Universiteit Twente

CTW Mechanics Workshop

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Wouter Quak

Universiteit Twente
de ondernemende universiteit

Meshless Methods in Forming Processes

Wouter Quak

Applied Mechanics
Mechanics of Forming Processes
UTwente

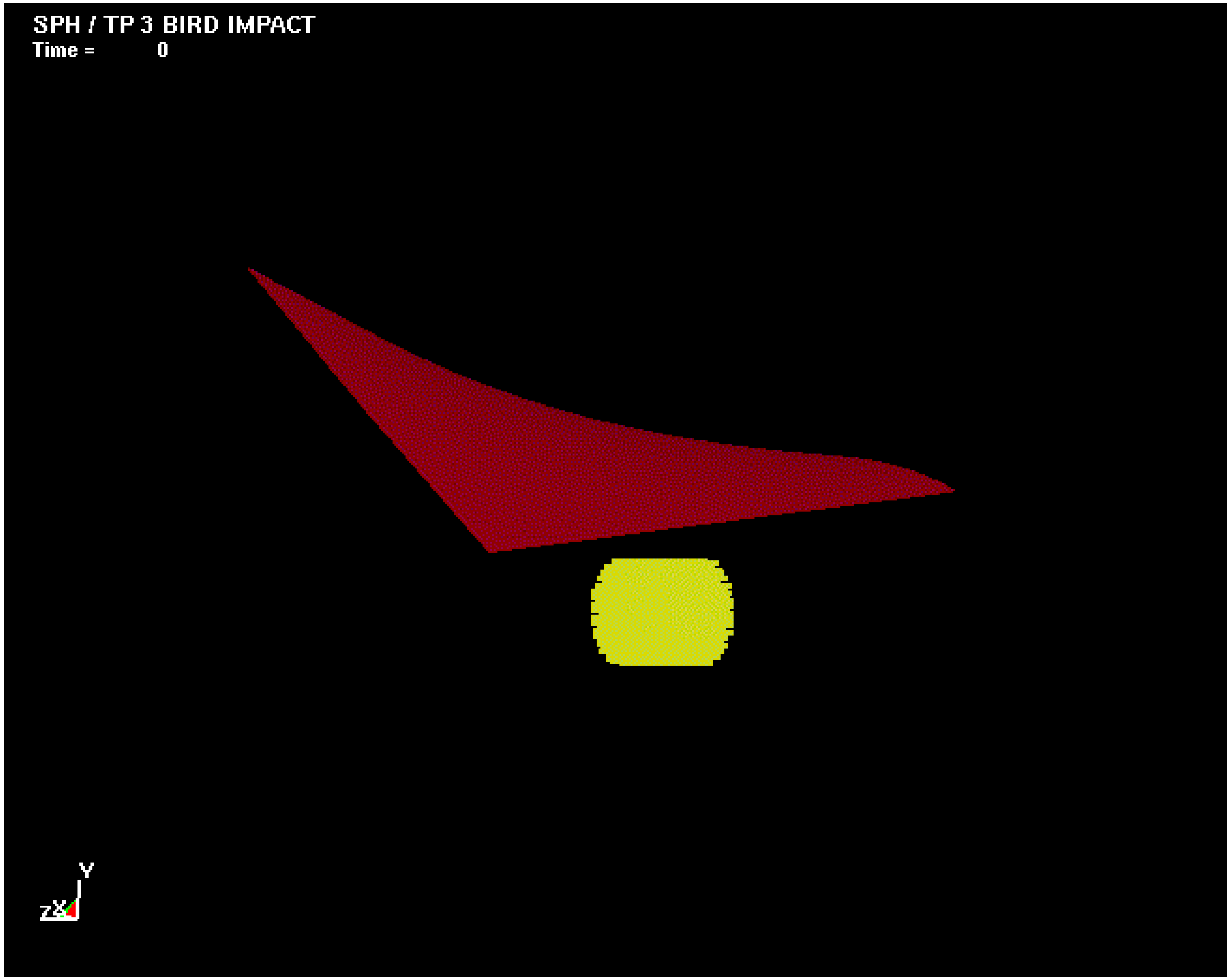
M2i Materials innovation institute

University of Twente
The Netherlands

Introduction

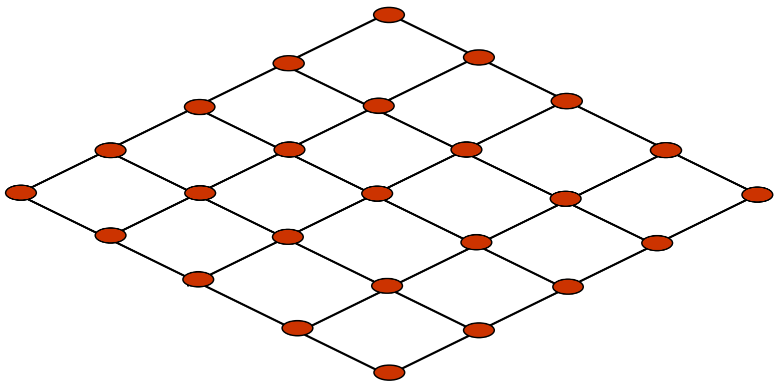
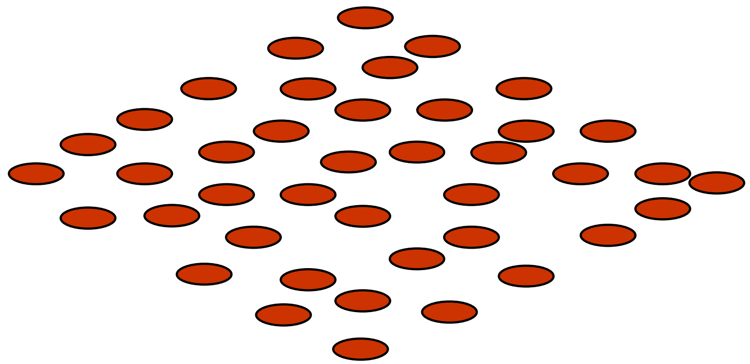
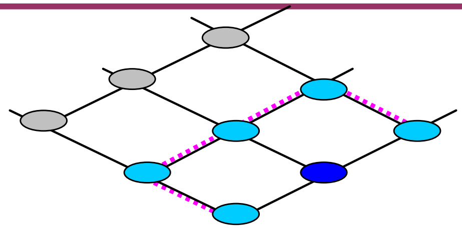
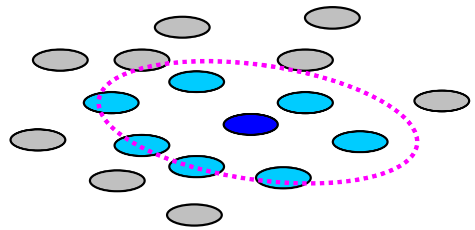
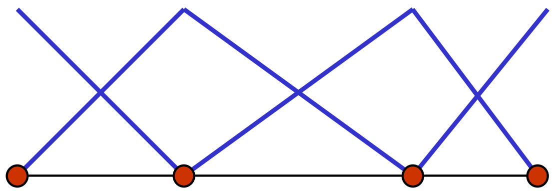
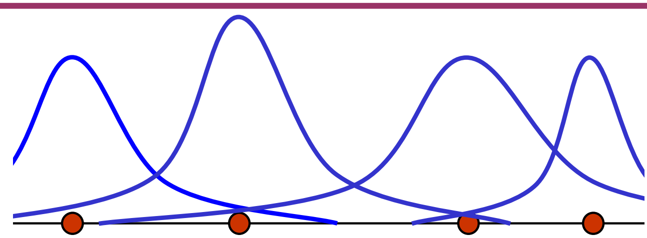
meshless...

- method for modeling continua
- started in the 1980's
- applied to large deformation problems:
  - forming
  - fracture/crack problems
  - fluid problems
  - explosive analysis



Theory

what is meshless?

	FEM	meshless
nodal distribution		
connectivity		
shape functions		

Theory

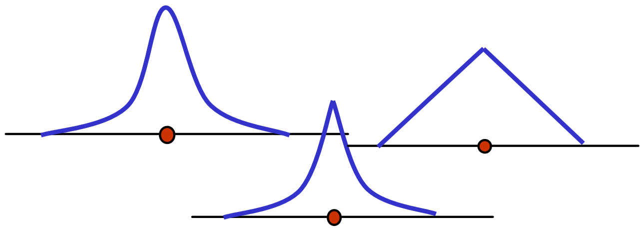
meshless methods

- CSPH
- RKPM
- MPM
- SPH
- DEM
- EFG
- NEM
- PFEM
- MLPG
- PIM
- PUM
- hp-clouds
- finite clouds
- finite spheres
- and some more...

shape function → PDE discretization → boundary method

Theory

classification of meshless

shape functions	PDE discretization	boundary conditions
$u_\mathrm{h}(x) = \sum_{i=1}^{n} \phi_i(x) u_i$	$\sigma_{ij,j} + f_i = 0$	$u_i - \tilde{u}_i = 0$ $\sigma_{ij} n_j - \tilde{t}_i = 0$
 - convolution - MLS	- Galerkin - Petrov-Galerkin - collocation - least-squares	- penalty - multipliers - direct

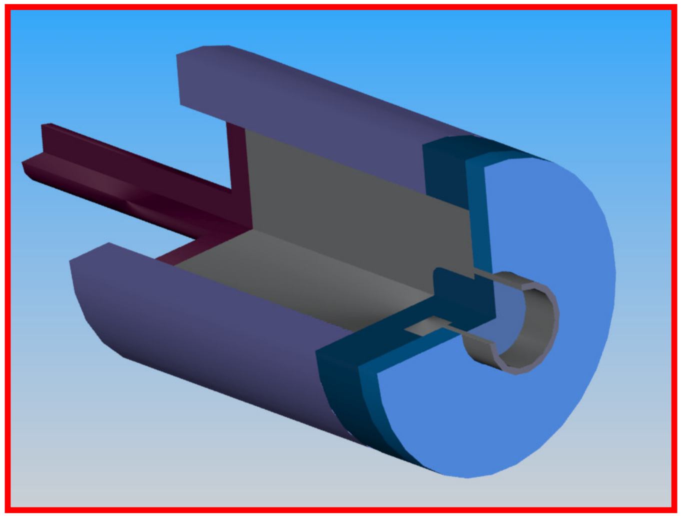
Theory

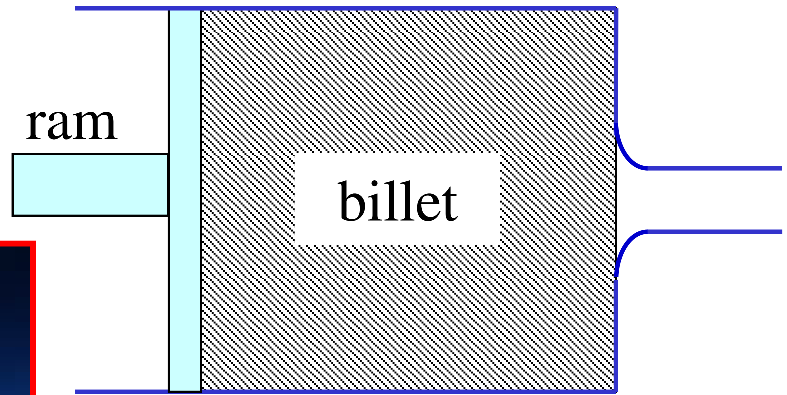
meshless methods

	FEM	meshless
• large deformations	-	+
• ease of discretizing	-	+
• computational time	+	-

Results

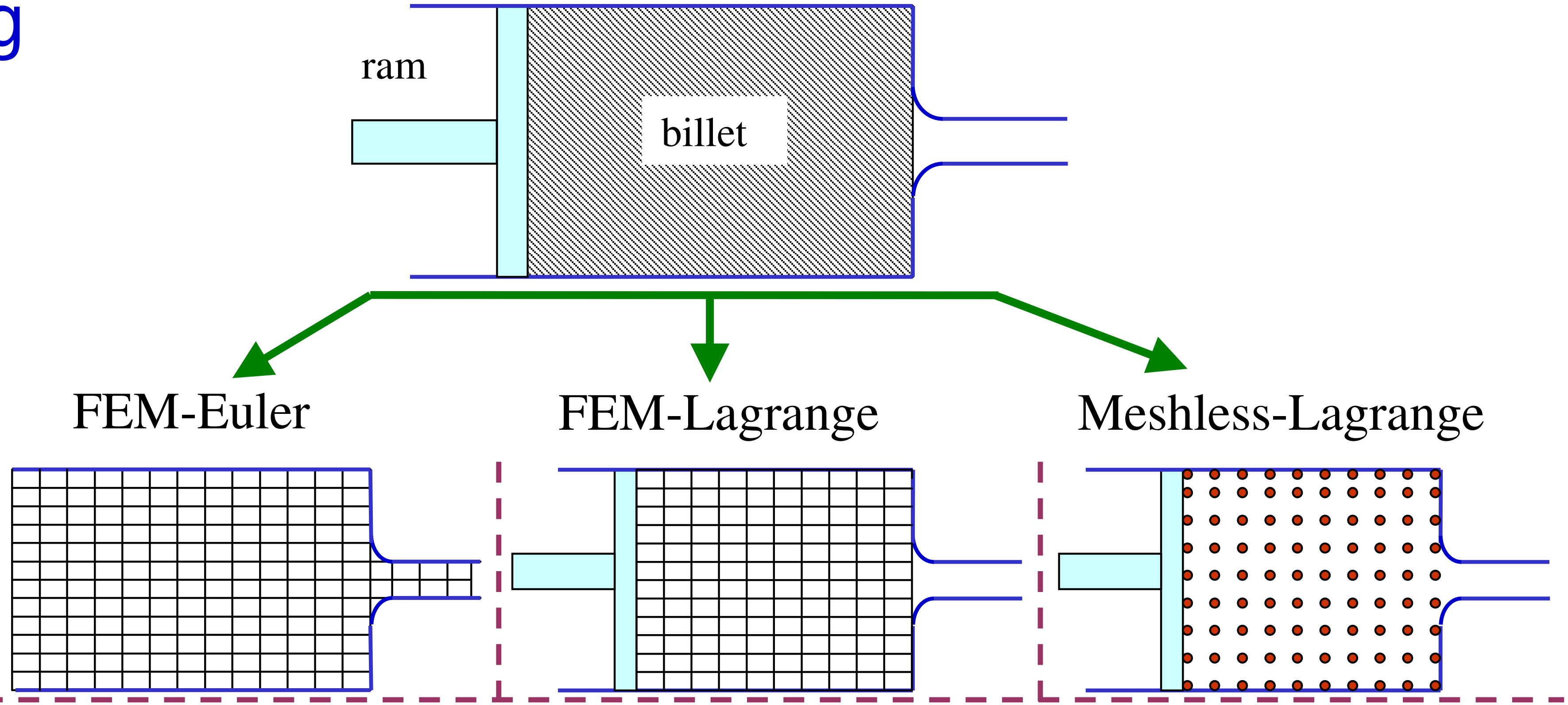
are currently available meshless methods suitable for simulating forming processes?





Results

Modeling



modeling issues	FEM-Euler	FEM-Lagrange	Meshless-Lagrange
	- convection (diffusion or instabilities) - tracking of interface	- mesh distortion	?

Results

Numerical schemes

FEM
Finite Element Method
- implicit
- Eulerian
- semi-coupled convection
- steady-state

SPH
Smooth Particle Hydrodynamics
- explicit
- updated Lagrangian
- global mass scaling
- transient

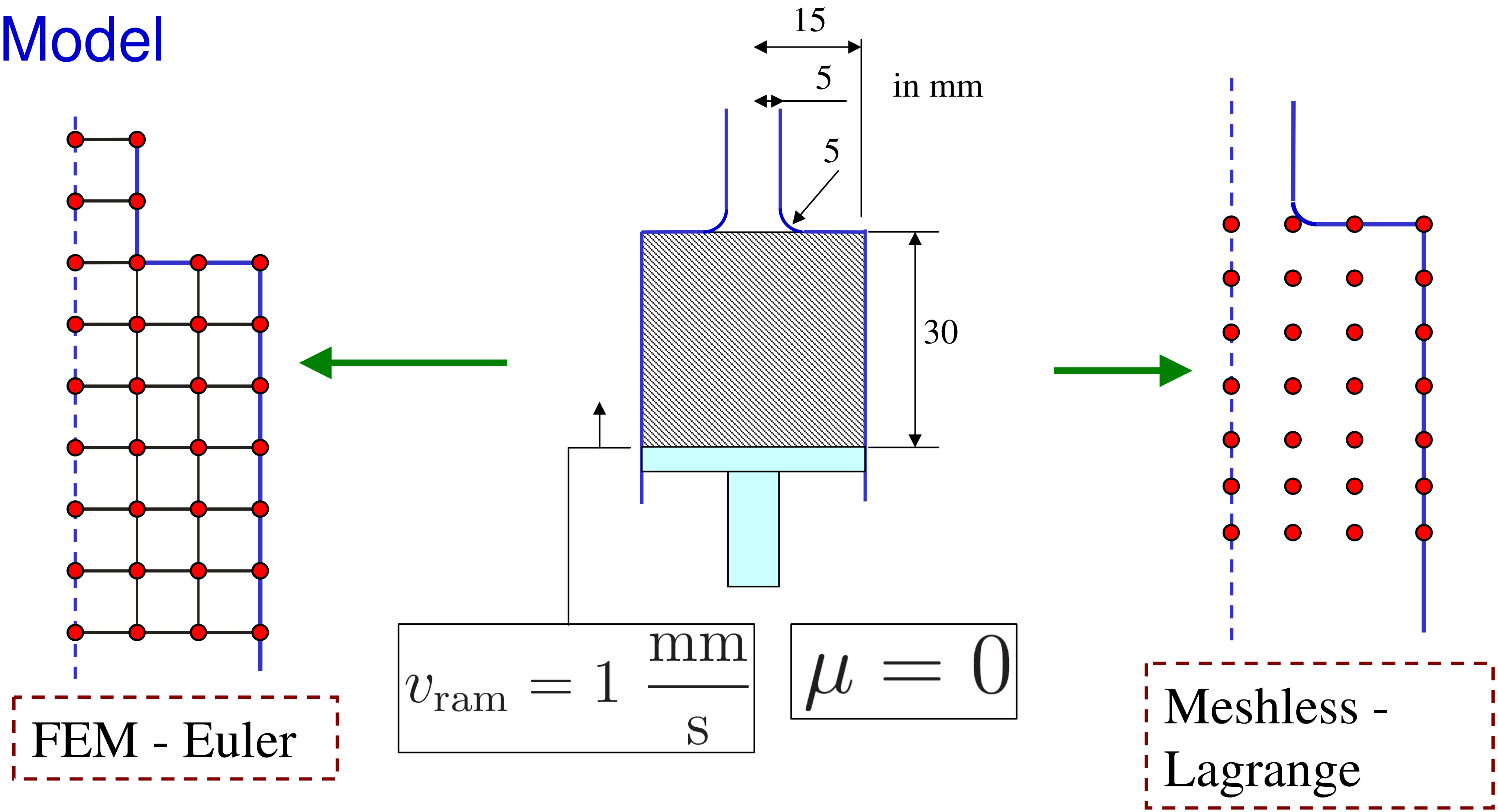
EFG
Element-Free Galerkin
- explicit
- updated Lagrangian
- global mass scaling
- transient

DIEKA

LS-DYNA

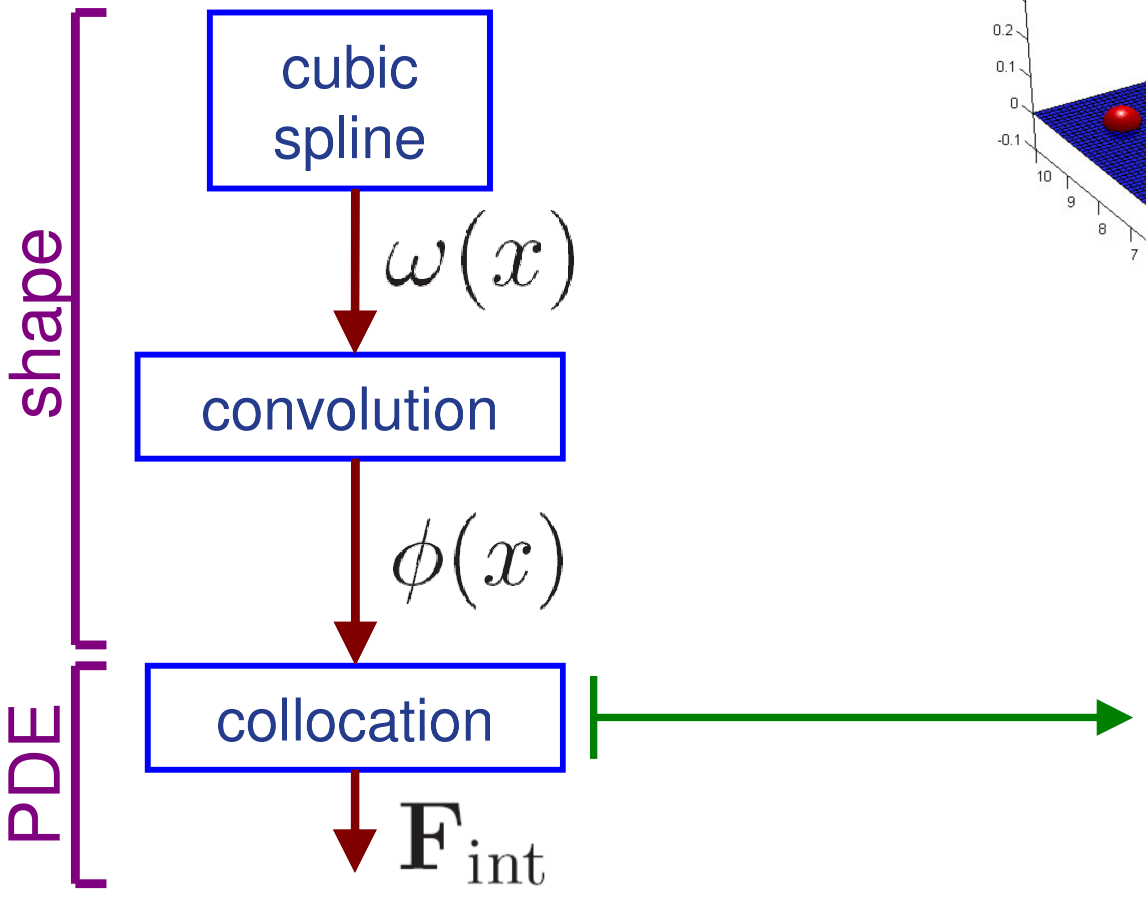
Results

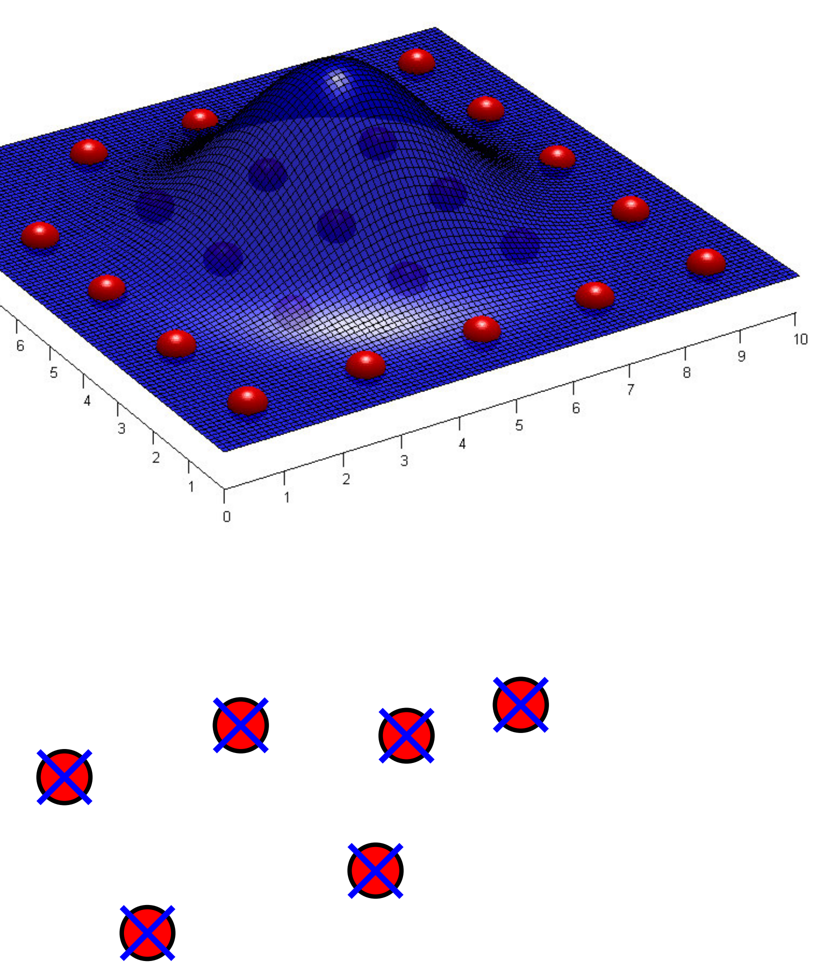
Model



Setup

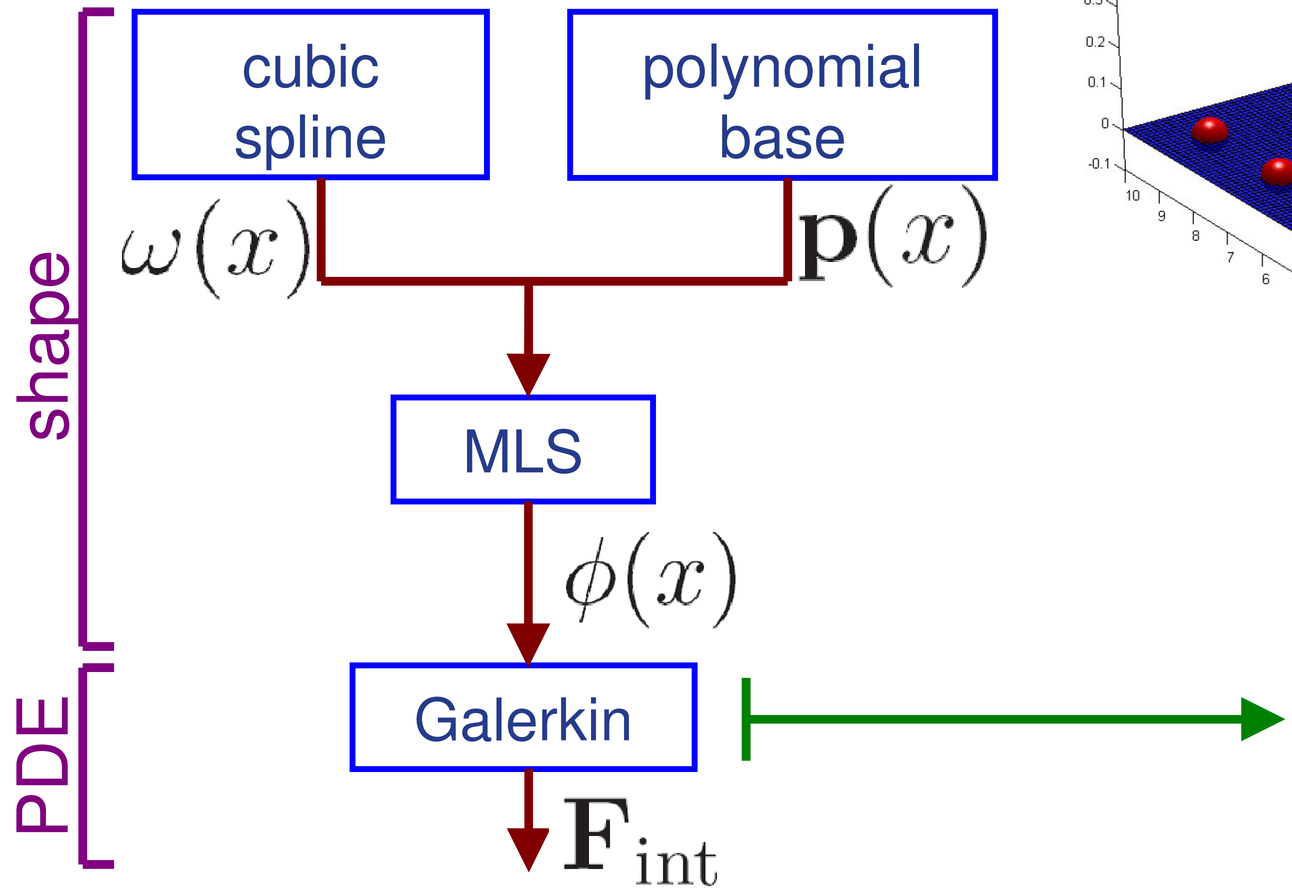
Numerical schemes - SPH

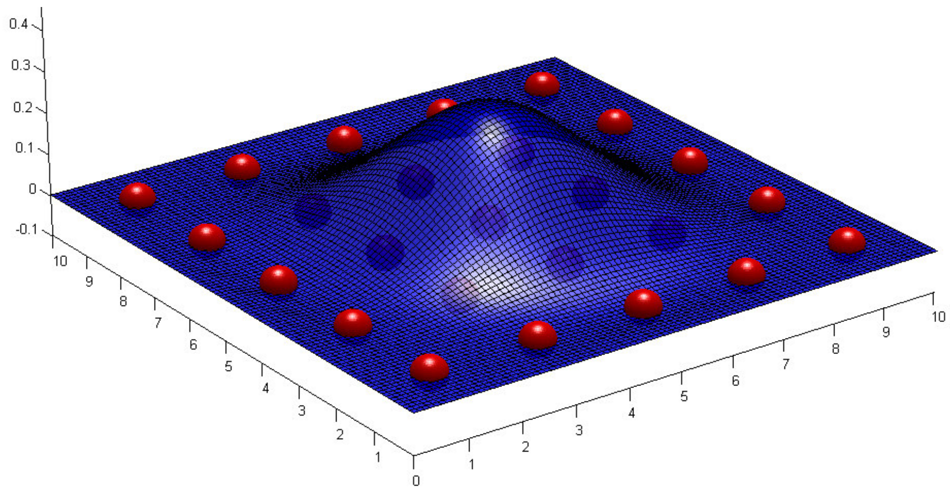


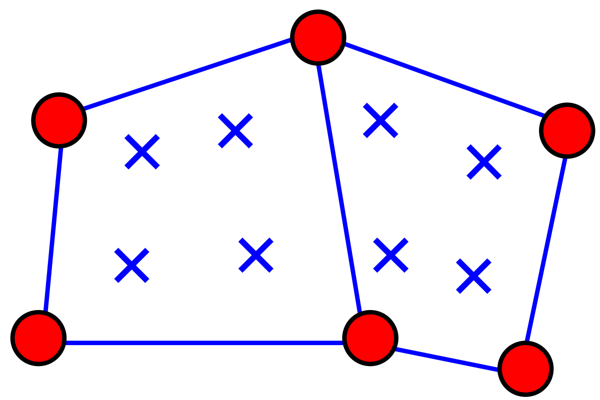


Setup

Numerical schemes - EFG



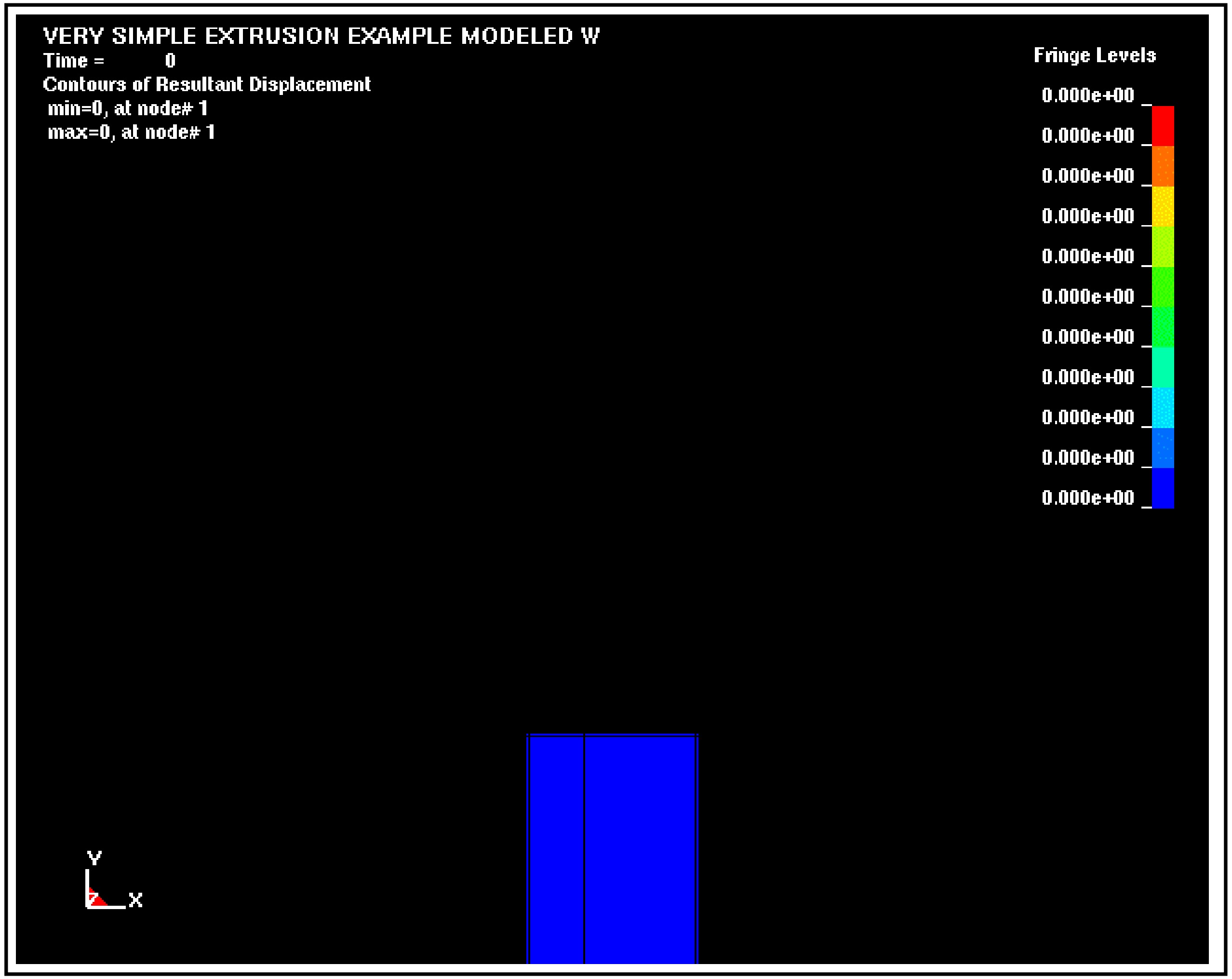




Results

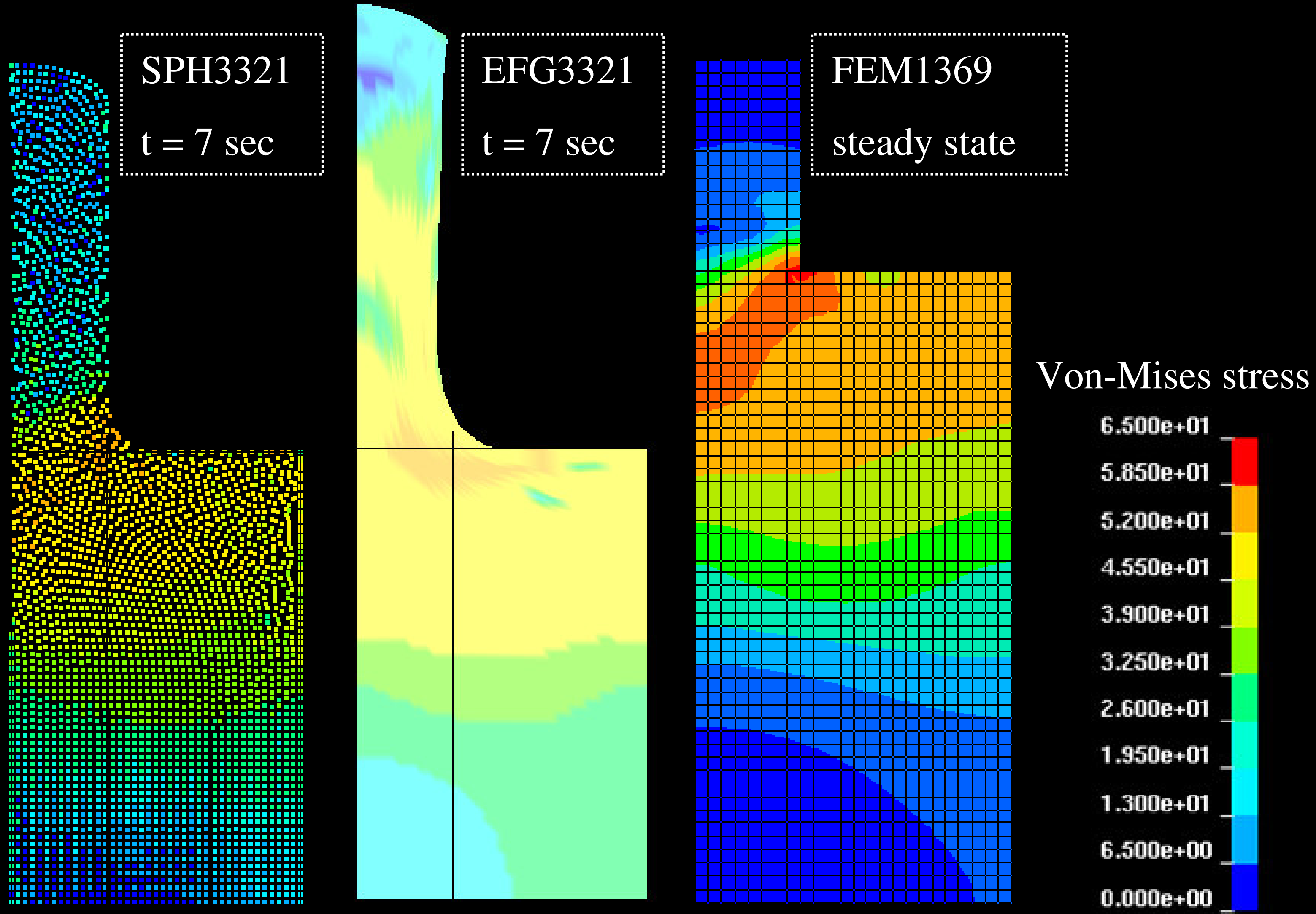
SPH simulation

contour
resultant
displacement



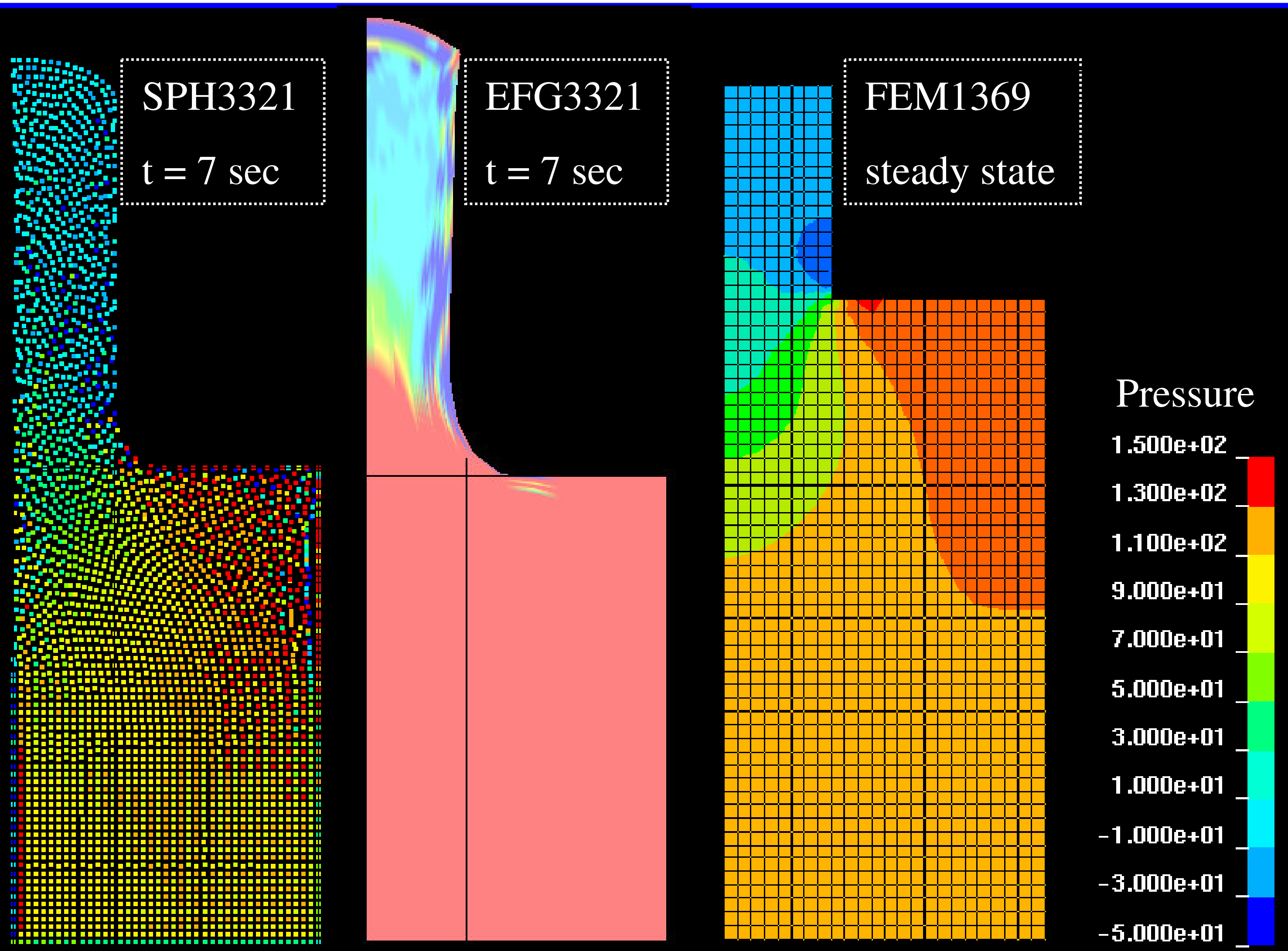
Results

Von-Mises



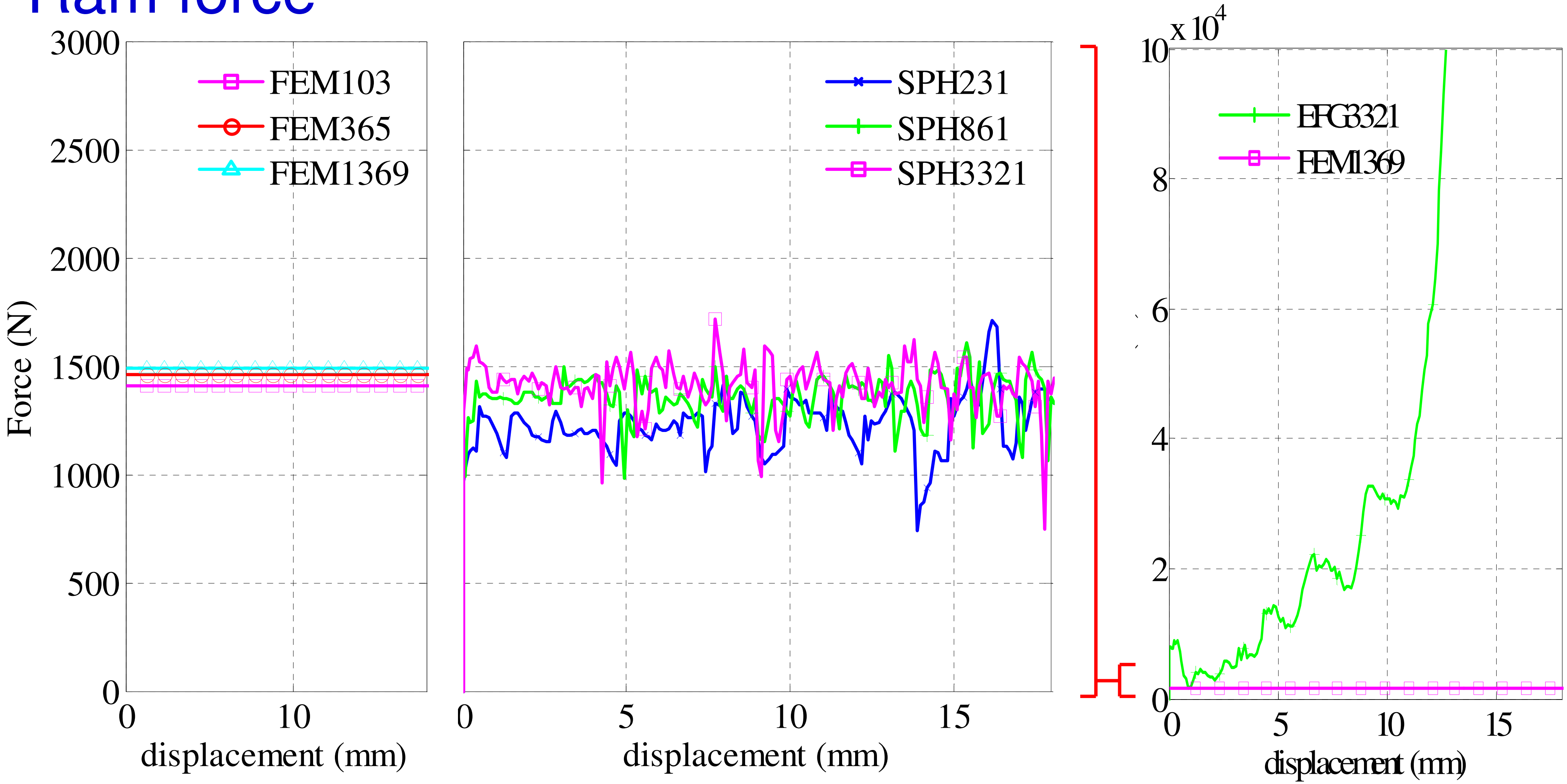
Results

Pressure



Results

Ram force



Conclusions

- of the methods tested; SPH seems most interesting for extrusion process

- numerical artefacts in methods:
  - oscillations (SPH)
  - locking (EFG)

Outlook

- remove the numerical artefacts
  - stabilization methods

Questions?