Advanced Coastal, Lab and Turbulence Studies

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Measurements of the Schmidt Number in an Oscillating Grid Turbulence Tank

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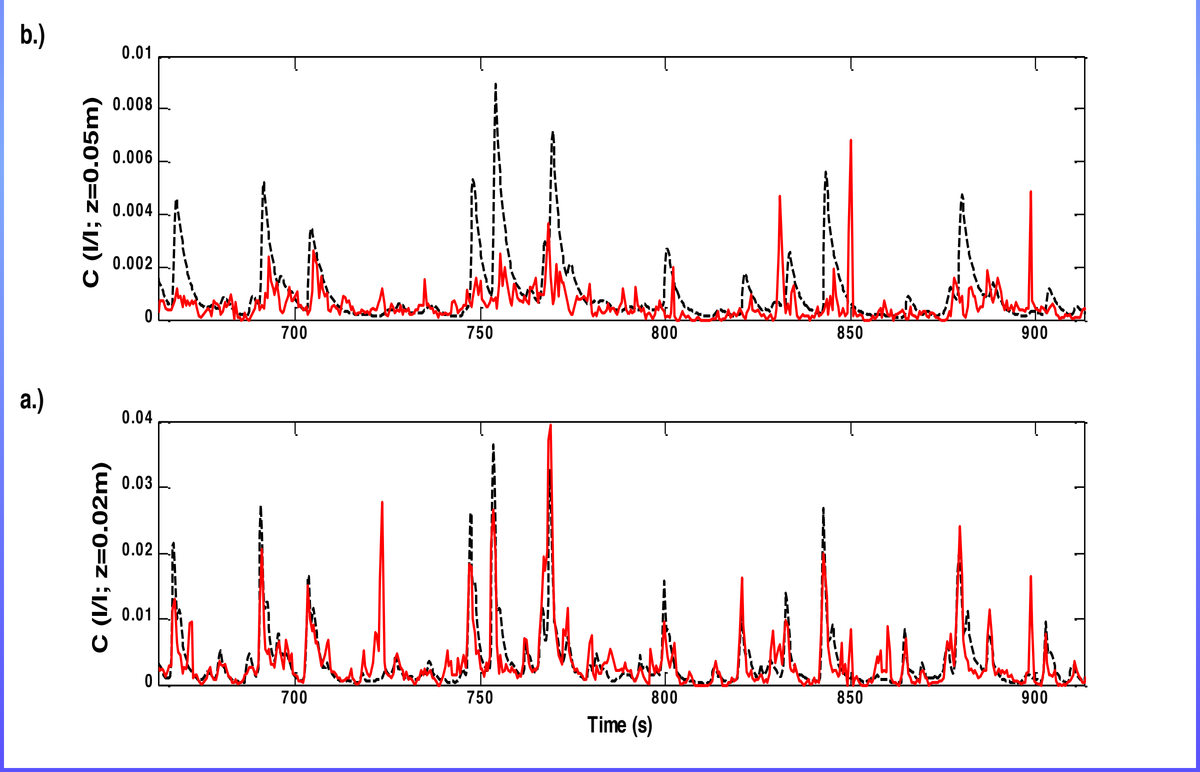
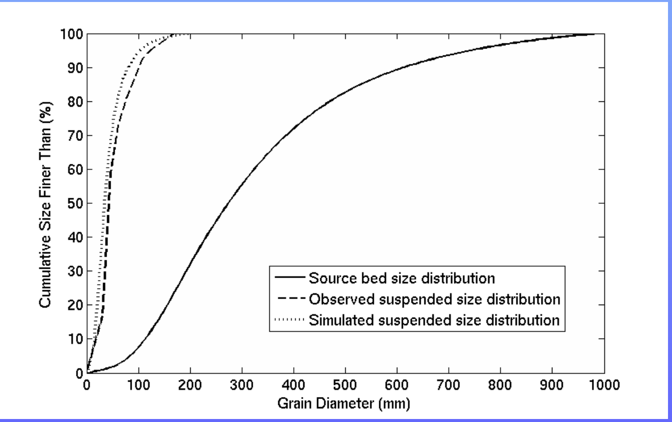
Advection Diffusion Simulations

$$\frac{\partial C_i}{\partial t} - \frac{\partial}{\partial z}\left[\mu_S \frac{\partial C_i}{\partial z}\right] = w_{s\,i}\frac{\partial C_i}{\partial z}$$





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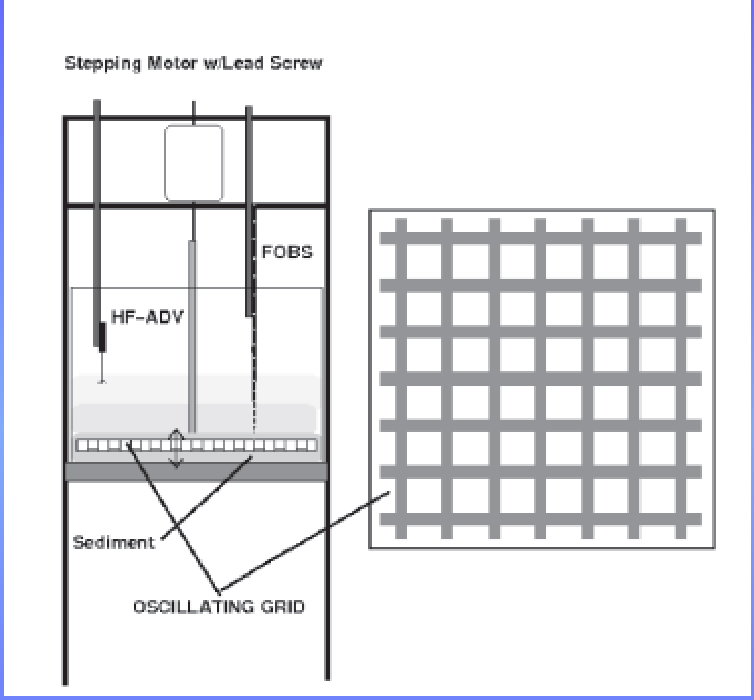
Turbulent Schmidt number for Sediments

$$\mu_S = \frac{1}{\beta} c_\mu^S \sqrt{k} L$$

$$\beta = \frac{\nu_T}{\mu_S}$$

Laboratory Approach



Dependence on:

- *grain size,*
- *Density*
- *Re*

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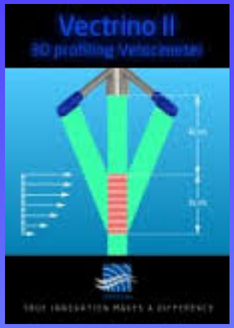
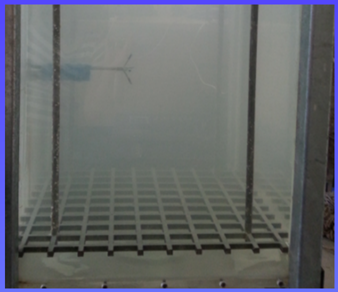
Laboratory Methodology



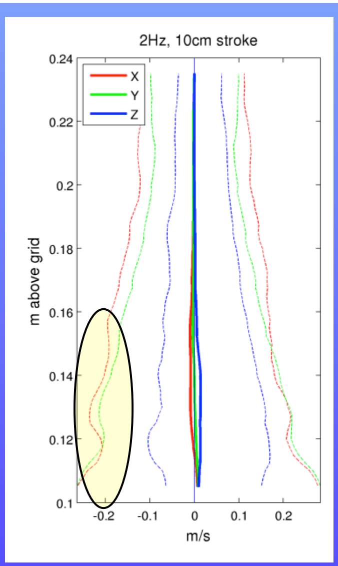


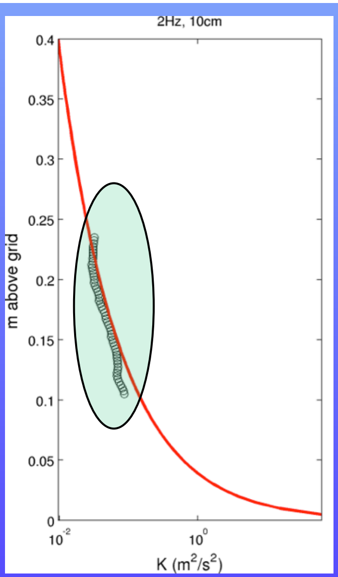
- Measurements with Vectrino II
- Vertical profiles of TKE (*zero mean shear, Isotropic turbulence, steady state*)
- Turbulent viscosity:

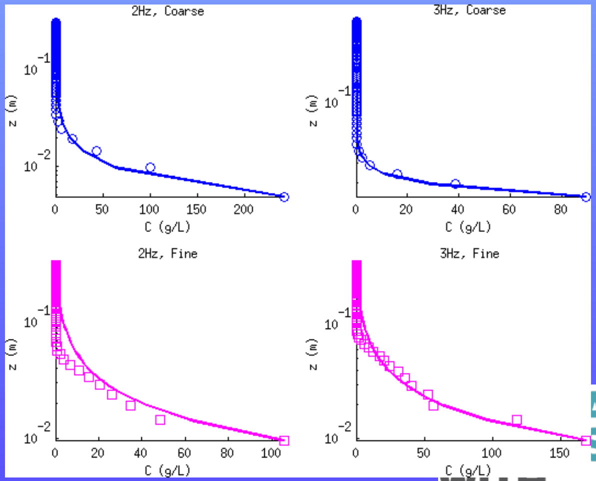
$$\nu_T = C_\mu \frac{k^2}{\varepsilon}; \quad \varepsilon = C_\mu^{3/4} \frac{k^{3/2}}{l}; \quad l = 0.1z$$

- C profile from pump samples
- Sediment Diffusivity:

$$\mu_S = \frac{-w_s \overline{C}}{\partial C / \partial z}$$



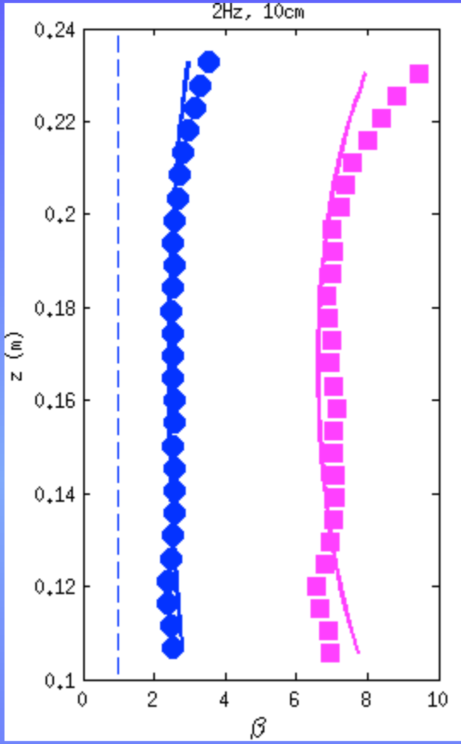




FINE

COARSE

Preliminary Results (ICCE 2012)



Points of Interest:

- β > 1
- Values may be constant
- β is higher for finer sediments?

Proposed Refinements:

- Determine ε experimentally
  - Spectral slope
  - Structure function (2nd)
- Eliminate mechanical noise

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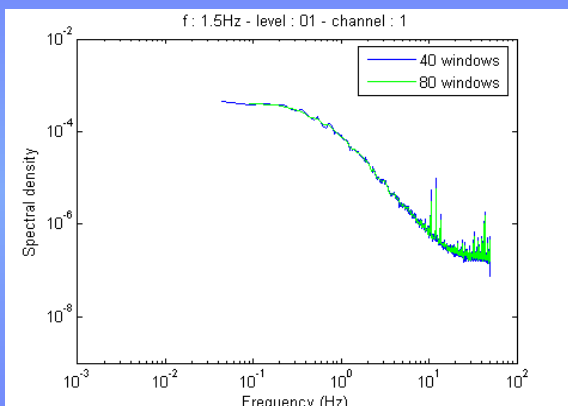
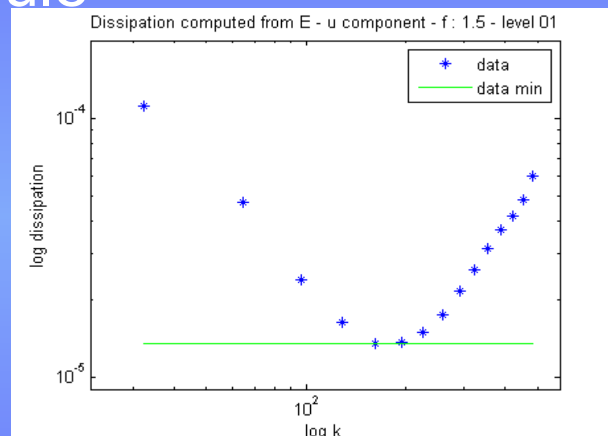
Spectral Slope

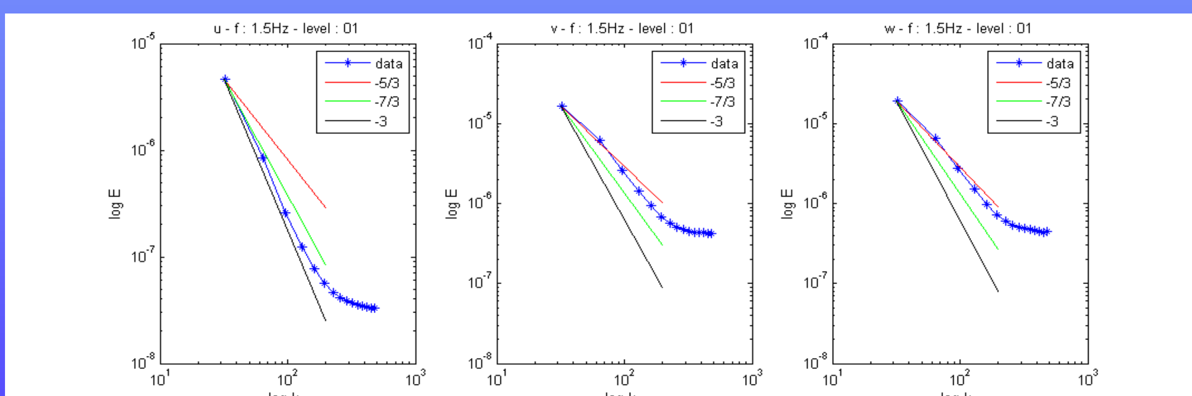
Kolmogorov turbulence theory suggests that in the inertial subrange the energy transfer across scales should follow the -5/3 rule

$$E(k) = C\varepsilon^{2/3} k^{-5/3}$$





There are numerous discussions as to why the energy transfer occurs at other slopes in special situations but the isotropic homogenous turbulence conditions with ideal measuring tool makes these results unfortunate.



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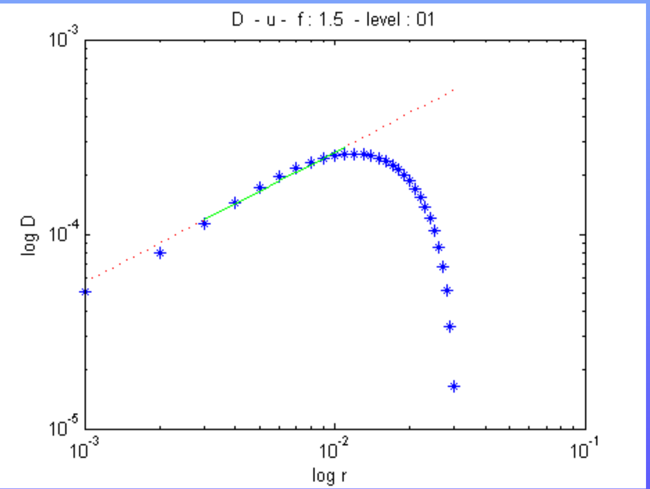
2^{nd} Order Structure Function

$$D_{ii}(r) = \left\langle \left[u'(x+r,t) - u'(x,t) \right]^2 \right\rangle$$

$$\varepsilon = \left(\frac{D_{11}(r)}{C_2 r^{2/3}} \right)^{3/2}$$



- There is a more satisfying fit to slope for the structure function than there is for the spectral slope
- Fit is typically good for a small number of ranges in the middle of results.
- Dissipation so calculated is O(5) times greater than minimum value from spectral slope.

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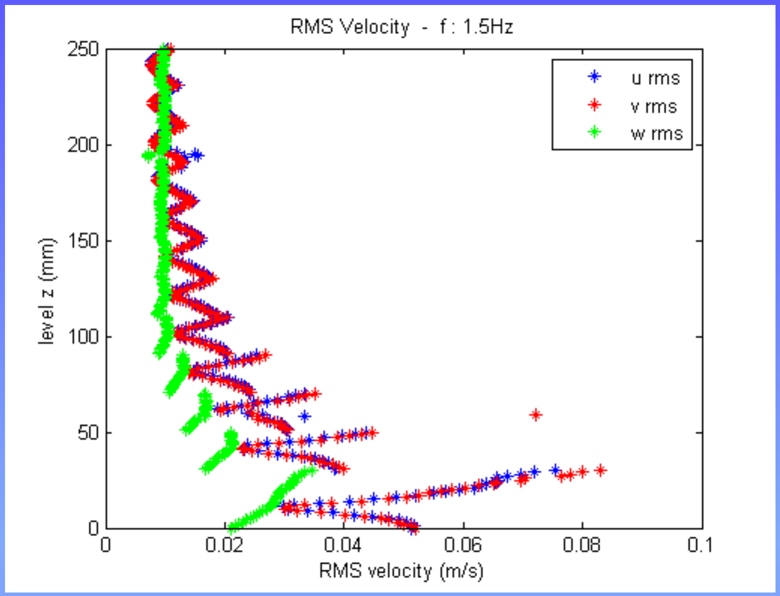
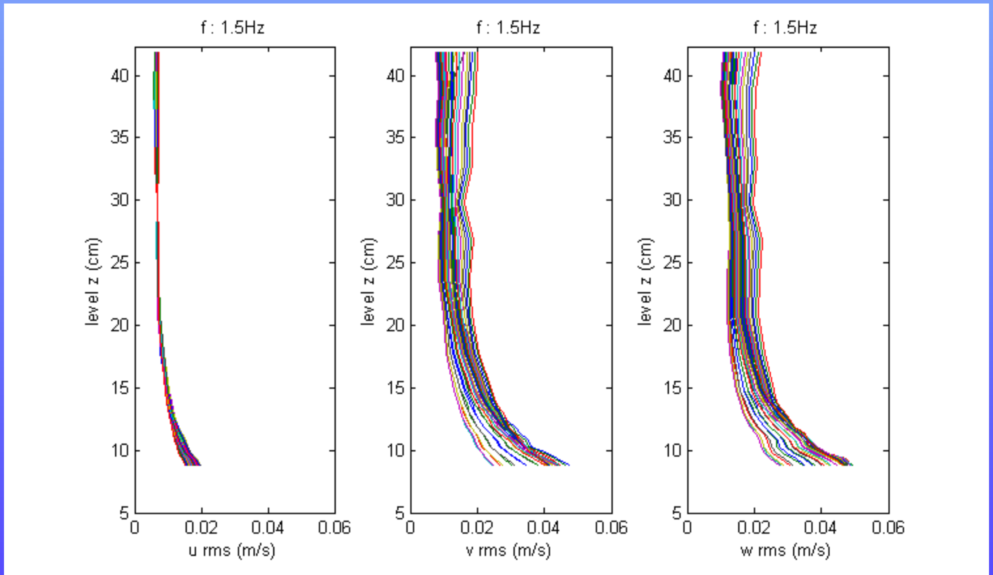
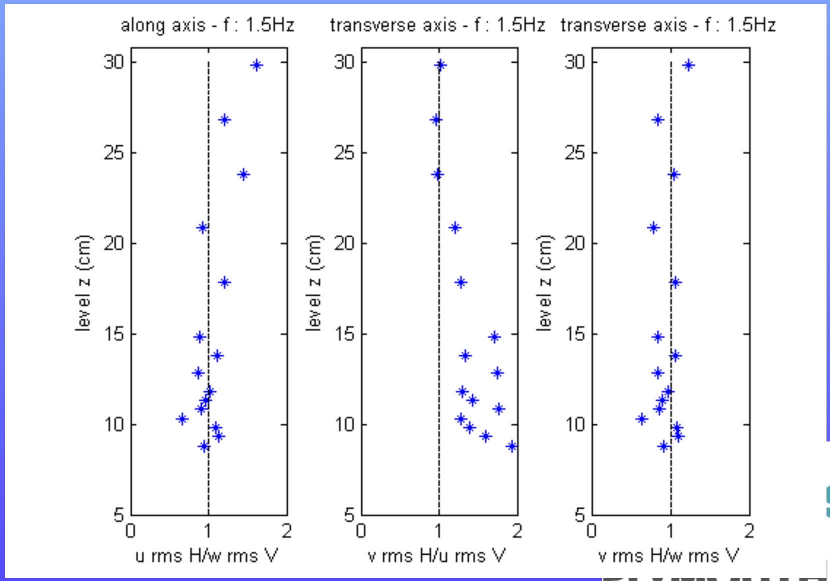
Measurement Issues

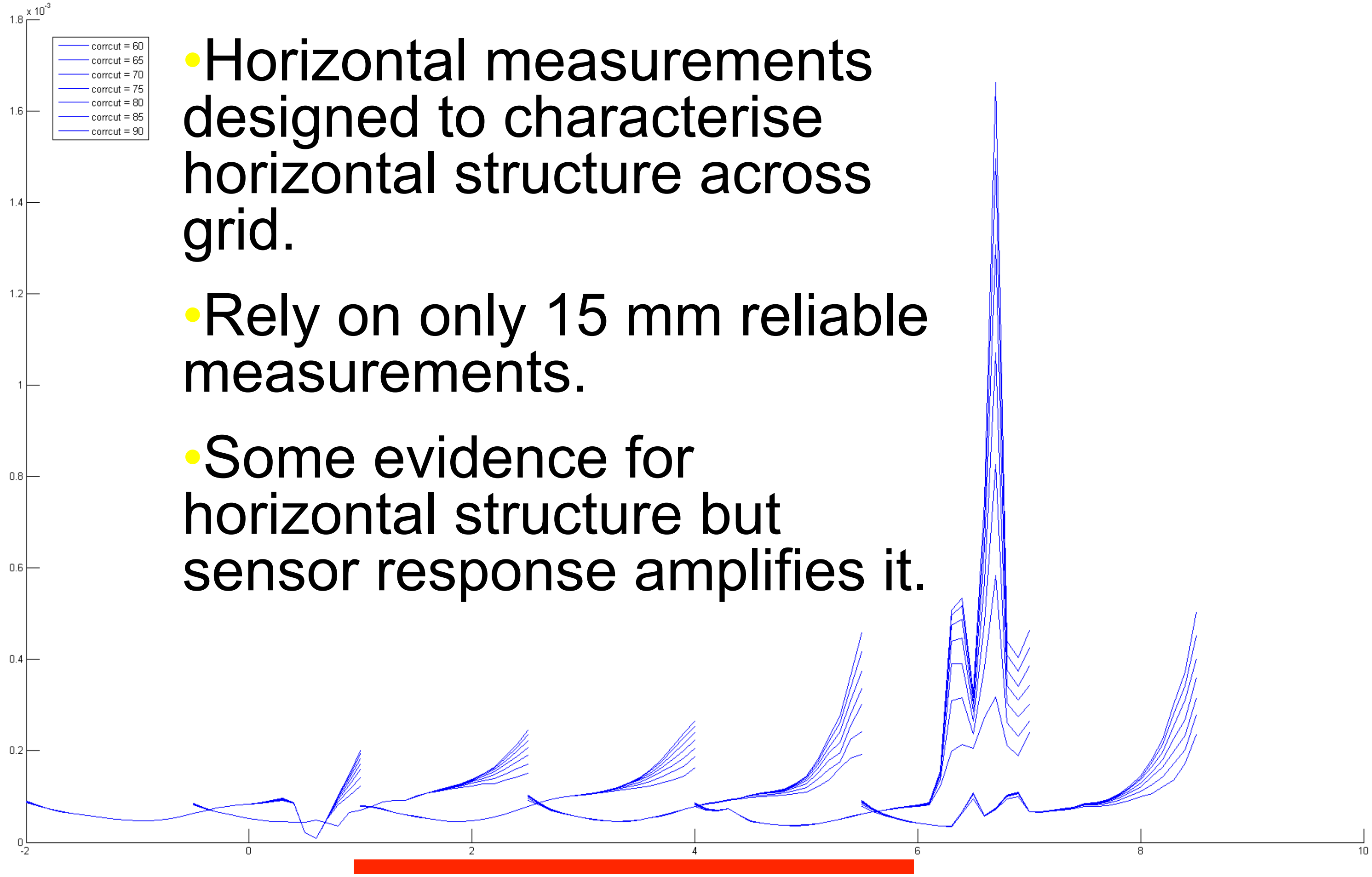
- Vectrino response exhibits a “hockey stick”.
- Reduced for measurement aligned with sensor axis.
- Concept of isotropy is supported when conistent measurements used.
- Sensor vibrations?







Independent Sensor Mounting Structure



- Horizontal measurements designed to characterise horizontal structure across grid.
- Rely on only 15 mm reliable measurements.
- Some evidence for horizontal structure but sensor response amplifies it.

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QUESTIONS?

- Sensor response with distance?
- Response of different channels?

What role do these have in:

- Absence of =5/3 spectral slope?
- Minimal structure function agreement?

- How to use theories designed for mean shear flows?

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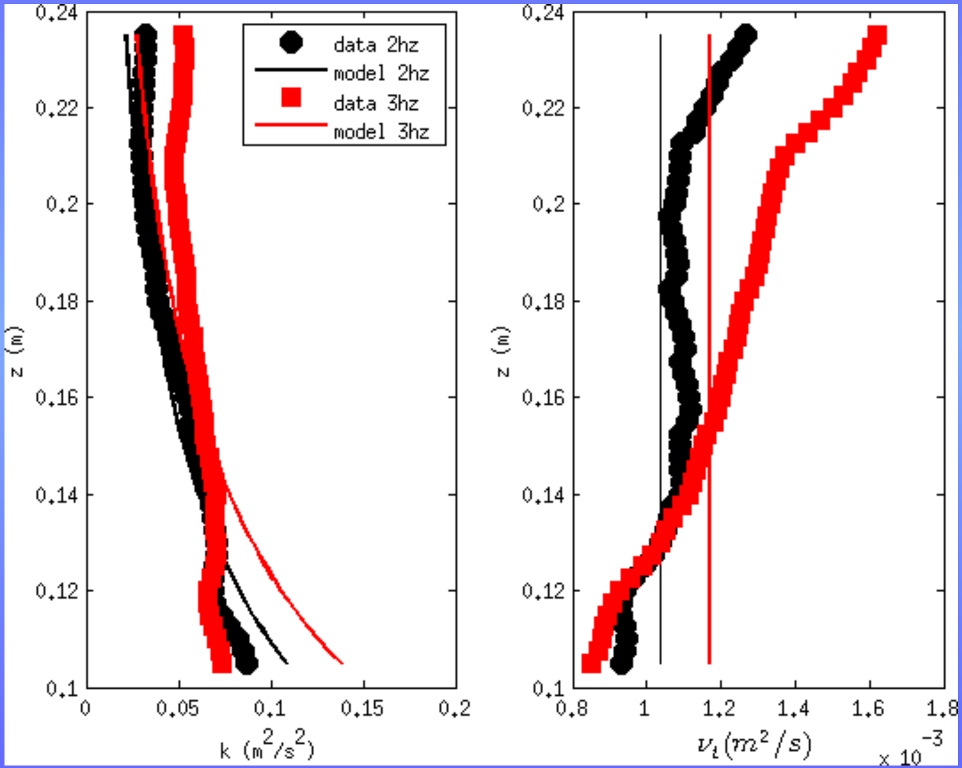

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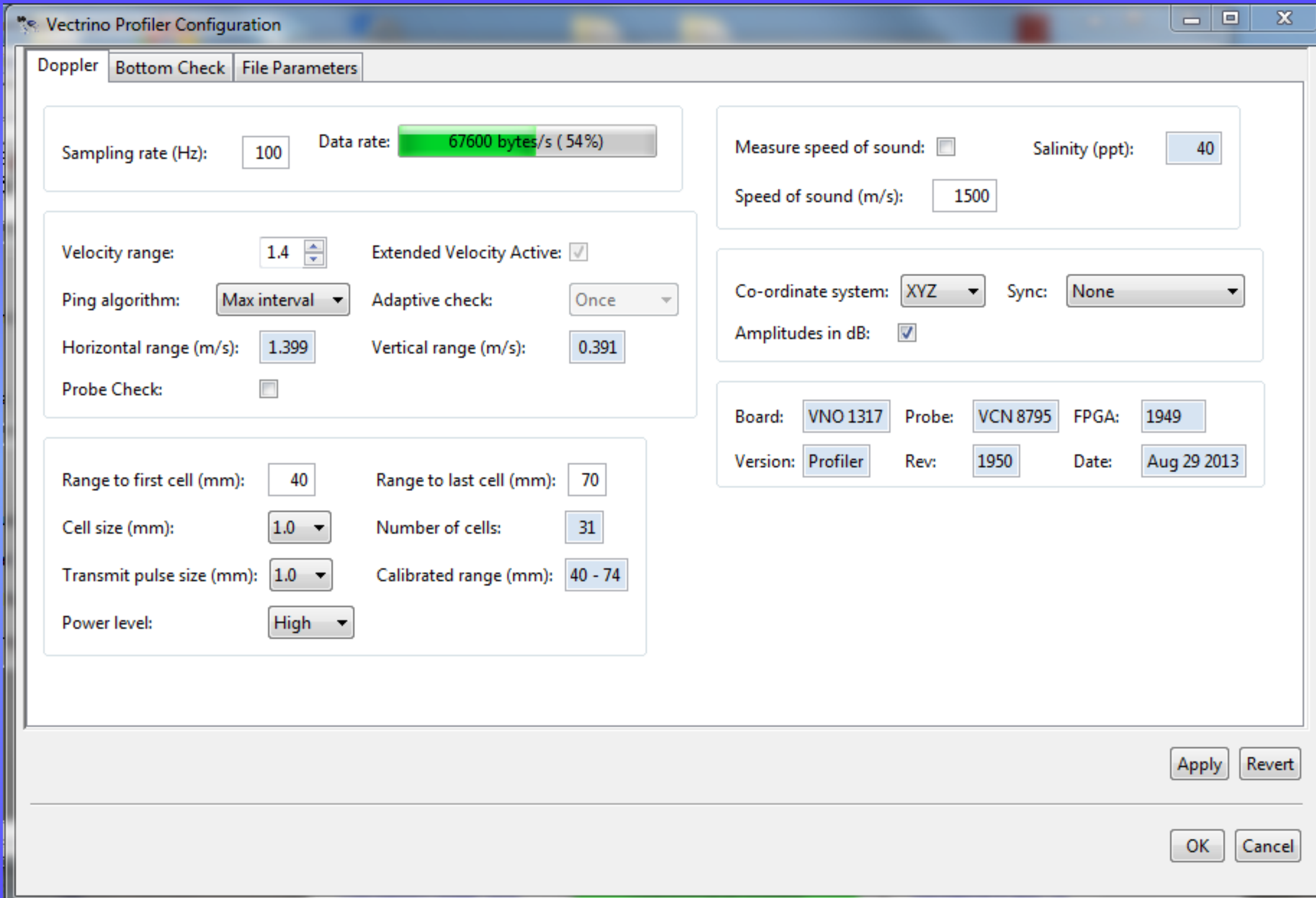

Vectrino Profiler Configuration
Doppler
Bottom Check
File Parameters
Sampling rate (Hz):
100
Data rate:
67600 bytes/s (54%)
Velocity range:
1.4
Extended Velocity Active:
Ping algorithm:
Max interval
Adaptive check:
Once
Horizontal range (m/s):
1.399
Vertical range (m/s):
0.391
Probe Check:
Range to first cell (mm):
40
Range to last cell (mm):
70
Cell size (mm):
1.0
Number of cells:
31
Transmit pulse size (mm):
1.0
Calibrated range (mm):
40 - 74
Power level:
High
Measure speed of sound:
Salinity (ppt):
40
Speed of sound (m/s):
1500
Co-ordinate system:
XYZ
Sync:
None
Amplitudes in dB:
Board:
VNO 1317
Probe:
VCN 8795
FPGA:
1949
Version:
Profiler
Rev:
1950
Date:
Aug 29 2013
Apply
Revert
OK
Cancel