Turbulent Flow in Various Bent Pipes

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Outline

- V&V of Turbulence Models
- Turbulent Flow in Bent Pipes

V&V of Turbulence Models — Test Pipe

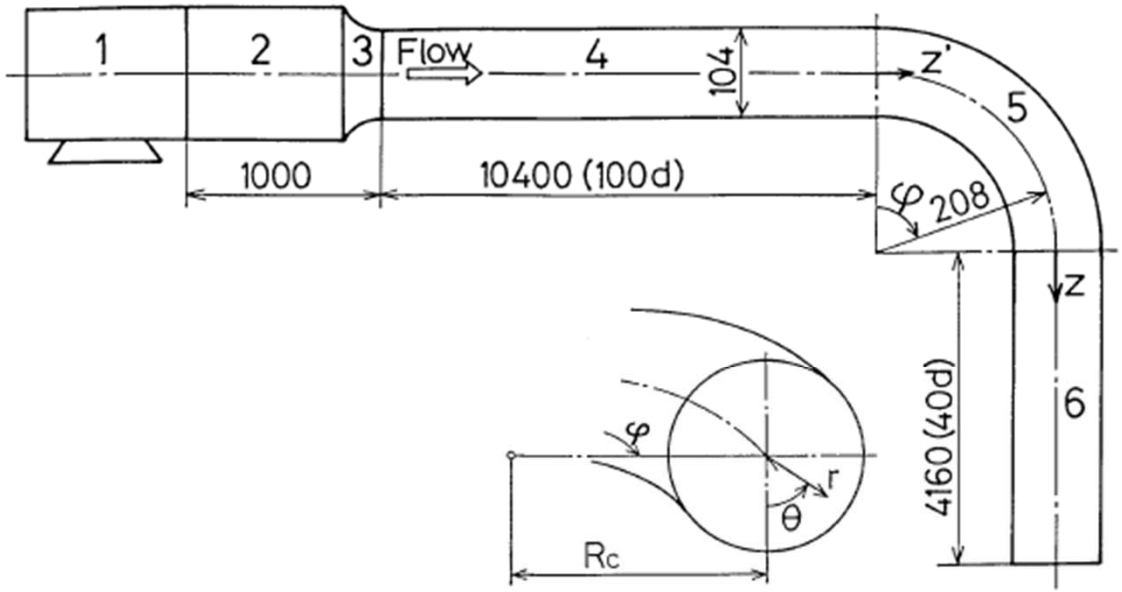
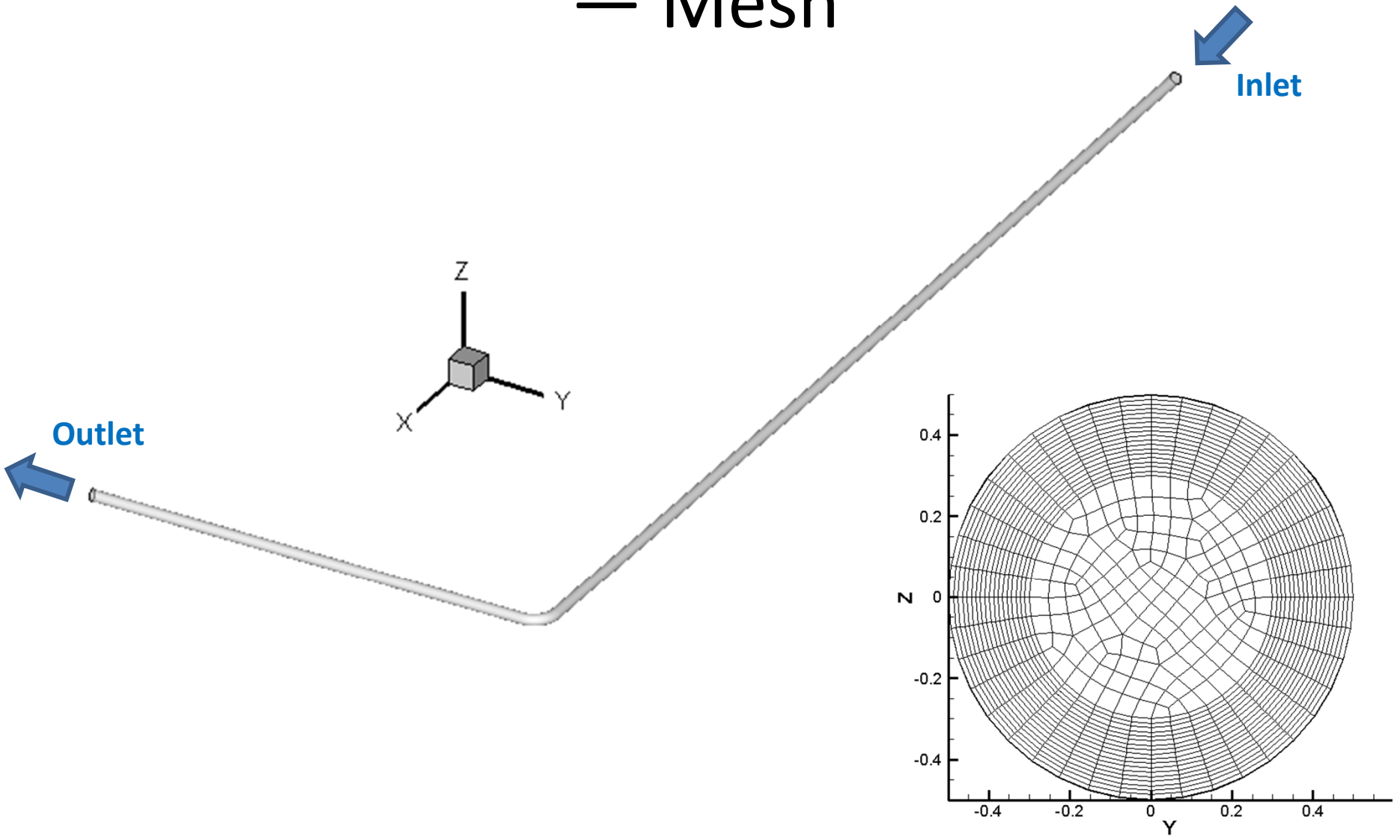


Fig. 1. Schematic diagram of test pipe and coordinate system. *1* Fan; *2* settling chamber; *3* contraction; *4* upstream tangent; *5* 90° bend; *6* downstream tangent

u_{ave} = 8.7 m/s; Re = 60000; ρ_{air} = 1.2647; $\mu_{air} = 1.983 \times 10^{-5}$; Pr = 0.712

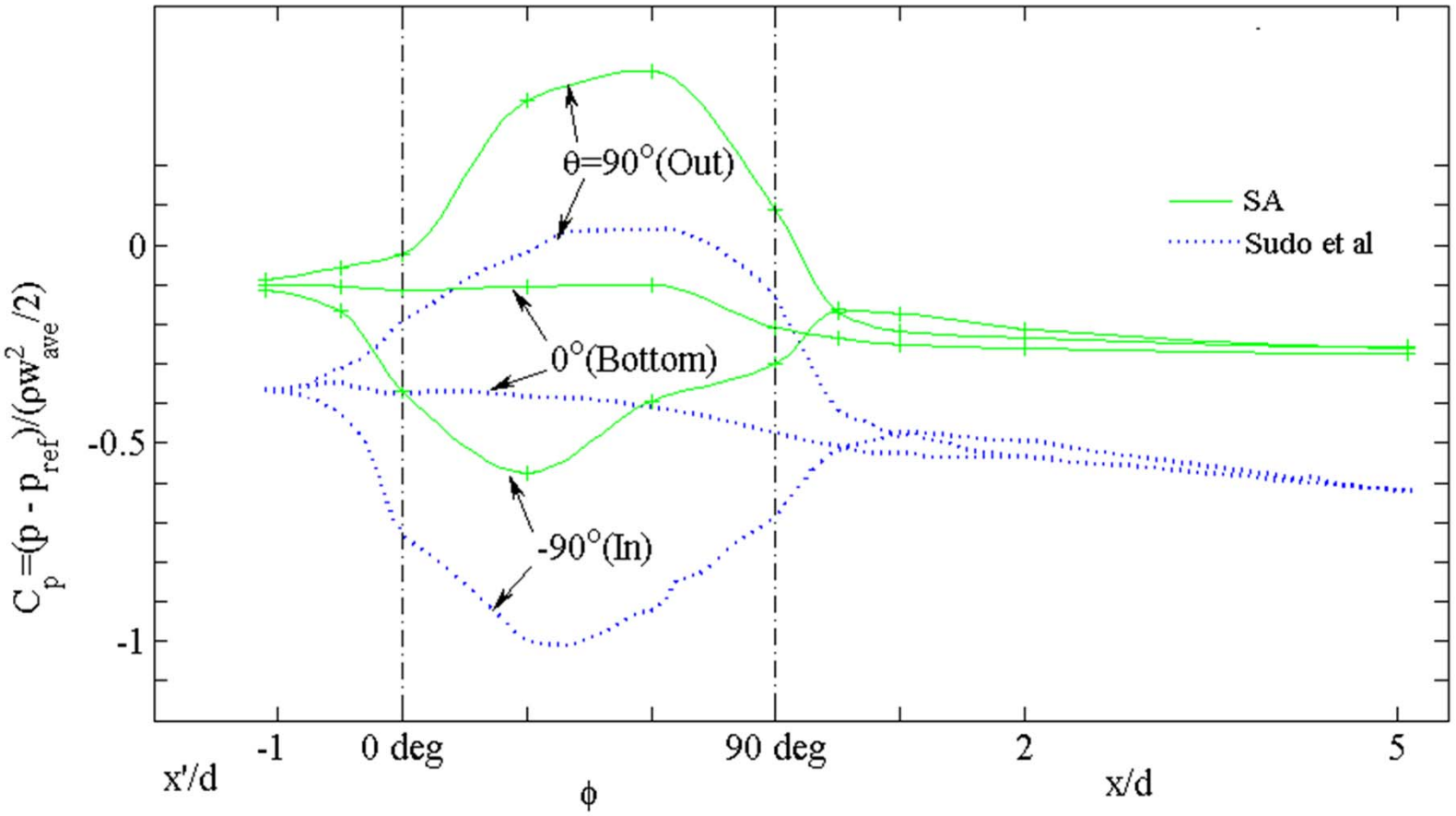
K. Sudo, M. Sumida, H. Hibara, "Experimental investigation on turbulent flow in a circular-sectioned 90-degrees bend," Experiments in Fluids 25 (1998) 42-49. http://puhep1.princeton.edu/~mcdonald/examples/fluids/sudo_ef_25_42_98.pdf

V&V of Turbulence Models — Mesh



V&V of Turbulence Models — Wall Static Pressure (1)

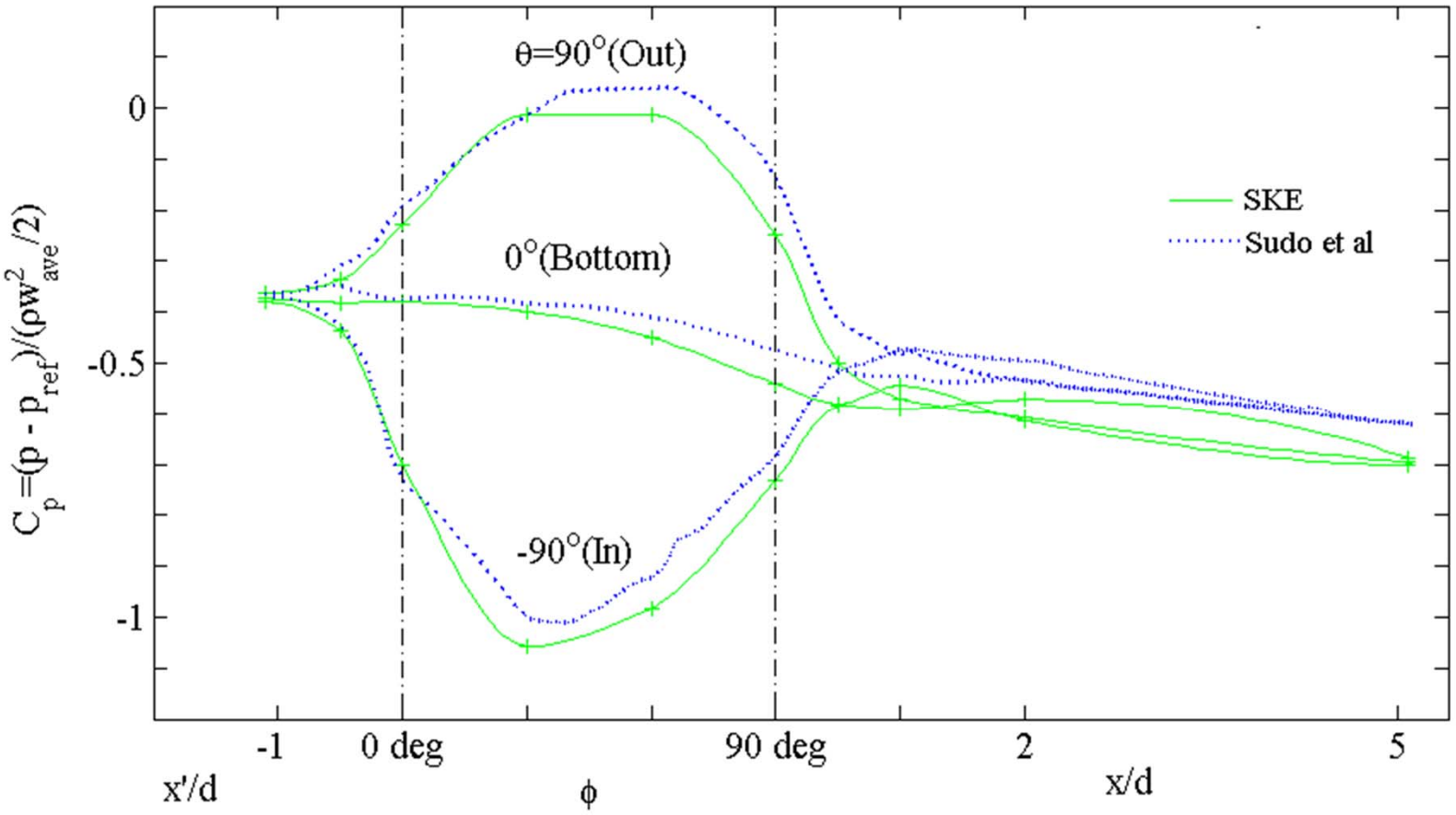
Spalart-Allmaras model *vs.* experiment



where P_{ref} = 100972.7 Pa at x'/d = -17.6

V&V of Turbulence Models — Wall Static Pressure (2)

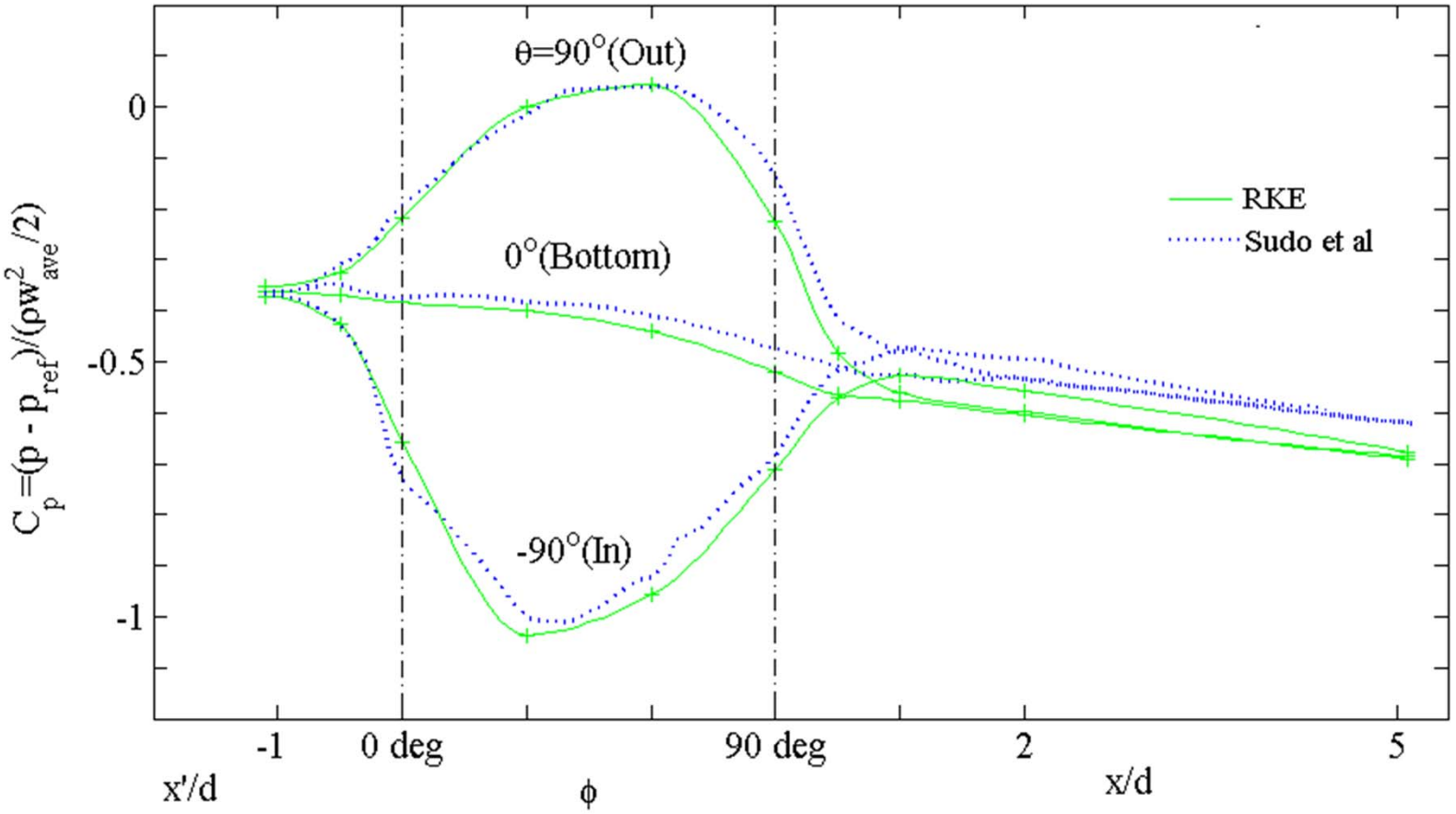
Standard k-e model *vs*. experiment



where P_{ref} = 100907.6 Pa at x'/d = -17.6

V&V of Turbulence Models — Wall Static Pressure (3)

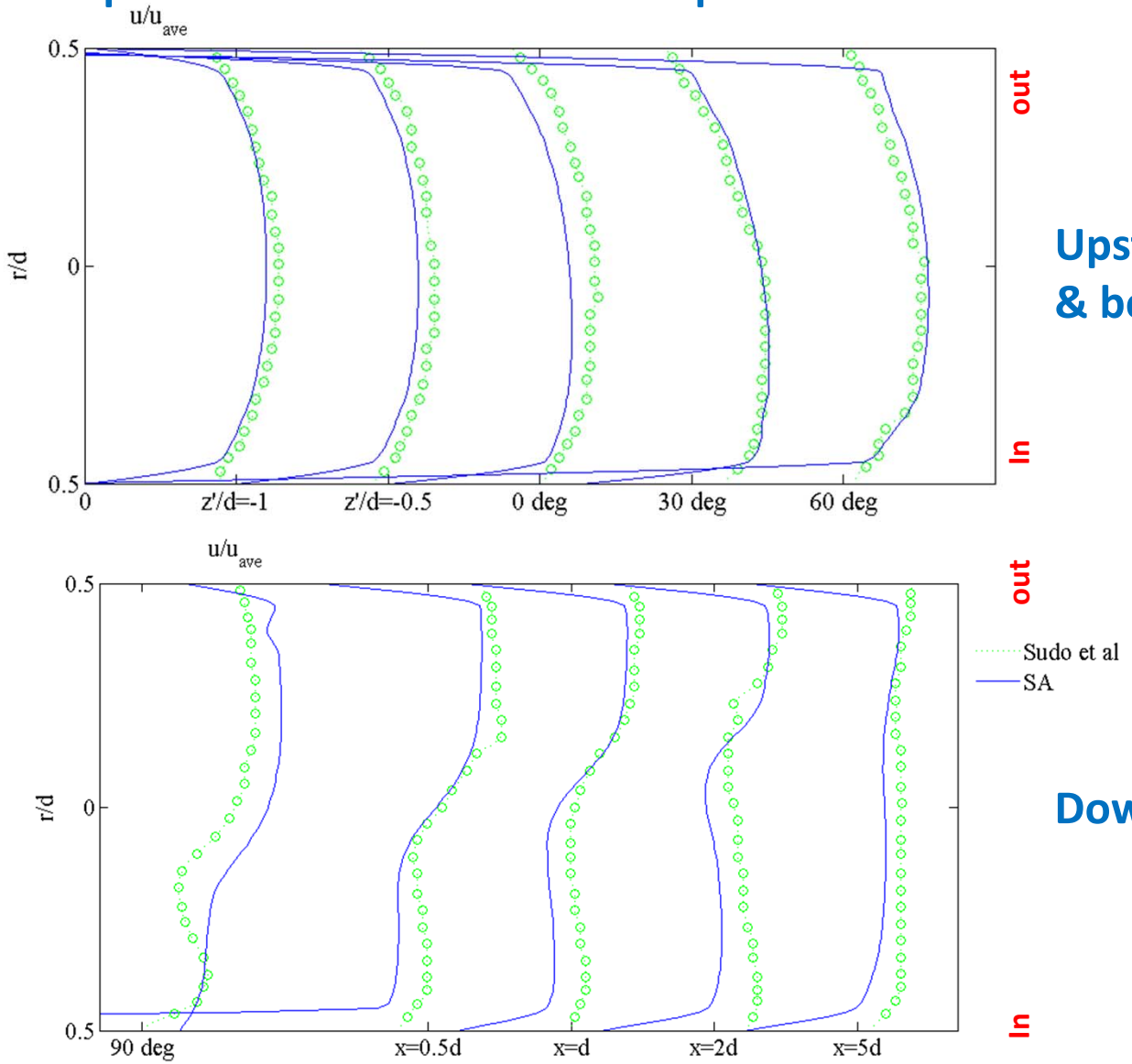
Realizable k-e model *vs.* experiment



where P_{ref} = 100910.1 Pa at x'/d = -17.6

V&V of Turbulence Models — Mean Longitudinal Velocity (1)

Spalart-Allmaras model *vs.* experiment

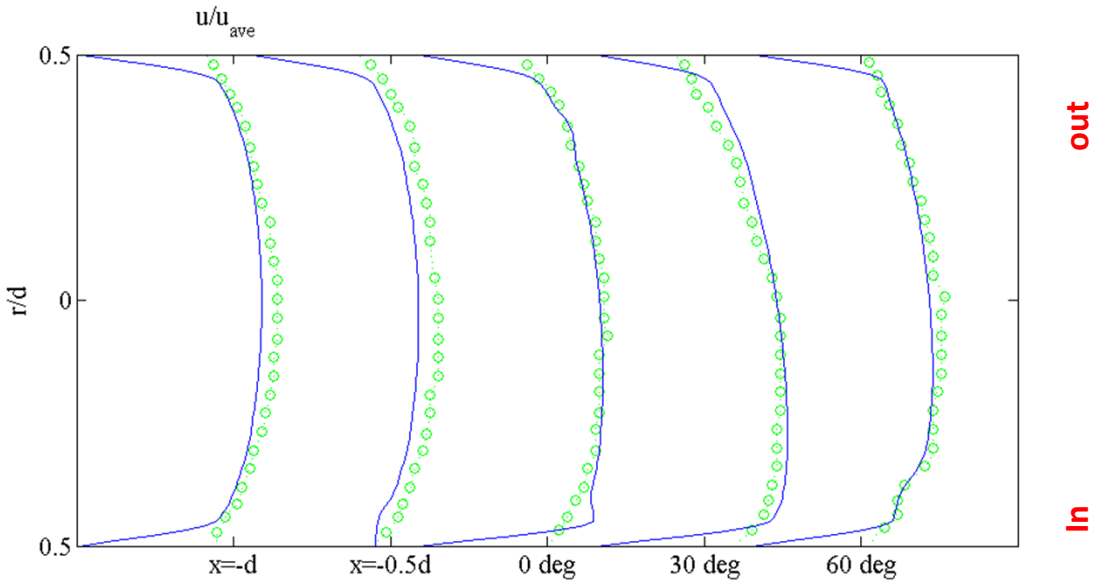


Upstream tangent & bend

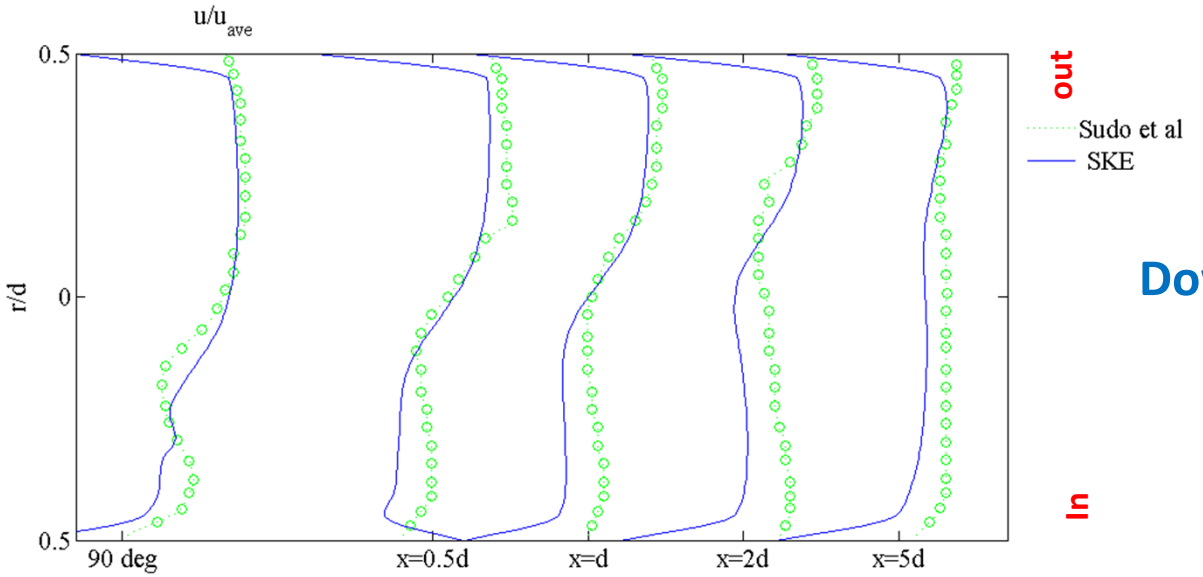
Downstream tangent

V&V of Turbulence Models — Mean Longitudinal Velocity (2)

Standard k-e model *vs*. experiment



Upstream tangent & bend



Downstream tangent

V&V of Turbulence Models — Conclusions

1. Wall Static Pressure

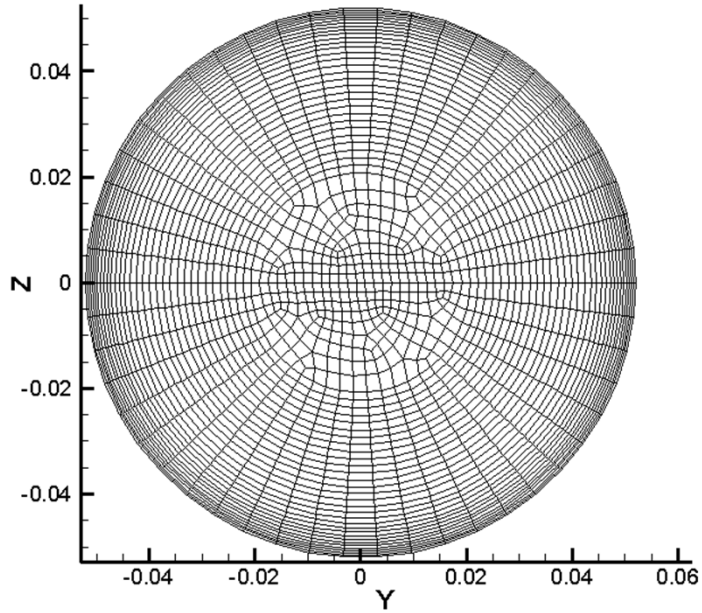
Adverse pressure gradient ($dp/d\phi > 0$) reduces the kinetic energy and even leads to flow separation;

Favorable pressure gradient ($dp/d\phi < 0$) accelerates the fluid;

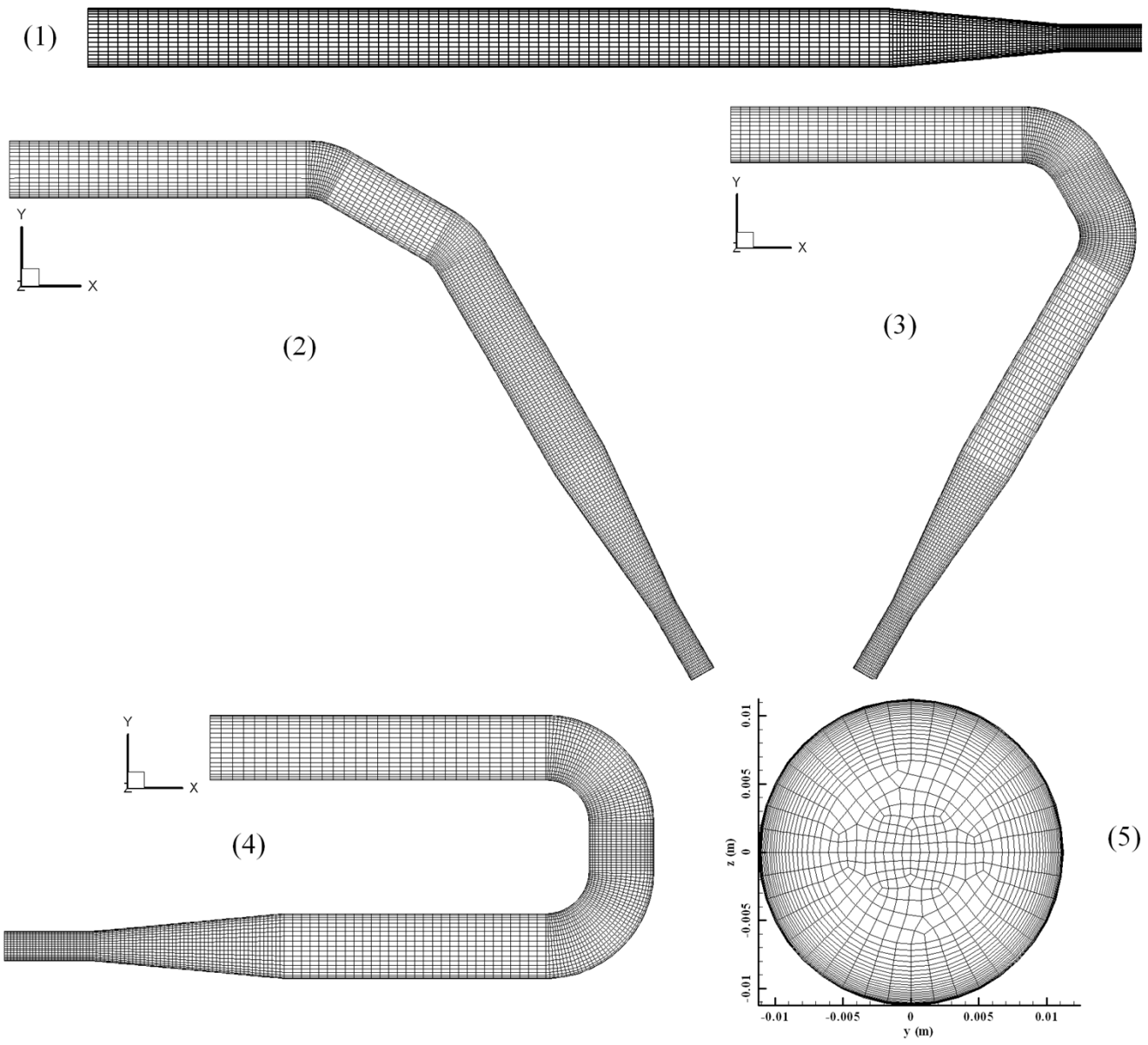
Secondary flow moves from high gradient region to low gradient region.

2. RKE model performs the best

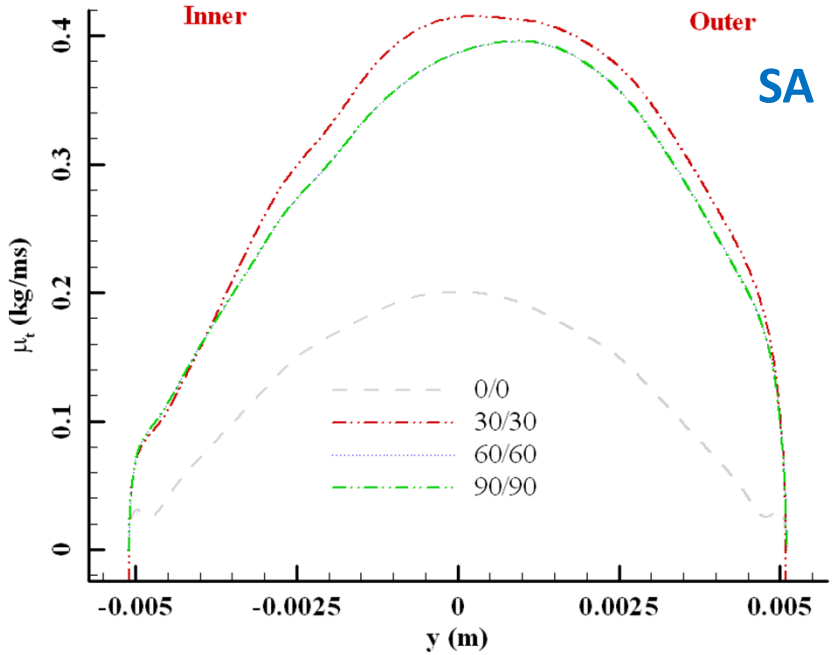
3. Refine Grid



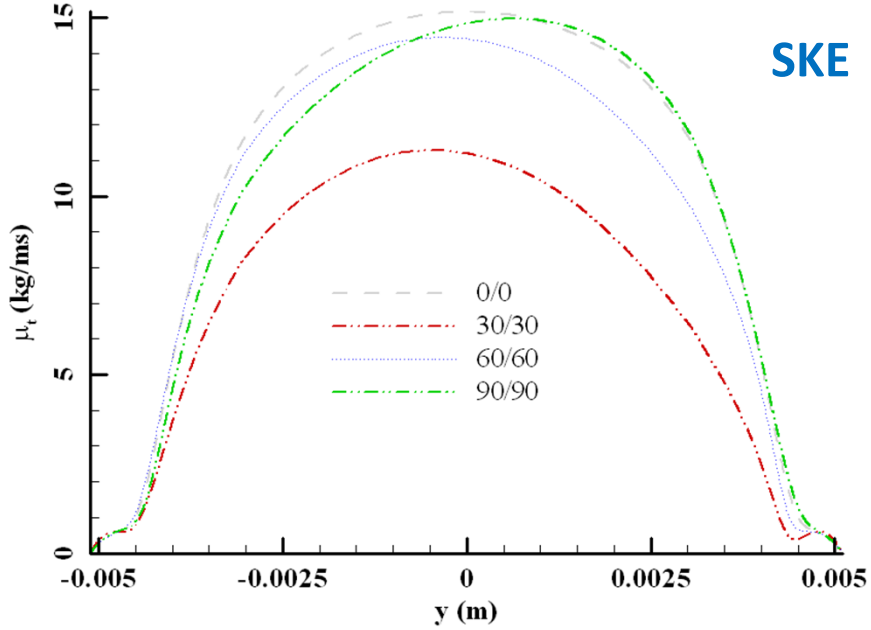
Turbulent Flow in Bent Pipes — Various Bent Pipes

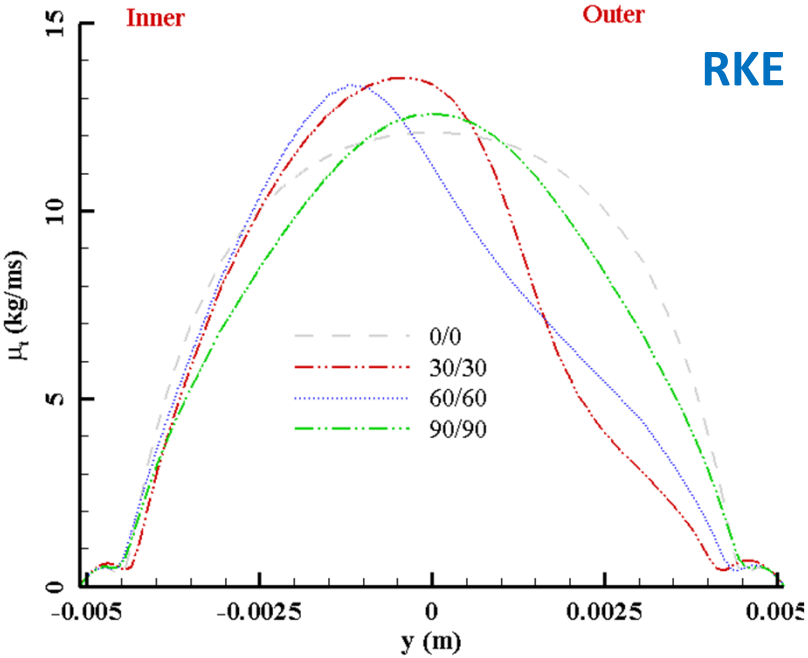


Turbulent Flow in Bent Pipes — Eddy Viscosity



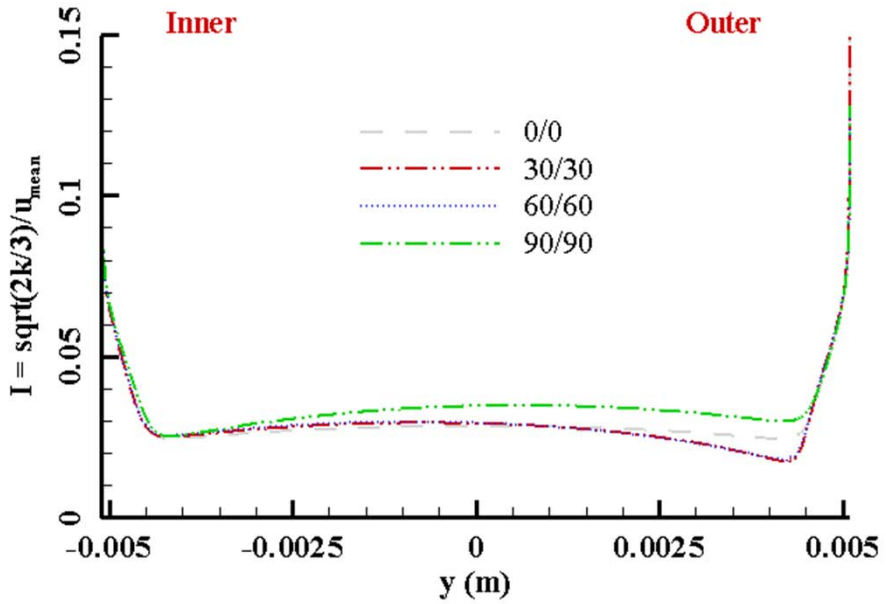
$$\mu_t = C_\mu \rho k^2 / e$$



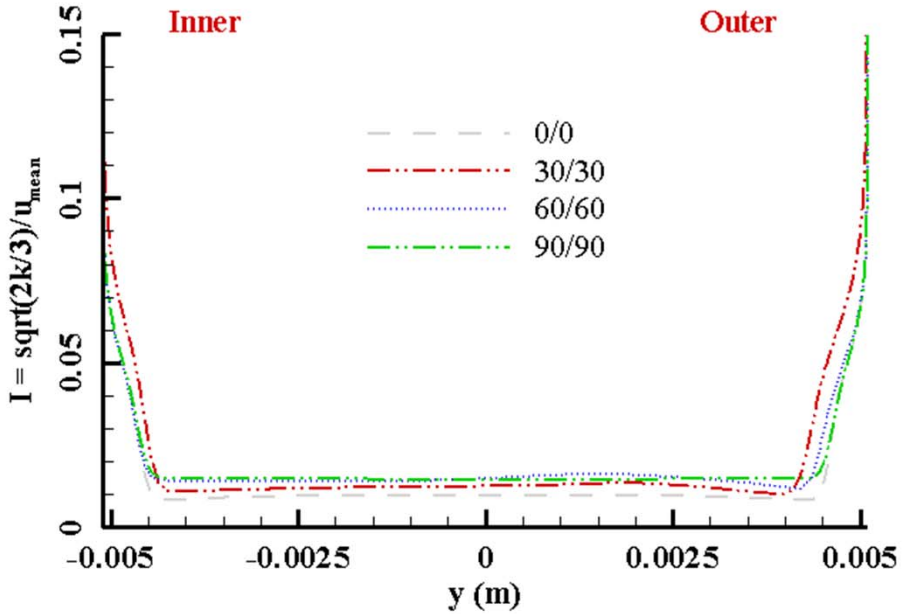


Turbulent Flow in Bent Pipes — Turbulence Level

$$I \equiv \frac{u'}{u_{mean}}$$



SKE



RKE