Full-waveform IP processing

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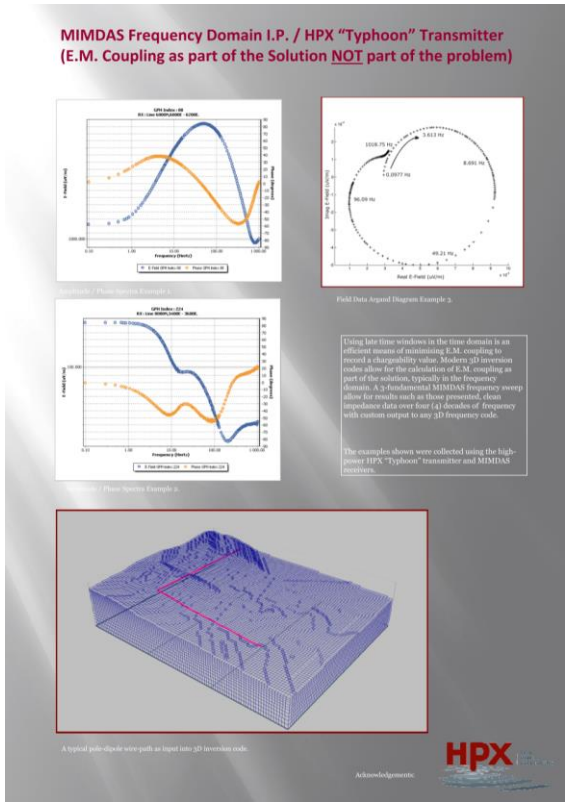
HPX Approach

- HPX operates its own high power IP & EM transmitter: Typhoon
  - High power
  - Clean & stable transmit waveform
  - Extremely fast and clean switching
  - Programmable
- Extensive pre- and post-survey modelling applied to understand the data
- Use the technology to leverage access to exploration deals
- Not offered as a service

HPX Approach

- We do not routinely operate our own receivers
  - We do have Iris Elrec Pro full waveform receivers
- Contract out our receiver acquisition to best local system/provider available
  - Any receiver system can be used
- Time or frequency domain
- Have worked with data from:
  - DIAS
  - GRS Australia & Chile
  - Search Ex
  - SJ Geophysics
  - Southern Rock



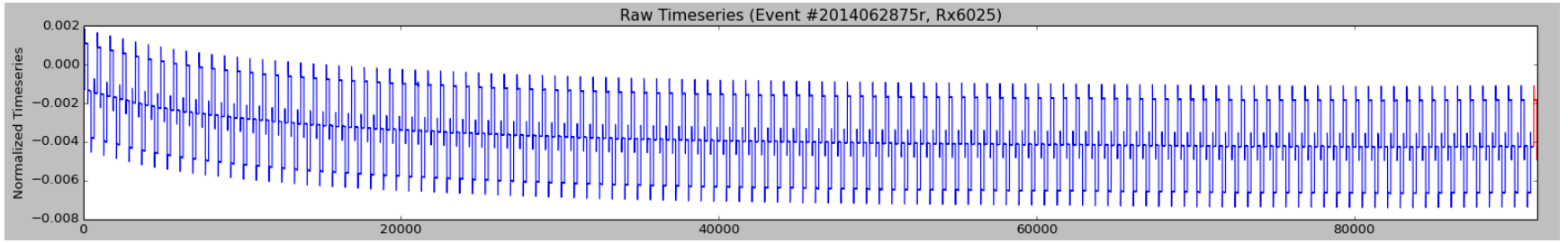
(GRS, ASEG, 2013)

Processing Workflow

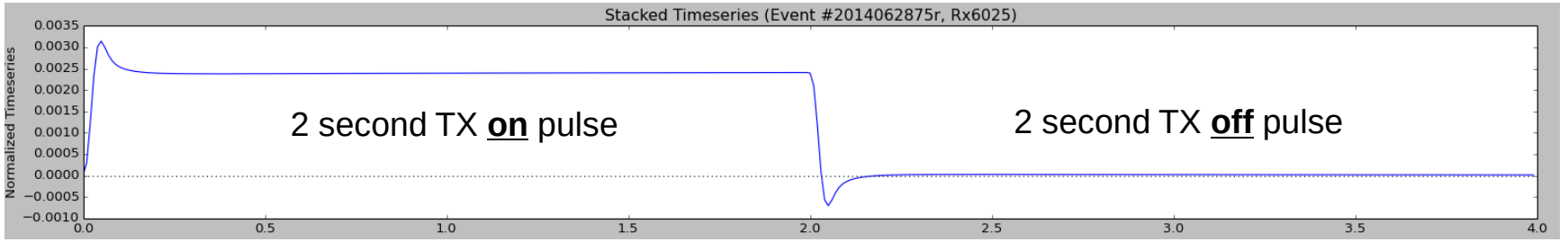
- Maintain our own custom full waveform processing software: IPQC
- Basic workflow:
  1. Convert file formats
  2. Import
  3. Deconvolve TX & RX (optional**) & normalise to current
  4. Trim RX timeseries (optional)
  5. Despike RX timeseries (optional)
  6. 50/60 Hz filtering (optional)
  7. Selective Halverson stacking
  8. Compute windows and errors
  9. Spatial QA/QC
  10. Export

IP Stacking

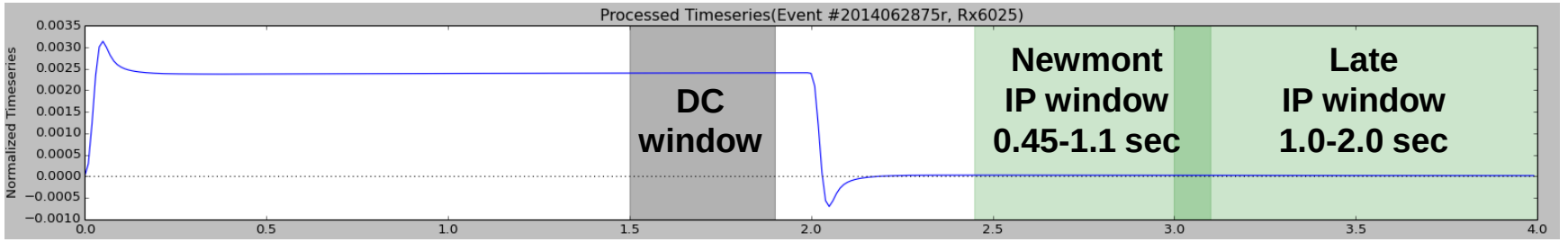
Raw Time Series



Stacked Series



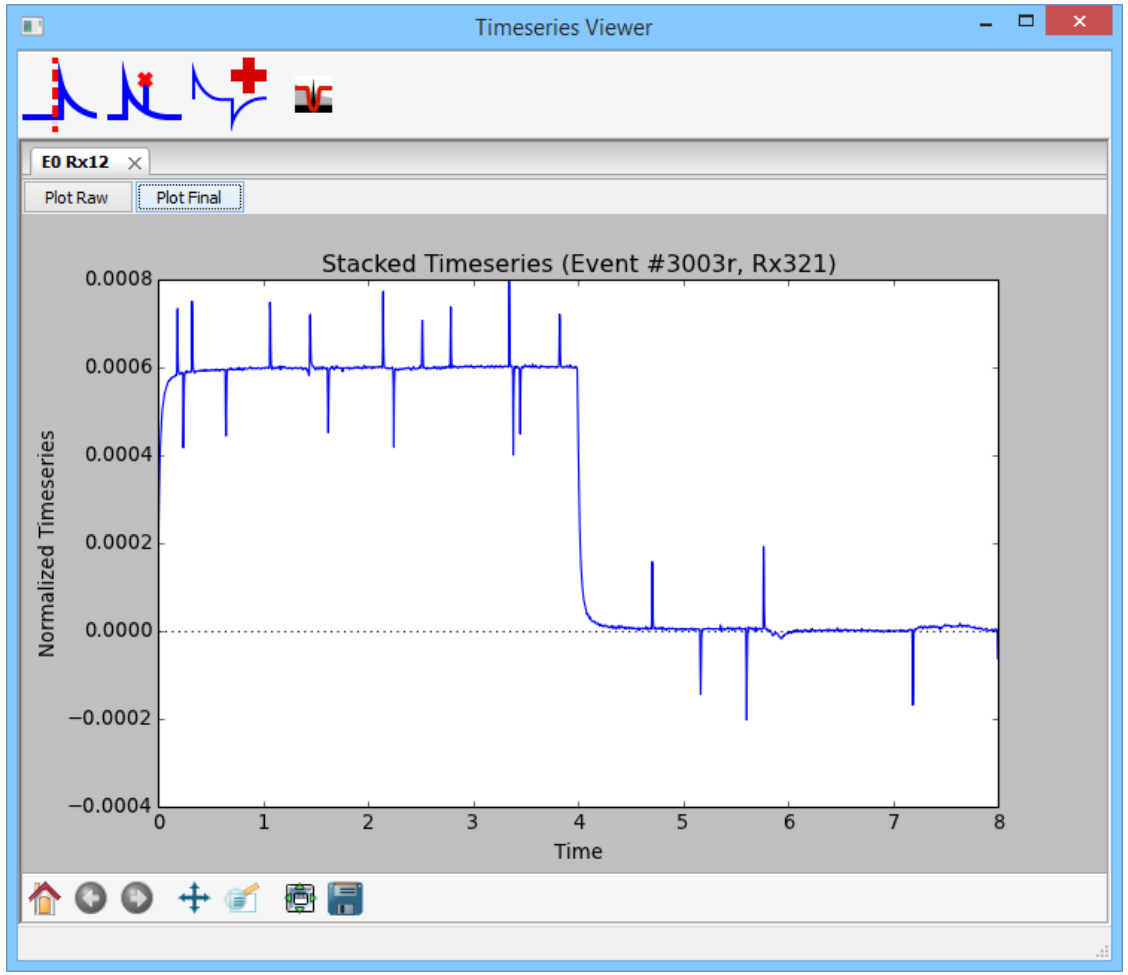
Windowed Series



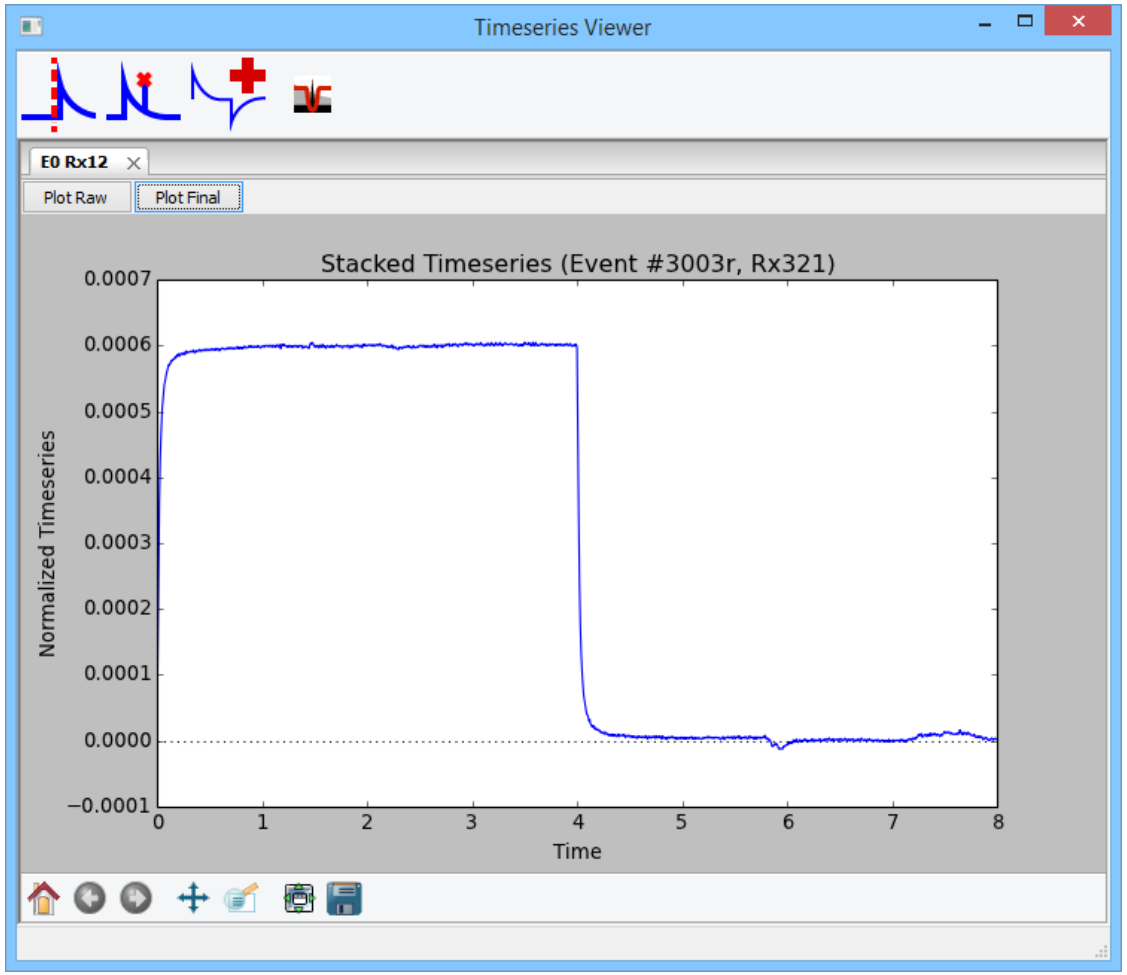
Despiking

TX Freq: 1/16 Hz
TX Amps: ~20 A
RX sample rate: 256 Hz

Before despiking



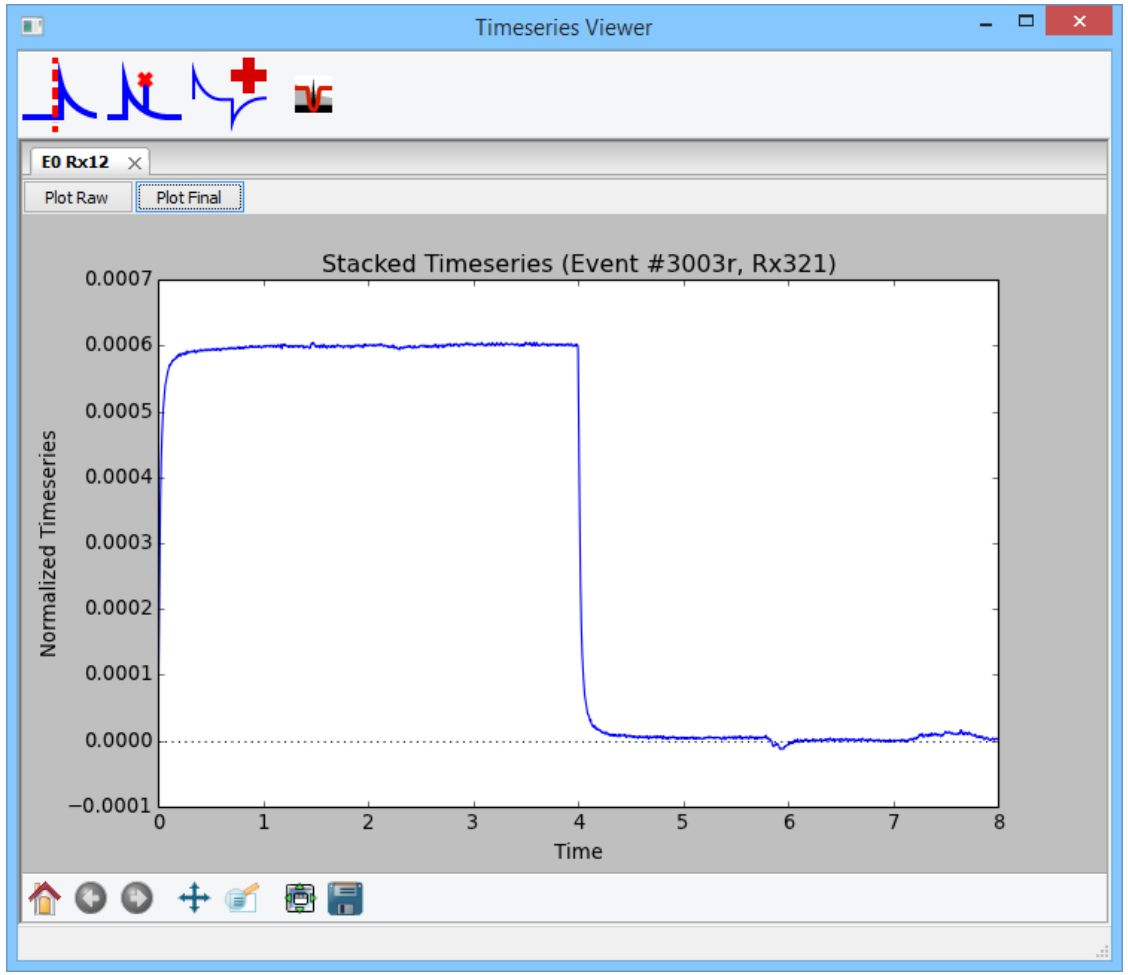
After despiking



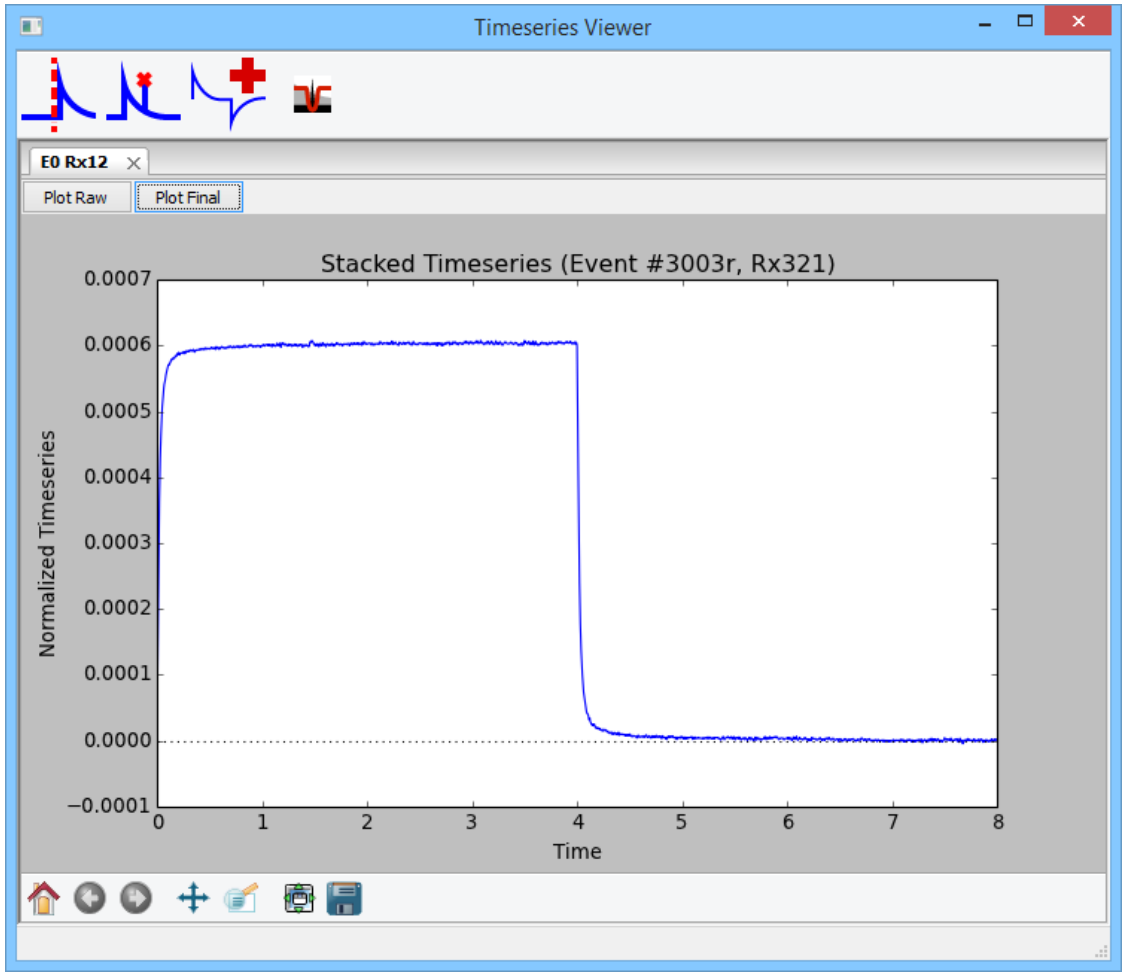
Selective stacking

TX Freq: 1/16 Hz
TX Amps: ~20 A
RX sample rate: 256 Hz

Before selective stacking



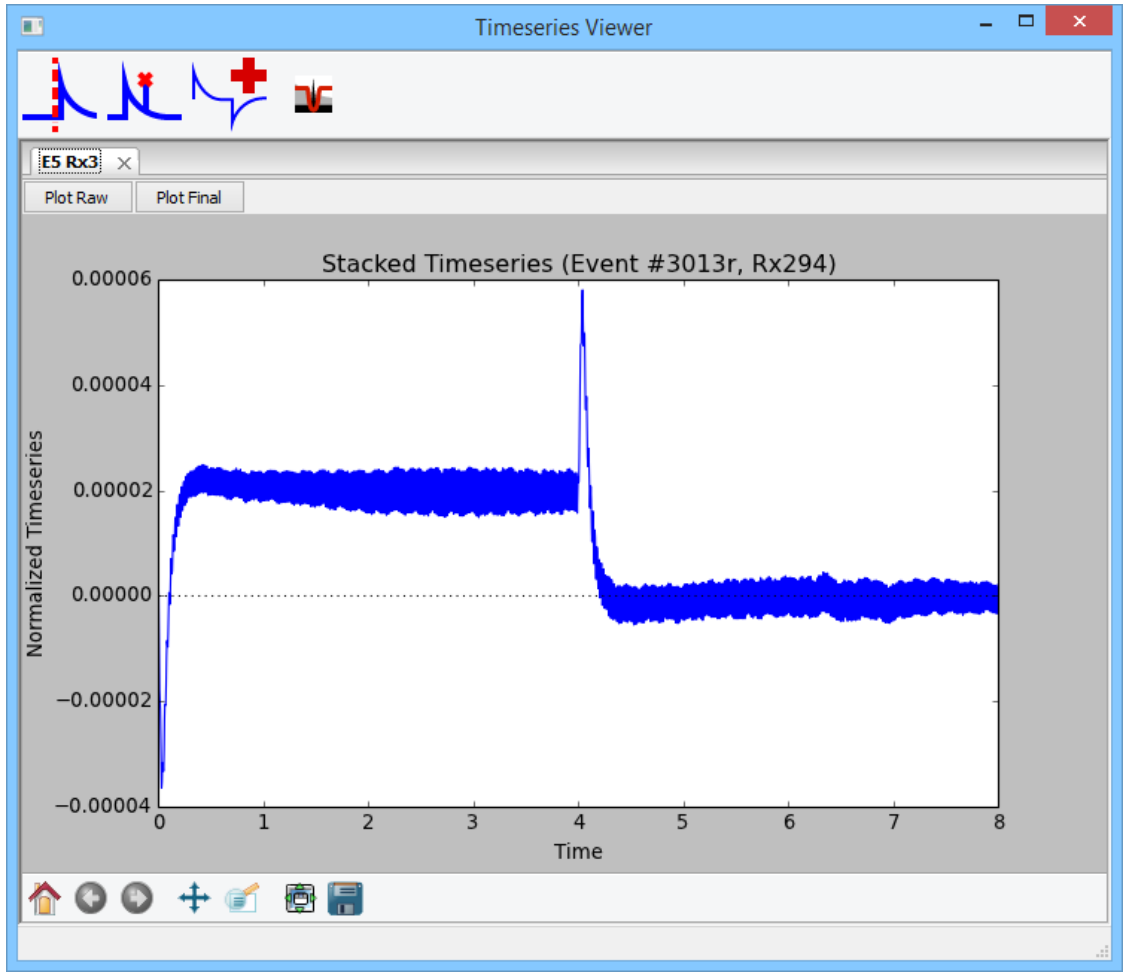
After selective stacking



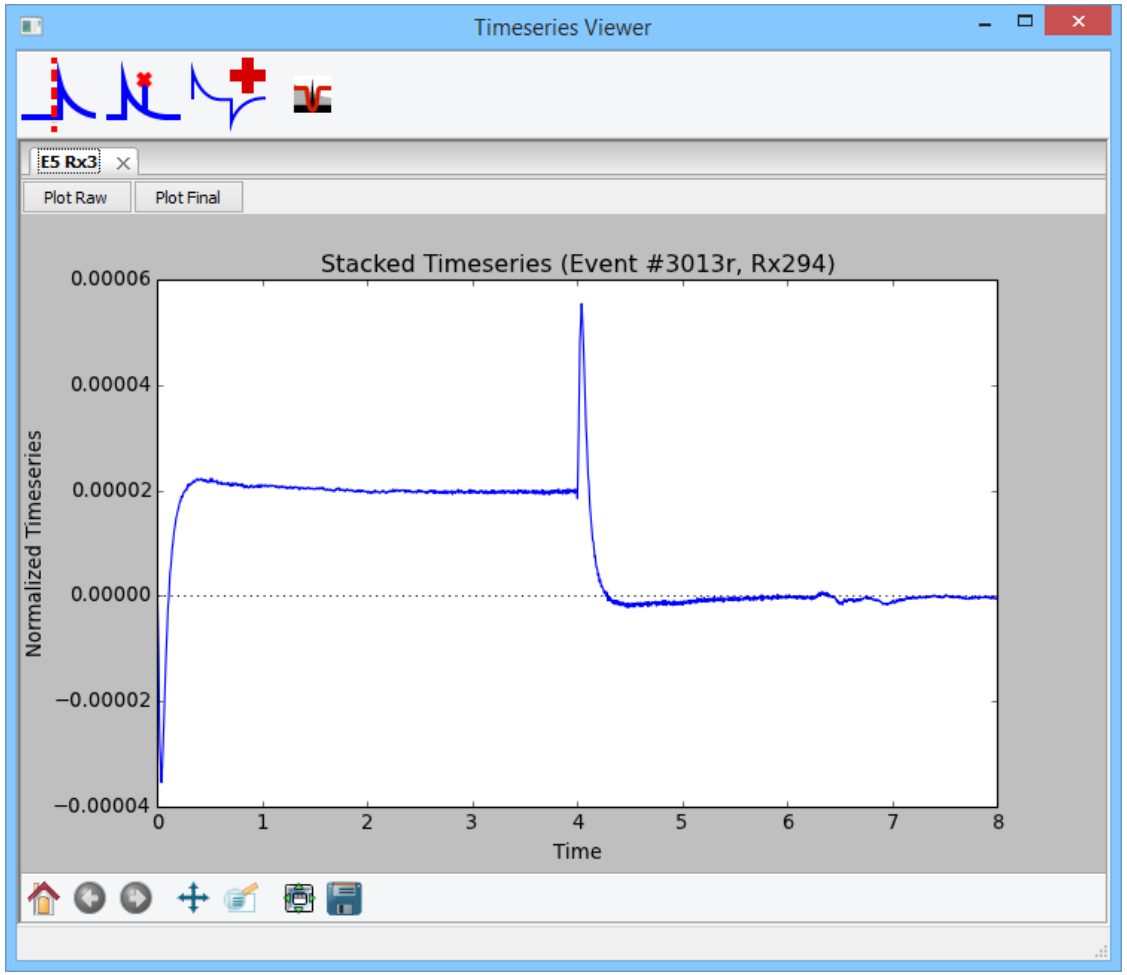
Filtering

TX Freq: 1/16 Hz
TX Amps: ~20 A
RX sample rate: 256 Hz

Before 50 Hz filtering



After 50 Hz filtering

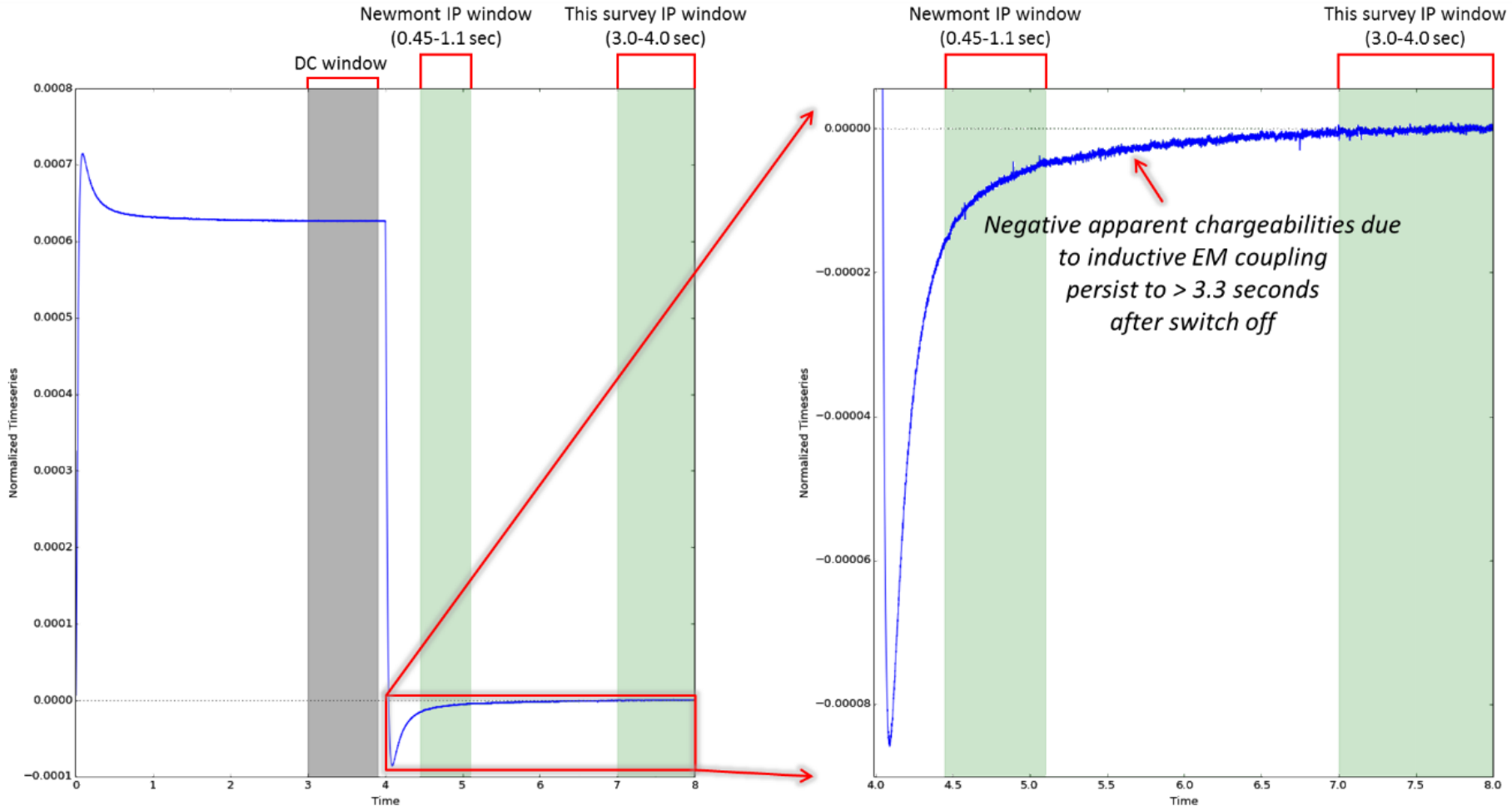


Common problems

- Inductive EM coupling
- Noise sources
- Tellurics
- Gas pipelines (cathodic protection)
- Contact problems
- Low signal

EM Coupling

TX Freq: 1/16 Hz
TX Amps: ~30 A
RX sample rate: 2000 Hz



EM Coupling

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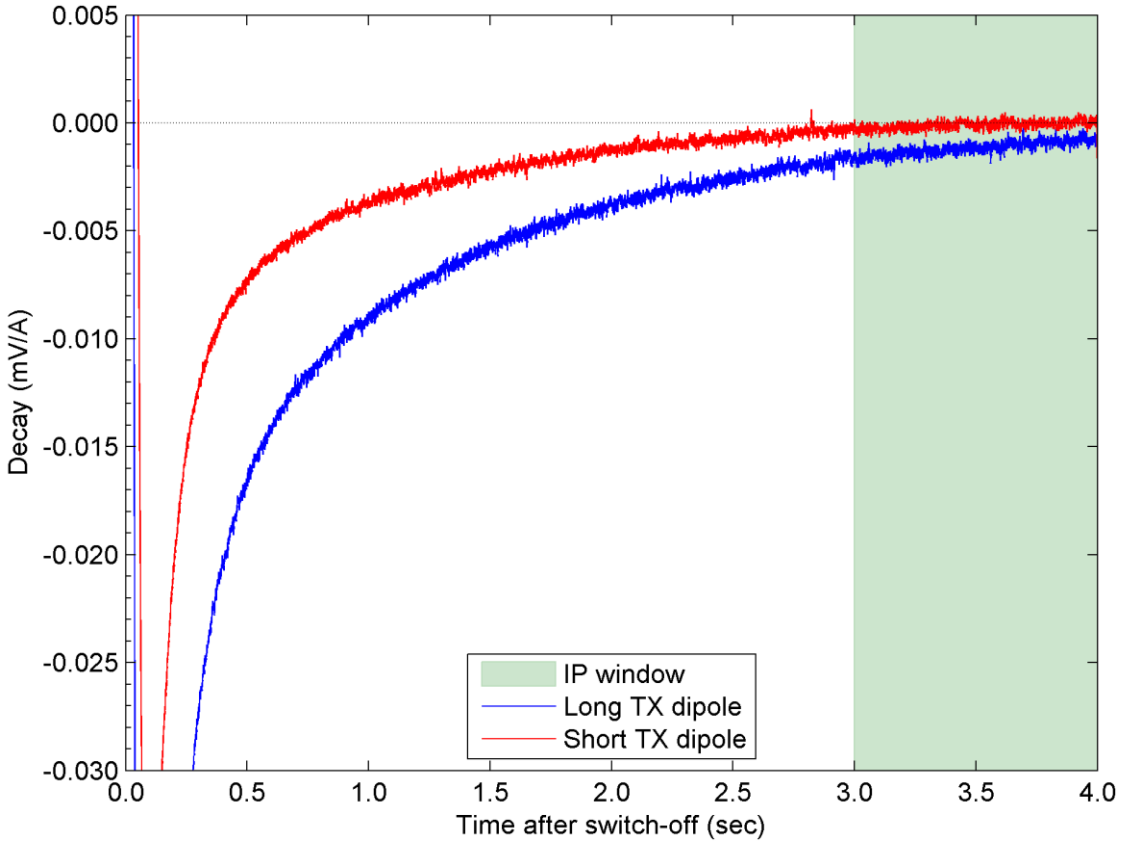
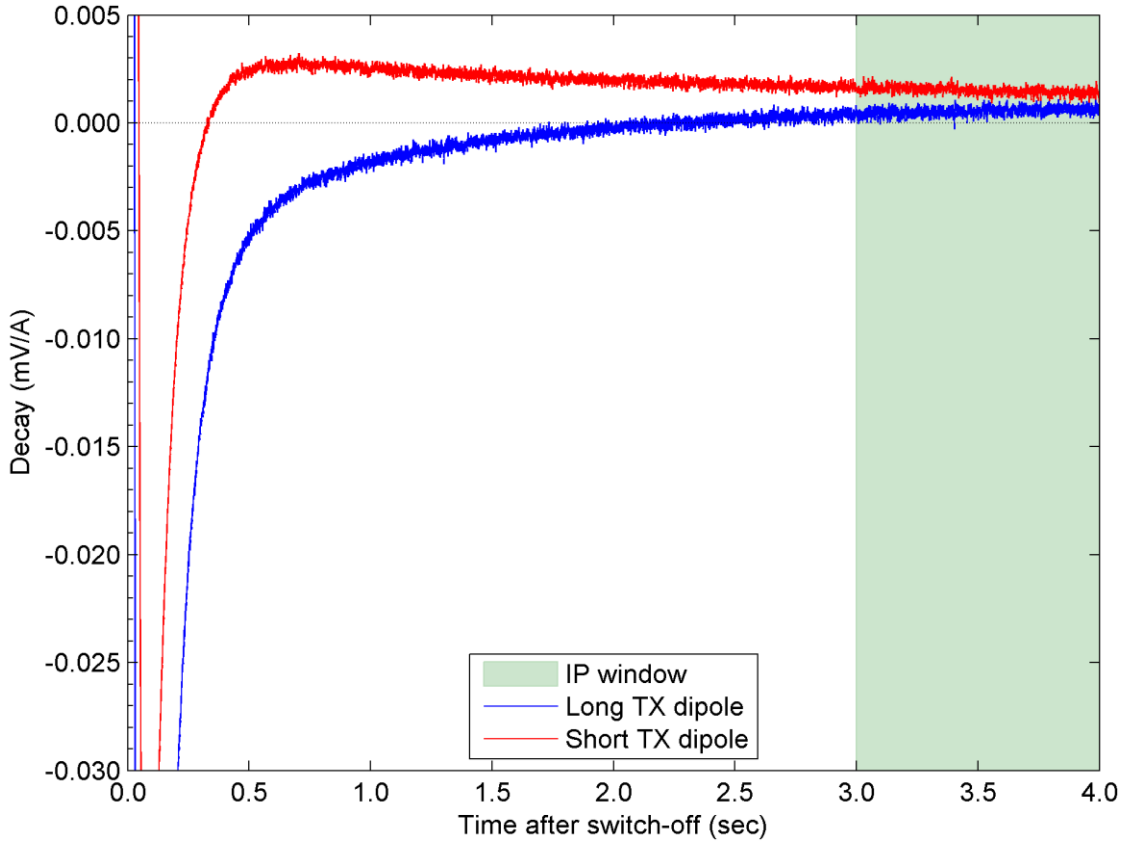
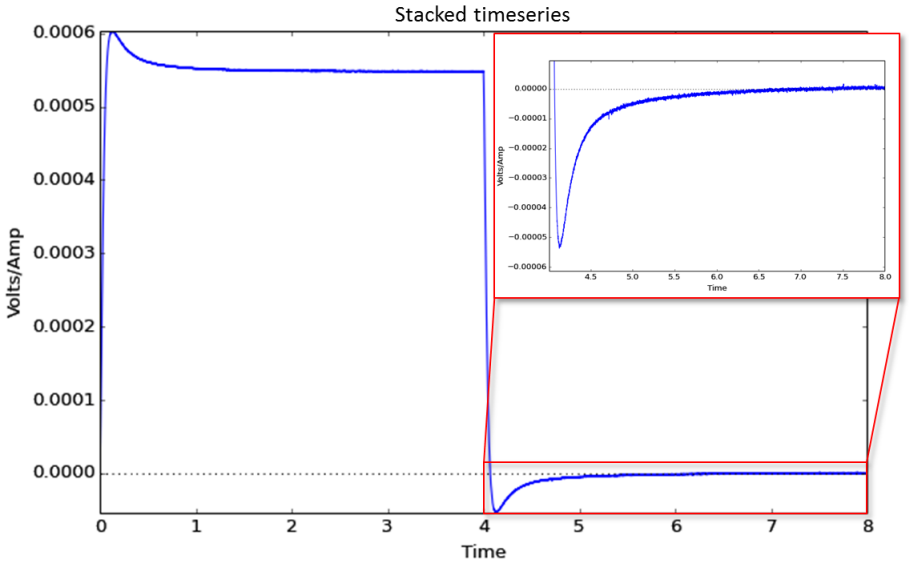
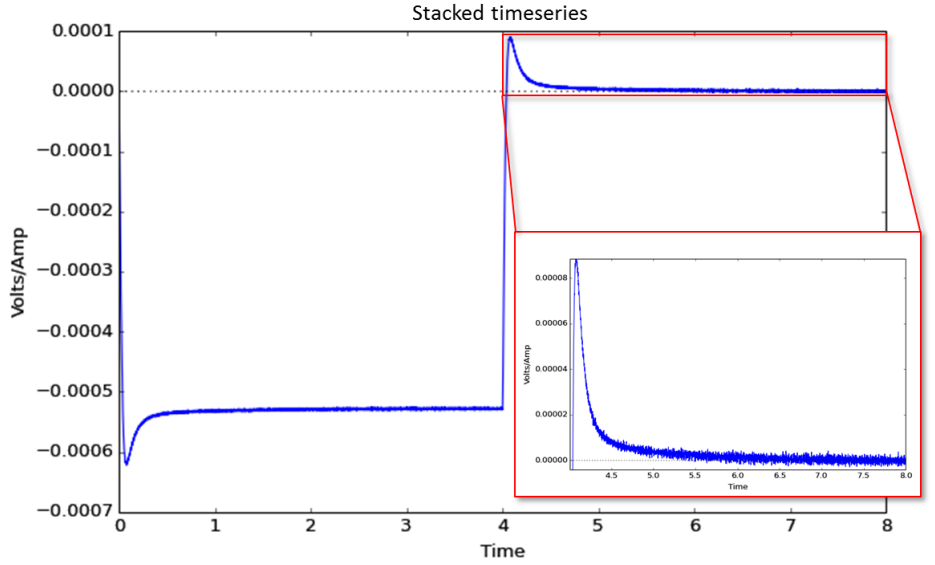


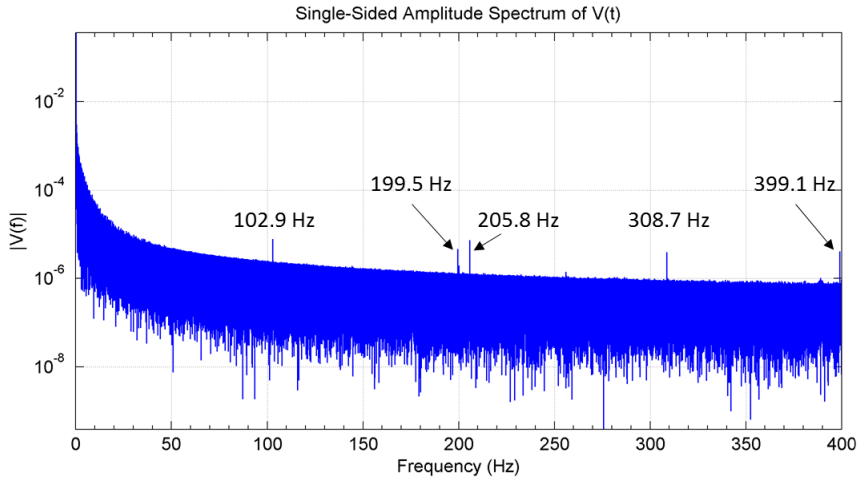


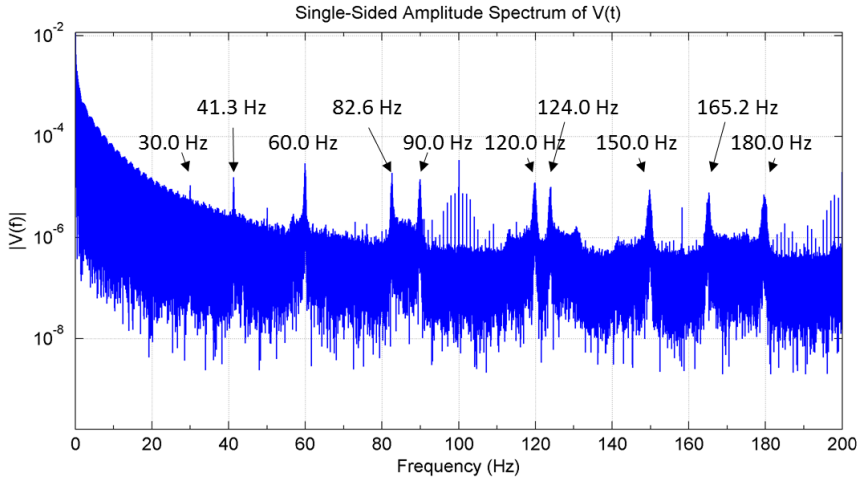
Noise sources

TX Freq: 1/16 Hz
TX Amps: ~30 A
RX sample rate: 2000 Hz









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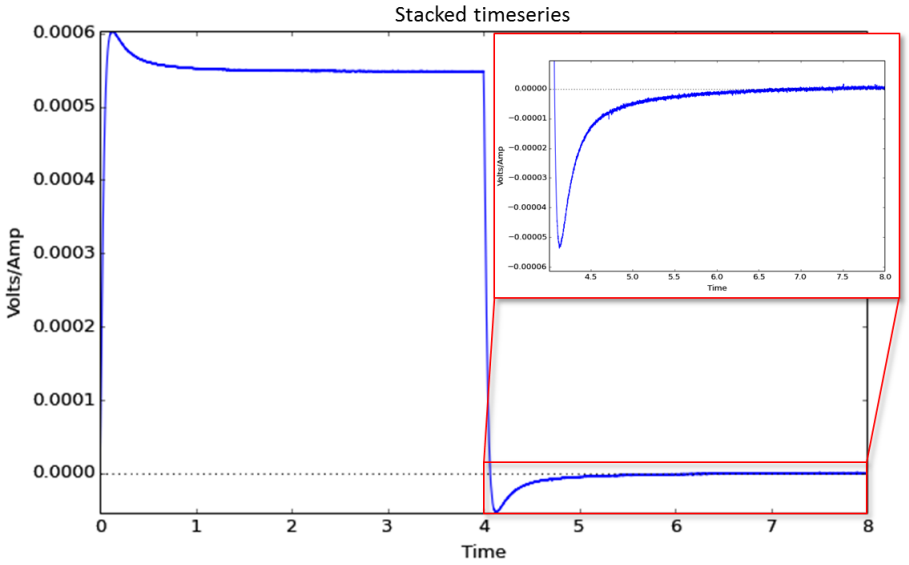
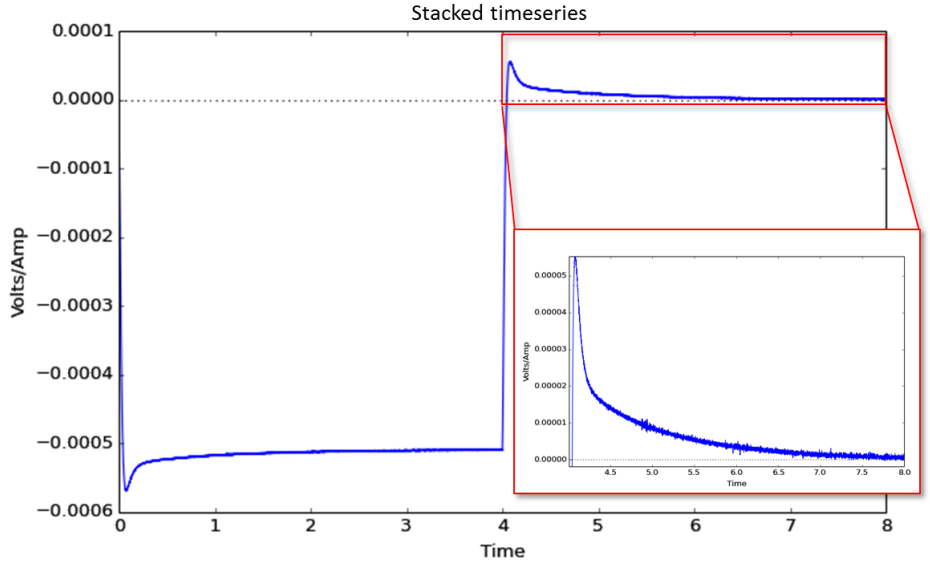
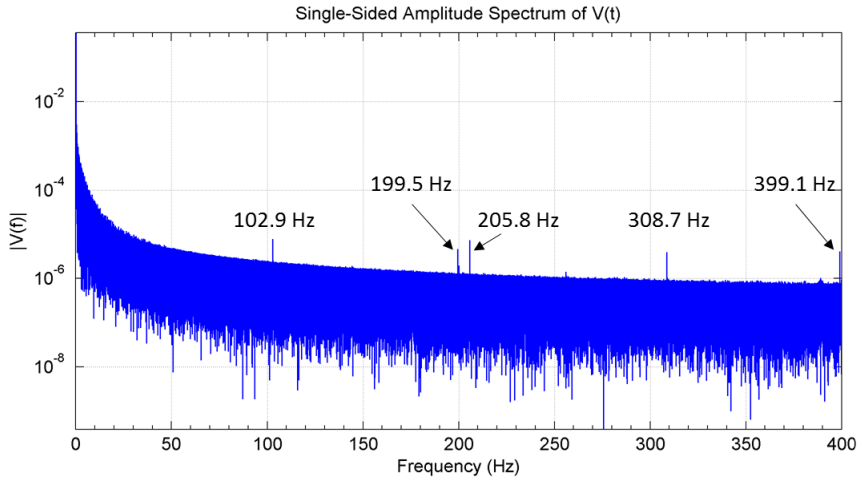
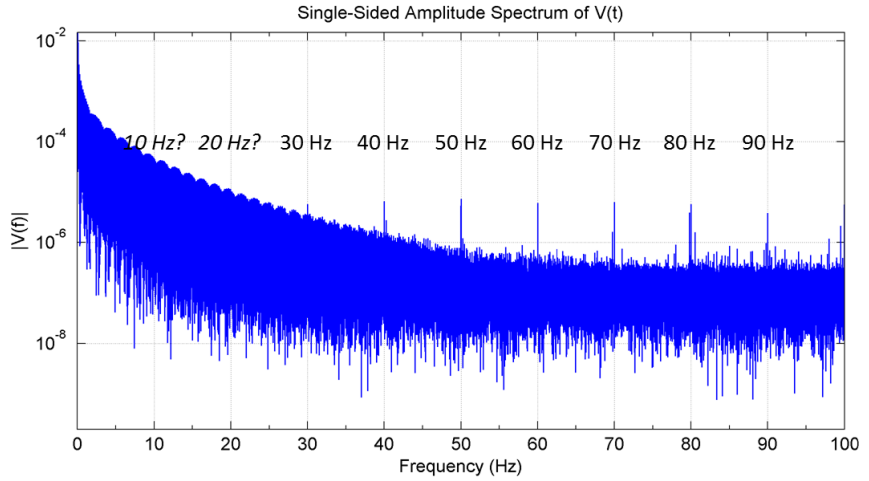


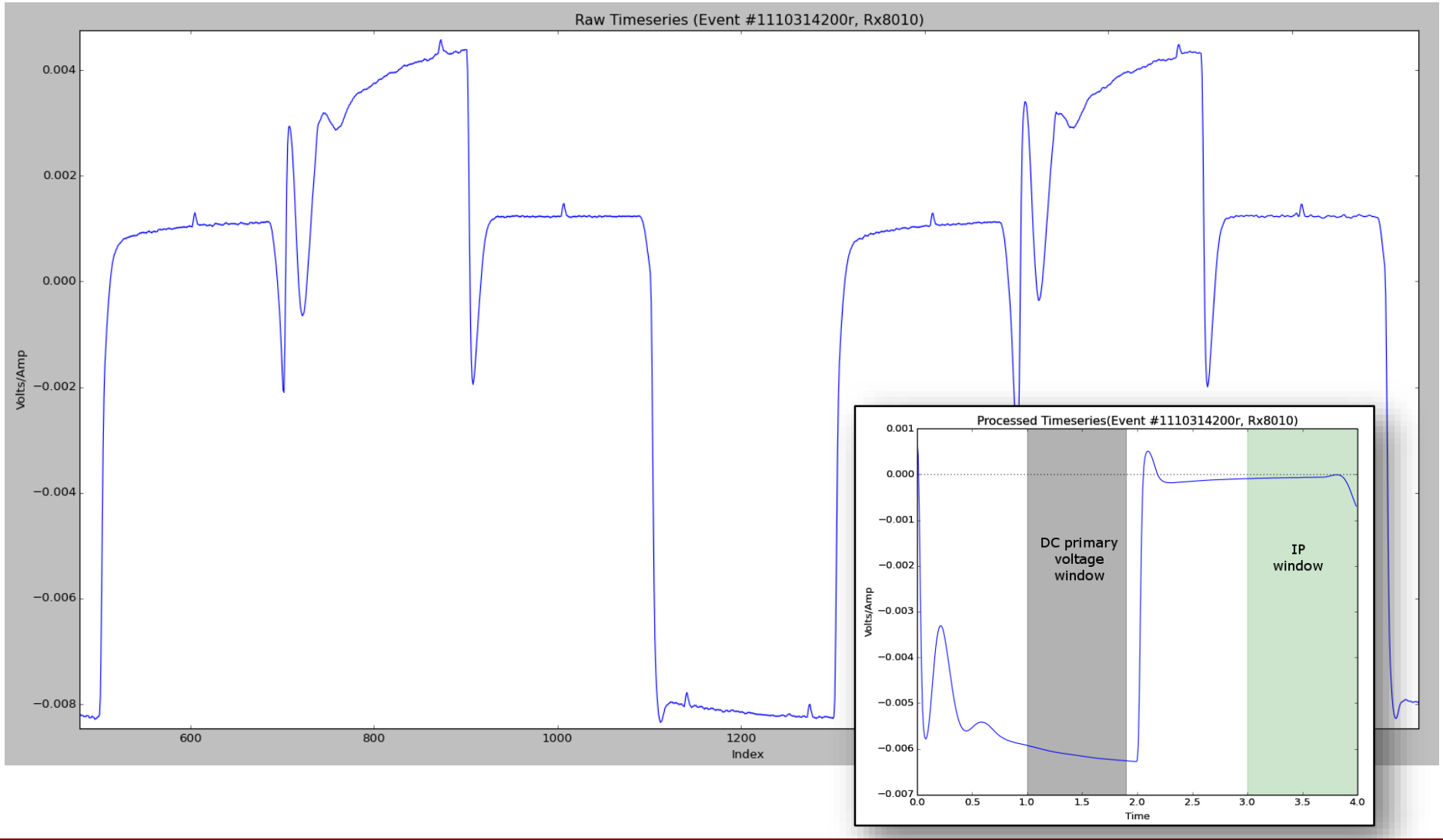




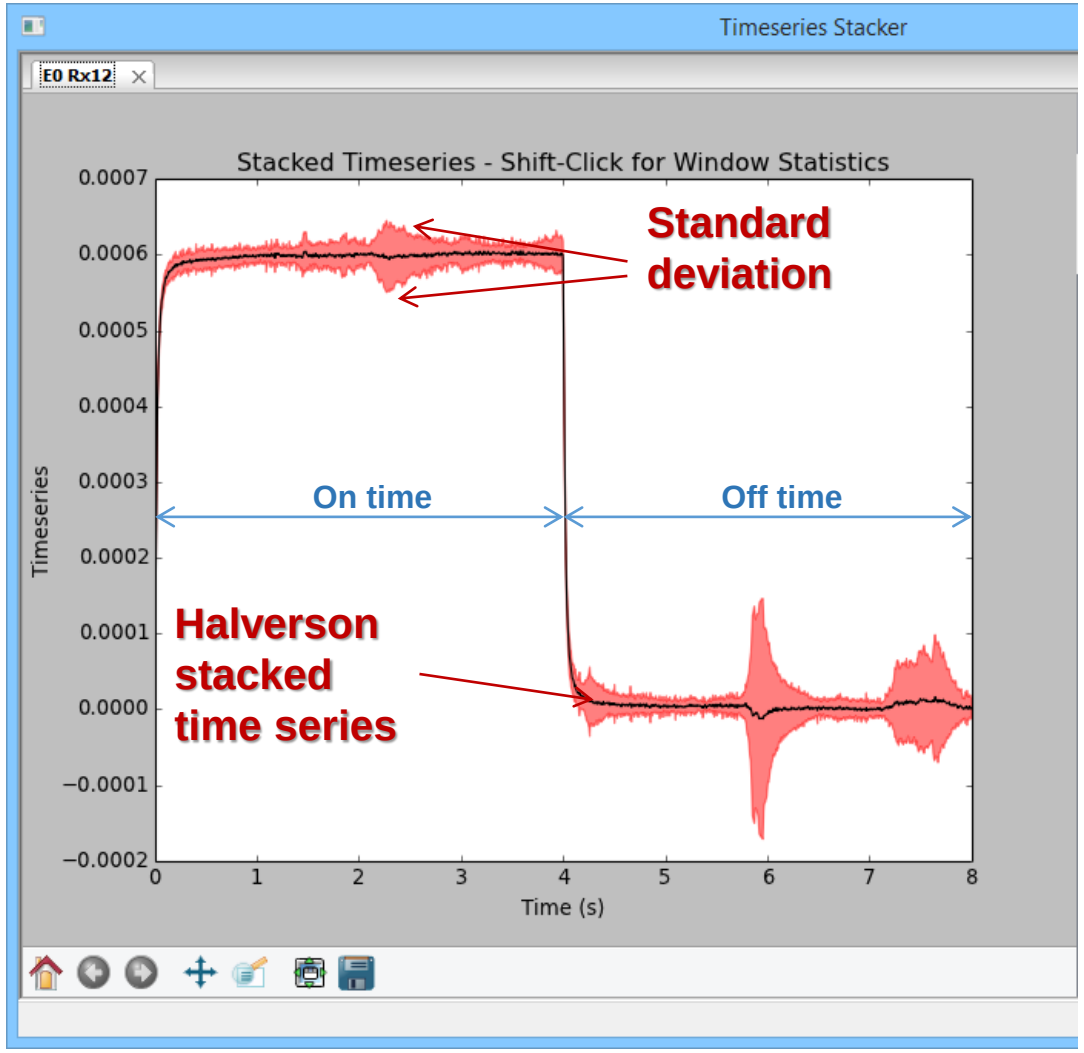


Pipeline

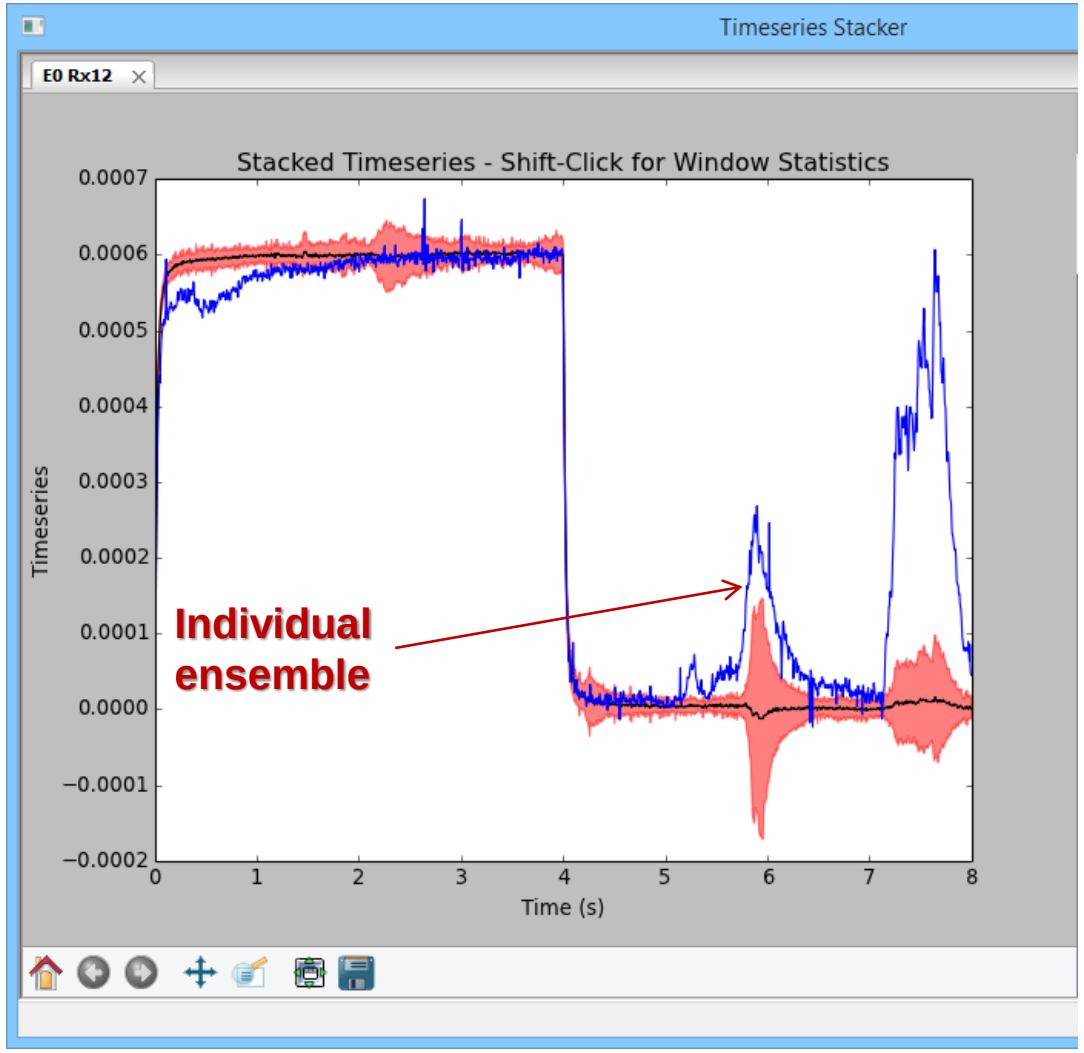
TX Freq: 1/8 Hz
TX Amps: ~7 A
RX sample rate: 100 Hz



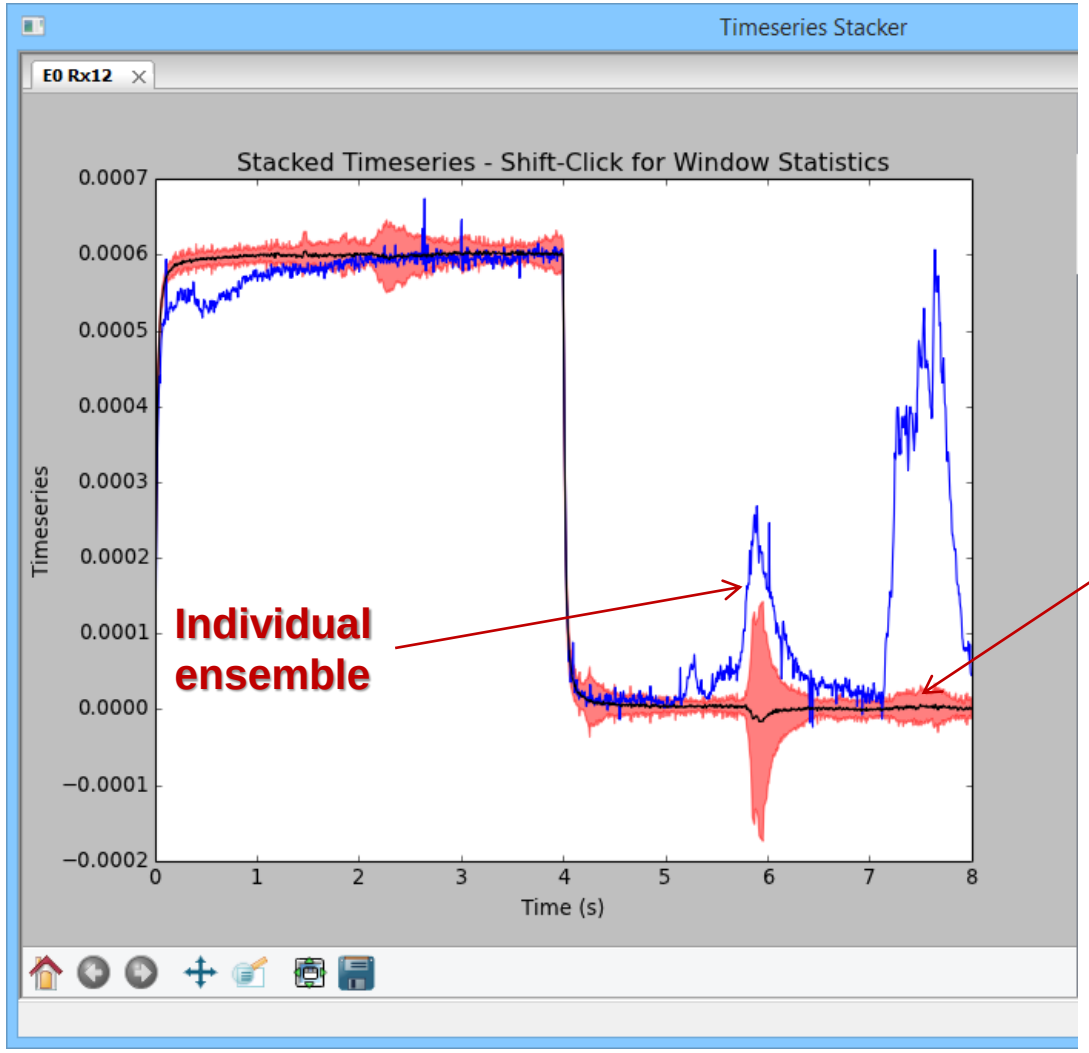
Selective stacking – example



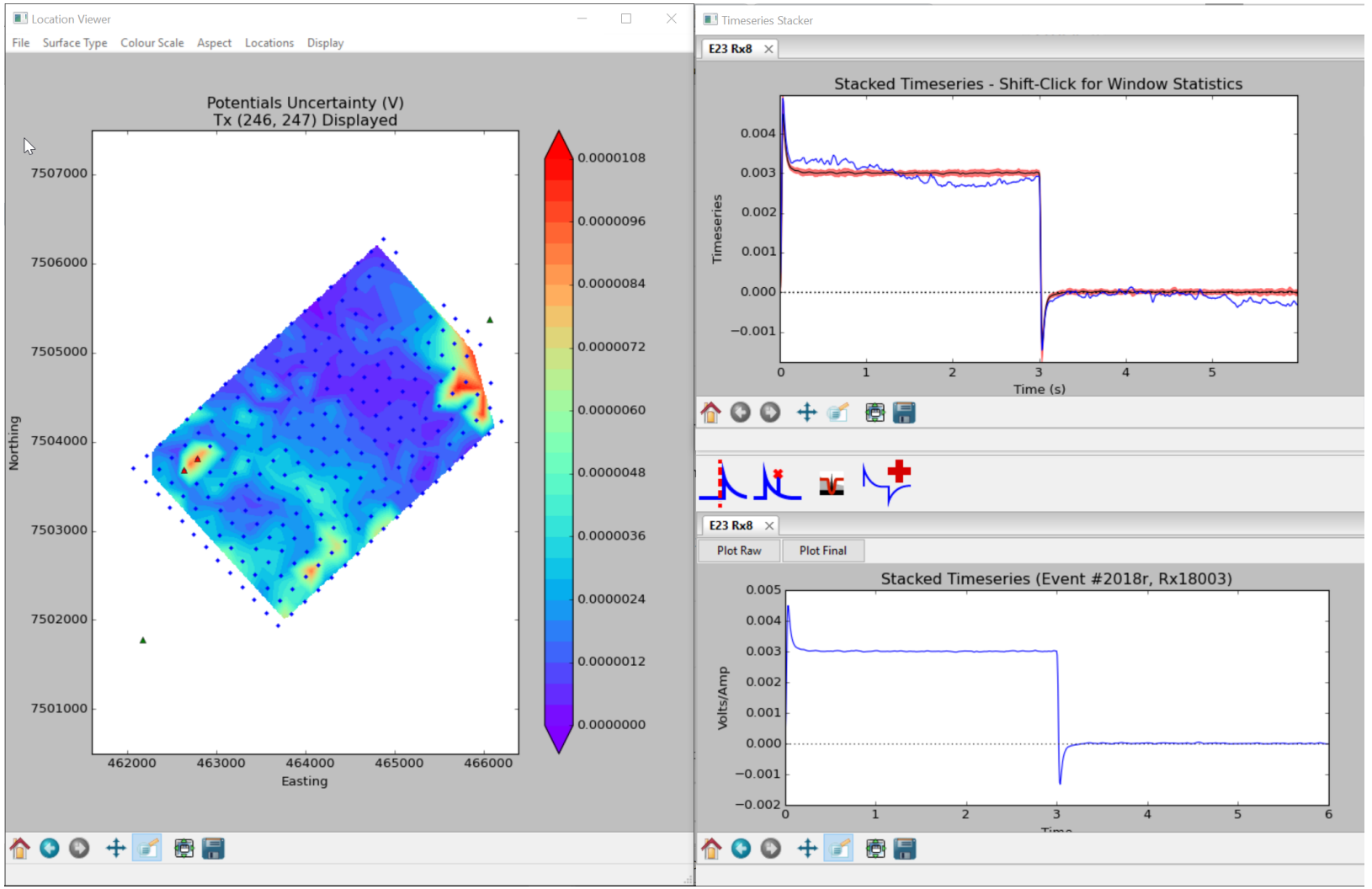
Selective stacking – example



Selective stacking – example



Spatial QA/QC



Processing example

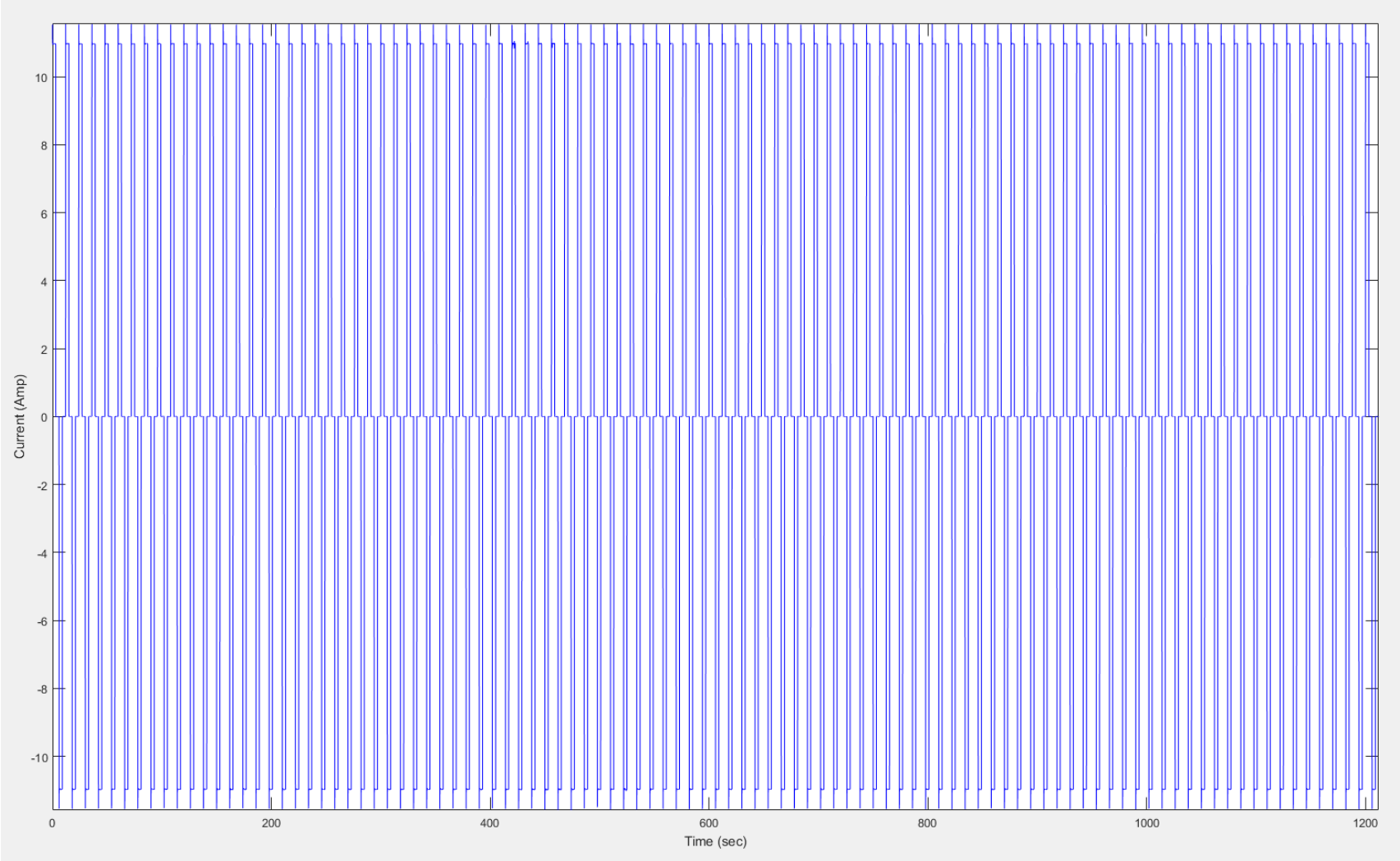
- One pathological recording
- Processed 4 different ways
  - 3x IPQC
    - Full timeseries
    - Selected portion of timeseries
    - Full timeseries with selective stacking
  - 1x Contractor

All other settings the same & same math

- Demonstrates the sensitivity of the result to processing methods

Processing example – TX

TX Freq: 1/12 Hz
TX Amps: ~11 A
RX sample rate: 150 Hz

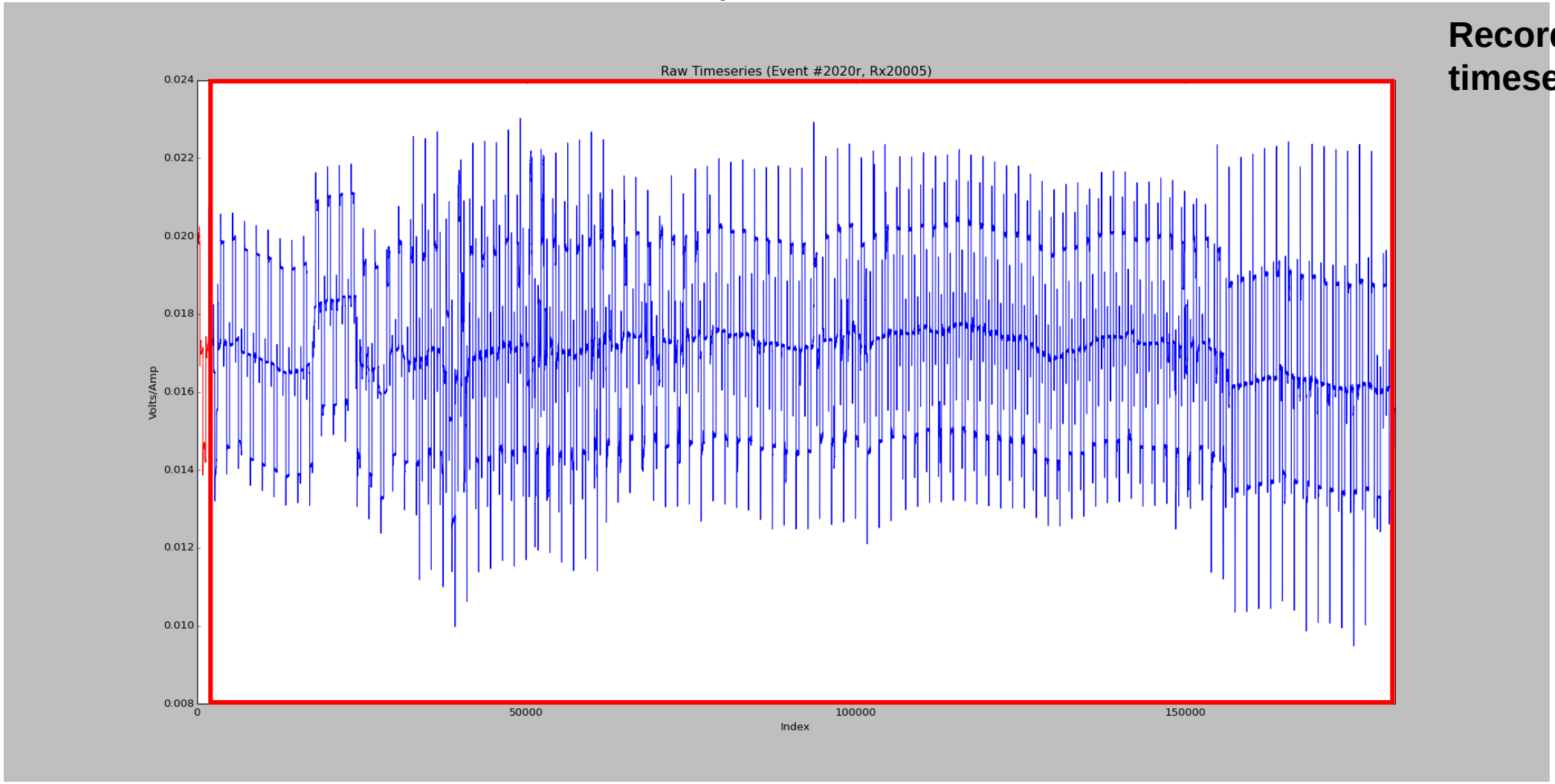


Typhoon Transmitted Current

Processing example – Full timeseries

TX Freq: 1/12 Hz
TX Amps: ~11 A
RX sample rate: 150 Hz

Recorded timeseries



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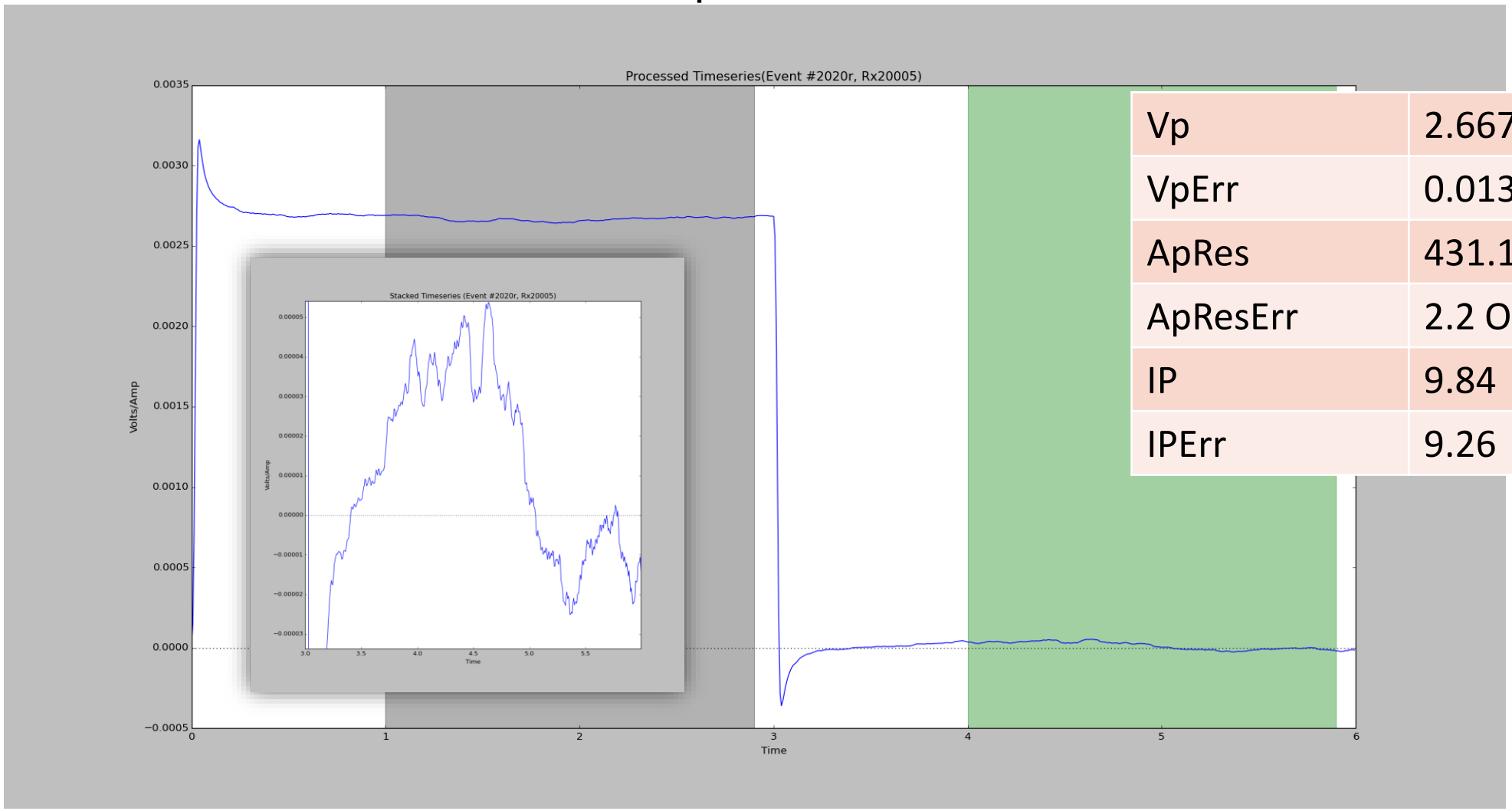
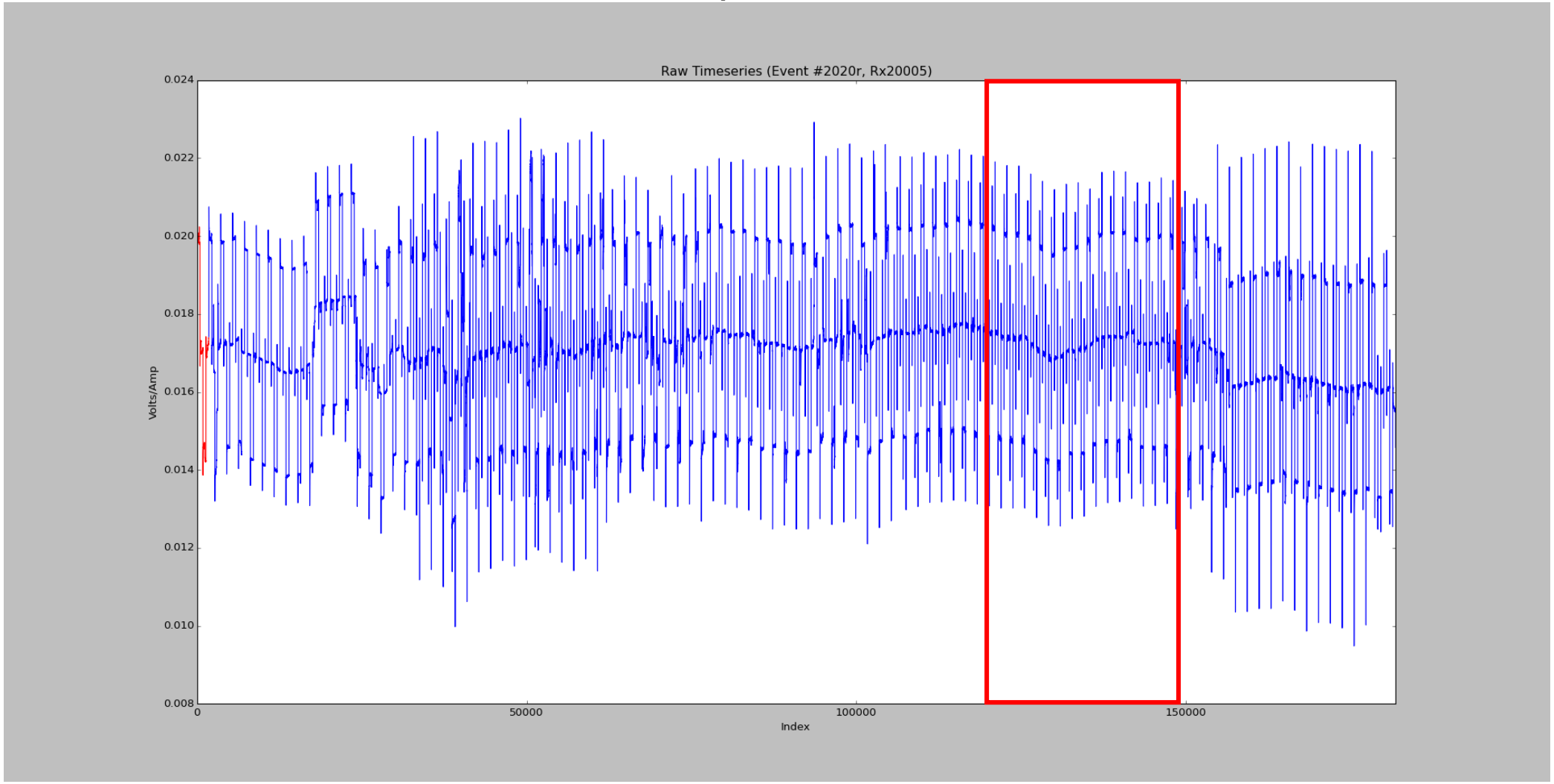


Vp	2.667 mV
VpErr	0.013 mV
ApRes	431.1 Ohm-m
ApResErr	2.2 Ohm-m
IP	9.84
IPErr	9.26

Processing example – Segment

TX Freq: 1/12 Hz
TX Amps: ~11 A
RX sample rate: 150 Hz



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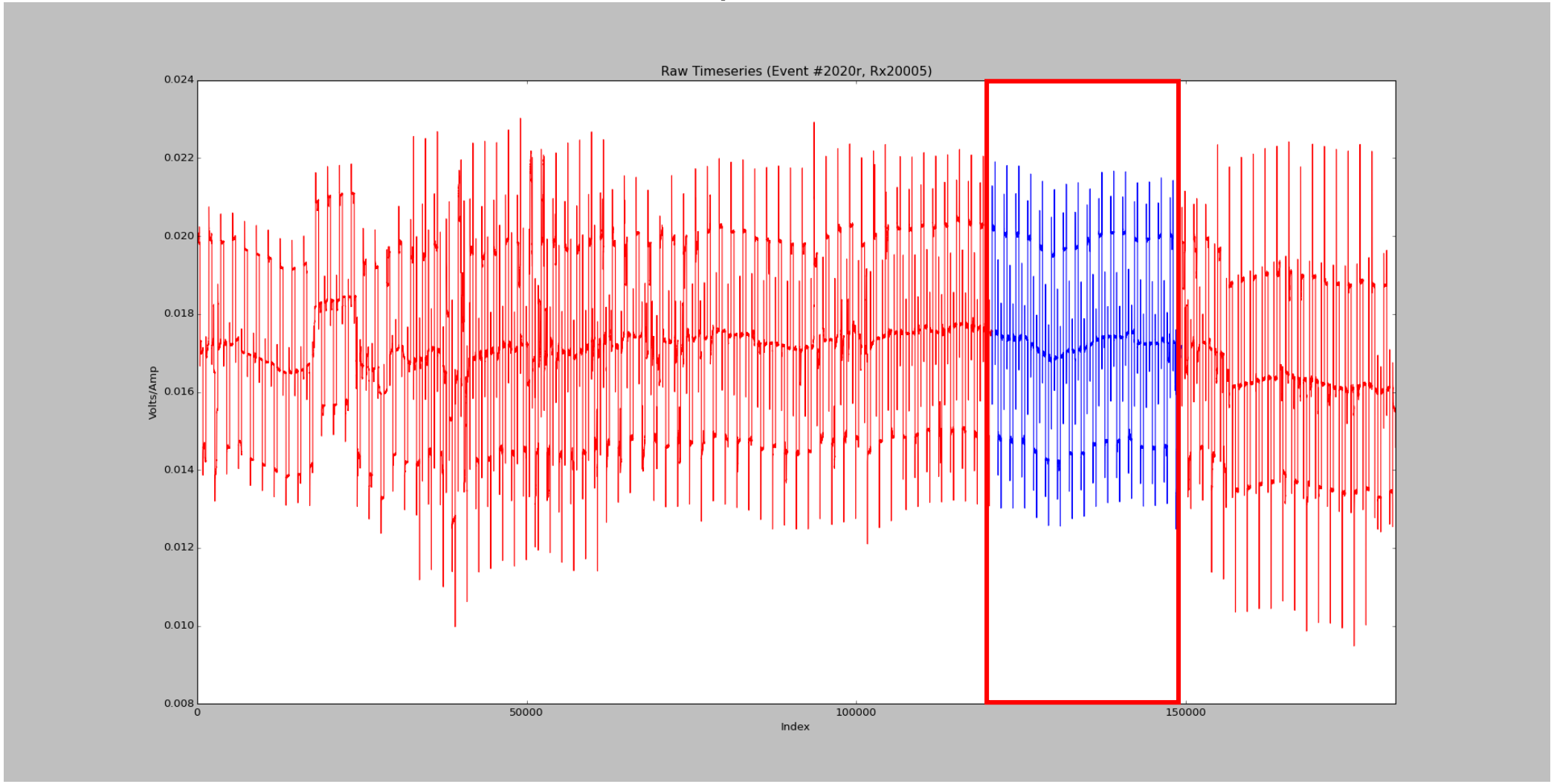

Processing example – Segment

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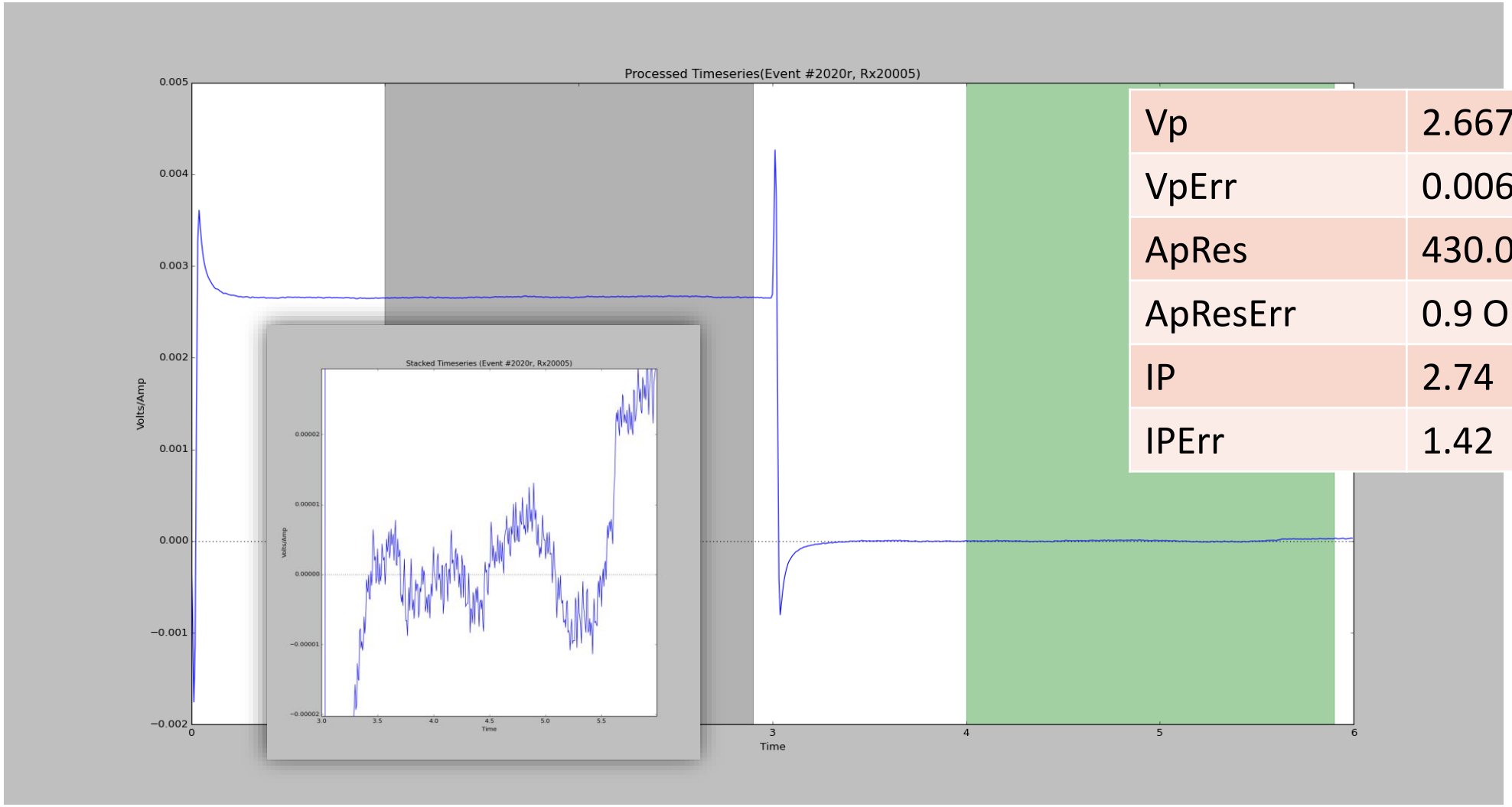
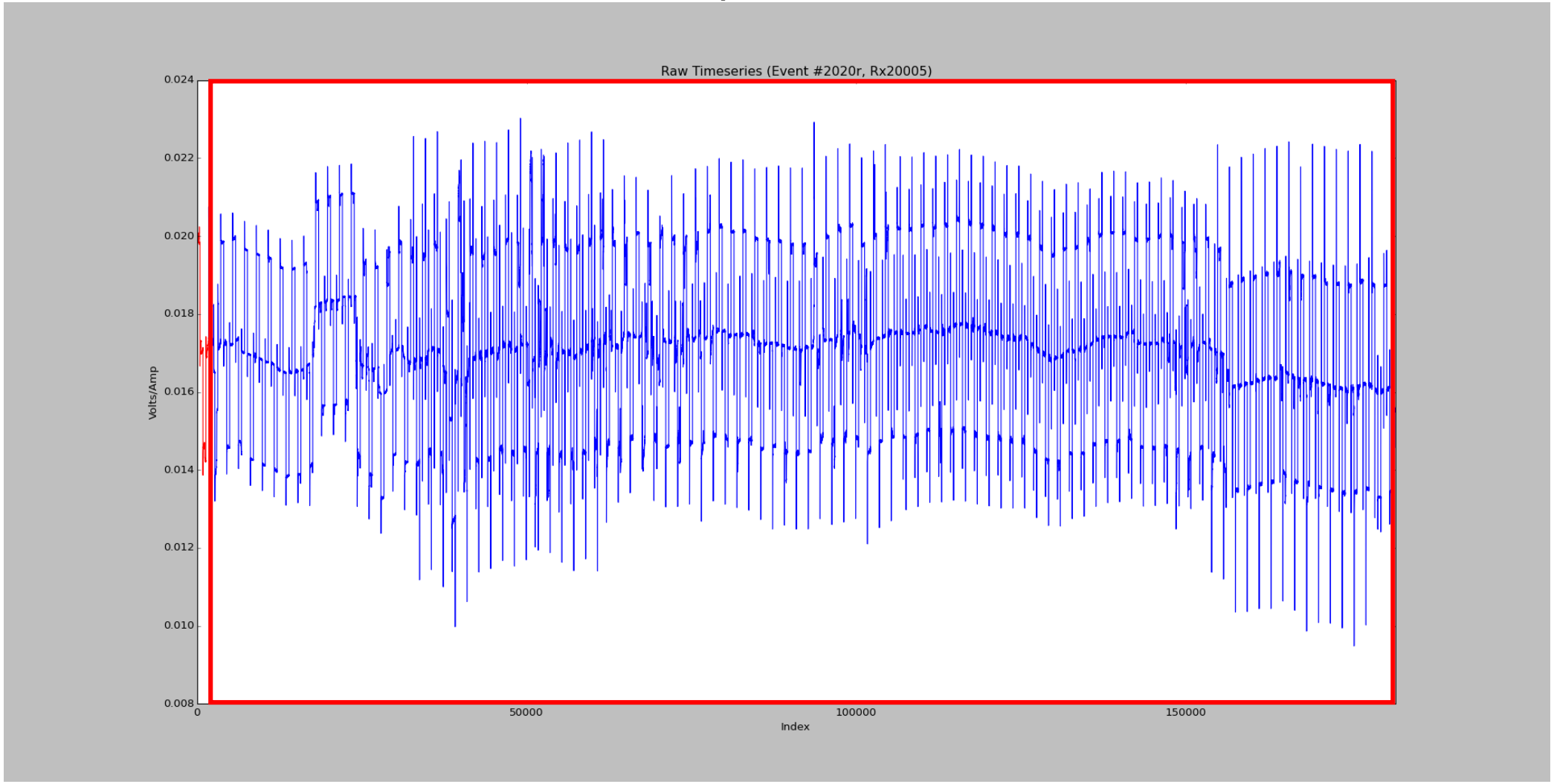


Vp	2.667 mV
VpErr	0.006 mV
ApRes	430.0 Ohm-m
ApResErr	0.9 Ohm-m
IP	2.74
IPErr	1.42

Select all 5 ensembles

Processing example – Selective stacking

TX Freq: 1/12 Hz
TX Amps: ~11 A
RX sample rate: 150 Hz



Processing example – Selective stacking

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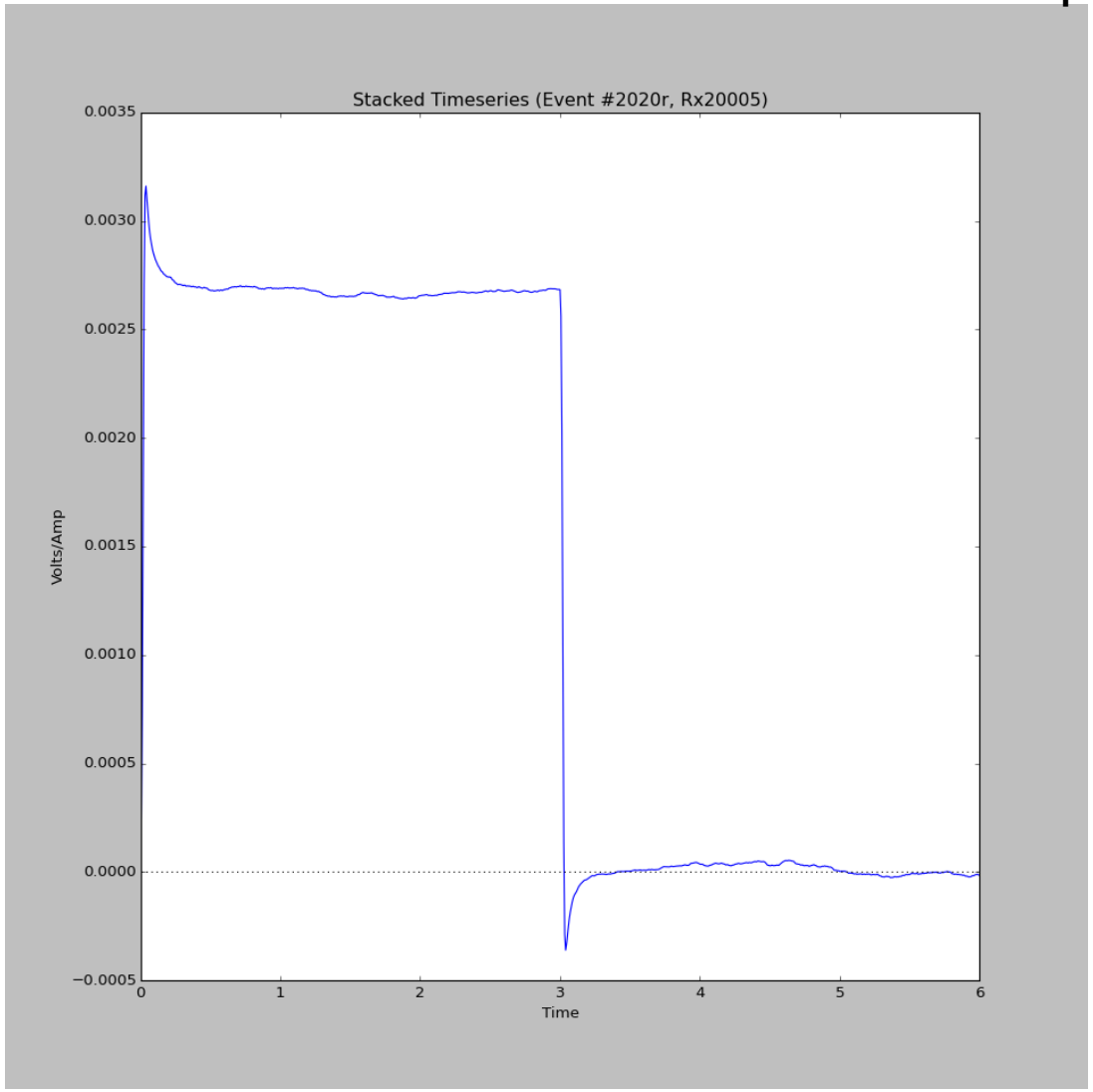
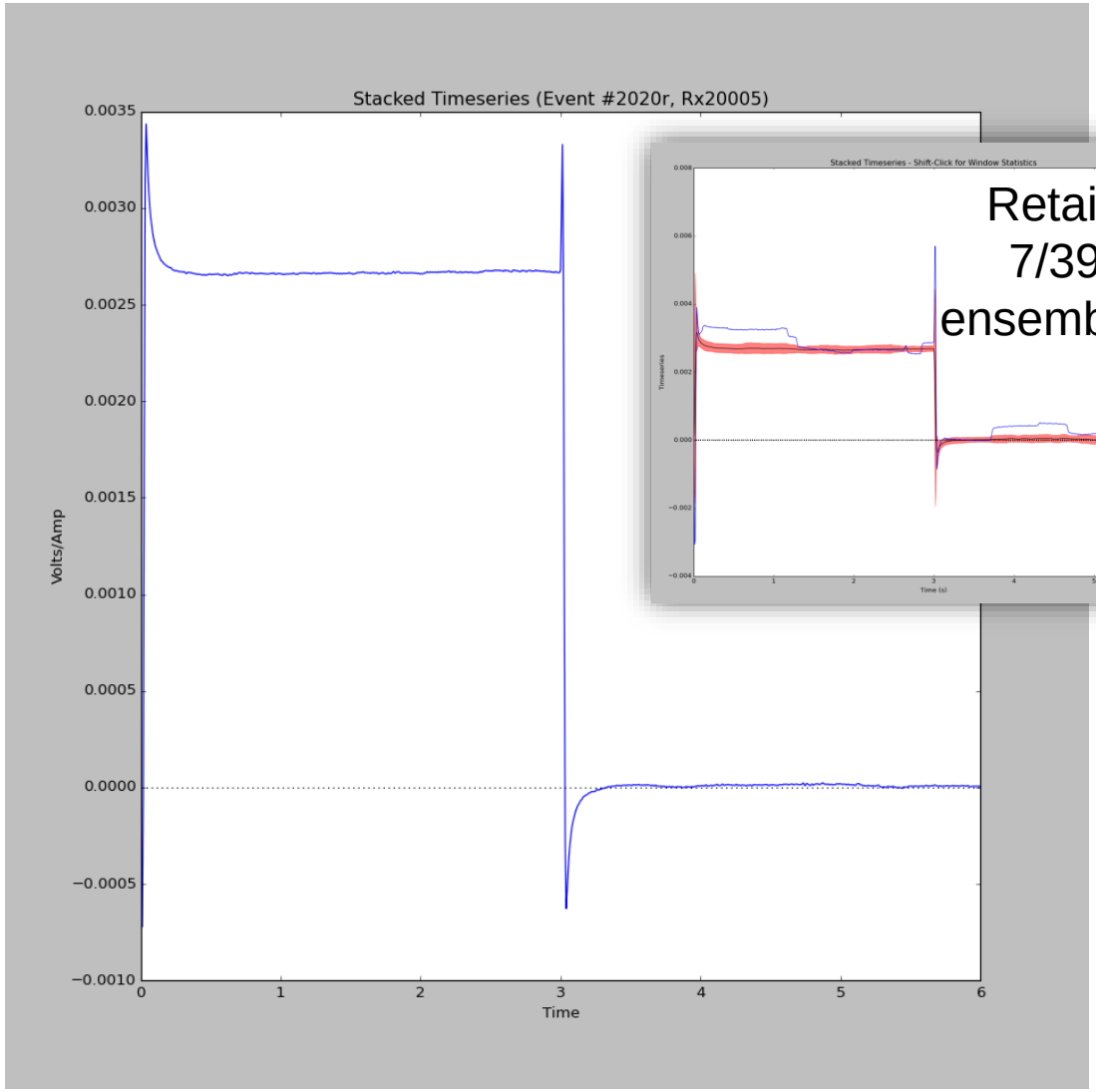
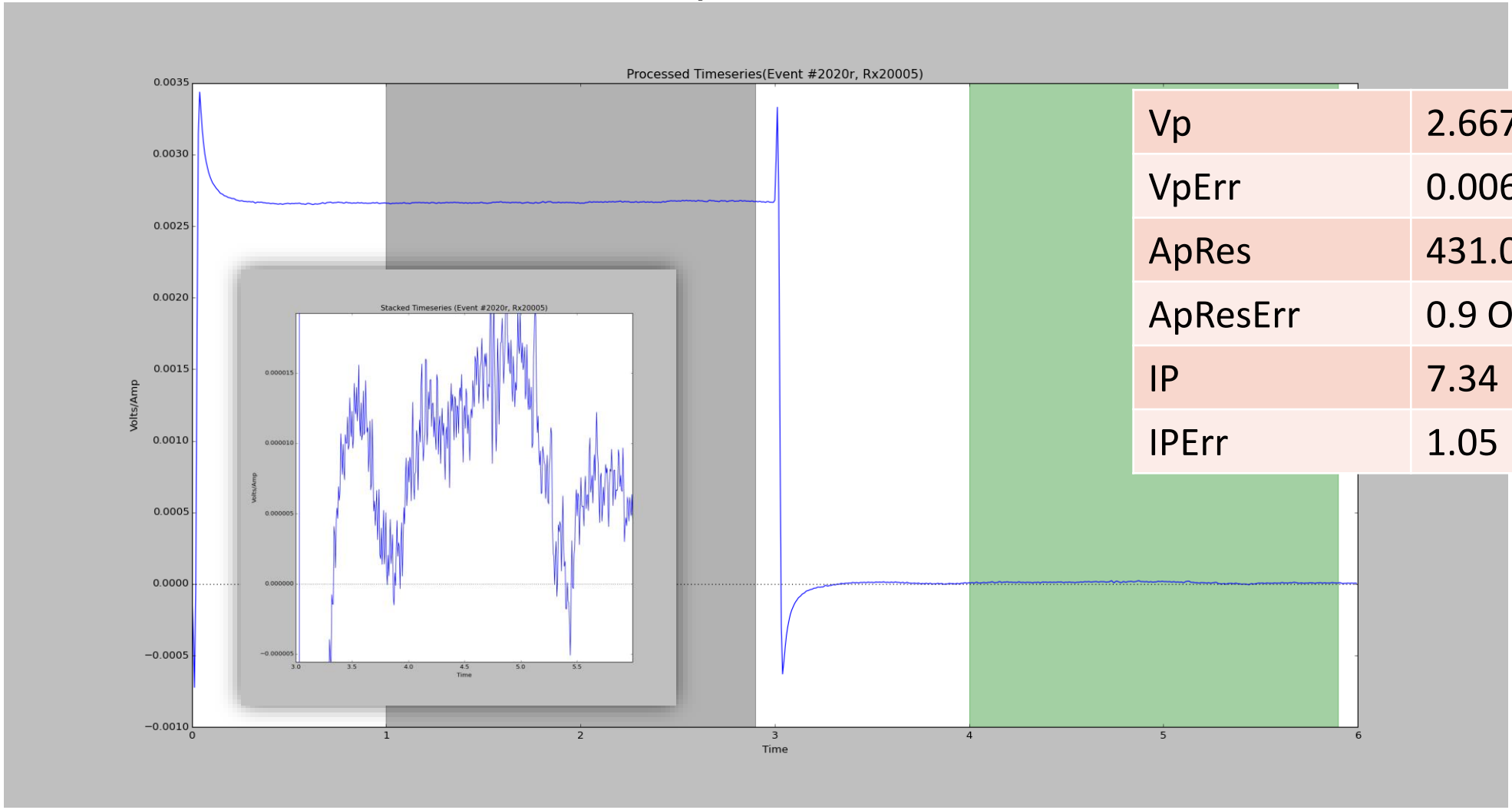




Processing example – Selective stacking

TX Freq: 1/12 Hz
TX Amps: ~11 A
RX sample rate: 150 Hz



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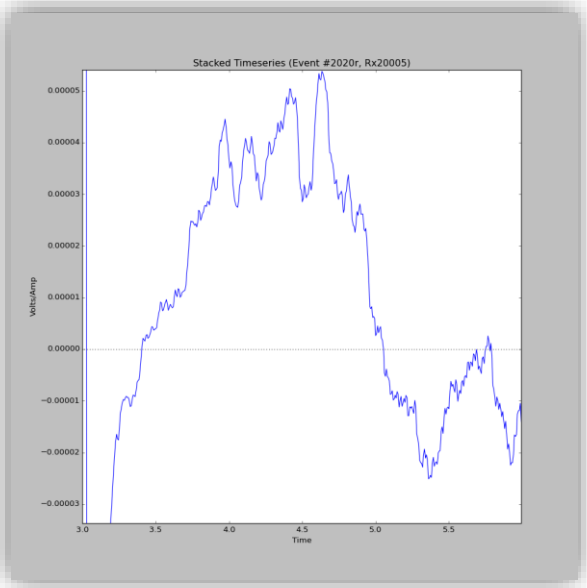
IP	7.34
IPErr	1.05

Processing example

TX Freq: 1/12 Hz
TX Amps: ~11 A
RX sample rate: 150 Hz

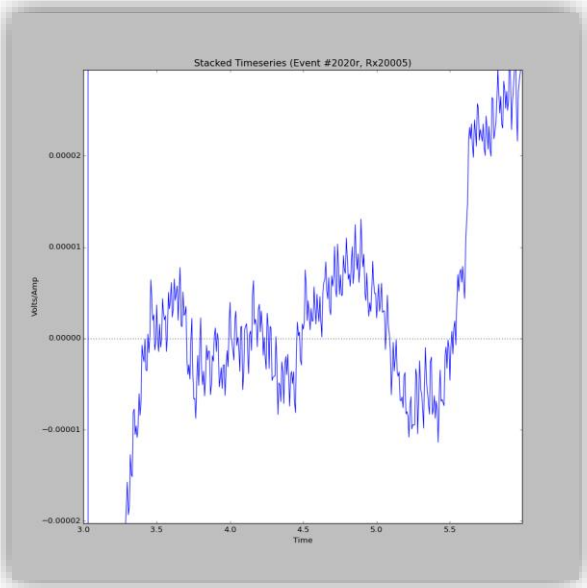
Full timeseries

Vp	2.667 mV
VpErr	0.013 mV
ApRes	431.1 Ohm-m
ApResErr	2.2 Ohm-m
IP	9.84 msec
IPErr	9.26 msec



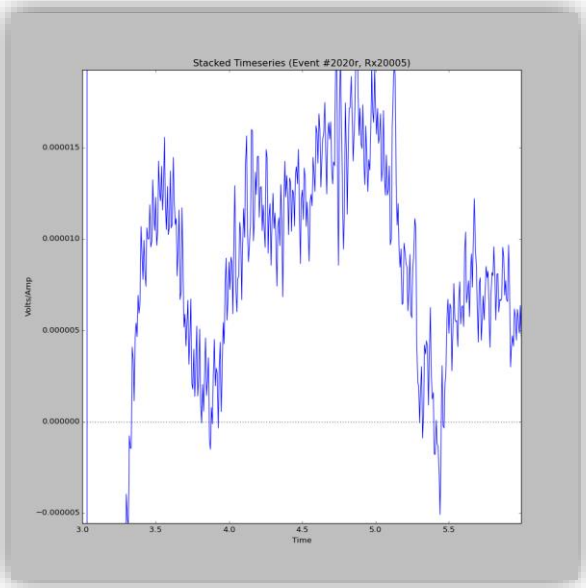
Manual trimming

Vp	2.667 mV
VpErr	0.006 mV
ApRes	430.0 Ohm-m
ApResErr	0.9 Ohm-m
IP	2.74 msec
IPErr	1.42 msec



Manual stack selection

Vp	2.667 mV
VpErr	0.006 mV
ApRes	431.0 Ohm-m
ApResErr	0.9 Ohm-m
IP	7.34 msec
IPErr	1.05 msec



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Full timeseries

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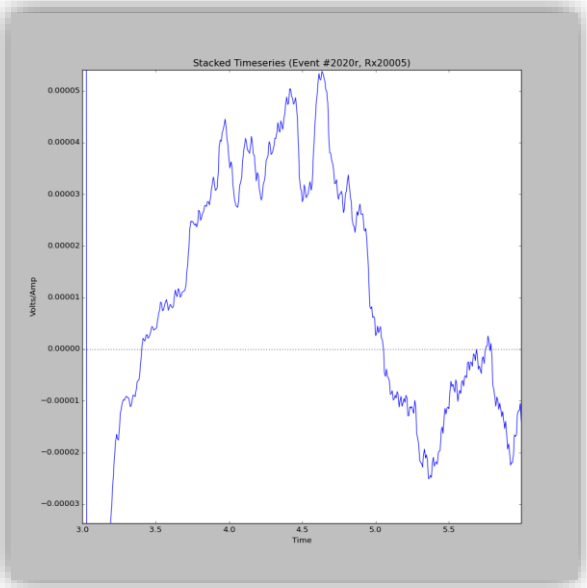

Manual trimming

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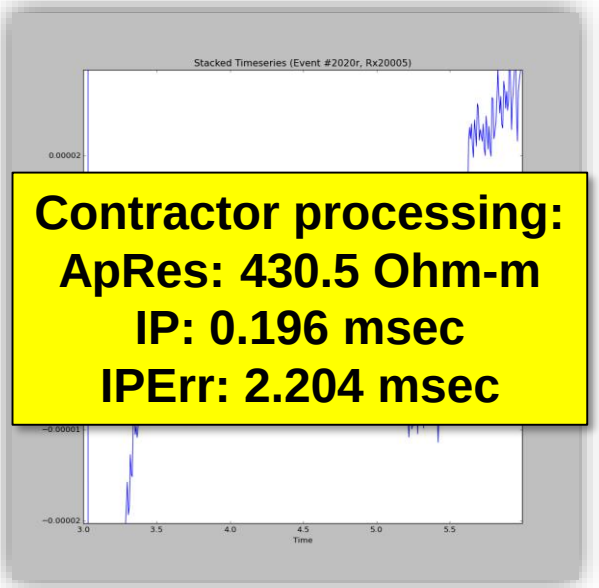
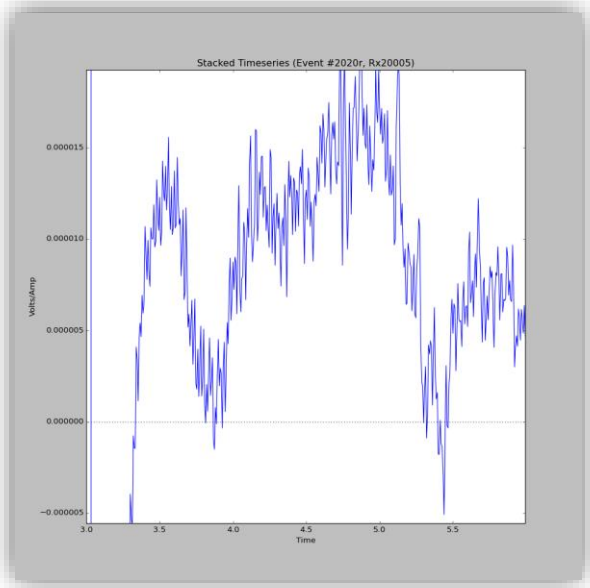


Contractor processing:
ApRes: 430.5 Ohm-m
IP: 0.196 msec
IPErr: 2.204 msec

Manual stack selection

Vp	2.667 mV
VpErr	0.006 mV
ApRes	431.0 Ohm-m
ApResErr	0.9 Ohm-m
IP	7.34 msec
IPErr	1.05 msec



Conclusions

- Collecting & processing high quality IP data is challenging
- Despite the challenges posed here, ground-truthing HPX surveys has **always** shown that the most chargeable targets in any area have always been the most anomalous
  - Sulfides
  - Oxides
  - Unusual lithologies
- The IP method definitely works well in exploration, but how can we get better at it?
- Perhaps the most import idea is that a dataset is processed consistently, not so much how it is processed?