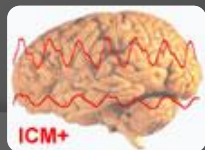




ICM+

Past, Present and Future

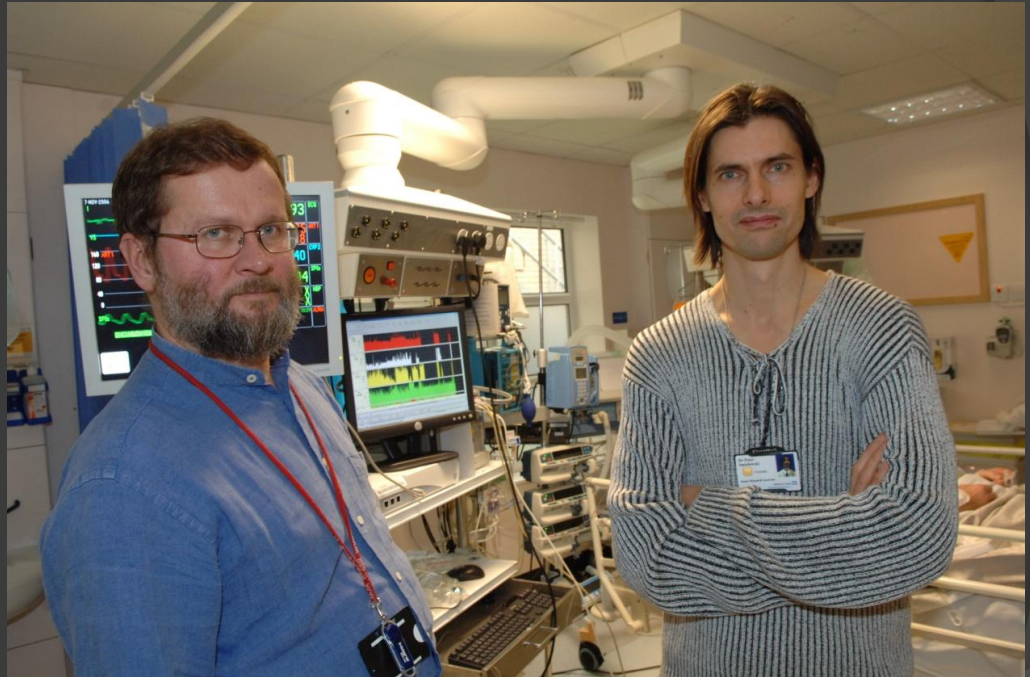


Dr Peter Smielewski
 Dept of Clinical Neurosciences
 University of Cambridge



Disclosure

ICM+ software is licensed by Cambridge Enterprise Ltd, subsidiary of University of Cambridge, UK.

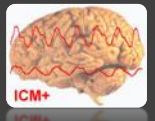


Gentlemen pictured above (Dr M. Czosnyka, left, and Dr P. Smielewski, right) have financial interest in part of the licensing fee for the ICM+ software

ICM+ TALK OUTLINE

- ◎ Brief history of almost everything (related to ICM+)
- ◎ Principles of ICM+
- ◎ New developments
- ◎ Where do we go from here ?

ICM+ Timeline



1980

1990

2000

2010

1982

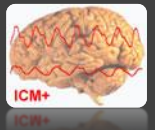
Warsaw University of Technology

University of Cambridge

First ICP Analyser – Sinclair ZX Spectrum !



ICM+ Timeline



1980

1990

2000

2010

1985

warsaw University of Technology

University of Cambridge

ICP Analyser for DOS

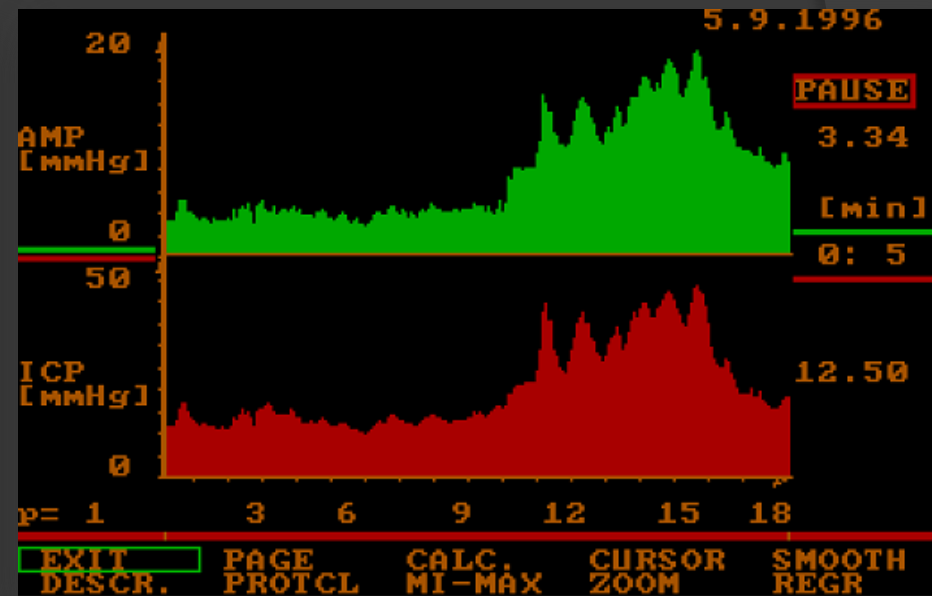
ICP ANALYZER FOR INTENSIVE CARE v2.2

(ICP, CPP, TEMP, PaCO₂ & CSF DRAINAGE)

Warsaw University of Technology & Child's Health Centre
(M. Czosnyka, M. Duda, P. Wollk-Laniewski, W. Zaworski, L. Batorski; 1989)

MAIN MENU: (press a number key)

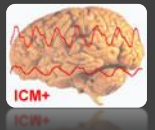
1. Calibration
2. Patient's description
3. Monitoring
4. On-line analysis
5. End of on-line analysis
6. Off-line analysis
7. Drainage & system profile
8. Quit



ICP via Analogue output



ICM+ Timeline



1980

1990

2000

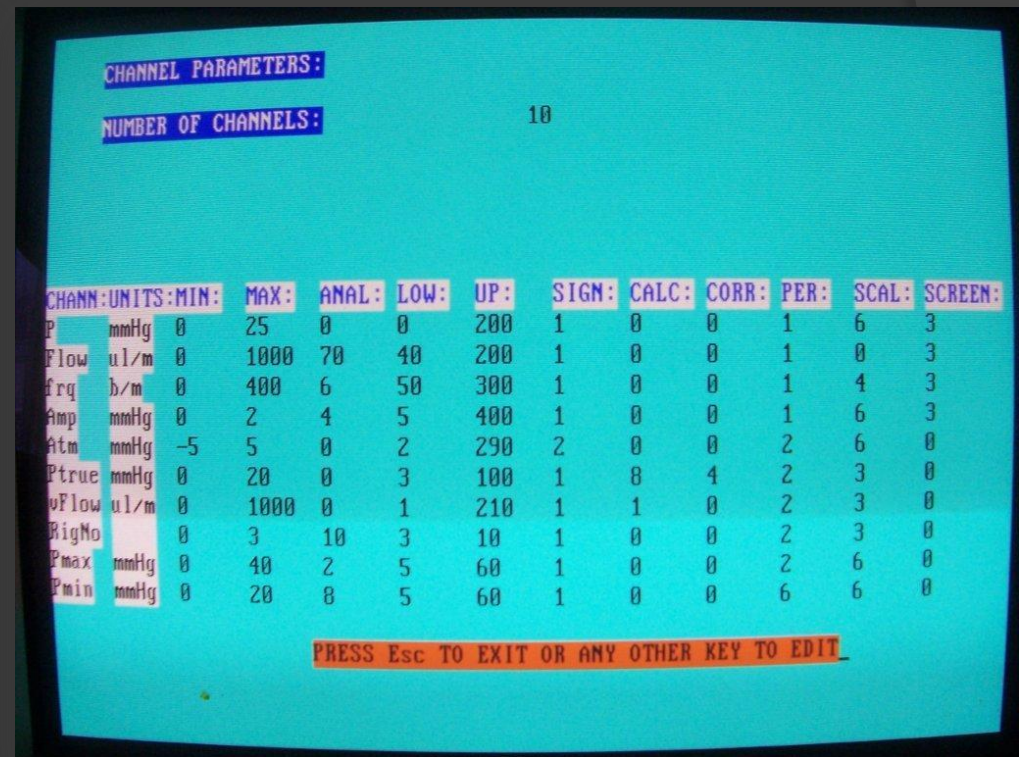
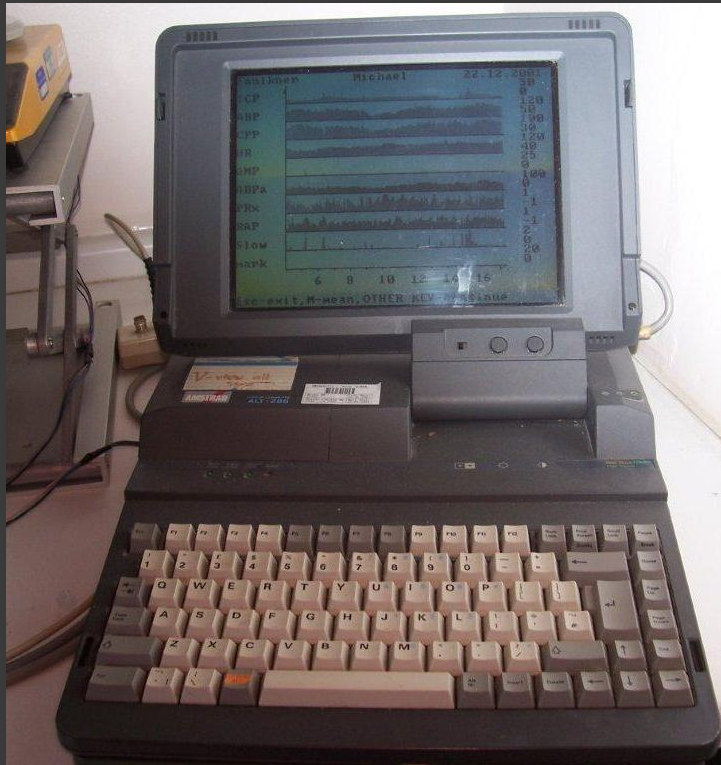
2010

1991

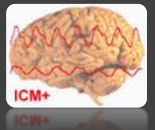
Warsaw University of Technology

University of Cambridge

Intensive Care Monitor - ICM



ICM+ Timeline



1980

1990

2000

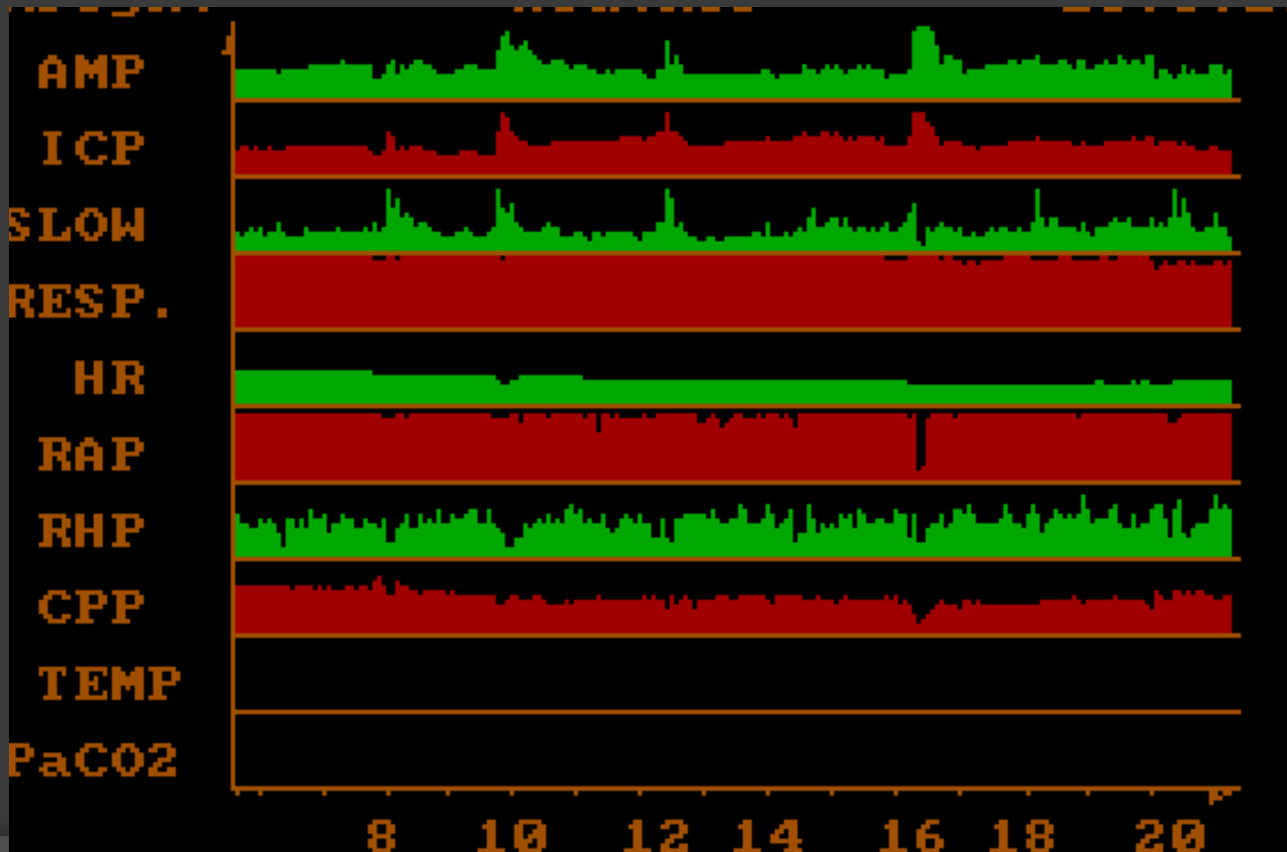
2010

1991

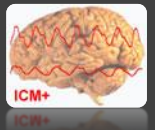
Warsaw University of Technology

University of Cambridge

ICM trends examples



ICM+ Timeline



1980

1990

2000

2010

1992

Warsaw University of Technology

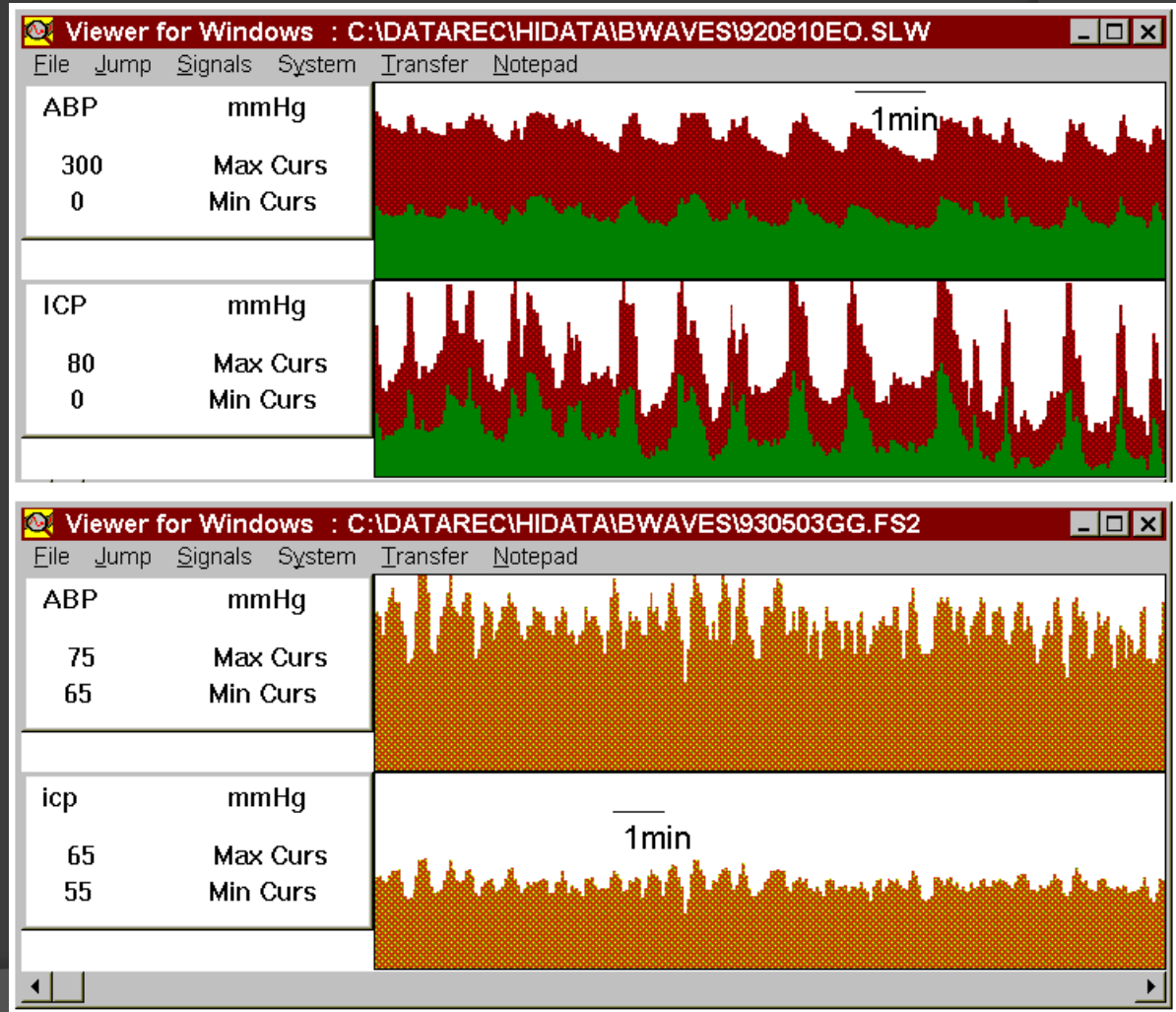
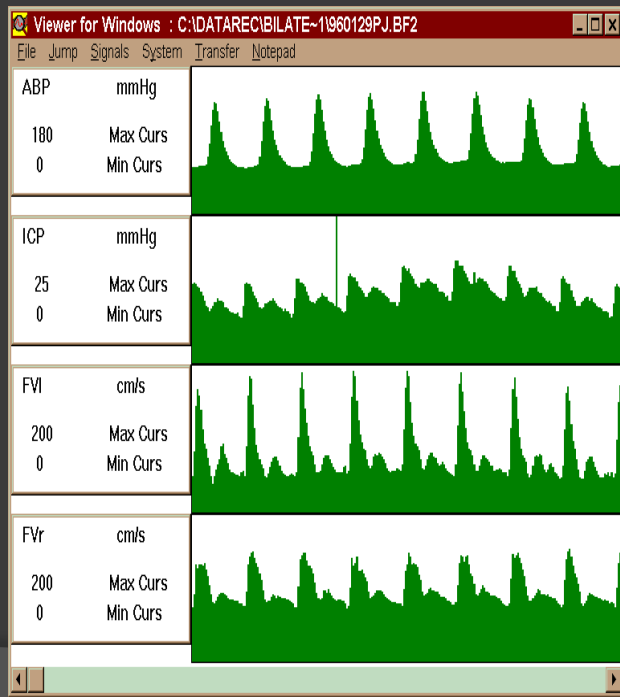
University of Cambridge

WREC

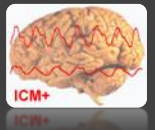
Windows Recorder

W. Zabolotny,

Warsaw University of Technology



ICM+ Timeline



1980

1990

2000

2010

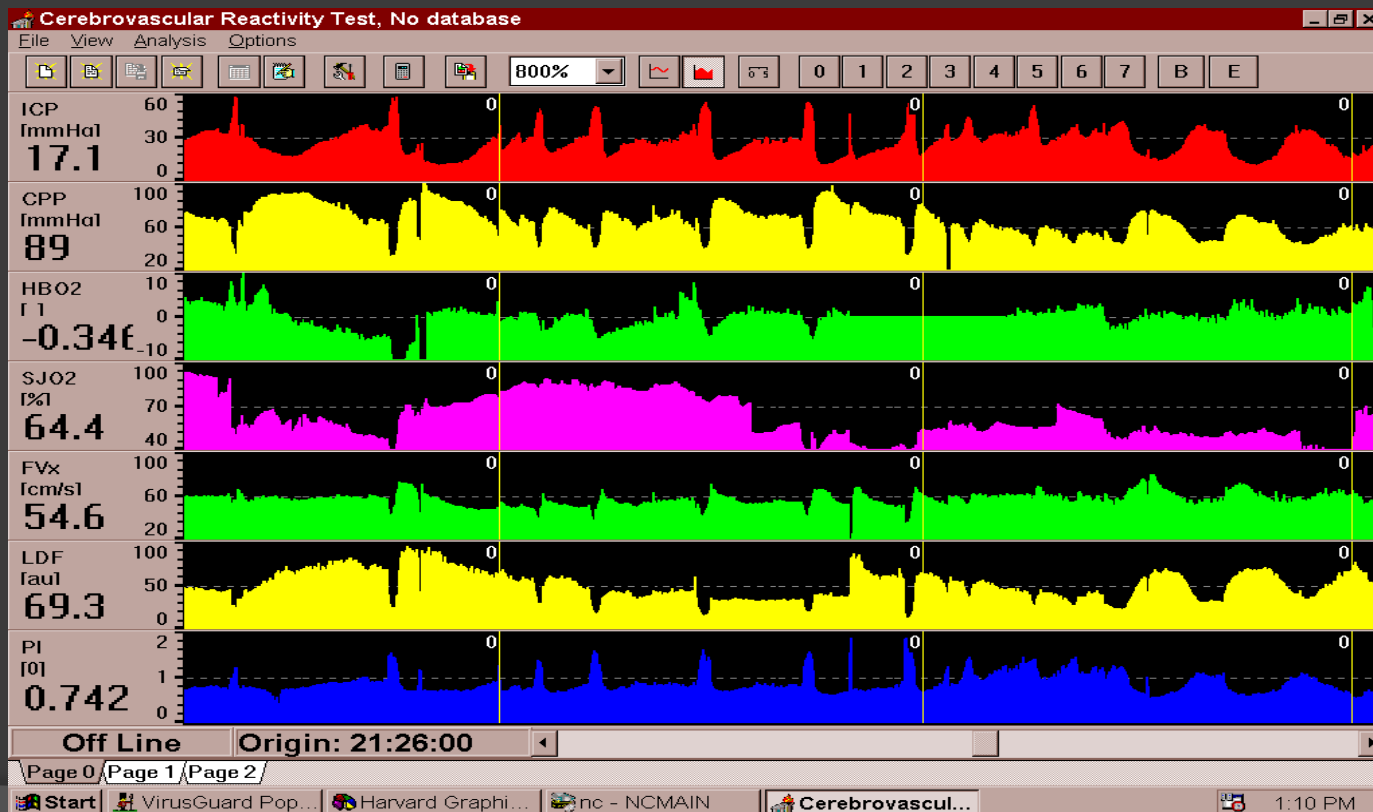
1995

Warsaw University of Technology

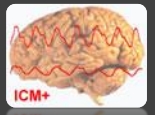
University of Cambridge

Biological Signals Analyser

Software for real time analysis of cerebrovascular reactivity tests



ICM+ Timeline



1980

1990

2000

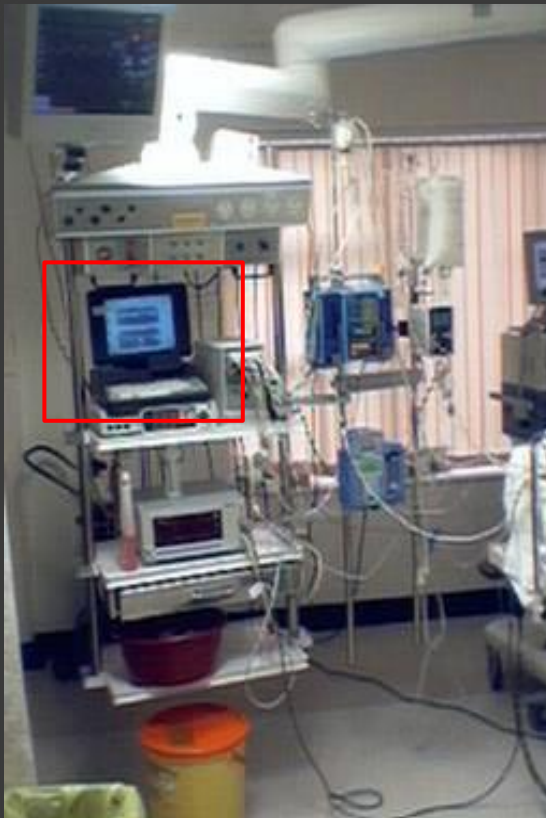
2010

2002

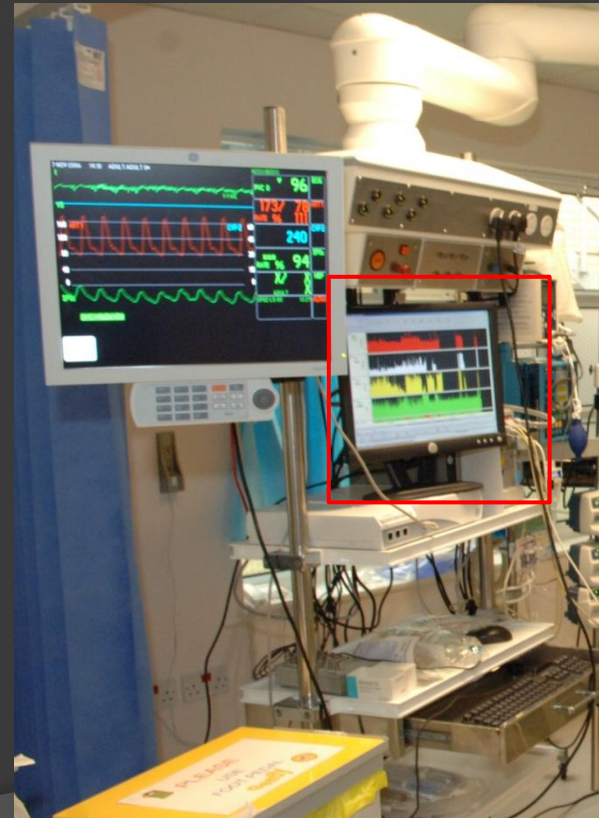
Warsaw University of Technology

University of Cambridge

ICM+ replaces ICM in the NCCU

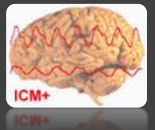


ICM



ICM+

ICM+ Timeline



1980

1990

2000

2010

2004

Warsaw University of Technology

University of Cambridge

Cambridge Enterprise (wholly own subsidiary of Cambridge University)

takes over IP rights to ICM+ and starts offering its licenses to other clinical research centres



cambridge enterprise
commercialising University science



Commercialising University Science

Cambridge Enterprise exists to help University of Cambridge inventors, innovators and entrepreneurs make their ideas and concepts more commercially successful for the benefit of society, UK economy, the inventors and the University.

Inventions, IP & Licensing

One of the ways Cambridge Enterprise works to make sure that important inventions made at the University reach the public is by working with University inventors to license patentable ideas to new and existing companies at fair and reasonable terms.

For Industry

Cambridge Enterprise strives to be a good partner with industry in acting as a business agent for academics...

University Community

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Consultancy services for University of Cambridge staff and research groups wishing to provide expert advice or...

Cambridge Enterprise Seed Funds

Cambridge Enterprise uses its seed funds to encourage commercialisation of University inventions by investing...

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University of Cambridge
Discovery Fund

Latest News

Astex announces start of Phase II clinical trials of AT7519 in Multiple Myeloma

Horizon joins personalised medicine consortium

CamSemi secures 10 major designs for C2160 controller family

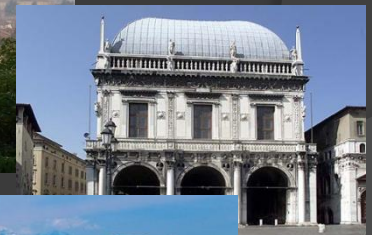
Enval Limited: value from waste

Success Stories

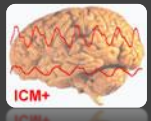
Cambridge Enterprise portfolio company Enval Limited has developed a patented process which offers a genuine recycling route for flexible laminate packaging, a process which is economically and environmentally viable and diverts waste from landfill.
[read more](#)

First ICM+ Installation: University Clinique, Brescia, Italy

Prof. N. Latronico, Dr F. Rasulo



ICM+ Timeline



1980

1990

2000

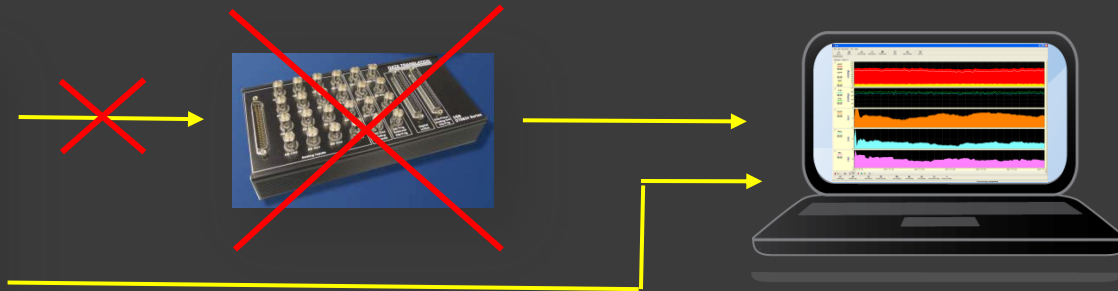
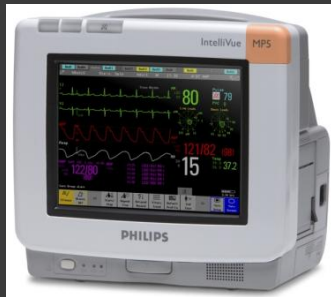
2005

2010

Warsaw University of Technology

University of Cambridge

First Digital Interface: Phillips monitors



Department of Neurology,
Medical Centre Haaglanden,
The Hague, Netherland

Joseph T Tans

EXTENDED POLL DATA REQUEST

The next example shows a message which could be used to access averaged data. The message will only be accepted if the optional package for Poll Profile Extensions has been negotiated during the association phase.

```

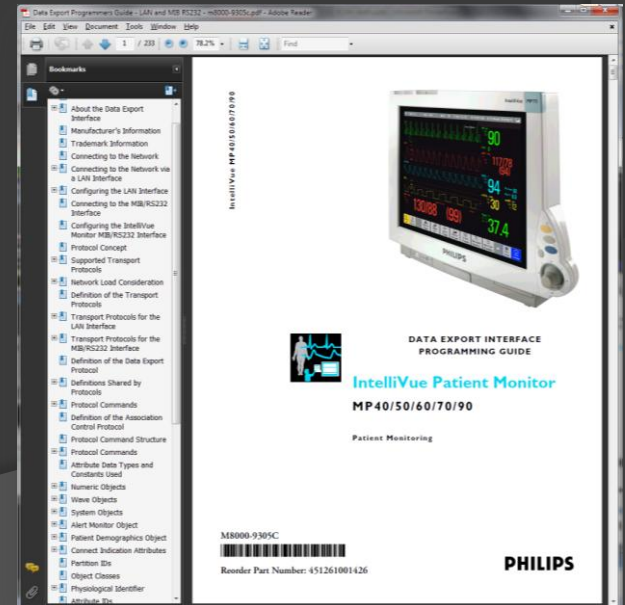
SPpdu      session_id      : 0xE100
           P_context_id    : 2
ROapdus    [0x01 0x00 0x00 0x02]
           ro_type         : ROIV_APDU
           length          : 32
ROIVapdus  invoke_id      : 0
           command_type    : CMD_CONFIRMED_ACTION
           length          : 26
           {0x00 0x01 0x00 0x07 0x00 0x1a}
ActionArgument
ManagedObjectId
  u_obj_class      : NCM_MOC_VMS_MDS
  context_id      : 0
  handle          : 0
  scope           : 0
  u_32            : 0
  QIDType         : NCM_ACT_POLL_MDIB_DATA_EXT
  u_16            : 12
  length          : 12
  {0x00 0x21 0x00 0x00 0x00 0x00 0x00 0x00
  0x00 0x00 0x01 0x0b 0x00 0x0c}
PollMdbDataReqBxt
  u_16            : 1
  TYPE           : partition
  code           : NCM_PART_CBJ
  AttributeList
  u_16            : 0
  u_16            : 0
  length          : 0
  {0x00 0x01 0x00 0x01 0x00 0x06 0x00 0x00
  0x00 0x00 0x00 0x00}
    
```

EXTENDED POLL DATA RESULT

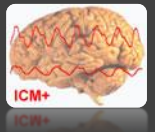
The Extended Poll Data Result message contains an additional *sequence_no*, which is used if the client requests periodic replies.

```

SPpdu      session_id      : 0xE100
           P_context_id    : 2
           [0x01 0x00 0x00 0x02]
    
```



ICM+ Timeline



1980

1990

2000

2010

2008

Warsaw University of Technology

University of Cambridge

ICM+ Portal



UNIVERSITY OF CAMBRIDGE
Neurosurgery Unit

School of Clinical Medicine > Department of Clinical Neurosciences > Neurosurgery Unit > ICM+

ICM+
Brain monitoring for neurosurgery and intensive care

- About ICM+
- Features
- Applications
- ICP Plugin
- References
- Getting started
- Ordering
- User Area

User Area
Hello **smielewski.p!**
ICM+ Main Program (version 6.4, released 2009-10-05)

Available monitor modules:

- Data Translation A/D Converter for version 6.4, released 2009-03-16
- National Instrument A/D Converter for version 6.4, released 2009-03-16
- Spiegelberg monitor for version 6.4, released 2009-03-16
- IntelliVue monitor for version 6.4, released 2009-03-16
- Data-Chimeda monitor for version 6.4, released 2009-03-16
- Raumedic Datalogger for version 6.4, released 2009-03-16

Archive
Forum

Documentation:

- ICM+ Getting Started Manual
- ICM+ Data Analysis Configuration Guide
- ICM+ Installation instructions

See [Articles and Publications](#) on our Forum. Please contact Administrator if you cannot access this site.

Submit a [Bug Report](#). Please contact Administrator if you cannot access this site.

In case of any trouble, please feel free to contact Dr Peter Smielewski (Administrator)

[Boxes](#) - share files with other ICM+ Users.

[Log Out](#)

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Website maintained by Dr Peter Smielewski

ICM+, Neurosurgery Unit, University of Cambridge
Forum on ICM+ brain monitoring

School of Clinical Medicine > Department of Clinical Neurosciences > Neurosurgery Unit > ICM+ User Area

[Board index](#)

[User Control Panel](#) (0 new messages) • [View your posts](#)

[FAQ](#) [Members](#) [Logout](#) [[smielewski.p](#)]

It is currently Thu Aug 19, 2010 10:45 am
[[Moderator Control Panel](#)]

Last visit was: Wed Jul 21, 2010 1:17 pm

[View unanswered posts](#) • [View new posts](#) • [View active topics](#) [Mark forums read](#)

FORUM	TOPICS	POSTS	LAST POST
Public Discussions General discussions	0	0	No posts

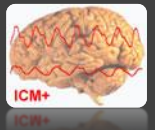
RESTRICTED AREA	TOPICS	POSTS	LAST POST
ICM+ General Forum Forum on ICM+ brain monitoring software related issues	1	2	by wolf.s on Sat May 16, 2009 11:37 am
ICM+ Related Articles & Publications Relevant documentation.	5	5	by smielewski.p on Fri Mar 05, 2010 2:11 pm
ICM+ Bugs Reports If you found one, please let us know.	0	0	No posts
ICM+ Wishes & Requests Express your ideas about ICM+.	0	0	No posts
ICM+ Related Research Areas/Projects Use this forum to discuss various ICM+ applications and research areas	1	1	by czesnyka.m on Wed Jan 14, 2009 11:46 am
ICM+ User's Meeting Tuebingen 2010 This is a forum to be used by the contributors of the ICM+ satellite meeting of the ICP 2010 conference in Tuebingen	0	0	No posts

WHO IS ONLINE
In total there is **1** user online :: 1 registered, 0 hidden and 0 guests (based on users active over the past 5 minutes)
Most users ever online was **4** on Fri Sep 19, 2008 11:21 am

Registered users: [smielewski.p](#)
Legend: [Administrators](#), [Global moderators](#)

STATISTICS
Total posts **8** • Total topics **7** • Total members **66** • Our newest member [widman.r](#)

ICM+ Timeline



1980

1990

2000

2010

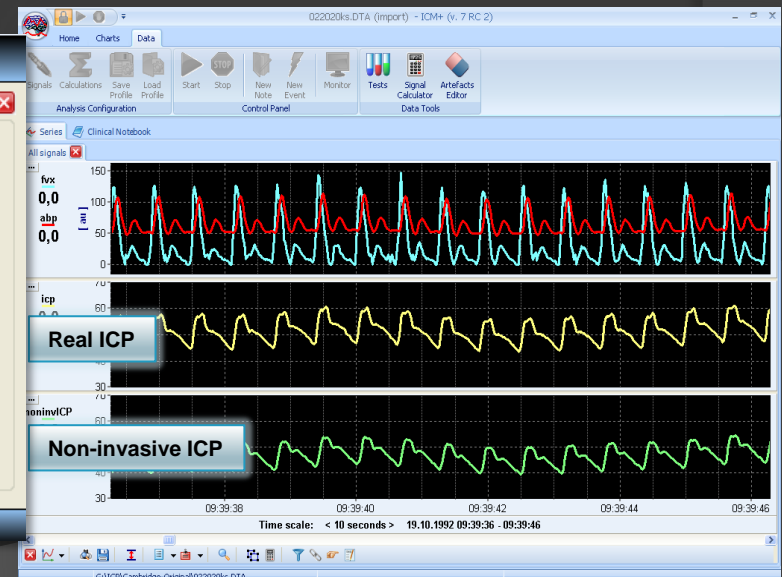
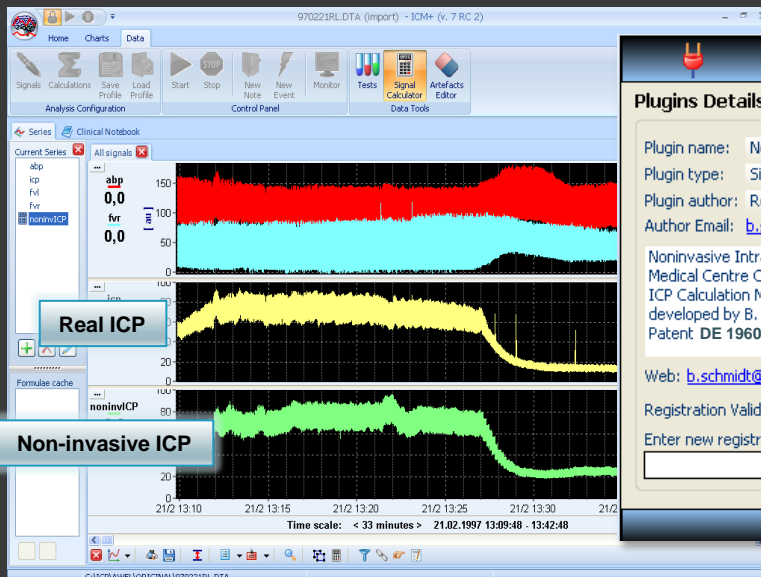
2009

Warsaw University of Technology

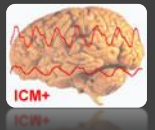
University of Cambridge

The plug-in interface

The first plugin – Non-invasive ICP
by B Schmidt and R Plontke, Chemnitz, Germany



ICM+ Timeline



1980

1990

2000

2010

2010

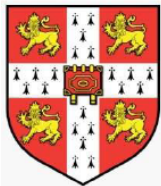
Warsaw University of Technology

University of Cambridge

First ICM+ users' group meeting

14th International Conference on
Intracranial Pressure and Brain Monitoring

12. - 16. 9. 2010
Tübingen/Germany



ICM+ users' club meeting

Department of Clinical Neuroscience,
Academic Neurosurgical Unit,
Addenbrooke's Hospital, Cambridge University, United Kingdom



Sunday, September 12th; 11:00-14.00

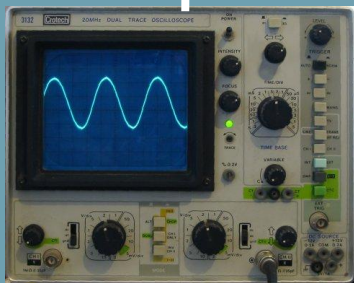
ICM+ Principles

Data collection interfaces

Analogue



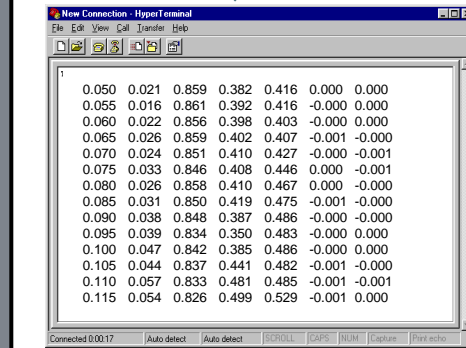
Coax cable



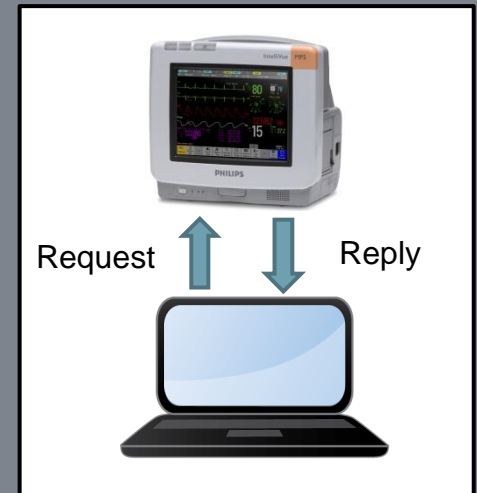
Digital (Serial Interface)



Ascii continuous export



Client/server model Proprietary language



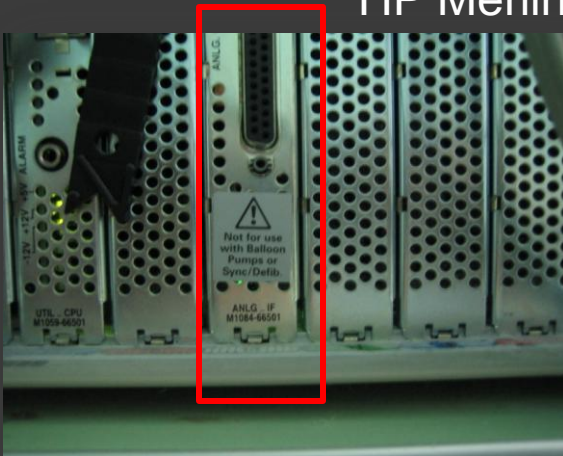
ICM+ Principles

Analogue interface

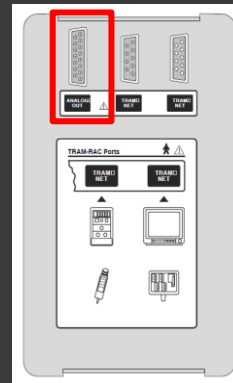
DWL TCD



HP Merlin



Marquette



Dräger



Spacelab



Surgical Display Controller

ICM+ Principles

Analogue interface



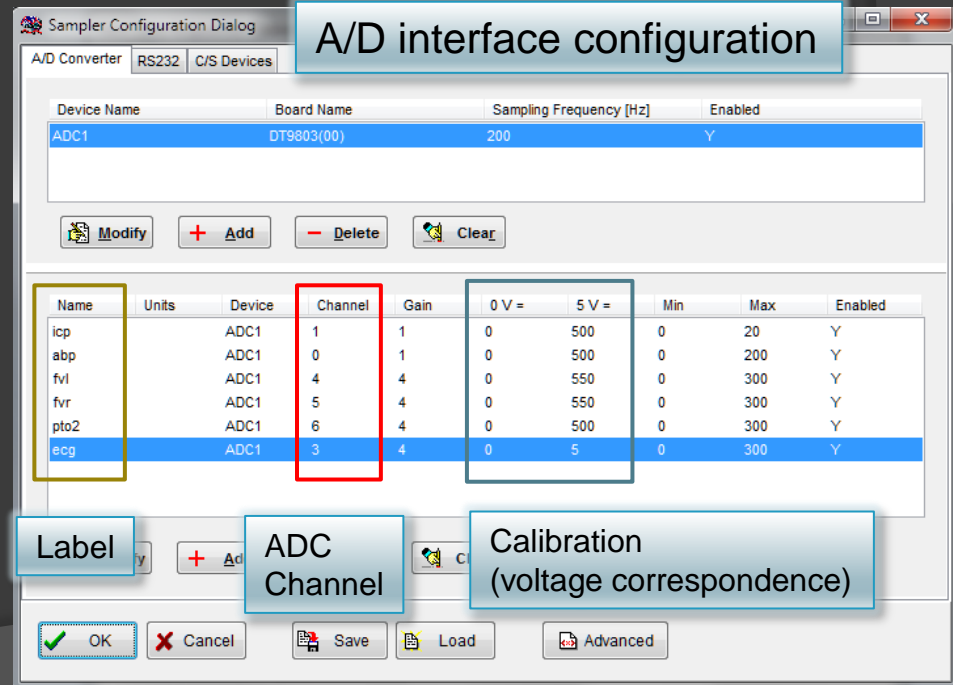
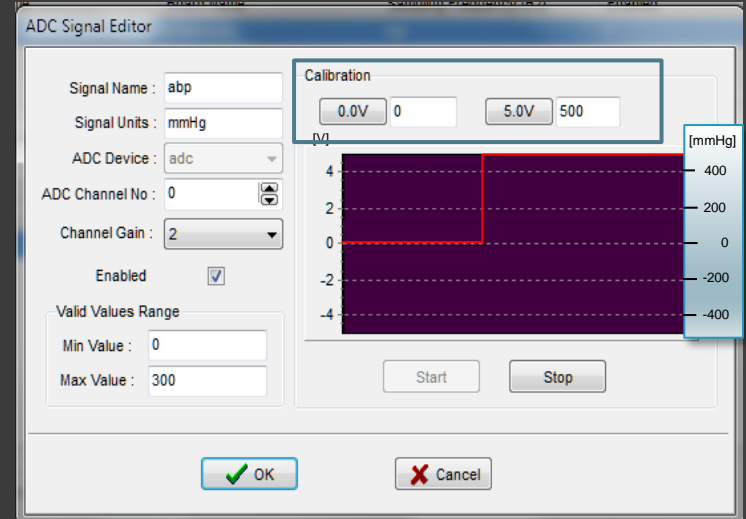
HP monitor module

Coax cable

A/D Converter (ADC)



Signal calibration



A/D interface configuration

Label

ADC Channel

Calibration (voltage correspondence)

ICM+ Principles

Digital Interface – network or serial (COM Port)

COM Port on a desktop PC



Monitor side connectors



USB – Serial adapter



ICM+ Principles

Continuous ASCII data export



Sampler Configuration Dialog

A/D Converter RS232 C/S Devices

Dev... Port B... RS232 Device

COM1 9

Continuous ASCII stream from the monitor

Device Name: NIRS Enabled:

0.050	0.021	0.859	0.382	0.416	0.000	0.000
0.055	0.016	0.861	0.392	0.416	-0.000	0.000
0.060	0.022	0.856	0.398	0.403	-0.000	0.000
0.065	0.026	0.859	0.402	0.407	-0.001	-0.000

Serial Settings

Start Char : <CR> Time field: 0

Stop Char : <LF> First data field: 2

Packet Size : 0

Separator Char :

Sampl. Freq. : 5

Max. Inactivity [s]: 0

Data:

Enabled

Parsing configuration

OK Cancel Save Load Advanced

COM Port Configuration

Setup

Settings

Port COM6

Baud rate 9600

Data bits 8

Stop bits 1

Parity None

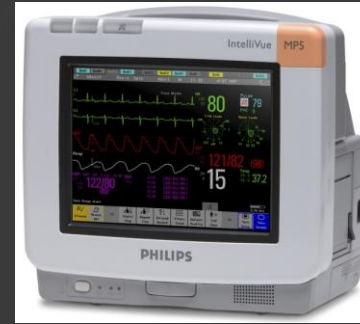
Flow control None

OK Cancel

ICM+ Principles

Client/server interface

Proprietary data exchange protocol



ICM+ Registration Info

Detailed ICM+ License Info

ICM+ Registration Status

Registered To: peter
Institution: University of Cambridge
Registration Valid Until: 09/07/12

Registered Features

- Data Acquisition And Real-time Analysis ✓
- Customisable Analysis Configuration ✓
- Raw Signals Recording ✓
- Off-line Analysis of Raw Signals ✓
- CSE Dynamics Tools ✓

Installed monitors

Installed Monitor Modules

- DTOpenLayers
- Simulator
- Raumedic
- Spiegelberg
- Intellivue

Close

Monitor connection configuration

Sampler Configuration Dialog

A/D Converter: RS232 C/S Devices

Name: icp abp

Client Server Device Configuration Dialog

Device Name: Phillips Device Type: **Intellivue**

- Spiegelberg
- Intellivue**
- DatexOhmeda
- PICCO2
- Licox
- Marquette
- OridionCap
- Mennen

Interface type

RS232 COM Port: COM6 Sampl. Freq. 100.00

Network Baud Rate: 115200 Enabled:

IP Address: 000.000.000.000 Communication Test

OK Cancel

Available modality selection

Client/Server Serial Device Signals Selection Dialog

Device: Phillips Preview

Signal Name: icp Signal Units: mmHg

Waveform: icp

Enabled

Physiological Values Range

Min Value: 0 Max Value: 100

Signal selection dialog

List of available signals

- ICP
- ART
- SAT
- HR
- CO2
- TEMP

OK Cancel

Valid values range specification

ICM+ Principles

Data collection configuration



Analogue

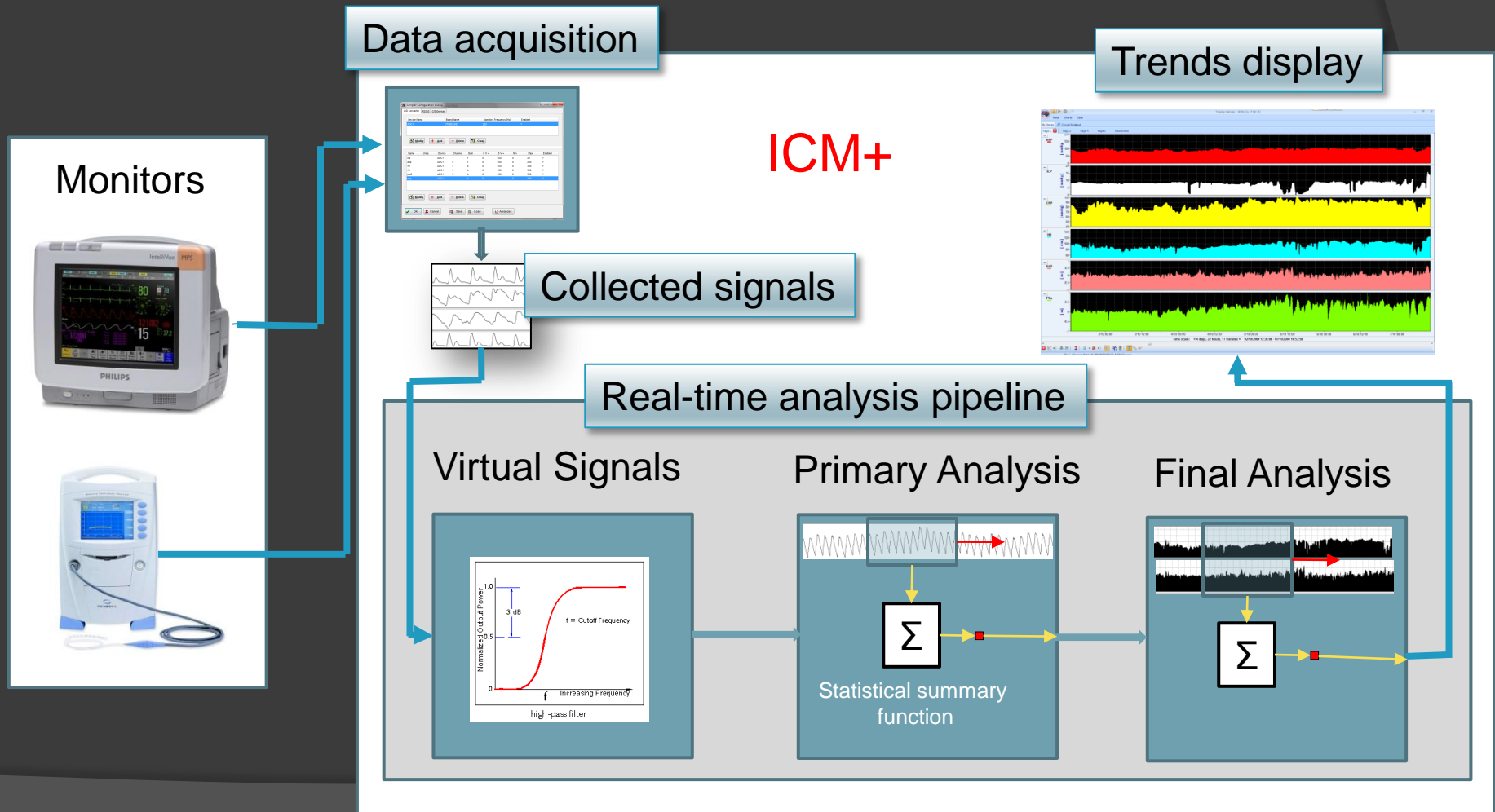
ASCII

Client/Server

```
1 <?xml version = "1.0"?>
2
3 <ICMDataConfig>
4   <SamplerConfig>
5     <ADCDevices>
6       <ADCDevice Name = "ADC1" Board = "DT9803(00)" SamplFrq = "100" Enabled = "Y">
7         <ADCSignal Name = "fv1" Units = "" Channel = "1" Gain = "1" Cal0VLevel = "0" Cal5VLevel = "500" MinValue = "0" MaxValue = "20" Enabled = "Y"/>
8         <ADCSignal Name = "fvr" Units = "" Channel = "0" Gain = "1" Cal0VLevel = "0" Cal5VLevel = "500" MinValue = "0" MaxValue = "200" Enabled = "Y"/>
9       </ADCDevice>
10    </ADCDevices>
11    <RS232Devices>
12      <RS232Device Name = "INVOs" Port = "COM1" BaudRate = "9600" DataBits = "8" StopBits = "1" ParityBits = "None" FlowControl = "None" StartChr = "&lt;&lt;CR>" StopChr = "&lt;&lt;LF>">
13        <RS232Signal Name = "rso21" Units = "%&lt;lt; Channel = "0" MinValue = "0" MaxValue = "100" Enabled = "Y"/>
14        <RS232Signal Name = "rso2r" Units = "%&lt;lt; Channel = "7" MinValue = "0" MaxValue = "100" Enabled = "Y"/>
15      </RS232Device>
16    </RS232Devices>
17    <CSCOMDevices>
18      <CSCOMDevice Name = "raumedic" DeviceType = "Raumedic" Port = "COM2" BaudRate = "0" SamplFrq = "1" Enabled = "Y">
19        <CSCOMSignal Name = "pt02" Units = "mmHg" Waveform = "P3" MinValue = "0" MaxValue = "100" Enabled = "Y"/>
20      </CSCOMDevice>
21      <CSCOMDevice Name = "phillips" DeviceType = "IntelliVue" Port = "COM3" BaudRate = "19200" SamplFrq = "100" Enabled = "Y">
22        <CSCOMSignal Name = "icp" Units = "mmHg" Waveform = "ICP" MinValue = "0" MaxValue = "100" Enabled = "Y"/>
23        <CSCOMSignal Name = "abp" Units = "mmHg" Waveform = "ABP" MinValue = "0" MaxValue = "200" Enabled = "Y"/>
24      </CSCOMDevice>
25    </CSCOMDevices>
26  </SamplerConfig>
27 </ICMDataConfig>
```

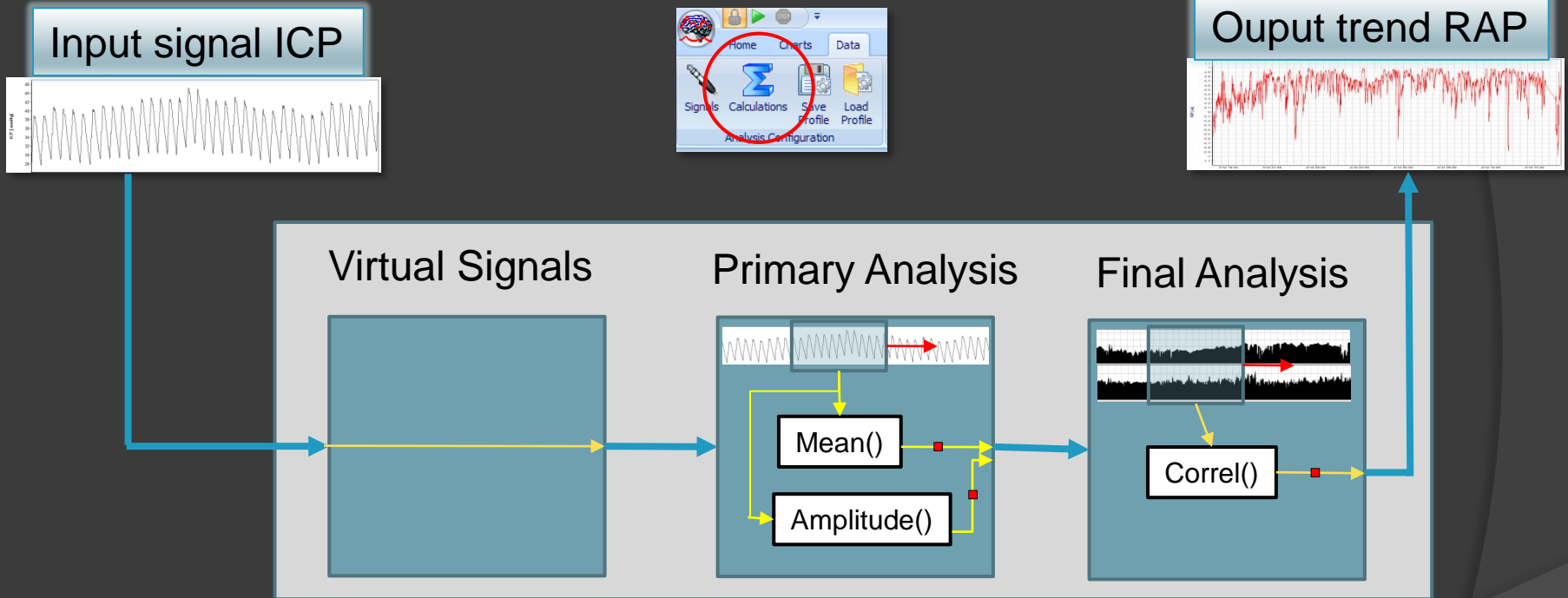
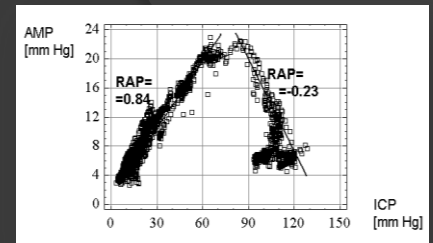
ICM+ Principles

Analysis pipeline



ICM+ Principles

Configuration example - RAP



Virtual signals

Name	Formula	Sampling Freq	Min	Max	Digital Filter	Enabled
ICP	icp	50	0	0	None	Y

ICP = icp

Modify + Add - Delete Clear Auto Fill Default Fs (Hz): 50.0

OK Cancel Save Load Advanced

Primary analysis

Name	Formula	Calc. Window [s]	Updated [s]	Min	Max	En
ICP	Mean(ICP)	10	10	0	0	Y
Amp	FundAmp(ICP,BPM&LWR=40&UPR=180)	10	10	0	0	Y

ICP = Mean(ICP)
Amp = FundFrg(ICP,...)

Modify + Add - Delete Clear Auto Fill Default Period [s]: 10.0

OK Cancel Save Load Advanced

Final analysis

Data Acquisition Period [s]: 30.0 Adjust Calc. Period

Name	Formula	Units	Calc. Wind...	Updated [s]	Min	Max
RAP	Correl(ICP,Amp,MDLM=50)		300	60	0	0

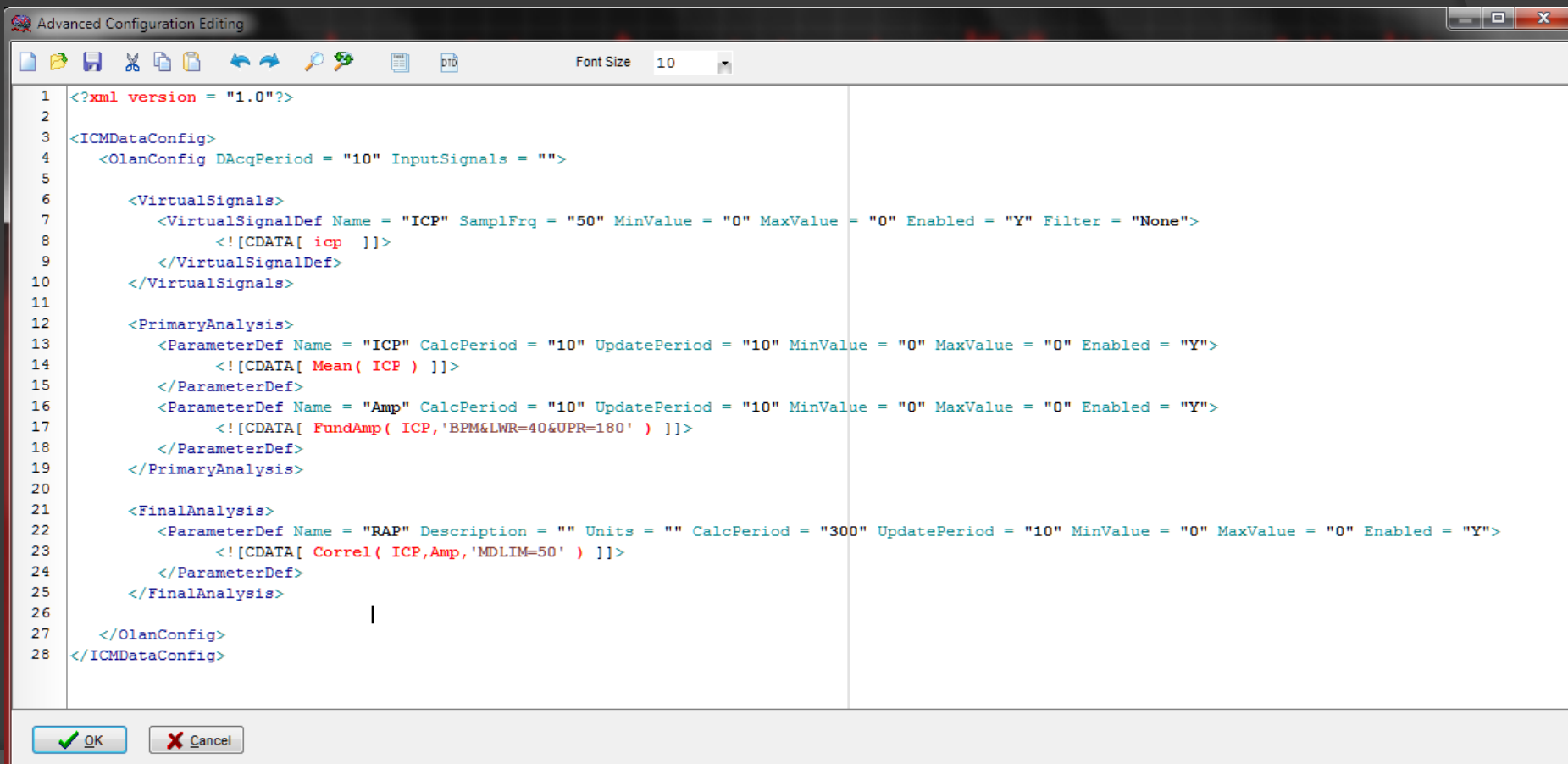
RAP = Correl(ICP,Amp,...)

Modify + Add - Delete Clear Auto Fill Default Period [s]: 60.0

OK Cancel Save Load Advanced

ICM+ Principles

Configuration example – Advanced mode



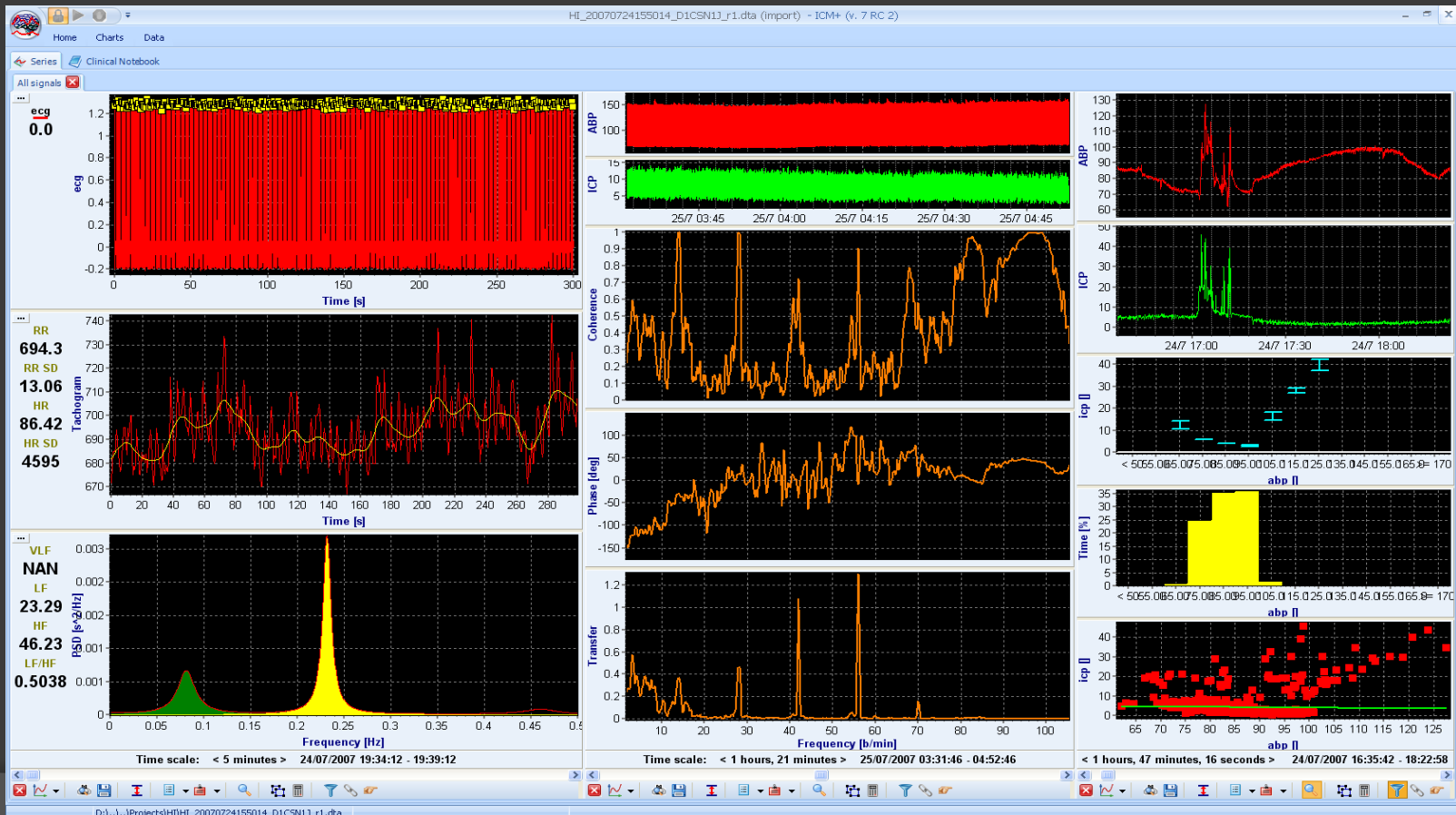
The screenshot shows a software window titled "Advanced Configuration Editing". The window contains a text editor with XML code. The code is as follows:

```
1 <?xml version = "1.0"?>
2
3 <ICMDataConfig>
4   <OlanConfig DACqPeriod = "10" InputSignals = "">
5
6     <VirtualSignals>
7       <VirtualSignalDef Name = "ICP" SamplFrg = "50" MinValue = "0" MaxValue = "0" Enabled = "Y" Filter = "None">
8         <![CDATA[ icp  ]]>
9       </VirtualSignalDef>
10    </VirtualSignals>
11
12    <PrimaryAnalysis>
13      <ParameterDef Name = "ICP" CalcPeriod = "10" UpdatePeriod = "10" MinValue = "0" MaxValue = "0" Enabled = "Y">
14        <![CDATA[ Mean( ICP ) ]]>
15      </ParameterDef>
16      <ParameterDef Name = "Amp" CalcPeriod = "10" UpdatePeriod = "10" MinValue = "0" MaxValue = "0" Enabled = "Y">
17        <![CDATA[ FundAmp( ICP,'BPM&LWR=40&UPR=180' ) ]]>
18      </ParameterDef>
19    </PrimaryAnalysis>
20
21    <FinalAnalysis>
22      <ParameterDef Name = "RAP" Description = "" Units = "" CalcPeriod = "300" UpdatePeriod = "10" MinValue = "0" MaxValue = "0" Enabled = "Y">
23        <![CDATA[ Correl( ICP,Amp,'MDLIM=50' ) ]]>
24      </ParameterDef>
25    </FinalAnalysis>
26
27   </OlanConfig>
28 </ICMDataConfig>
```

The window has a standard toolbar with icons for file operations and editing. The font size is set to 10. At the bottom of the window, there are "OK" and "Cancel" buttons.

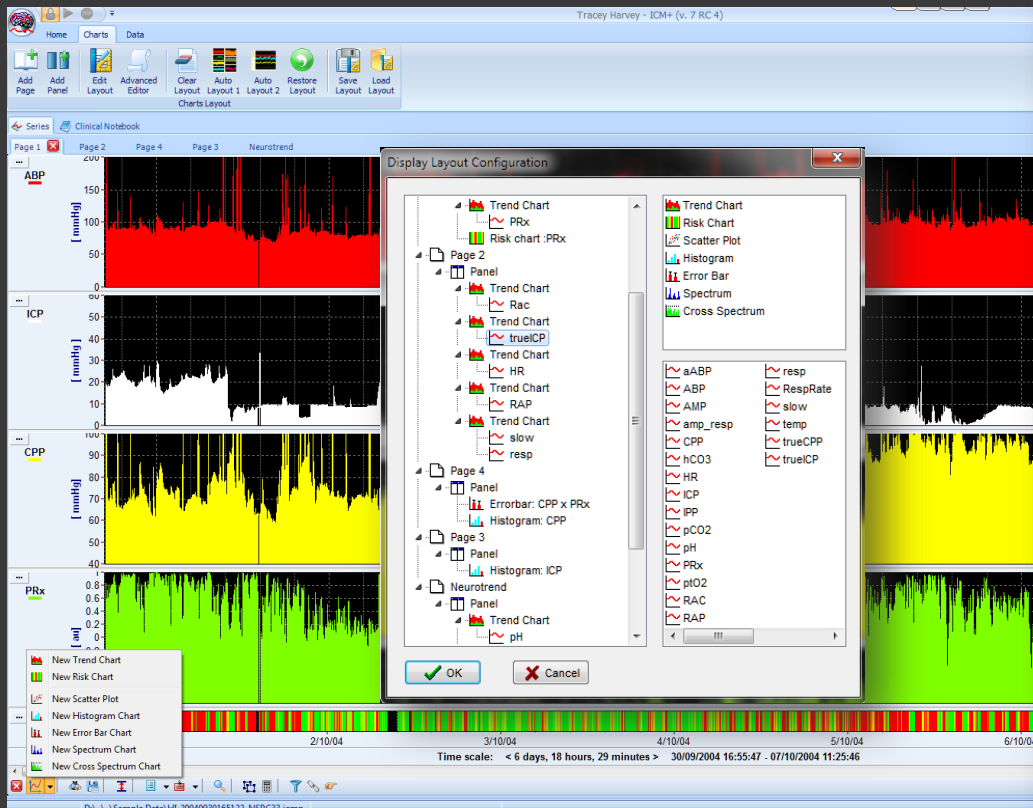
ICM+ Principles

Data display



ICM+ Principles

Data display - configuration

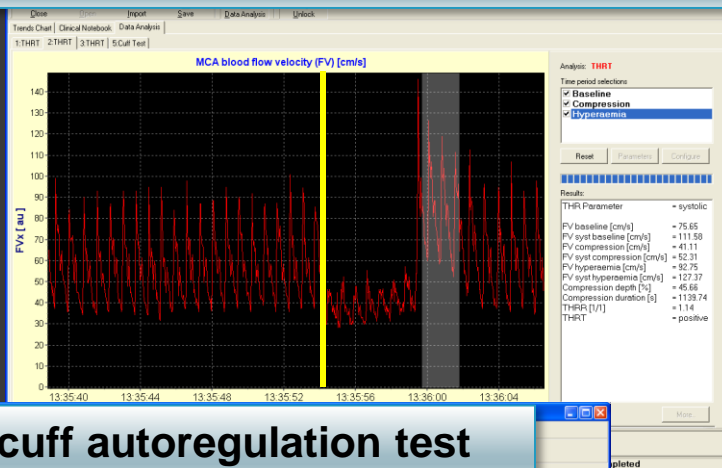


```
<?xml version = "1.0"?>
<ICMDataConfig>
  <DisplayConfig>
    <Page Title = "Page 1">
      <Panel Width = "47" TimeScale = "6" LabelIncrement = "1" TimeUnits = "days">
        <ChartUnit Height = "24.96">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "0" MaxAuto = "N" MaxValue = "200">
            <ChartSeries SeriesName = "ABP" SeriesColor = "255" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
        <ChartUnit Height = "24.96">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "0" MaxAuto = "N" MaxValue = "60">
            <ChartSeries SeriesName = "ICP" SeriesColor = "16777215" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
        <ChartUnit Height = "24.96">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "40" MaxAuto = "N" MaxValue = "100">
            <ChartSeries SeriesName = "CPP" SeriesColor = "65535" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
        <ChartUnit Height = "25.11">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "-1" MaxAuto = "N" MaxValue = "1">
            <ChartSeries SeriesName = "PRx" SeriesColor = "65408" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
        <RiskChartUnit>
          <RiskSeries SeriesName = "PRx" LowRiskLevel = "0" HighRiskLevel = "0.3"/>
        </RiskChartUnit>
      </Panel>
    </Page>
    <Page Title = "Page 2">
      <Panel Width = "0" TimeScale = "6" LabelIncrement = "1" TimeUnits = "days">
        <ChartUnit Height = "20.05">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "-1" MaxAuto = "N" MaxValue = "1">
            <ChartSeries SeriesName = "Rac" SeriesColor = "65535" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
        <ChartUnit Height = "20.05">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "0" MaxAuto = "N" MaxValue = "25">
            <ChartSeries SeriesName = "trueICP" SeriesColor = "65408" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
        <ChartUnit Height = "20.05">
          <ChartAxis Type = "Y" MinAuto = "N" MinValue = "0" MaxAuto = "N" MaxValue = "200">
            <ChartSeries SeriesName = "HR" SeriesColor = "16776960" SeriesClass = "Area" PointSize = "100">
          </ChartSeries>
        </ChartUnit>
      </Panel>
    </Page>
  </DisplayConfig>
</ICMDataConfig>
```

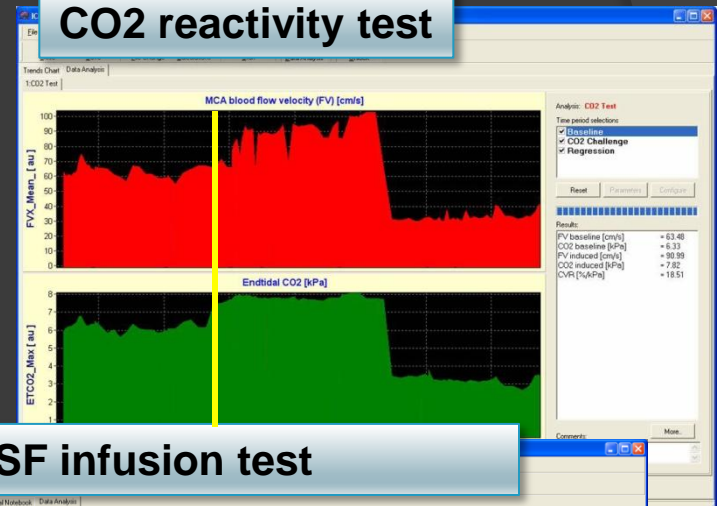
ICM+ Principles

Intervention tests analysis

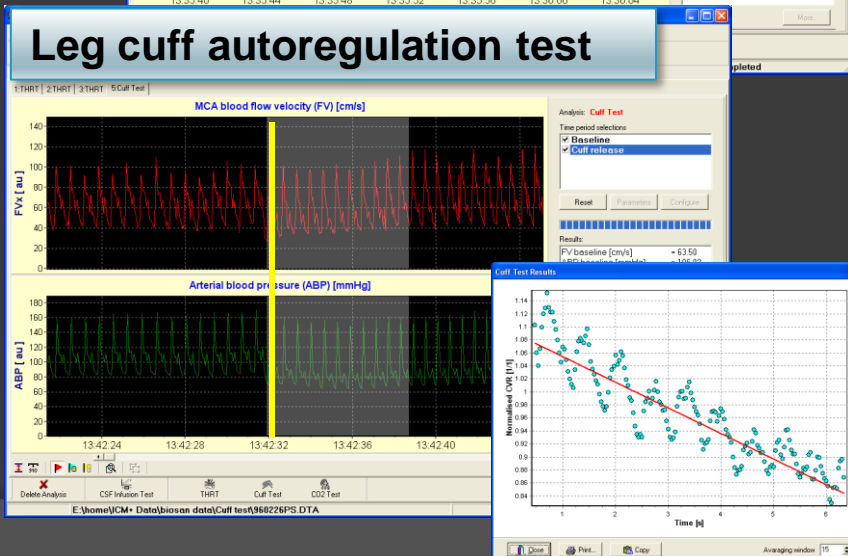
Transient Hyperaemic Response Test



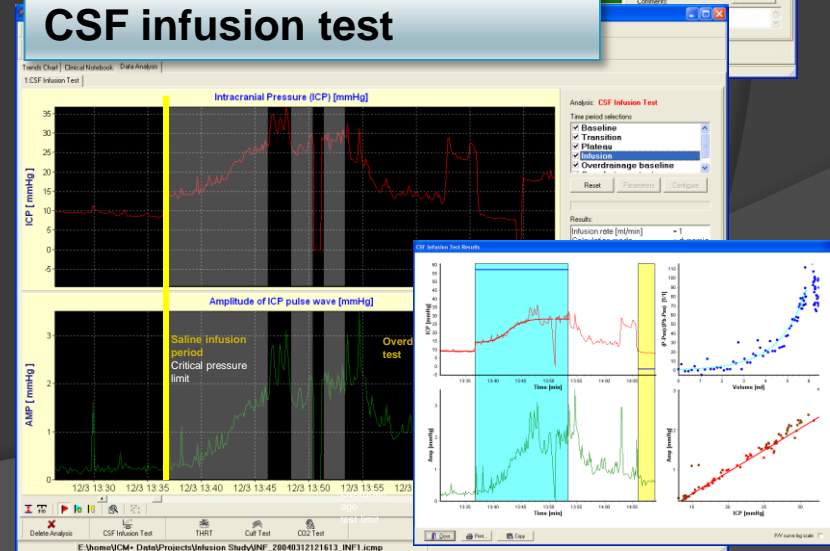
CO2 reactivity test



Leg cuff autoregulation test



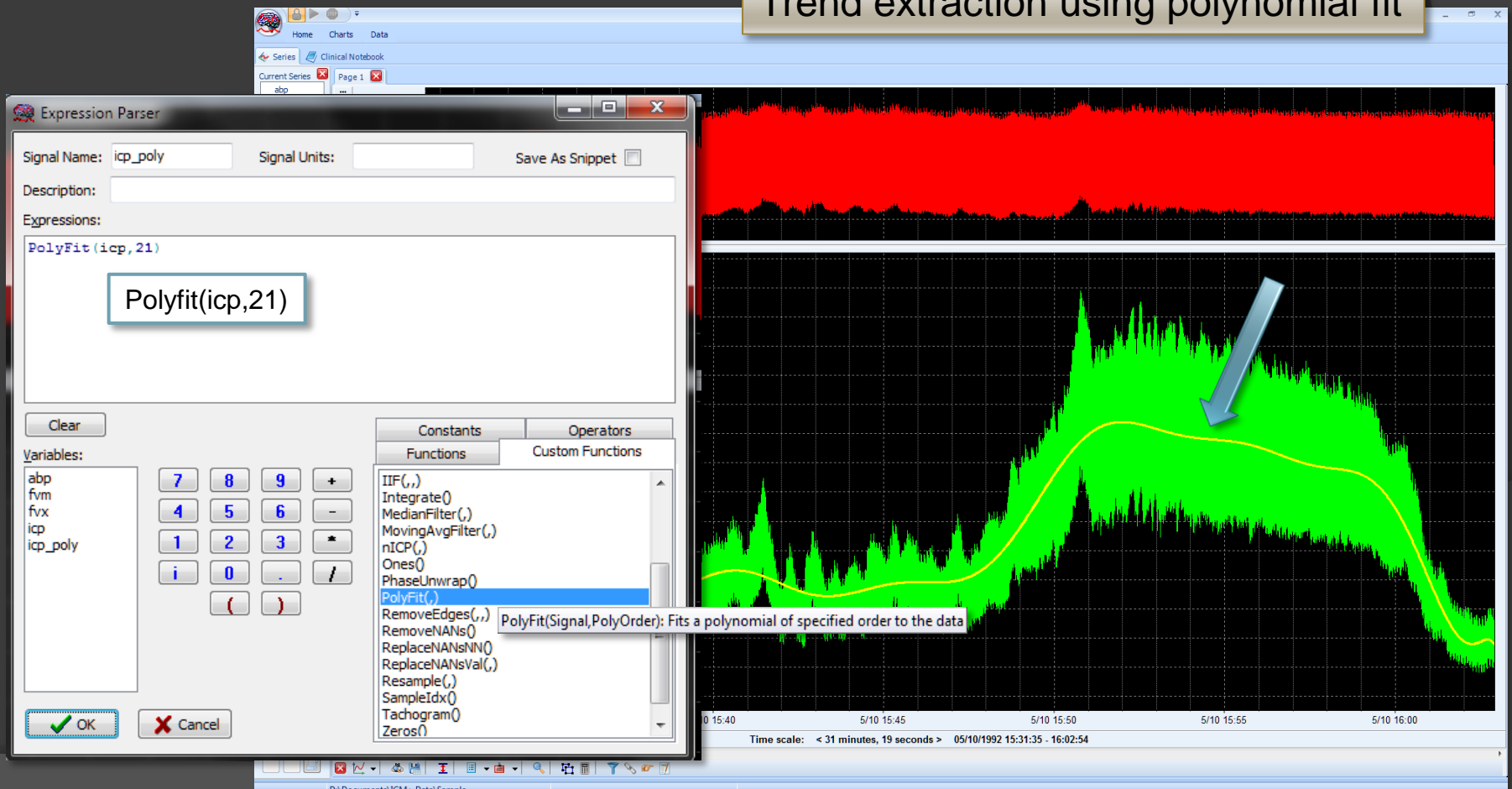
CSF infusion test



ICM+ New features

Signals calculator

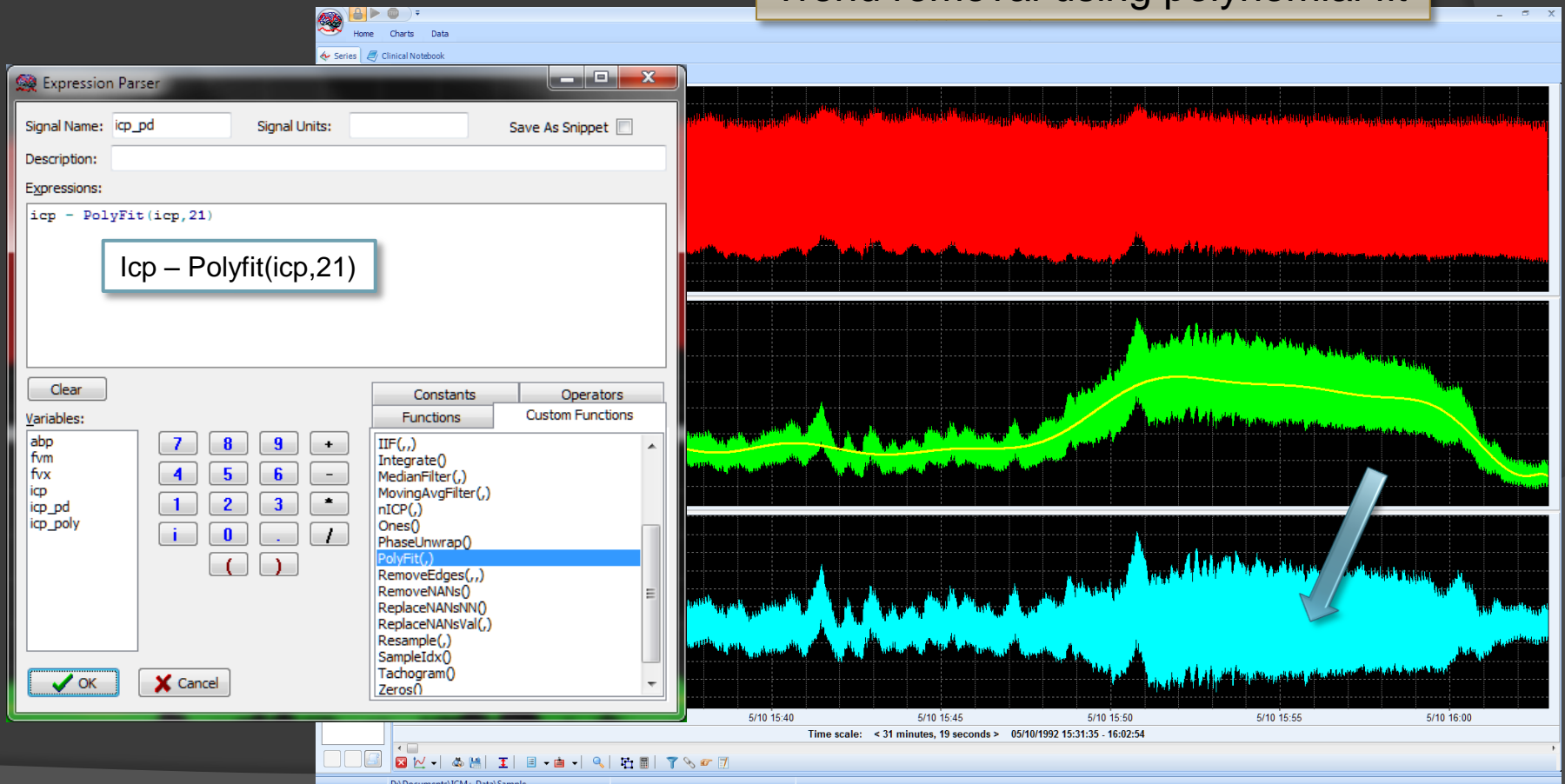
Trend extraction using polynomial fit



ICM+ New features

Signals calculator

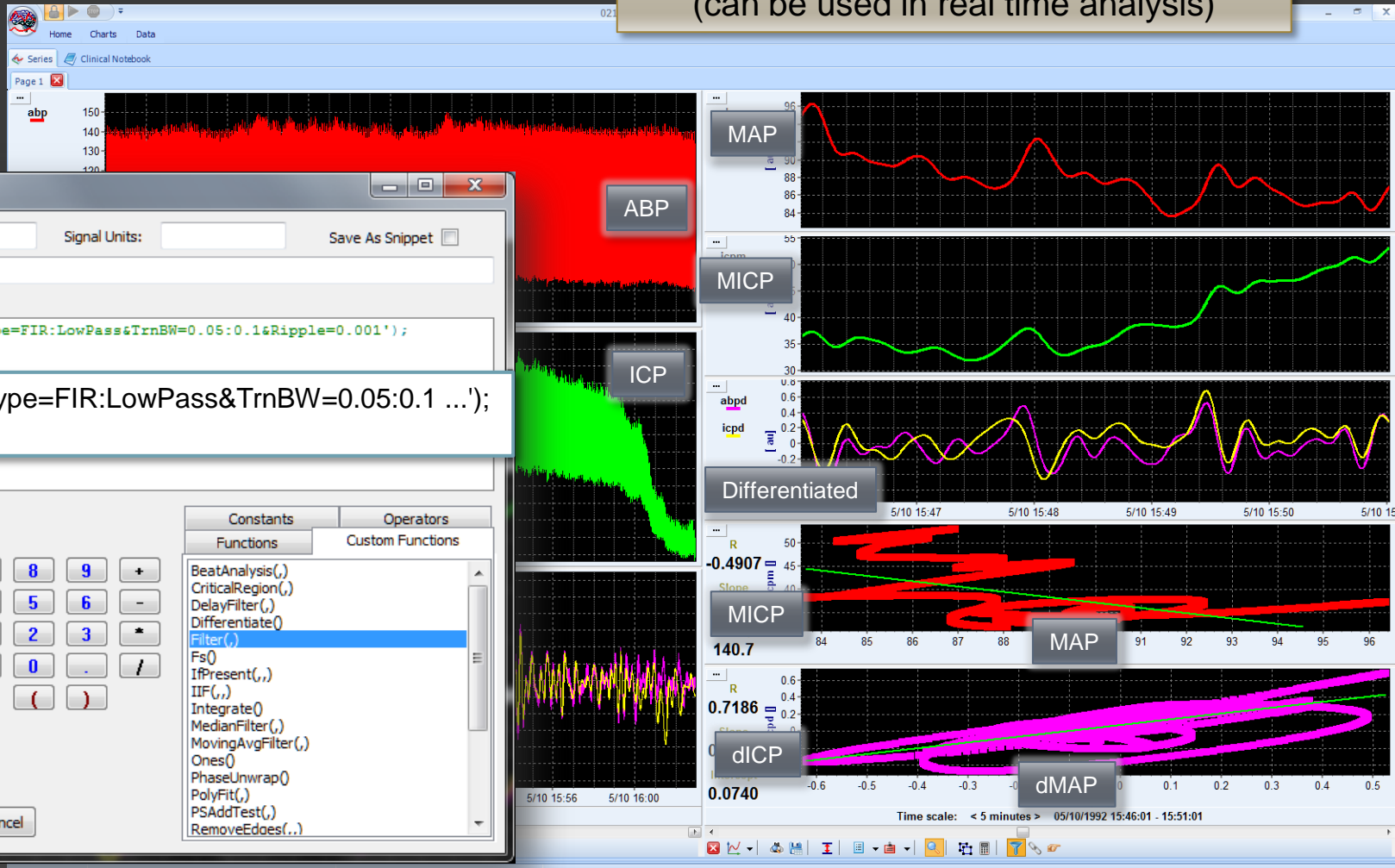
Trend removal using polynomial fit



ICM+ New features

Signals calculator

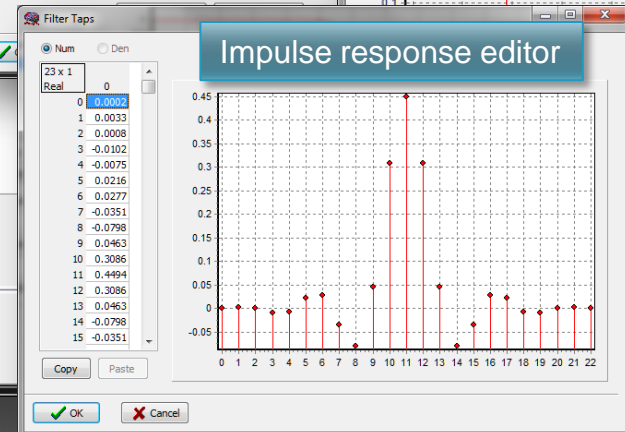
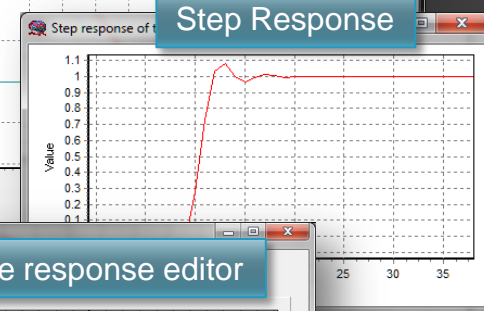
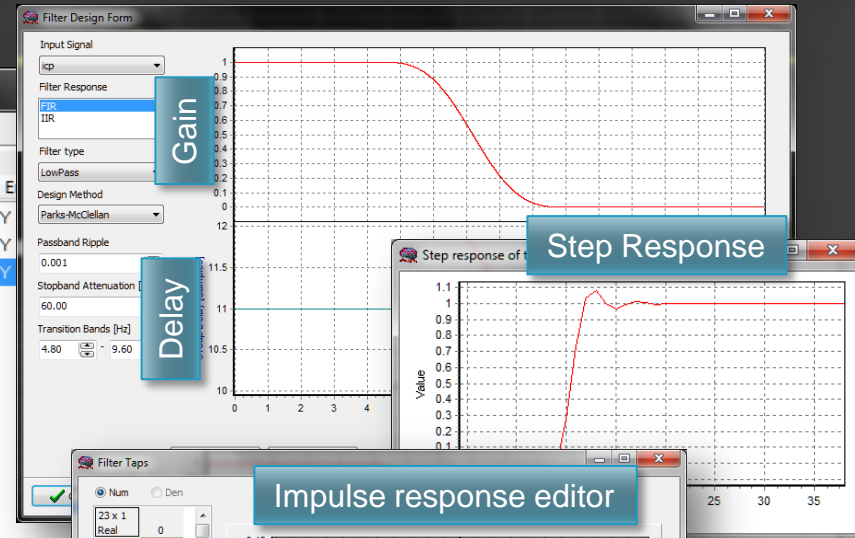
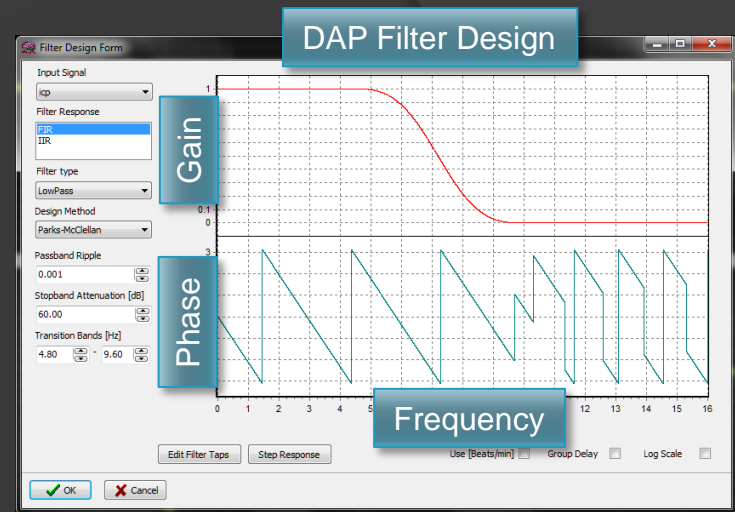
Trend removal using differentiation
(can be used in real time analysis)



ICM+ New features

New calculation engine

'Virtual Signals' with DSP support



Virtual Signal Definition Editor

Name: icp | Valid range for values: Min Value 0, Max Value 0, Enabled

Formula: Filter(icp, Type=FIR:LowPass&TmBW=0.2:0.5&Ripple=0.001)

Variables: abp, icp

Sampling frequency conversion: Sampling Frq [Hz]: 32.0, Use Decimating Filter

Functions: DelayFilter(), Differentiate(), Filter(), Fs(), IFPresent(), Filter(Signal, Specs): Digital filter, IIF(), Integrate(), MedianFilter(), MovingAvgFilter(), Ones(), PSAddTest(), ReplaceNaNsVal(), SampleIdx(), Zeros()

Modify Add Delete Clear Auto Fill Default Fs [Hz]: 32.0

OK Cancel Save Load Advanced

ICM+ New features

New calculation engine

'summary functions' with advanced options support

The image shows a software interface for configuring a primary analysis. The main window is titled "Primary Analysis Configuration Editor" and contains several sections:

- Name:** COH_ap
- Enabled:**
- Calculation Window Specification:**
 - Calculation Period: 300 s
 - Update Period: 10 s
- Valid values range:**
 - Max Value: 0
 - Min Value: 0
- Formula:** Coherence(ICP,ABP,'LWR=0.04&UPR=0.15&SWLEN=17')
- Function list:** A list of functions including abs, Correl, CSPower, Diast, Filter, FundAmp, FundFrq, and Gain. The "Coherence" function is selected.
- Options:** A list of options for the Coherence function, including BPM, LWR, UPR, ZPAD, WND, AVG, OVRLP, SWLEN, and SWIND. The "Options" list is highlighted with a red box.
- Function description:** Function calculates coherence within given frequency range using cross spectral analysis and reports its mean value or returns frequency of the max value. It can also return value at the point of maximum cross-spectrum amplitude. Use zero padding to increase frequency resolution, if needed

A secondary window titled "Function options" is overlaid on the main window, showing the configuration for the "Coherence" function:

- Function:** Coherence
- Frequency in [1/min]:**
- Lower frequency limit:** 0.04
- Upper frequency limit:** 0.15
- Zero padding:** 0
- Data window:** Hamming
- Number of segments to average:** 1
- Segments overlap [%]:** 0
- Spectrum Smoothing:** 17
- Spectrum Window type:** Bartlett
- Modulus squared:**
- Output Type:** Mean

Buttons for "OK" and "Cancel" are visible at the bottom of both windows.

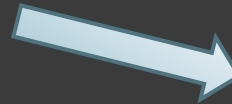
ICM+ New features

Analysis options

Jennifer Diedler's talk:
'Dealing with artefacts'



Phil Lewis' talk:
'Time series and batch data analysis'



Options

General Display Analysis Raw Data Rec System

Default sampling frequency [Hz]: 50.0

Default data analysis period [sec]: 10.0

Ignore Manual Artefacts Descriptor Files

Automatic artefacts treatment

- Disabled - the Min/Max analysis attributes will be ignored
- Remove individual invalid (NAN) values
- Treat the whole period containing NAN values as invalid

Data gaps treatment

- Always reset calculation engine
- Reset only if the data gap exceeds the analysis period
- Reset only if the data gap exceeds specified length
- Never reset the calculation engine

Maximum data gap tolerance period [sec] 0

Allow incomplete data buffer

Missing signals treatment

List of input signal aliases (use ',' as separator, eg 'fv, fvx')

+ Add fv, fvx, fvl, fvr

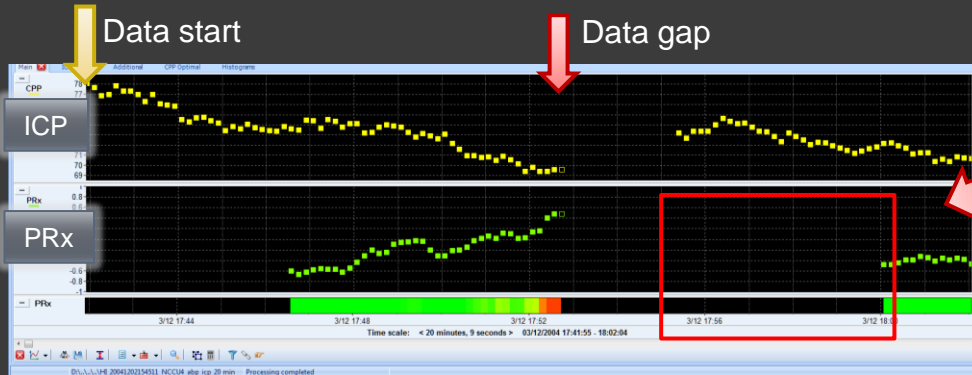
Delete

Allow incomplete input signal list

OK Cancel

ICM+ New features

Data gaps treatment



Data gaps treatment

- Always reset calculation engine
- Reset only if the data gap exceeds the analysis period
- Reset only if the data gap exceeds specified length
- Never reset the calculation engine

Maximum data gap tolerance period [sec] 0

Allow incomplete data buffer

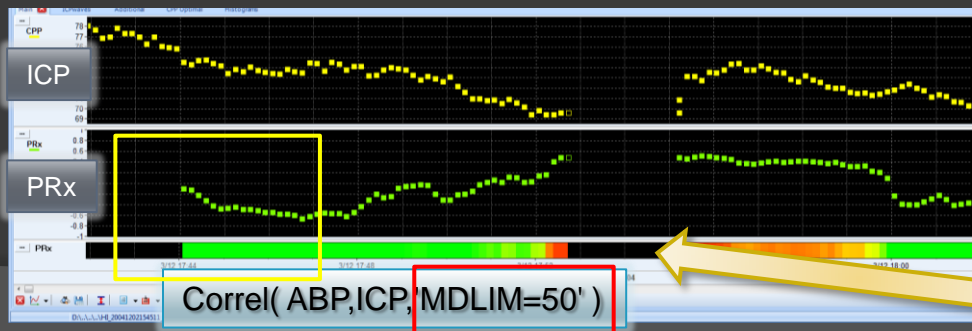


Data gaps treatment

- Always reset calculation engine
- Reset only if the data gap exceeds the analysis period
- Reset only if the data gap exceeds specified length
- Never reset the calculation engine

Maximum data gap tolerance period [sec] 0

Allow incomplete data buffer



Data gaps treatment

- Always reset calculation engine
- Reset only if the data gap exceeds the analysis period
- Reset only if the data gap exceeds specified length
- Never reset the calculation engine

Maximum data gap tolerance period [sec] 0

Allow incomplete data buffer

ICM+ New features

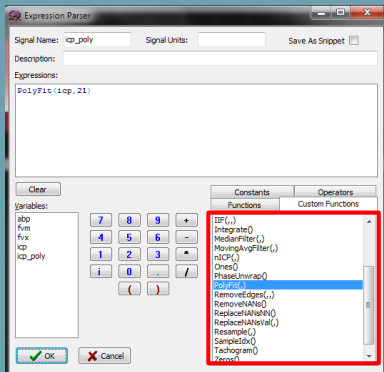
Plug-in system

DLL library
Implementing
DSP interface

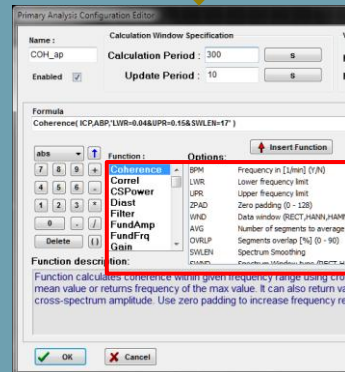
DLL library
Implementing
Stats interface

DLL library
Implementing
Chart interface

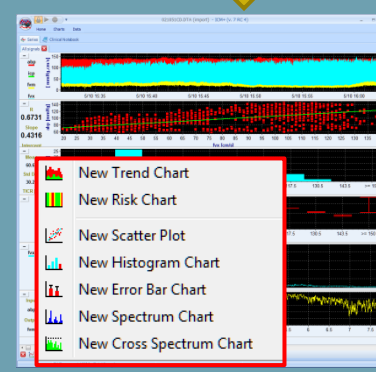
DLL library
Implementing
Tools interface



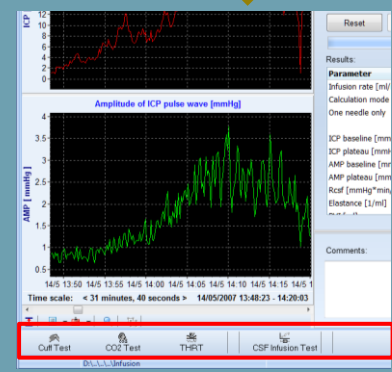
DSP
(Signal Calculator)



Stats functions
(Real-time analysis)



Charts



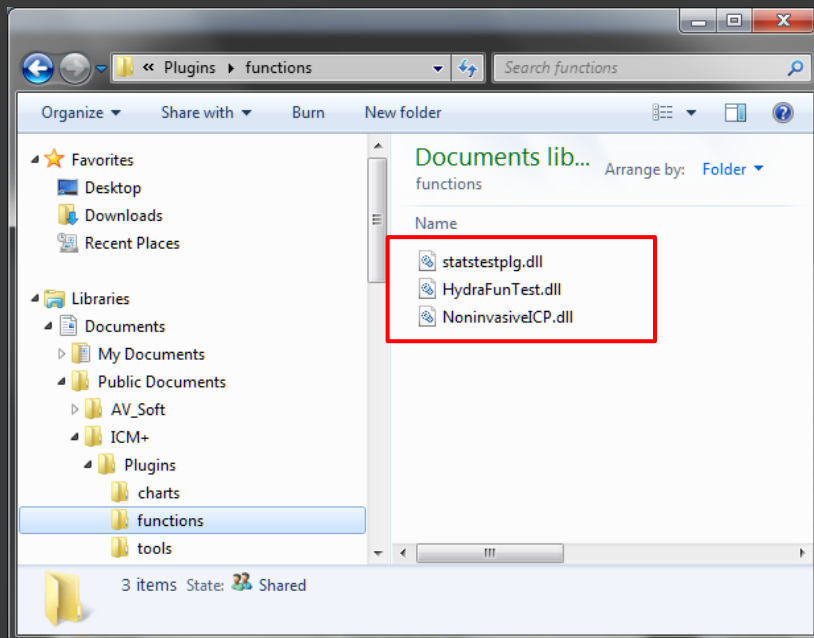
Tools
(Intervention tests)

ICM+

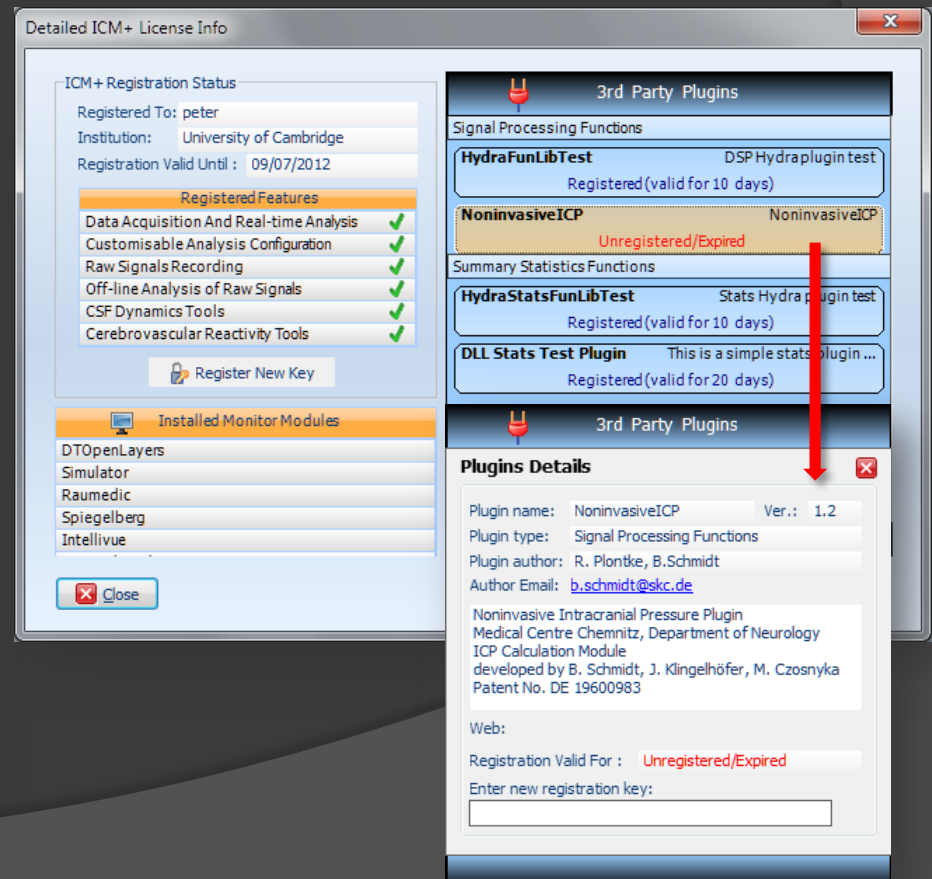
ICM+ New features

Plug-in system

Plug-ins' location in the file system



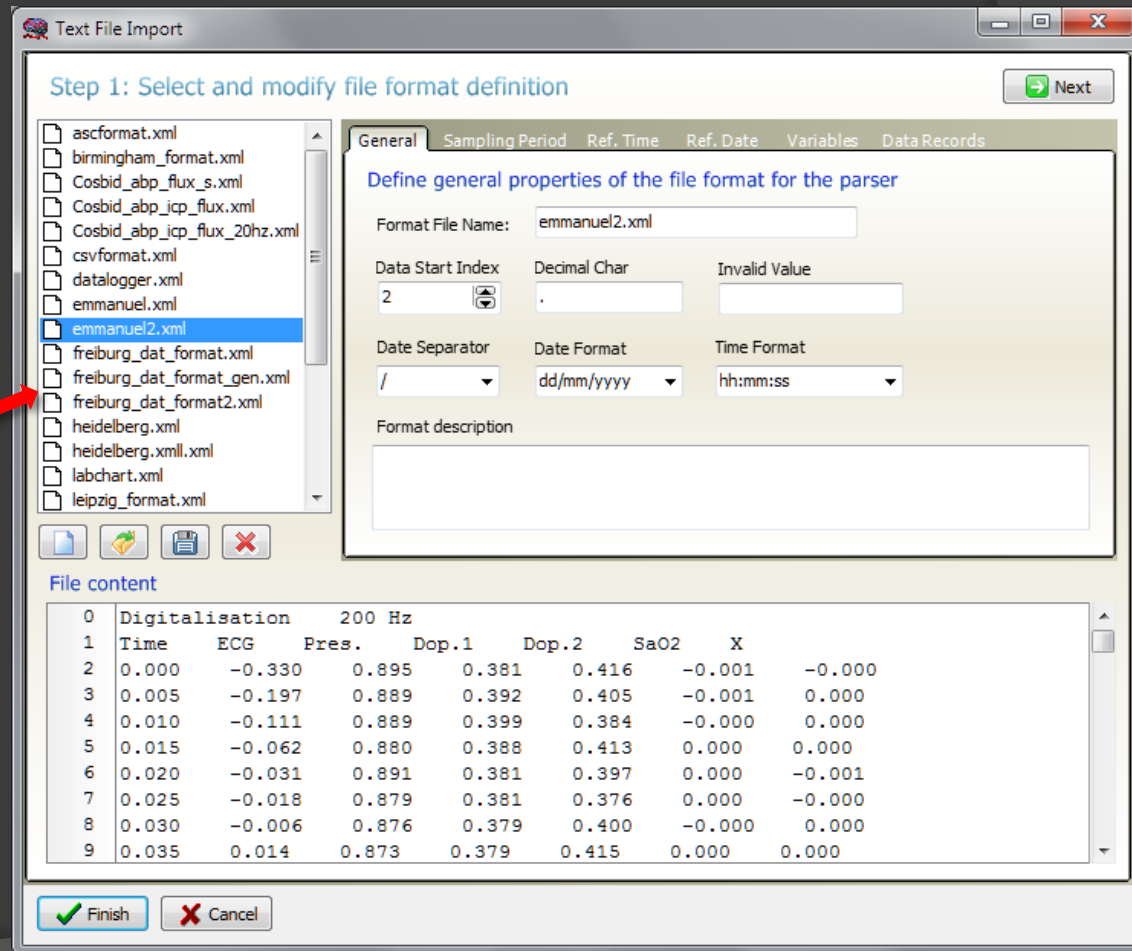
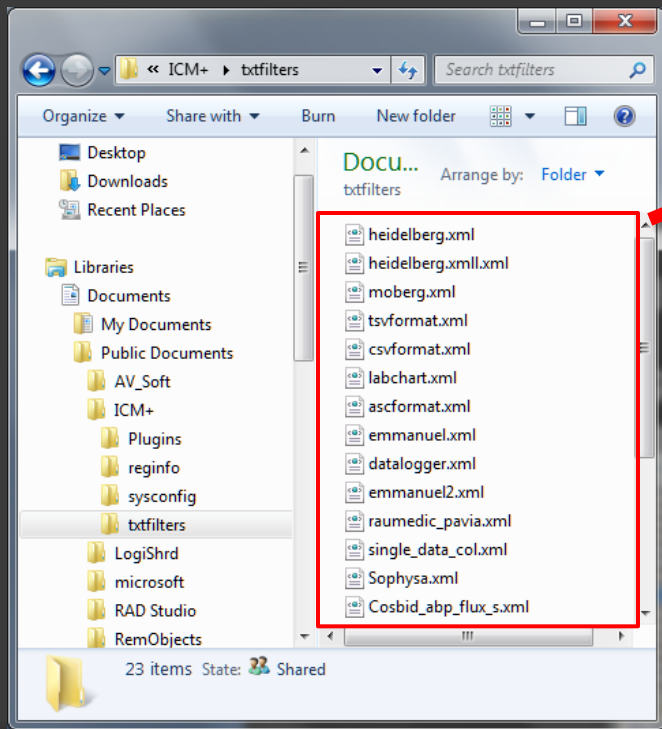
Plug-in registration (author's led)



ICM+ New features

Text import configuration

Definition files location



ICM+ New features

Text import configuration – sampling frequency parsing

Step 1: Select and modify file format definition

General | **Sampling Period** | Ref. Time | Ref. Date | Variables | Data Records

Define how to extract sampling period/frequency if present

Include in the parsing definition

Period Frequency Units: Hz Default Frequency [Hz]: 100.00

Pattern: ^Digitalisation\s*(\d+\.?\d*)\s Subexpression: 1

Value Type: number Multiplier: 1.00

File content

0	Digitalisation	200 Hz					
1	Time	ECG	Pres.	Dop.1	Dop.2	SaO2	X
2	0.000	-0.330	0.895	0.381	0.416	-0.001	-0.000
3	0.005	-0.197	0.889	0.392	0.405	-0.001	0.000
4	0.010	-0.111	0.889	0.399	0.384	-0.000	0.000
5	0.015	-0.062	0.880	0.388	0.413	0.000	0.000
6	0.020	-0.031	0.891	0.381	0.397	0.000	-0.001
7	0.025	-0.018	0.879	0.381	0.376	0.000	-0.000
8	0.030	-0.006	0.876	0.379	0.400	-0.000	0.000
9	0.035	0.014	0.873	0.379	0.415	0.000	0.000

Regular Expression

The following special characters match:

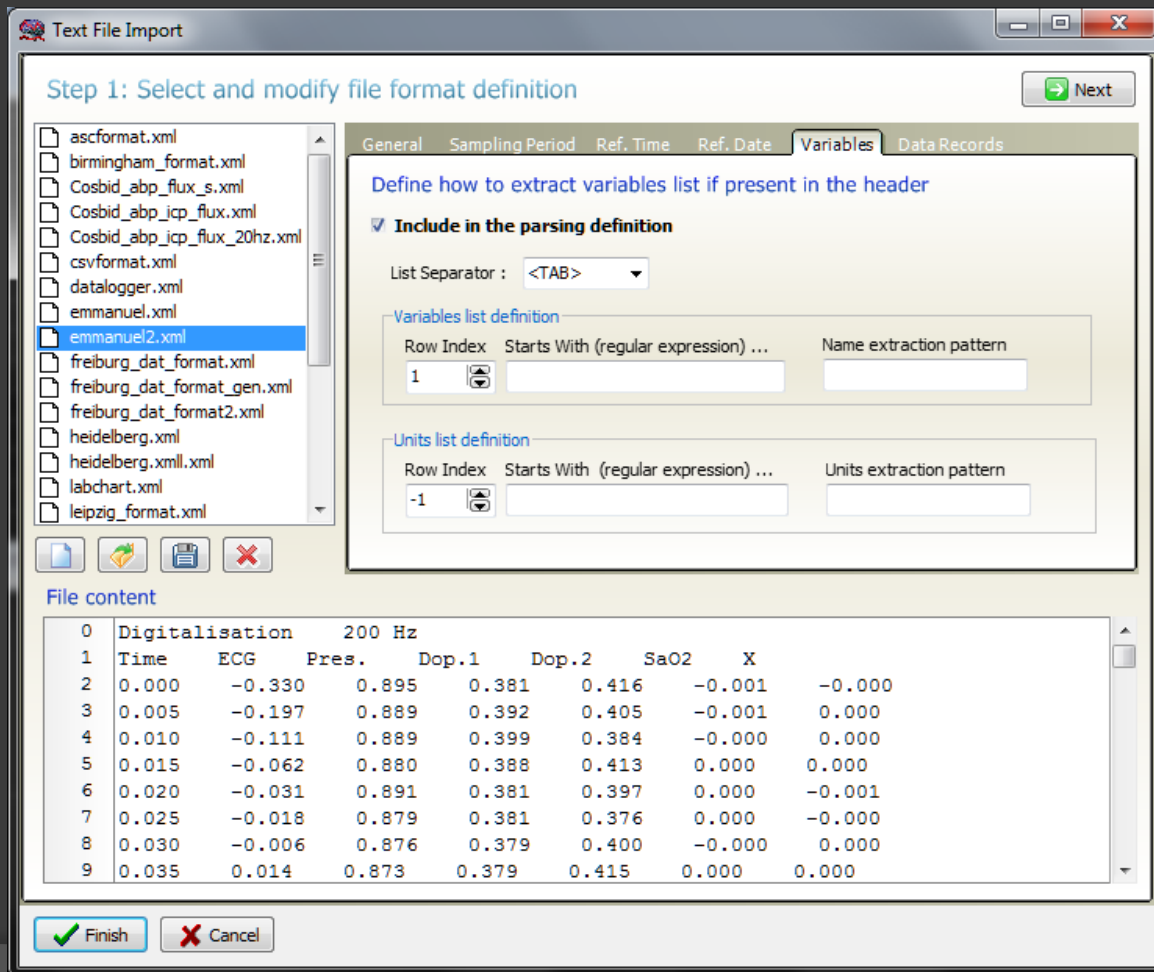
- any character
- \w an alphanumeric character
- \W a non-alphanumeric character
- \s a whitespace character
- \S anything BUT a whitespace.
- \d a digit
- \D a non-digit
- [...] any listed character.
- [^...] any character except listed.
- \b a word boundary.
- ^ the beginning of a line.
- \$ the end of a line.
- + the preceding element one or more times.
- ? the preceding element zero or one times.
- * the preceding element zero or more times.

In addition:

- () Groups into sub-expressions
- | Separates alternate possibilities

ICM+ New features

Text import configuration – variable names parsing



ICM+ New features

Text import configuration – data records parsing

Step 1: Select and modify file format definition

General Sampling Period Ref. Time Ref. Date Variables **Data Records**

Define how to parse individual data records

Values Separator: <TAB> First Data Row Starts With (regular expression) ...: \d

Date Variable Name: Index: -1 Time Variable Name: Time Index: 0 Milisec. Var Name: Index: -1

Name	Type	Format	Multiplier	Units
Time	number		1	s
*	number		1	

File content

```
0 Digitalisation 200 Hz
1 Time ECG Pres. Dop.1 Dop.2 SaO2 X
2 0.000 -0.330 0.895 0.381 0.416 -0.001 -0.000
3 0.005 -0.197 0.889 0.392 0.405 -0.001 0.000
4 0.010 -0.111 0.889 0.399 0.384 -0.000 0.000
5 0.015 -0.062 0.880 0.388 0.413 0.000 0.000
6 0.020 -0.031 0.891 0.381 0.397 0.000 -0.001
7 0.025 -0.018 0.879 0.381 0.376 0.000 -0.000
8 0.030 -0.006 0.876 0.379 0.400 -0.000 0.000
9 0.035 0.014 0.873 0.379 0.415 0.000 0.000
```

Finish Cancel

ICM+ New features

Text import configuration – preview and signals selection

Text File Import

Step 2: Check parser performance

Back Next

Time	ECG[200	Pres.	Dop.1	Dop.2	SaO2	X
30/12/1899	-0.33	0.895	0.381	0.416	-0.001	0
30/12/1899	-0.197	0.889	0.392	0.405	-0.001	0
30/12/1899	-0.111	0.889	0.399	0.384	0	0
30/12/1899	-0.062	0.88	0.388	0.413	0	0
30/12/1899	-0.031	0.891	0.381	0.397	0	-0.001
30/12/1899	-0.018	0.879	0.381	0.376	0	0
30/12/1899	-0.006	0.876	0.379	0.4	0	0
30/12/1899	0.014	0.873	0.379	0.415	0	0
30/12/1899	0.011	0.867	0.381	0.416	0	0
30/12/1899	0.013	0.865	0.381	0.415	0	0
30/12/1899	0.021	0.859	0.382	0.416	0	0
30/12/1899	0.016	0.861	0.392	0.416	0	0
30/12/1899	0.022	0.856	0.398	0.403	0	0
30/12/1899	0.026	0.859	0.402	0.407	-0.001	0
30/12/1899	0.024	0.851	0.41	0.427	0	-0.001
30/12/1899	0.033	0.846	0.408	0.446	0	-0.001
30/12/1899	0.026	0.858	0.41	0.467	0	0
30/12/1899	0.031	0.85	0.419	0.475	-0.001	0
30/12/1899	0.038	0.848	0.387	0.486	0	0
30/12/1899	0.039	0.834	0.35	0.483	0	0
30/12/1899	0.047	0.842	0.385	0.486	0	0

Finish Cancel

Text File Import

Step 3: Select variables and accept import

Back Finish

Legend:

- ECG[200 Hz]
- Pres.
- Dop.1
- Dop.2
- SaO2
- X

Finish Cancel

Where do we go from here?

- ⦿ There are many promising methods of data analysis and display available for intensive care and more are being invented.
- ⦿ Most of the methods do not see wider clinical application, usually the clinical studies presented are more of a proof of concept
- ⦿ This is mostly because, at the moment, they require specialised software and/or engineering support, not widely available in clinical centres.
- ⦿ Industry support is essential to incorporate new methods into general clinical practice. However this normally requires large scale studies/clinical trials to justify new investments and ensure medical governing body approval.
- ⦿ Interim/hybrid solutions of integrating research orientated data analysis solutions into standard clinical monitoring might be a way of facilitating transfer of new technologies into industry supported medical practice.

Where do we go from here?

Data exchange

Boxes



ICM+ Software for Brain Monitoring: User Area - Mozilla Firefox
http://www.neurosurg.cam.ac.uk/icmplus/user/boxes.php

UNIVERSITY OF CAMBRIDGE
Neurology Unit
School of Clinical Medicine > Department of Clinical Neurosciences > Neurosurgery Unit > ICM+

ICM+
Brain monitoring for neurosurgery and intensive care

- About ICM+
- Features
- Applications
- niCP Plugin
- References
- Getting started
- Ordering
- User Area

User Area
Hello smielewski.p and welcome to Boxes!

A Box - is a concept of shared space, which you can use to store files, and share them with a group of people. Box allows you to specify users (Institutions) who should have access to particular box.

Create a box

List of Boxes

ID	Name	Description	Owner	Institution
1	Project1	Example project data	smielewski.p	Addenbrookes Hospital, Cambridge
2	Presentation	asdas	carrera.e	Addenbrookes Hospital, Cambridge
3	Hogue_adult_CPB_data	Data from adult cardiopulmonary bypass study at Johns Hopkins Hospital conducted by Dr. Charles Hogue	brady.k	Johns Hopkins Hospital, Pediatric ICU, Baltimore
4	Beta_Versions	Beta versions of the ICM+ program and its modules	smielewski.p	Addenbrookes Hospital, Cambridge
5	ICM_data_for_entropy_analysis	ICM+ raw data- long series of ICP and ABP	czosnyka.m	Addenbrookes Hospital, Cambridge
6	ICM_Files	Analysed data for sharing	lewis.p	Alfred Hospital, Neurosurgery Dept, Melbourn
7	REG_data	9 piglet experiments of lowering of ABP past the LLA. ICP, laser Doppler, NIRS (%sat only), and REG were measured. In these experiments, REG is impedance across 19mm of frontal and parietal brain measured with a wheatstone bridge using electrodes implanted to a 4mm depth in the piglet brain.	brady.k	Johns Hopkins Hospital, Pediatric ICU, Baltimore
8	Sample_Data	This is a selection of data samples to be used for exploring some of the ICM+ functionality	smielewski.p	Addenbrookes Hospital, Cambridge

X Find: tuebin Next Previous Highlight all Match case Done

Where do we go from here?

Expansion of available methods

- Artefacts detection/treatment
- Systemic variability measures (heart rate, respiration rate, pulse amplitude etc)
- Pulse morphology
- Time series complexity measure (chaos theory)

These will be done either as internal implementations or, preferably, as 3rd 'plug-in' solutions

Where do we go from here?

Integration with other, clinically approved, data acquisition systems

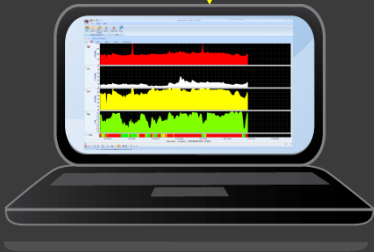
Example: CNS Technology, by Moberg Research Inc



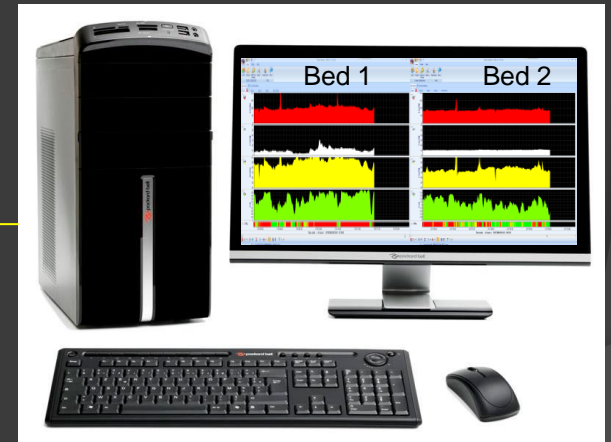
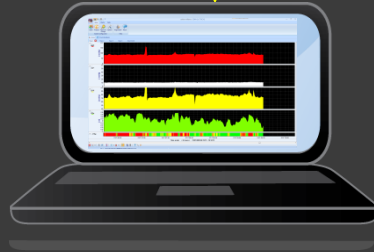
Where do we go from here?

Remote access to ICM+ monitoring

Bed 1



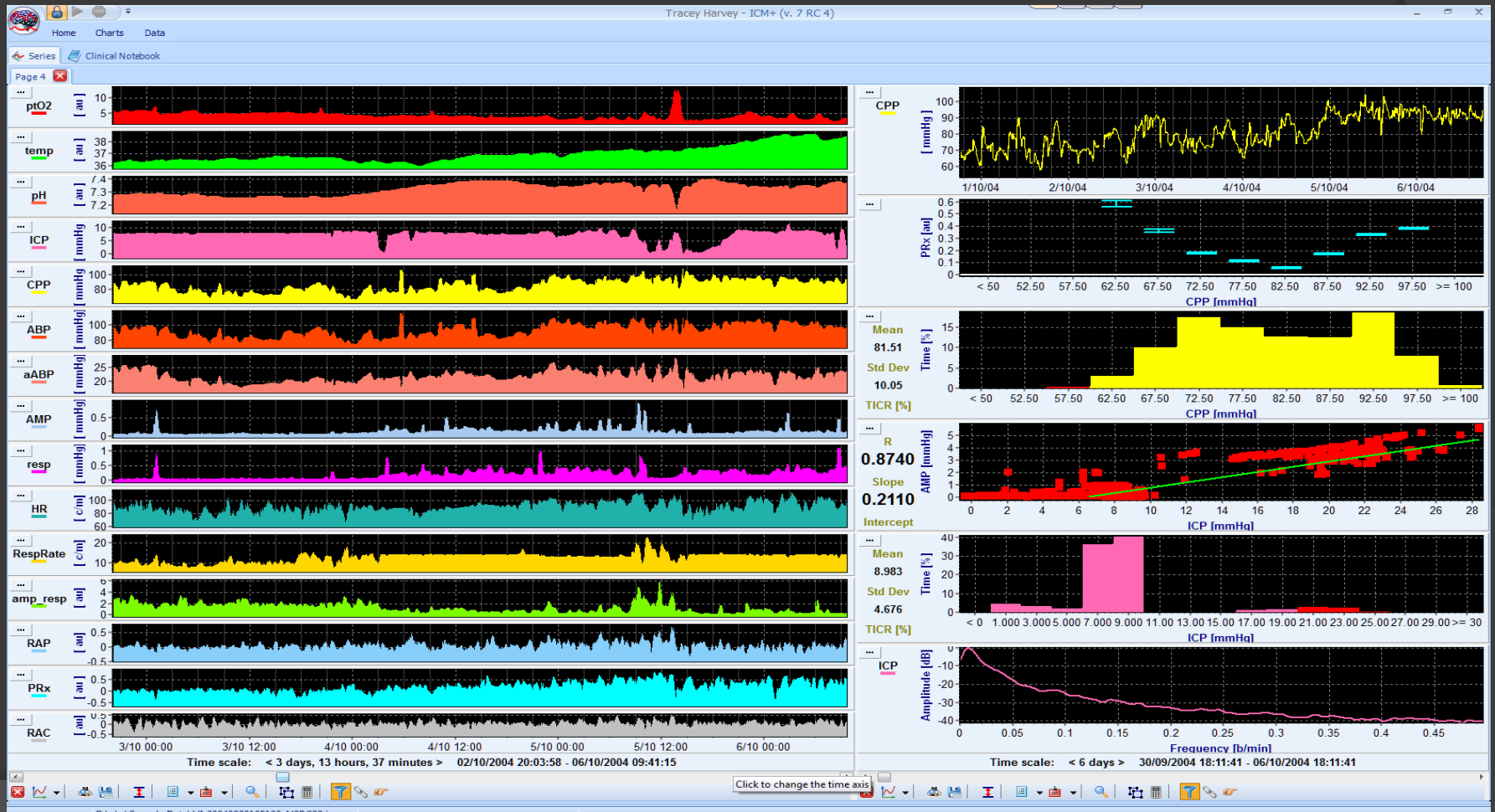
Bed 2



Network

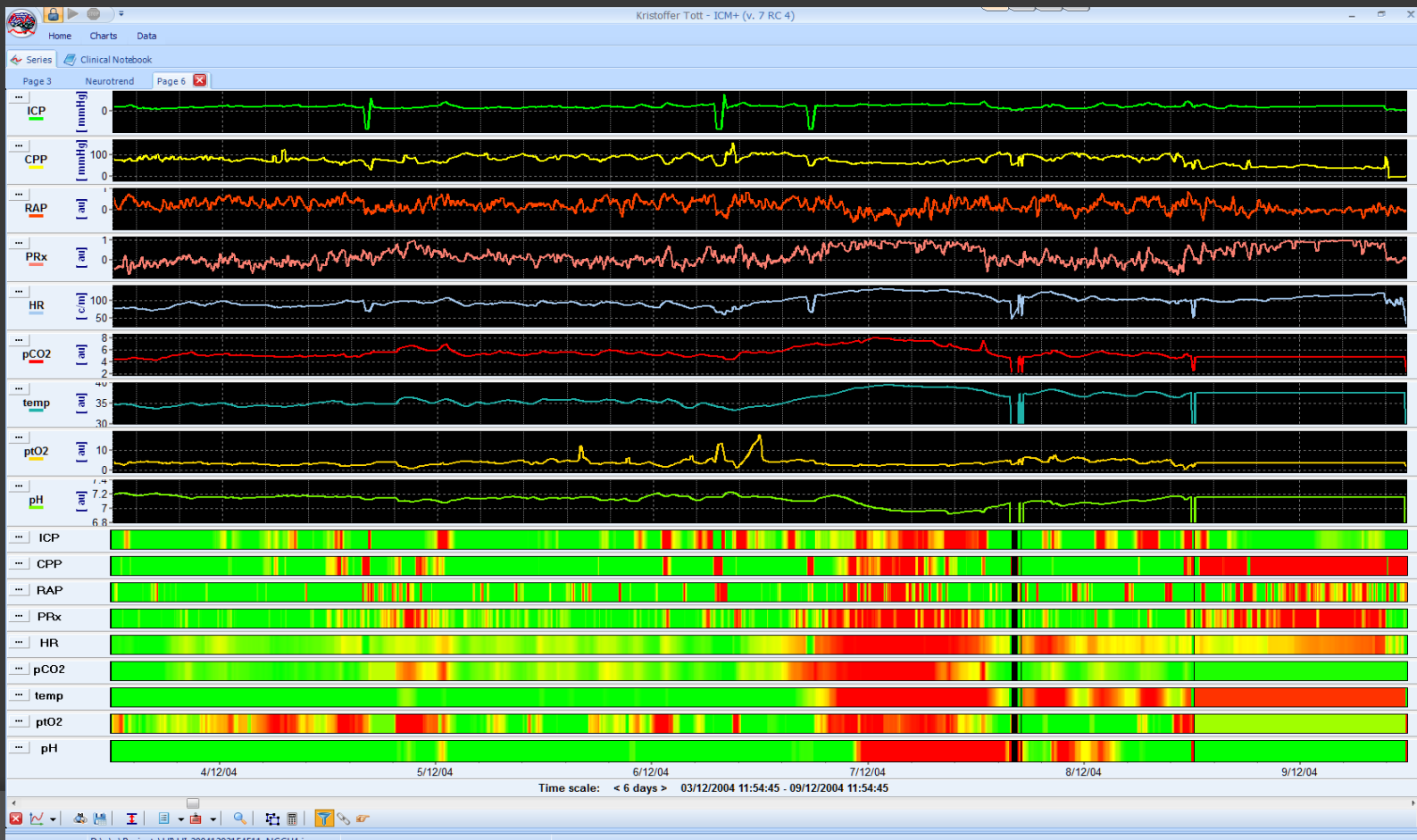
Where do we go from here?

Data visualisation improvements



Where do we go from here?

Imaging time series



Where do we go from here?

Other pending tasks

- Extended data import - synchronising data from multiple sources based on series re-sampling
- Increasing number of signals to acquire and store in raw format: NEW RAW DATA FORMAT required
- DOCUMENTATION
- New digital interface devices support – ongoing task

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- J. D. Pickard: University of Cambridge, U.K.

.... and many more

USERS' OWN EXPERIENCE WITH ICM+

- **Ken Brady, MD:** Laboratory vs. clinical uses of ICM+
- **Christian Zweifel, MD:** Multimodal signal acquisition and data processing using ICM+
- **Kristian Aquilina, MD:** Assessment of CSF dynamics in hydrocephalus
- **Christina Haubrich, MD, PhD:** ICM+ and the blood pressure - flow velocity relationship
- **Magdalena Kasprowicz, PhD:** How can we create and analyze new signals using ICM+?
- **Jennifer Diedler, MD:** Dealing with artefacts
- **Phil Lewis , BSc:** Time series and batch data analysis with ICM+
- **Martin Soehle, MD:** Options and pitfalls when using ICM+ for collecting data from Philips Intellivue- and Hemedex CBF-monitors
- **Bernhard Schmidt, PhD:** How to use plug-in for non-invasive ICP
- **Martin Schuhmann MD, PhD:** Overnight ICP monitoring
- **Luzius Steiner MD, PhD:** Intraoperative non-invasive monitoring of cerebral perfusion

All presentations will be available on <http://www.neurosurg.cam.ac.uk/icmplus>