

Sediment Resuspension and Bed Morphology in Highly Turbulent Flows

Blair A. Johnson, Edwin A. Cowen
DeFrees Hydraulics Laboratory
School of Civil & Environmental Engineering
Cornell University



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Motivation & Objectives

Goal: Isolate turbulence absent shear to study mechanisms of sediment resuspension



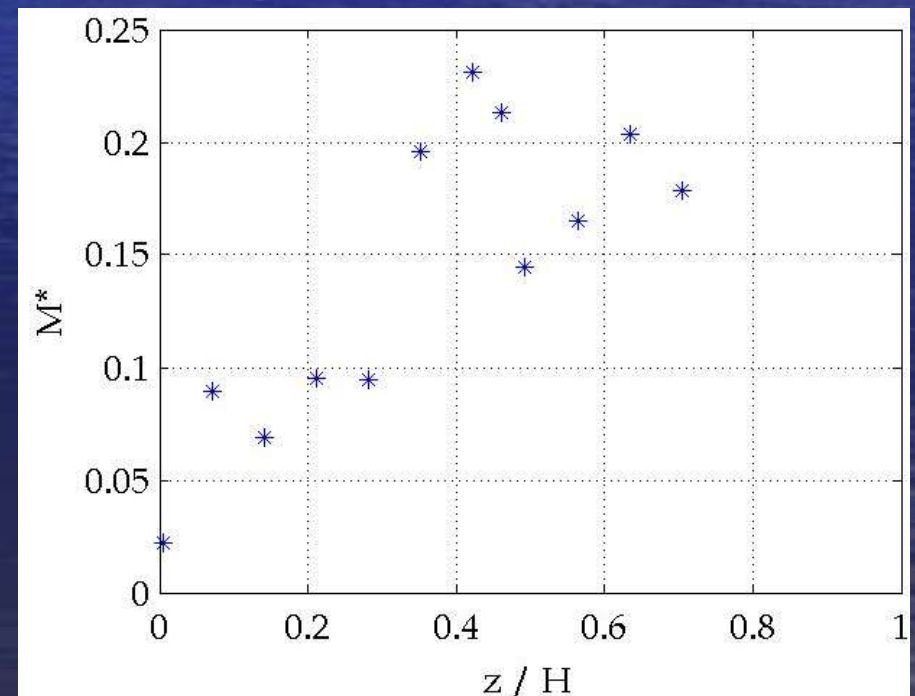
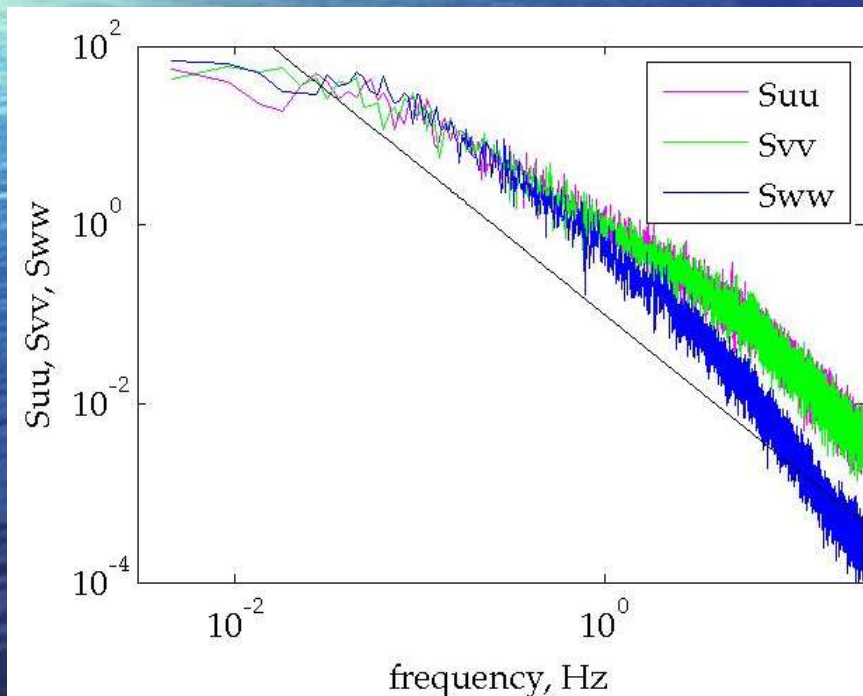
Generation of Turbulence Absent Mean Shear



- 82cm x 82cm x 100cm
- Glass or sediment ($D_{50} = 260\mu\text{m}$) bed
- 64 jets, 8x8 grid
- 12-volt bilge pumps, 2.19cm diameter
- 10cm jet spacing
- Adjustable jet height

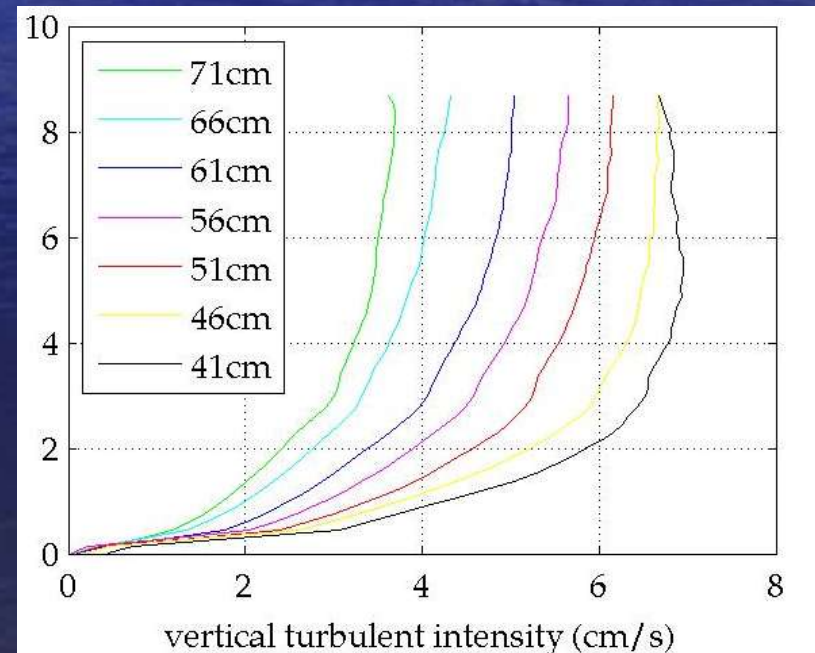
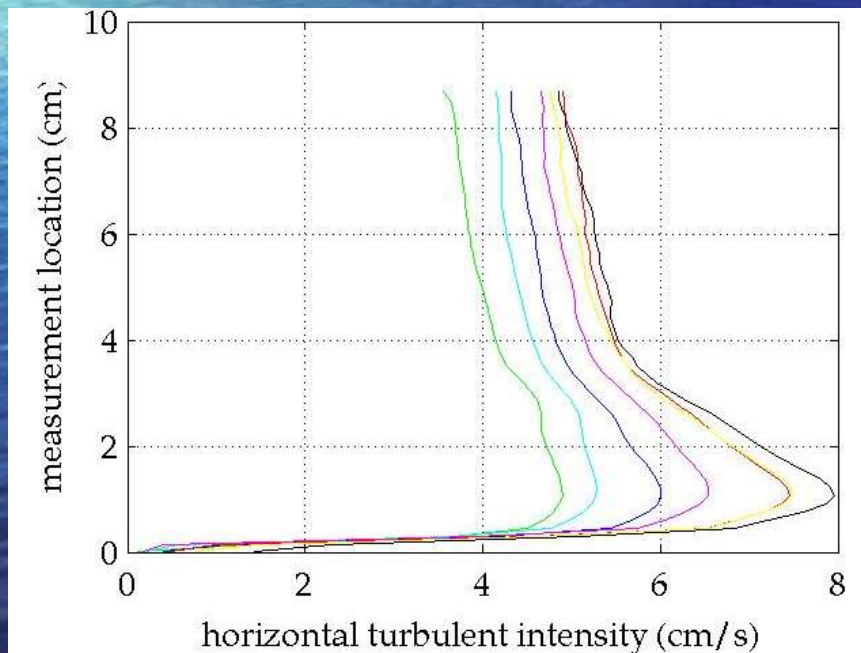
Characterization of Tank

- Nortek Vectrino Acoustic Doppler Velocimeter (ADV)
- 40 minute record, 50Hz sampling rate
- $M^* = \text{secondary mean flow strength} = \text{MKE/TKE}$



Turbulence at an Impermeable Bed: Altering Jet Heights

- 30 minute Particle Image Velocimetry (PIV)
- 1Hz sampling, Δt 7ms, 10cm field of view
- T.I. = $\langle u'^2 \rangle^{1/2}$



Evolution of Sand Bed

Initial



15 minutes

1/2 hour



1 hour

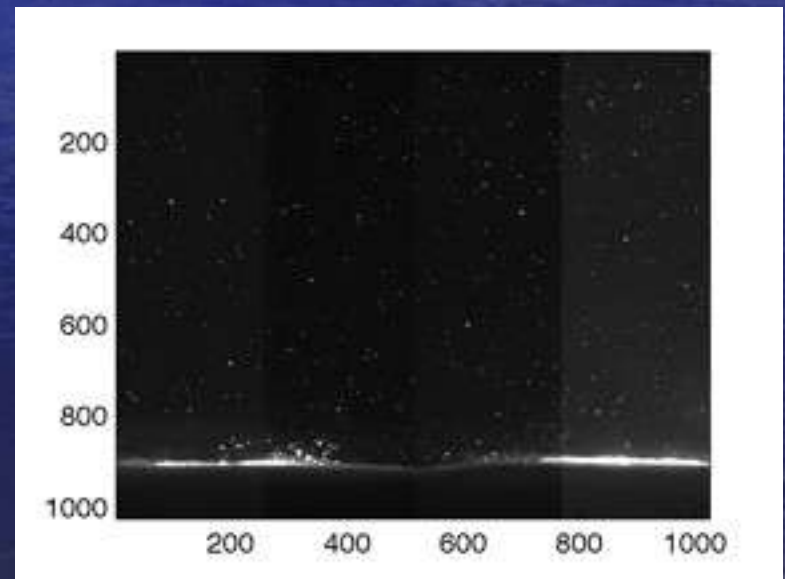
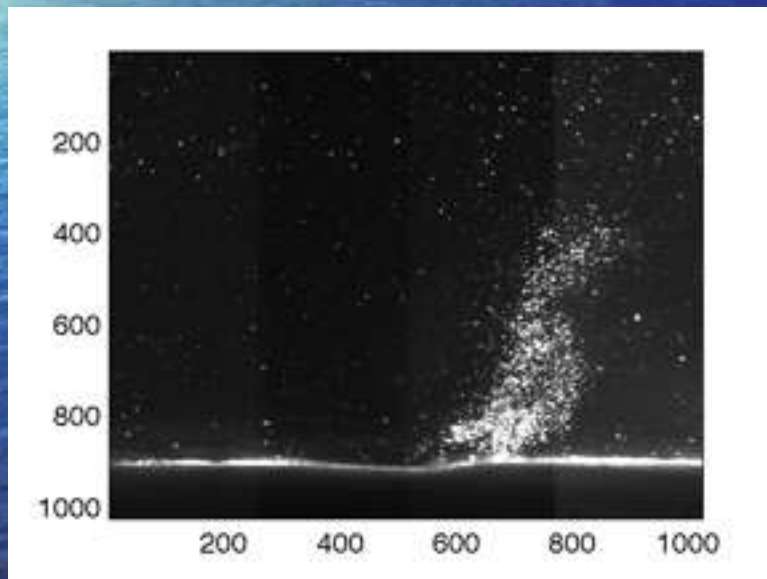
2 hours



4 hours

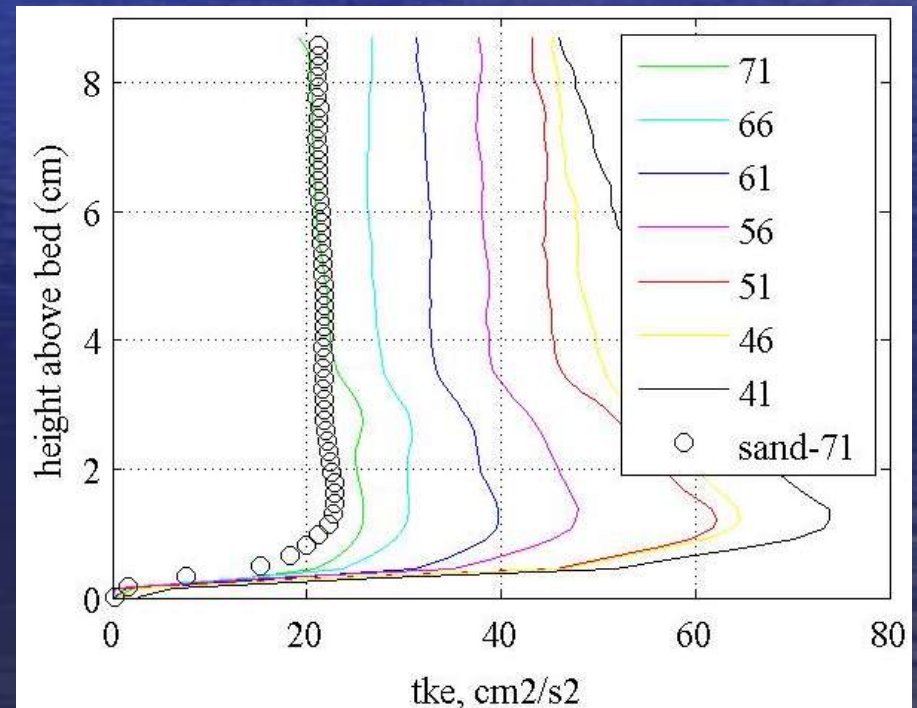
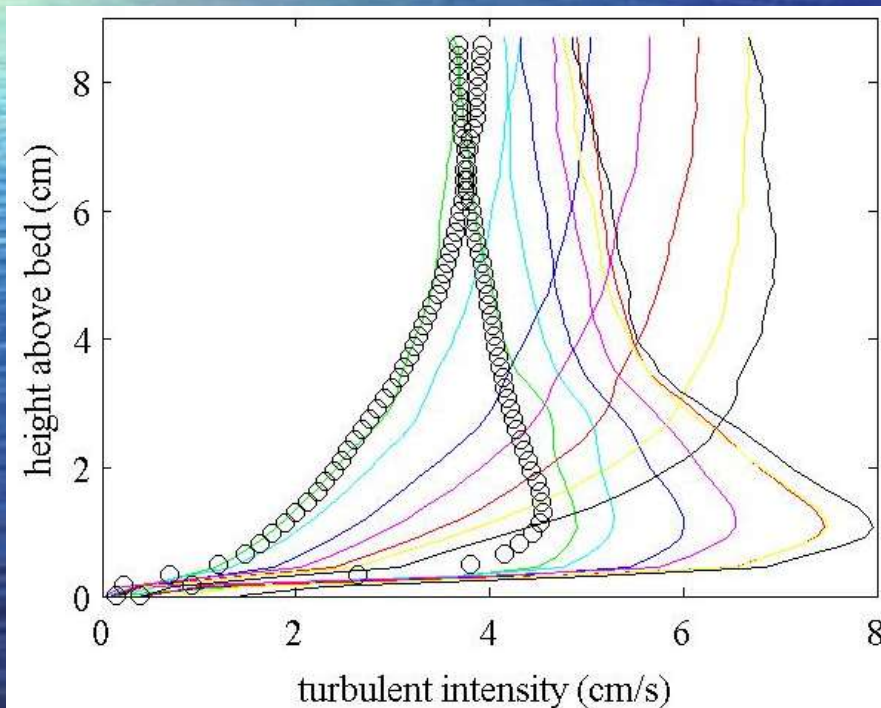
Observed Resuspension

- 10cm PIV image of vertical vortex (left),
- Bed-parallel splat / anti-splat (right)

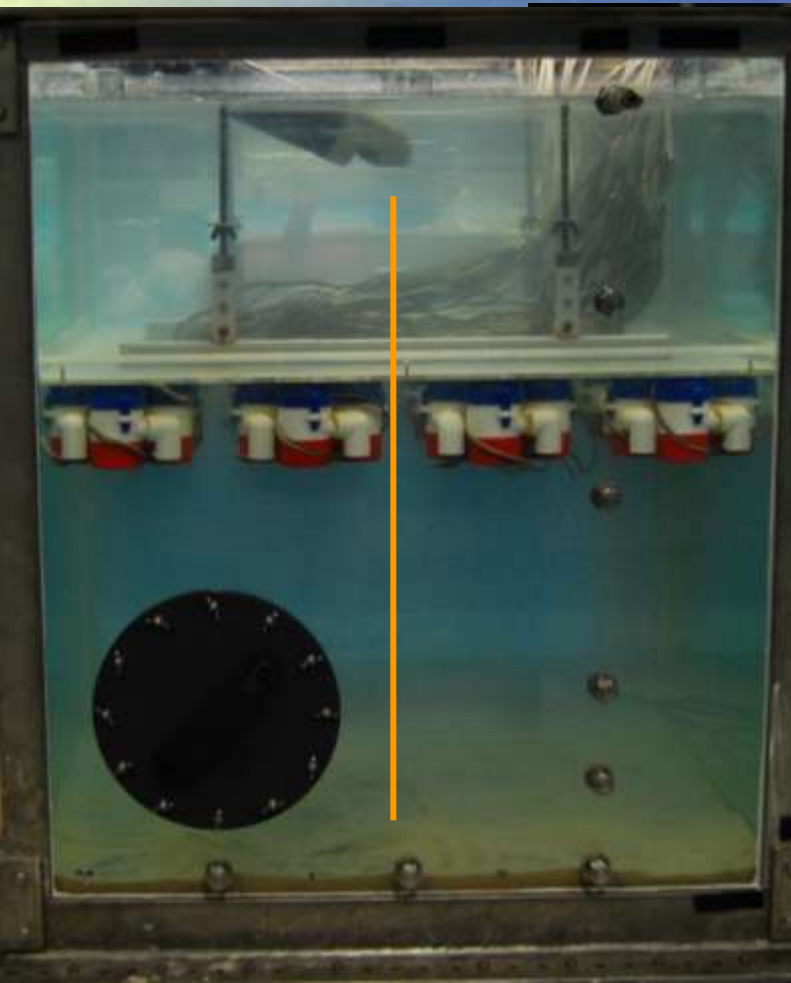


Turbulence Above Sand Bed

- Turbulent Intensity and Turbulent Kinetic Energy of sediment and solid boundaries

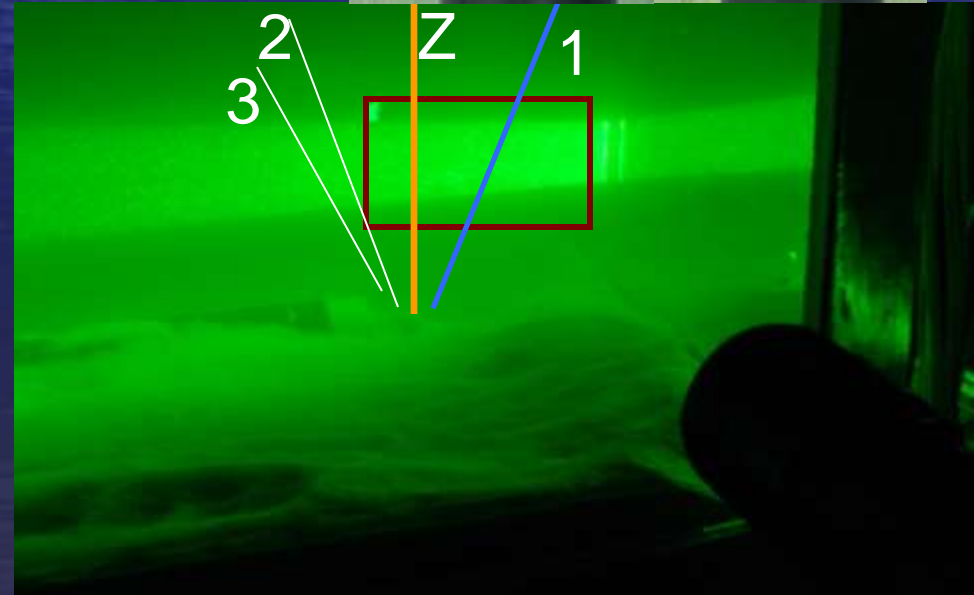


Nortek Aquadopp HR Profiler: Vertical Mount for Center Profiles



HR Profiler: Bed-mount with PIV

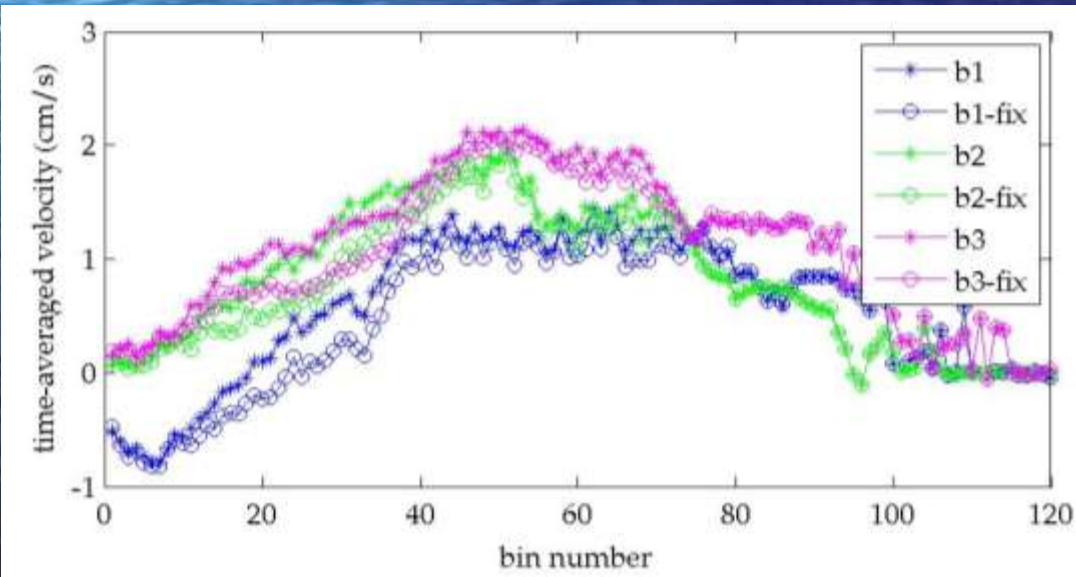
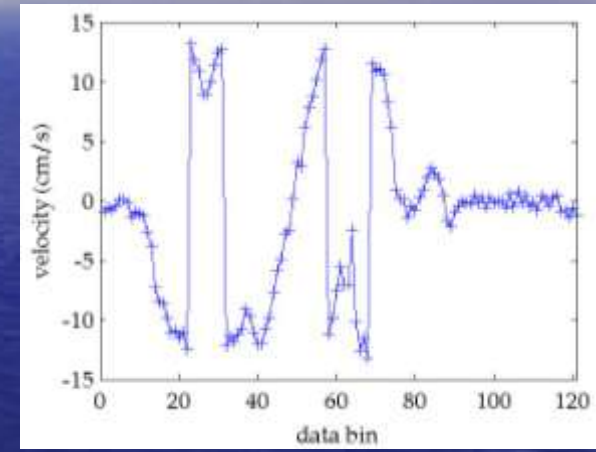
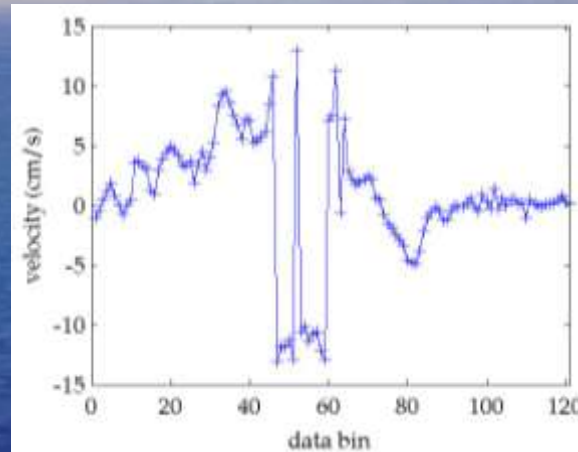
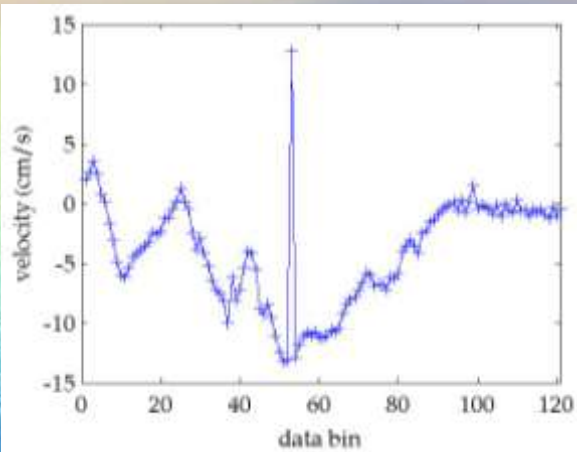
- Upward-facing Profiler
- Near-wall FOV in decaying homogeneous turbulence
- Beam and 3-D velocity comparisons
- 30-minute record
- 1Hz sampling
- 4cm x 6cm FOV



HR Profiler Data Acquisition

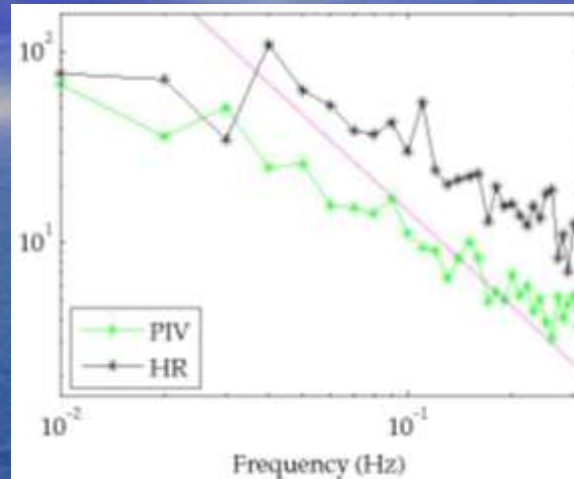
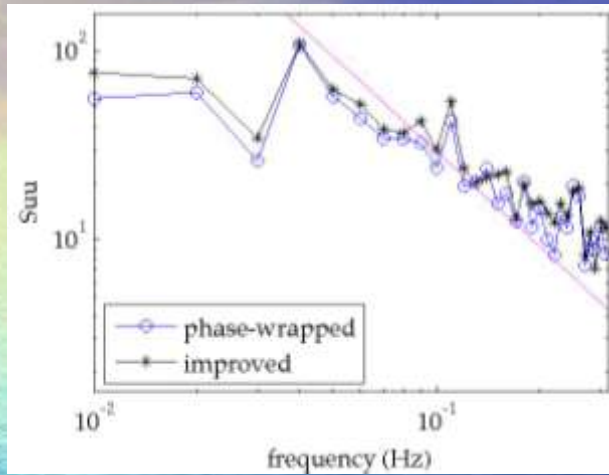
- Measurement volume 7mm over 1m length
- Sampling rate 1Hz, 30-minute data record
- Blanking distance of 10cm from instrument head
- Maximum velocity range ~13 cm/s
- Beam coordinates with XYZ post-processing
- Measurements “in” sediment recorded; identified boundary position with amplitude and correlation measurements

Phase-wrapping: velocity effects



20% of data affected
Mean velocity:
2% absolute error
typical error of -0.3 cm/s

Phase-wrapping: energy effects

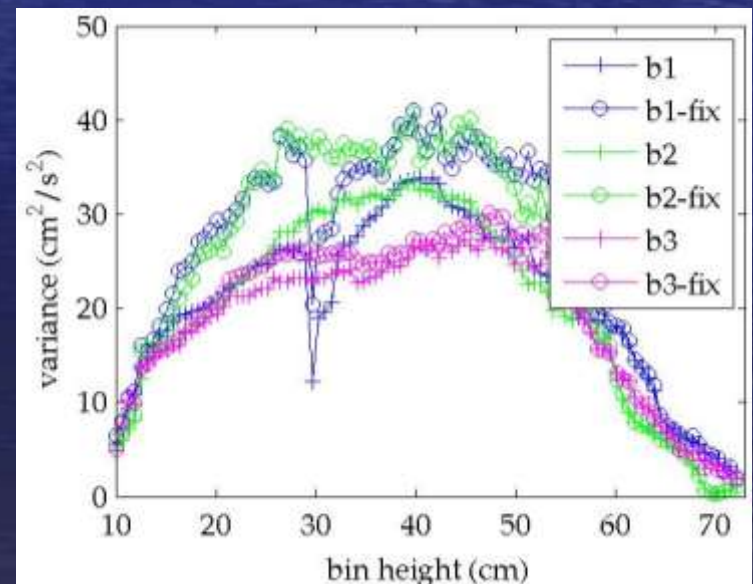


HR spectra 3x greater than PIV spectra;
significant noise floor

Spectra before/after:

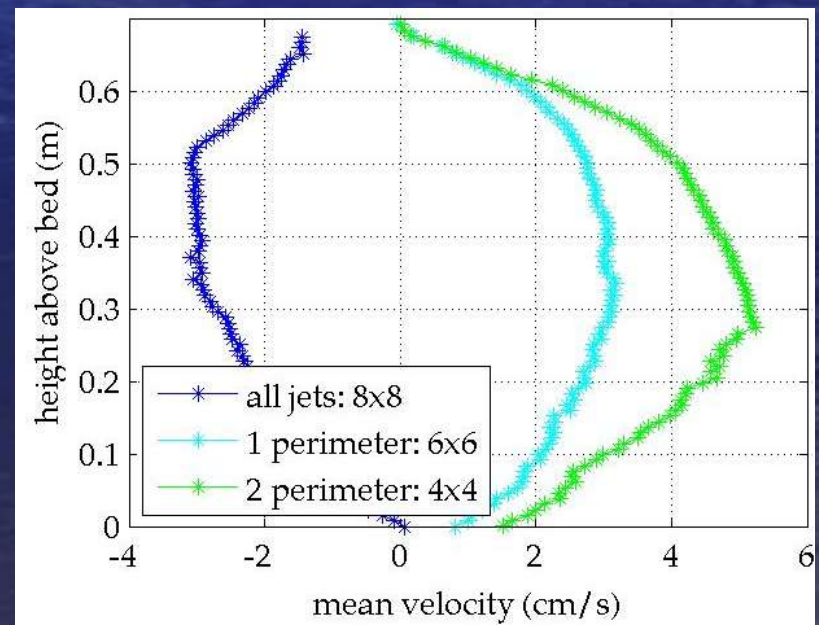
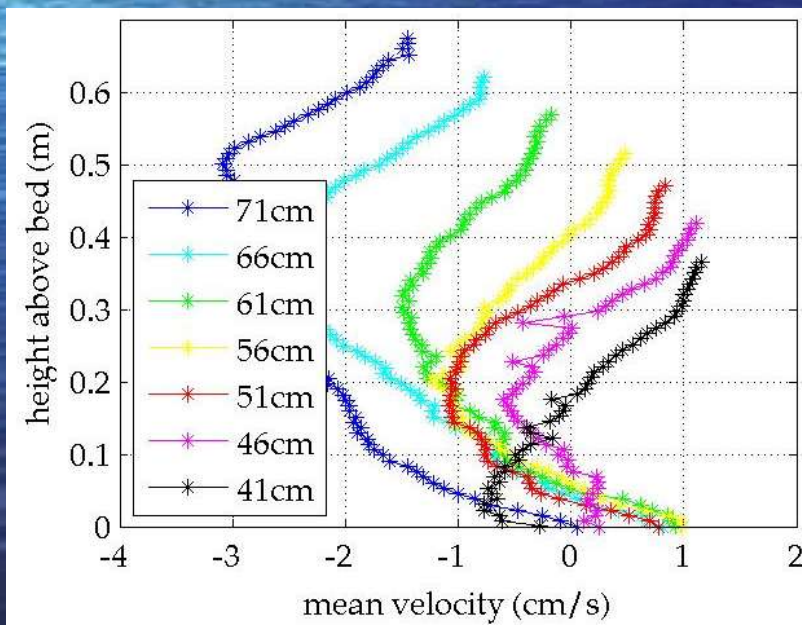
- * similar slope & structure
- * slightly greater magnitude

Variance increase by 20% after removing phase-wrapping



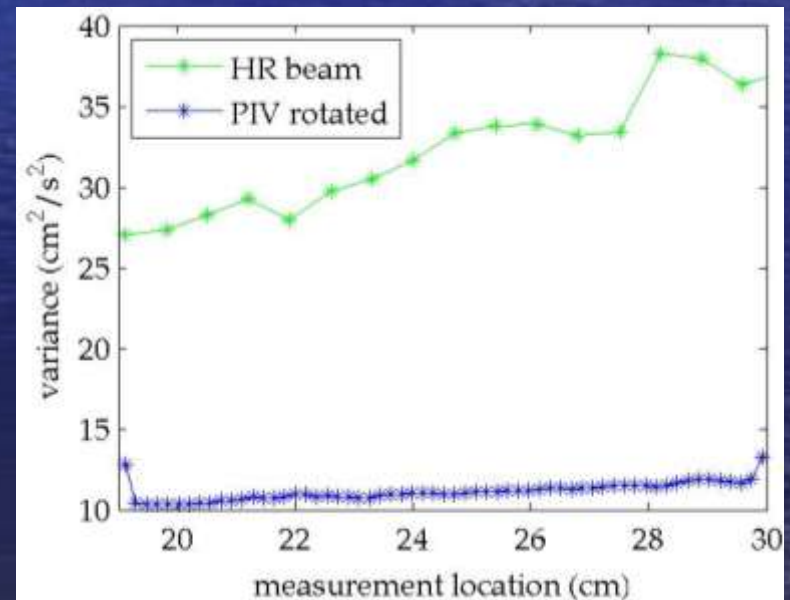
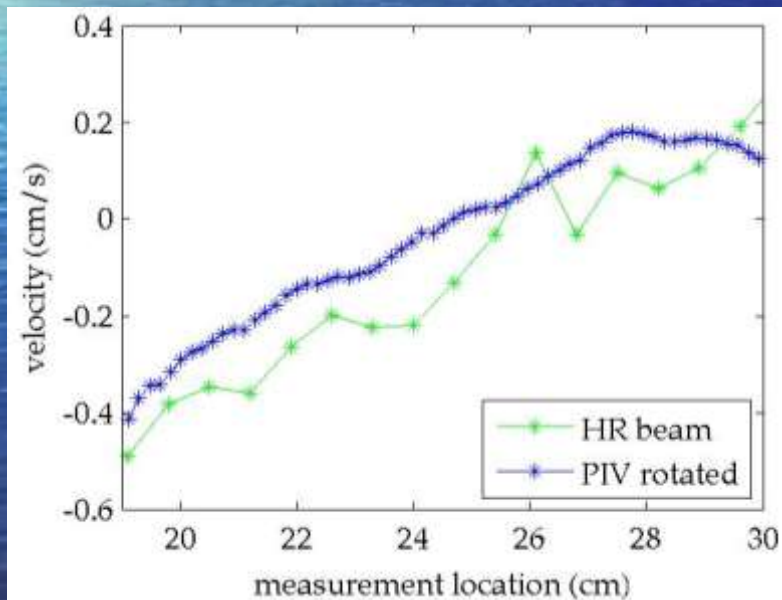
Center Vertical Velocity Profiles

- Velocity profiles changing jet heights
- Mean velocity without outer rings of jets
- Note: negative reading = upward velocity



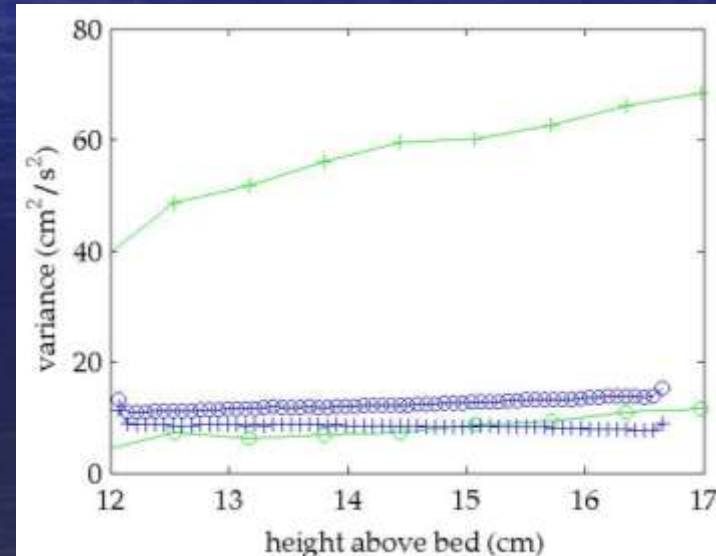
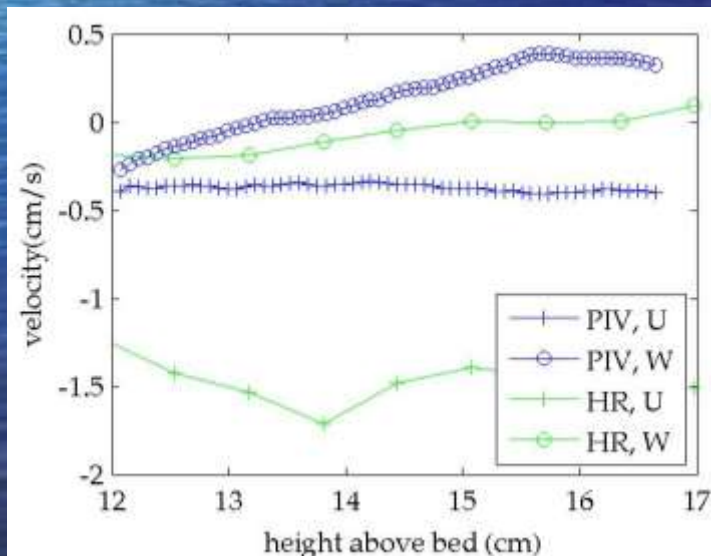
PIV & Beam Comparison

- Velocity profiles closely matched
- High variance of HR Profiler velocity data



PIV & 3-D Profiler Comparison

- Vertical velocity: good agreement in both velocity (0.2 cm/s error) and variance
- Horizontal velocity: 5% absolute error in velocity (1.2 cm/s); high variance of HR velocity data



Conclusions & Applications of Aquadopp HR Profiler

- Beam coordinates sufficient for capturing velocity profiles; good agreement with PIV in turbulence
- XYZ-velocities show fair agreement; with larger scales of turbulence (e.g. ocean swash zone), XYZ velocities able to better capture turbulence, but limited in confined laboratory spaces
- Spectra rather unaffected by phase-wrapping excursions; variance showed 20% increase after unwrapping
- Ultimately, combine bed morphology and parameterized critical stress to examine incipient sediment motion

Thank You!

QuickTime™ and a
H.264 decompressor
are needed to see this picture.