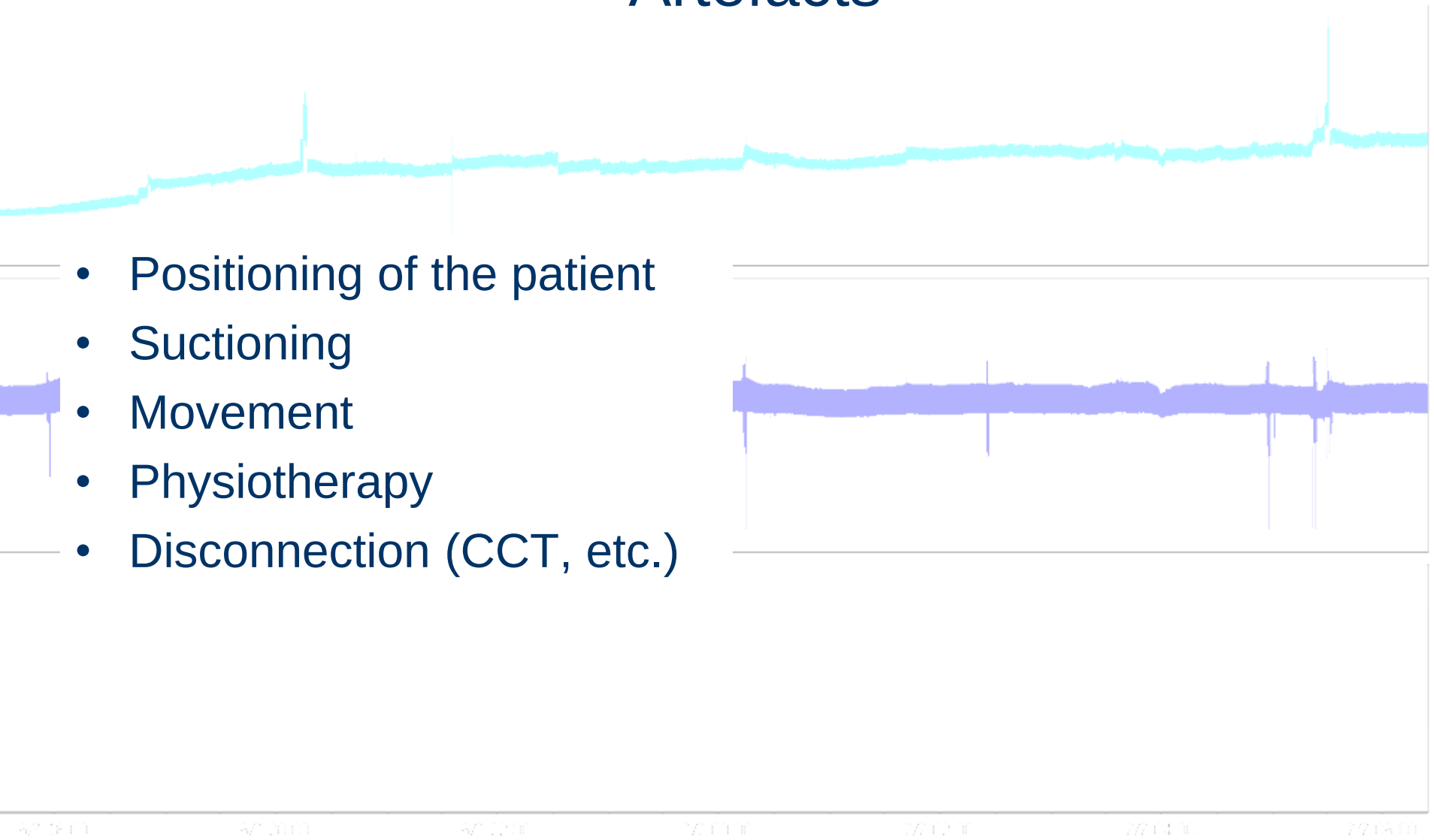
UniversityHospital Heidelberg

Dealing with Artefacts

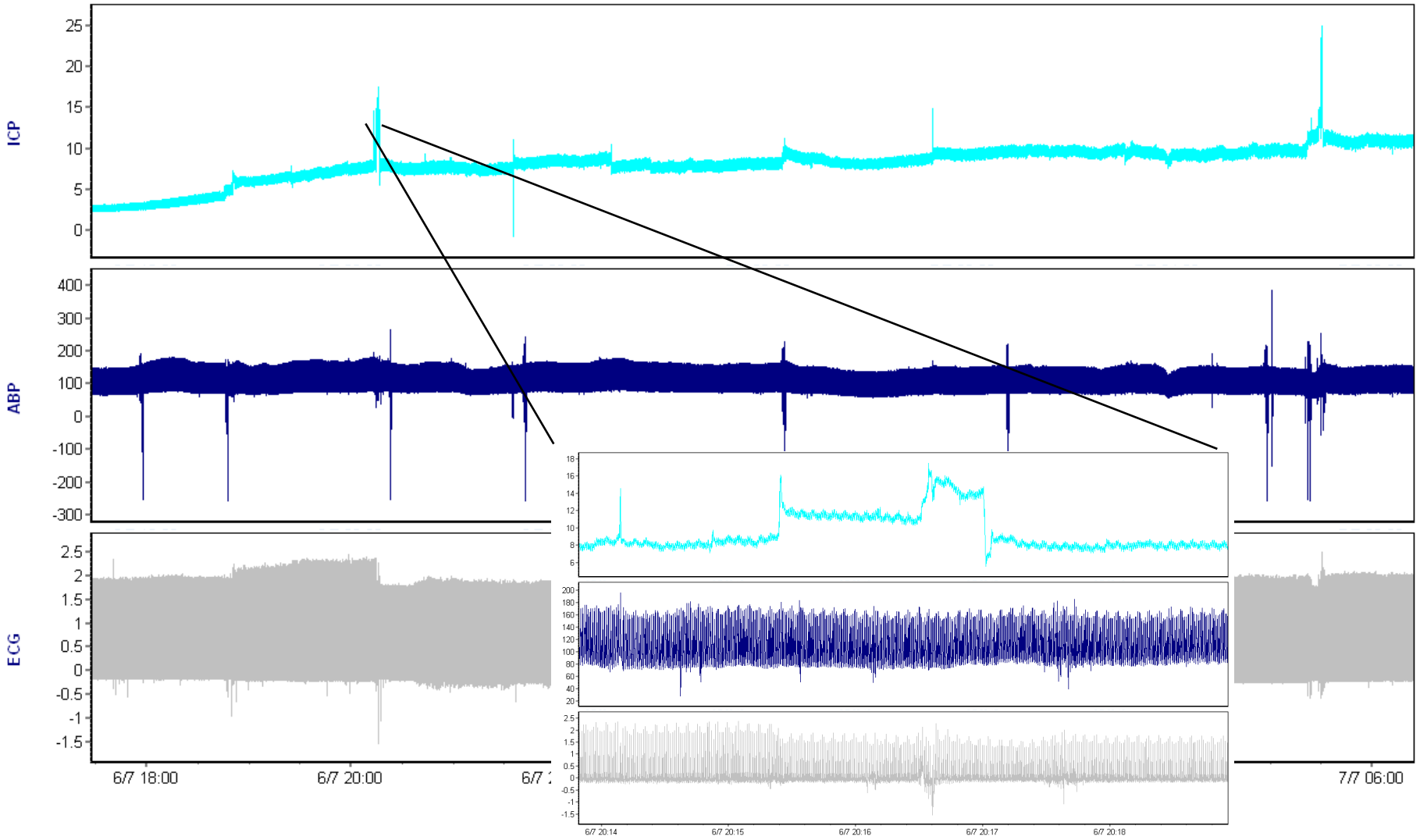
Dr. Jennifer Diedler
Department of Neurology, University of Heidelberg

Artefacts

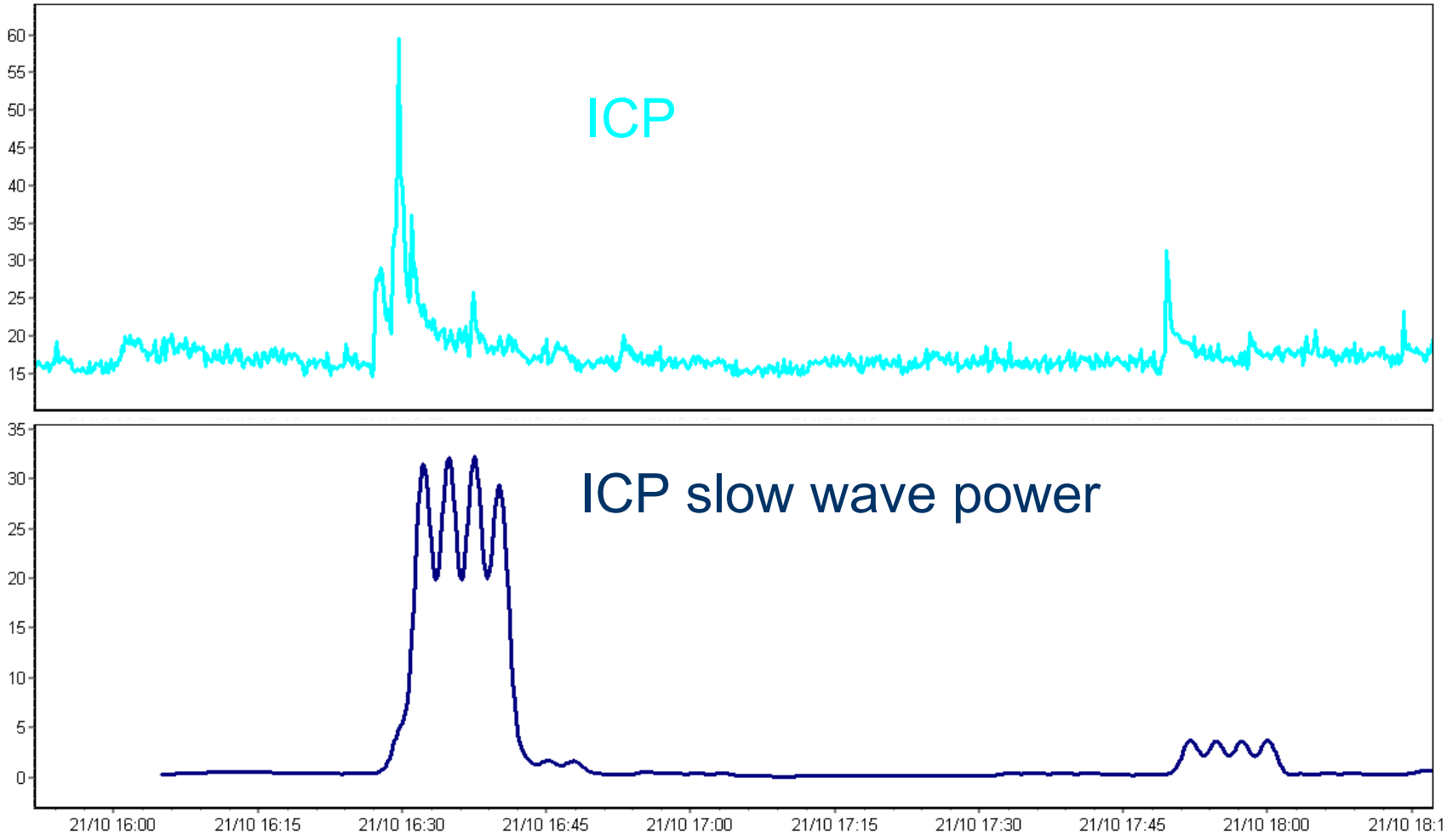


- Positioning of the patient
- Suctioning
- Movement
- Physiotherapy
- Disconnection (CCT, etc.)

Just let them in?



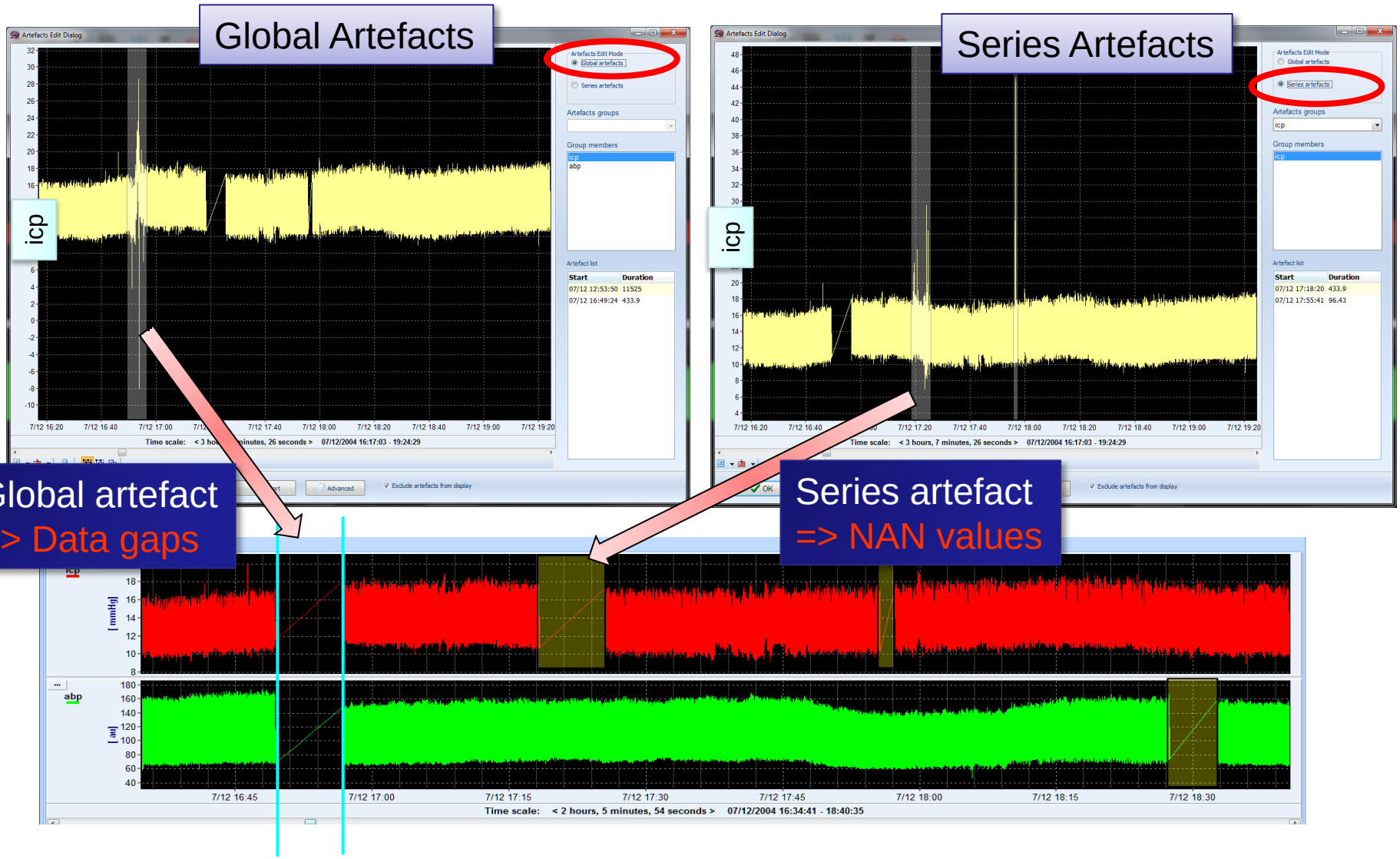
Calculation of ICP slow waves



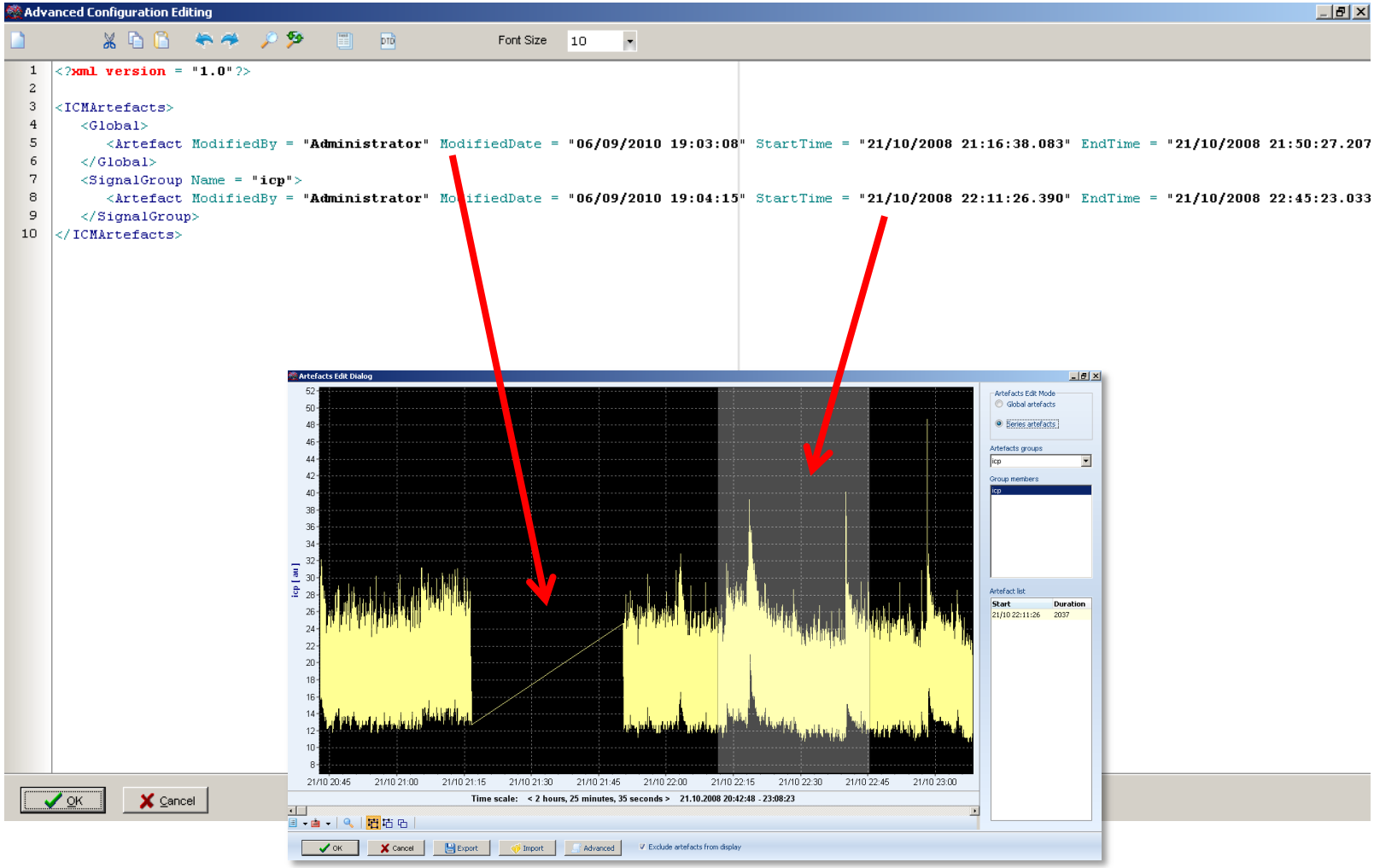
Manual vs. automated removal

	Manual	Automated
Pro	• Direct control	• Saves data • Comfortable • More objective
Con	• Loss of data • Time Consuming • Subjective	• Distortion of signal

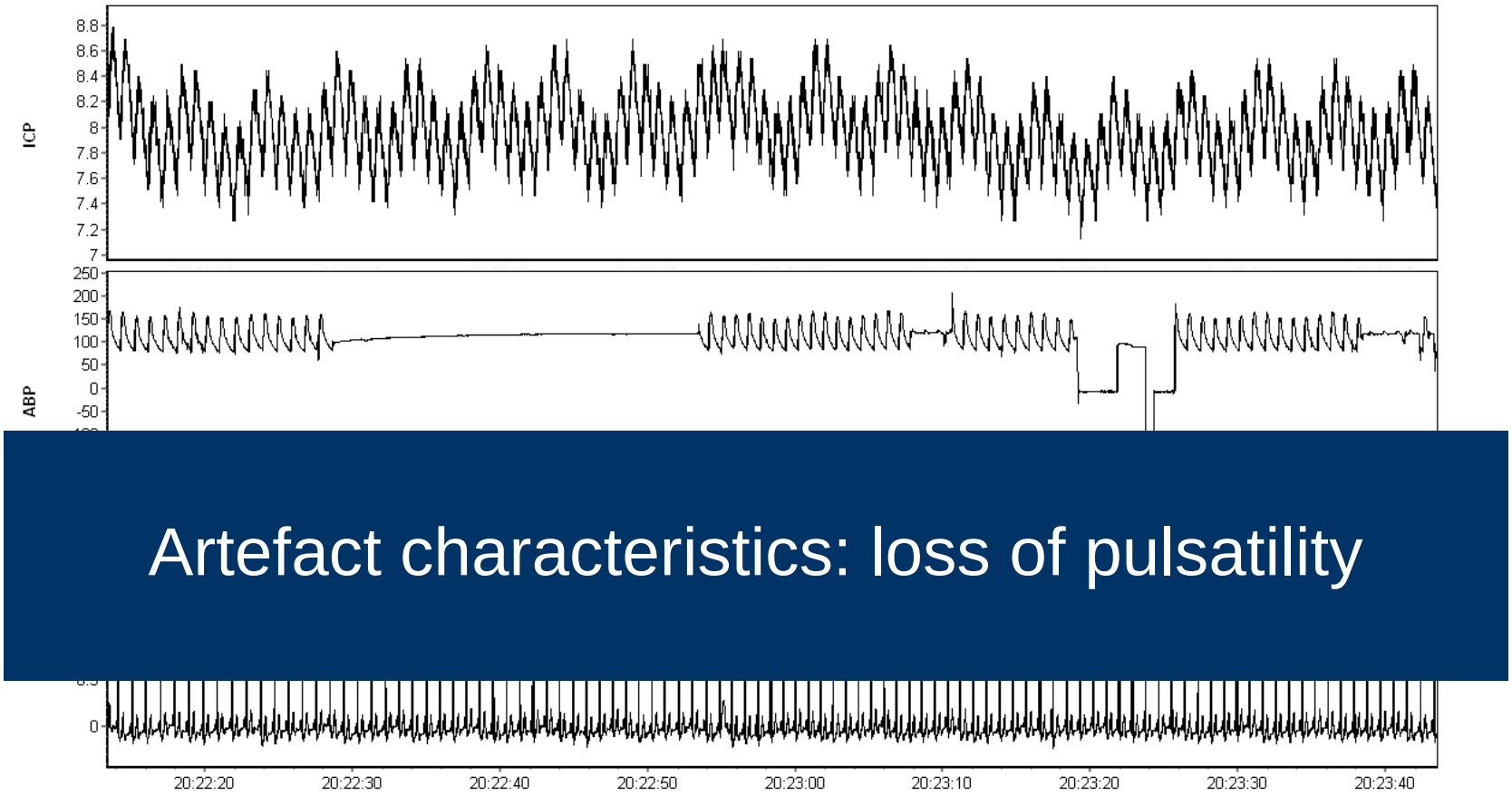
Artefact Editor



Advanced Artefact Editor



Artefact extraction algorithm I



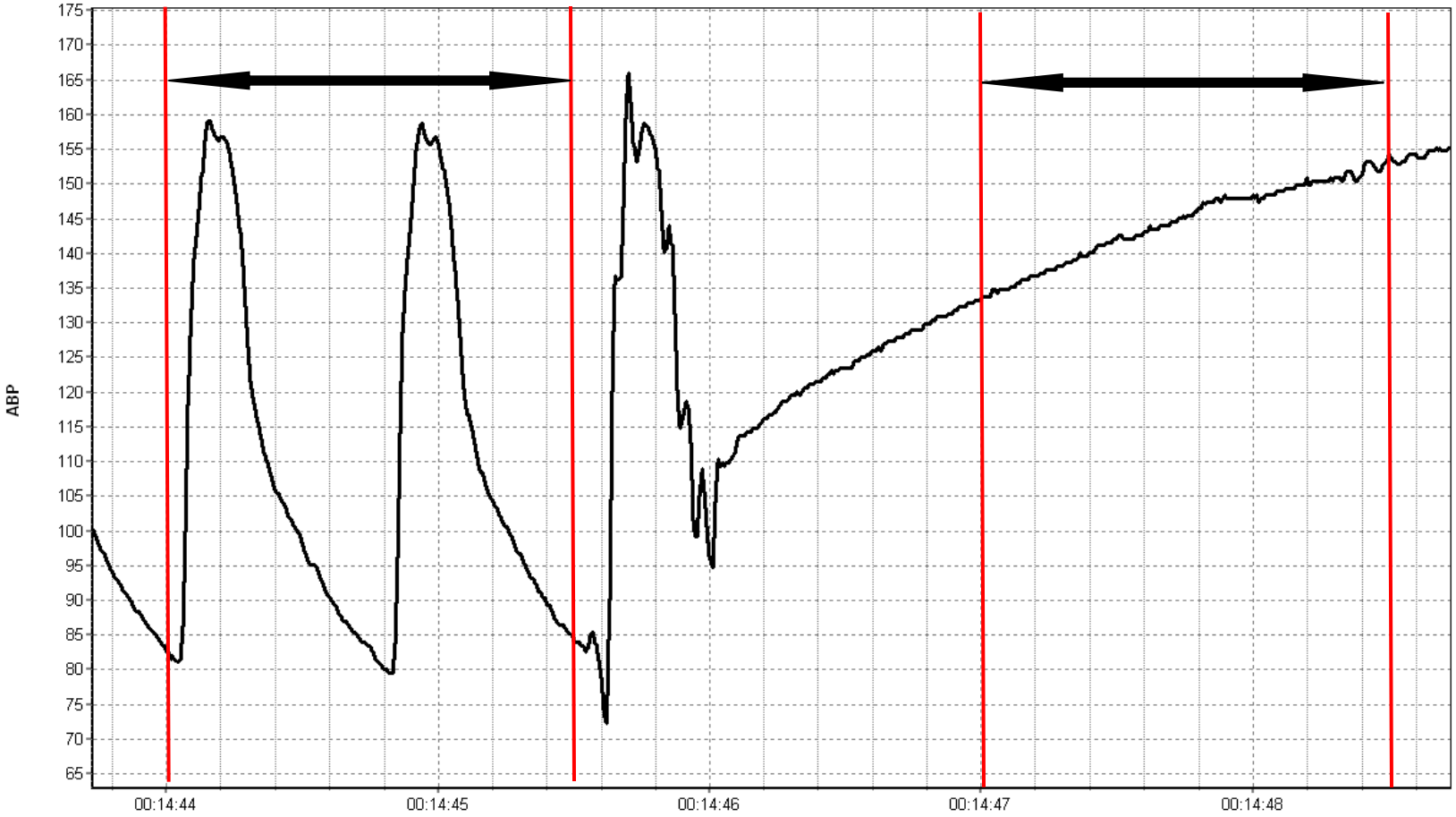
Artefact characteristics: loss of pulsatility

Basic Features

(1) Define thresholds

(2) Use „isNANfree“

ABPpp= Max (ABP) - Min (ABP)

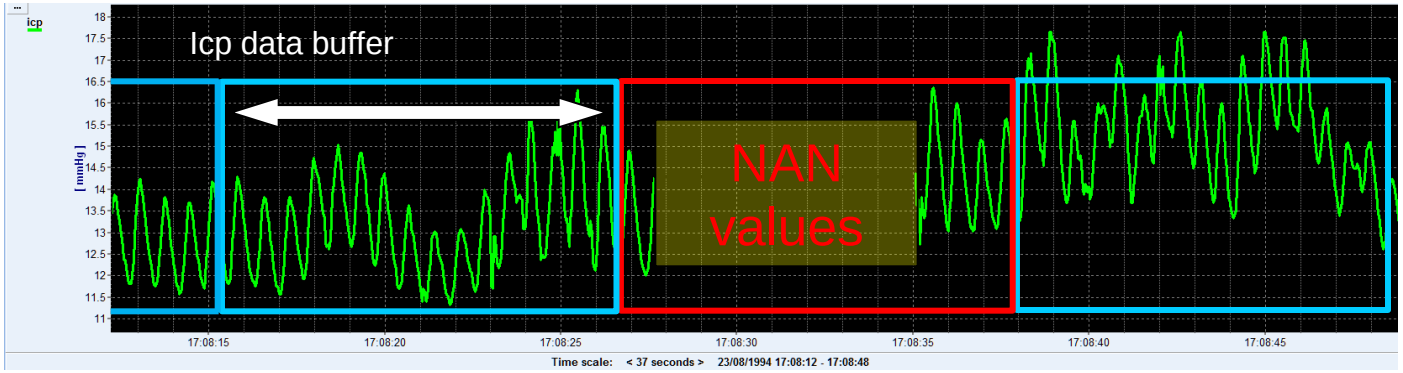


ABPpp =160-80
= 80
⇒ Within threshold

ABPpp = 153-134
= 19
⇒ Below threshold
⇒ 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: ABPpp = Max(ABP) – Min(ABP)

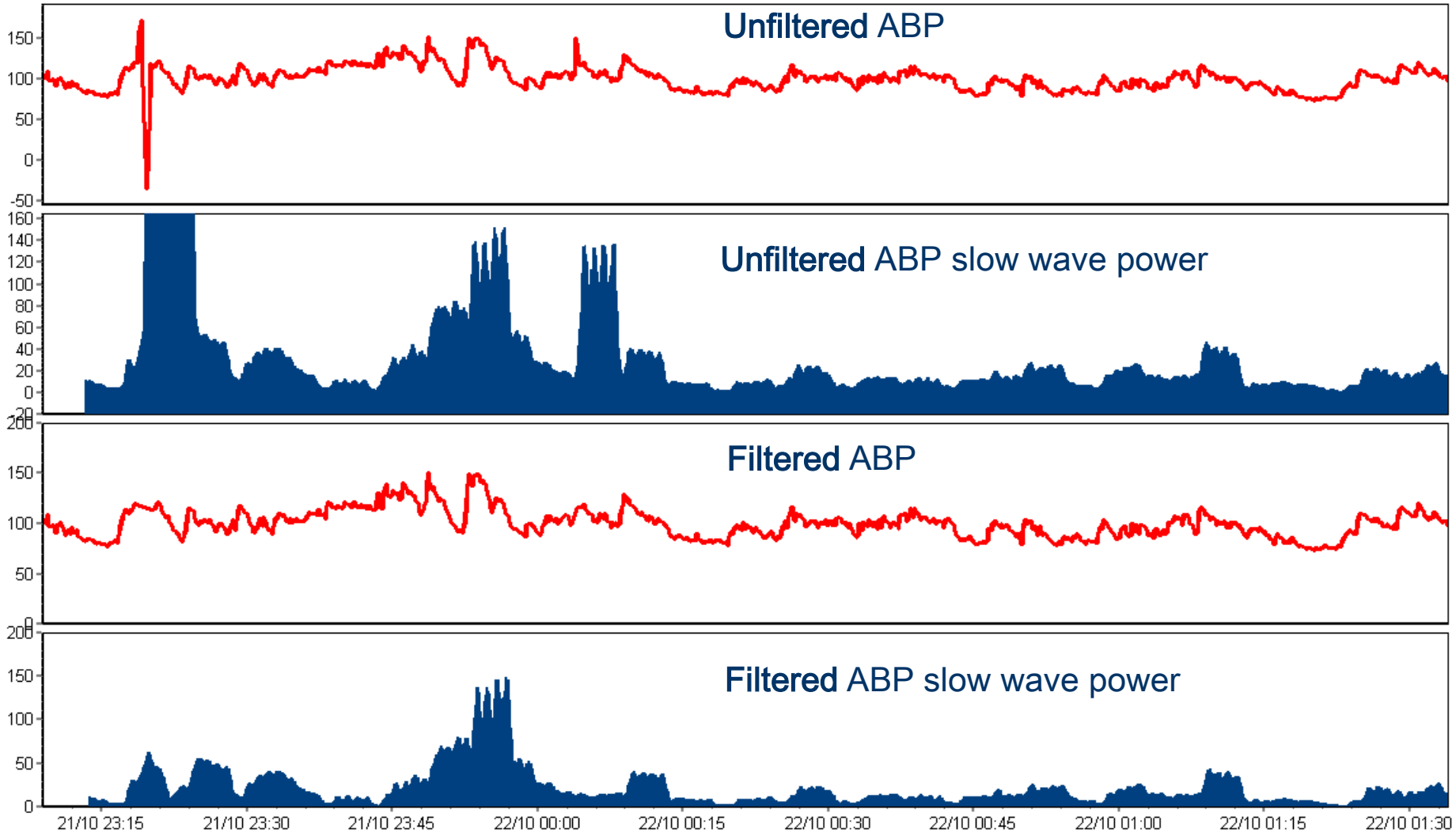
ABPpp = 75 68 42 90 56 72 78 53 49 88 90 67 89 90 92 67 NAN 93 55 78 89 89 91 97 90, etc.

SA : ABP = Mean(ABP)*isNANfree(ABPpp)

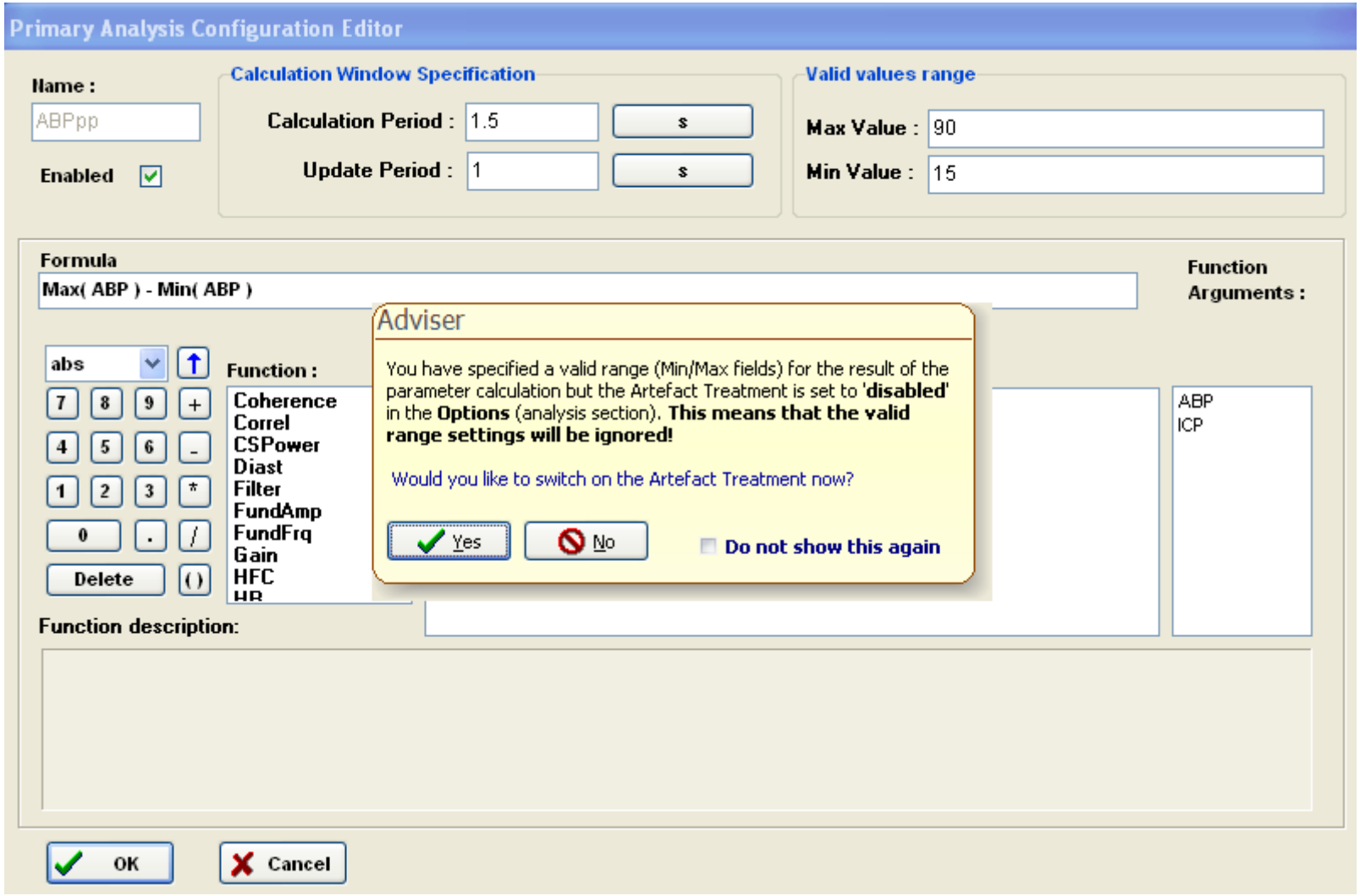
ABP = 145*1 = 145 156*NAN = NAN 151*1 = 151, etc

FA: ABP = Mean(ABP)

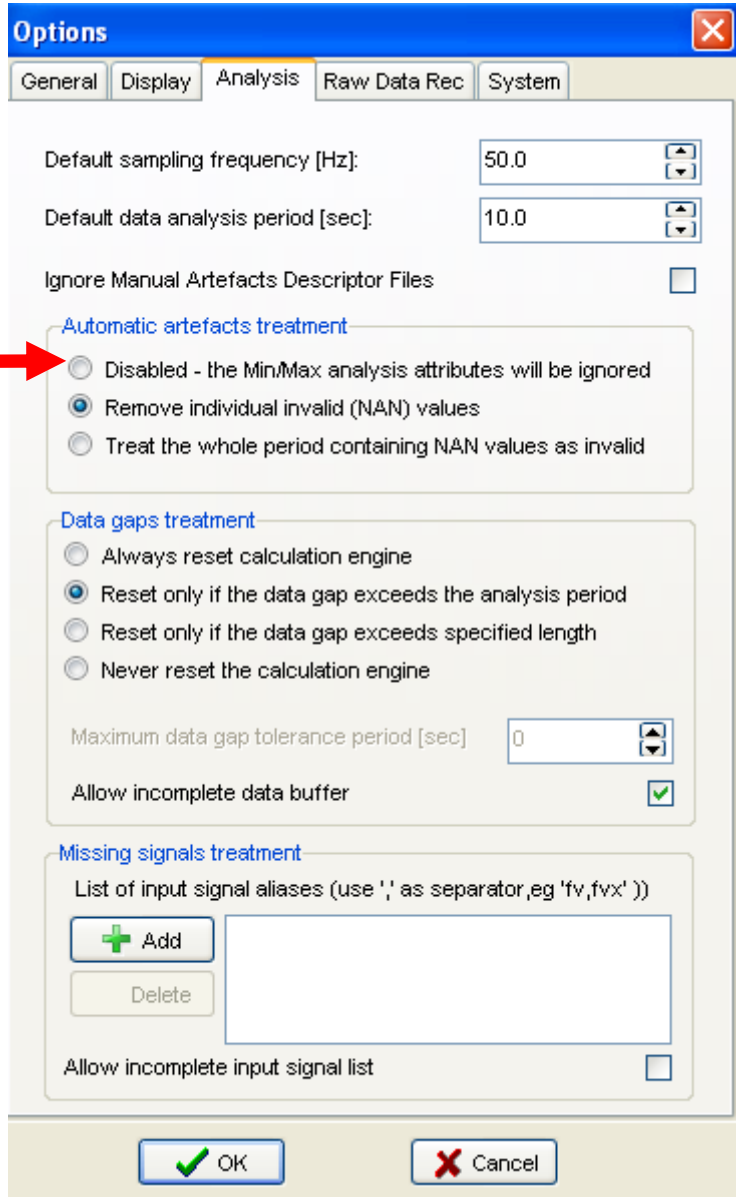
ABP = (145 + 151)/2 = 150


Unfiltered ABP
150
100
50
0
-50
Unfiltered ABP slow wave power
160
140
120
100
80
60
40
20
0
-20
Filtered ABP
200
150
100
50
0
Filtered ABP slow wave power
200
150
100
50
0
21/10 23:15
21/10 23:30
21/10 23:45
22/10 00:00
22/10 00:15
22/10 00:30
22/10 00:45
22/10 01:00
22/10 01:15
22/10 01:30

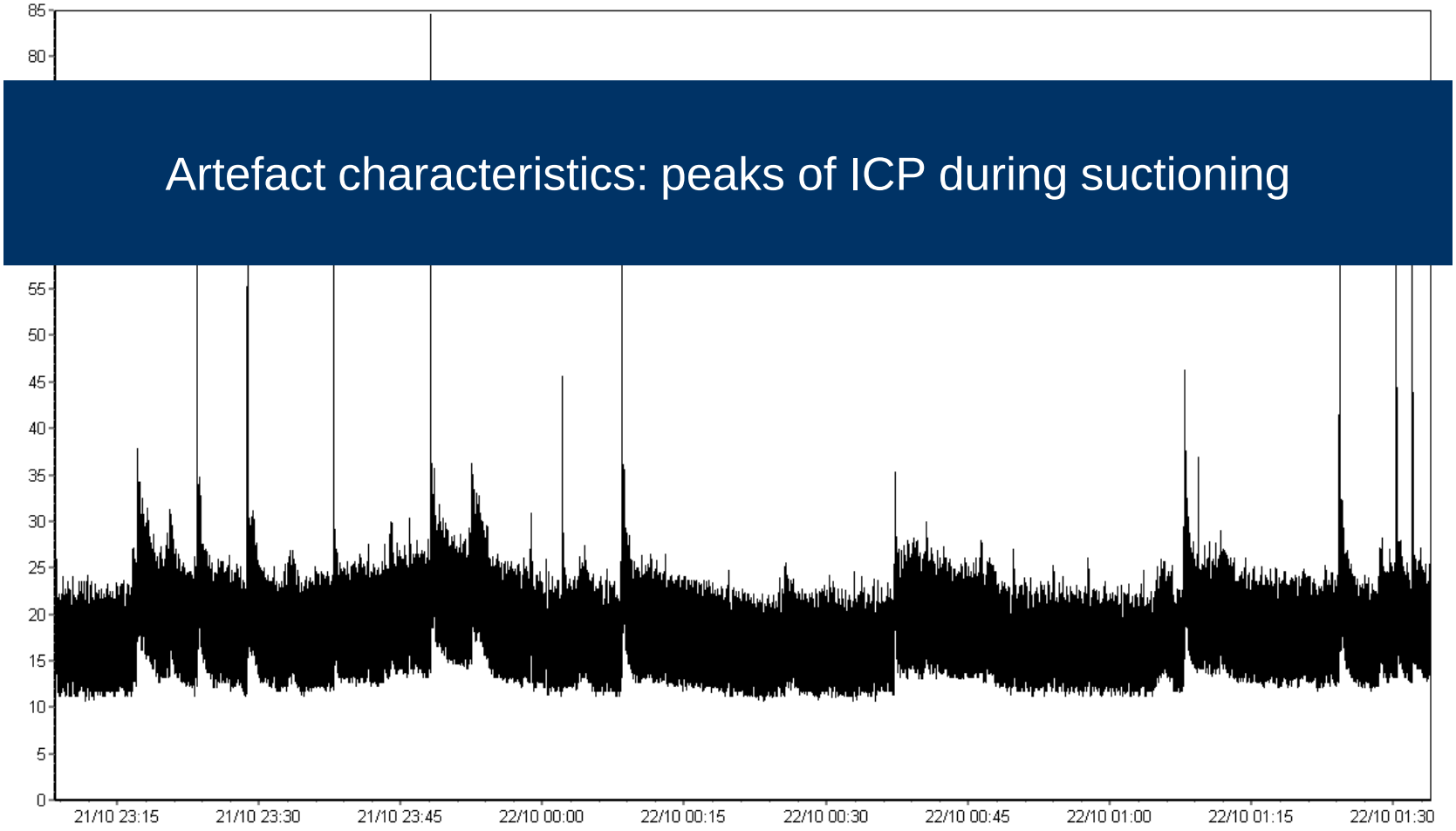
Pitfalls


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 :
abs
Function :
Coherence
Correl
CSPower
Diast
Filter
FundAmp
FundFrq
Gain
HFC
ABP
ICP
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
Function description:
OK
Cancel

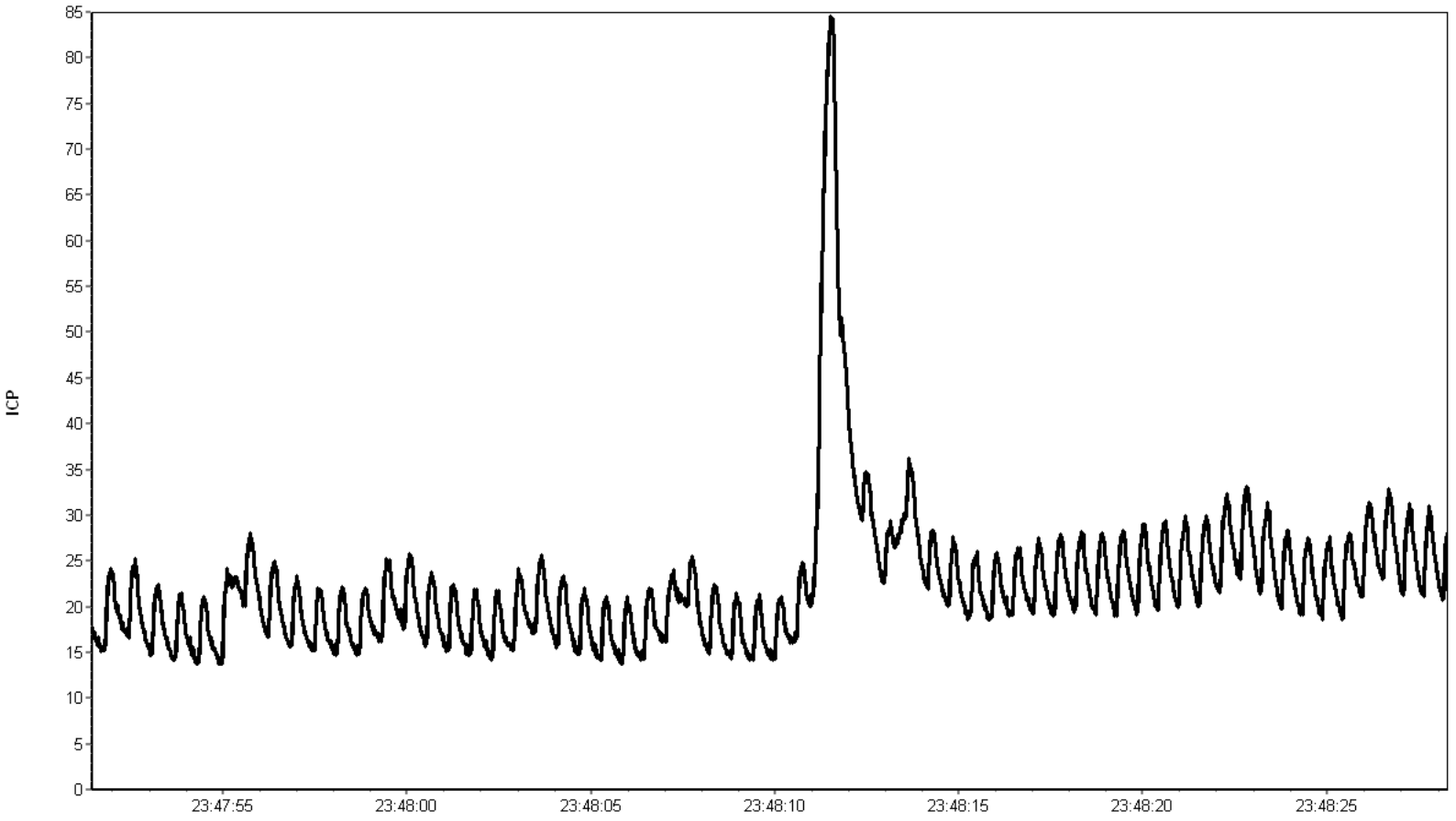
If this setting is set as ‘Disabled’ the Min/Max ranges will be ignored and so the artefact detection formulas will not work!



Artefact extraction algorithm II



Close up

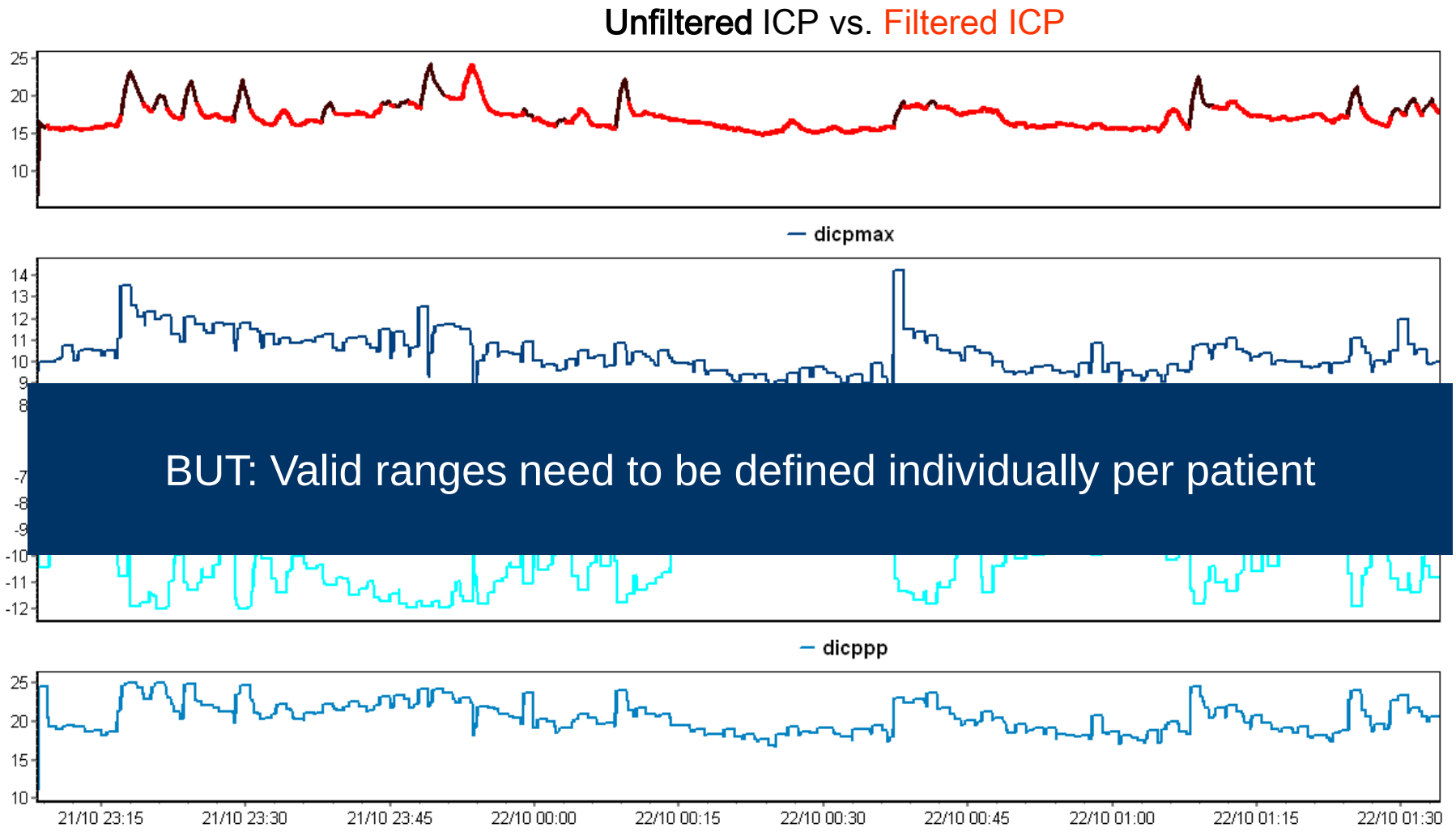

ICP
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
23:47:55
23:48:00
23:48:05
23:48:10
23:48:15
23:48:20
23:48:25

- Virtual Signals:
  - **dICP** = differentiate(movingaveragefilter(icp,200))
  - **ICP** = delayfilter(icp,100)

- Primary Analysis:
  - **dICPmax** = Max(dICP), valid value range: 0 to15
  - **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)



BUT: Valid ranges need to be defined individually per patient

… and more

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