UNIVERSITY OF CAMBRIDGE

ICM+® Users' Meeting

Reflecting on 15 years of global use of ICM+

How is it commonly used and what else could it do for you?

Dr Peter Smielewski

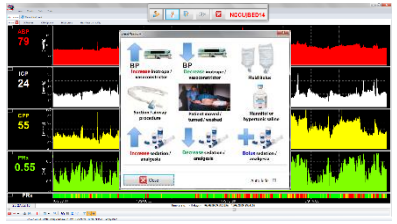
ps10011@cam.ac.uk

8th September 2019

Division of Neurosurgery, Department of Clinical Neurosciences

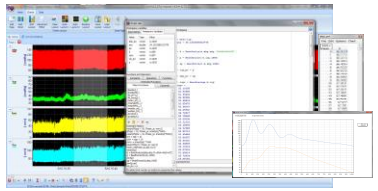
Brain Physics Lab

What is ICM+



Annotations & Clinical Trials

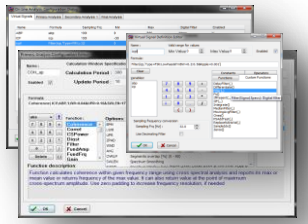
MMM data acquisition



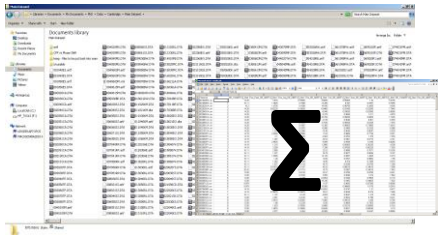
Off-line data analysis explorations

Other tools: Matlab, C-Code, Python

Archiving
Single and Multi-centre



ICM+ Analysis Configuration



Batch analysis and statistical validation

Real time application at the bed side

Need for a solution like ICM+

- Push for individualised ICU treatment targets (personalised medicine)
  - CPP, ICP

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  - ‘Undersampling’ of the medical record systems
  - Analysis like: HRV, BRS, CrCP, ICP pulse morphology, Non-invasive ICP and Cerebral Autoregulation requiring high fidelity waveform recording

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- Multicentre multimodality data collection projects
  - eg CENTER-TBI, TRACK-TBI, ADAPT

How did we get here ?

Warsaw 1982

How did we get here ?

Cambridge 2019

Clinical trials

STARSHIP

COGiTATE

CENTER-TBI

PANGEA

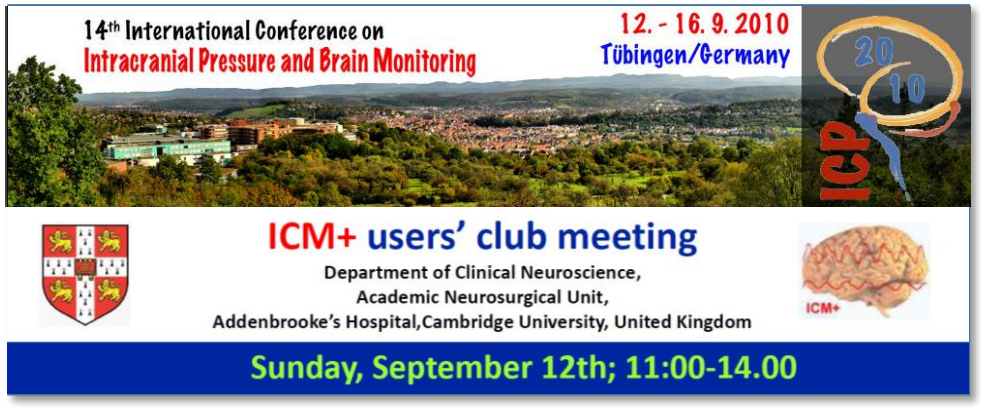
Public title	A double-blind placebo-controlled st and safety of EU-C-001 in patients wi
Scientific title	A double-blind placebo-controlled st and safety of EU-C-001 in patients wi
Secondary ID [1]	PresSura Neuro EU-C-001-II-01
Secondary ID [2]	EUDRACT 2017-004890-15
Universal Trial Number (UTN)	UTN U1111-1226-7276
Trial acronym	PANGEA
Linked study record	

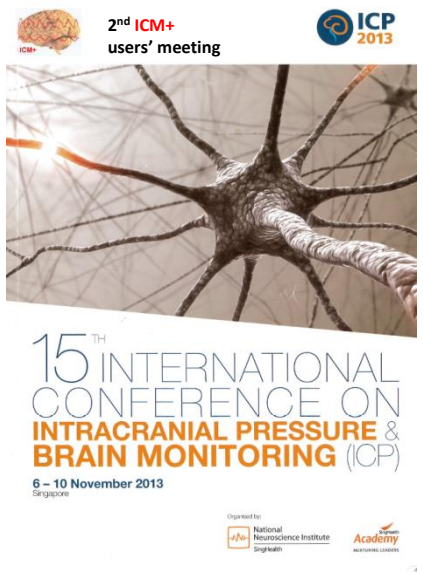
ClinicalTrials.gov

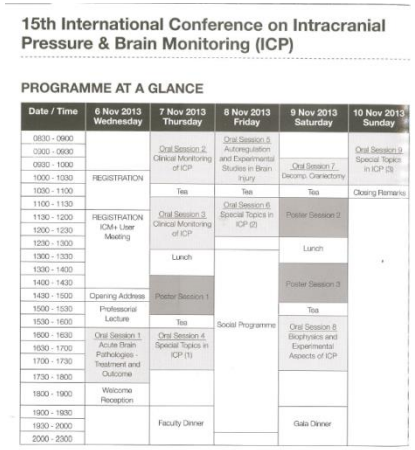
Home > Search Results > Study Record Detail

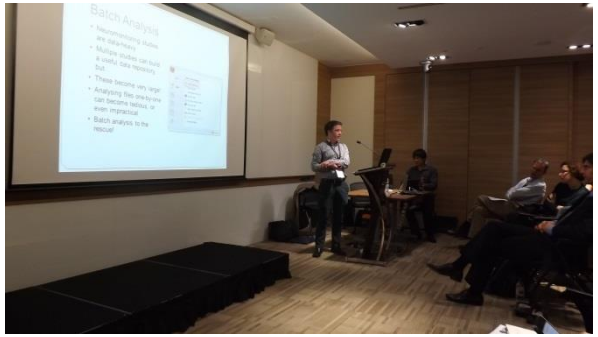
Cerebral Autoregulation Monitoring During Cardiac Surgery

ICM+ Users' group meetings









ICM+ powered workshops

NCS 2017, Hawaii

Applied Neuromonitoring workshop, NCS 2018, Florida

AO Neuro autoregulation course, Hong-Kong 2017

A dedicated ICM+ Workshop, September 2018

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USER TESTIMONIES

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'Big congratulations for this well-organized workshop, very interesting and very ambitioned and very instructive!!!'
Dr Bernhard Schmidt, Chemnitz Medical Centre, Germany
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Thanks again for the organization of the workshop, it was exactly what we needed in order to improve our use of the software and all the discussions that we could have with the other users were very invaluable for our next researchs.'
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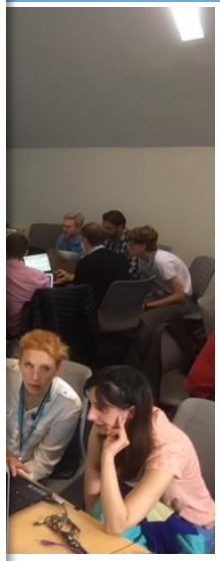

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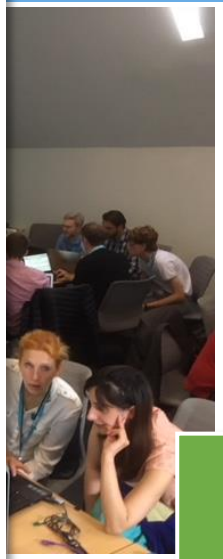
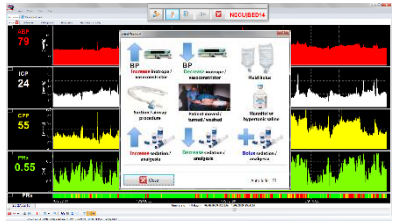


We'll be back soon !

UNIVERS
CAMBR

Brain Physics Lab

So what is ICM+ ?



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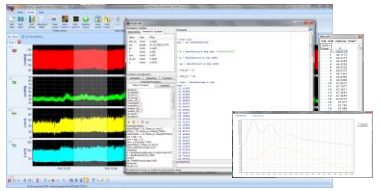

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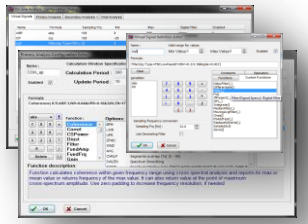

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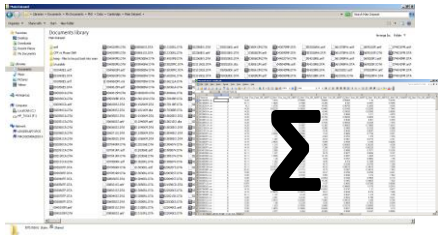

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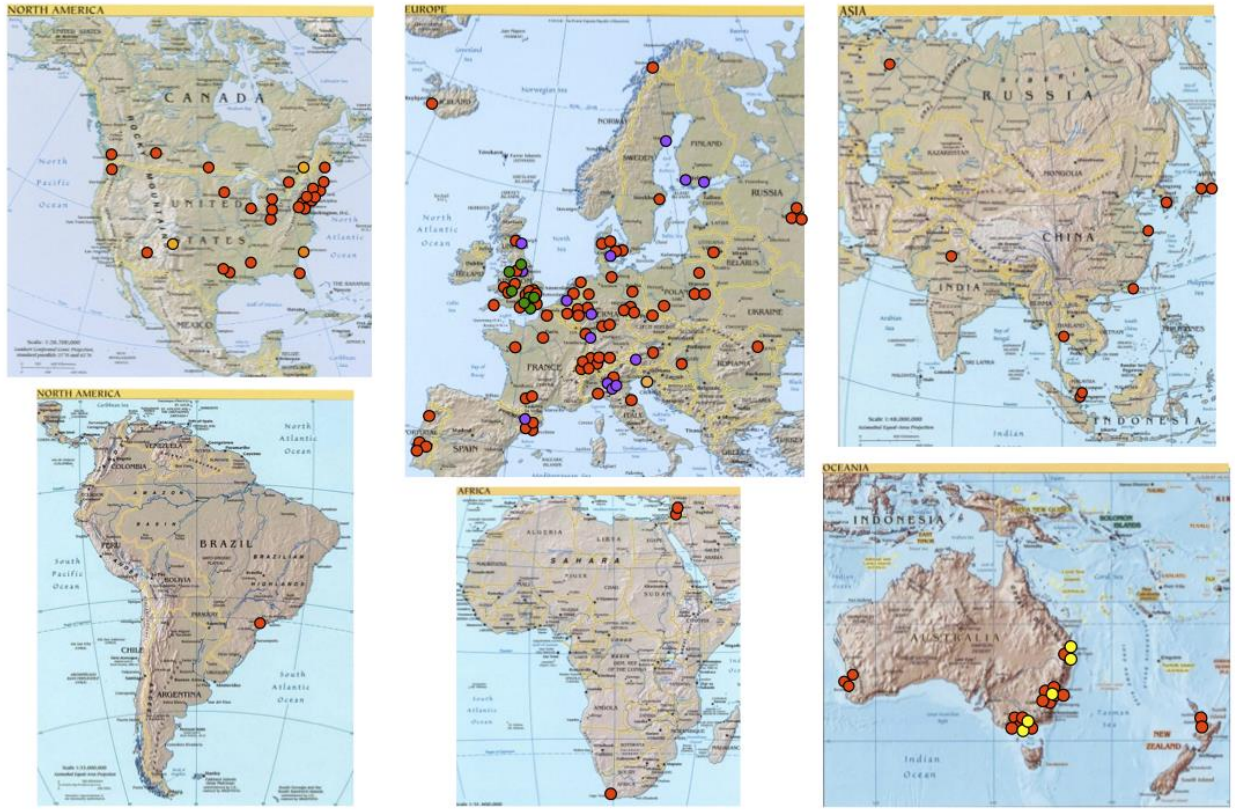
So what is ICM+ ?

Its a thriving and growing community

ICM+ Impact

ICM+ Installations map (Sept 2019)



Key facts

- ✓ **Many 1000s of high resolution datasets from TBI, SAH, NPH and interoperative monitoring distributed across centres**
- ✓ **Over 300 ICM+ based publications on PubMed**
- ✓ **Prx, Optimal CPP, RAP, Closing Diastolic Margins and more**
- ✓ **Multicentre data collection projects**
  - **CENTER-TBI** (22 centres using ICM+ as a data collection platform, 256 patients collected)
  - **Cerebral Oxygenation Monitoring during Cardiac Surgery** (Multicentre, randomised trial, over 600 participants)
  - **Optimal CPP projects** (ICM+ core users group)
  - **COGiTATE** CPPopt feasibility and safety Phase II randomised trial
  - **STARSHIP** – autoregulation monitoring in Paediatric TBI (10 UK centres)
  - **PANGEA** – multicentre neuroprotective drug trial by Pressura-Neuro
- **Continually growing network of like-minded friends in research!**

What are the typical uses of ICM+ ? For clinicians

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- Emerging – autonomic system monitoring

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- Data browsing and extraction using basic stats tools
- Analysis or raw data using simply time based correlation concepts or dedicated functions, like Heart Rate Variability
- Processed trends data export to csv for further processing in Excel or Matlab

ICM+ data collection

Software Configuration

Sampler Configuration Dialog

Digital output devices | Analogue output devices | RS232 ASCII streaming devices

Configured devices with proprietary digital output protocols

Name	Type	Port	Baud ...	Sampl Frq	Enabled
DatexS5	DatexS5	COM1	19200	300	Y
Primus	Primus	COM2	9600	1	Y
INVOS	INVOS	COM3	9600	1	Y

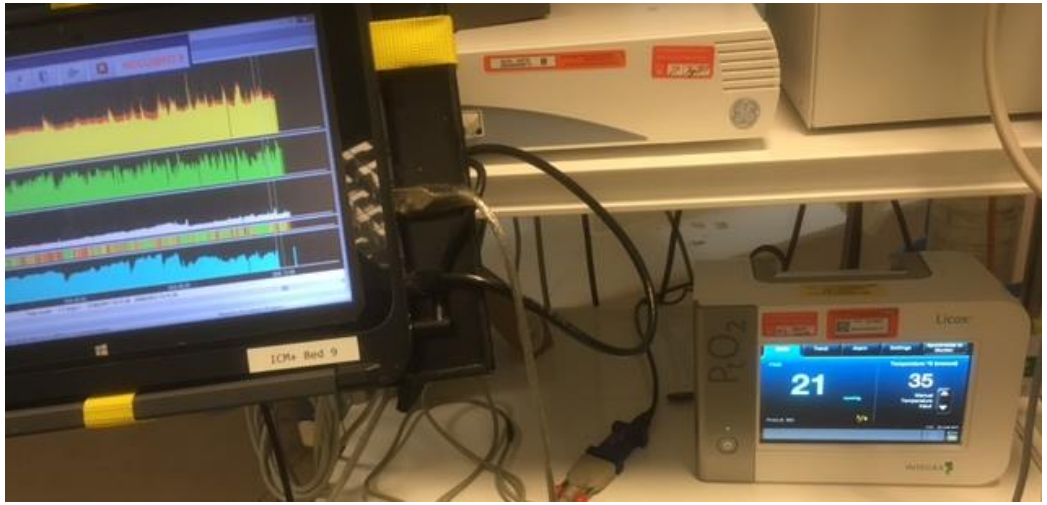
Modify | Add | Delete | Clear

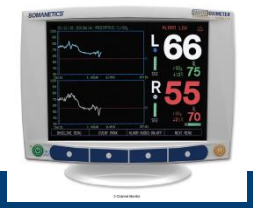
Configured modalities to be collected

Name	Units	Device	Waveform	Min V...	Max ...	Enabled
abp	mmHg	DatexS5	INVP1	0	200	Y
ecg	mmHg	DatexS5	ECG1	-100	100	Y
Temp	Grad	DatexS5	Temp1	0	50	Y
SpO2	%	DatexS5	SpO2	0	300	Y
EtCO2	mmHg	Primus	EtCO2mmHg	0	100	Y
EtO2	%	Primus	EtO2	0	100	Y
PEEP	cmH2O	Primus	PEEP	0	20	Y
MV	ml	Primus	MV	0	20	Y
rSO2l	%	INVOS	rSO2l	0	100	Y
rSO2r	%	INVOS	rSO2r	0	100	Y

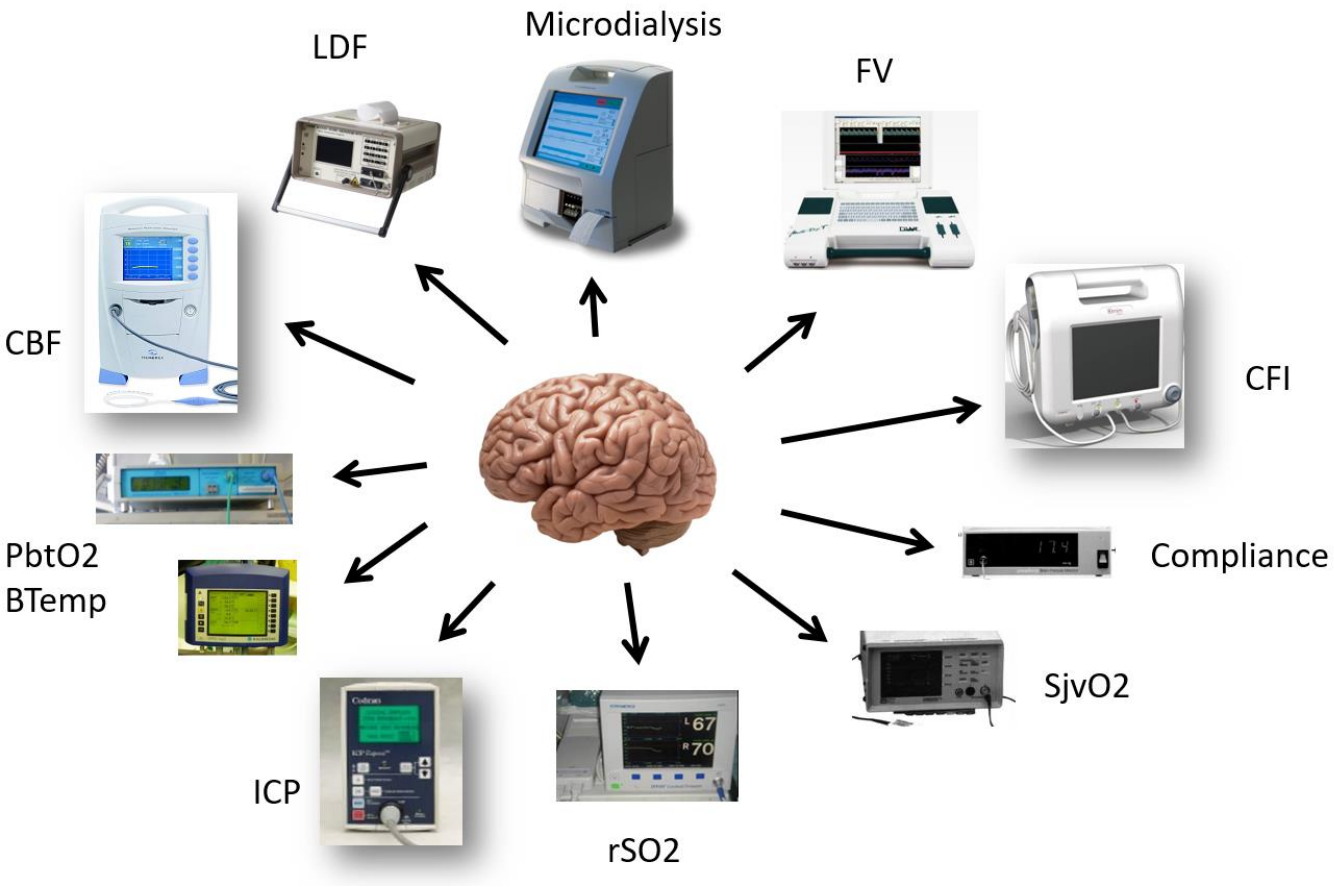
Modify | Add | Delete | Clear

OK | Cancel | Save | Load | Advanced | Keyboard

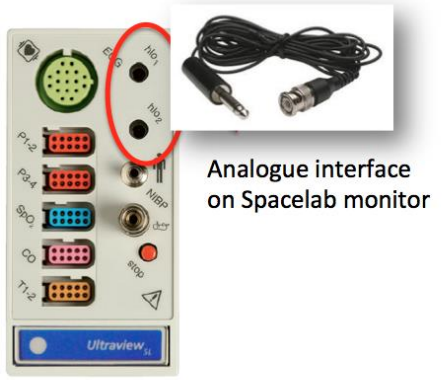




ICU monitoring devices and their modes of data export

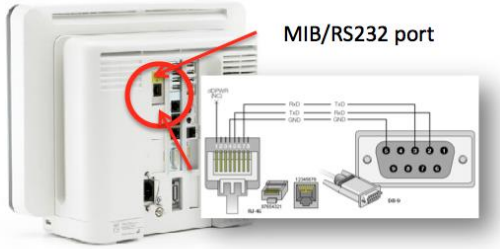


Classic serial port on GE Datex-Ohmeda monitor



Analogue interface
on Spacelab monitor

RJ45 serial connector on Philips



MIB/RS232 port

USB serial connector on GE Carescape

Network connector
On Benevision monitors

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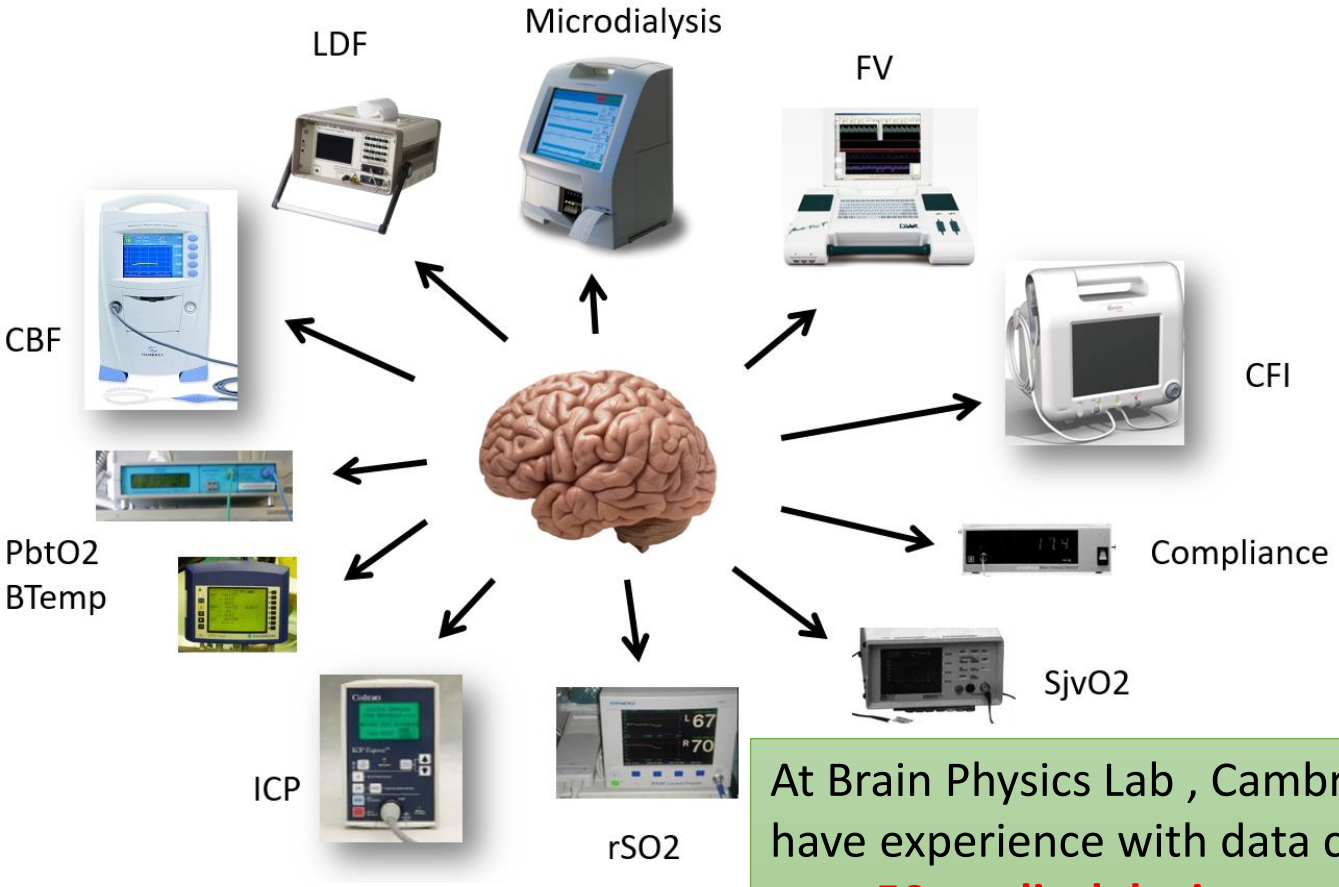

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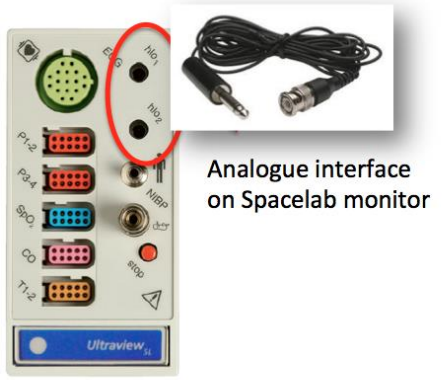
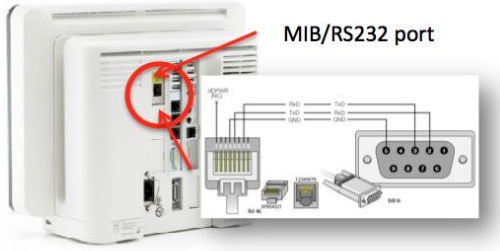


RJ45 serial connector on Philips



USB serial connector on GE Carescape

ector
monitors

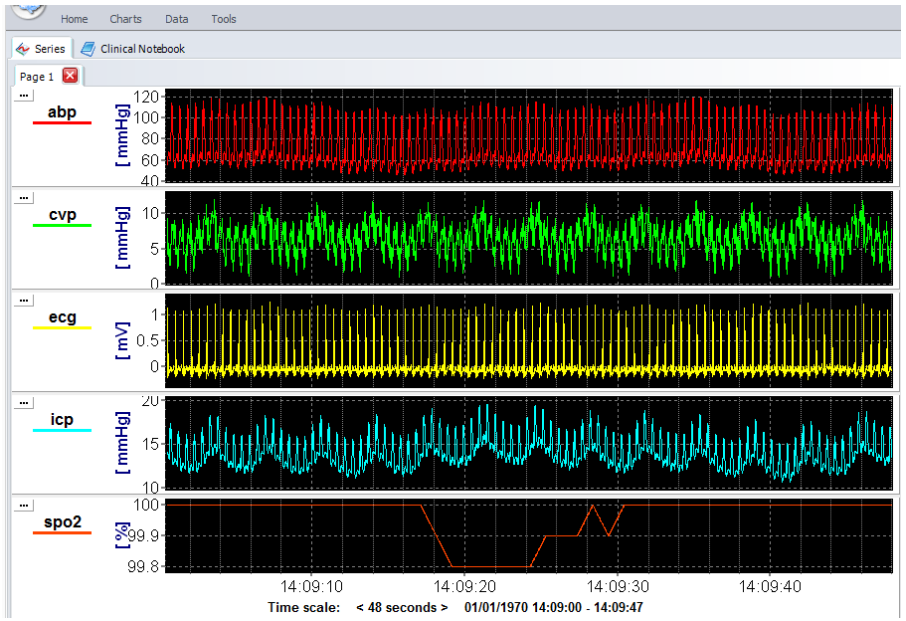
At Brain Physics Lab , Cambridge, UK, we have experience with data collection from **over 50 medical devices** – **there are no two with the same specification** for data export (hardware and software) !

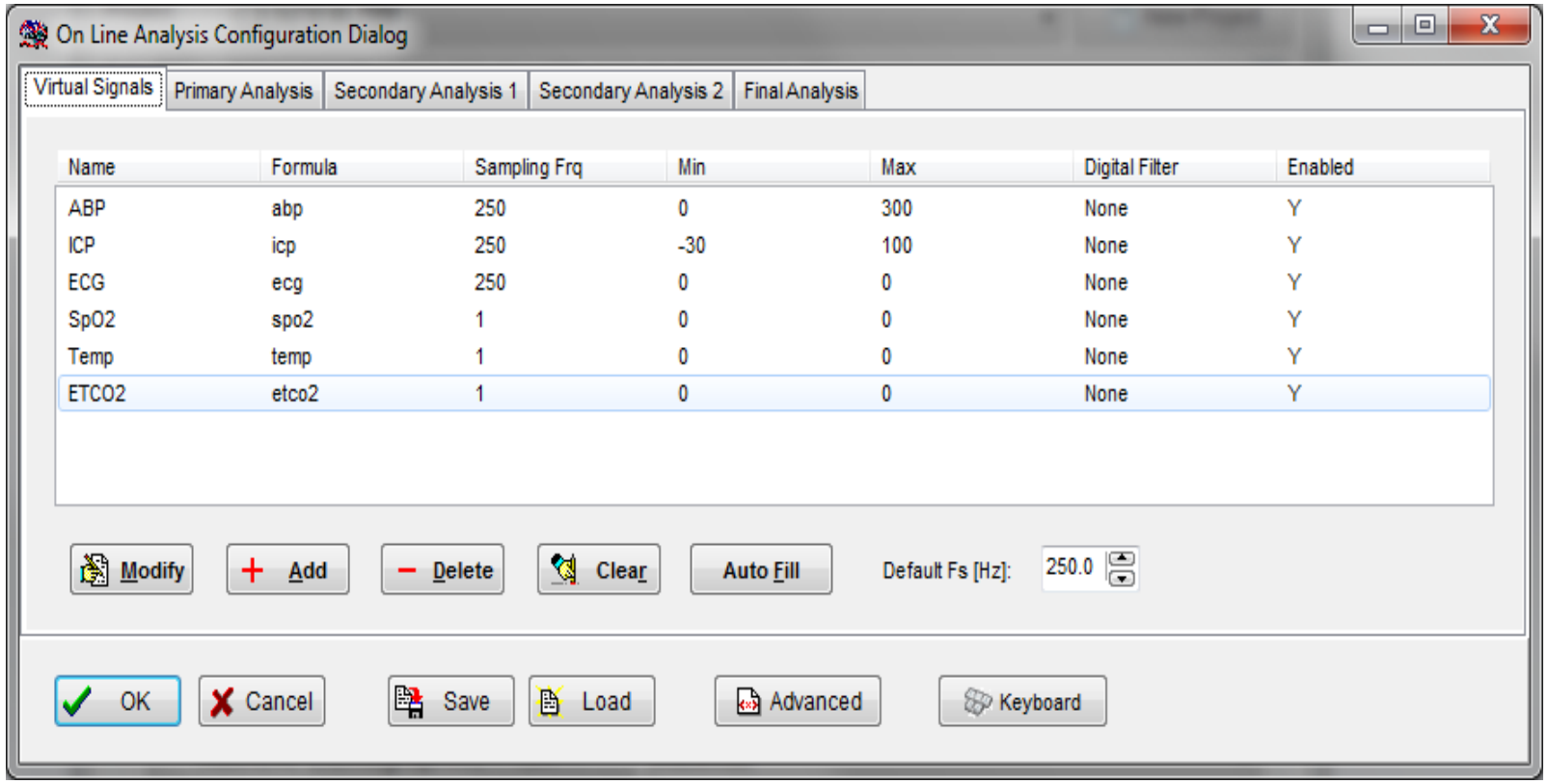
Data collection: supported monitors (Sept 2019)

- ASPECT BIS monitor, A2000 & Vista
- CMA Microdialysis monitor
- CNAP non-invasive ABP monitor
- Data Translation A/D Converter
- Delica TCD
- Draeger Medibus module
- Draeger MedibusX Module
- Draeger WinAccess Module
- DWL TCD monitors
- Edwards Vigileo monitor
- Foresight CASMED NIRS monitor
- Finapress non-invasive ABP monitor
- GE Carescape monitor
- GE Dash monitors
- GE Datex-Ohmda monitor
- GE Solar monitors
- Hemedex CBF monitor
- Hamamatsu NIRO monitors
- ICON Cardiac Output monitors
- Integra Camino ICP monitor
- Integra Licox 2 PbtO2 monitor
- Integra Licox PbtO2 monitor
- Integra Cere-Link
- IntelliVue MP and MX monitors
- Neural Analytics Lucid TCD
- Maquet Servo-i ventilator
- Masimo Root/Radical monitors
- Medtronic INVOS NIRS monitor
- Mennen monitor
- Mindray Benevision monitors
- Moberg CNS Monitor
- Nexfin non-invasive ABP monitor
- Nonin RespSense monitor
- Nonin SenSmart monitor
- Oridion Capnostream monitor
- Ornim CerOx monitor
- PiCCO2 monitor
- Portalite NIRS
- Puritan Bennett 840 Ventilator
- Raumedic Datalogger monitors
- Rimmed TCD monitor
- Spacelab Ultraview monitor
- Sophysa Pressio ICP monitor
- Sophysa Pressio 2 ICP monitor
- Spencer TCD monitor
- Spiegelberg monitor

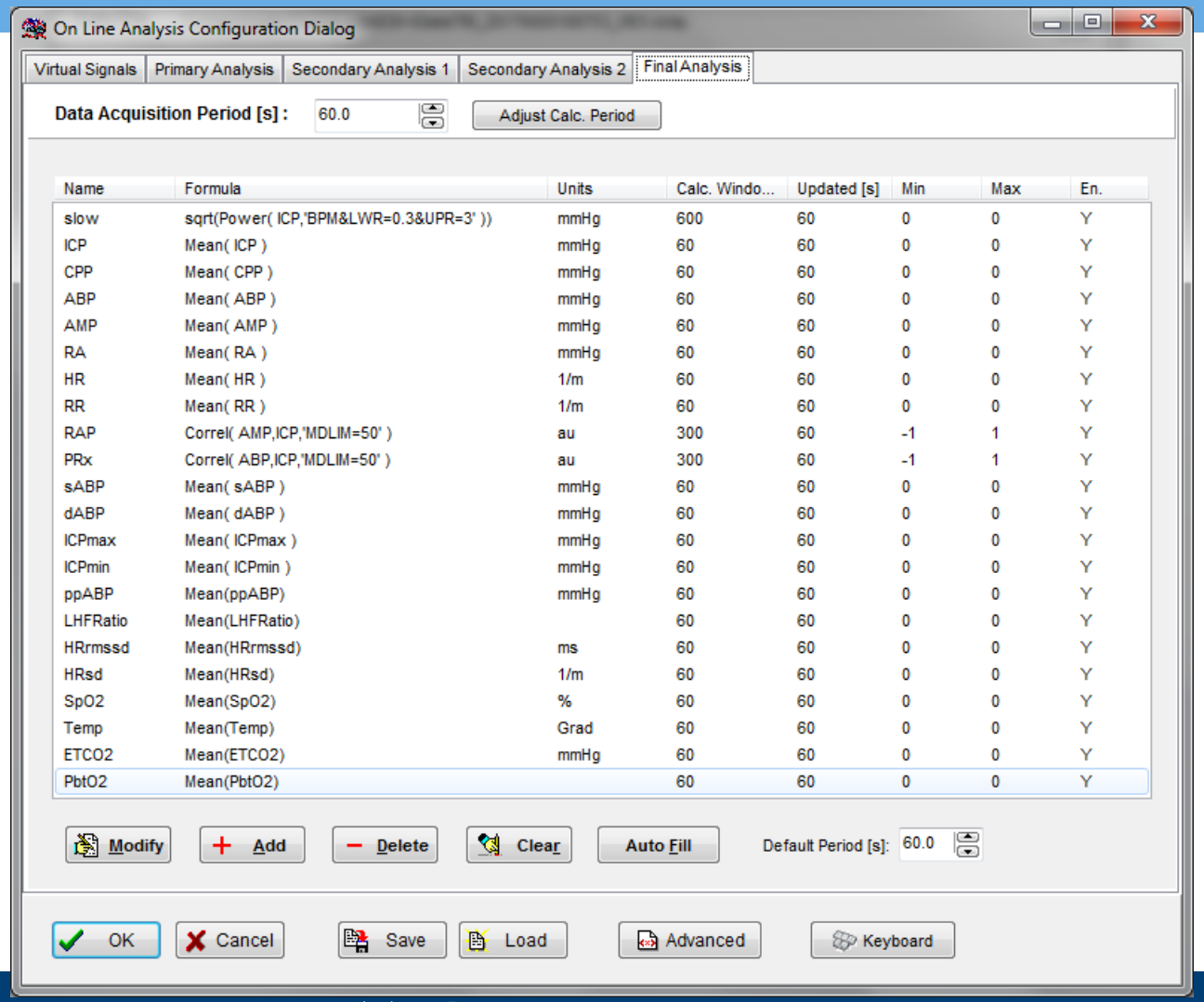
- Any monitor with an analogue output

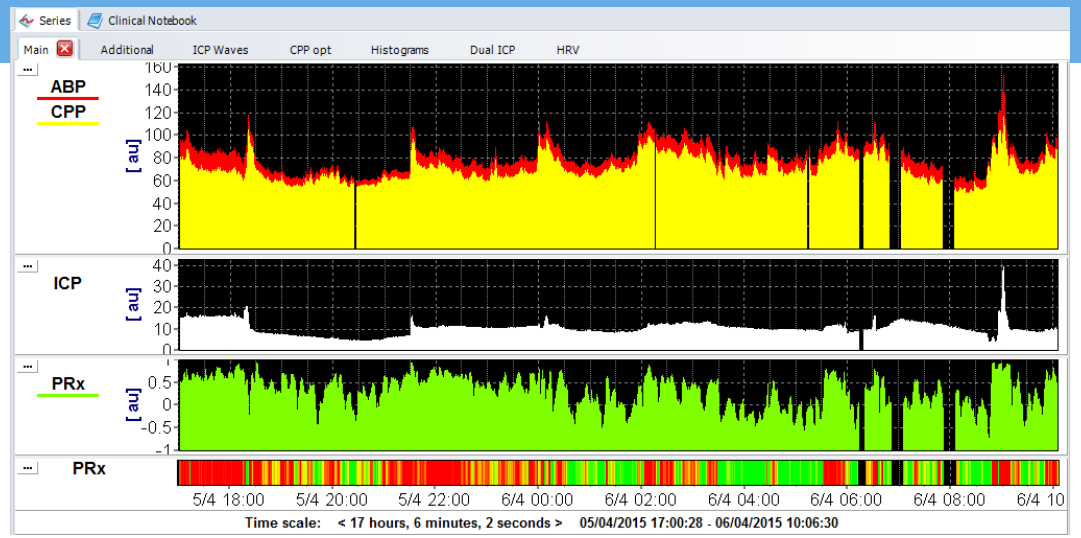
The true essense of ICM+ : the real time calculation engine

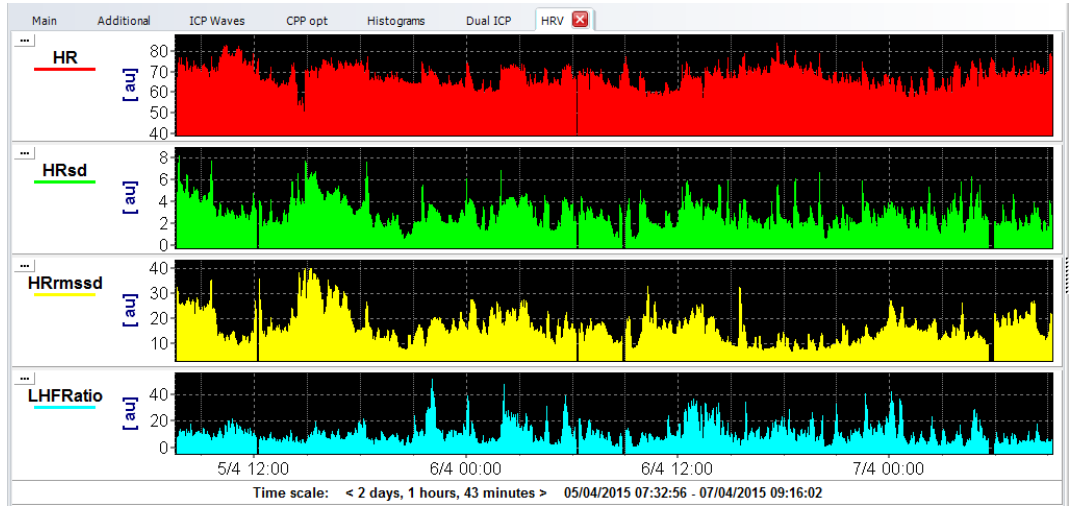




Calculation pipeline allows putting together complex analysis in a simple way







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The more established secondary indices based on waveforms analysis

Cerebral Autoregulation

Mx

ORx

COx

PAx

PRx

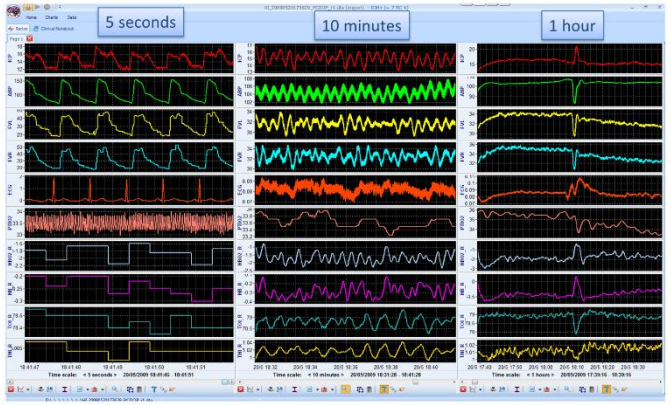
ARI

Optimal Arterial And Cerebral Perfusion pressure

Complexity of Homeostatic Regulation

MSE

Entropy



CPPopt

ABPopt

RAP

Non-invasive ICP

nICP

nCPP

Brain Compliance

Ci

Arterial walls properties

CM

CrCP

Ca

HRV

BRS

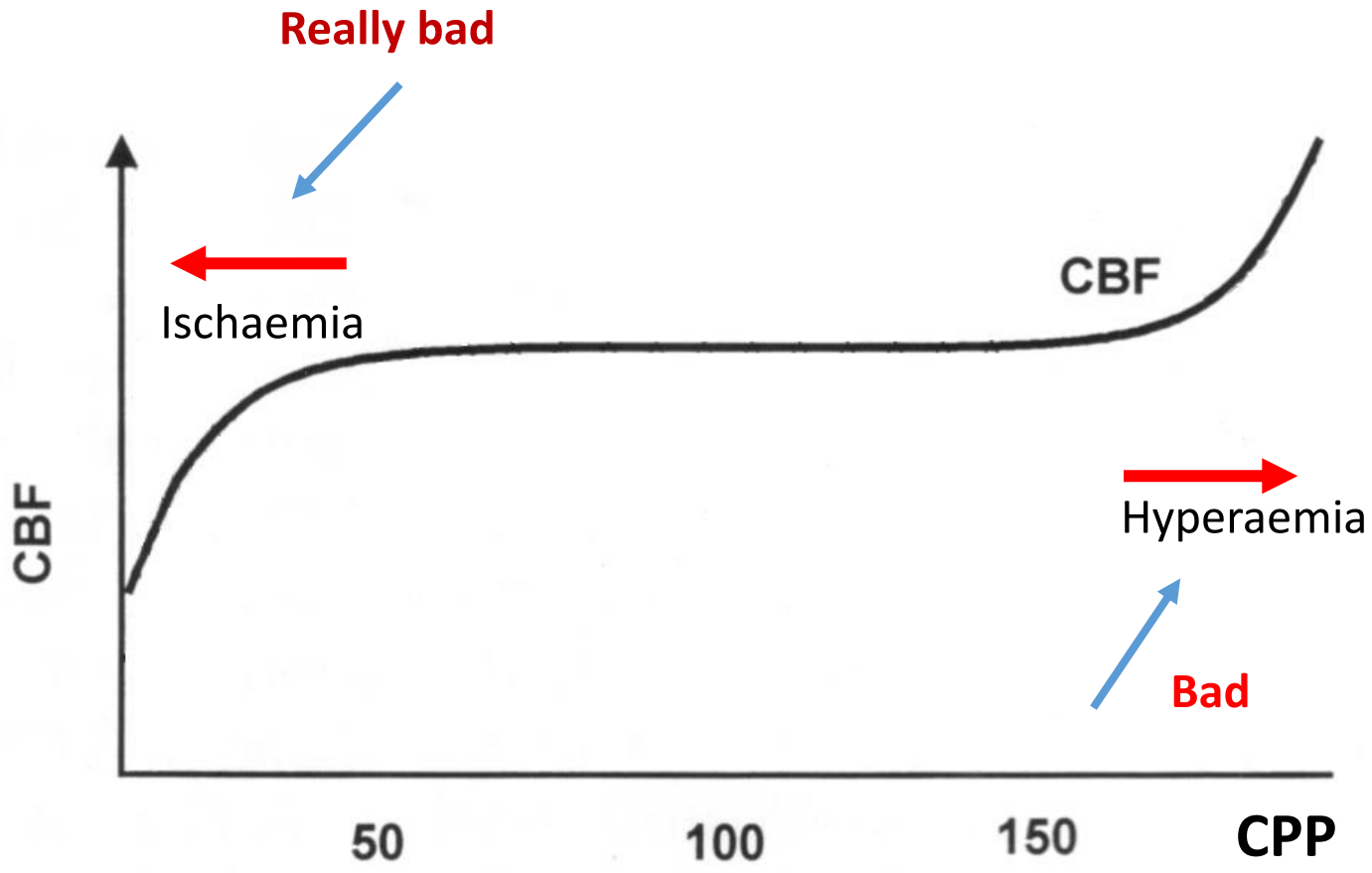
Tau

Autonomic system

Cerebrovascular Compliance

Monitoring of cerebral autoregulation in TBI

Monitoring cerebral autoregulation is easily disturbed in TBI



Monitoring cerebral autoregulation is easily disturbed in TBI

- "Minor head injury": 28% impaired
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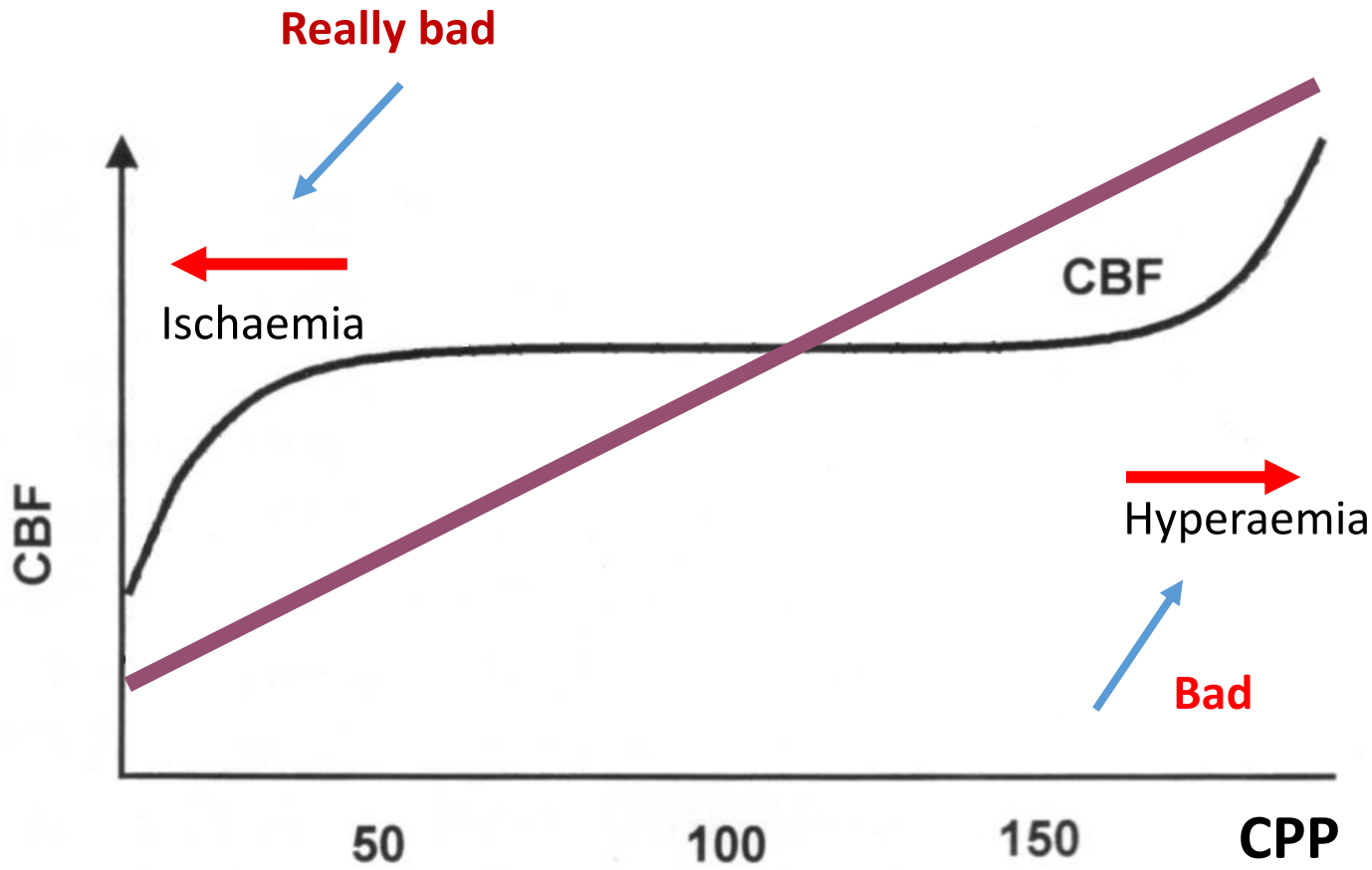

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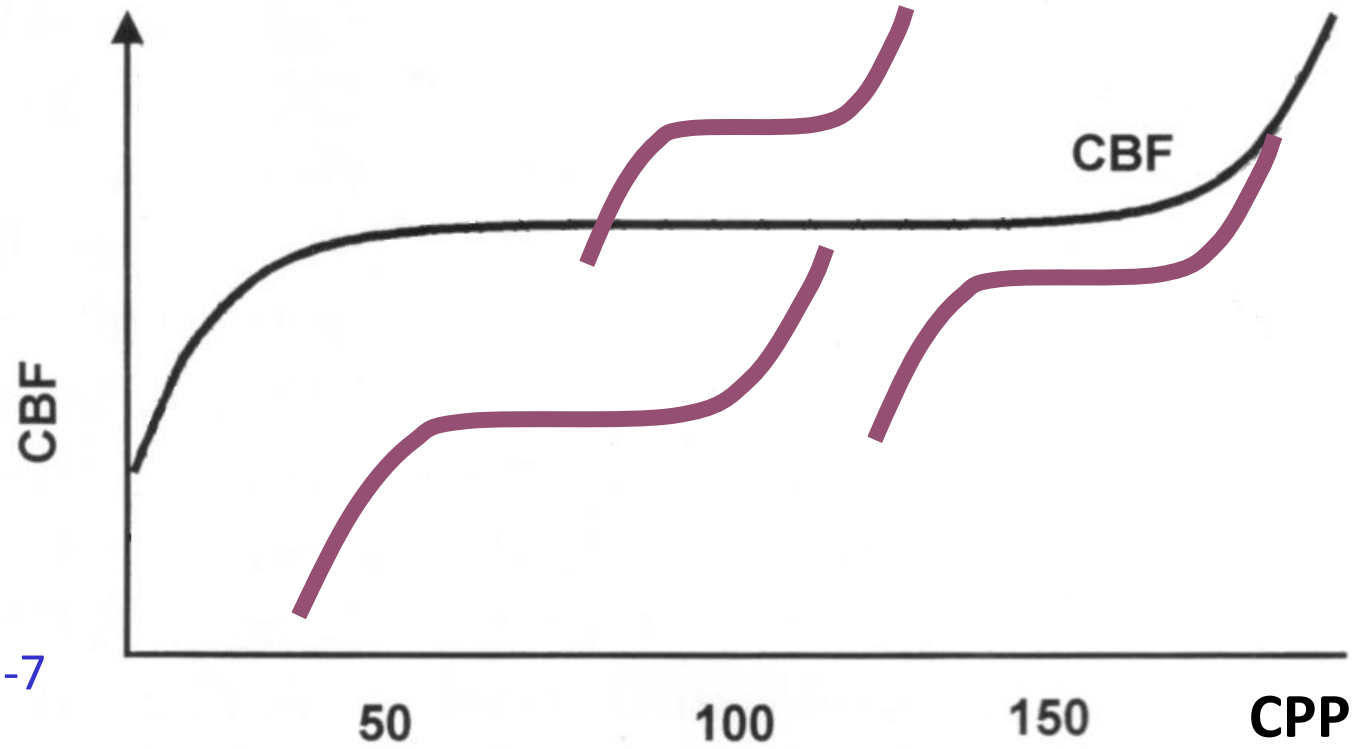
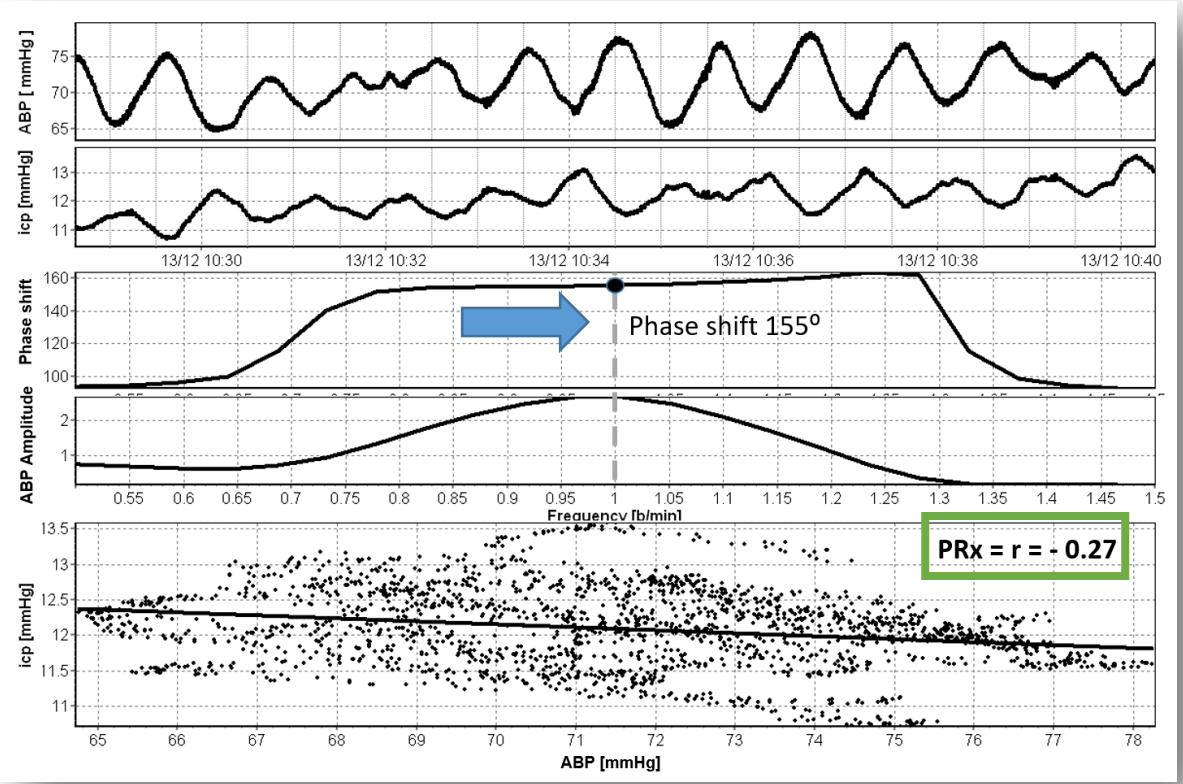
- Upper limit shifted to the left
  Hauerberg J, et al. J Neurosurg Anesthesiol 1998;10(2):106-12
- Lower limit shifted to the right
  Cremer OL, et al. Anesth Analg 2004;99(4):1211-7

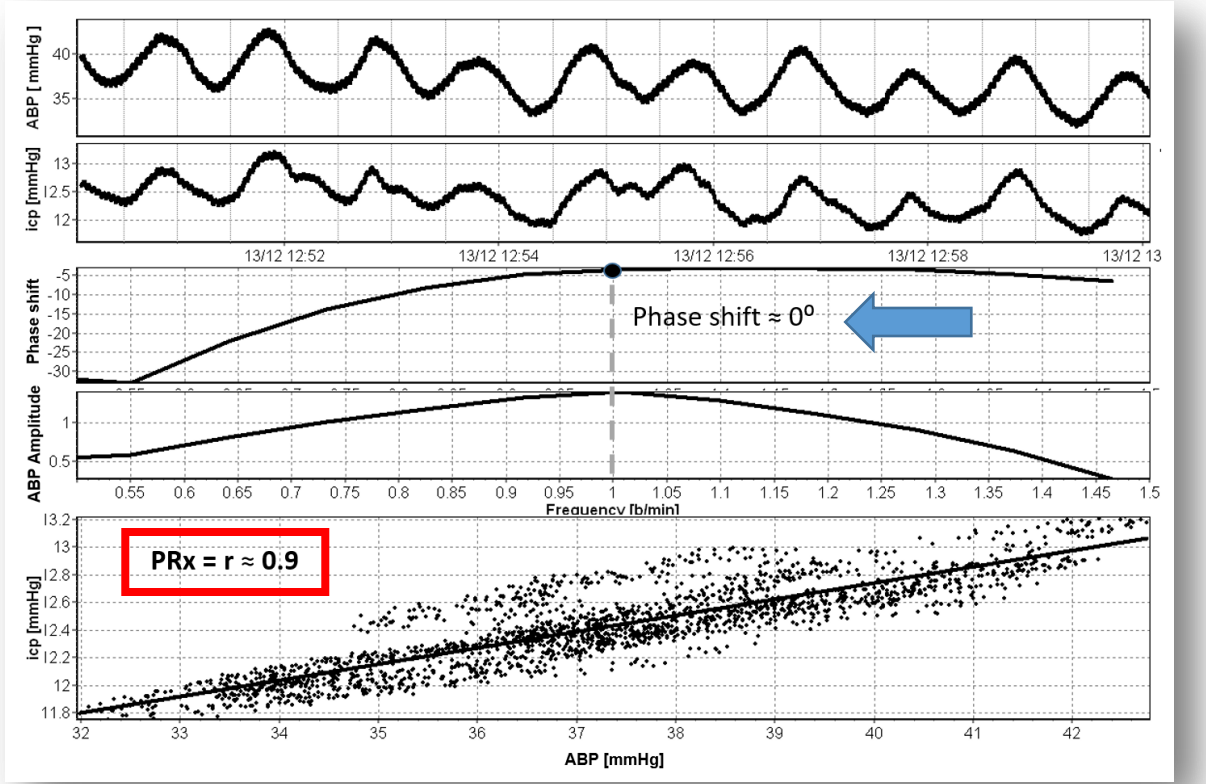


Pressure reactivity index PRx

Good pressure reactivity



Poor pressure reactivity



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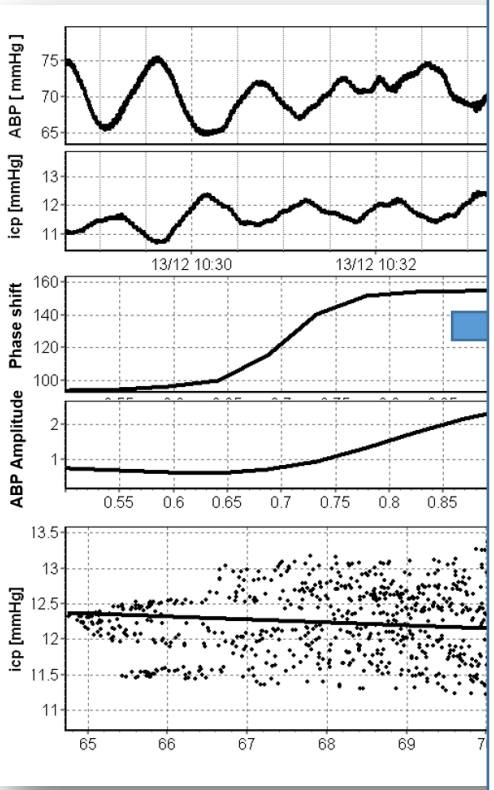

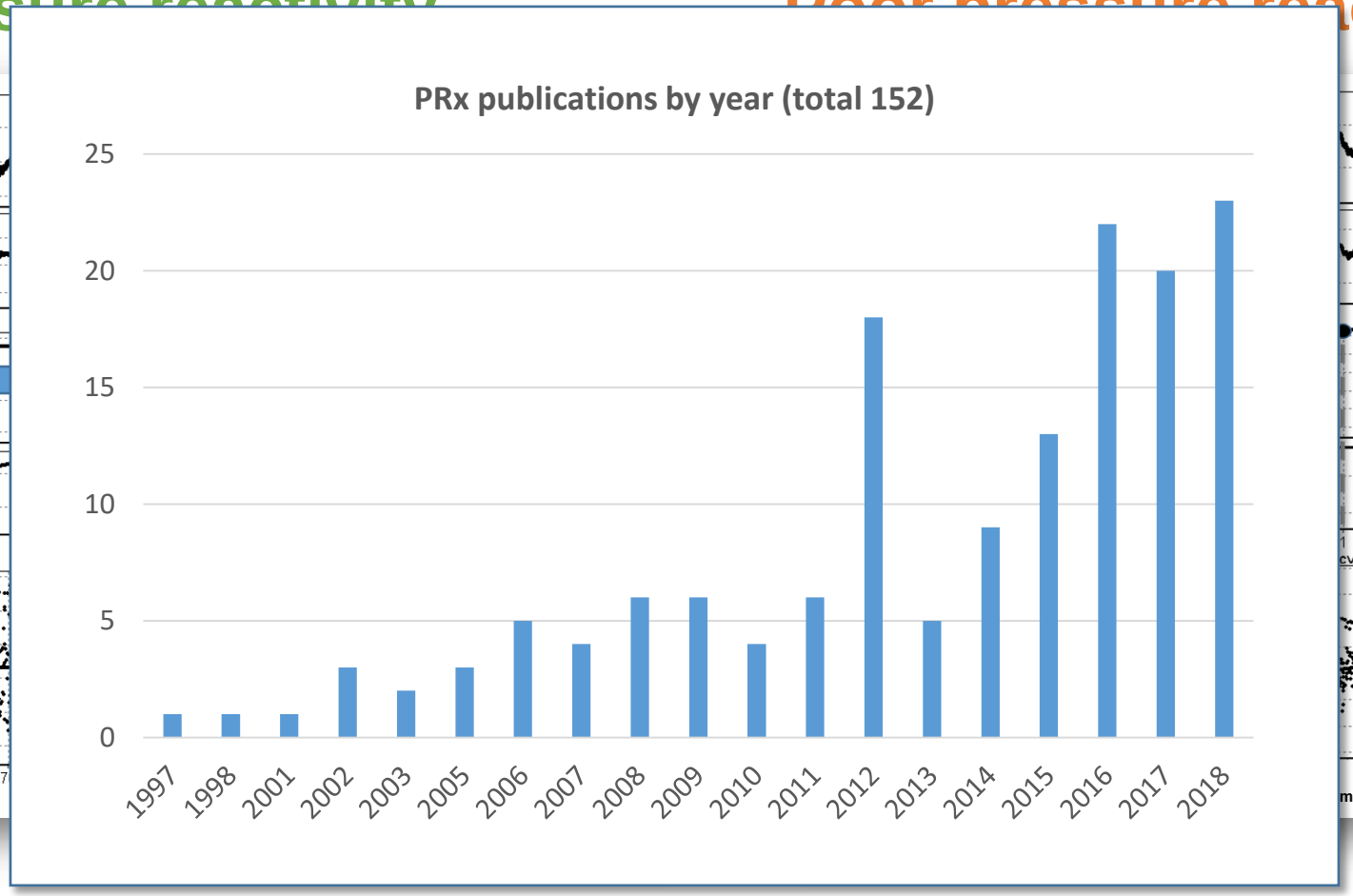

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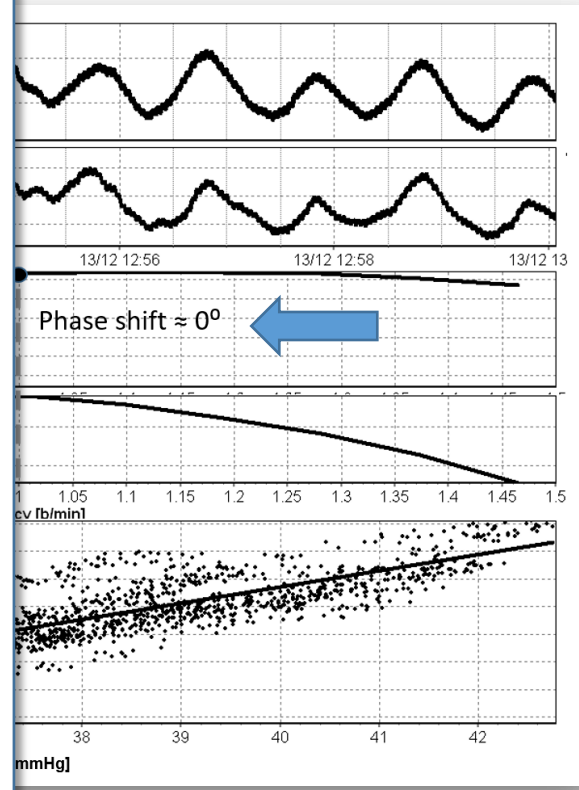
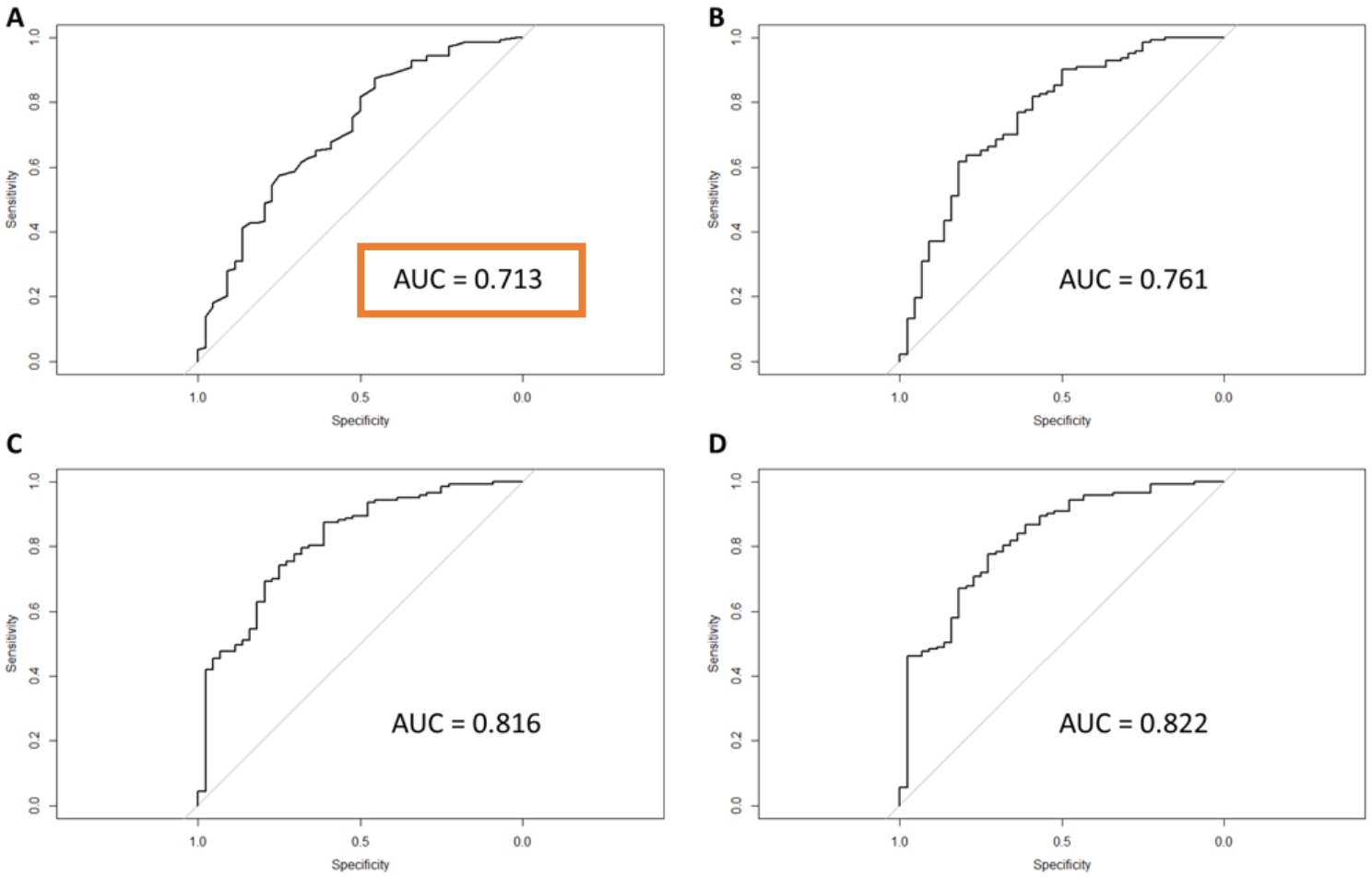


PRx and the IMPACT model – CENTER-TBI data (N=185, 22 centres)

IMPACT model *

Age,
GCS Motor,
pupillary response

* Model for outcome prediction based on parsimony, N = 10,000



IMPACT model
+ ICP

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+ % (PRx > 0.25)

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Thanks to Fred Zeiler

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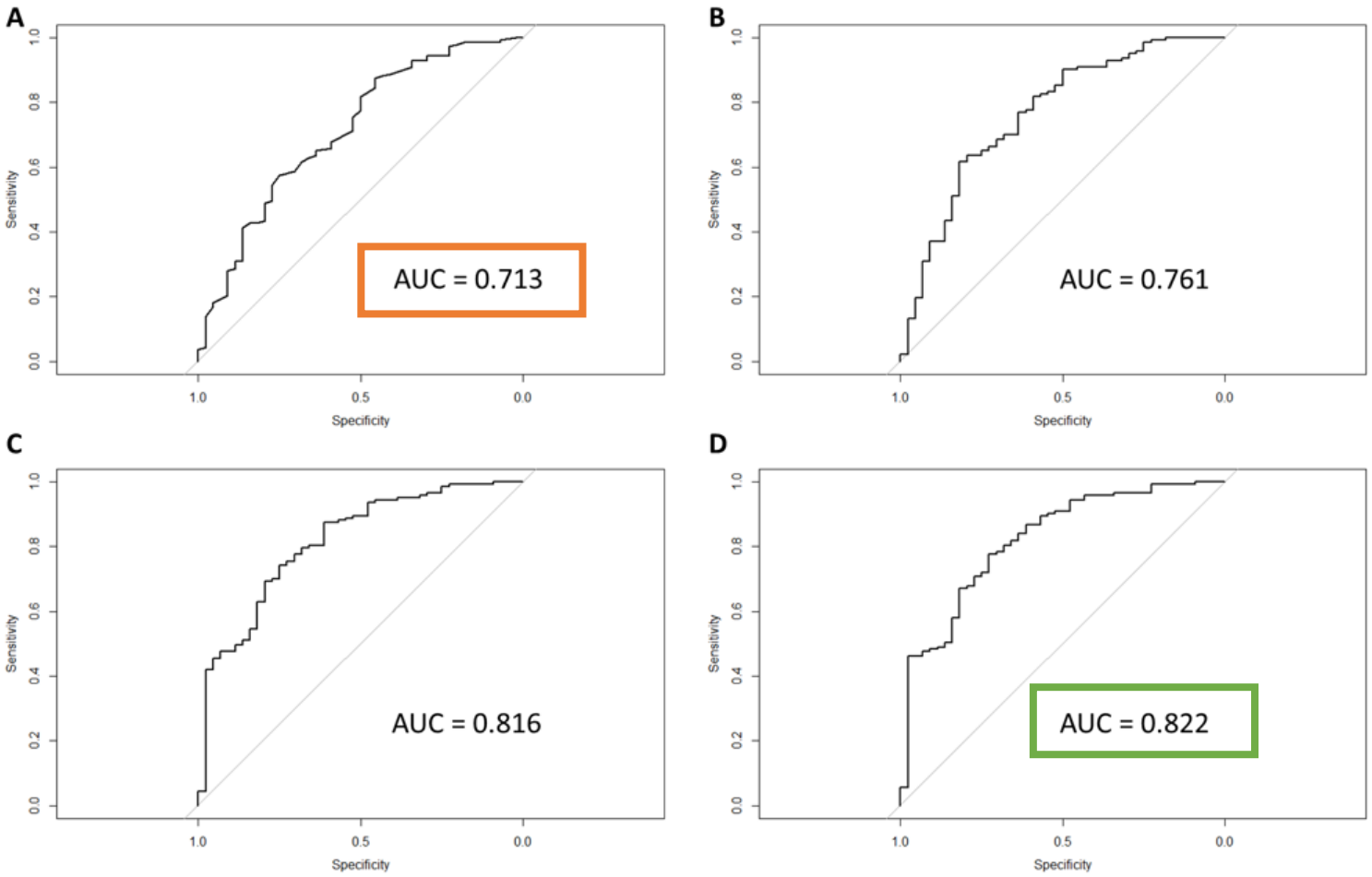

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TBI guidelines 2016

Brain Trauma FOUNDATION

- ICP < 22 mmHg
- CPP 60-70 mmHg
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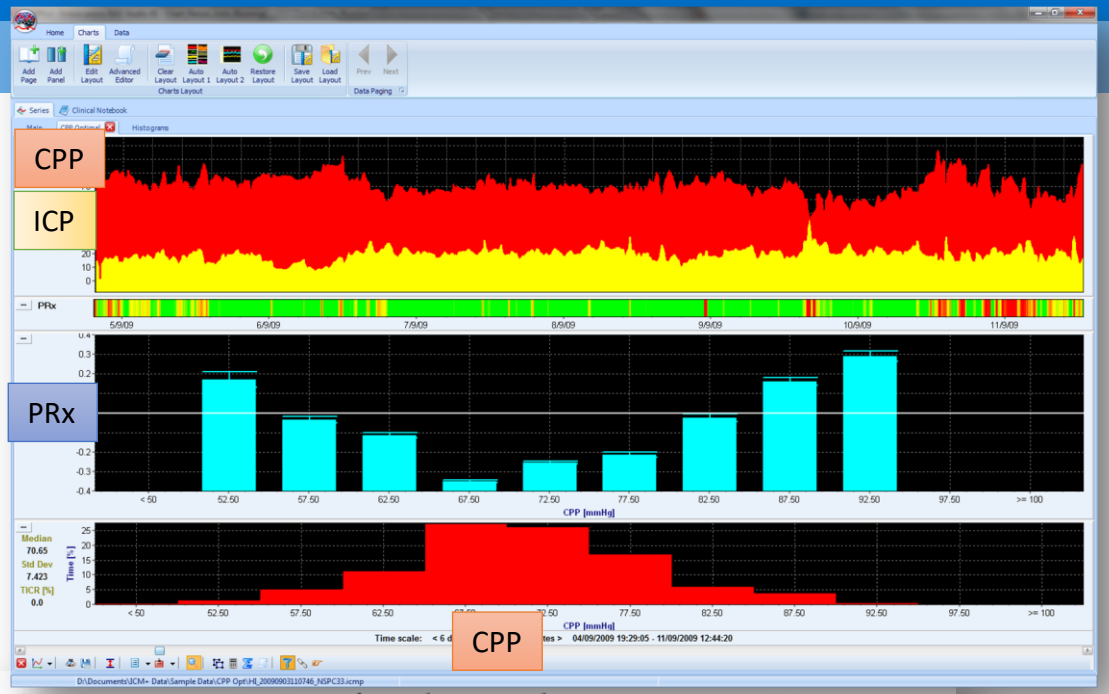
How to incorporate autoregulation into the clinical management protocol of TBI patients ?

Individualising Cerebral Perfusion Pressure Management



Continuous monitoring of cerebrovascular pressure reactivity allows determination of optimal cerebral perfusion pressure in patients with traumatic brain injury

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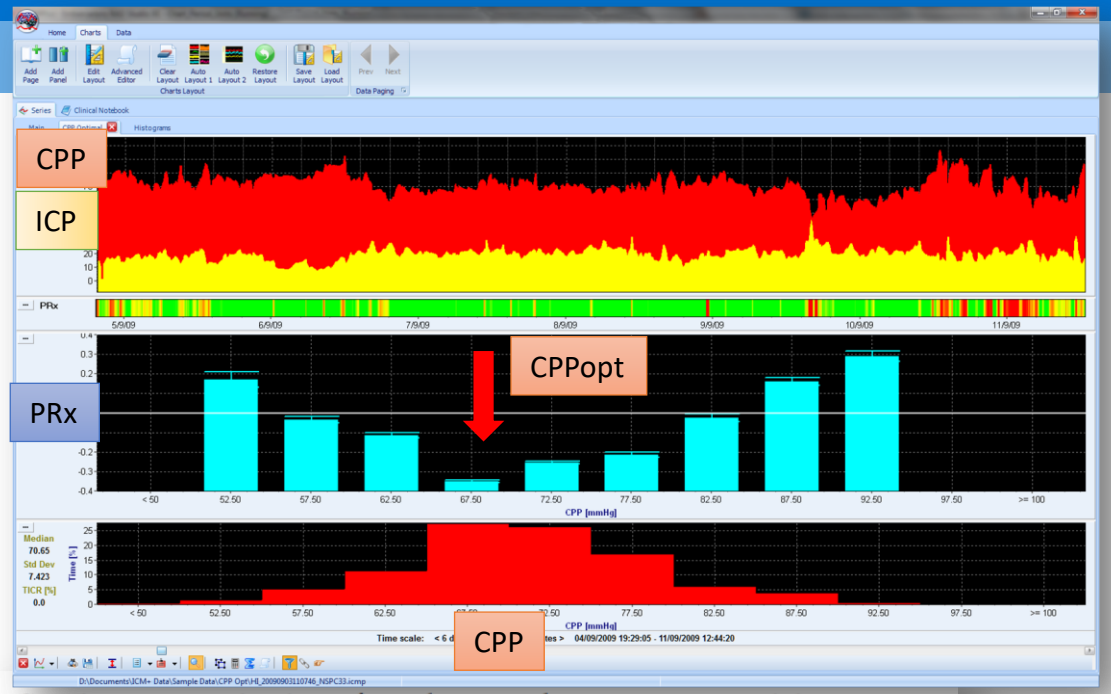

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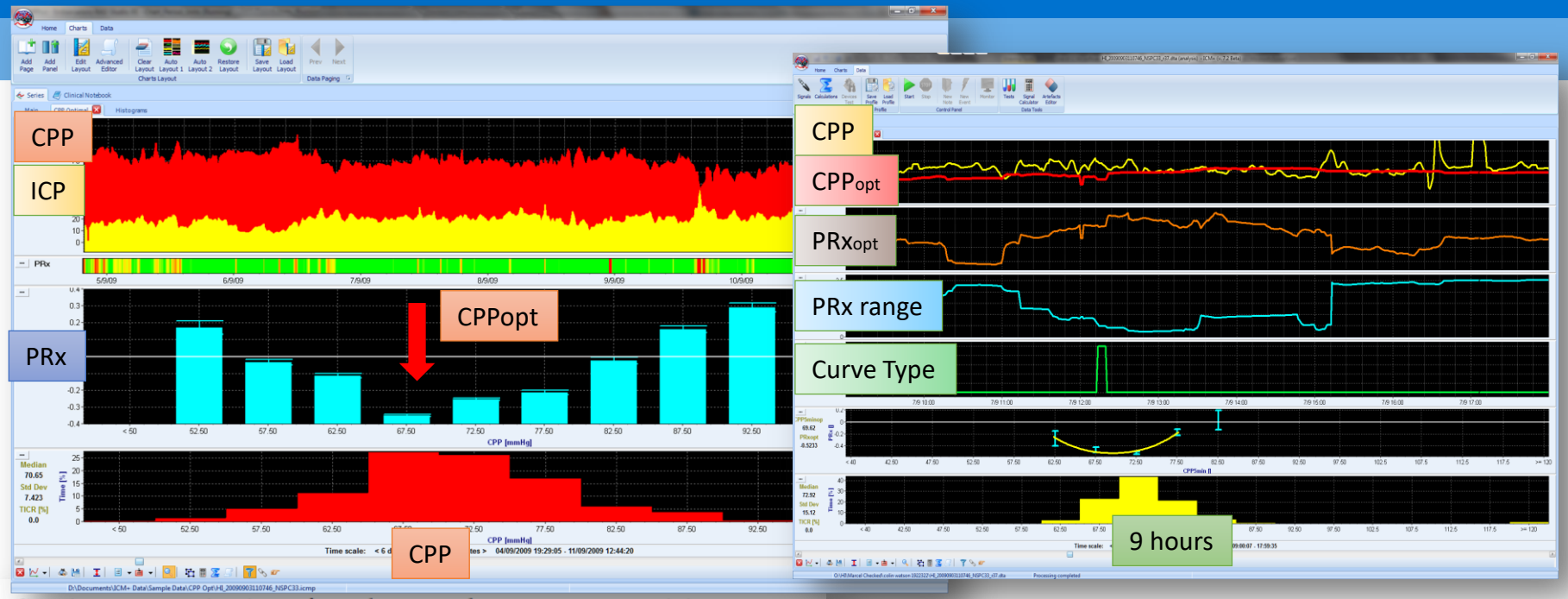

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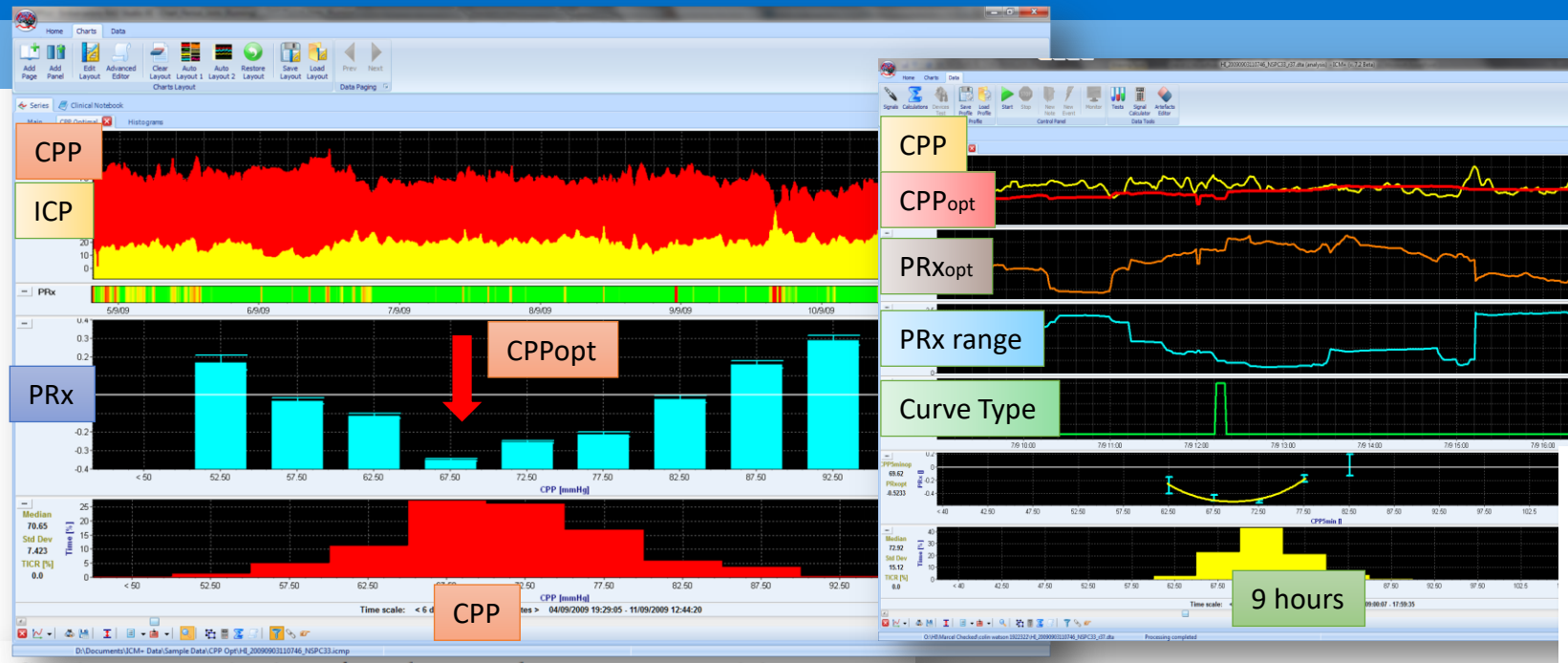

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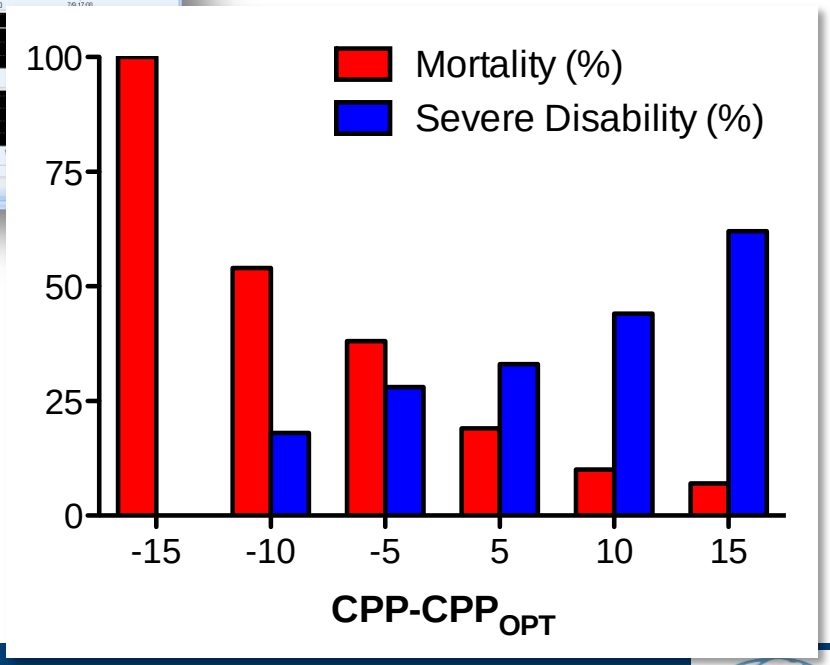

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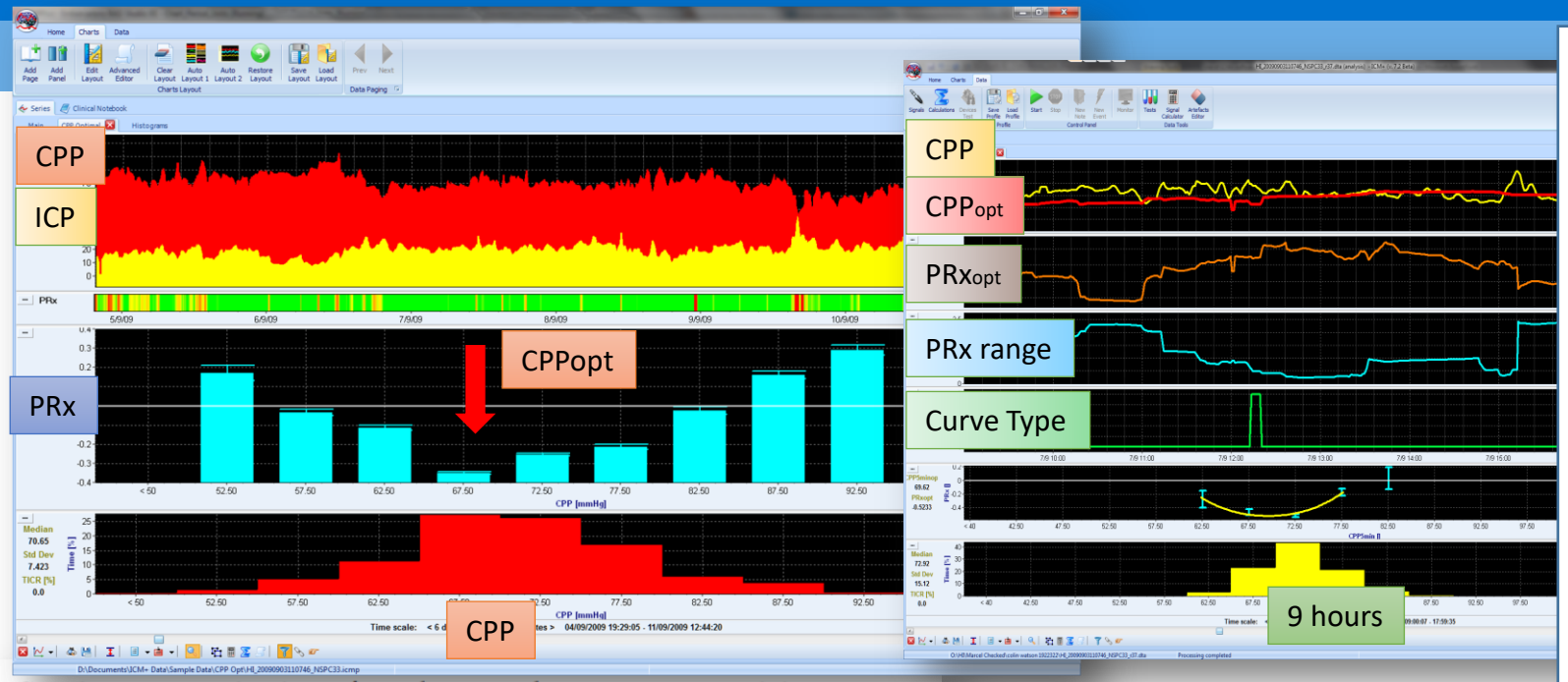

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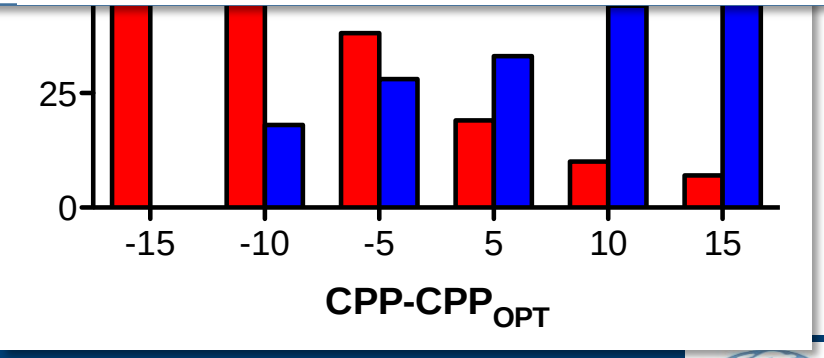
Consensus summary statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical Care

A statement for healthcare professionals from the Neurocritical Care Society and the European Society of Intensive Care Medicine

injury [46].

More refined monitoring of autoregulatory efficiency is now possible through online calculation of derived indices such as the pressure reactivity index (PRx) [45].

About two-thirds of TBI patients have an optimum CPP range (CPPopt) where their autoregulatory efficiency is maximized, and that management at or close to CPPopt is associated with better outcomes [47]. The safety of titrating therapy to target CPPopt requires further study, and validation in a formal clinical trial before it can be recommended.



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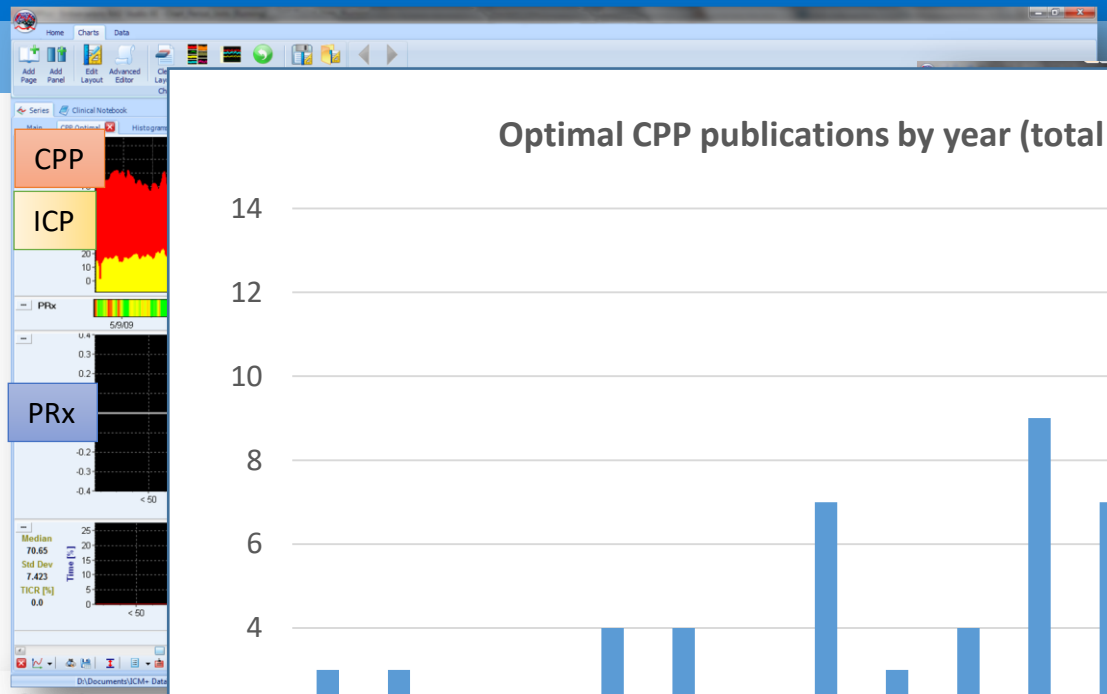

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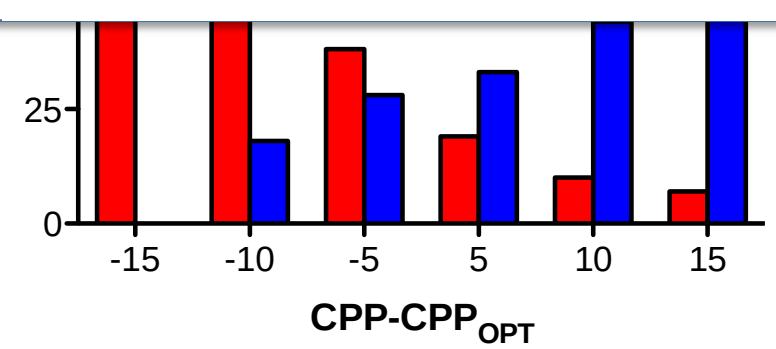

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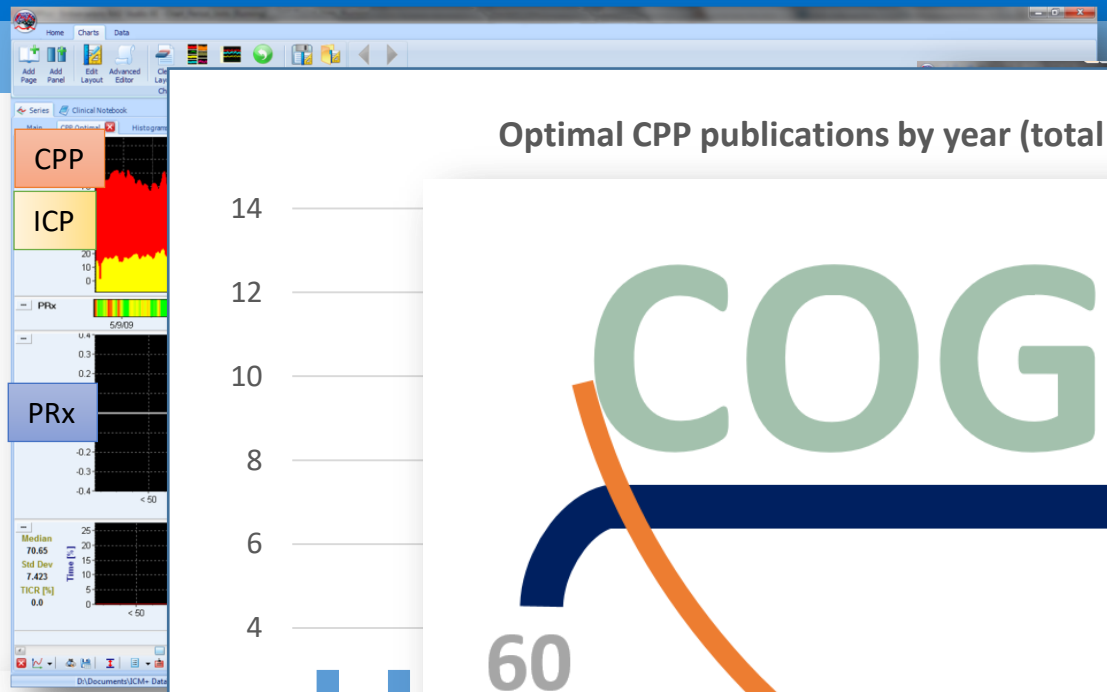

Optimal CPP publications by year (total 93)

COGiTATE

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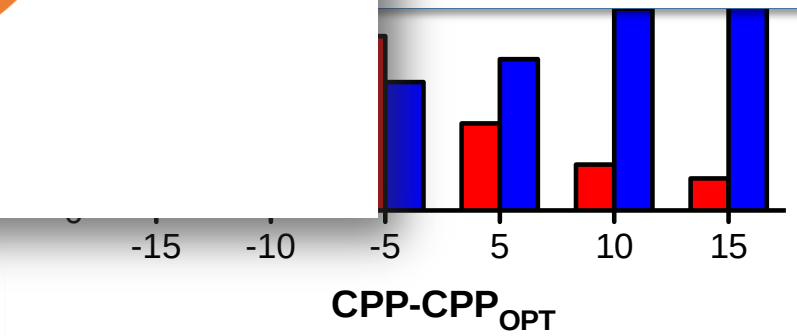

Optimising Arterial Blood Pressure

Critical Care Medicine. Publish Ahead of Print(): , JULY 26, 2019
DOI: 10.1097/CCM.0000000000003908, PMID: 31356469
Issn Print: 0090-3493
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Print

Optimizing Mean Arterial Pressure in Acutely Comatose Patients Using Cerebral Autoregulation Multimodal Monitoring With Near-Infrared Spectroscopy

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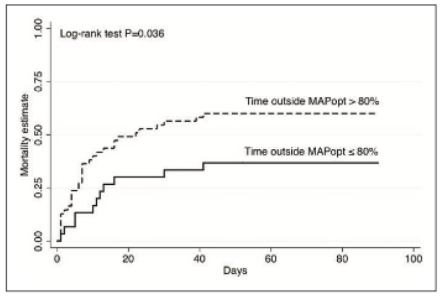

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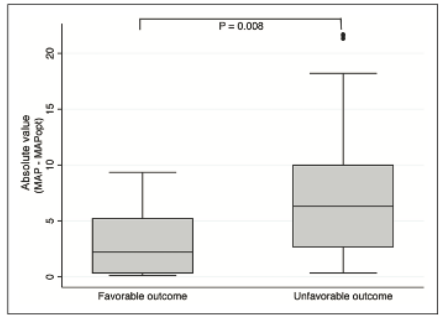

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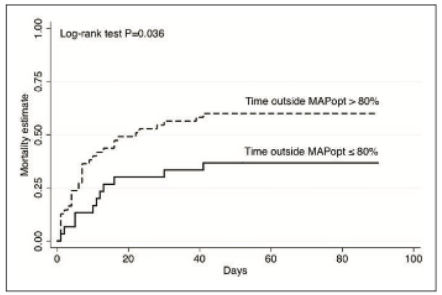

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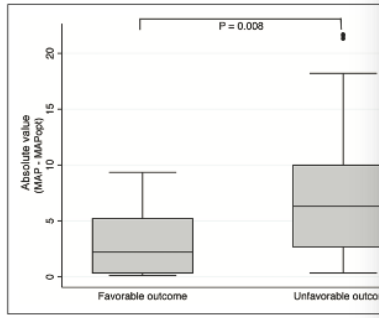

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JAMA Surgery | Original Investigation

Effect of Targeting Mean Arterial Pressure During Cardiopulmonary Bypass by Monitoring Cerebral Autoregulation on Postsurgical Delirium Among Older Patients

A Nested Randomized Clinical Trial

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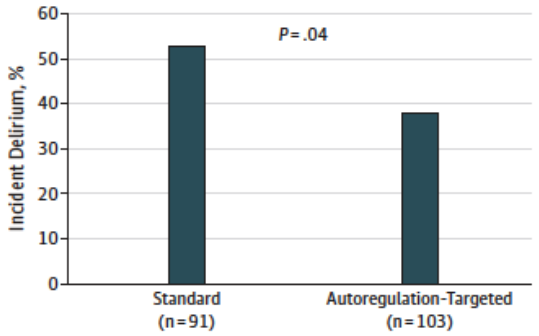
Figure 2. Delirium Incidence by Randomization Group

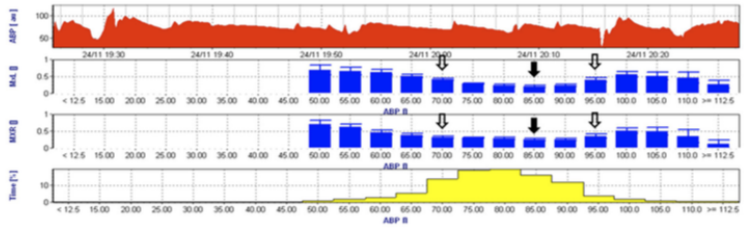


Mean arterial pressure during cardiopulmonary bypass was managed according to standard care or autoregulation-targeted goals. Delirium incidence by randomization group is shown.

Optimal blood pressure during cardiopulmonary bypass defined by cerebral autoregulation monitoring

Read at the 96th Annual Meeting of The American Association for Thoracic Surgery, Baltimore, Maryland, May 14-18, 2016.

Daijiro Hori MD [a], Yohei Nomura MD [a], Masahiro Ono MD [b], Brijen Joshi MD [c], Kaushik Mandal MD [a], Duke Cameron MD [a], Masha Kocherginsky PhD [d], Charles W. Hogue MD [e]



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Representative graph of cerebral autoregulation monitoring by mean velocity index (Mx) during cardiopulmonary bypass. The top graph represents the time-series of arterial blood pressure (ABP) while the bottom bar-graph the percentage of the time of the recording spent at 5 mmHg bin. Optimal mean arterial pressure (MAP, ABP) for the left and right side of the brain was defined as that MAP with the lowest Mx. Lower limit of cerebral autoregulation (LLA) and upper limit of cerebral autoregulation (ULA) were defined as the MAP at which

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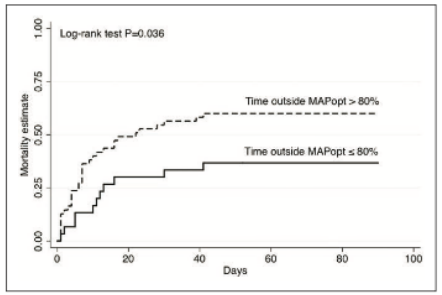

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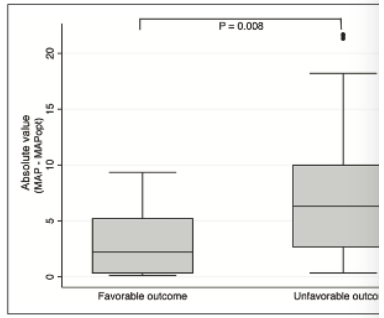

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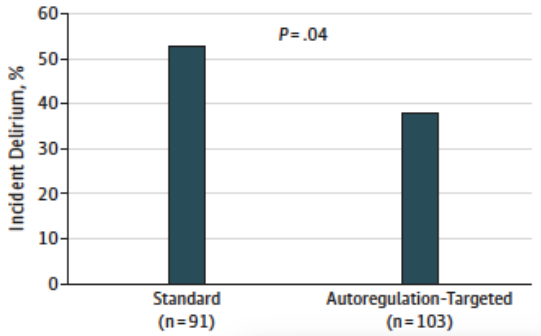

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Optimal blood pressure during cardiopulmonary bypass defined by cerebral autoregulation monitoring

Read at the 96th Annual Meeting of The American Association for Thoracic Surgery, Baltimore, Maryland, May 14-18, 2016.

Daijiro Hori MD [a], Yohei Nomura MD [a], Masahiro Ono MD [b], Brijen Joshi MD [c], Kaushik Mandal MD [a], Duke Cameron MD [a], Masha Kocherginsky PhD [d], Charles W. Hogue MD [e]

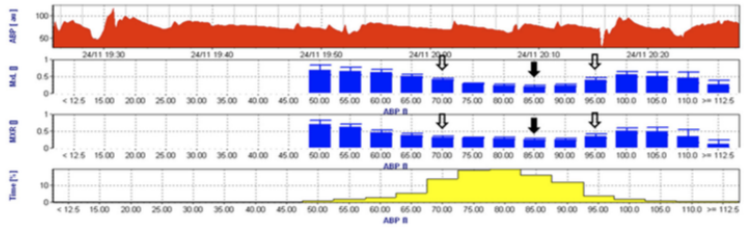

Figure 2.
Representative graph of cerebral autoregulation monitoring by mean velocity index (Mx) during cardiopulmonary bypass. The top graph represents the time-series of arterial blood pressure (ABP) while the bottom bar-graph the percentage of the time of the recording spent at 5 mmHg bin. Optimal mean arterial pressure (MAP, ABP) for the left and right side of the

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Individualizing intraoperative management of arterial blood pressure to optimize cerebral autoregulation during neurosurgery

E. Beqiri[1-2], M. García-Orellana[3], A. Politi[4], R. Valero[3], N. Fàbregas[3], J. Tas[5], V. de Sloovere[6], M. Czosnyka[1], M. Aries[5], N. de Riva[3] and P. Smielewski[1]

[1]Brain Physics Laboratory, Division of Neurosurgery, Department of Clinical Neurosciences, University of Cambridge, UK ; [2]Department of Physiology and Transplantation, Milan University, Italy; [3]Neuroanesthesia Division, Anesthesiology Department, Hospital Clinic de Barcelona, Universitat de Barcelona, Spain; [4]Department of Anesthesiology, Intensive Care and Pain Medicine - Milano Bicocca University - San Gerardo Hospital – Monza, Italy; [5]Department of Intensive Care, Maastricht UMC, The Netherlands; [6] Department of Anesthesiology, University Hospitals Leuven

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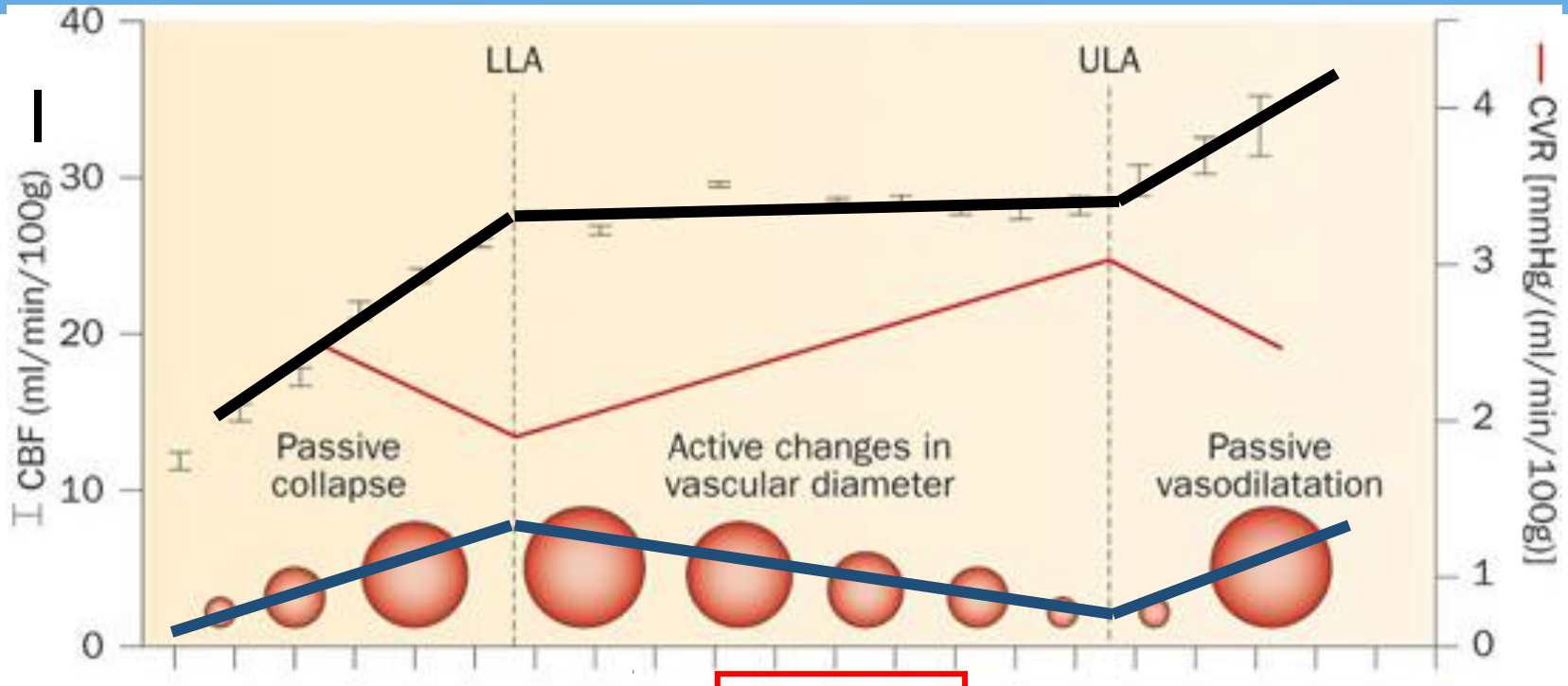
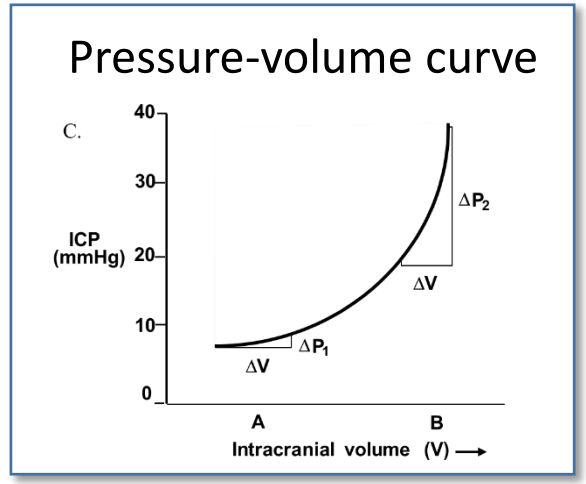
Many approaches for monitoring of Cerebral Autoregulation – surrogates of CBF or CBV



Blood Volume



ICP

ABP/CPP

Blood flow measures


CBFx


CFIx


LDFx


Mx Sx ARI

Blood flow surrogates

COx


ORx

Blood volume

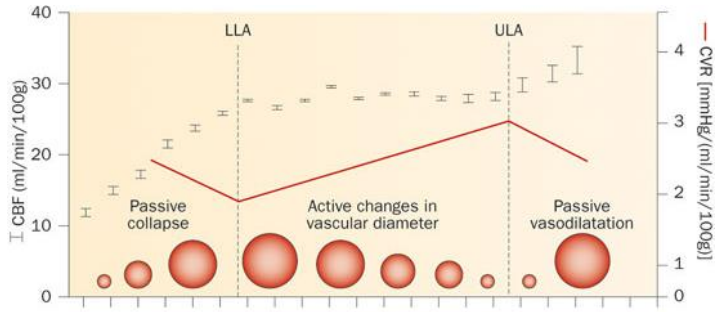

THx

Blood volume surrogate


PRx

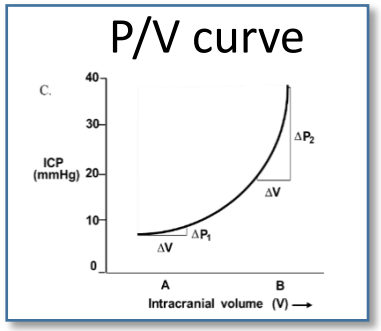
Problems with PRx

- Uses **Volume**, NOT **Flow** surrogate



Problems with PRx

- Uses **Volume**, NOT **Flow** surrogate
- Relies on adequate transmission of volume change into intracranial pressure (**may not work very well in circumstance of high compliance**, eg after decompressive craniectomy)



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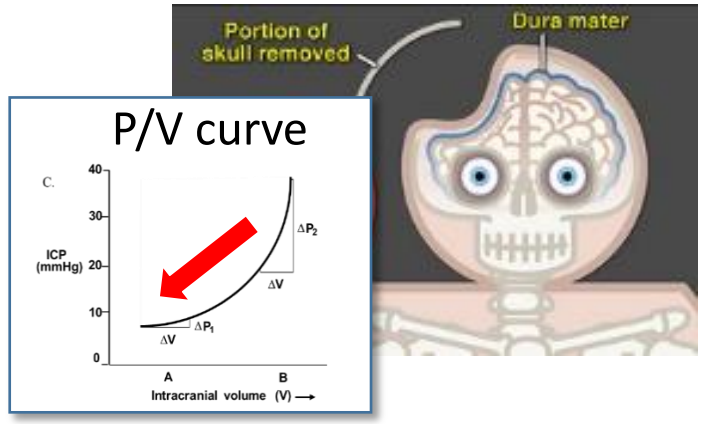

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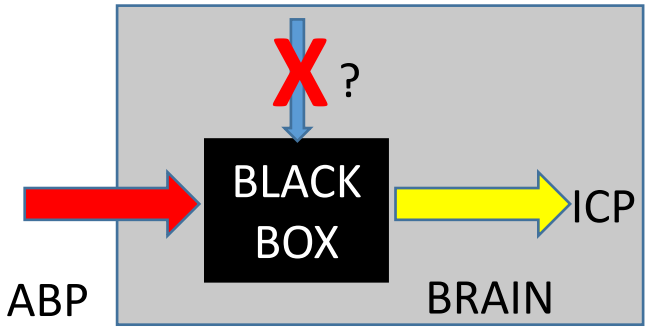

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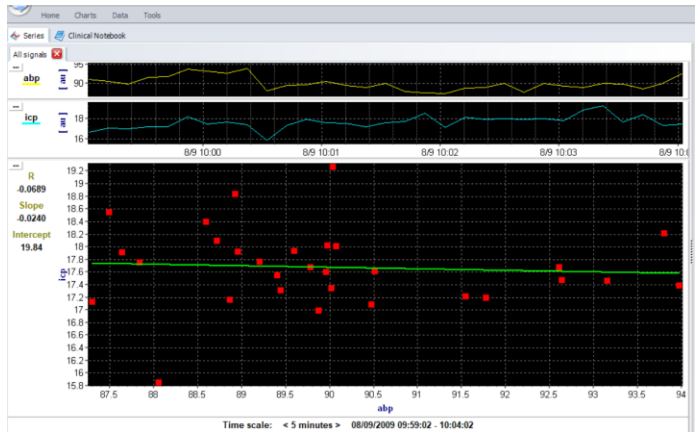
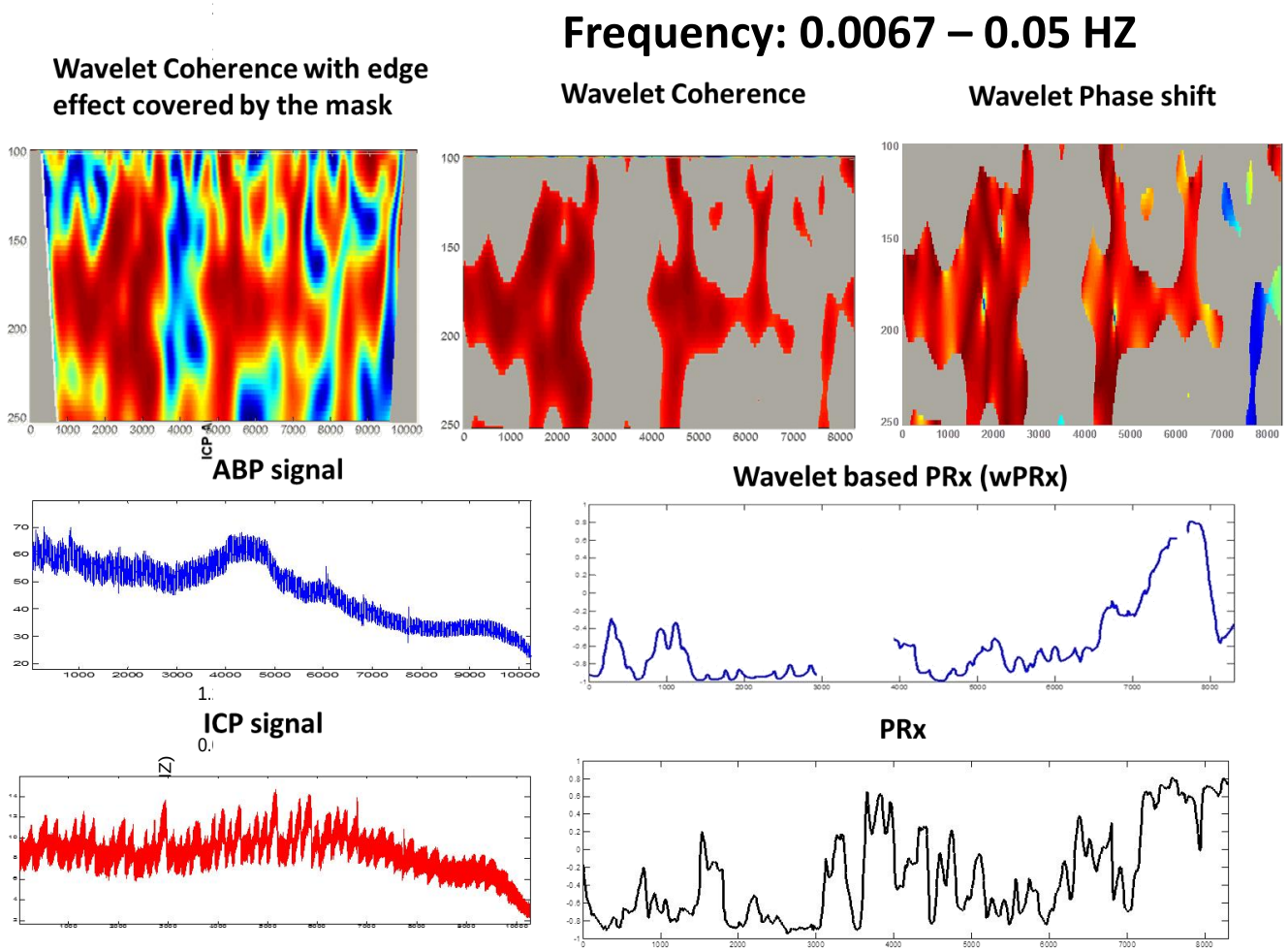
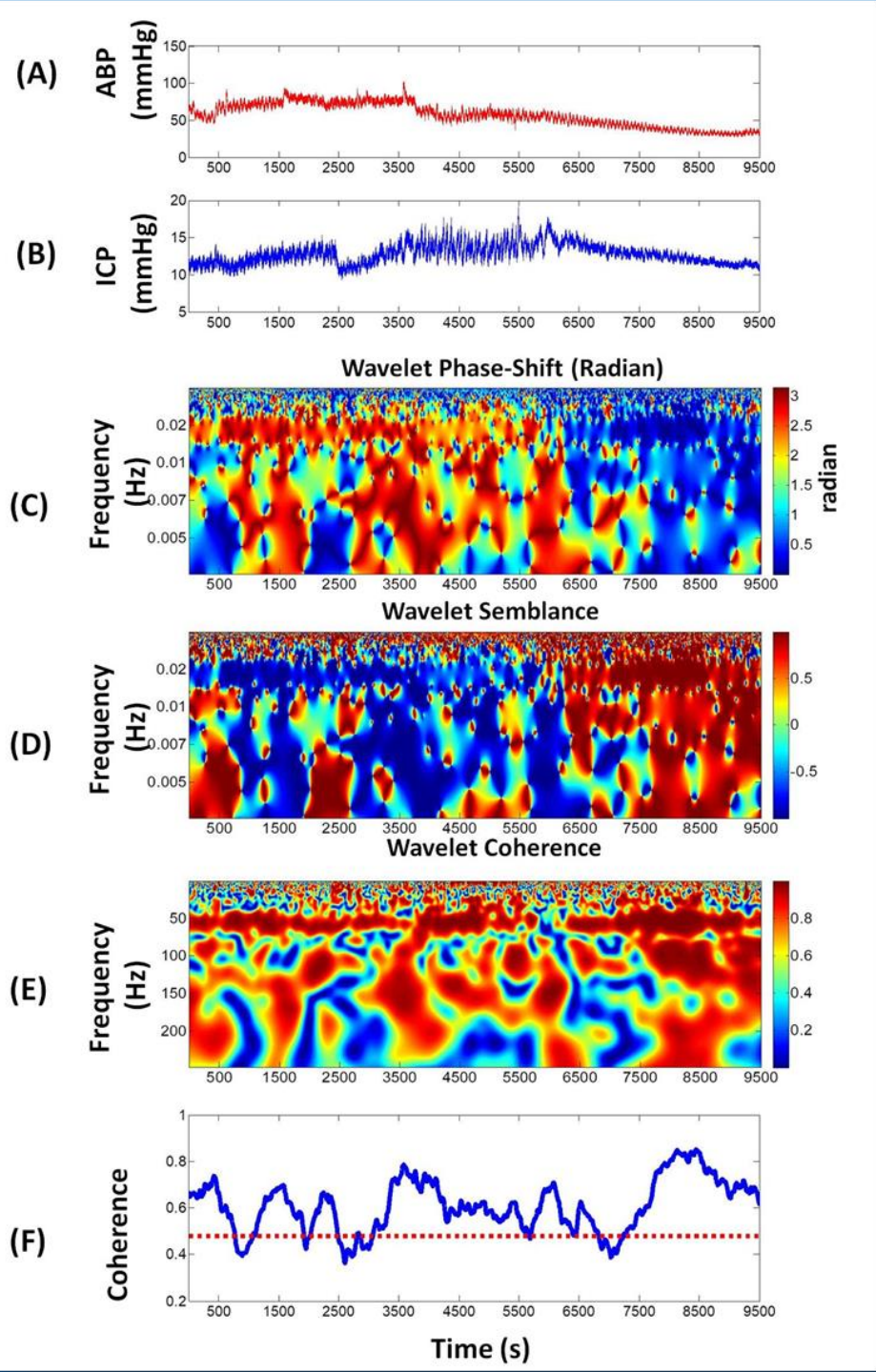
- Thus values PRx close to 0 may reflect either working autoregulation OR incoherent variability in ICP and ABP



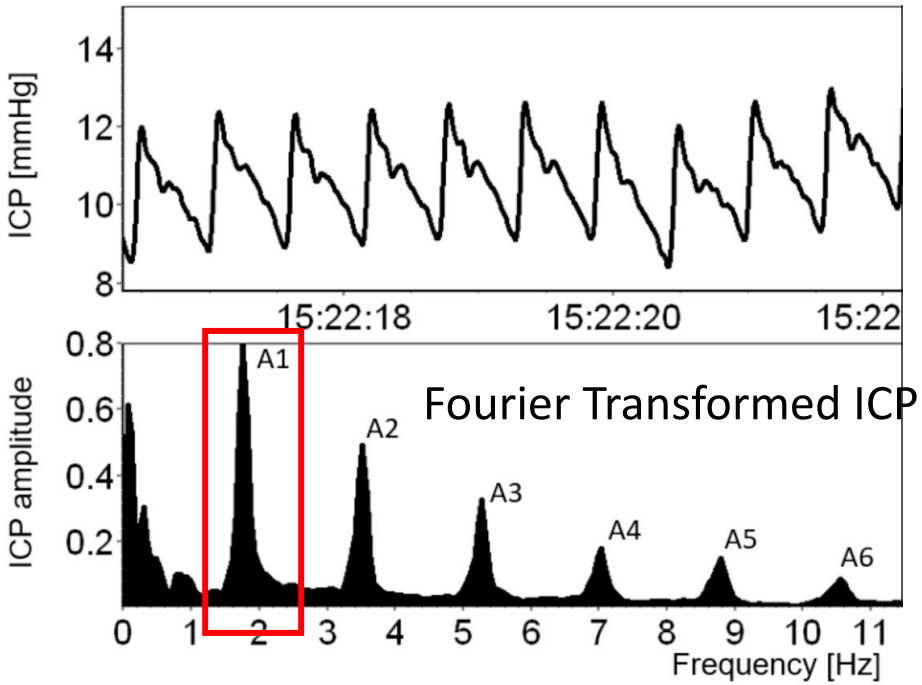
Wavelet analysis of ABP – ICP relationship - wPRx





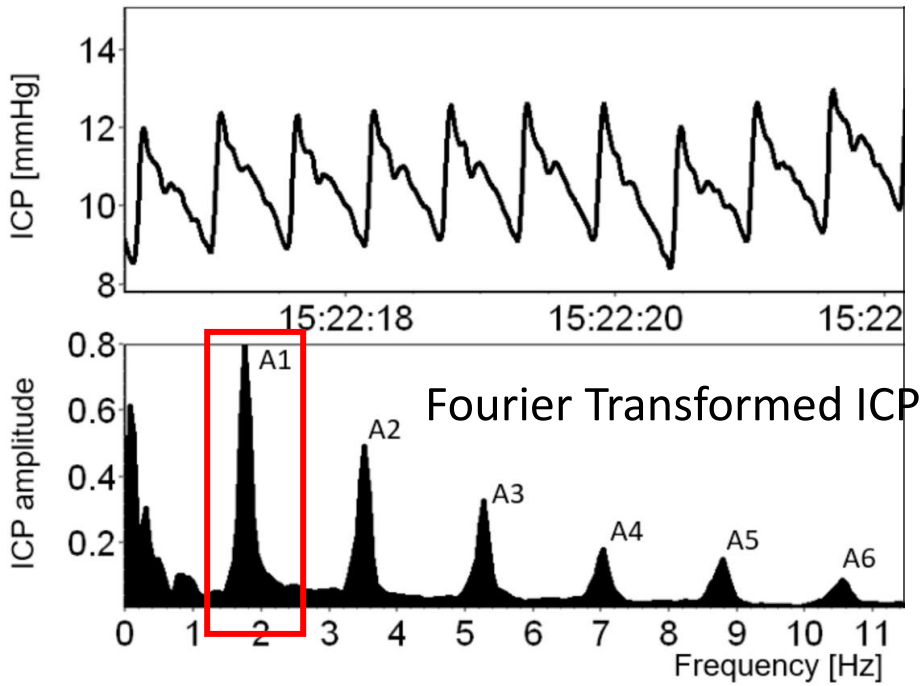
Liu X et al. J Physiol. 2018

RAC – correlation between amplitude of ICP pulse (AMP) and CPP



A1 = AMP

RAC – correlation between amplitude of ICP pulse (AMP) and CPP



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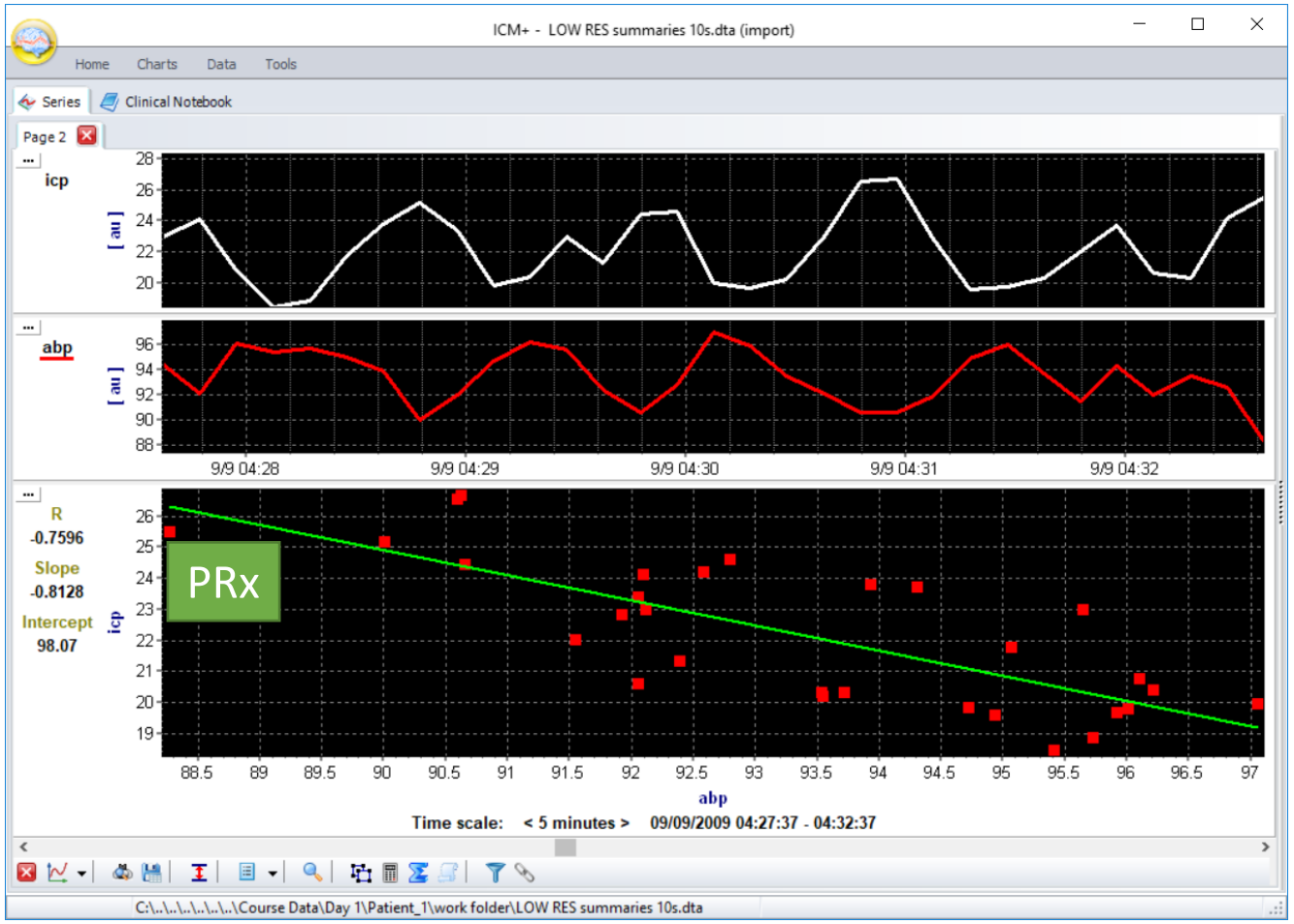

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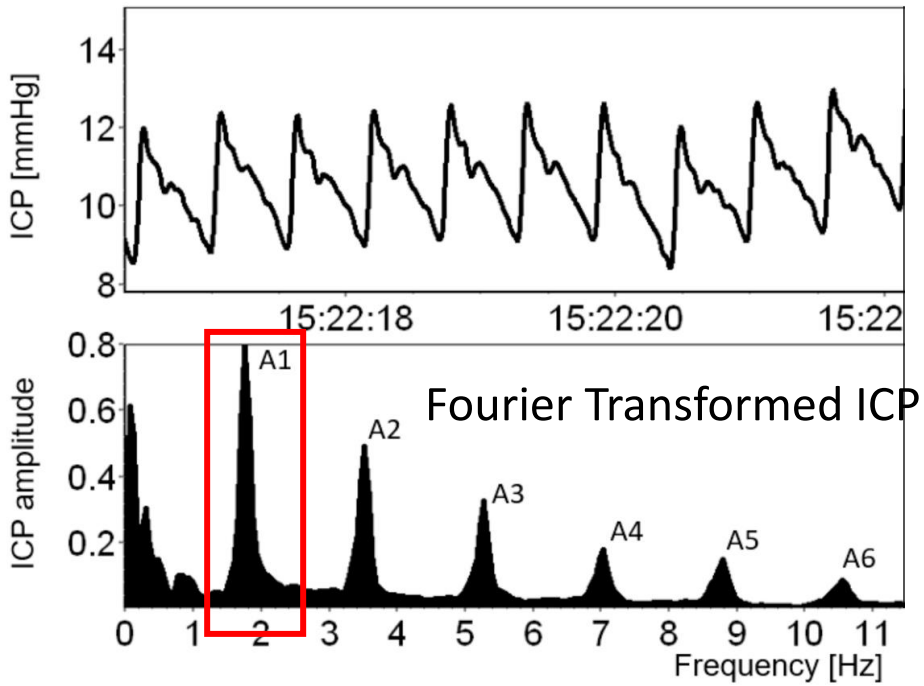

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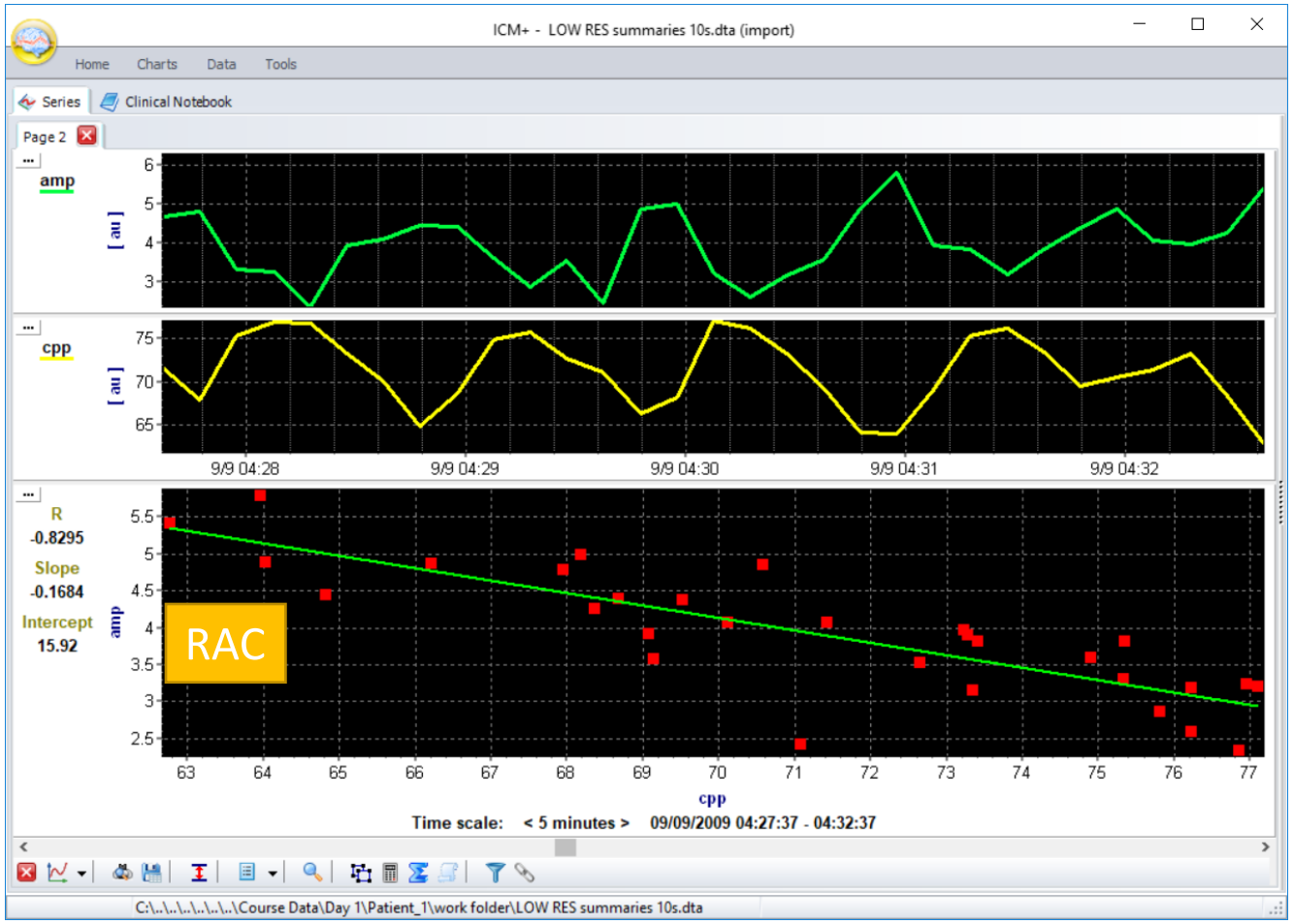
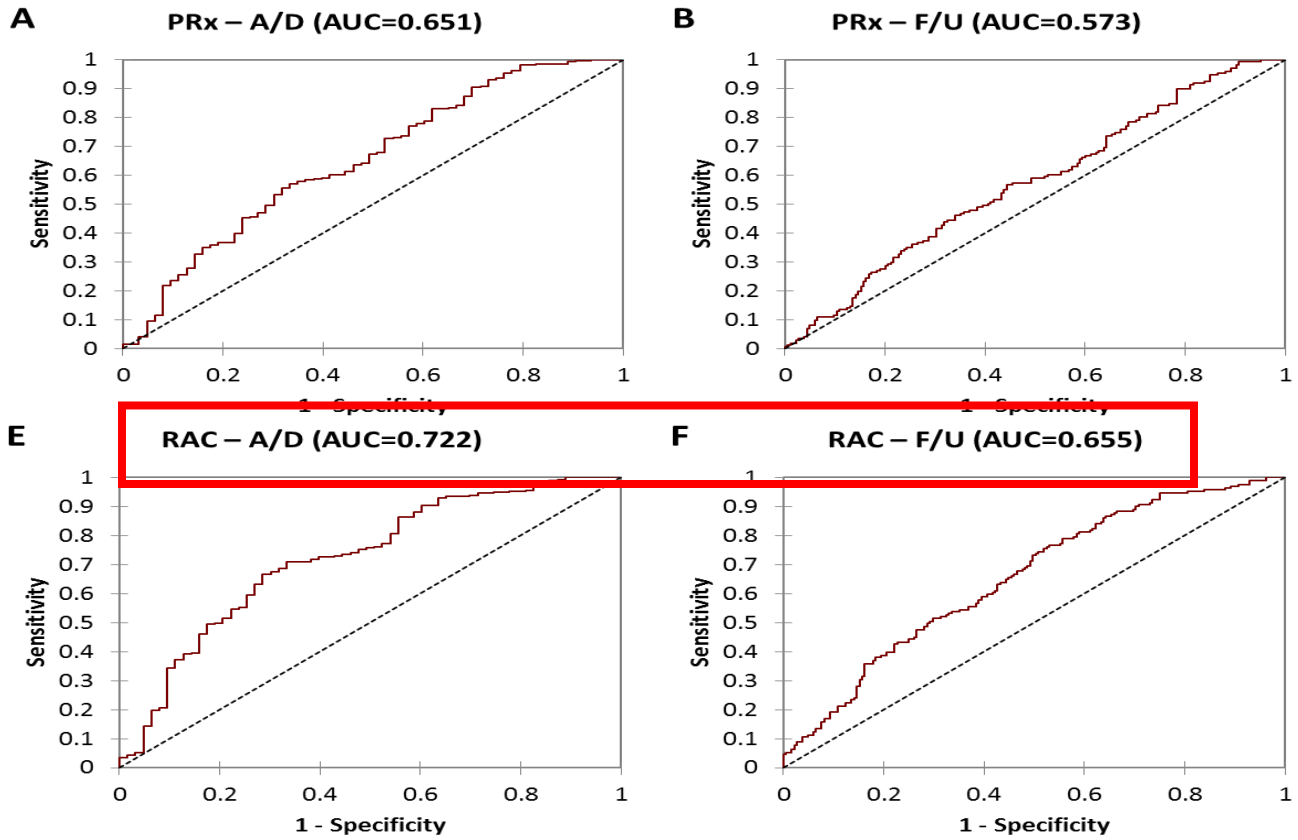
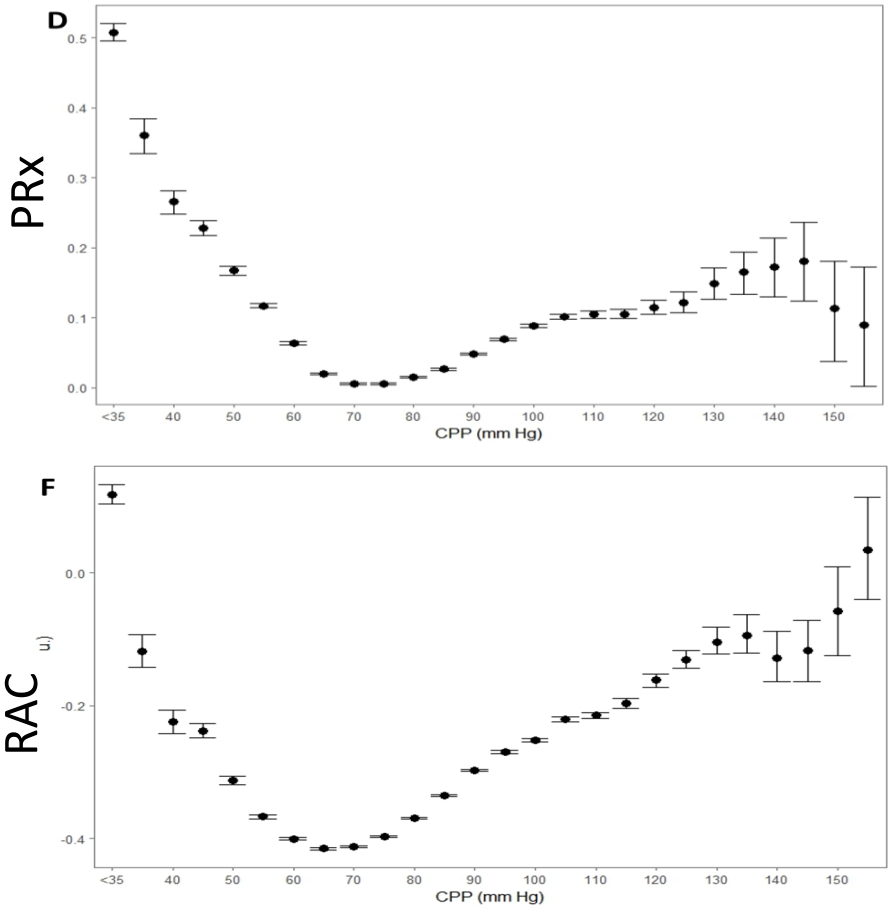


PRx and RAC in non-DC TBI patients (N = 358)

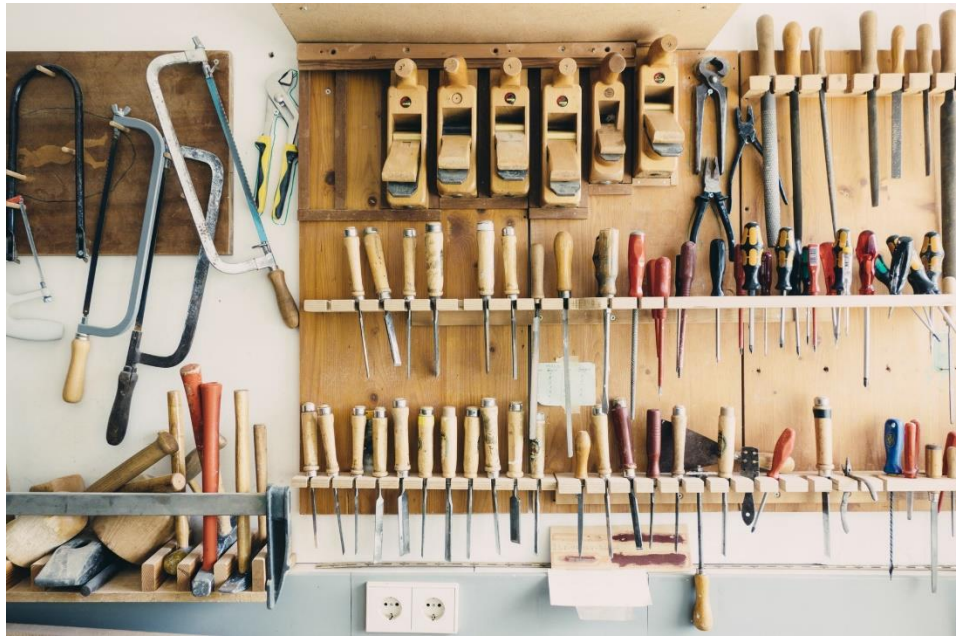
Mortality

Favourable Outcome



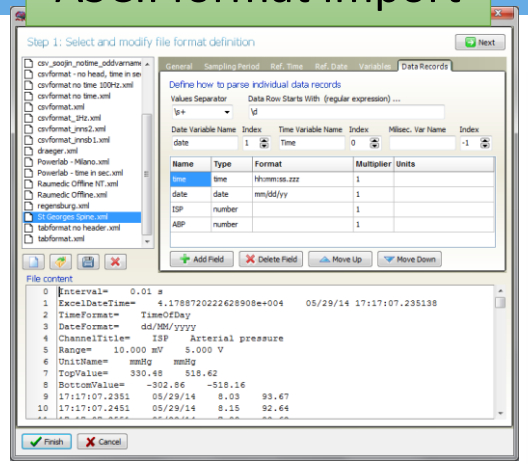


Advanced data browsing and interrogation tools

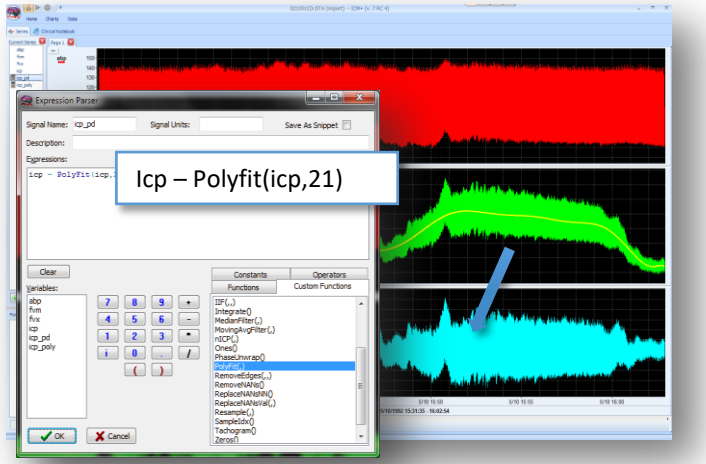


ICM+ advanced features

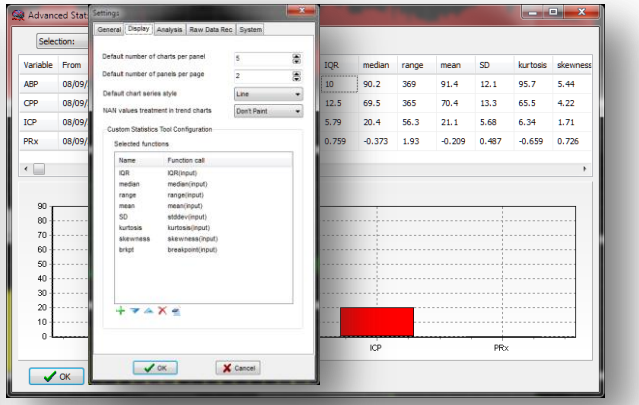
ASCII format import



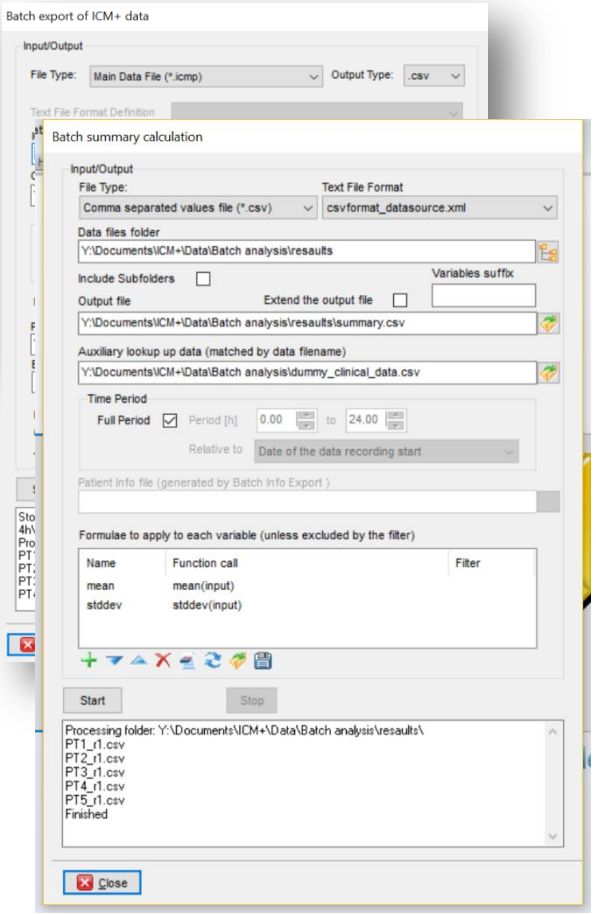
Signals calculator



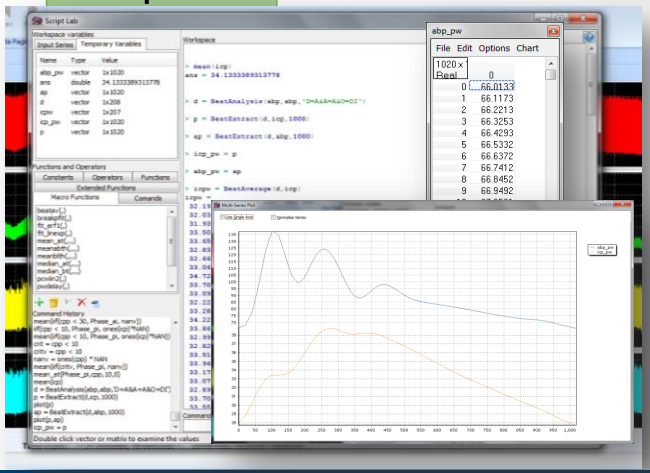
Advanced Stats tool



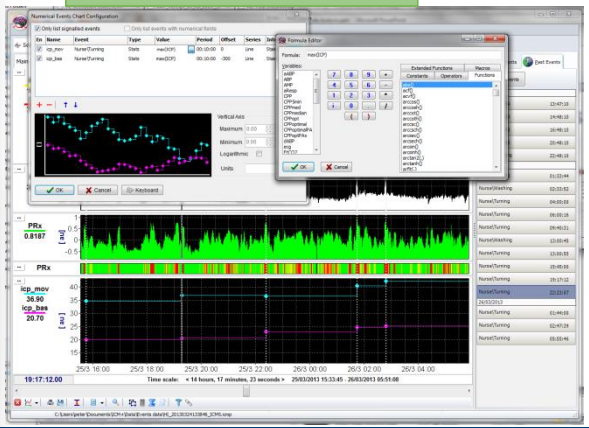
Batch Analysis tools



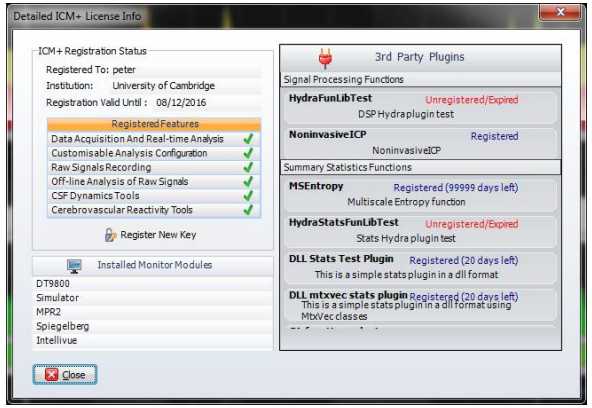
ScriptLab



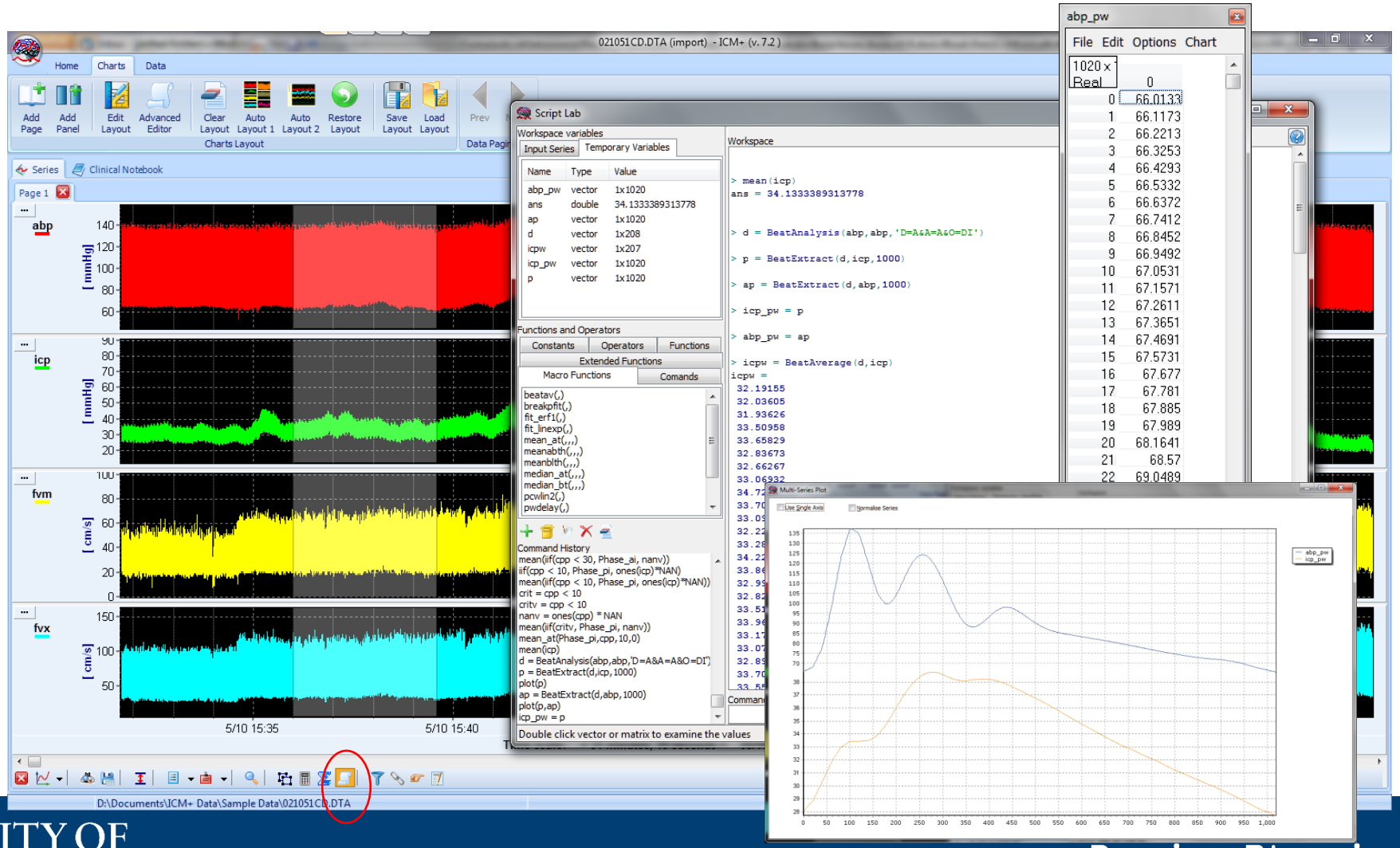
Event analysis



3rd party extensions



ICM+ ScriptLab tool



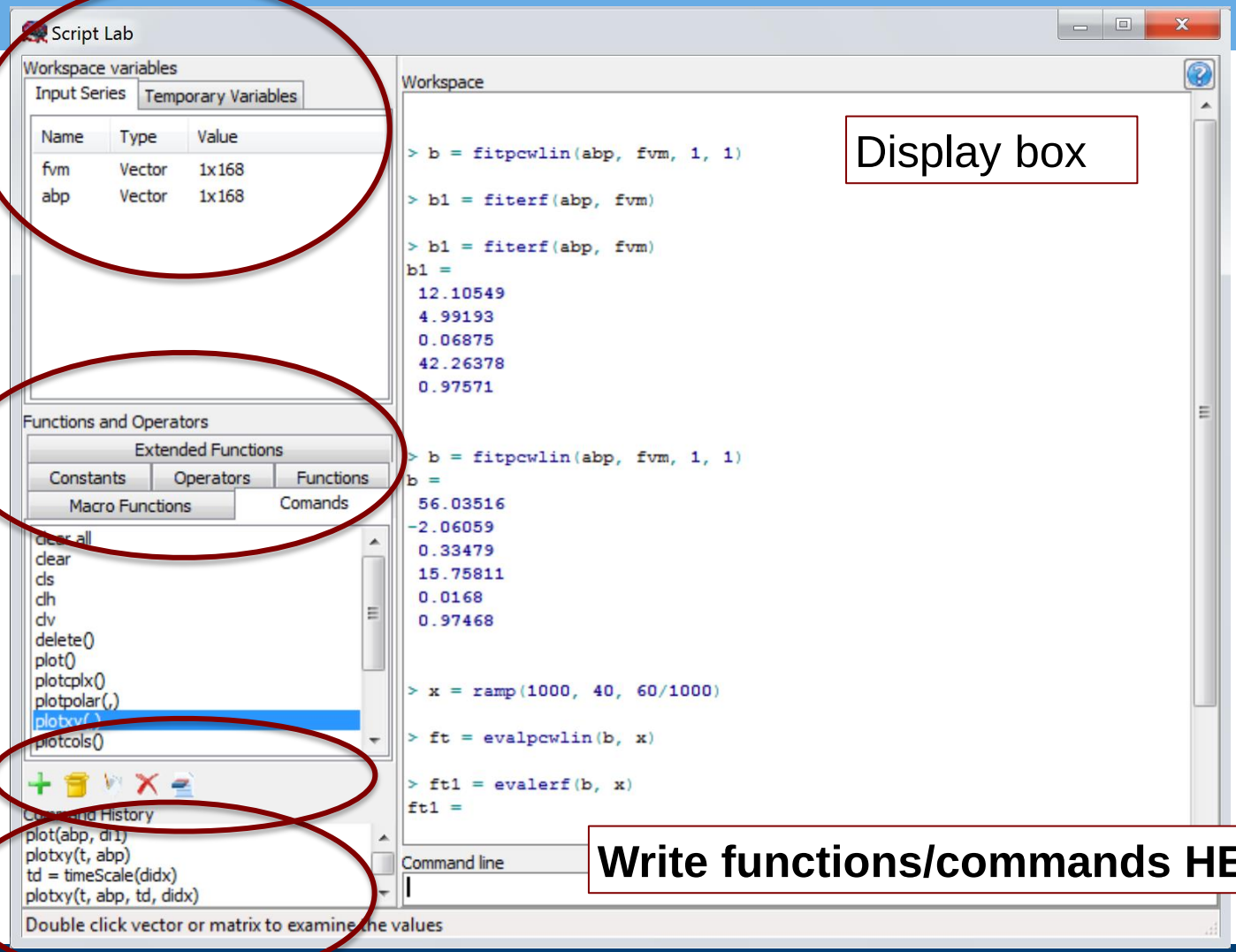
ICM+ ScriptLab tool

Available series/variables

Commands, functions, etc

Edit/save analyses
Make macros

History of activities



Display box

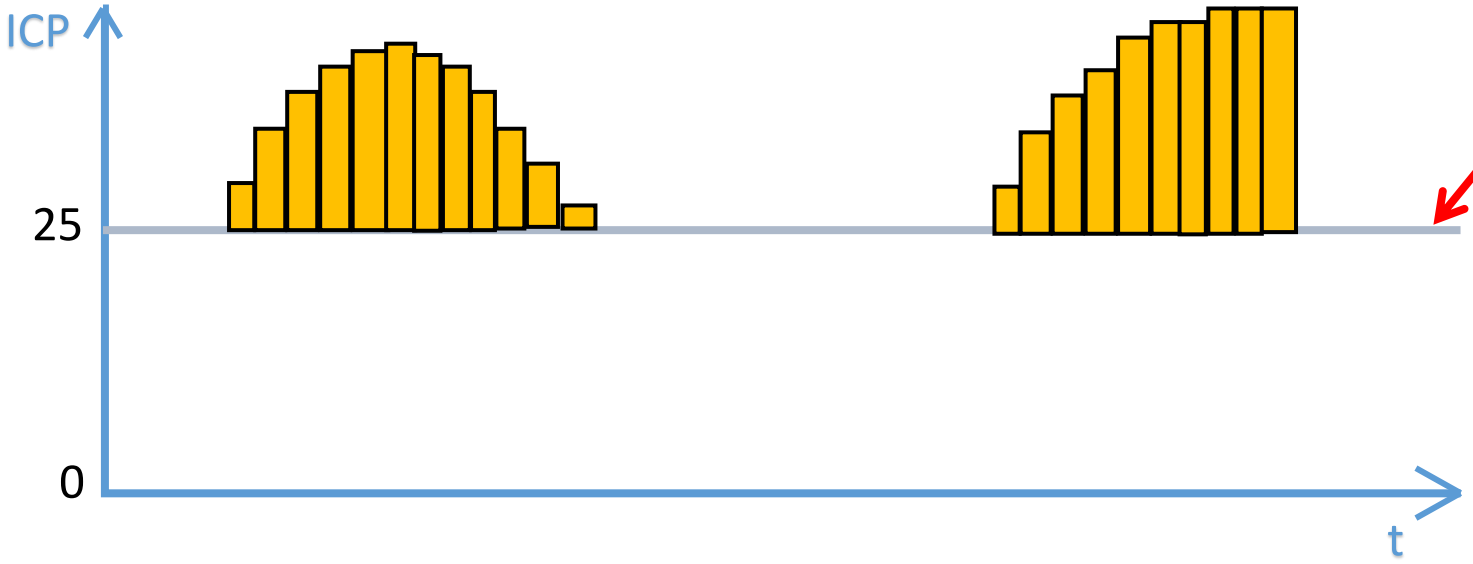
Write functions/commands HERE

Definition of Dose of high ICP (using in this case 25 mmHg Threshold)

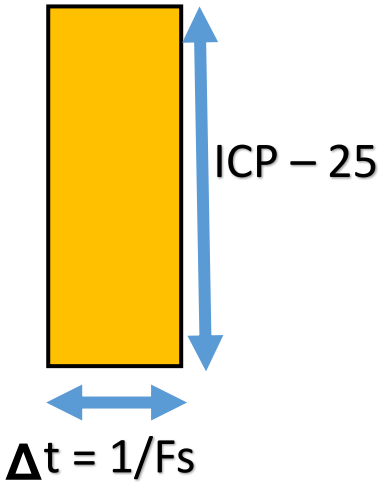
$$Dose_{icp} = \square\,(icp_{hyper} \cdot Dt) = Dt \cdot \square\, icp_{hyper} = \frac{1}{Fs} \cdot \square\, icp_{hyper}$$

$$Fs = SamplingFrequency(icp)$$

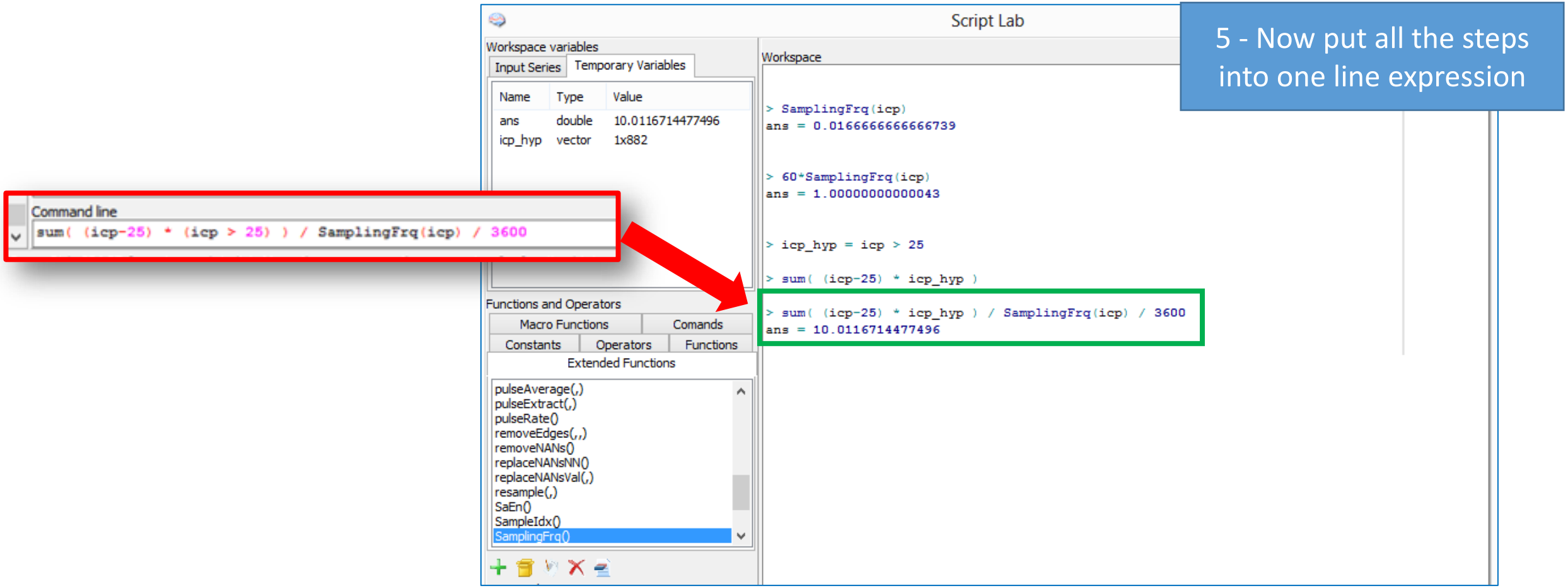
$$icp_{hyper} = (icp - icp_{threshold})_{icp>icp\_threshold}$$



ICP threshold = 25 mmHg



Dose configuration for ICP > 25

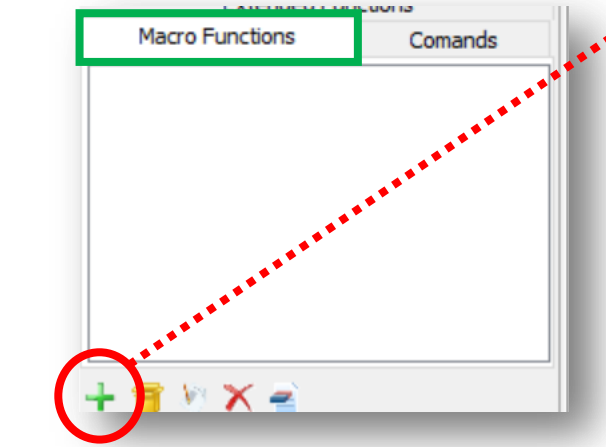


How to create a macro for Dose calculation with generic parameters input and threshold

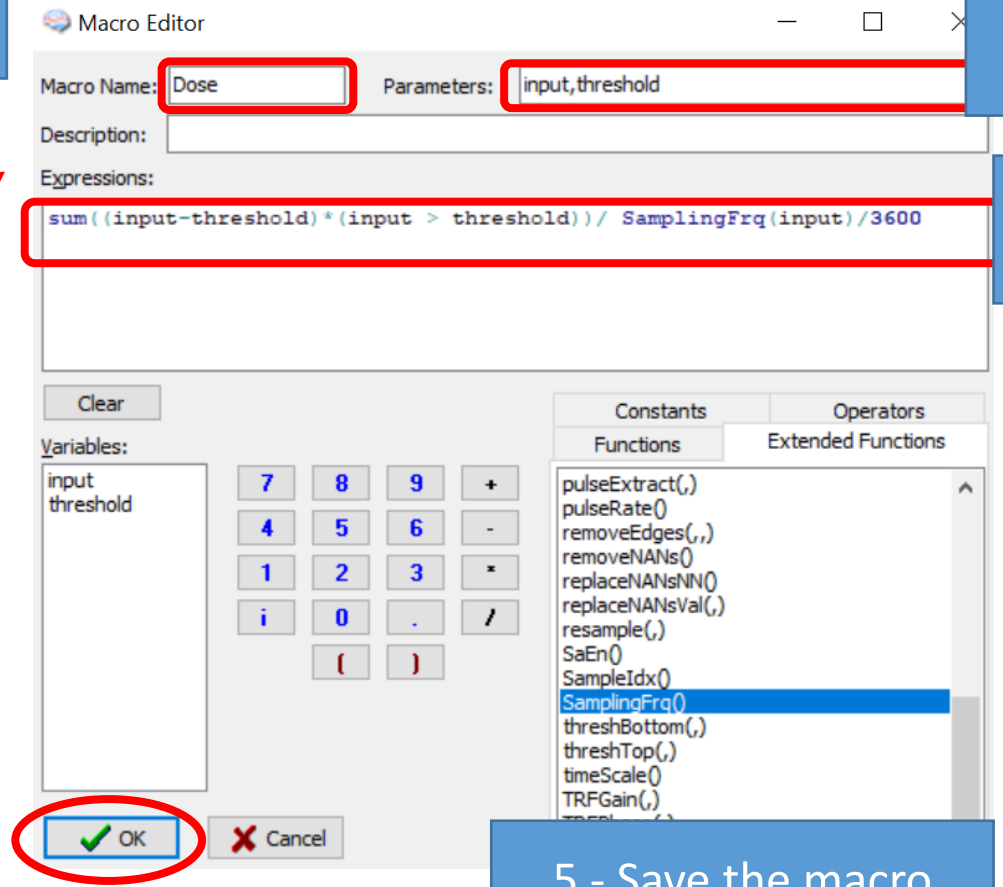
2 - Name the macro

3 – Define the generic parameters

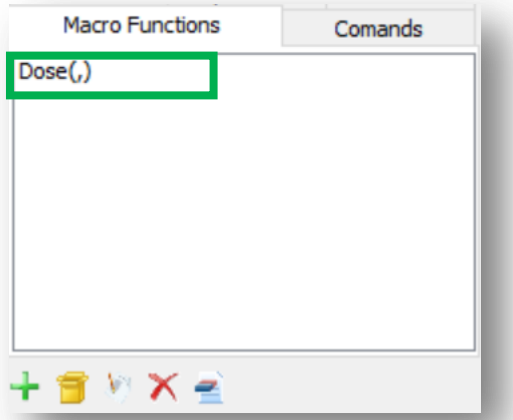
4 - Type the formula for the dose



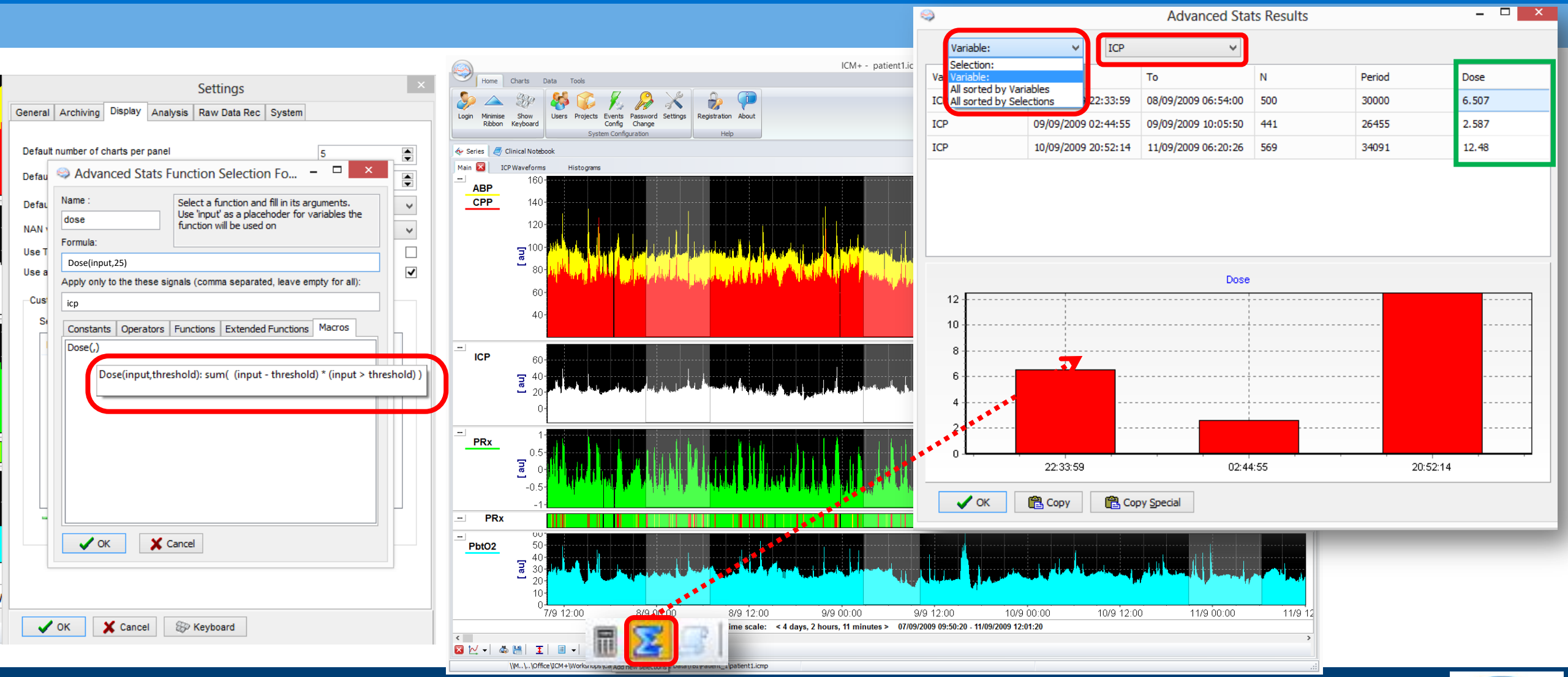
1 – Add a new macro function



5 - Save the macro



Advanced statistics tool



A typical ICM+ enabled pipeline for analysis involving multimodal monitoring data

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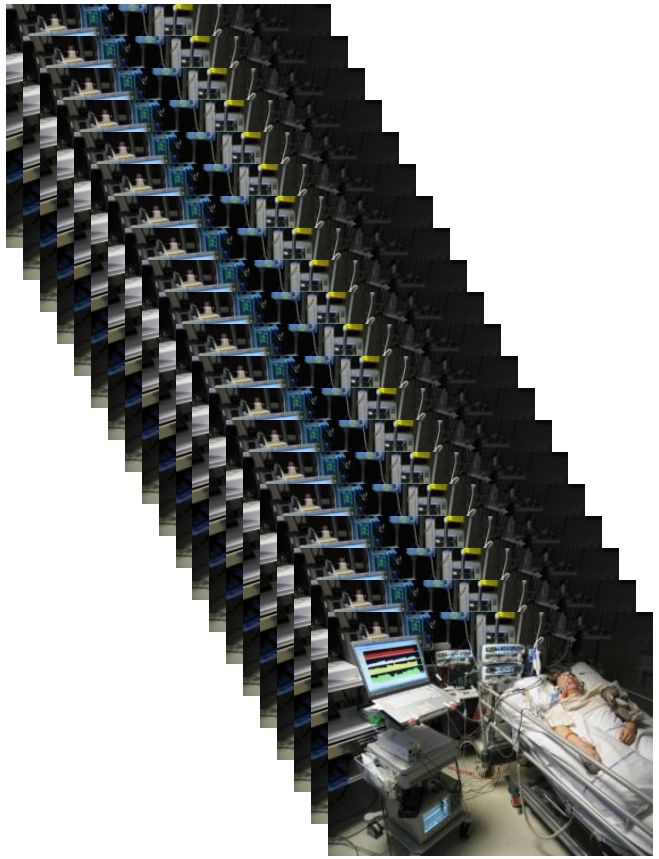

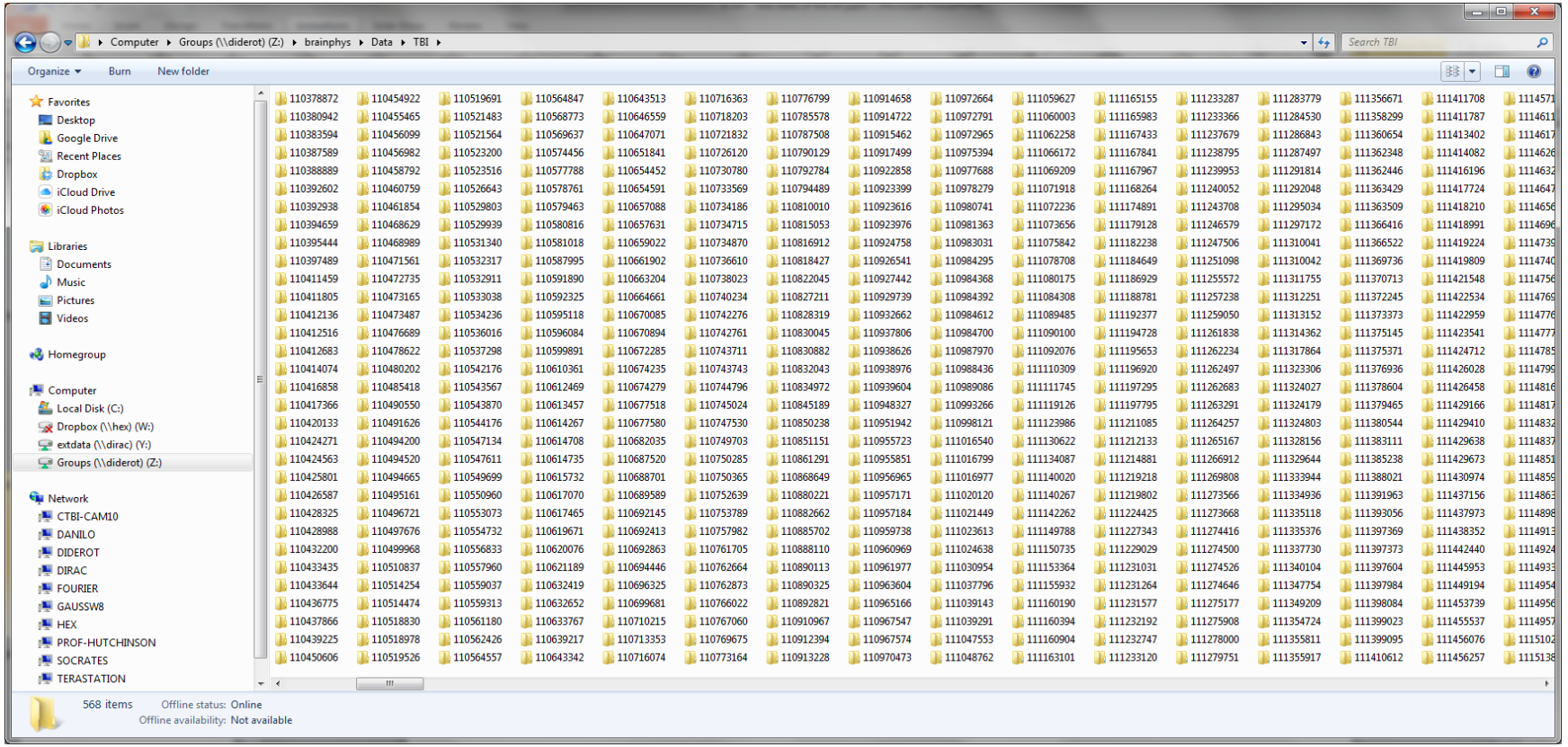

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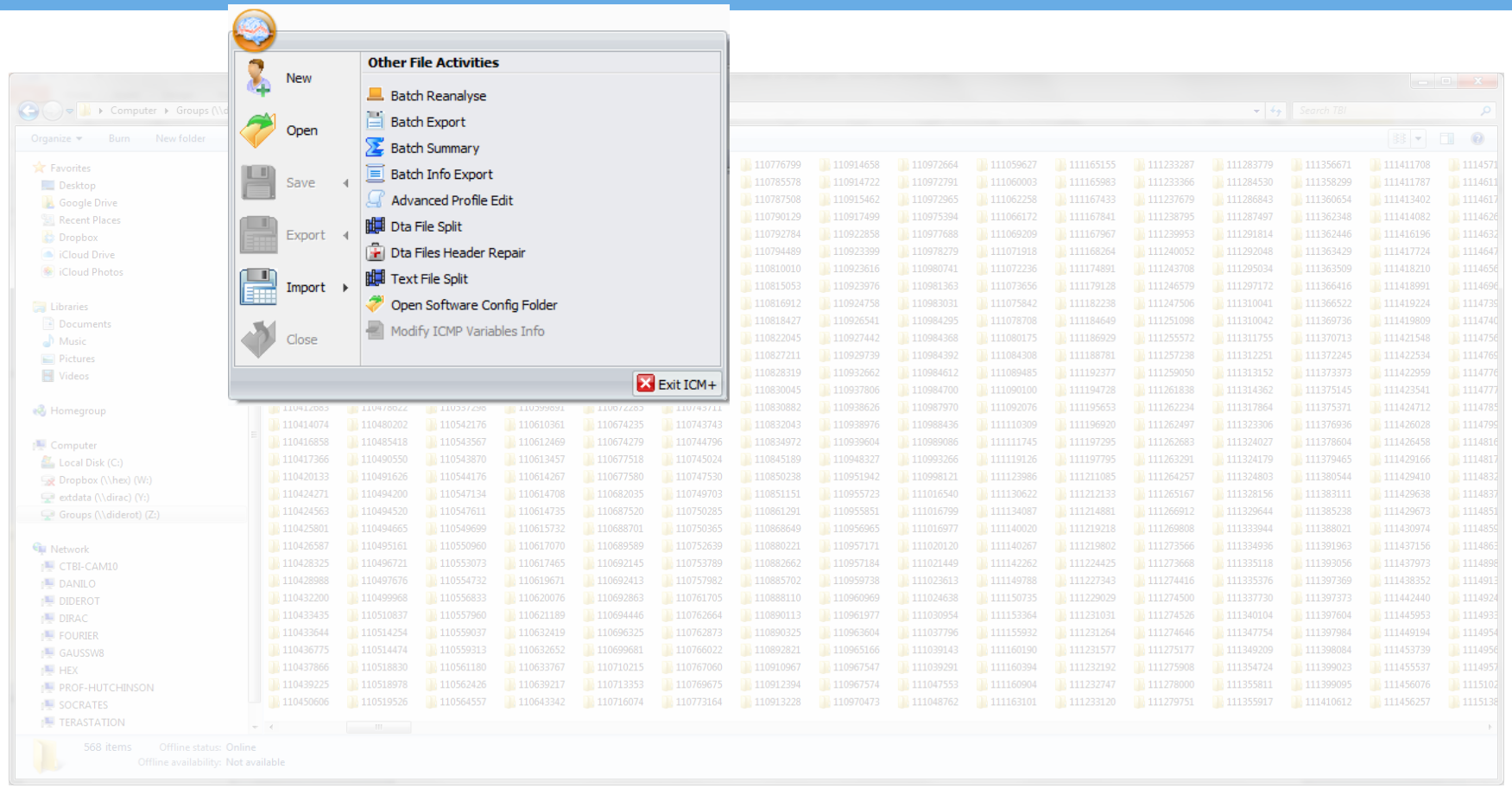

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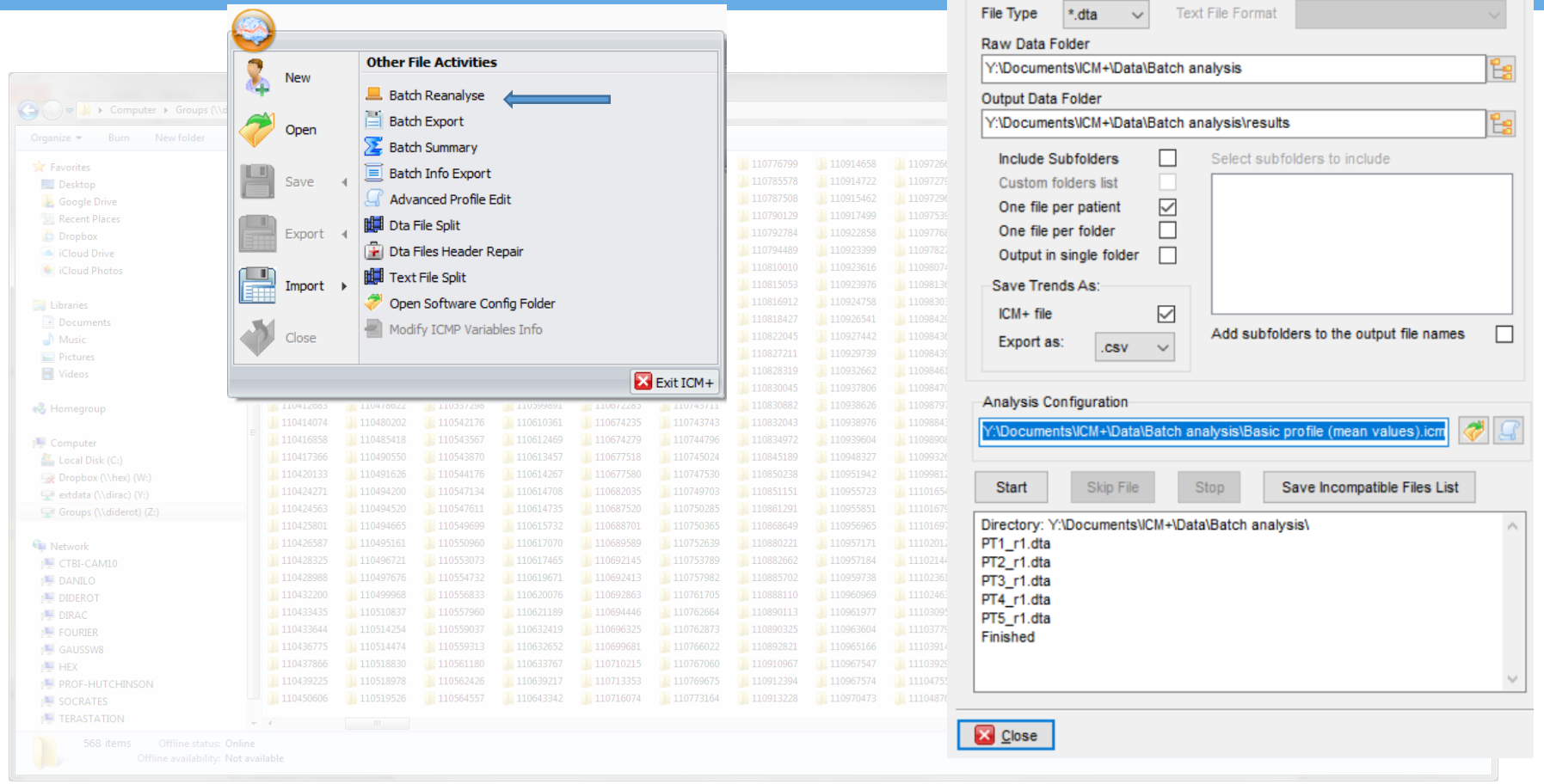

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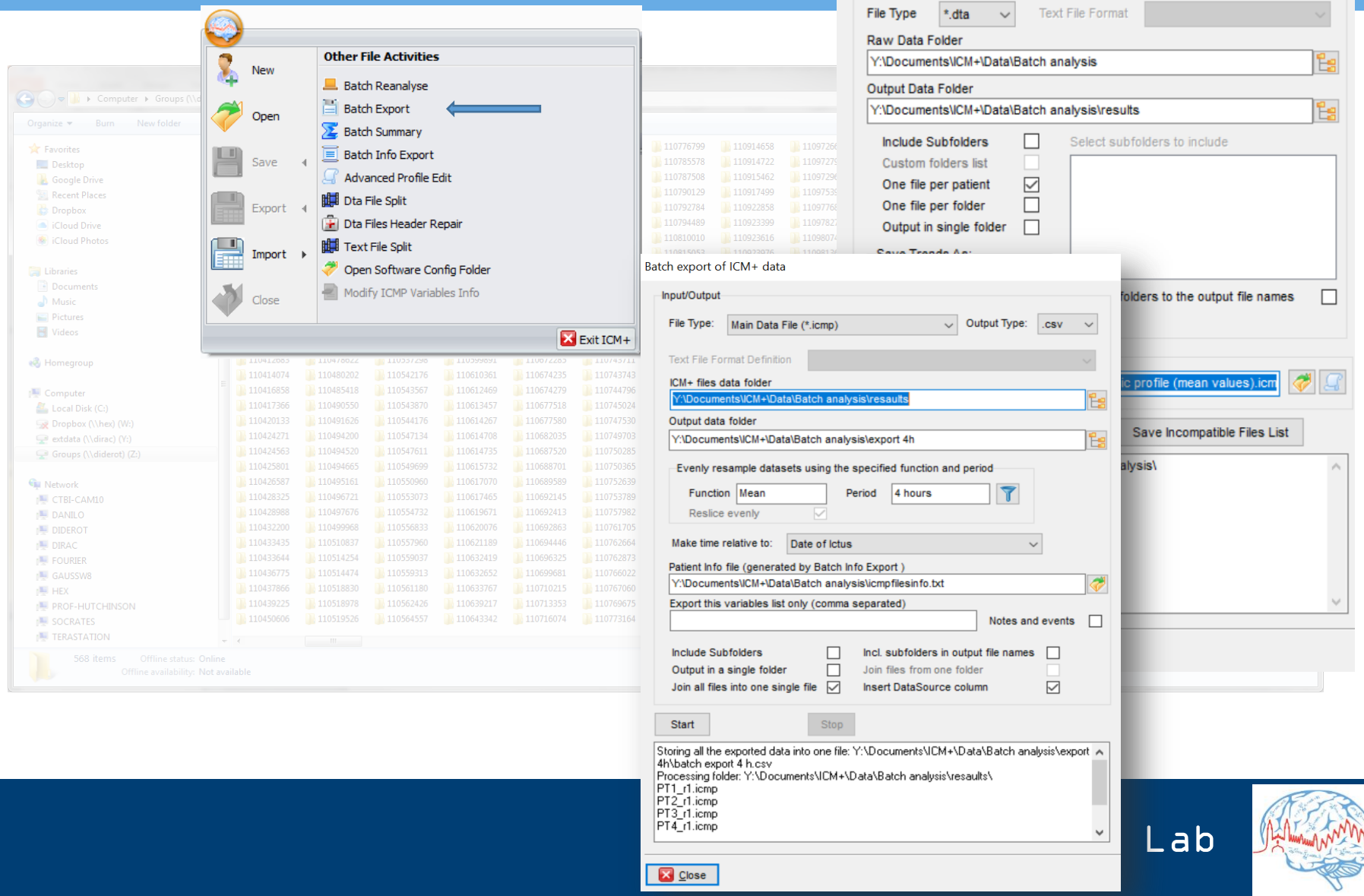

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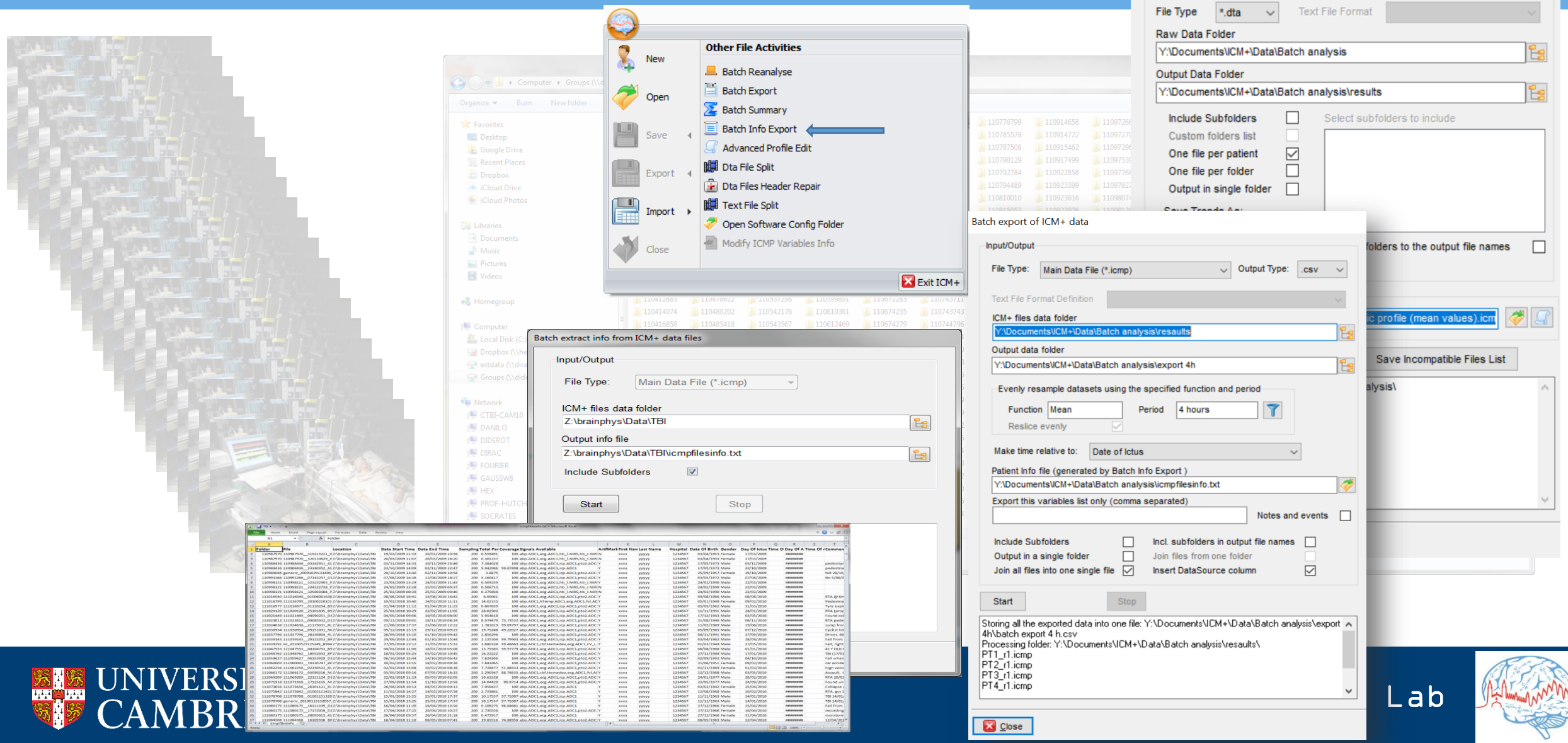

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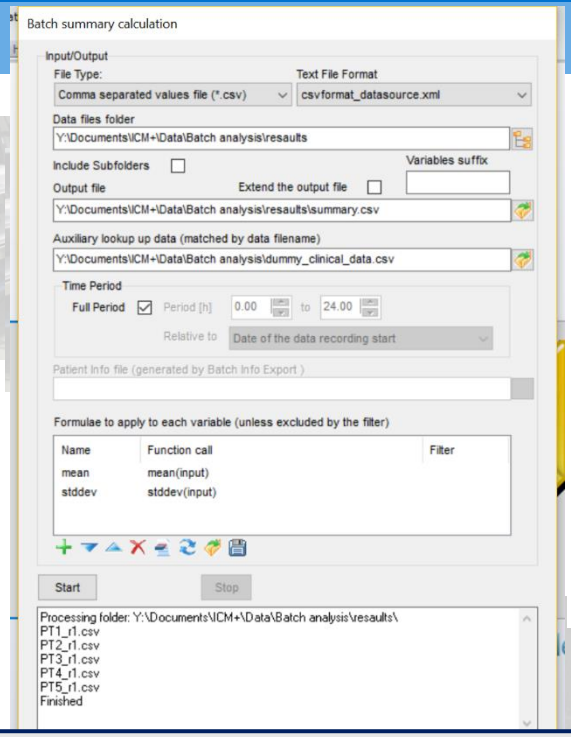
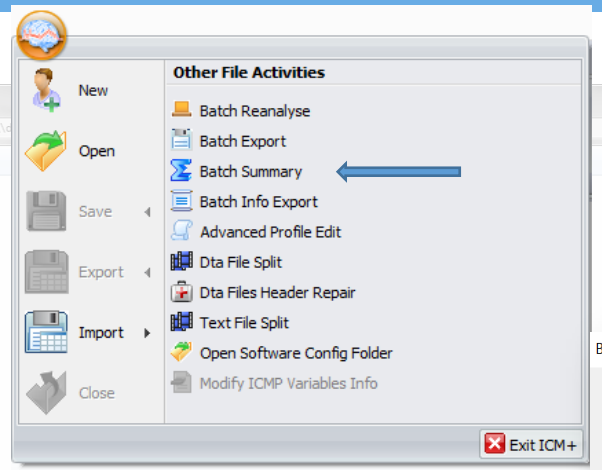
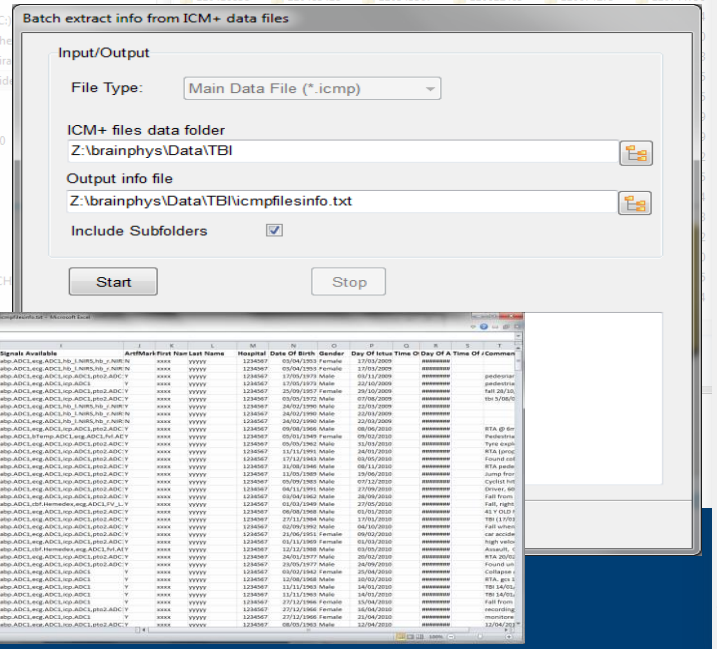
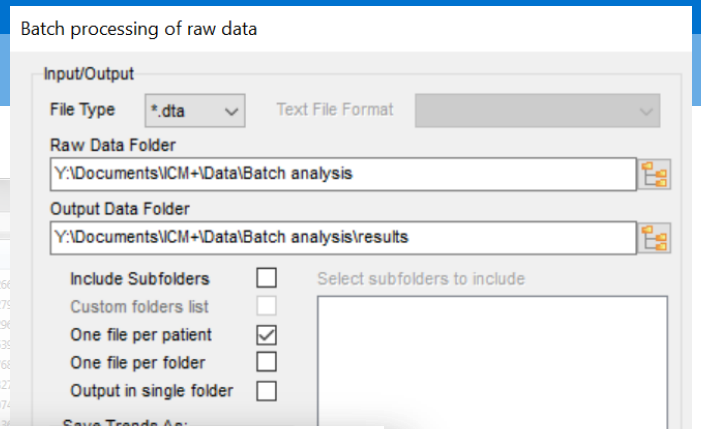
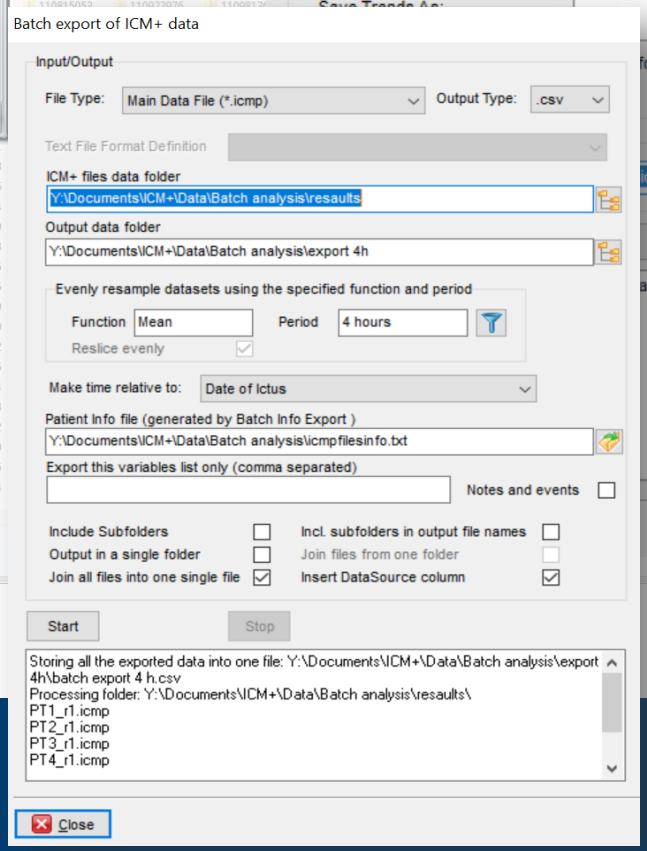


	A	B	C	D	E	F	G
1	DataSourc	GOS	GCS	abp_mean	abp_stdde	icp_mean	icp_stddev
2	PT1_r1	1	3	88.82	8.728	13.85	2.953
3	PT2_r1	2	5	86.46	12.3	11.04	4.71
4	PT3_r1	3	6	0	NAN	0	NAN
5	PT4_r1	4	9	73.81	13.49	10.03	7.001
6	PT5_r1	5	5	89.12	9.894	13.79	2.98









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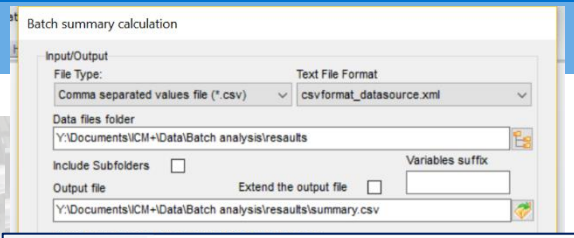

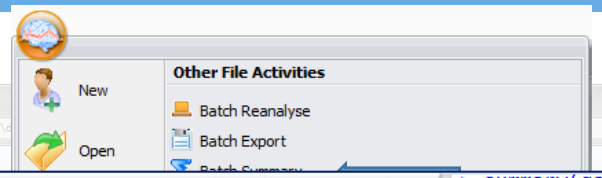

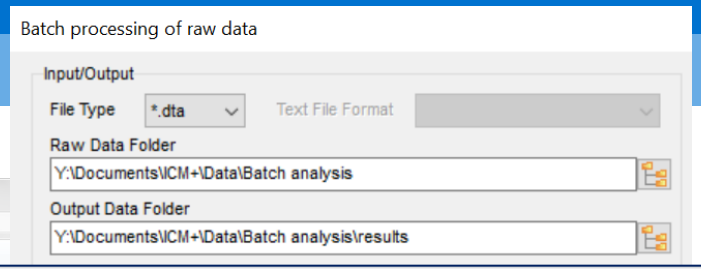

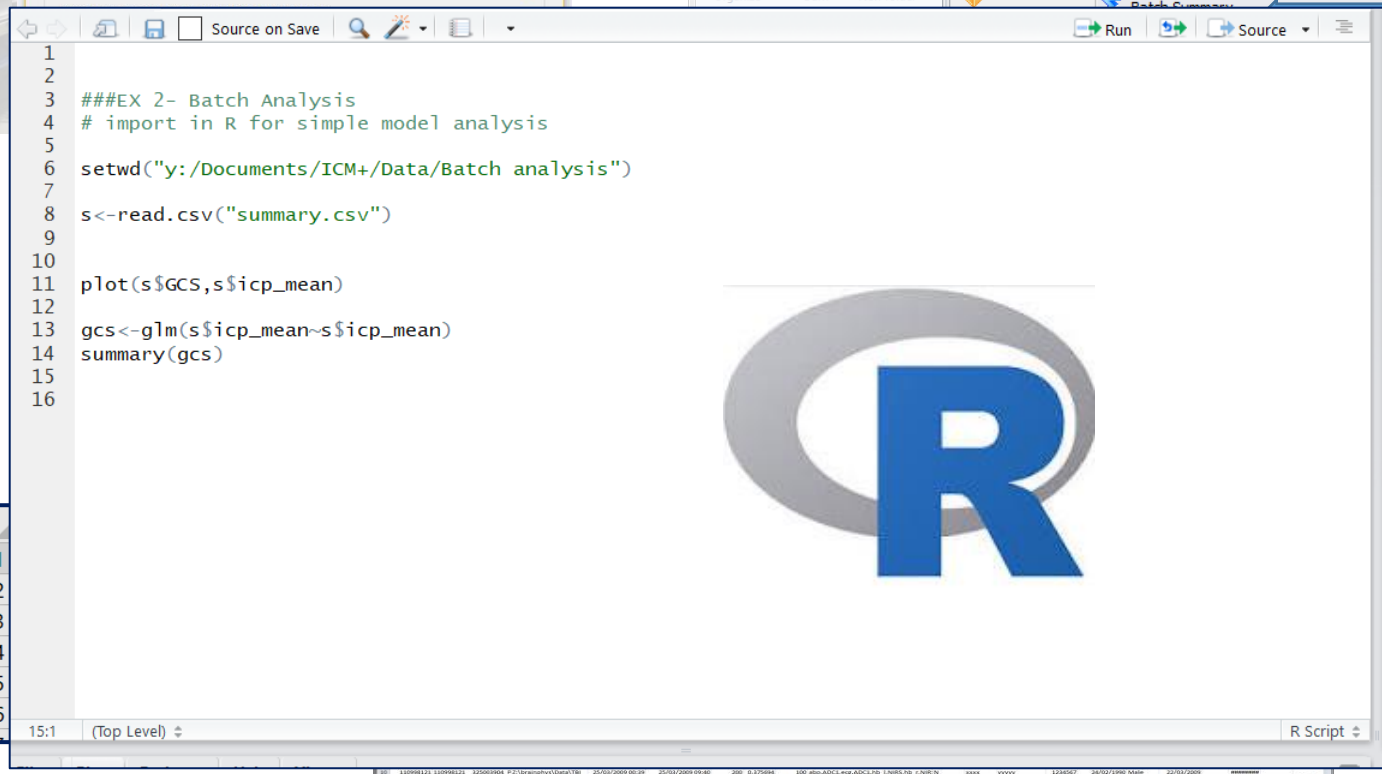

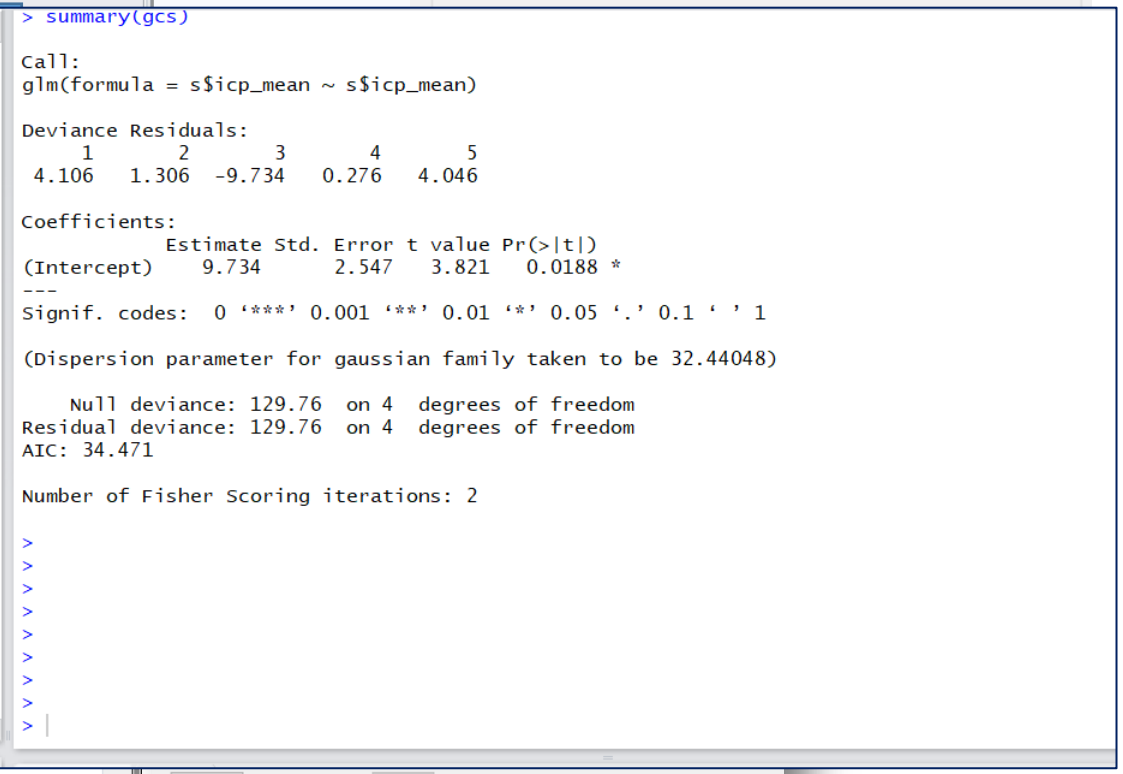

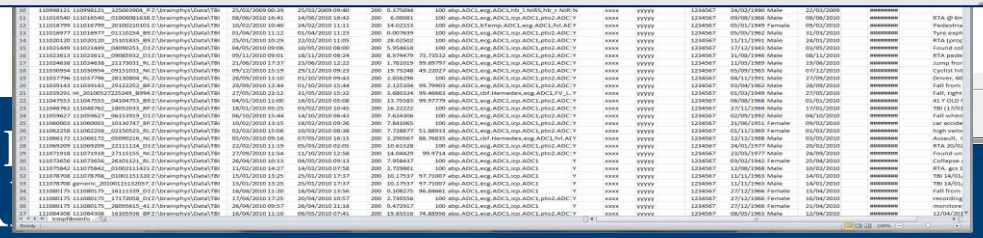

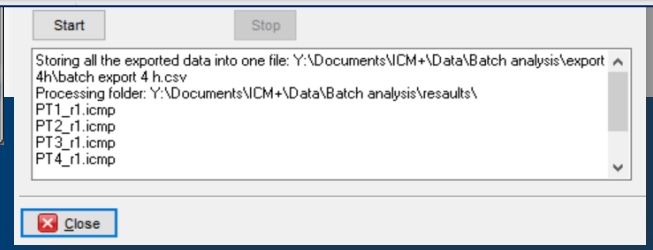

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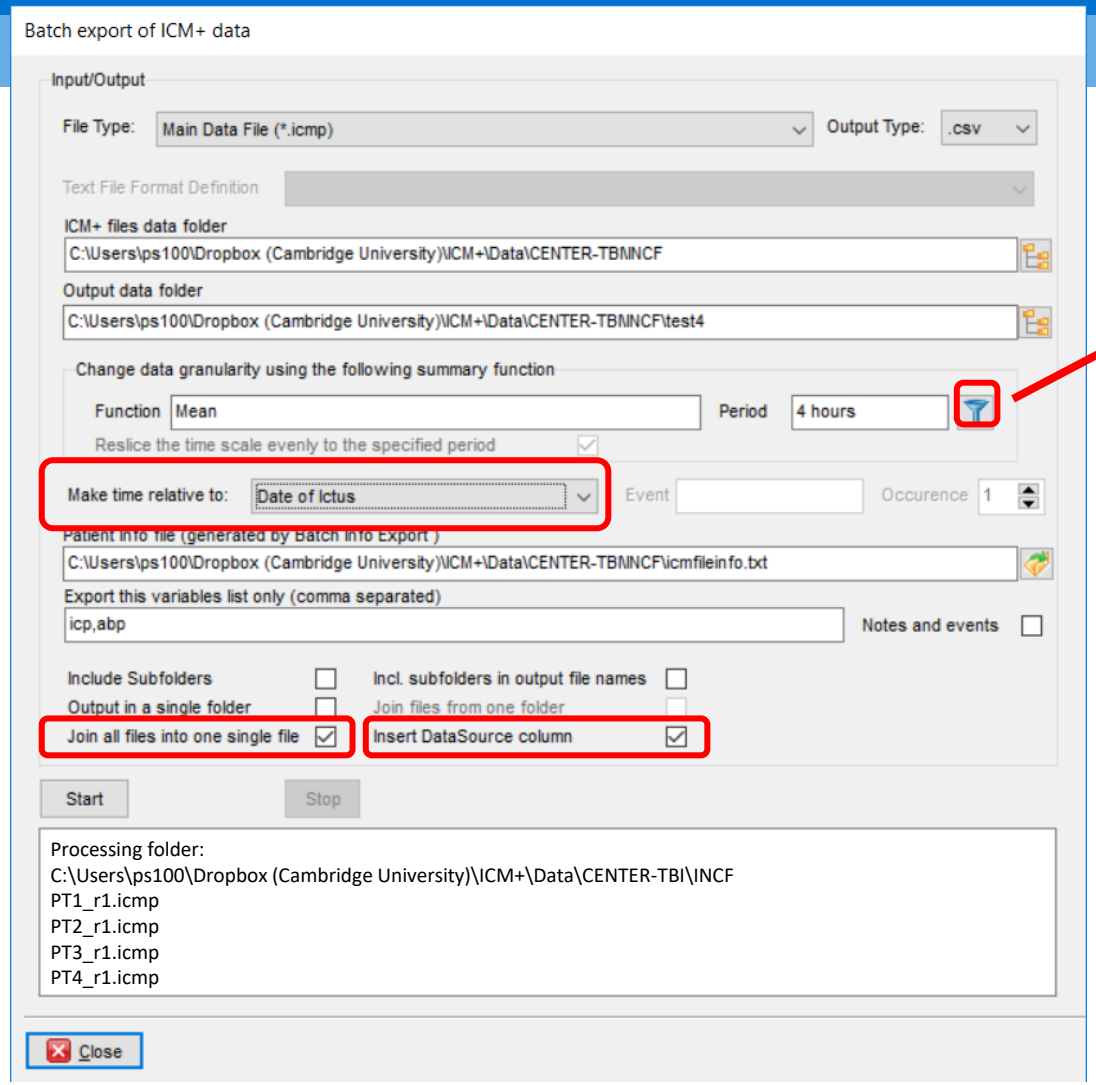
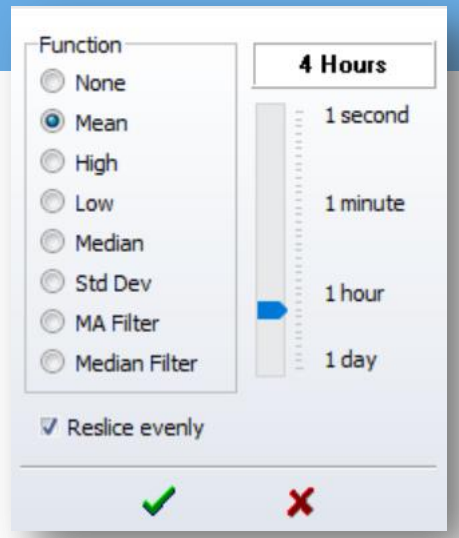
Lab

Batch export tool

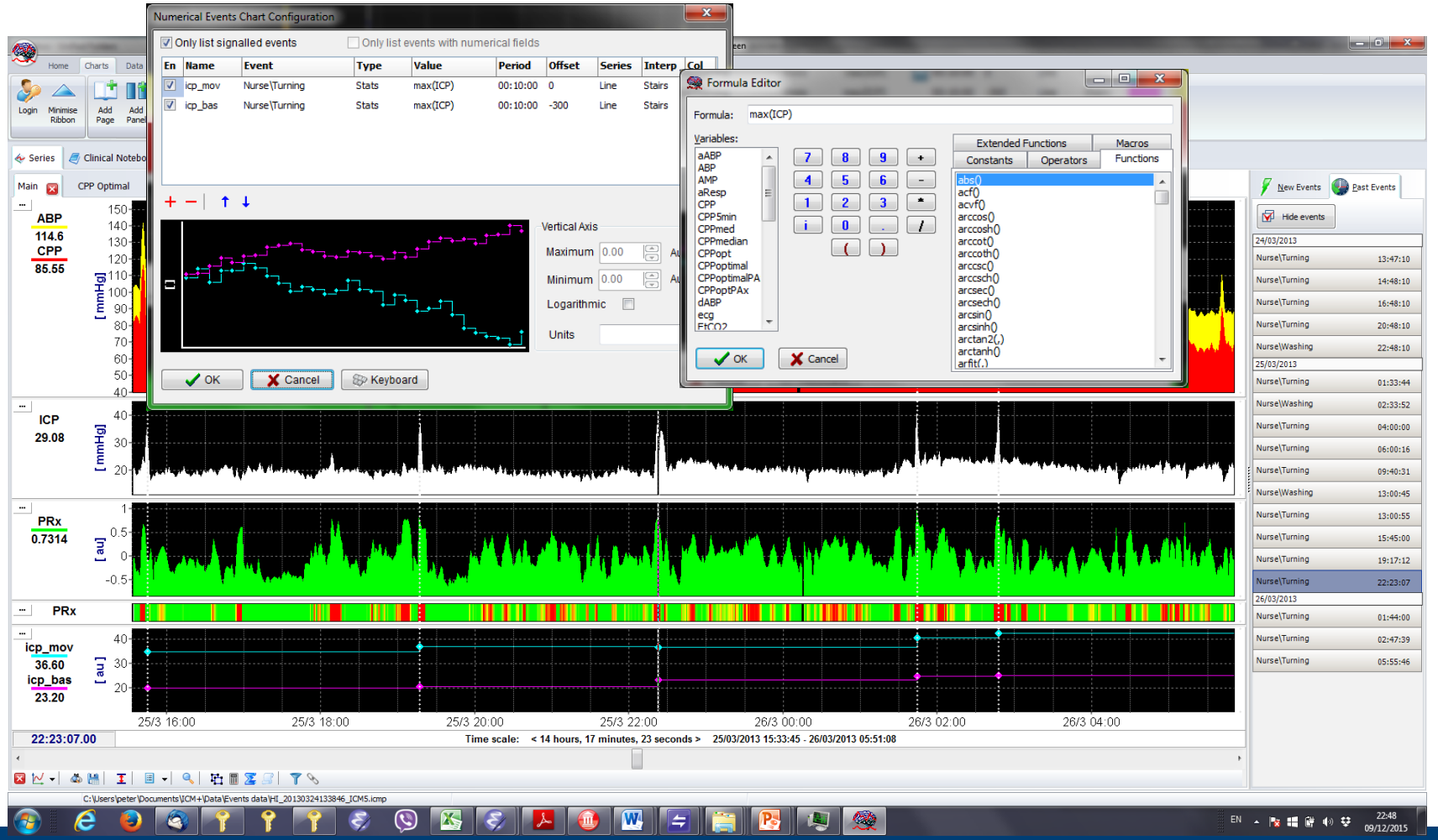




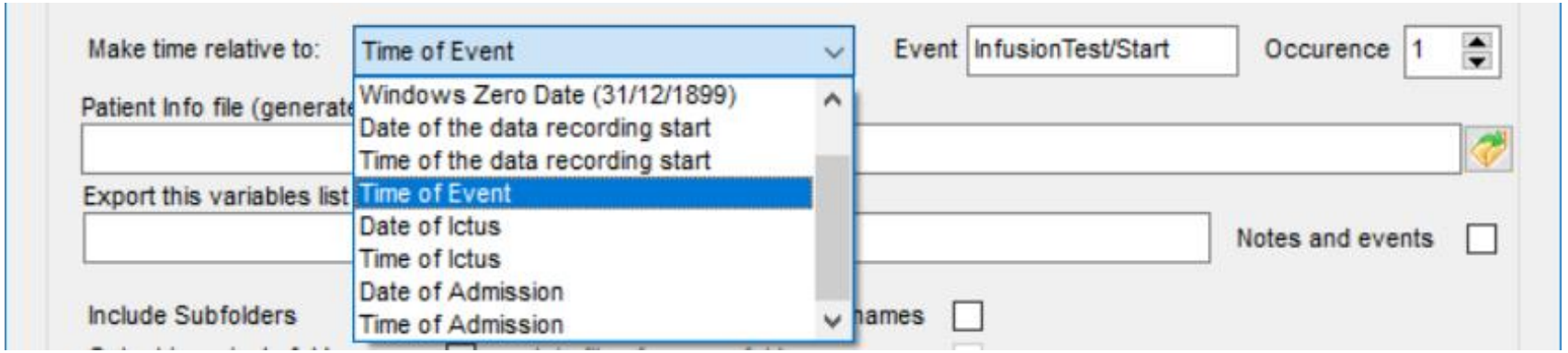
The DateTime variable is expressed in days from ictus

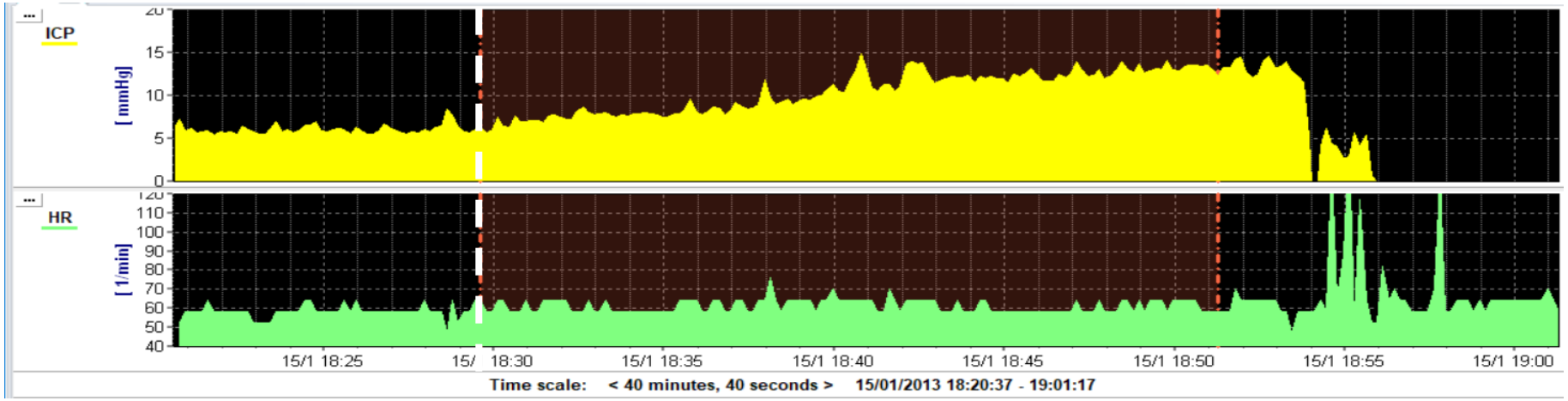
	A	B	C	D
1	DataSource	DateTime	abp	icp
2	PT1_r1	1.5	86.57	16.8
3	PT1_r1	1.666667	91.39	14.29
4	PT1_r1	1.833333	88.49	10.67
5	PT1_r1	2	88.42	14.16
6	PT1_r1	2.166667		
7	PT2_r1	0.666667	82.3	9.436
8	PT2_r1	0.833333	83.68	8.32
9	PT2_r1	1	85.45	8.632
10	PT2_r1	1.166667	93.45	16.96
11	PT2_r1	1.333333	91.22	17.68
12	PT3_r1	1.5		
13	PT3_r1	1.666667		
14	PT3_r1	1.833333		
15	PT3_r1	2		
16	PT3_r1	2.166667		
17	PT4_r1	1.5		
18	PT4_r1	1.666667		
19	PT4_r1	1.833333	67.9	8.574
20	PT4_r1	2	85.06	16.39
21	PT4_r1	2.166667		
22	PT5_r1	2.5	96.5	15.56
23	PT5_r1	2.666667	85.48	13.61
24	PT5_r1	2.833333	86.24	14.18
25	PT5_r1	3	91.04	12.5
26	PT5_r1	3.166667	91.5	14.29

ICM+ Event oriented analysis



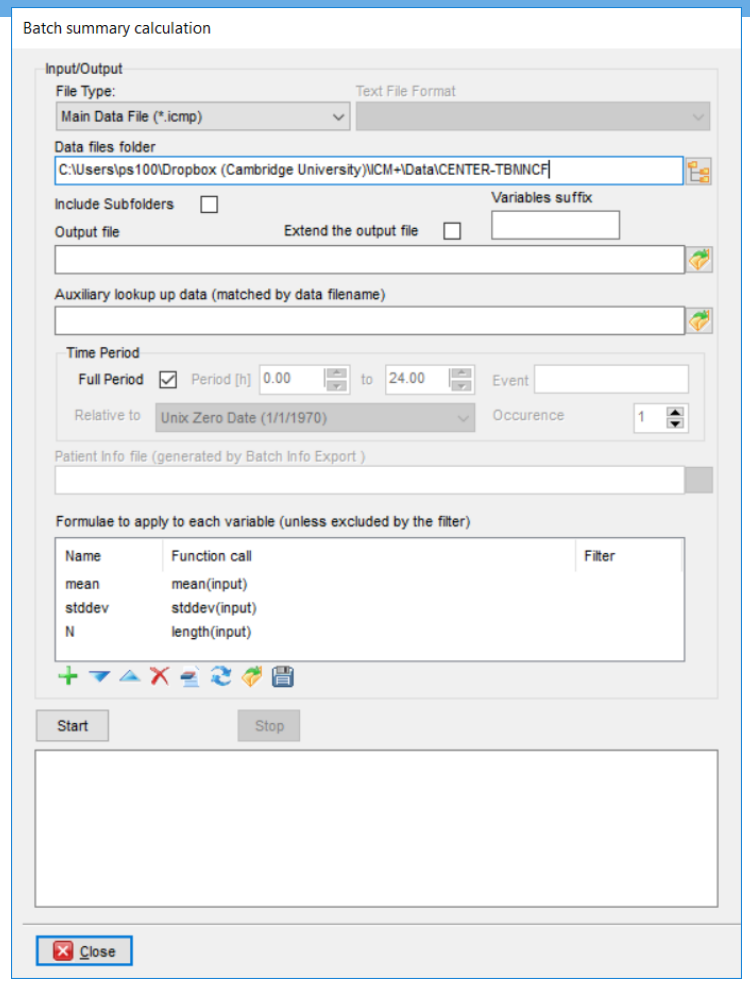
Time anchoring for batch analysis



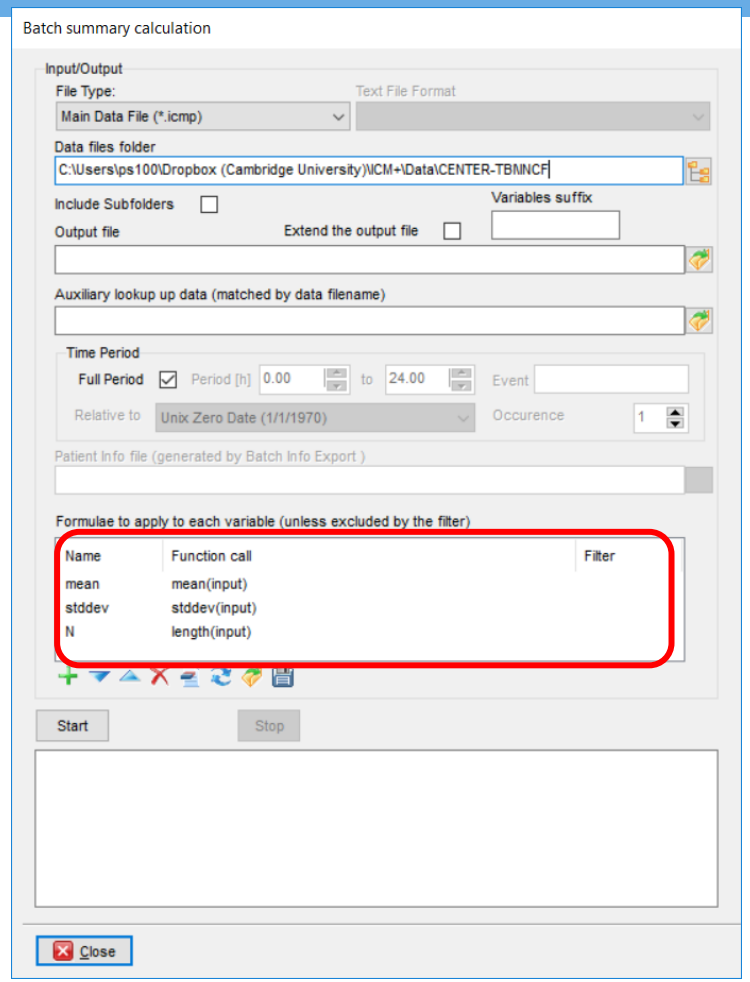


Negative time ⟵ ⟶ Positive time

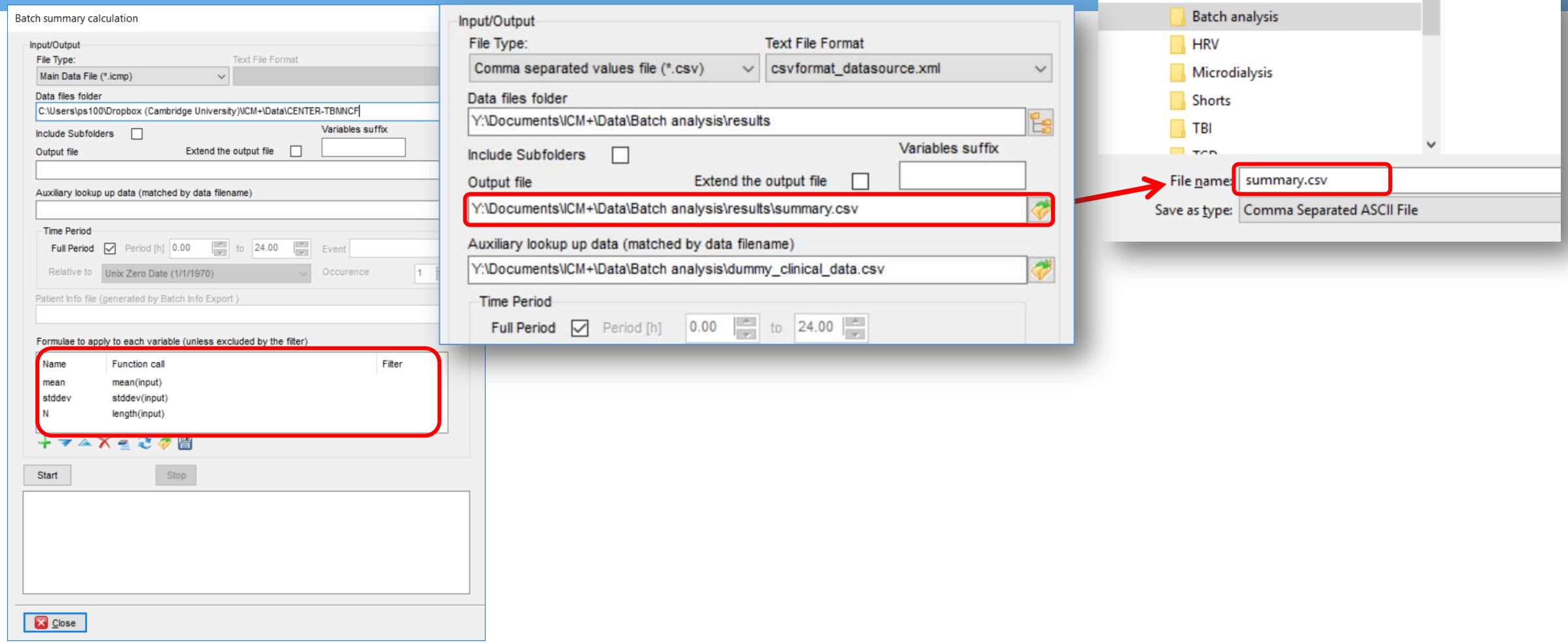
Batch summary calculation, linking with the clinical database



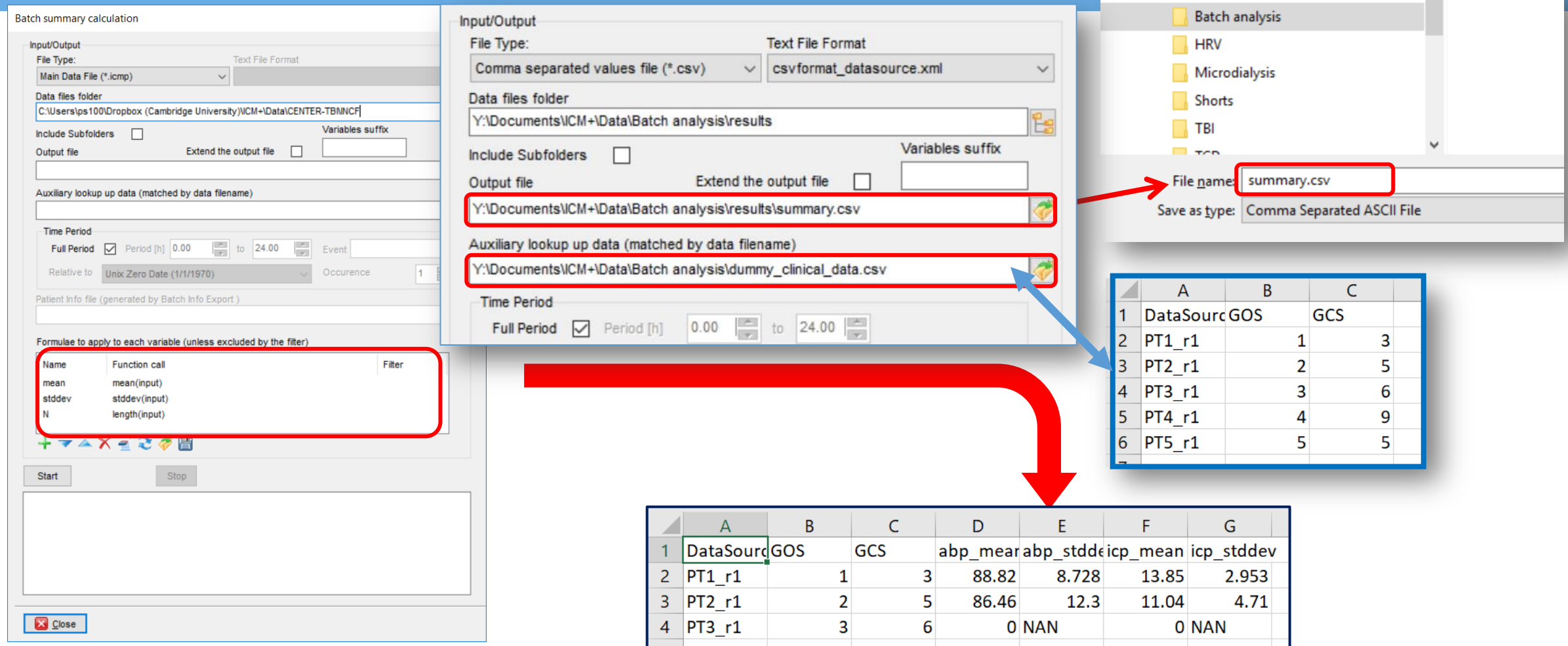
Batch summary calculation, linking with the clinical database



Batch summary calculation, linking with the clinical database



Batch summary calculation, linking with the clinical database



	A	B	C
1	DataSourc	GOS	GCS
2	PT1_r1	1	3
3	PT2_r1	2	5
4	PT3_r1	3	6
5	PT4_r1	4	9
6	PT5_r1	5	5

	A	B	C	D	E	F	G
1	DataSourc	GOS	GCS	abp_mean	abp_stdde	icp_mean	icp_stddev
2	PT1_r1	1	3	88.82	8.728	13.85	2.953
3	PT2_r1	2	5	86.46	12.3	11.04	4.71
4	PT3_r1	3	6	0	NAN	0	NAN
5	PT4_r1	4	9	73.81	13.49	10.03	7.001
6	PT5_r1	5	5	89.12	9.894	13.79	2.98

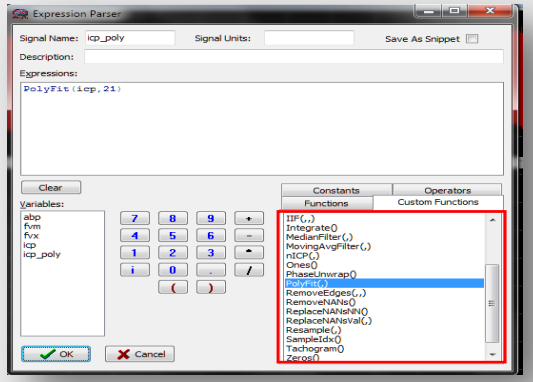
ICM+ functionality can be extended using 3rd party plugins

DLL library Implementing **DSP** interface

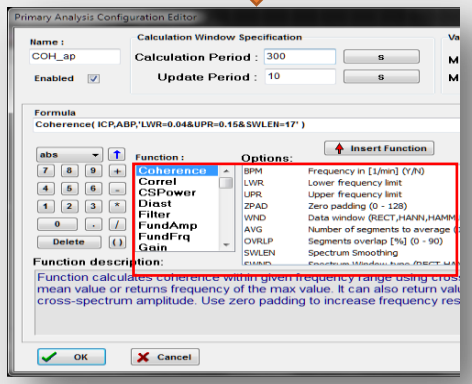
DLL library Implementing **Stats** interface

DLL library Implementing **Chart** interface

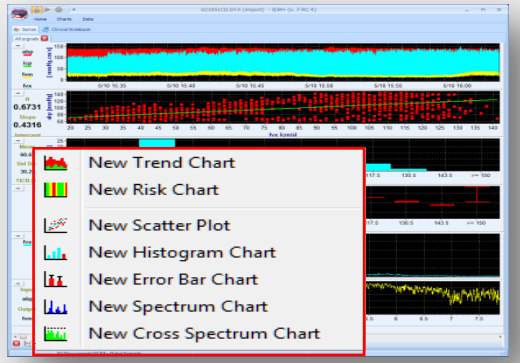
DLL library Implementing **Tools** interface



DSP
(Signal Calculator)

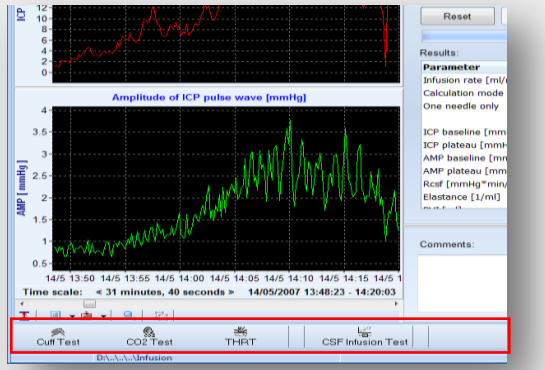


Stats functions
(Real-time analysis)



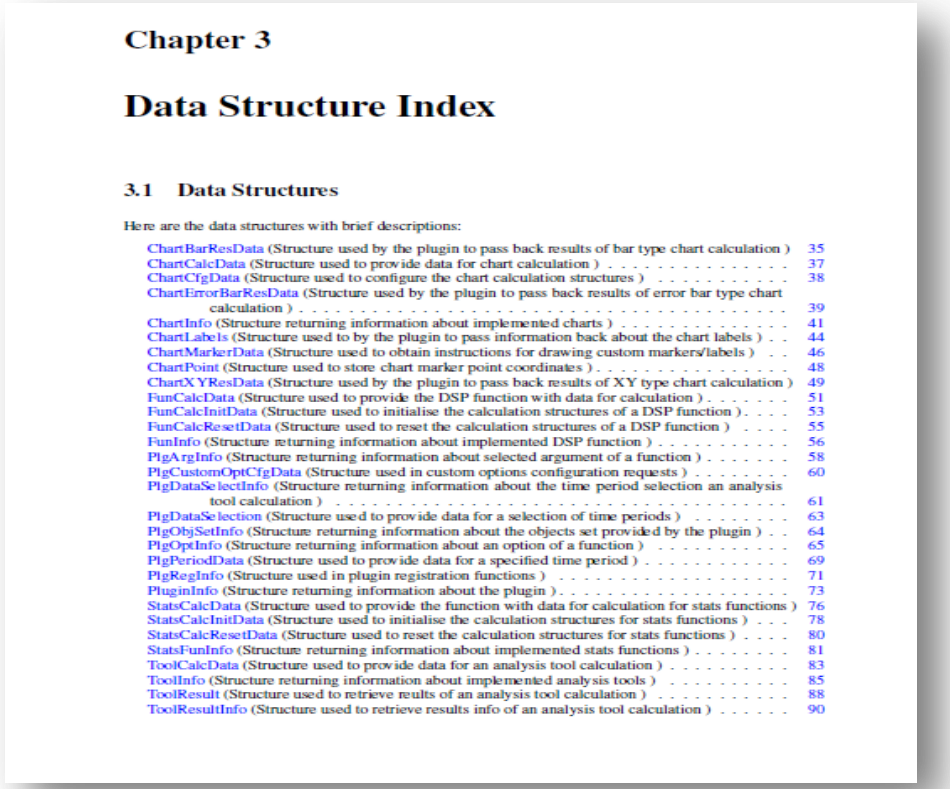
Charts

ICM+



Tools
(Intervention tests)

Advanced features: Plugins



Chapter 3

Data Structure Index

3.1 Data Structures

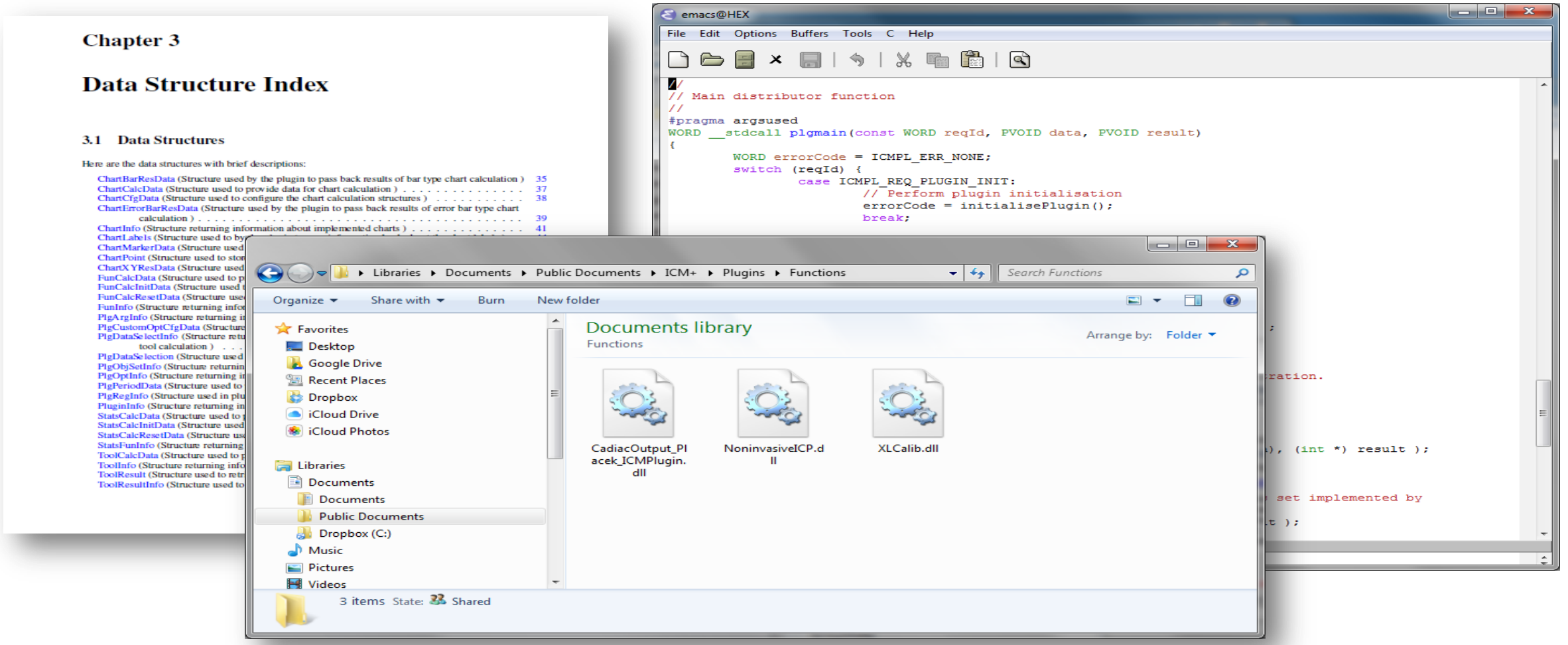
Here are the data structures with brief descriptions:

emacs@HEX

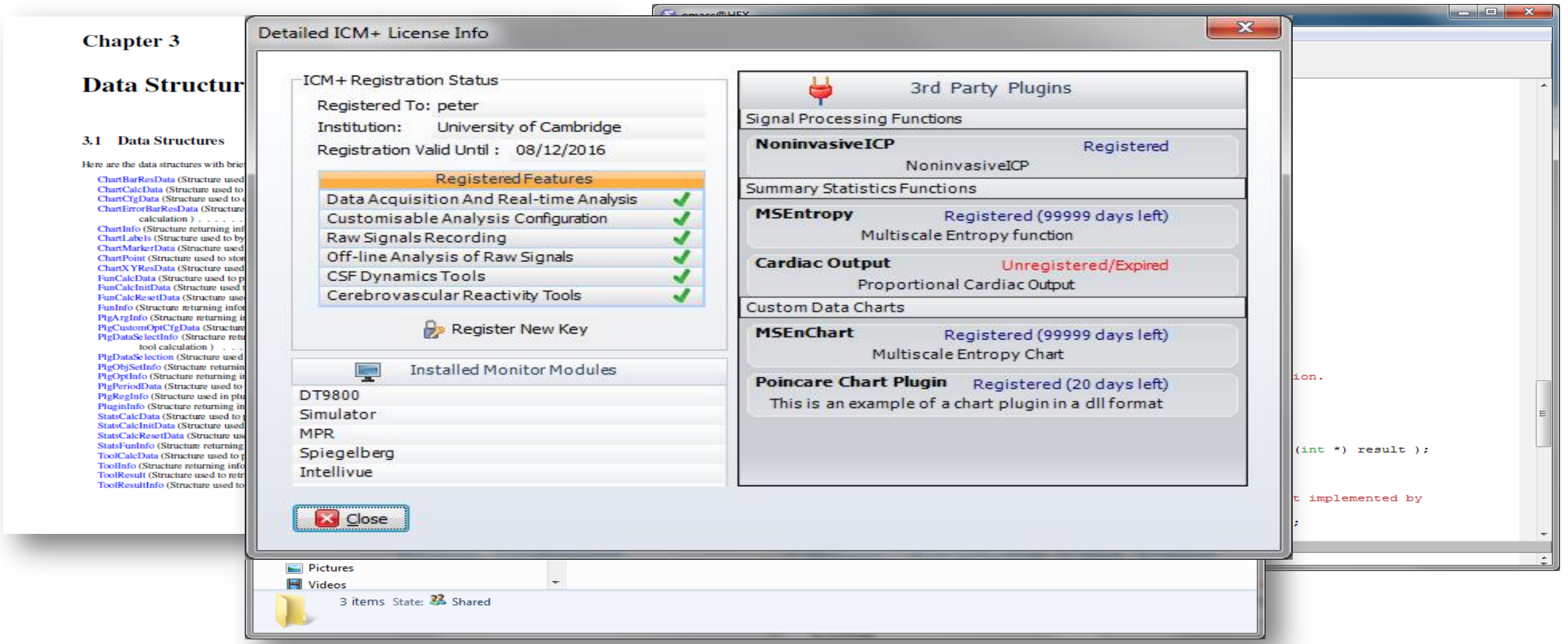
File Edit Options Buffers Tools C Help

```
//
// Main distributor function
//
#pragma argsused
WORD __stdcall plgmain(const WORD reqId, PVOID data, PVOID result)
{
        WORD errorCode = ICMPL_ERR_NONE;
        switch (reqId) {
                case ICMPL_REQ_PLUGIN_INIT:
                        // Perform plugin initialisation
                        errorCode = initialisePlugin();
                        break;

                case ICMPL_REQ_PLUGIN_FREE:
                        // Perform plugin cleanup
                        errorCode = finalisePlugin();
                        break;

                case ICMPL_REQ_PLUGIN_INFO:
                        // Request for information about the plugin.
                        errorCode = getPluginInfo( (PluginInfo *) result );
                        break;

                case ICMPL_REQ_REG_INFO:
                        // Request for information about the plugin registration.
                        errorCode = getRegInfo( (PlgRegInfo *) result );
                        break;

                case ICMPL_REQ_REGISTER:
                        // Request to register the plugin.
                        errorCode = registerLicense( *((PlgRegInfo *) data), (int *) result );
                        break;

                case ICMPL_REQ_FUNSET_INFO:
                        // Request for information about the DSP functions set implemented by
                        // the plugin.
                        errorCode = getFunSetInfo( (PlgObjSetInfo *) result );
                        break;
-\---   dsp_main.c      67% L144    (C/l Abbrev)
```

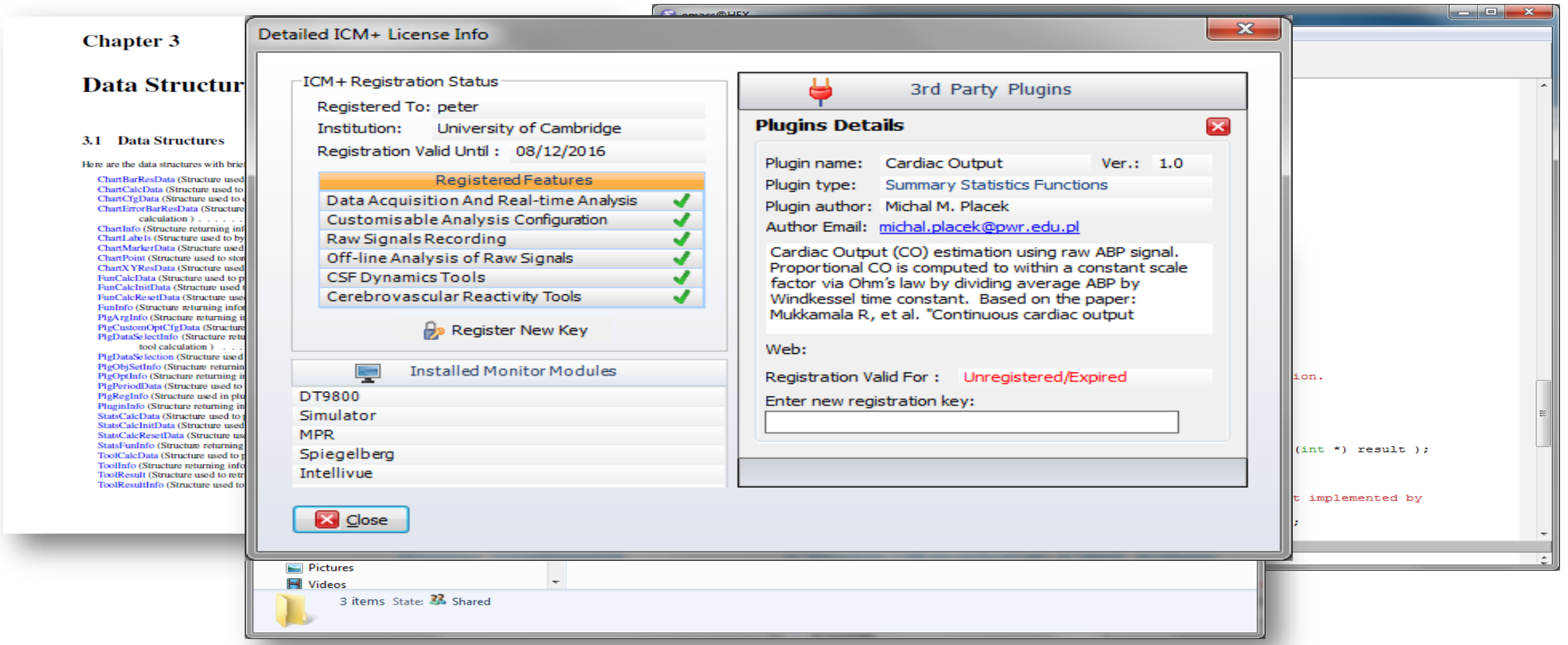
Advanced features: Plugins



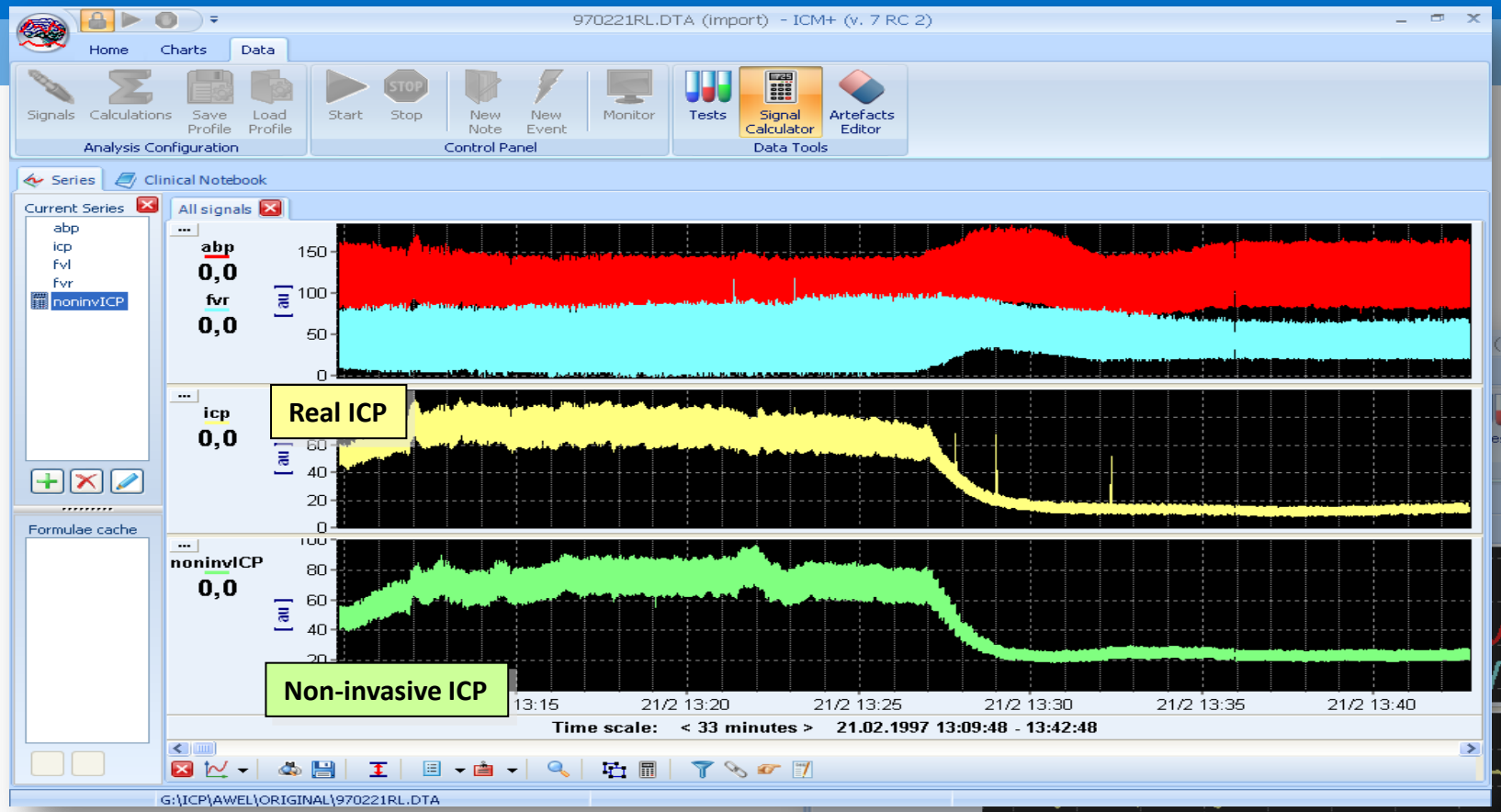
Advanced features: Plugins

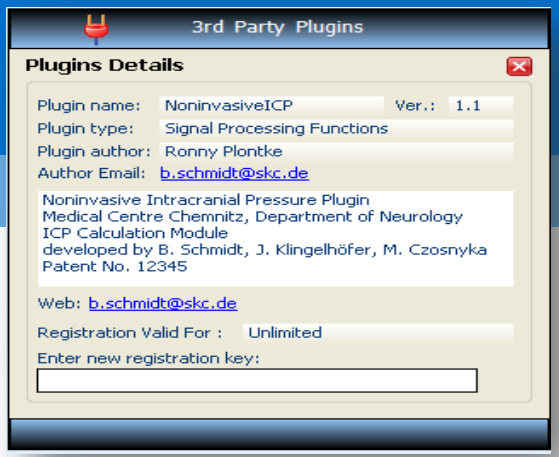


Advanced features: Plugins



nICP plugin for ICM+





Schmidt B *at al*: Adaptive non-invasive assessment of cerebral autoregulation and ICP. *Stroke* 34:84-89; 2003

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Writing plugins for ICM+ requires some fundamental programming skills

- Hi performance code – important for complex functions
- The code is distributed as a binary - protected, allowing 3rd party licensing

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- Needs a full C/C++ development environment – eg Visual C++ or gcc for Windows and a good understanding of building dll libraries
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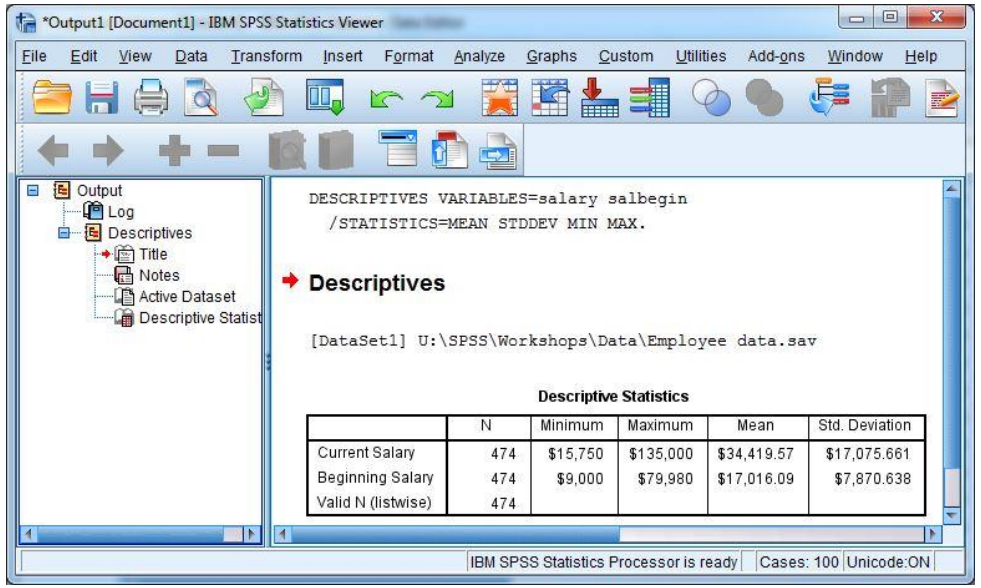
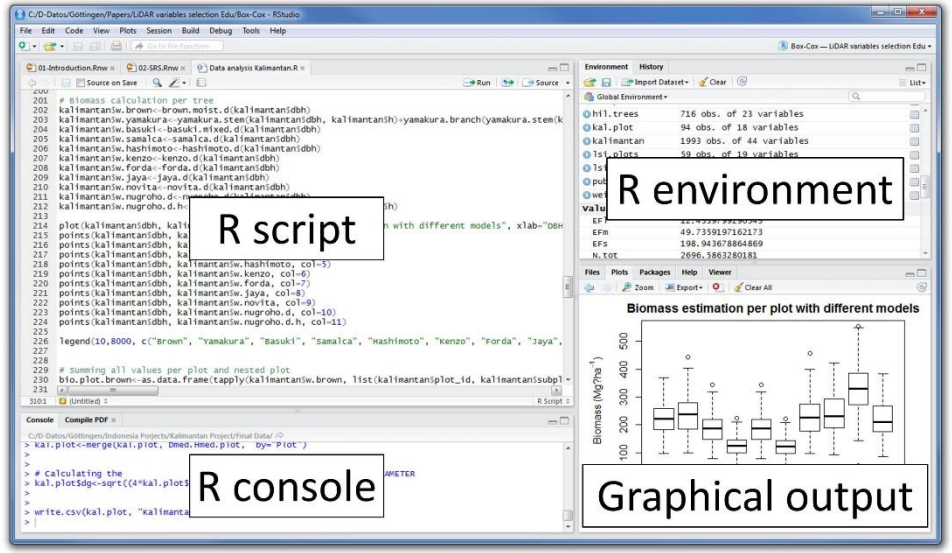
- **In short, it needs a true coder**

Enter new age clinical researcher …

- New generation of clinicians are very used to scripting languages
- This is clear by the observed global shift away from GUI based statistical packages like SPSS to command line /script based environments like R, Matlab, or Python





If statistics programs were cars …

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If statistics programs were cars …

Algorithmic thinking and scripting is becoming a second nature to our youngsters

COMPUTING

Computing combines logic and creativity in problem-solving, while also enabling competence and confidence in the use of developing technologies.

Prep (Age 7-13)

Education For The Future

› Academic Curriculum

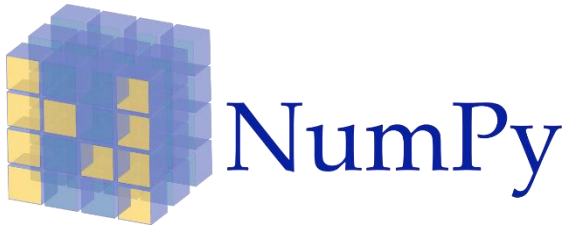
Learning at St Faith's

Brief Computing curriculum highlights include:

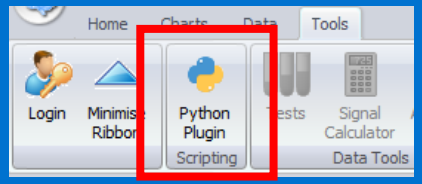
- **Year 3** control a screen turtle to draw complex patterns using just a few lines of code
- **Year 4** use ProBots, robotic floor toys with programmable sensors that link in with their understanding of angles in maths
- **Year 5** pupils write their own games in Scratch and put them on our Virtual Learning Environment for other children to play, view the code, and leave feedback
- **Year 6** program Raspberry Pis to switch lights on and off and control buzzers and switches
- **Year 7** children take part in the Robot Olympics: small groups of children design, build, program and test a robot, then race against each other to see whose is the fastest
- **Year 8** pupils write their own text adventure games using Python

What is Python

- It is a fully Object Oriented scripting language, with easy, intuitive syntax, and a huge library base, including many complex maths, signal processing and stats libraries, also machine learning support. Easy to install, easy to use (for the modern clinical researcher).

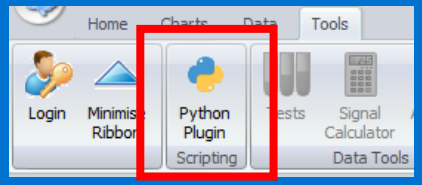


Extending ICM+ with Python




```python
# from scipy.stats import spearmanr
import numpy as np
from scipy import stats

class Correlation_v2:

    # DO NOT MODIFY THIS METHOD..
    def set_parameter(self, param_name, param_value):
        setattr(self, param_name, param_value)

    # Class constructor.
    def __init__(self):
        self.sampling_freq = None

    # must return one floating-point number
    # sig1 - input data sequence 1
    # sig2 - input data sequence 2
    def calculate(self, sig1, sig2, *_):
        x = np.compress(~bad, sig1)
        y = np.compress(~bad, sig2)
        R, p = stats.pearsonr(x, y)

        if self.pValue == True:
            return p # p-value
        else:
            return R # correlation coeffient
```

Extending ICM+ with Python

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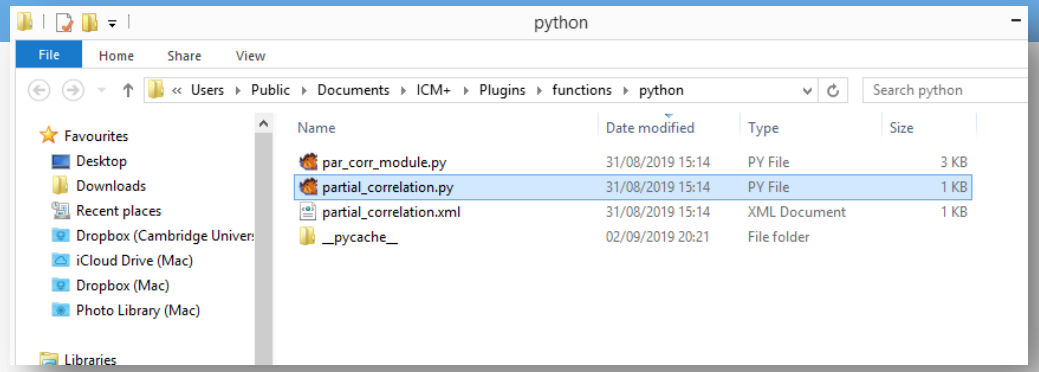
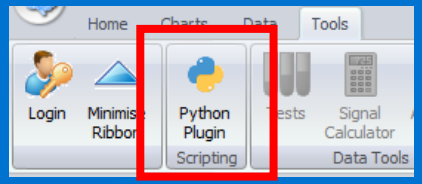


Extending ICM+ with Python

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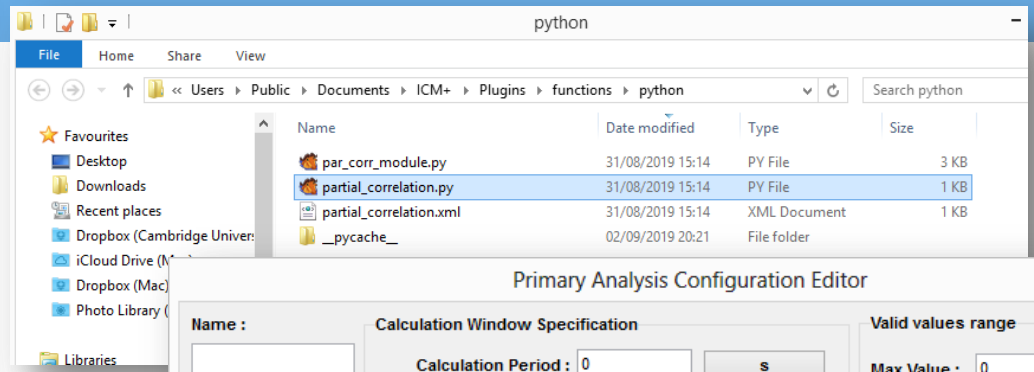
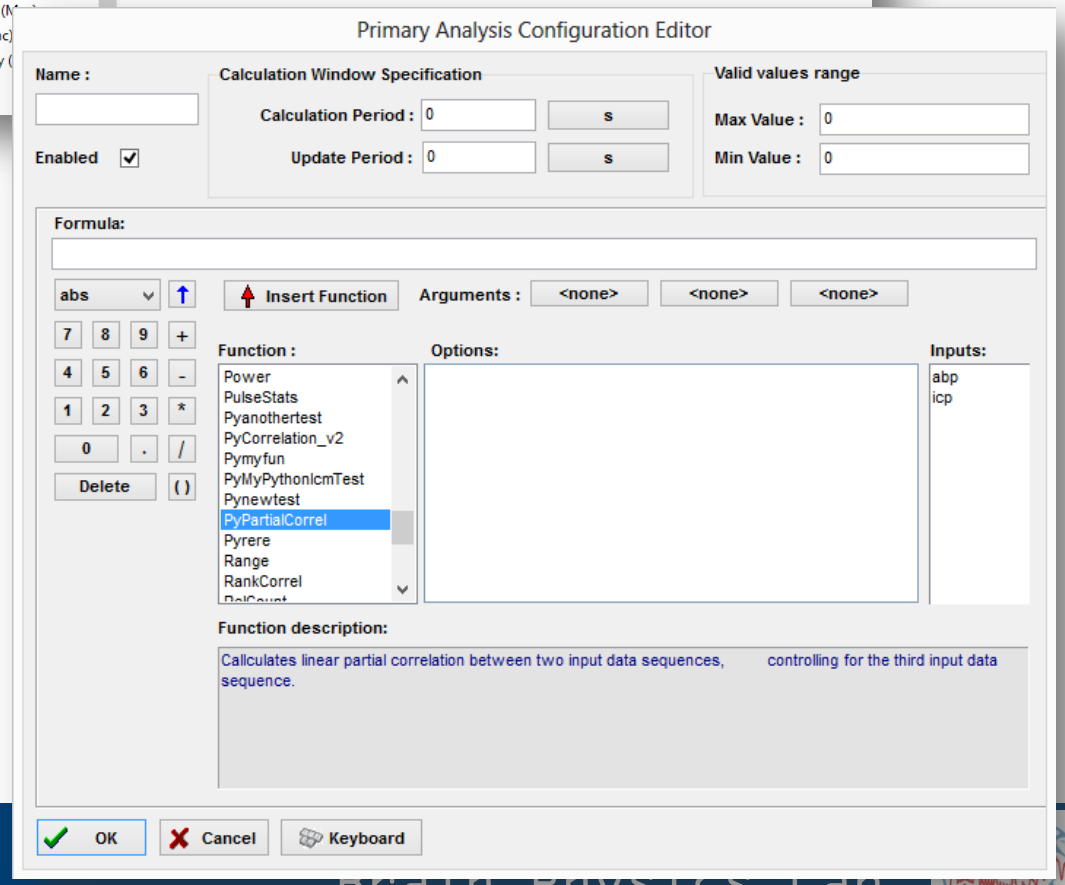
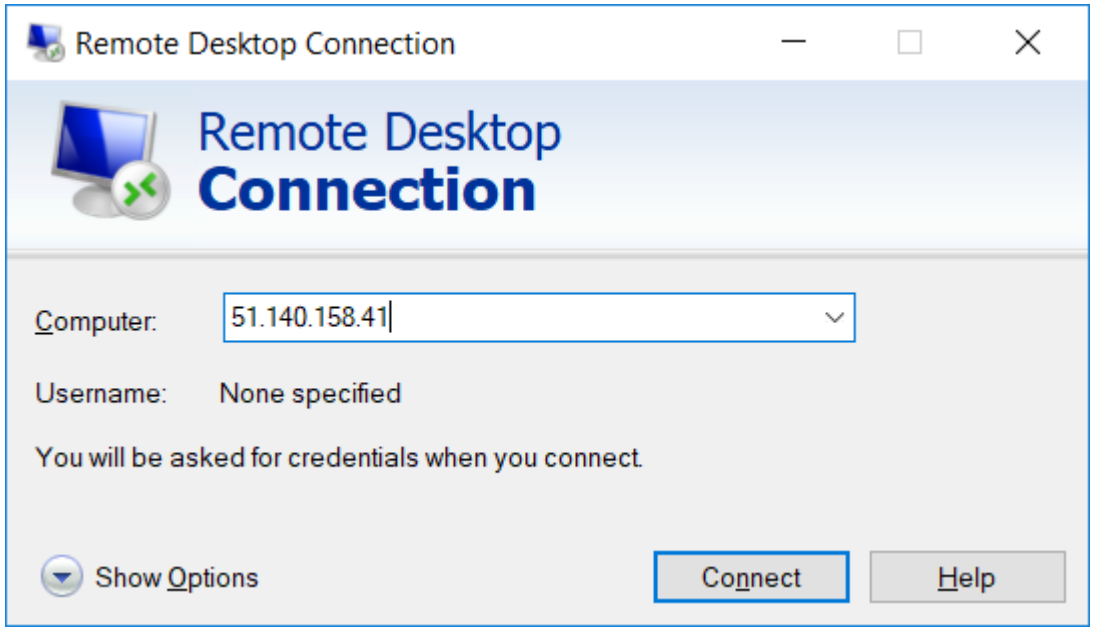
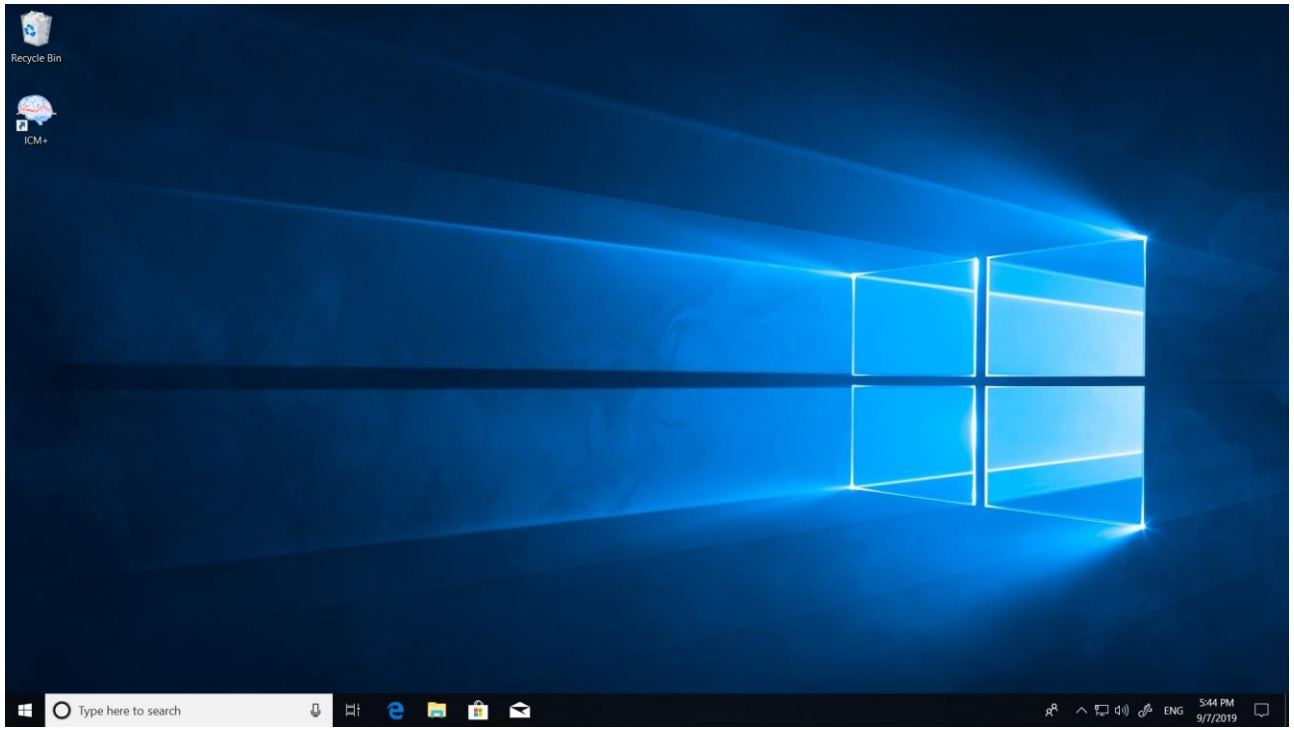




And if you are feeling particularly playful ….

Virtual workstations with ICM+ and Python installed





Lunch will be served at 12:30 in Alma (the student restaurant)

- Virtual servers set up for you to play
  - 51.140.158.41
  - 51.145.54.187
  - 51.145.54.65
  - User: icmpugm
  - Pass: leuven2019

Lunch sponsored by