Karlsruhe Institute of Technology

Realistic FD modeling of the tunnel environment for seismic tomography

Stefan Jetschny

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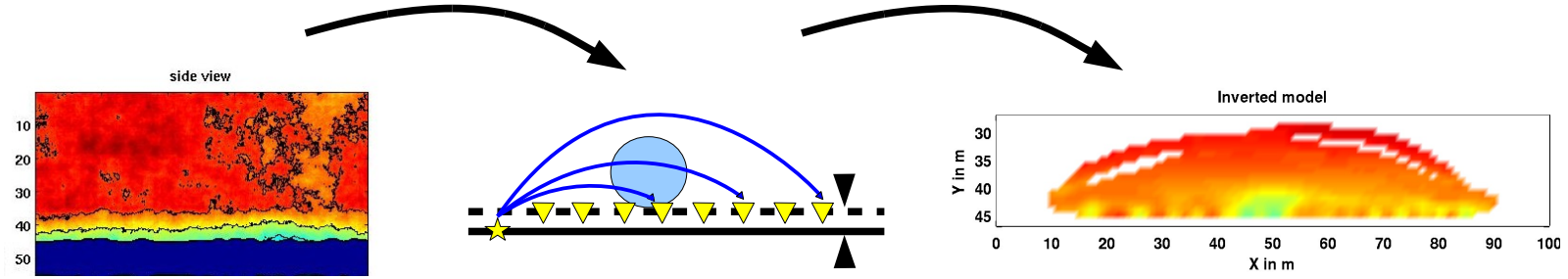
Geophysical Institute, Department of Physics

Outline

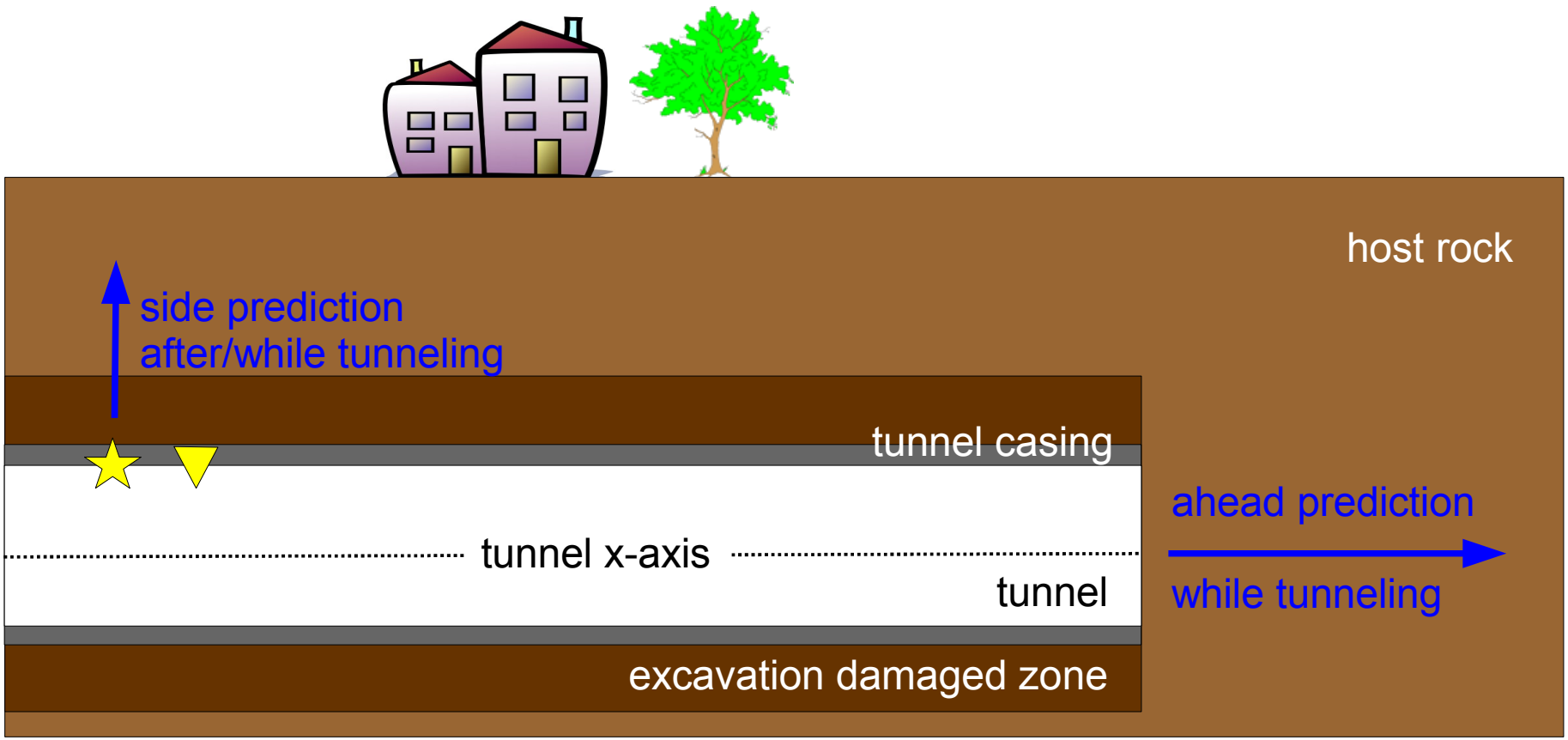
- Motivation
- Model description
- Seismic tomography
- Parameters & workflow
- Results of first arrival travel time tomography
- Conclusion

Gotthard Base Tunnel

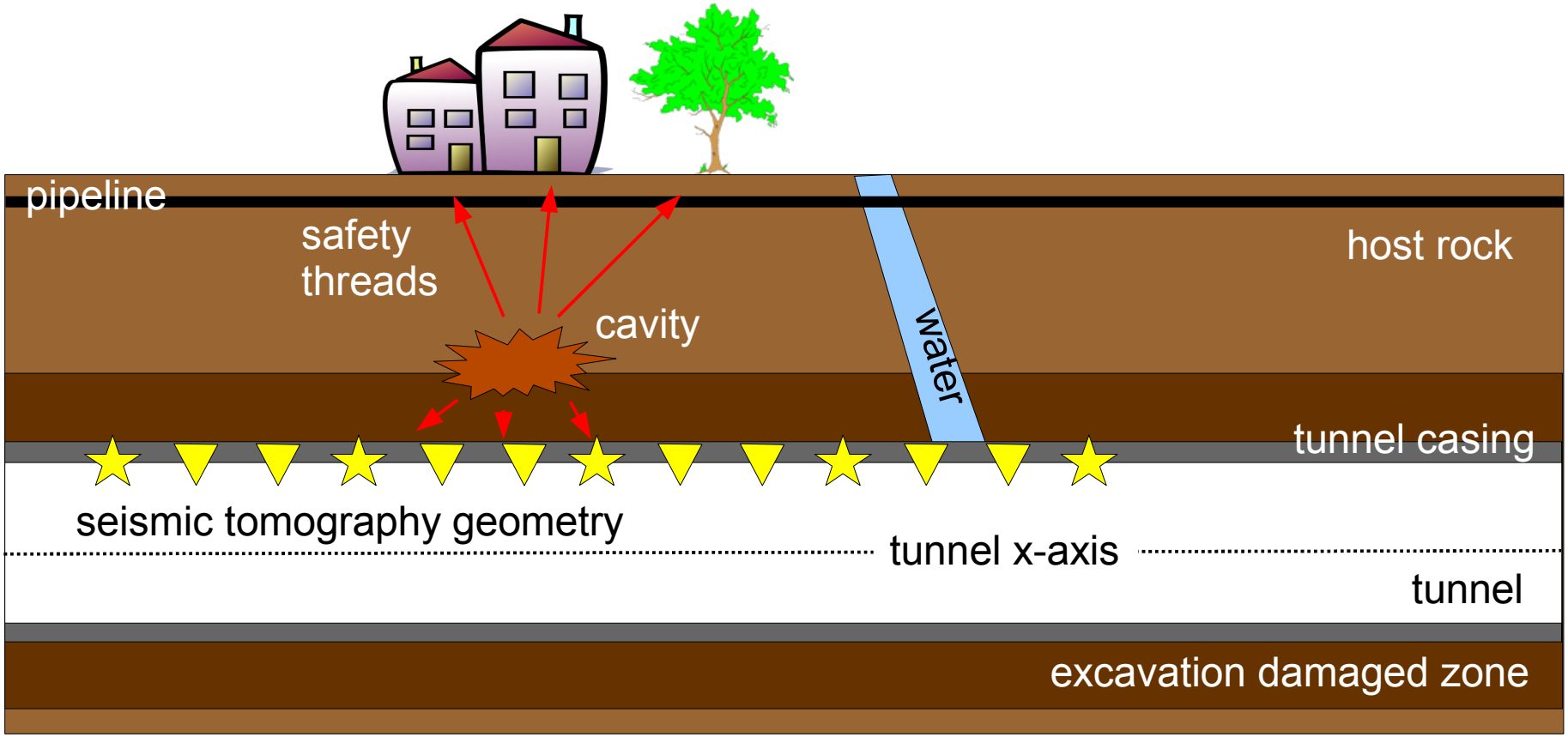


Model Seismic Tomography Inverted Model Section

Motivation – Tunnel sketch

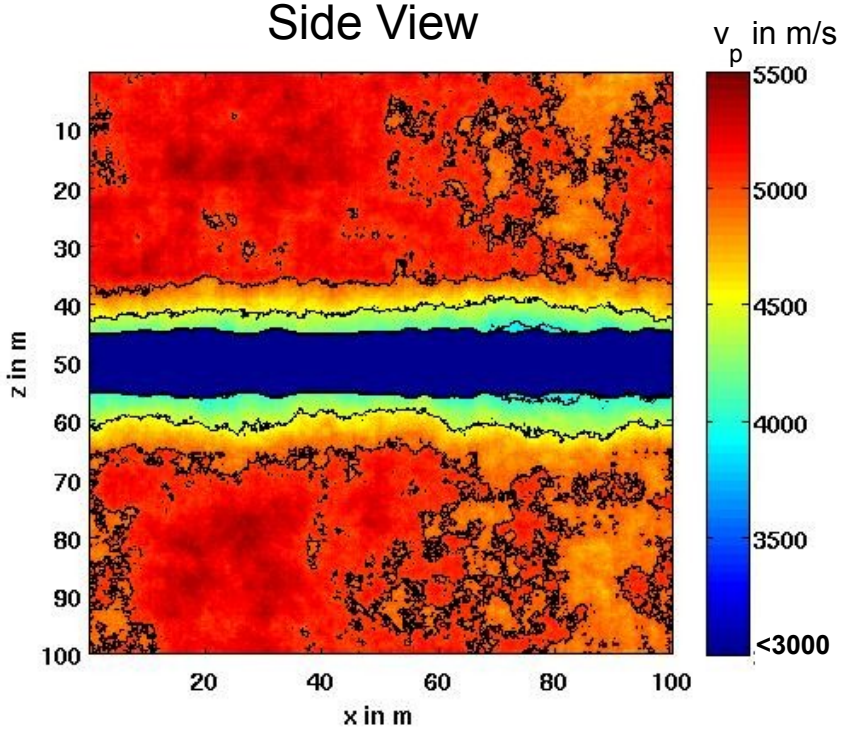


Motivation – Safety risks

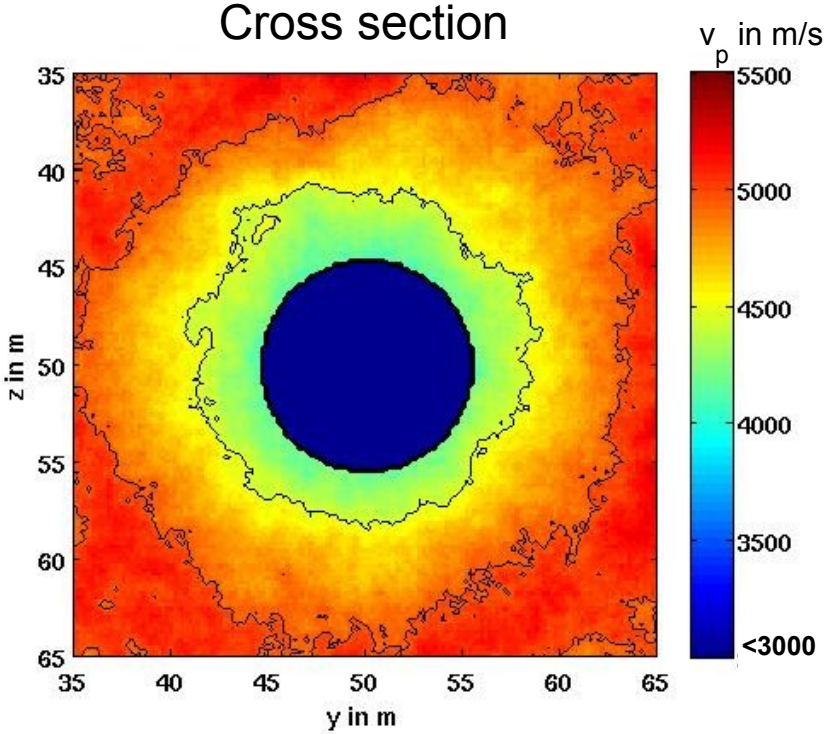


3-D Model

Side View

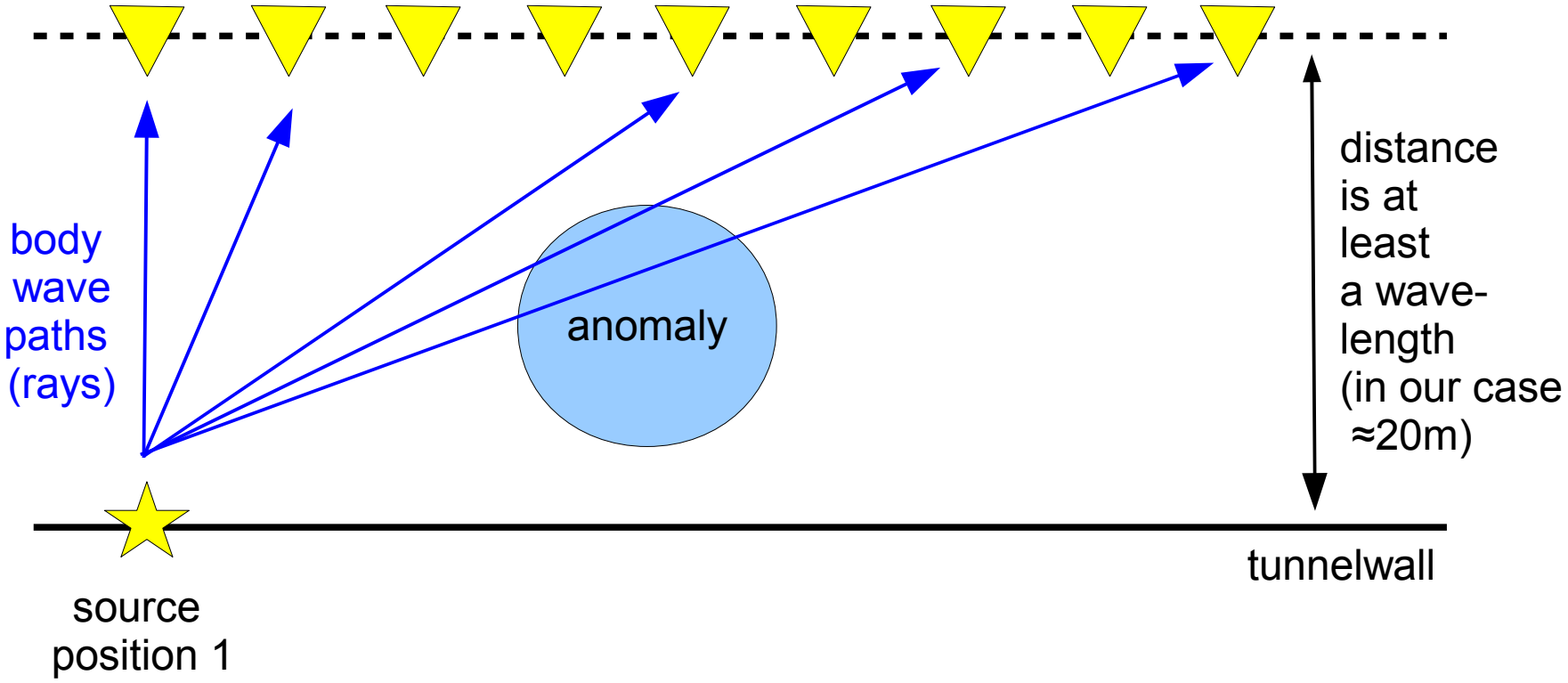


Cross section

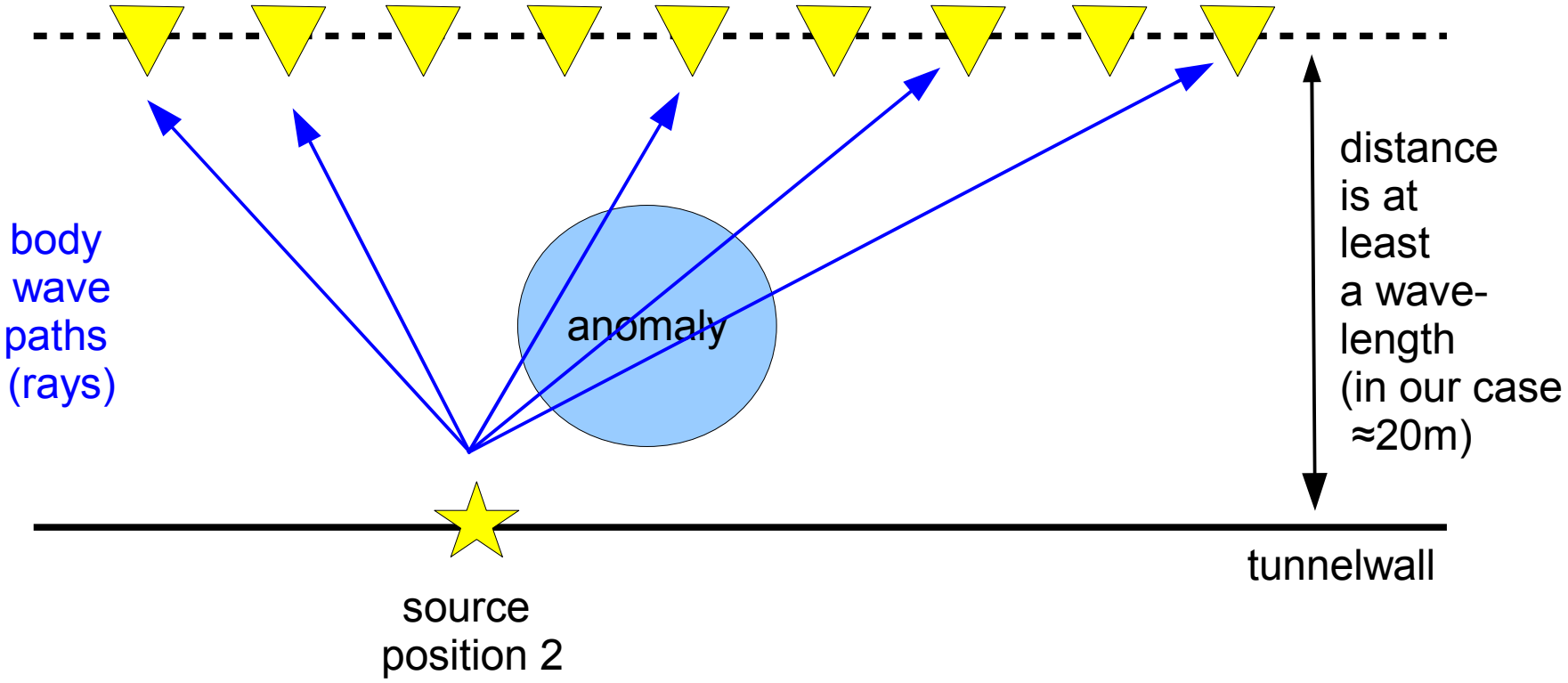


side view (vertical slice) also used for 2-D modeling

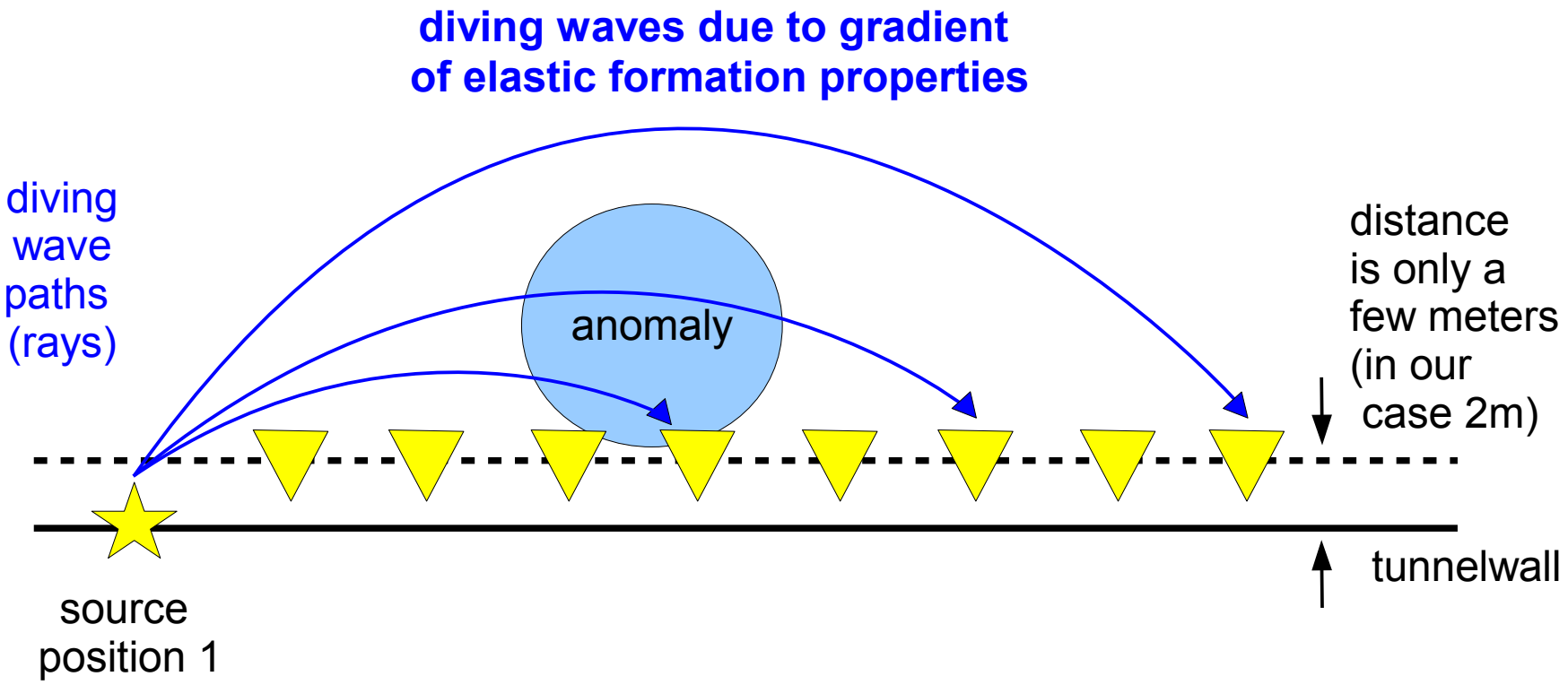
Seismic Tomography – Transmission Geometry



Seismic Tomography – Transmission Geometry



Seismic Tomography – Tunnel Geometry



resolution of inverted model is expected to be worse than for Transmission geometry

Seismic Tomography – Parameters

Number of sources  11

Number of receivers per line  120 – 140

1st receiver line 2m behind tunnel wall (tunnel geometry)
2nd receiver line 20m behind tunnel wall (transmission geometry, for comparison only)

three different models including
(1) no anomaly
(2) low velocity dike (water bearing zone)
(3) air filled sphere (cavity)

each 2-D modeling on a 800x600 grid takes about 2 minutes
on 20 cores
each 3-D modeling on a 1000x1000x1000 grid takes about 2.5 hours
on 250 cores

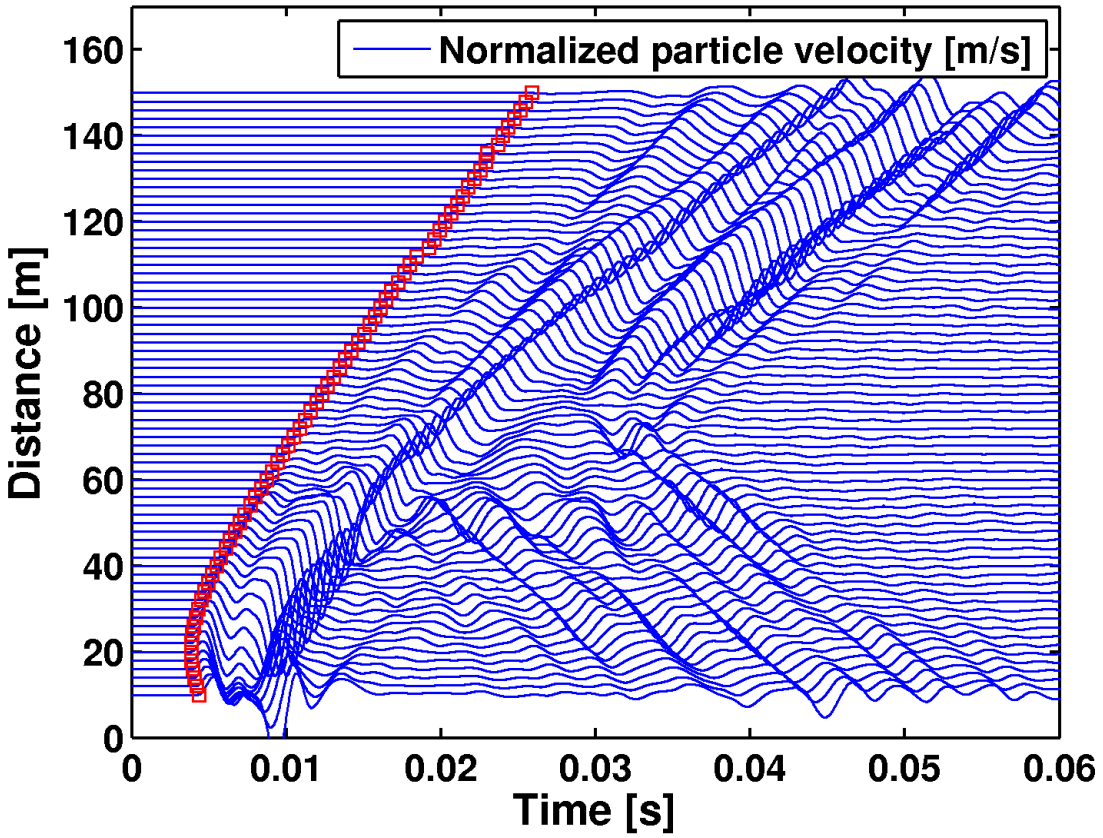
2-D, 3-D FD parallel viscoelastic modeling code: http://www.gpi.kit.edu/SOFI3D.php

Seismic Tomography – Work flow

(1) Modeling of synthetic data using SOFI2D or SOFI3D (parallel viscoelastic FD modeling code)

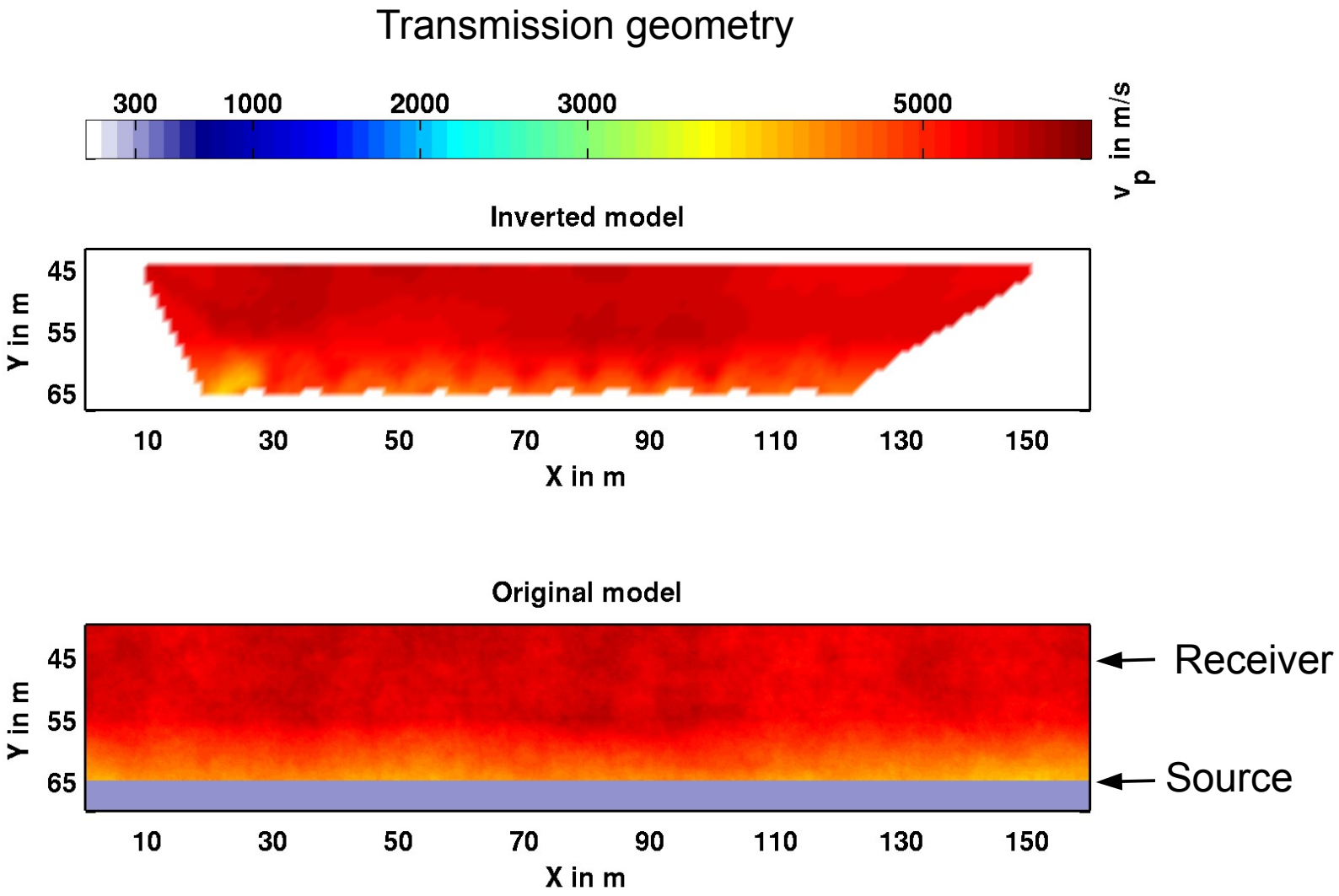
(2) First arrival picking for each shot by threshold using Matlab

(3) First arrival tomography using GeoTomCG 11.3

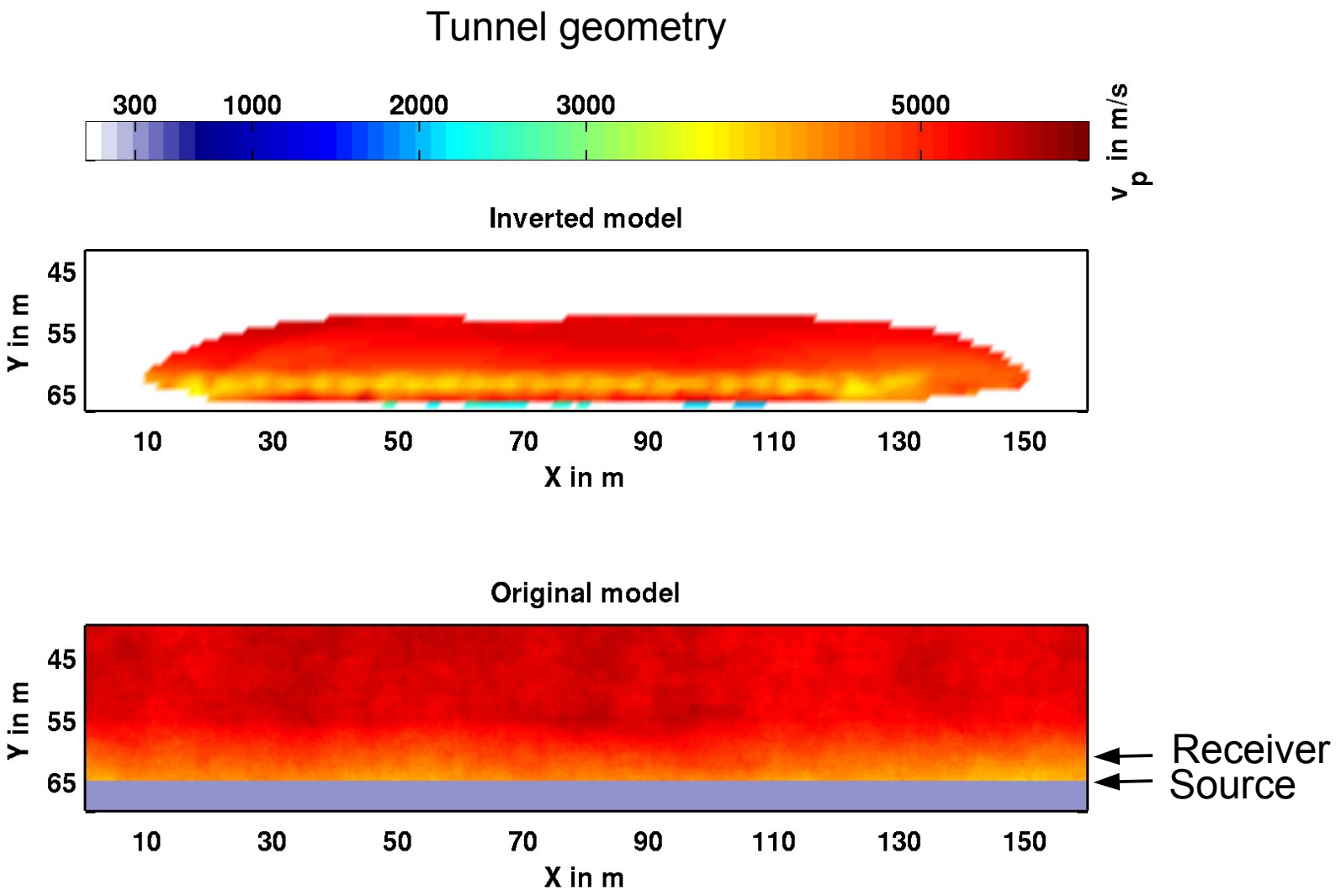


2-D, 3-D FD parallel viscoelastic modeling code: http://www.gpi.kit.edu/SOFI3D.php

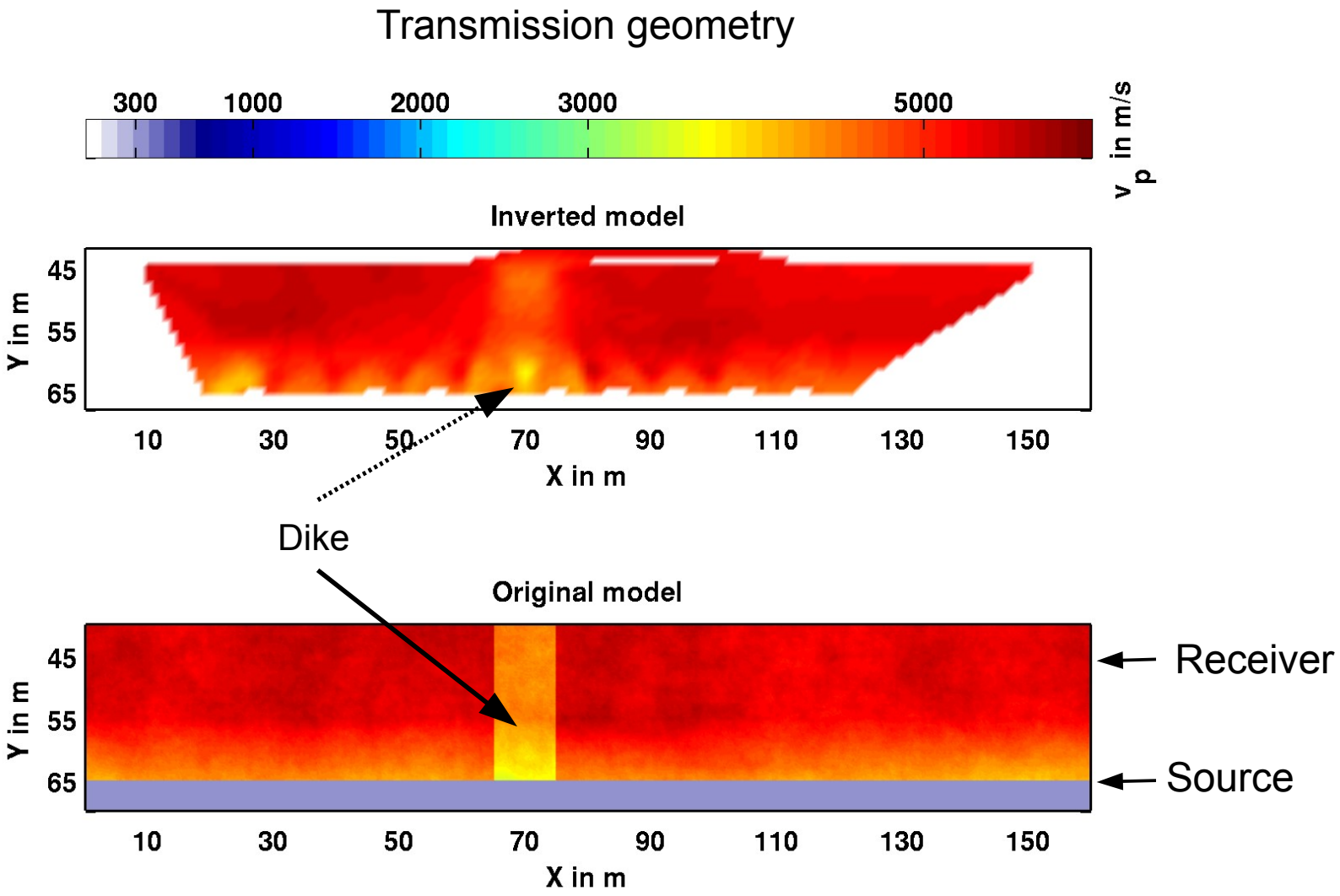
Inversion Result – 2-D Model with no Anomaly



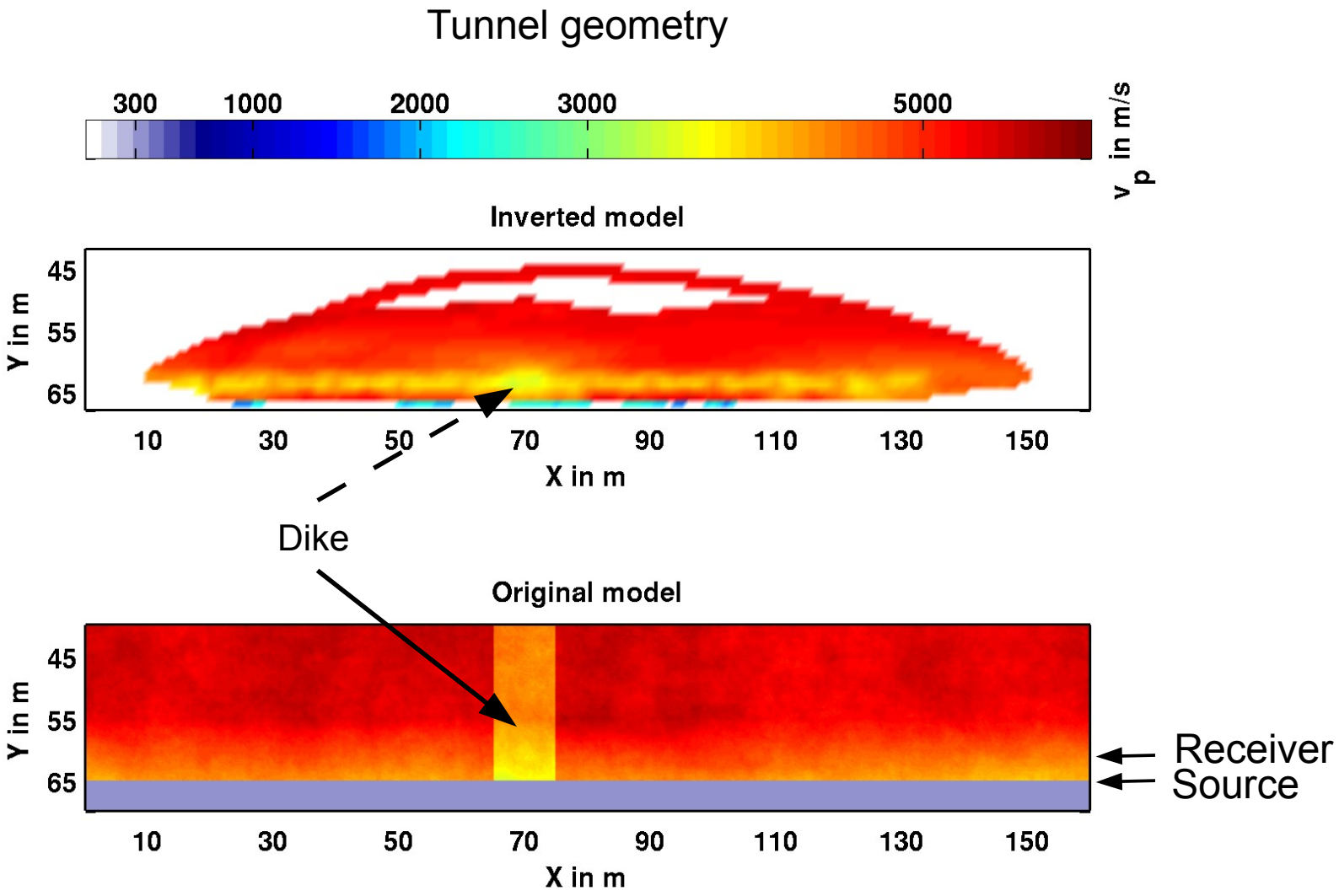
Inversion Result – 2-D Model with no Anomaly



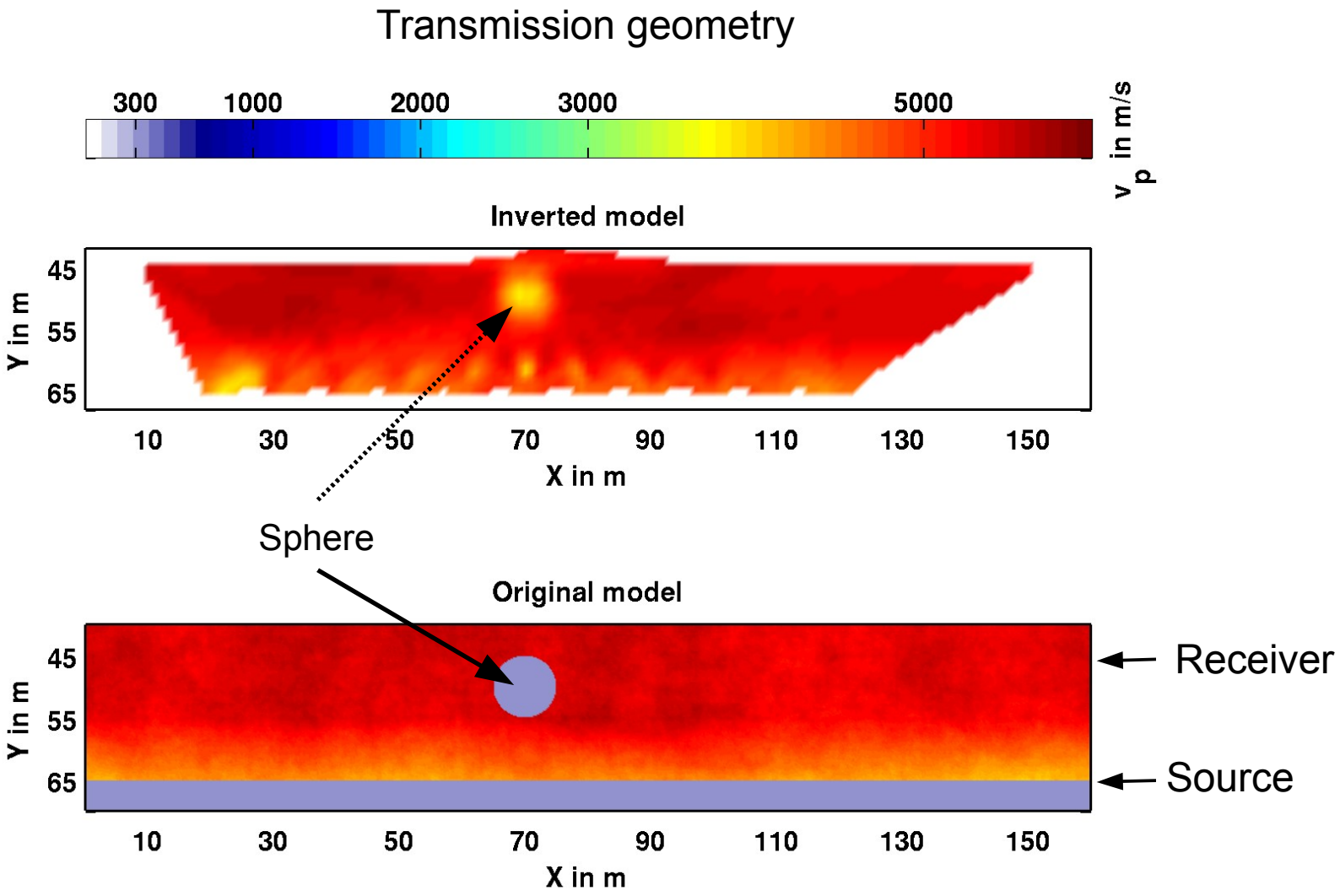
Inversion Result – 2-D Model with Dike Anomaly



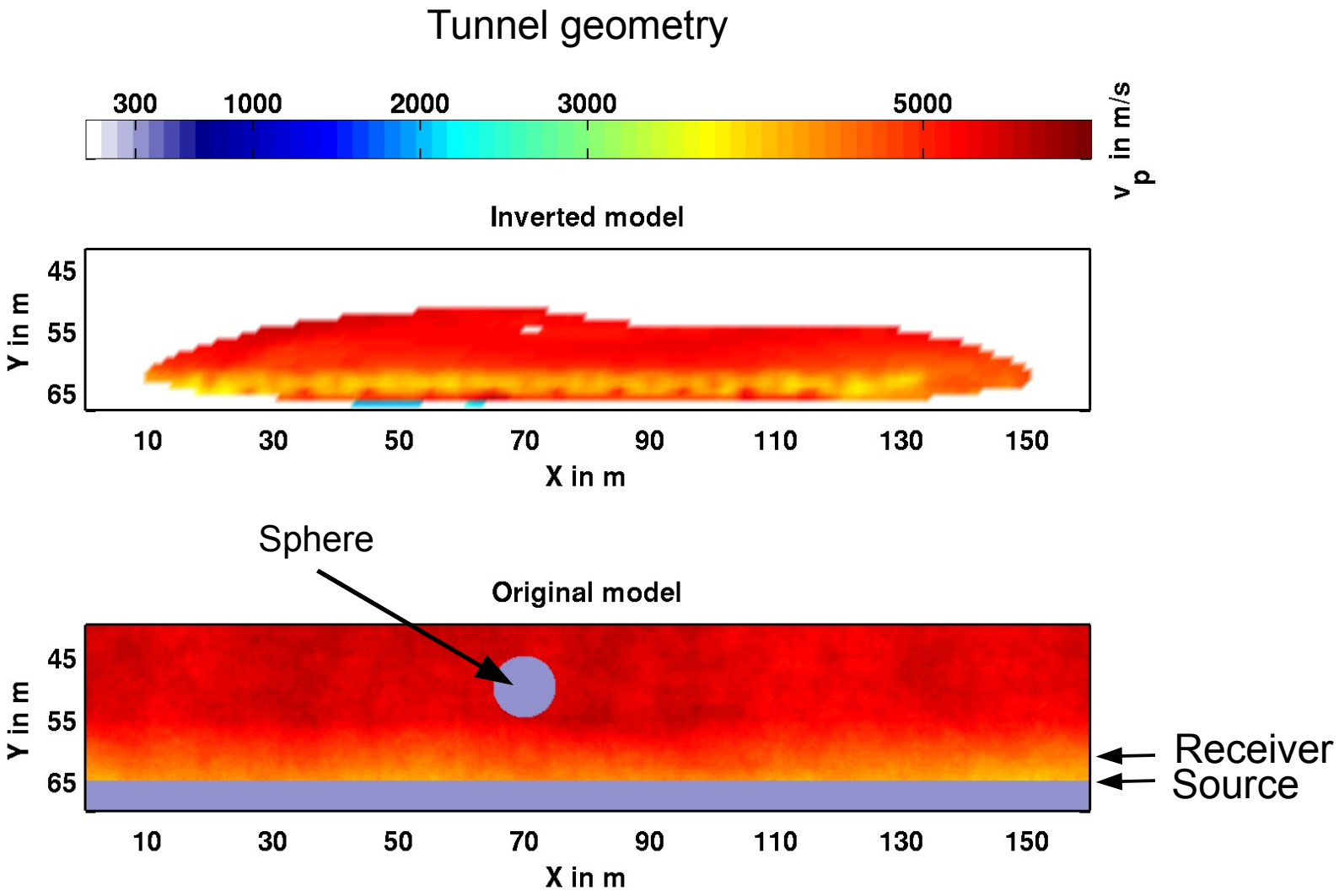
Inversion Result – 2-D Model with Dike Anomaly



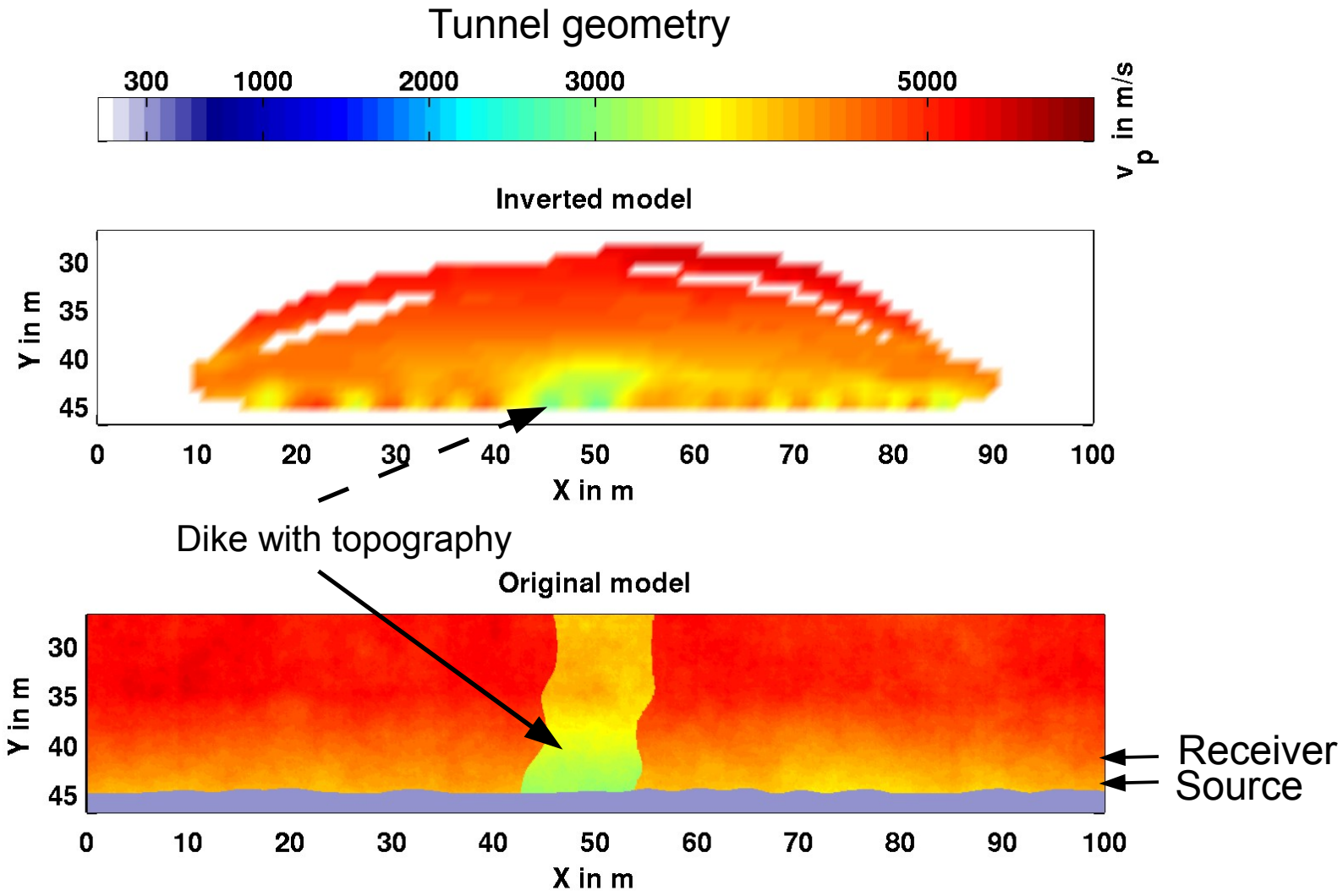
Inversion Result – 2-D Model with Sphere Anomaly



Inversion Result – 2-D Model with Sphere Anomaly



Inversion Result – 3-D Model with Sphere Anomaly



Conclusions & Outlook

- modeling of realistic tunnel environment including EDZ, tunnel wall, topography, heterogeneous host rock
- arbitrary source- and receiver geometry according to tunnel wall topography
- inversion of first arrivals for the detection of anomalies in the vicinity of the tunnel wall is not sufficient

→ additional information (e.g. reflection, scattering events) have to be taken into account

→ Full waveform inversion

Thank you for your attention!

Acknowledgement

- Federal ministry of Education and research, program Geotechnologien
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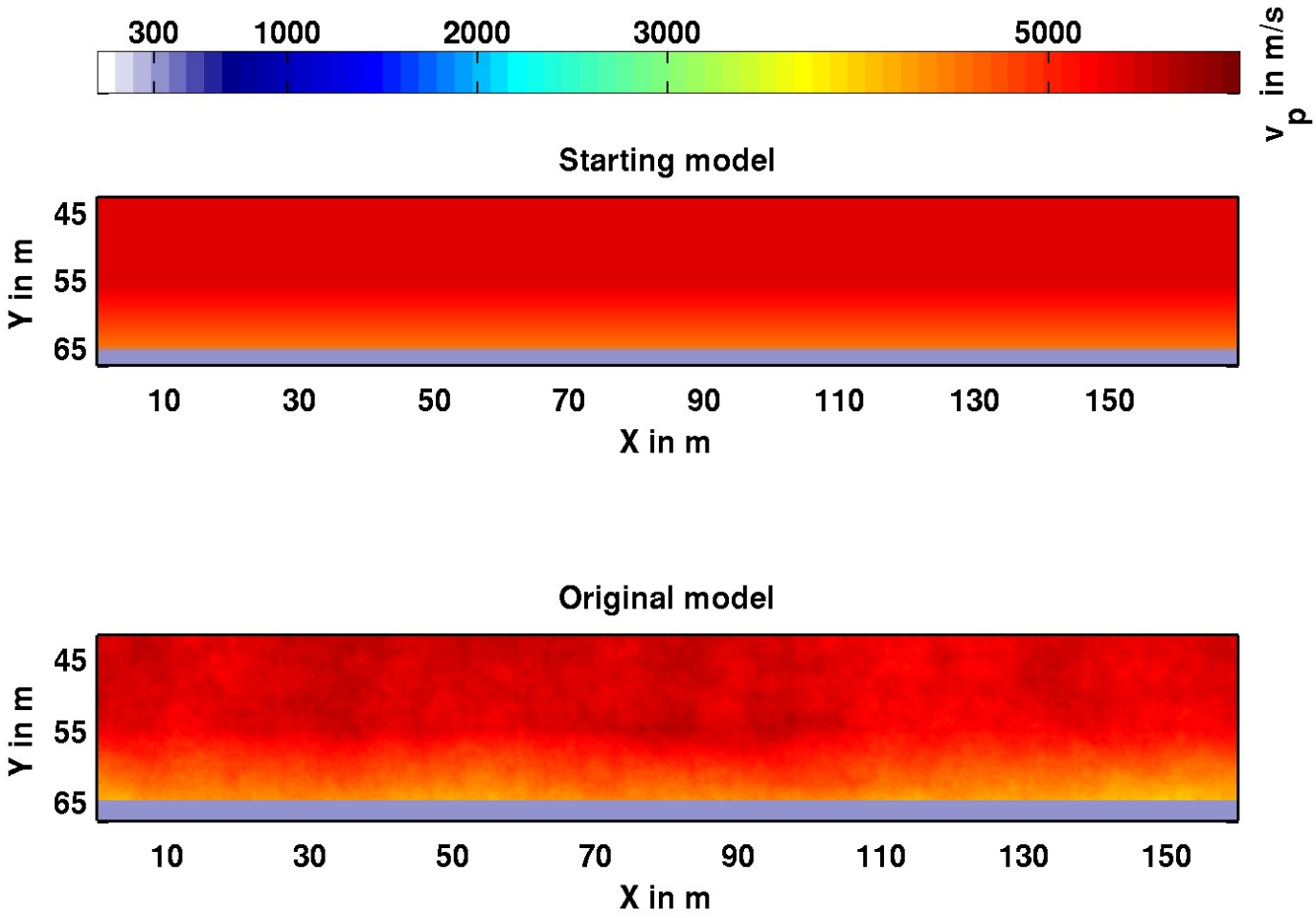
- GFZ German Research Centre for Geosciences (Aissa Rechlin, Stefan Lueth & Ruediger Giese)

Contact

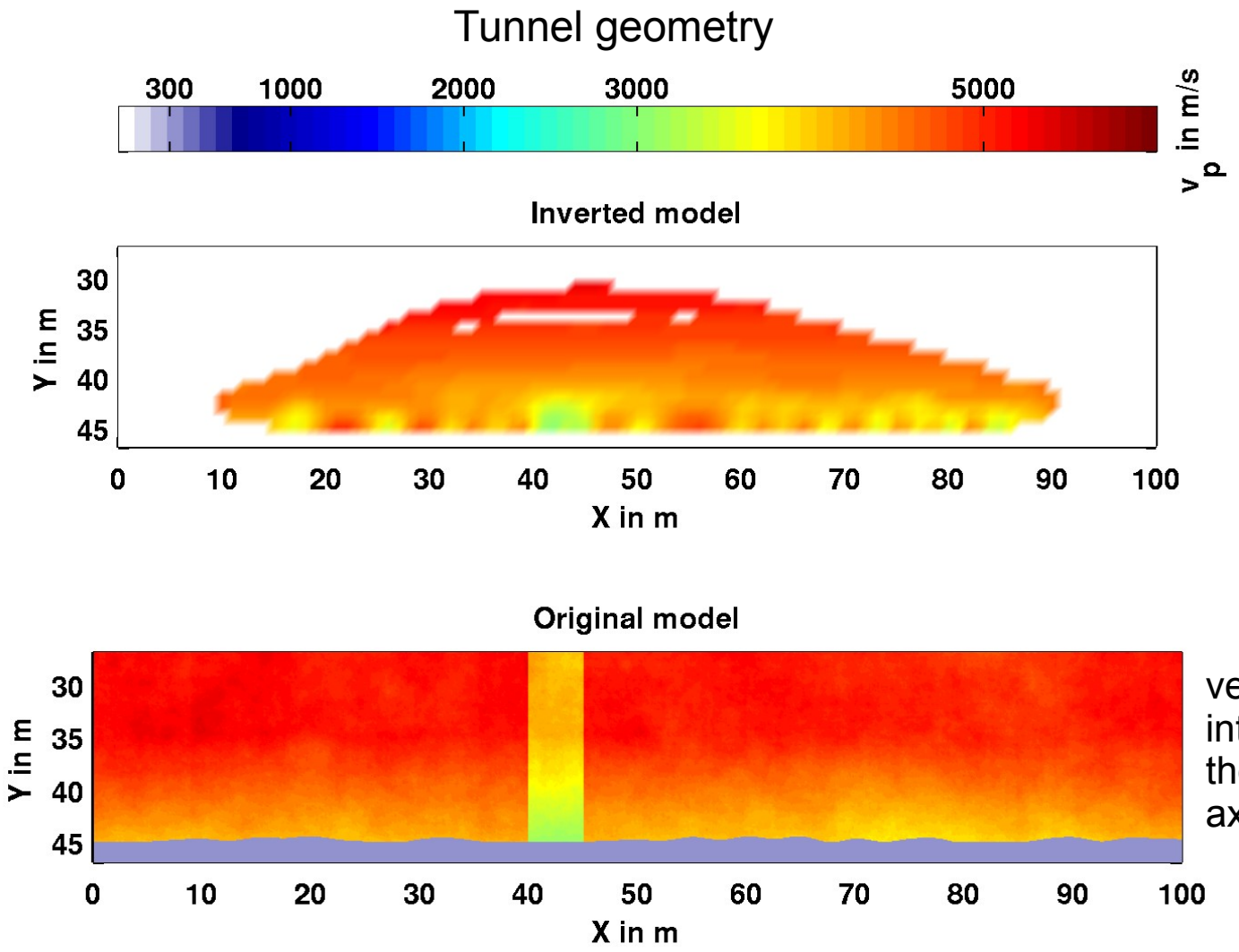
- jetschny@kit.edu

Leipzig City-Tunnel

Starting model for 1st arrival tomography

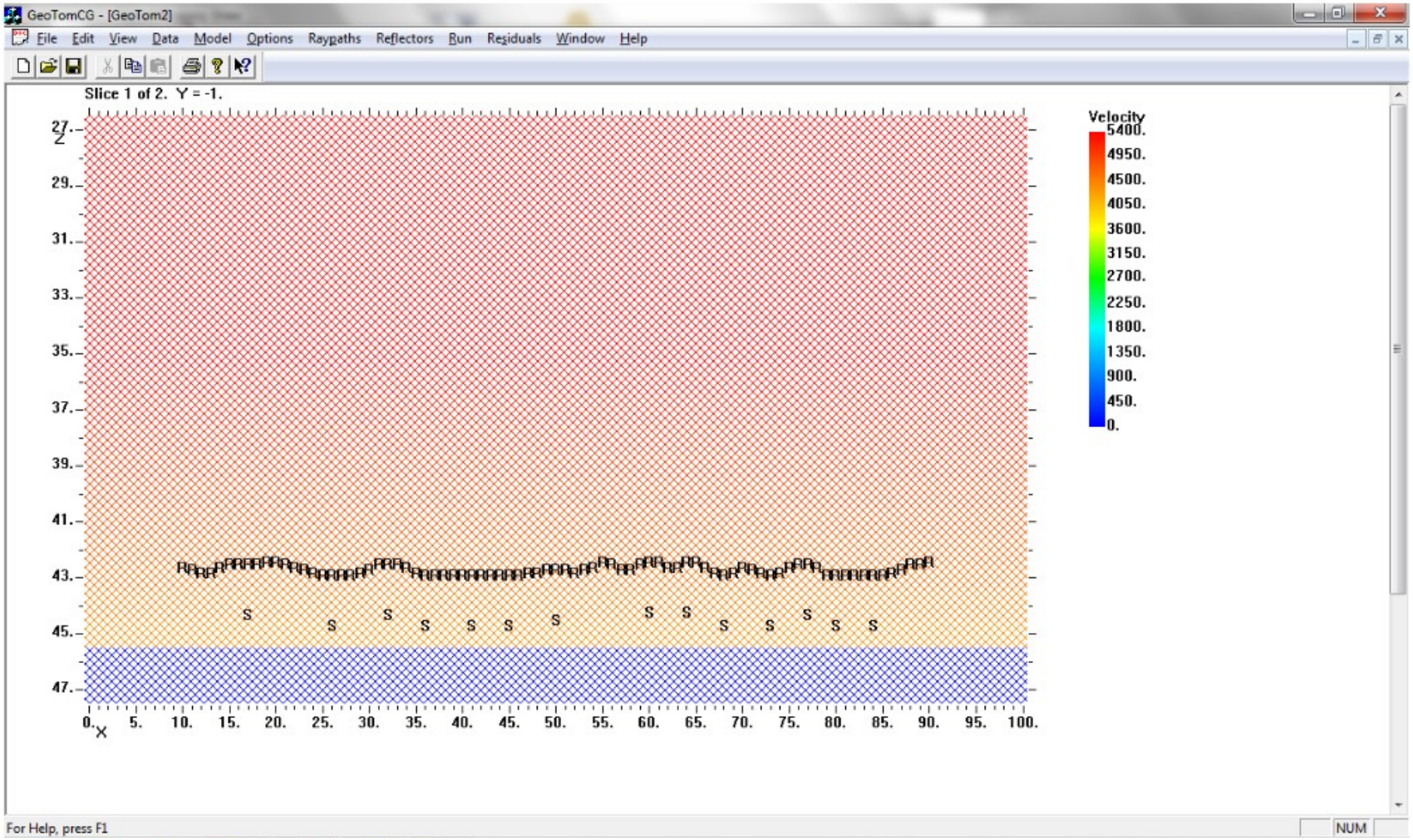


3-D topography model – Dike Anomaly



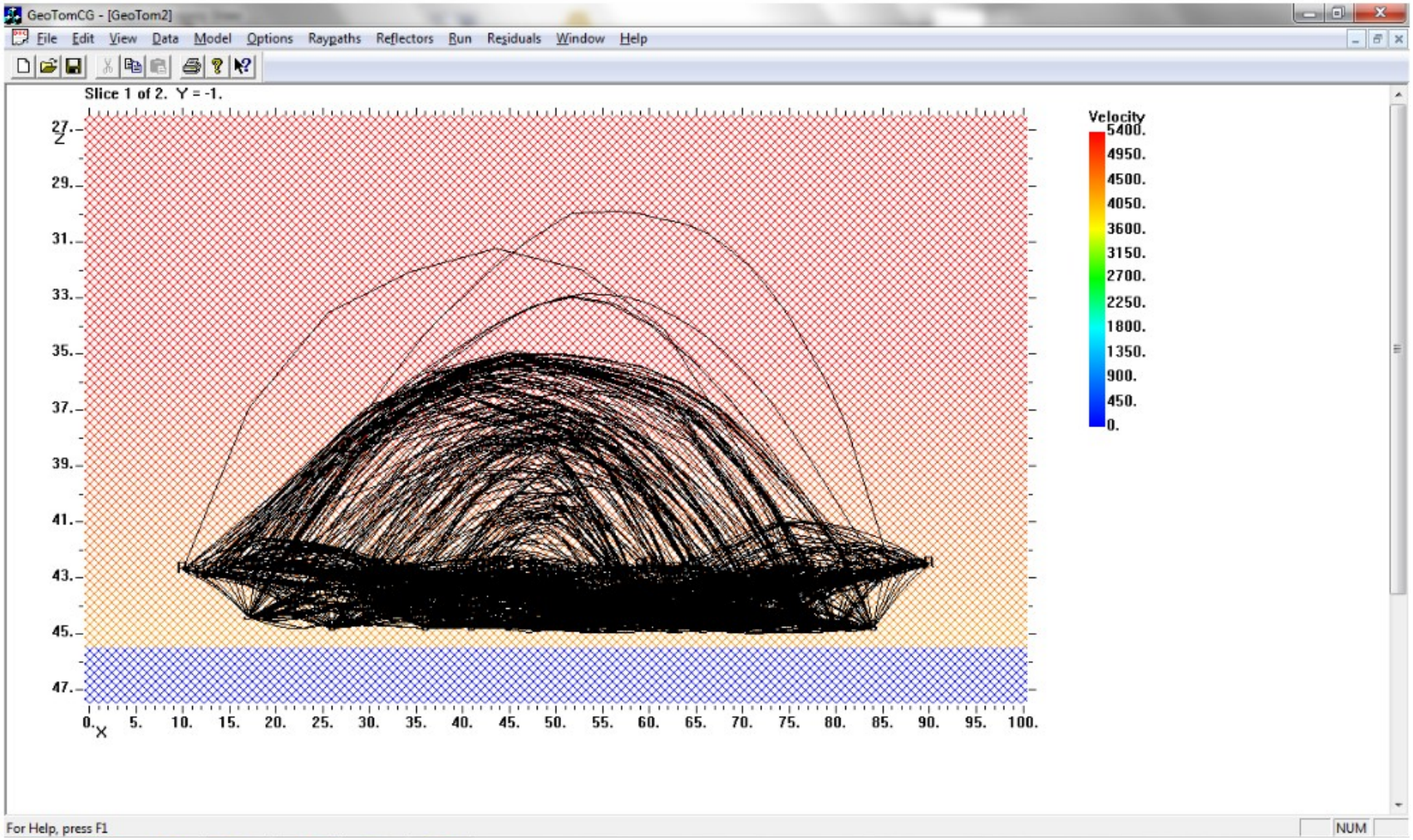
vertical slice intersecting the tunnel axis

Screenshots of GeoTomCG Program



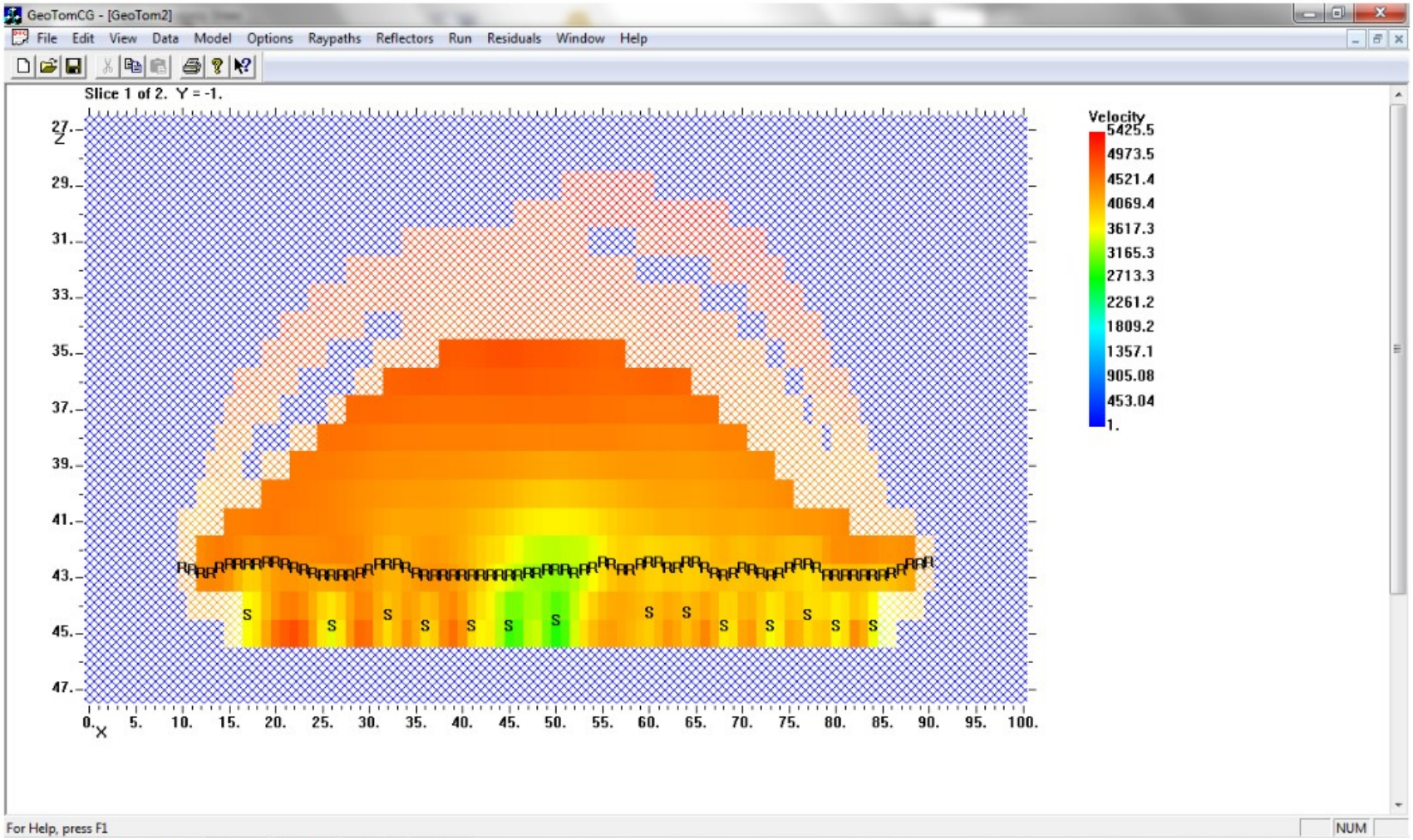
Starting model + Source & Receiver Geometry

Screenshots of GeoTomCG Program



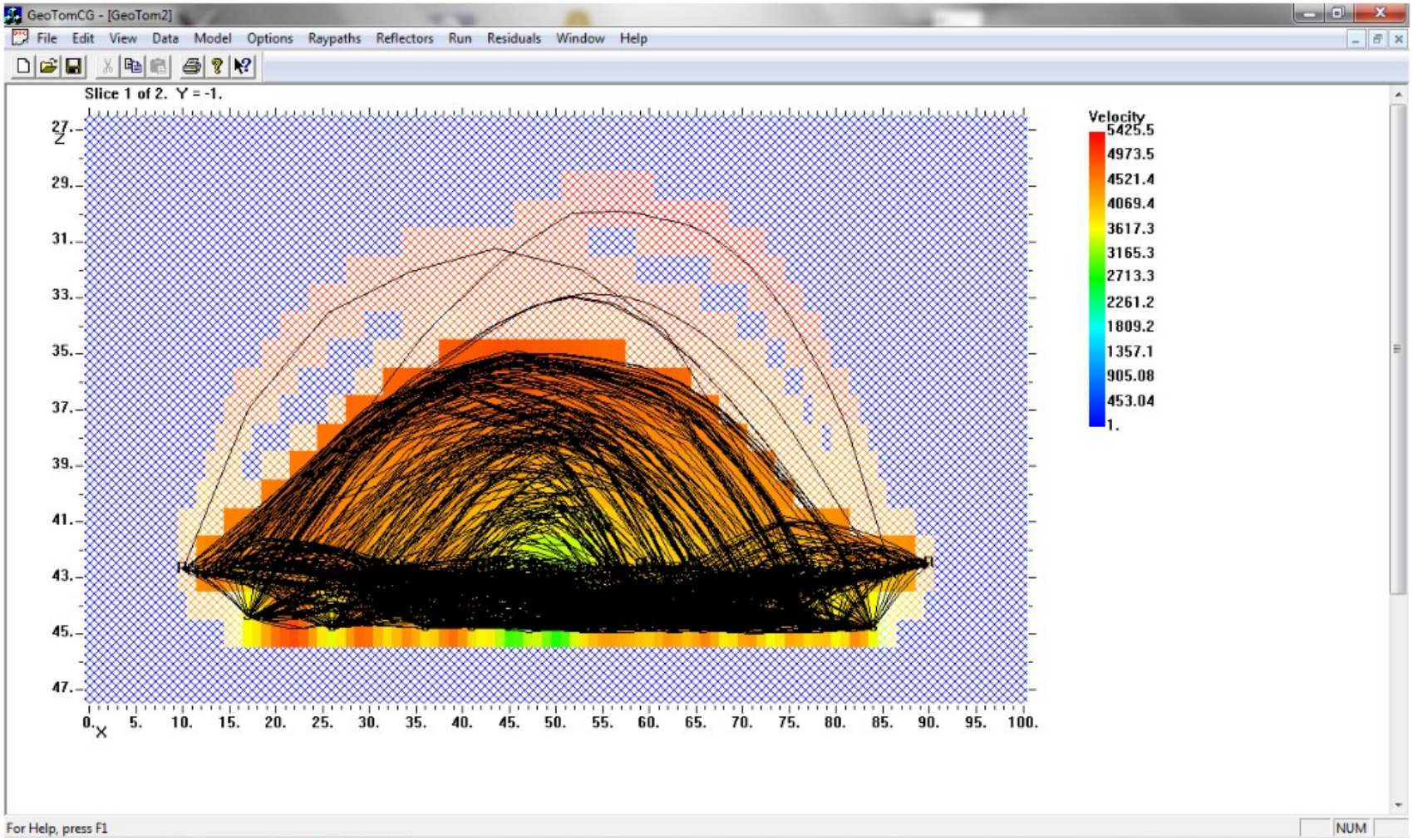
Starting model + Source & Receiver Geometry + Raypaths

Screenshots of GeoTomCG Program



Inverted model + Source & Receiver Geometry

Screenshots of GeoTomCG Program



Inverted model + Source & Receiver Geometry + Raypaths