TECHNISCHE UNIVERSITÄT
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Need for flexible volume discretization of a 3D surface model

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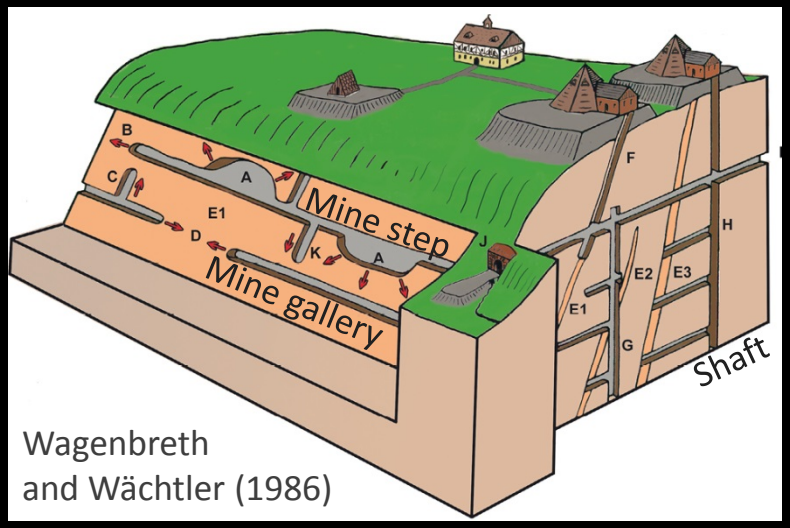
Research and Education Mine Freiberg

Reiche Zeche = Rich Mine

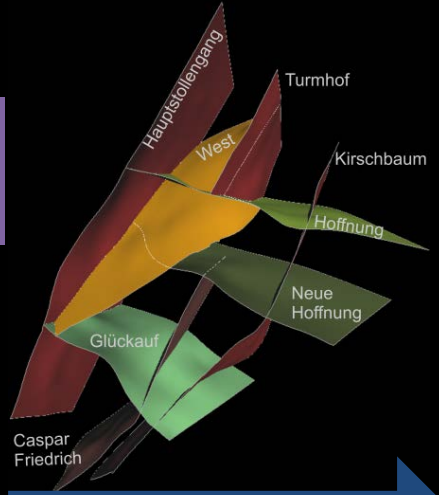
Müller (1901)



Wagenbreth
and Wächtler (1986)

3D Mine Model

fault kinematics
geological data



mine maps

digitizing, 3D geometry modeling

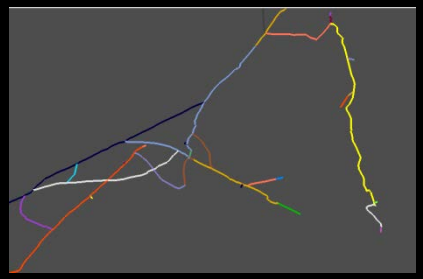
Löwe (2011)

ore veins

quality check, harmonization

3D
model

Export



Benkert (2013)

GIS based
model

3D geometry modeling

mine galleries

precise geodetic
position +orientation
measurements

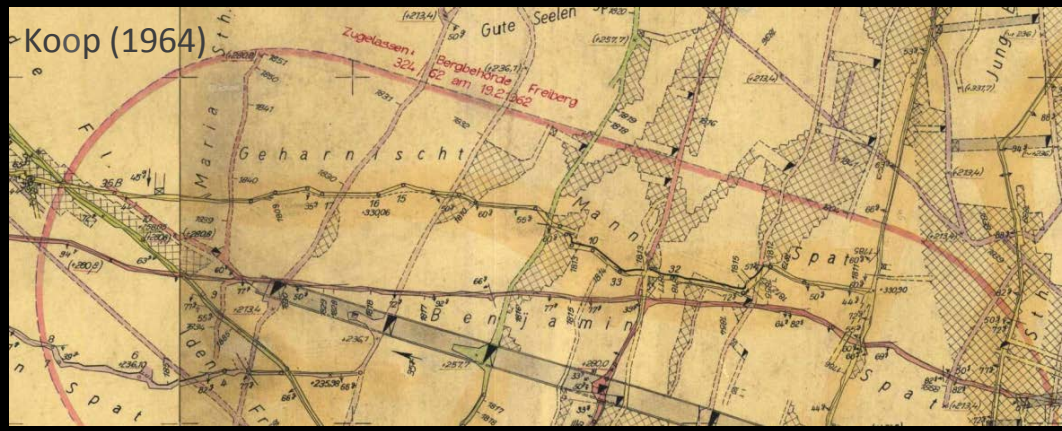
digital mine map

scanning
georeferencing
height referencing
digitizing
labeling

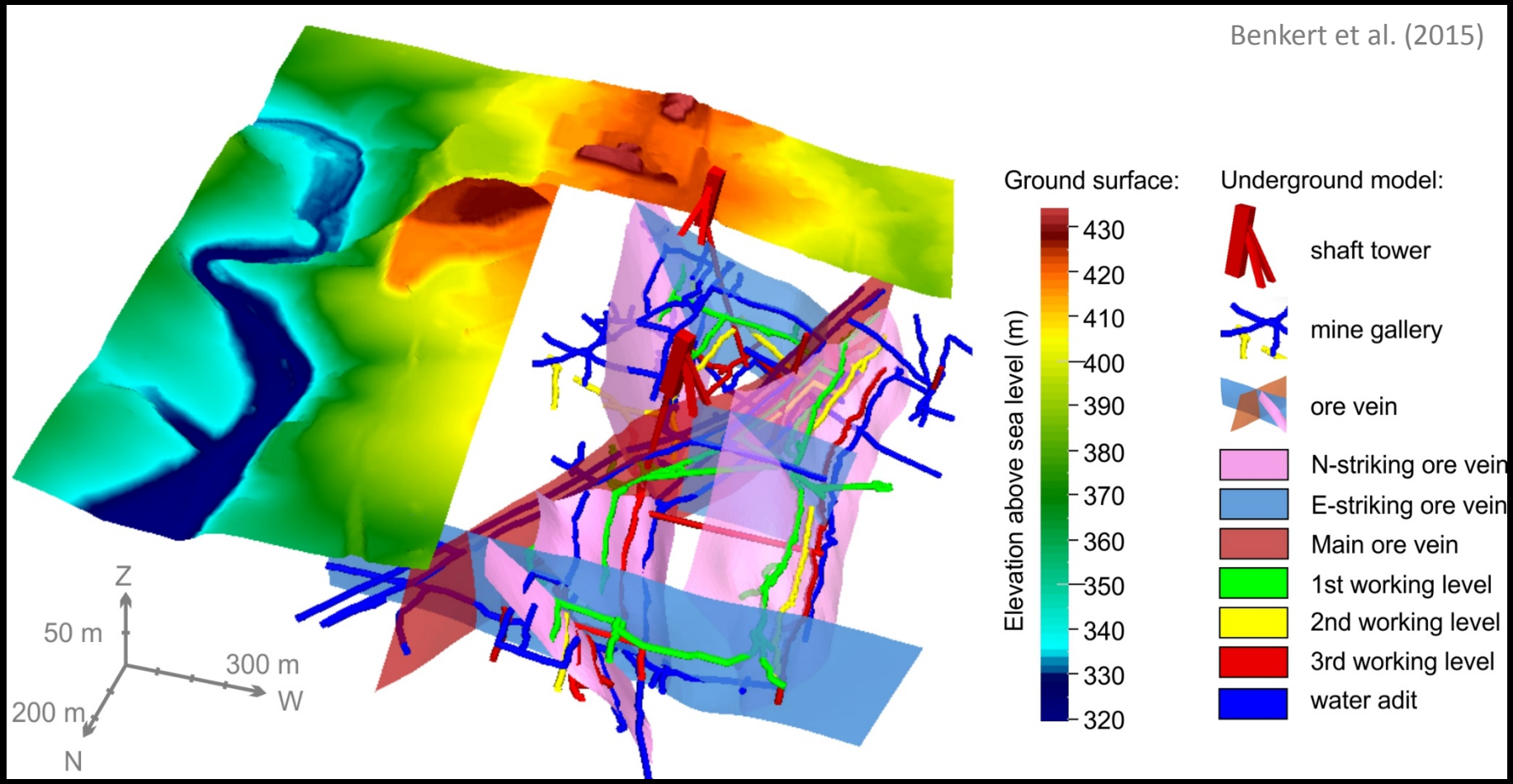
hand-colored
grouped
level plots

Grund (2010)

Koop (1964)



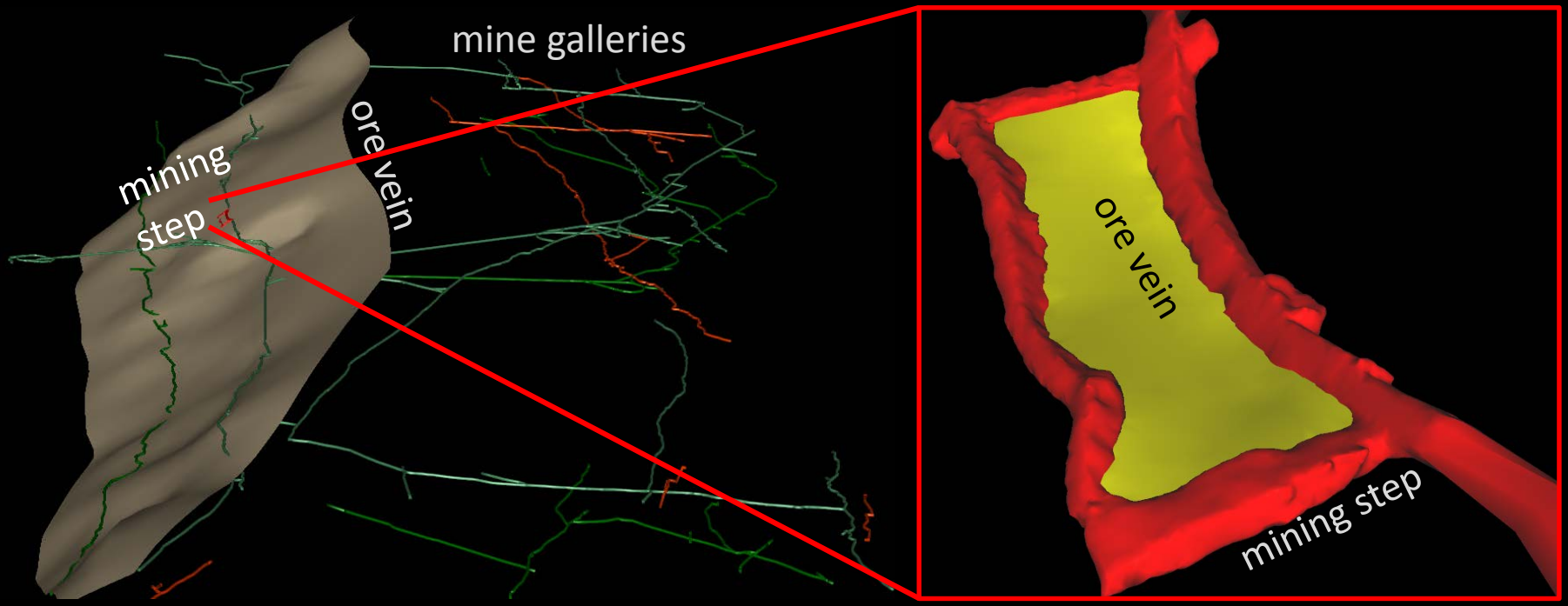
3D Mine Model



Investigation Site

Nature

Excellent measurement arrangement is possible



data provided by Martinßen (2015)

Model

Use the 3D model for mine planning and process simulations
Simulation of the experiments and reproduction of data

Experimental Design

Direct-current resistivity method

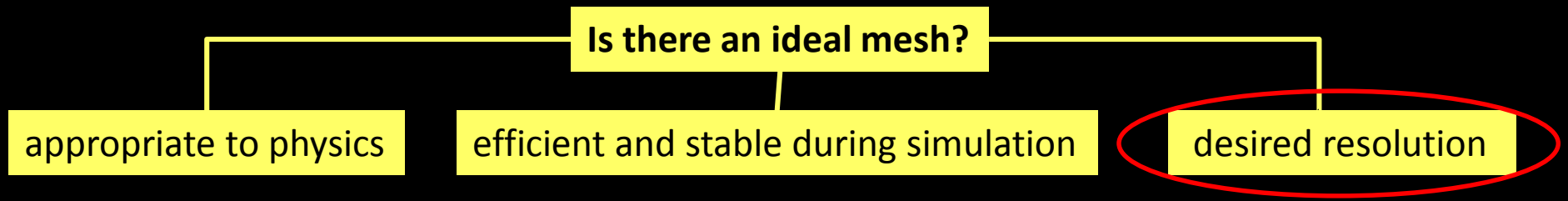
http://en.openei.org/wiki/

Simulation of the electric field is necessary

Simulation Methods

Solve partial differential equations

	Finite Difference Method	Distinct Element Method	Finite Element Method
Equation replaced by	differences	contact force-displacement and motion law	piecewise continuous basis functions
Discretization	**regular grid**	**unstructured set of particles**	**unstructured mesh**



Simulation Design

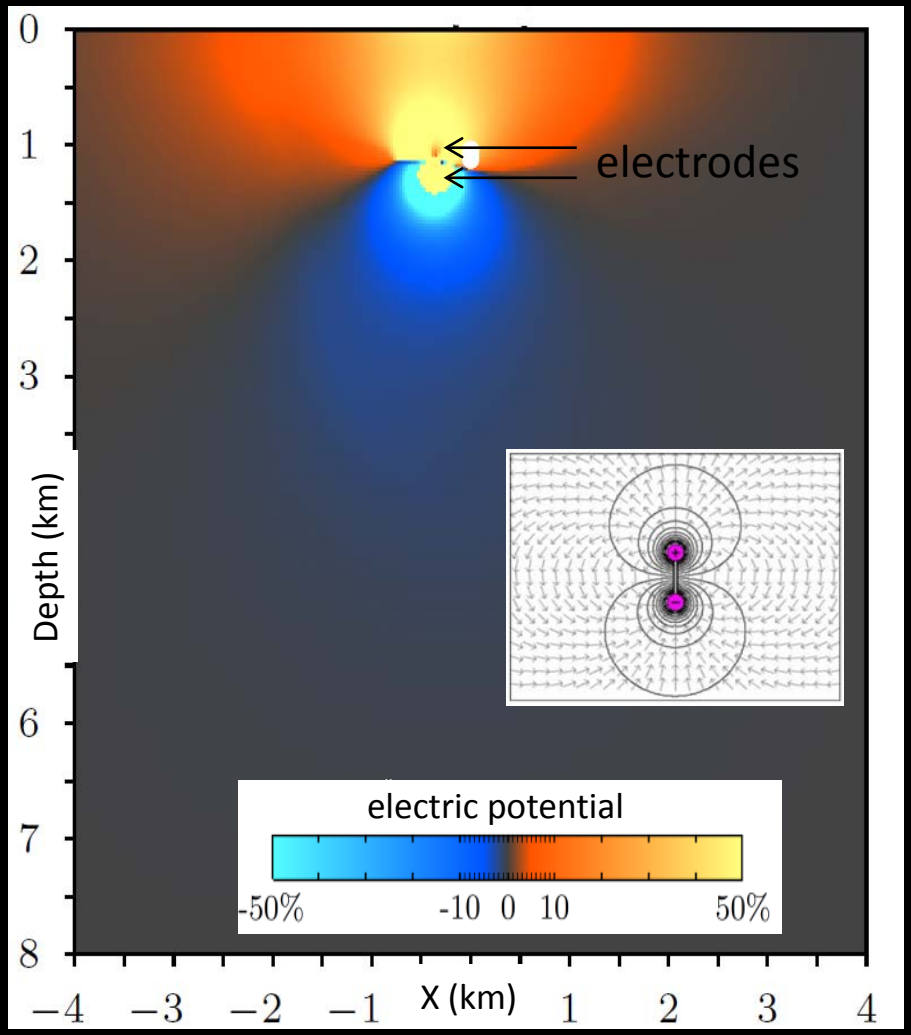
Simulated Process

Continuity equation of the electric potential

$$-\nabla \cdot (\sigma \nabla \varphi) = I\delta(\mathbf{x} - \mathbf{x}_0)$$

- φ … Electric potential
- σ … Electrical conductivity
- I … Source strength
- $\mathbf{x}_0$ … Location of the source strength
- $\mathbf{x}$ … Location

Finite Element Code of Weißflog et al. (2012)

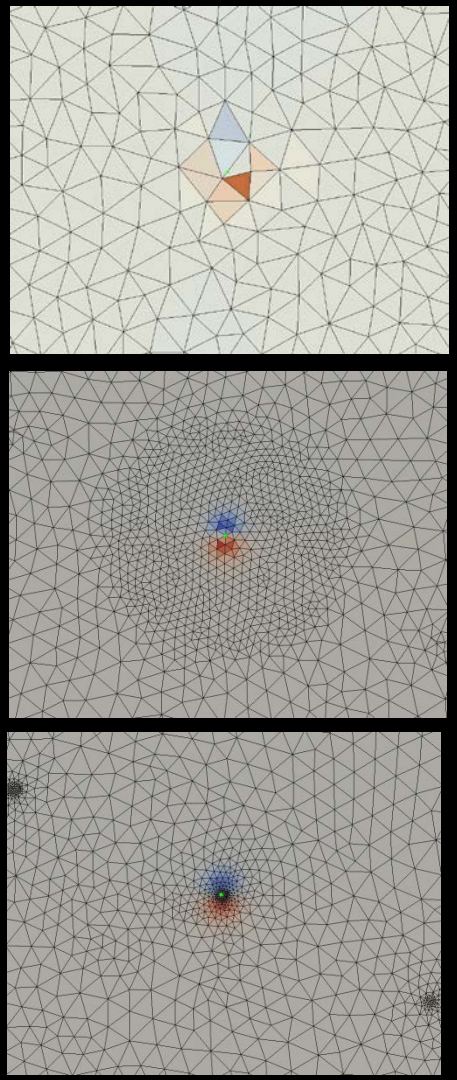


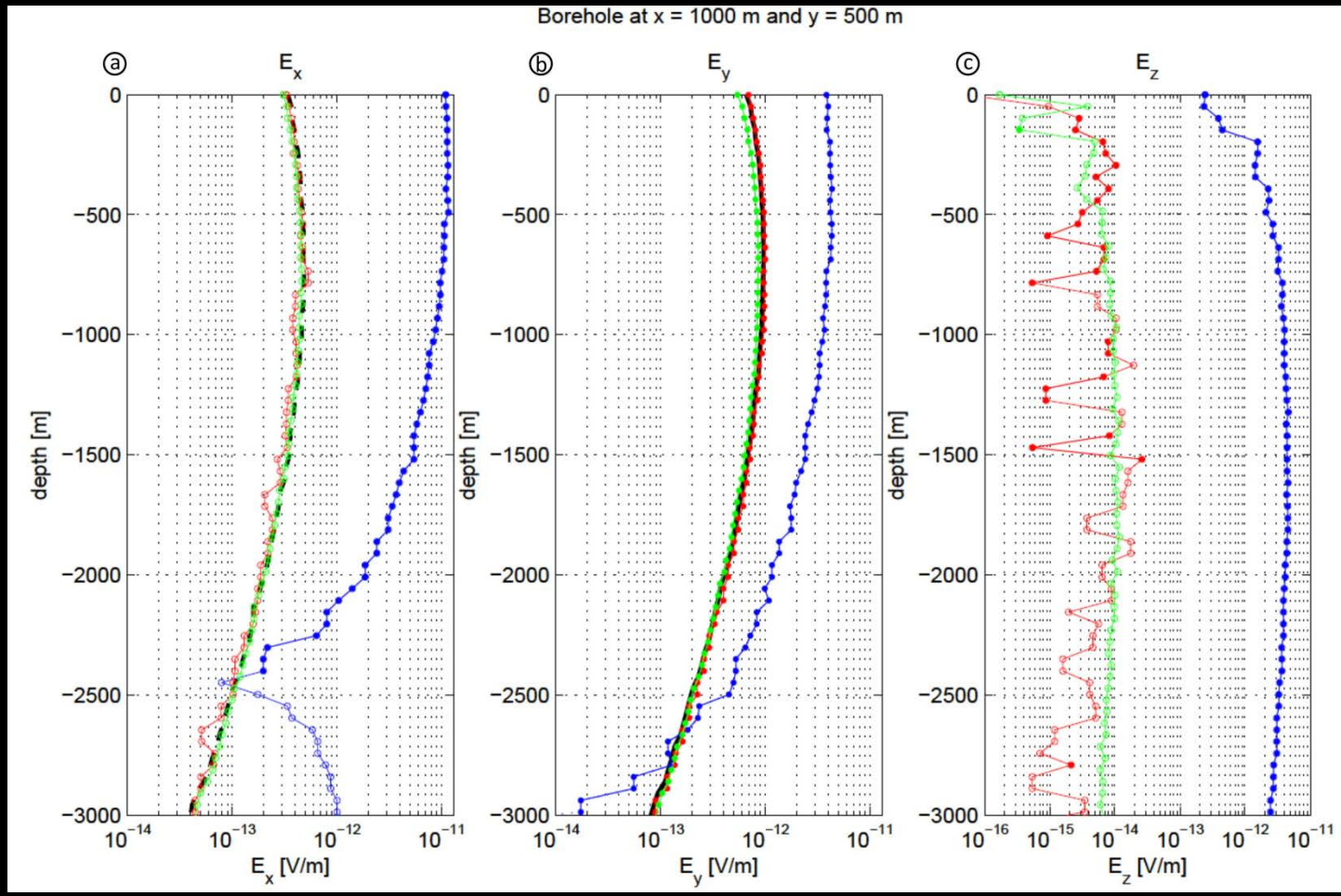
Börner et al. (2015)

http://mw.concord.org/modeler/showcase/electrostatics/dipole.html

Unstructured tetrahedral mesh
Electrodes are nodes of the meh

Critical: Mesh Resolution at the source

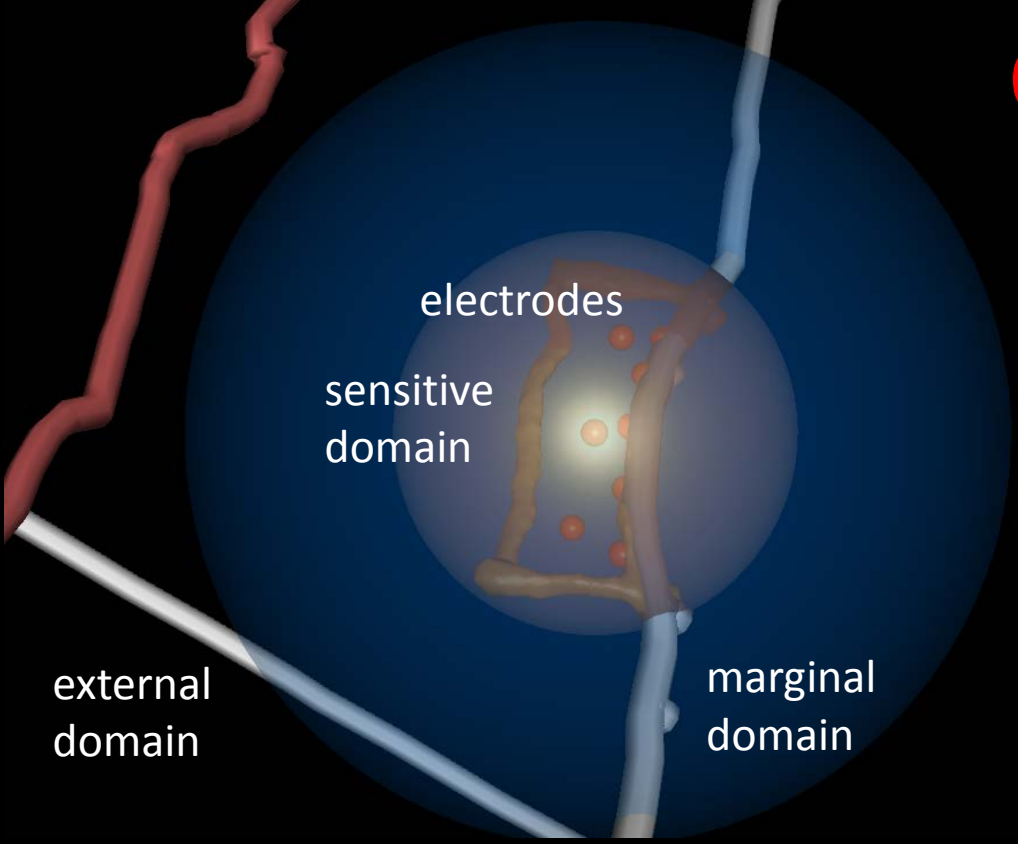




Zehner et al. (2015)

Local mesh refinement around the electrodes is necessary

Optimize Simulation



One ideal unstructured tetrahedral mesh

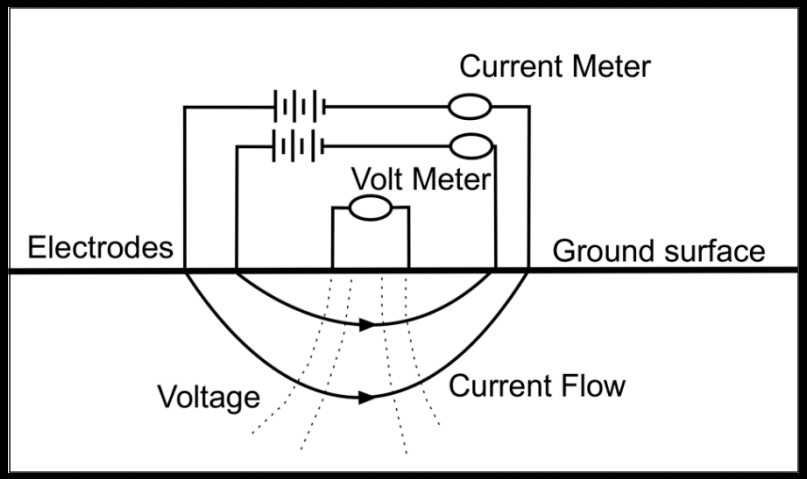
Electrodes are nodes of the mesh

Extremely fine resolution around electrodes

Fine resolution in the sensitive domain

Coarse resolution in the marginal domain

Exclude galleries in the external domain

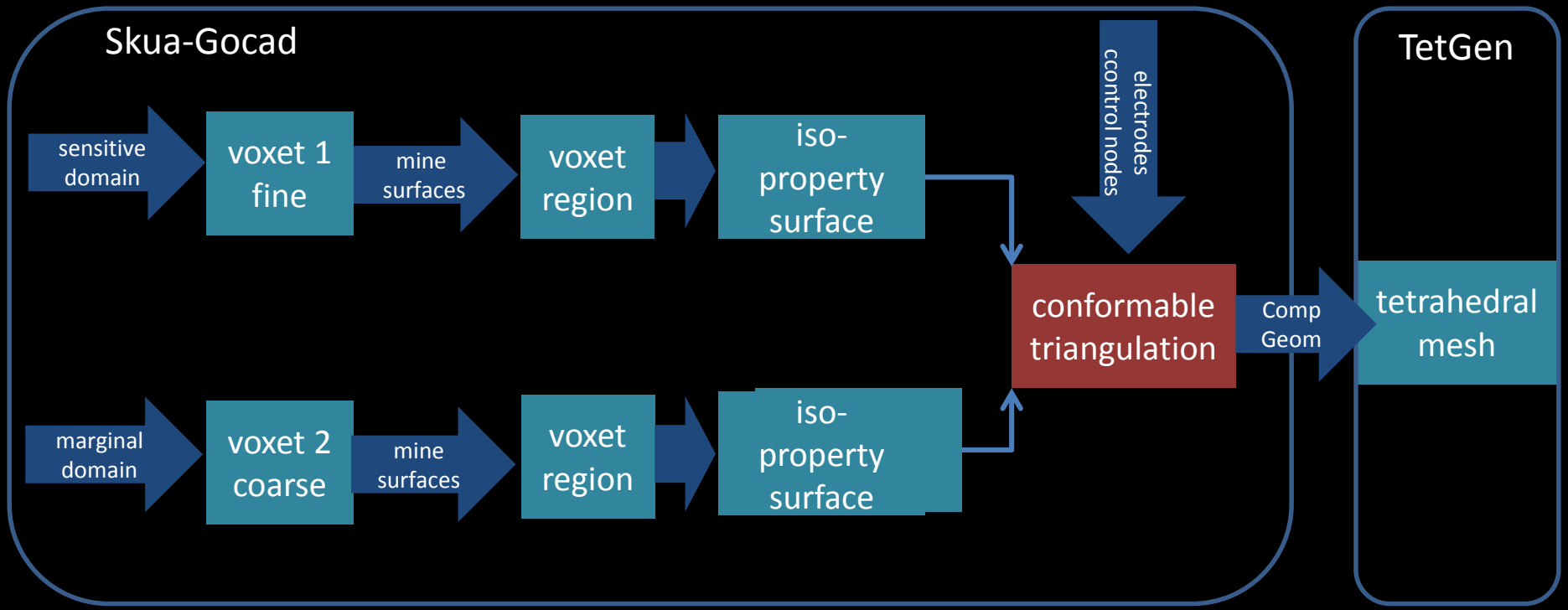


Optimum simulation quality
Accuracy
Level of detail

Minimum degrees of freedom
Calculation time
Storage

Approach 1: Voxet Iso-Property

Size of grid cells controls size of tetrahedra

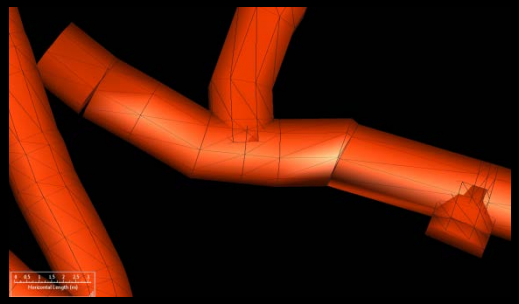


Advantages:
- Corrects meshing error
- Fast
- Two Apps involved

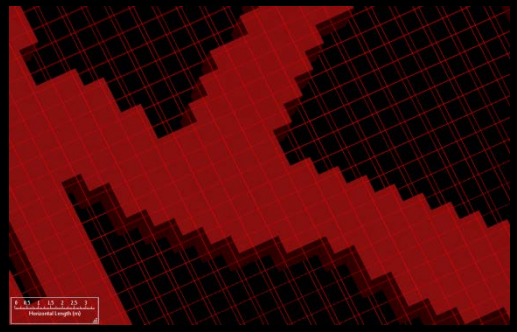
Disadvantages:
- Connect sensitive and marginal domain „by hand“
- No adaptive mesh refinement around the electrodes

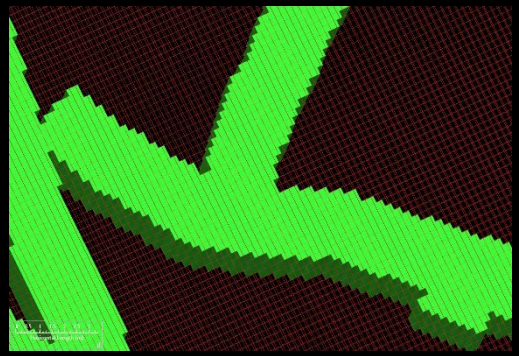
Approach 1: Voxet Iso-Property

Size of grid cells controls size of tetrahedra

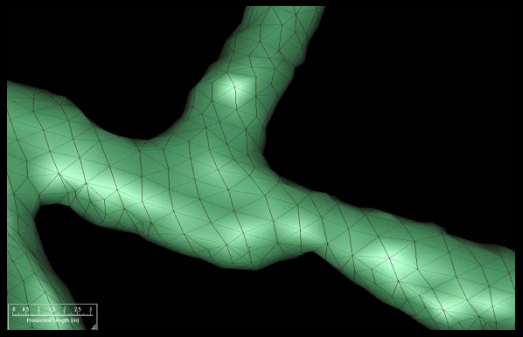


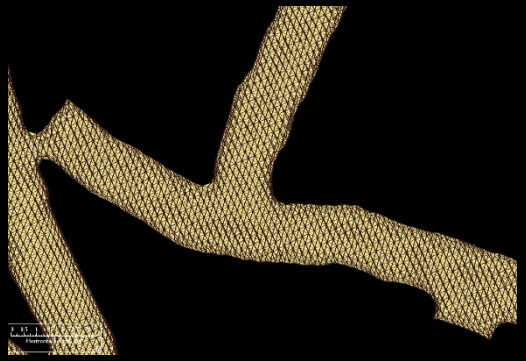
Voxet with region





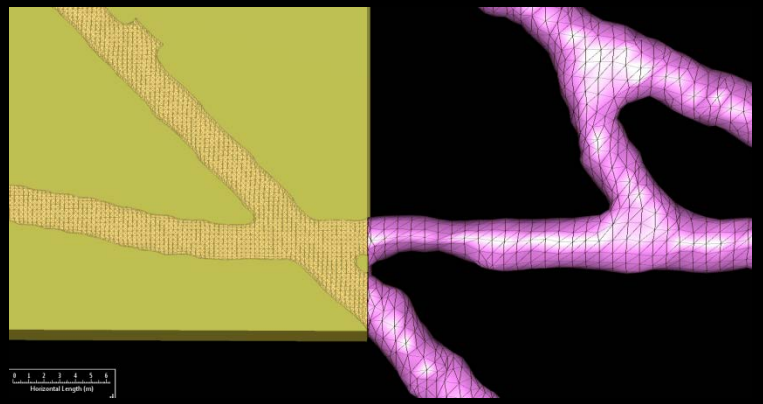
Grid Iso-property





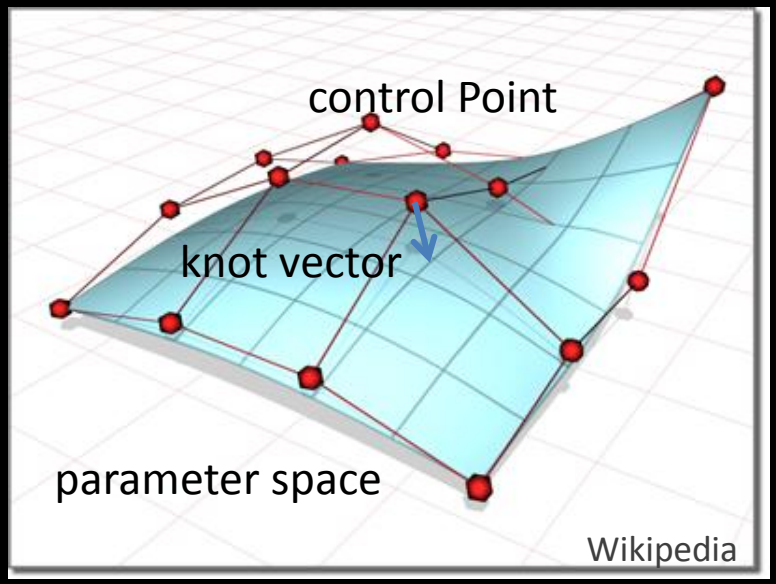
sensitive doamin

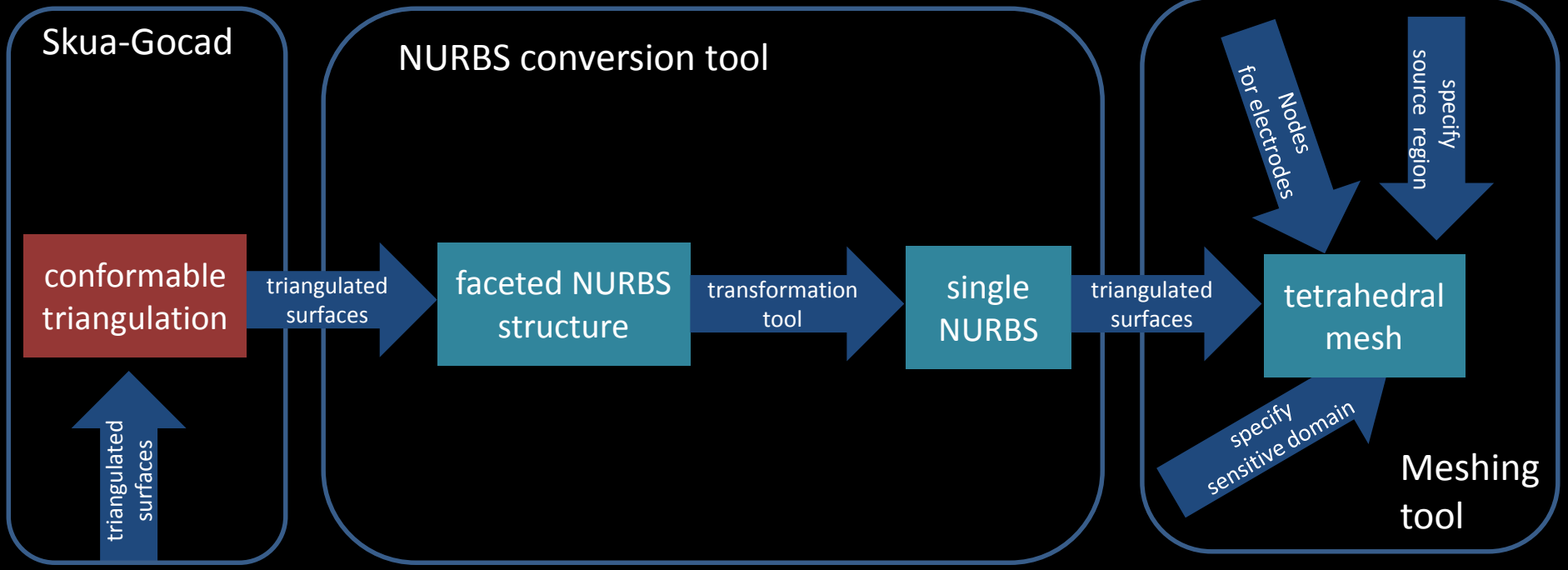
marginal domain



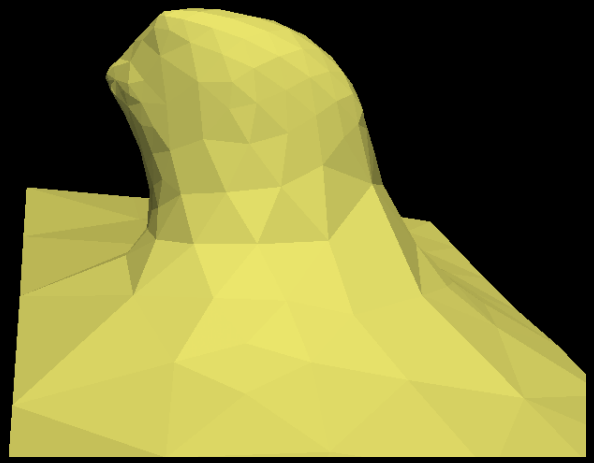
Approach 2: NURBS

Representation o complex free forms by a continuous function

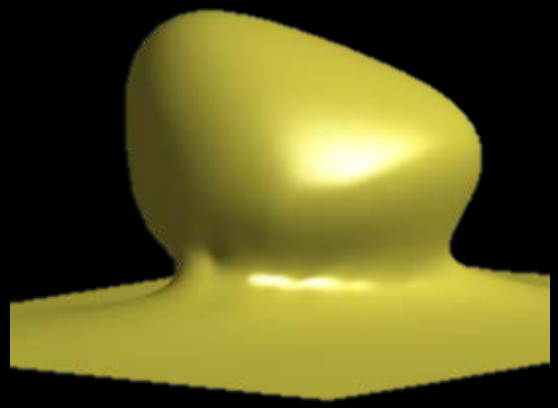




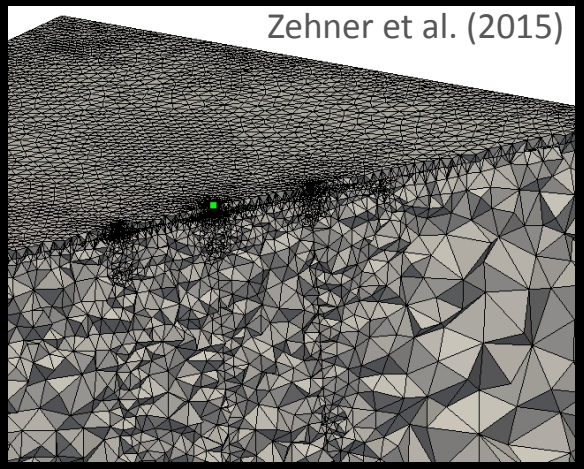
Approach 2: NURBS function



faceted NURBS strucuture



NURBS



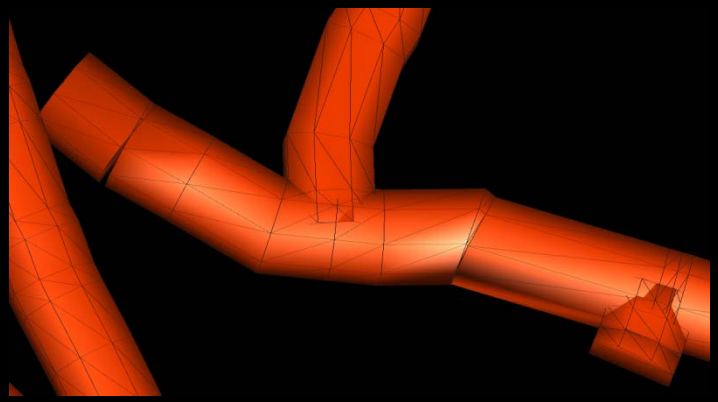
unstructured tetrahedral mesh

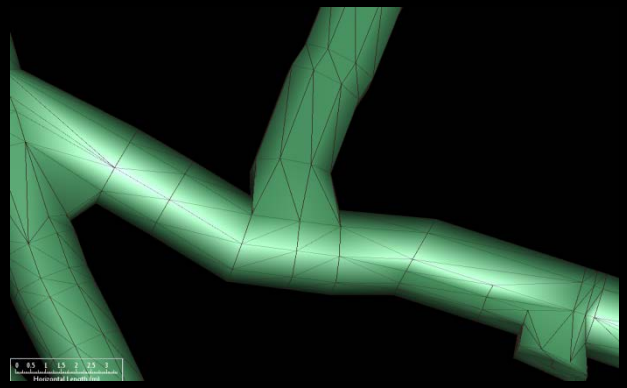
Advantages: Volume tesselation independent on surface mesh
Detailed, flexible, adaptive mesh refinement

Disadvantages: Watertight boundary representation
Model size and coordinates
Some Conversion tools need unique z-values

Approach 2: NURBS Function

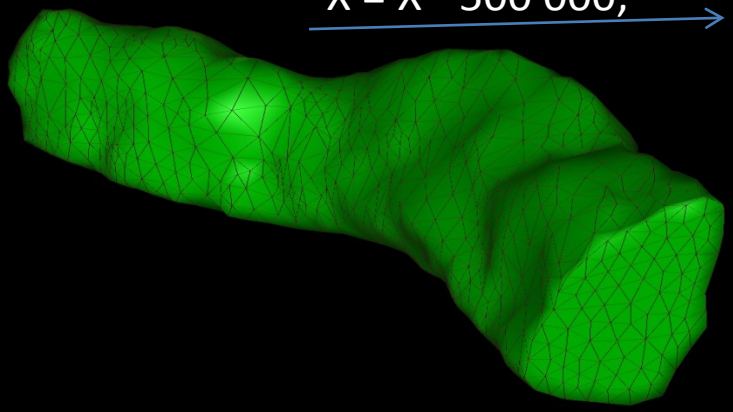
Coherent triangulation

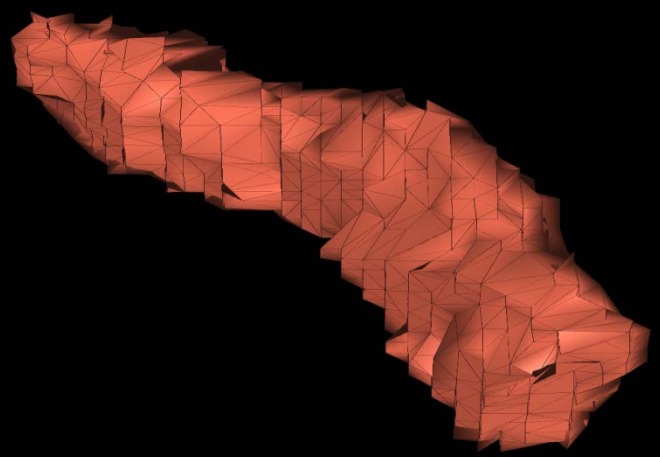




Translate to Coordinate Origin

X = X - 500 000;





Find a suitable NURBS conversion tool Rhino ☹ Ansys ☹

Conclusions

The good news:
There are many applications for the 3D model with practical relevance

Cableless data transmission
Ore exploration
Air way simulation
Mine management

The problem:
Some of these applications require very specific discretizations of the model

The questions:
Who knows a good NURBS conversion tool that can deal with multiple Z-values?
How to specify automatically the source regions of 100 electrodes?
What is the best data model with regard to the DC experiments?