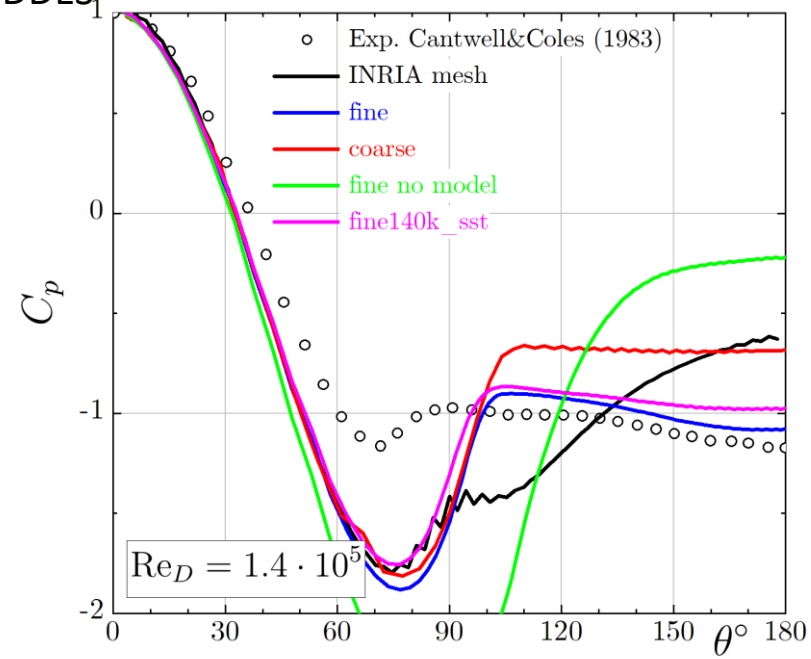
Simulations of the flows over round cylinder at different Reynolds' numbers

Re_D=140000

- The basic turbulence model does not influence on the results noticeably
- The usage of less dissipative SGS model (DDES based on Δ_{lsq}+S3QR) has led to worse results (more close to *no model* ones)
- The most challenging case
  - due to laminar separation (in the shear layer) without turbulent reattachment
  - the results depend on too many options (SGS model, numerics, mesh, luck, …)
  - mesh refinement does not lead to convergence [Breuer, 2000]
  - the most challenging for the DES [Travin et al, 1999]
  - is challenging for "the best" recent DDES formulation too (maybe classic old-school DDES can work better because it "properly" delays RANS-to-LES transition in shear layers)
  - can be solved using (I)DDES+LT transition model [Kim&Kwon, 2021]

	$\overline{C}_d$	$\overline{C}_{l,\mathrm{rms}}$	$-\overline{C}_{p,\mathrm{b}}$	St	$\theta_{\mathrm{sep}},^\circ$
Experiments					
Cantwell&Coles (1983) [2]	1.24		1.21	0.179	
Zdravkovich (1997) [3]				0.2	
KIAM simulations					
fine SA	0.458	0.243	1.079	0.265	107.5
fine SST	0.439	0.17	0.975	0.23	93.2
fine no model	0.154	0.039	0.22		95.65
fine lsq+S3QR	0.209	0.06			
coarse	0.309	0.048	0.686	0.225	96.5



$Re_D=10^6$ and $Re_D=2\cdot10^6$

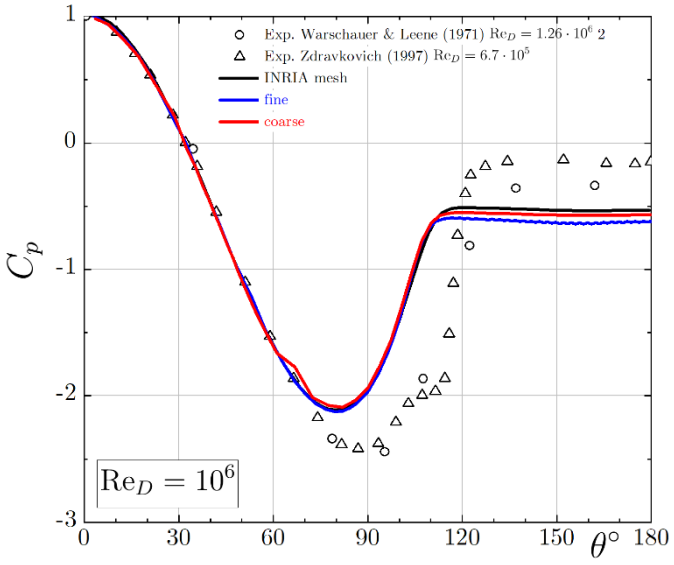
- The DDES results are becoming converged while Re_D is increasing
  - with the corresponding experimental values
  - with each other for different Reynolds numbers

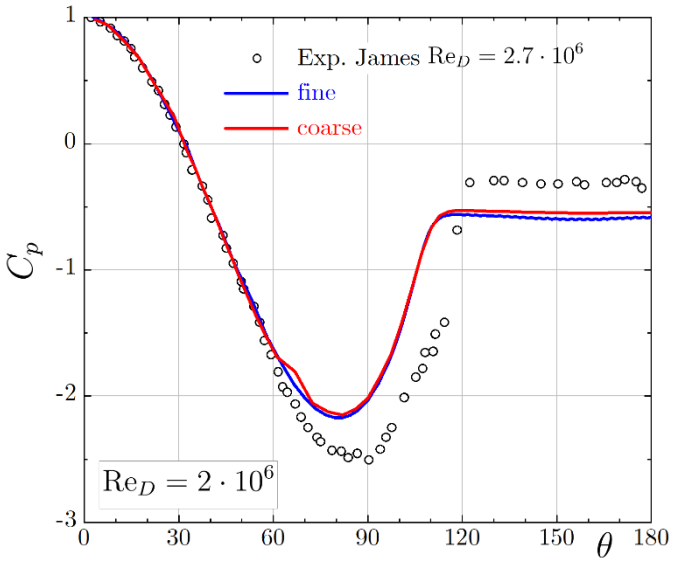
Re=10^6

	$\overline{C_d}$	$\overline{C_{l,\mathrm{rms}}}$	$-\overline{C_{p,\mathrm{b}}}$	St	$\theta_{\mathrm{sep}},^\circ$
Experiments					
Szechenyi (1975) [4]	0.25		0.32	0.35	
Goelling (2006) [5]				0.35	
Zdravkovich (1997) [3]	0.2-0.4	0.1-0.15	0.2-0.34	0.5	
KIAM simulations					
fine	0.255	0.065	0.618	0.3	107.5
coarse	0.226	0.027	0.568	0.32	107.1

Re=2·10^6

	$\overline{C_d}$	$\overline{C_{l,\mathrm{rms}}}$	$-\overline{C_{p,\mathrm{b}}}$	St	$\theta_{\mathrm{sep}},^\circ$
Experiments					
Shih et al.	0.24		0.33		
Schewe	0.24	0.02	0.48		
Szechenyi	0.25		0.32	0.35	
Golling				0.35	130
Zdravkovich	0.17-0.4	0.1-0.15	0.2-0.34	0.5-0.18	
KIAM simulations					
fine	0.234	0.051	0.583	0.315	109.5
coarse	0.215	0.027	0.548	0.34	109.4





Suggestions for the paper

- Focus only on the cylinder cases (with different Re numbers)
- Experimental values vary much: use all of them to emphasize the complexity and sensitivity of the case (and its uncertainty)
- The case is challenging for both simulation and experiment. We should focus on basic trends and peculiarities of different hybrid models
  - **why DDES/DVMS is good** but recent DDES is not
- One more “let’s refine the mesh and hope to obtain similar to experiment results” attempt is to be done (only for the 1M and 2M cases)