

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

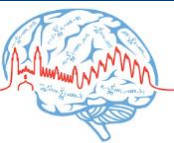
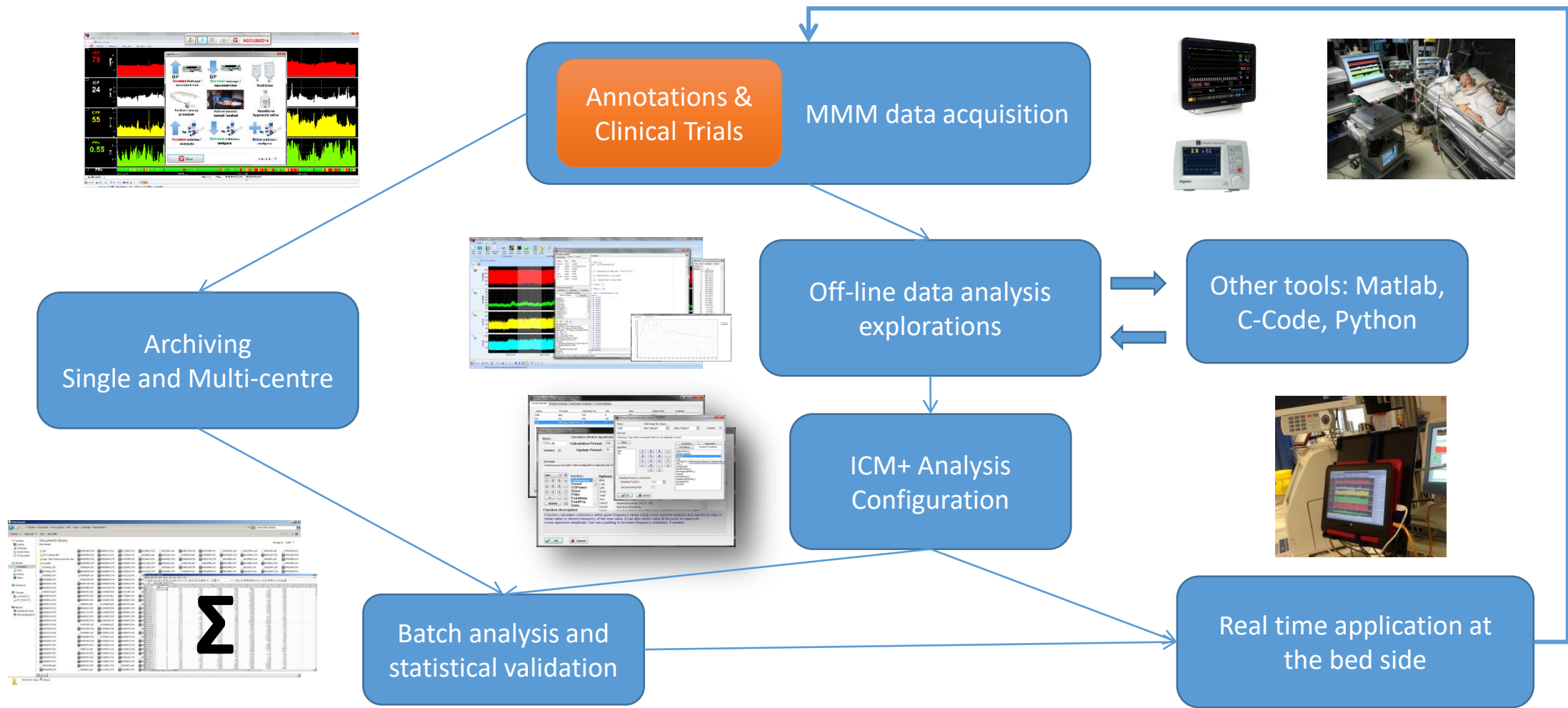
ps10011@cam.ac.uk

8th September 2019

Division of Neurosurgery, Department of Clinical Neurosciences



What is ICM+



Need for a solution like ICM+

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



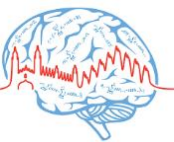
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 - ‘Undersampling’ of the medical record systems
 - Analysis like: HRV, BRS, CrCP, ICP pulse morphology, Non-invasive ICP and Cerebral Autoregulation requiring high fidelity waveform recording



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 - 215 publications on PubMed (180 over the last 10 years)
- Multicentre multimodality data collection projects
 - eg CENTER-TBI, TRACK-TBI, ADAPT



How did we get here ?

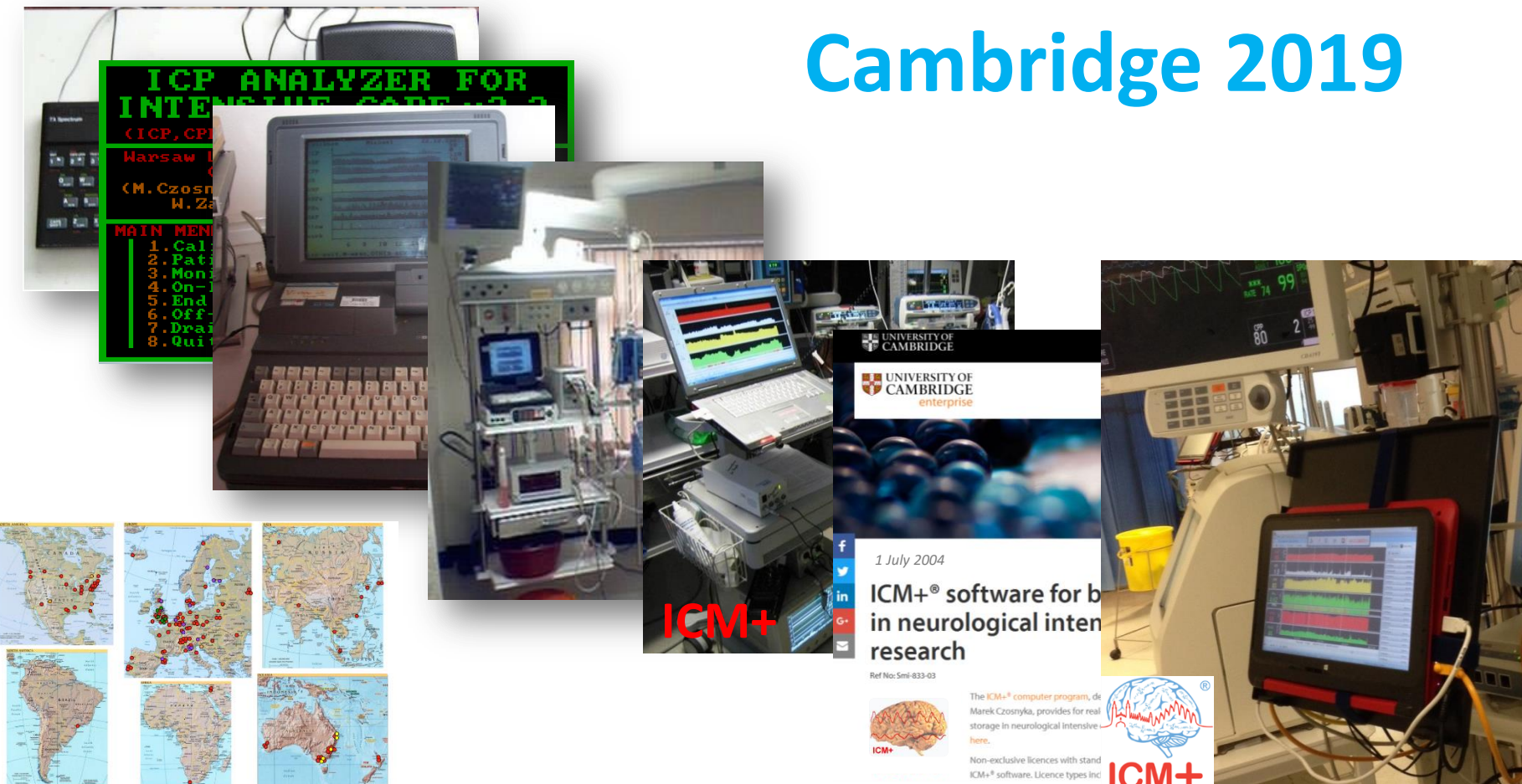


Warsaw 1982

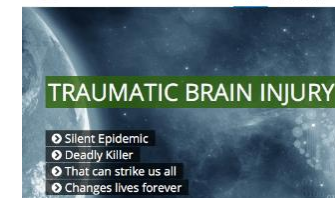


How did we get here ?

Cambridge 2019



Clinical trials



PANGEA

Public title	A double-blind placebo-controlled trial and safety of EU-C-003 in patients with
Scientific title	A double-blind placebo-controlled trial and safety of EU-C-003 in patients with
Secondary ID 1a1	Pressure Neuro EU-C-003-01-01
Secondary ID 1a2	EUDRACT 2017-004820-05
Universal Trial Number (UTN)	UTN U1111-1126-7276
Trial acronym	PANGEA
Linked study record	

ClinicalTrials.gov

[Home](#) > [Search Results](#) > [Study Record Detail](#)

Cerebral Autoregulation Monitoring During Cardiac Surgery



ICM+ Users' group meetings

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

2nd ICM+ users' meeting **ICP 2013**



15th INTERNATIONAL CONFERENCE ON INTRACRANIAL PRESSURE & BRAIN MONITORING (ICP)
 6 - 10 November 2013
 Glasgow

15th International Conference on Intracranial Pressure & Brain Monitoring (ICP)

PROGRAMME AT A GLANCE

Date / Time	6 Nov 2013 Wednesday	7 Nov 2013 Thursday	8 Nov 2013 Friday	9 Nov 2013 Saturday	10 Nov 2013 Sunday
09:00 - 09:00		Chair Session 2: Critical Monitoring of ICP	Chair Session 3: Autoregulation and Experimental Studies in Brain Injury	Chair Session 7: Decore: Connectivity	Chair Session 9: Special Topics in ICP (2)
09:00 - 10:00	REGISTRATION	Tea	Tea	Tea	Closing Remarks
10:00 - 10:30		Chair Session 3: Critical Monitoring of ICP	Chair Session 8: Special Topics in ICP (2)	Poster Session 2	
10:30 - 11:00	REGISTRATION ICM+ User Meeting	Lunch		Lunch	
11:00 - 11:30				Poster Session 3	
11:30 - 12:00		Opening Address	Professional Lecture	Tea	Social Programme
12:00 - 12:30		15:00 - 15:30	15:30 - 16:00		
12:30 - 13:00		16:00 - 16:30	16:30 - 17:00		
13:00 - 13:30		17:00 - 17:30	17:30 - 18:00		
13:30 - 14:00		18:00 - 19:00	19:00 - 20:00		
14:00 - 14:30		20:00 - 23:00			
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18:00 - 19:00					
19:00 - 20:00					
20:00 - 23:00					

UNIVERSITY OF CAMBRIDGE enterprise **ICM+**

ICM+® Users' Club Meeting
 28th June 2016, MIT
 Chairmen: Prof Lizous Steiner & Prof Marek Czosnyka
 Secretary: Mr Manuel Calvo (mrc116@cam.ac.uk)



11:00 **Dr Peter Smielewski**
 ICM+ - the state of the art

11:45 Refreshments

12:00 **Prof Christine Haubrich**
 Autonomic system monitoring using ICM+

12:10 **Prof Ken Brady**
 Experimental monitoring using ICM+

12:25 **Dr Eric Schmidt**
 CSF infusion study using ICM+

12:30 **Prof Martin Schuhmann**
 Overnight ICP monitoring in hydrocephalic kids using ICM+

12:40 **Dr Bernd Schulte**
 Non-invasive ICP assessment using ICM+

12:50 **Prof Bart Dingsdorens**
 Nearly 100 beds for monitoring - how to do it using ICM+

13:00 **Mr Manuel Calvo**
 High volume multi-center brain monitoring project using ICM+

13:10 **Prof Charles Hoog**
 Monitoring cerebral ICP

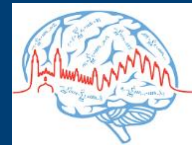
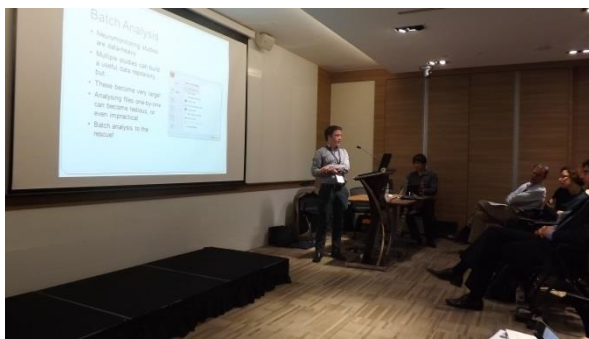
13:20 **Dr Marcel Aries**
 Monitoring cerebral ICP

13:30 **Dr Calista Dill**
 Technical ICP in clinical practice

13:40 **Dr Andrej Dobson**
 Technical ICP in clinical practice

13:50 **Dr Christopher Blue**
 Monitoring intracranial pressure

14:00 Lunch

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

'Congrats on a great conference! We really enjoyed our time in Cambridge and learned a lot.'
Dr Charles Brown, John Hopkins, USA

'.. thank you for the great workshop this week in Cambridge, learned a lot!
Dr Uud van Kaam, Radboud University medical center, the Netherlands

'Thanks again for the course: very pleasant and certainly useful for me.'
Prof Bart Depreitere, Leuven University Hospital, Belgium

'Big congratulations for this well-organized workshop, very interesting and very ambitious and very instructive!!!'
Dr Bernhard Schmidt, Chemnitz Medical Centre, Germany

'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.'
Dr Nicolas Joram, Nantes Cedex

'I am more than satisfied by unique ICM+ event.'
Prof Arminas Ragauskas, Kaunas University, Lithuania

'The workshop was fantastic -- thank you again for inviting me'
Dr Jennifer Lee, Johns Hopkins, USA

'Congratulations on the successful ICM+ workshop. I really enjoyed learning about how to exploit it better.'
Dr Hari Krishnan, Birmingham Children's Hospital, UK

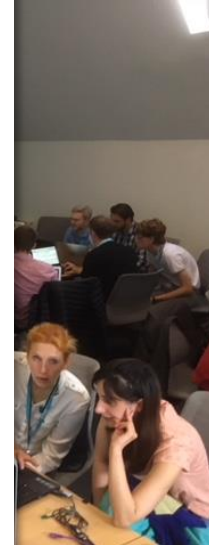
'I really wanted thank you for an excellent ICM+ workshop last week. I really learned a lot and have a great deal I can bring my back to my institution. I look forward to using ICM+ in more robust ways at Phoenix Children's Hospital to delivery better neurocritical care at my hospital.'
Dr Brian Appavu, Phoenix Children's Hospital, Philadelphia

'Still enjoying the taste of the workshop, I had a great time in absolutely every way. Congratulations again Erta and Peter!'
Dr Nico De Riva, Hospital Clinic of Barcelona

'Thank you for putting together the ICM+ workshop. It was excellent.'
Dr Nils Petersen, Yale University School of Medicine.'

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Marc Baroncini, MD PhD, Neurosurgery, Lille University Hospital, France

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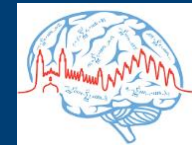
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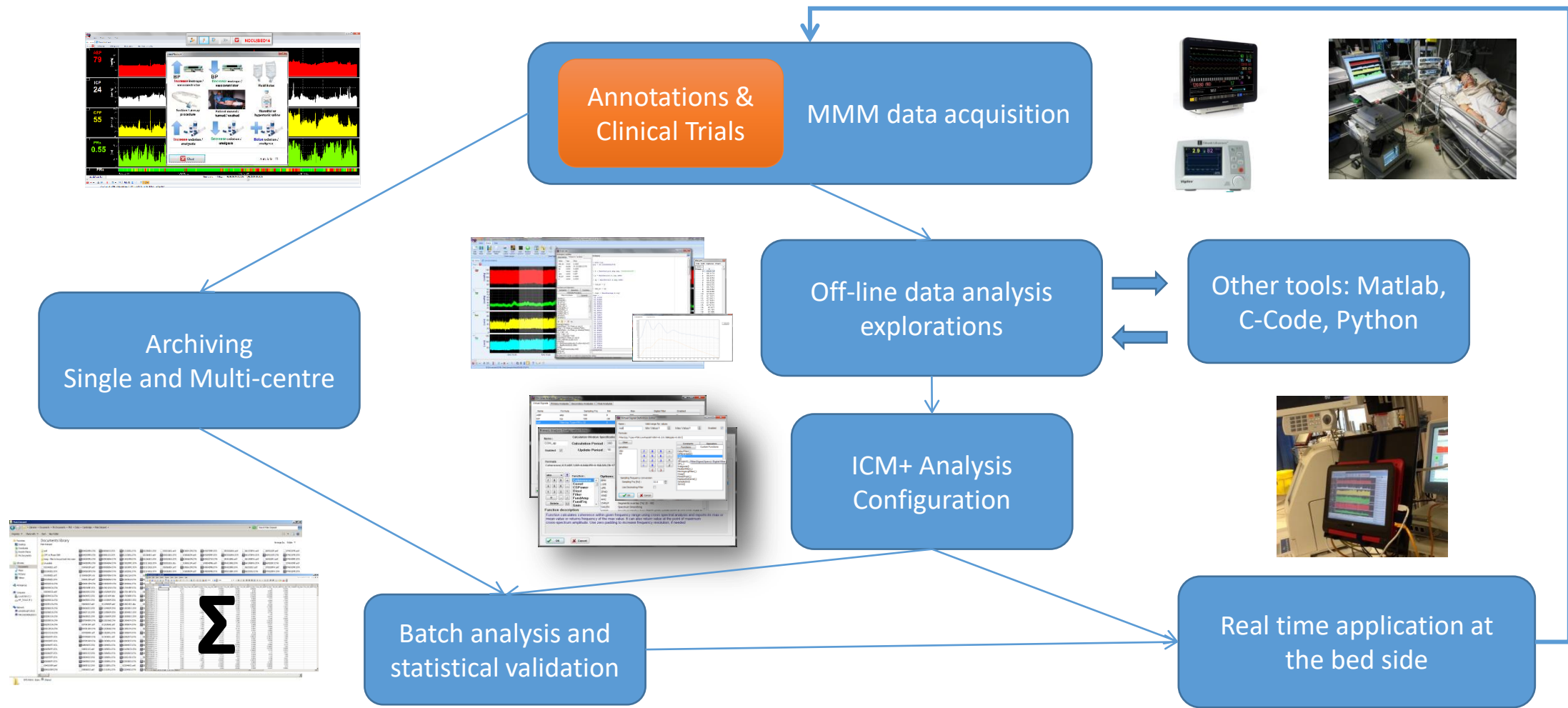


UNIVERSITY
CAMBRIDGE

Brain Physics Lab



So what is ICM+ ?



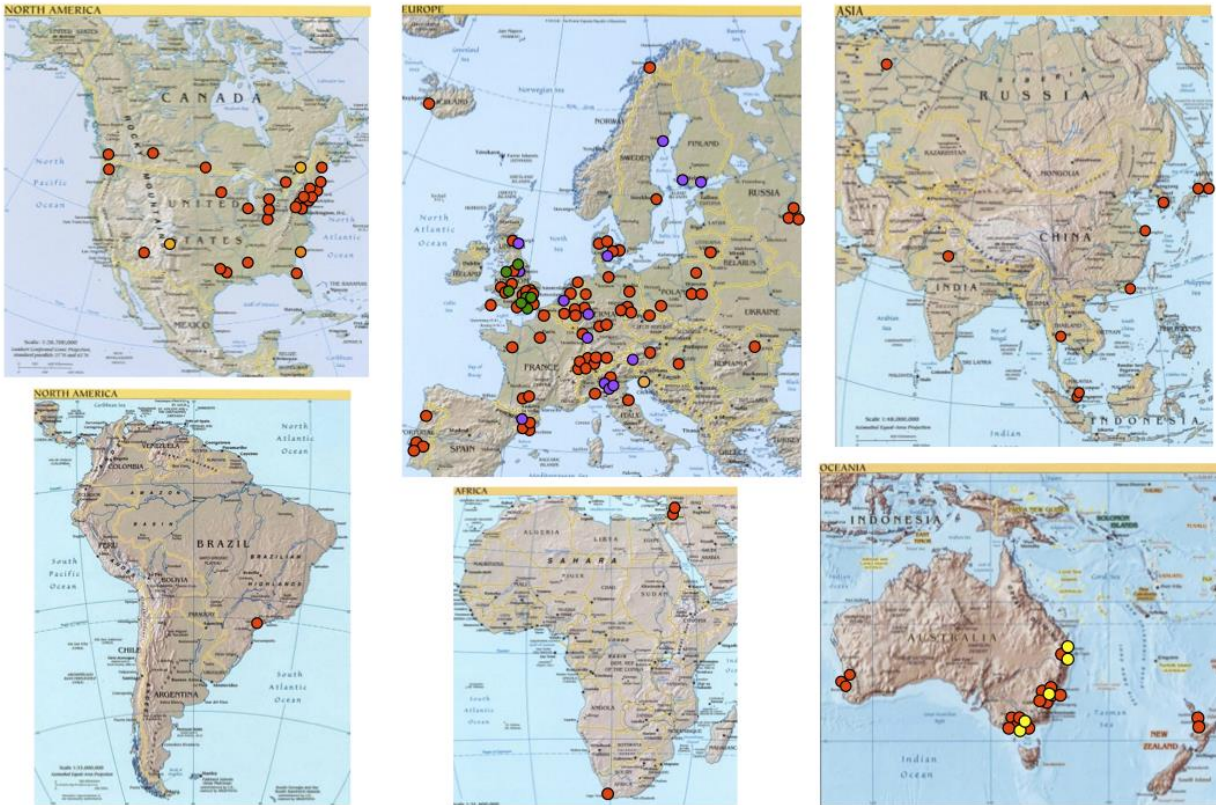
So what is ICM+ ?

Its a thriving and growing community



ICM+ Impact

ICM+ Installations map (Sept 2019)



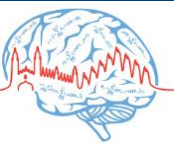
Key facts

- ✓ 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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➤ CSF dynamics investigations



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- Monitoring of cerebral autoregulation in TBI (PRx)



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 - emerging - autoregulation guided management of CPP
- Monitoring of cerebrovascular properties (TCD) – including cerebral autoregulation but also critical closing pressure, non-invasive estimation of CPP and ICP



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- Intraoperative monitoring of autoregulation (NIRS) – guided management of ABP



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- Emerging – autonomic system monitoring

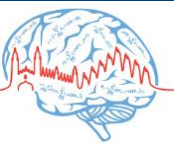


So what are the typical uses of ICM+ ? For clinical researchers



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- Integrated high resolution data collection



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- Multicentre data collection – emerging intervention trial assistants



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- Data browsing and extraction using basic stats tools
- Analysis of raw data using simply time based correlation concepts or dedicated functions, like Heart Rate Variability



So what are the typical uses of ICM+ ? For clinical researchers

- Integrated high resolution data collection
- Multicentre data collection – emerging intervention trial assistants
- Data browsing and extraction using basic stats tools
- Analysis of 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

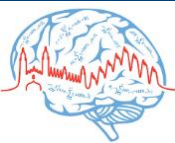
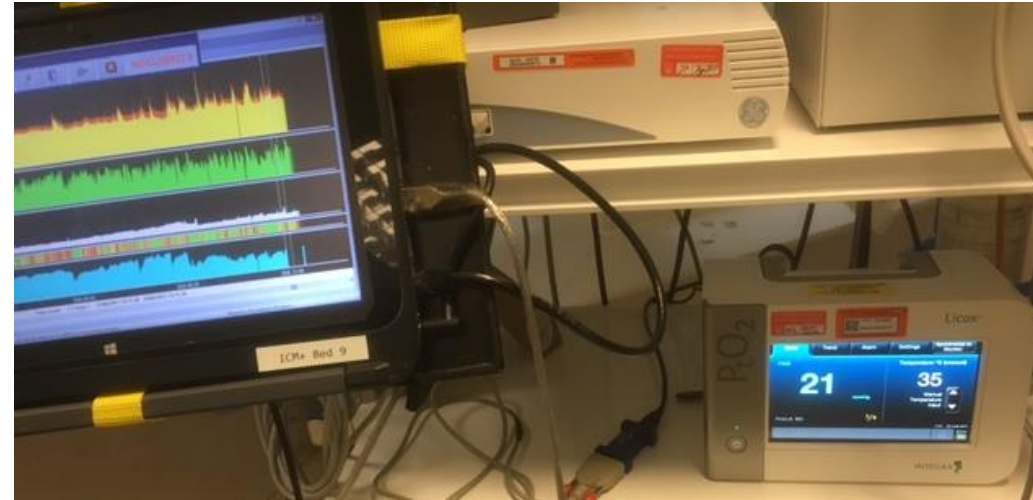
Modify Add Delete Clear

Configured modalities to be collected

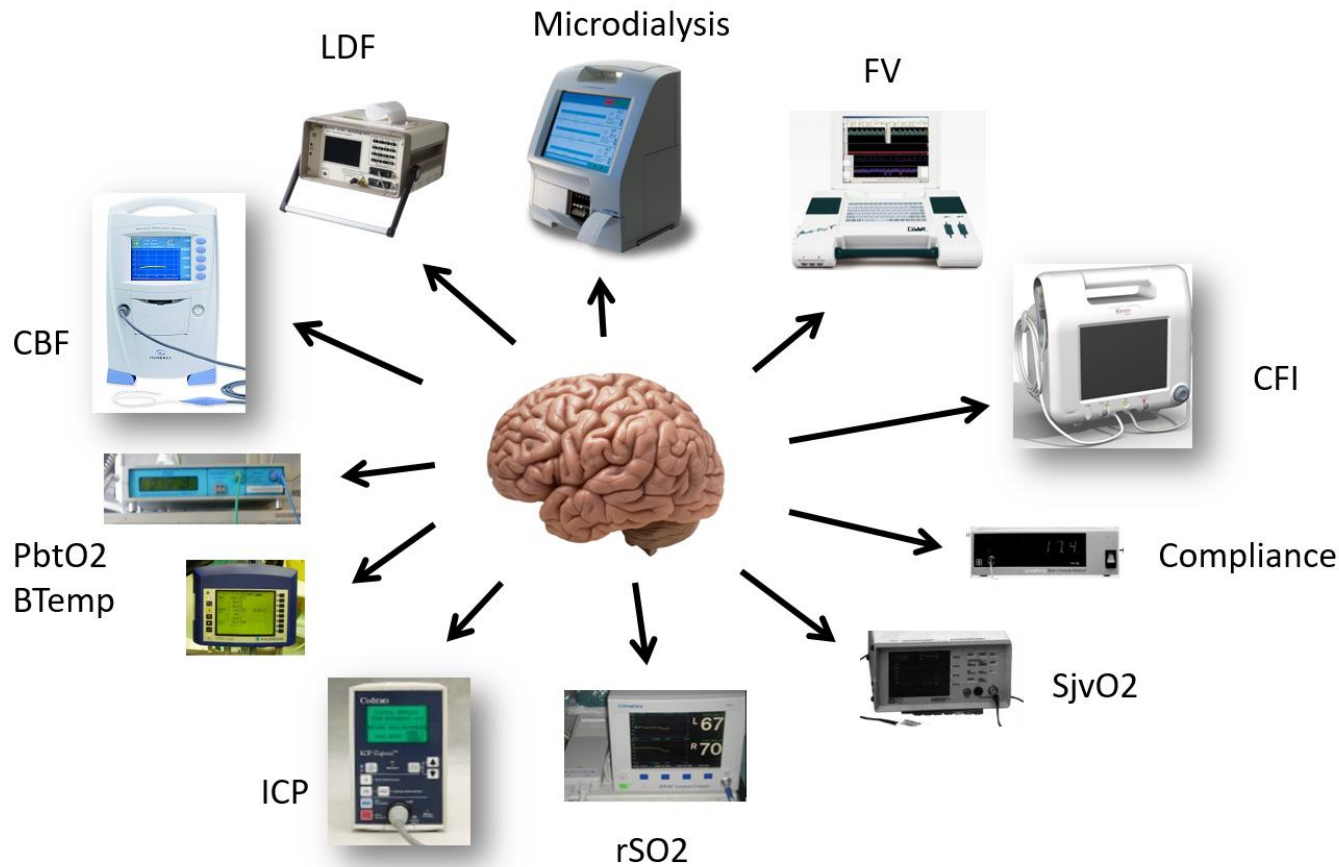
Name	Units	Device	Waveform	Min V...	Max ...	Enabled
abp	mmHg	DatexS5	INVP1	0	200	Y
ecg	mmHg	DatexS5	ECG1	-100	100	Y
Temp	Grad	DatexS5	Temp1	0	50	Y
SpO2	%	DatexS5	SpO2	0	300	Y
EtCO2	mmHg	Primus	EtCO2mmHg	0	100	Y
EtO2	%	Primus	EtO2	0	100	Y
PEEP	cmH2O	Primus	PEEP	0	20	Y
MV	ml	Primus	MV	0	20	Y
rSO2l	%	INVOS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

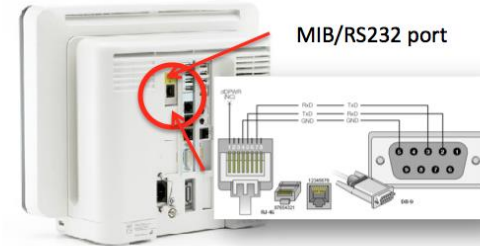


Classic serial port on GE Datex-Ohmeda monitor



Analogue interface on Spacelab monitor

RJ45 serial connector on Philips



MIB/RS232 port

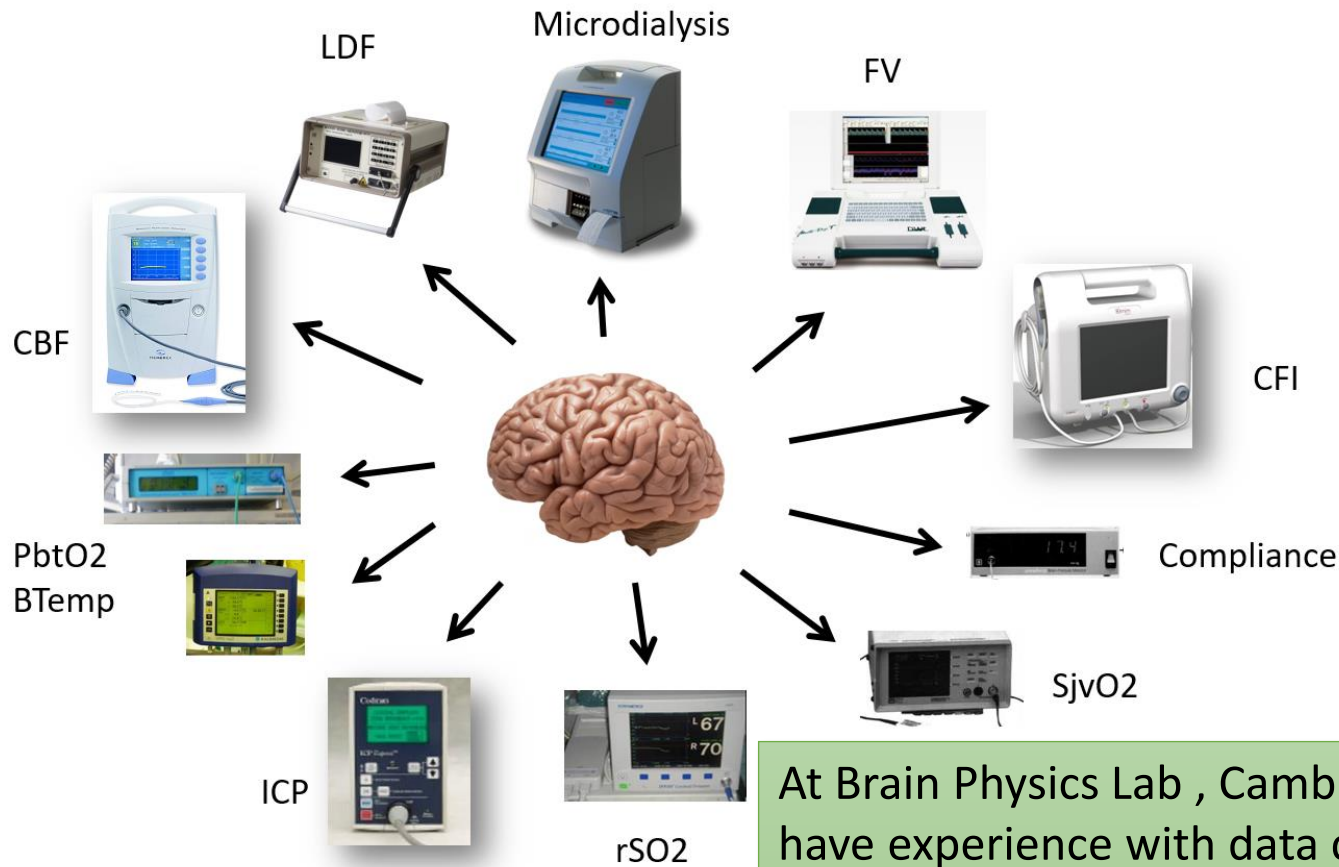


USB serial connector on GE Carescape

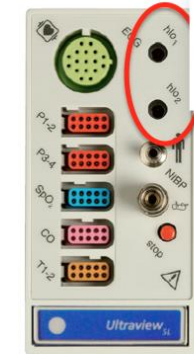
Network connector On Benevision monitors



ICU monitoring devices and their modes of data export

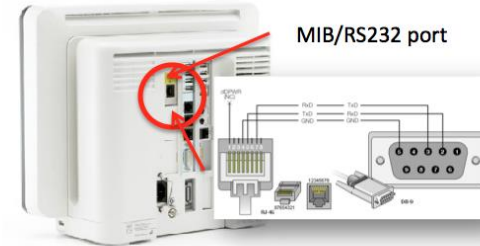


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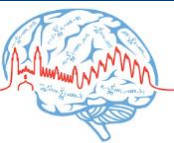


At Brain Physics Lab , Cambridge, UK, we have experience with data collection from **over 50 medical devices** – **there are no two with the same specification** for data export (hardware and software) !

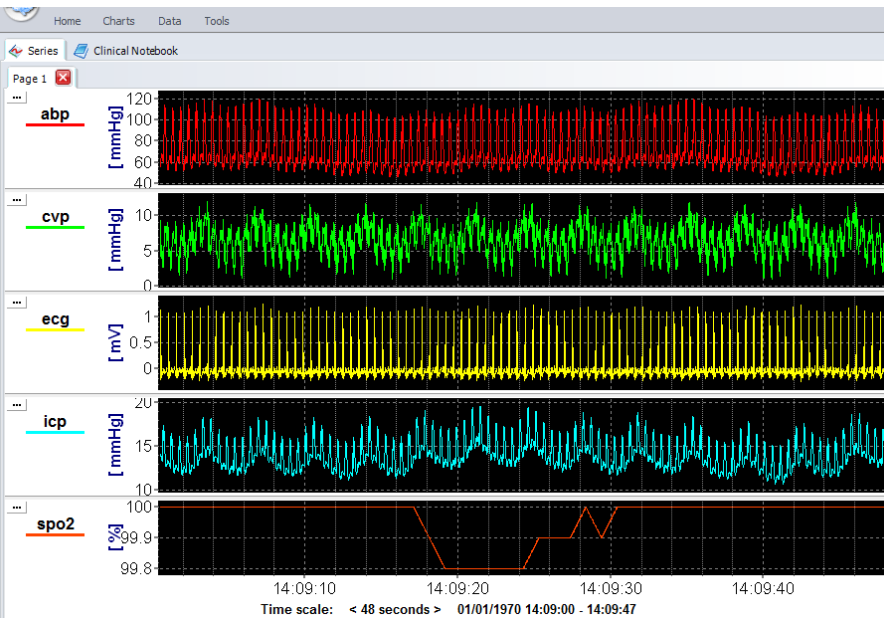


Data collection: supported monitors (Sept 2019)

- 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
- Finapres 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
- Rimmec 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 essence of ICM+ : the real time calculation engine



On Line Analysis Configuration Dialog

Virtual Signals Primary Analysis Secondary Analysis 1 Secondary Analysis 2 Final Analysis

Name	Formula	Sampling Frq	Min	Max	Digital Filter	Enabled
ABP	abp	250	0	300	None	Y
ICP	icp	250	-30	100	None	Y
ECG	ecg	250	0	0	None	Y
SpO2	spo2	1	0	0	None	Y
Temp	temp	1	0	0	None	Y
ETCO2	etco2	1	0	0	None	Y

Modify Add Delete Clear Auto Fill

Default Fs [Hz]: 250.0

OK Cancel Save Load Advanced Keyboard



Calculation pipeline allows putting together complex analysis in a simple way

On Line Analysis Configuration Dialog

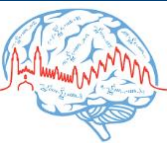
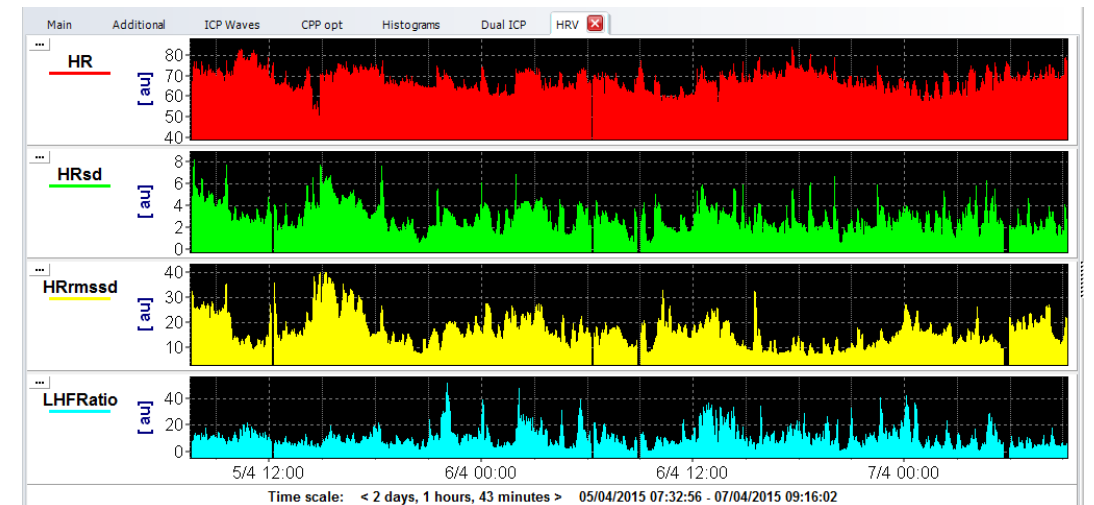
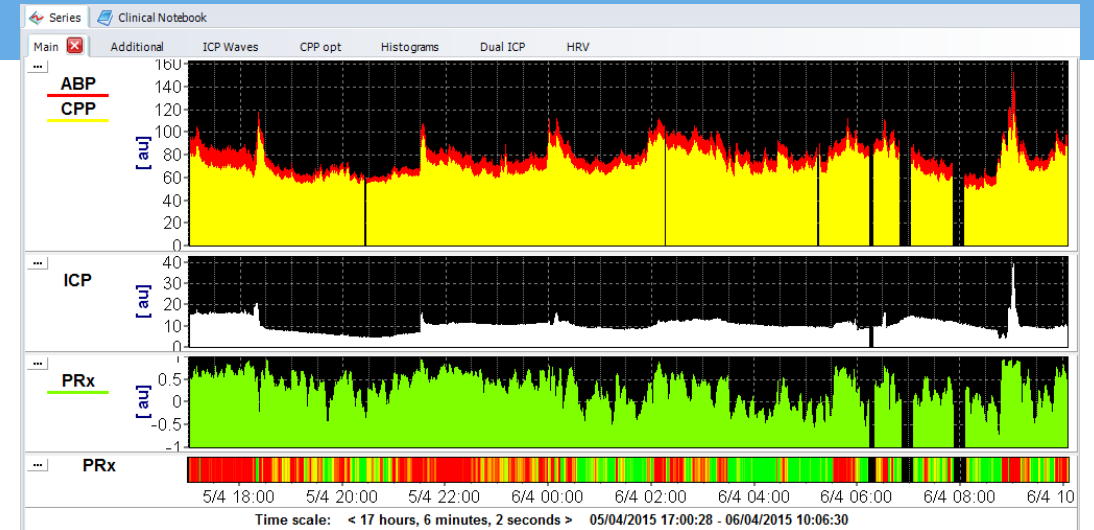
Virtual Signals | Primary Analysis | Secondary Analysis 1 | Secondary Analysis 2 | **Final Analysis**

Data Acquisition Period [s]: 60.0 Adjust Calc. Period

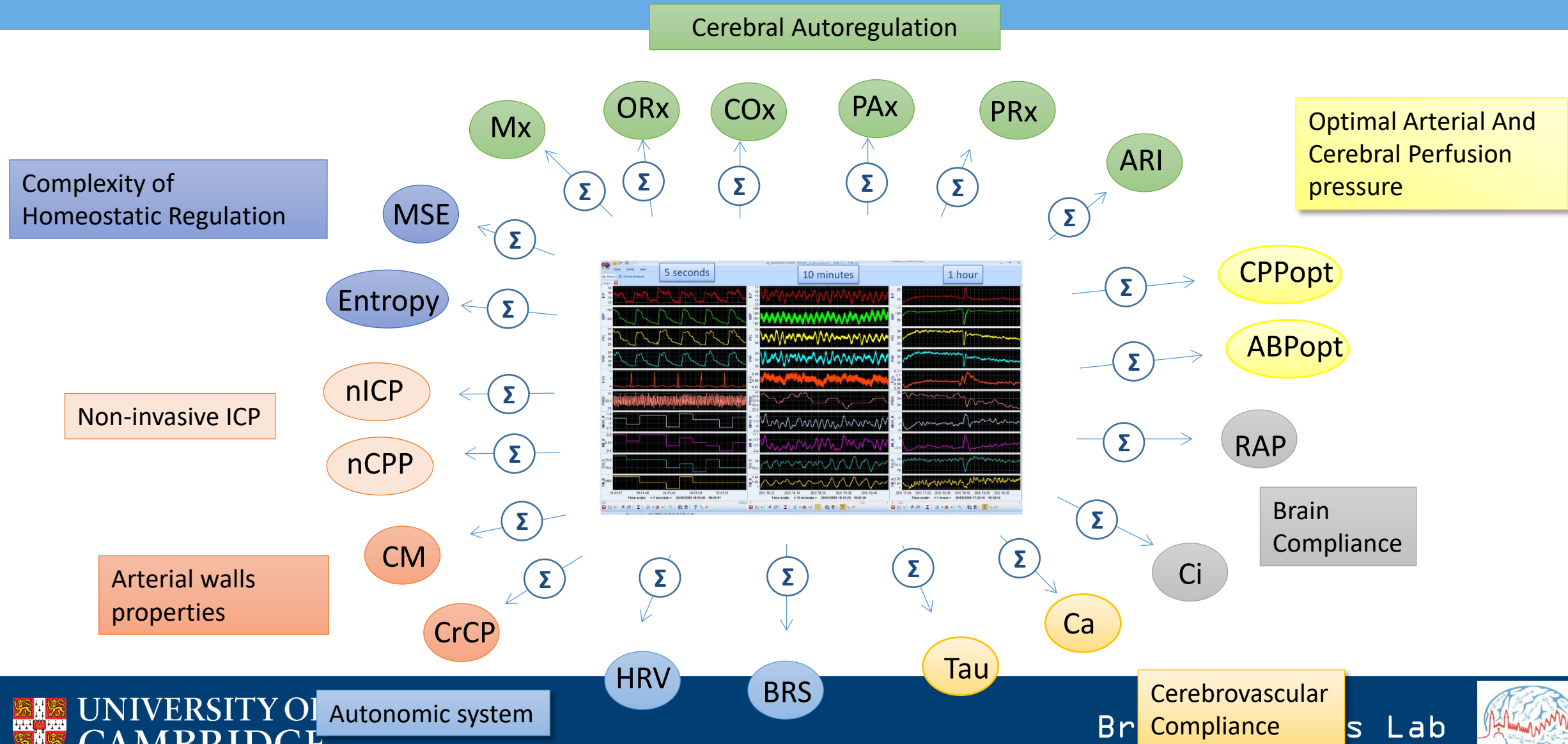
Name	Formula	Units	Calc. Windo...	Updated [s]	Min	Max	En.
slow	$\sqrt{\text{Power}(\text{ICP}, \text{BPM} \& \text{LWR} = 0.3 \& \text{UPR} = 3')}$	mmHg	600	60	0	0	Y
ICP	Mean(ICP)	mmHg	60	60	0	0	Y
CPP	Mean(CPP)	mmHg	60	60	0	0	Y
ABP	Mean(ABP)	mmHg	60	60	0	0	Y
AMP	Mean(AMP)	mmHg	60	60	0	0	Y
RA	Mean(RA)	mmHg	60	60	0	0	Y
HR	Mean(HR)	1/m	60	60	0	0	Y
RR	Mean(RR)	1/m	60	60	0	0	Y
RAP	Correl(AMP, ICP, 'MDLIM=50')	au	300	60	-1	1	Y
PRx	Correl(ABP, ICP, 'MDLIM=50')	au	300	60	-1	1	Y
sABP	Mean(sABP)	mmHg	60	60	0	0	Y
dABP	Mean(dABP)	mmHg	60	60	0	0	Y
ICPmax	Mean(ICPmax)	mmHg	60	60	0	0	Y
ICPmin	Mean(ICPmin)	mmHg	60	60	0	0	Y
ppABP	Mean(ppABP)	mmHg	60	60	0	0	Y
LHFRatio	Mean(LHFRatio)		60	60	0	0	Y
HRrmsd	Mean(HRrmsd)	ms	60	60	0	0	Y
HRsd	Mean(HRsd)	1/m	60	60	0	0	Y
SpO2	Mean(SpO2)	%	60	60	0	0	Y
Temp	Mean(Temp)	Grad	60	60	0	0	Y
ETCO2	Mean(ETCO2)	mmHg	60	60	0	0	Y
PbtO2	Mean(PbtO2)		60	60	0	0	Y

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

OK Cancel Save Load Advanced Keyboard



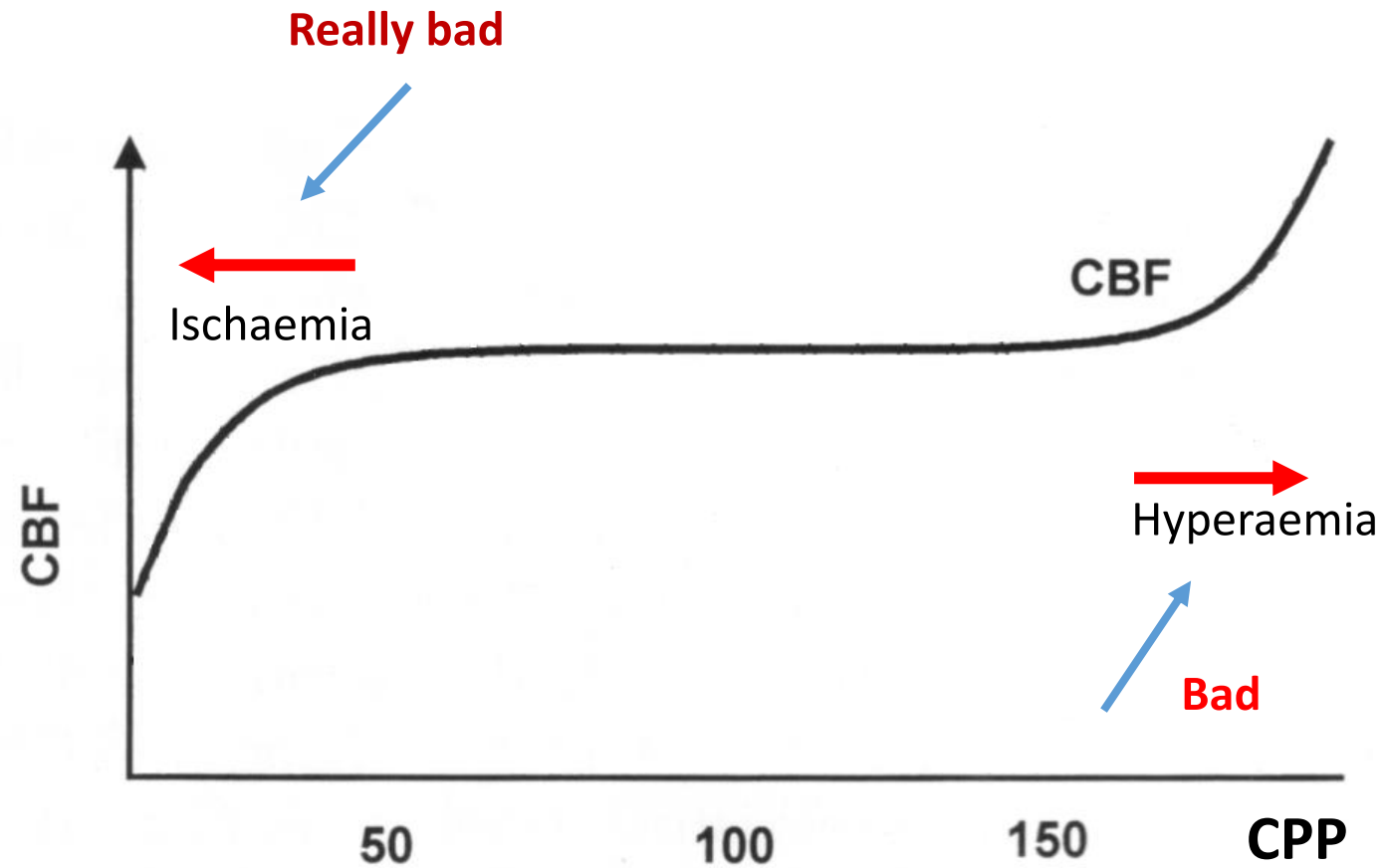
The more established secondary indices based on waveforms analysis



Monitoring of cerebral autoregulation in TBI

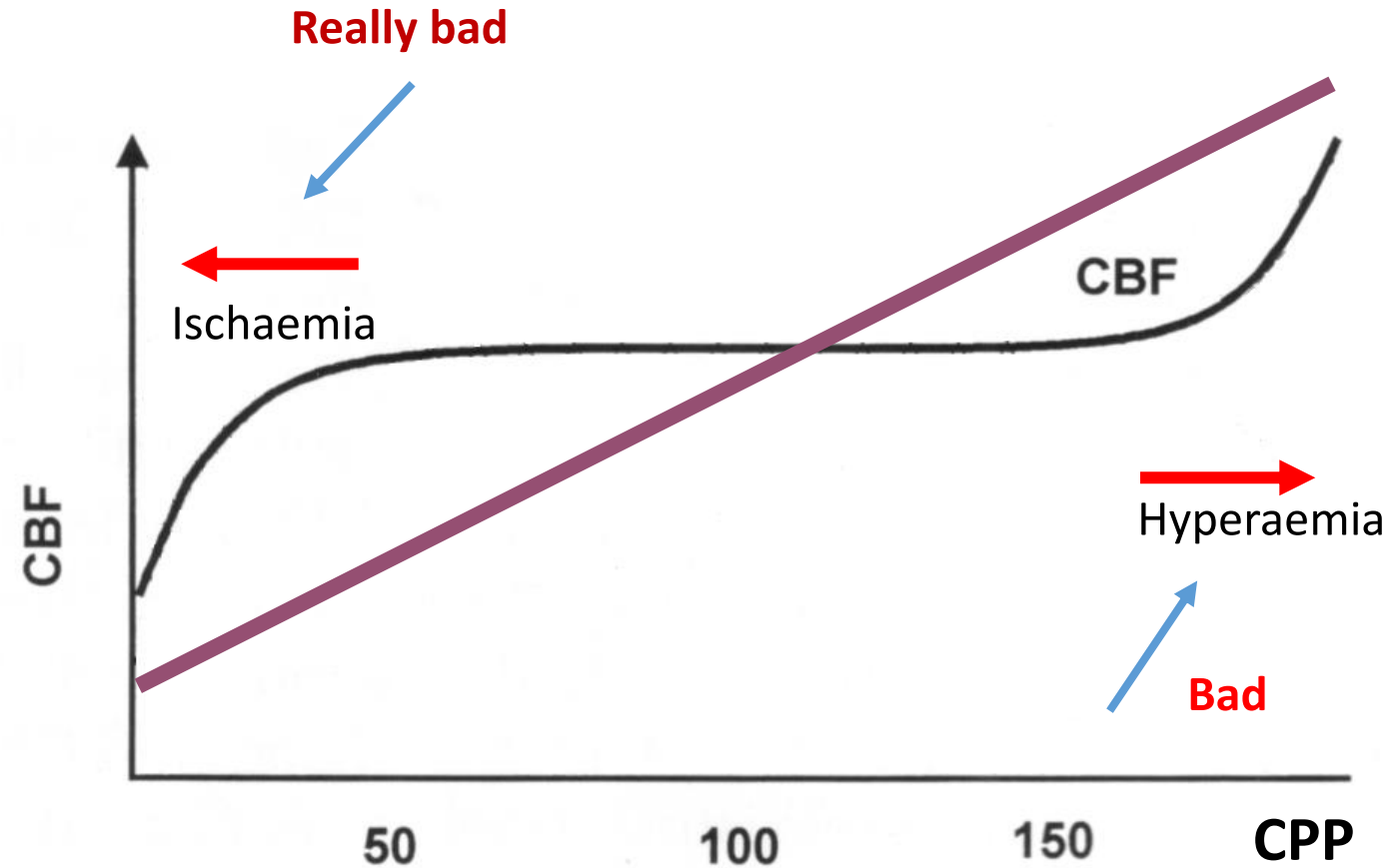


Monitoring cerebral autoregulation is easily disturbed in TBI



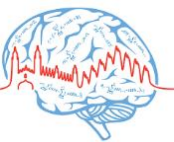
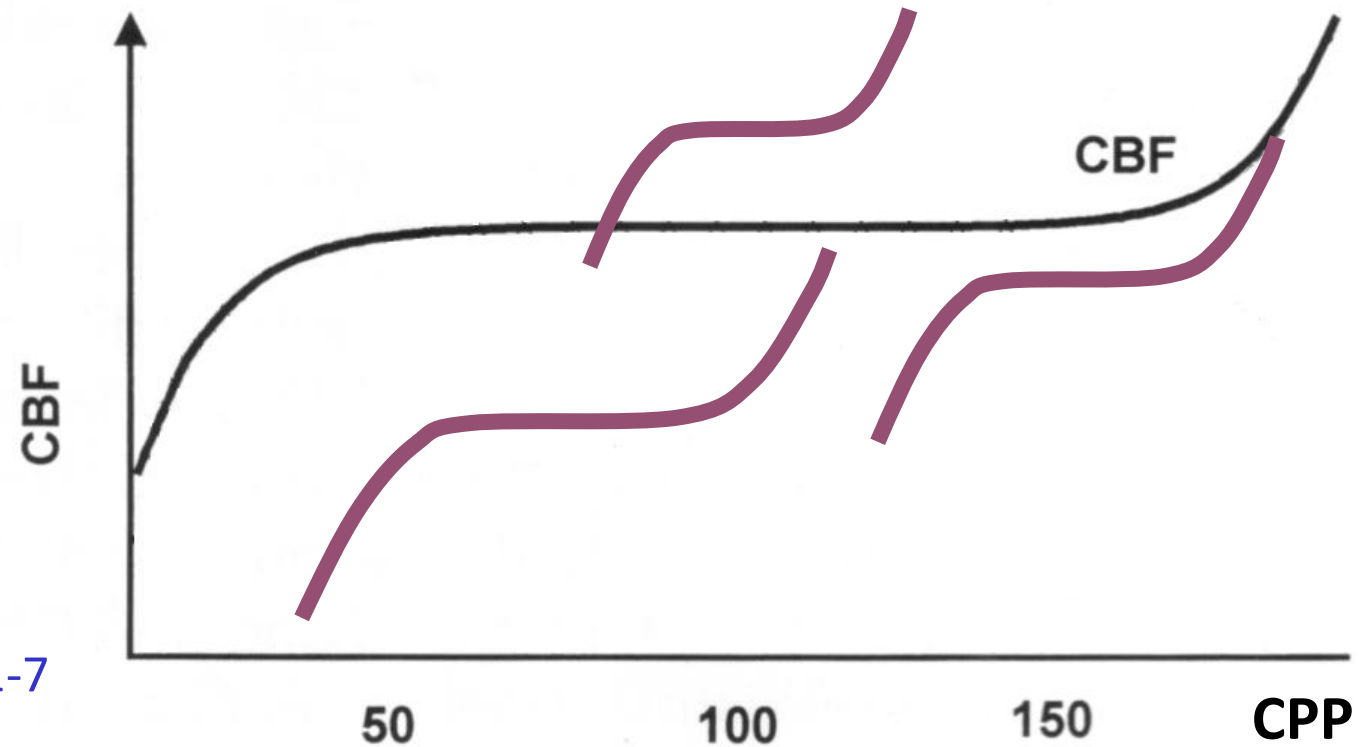
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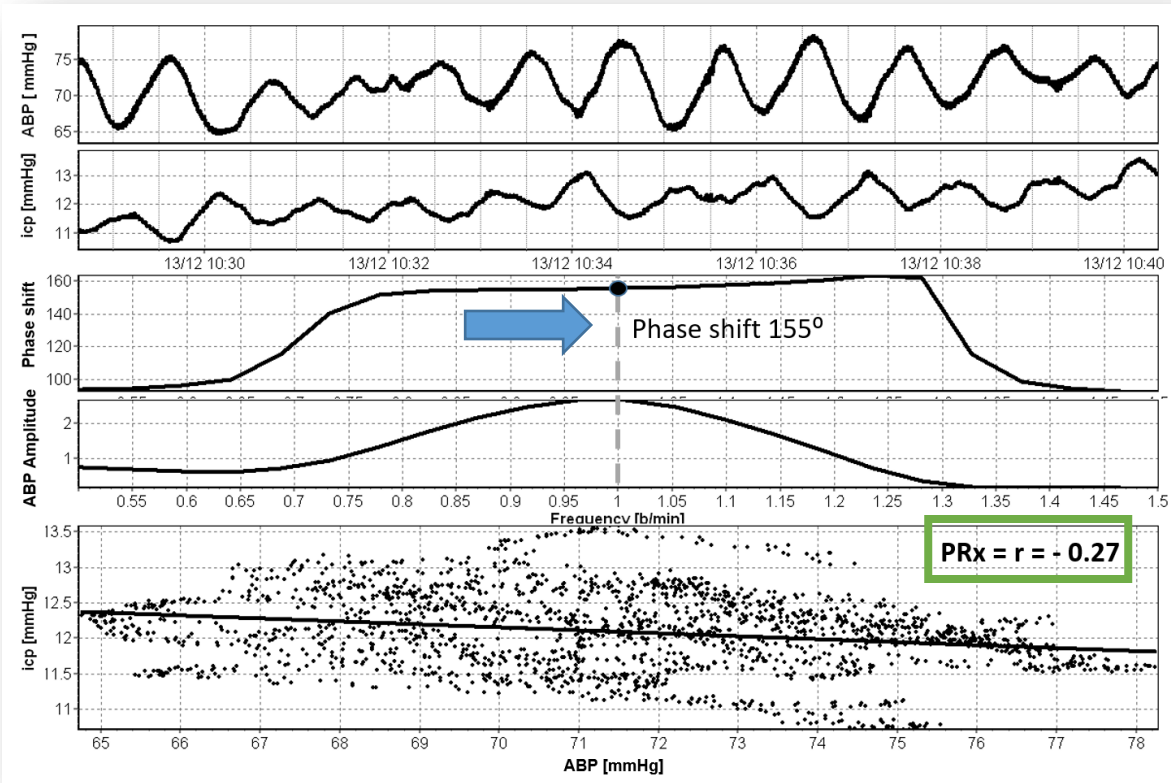
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- Lower limit shifted to the right
Cremer OL, et al. Anesth Analg 2004;99(4):1211-7

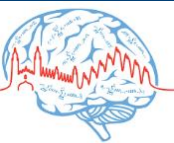
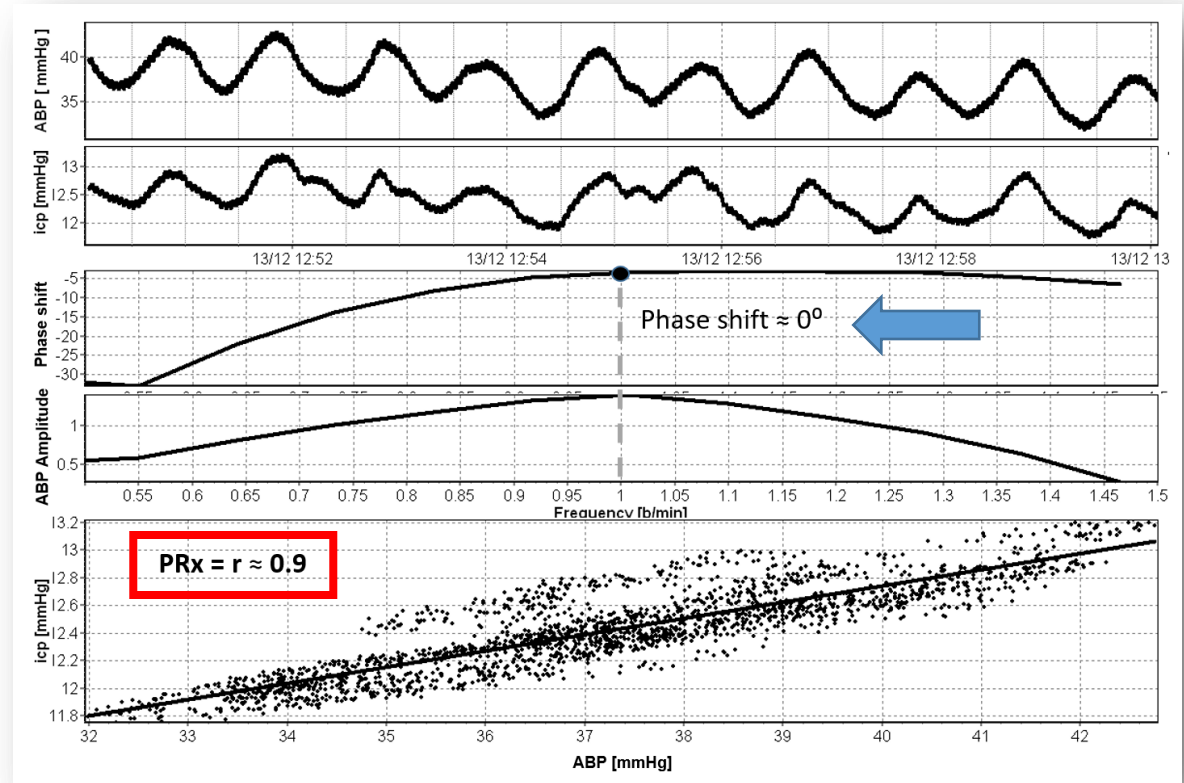


Pressure reactivity index PRx

Good pressure reactivity



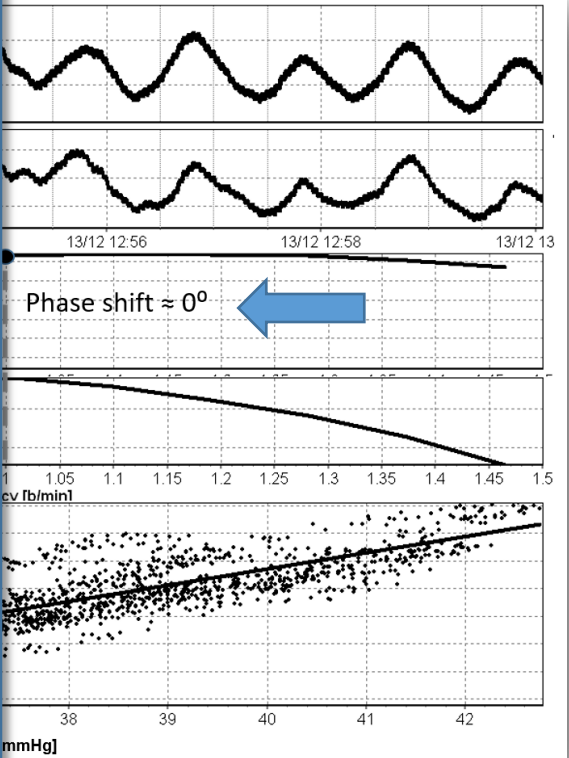
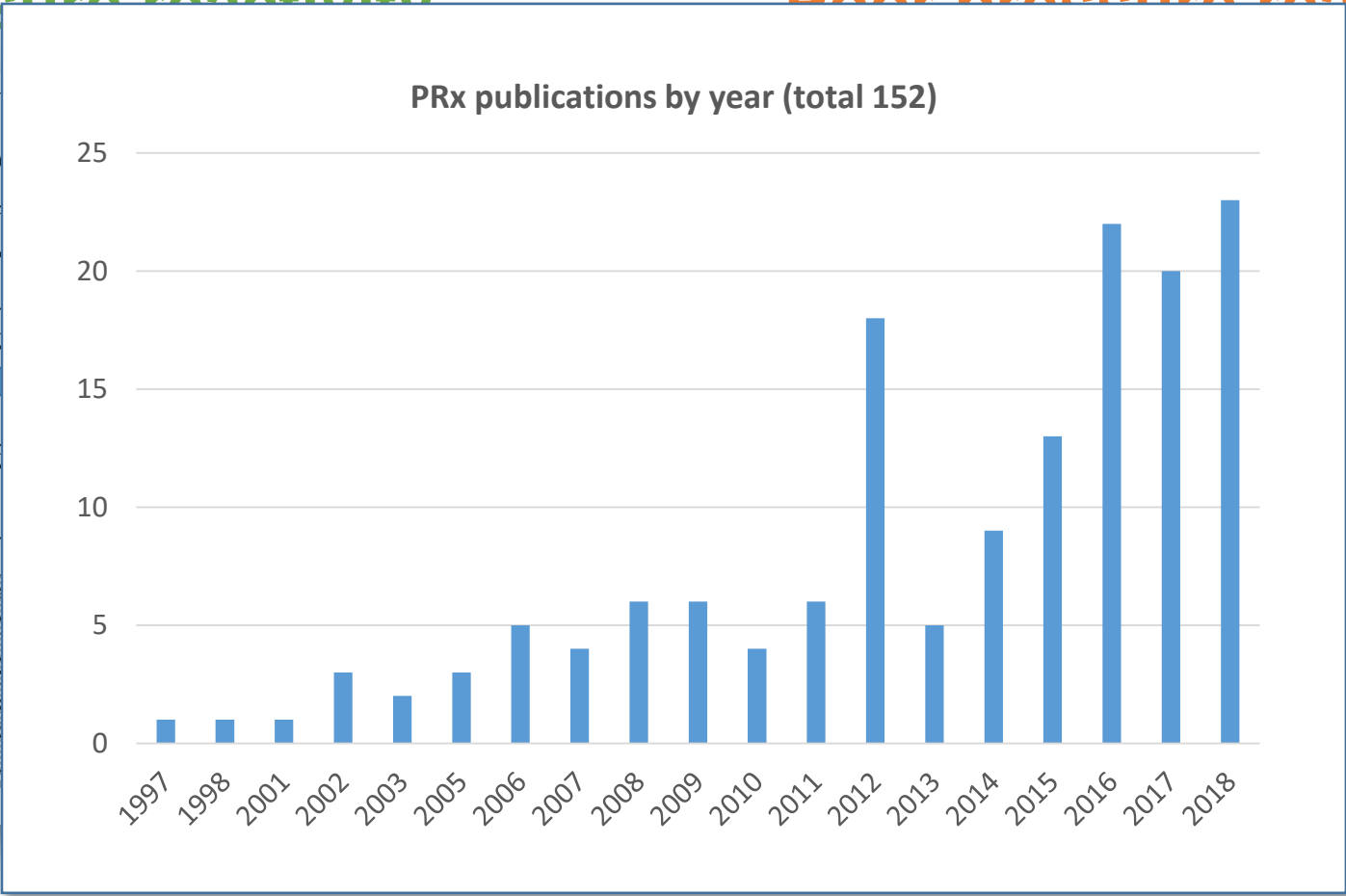
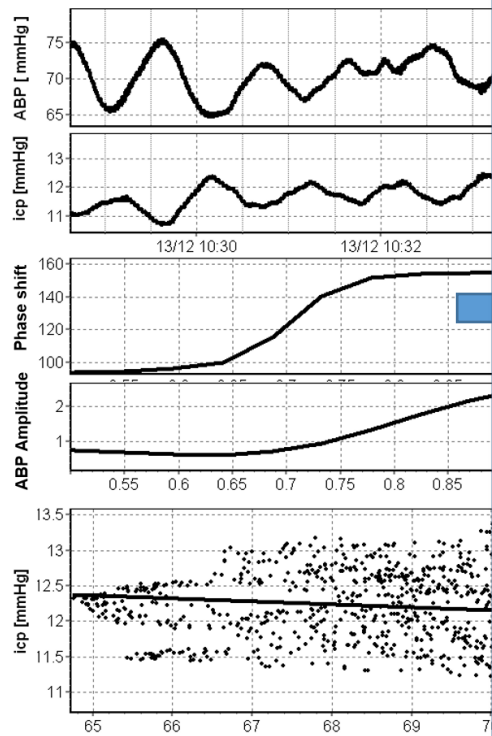
Poor pressure reactivity



Pressure reactivity index PRx

Good pressure reactivity

Poor pressure reactivity

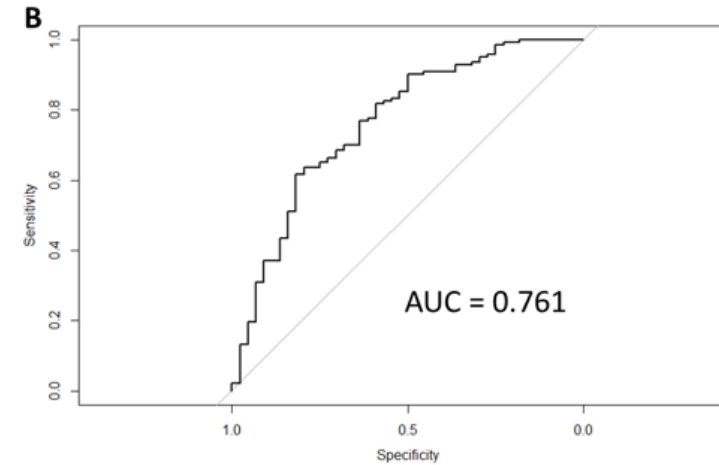
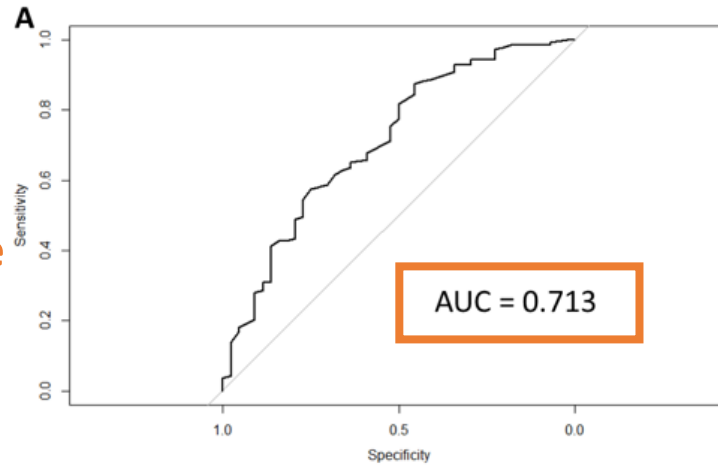


PRx and the IMPACT model – CENTER-TBI data (N=185, 22 centres)

IMPACT model *

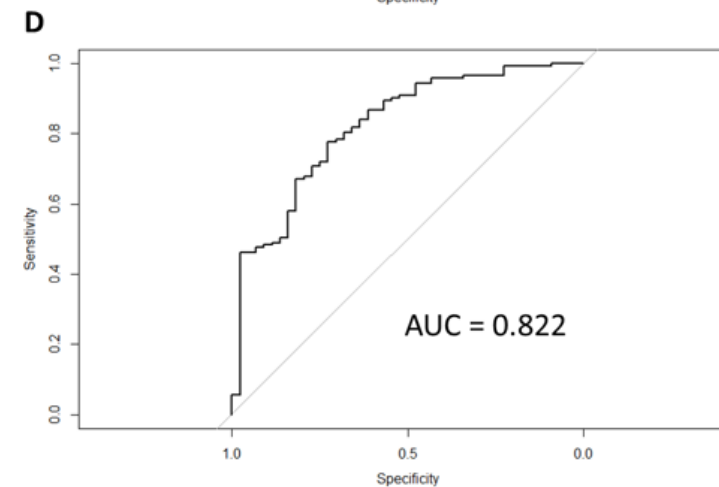
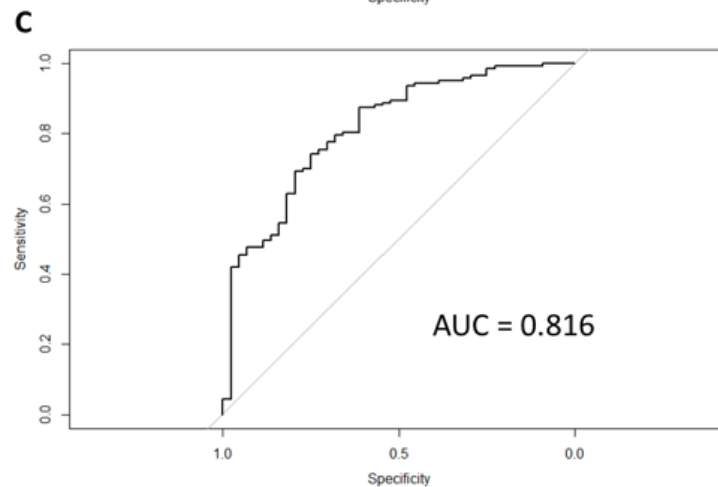
Age,
GCS Motor,
pupillary response

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



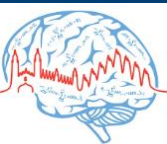
IMPACT model
+ ICP

IMPACT model
+ ICP
+ % (PRx > 0.25)



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Thanks to Fred Zeiler

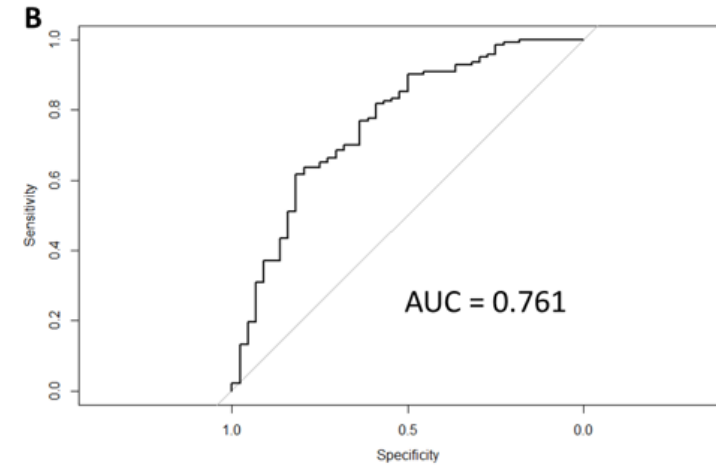
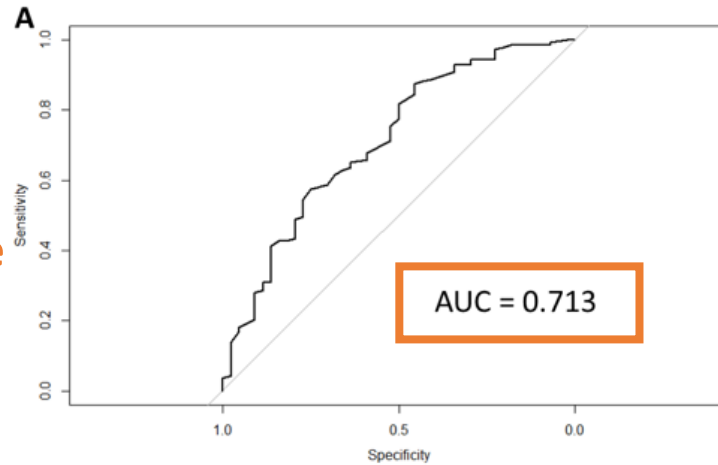


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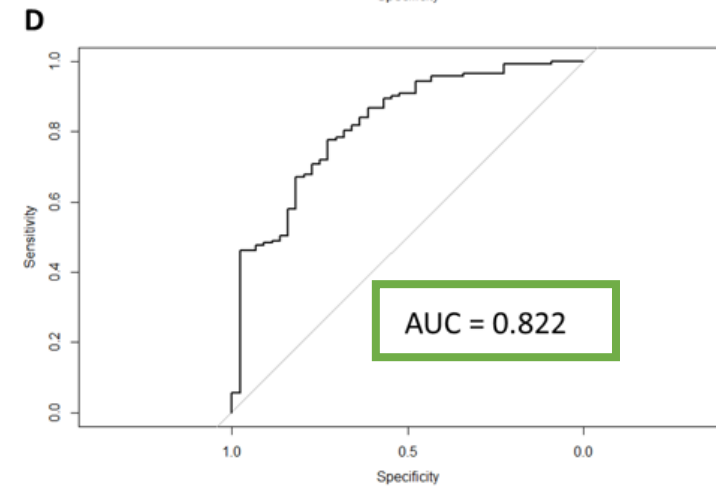
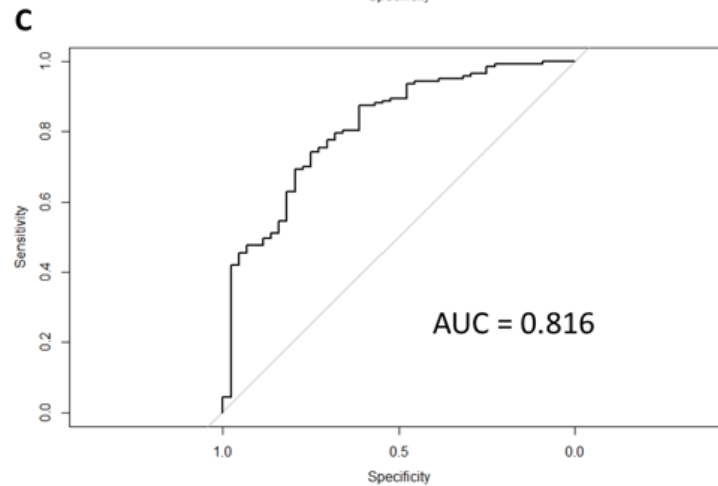
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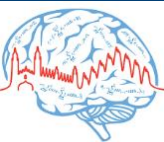
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- ICP < 22 mmHg
- CPP 60-70 mmHg
- Autoregulation status





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- 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

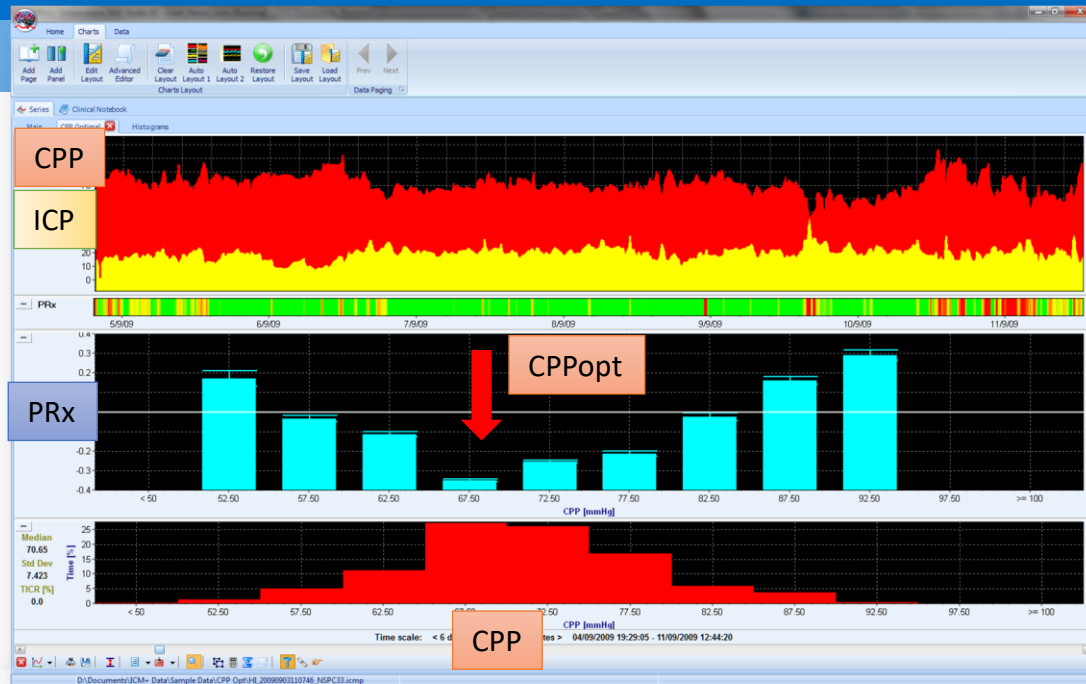


Continuous monitoring of cerebrovascular pressure reactivity allows determination of optimal cerebral perfusion pressure in patients with traumatic brain injury

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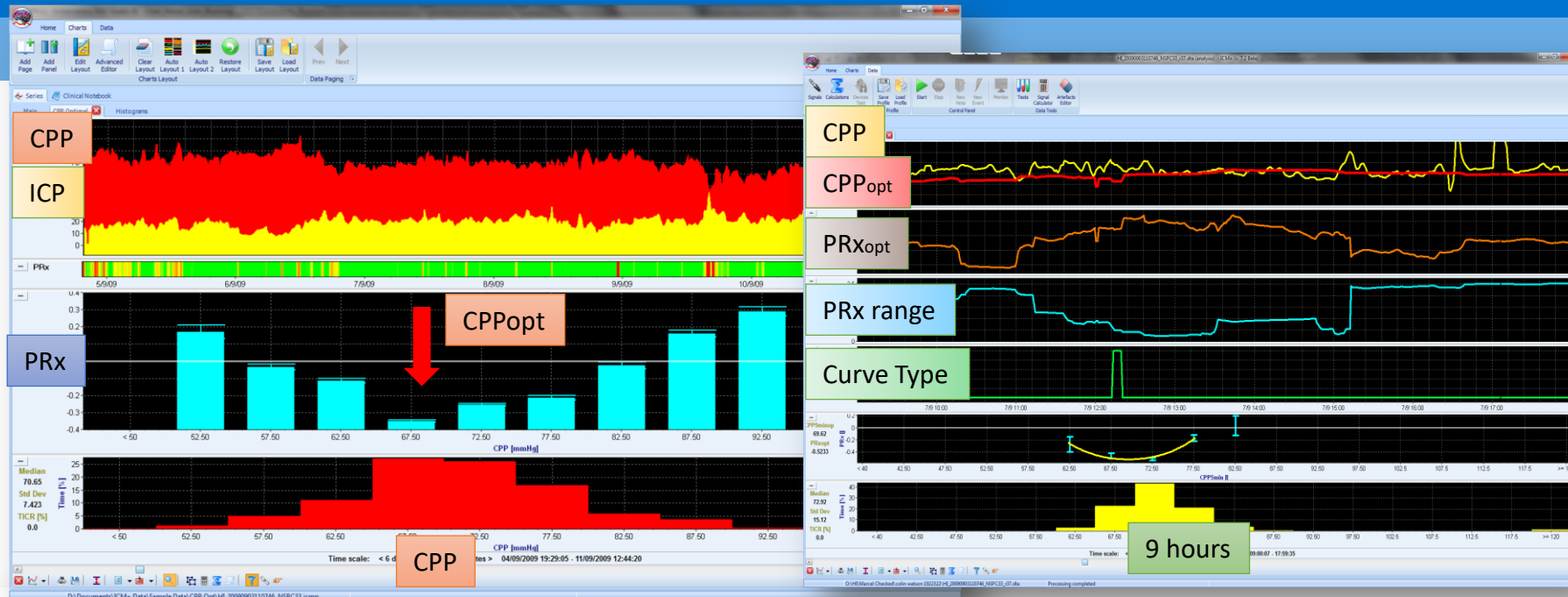


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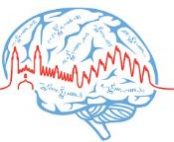


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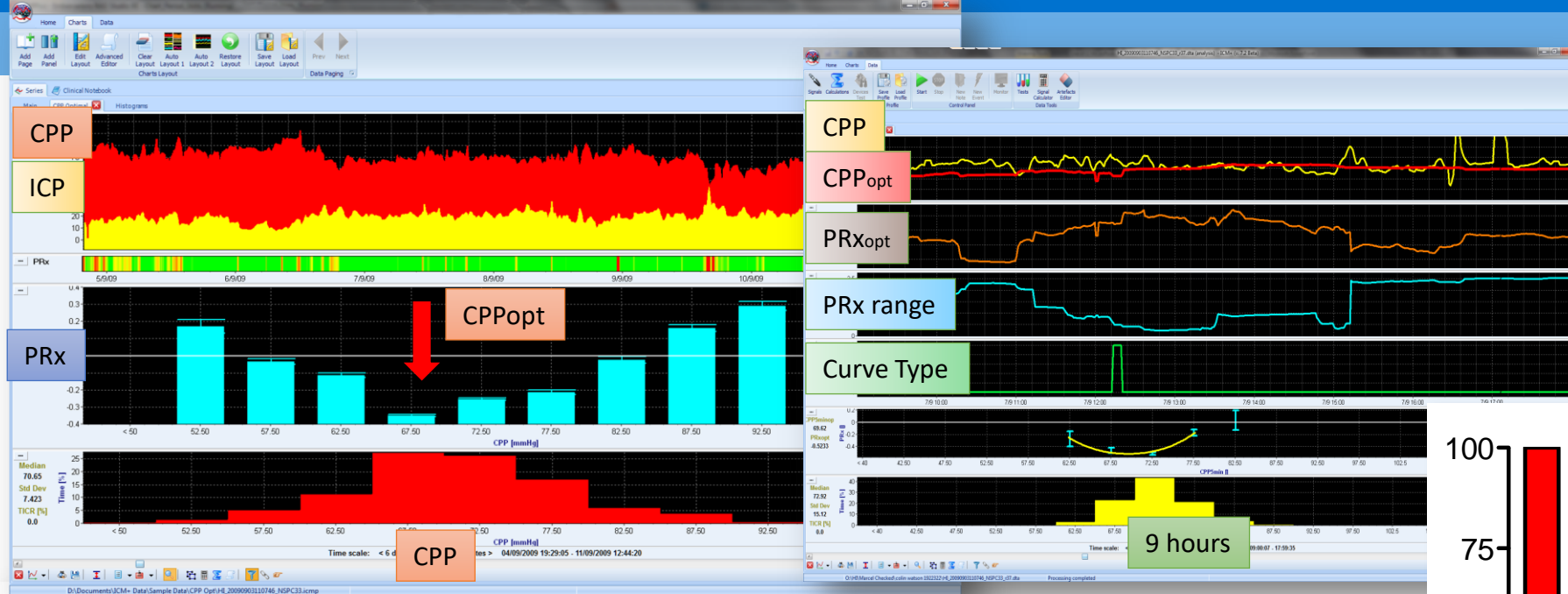


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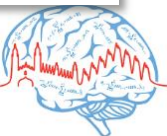
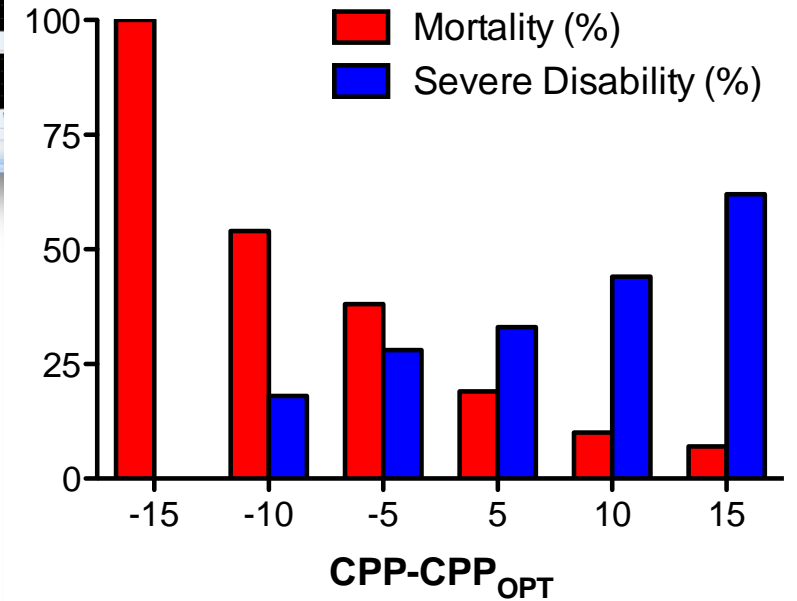


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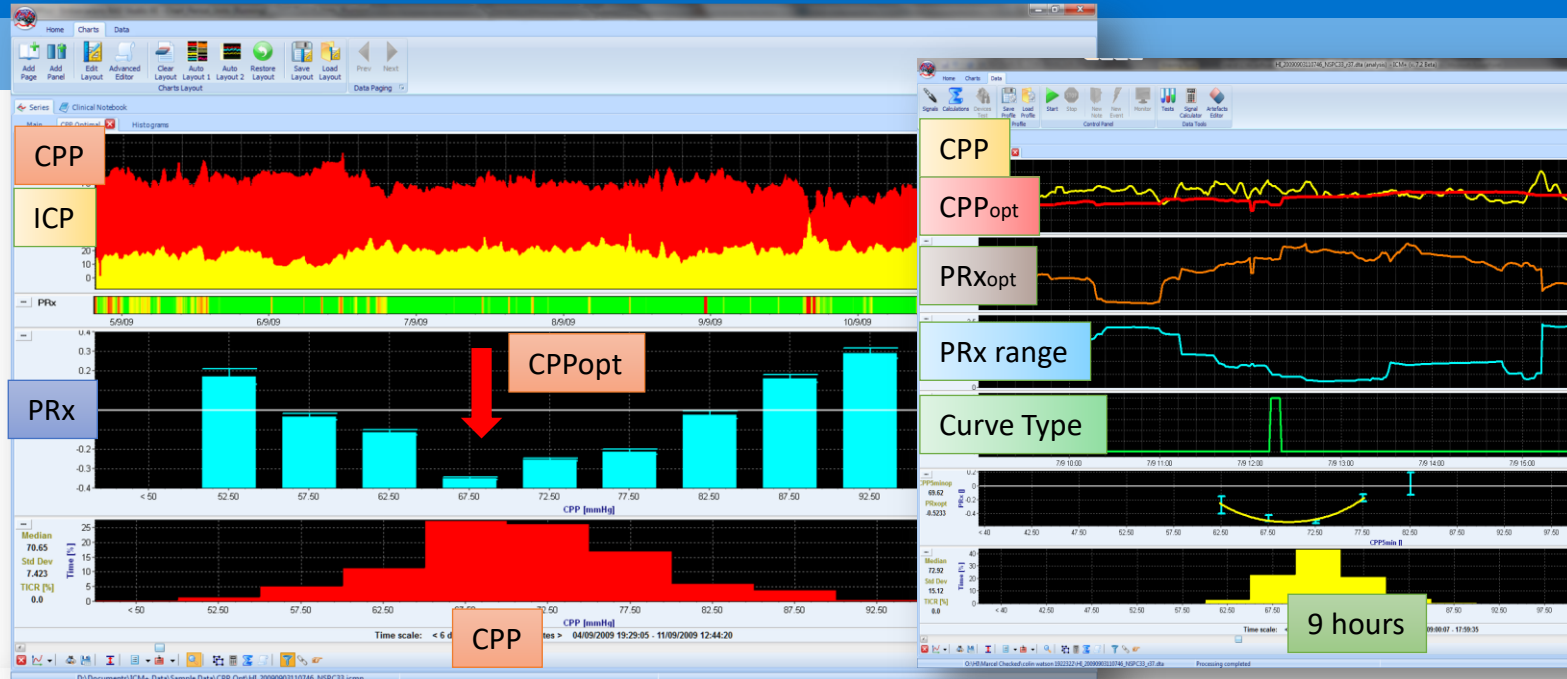
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Consensus summary statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical Care

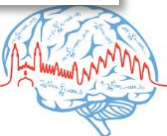
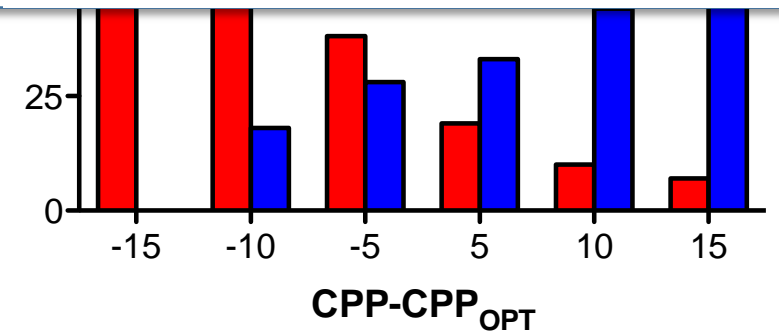
A statement for healthcare professionals from the Neurocritical Care Society and the European Society of Intensive Care Medicine

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

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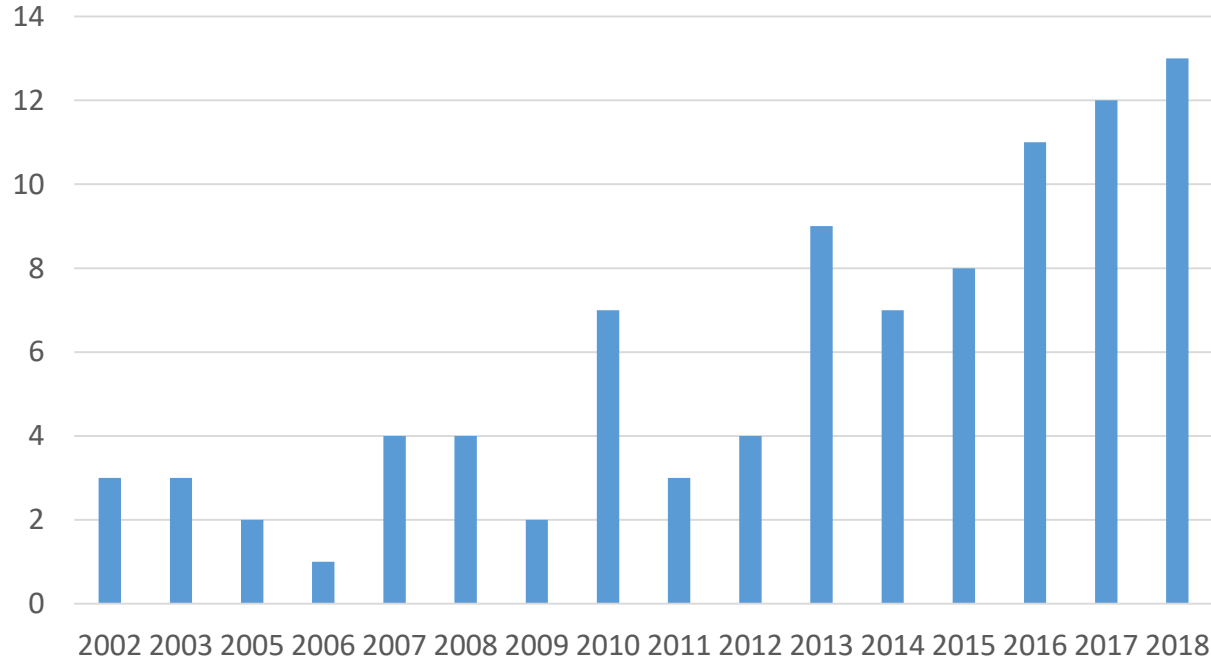
Individualising Cerebral Perfusion Pressure Management



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Optimal CPP publications by year (total 93)



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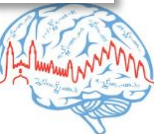
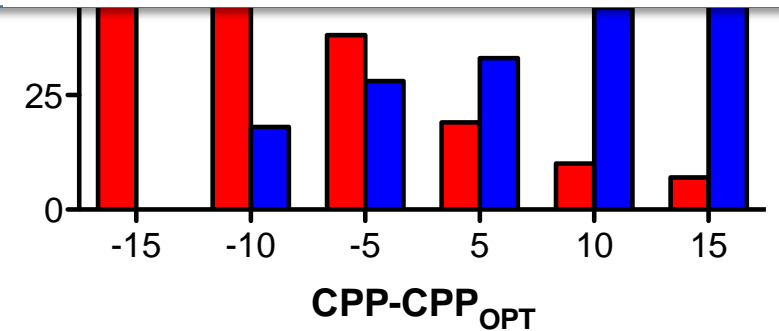
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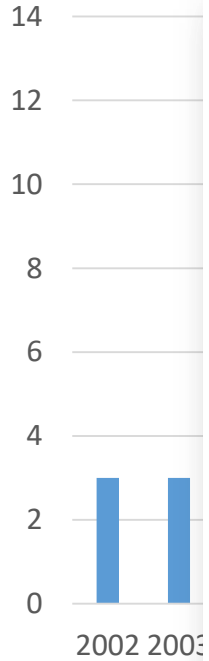
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Individualising Cerebral Perfusion Pressure Management

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COGiTATE



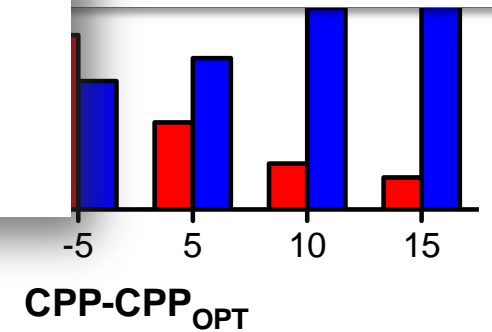
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Critical Care

Professionals from the European Society

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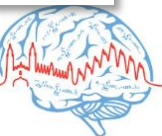


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Optimising Arterial Blood Pressure

Critical Care Medicine. Publish Ahead of Print(), JULY 26, 2019

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Print

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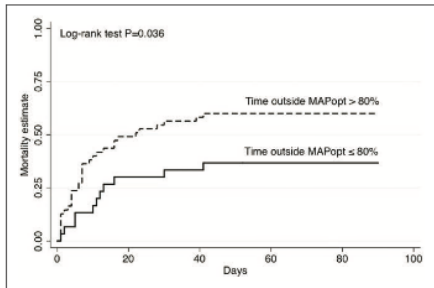


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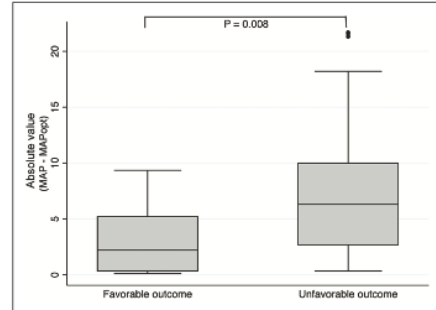


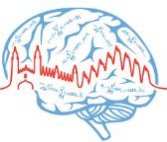
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JAMA Surgery | Original Investigation

Effect of Targeting Mean Arterial Pressure During Cardiopulmonary Bypass by Monitoring Cerebral Autoregulation on Postsurgical Delirium Among Older Patients A Nested Randomized Clinical Trial

Charles H. Brown IV, MD, MHS; Karin J. Neufeld, MD, MPH; Jing Tian, MS; Julia Probert, BA; Andrew LaFlam, BA; Laura Max, MHS, PhD; Yohei Nomura, MD; Kaushik Mandal, MD; Ken Brady, MD; Charles W. Hogue, MD; and the Cerebral Autoregulation Study Group

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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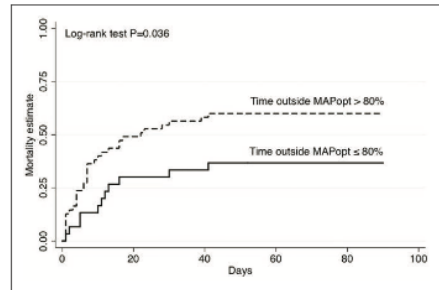


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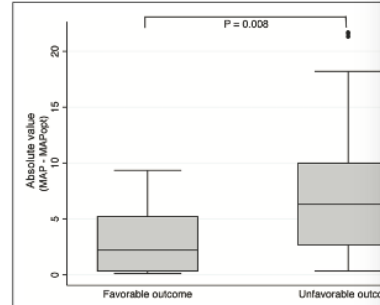
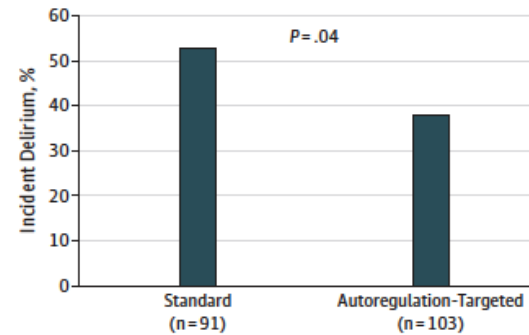


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Figure 2. Delirium Incidence by Randomization Group



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

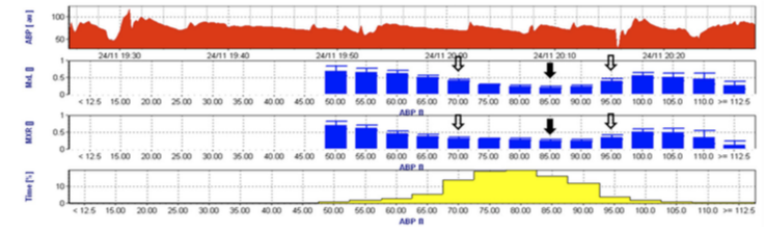


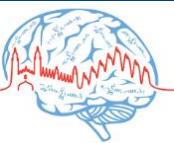
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Representative graph of cerebral autoregulation monitoring by mean velocity index (Mx) during cardiopulmonary bypass. The top graph represents the time-series of arterial blood pressure (ABP) while the bottom bar-graph the percentage of the time of 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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Brain Physics Lab



Optimising Arterial Blood Pressure

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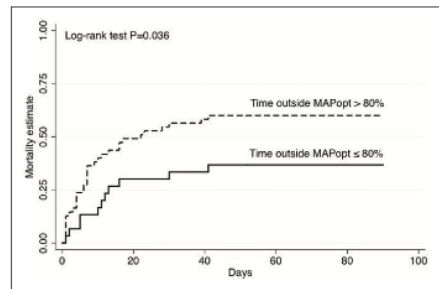


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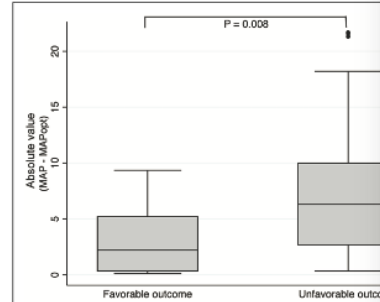
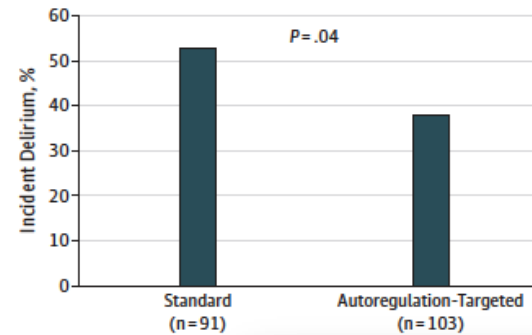


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Figure 2. Delirium Incidence by Randomization Group



Mean arterial pressure during care to standard care or autoregulation randomization group is shown.

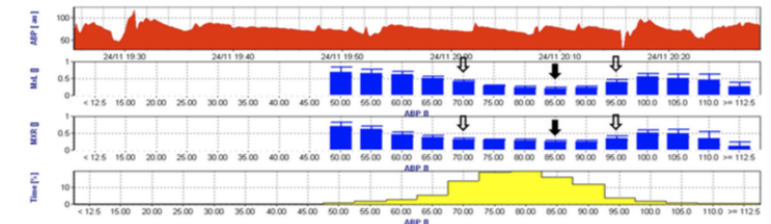


Figure 2. Representative graph of cerebral autoregulation monitoring by mean velocity index (Mx) during cardiopulmonary bypass. The top graph represents the time-series of arterial blood pressure (ABP) while the bottom bar-graph the percentage of the time of the recording spent at 5 mmHg bin. Optimal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

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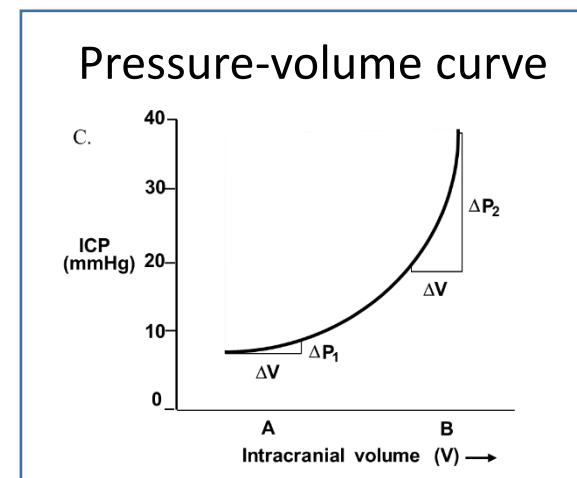
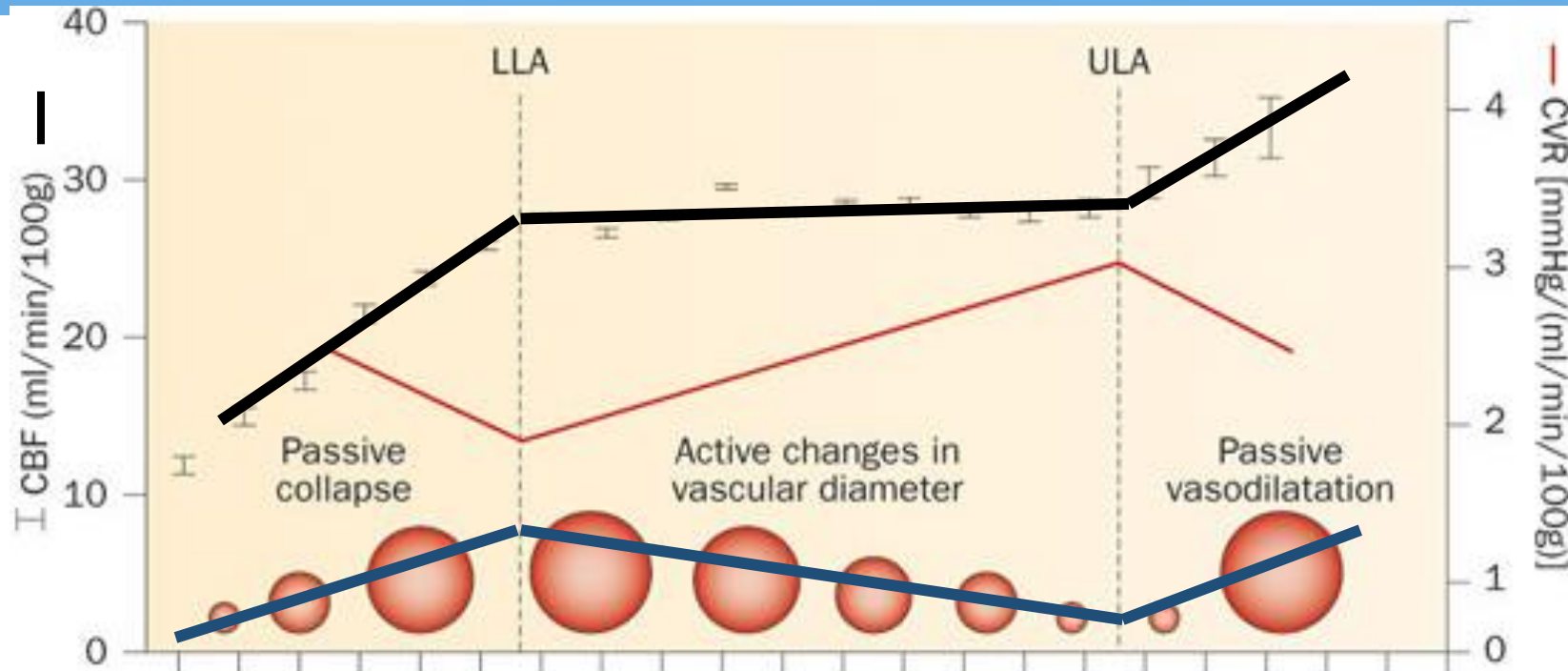
Individualizing intraoperative management of arterial blood pressure to optimize cerebral autoregulation during neurosurgery

E. Beqiri^{1,2}, M. García-Orellana³, A. Politi⁴, R. Valero³, N. Fàbregas³, J. Tas⁵, V. de Sloovere⁶, M. Czosnyka¹, M. Aries⁵, N. de Riva³ and P. Smielewski¹

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



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



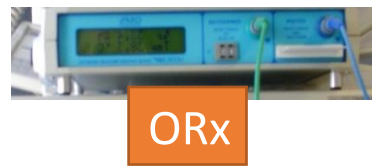
Blood flow measures

ABP/CPP

Blood flow surrogates

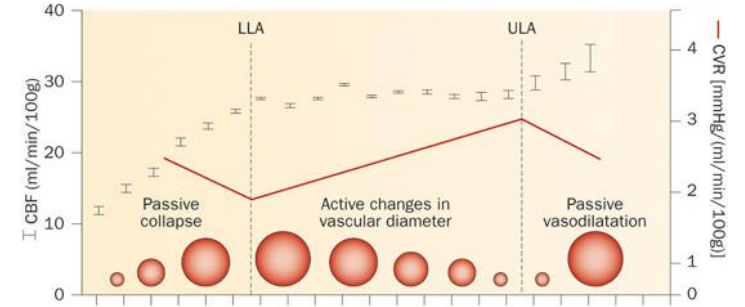
Blood volume

Blood volume surrogate



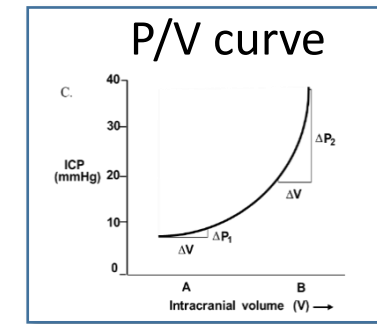
Problems with PRx

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



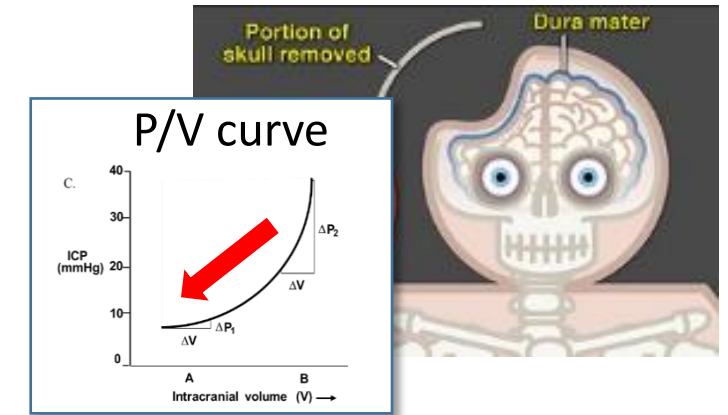
Problems with PRx

- 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)



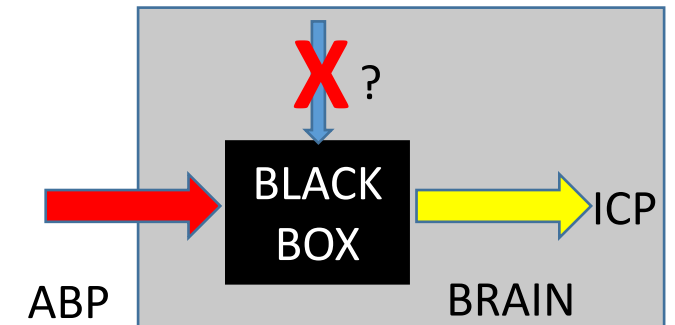
Problems with PRx

- 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)



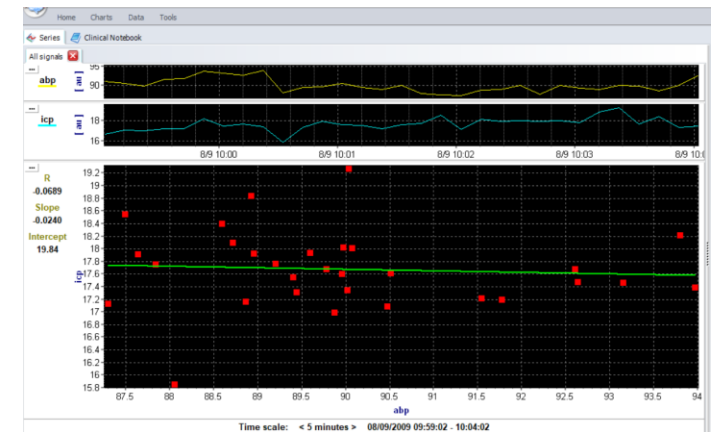
Problems with PRx

- 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)
- Relies on the **assumption** that **variability of ICP** is purely **due to** extracranial sources (reflected in **MAP changes**)



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)
- Relies on the **assumption** that **variability of ICP** is purely **due to** extracranial sources (reflected in **MAP changes**)
- Thus values PRx close to 0 may reflect either working autoregulation OR incoherent variability in ICP and ABP



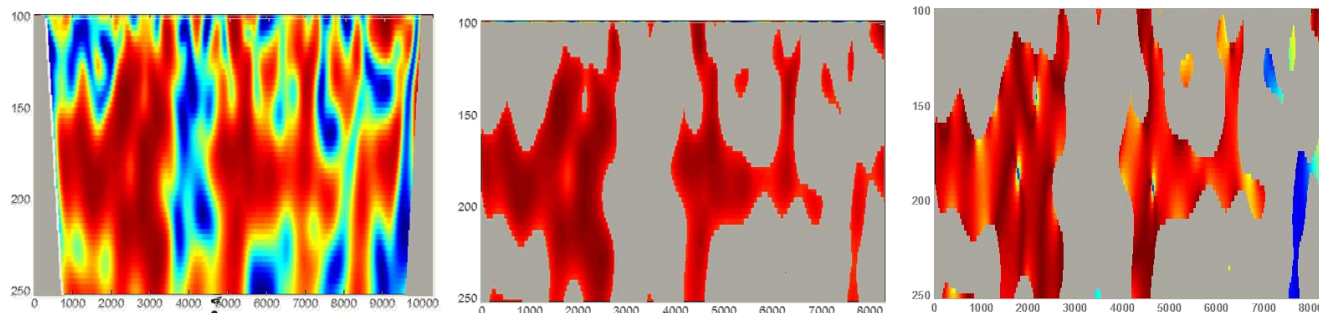
Wavelet analysis of ABP – ICP relationship - wPRx

Frequency: 0.0067 – 0.05 HZ

Wavelet Coherence with edge effect covered by the mask

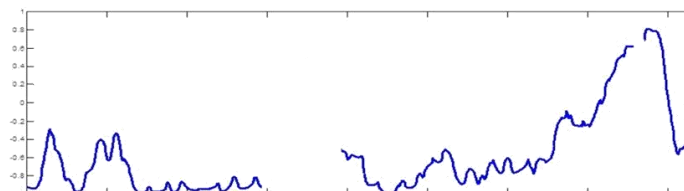
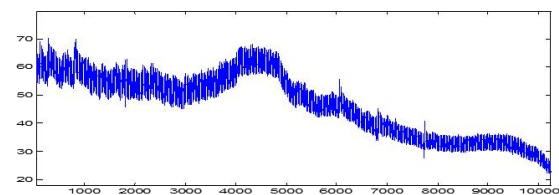
Wavelet Coherence

Wavelet Phase shift



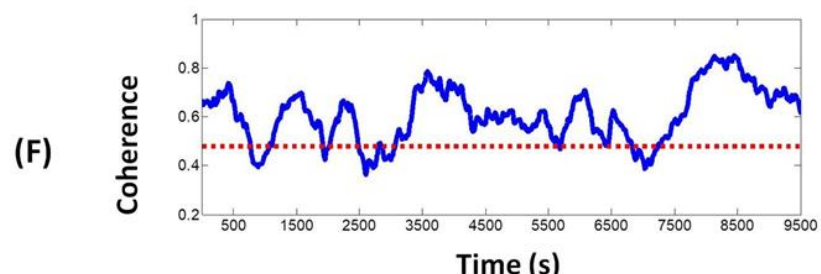
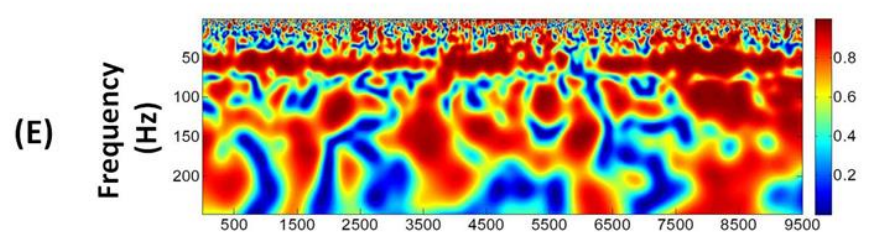
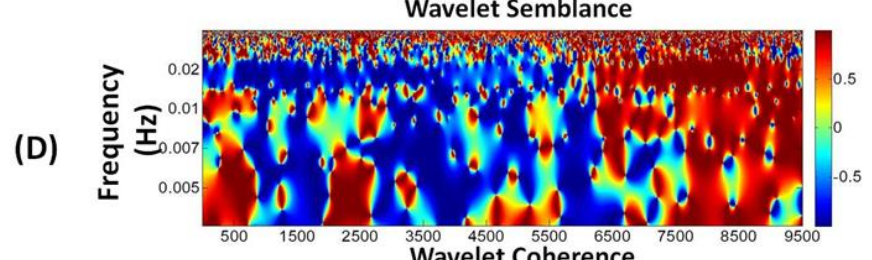
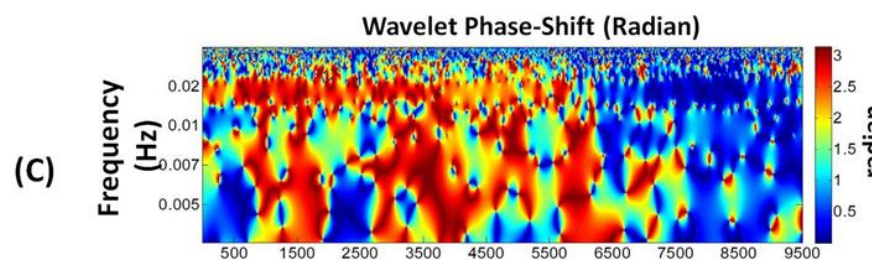
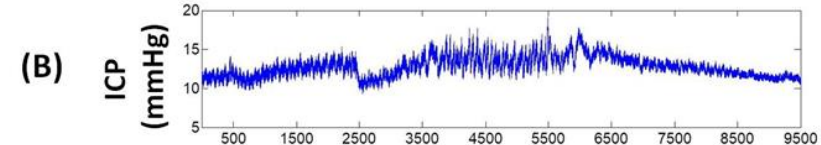
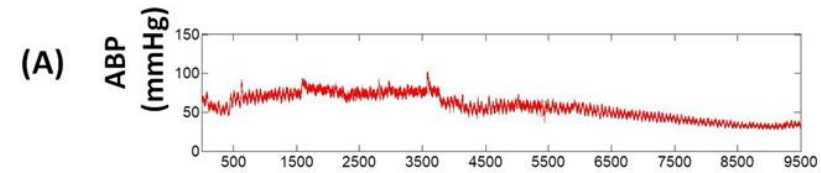
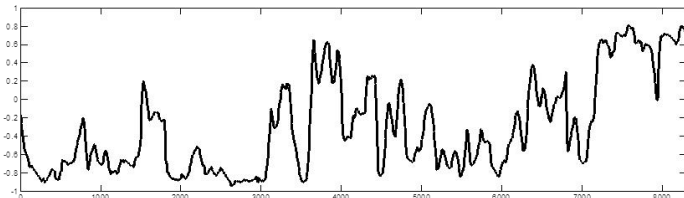
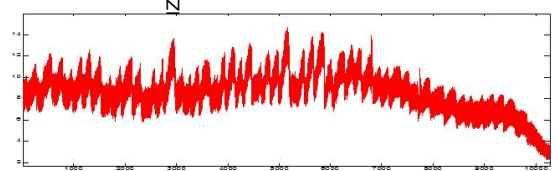
ABP signal

Wavelet based PRx (wPRx)

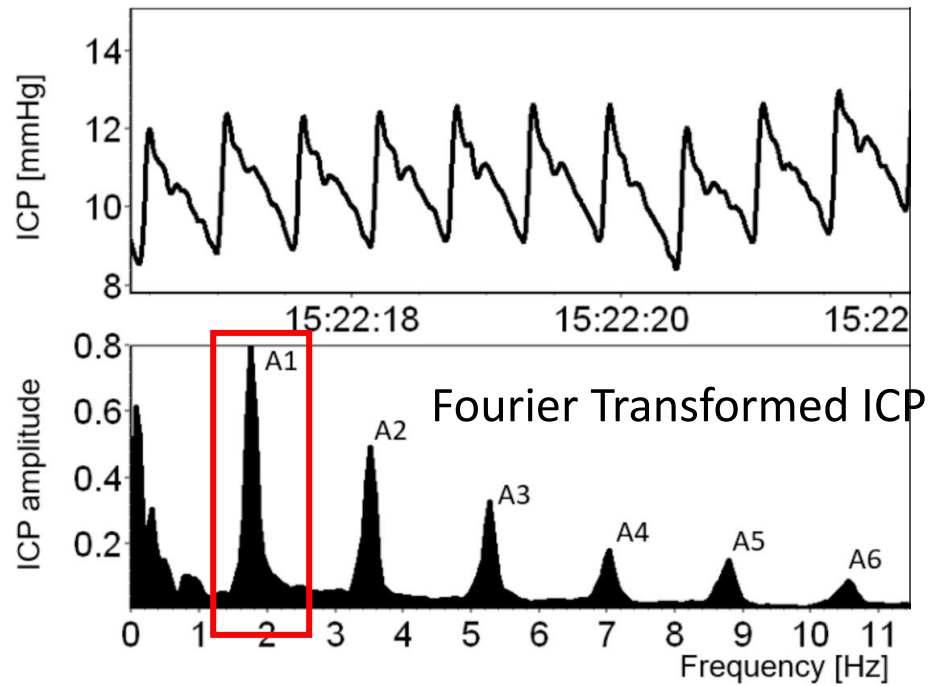


ICP signal

PRx



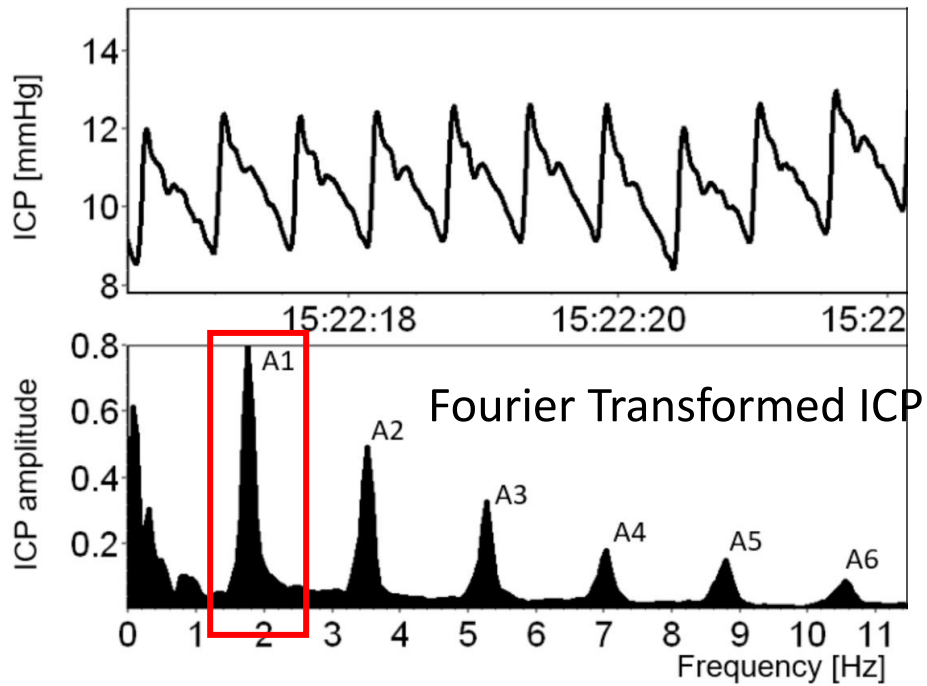
RAC – correlation between amplitude of ICP pulse (AMP) and CPP



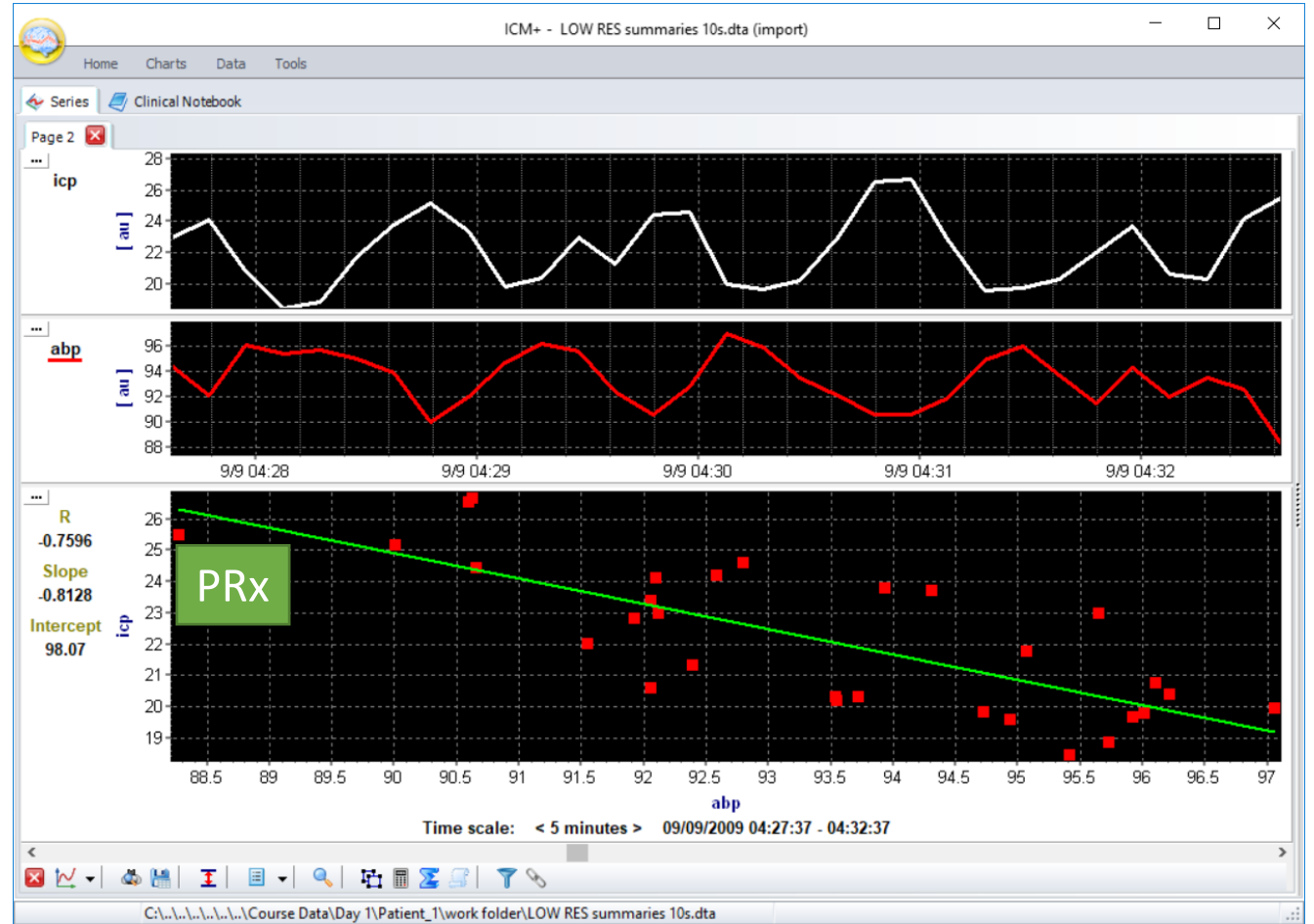
A1 = AMP



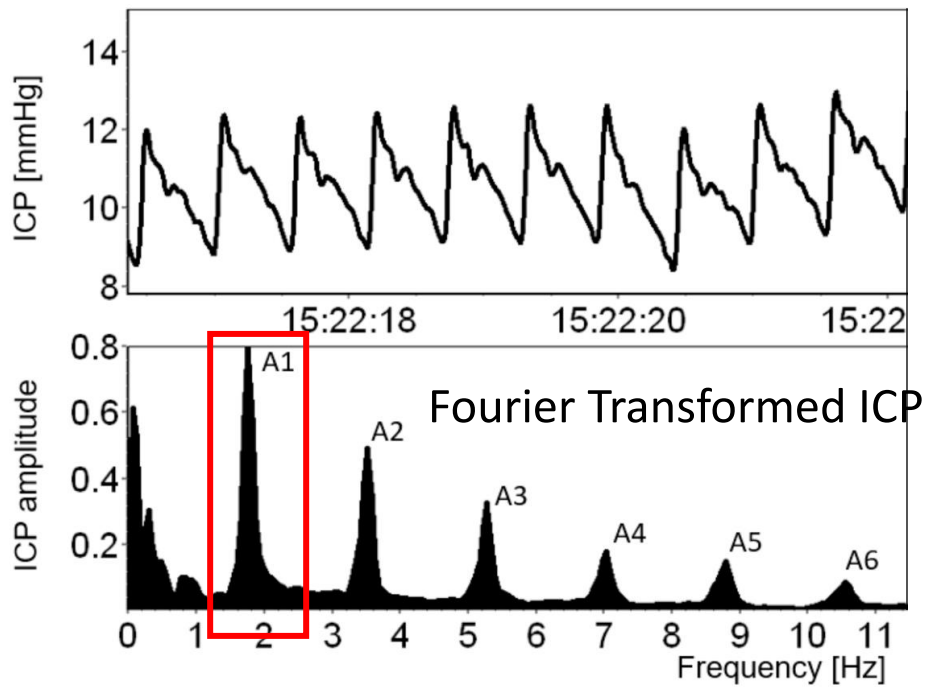
RAC – correlation between amplitude of ICP pulse (AMP) and CPP



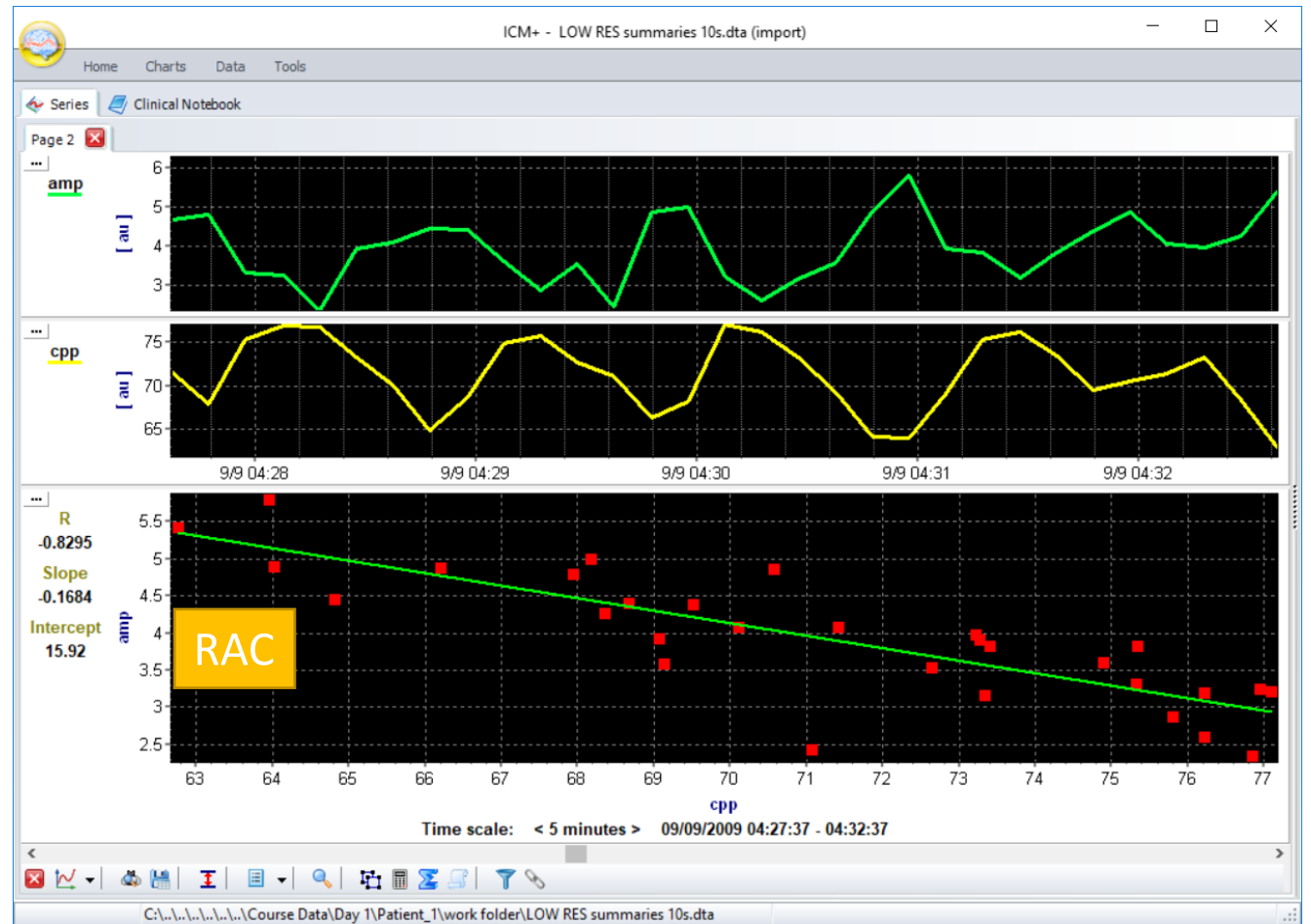
A1 = AMP



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



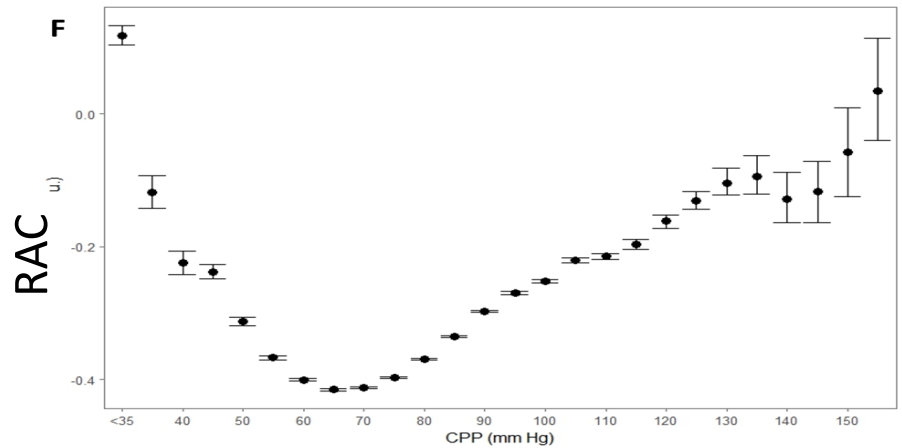
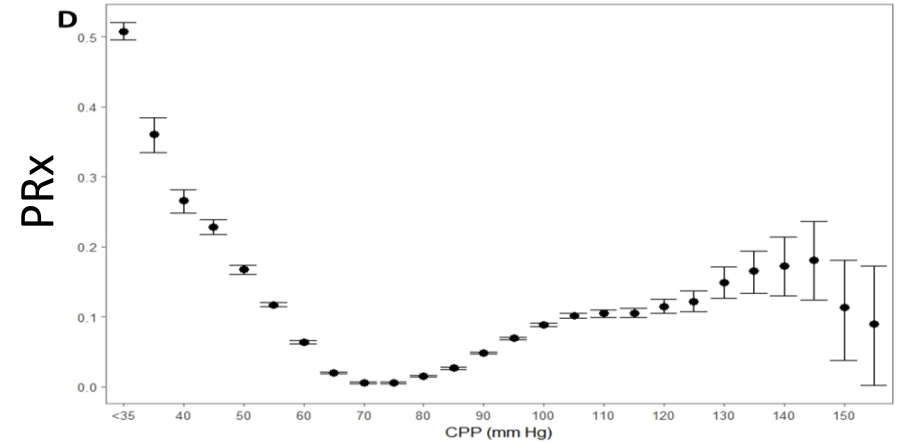
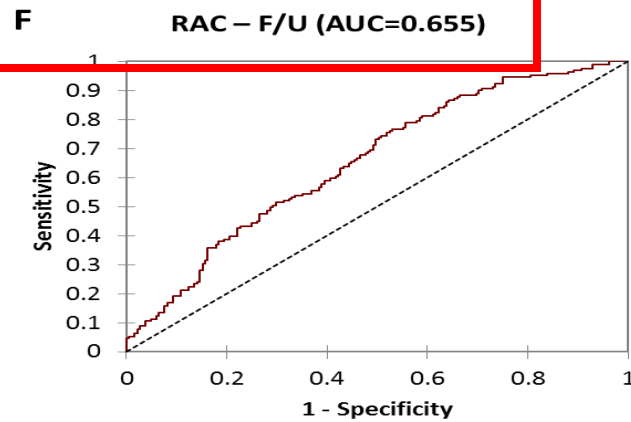
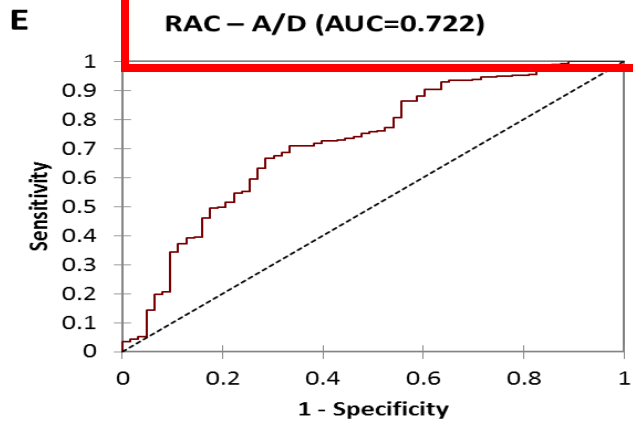
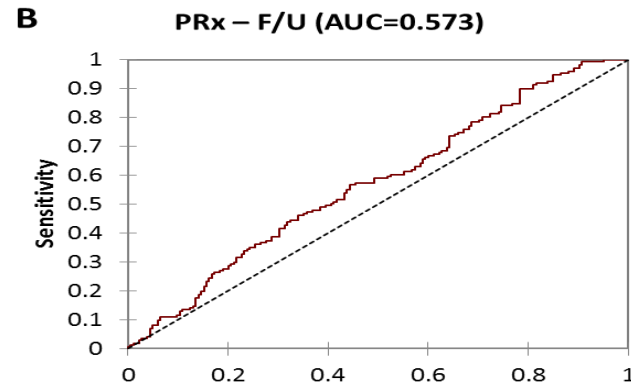
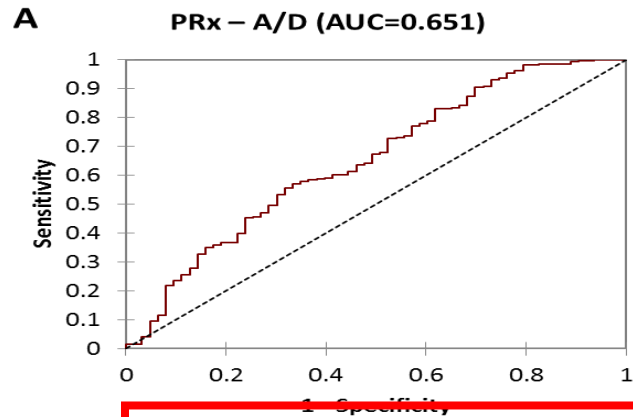
A1 = AMP



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

Mortality

Favourable Outcome

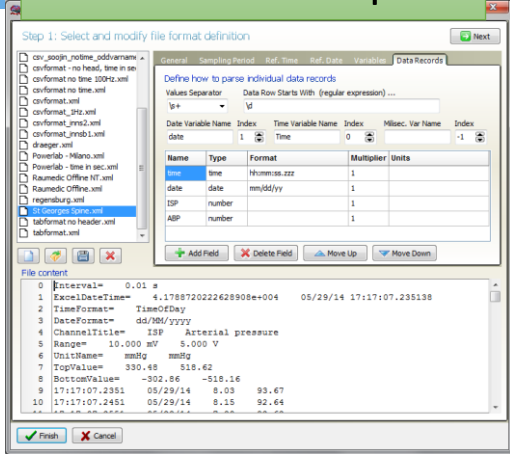


Advanced data browsing and interrogation tools

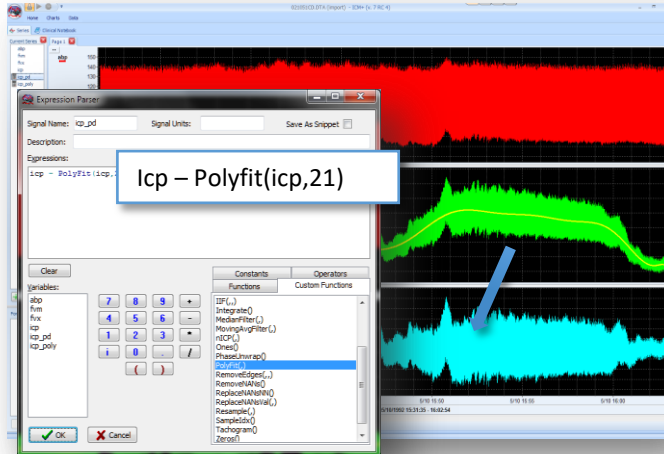


ICM+ advanced features

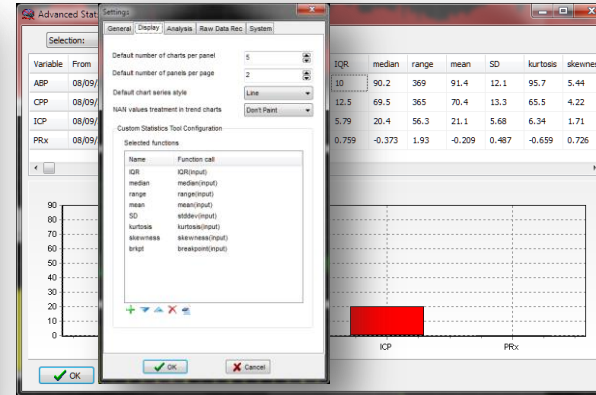
ASCII format import



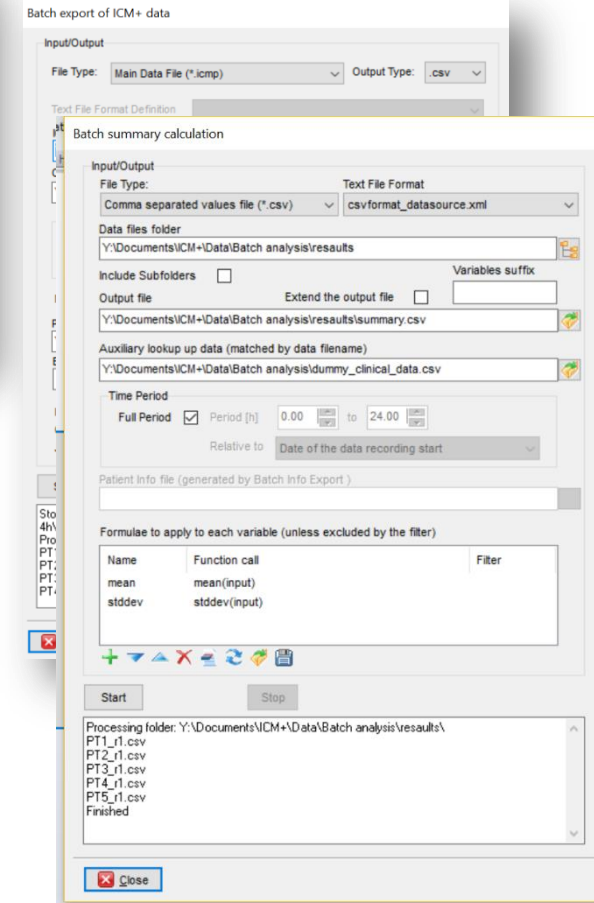
Signals calculator



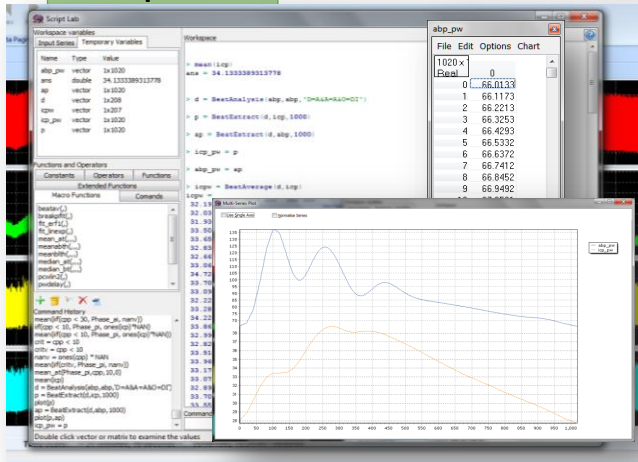
Advanced Stats tool



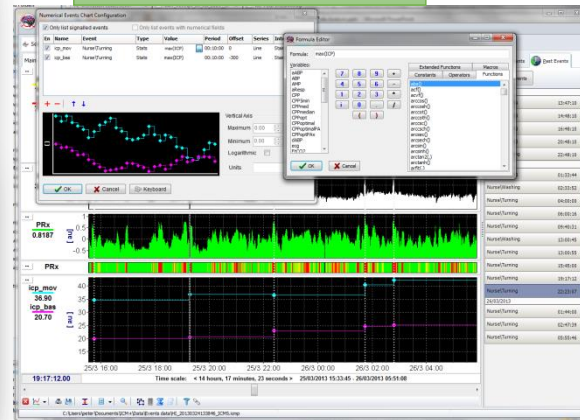
Batch Analysis tools



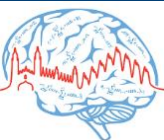
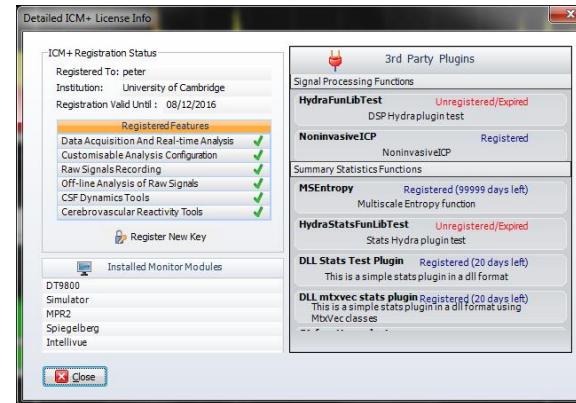
ScriptLab



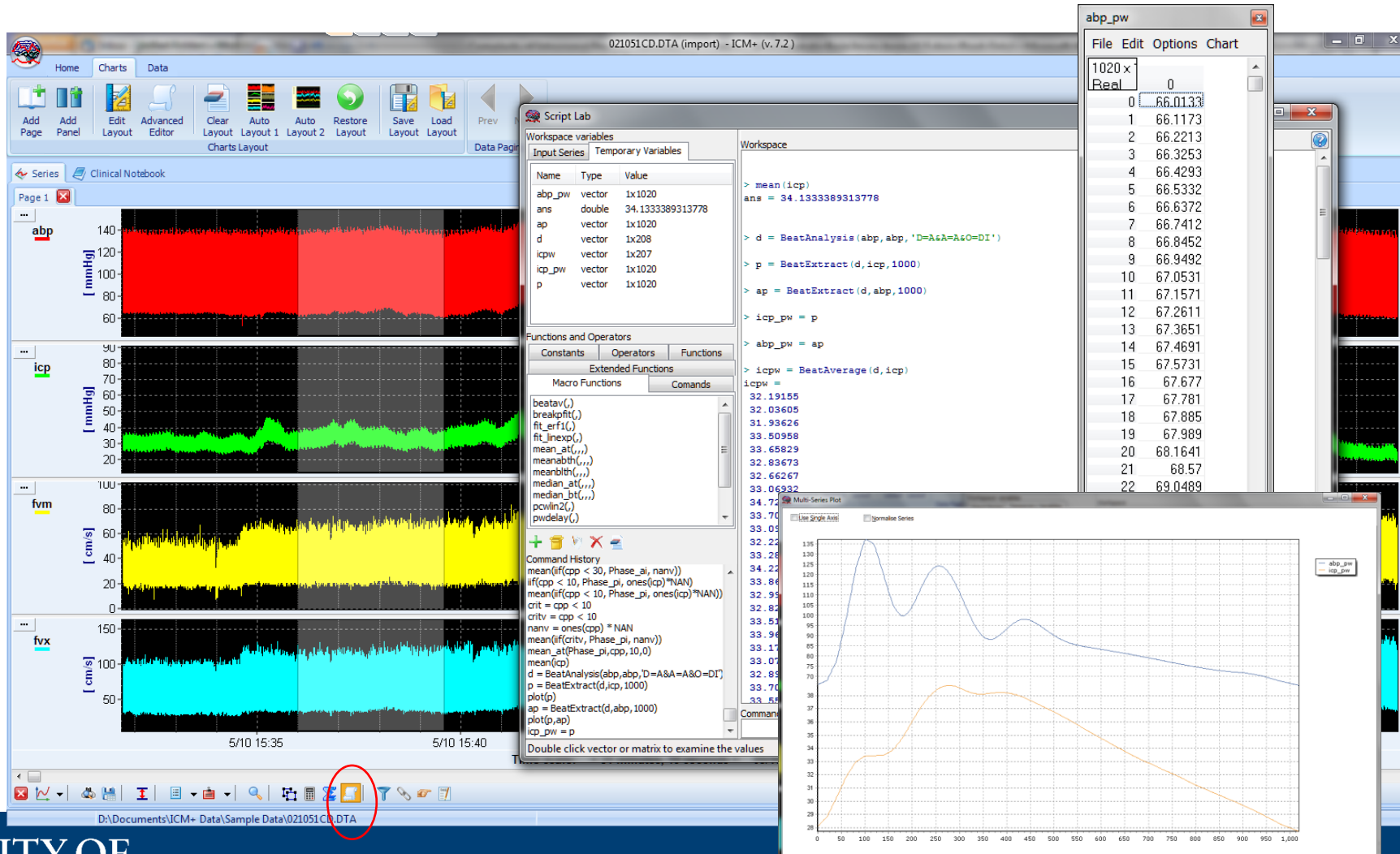
Event analysis



3rd party extensions



ICM+ ScriptLab tool



ICM+ ScriptLab tool

Available series/variables

Workspace variables

Input Series Temporary Variables

Name	Type	Value
fvm	Vector	1x168
abp	Vector	1x168

Display box

```
> b = fitpcwlin(abp, fvm, 1, 1)
> b1 = fiterf(abp, fvm)
> b1 = fiterf(abp, fvm)
b1 =
12.10549
4.99193
0.06875
42.26378
0.97571
```

Commands, functions, etc

Functions and Operators

Extended Functions

Constants Operators Functions

Macro Functions Comands

clear all
clear
cls
clh
clv
delete()
plot()
plotcplx()
plotpolar(),
plotxy(),
plotcols()

```
> b = fitpcwlin(abp, fvm, 1, 1)
b =
56.03516
-2.06059
0.33479
15.75811
0.0168
0.97468
```

Edit/save analyses
Make macros



History of activities

Command History
plot(abp, d1)
plotxy(t, abp)
td = timeScale(didx)
plotxy(t, abp, td, didx)

Write functions/commands HERE

Command line

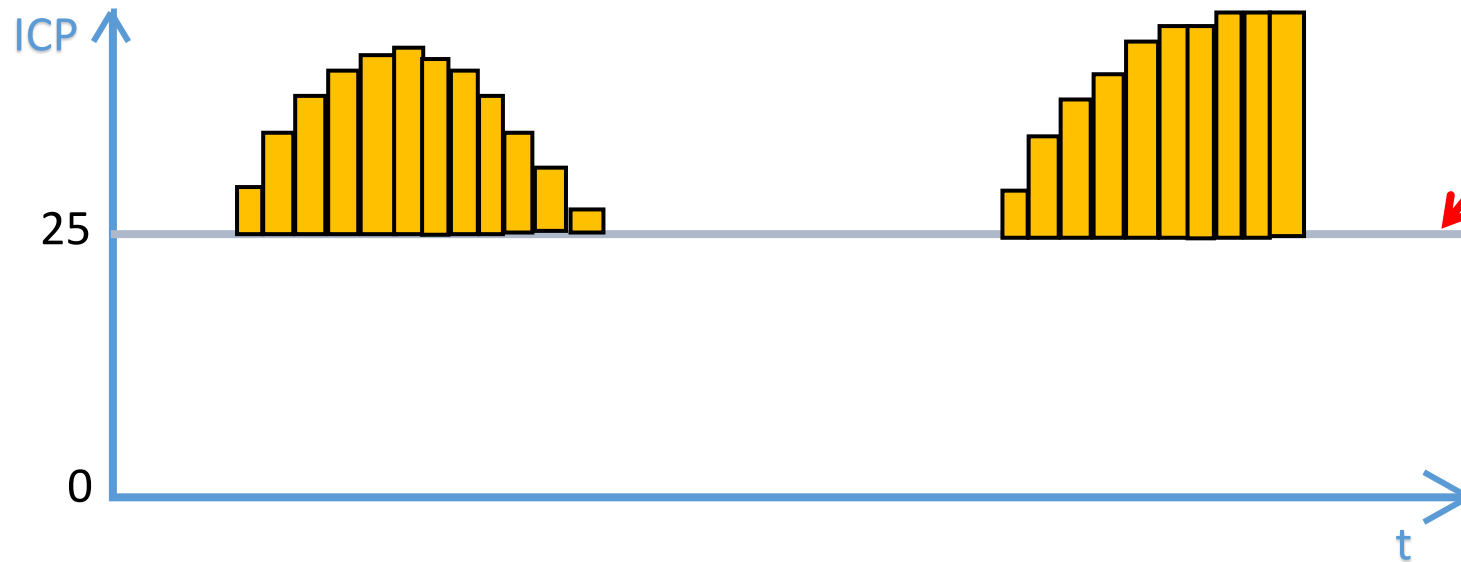


Definition of Dose of high ICP (using in this case 25 mmHg Threshold)

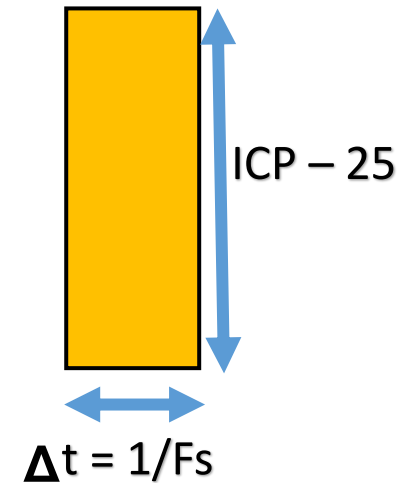
$$Dose_{icp} = \int (icp_{hyper} \cdot Dt) = Dt \cdot \int icp_{hyper} = \frac{1}{Fs} \cdot \int icp_{hyper}$$

$Fs = \text{SamplingFrequency}(icp)$

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



ICP threshold = 25 mmHg

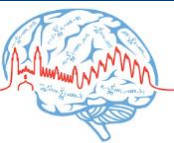


Dose configuration for ICP > 25

5 - Now put all the steps into one line expression

The screenshot shows a 'Script Lab' window with several panels:

- Workspace variables:** A table with columns 'Name', 'Type', and 'Value'. It contains two rows: 'ans' (double, 10.0116714477496) and 'icp_hyp' (vector, 1x882).
- Command line:** A text box containing the expression `sum((icp-25) * (icp > 25)) / SamplingFrq(icp) / 3600`, highlighted with a red border. A red arrow points from this box to the workspace.
- Workspace:** A code editor showing the execution of several commands:
 - `> SamplingFrq(icp)` resulting in `ans = 0.01666666666666739`
 - `> 60*SamplingFrq(icp)` resulting in `ans = 1.0000000000000043`
 - `> icp_hyp = icp > 25`
 - `> sum((icp-25) * icp_hyp)`
 - `> sum((icp-25) * icp_hyp) / SamplingFrq(icp) / 3600` resulting in `ans = 10.0116714477496`, which is highlighted with a green border.
- Functions and Operators:** A list of functions including `SamplingFrq()`, which is selected.



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

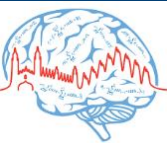
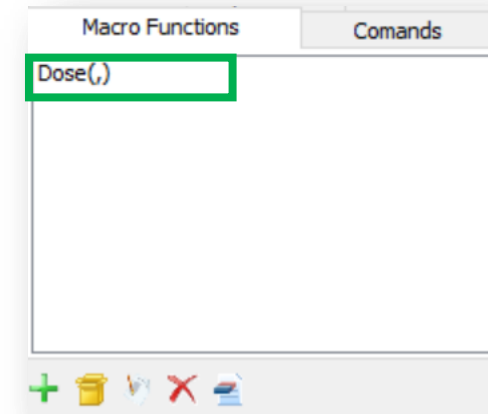
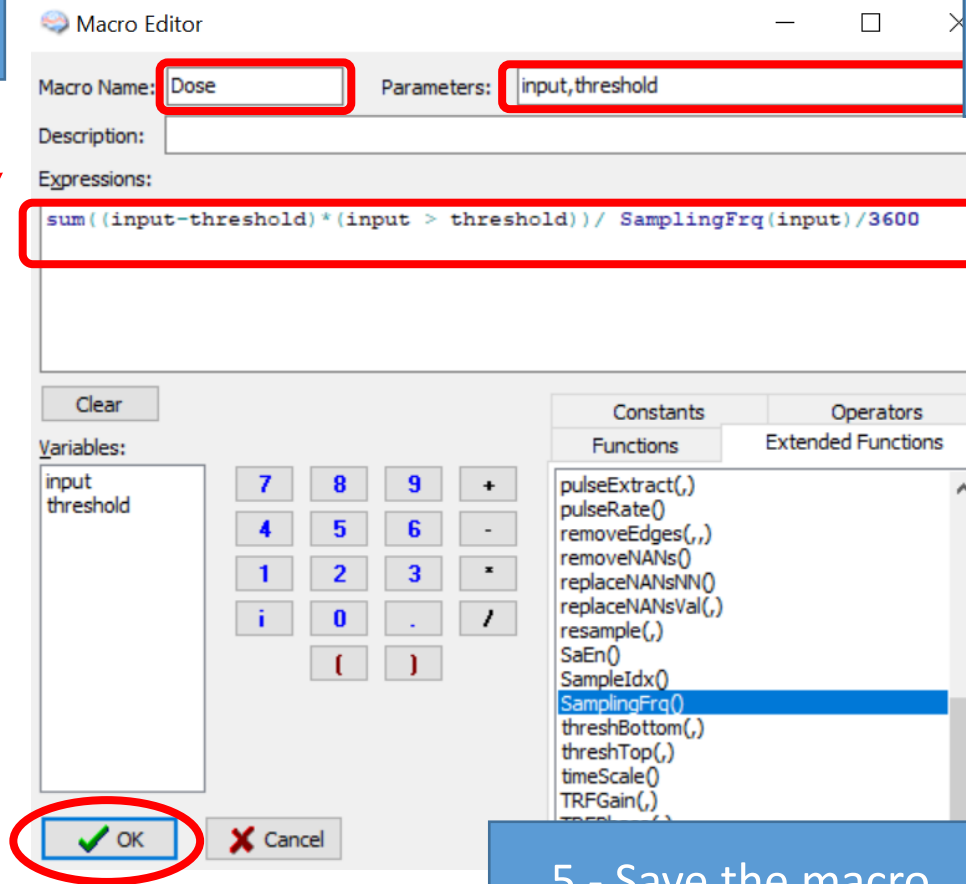
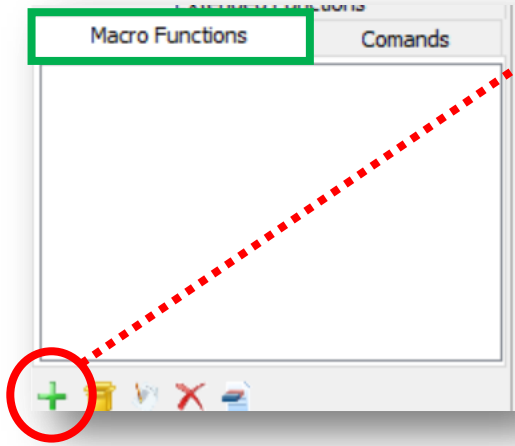
2 - Name the macro

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

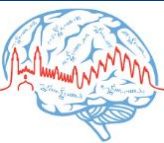
The screenshot displays the 'Advanced Stats Results' window, which includes a table of data and a bar chart. The table lists variables (ICP), their selection criteria, time periods, and calculated doses. The bar chart visualizes these doses for three specific time intervals. The 'Settings' window in the background shows a custom function for calculating the dose based on a threshold.

Variable:	To	N	Period	Dose
ICP	08/09/2009 22:33:59	500	08/09/2009 06:54:00	6.507
ICP	09/09/2009 02:44:55	441	09/09/2009 10:05:50	2.587
ICP	10/09/2009 20:52:14	569	11/09/2009 06:20:26	12.48

Bar Chart Data:

Time Interval	Dose
08/09/2009 22:33:59	6.507
09/09/2009 02:44:55	2.587
10/09/2009 20:52:14	12.48

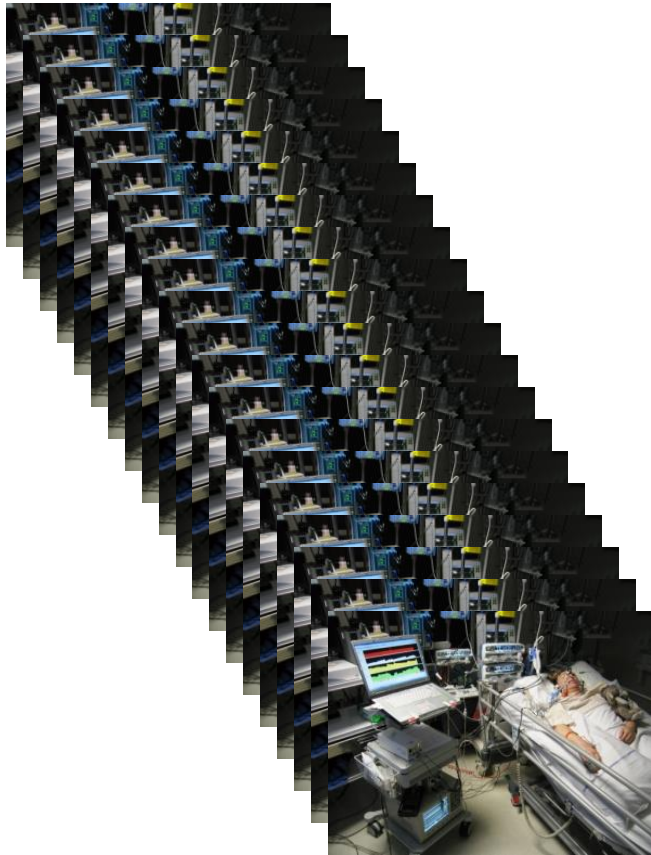
Settings - Advanced Stats Function Selection Fo...
Name: dose
Formula: Dose(input,25)
Apply only to the these signals (comma separated, leave empty for all): icp
Custom Functions: Dose(input,threshold): sum((input - threshold) * (input > threshold))



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



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



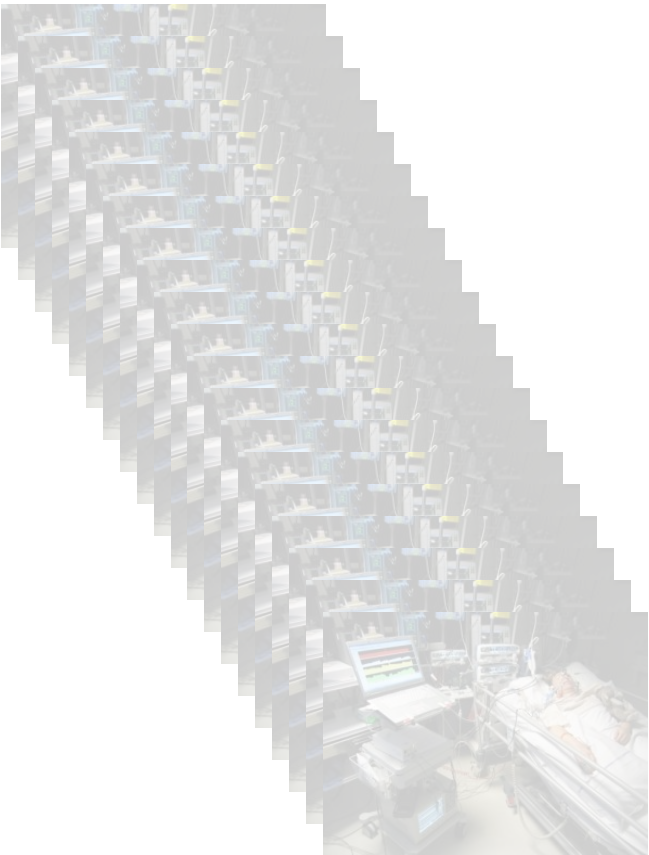
Computer > Groups (\diderot) (Z) > brainphys > Data > TBI

110378872	110454922	110519691	110564847	110643513	110716363	110776799	110914658	110972664	111059627	111165155	111233287	111283779	111356671	111411708	1114571
110380942	110455465	110521483	110568773	110646559	110718203	110785578	110914722	110972791	111060003	111165983	111233366	111284530	111358299	111411787	1114611
110383594	110456099	110521564	110569637	110647071	110721832	110787508	110915462	110972965	111062258	111167433	111237679	111286843	111360654	111413402	1114617
110387589	110456982	110523200	110574456	110651841	110726120	110790129	110917499	110975394	111066172	111167841	111238795	111287497	111362348	111414082	1114626
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110392938	110461854	110529803	110579463	110657088	110734186	110810010	110923616	110980741	111072236	111174891	111243708	111295034	111363509	111418210	1114656
110394659	110468629	110529939	110580816	110657631	110734715	110815053	110923976	110981363	111073656	111179128	111246579	111297172	111366416	111418991	1114696
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110424563	110494520	110547611	110614735	110687520	110750285	110861291	110955851	111016799	111134087	111214881	111266912	111329644	111385238	111429673	1114851
110425801	110494665	110549699	110615732	110688701	110750365	110868649	110956965	111016977	111140020	111219218	111269808	111333944	111388021	111430974	1114859
110426587	110495161	110550960	110617070	110689589	110752639	110880221	110957171	111020120	111140267	111219802	111273566	111334936	111391963	111437156	1114866
110428325	110496721	110553073	110617465	110692145	110753789	110882662	110957184	111021449	111142262	111224425	111273668	111335118	111393056	111437973	1114898
110428988	110497676	110554732	110619671	110692413	110757982	110885702	110959738	111023613	111149788	111227343	111274416	111335376	111397369	111438352	1114913
110432200	110499968	110556833	110620076	110692863	110761705	110888110	110960969	111024638	111150735	111229029	111274500	111337730	111397373	111442440	1114924
110433435	110510837	110557960	110621189	110694446	110762664	110890113	110961977	111030954	111153364	111231031	111274526	111340104	111397604	111445953	1114933
110433644	110514254	110559037	110632419	110696325	110762873	110890325	110963604	111037796	111155932	111231264	111274646	111347754	111397984	111449194	1114954
110436775	110514474	110559313	110632652	110699681	110766022	110892821	110965166	111039143	111160190	111231577	111275177	111349209	111398084	111453739	1114956
110437866	110518830	110561180	110633767	110710215	110767060	110910967	110967547	111039291	111160394	111232192	111275908	111345474	111399023	111455337	1114957
110439225	110518978	110562426	110639217	110713353	110769675	110912394	110967574	111047553	111160904	111232747	111278000	111355811	111399095	111456076	1115102
110450606	110519526	110564557	110643342	110716074	110773164	110913228	110970473	111048762	111163101	111233120	111279751	111355917	111410612	111456257	1115138

568 items Offline status: Online
Offline availability: Not available



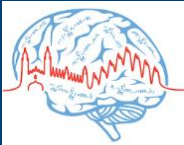
A typical ICM+ enabled pipeline for analysis involving multimodal monitoring data



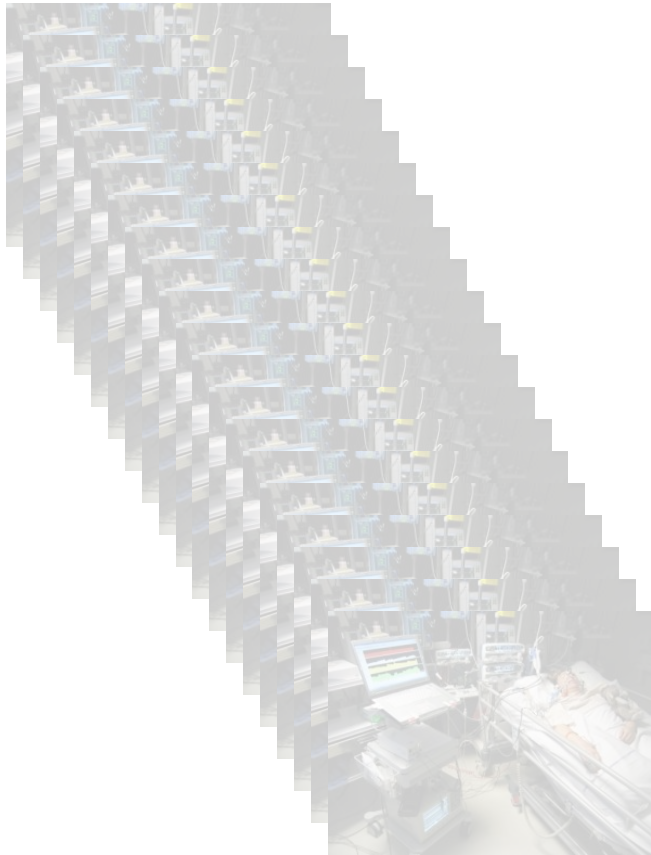
Other File Activities

- New
- Open
- Save
- Export
- Import
- Close
- Batch Reanalyse
- Batch Export
- Batch Summary
- Batch Info Export
- Advanced Profile Edit
- Dta File Split
- Dta Files Header Repair
- Text File Split
- Open Software Config Folder
- Modify ICM+ Variables Info

110776799	110914658	110972664	111059627	111165155	111233287	111283779	111356671	111411708	1114571
110785578	110914722	110972791	111060003	111165983	111233366	111284530	111358299	111411787	1114611
110787508	110915462	110972965	111062258	111167433	111237679	111286843	111360654	111413402	1114617
110790129	110917499	110975394	111066172	111167841	111238795	111287497	111362348	111414082	1114626
110792784	110922858	110977688	111069209	111167967	111239953	111291814	111362446	111416196	1114632
110794489	110923399	110978279	111071918	111168264	111240052	111292048	111363429	111417724	1114647
110810010	110923616	110980741	111072236	111174891	111243708	111295034	111363509	111418210	1114656
110815053	110923976	110981363	111073656	111179128	111246579	111297172	111366416	111418991	1114669
110816912	110924758	110983031	111075842	111182238	111247506	111310041	111366522	111419224	1114738
110818427	110926541	110984295	111078708	111184649	111251098	111310042	111369736	111419809	1114740
110822045	110927442	110984368	111080175	111186929	111255572	111311755	111370713	111421548	1114756
110827211	110929739	110984392	111084308	111188781	111257238	111312251	111372245	111422534	1114768
110828319	110932662	110984612	111089485	111192377	111259050	111313152	111373373	111422959	1114776
110830045	110937806	110984700	111090100	111194728	111261838	111314362	111375145	111423541	1114777
110830882	110938626	110984790	111092076	111195653	111262234	111317864	111375371	111424712	1114785
110414074	110480202	110542176	110610361	110674235	110743743	110832043	110938976	110988436	111110309
110416858	110485418	110543567	110612469	110674279	110744796	110834972	110939604	110989086	111111745
110417366	110490550	110543870	110613457	110677518	110745024	110845189	110948327	110993266	111119126
110420133	110491626	110544176	110614267	110677580	110747530	110850238	110951942	110998121	111123986
110424271	110494200	110547134	110614708	110682035	110749703	110851151	110955723	111016540	111130622
110424563	110494520	110547611	110614735	110687520	110750285	110861291	110955851	111016799	111134087
110425801	110494665	110549699	110615732	110688701	110750365	110866849	110956965	111016977	111140020
110426587	110495161	110550960	110617070	110689589	110752639	110880221	110957171	111020120	111140267
110428325	110496721	110553073	110617465	110692145	110753789	110882662	110957184	111021449	111142262
110428988	110497676	110554732	110619671	110692413	110757982	110885702	110959738	111023613	111149788
110432200	110499968	110556833	110620076	110692863	110761705	110888110	110960969	111024638	111150735
110433435	110510837	110557960	110621189	110694446	110762664	110890113	110961977	111030954	111153364
110433644	110514254	110559037	110632419	110696325	110762873	110890325	110963604	111155932	111231264
110436775	110514474	110559313	110632652	110699681	110766022	110892821	110965166	111039143	111160190
110437866	110518830	110561180	110633767	110710215	110767060	110910967	110967547	111039291	111160394
110439225	110518978	110562426	110639217	110713353	110769675	110912394	110967574	111047553	111160904
110450606	110519526	110564557	110643342	110716074	110773164	110913228	110970473	111048762	111163101



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



Other File Activities

- Batch Reanalyse
- Batch Export
- Batch Summary
- Batch Info Export
- Advanced Profile Edit
- Dta File Split
- Dta Files Header Repair
- Text File Split
- Open Software Config Folder
- Modify ICM+ Variables Info

110412003	110470622	110537236	110599891	110672283	110743711	110830882	110938626	110987979
110414074	110480202	110542176	110610361	110674235	110743743	110832043	110938976	110988479
110416858	110485418	110543567	110612469	110674279	110744796	110834972	110939604	110989906
110417366	110490550	110543870	110613457	110677518	110745024	110845189	110948327	110993266
110420133	110491626	110544176	110614267	110677580	110747530	110850238	110951942	110998171
110424271	110494200	110547134	110614708	110682035	110749703	110851151	110955723	111016654
110424563	110494520	110547611	110614735	110687520	110750285	110861291	110955851	111016756
110425801	110494665	110549699	110615732	110688701	110750365	110868649	110956965	111016979
110426587	110495161	110550960	110617070	110689589	110752639	110880221	110957171	111020111
110428325	110496721	110553073	110617465	110692145	110753789	110882662	110957184	111021444
110428988	110497676	110554732	110619671	110692413	110757982	110885702	110959738	111023611
110432200	110499968	110556833	110620076	110692863	110761705	110888110	110960969	111024611
110433435	110510837	110557960	110621189	110694446	110762664	110890113	110961977	111030999
110433644	110514254	110559037	110632419	110696325	110762873	110890325	110963604	111037779
110436775	110514474	110559313	110632652	110699681	110766022	110892821	110965166	111039911
110437866	110518830	110561180	110633767	110710215	110767060	110910967	110967547	111039225
110439225	110518978	110562426	110639217	110713353	110769675	110912394	110967574	111047555
110450606	110519526	110564557	110643342	110716074	110773164	110913228	110970473	111048706

Batch processing of raw data

Input/Output

File Type: *.dta

Raw Data Folder: Y:\Documents\ICM+\Data\Batch analysis

Output Data Folder: Y:\Documents\ICM+\Data\Batch analysis\results

Include Subfolders:

One file per patient:

One file per folder:

Output in single folder:

Save Trends As:

ICM+ file:

Export as: .csv

Analysis Configuration

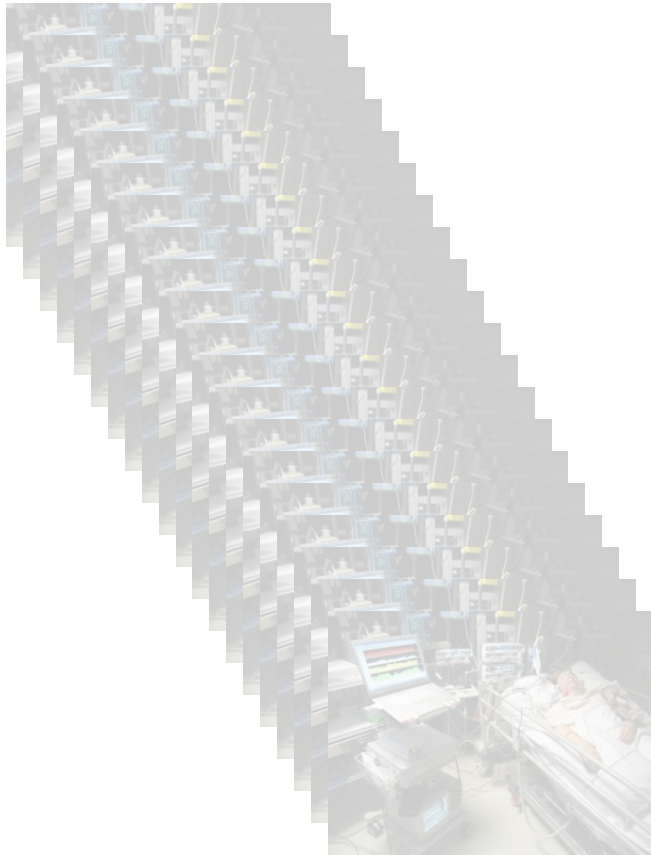
Y:\Documents\ICM+\Data\Batch analysis\Basic profile (mean values).icm

Start Skip File Stop Save Incompatible Files List

Directory: Y:\Documents\ICM+\Data\Batch analysis\
PT1_r1.dta
PT2_r1.dta
PT3_r1.dta
PT4_r1.dta
PT5_r1.dta
Finished



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



Batch processing of raw data

Input/Output
File Type: *.dta
Text File Format: [dropdown]
Raw Data Folder: Y:\Documents\ICM+Data\Batch analysis
Output Data Folder: Y:\Documents\ICM+Data\Batch analysis\results
Include Subfolders: [checkbox]
Custom folders list: [text area]
One file per patient: [checked]
One file per folder: [checkbox]
Output in single folder: [checkbox]

Batch export of ICM+ data

Input/Output
File Type: Main Data File (*.icmp)
Output Type: .csv
Text File Format Definition: [dropdown]
ICM+ files data folder: Y:\Documents\ICM+Data\Batch analysis\results
Output data folder: Y:\Documents\ICM+Data\Batch analysis\export 4h
Evenly resample datasets using the specified function and period
Function: Mean
Period: 4 hours
Reslice evenly: [checked]
Make time relative to: Date of ictus
Patient info file (generated by Batch Info Export): Y:\Documents\ICM+Data\Batch analysis\icmpfilesinfo.txt
Export this variables list only (comma separated): [text area]
Notes and events: [checkbox]
Include Subfolders: [checkbox]
Output in a single folder: [checkbox]
Join all files into one single file: [checked]
Incl. subfolders in output file names: [checkbox]
Join files from one folder: [checkbox]
Insert DataSource column: [checked]

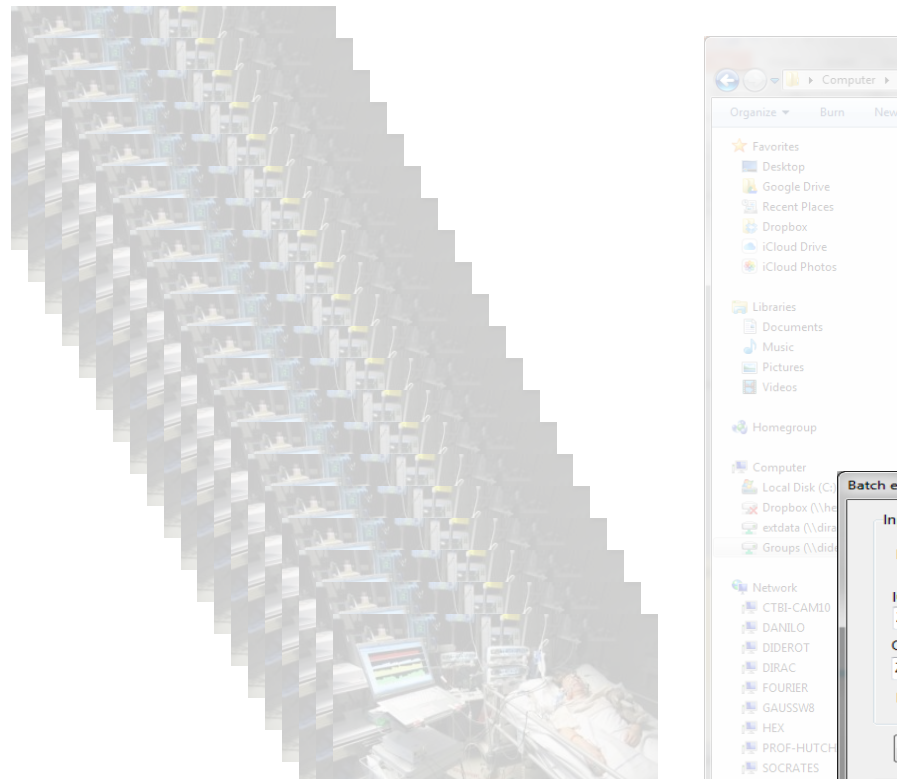
Start Stop

Storing all the exported data into one file: Y:\Documents\ICM+\Data\Batch analysis\export 4h\batch export 4 h.csv
Processing folder: Y:\Documents\ICM+\Data\Batch analysis\results\
PT1_r1.icmp
PT2_r1.icmp
PT3_r1.icmp
PT4_r1.icmp

Close



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



Other File Activities

- Batch Reanalyse
- Batch Export
- Batch Summary
- Batch Info Export** ←
- Advanced Profile Edit
- Dta File Split
- Dta Files Header Repair
- Text File Split
- Open Software Config Folder
- Modify ICM+ Variables Info

Batch extract info from ICM+ data files

Input/Output

File Type: Main Data File (*.icmp)

ICM+ files data folder: Z:\brainphys\Data\TBI

Output info file: Z:\brainphys\Data\TBI\icmpfilesinfo.txt

Include Subfolders

Start Stop

Batch processing of raw data

Input/Output

File Type: *.dta

Raw Data Folder: Y:\Documents\ICM+\Data\Batch analysis

Output Data Folder: Y:\Documents\ICM+\Data\Batch analysis\results

Include Subfolders

One file per patient

Output in single folder

Batch export of ICM+ data

Input/Output

File Type: Main Data File (*.icmp) Output Type: .csv

ICM+ files data folder: Y:\Documents\ICM+\Data\Batch analysis\results

Output data folder: Y:\Documents\ICM+\Data\Batch analysis\export 4h

Evenly resample datasets using the specified function and period

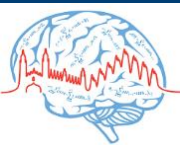
Function: Mean Period: 4 hours

Make time relative to: Date of Ictus

Patient Info file: Y:\Documents\ICM+\Data\Batch analysis\icmpfilesinfo.txt

Export this variables list only: PT1_r1.icmp, PT2_r1.icmp, PT3_r1.icmp, PT4_r1.icmp

Start Stop



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

Batch summary calculation

Input/Output
File Type: Comma separated values file (*.csv) Text File Format: csvformat_datasource.xml

Data files folder
Y:\Documents\ICM+Data\Batch analysis\resaults

Output file
Y:\Documents\ICM+Data\Batch analysis\resaults\summary.csv

Auxiliary lookup up data (matched by data filename)
Y:\Documents\ICM+Data\Batch analysis\dummy_clinical_data.csv

Time Period
Full Period Period [h]: 0.00 to 24.00

Formulae to apply to each variable (unless excluded by the filter)

Name	Function call	Filter
mean	mean(input)	
stddev	stddev(input)	

Processing folder: Y:\Documents\ICM+Data\Batch analysis\resaults\
PT1_r1.csv
PT2_r1.csv
PT4_r1.csv
PT5_r1.csv
Finished

Other File Activities

- Batch Reanalyse
- Batch Export
- Batch Summary
- Batch Info Export
- Advanced Profile Edit
- Dta File Split
- Dta Files Header Repair
- Text File Split
- Open Software Config Folder
- Modify ICM+ Variables Info

Batch extract info from ICM+ data files

Input/Output
File Type: Main Data File (*.icmp)

ICM+ files data folder
Z:\brainphys\Data\TBI

Output info file
Z:\brainphys\Data\TBI\icmpfilesinfo.txt

Include Subfolders

Start Stop

Part Coverage Signals Available

ID	Mark	Year	Last Name	Hospital	Date of Birth	Gender	Day Of	Time Of	Day Of A	Time Of	Comment
1091	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1092	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1093	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1094	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1095	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1096	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1097	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1098	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1099	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red
1100	100	1991	ADIC.Lup.ADIC.Lup.NURS.abp_nurb	xxxx	1991/04/19	Female	17/01/2009	09:00:00	09:00:00	09:00:00	Found red

	A	B	C	D	E	F	G
1	DataSource	GOS	GCS	abp_mean	abp_stddev	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

Batch processing of raw data

Input/Output
File Type: *.dta Text File Format

Raw Data Folder
Y:\Documents\ICM+Data\Batch analysis

Output Data Folder
Y:\Documents\ICM+Data\Batch analysis\results

Include Subfolders Select subfolders to include

Custom folders list

One file per patient

One file per folder

Output in single folder

Save Trends As

Batch export of ICM+ data

Input/Output
File Type: Main Data File (*.icmp) Output Type: .csv

Text File Format Definition

ICM+ files data folder
Y:\Documents\ICM+Data\Batch analysis\resaults

Output data folder
Y:\Documents\ICM+Data\Batch analysis\export 4h

Evenly resample datasets using the specified function and period

Function: Mean Period: 4 hours

Reslice evenly

Make time relative to: Date of Ictus

Patient info (generated by Batch Info Export)
Y:\Documents\ICM+Data\Batch analysis\icmpfilesinfo.txt

Export this variables list only (comma separated)

Include Subfolders Incl. subfolders in output file names

Output in a single folder Join files from one folder

Join all files into one single file Insert DataSource column

Storing all the exported data into one file: Y:\Documents\ICM+Data\Batch analysis\export 4h\batch export 4 h.csv

Processing folder: Y:\Documents\ICM+Data\Batch analysis\resaults\
PT1_r1.icmp
PT2_r1.icmp
PT3_r1.icmp
PT4_r1.icmp



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

Batch summary calculation

Input/Output

File Type: **Text File Format**
 Comma separated values file (*.csv) | csvformat_datasource.xml

Data files folder
 Y:\Documents\ICM+Data\Batch analysis\resaults

Include Subfolders Variables suffix

Output file
 Extend the output file
 Y:\Documents\ICM+Data\Batch analysis\resaults\summary.csv

Other File Activities

- Batch Reanalyse
- Batch Export
- Batch Summary

Batch processing of raw data

Input/Output

File Type: *.dta | Text File Format

Raw Data Folder
 Y:\Documents\ICM+Data\Batch analysis

Output Data Folder
 Y:\Documents\ICM+Data\Batch analysis\results

```

1
2
3 ###EX 2- Batch Analysis
4 # import in R for simple model analysis
5
6 setwd("y:/Documents/ICM+/Data/Batch analysis")
7
8 s<-read.csv("summary.csv")
9
10
11 plot(s$GCS,s$icp_mean)
12
13 gcs<-glm(s$icp_mean~s$icp_mean)
14 summary(gcs)
15
16
    
```



```

> summary(gcs)

Call:
glm(formula = s$icp_mean ~ s$icp_mean)

Deviance Residuals:
    1      2      3      4      5
 4.106  1.306 -9.734  0.276  4.046

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    9.734      2.547   3.821  0.0188 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 32.44048)

Null deviance: 129.76  on 4  degrees of freedom
Residual deviance: 129.76  on 4  degrees of freedom
AIC: 34.471

Number of Fisher Scoring iterations: 2
    
```

>
>
>
>
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>
>
>
>
>

1
2
3
4
5
6

ID	ICM+ ID	ICM+ Name	ICM+ Type	ICM+ Status	ICM+ Date	ICM+ Time	ICM+ Location	ICM+ Description	ICM+ Notes
1	110098121	110098121_20090304_P2	ICM+	Active	20/03/2009 00:39	20/03/2009 00:40	200	8.75584	100
2	110098121	110098121_20090304_P3	ICM+	Active	20/03/2009 00:41	20/03/2009 00:42	200	6.00861	100
3	110098121	110098121_20090304_P4	ICM+	Active	20/03/2009 00:43	20/03/2009 00:44	200	14.02133	100
4	110098121	110098121_20090304_P5	ICM+	Active	20/03/2009 00:45	20/03/2009 00:46	200	0.90783	100
5	110098121	110098121_20090304_P6	ICM+	Active	20/03/2009 00:47	20/03/2009 00:48	200	26.02592	100
6	110098121	110098121_20090304_P7	ICM+	Active	20/03/2009 00:49	20/03/2009 00:50	200	0.93688	100
7	110098121	110098121_20090304_P8	ICM+	Active	20/03/2009 00:51	20/03/2009 00:52	200	8.97479	75
8	110098121	110098121_20090304_P9	ICM+	Active	20/03/2009 00:53	20/03/2009 00:54	200	1.91032	95
9	110098121	110098121_20090304_P10	ICM+	Active	20/03/2009 00:55	20/03/2009 00:56	200	15.70448	95
10	110098121	110098121_20090304_P11	ICM+	Active	20/03/2009 00:57	20/03/2009 00:58	200	2.85024	95
11	110098121	110098121_20090304_P12	ICM+	Active	20/03/2009 00:59	20/03/2009 01:00	200	2.23168	95
12	110098121	110098121_20090304_P13	ICM+	Active	20/03/2009 01:01	20/03/2009 01:02	200	13.70438	95
13	110098121	110098121_20090304_P14	ICM+	Active	20/03/2009 01:03	20/03/2009 01:04	200	15.23232	100
14	110098121	110098121_20090304_P15	ICM+	Active	20/03/2009 01:05	20/03/2009 01:06	200	7.62006	100
15	110098121	110098121_20090304_P16	ICM+	Active	20/03/2009 01:07	20/03/2009 01:08	200	7.88105	100
16	110098121	110098121_20090304_P17	ICM+	Active	20/03/2009 01:09	20/03/2009 01:10	200	7.22877	100
17	110098121	110098121_20090304_P18	ICM+	Active	20/03/2009 01:11	20/03/2009 01:12	200	15.26267	88
18	110098121	110098121_20090304_P19	ICM+	Active	20/03/2009 01:13	20/03/2009 01:14	200	10.45208	100
19	110098121	110098121_20090304_P20	ICM+	Active	20/03/2009 01:15	20/03/2009 01:16	200	7.72861	100
20	110098121	110098121_20090304_P21	ICM+	Active	20/03/2009 01:17	20/03/2009 01:18	200	10.17017	97
21	110098121	110098121_20090304_P22	ICM+	Active	20/03/2009 01:19	20/03/2009 01:20	200	0.12679	96
22	110098121	110098121_20090304_P23	ICM+	Active	20/03/2009 01:21	20/03/2009 01:22	200	2.74005	100
23	110098121	110098121_20090304_P24	ICM+	Active	20/03/2009 01:23	20/03/2009 01:24	200	0.472917	100
24	110098121	110098121_20090304_P25	ICM+	Active	20/03/2009 01:25	20/03/2009 01:26	200	15.20318	74

Start Stop

Storing all the exported data into one file: Y:\Documents\ICM+\Data\Batch analysis\export 4h\batch export 4 h.csv

Processing folder: Y:\Documents\ICM+\Data\Batch analysis\resaults\

PT1_r1.icmp
 PT2_r1.icmp
 PT3_r1.icmp
 PT4_r1.icmp

Close



Lab



Batch export tool

Batch export of ICM+ data

Input/Output


File Type: Output Type:

Text File Format Definition

ICM+ files data folder
C:\Users\ps100\Dropbox (Cambridge University)\ICM+\Data\CENTER-TBNNCF

Output data folder
C:\Users\ps100\Dropbox (Cambridge University)\ICM+\Data\CENTER-TBNNCF\test4

Change data granularity using the following summary function

Function Period 

Reslice the time scale evenly to the specified period

Make time relative to: Event Occurrence

Patient info file (generated by Batch Info Export)
C:\Users\ps100\Dropbox (Cambridge University)\ICM+\Data\CENTER-TBNNCF\icmfileinfo.txt

Export this variables list only (comma separated)
 Notes and events

Include Subfolders Incl. subfolders in output file names

Output in a single folder Join files from one folder

Join all files into one single file Insert DataSource column

Start Stop

Processing folder:
C:\Users\ps100\Dropbox (Cambridge University)\ICM+\Data\CENTER-TBI\INCF
PT1_r1.icmp
PT2_r1.icmp
PT3_r1.icmp
PT4_r1.icmp

Function

None Mean High Low Median Std Dev MA Filter Median Filter

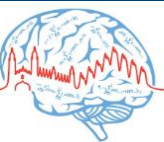
Reslice evenly

4 Hours

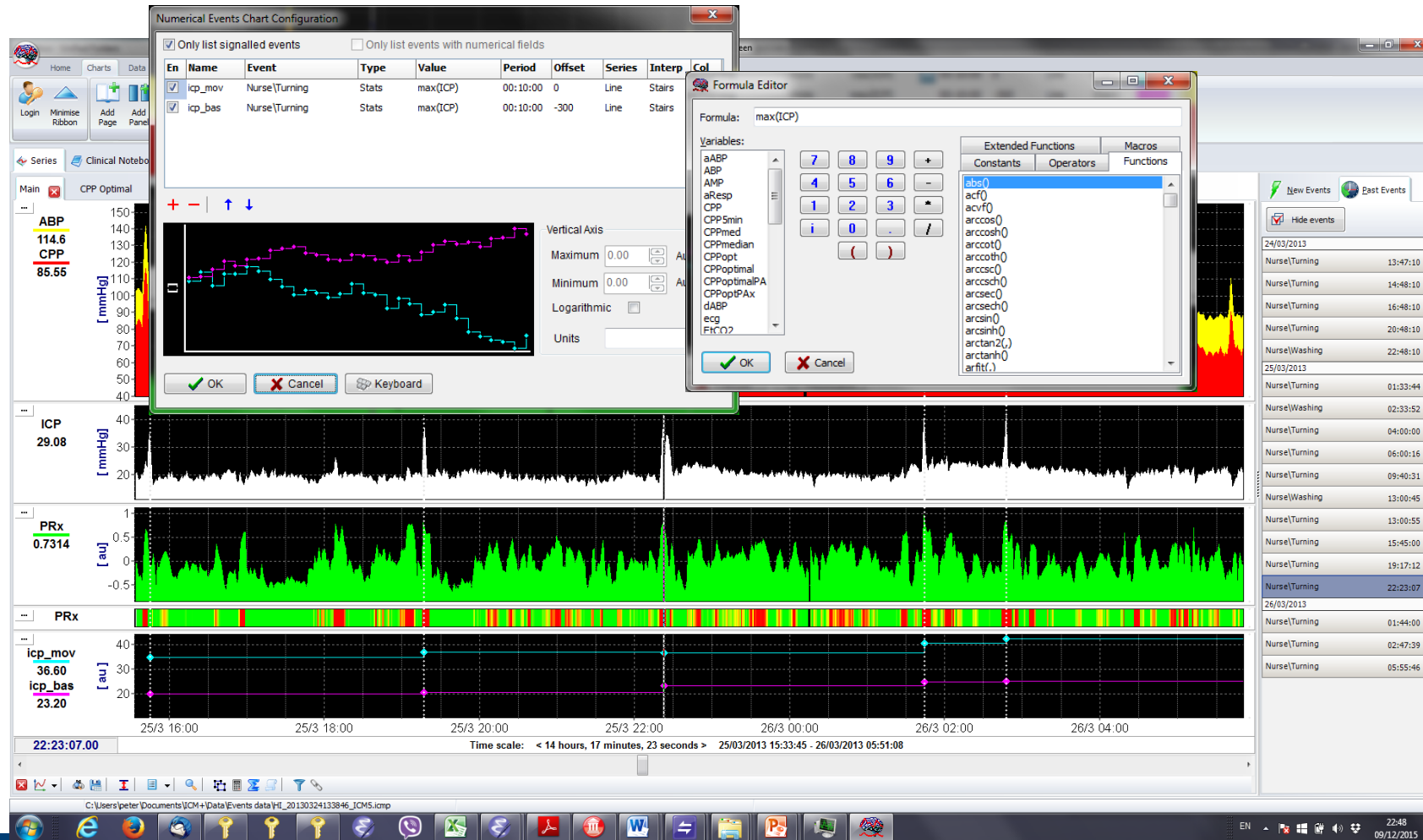
1 second
1 minute
1 hour
1 day

	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

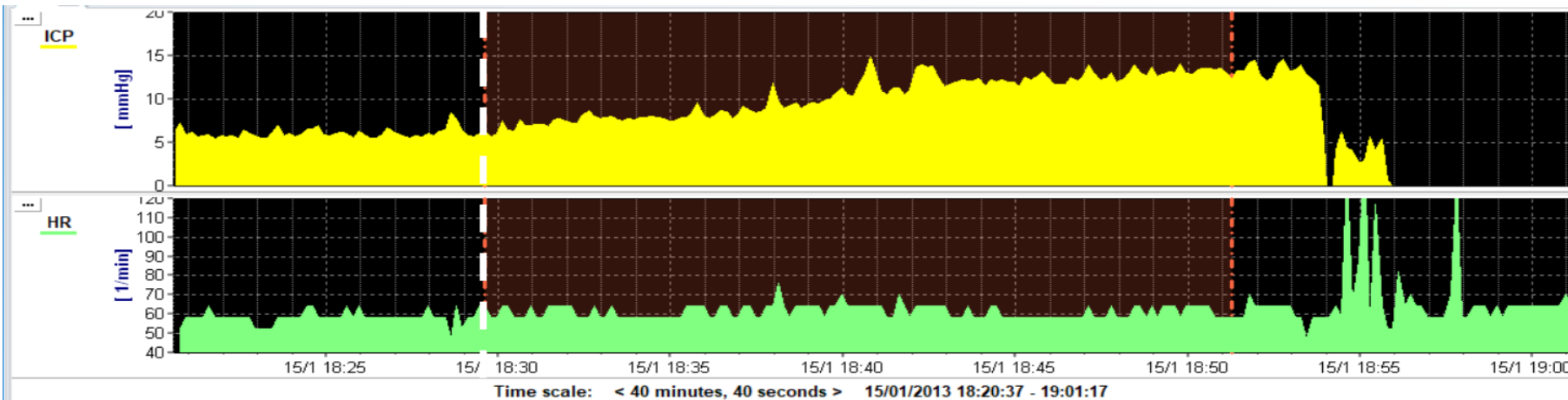
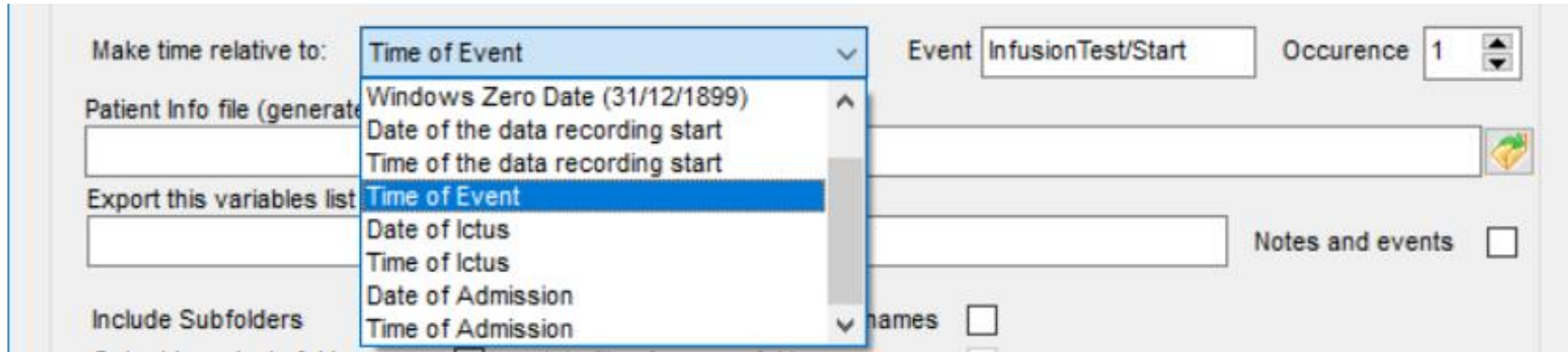
The DateTime variable is expressed in days from ictus



ICM+ Event oriented analysis



Time anchoring for batch analysis



Negative time ← → Positive time



Batch summary calculation, linking with the clinical database

Batch summary calculation

Input/Output

File Type: Text File Format

Main Data File (*.icmp)

Data files folder
C:\Users\ps100\Dropbox (Cambridge University)\ICM+IData\CENTER-TBNNCF

Include Subfolders

Output file

Extend the output file

Auxiliary lookup up data (matched by data filename)

Time Period

Full Period Period [h] 0.00 to 24.00 Event

Relative to Unx Zero Date (1/1/1970) Occurrence 1

Patient info file (generated by Batch Info Export)

Formulae to apply to each variable (unless excluded by the filter)

Name	Function call	Filter
mean	mean(input)	
stddev	stddev(input)	
N	length(input)	

Start Stop

Close



Batch summary calculation, linking with the clinical database

Batch summary calculation

Input/Output

File Type: Text File Format

Main Data File (*.icmp)

Data files folder
C:\Users\ps100\Dropbox (Cambridge University)\ICM+1Data\CENTER-TBNNCF

Include Subfolders

Output file

Extend the output file

Auxiliary lookup up data (matched by data filename)

Time Period

Full Period Period [h] 0.00 to 24.00 Event

Relative to Unx Zero Date (1/1/1970) Occurrence 1

Patient info file (generated by Batch Info Export)

Formulae to apply to each variable (unless excluded by the filter)

Name	Function call	Filter
mean	mean(input)	
stddev	stddev(input)	
N	length(input)	

Start Stop

Close



Batch summary calculation, linking with the clinical database

Batch summary calculation

Input/Output
File Type: Text File Format
Main Data File (*.icmp)

Data files folder
C:\Users\ps100\Dropbox (Cambridge University)\ICM+Data\CENTER-TBAINCF

Include Subfolders Variables suffix

Output file Extend the output file

Auxiliary lookup up data (matched by data filename)

Time Period
Full Period Period [h] 0.00 to 24.00 Event
Relative to Unx Zero Date (1/1/1970) Occurrence 1

Patient info file (generated by Batch Info Export)

Formulae to apply to each variable (unless excluded by the filter)

Name	Function call	Filter
mean	mean(input)	
stddev	stddev(input)	
N	length(input)	

Start Stop

Close

Input/Output

File Type: Text File Format
Comma separated values file (*.csv) csvformat_datasource.xml

Data files folder
Y:\Documents\ICM+Data\Batch analysis\results

Include Subfolders Variables suffix

Output file Extend the output file

Y:\Documents\ICM+Data\Batch analysis\results\summary.csv

Auxiliary lookup up data (matched by data filename)
Y:\Documents\ICM+Data\Batch analysis\dummy_clinical_data.csv

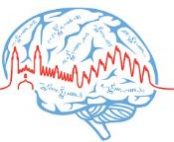
Time Period
Full Period Period [h] 0.00 to 24.00

Data

- Batch analysis
- HRV
- Microdialysis
- Shorts
- TBI
- TCP

File name: summary.csv

Save as type: Comma Separated ASCII File



Batch summary calculation, linking with the clinical database

Batch summary calculation

Input/Output
File Type: Text File Format
Main Data File (*.icmp)

Data files folder
C:\Users\ps100\Dropbox (Cambridge University)\ICM+Data\CENTER-TBINCF

Include Subfolders Variables suffix

Output file Extend the output file

Auxiliary lookup up data (matched by data filename)

Time Period
Full Period Period [h] 0.00 to 24.00 Event

Relative to Unx Zero Date (1/1/1970) Occurrence 1

Patient info file (generated by Batch Info Export)

Formulae to apply to each variable (unless excluded by the filter)

Name	Function call	Filter
mean	mean(input)	
stddev	stddev(input)	
N	length(input)	

Start Stop

Close

Input/Output
File Type: Text File Format
Comma separated values file (*.csv) csvformat_datasource.xml

Data files folder
Y:\Documents\ICM+Data\Batch analysis\results

Include Subfolders Variables suffix

Output file Extend the output file

Y:\Documents\ICM+Data\Batch analysis\results\summary.csv

Auxiliary lookup up data (matched by data filename)
Y:\Documents\ICM+Data\Batch analysis\dummy_clinical_data.csv

Time Period
Full Period Period [h] 0.00 to 24.00

Data

Batch analysis

HRV

Microdialysis

Shorts

TBI

TCO

File name: summary.csv

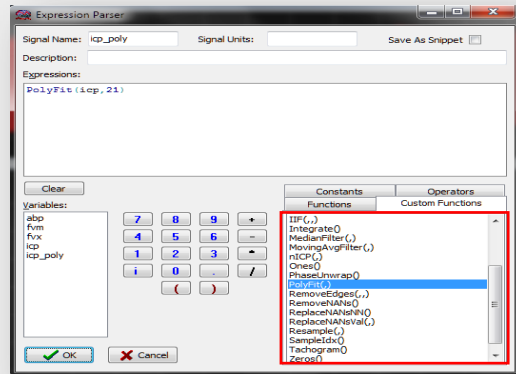
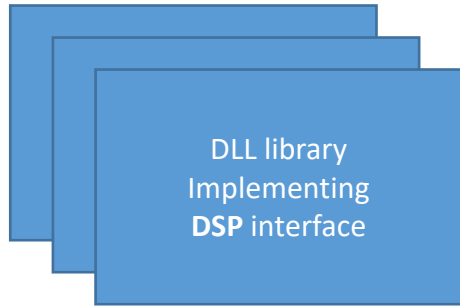
Save as type: Comma Separated ASCII File

	A	B	C
1	DataSource	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

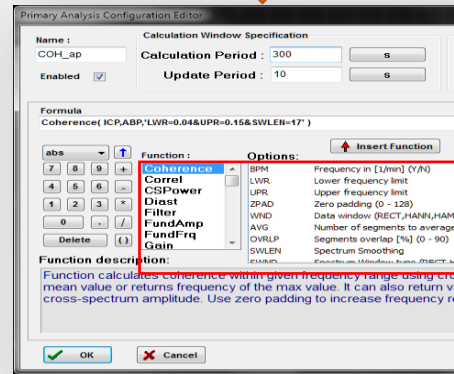
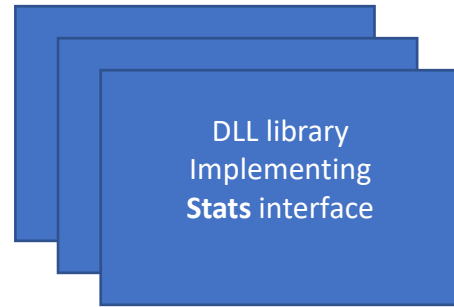
	A	B	C	D	E	F	G
1	DataSource	GOS	GCS	abp_mean	abp_stddev	icp_mean	icp_stddev
2	PT1_r1	1	3	88.82	8.728	13.85	2.953
3	PT2_r1	2	5	86.46	12.3	11.04	4.71
4	PT3_r1	3	6	0	NAN	0	NAN
5	PT4_r1	4	9	73.81	13.49	10.03	7.001
6	PT5_r1	5	5	89.12	9.894	13.79	2.98



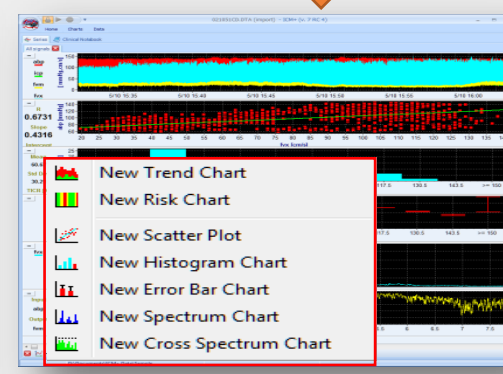
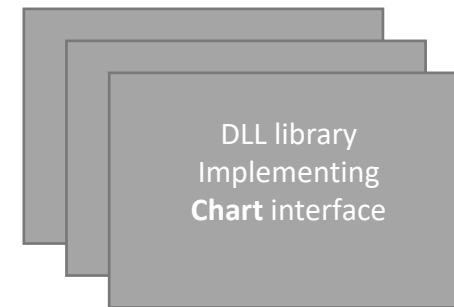
ICM+ functionality can be extended using 3rd party plugins



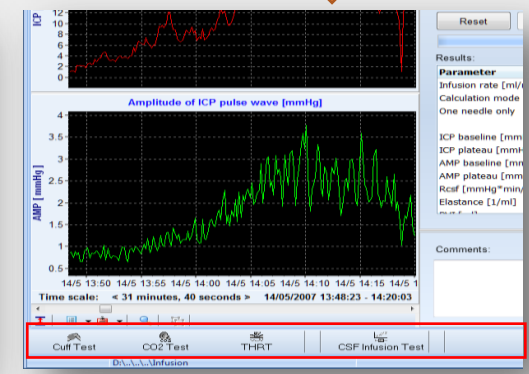
DSP
(Signal Calculator)



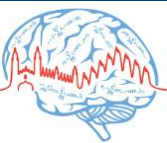
Stats functions
(Real-time analysis)



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:

ChartBarResData (Structure used by the plugin to pass back results of bar type chart calculation)	35
ChartCalcData (Structure used to provide data for chart calculation)	37
ChartCfgData (Structure used to configure the chart calculation structures)	38
ChartErrorBarResData (Structure used by the plugin to pass back results of error bar type chart calculation)	39
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FunCalcData (Structure used to provide the DSP function with data for calculation)	51
FunCalcInitData (Structure used to initialise the calculation structures of a DSP function)	53
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PlgRegInfo (Structure used in plugin registration functions)	71
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StatsCalcData (Structure used to provide the function with data for calculation for stats functions)	76
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StatsCalcResetData (Structure used to reset the calculation structures for stats functions)	80
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ToolCalcData (Structure used to provide data for an analysis tool calculation)	83
ToolInfo (Structure returning information about implemented analysis tools)	85
ToolResult (Structure used to retrieve results of an analysis tool calculation)	88
ToolResultInfo (Structure used to retrieve results info of an analysis tool calculation)	90

```
emacs@HEX
File Edit Options Buffers Tools C Help
[Icons]
// Main distributor function
//
#pragma argsused
WORD __stdcall plgmain(const WORD reqId, PVOID data, PVOID result)
{
    WORD errorCode = IC MPL_ERR_NONE;
    switch (reqId) {
        case IC MPL_REQ_PLUGIN_INIT:
            // Perform plugin initialisation
            errorCode = initialisePlugin();
            break;

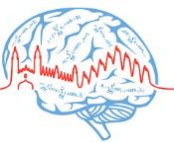
        case IC MPL_REQ_PLUGIN_FREE:
            // Perform plugin cleanup
            errorCode = finalisePlugin();
            break;

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

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

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

        case IC MPL_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/1 Abbrev)
```



Advanced features: Plugins

Chapter 3

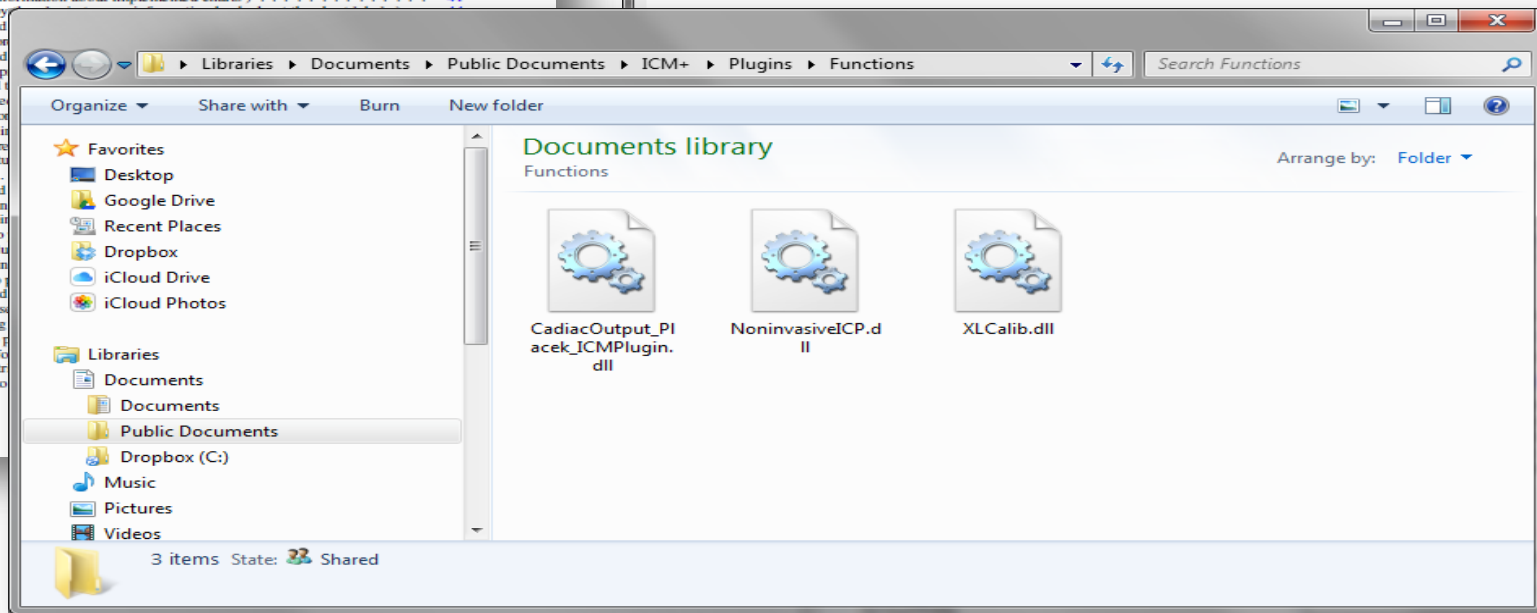
Data Structure Index

3.1 Data Structures

Here are the data structures with brief descriptions:

ChartBarResData (Structure used by the plugin to pass back results of bar type chart calculation)	35
ChartCalcData (Structure used to provide data for chart calculation)	37
ChartCfgData (Structure used to configure the chart calculation structures)	38
ChartErrorBarResData (Structure used by the plugin to pass back results of error bar type chart calculation)	39
ChartInfo (Structure returning information about implemented charts)	41
ChartLabels (Structure used to by)	
ChartMarkerData (Structure used)	
ChartPoint (Structure used to store)	
ChartXYResData (Structure used)	
FunCalcData (Structure used to p)	
FunCalcInitData (Structure used t)	
FunCalcResetData (Structure use)	
FunInfo (Structure returning info)	
PlgArgInfo (Structure returning it)	
PlgCustomOptCfgData (Structure)	
PlgDataSelectInfo (Structure retu	
PlgDataSelection (Structure used)	
PlgObjSetInfo (Structure returnin	
PlgOpInfo (Structure returning it)	
PlgPeriodData (Structure used to)	
PlgRegInfo (Structure used in plu	
PluginInfo (Structure returning in	
StatsCalcData (Structure used to)	
StatsCalcInitData (Structure used)	
StatsCalcResetData (Structure us)	
StatsFunInfo (Structure returning	
ToolCalcData (Structure used to p)	
ToolInfo (Structure returning info	
ToolResult (Structure used to retr	
ToolResultInfo (Structure used to	

```
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 = ICMP_ERR_NONE;
    switch (reqId) {
        case ICMP_REQ_PLUGIN_INIT:
            // Perform plugin initialisation
            errorCode = initialisePlugin();
            break;
    }
}
```



Advanced features: Plugins

Chapter 3

Data Structures

3.1 Data Structures

Here are the data structures with brief

ChartBarResData (Structure used
ChartCalcData (Structure used to
ChartCfgData (Structure used to
ChartErrorBarResData (Structure
calculation)
ChartInfo (Structure returning inf
ChartLabels (Structure used to by
ChartMarkerData (Structure used
ChartPoint (Structure used to store
ChartXYResData (Structure used
FunCalcData (Structure used to p
FunCalcInitData (Structure used f
FunCalcResetData (Structure use
FunInfo (Structure returning info
PlgArgInfo (Structure returning it
PlgCustomOptCfgData (Structure
PlgDataSelectInfo (Structure retur
tool calculation)
PlgDataSelection (Structure used
PlgObjSetInfo (Structure returnin
PlgOpInfo (Structure returning in
PlgPeriodData (Structure used to
PlgRegInfo (Structure used in plu
PluginInfo (Structure returning in
StatsCalcData (Structure used to
StatsCalcInitData (Structure used
StatsCalcResetData (Structure us
StatsFunInfo (Structure returning
ToolCalcData (Structure used to p
ToolInfo (Structure returning info
ToolResult (Structure used to retr
ToolResultInfo (Structure used to

The screenshot displays the ICM+ software interface. A 'Detailed ICM+ License Info' dialog box is open, showing registration details for 'peter' at the 'University of Cambridge', with a valid registration until '08/12/2016'. Below this, a 'Registered Features' list includes: Data Acquisition And Real-time Analysis, Customisable Analysis Configuration, Raw Signals Recording, Off-line Analysis of Raw Signals, CSF Dynamics Tools, and Cerebrovascular Reactivity Tools, all marked as available. A 'Register New Key' button is also present. The 'Installed Monitor Modules' list includes DT9800, Simulator, MPR, Spiegelberg, and Intellivue. A 'Close' button is at the bottom of the dialog. In the background, a '3rd Party Plugins' window is visible, listing 'NoninvasiveICP' (Registered), 'MSEntropy' (Registered, 99999 days left), 'Cardiac Output' (Unregistered/Expired), 'MSEnChart' (Registered, 99999 days left), and 'Poincare Chart Plugin' (Registered, 20 days left). A code editor window is partially visible on the right, showing a function signature: `(int *) result);` and a comment: `t implemented by`.



Advanced features: Plugins

Chapter 3

Data Structures

3.1 Data Structures

Here are the data structures with brief

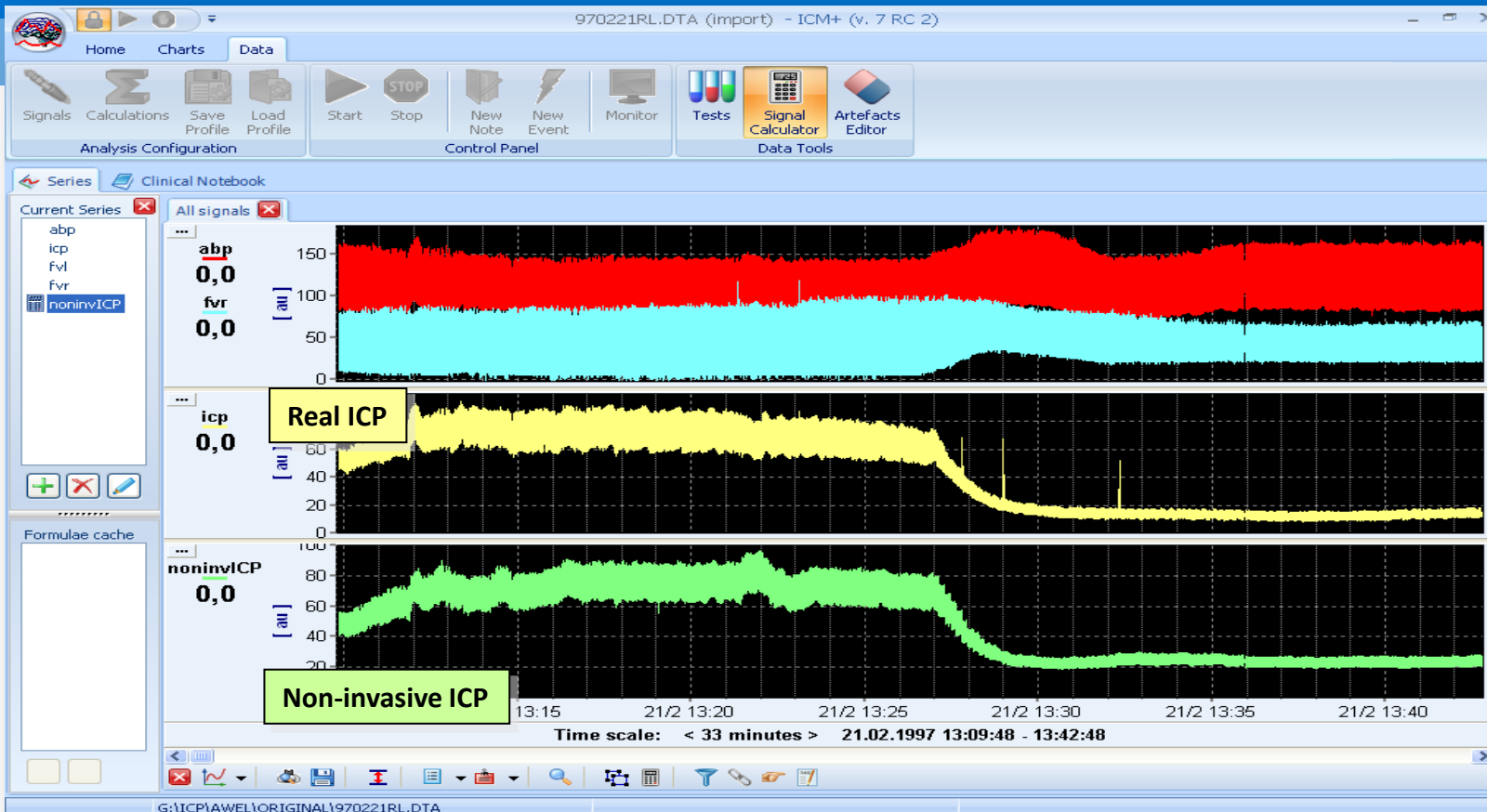
ChartBarResData (Structure used to store bar chart data)
ChartCalcData (Structure used to store calculation data)
ChartCfgData (Structure used to store chart configuration data)
ChartErrorBarResData (Structure used to store error bar chart data)
ChartInfo (Structure returning information about the chart)
ChartLabels (Structure used to store chart labels)
ChartMarkerData (Structure used to store chart marker data)
ChartPoint (Structure used to store chart point data)
ChartXYResData (Structure used to store XY chart data)
FunCalcData (Structure used to store function calculation data)
FunCalcInitData (Structure used to store function calculation initialization data)
FunCalcResetData (Structure used to store function calculation reset data)
FunInfo (Structure returning information about the function)
PigArgInfo (Structure returning information about the pig)
PigCustomOptCfgData (Structure used to store pig custom optimization configuration data)
PigDataSelectInfo (Structure returning information about the pig data selection tool calculation)
PigDataSelection (Structure used to store pig data selection data)
PigObjSetInfo (Structure returning information about the pig object set)
PigOpInfo (Structure returning information about the pig operation)
PigPeriodData (Structure used to store pig period data)
PigRegInfo (Structure used to store pig registration information)
PluginInfo (Structure returning information about the plugin)
StatsCalcData (Structure used to store statistics calculation data)
StatsCalcInitData (Structure used to store statistics calculation initialization data)
StatsCalcResetData (Structure used to store statistics calculation reset data)
StatsFunInfo (Structure returning information about the statistics function)
ToolCalcData (Structure used to store tool calculation data)
ToolInfo (Structure returning information about the tool)
ToolResult (Structure used to store tool result data)
ToolResultInfo (Structure used to store tool result information data)

The screenshot displays the ICM+ software interface. A window titled "Detailed ICM+ License Info" is open, showing registration details for "peter" at the "University of Cambridge", with a registration valid until "08/12/2016". Below this, a table lists "Registered Features" with green checkmarks: "Data Acquisition And Real-time Analysis", "Customisable Analysis Configuration", "Raw Signals Recording", "Off-line Analysis of Raw Signals", "CSF Dynamics Tools", and "Cerebrovascular Reactivity Tools". A "Register New Key" button is also visible. To the right, a "3rd Party Plugins" window shows details for the "Cardiac Output" plugin (Ver.: 1.0), including its type, author (Michal M. Placek), and author email (michal.placek@pwr.edu.pl). The plugin description states: "Cardiac Output (CO) estimation using raw ABP signal. Proportional CO is computed to within a constant scale factor via Ohm's law by dividing average ABP by Windkessel time constant. Based on the paper: Mukkamala R, et al. 'Continuous cardiac output'". The registration status is "Unregistered/Expired", and there is a field to "Enter new registration key:". In the background, a code editor window shows a snippet of C++ code:

```
ion.  
  
(int *) result );  
  
t implemented by  
;
```



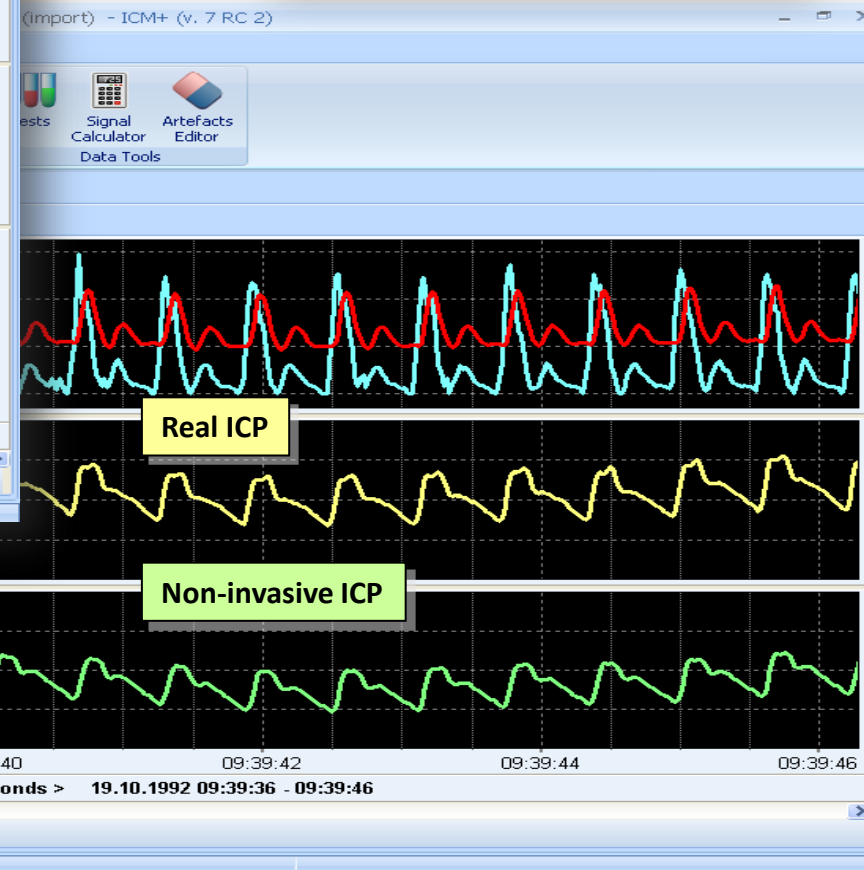
nICP plugin for ICM+



3rd Party Plugins

Plugins Details

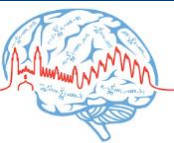
Plugin name: NoninvasiveICP Ver.: 1.1
Plugin type: Signal Processing Functions
Plugin author: Ronny Plontke
Author Email: b.schmidt@skc.de
Noninvasive Intracranial Pressure Plugin
Medical Centre Chemnitz, Department of Neurology
ICP Calculation Module
developed by B. Schmidt, J. Klingelhöfer, M. Czosnyka
Patent No. 12345
Web: b.schmidt@skc.de
Registration Valid For: Unlimited
Enter new registration key:



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

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



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
- Needs a full C/C++ development environment – eg Visual C++ or gcc for Windows and a good understanding of building dll libraries
- Every little change in the code, requires rebuilding the library
- The debugging process is tedious
- Small mistakes in memory handling may bring the whole parent application, ICM+, crashing down – not ideal in real time analysis scenario



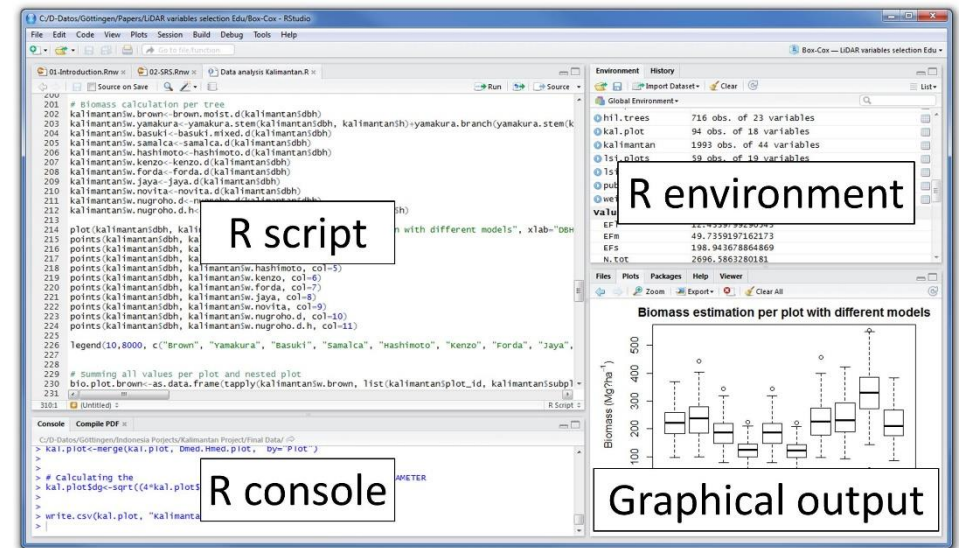
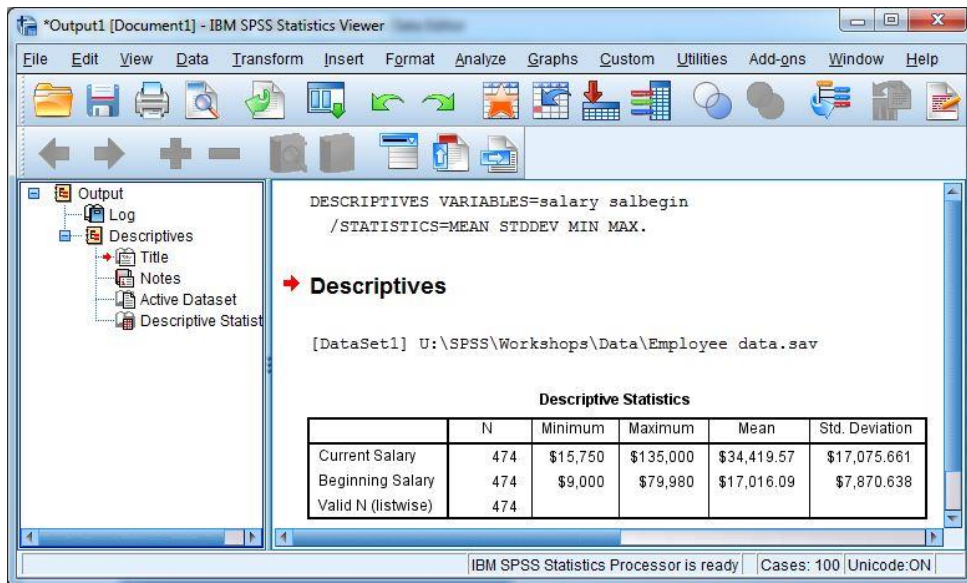
Writing plugins for ICM+ requires some fundamental programming skills

- Hi performance code – important for complex functions
- The code is distributed as a binary - protected, allowing 3rd party licensing
- Needs a full C/C++ development environment – eg Visual C++ or gcc for Windows and a good understanding of building dll libraries
- Every little change in the code, requires rebuilding the library
- The debugging process is tedious
- Small mistakes in memory handling may bring the whole parent application, ICM+, crashing down – not idea in real time analysis scenario
- **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



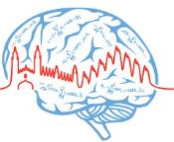
If statistics programs were cars ...



If statistics programs were cars ...



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

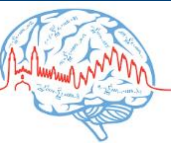
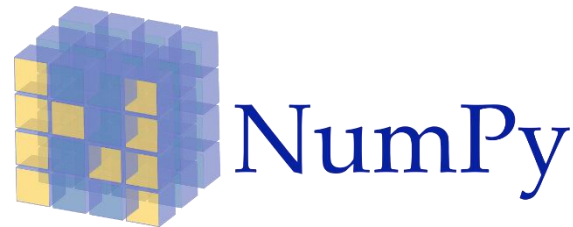
Brief Computing curriculum highlights include:

- **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

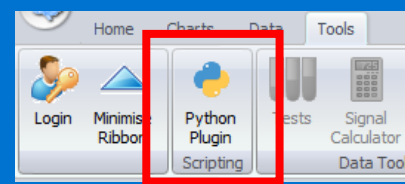


What is Python

- 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



```
# 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)

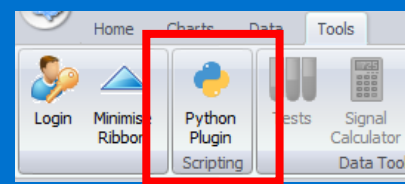
    # Class constructor.
    def __init__(self):
        self.sampling_freq = None

    # 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 coefficient
```



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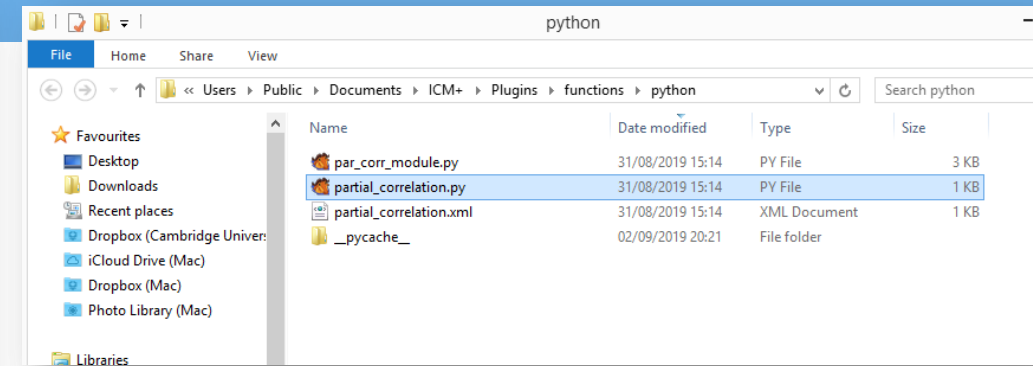
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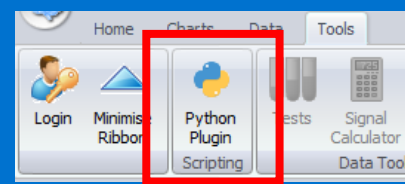
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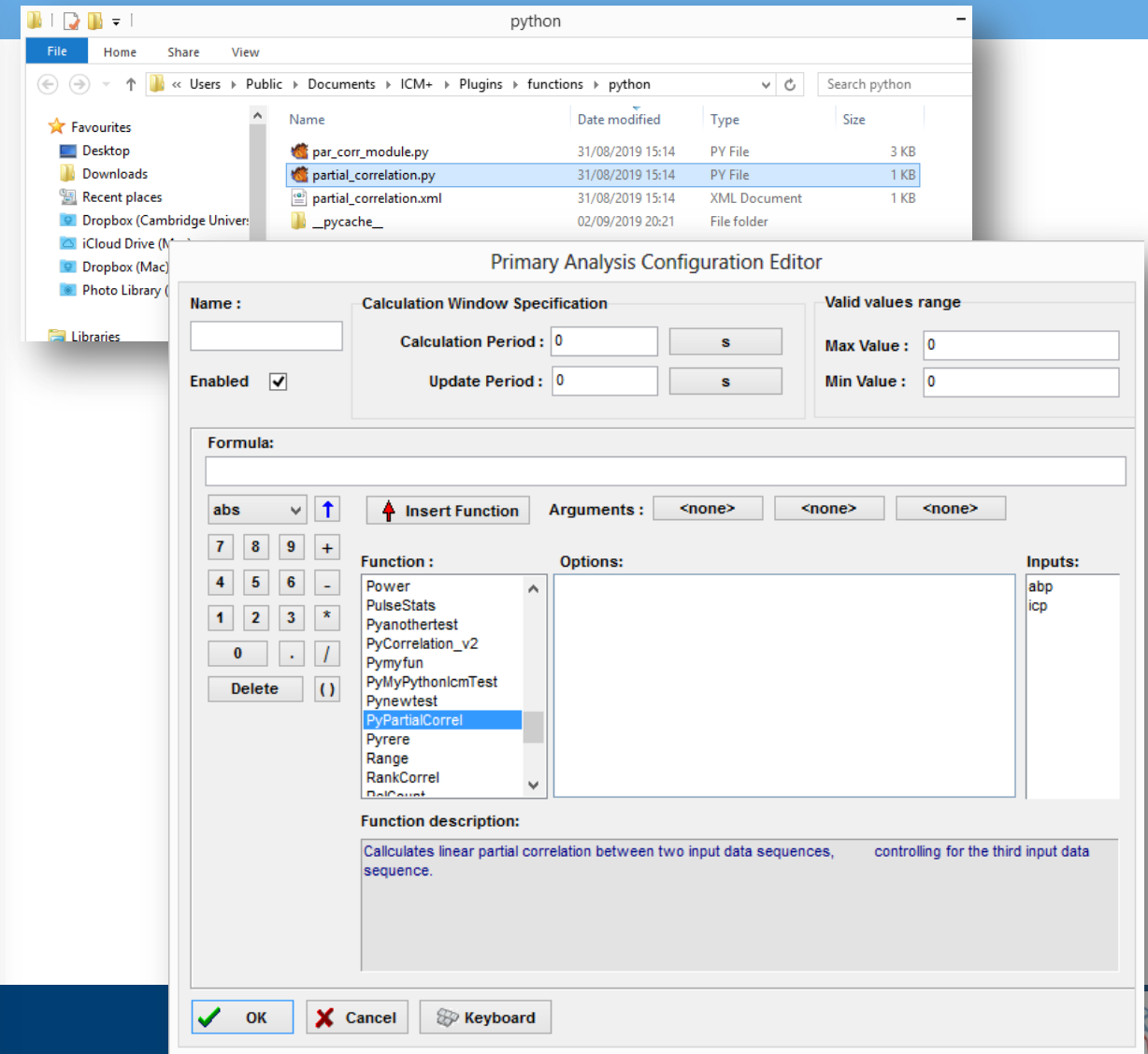
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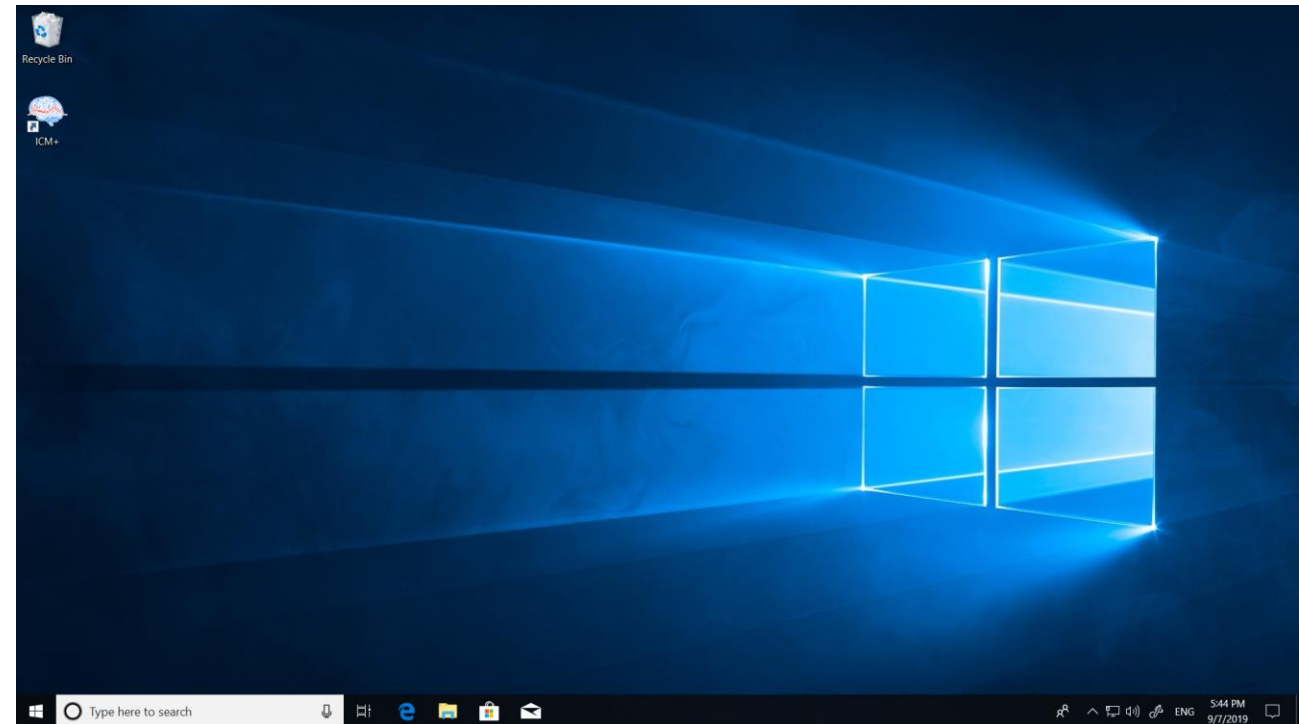
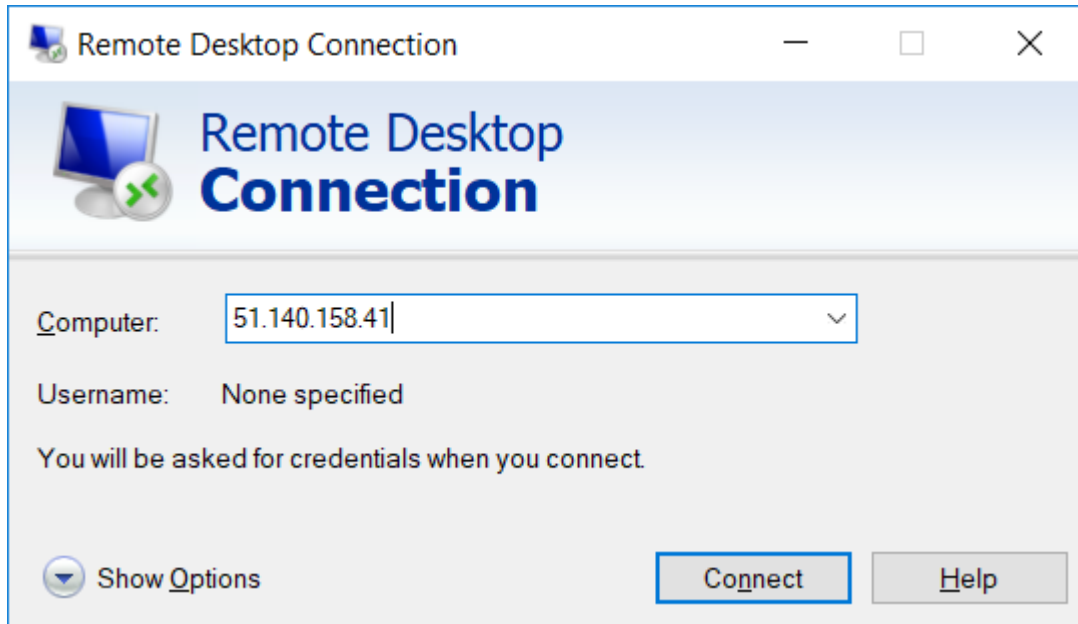
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```



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

