Explosive decay product detection inside moving vehicle using TDLS

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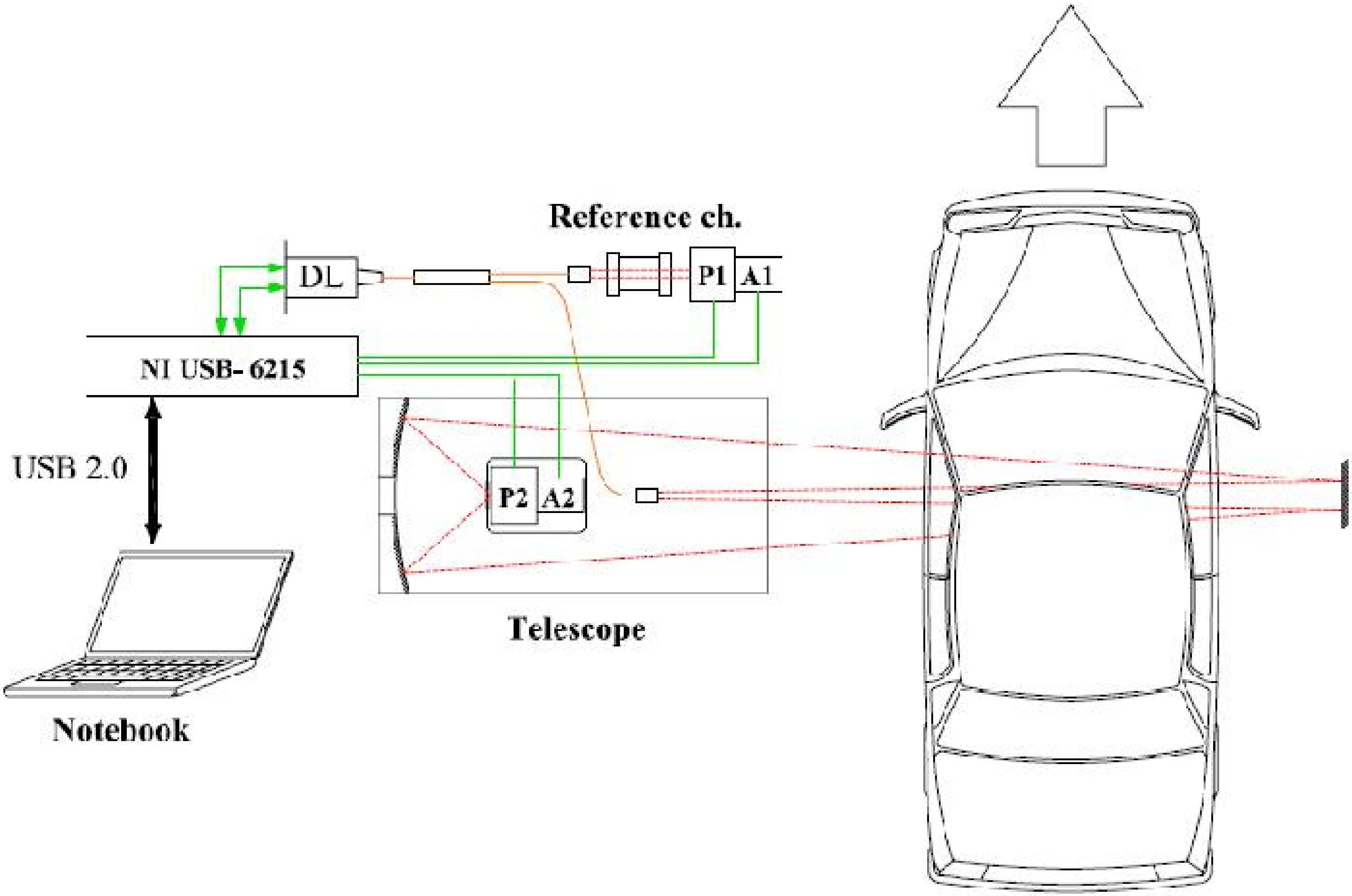
Abstract

Explosives are energetic substances, which are unstable and can decay even at room temperature. Decay probability is low; the half-life period varies from years to tenth of years. Molecular products of this decay can be detected via TDLS technique (see separate poster). In this paper we will consider a scenario for detection of explosive decay products inside a vehicle passing through a check point.

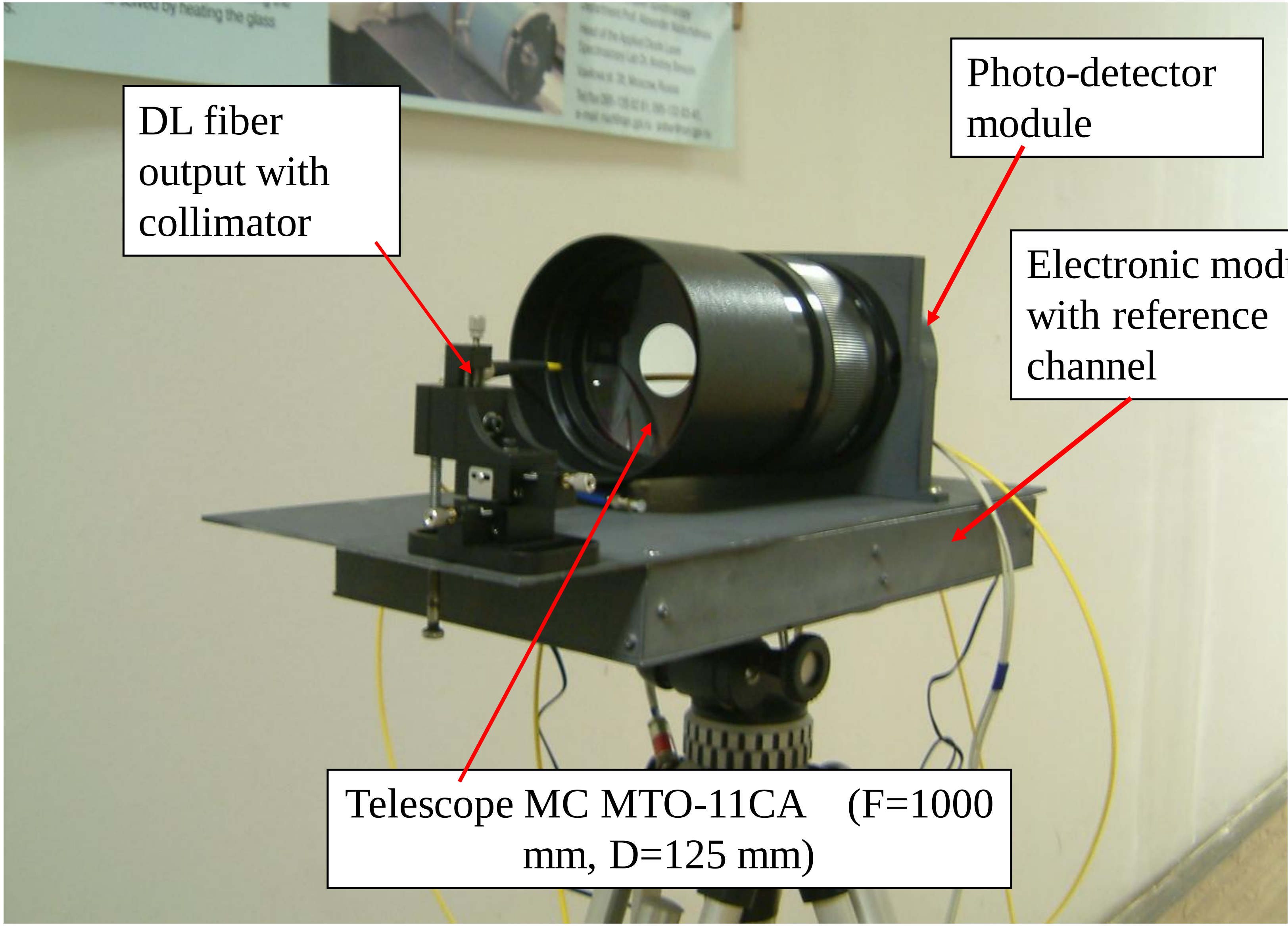
The detector contains a DL module with fiber output, electronics, and optics. DL radiation is collimated in a parallel beam and is directed to a reflector located 5 – 50 m from the detector. DL light scattered by the reflector is received by a 5 cm telescope and is focused on the photo-diode. Instrument sensitivity will be analyzed. Sensitivity was limited by the thermal noise of photo-diode trans-impedance preamplifier resistor.

Indoor and outdoor tests were performed both in Moscow and Albuquerque. For safety reasons most experiments were conducted with ammonium fertilizer (containing mostly ammonium nitrate NH_4NO_3), which in many cases is one of the components of ammonium-nitrate based explosives. For indoor tests a glass box with a sample of ammonium nitrate was used. Outdoor experiments using moving car were performed.

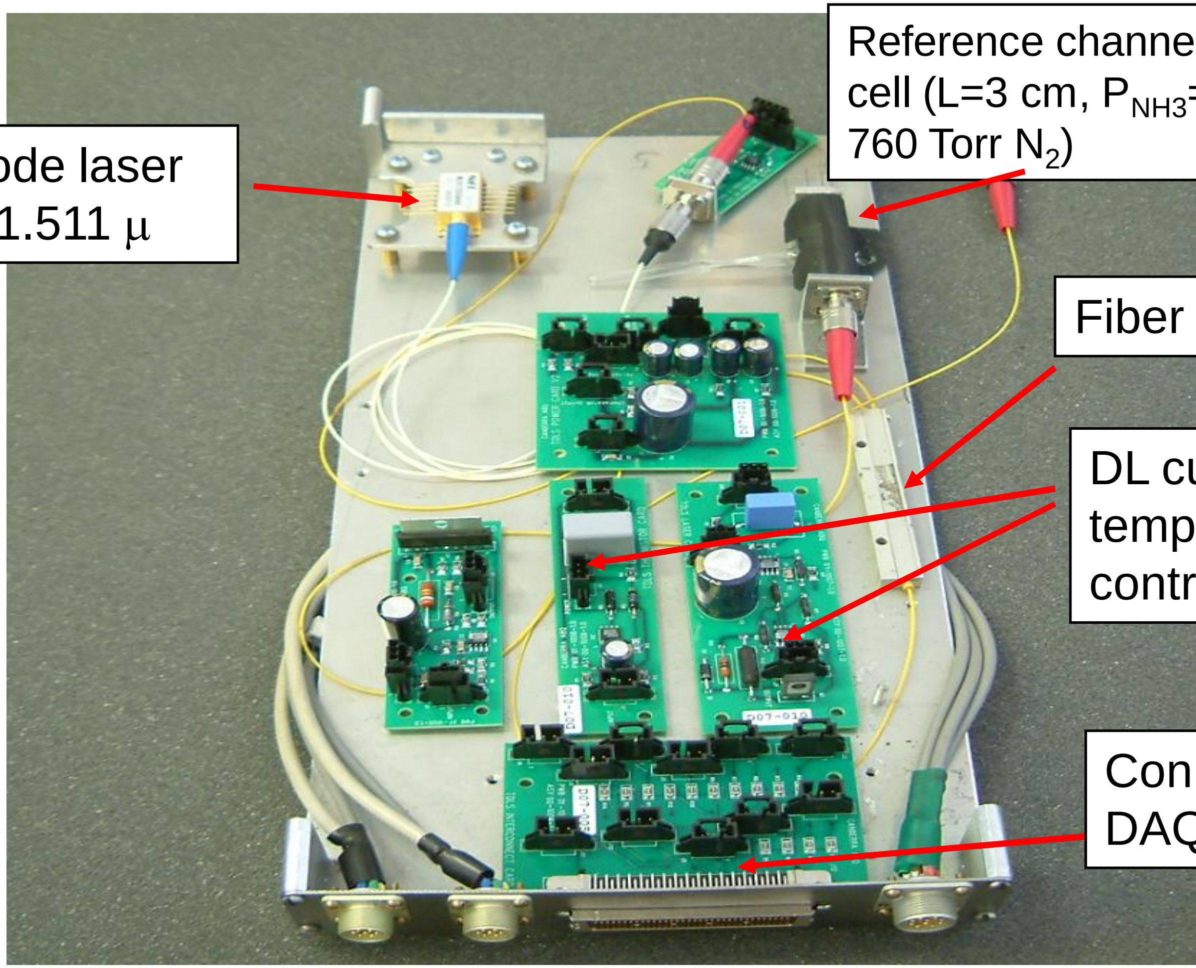
Block-scheme of experiment



View of NH_3 DL based sensor

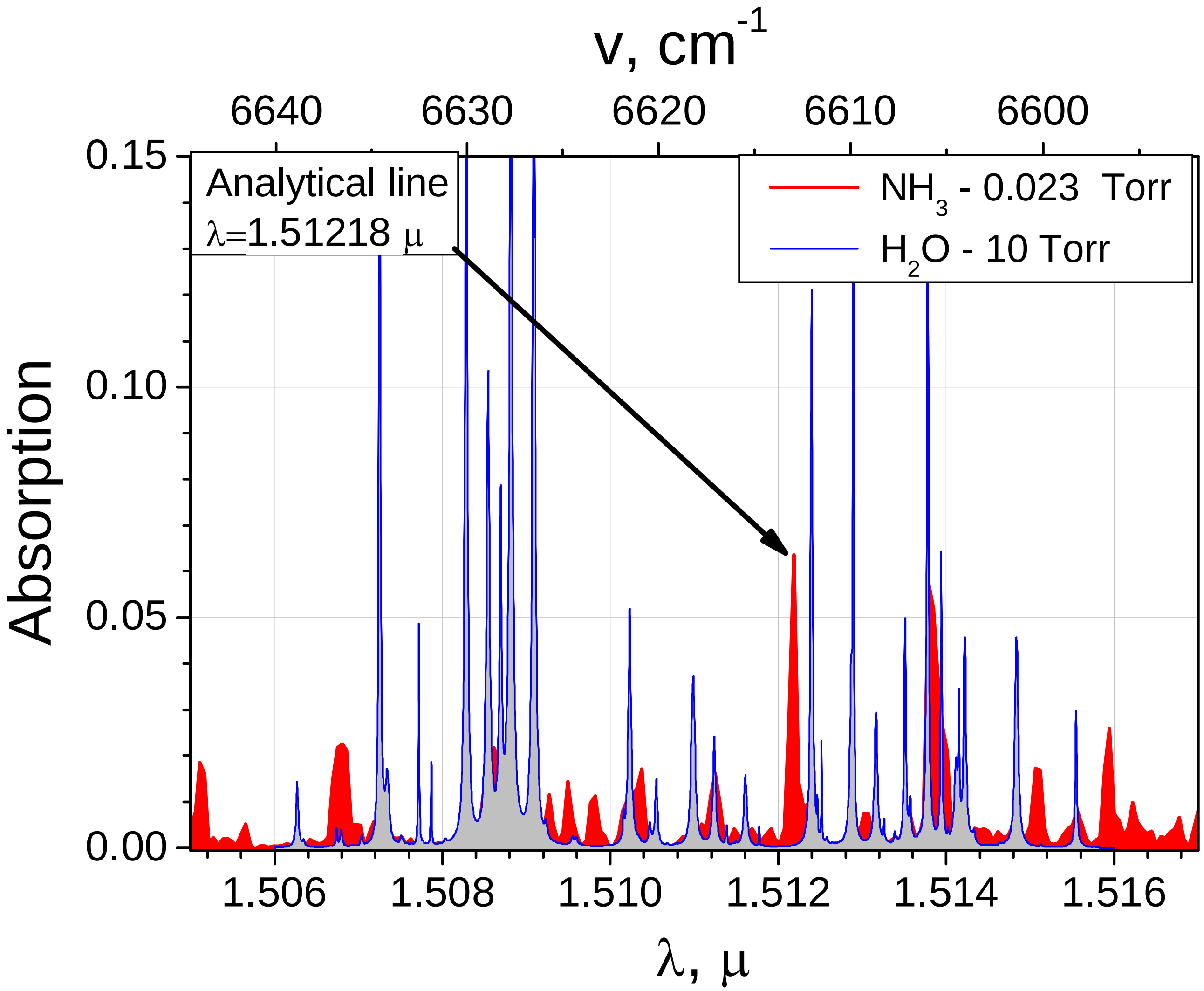


View of electronic module



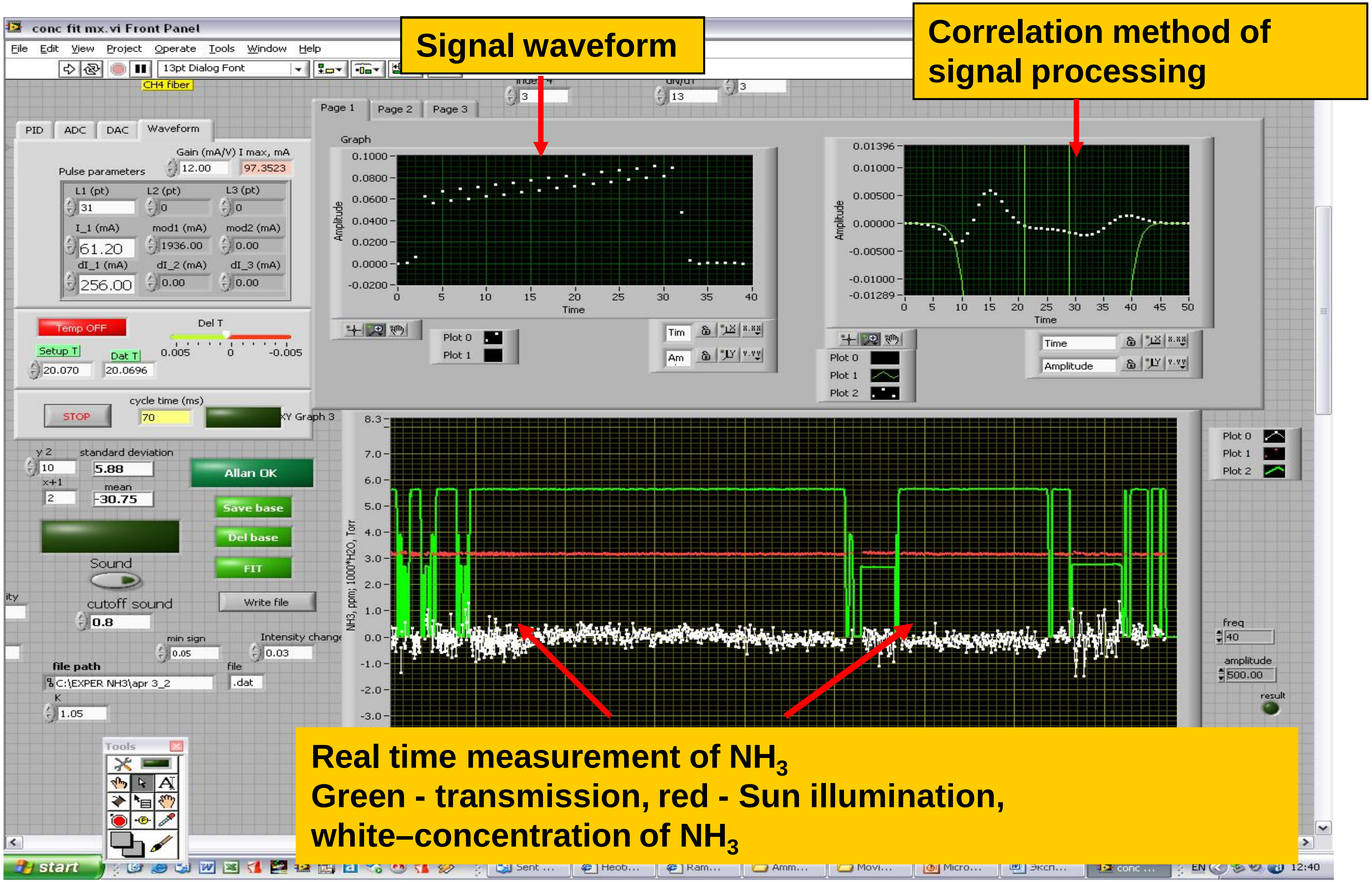
The electronic was developed by GPI and Canberra Albuquerque

NH_3 and H_2O spectra

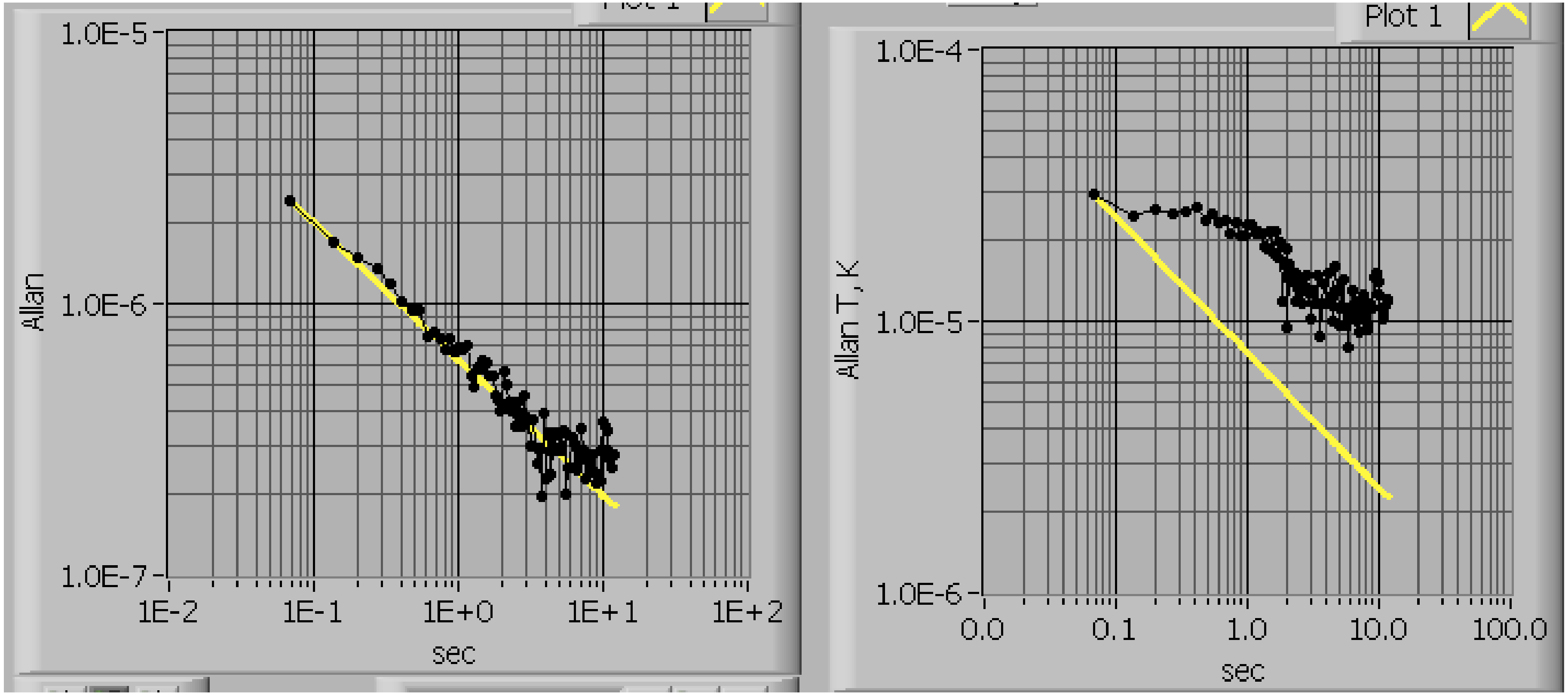


NH_3 and H_2O absorption spectra for 60 m optical length

Instrument operation program interface ("LabView 8.2")

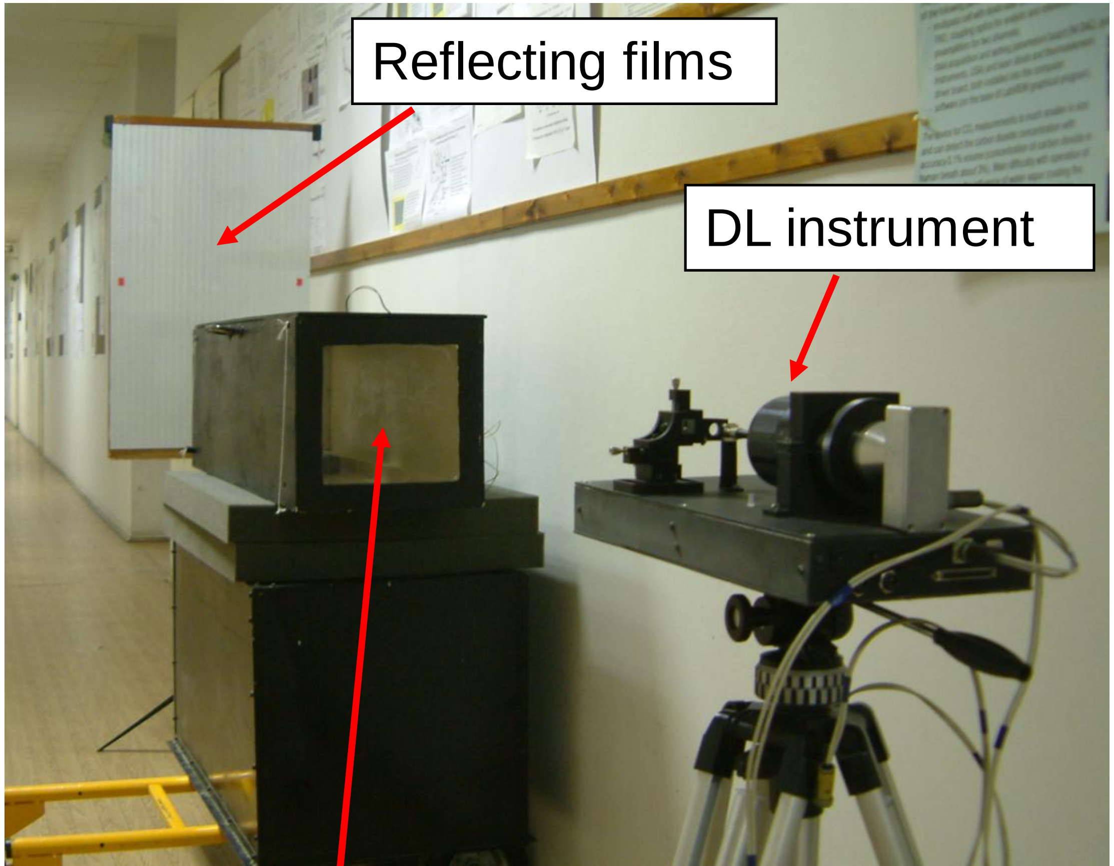


Allan plots



Allan plots of absorption (left) and DL temperature stability (right).
Temperature stability $\Delta T \sim 2.5*10^{-5}$ K.
For 1 sec registration time minimum detectable absorption was found $\sim 7*10^{-7}$.

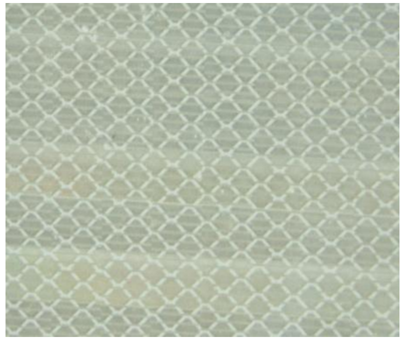
Laboratory test measurements



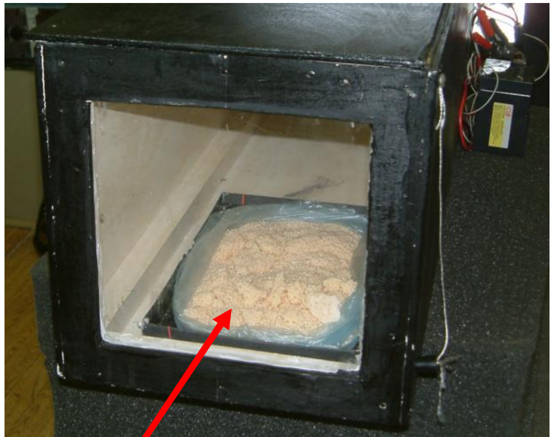
Reflecting films

DL instrument

Box with glass windows (car imitator)

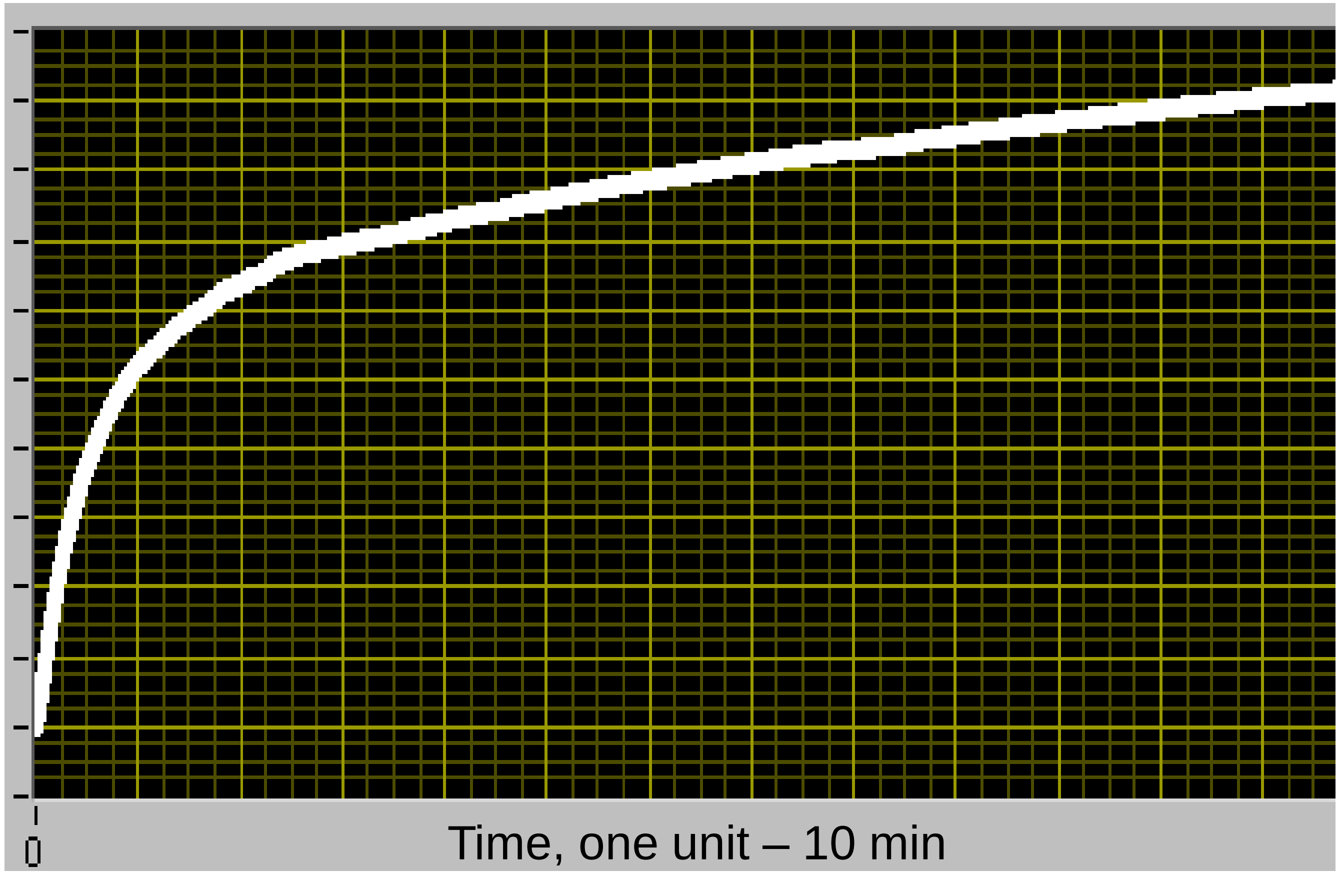


Reflecting film (pyramid structure)



Ammonium nitrate was used as explosives imitator

Non-contact explosive detection



Example of non-contact registration (in box) of explosive sample (130 g). Given example is equivalent to measurement of 20 kg explosive in moving vehicle.

Field test

View of field test of NH_3 measurements inside moving vehicle

Field measurements of NH_3 inside moving car

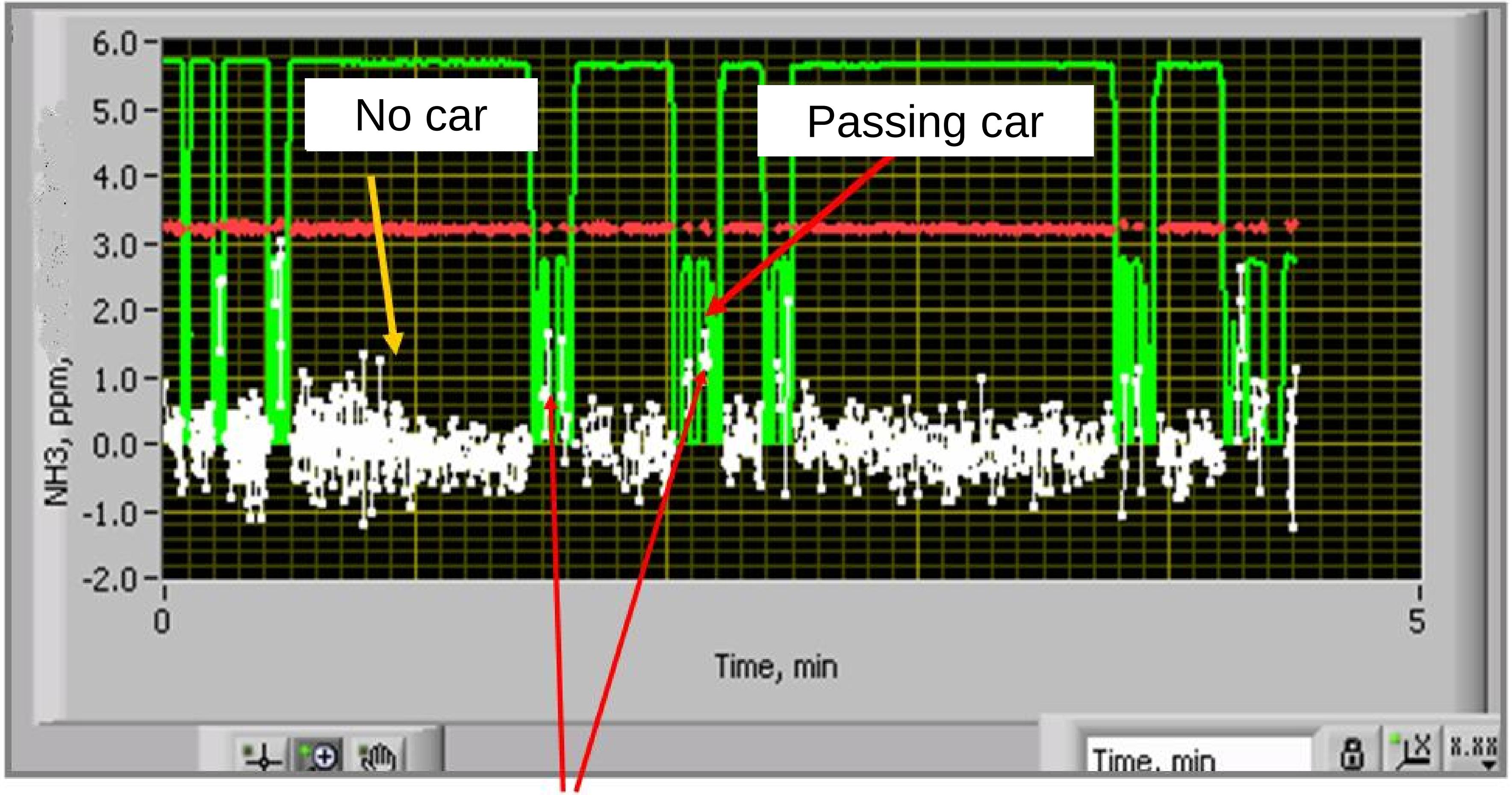
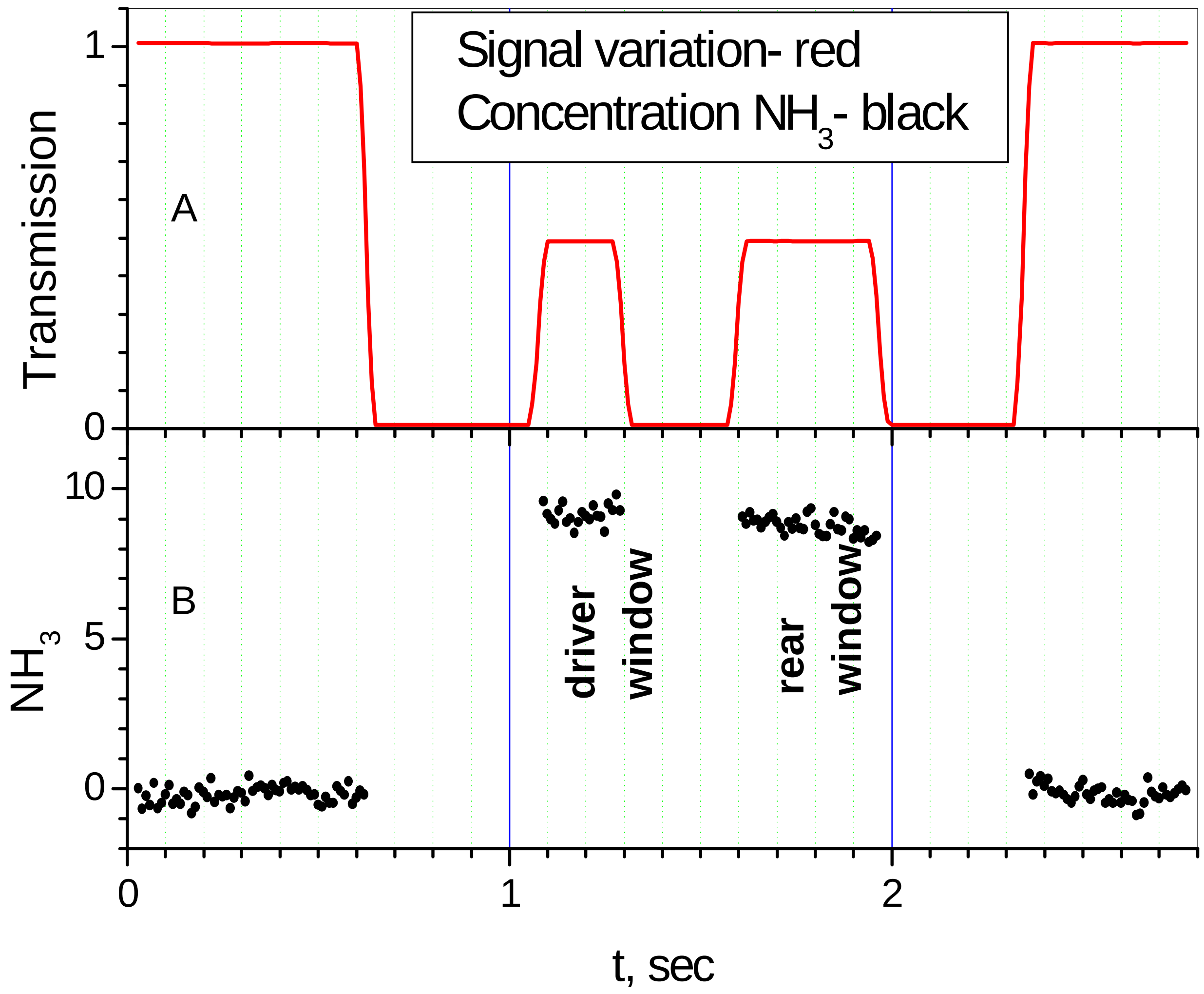


Fig. shows an example of the results of tests when the vehicle passed through the check point

Tests result of single passing



NH_3 concentration is presented in S/N units

Conclusion

1. Pig-tail diode laser $\lambda = 1.51\ \mu$ ("NTT ELECTRONICS") was used to detect ammonia (explosive decay product) inside moving car.
2. New instrument based on telescope MC MTO-11CA was developed.
3. Different noise sources were investigated and methods were developed to suppress them.
4. Temperature stability $\Delta T \sim 2.5*10^{-5}$ K. For 1 sec registration time minimum detectable absorption was achieved $\sim 7*10^{-7}$ corresponding to 200 ppb.
5. Indoor and outdoor tests were performed.