# Pressure measurement in 2D sloshing simulations with SPH

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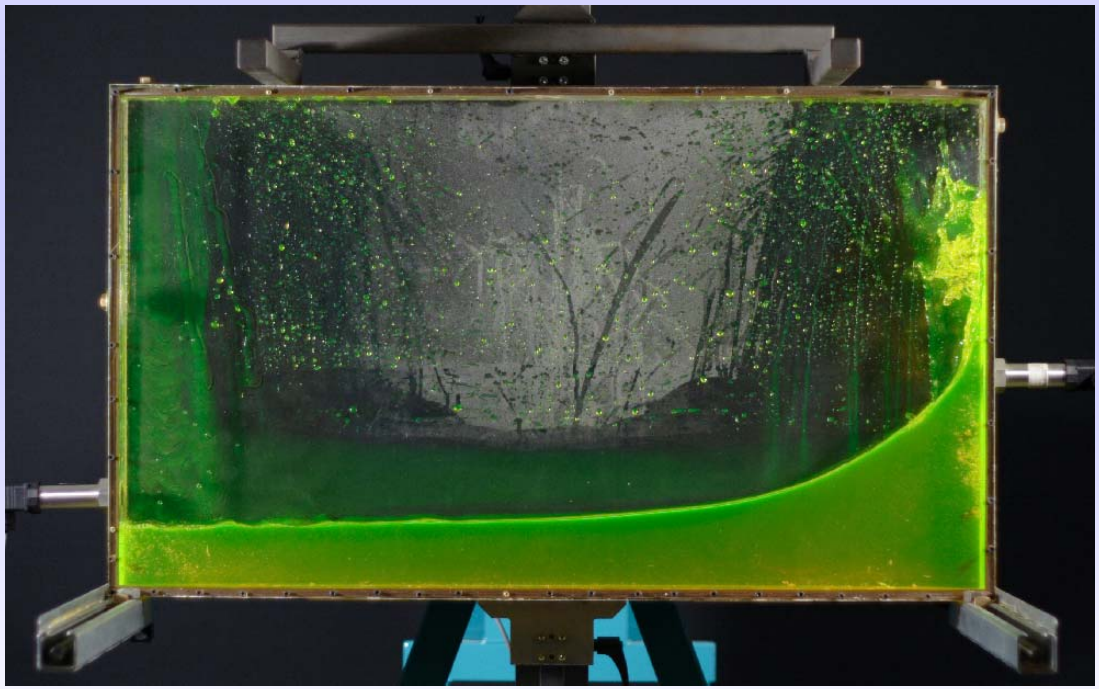
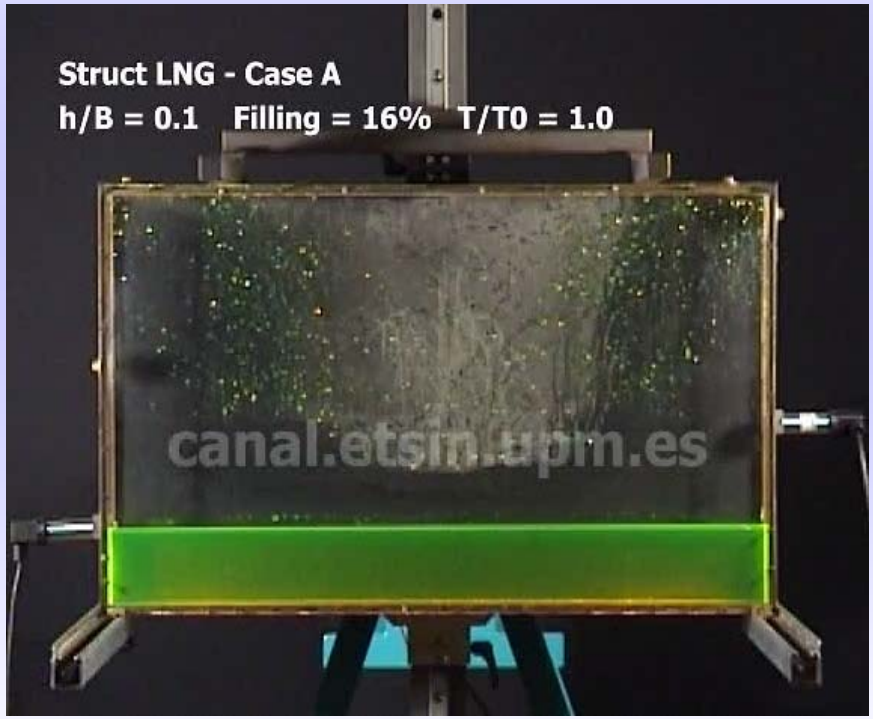
# Introduction

## Impact of waves on structures



# Case Study

- Model of a section of one of the tank of a LNG tanker
- Pitch oscillation at the resonance frequency
- Pressure transducer at the free surface location

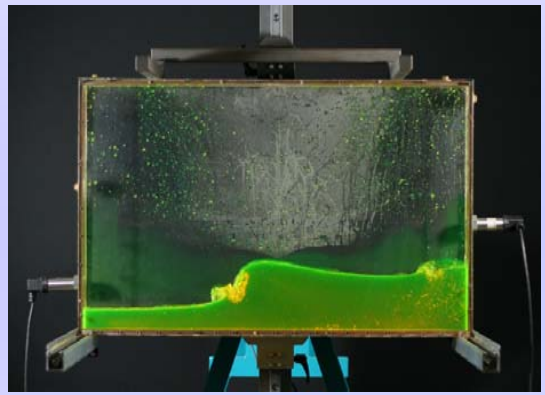


# Impact Pressure

( Bass *et.al.*, 1985, Berg, 1987)

**The impact pressure is affected by:**

- The dynamics of the flow (Froude number)
- Ullage pressure
- Air-water mixture
- Wall flexibility

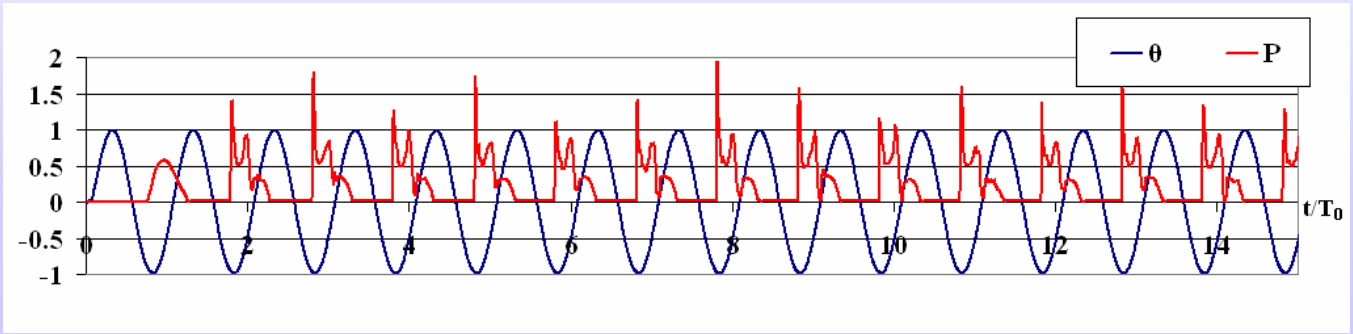


**Liquid compressibility and viscosity do not have a significant effect on impact pressure**

# Impact Pressure

(Peregrine, 2002)

**The impact pressure has a random character**

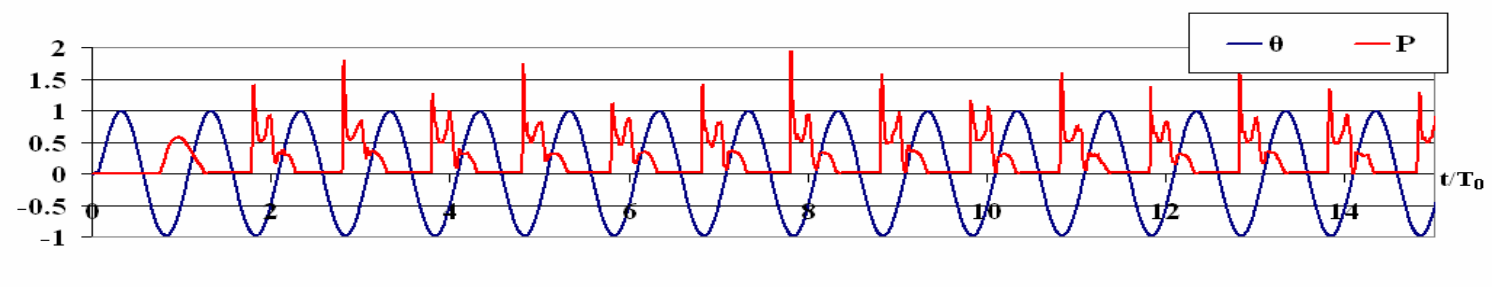



→ **Provide pressure with their probability**

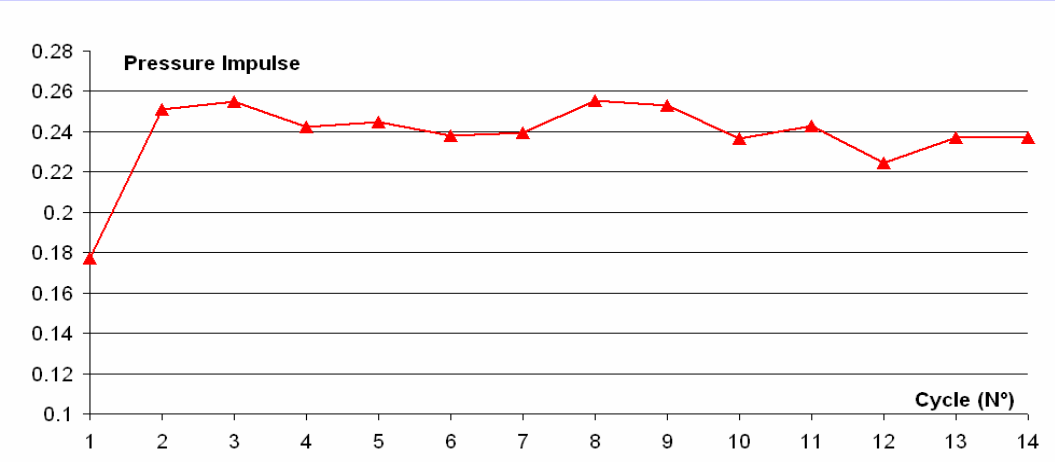
→ **Pressure impulse: Integral of the pressure over the impact duration**

# Pressure Impulse

(Peregrine, 2002)




**The pressure impulse presents lower variation than the impact pressure**



# Numerical Simulation: SPH

**Standard formulation (Monaghan, 2005)**

**Artificial viscosity: $\alpha = 0.02$**

**Predictor-Corrector: courant factor = 0.15**

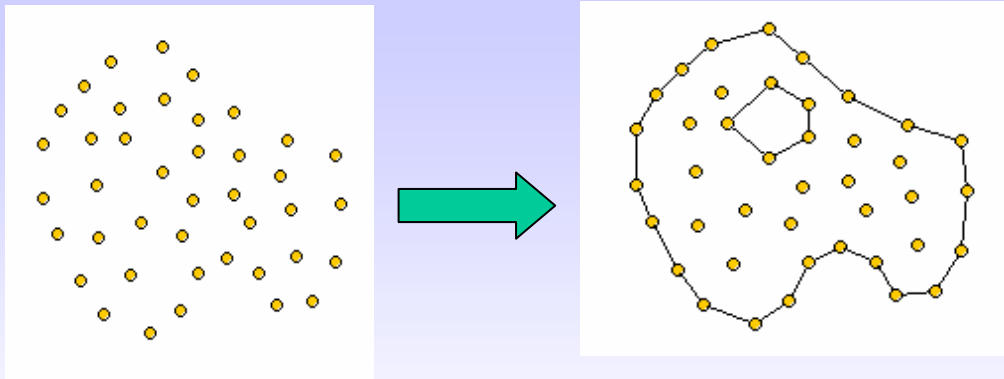
**Boundary: Repulsive force using boundary particles**

**Resolution: 3000, 5000, 10 000 and 20 000 fluid particles**

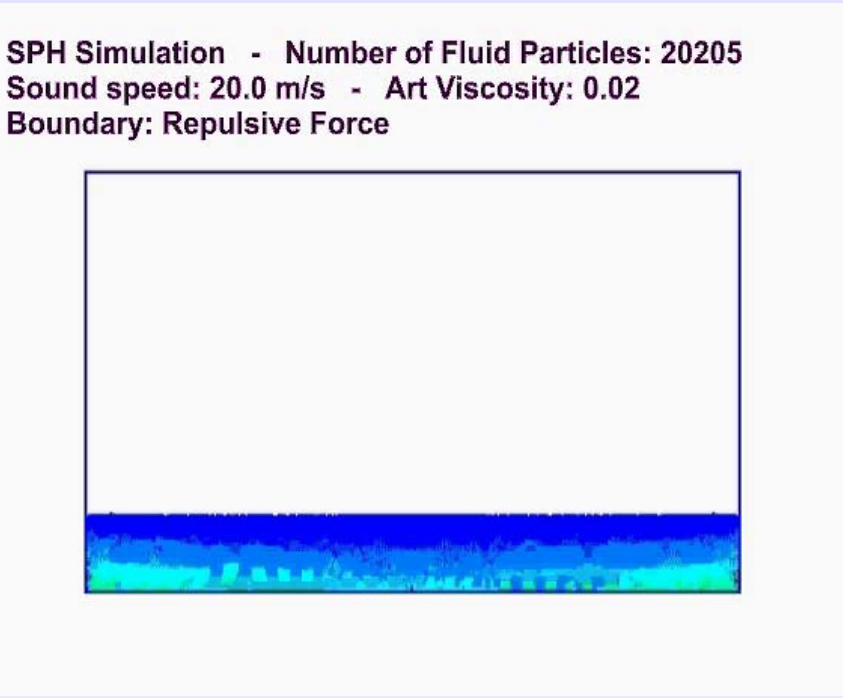
**Sound speed: 20 and 40 m/s**

# Numerical Simulation: PFEM

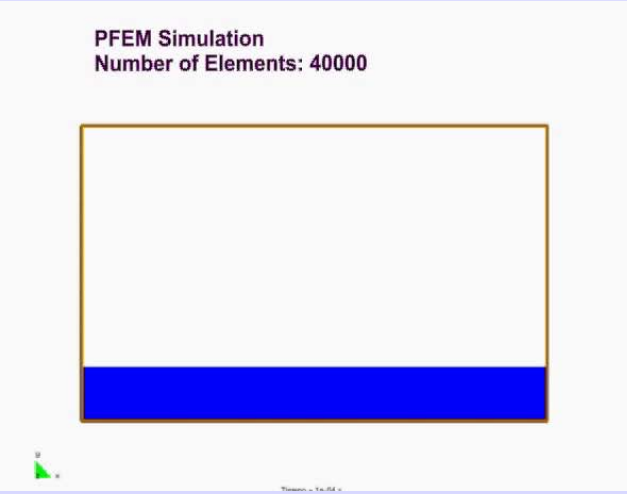
- Lagrangian formulation: The mesh velocity is the same as the fluid velocity.
- Fast re-meshing algorithm: Extended Delaunay Tesselation , used at every time step, to avoid large distortion of elements.
- The Alpha-shape technique to identify the boundary
- Standard FEM.

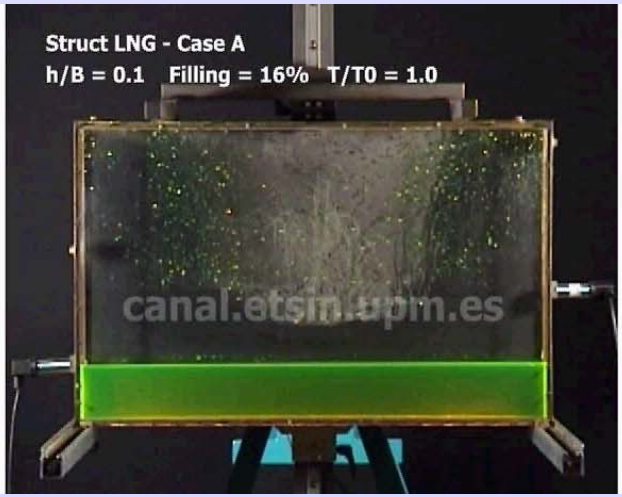


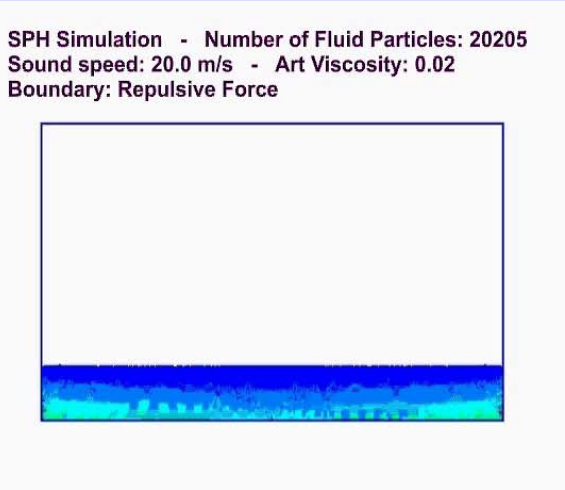
# Experiments Vs SPH : General Dynamics

# EXPERIMENT – SPH – PFEM
## General Dynamics

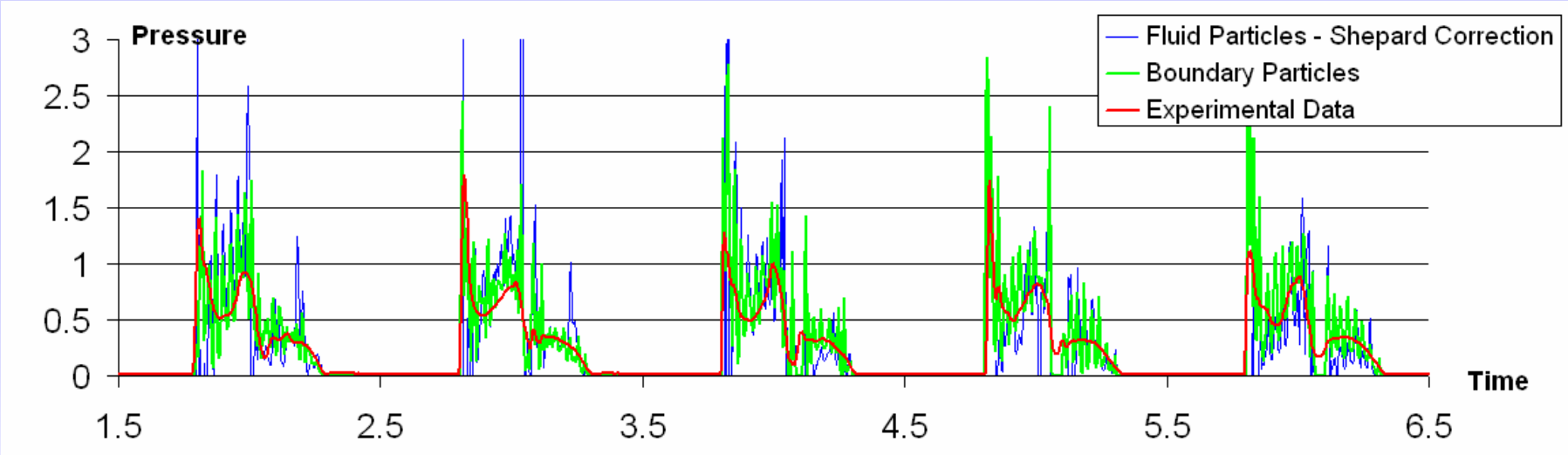


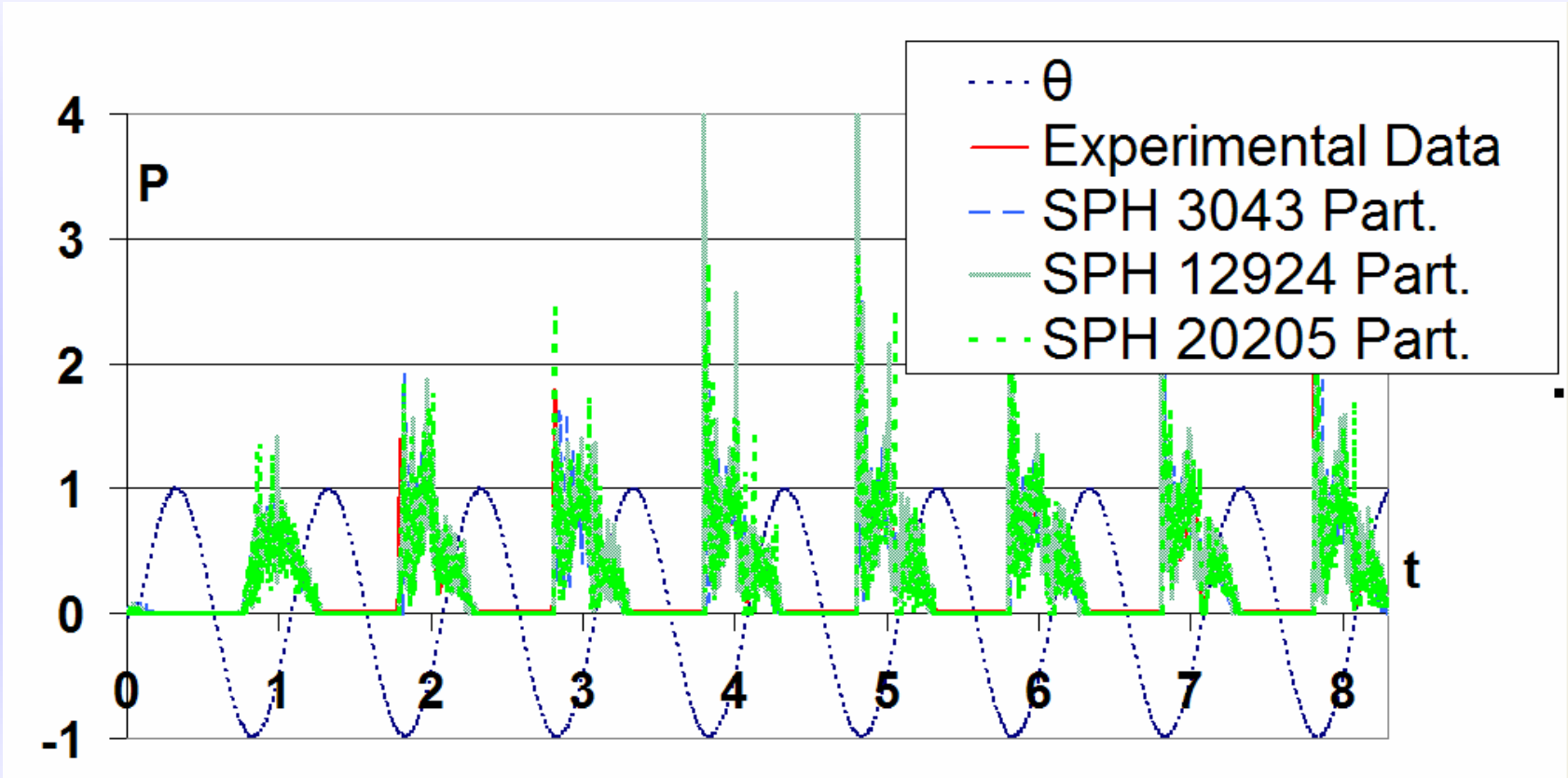



# SPH – Pressure on the wall

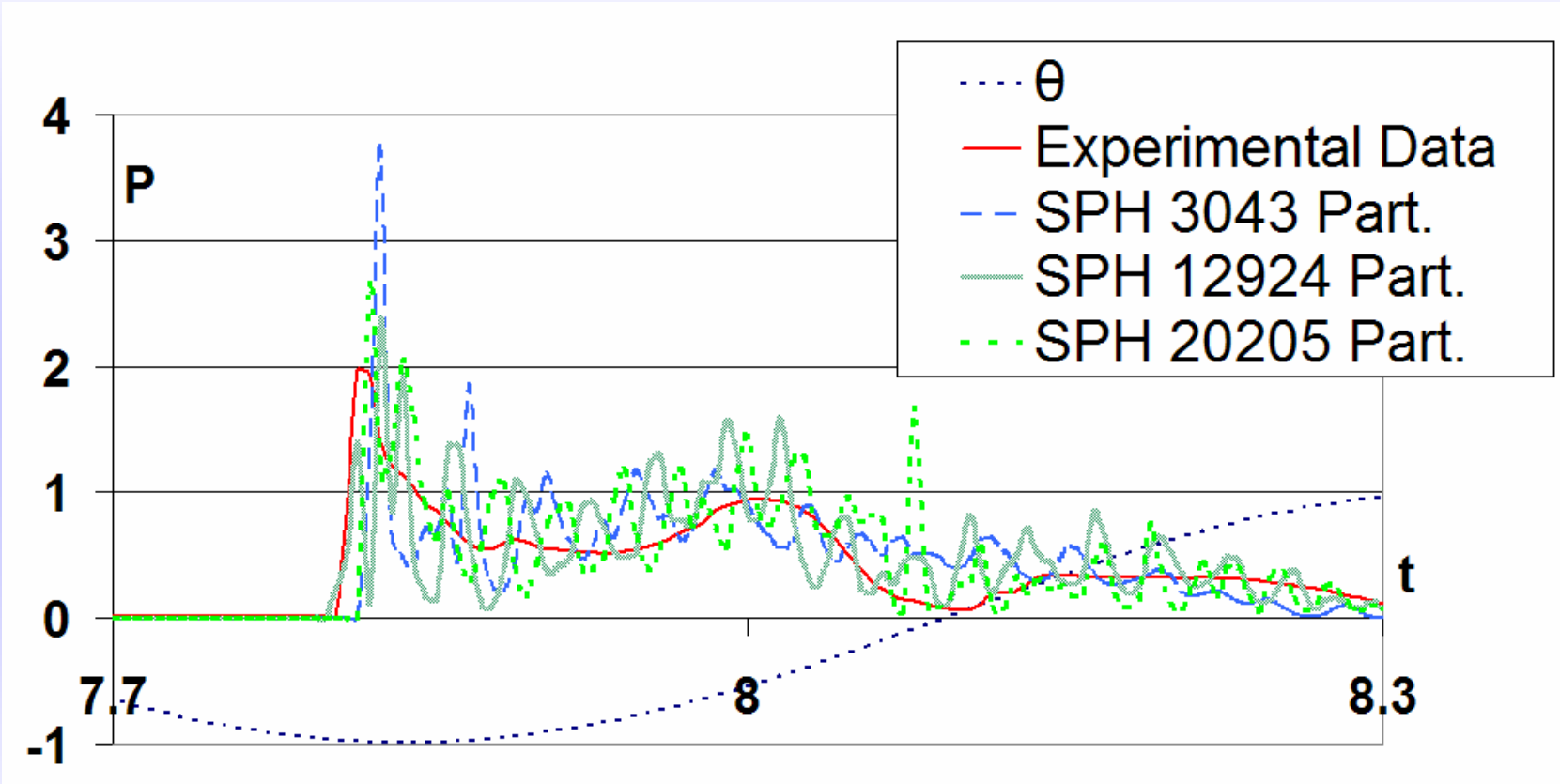
- **By means of fluid particles**
- **By means of boundary particles**



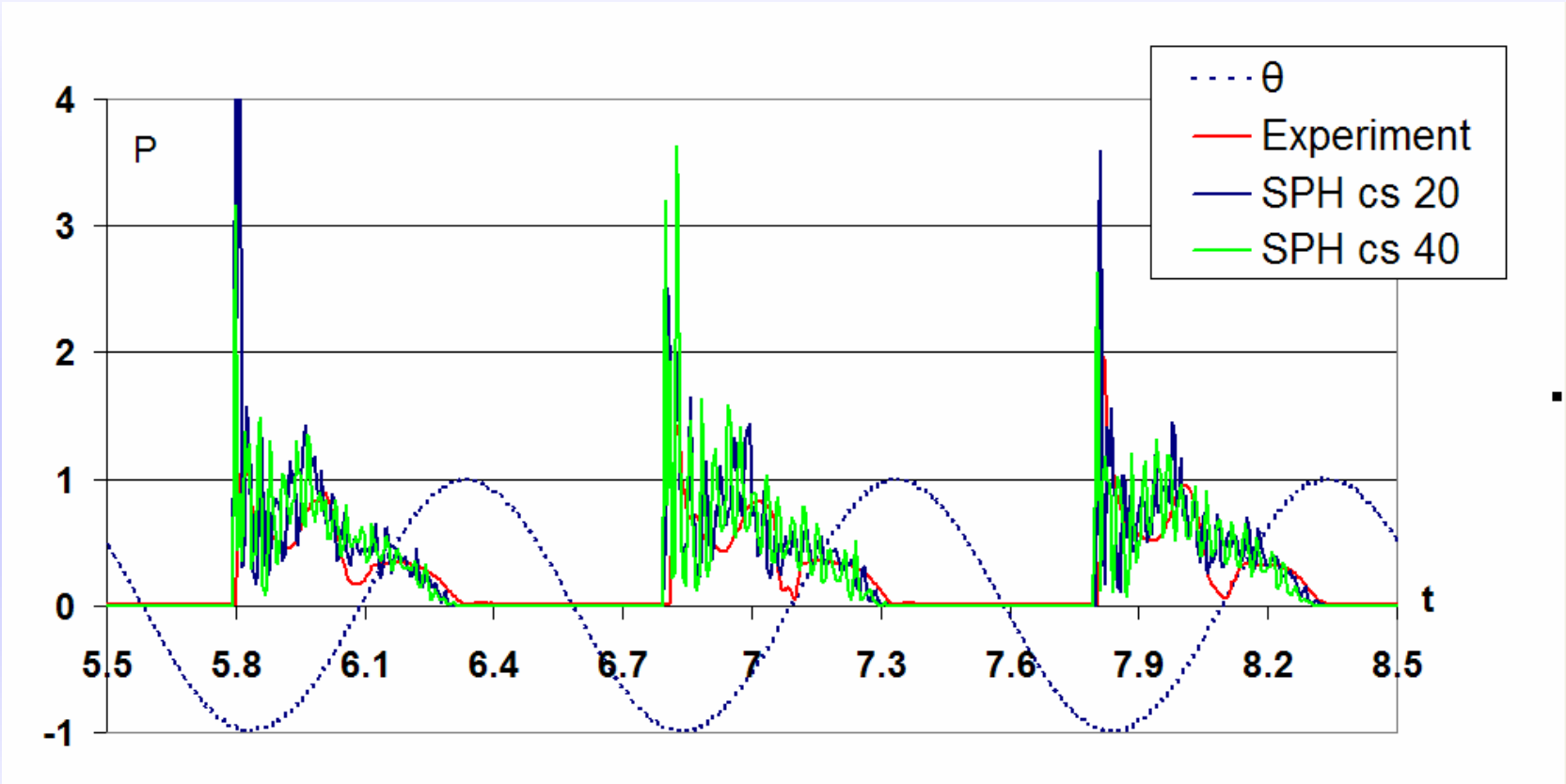
# Results SPH - Resolution



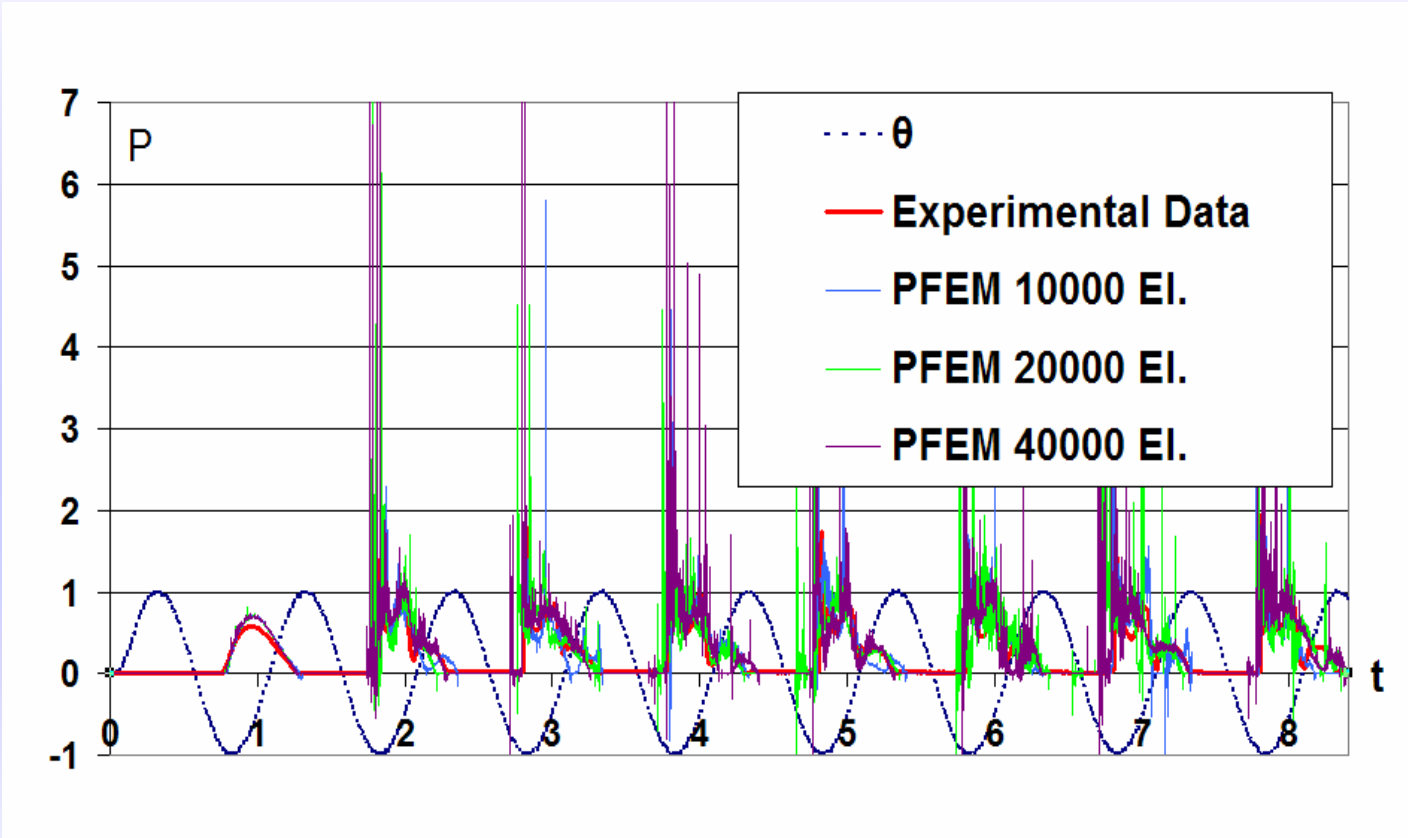
# Results SPH - Resolution



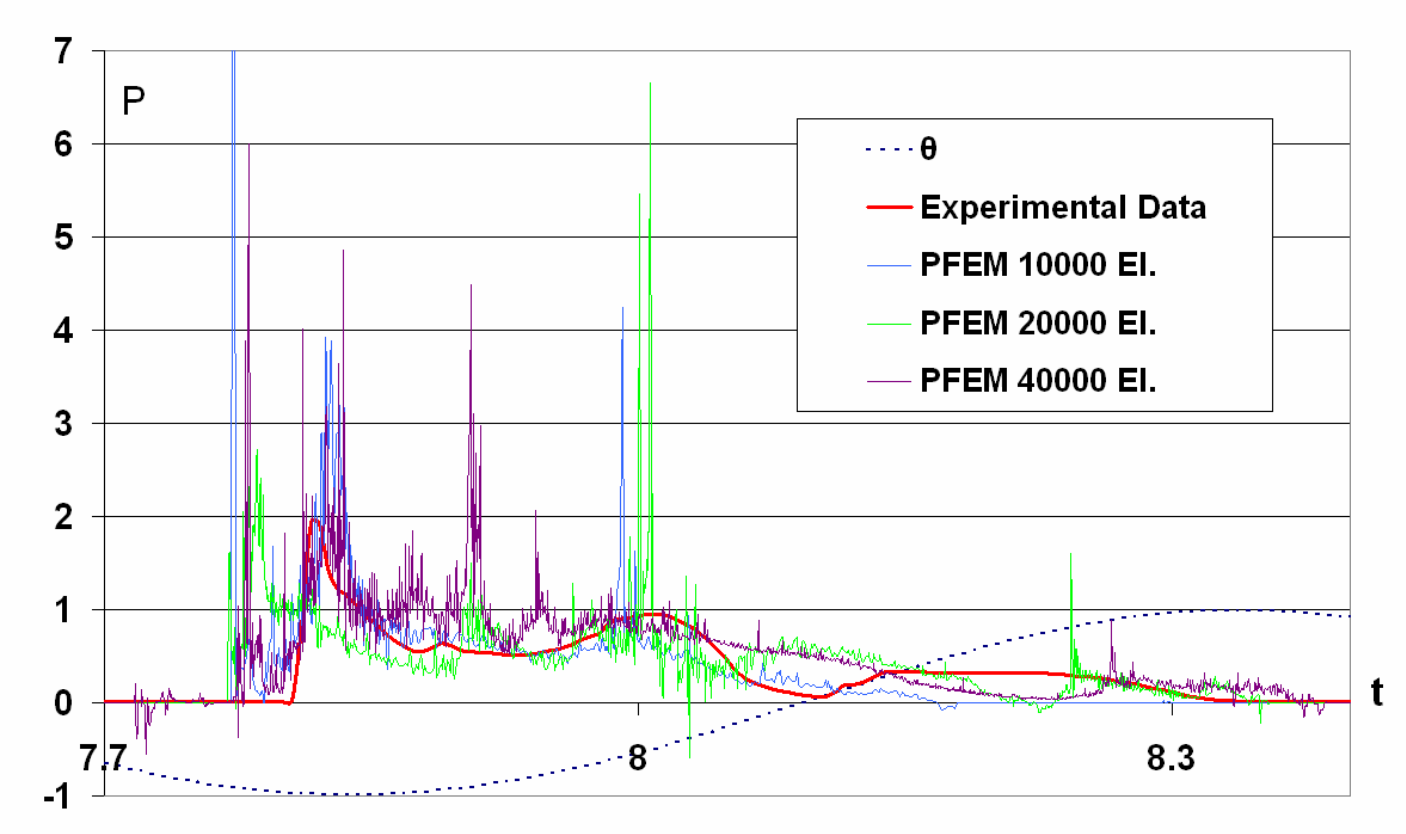
# Results SPH – Sound speed



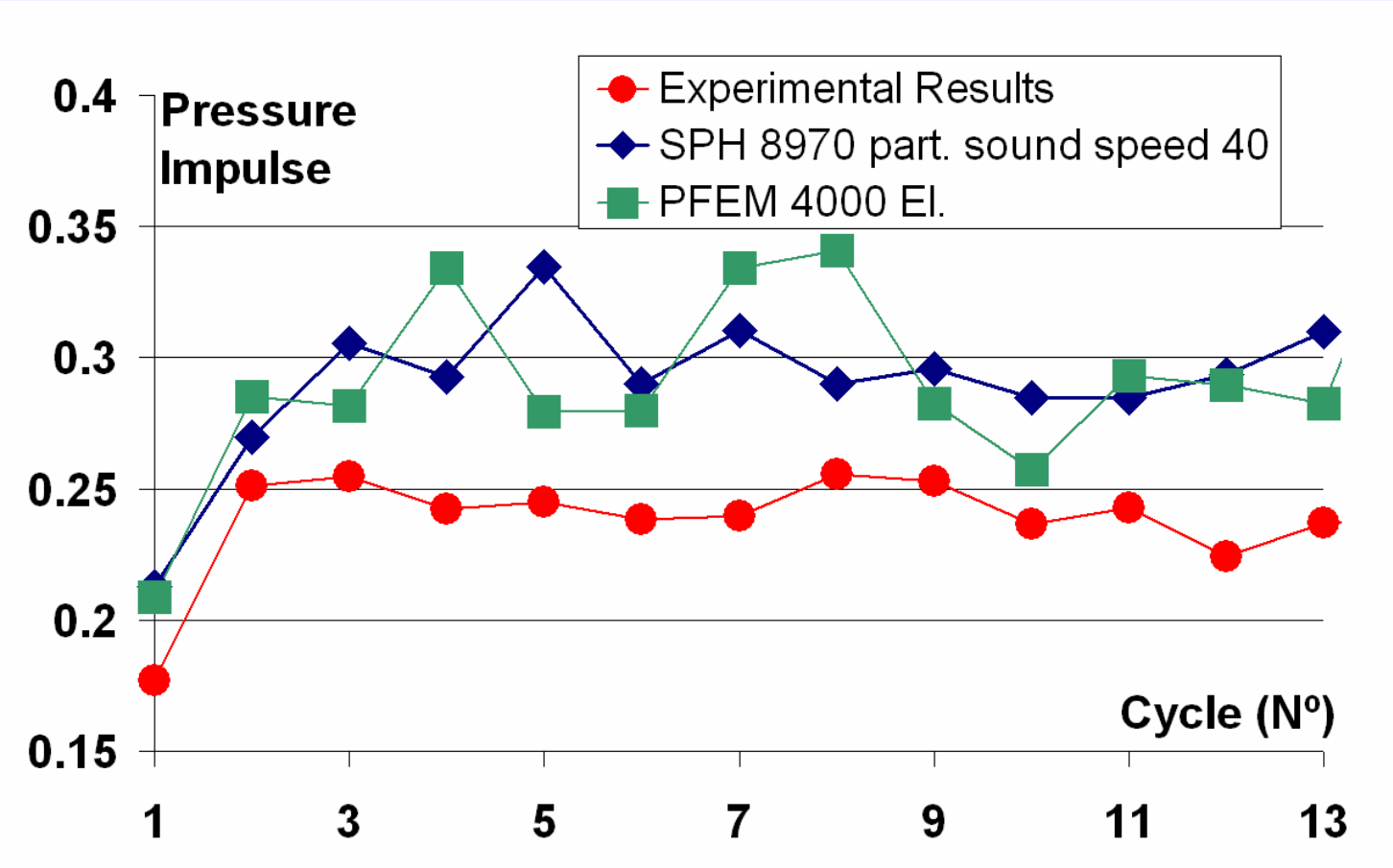
# Results PFEM Resolution



# Results PFEM Resolution



# Results Pressure Impulse



# Conclusions & Future Works

- Shape of the pressure curve is reproduced qualitatively
- Not a specific trend incresasing the resolution
- Sound speed does not affect significantly the pressure curve
- Unphysical Numerical oscillations appear
- Over-estimated pressure peak with both methods

Multi-phase simulations or single phase experiments

# THANKS FOR YOUR ATTENTION !