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Validation of bulk solids and vertical load analysis of a silo

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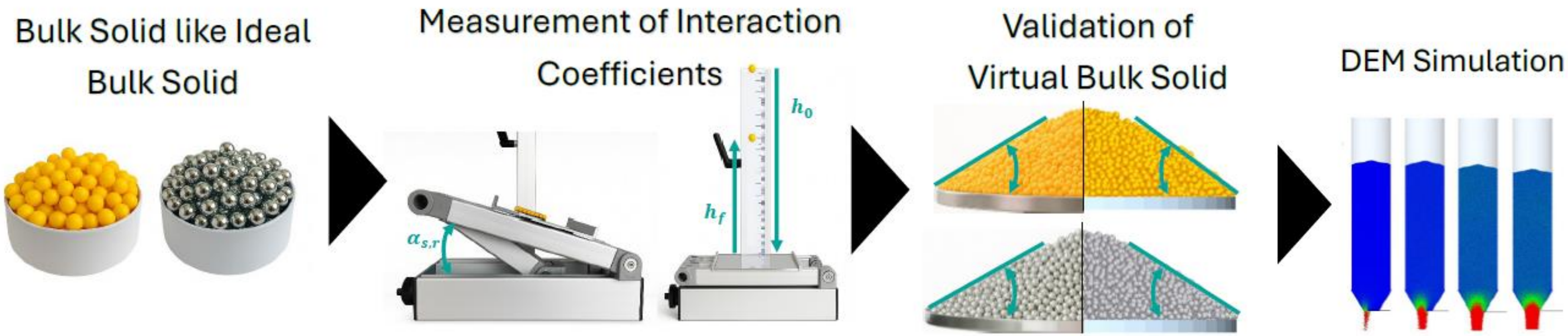
Motivation

- Dissertation: Influence of the size of the outlet opening of the particulate matter storage system on the inertial forces during the emptying process



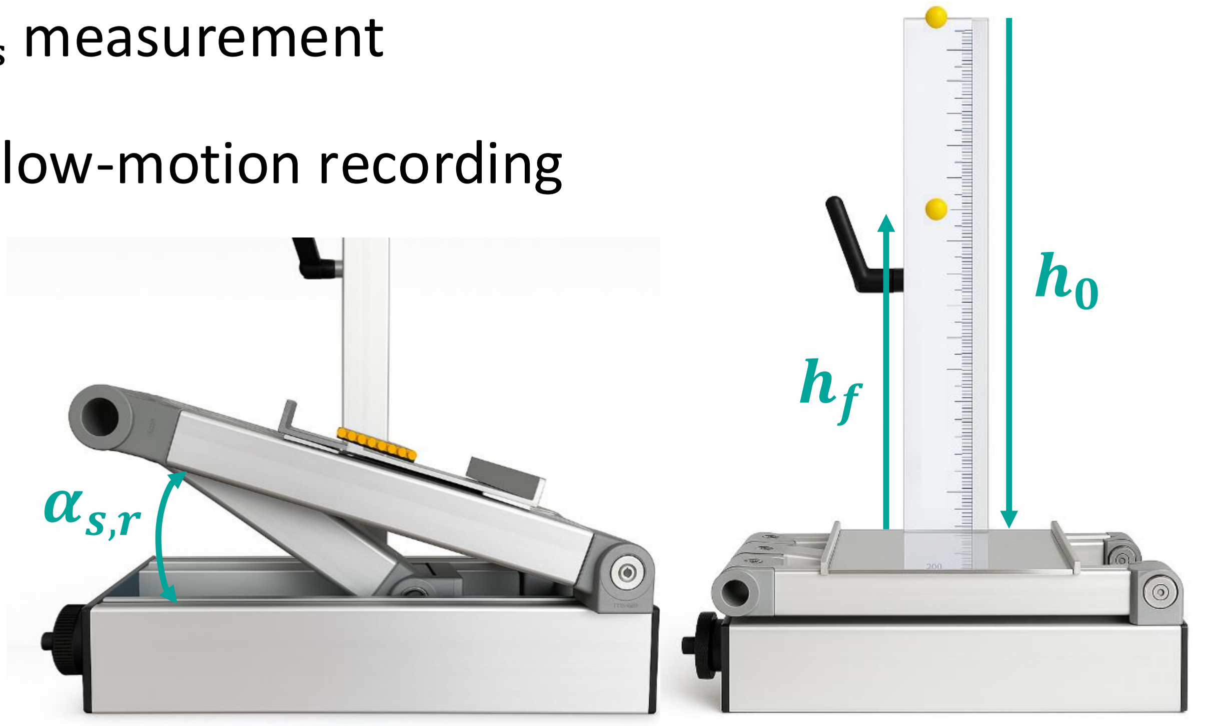
Bulk Solid

- Idealized models for evaluation
- Ideal bulk solid: φ = 30°
- Uniform spherical particles
- Airsoft and steel balls (significantly heavier)
- Particle diameter 6 mm
- Commercially available materials

Measurement of Interaction Coefficients

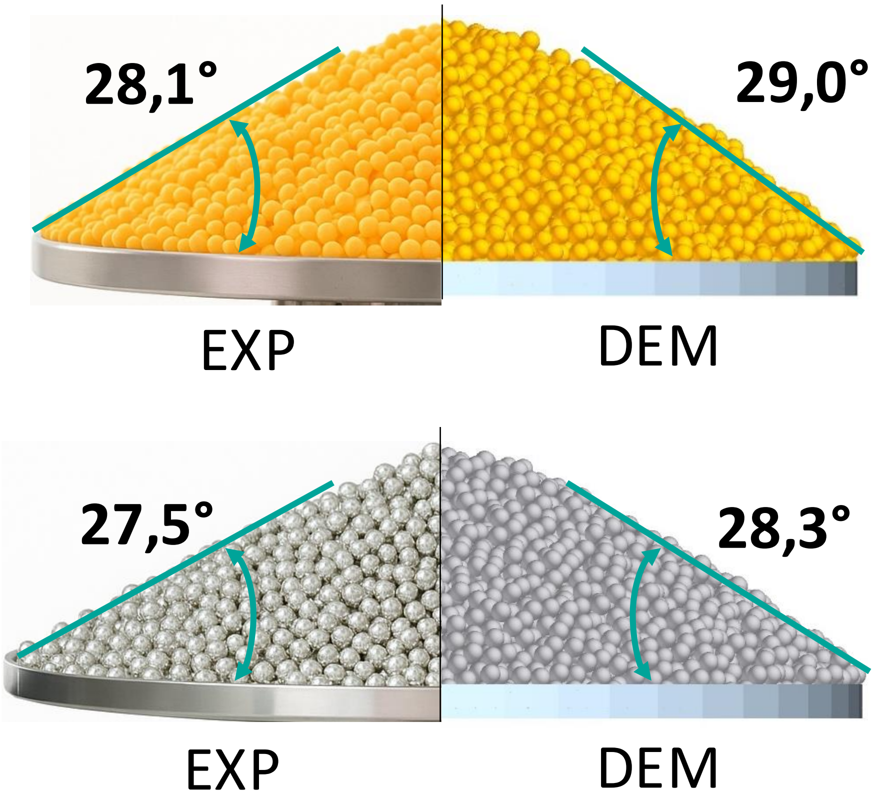
- Coefficient of static friction (μ_s), rolling friction (μ_r) and restitution (ε)
- Defined for particle – particle and particle – wall (steel) interactions
- Particles glued to prevent rolling for μ_s measurement
- ε measured via drop test (400 mm) + slow-motion recording

$$\mu_{s,r} = tg\left(\alpha_{s,r}\right) \qquad \varepsilon = \sqrt{\frac{h_f}{h_0}}$$



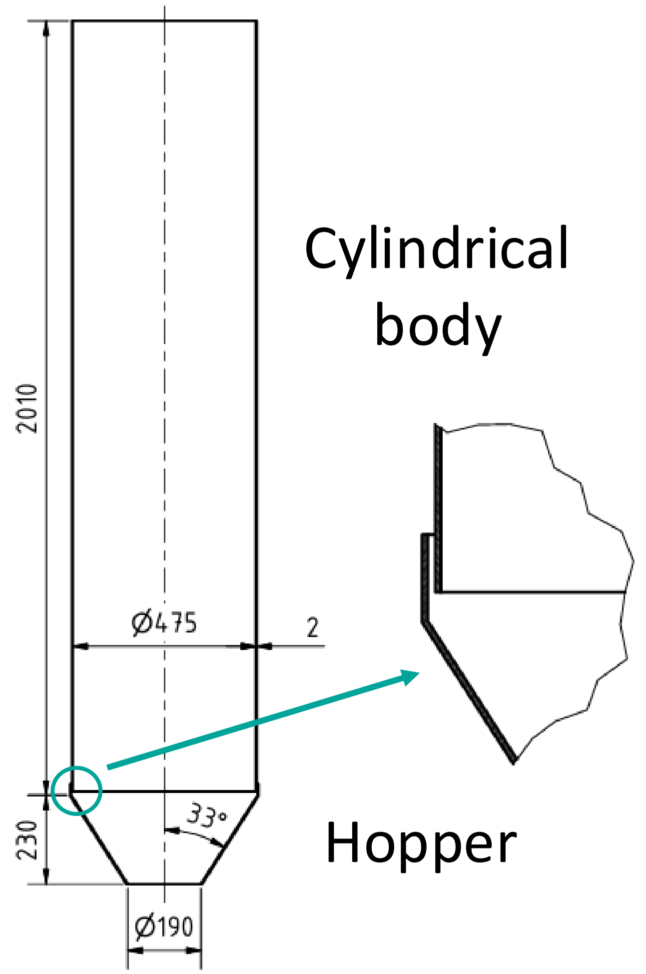
Validation of Virtual Bulk Solid

- Comparison between virtual and real bulk solids
- Angle of repose – plate rotated in 45° steps
- Bulk density measured for different volumes
- DEM Simulation performed under same conditions
- Difference in averaged values 2,9 % – 4,7 %

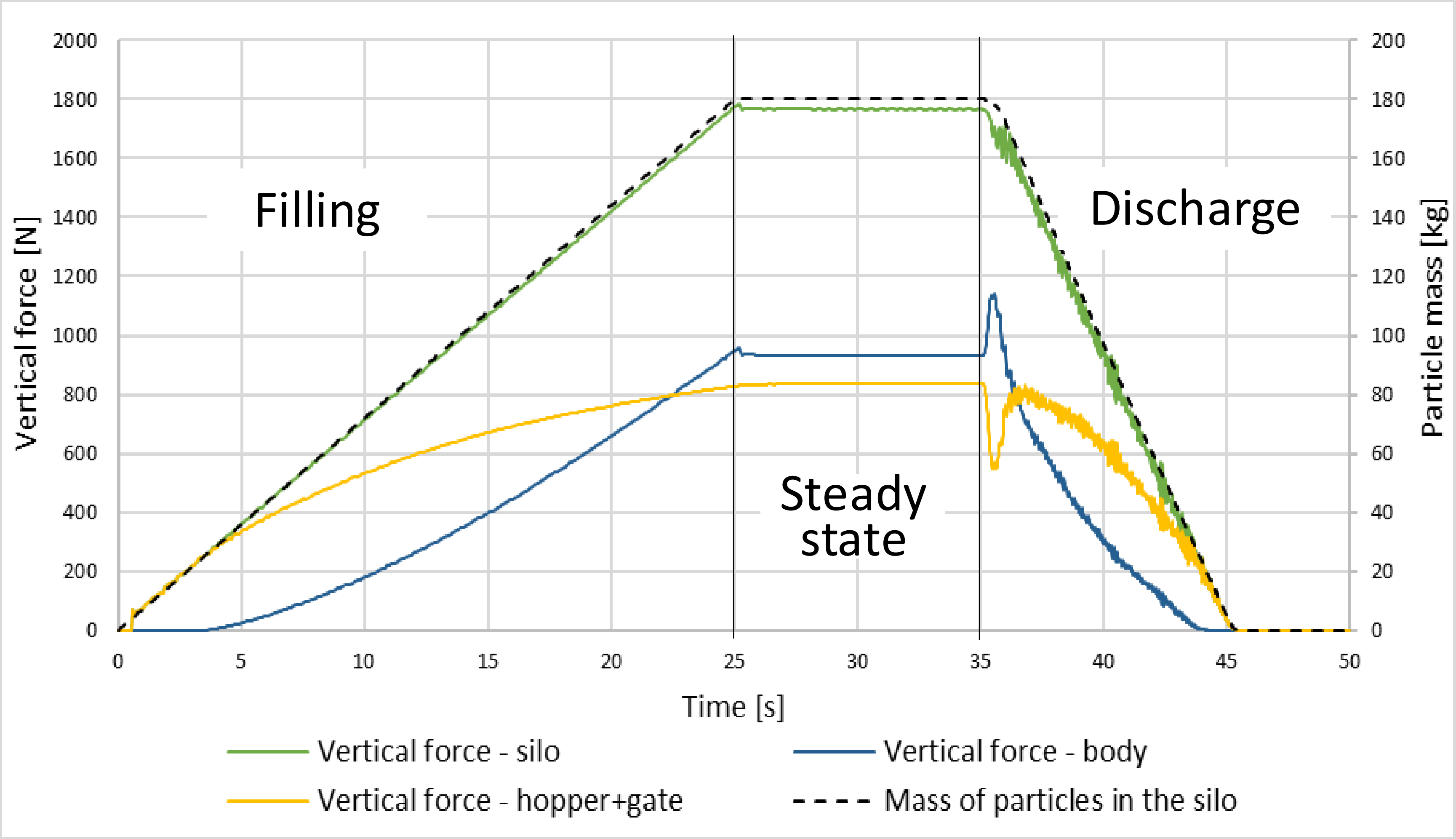


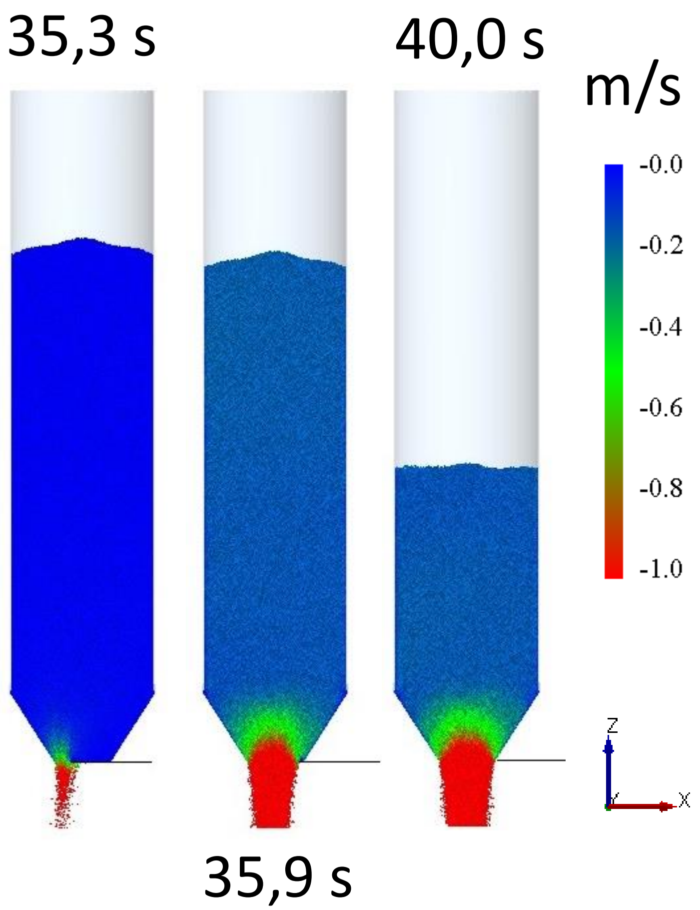
Simulation Parameters

- Hertz-Mindlin contact model (no slip)
- Silo filling – Dynamic factory (1 500 000 particles)
- Outlet gate speed 0,2 $m \cdot s^{-1}$
- GPU CUDA Solver – hybrid mode (12 CPU cores)
- Rayleigh Time Step 20 %
- Reduced shear modulus (optimize computation time)
- Vertical forces on silo components
- Particle velocity, discharge rate



Distribution of vertical forces





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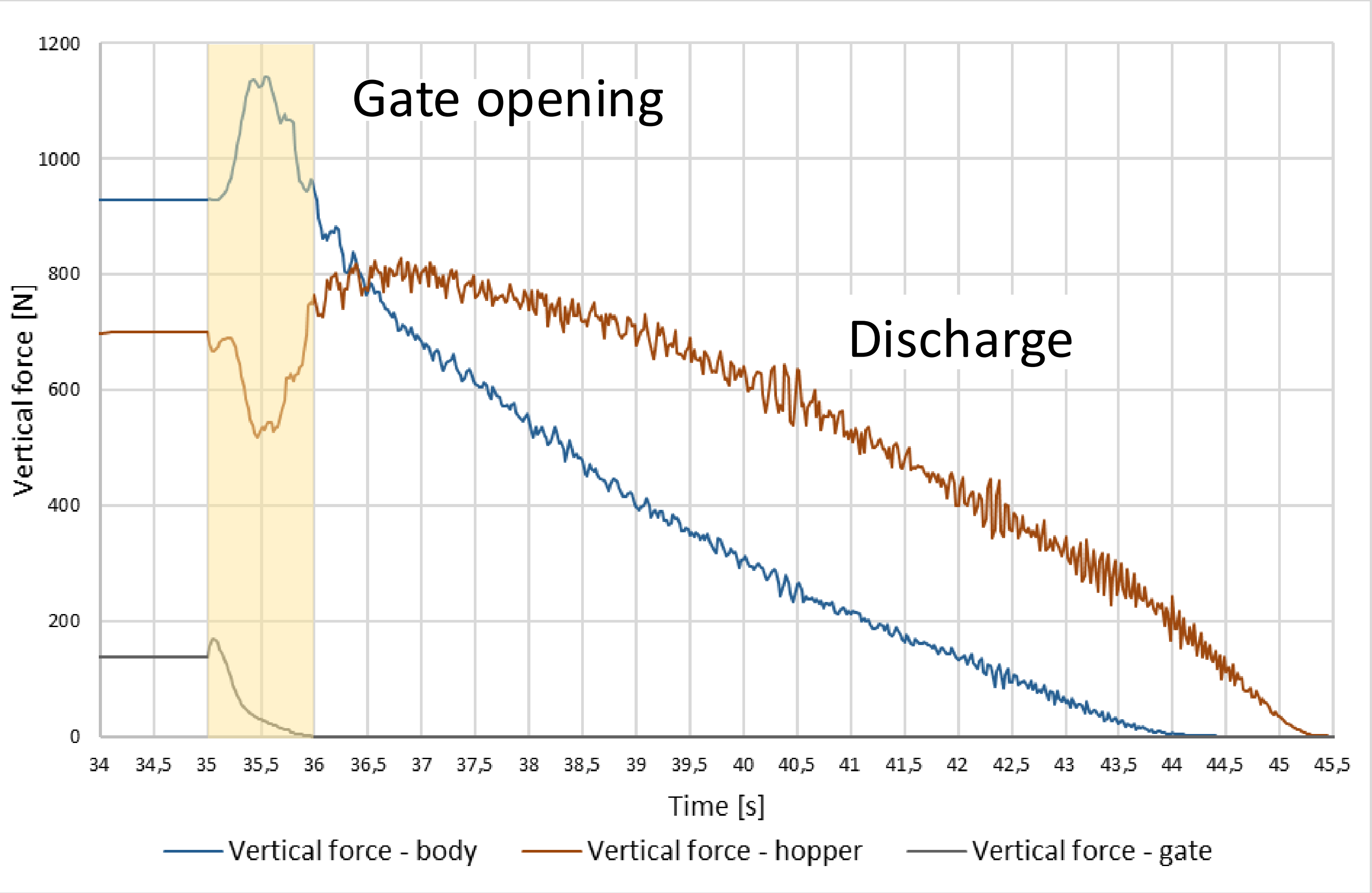

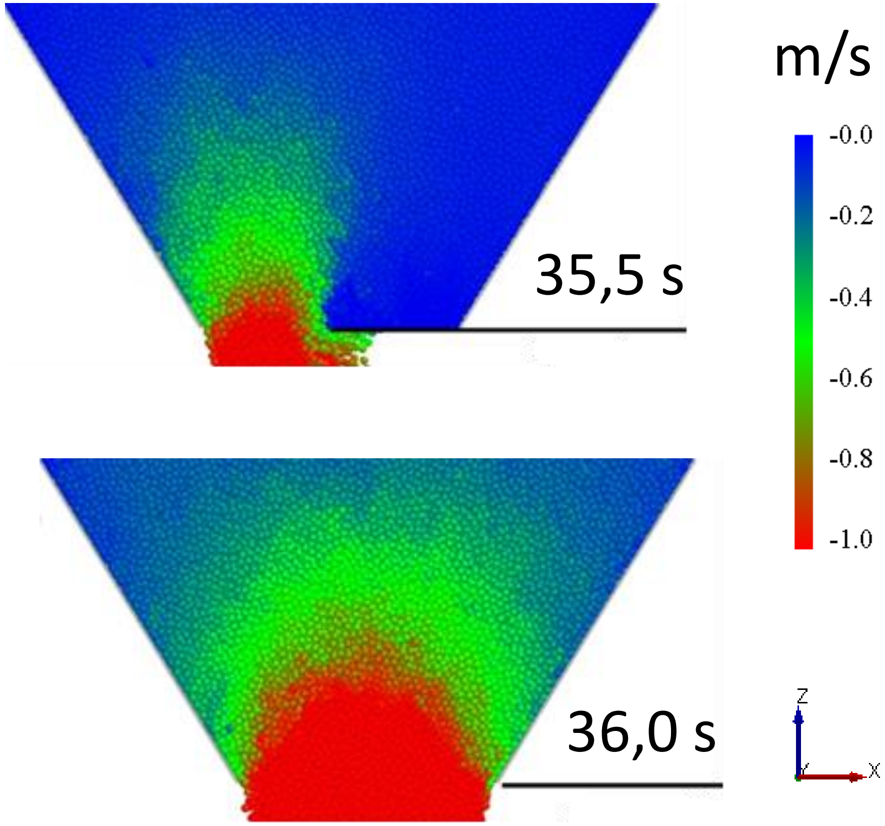

Thank you for your attention