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Numerical simulation of peen forming induced deformations: modeling and experimental validation

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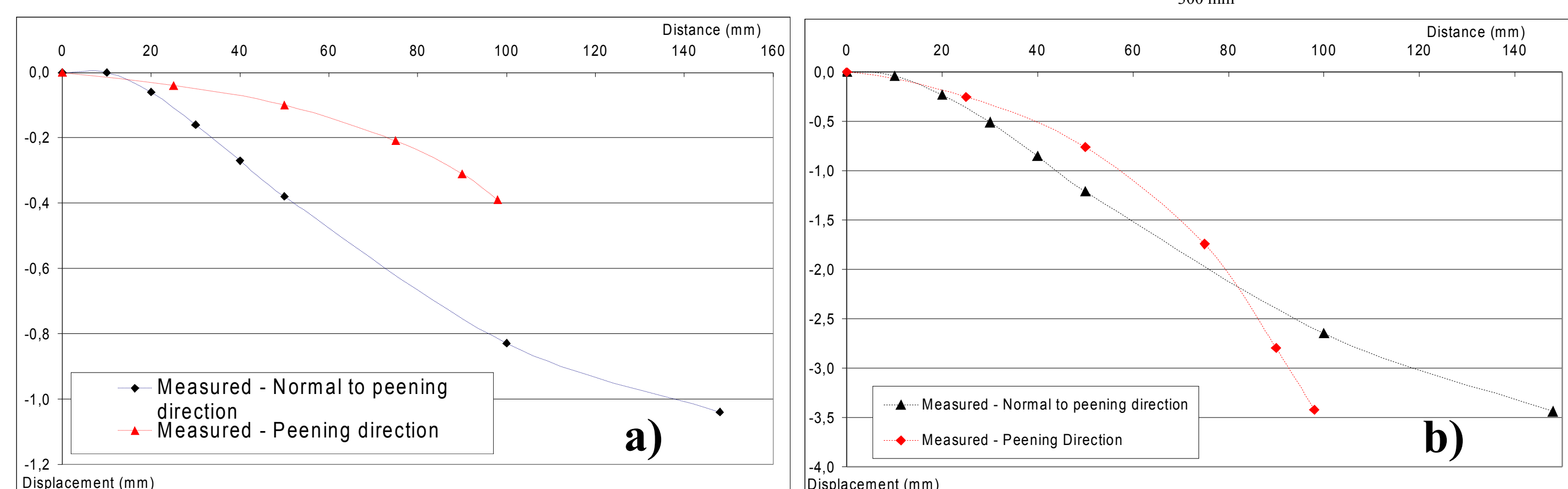
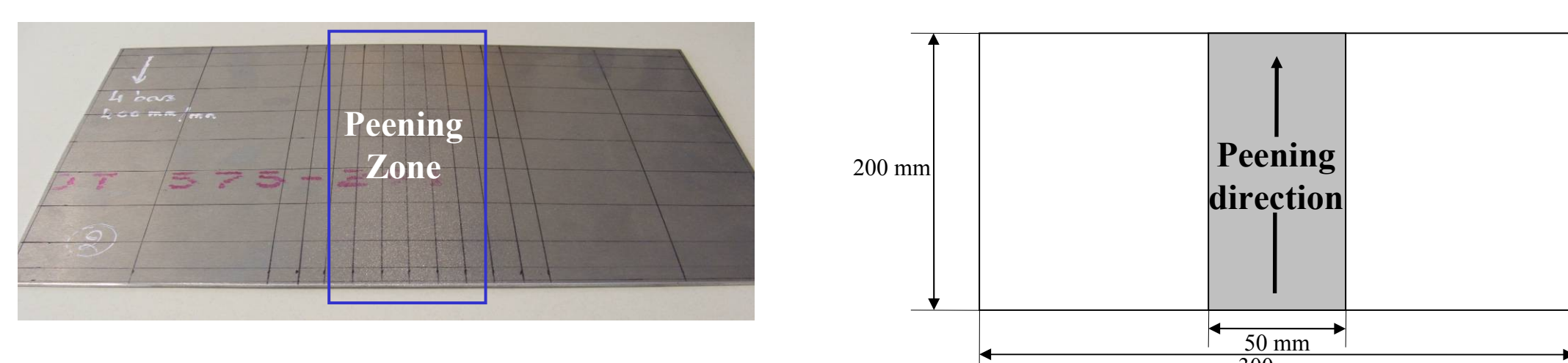
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CONTEXT

- Experimental and numerical study of the peen forming process: *study of the deformation mechanisms involved in shot-peening.*
- The scope of the work is to identify data that permit to *simulate the peen forming process.*
- The choice of **plastic strains as process data** is made. The plastic strains induced by the impacts are identified on simple cases and then numerically introduced in a Finite Element program to predict the deformation of more complex parts.

EXPERIMENTAL CASES

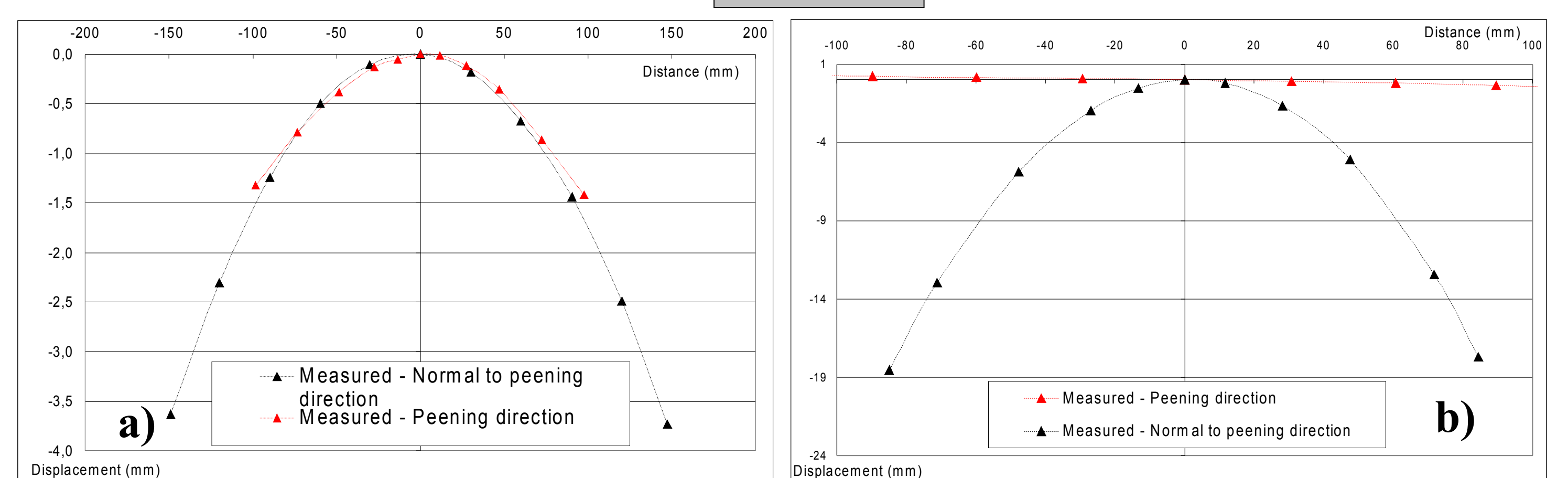
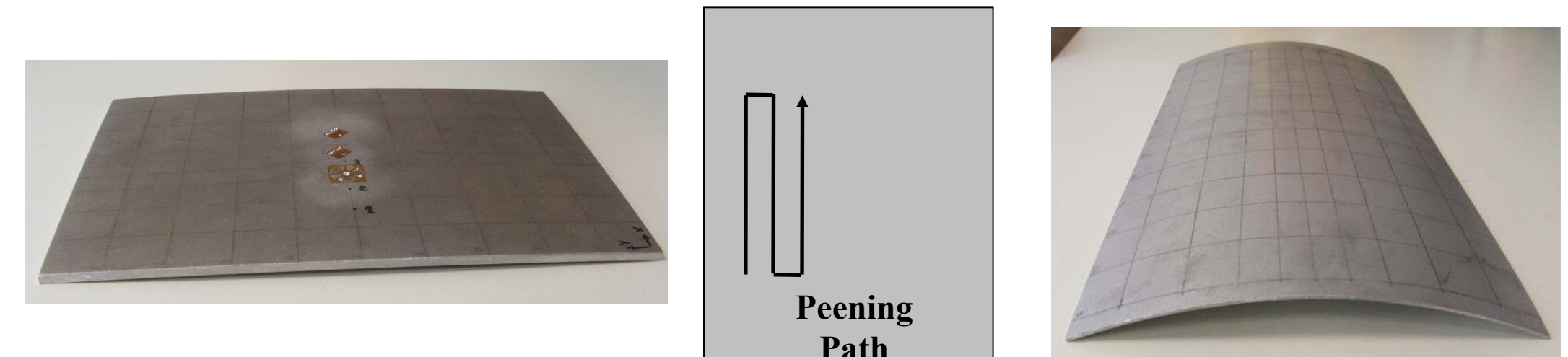
Partially shot-peened aluminum 2024T3 alloy plates



Measured displacements after shot-peening (3-axial measuring machine)

a) 5 mm thick specimen b) 2 mm thick specimen

Totally shot-peened aluminum 2024T3 alloy plates



Measured displacements after shot-peening (3-axial measuring machine)

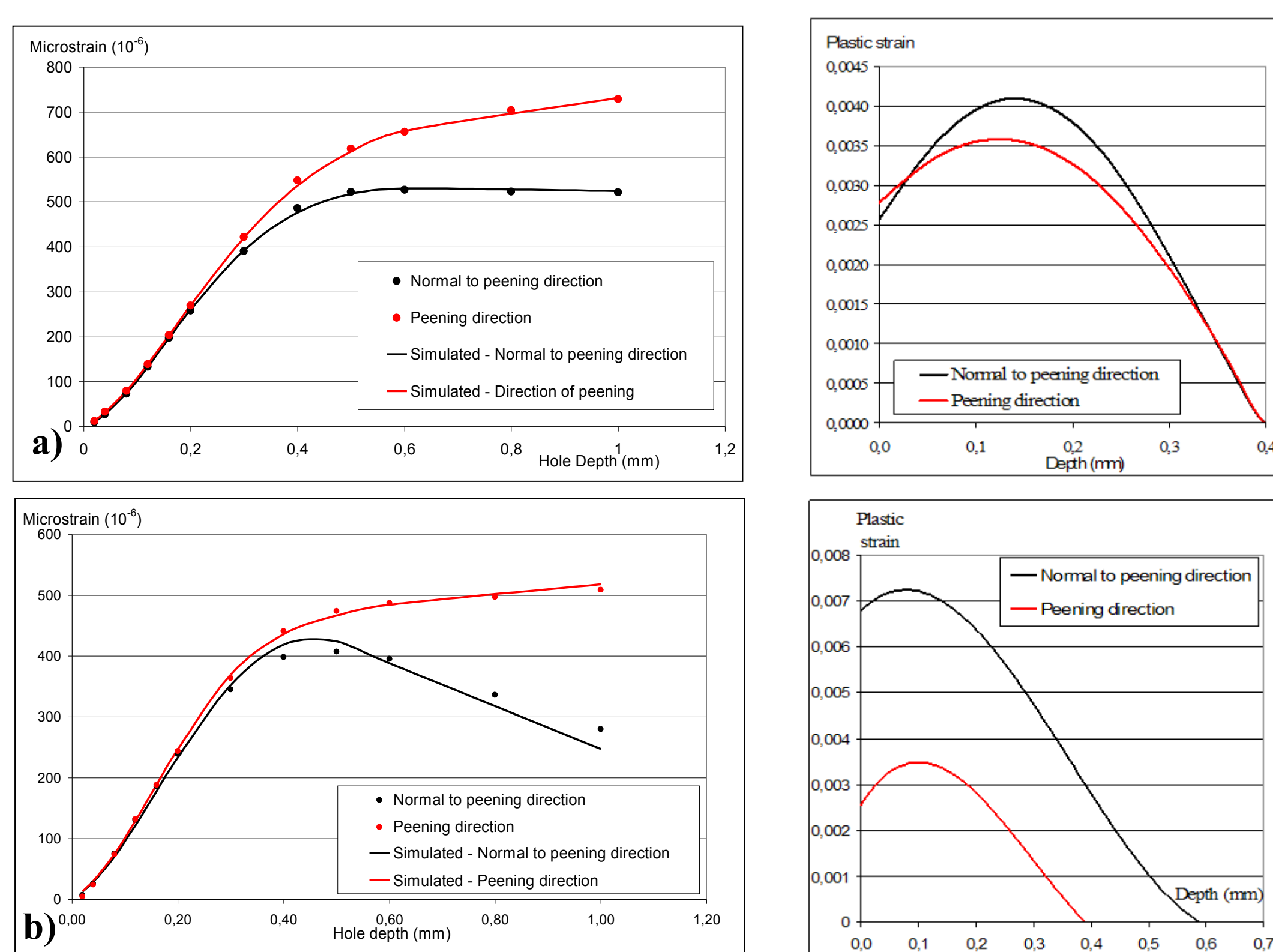
a) 5 mm thick specimen b) 2 mm thick specimen

- No influence of the peening path on global deformations for relatively thick specimens.
- Huge influence of the peening path on global deformations for thin specimens (cylindrical form depending on peening direction).

NUMERICAL SIMULATION

Incremental Hole Drilling results

- Classical method using strain gages.
- Model based on eigenstrains theories. Elastic FE problem with initial strains.
- Numerical model coupled to optimization program to identify plastic strains.
- Plates supposed to be free of external constraints during drilling.



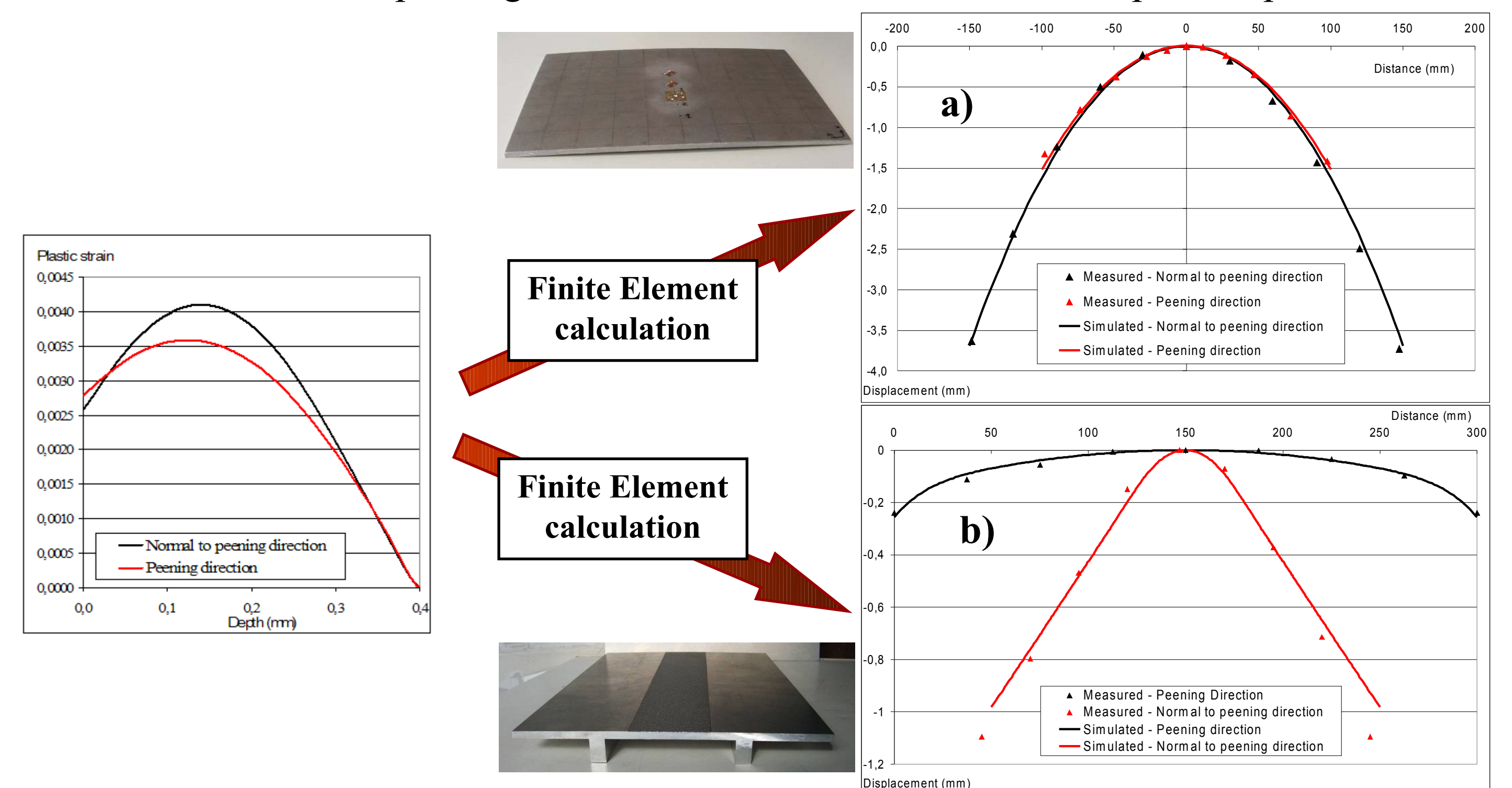
Numerical results – Partially shot-peened plates

a) 5 mm thick specimen b) 2 mm thick specimen

- Nearly equi-biaxial plastic strain field identified in 5 mm thick specimen.
- Plasticity oriented in the normal to peening direction in 2 mm thick specimen.
- Non realistic modeling of the boundary conditions of the 2 mm thick specimen: measured microstrains evolution do not correspond to the theoretical one.

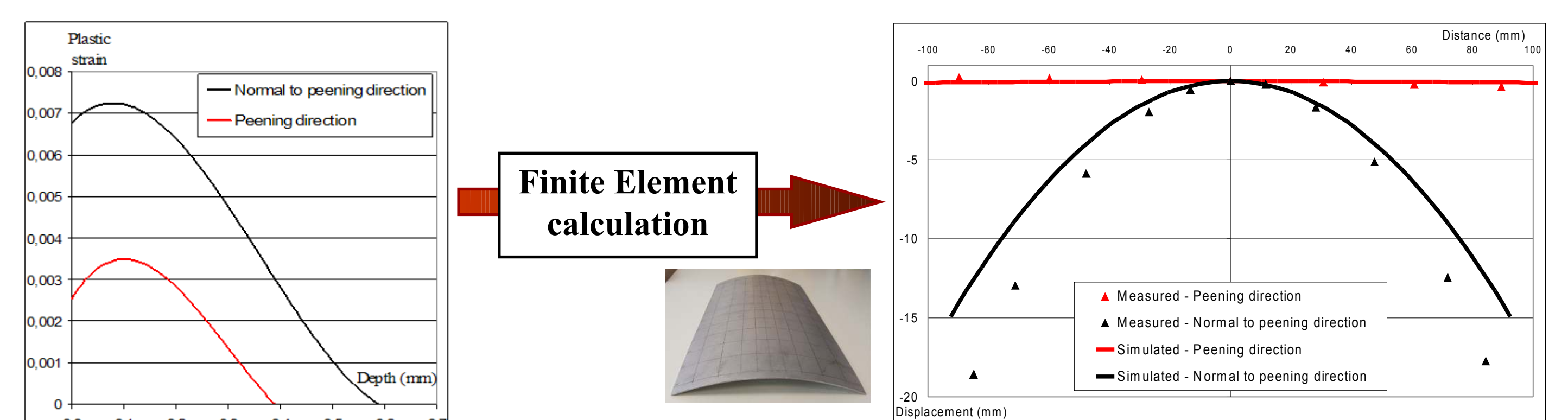
Application to peen forming simulation

- Identified plastic strains as process data.
- Simulation of the shot-peening of the same materials, with the same process parameters.



Numerical results – 5 mm thick specimens

a) totally shot-peened plate b) stiffened panel



Numerical results – 2mm thick totally shot-peened plate

CONCLUSION

- Measurements show the influence of the shot-peening path on the global deformations.
 - Negligible for relatively thick specimens.
 - Appreciable for relatively thin specimens.
- Peen forming simulation gives good results for these first application cases.

FURTHER WORK

- Investigation of the deformation mechanisms of thin metallic parts.
 - To give a better understanding of the influence of the shot-peening path.
- Application to more complex geometries.
 - To fit the industrial needs (large aeronautical stiffened panels).