4 Code Verification

a) Calculations performed

	Code	MS	Turbulence Model	Observations
A	FLUENT	MS4	Laminar	1st-order convection
B	FLUENT	MS4	Laminar	2nd-order convection
C	CADYF	$MS4_{mod}$	SKE	Wall functions
D	CHAPMAN	MS4	BSL	
E	CFL3D	MS1	SA	1st-order convection for $\tilde{\nu}$
F	CFL3D	MS1	SA	2nd-order convection for $\tilde{\nu}$
G	FUN3D	MS1	SA	1st-order convection for $\tilde{\nu}$
H	FUN3D	MS1	SA	2nd-order convection for $\tilde{\nu}$

MS1 – Manufactured solution with $\tilde{\nu}$ varying with y at the wall
MS4 – Manufactured solution with ν_t varying with y^4 at the wall
$MS4_{mod}$ – MS4 with constants added to k and ε
SA – Spalart & Allmaras one-equation model
BSL – Baseline k-ω two-equation model
SKE – Standard k-ε two-equation model

b) Global Convergence

Observed order of accuracy		u_x	u_y	C_p	ν_t
A	FLUENT	NA	NA	NA	
B	FLUENT	NA	NA	NA	
C	CADYF	2.089	2.089	2.063	3.062
D	CHAPMAN	1.99	1.69	1.69	2.89
E	CFL3D	1	1	1	1
F	CFL3D	2	2	2	2
G	FUN3D	1	1	1	1
H	FUN3D	2	2	2	2

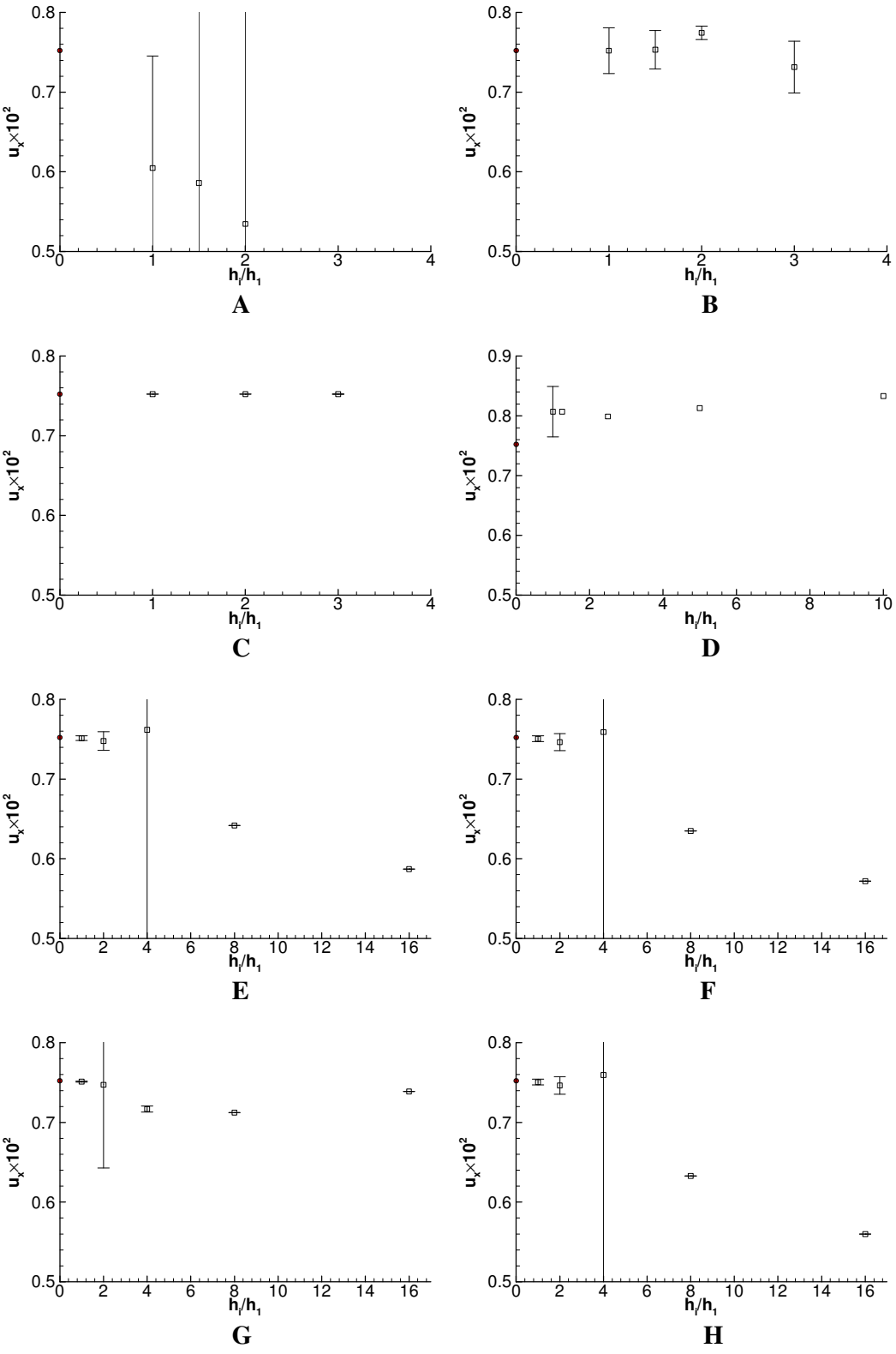
NA: Not Available, because it is not required by the uncertainty method applied

c) Meaning of h_i/h_1

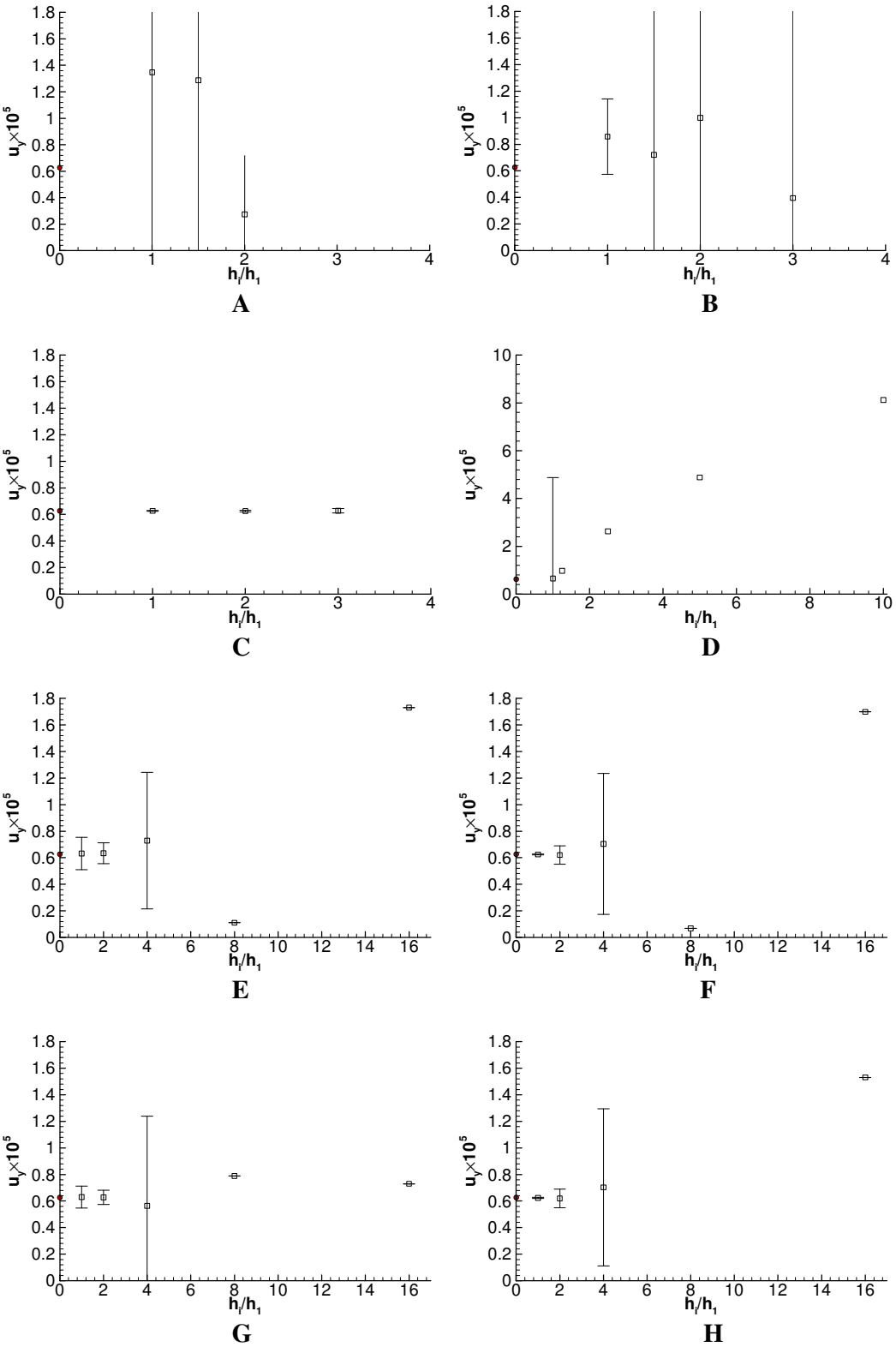
	Code	h_i/h_1
A	FLUENT	1-30,60,120; 1.5-19,40,80; 2-15,30,60; 3-10,19,40
B	FLUENT	1-30,60,120; 1.5-19,40,80; 2-15,30,60; 3-10,19,40
C	CADYF	1-Level 9, 2-Level 8, 3-Level 7
D	CHAPMAN	Sqrt(Cells finest grid/cells of $grid_i$)
E	CFL3D	Sqrt(Cells finest grid/cells of $grid_i$)
F	CFL3D	Sqrt(Cells finest grid/cells of $grid_i$)
G	FUN3D	Sqrt(Cells finest grid/cells of $grid_i$)
H	FUN3D	Sqrt(Cells finest grid/cells of $grid_i$)

d)Local flow quantities

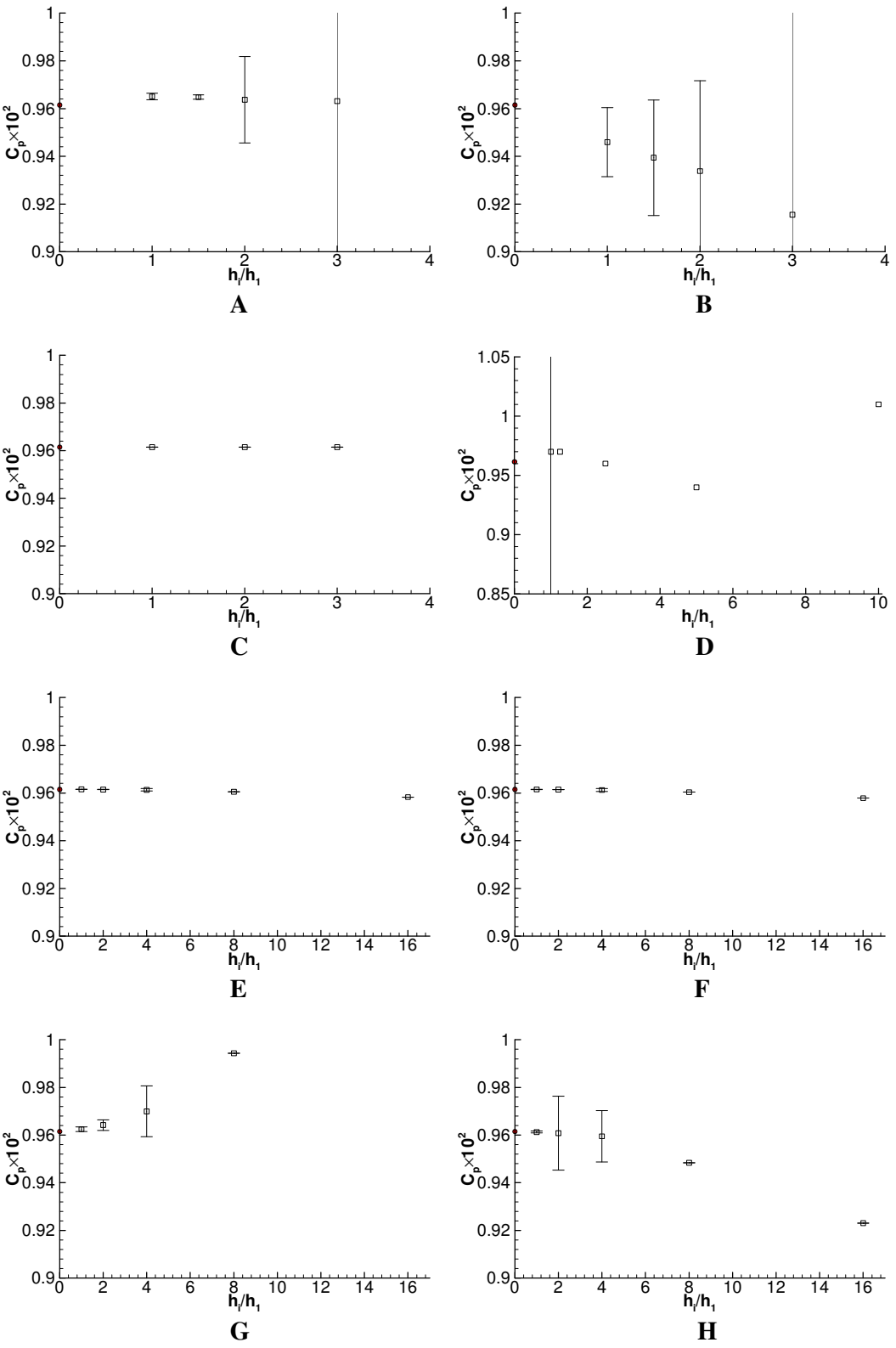
u_x velocity component at ***x=0.6, y=0.001***



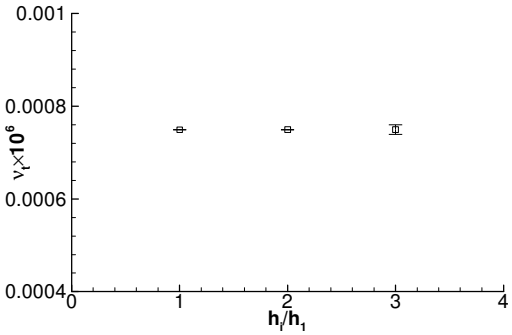
u_y velocity component at ***x=0.6, y=0.001***



C_p pressure coefficient at ***x=0.6, y=0.001***



ν_t eddy viscosity at ***x=0.6, y=0.001***



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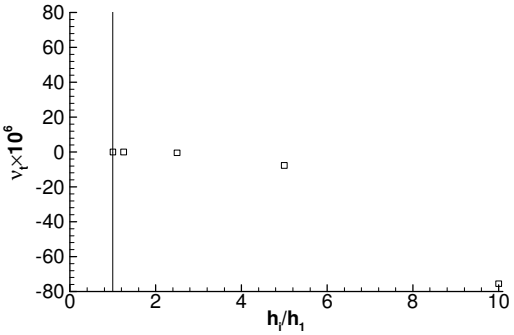

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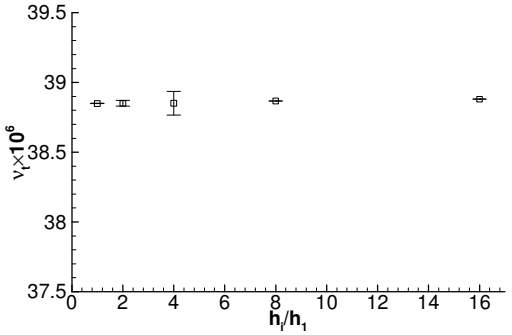

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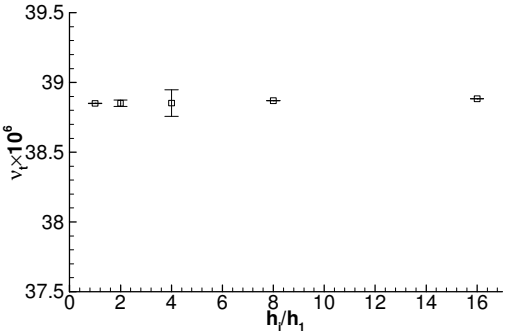

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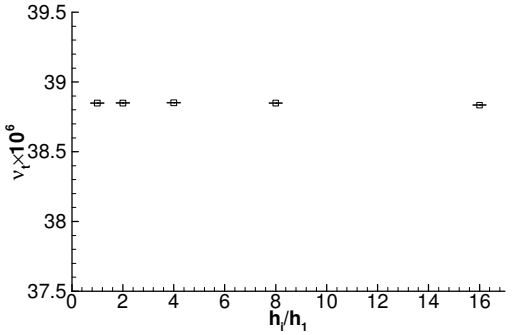

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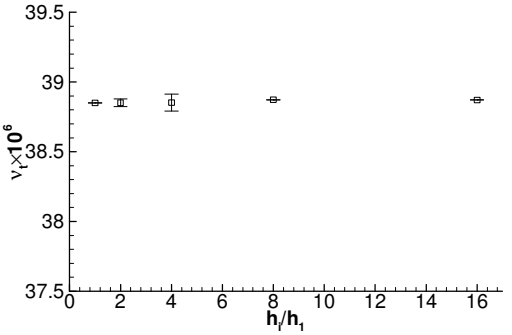
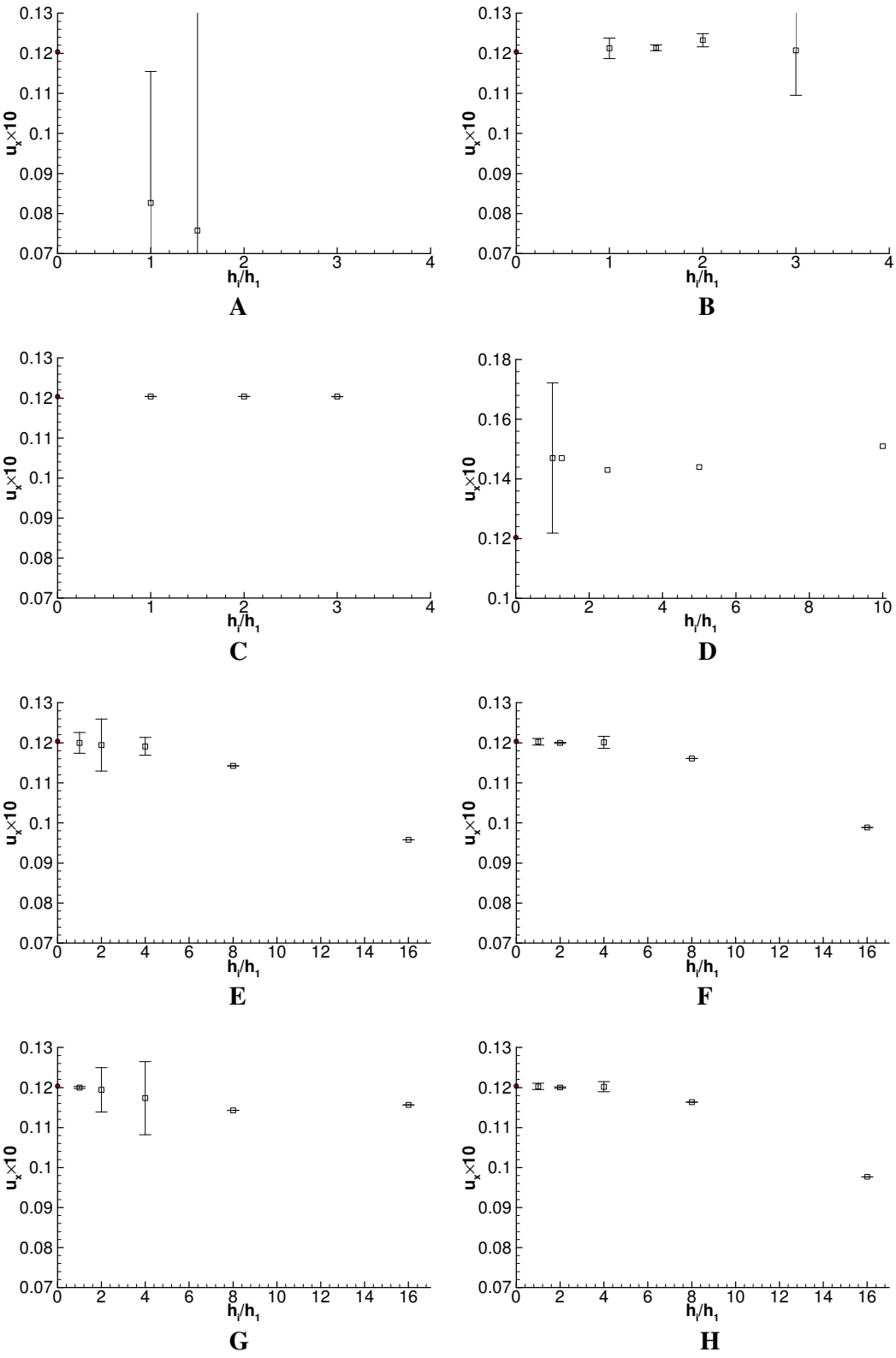
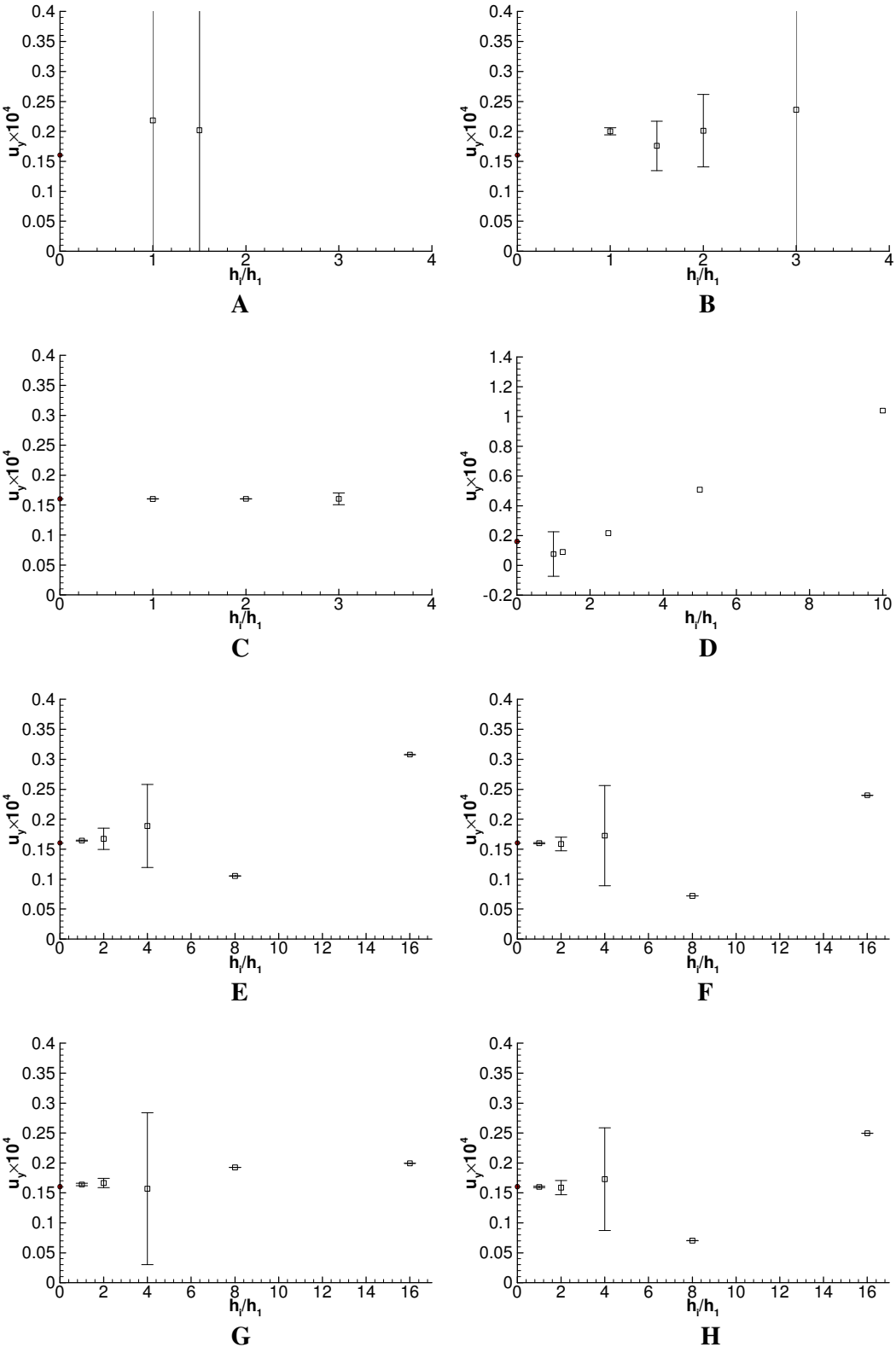


H

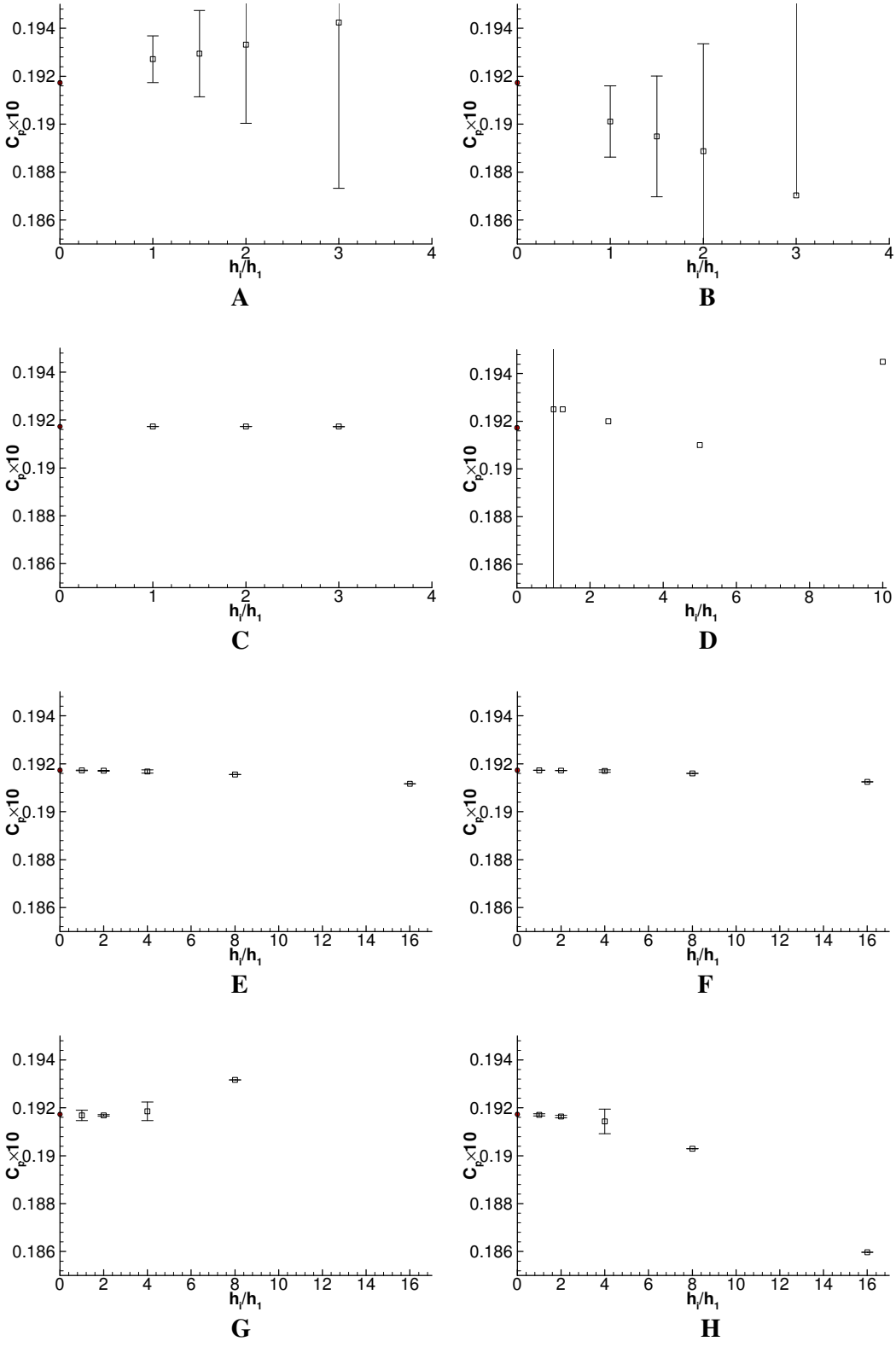
u_x velocity component at ***x=0.75, y=0.002***



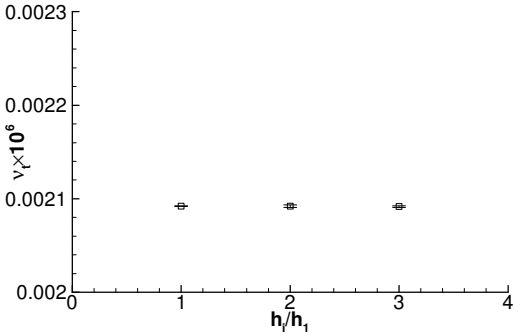
u_y velocity component at ***x=0.75, y=0.002***



C_p pressure coefficient at ***x=0.75, y=0.002***



ν_t eddy viscosity at ***x=0.75, y=0.002***



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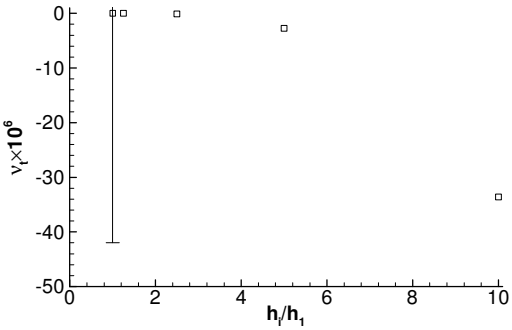

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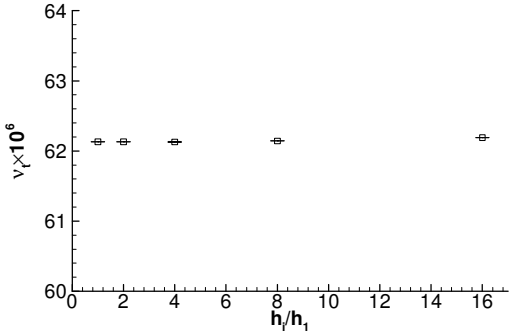

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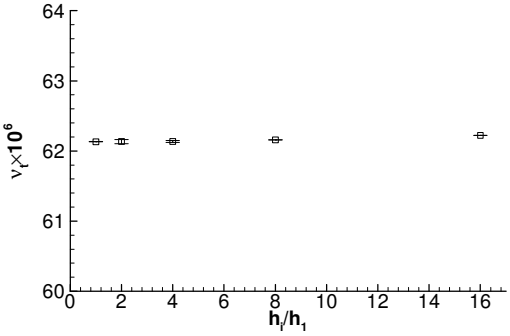

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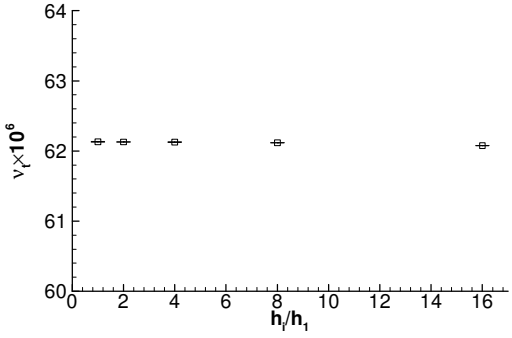

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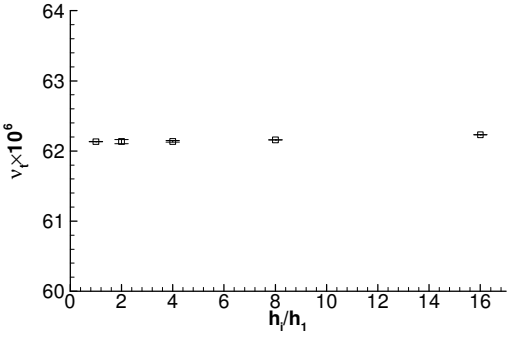
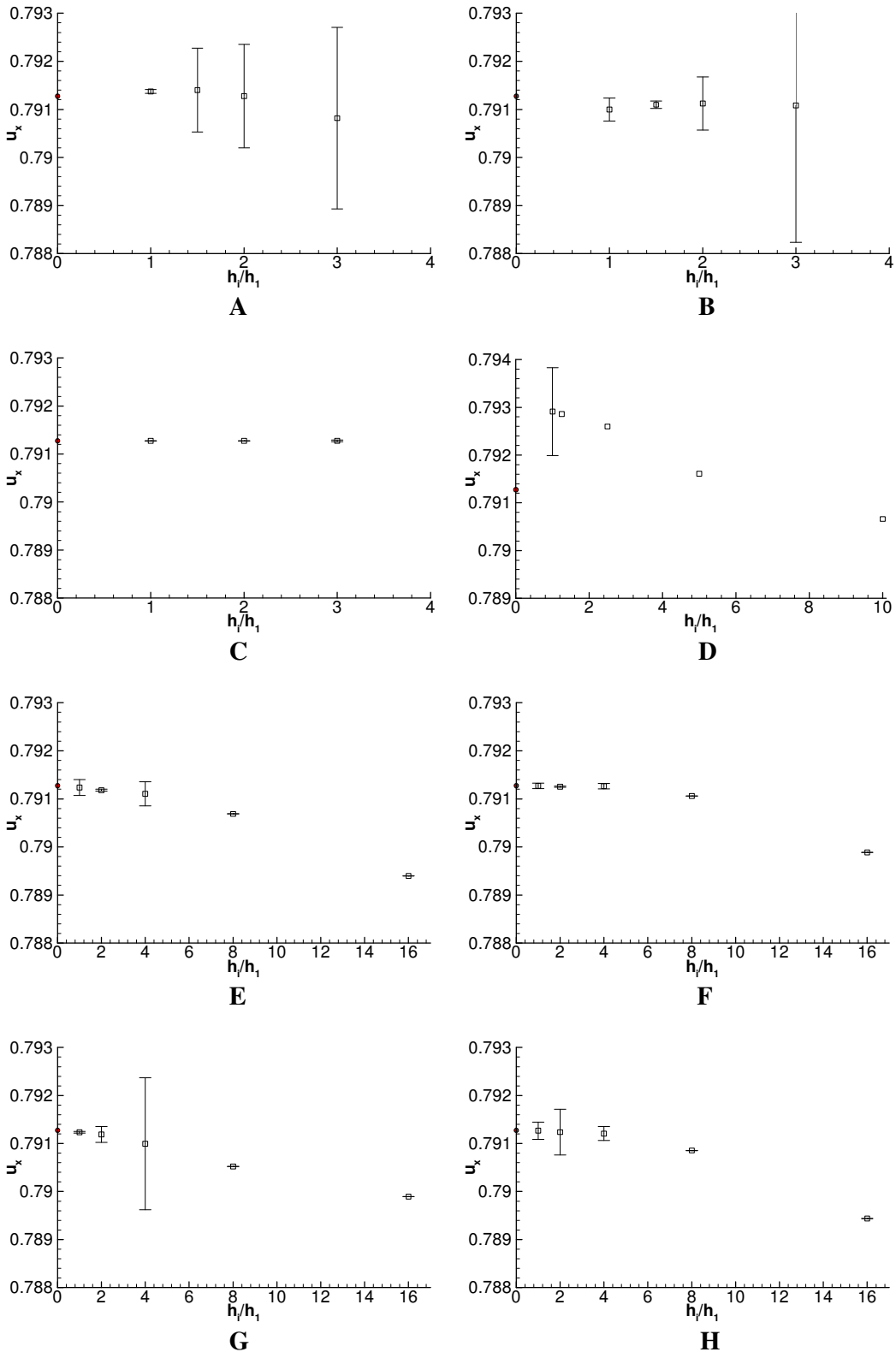
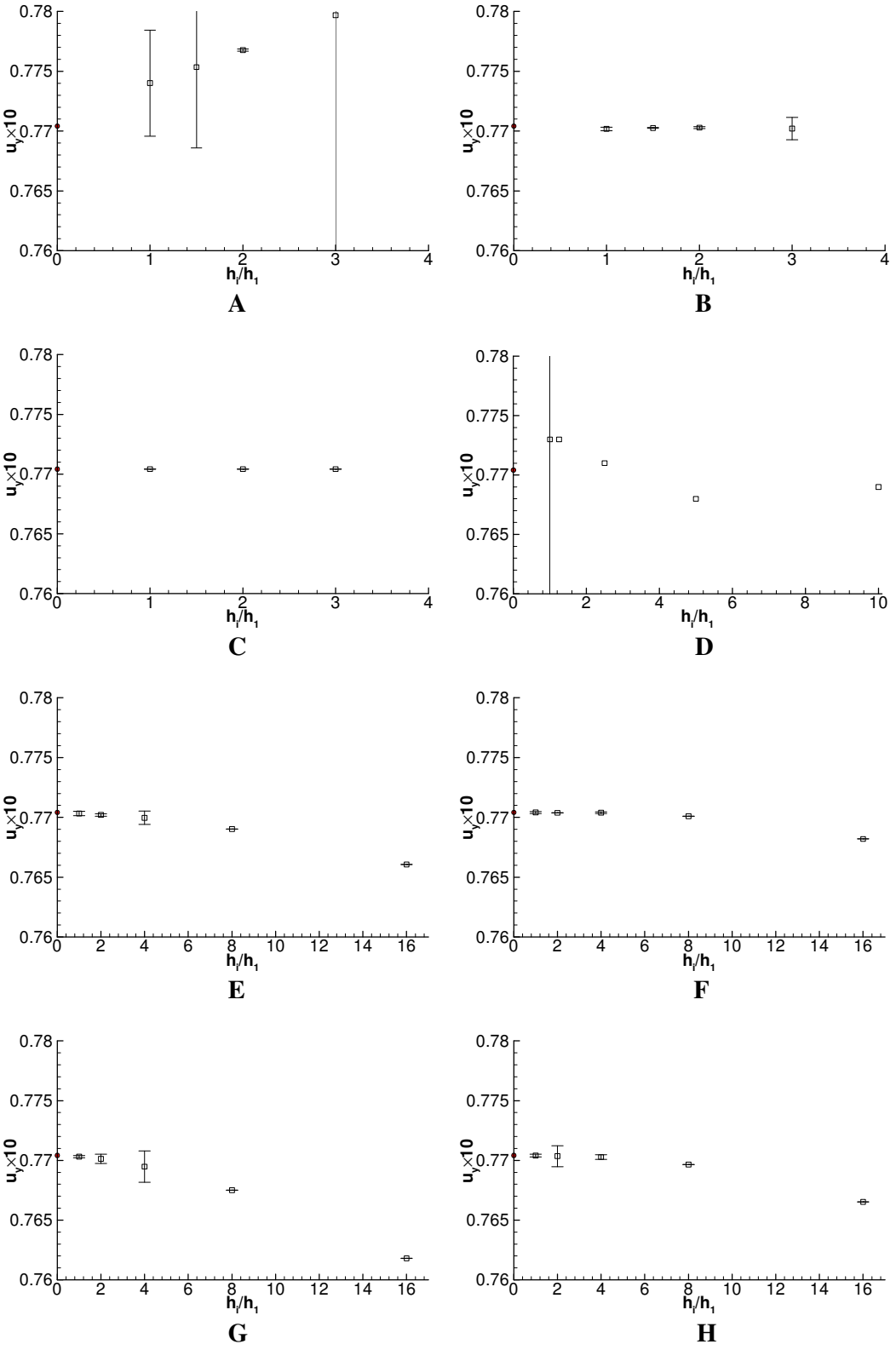


H

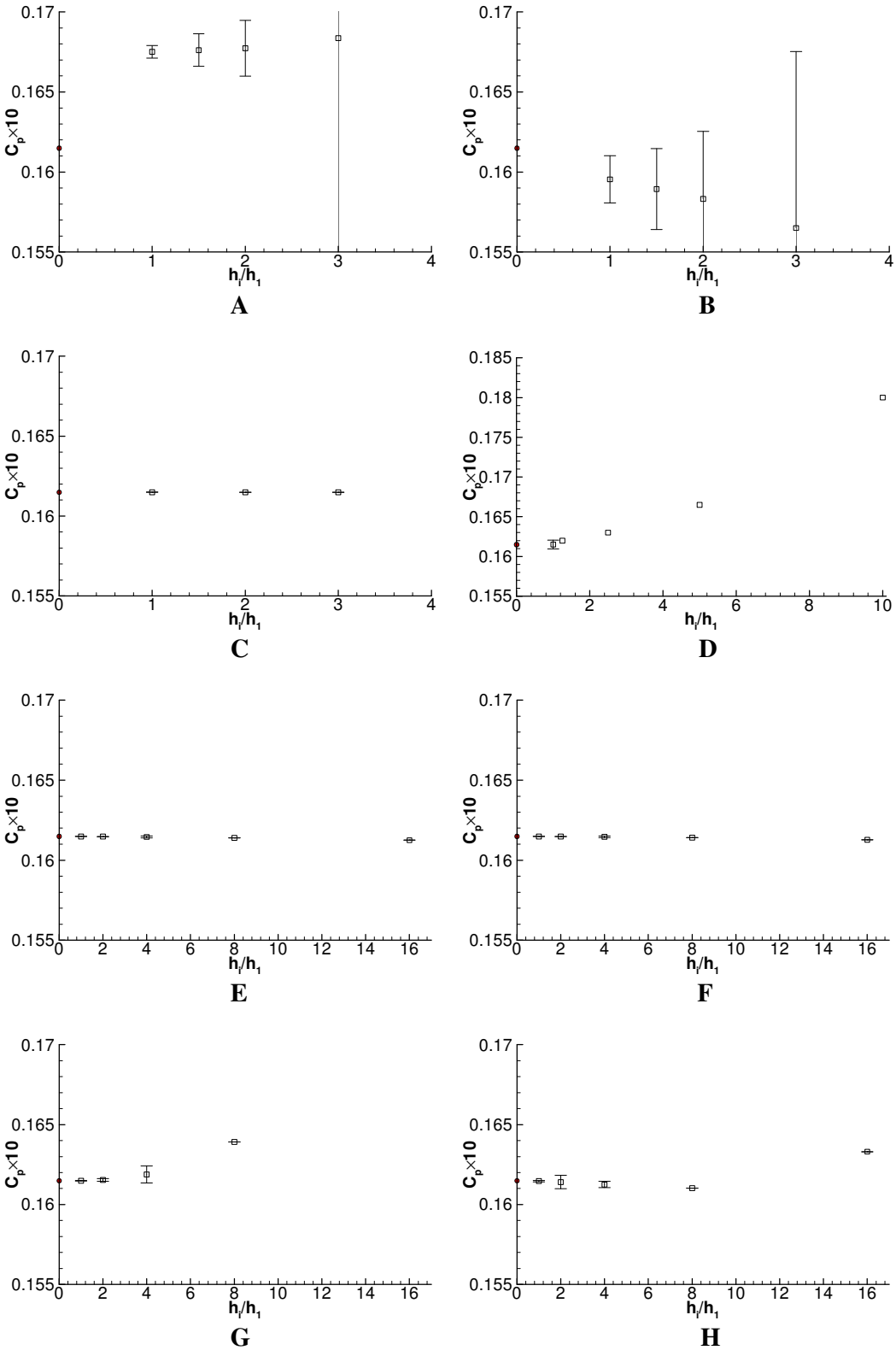
u_x velocity component at ***x=0.9, y=0.2***



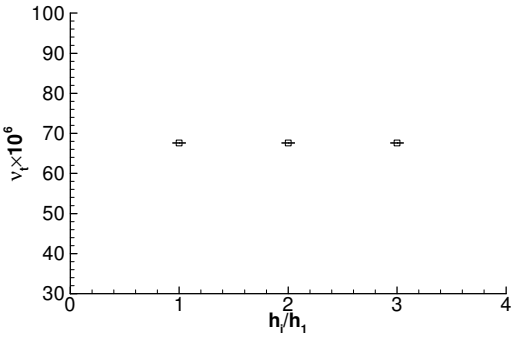
u_y velocity component at ***x=0.9, y=0.2***



C_p pressure coefficient at ***x=0.9, y=0.2***



ν_t eddy viscosity at ***x=0.9, y=0.2***



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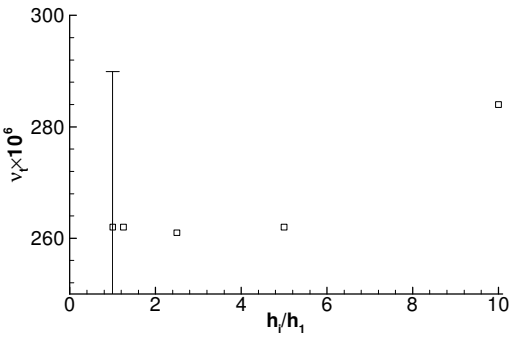

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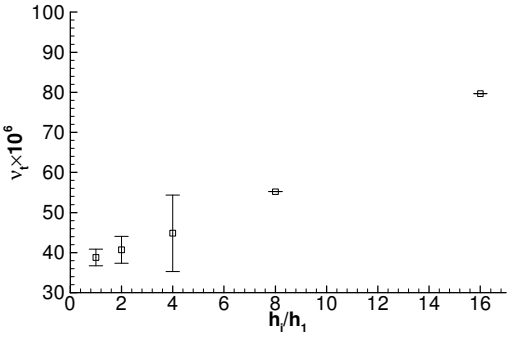

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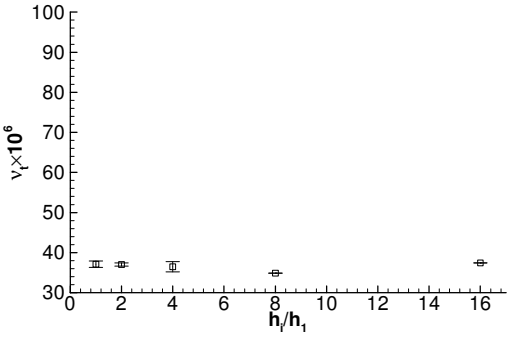

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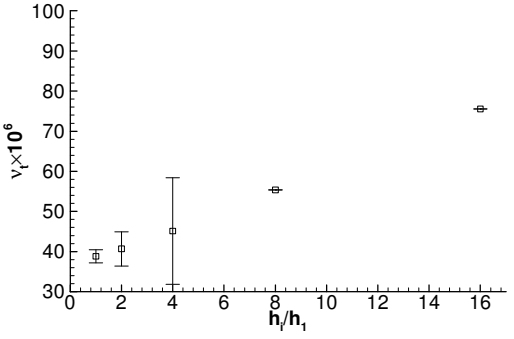

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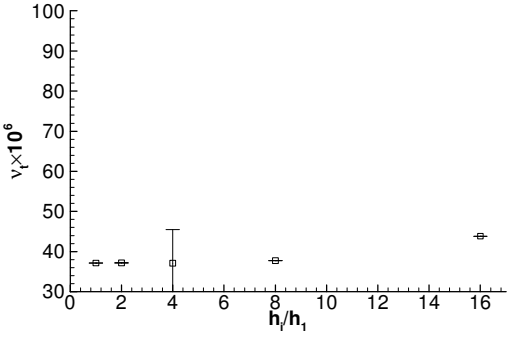
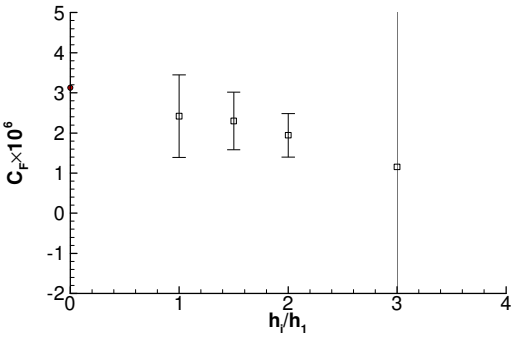


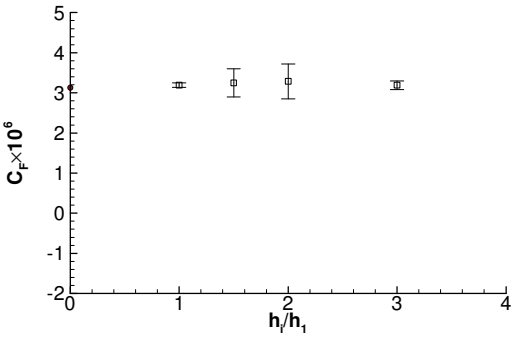
H

e) Integral quantities

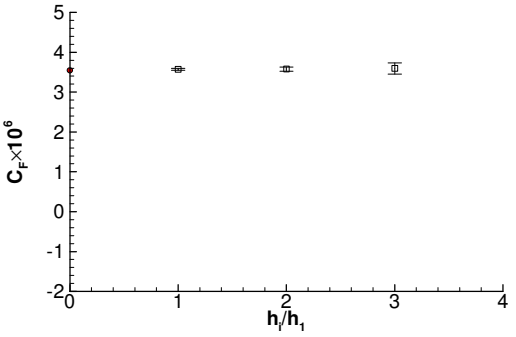
Friction resistance of the bottom wall



A



B



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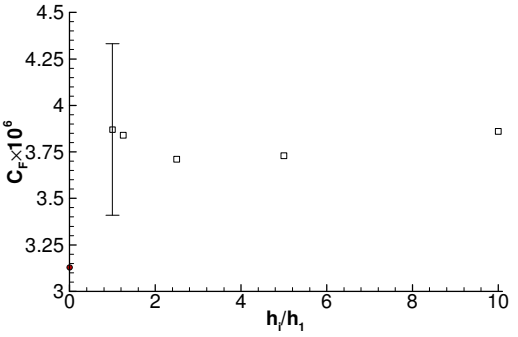

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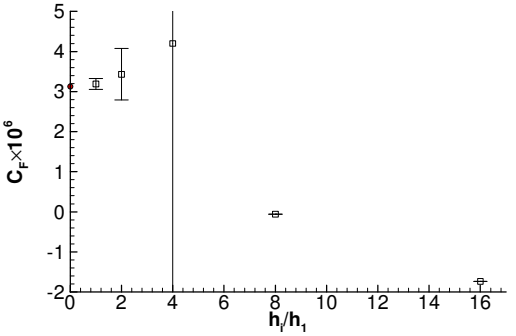

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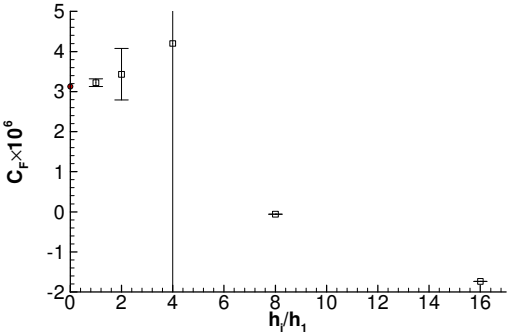

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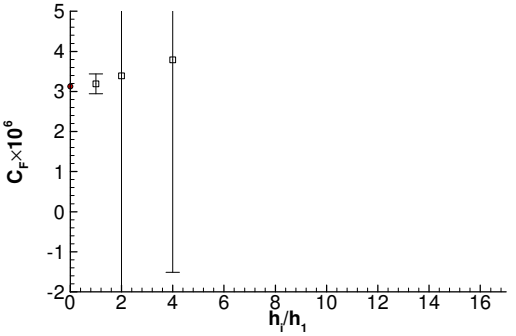

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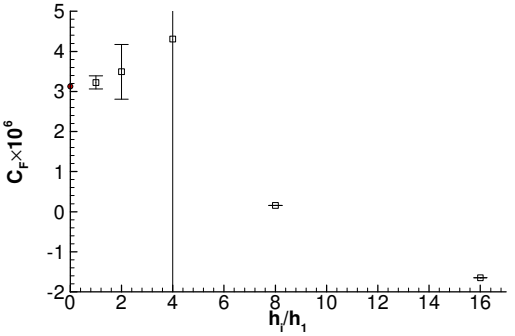

H