Supersonic Flow Over a Diamond Shape Airfoil

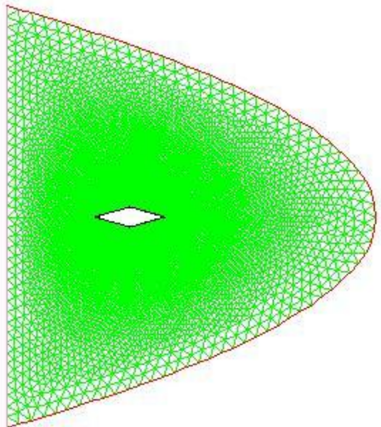
1/**INVISCID** run: alpha = 0 and alpha = 3

- -Mach = 1.3
- -Mach = 2 ➔ compare solutions with oblique-shock theory

2/**VISCOUS** run

- -Grid sensitivity study
- -Comparison turbulence models: Spalart-Allmaras/k-ε model

3/Comparison **VISCOUS/INVISCID**



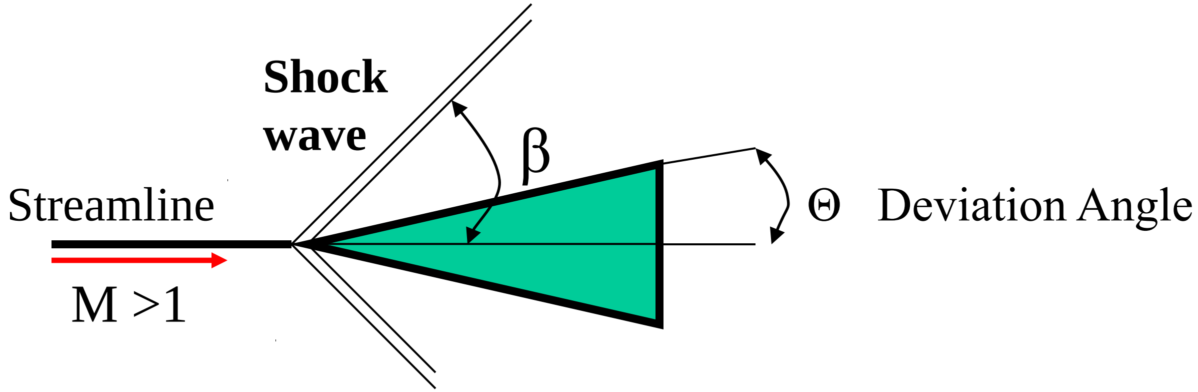
INVISCID RUN

Oblique Shock Theory

For any mach number there is a maximum angle of deflection θ.

In our case $\theta = 16°$ ==> Mach < 1.65 Detached Shock **(M = 1.3)**

Mach > 1.65 Attached shock **(M = 2)**



Shock angle and flow conditions behind the shock

M1 = 2 and θ = 16 º

β = 47 º weak shock solution

β = 79 º strong shock solution

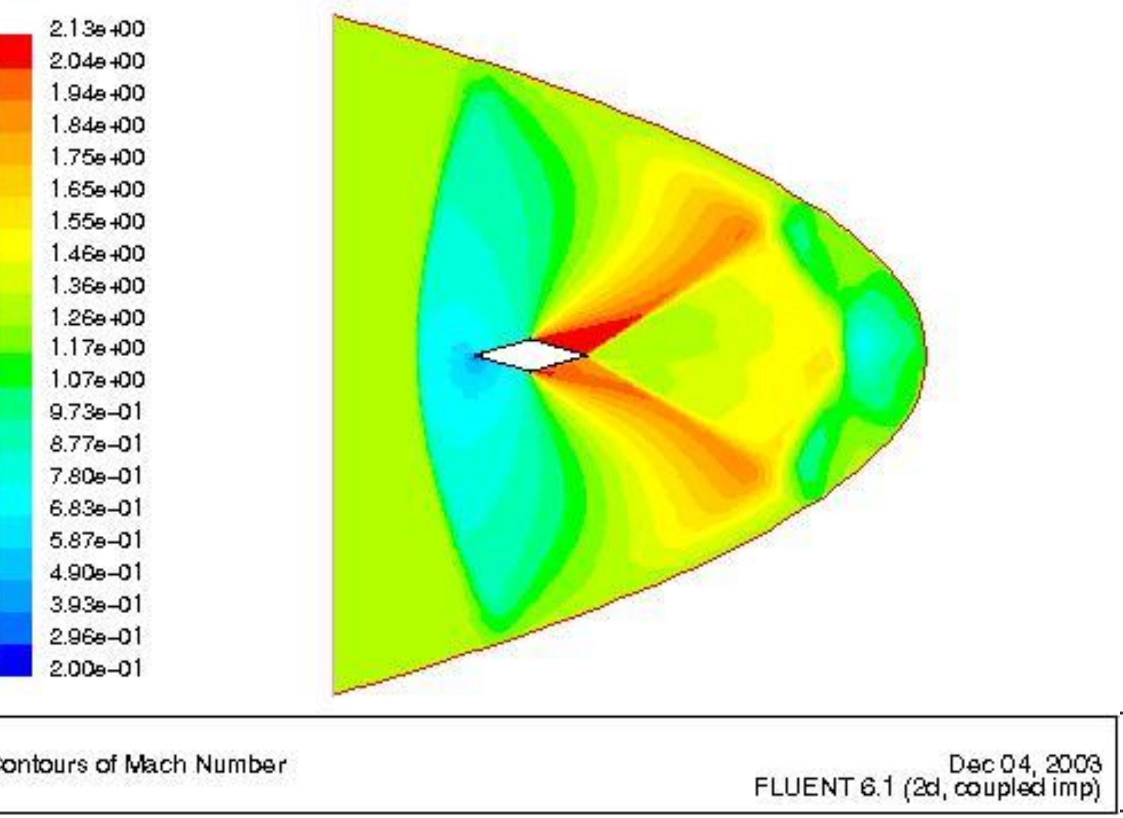
Normal mach : $Mn1 = M1 \sin \beta$ Mn1 = 1.46

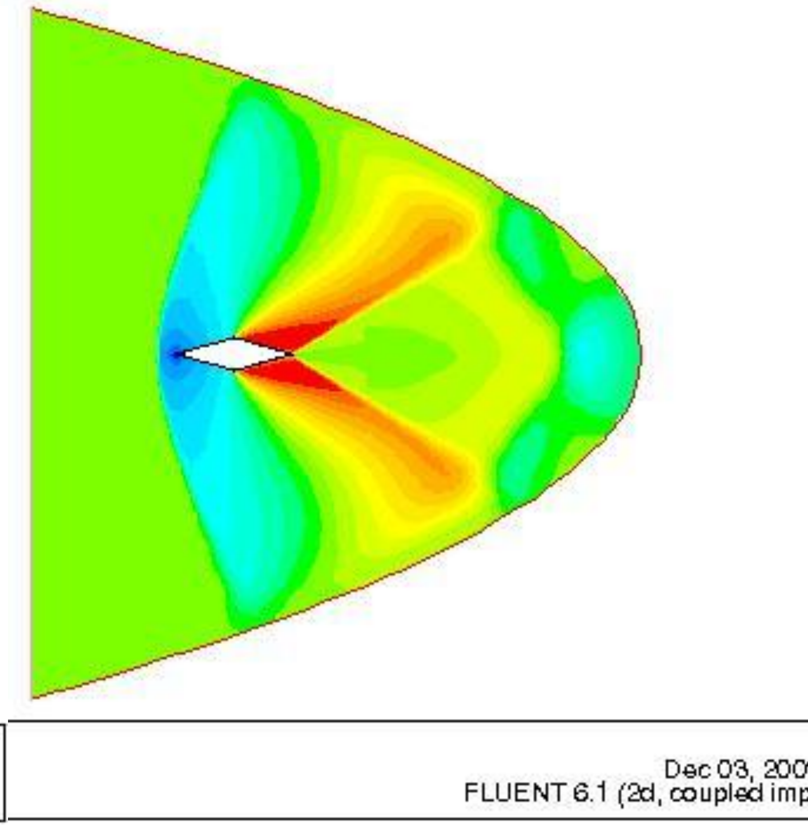
From Mn1 we get P2/P1, T2/T1, Mn2 from the shock tables:

P2 = 60320 Pa

T2 = 288.77 K

M2 = 1.39



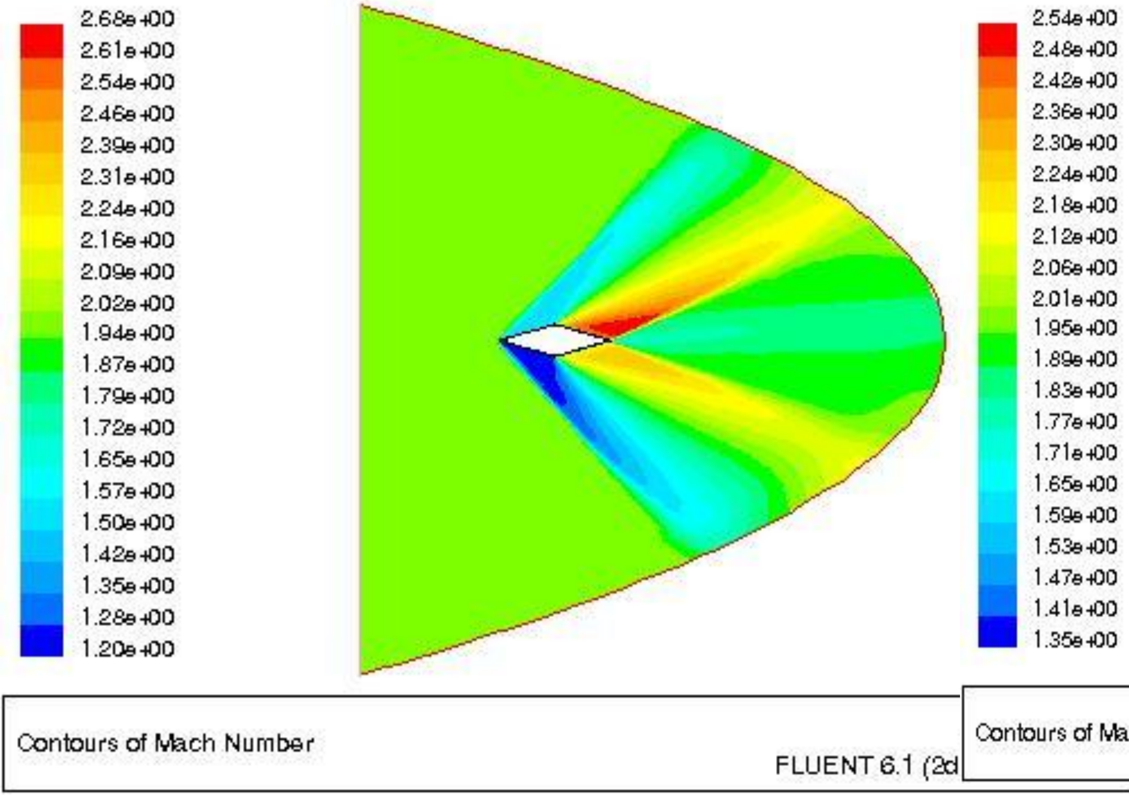


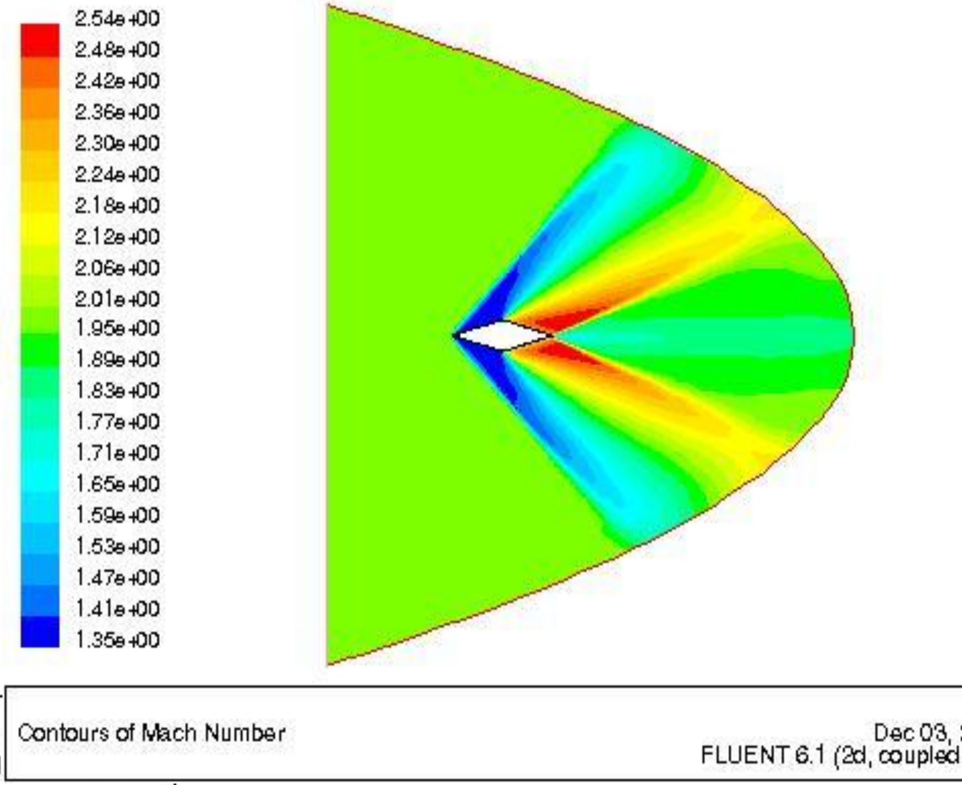
INVISCID **alpha=3**
2^{nd} order upwind

INVISCID **alpha=0**
2^{nd} order upwind

Detached shock **M=1.3**

MACH NUMBER DISPLAY



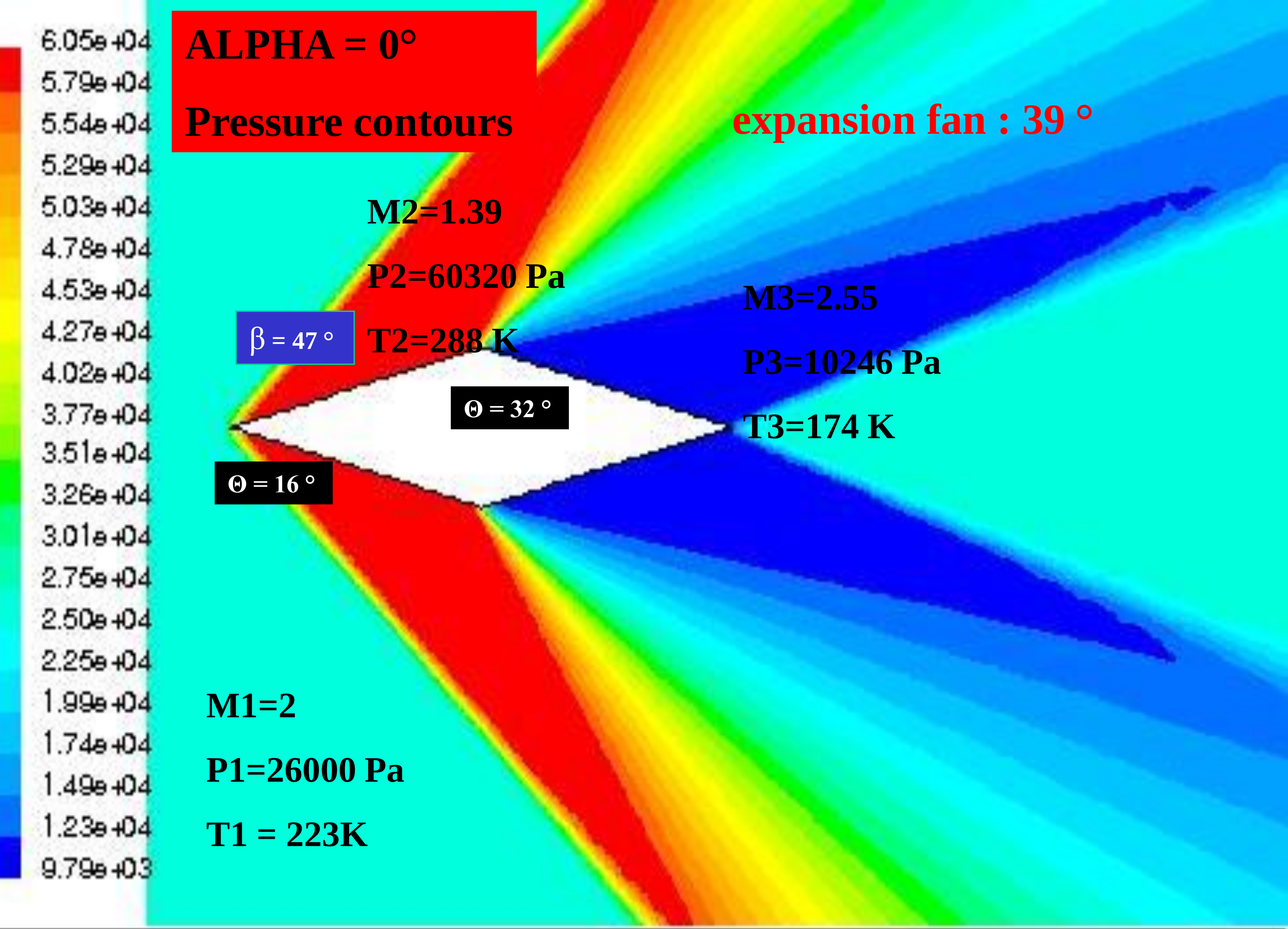


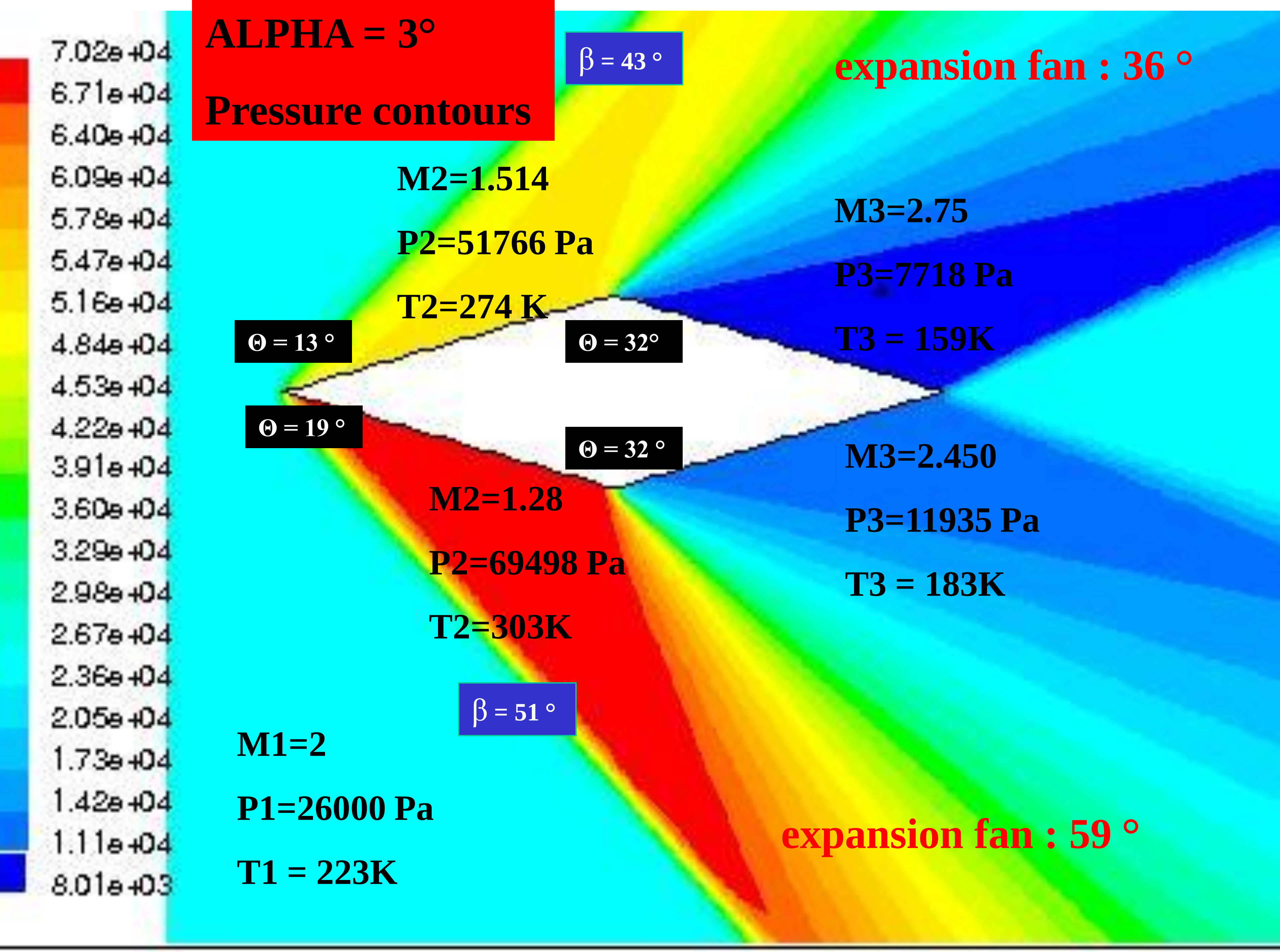
INVISCID **alpha=3**
2nd order upwind

INVISCID **alpha=0**
2nd order upwind

Attached shock **M=2**

MACH NUMBER DISPLAY


ALPHA = 0°
Pressure contours
expansion fan : 39 °
6.05e+04
5.79e+04
5.54e+04
5.29e+04
5.03e+04
4.78e+04
4.53e+04
4.27e+04
4.02e+04
3.77e+04
3.51e+04
3.26e+04
3.01e+04
2.75e+04
2.50e+04
2.25e+04
1.99e+04
1.74e+04
1.49e+04
1.23e+04
9.79e+03
M2=1.39
P2=60320 Pa
T2=288 K
β = 47 °
Θ = 32 °
M3=2.55
P3=10246 Pa
T3=174 K
Θ = 16 °
M1=2
P1=26000 Pa
T1 = 223K



ALPHA = 3°
Pressure contours
β = 43 °
expansion fan : 36 °
M2=1.514
P2=51766 Pa
T2=274 K
M3=2.75
P3=7718 Pa
T3 = 159K
Θ = 13 °
Θ = 32°
Θ = 19 °
Θ = 32 °
M3=2.450
P3=11935 Pa
T3 = 183K
M2=1.28
P2=69498 Pa
T2=303K
β = 51 °
M1=2
P1=26000 Pa
T1 = 223K
expansion fan : 59 °
7.02e+04
6.71e+04
6.40e+04
6.09e+04
5.78e+04
5.47e+04
5.16e+04
4.84e+04
4.53e+04
4.22e+04
3.91e+04
3.60e+04
3.29e+04
2.98e+04
2.67e+04
2.36e+04
2.05e+04
1.73e+04
1.42e+04
1.11e+04
8.01e+03

VISCOUS RUN

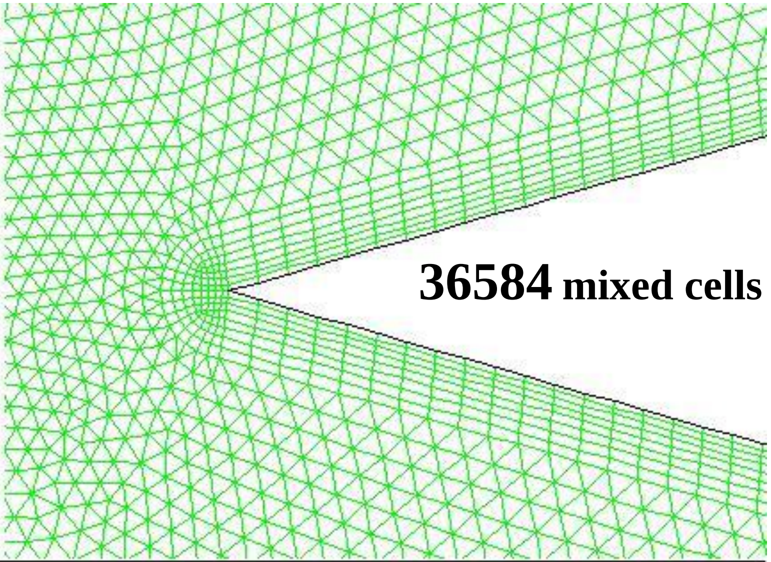
GRID SENSITIVITY STUDY

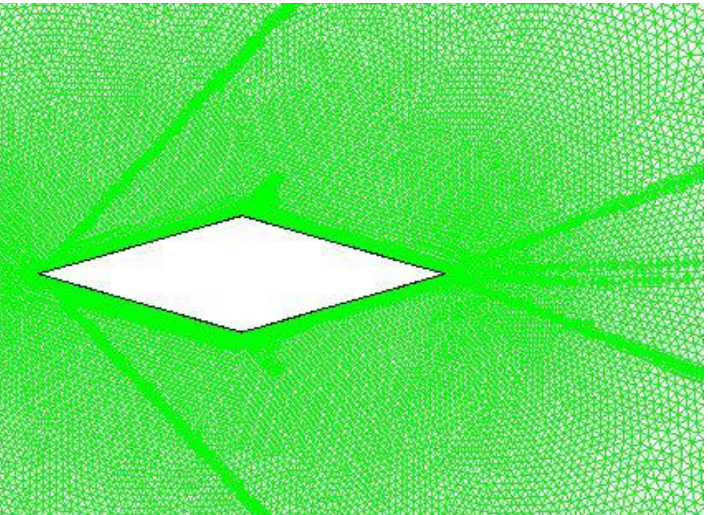
Original Grid: **27402** triangular cells

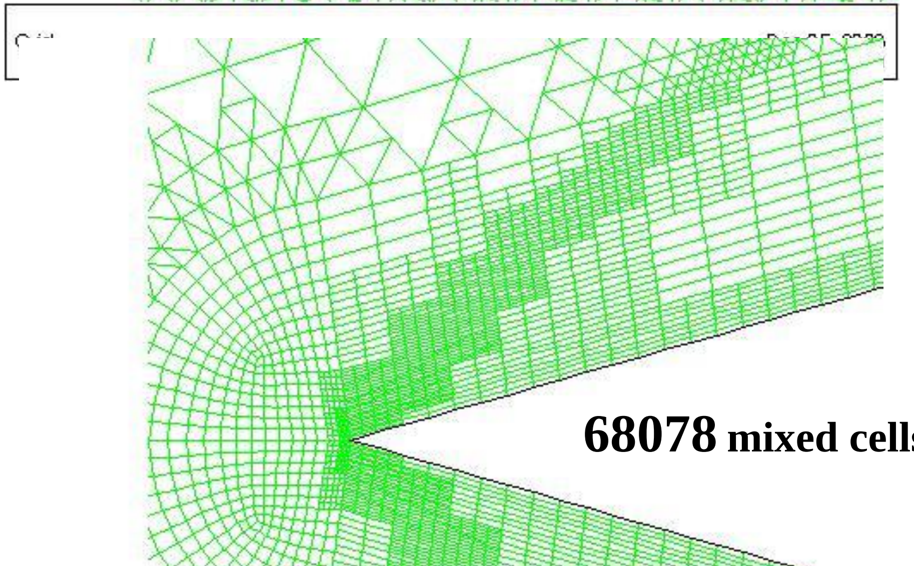
Final refined grid : **68078 mixed cells**

•Pressure gradient adaptation

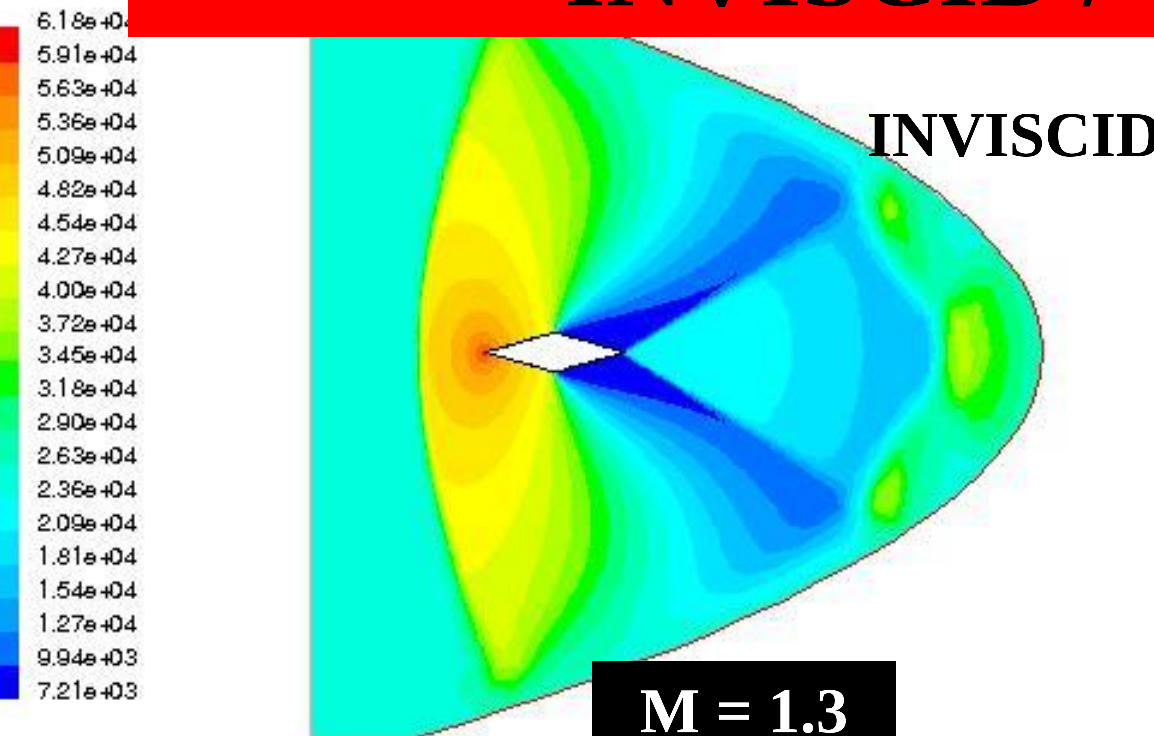
•Boundary Layer adaptation



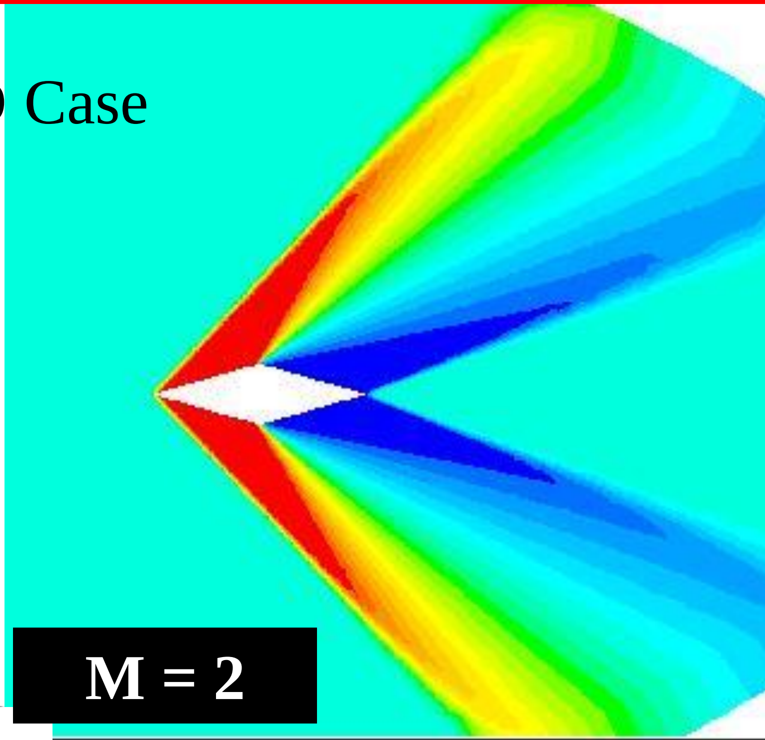




INVISCID / VISCOUS

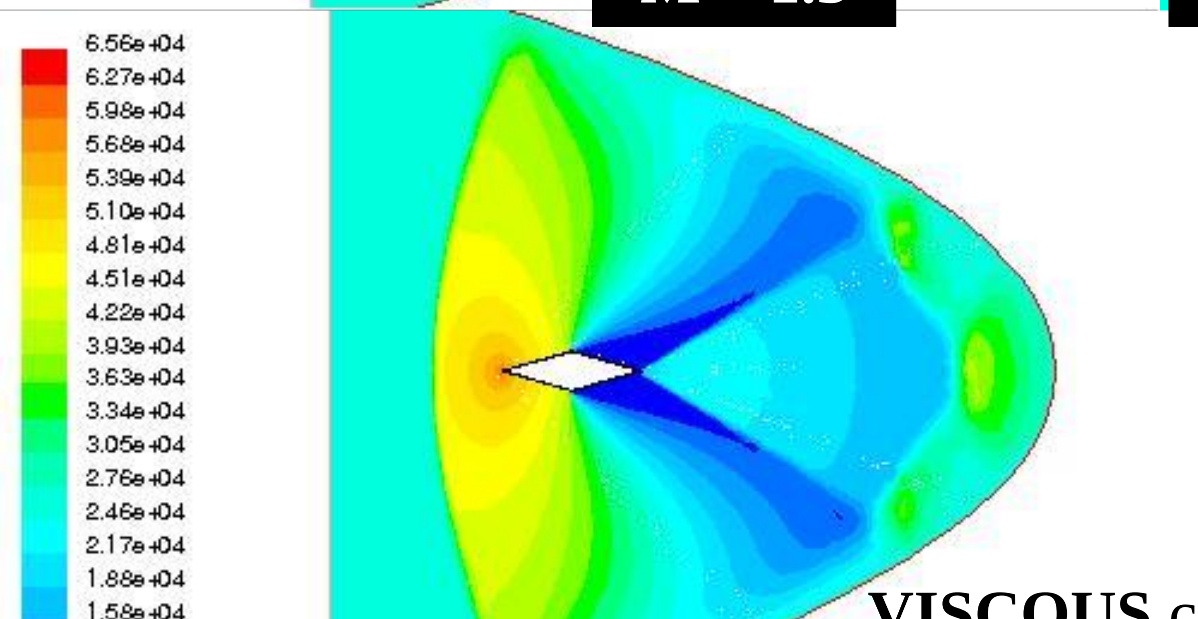


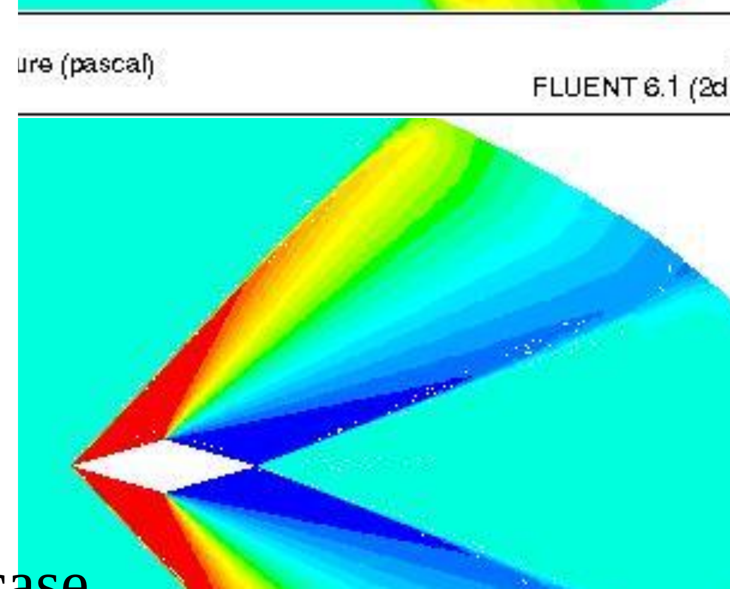
INVISCID Case



M = 1.3

M = 2





VISCOUS case