The Extended Discrete Element Method (XDEM) as a Flexible and Advanced Tool in Multi-physics Applications

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Prof. Dr.-Ing. Bernhard Peters

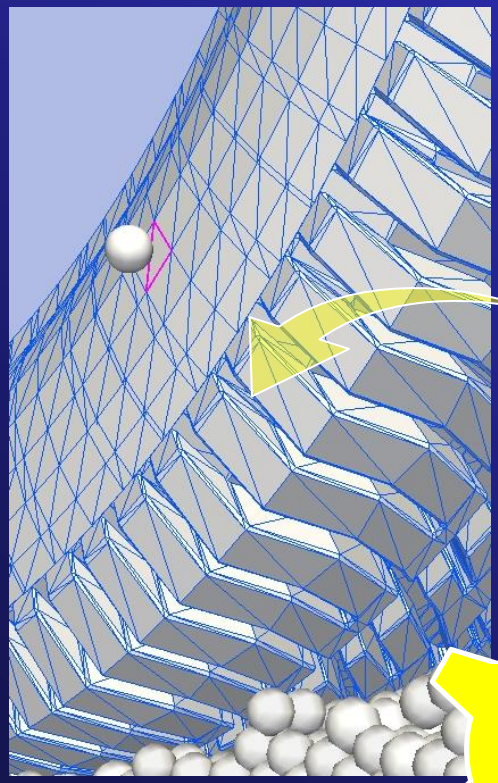
EXTENDED DISCRETE ELEMENT METHOD

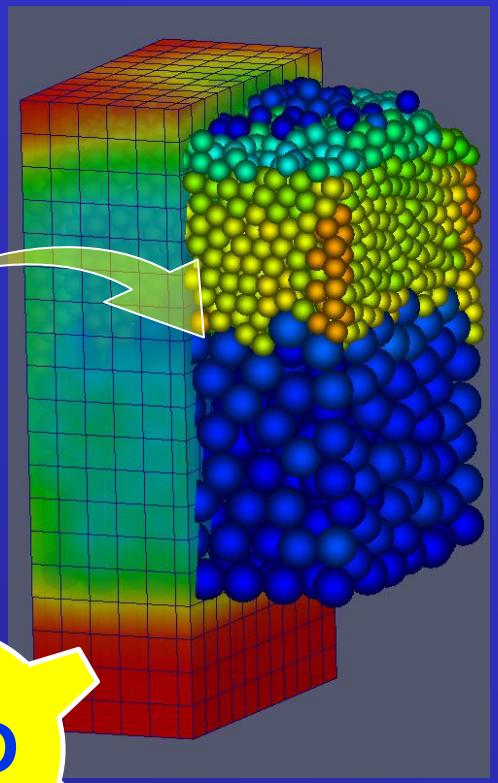
XDEM

E**x**tended **D**iscrete **E**lement **M**ethod:

- based on the classical Discrete Element Method (DEM) to describe motion of granular materials (discrete phase)
- extended by
  - thermodynamics for particles
  - an interface to Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA)
- Coupling to external commercial/OpenSource software

Technology Concept





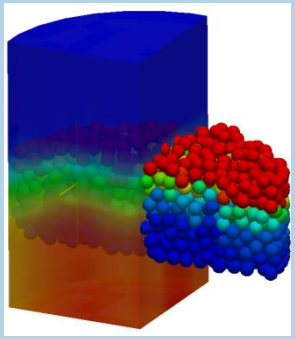
FEA

XDEM

CFD

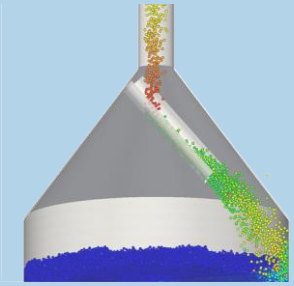
Applications

Computational Process Engineering



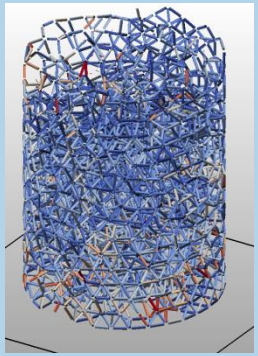
- Thermal conversion of packed/moving beds
- Conjugate heat/mass transfer
- Reactor design

Computational Dynamics



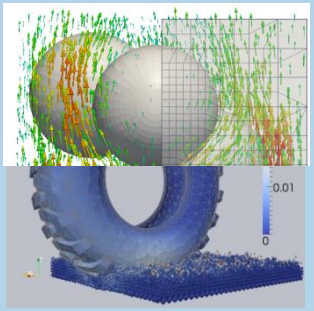
- Transport and storage of granular media
- Impact of granular media on structures

Computational Material Science



- Advanced materials
- Material processing
- Fracture

CFD / FEA



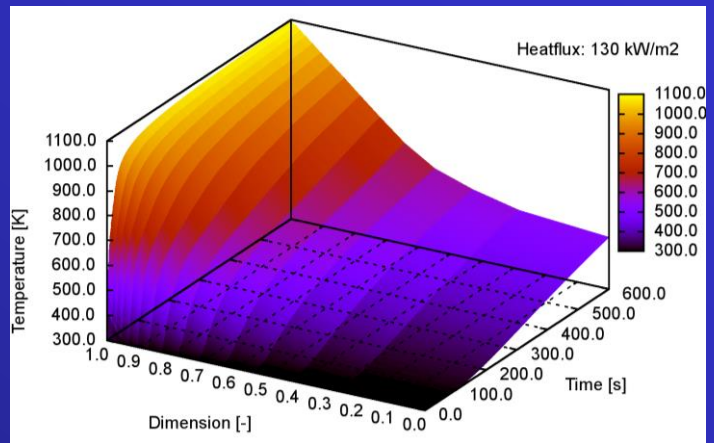
- Single/multi-phase reacting flow
- Emissions
- Simultaneous FEA/CFD analysis

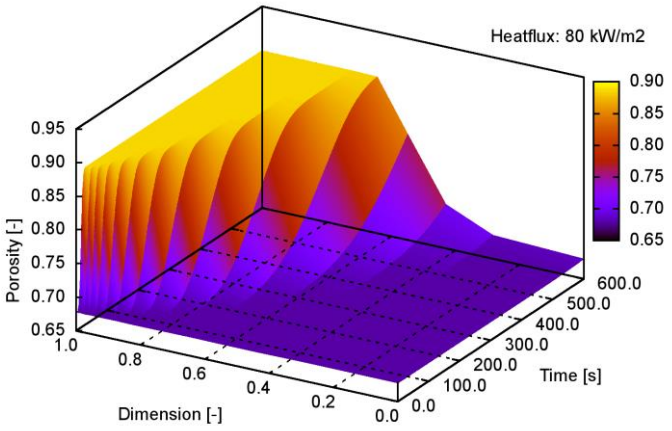
XDEM

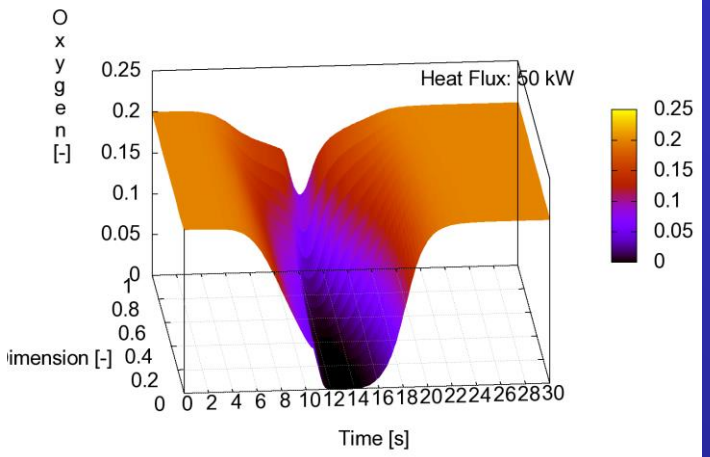
COMPUTATIONAL PROCESS ENGINEERING

Computational Process Engineering

- Generic model to describe particle processes:
  - Temperature distribution
  - Flow inside pore space
  - Chemical conversion
  - Distribution of reactands and products
- Interface to CFD via heat and mass trans

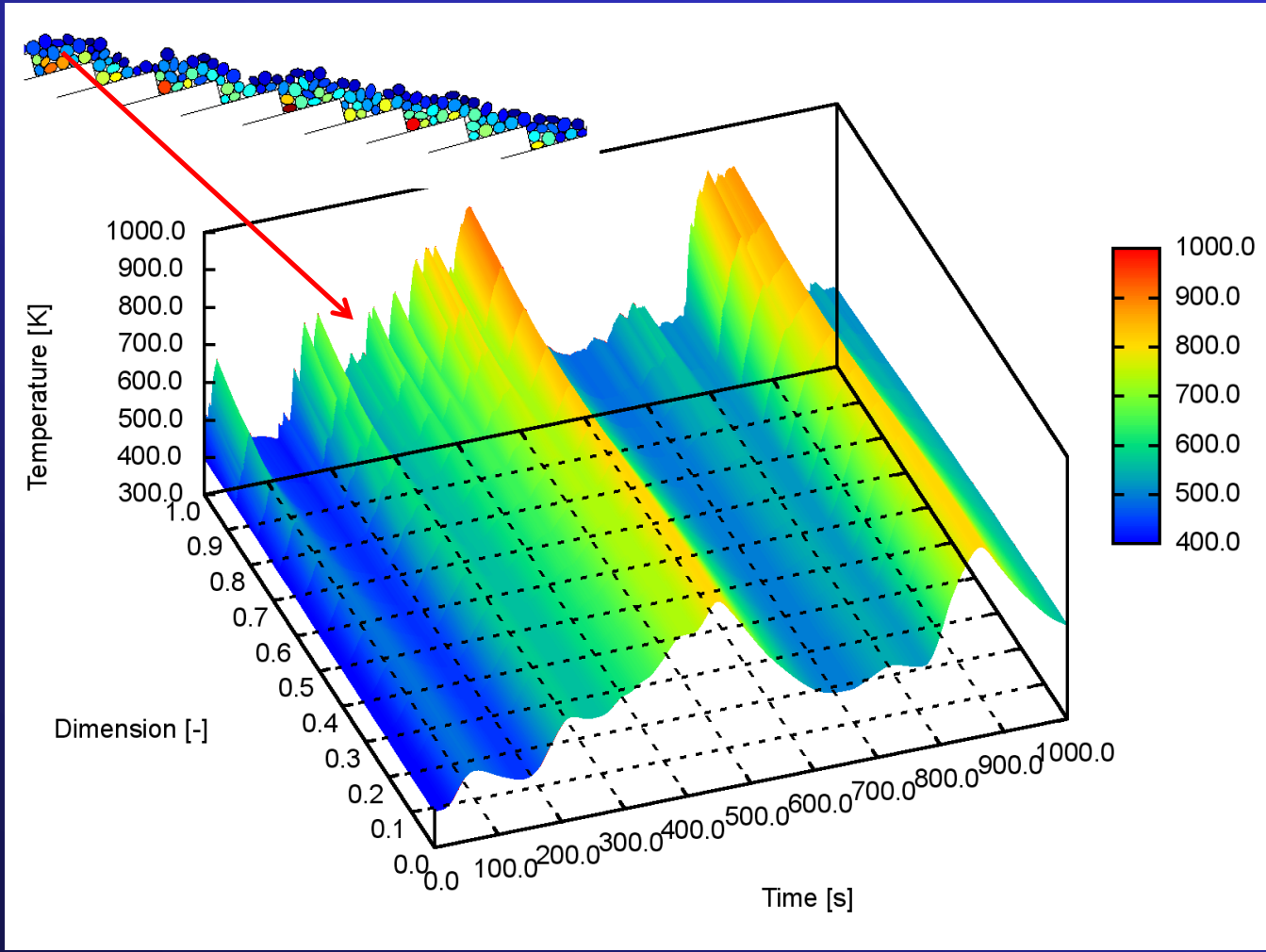




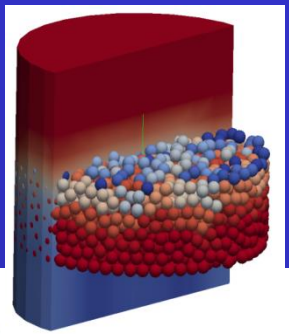


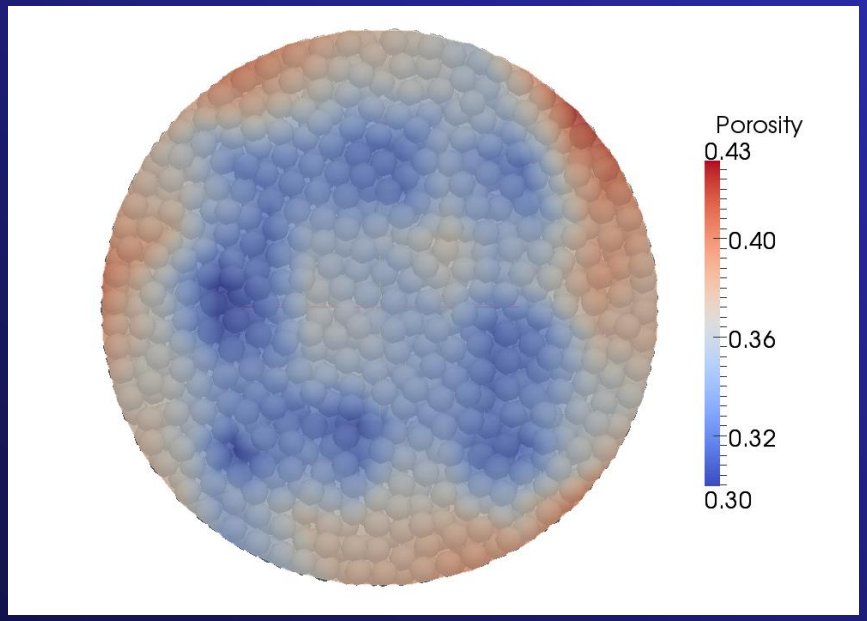
Forward Acting Grate

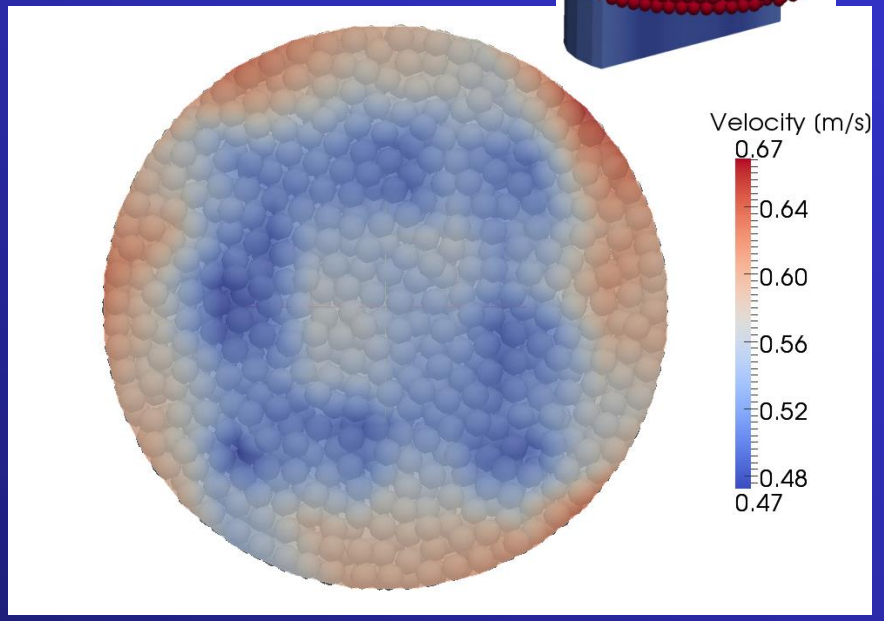
Spatial and Temporal Temperature Distribution



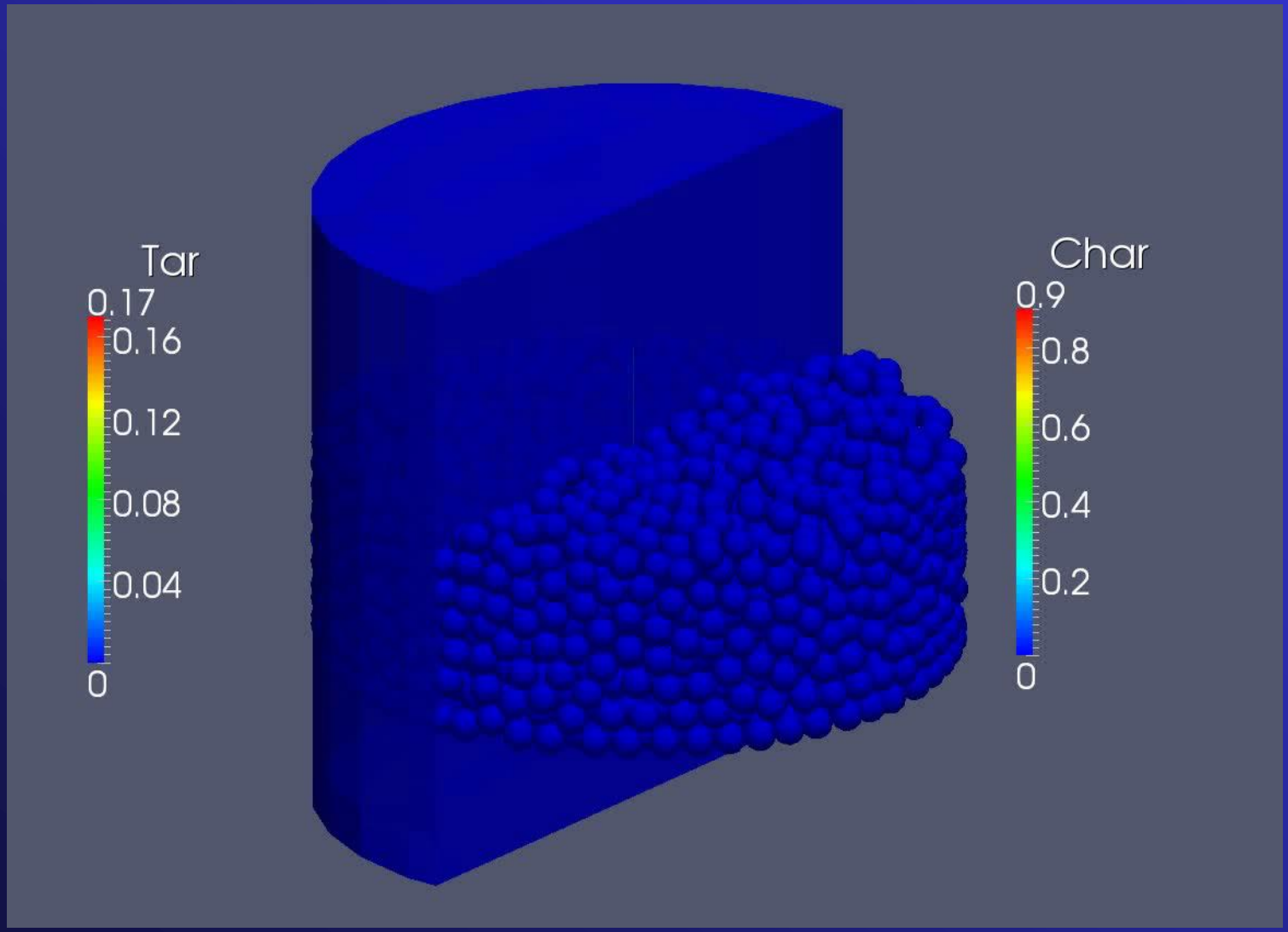
Void Space and Gas Velocity







Packed Bed Conversion

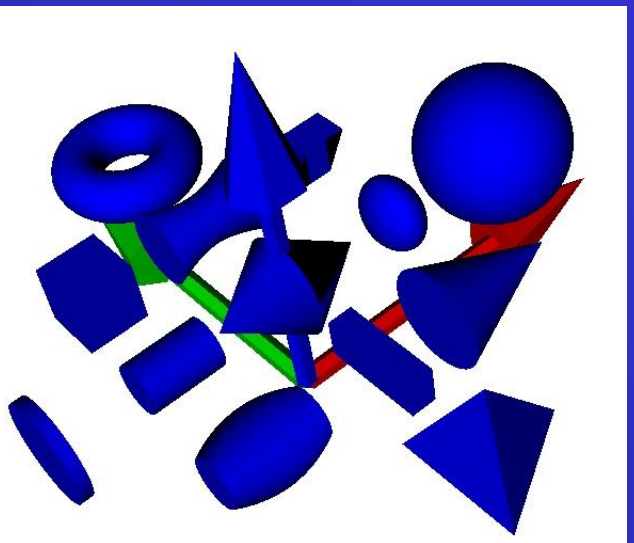


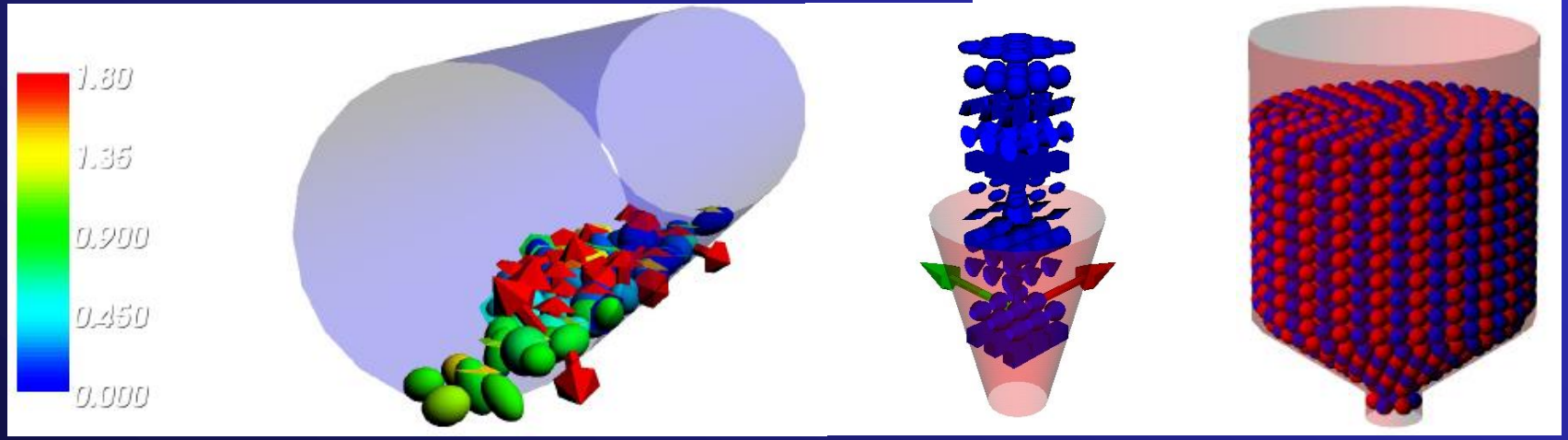
XDEM

COMPUTATIONAL DYNAMICS

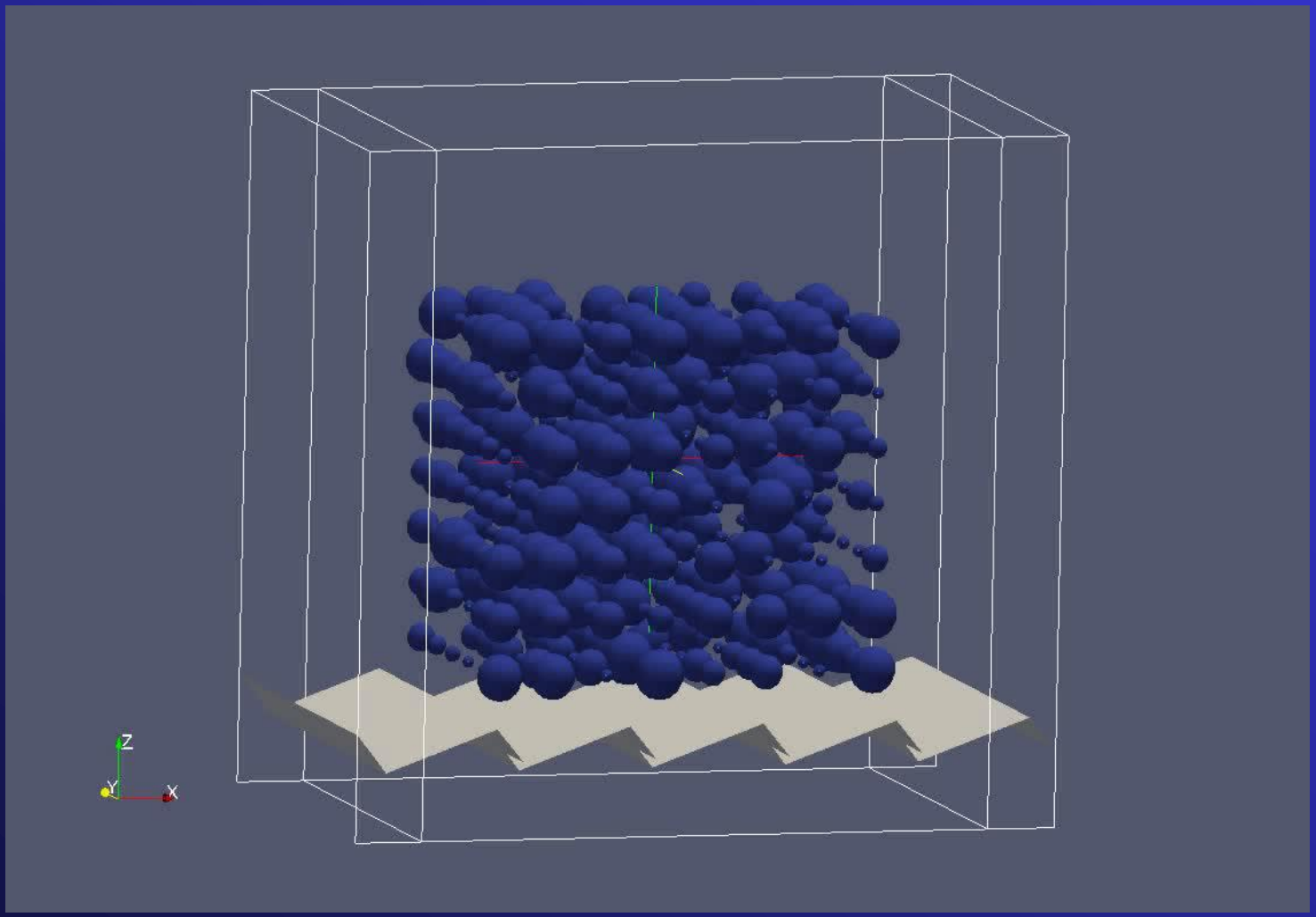
Computational Dynamics

- Prediction of motion of granular material for industrial applications
- Based on the Discrete-Element Method Dynamics
- Integration of Newtonian dynamics to yield position and orientation
- Interface to FEM for mechanical load





Vibrating Grate

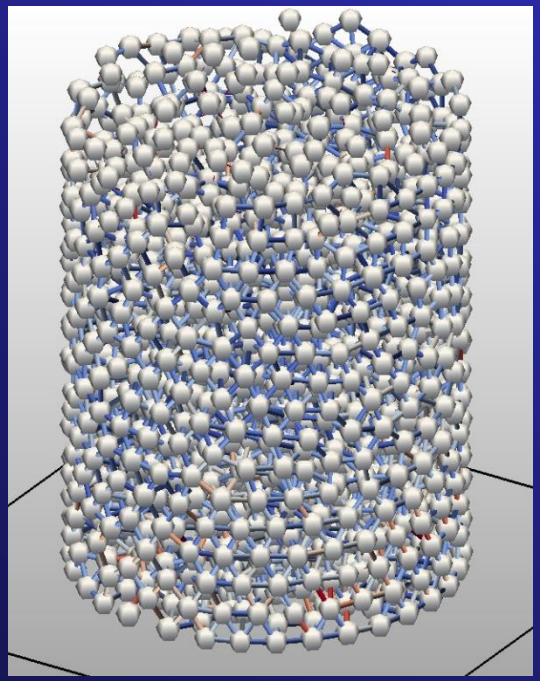


Transport of Debris

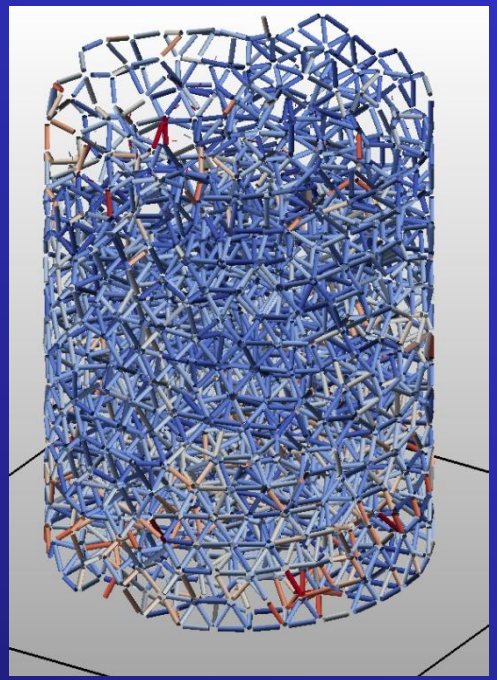
XDEM

COMPUTATIONAL MATERIAL SCIENCE

Computational Material Science



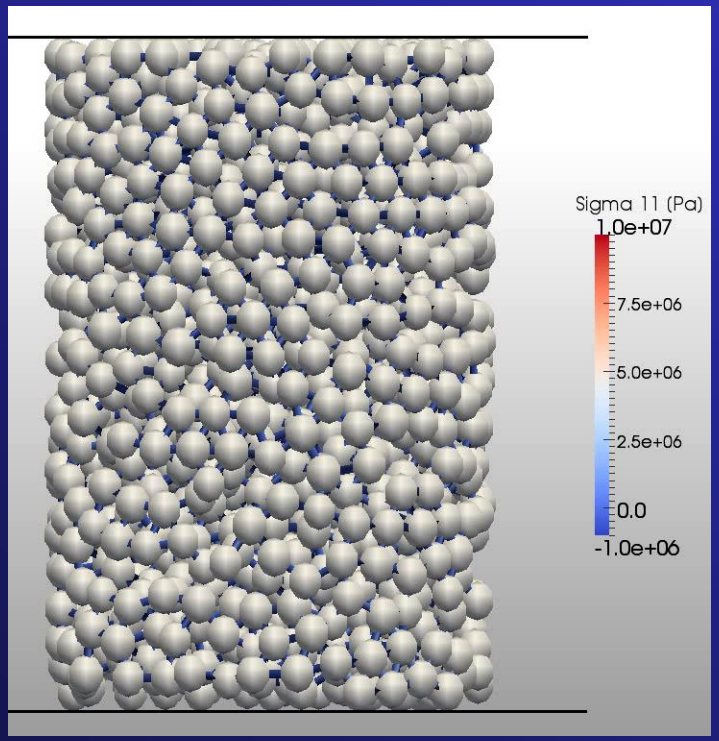
- Inclusion of arbitrary adhesive/bonding forces
- isotropic/anisotropic material behaviour
- crack development and propagation
- fracture mechanics due to mechanical impact or gas forces



Ductile – Brittle Behaviour

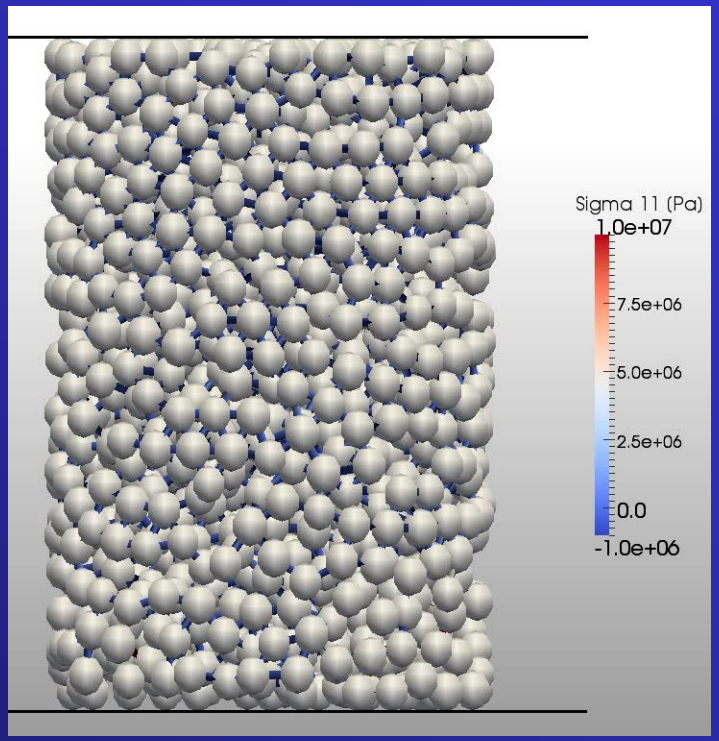
Duktile Failure

$10^{-6}s^{-1}$



Brittle Failure

$10^{-2}s^{-1}$



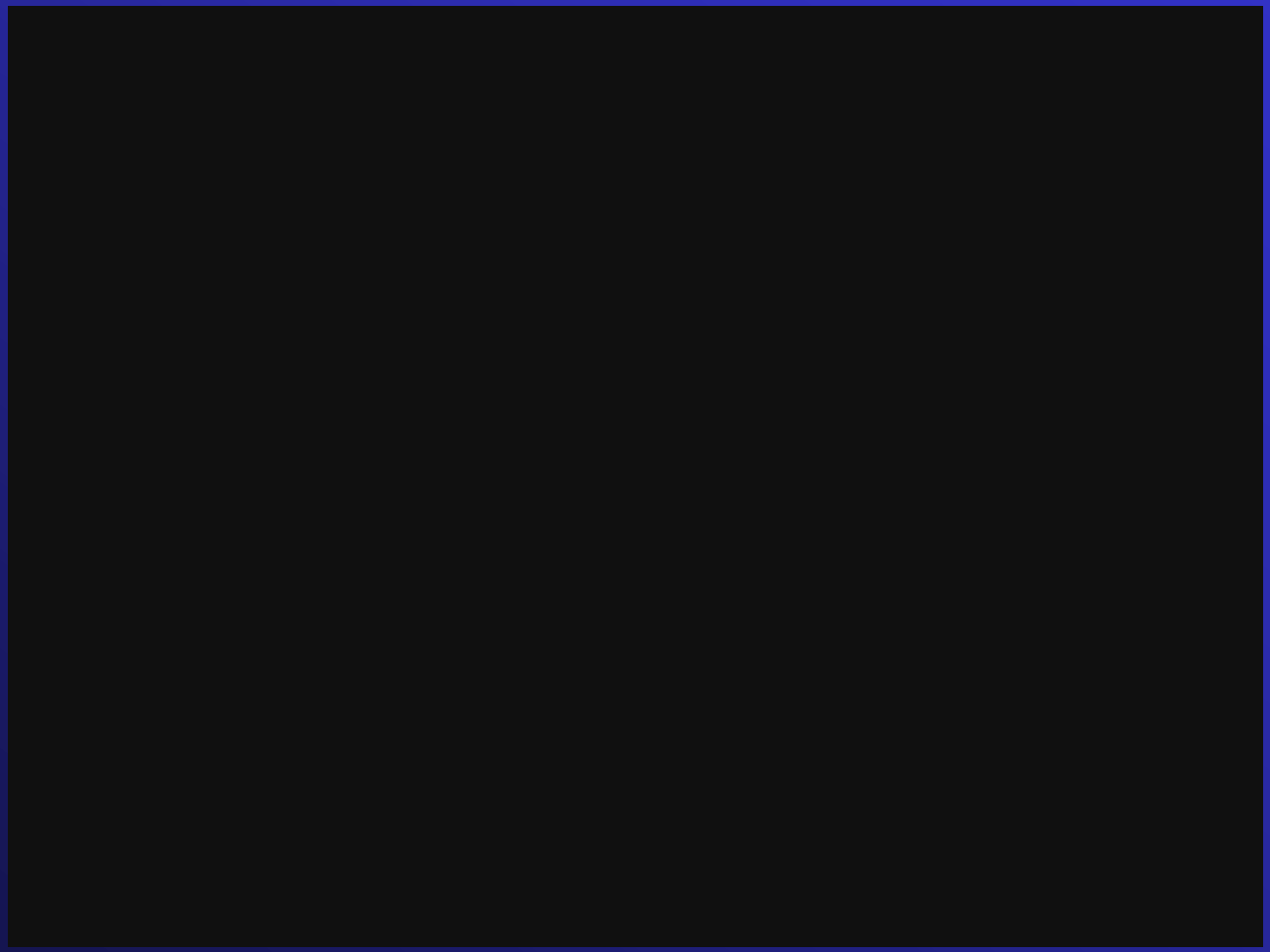
XDEM

COMPUTATIONAL FLUID DYNAMICS FINITE ELEMENT ANALYSIS

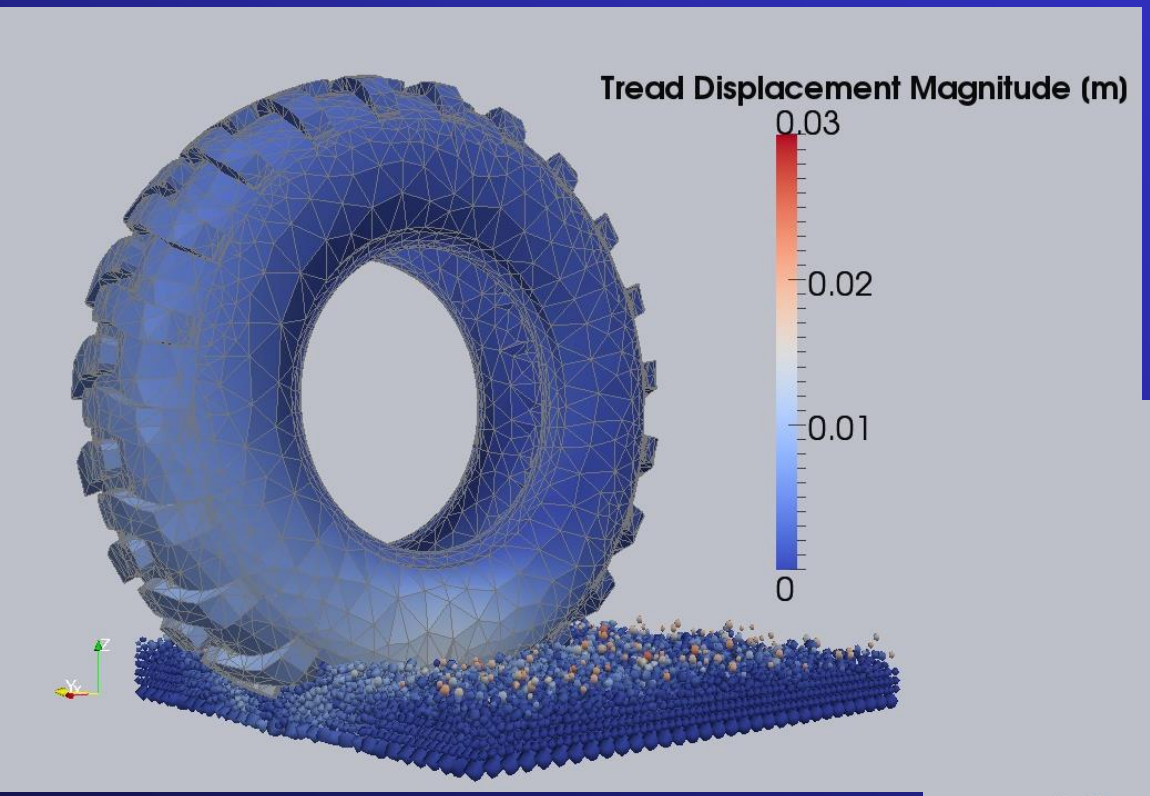
Suspended/Floating Particles

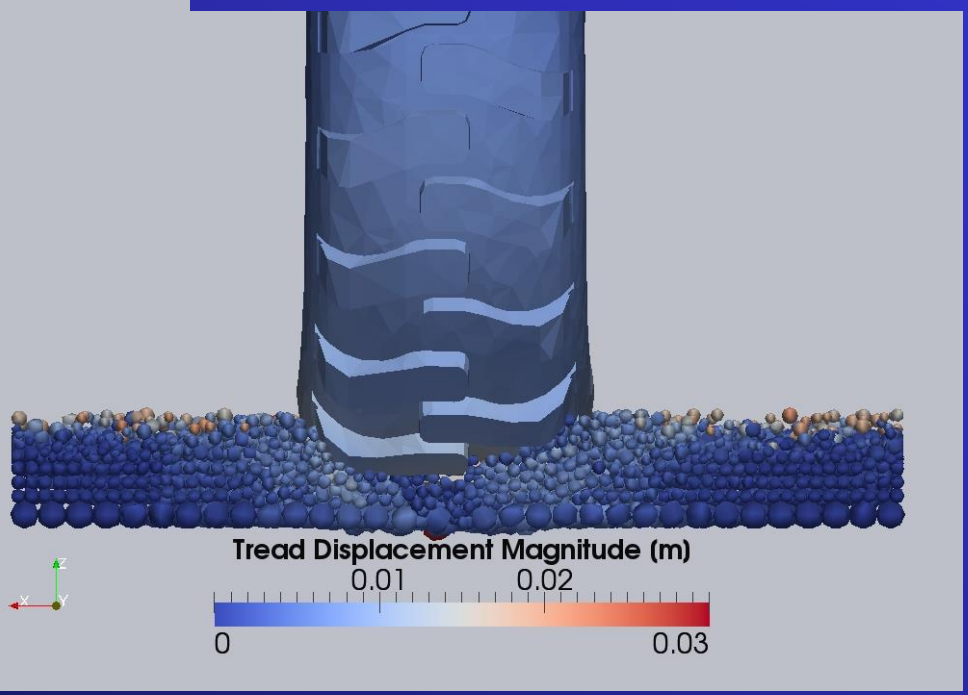
Stress/strain analysis of a Membrane

Tire-Ground Interaction



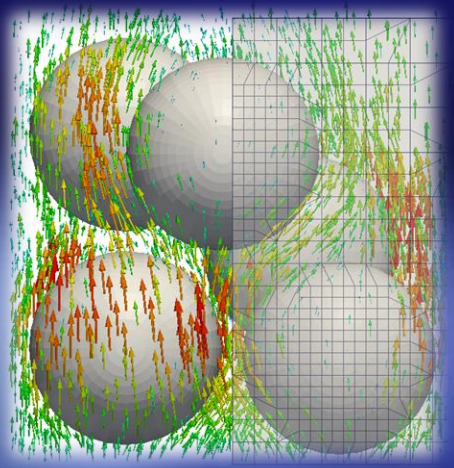
Deformation of a Tire



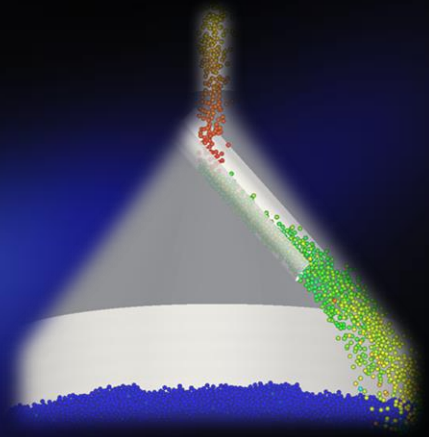


Summary

- XDEM as a novel and advanced simulation framework for multi-physics applications
- Description of particulate phase under thermal and mechanical load
- Efficient and flexible coupling to CFD/FEM solvers
  - Mechanical interaction
  - Heat/mass/momentum transfer
- High resolution of discrete and continuous phases
- Significant reduction of empirical correlations
- Broad application spectra with a high potential for adaptation and extension



www.xdem.de



Thank you very much for your attention