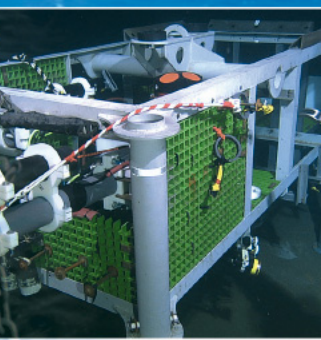


NORTEK

TRUE INNOVATION MAKES A DIFFERENCE



Introduction to NORTEK's
Signature1000 & Signature500
Systems for High-Energy DYNAMIC Environments

Eric Siegel



TRUE INNOVATION MAKES A DIFFERENCE



AD2CP Platform – a new generation of current profilers

Primary Goal: Increased flexibility

- Multi-function systems – many combinations of beams, ping sequences & acoustic frequencies
- Proper broadband processing
- Smaller, lighter, lower power
- Smarter interfaces

Secondary Goal

- Develop a hardware/firmware structure that allows **you** to innovate and expand your capabilities for the next 10 years



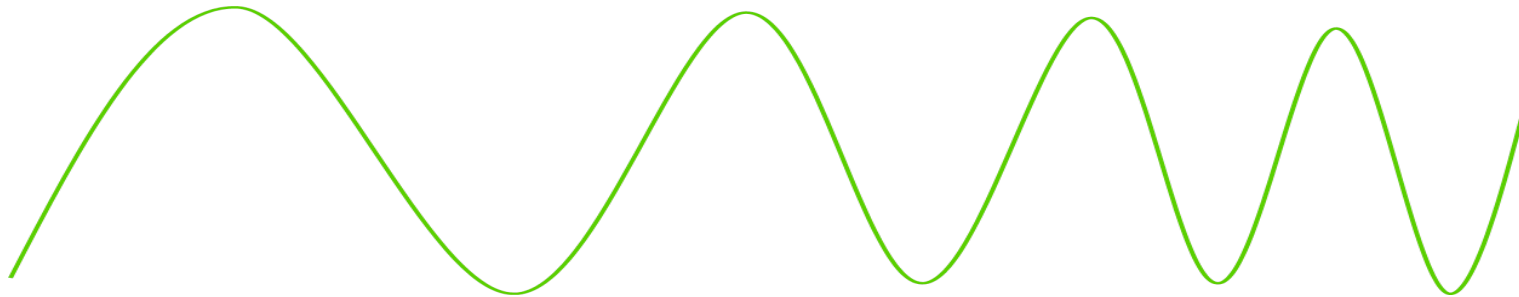
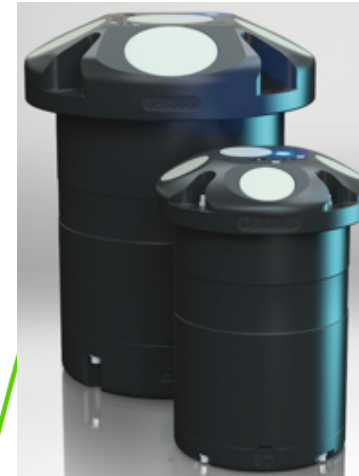
Multi-Function Systems

Try to implement systems that can do more than one thing at a time:

- Collect both mean velocity profile and high resolution data
- Different data types – water velocity, tracking velocities, distances measurements
- More than one frequency
- More beams pointing in more directions
- Internal processing of data

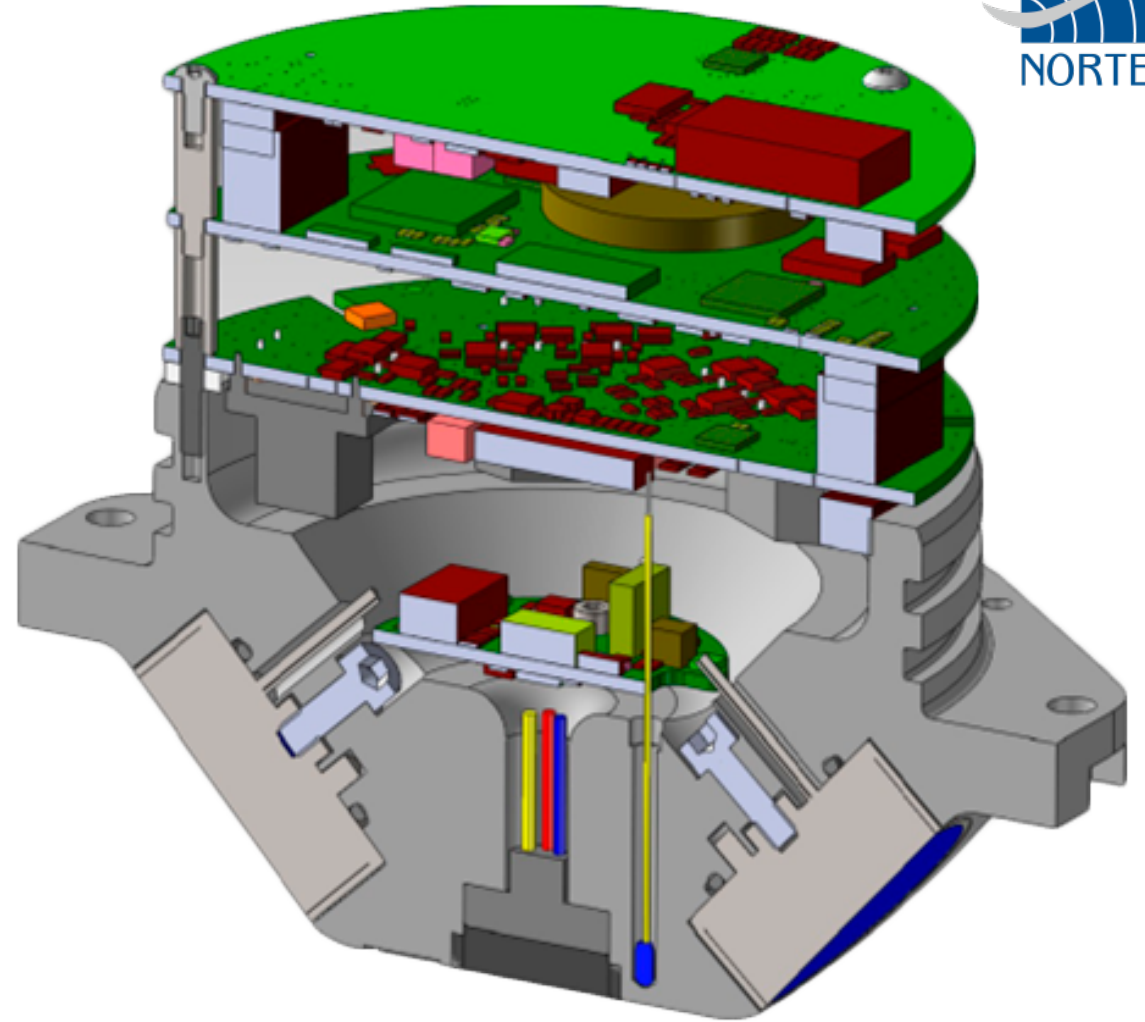
Broadband Processing

- Hardware development timed to the international expiry of the “Broadband” patent
- Lower noise in the velocity data particularly important:
 - Moving platforms – Glider AD2CP
 - Long range current profilers – Signature55
 - Turbulence measurements – Signature500/1000
 - Bottom tracking – DVL



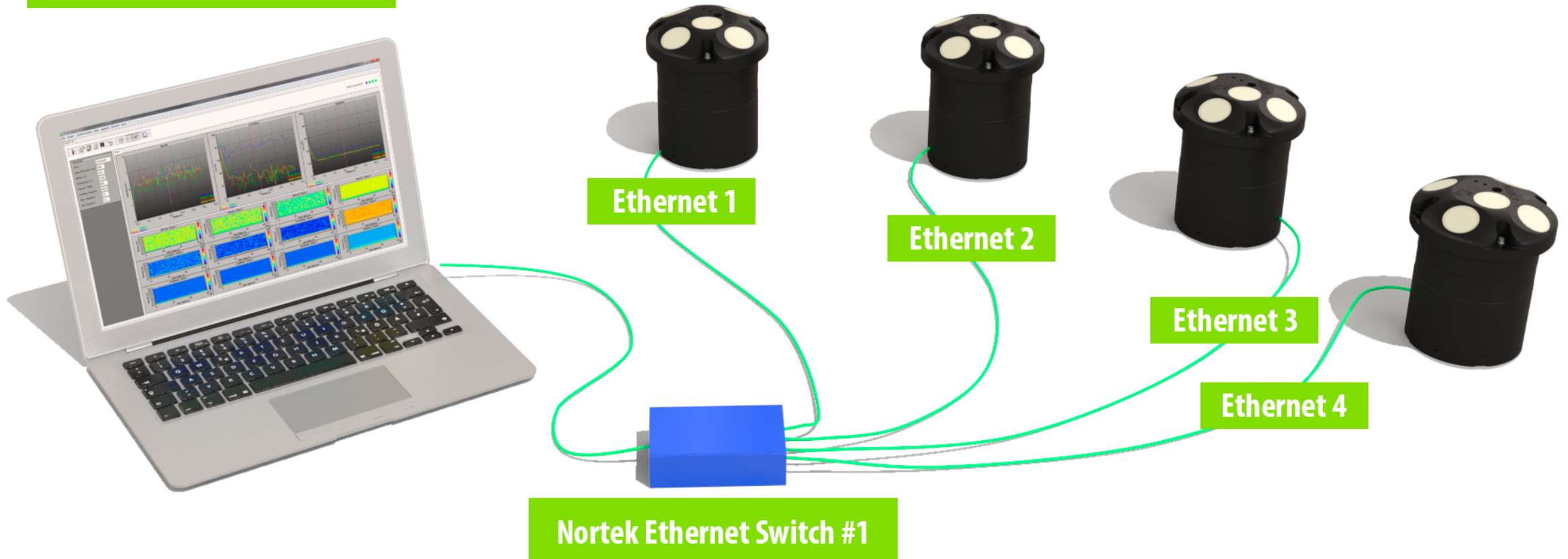
Smaller, lighter, lower power

- PCB area reduced by a factor of 2
- System close to neutrally buoyant in water
- Power consumption as low as 0.2W when sampling every 10 seconds



Smarter Interfaces

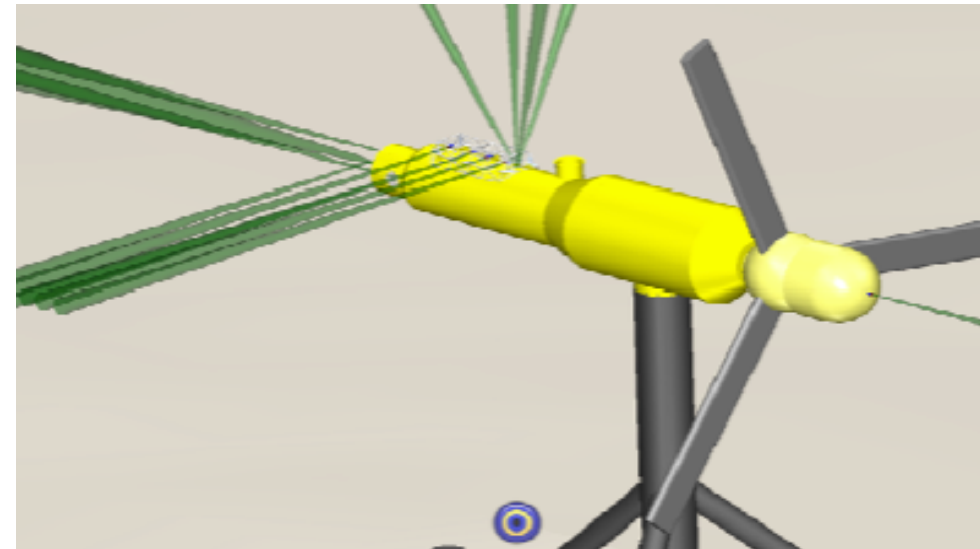
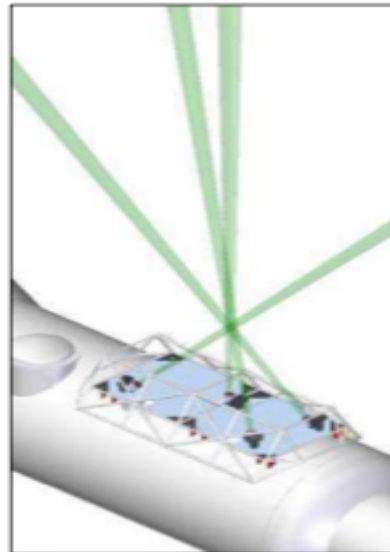
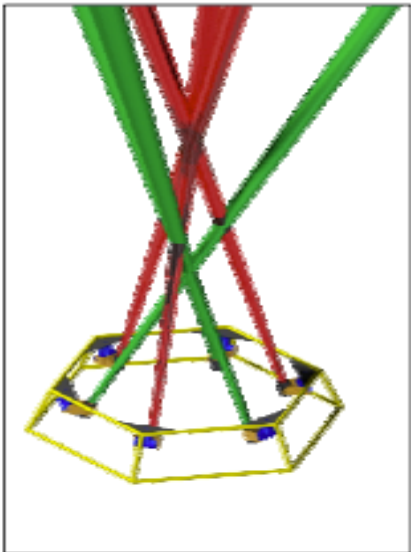
“Midas” software controls multiple AD2CPs



Integrated Systems

EMEC ReDAPT

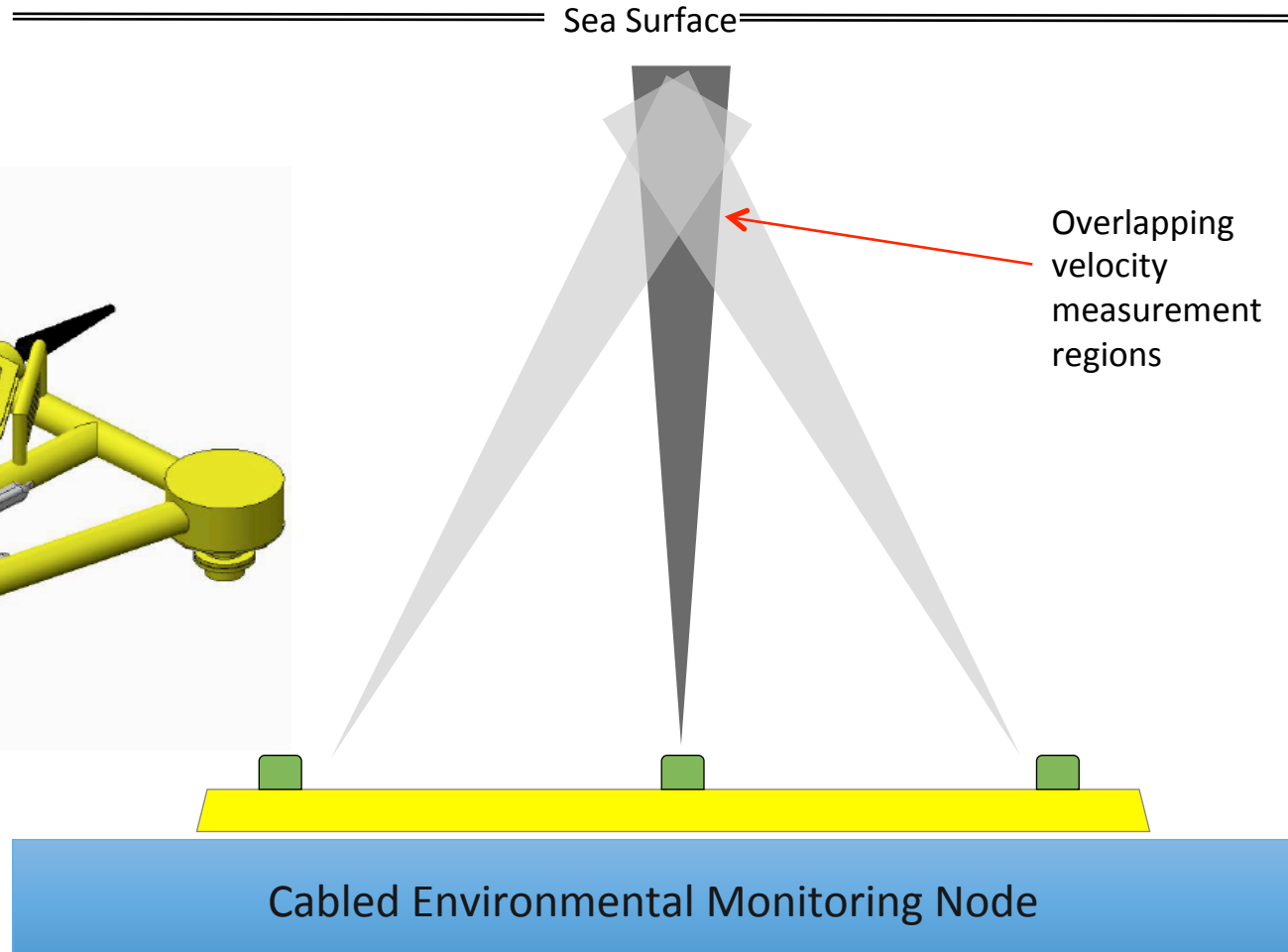
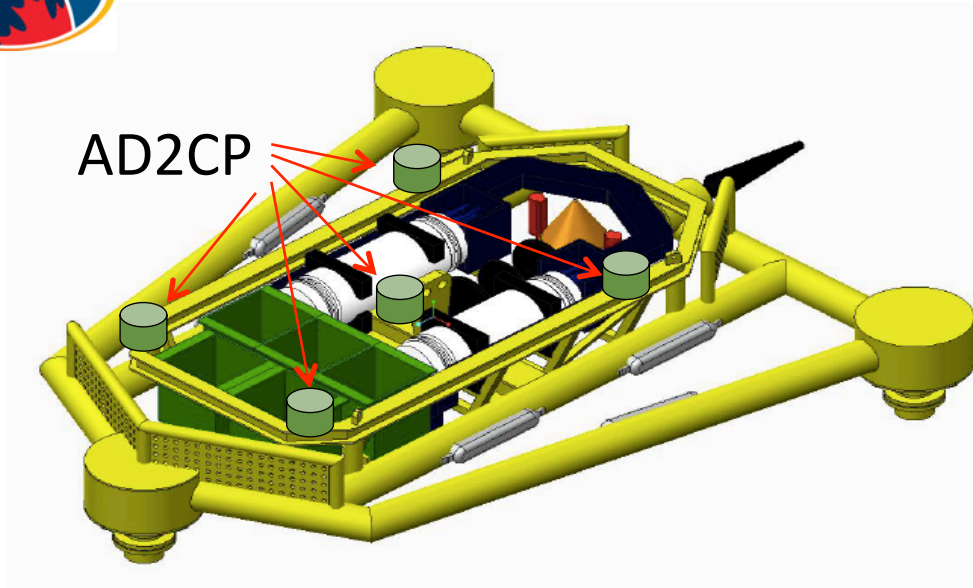
- Network of 16 single-beam AD2CP's
- Individual pan & tilt control
- Beam velocity measurements
- Integrated by University of Edinburgh



ReDAPT: Reliable Data Acquisition Platform for Tidal

Integrated Systems

Vectron: Field-Scale Acoustic Doppler Velocimeter



Introduction – Signature1000 & Signature500



Signature1000



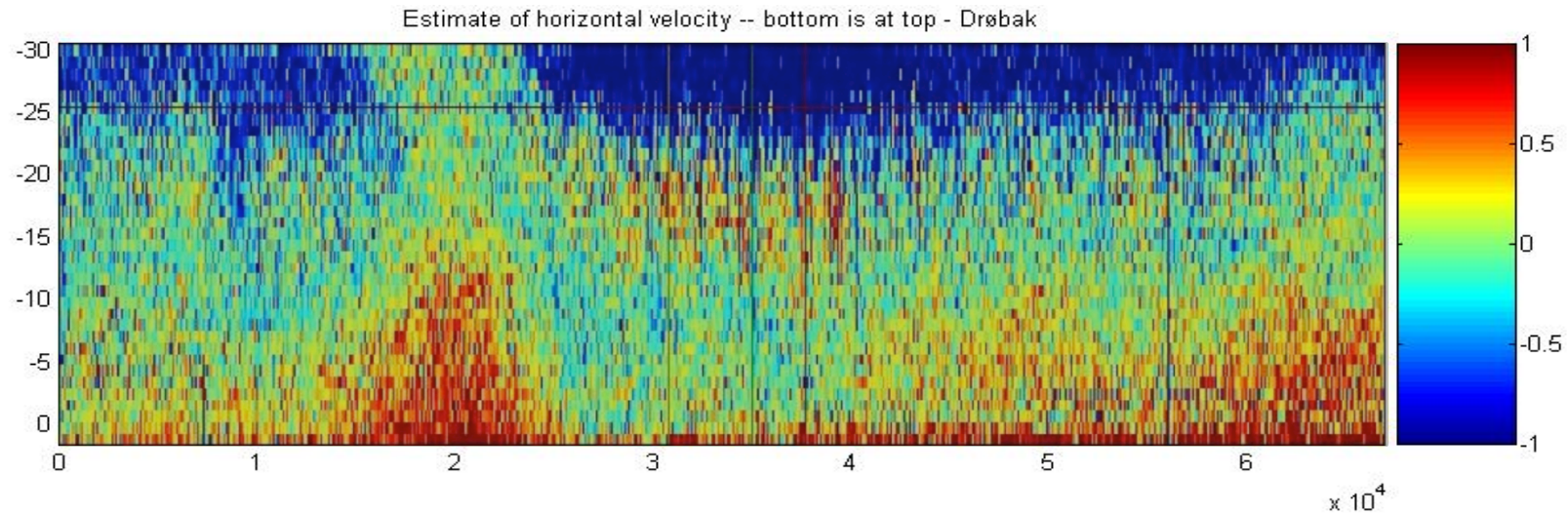
Signature500



Signature1000/500 Advantages



1. Broadband processing



Broadband

Signature1000/500 Advantages

2. Patented concurrent mode technology

- Example: measure small cells at fast rate in bursts for turbulence and at the same time measure large cells at regular intervals for mean currents.



Deployment Wizard

Concurrent plans (with)

Current profile
 Turbulence using 4 beams
 Turbulence using 5 beams
 Turbulence using vertical beam

using 5 beams and AST

Deployment length (days)

Horizontal vel. range (m/s)	5.92
Measurement range	
Configured range (m)	58.5
Estimated max range (m)	68.2
Blanking distance (m)	0.5
Cell size	2
Number of cells	29
Number of beams	4
Altimeter	Off
Sampling rate	
Measurement interval (s)	600
Average interval (s)	120
Performance	
Power usage (Wh)	536.5
Memory usage (MB)	1522.7

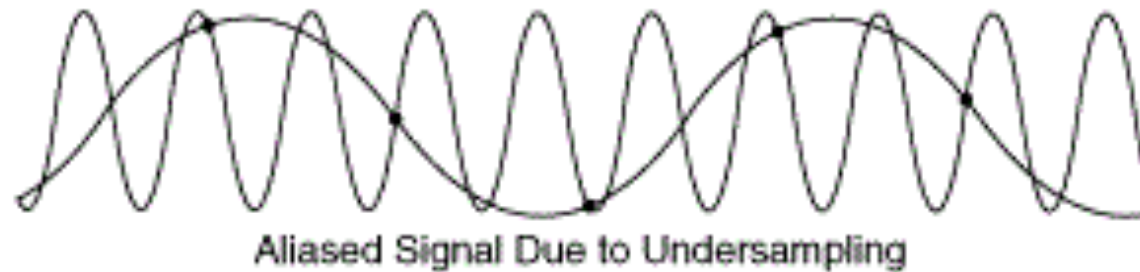
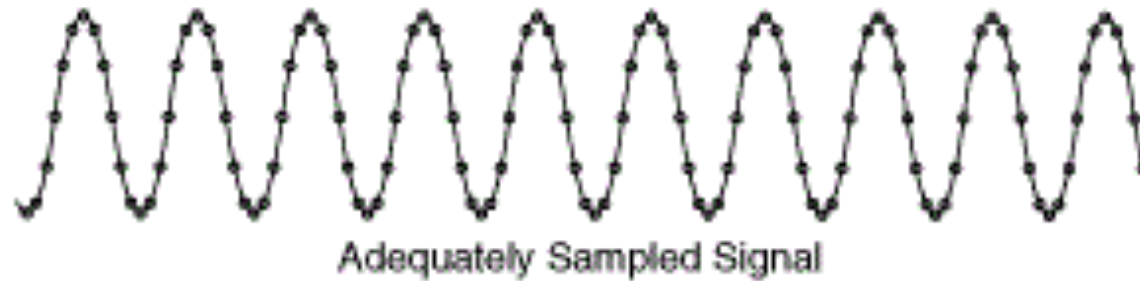
Consequences		Summary	
	Current profile	Turbulence	
Long range mode	OFF	n/a	
Multiplexing	OFF	n/a	
Number of pings	13	2	
▲ Slanted beams			
Horizontal prec. (cm/s)	0.97	5.19	
Vertical prec. (cm/s)	0.32	1.71	
Velocity range (m/s)	2.5	2.5	
▲ Measurement range			
Desired range (m)	20	20	
Configured range (m)	21.2	21.6	
Estimated max range (m)	23.7	20.9	
Blanking distance (m)	0.2	0.1	
Cell size	1	0.5	
Number of cells	21	43	
Number of beams	4	4	
Ice measurement	OFF	OFF	
▲ Sampling rate			
Measurement interval (s)	00:10:00	01:00:00	
Average interval (s)	00:02:00		
Sampling rate (Hz)		4	
#Samples		4096	
Burst duration (s)		1024	

Signature1000/500 Advantages



3. Fast sampling rate

- Up to 16 Hz sampling on all beams for superior turbulence characterization
- 4 times faster than any other ADCP

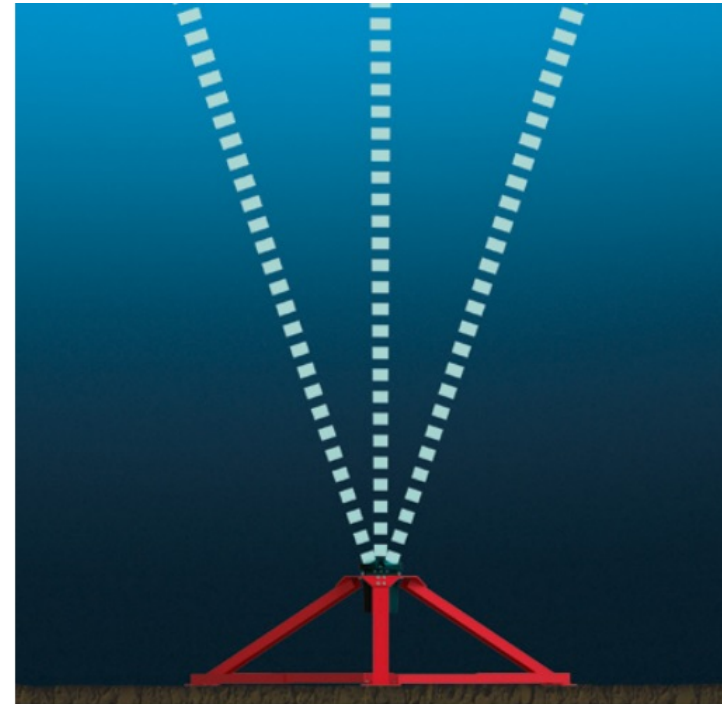
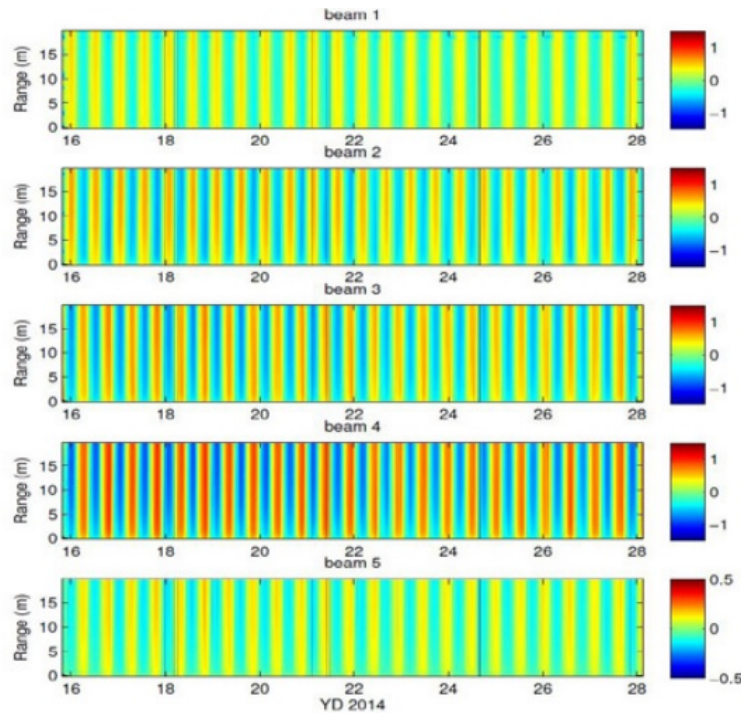


Signature1000/500 Advantages



4. Multiple Beam Operation

- Perfect for turbulence measurements where velocity is sampled along 5 beams
- Allows direct estimate of all five second-order turbulent variables



Signature1000/500 Advantages



6. Records All Raw Data

- Takes the guess work out of data processing
- Improves data quality by removing contamination from fish or other influences
- Allows researcher to decide which time scale to study later
- 16 GB memory is standard, upgradable to 64 GB memory



Signature1000/500 Advantages



7. Low Power

- On average 50% reduction in power consumption compared to competition
- Longer deployment time, smaller batteries, less time in the field = lower costs

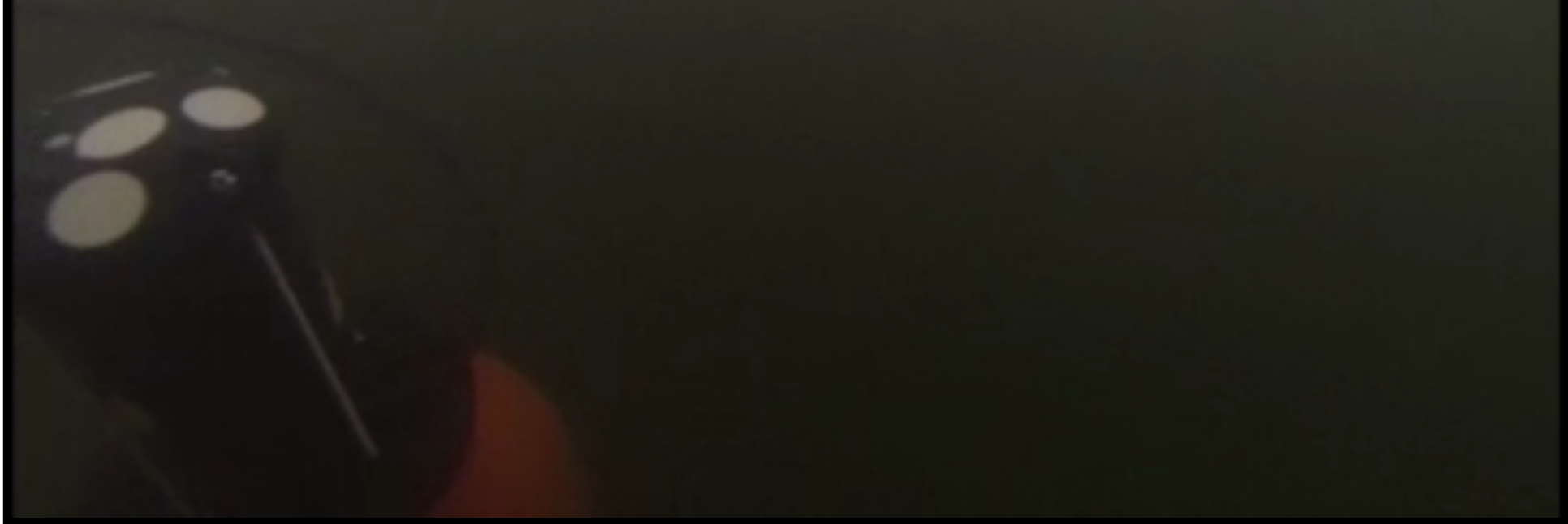


Signature1000/500 Advantages



LED Indicator

- So you can be sure the instrument is recording





Data collection – AD2CP

Structure of available data collection schemes.

1 MHz:

Slot:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Data																

500 kHz:

Slot:	1	2	3	4	5	6	7	8
Data								

Types of Data:

AP4 - Current profile along four beams

BP4 - Burst profile along four beams

BP5 - Burst profile along vertical beam

Alt – Altitude data (distance measurements along vertical beam)



Average profiling mode (AP)

1 MHz:

Slot:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Data		Alt		AP4		AP4		AP4		AP4						

Mode AP = current profiling along four beams with optional altimeter ping. Max output rate is 1 Hz.



Burst mode (BM) – 1 MHz examples

1 MHz:

Slot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Opt 1	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4	BP4
Opt 2	BP4	BP5	BP4	BP5	BP4	BP5	BP4	BP5	BP4	BP5	BP4	BP5	BP4	BP5	BP4	BP5
Opt 3	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5	BP5

Mode Burst = Stores data at sampling rate, maximum rate shown above.



Combination AP and BM - 1 MHz examples

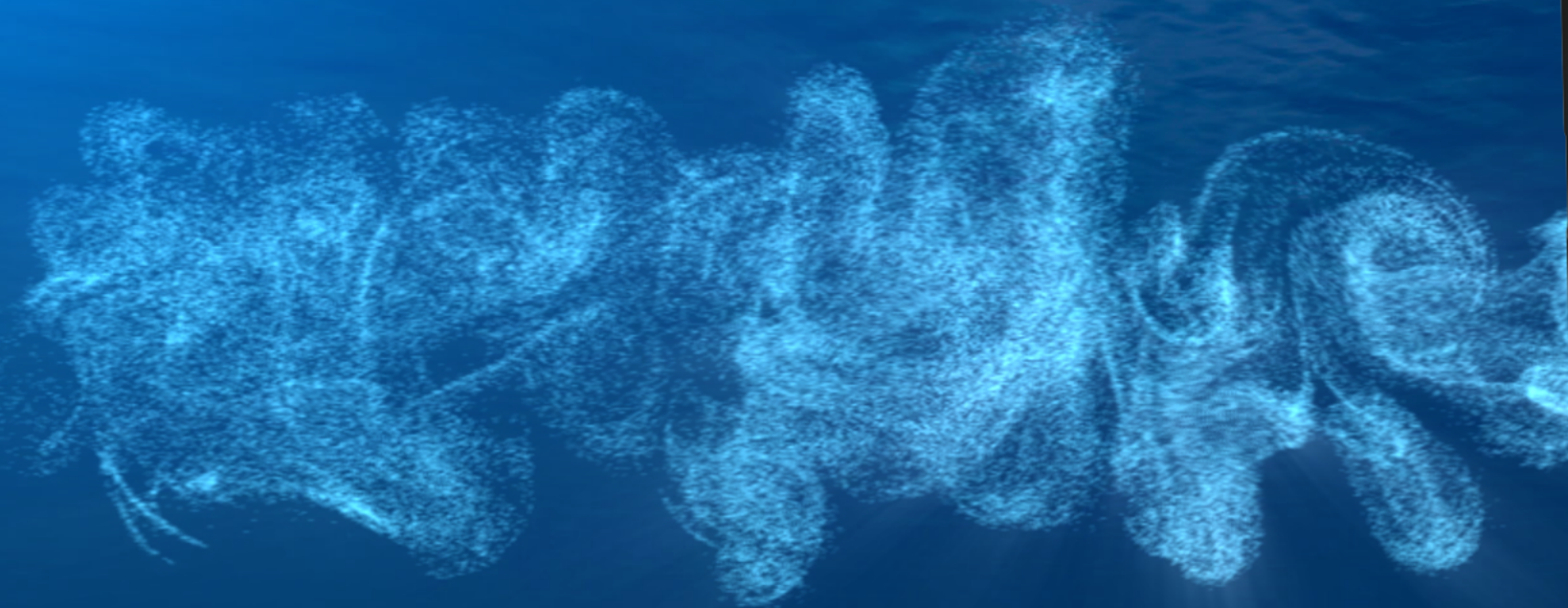
Alternative 1:

Slot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AP -1Hz out				AP4		AP4		AP4		AP4						
BM - 8Hz	BP5		BP5		BP5		BP5		BP5		BP5		BP5		BP5	

Alternative 2:

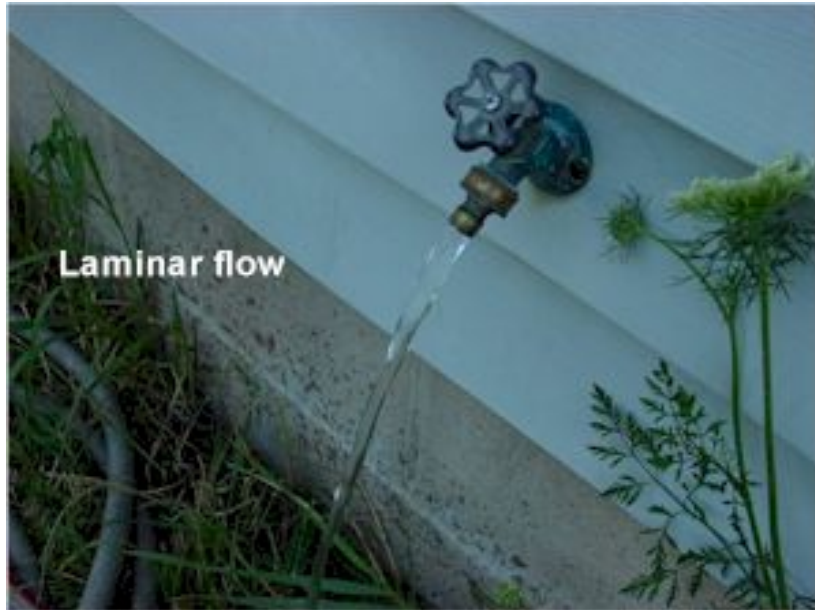
Slot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AP -1Hz out				Alt		AP4		AP4		AP4		AP4				
BM - 4 Hz	BP4		BP5		BP4		BP5		BP4		BP5		BP4		BP5	

Introduction to AD2CP TURBULENCE MEASUREMENTS

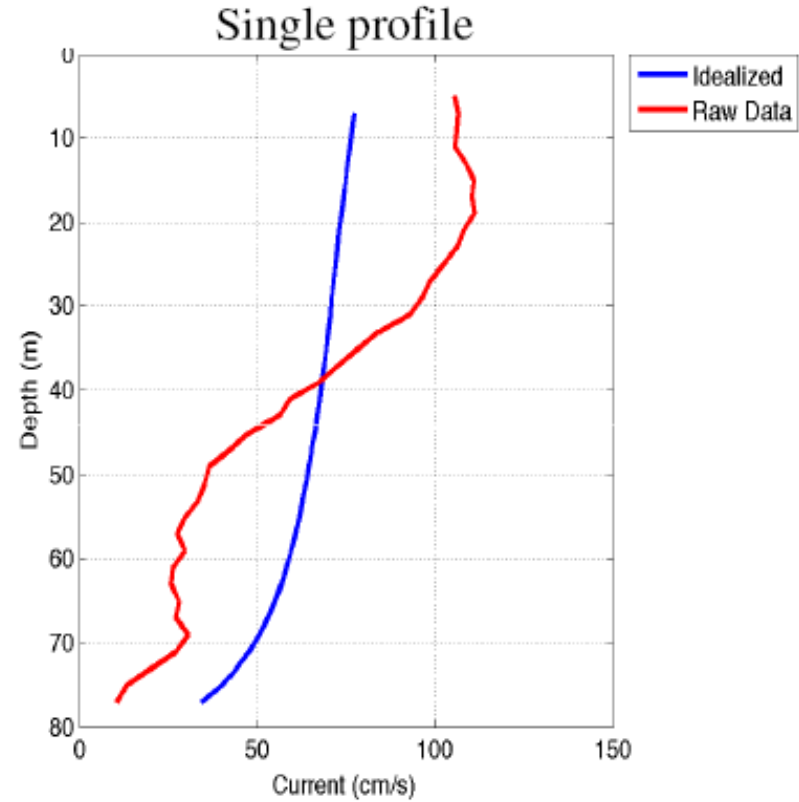
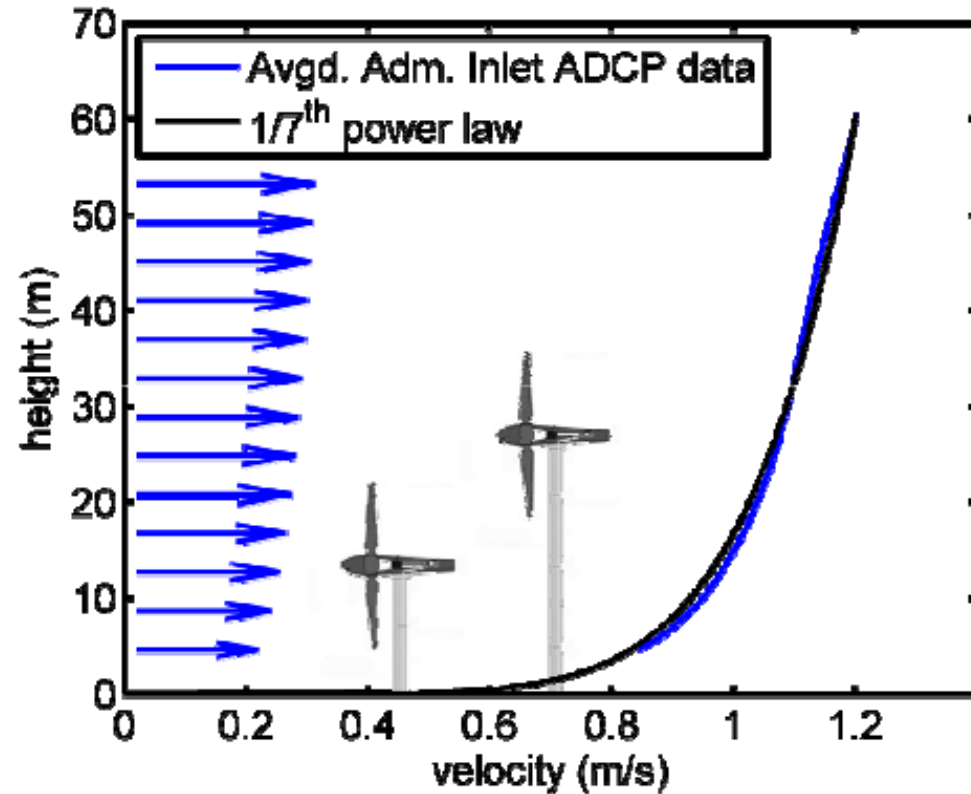


From Everyday Life

Turbulence is that state of fluid motion which is characterized by random and chaotic motions.

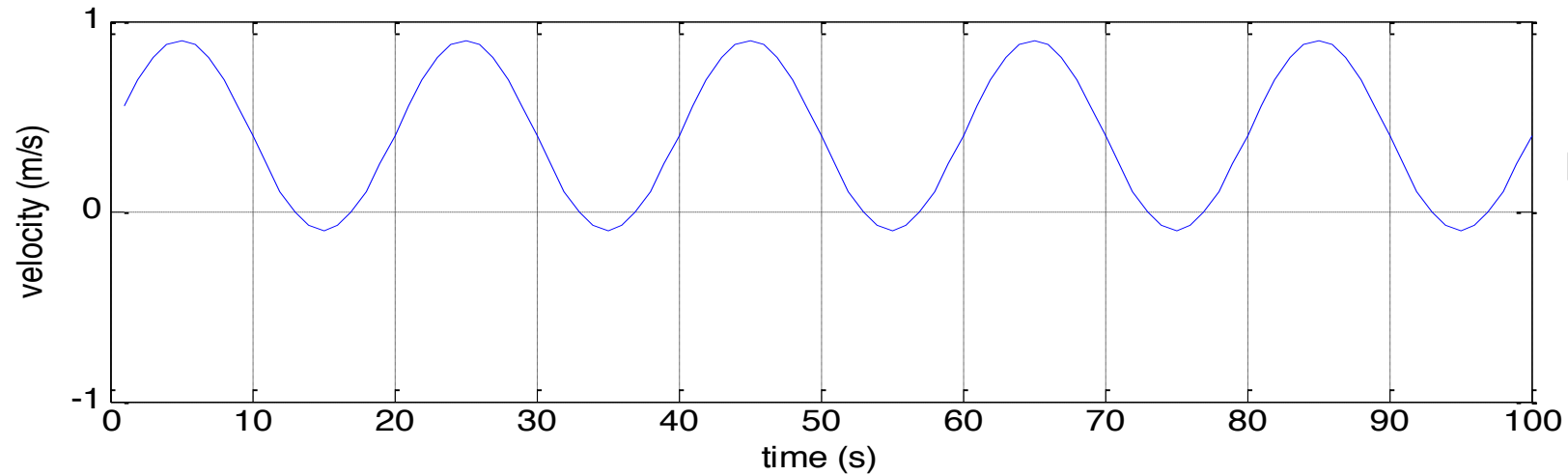
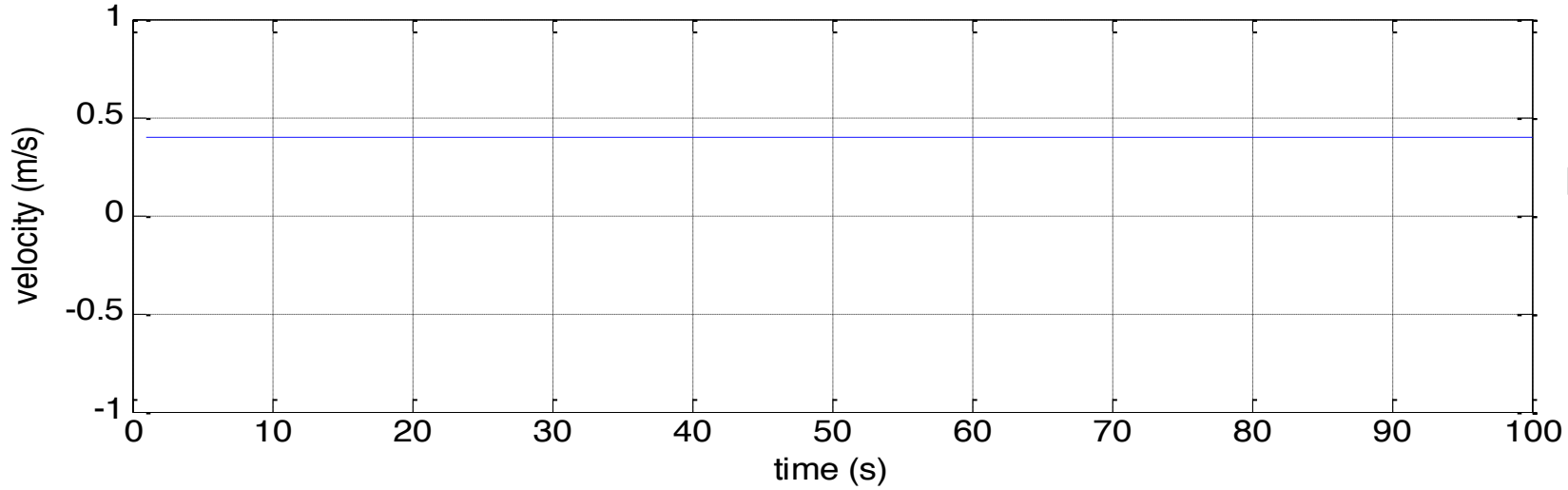


Tidal Energy – Current Profiles

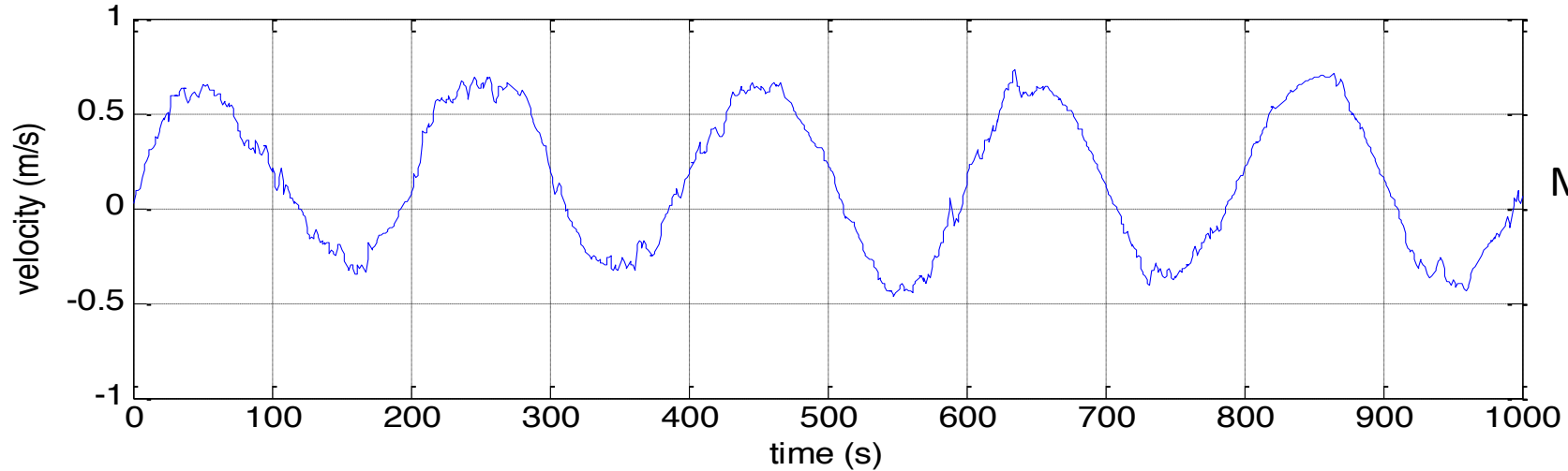


Gooch et al, 2009

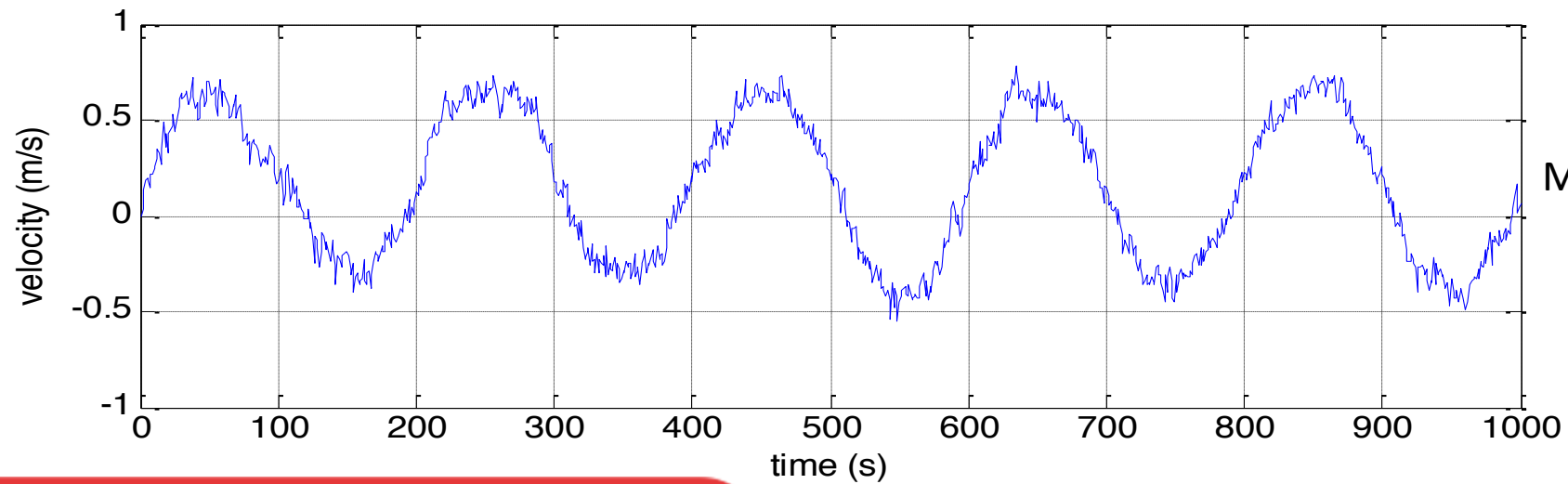
Building a time series



Building a time series



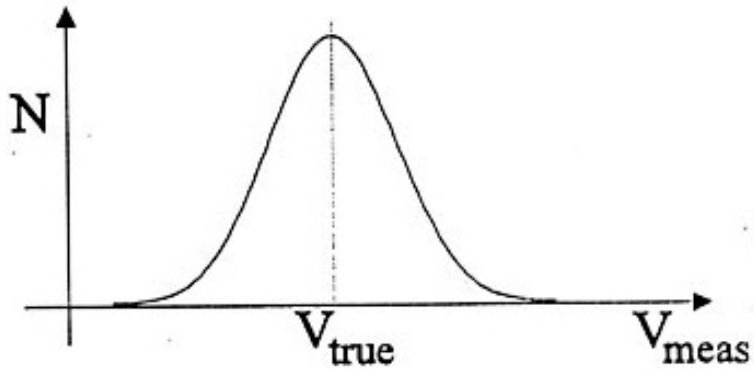
Mean + wave + turbulence



Mean + wave + turbulence + noise

Doppler noise characteristics

1) Gaussian



2) Random, non-biased

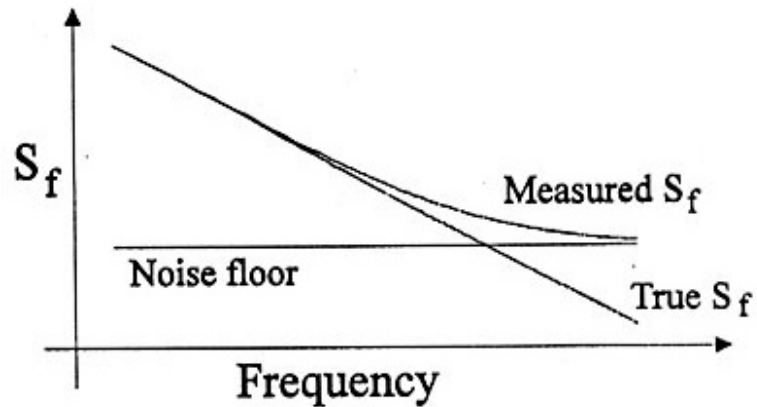
$$V_{\text{mean}} (\text{true}) = V_{\text{mean}} (\text{measured})$$

Doppler noise characteristics

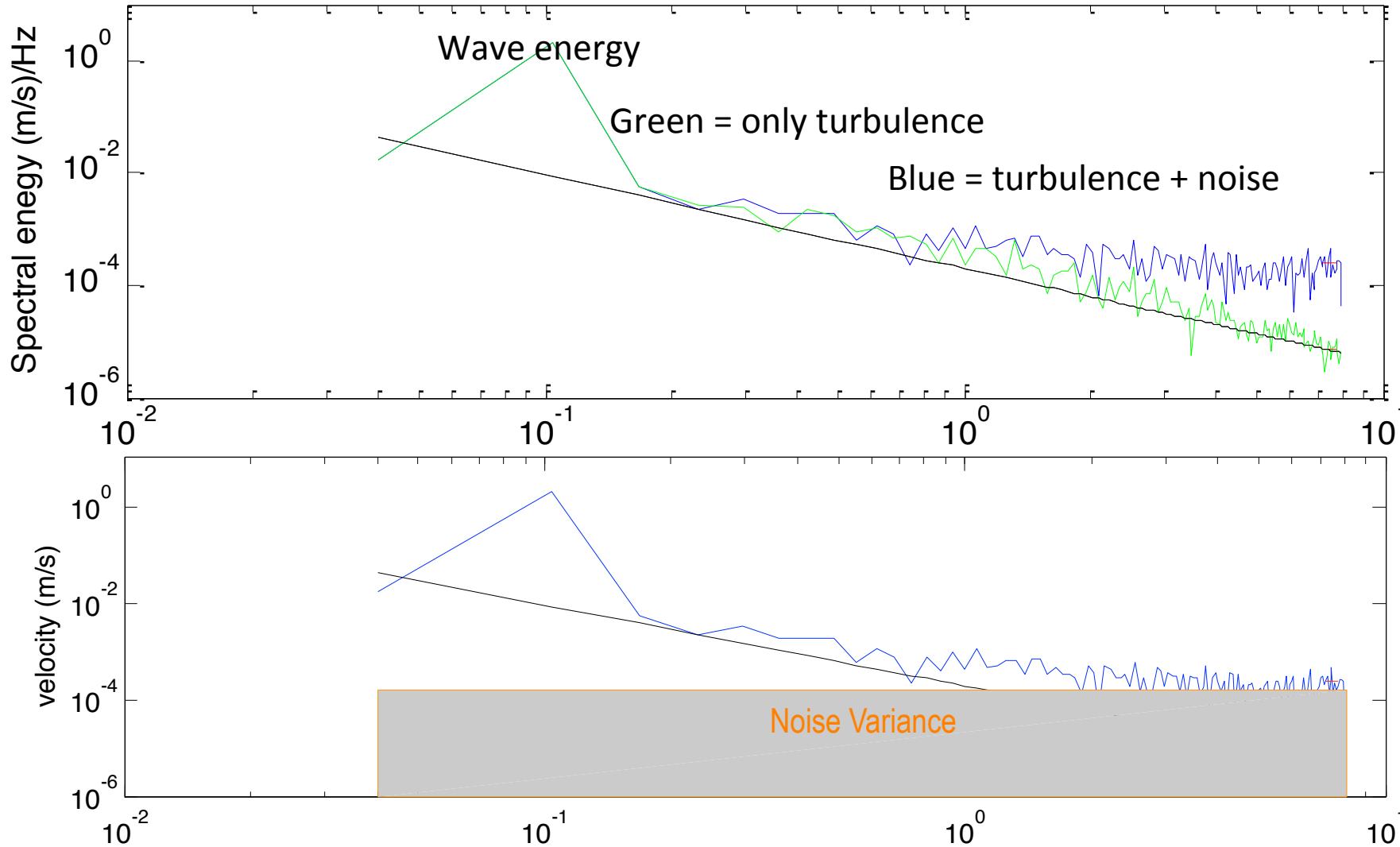
3) Averaging reduces uncertainty

$$\sigma V_{.mean} = \frac{\sigma V_i}{\sqrt{N}}$$

4) Noise spectrum is white



Spectral Analyses



$\text{sqrt}(\text{variance}) =$

“single ping standard deviation”

“velocity uncertainty”

Noise level is primarily determined by processing technique

1. Single monochromatic transmit pulse (“Narrowband”)
2. Repeated, coded pulse (“Broadband”)
3. Short pulses without pulse-to-pulse interference (“Coherent”)

Processing Techniques

Processing techniques	Effect on noise	Instruments
Narrowband (incoherent) <ul style="list-style-type: none"> • Little room for turbulence measurements 	<ul style="list-style-type: none"> • Robust estimator • Optimal range • Measure close to boundaries 	<ul style="list-style-type: none"> • Aquadopp profilers • AWAC
Broadband <ul style="list-style-type: none"> • Small scale variations in areas with “intense” turbulence (BBL, tidal channels, fast sampling) 	<ul style="list-style-type: none"> • Reduces noise variance in spectrum by a factor of 25 (one order for magnitude) 	<ul style="list-style-type: none"> • Signature55, 250, 500/1000, AD2CP Glider
Coherent <ul style="list-style-type: none"> • Profile range limited to lower flow speeds 	<ul style="list-style-type: none"> • Reduces spectral noise level by four orders of magnitude 	<ul style="list-style-type: none"> • Vectrino • Vector • Aquadopp HR Profiler

Correlation, SNR, Uncertainty, Profile Range

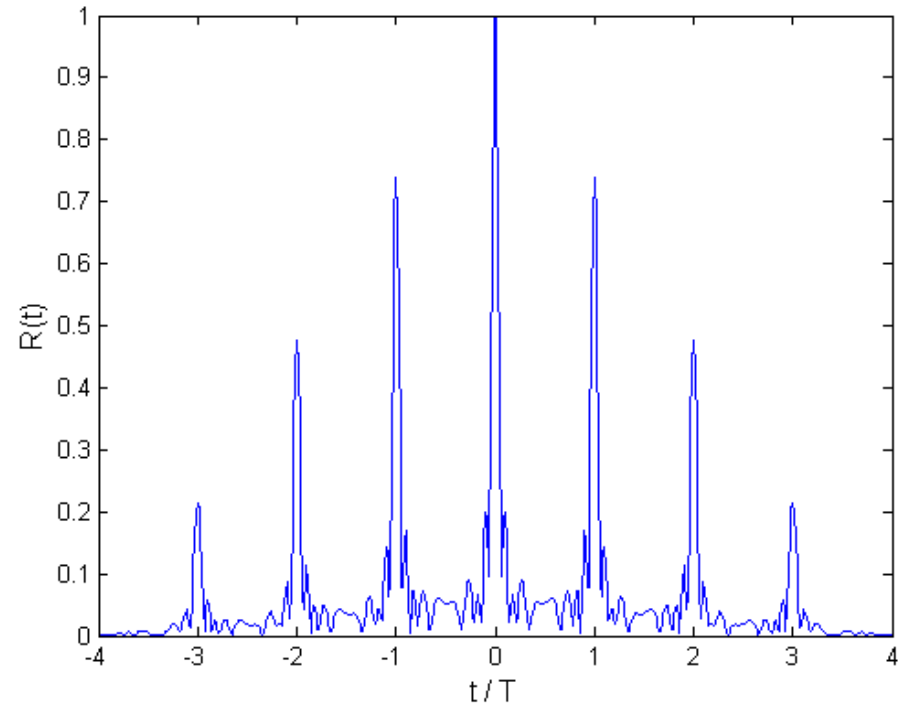
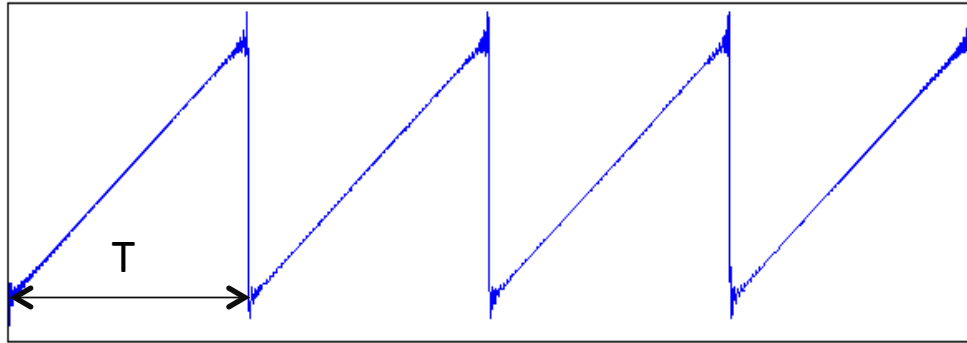
- Correlation – Statistical measure of similarity in behaviour between two observed time series.
- Autocorrelation – Similarity with itself at a delayed time.
- Ideal tool to look for repeating patterns, finding frequencies.

$$R(\tau) = \frac{E[(X_t - \mu)(X_{t+\tau} - \mu)]}{\sigma^2}$$

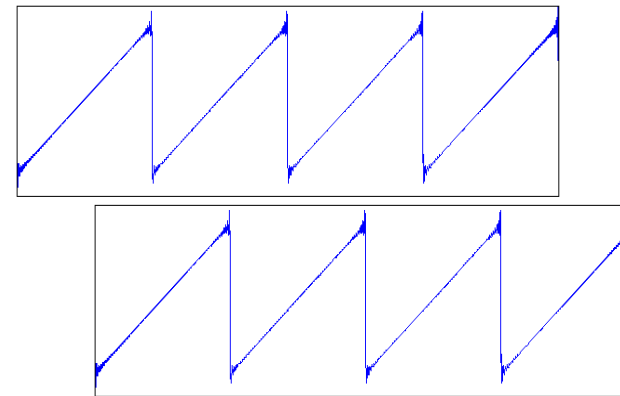
Autocorrelation



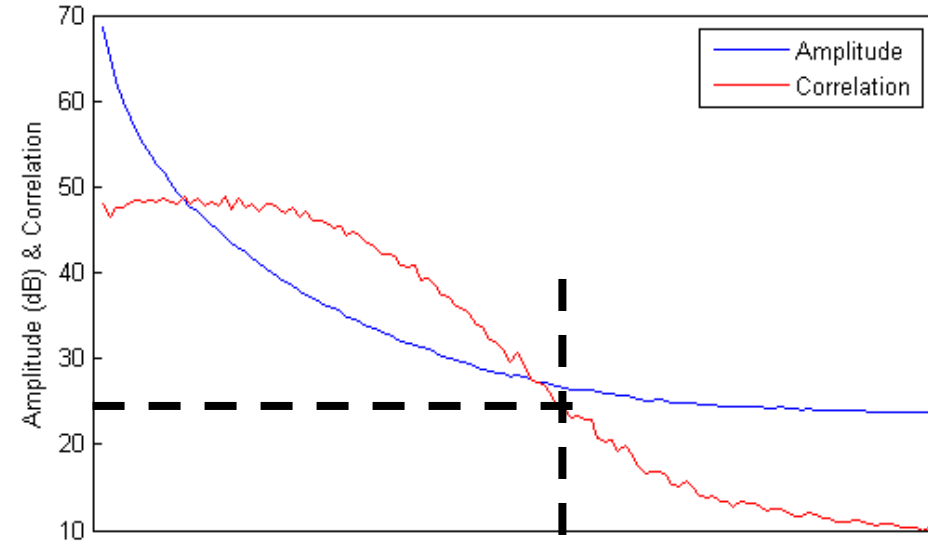
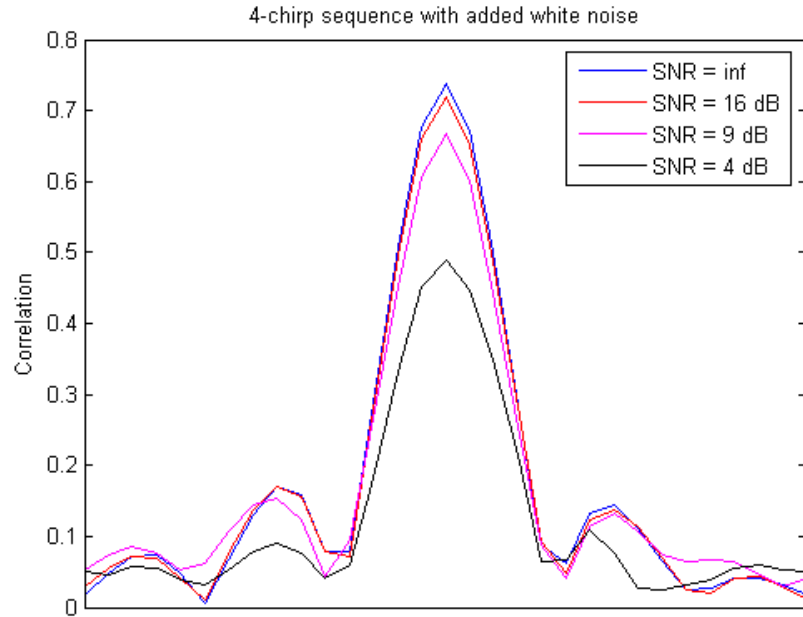
Instantaneous frequency - 4 chirp sequence



- Autocorrelation peaks when the lag equals the signal period ($\tau = T$).
- Position of autocorrelation peak yields Doppler shift.



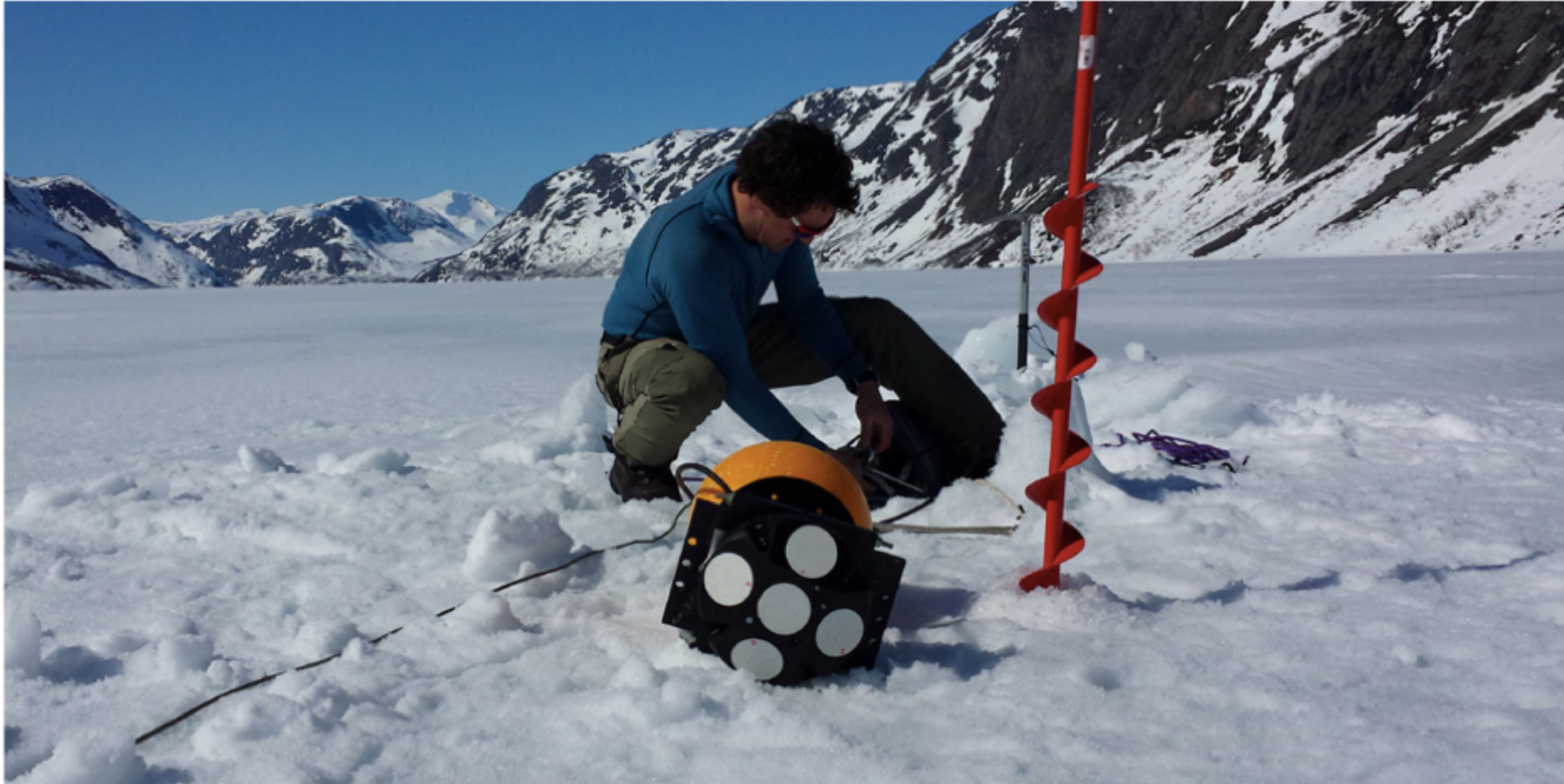
Signal-to-Noise Ratio (SNR)



- Correlation reduces with noise.
- Noise-limited towards end of range.
- Rule of thumb: OK until correlation has dropped by 50%.

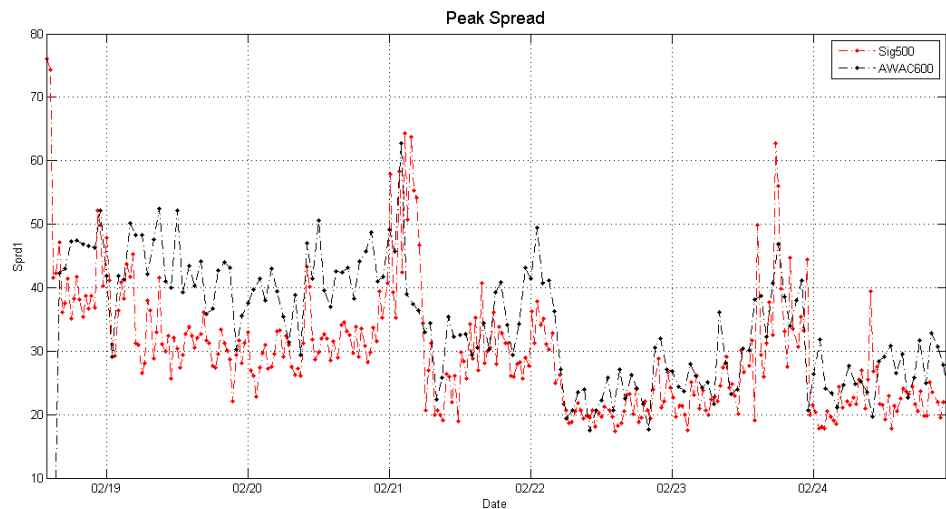
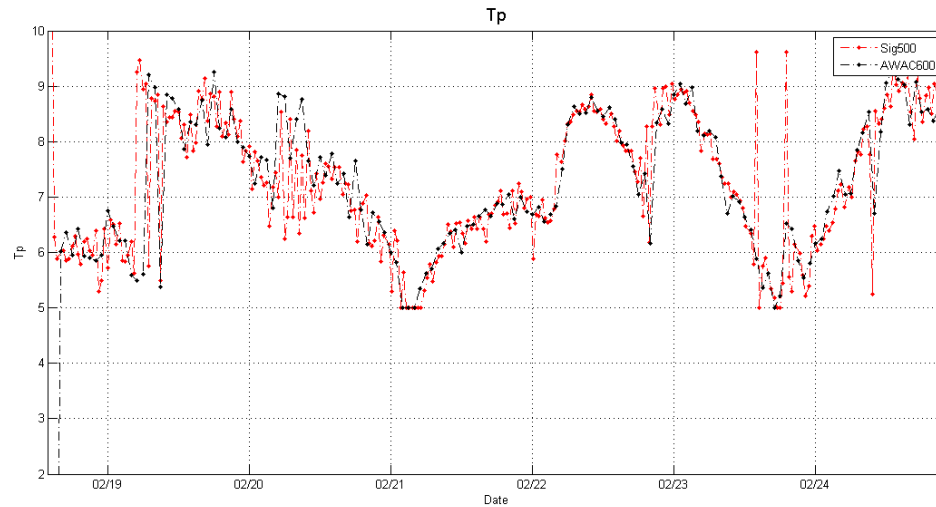
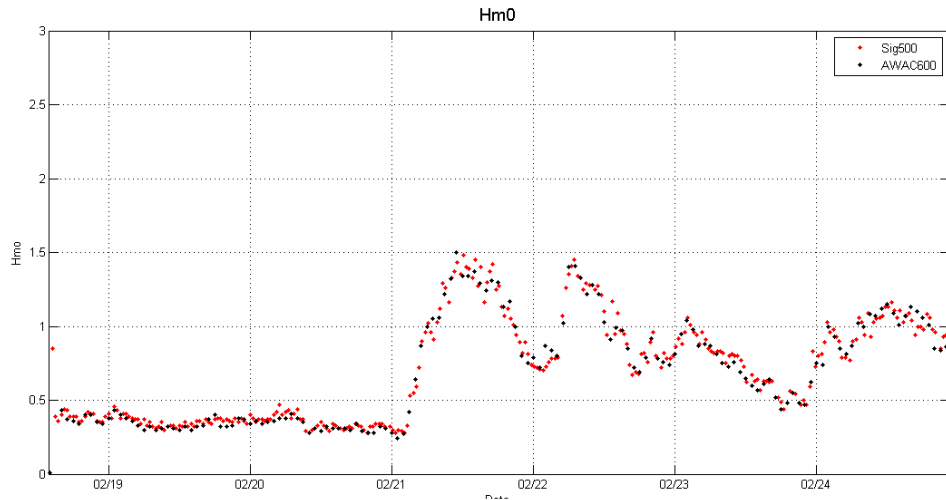


New Opportunities - Ice Measurements



- Ice draft (altimeter)
- Ice tracking (inverted bottom tracking)

New Opportunities - Wave Measurements

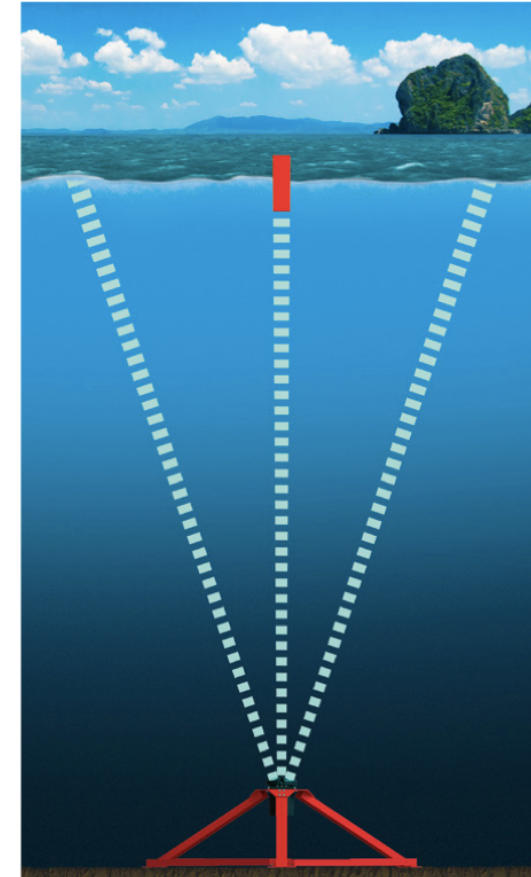


AWAC

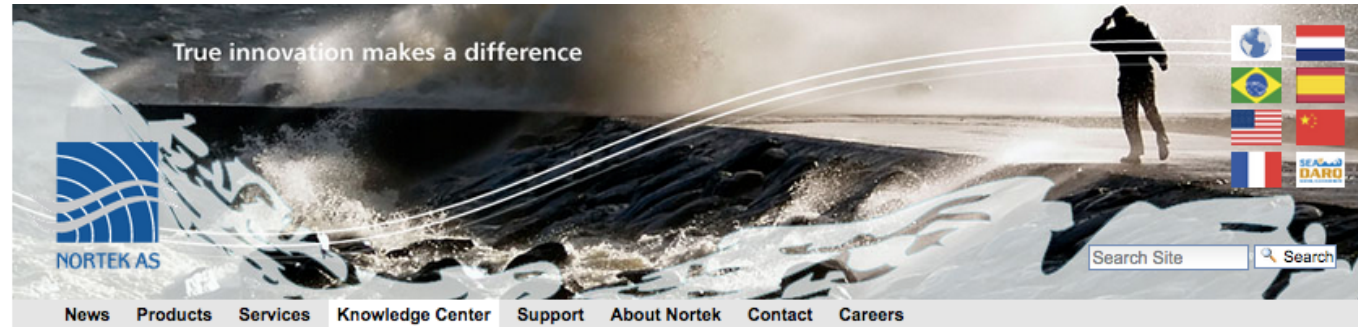
- Still great for waves
- Operational measurements
- Real-time processing / system integration

Signature

- Academic applications
- Measure waves & currents simultaneously



Speaker Series



- Nortek Forum
- Bibliography
- Technical Notes
- Demonstration Videos
- User seminars
- Speaker Series**

Speaker Series



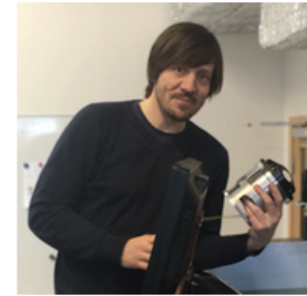
Performance Model for Nortek Signature Series

Live Session: 10 March 2015 [Replay](#)

Audun Ramstad

Development Engineer, Nortek

Oslo, Norway



Introduction to AD2CP turbulence measurements

Live Session: 24 February 2015 [Replay](#)

Atle Lohrmann

Chief Technology Officer, Nortek

Oslo, Norway

