

**NERC**

NORTH AMERICAN ELECTRIC  
RELIABILITY CORPORATION

# PMUs and Blackout Analysis

Robert W. Cummings

NERC Director, Reliability Initiatives and System Analysis

NASPI Working Group Meeting – Technical Session 2

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**RELIABILITY | ACCOUNTABILITY**

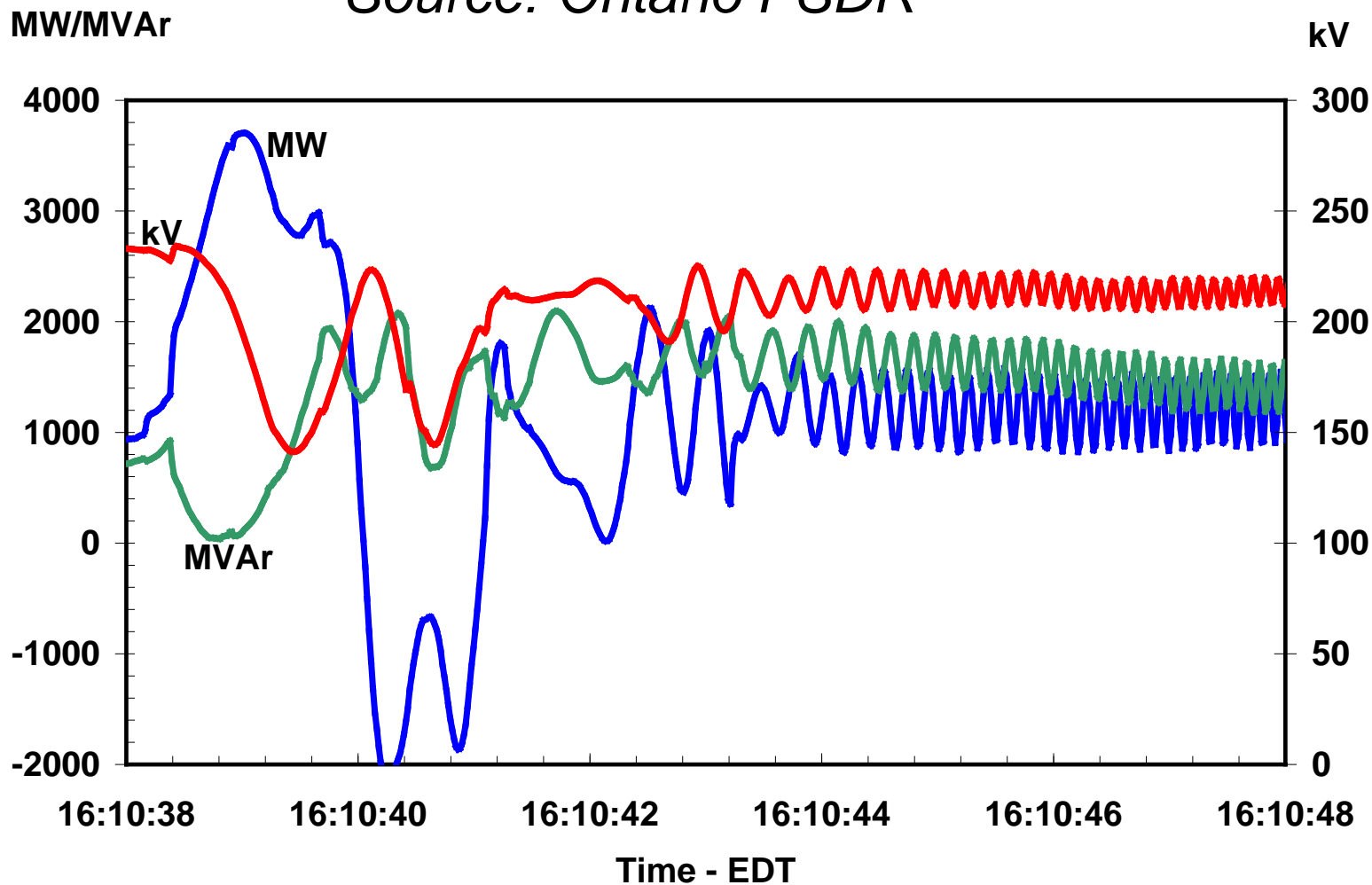


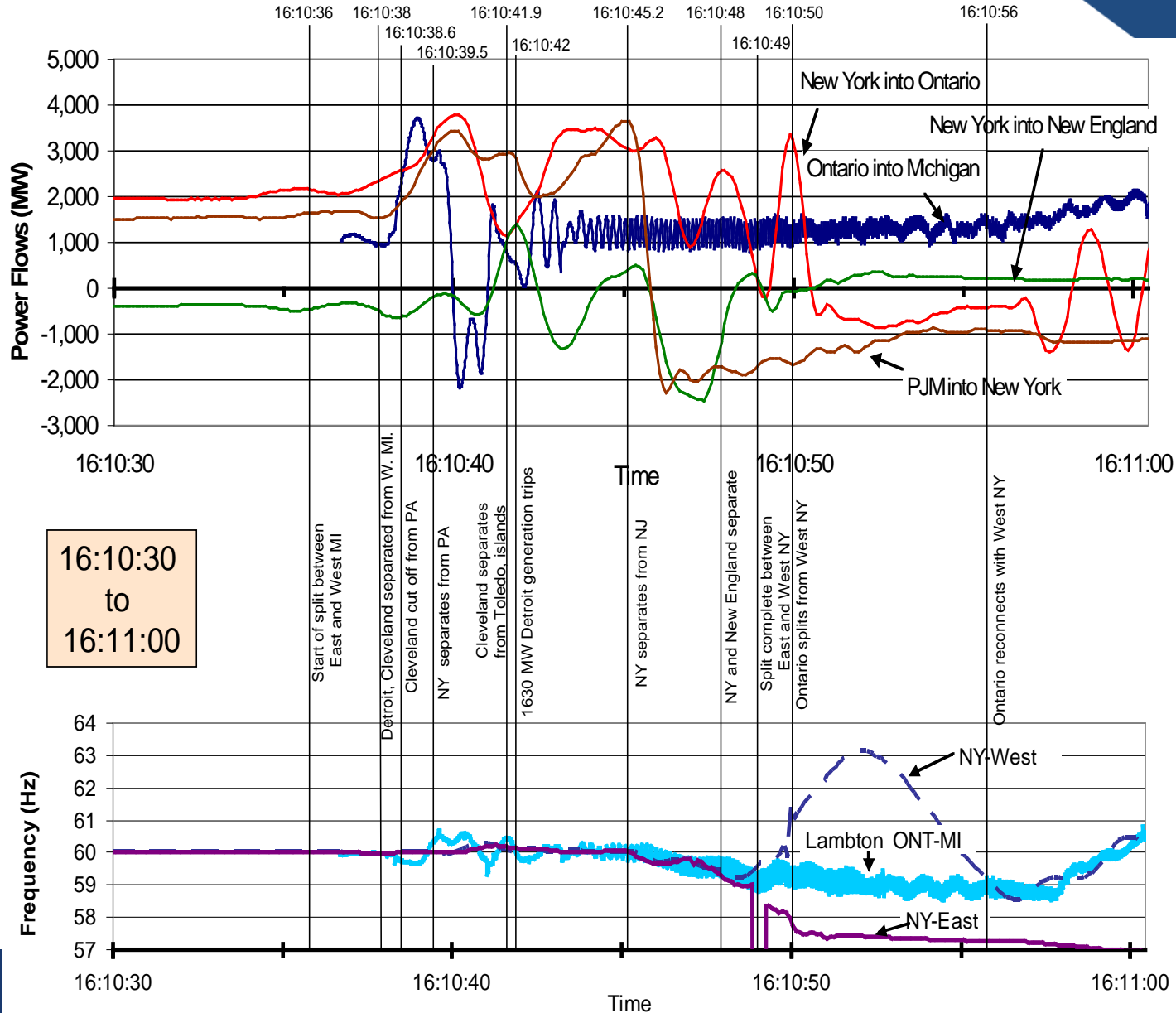


*Use of PMUs in EA*

# IESO-MECS Voltage and Flows Measured from Lambton

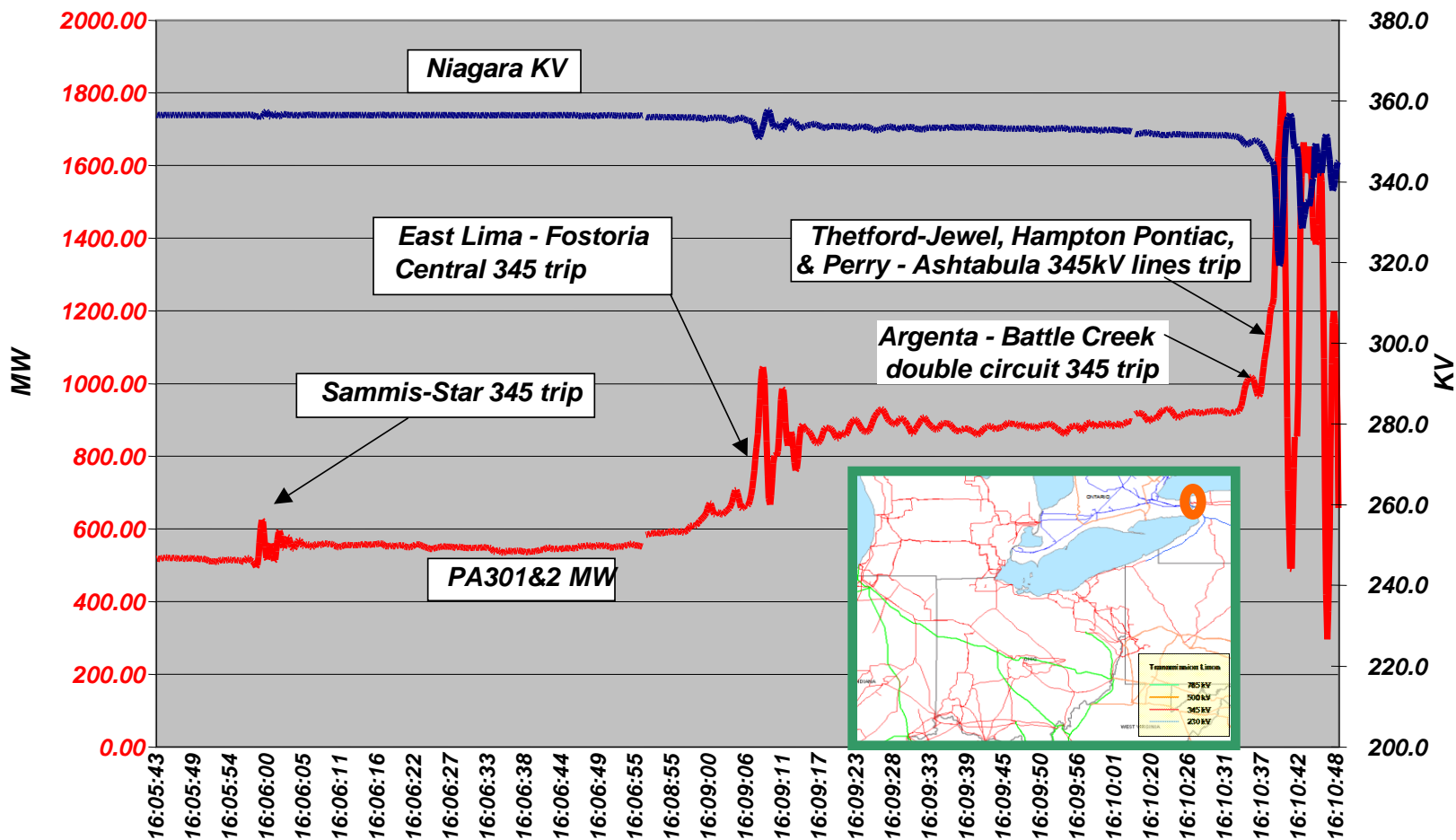
Source: Ontario PSDR



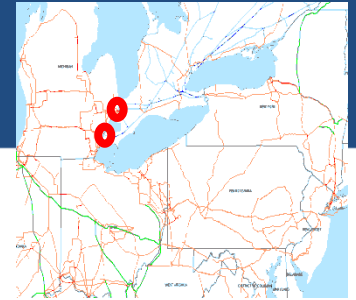


16:10:30  
to  
16:11:00

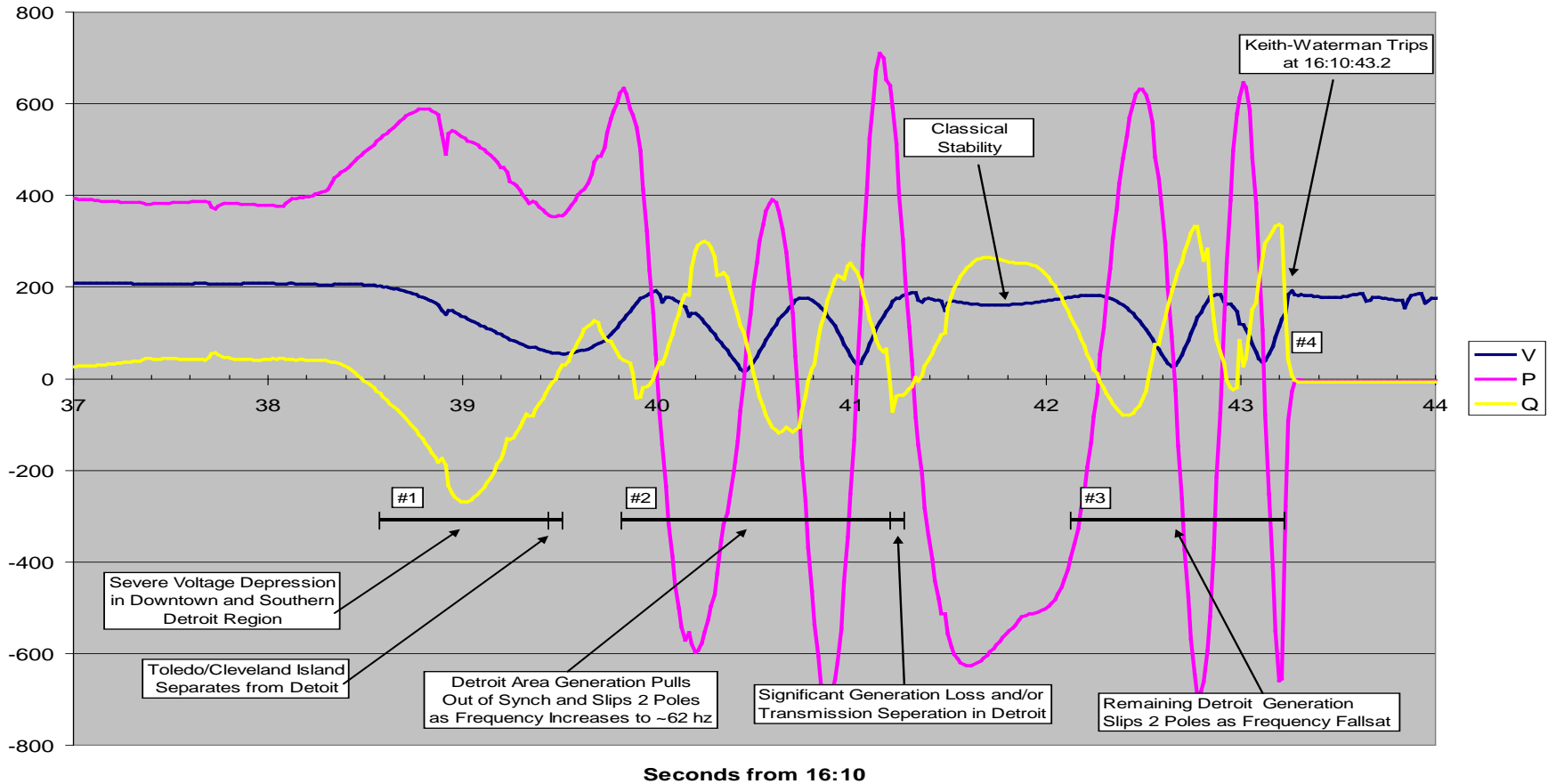
**New York to Ontario 345 kV Line Flow at Niagara**  
(does not include 230 kV line flow)



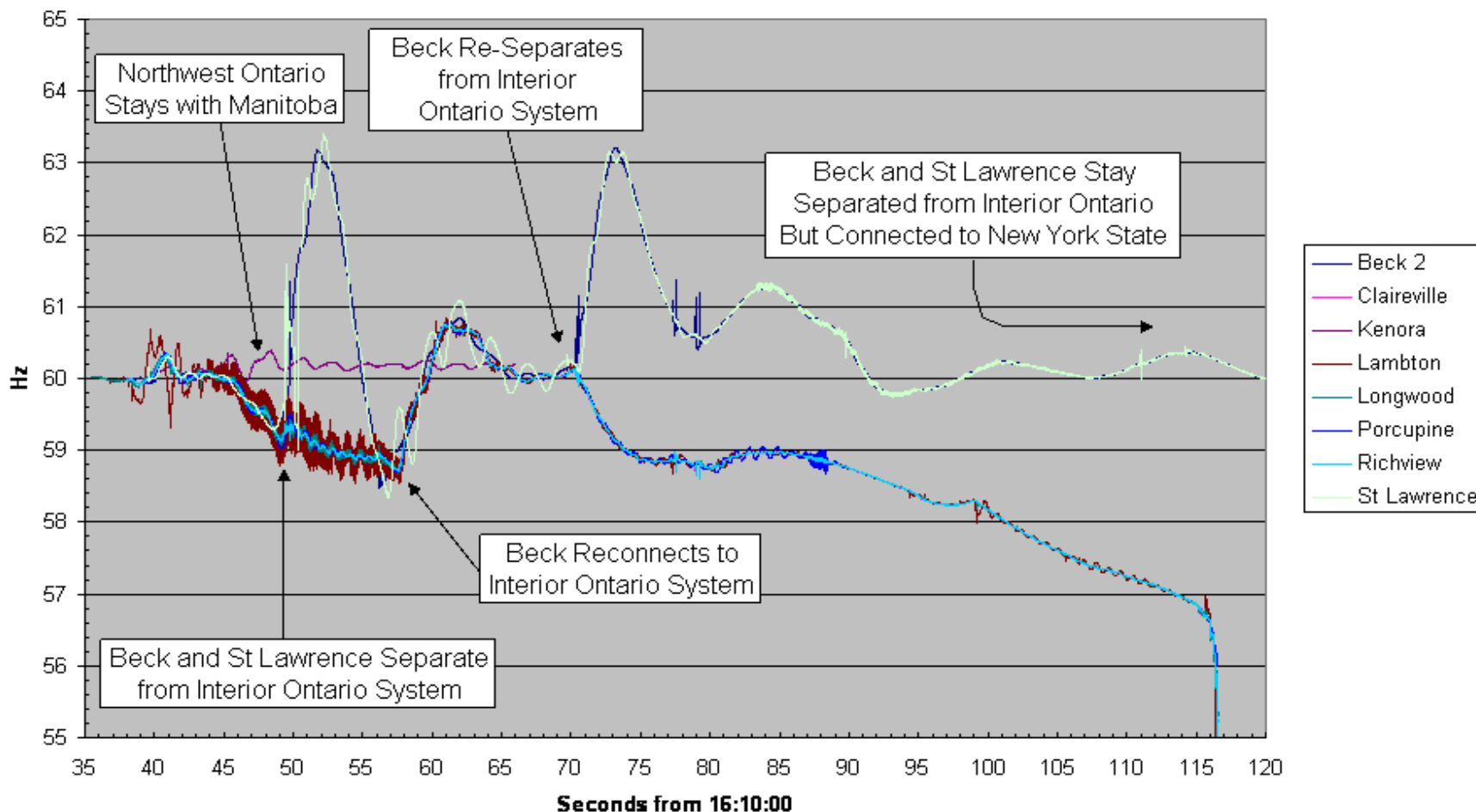
# Detroit Units Slip Poles



**Keith-Waterman (J5D) 230 kV - Tie Line**



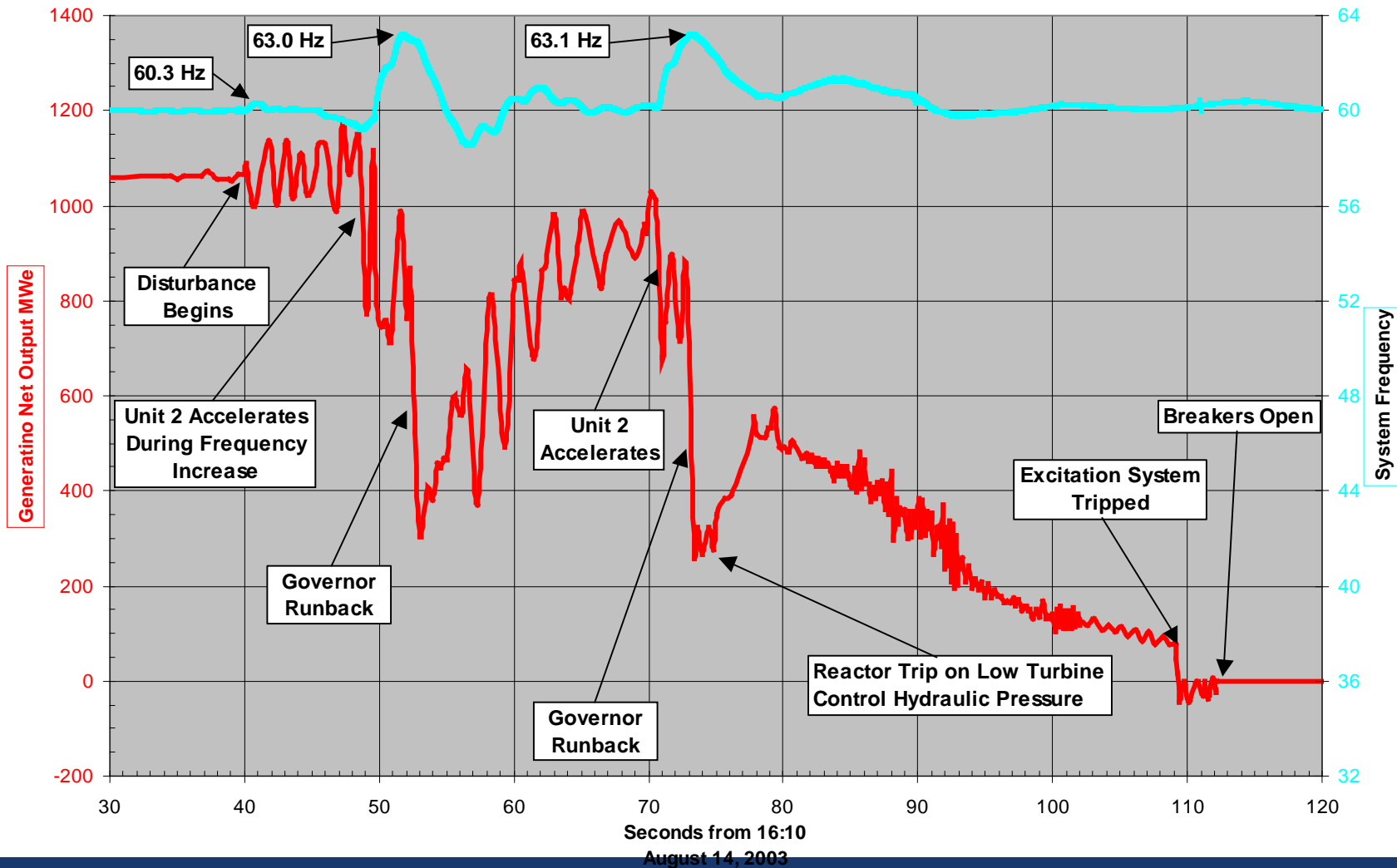
## Frequency Separation Interior Ontario and Northern New York





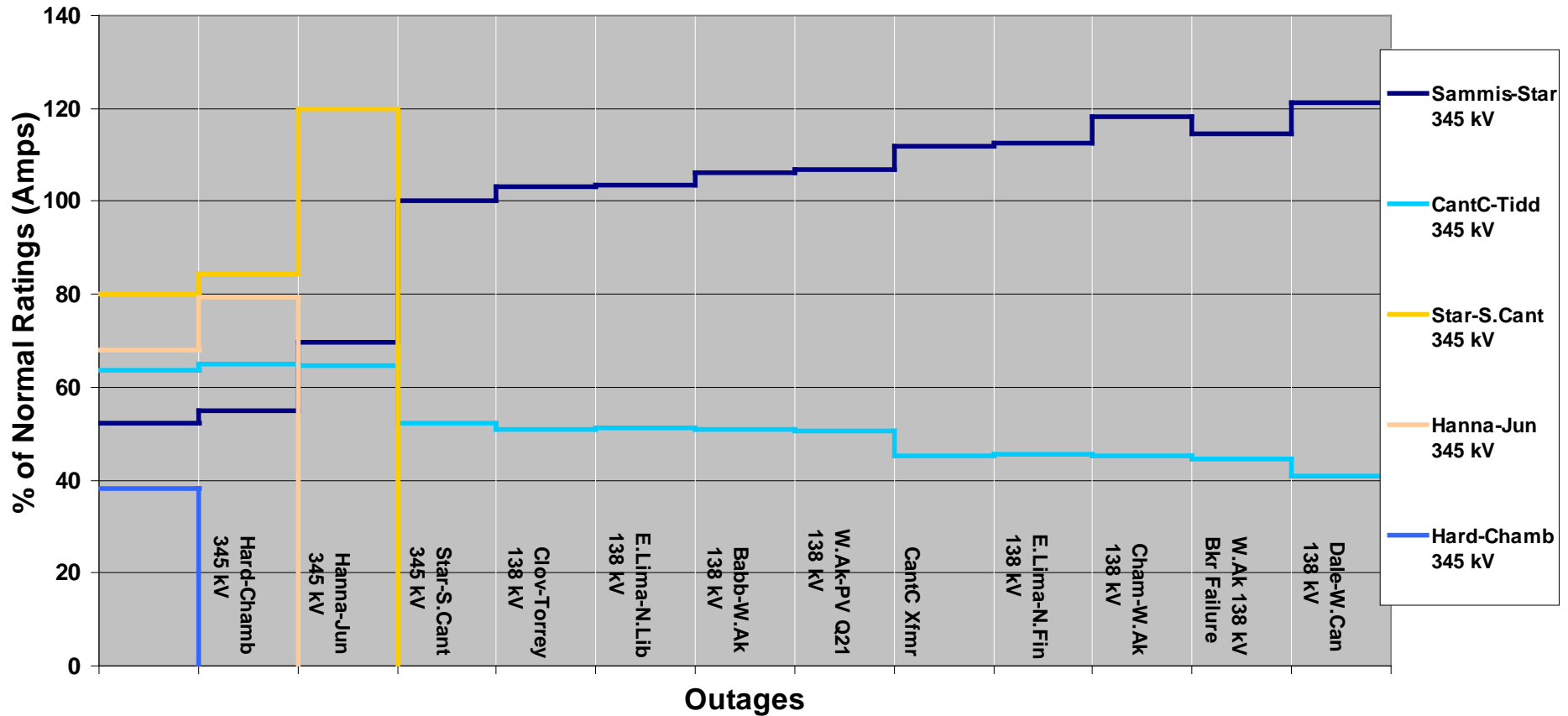
# Nine Mile Point Unit 2 Trips

**Nine Mile Point Unit 2 Generation Data**  
(Reconstructed)



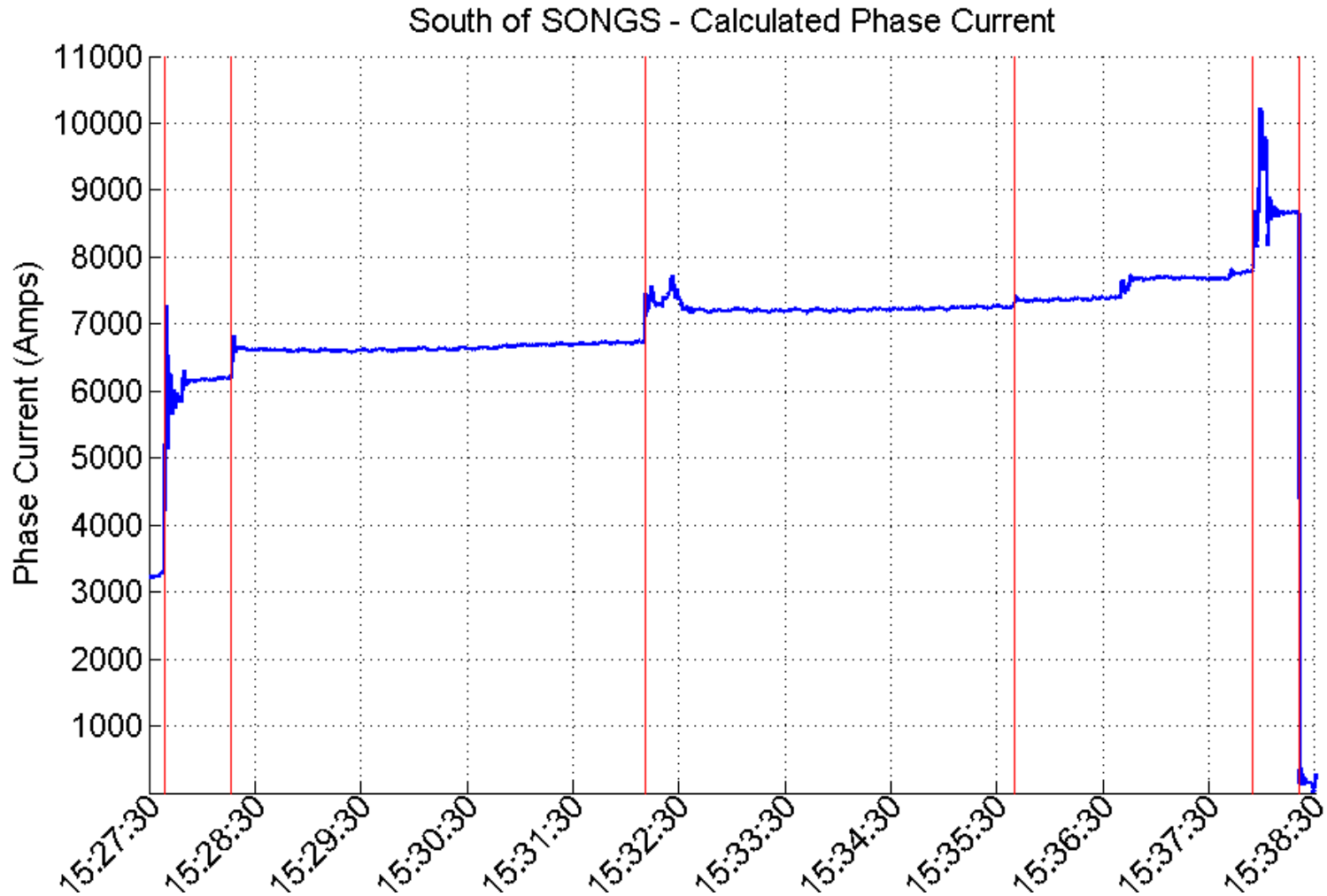


# 2003 Blackout Simulations



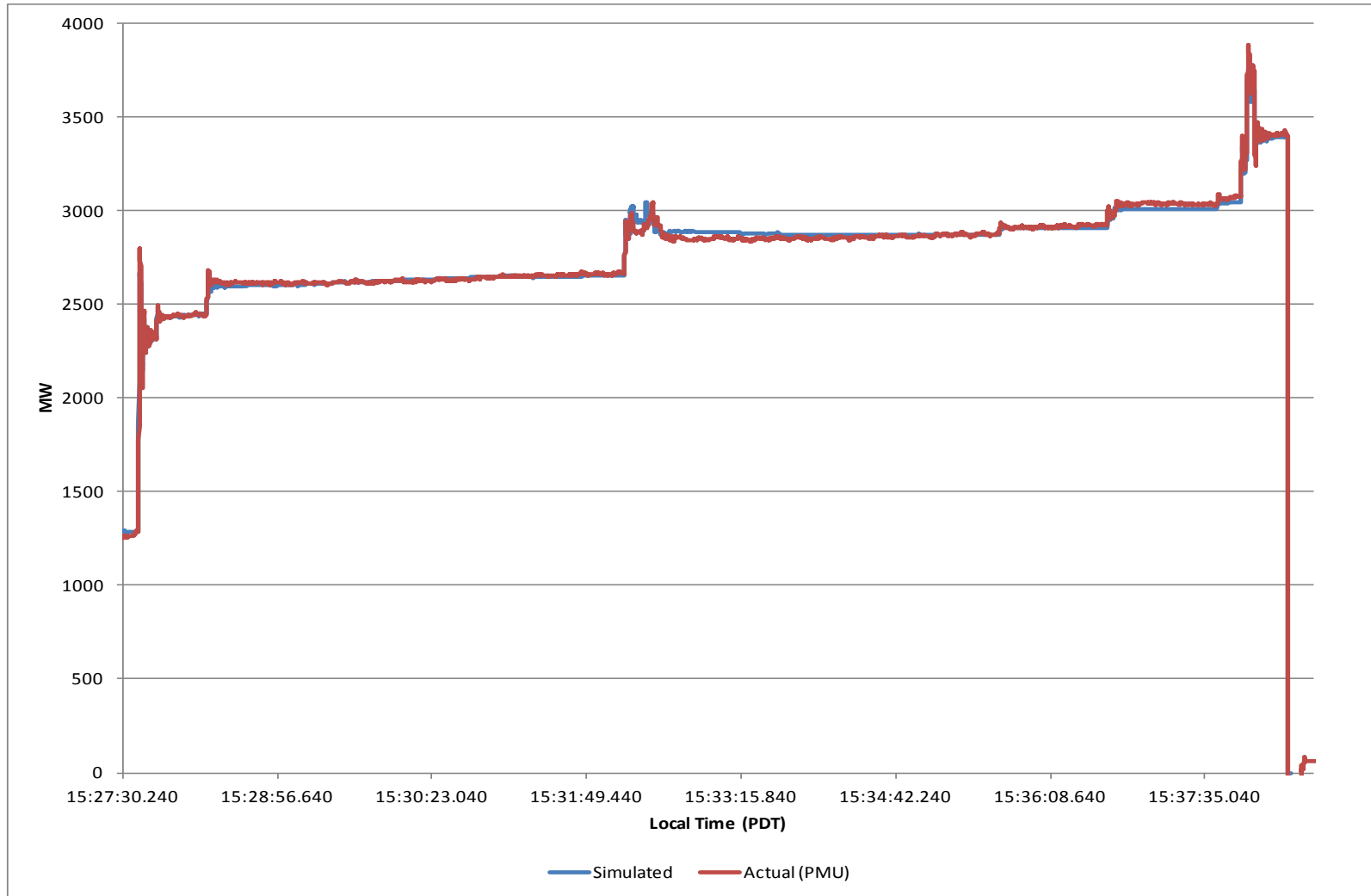


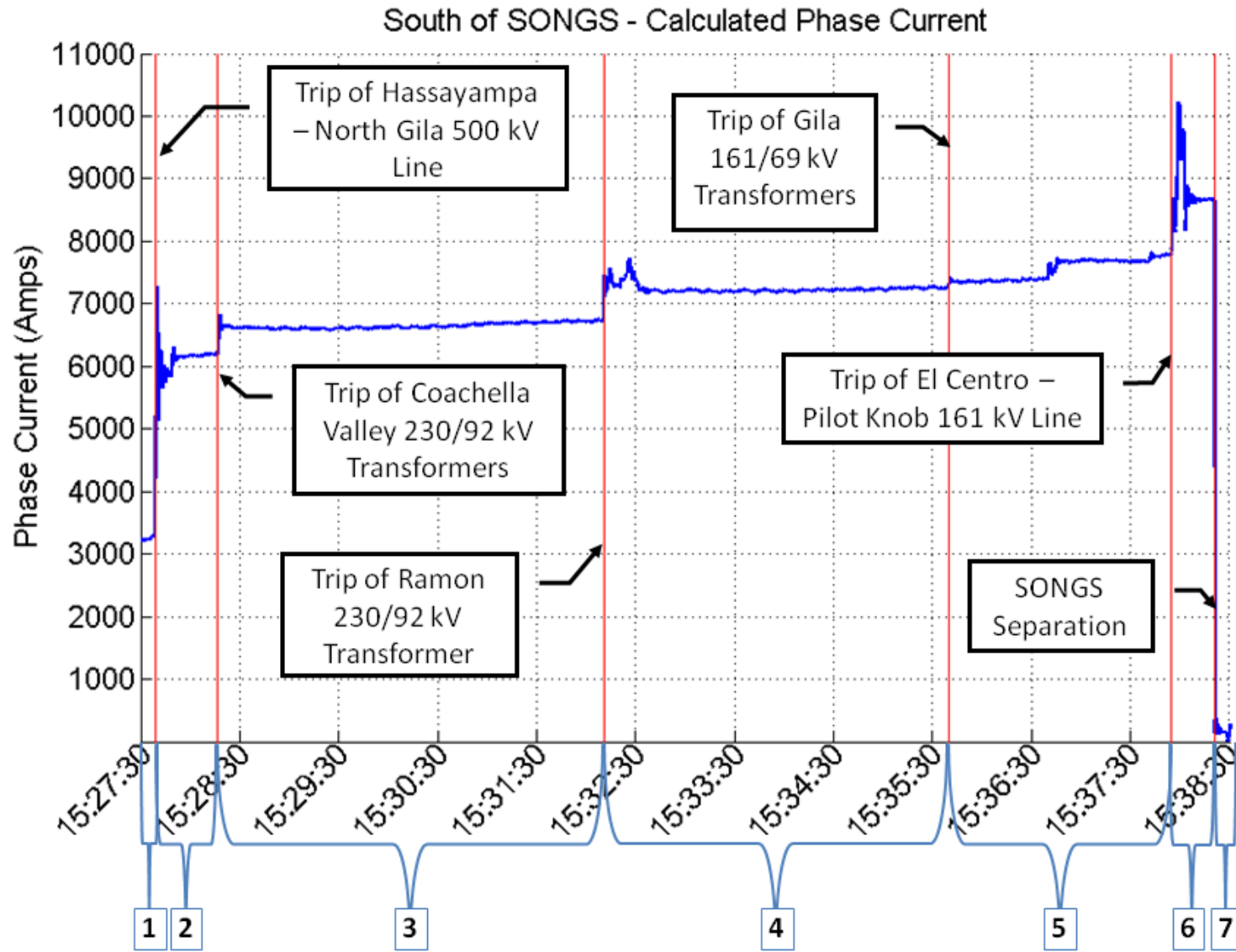
*8 Years Later*



# Simulation vs. Actual Flows

## South of SONGS Flows





We heard there was a blackout in Southern California

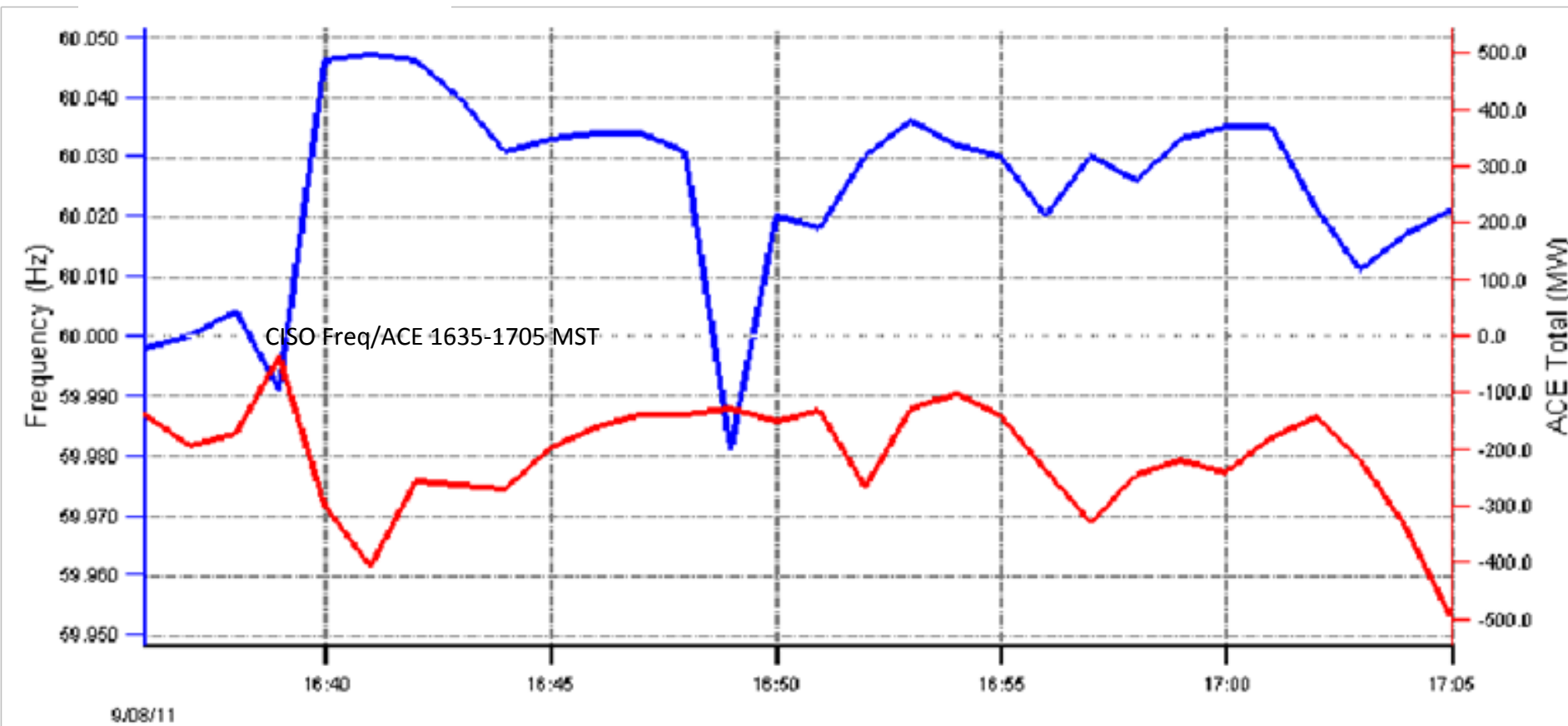
- Was it an attack tripping multiple lines?
- Did the San Onofre plant trip cause San Diego to go black?
- Was it a simple switching error?
- Did generation trip in Mexico cause it?



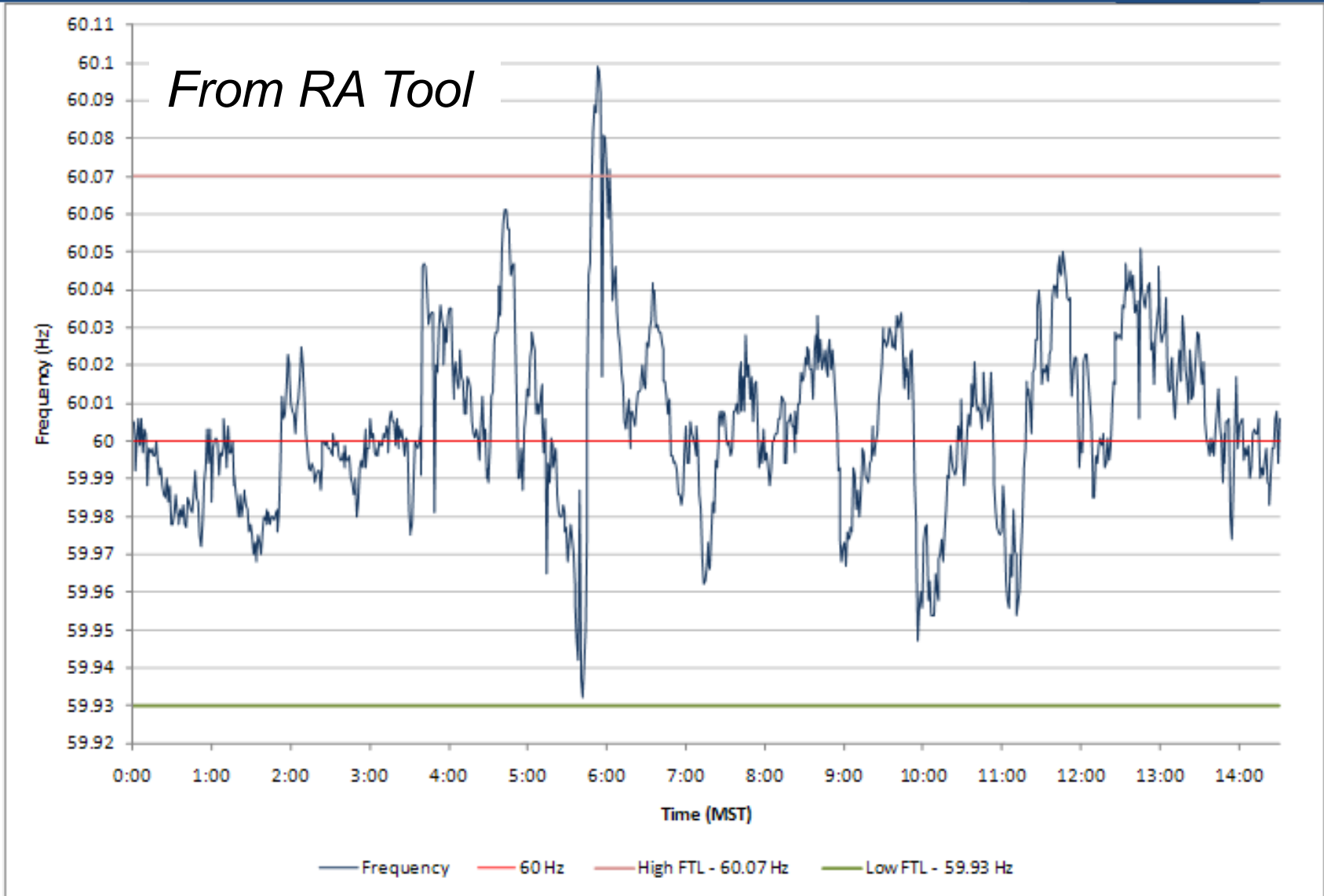
*Initial (overnight) Analysis*

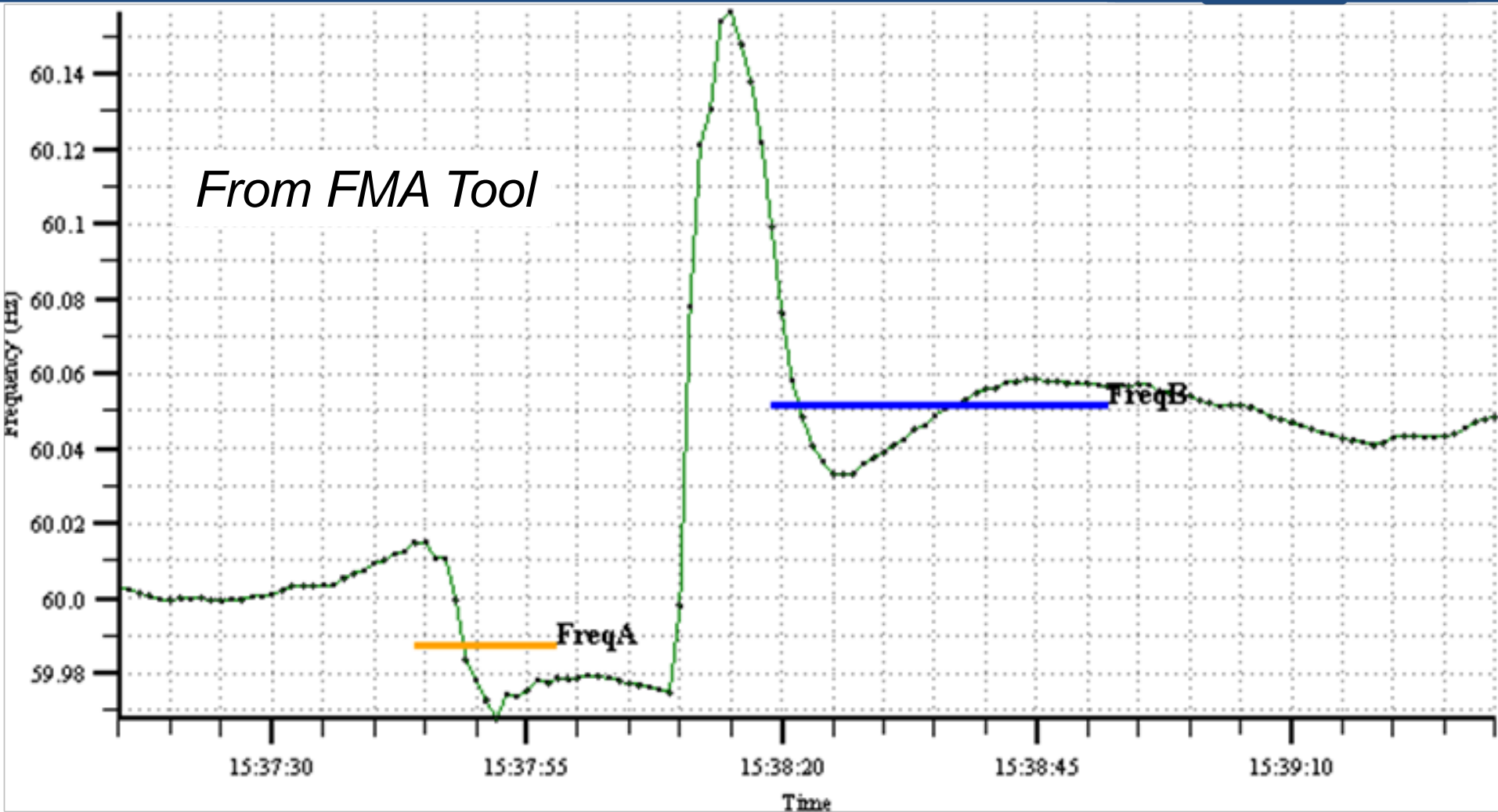


*From RA Tool*

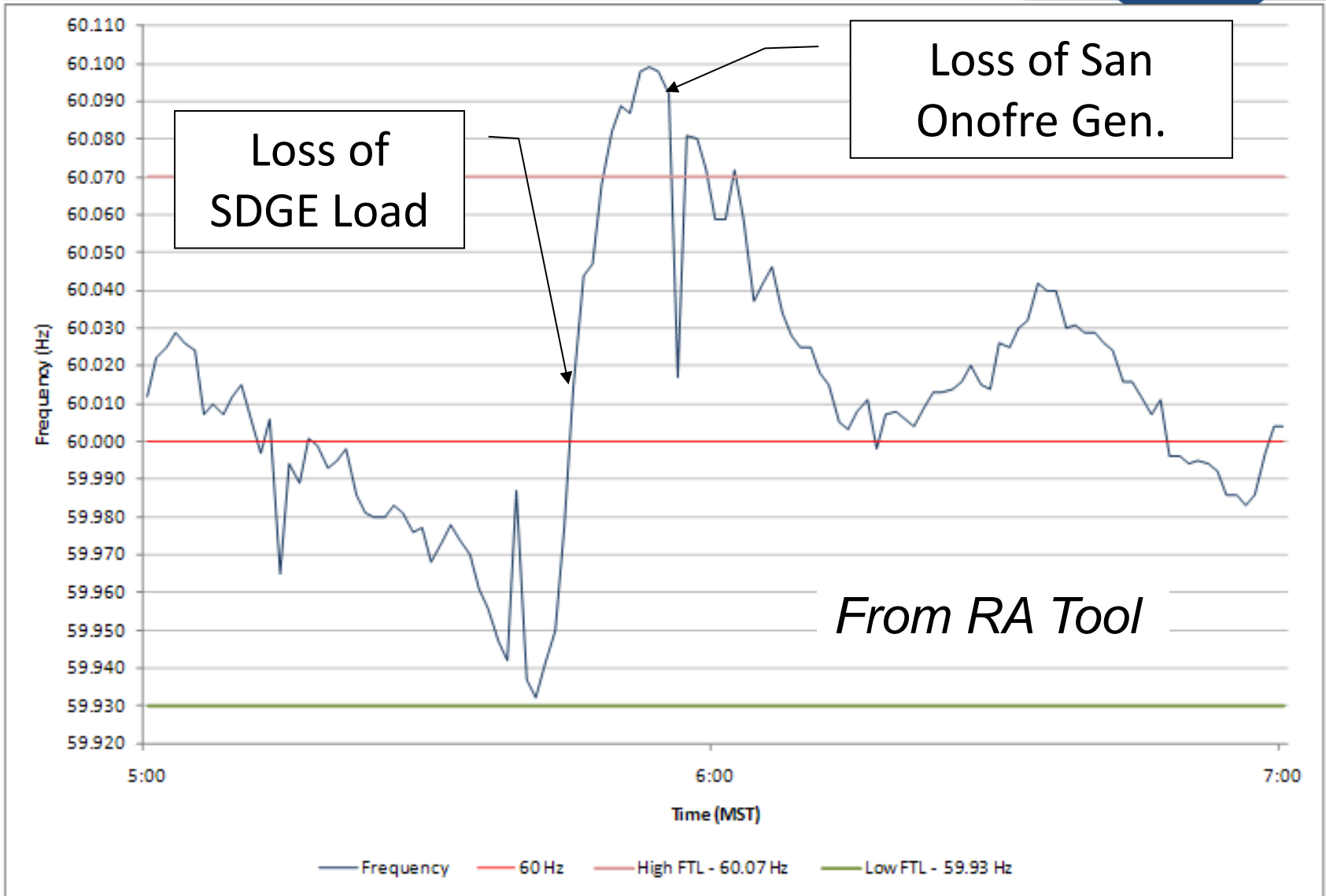


# 1-Min. CAISO Freq. 1500-0530 MST

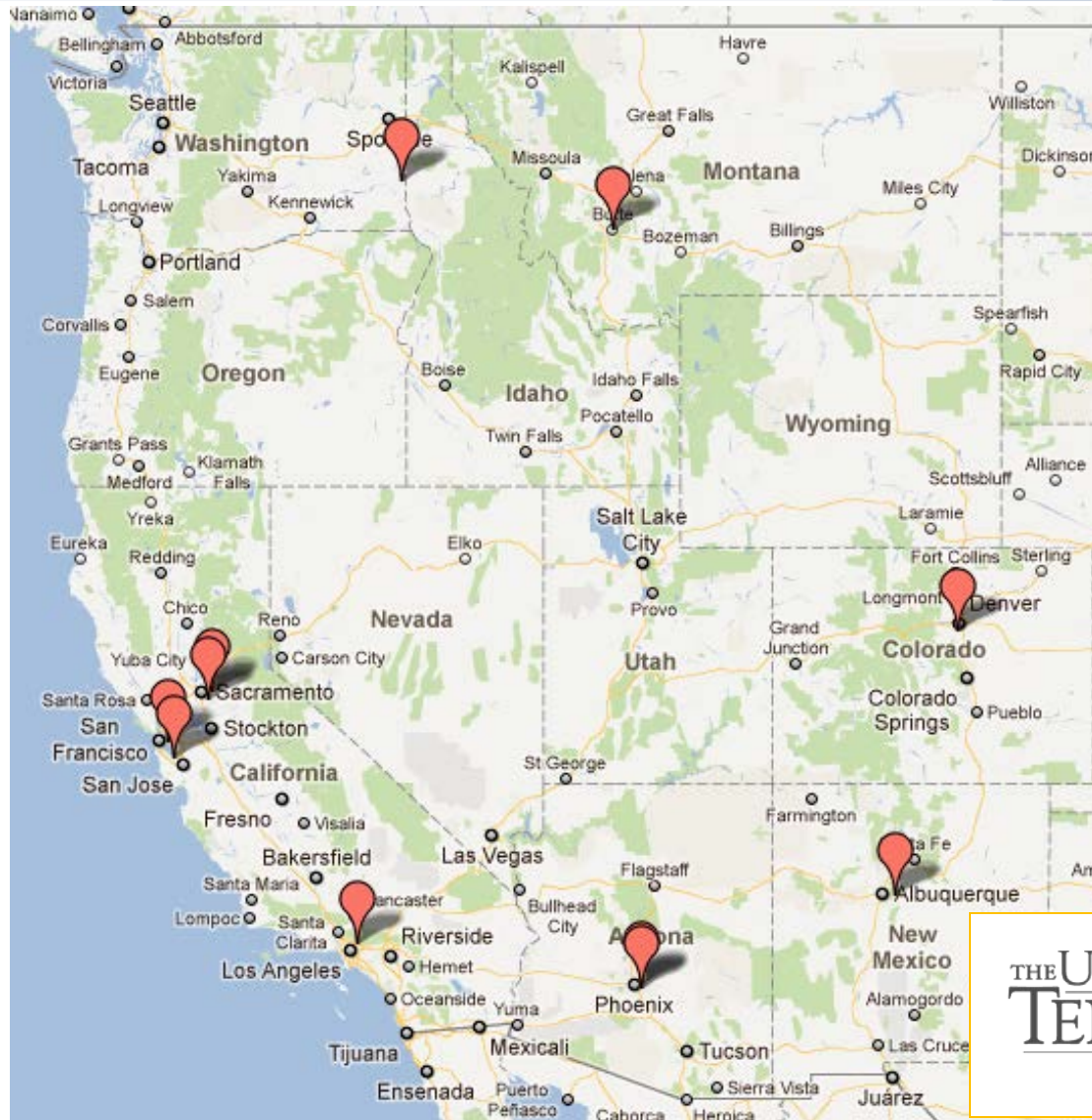




# System Separation & SONGS Trip



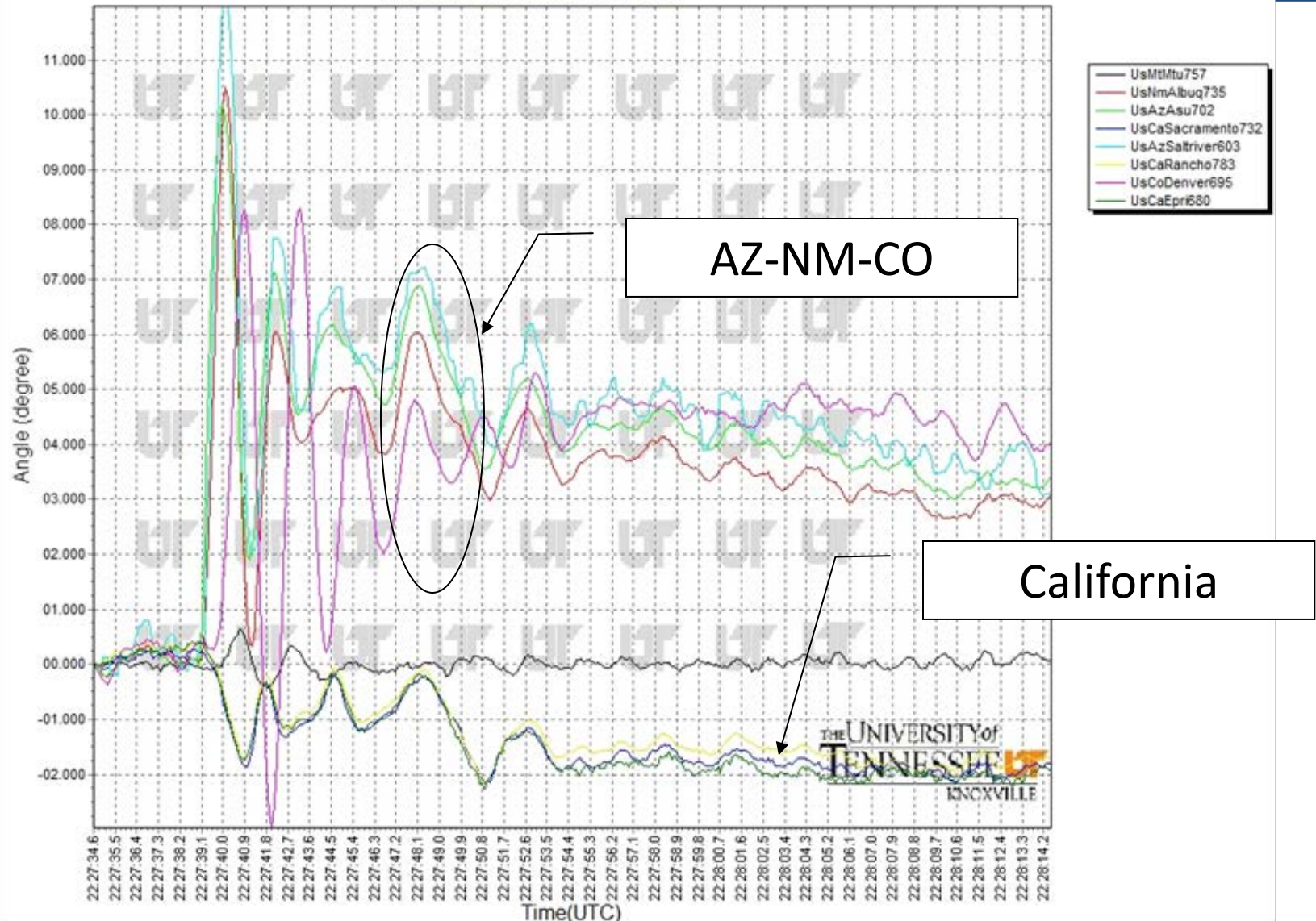
# FNET FDR Locations



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**TENNESSEE**   
KNOXVILLE



# Initial FNet FDR Angular Plot

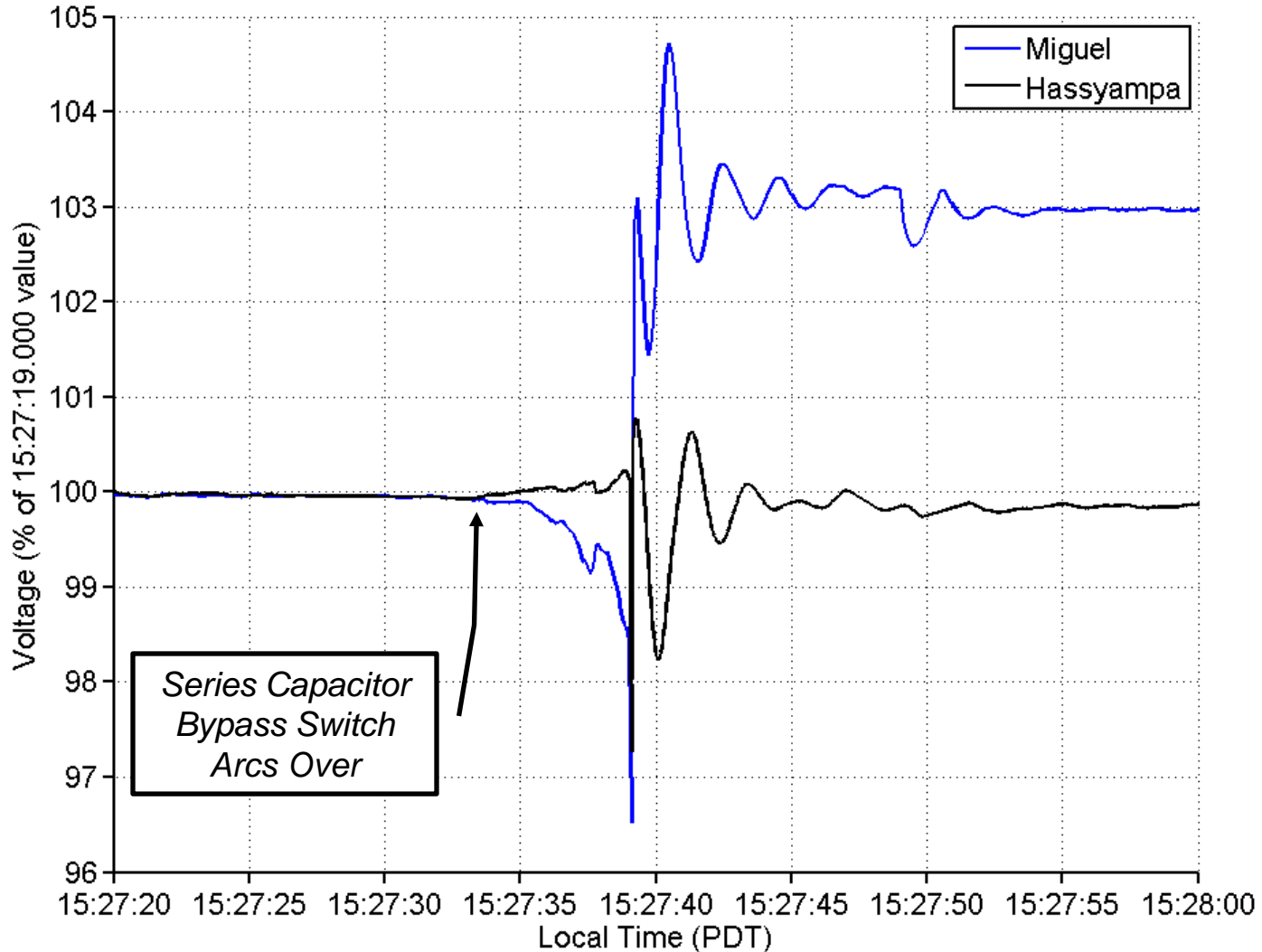




*Sequence of Events  
Analysis with PMUs*

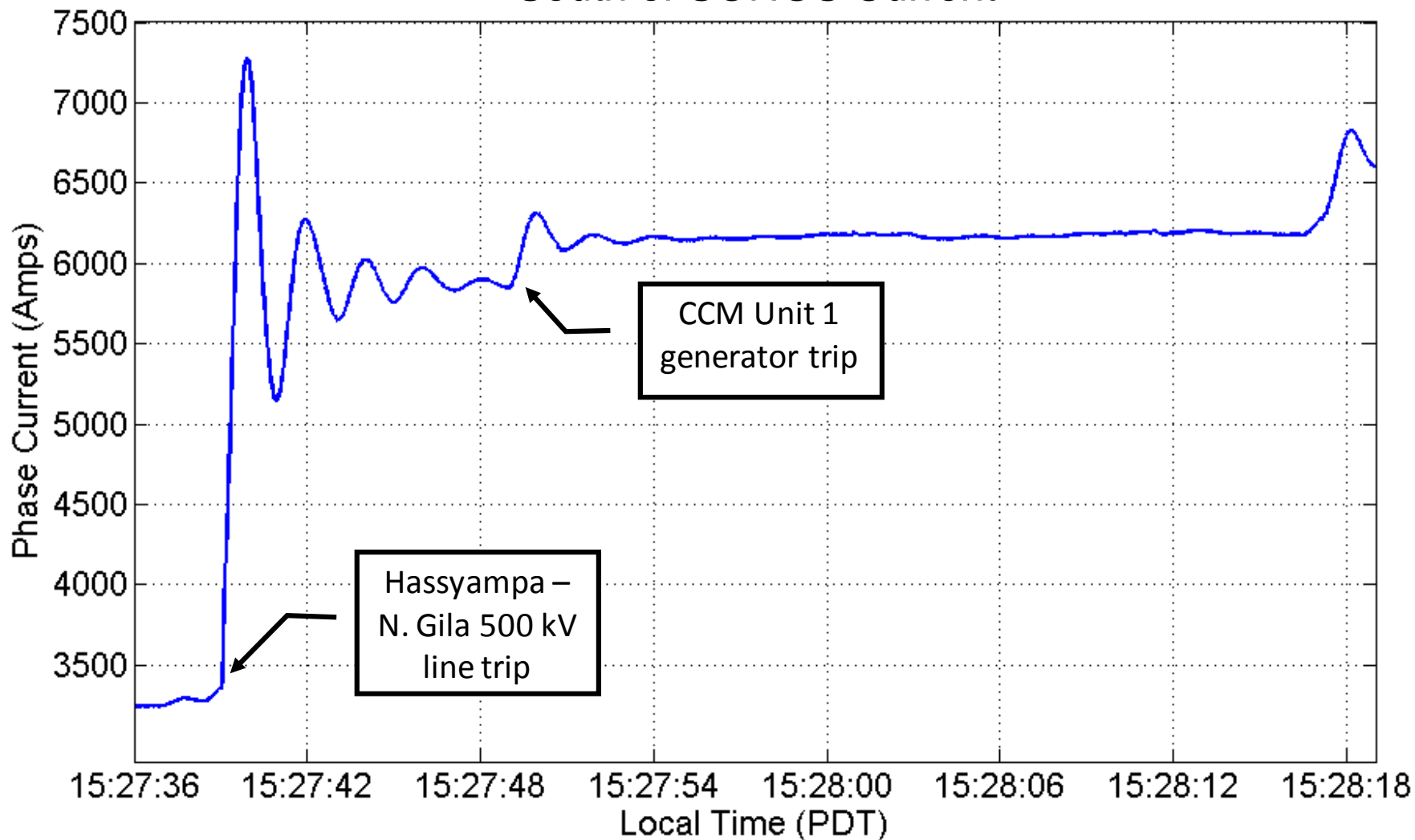


# Initiating Event – Voltage Divergence Hassayampa – North Gila 500 kV Trip

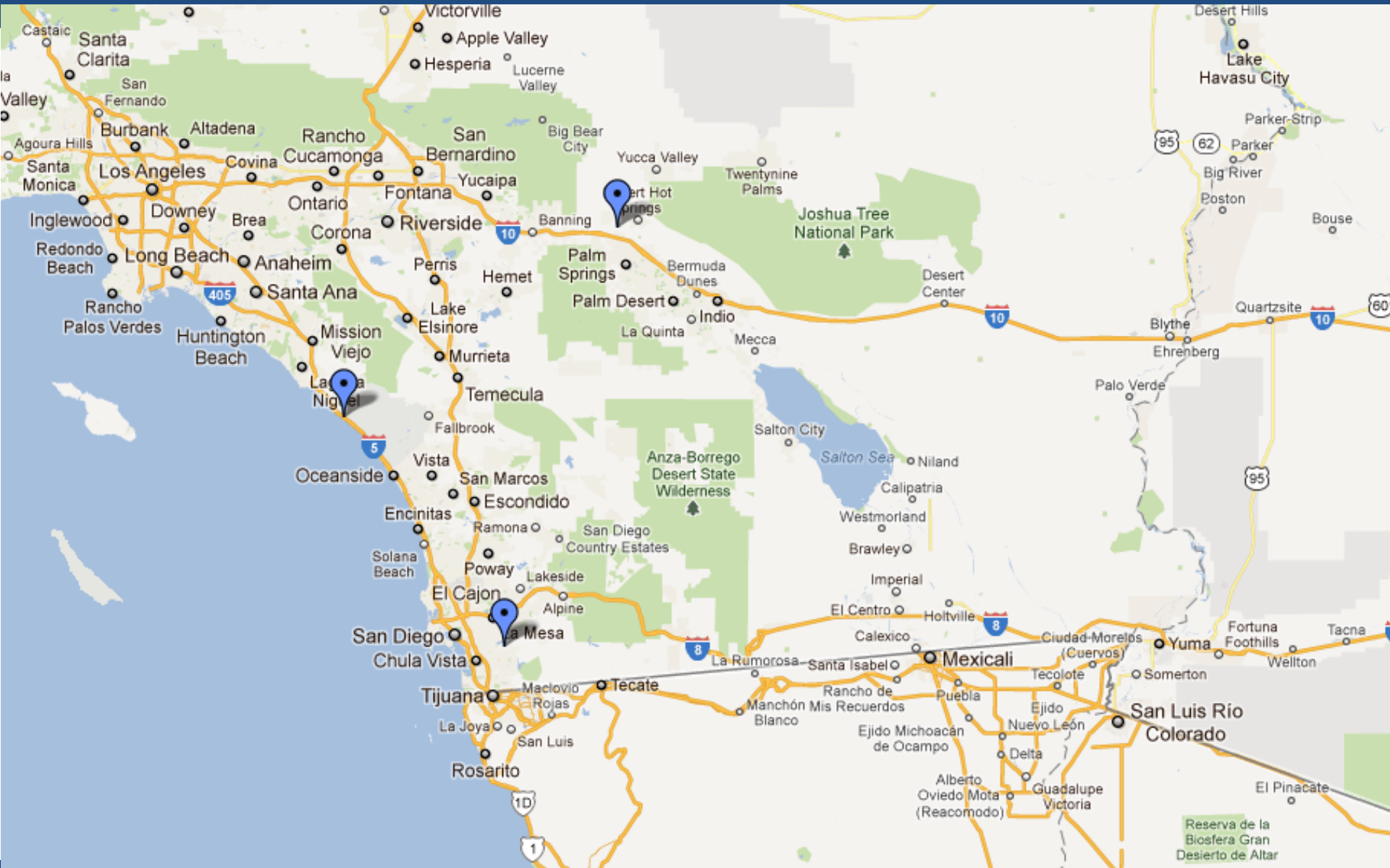


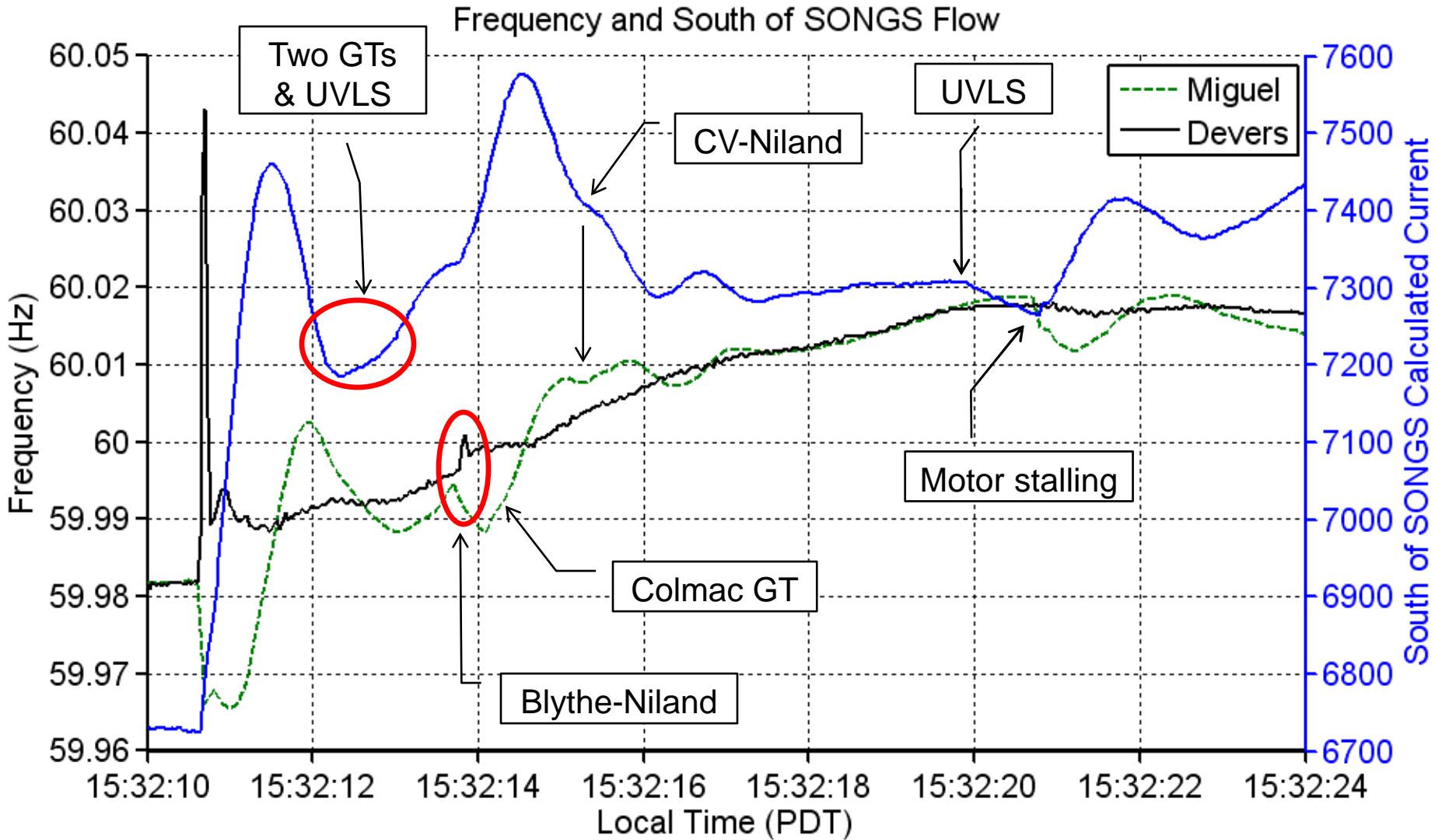
# Hass. – N. Gila 500 kV Line Trip

## South of SONGS Current

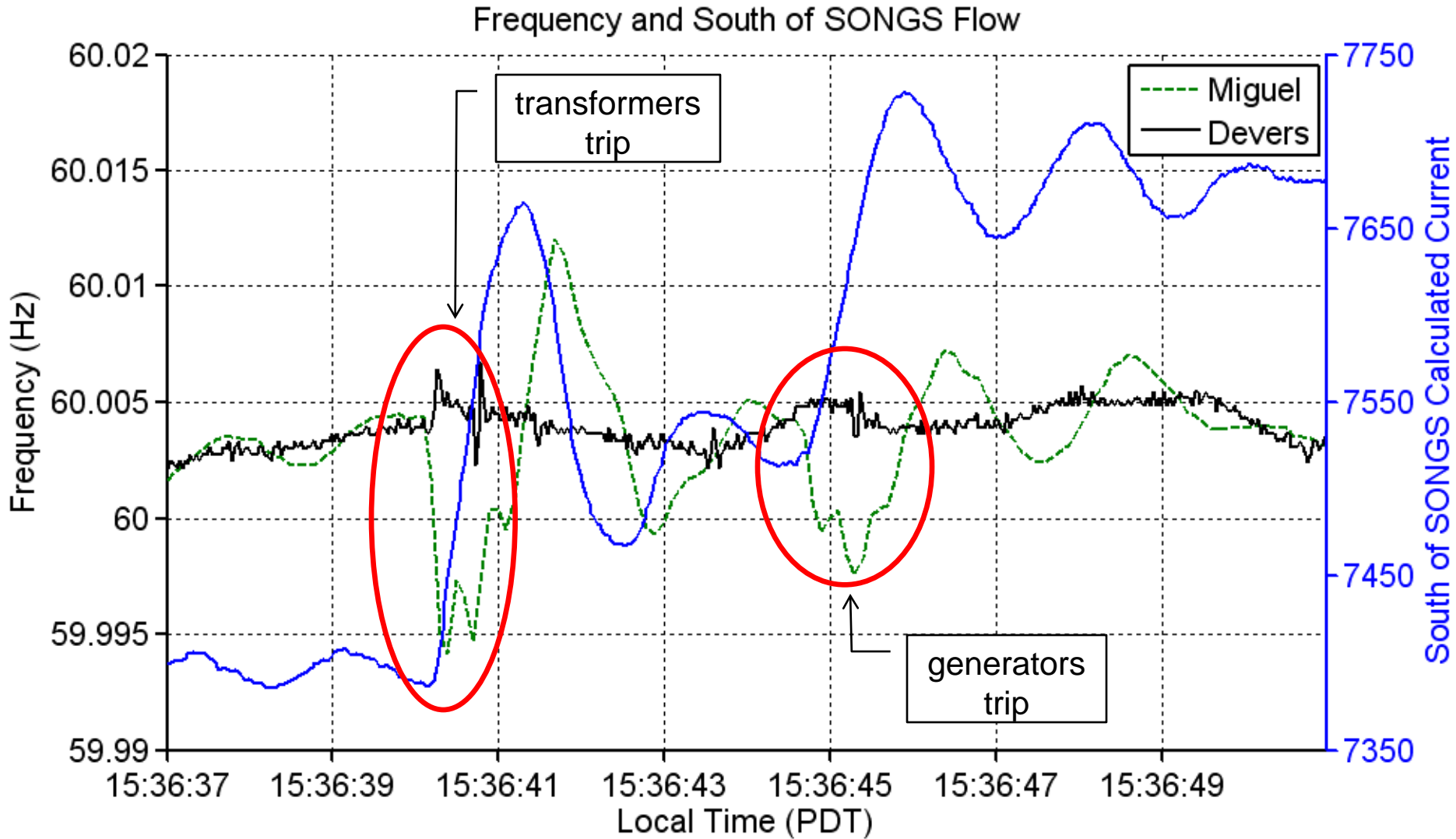


# Critical PMU Locations

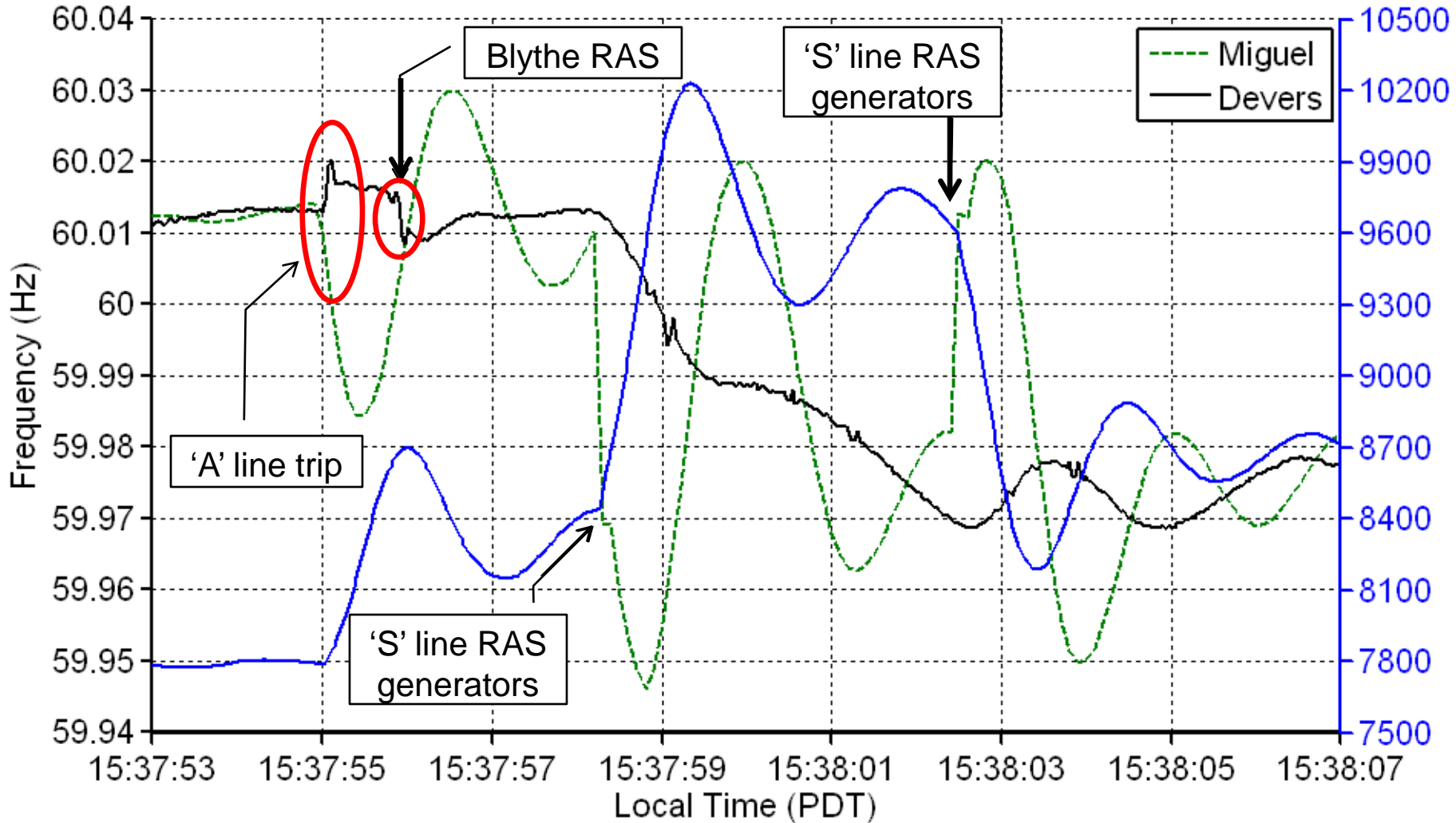




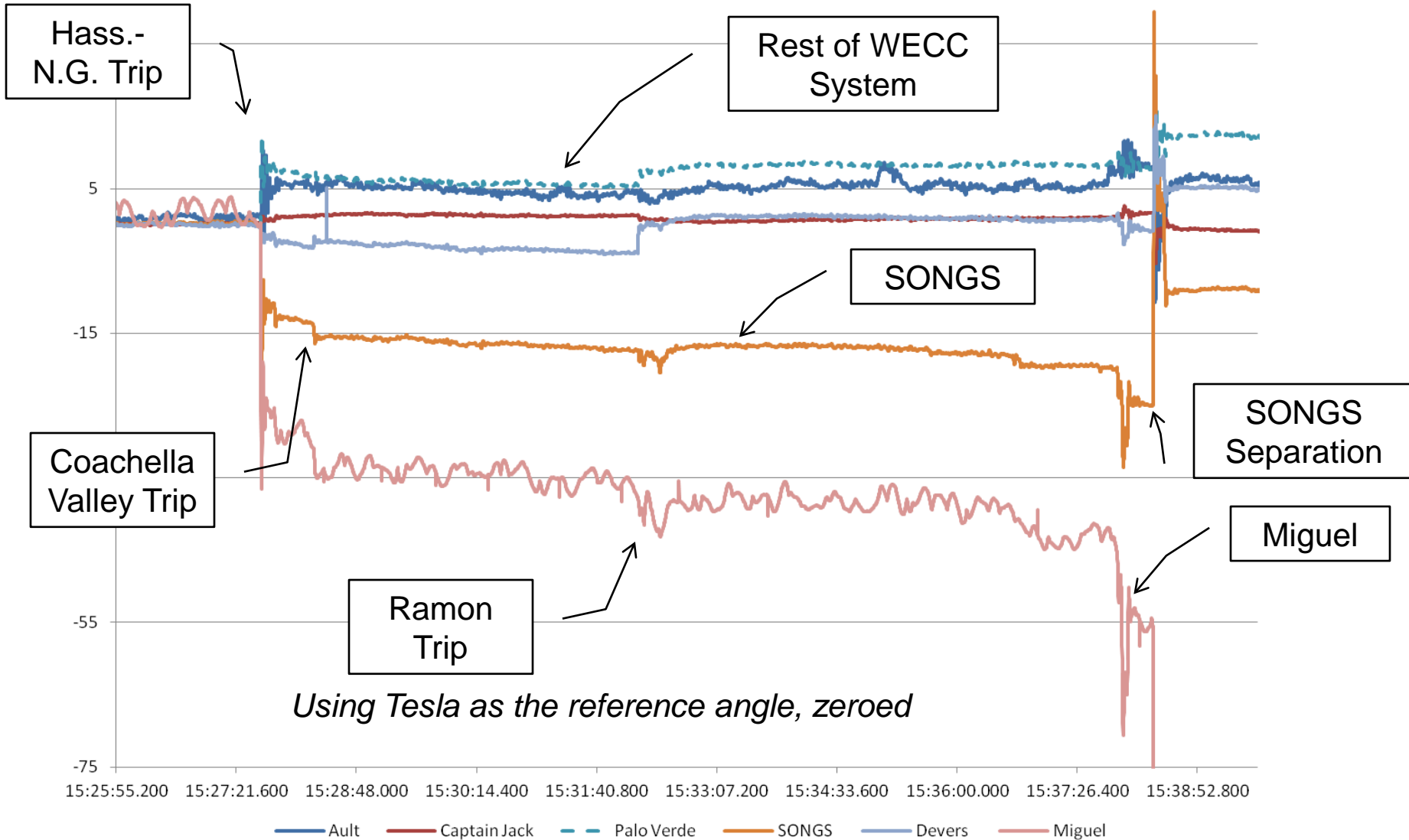
# Phase 5 Example



Frequency and South of SONGS Flow



# PMU Measured Phase Angles







*Questions?*