

RANDOM MICRON SURFACE ROUGHNESS

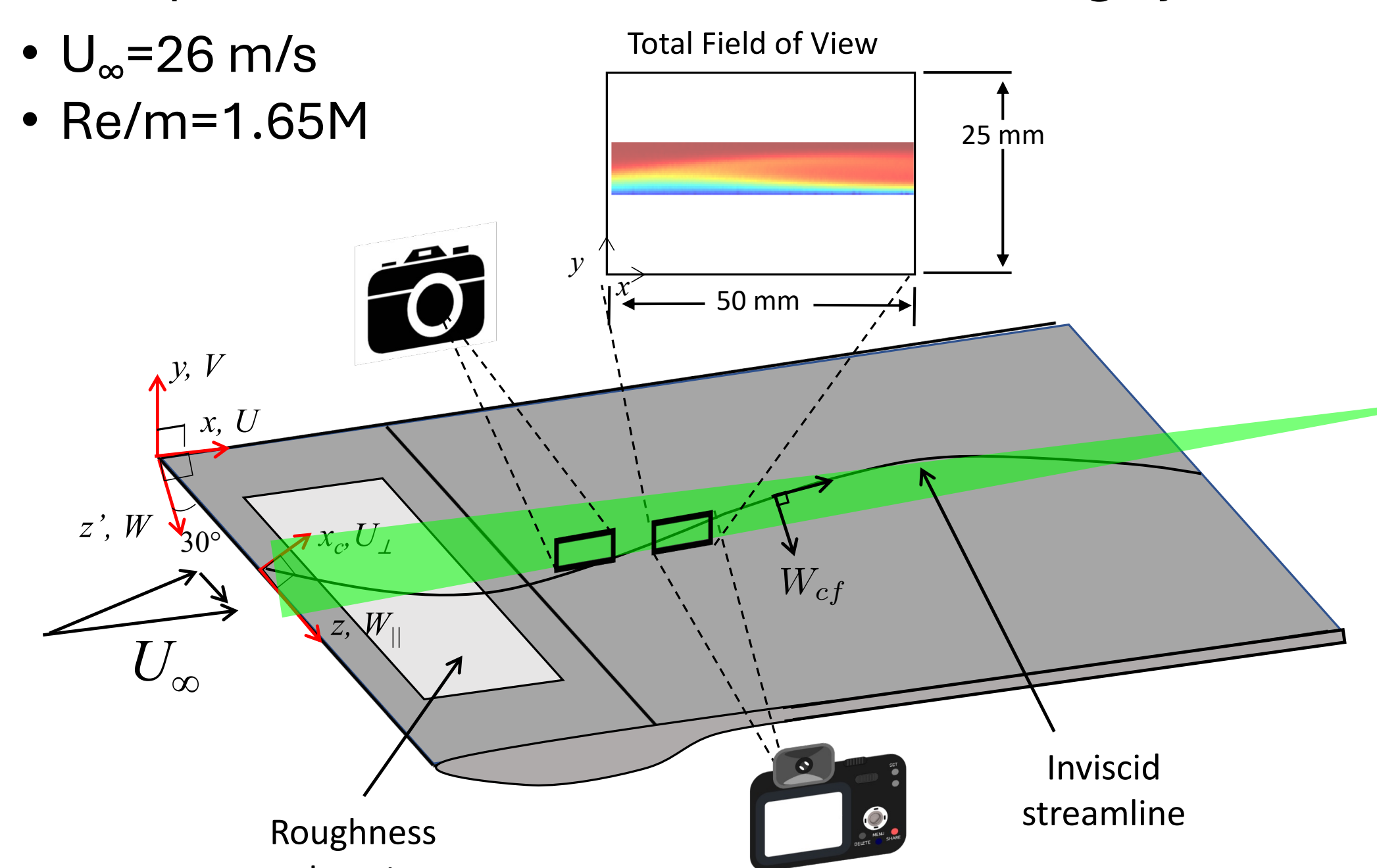
EFFECTS ON SWEEP WING BOUNDARY LAYER TRANSITION

INTRODUCTION

- Micron-level surface roughness has a significant impact on stationary crossflow (SCF) instability initial amplitude.
- Typically, root-mean-square measurements of roughness amplitude are reported, but RMS alone does not fully characterize a roughness topology.
- Better transition models require improvement in this area.

EXPERIMENT SETUP

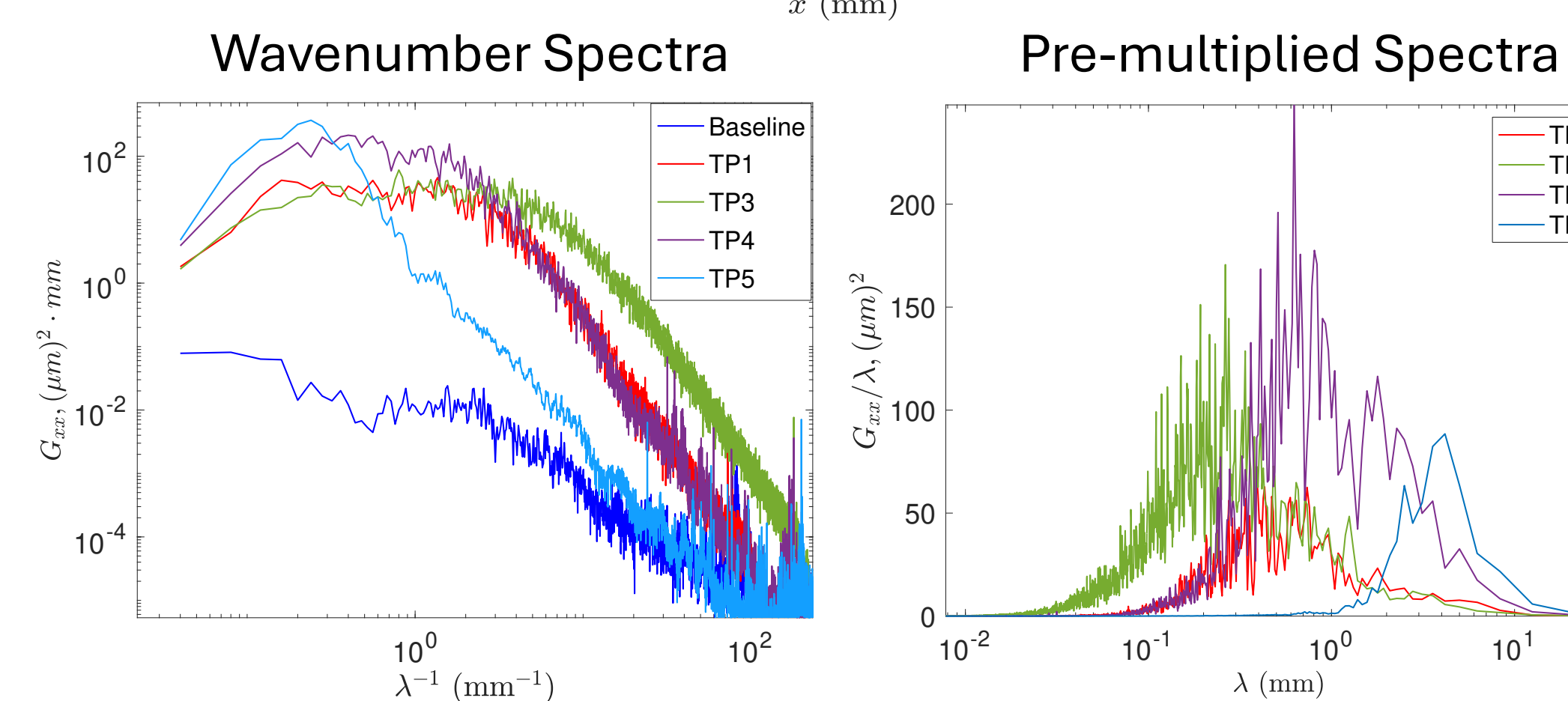
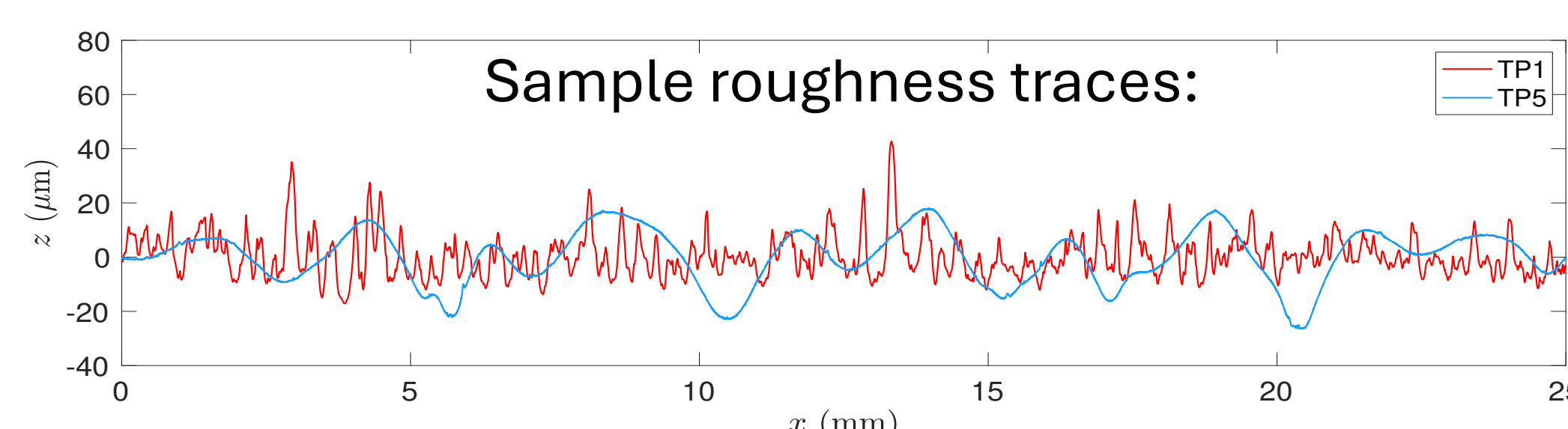
- Particle Image Velocimetry (PIV) measurements were performed on a 30° swept flat plate with ceiling liner.
- Test performed in 2'x3' Tunnel at NASA Langley.
- $U_\infty = 26$ m/s
- $Re/m = 1.65M$



ROUGHNESS CHARACTERIZATION

- Roughness panels were fabricated using spray-on nano-particle coatings of different formulations designed to create roughness panels with varying topologies.

Panel	RMS (μm)	Peak-to-peak (μm)	Correlation length (μm)
Baseline	0.42	1.79	822
TP1	8.64	39.36	172
TP3	13.93	66.21	92
TP4	16.92	65.85	317
TP5	8.78	29.09	876

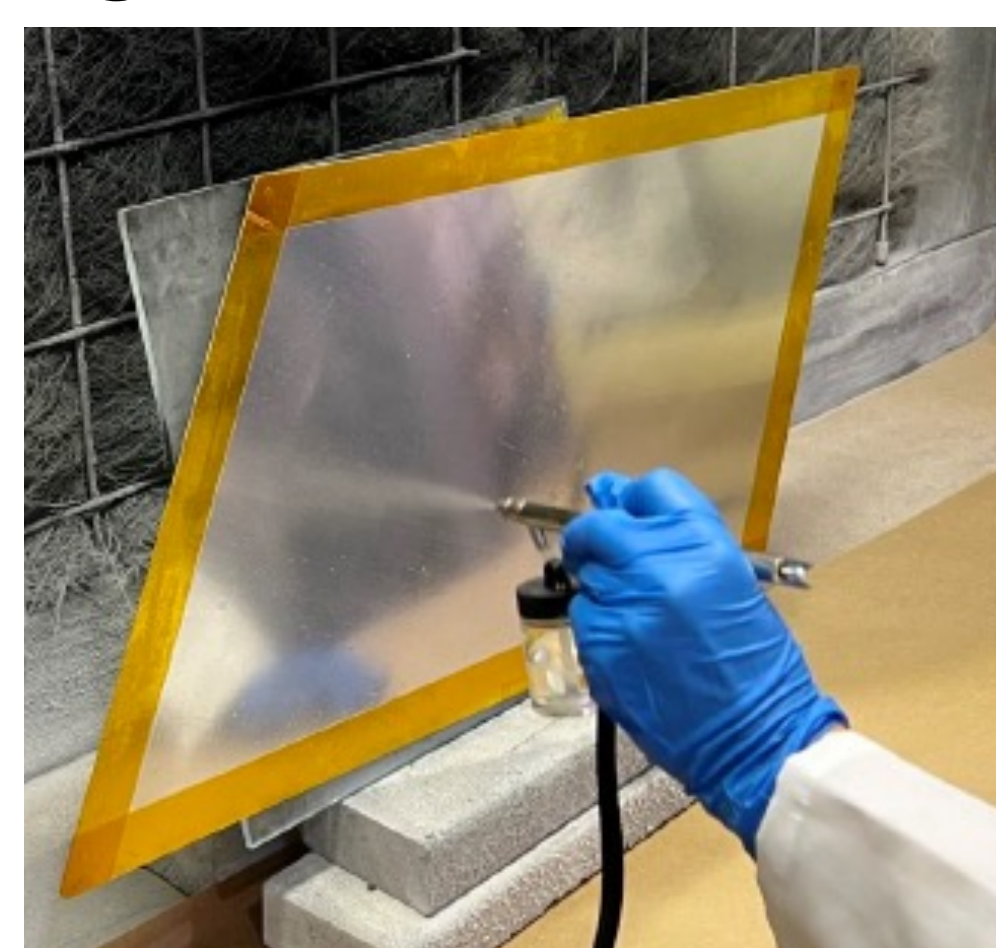


CONCLUSION:

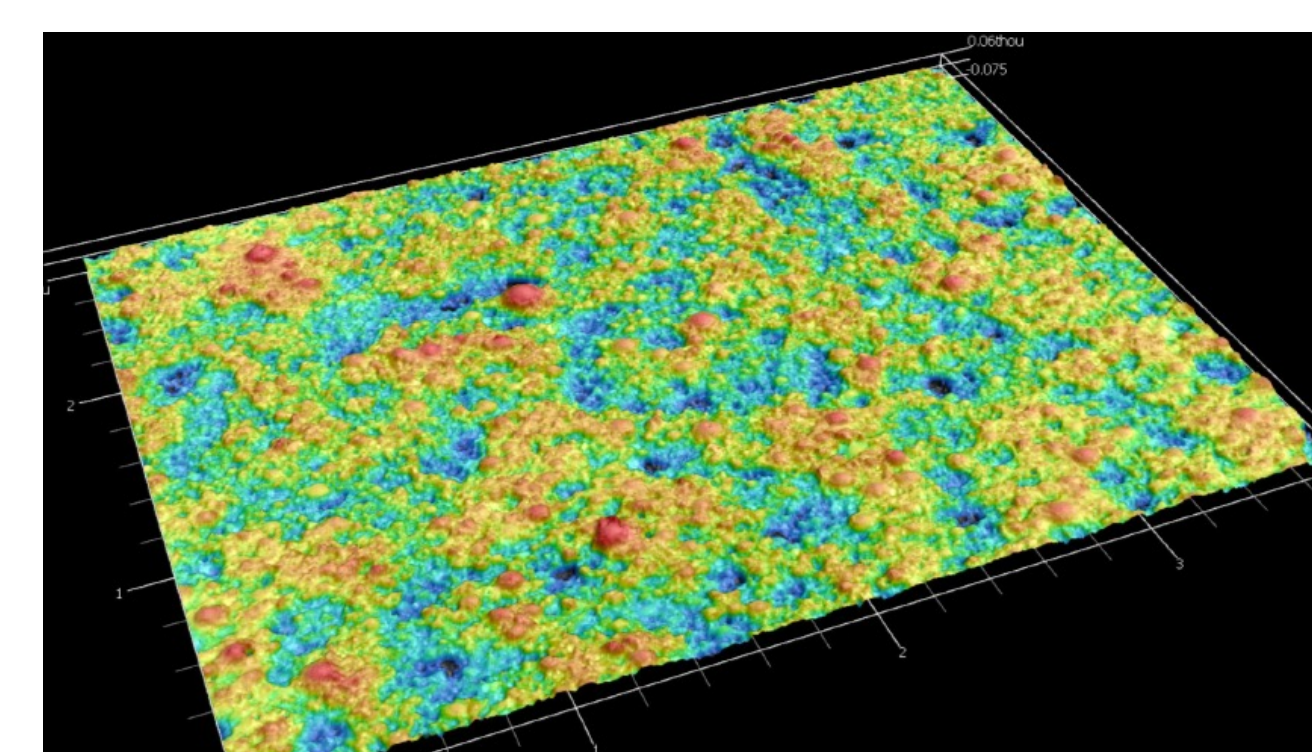
Surface roughness characterization of only root-mean-square and wavelength spectra is not sufficient to predict receptivity of stationary crossflow modes.

SUMMARY

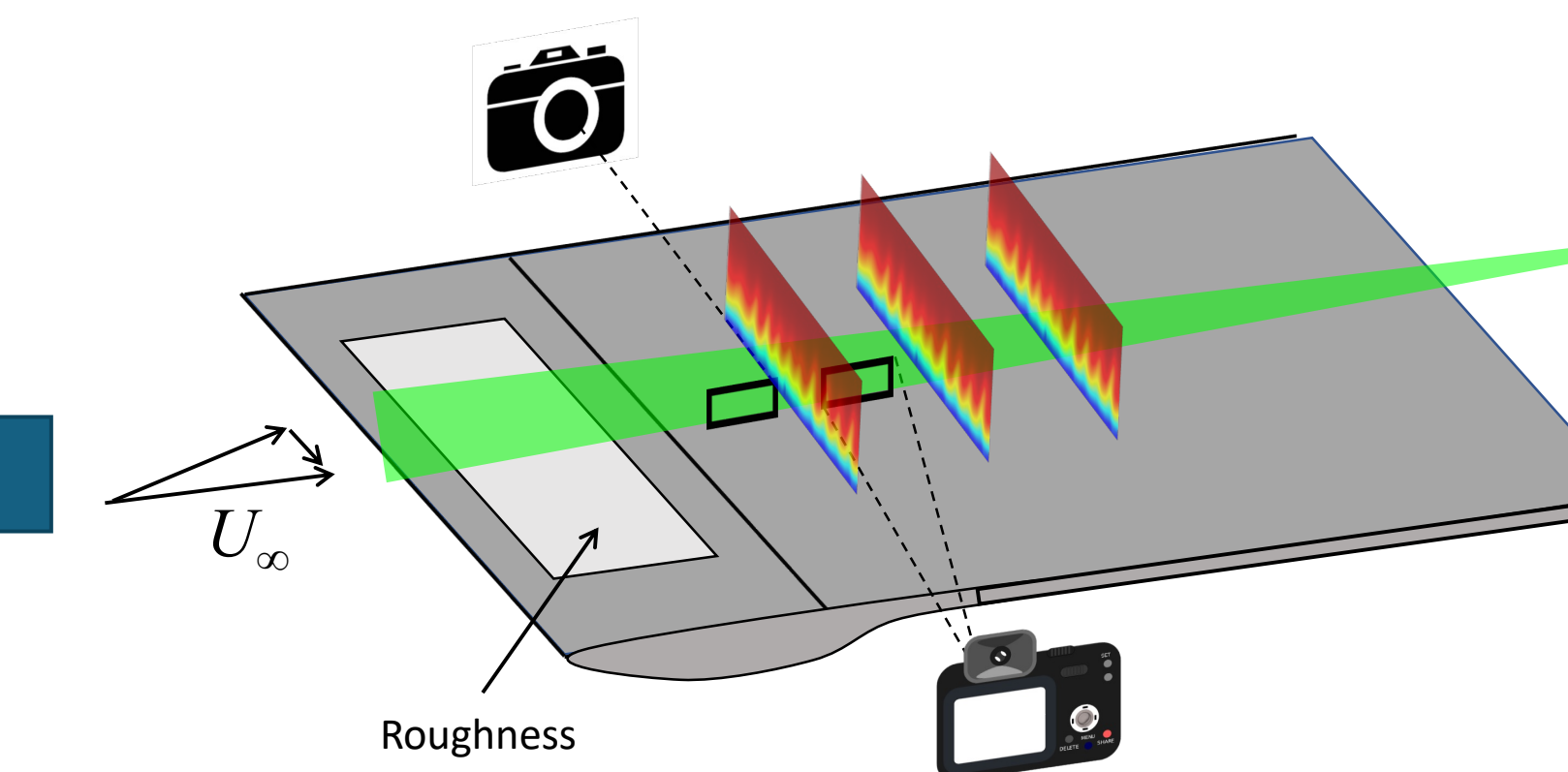
Roughness Panel Fabrication



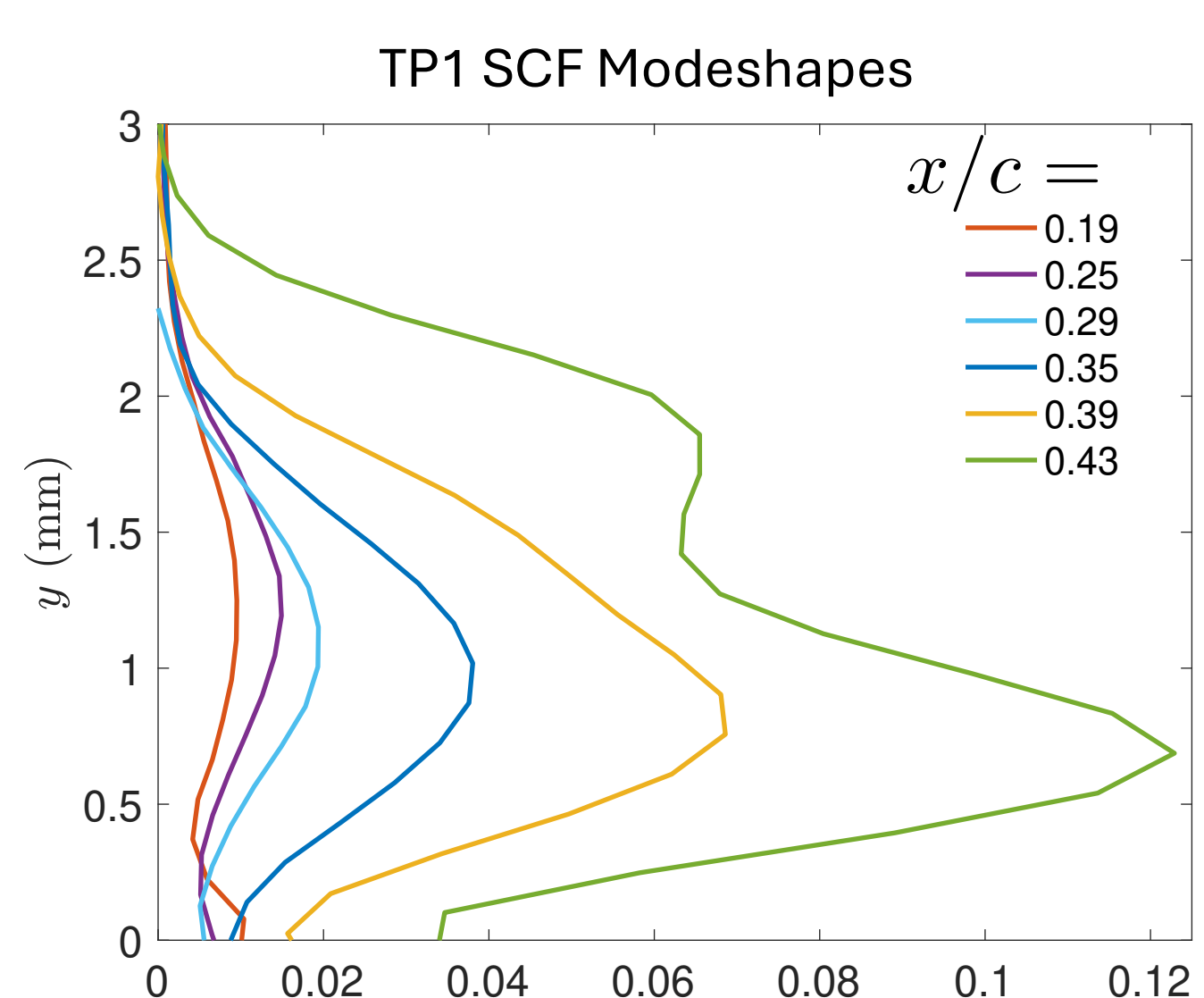
Roughness Measurements



Installation and Testing



Stationary Crossflow Analysis

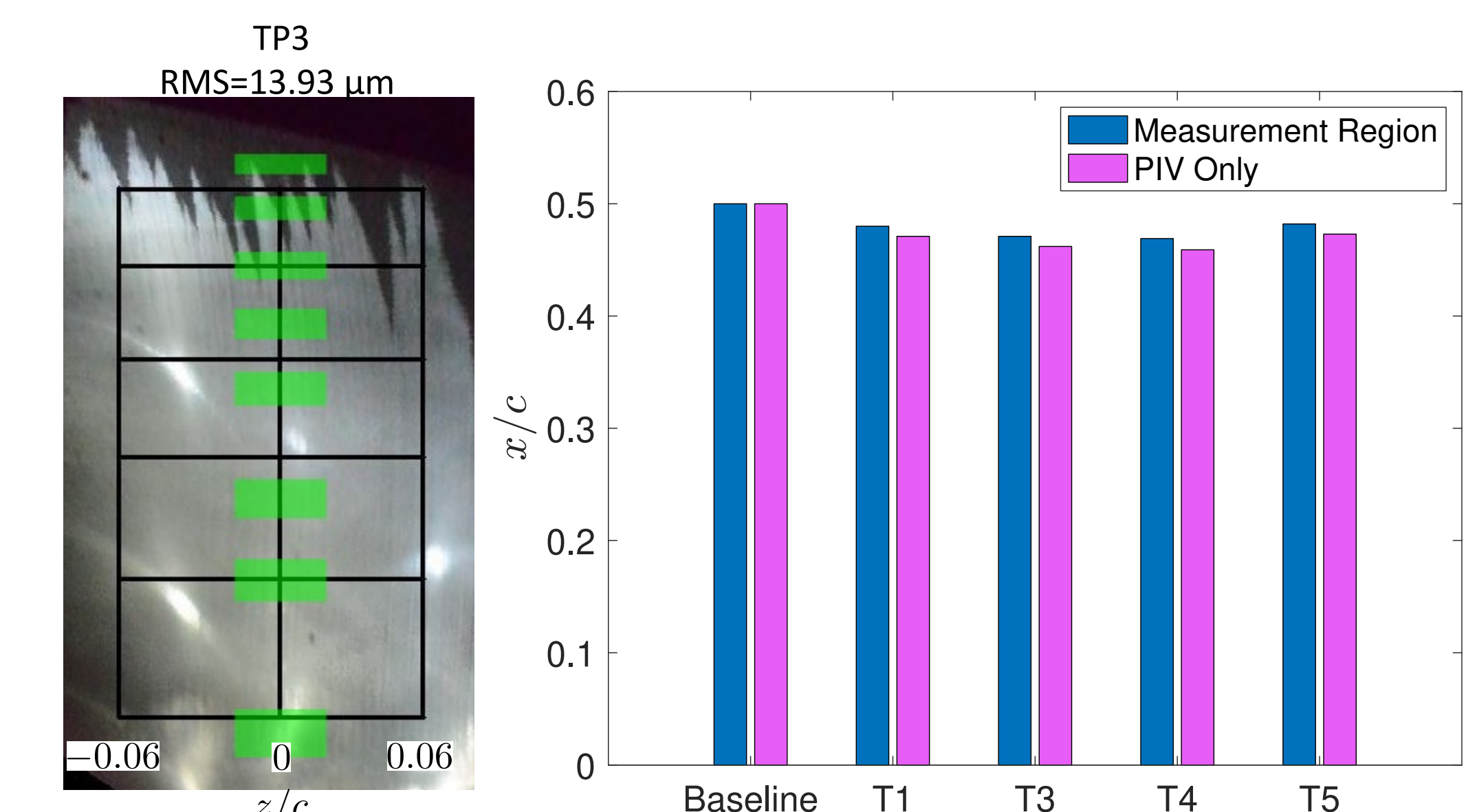


Panels with similar RMS levels resulted in very different behavior. Results indicate that better roughness quantification methods are needed to predict the impact on SCF amplitudes.

RESULTS

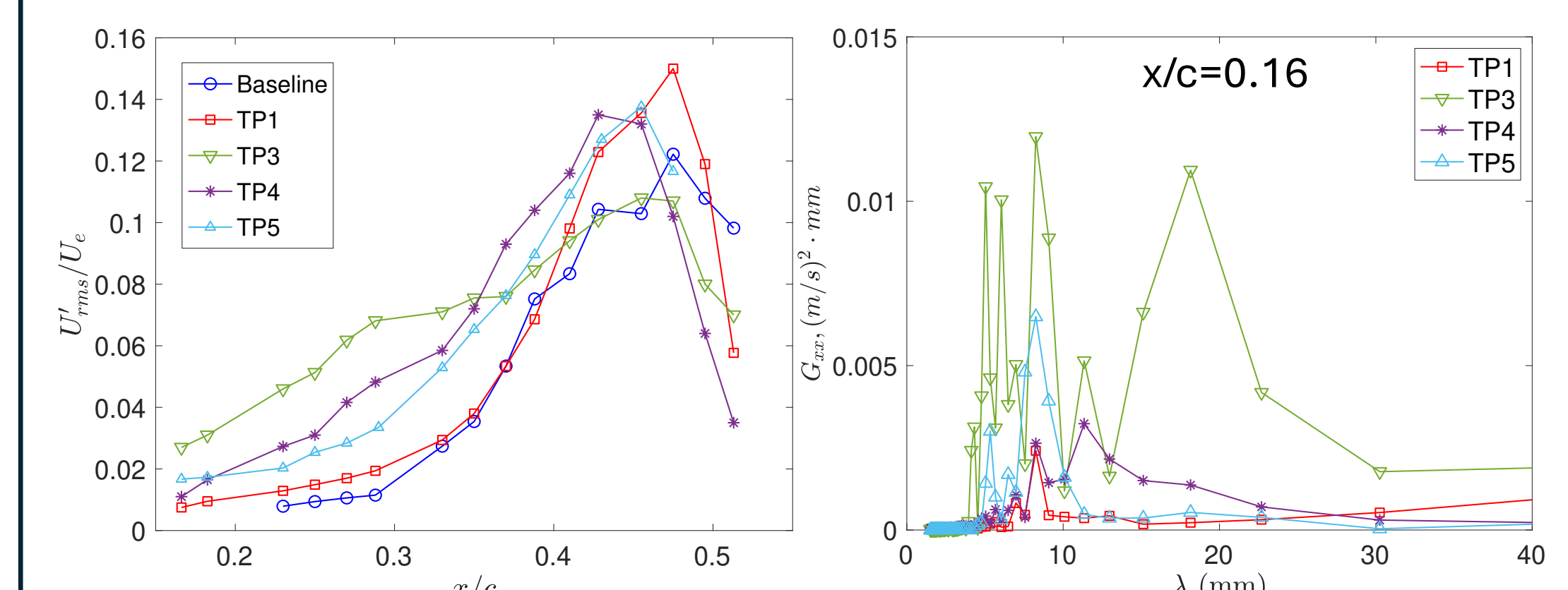
Transition locations only mildly affected by addition of roughness

- Transition front visualized using naphthalene sublimation.
- Average transition locations averaged across full measurement region ($z/c = -0.06$ to 0.06) and over PIV measurement region (indicated by green squares).



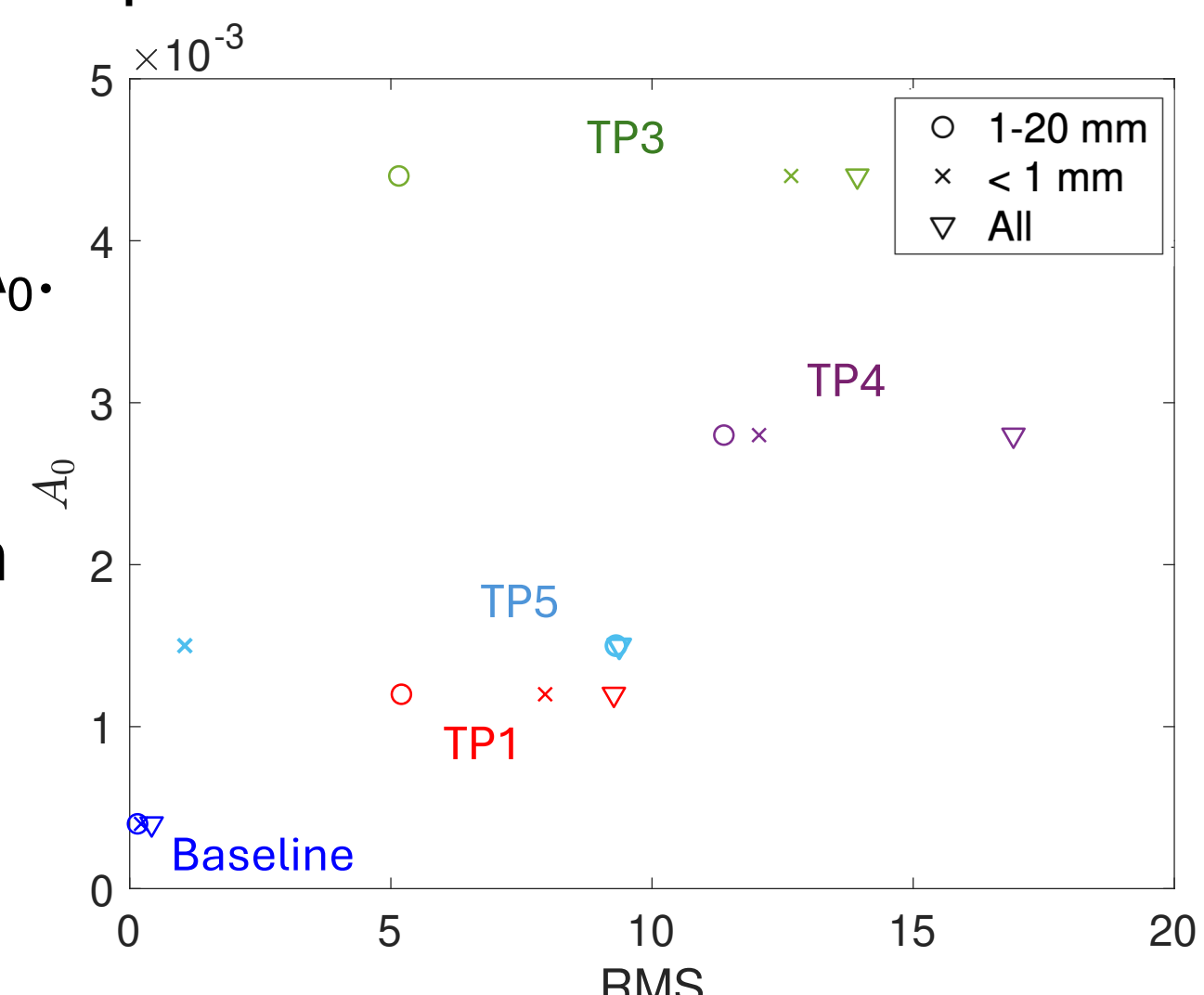
Roughness causes significant variations in stationary crossflow amplitudes and wavelengths

- SCF amplitudes integrated from $\lambda = 5$ -20 mm.
- Wavelength content varied significantly for each panel.



Estimated initial amplitudes do not indicate simple relationship with RMS or wavelength content

- Initial amplitudes of $\lambda = 8$ mm mode (A_0) estimated assuming linear growth up to $x/c = 0.23$.
- No obvious trend is observed between roughness RMS and A_0 .
- The RMS is also integrated over large and small wavelength ranges, but still no trend is observed.



FUTURE WORK

- Repeat measurements with same and rotated panels.
- Testing of additional roughness panels.
- More in-depth analysis of roughness parameters and relationship to SCF initial amplitudes.