SOCRATES Teaching Staff Mobility Program
2000 - 2001

Technical University of Budapest
1782
Department of Fluid Mechanics

DMA-URLS

Finite Element Method
for Turbomachinery Flows

Test Cases

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PARALLEL RESULTS

- EVALUATION OF PARALLEL SOLVER PERFORMANCES

Speed-up Factor $S(pr)=T(pr_{ref})/T(pr)$

Efficiency $E(pr)=S(pr)/(pr/pr_{ref})$

pr=processors number

T=elapsed time

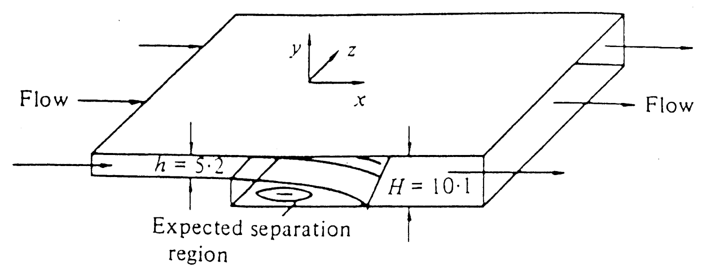
pr_{ref}= reference processors numbers

- CODE SETTING PARAMETERS
  - MIXED ORDER FEM INTERPOLATION FUNCTIONS (Q2/Q1)
  - STANDARD κ-e MODEL
  - GMRES(50), GAUSS-SIEDEL PRECONDITIONER
  - *CONDENSED* CYCLES CONFIGURATION

- CONVERGENCE CRITERIA

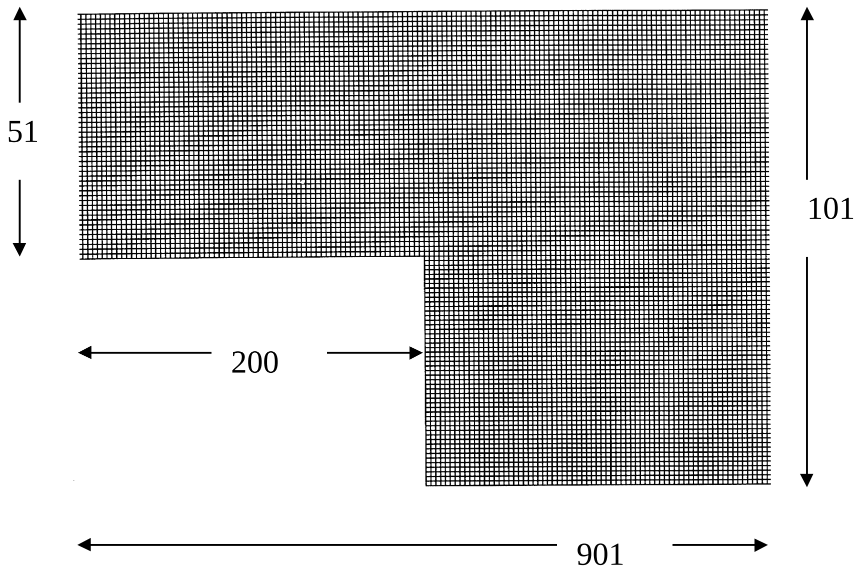
$$R_{res} = \|r_k\|_2 / \|r_0\|_2 = 10^{-4}, \; R_{sol} = \left(\|U_k\|_2 - \|U_{k-1}\|_2\right) / \|U_k\|_2 = 10^{-4}$$

LAMINAR FLOW IN A BACKWARD FACING STEP



- EXPERIMENTS ARMALY ET AL. (1983)
- RE=300
- CRAY T3E

- GRID DETAIL (81001 GRID POINTS)

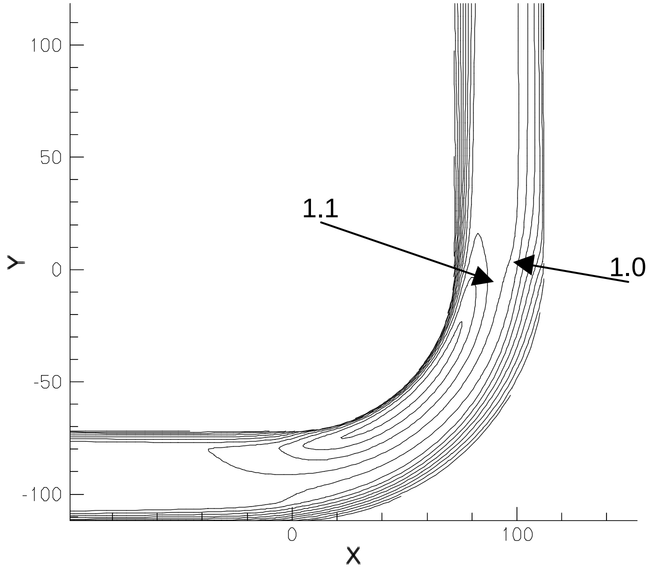


Domains	Reattachment point coordinate (x_s/h)
4	6.323
16	6.324
32	6.320
Experiments	6.326

Domains	S(pr)*4	E(pr)
4	4.00	1.00
16	15.38	0.96
32	21.63	0.68

COMPARATIVE ANALYSIS OF PARALLEL SOLUTION TECHNIQUES (ii)

TURBULENT FLOW IN A TWO-DIMENSIONAL 90° BEND

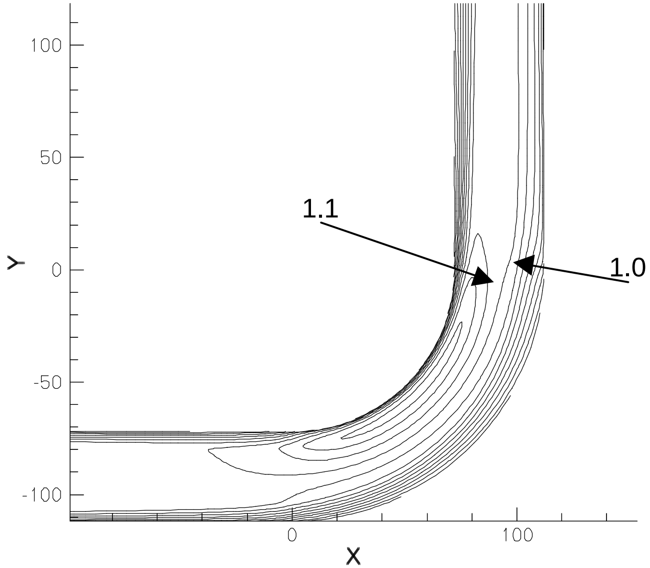


Computed velocity contour

- RE=40.000
- 19521 GRID POINTS (241×81)
- GMRES(50)
- CONVERGENCE THRESHOLD R_{res}, $R_{sol} = 10^{-4}$

Domains	***n_{it}=n_{tot} Condensed cycles***	***n_{it} Nested cycles***	***n_{tot} Nested cycles***
2	250	201	804
3	234	151	604
6	228	138	552

TURBULENT FLOW IN A TWO-DIMENSIONAL 90° BEND



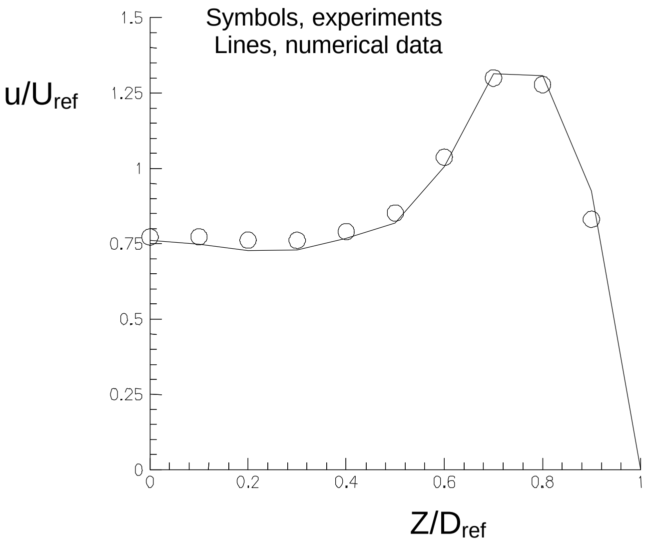
Computed velocity contour

- RE=40.000
- 19521 GRID POINTS (241×81)
- IBM SP2

Domains	***S(pr)***	***E(pr)***
2	2.00	1.00
3	3.16	1.05
6	6.28	1.05

LAMINAR FLOW IN A 90° THREE-DIMENSIONAL ELBOW

- EXPERIMENTS TAYLOR ET AL. (1981)
- RE=790
- GRID (74151 POINTS, 321×21×11)
- CRAY T3E



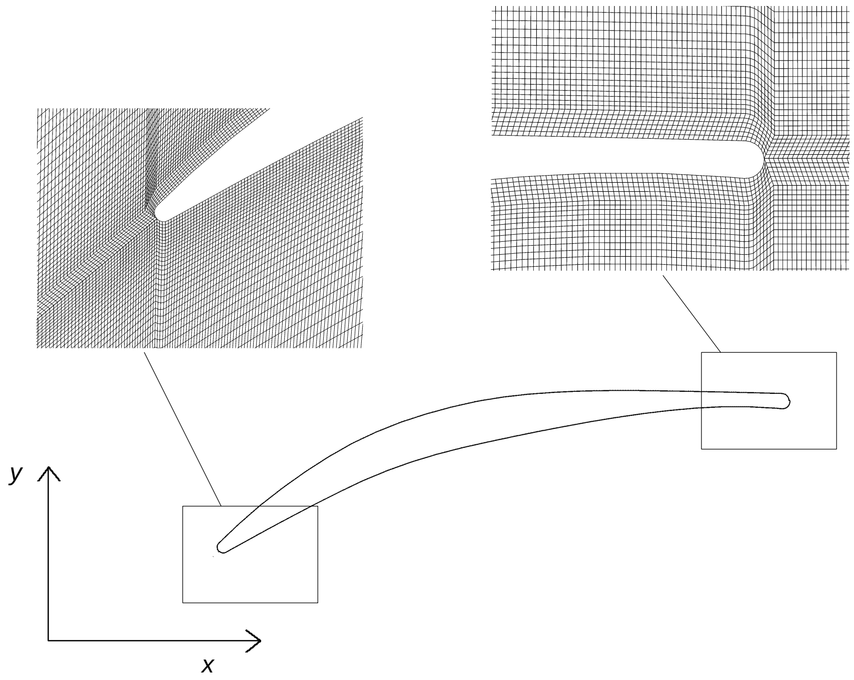
Non-dimensional streamwise velocity profile along span - mid of outlet bend section experiments (Taylor et al., 1981)

Domains	***S(pr)***	***E(pr)***
8	8.00	1.00
16	11.23	0.70
32	16.51	0.50

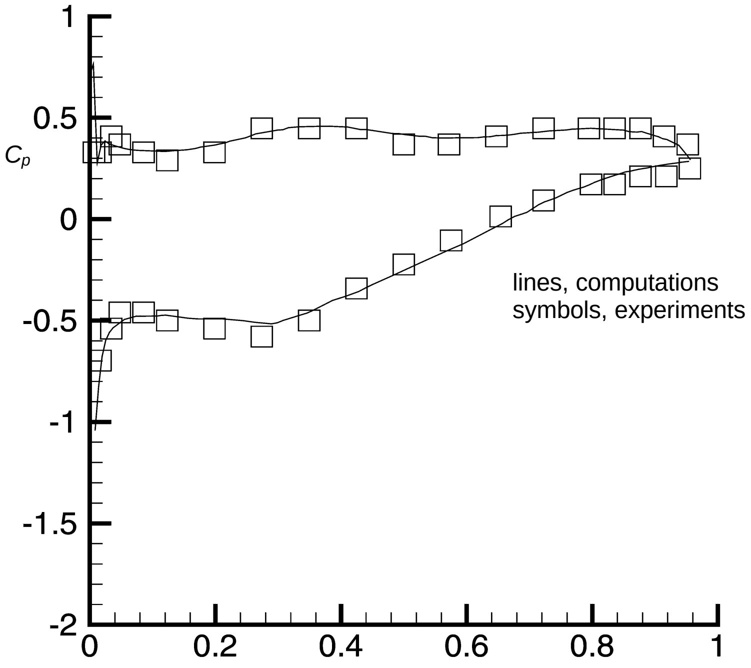
VISCOUS FLOW IN A CONTROLLED DIFFUSION PROFILE CASCADE

- EXPERIMENTS ELAZAR AND SHREEVE (1990)
- RE=700.000, $i = 0$ (DESIGN INLET FLOW ANGLE)
- Ma_{inlet} @ *0.25*
- GRID (46737 POINTS, 577×81)
- IBM SP2

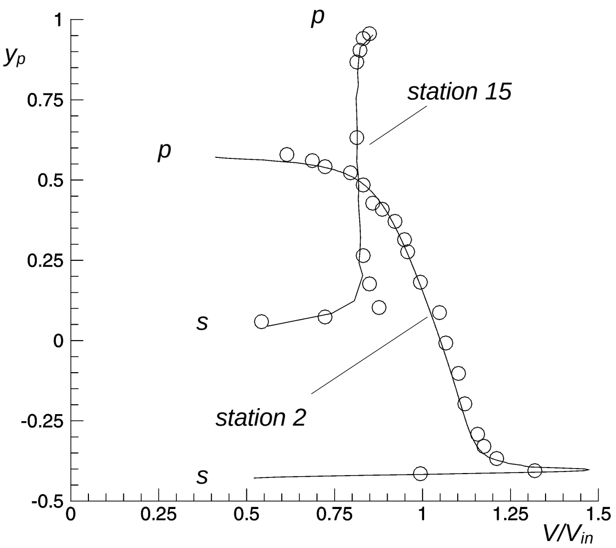
Domains	*S(pr)*	*E(pr)*
2	2.00	1.00
4	3.34	0.83
6	4.78	0.80
8	6.60	0.825
12	9.95	0.83



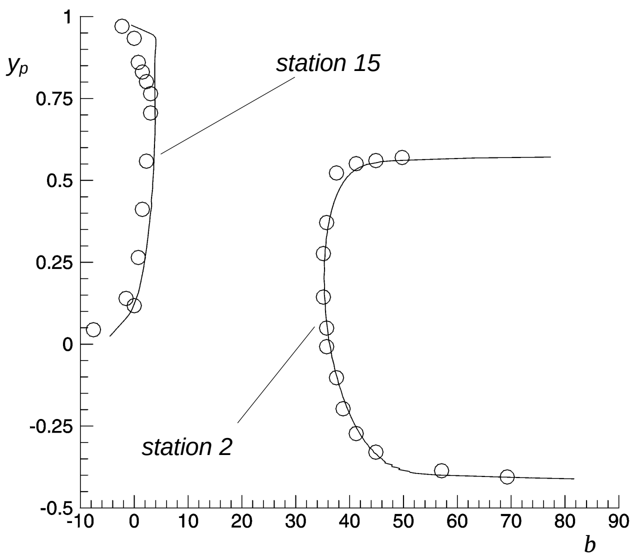
pressure coefficient distributions



streamwise velocity distributions



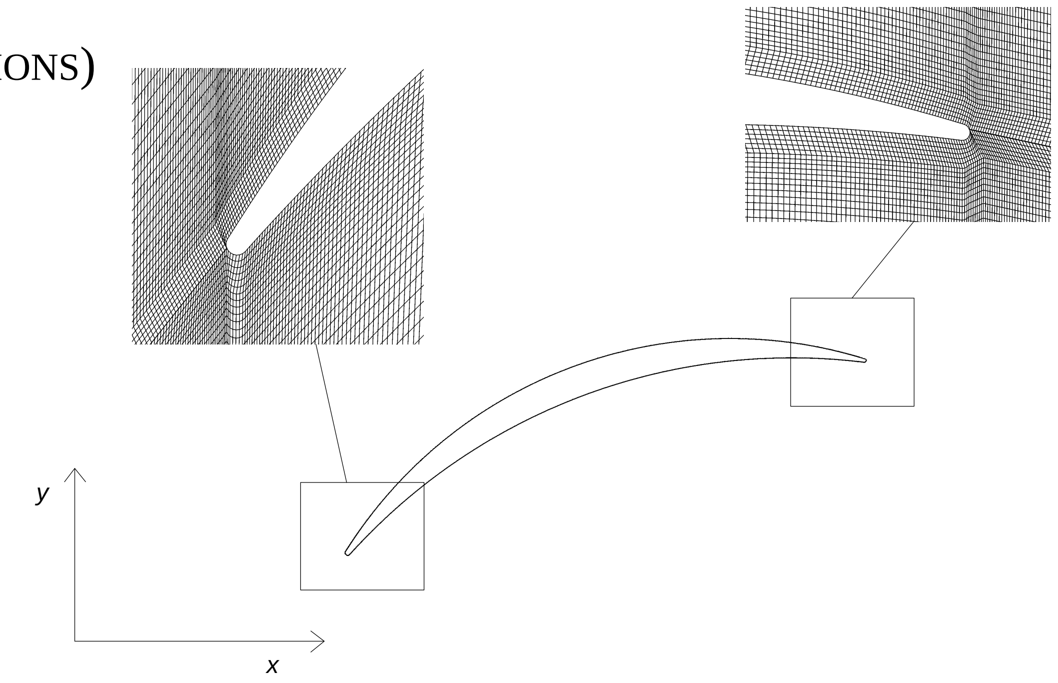
flow angle distributions



Flow survey at cascade entrance (station 2) and exit (station 15)
(lines: computations, symbols, experiments)

VISCOUS FLOW IN A DCA CASCADE

- EXPERIMENTS ZIERKE AND DEUTCH (1989)
- RE=501.000, $i = -1.5°$ (NEAR DESIGN CONDITIONS)
- Ma_{inlet} @ 0.1
- GRID (46737 POINTS, 577×81)
- IBM SP2



Domains	S(pr)	E(pr)
2	2.00	1.00
4	3.06	0.76
6	4.54	0.75
8	6.02	0.75
12	8.28	0.69

DCA GLOBAL PERFORMANCE COEFFICIENTS

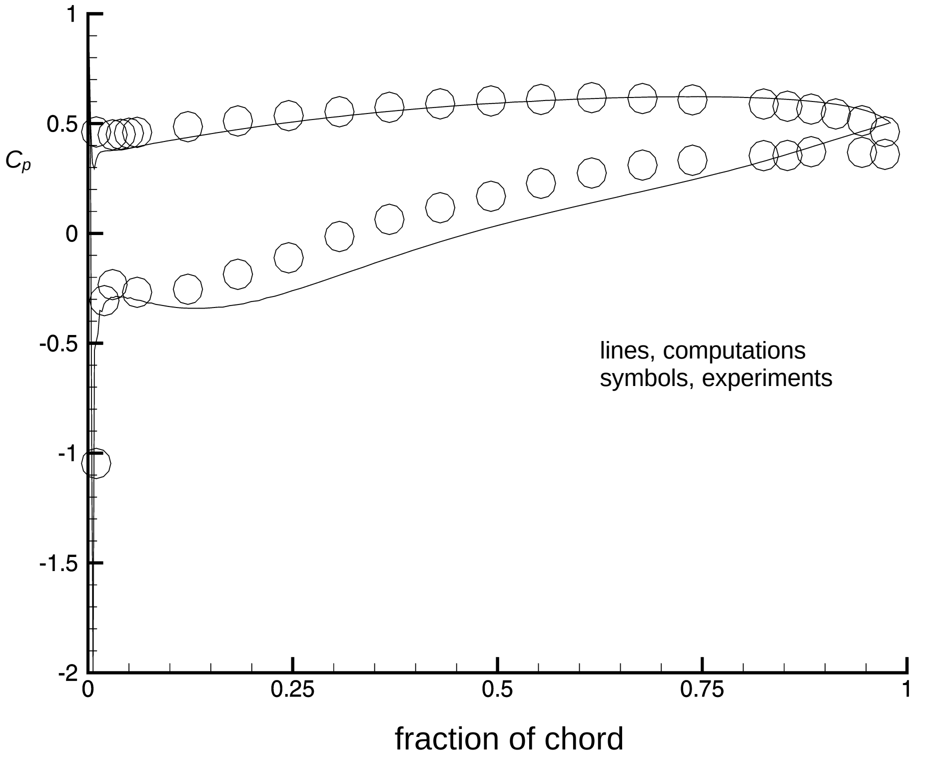
	$\overline{w}$	$\overline{C}_{p_2}$	$\overline{D}$
experiments	0.09	0.47	0.55
computation	0.07	0.55	0.58

Pitchwise averaged cascade parameters

TOTAL PRESSURE LOSS COEFF. $$\overline{w} = \frac{\overline{p_{0_1}} - \overline{p_{0_2}}}{\frac{1}{2} r \overline{U}_1^2}$$

GLOBAL PRESURE COEFF. $$\overline{C}_{p_2} = \frac{\overline{p}_2 - \overline{p}_1}{\frac{1}{2} r \overline{U}_1^2}$$

DIFFUSION FACTOR $$\overline{D} = \left(1 - \frac{\overline{U_2}}{\overline{U_1}}\right) + \left(\frac{\overline{U}_{t1} - \overline{U}_{t2}}{2s\,\overline{U}_1}\right)$$



Streamwise velocity profiles in the boundary layer (suction side)