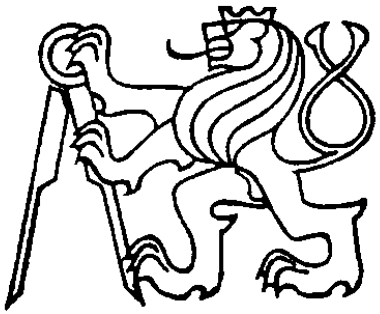
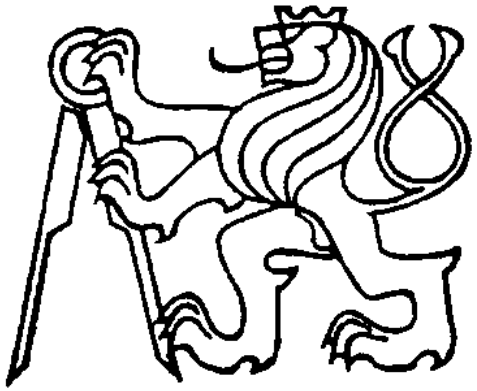


ČVUT Czech Technical University Prague,
Faculty of Transportation Sciences
Institute of Control Technology and Telematics
Joint Laboratory of System Reliability
Konviktská 20, 11000 Prague 1
tel. 24221721/416 (fax), 417(secr), 418, 413 (lab)
e-mail: mirko@fd.cvut.cz

SIMULTANEOUS RECORDING OF ELECTRIC AND METABOLIC BRAIN ACTIVITY.

J. Faber, J. Pěkný, R. Pieknik, T. Tichý, V.Faber, P. Bouchner, M. Novák



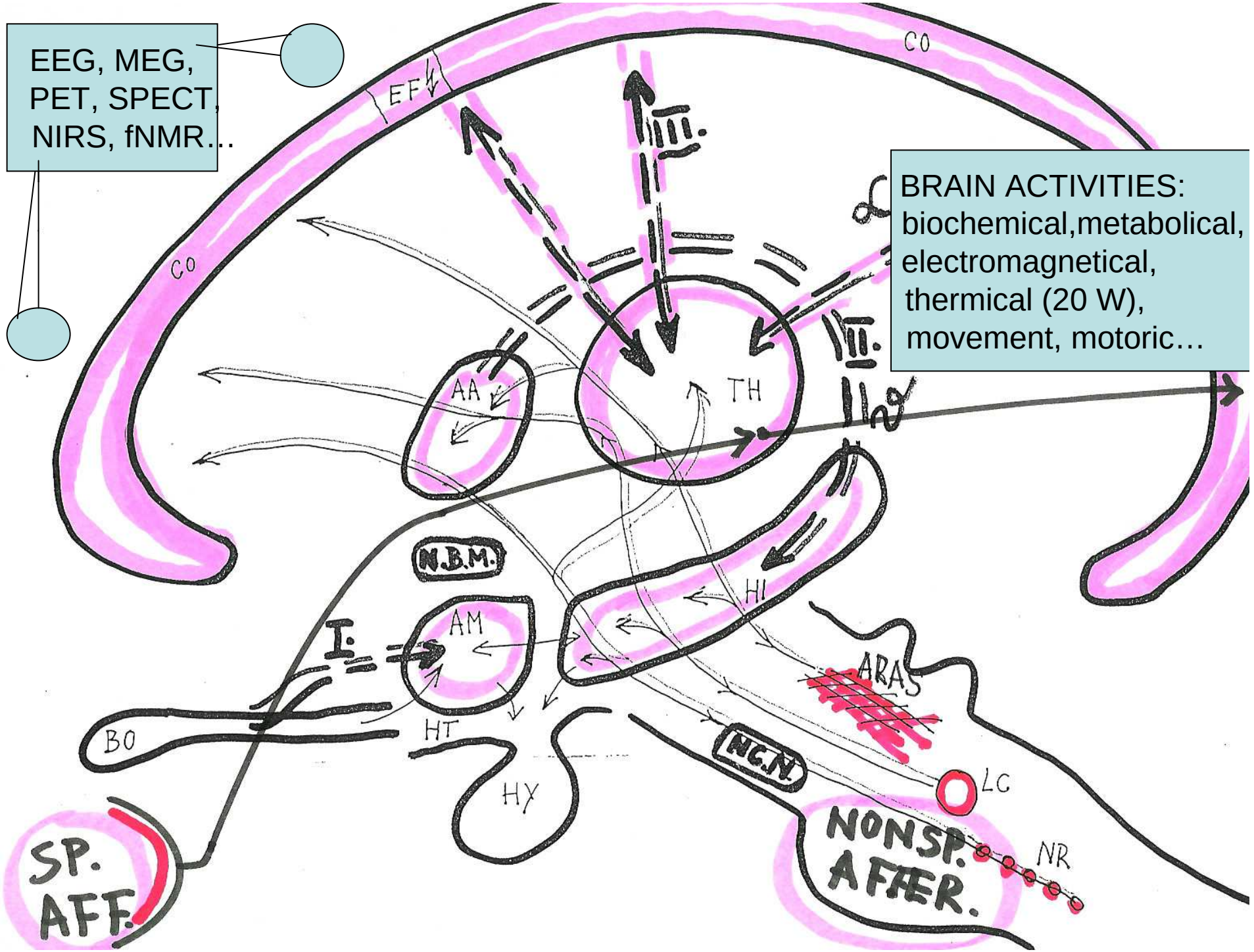
SIMULTANEA NOTATIO ELECTRICAM ET METABOLICAM (OXIDATIONEM) ACTIONEM CEREBRI.

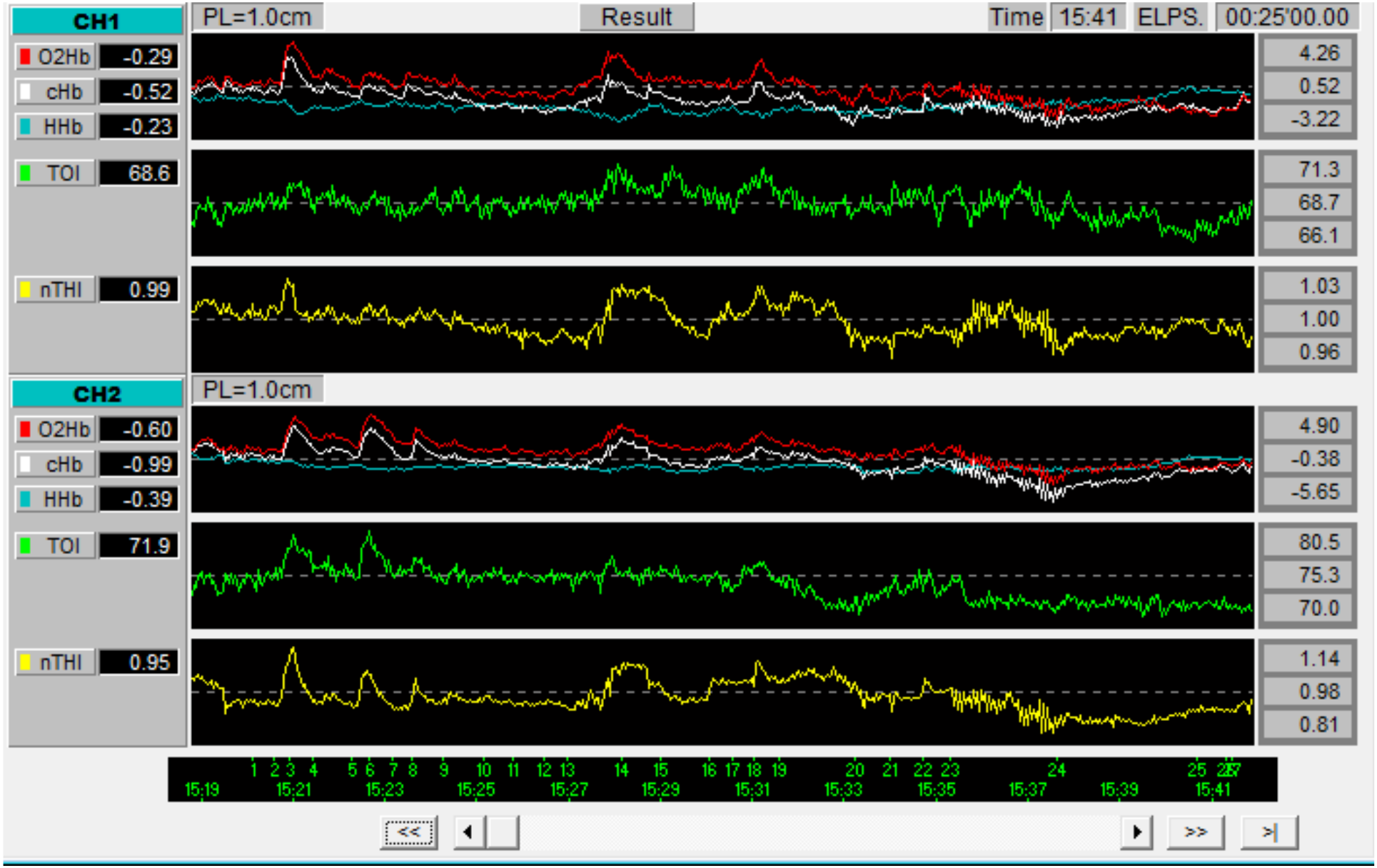
J. FABER, R.PIEKNIK, J. PĚKNÝ, T.TICHÝ, V.FABER, M.NOVÁK
TRANSPORTATIONIS FACULTAS
UNIVERSITATIS TECHNICAE BOHEMIAE, PRAGA, 2009.

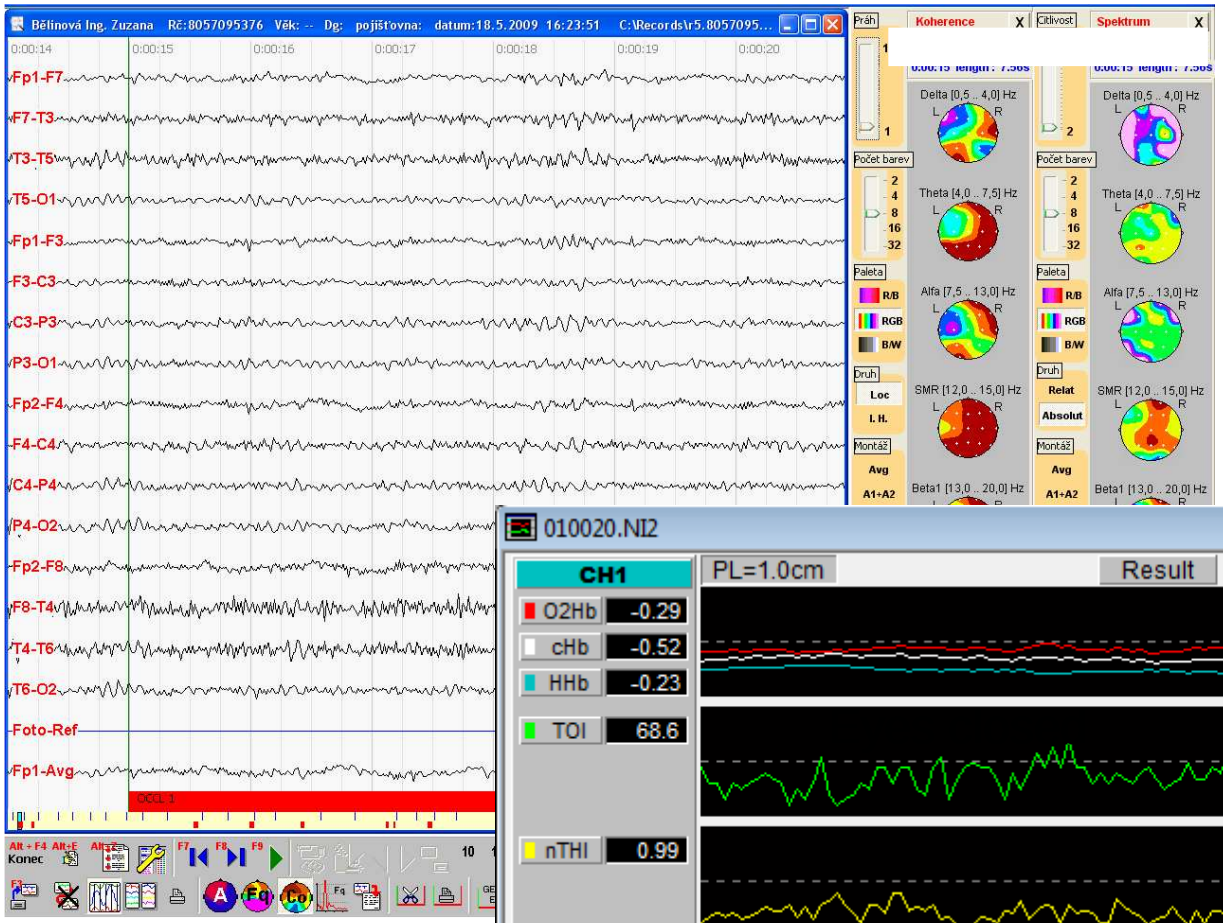
We monitor the state of attention in control probands and in persons, whose occupation requires sound concentration and constant vigilance. The aim is to define objective parameters indicating the physiological and psychological state of the brain in drivers, railway engineers, pilots, air traffic controllers, etc.

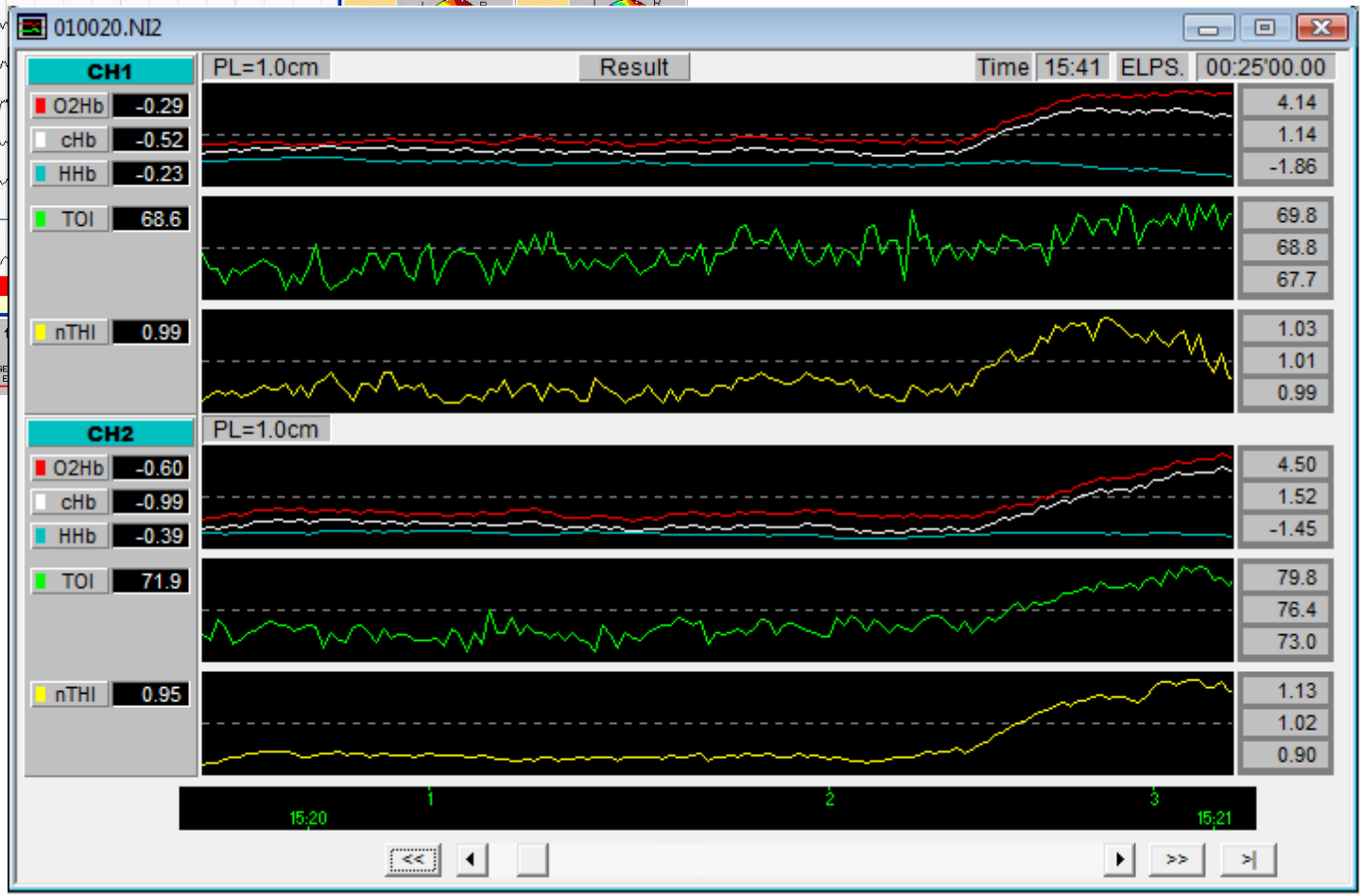
For years now, we have been using electroencephalography, for the purpose EEG system made by Czech manufacturers DayMad. As a standard, we use 19 electrodes arrayed according to the Jasper system of 10-20 covering most of the skull surface.

For a number of months now, we have had use of another apparatus for near-infrared spectroscopy (NIRS),(NIRO-2OO of Japan provenience, near infrared oxygenation monitor, Hamamatsu Photonic Deutschland GmbH), a device sending an infrared laser beam through the intact scalp and diploic bone into the brain 4 cm deep. A special technical receptor registrating reflected light then provides information on the oxidation of the cortex.


EEG, MEG,
PET, SPECT,
NIRS, fNMR…
BRAIN ACTIVITIES:
biochemical,metabolical,
electromagnetical,
thermical (20 W),
movement, motoric…
CO
CO
EF
AA
TH
N.B.M.
AM
HI
ARAS
BO
HT
HY
N.G.N.
LC
NONSP.
AFFER.
NR
SP.
AFF.


CH1
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
4.26
0.52
-3.22
71.3
68.7
66.1
1.03
1.00
0.96
CH2
PL=1.0cm
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
4.90
-0.38
-5.65
80.5
75.3
70.0
1.14
0.98
0.81
15:19
15:21
15:23
15:25
15:27
15:29
15:31
15:33
15:35
15:37
15:39
15:41
<<
>>
>|

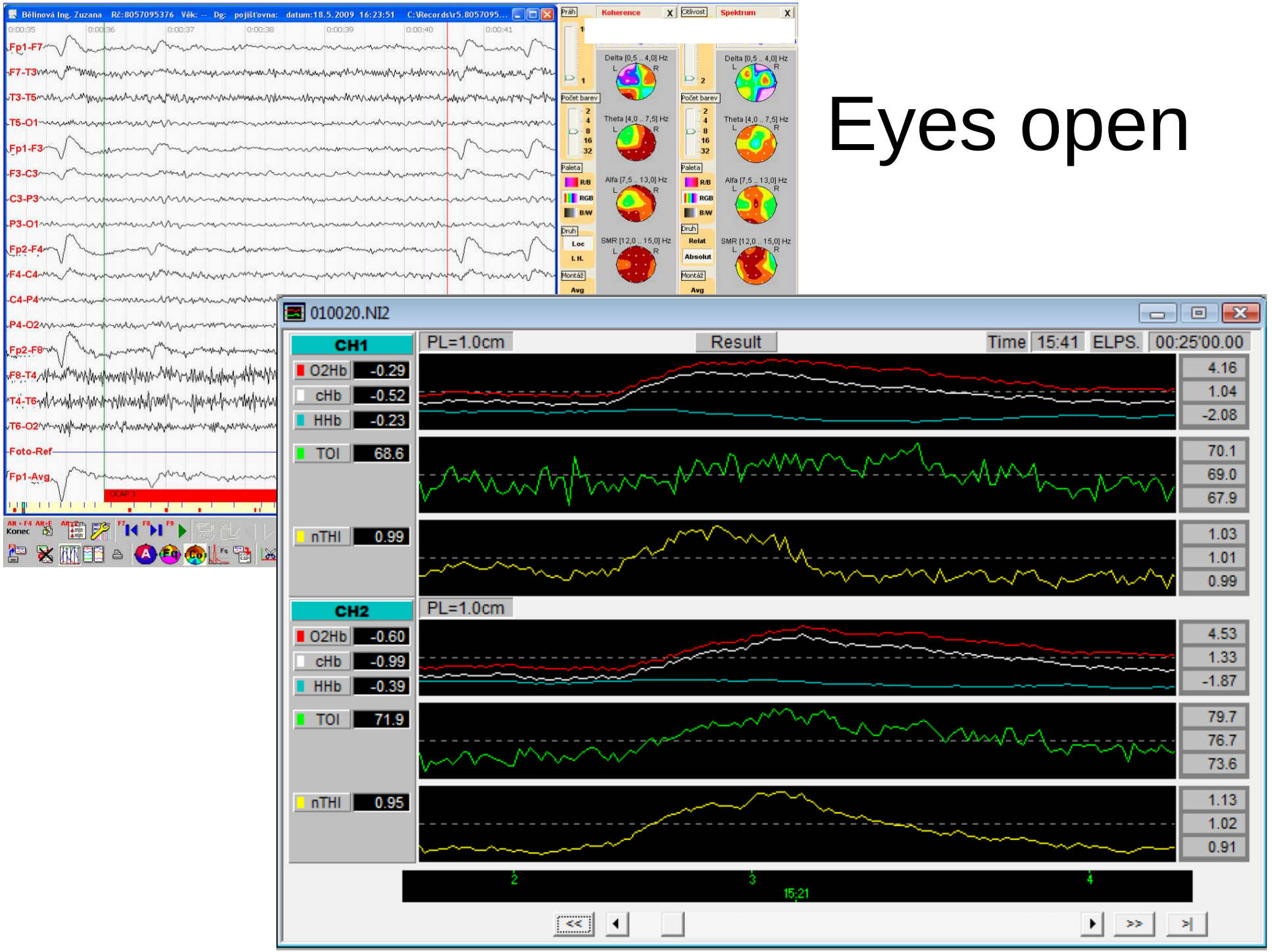




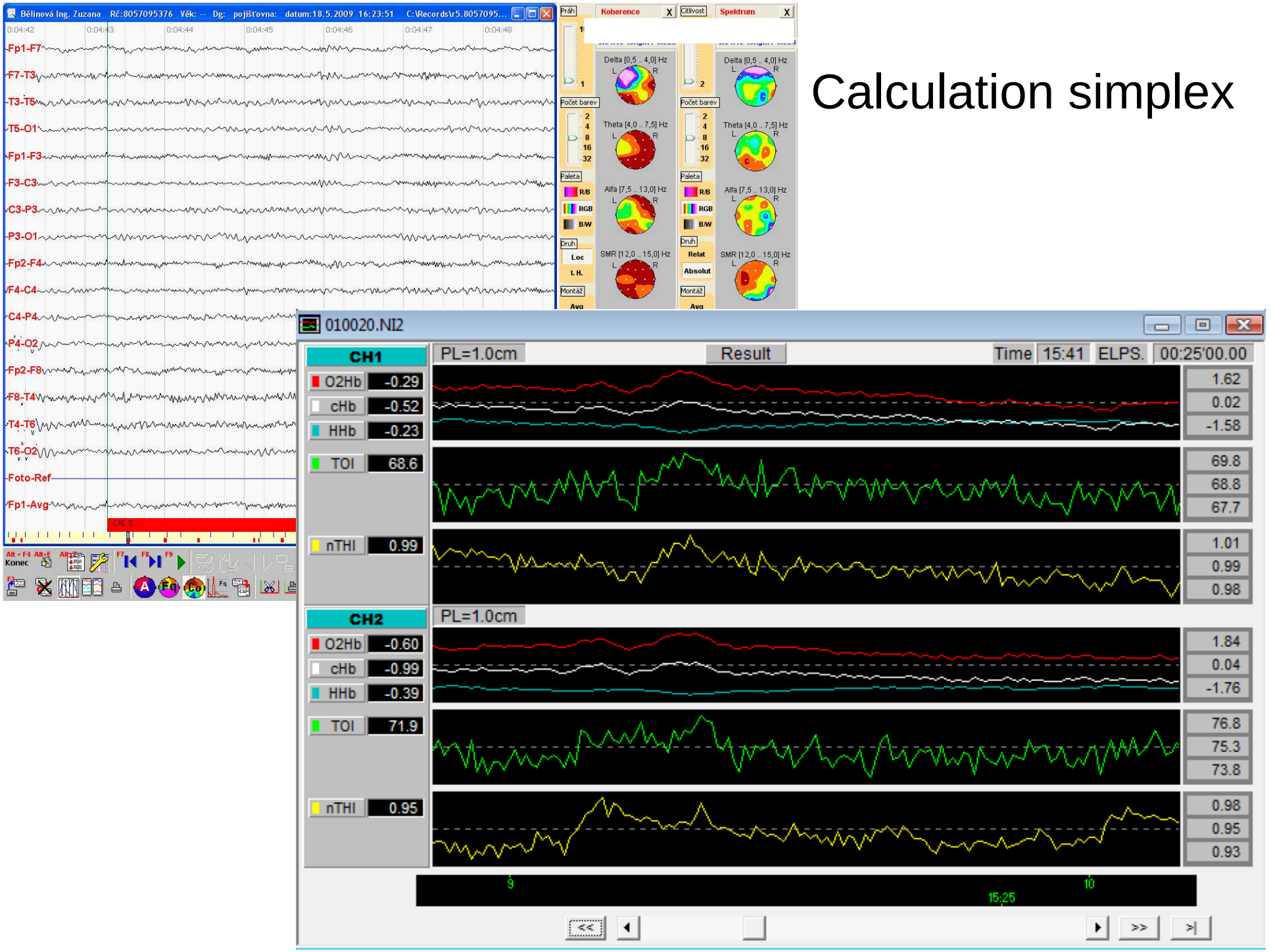
Eyes closed

1 s. EEG

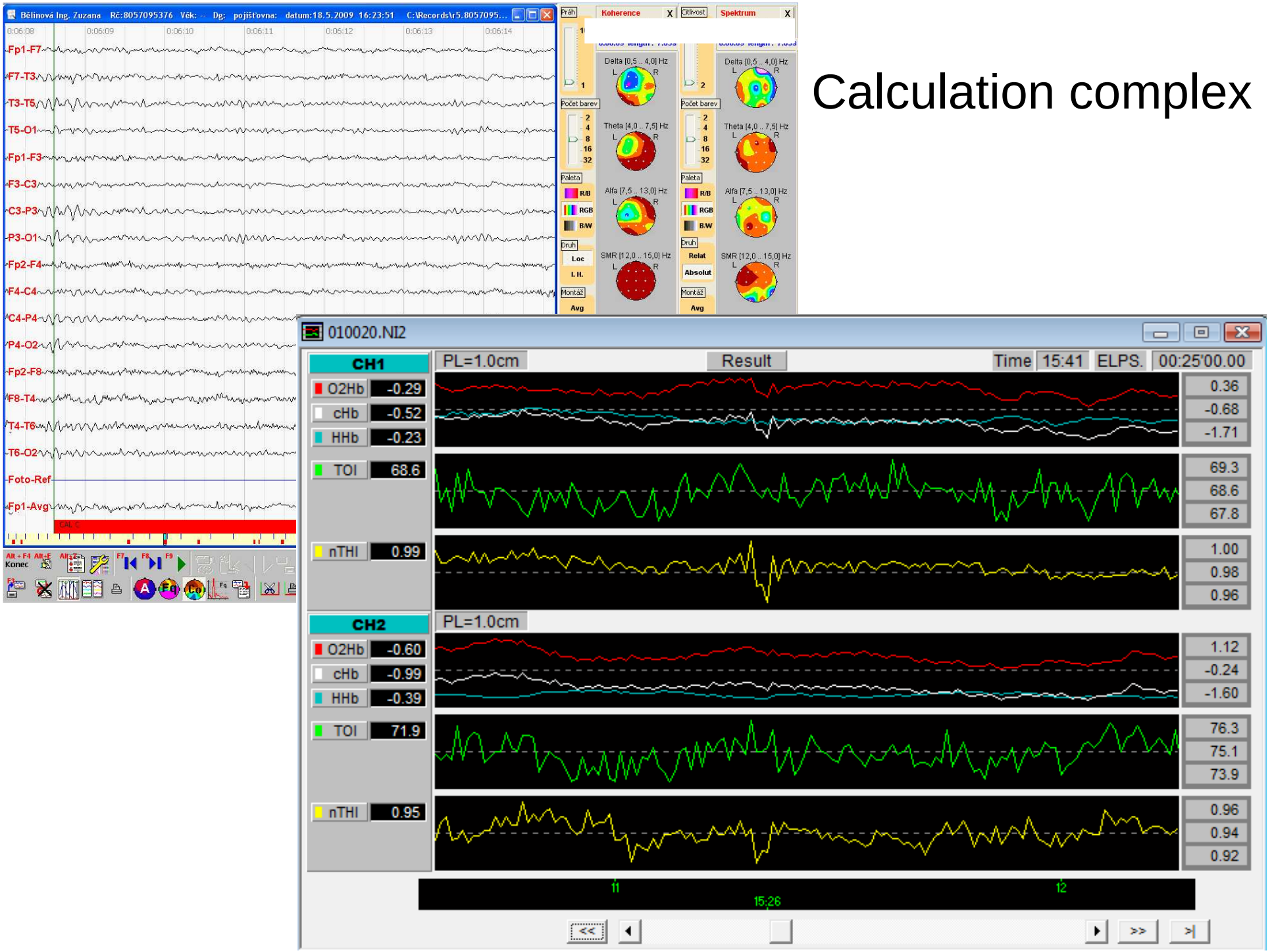
15 s. NIRS


Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
4.16
1.04
-2.08
70.1
69.0
67.9
1.03
1.01
0.99
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
4.53
1.33
-1.87
79.7
76.7
73.6
1.13
1.02
0.91
15:21

Eyes open



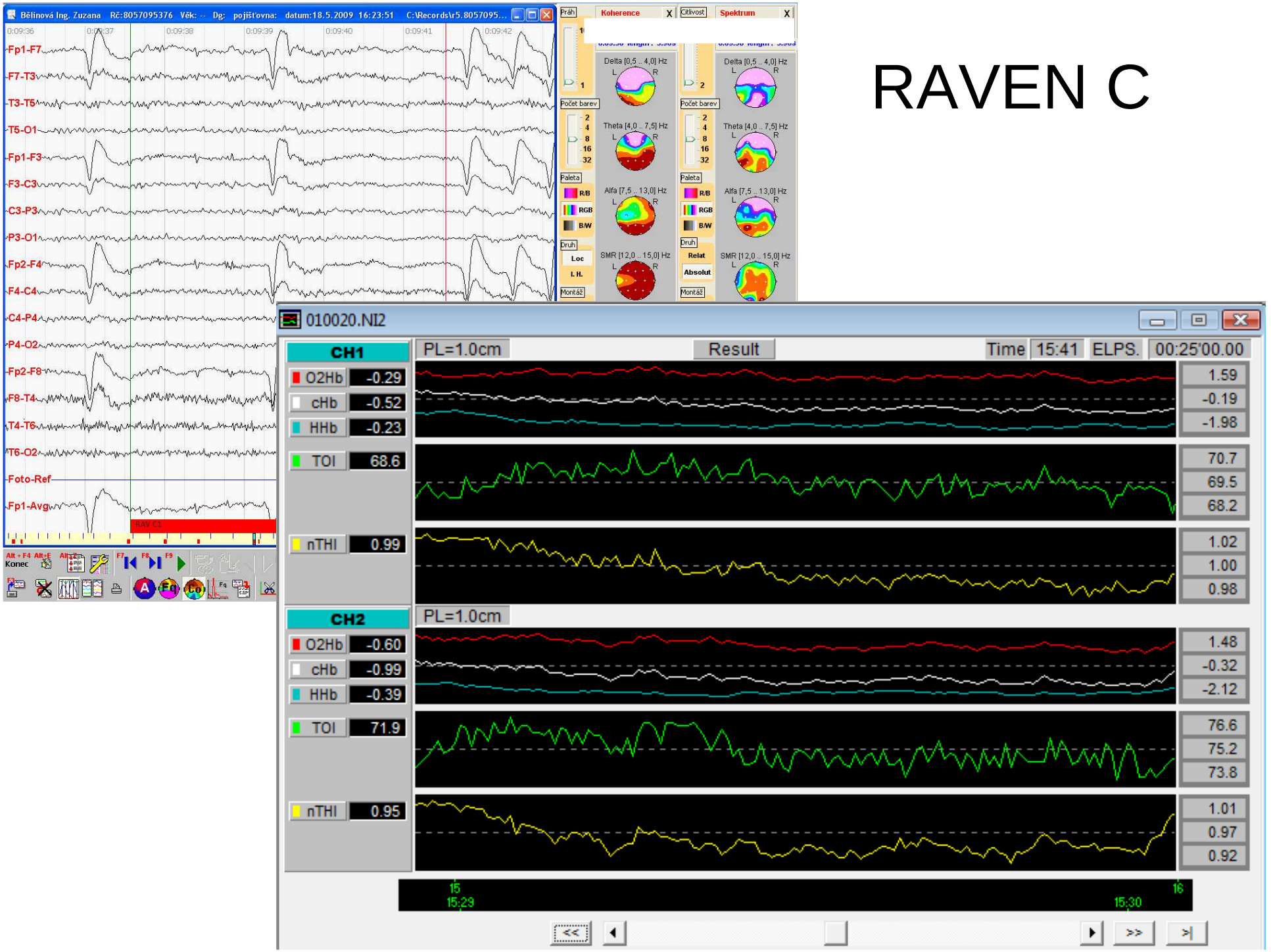
Calculation simplex



Calculation complex

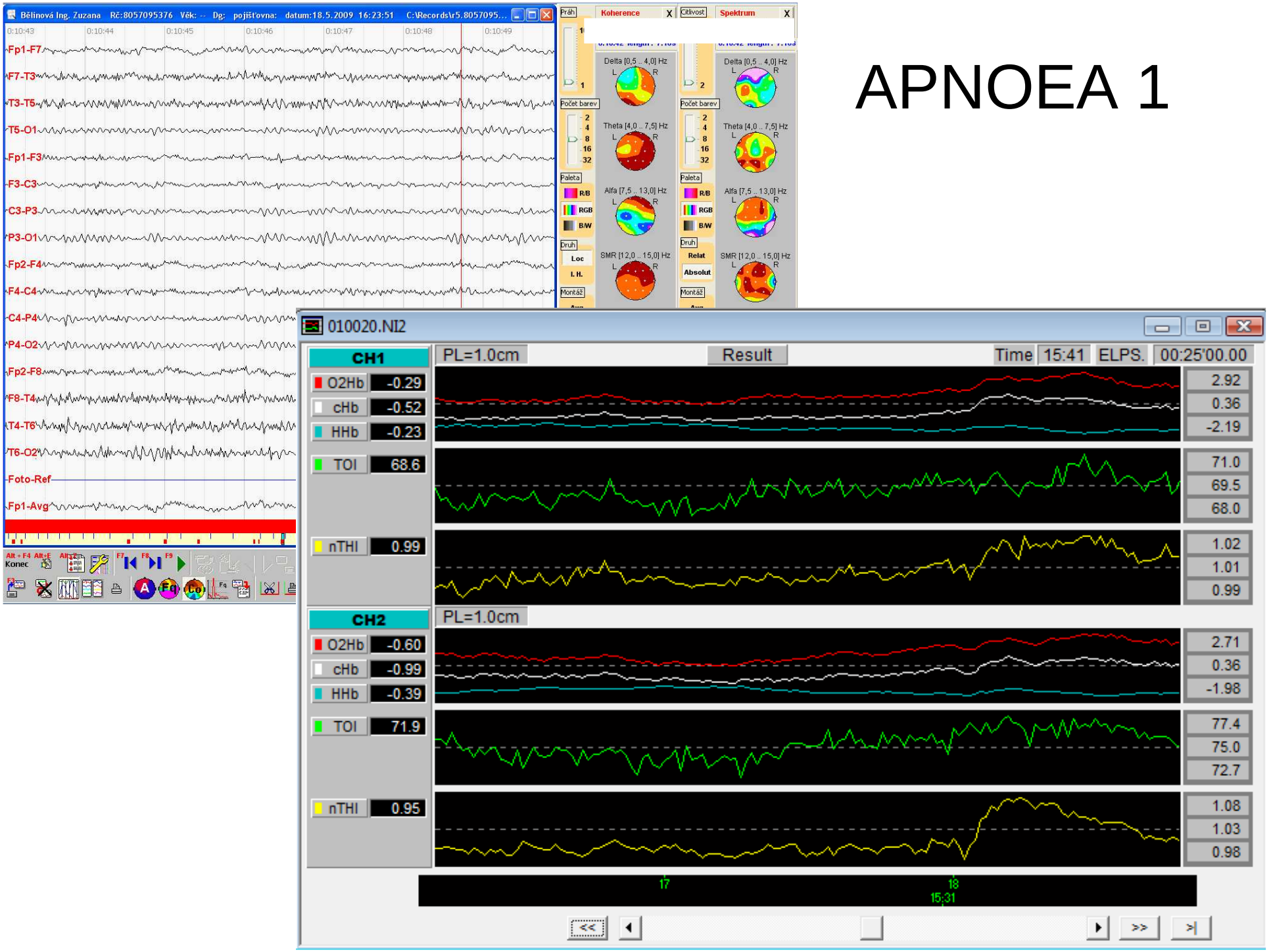
RAVEN A


Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
Počet barev
Paleta
R/B
RGB
B/W
Druh
Loc
I. H.
Relat
Absolut
Montáž
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
3.51
0.44
-2.64
71.1
69.9
68.6
1.03
1.01
1.00
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
3.45
0.68
-2.09
76.7
75.1
73.5
1.08
1.01
0.94
14
15
15:29

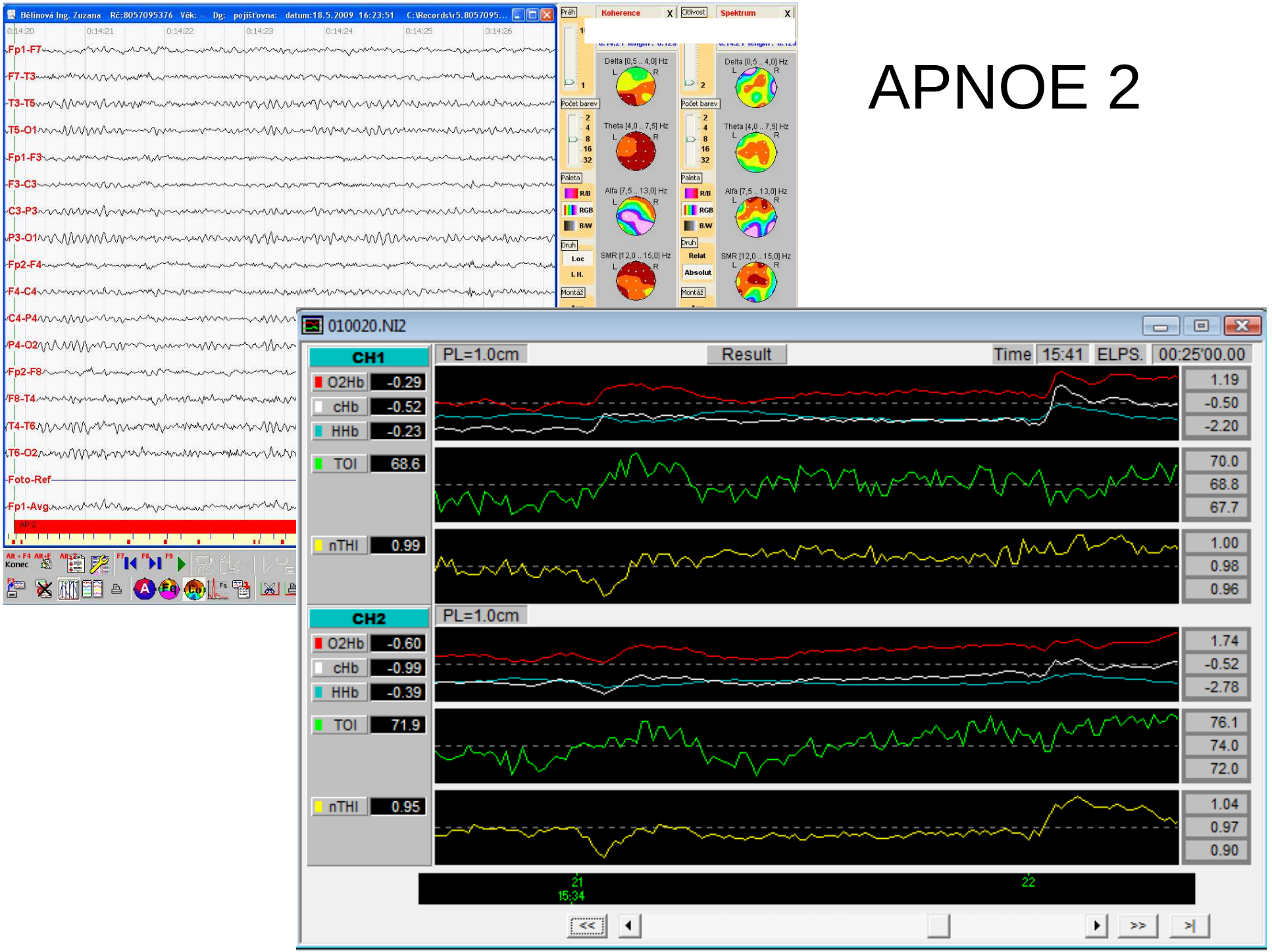

Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
Počet barev
Paleta
Druh
Loc
I. H.
Relat
Absolut
Montáž
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
1.59
-0.19
-1.98
70.7
69.5
68.2
1.02
1.00
0.98
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
1.48
-0.32
-2.12
76.6
75.2
73.8
1.01
0.97
0.92
15
15:29
16
15:30

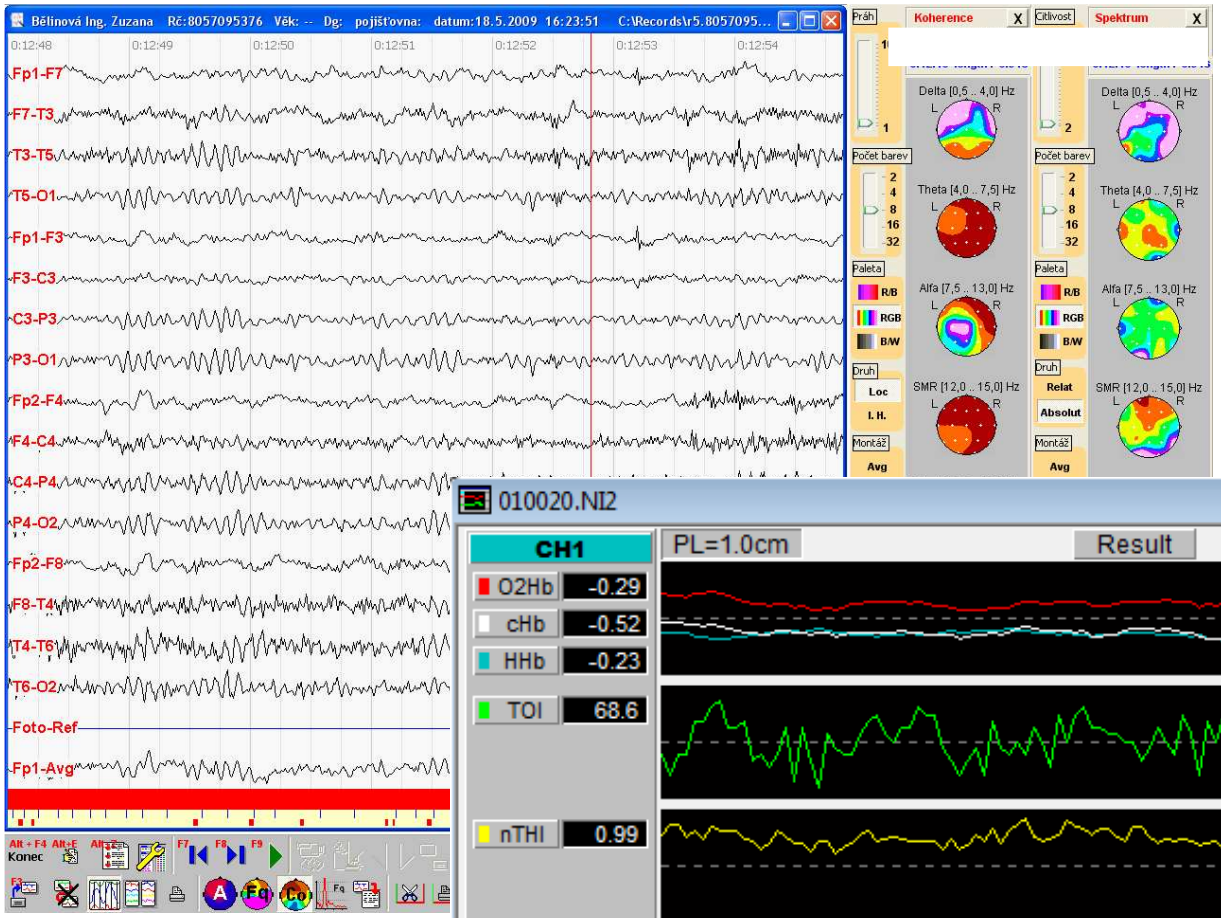
RAVEN C

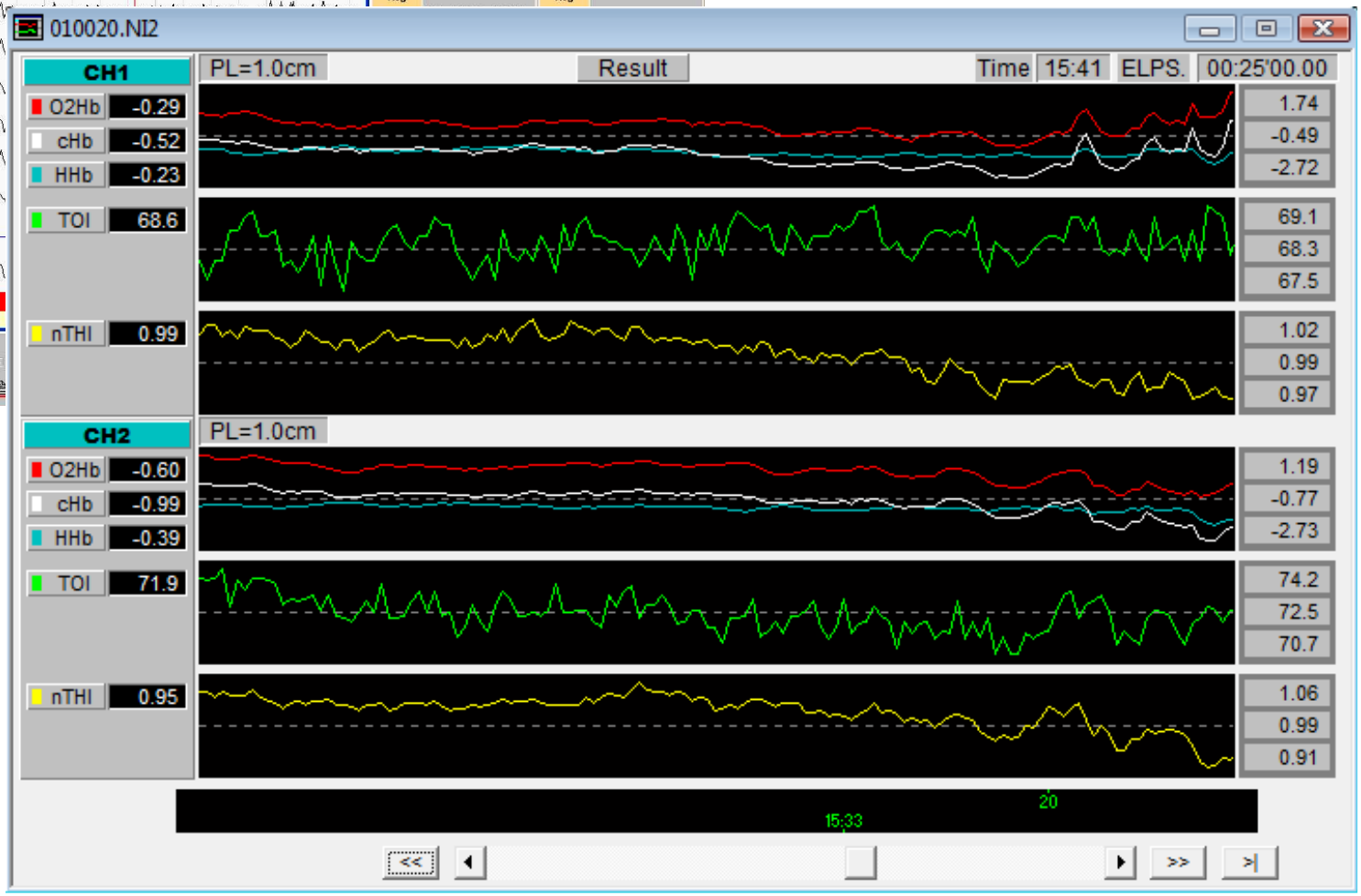
APNOEA 1


Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
2.92
0.36
-2.19
71.0
69.5
68.0
1.02
1.01
0.99
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
PL=1.0cm
2.71
0.36
-1.98
77.4
75.0
72.7
1.08
1.03
0.98
17
18
15:31

APNOE 2

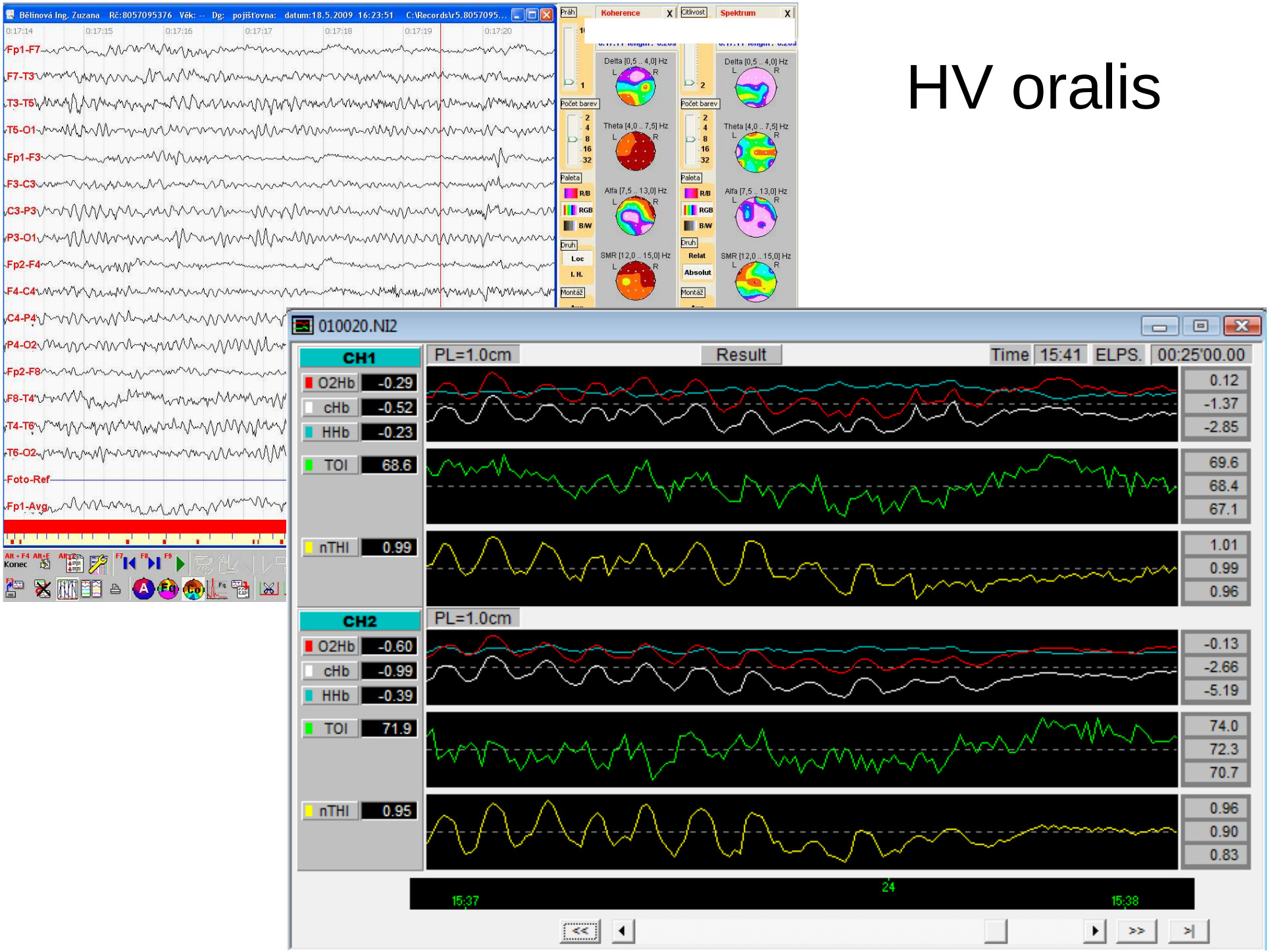

Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
1.19
-0.50
-2.20
70.0
68.8
67.7
1.00
0.98
0.96
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
1.74
-0.52
-2.78
76.1
74.0
72.0
1.04
0.97
0.90
21
15:34
22


Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
0:12:48
0:12:49
0:12:50
0:12:51
0:12:52
0:12:53
0:12:54
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Alt+F4 Konec
Práh
Koherence
Citlivost
Spektrum
Počet barev
Paleta
R/B
RGB
B/W
Druh
Loc
I. H.
Relat
Absolut
Montáž
Avg
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz


010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
1.74
-0.49
-2.72
69.1
68.3
67.5
1.02
0.99
0.97
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
PL=1.0cm
1.19
-0.77
-2.73
74.2
72.5
70.7
1.06
0.99
0.91
20
15:33
<<
>>
>|

HV nasalis

HV oralis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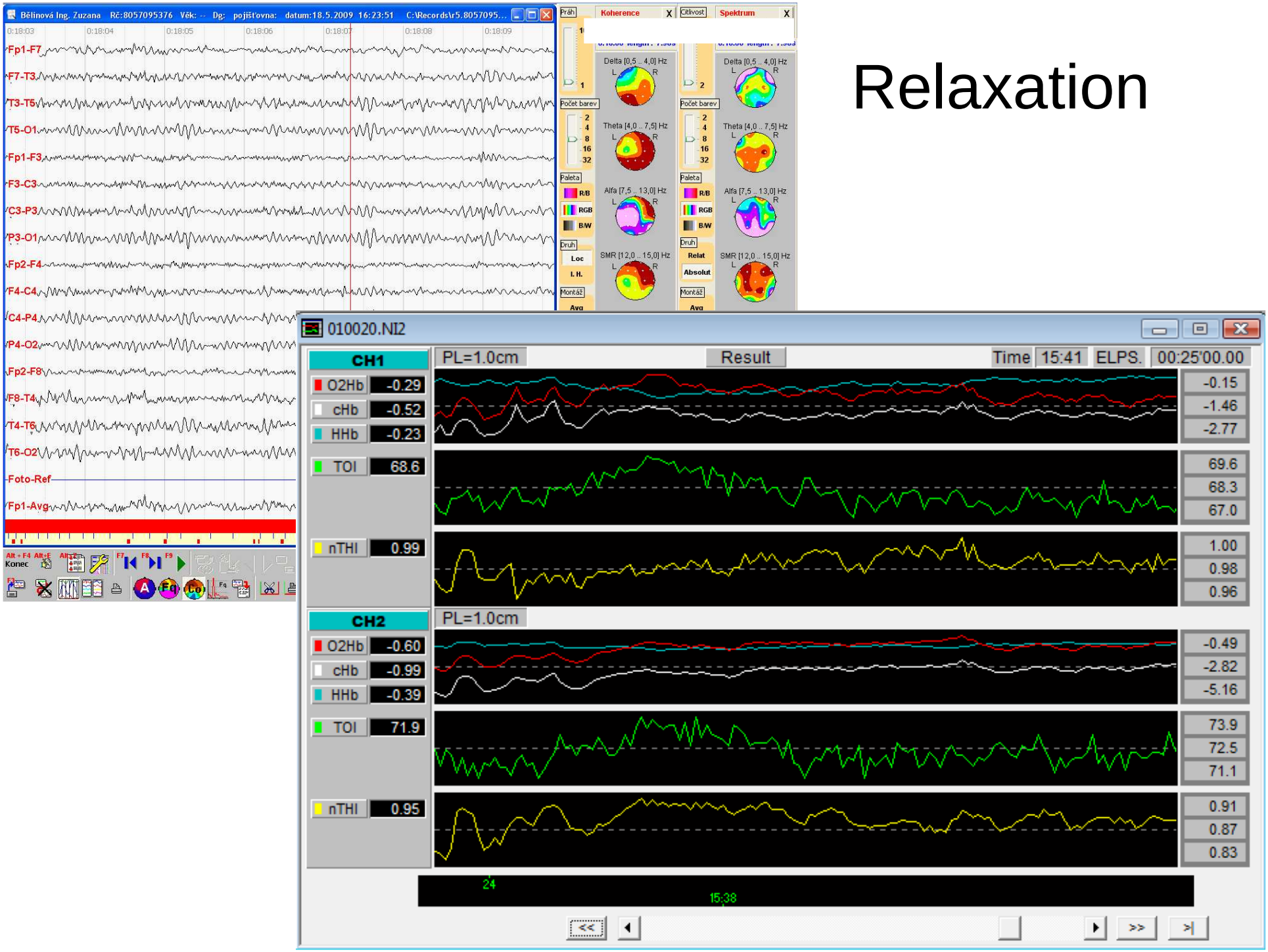
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41 ELPS. 00:25'00.00
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
15:37
24
15:38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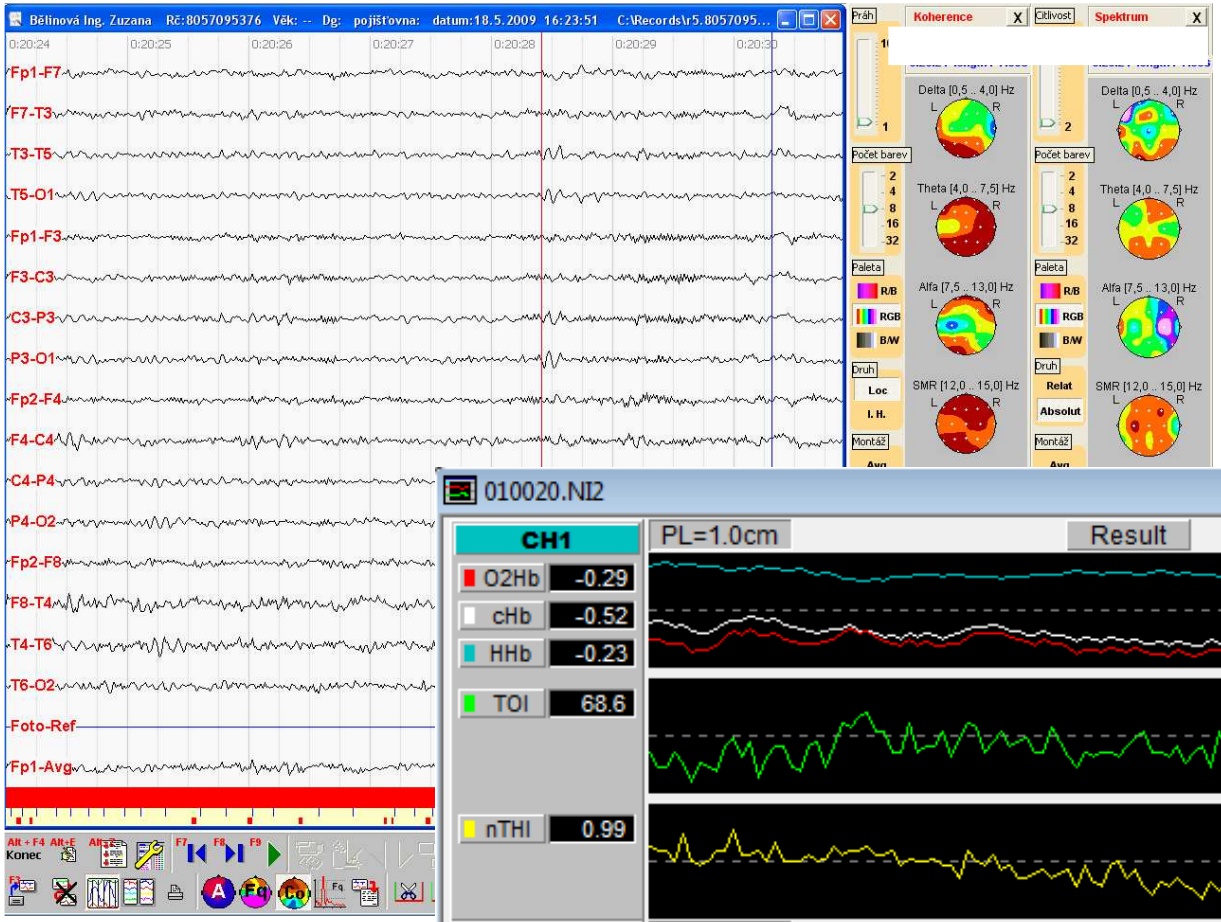
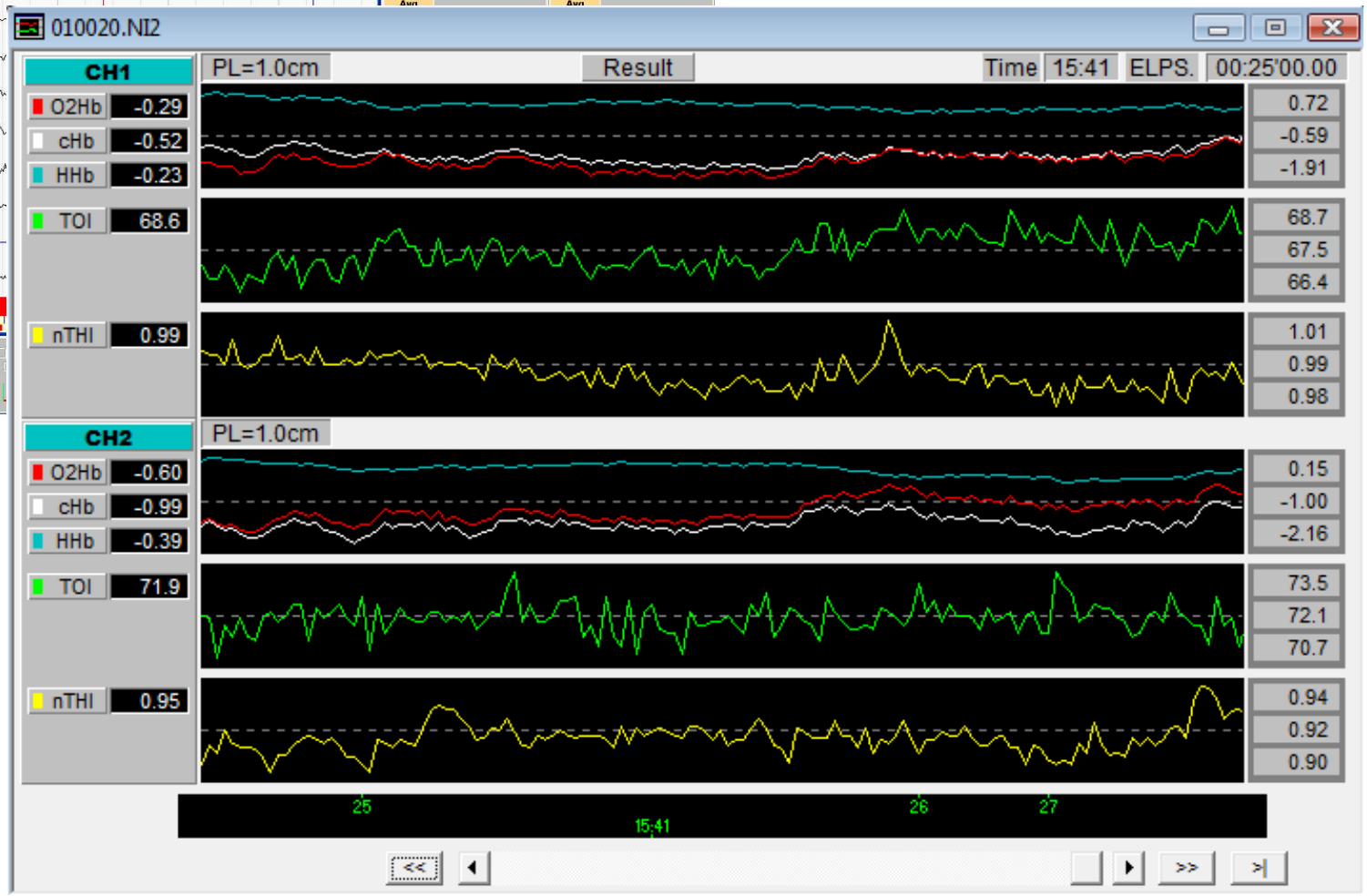
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz
Počet barev
Paleta
Druh
Montáž
010020.NI2
CH1
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
PL=1.0cm
Result
Time 15:41 ELPS. 00:25'00.00
-0.15
-1.46
-2.77
69.6
68.3
67.0
1.00
0.98
0.96
CH2
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
-0.49
-2.82
-5.16
73.9
72.5
71.1
0.91
0.87
0.83
24
15:38

Relaxation


Bělinová Ing. Zuzana Rč:8057095376 Věk: -- Dg: pojišťovna: datum:18.5.2009 16:23:51 C:\Records\r5.8057095...
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Foto-Ref
Fp1-Avg
Koherence
Citlivost
Spektrum
Delta [0,5 .. 4,0] Hz
Theta [4,0 .. 7,5] Hz
Alfa [7,5 .. 13,0] Hz
SMR [12,0 .. 15,0] Hz

Somnolence


010020.NI2
CH1
PL=1.0cm
Result
Time 15:41
ELPS. 00:25'00.00
O2Hb -0.29
cHb -0.52
HHb -0.23
TOI 68.6
nTHI 0.99
0.72
-0.59
-1.91
68.7
67.5
66.4
1.01
0.99
0.98
CH2
PL=1.0cm
O2Hb -0.60
cHb -0.99
HHb -0.39
TOI 71.9
nTHI 0.95
0.15
-1.00
-2.16
73.5
72.1
70.7
0.94
0.92
0.90
25
26
27
15:41

Physiolog. & Psycholog. states FIG.:		EEG & QEEG		NIRS				
		alpha frequency band	delta frequency band	O2Hb	CO2Hb	satura-tion	perfus-ion	symetry, left / right, prevalence left / right
Ey.cl.	3	increases	medial	med.	med.	med.	med.	symmetry
Ey.op.	4	decreases	incr./decr.	incr.	decr.	incr.	incr.	symmetry
Cal.sim.	5	faster	medial	med.	med.	med.	med.	symmetry
Cal.com	.6	faster	increases	incr.	med.	med.	decr?	symmetry
RAV.A	7	decreases	increases	incr.	decr.	incr.	incr.	symmetry
RAV.C	8	decreases	increases	incr.	decr.	incr.	incr.	symmetry
APN1	9	increases	medial	decr.	incr.	incr.	incr.	symmetry
APN2	10	increases	medial	incr.	incr.	decr.	decr.	asymmetry
HVN	11	increases	medial	decr.	med.	decr.	incr.	right
HVO.F.	12	increases	increases	decr.	incr.	decr.	decr.	right
Relax.	13	increases	decreases	decr.	incr.	decr.	decr.	asymmetry
Somnol.	14	increases	decreases	decr.	incr.	decr.	decr.	symmetry?

Conclusion

Electric and metabolic brain activities were controled in 23 persons by help of electroencephalography (EEG) and near infrared spectroscopy (NIRS) during different physiological and psychological states:

eyes open or closed, hyperpnoea (HV) or apnoea (AP) and during calculation [addition of one- (CAL.S.) or two-digit numbers (CAL C.)] or Raven test solution, set A (RAV A) or more difficult set C (RAV C). Both diagnostic methods confirm one another.

But sometimes are present more expresive changes in one methods than in another. E.g. during HV is more prominent deoxyhemoglobin (CO2Hb) increasing in NIRS than alpha frequency band increasing in EEG curves.

On the other side very marked alpha frequency band decreasing in EEG during eyes open is folowed by only weak oxyhemoglobin (O2Hb) increasing.

Synchronous activities are good visible during psychic test: increasing O2Hb in NIRS and increasing delta frequency band in EEG.

Decreasing alpha with increasing theta activity during relaxation and somnolence is accompanied by decreasing O2Hb and prominent increasing CO2Hb.

Interindividualy differences are often but not big. We suggest both methods are good tools for attention and psychic states control.

Thank you for your attention