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

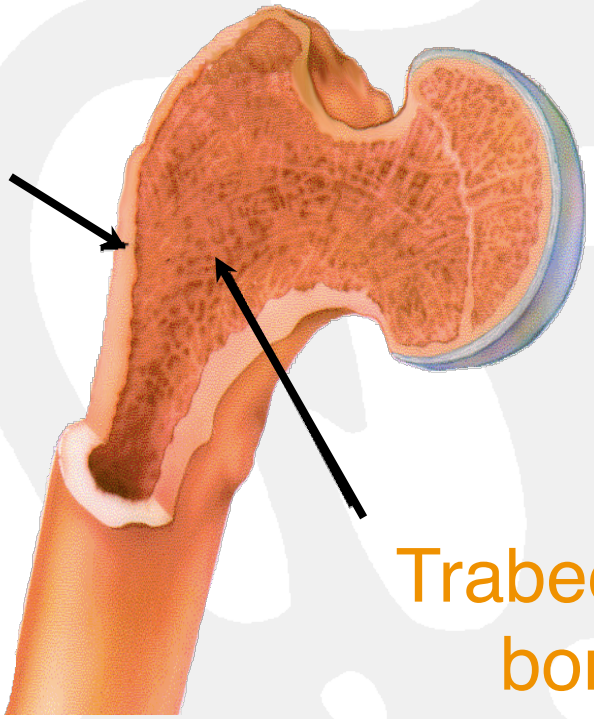
(excerpts)

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

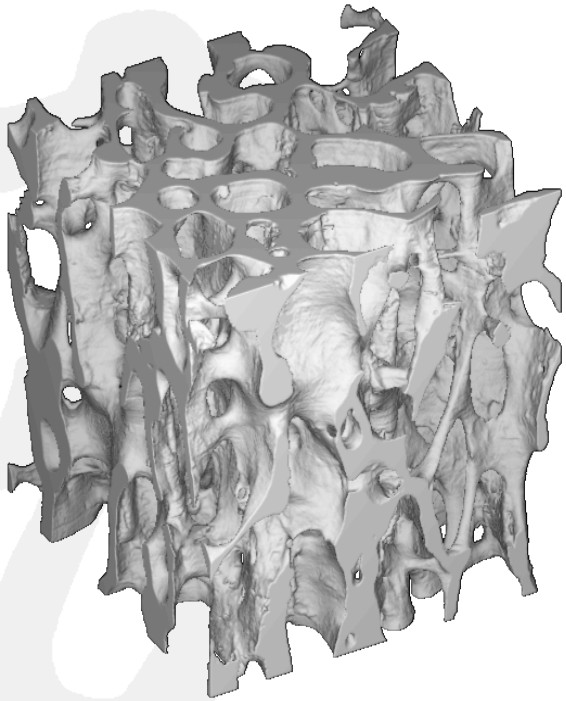
PPPL
PRINCETON PLASMA PHYSICS LABORATORY

Trabecular Bone

Cortical bone



Trabecular bone

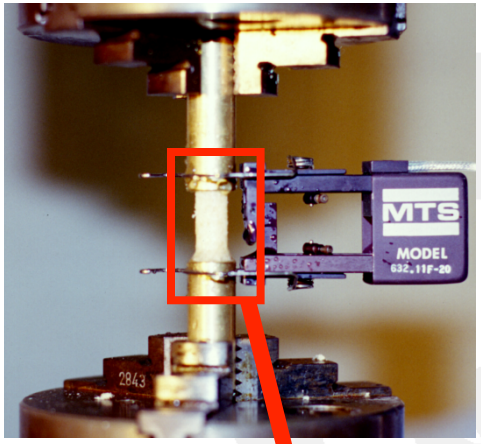


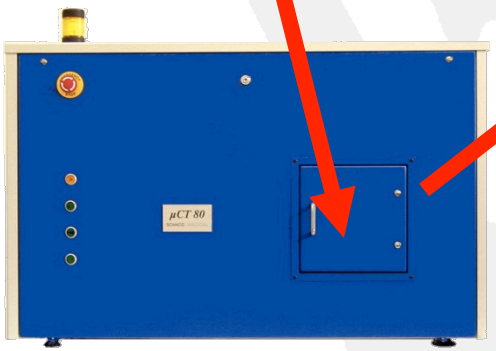
5-mm Cube

PPPL PRINCETON PLASMA PHYSICS LABORATORY

Methods: μFE modeling

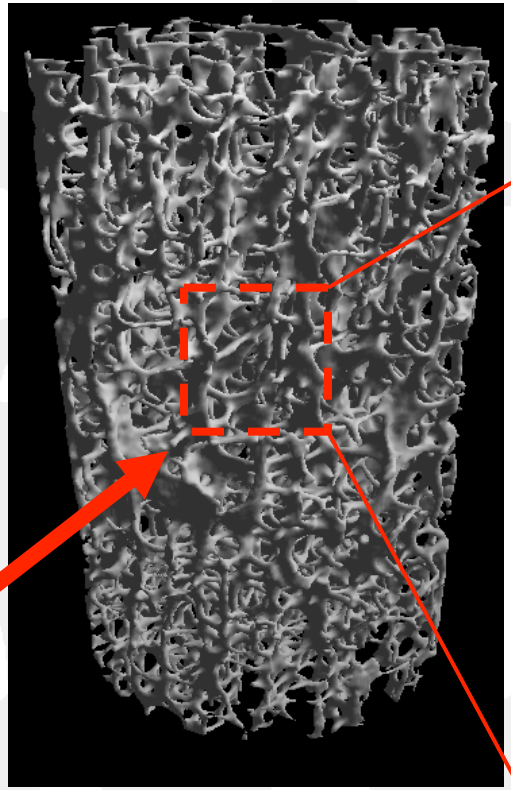
Mechanical Testing
E, ε_{yield}, σ_{ult}, etc.



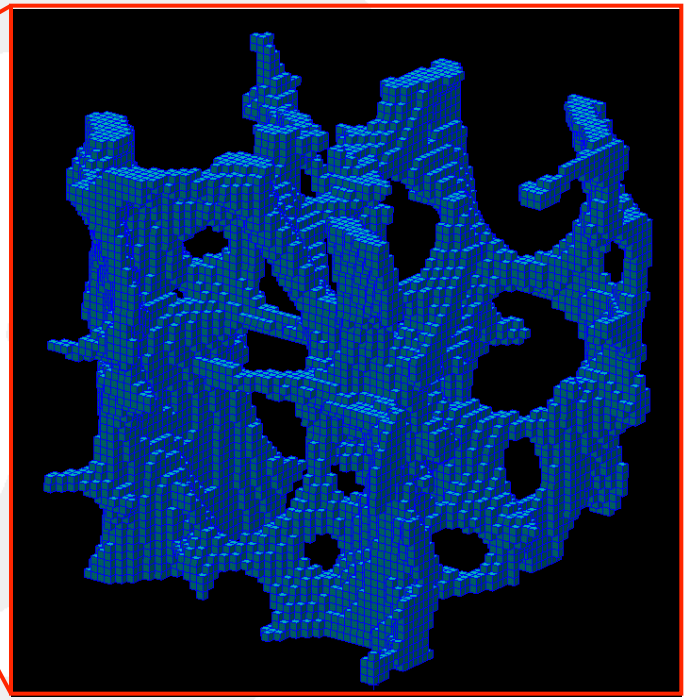


Micro-Computed Tomography
μCT @ 22 μm resolution

3D image



μFE mesh

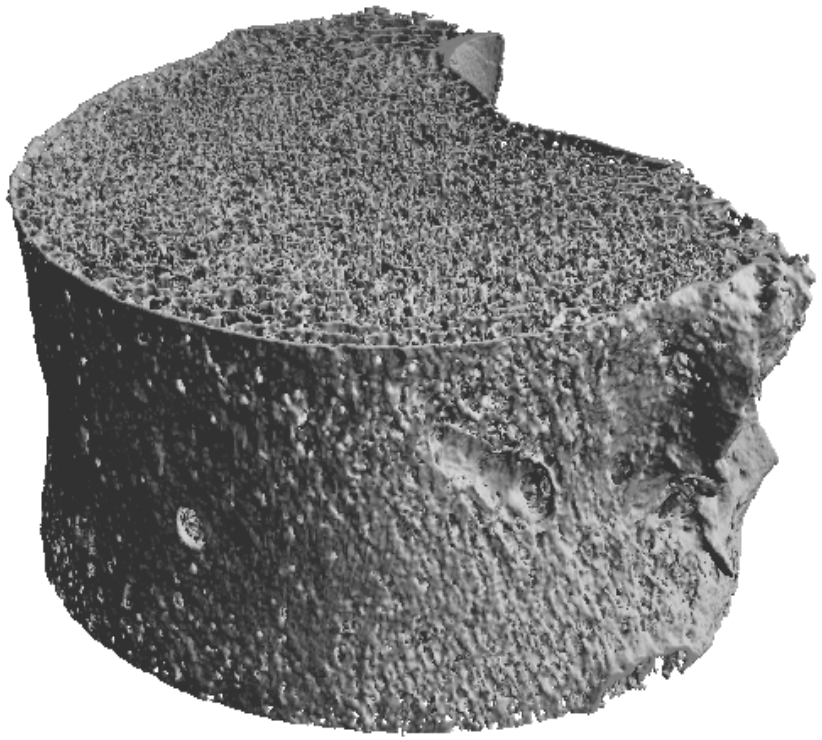


2.5 mm cube
44 μm elements

PPPL
PRINCETON PLASMA PHYSICS LABORATORY

Vertebral Body With Shell

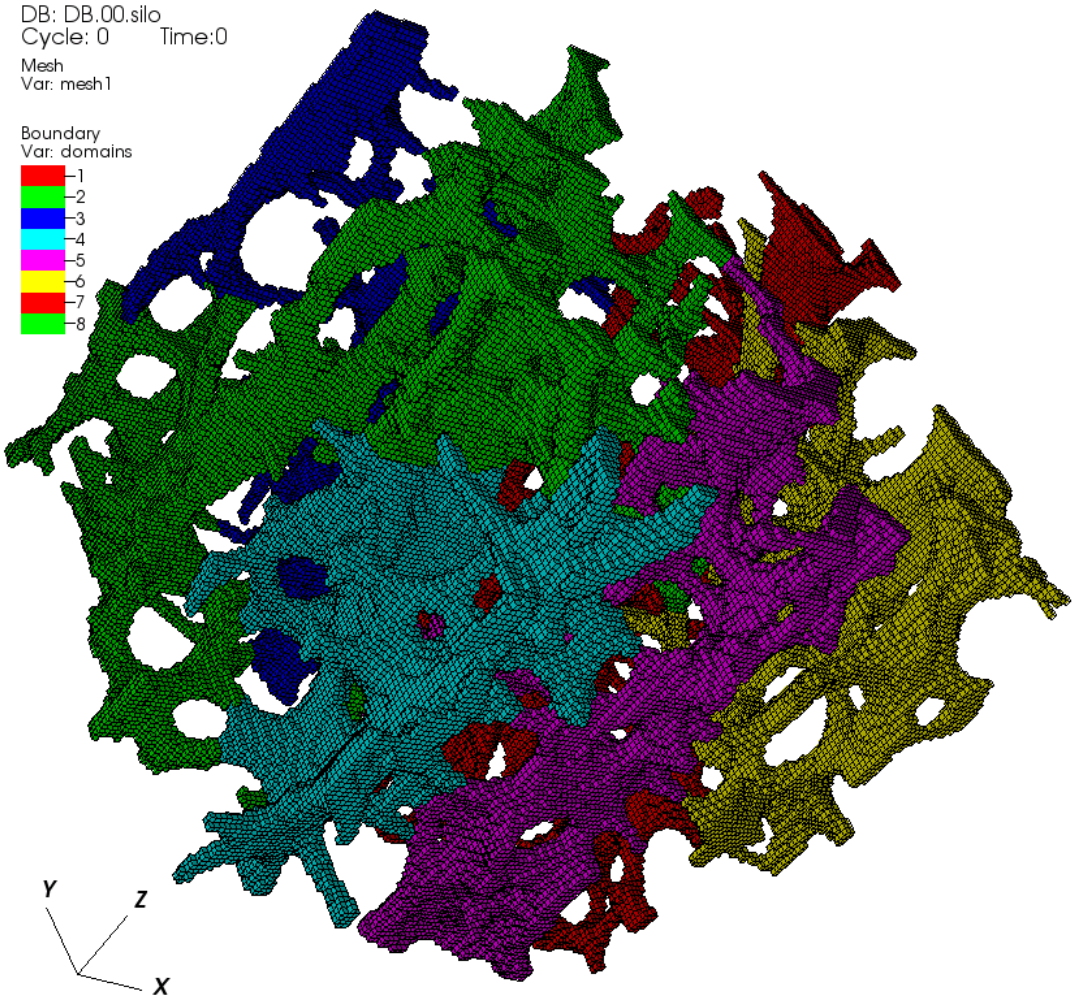
- Large deformation elast.
- 6 load steps (3% strain)
- Scaled speedup
  - ~131K dof/processor
- 7 to 537 million dof
- 4 to 292 nodes
- IBM SP Power3
  - 14 of 16 procs/node



80 μm w/ shell

PPPL PRINCETON PLASMA PHYSICS LABORATORY

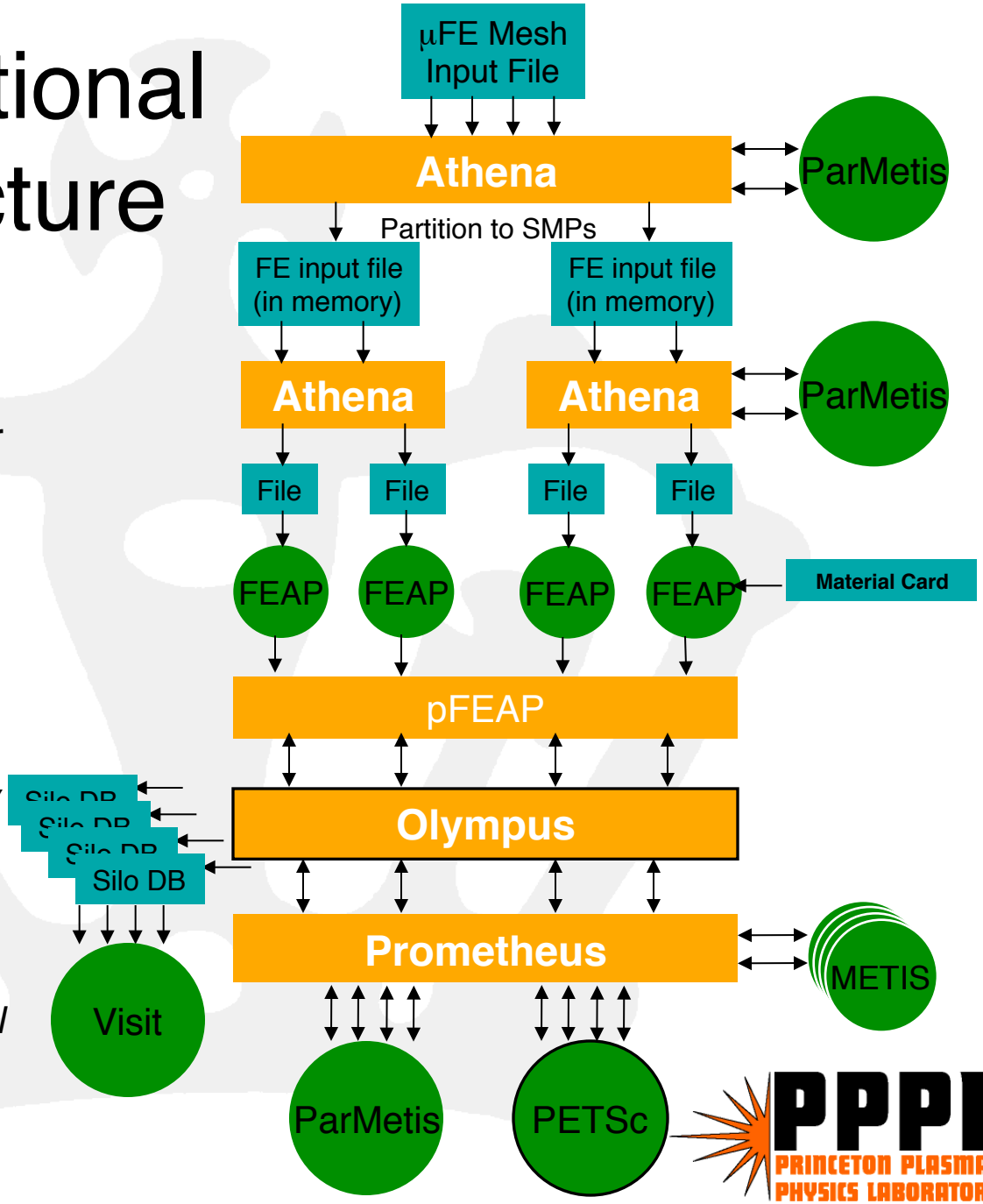
ParMetis partitions



PPPL
PRINCETON PLASMA
PHYSICS LABORATORY

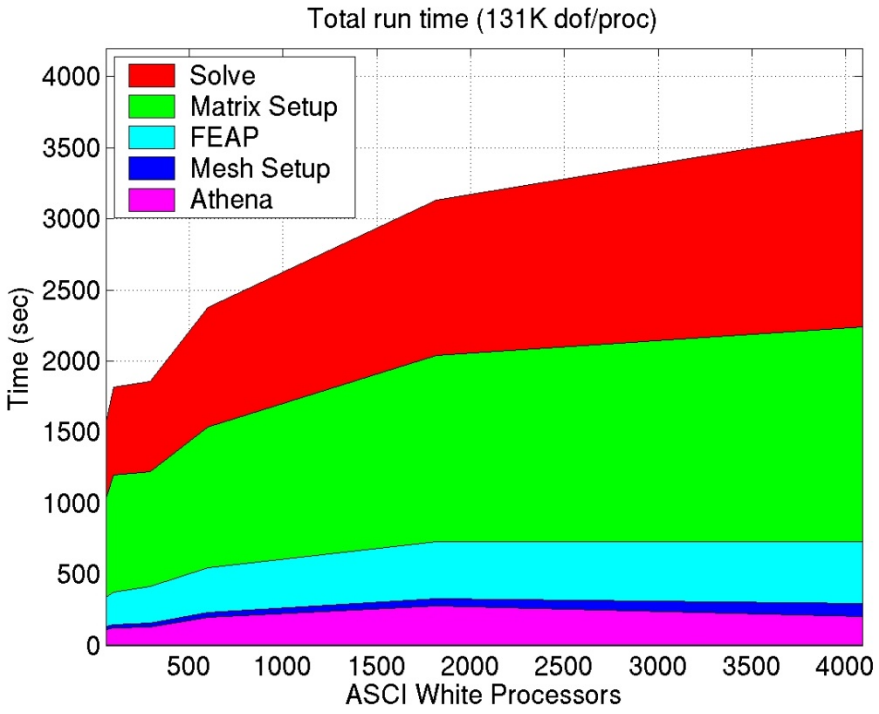
Computational Architecture

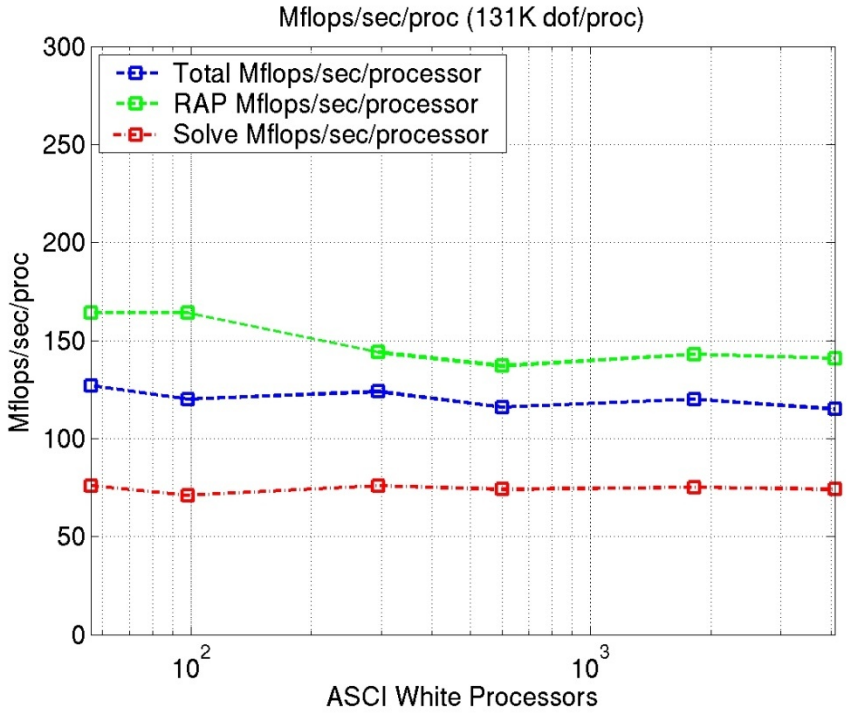
- Athena: Parallel FE
- ParMetis
  - Parallel Mesh Partitioner *(Univerisity of Minnesota)*
- Prometheus
  - Multigrid Solver
- FEAP
  - Serial general purpose FE application *(University of California)*
- PETSc
  - Parallel numerical libraries *(Argonne National Labs)*



PPPL PRINCETON PLASMA PHYSICS LABORATORY

131K dof / proc
.47 Teraflops - 4088 processors





PPPL
PRINCETON PLASMA PHYSICS LABORATORY