Interconnection vs Regional Inertia from Events

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Different inertia estimation methods

- **Challenges**

Dispatch-based method:

- Ignores IBRs and load inertia

Ambient data- based method:

- Unknown and small disturbances

Probing signal- based method:

- Invasive and requires extra setup

- **Large event-based (preferred)**

Includes inertia contribution from IBRs and loads

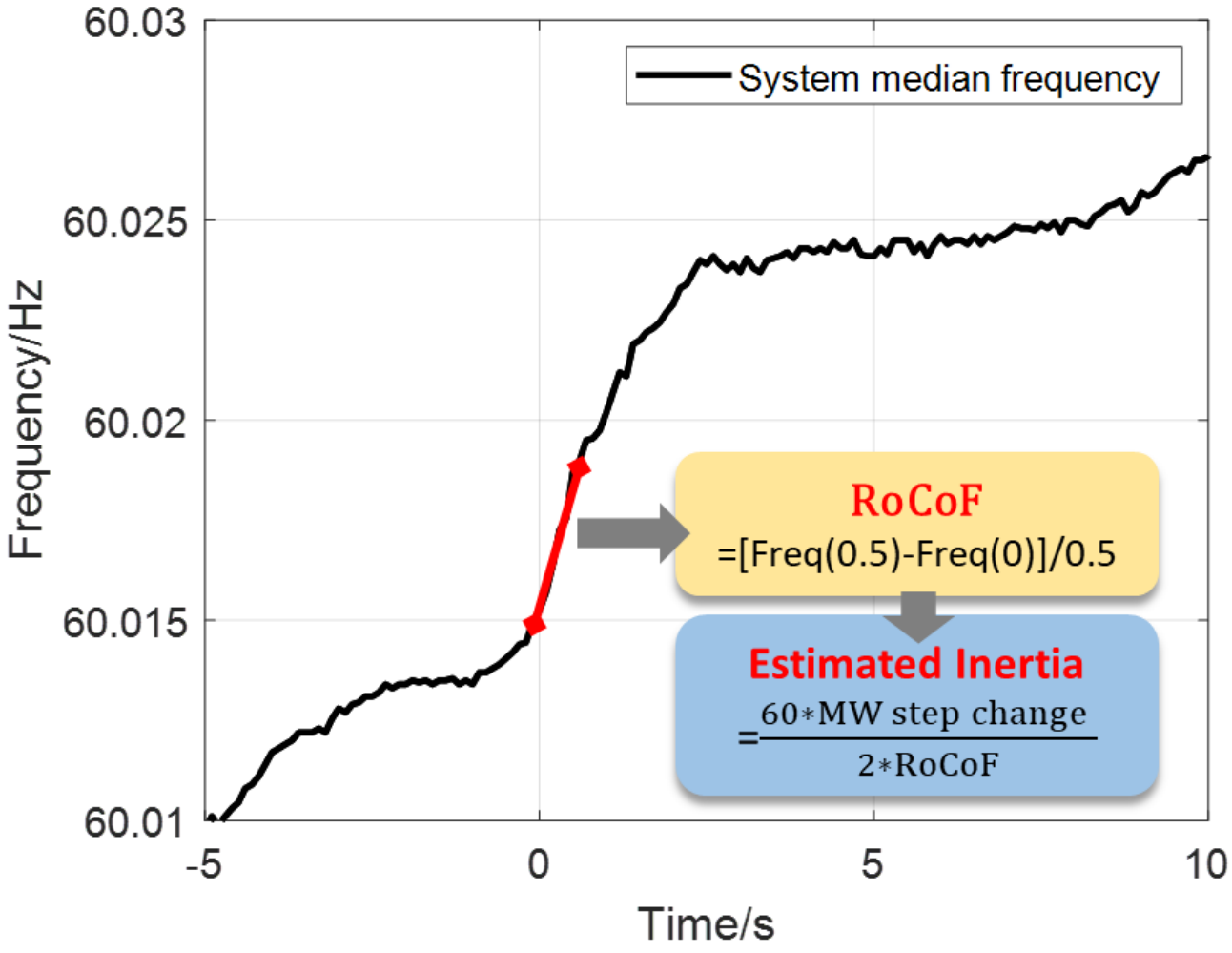
Reflects true system dynamics

High signal to noise ratio

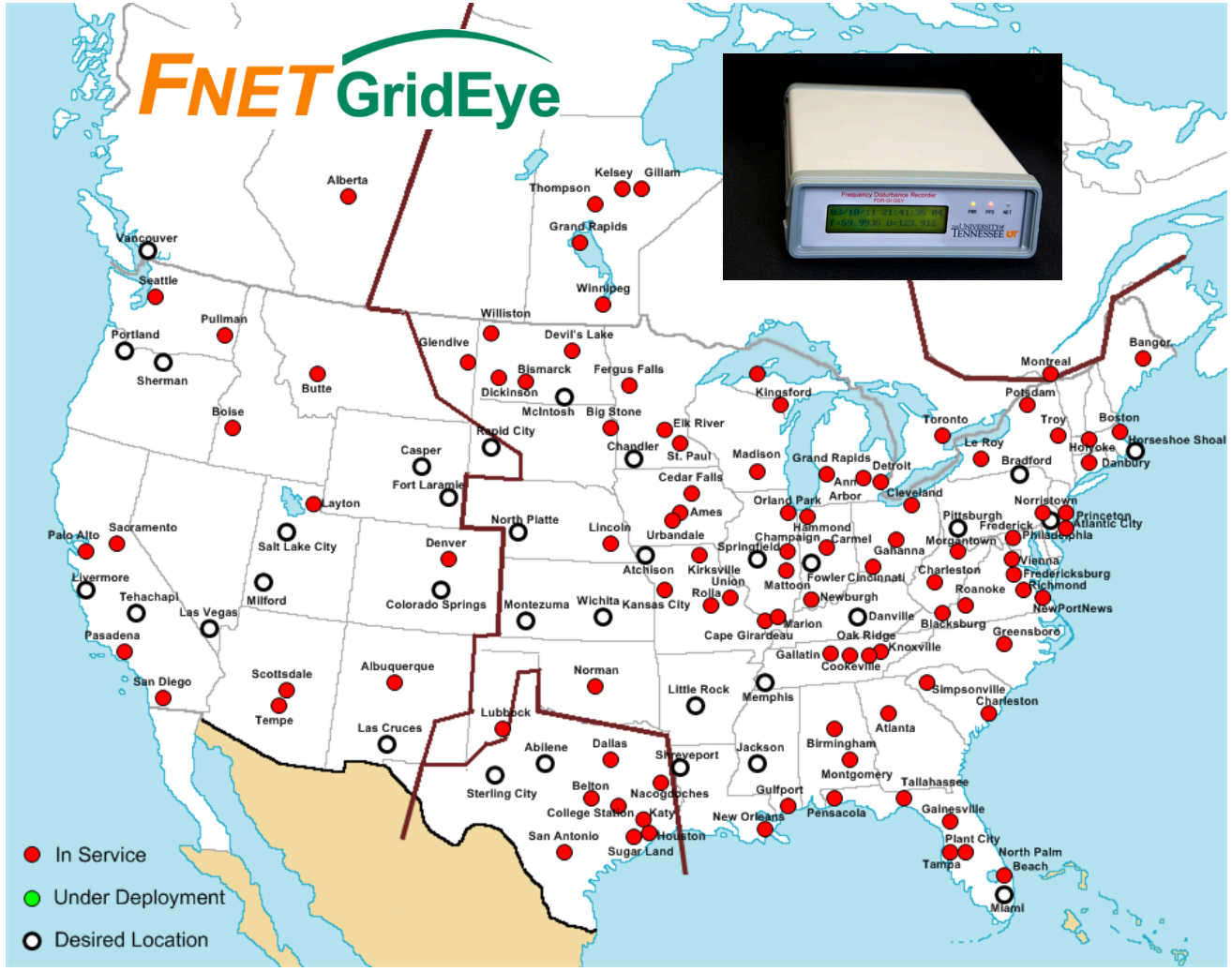
low cost and easy to implement

Event based Method from Pump Hydro Operations

The rate of change of frequency **(RoCoF)** after a step change in MW is proportional to the **MW change** and the inverse of system **inertia**



Grid PMU Monitors in US and World



Live data streaming

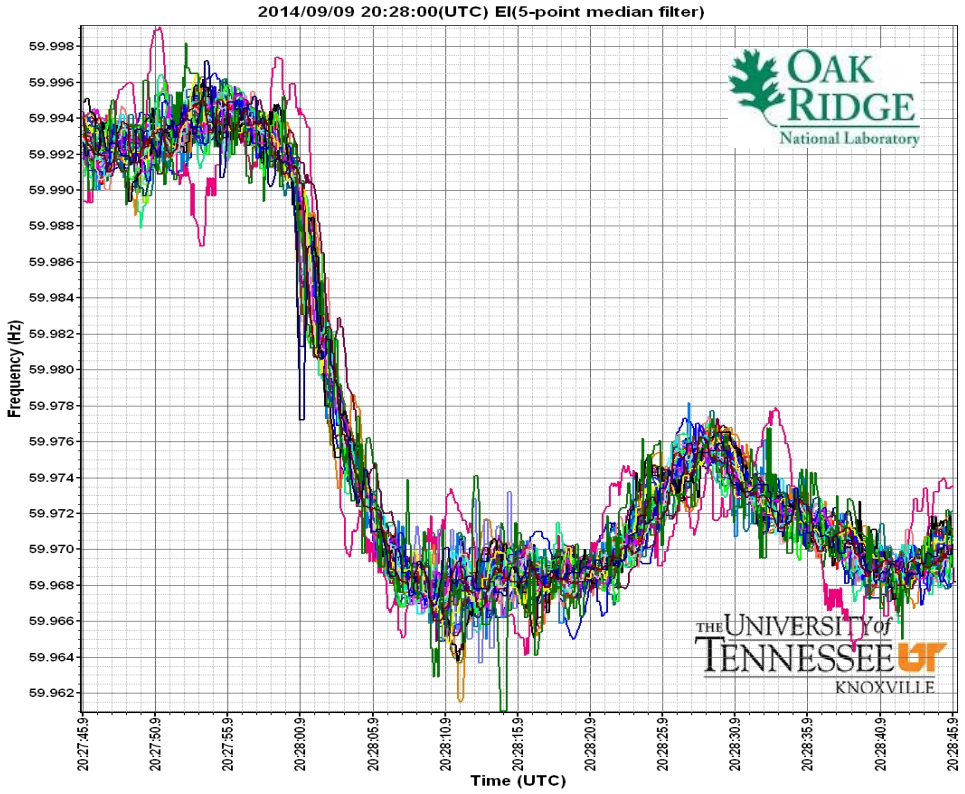
https://fnetpublic.utk.edu/

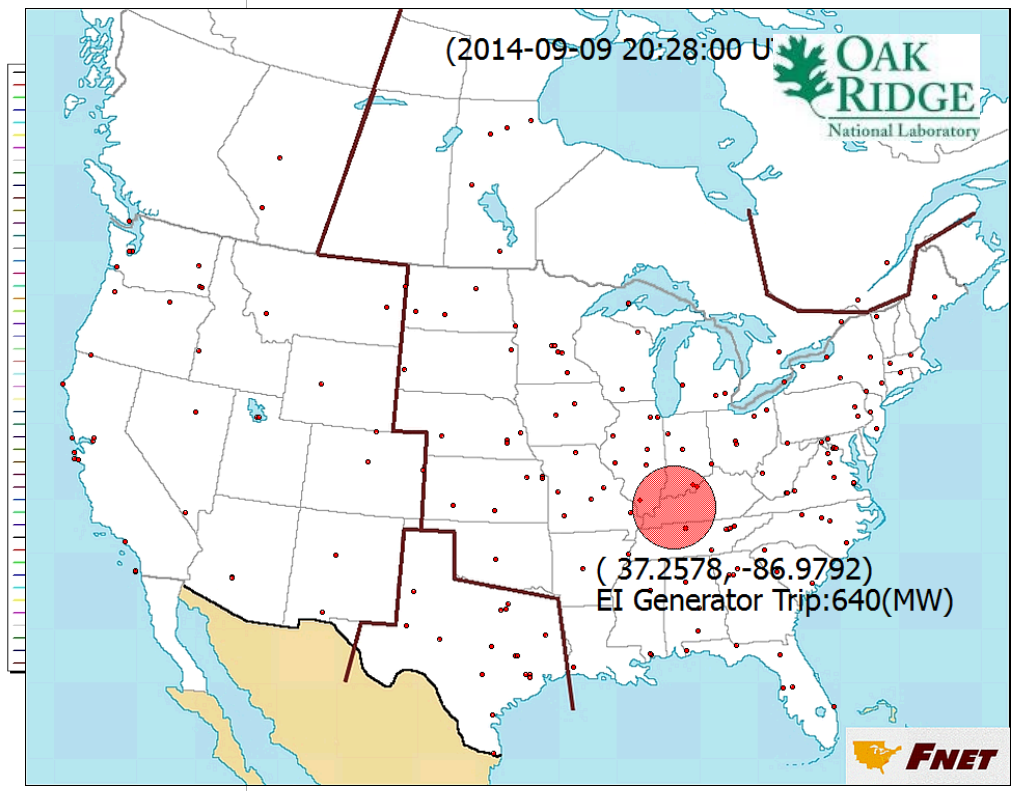
CURENT

Sample automatic event alert

Event Estimation:
640MW EI Generator Trip at 20:28:00UTC, on 09/09/2014 near Paradise power plant (SERC)
((Muhlenberg,KY,42337; Latitude: 37.2578, Longitude: -86.9792)

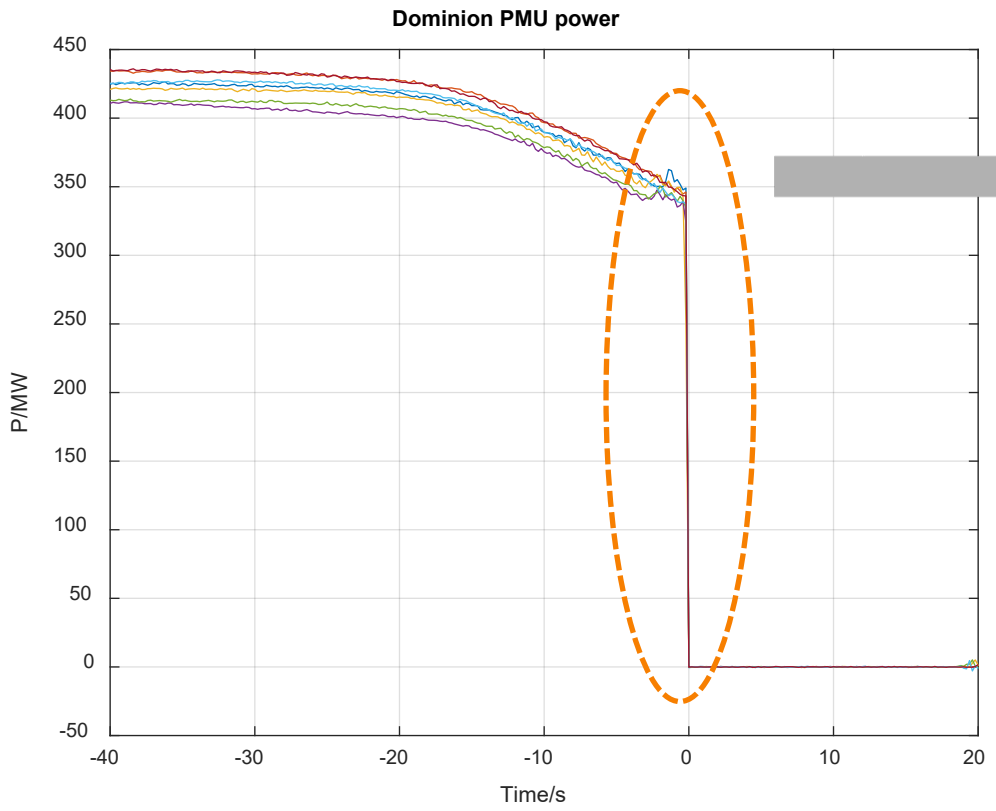
PLEASE KEEP THIS INFORMATION CONFIDENTIAL.





Pumped Storage Operation Provide Probing Signal

PMU data of Bath County pump switching off events show that the MW change is relatively constant.



PMU power of ten Bath county pump switching off events

Event #	Time EDT	Step change, MW
1	06/30/2021 13:13:30	347.7
5	06/28/2021 11:11:00	342.5
6	06/24/2021 05:52:23	339.2
7	06/18/2021 07:05:26	339.8
8	06/12/2021 08:51:15	339.1
9	05/30/2021 07:27:00	343.5
10	05/17/2021 02:25:00	344.8

MW step change difference

(Max-Min)/Average=(347.7-339.1)/342.4=**2.5%**

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Monitors Deployed near Helms Pump Storage Plant

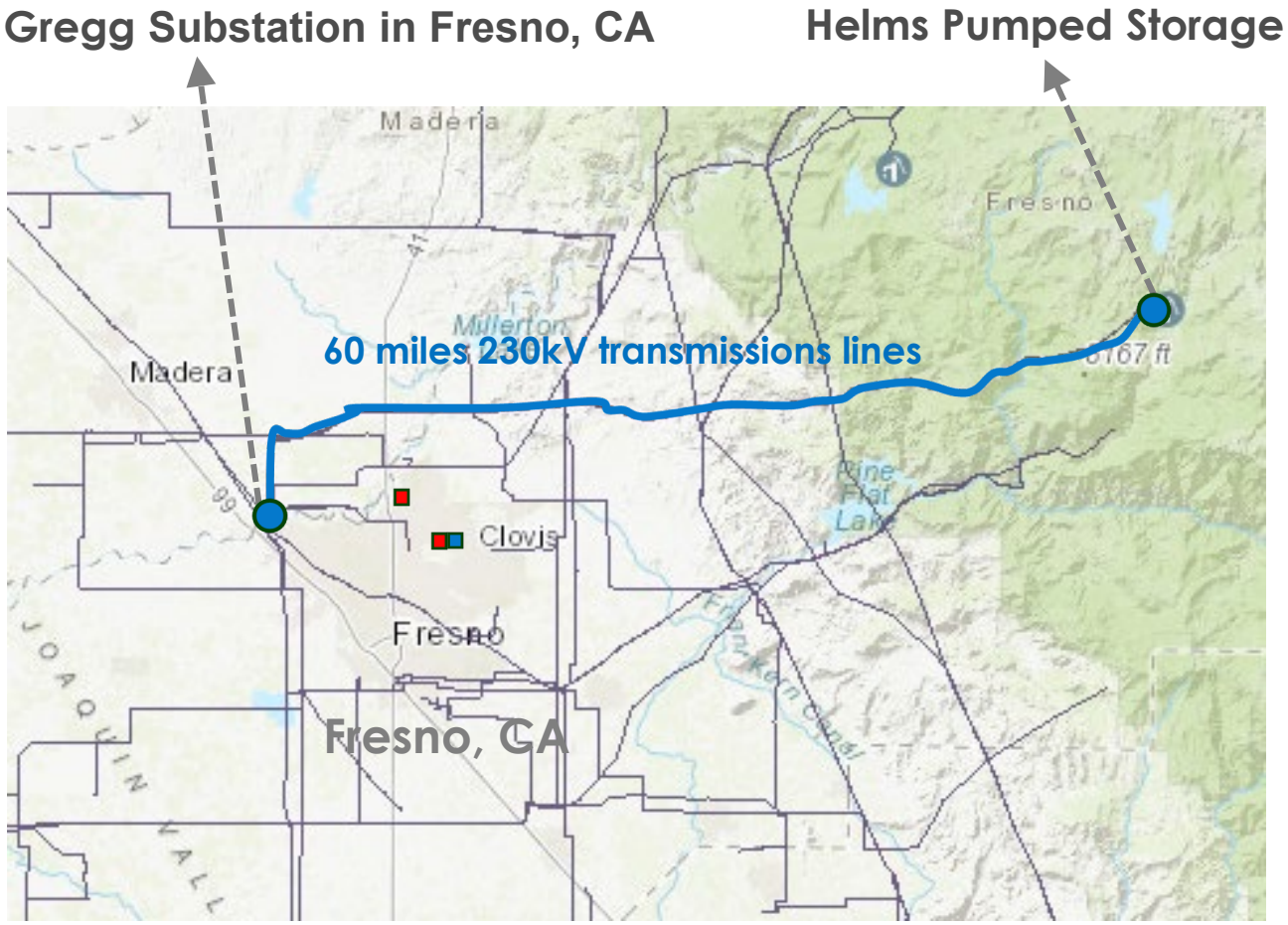
- Three monitors deployed in Fresno City near Helms pump storage plant:
  - One UGA-POW and one FDR: Prof. Carlos Perez, a faculty from Fresno City College.
  - One UGA-POW: Dr. Ram Adapa, Technical Executive, EPRI

FDR

Measured Signal	Resolution (points/s)
Frequency	10
Voltage	10
Angle	10

UGA-POW

Measured Signal	Resolution (points/s)
Phase data (POW voltage)	**1440**
Frequency	**120**
Voltage	10
Angle	10



Available from EIA U.S. Energy Mapping System: https://www.eia.gov/state/maps.php

UGA-POW FDR

Pump Storage Event Inertia Estimation Visualization

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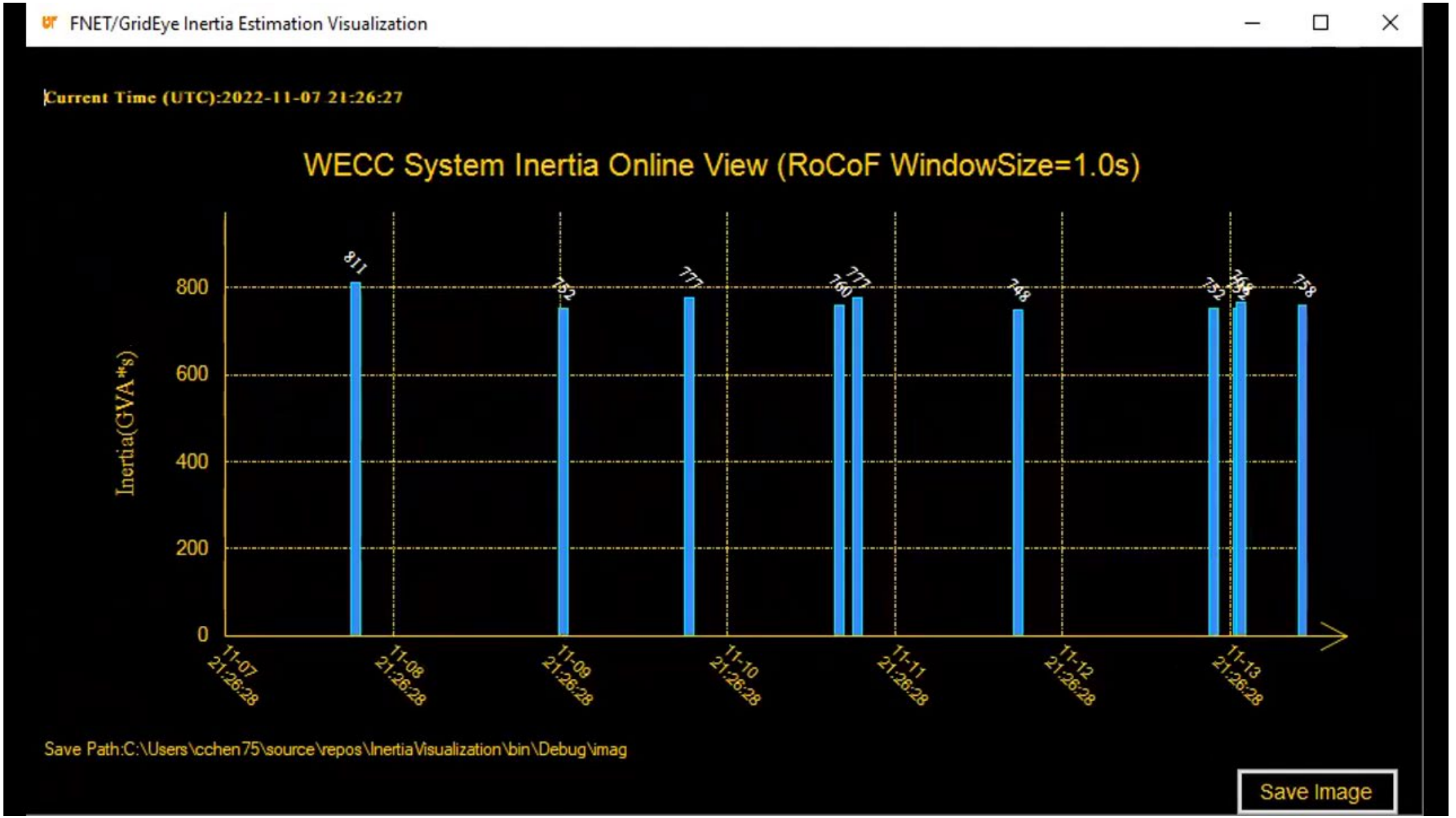
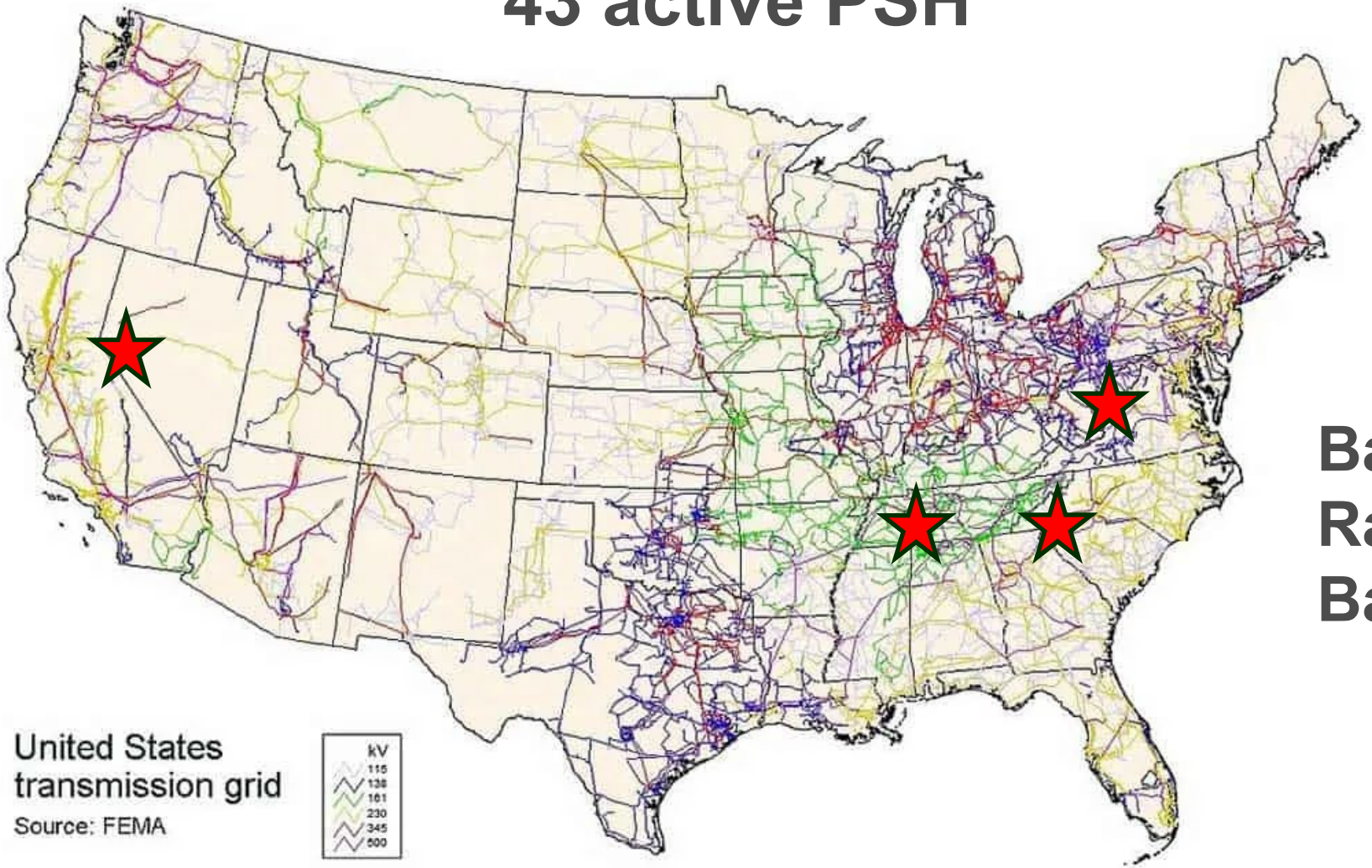


Inertia estimation at four pump storage sites

43 active PSH

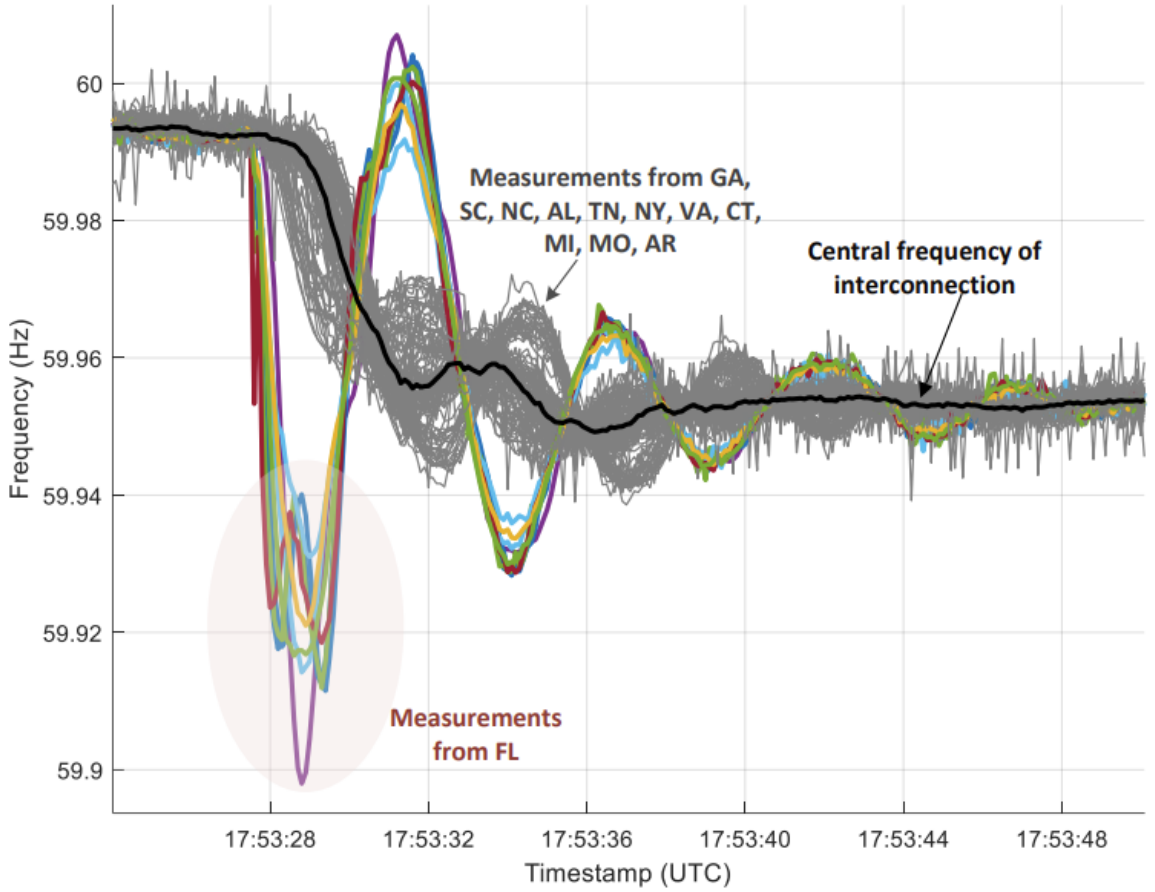
HELMS



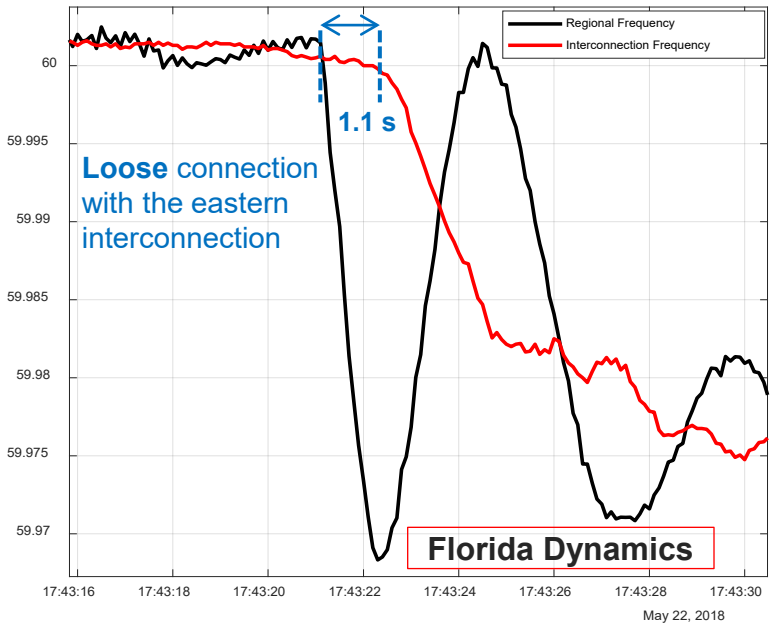
Bath county
Racoon mt
Bad creek

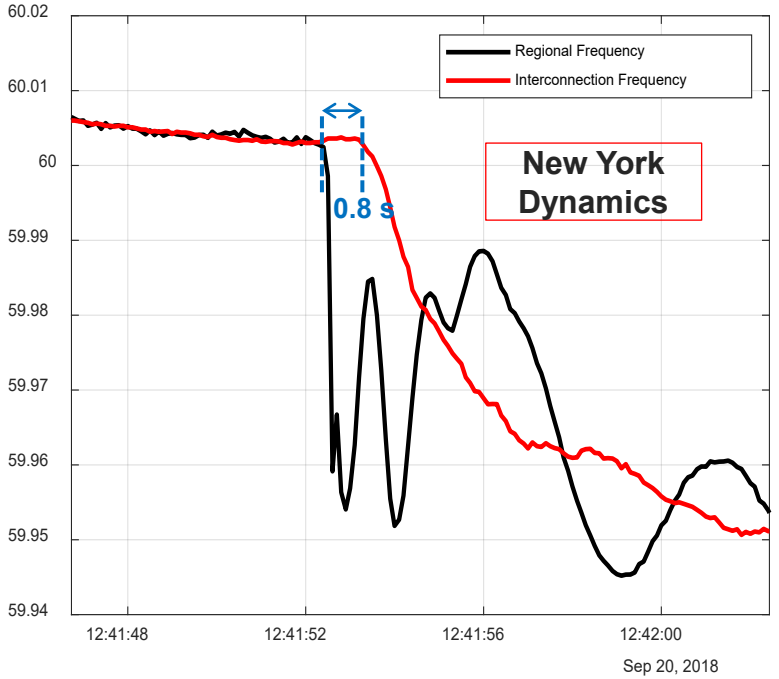
Regional Dynamics -- inertia

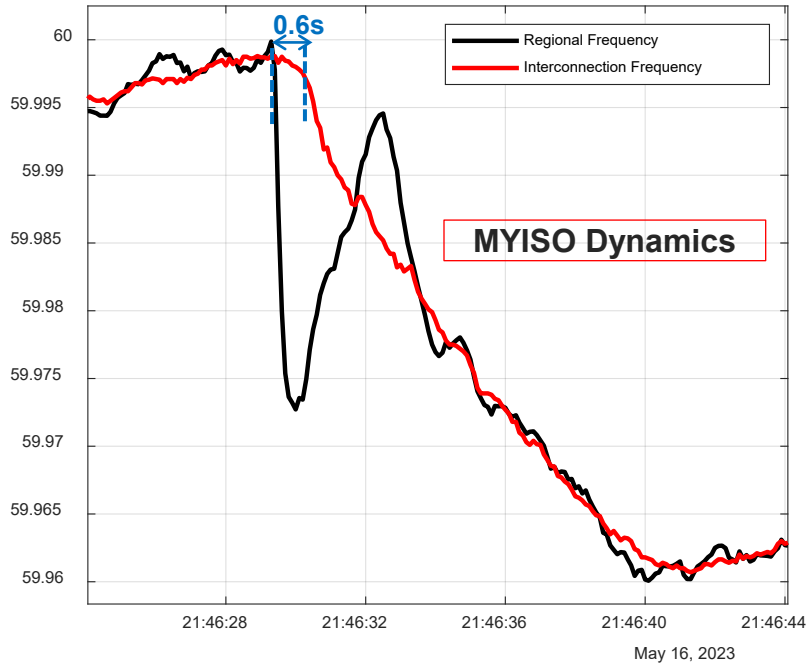
- Regional inertia defines the ability of a local area to resist and recover from disturbances prior to receiving support from the broader grid.
- Regional frequency analysis reveals coupling strength.
- Identifying weakly coupled regions enables targeted planning for grid hardening.

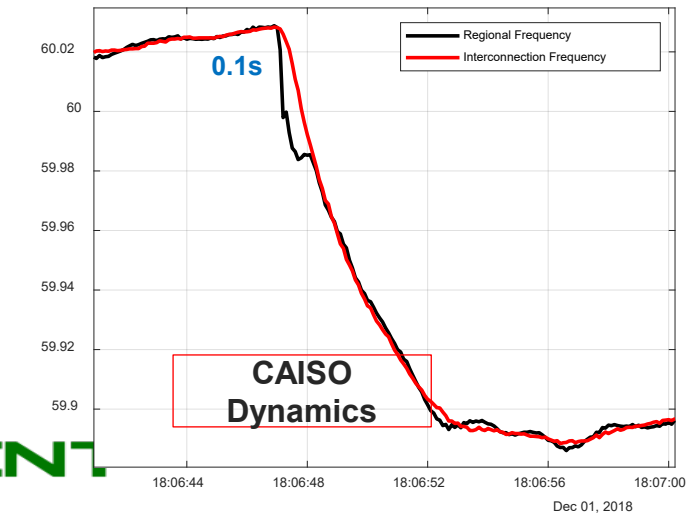


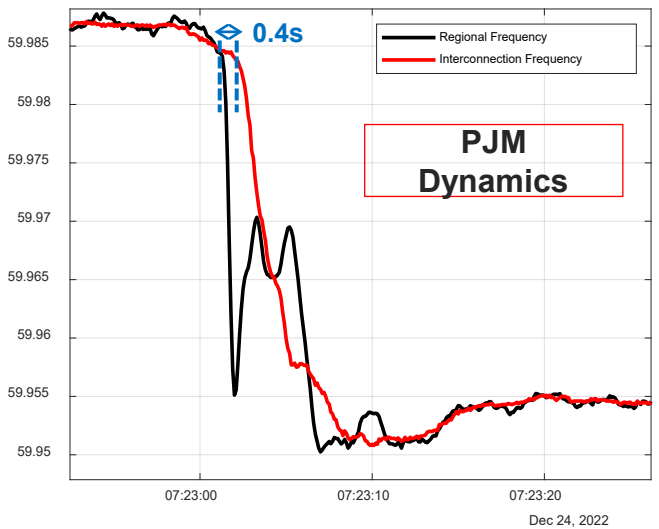
Coupling of different regions (inertia support arrival time)











Remaining Challenges

- What size event is sufficient if we hope to get accurate large interconnection inertia,
- How to best define regions, boundary monitors
- Event occurring system frequency matters (dead band impact)

Acknowledgement

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