RDX Remote Raman Detection on NATO SET-237 Samples

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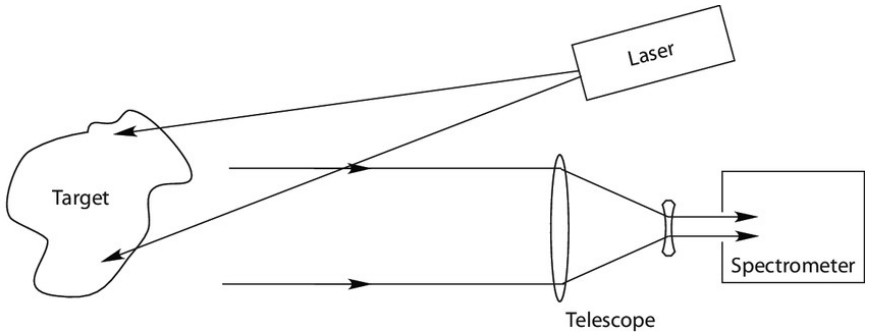
Motivations

- Safety for
  - Operator
  - Equipment
- Time consuming
  - to probe
  - to scan

How to improve?

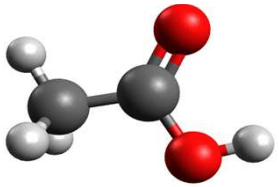
- Remote detection through laser-based techniques
  - Faster sampling
  - Faster data analysis, classification and identification
  - No direct contact with possible threats



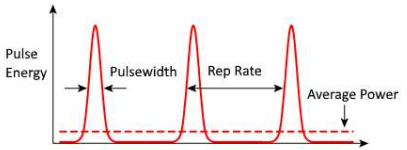
Simplified sketch of laser-based remote detection

Why Short-Pulse Laser Techniques?

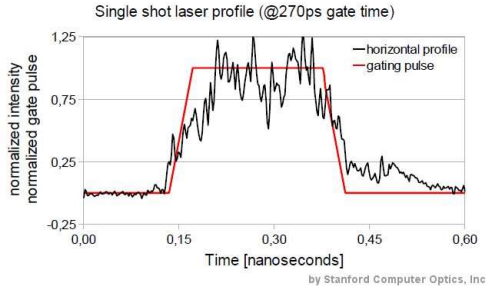
- Samples can thermodynamically relax between each laser pulse



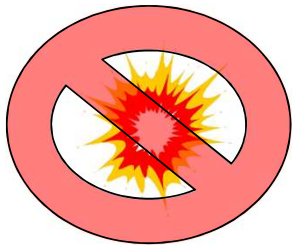
- Measurements possible at each laser pulse :
  - Pulse duration 8 ns



- Camera gating possible (minimize interferences)



- Less/no energy accumulation in the sample
  - Molecule return to ground state after each laser pulse
  - **NO EXPLOSION / IGNITION**



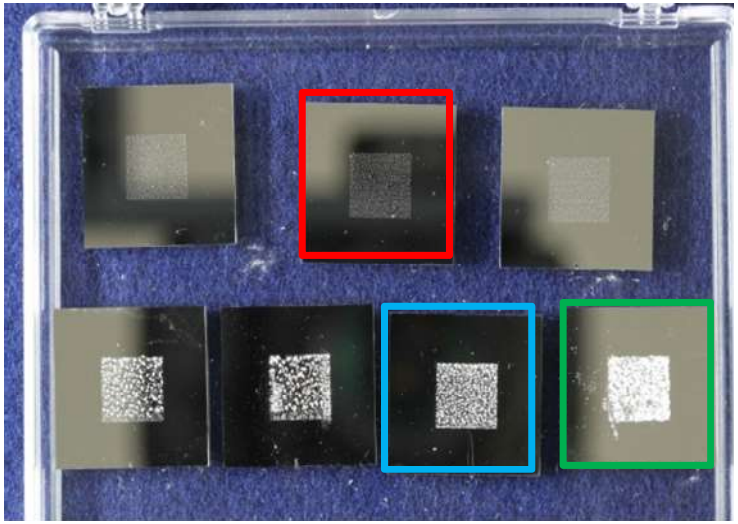
Objectives

- Raman spectroscopy as a remote detection systems for:
  - RDX
  - TNT
  - Chemical warfare agent (CWA) simulants
- Tests designed to determine:
  - Sensitivity:
    - Lowest possible Explosives / CWA simulants concentration
    - Maximize signal to noise ratio (SNR)
  - Selectivity:
    - Distinguishing between dangerous and safe compounds
      - Minimize false positives / false negatives
      - Minimize / recognize background interferences

Samples – Explosives

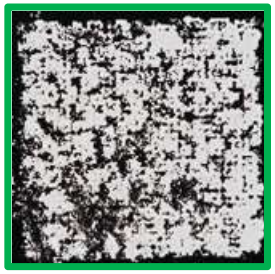
- NATO SET-237 standard samples
  - Well defined and uniform explosive distribution
- Ink-jet printed drop-on-demand (DOD) by Fraunhofer ICT
  - Concentration: 50 – 1000 µg/cm^2
  - Area: 1 cm x 1 cm
  - Multi-layer printing
  - Solvent:
    - ACN → 50 µg/cm^2
    - MEK → 250, 1000 µg/cm^2

RDX



50 µg/cm^2

250 µg/cm^2

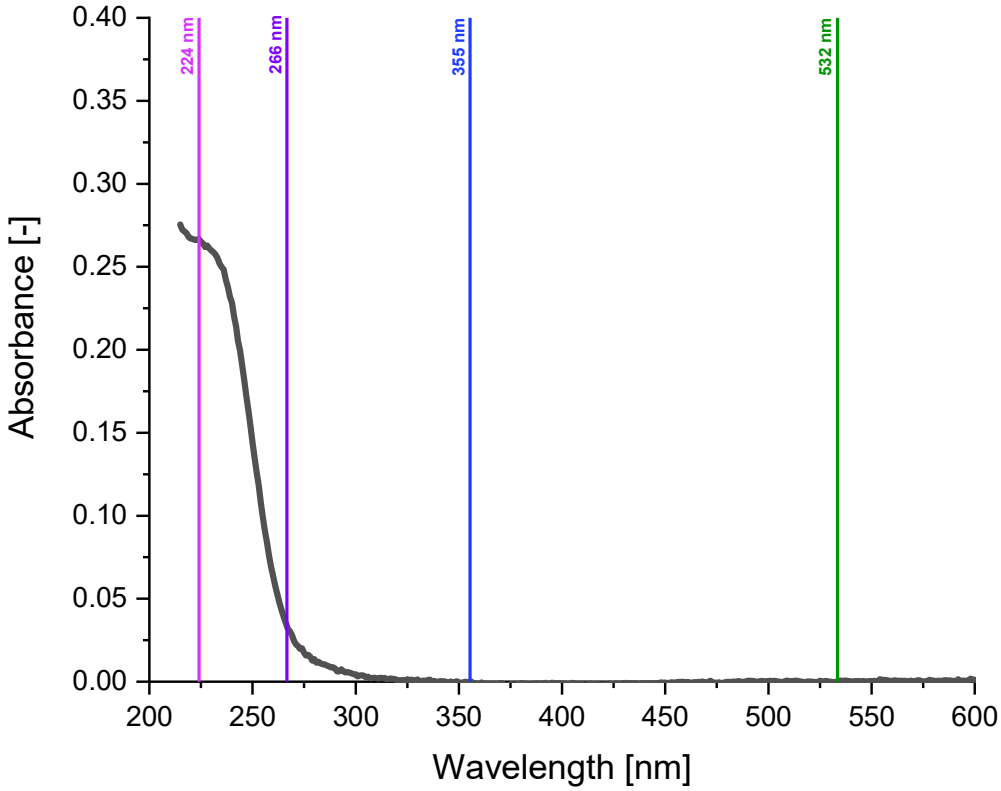


1000 µg/cm^2

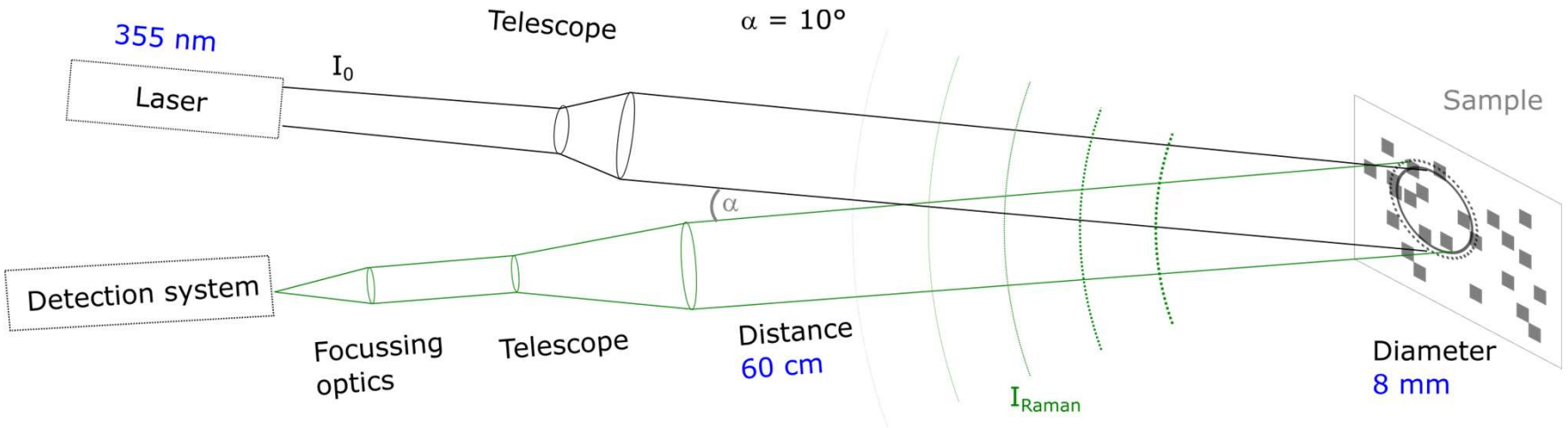
Absorbance

- Tested standard wavelengths:
  - **224 nm**
  - **266 nm**
  - **355 nm**
  - **532 nm**
- ACN Solvent
  - 5.44 x 10^{-3} mg/ml RDX

Edinburgh Instruments Spectrofluorometer FS5



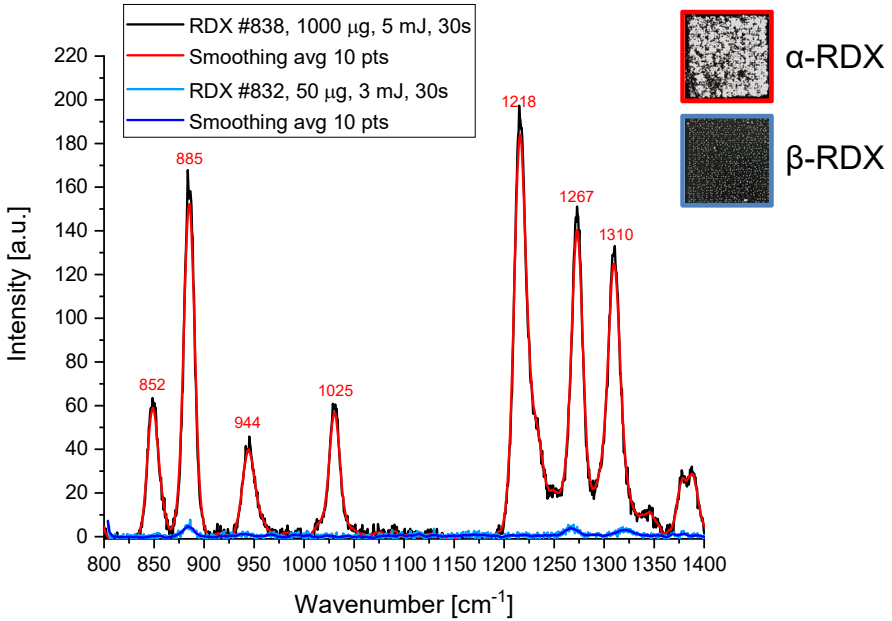
Experimental Setup



- 355 nm, 8 ns pulse width
- 1.5, 3.0, 5.0 mJ/pulse @ 10 Hz
- 60 cm distance
- CCD camera
- 2400 grooves/mm

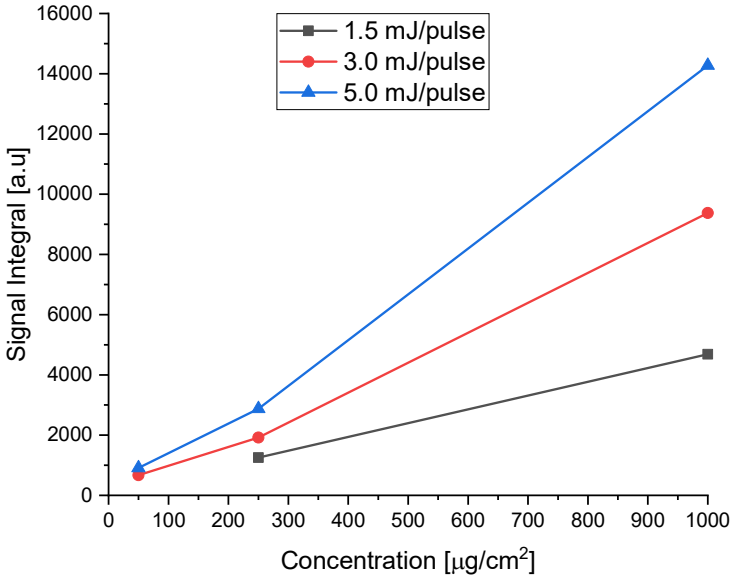
Results – Raman Spectroscopy on RDX

- RDX spectra



- Detection distance 60 cm
- Acquisition time 30 s
- Peaks at 885 cm^{-1}, 1287 cm^{-1} and 1310 cm^{-1}, always distinguishable
- Shift in peaks due to α or β crystallization

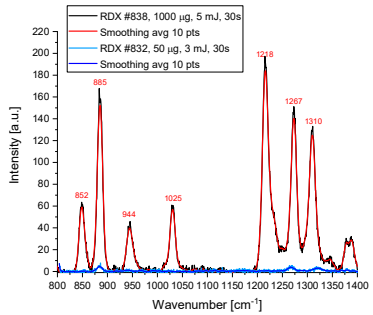
- Sensitivity



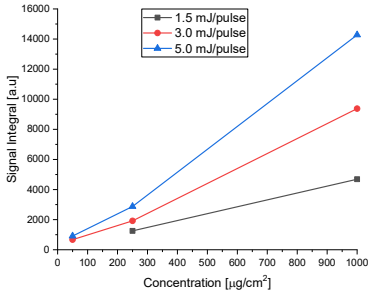
- Limits found:
  - Minimum laser energy 1.5 mJ/pulse to probe 250 µg/cm^2
  - Minimum sample concentration 50 µg/cm^2 at 3.0 mJ/pulse

Summary and Conclusions

- RDX measurements obtained at DLR-LA using short-pulse Raman scattering:
  - RDX Raman signature corresponds to signature of pure substance known from literature:
    - Excellent SNR leading to identification vs background



  - Successful identification of the operational limits for a 355 nm excitation laser at 60 cm distance:
    - Minimum laser energy 1.5 mJ/pulse to probe 250 µg/cm^2 RDX
    - Minimum RDX amount 50 µg/cm^2 with 3.0 mJ/pulse laser energy



In Progress

- New tests planned to measure:
  - Explosives and chemicals contaminated realistic surfaces in different concentrations with self-prepared samples using drop-cast method

- New optical setup coupled with an improved detection system:
  - ICCD camera
  - <9 ns gate
  - intensifier QE ~ 30% in the deep UV

- New laser source (355 nm) capable to provide higher output energy (max. 600 mJ/pulse)
  - Possibility to increase beam size (up to ~28 cm diameter)
  - Possibility to photo-dissociate explosives (PD-LIF)

- Further system optimization includes:
  - Acquisition time ⟹ Faster detection
  - Laser pulse energy ⟹ Higher SNR
  - Laser beam diameter ⟹ Larger interrogation area

Thank You for Your Attention

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QUESTIONS

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