Earth tide study at VIRGO system

Matteo Passuello

October 27, 2009

Table of contents

Introduction

- Tidal forces from Sun and Moon on VIRGO systems have to be compensated properly
- This type of strain is about a few hundreds of microns

Introduction

- Tidal forces from Sun and Moon on VIRGO systems have to be compensated properly
- This type of strain is about a few hundreds of microns
- The stalibilized platform on the top of the seismic chain filter compensates the high amplitude motions at low frequencies, such as Earth tidal forces

Introduction

- Tidal forces from Sun and Moon on VIRGO systems have to be compensated properly
- This type of strain is about a few hundreds of microns
- The stalibilized platform on the top of the seismic chain filter compensates the high amplitude motions at low frequencies, such as Earth tidal forces

Current situation

- Measure of the forces on the mirrors needed to keep the interferometer locked
- Displace the inverted pendulum to compensate and reduce the correction value to zero (zCorr)

Current situation

- Measure of the forces on the mirrors needed to keep the interferometer locked
- Displace the inverted pendulum to compensate and reduce the correction value to zero (zCorr)

Object

Main aim

Introduce a tidal strain prediction system to keep the Superattenuator near the operating point also during the Unlock phase

Use of the strain prediction

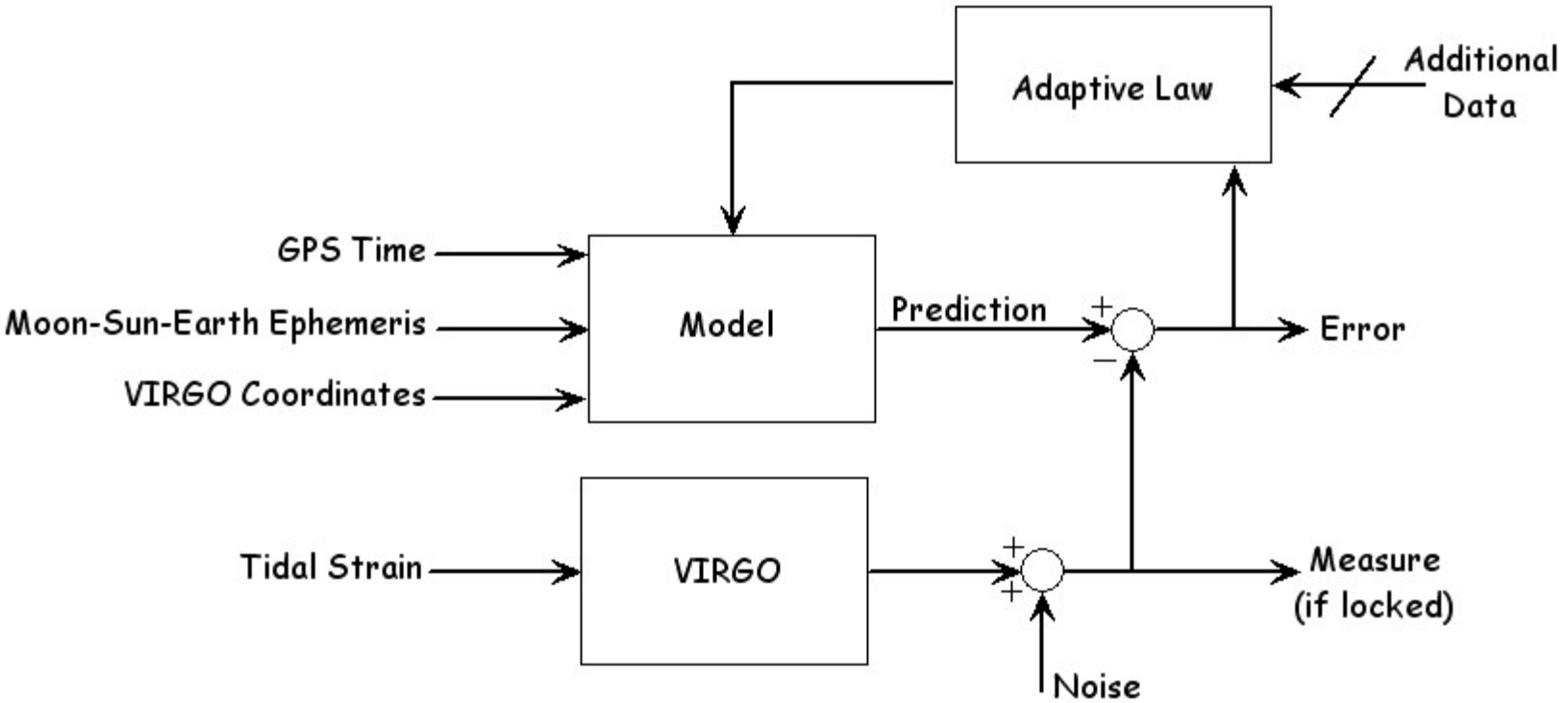
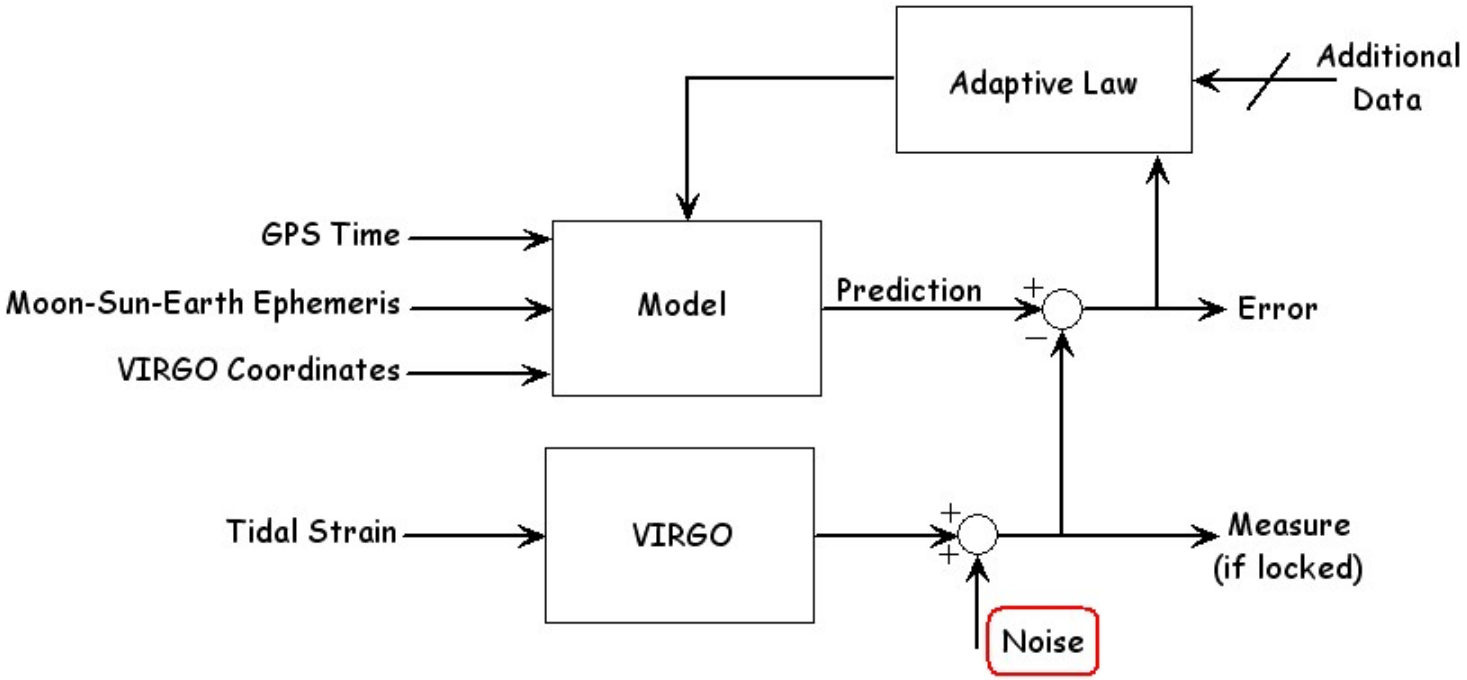


Figure: Strain prediction system scheme

- The data time analysis doesn't highlight the dominating noise on the Lvdt signal respect to the ideal tidal strain prediction



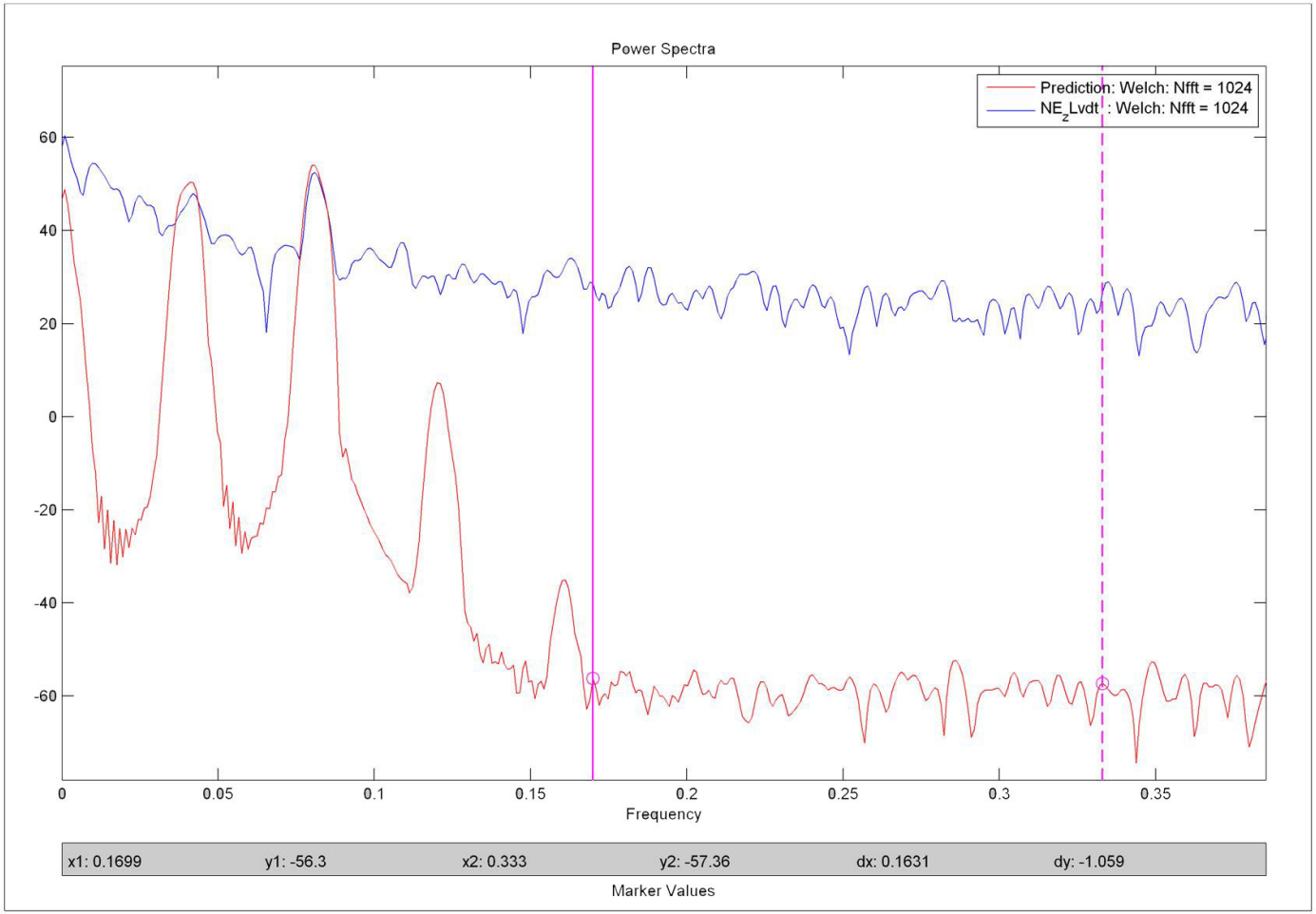
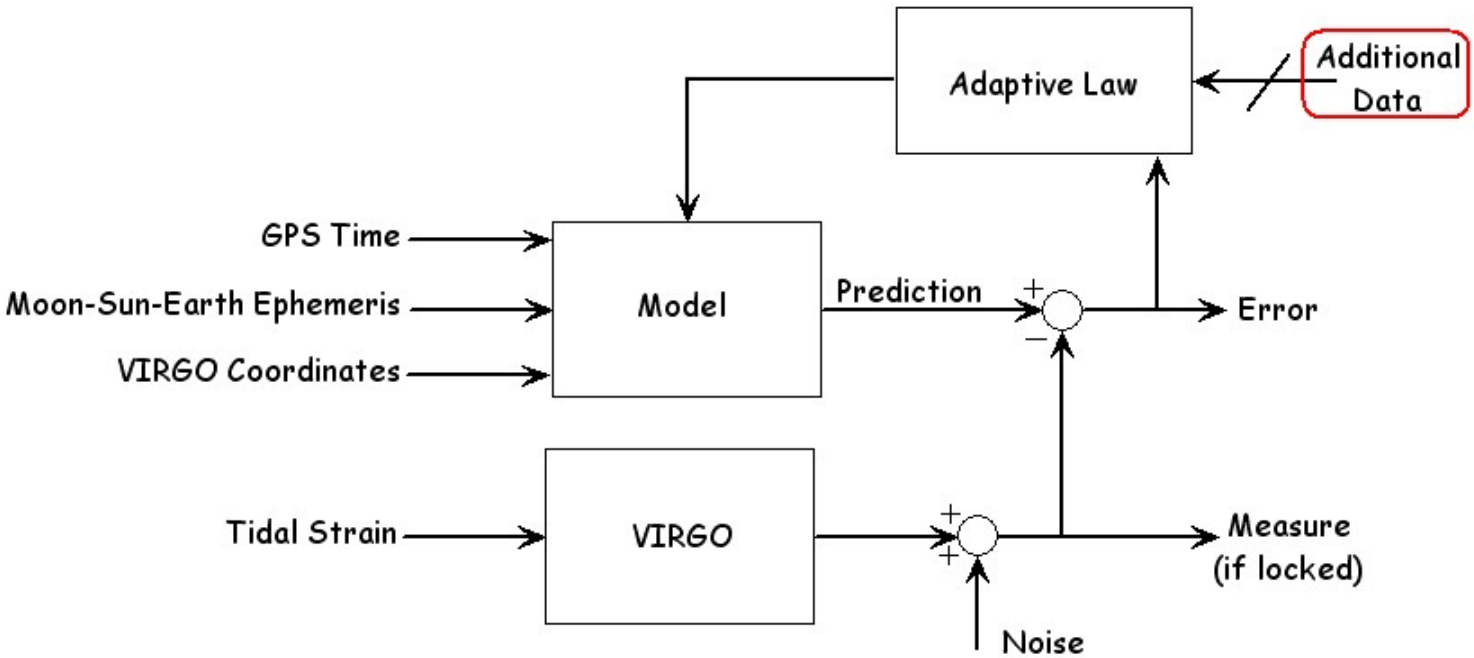


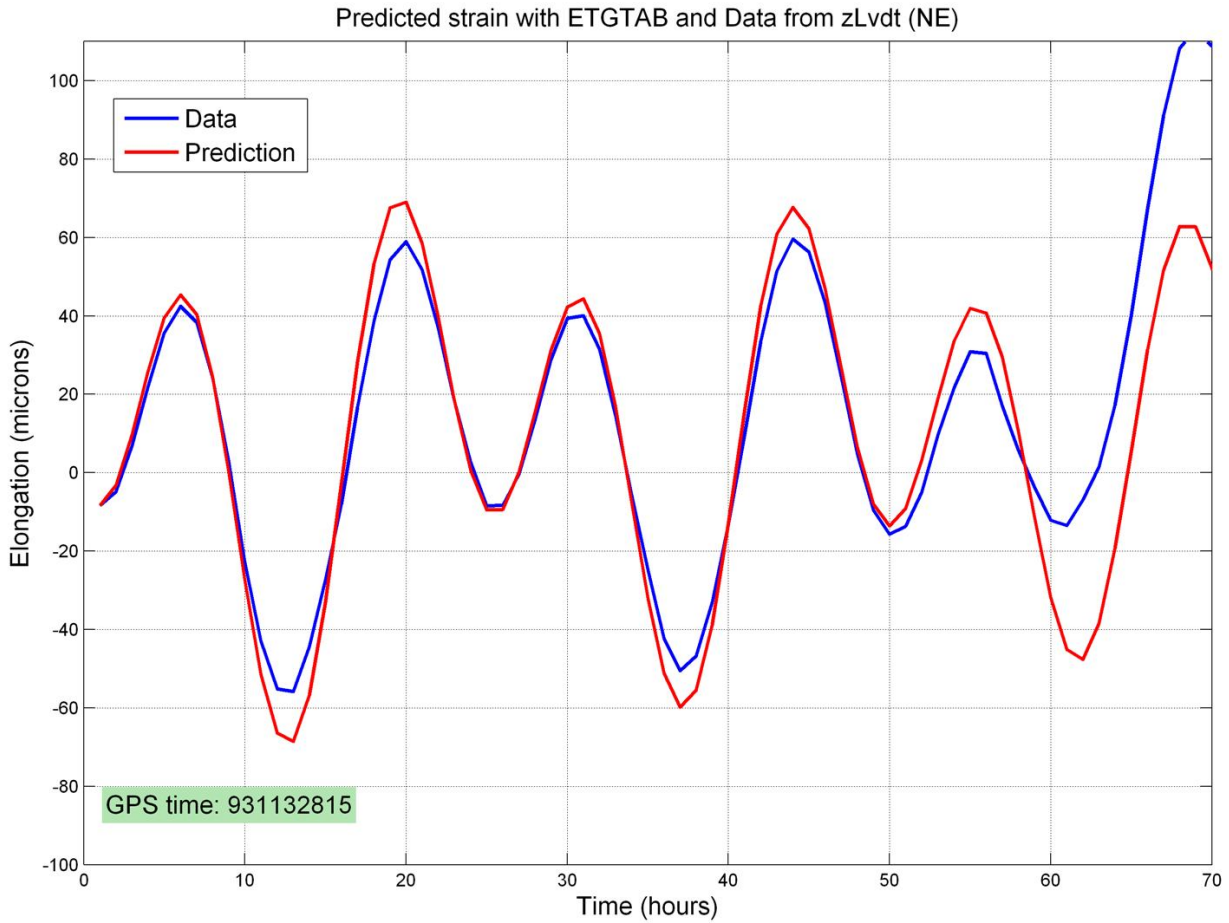
Figure: Spectral results for prediction and NE zLvdt signal

- In order to improve the noise bugdet for the prediction, a more precise model could consider thermal effects, environmental effects and related to ground subsidence (tilt) using additional interferometer signals



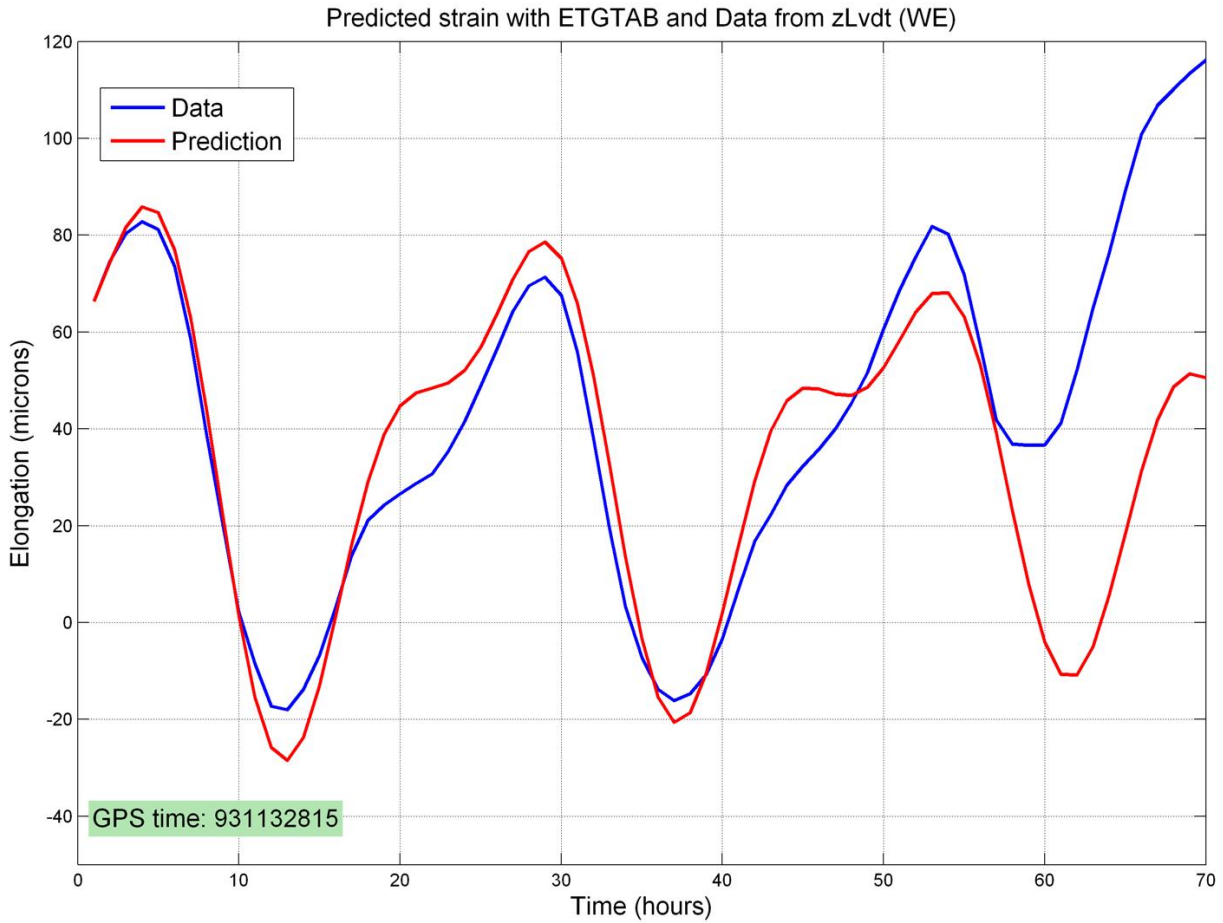
Simulation results using ETGTAB prediction (1)

- Prediction and Lvdt Data from North arm



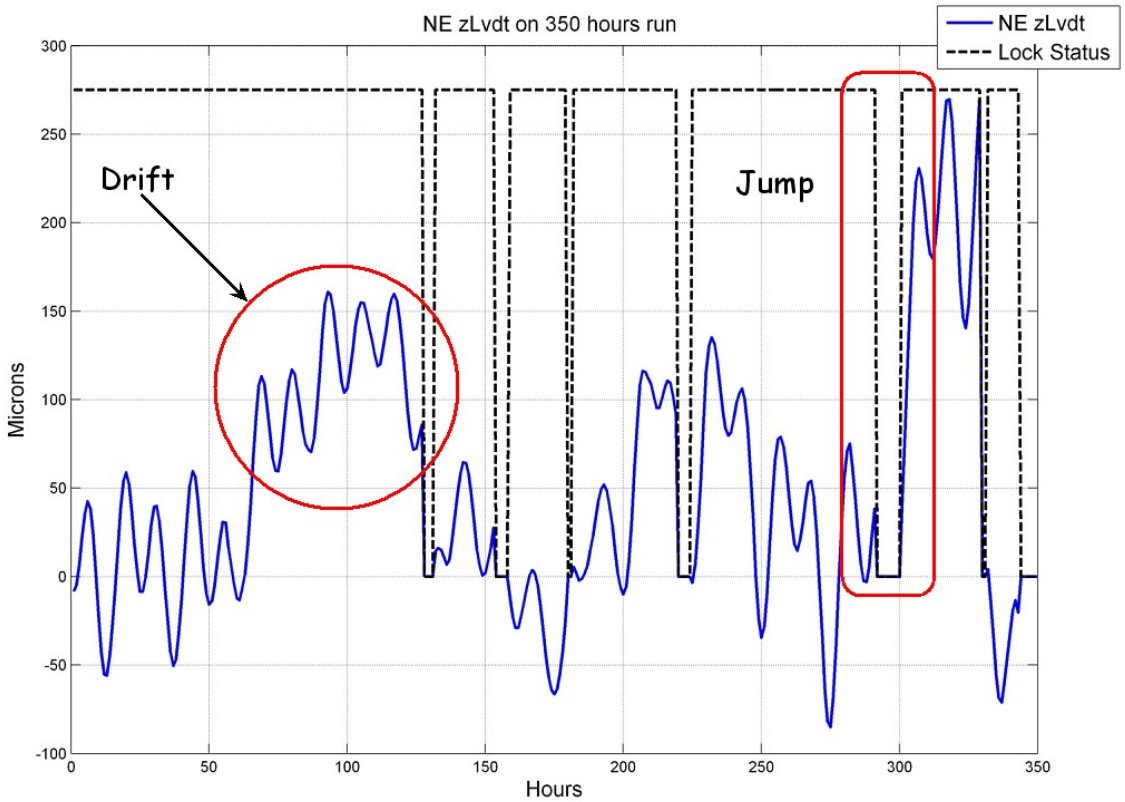
Simulation results (2)

- Prediction and Lvdt Data from West arm



Lock and Unlock

- The measurement of the position sensor is dependent from Unlock phases



Lock e Unlock (2)

- The Lock could cause the restart of the Lvdt measure from an arbitrary point
- The use of the predicted tidal strain value could reduce this event

Lock e Unlock (2)

- The Lock could cause the restart of the Lvdt measure from an arbitrary point
- The use of the predicted tidal strain value could reduce this event
- Furthermore, the technique implies a continue correction signal, also in a Unlock case

Lock e Unlock (2)

- The Lock could cause the restart of the Lvdt measure from an arbitrary point
- The use of the predicted tidal strain value could reduce this event
- Furthermore, the technique implies a continue correction signal, also in a Unlock case

Adaptive Filtering

Strategy

Create a prediction signal useful for Unlock period (e.g. when the Lvdt measure is unusable)

Tools

- Use of an adaptive filter for the ideal prediction with the Lvdt signal as reference during the Lock

Adaptive Filtering

Strategy

Create a prediction signal useful for Unlock period (e.g. when the Lvdt measure is unusable)

Tools

- Use of an adaptive filter for the ideal prediction with the Lvdt signal as reference during the Lock
- When the Lock is lost, use of the new reference produced from prediction and previous valid Lvdt informations

Adaptive Filtering

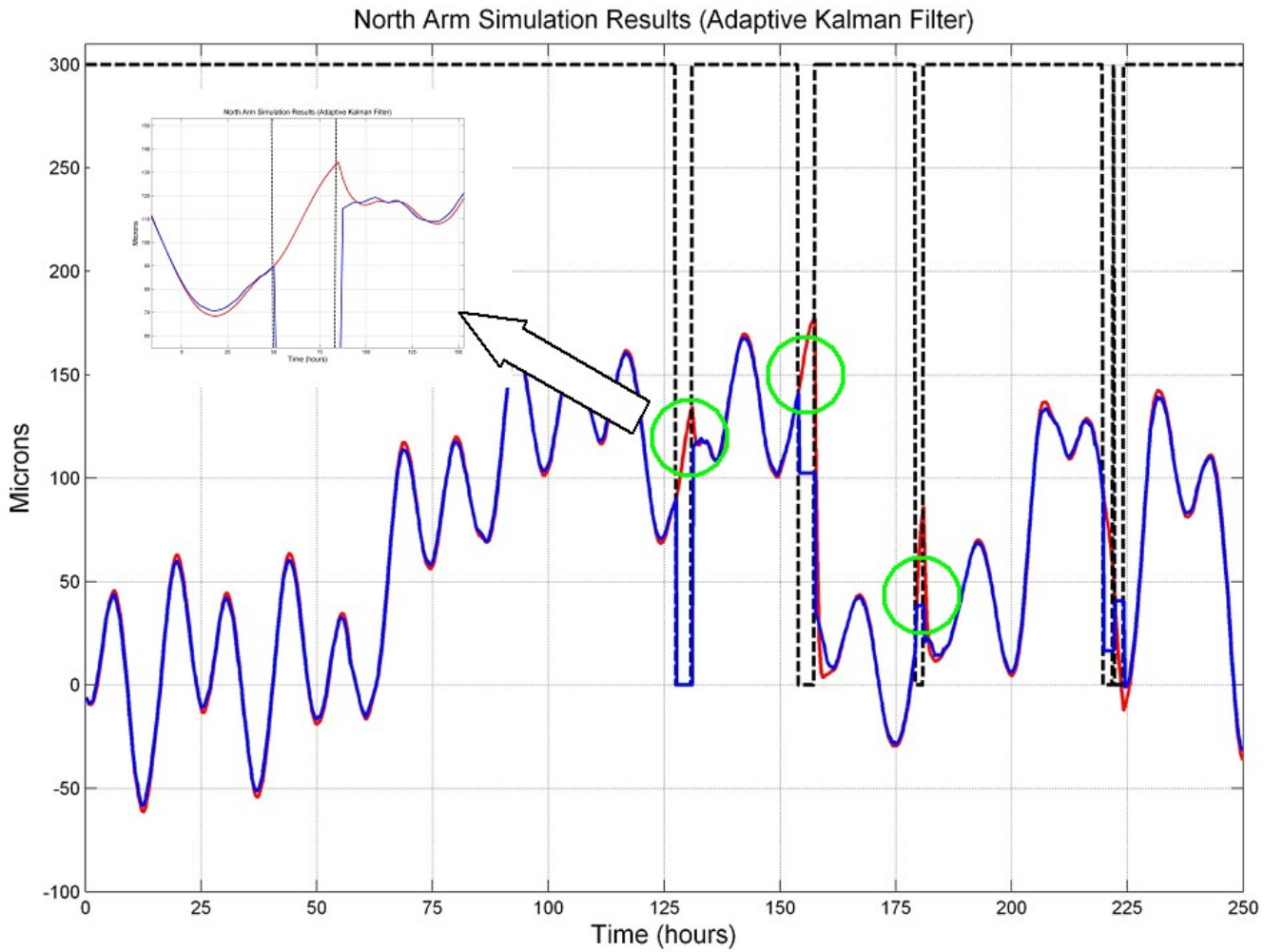
Strategy

Create a prediction signal useful for Unlock period (e.g. when the Lvdt measure is unusable)

Tools

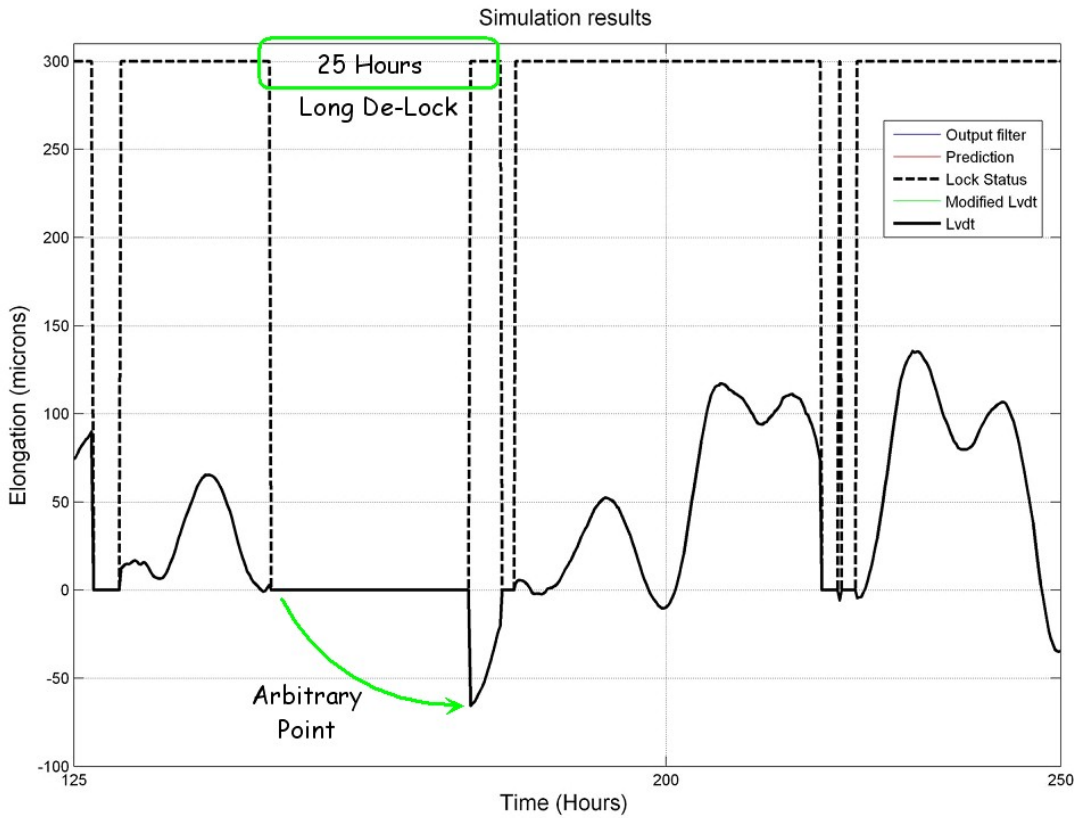
- Use of an adaptive filter for the ideal prediction with the Lvdt signal as reference during the Lock
- When the Lock is lost, use of the new reference produced from prediction and previous valid Lvdt informations

Simulation Results: adaptive Kalman filtering (1)



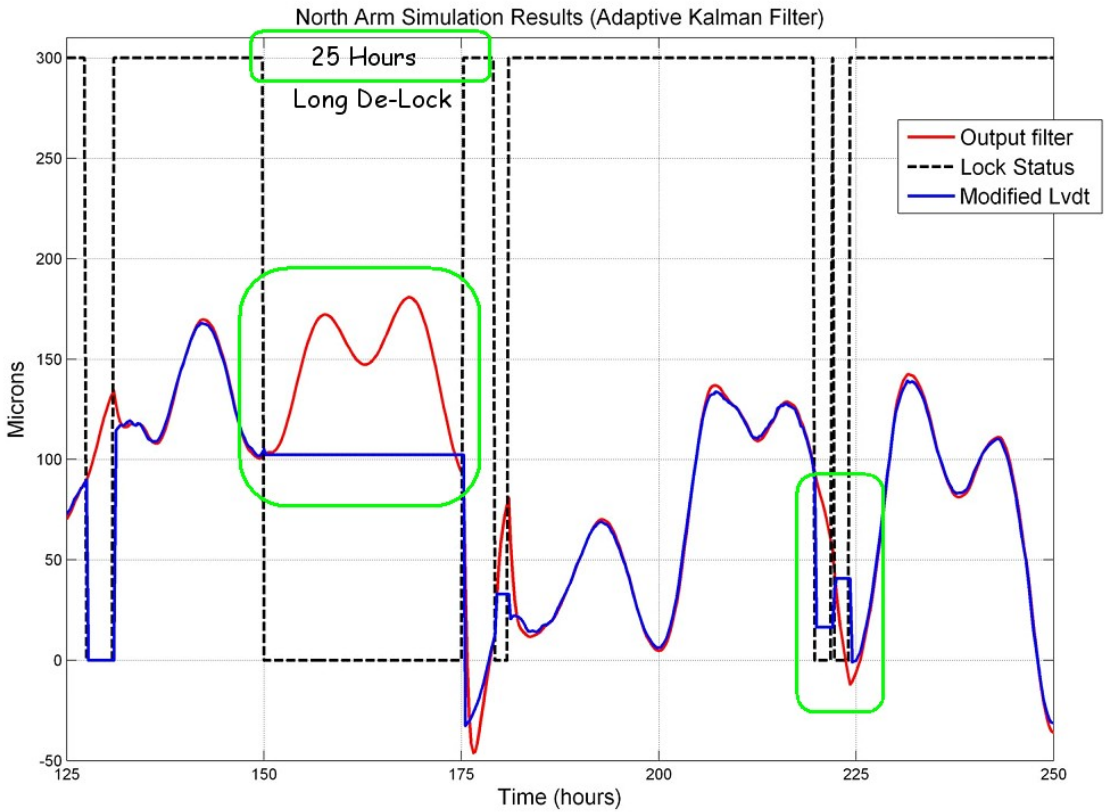
Simulated durable *Unlock* (1)

Current situation: the Lvdt measure restarts from an arbitrary point during the Lock phase



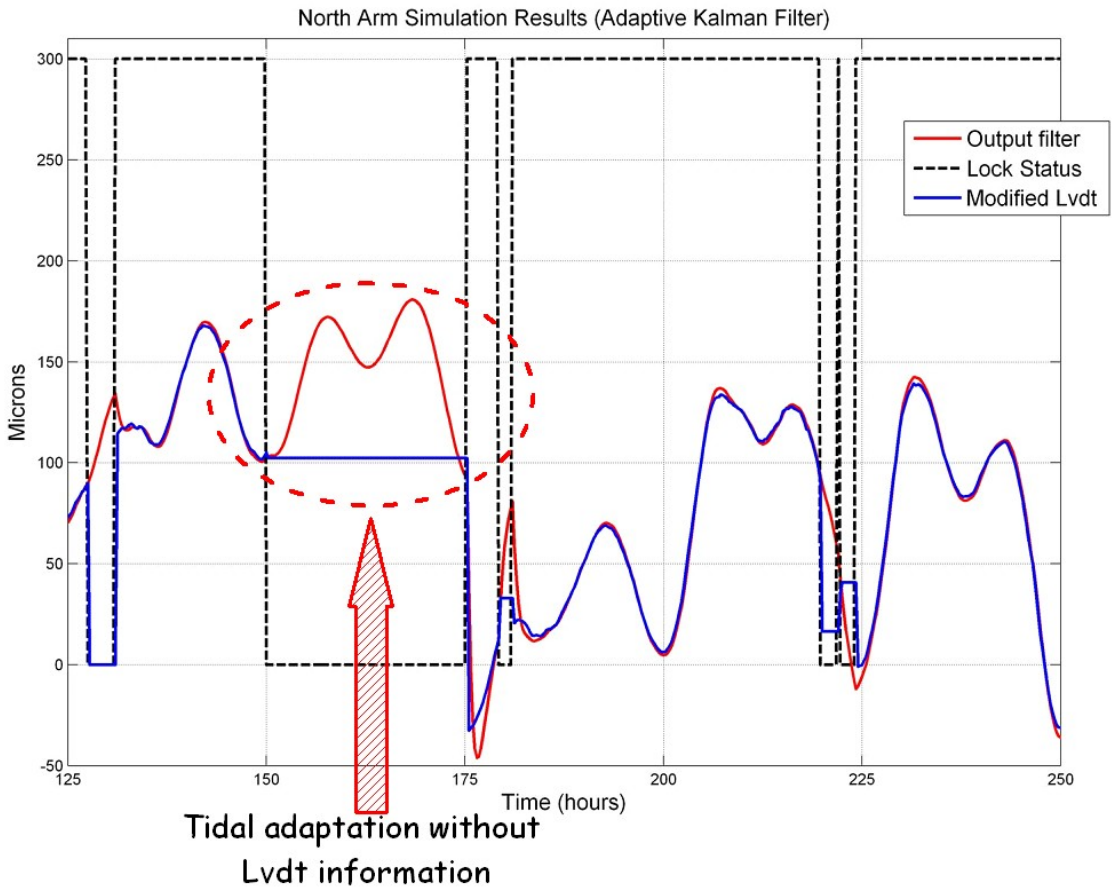
Simulated durable *Unlock* (2)

Upgrade: use the tide prediction to obtain a new reference signal during the Unlock phase



Simulated durable *Unlock* (3)

Result: The Lvdt signal has been modified using the prediction



Prediction Errors (1)

Definitions:

- y: filter output
- d: desired signal (Lvdt during Lock phase)
- p: prediction signal
- eL: error during Lock phase: $eL = y - d$
- eU: error during Unlock phase: $eU = y - p$

- During the Lock phase, the error is computed respect to the Lvdt measure

Prediction Errors (1)

Definitions:

- y: filter output
- d: desired signal (Lvdt during Lock phase)
- p: prediction signal
- eL: error during Lock phase: $eL = y - d$
- eU: error during Unlock phase: $eU = y - p$

- During the Lock phase, the error is computed respect to the Lvdt measure
- During the Unlock phase, the Lvdt signal is no longer useful. We use the prediction signal in this phase

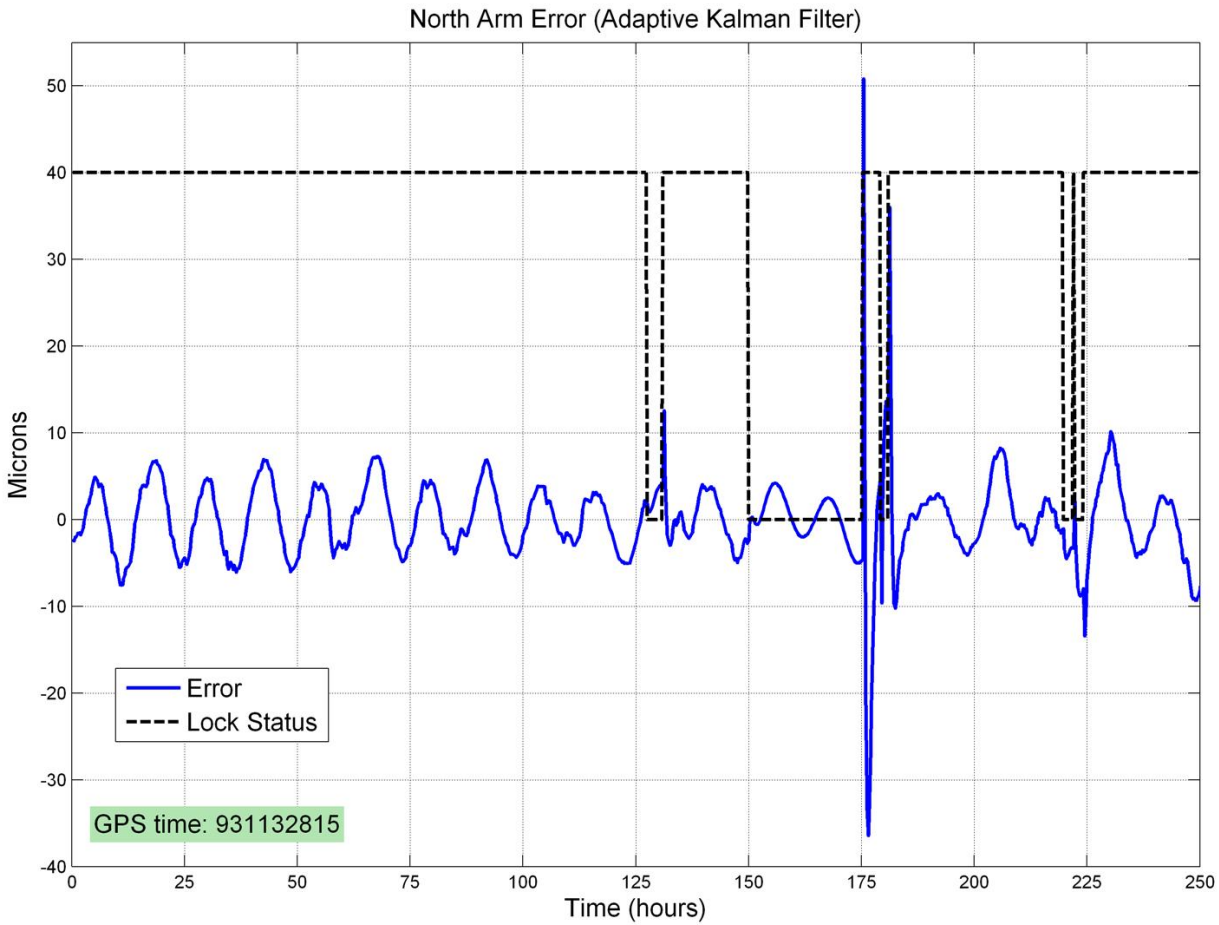
Prediction Errors (1)

Definitions:

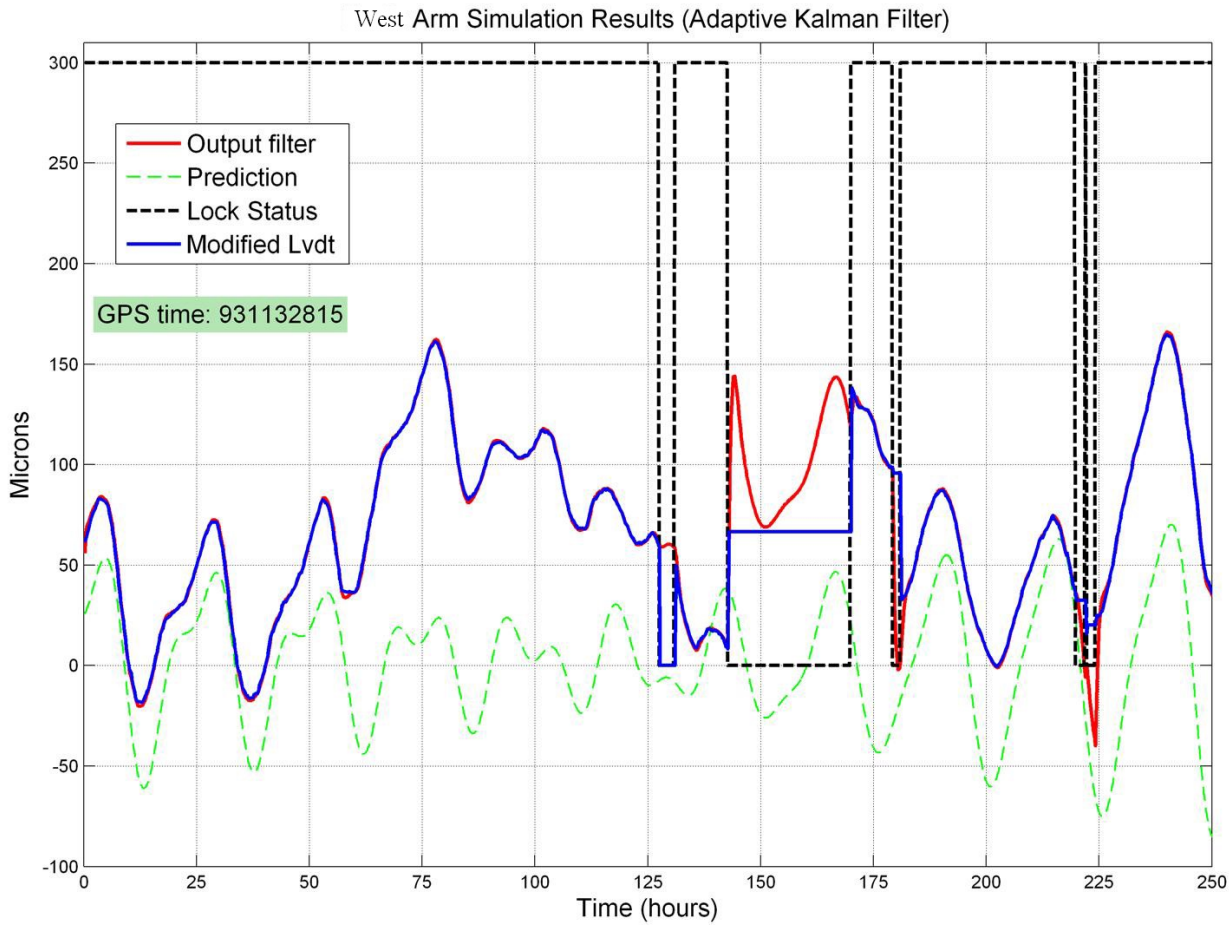
- y: filter output
- d: desired signal (Lvdt during Lock phase)
- p: prediction signal
- eL: error during Lock phase: $eL = y - d$
- eU: error during Unlock phase: $eU = y - p$

- During the Lock phase, the error is computed respect to the Lvdt measure
- During the Unlock phase, the Lvdt signal is no longer useful. We use the prediction signal in this phase

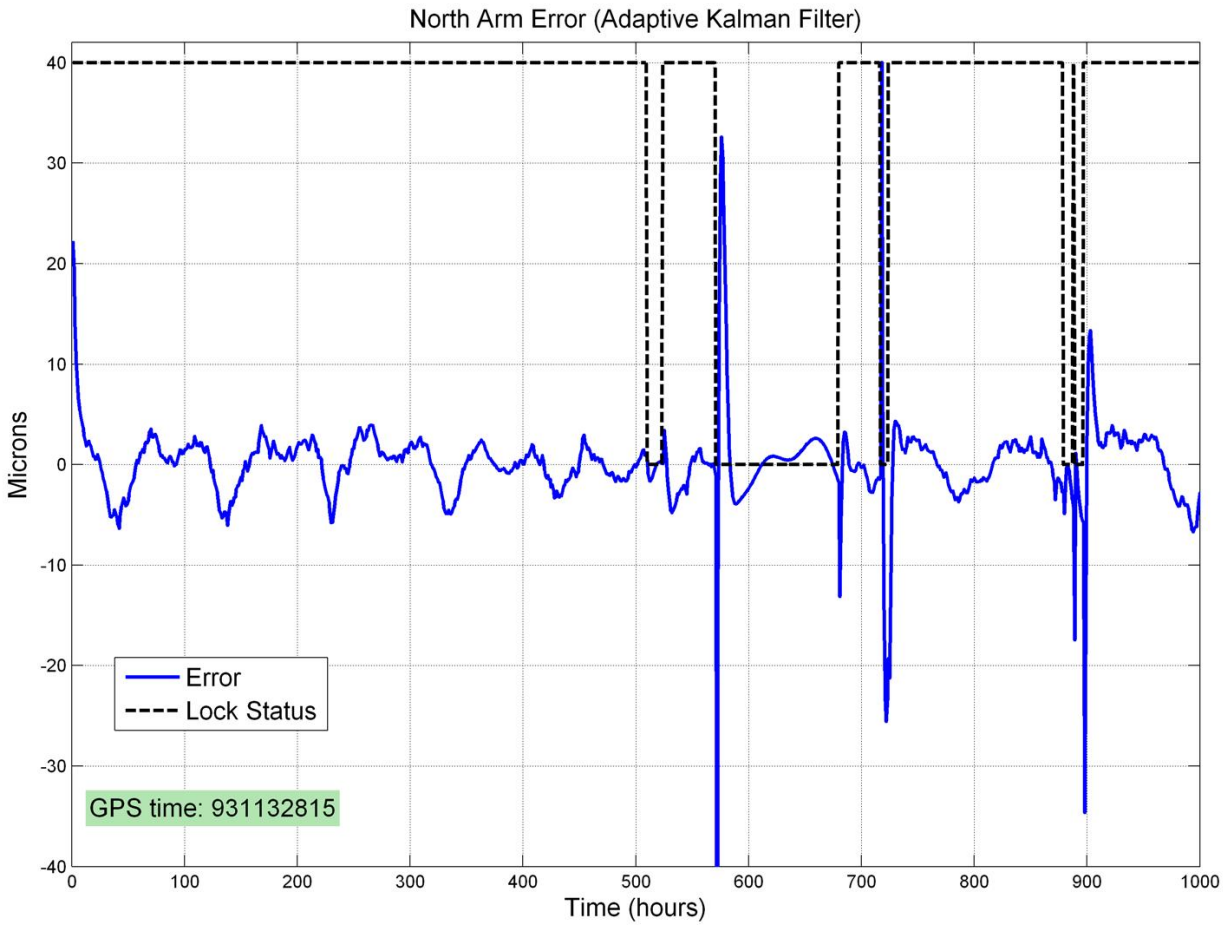
Prediction Error (2)



West Arm Results (1)



West Arm Results: Error (2)



Signal Drift

- The adaptive filtering applied corrects the predicted signal also in presence of drift measure
- Understand better the causes of these drifts could improve the accuracy of the prediction

Signal Drift

- The adaptive filtering applied corrects the predicted signal also in presence of drift measure
- Understand better the causes of these drifts could improve the accuracy of the prediction
- This analysis assumes that different kind of interferometer signals could be used in the system for tidal forces compensation

Signal Drift

- The adaptive filtering applied corrects the predicted signal also in presence of drift measure
- Understand better the causes of these drifts could improve the accuracy of the prediction
- This analysis assumes that different kind of interferometer signals could be used in the system for tidal forces compensation