Community Christmas Competition IV

Simulation of the backward facing step

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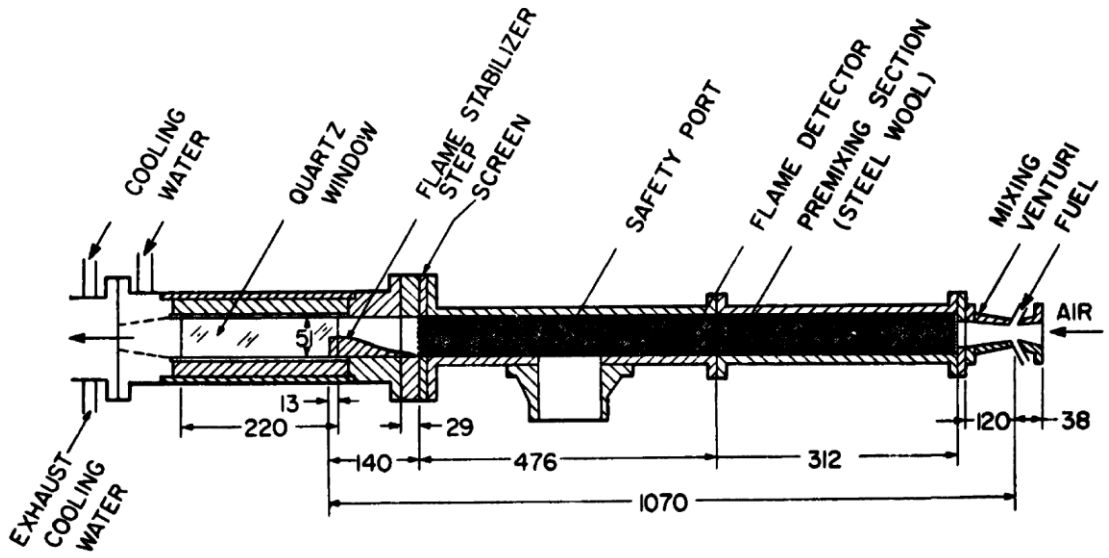
Goal, Challenge & Hypothesis

- Goals:
  - Estimation of the reattachment length at several inlet velocity
  - Velocity profile comparison
- Challenge:
  - Transitional $\boldsymbol{R_e}$
- Influence of turbulence model on the solution
  - Standard *k-ε*
  - RNG *k-ε*
  - *k-ω* SST
  - *k-ω* SST LM

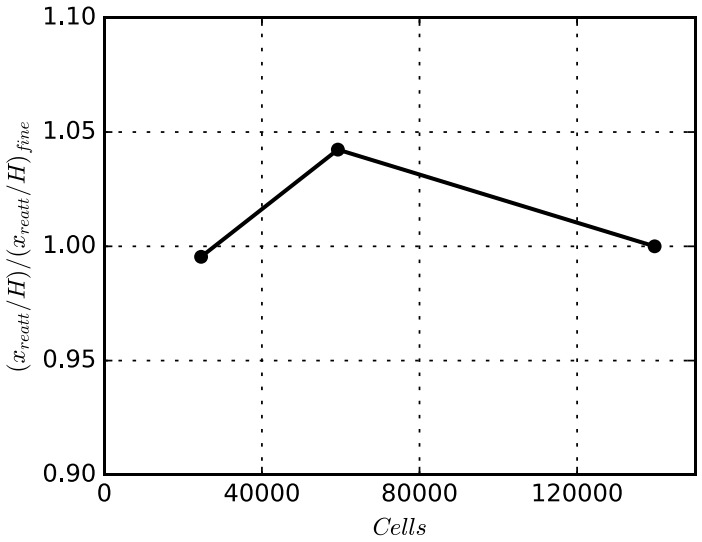
- Hypothesis
  - Steady, no-combustion (simpleFoam)
  - 2D
  - 2% Inlet turbulent intensity (why not...)

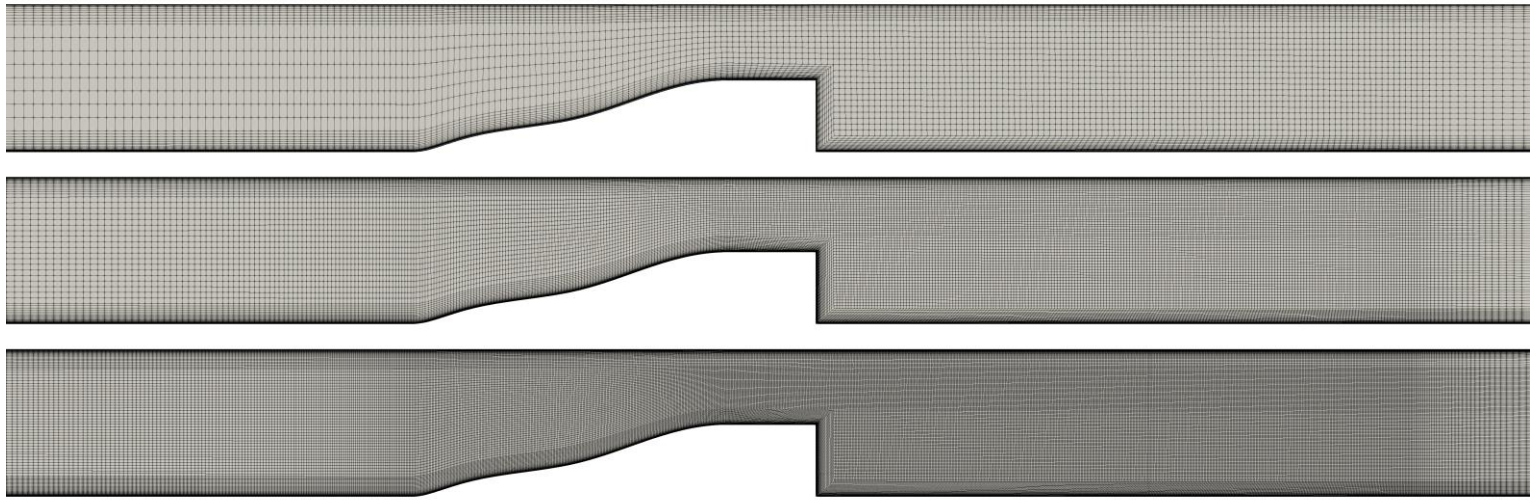


Mesh sensitivity

- Done with ***k-ω SST*** - ***y^+ < 1*** aimed* - at the highest speed ***U_0 = 22.2 m.s^{-1}***
- Reattachment length as the parameter probed at first cell showing ***$U_x > 0$***
- Same wall-treatment - Core mesh cell aimed at ***2x2/1x1/0.5x0.5 mm²*** for the 3 meshes

- "Oscillatory" convergence. We select the medium mesh ***1x1 mm²*** for time saving purposes and because it looks good enough





*Low-Reynolds number wall-BC were used for ***k-ε*** based models also later on

Results – Reattachment Length

- Evaluated as:

$$\frac{(x/H)_{OF} - (x/H)_{REF}}{(x/H)_{REF}} \ [\%]$$

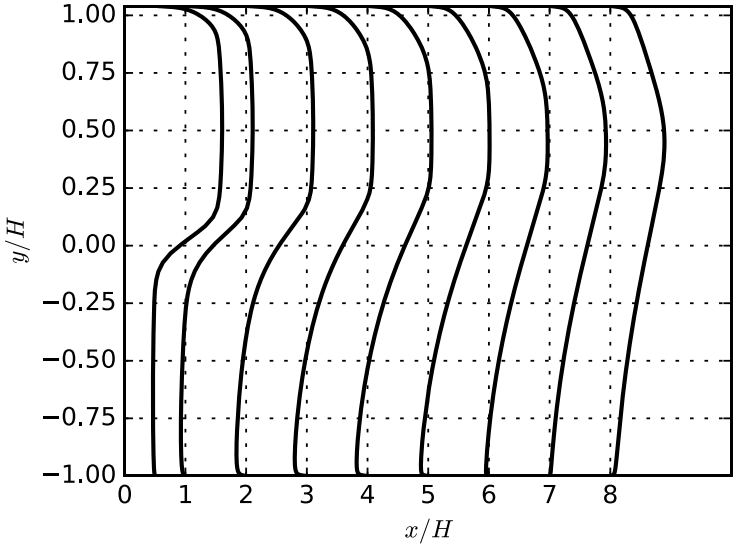
U0 (m/s)	*REF x/H*	*k-ε*	*RNG k-ε*	*k-ω SST*	*k-ω SST LM*
9,1	6,5	*+5,0%*	*+19,0%*	*+23,0%*	*+23,3%*
13,3	7	*-0,8%*	*+14,7%*	*+31,3%*	*+31,5%*
22,2	6,8	*+3,8%*	*+19,2%*	*+26,2%*	*+24,9%*

- ***k-ε*** presents the closest results, followed by ***RNG k-ε***. ***k-ω*** models far overestimates the reattachment length.

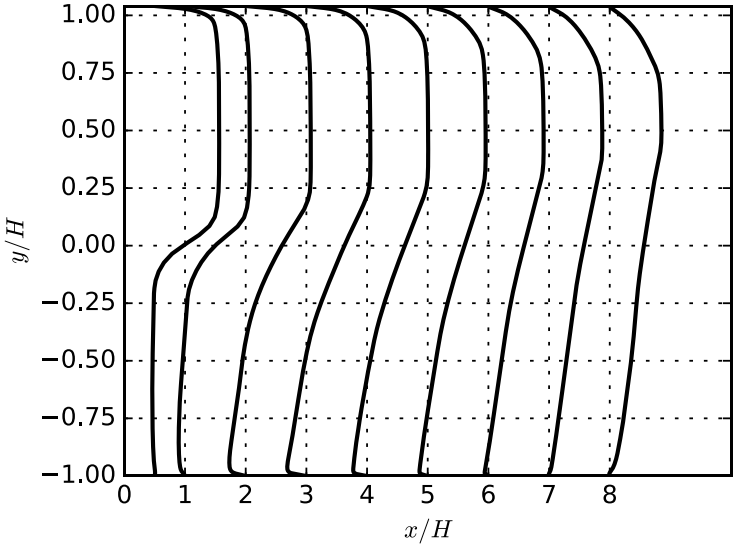
Move fast slides #5 #6 #7, looks like a GIF

Results – Velocity profiles – U_0 = 9,1 m.s^{-1}

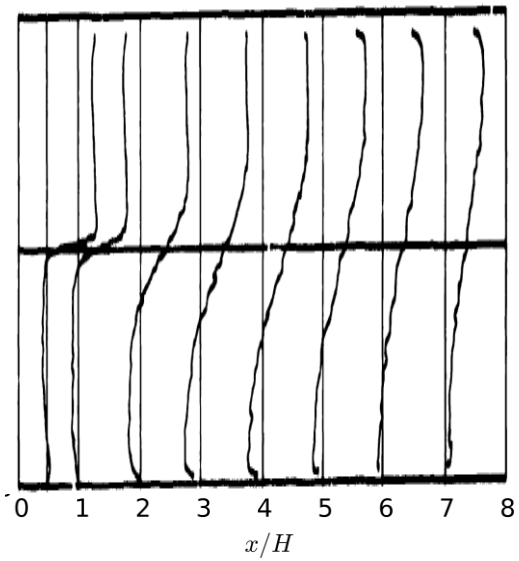
k-ε



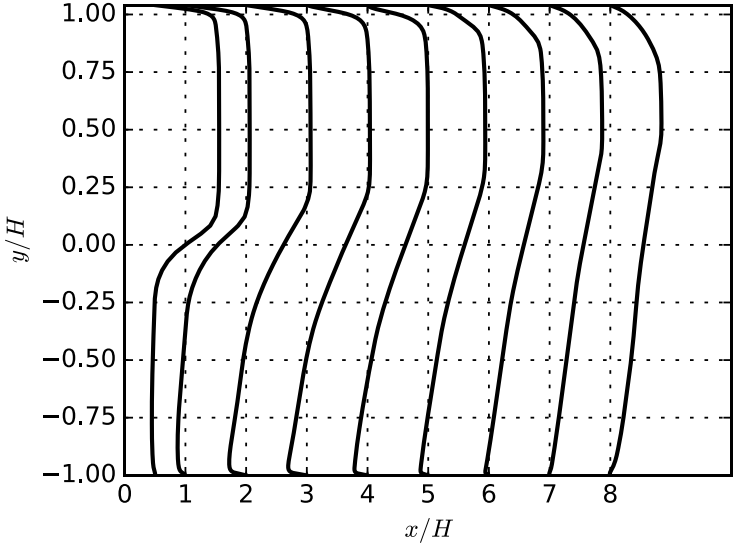
k-ω SST



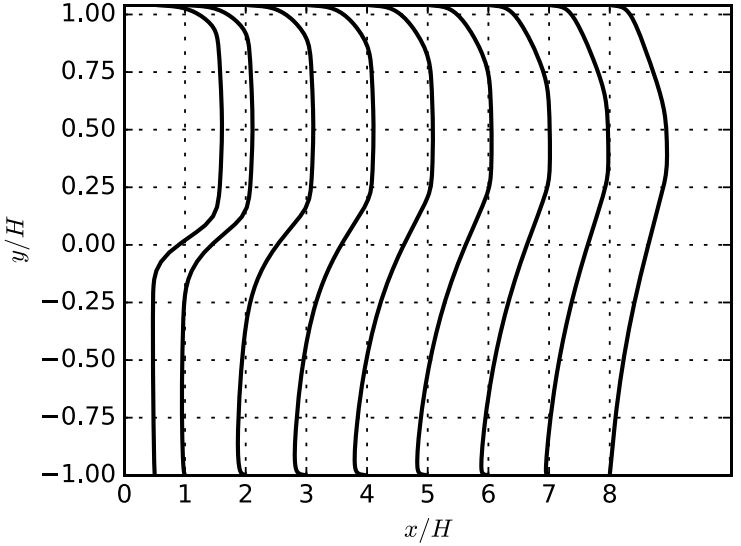
Exp.



k-ω SST LM



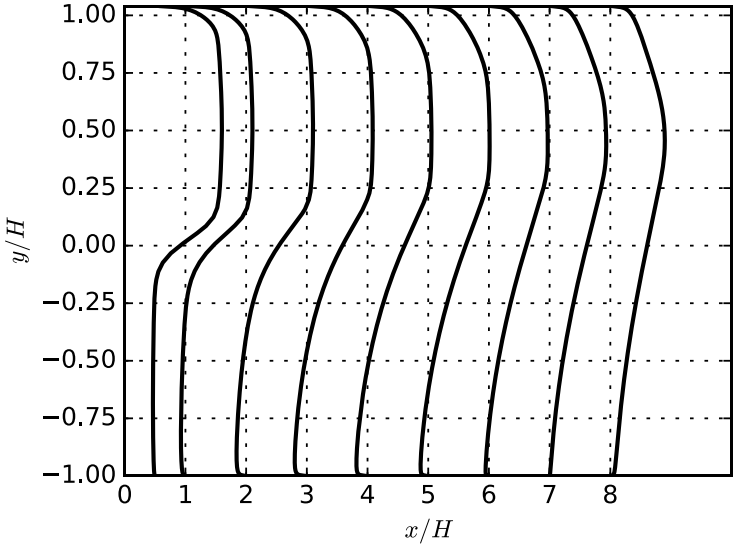
RNG k-ε



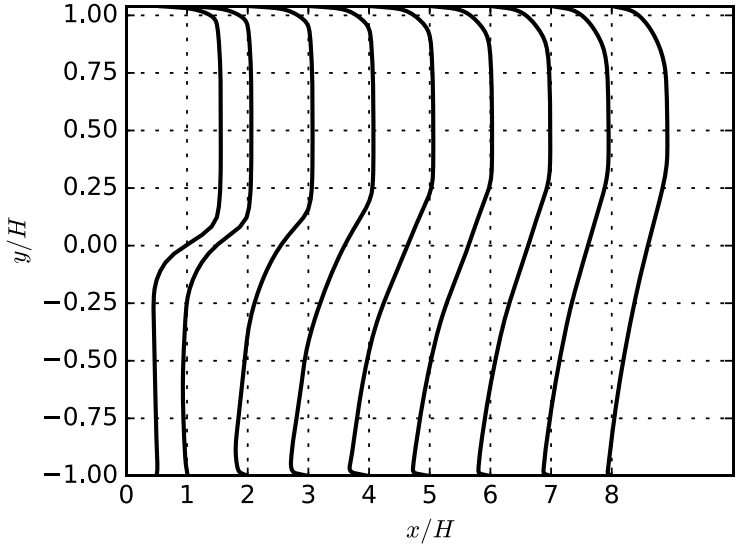
Move fast slides #5 #6 #7, looks like a GIF

Results – Velocity profiles – U_0 = 13,3 m.s^{-1}

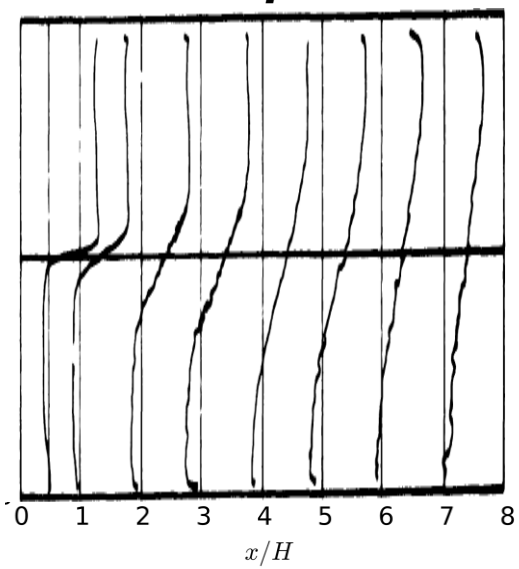
k-ε



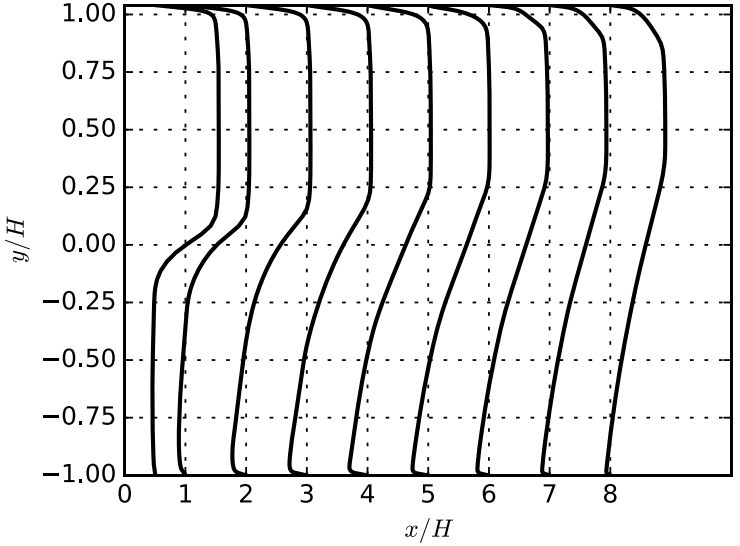
k-ω SST



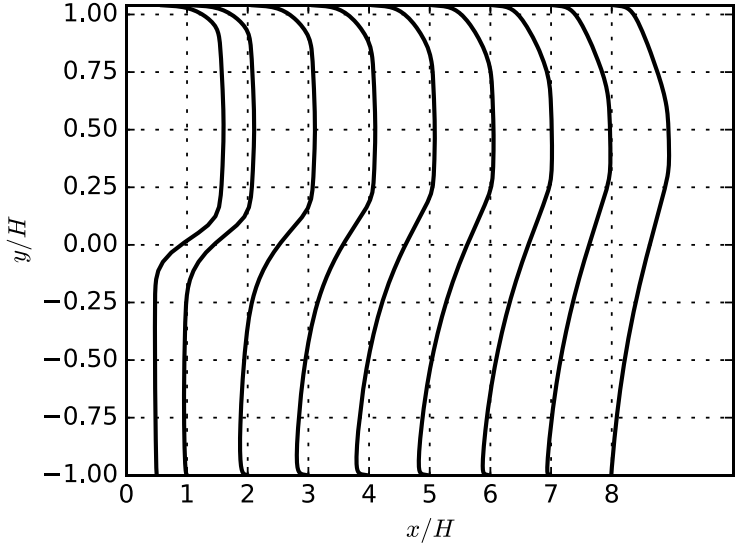
Exp.



k-ω SST LM



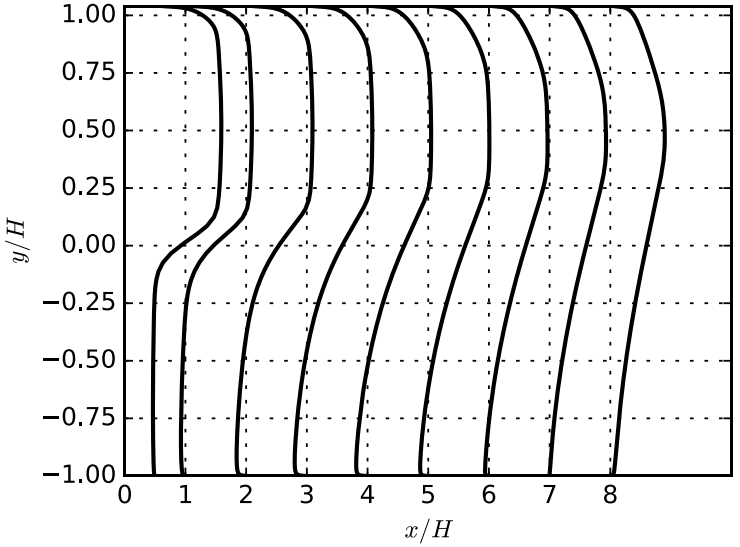
RNG k-ε



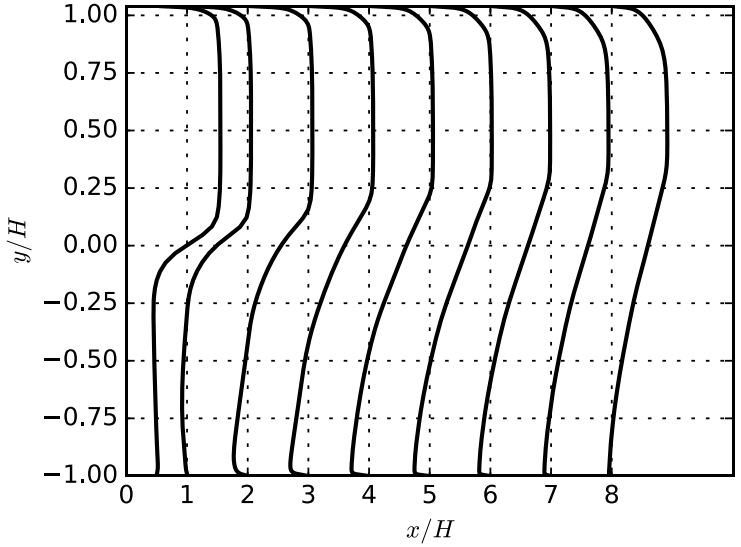
Move fast slides #5 #6 #7, looks like a GIF

Results – Velocity profiles – U_0 = 22,2 m.s^{-1}

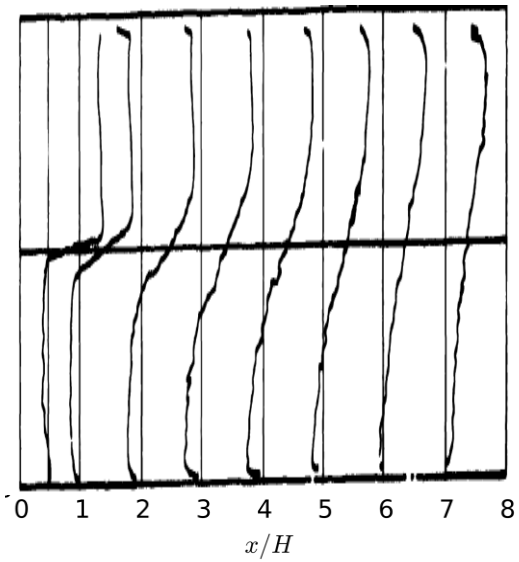
k-ε



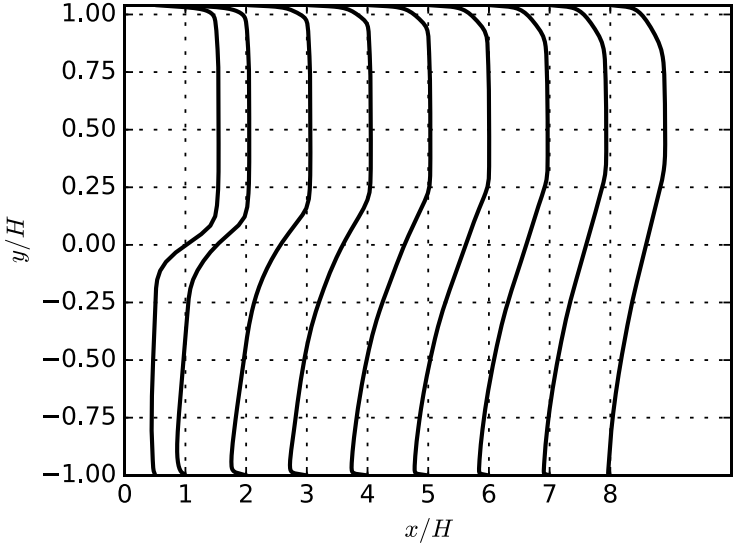
k-ω SST



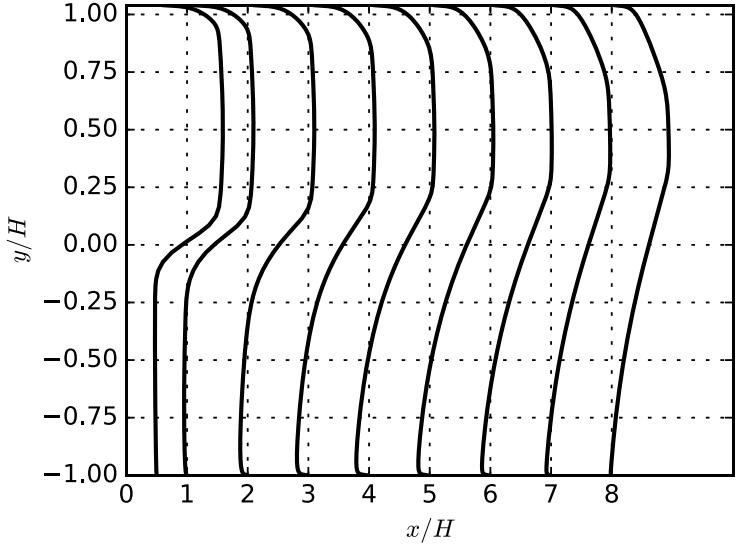
Exp.



k-ω SST LM



RNG k-ε



Comments

- Problem is more difficult than it seems at first sight. It requires a good understanding of the physics and CFD. Source of the problem can be anywhere at this point (2D, steady-state, BC, fv* files…) and I let other participants enlighten me on the proper approach ☺

- k-ε based model are closer to Exp. on the reattachment length. k-ω based models seem to have closer velocity profiles (check especially at x/H = 4-5 at y/H = -1) although it is hard to assess.

- Overall, the results over-estimate the reattachment length, which suggest either too diffusive numerics (I guess), or simply wrong assumption when creating the fluid domain:
  - Inlet diffuser was neglected.
  - Outlet confuser was neglected > It may be assumed that the confusor at the outlet (close to the step) creates a positive pressure gradient upstream and that the flow is « pushed » down earlier than in our simulations where this feature is absent. This could partially explain our overall overestimated reattachment length.