Spontaneous Raman spectroscopy for the standoff detection of Cl_2 & H_2 gas

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INTRODUCTION & REQUIREMENTS

200 liquid chlorine (6.7 bar)
Moderate wind (30 km/h)
Release:

- > 200 mbar chlorine in few meters and seconds
- 1000 m from observer

Time for counter measures (protection): 2 min

Industrial hydrogen transport and storage facilities

Both H_2 and Cl_2 can hardly be detected by existing infrared standoff spectroscopic methods

APPROACH AND METHODS

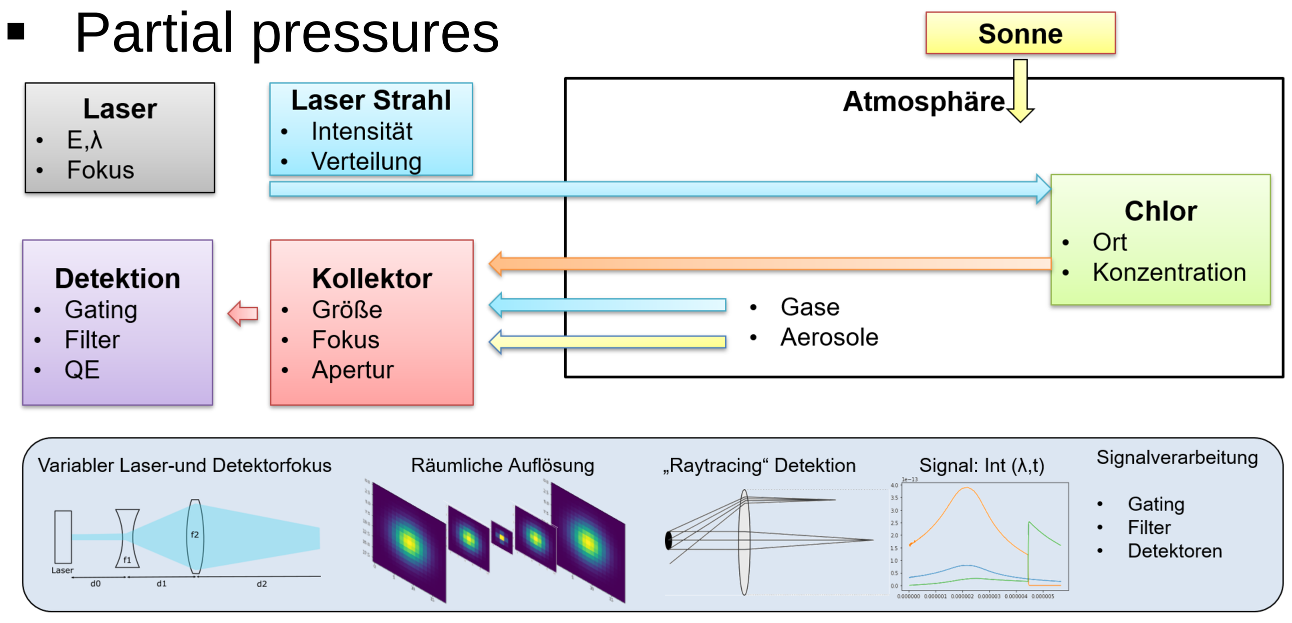
Chlorine

- Toxic threat (see e. g. Akaba Port (Jordan, 2020) and misuse as warfare agent)

Modeling

Propagation of spontaneous Raman signal (and exciting laser light) with existing standard equipment in terms of

- Excitation wavelength
- Remote detection distance
- Partial pressures



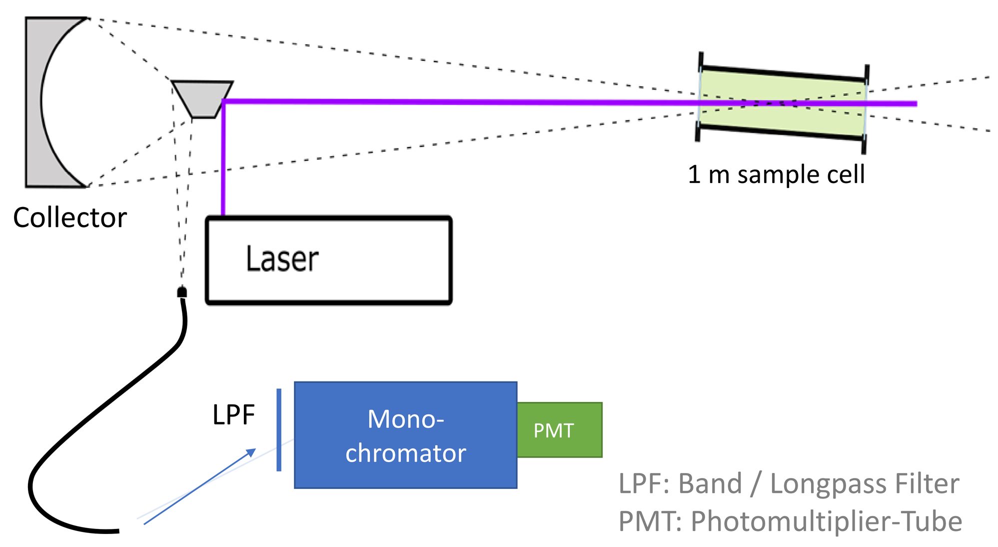
Scheme of signal propagation model

Hydrogen

- Reduction of hydrogen losses in pipelines
- Increase of safety (H_2 forms combustible and explosive mixtures with atmospheric oxygen over a range of concentrations in the range 4.0%–75% and 18%–59%, respectively.)
- Improved maintenance in H_2 infrastructures

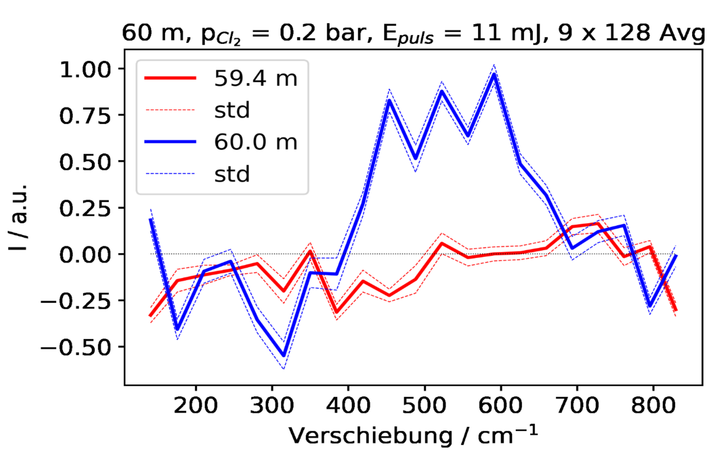
Experimental

- Application of pulsed Raman spectroscopy to Cl_2 and H_2
- in a 1 m gas cell emulating a more realistic (larger) cloud
- in open space (optical test range, 20-60 m)

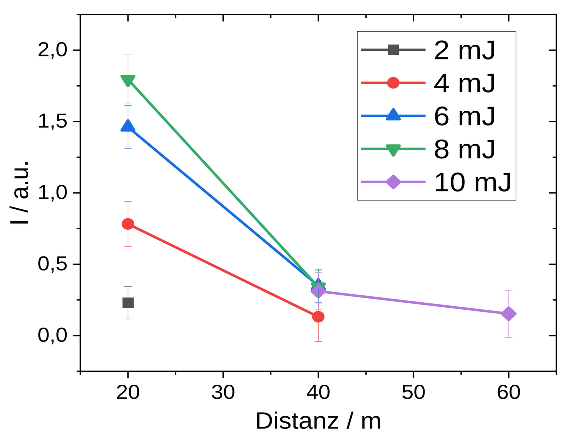


Optical setup (266 nm, 100 Hz DPSS, 760 ns)

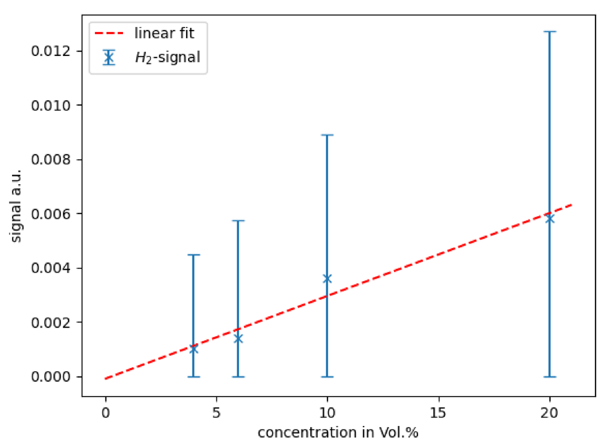
RESULTS



Raman signal of air/ and chlorine at 59.4 and 60 m, respectively.



Raman signal intensity of chlorine (200 mbar) for pulse energies from 2-10 mJ at distances from 20-60 m



Raman signal of hydrogen for partial pressures of 40 to 200 mbar at 200 uJ pulse energy and 100 m distance

SUMMARY

Chlorine

- Standoff model approved
- Distances of 60 m

Hydrogen

- Cl_2 standoff model valid for H_2
- Extrapolated detection limit: 4 Vol.-%

REFERENCES

A. Walter et al., JINST 18 (2023), C05008, DOI 10.1088/1748-0221/18/05/C05008

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