Alberta Electric System Operator (AESO)

Oscillatory dynamics and corridor stress in the Alberta electric system

North American SynchroPhasor Initiative March 2015

Agenda

- Alberta Electrical System Overview
- Operational Challenges
- WISP Participation
- HVDC integration
- Synchrophaser monitoring software
- Integration into control room/EMS
- Data Mining Overview
- Results of Data Mining Project

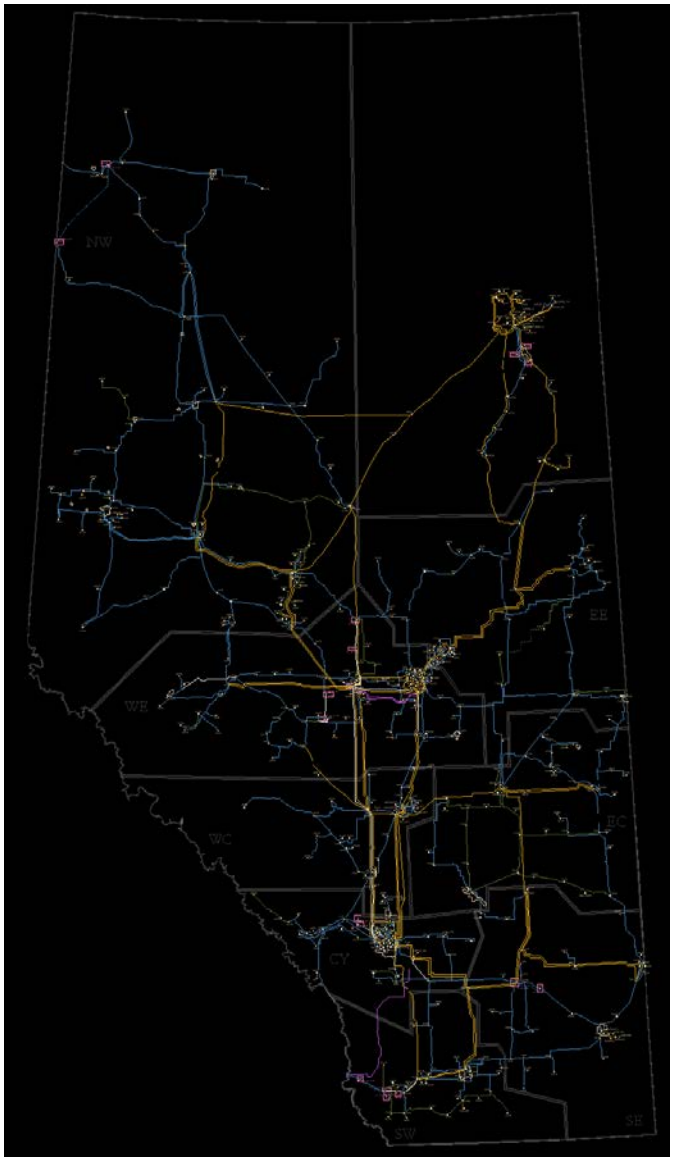
Alberta Grid - Topology

- 11,169 MW peak and 80% load factor
- 15,526 MW total generation

COAL-FIRED PLANTS	6513 MW	GREEN POWER (Wind)	1674 MW
NATURAL GAS-FIRED PLANT	6553 MW	GREEN POWER (Other renewables)	272 MW
HYDRO POWER	514 MW		

- Over 280 generating units
- > 22,322 km of transmission
- Interties to BC (up to 780 MW) & Saskatchewan (up to 150 MW)
- Intertie to Montana (230KV)

Geographic map of Alberta



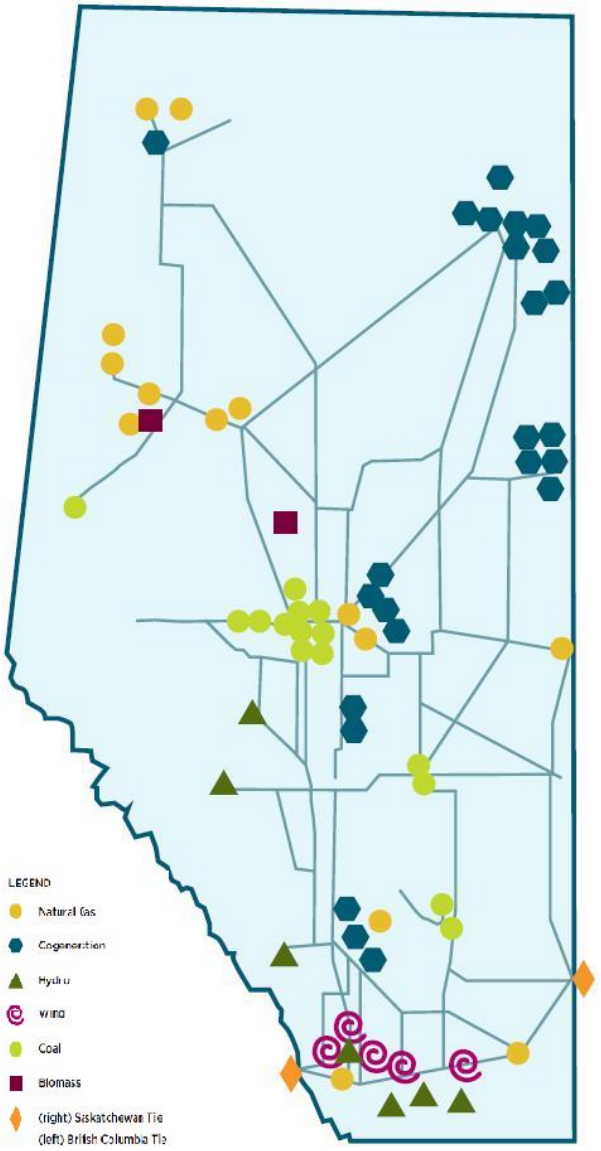
Voltage Levels:

- 500KV
- 240KV
- 138KV
- 69KV

Load vs Generation Locations

- Fort McMurray Oil Sands in NE of province (BTF Generation)
- Major load centers in Calgary(South) and Edmonton (Center)
- Major Generation in Center West of province and FT Mc Murray areas
- 1.5GW of wind in south of province
- 500KV intertie to BCH located east of Calgary (South)
- 230KV intertie to Montana located at southern most point of province

Generation Locations

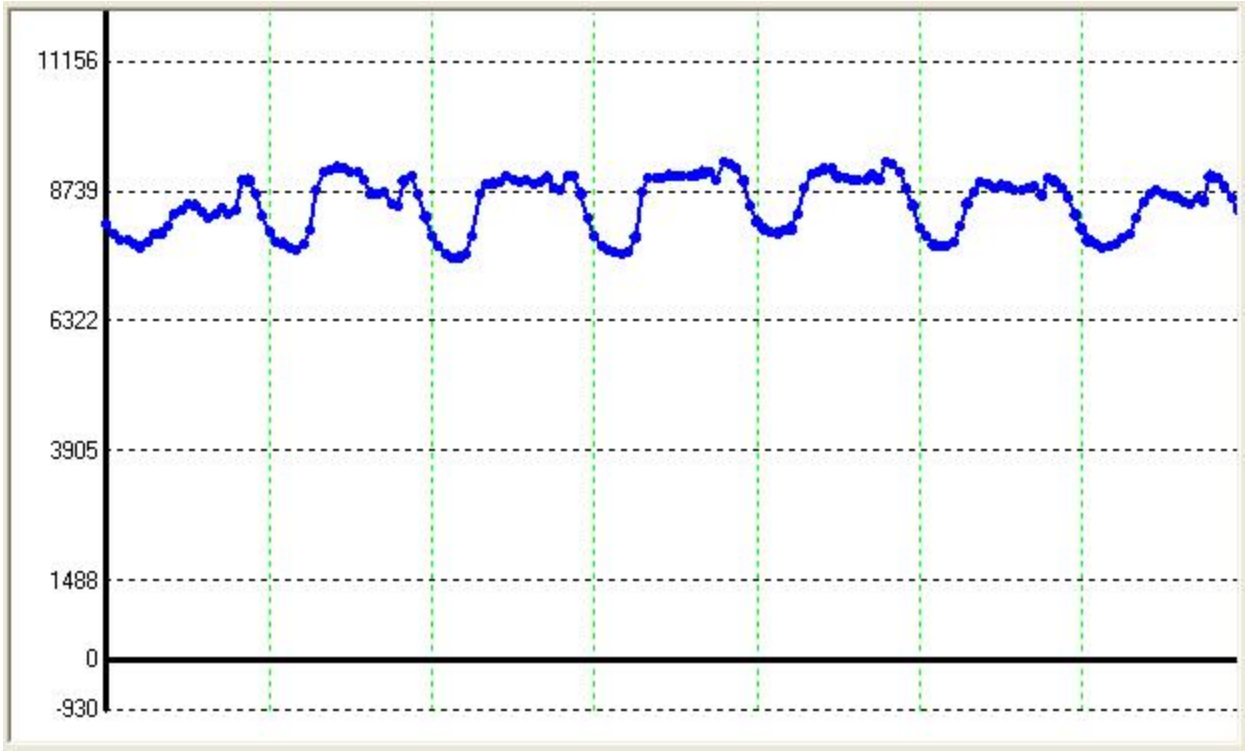


Operational Challenges

- 240KV backbone south to central and central to north
- Wind ramp in the province can incur issues (WPRM)
- Intertie 500KV from south and 240KV to Montana
  - WECC Loop Model to reduce contingencies from loop flows
- Large volume of North to south power transfers
- Industrial load

Load Schedule - Weekly

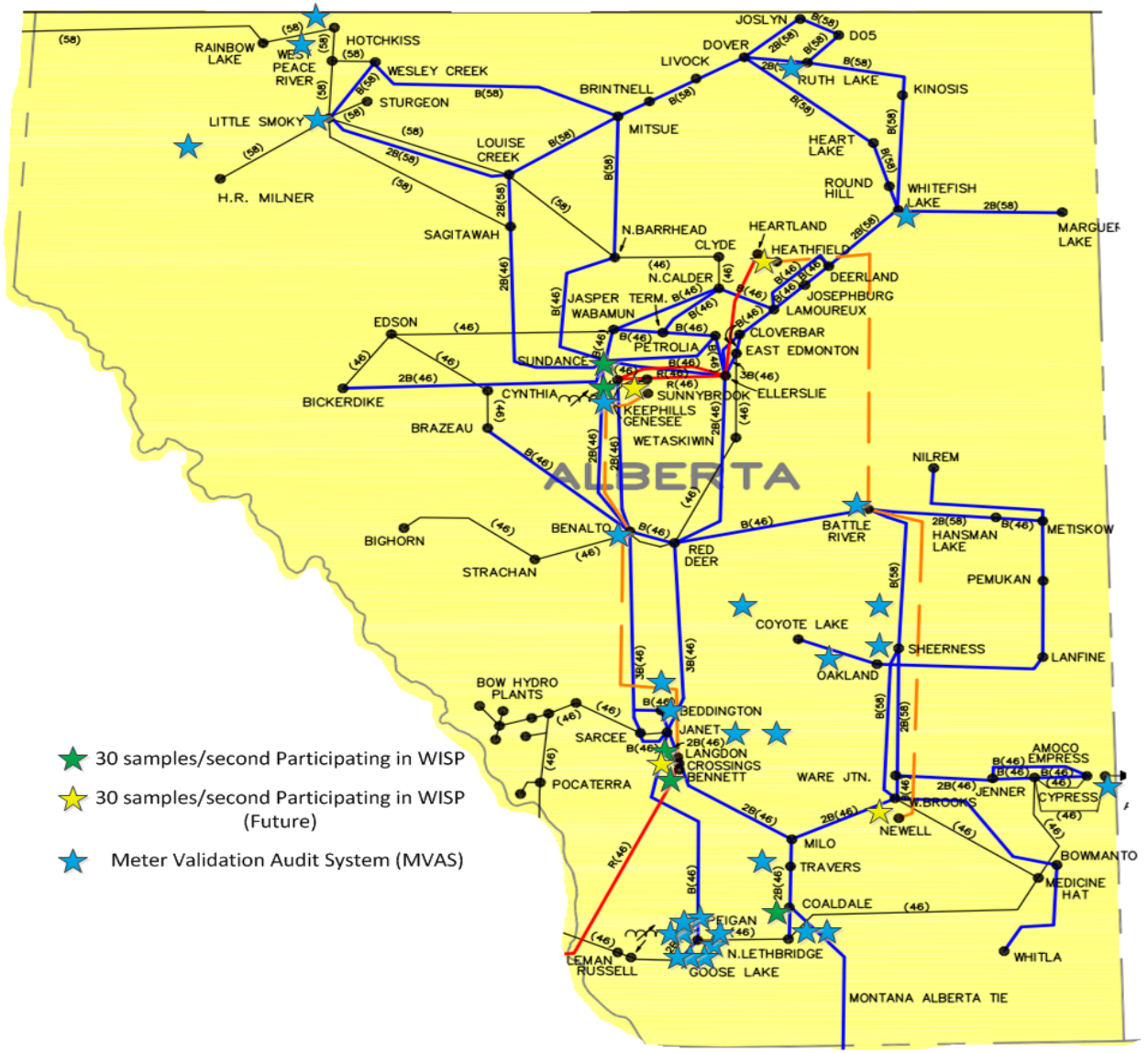
- AIES Weekly Winter Load Schedule



WISP Participation

- The AESO as part of the Wisp Program installed SEL Phasor Measurement Units at 5 location in Alberta
  - Bennett (500KV tie to BCH)
  - Picture Butte (240KV tie to Montana)
  - Langdon (240KV SVC and (4) 240KV Lines)
  - Sundance (Generator and 240KV Lines)
  - Genesee (Generator)
- Future Locations (HVDC)
  - Sunnybrook (Northwest converter station)
  - Crossings (Southwest converter station)
  - Newell (Southeast converter station)
  - Heathfield (Northeast converter station)

PMU Locations



Purpose

- Drivers
  - Eastern Alberta Transmission Line (485KM - 500KV DC) will extend from the southeast of Alberta to the northeast.
  - Western Alberta Transmission Line (347KM – 500KV DC) will extend from the south of Alberta to the central west
  - Expected in service date in 2015
- As part of the HVDC integration we will be installing PMU's at both ends of the HVDC lines
- AESO pursued an integrated real time toolset to provide real time monitoring and early warning capability of transient stability issues

ALSTOM Phasor Point/OpenPDC

- The ALSTOM Phasor Point was selected for the Real time monitoring tool to be integrated as a stand-alone application
- OpenPDC (GPA) was selected as the Data Concentrator for Phasor data
- Data connections with external entities
  - WECC
  - Northwest Energy (Montana)
  - BC Hydro
  - Bonneville Power Administration

Control Room/EMS Integration

- Phasorpoint Sandbox was delivered from ALSTOM in 2013
  - Used for application training and proof of concept
- Production standalone Phasorpoint integration
  - Integrated with the OpenPDC to gather real time PMU data from remote PMU sites
  - Engineering support staff used to gain knowledge of the product
  - Available outside the control room to operators to gain familiarity with
- No Control Room consoles have been deployed with the Phasorpoint software at this time, expected to be completed by HVDC commissioning.

Problem

- Determine ‘How To Operate with Phasor data in Real Time”

- Determine what are acceptable limits for the PMU fluctuation vs. what is considered an alarm and what is considered an actionable event for the SC

Data Mining with Alstom

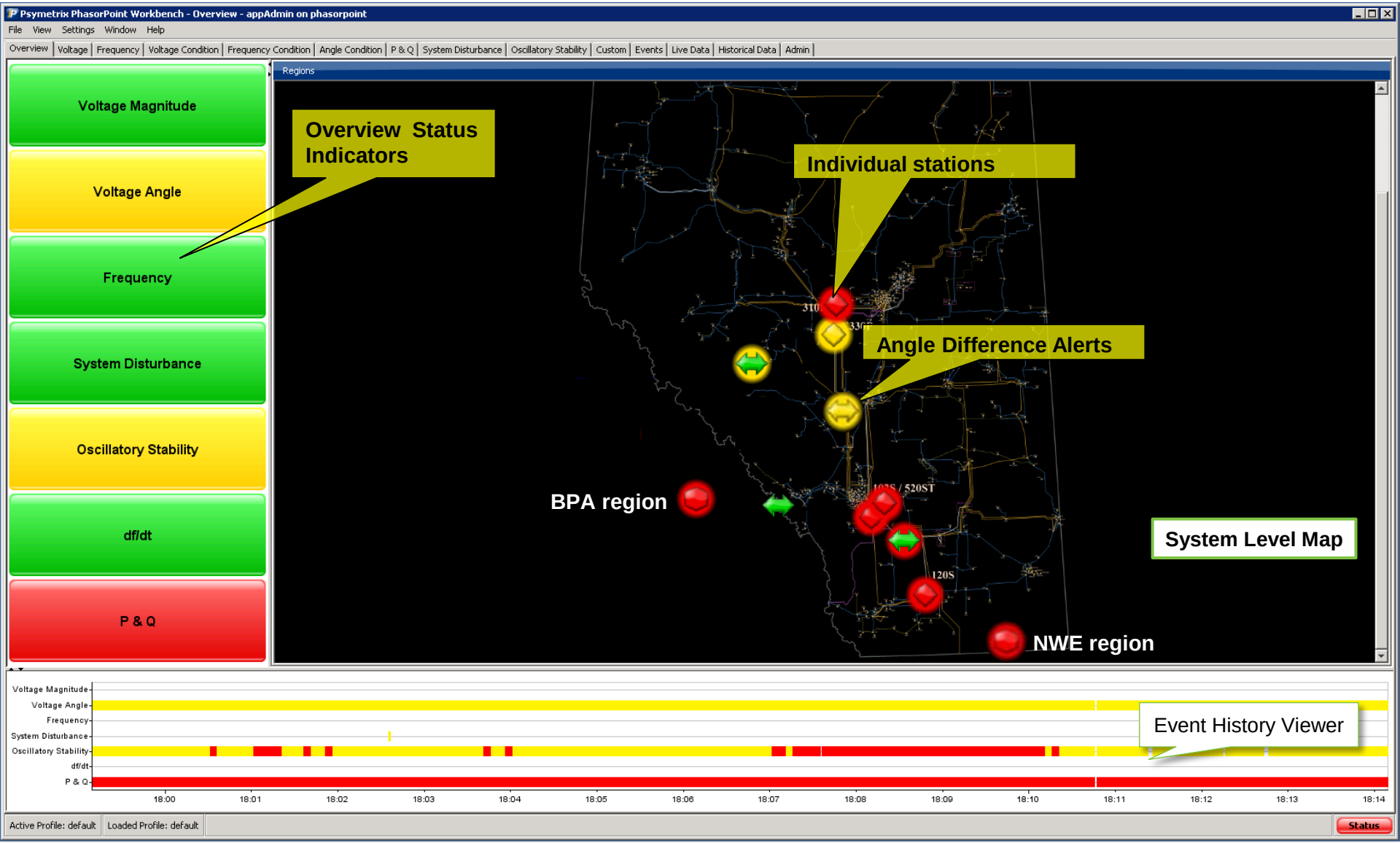
Dynamic Performance Baselining

- Identify oscillatory modes
  - Estimate where the modes are “observable”.
  - Typical amplitude and damping levels.
- Suggest alarm/alert limits in **e-terra***PhasorPoint*

Angle Baselining

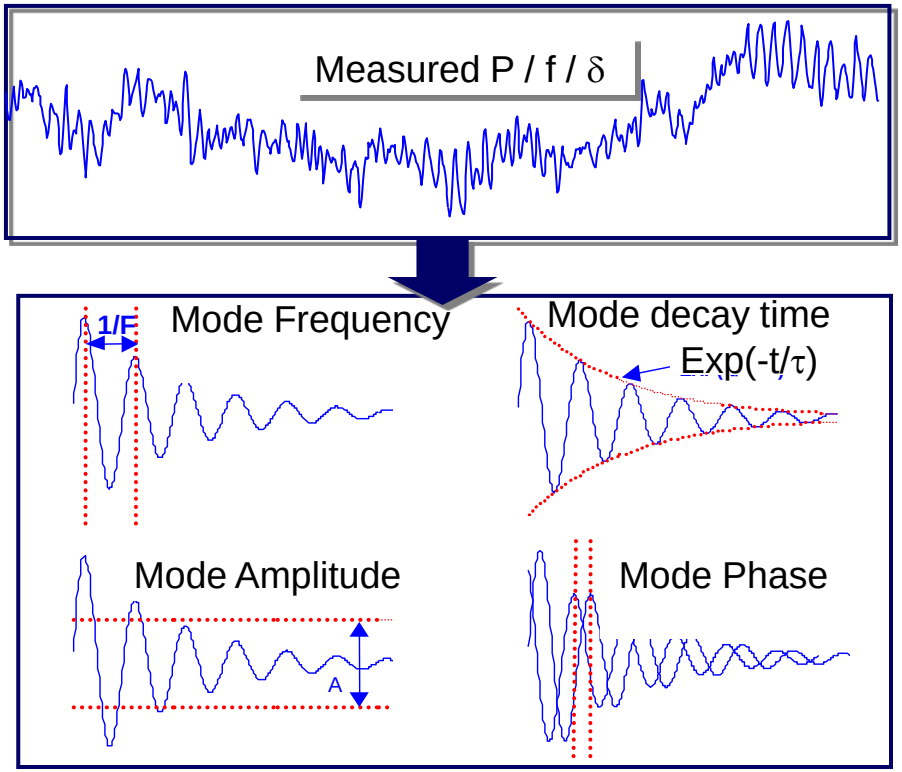
- Identify distribution of angle differences across critical transfer paths
  - Under different operational conditions
  - Correlate MW transfers
  - Change in angular separation for every 100MW change in power

AESO PhasorPoint System



Oscillatory Stability Management in PhasorPoint

Simultaneous multi-oscillation detection and characterisation direct from measurements



Fast Modal Analysis: **Alarms**

Trend Modal Analysis: **Analysis**

Does not use system model

In operational use since 1995

Operations

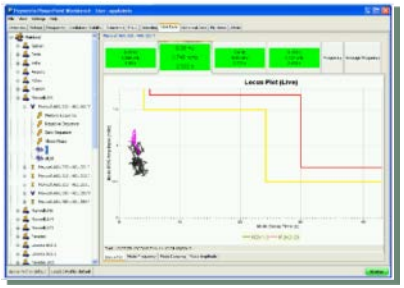
Early warning of poor damping (two level alarms)

Unlimited oscillation frequency sub-bands

Individual alarm profiles for each sub-band

For each oscillation detected, alarm on:
mode damping and/or
mode amplitude for

Wide area mode alarms



Mode locus plot with alarm thresholds

Planning & Analysis, Plant Performance

Post-event analysis

Dynamic performance baselining

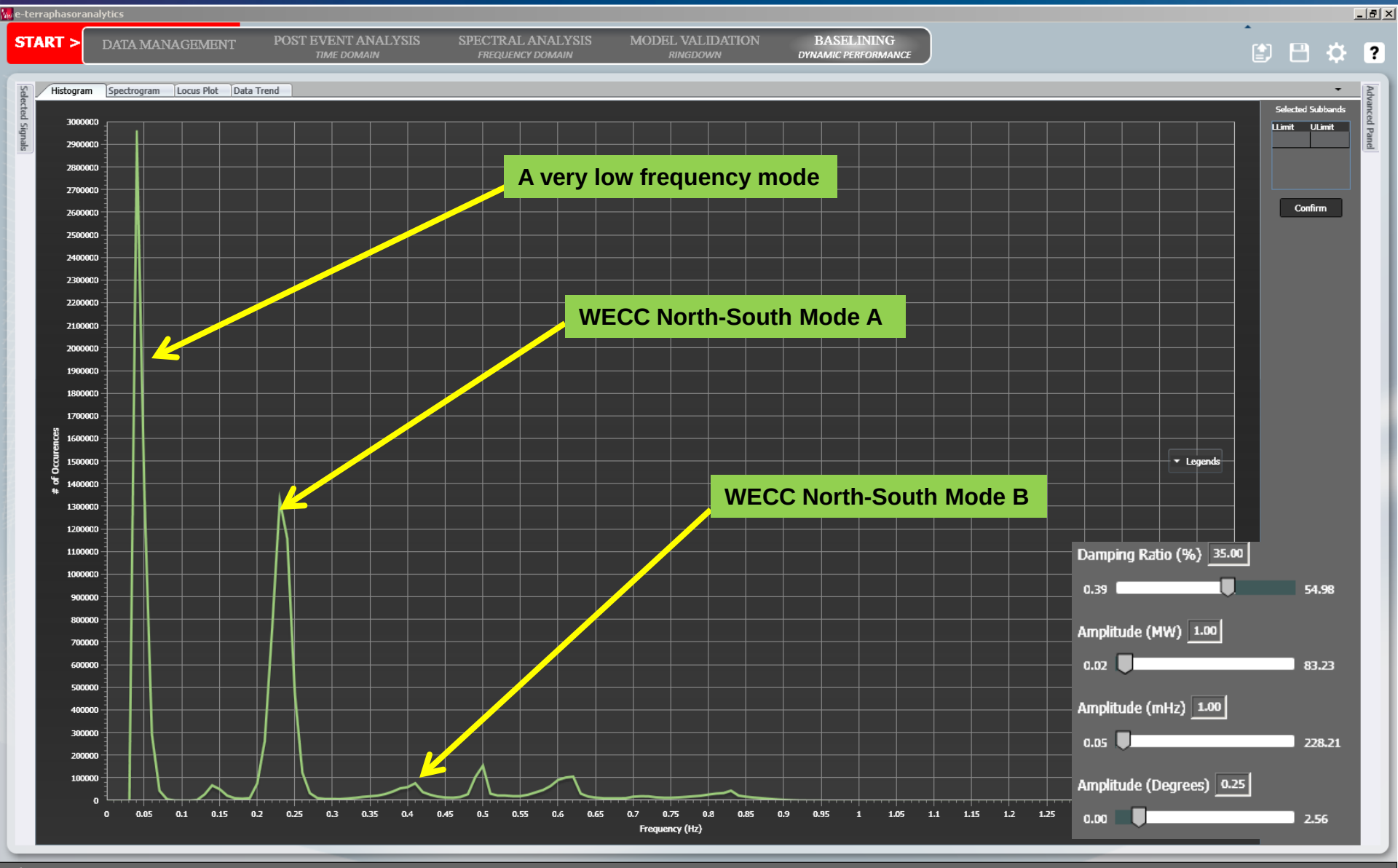
Dynamic model validation

Damping controller performance assessment

So ……

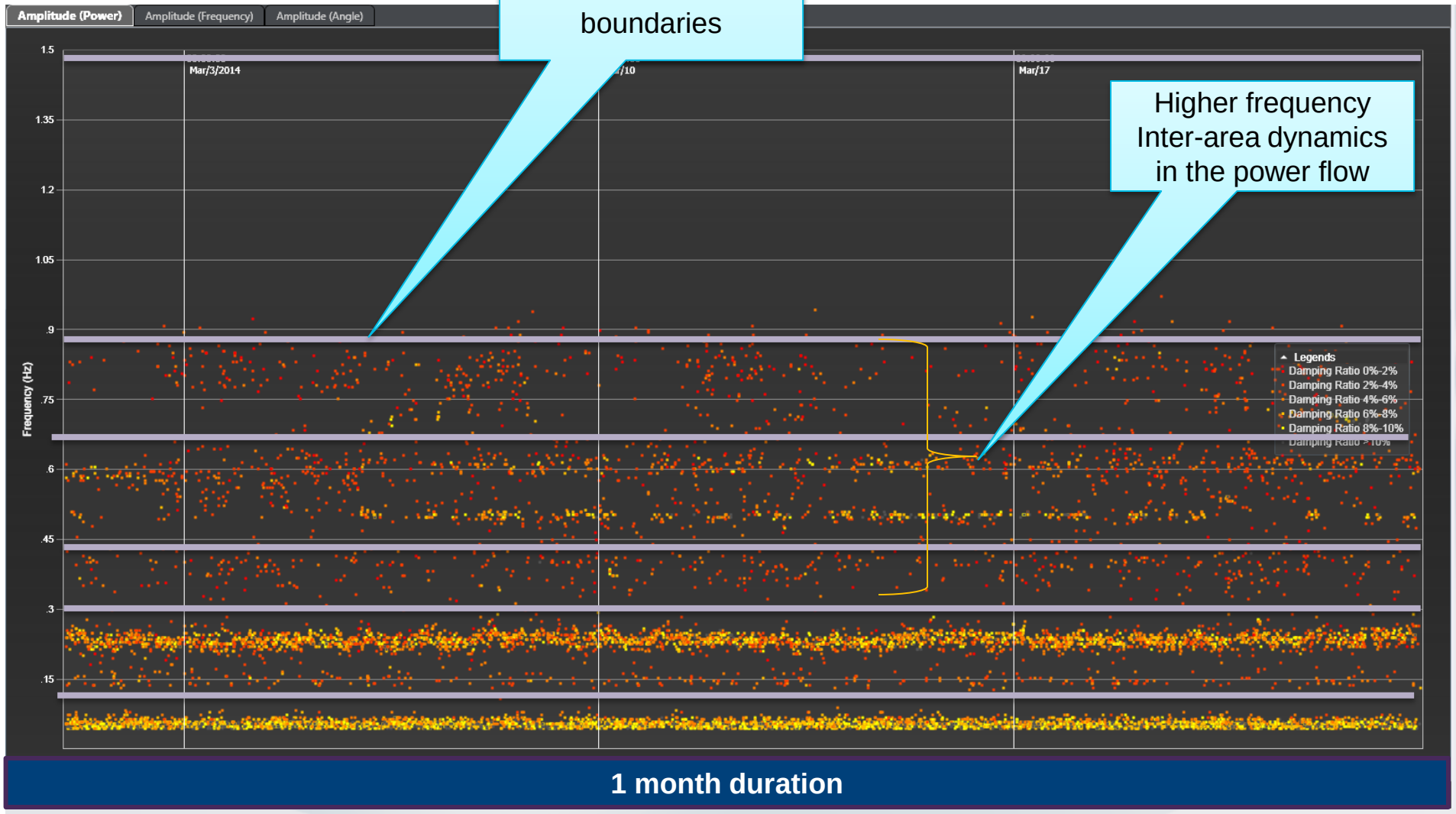
- Needs to be information for the Operator
- Great data does not mean anything if we cant take action
- Napsi challenge
- Without RT just theoretical
- Huge value in decision making, financial and reliable

Dominant Modes – aggregated view



Inter-area Dynamical Behavior

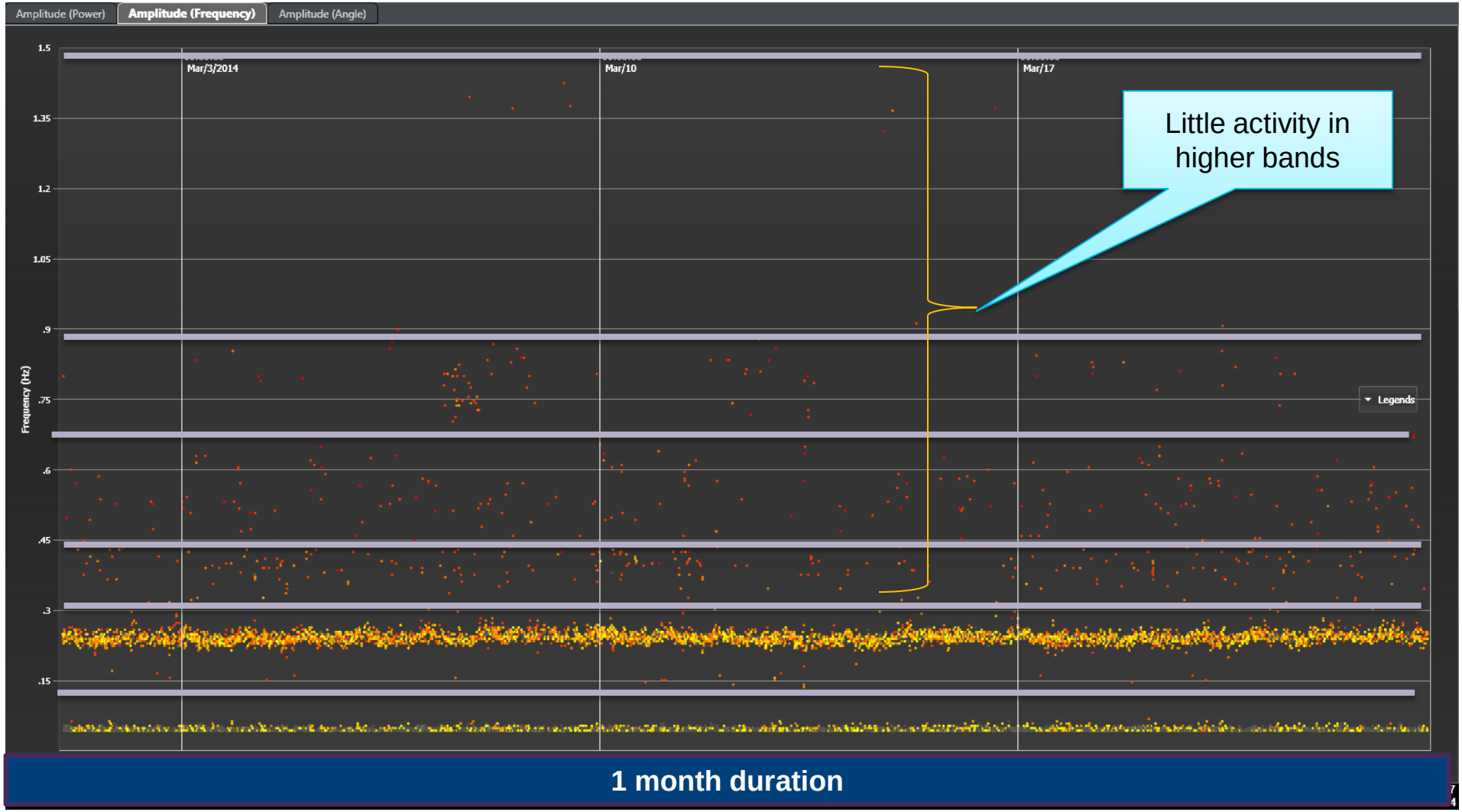
MW



1 month duration

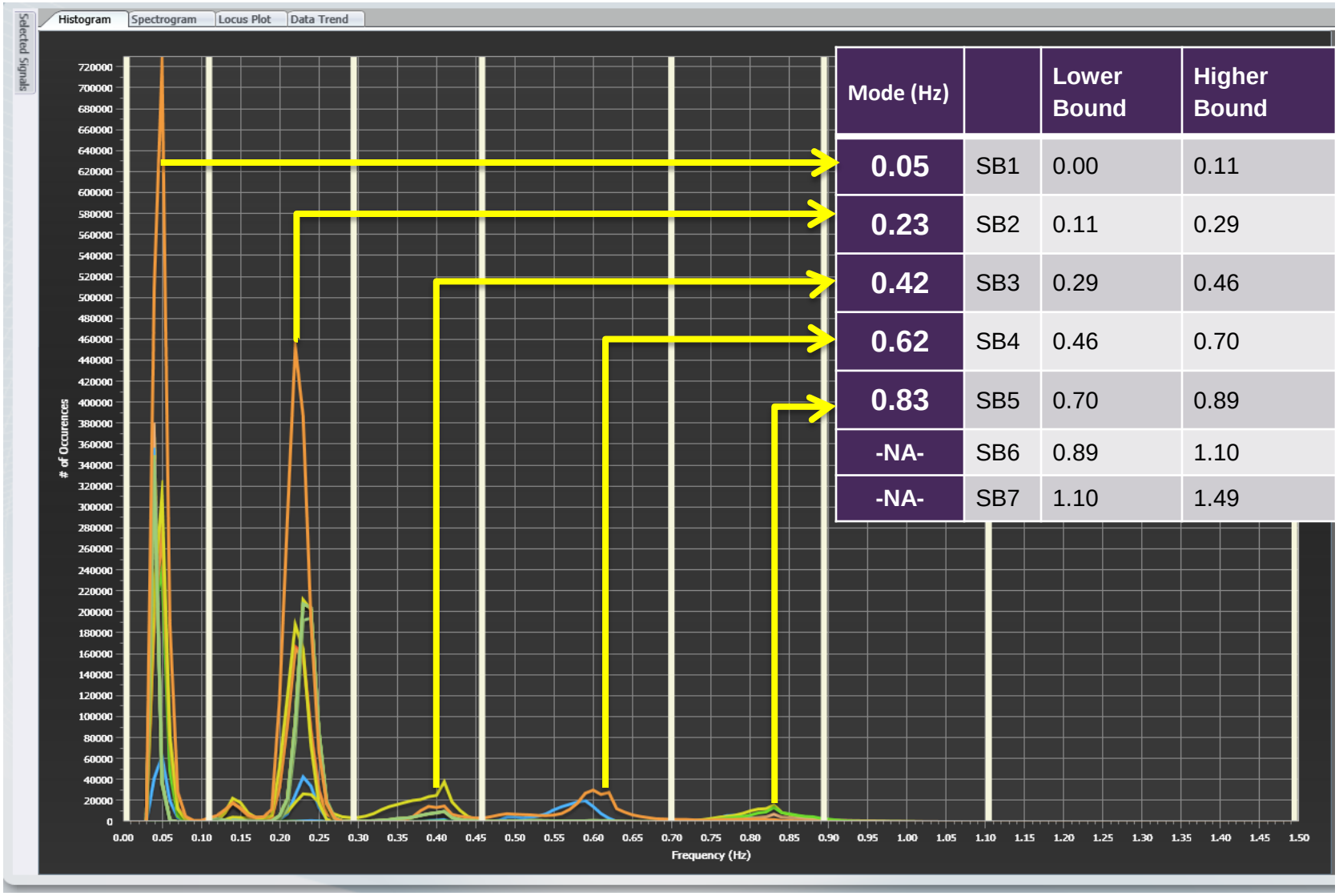
Inter-area Dynamical Behavior

System Frequency



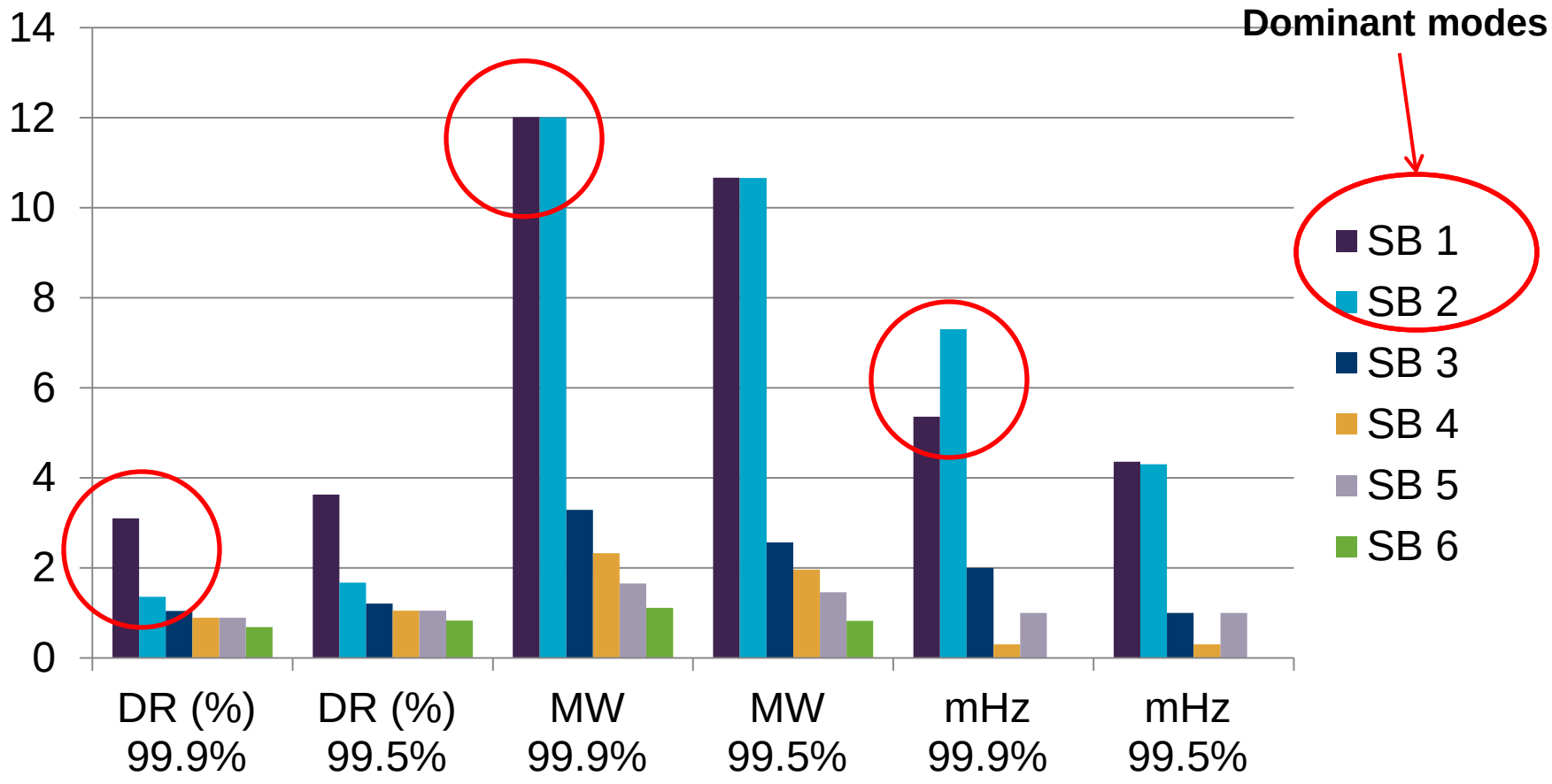
1 month duration

Modes and Sub-band Boundaries

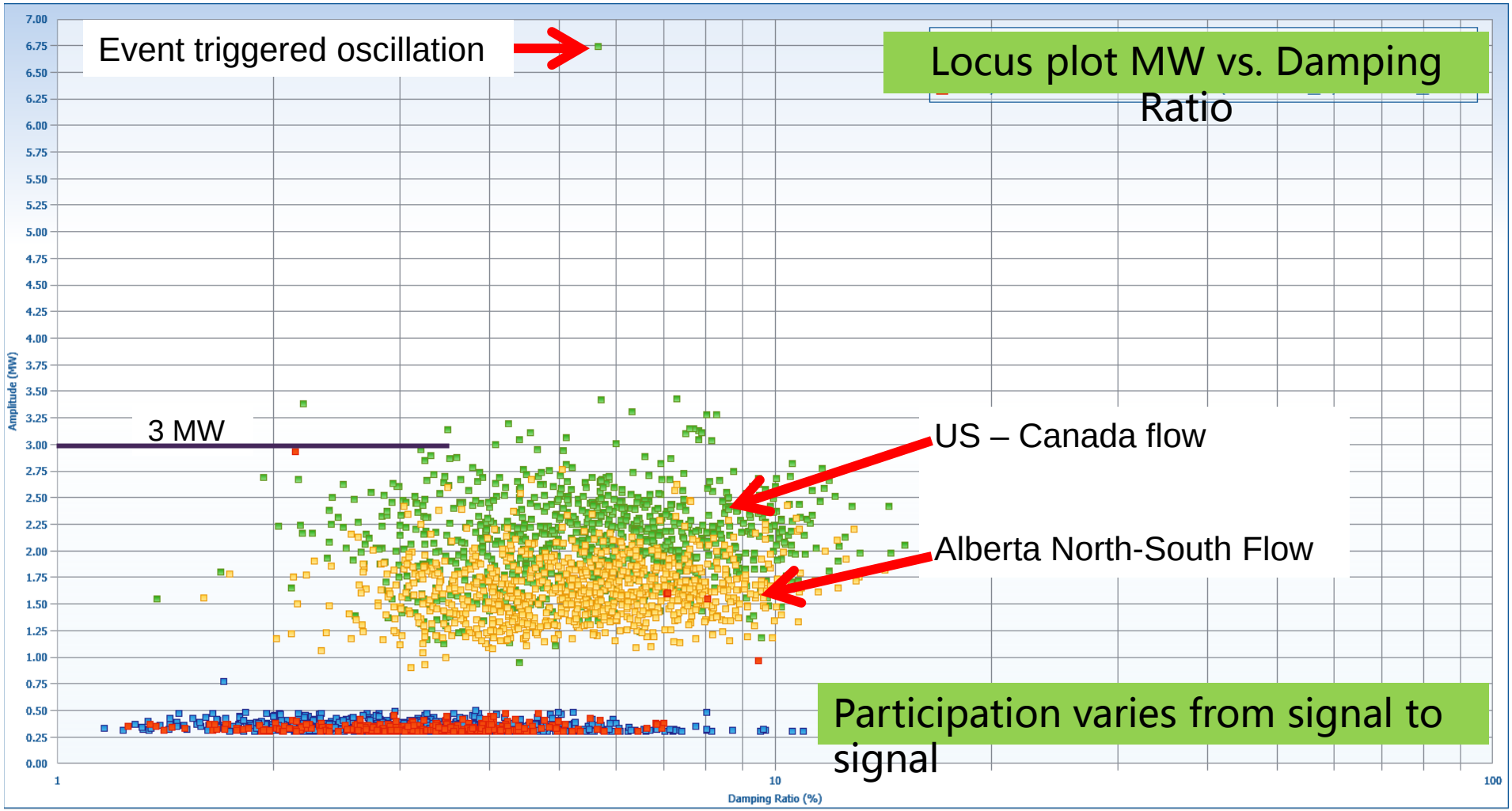


Mode (Hz)		Lower Bound	Higher Bound
0.05	SB1	0.00	0.11
0.23	SB2	0.11	0.29
0.42	SB3	0.29	0.46
0.62	SB4	0.46	0.70
0.83	SB5	0.70	0.89
-NA-	SB6	0.89	1.10
-NA-	SB7	1.10	1.49

Summary – Damping Ratio by Sub-bands

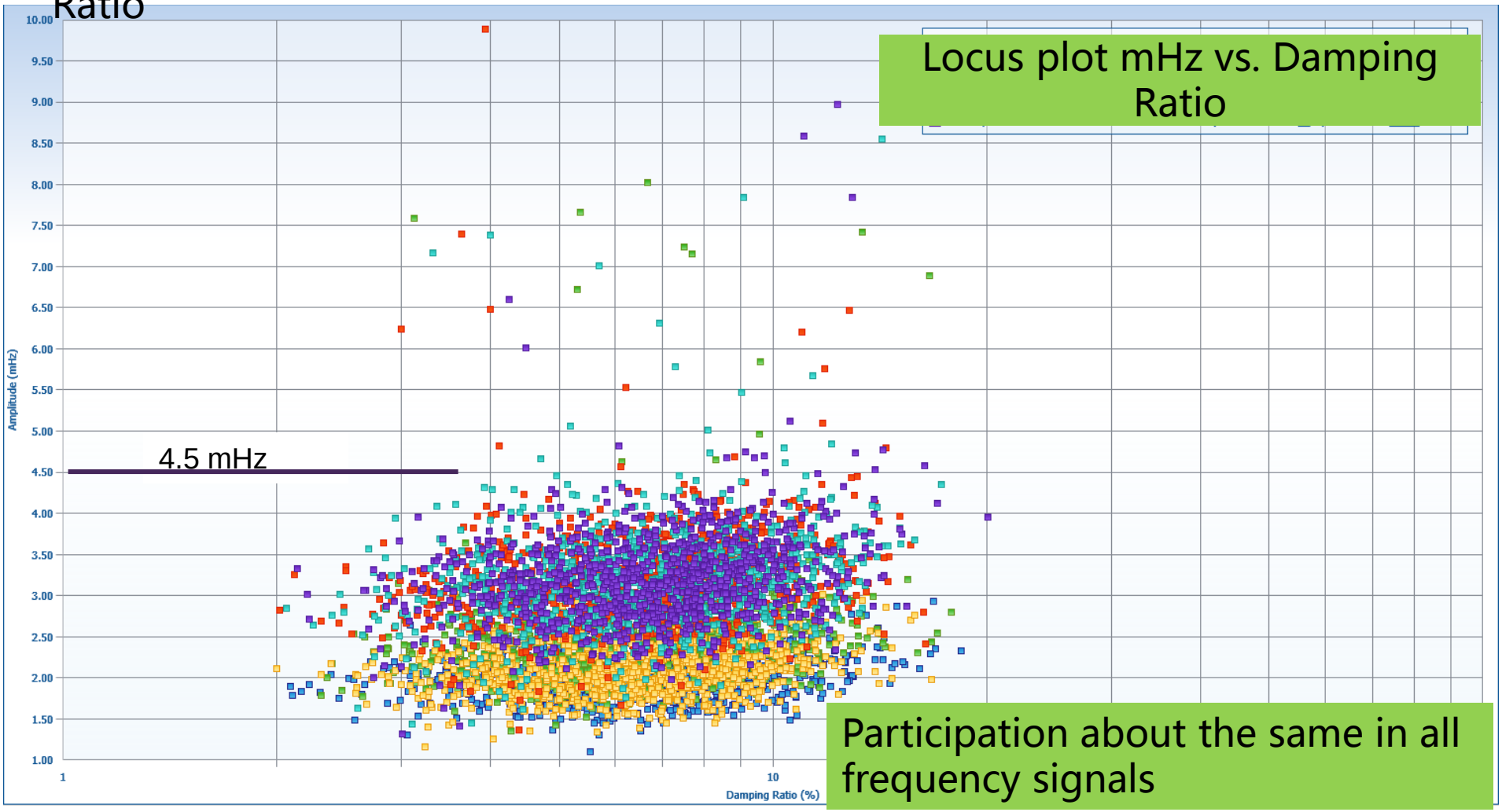


Example – Sub-band 2 [0.11 – 0.29Hz]



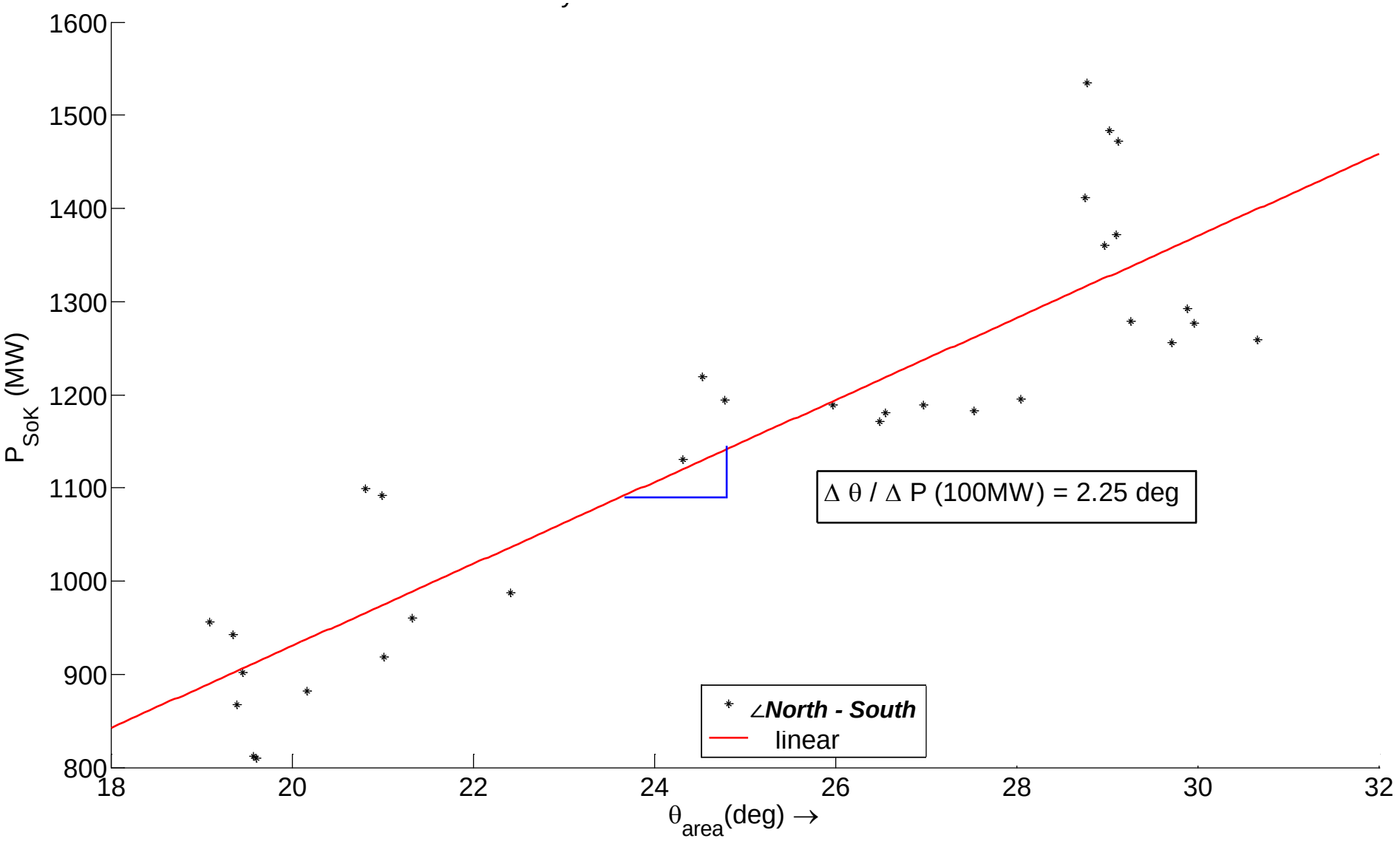
Example – Sub-band 2 [0.11 – 0.29Hz]

Locus plot mHz vs. Damping Ratio



Participation about the same in all frequency signals

MW angle Correlation

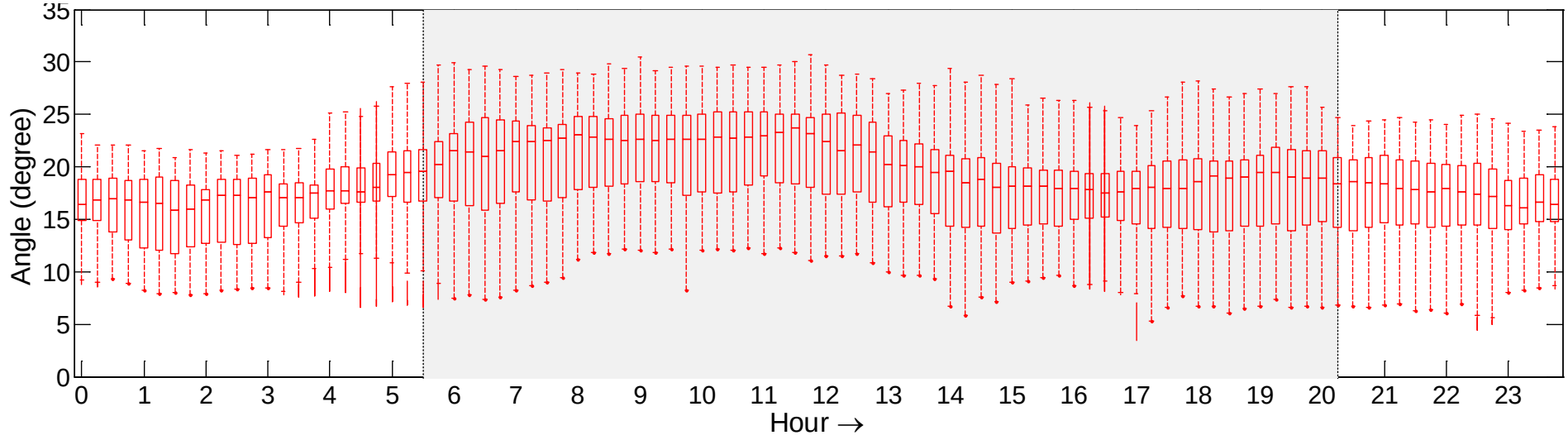


Summary

- Recommended Limits
  - For oscillation monitoring
  - For monitoring angle-pairs
- Derived from data statistics and field expertise
- Minimizes false alarms
- Much lower hysteresis to be able to detect events!
- No significant difference in angle base-lines for
  - Weekdays and week-ends
  - Net Import vs. Net Export
- Should be repeated with HVDC system in-service.

Thank you

“Importing” vs. “Exporting”



Typical Angle behavior