

# Data analysis with ICM+

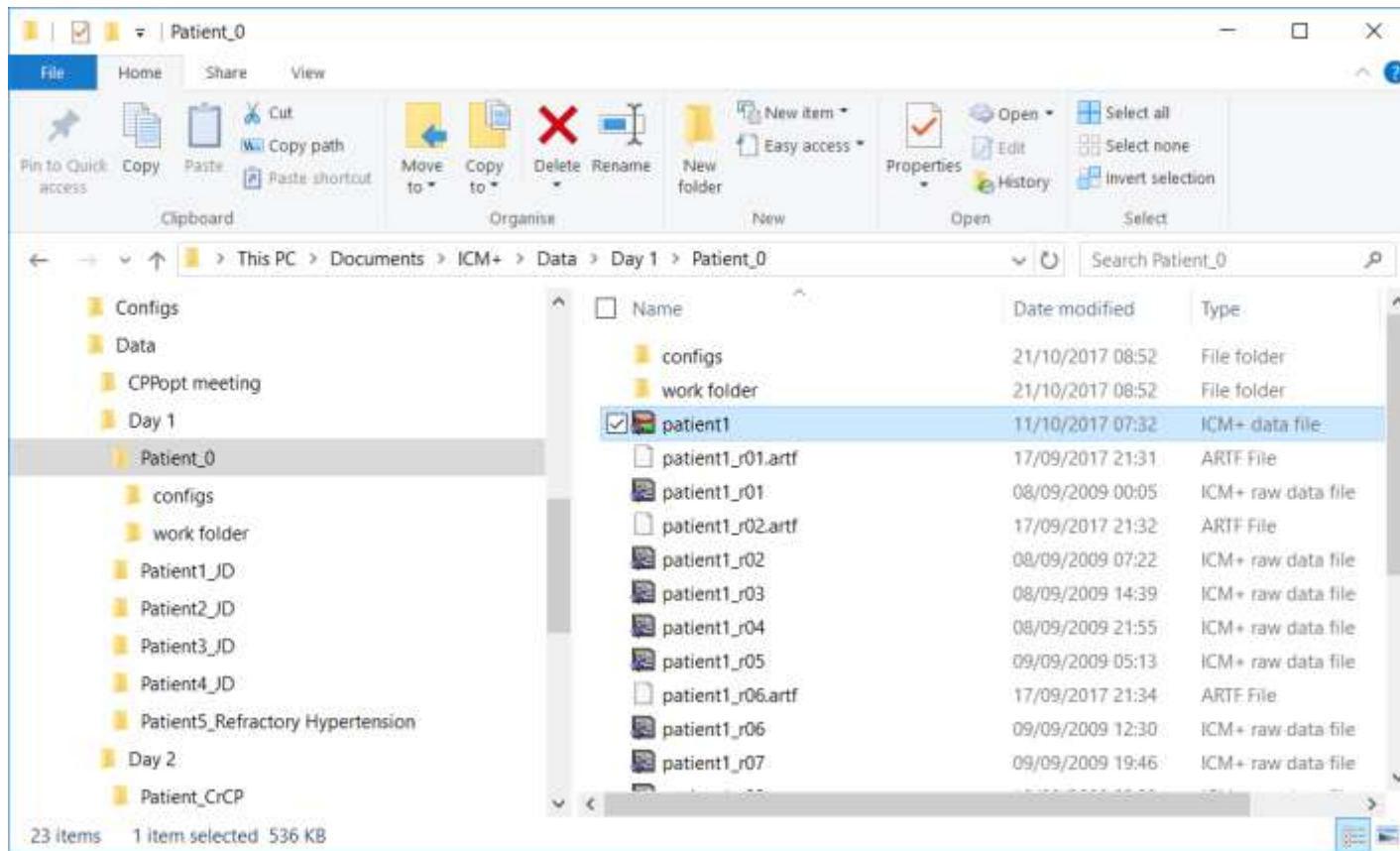
Peter Smielewski, PhD

Division of Neurosurgery, Department of Clinical Neurosciences

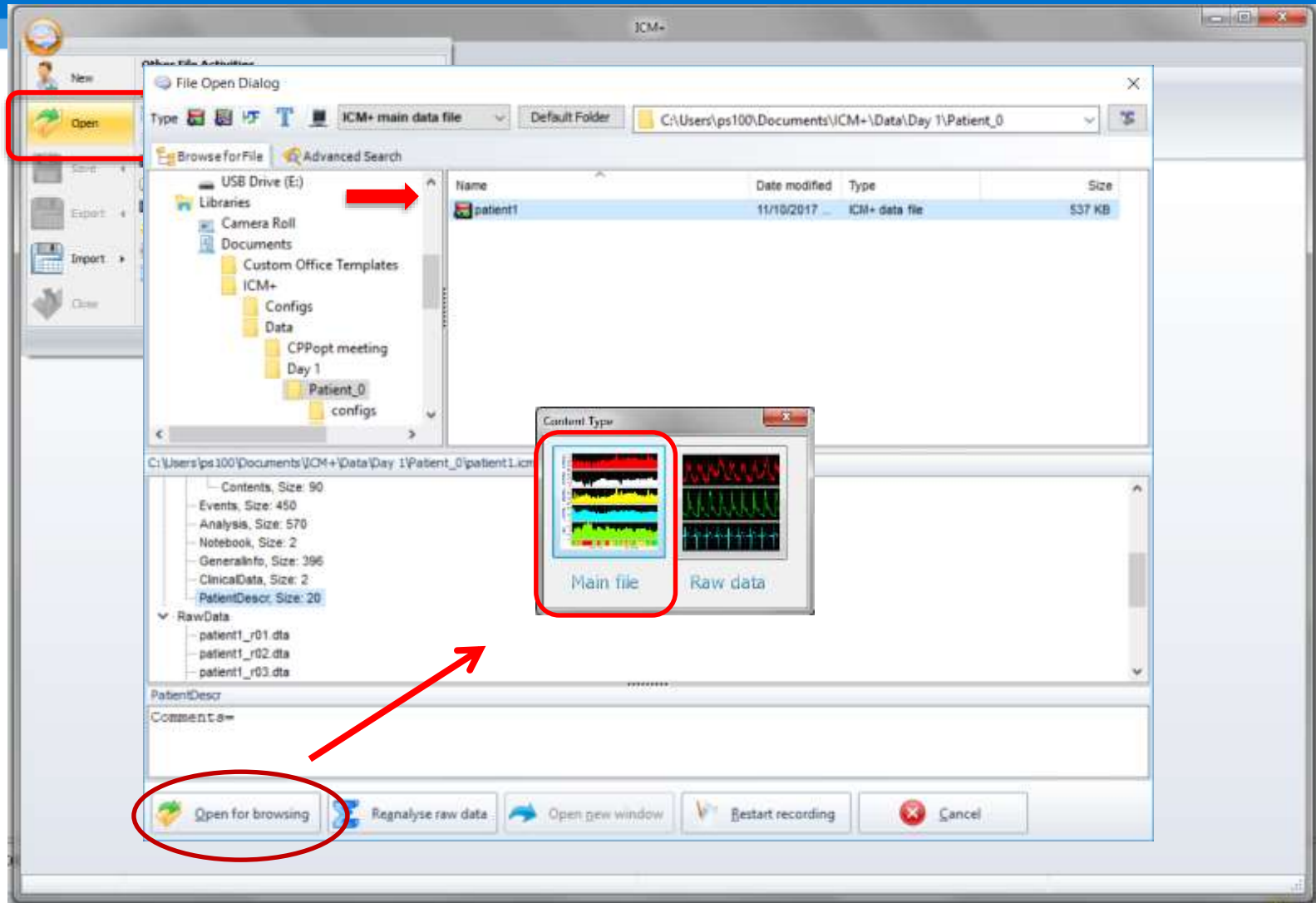
ICM+ software is licensed by Cambridge Enterprise LTD, subsidiary of Cambridge University, UK, and Dr Peter Smielewski receives a fraction of the licensing fee.

# DISCLOSURE

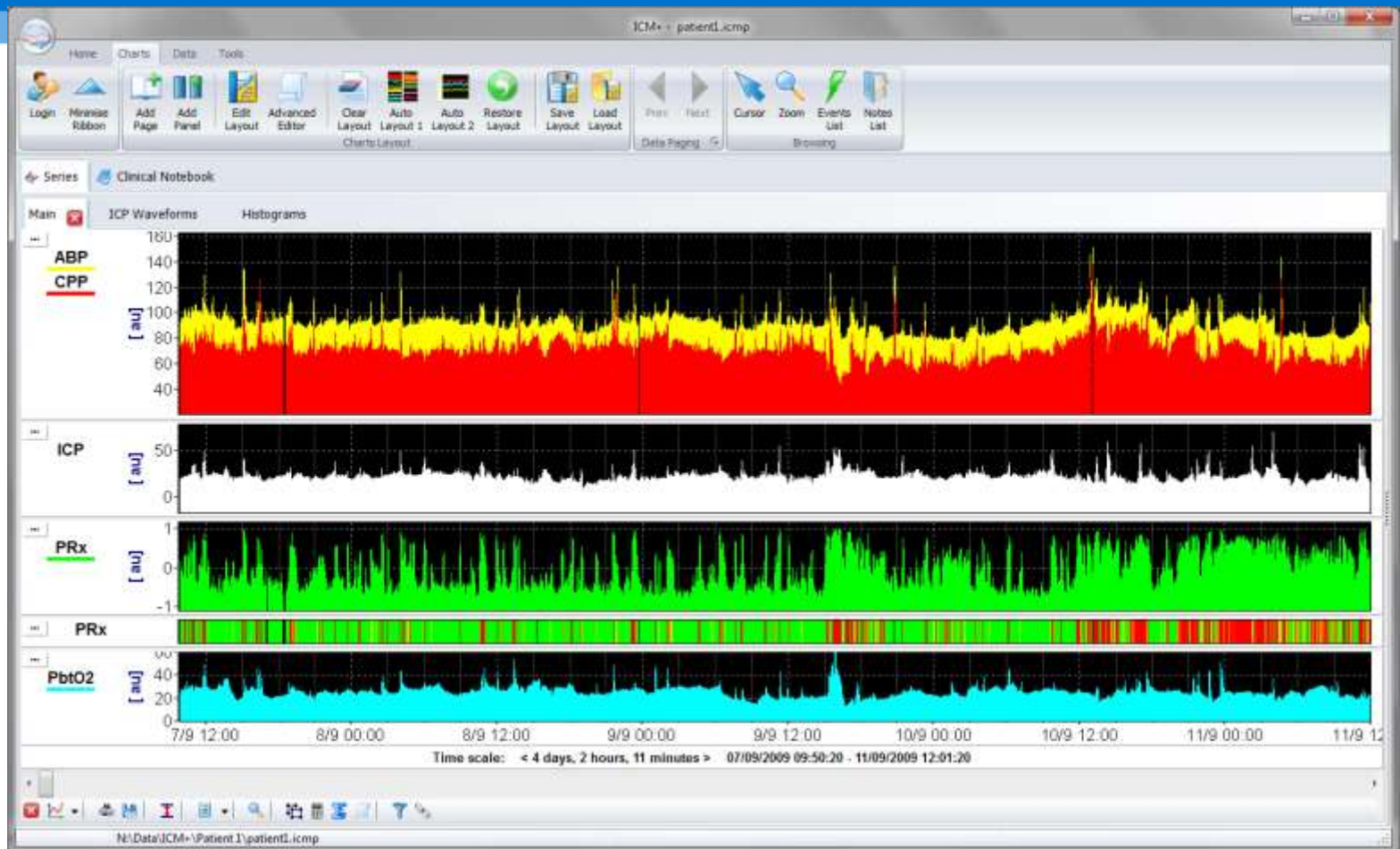
# Data examples



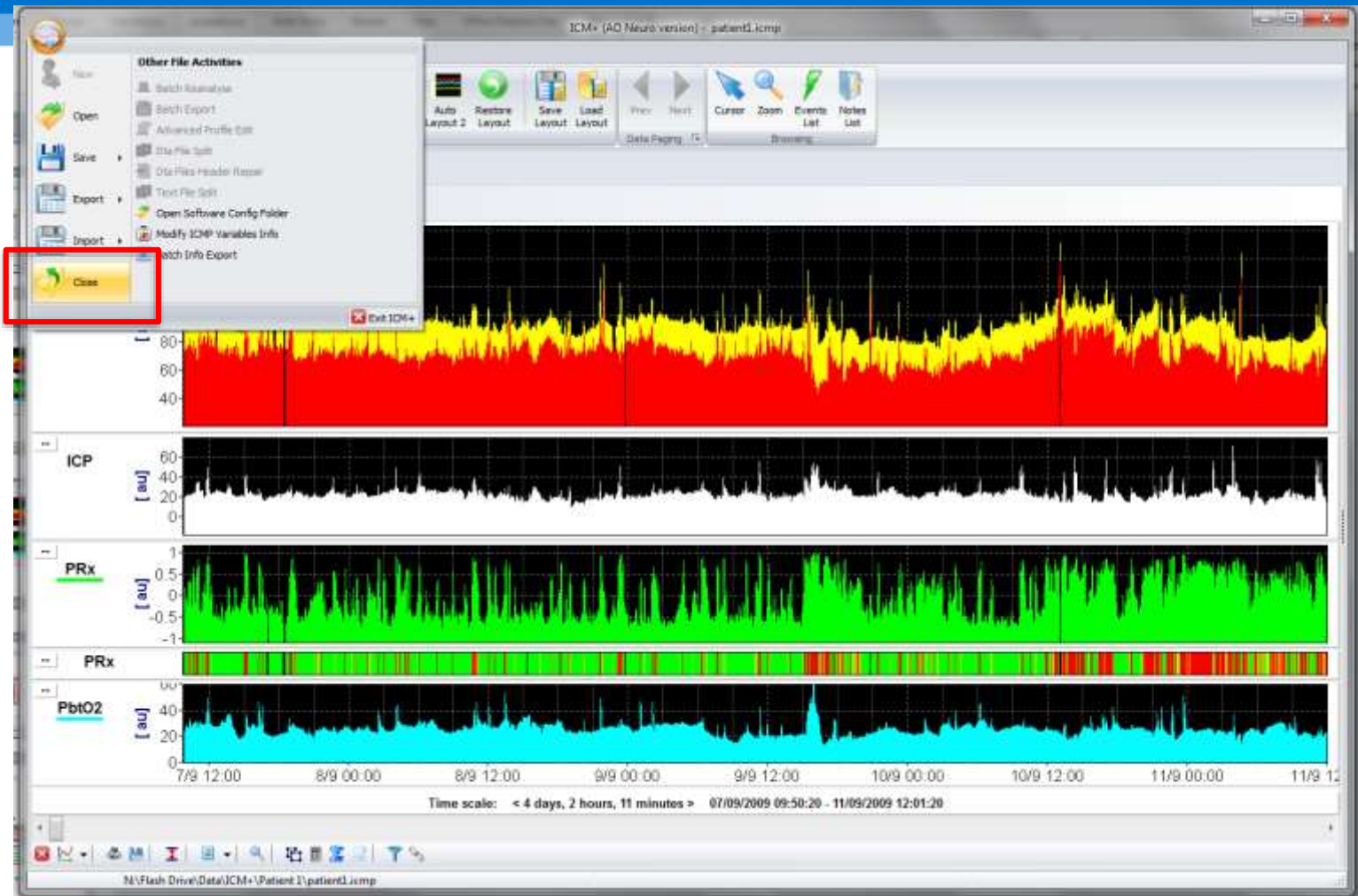
# Open the data file



# The main (summaries) file

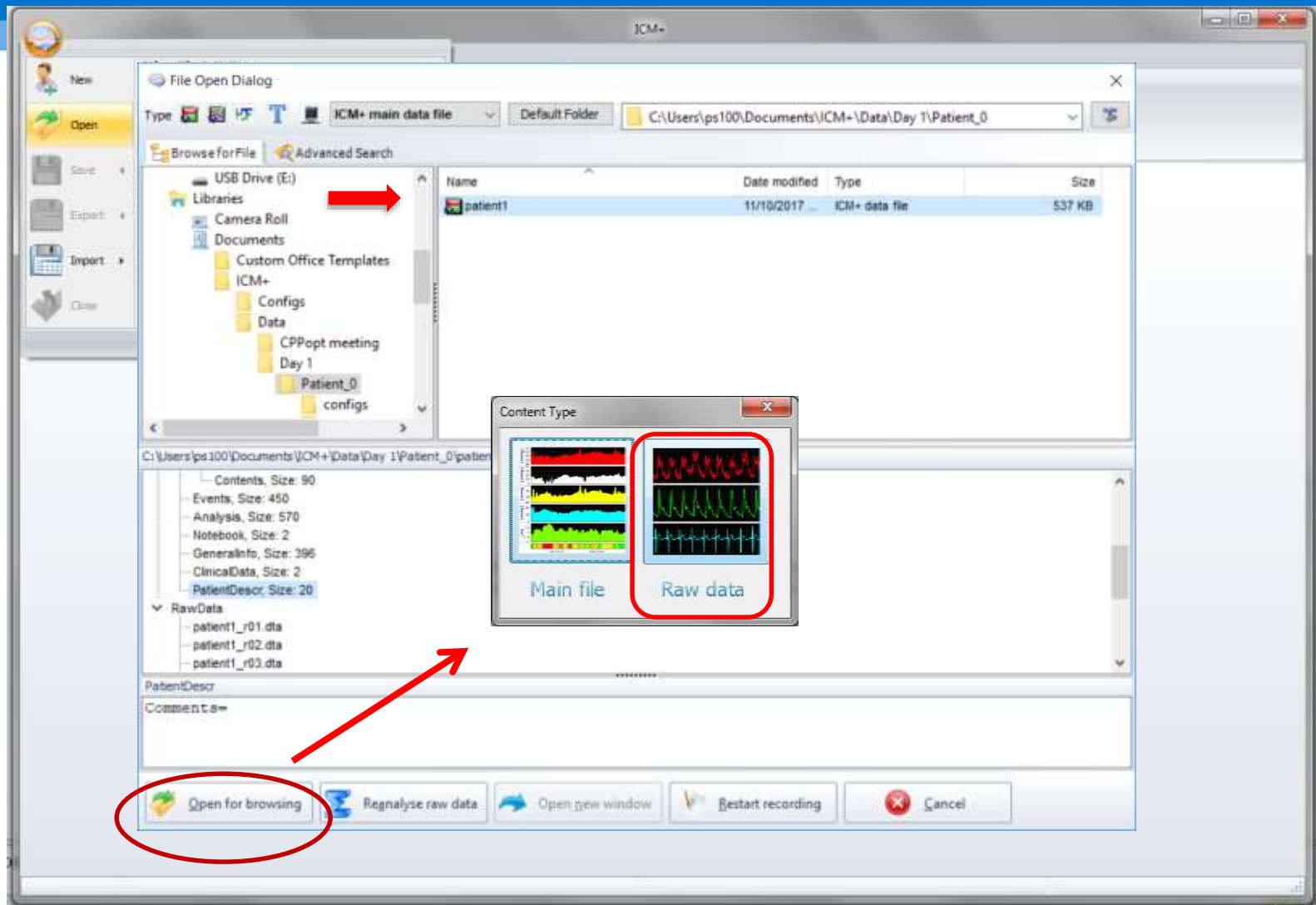


# Close the file



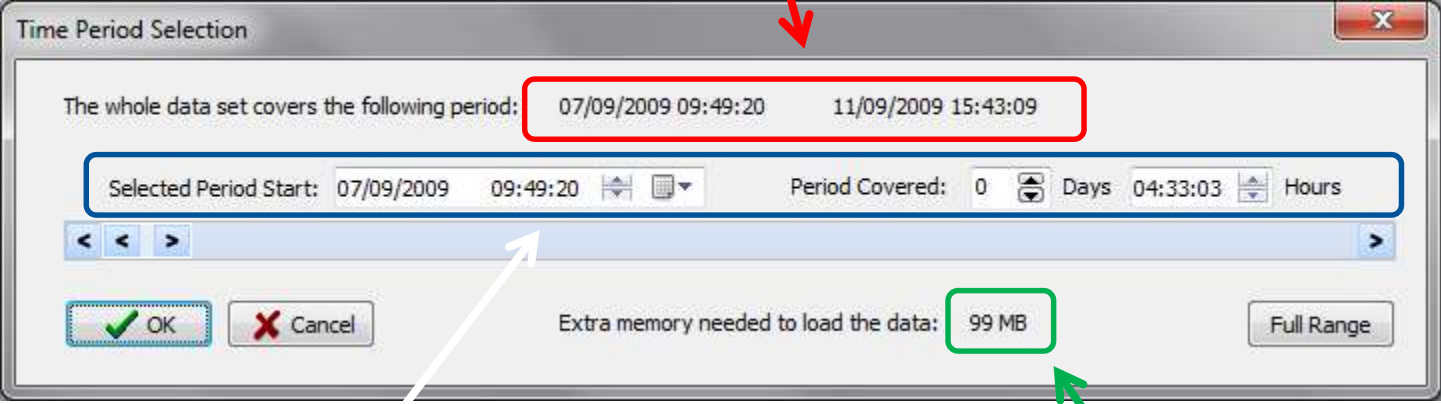


# Open the raw data file



# Raw data loading period selection

Total period covered



The whole data set covers the following period: 07/09/2009 09:49:20 11/09/2009 15:43:09

Selected Period Start: 07/09/2009 09:49:20 Period Covered: 0 Days 04:33:03 Hours

Extra memory needed to load the data: 99 MB

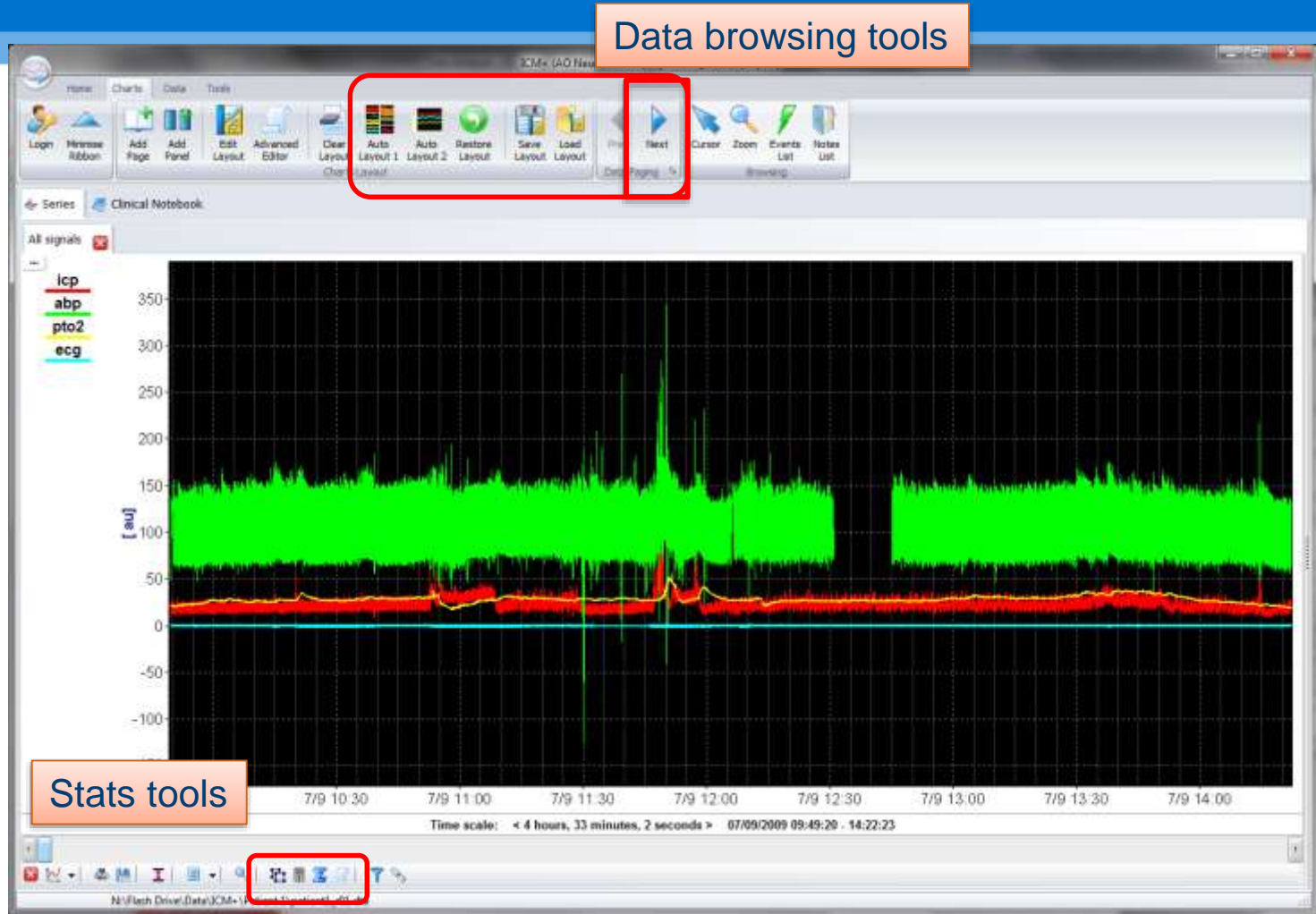
OK Cancel Full Range

Data period to load

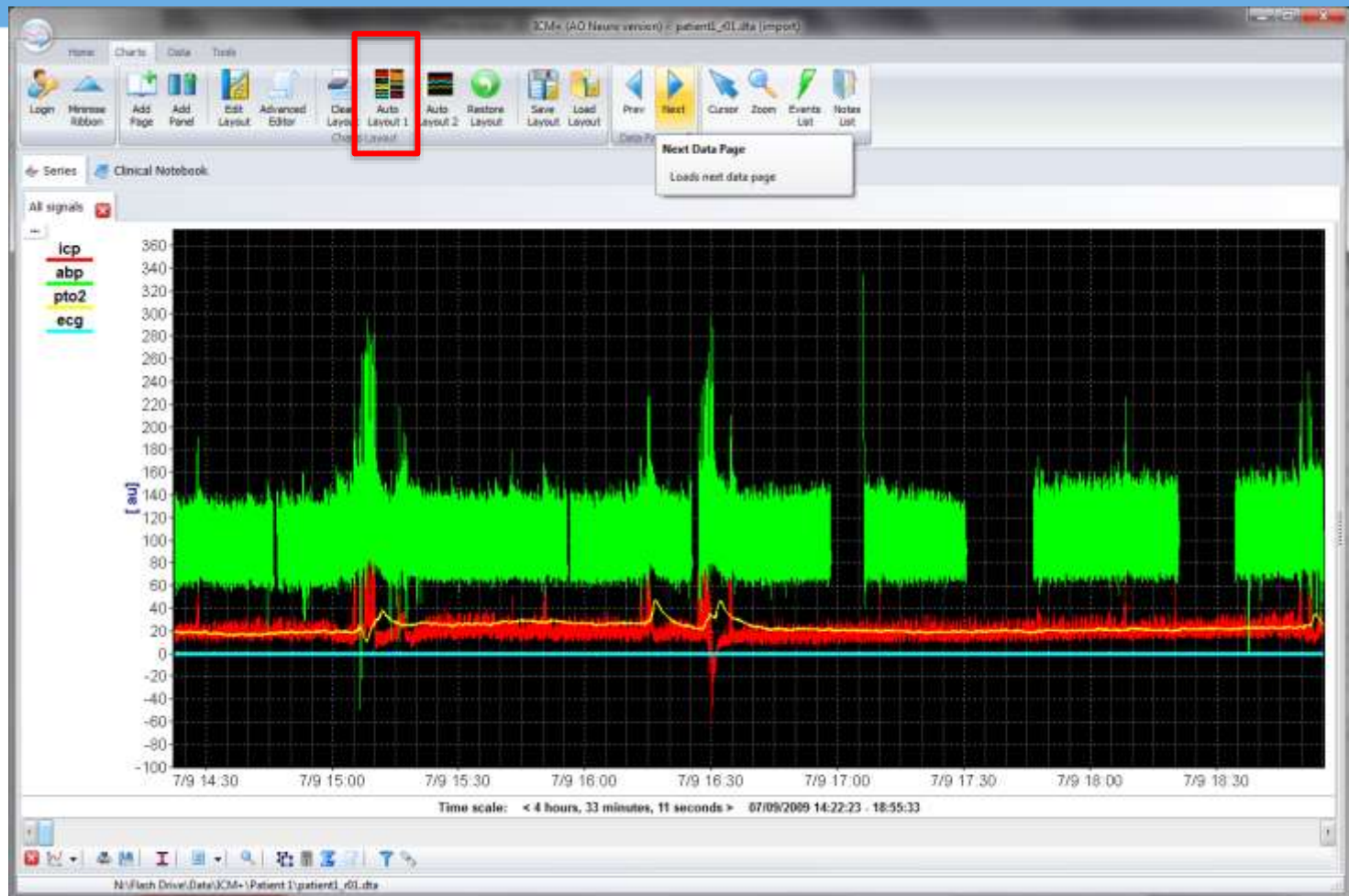
Estimate of memory needed to load



# Viewing the data



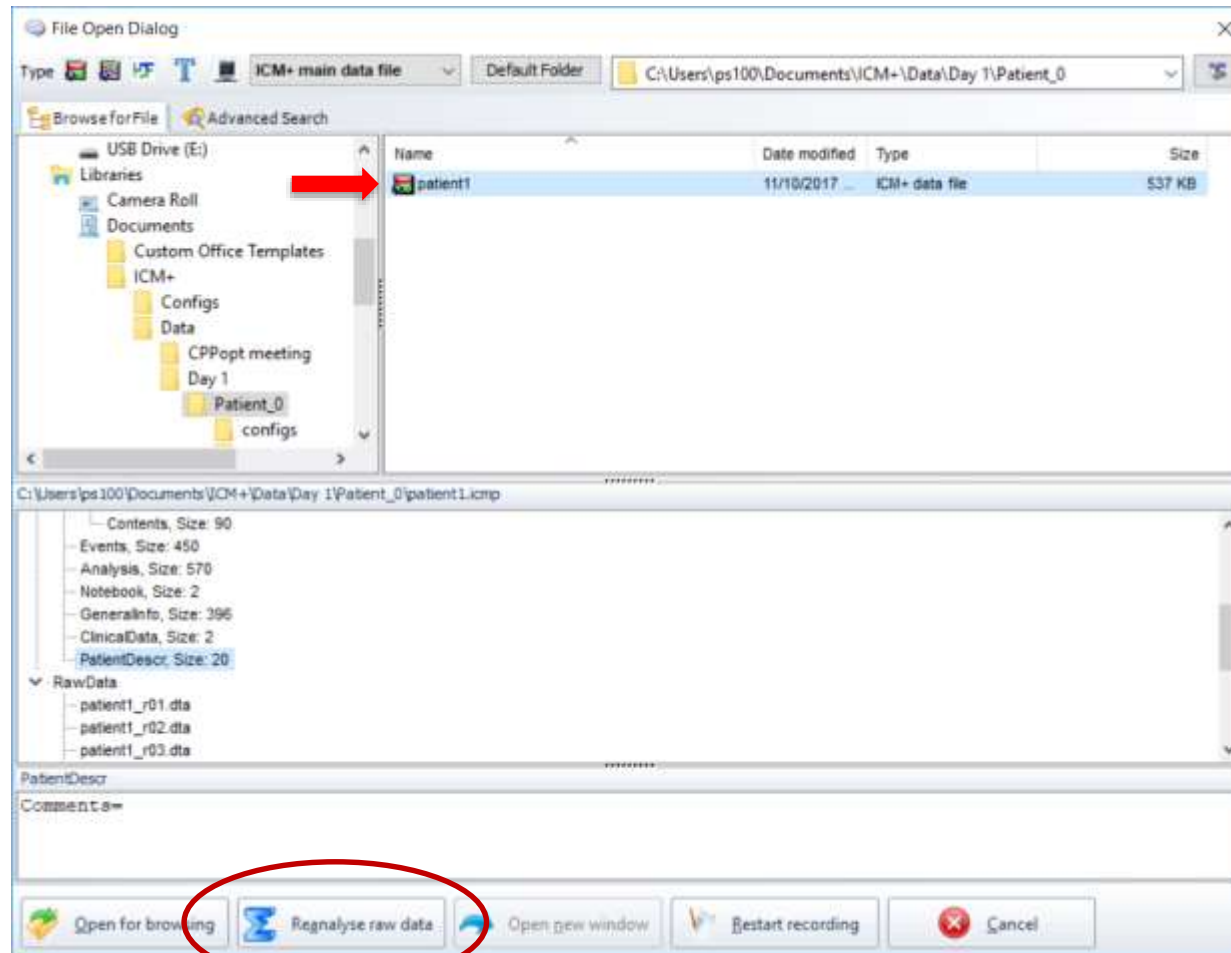
# Viewing the data



# Viewing the data

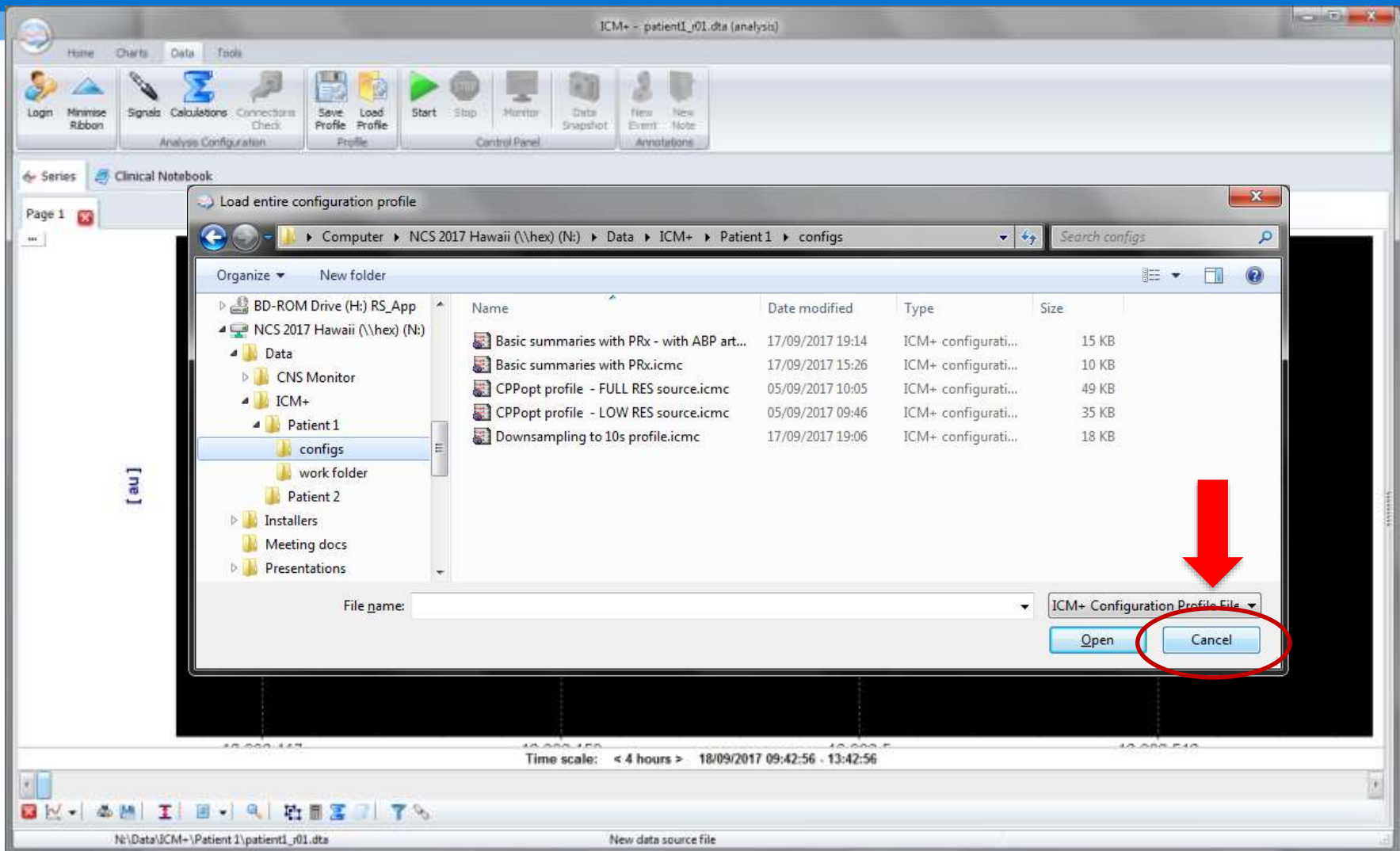


# Open the file in 're-analysis' mode

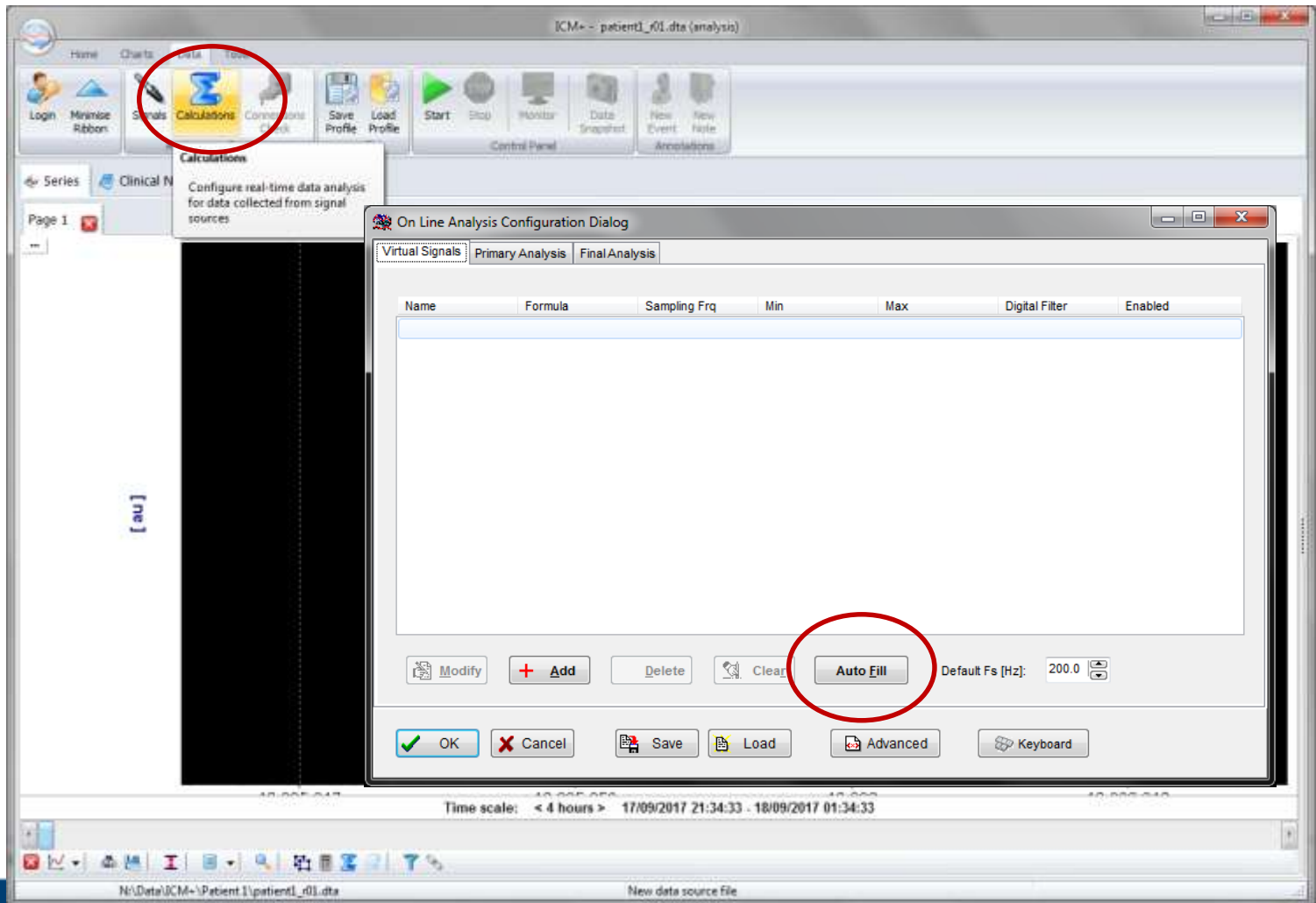




# Do **NOT** load any configuration yet

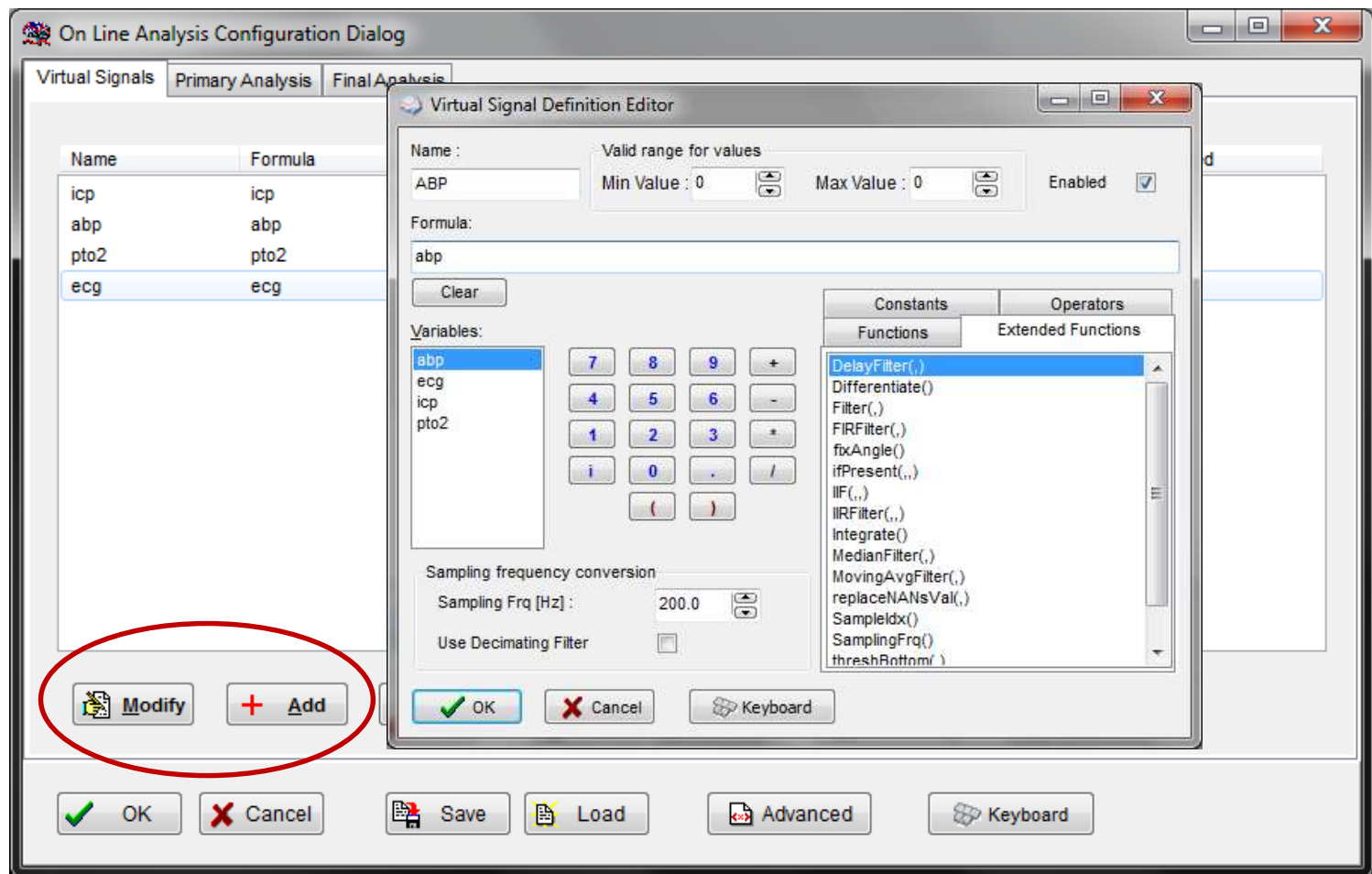


# Analysis configuration editor

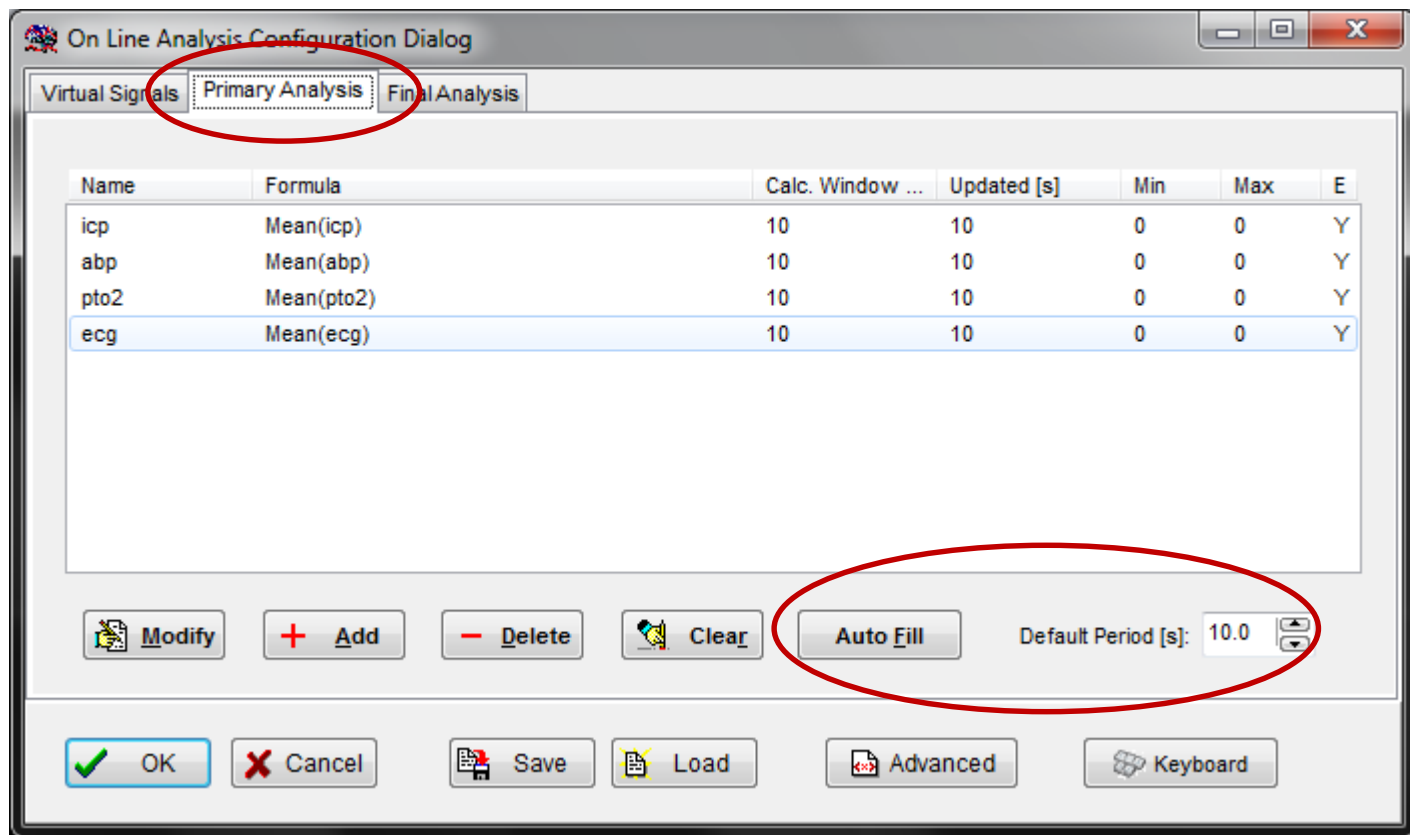




# Add signals to be analysed



# Add basic summaries



# Adding more formulae

**On Line Analysis Configuration Dialog**

Virtual Signals | **Primary Analysis** | Final Analysis

Name	Formula	Calc. Window ...	Updated [s]	Min	Max	E
icp	Mean(icp)	10	10	0	0	Y
abp			10	0	0	Y
pto2						
ecg						

**Choose the calculation window size**

Name : CPP  
Enabled ☒

**Calculation Window Specification**

Calculation Period : 10 s  
Update Period : 10 s

**Valid values range**

Max Value : 0  
Min Value : 0

Formula: Mean( abp ) - Mean( icp )

**Function Arguments :**

Series 1 : icp

**Choose Mean function**

**Double click to choose the variable**

Function description:  
Function calculates mean value of samples over the specified buffer

OK Cancel Keyboard

# Adding PRx calculation

Calculation window size 5 min

Final Analysis Configuration Editor

Name : PRx

Calculation Window Specification

Calculation Period : 300 s

Valid values range

Max Value : 0

Units :

Update Period : 60

Calculation rate – every 1 minute

Enabled ☒

Brief description of the parameter

Formula:

Correl( abp,icp )

Double click 'abp' and then 'icp'

Choose Correl function

abs

Function :

AUC  
BaroIndex  
BaroIndexEx  
BaroSpldx  
BaroSpldxEx  
Coherence  
Correl  
CrossCorrel  
CSPower

Options:

Insert Function

MDLIM Missing Data Limit [%] (0 - 100)

Function Arguments :

Series 1 : abp

Series 2 : icp

abp  
ecg  
icp  
pto2

Function description:

Function calculates Pearson coefficient of correlation between two variables

OK

OK

Cancel

Keyboard

# Final parameters

On Line Analysis Configuration Dialog

Virtual Signals Primary Analysis Final Analysis

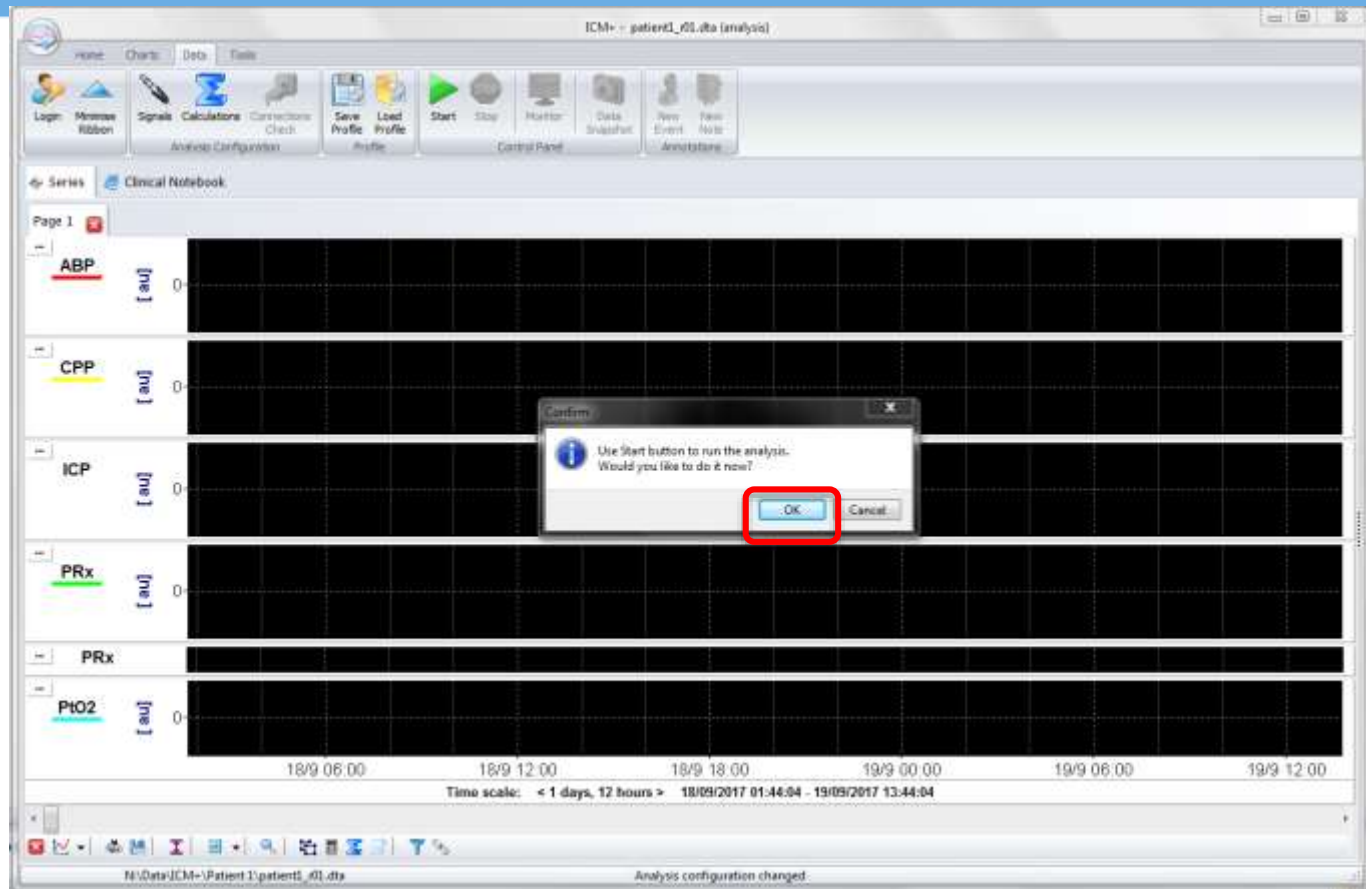
Data Acquisition Period [s]: 60.0 Adjust Calc. Period

Name	Formula	Units	Calc. Windo...	Updated [s]	Min	Max	En.
icp	Mean(icp)		60	60	0	0	Y
abp	Mean(abp)		60	60	0	0	Y
pto2	Mean(pto2)		60	60	0	0	Y
CPP	Mean(CPP)		60	60	0	0	Y
PRx	Correl( abp,icp )		300	60	0	0	Y

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

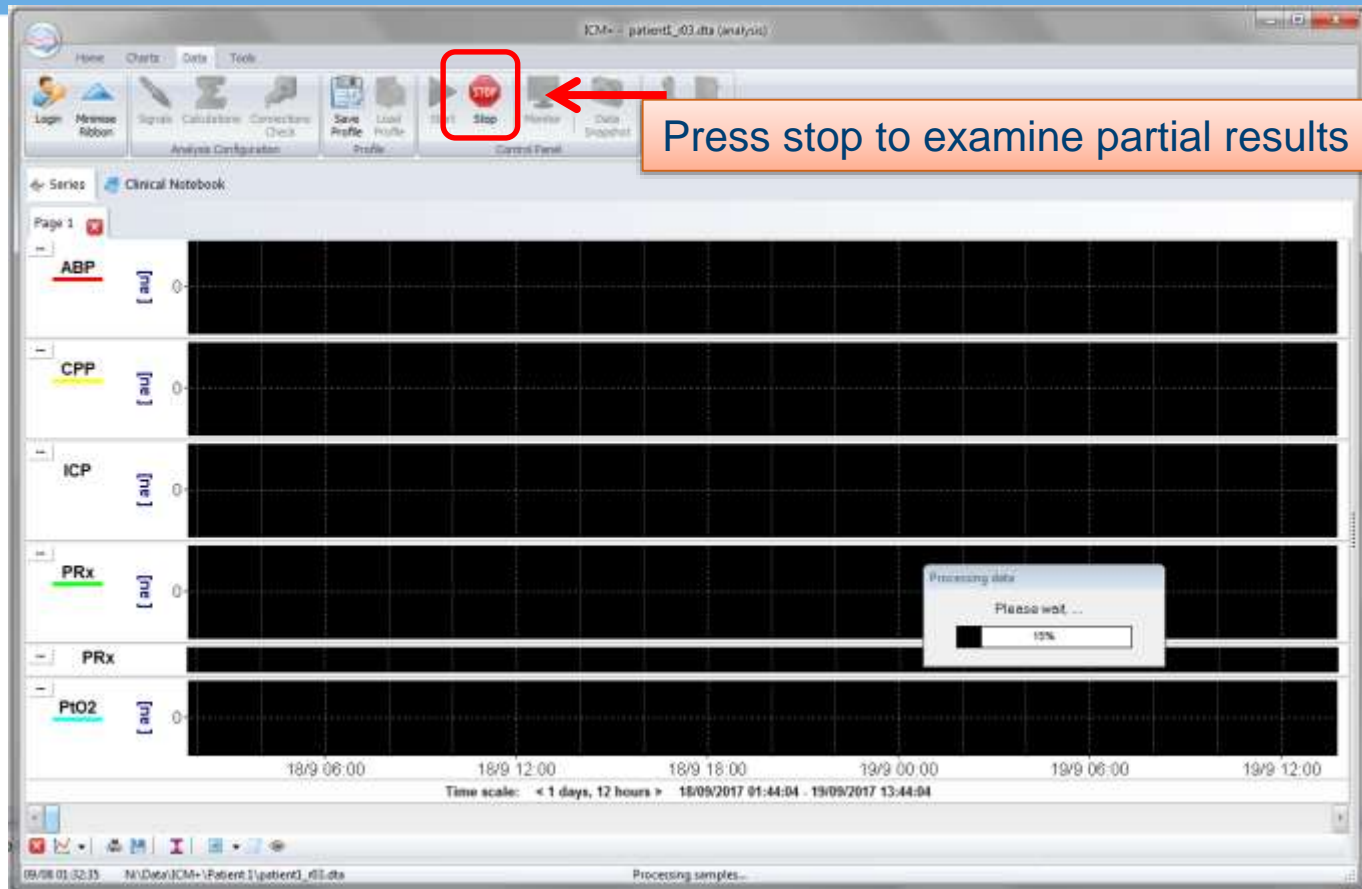
OK Cancel Save Load Advanced Keyboard

# Start analysis

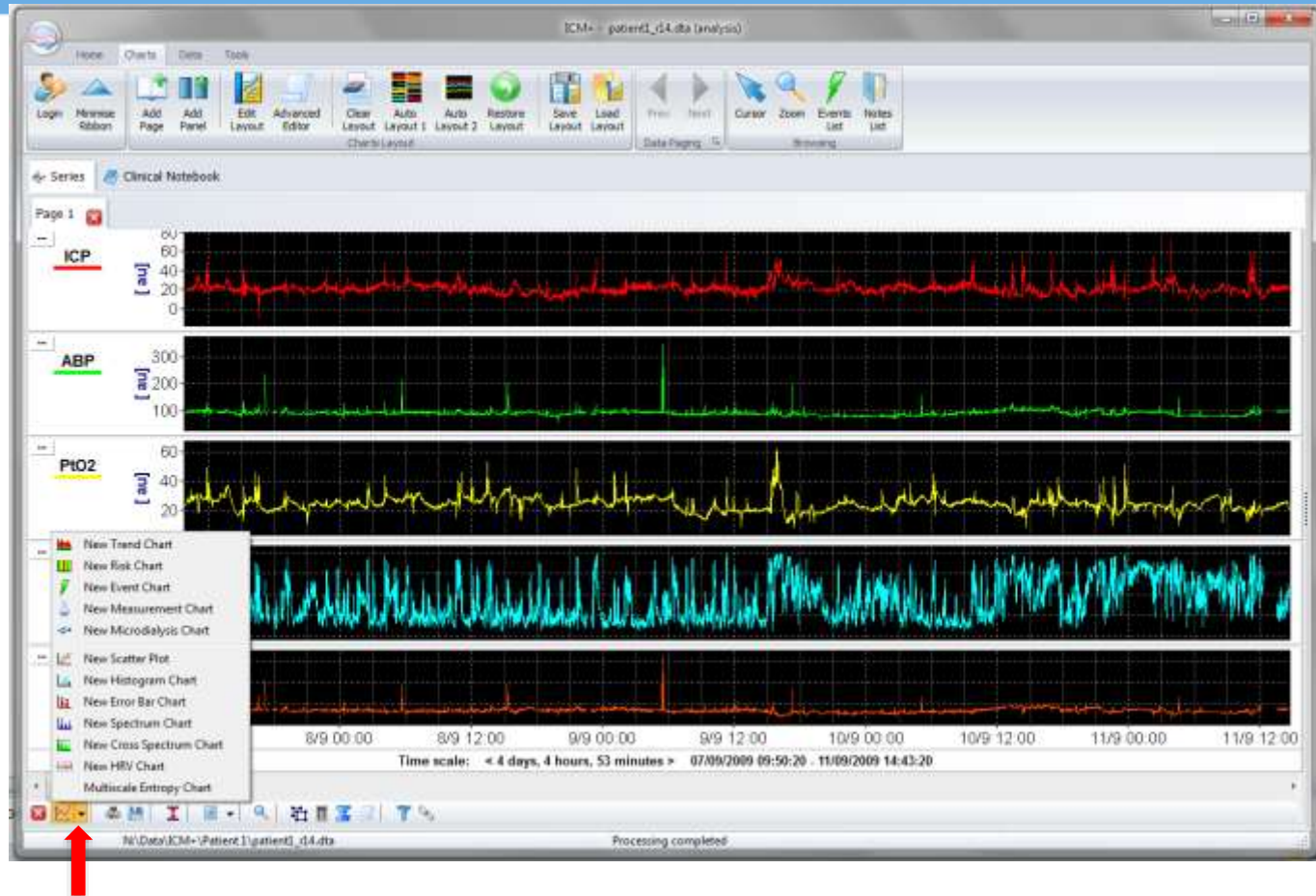




# Running the calculation

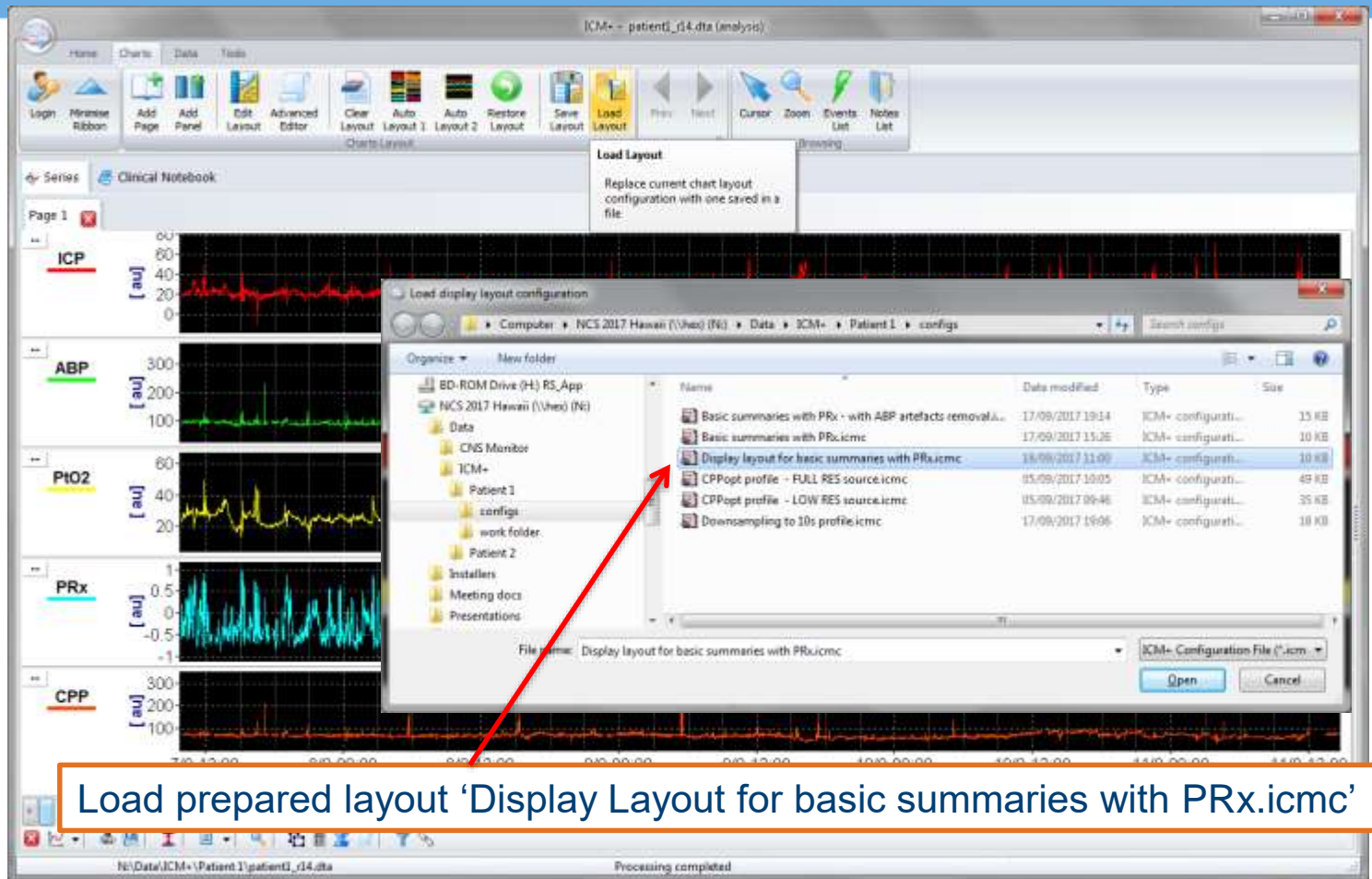


# Resulting trends

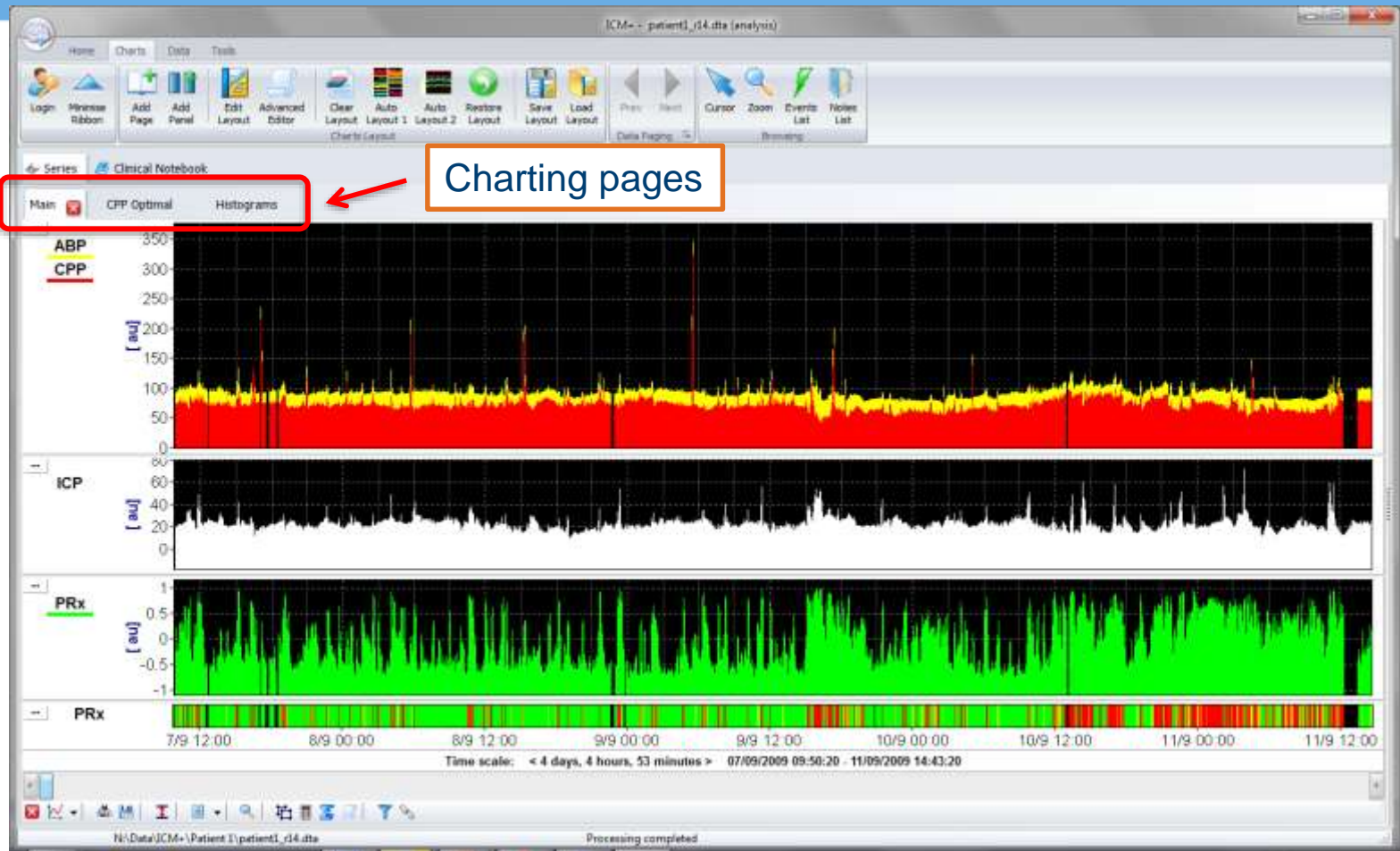


Build the desired visualisation by adding more charts

# Load preconfigured charts layout

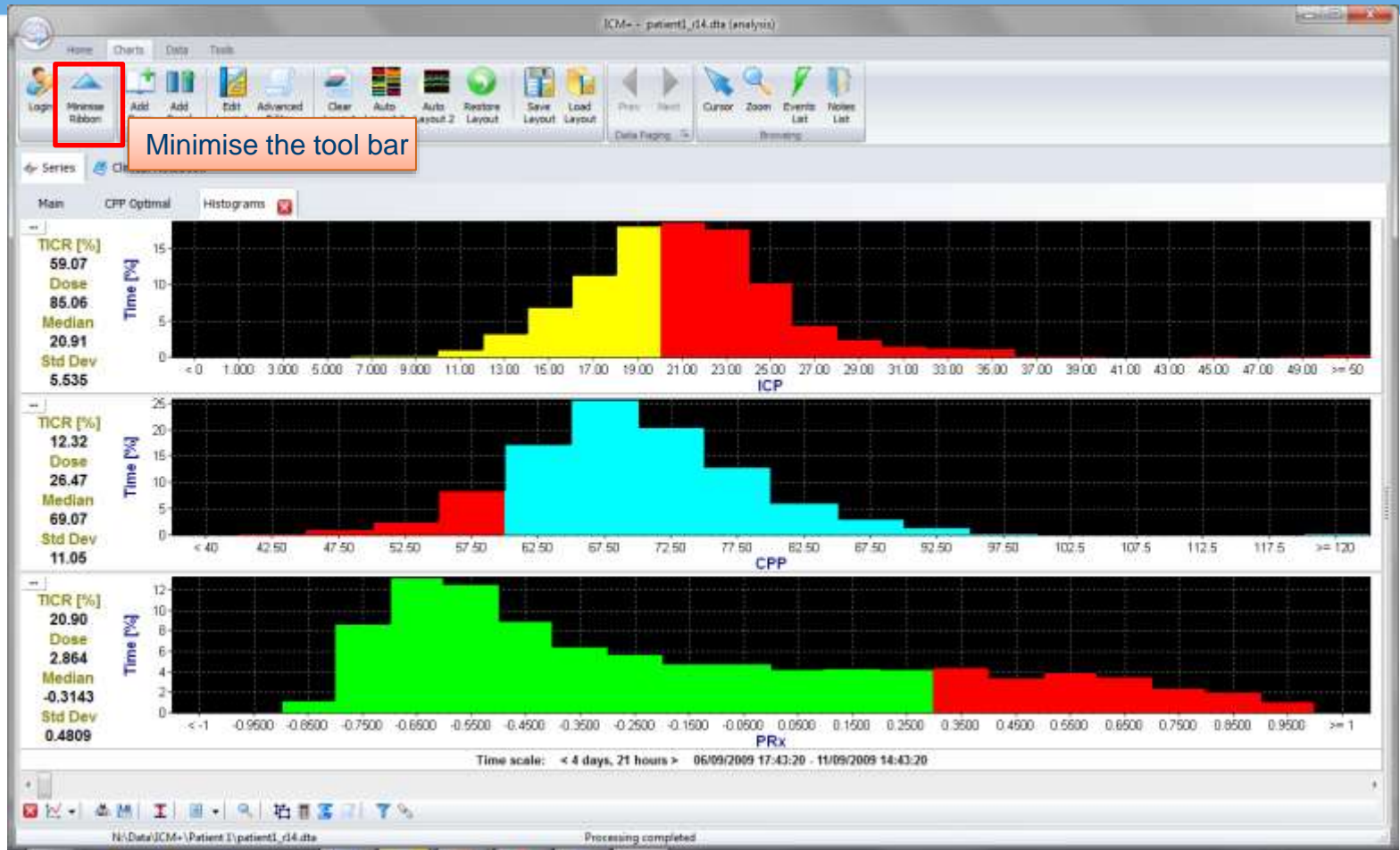


# Multipage view of the data

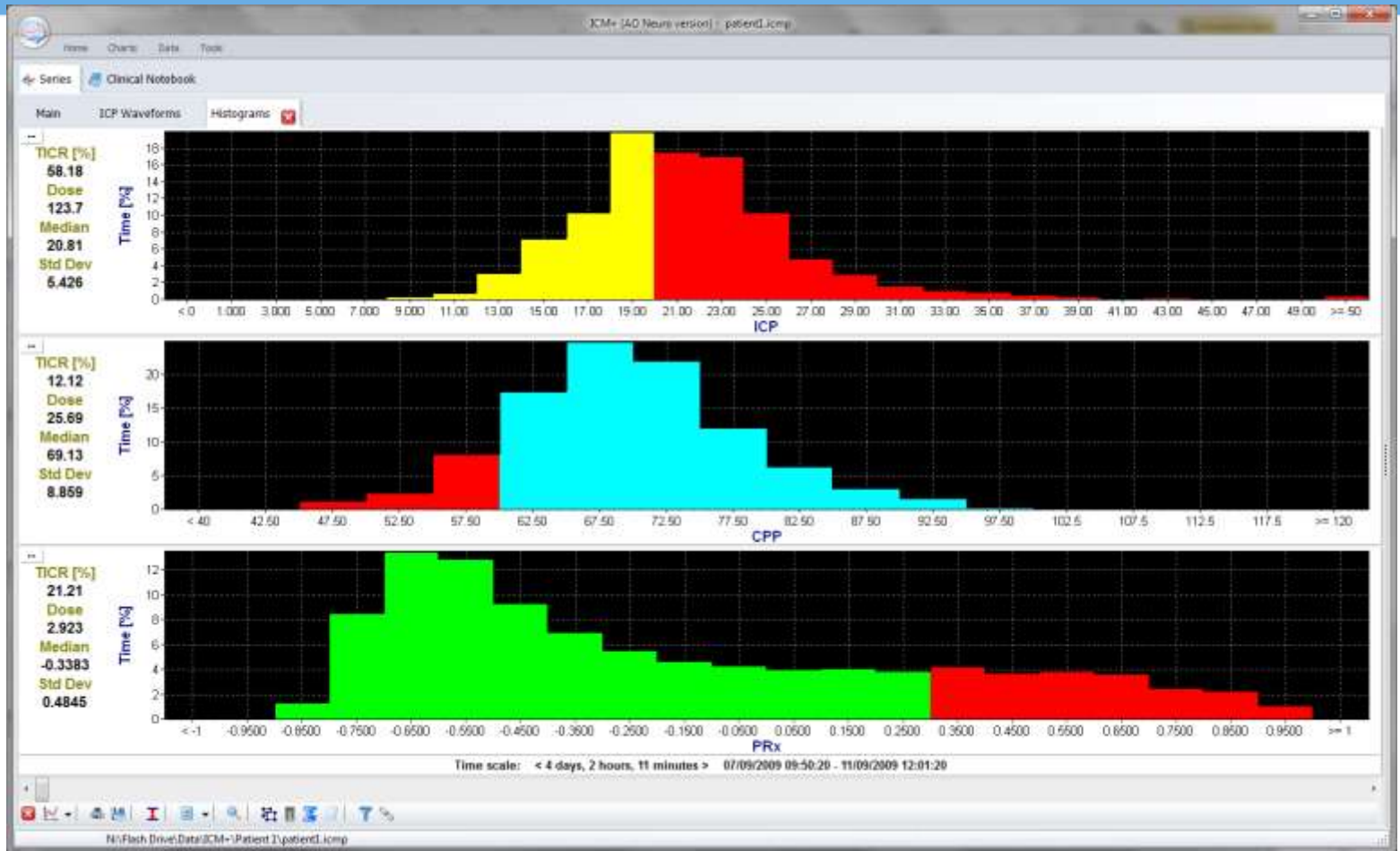




# Histograms

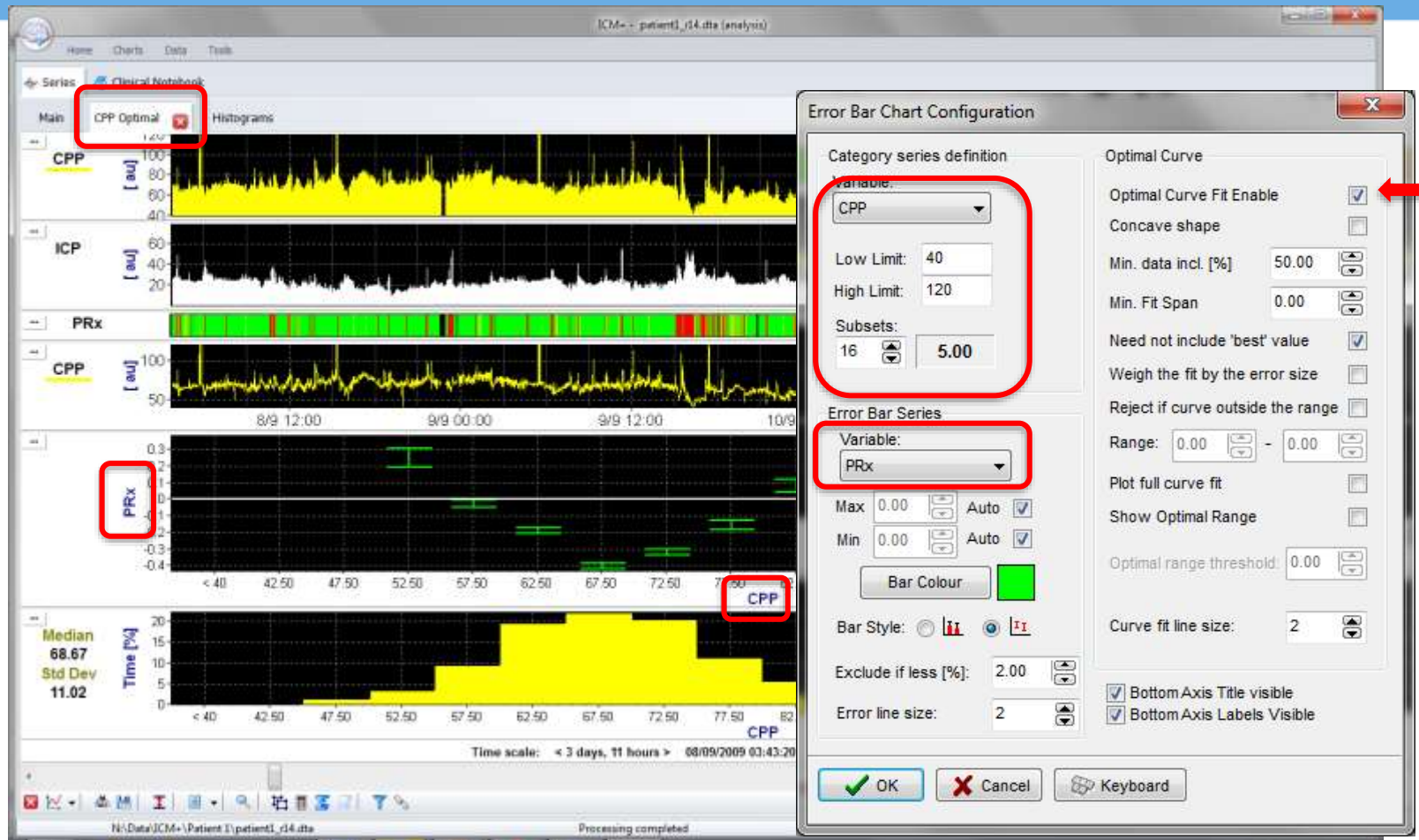


# Histograms

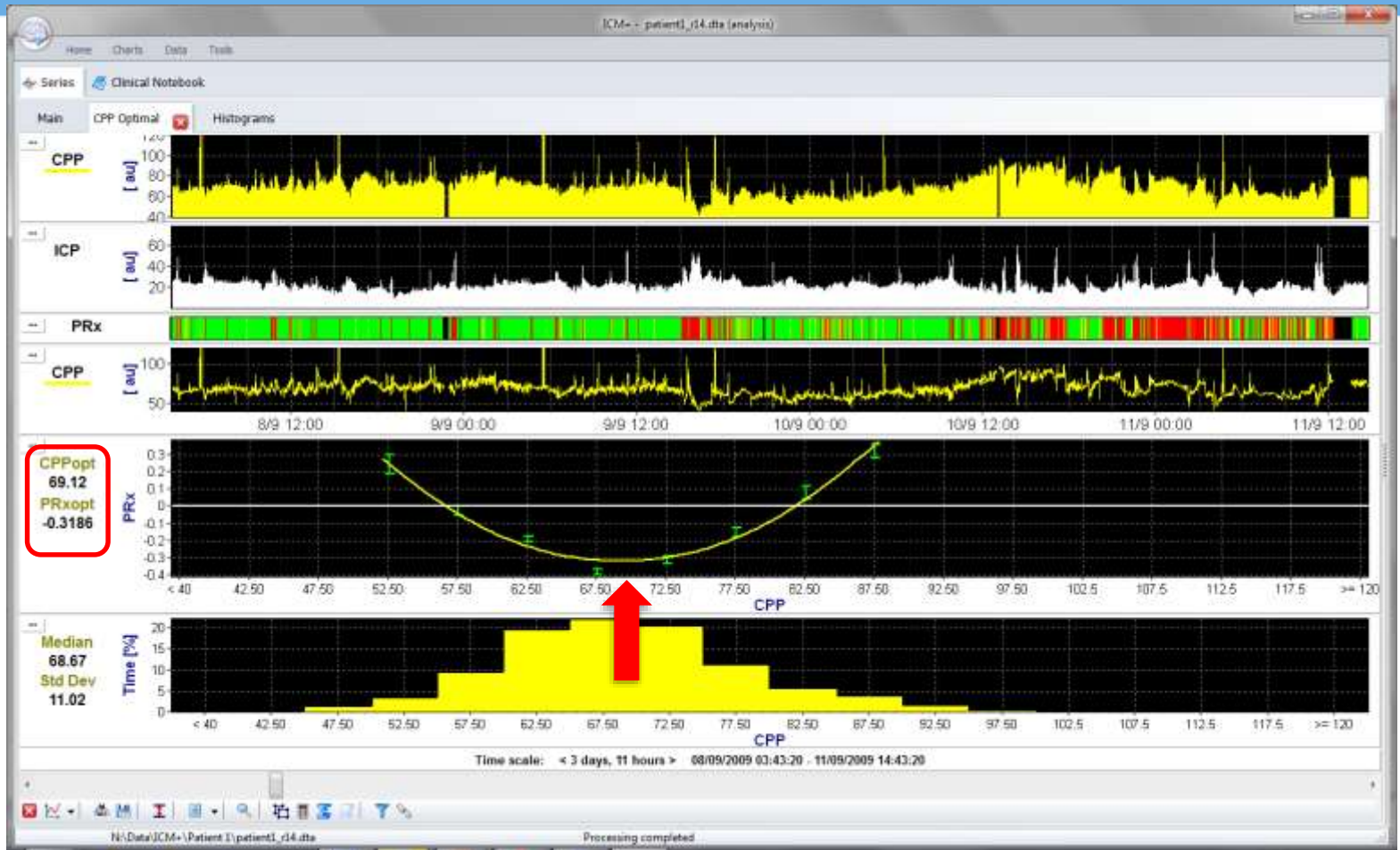




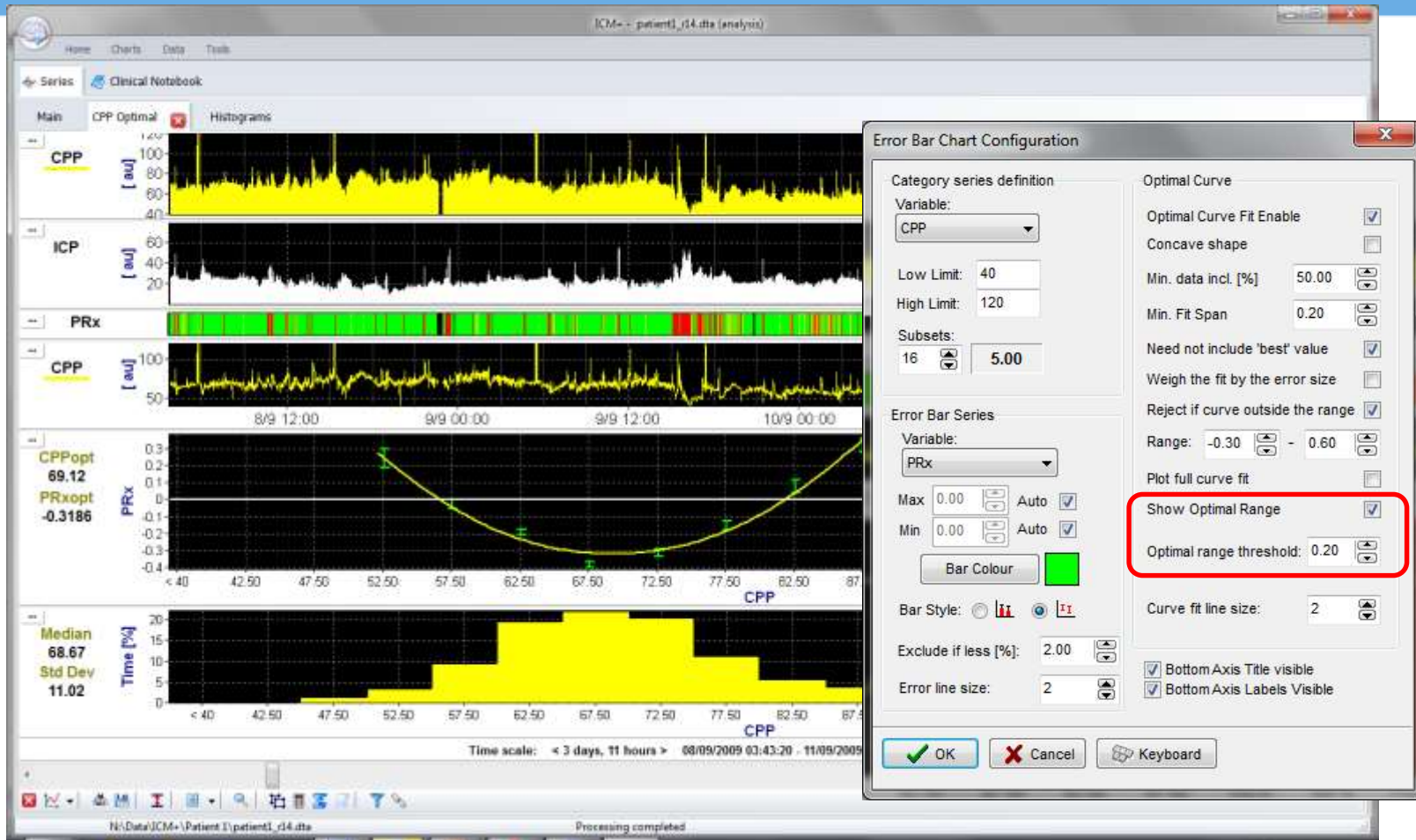
# Visualising PRx against CPP



# 'Optimal CPP' curve

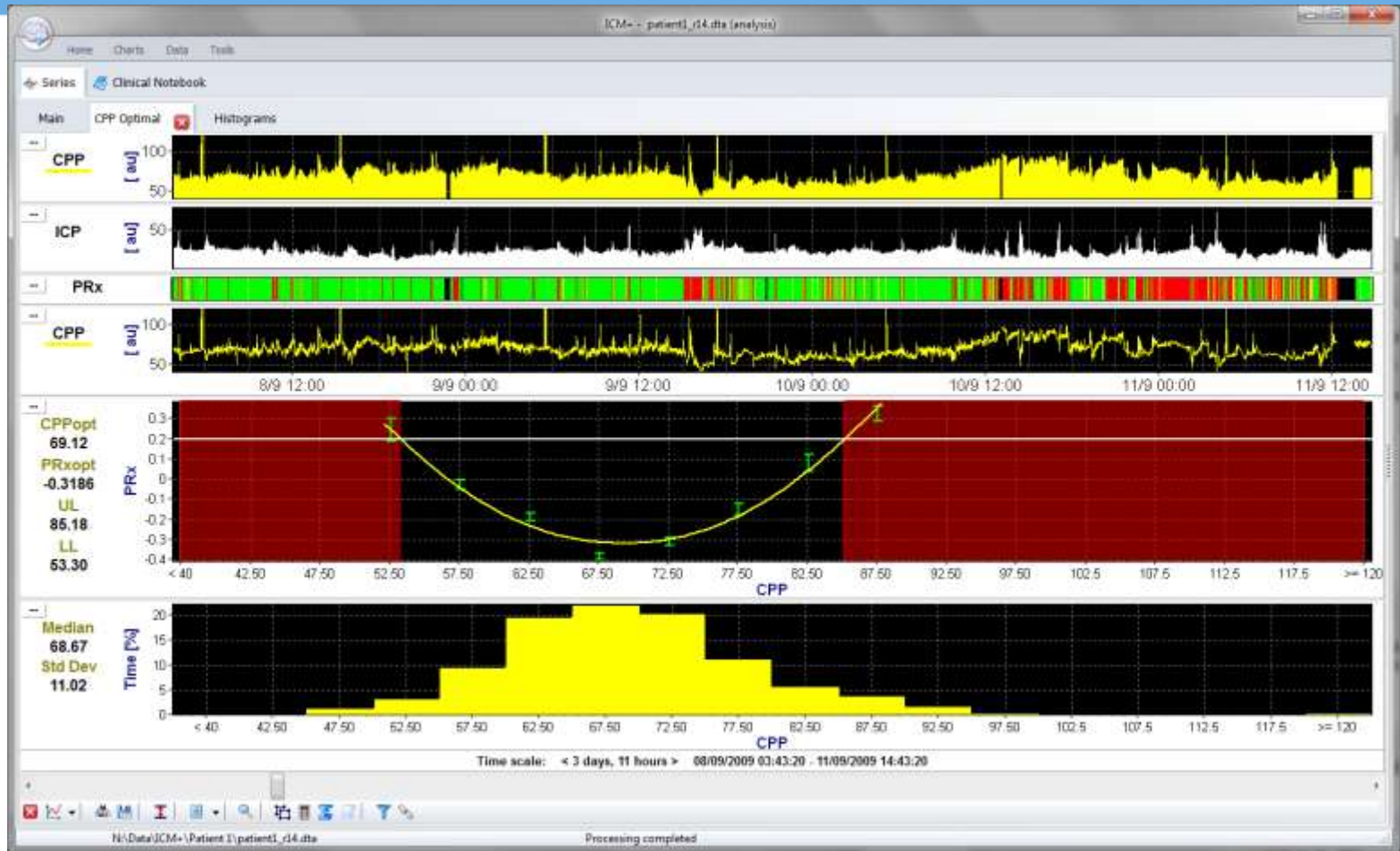


# 'Optimal CPP' curve



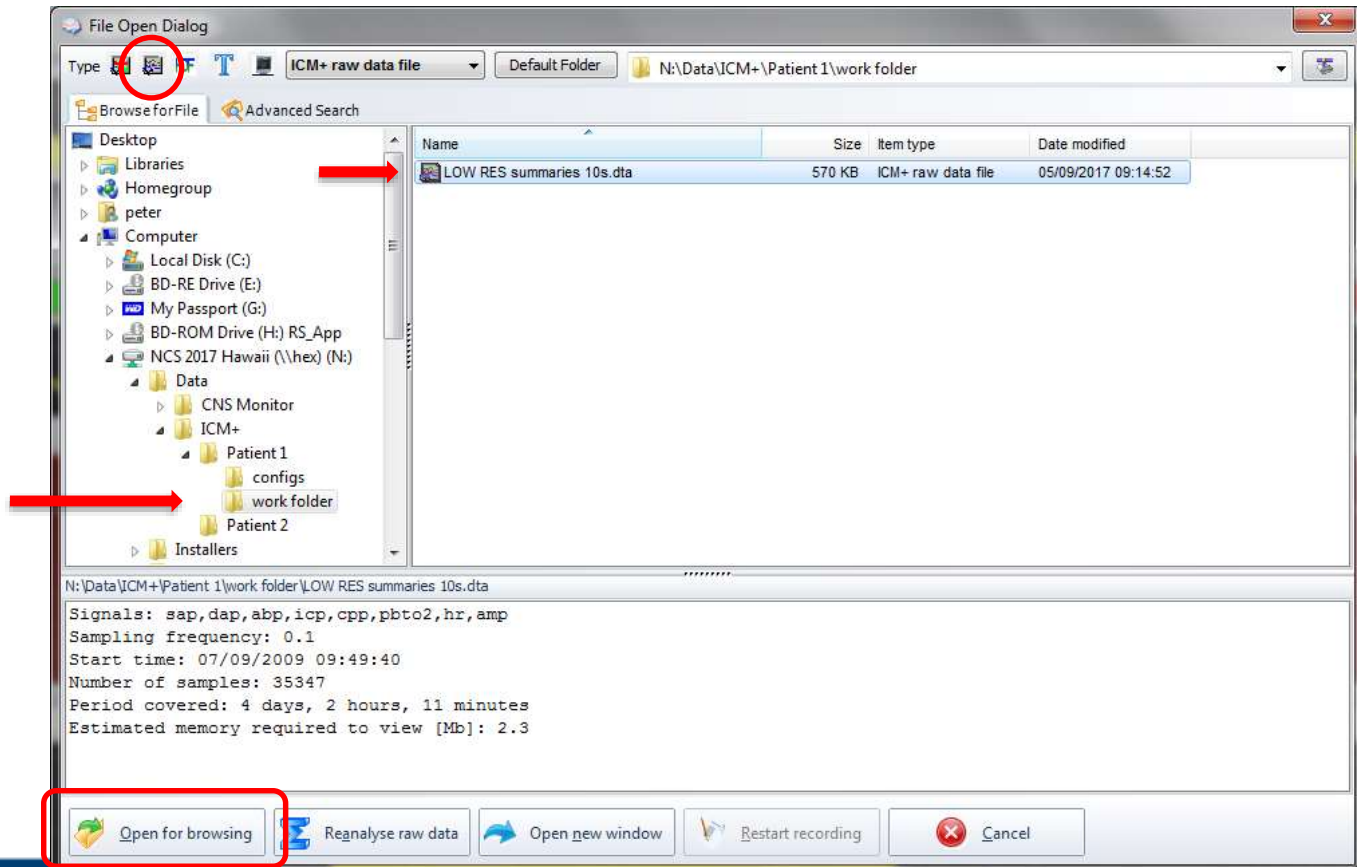


# Limits of autoregulation

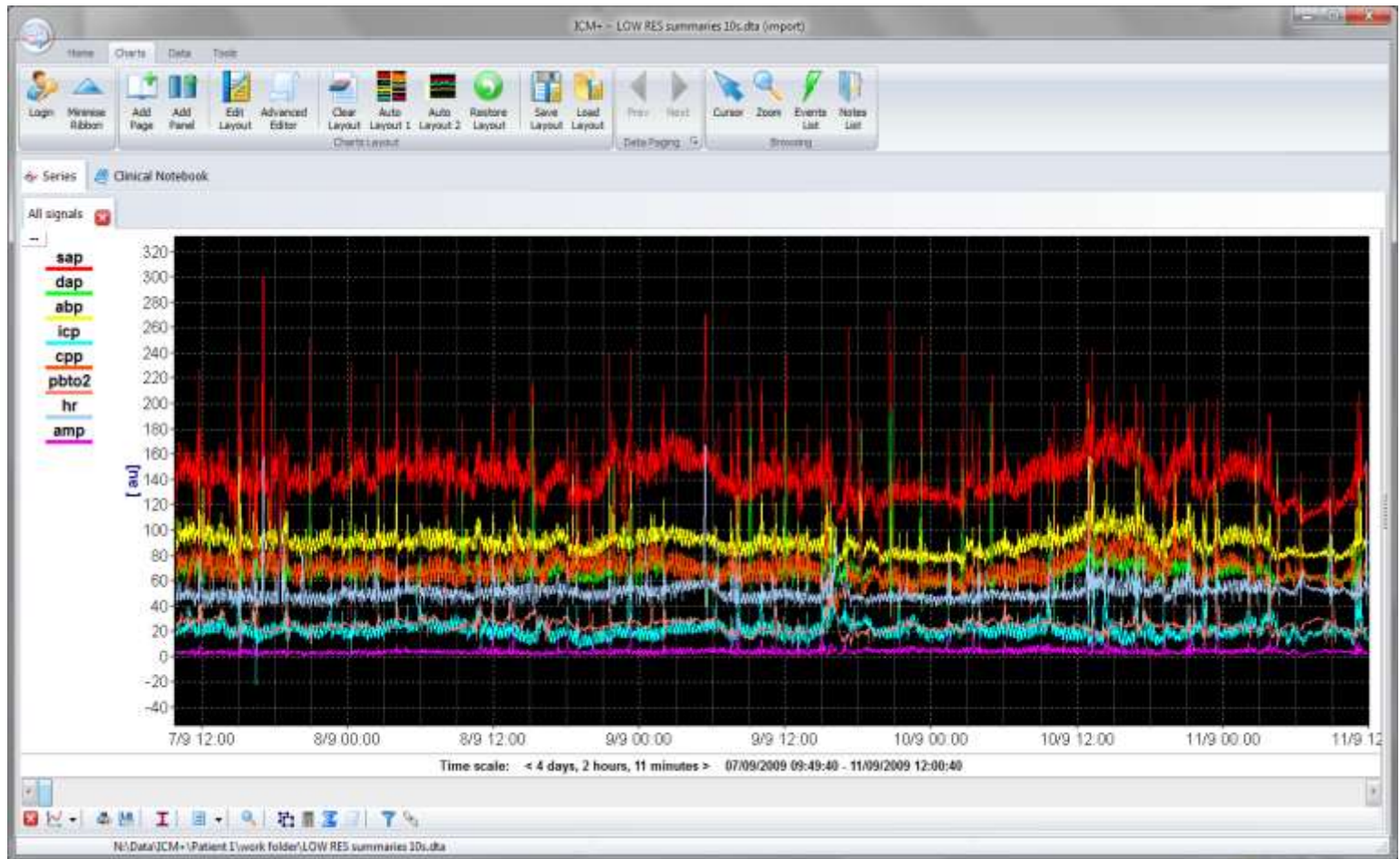


# 'LOW RES summaries 10s.dta' data file

To speed up further analysis we'll use pre-processed data source file (for the purpose of this workshop)

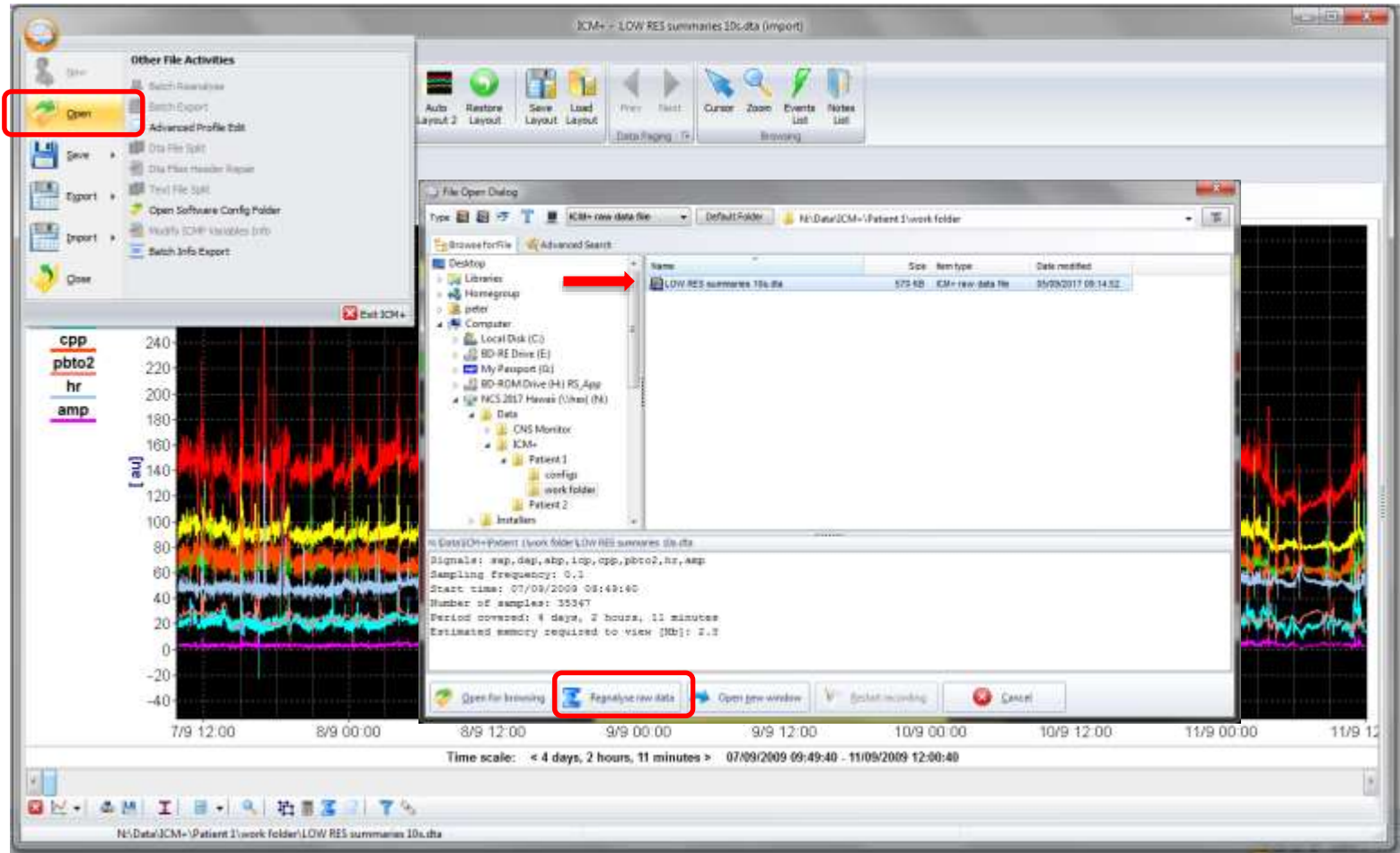


# 10s downsampled data file



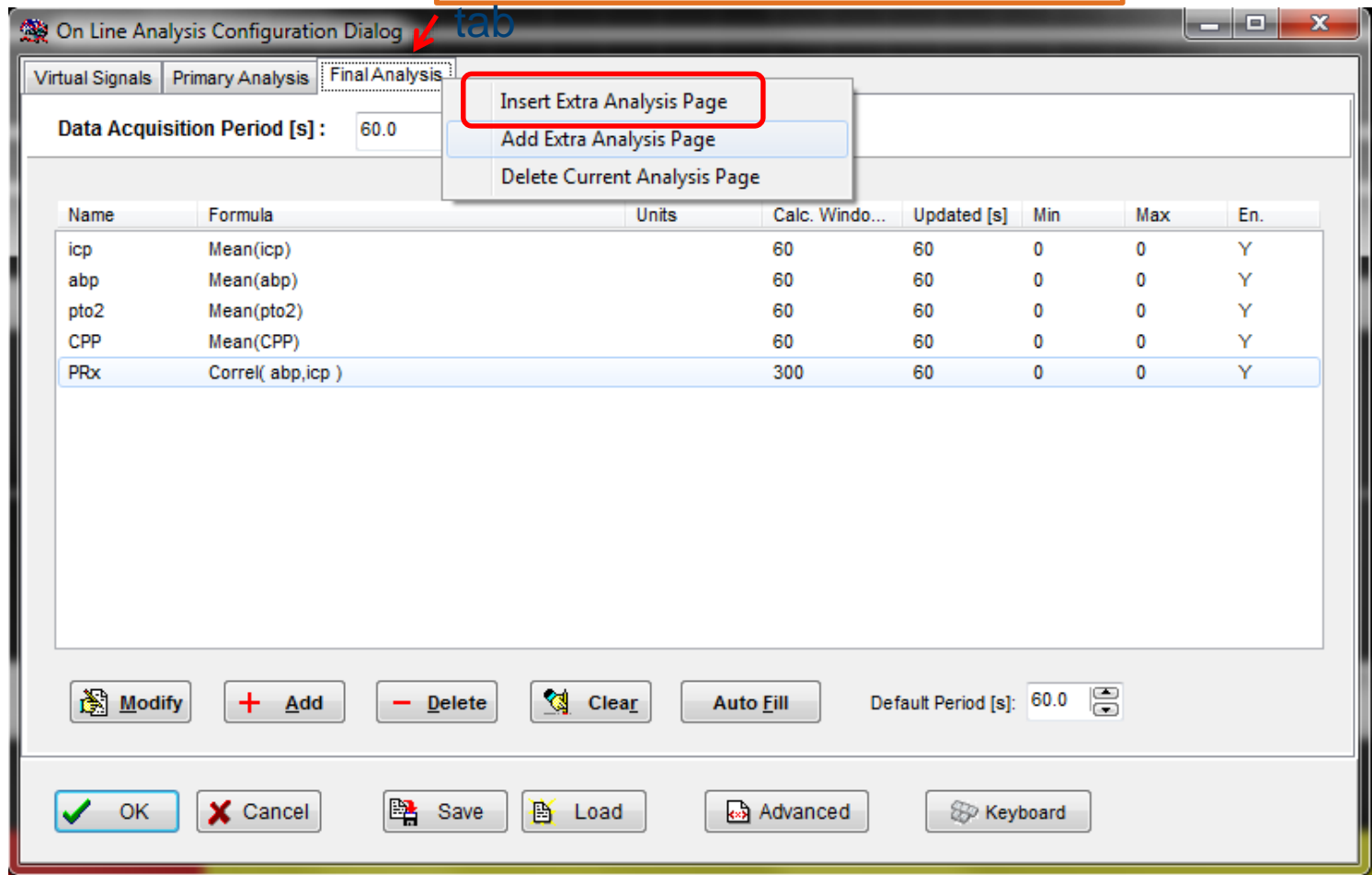


# Select the LOW RES data file for analysis

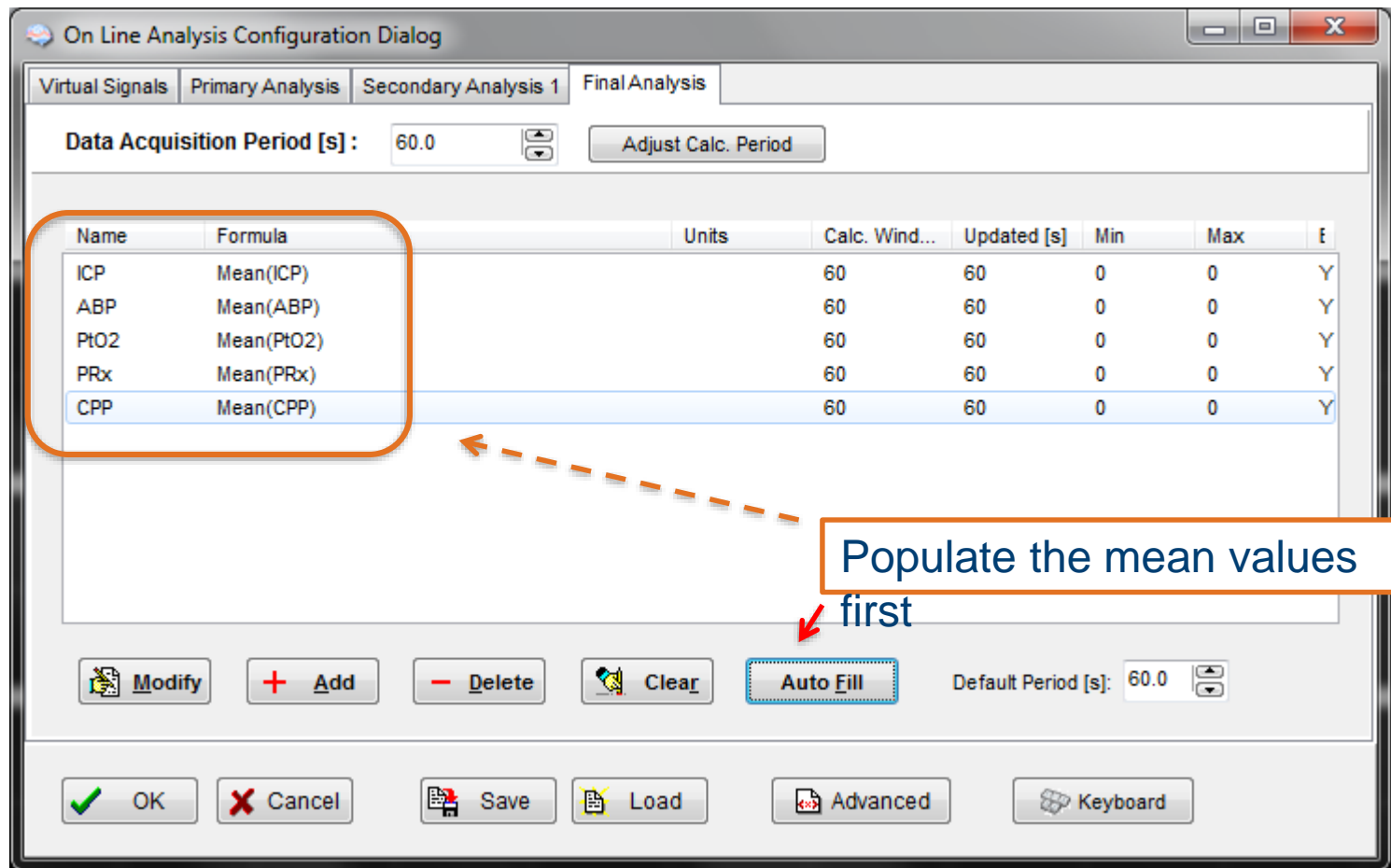


# Configuring real time CPPopt calculation

Right click on the 'Final Analysis' tab



# Configuring real time CPPopt calculation



# Configuring real time CPPopt calculation

Final Analysis Configuration Editor

Name : CPPopt

Units :

Calculation Window Specification

Calculation Period : 1440

Update Period : 60

Brief description of the parameter

Optimal Cerebral Perfusion

Enabled ☒

Formula:

`OptimalValue( CPP,PRx,'BINS=16&MINVAL=40&MAXVAL=120')`

Function description:

This function, which can be used to track 'Optimal CPP', divides the data into bins and fits a parabolic function to the resulting XY plot. Point of the minimum of the curve is the optimal CPP. If the threshold is set the function can return the lower and upper breakpoints. The function can also return:

- relative size of data included in the curve
- span of the fitted curve, and
- the fit type:
- 0 - no fit possible,

Function options

Function: **OptimalValue**

Missing Data Limit [%]	100.00
Number of bins	16
Minimum bin value	40
Maximum bin value	120
Minimum bin data count [%]	1.00
Minimum included data [%]	50.00
Minimum Y span	0.00
Concave	<input type="checkbox"/>
Need not include 'best'	<input type="checkbox"/>
Use error weighting	<input type="checkbox"/>
Enforce Y range	<input type="checkbox"/>
Enforce Y region - Min	0.00
Enforce Y region - Max	0.00
Optimal range threshold	NAN
Min value of lower breakpoint	0.00
Max value of upper breakpoint	0.00
Output value type	Optimal X

Function Arguments :

CPP

PRx

abp

CPP

icp

PRx

pto2

Choose Optimal Value function

the input variables

# Calculating lower limit of AR

Final Analysis Configuration Editor

Name : LLA

Units :

Enabled ☒

Calculation Window Specification

Calculation Period : 14400 s

Update Period : 60 s

Brief description of the parameter

Lower limit of autoregulation

Formula:

OptimalValue( CPP,PRx,'BINS=16&MINVAL=40&MAXVAL=120&THRSHLD=0.2&OUT=LL' )

abs

Function :

OptimalValue

Options:

MDLIM Missing Data Limit [%] (0 - 100)

BINS Number of bins (1 - 1000)

MINVAL Minimum bin value

MAXVAL Maximum bin value

MINBIN Minimum bin data count [%]

MINDATA Minimum included data [%]

MINYSP Minimum Y span

CONCAVE Concave (Y/N)

Function description:

This function, which can be used to track 'Optimal CPP', divides X variables values into bins and calculates a parabolic function to the resulting XY plot. Point of the minimum/maximum of the function is returned. If the threshold is set the function can return the lower and upper limit of the optimal range. The function can also return:

- relative size of data included in the curve fit,
- span of the fitted curve, and
- the fit type:

0 - no fit possible,

Function options

Function: OptimalValue

Missing Data Limit [%] 100.00

Number of bins 16

Minimum bin value 40

Maximum bin value 120

Minimum bin data count [%] 1.00

Minimum included data [%] 50.00

Minimum Y span 0.00

Concave ☐

Need not include 'best' ☐

Use error weighting ☐

Enforce Y range ☐

Enforce Y region - Min 0.00

Enforce Y region - Max 0.00

Optimal range threshold 0.2

Min value of lower breakpoint 0.00

Max value of upper breakpoint 0.00

Output value type Lower Opt Limit

OK Cancel Keyboard



# Analysis with CPPopt added

On Line Analysis Configuration Dialog

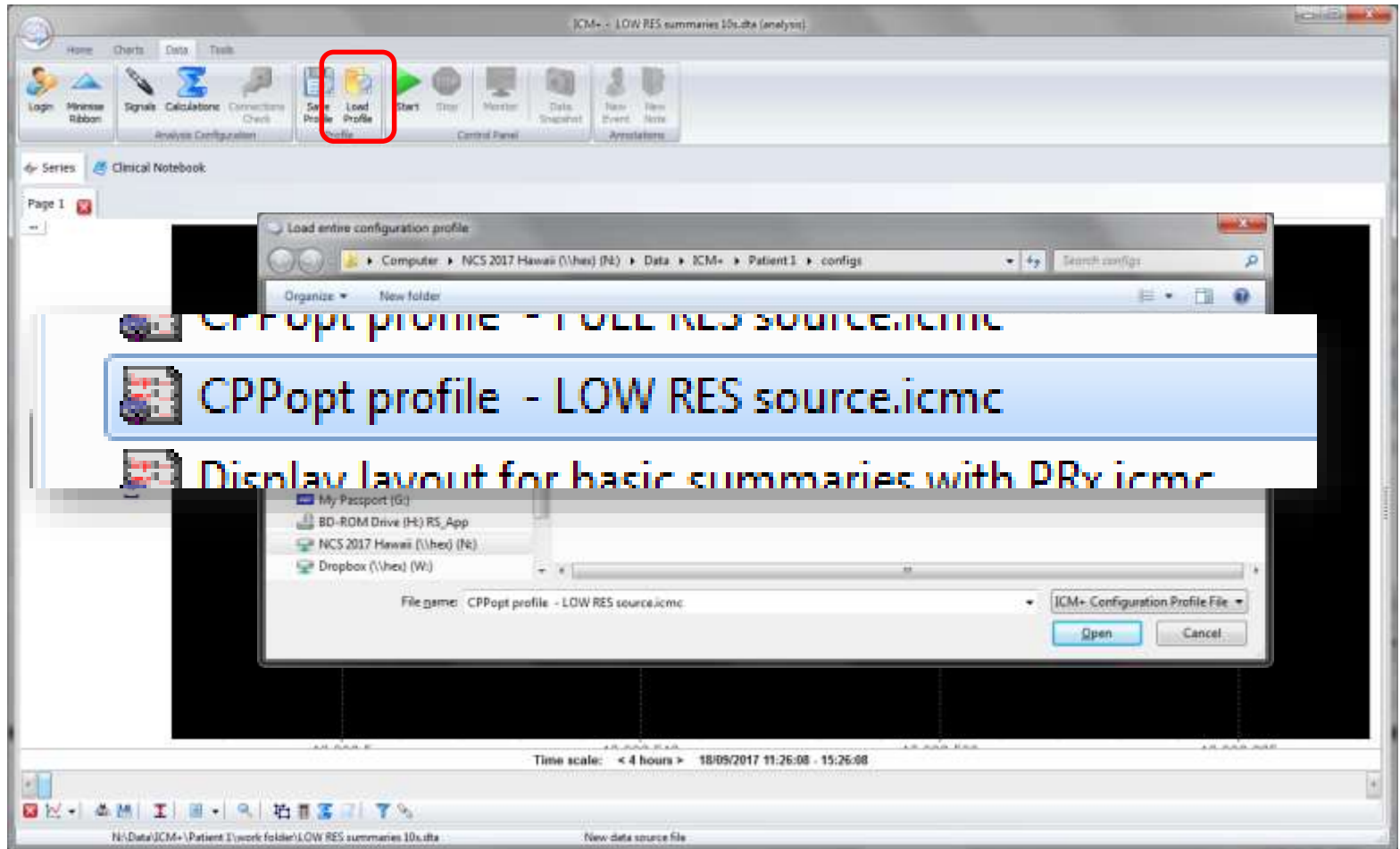
Virtual Signals Primary Analysis Secondary Analysis 1 Final Analysis

Data Acquisition Period [s]: 60.0

Name	Formula	Units	Calc. Windo...	Updated [s]	Min	Max	En.
icp	Mean(icp)		60	60	0	0	Y
abp	Mean(abp)		60	60	0	0	Y
pto2	Mean(pto2)		60	60	0	0	Y
CPP	Mean(CPP)		60	60	0	0	Y
PRx	Mean(PRx)		60	60	0	0	Y
CPPopt	OptimalValue( CPP,PRx,'BINS=16&MINVAL=40&MA		1440	60	0	0	Y

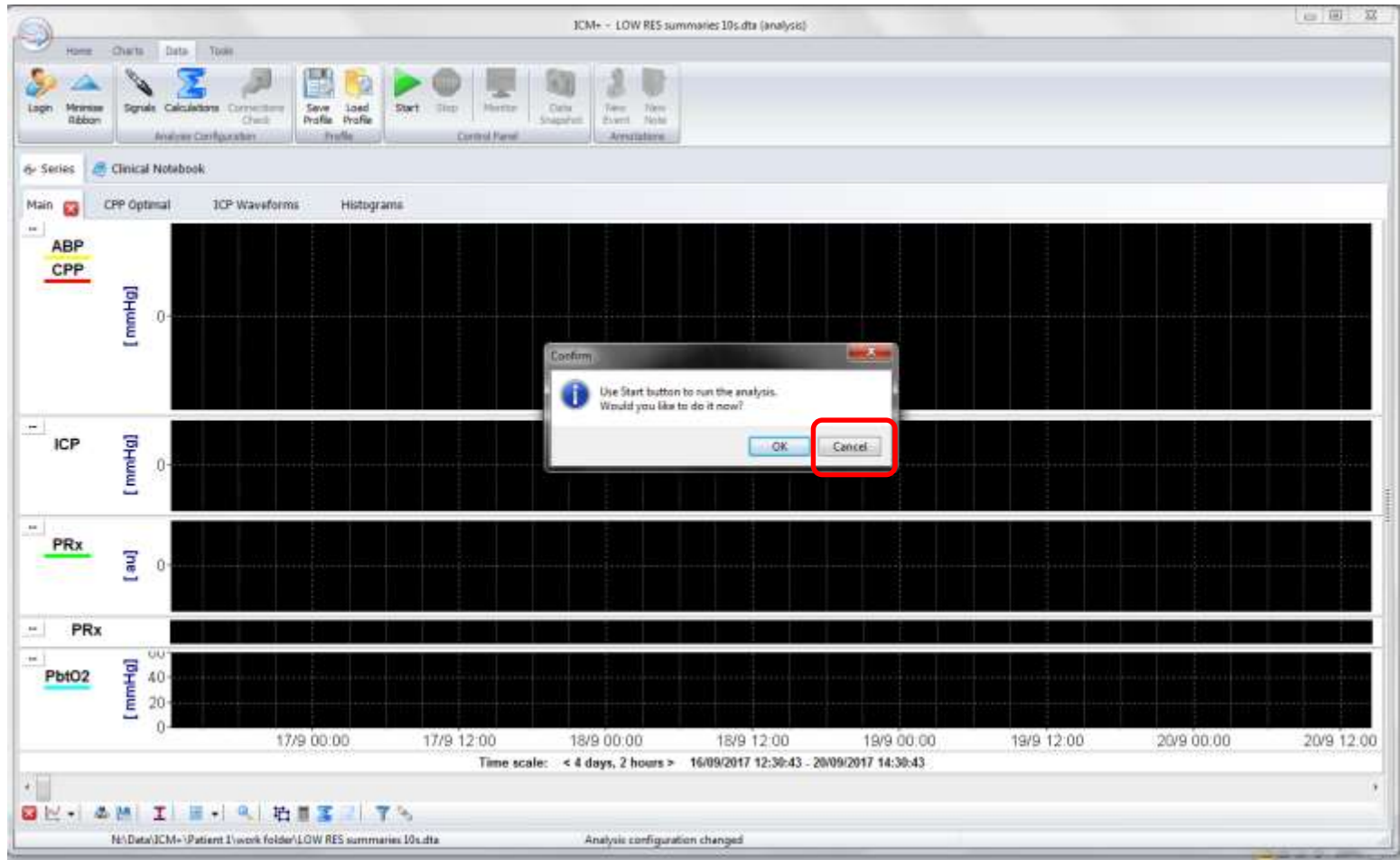
Default Period [s]: 60.0

# Load the complete analysis configuration profile



# Do not start analysis yet

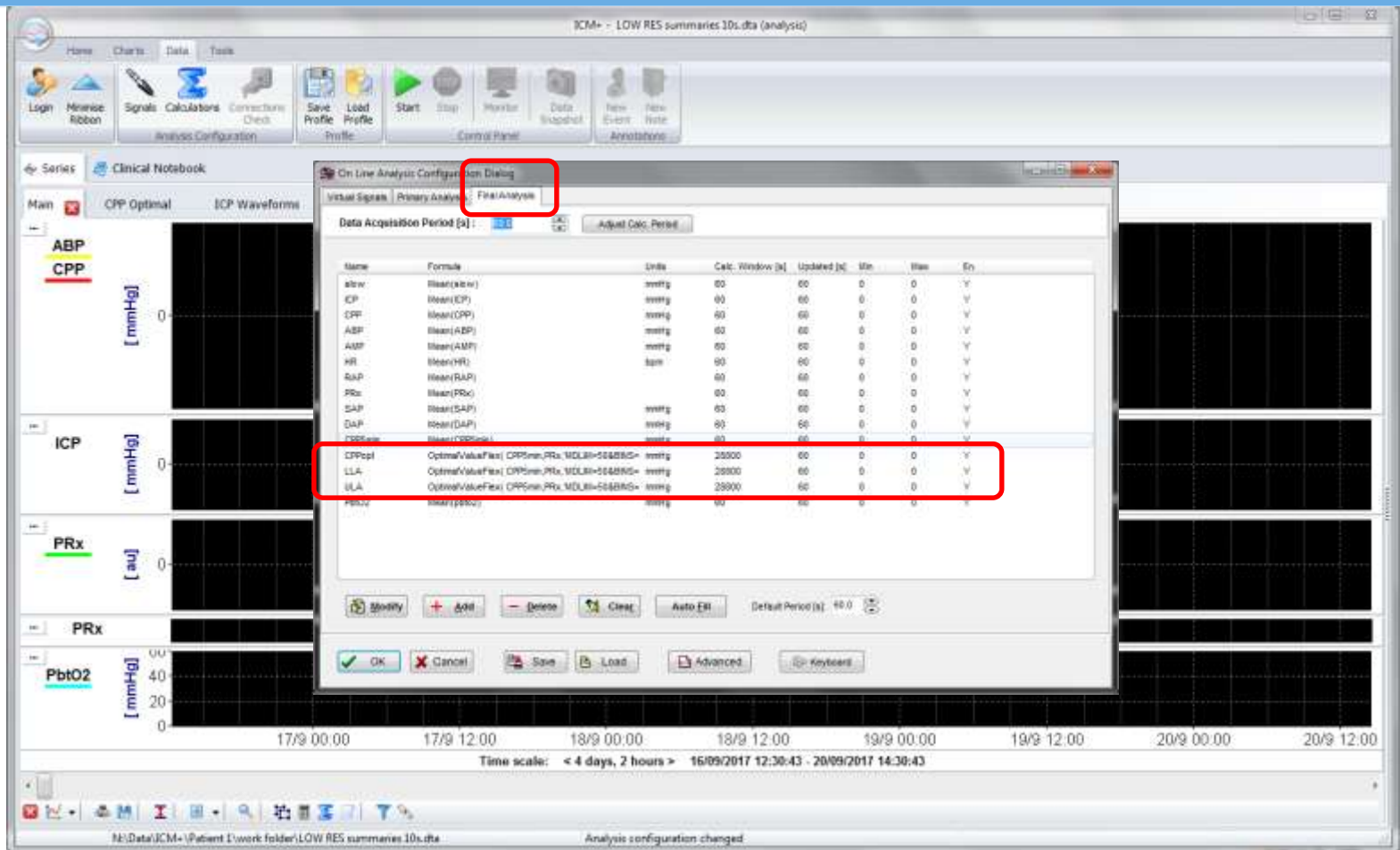
## Lets examine the configuration first



# View the analysis configuration

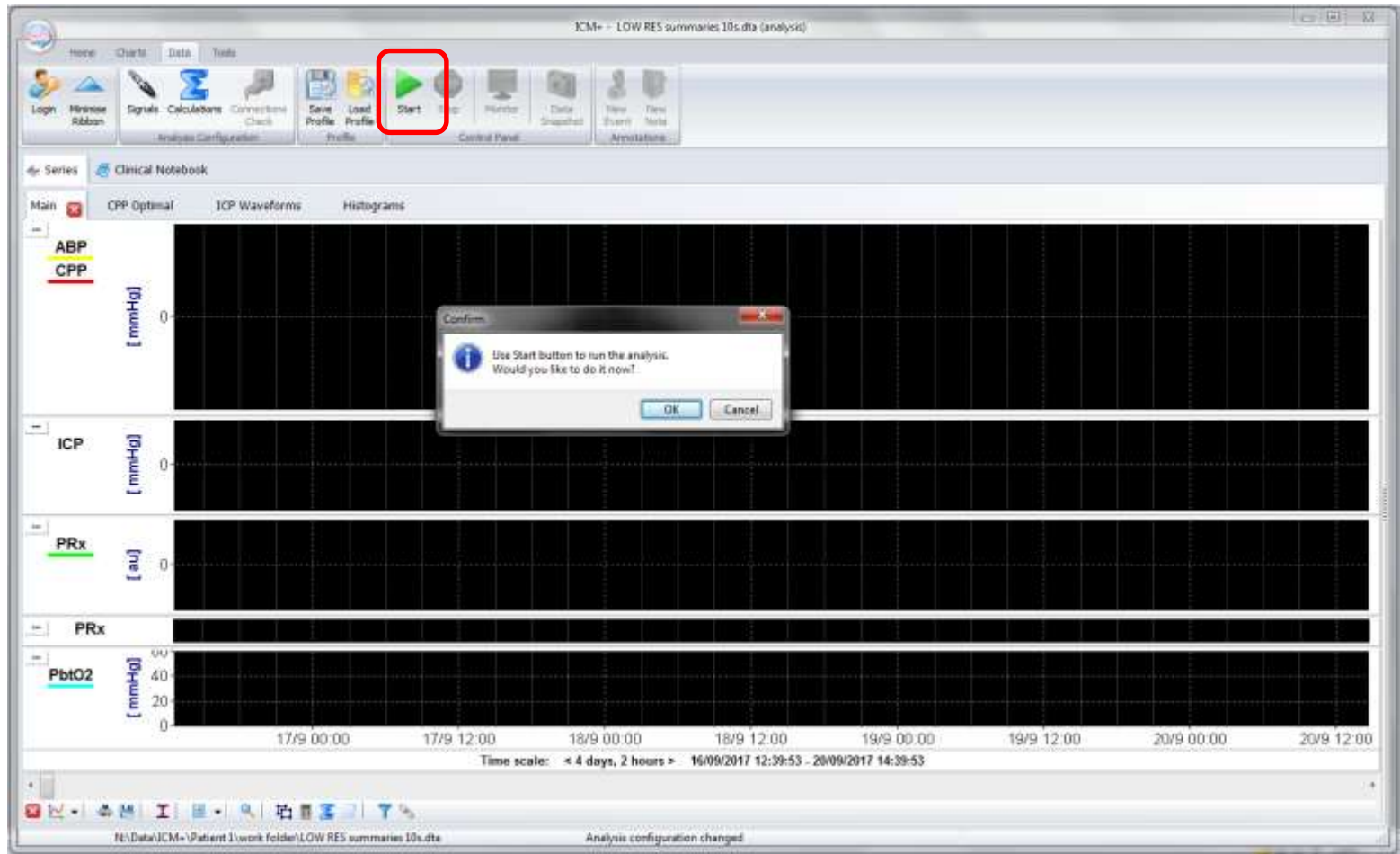


# View the analysis config

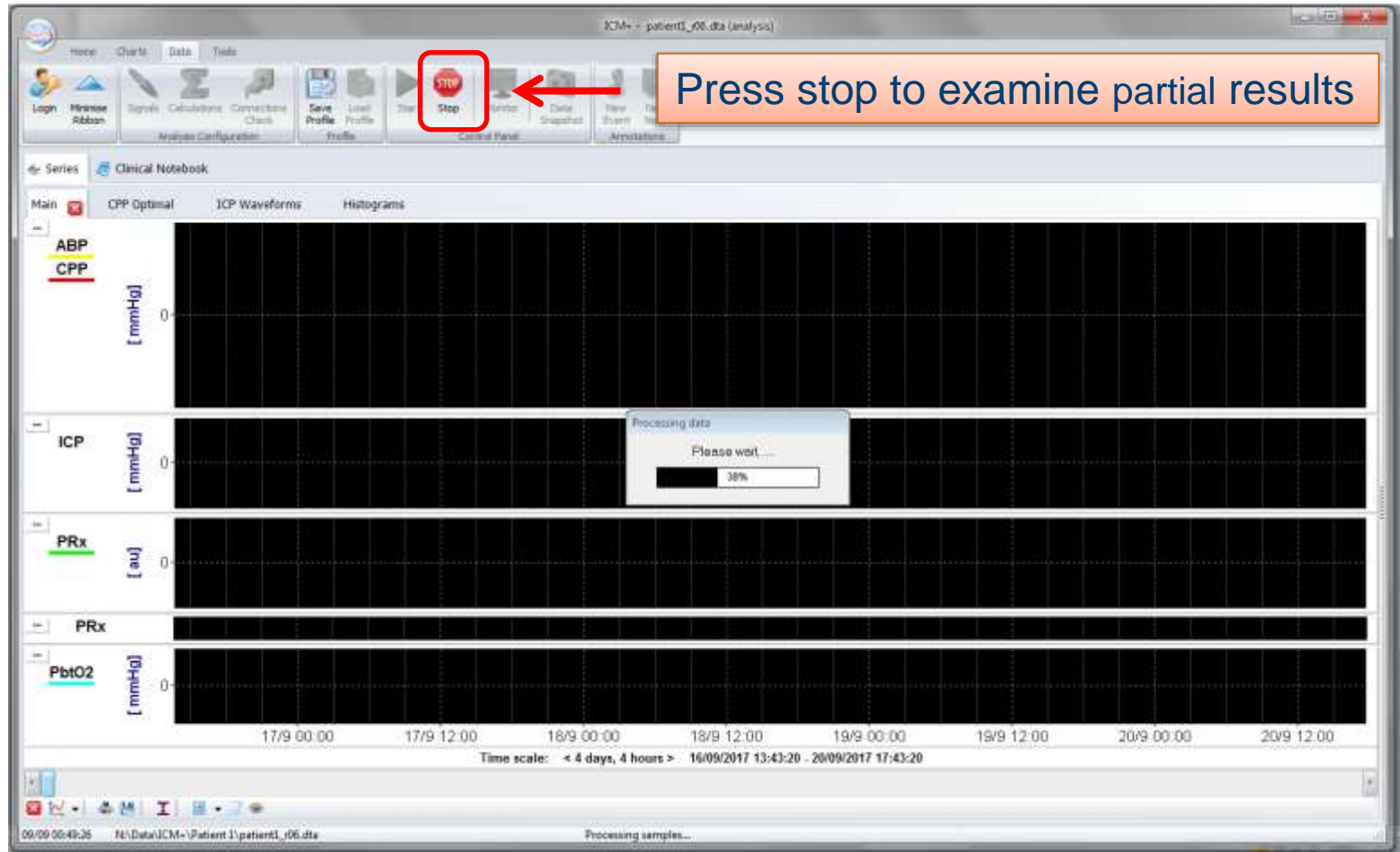




# Start the analysis



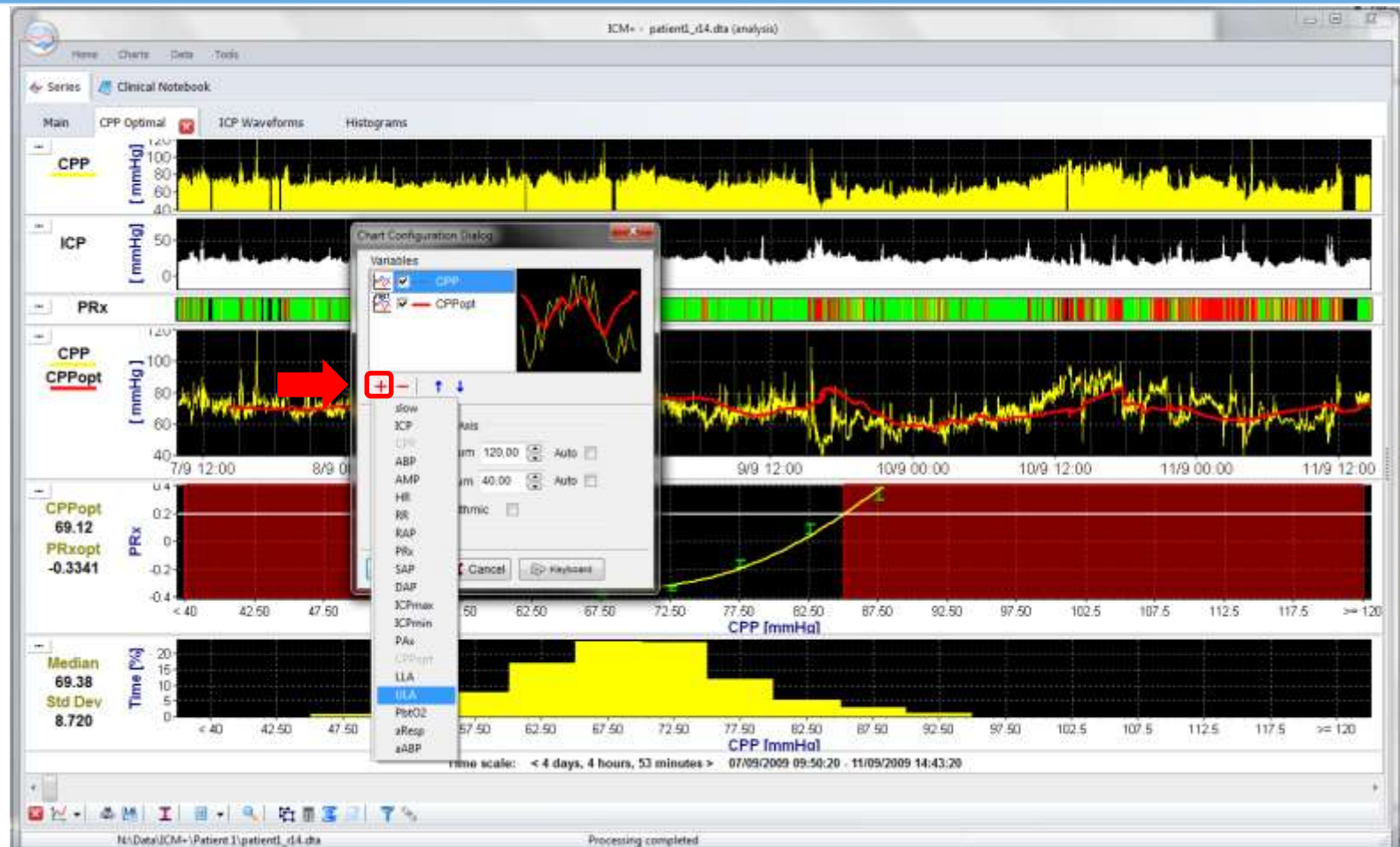
# Running the calculation



# Results - CPPopt trend page



# Adding variables to the chart





# Adding ULA and LLA to the chart

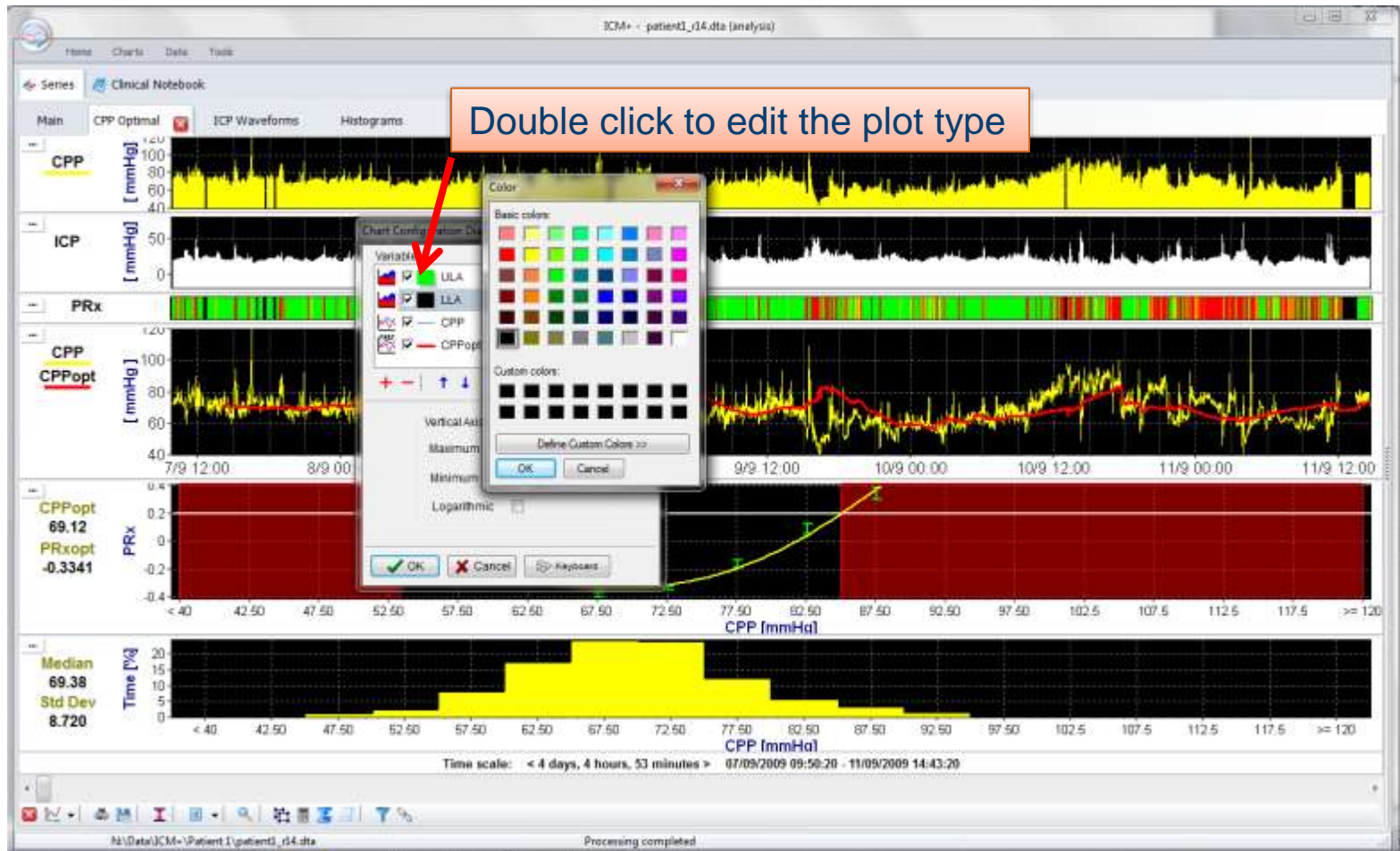




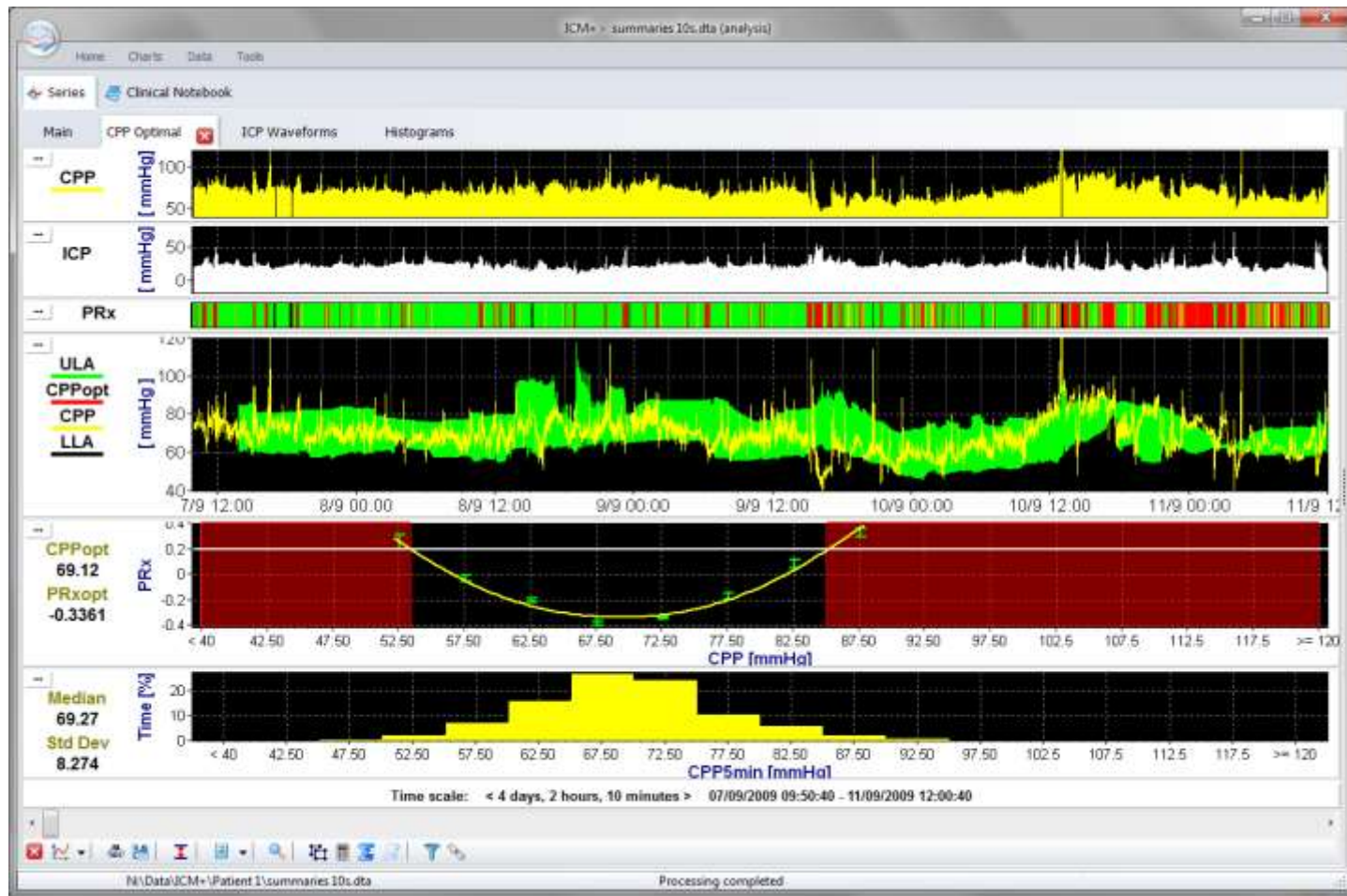
# Modify the plot type to 'Area'



# Modify the colours



# Final presentation of the limits of autoregulation trend (the green band)



# Time to explore other examples

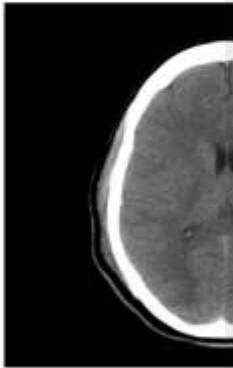
## Patient 1

### Presentation:

19 year old male

GCS 7

diffuse axonal injury on



Monitoring shows good

Good recovery at 6 months

## Patient 2

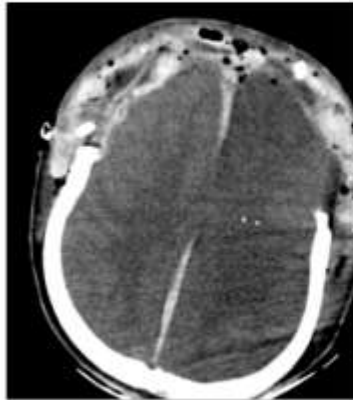
### Presentation:

20 yr male,

Motor cyclist hit by a car.

GCS 9,

initial CT with left frontal contusions (op CT shown).



Monitoring features – Disturbed PRx,

Patient died.

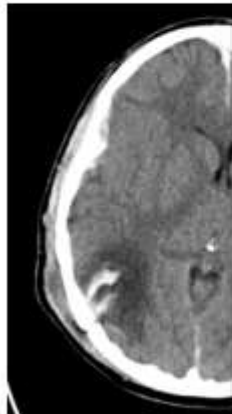
## Patient 3

### Presentation

18 year-old female

RTA GCS 6, pupils reactive

On CT contusions with oedema  
Decompression after 4 days



Before

Severe disability at 6 months

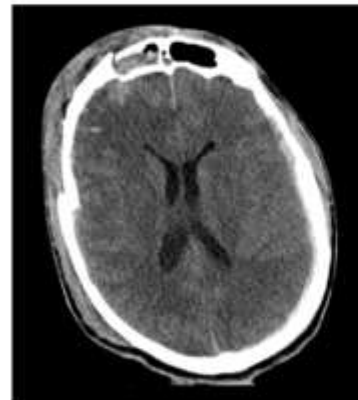
## Patient 4

### Presentation

25 year-old male RTA (pedestrian hit by lorry).

Both pupils reactive and GCS 3.

Initial CT: Left subdural, frontal contusions, skull fracture.



Monitoring features- 'solid red line' PRx, and high PbT02 and then refractory high ICP.

Patient died.