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Bighorns Discrimination Study



Ground-Based Nuclear Explosion Monitoring R&D



- **By Hans Hartse (hartse@lanl.gov)**
- **LANL, EES Division, Geophysics Group**
- **Work performed FY2012**
- **Talk assembled August, 2012**

Bighorns Discrimination Study



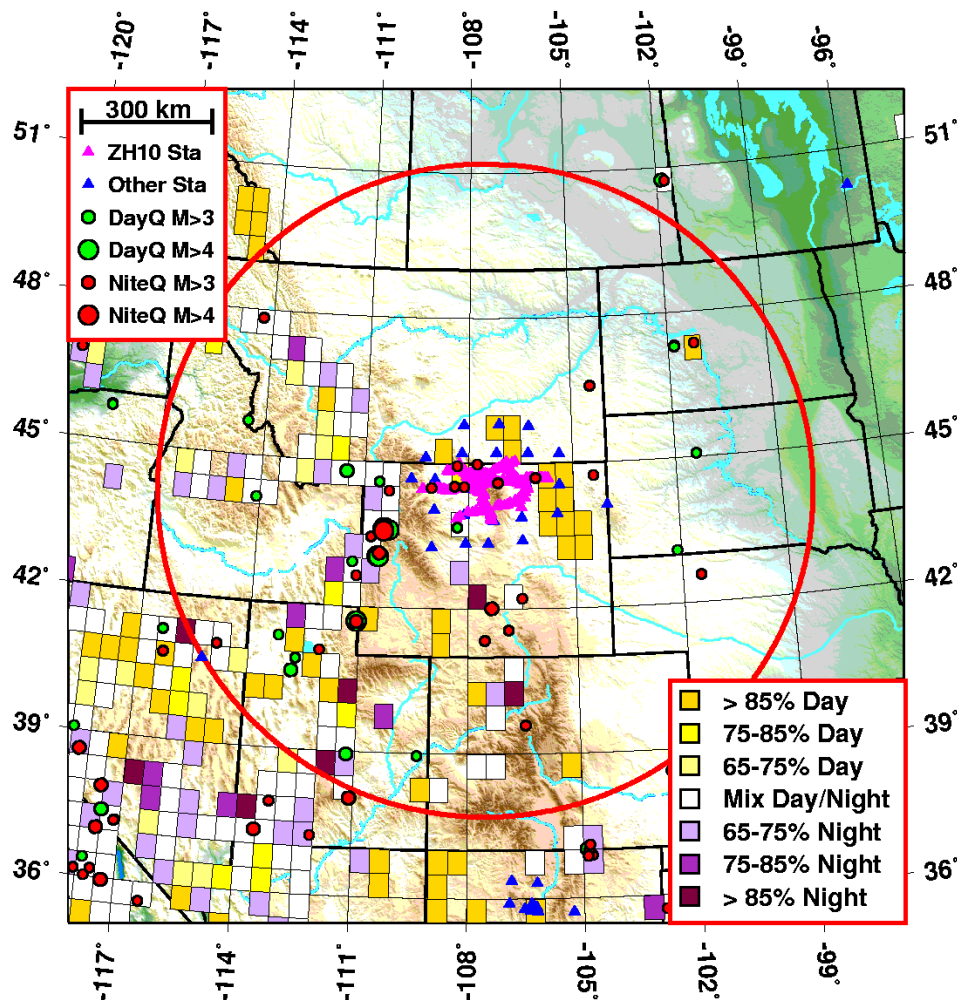
Ground-Based Nuclear Explosion Monitoring R&D

- Stations and events used
- Which events to use as earthquake GT?
- Sample waves
- Discrimination results
- Thanks to: Richard Stead (data assembly and limestone quarry id; Jonathan MacCarthy (coordinate transformations to lat-lon); TAMU, UTEP, and U Colorado collaborators
- Remember – these are preliminary, “fast” results

Regional Map – 750 km Radius

Ground-Based Nuclear Explosion Monitoring R&D

20100415 - 20101130



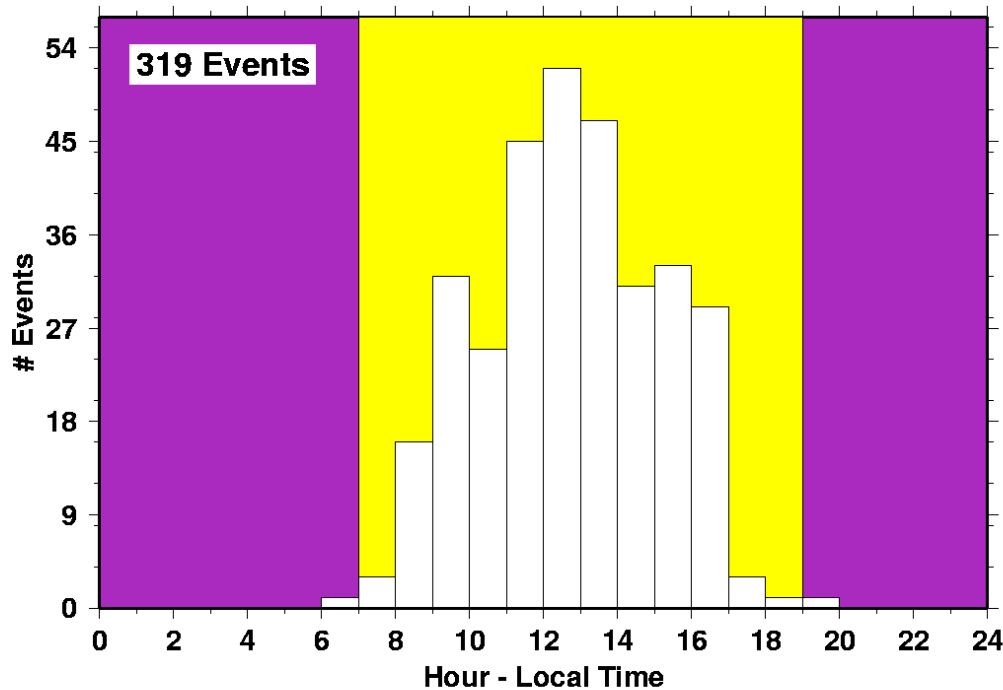
- From LANL database
- Blue stations - USARRAY
- Pink lines – SP stations
- Gold and yellow – daytime events
- Red – “night quakes” – note a few BH explosions reached the ANF bulletin
- Green – “day quakes”

Typical PRB Mining Event Bin



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43.25_x_-105.25



- Nearly all events from local daytime (yellow)
- Each bin 0.5 x 0.5 degrees
- Day event in this type of bin must have $M > 4$ to be declared a quake

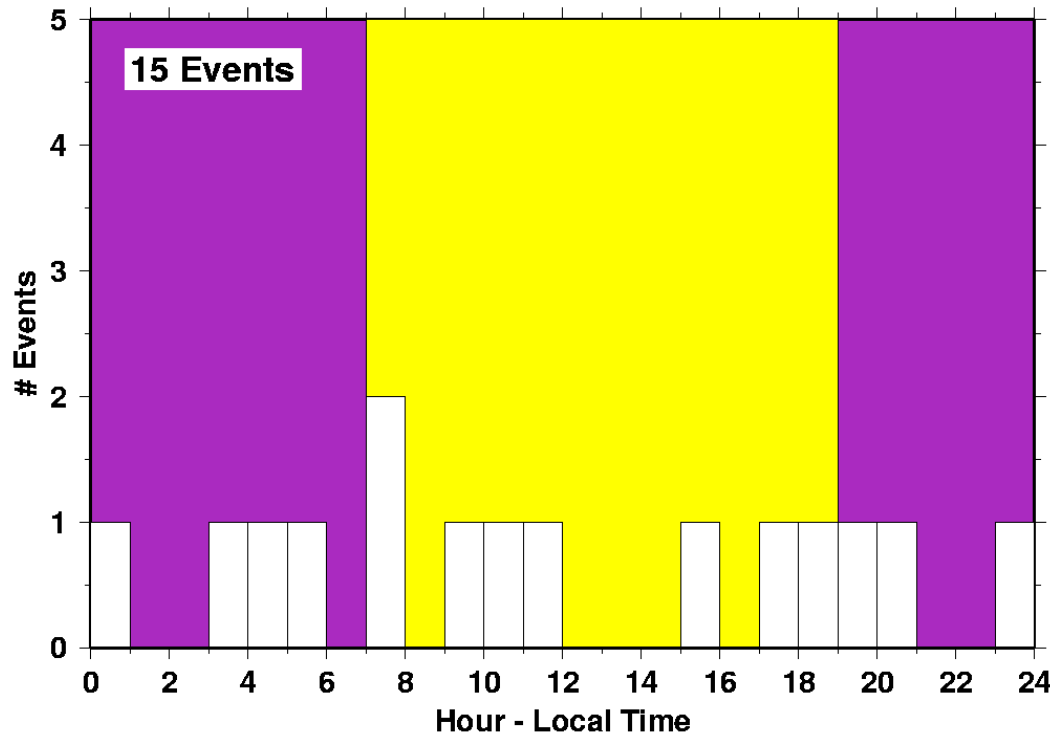
Typical “White” Bin From Yellowstone Park Area



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43.75_x_-110.25



- Nearly even numbers of events from day and night
- Both day and night events are selected from this type of bin, regardless of mag
- “Solitary” night events of any size are selected
- “Solitary” day quakes not selected

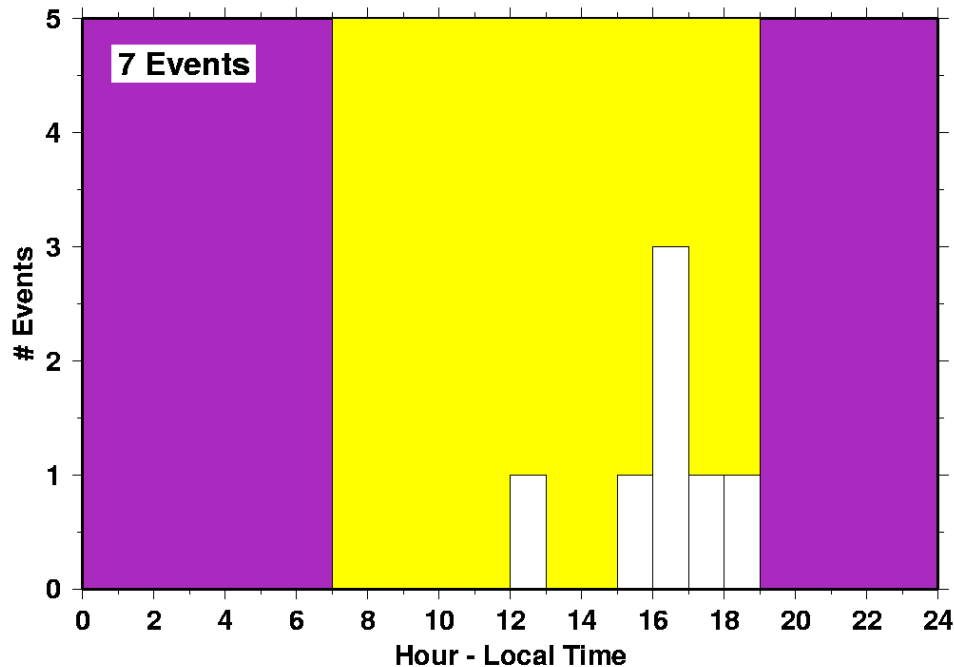
Limestone Quarry Event Bin



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45.25_x_-108.75

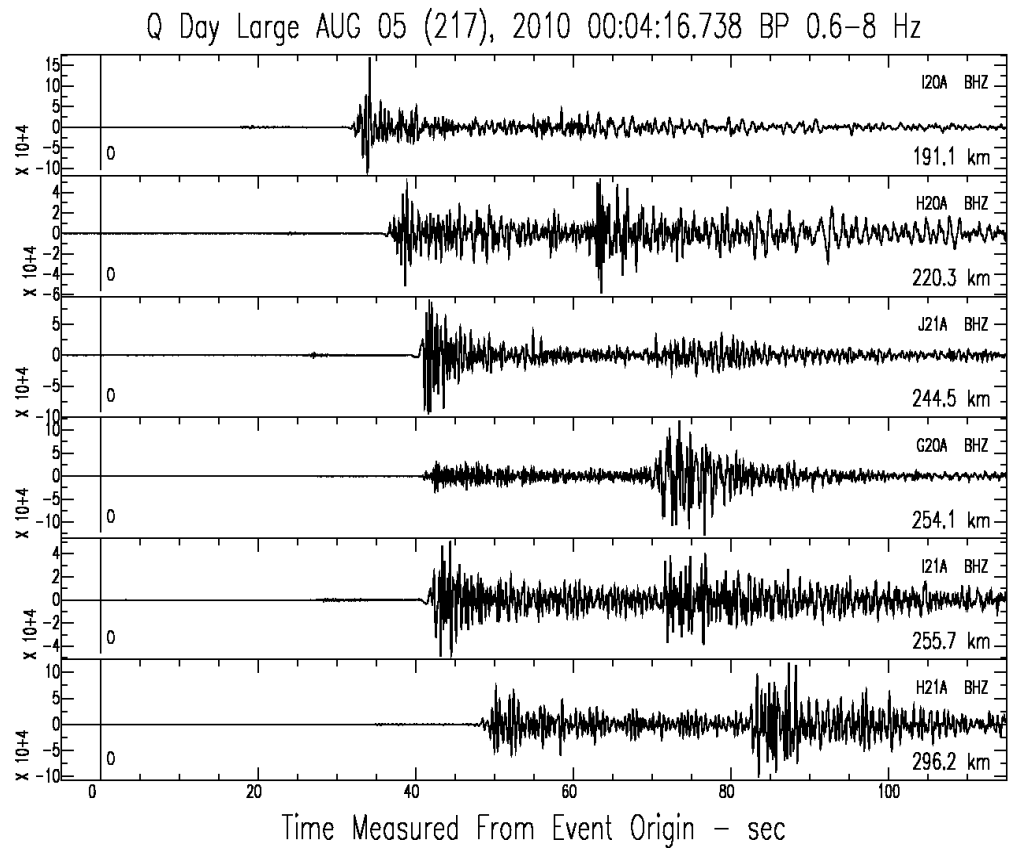
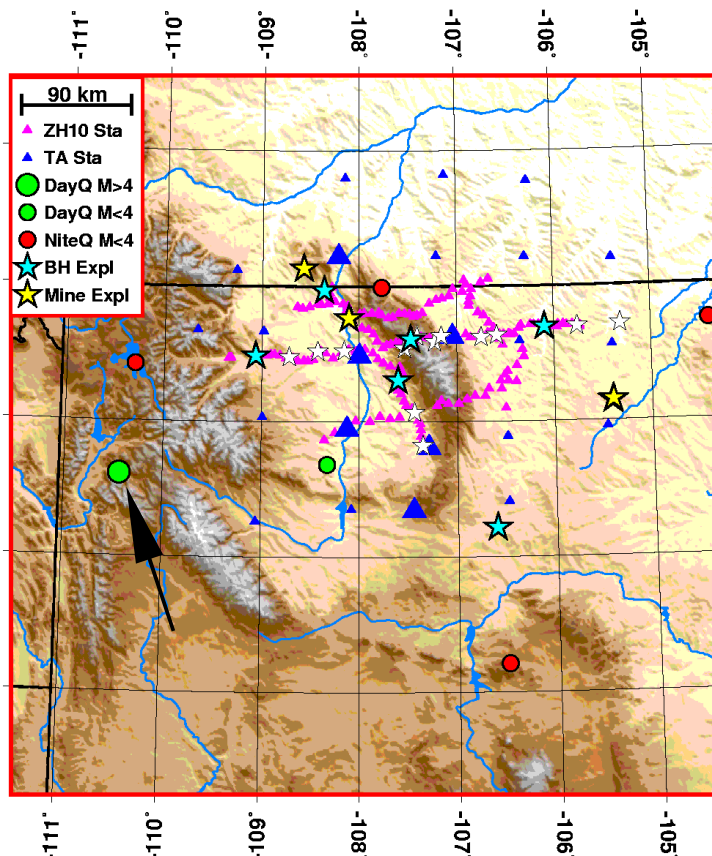


- All events from local daytime (yellow)
- Near BigH SP 208
- Quarry on Google Earth
- Limestone mining company mentioned on Web for this location

Sample Waves – Large Day Quake



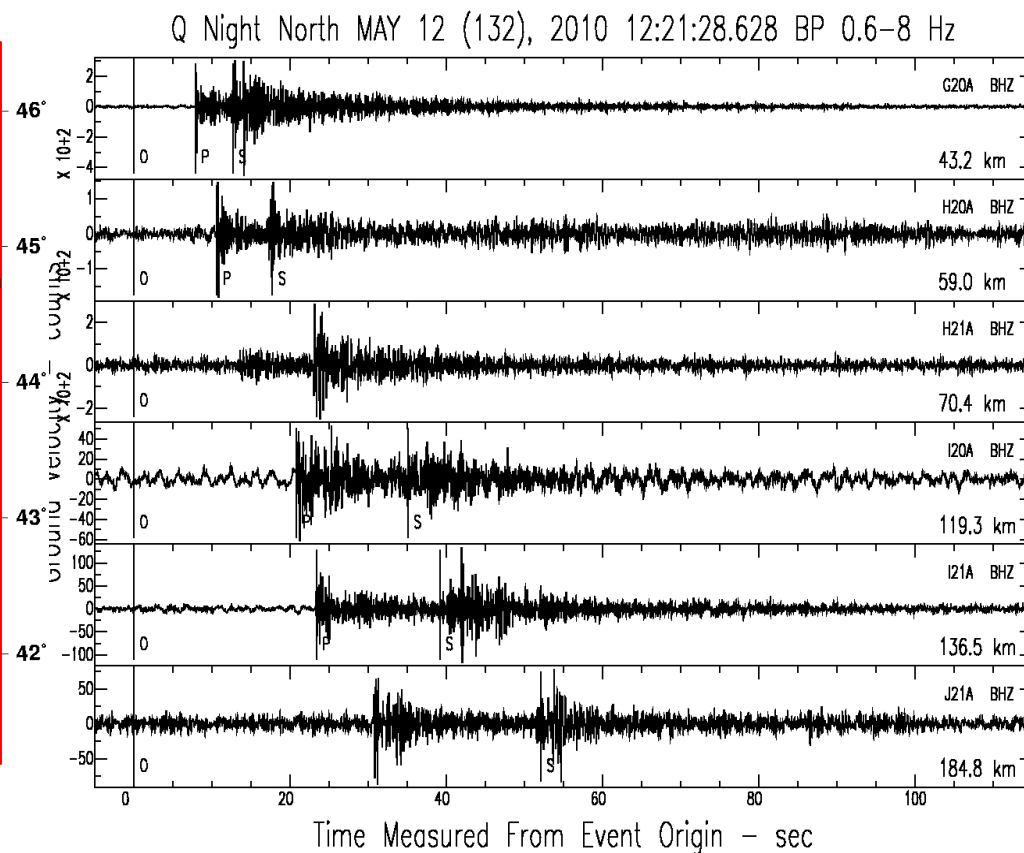
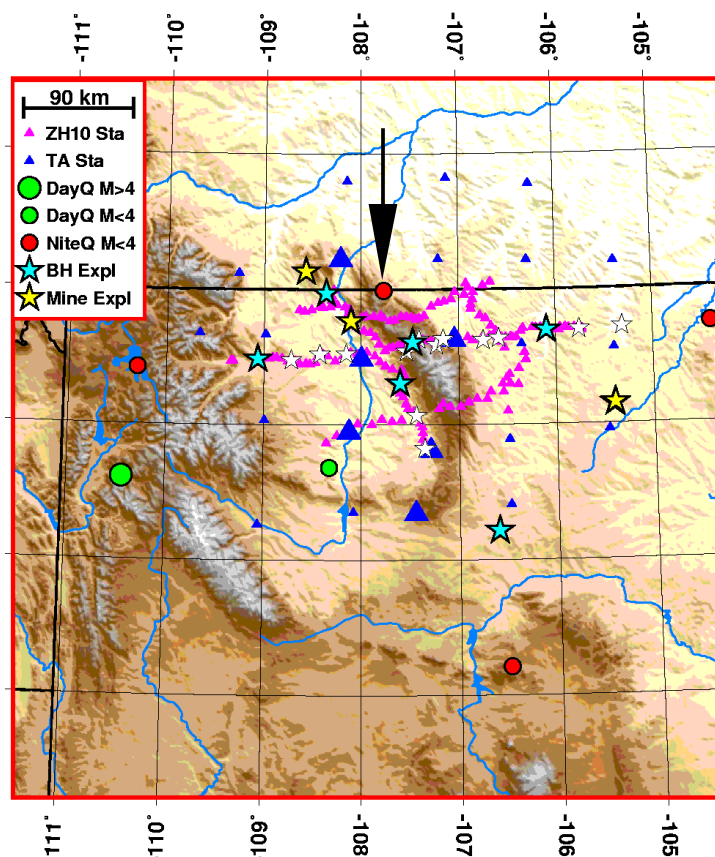
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Sample Waves – Night Quake North



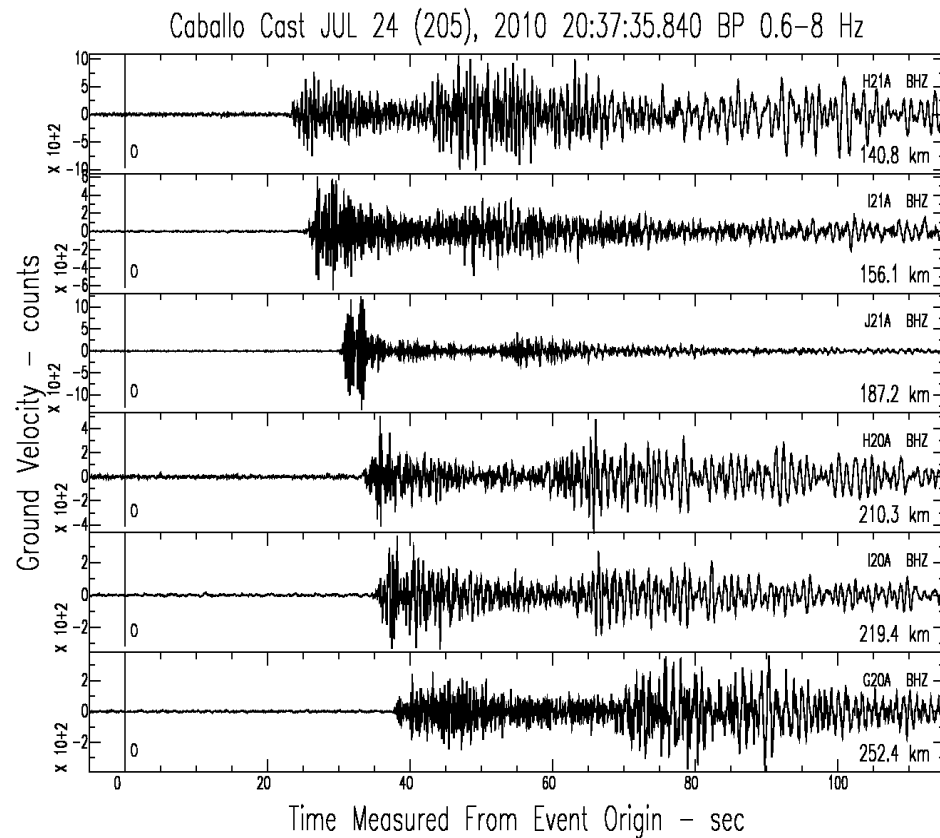
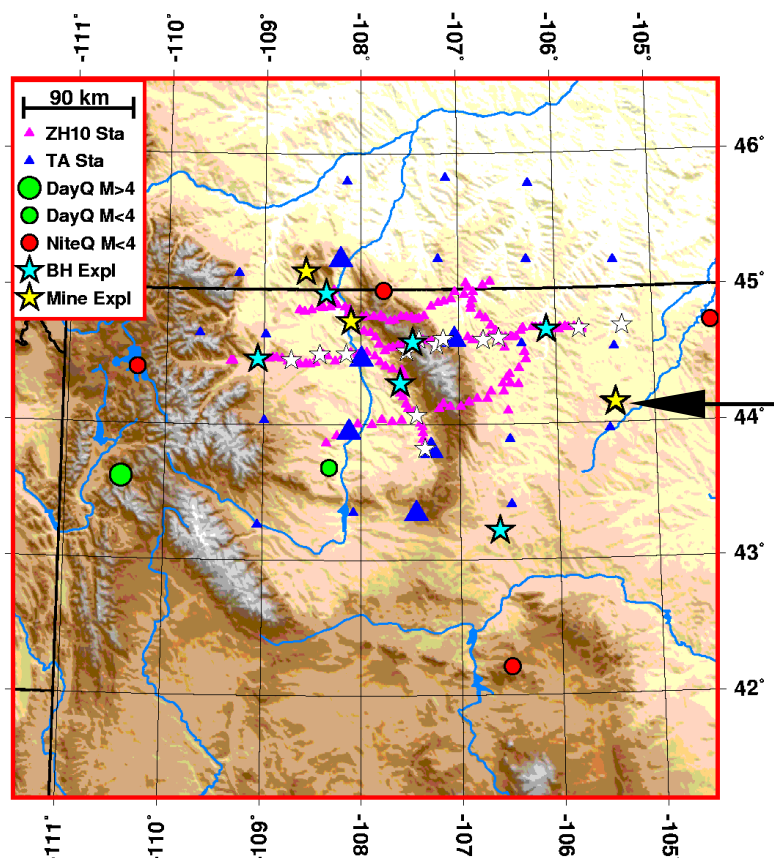
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Sample Waves – Caballo Cast Blast



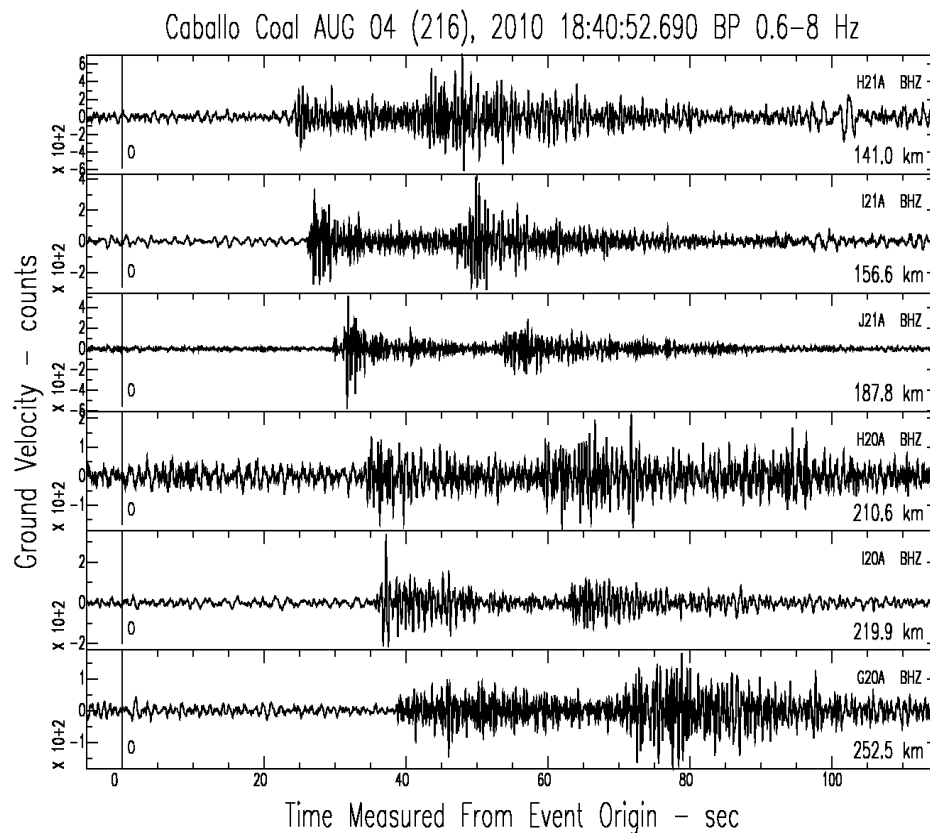
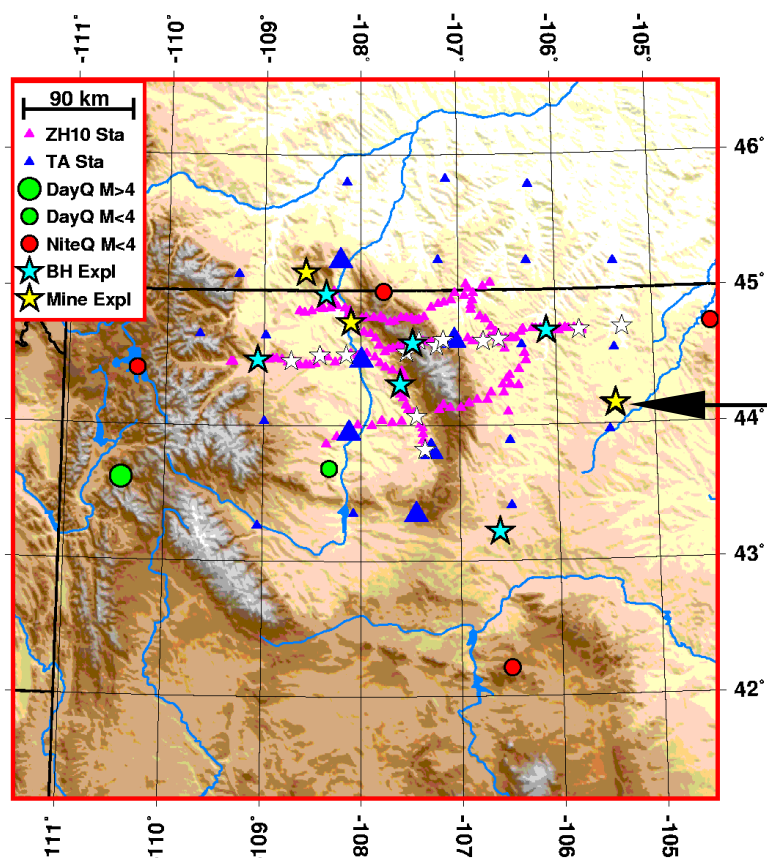
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Sample Waves – Caballo Coal Shot



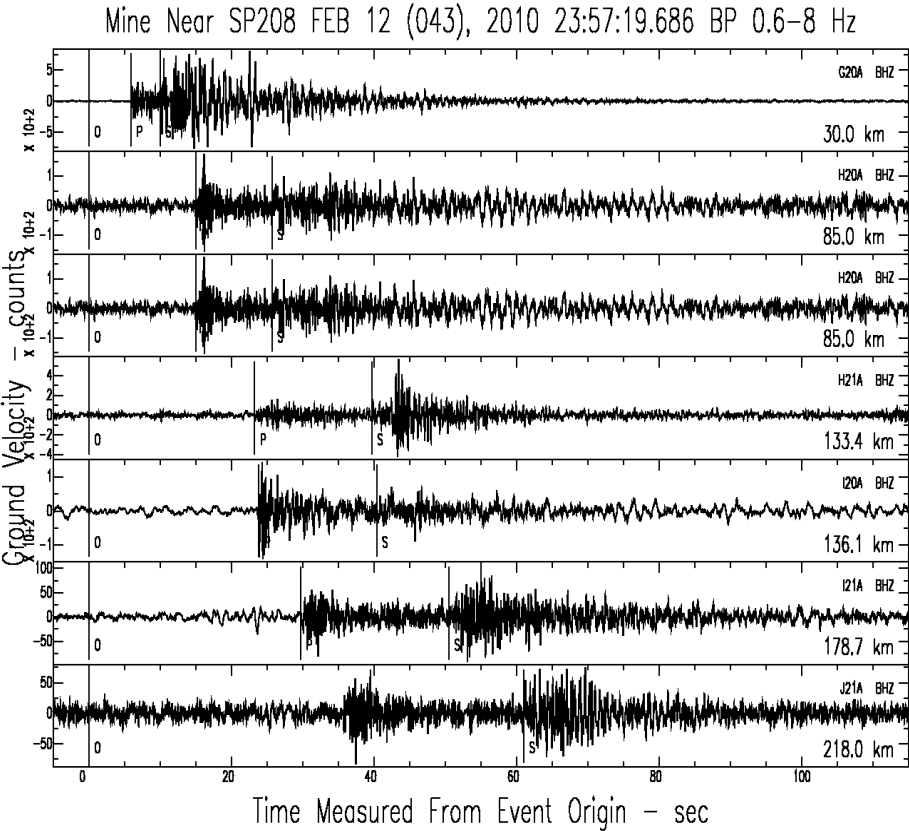
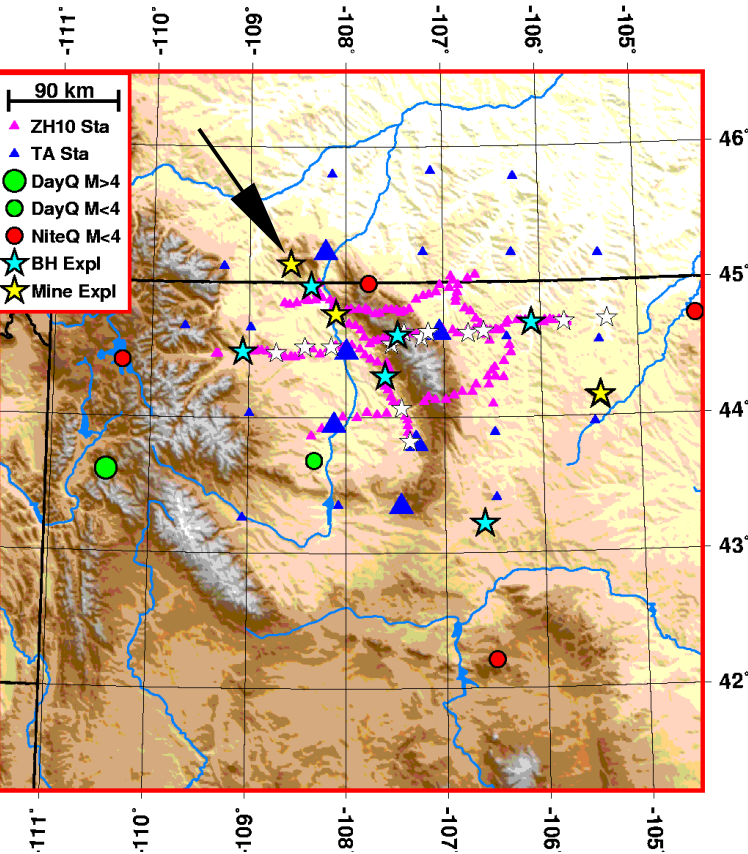
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Sample Waves – Limestone Quarry



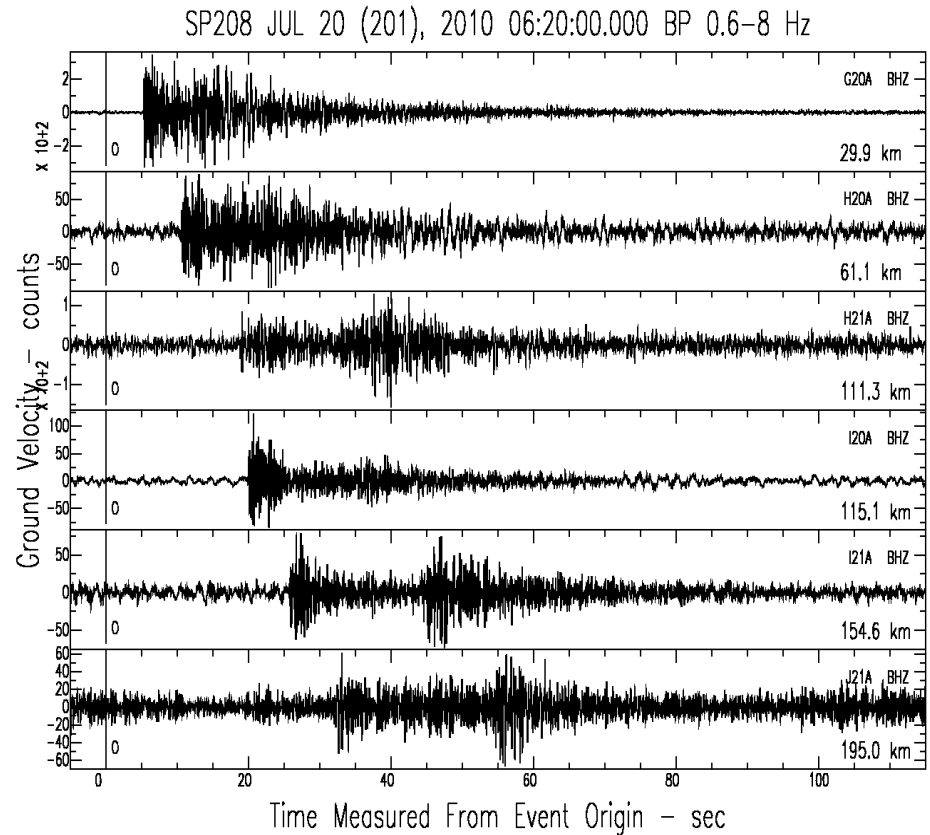
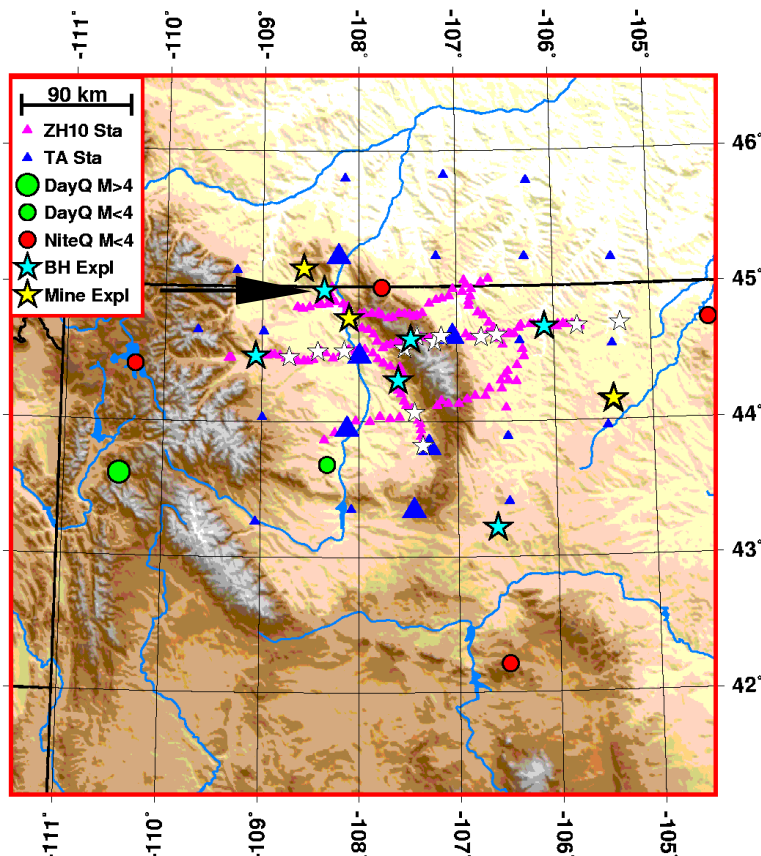
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Sample Waves – Big SP 208: 1 ton



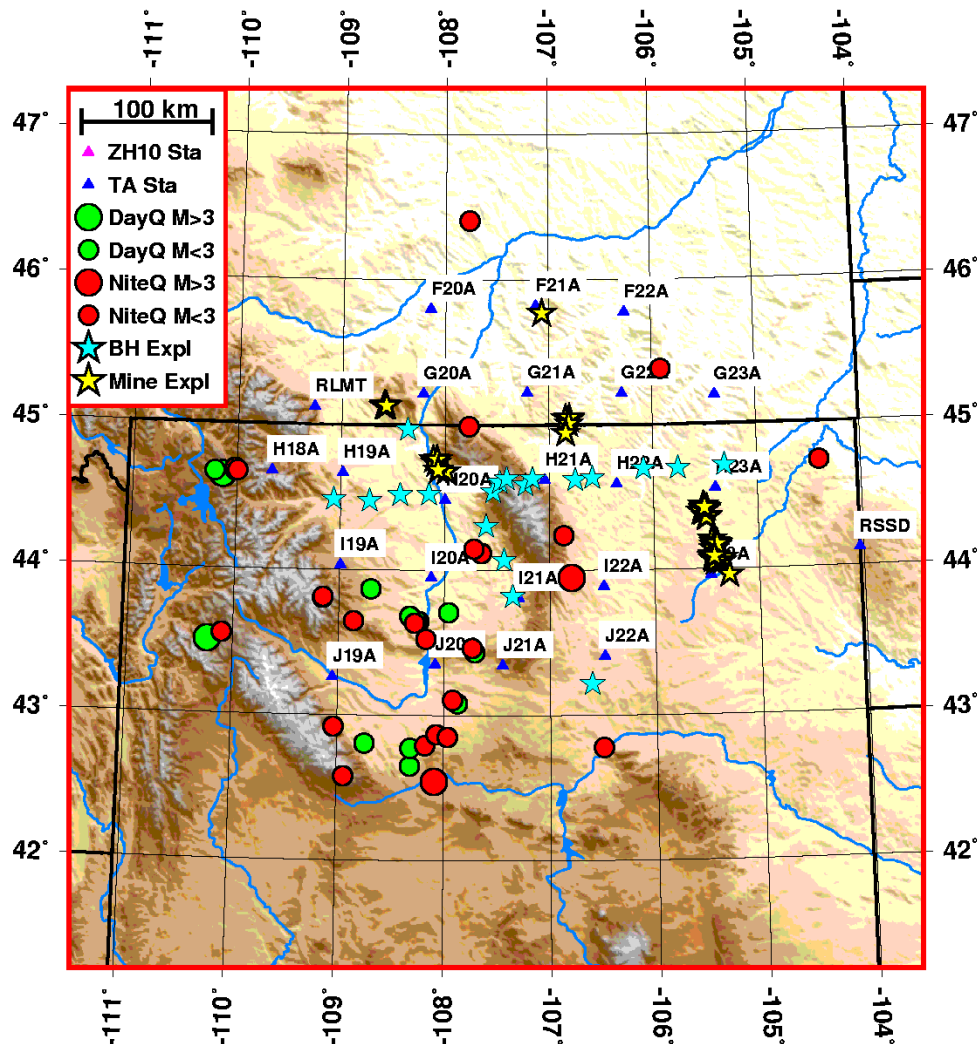
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Close-in Map Showing Events Used for Discrimination



Ground-Based Nuclear Explosion Monitoring R&D



Labeled stations – 200808 to 201009

13 day quakes and 27 night quakes – 20 km to 500 km and mag 1.4 to 4.0

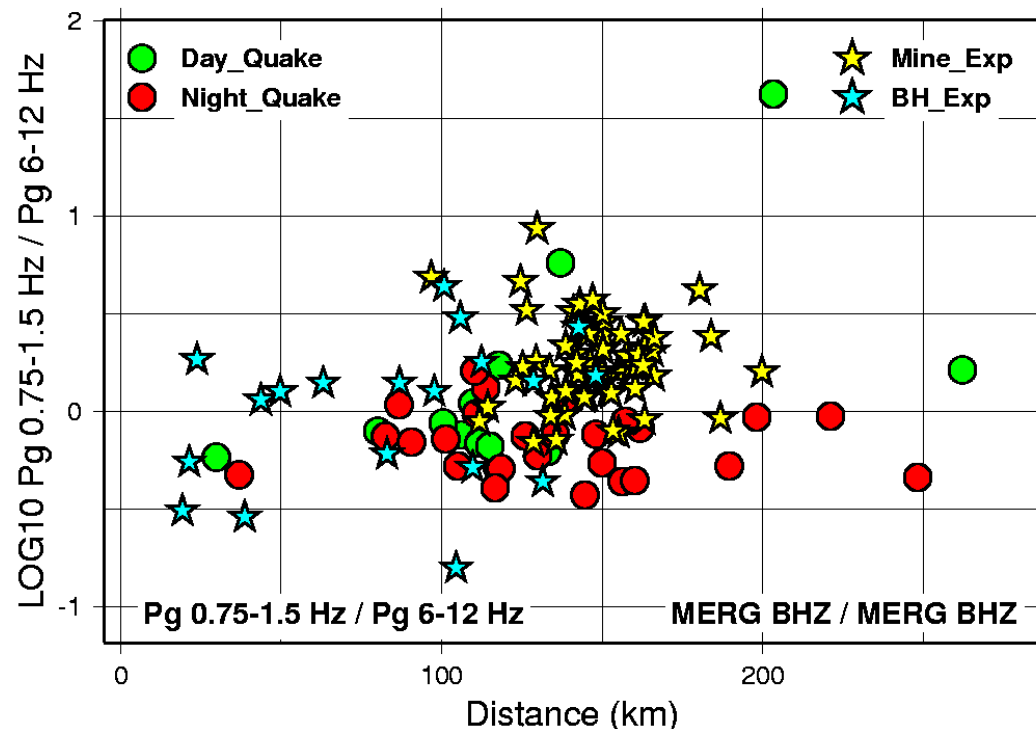
60 mining explosions from GT gathered by collaborators

23 Bighorns explosions – 201007 and 201008 – from 0.25 tons to 1 ton

Discrimination: Pg Spectral Ratio



Ground-Based Nuclear Explosion Monitoring R&D

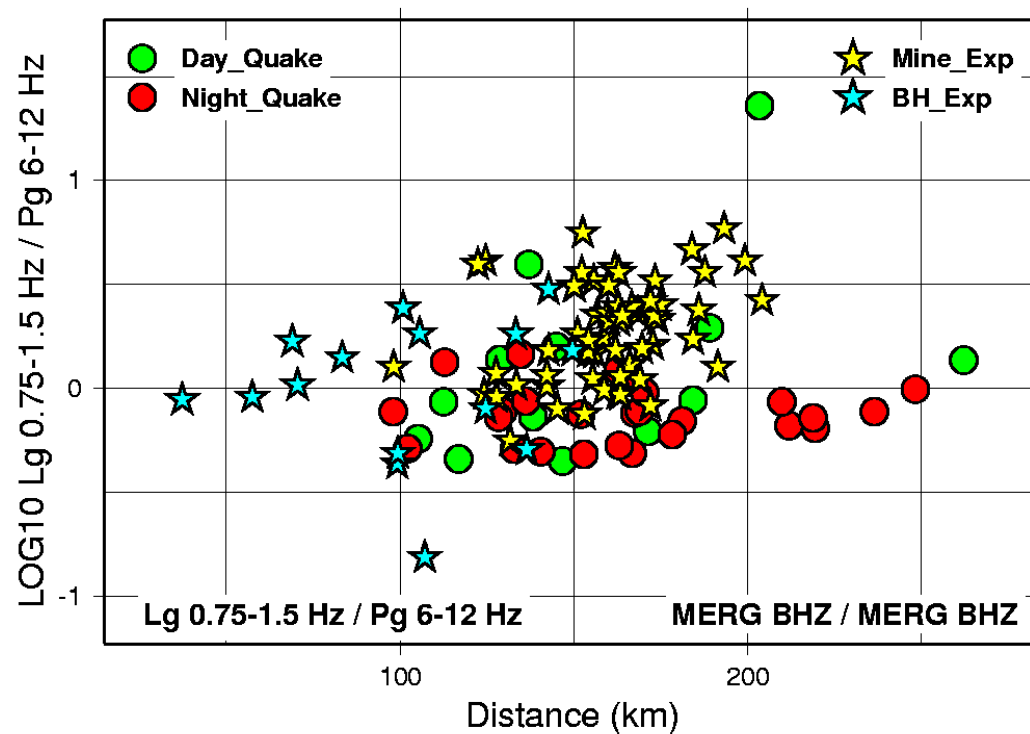


- **Ratio vs Distance Plot**
- **20 USArray stations measured, ratios distance corrected, and averaged**
- **More overlap between event types compared to Lg spectral ratio**

Discrimination: Lg/Pg Cross-Spectral Ratio



Ground-Based Nuclear Explosion Monitoring R&D

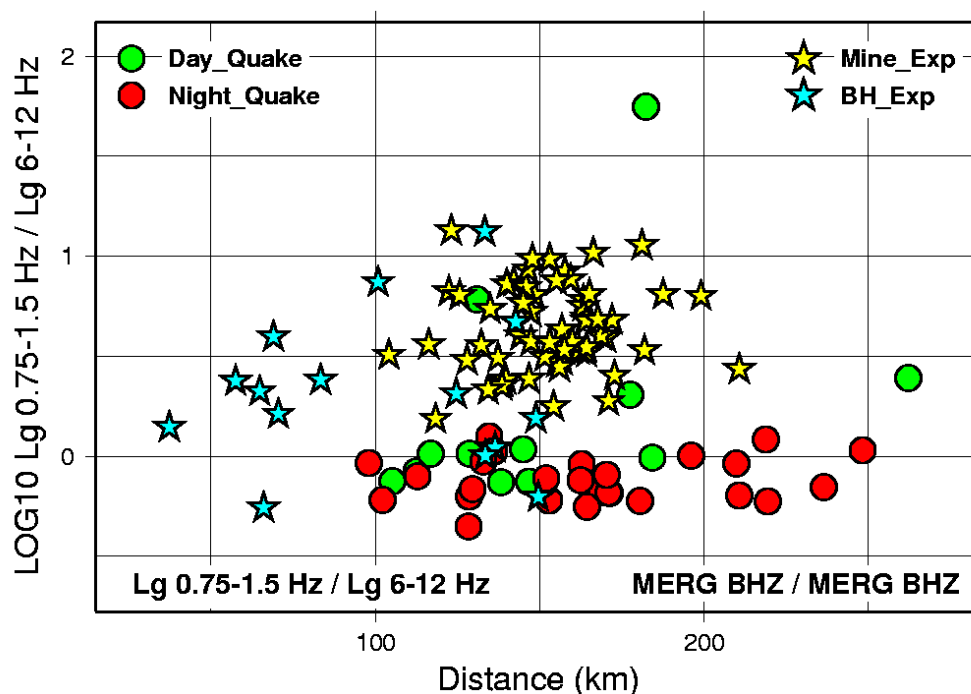


- **Ratio vs Distance Plot**
- **20 USArray stations measured, ratios distance corrected, and averaged**
- **More overlap between event types compared to Lg spectral ratio**

Discrimination: Lg Spectral Ratio



Ground-Based Nuclear Explosion Monitoring R&D



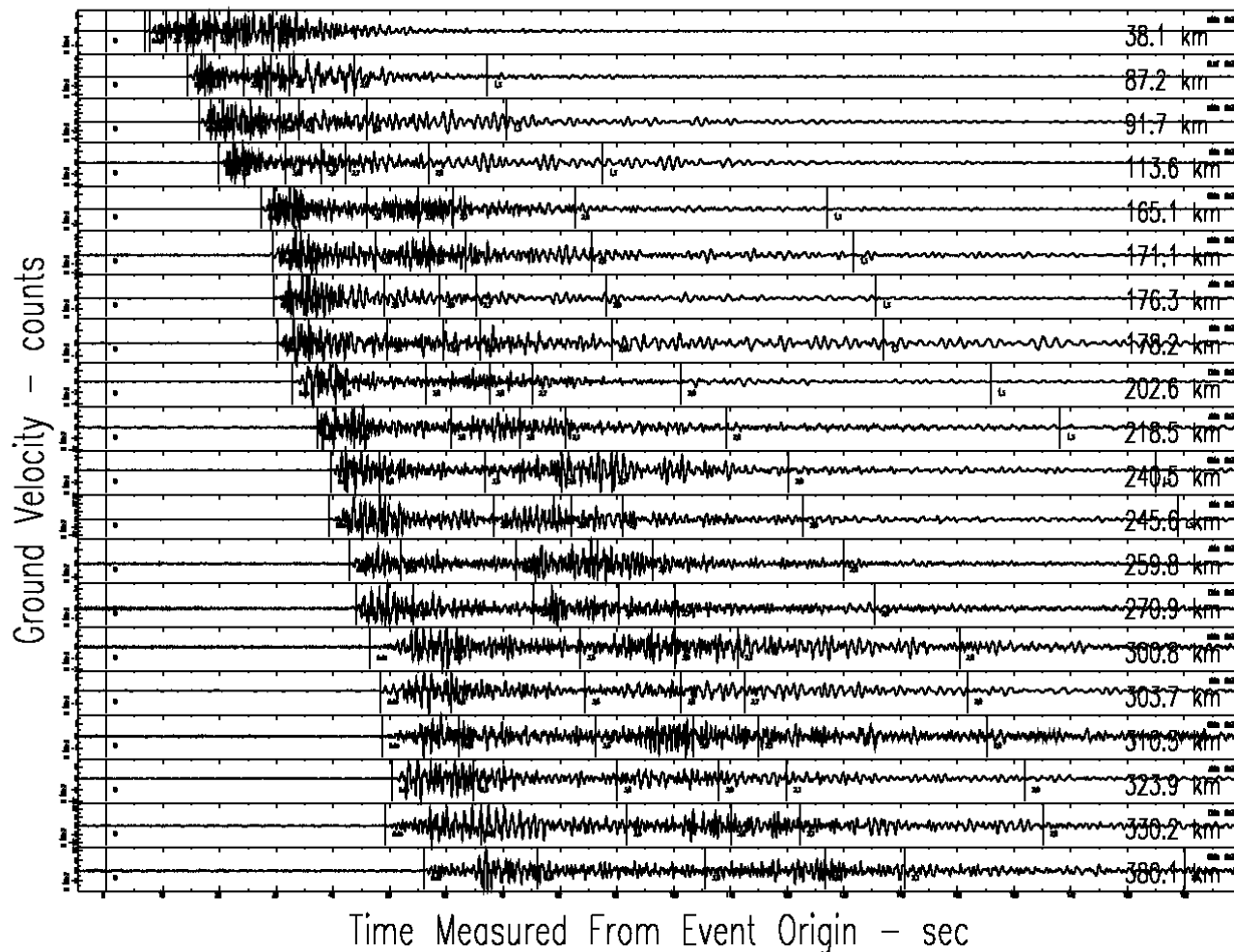
- **Ratio vs Distance Plot**
- **20 USArray stations measured, ratios distance corrected, and averaged**
- **About 4 BigH explosions mixed with quakes**
- **About 3 day quakes mixed with explosions**

Discrimination: Low Freq Quake From Yellowstone - Shallow?



Ground-Based Nuclear Explosion Monitoring R&D

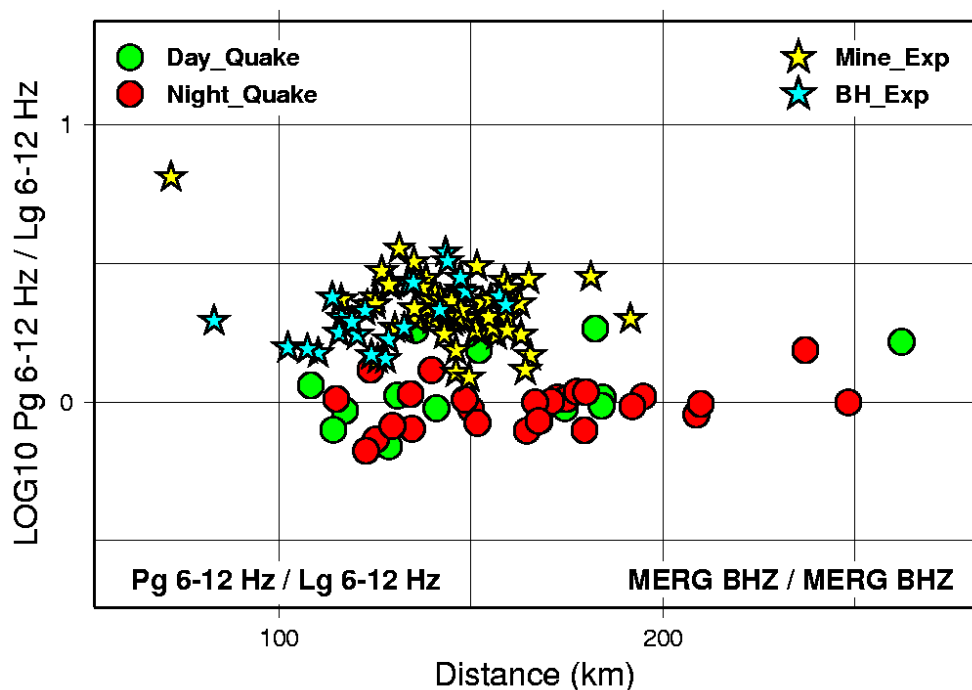
Day Time 2 JAN 09 (009), 2009 18:17:32.914 BP 0.5-8 Hz



Discrimination: Pg/Lg (6-12 Hz) Ratio



Ground-Based Nuclear Explosion Monitoring R&D



- **Ratio vs Distance Plot**
- **20 USArray stations measured, ratios distance corrected, and averaged**
- **All BigH events move above most quakes**
- **Some magnitude trend possibly remains**
- **A few day quakes may be explosions?**

Summary



Ground-Based Nuclear Explosion Monitoring R&D

- **Preliminary results for discrimination – high frequency Pg/Lg ratio looks best**
- **23 single-charge explosions, 40 quakes, 60 mining explosions**
- **20 stations measured, many more available**
- **Near-regional to local distances**
- **Infrasonic data not yet examined**
- **Need seismic magnitudes for all events and attenuation model for full MDAC corrections**
- **Need to examine surface waves (including Rg) and coda amplitude ratios to test single-charge vs distributed explosions discrimination**