Thanks to **CGGVeritas** for sponsoring last night's icebreaker.

Thanks to **Shell**, **GEDCO**, **ConocoPhillips**, **Landmark Graphics**, and **Tullow Oil** for sponsoring tonight's banquet.

CREWES

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The ??? Experiment

What field experiment should CREWES do next year?

Will your company help?

Please give us your opinions on the matter.

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The Hussar Experiment

An investigation into low-frequency seismic recording

September 5-9, 2011

Gary Margrave, Larry Mewhort, Tom Phillips, Mike Hall, Malcolm Bertram, Don Lawton, Kris Innanen, Kevin Hall, and Kevin Bertram.

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Outline

Purpose

Location

Wells and logs

Receivers

Sources

Sweeps

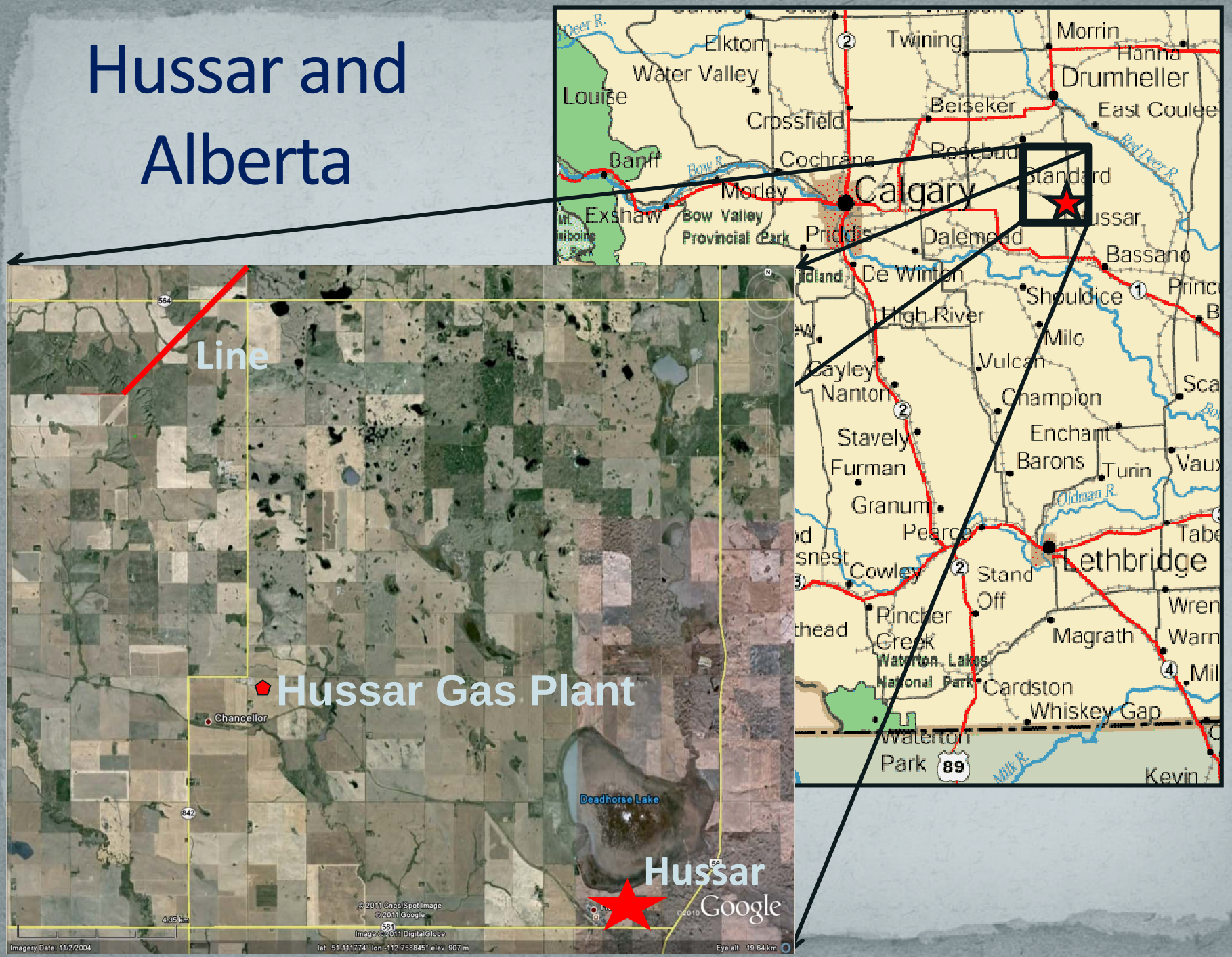
Data and Spectra

Conclusions

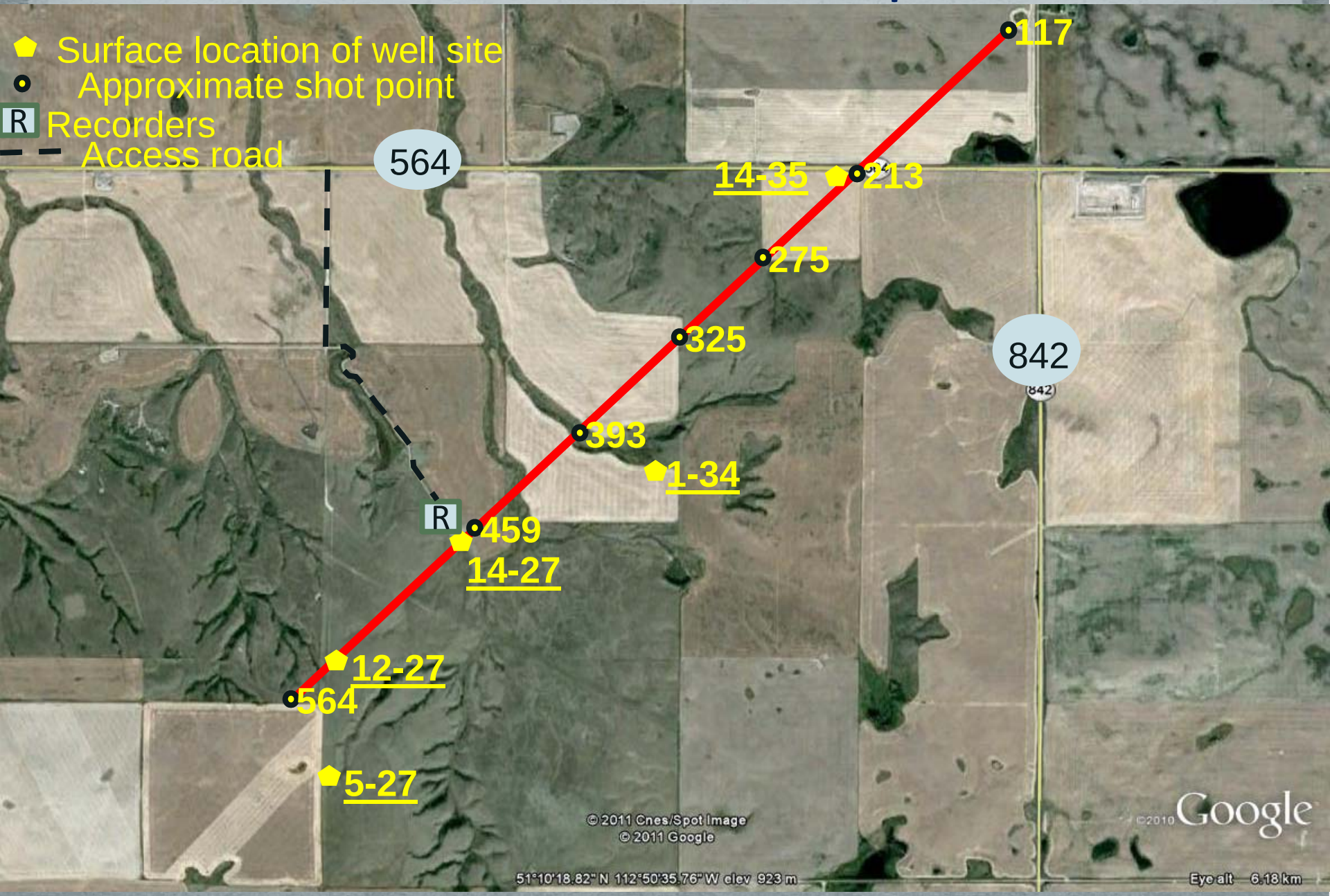
Purpose

- Push low-frequency acquisition while maintaining high frequencies.
- Investigate processing to preserve and enhance low frequencies.
- Use low frequency information in inversion.

Hussar and Alberta



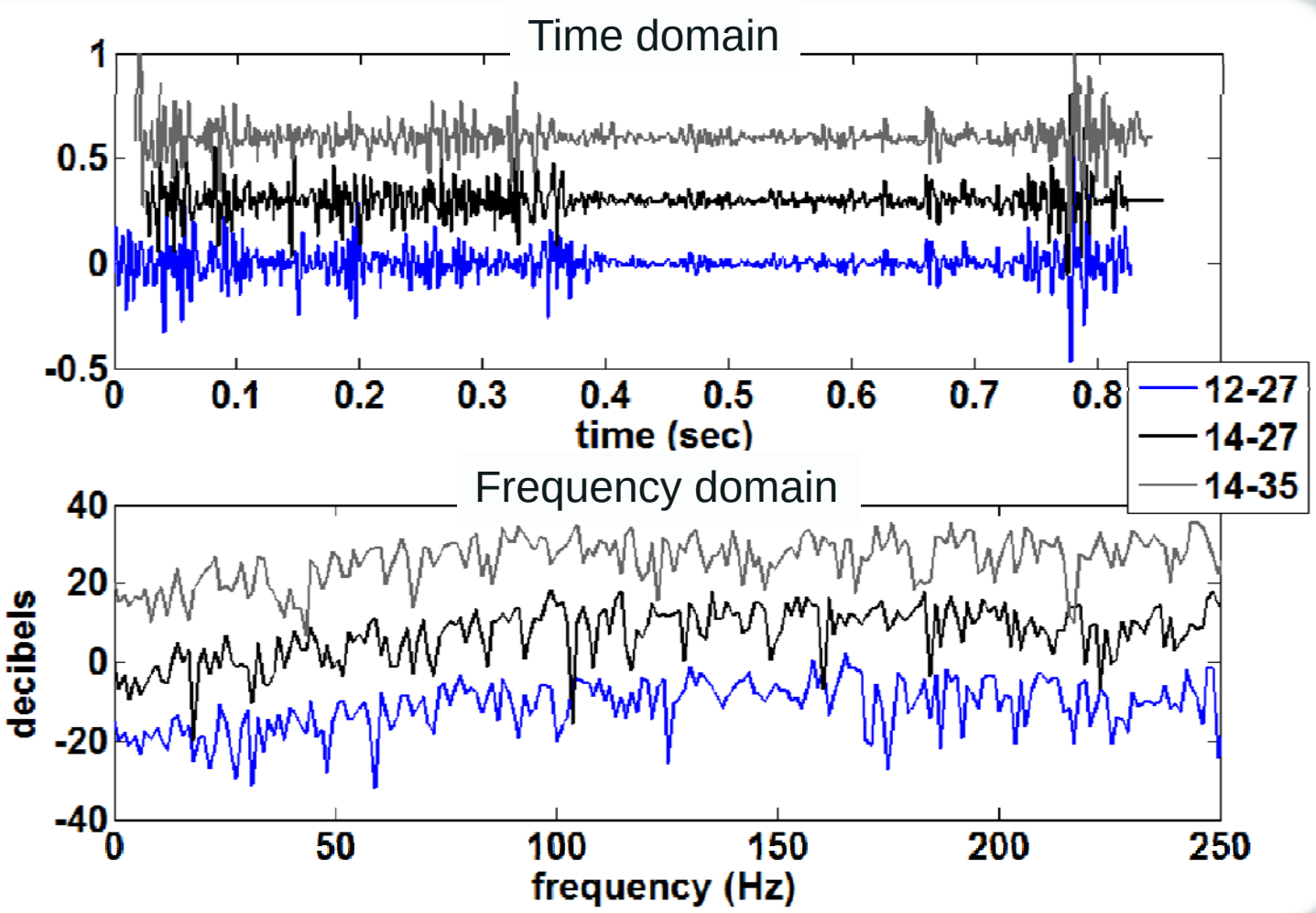
Hussar line on Satellite photo



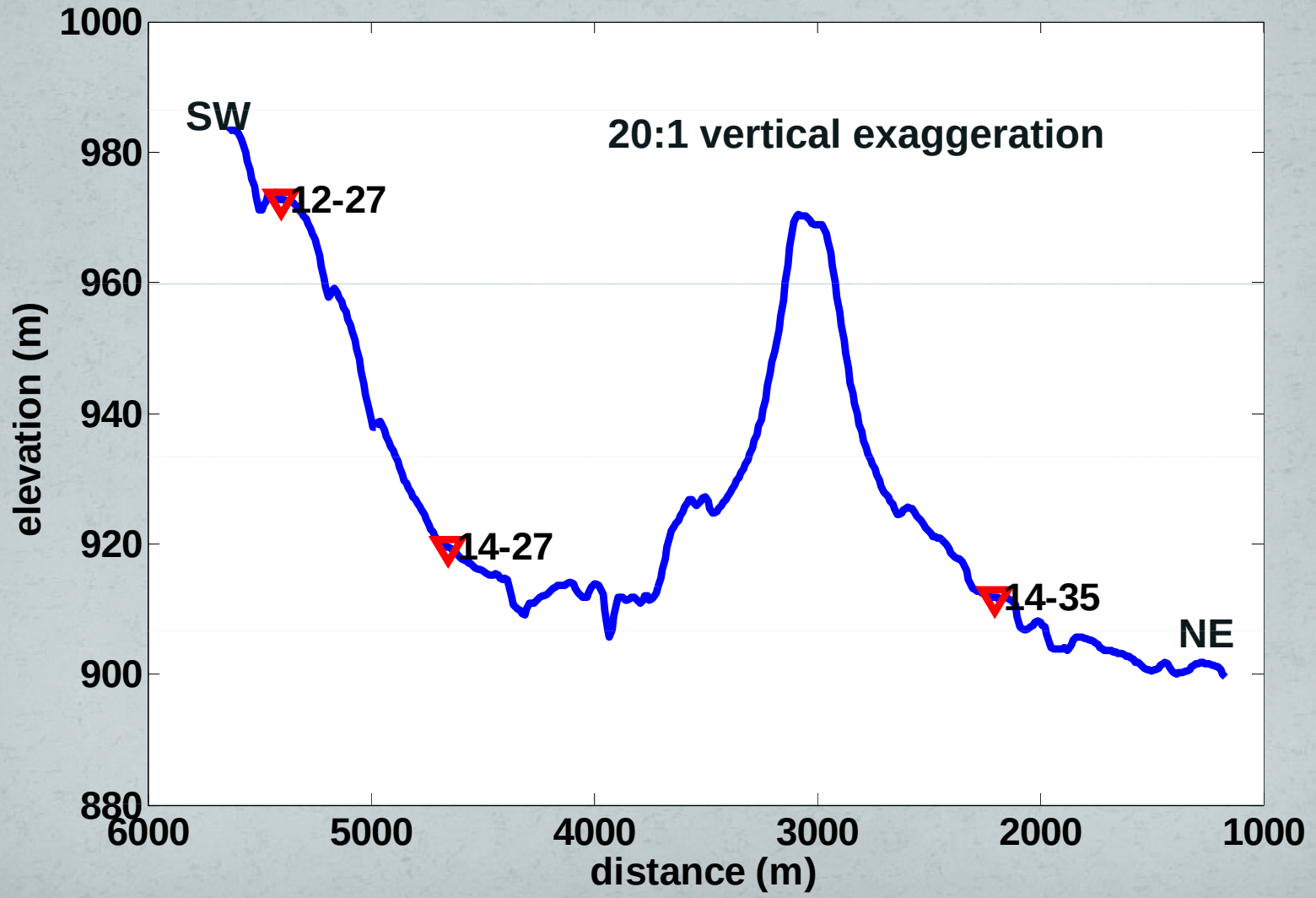
Sponsor participation at Hussar

- **Husky Energy**: Managed the survey, negotiated land access, provided well logs, assisted with myriad details.
- **Geokinetics**: Provided 600 3C Vectorseis receivers, field crew for layout, cables, recording system, on site expertise.
- **INOVA**: Mobilized an AHV-IV (model 364) Vibrator from Houston, plus an operator and an onsite scientist (Tom Phillips). Also donated 50 SM24 high-sensitivity geophones.

Reflection Coefficients for 3 Wells

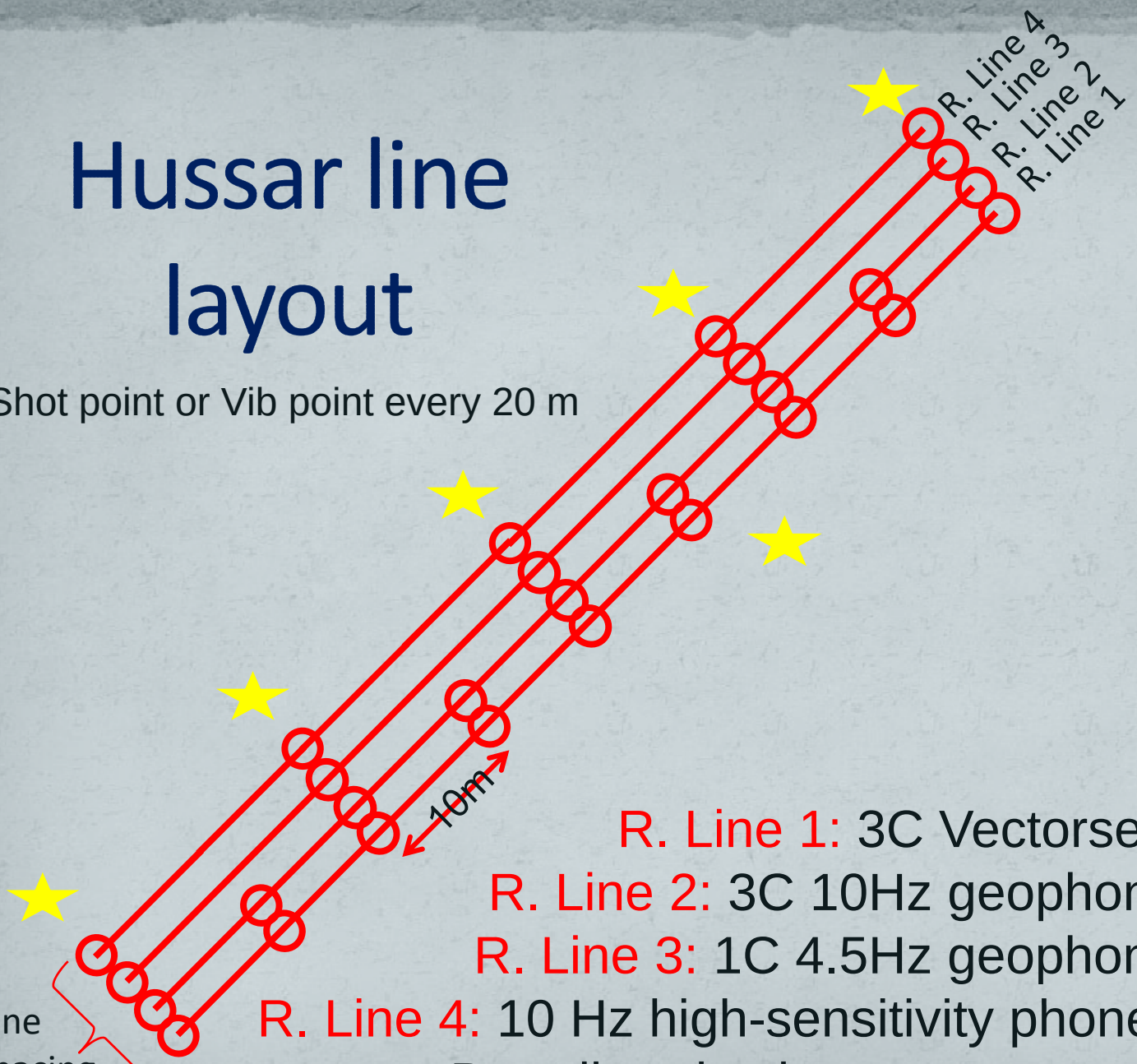


Elevations


1000
980
960
940
920
900
880
elevation (m)
SW
20:1 vertical exaggeration
12-27
14-27
14-35
NE
6000
5000
4000
3000
2000
1000
distance (m)

Hussar line layout

Shot point or Vib point every 20 m



R. Line 1: 3C Vectorseis every 10m
R. Line 2: 3C 10Hz geophone every 10m
R. Line 3: 1C 4.5Hz geophone every 20m
R. Line 4: 10 Hz high-sensitivity phones every 20m
Broadband seismometers every 200m and

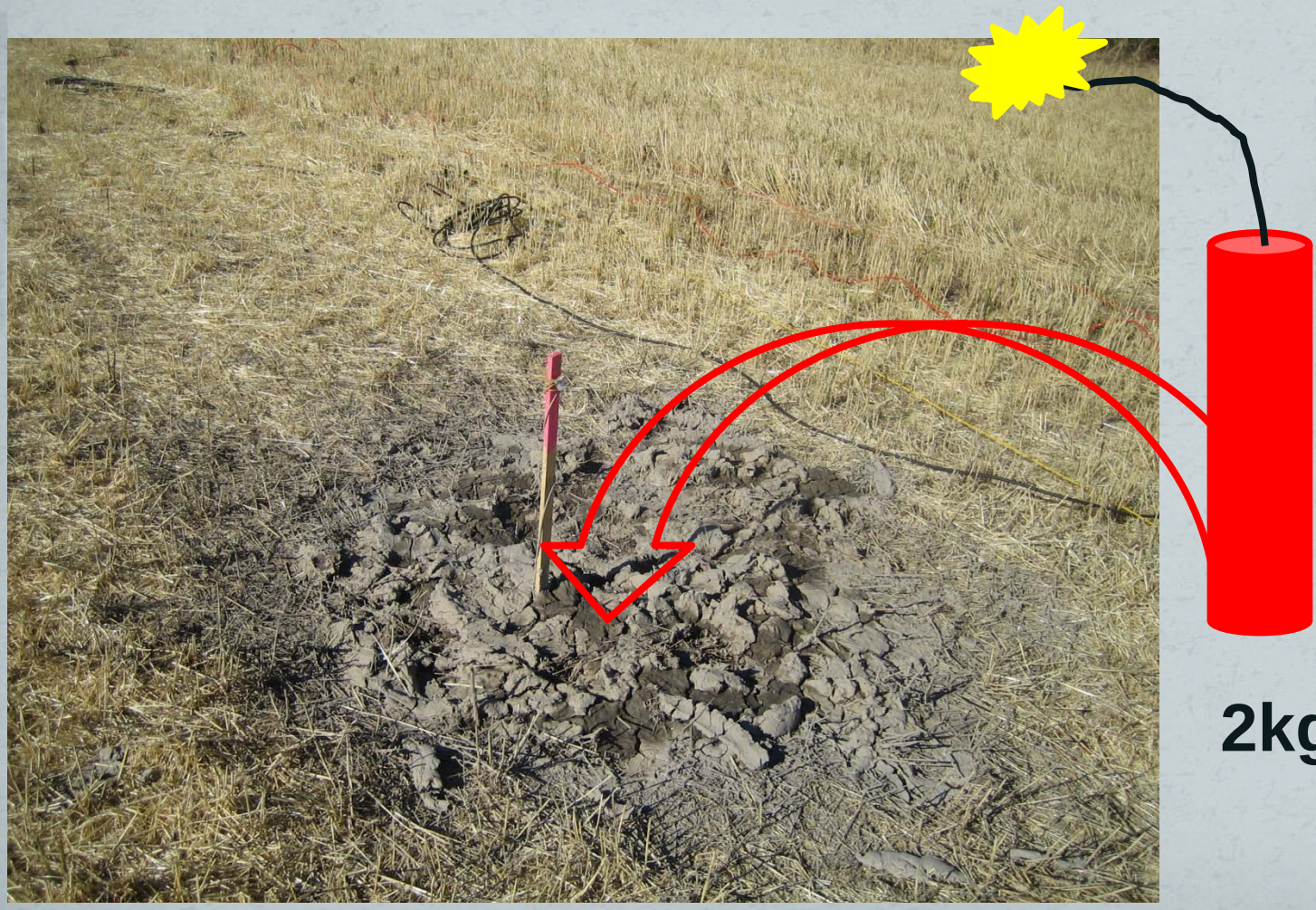
INOVA 364 Low-frequency Vibrator

Both linear and low-dwell sweeps, 1-100Hz,
24 seconds long, were used.

Failing Y2400 Vibrator

Only a low-dwell sweep, 1-100Hz,
24 seconds long, was used.

Dynamite

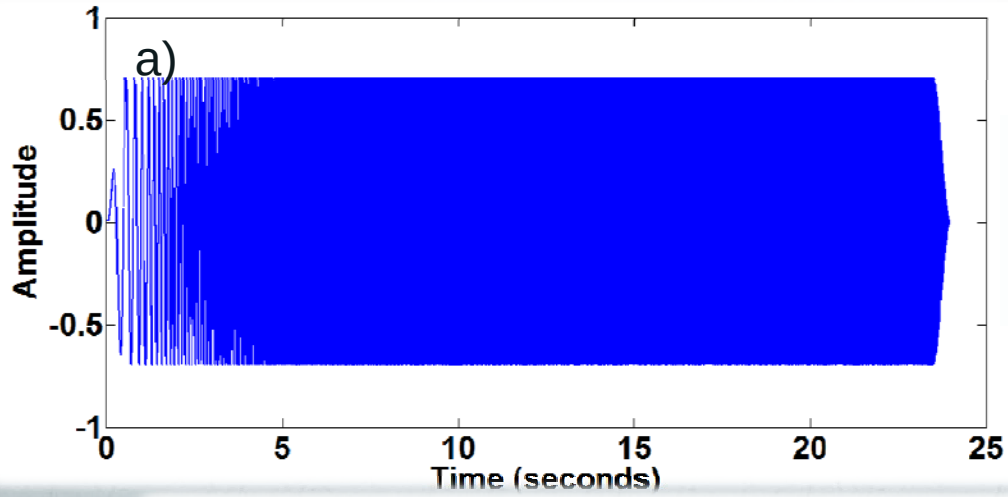


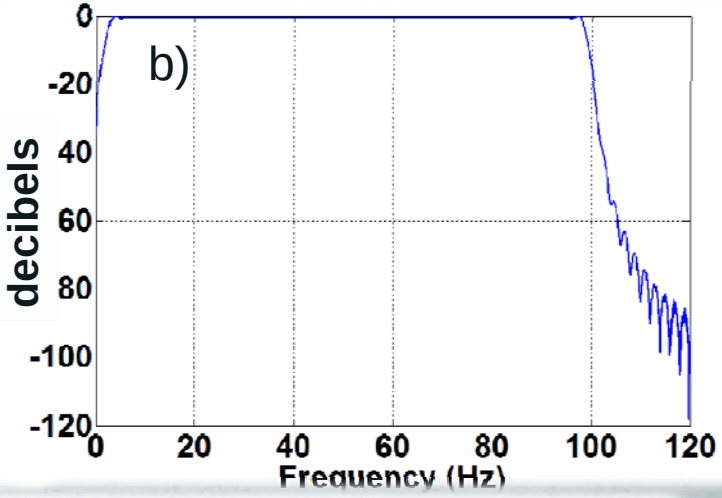
2kg at 15m

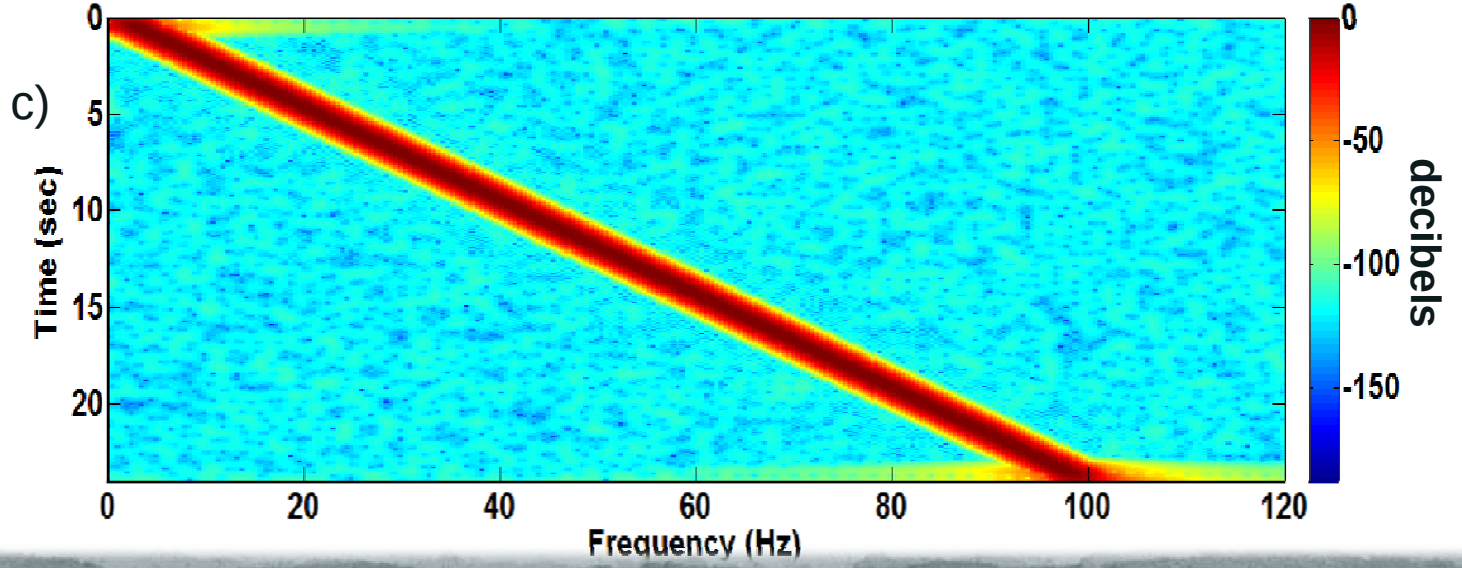
Lines

12 P-P lines
8 P-S lines
10 second records, correlated and uncorrelated

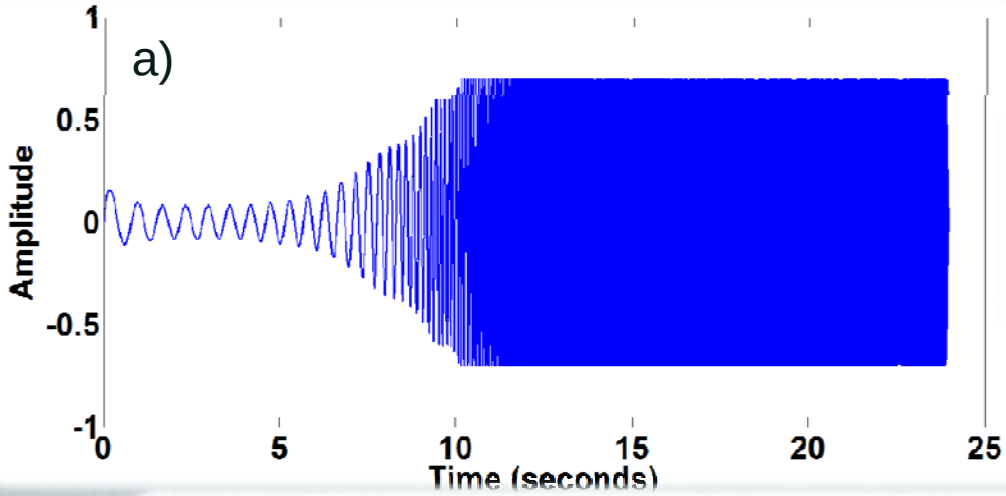
Linear sweep for 364 Vibrator

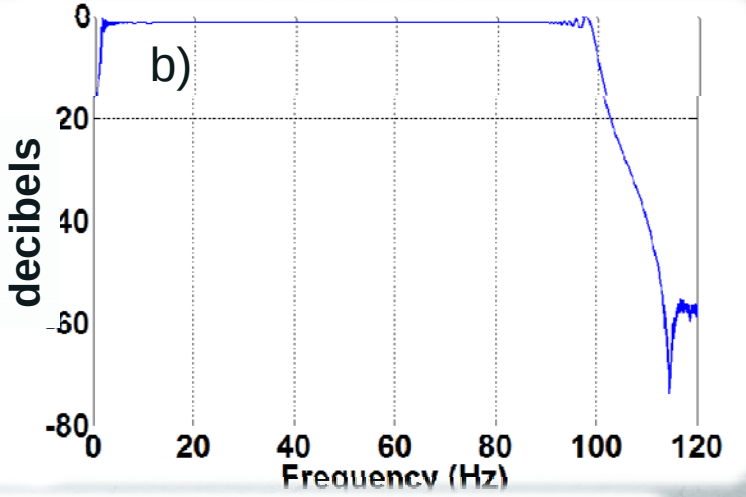


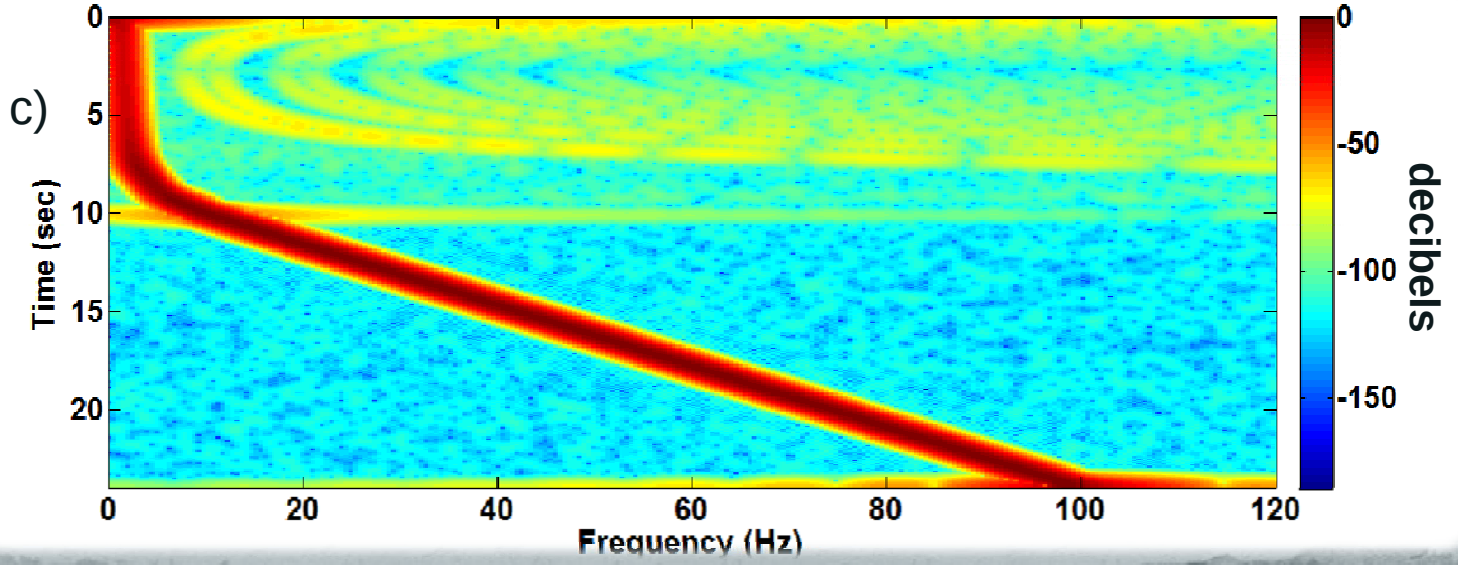




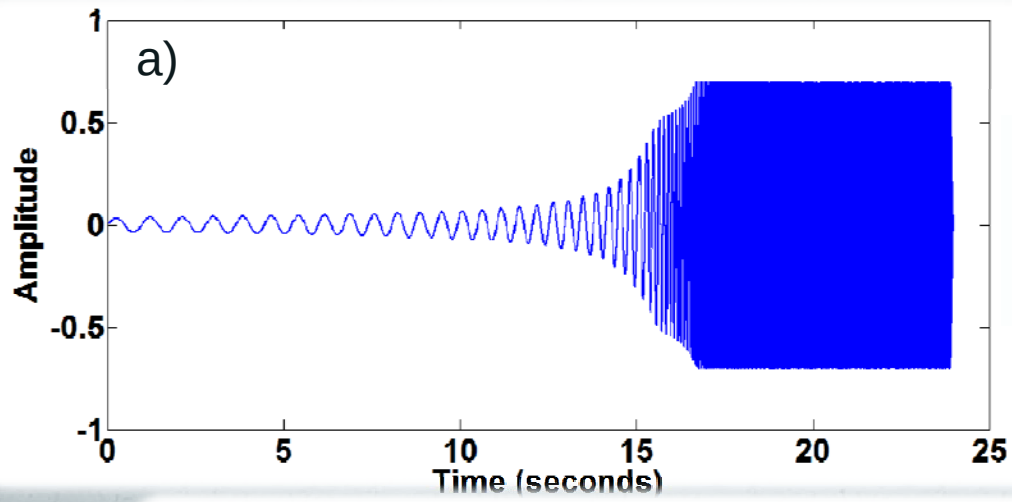
Low-dwell sweep for 364 Vibrator

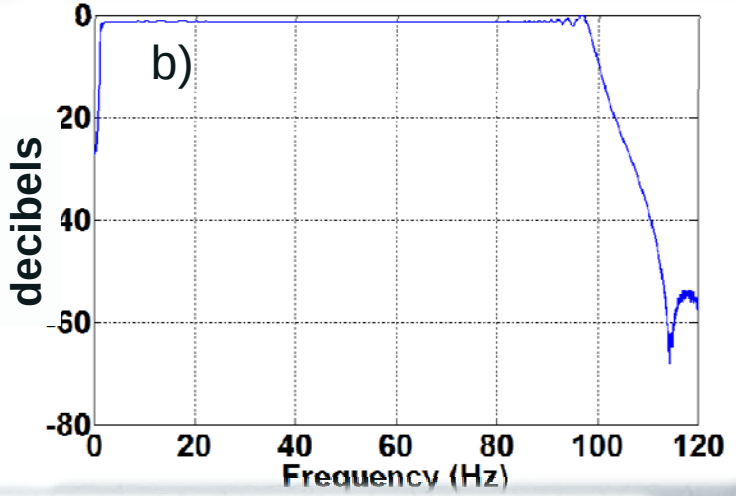


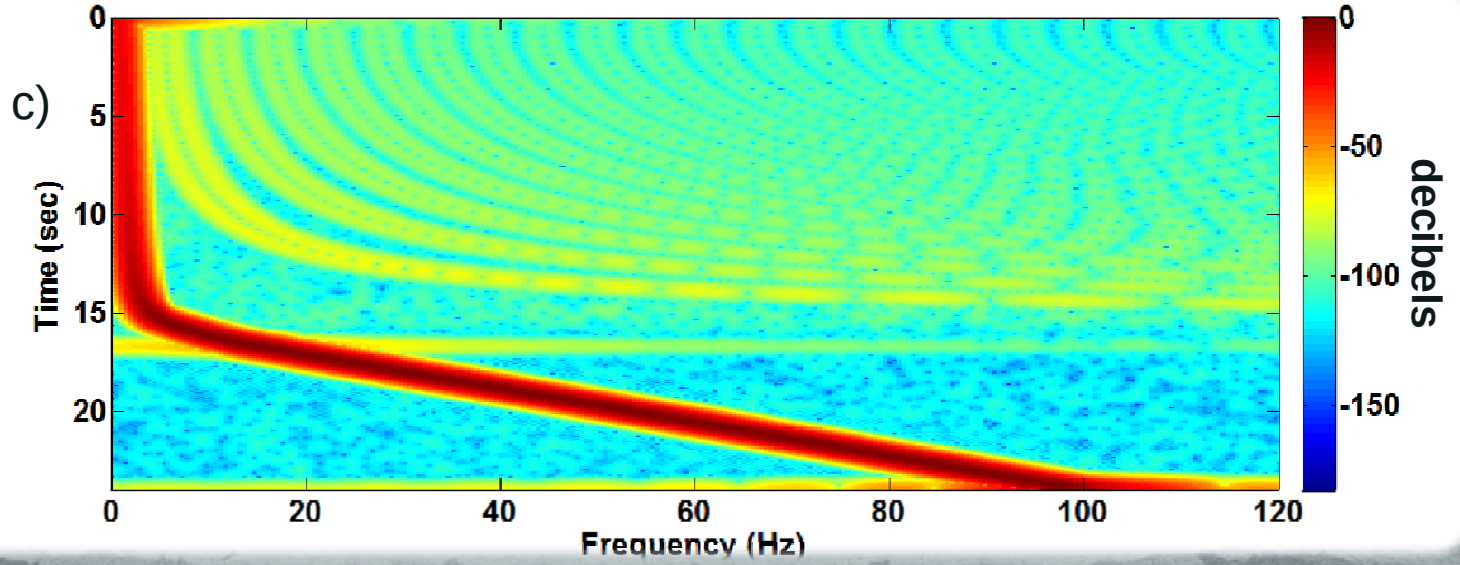




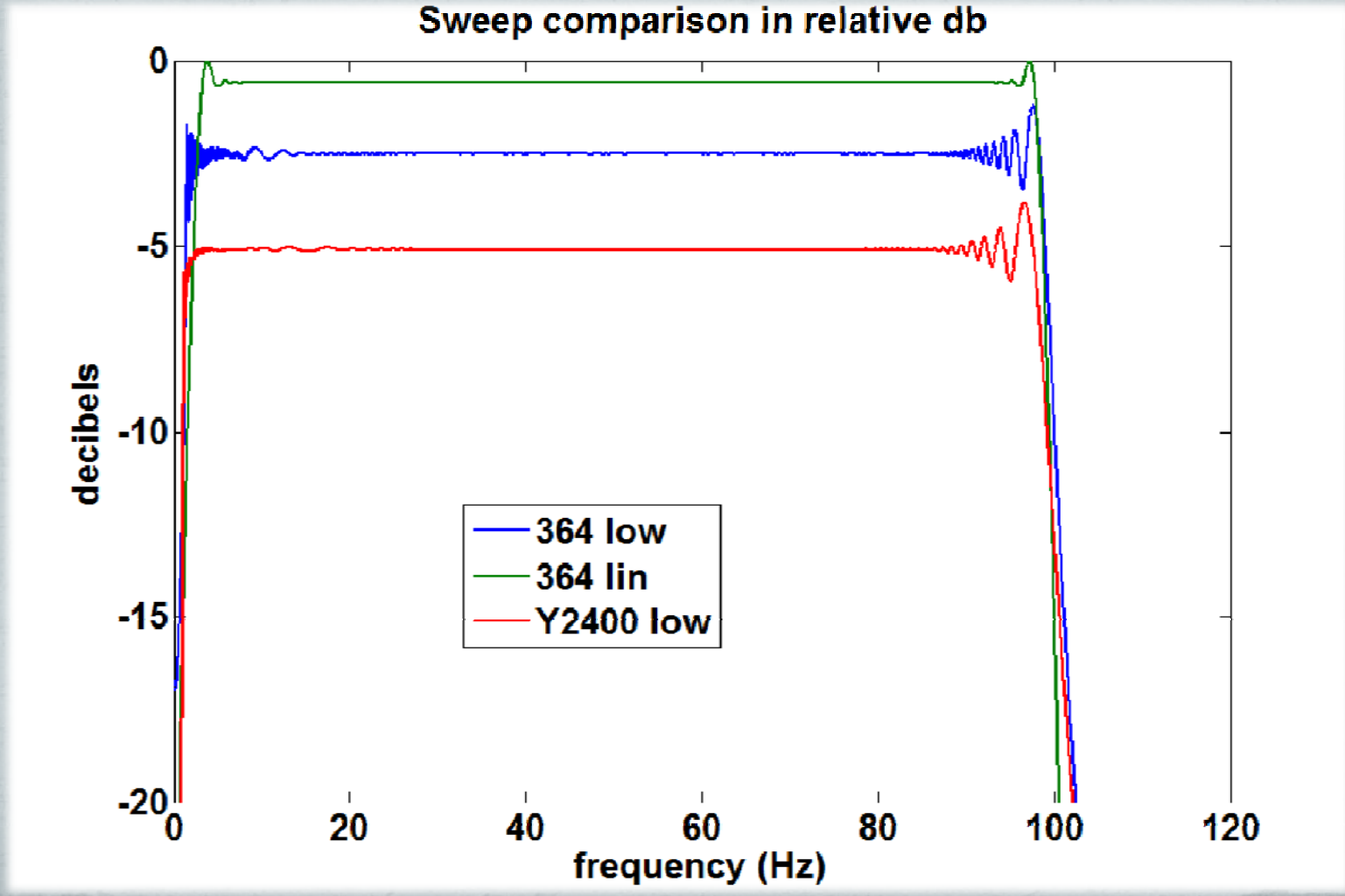
Low-dwell sweep for Failing Vibrator







Sweep comparisons (db)



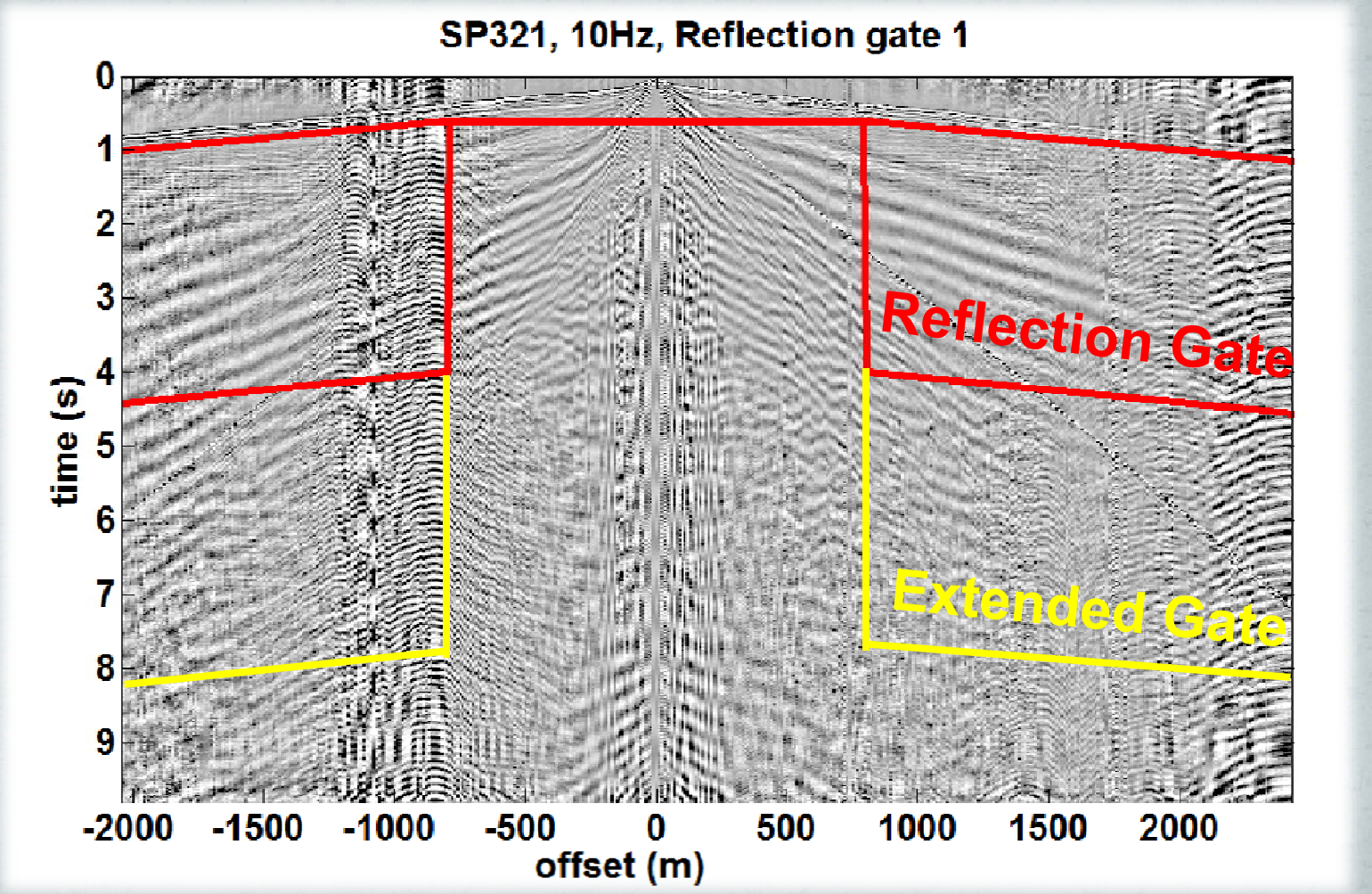
Other Hussar Papers

- Hurrah for Hussar! Comparisons of stacked data: Helen Isaac
- Source and receiver comparisons from Priddis and Hussar: Malcolm Bertram
- Earthquake on the Hussar low-frequency experiment: Kevin Hall
- How low can you go?: Finding low frequencies in various places - A Hussar example: Heather Lloyd

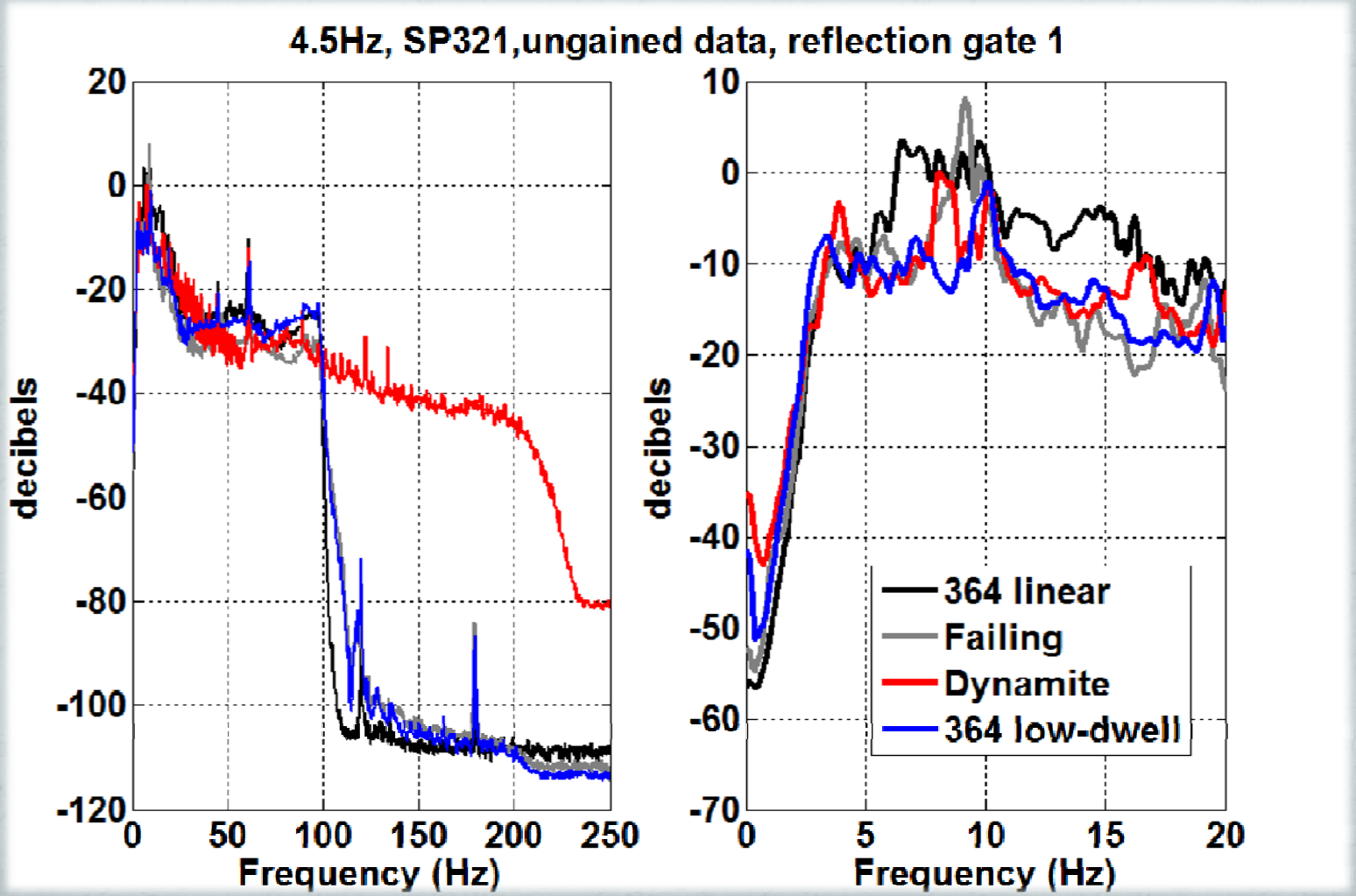
Also, please visit the Hussar posters at the CREWES booth

Spectral analysis of raw data

Analysis gate for SP321

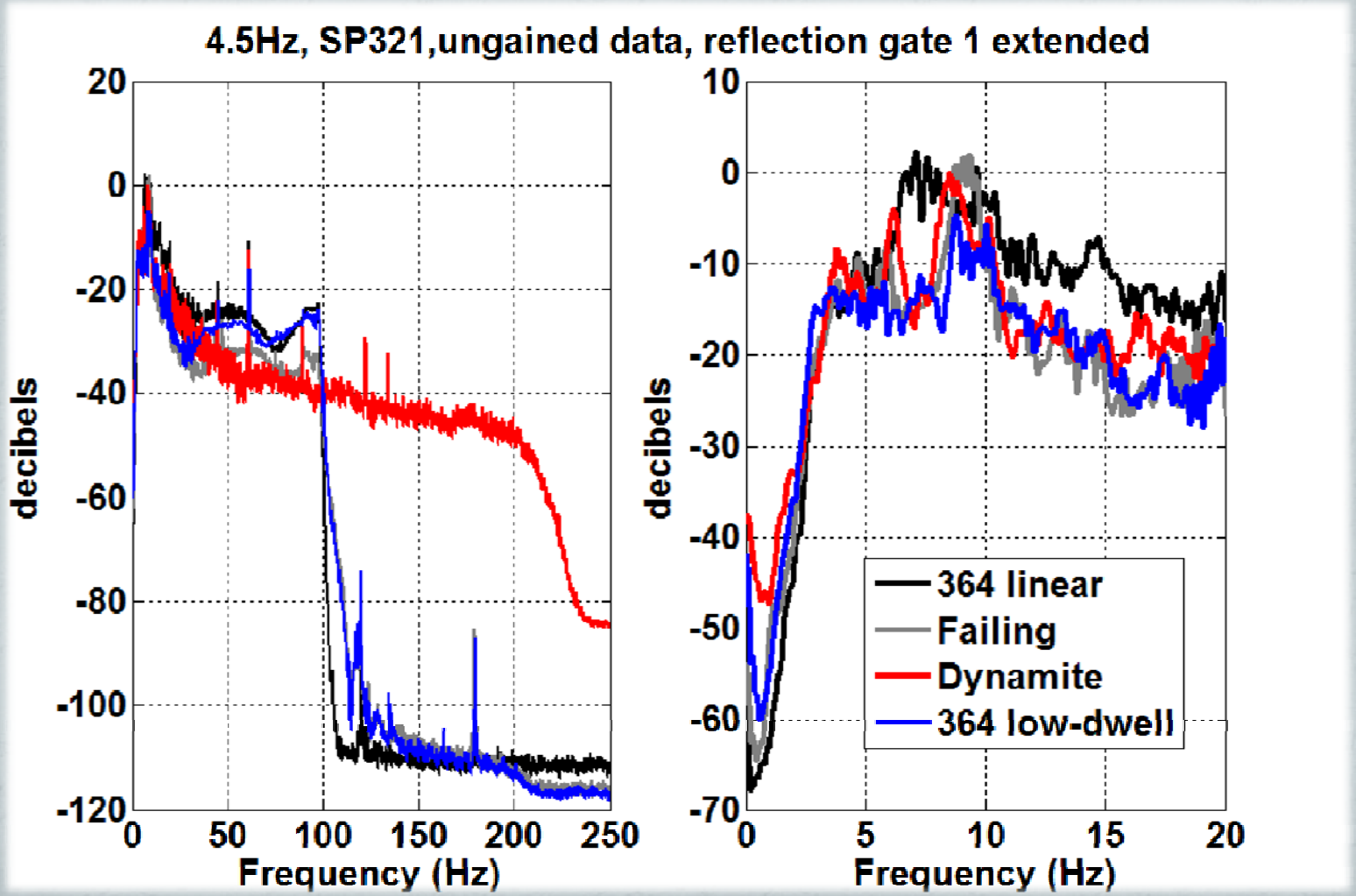


Spectral analysis, SP321, 4.5Hz (Sunfull) 3.5 second gate



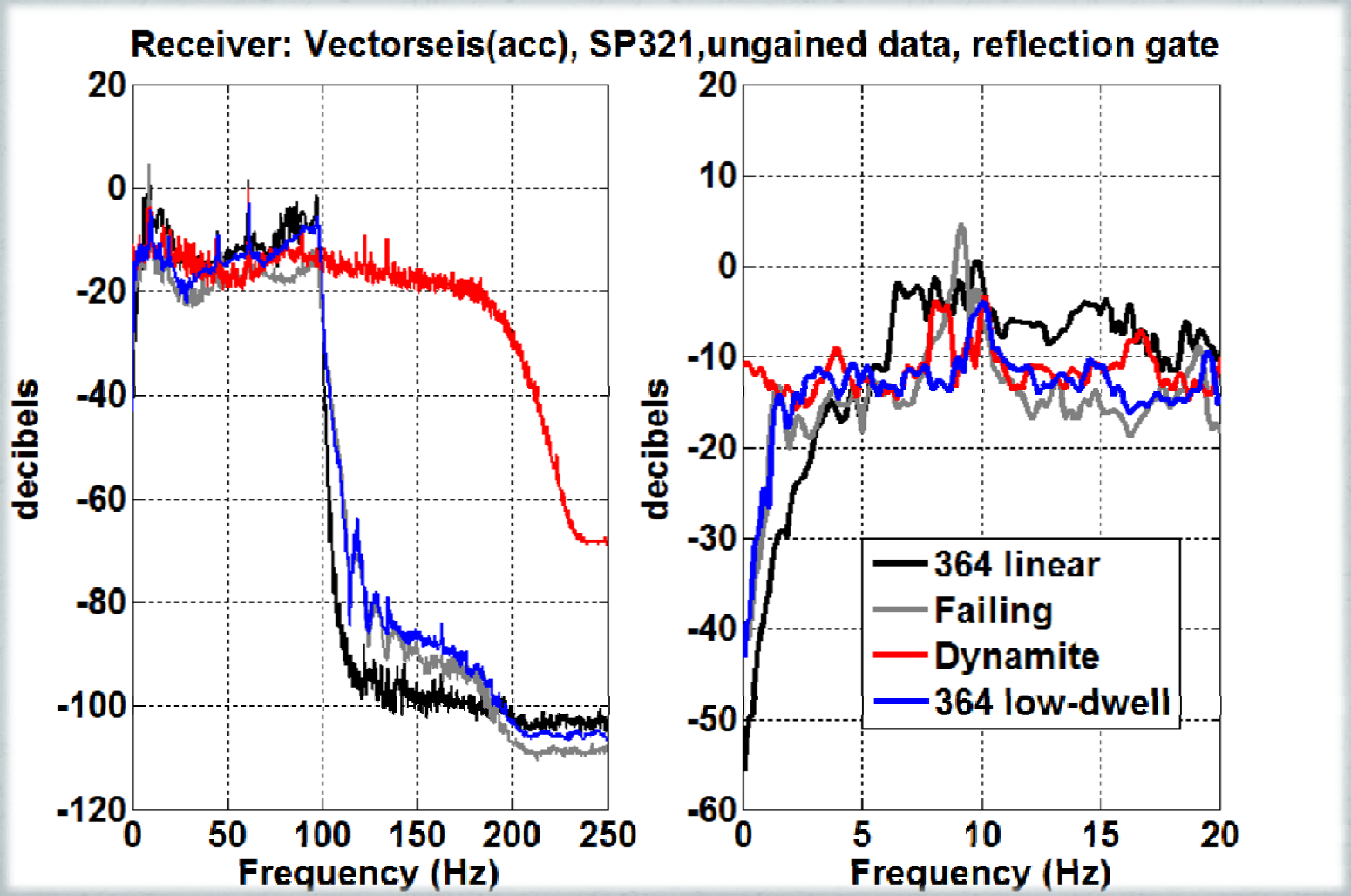
Single receiver, all sources

Spectral analysis, SP321, 4.5Hz (Sunfull) 7 second gate



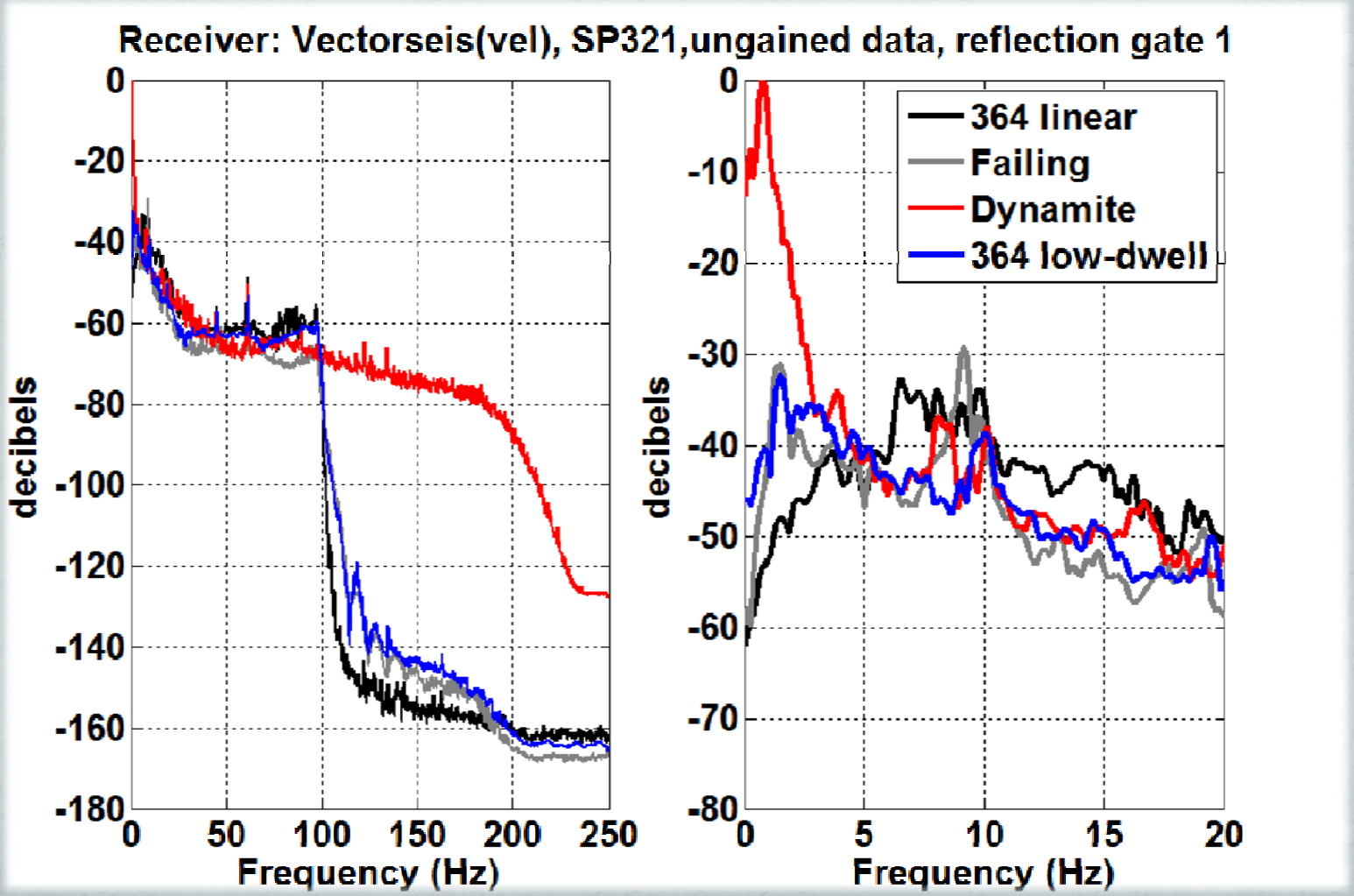
Single receiver, all sources

Spectral analysis, SP321, Vectorseis(acc)



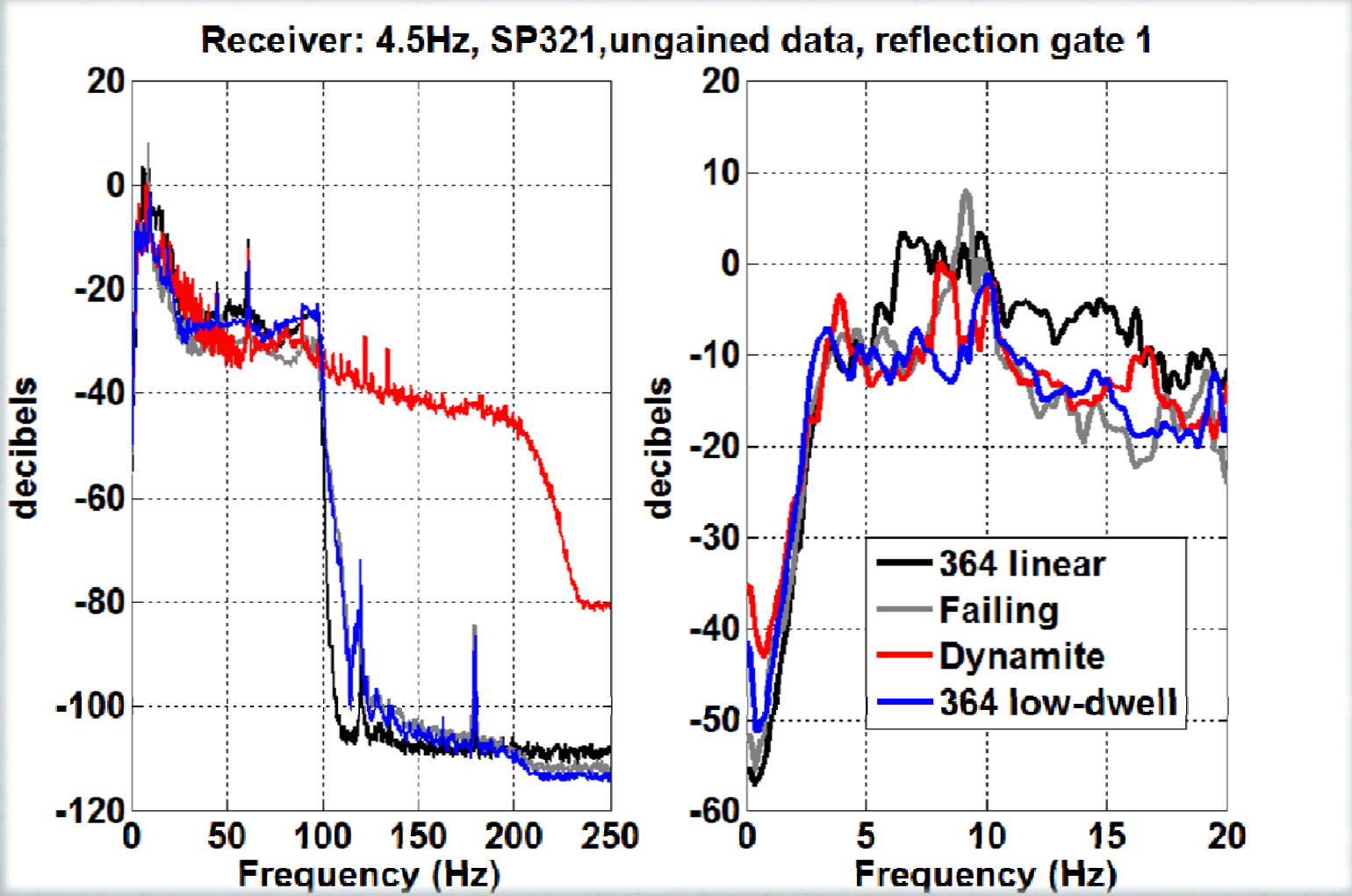
Single receiver, all sources

Spectral analysis, SP321, Vectorseis(vel)



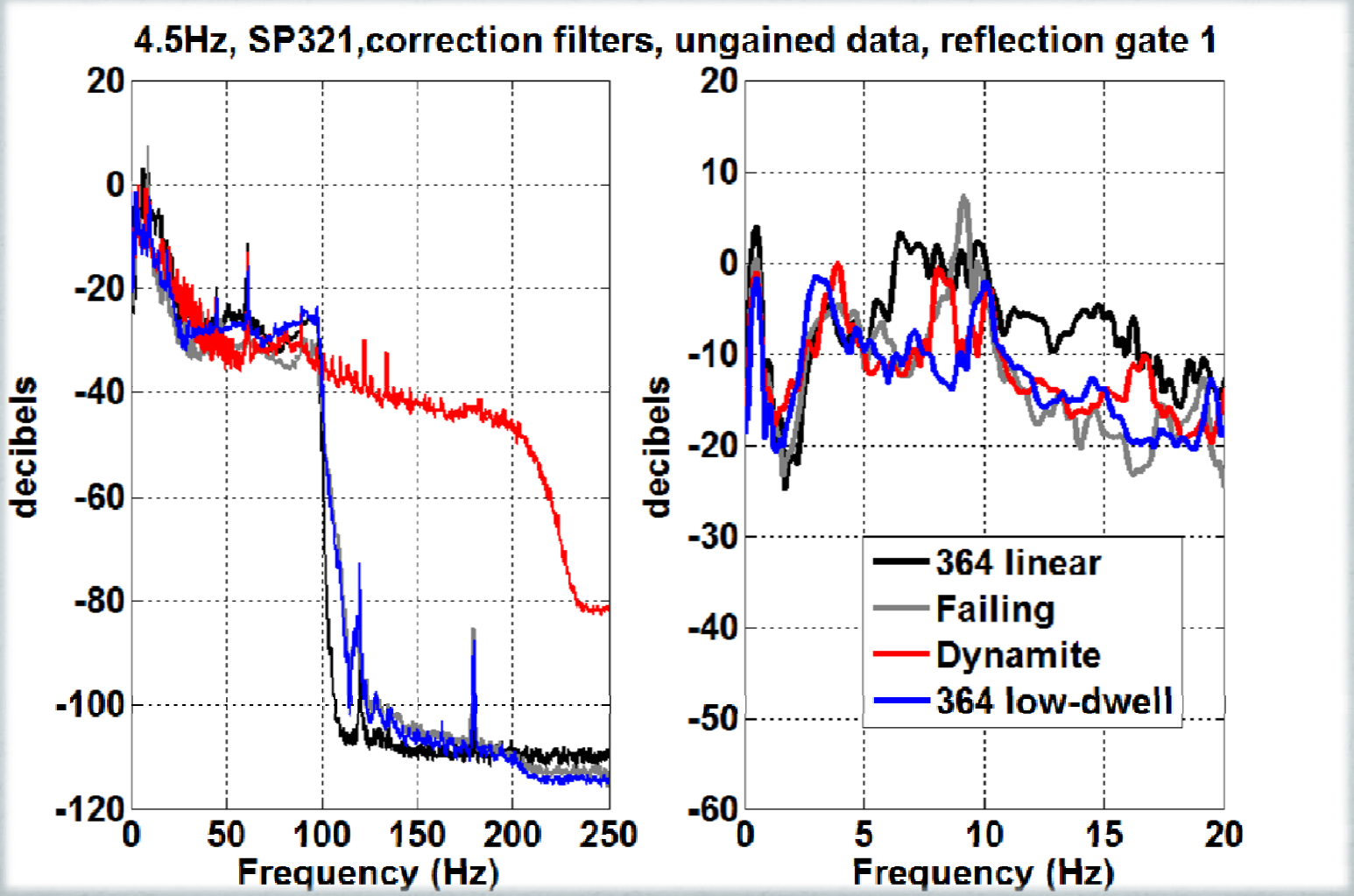
Single receiver, all sources

Spectral analysis, SP321, 4.5Hz (Sunfull)



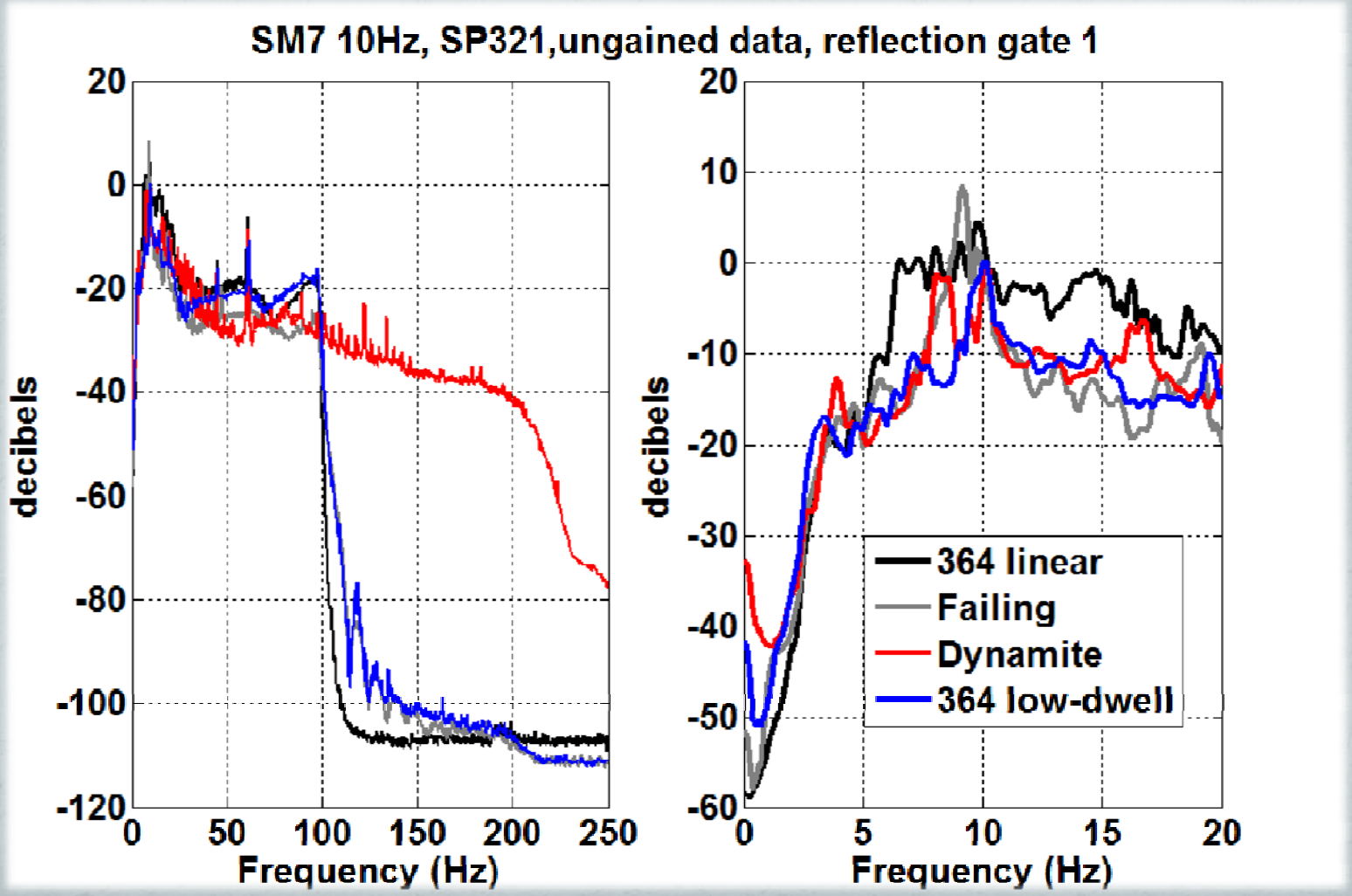
Single receiver, all sources

Spectral analysis, SP321, 4.5Hz (Sunfull) with geophone correction



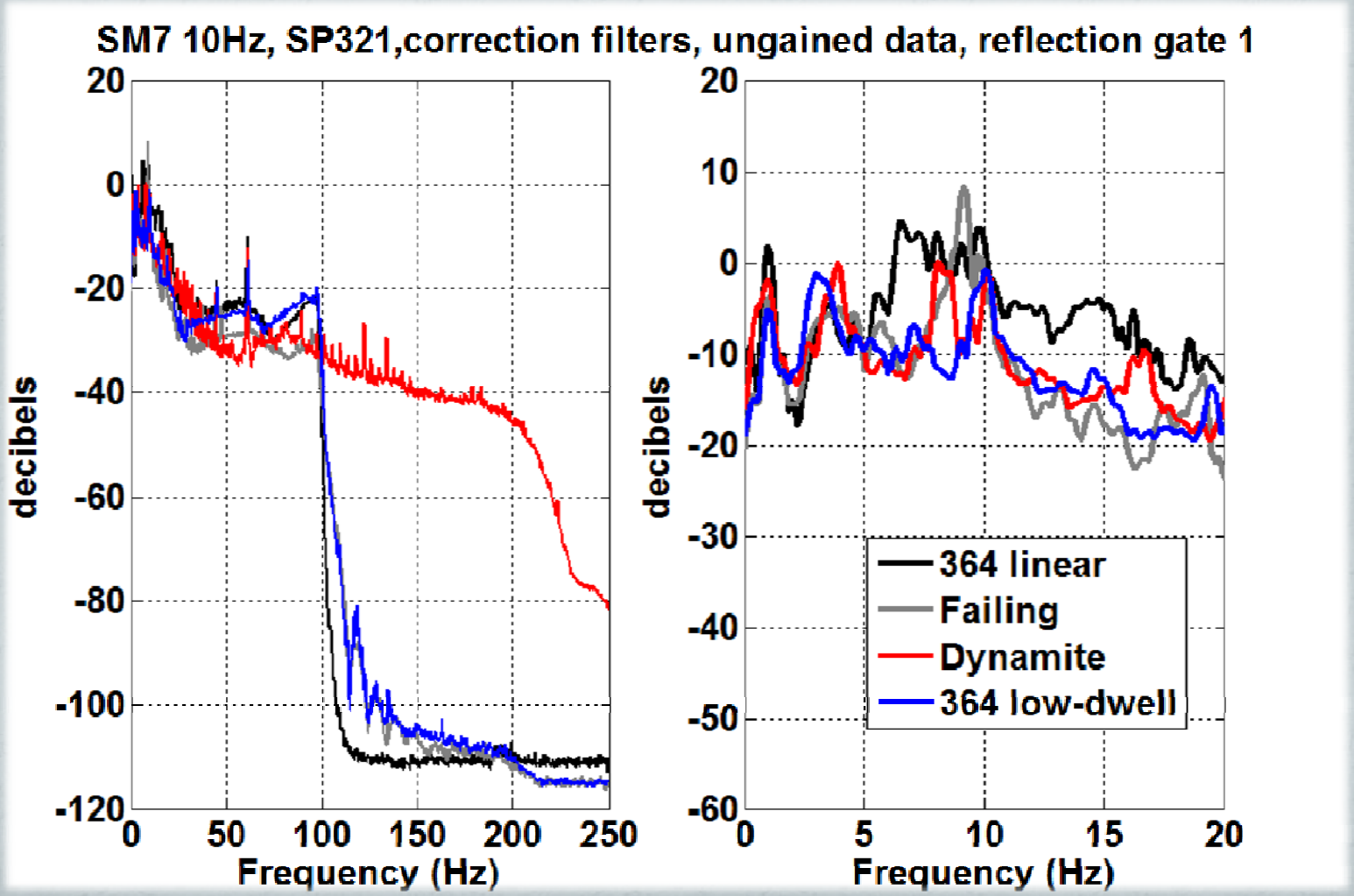
Single receiver, all sources

Spectral analysis, SP321, SM7 (10Hz)



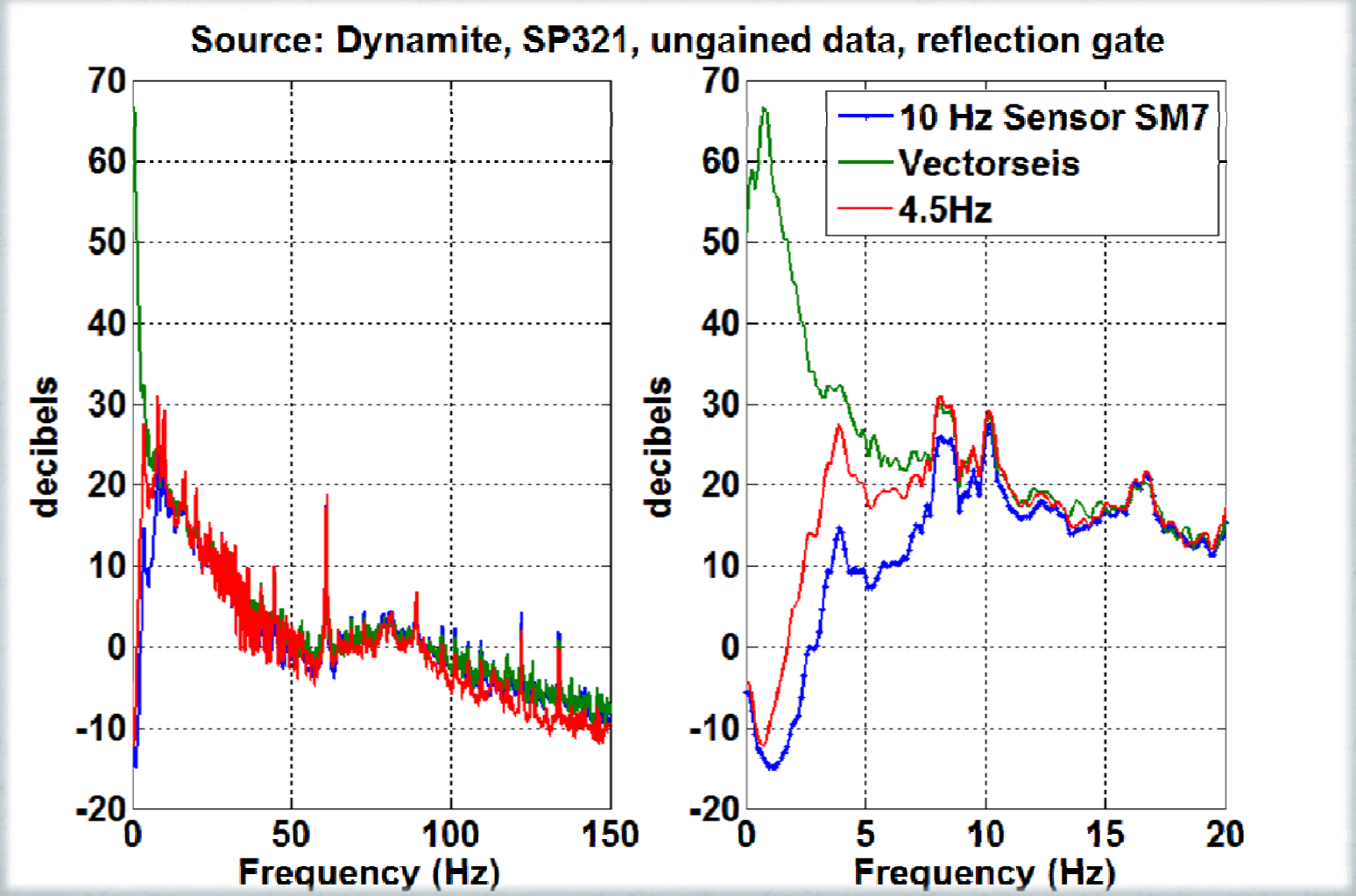
Single receiver, all sources

Spectral analysis, SP321, SM7 (10Hz) with geophone correction



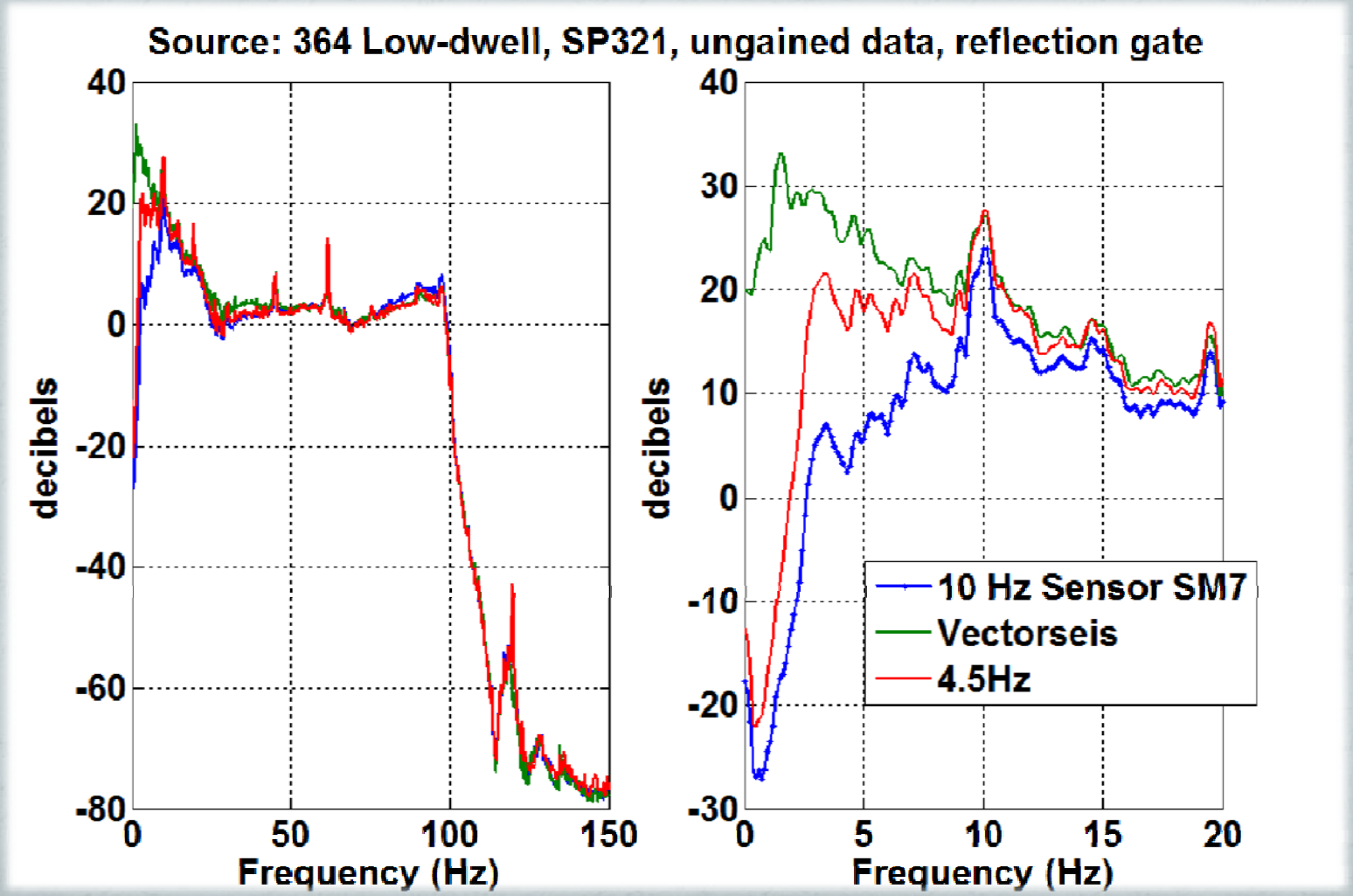
Single receiver, all sources

Spectral analysis, SP321, Dynamite, all receivers



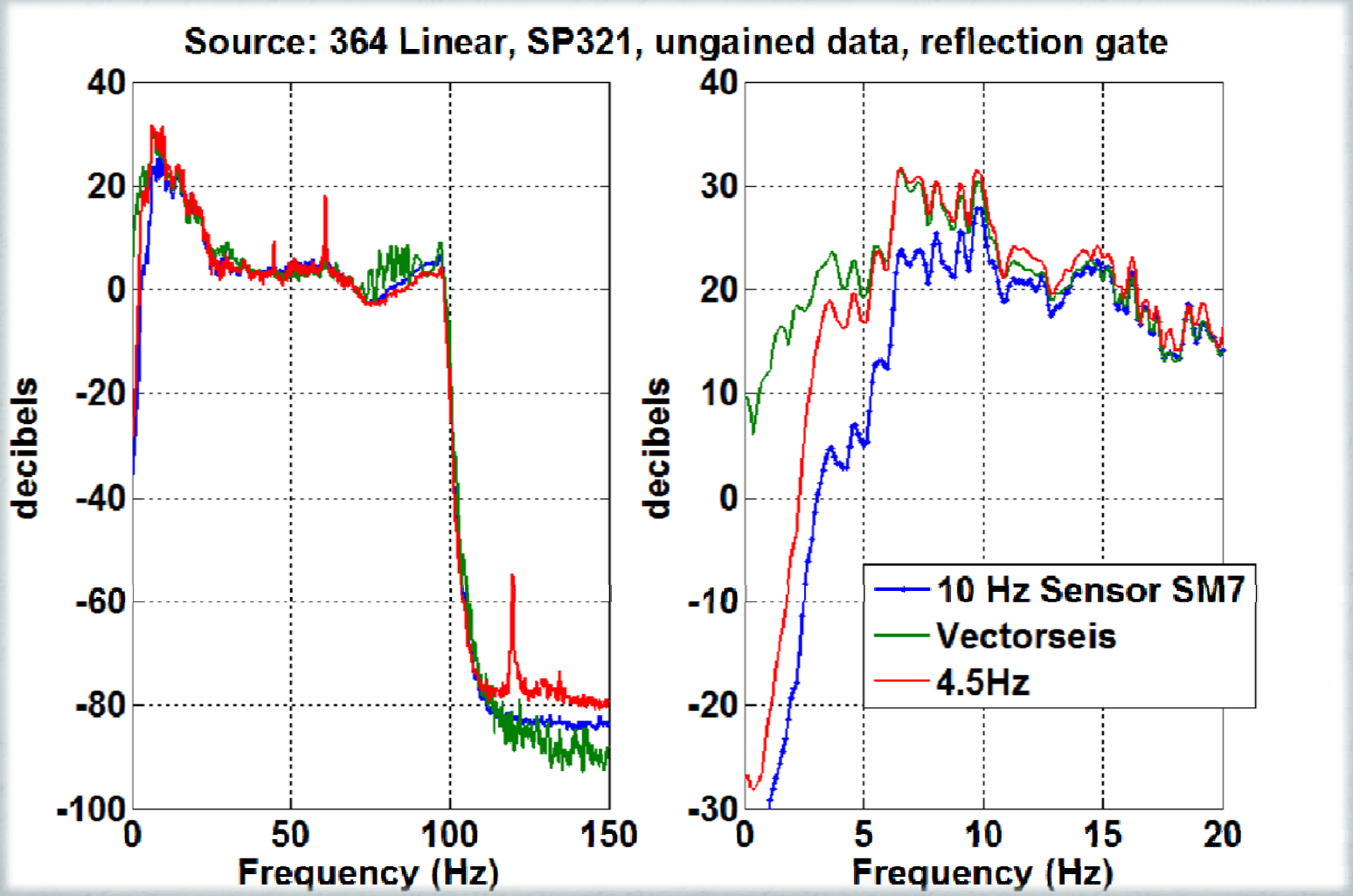
Single source, all receivers

Spectral analysis, SP321, 364-Low, all receivers



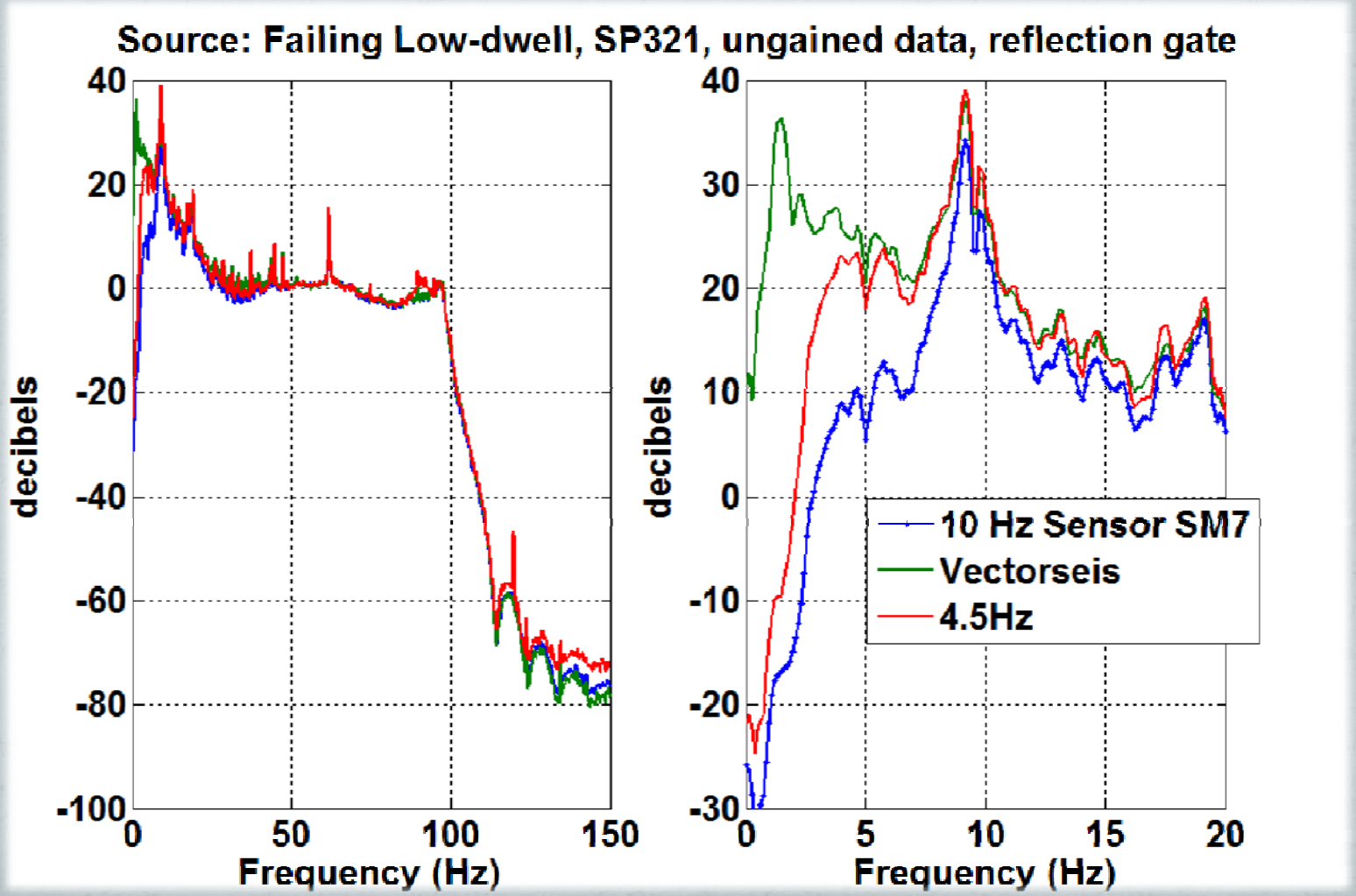
Single source, all receivers

Spectral analysis
SP321, 364-Linear, all receivers



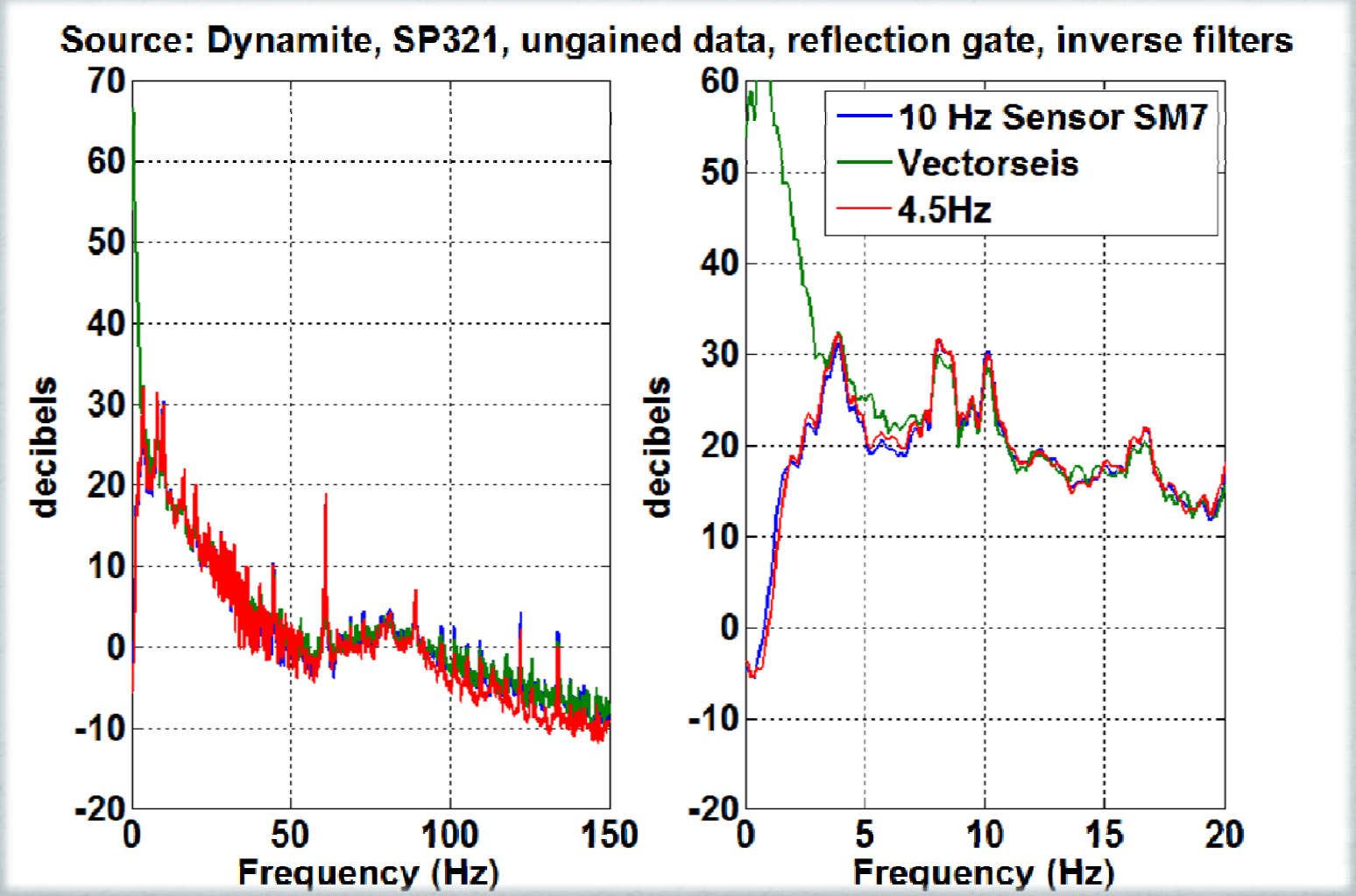
Single source, all receivers

Spectral analysis
SP321, Failing, all receivers



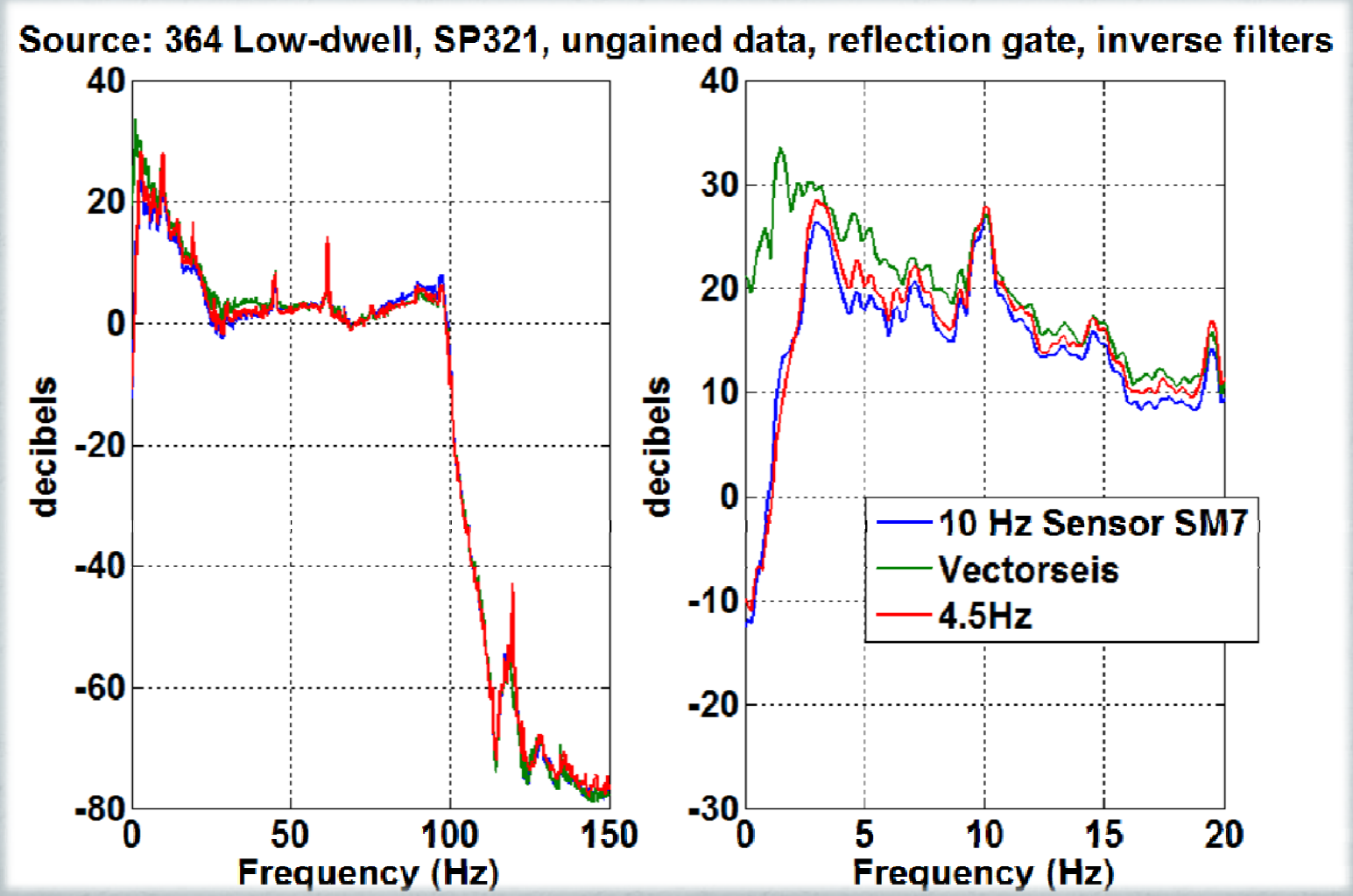
Single source, all receivers

Spectral analysis
SP321, Dynamite, all receivers, geophones corrected



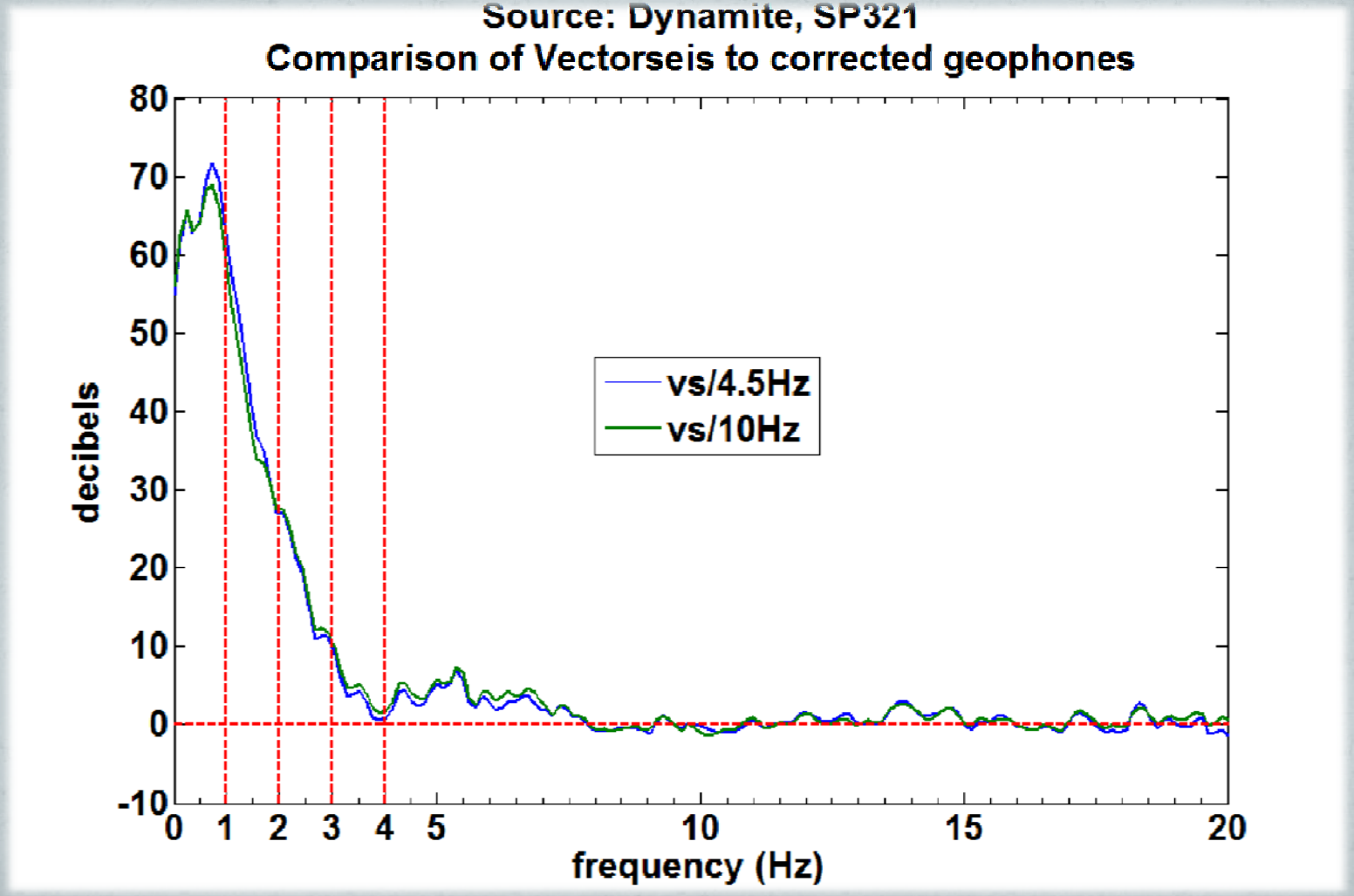
Single source, all receivers

Spectral analysis
SP321, 364-Low, all receivers, geophones corrected



Single source, all receivers

Spectral analysis
Comparison of Vectorseis to Corrected Geophones



Conclusions

- CREWES has acquired a very interesting low-frequency dataset.
- Dynamite produced the strongest low-frequency content.
- INOVA 364 vibrator did very well with both linear and low-dwell sweeps. Conventional vibe with low-dwell is an option.
- Vectorseis records down to very low frequencies but instrument noise seems a problem below 3Hz.
- 4.5Hz and 10Hz geophones show the expected roll-off below resonance.
- Geophone correction filters seem very effective in restoring low frequency content.
- **Dataset is available to all sponsors beginning in Jan. 2012.**

Acknowledgements

- Husky Energy provided land access, well access, and survey management.
- Geokinetics provided Vectorseis receivers, recording system, and field crew.
- INOVA provided the INOVA AHV-IV (model 364) and donated the 50 SM24 receivers.
- Nanometrics provided 15 Trillium broadband seismometers.
- All CREWES sponsors and NSERC provided financial support.

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