

Ultrascaleable Implicit Finite Element Analyses in Solid Mechanics with over a Half a Billion Degrees of Freedom

(excerpts)

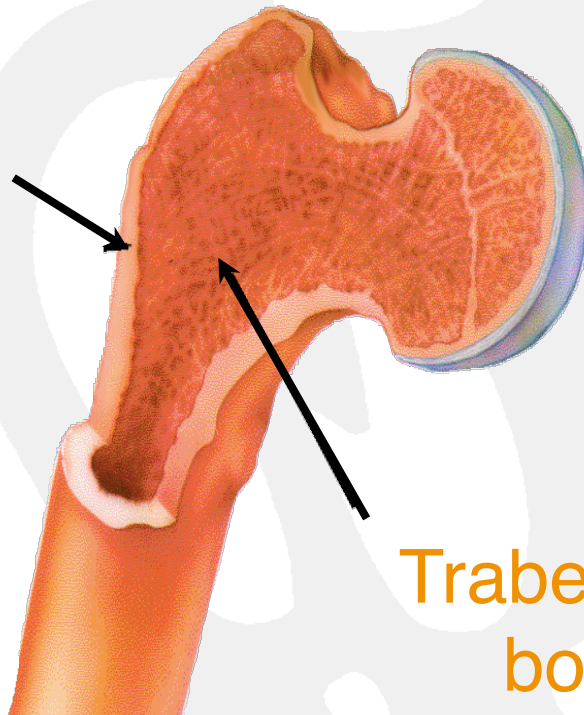
Mark F. Adams

H.H. Bayraktar, T.M. Keaveny, P. Papadopoulos and Atul Gupta

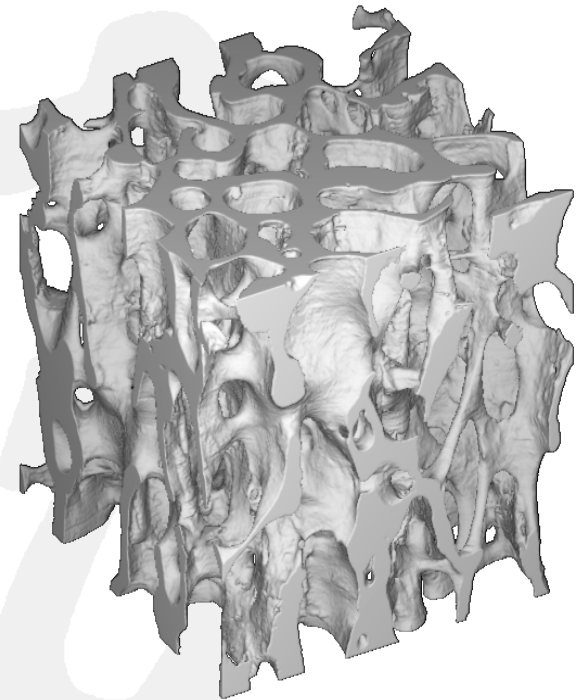


Trabecular Bone

Cortical
bone



Trabecular
bone

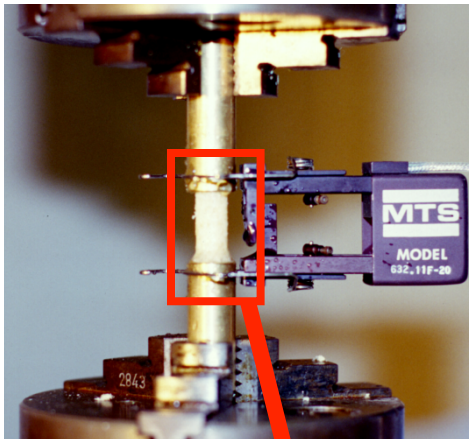


5-mm Cube

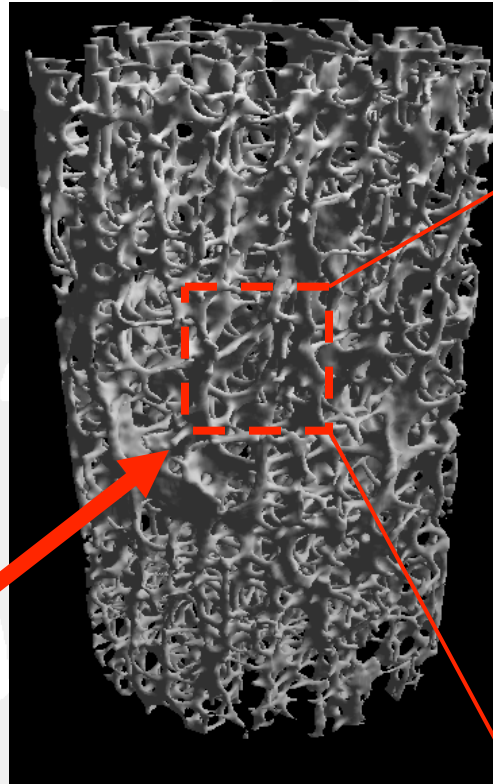
Methods: μ FE modeling

Mechanical Testing

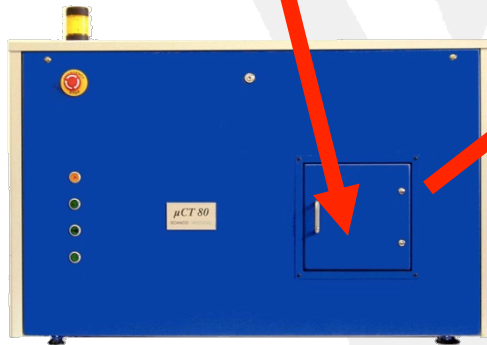
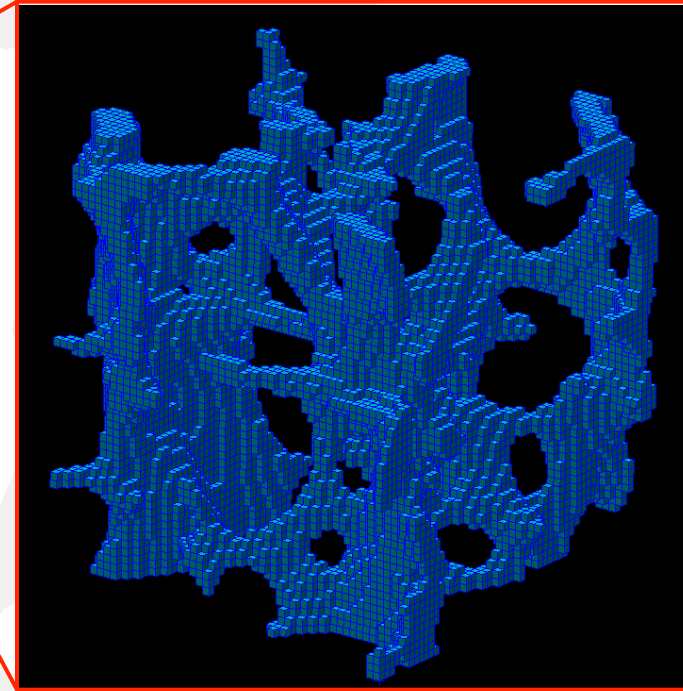
E , ϵ_{yield} , σ_{ult} , etc.



3D image



μ FE mesh



Micro-Computed Tomography

μ CT @ 22 μm resolution

3

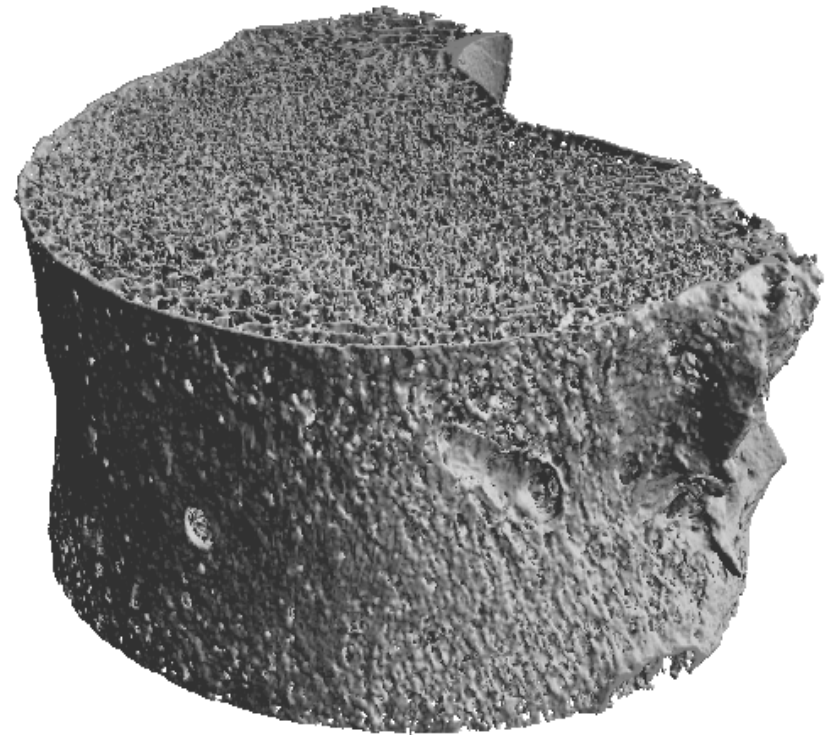
2.5 mm cube
44 μm elements



PPPL
PRINCETON PLASMA
PHYSICS LABORATORY

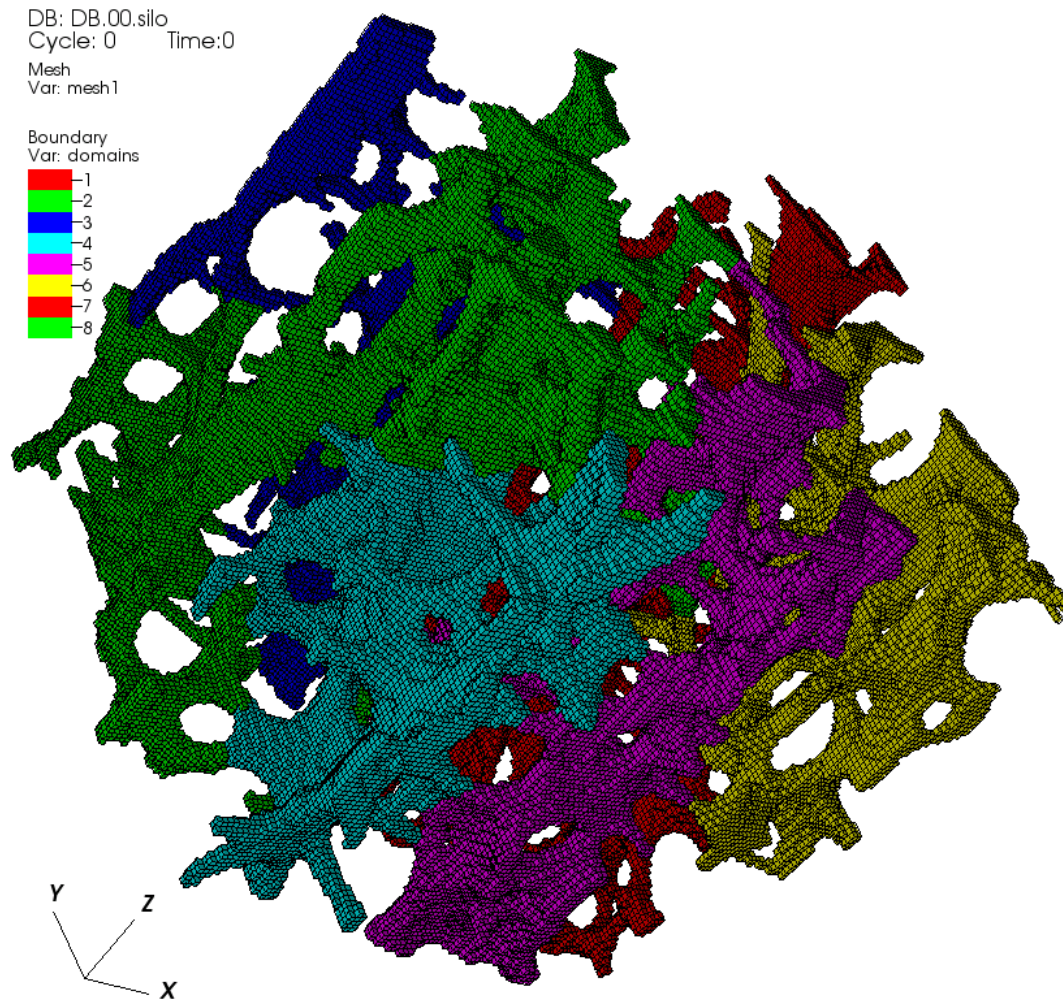
Vertebral Body With Shell

- Large deformation elast.
- 6 load steps (3% strain)
- Scaled speedup
 - ~131K dof/processor
- 7 to 537 million dof
- 4 to 292 nodes
- IBM SP Power3
 - 14 of 16 procs/node



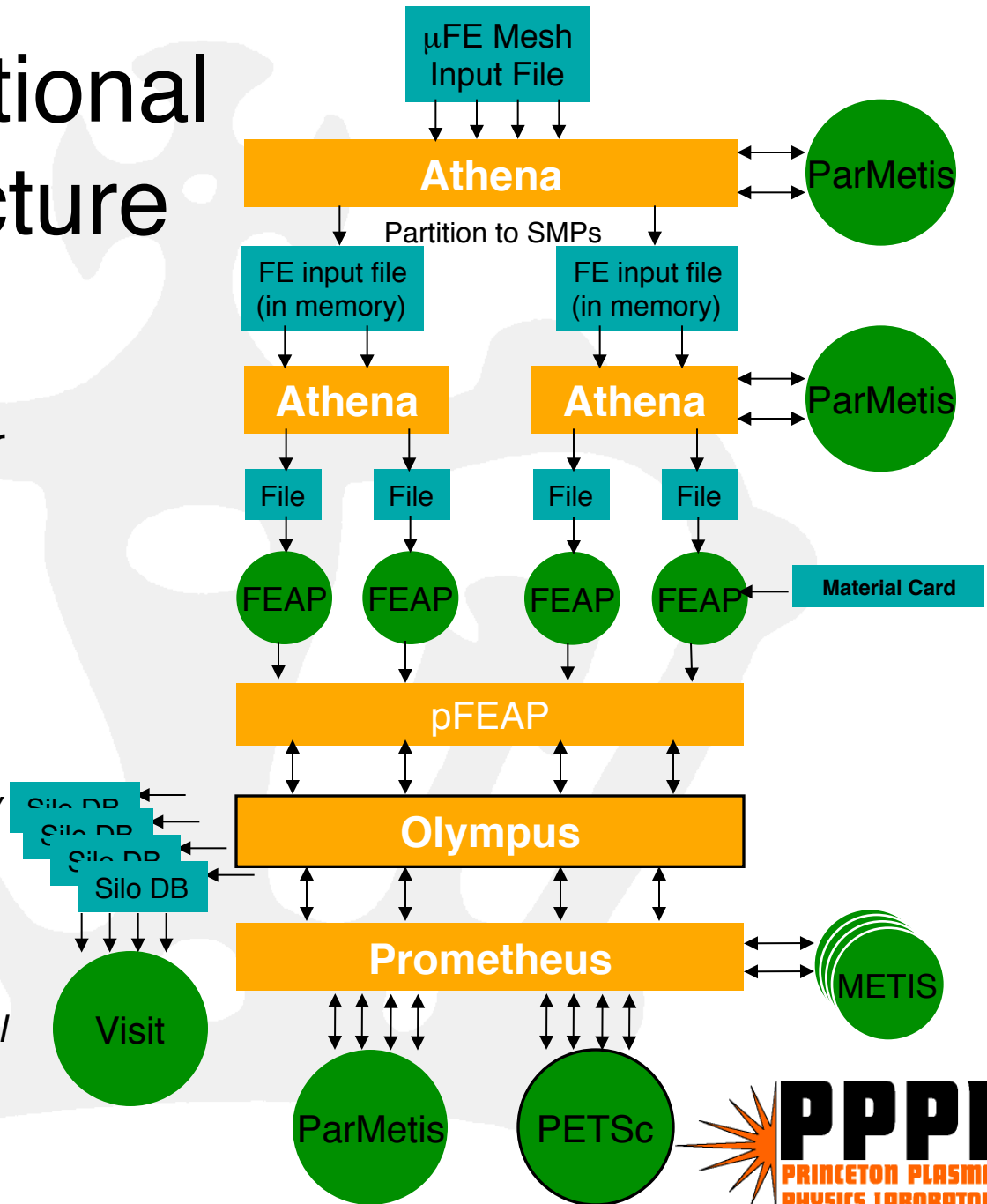
80 μm w/ shell

ParMetis partitions



Computational Architecture

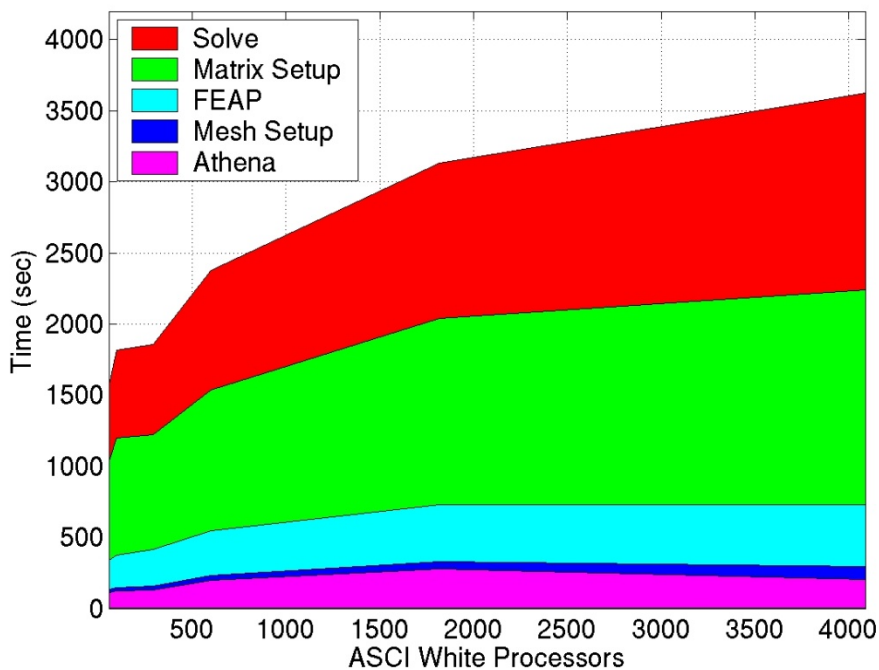
- Athena: Parallel FE
- ParMetis
 - Parallel Mesh Partitioner
(University of Minnesota)
- Prometheus
 - Multigrid Solver
- FEAP
 - Serial general purpose
FE application (University
of California)
- PETSc
 - Parallel numerical
libraries (Argonne National
Labs)



131K dof / proc

.47 Teraflops - 4088 processors

Total run time (131K dof/proc)



Mflops/sec/proc (131K dof/proc)

