



UniversityHospital Heidelberg

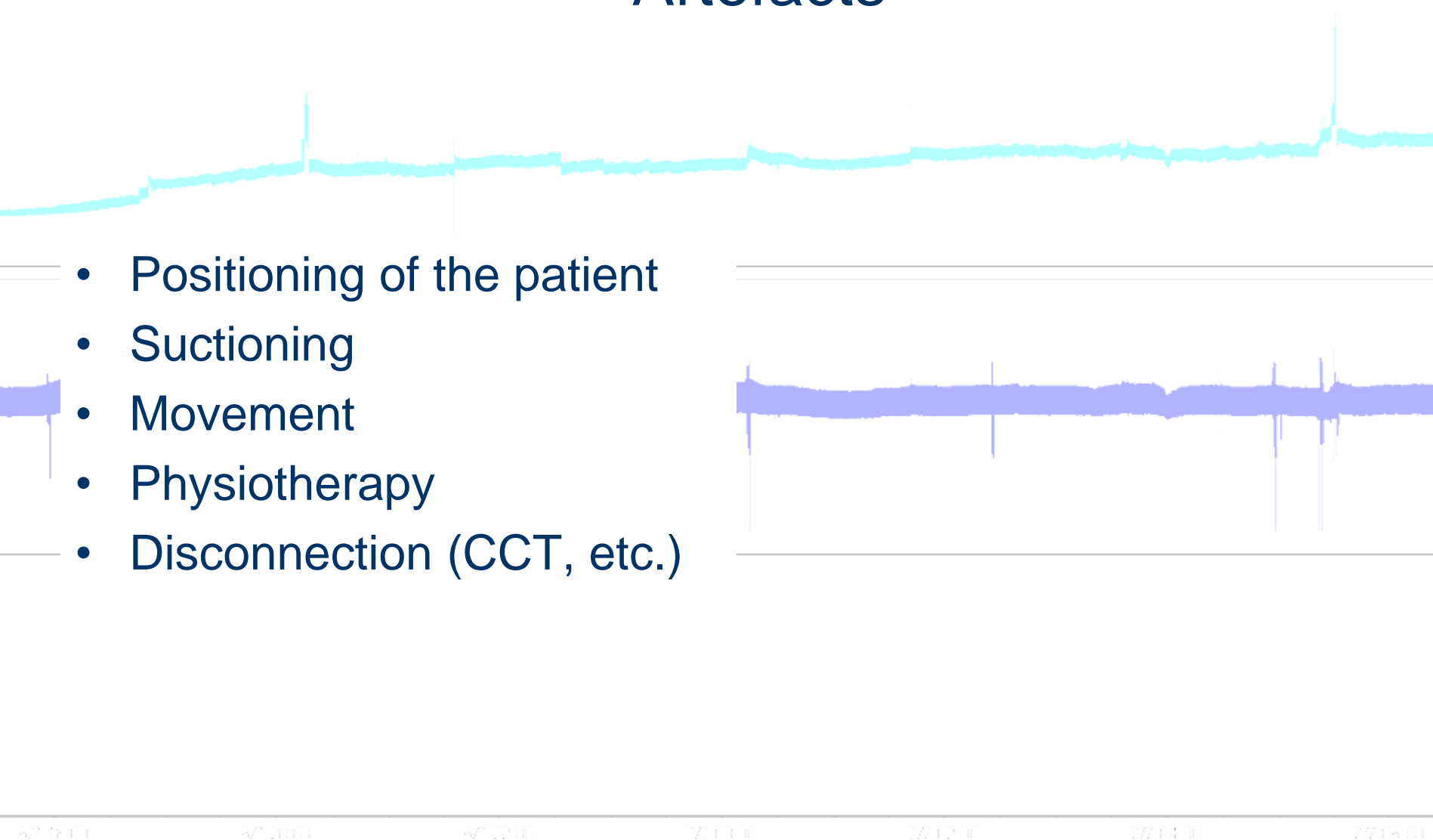
Dealing with Artefacts

Dr. Jennifer Diedler

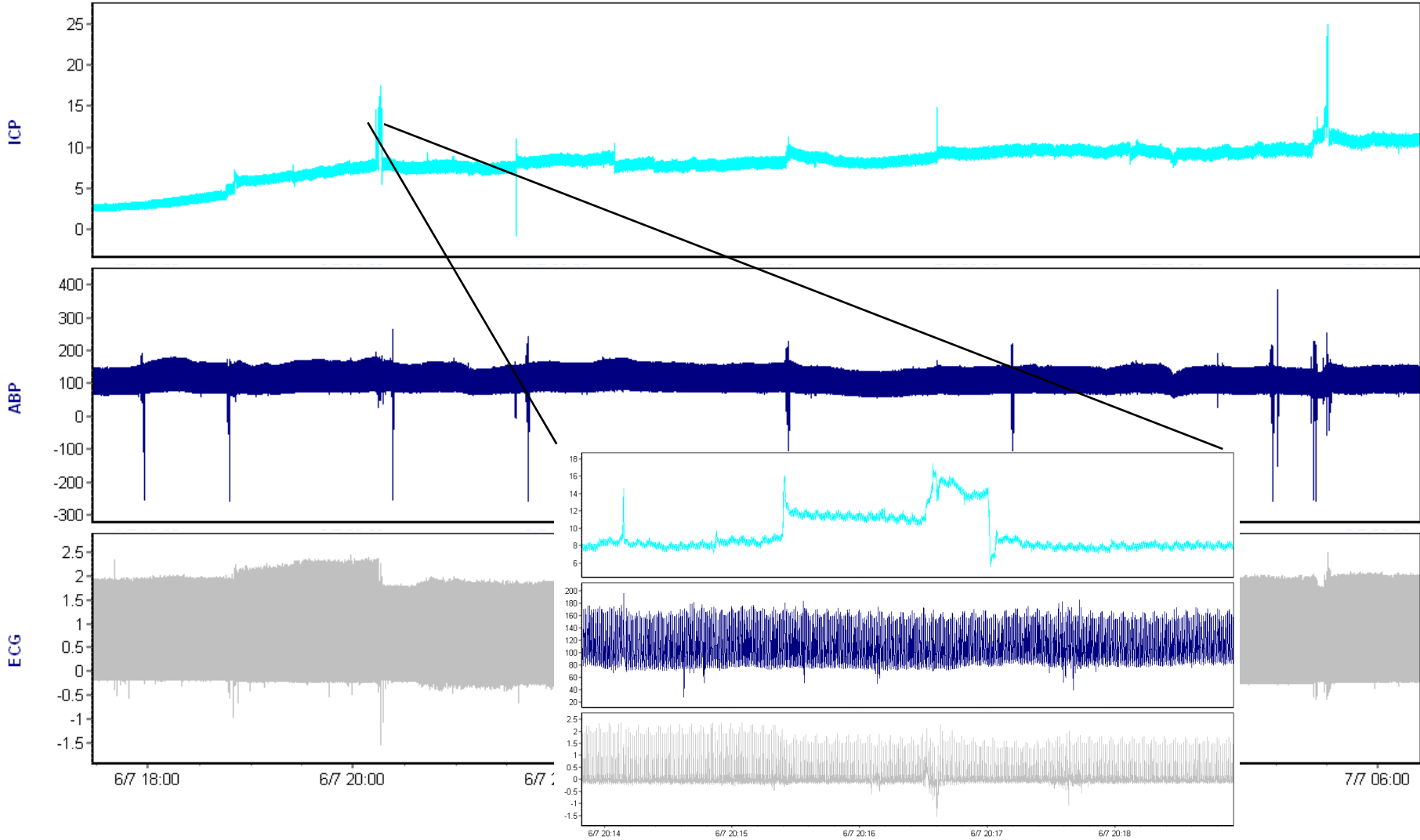
Department of Neurology, University of Heidelberg

Artefacts

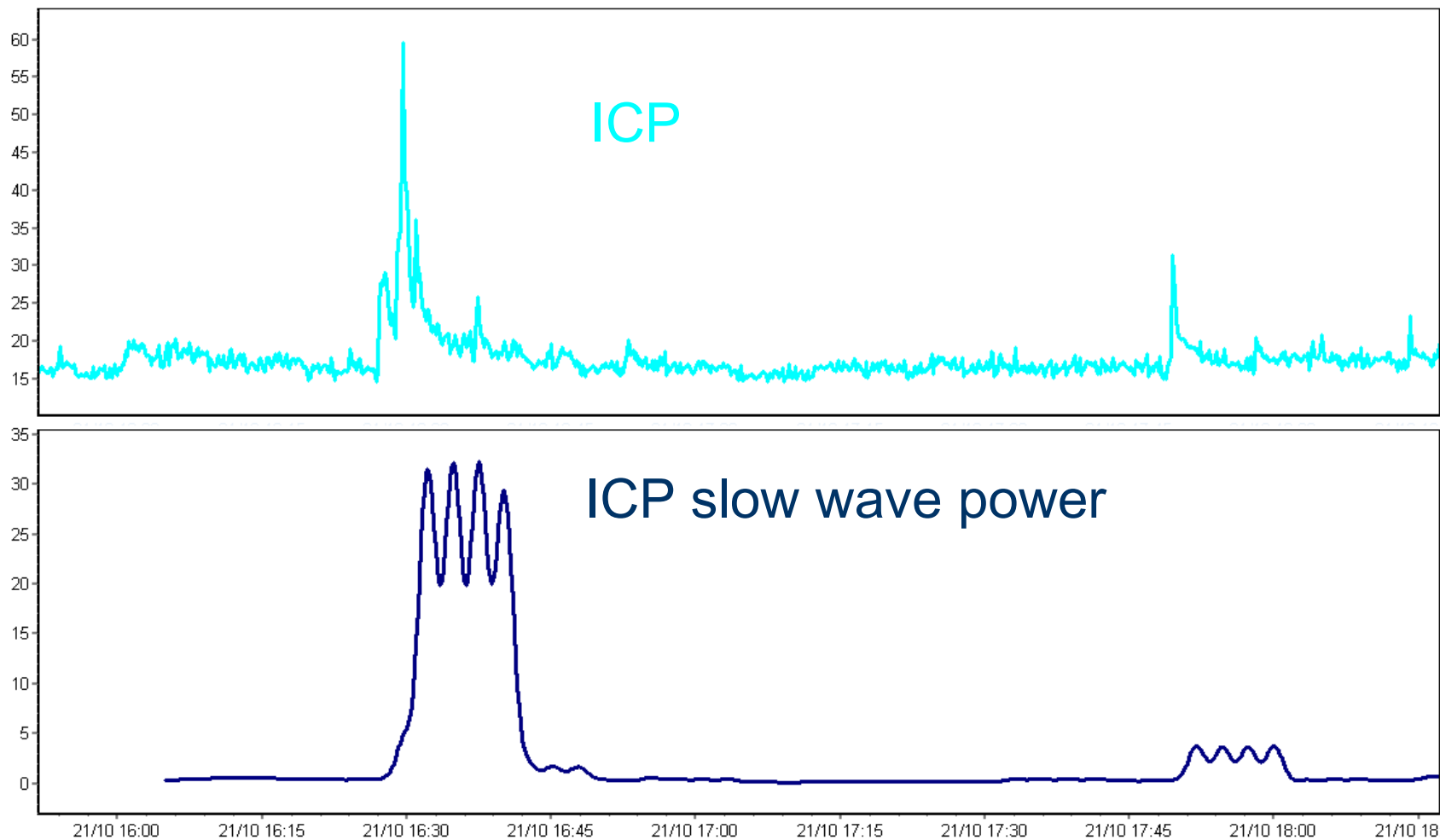
- Positioning of the patient
- Suctioning
- Movement
- Physiotherapy
- Disconnection (CCT, etc.)



Just let them in?



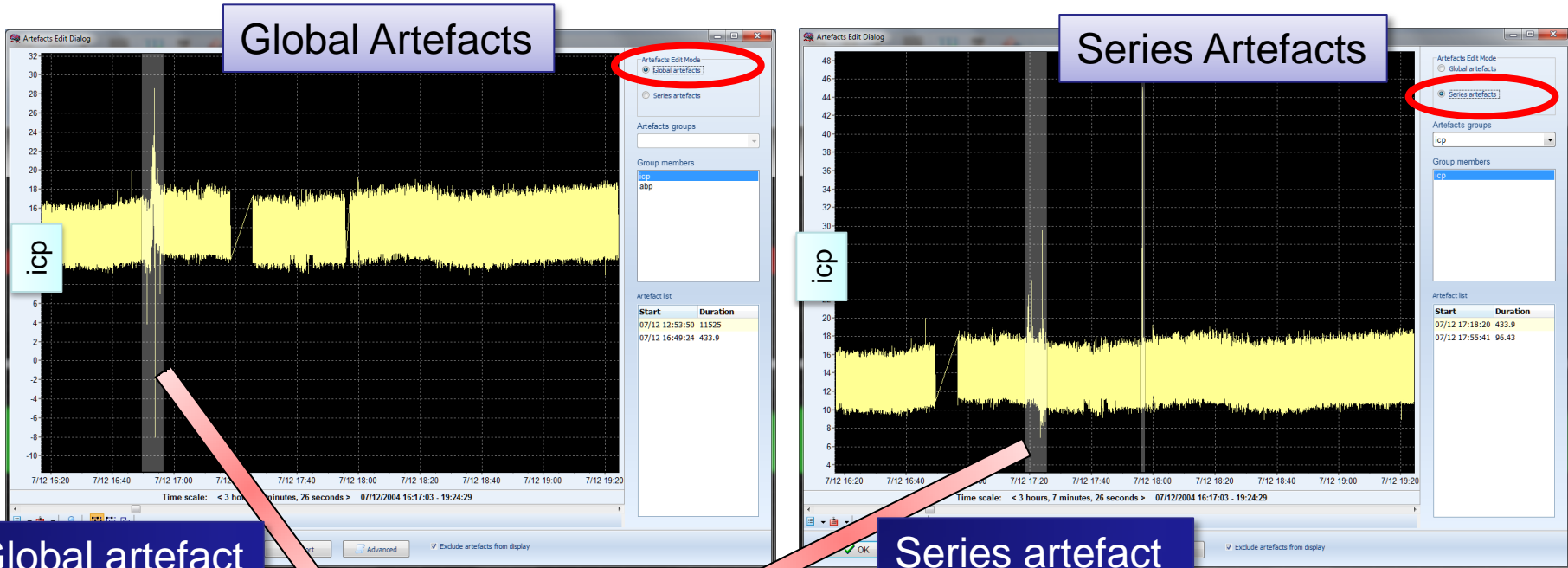
Calculation of ICP slow waves



Manual vs. automated removal

	Manual	Automated
Pro	<ul style="list-style-type: none">• Direct control	<ul style="list-style-type: none">• Saves data• Comfortable• More objective
Con	<ul style="list-style-type: none">• Loss of data• Time Consuming• Subjective	<ul style="list-style-type: none">• Distortion of signal

Artefact Editor



**Global artefact
=> Data gaps**

**Series artefact
=> NAN values**



Advanced Artefact Editor

The screenshot displays the 'Advanced Configuration Editing' window with the following XML code:

```
1 <?xml version = "1.0" ?>
2
3 <ICMArtefacts>
4   <Global>
5     <Artefact ModifiedBy = "Administrator" ModifiedDate = "06/09/2010 19:03:08" StartTime = "21/10/2008 21:16:38.083" EndTime = "21/10/2008 21:50:27.207" />
6   </Global>
7   <SignalGroup Name = "icp">
8     <Artefact ModifiedBy = "Administrator" ModifiedDate = "06/09/2010 19:04:15" StartTime = "21/10/2008 22:11:26.390" EndTime = "21/10/2008 22:45:23.033" />
9   </SignalGroup>
10 </ICMArtefacts>
```

Below the XML editor is the 'Artefacts Edit Dialog' window, which features a waveform plot. The plot shows a signal labeled 'icp [mm]' on the y-axis (ranging from 8 to 52) against time on the x-axis (ranging from 21/10 20:45 to 21/10 23:00). The signal is represented by a yellow-filled area with a black outline, showing a noisy pattern. Two red arrows point from the XML code to the plot: one from the first artefact's 'EndTime' to a shaded region on the plot, and another from the second artefact's 'StartTime' to a specific peak in the signal.

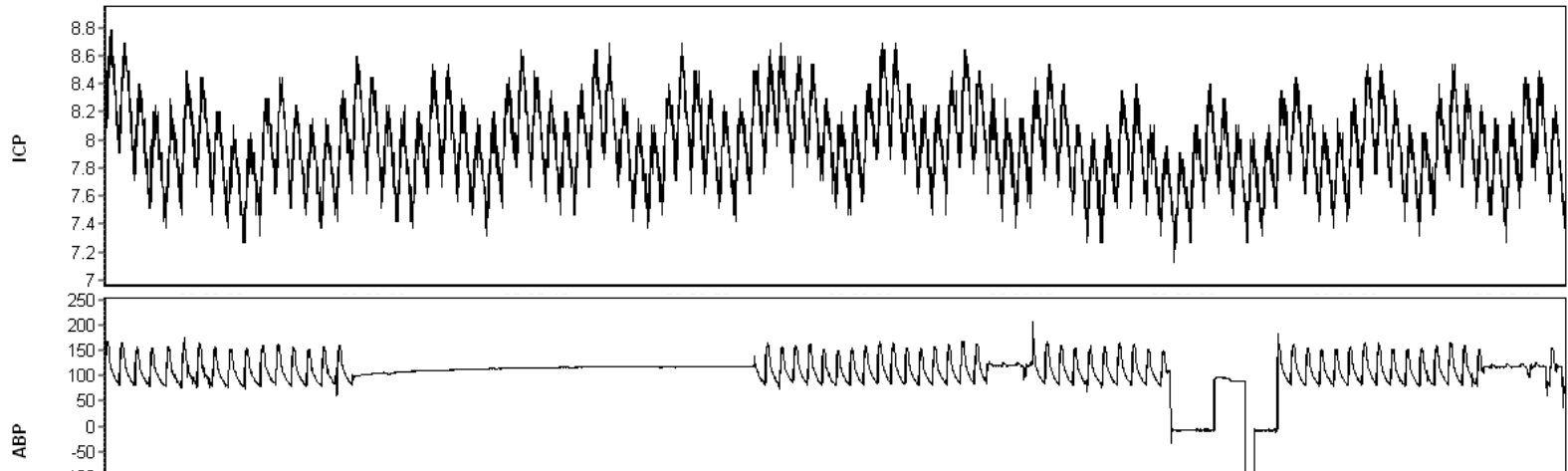
The 'Artefacts Edit Dialog' includes the following controls:

- Artefacts Edit Mode: Global artefacts, Series artefacts
- Artefacts groups: icp
- Group members: icp
- Artefact list table:

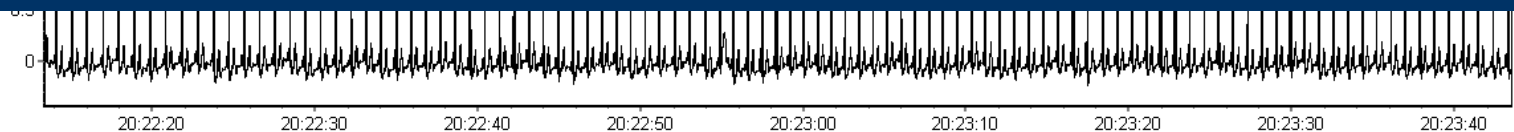
Start	Duration
21/10 22:11:26	2037

At the bottom of the dialog, there are buttons for 'OK', 'Cancel', 'Export', 'Import', and 'Advanced', along with a checkbox for 'Exclude artefacts from display'.

Artefact extraction algorithm I



Artefact characteristics: loss of pulsatility

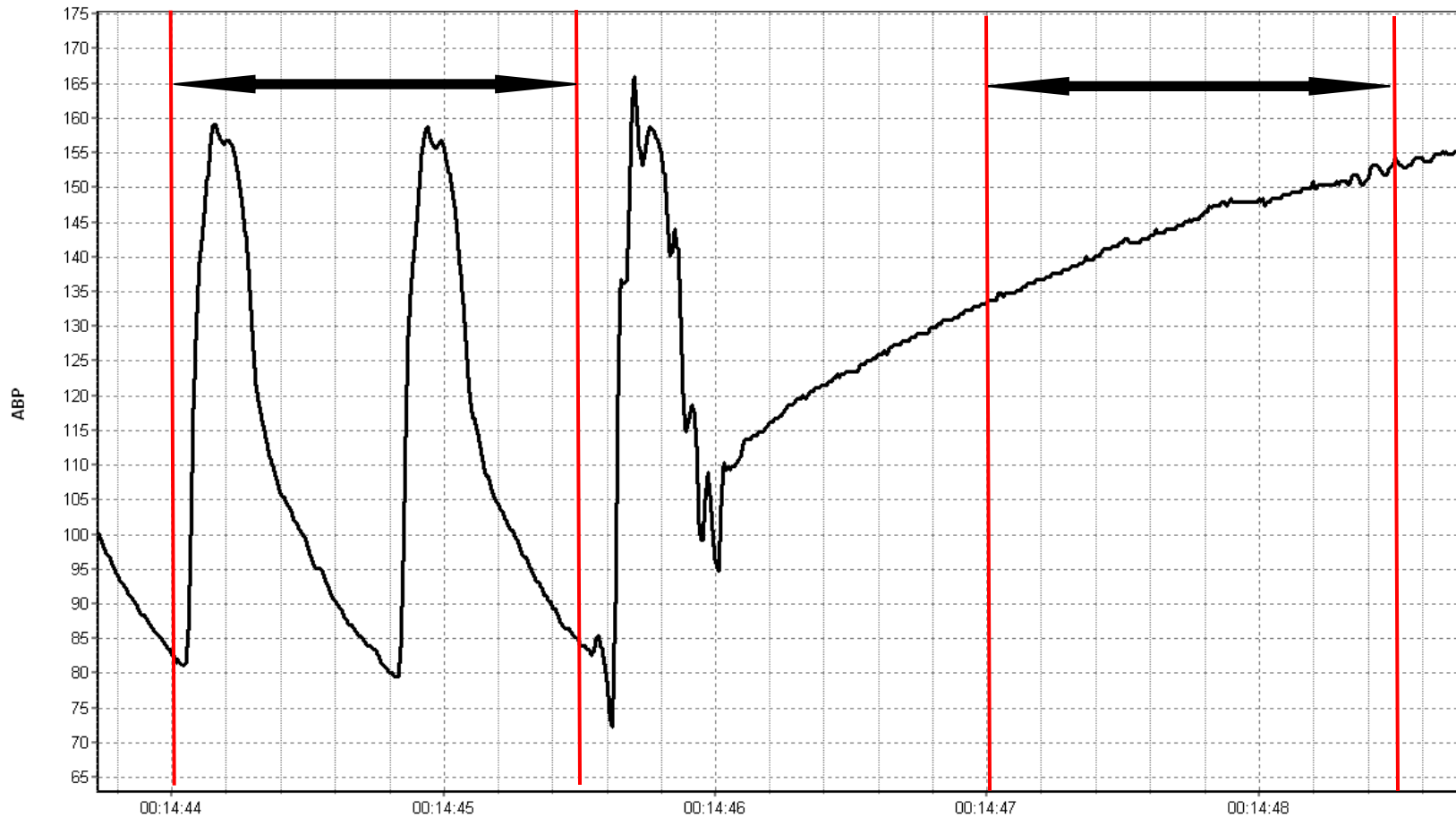


Basic Features

- (1) Define thresholds
- (2) Use „isNANfree“



$$ABP_{pp} = \text{Max (ABP)} - \text{Min (ABP)}$$

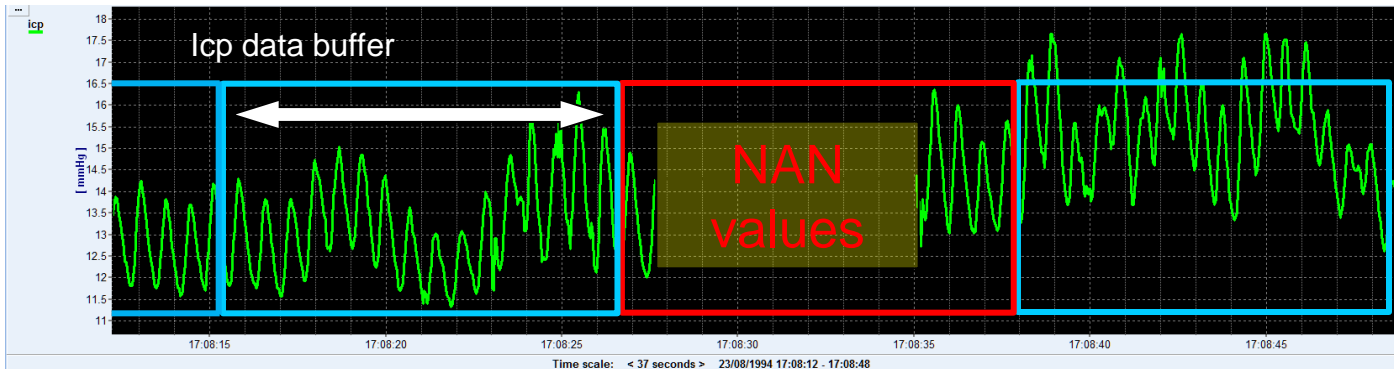


$ABP_{pp} = 160 - 80$
 $= 80$
 \Rightarrow Within threshold

$ABP_{pp} = 153 - 134$
 $= 19$
 \Rightarrow Below threshold
 \Rightarrow NAN

„isNANfree“

The function returns **1** if its input data buffer does not contain *any* invalid (NAN) values or it returns **NAN** otherwise.



isNANfree(icp) =

1

NAN

1

- Primary Analysis:
 - **ABPpp = Max (ABP) – Min (ABP)**
 - Calculation period: 1.5 sec (= 75 samples @ 50 Hz sf)
 - Update 1 sec
 - Define valid values thresholds: Max ABPpp = 90, Min ABPpp = 15
- Secondary Analysis 1:
 - **ABPpp = Mean (ABPpp) * IsNANFree (ABPpp)**
 - Calculation period: 10 sec, Update 10 sec
- Secondary Analysis 2:
 - **ABP = Mean (ABP) * IsNANFree (ABPpp)**
 - Calculation period: 10 sec, Update 10 sec
- Final Analysis:
 - **ABP = Mean (ABP)**
 - Calculation period: 10 sec, Update 10 sec

Example of „isNANfree“ function in action

Invalid value

(value outside of valid range replaced by NAN)

PA: $ABP_{pp} = \text{Max}(ABP) - \text{Min}(ABP)$

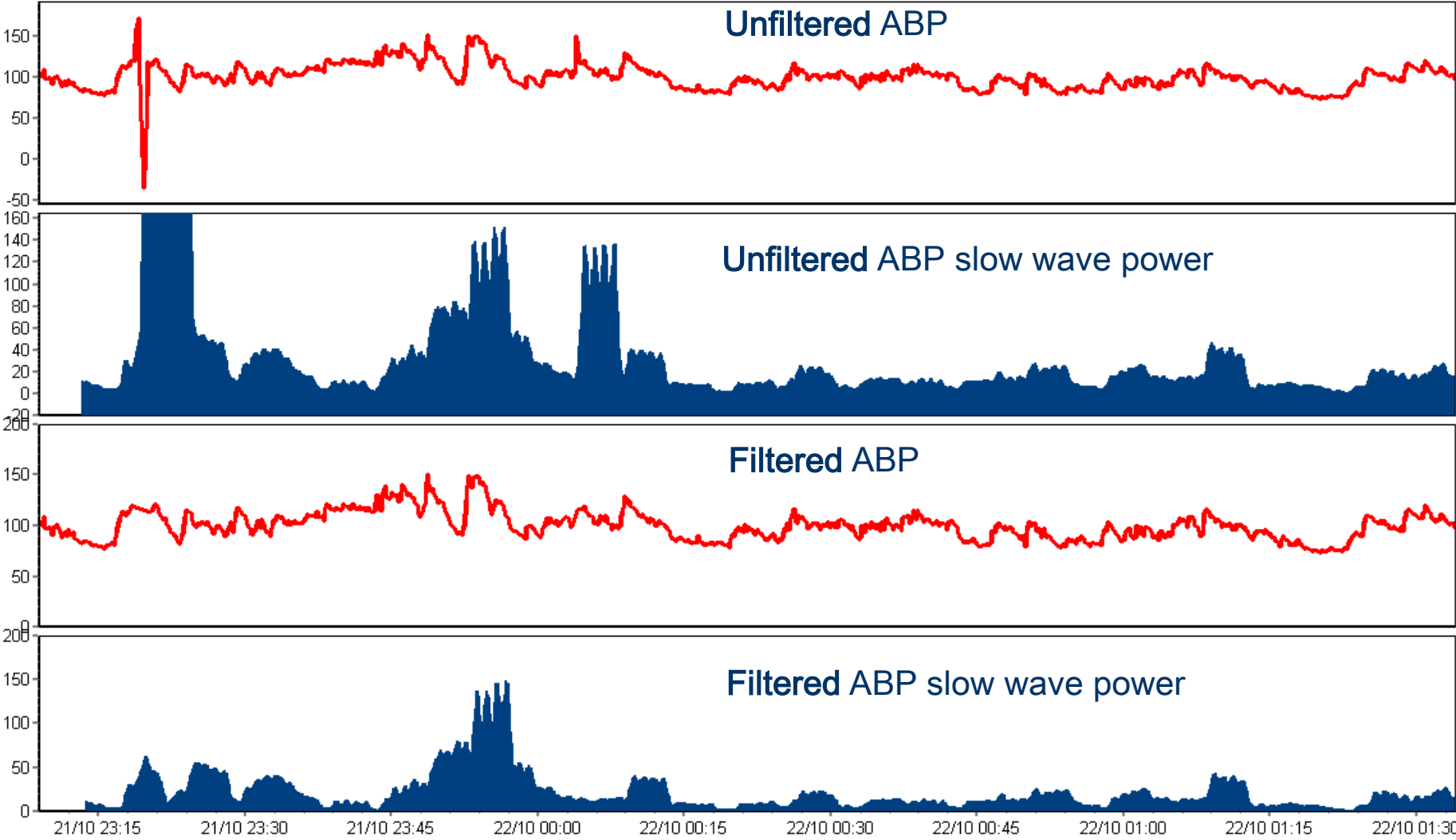
ABP_{pp} = 75 68 42 90 56 72 78 53 49 88 90 67 89 90 92 67 **NAN** 93 55 78 89 89 91 97 90, etc.

SA : $ABP = \text{Mean}(ABP) * \text{isNANfree}(ABP_{pp})$

ABP = 145*1 = 145 156*NAN = NAN 151*1 = 151, etc

FA: $ABP = \text{Mean}(ABP)$

ABP = (145 + 151)/2 = 150



Pitfalls

Primary Analysis Configuration Editor

Name : ABPpp

Enabled

Calculation Window Specification

Calculation Period : 1.5 s

Update Period : 1 s

Valid values range

Max Value : 90

Min Value : 15

Formula

Max(ABP) - Min(ABP)

Function Arguments :

ABP
ICP

Function :

- abs
- Coherence
- Correl
- CSPower
- Diast
- Filter
- FundAmp
- FundFrq
- Gain
- HFC
- HR

Function description:

Adviser

You have specified a valid range (Min/Max fields) for the result of the parameter calculation but the Artefact Treatment is set to 'disabled' in the **Options** (analysis section). **This means that the valid range settings will be ignored!**

Would you like to switch on the Artefact Treatment now?

Yes No Do not show this again

OK Cancel

If this setting is set as 'Disabled' the Min/Max ranges will be ignored and so the artefact detection formulas will not work!



Options [X]

General | Display | **Analysis** | Raw Data Rec | System

Default sampling frequency [Hz]: 50.0

Default data analysis period [sec]: 10.0

Ignore Manual Artefacts Descriptor Files

Automatic artefacts treatment

Disabled - the Min/Max analysis attributes will be ignored

Remove individual invalid (NaN) values

Treat the whole period containing NaN values as invalid

Data gaps treatment

Always reset calculation engine

Reset only if the data gap exceeds the analysis period

Reset only if the data gap exceeds specified length

Never reset the calculation engine

Maximum data gap tolerance period [sec] 0

Allow incomplete data buffer

Missing signals treatment

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

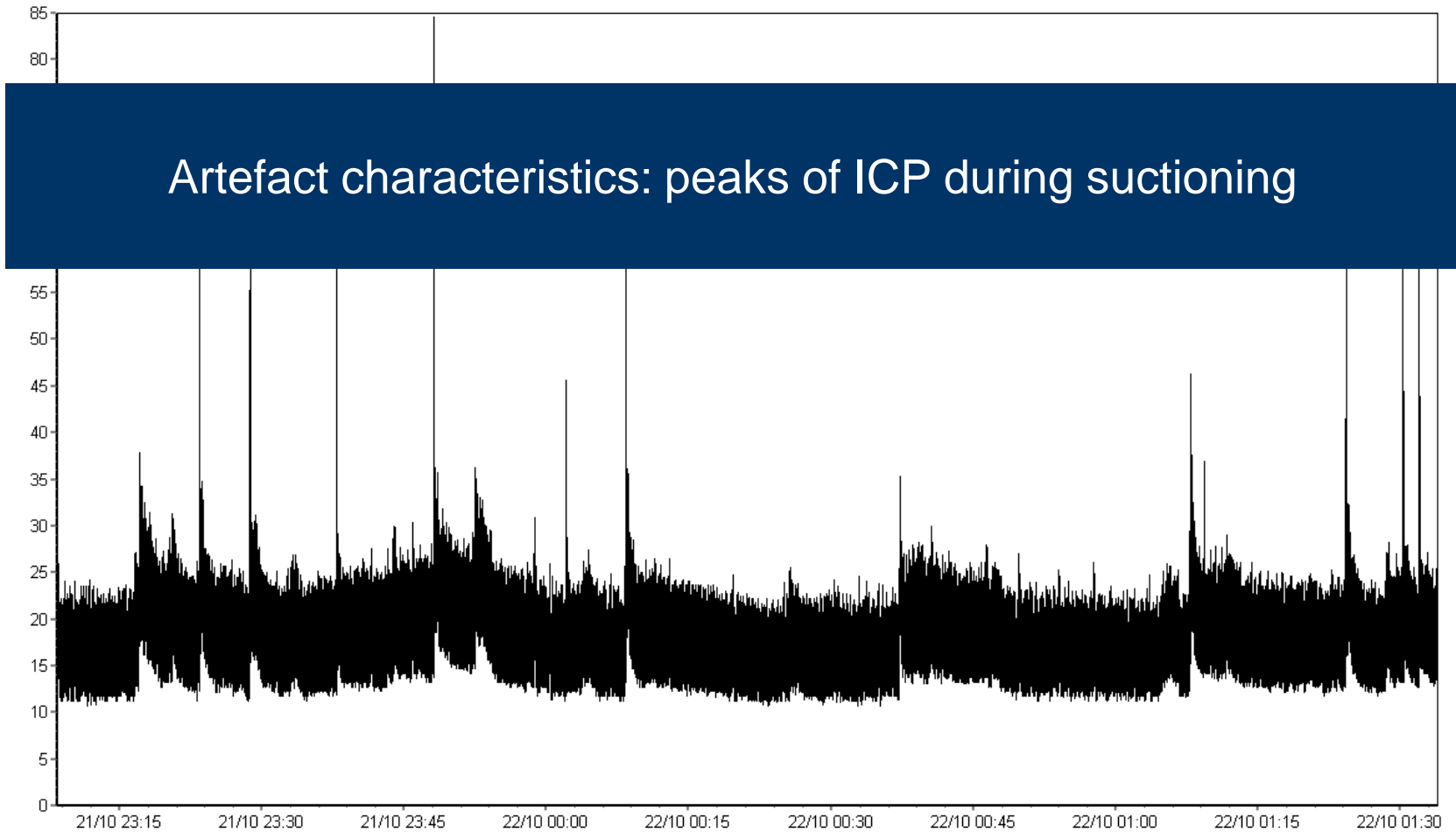
+ Add

Delete

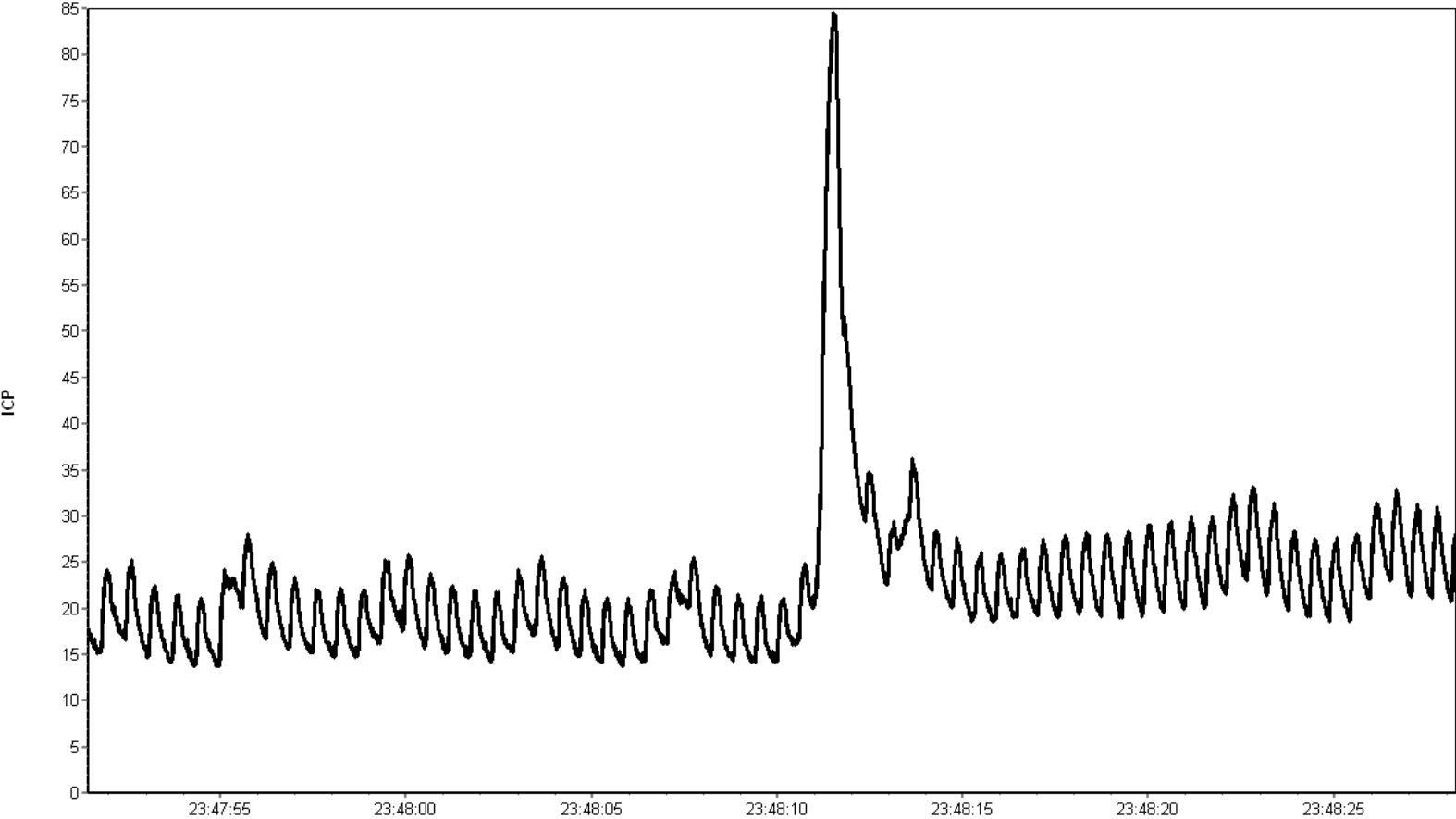
Allow incomplete input signal list

OK Cancel

Artefact extraction algorithm II

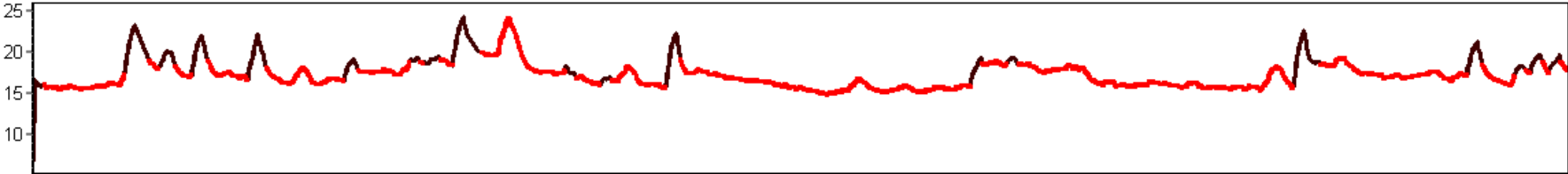


Close up

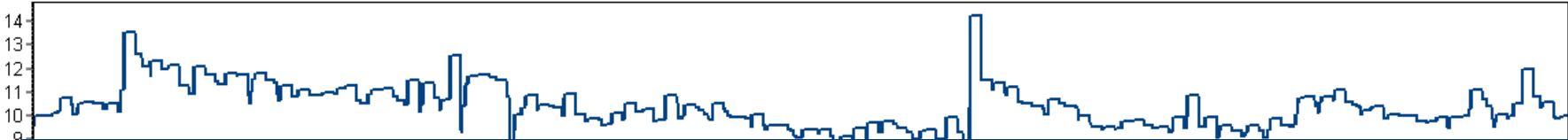


- Virtual Signals:
 - **dICP** = differentiate(movingaveragefilter(icp,200))
 - **ICP** = delayfilter(icp,100)
- Primary Analysis:
 - **dICPmax** = Max(dICP), valid value range: 0 to 15
 - **dICPmin** = Min(dICP), valid value range: -12 to 0
 - **dICPpp** = Max(dICP) – Min(dICP), valid value range: 0 to 25
 - **ICP** = Mean(ICP)
 - Calculation period: 5 sec, Update: 1 sec
- Final Analysis:
 - **ICP_filt** =
Mean(ICP) * IsNANFree(dICPmax) * IsNANFree(dICPmin) * IsNANFree(dICPpp)

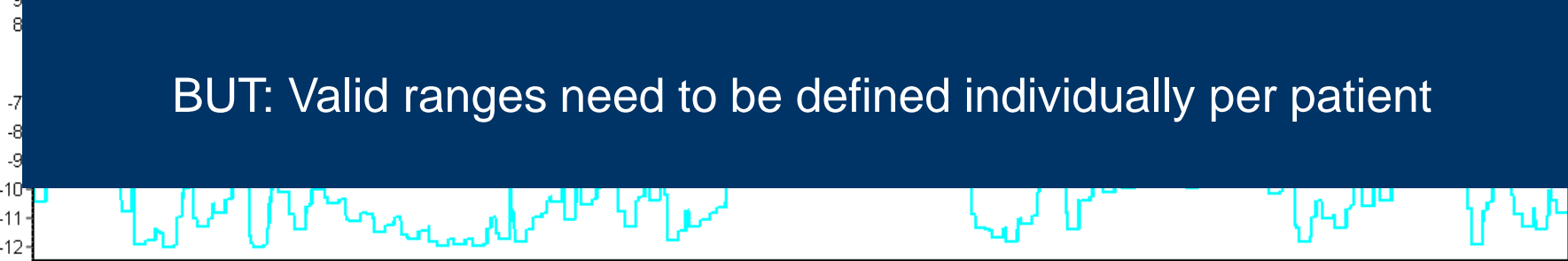
Unfiltered ICP vs. Filtered ICP



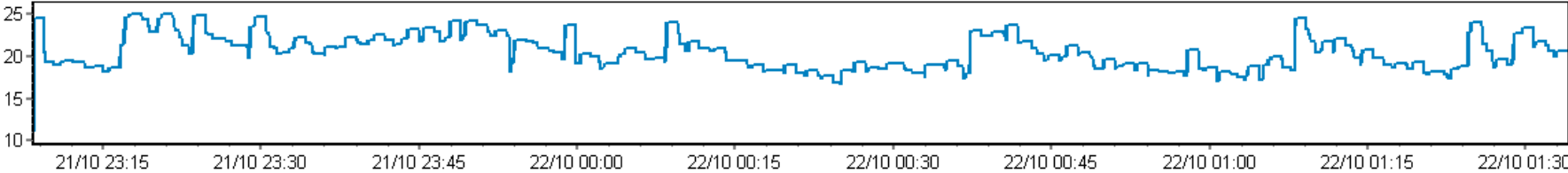
— dicpmax



BUT: Valid ranges need to be defined individually per patient



— dicppp



... and more

- Median function for removal of spikes
- Time series forecast models
- More advanced pulse detection and rejection algorithms
- ...