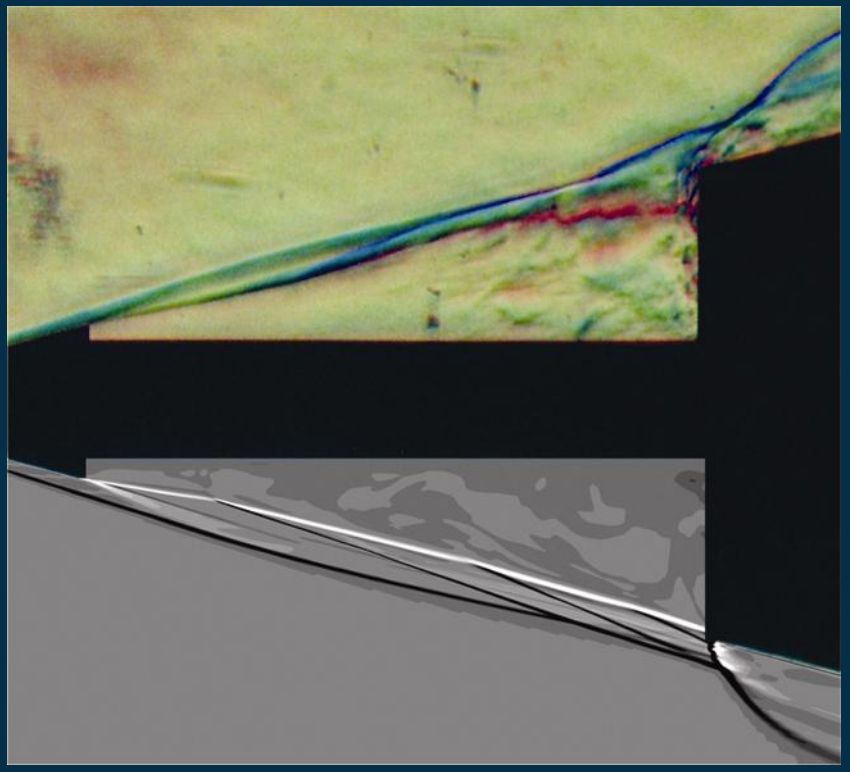
Integrating CFD and Experiments: September 8-9, 2003 Glasgow, United Kingdom

Hypersonic separated flows: combining CFD and experiment



Sean Creighton, Richard Hillier, Samuel Mallinson & Simon Williams

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Experiment-CFD partnership

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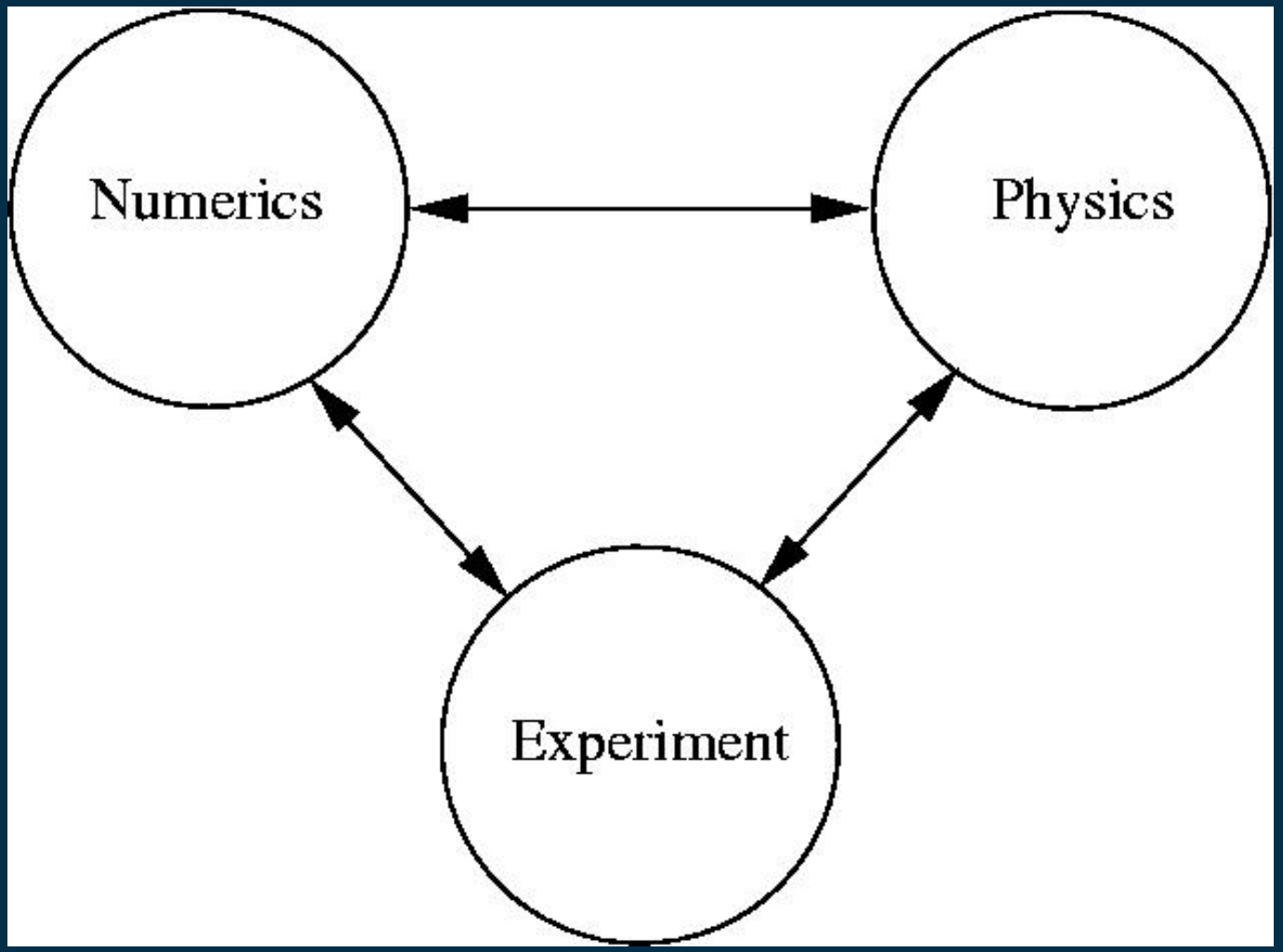

Role of CFD and experiments

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CFD

- Design of configuration
- Location of instrumentation
- Probes regions of flow field that experimental methods cannot reach
- Explore new physics

Experiments

- Benchmark and `building block' studies
- 2D and `controlled' 3D CFD evaluation
- Explore new physics

The gun tunnel and flow calibration

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M_∞	dM_∞/dx (%/m)	$P0_\infty$ (bar)	$T0_\infty$ (K)	T_{wall} (K)	$Re_\infty(/metre)$
8.9 (± 0.5%)	0	98 (±2%)	1000 (±4%)	293 (±2%)	9,540,000 (±6%)
8.9 (± 0.5%)	2.7	600 (±2%)	1150 (±4%)	293 (±2%)	47,400,000 (±6%)

- Gun tunnel
- Nitrogen Gas
- 20 ms of useful run time, 4-6 ms `steady flow' window
- 32 channels data logging
- Extensive flow calibration

The gun tunnel and flow calibration

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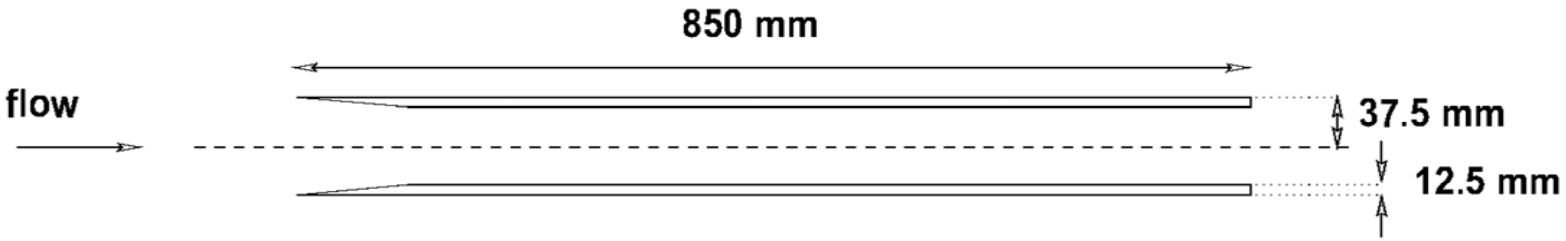

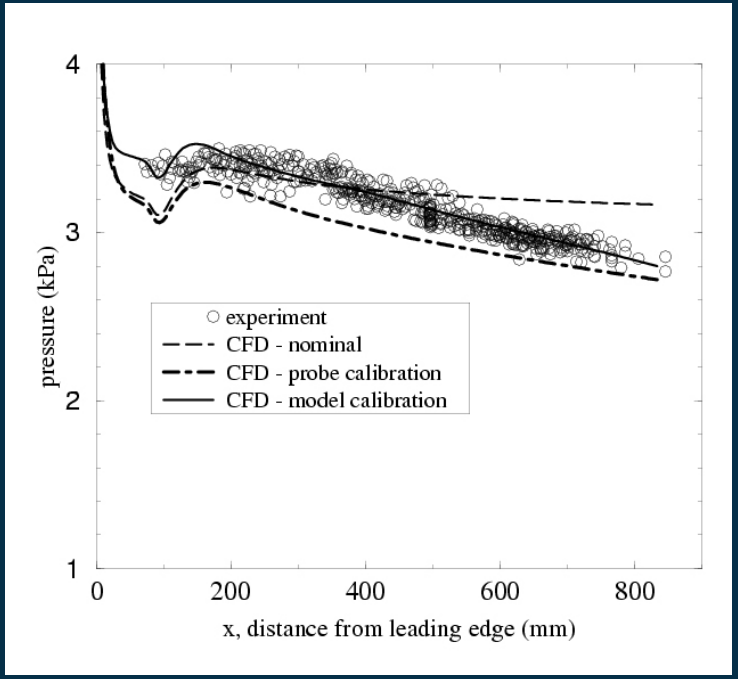

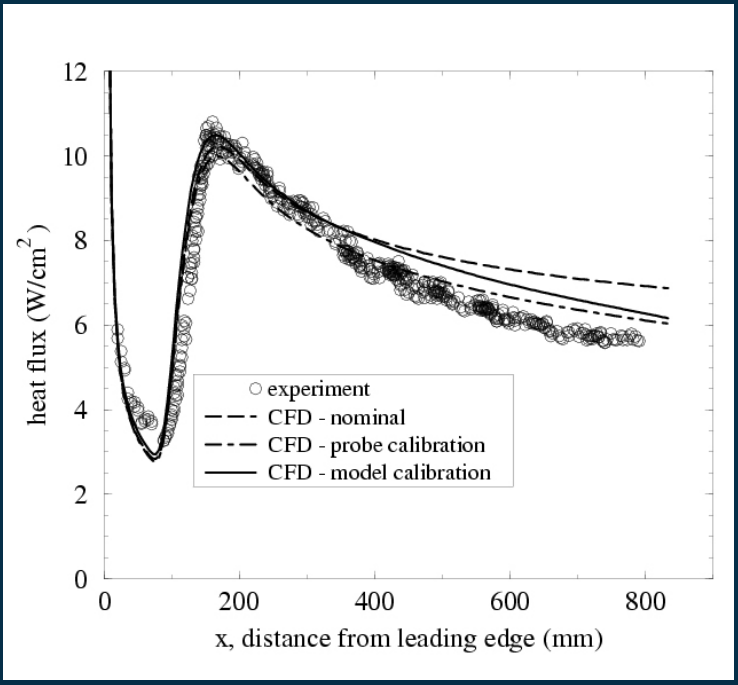

CFD design for imposed adverse pressure gradient on turbulent boundary layer.

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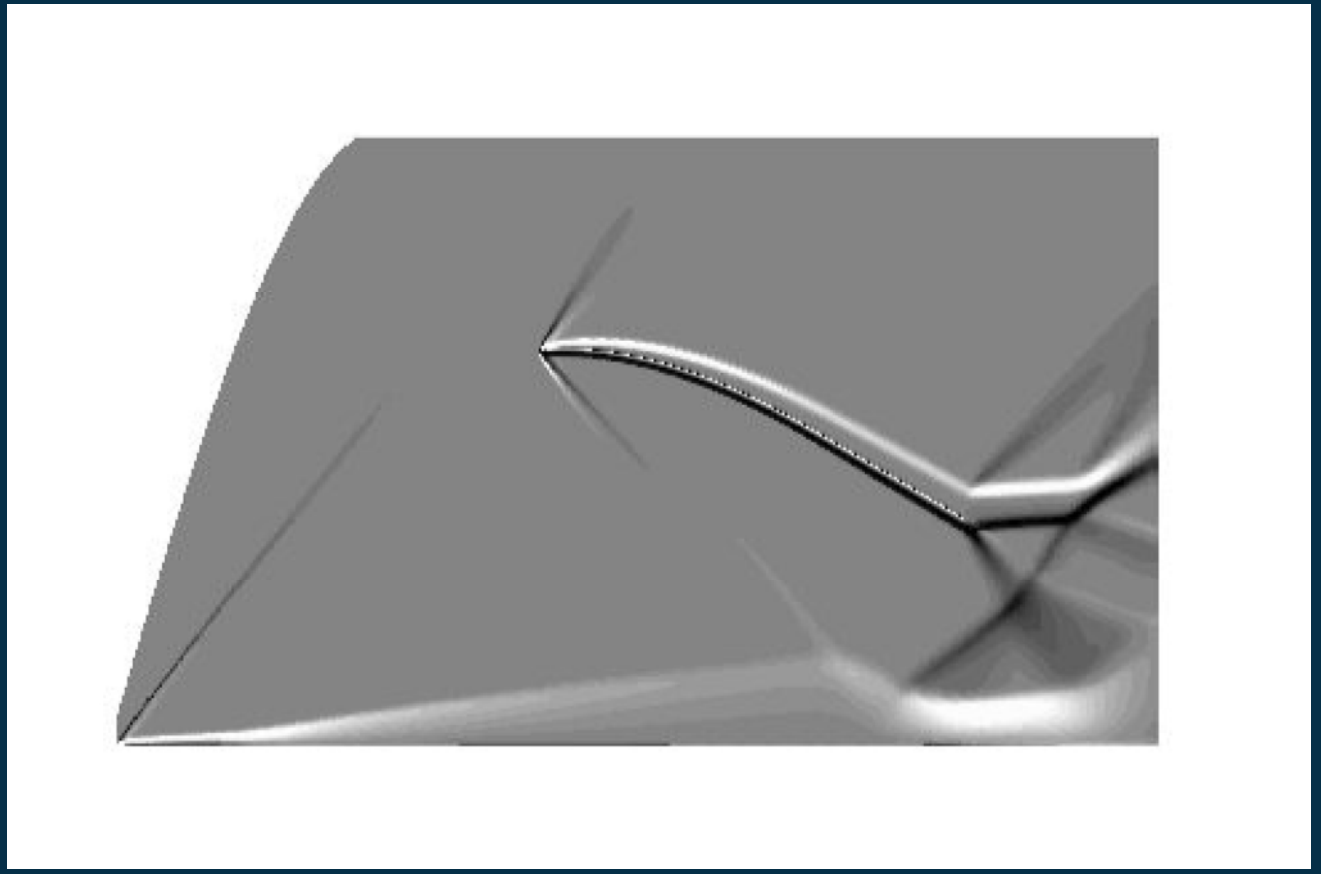

CFD design for imposed adverse pressure gradient on turbulent boundary layer.

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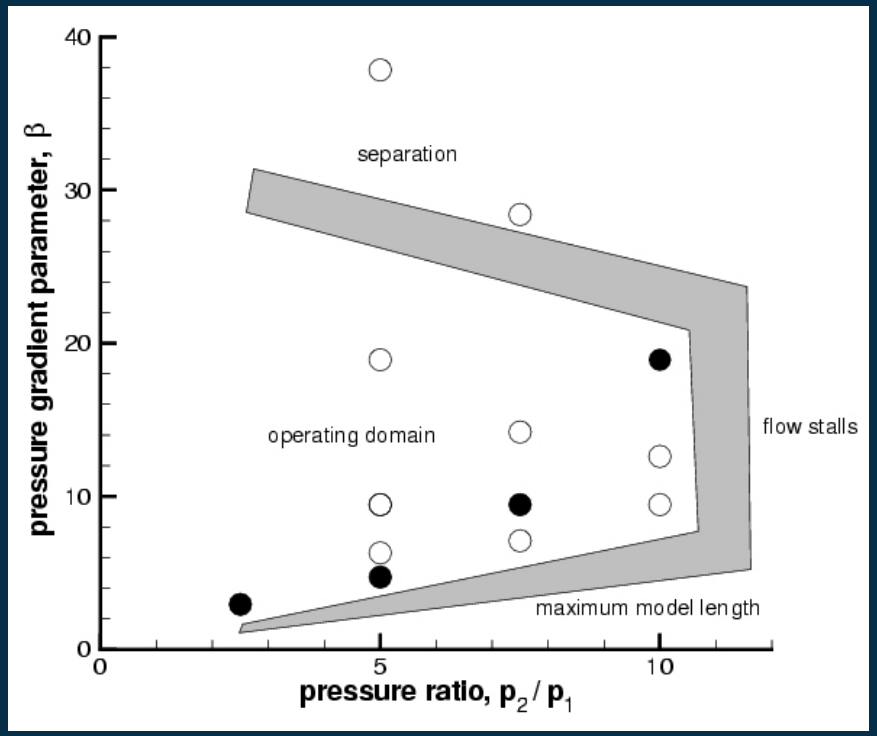

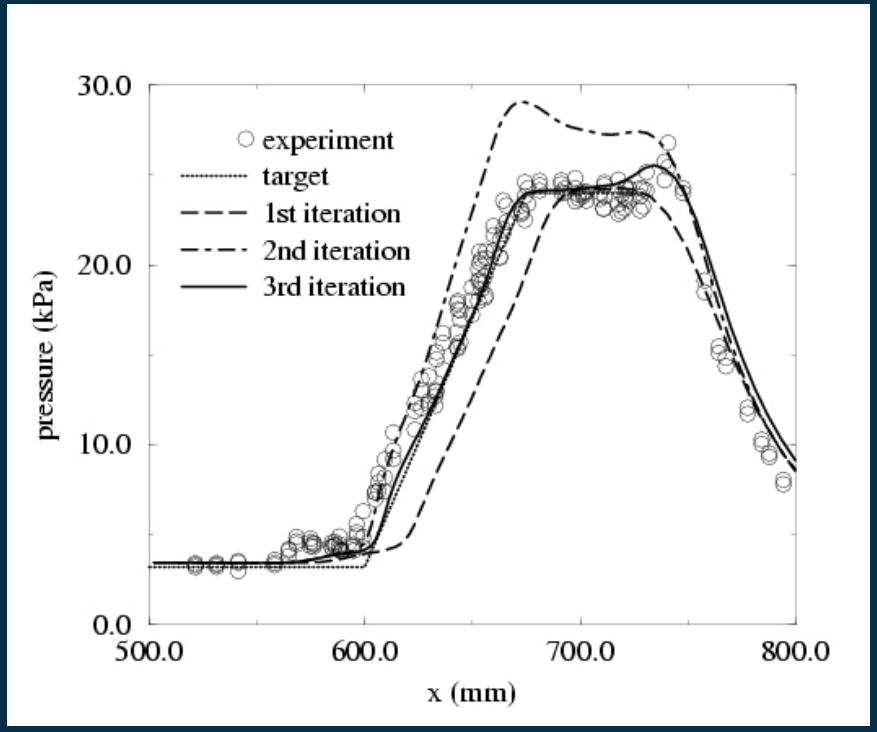

CFD Design for 2D (axisymmetric) laminar cavity flows

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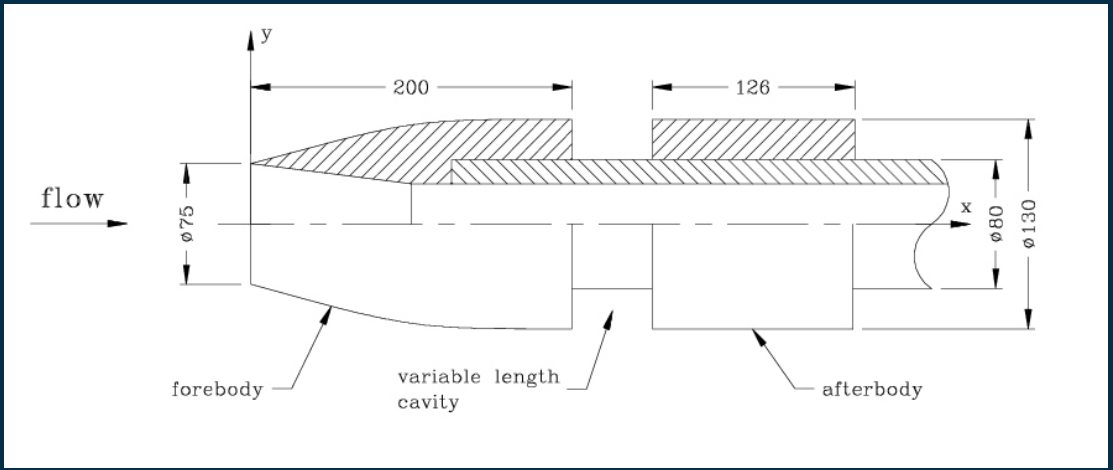

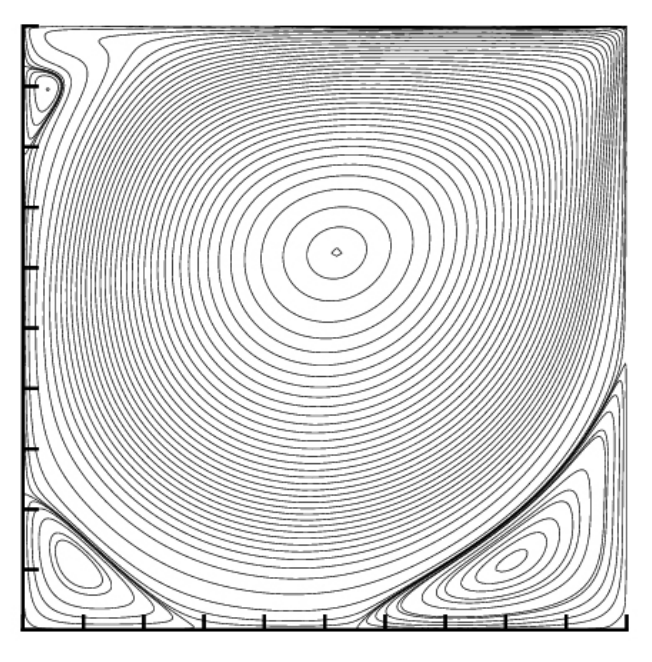

2D (axisymmetric) laminar cavity flow

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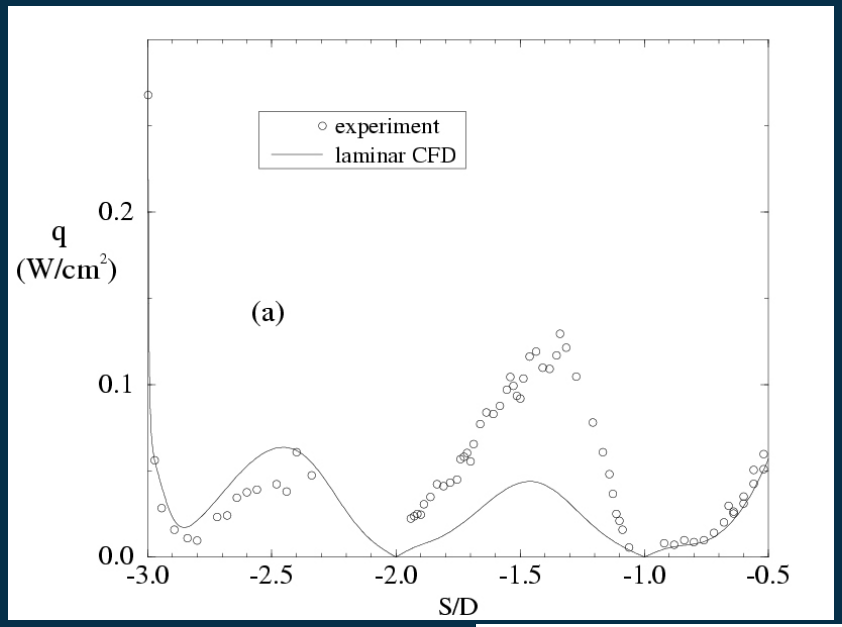

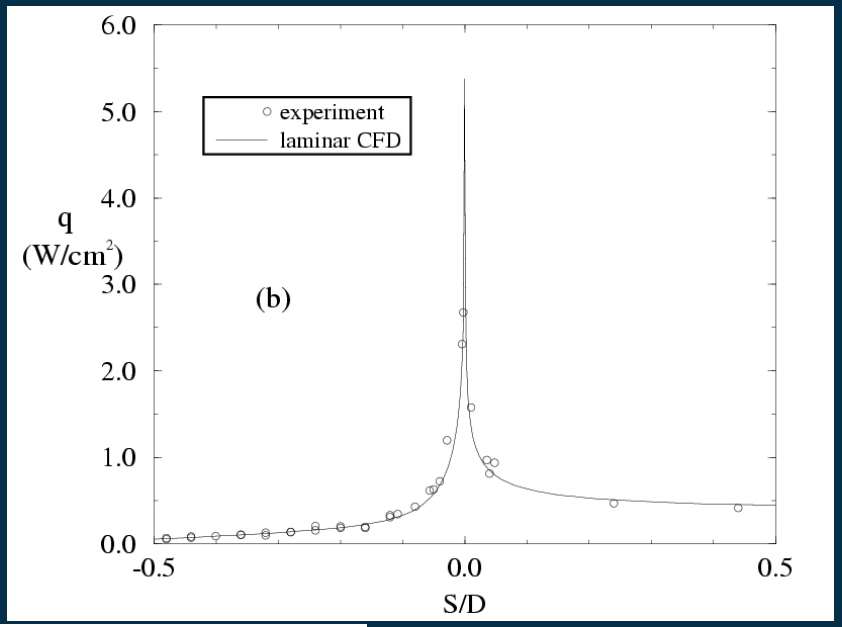

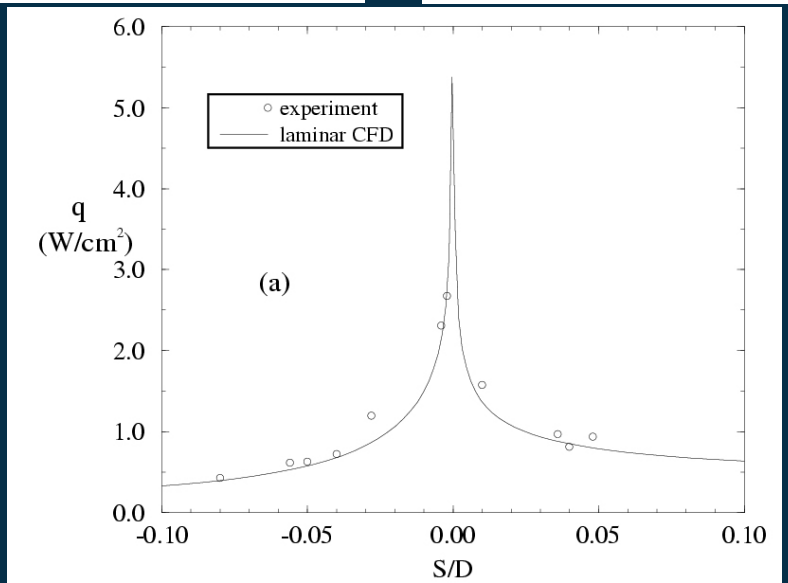

Controlled 3D laminar cavity flow

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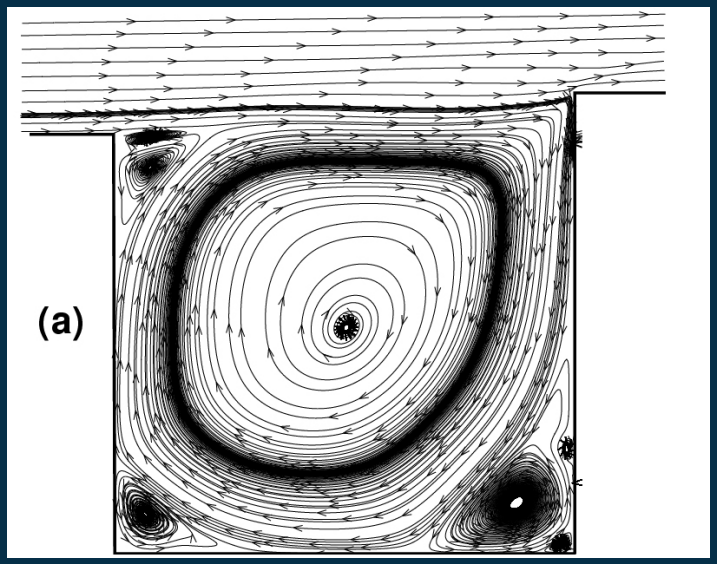

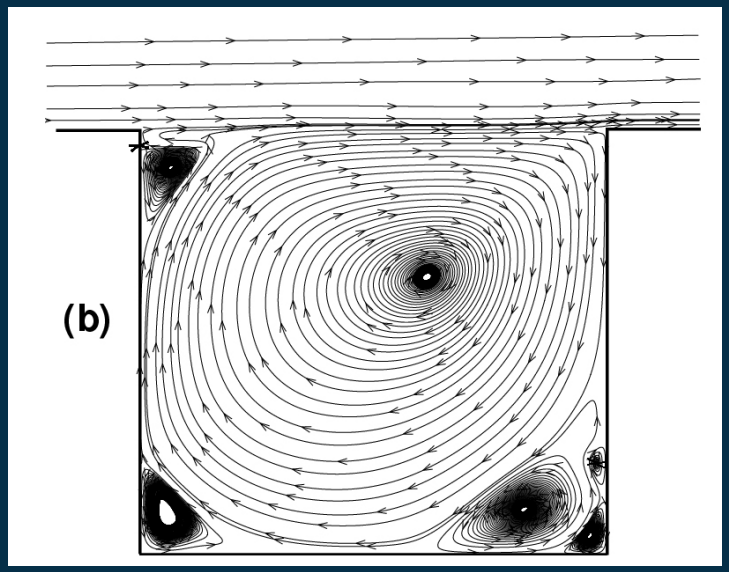

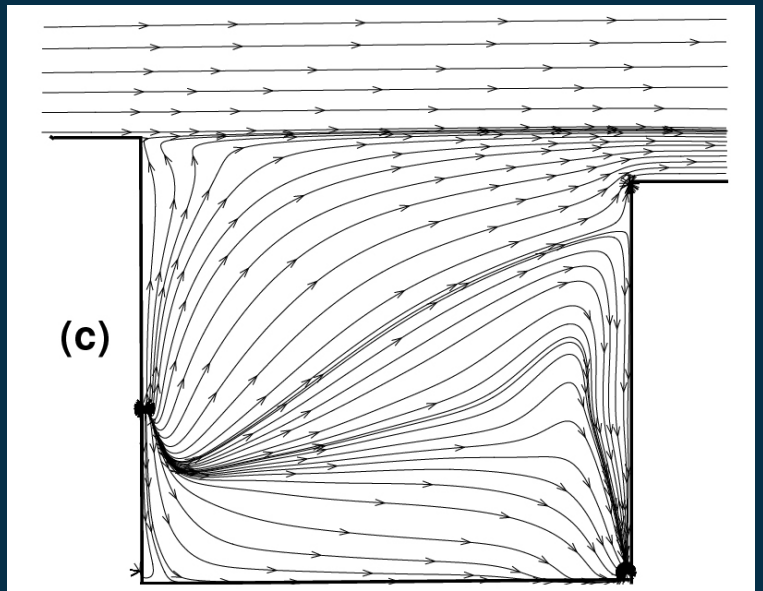

Unsteady cavity flows on body of revolution

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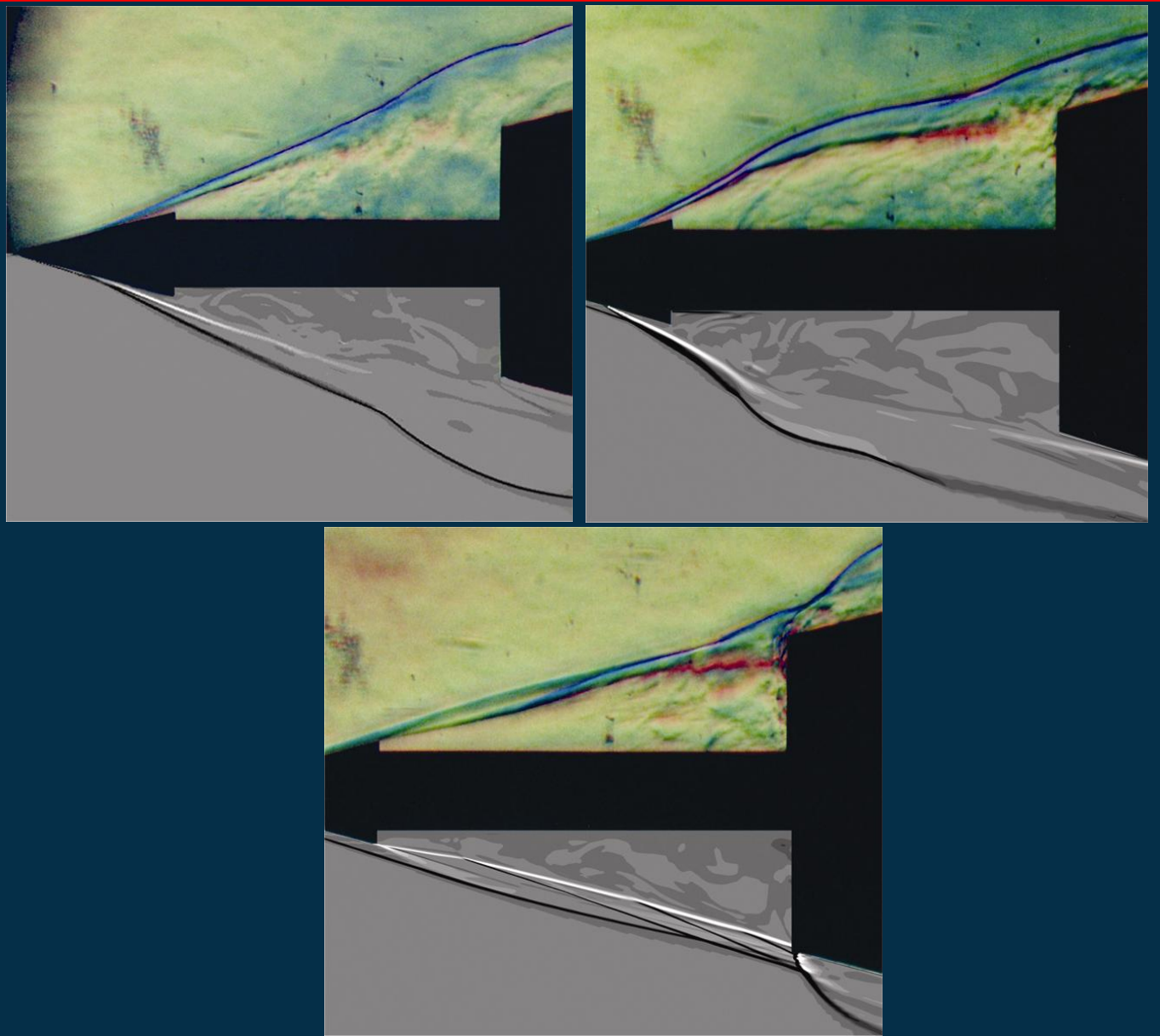

3D Controlled shock-induced separation

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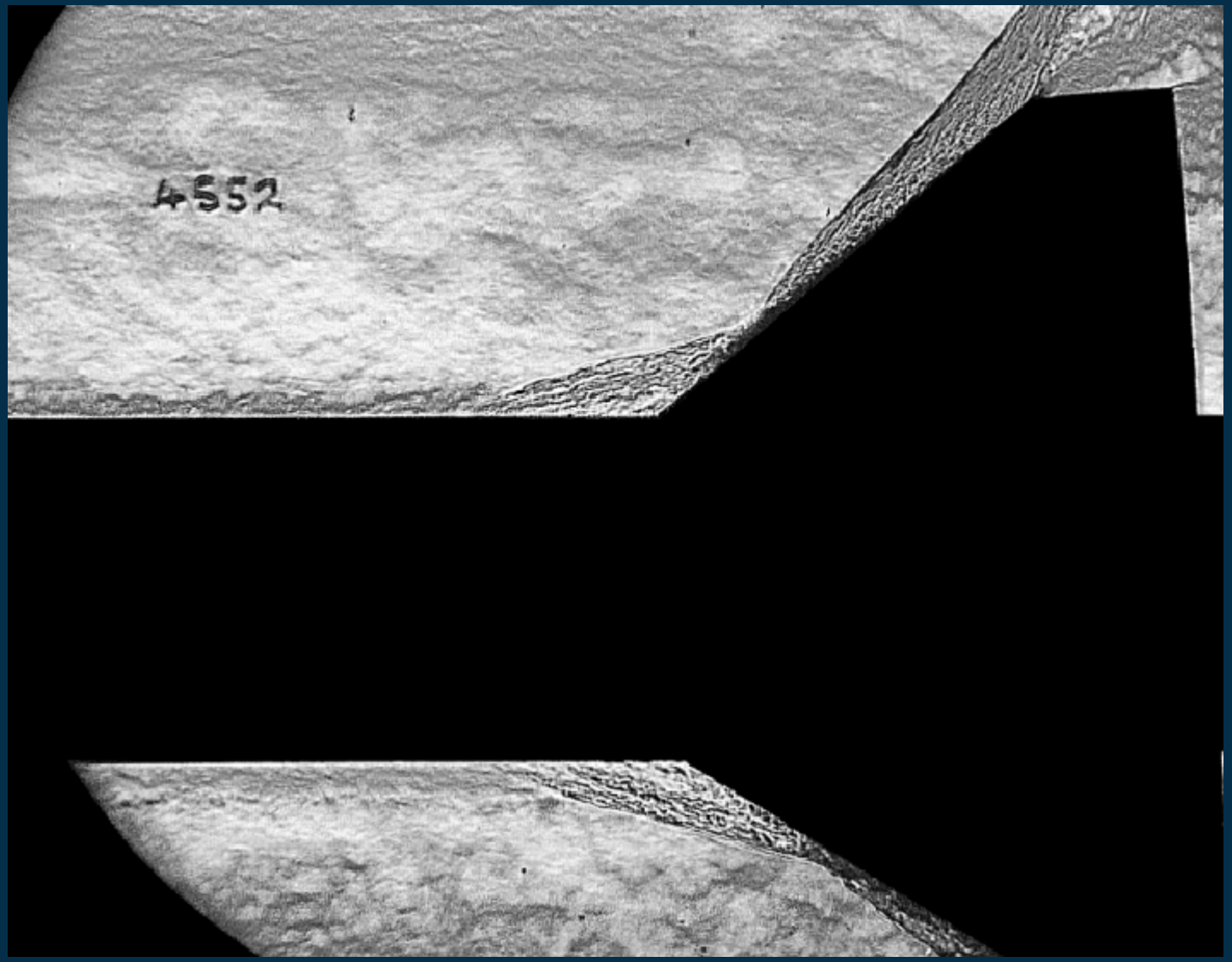

Concluding remarks

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- Cost of experiments is so high that CFD is invaluable in optimising model design
- Our studies are principally focussed on `building block' studies and benchmartk experiments
- Difficulties in producing the required experimental data for the evaluation of CFD for complex flows – 3D, turbulent