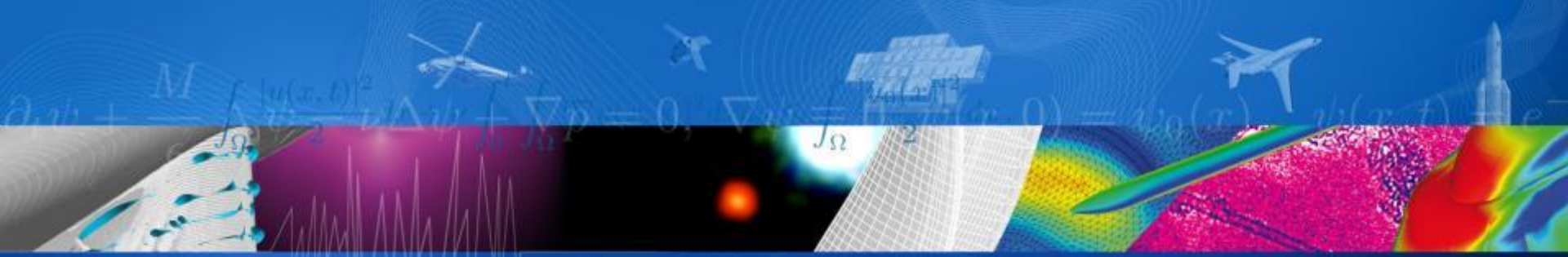

AS2 – Transitional flow in the T106C LPT

Marta de la Llave Plata
ONERA - CFD department

4th International Workshop on High-Order CFD Methods
4-5 June 2016, Heraklion, Crete

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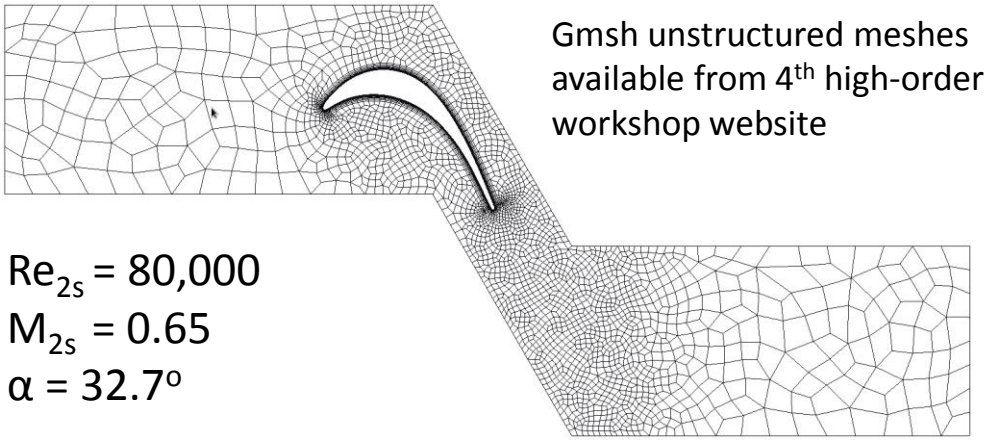
return on innovation

AS2 - Transitional flow in the T106C LPT



Gmsh unstructured meshes available from 4th high-order workshop website

Re_{2s} = 80,000
M_{2s} = 0.65
α = 32.7°

Simulation	# Elements	Order	# MDOFs
DG-P4 Coarse	30,768	5	1.1
DG-P5 Coarse	30,768	6	1.7
DG-P3 Baseline	146,426	4	2.9
DG-P4 Baseline	146,426	5	5.1
DG-P5 Baseline	146,426	6	8.2

Additional DG-P3 on baseline resolution to study effect of injection angle

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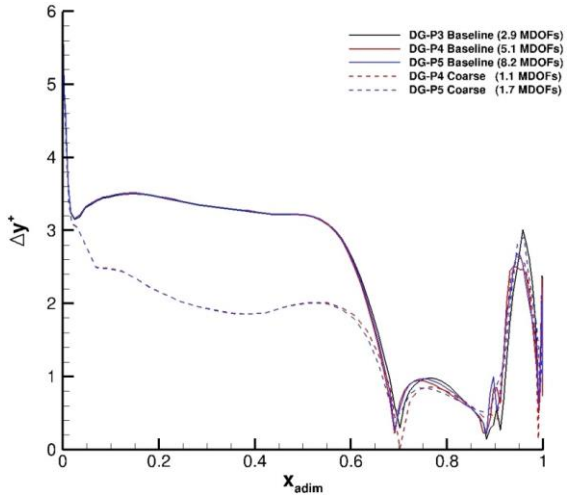
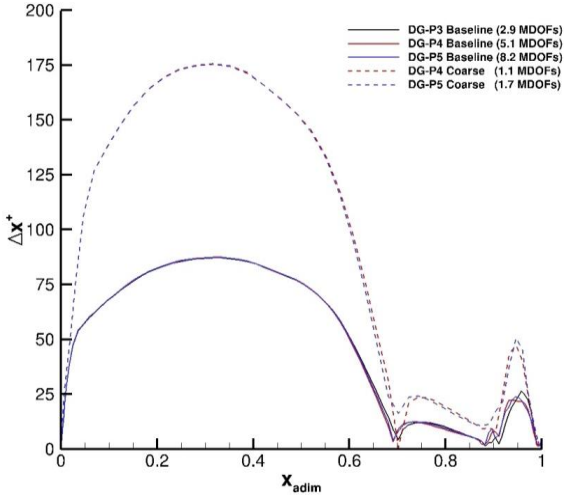
Under-resolved DNS simulations & de-aliasing through over-integration
p+2 integration points (except for DG-P5 baseline simulation, p+1)

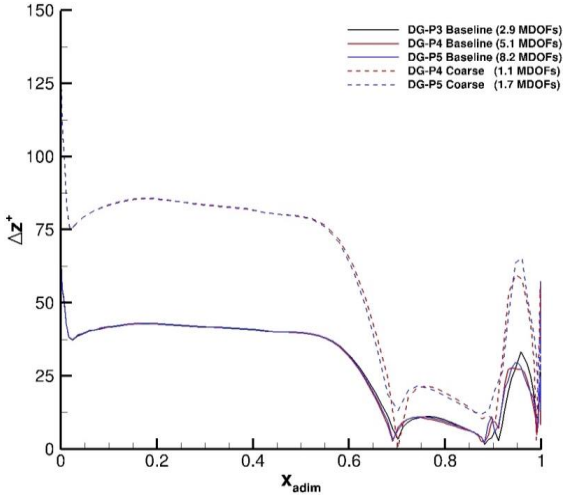
Grid resolution

$\Delta y^+_{DG} \approx \Delta y^+/(p+1)$
$\Delta x^+_{DG} \approx \Delta x^+/(p+1)$
$\Delta z^+_{DG} \approx \Delta z^+/(p+1)$

Simulation	Δy^+_{DG}	Δx^+_{DG}	Δz^+_{DG}
DG-P4 Coarse	0.6	35	16
DG-P5 Coarse	0.5	29	13
DG-P3 Baseline	0.9	20	10
DG-P4 Baseline	0.7	16	8
DG-P5 Baseline	0.6	13	7







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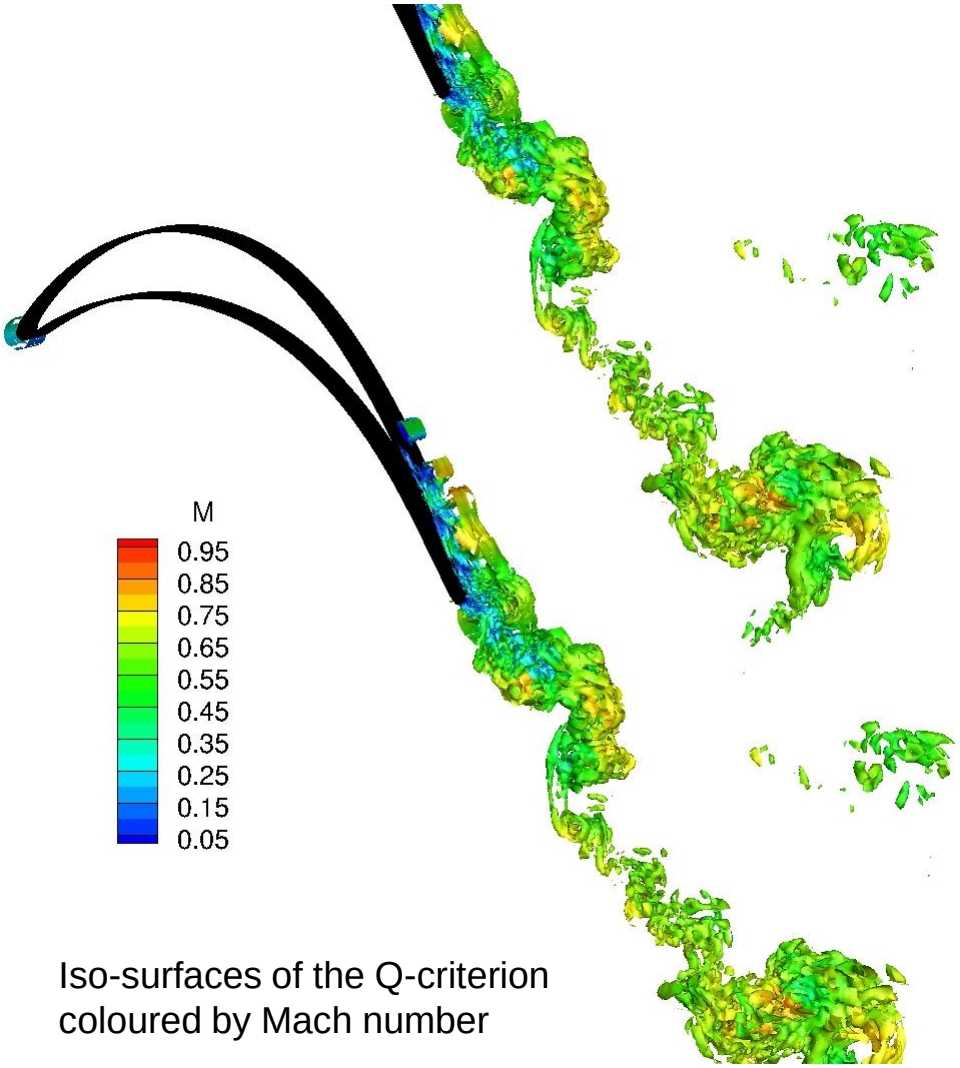
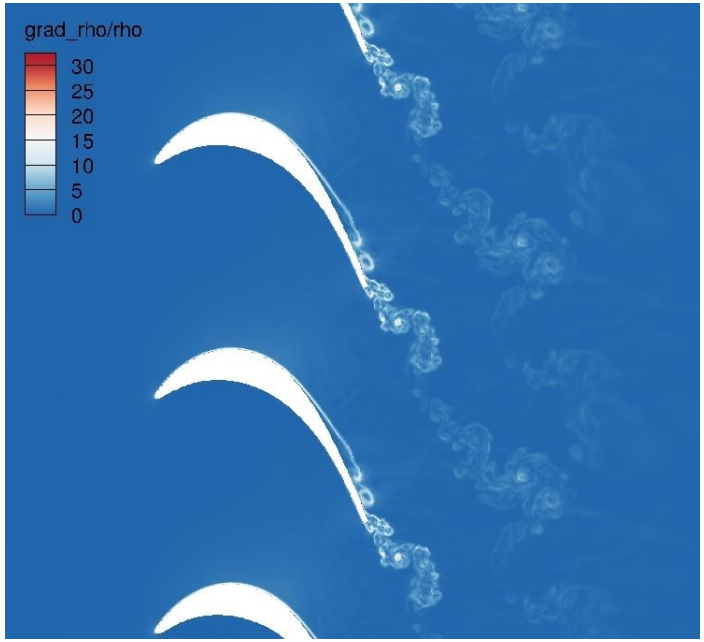


Iso-surfaces of the Q-criterion coloured by Mach number

DG-P3 simulation on baseline grid
2.9 MDOFs



Contours of grad (ρ)/ρ

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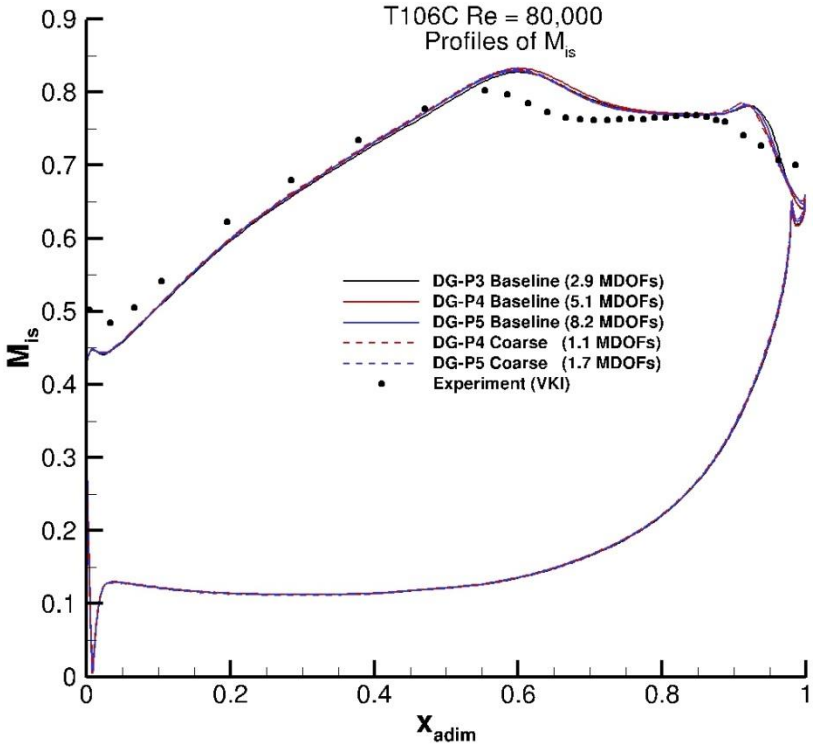
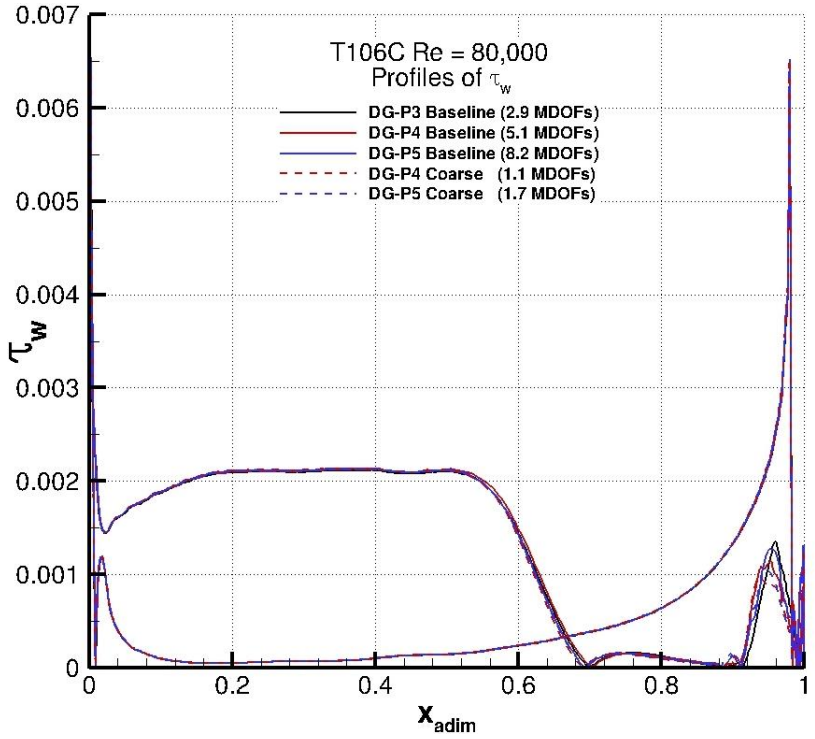
All hp-discretizations (1.1 to 8.2 DOFs) provide comparable results for M_{is} and τ_w



Distribution of isentropic Mach number

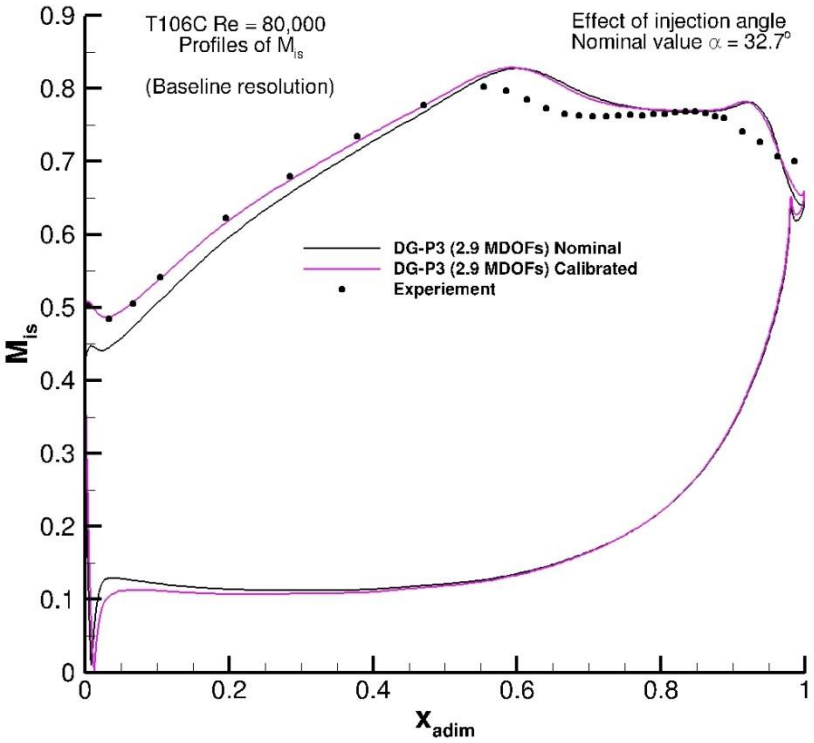


Distribution of wall shear stress

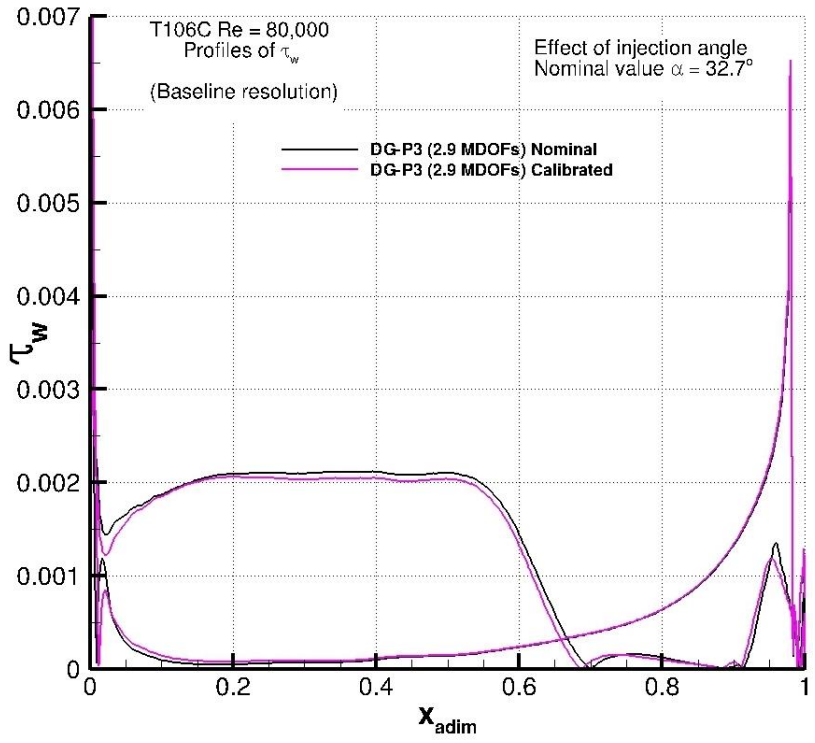
AS2 - Transitional flow in the T106C LPT

Effect of injection angle : nominal value $\alpha = 32.7^{o}$

Based on work by J. Marty using elsA: “Numerical investigations of separation-induced transition on high-lift low-pressure turbine using RANS and LES methods”, Journal of Power and Energy, 2014

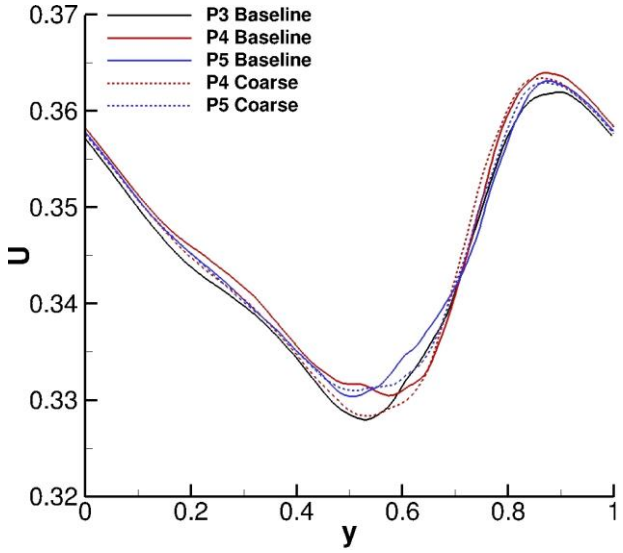


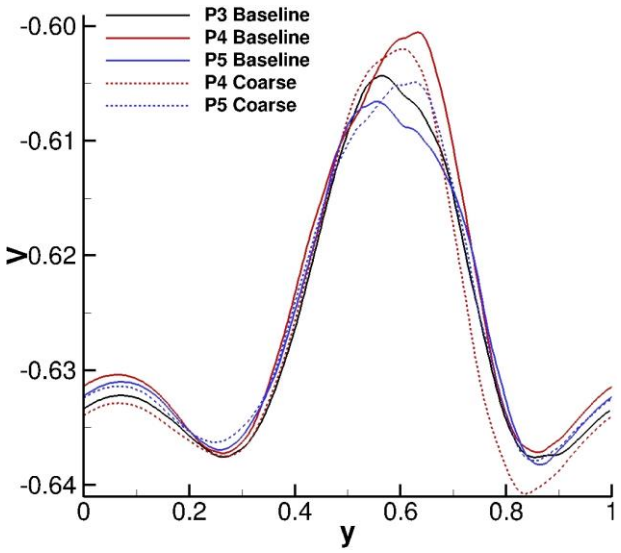
Distribution of isentropic Mach number

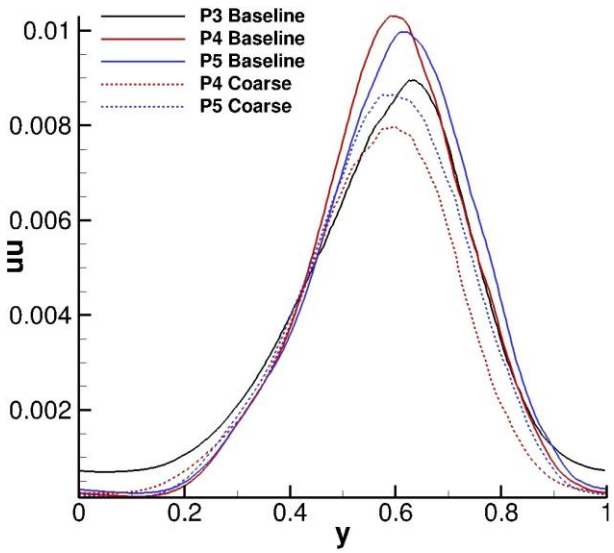


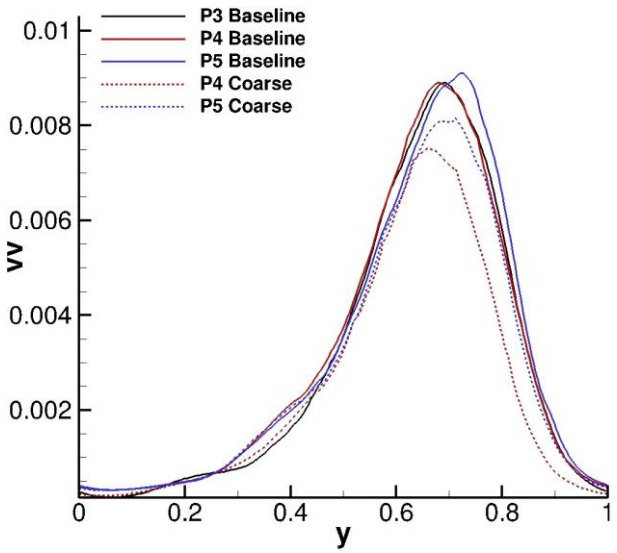
Distribution of wall shear stress

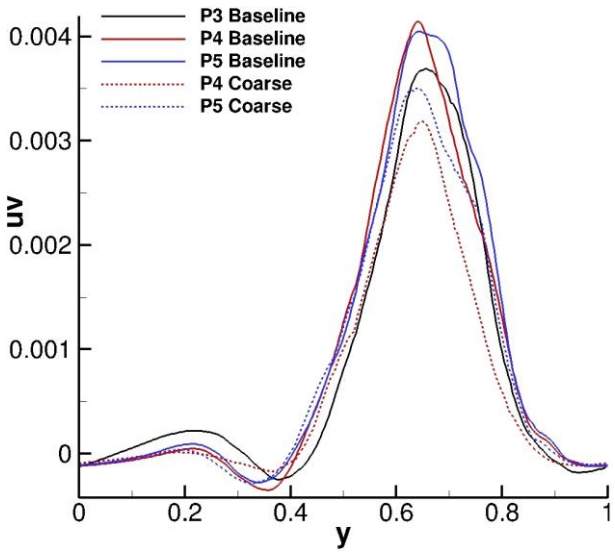
AS2 - T106C LPT : Wake Statistics











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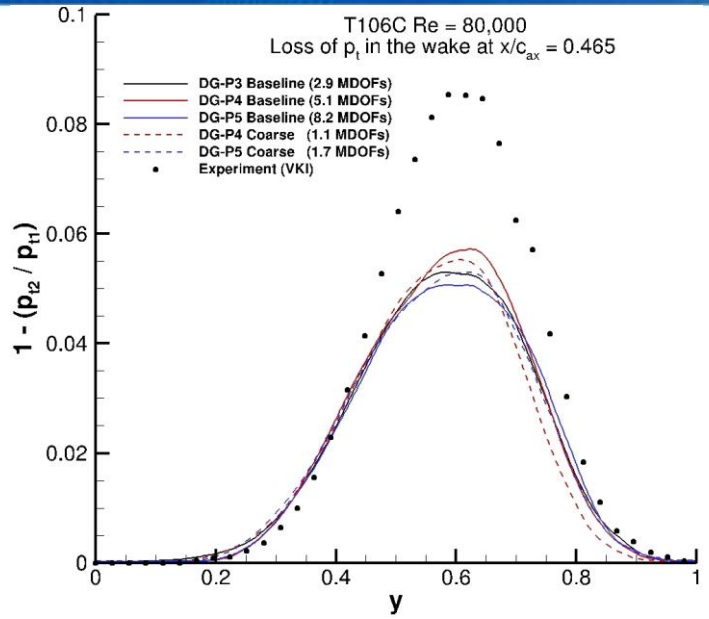
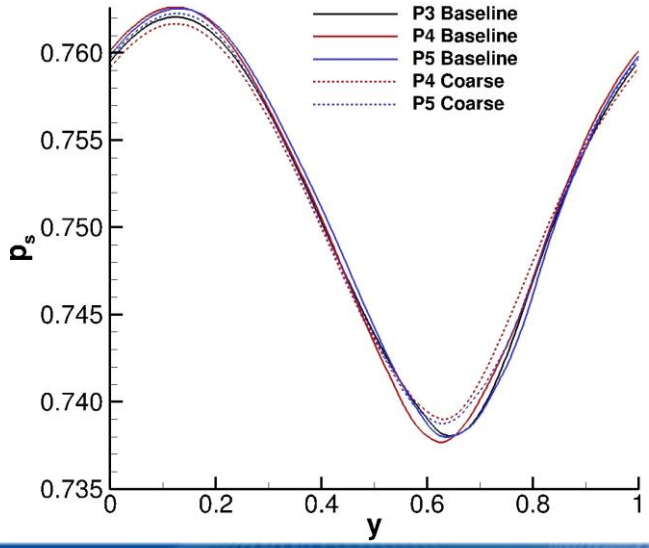
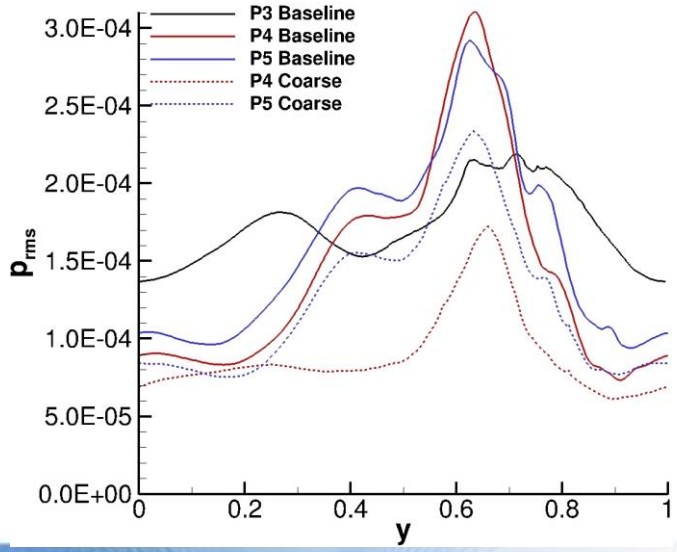
AS2 - T106C LPT : Wake Statistics



- Width of wake correctly captured.
- Total pressure losses well below experimental values : closed long bubble in simulation as opposed to open bubble in the experiment.





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Simulation	# MDOFs	CFL	$\Delta t/10^{-4}$	# cores	WU/iter
DG-P4 Coarse	1.1	0.15	0.21	384	5.1
DG-P5 Coarse	1.7	0.10	0.10	384	9.4
DG-P3 Baseline	2.9	0.20	0.49	2400	15.4
DG-P4 Baseline	5.1	0.15	0.24	2400	31.0
DG-P5 Baseline	8.2	0.10	0.11	2400	38.8

- All simulations provide similar results apart from coarsest simulation DG-P4 on coarse
- Study the effect of the turbulence injection (SEM) on the solution : tests are on progress for the transonic VKI-LS89 configuration
- Comparison of DG results from Aghora with those produced by the elsA code (Marty ’14)

AS2 - Transitional flow in the T106C LPT

This work was performed using HPC resources from GENCI
Grant 2016 – c20162a7622