

# 3D Geophysical Inversion for Surface-Based Model Geometry



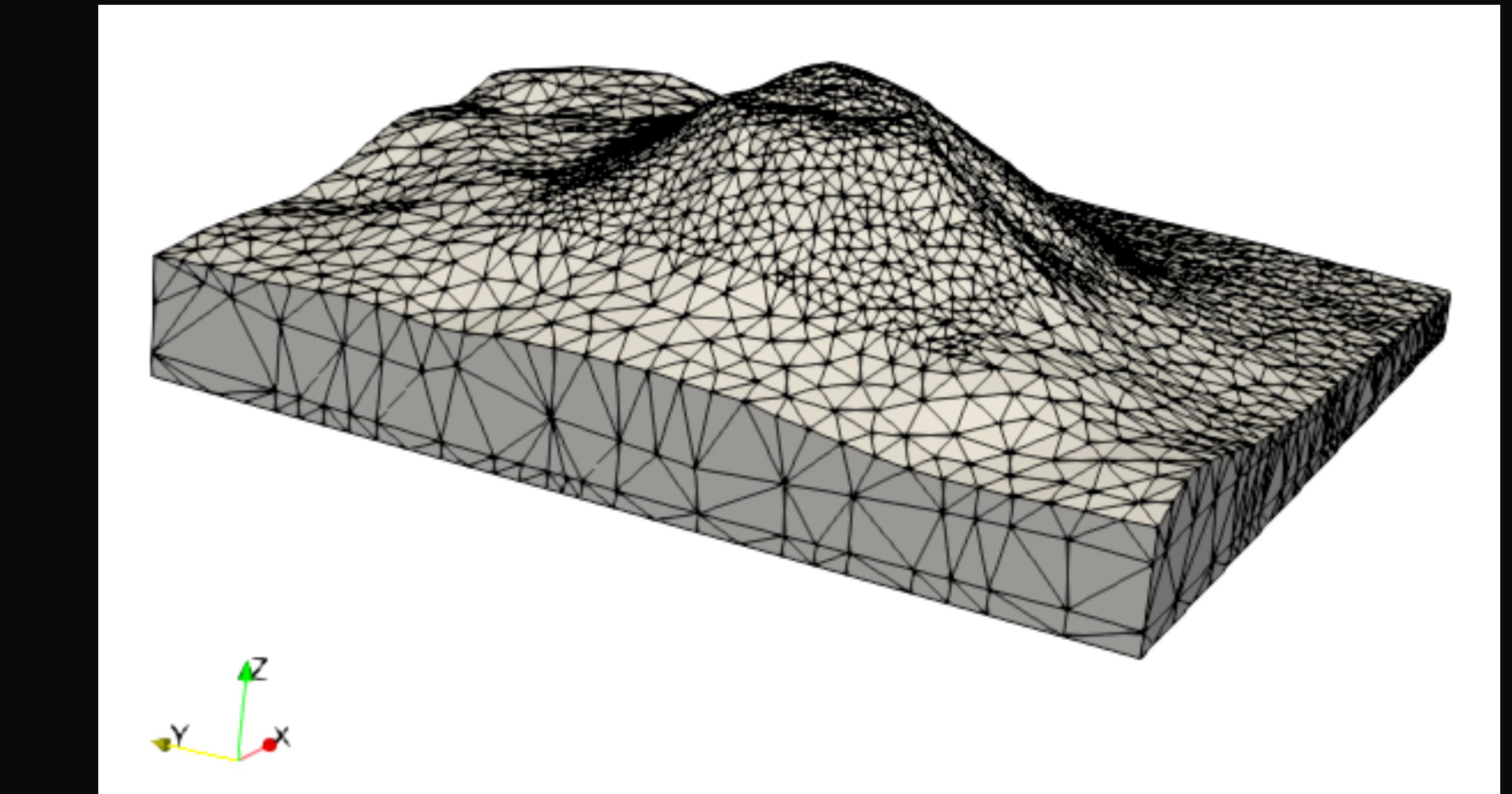
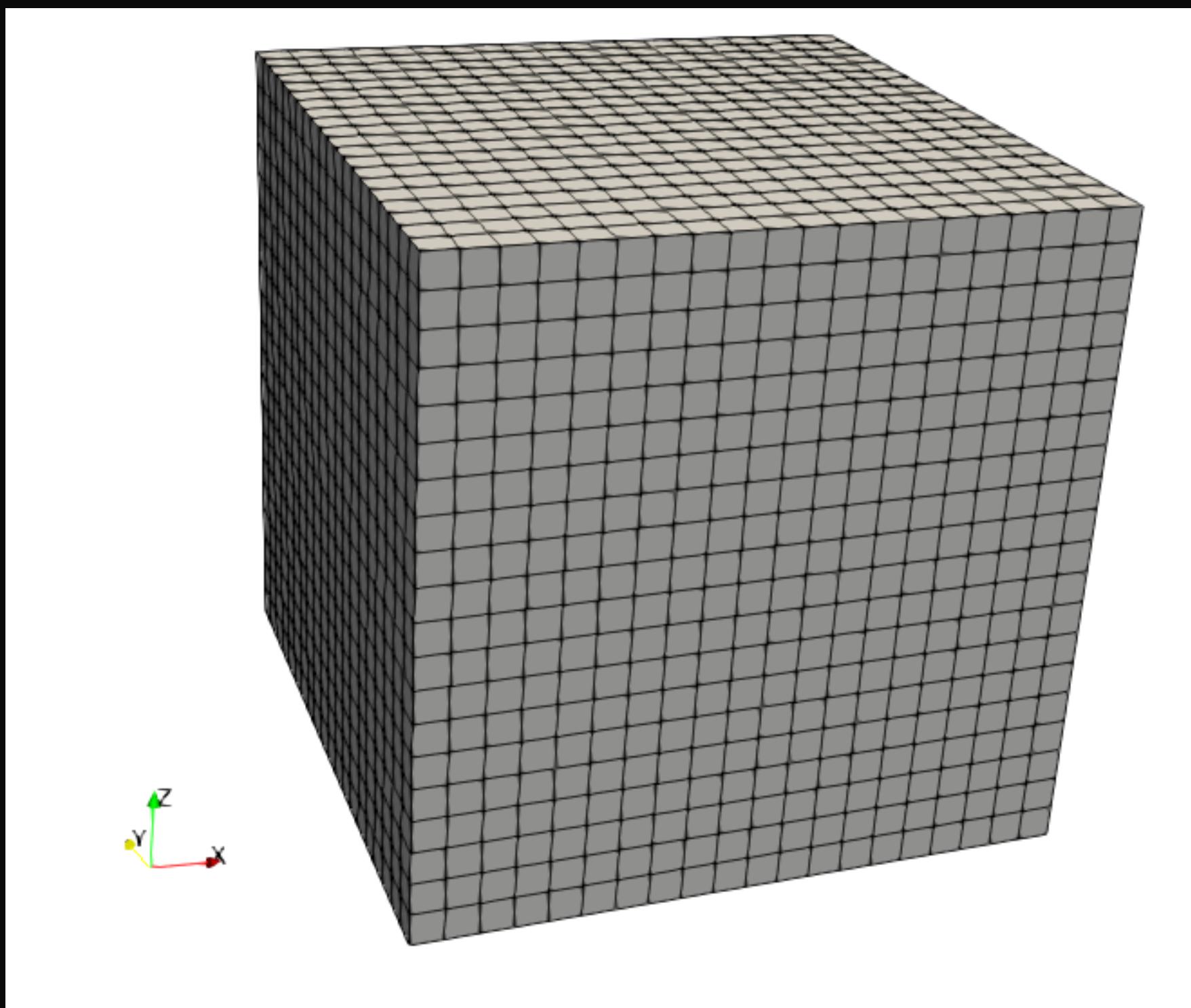
Peter Lelièvre, Christopher Galley  
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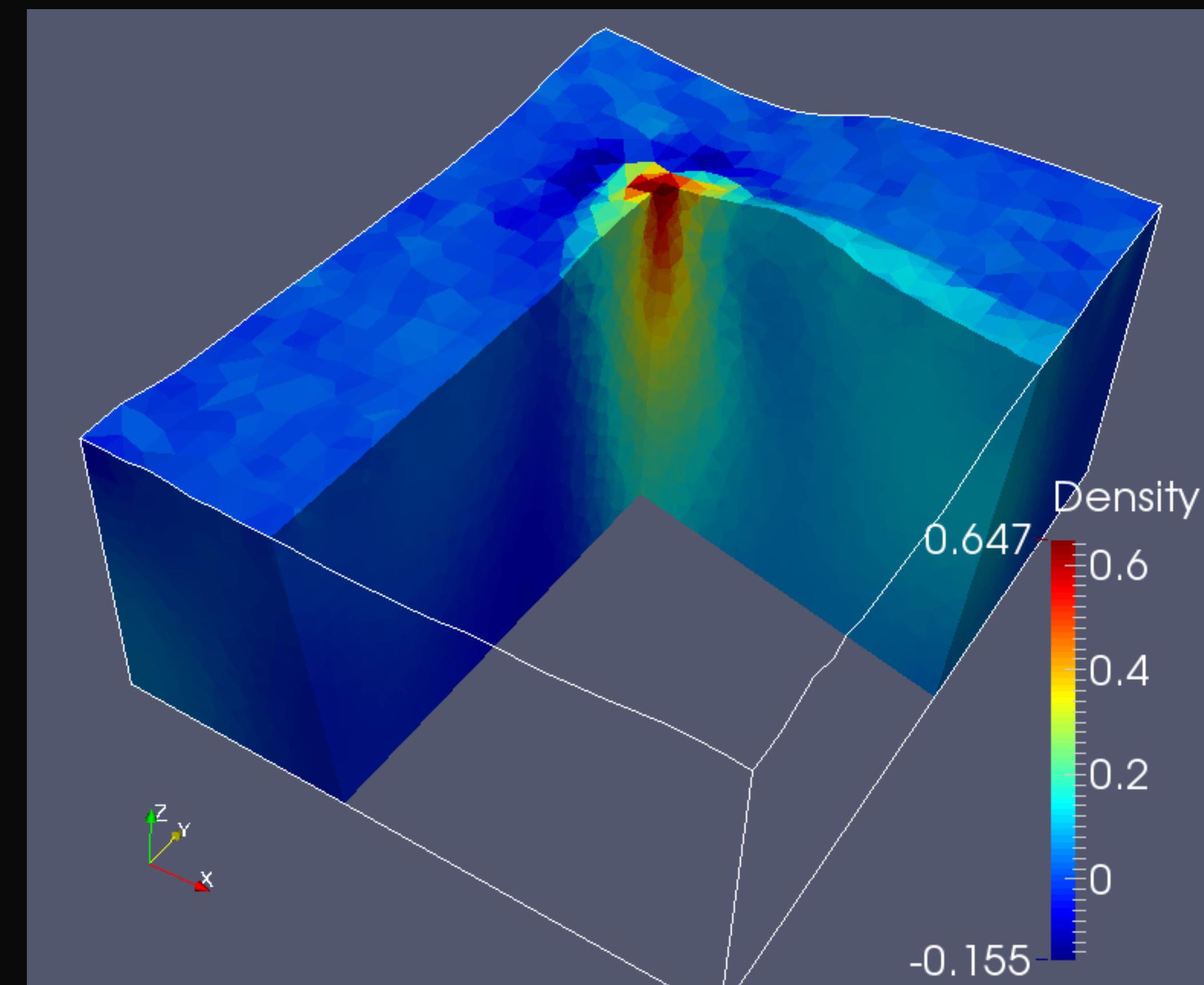
[plelievre@mun.ca](mailto:plelievre@mun.ca)



- ▶ Physical property distributions
- ▶ Many parameters
- ▶ General



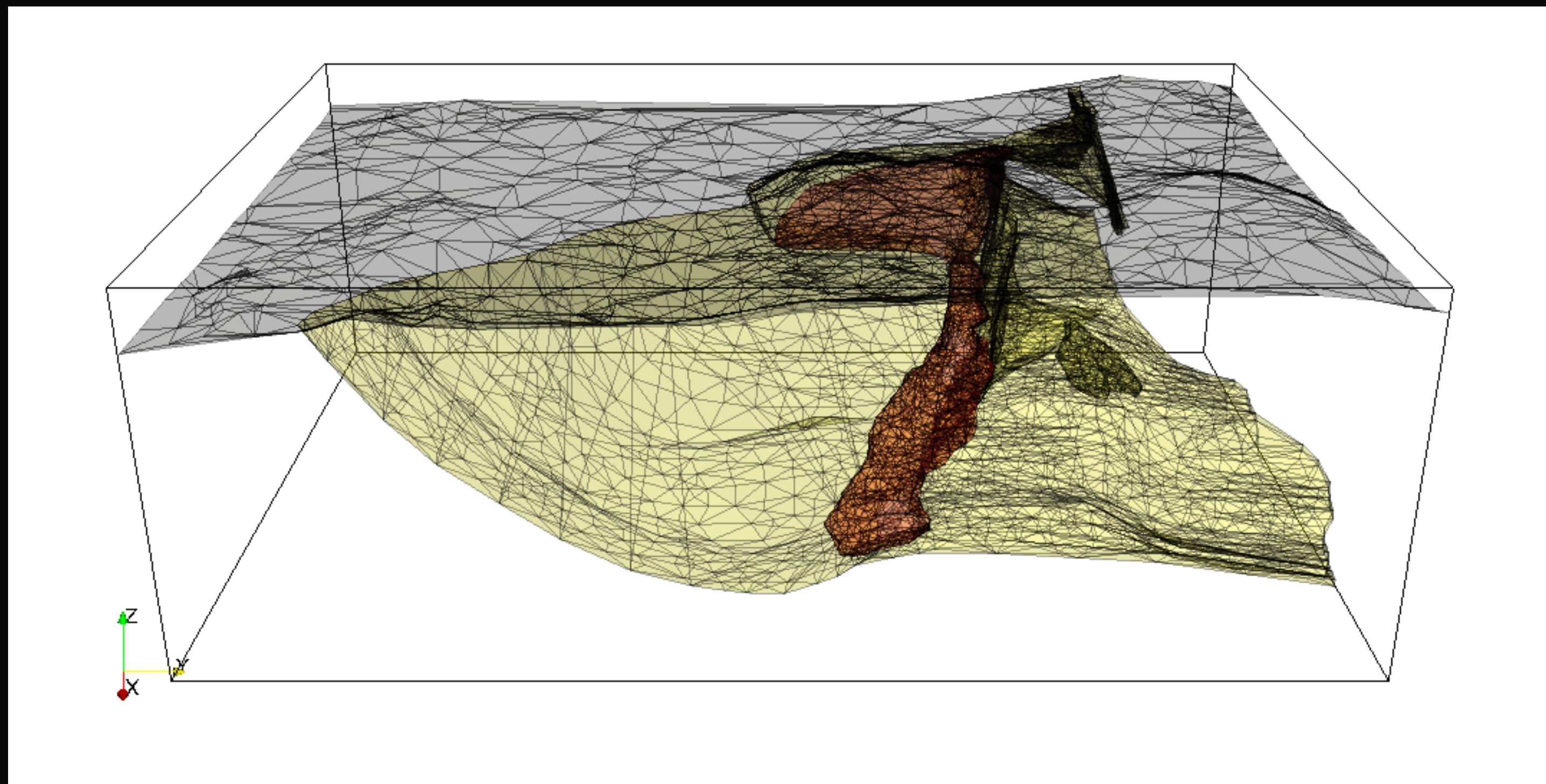
- ▶ Smooth distributions
- ▶ Inconsistent?



# What is surface-geometry inversion?



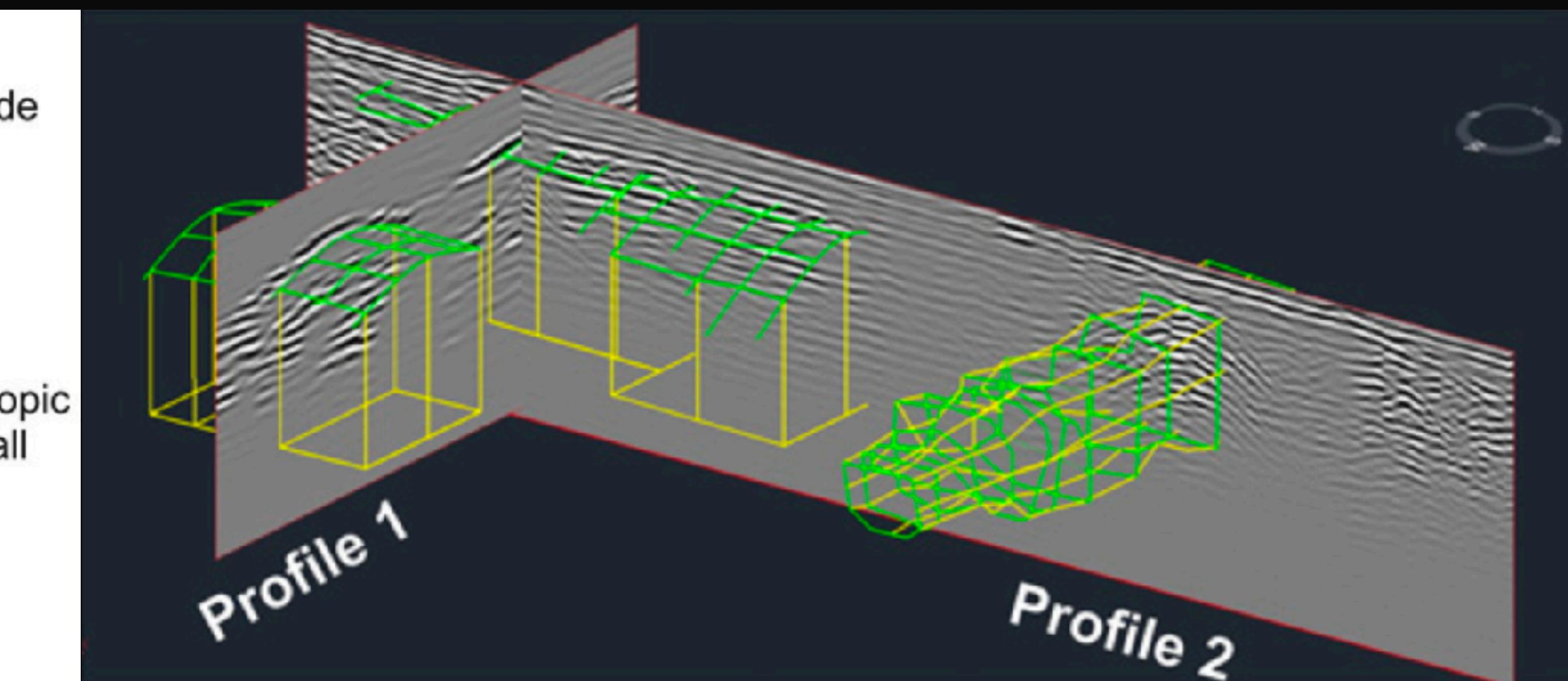
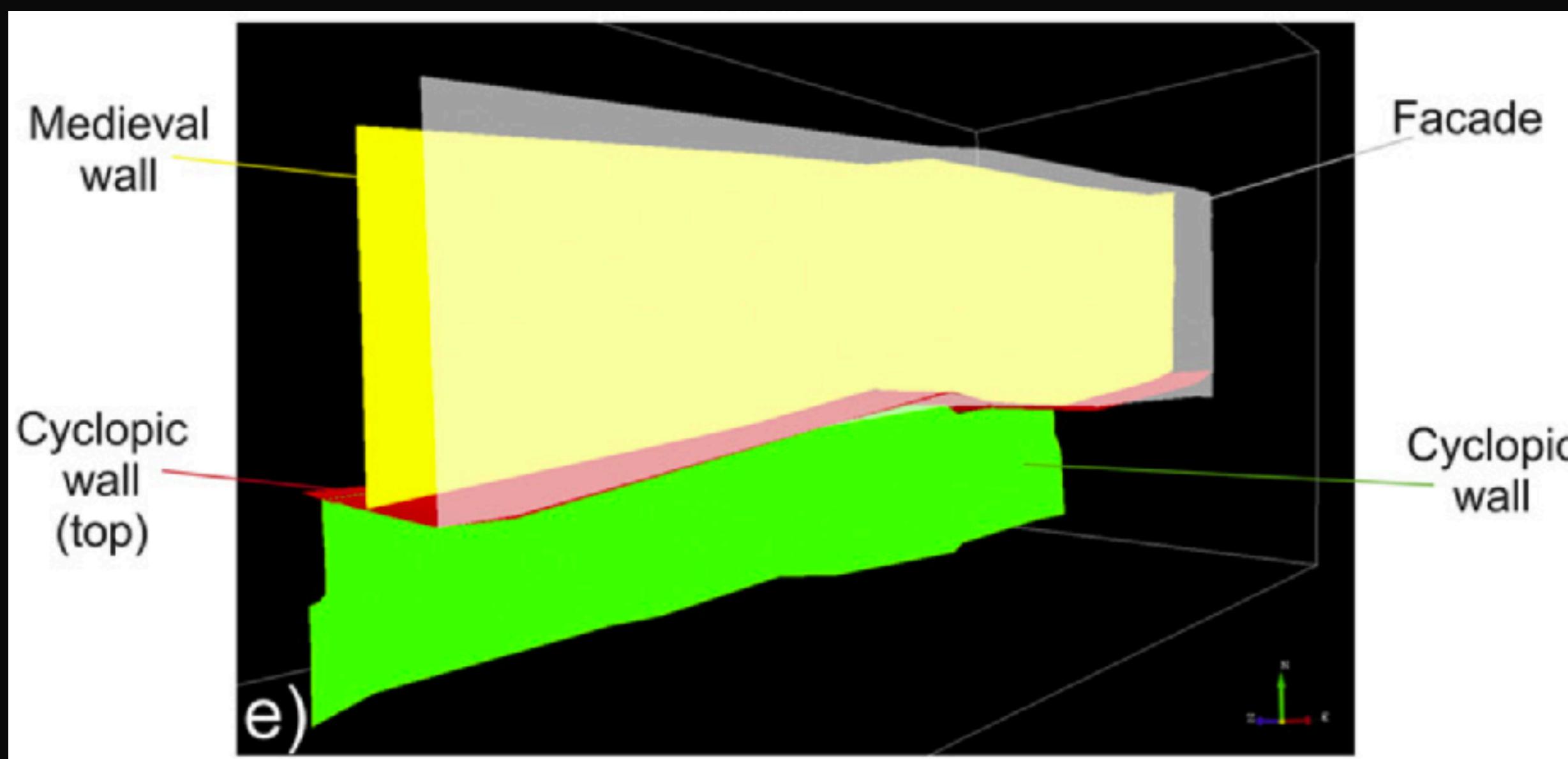
- ▶ Fundamentally different
- ▶ Use geological models directly



# What is surface-geometry inversion?



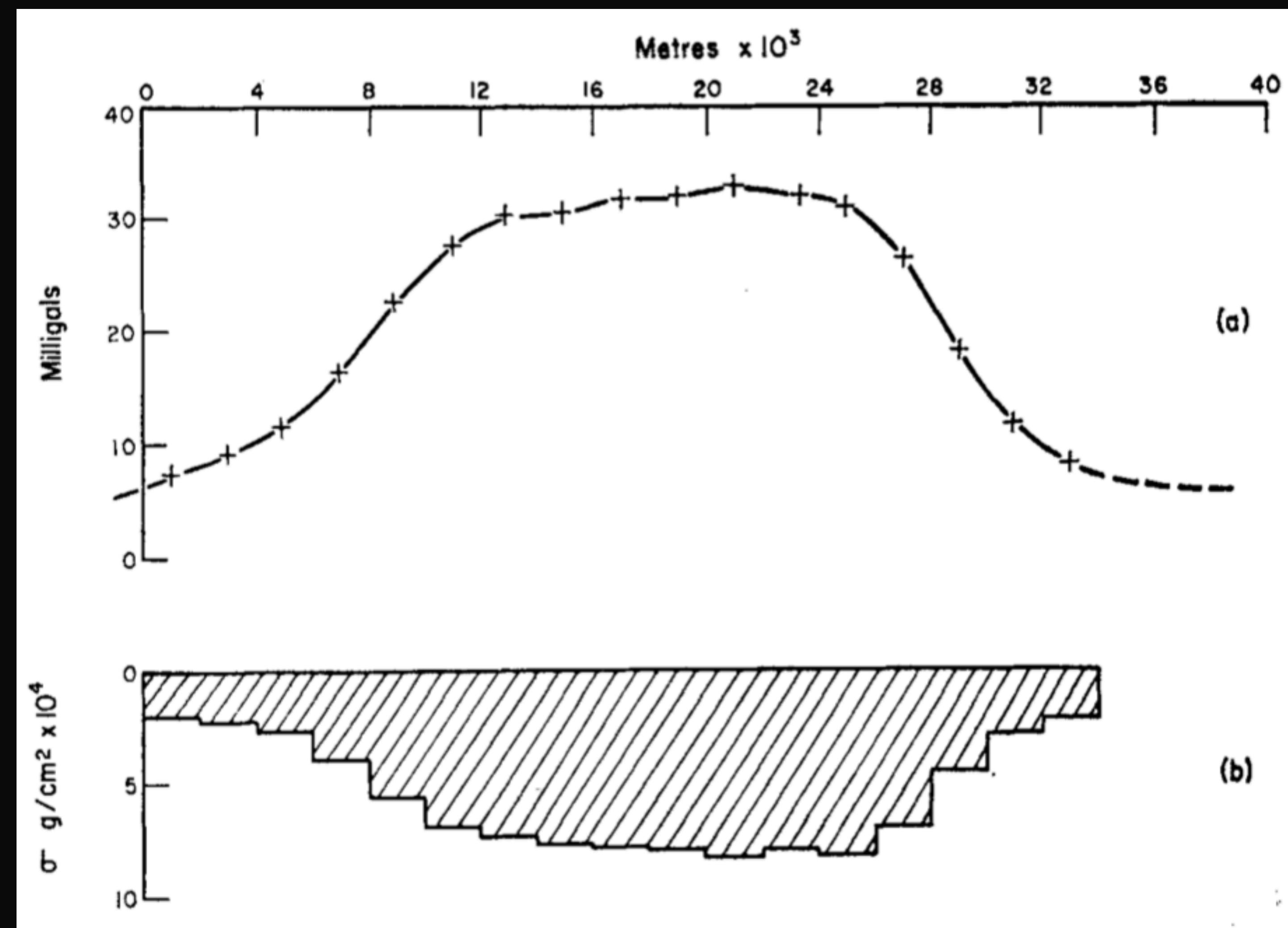
- ▶ Fundamentally different
- ▶ Use archaeological, etc., models directly



Ercoli et al., 2016, "Inside the polygonal walls of Amelia (Central Italy) ...", JAG

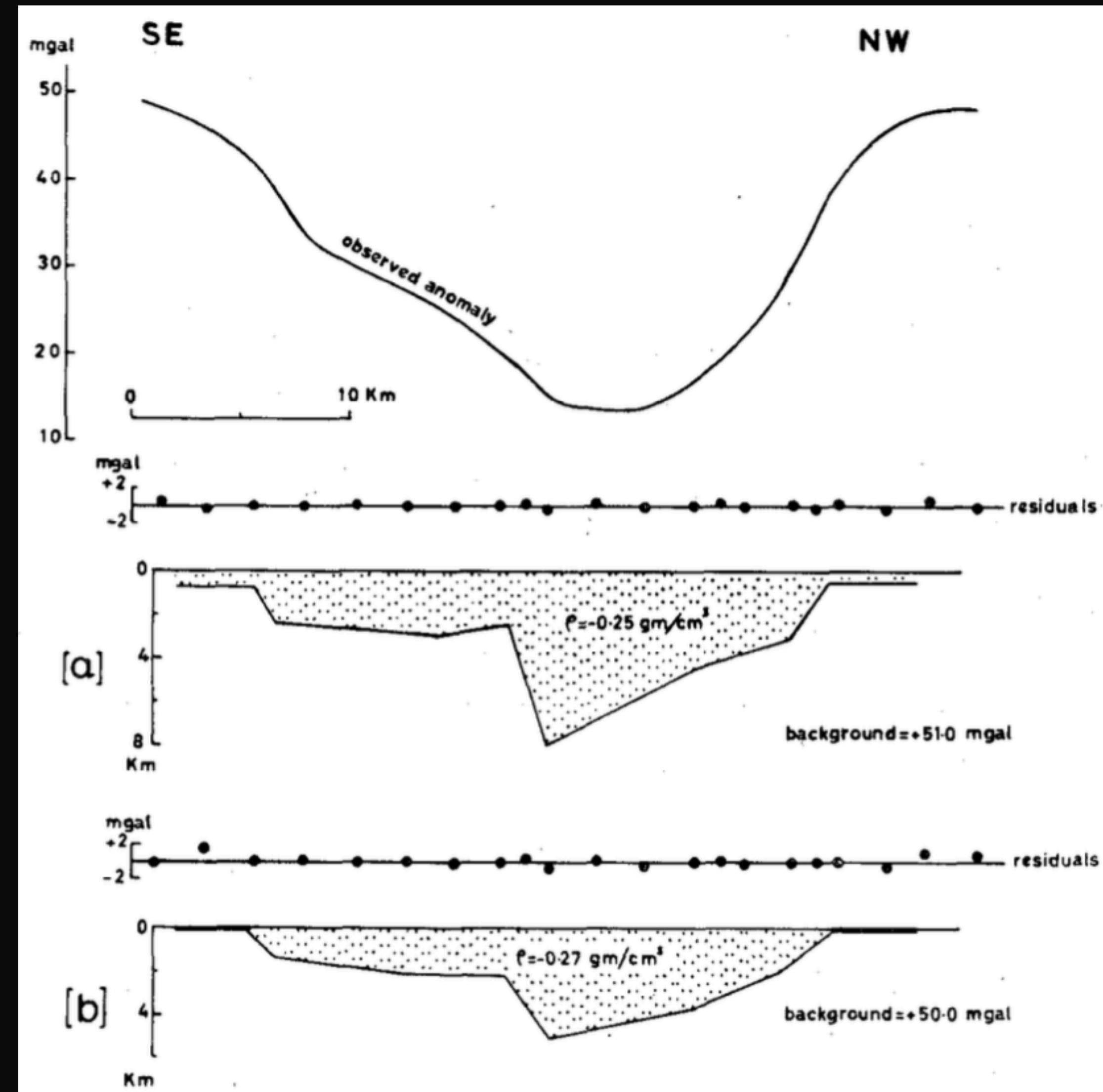
Panisova et al., 2016, "Geophysical fingerprints ... in the Church of St. George ...", JAG

# Historical attempts



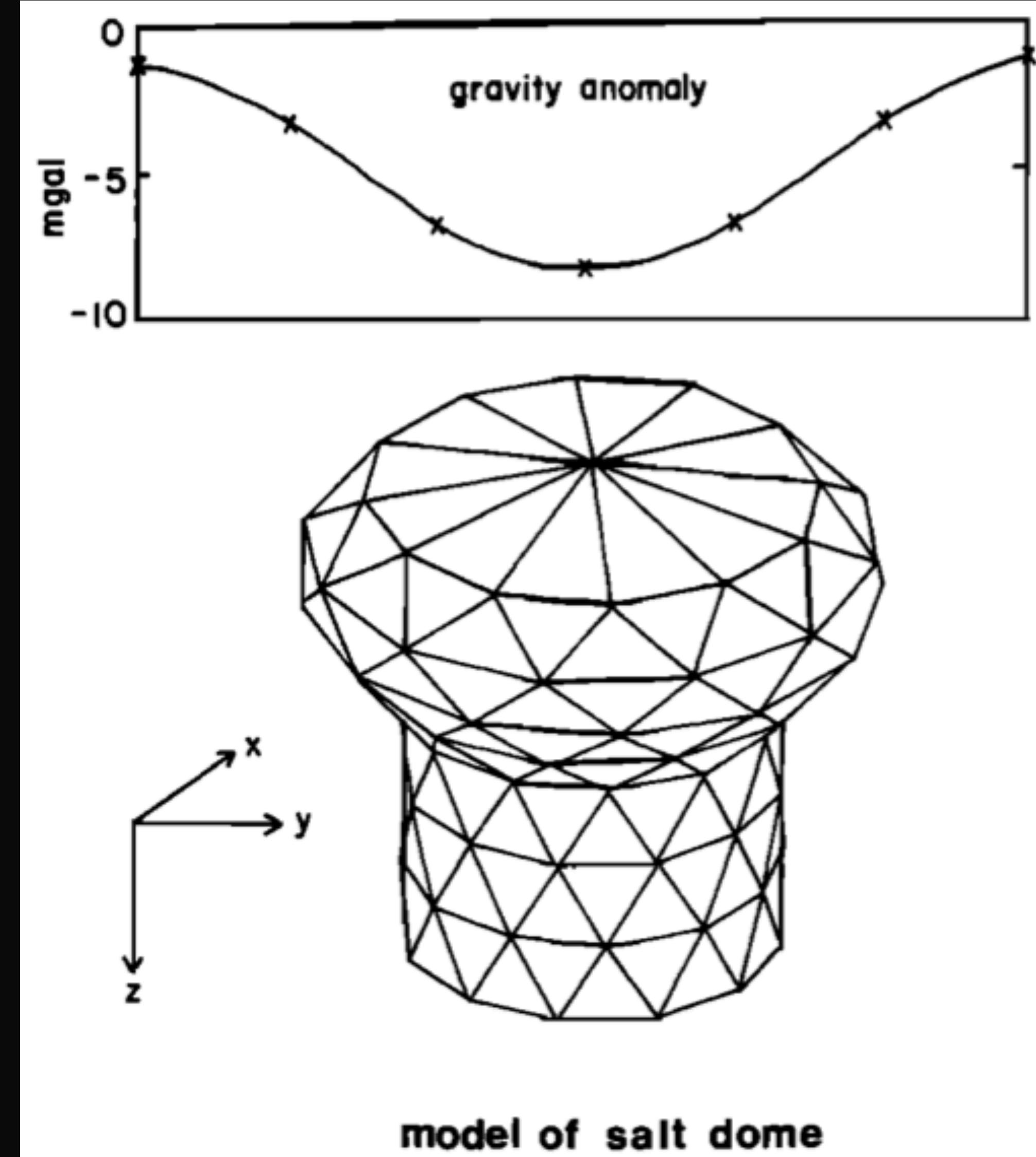
Tanner, 1967, An automated method of gravity interpretation, Geophys. J. R. Astr. Soc.

# Historical attempts



Al-Chalabi, 1971, Interpretation of gravity anomalies by non-linear optimisation, Geophys. Prosp.

# Historical attempts

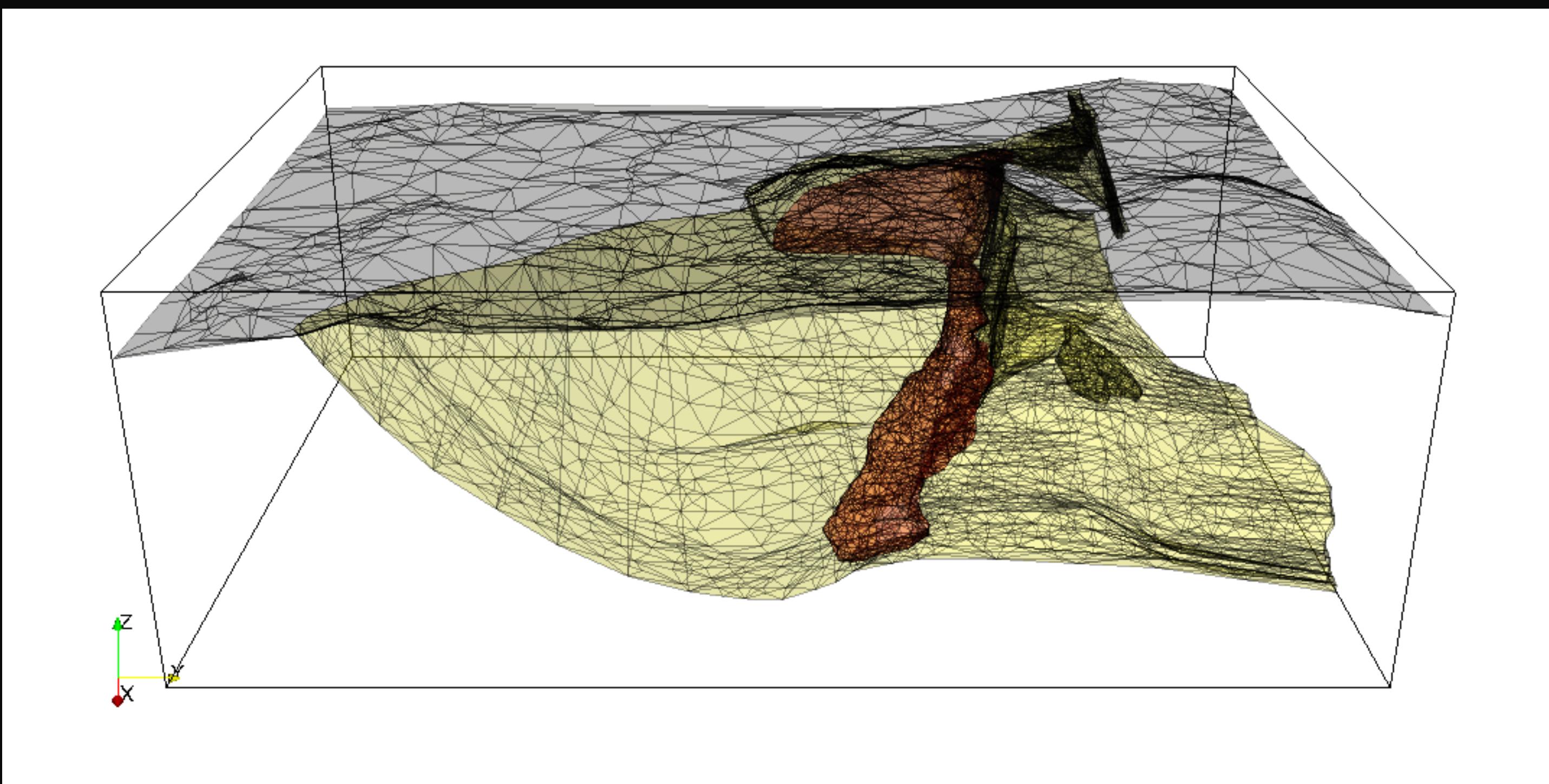


Richardson & MacInnes, 1989, The inversion of gravity data into three-dimensional polyhedral models, JGR

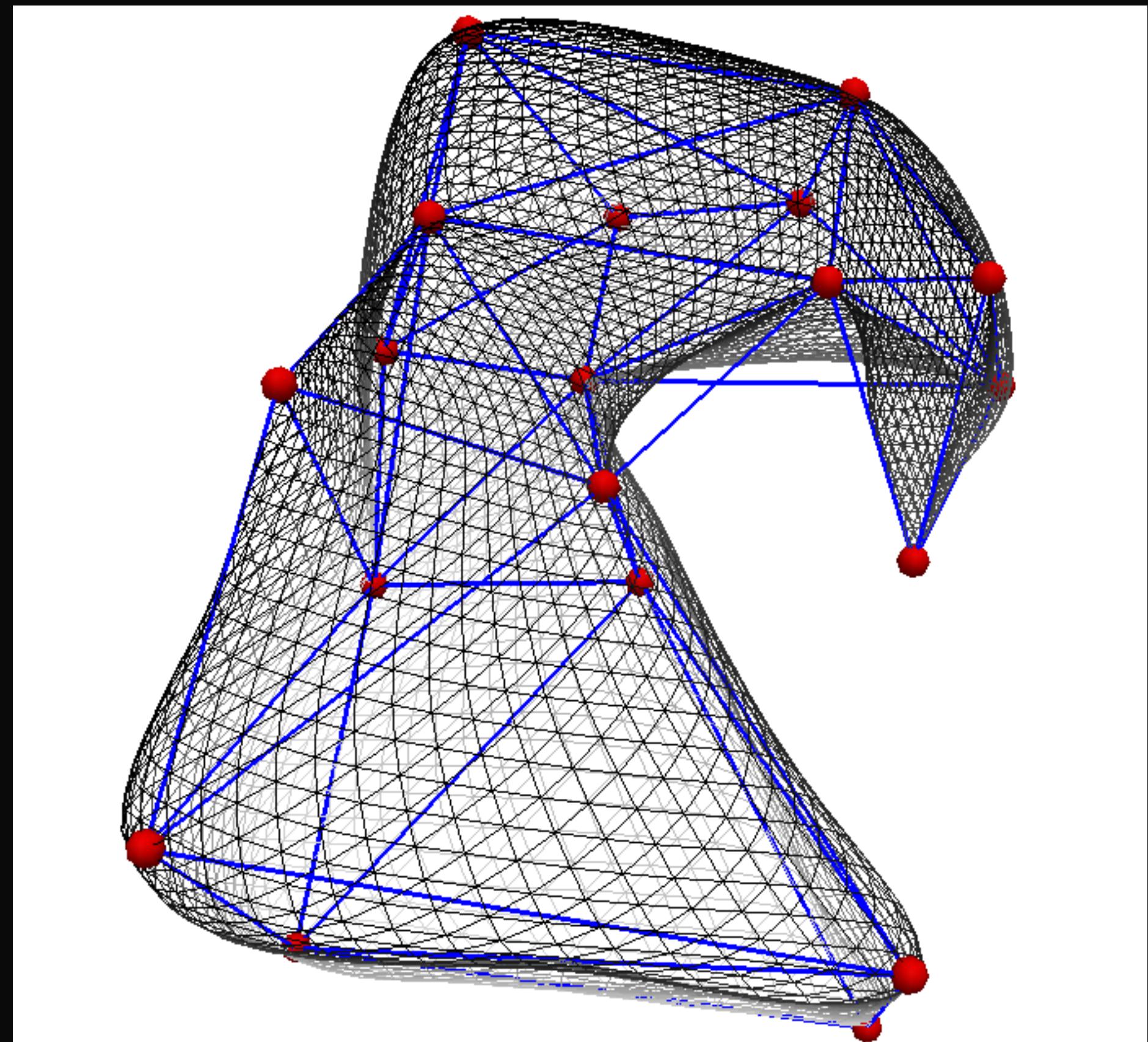
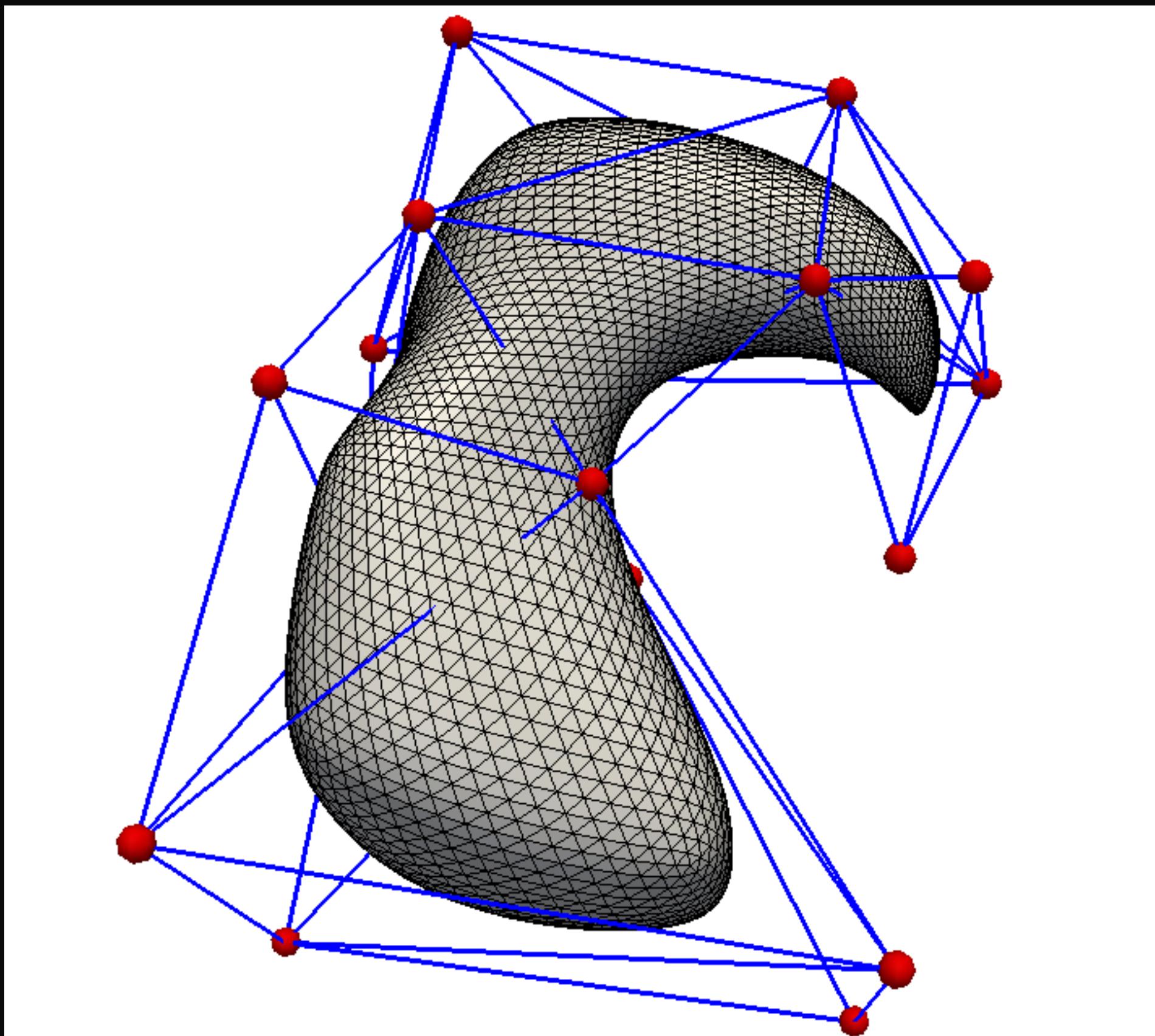
**1. Parameterize effectively  
and efficiently**

**2. Difficult numerical  
problem**

**3. Topological rules**



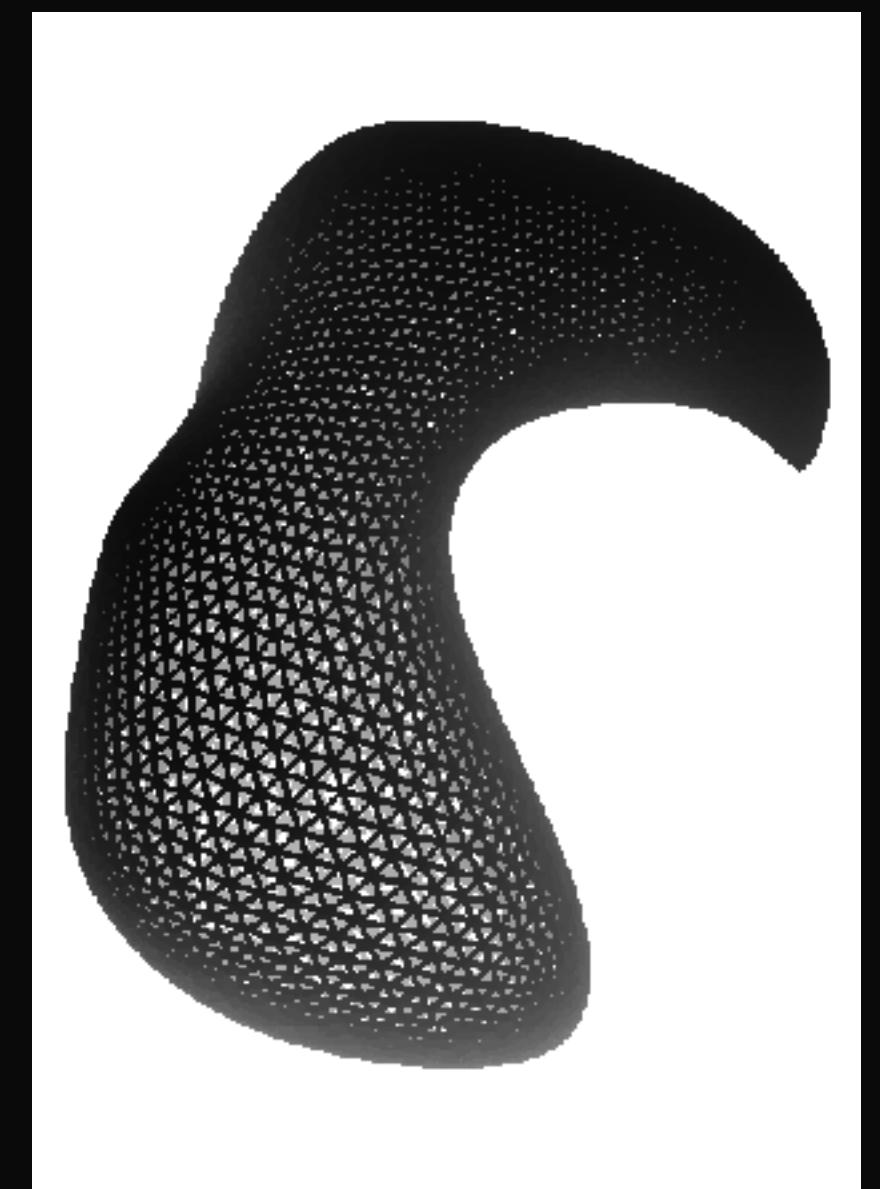
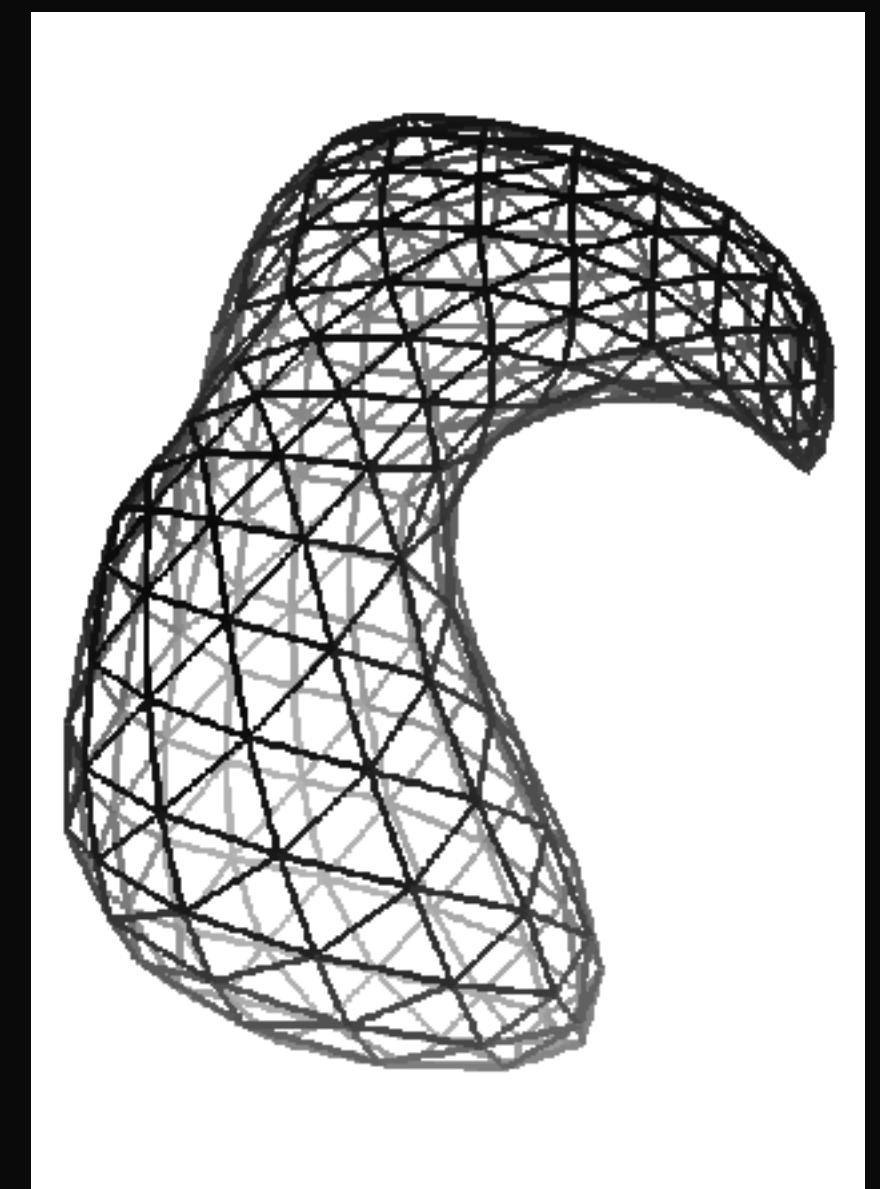
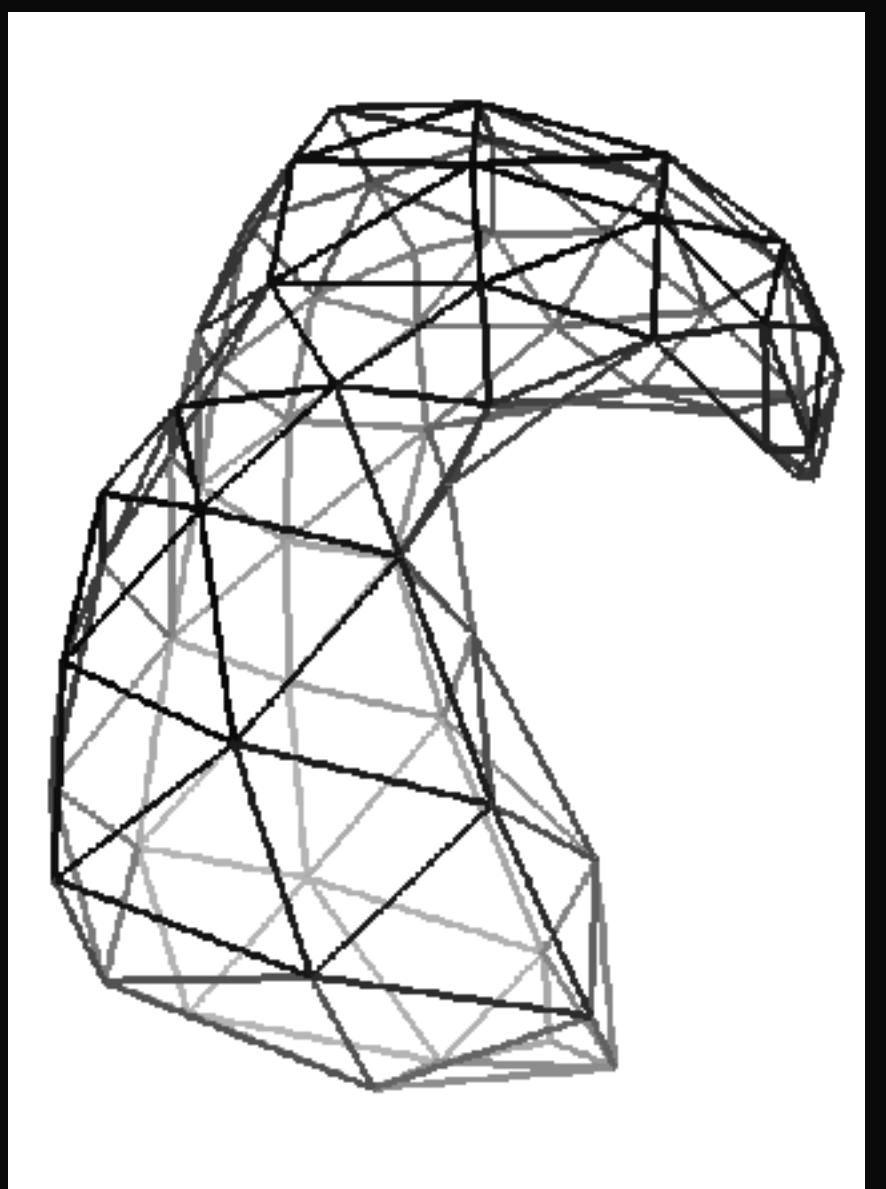
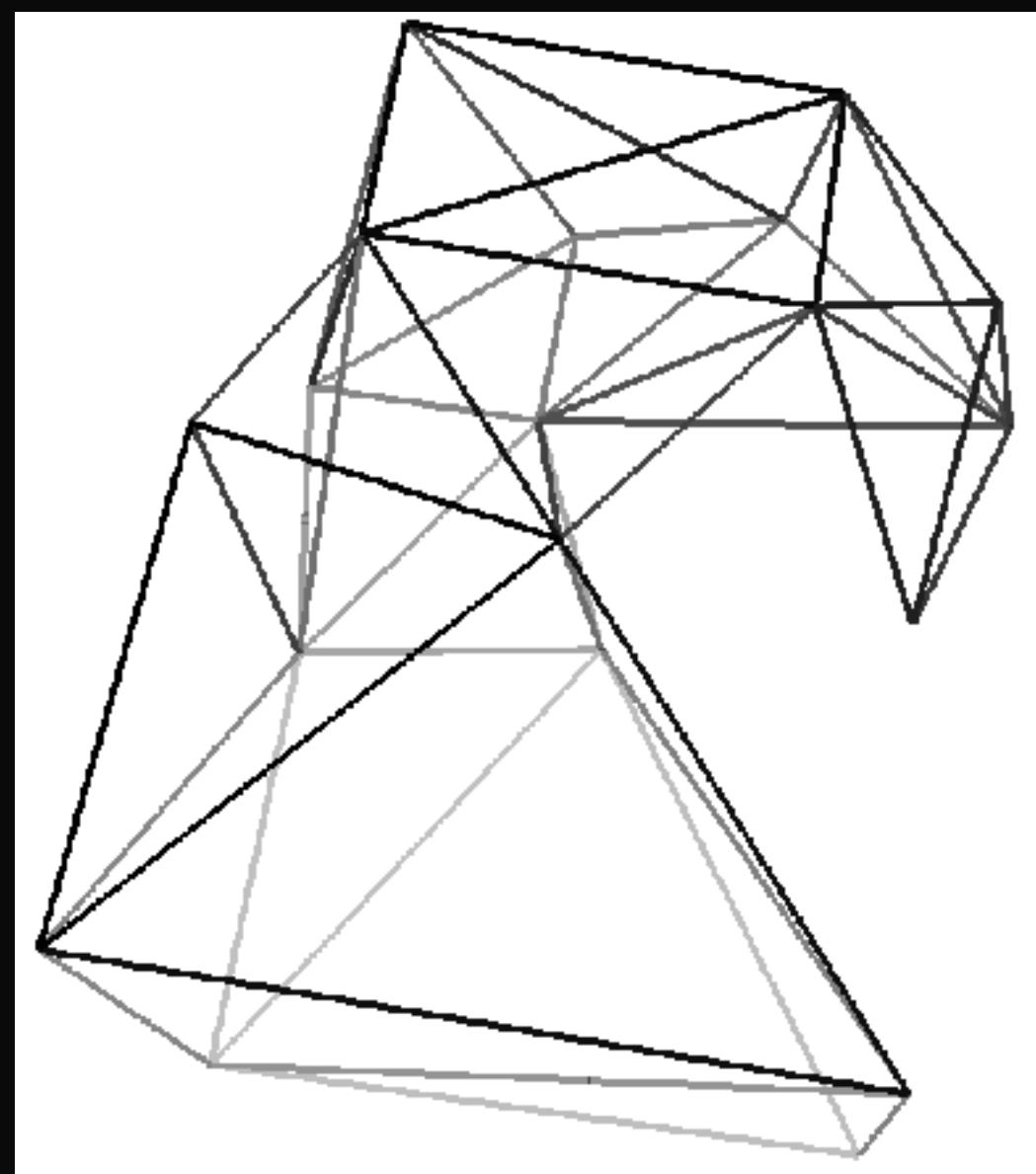
- ▶ Node coordinates
- ▶ Control nodes + splines



- ▶ Only misfit measure required

$$\Phi_d = \sum_i \left( \frac{F(m)_i - d_i}{\sigma_i} \right)^2$$

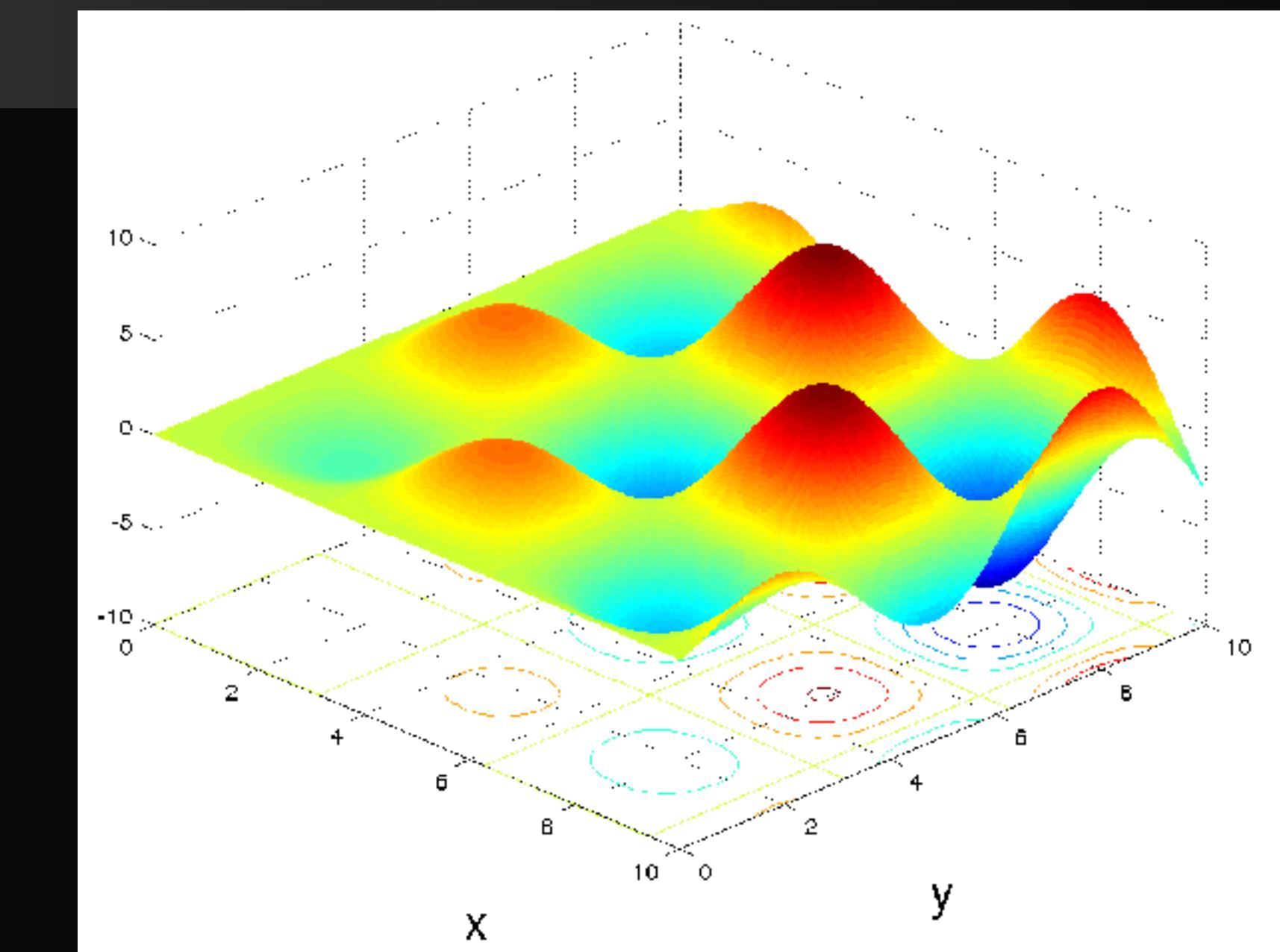
- ▶ Regularization optional



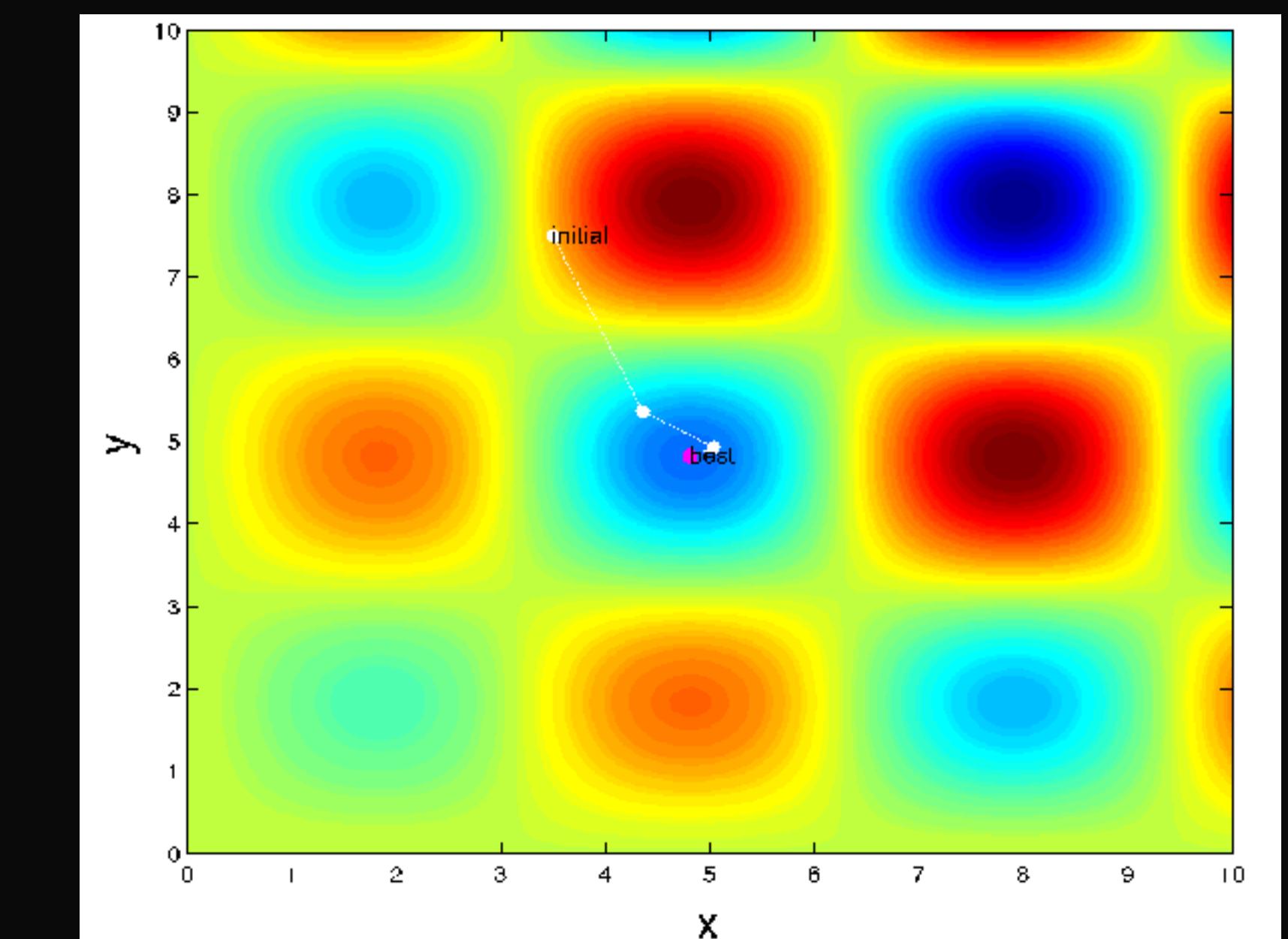
# Numerical solution



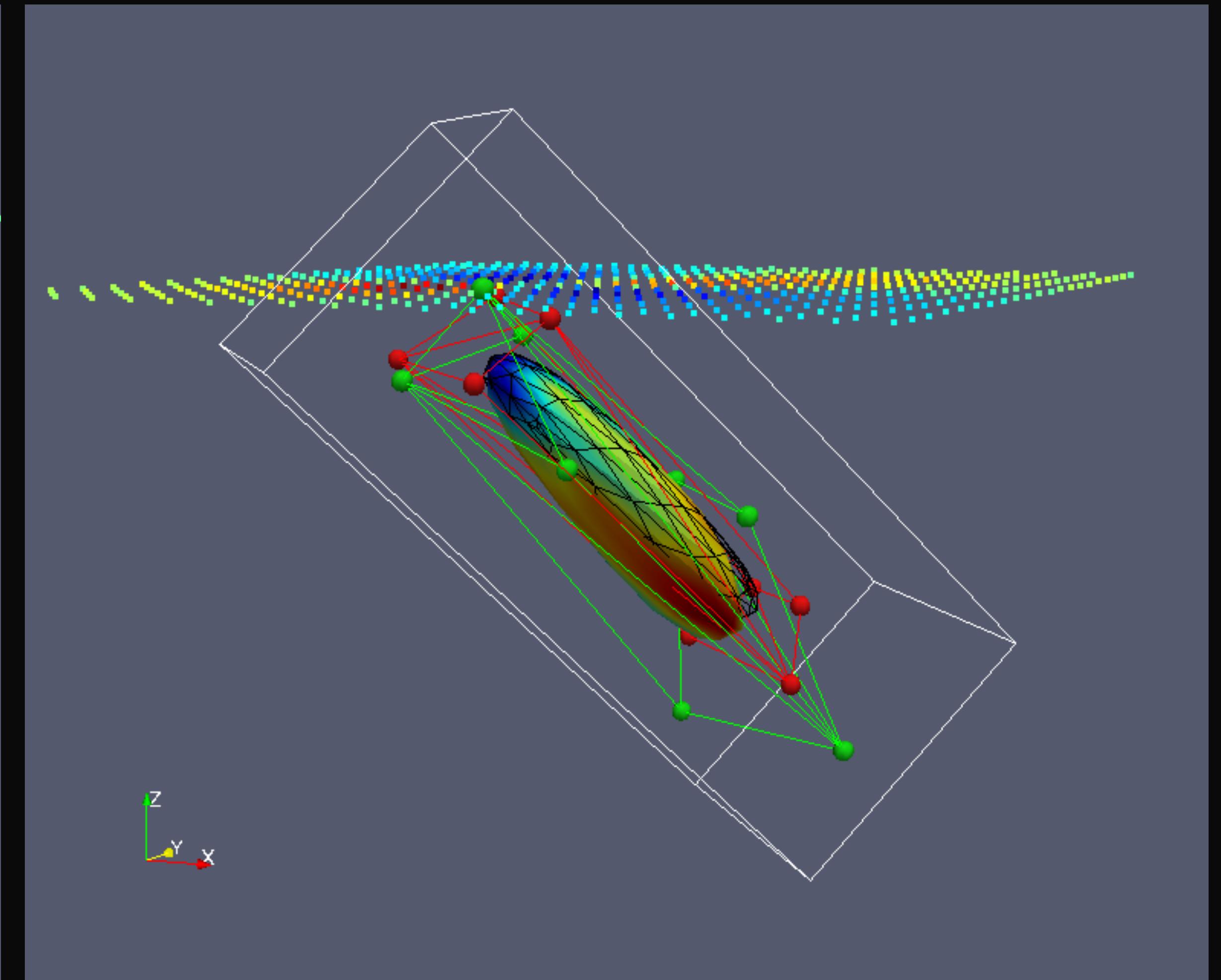
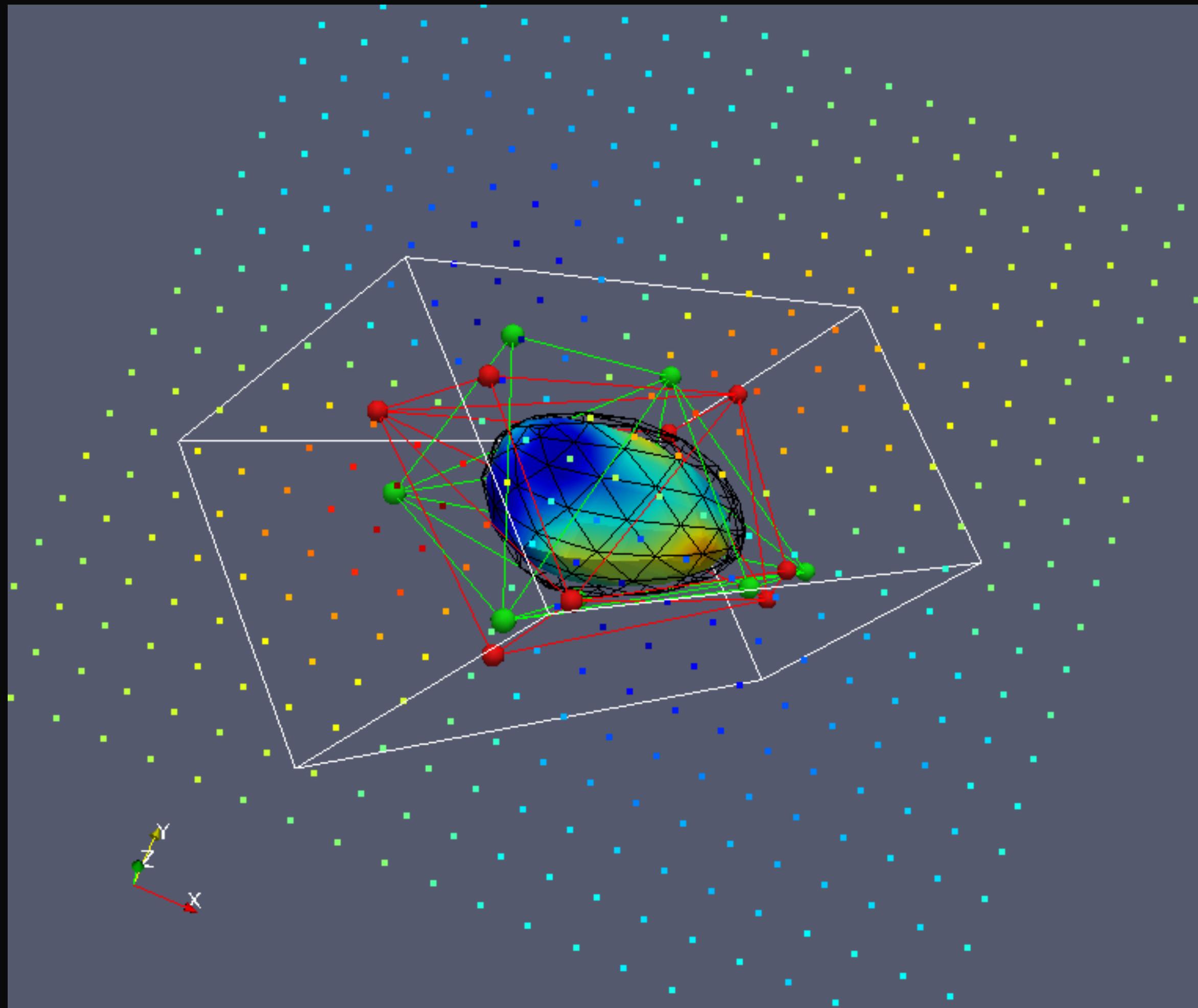
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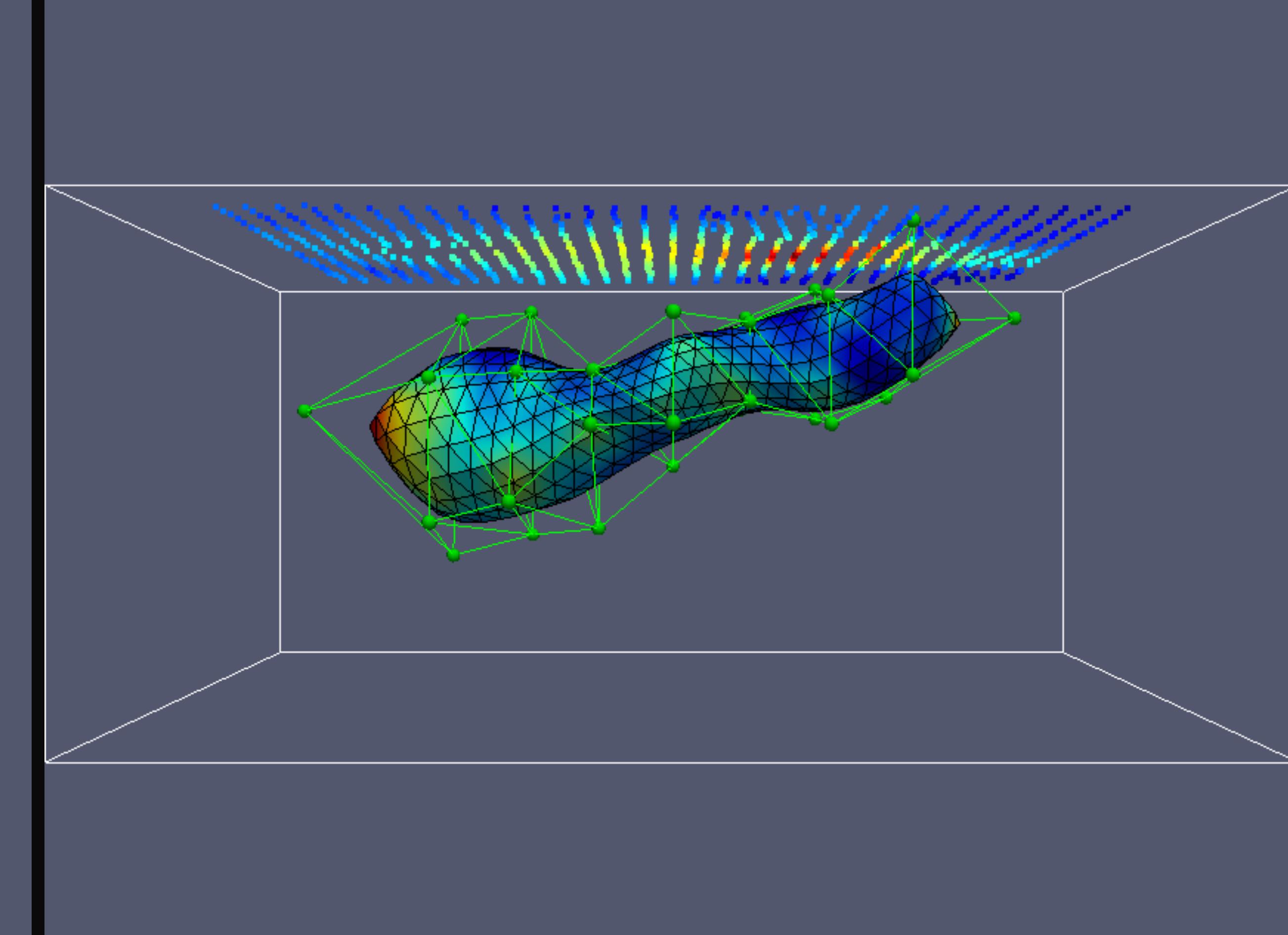
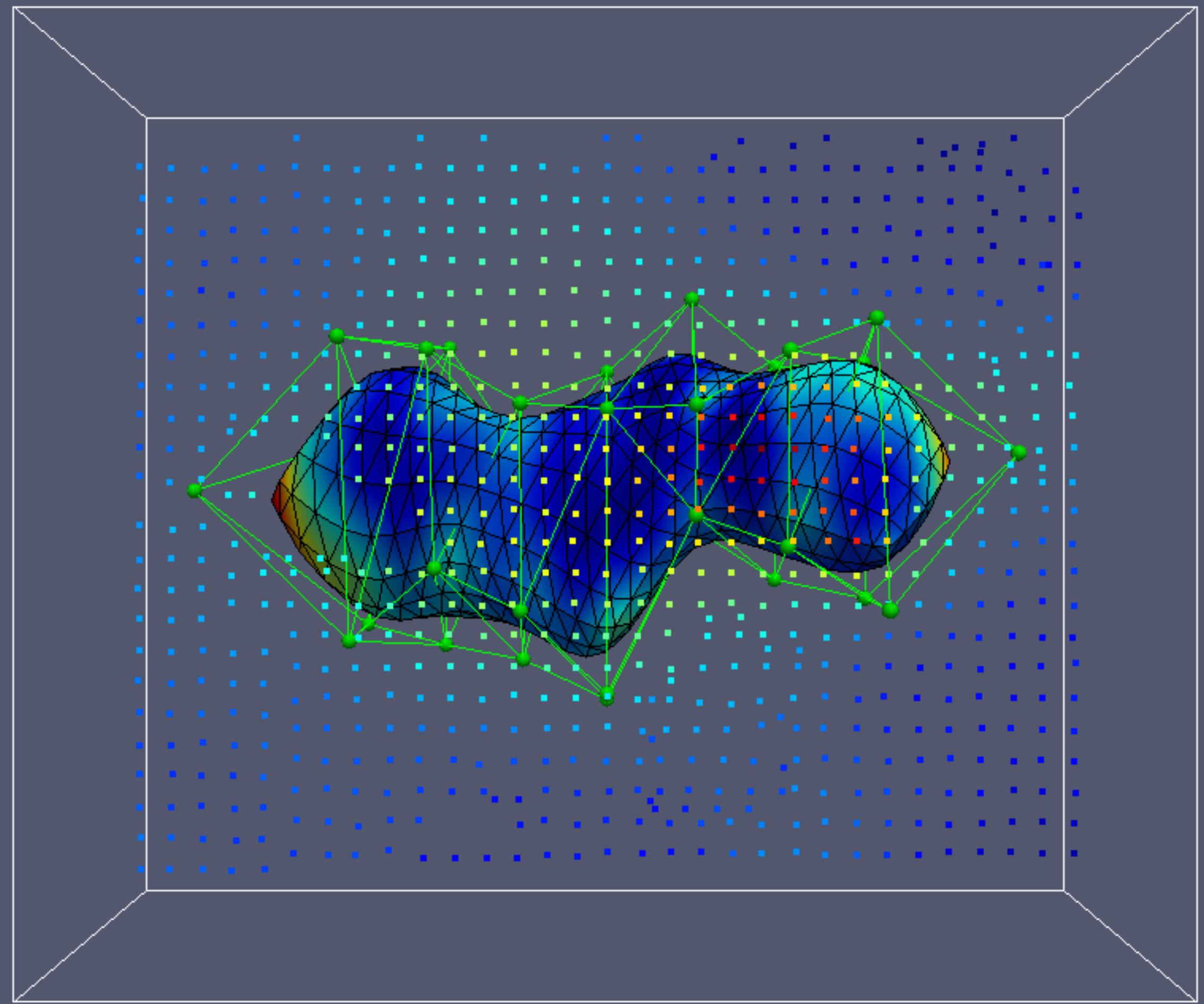
► Global optimization  
(PSO, GA, MCMC)



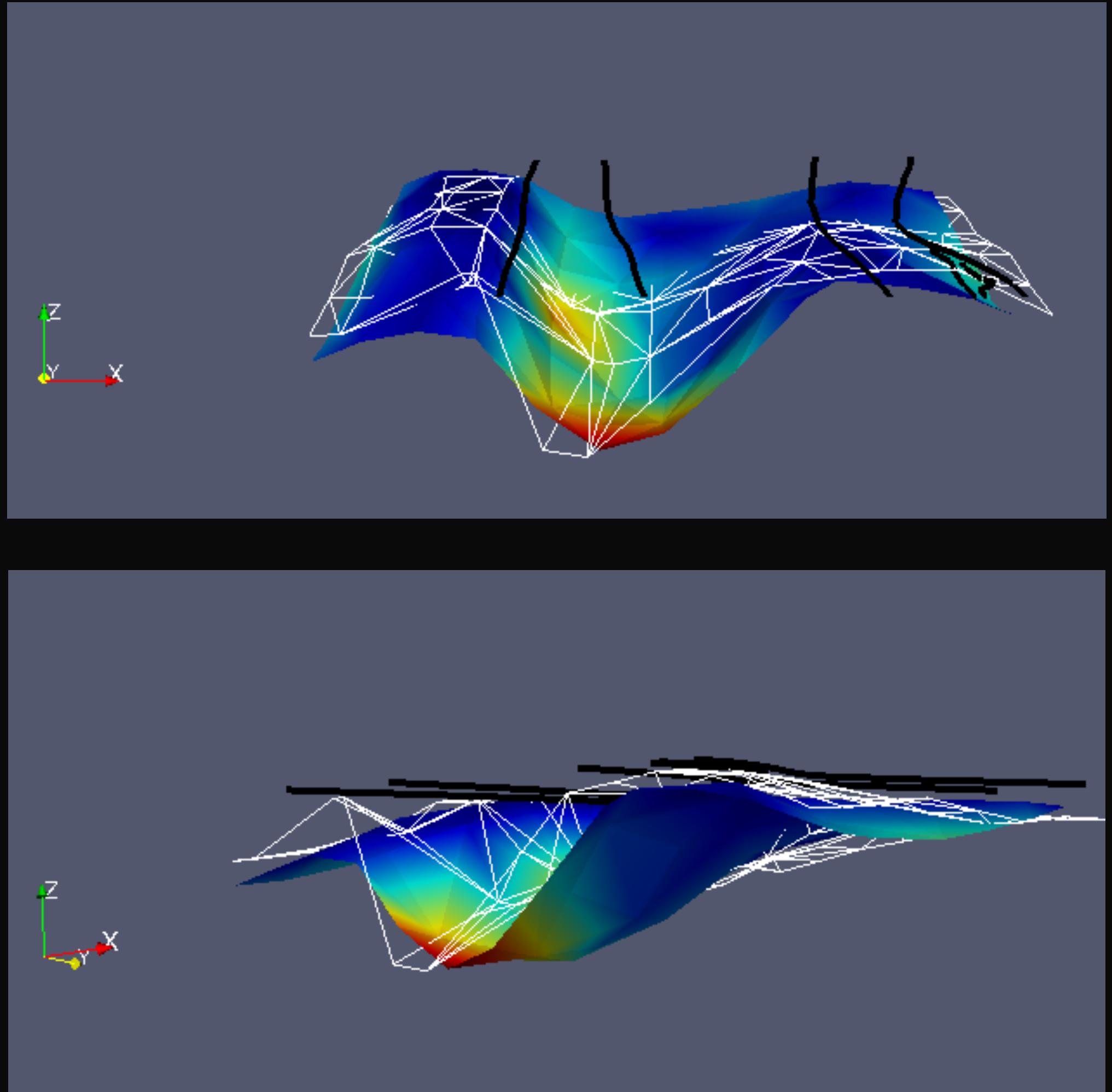
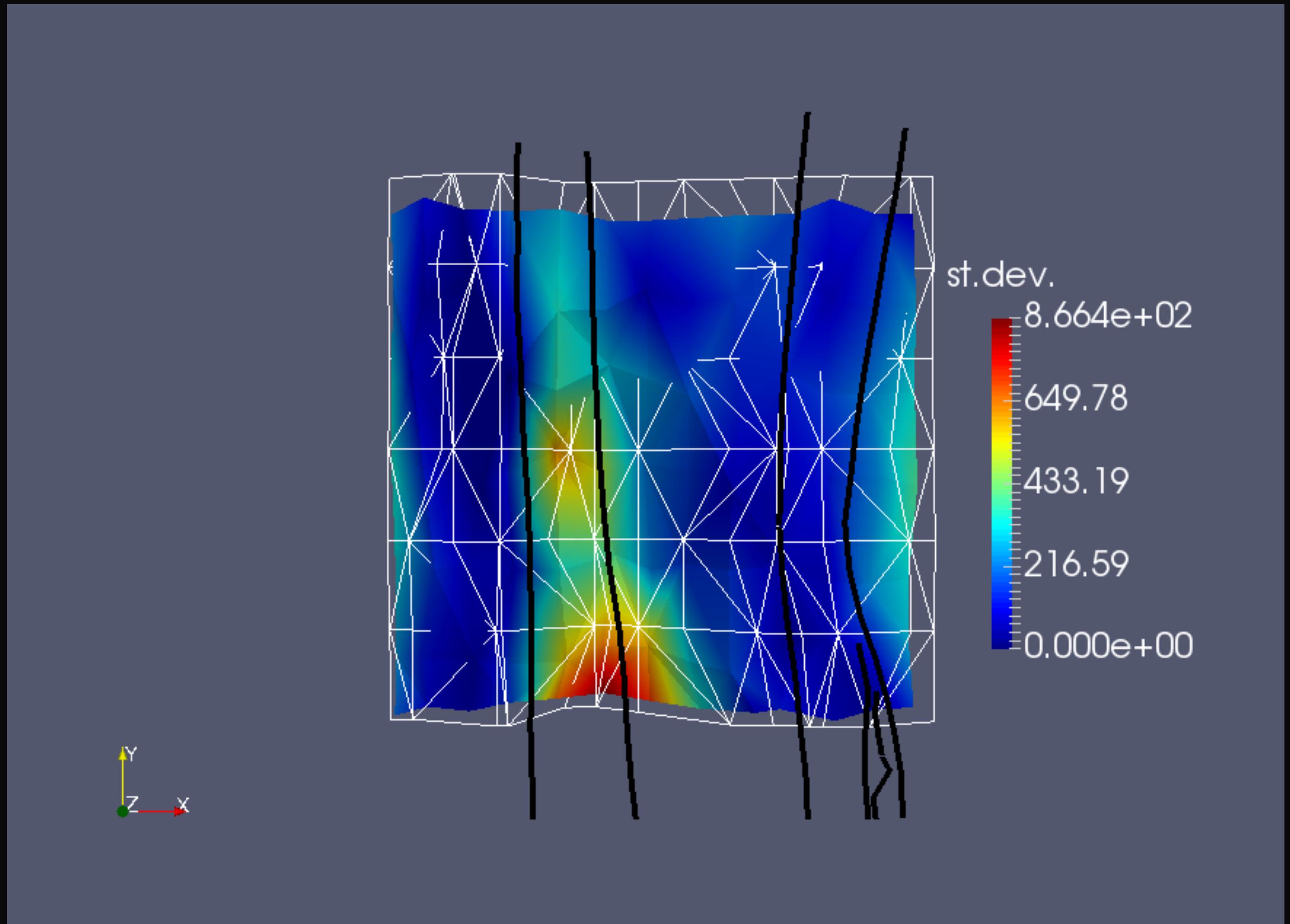
## ► Ellipsoid, gravity data



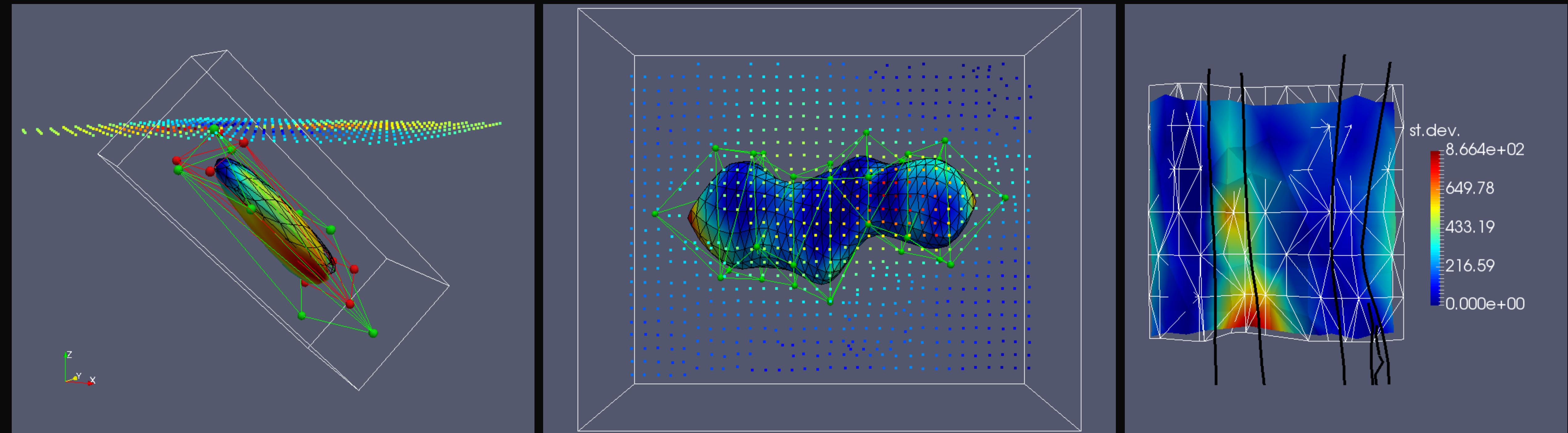
## ► IOCG deposit



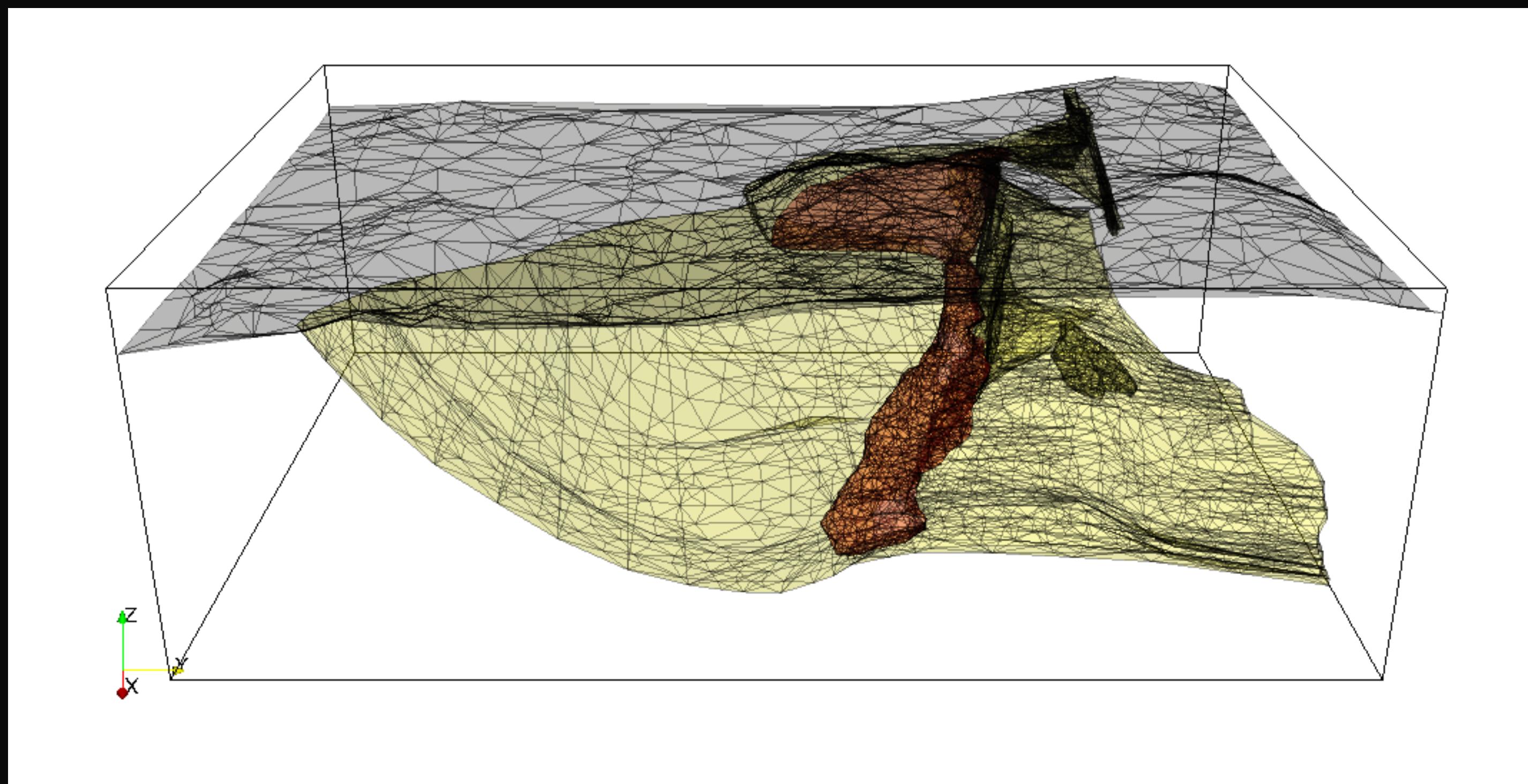
## ►Cocagne Subbasin



## ►Ignore? Avoid?



# Topological rules

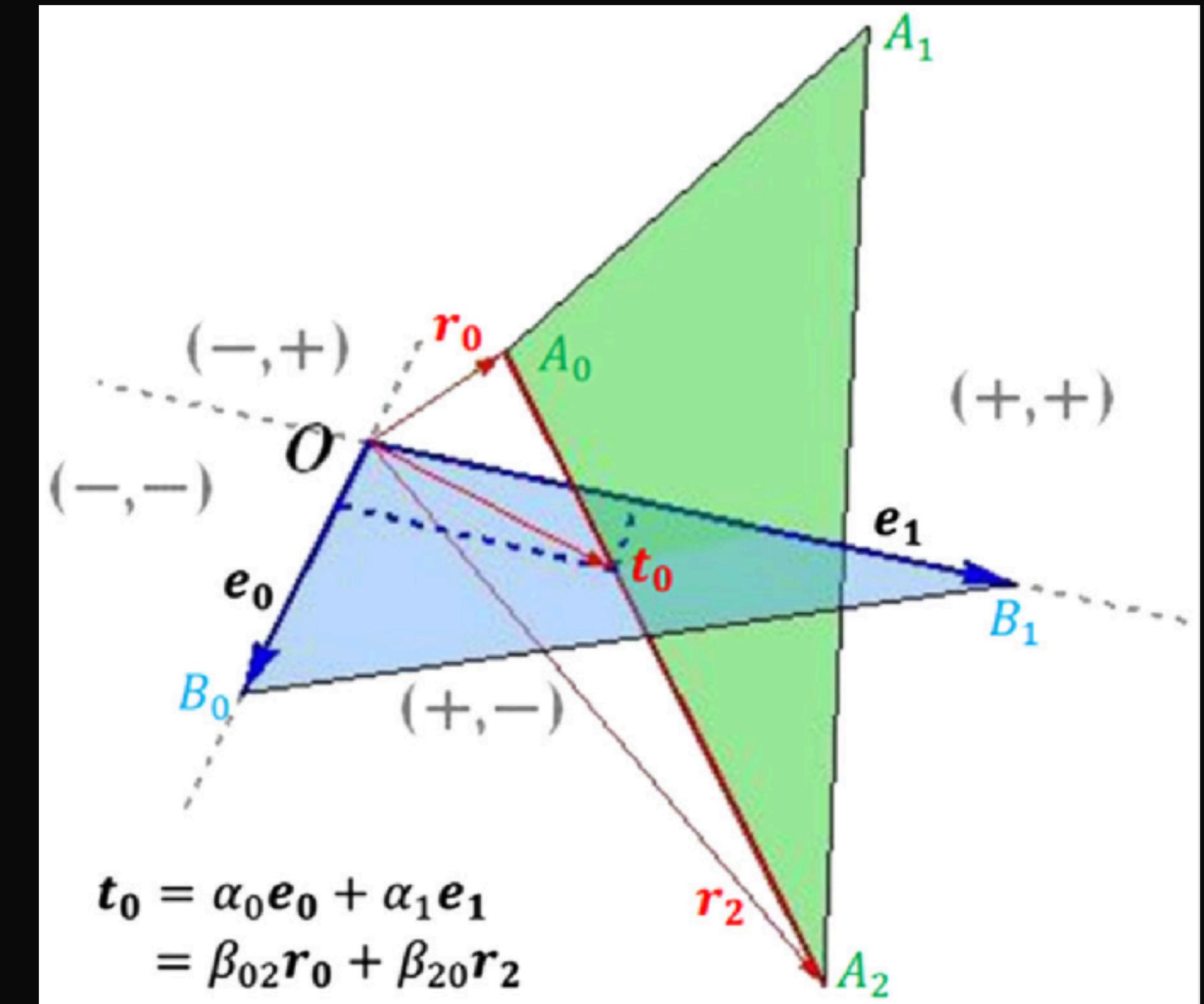
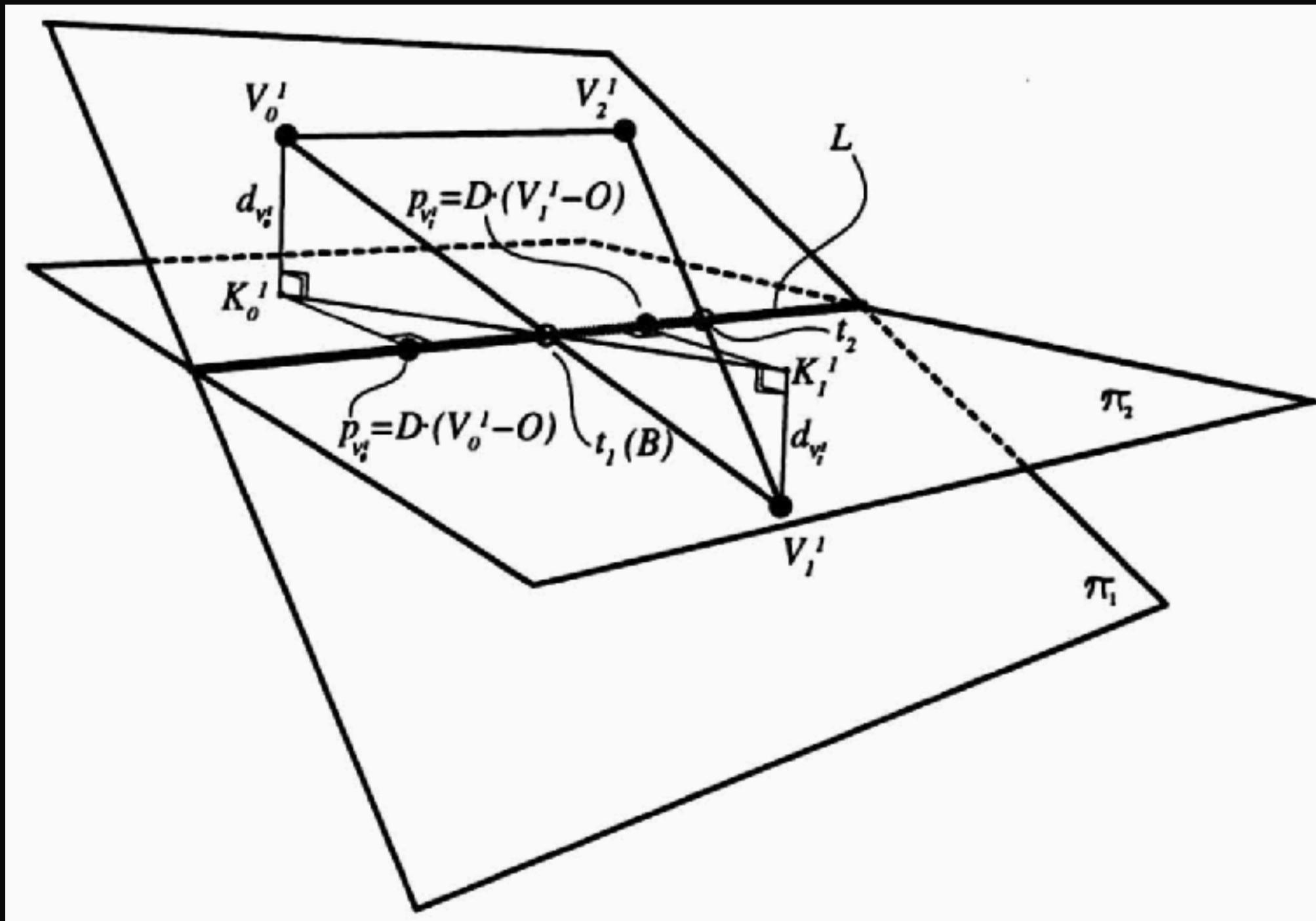


## ► Collision detection



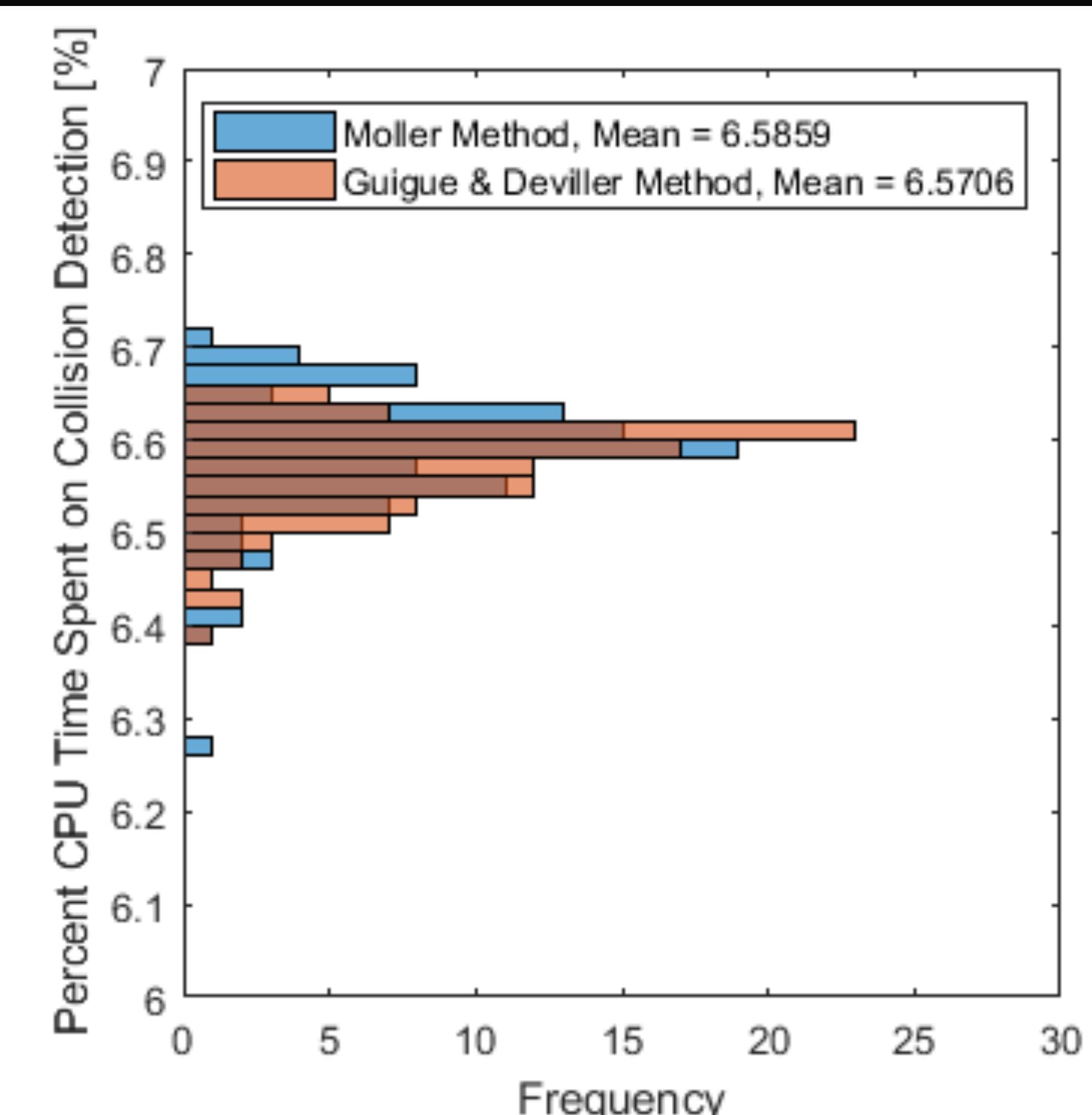
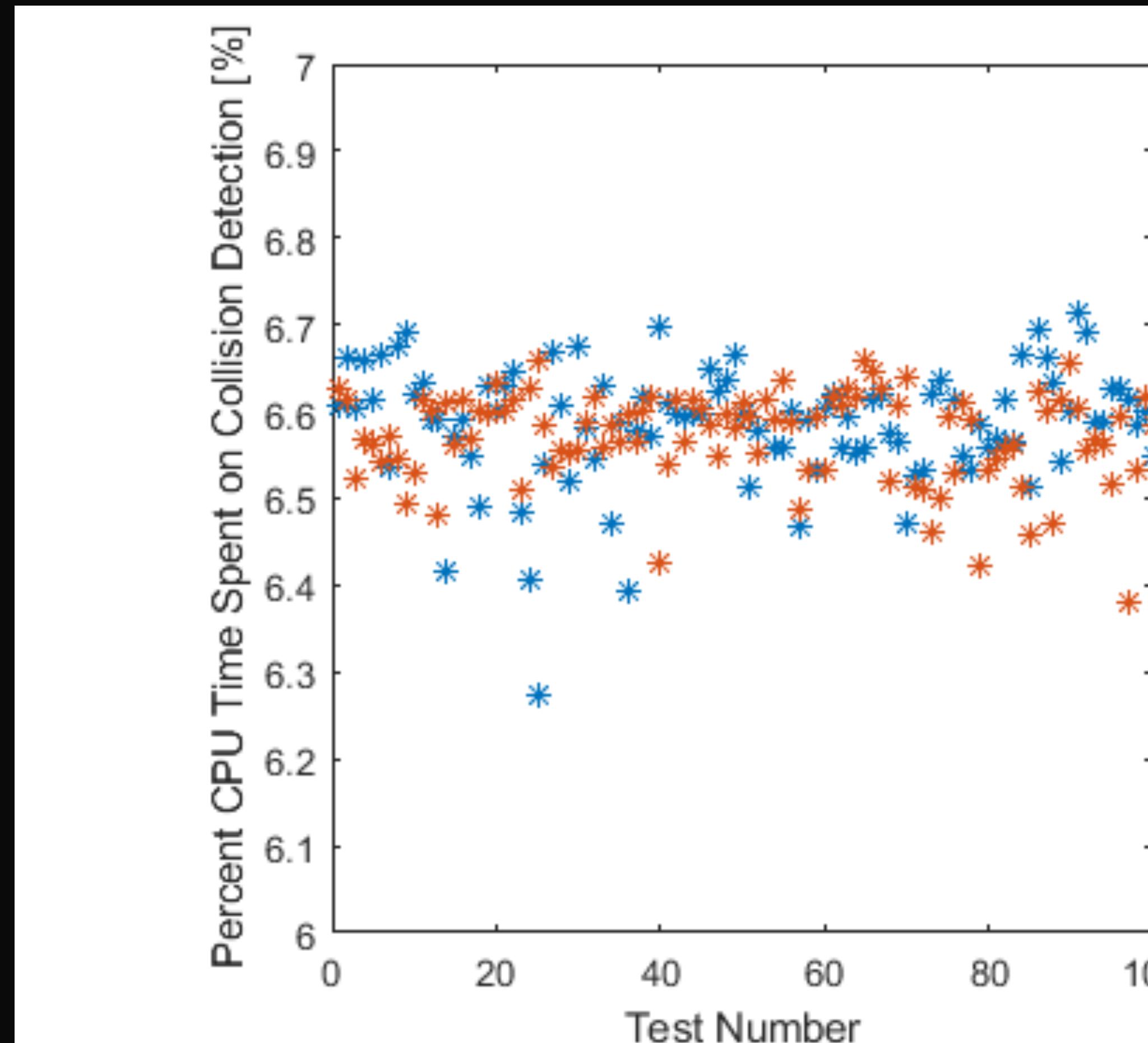
## ► Triangle-triangle intersection tests

- Moller, 1997
- Guigue & Devillers, 2003
- Tropp et al., 2006
- Wei, 2014
- Sabharwal & Leopold, 2015
- ... and more

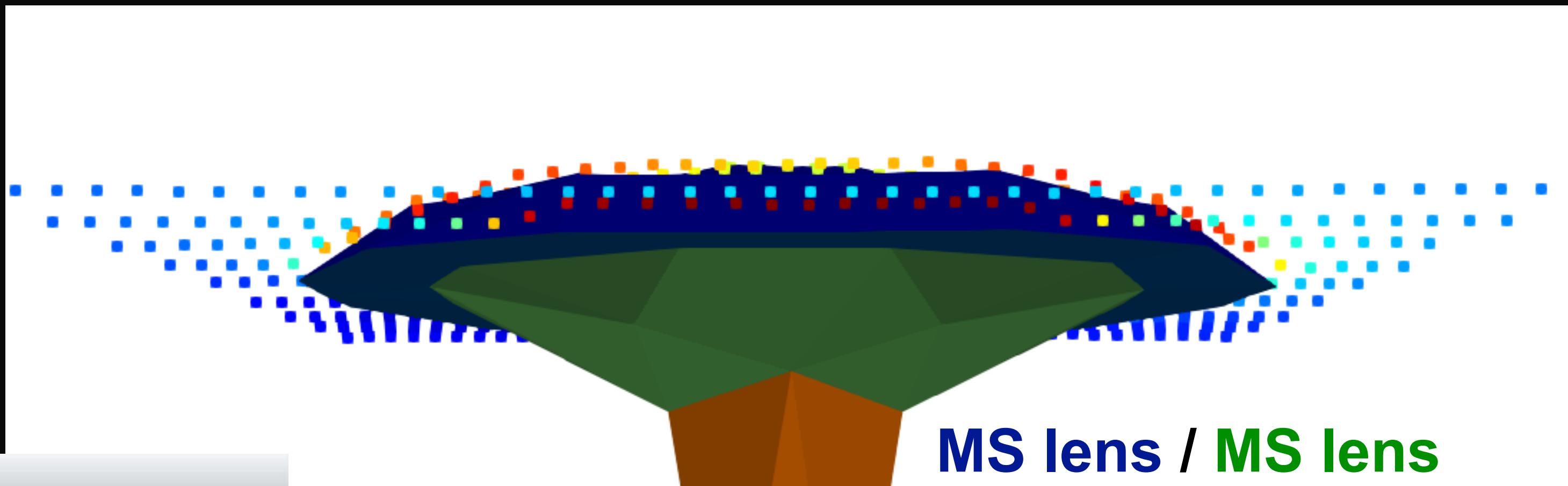
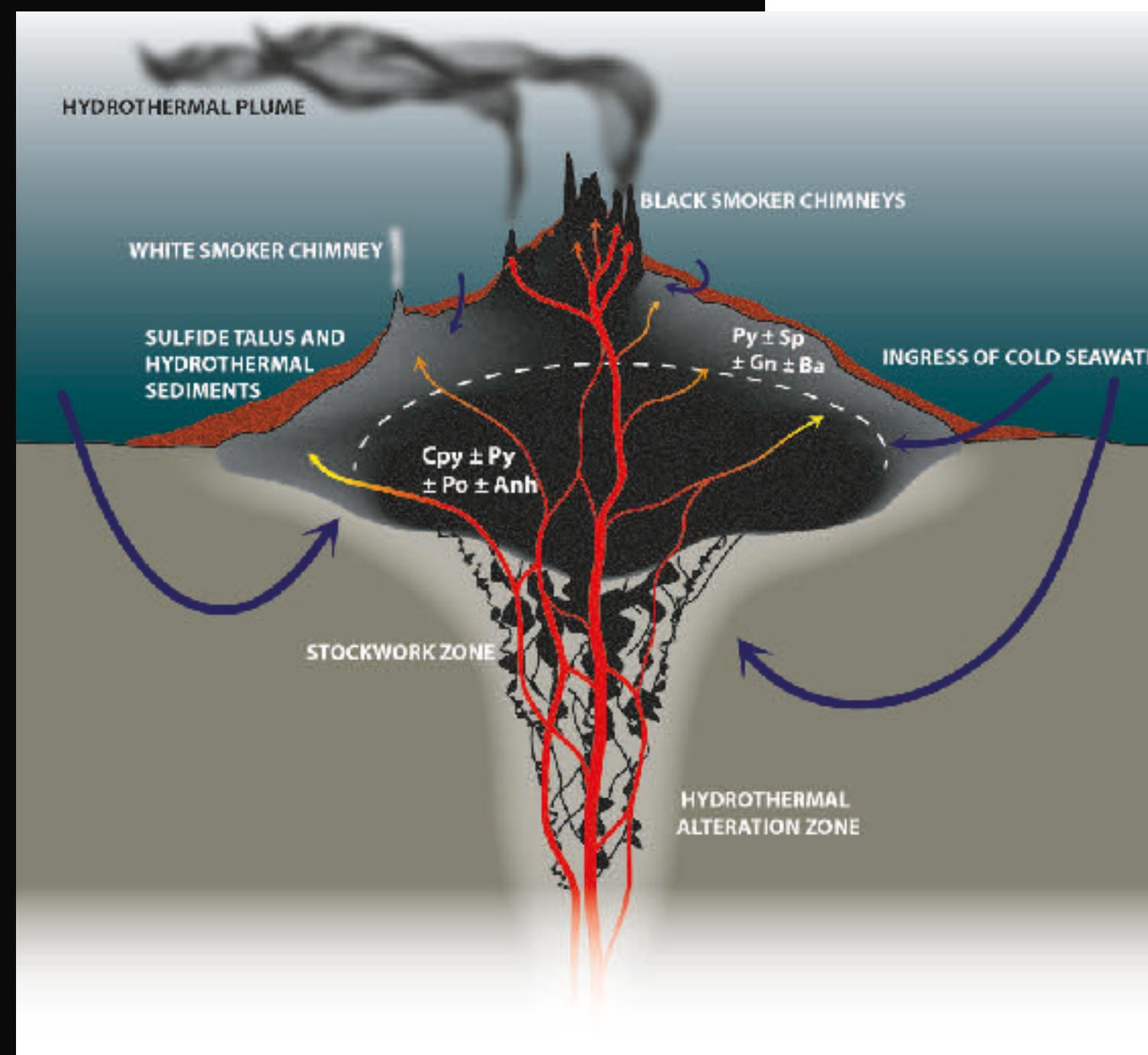


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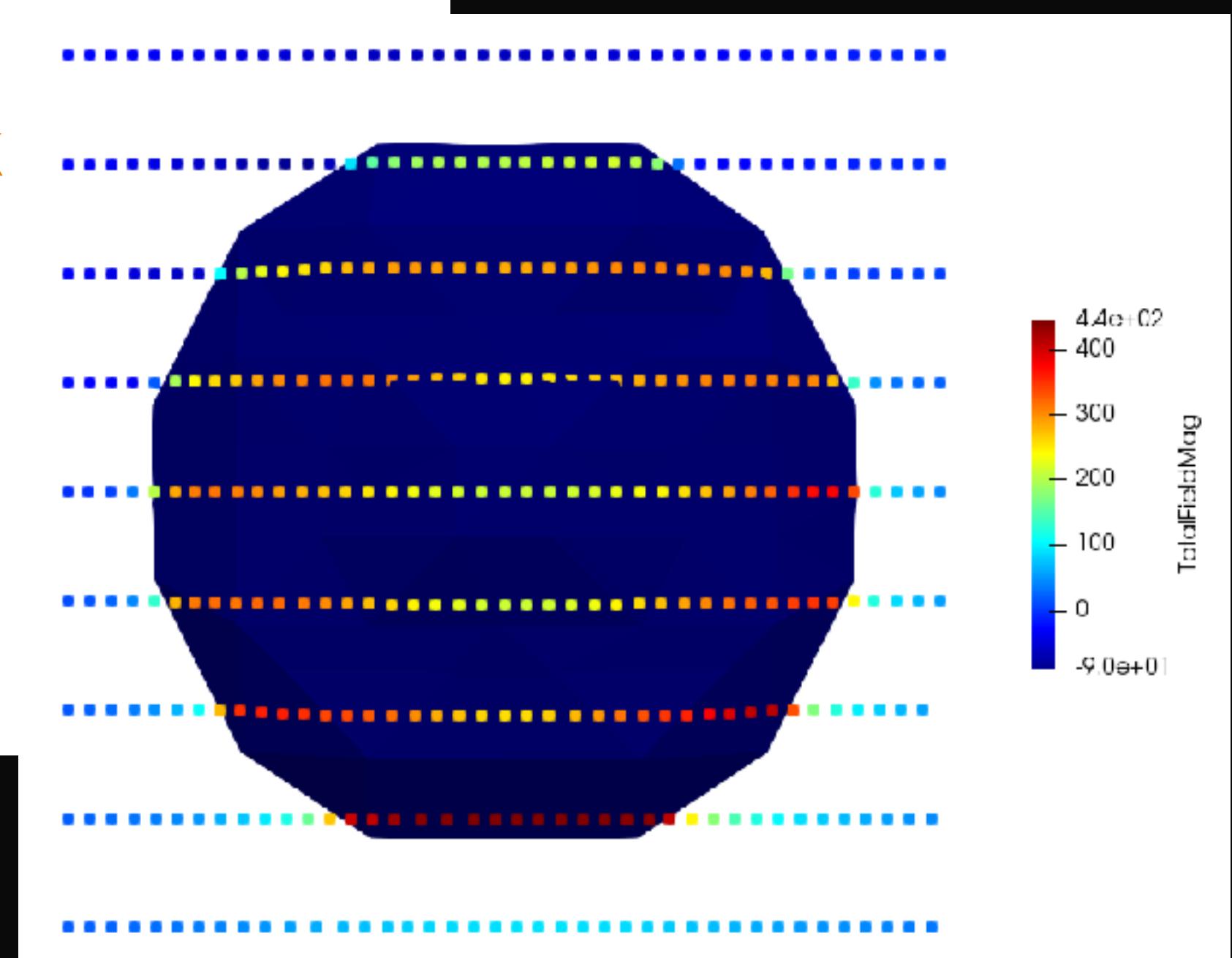


# Our current examples: SMS synthetic

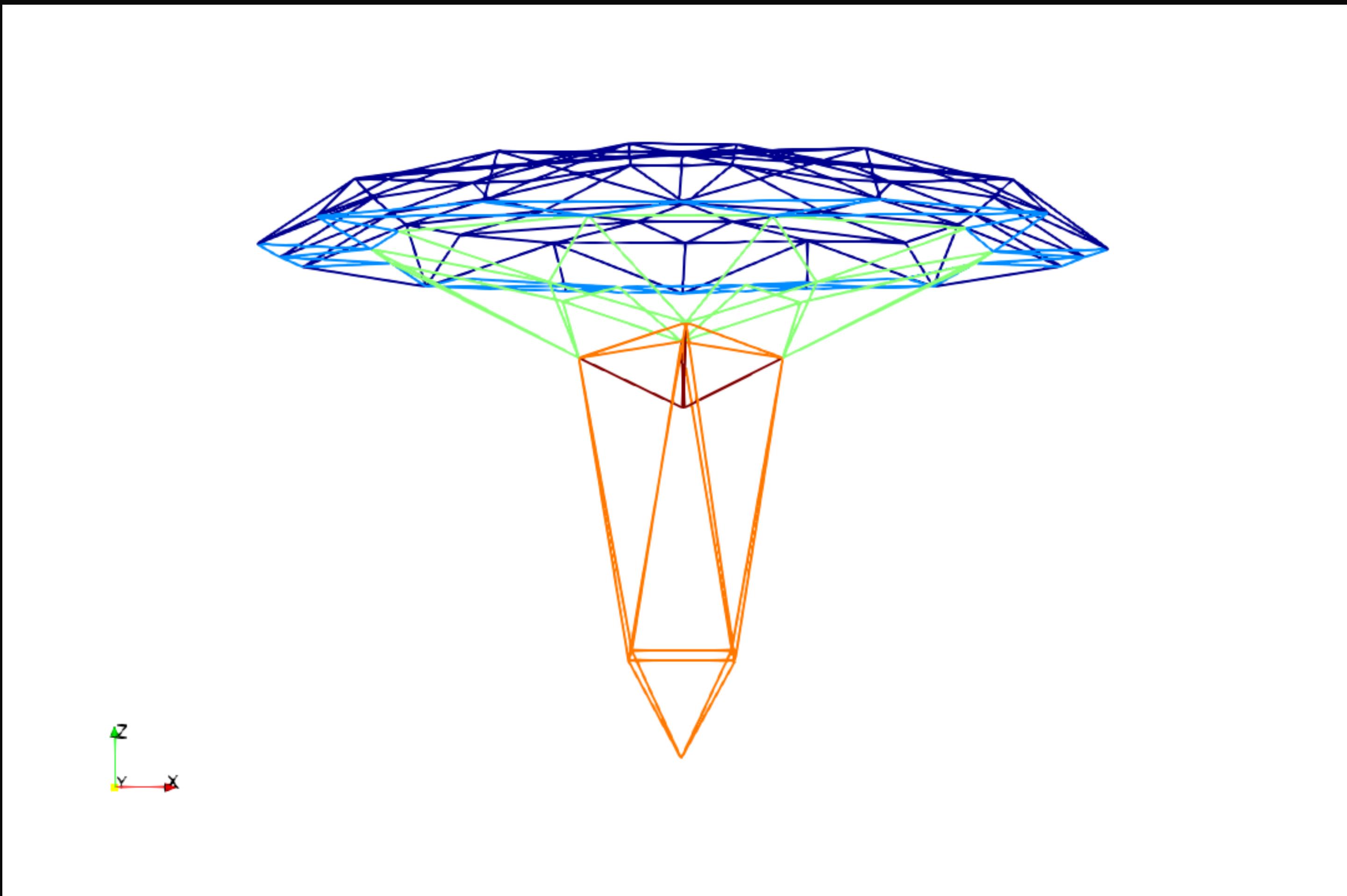


MS lens / MS lens

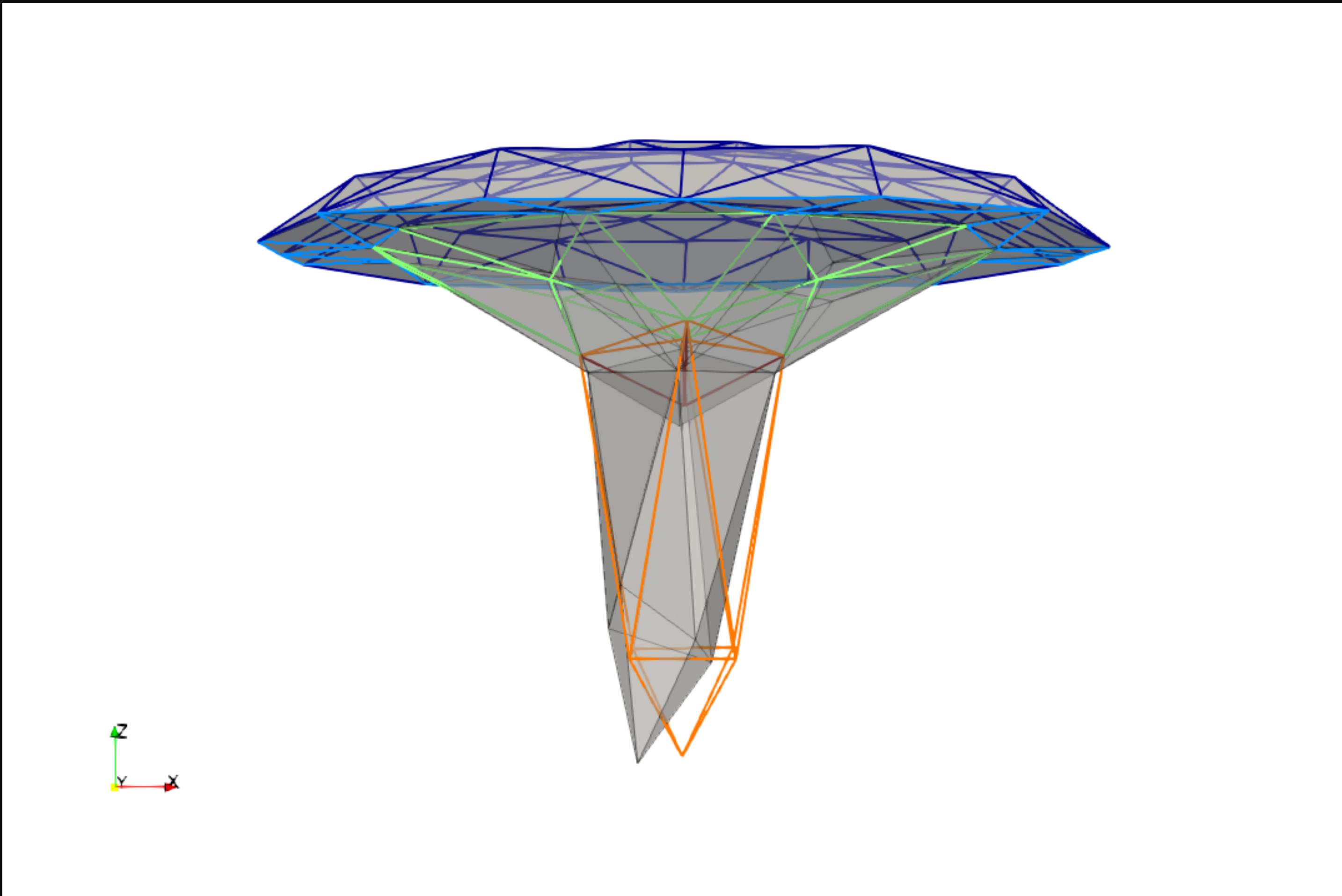
Stockwork



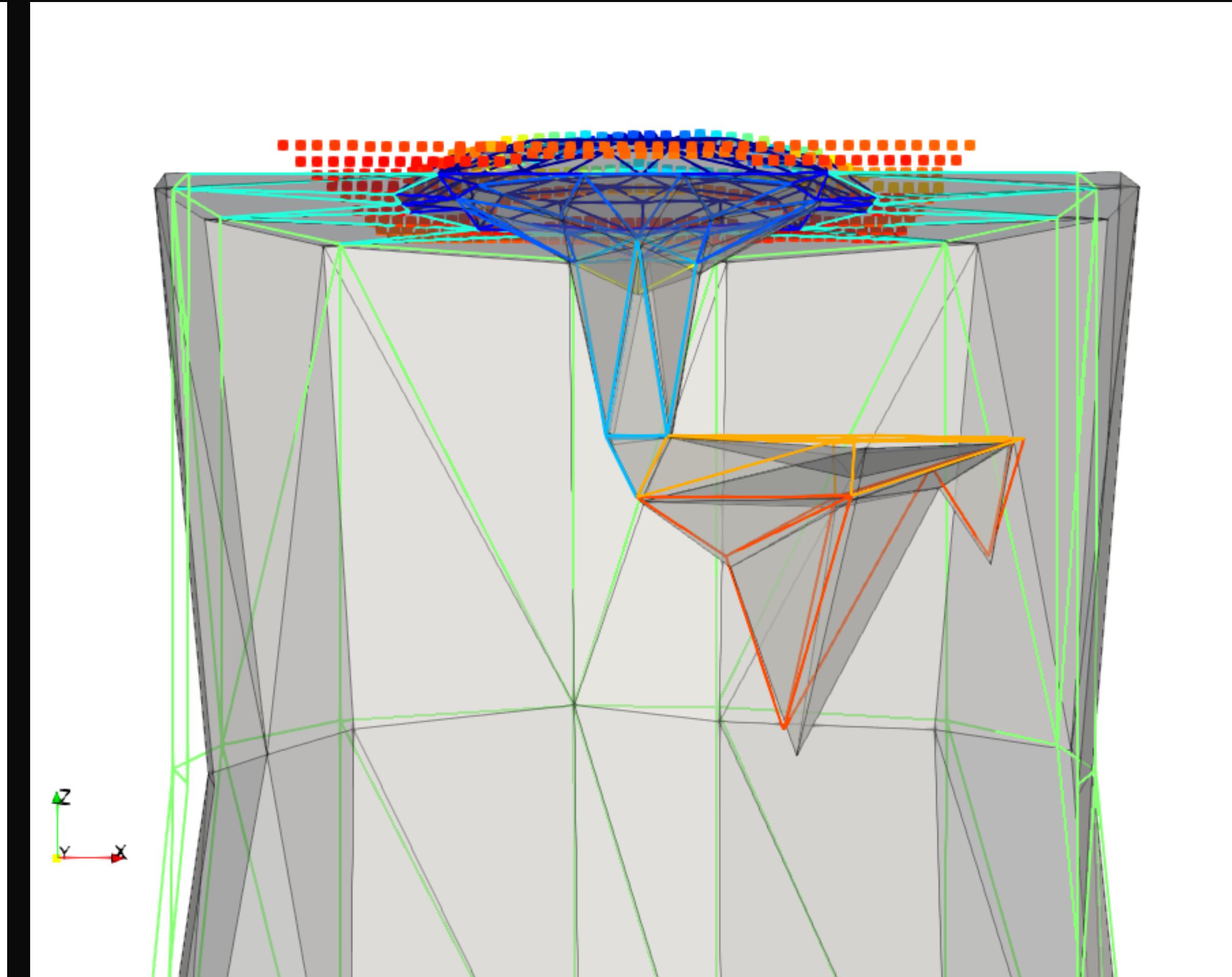
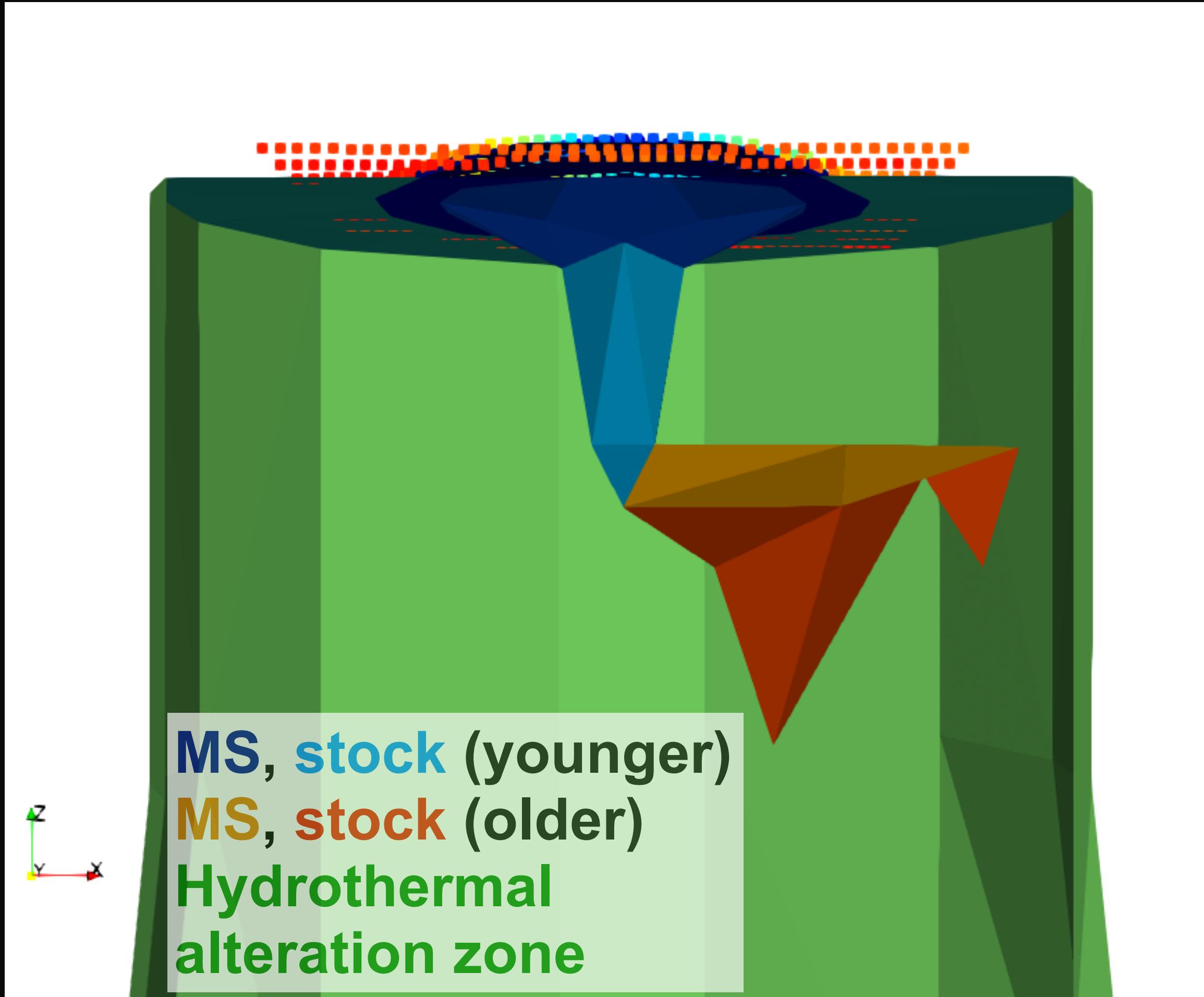
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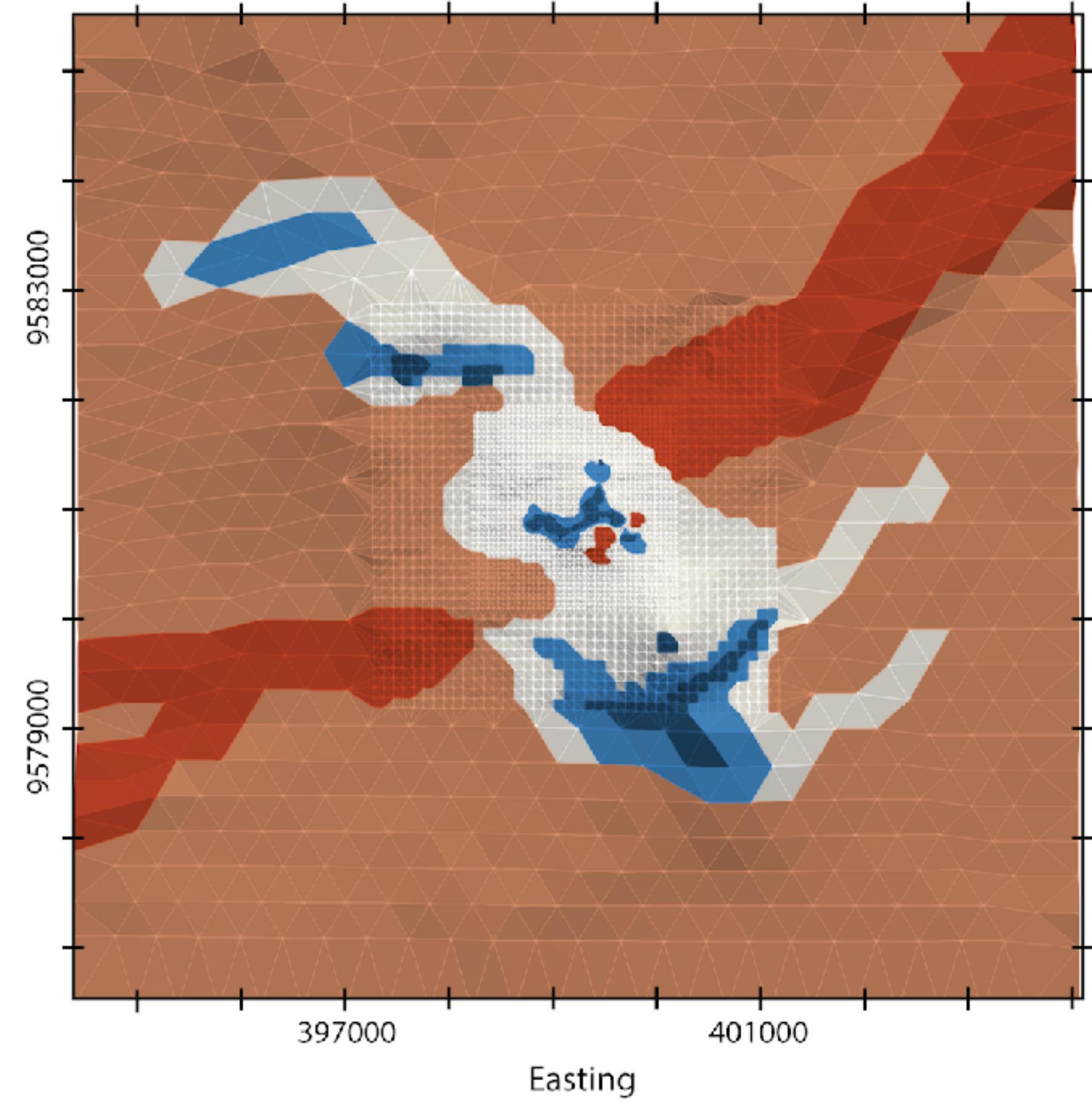
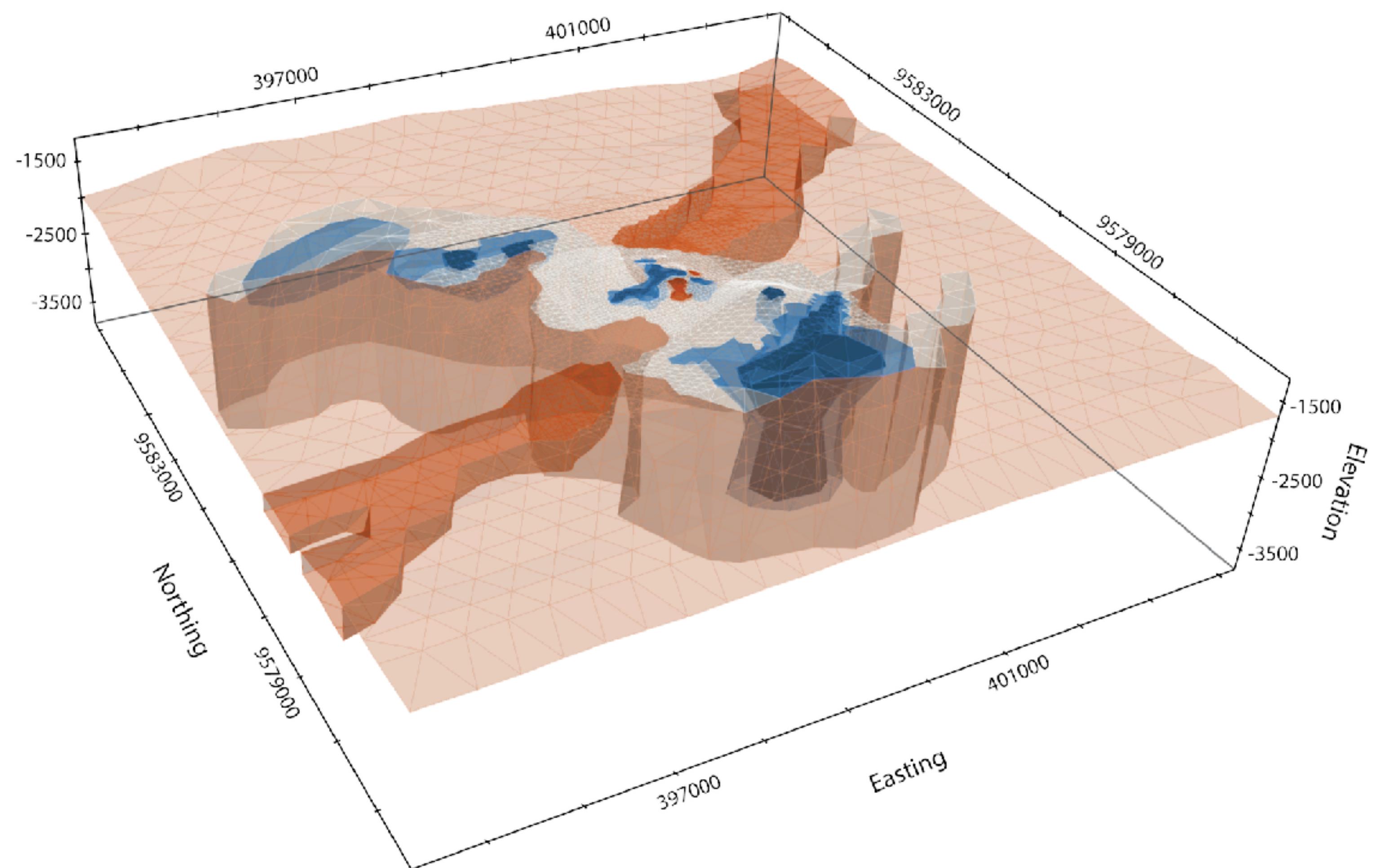
# Our current examples: SMS synthetic



# Our current examples: SMS synthetic - bimodal system



# Our current examples: SMS real data



- ▶ Invert for surface position
- ▶ Single, unified models for geophysics & geology
- ▶ Provide statistical information

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