UNIVERSITÄT BERN

Fabric-Elasticity Relationships in Cortical Bone

Mathieu Simon

July 17, 2025

UNIVERSITÄT BERN

Samples

Bone matrix

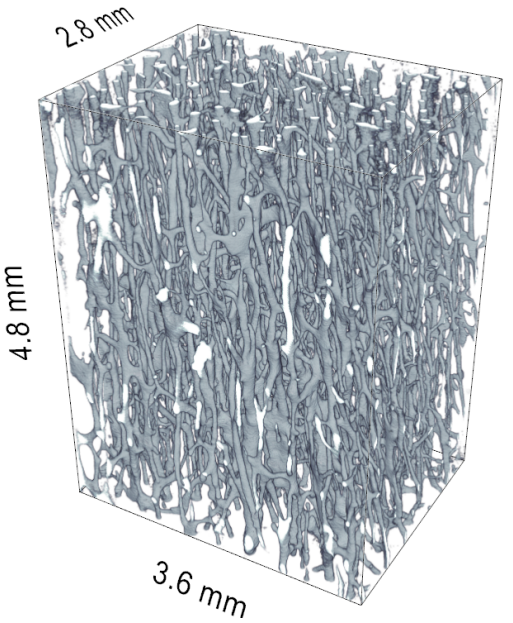
- Franzoso et al. [1]
- Dall'Ara et al. [2]

Cortical bone

- Femur
- µCT at 6.5 µm voxel size
- RUS measurement

Trabecular bone

- Tibia
- HR-pQCT at 61 µm voxel size



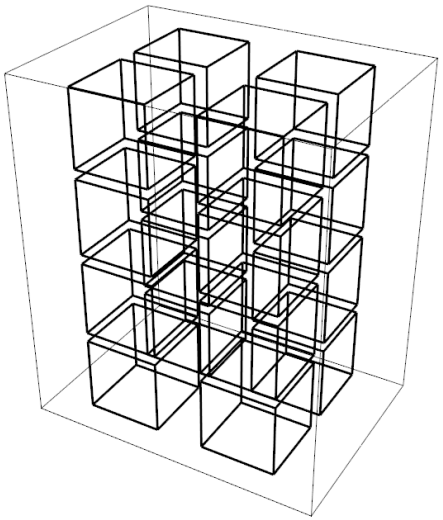
Numerical Analysis

Cortical bone

- 16x 1mm^3 ROIs
- Fabric (Medtool)
- Coarsening factor 2
- Homogenisation (Abaqus)
  Transverse isotropic
  Isotropic

Trabecular bone

- Homogenisation (Abaqus)
  Isotropic



Comparison to Experiment

Analysis pipeline

- Homogenisation with tranverse isotropic matrice
- Average 16 tensors
- ROI's CV < 0.263
- Project to transverse isotropy
- Linear regression (BV/TV and $\mathbb{S}$)
- $\mathbb{S}$ and $\mathbb{E}$ anisotropy

Cortical and Trabecular

Cortical and Trabecular Fabric

Cortical and Trabecular CV vs BV/TV

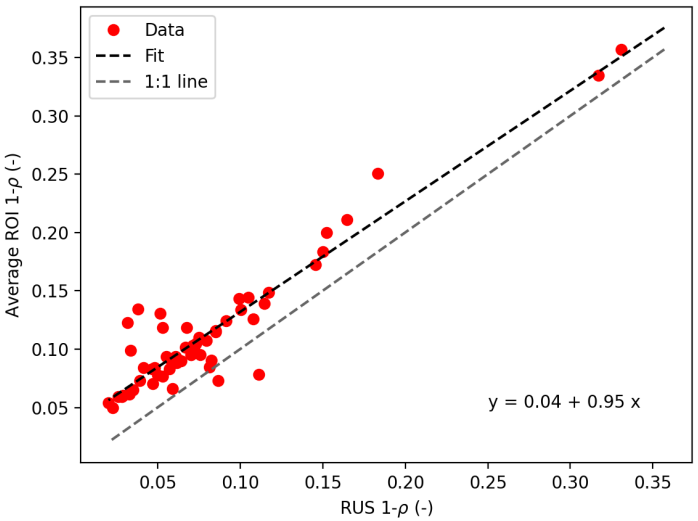
Cortical Constitutive Models

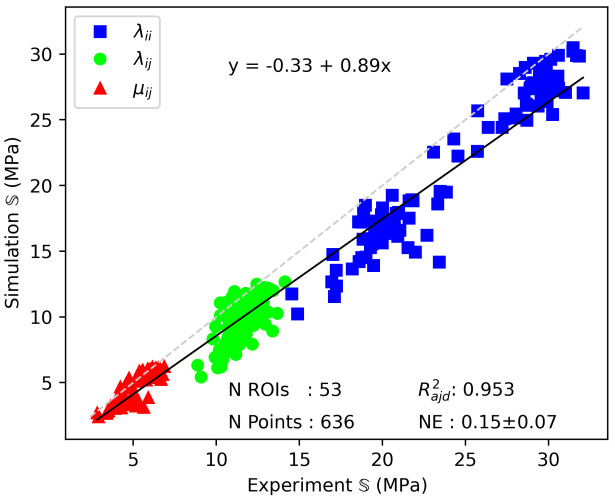
- Zysset-Curnier in orthotropic space
- Zysset-Curnier in transverse isotropic space
- Yang and Cowin in transverse isotropic space

Cortical and trabecular

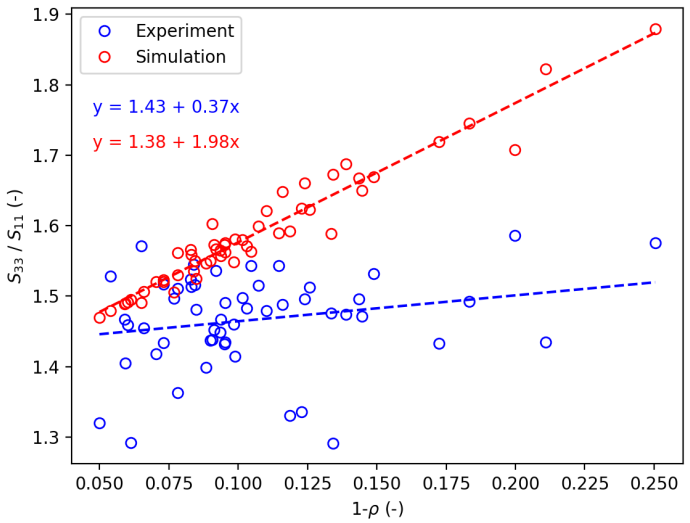
- Transverse isotropic space
- Yang and Cowin model

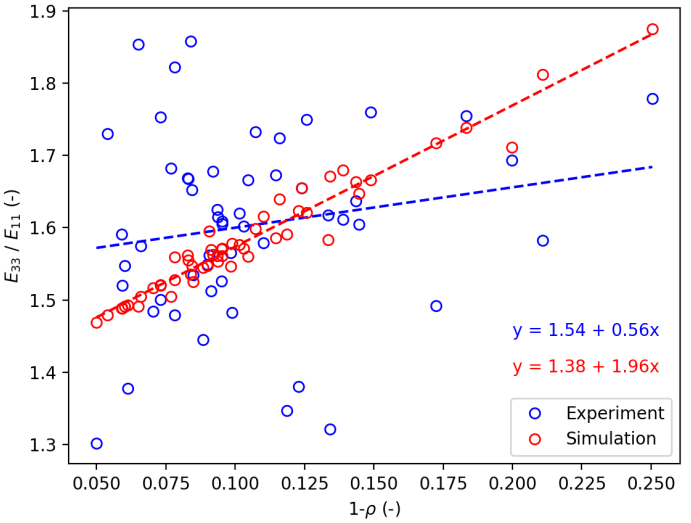
Comparison to Experiment



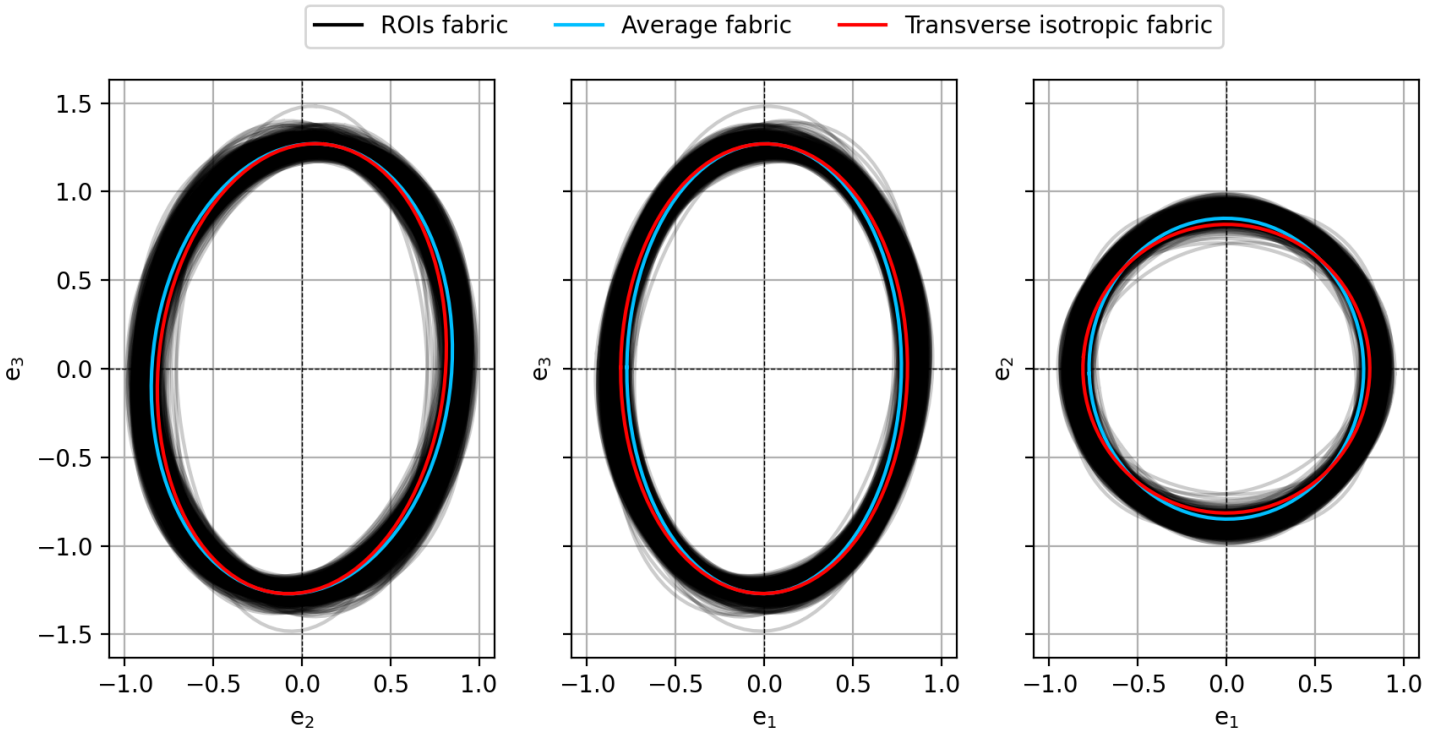


Comparison to Experiment

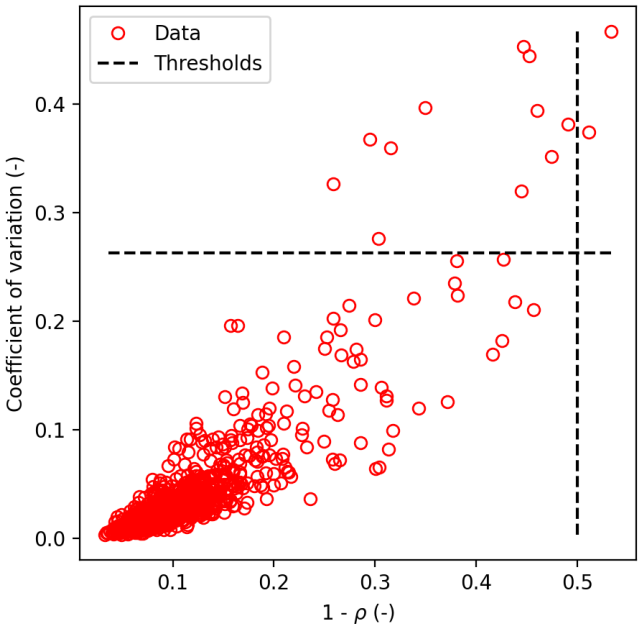


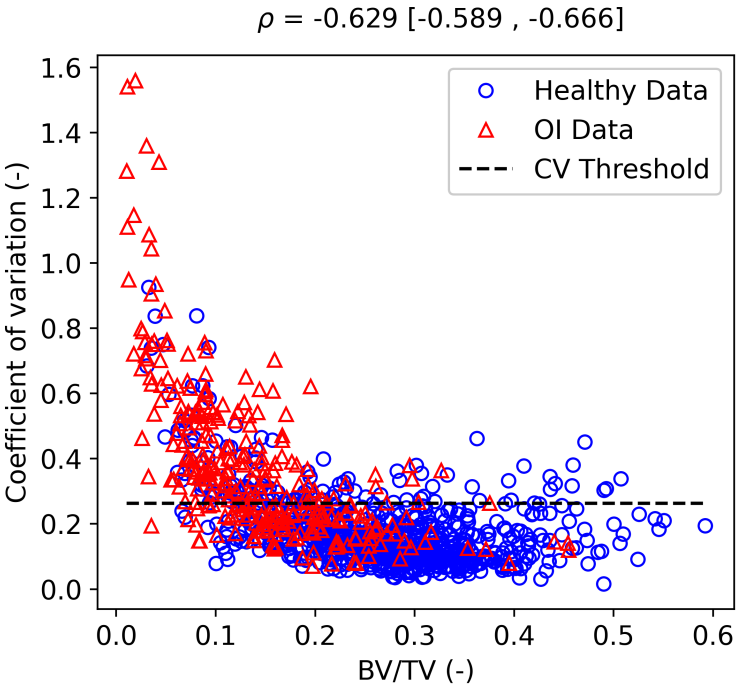


Cortical Bone

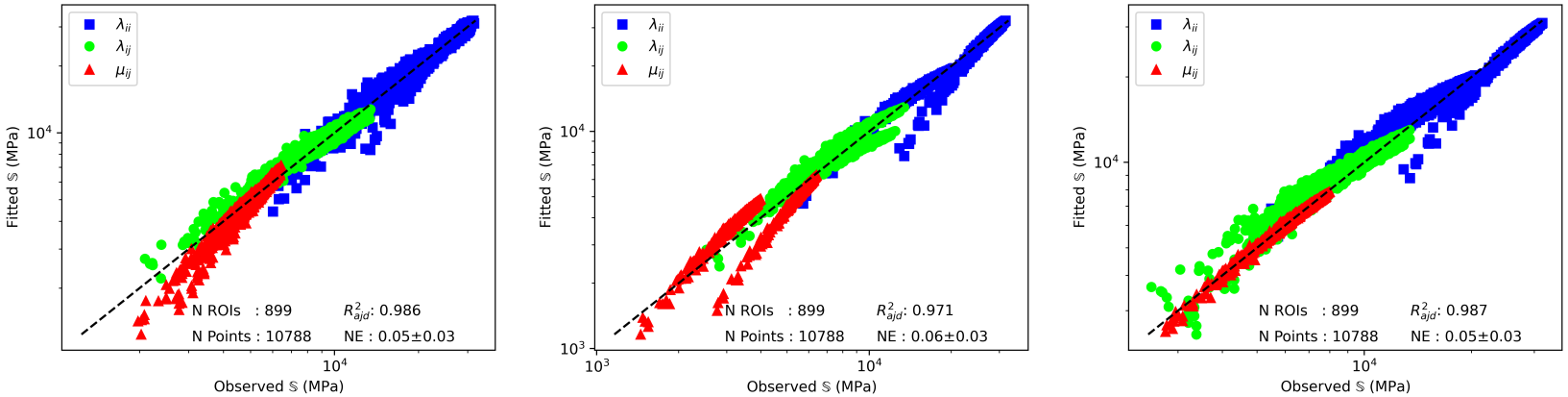


Cortical and Trabecular Bone

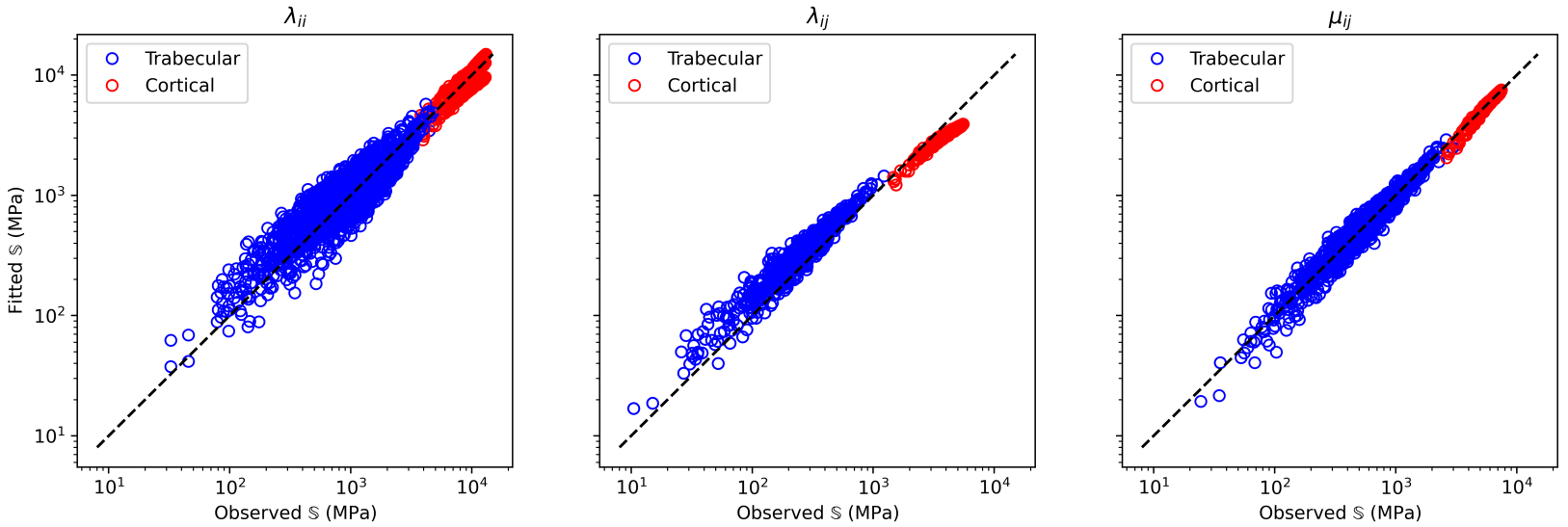




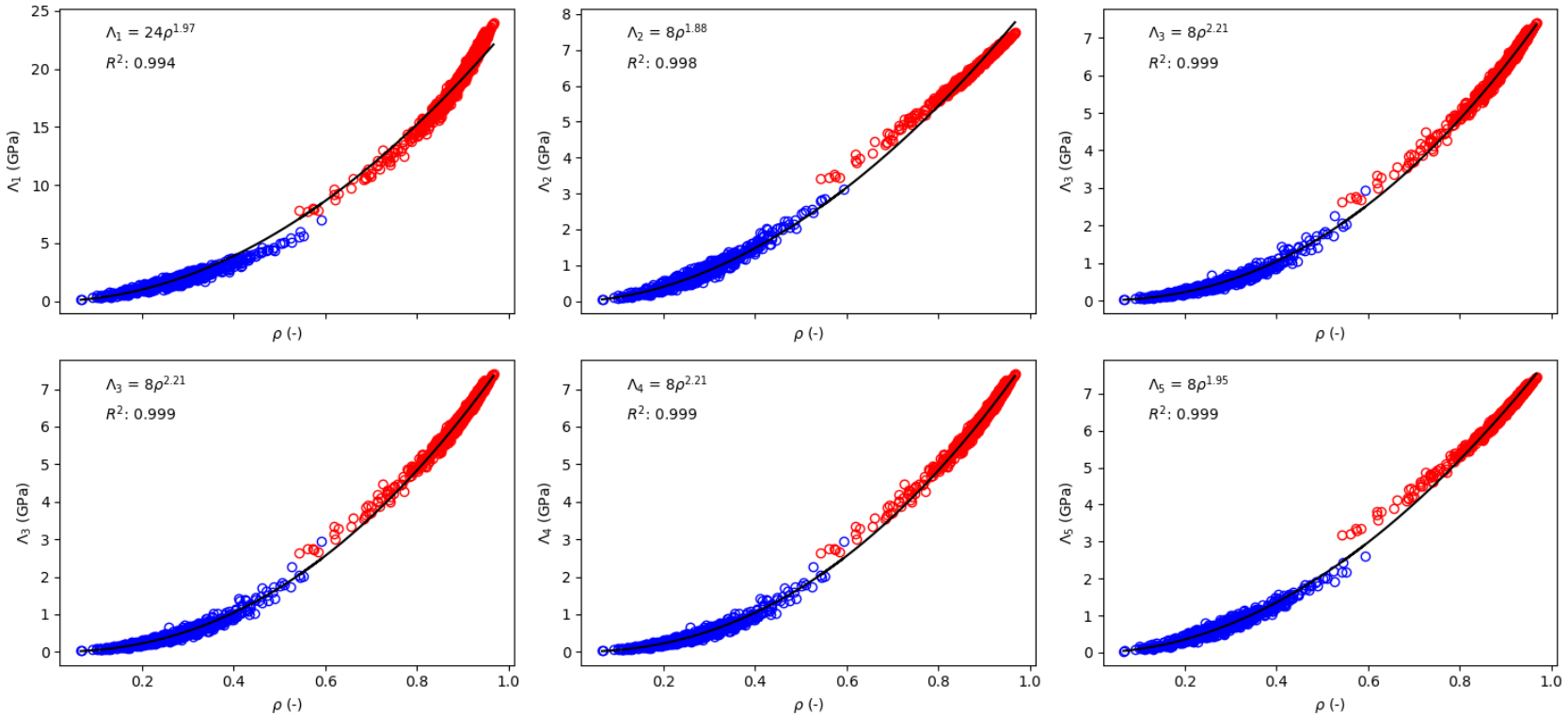
Constitutive Models



Constitutive Models



Cortical and Trabecular Bone



References

- Franzoso, G. and Zysset, P. (2009)
  Elastic anisotropy of human cortical bone secondary osteons measured by nanoindentation
  J Biomech Eng., 131(2)
  https://api.semanticscholar.org/CorpusID:25765365
- Enrico, D., Schmidt, R. and Zysset P. (2012)
  Microindentation can discriminate between damaged and intact human bone tissue
  Bone, 50(4)
  https://api.semanticscholar.org/CorpusID:23349859