Residential Roof Covering Investigation of Wind Resistance of Asphalt Shingles

SERRI Project No. 90100

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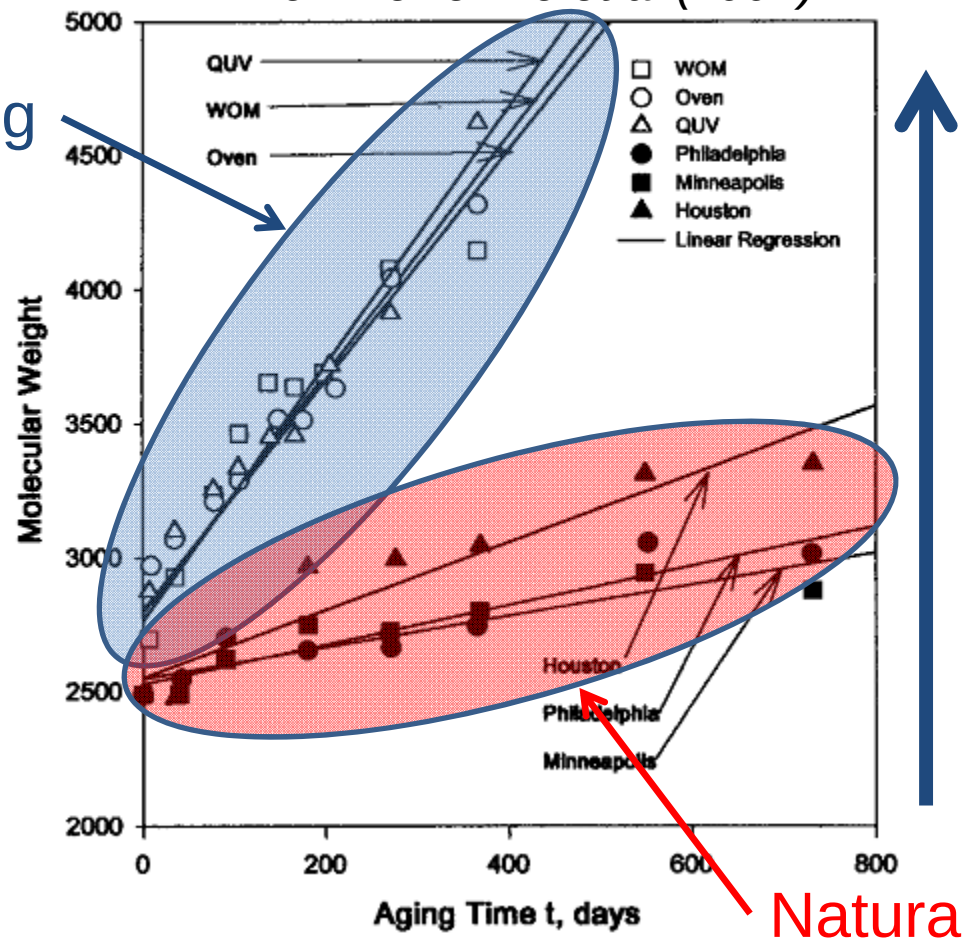
Key Activities

- Uplift Resistance of Aged Shingles
  - Design/construction of aging chambers (heat, UV, H_20)
  - Design/construction of uplift apparatus for ASTM D 7158
  - Quantify mechanical uplift resistance as a function of exposure; relate to new product performance
- Realistic Wind Load Simulation vs. Simplified Test
  - PIV Wind Tunnel Study at UWO (follow-up on Peterka's work)
  - Design dynamic wind simulator (construction underway)
  - Construct roof mockups for testing in IBHS Windstorm Simulator
- Cross-Thrusts
  - Harvesting of specimens from single-family homes in FL
  - Field damage surveys (coordination with FEMA MAT planned)

Uplift Resistance of Aged Shingles

From Terrenzio et al (1997)

Accelerated Aging



Increased Asphalt Stiffness

Natural Aging

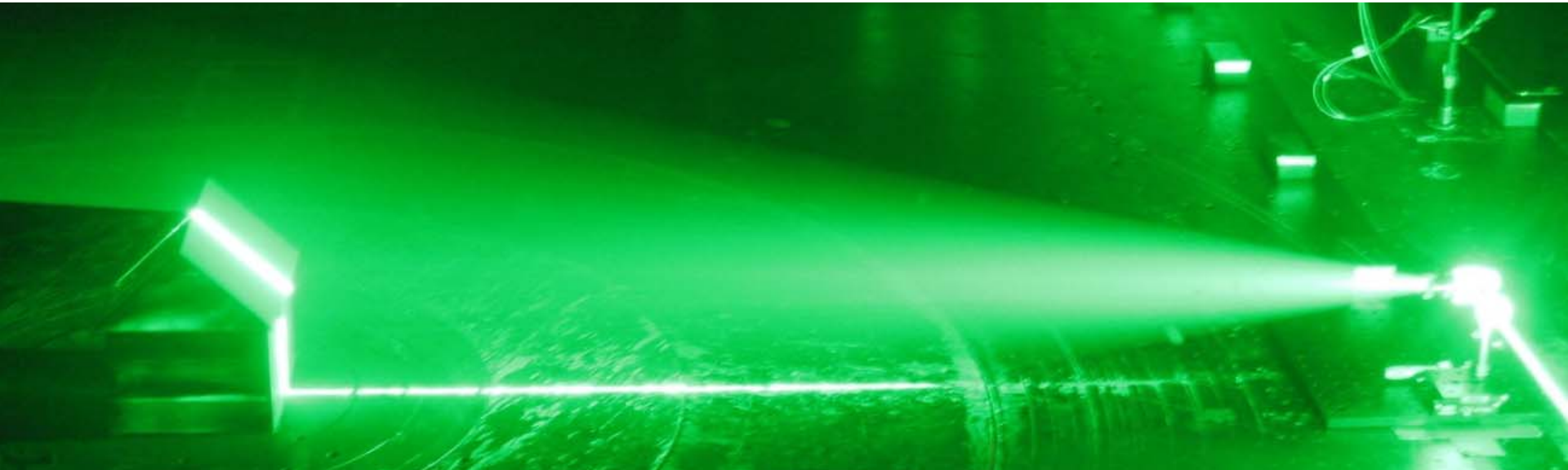
Age Uplift Resistance of Aged Shingles

- Methodology = combination of ASTM D 4799 (aging) and ASTM D 7158 (mechanical uplift)
- Preliminary approach is to expose shingles to 200,400,…,2000 hrs of
  - Heat
  - Heat + UV
  - Heat + UV + Water
- Following exposure
  - Perform mechanical uplift tests (two types)
  - Chemical composition tests
- Related project
  - Acquire homes for naturally aged asphalt shingle testing
  - Remove full roof system panels (sheathing + underlayment + shingles) for wind simulation testing at IBHS

Development of Dynamic Wind Simulator

Two thrusts

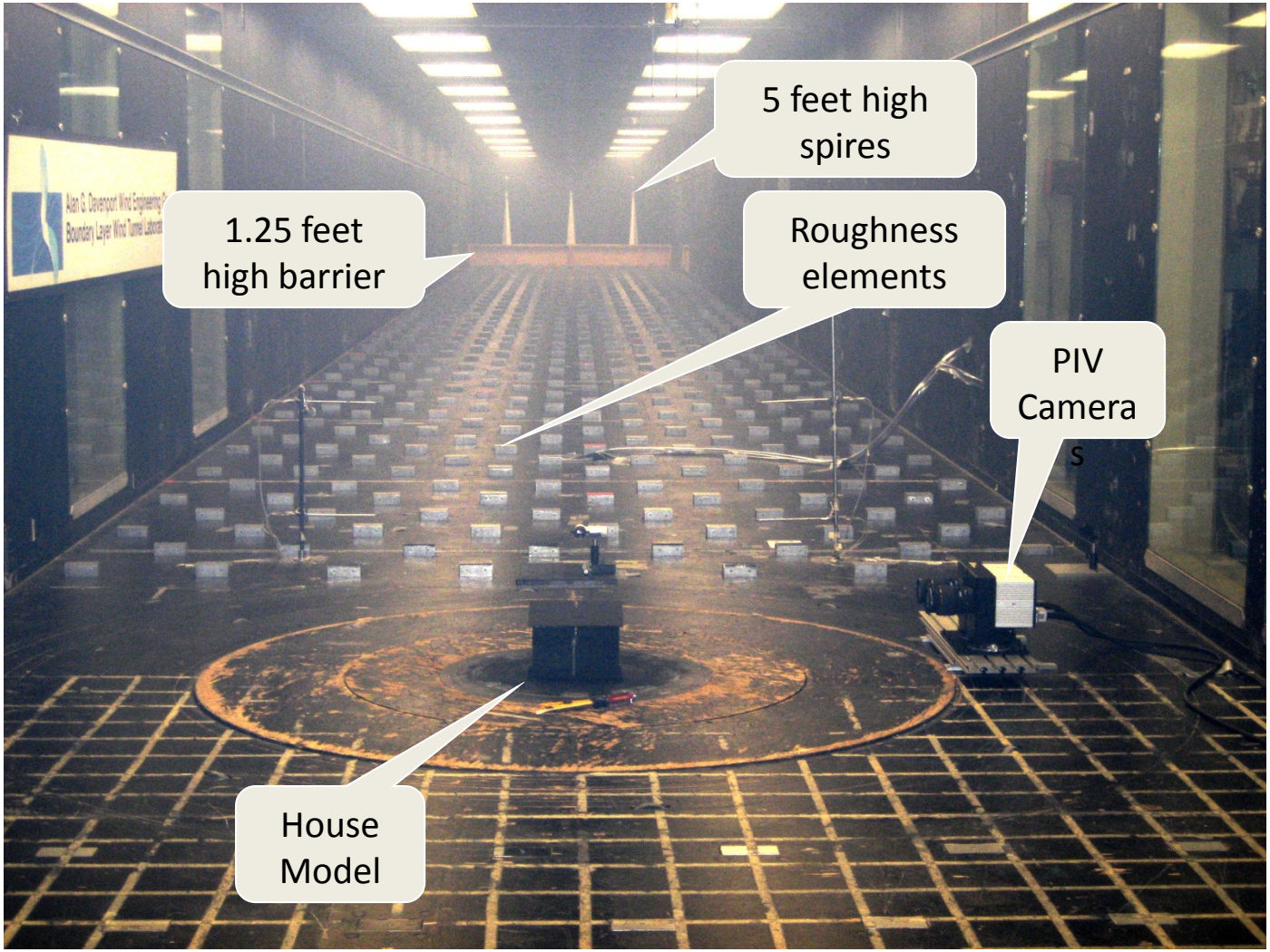
- Particle Image Velocimetry study performed at the University of Western Ontario
- Design and development of a dedicated dynamic wind field simulator



UWO Wind Tunnel Tests

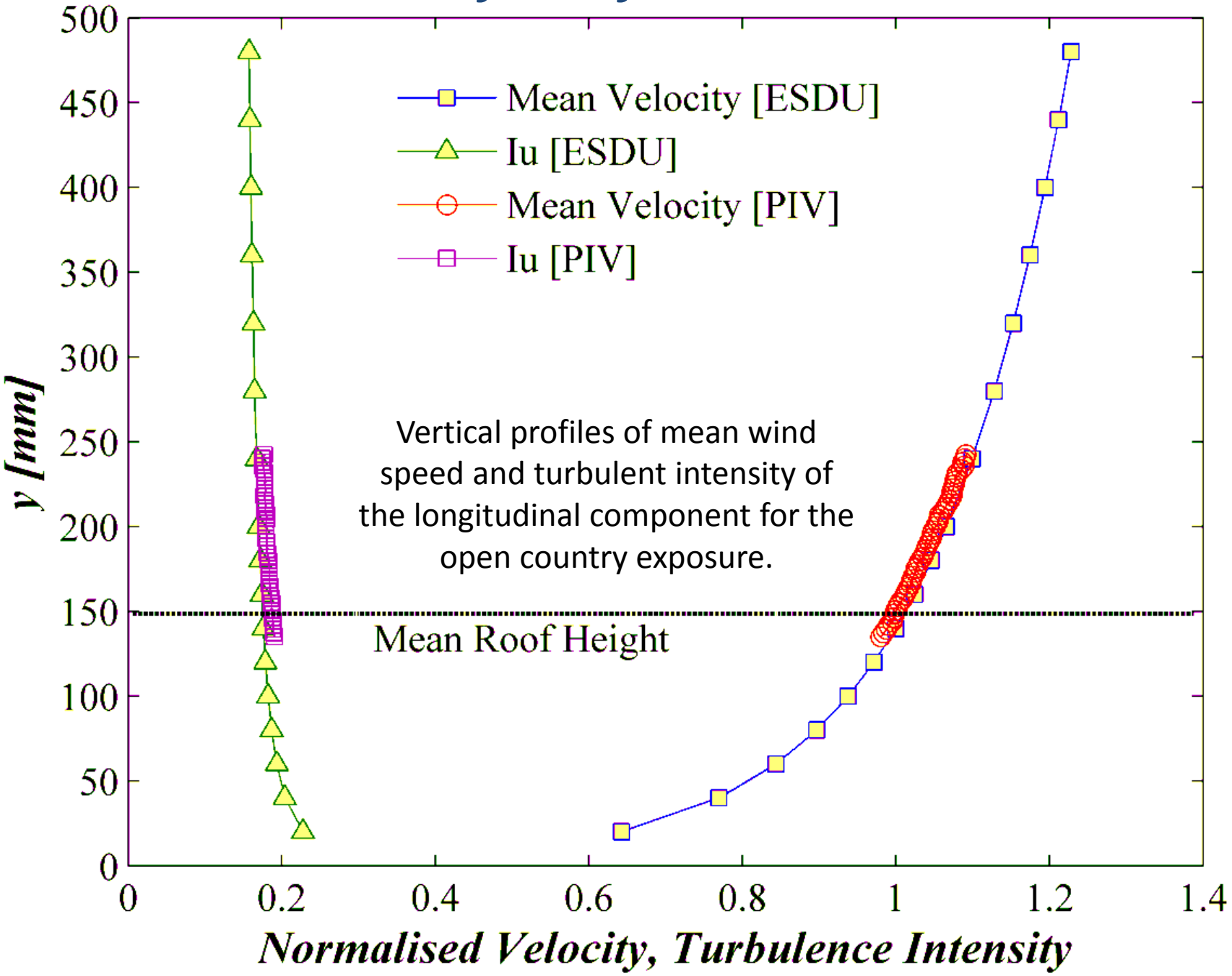
- Funded by the Florida Building Commission
- High suctions and high wind speeds above a house roof are important for the performance of roof cover, such as shingles, in extreme wind conditions.
- In order to better understand which flow features cause these, Particle Image Velocimetry (PIV) experiments were performed on the wind tunnel model.
- Experiments were performed with time-resolved PIV (sampling rate of 500 Hz) for a duration of 120 seconds simultaneously with pressure measurements.
- A work prior to this study can be found in the following video showcase, which portrayed the significance of the current study.

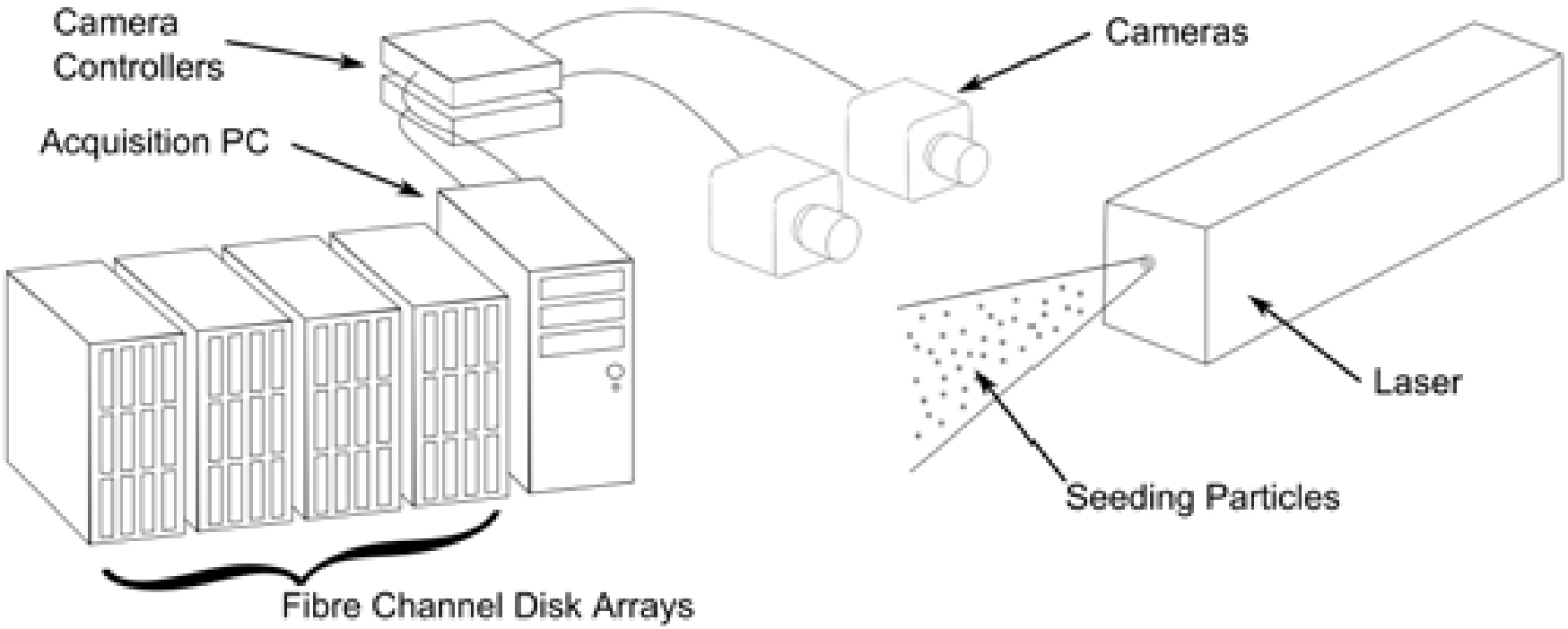
Boundary Layer Simulation

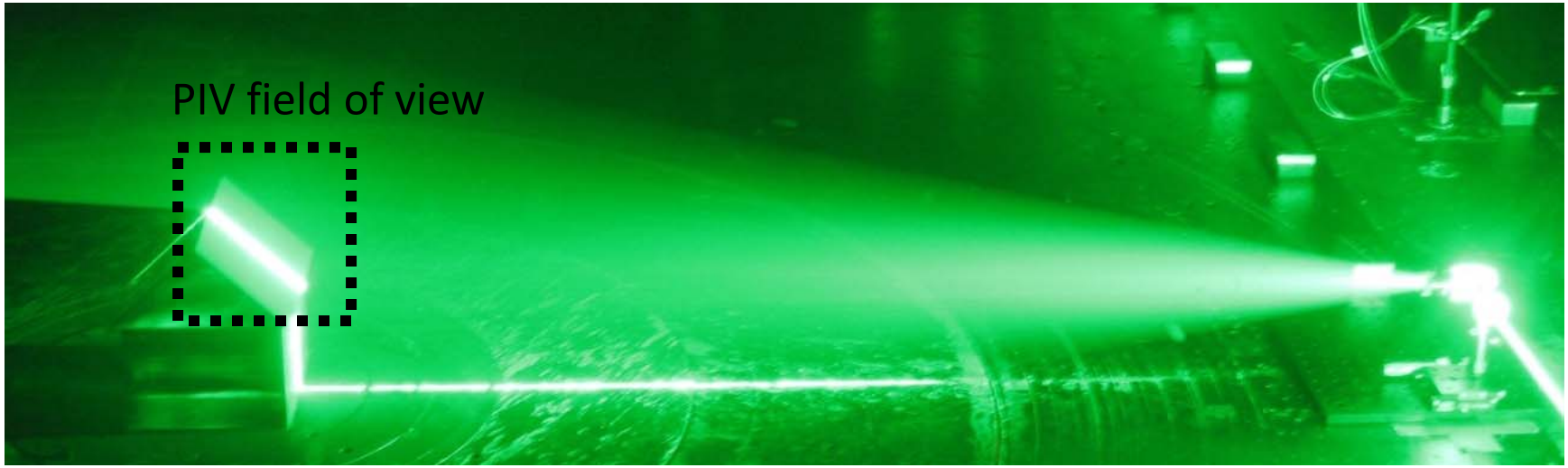


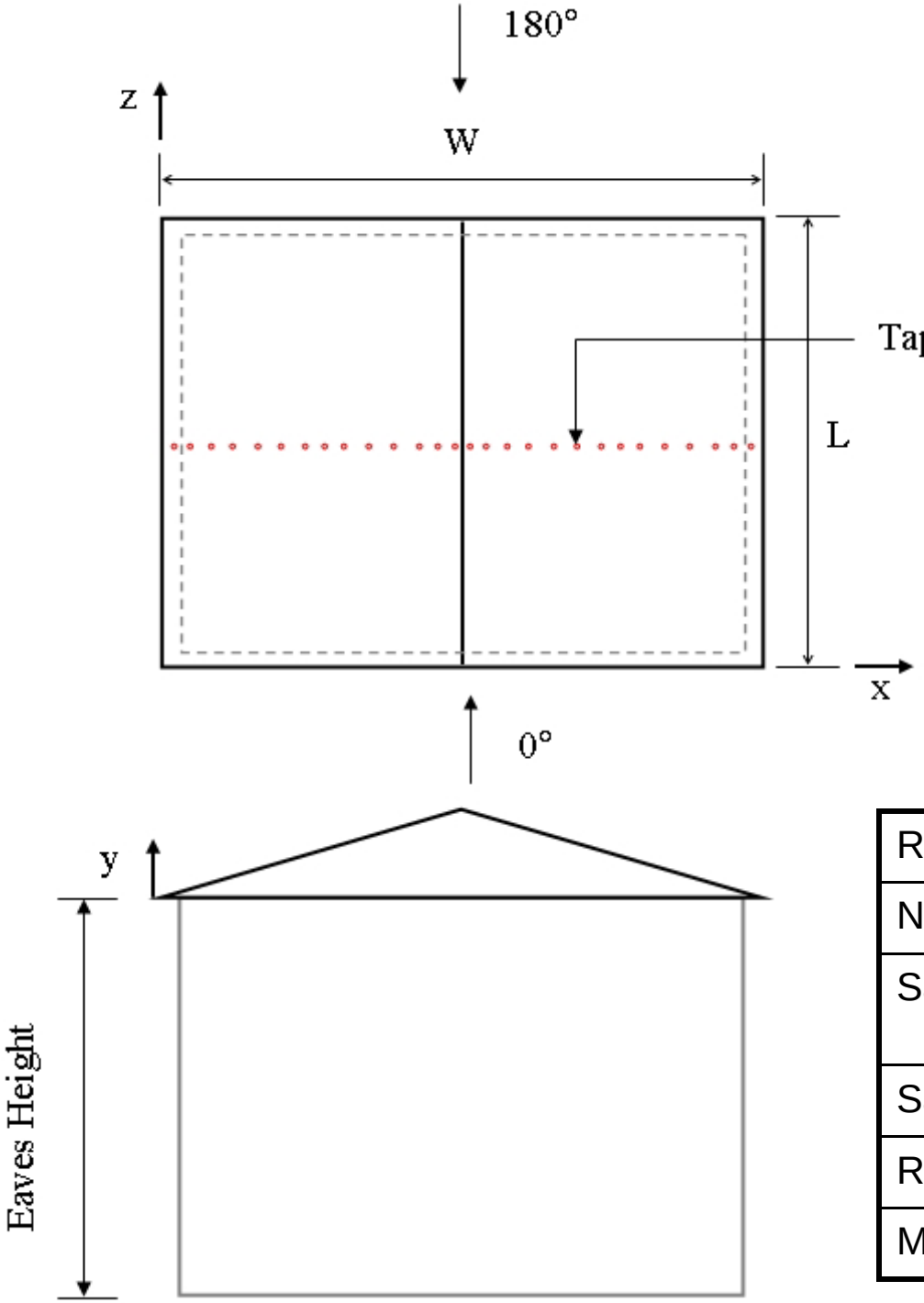
Photograph of the upstream terrain model in the wind tunnel

Boundary Layer Simulation




Camera
Controllers
Acquisition PC
Cameras
Laser
Seeding Particles
Fibre Channel Disk Arrays


PIV field of view

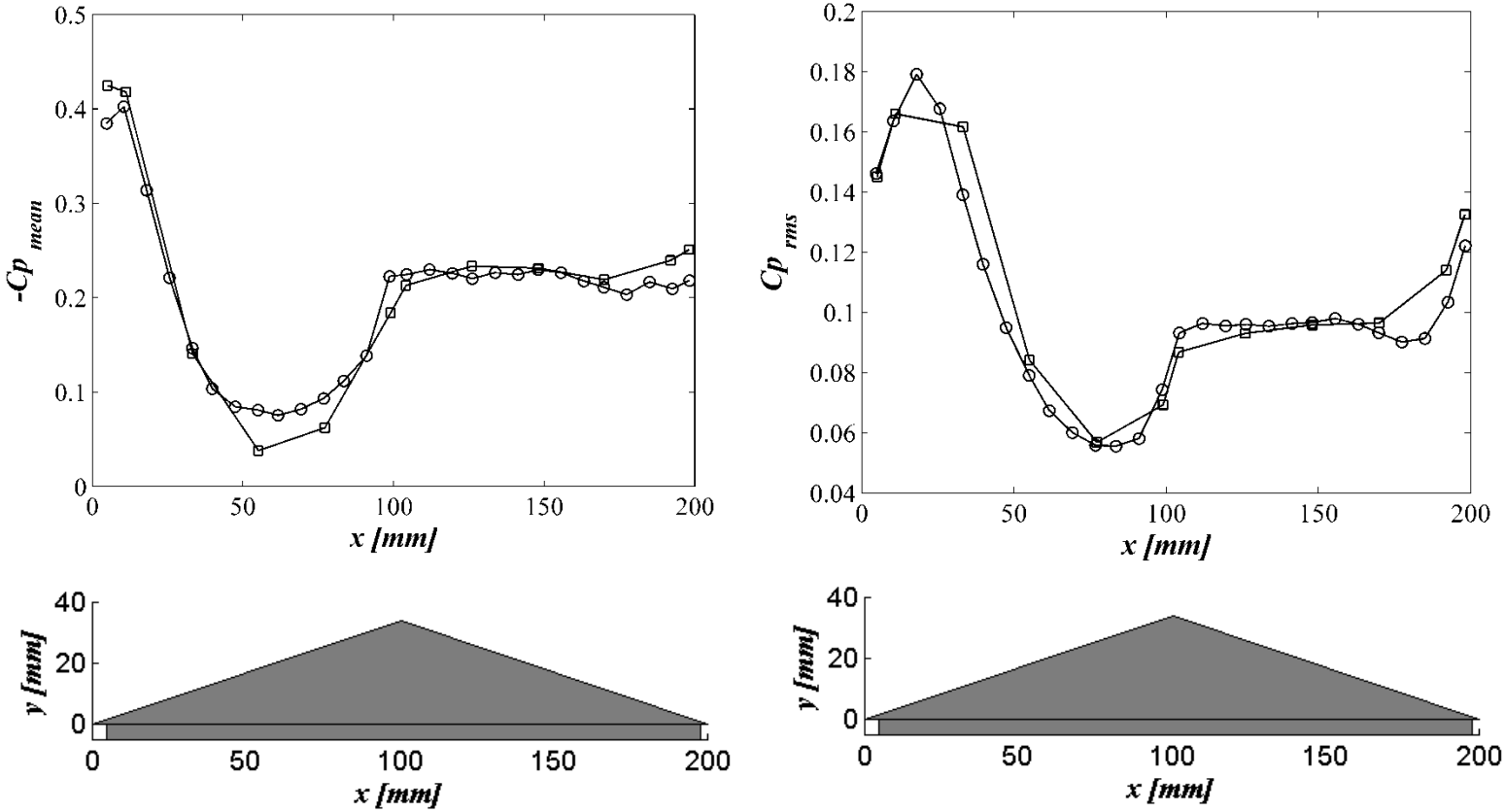


Pressure tap layout and dimension of the house model with coordinates

WIND DIRECTION

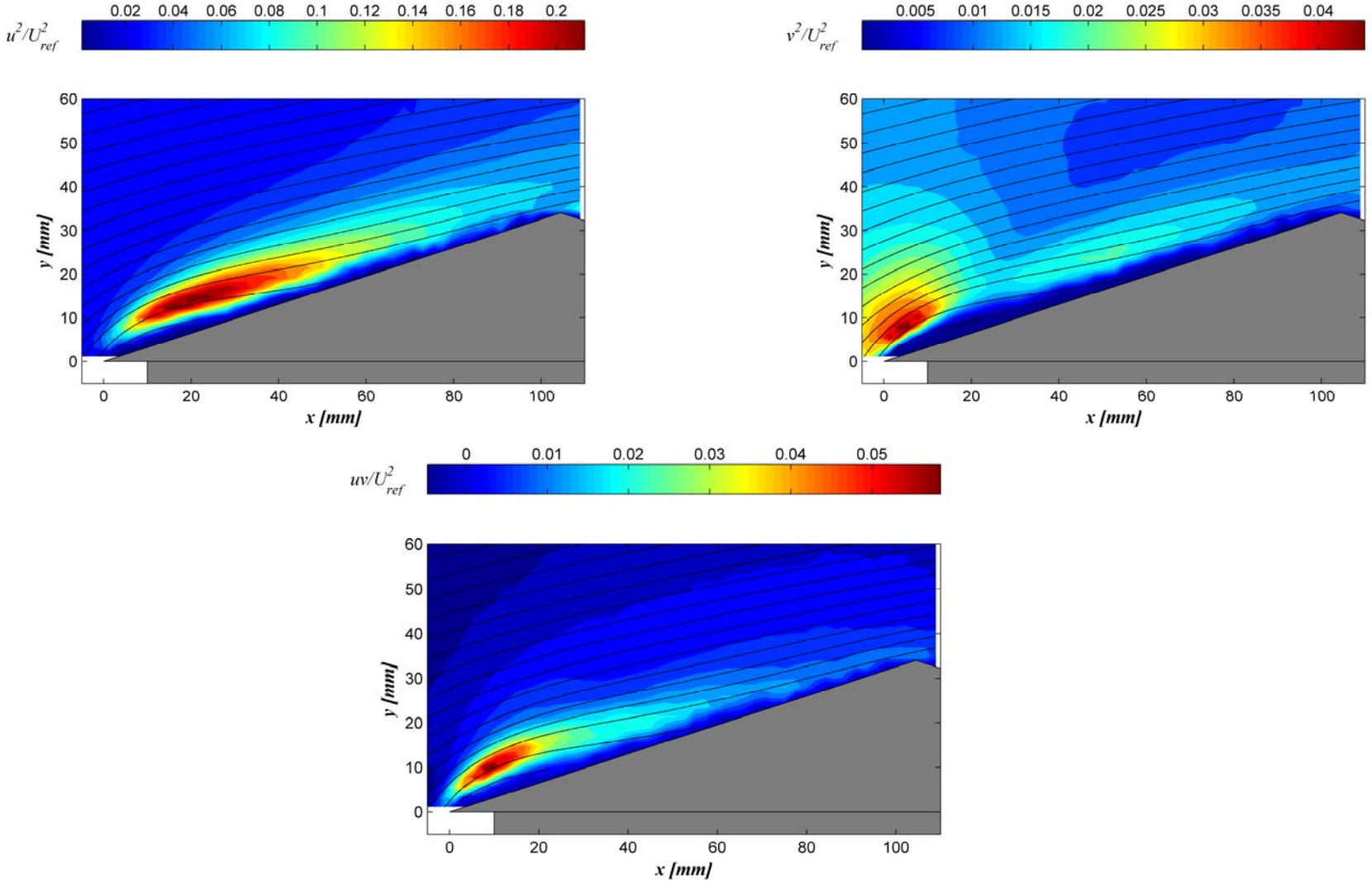
Roughness, z_o	0.03 m
Number of taps	50~60 on each
Sampling frequency	1100 Hz
Sampling time	120 s
Ref. speed	~15 m/s (~50 ft/s)
Model scale	1:50

Results



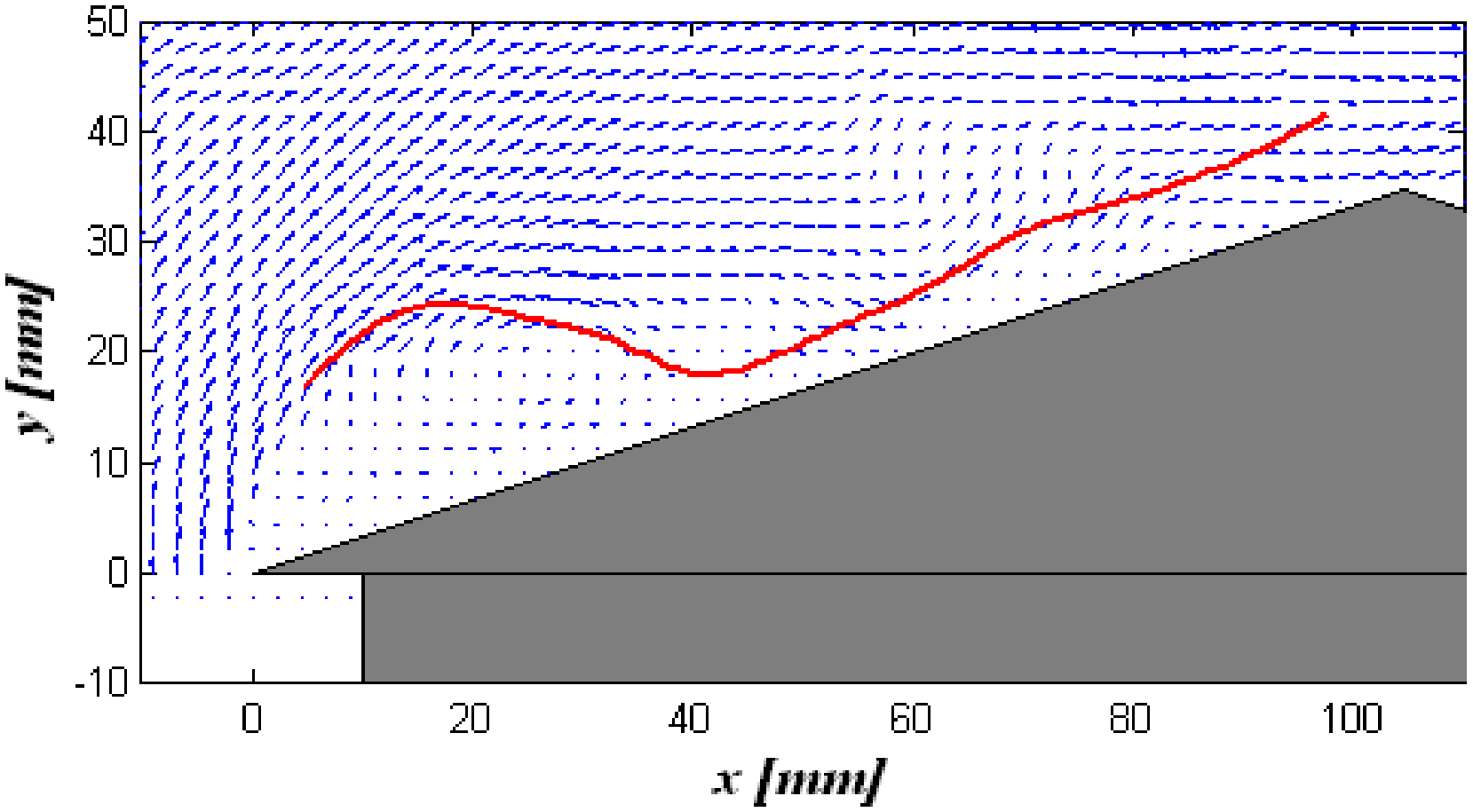
Mean and rms pressure on a gable roof (circles) compared with pressure measurements (squares) in the wind tunnel for ‘Three Little Pigs’ house model

Results



Contour plot of normalized stresses (the lines are stream lines of the mean flow field)

Results



Simultaneous velocity vectors and surface pressures in the mid-plane of a 4:12 gable roofed house for a wind direction perpendicular to the wall/ridge

- PIV data: High resolution, time varying, spatially varying wind vectors near the roof
- Dynamic wind action causes the uplift forces that act on discontinuous roof coverings
- *Now* developing an experimental simulation apparatus capable of replicating the dynamic wind field observed in the wind tunnel
- Aerodynamic objective: Create 180+ mph wind speeds over an 8 ft x 1.5 ft cross section

Design

- Components
  - 3512 Caterpillar 1800 hp Diesel Prime Mover
  - Centrifugal blower (200,000 cfm @ 20 in WC)
  - Sound attenuation (multiple measures)
  - Ductwork
  - Flow control
- FBC contributed to prime mover
- Preliminary design of ducting completed but flow control still in development

Full scale testing also conducted in the IBHS Windstorm facility

End

This project will refine the understanding of asphalt shingle wind performance throughout the lifespan of the shingle

- Linking shingle aging → wind uplift performance
- Accurately simulating turbulent wind flow over roof surface
- Conducting full scale testing of new and aged shingles
- Informing all stakeholders of findings and possible solutions