

Acoustic noise in deep ice and environmental conditions at the South Pole

Timo Karg

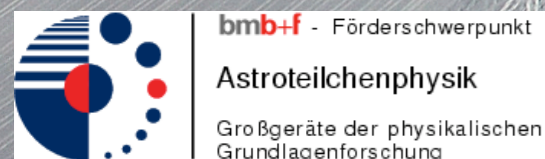
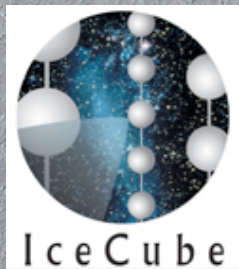
Bergische Universität Wuppertal

for the

IceCube Acoustic Neutrino Detection Working Group

ARENA 2008

25-27 June 2008 in Rome

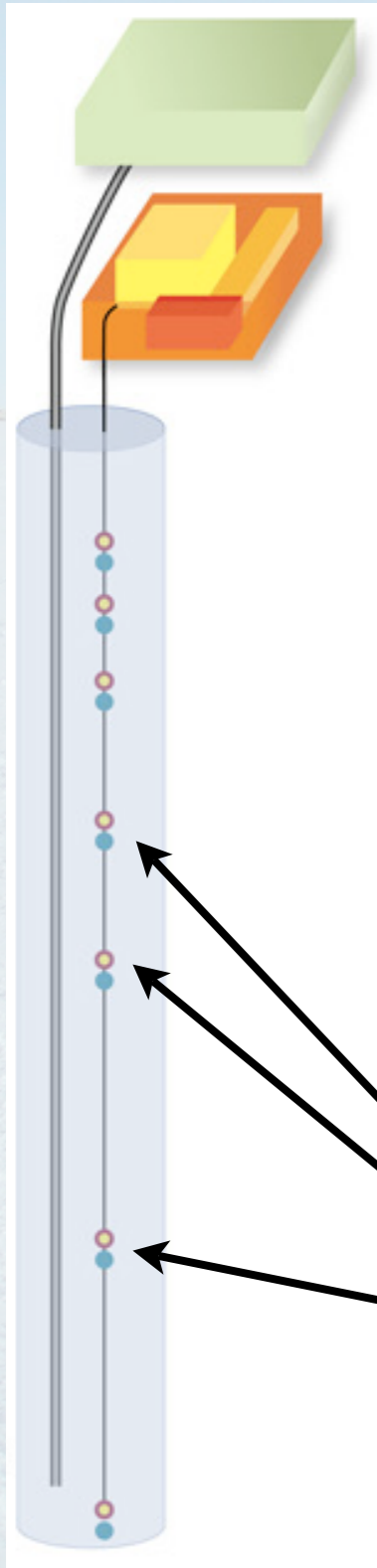


bmb+f - Förderschwerpunkt

Astroteilchenphysik

Großgeräte der physikalischen
Grundlagenforschung

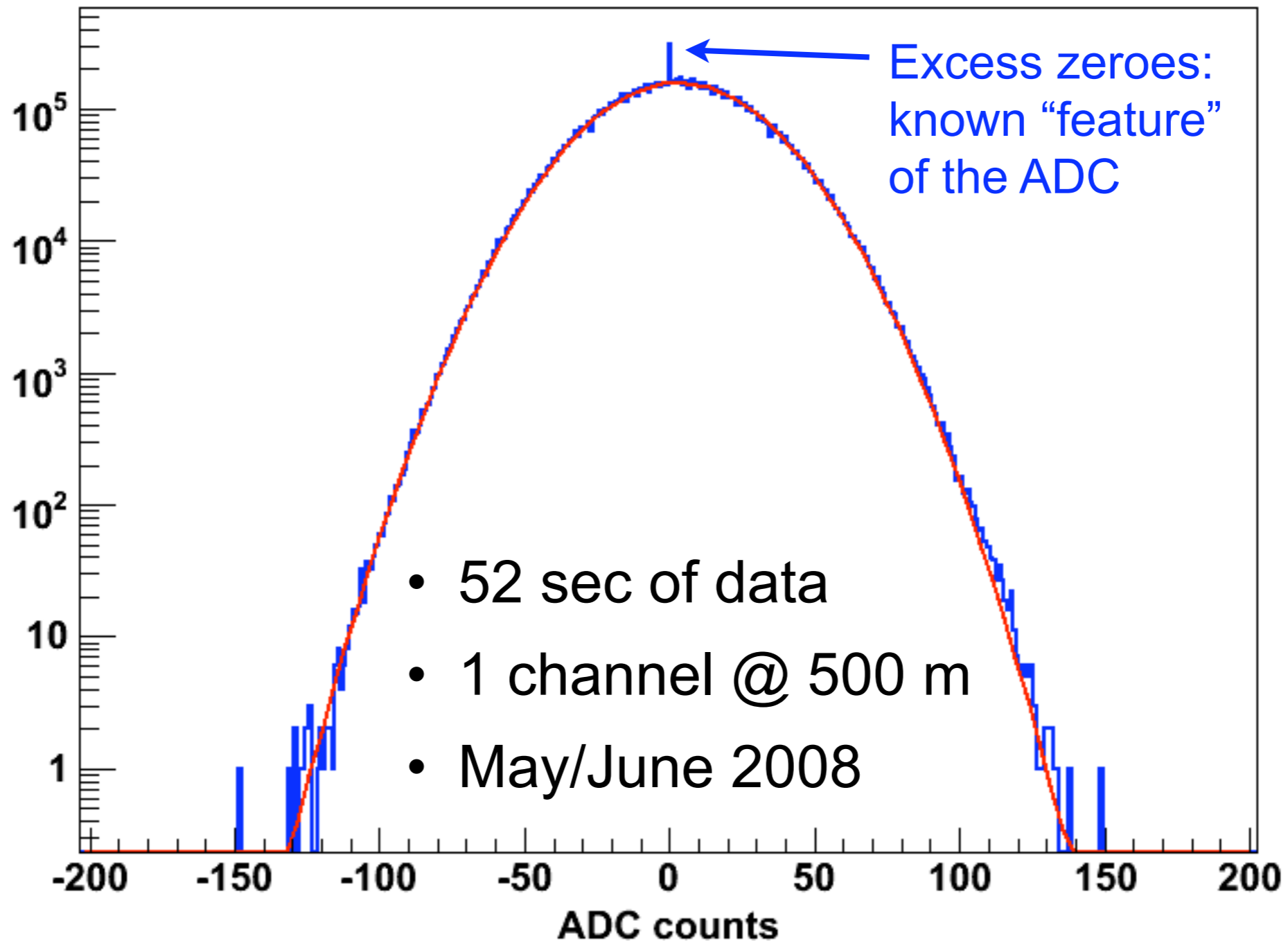
Noise measurement in SPATS



- Absolute level?
 - Temporal variation?
 - Transient rate / sources?
-
- Noise runs taken every hour
 - Unbiased monitoring
 - forced readout of all 3 channels of a sensor
 - sampling rate 200 kHz
 - loop over all sensors
 - Transient runs
 - 3 sensors per string (190 m, 250 m, 320 m)
 - threshold $\sim 4.8 \sigma$ (Noise RMS)
 - record 5 ms @ 200 kHz around every trigger

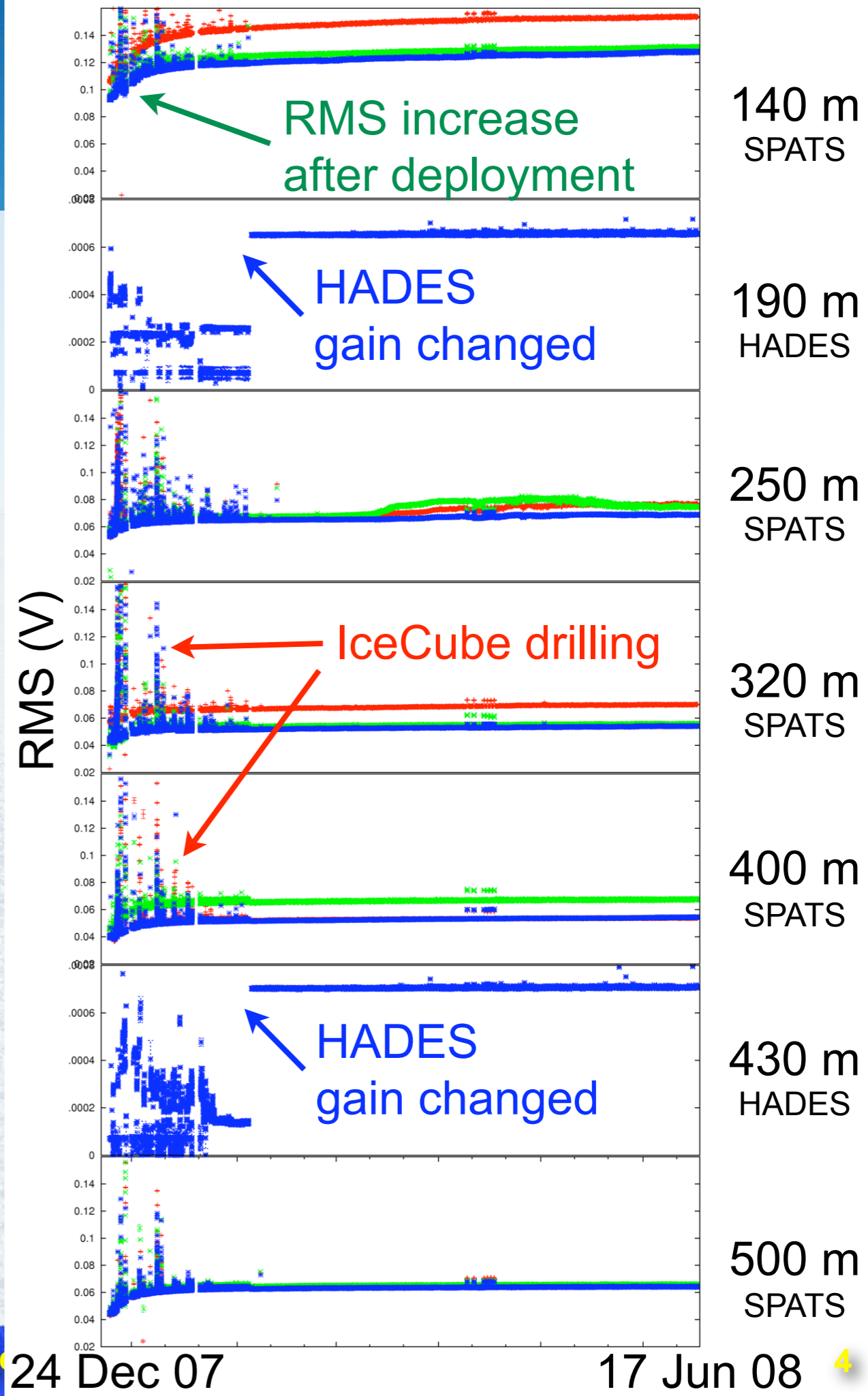
Noise is Gaussian

String D, Stage 7, Channel 2

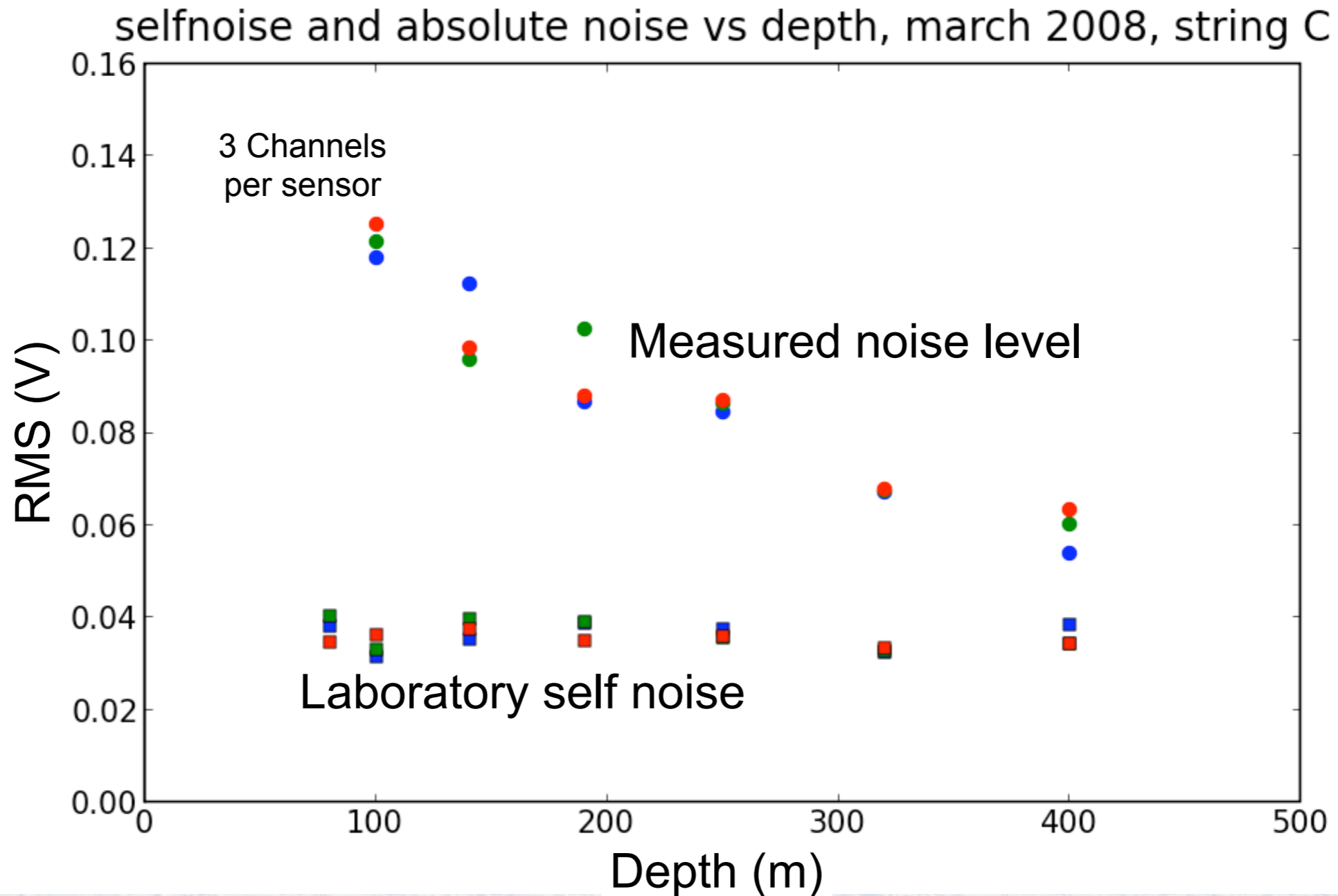


Temporal evolution

- String D: deployed 24 Dec 2007
- RMS very stable over time
 - large peaks correlated with IceCube drilling
- RMS increases during freeze-in
 - better coupling to bulk ice
 - increased sensitivity at low temperatures

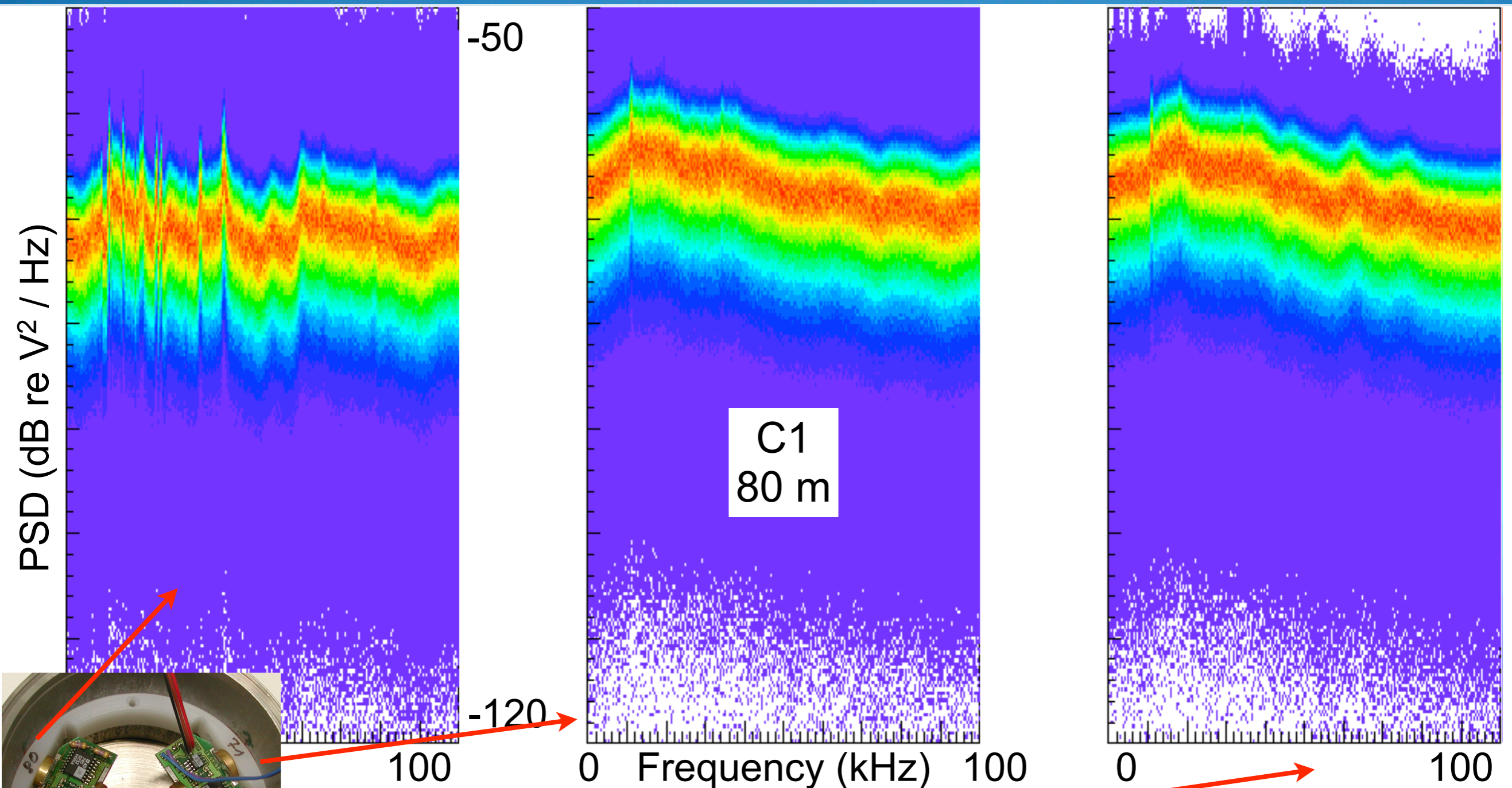


Evolution with depth

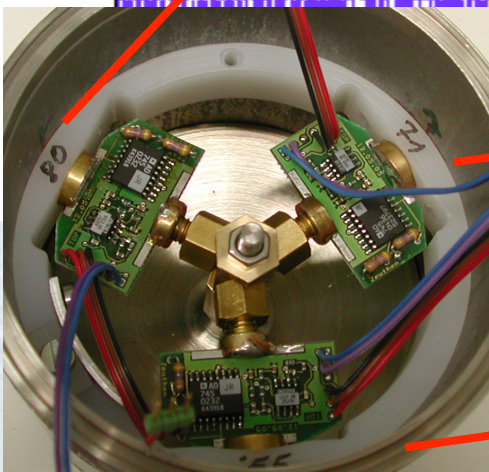


- SPATS self noise well below noise level
- Voltage noise level decreases with depth

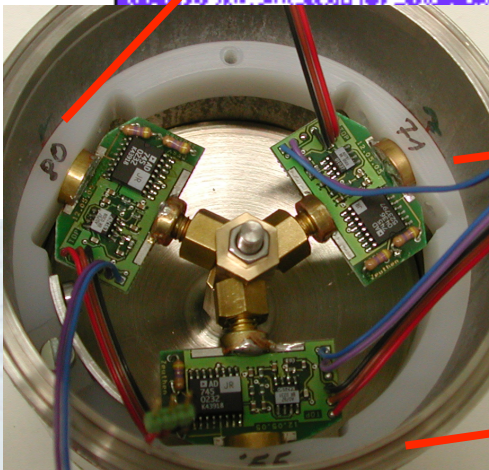
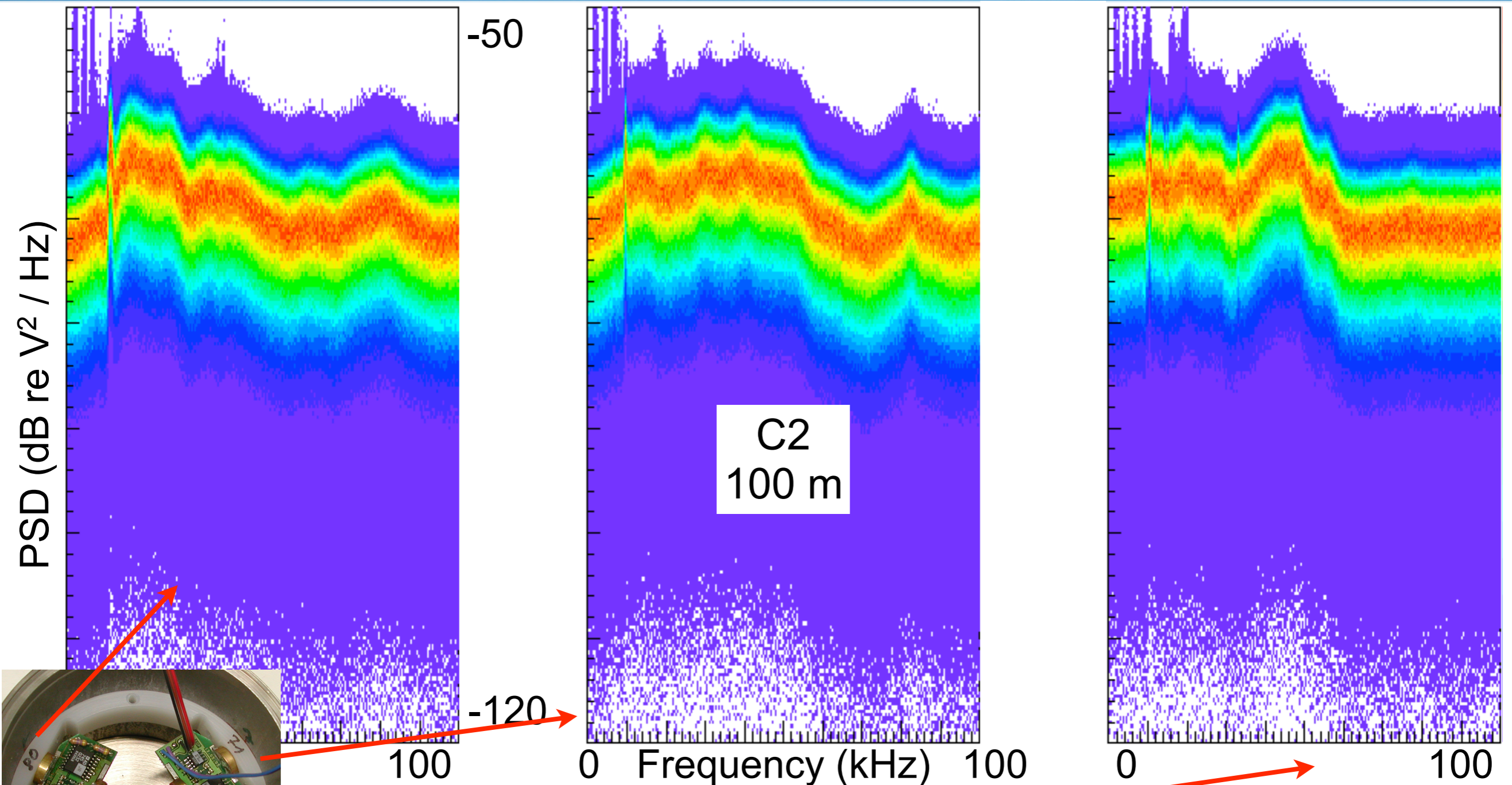
Power Spectral Density



- Data from Jan 08 to May 08
- Spectra differ strongly between sensors and channels

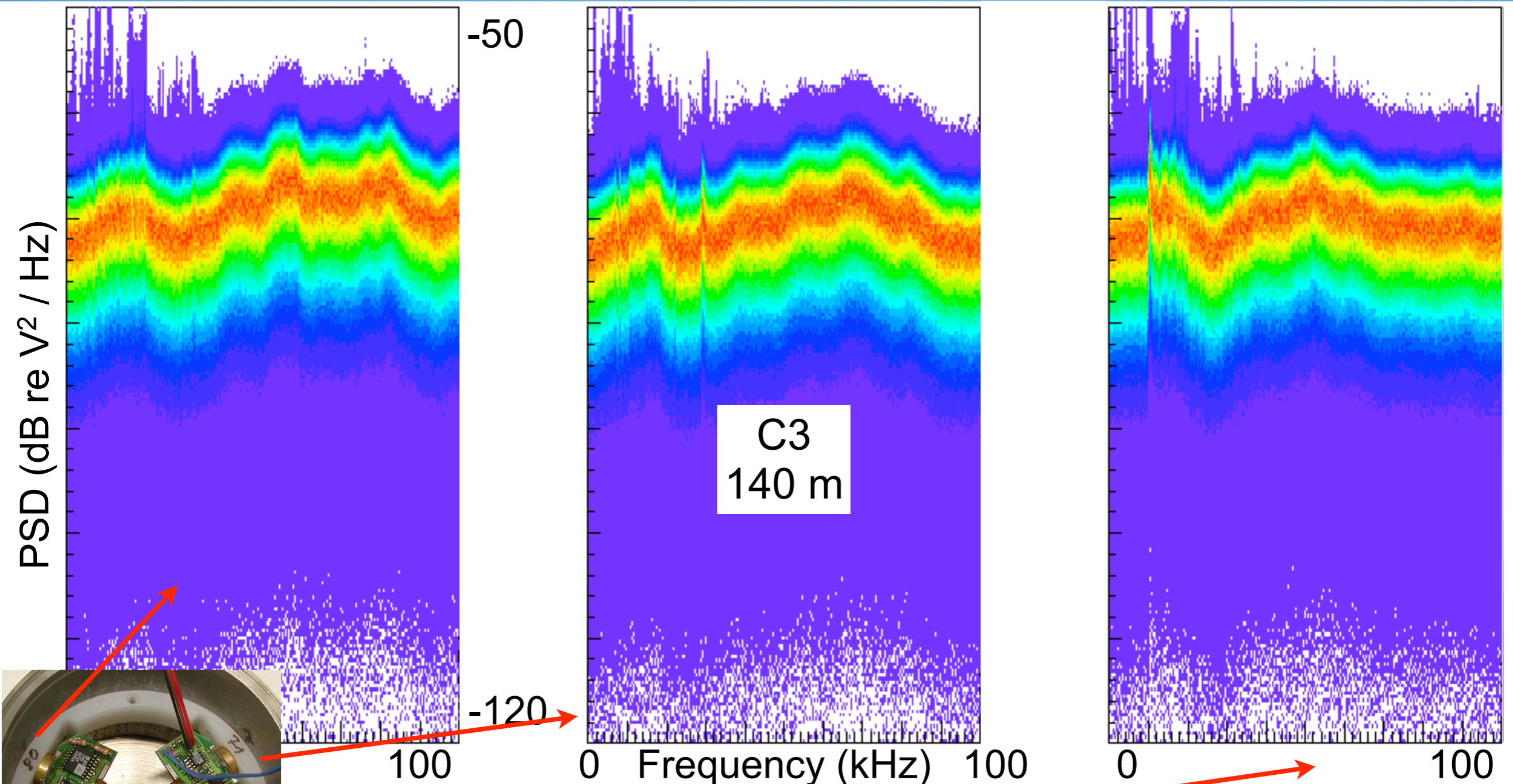


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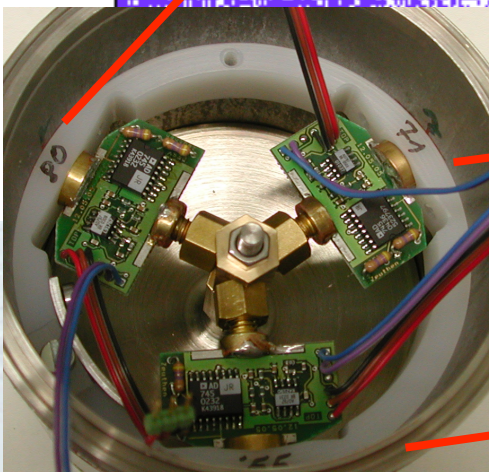


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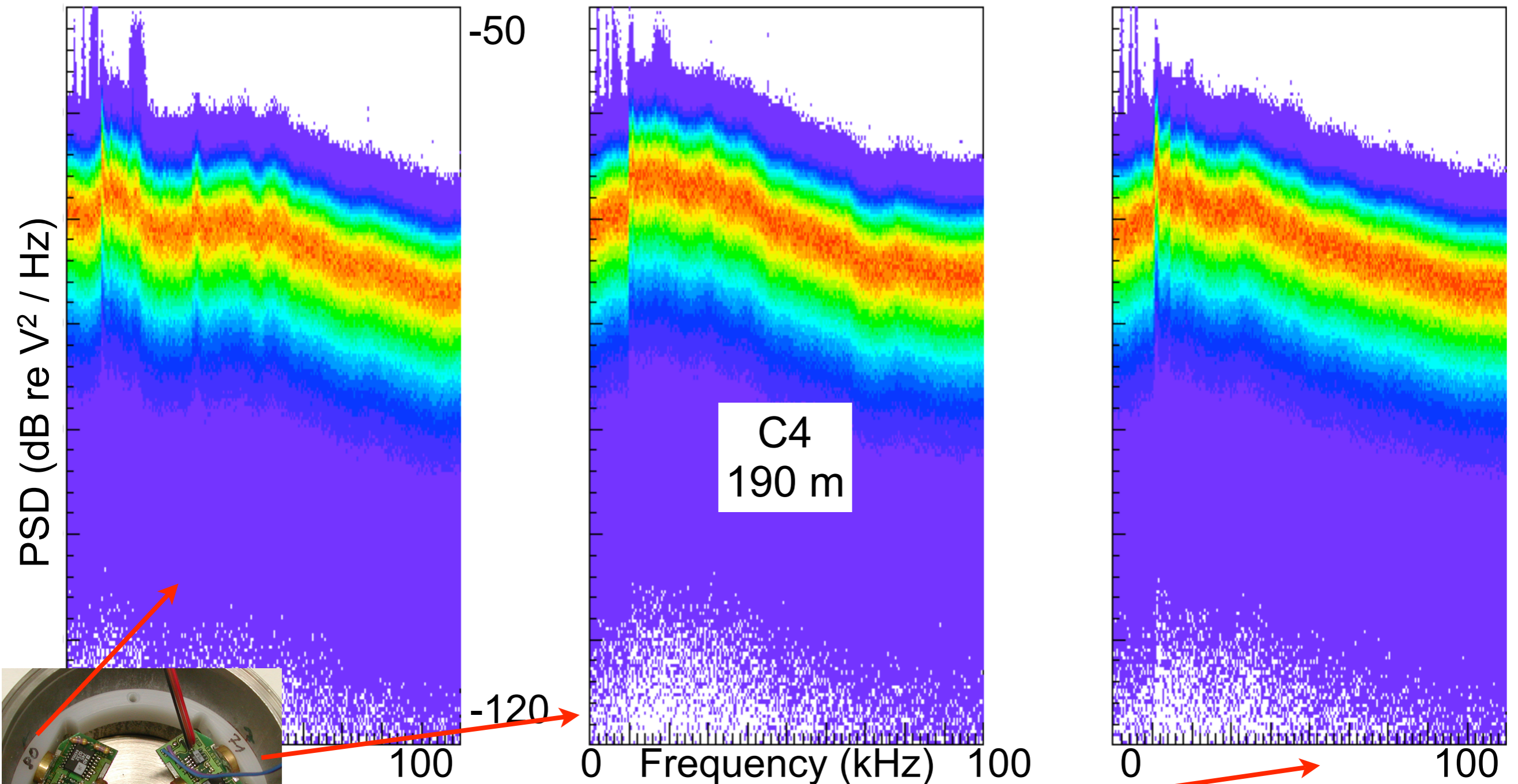
Power Spectral Density



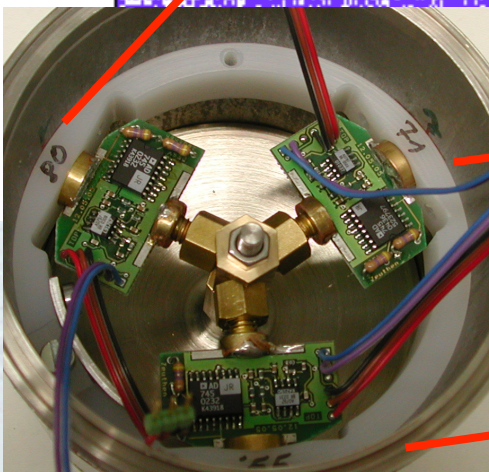
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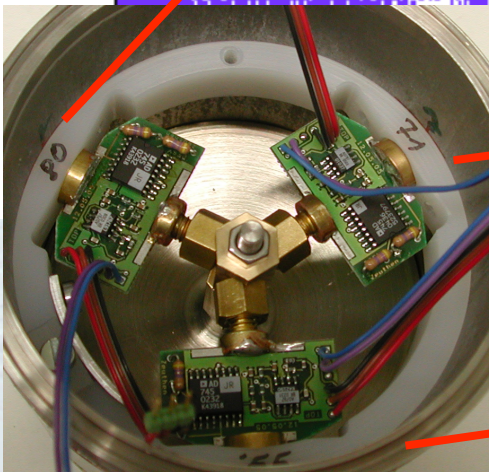
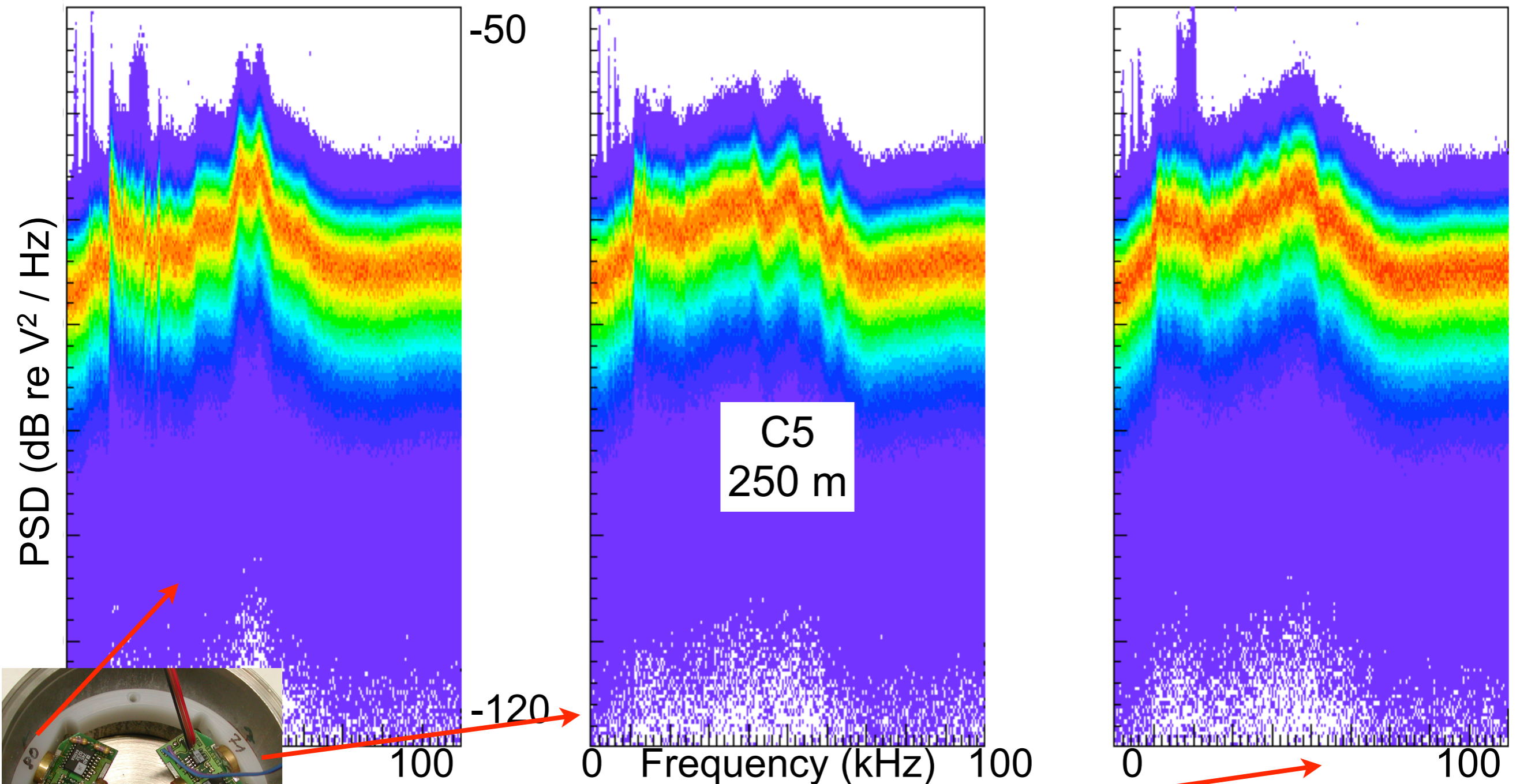
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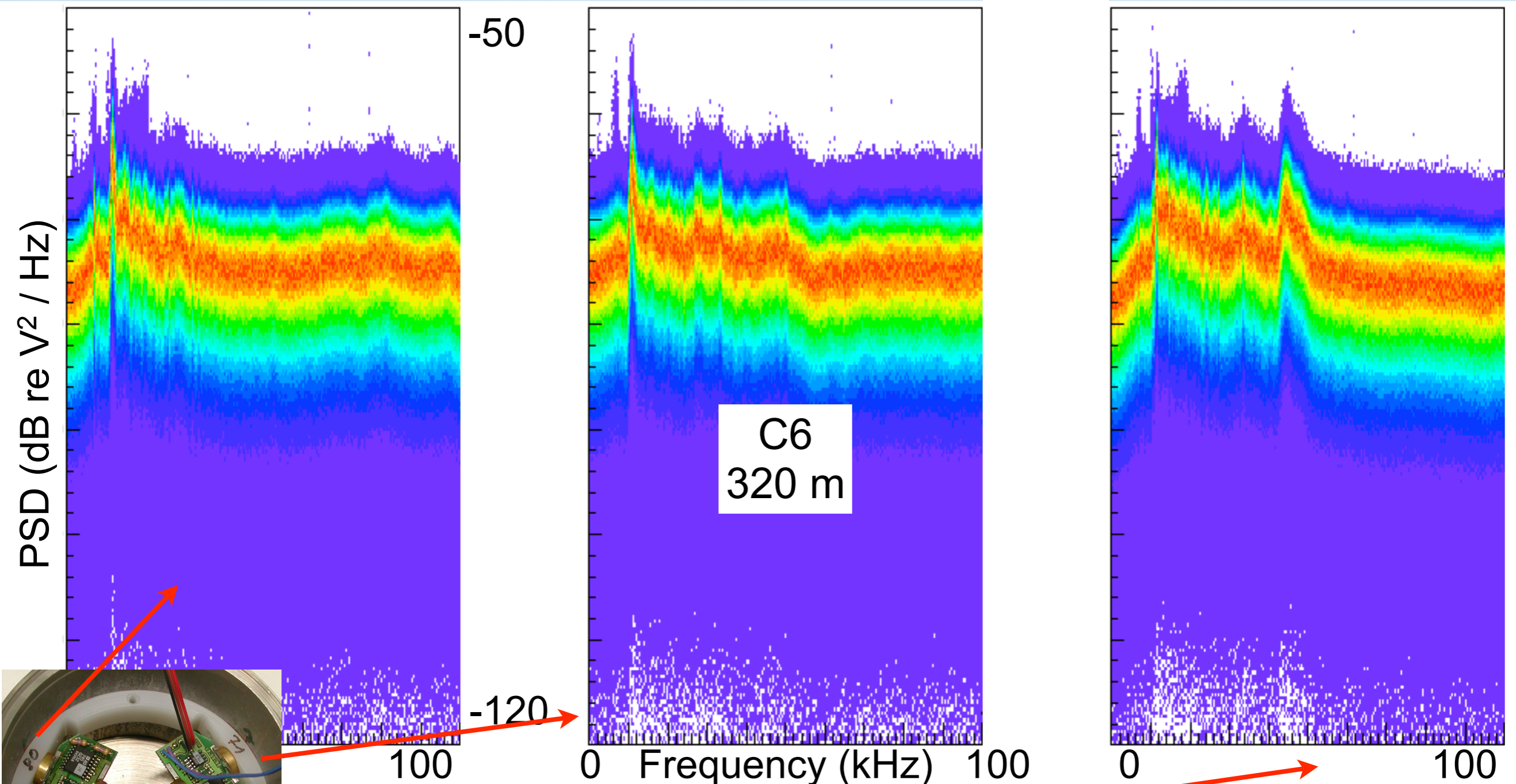


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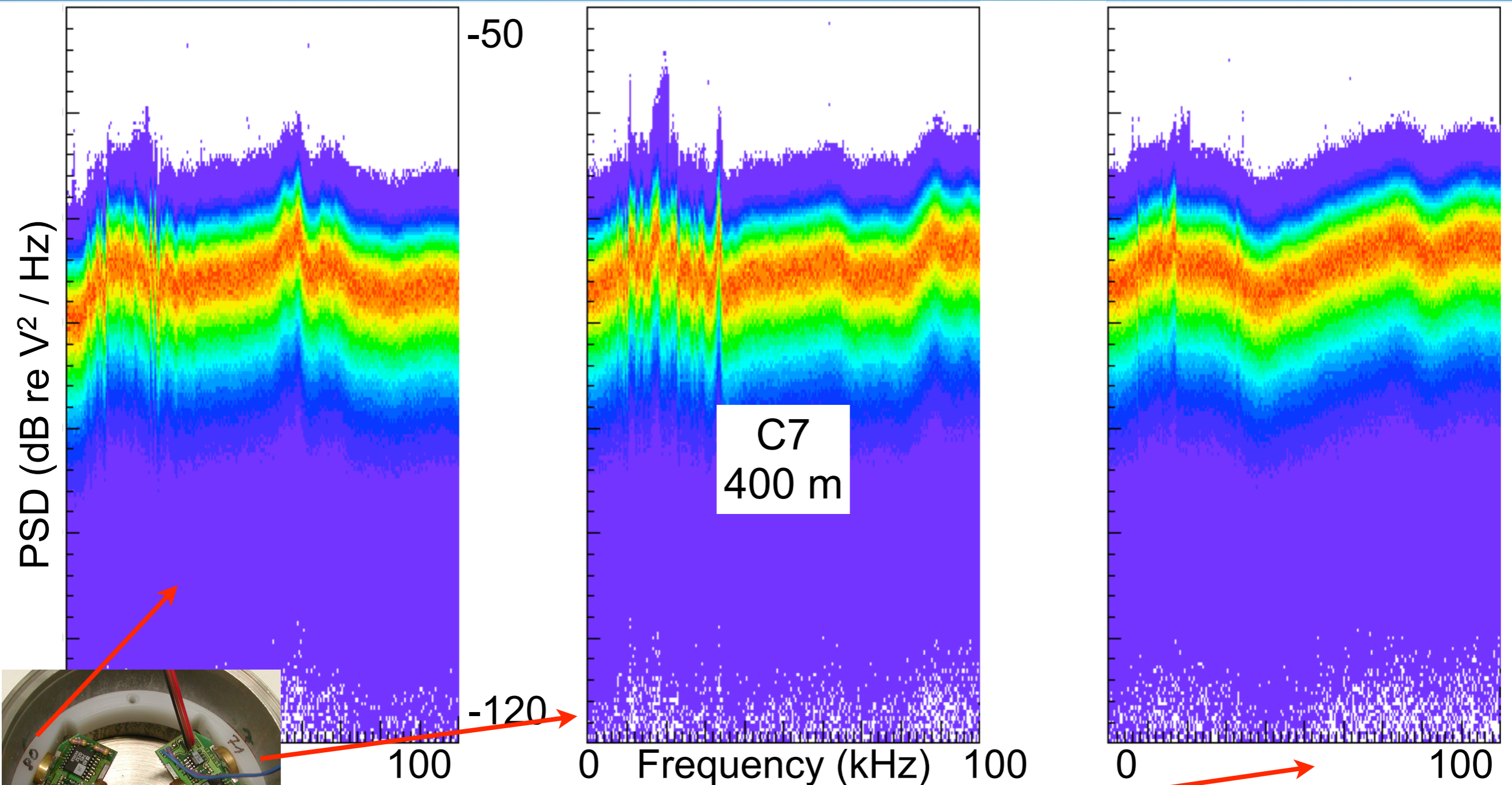
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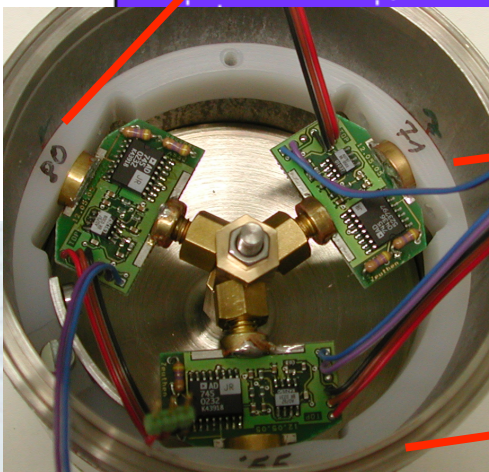


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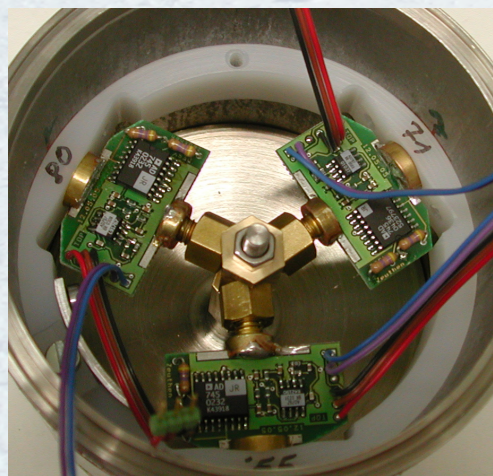
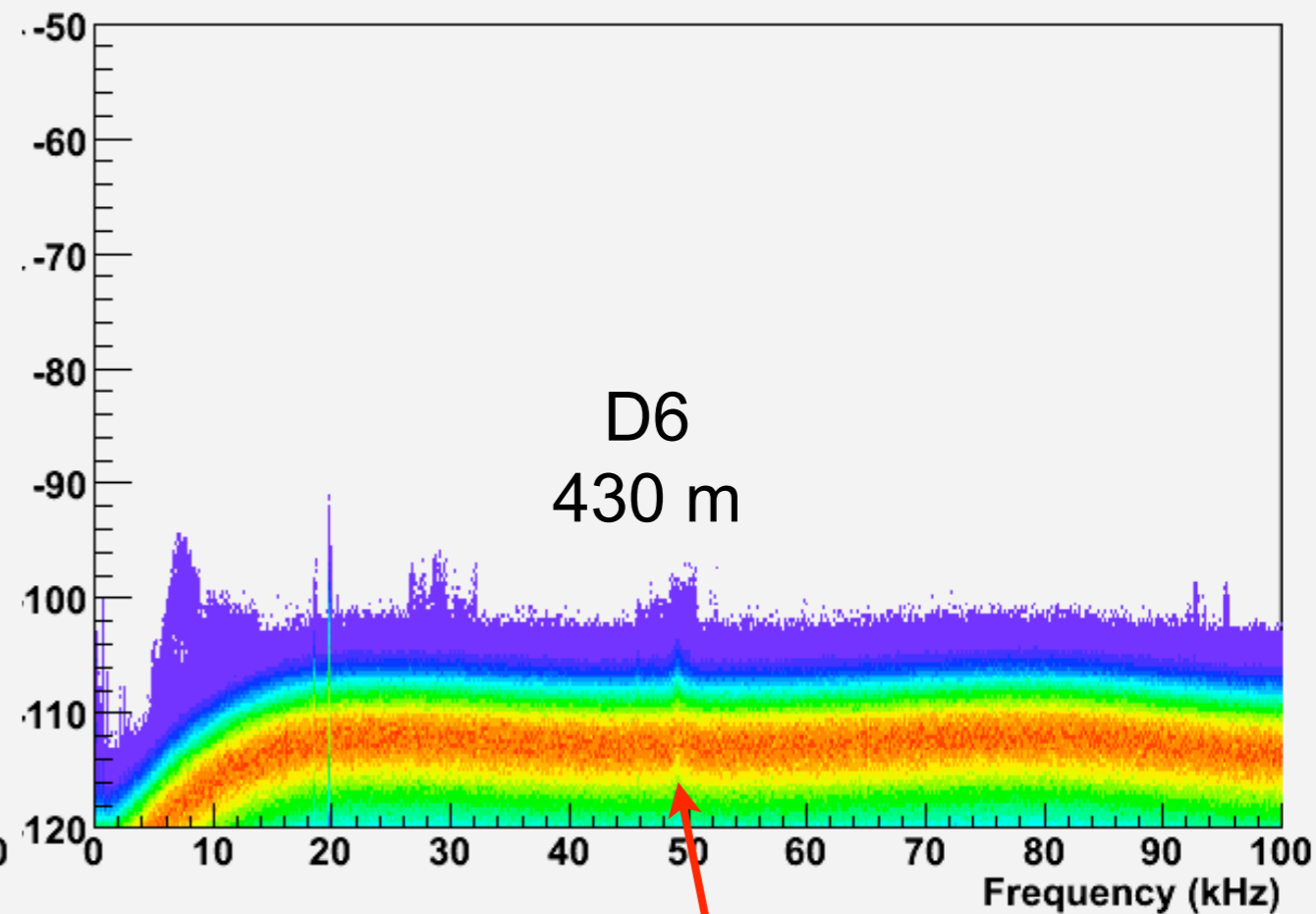
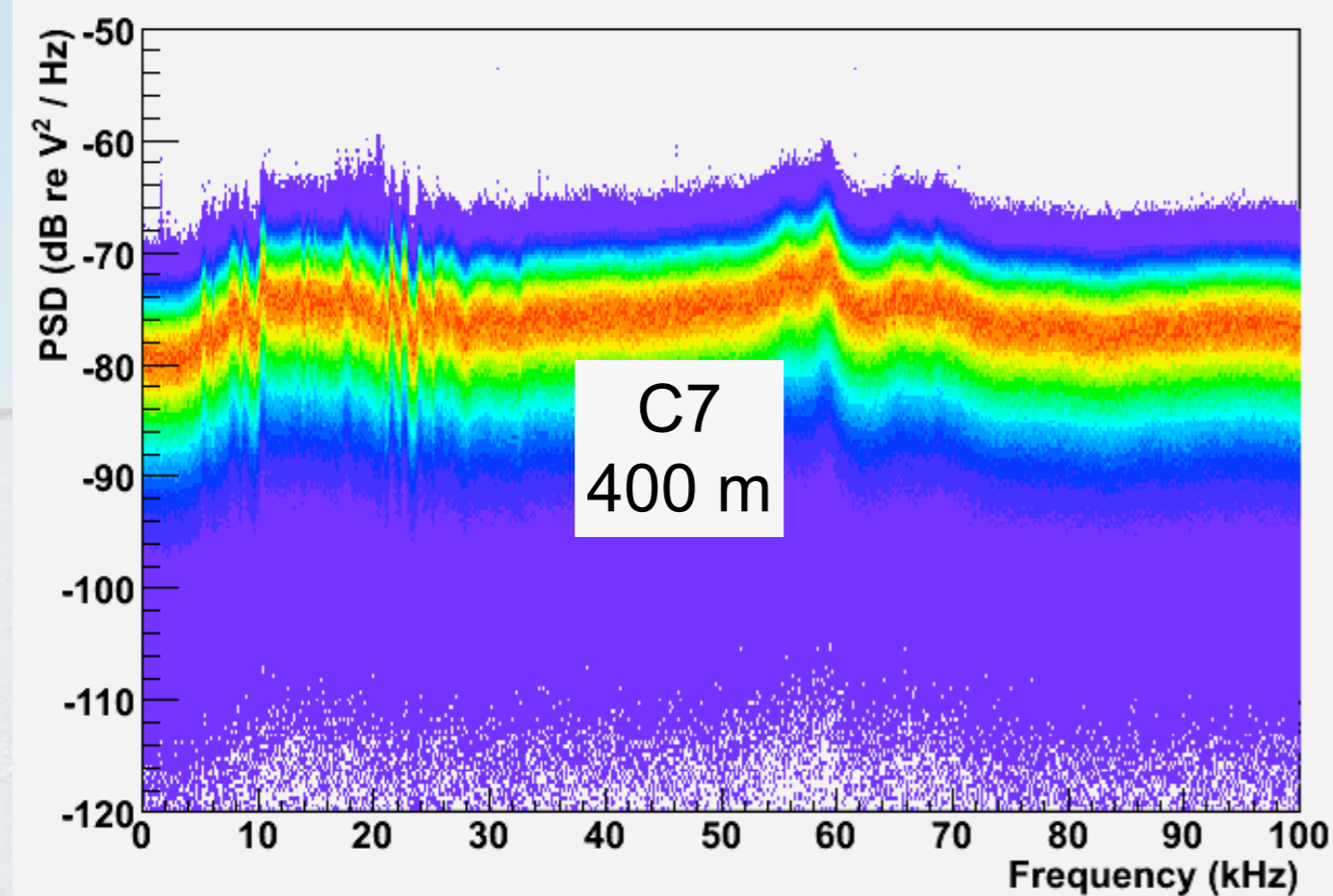
Power Spectral Density



- Data from Jan 08 to May 08
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Spectra dominated by sensor properties



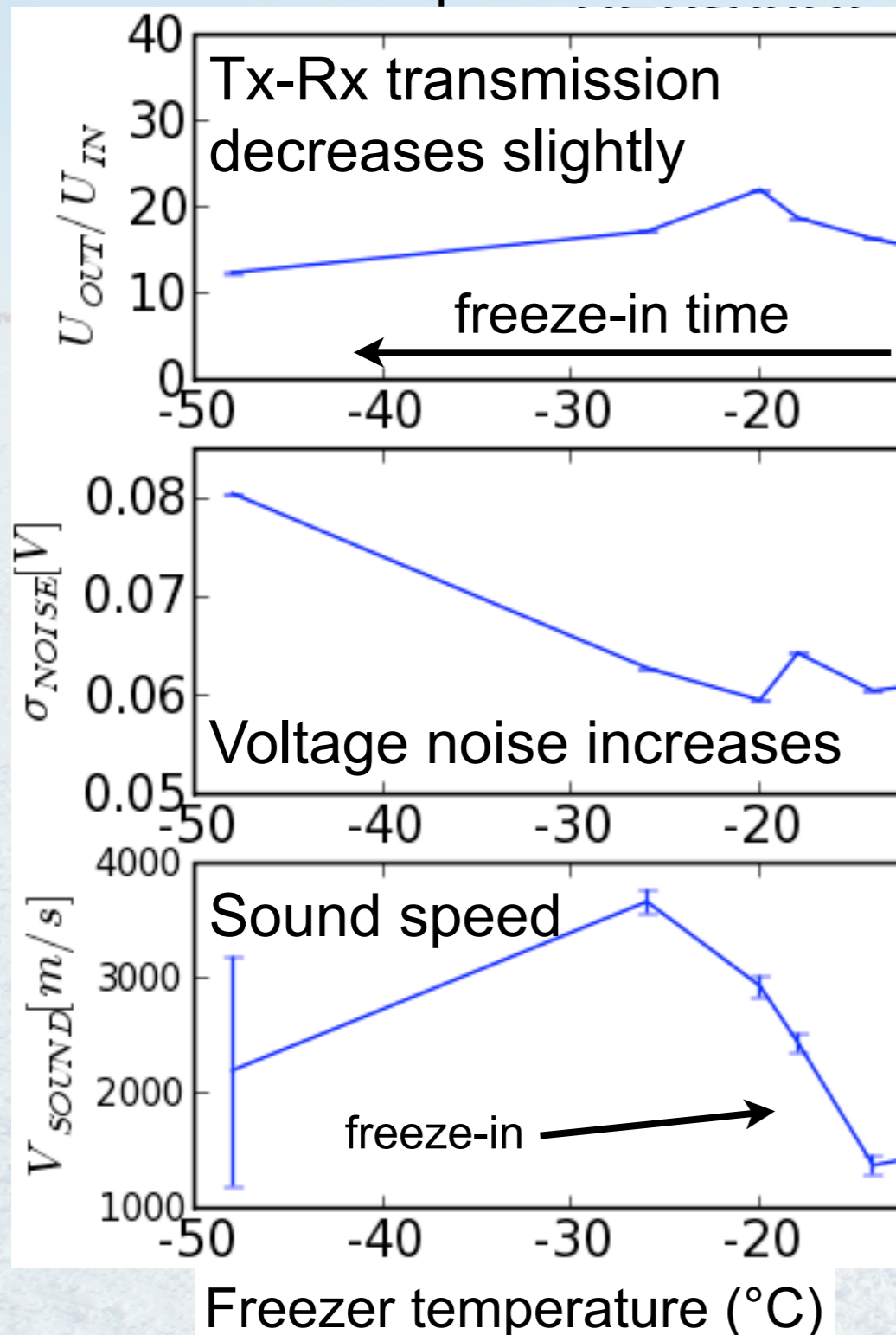
- SPATS Sensor
- Piezos coupled to steel housing
- Many resonance modes



- HADES Sensor
- Piezo coated in resin
- Single resonance @ 49 kHz

Absolute noise - Environmental conditions are important

Lab temperature data:

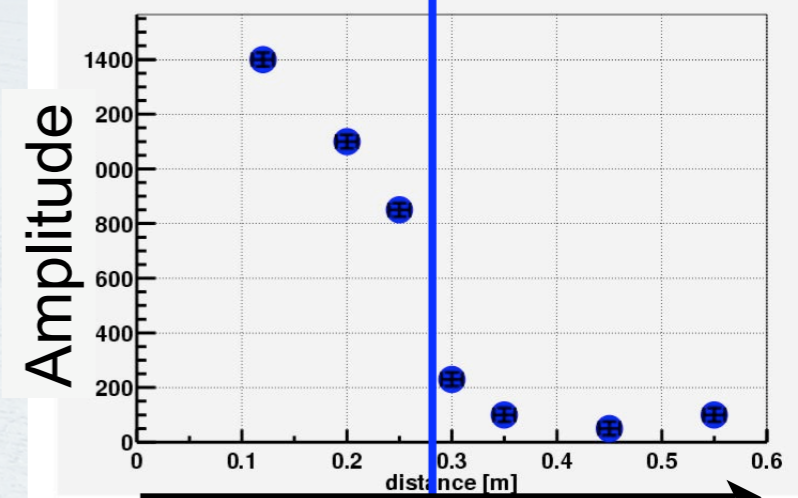
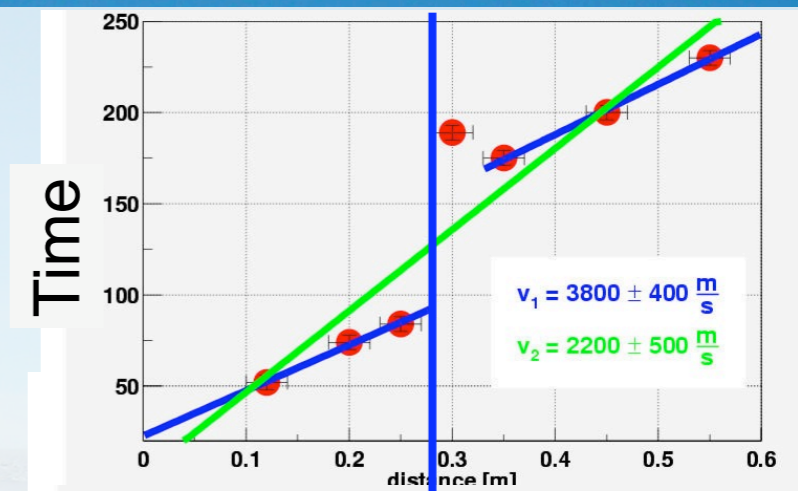


- Rapid freeze-in
- Signal amplitudes change during freeze-in
 - Better coupling of sensor / transmitter to ice?
 - Increased sensitivity at low temperatures?
 - Transmission decreases due to bad ice quality?
- Measurements of sensitivity change planned:
 - in pressure chamber
 - in ice

Ice Quality: Lab studies

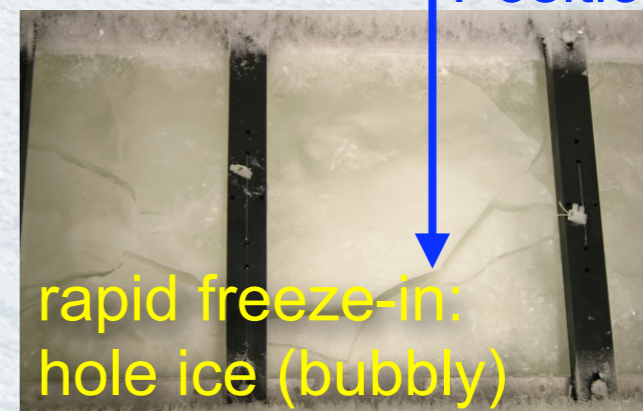
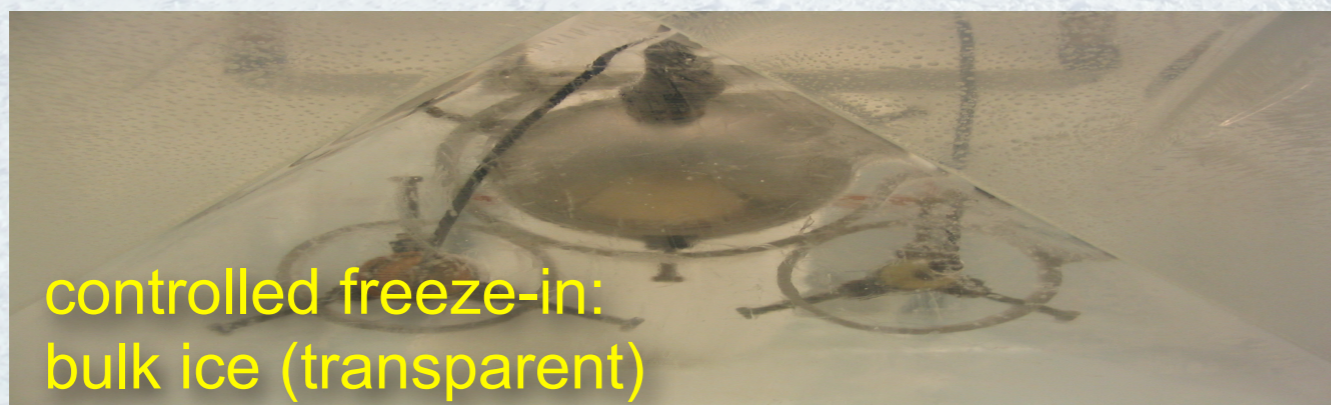
SPATS freeze-in studies:

- “Hole-ice” properties potentially important
- Non-isotropic appearance of bubbles and micro-cracks
- Laboratory studies give first clue of influence on sensitivity
- Observe “arbitrary” absorption of transmitted and received signals
- ▶ **In-situ calibration necessary**



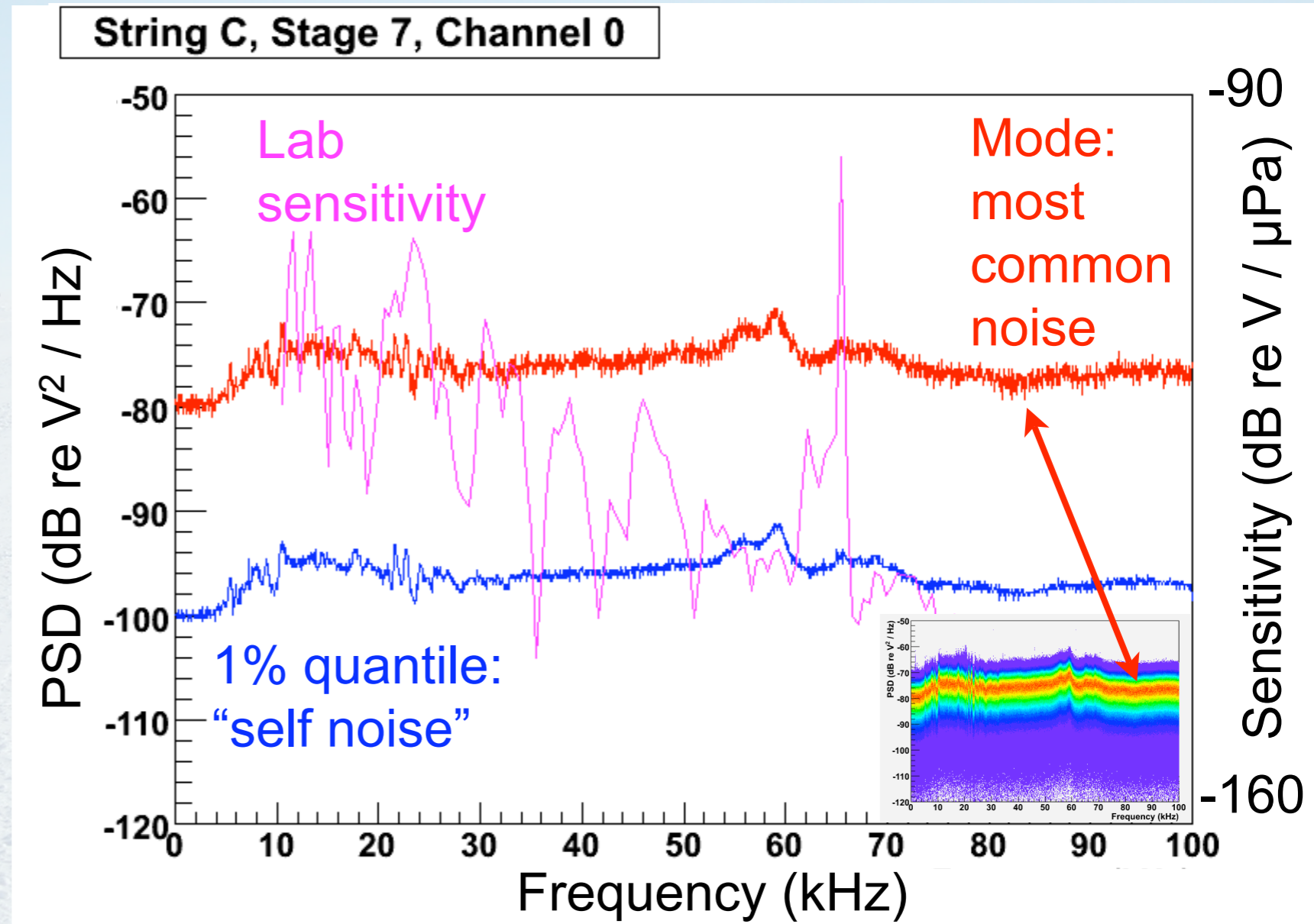
Distance
transmitter - sensor

Position of crack



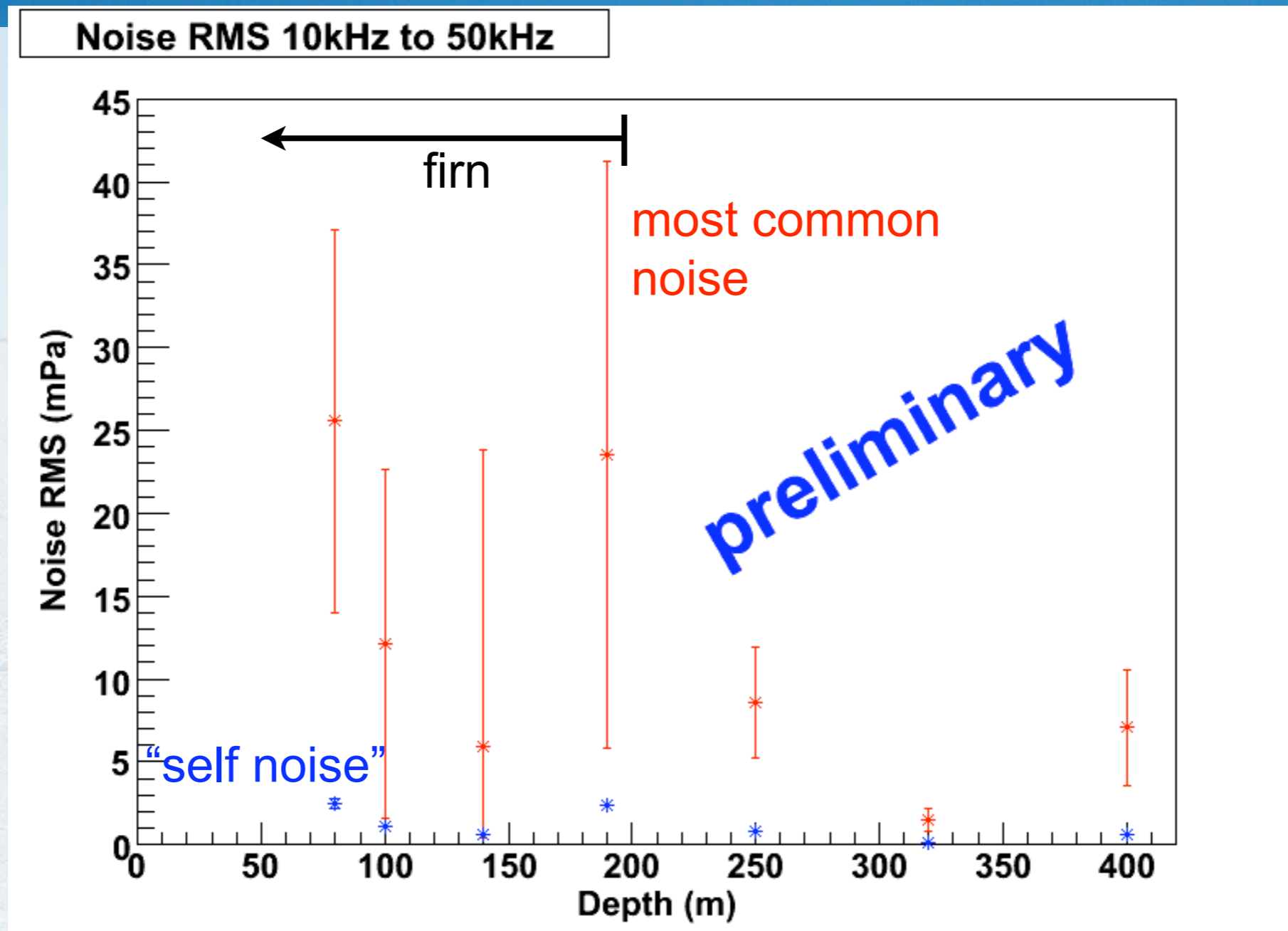
Calibration

- Only lab calibration available
- All sensors calibrated in water at room temperature
- Sensitivity in -50°C air is 1.4 times sensitivity at room temperature
- Influence of pressure and coupling to ice under study



- Sensitivity above 50 kHz very low
 - ▶ use 10 kHz — 50 kHz band
- Integral over PSD gives noise RMS

Noise depth profile

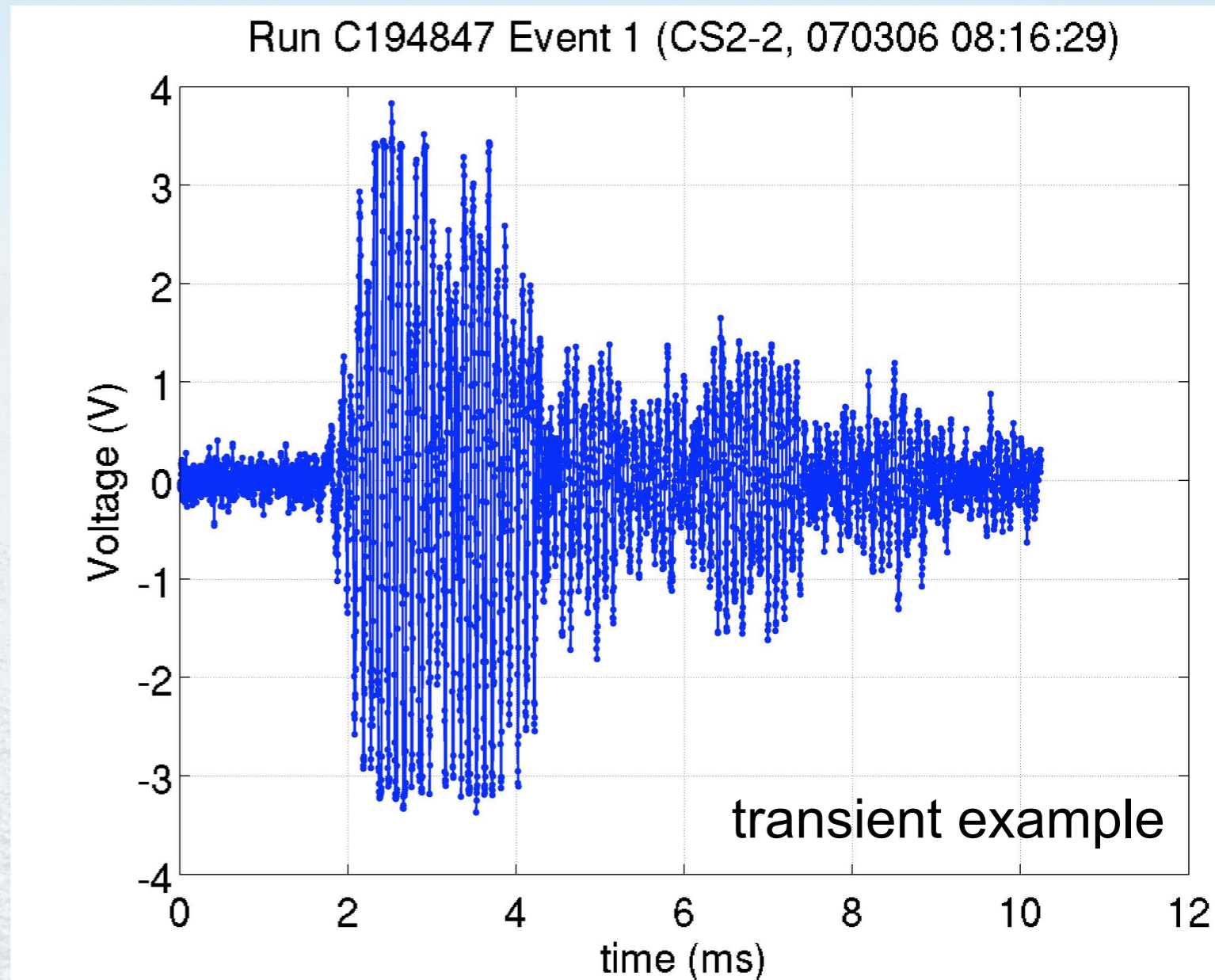


- Assumption: Pole sensitivity = 1.4 Lab sensitivity
- Error bars only represent sensor to sensor variations
- Noise consistent between different strings

Transient data taking and analysis

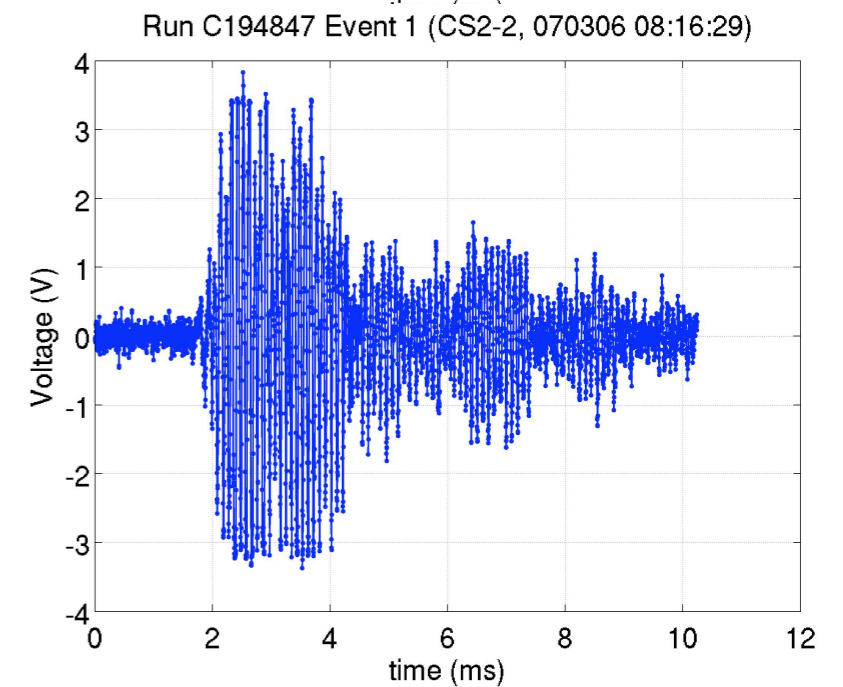
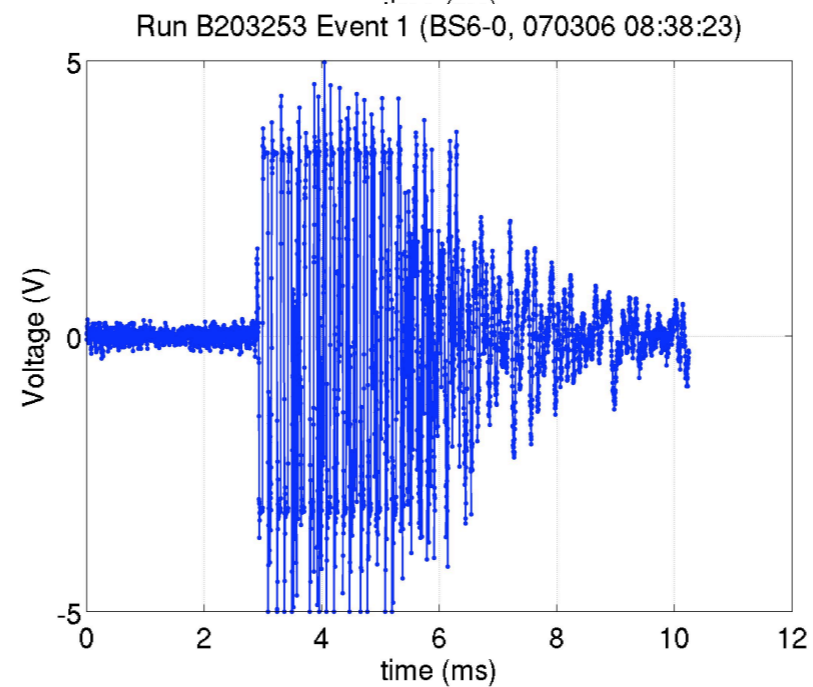
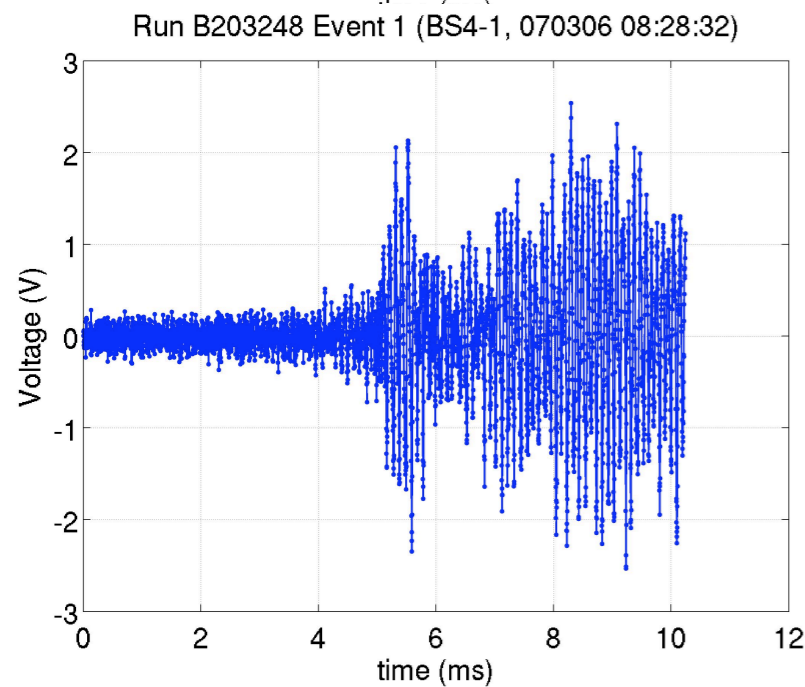
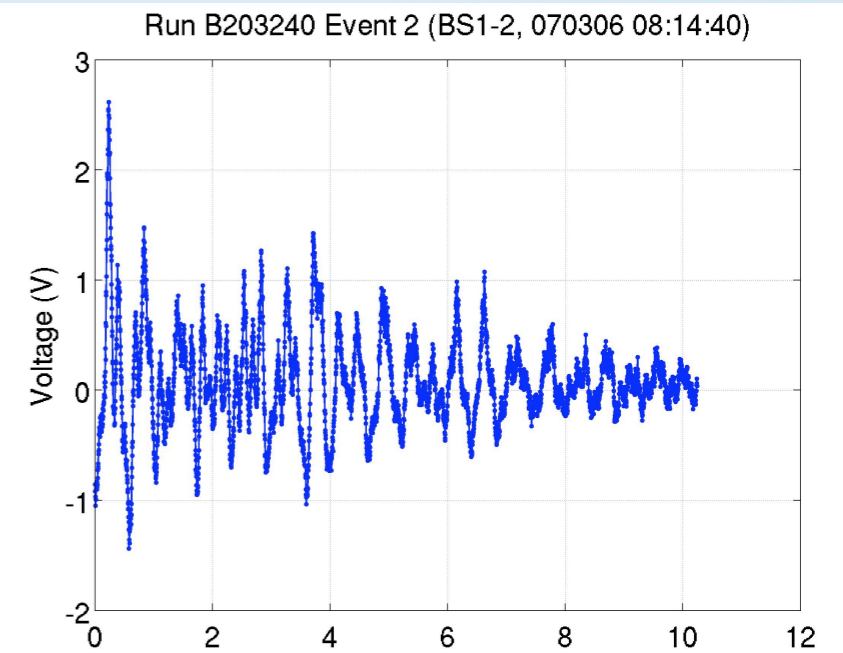
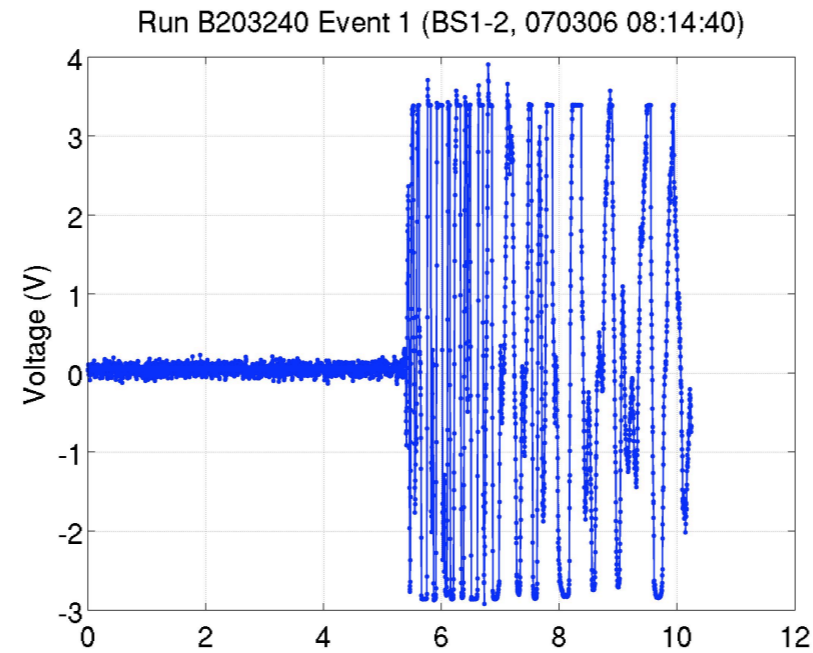
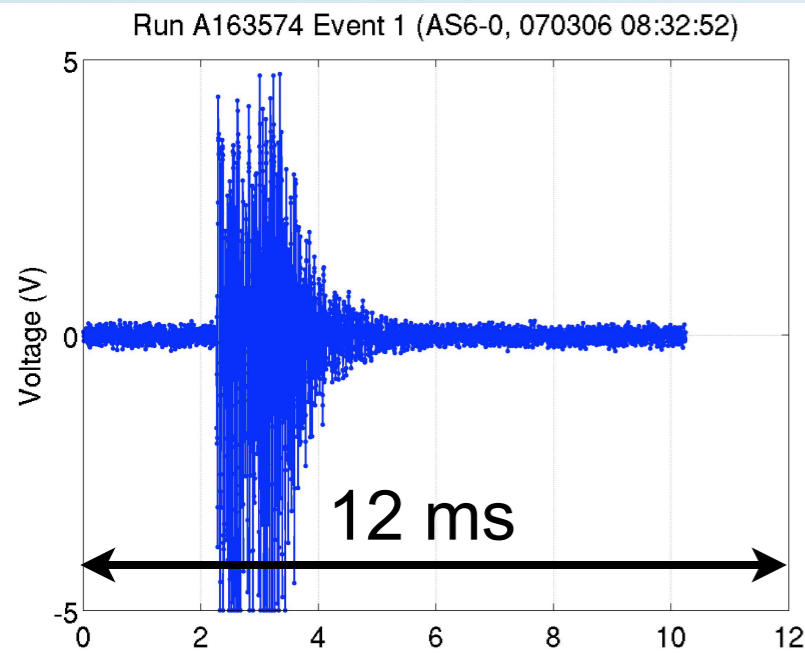
- Distribution of sources in time and space?
- Pulse shapes?
- Significant neutrino backgrounds?
- Anything else interesting? ice cracking, glacier stick/slip, ...
- Multi-channel long duration threshold triggered runs underway now at Pole

▶ Will search for coincidences and attempt source location



Background transients

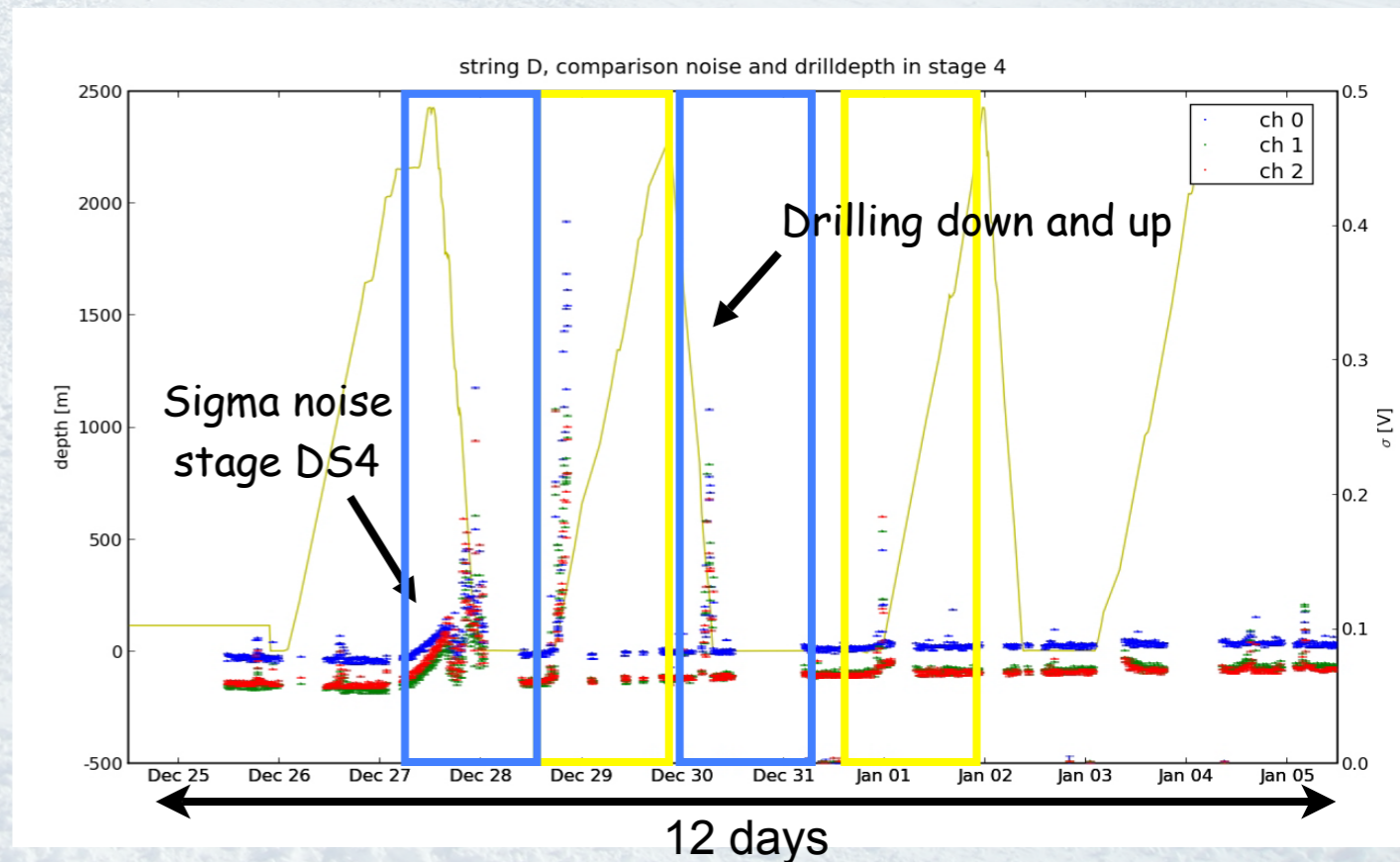
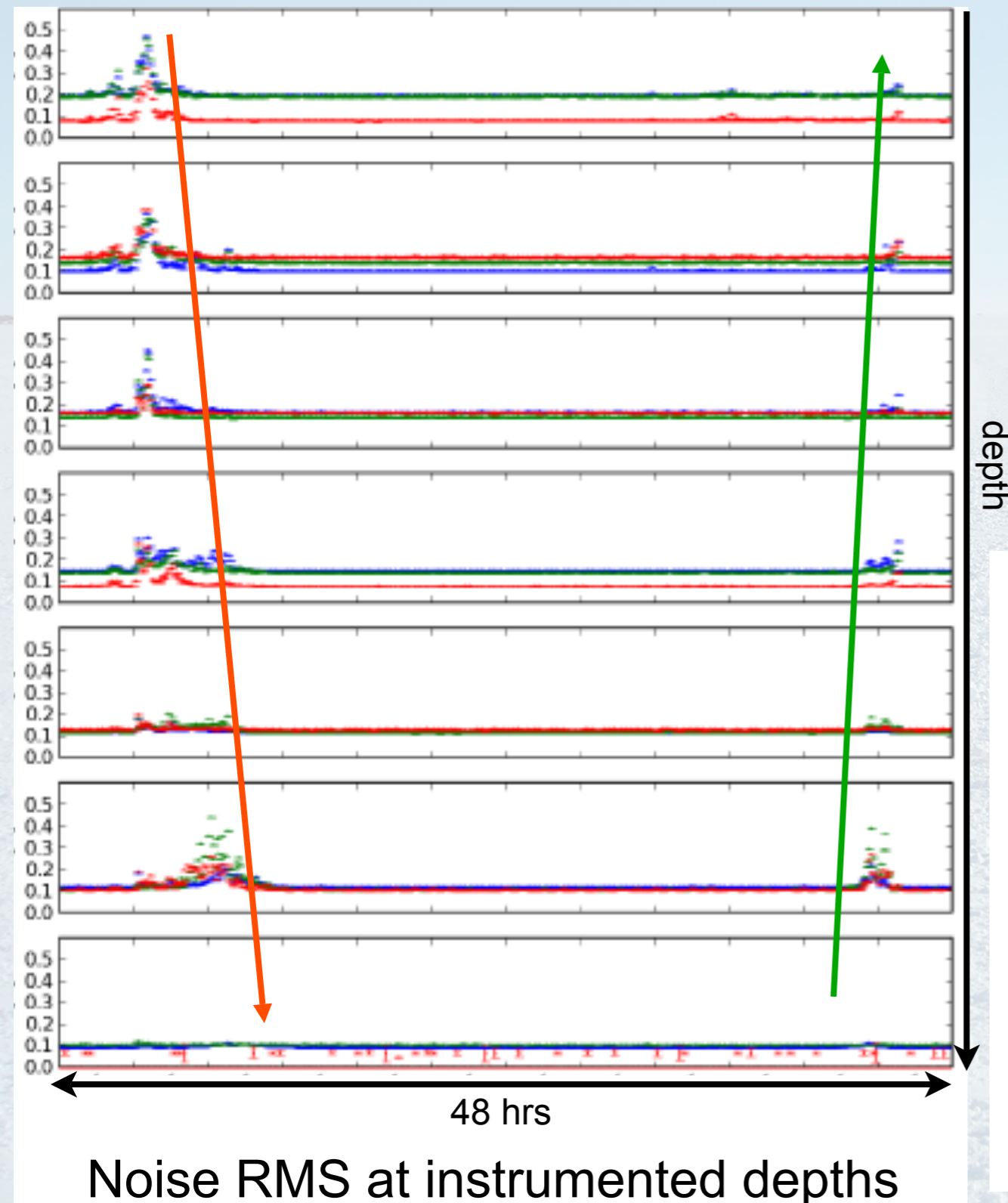
Loud examples:



- Rate: ~ 1 / minute / channel

SPATS hears the IceCube drill!

- SPATS running throughout 07/08 drilling season
- Drill in each hole heard
- On way down and up
- Up to 660 m distance



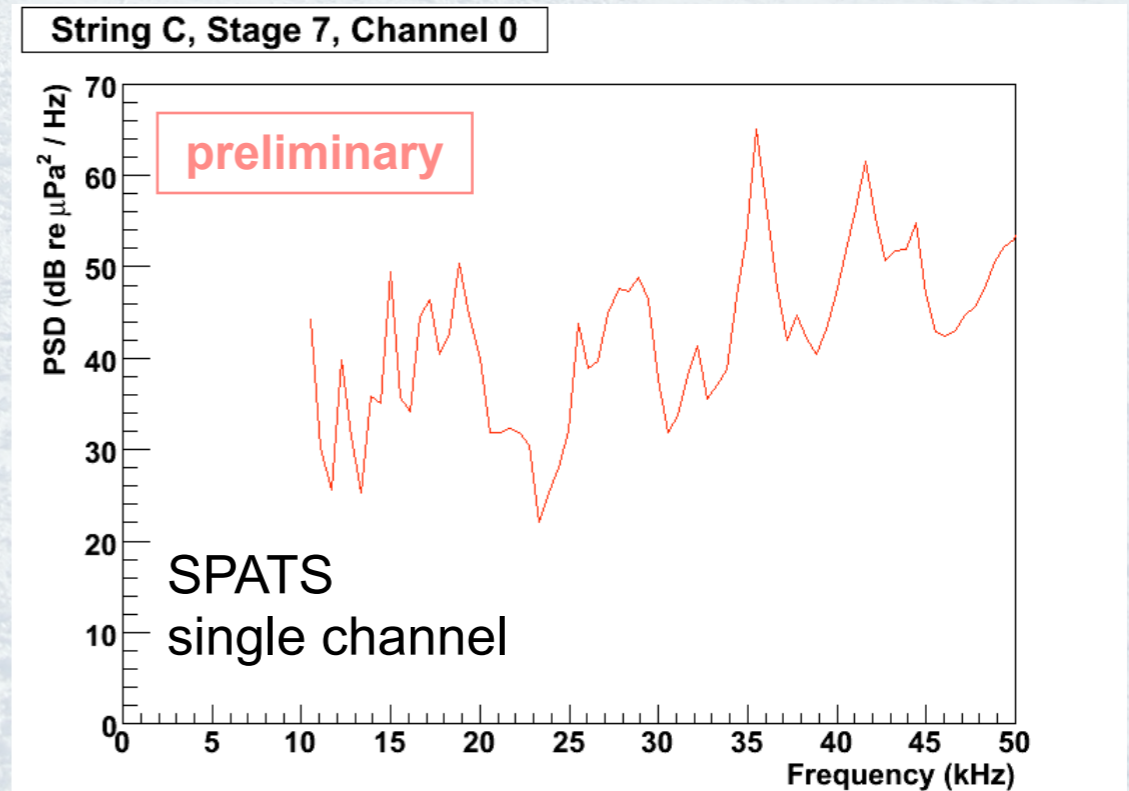
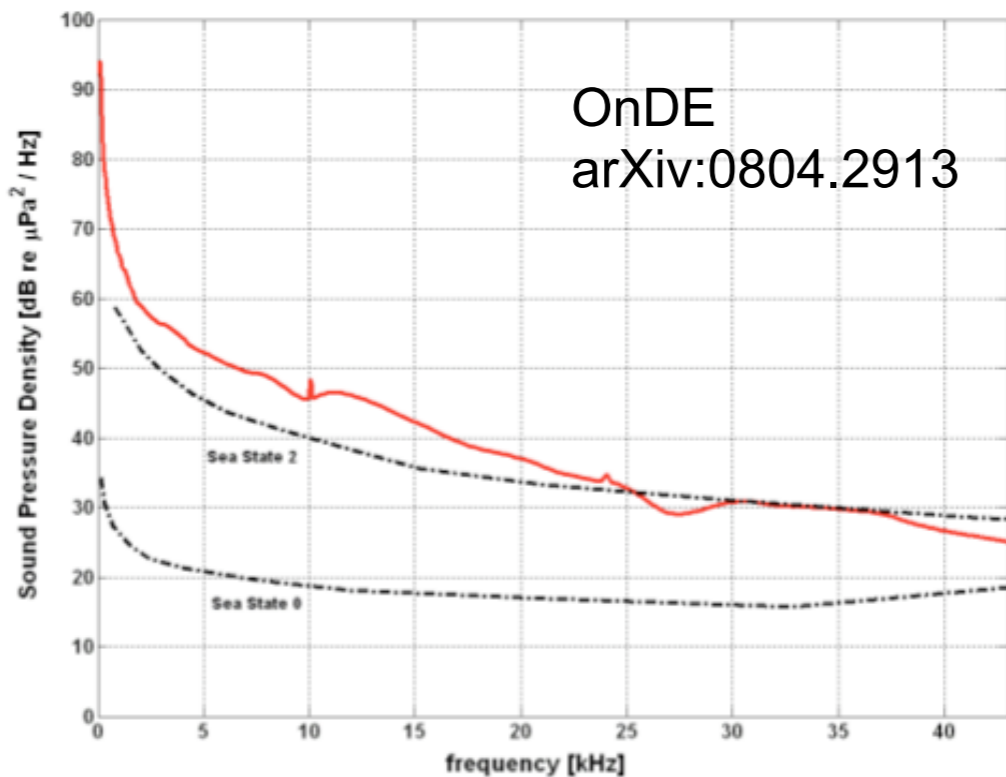
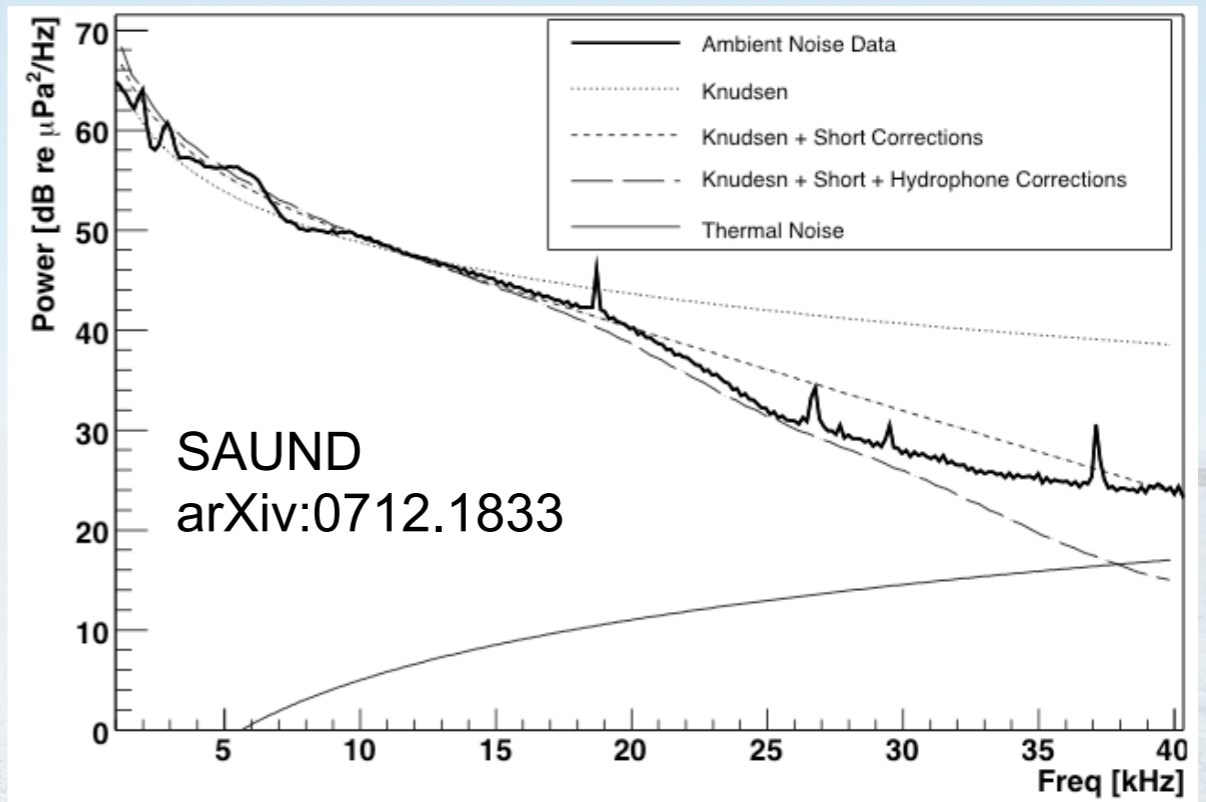
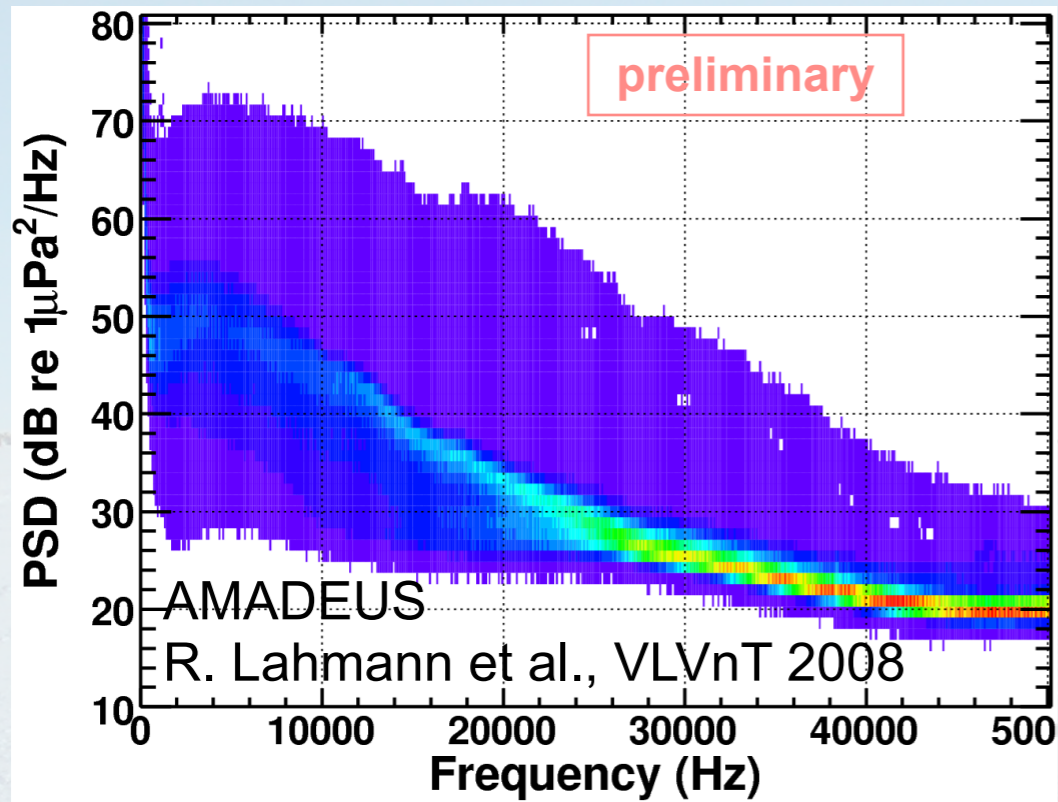
Summary and Outlook

- SPATS measured 1.5 years of noise data
- Acoustic background is
 - Gaussian
 - stable over time
- Measurements indicate absolute noise level < 10 mPa (10 kHz - 50 kHz, below firn)
- Sensor calibration in pressure chamber under preparation
- SPATS starting to operate as an event detector
 - spatial and temporal distribution of transients

Backup slides



Comparison with other experiments



Calculated acoustic radiation pattern in ice

