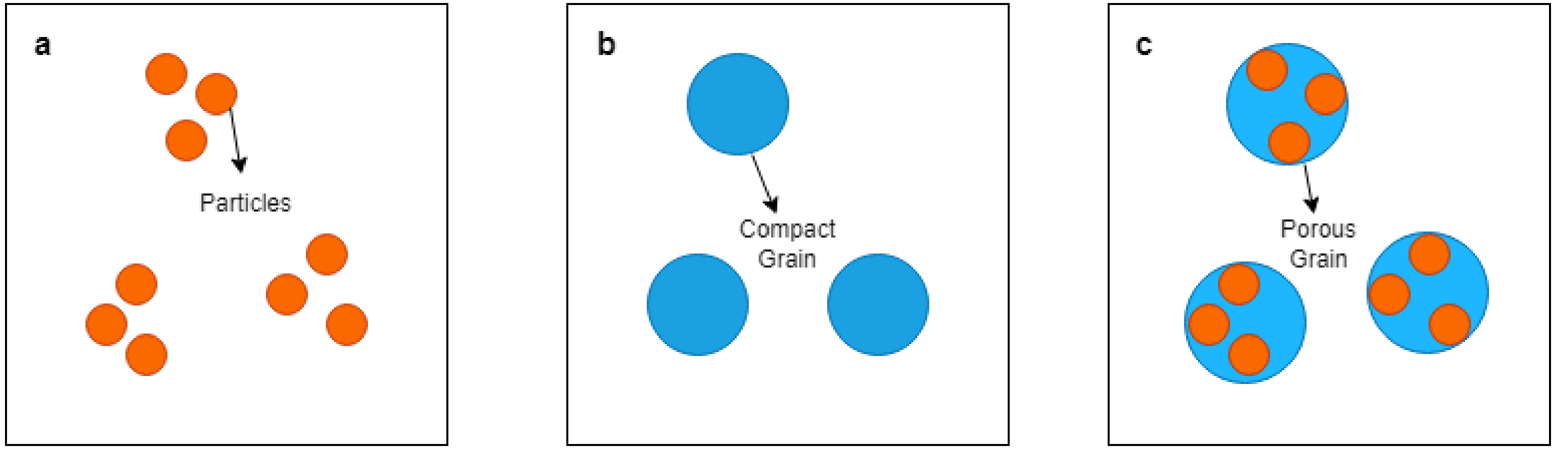
Coarse-graining

Motivation behind coarse-graining

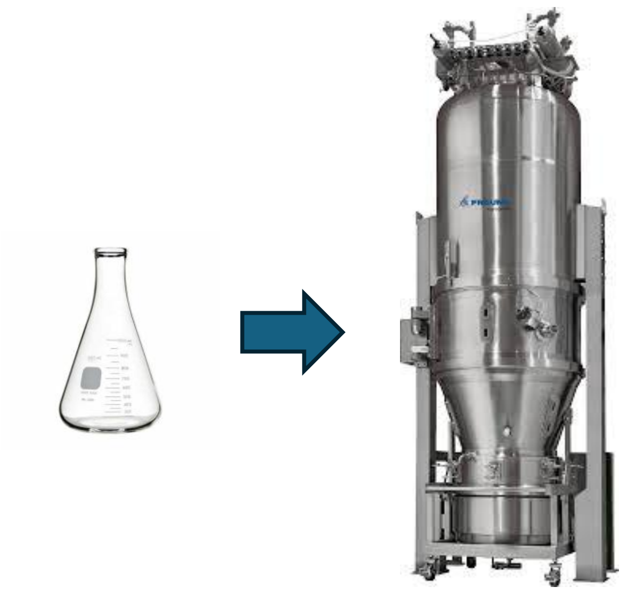
- What is coarse-graining?
  - Representing a **group of particles** with a **grain** and modifying the contact properties to get the same **particle-scale** and **bulk** behavior



Motivation behind coarse-graining

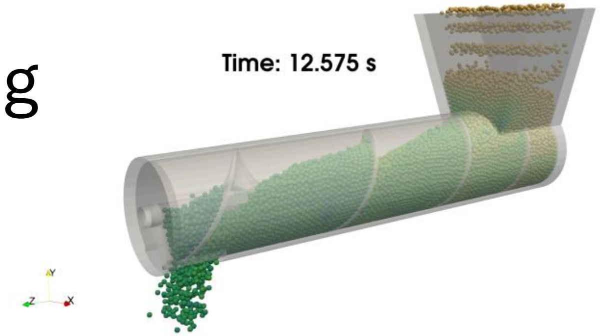
- Computation time

- Larger simulations



- Less memory requirement

- Visualization and post-processing



Models (compact grain)

- Contact force
  - Constant absolute overlap models: the absolute overlap (δ) between particle-particle is equal to the overlap between grain-grain [1]

$$F_{cn,g} = f^3 F_{cn,p} = f^3\left(-K_n \overline{\delta}_{n,p} - \eta_n \overline{v}_{n,p}\right) \qquad F_{ct,g} = f^3 F_{ct,p} = f^3\left(-K_t \overline{\delta}_{t,p} - \eta_t \overline{v}_{t,p}\right)$$

  - Constat relative overlap models: the relative overlap (δ/d_p) between particle-particle is equal to the relative overlap between grain-grain [2]

$$\frac{K_{ng}}{R_g} = \frac{K_{np}}{R_p} \qquad \frac{\eta_{ng}}{R_g^2} = \frac{\eta_{np}}{R_p^2}$$

[1] Sakai, M.; Koshizuka, S. Large-scale discrete element modeling in pneumatic conveying. Chem. Eng. Sci. **2009**, 64, 533–539.
[2] Radl, S.; Radeke, C.; Khinast, J.G.; Sundaresan, S. Parcel-Based Approach For The Simulation Of Gas-Particle Flows

Models (compact grain)

- Additional dissipation models

  - Simplified (GB in the code) [1]:

$$e_g = e_p^{\sqrt{n_{CG}}}$$

  - KTGF (Lu in the code) [2]:

$$e_g = \sqrt{1 + (e_p^2 - 1)f}$$

[1] Benyahia, S.; Galvin, J.E. Estimation of Numerical Errors Related to Some Basic Assumptions in Discrete Particle Methods. Ind. Eng. Chem. Res. 2010
[2] Lu, L.; Yoo, K.; Benyahia, S. Coarse-Grained-Particle Method for Simulation of Liquid–Solids Reacting Flows. Ind. Eng. Chem. Res. **2016**, 55, 10477–10491.