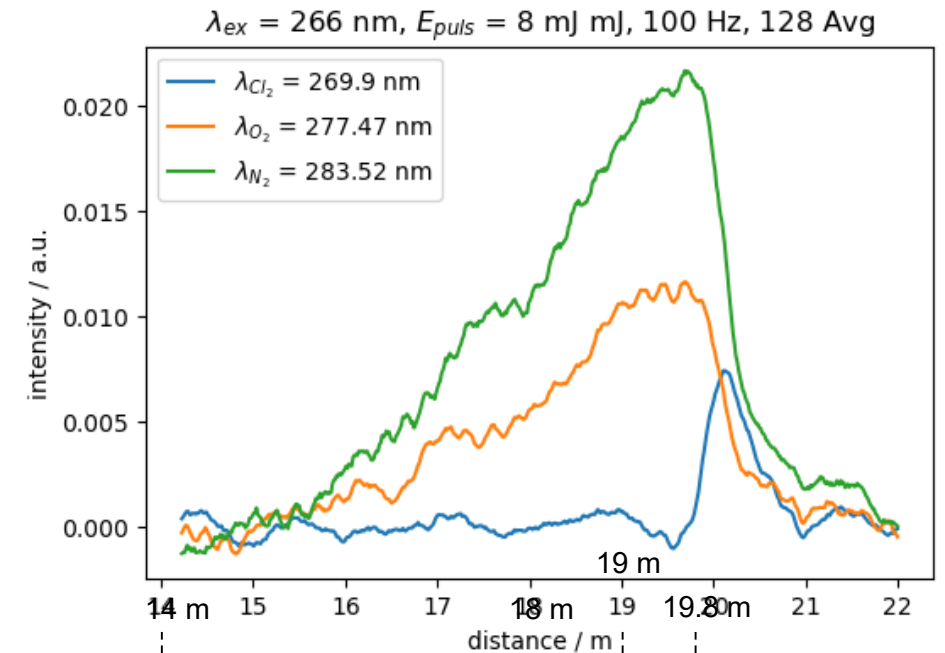
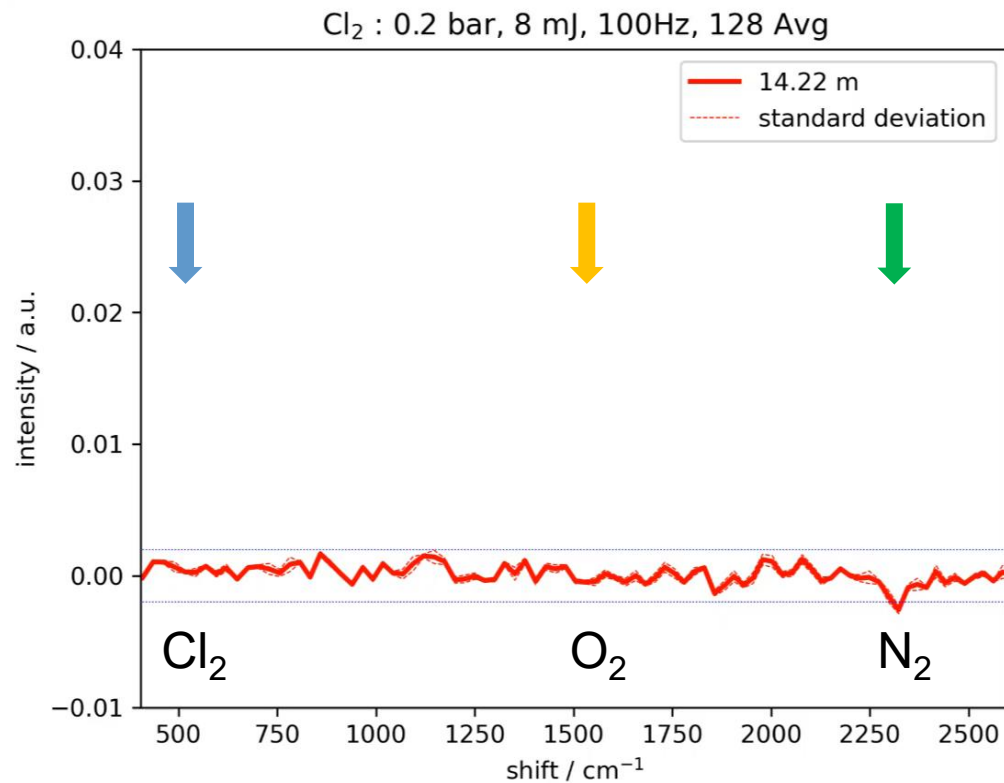
Longpass Edge Filter

- Edge 2 nm
- $T_{\text{pass}} = 0.72$, $T_{\text{block}} = 1 \cdot 10^{-4.3}$
- Monochromator

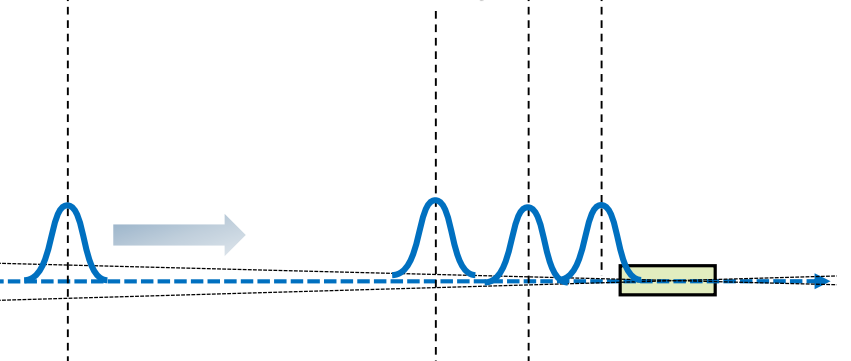




From the model to the street - Measurement



Detection Setup



Detection Range and Limits



Duration

- Dynamic Situation

Laser Power

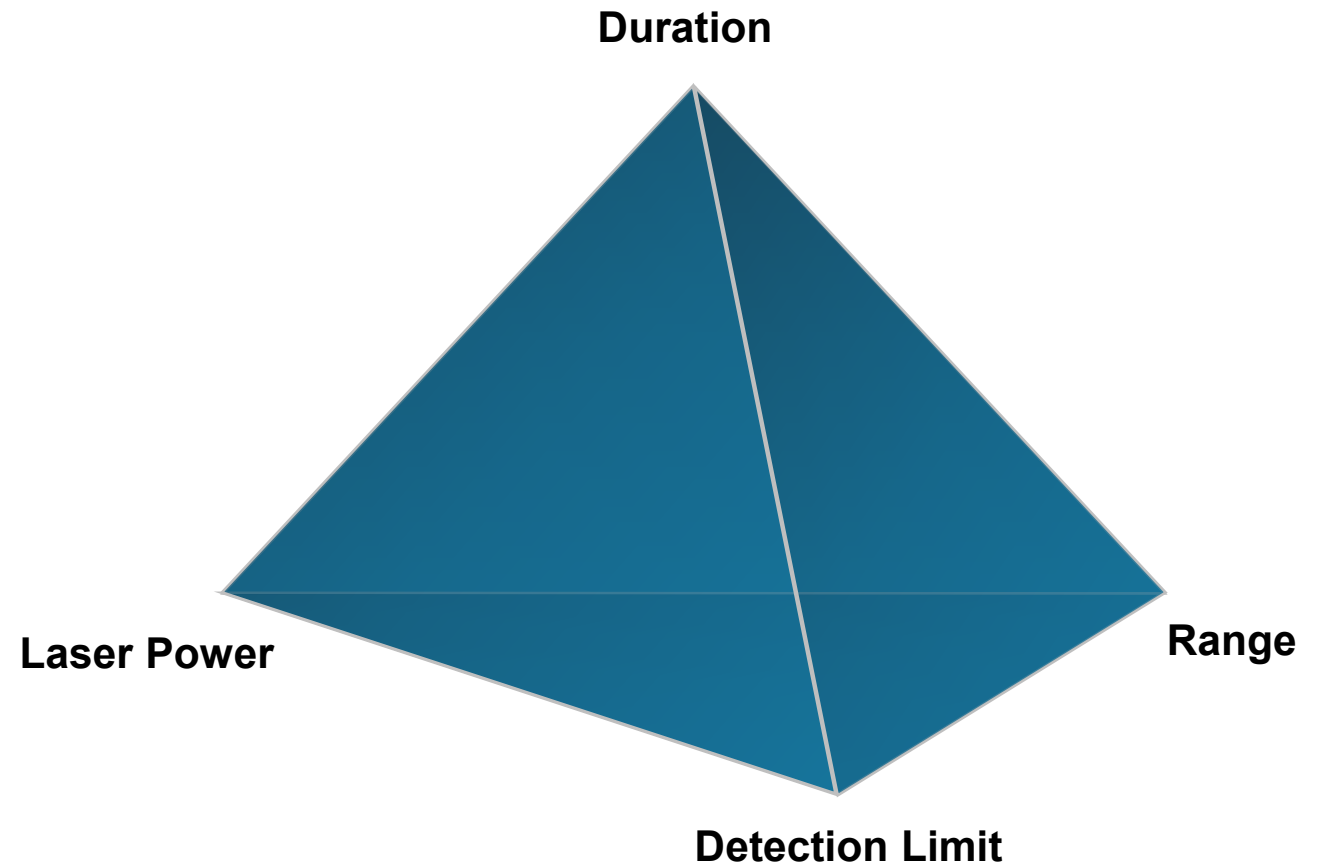
- Eye Safety
- Availability

Detection Range

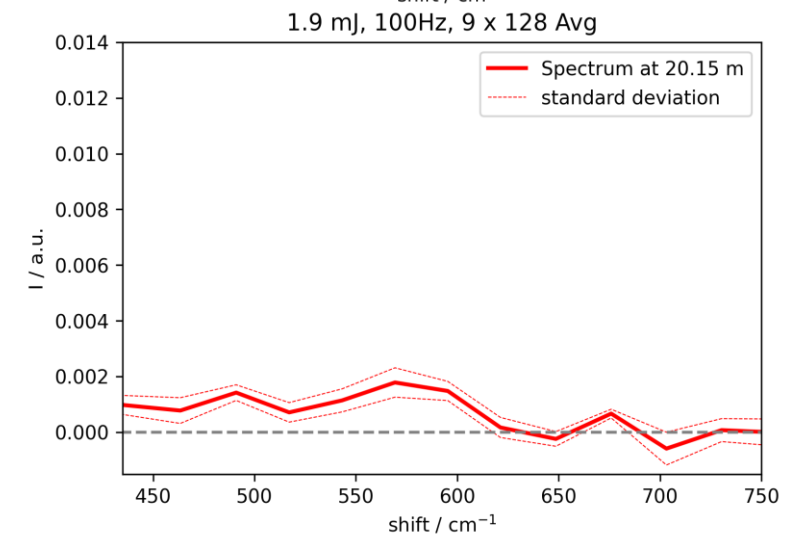
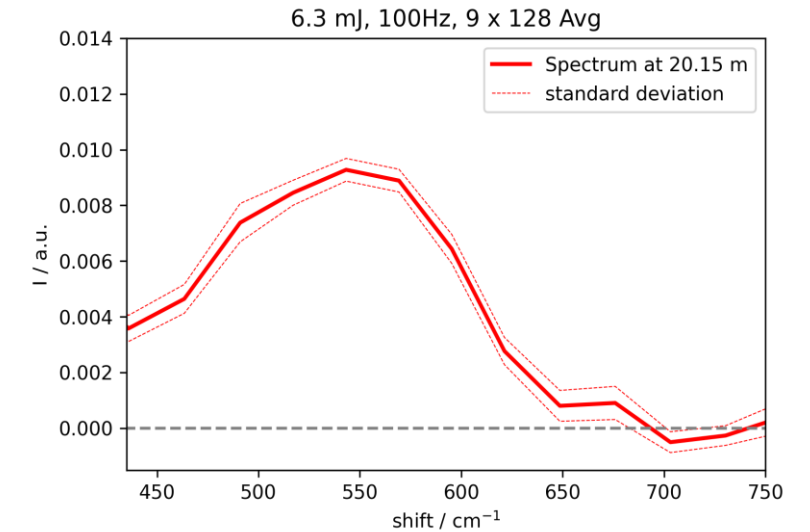
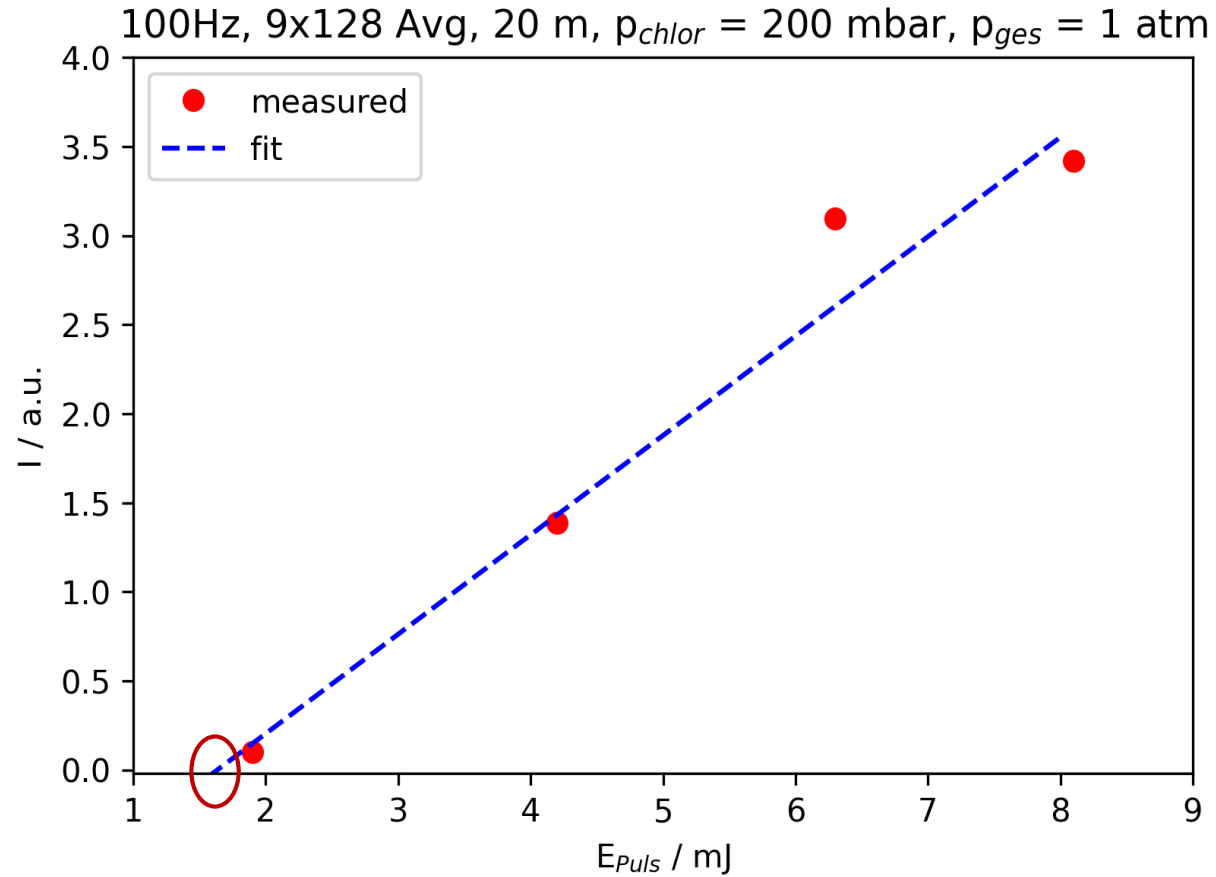
- Standoff Detection

Detection Limit

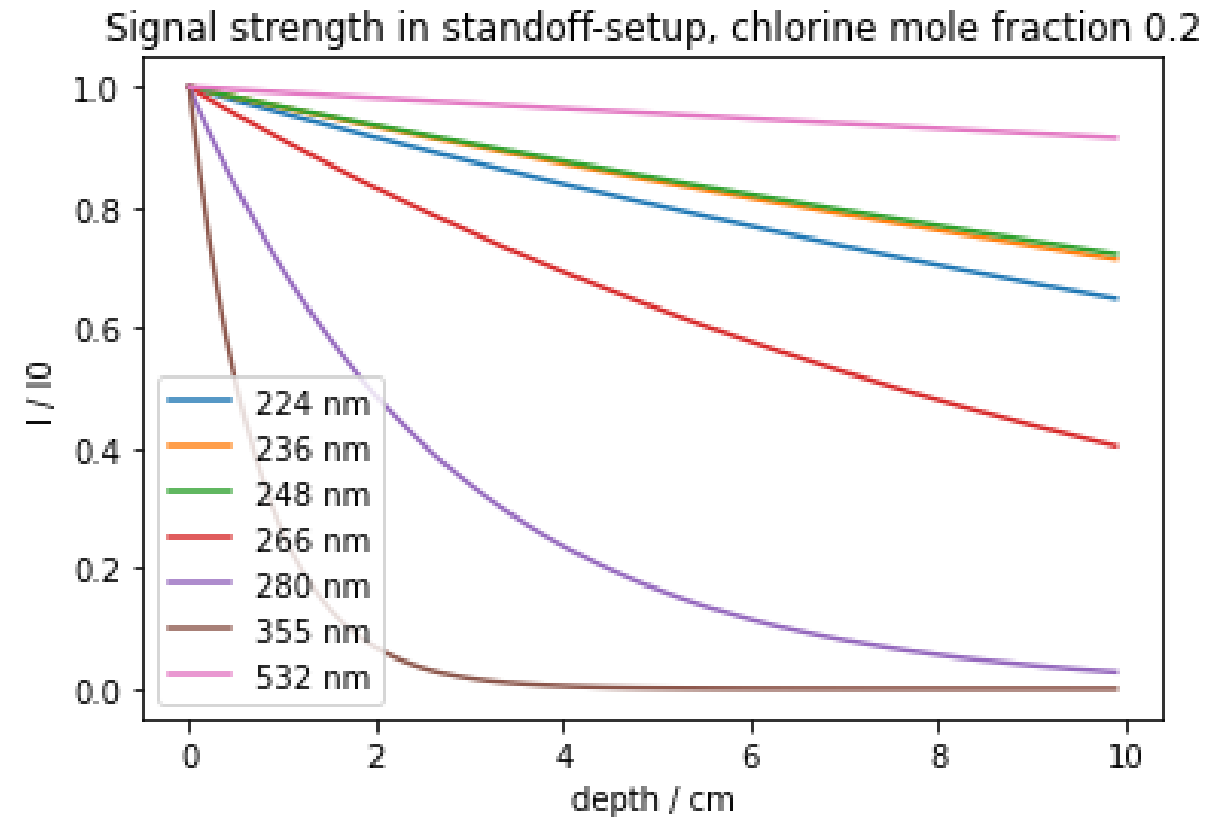
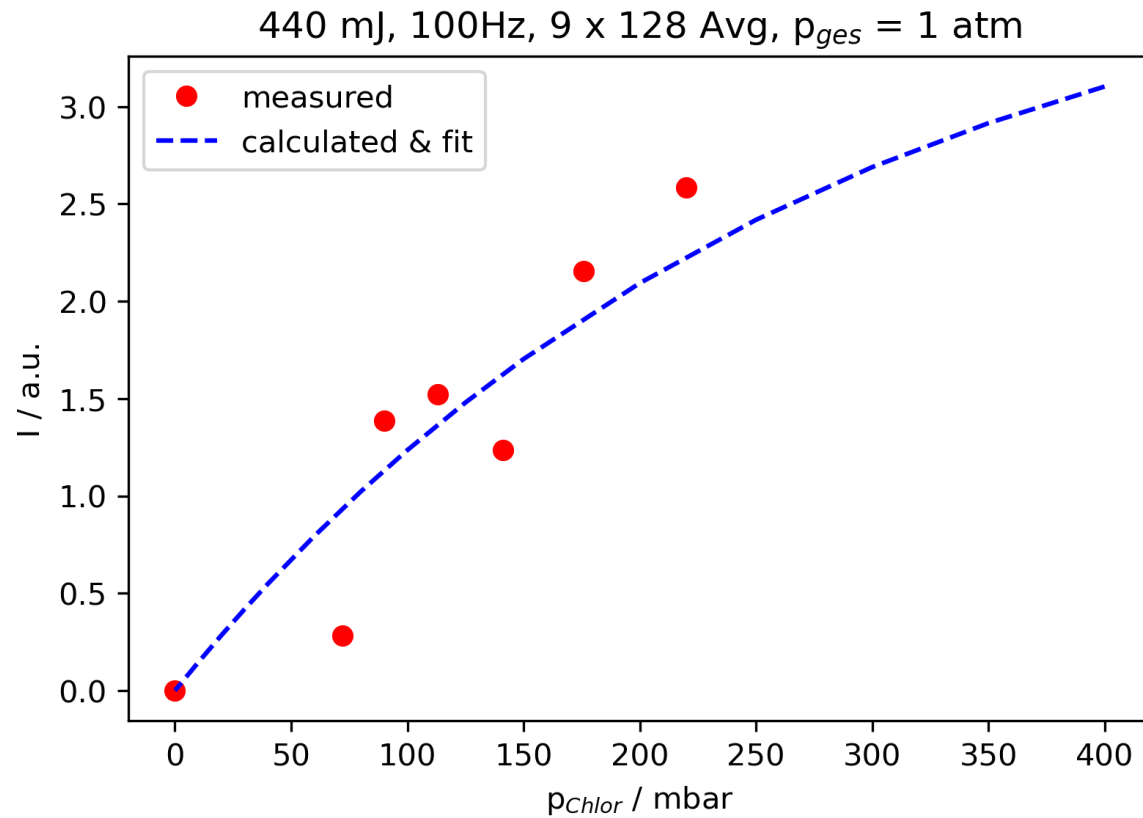
- 0.5 – 1 % acute toxic



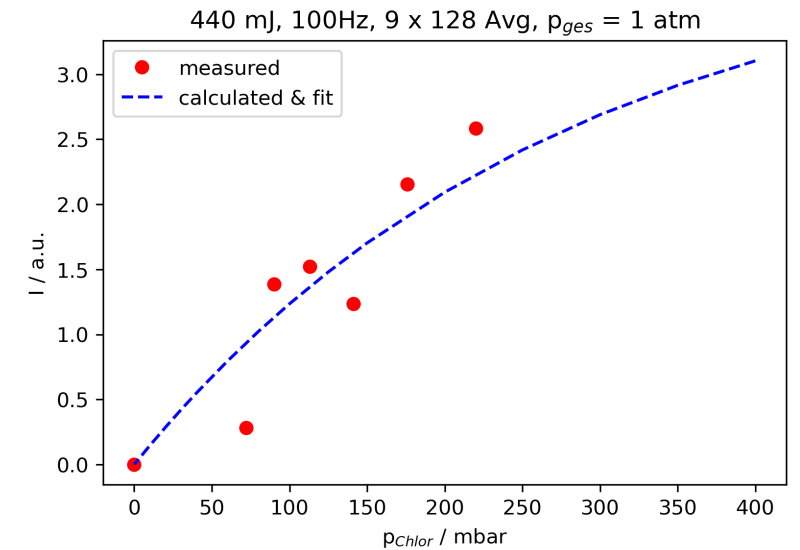
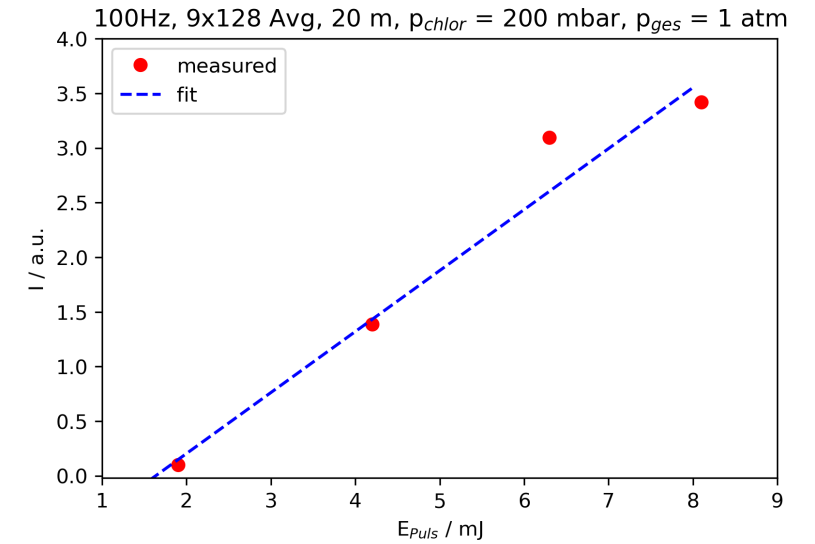
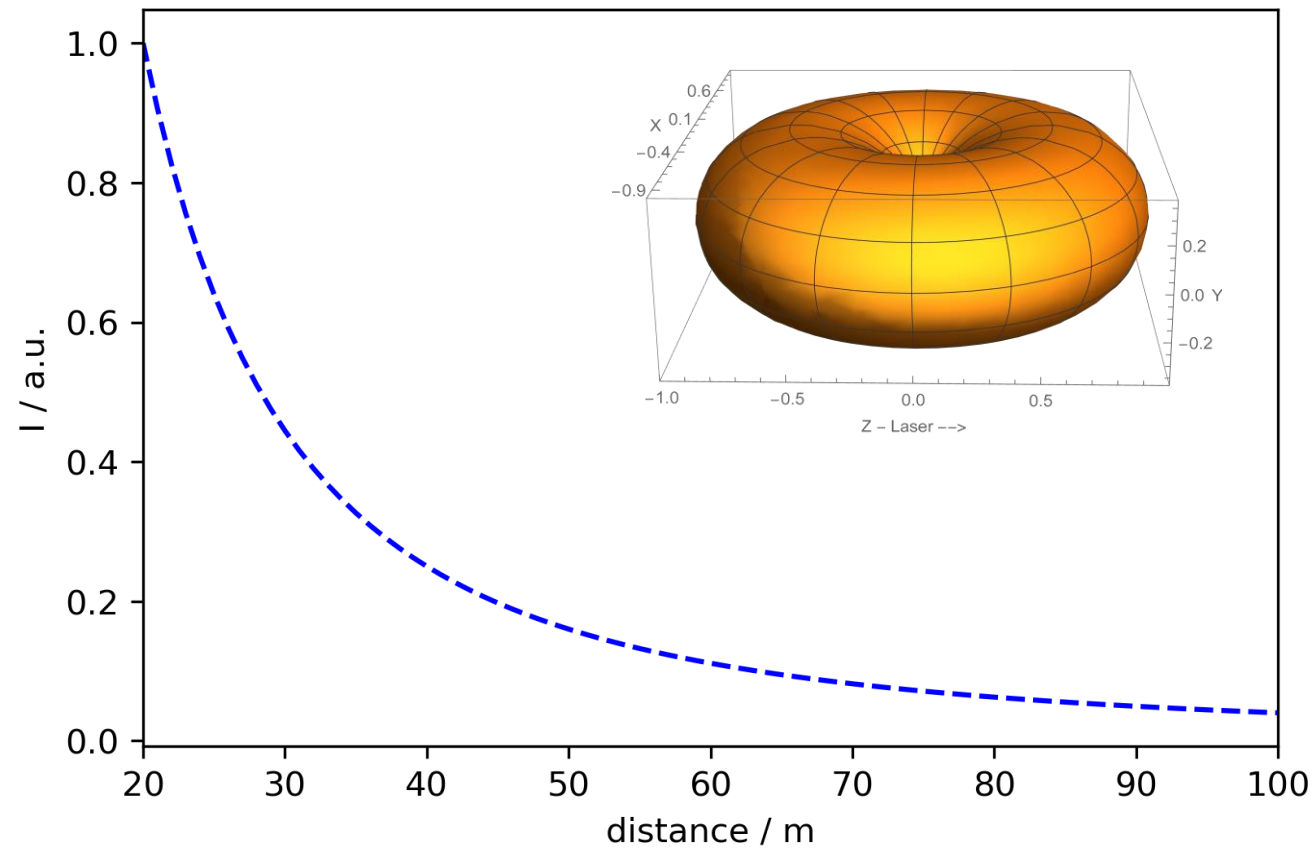
Parameters - Laser Intensity



Parameters – Concentration



Detection Range



Chlorine Detection

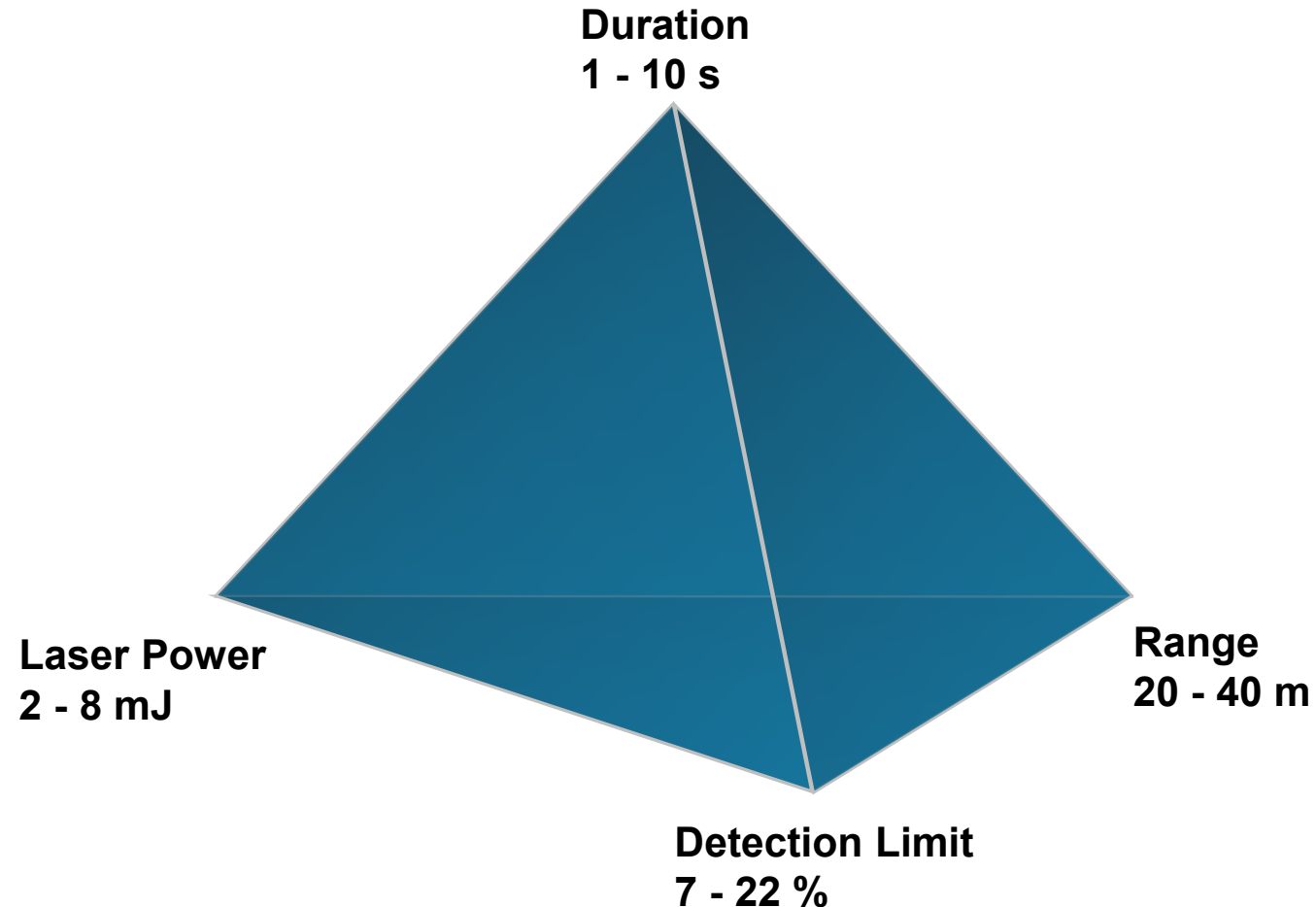


Dependent Parameters

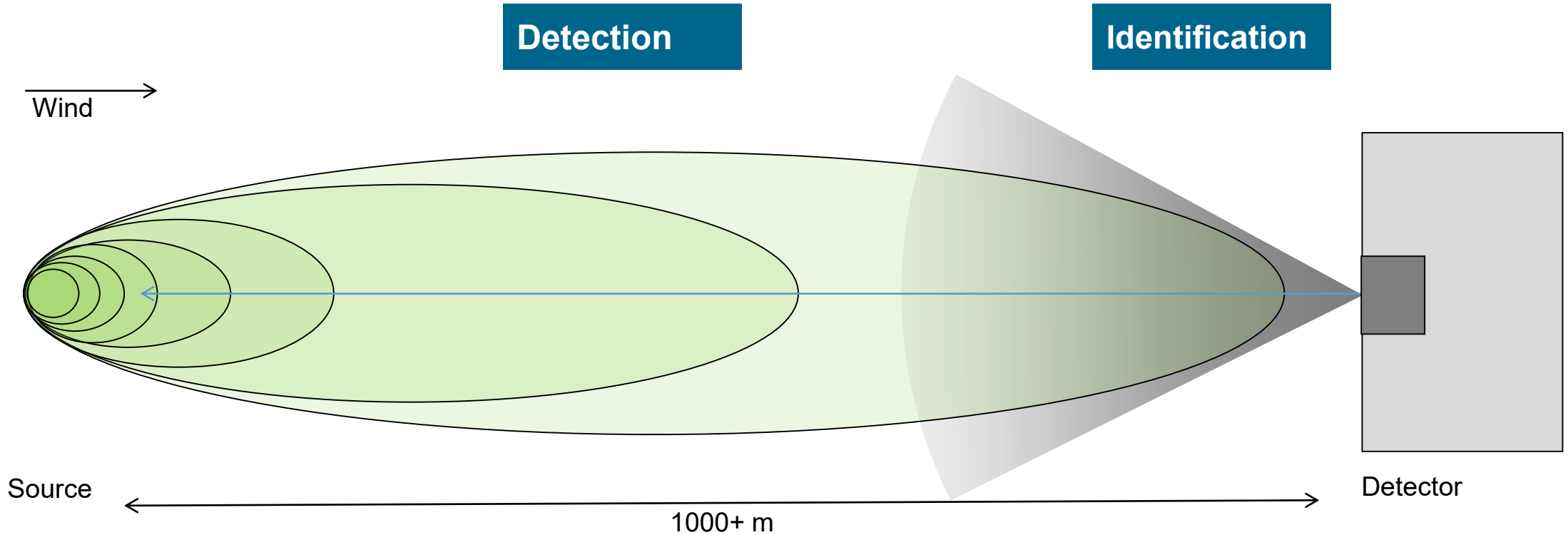
- More Laser Power
 - Shorter duration
 - Longer range
 - Lower detection limit

Next steps

- Test setup limits (100+ m)
- Photon counting
- DIAL + UV-Raman



Scenario / Conclusion



- DIAL Laser System: long range fast detection
- Raman Channel: mid range fast identification

Impressum



Thema: **Advances in a Standoff Raman System for Chlorine Gas Detection**

Datum: 21.9.2022

Autor: Arne Walter

Institut: Institute of Technical Physics

Bildcredits: „DLR (CC BY-NC-ND 3.0)“