

# Prospects for biological and chemical substance classification using a standoff laser induced fluorescence detection system

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Protection Capabilities  
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Knowledge for Tomorrow



# Scenarios

intended release

infrastructure targets



accidental release

industrial accidents



public / crowded targets



natural events



**Fast detection and early identification of hazardous substances with low risk for people and low false alarm rates are essential!**



# Detection schemes

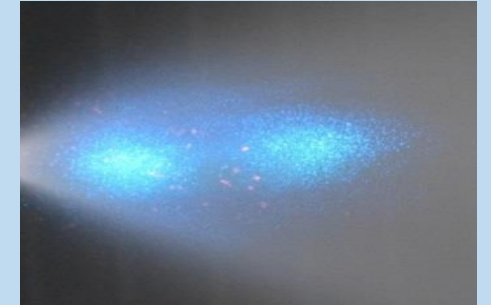
local  
information

## laser-based detection

- + fast localization / time-dependent mapping
- + classification
- limited identification



laser test range,  
DLR Lampoldshausen



fluorescent aerosols,  
DLR Lampoldshausen

## particle samplers

- + identification ability
- „right“ positioning?
- origin / movement / distribution of cloud?

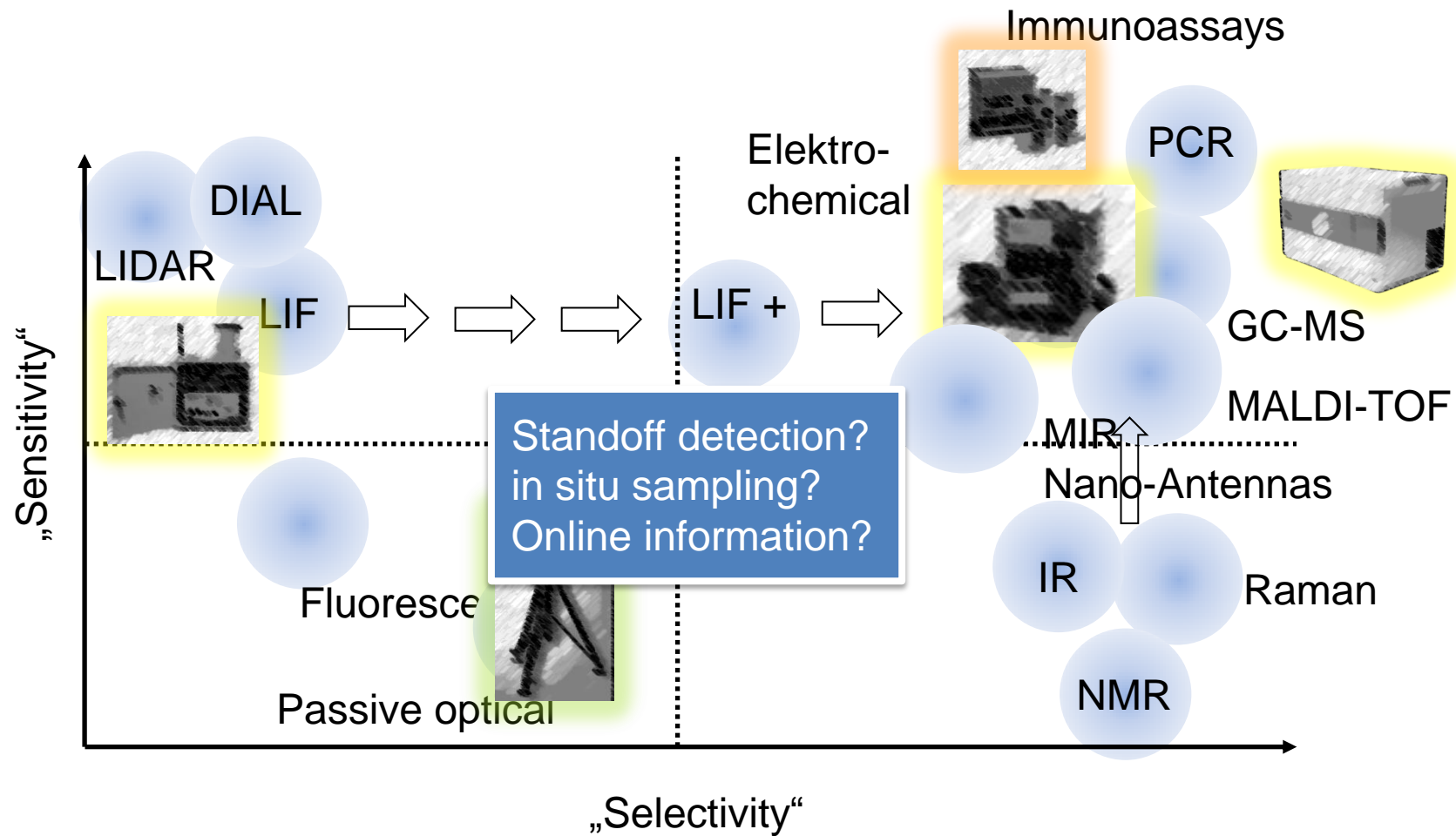


gas chromatograph/  
mass spectrometer\*

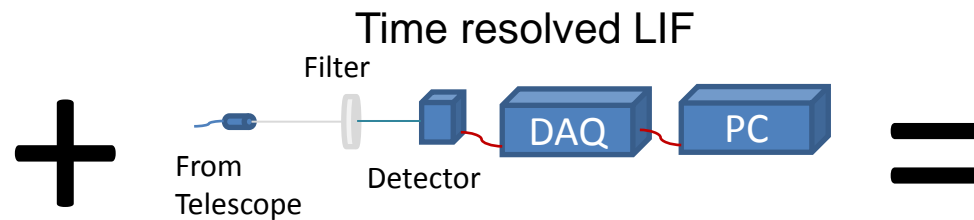
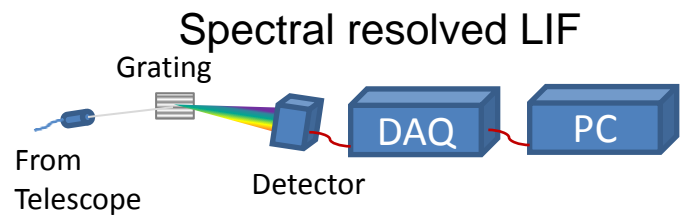
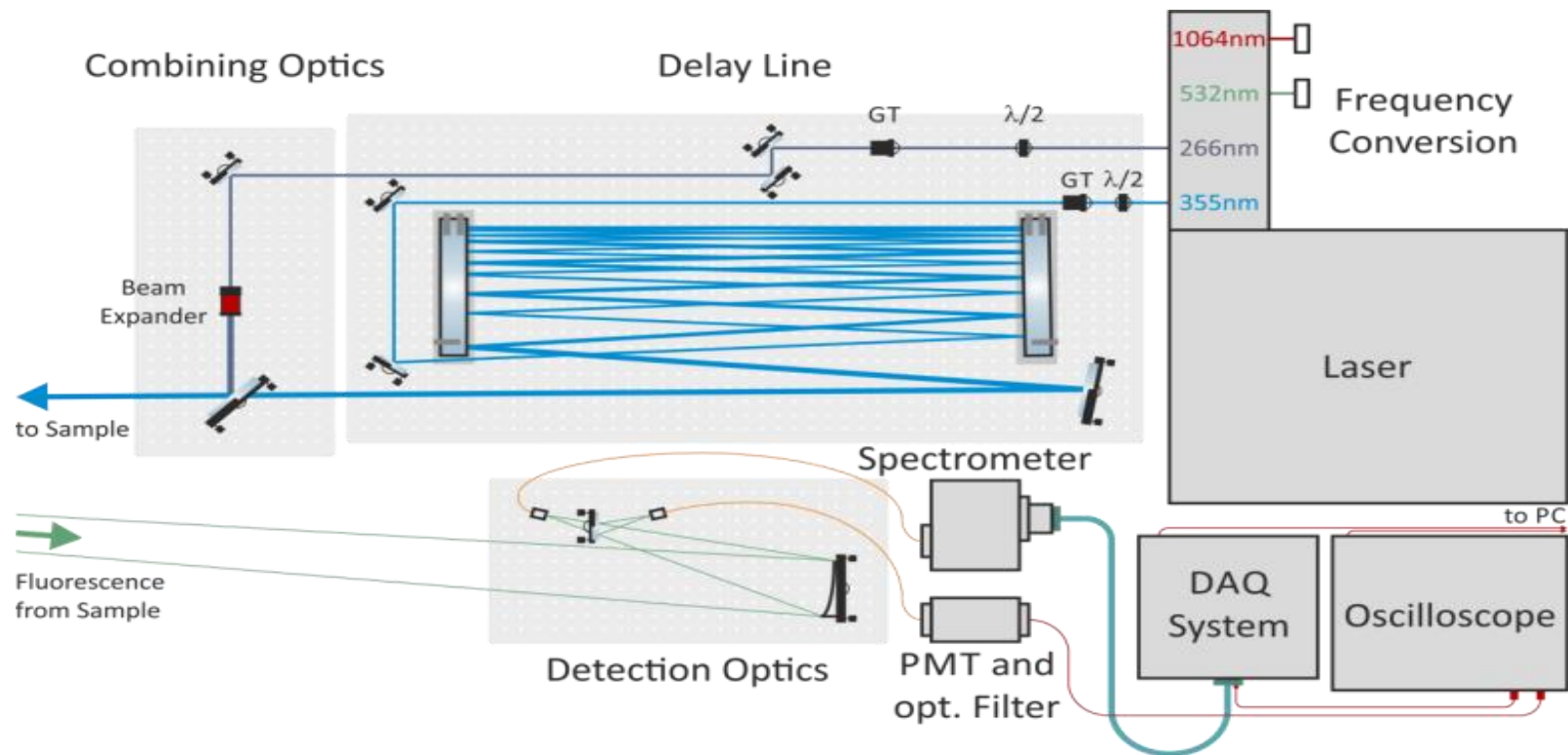


UAV\*

# CBE detection techniques



# Experimental Setup



**Dataset**

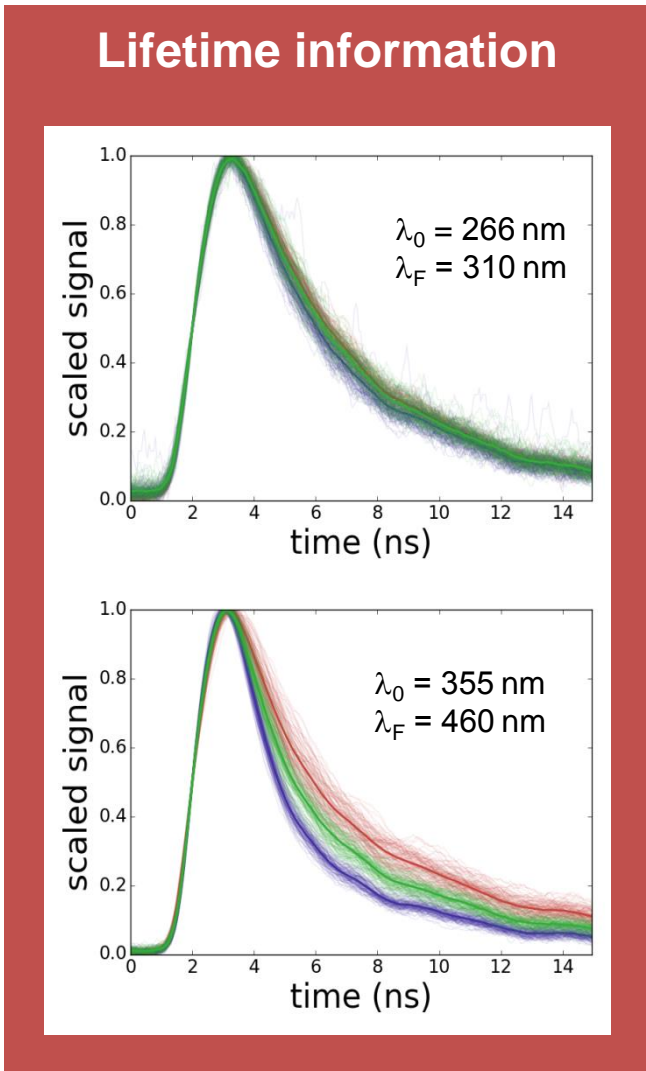
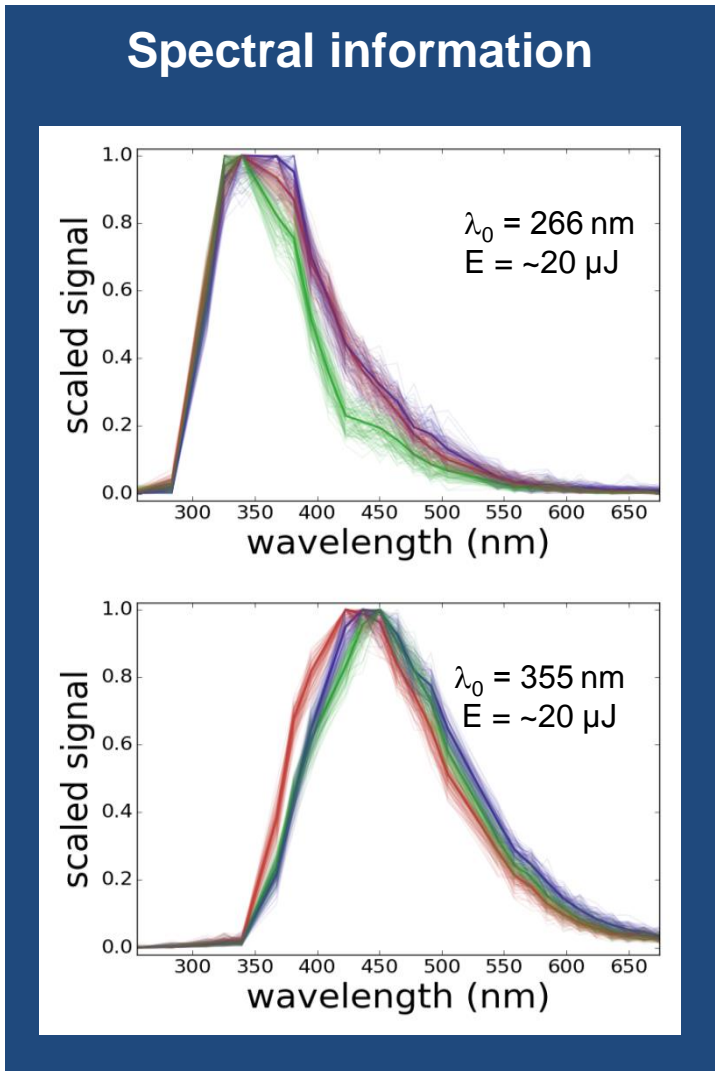
1. LIF spectra (32 chan.)
2. Lifetime data (2 chan.)

for each excitation wavelength



# First results

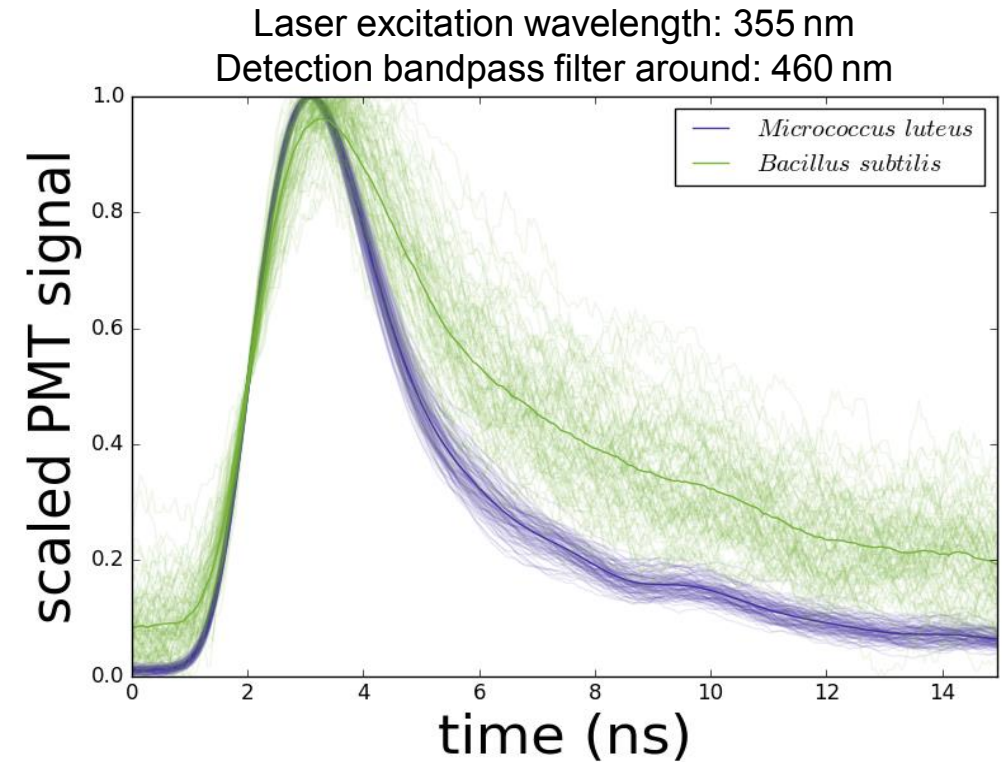
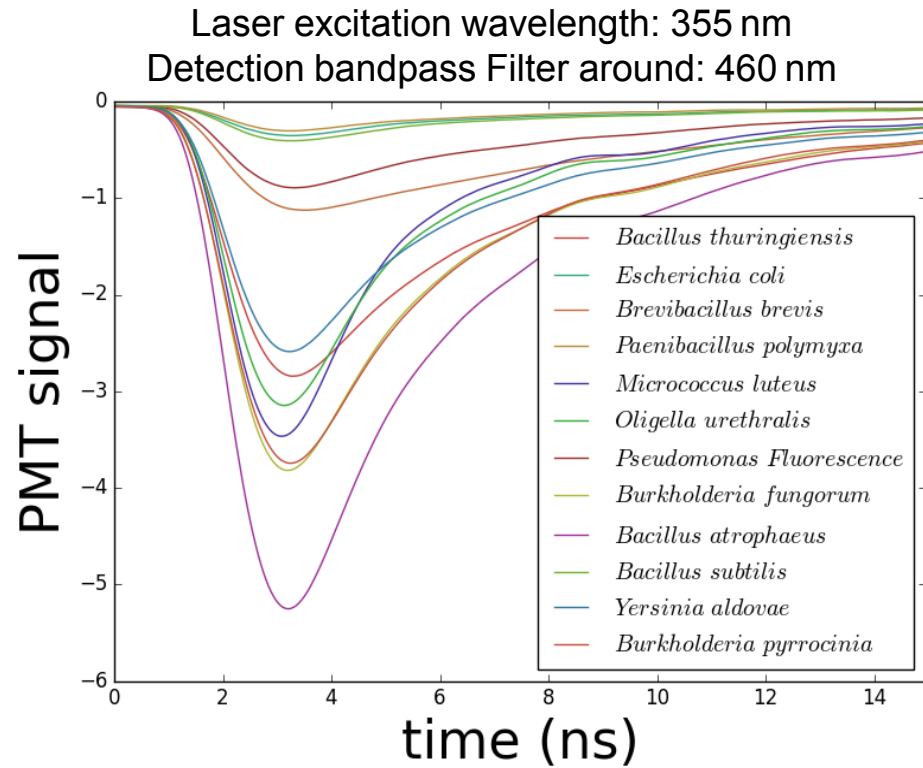
- █ *O. urethralis*
- █ *M. luteus*
- █ *B. thuringiensis*



	<i>B. thur.</i>	<i>M. luteus</i>	<i>O. ureth.</i>	Accuracy
<i>B. thur.</i>	124	0	4	Spectral 97.3 %
<i>M. luteus</i>	0	120	0	
<i>O. ureth.</i>	1	5	121	
<i>M. luteus</i>	122	0	2	Lifetime 98.4 %
<i>O. ureth.</i>	0	125	1	
<i>O. ureth.</i>	3	0	122	
<i>B. thur.</i>	122	0	2	Combined 98.4 %
<i>M. luteus</i>	0	125	1	
<i>O. ureth.</i>	3	0	122	



# Temporal measurements of more bacteria



Fluorescence intensity varies strongly for different samples.  
=> Setup integrated for automated laser pulse energy adjustment



## Reproducibility / Concentration dependence

substance	class
Beta Carotene	Natural dye
Oxyfluorfen	Pesticide
Terbuthylazine	Pesticide
Isoproturon	Pesticide
Piperine	Pesticide
Permethrin	Pesticide
B. thuringiensis	Bacterium
B. fungorum	Bacterium
Y. aldovae	Bacterium

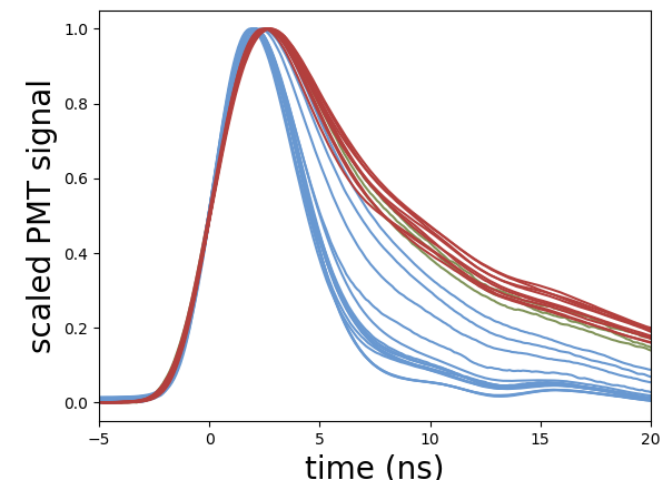
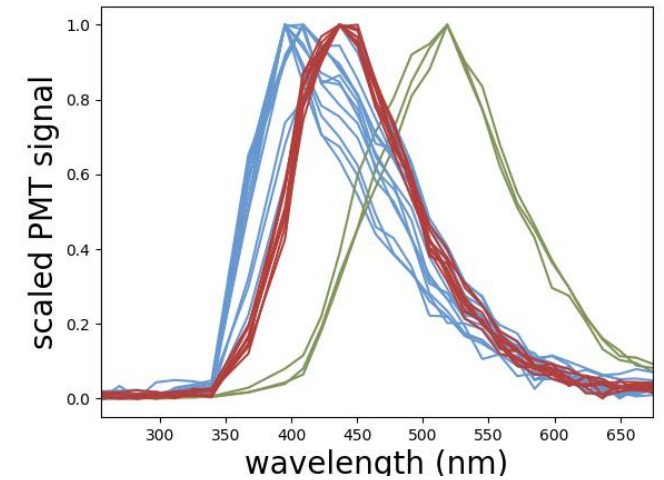
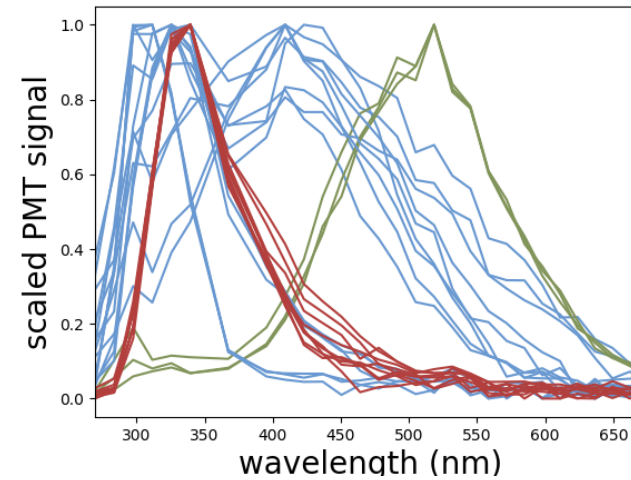
- Measurements of 9 different substances with 3 different concentrations
- Repeated on 3 different days
- Beta Carotene and pesticides solved in diethyl ether
- Bacteria diluted with phosphate-buffered saline (PBS)
- Measured in laboratory with standoff distance of 5 m
- Number of lifetime channels reduced to one





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Excitation wavelength or temporal data	Accuracy for recognition within dataset in %	Accuracy for recognition new dataset in %
266nm	92.1	82.4
355nm	62.4	48.7
temporal	59.0	23.5
266nm & 355nm	93.5	85.1
266nm & temporal	91.8	85.8
355nm & temporal	79.5	40.2
Complete dataset	93.5	86.2



# Reproducibility / Concentration dependency

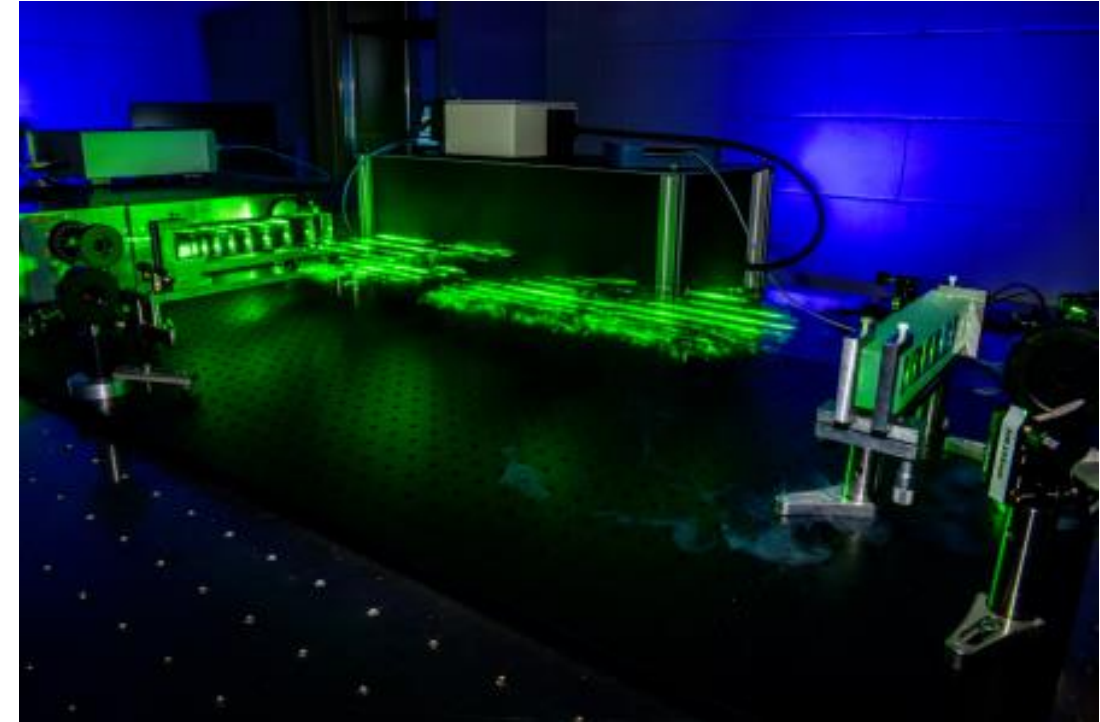
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Y. aldovae	Bacterium

Excitation wavelength or temporal data	Accuracy for recognition new dataset in %	Accuracy for classification new dataset in %
266nm	82.4	99.4
355nm	48.7	78.8
temporal	23.5	60.6
266nm & 355nm	85.1	99.5
266nm & temporal	85.8	100.0
355nm & temporal	40.2	85.2
Complete dataset	86.2	100.0



# Summary

- Compact, modular detection system
- Fast sensitive data acquisition
- Reliable recognition of bacterial samples
- Classification of bacteria in medium sized datasets with excellent accuracy
- Excellent accuracy of the classifier during evaluation



# Outlook

- Start of operation on free space optical test range for standoff distances above 100 m
- For the influence of background signals and atmospheric effects on this system
- Concentration dependencies on classification
- Detection limits for biological substances esp. on different background materials
- Measurements of aerosols



Up to now: Very promising technology for recognition of agents in special scenarios (incl. mixtures)

