

Inter-calibration measurements of ethylene absorption spectrum with $3 \cdot 10^{-4} \text{ cm}^{-1}$ resolution on two types of diode laser spectrometers



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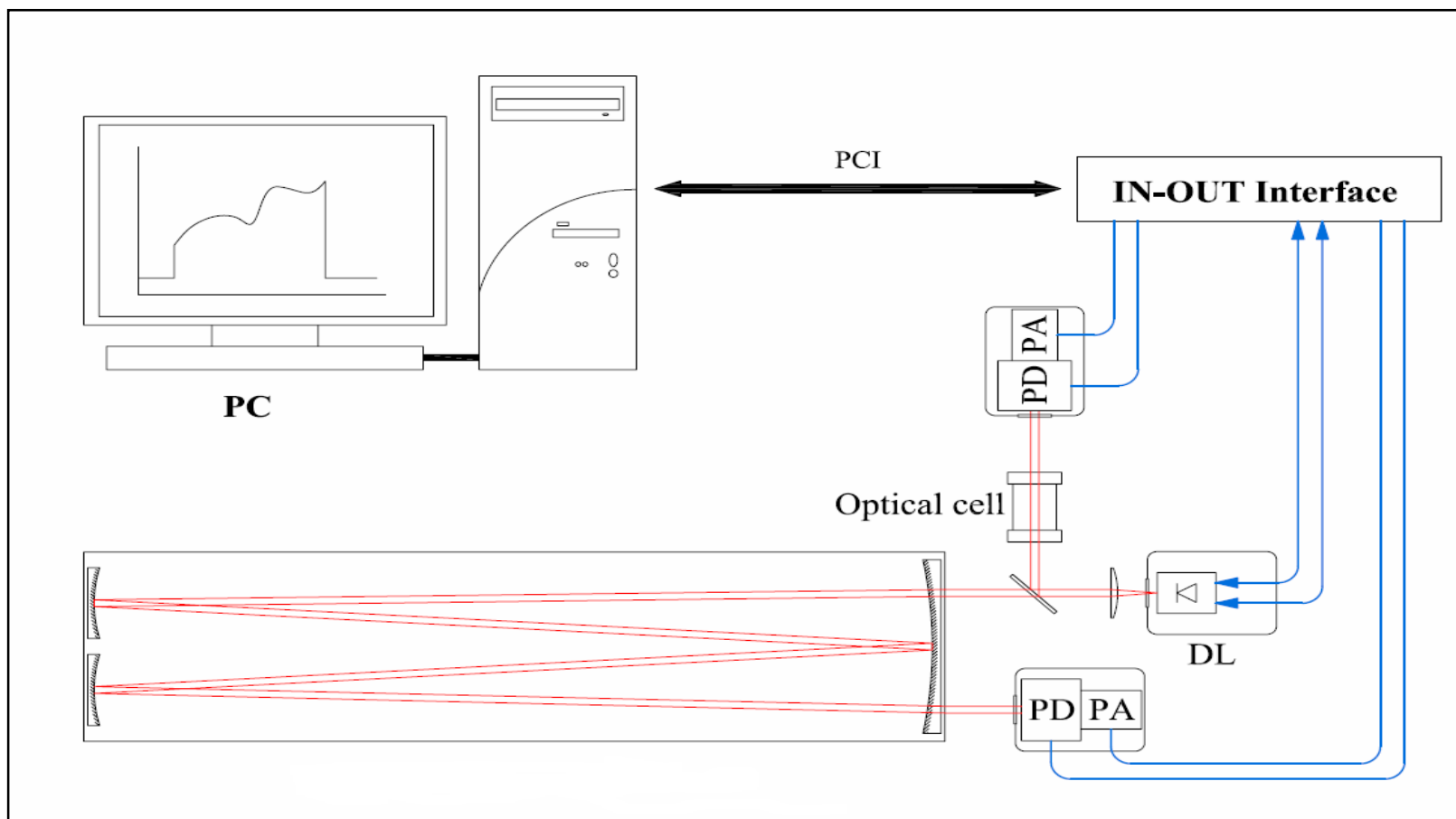
DLS

LAB

There were made independent measurements of high purity (99,99%) gaseous ethylene absorption spectrum at 6046-6067 cm⁻¹ spectral range on two laser spectrometers. In first one were used two differential type resonant photoacoustic cells, which allow to register absorption spectrum at two different pressures (or two different gases) simultaneously [1]. In second spectrometer for measurement of transmission spectrum was used cell with multipass matrix system by S.M. Chernin with 39 m full optical path length. The source of radiation in optico-acoustical spectrometer was tunable diode laser TЭC-100 (Sacher Laser Technik) with generation line width which is not exceed 10 MHz, and 3-7 mW output power. In second spectrometer was used DFB DL with fiber output (l=1,651 μ, 20 mW output power). Measurements were made at 20 Torr ethylene pressure and 293K temperature. As a whole the difference in absorption cross-section measured values does not exceed 10%, and discrepancy in lines centers position ≤ 0.002 cm⁻¹. Results represent identity of obtained spectral information. Conducted intercalibration allows improving OA spectrometer sensitivity value.

- [1]. V.A. Kapitanov, Yu.N. Ponomarev, I.S. Tyryshkin, A.P. Rostov. Two-channel opto-acoustic diode laser spectrometer and fine structure of methane absorption spectra in 6070-6180 cm⁻¹ region. *Spectrochimica Acta Part A*, 66A, 811-818 (2007).

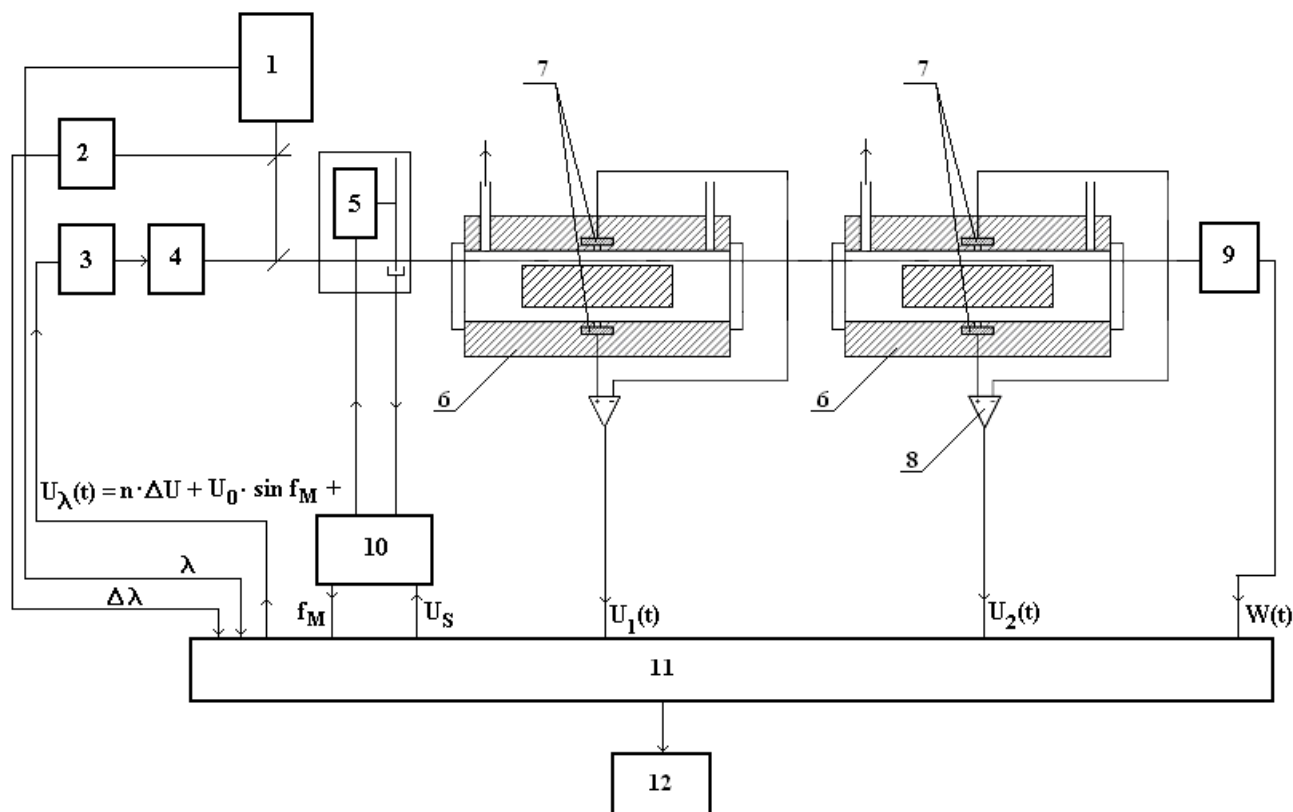
Block-scheme of the DL Spectrometer



S.M. Chernin Multipass optical cell. $L = 39\text{ m}$ $P = 25\text{ Torr}$. In spectrometer was used DFB DL “NTT Electronics” with fiber output ($l = 1,651\text{ m}$, 20 mW output power). Source of C_2H_4 : 99.99 % purity .

OA Spectrometer

Kapitanov V.A., Ponomarev Yu.N., Tyryshkin I.S and Rostov A.P.:
Spectrochimica Acta Part A, 66A, 4-5, 811-818 (2007)



Laser:

$$\Delta \nu - 6060-6250 \text{ cm}^{-1}$$

$$d\nu - 2,5-3 \text{ cm}^{-1}$$

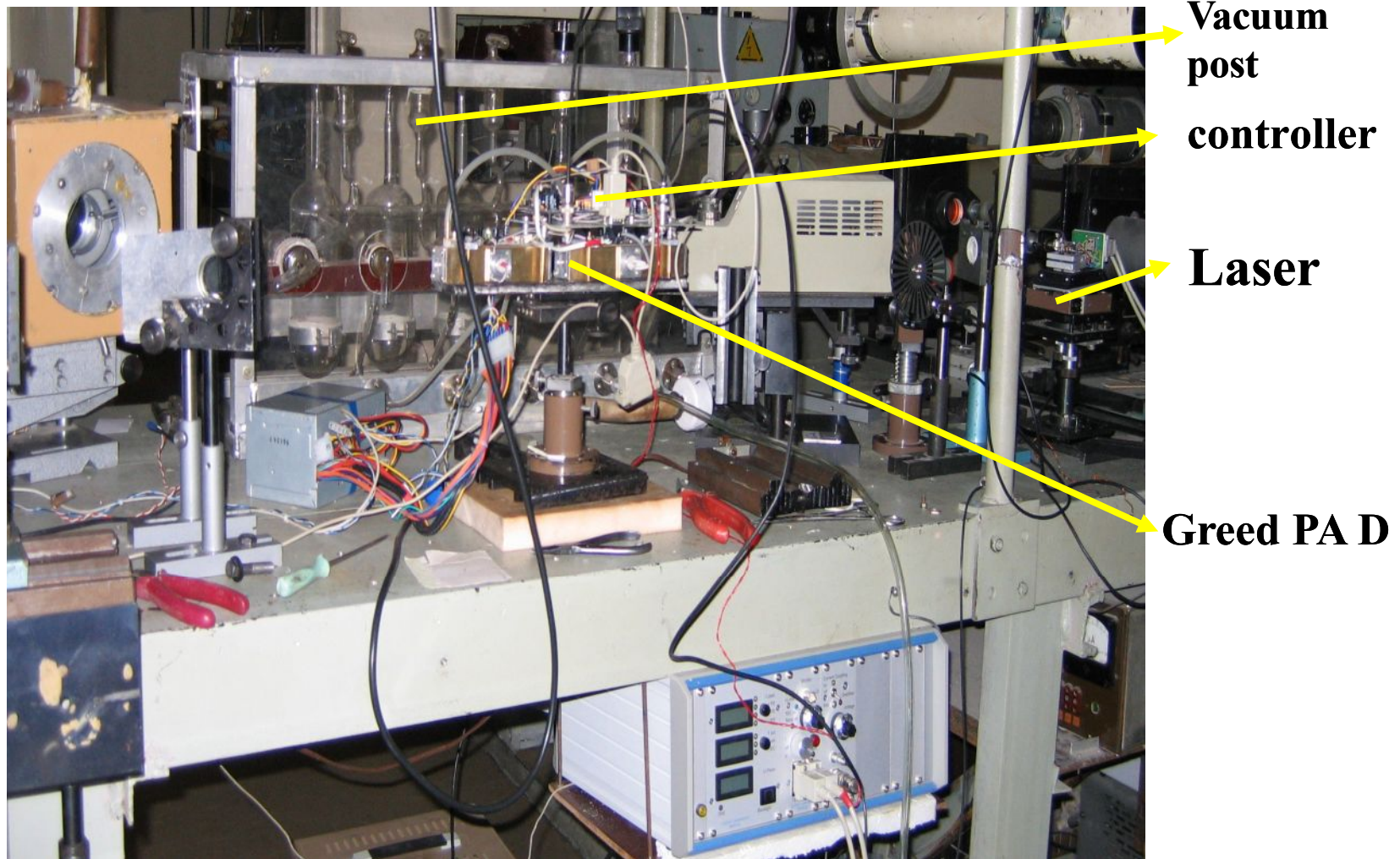
$$W - 3-7 \text{ mW}$$

ОАД:

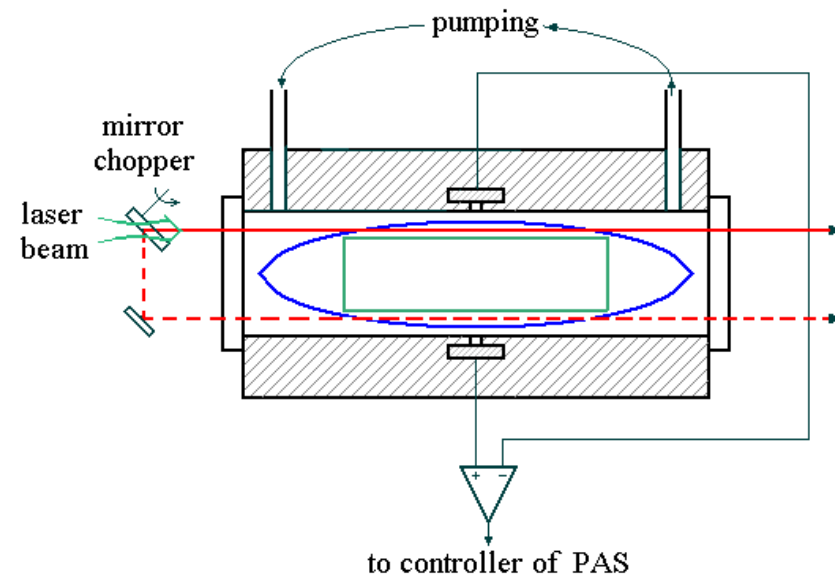
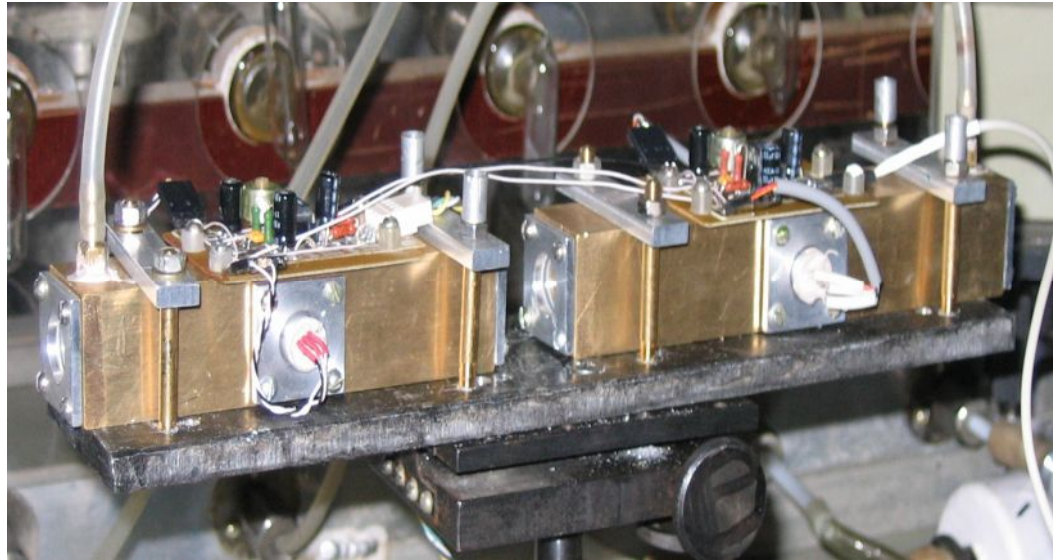
$$\Delta = (U_n^2)^{1/2}/R$$

$$4 \cdot 10^{-9} \text{ cm}^{-1} \text{ W}$$

View OA spectrometer

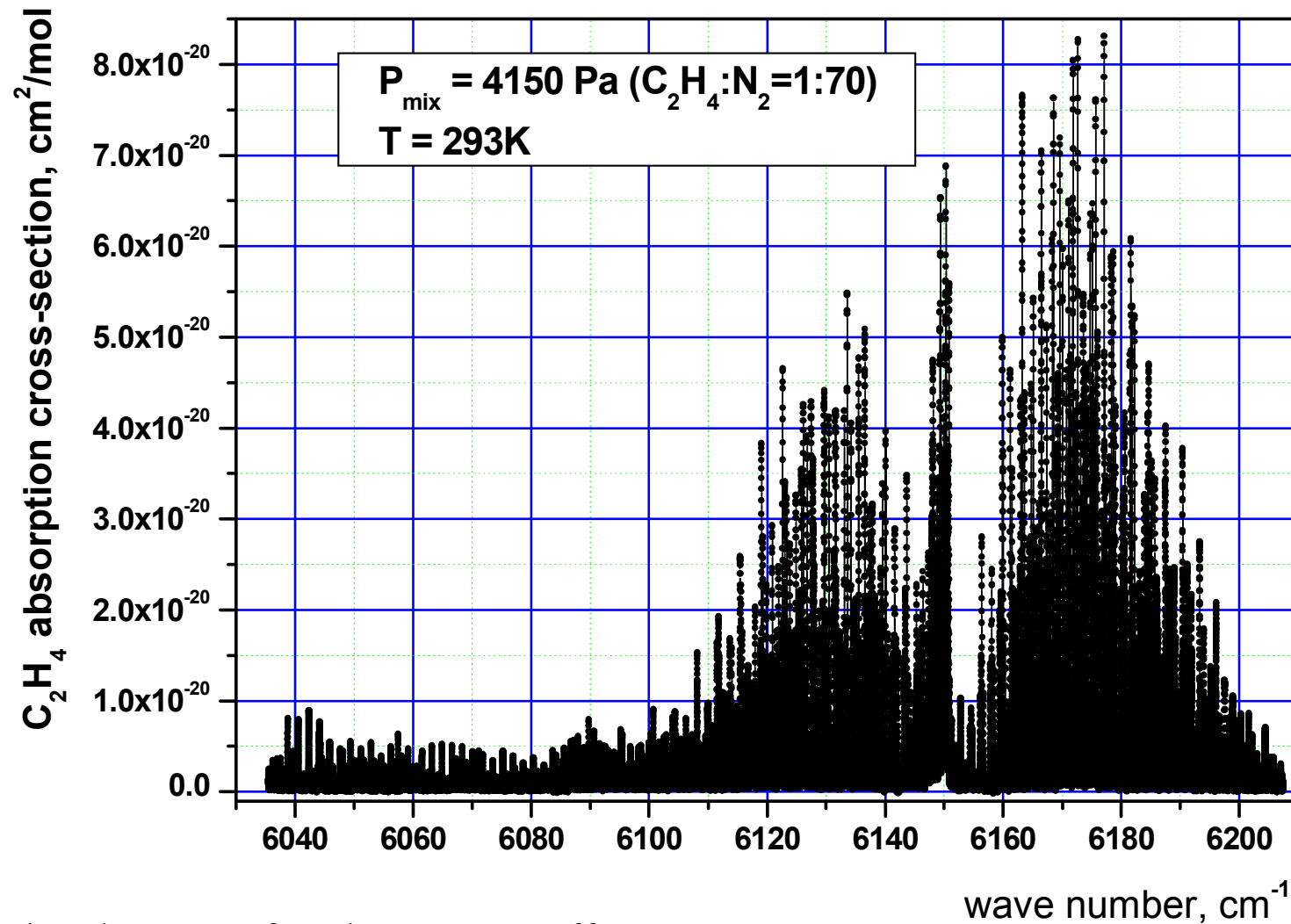


OA detectors



$L_1 = 120 \text{ mm};$
 $L_2 = 150 \text{ mm};$
 $\varnothing = 5 \text{ mm};$
 $R = 7 \text{ mm}$

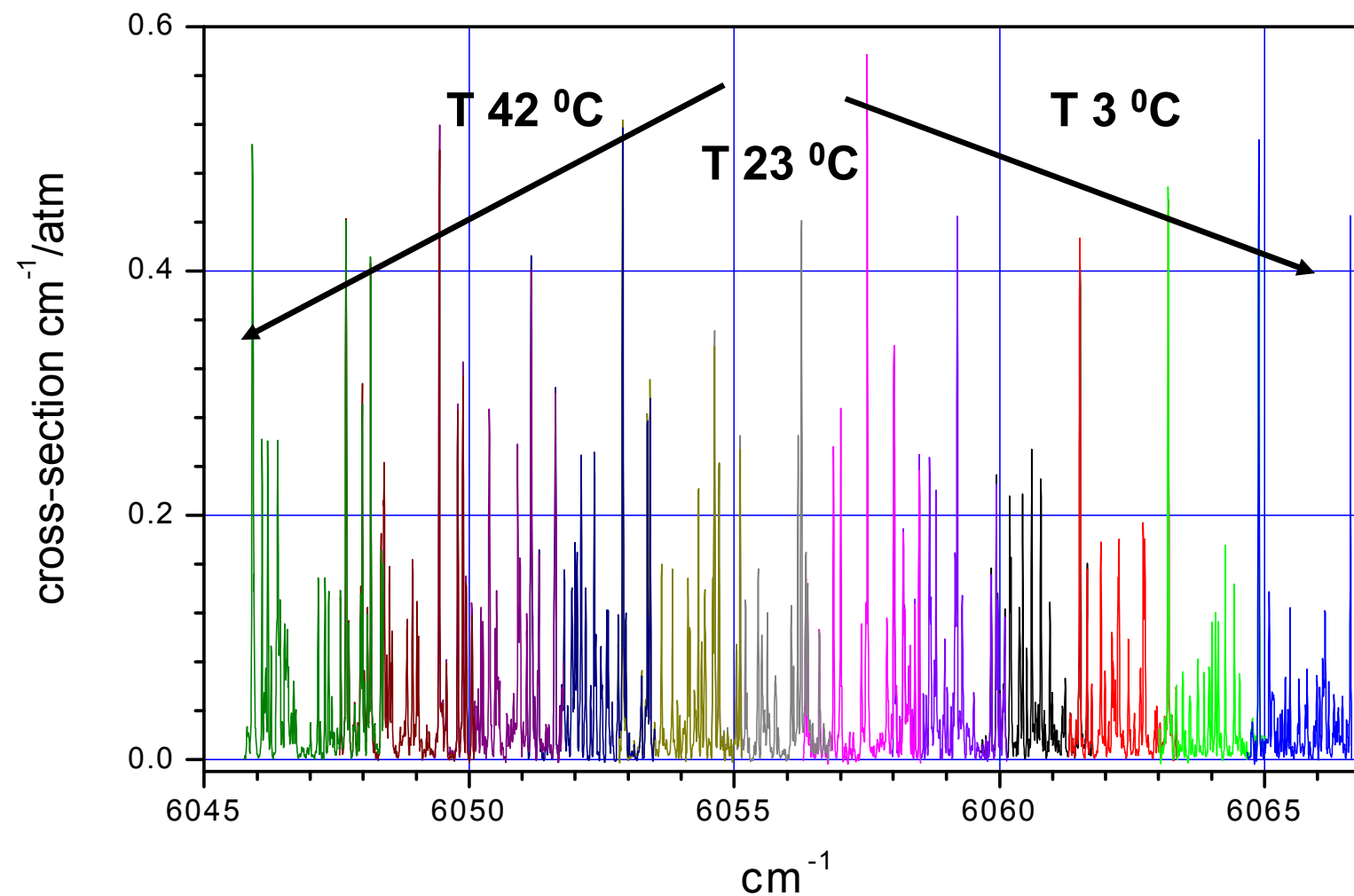
Absorption cross-section ethylene, cm²/mol.



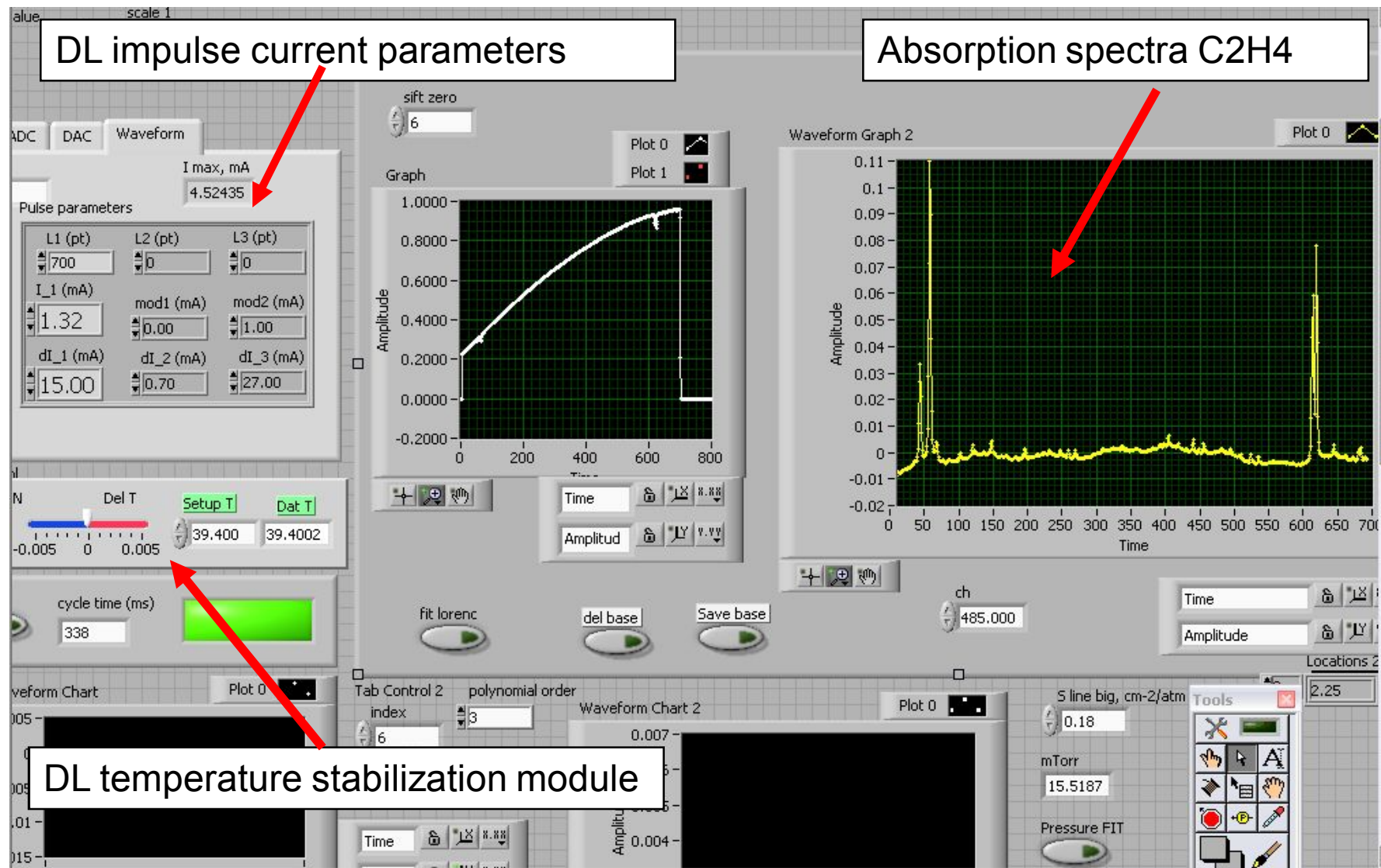
$\Delta\nu = 10^{-4}\text{cm}^{-1}$, $\delta\nu = 10^{-3}\text{cm}^{-1}$, $\text{SD} = 5 \cdot 10^{-23}\text{cm}^2/\text{mol}$

DL spectra ethylene

Ethylene (99,9 %), $P=20$ Torr, $L_{\text{cell}}=200$ cm

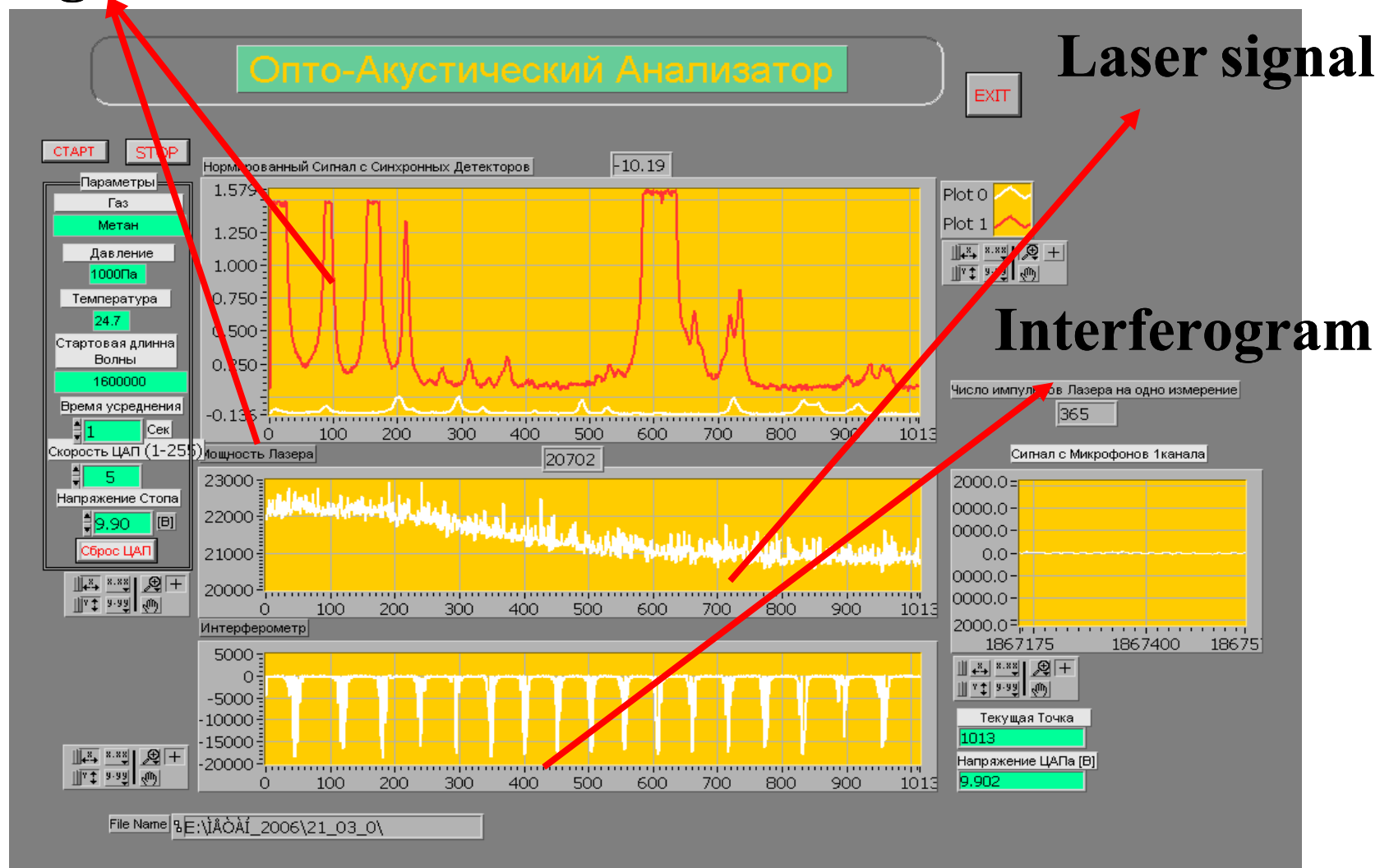


View of work DL program

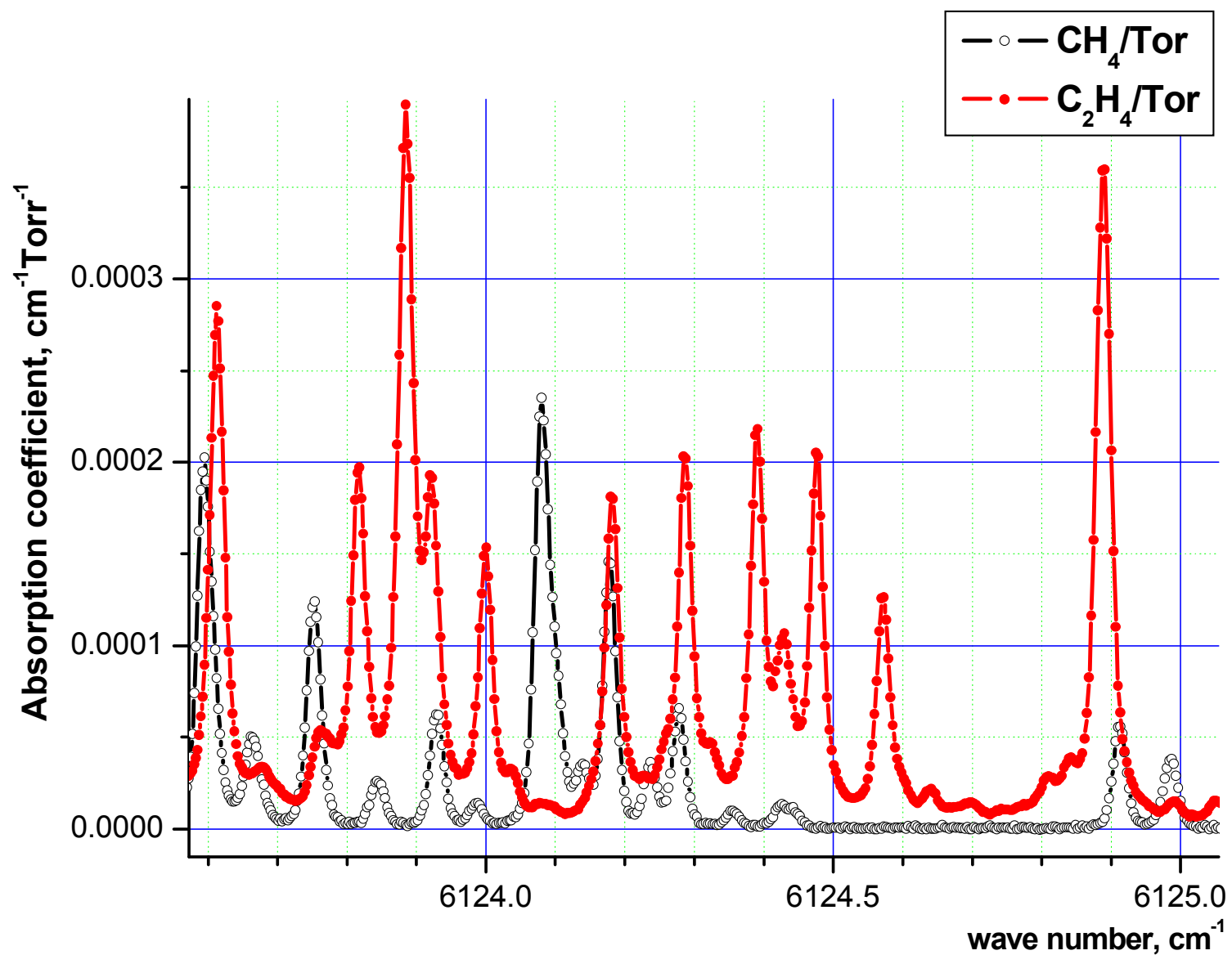


View of work program OAD

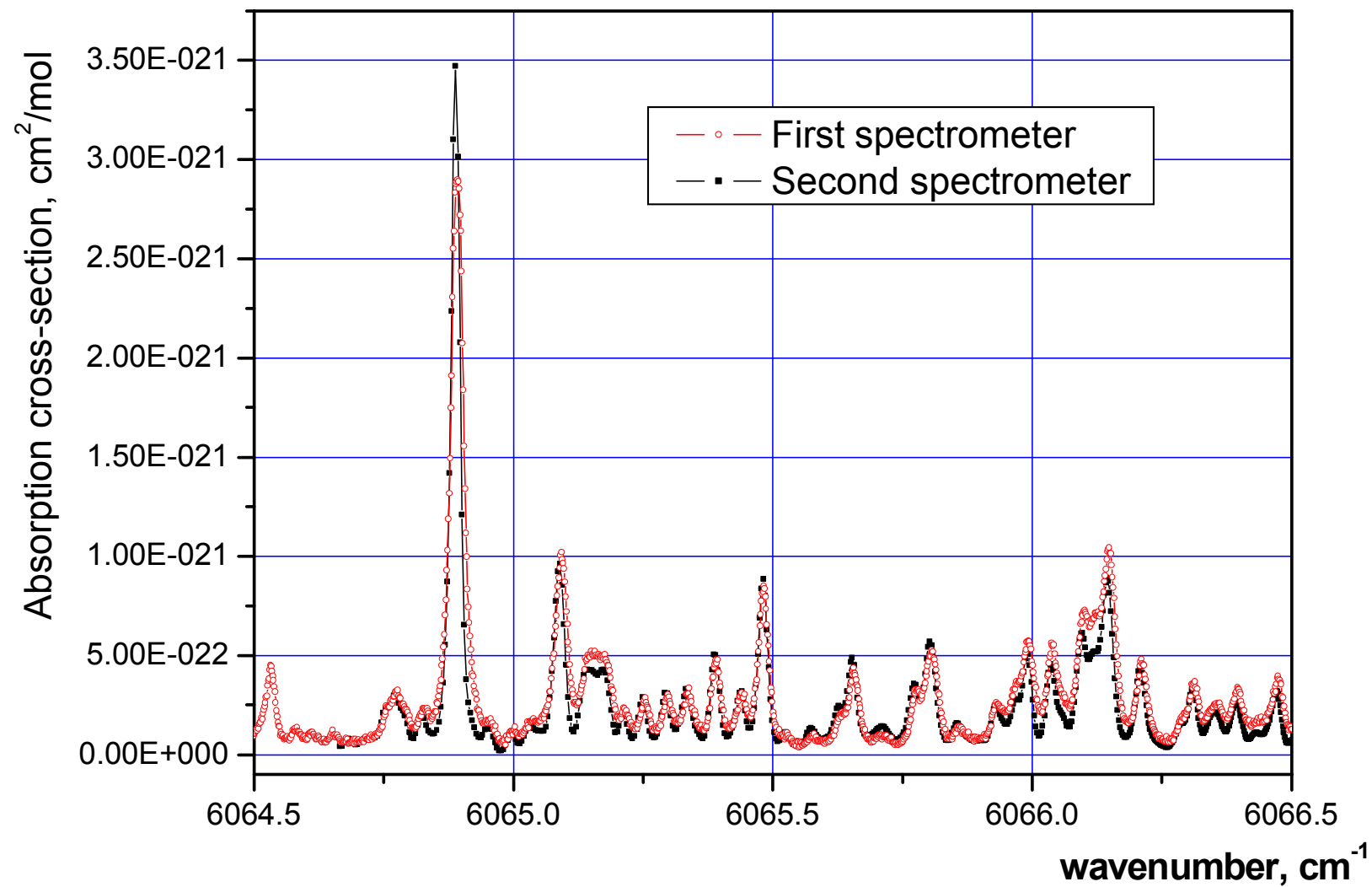
Signal



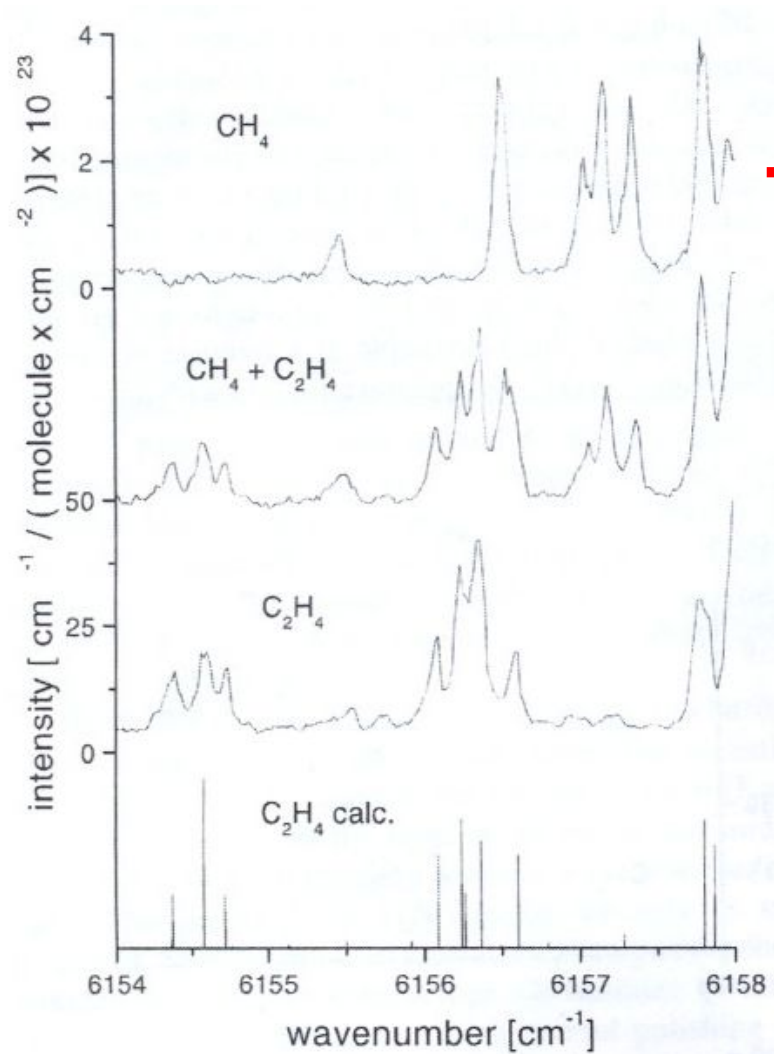
Calibration frequency scale by CH₄ line



C₂H₄ spectrum, P=20 torr, T=293K

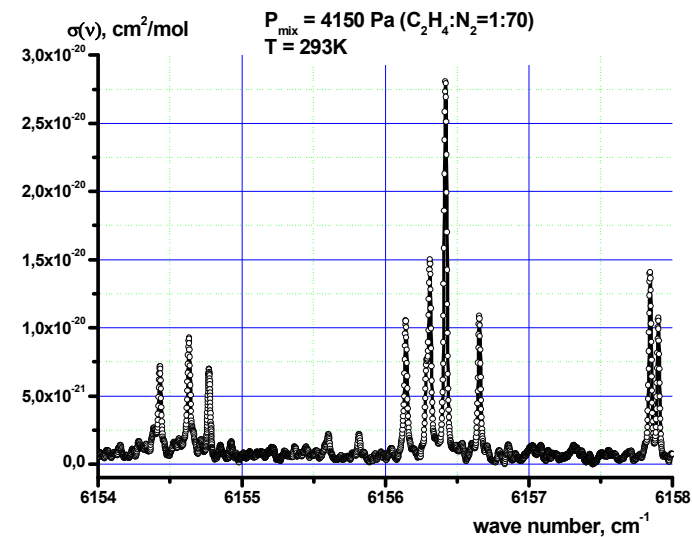


Ethylene spectrum comparison



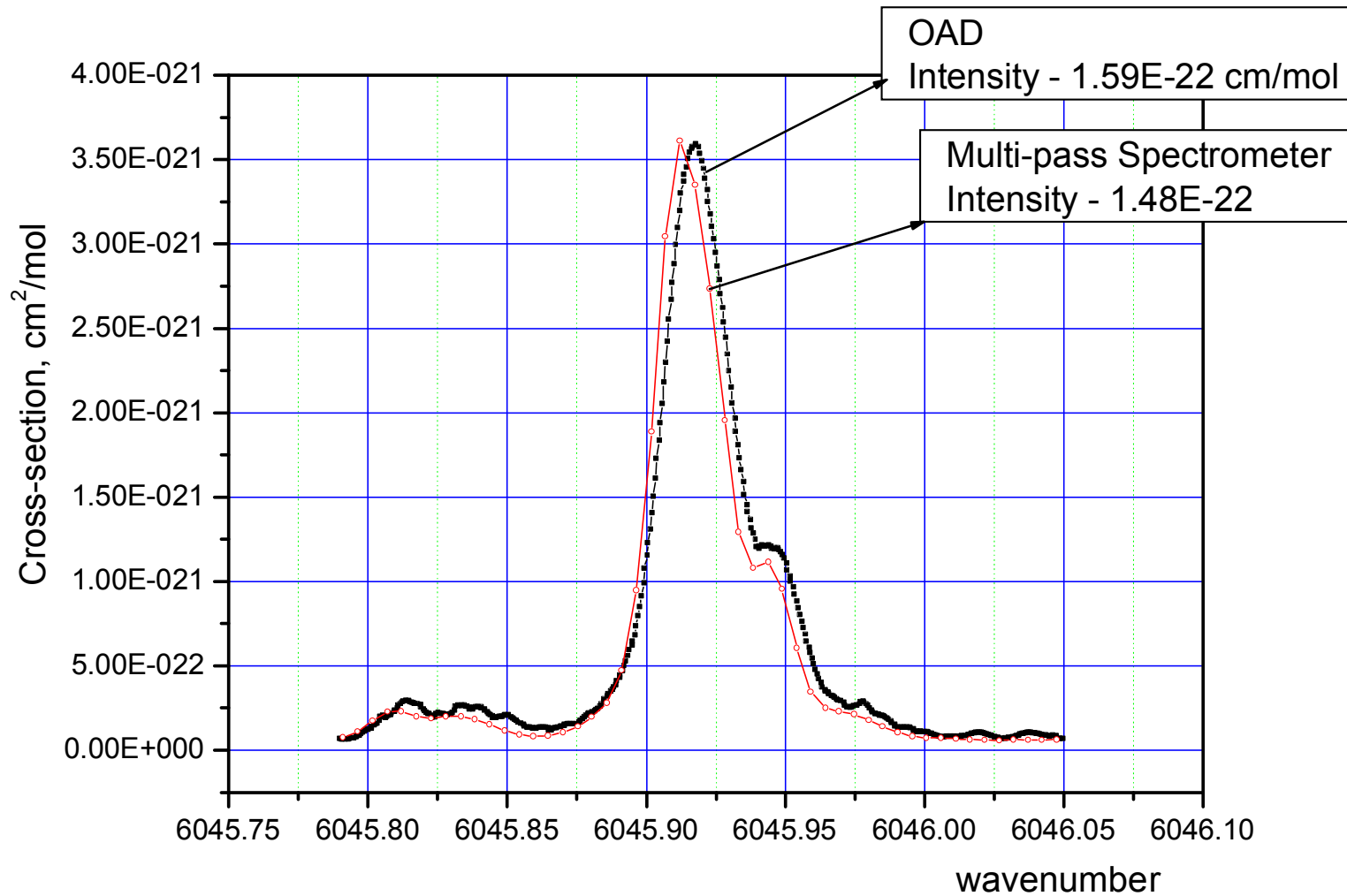
Detail of the survey spectrum of the ethylene/methane mixture around 6156 cm⁻¹. $\Delta\nu=0.1$ cm⁻¹

A.Boschetti, D.Bassi, E.Iacob, S.Iannotta, L.Ricci, M.Scotoni:
Appl.Phys.B 74, 273-278, (2002)



(our measurements)

Ethylene spectrum comparison (continue)



Literature data on ethylene NIR absorption between 5900 and 6400 cm^{-1}

- **Low resolution:**

- M.Buback, and F.W.Nees: Phys.Chem., 80, 650, (1976)
- Duncan [J.L.Duncan, A.M.Ferguson: J.Chem.Phys. 89, 4216, (1988)]

- **High resolution:**

- M.Bach, R.Georges, M.Herman, A.Perrin: Mol.Phys. 97, 265 , (1999)
- T.Platz, W.Demtroder: Chem.Phys.Lett. 294, 397 (1998).

- **Laser spectroscopy:**

6131-6135 cm^{-1} ; 6154-6159 cm^{-1}

- A.Boschetti, D.Bassi, E.Iacob, S.Iannotta, L.Ricci, M.Scotoni: Appl.Phys.B 74, 273-278, (2002)

6149.7-6150.38 cm^{-1}

- A.M.Parkes, R.E.Lindley and A.J.Orr-Ewing: Phys.Chem. 6, 5313-5317, (2004),

6157.55-6158.25 cm^{-1}

- A.Rossi, R.Buffa, M.Scotony, D.Bassi, S. Iannotta, A.Boschetti: Appl.Phys.Lett. 87, 041110, (2005).

Conclusions

- The detail ethylene absorption spectrum between 6035 and 6210 cm^{-1} is measured with spectral resolution $\sim 10^{-4} \text{ cm}^{-1}$ by TDLS and OAS.
- 2826 absorption lines of ethylene, line positions measured with uncertainty less than 10^{-3} cm^{-1} . Absorption cross sections measured with uncertainty less than $5 \cdot 10^{-23} \text{ cm}^2/\text{mol}$.
- As a whole the difference in absorption cross-section measured by TDLS and OAS values does not exceed 10%, and discrepancy in lines centers position $\leq 0.002 \text{ cm}^{-1}$. Results represent identity of obtained spectral information. Conducted intercalibration allows improving OA spectrometer sensitivity value.