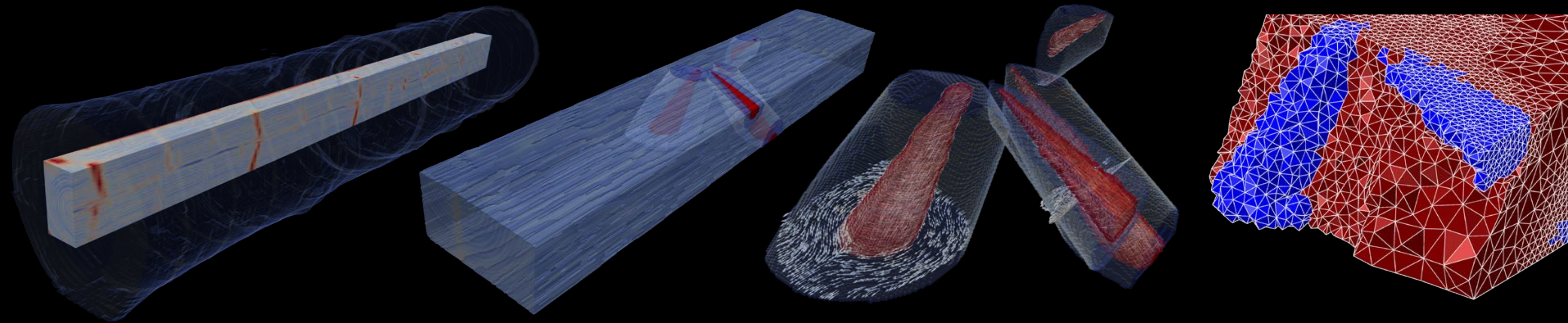


# KAN VI SE PLANKANS HÅLLFASTHET I STOCKEN FÖRE SÅGNINGEN?



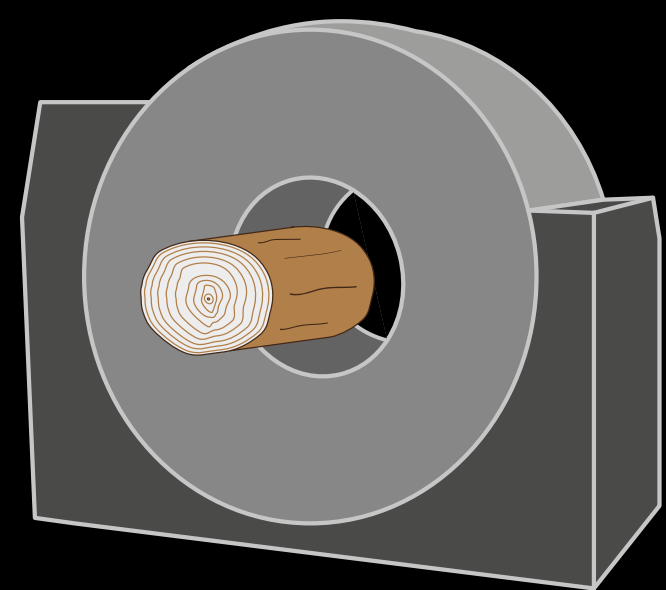
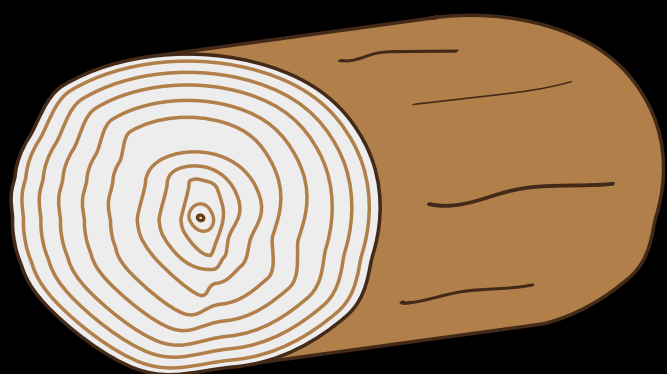


[johannes.huber@ltu.se](mailto:johannes.huber@ltu.se)

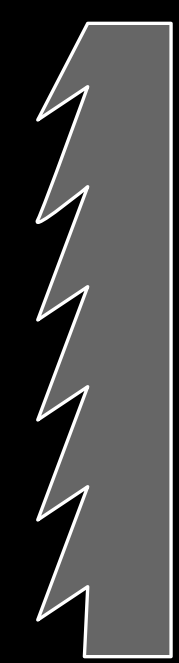
PhD, Bitr. lektor  
Skellefteå

LULEÅ  
UNIVERSITY  
OF TECHNOLOGY  
WOOD SCIENCE, SKELLEFTEÅ

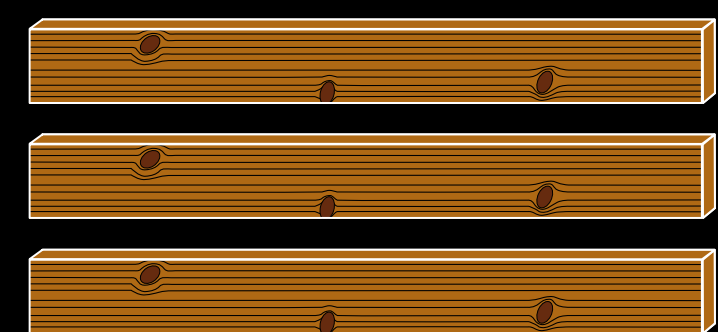
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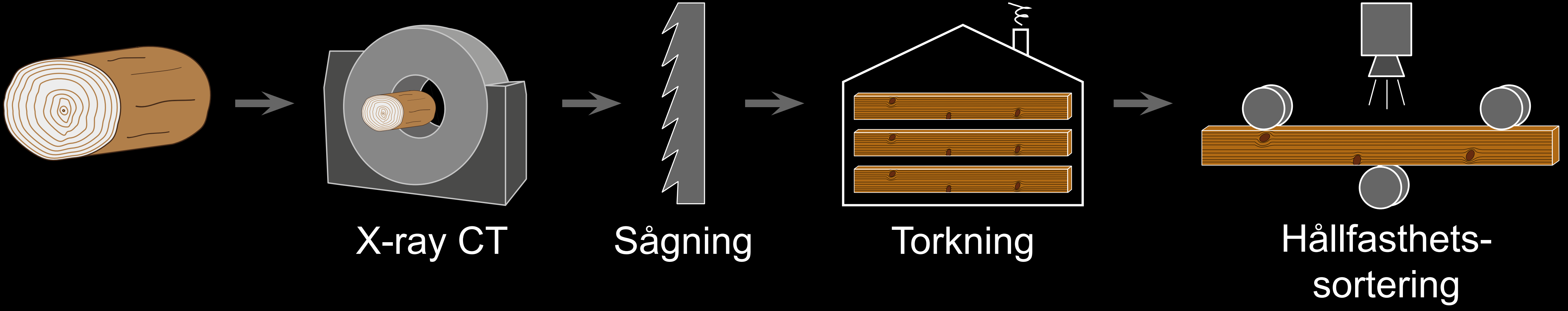


X-ray CT



Sågning



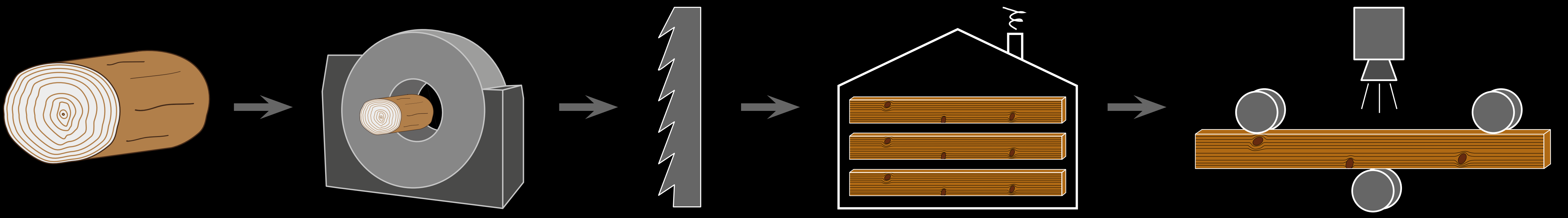


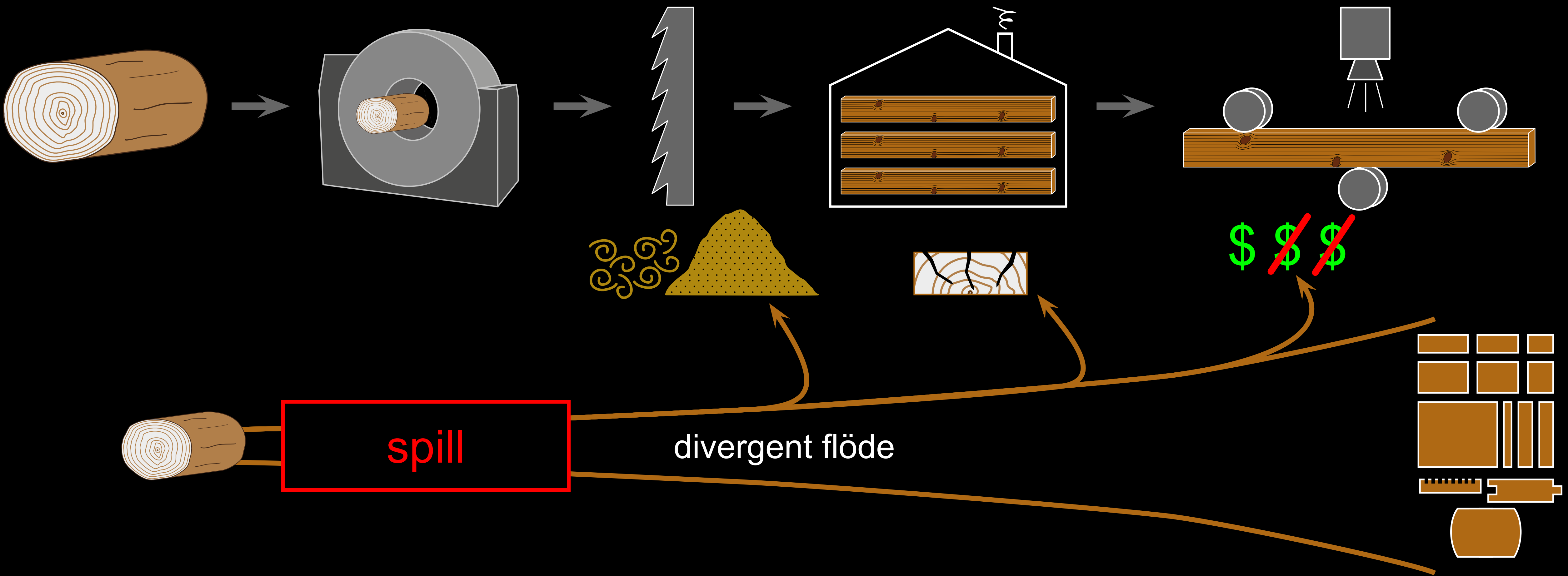
X-ray CT

Sågning

Torkning

Hållfasthets-  
sortering

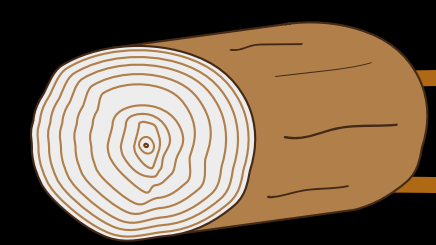
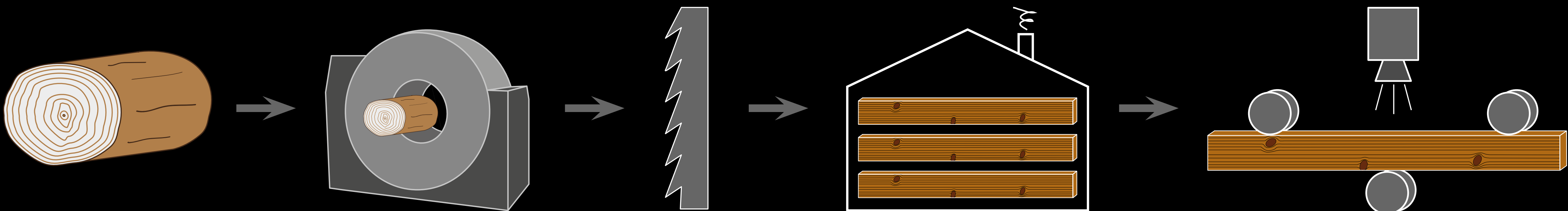




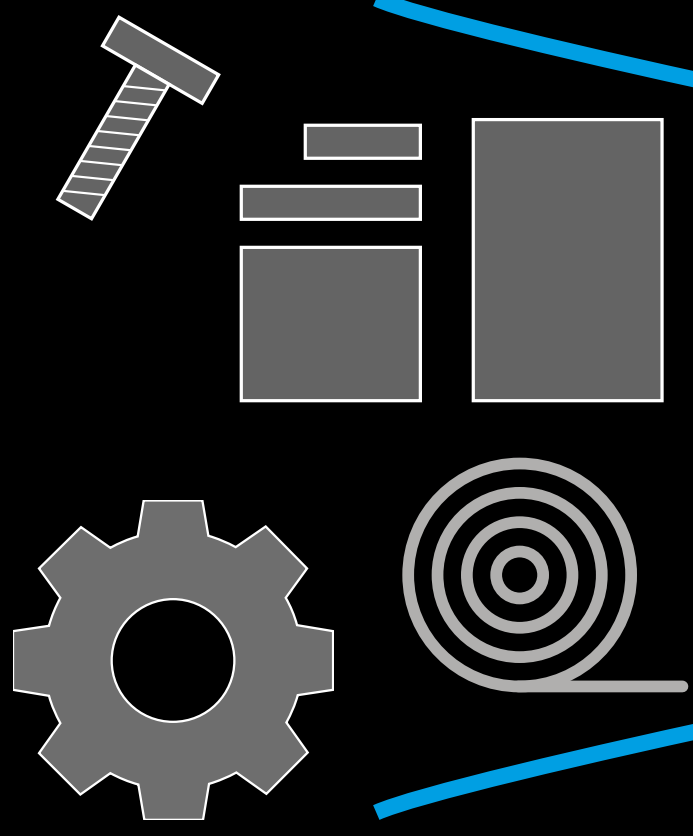
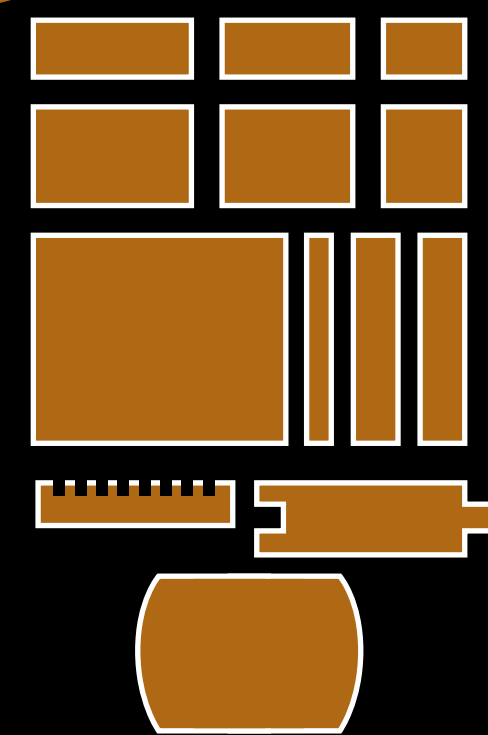
spill

divergent flöde

\$ \$ \$

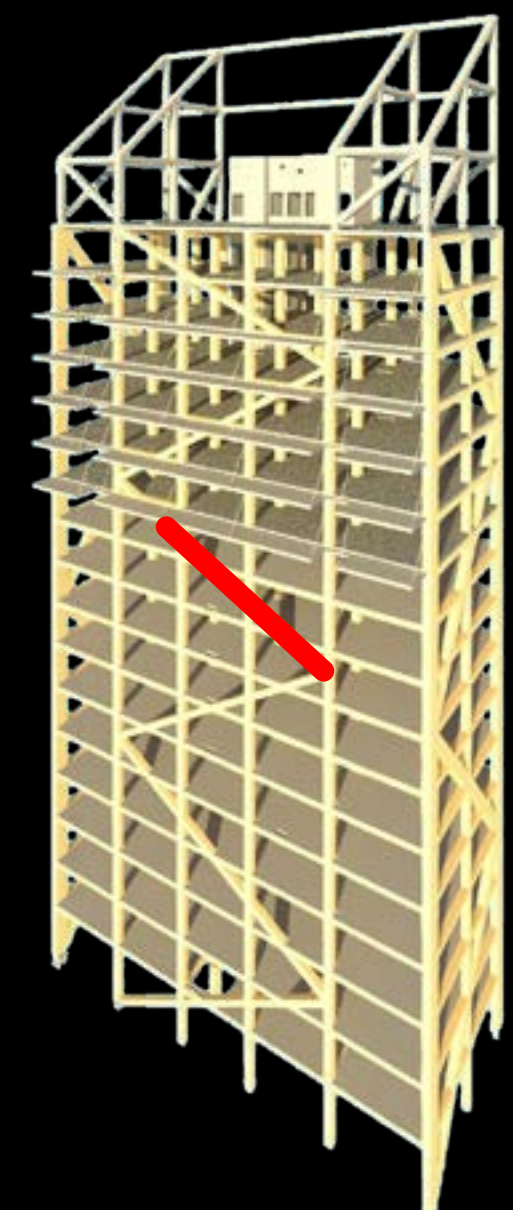
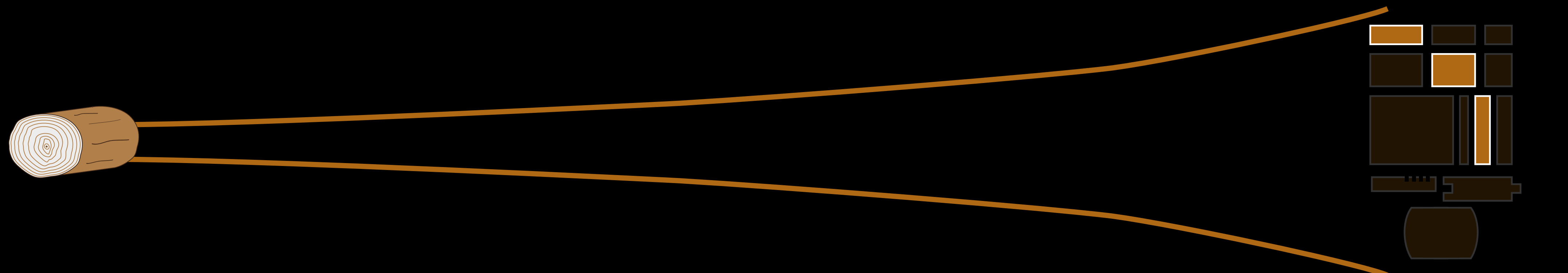
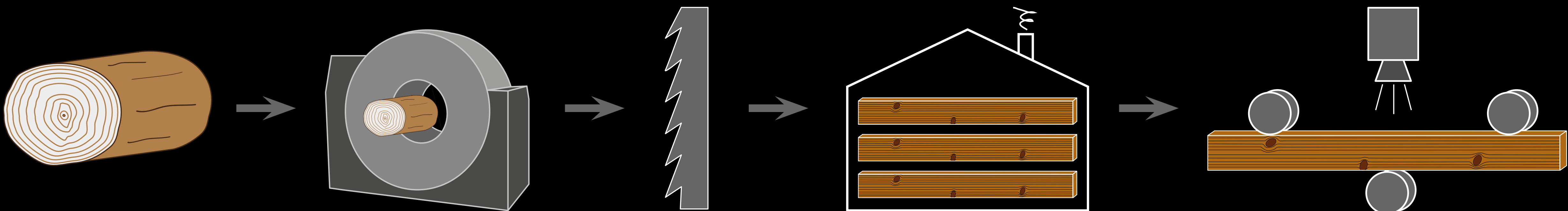


divergent flöde



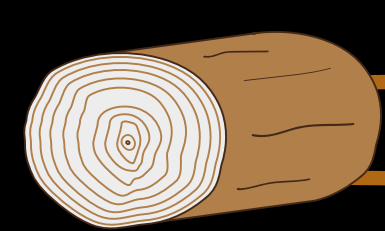
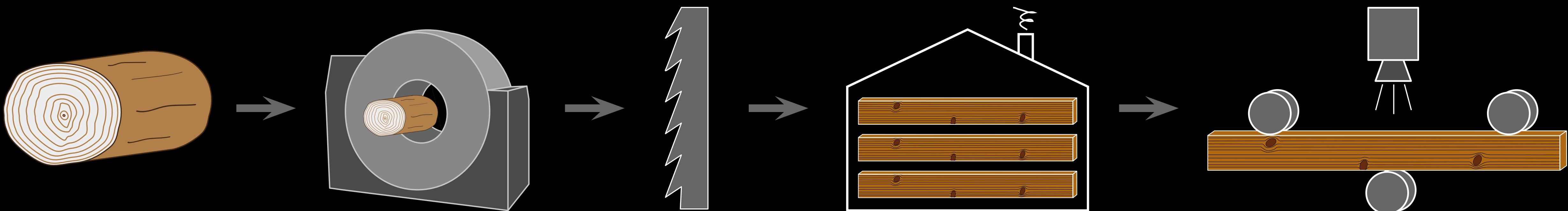
konvergent flöde



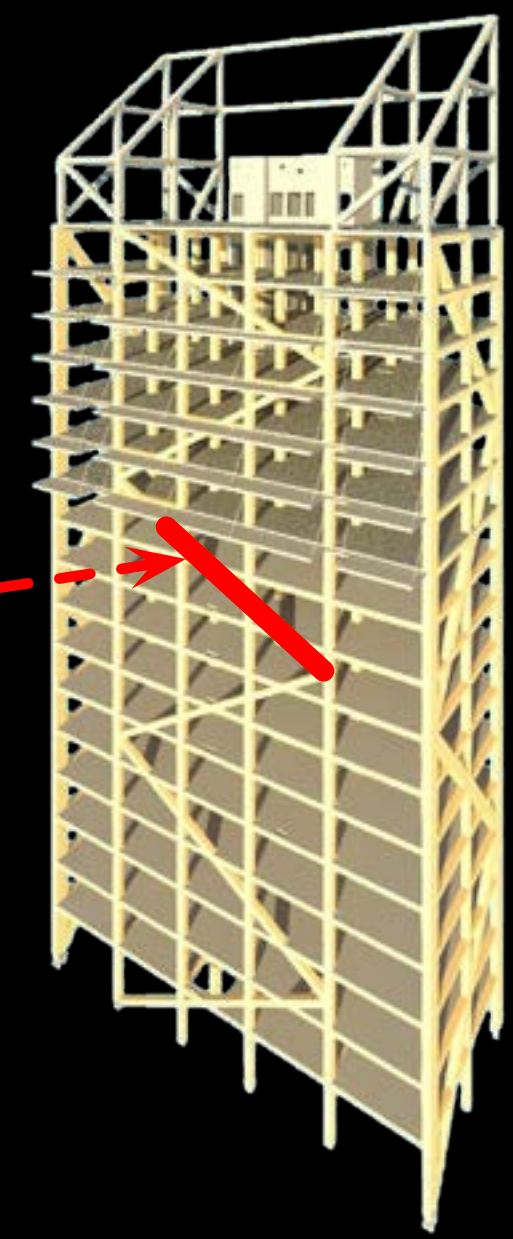
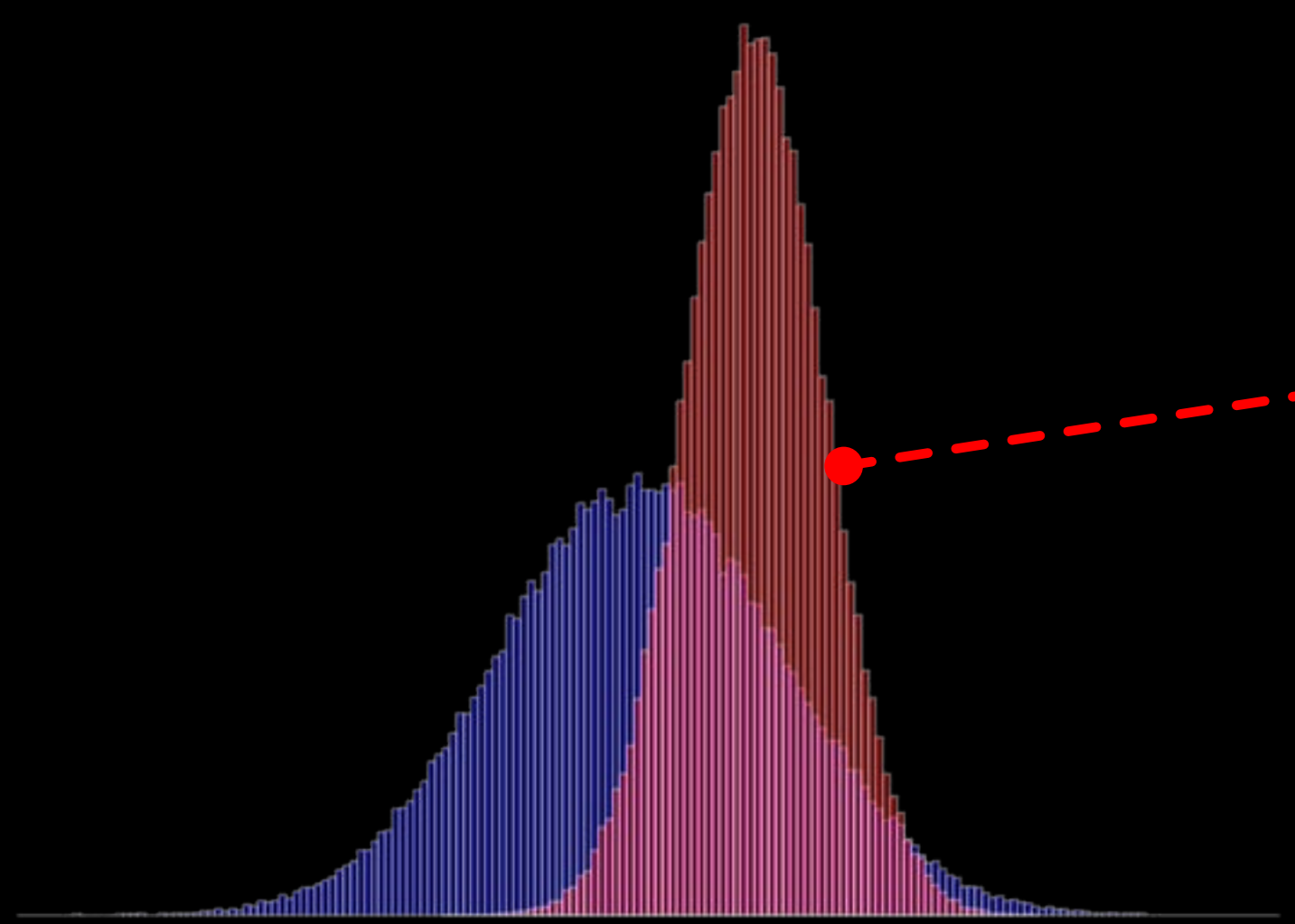


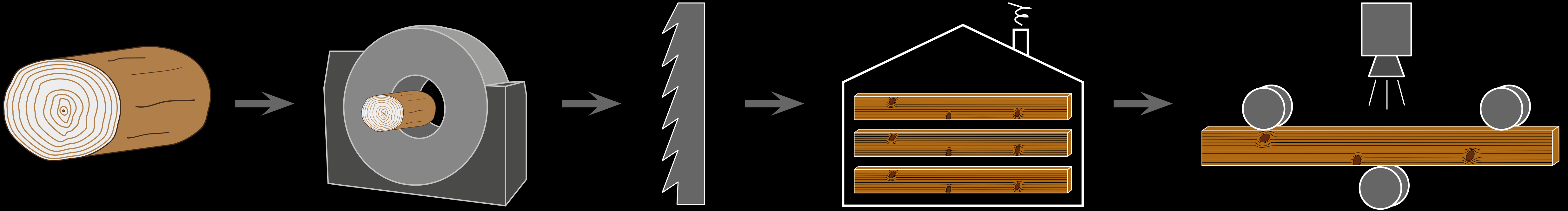
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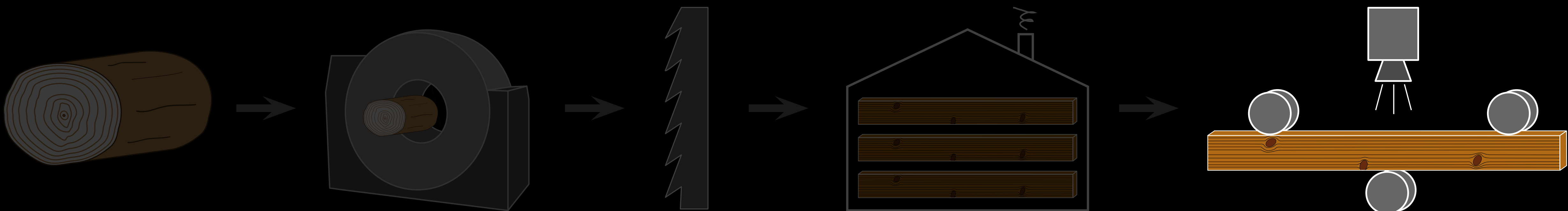




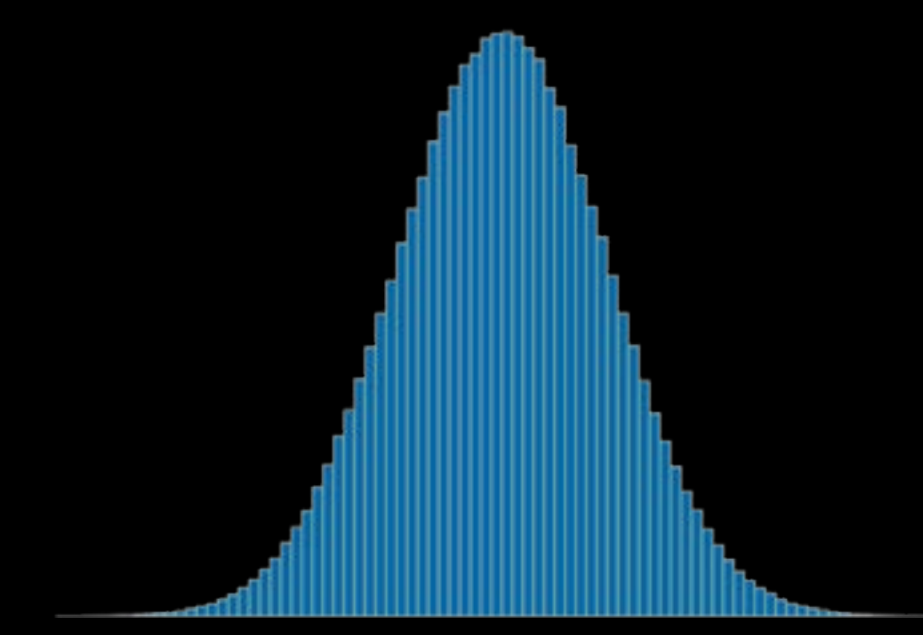
bestäm ändamål  
minska osäkerhet



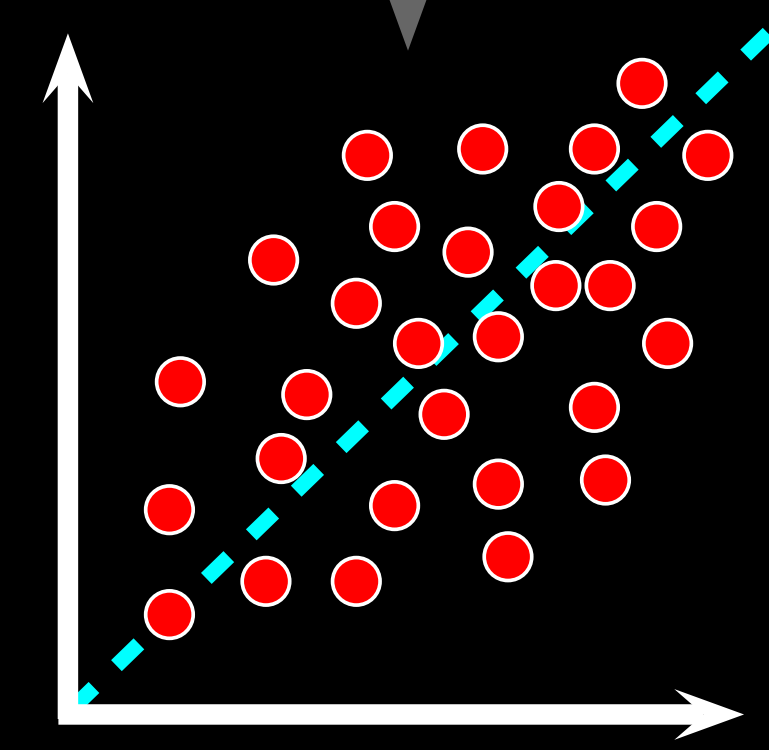




X-ray CT

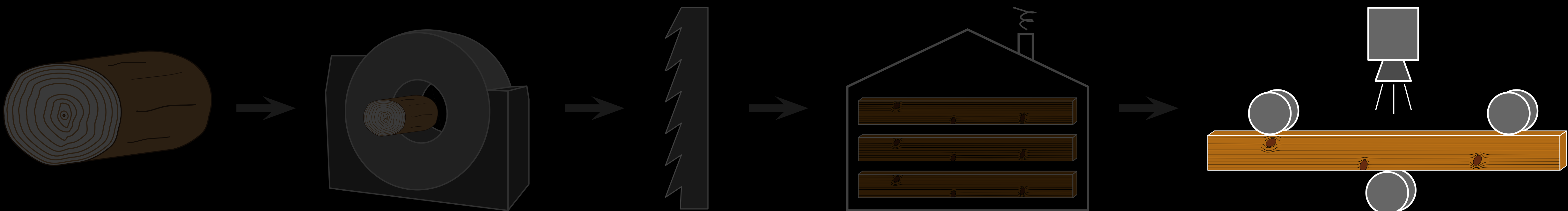


Mekaniska egenskaper



indikator

EFTER



X-ray CT

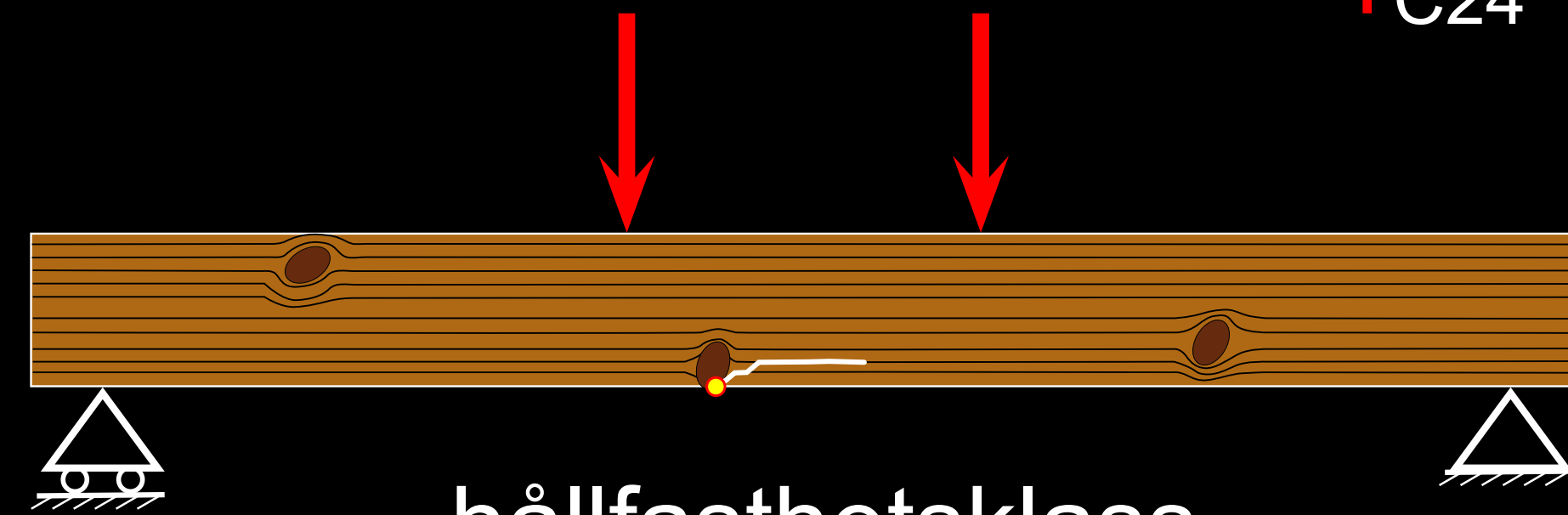
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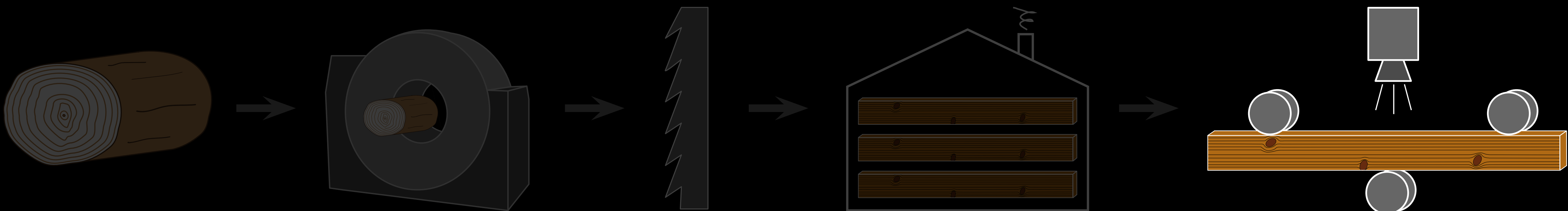
indikator

C24

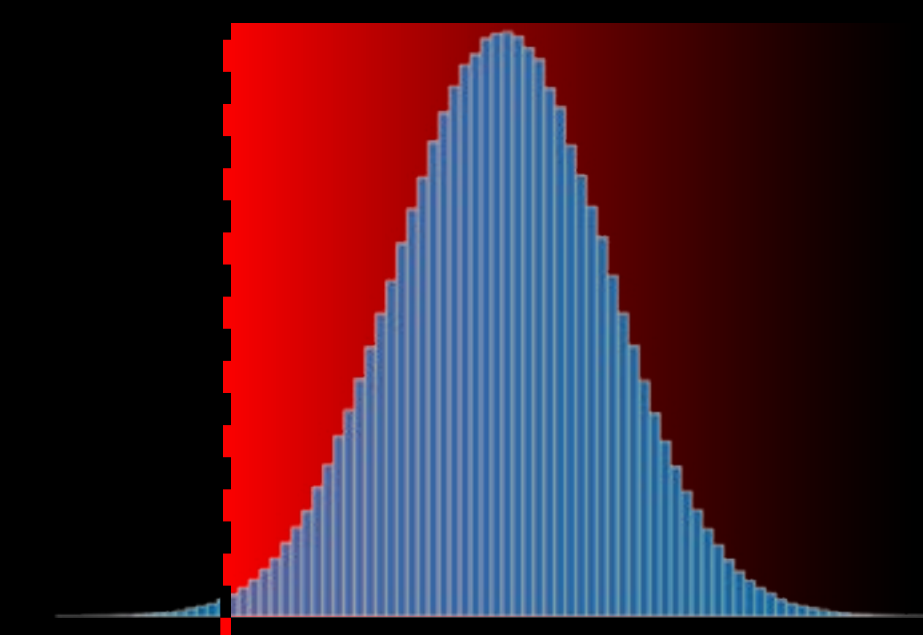
EFTER

hållfasthetsklass

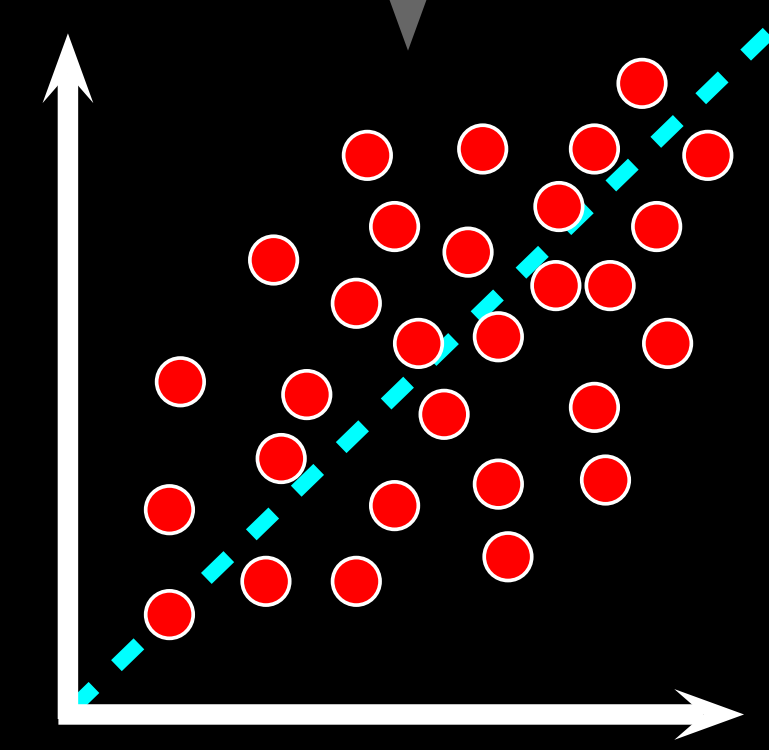




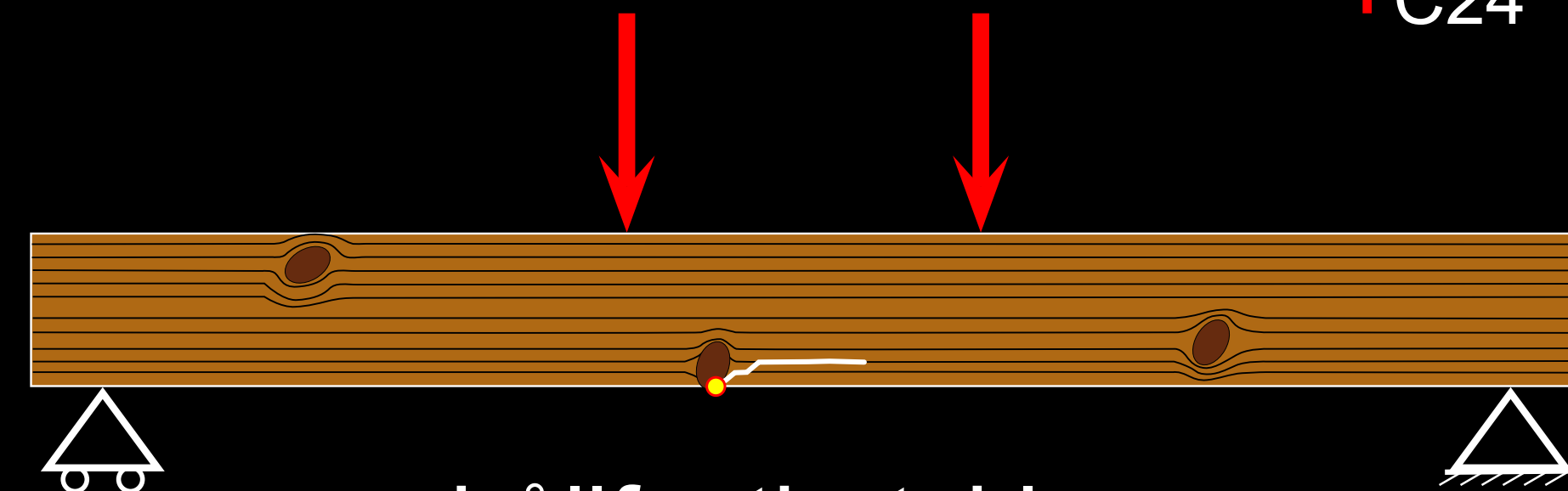
X-ray CT



Mekaniska egenskaper



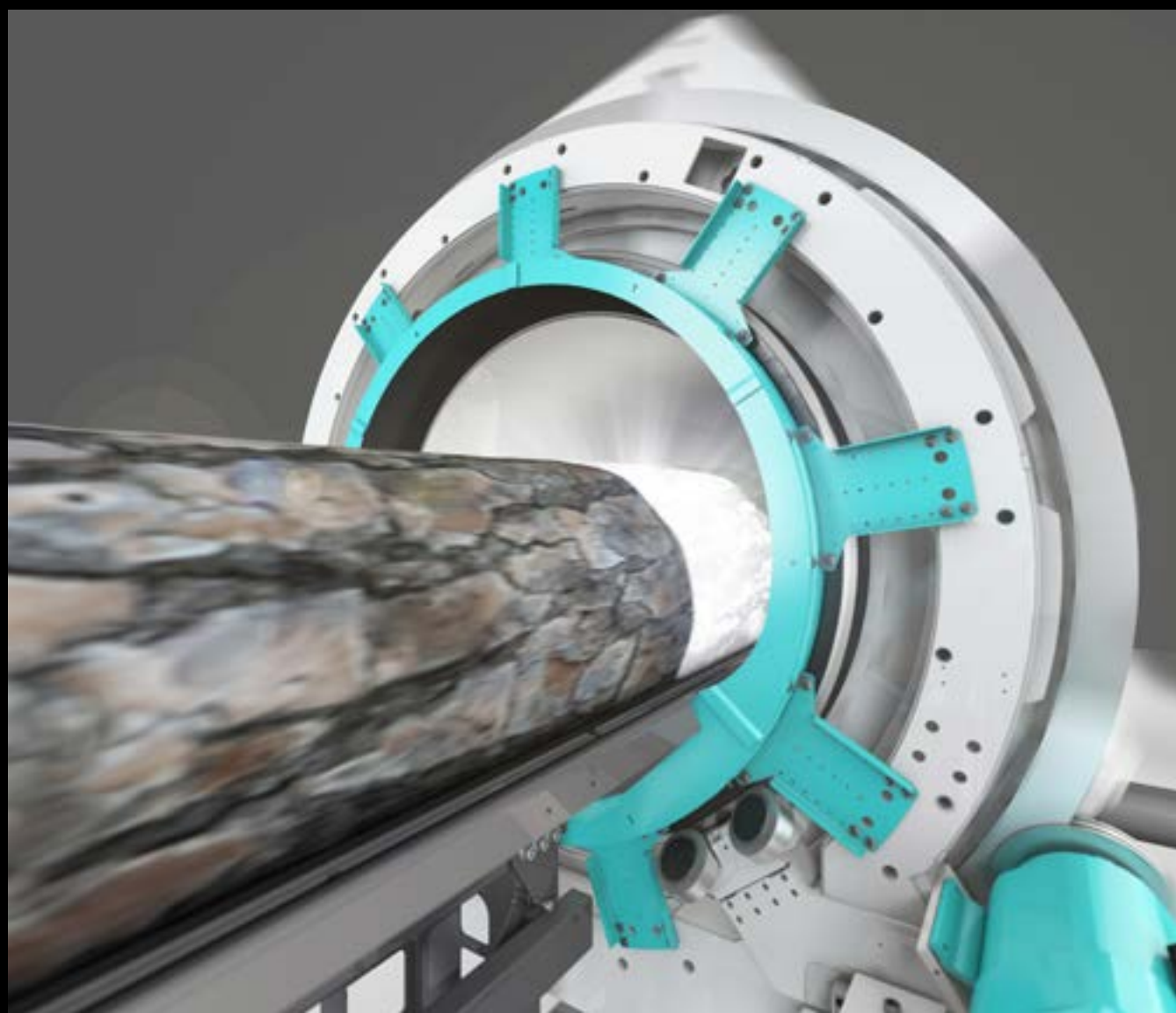
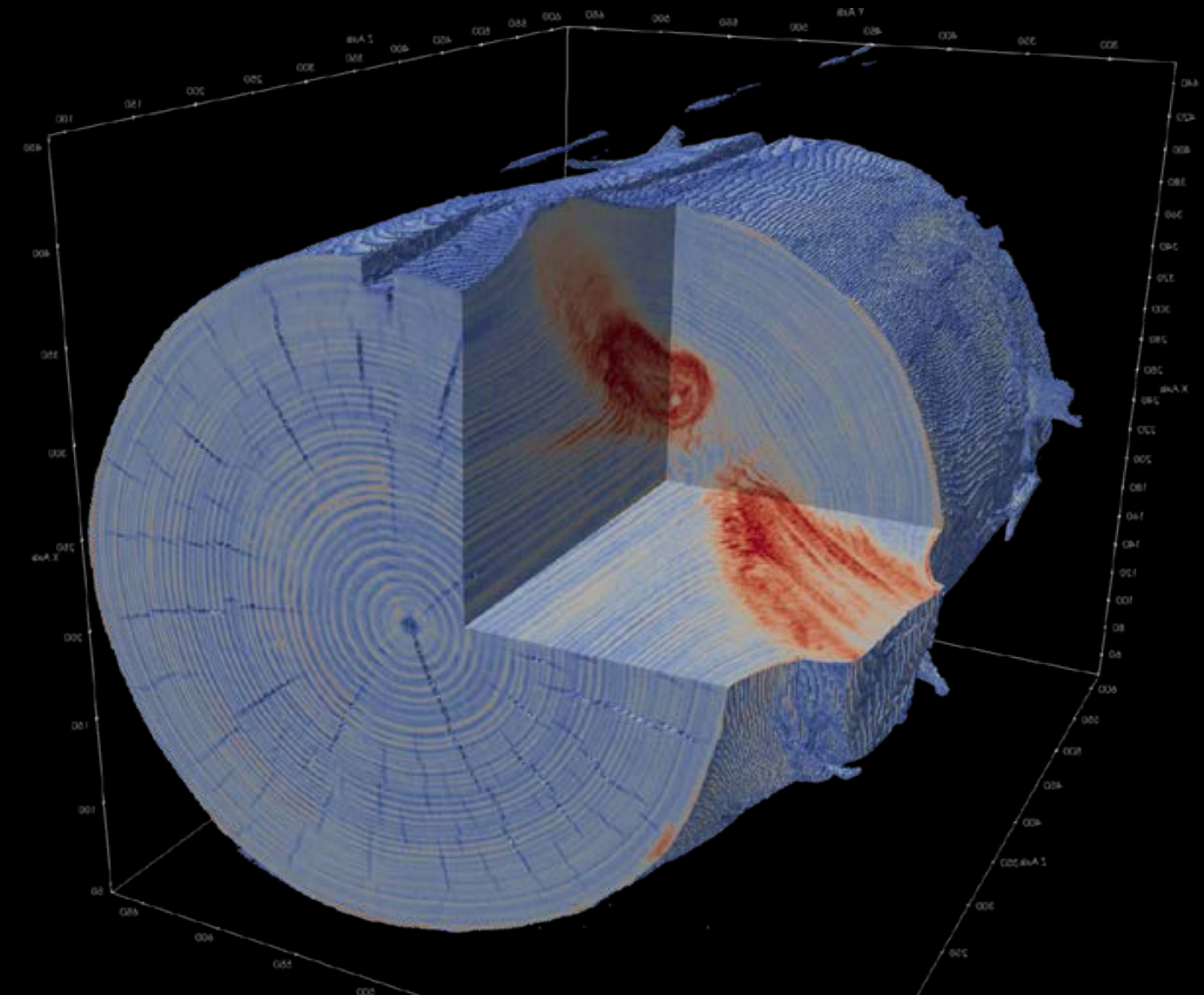
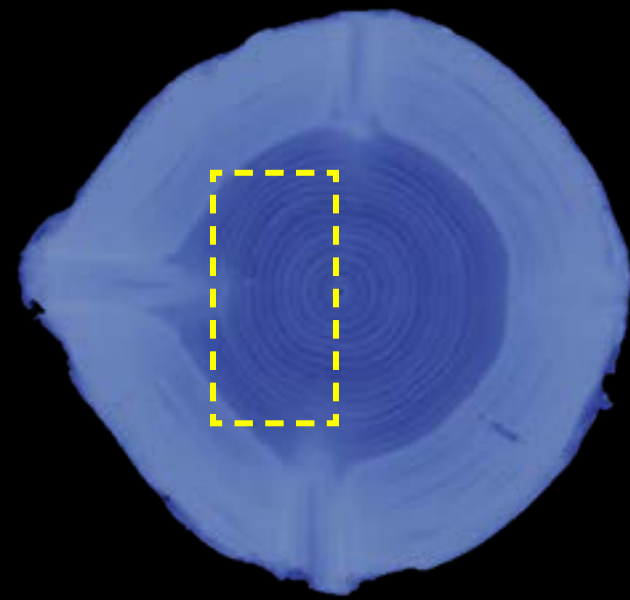
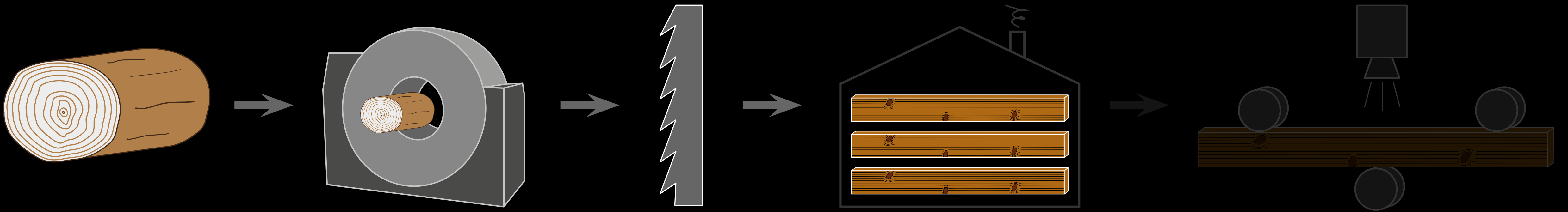
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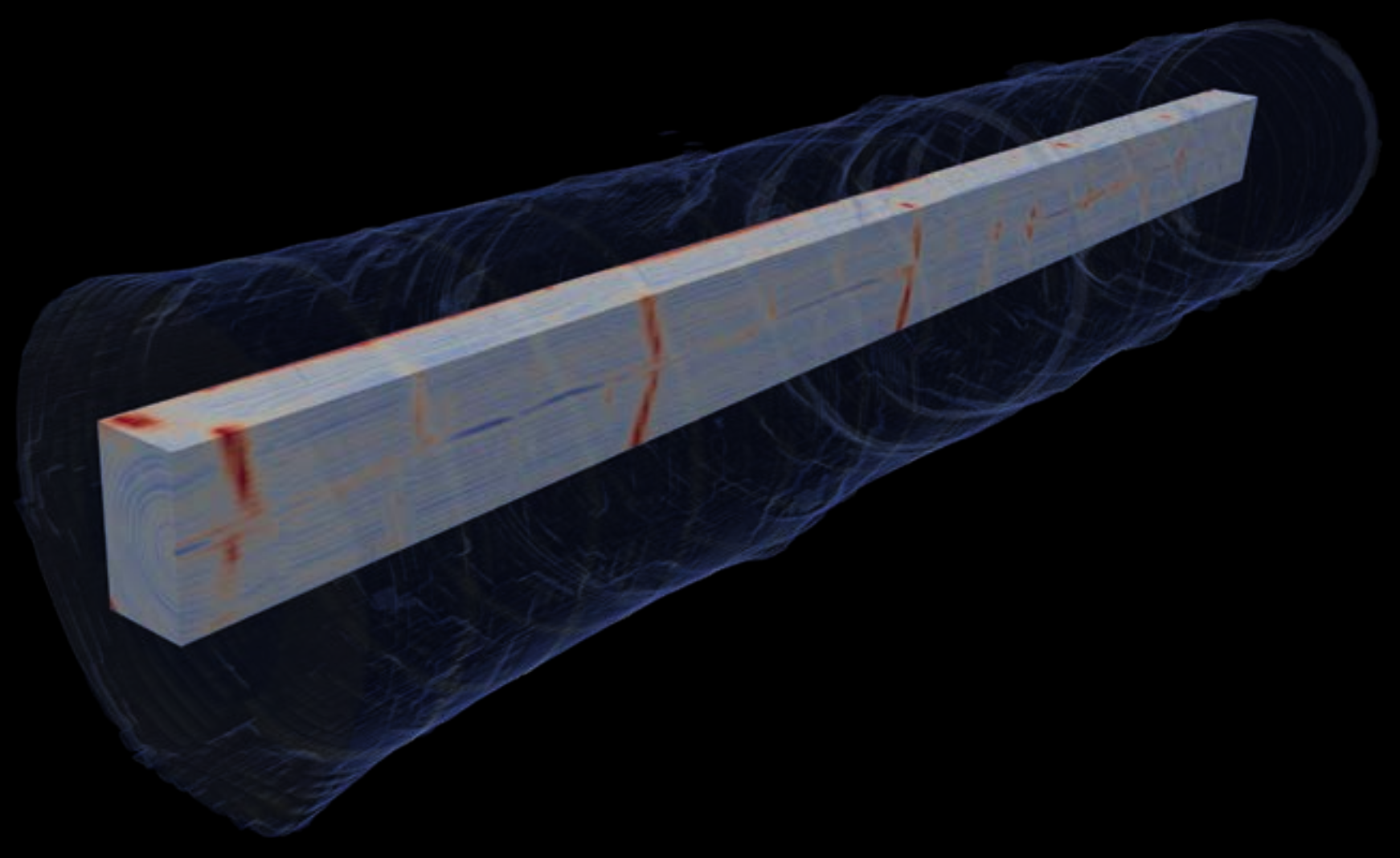
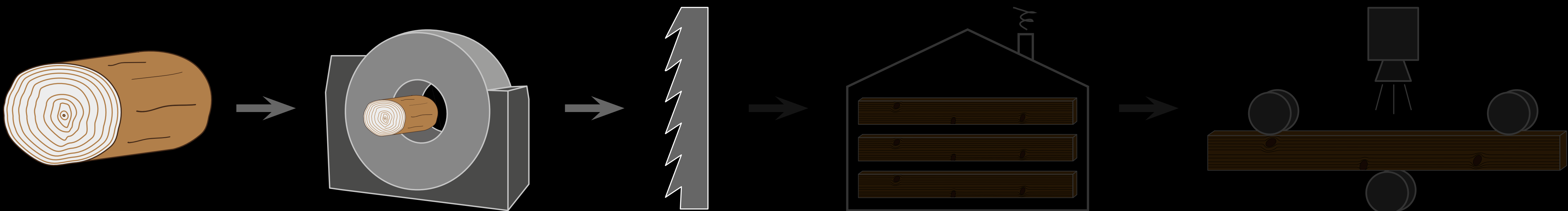
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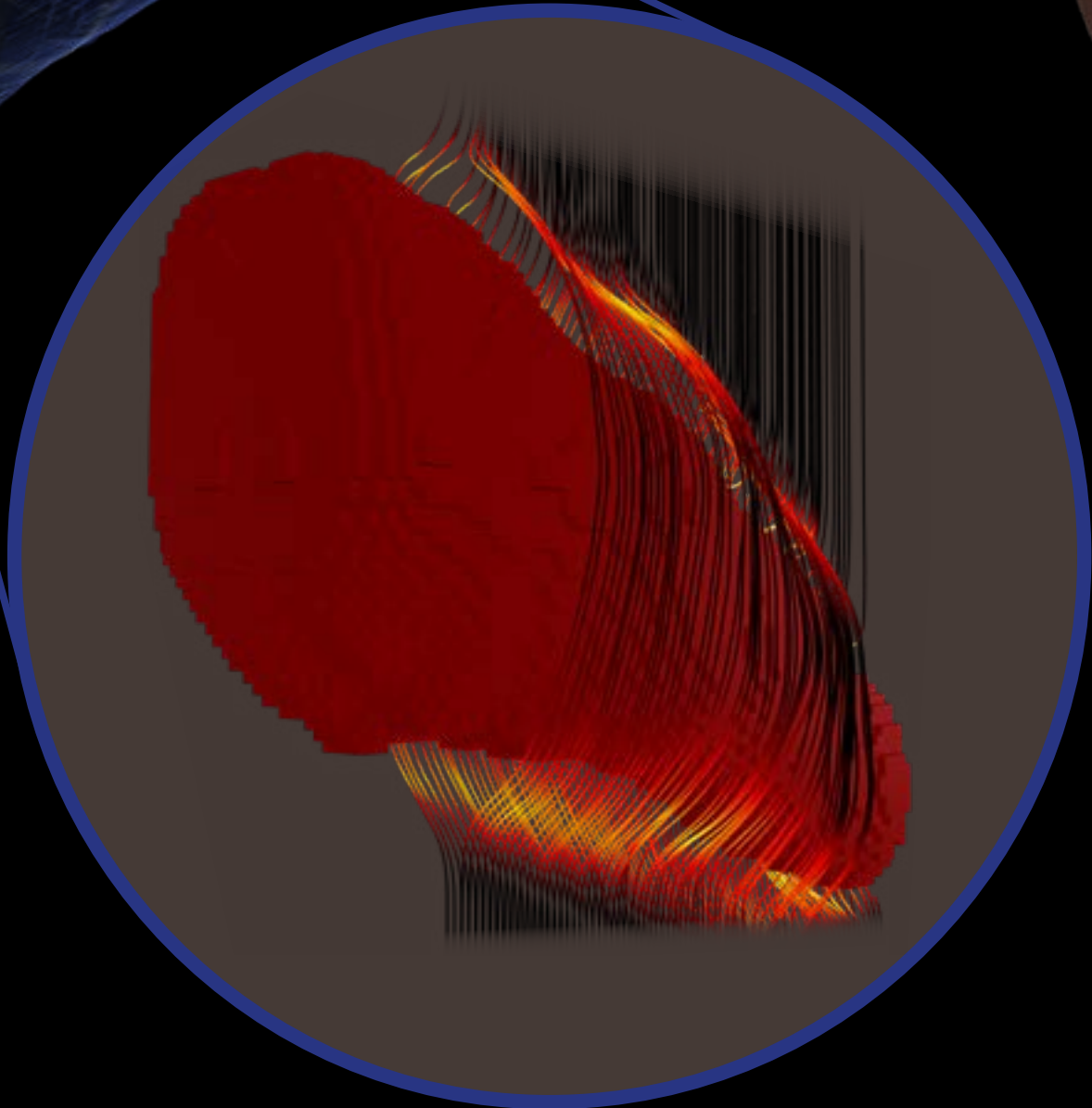
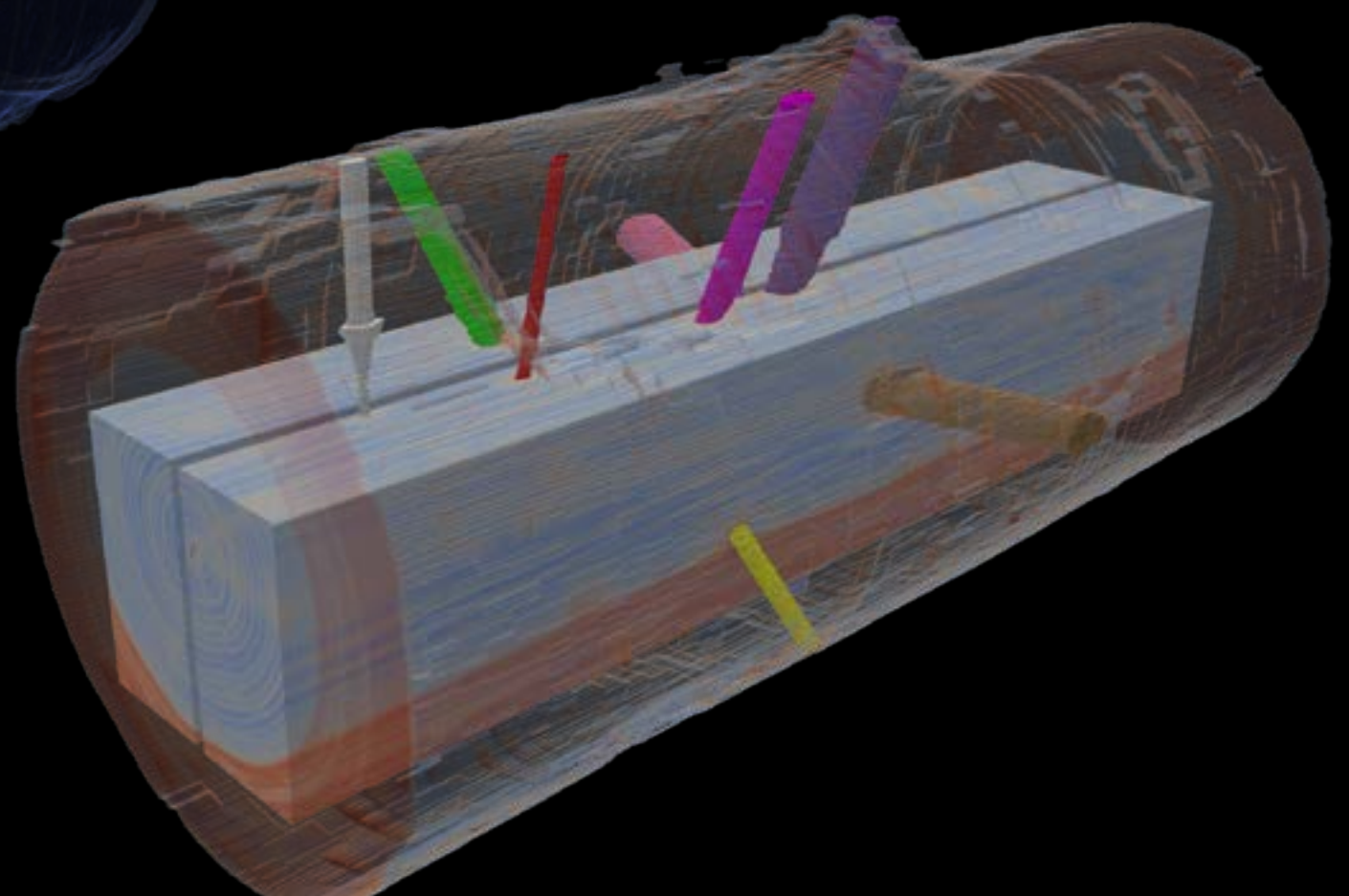
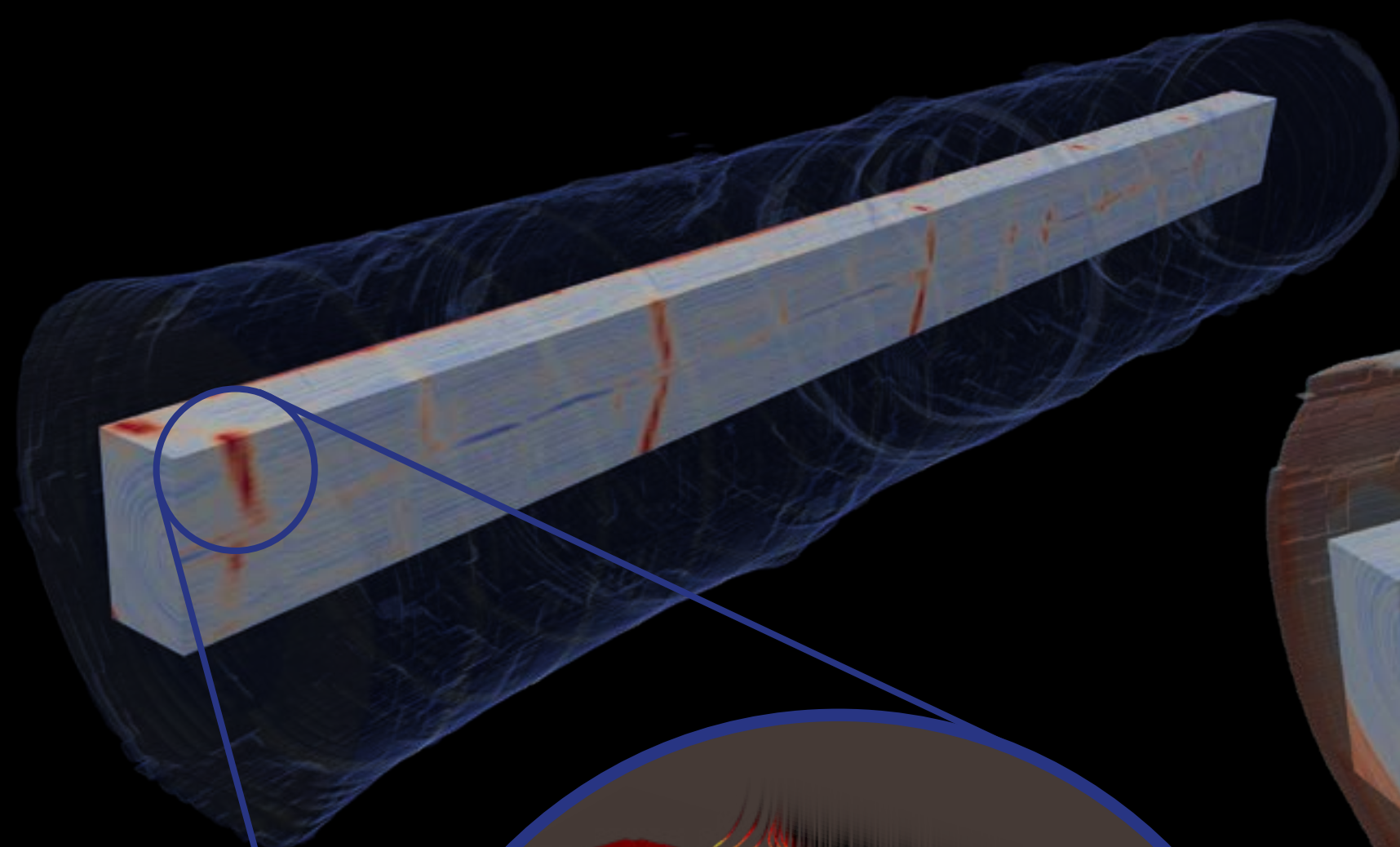
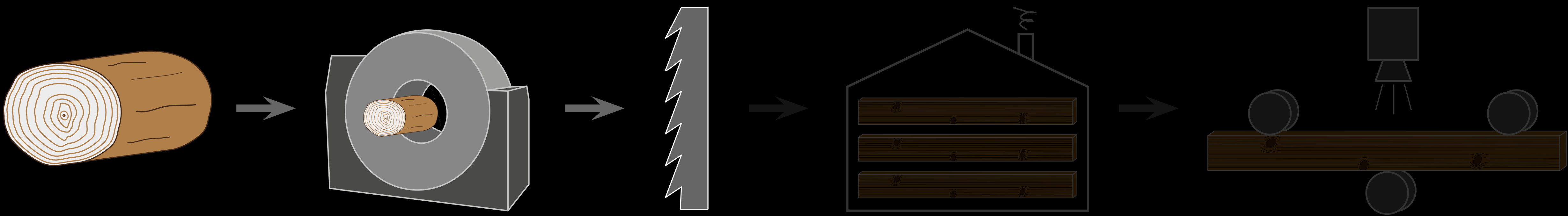
EFTER



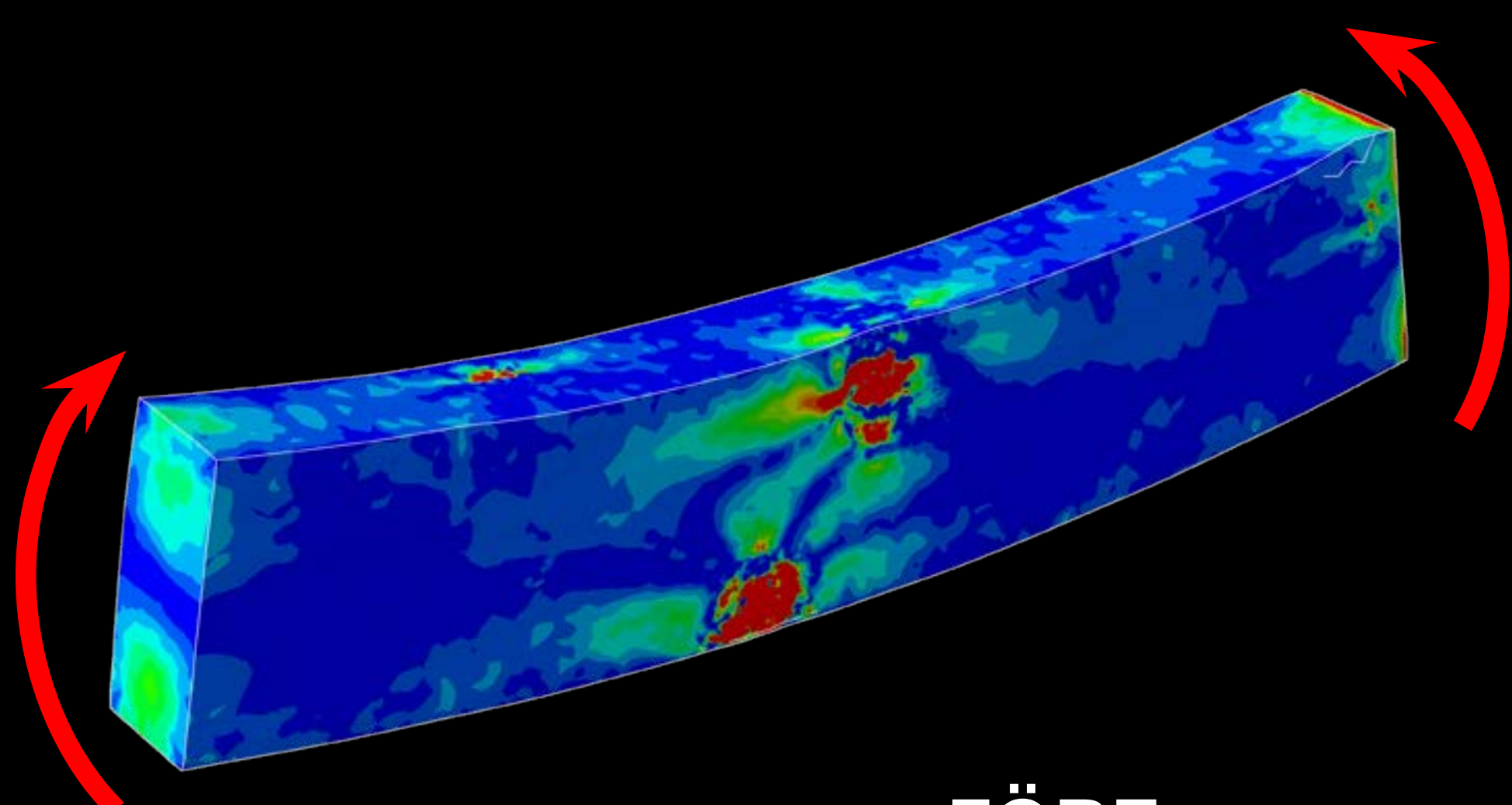
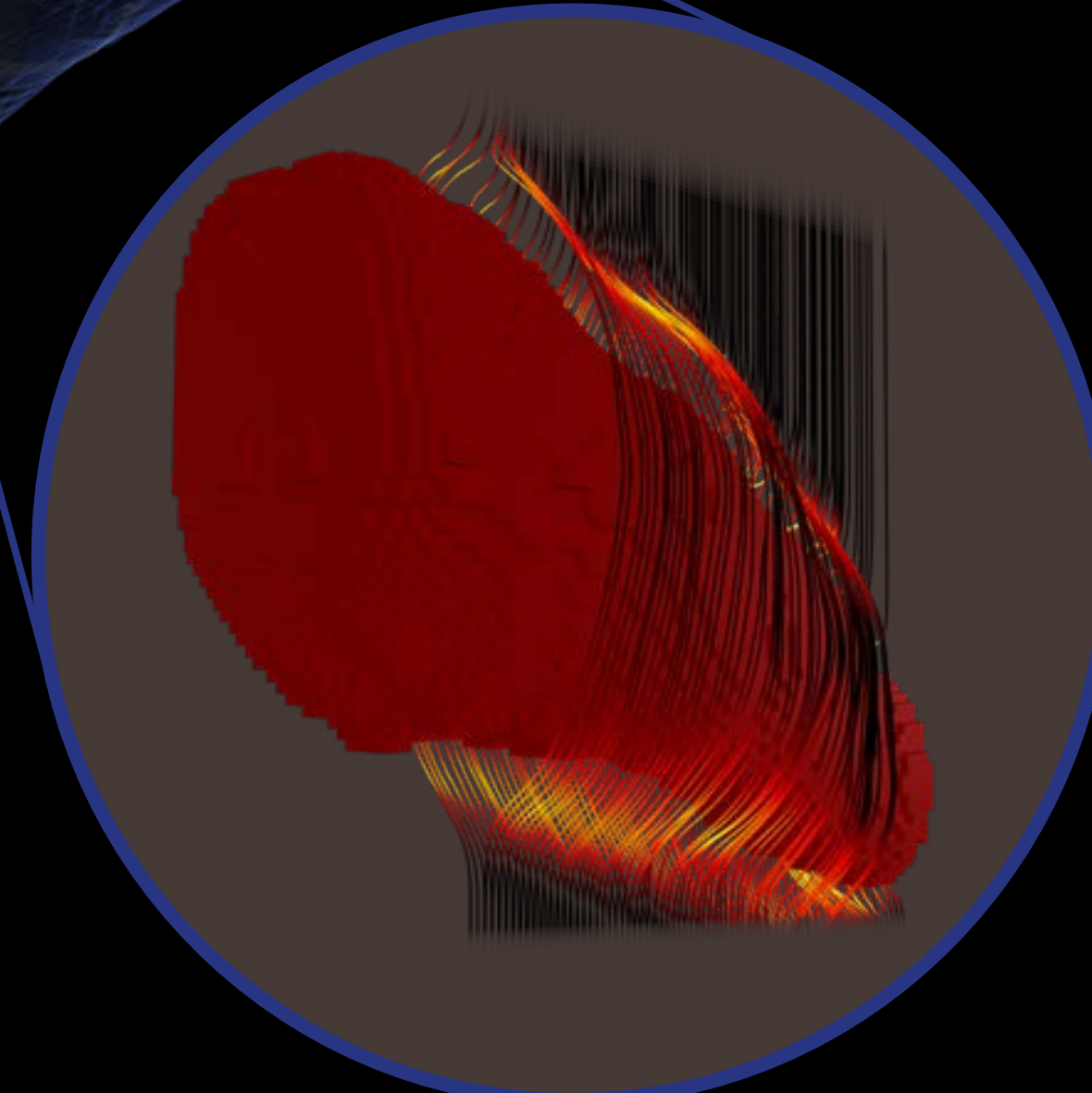
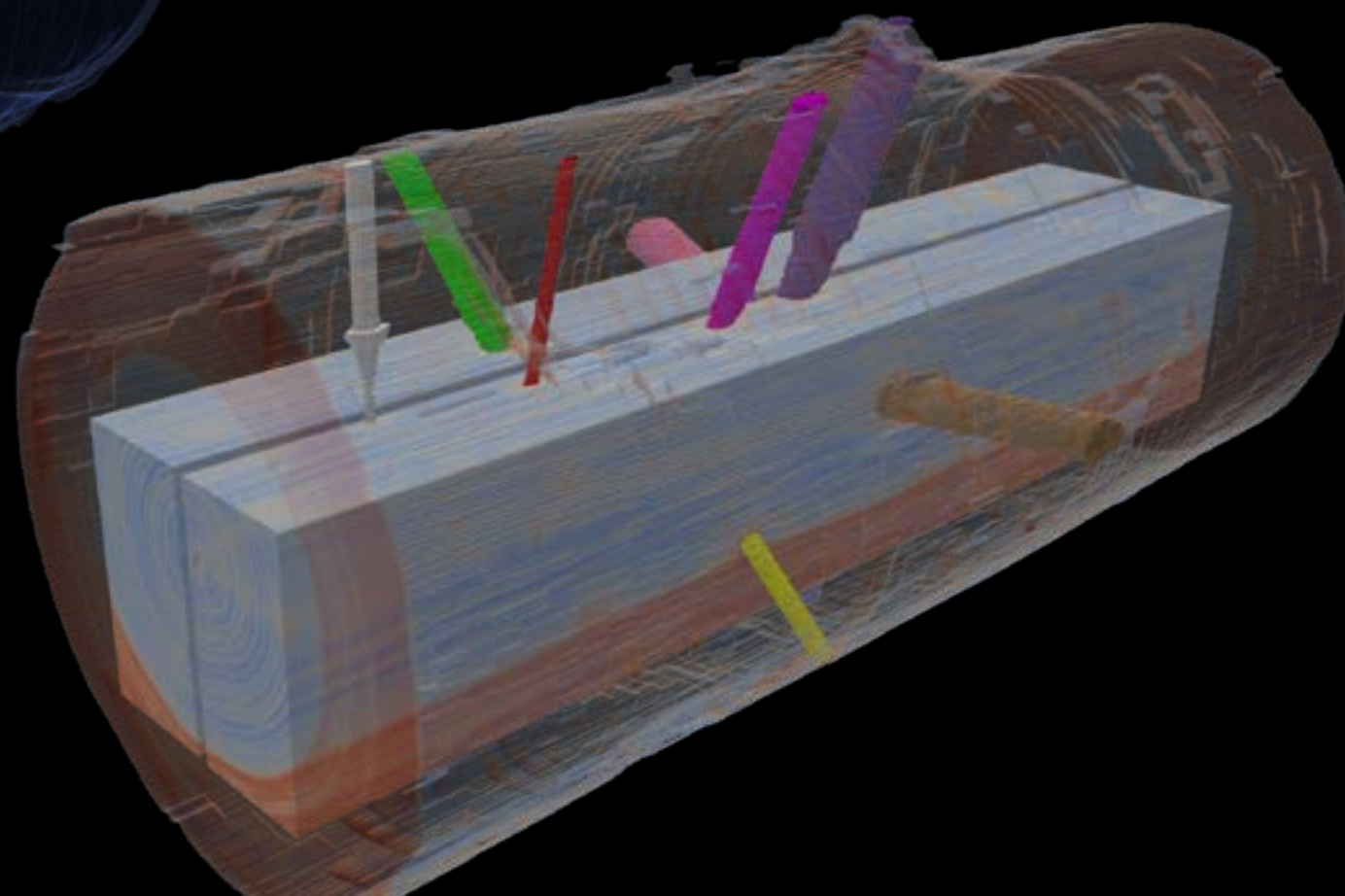
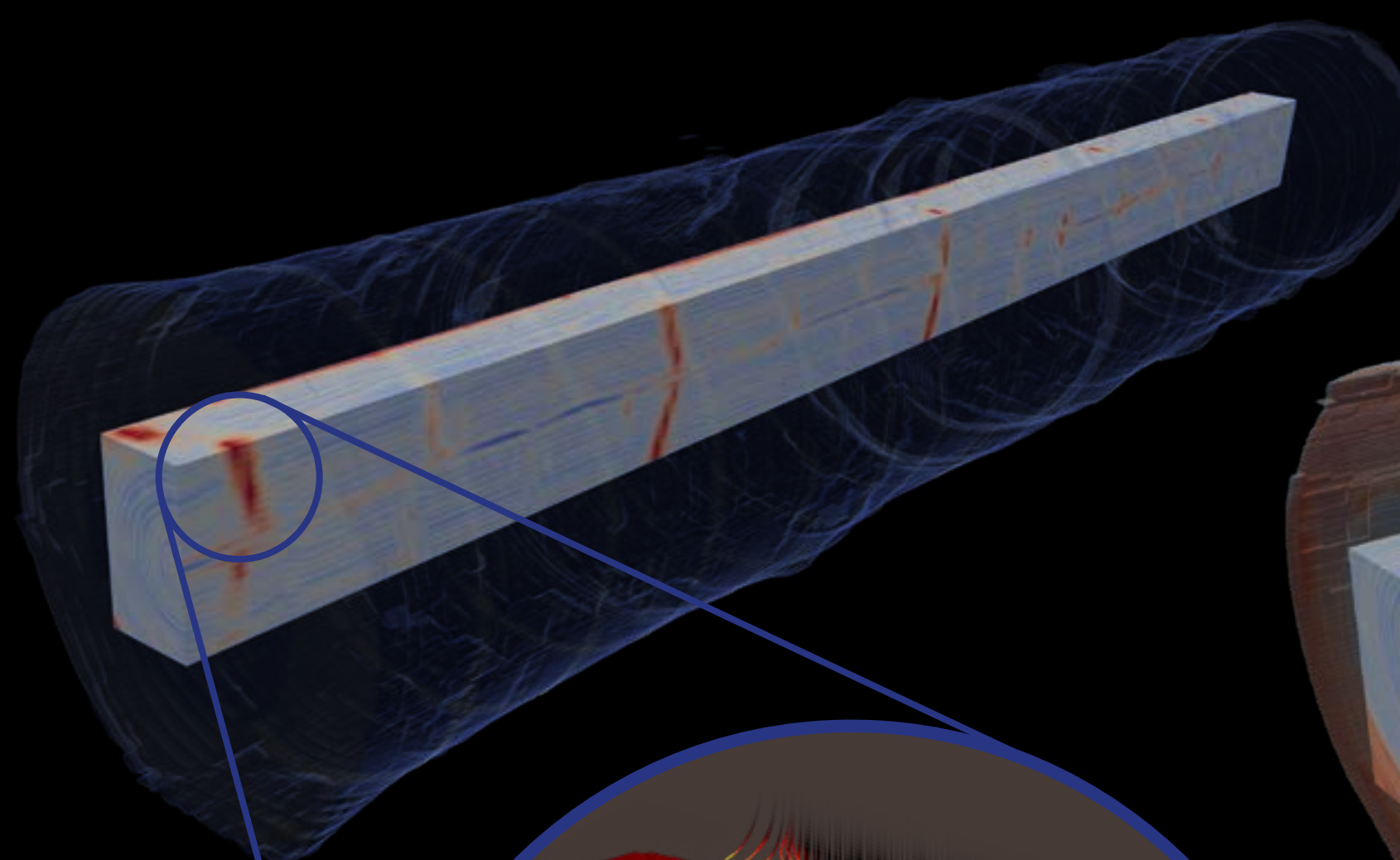
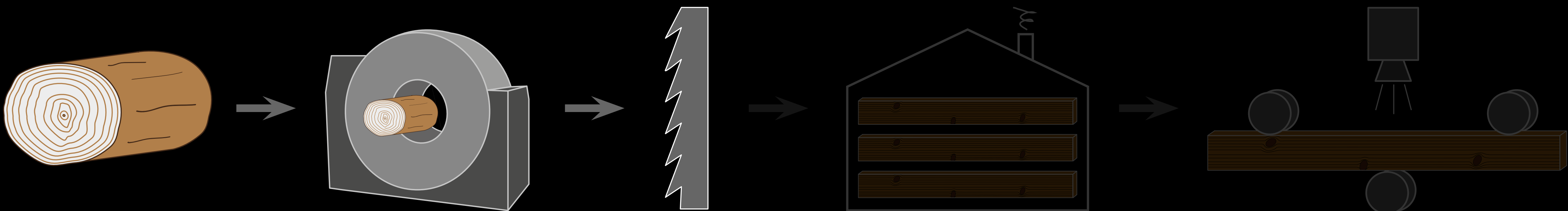


Röntgendatortomografi  
(X-ray Computed Tomography)

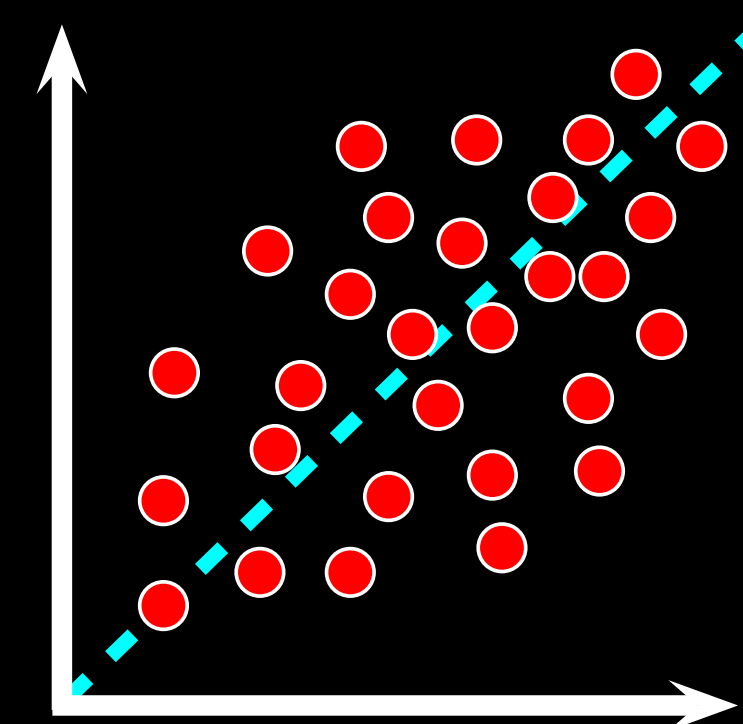
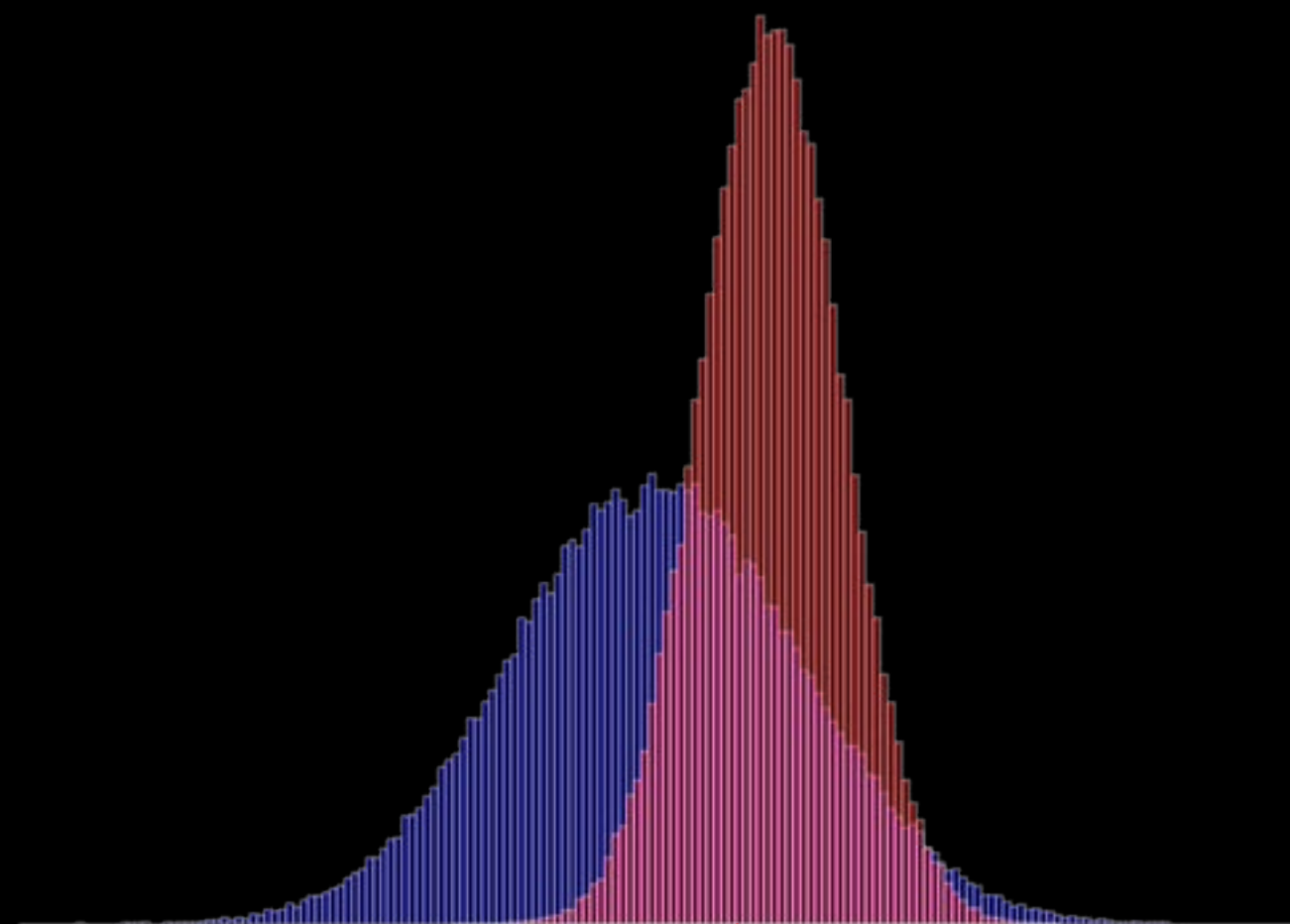
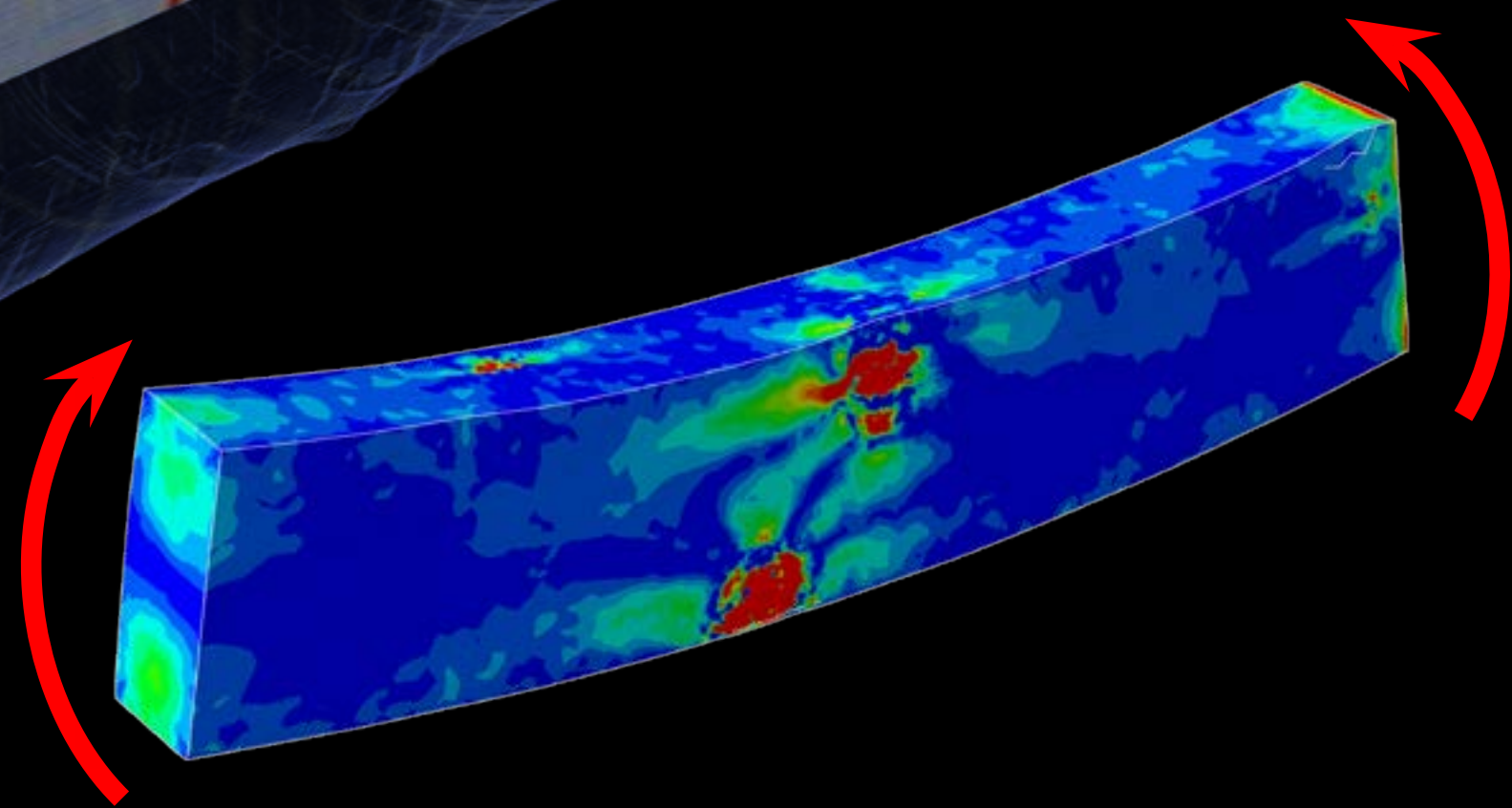
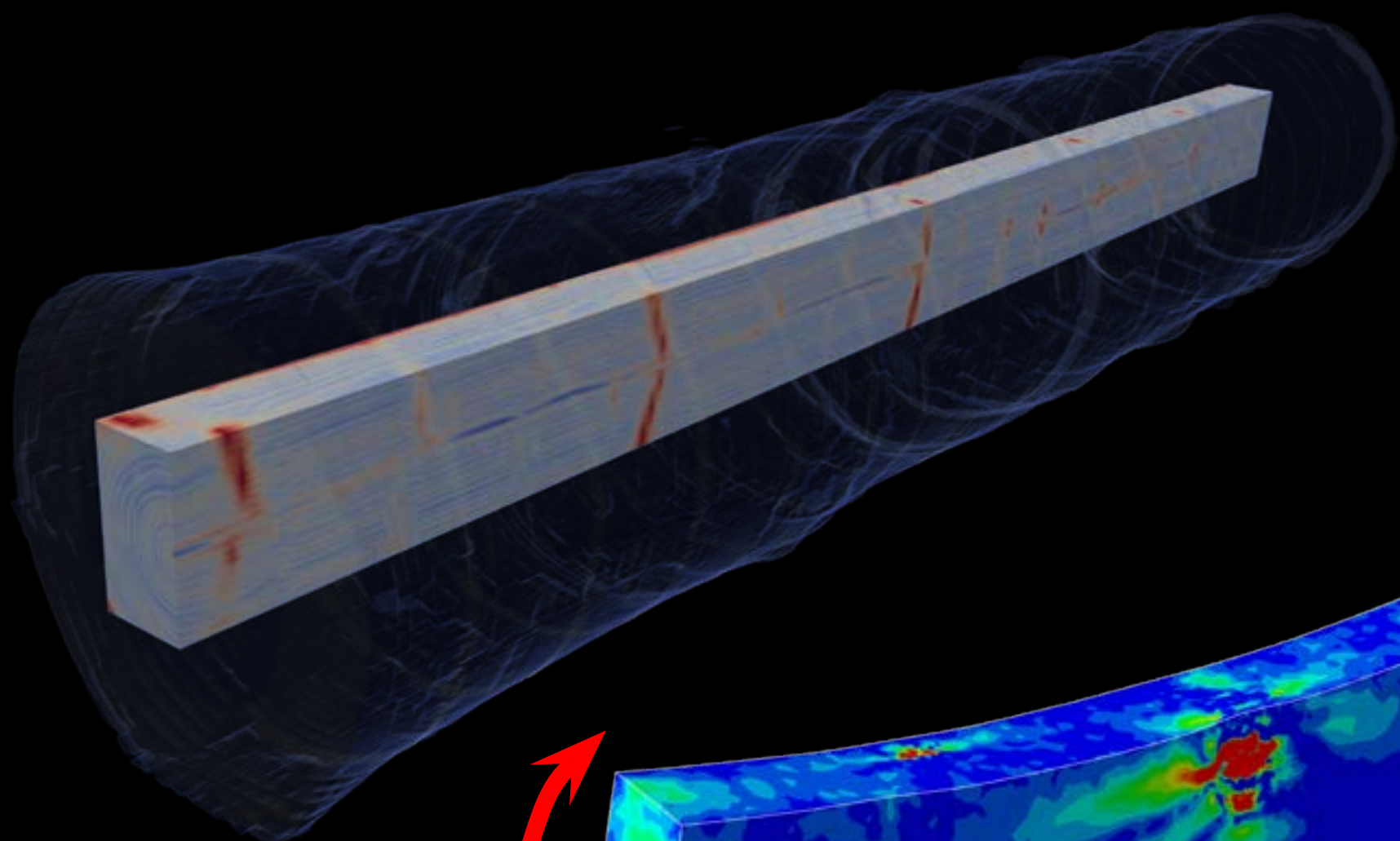
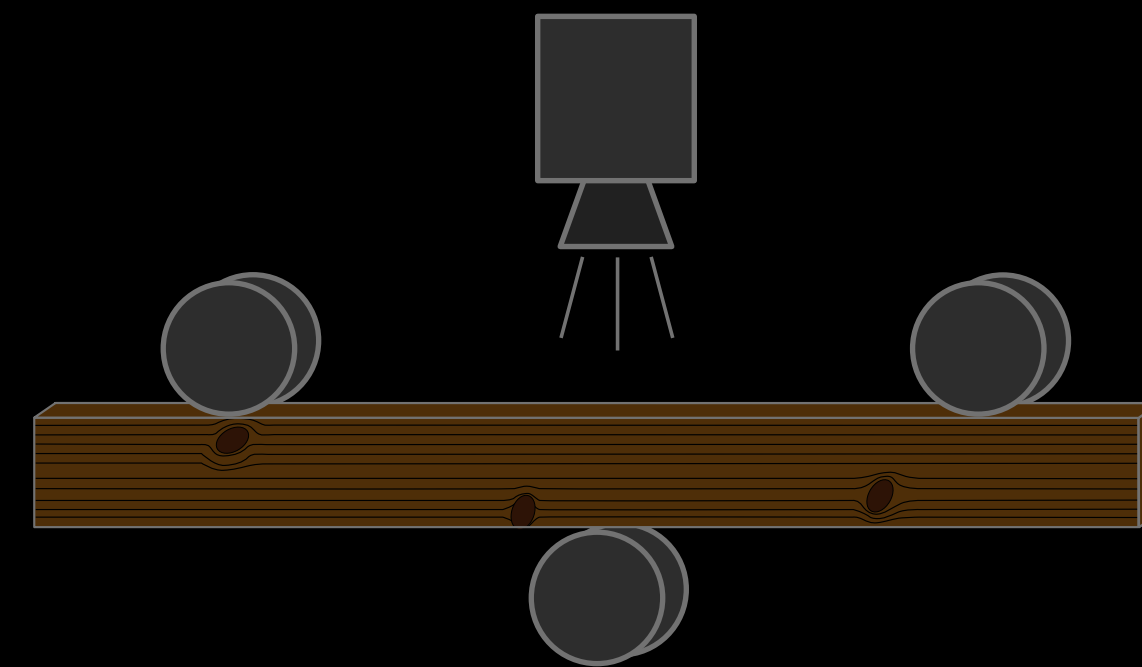
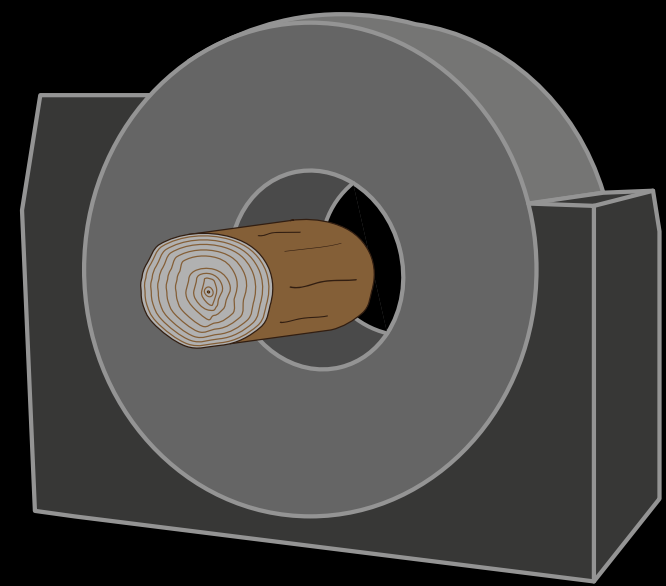








FÖRE



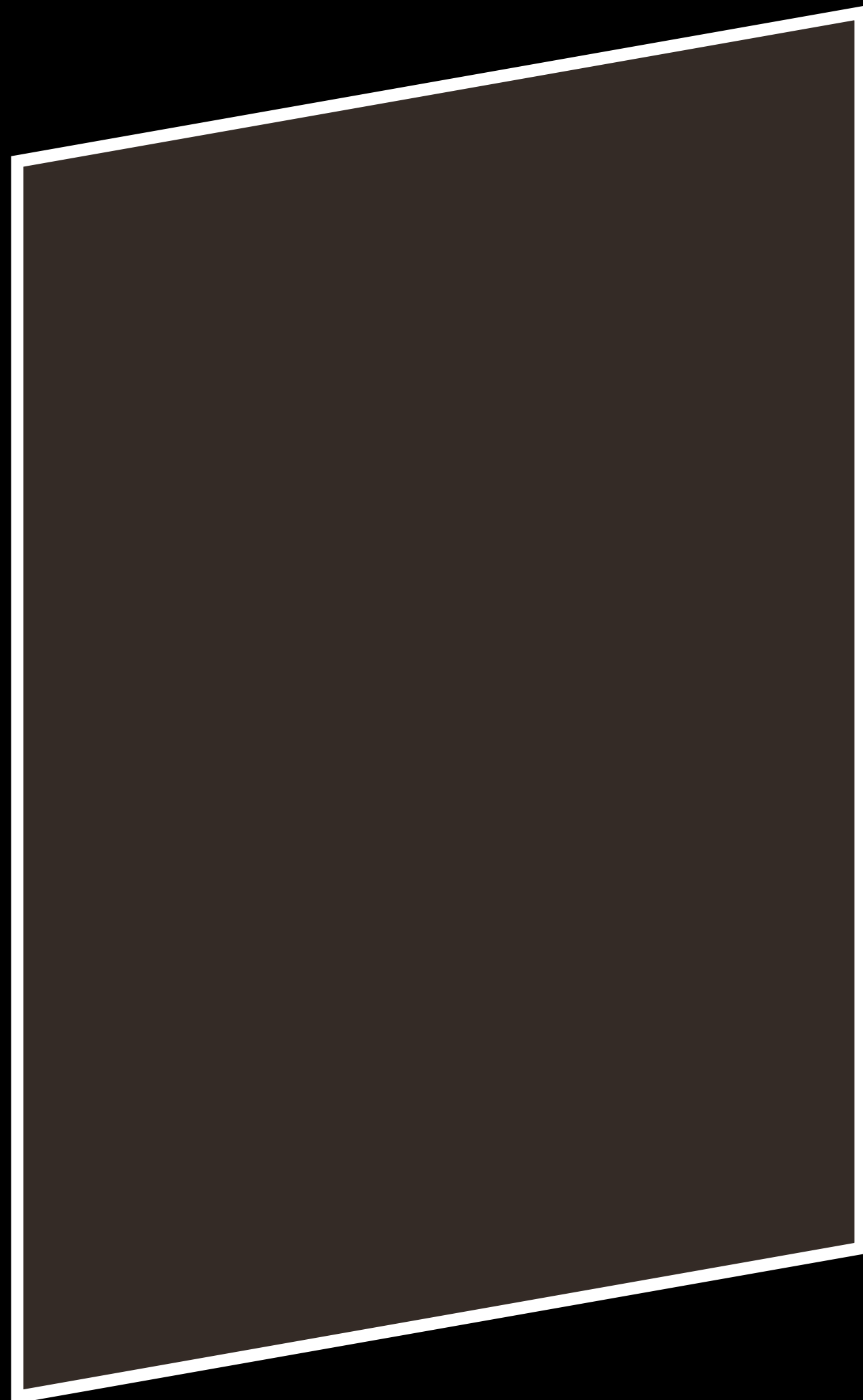
FÖRE

ÄNDAMÅL

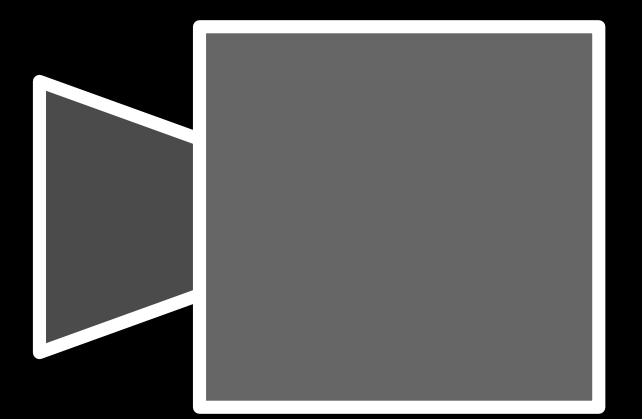
EFTER

# DATORTOMOGRAFI

Detektor



Röntgenkälla

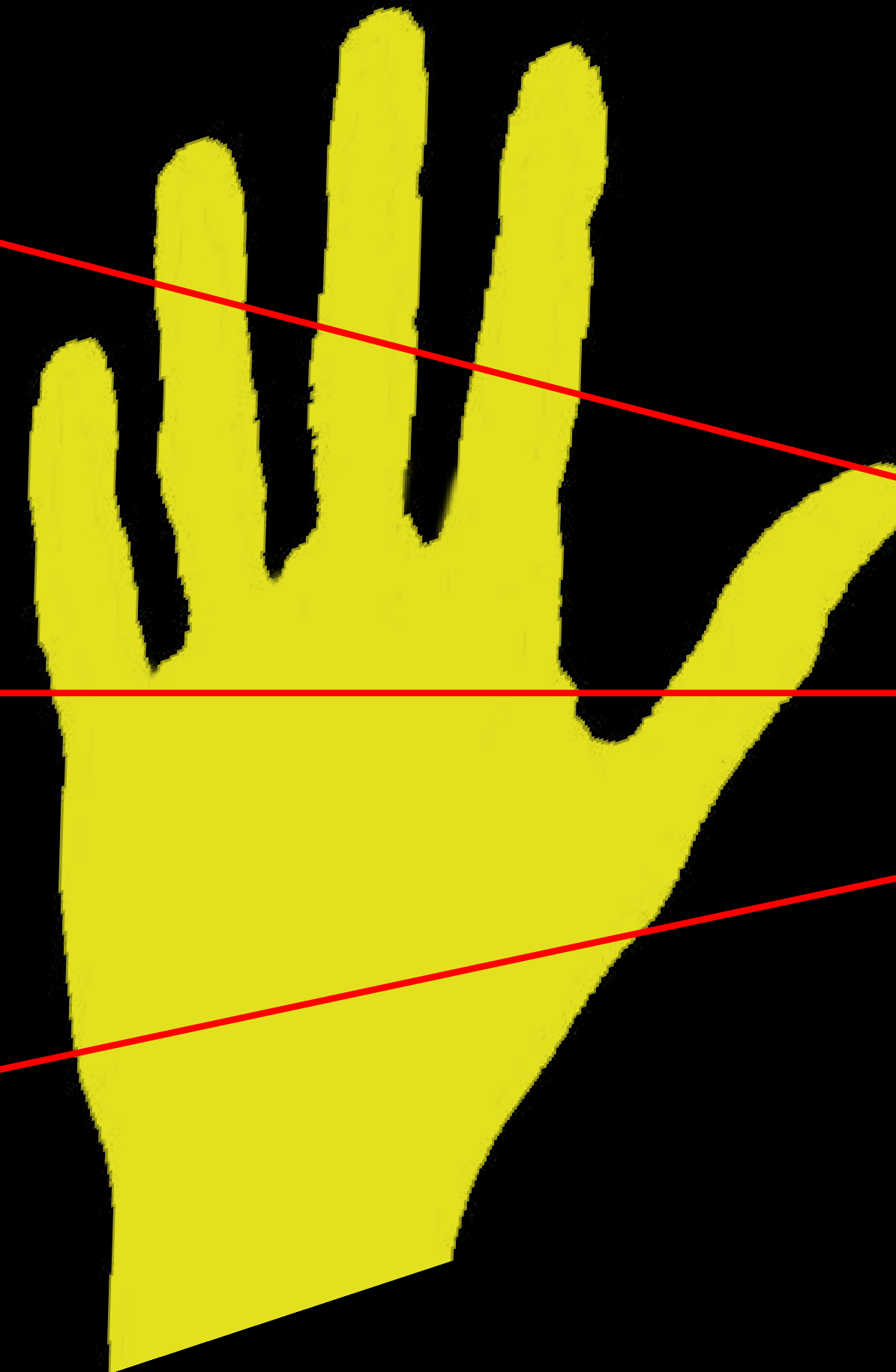


Röntgenljus

Detektor



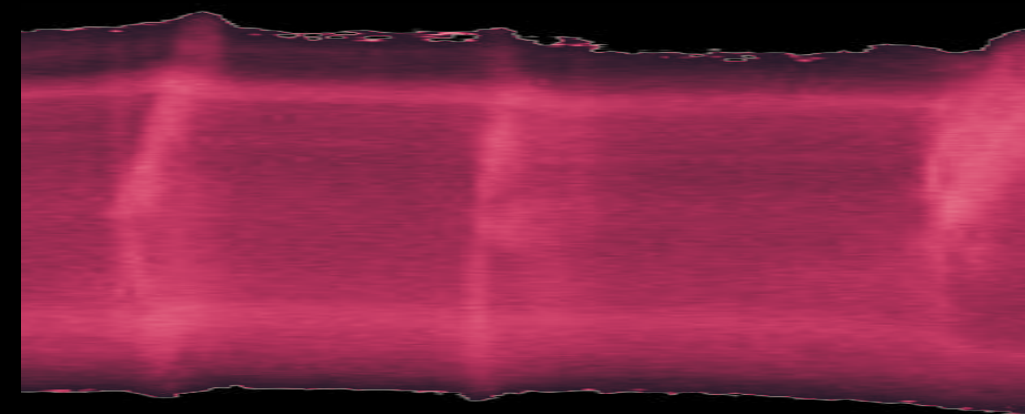
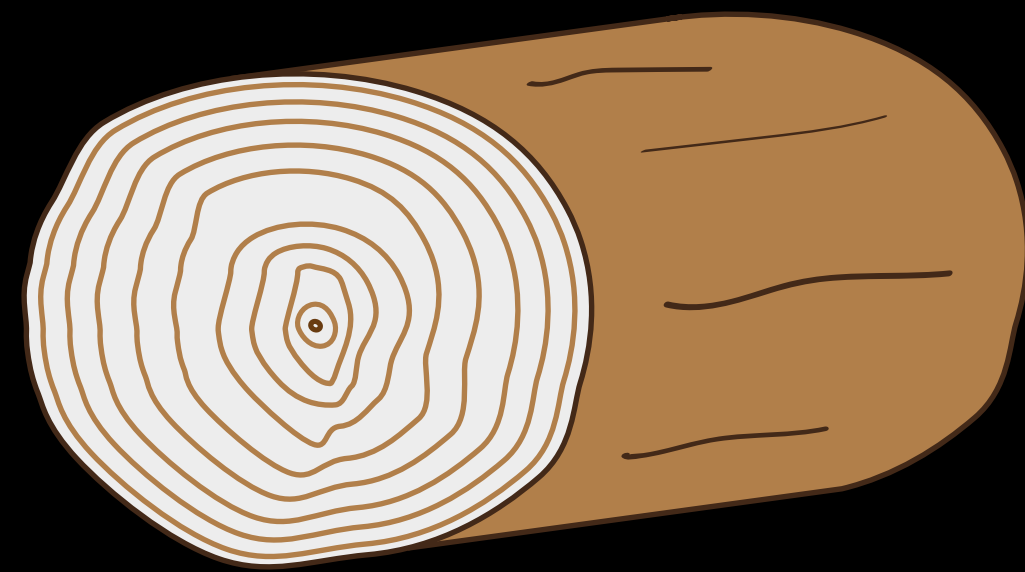
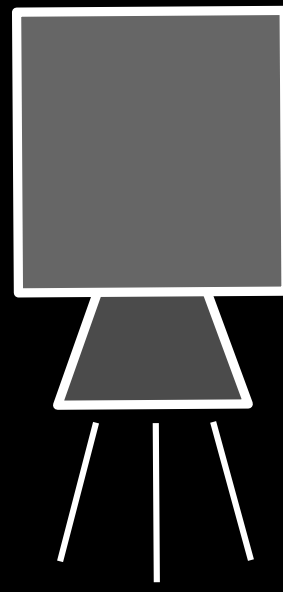
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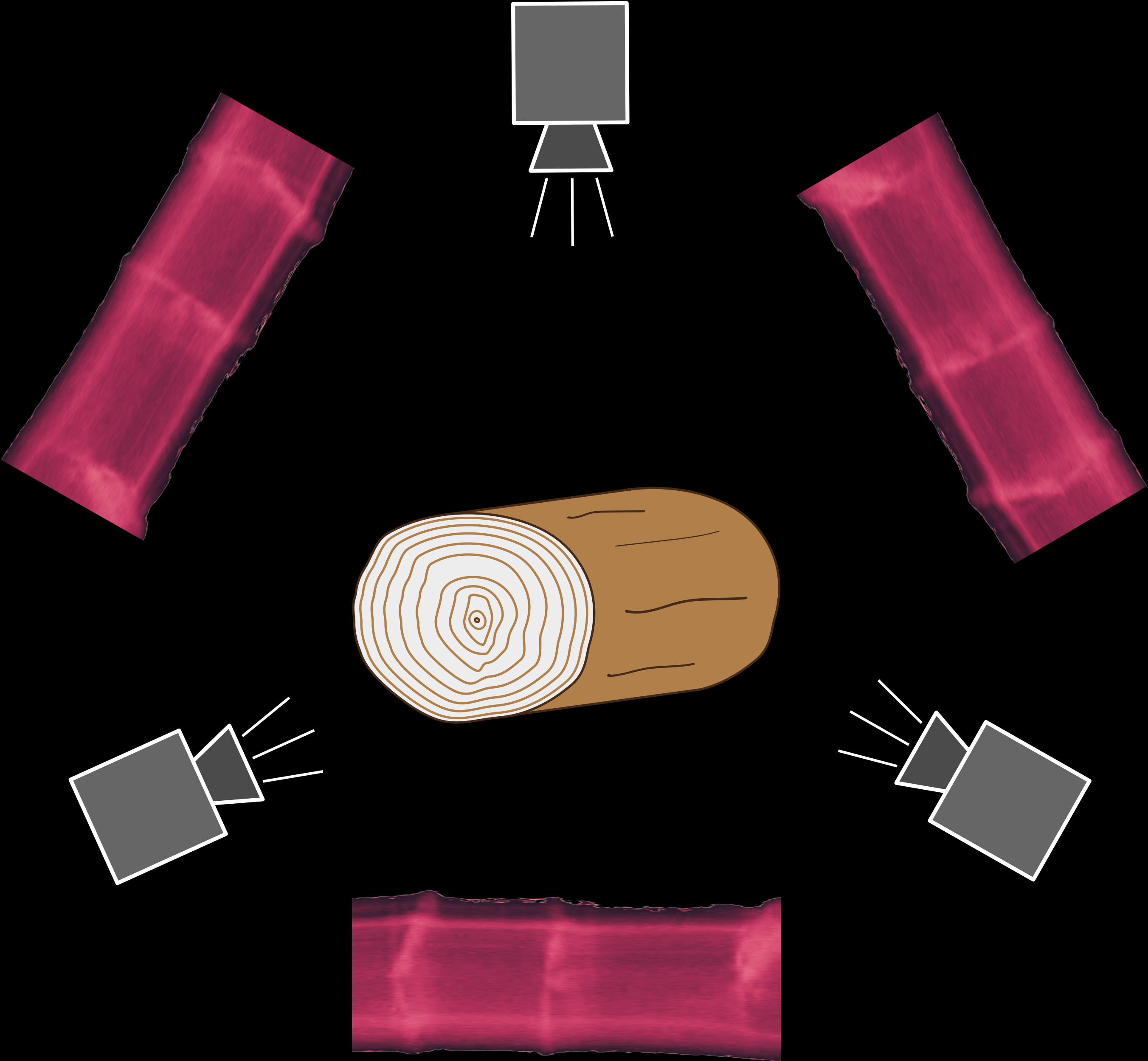


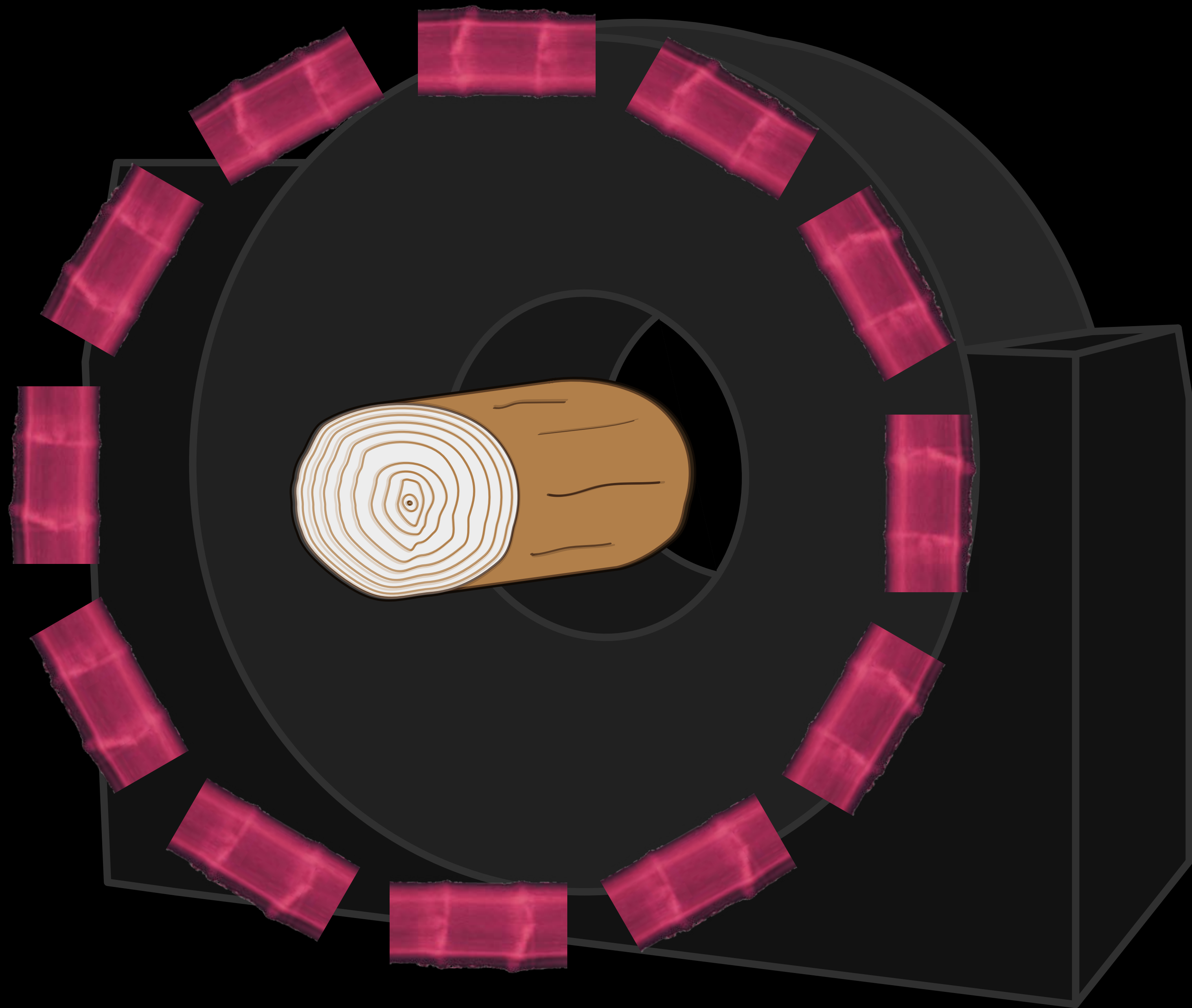
Röntgenkälla



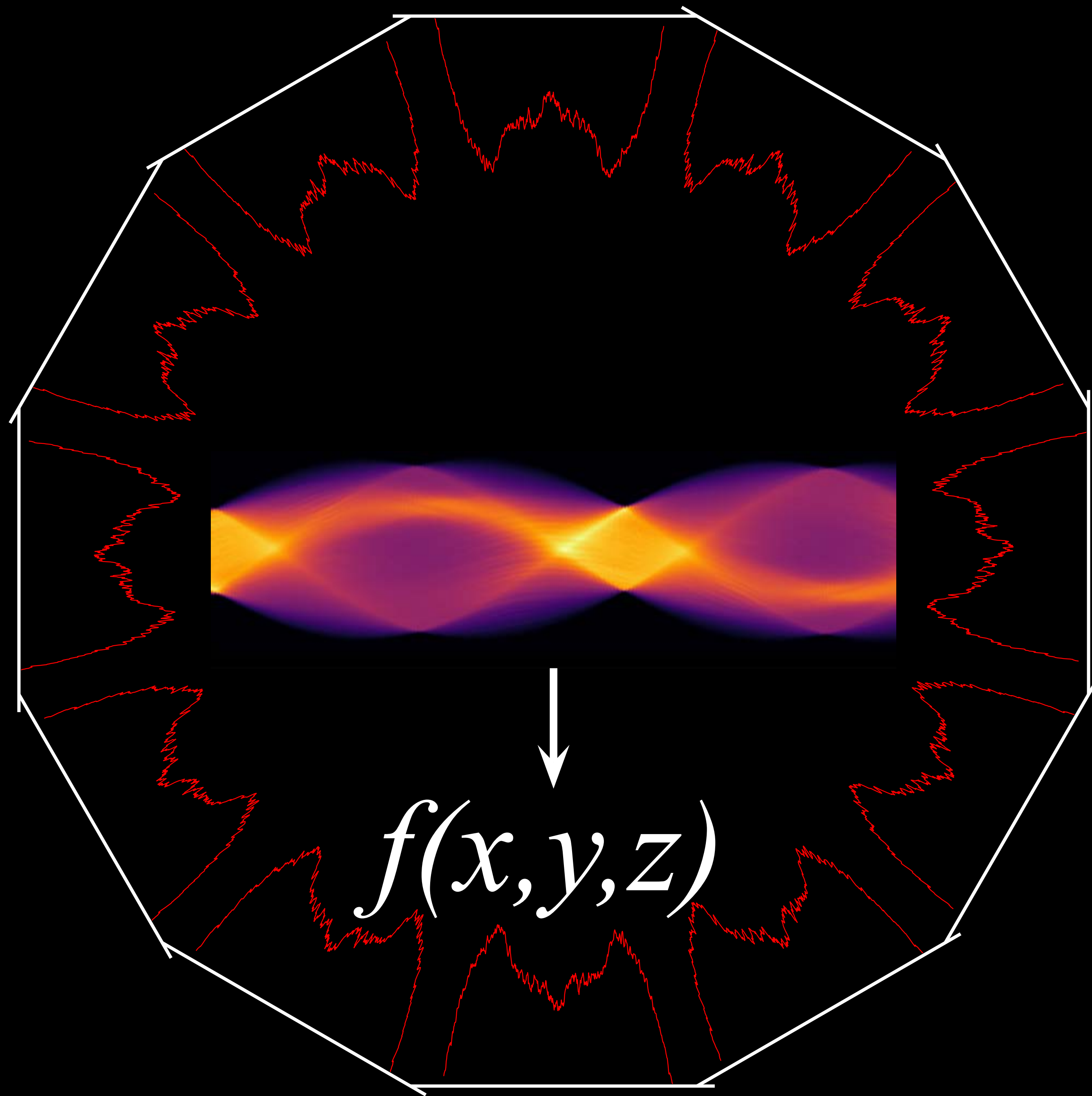
Röntgenljus

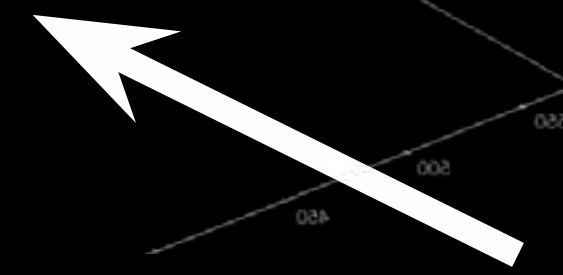
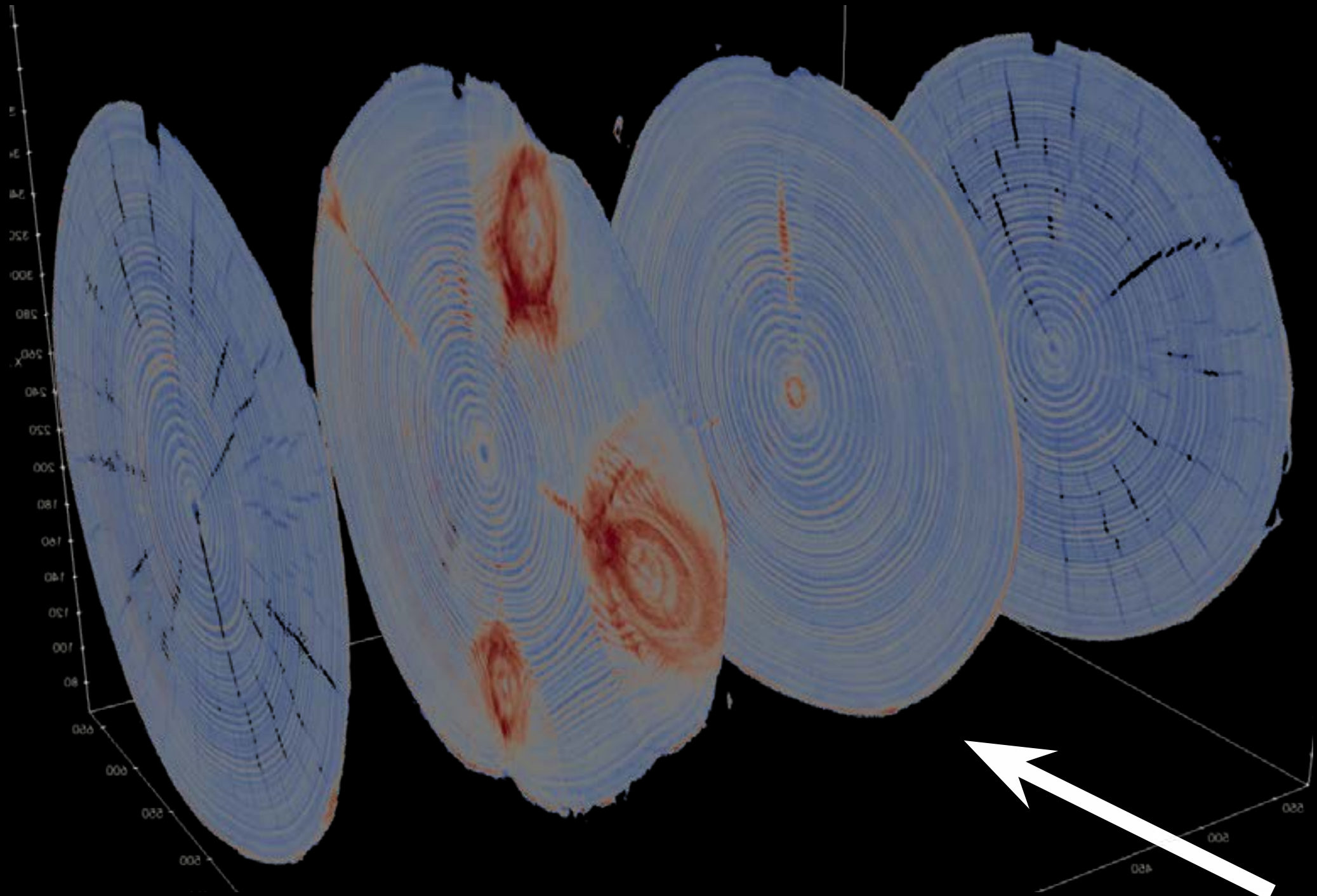




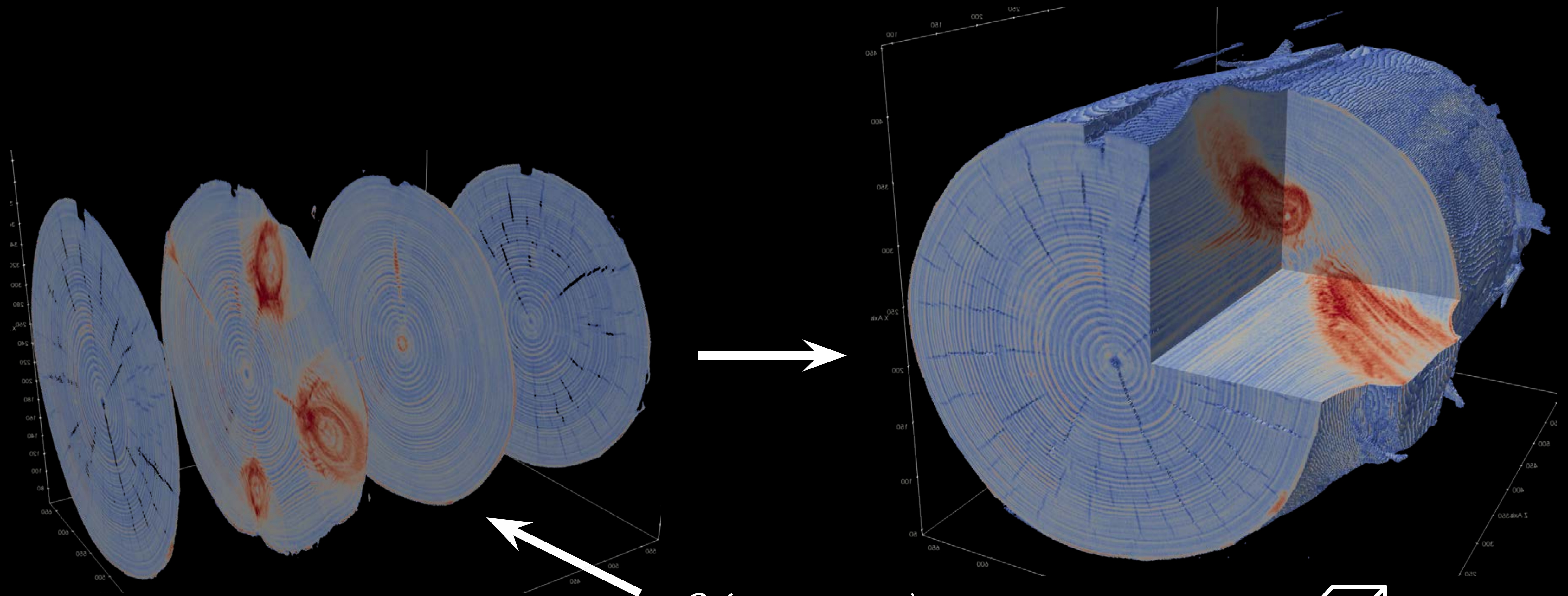








$$f(x, y, z)$$



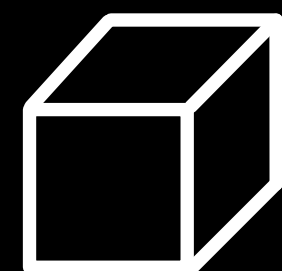
$$f(x,y,z)$$

voxlar 

# HÅLLFASTHETSMODELLER

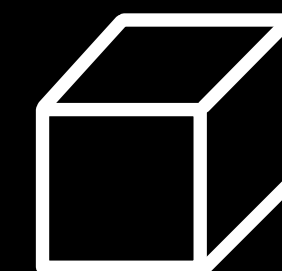


SIEMENS SOMATON

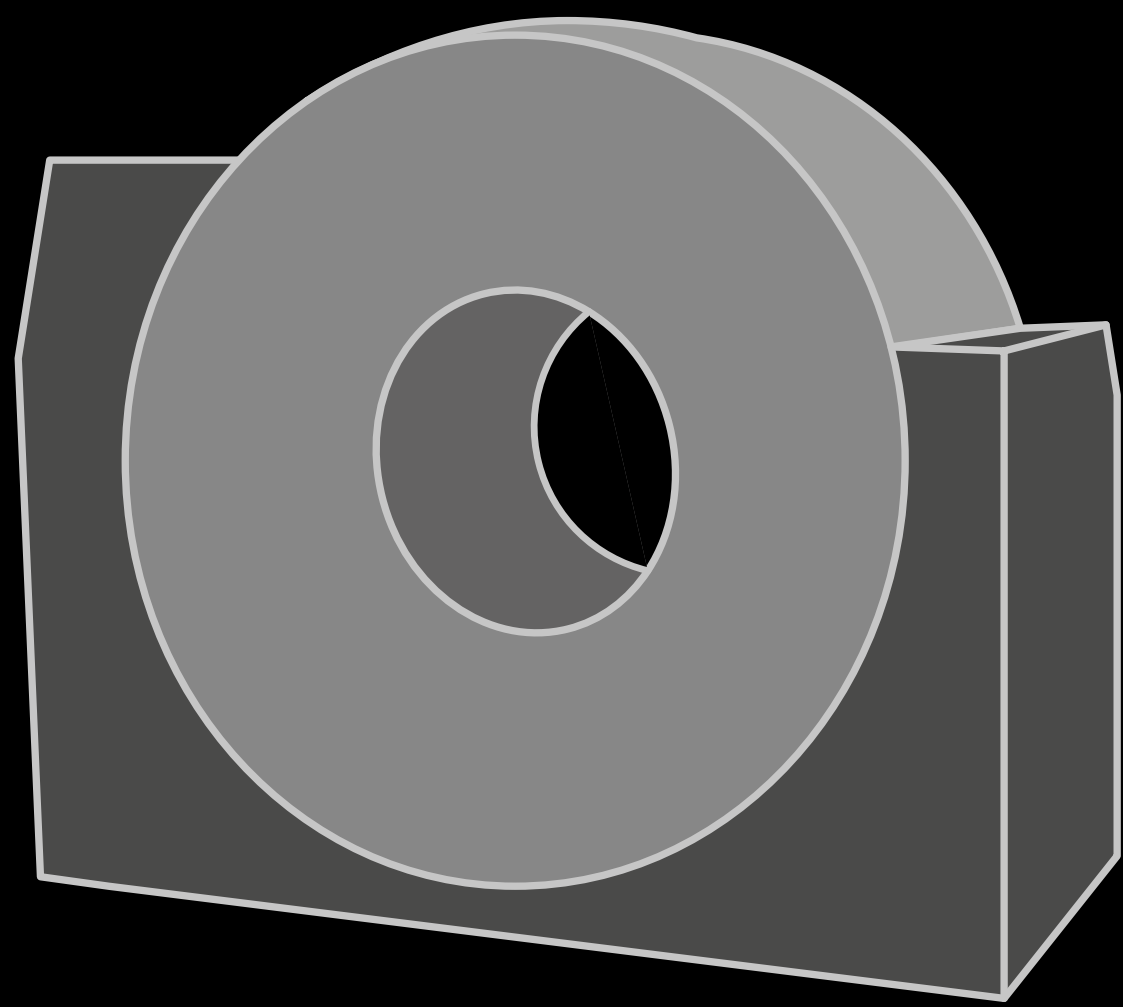


$1 \times 1 \times 1 \text{ mm}^3$

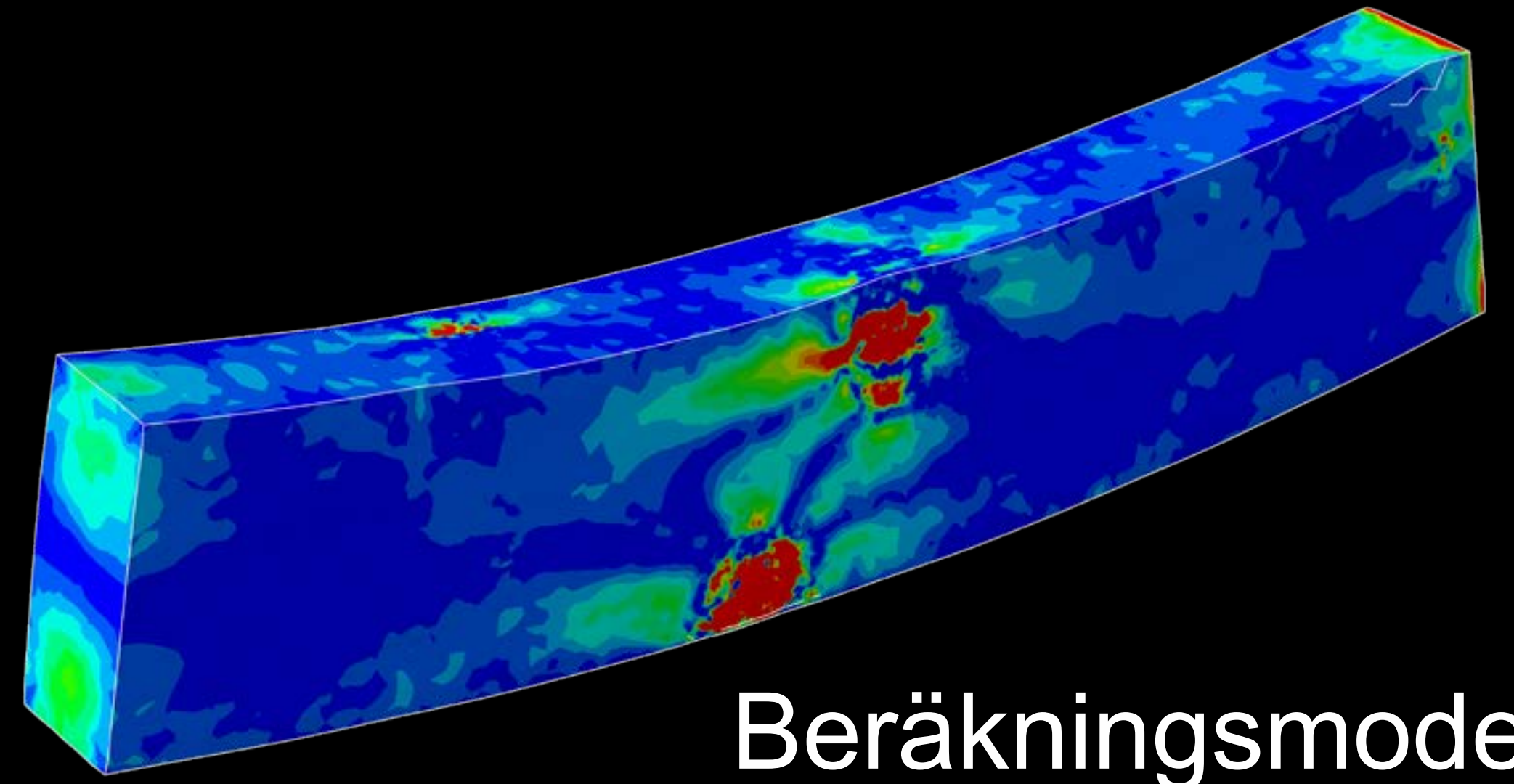
MICROTEC MITO



$0.3 \times 0.3 \times 0.3 \text{ mm}^3$

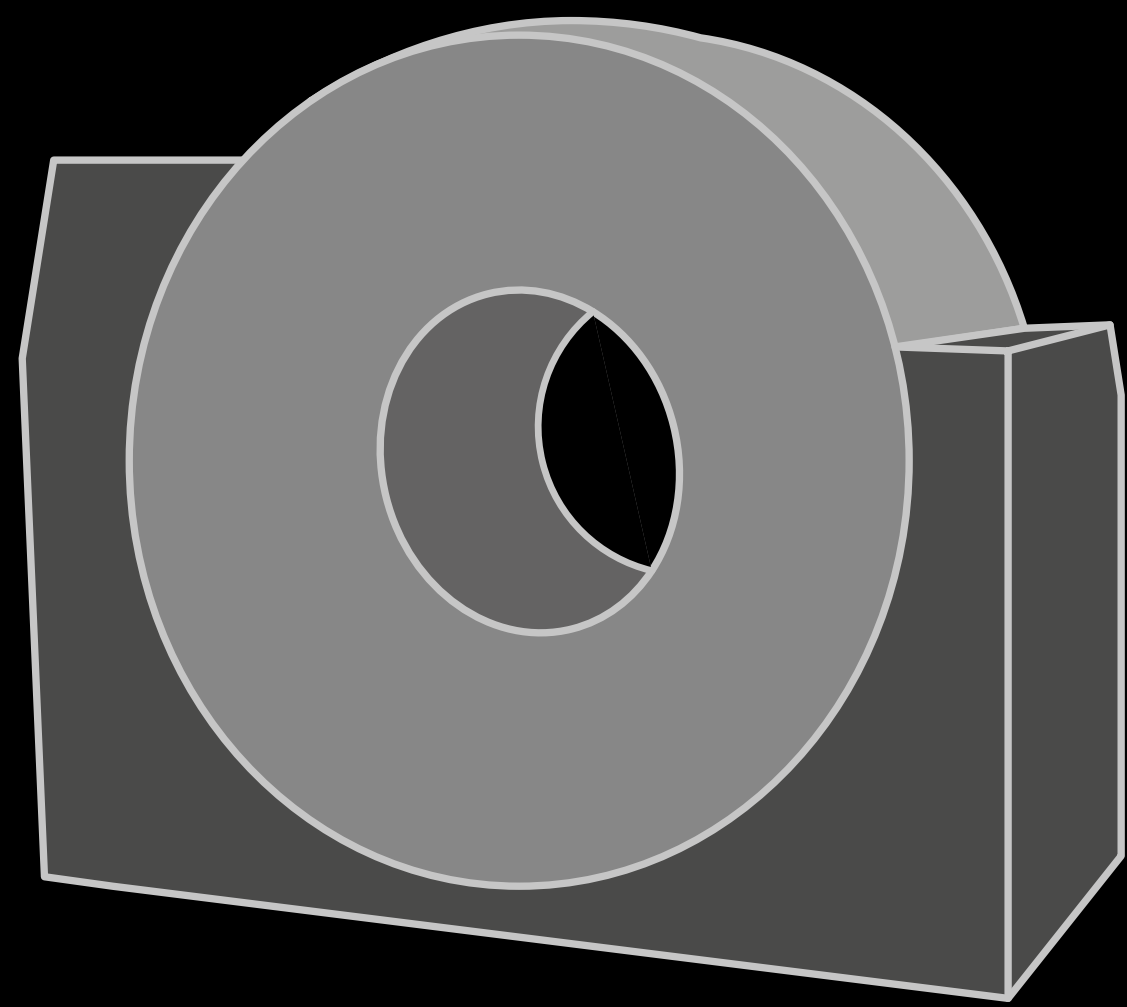


CT

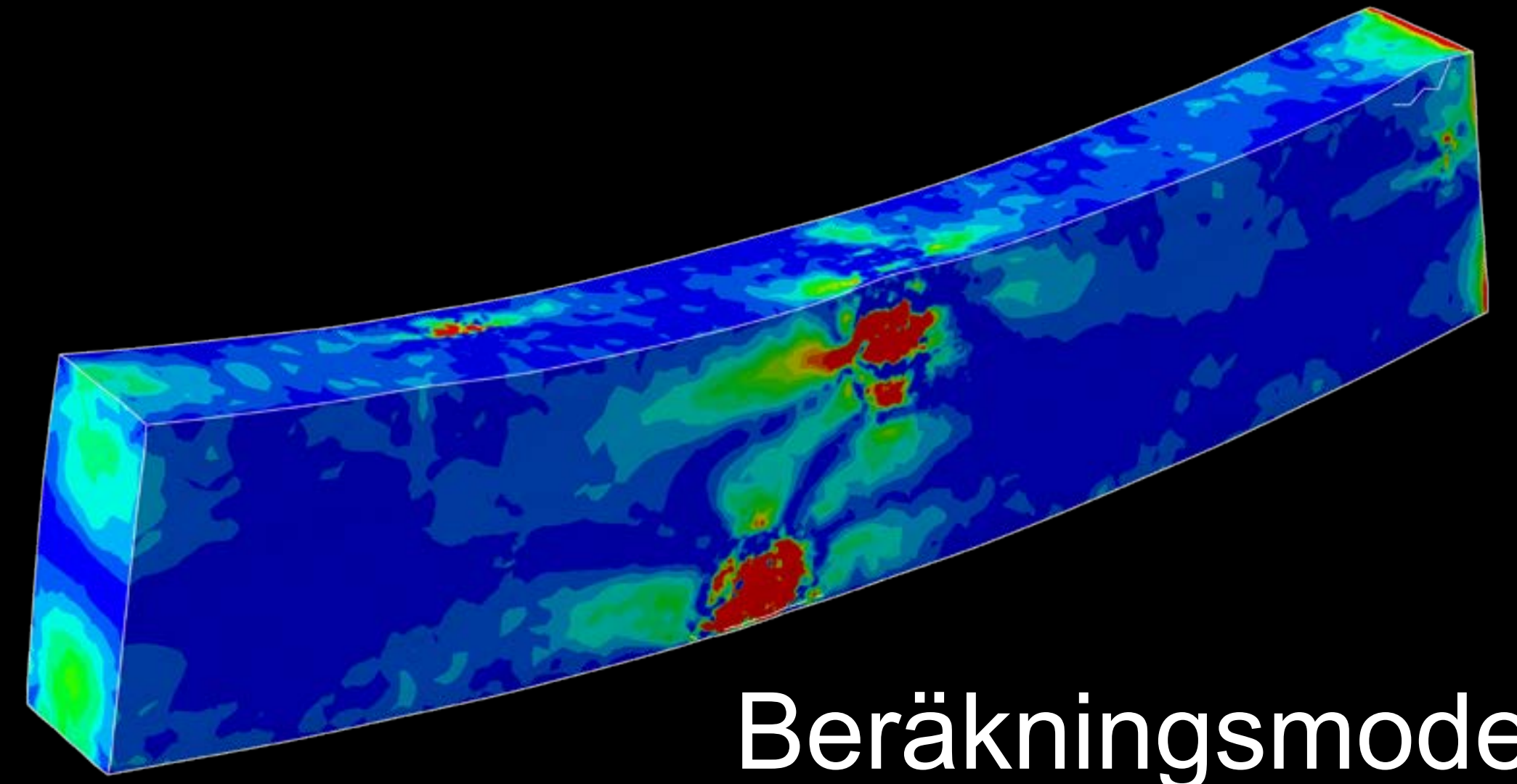


Beräkningsmodell

?

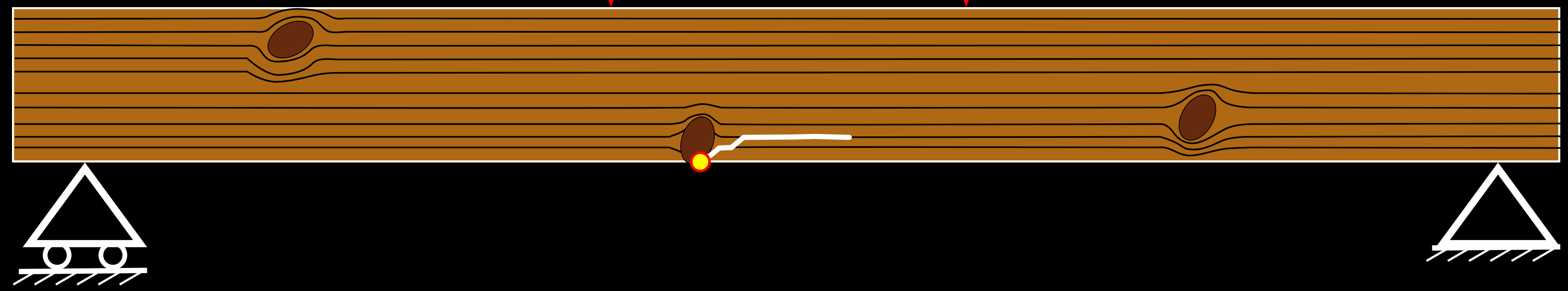


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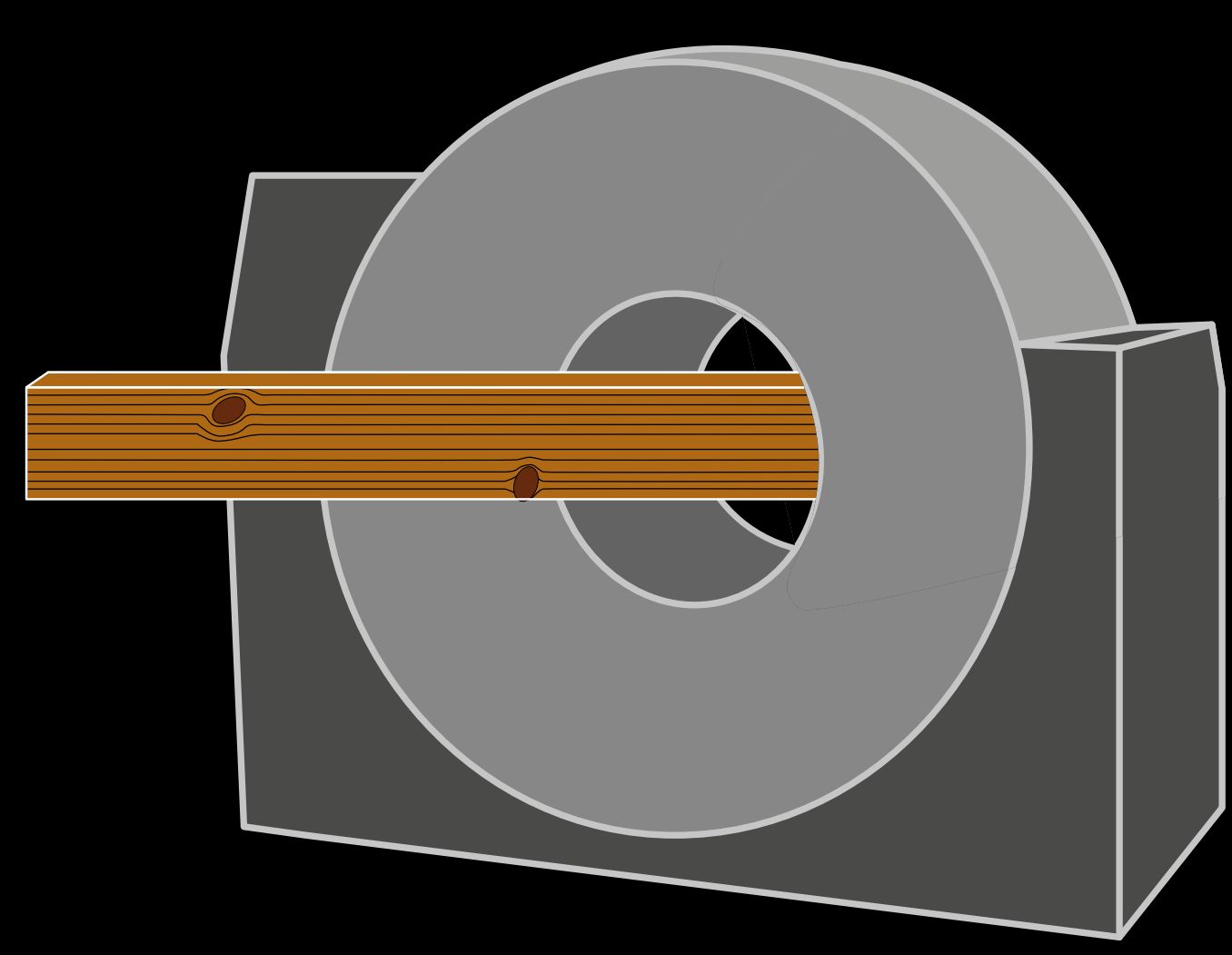


Beräkningsmodell

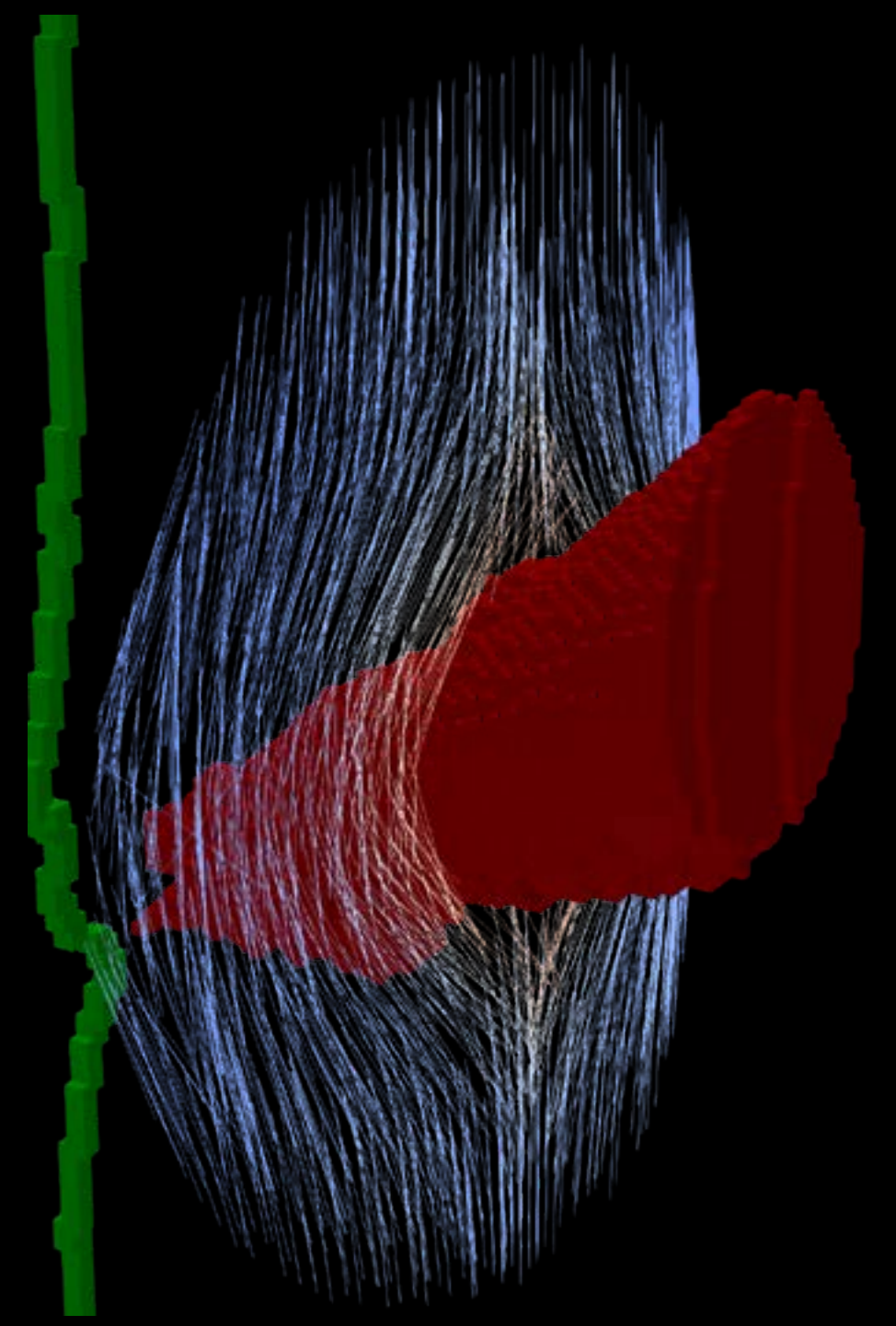
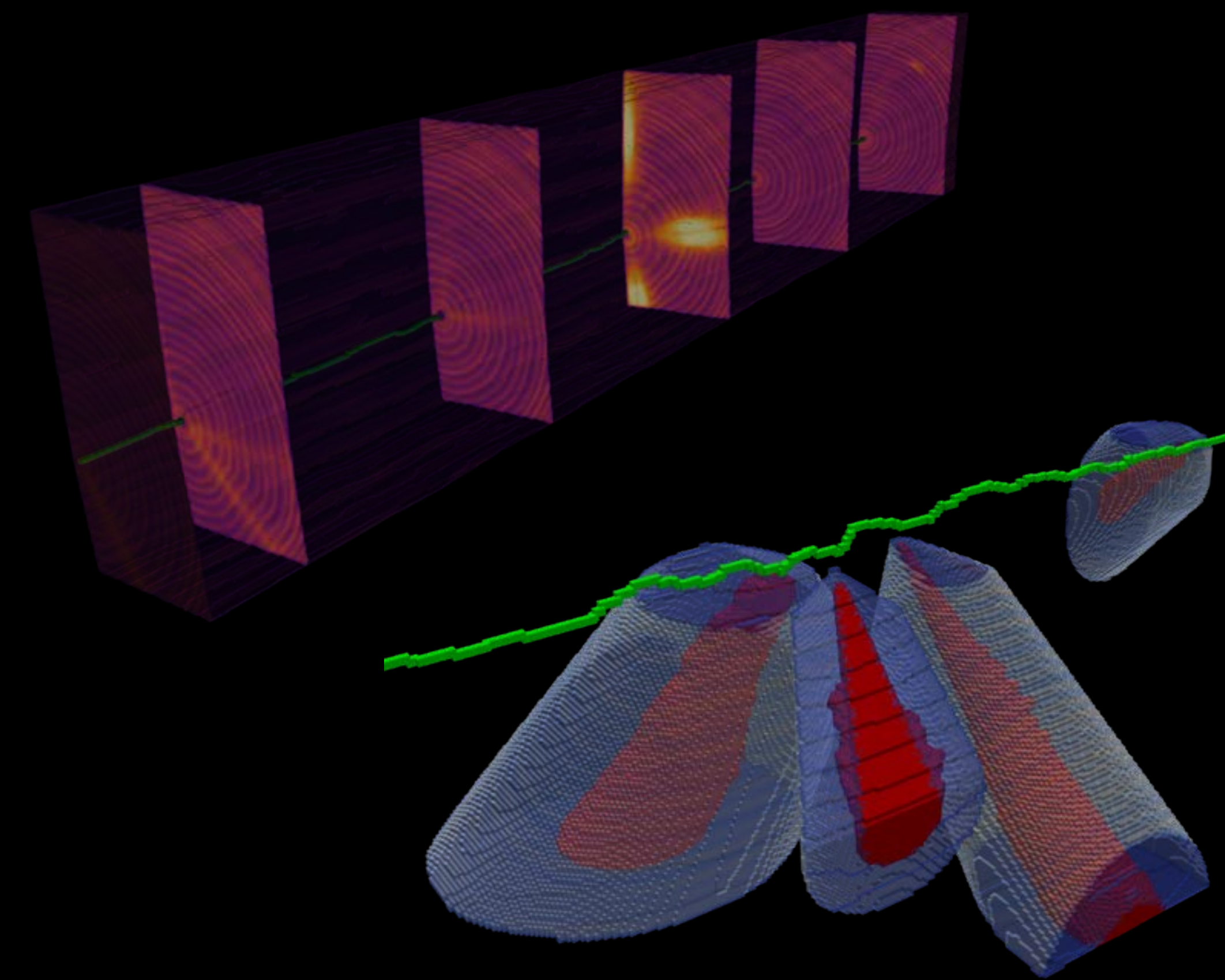
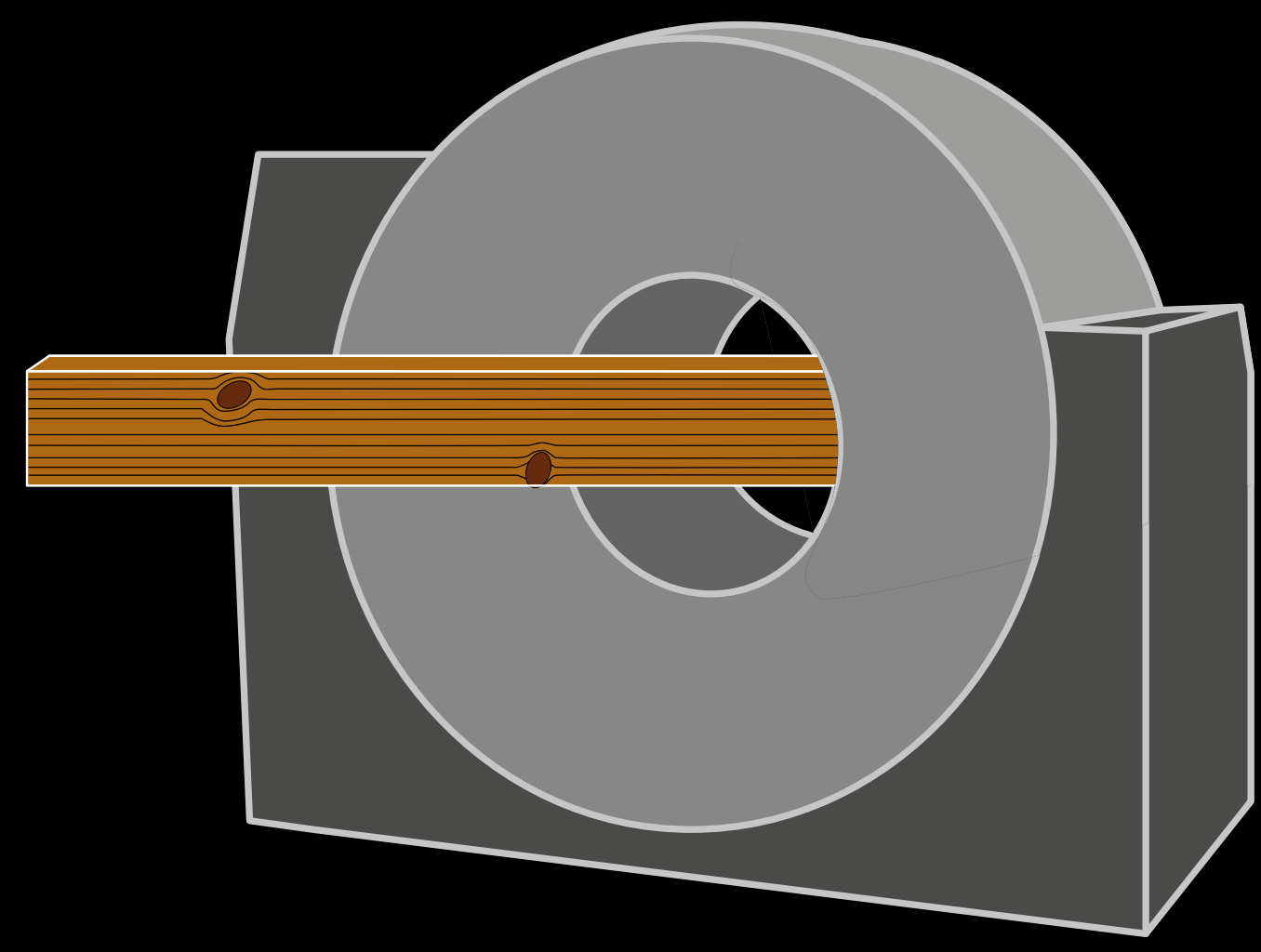
?

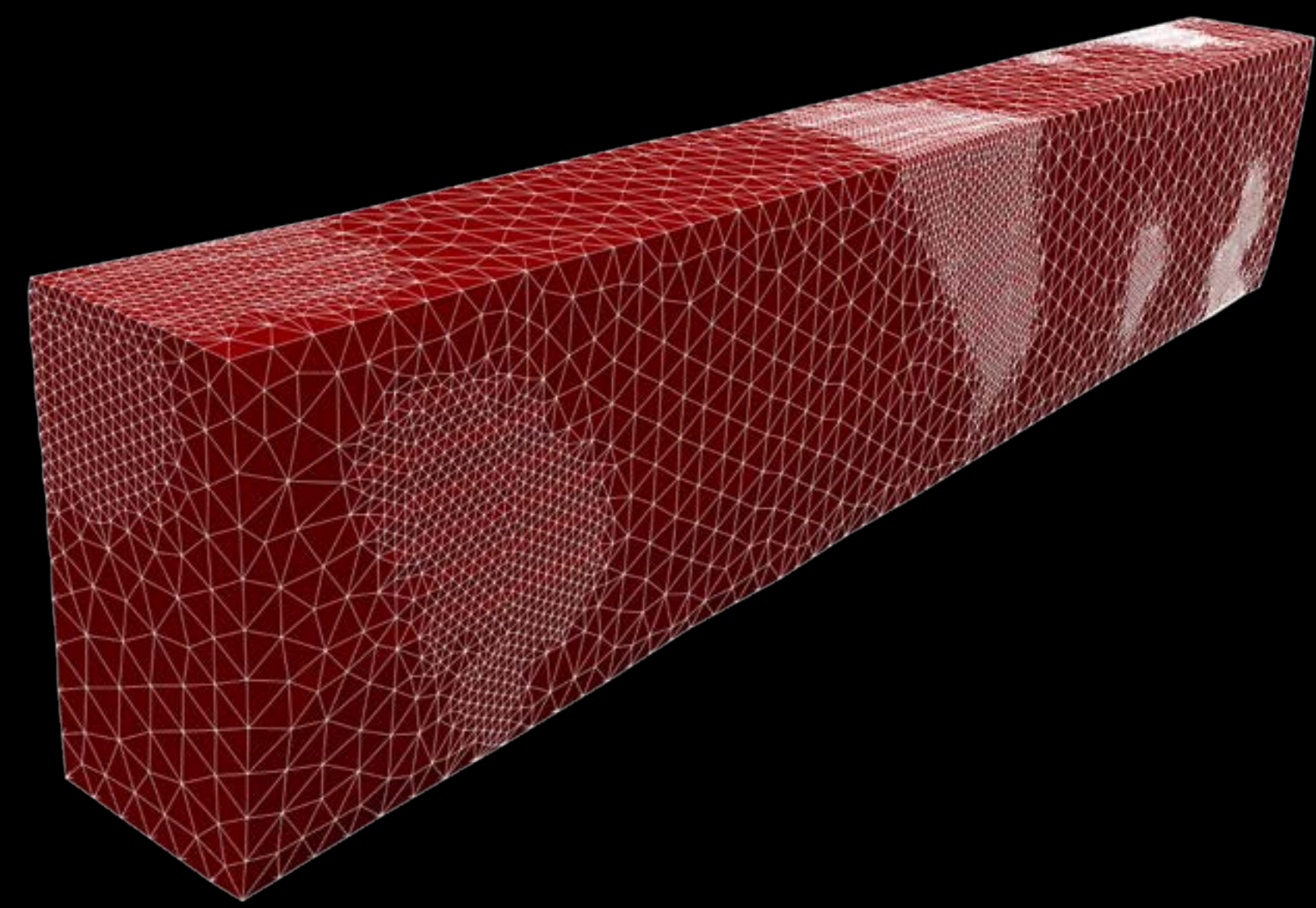
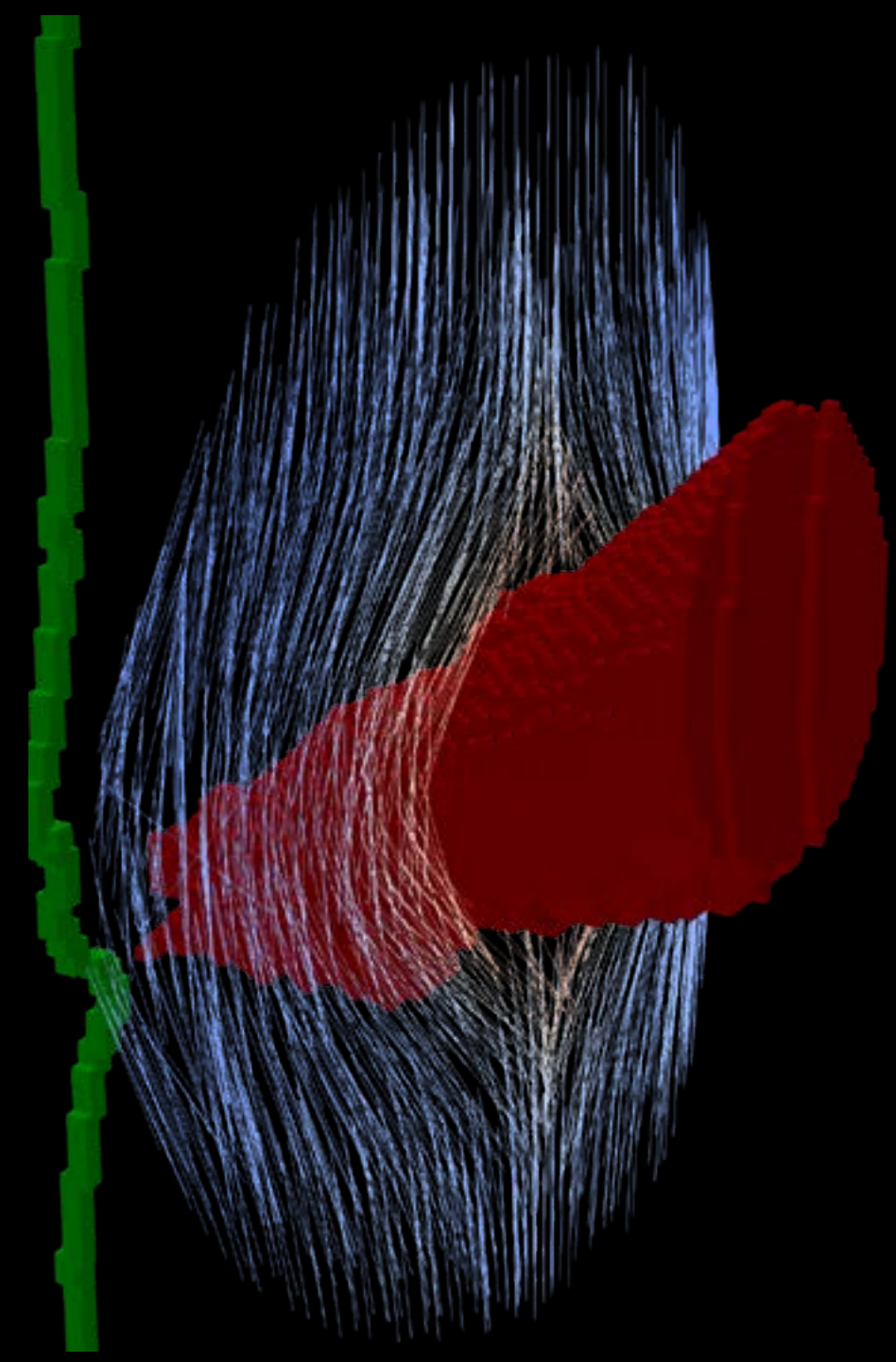
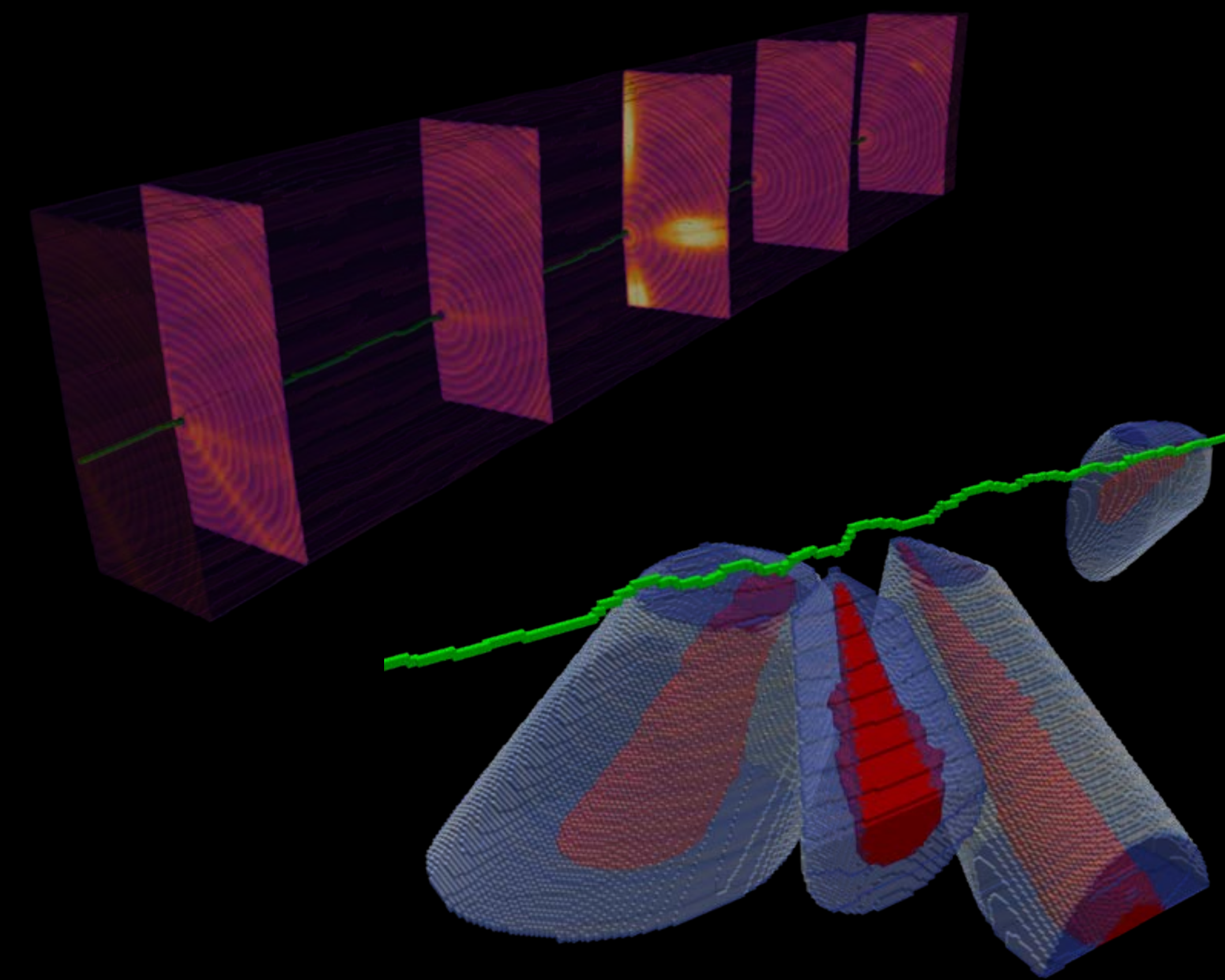
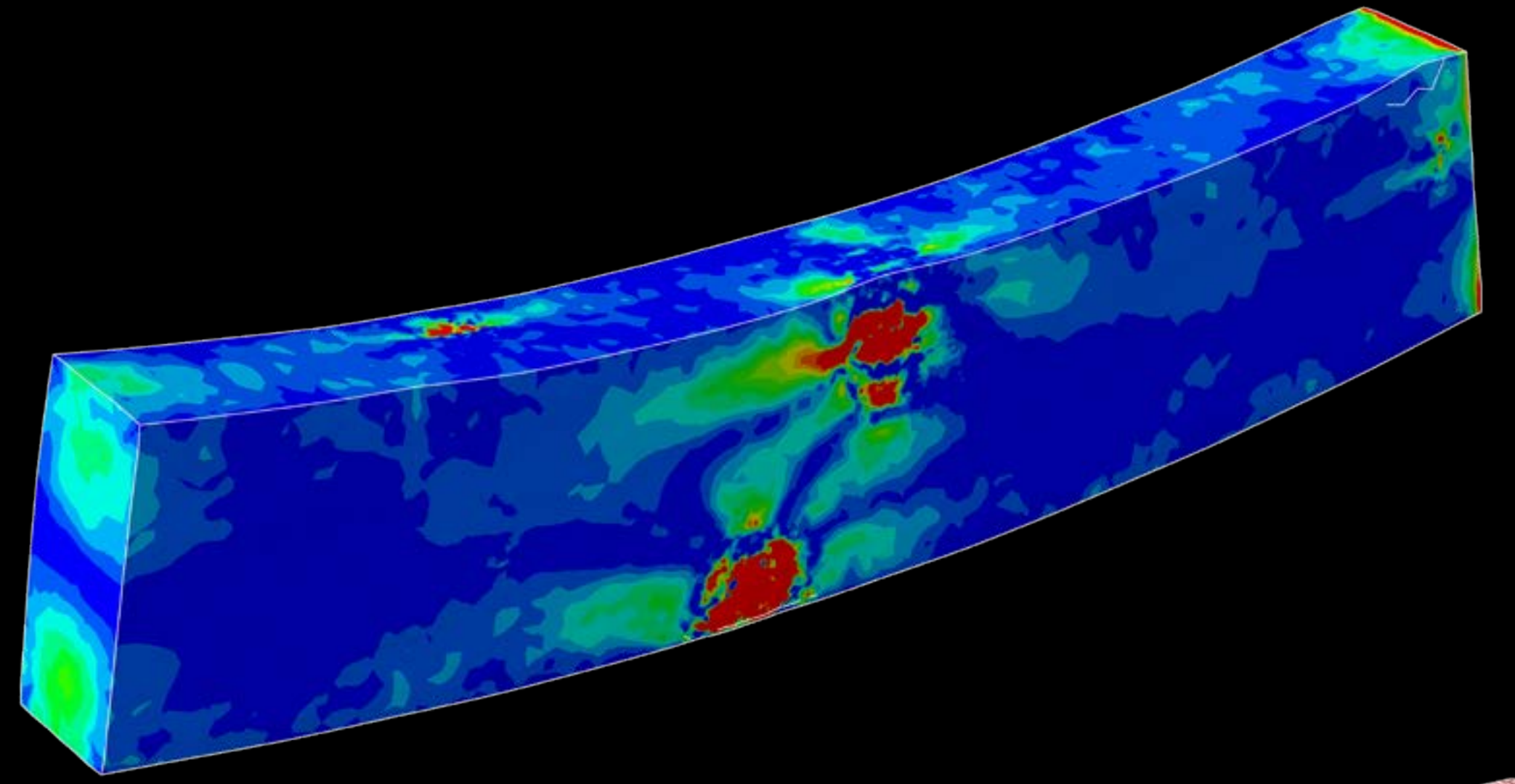
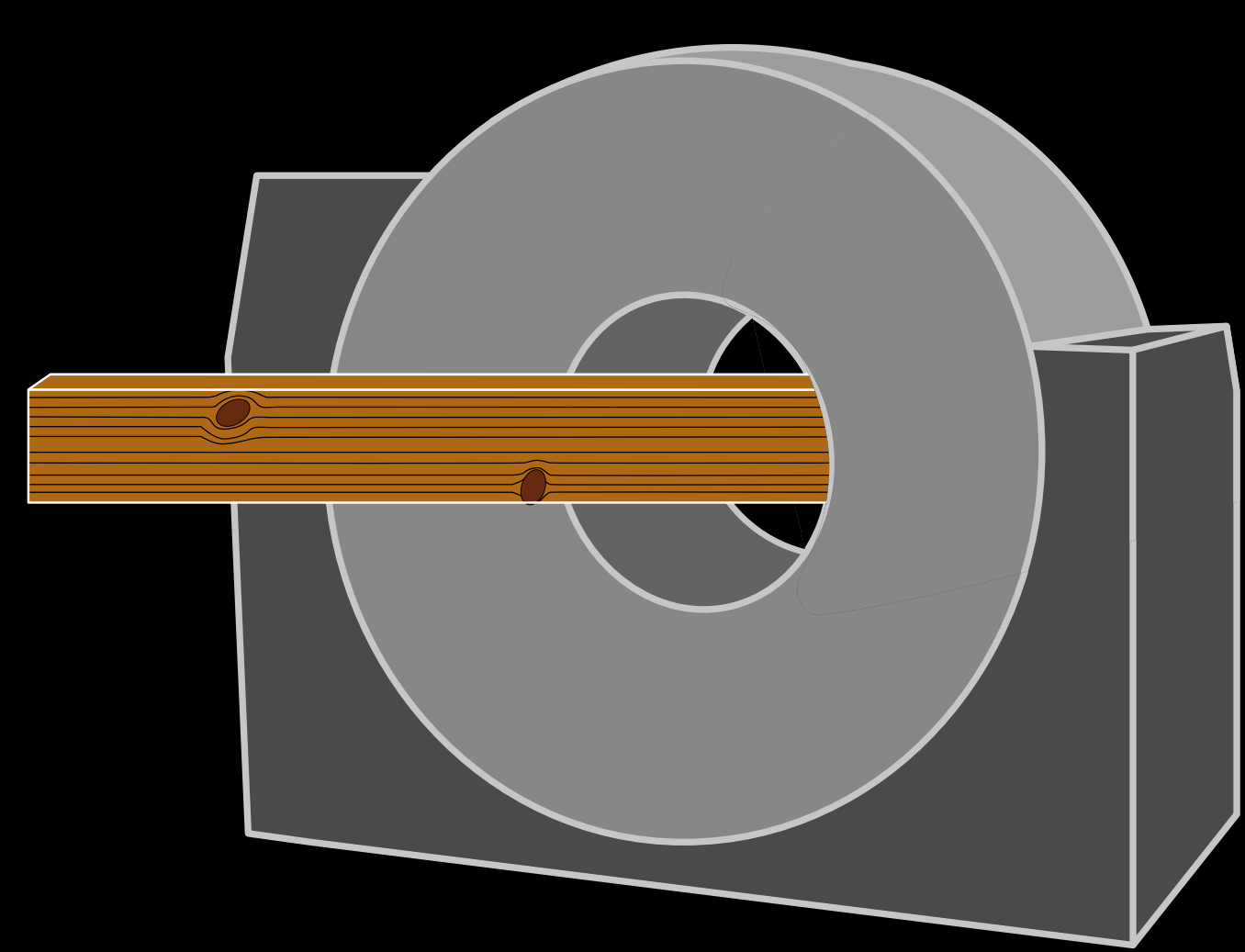


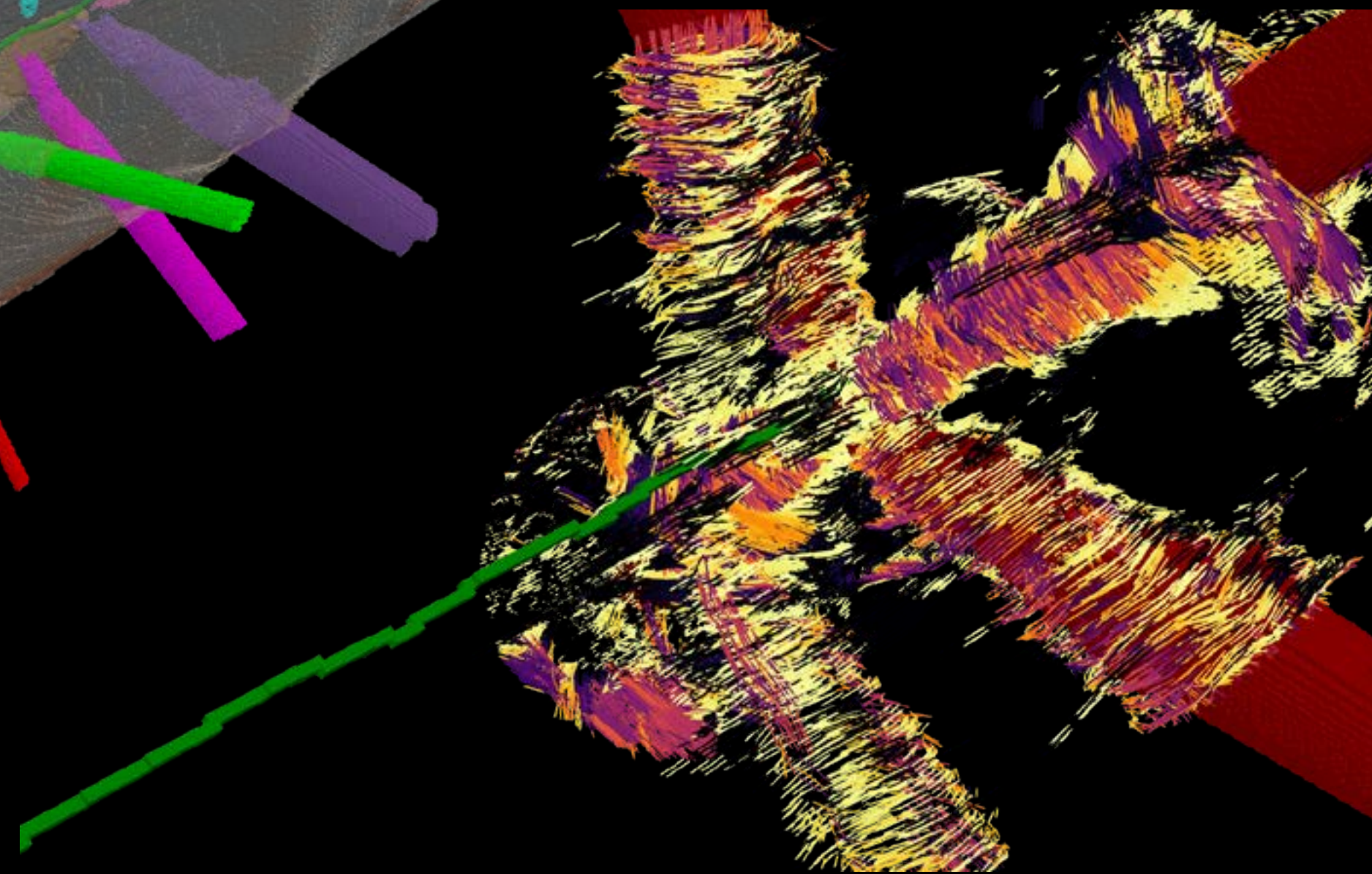
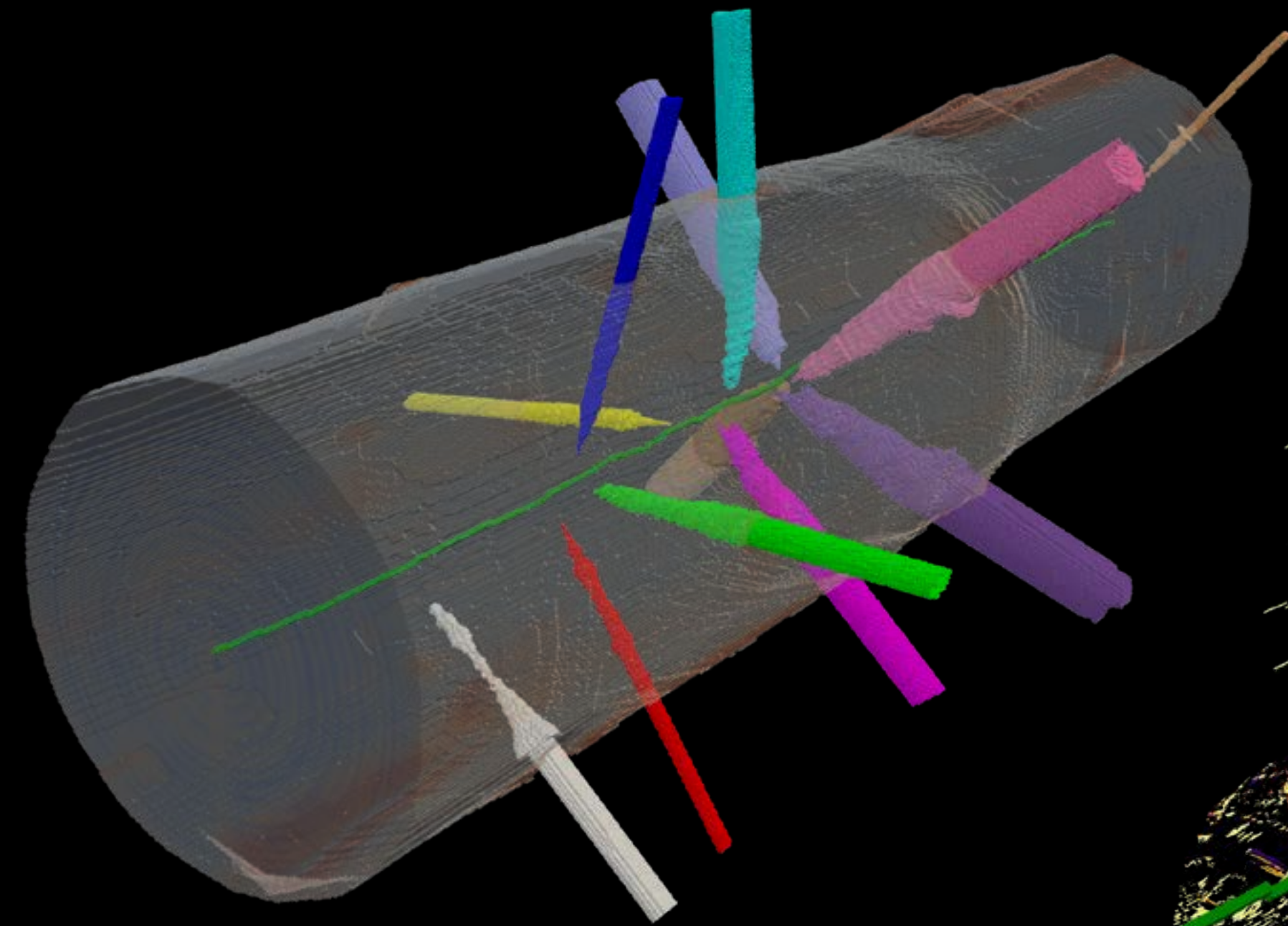
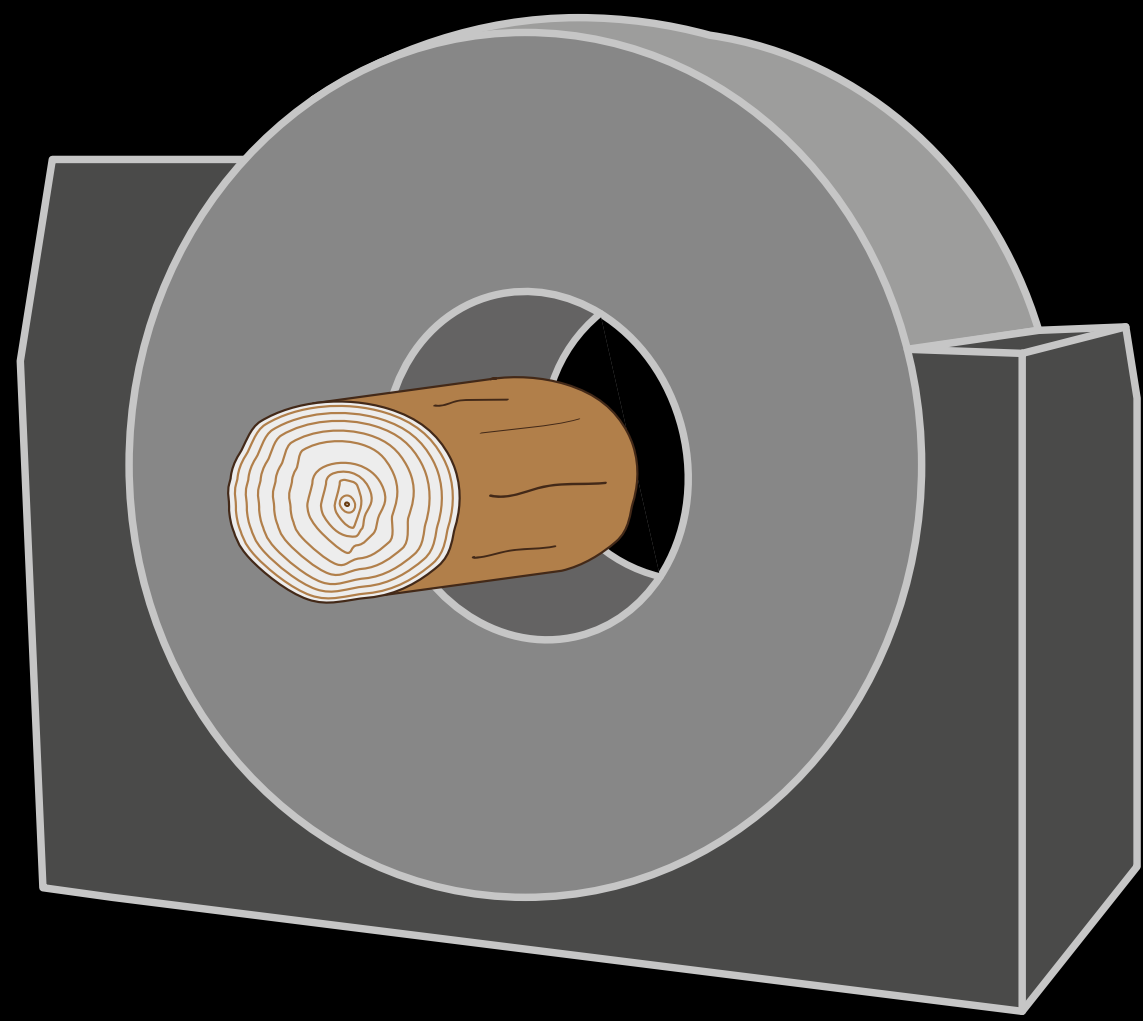
Böjtest

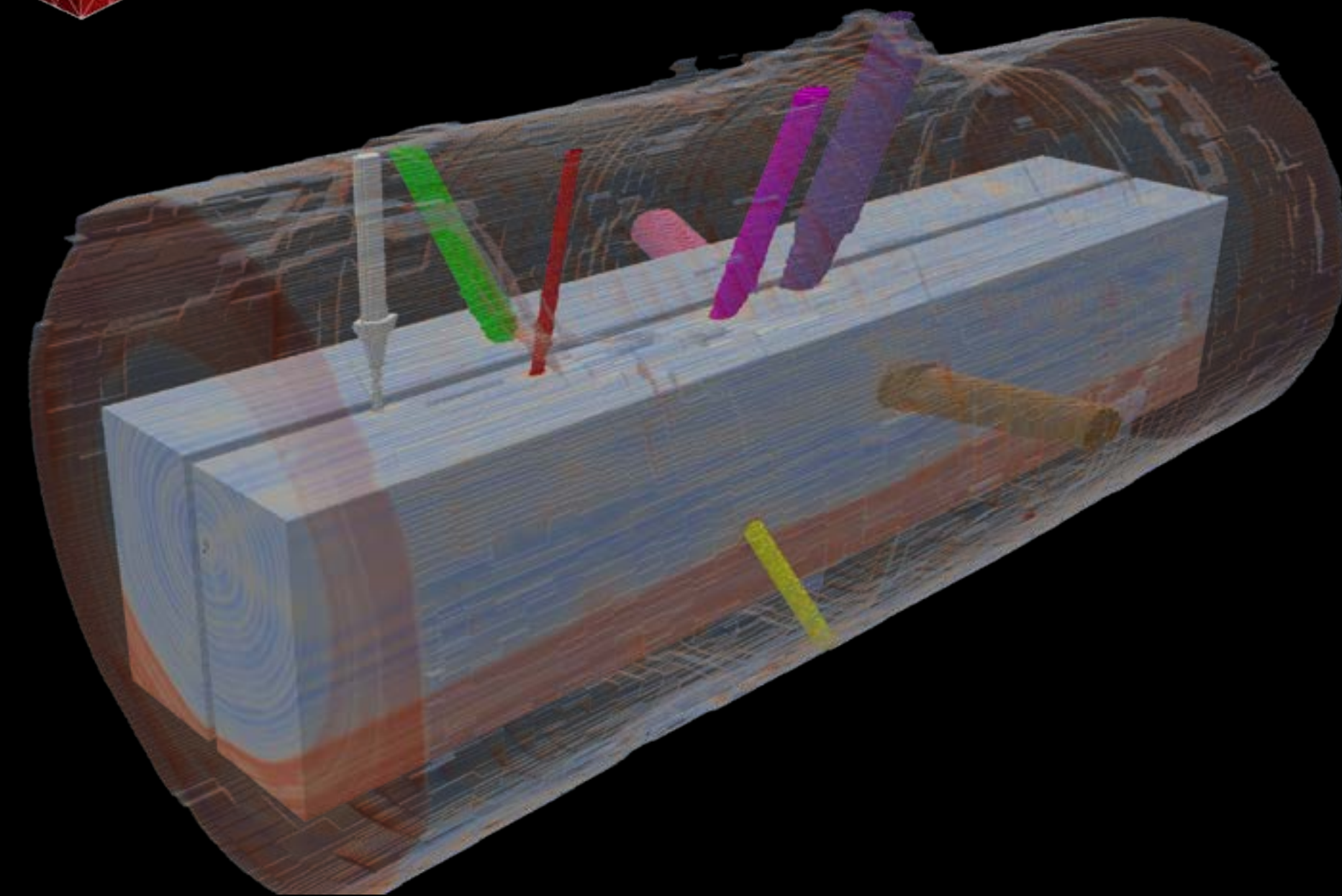
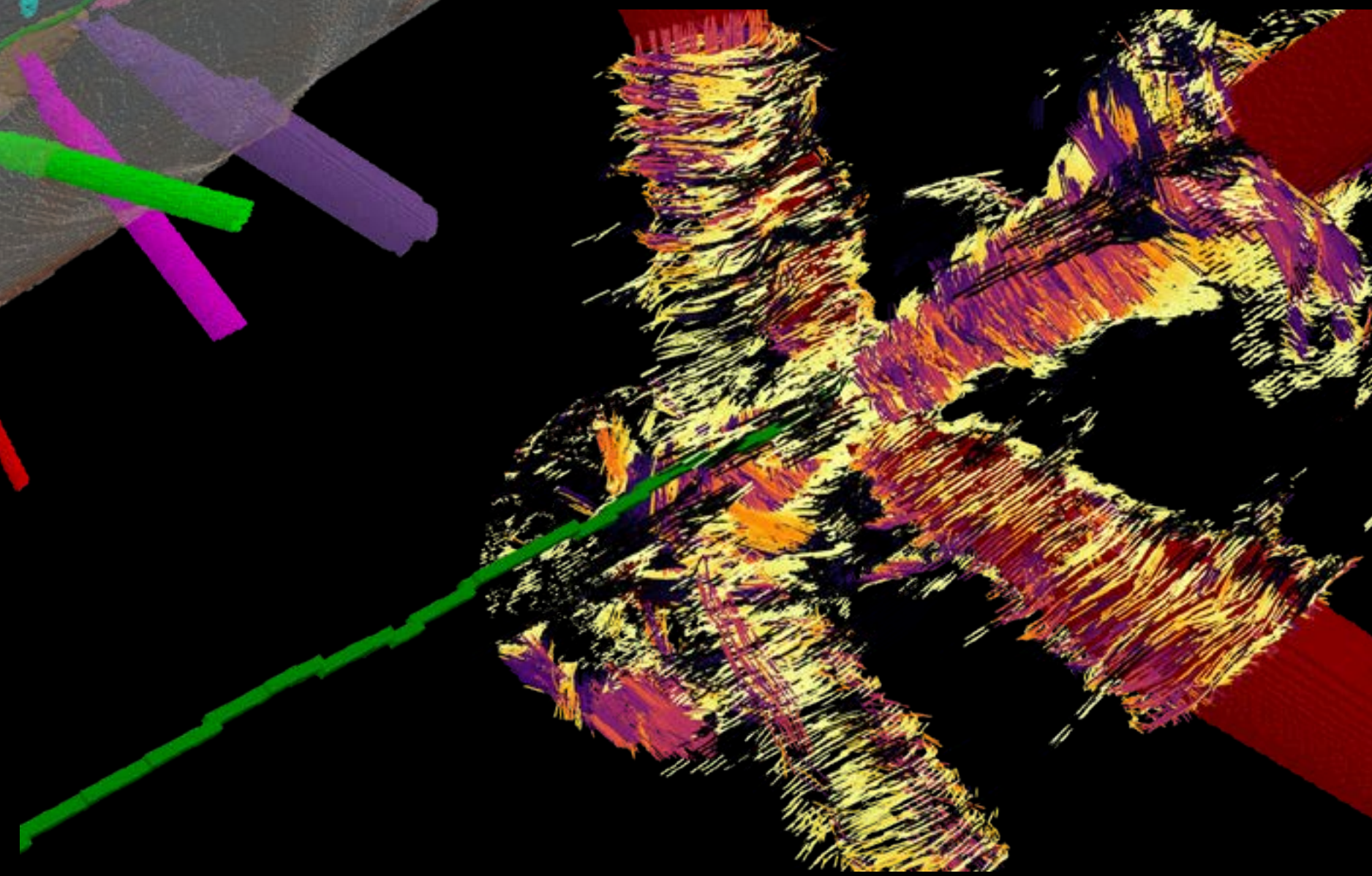
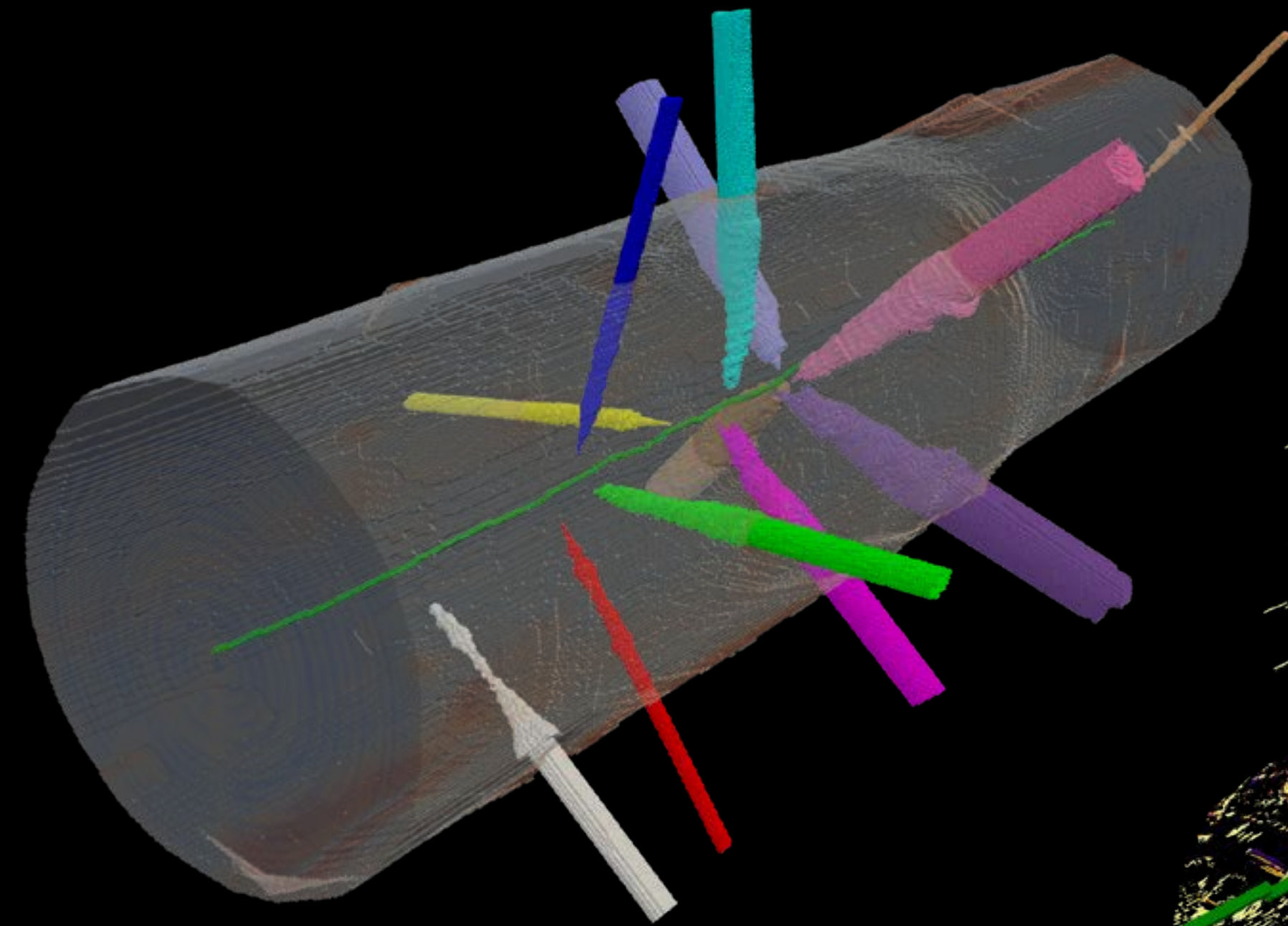
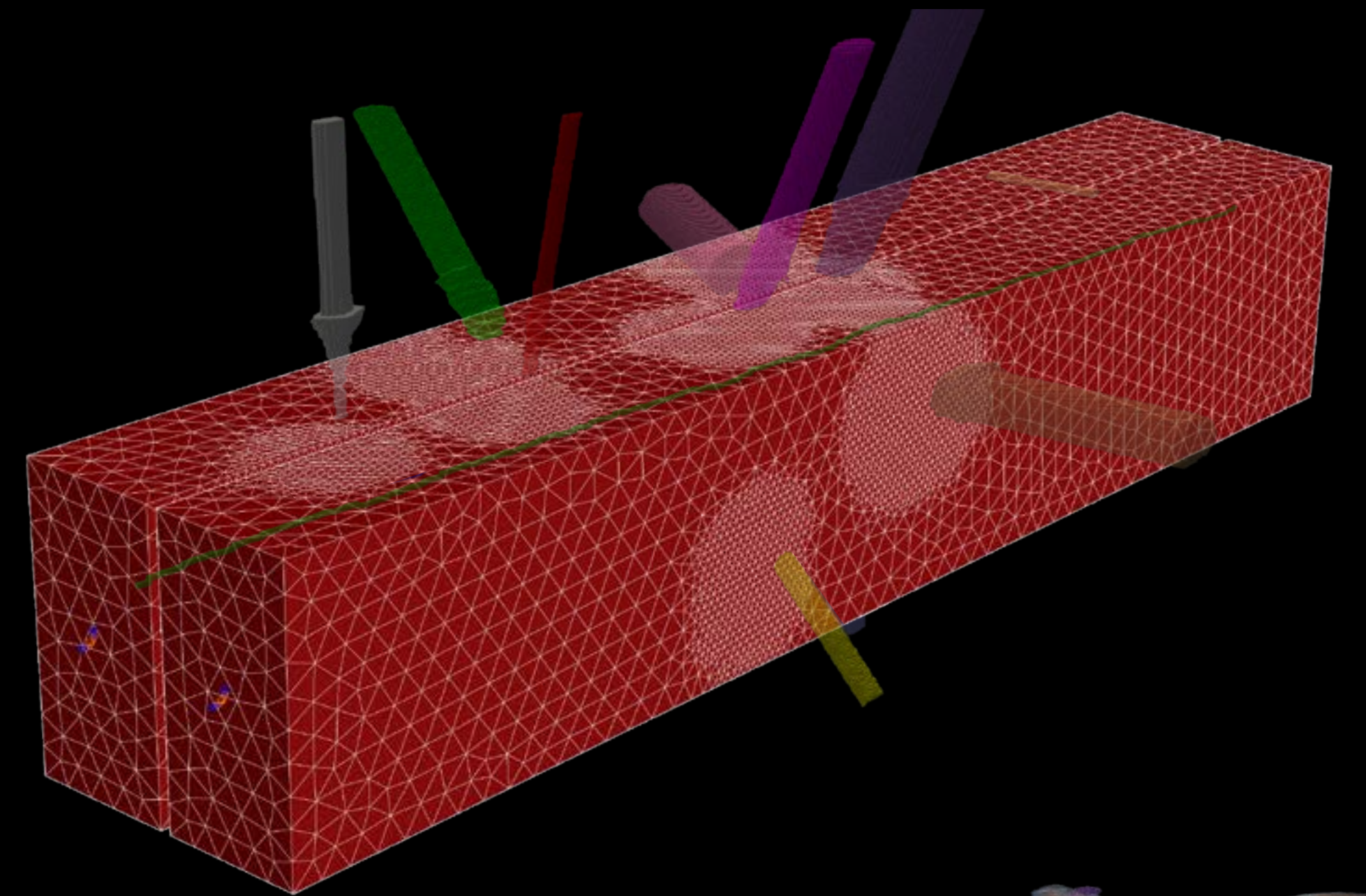
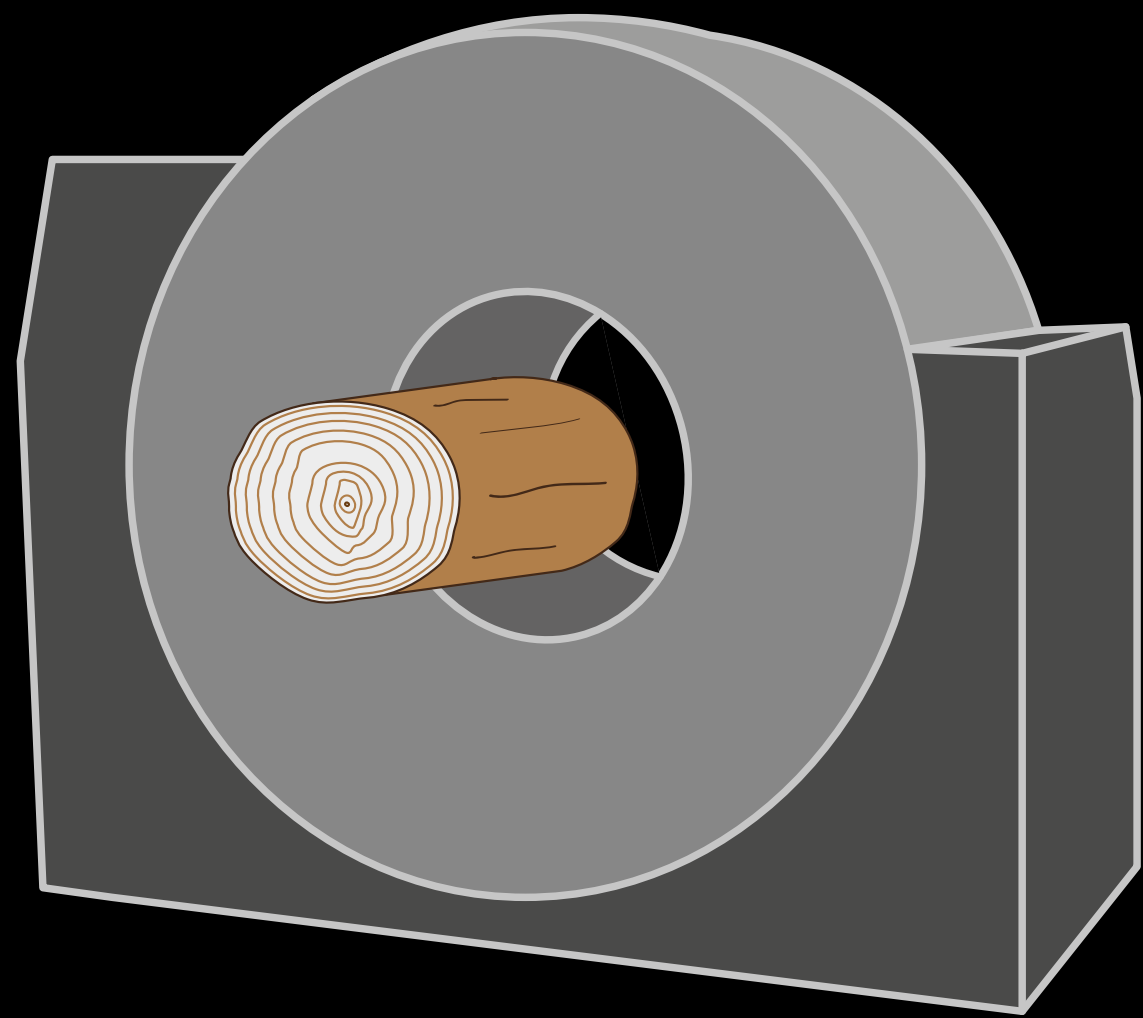


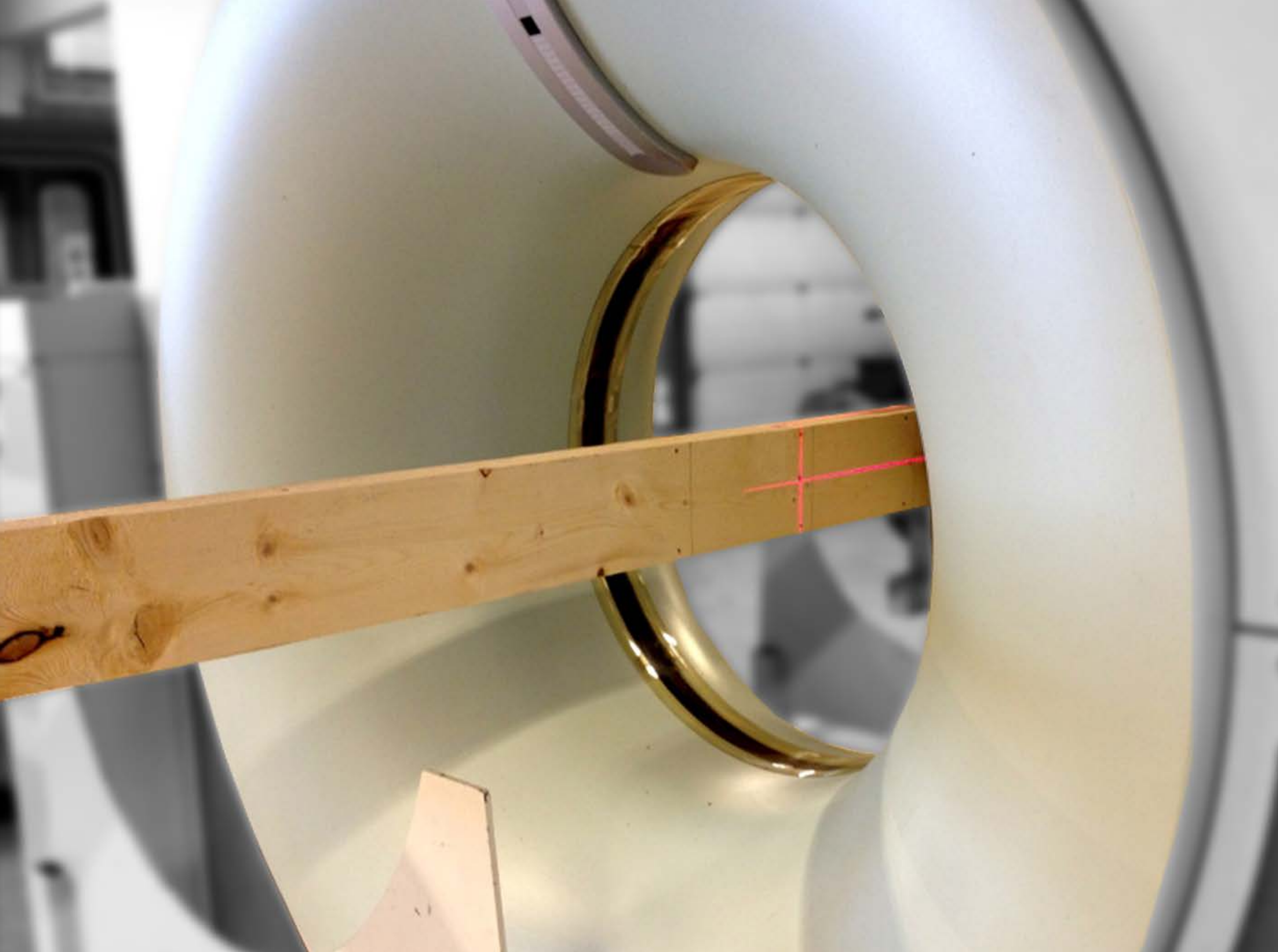




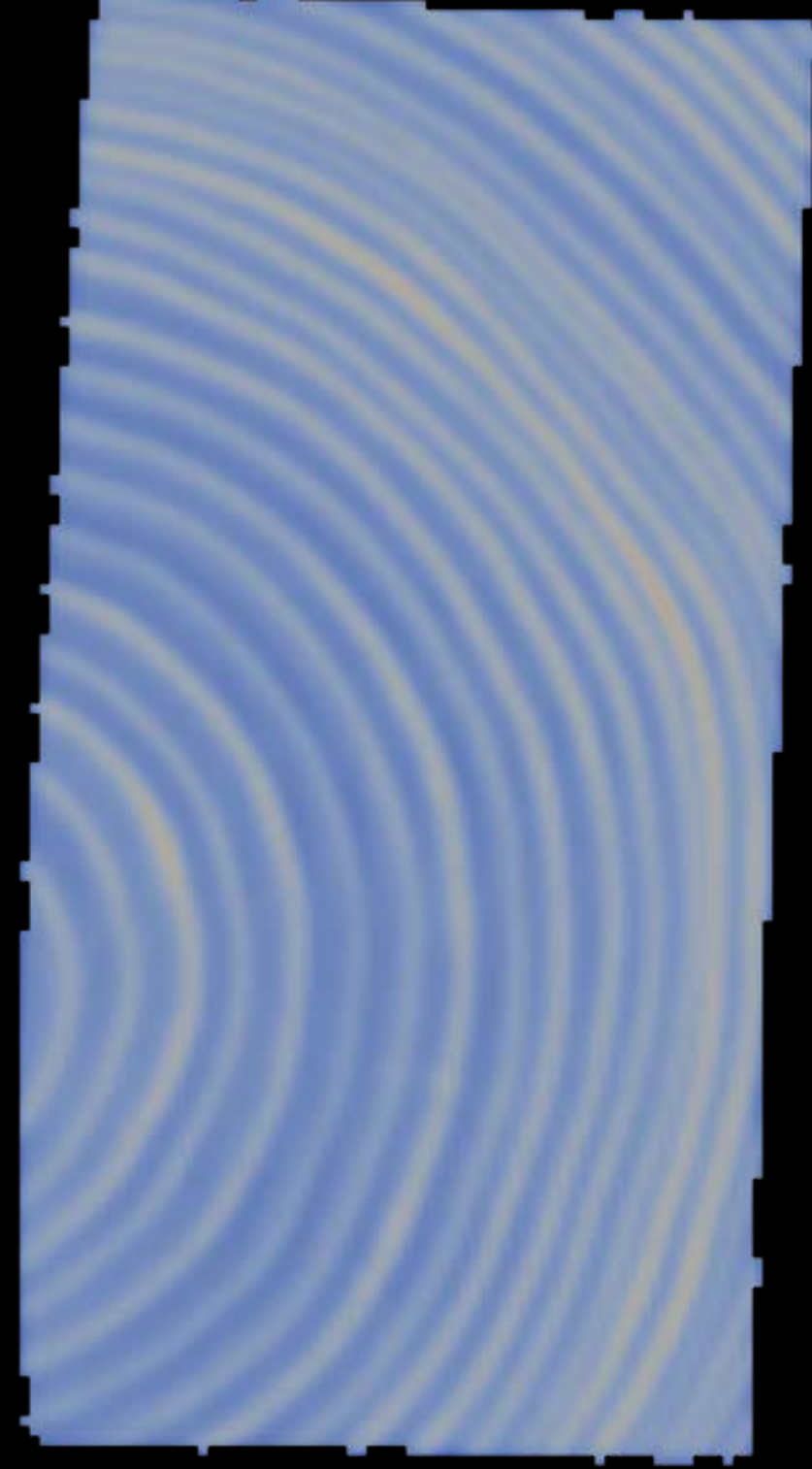


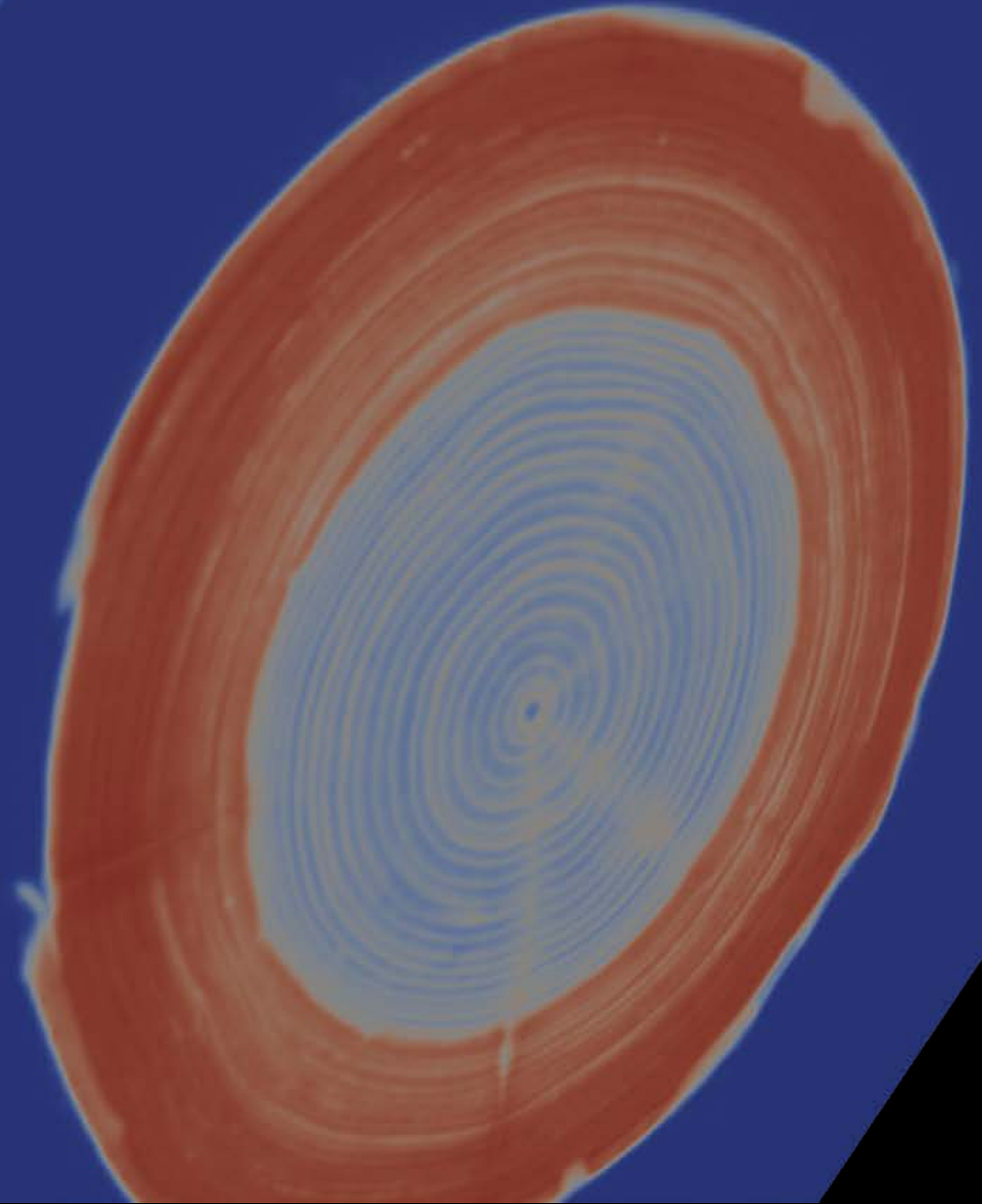




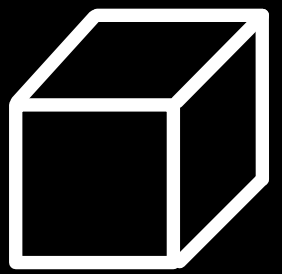


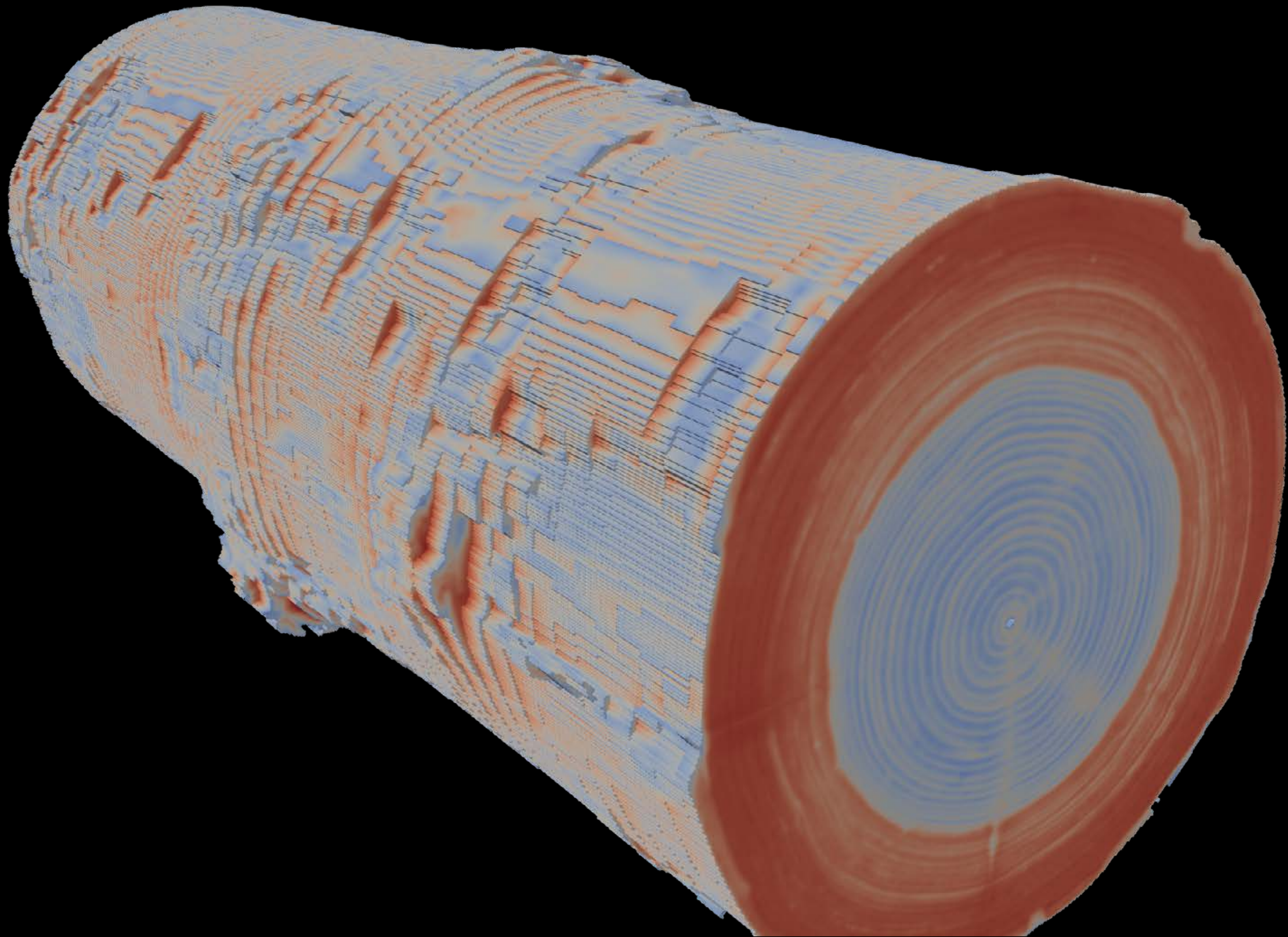
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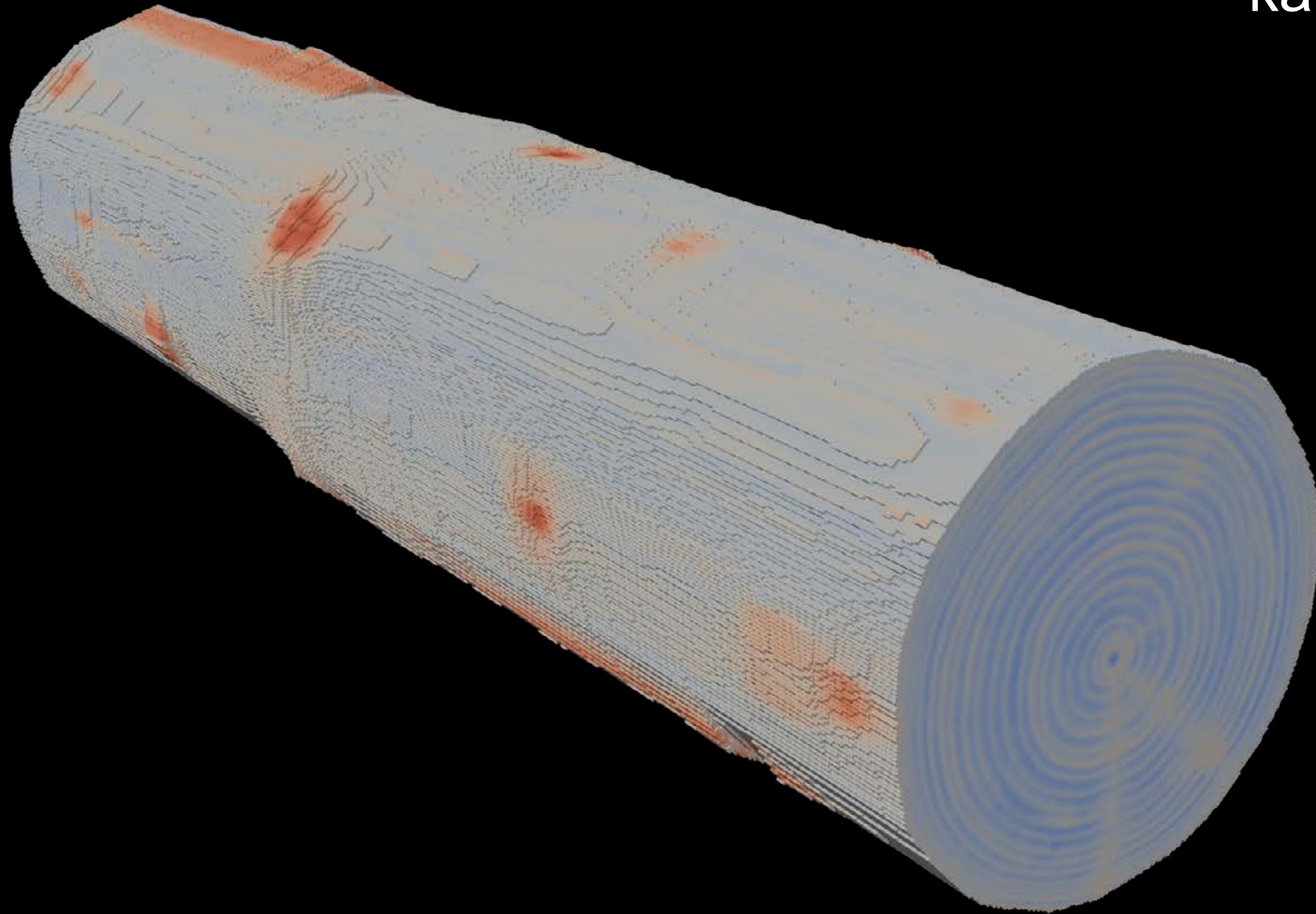


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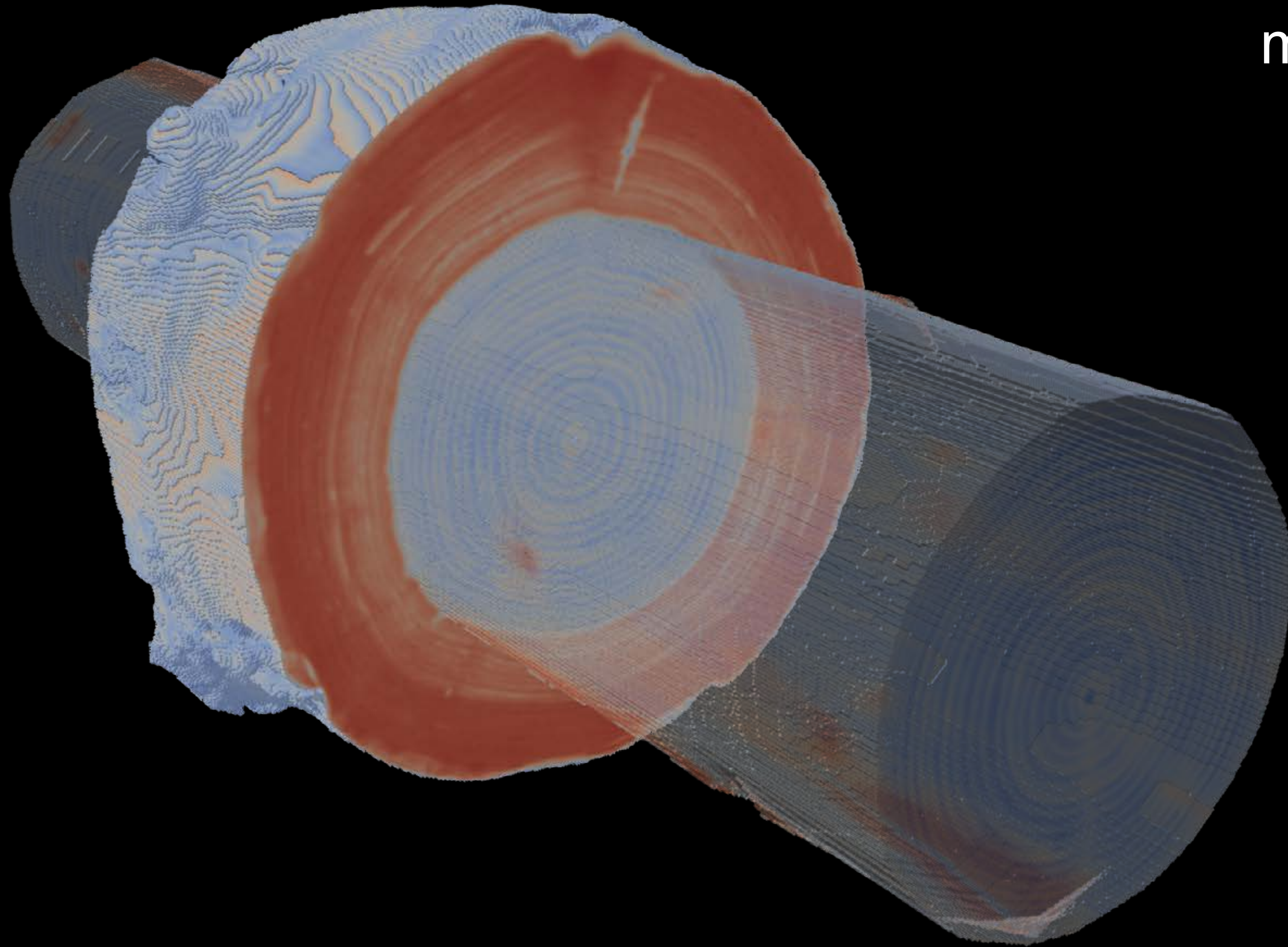




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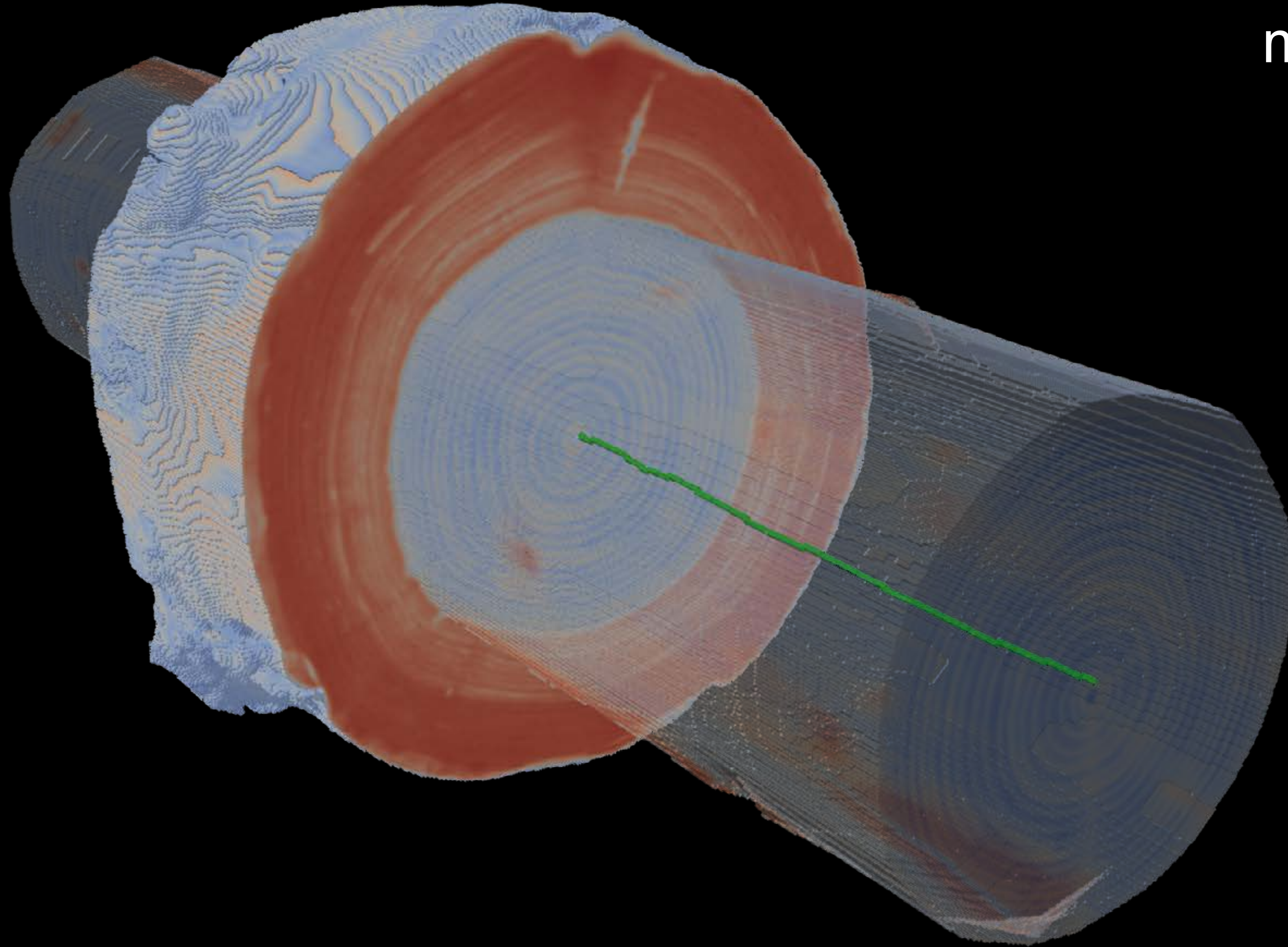


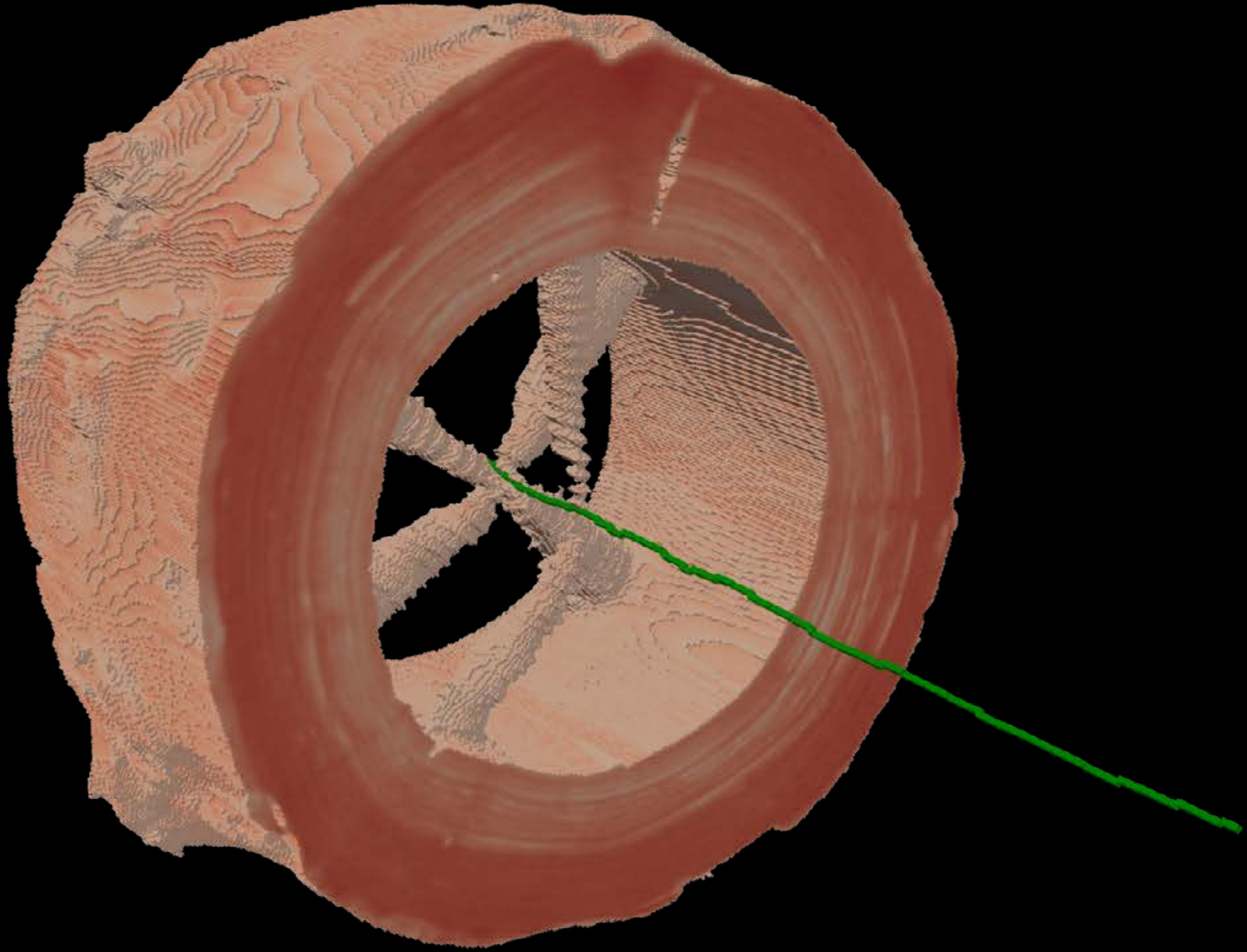


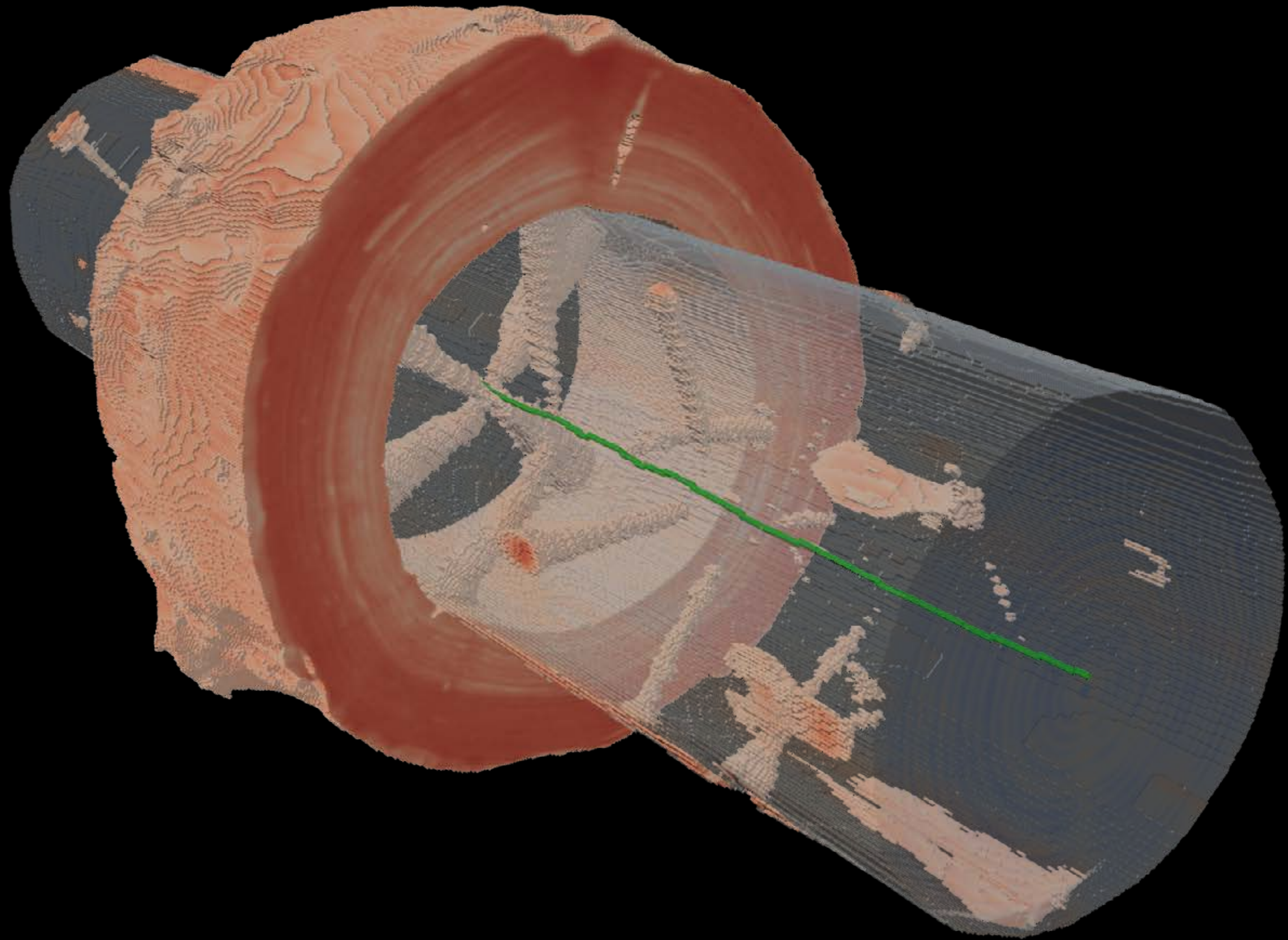


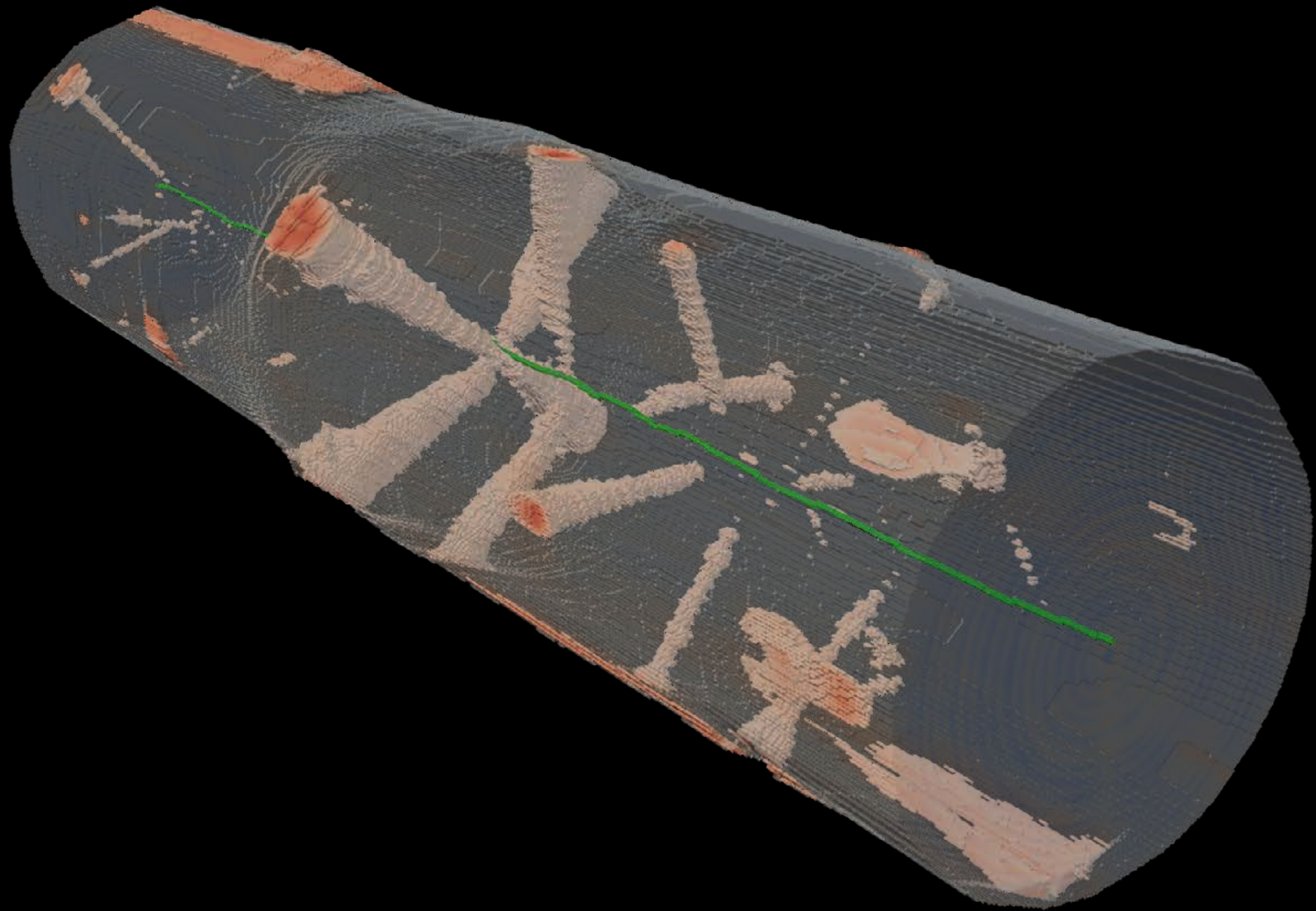
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märg

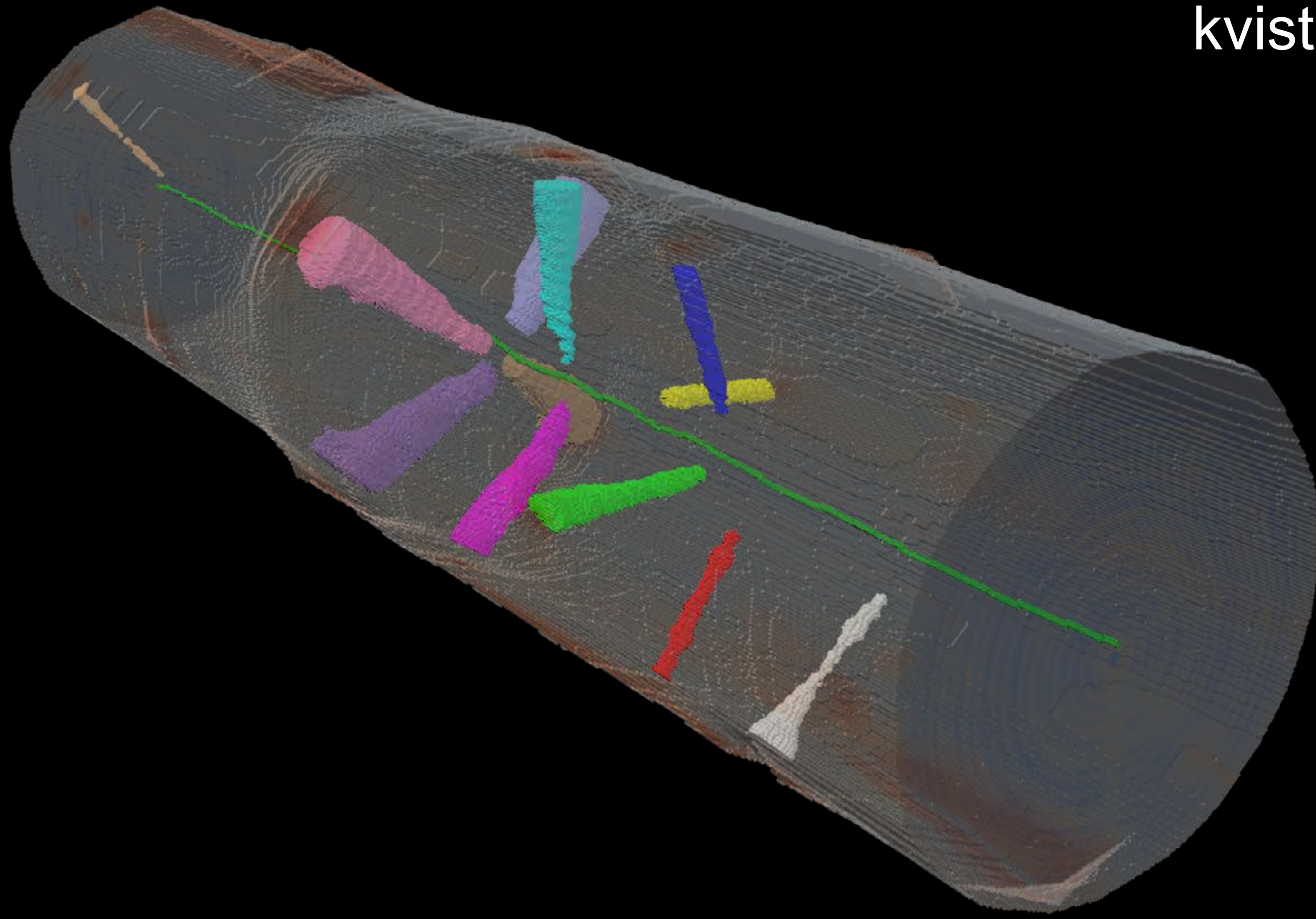


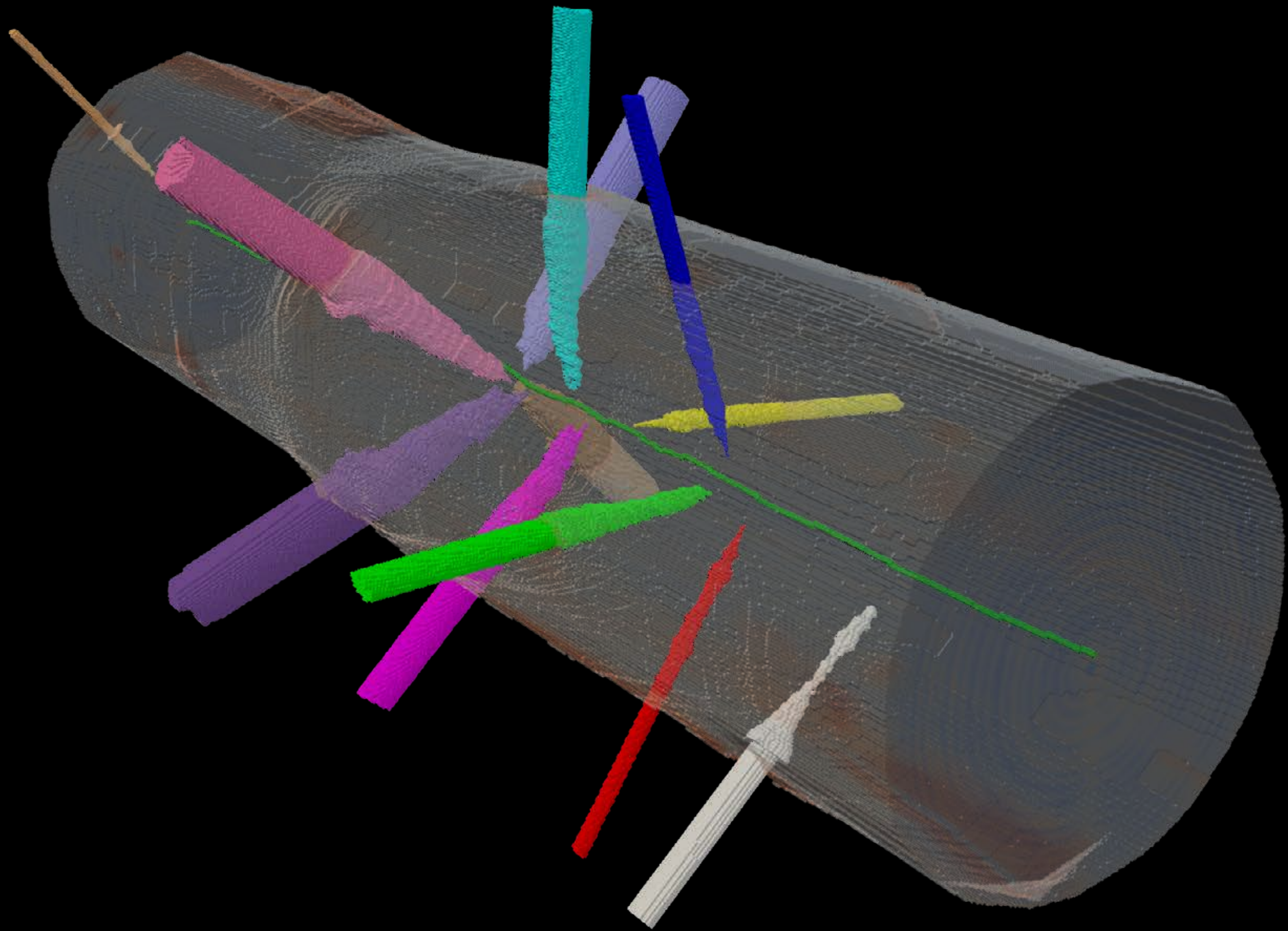


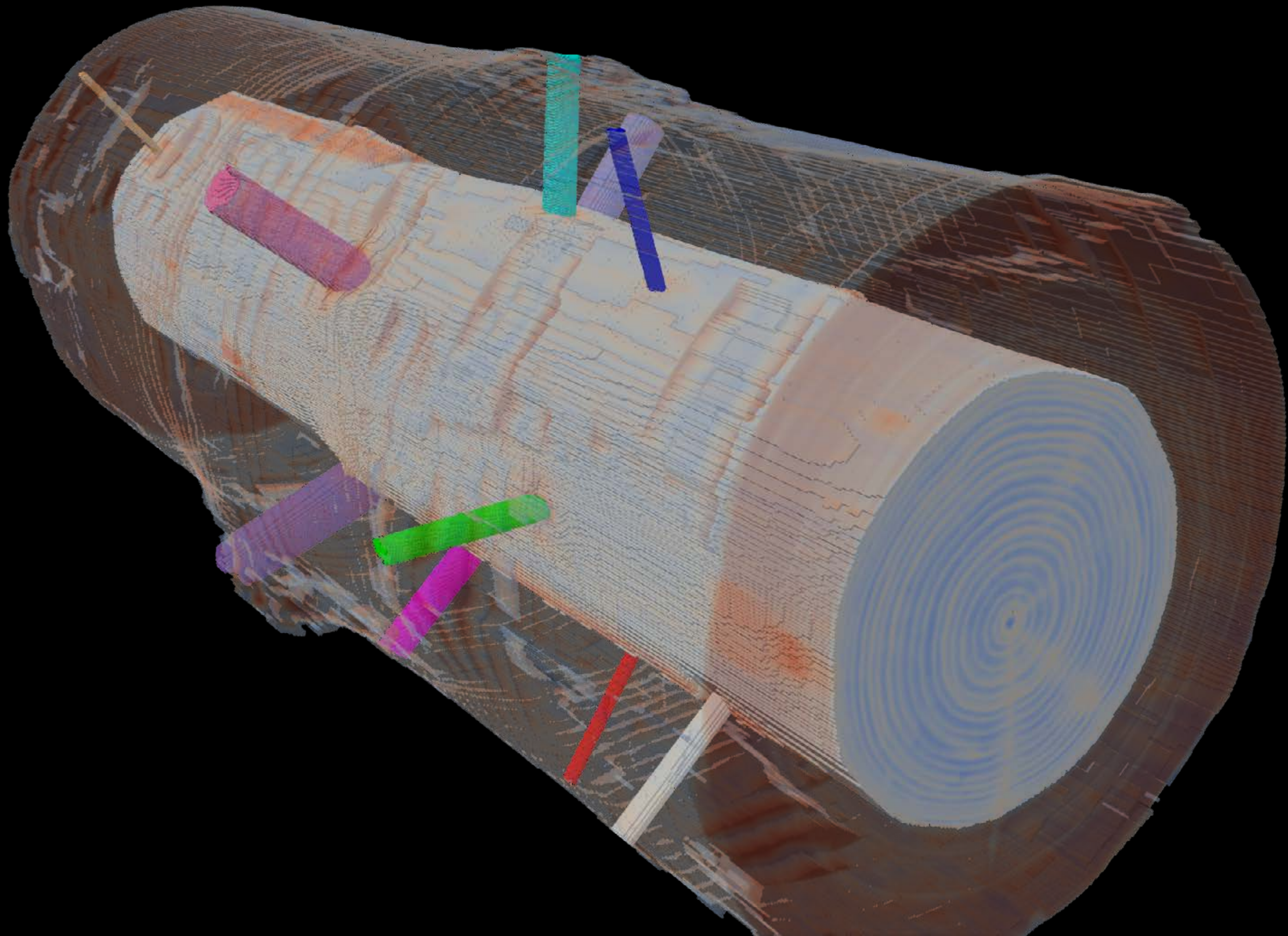




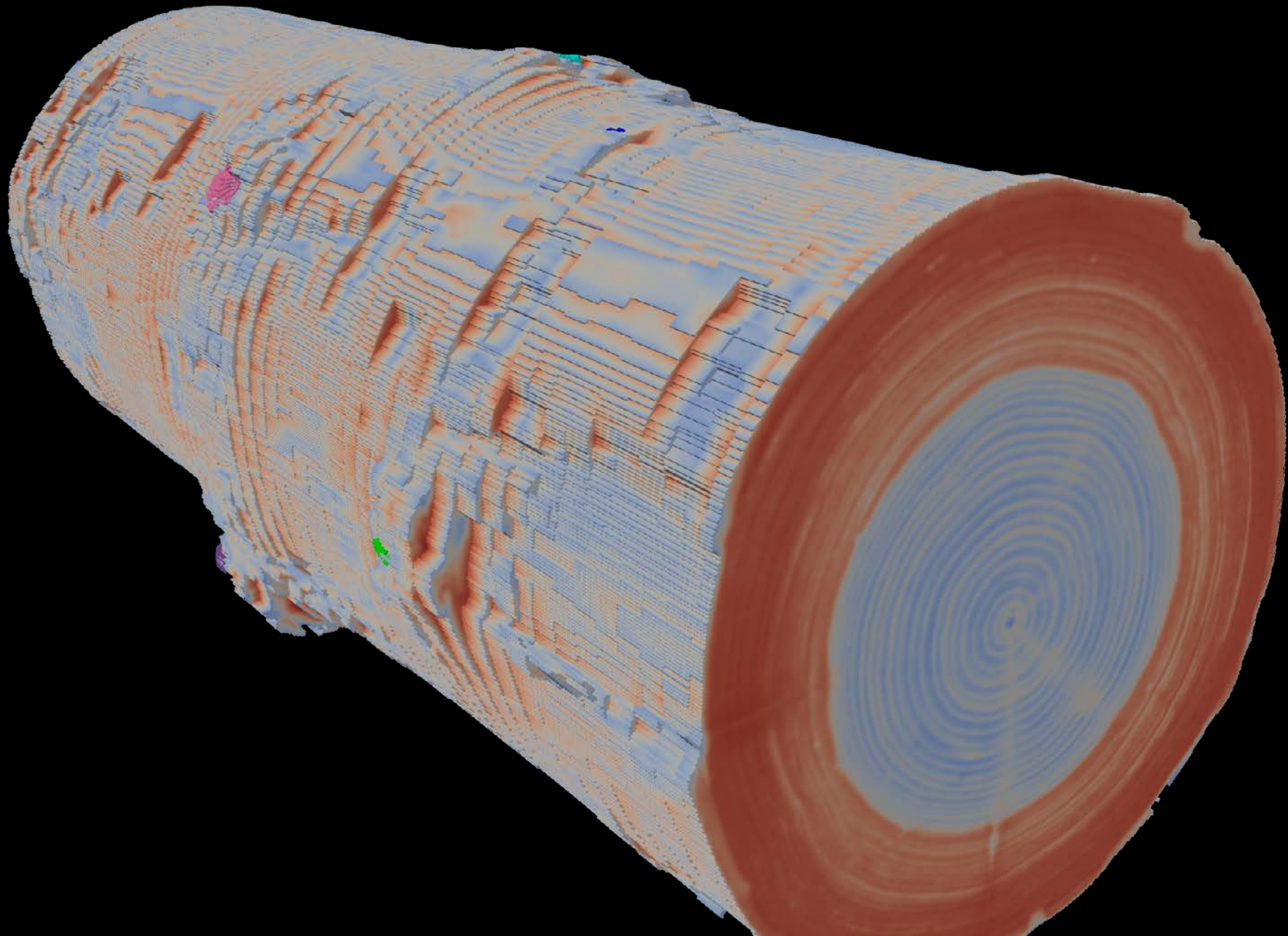
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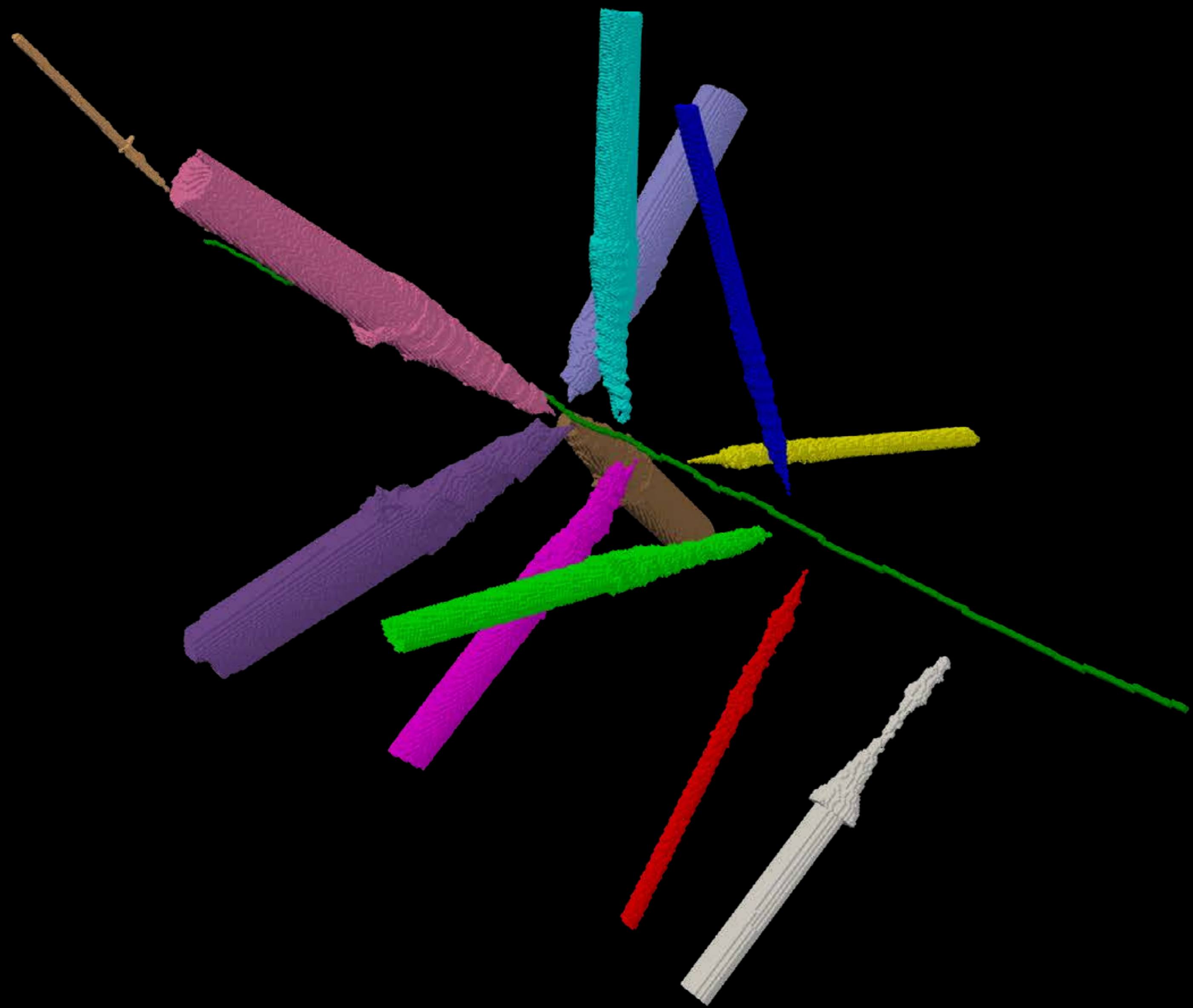


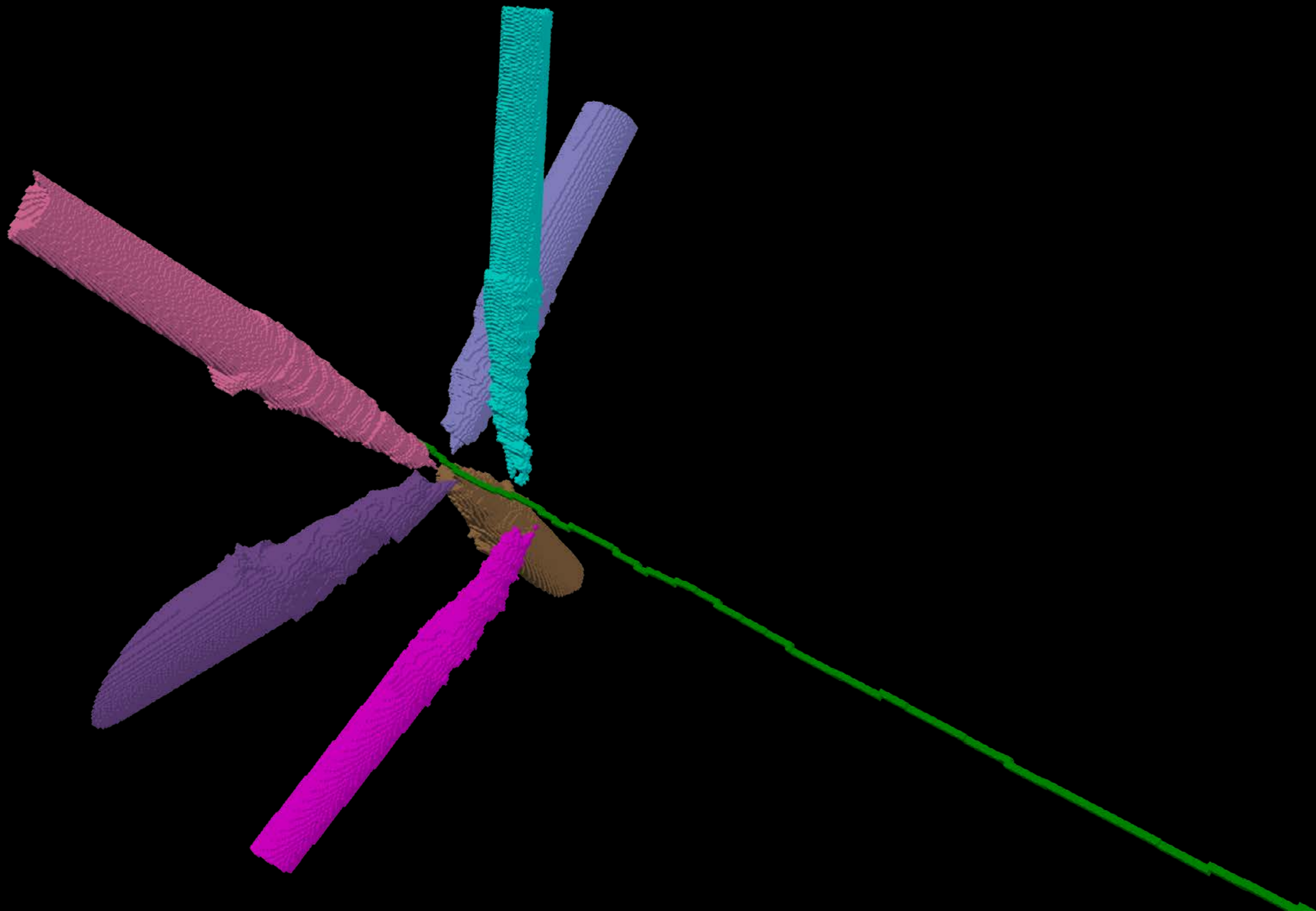


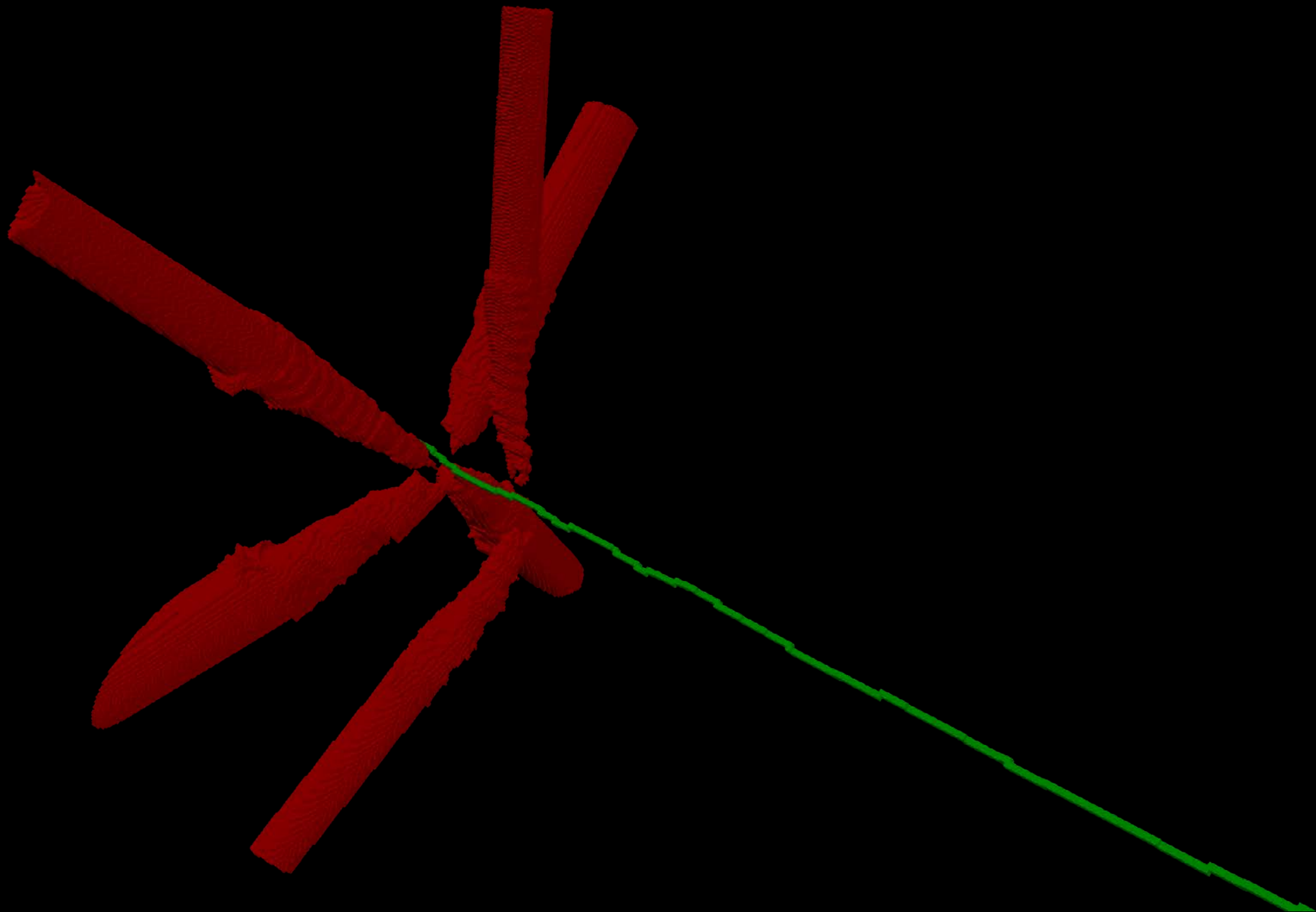


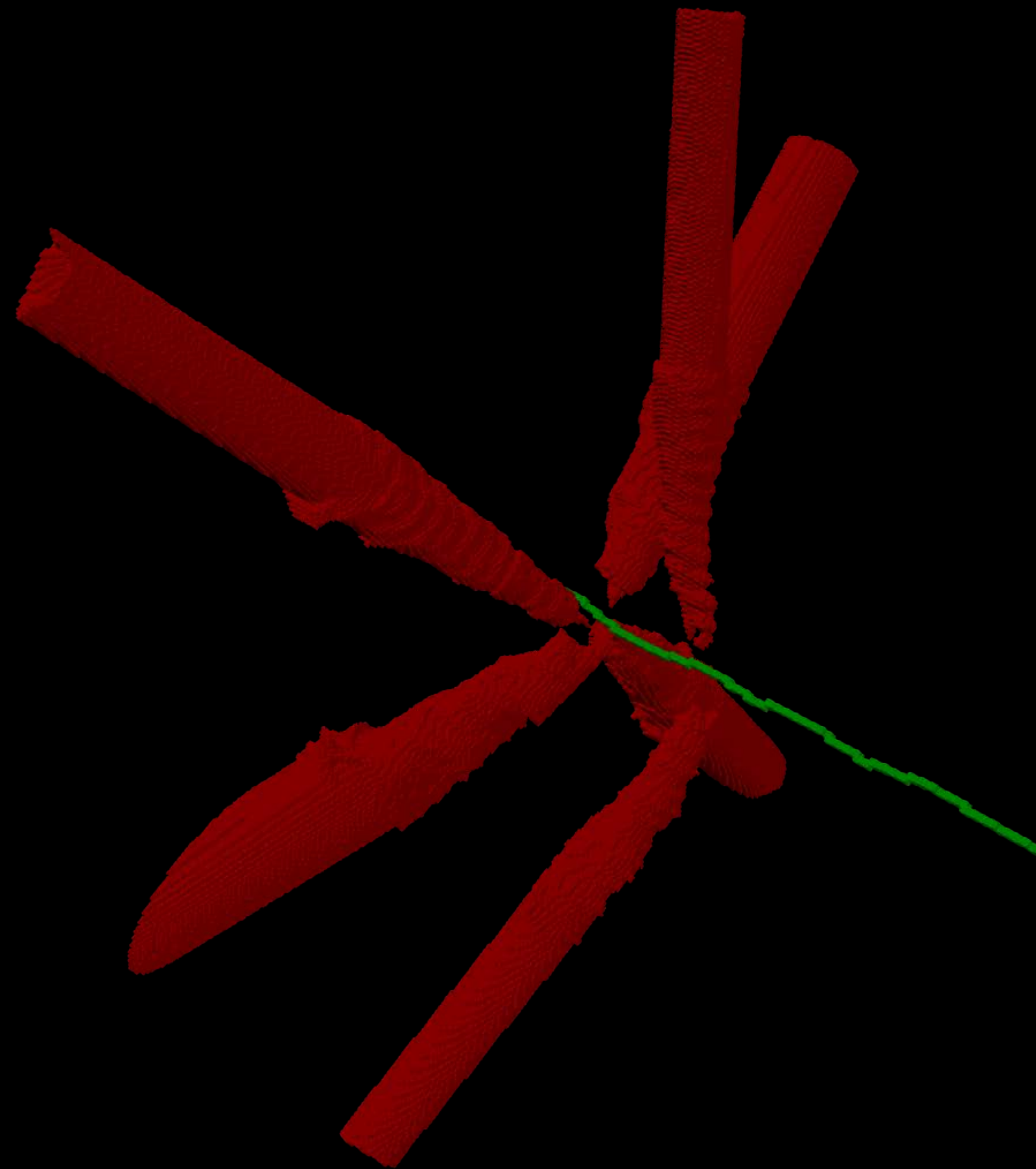




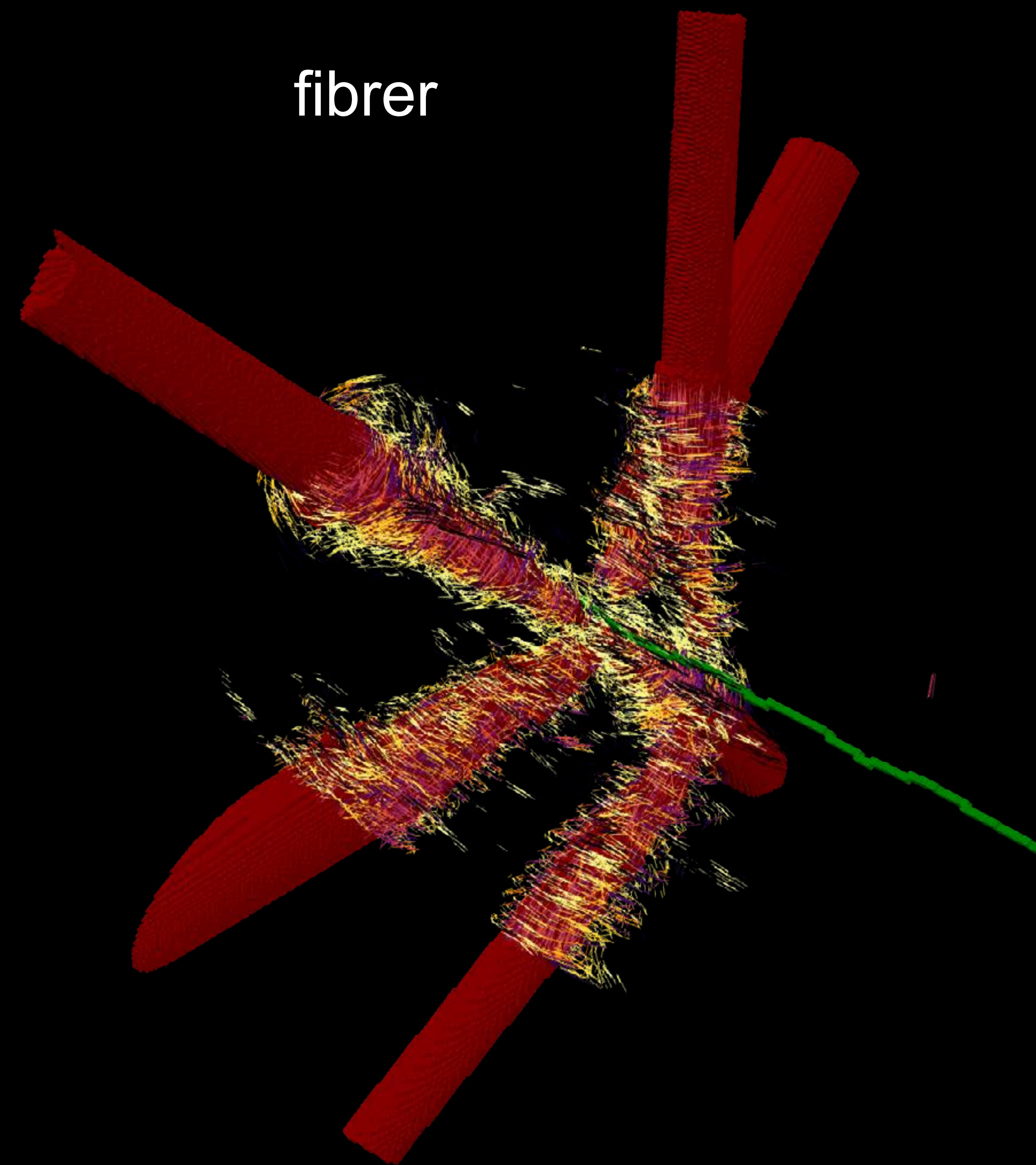


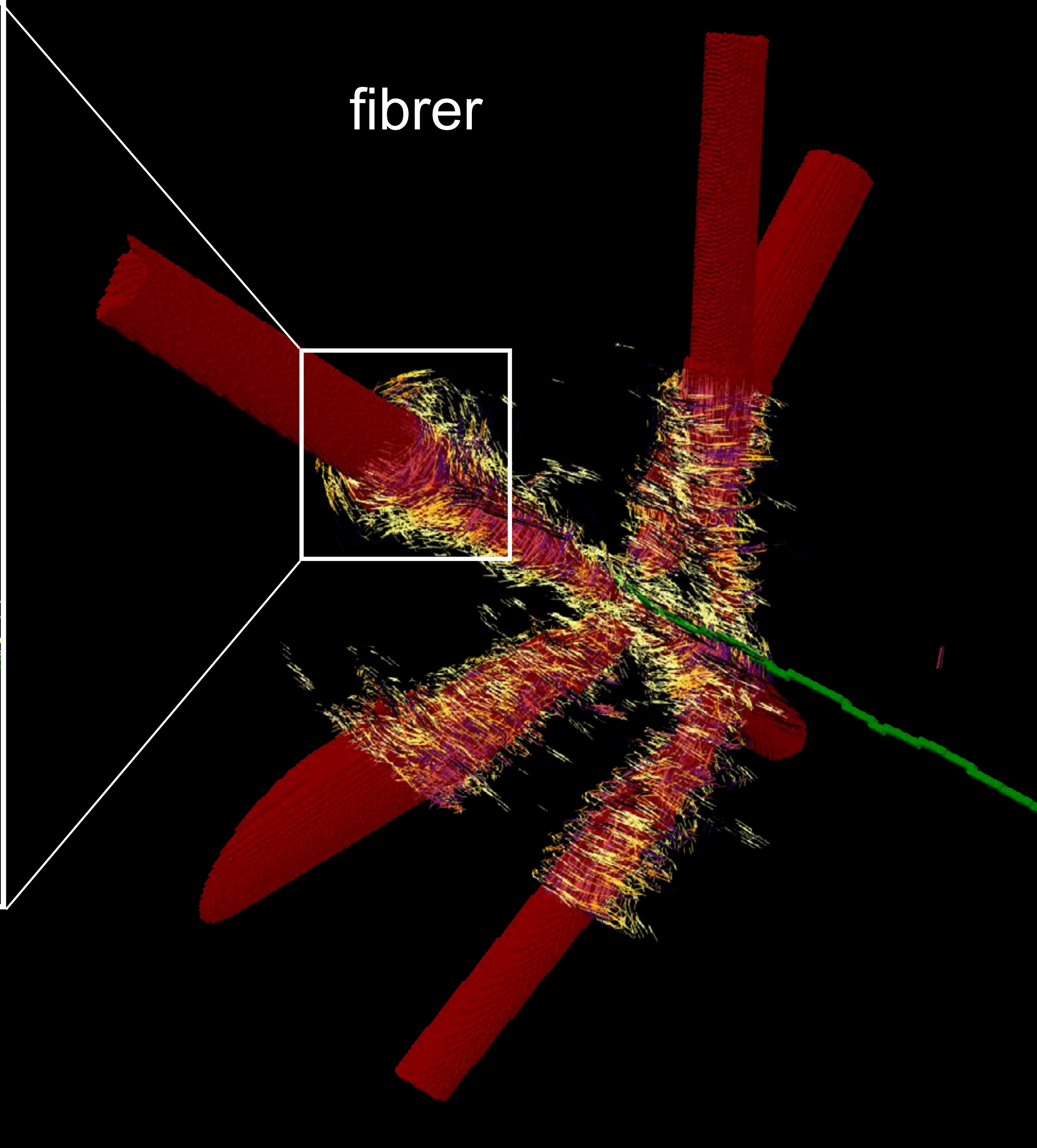
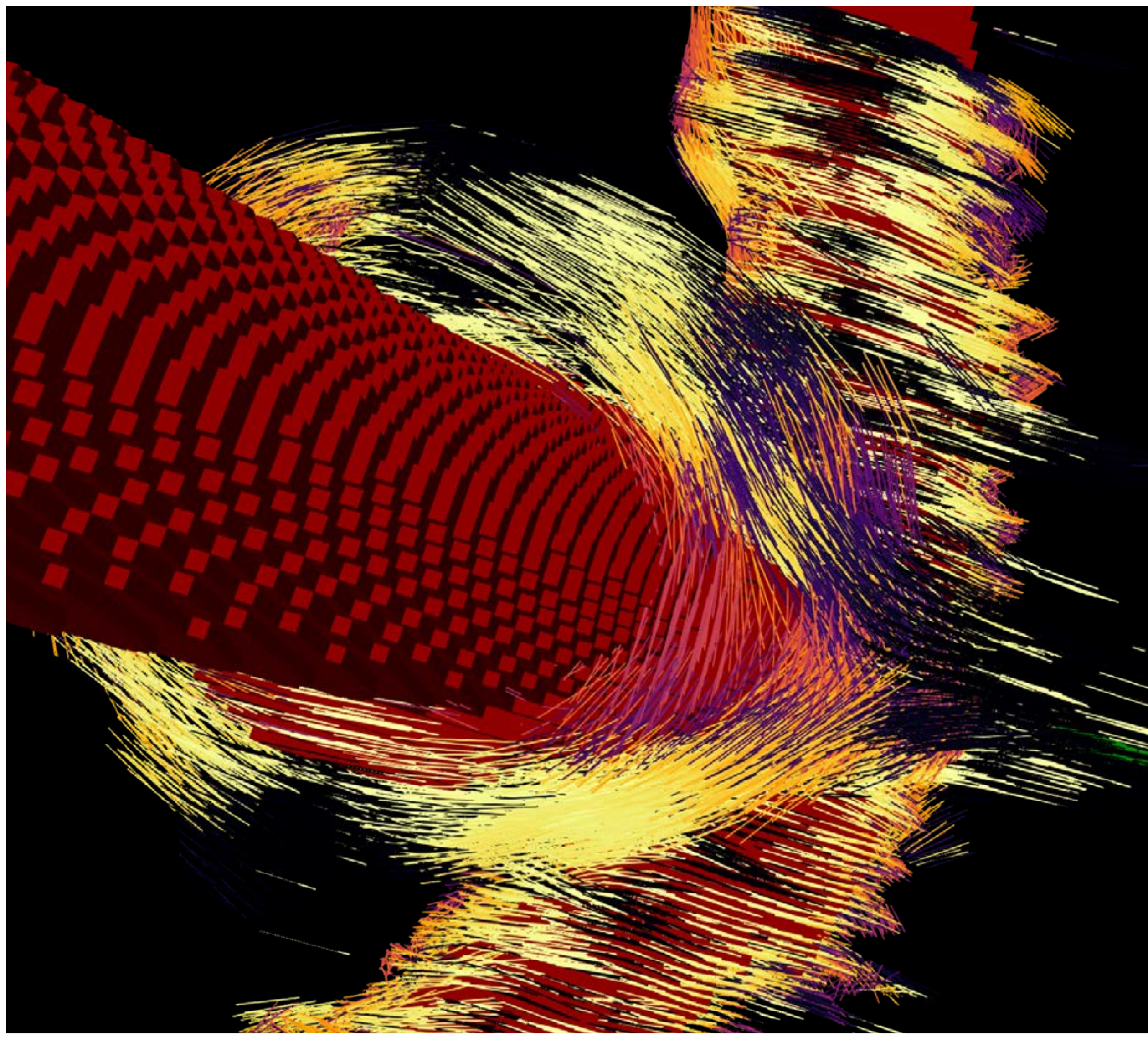


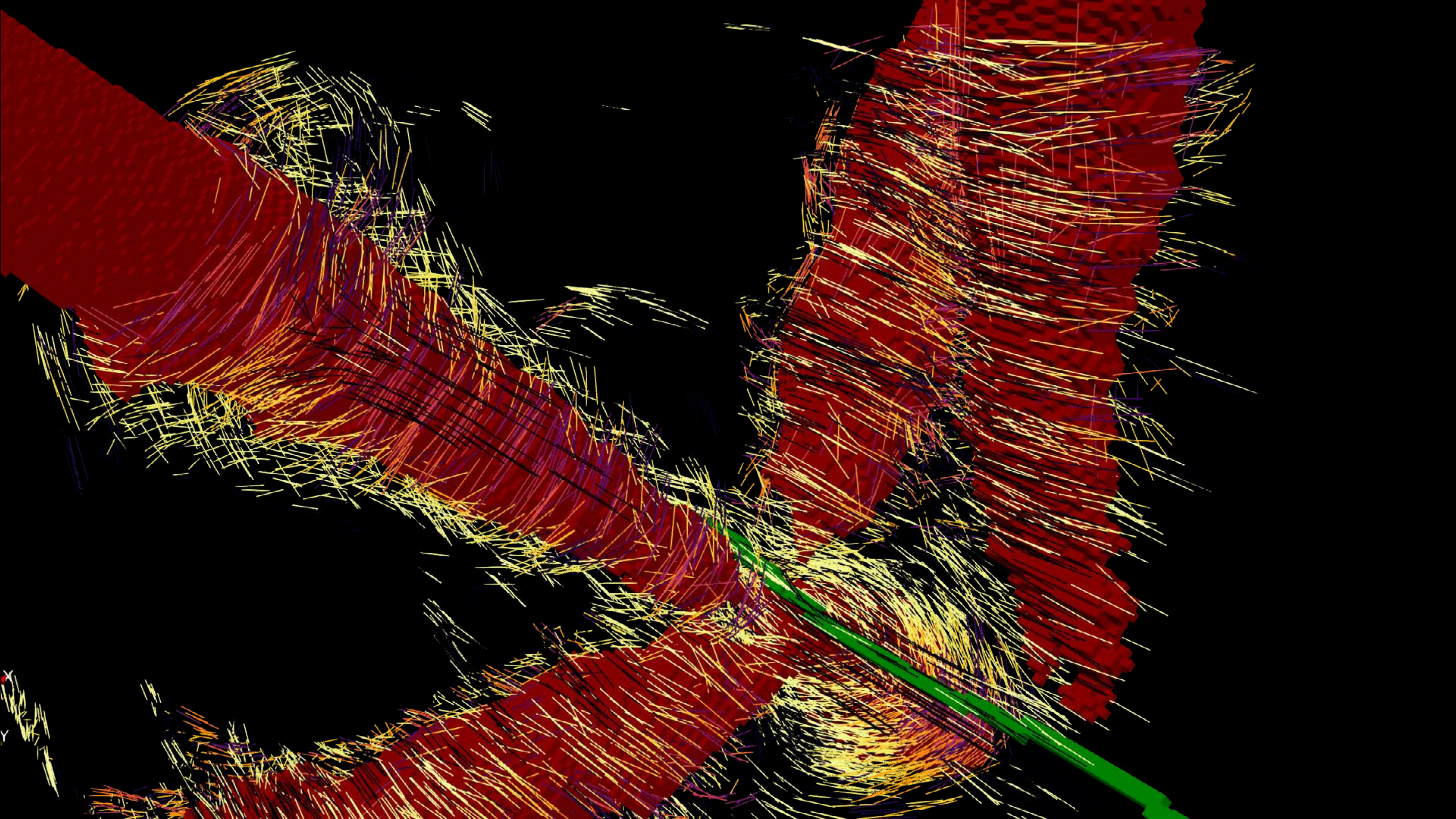




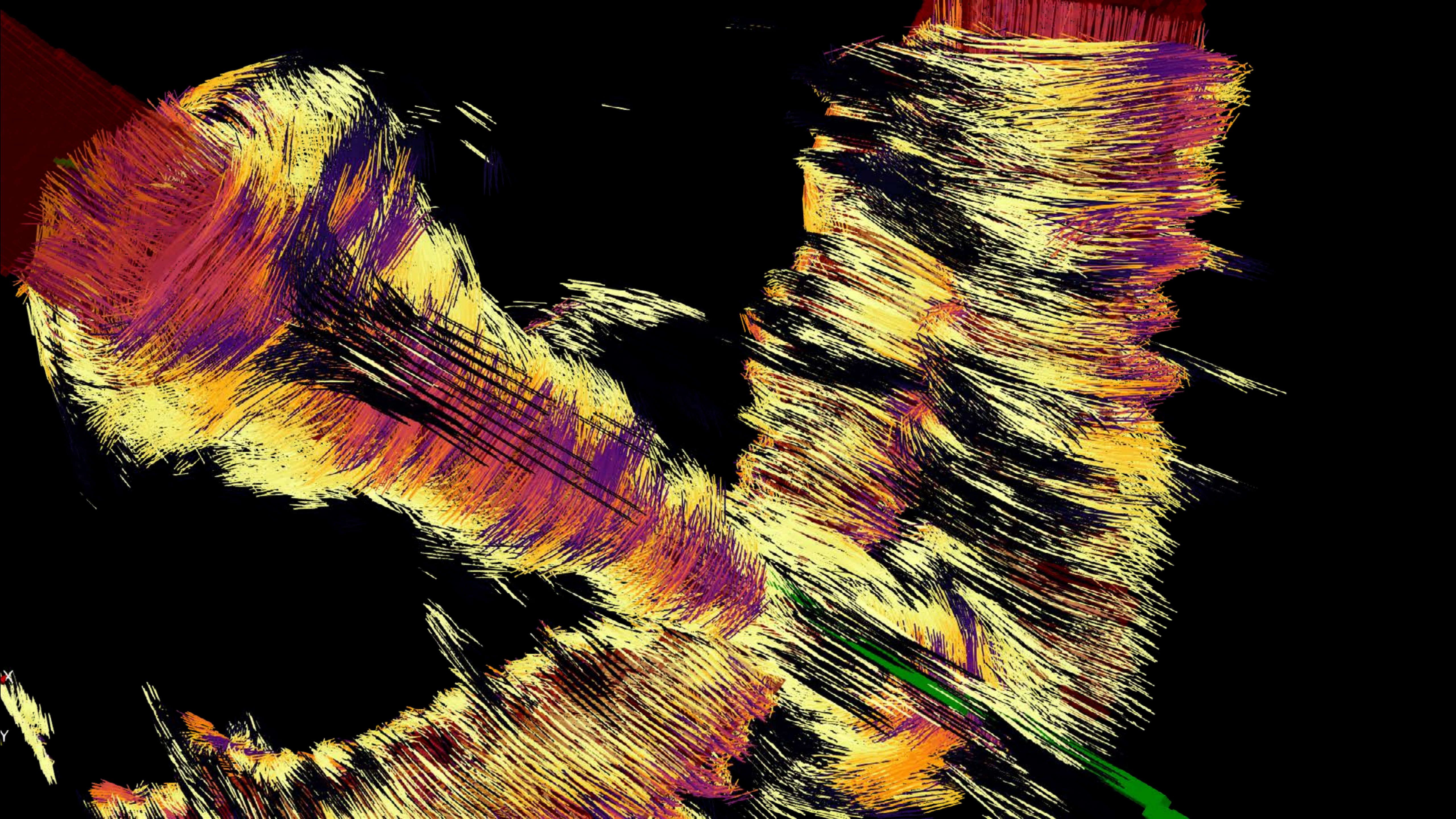
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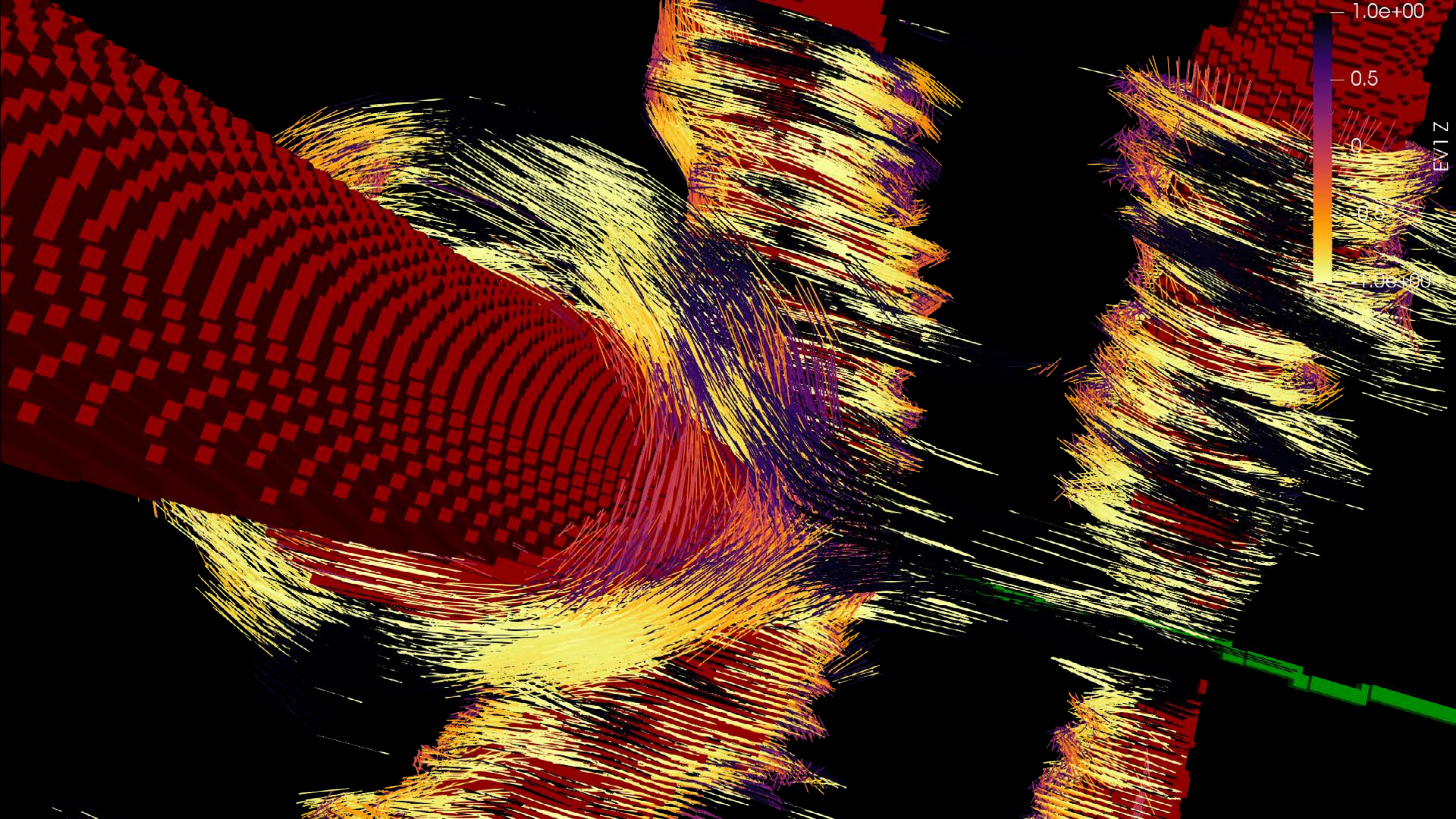


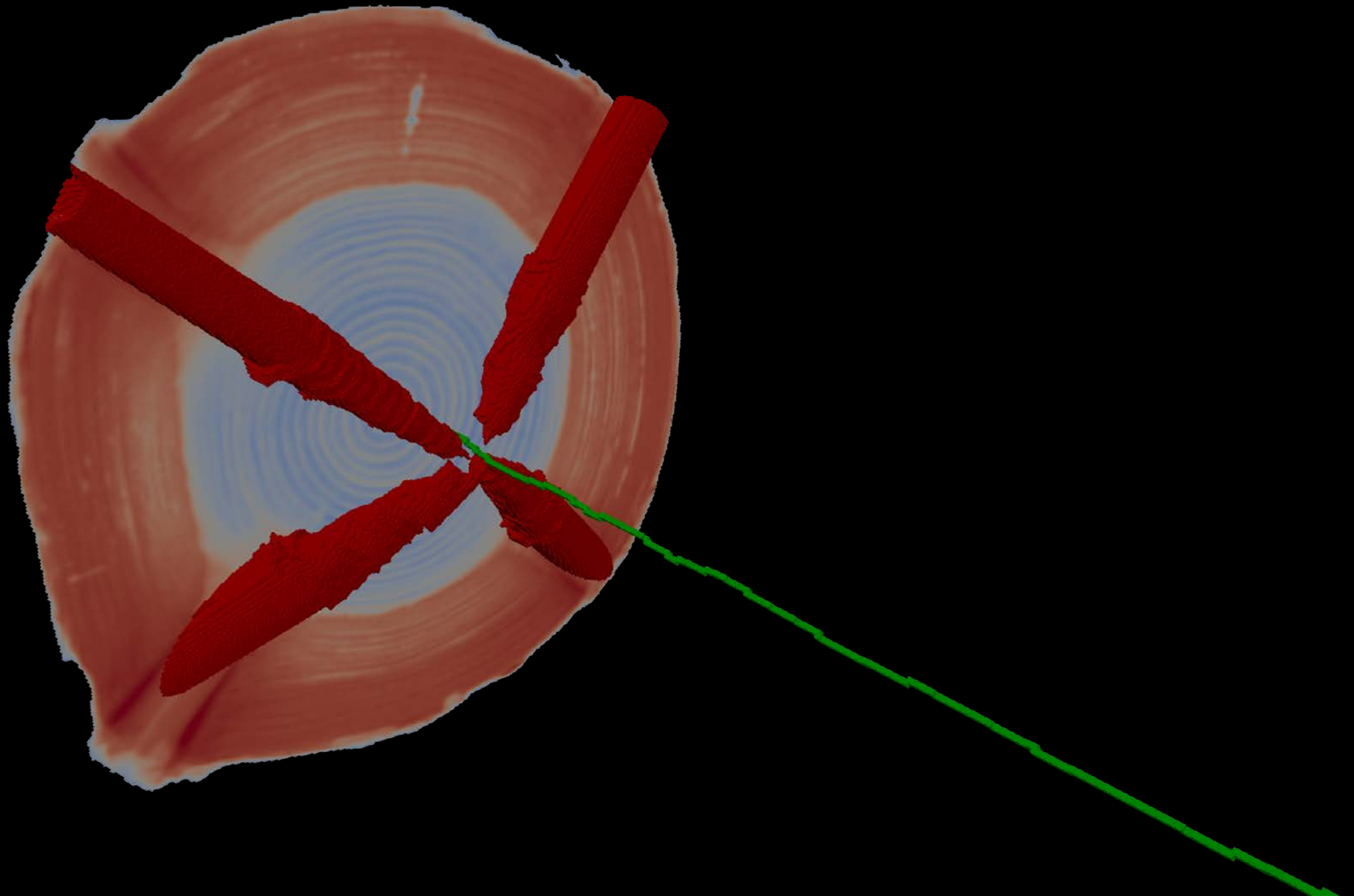


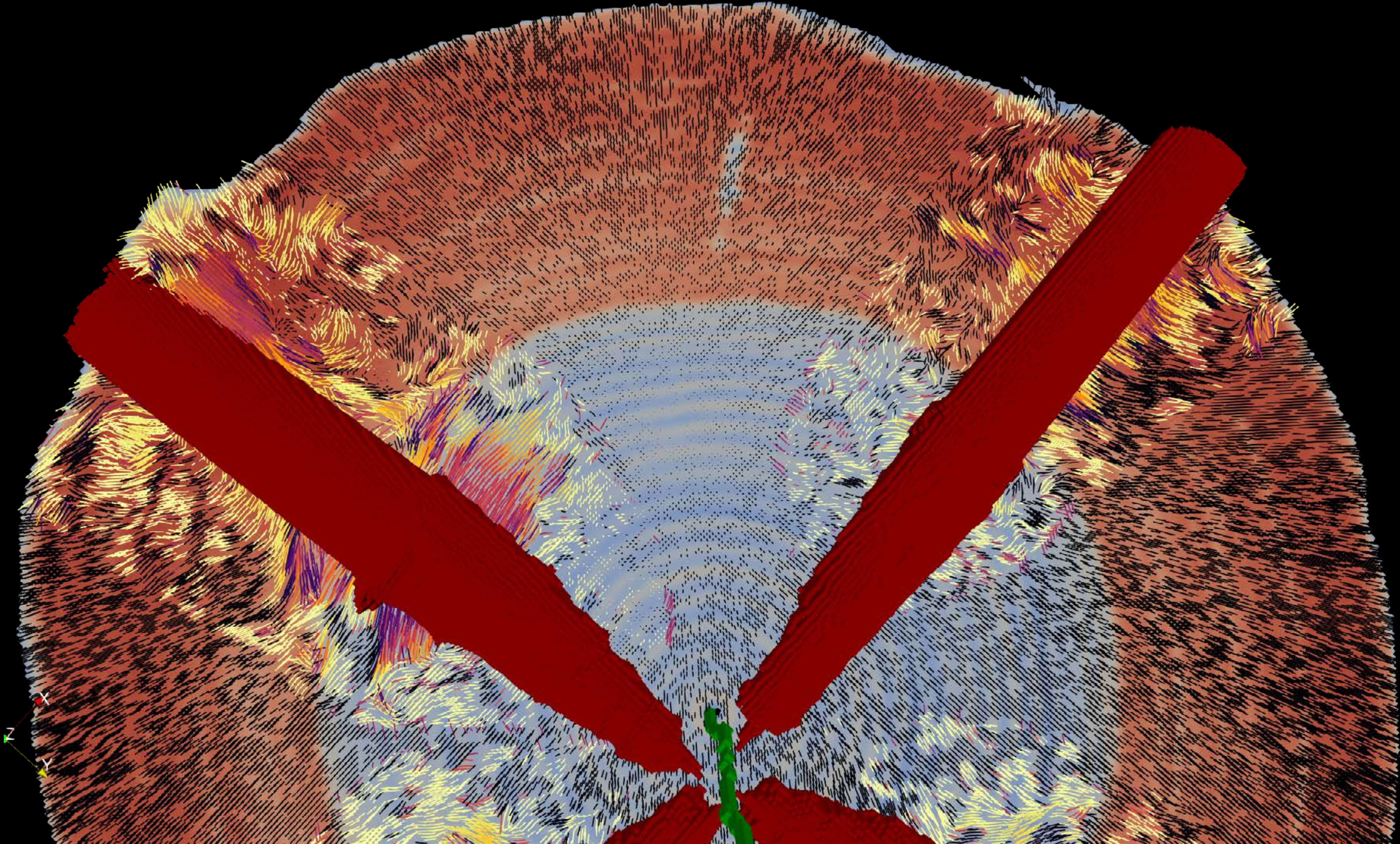


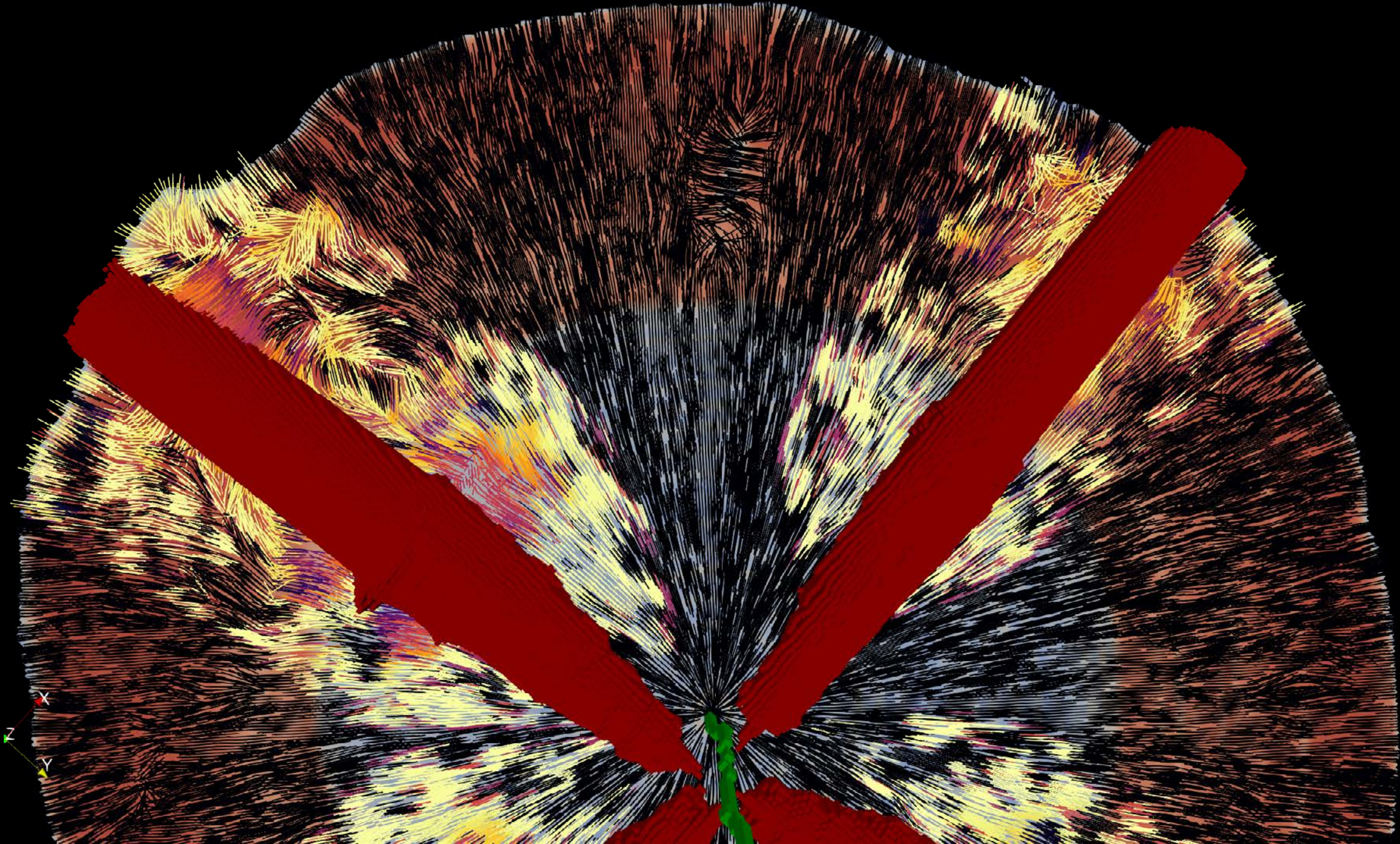


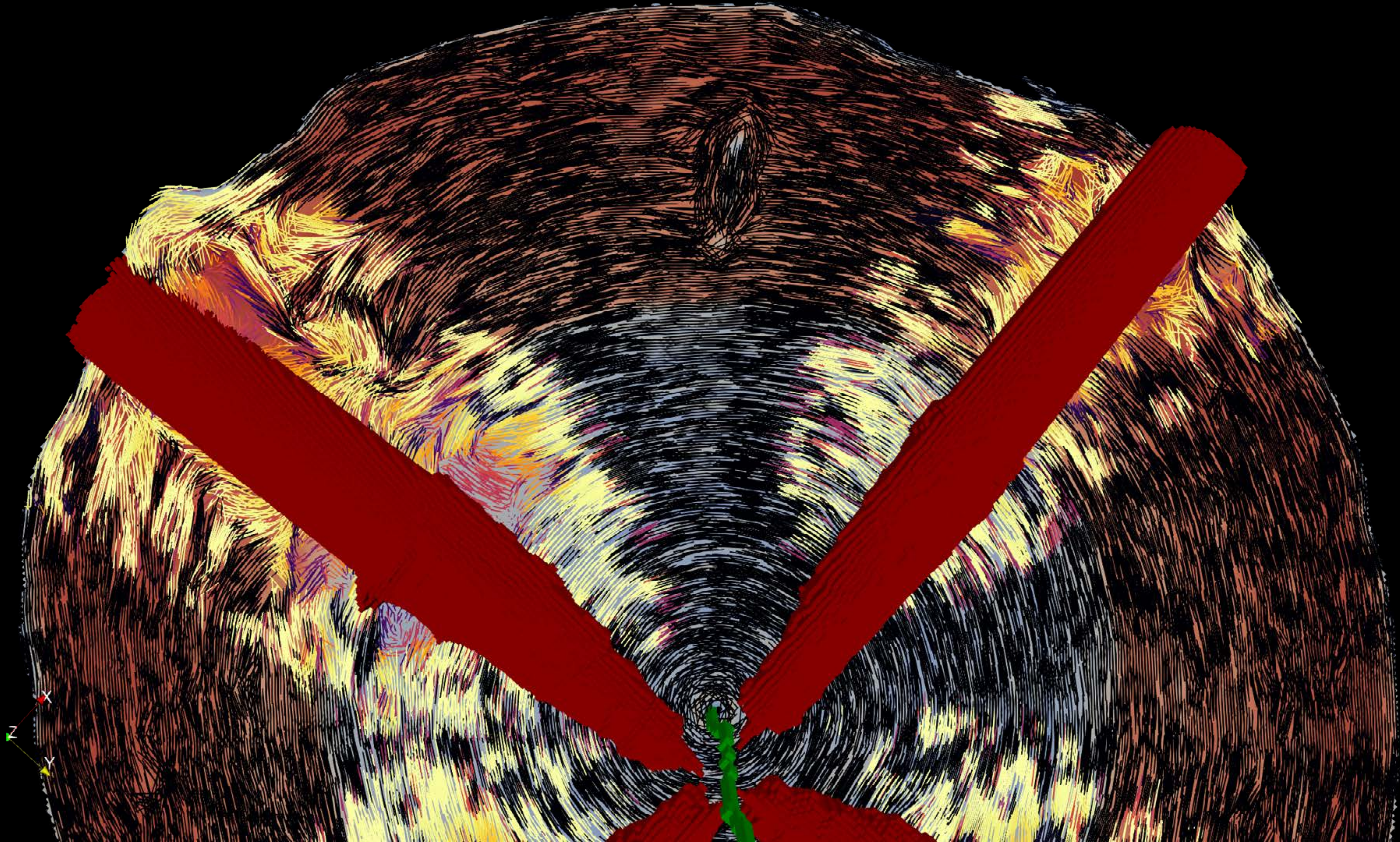


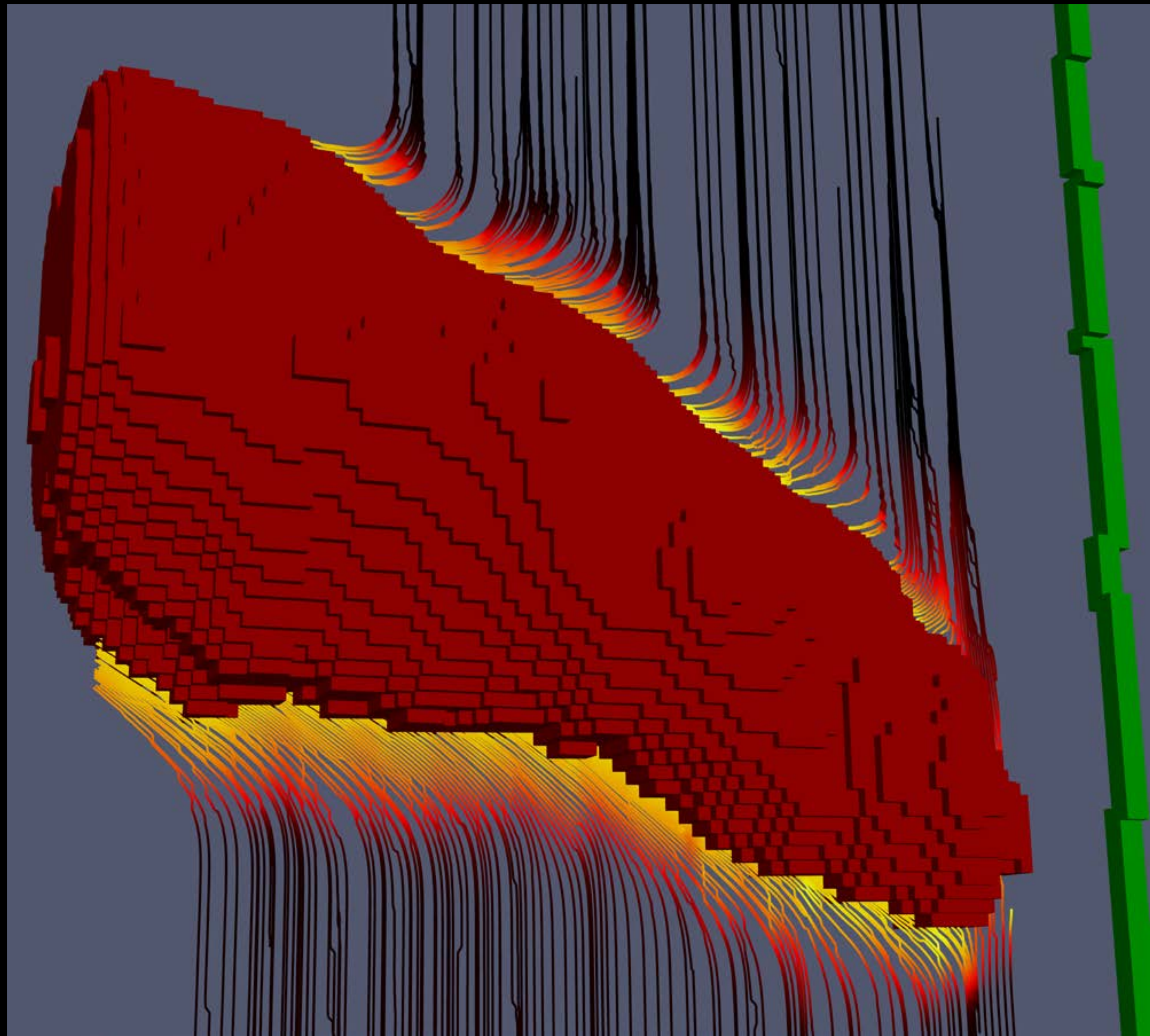
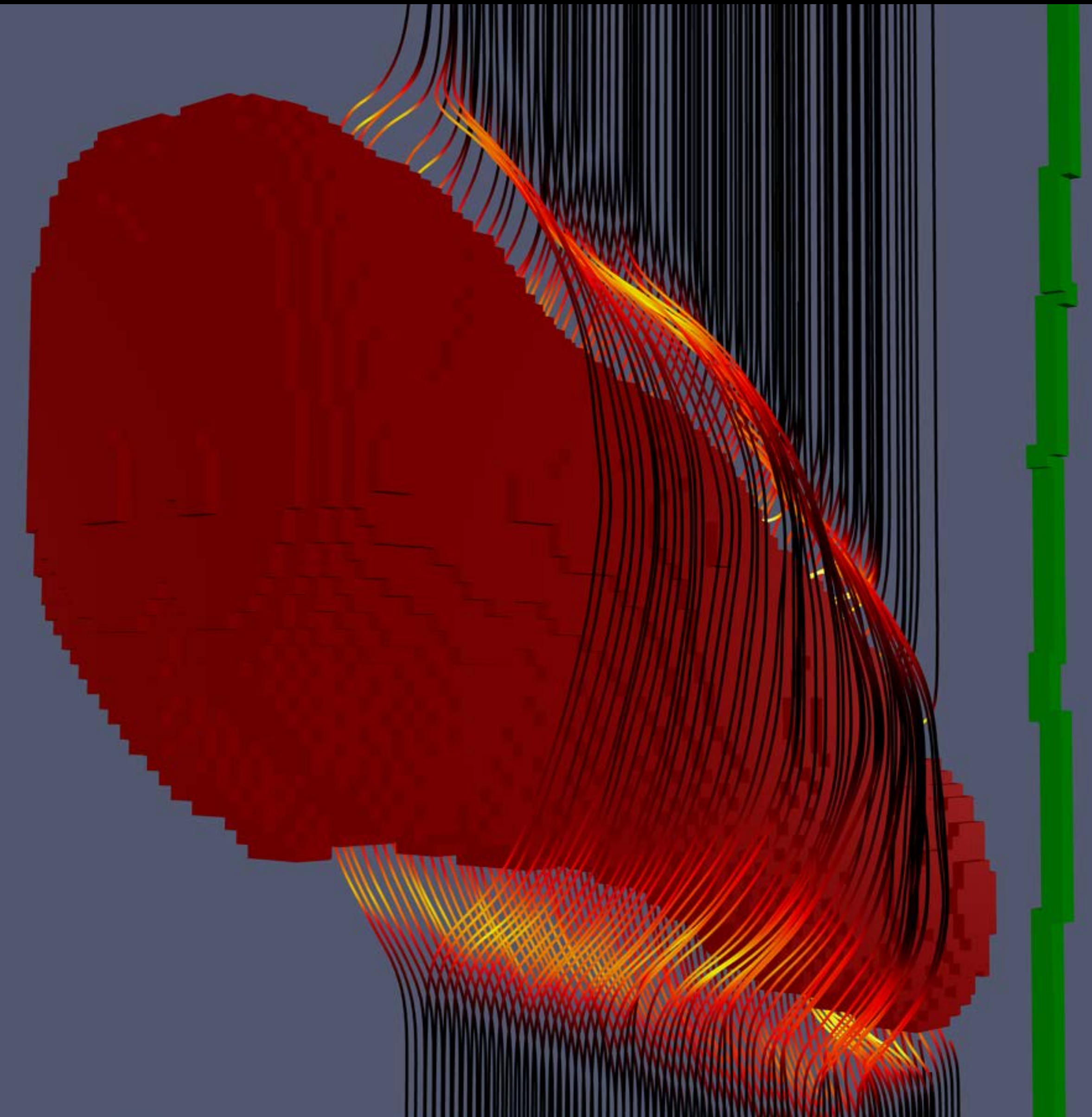


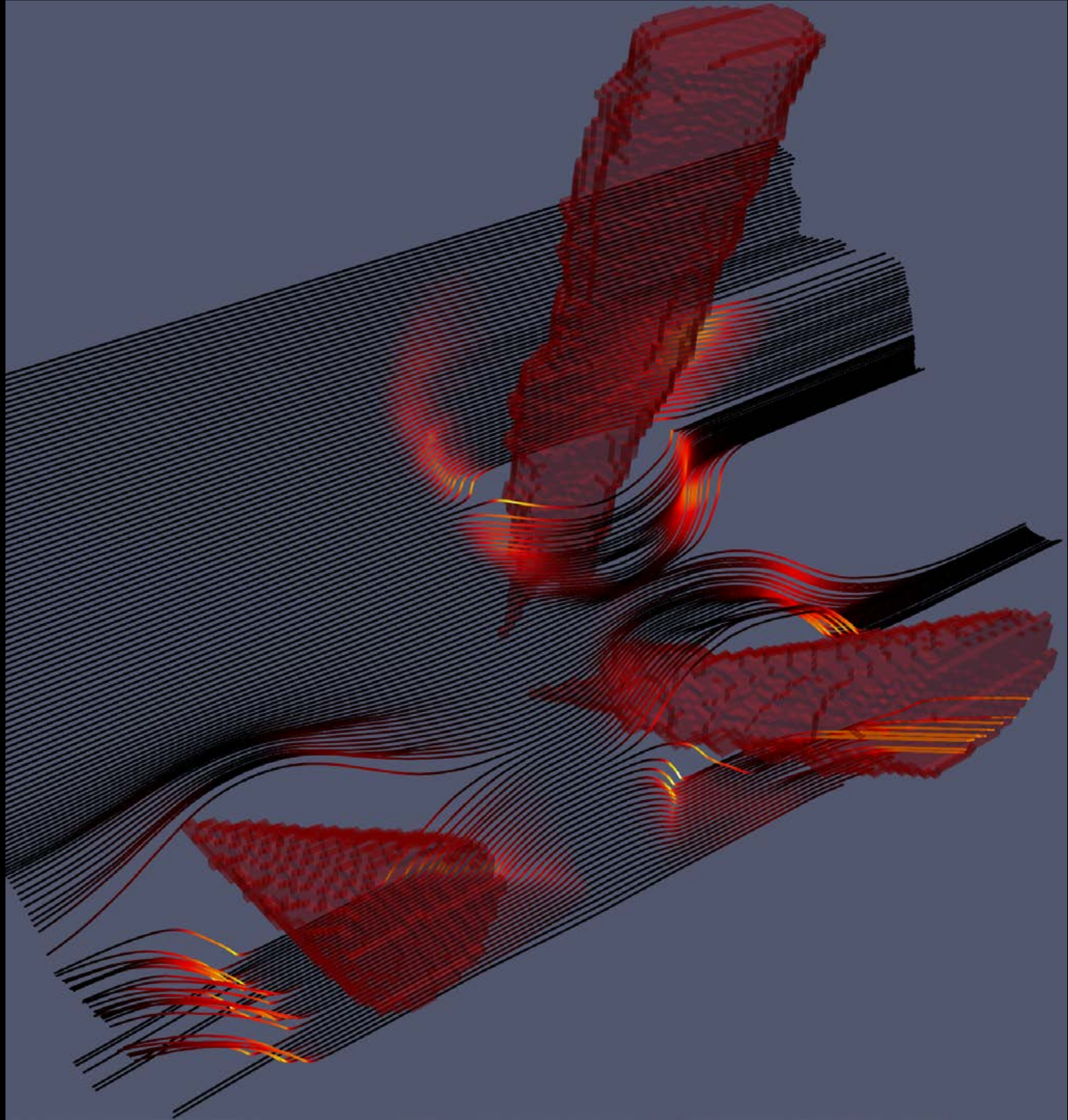
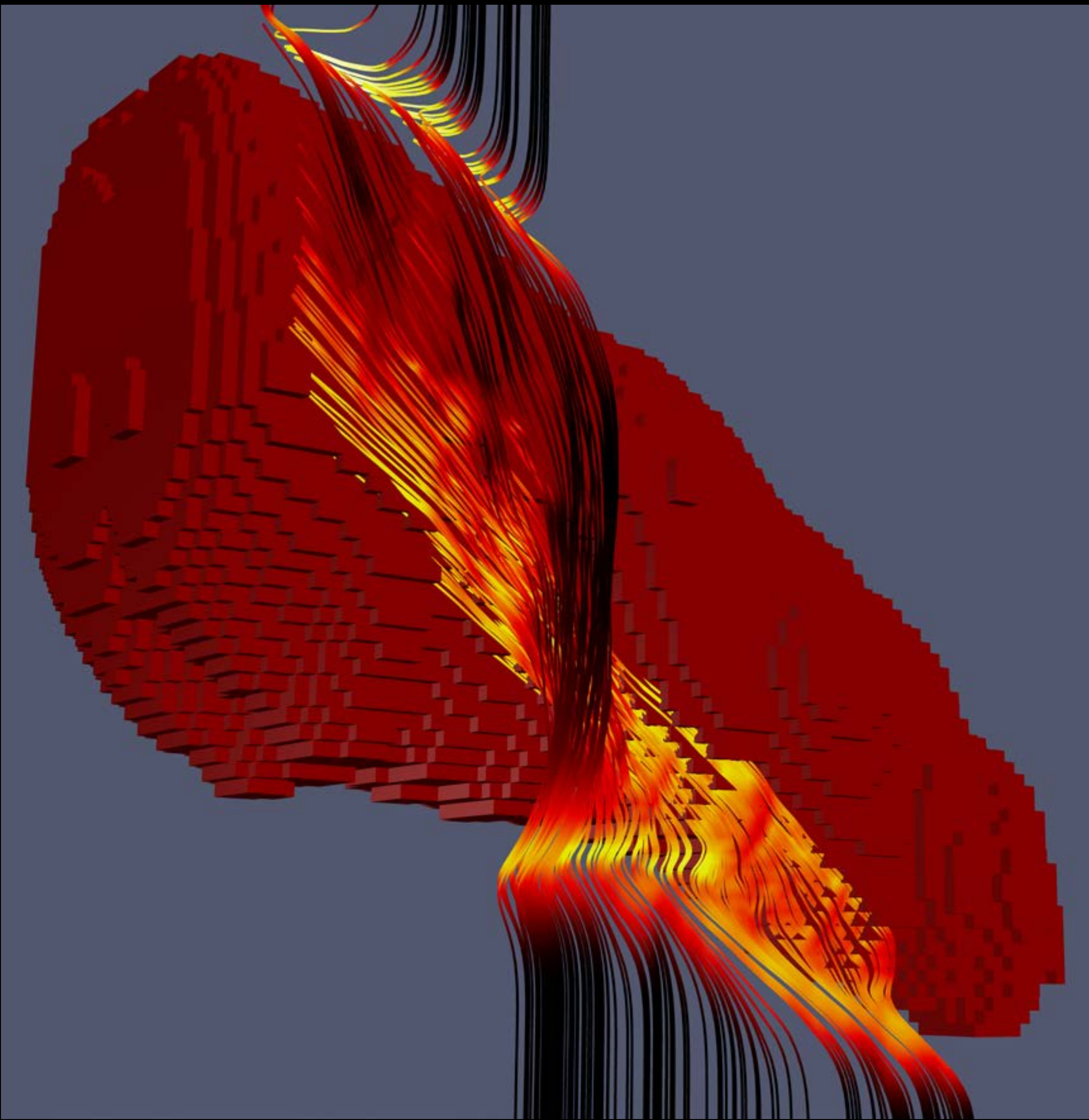




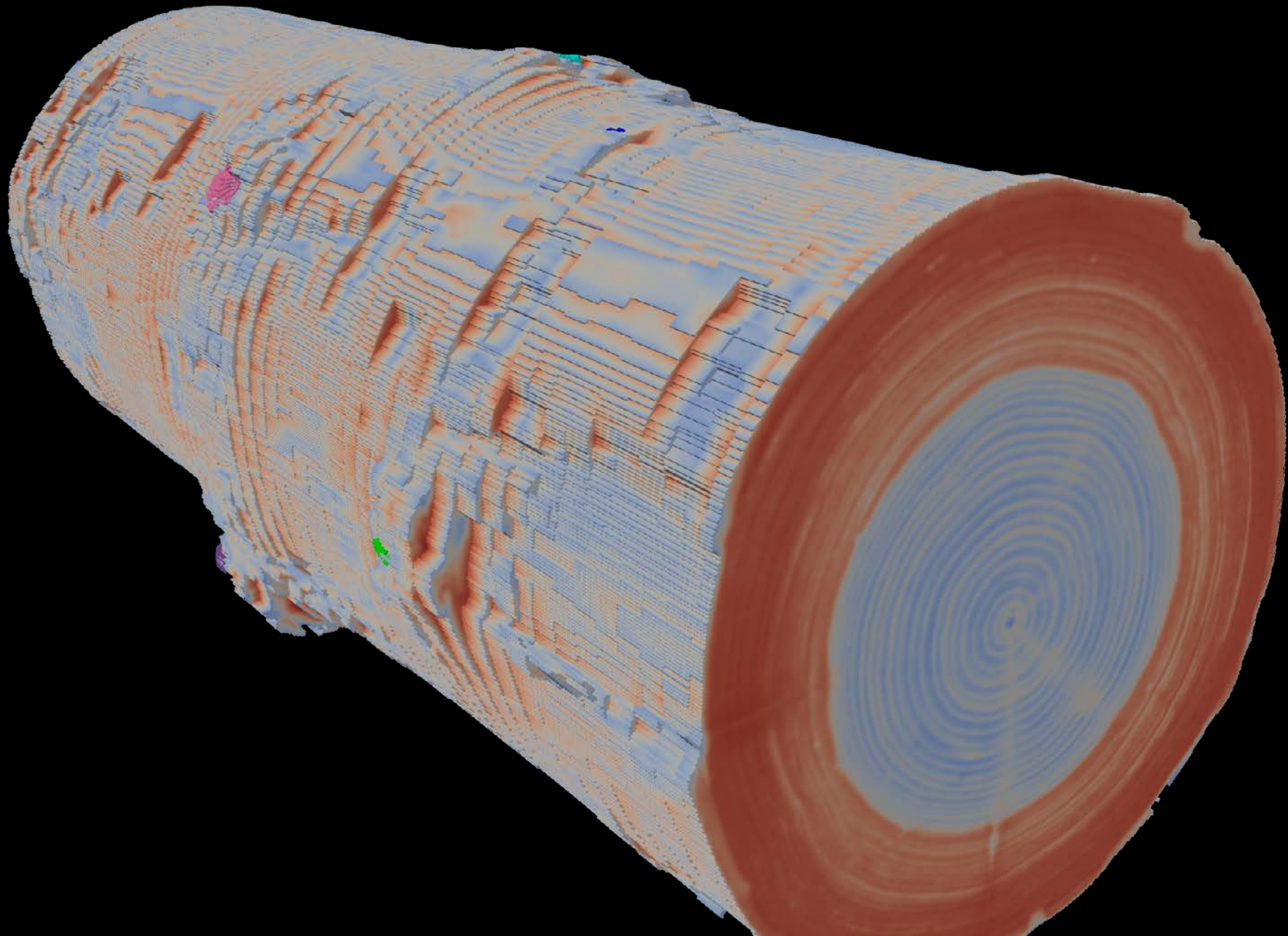




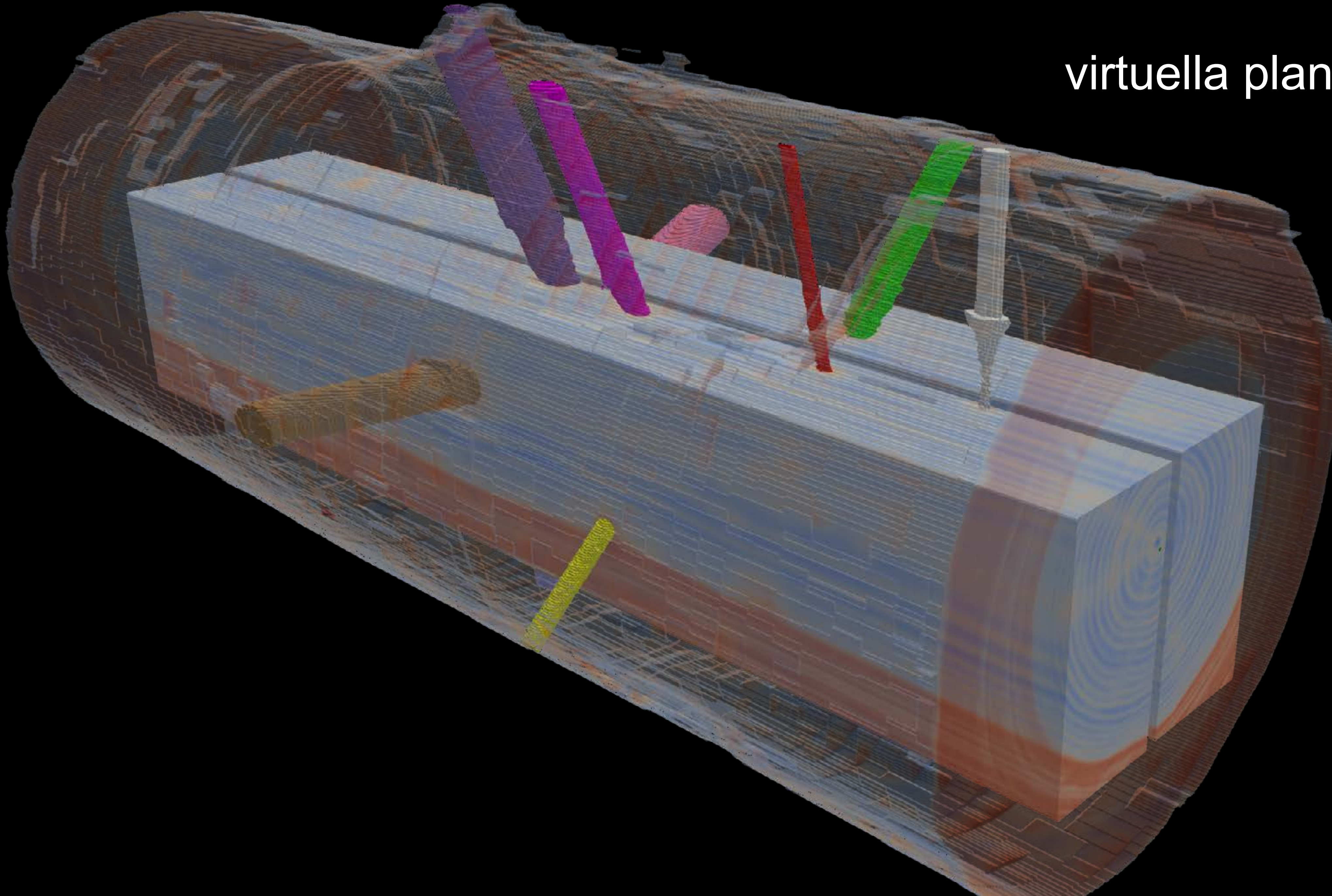




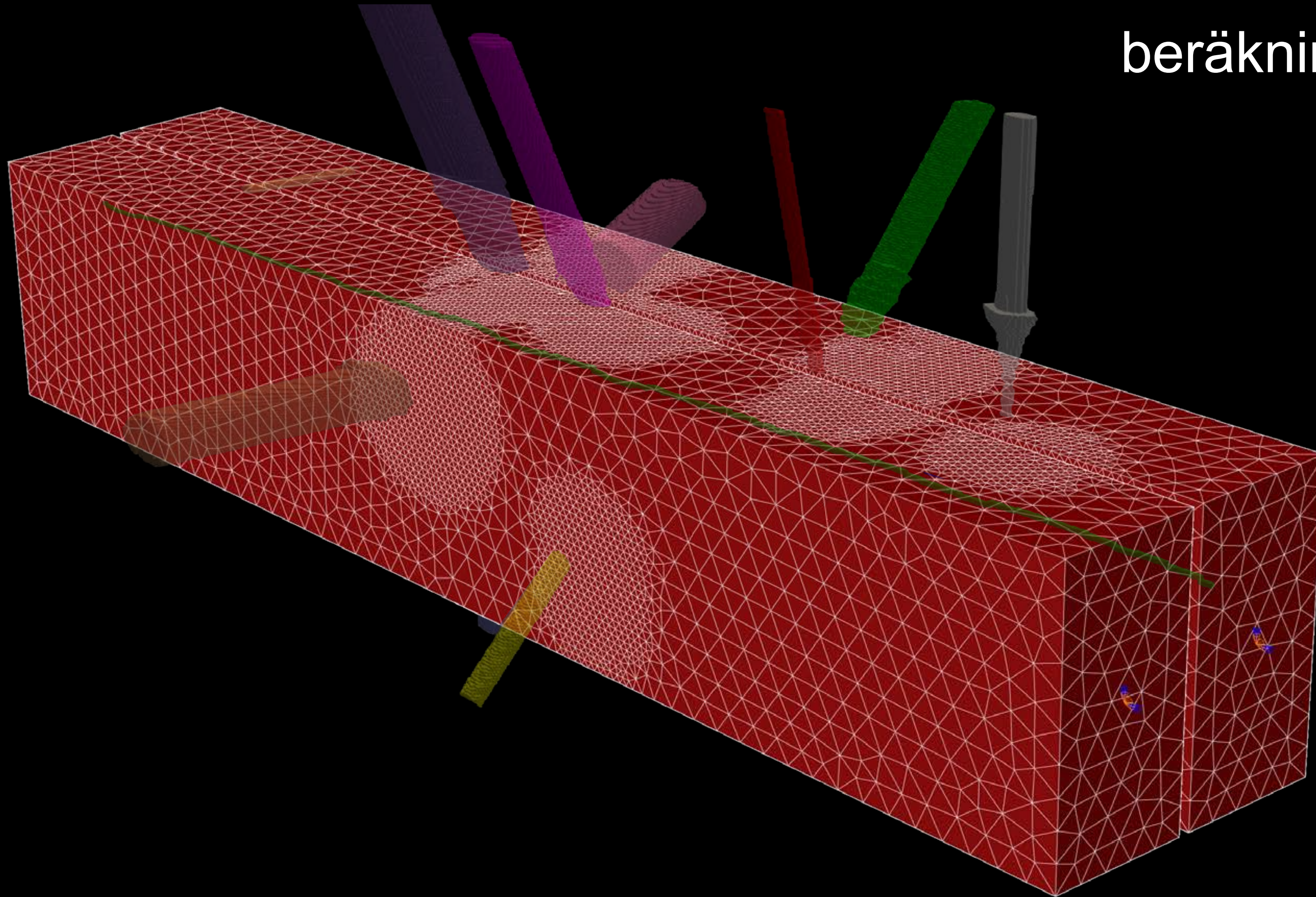


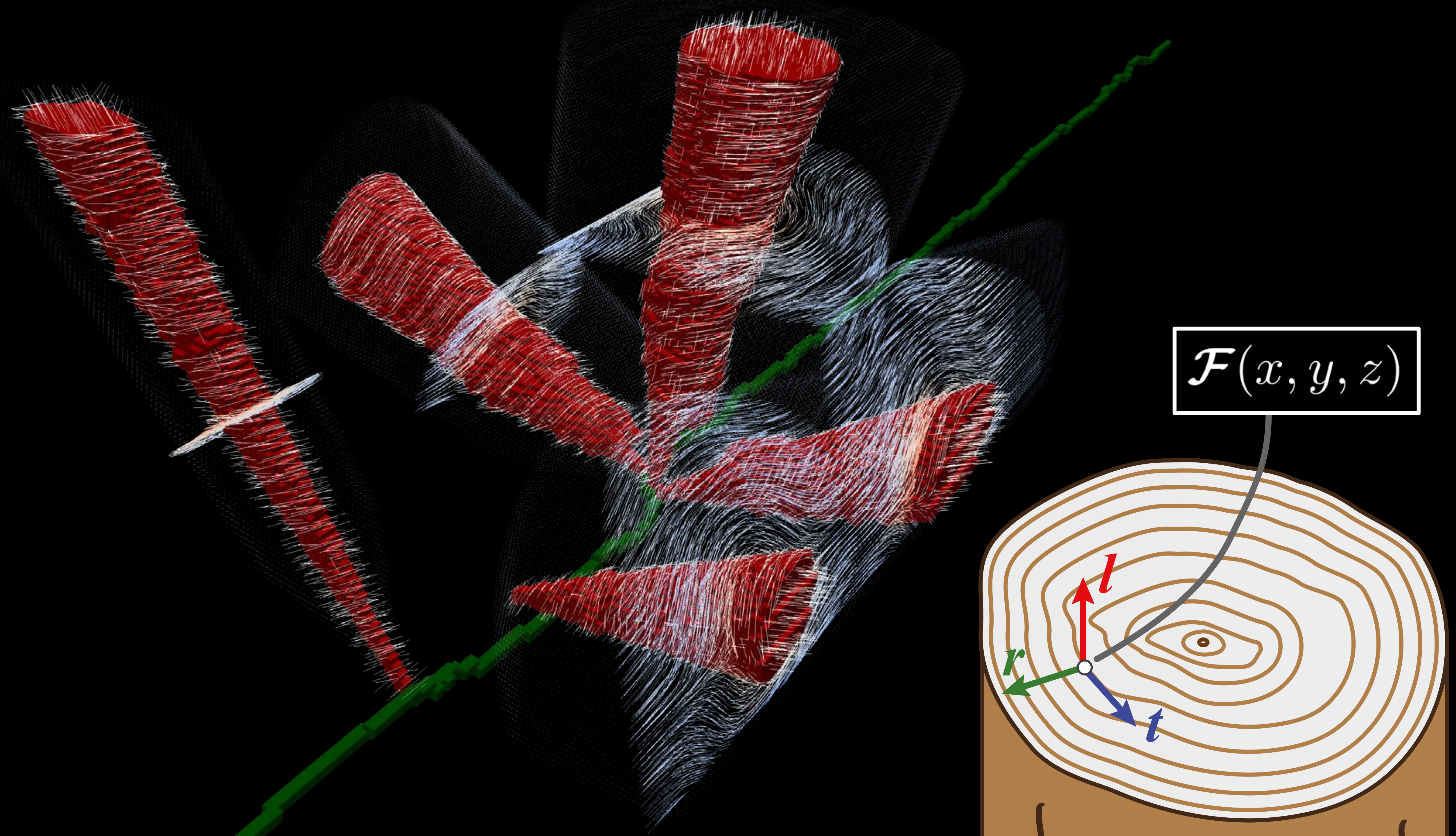


virtuella plankor

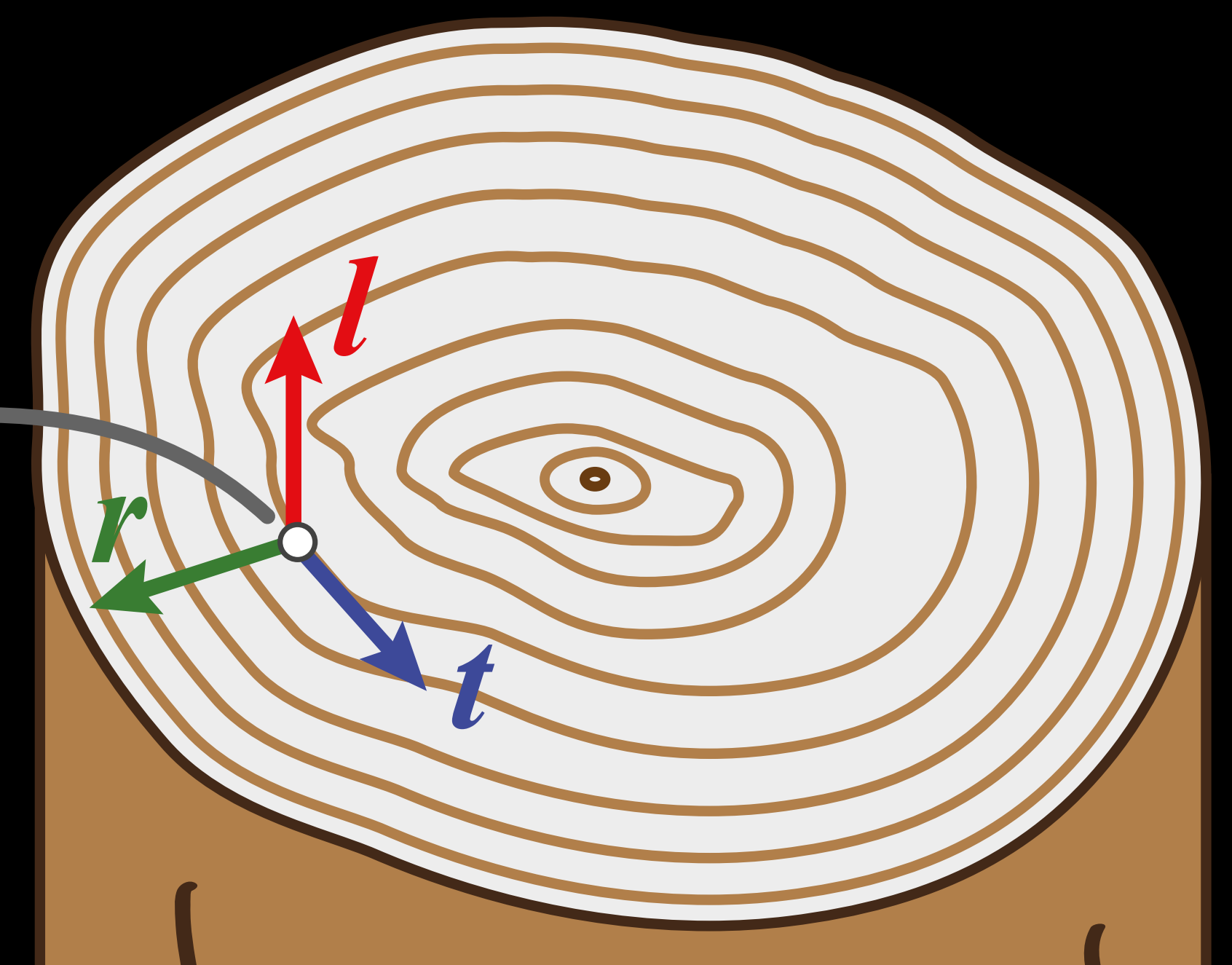


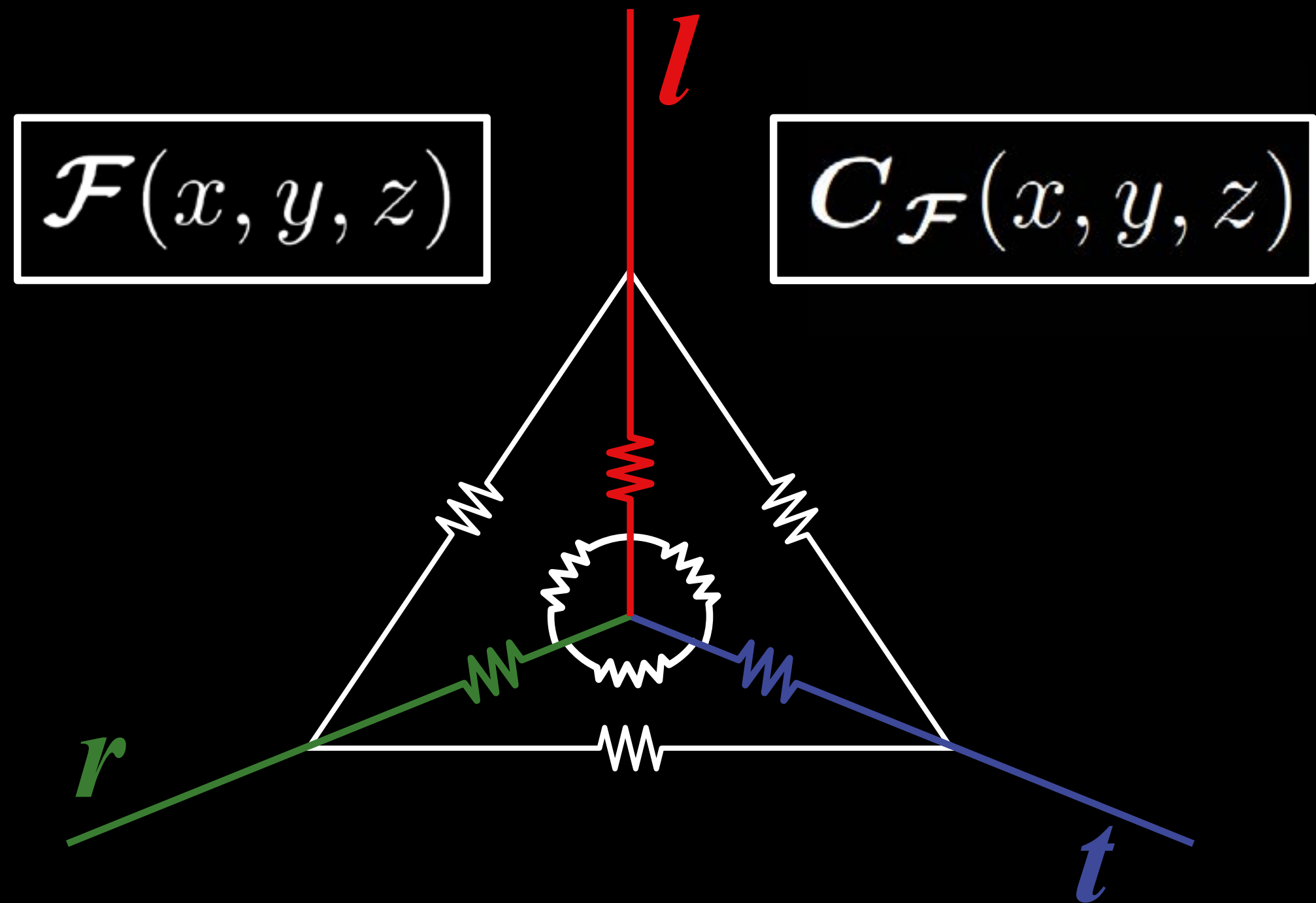
beräkningsnät



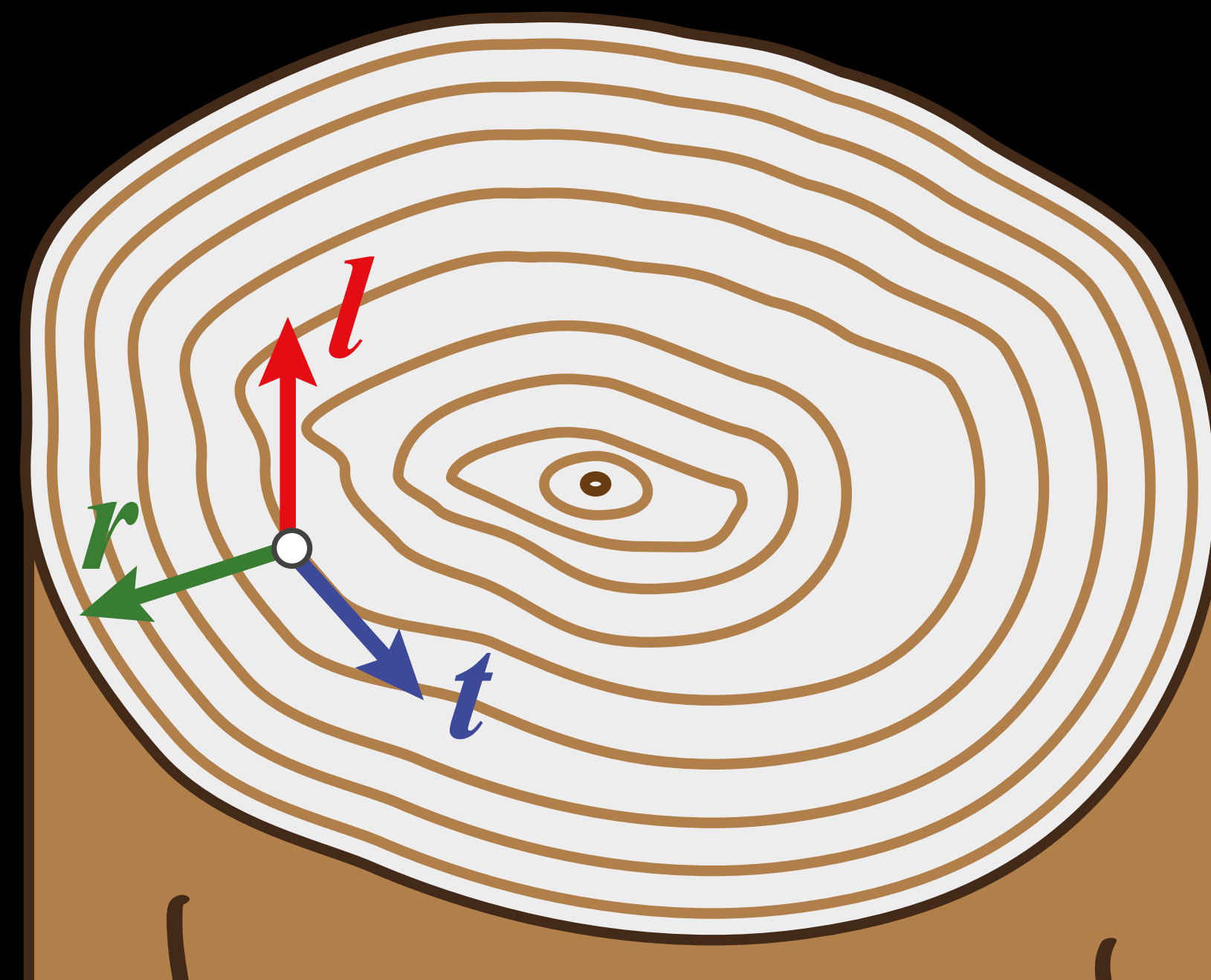


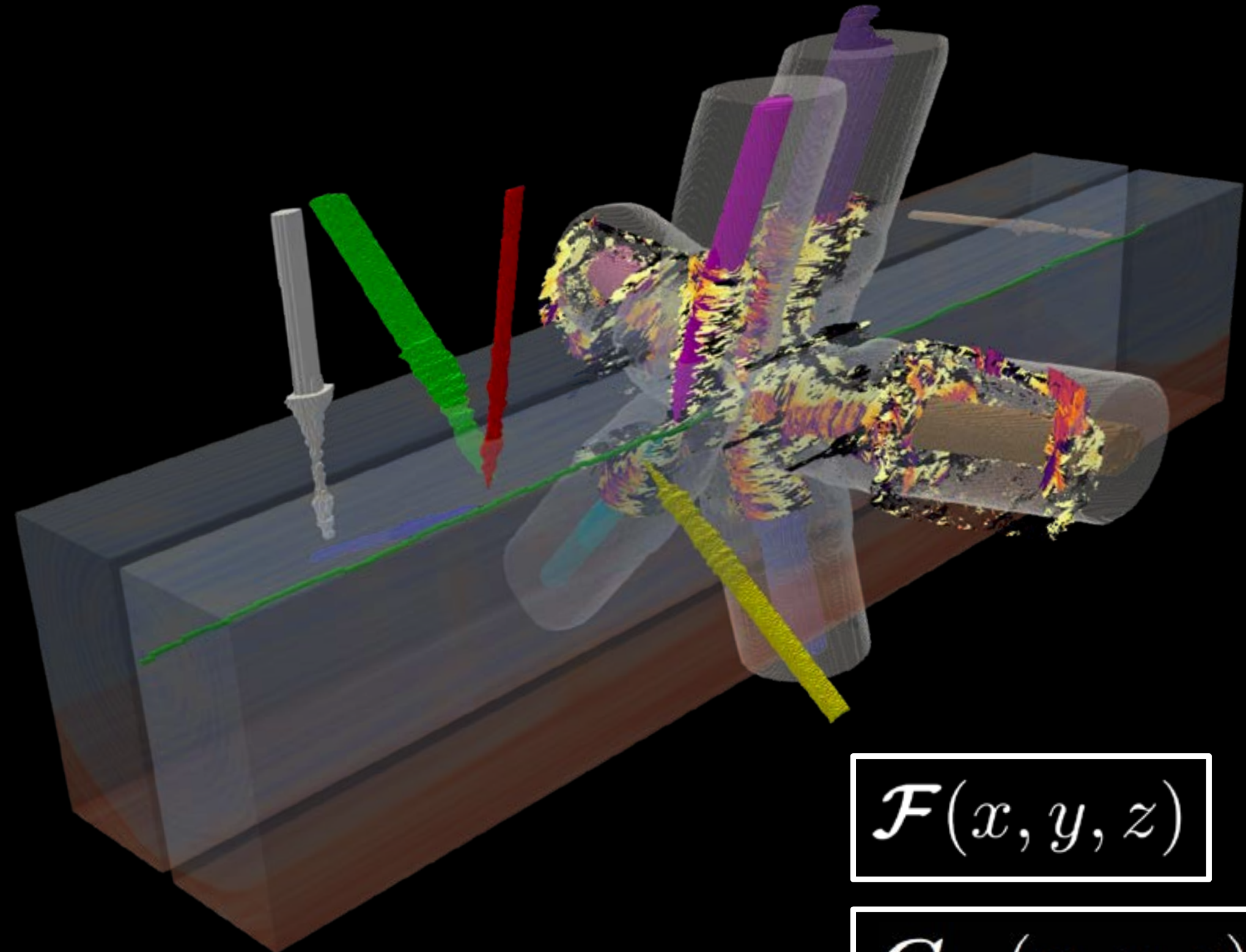
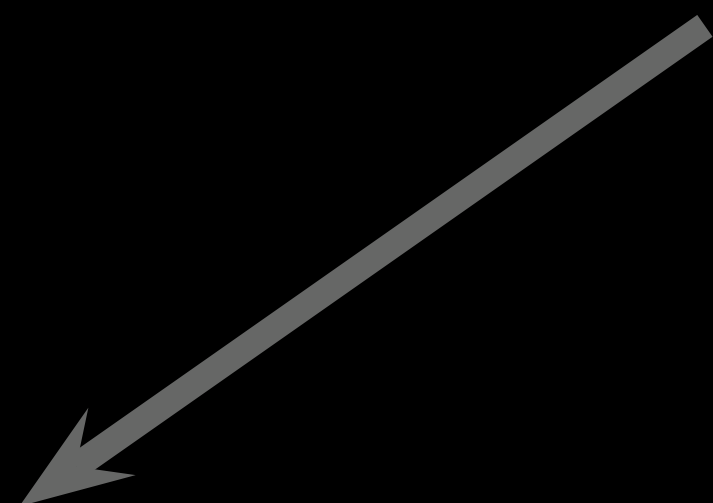
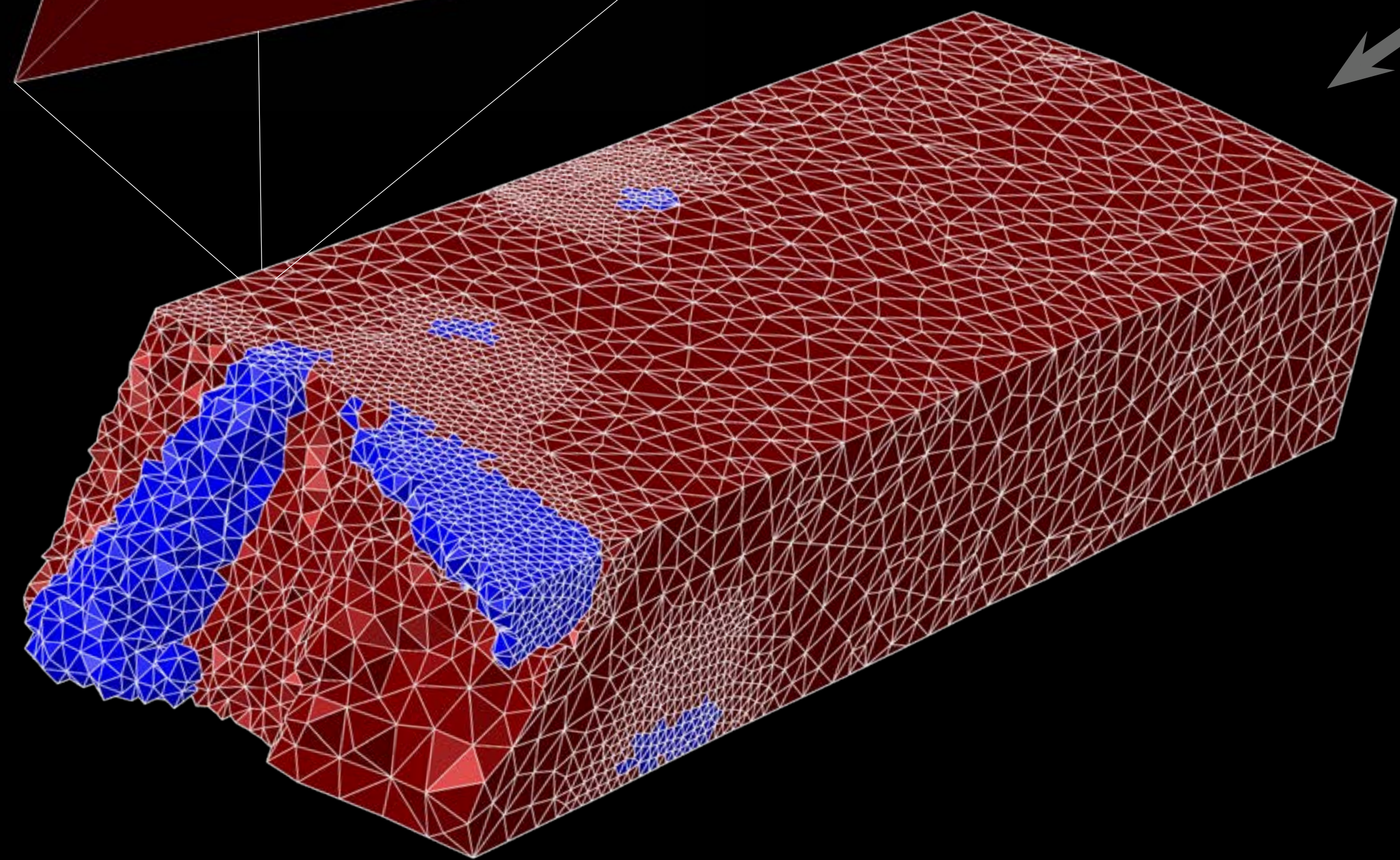
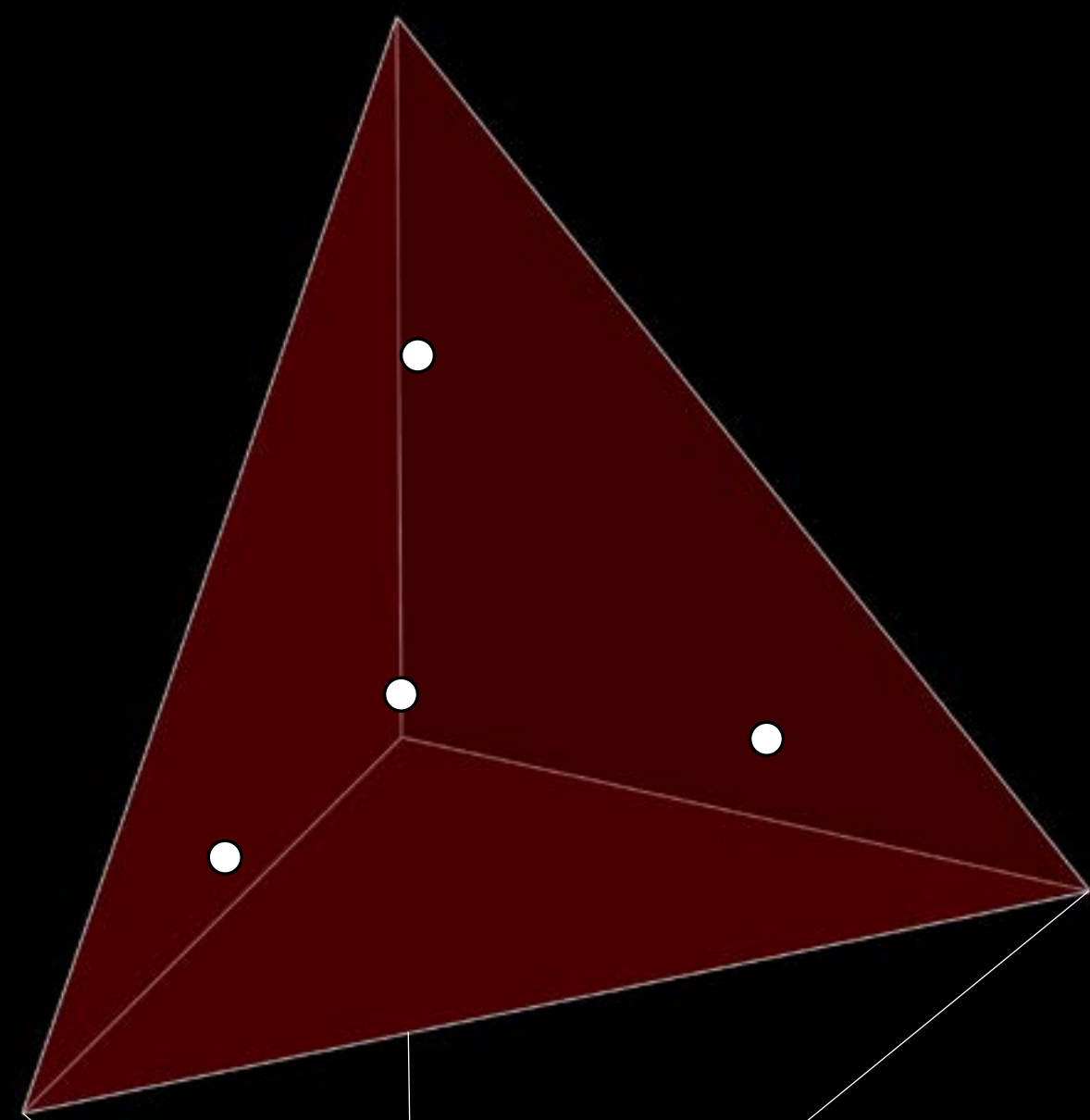
$$\mathcal{F}(x, y, z)$$

 $l$  $r$  $t$ 



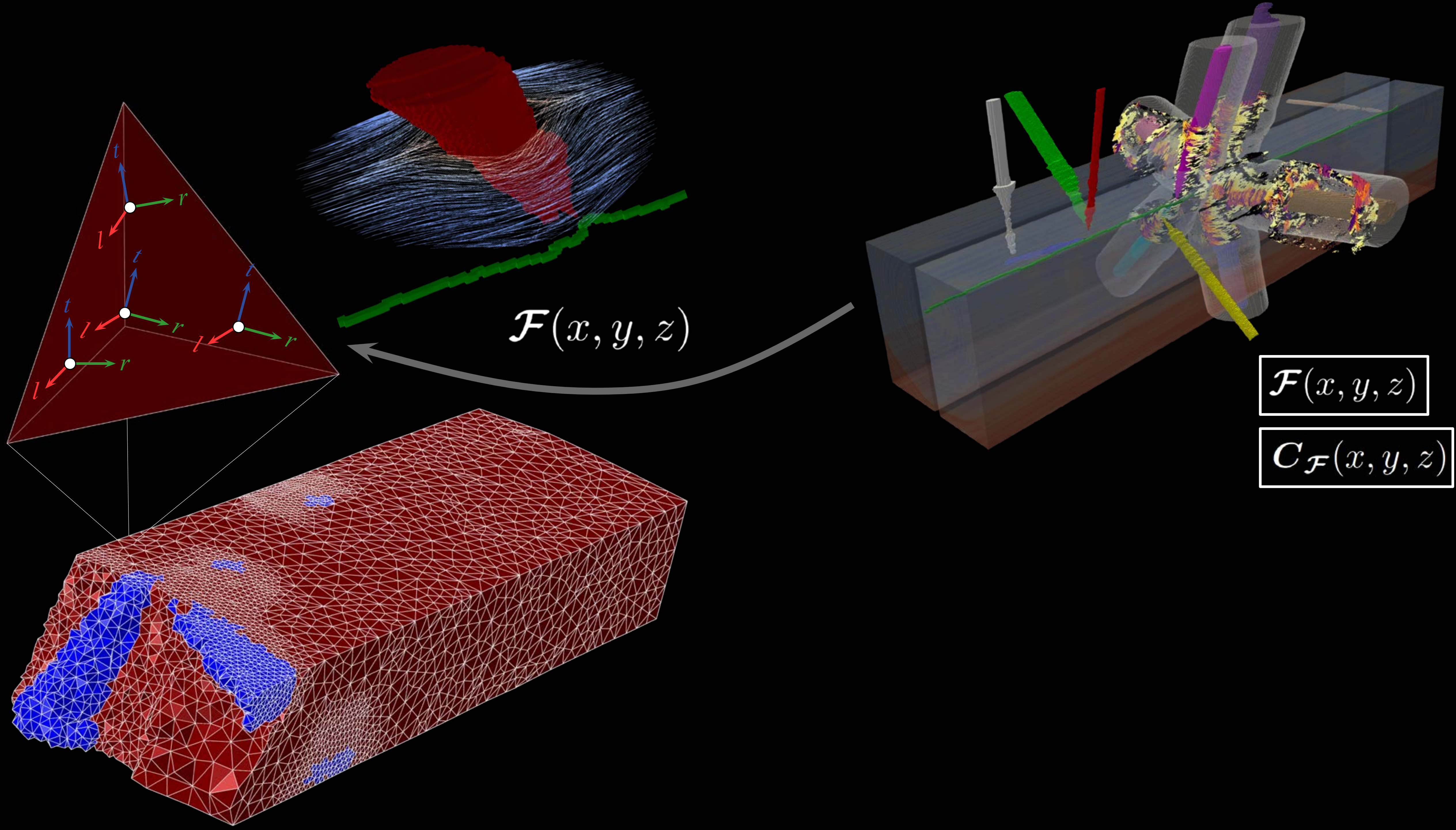
$$\begin{bmatrix}
 C_{rrrr} & C_{rrtt} & C_{rrll} & & & & \\
 & C_{tttt} & C_{ttll} & & & & \\
 & & C_{llll} & & & & \\
 & & & C_{rtrt} & & & \\
 \text{sym.} & & & & C_{rlrl} & & \\
 & & & & & & C_{tlll}
 \end{bmatrix}$$



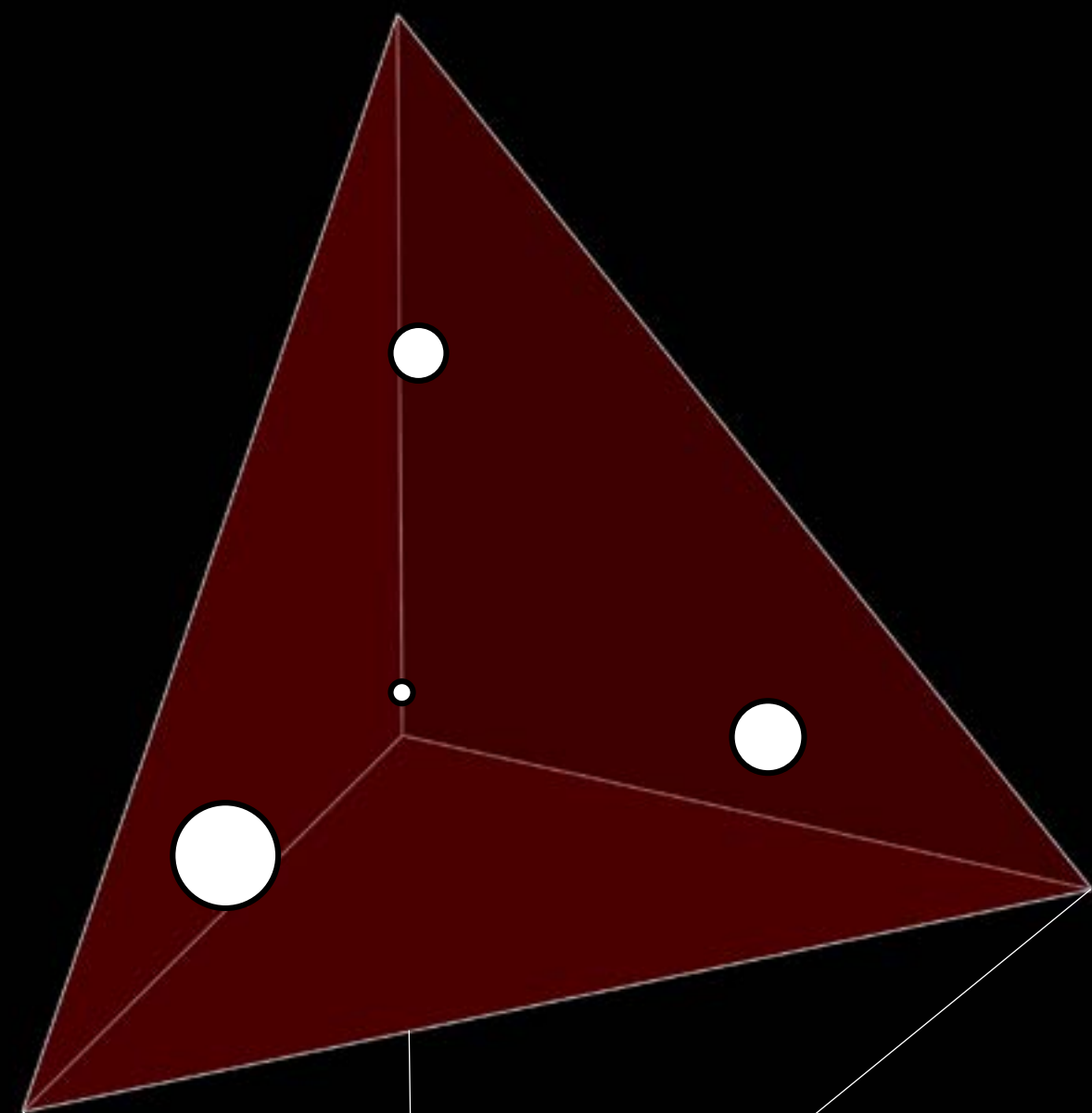


$$\mathcal{F}(x, y, z)$$

$$C_{\mathcal{F}}(x, y, z)$$

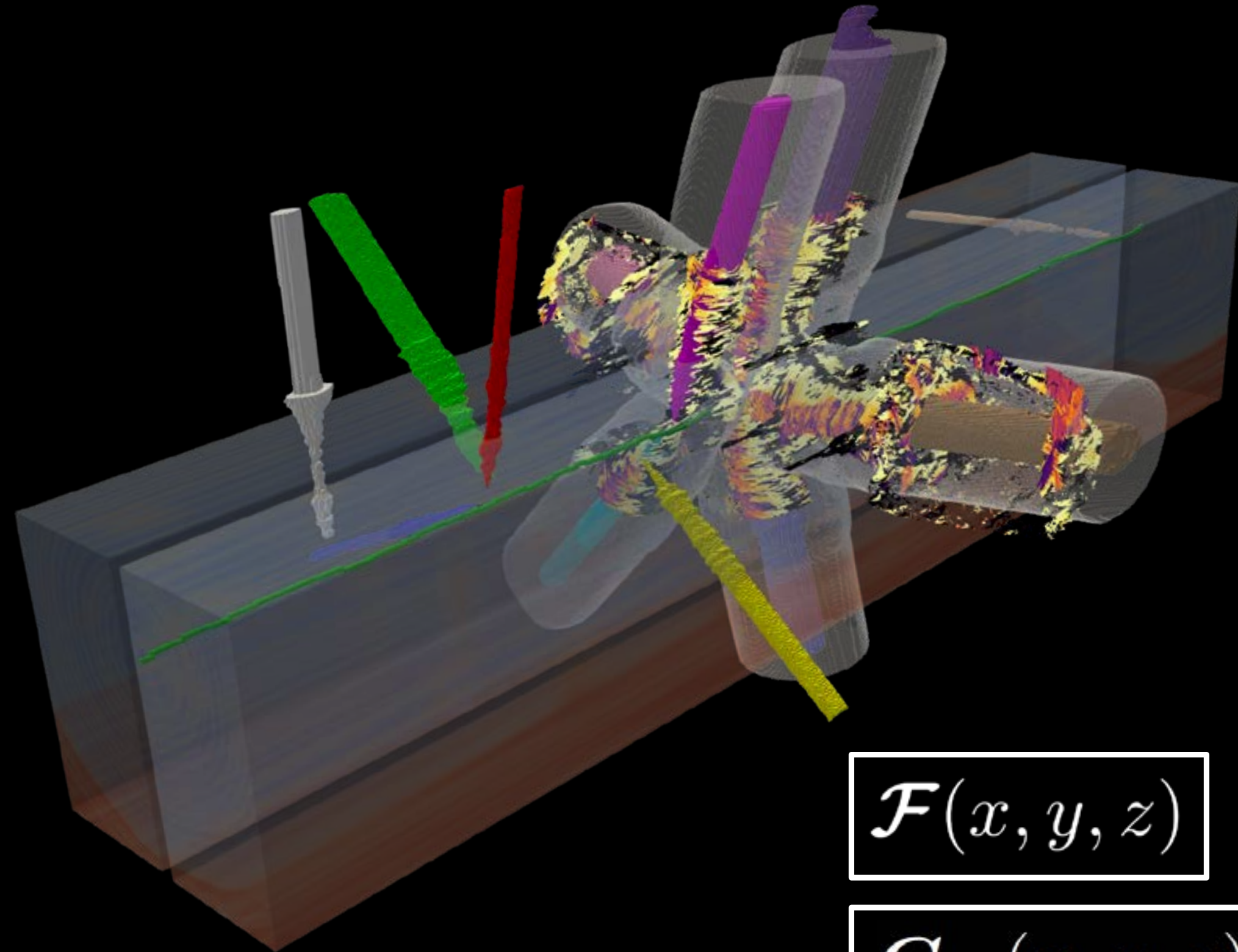






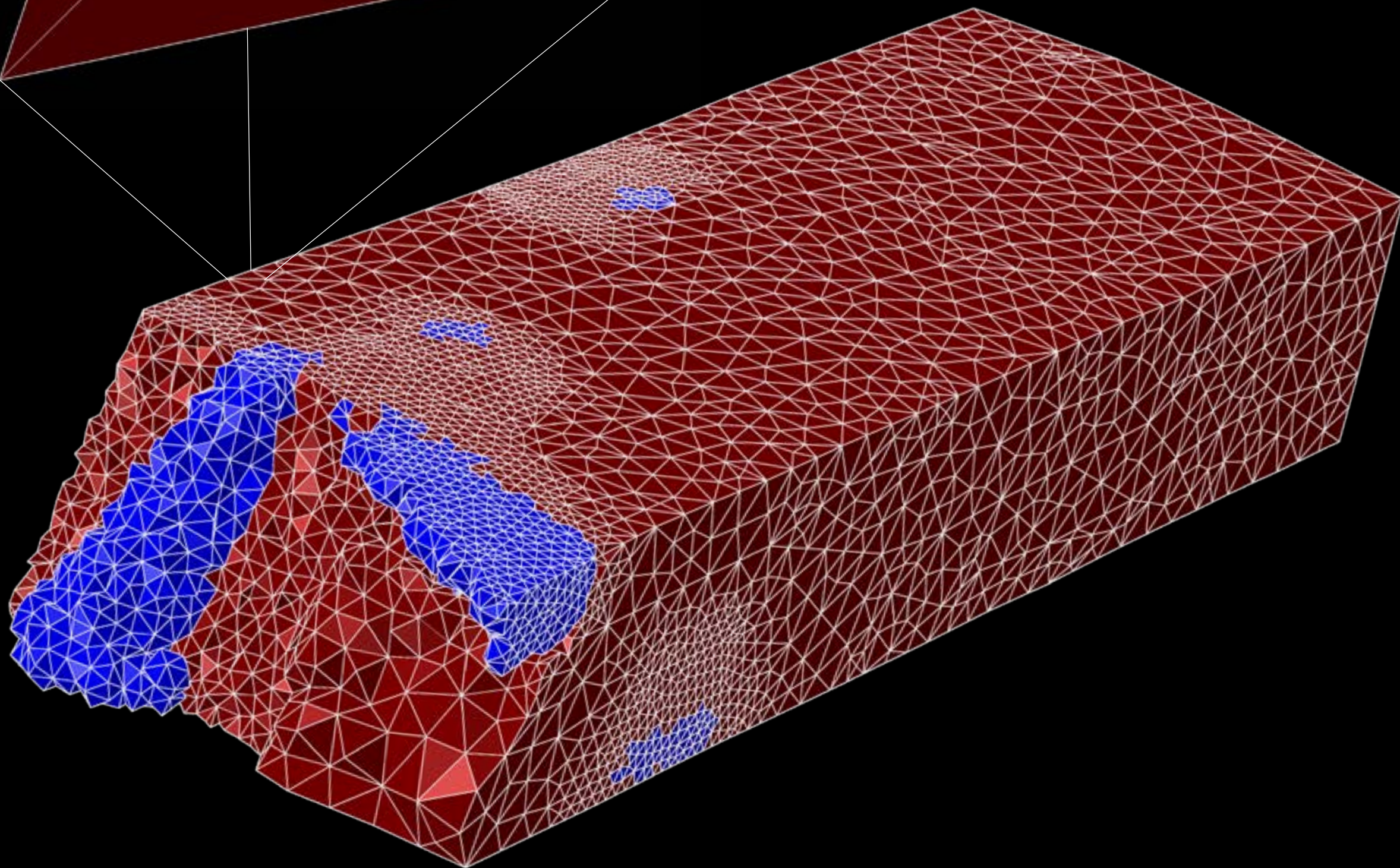
$$\begin{bmatrix} C_{rrrr} & C_{rrtt} & C_{rrll} \\ & C_{tttt} & C_{ttll} \\ & & C_{llll} \\ & & & C_{rtrt} \\ \text{sym.} & & & & C_{rlrl} \\ & & & & & C_{tltl} \end{bmatrix}$$

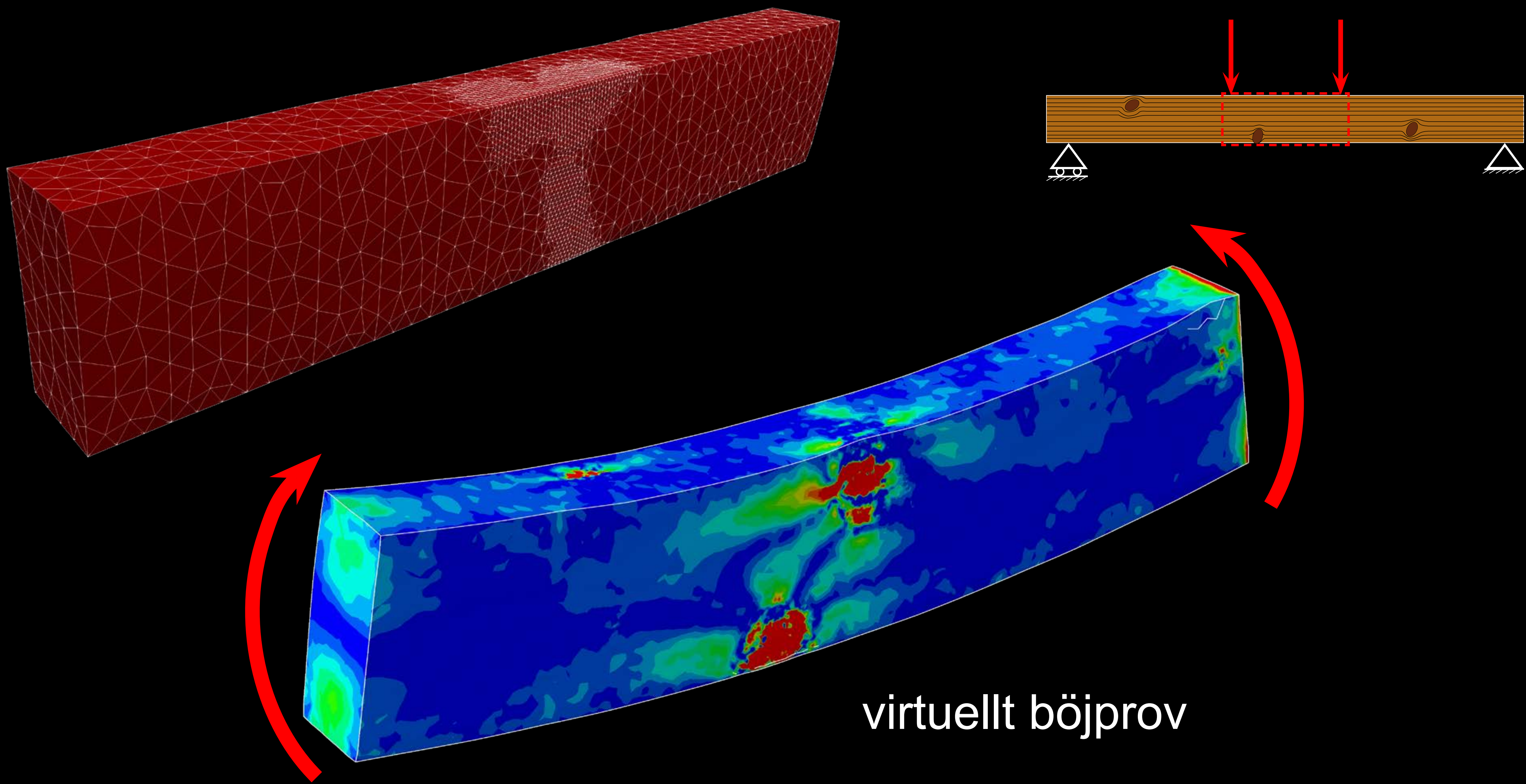
$$C_{\mathcal{F}}(x, y, z)$$



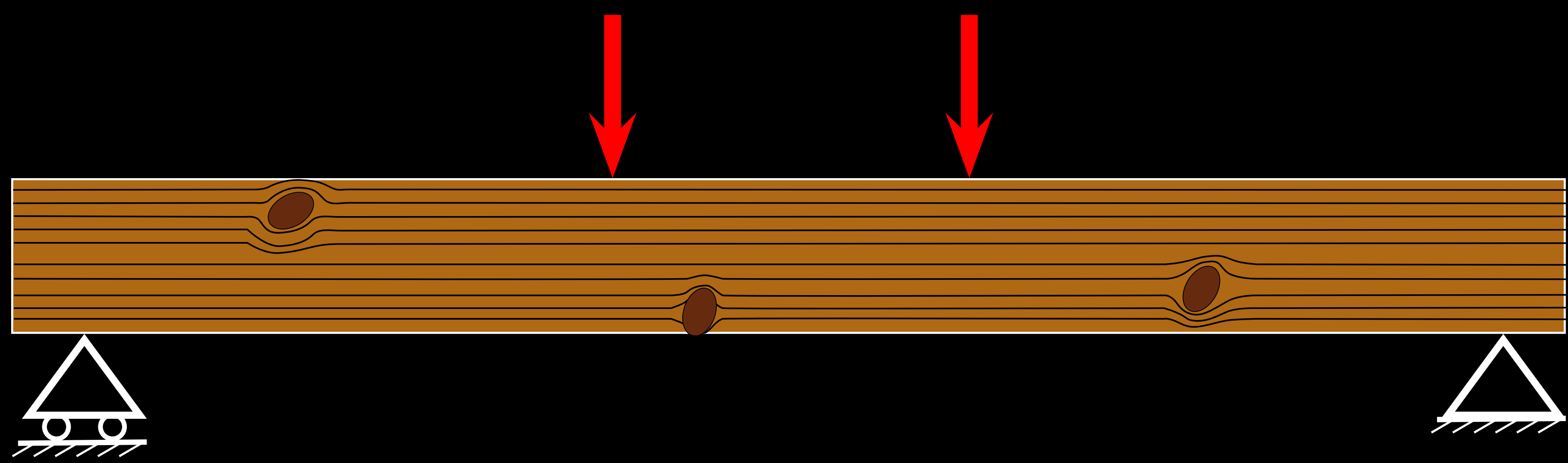
$$\mathcal{F}(x, y, z)$$

$$C_{\mathcal{F}}(x, y, z)$$

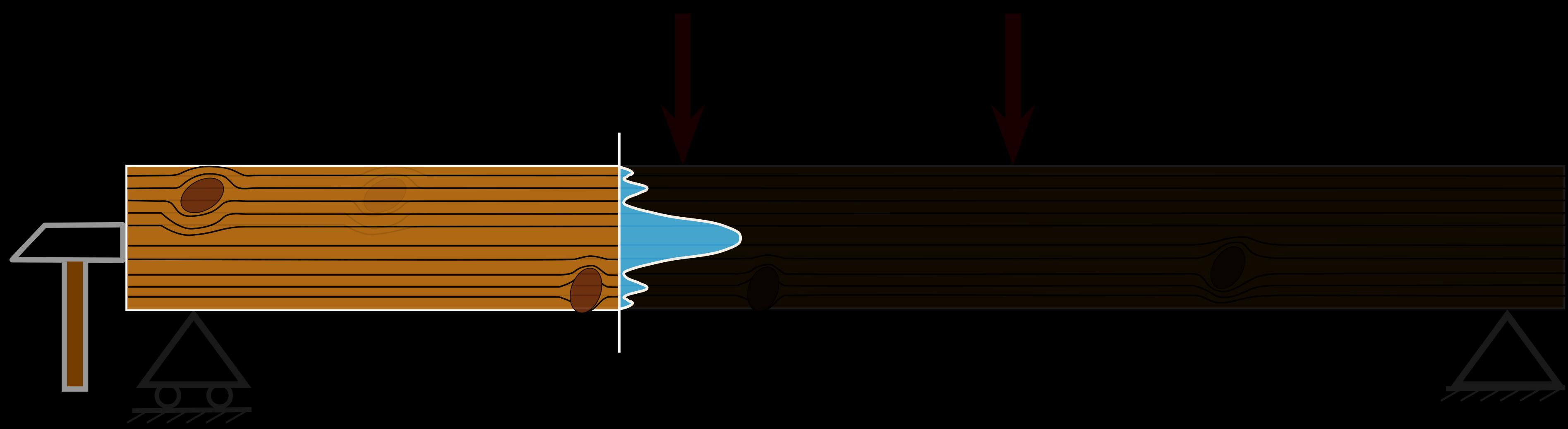




virtuellt böjprov

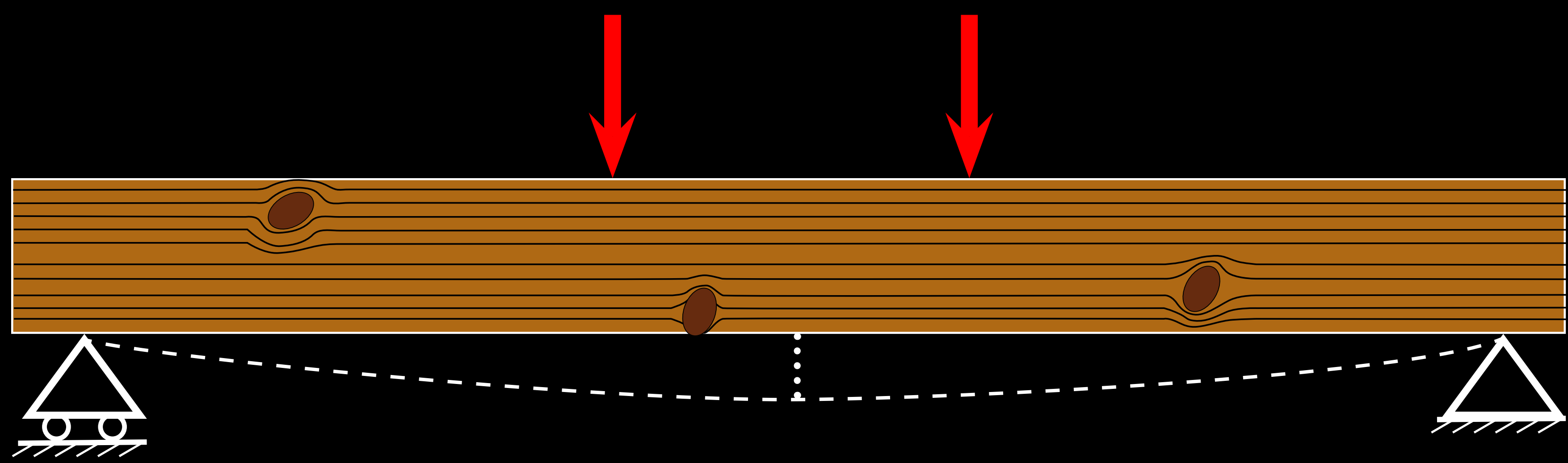


Egenfrekvens



Styvhet

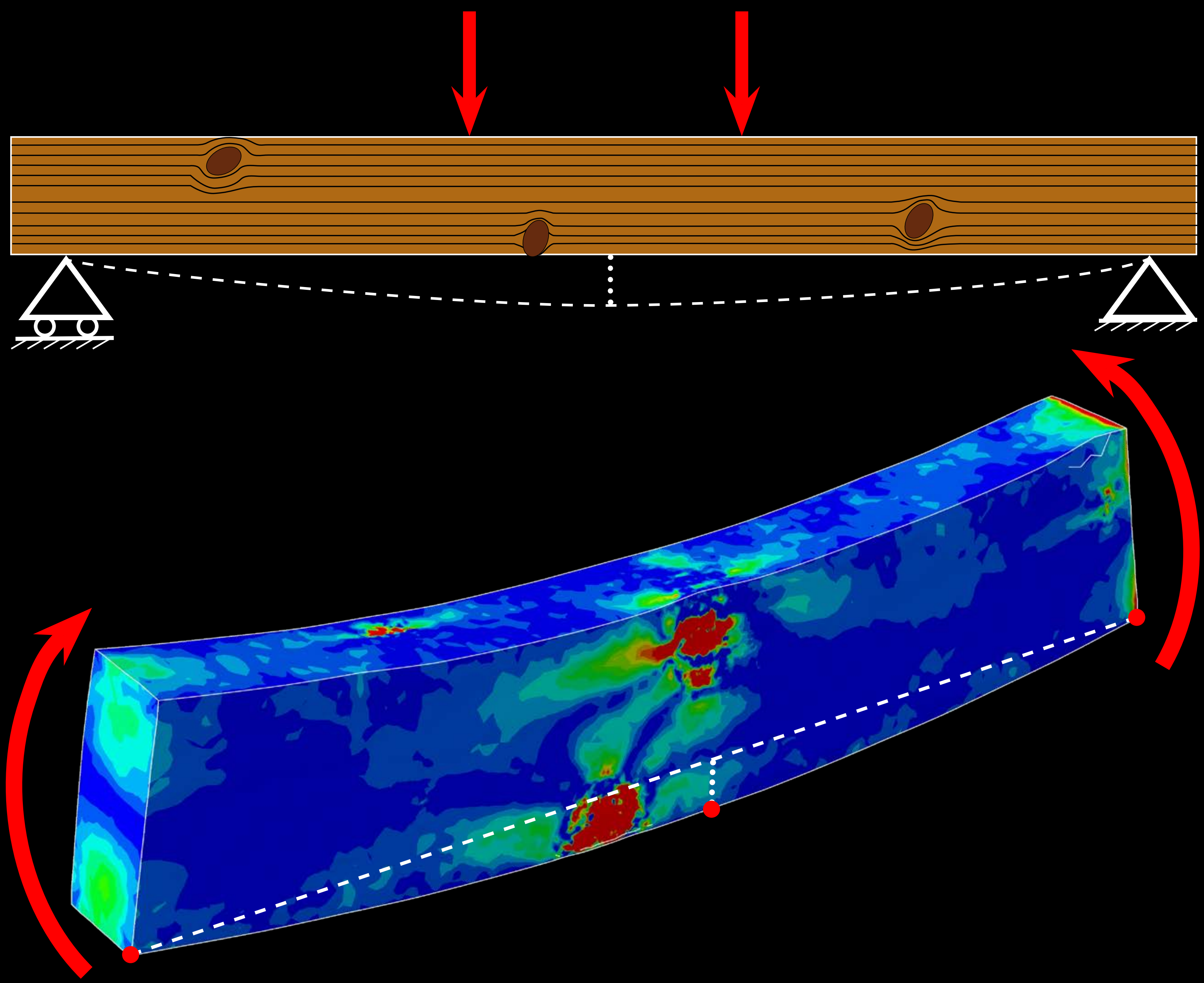


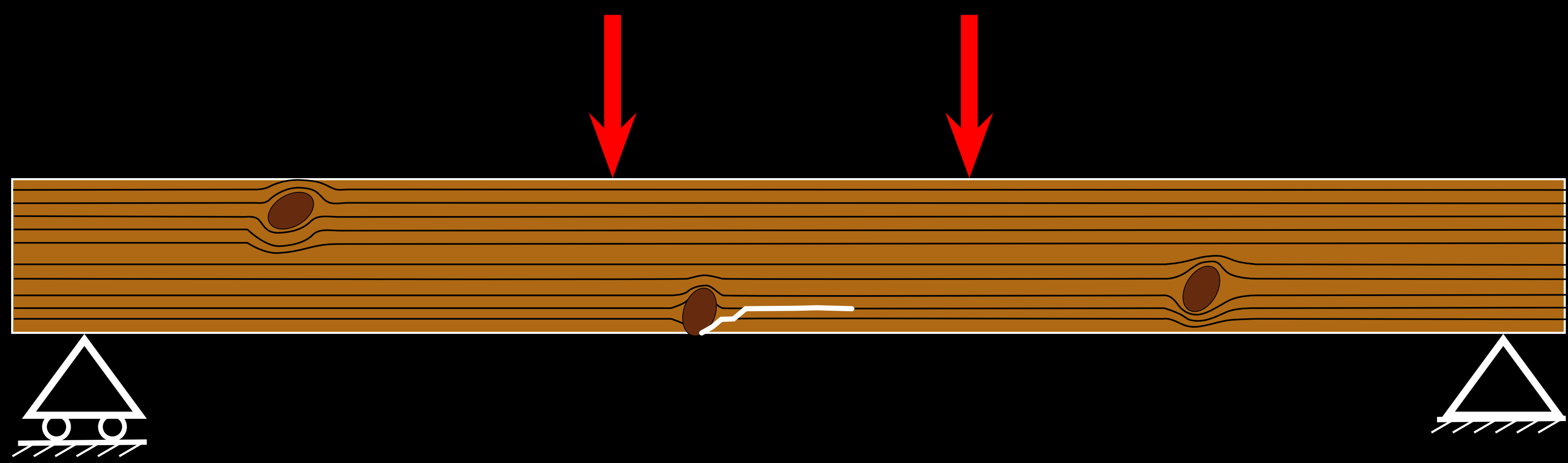


Styvhet



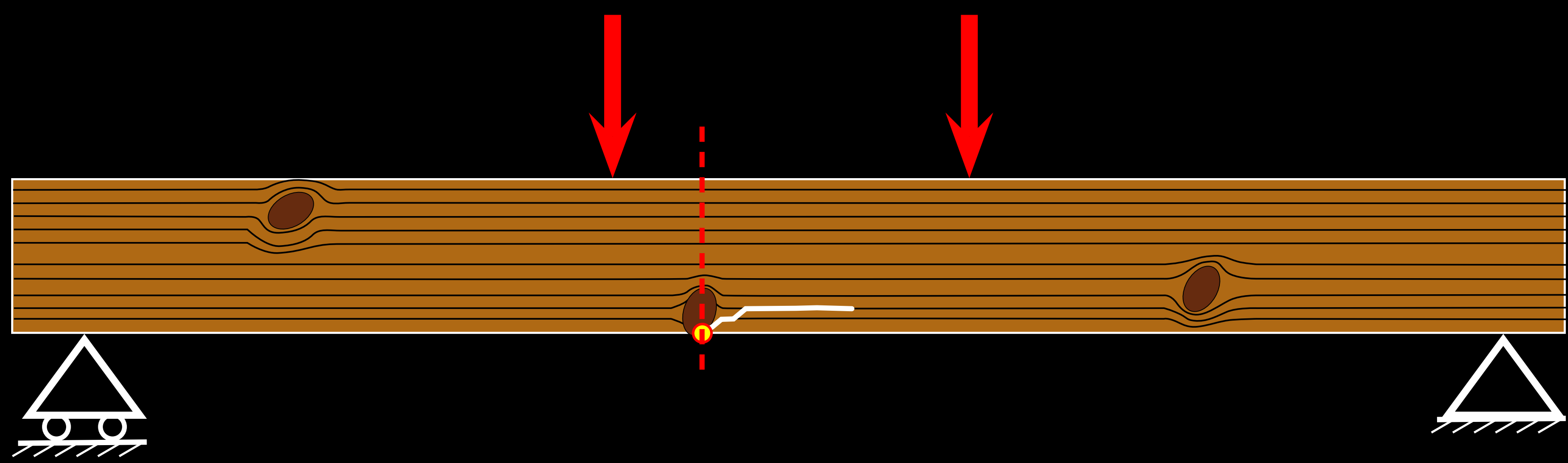
Styvhet





Styvhet  
Styrka





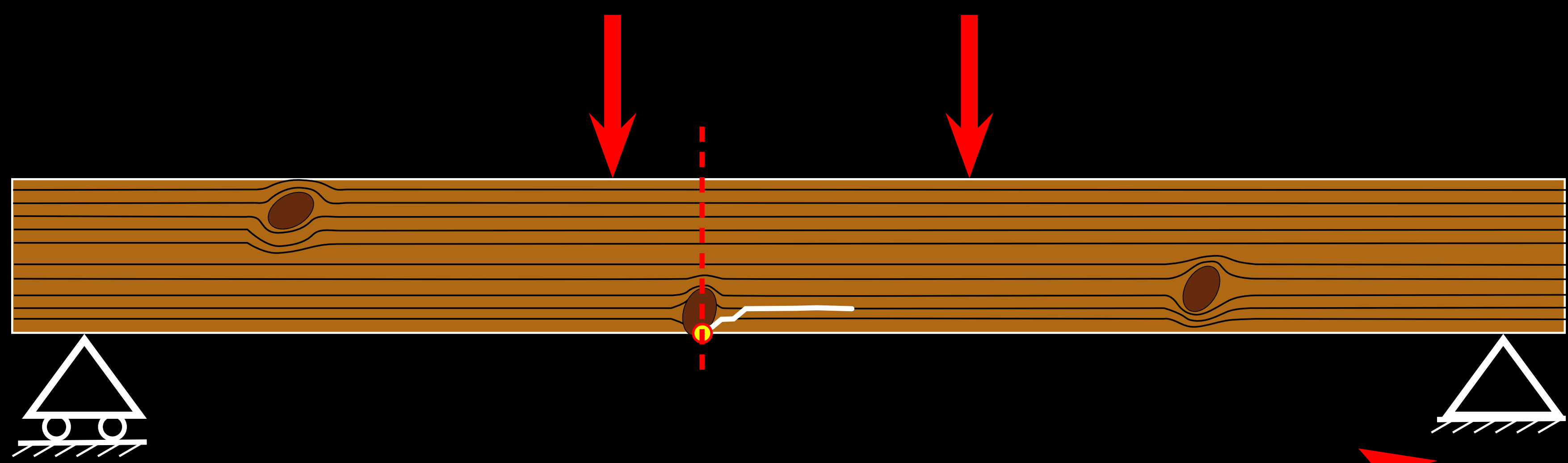
Styvhet

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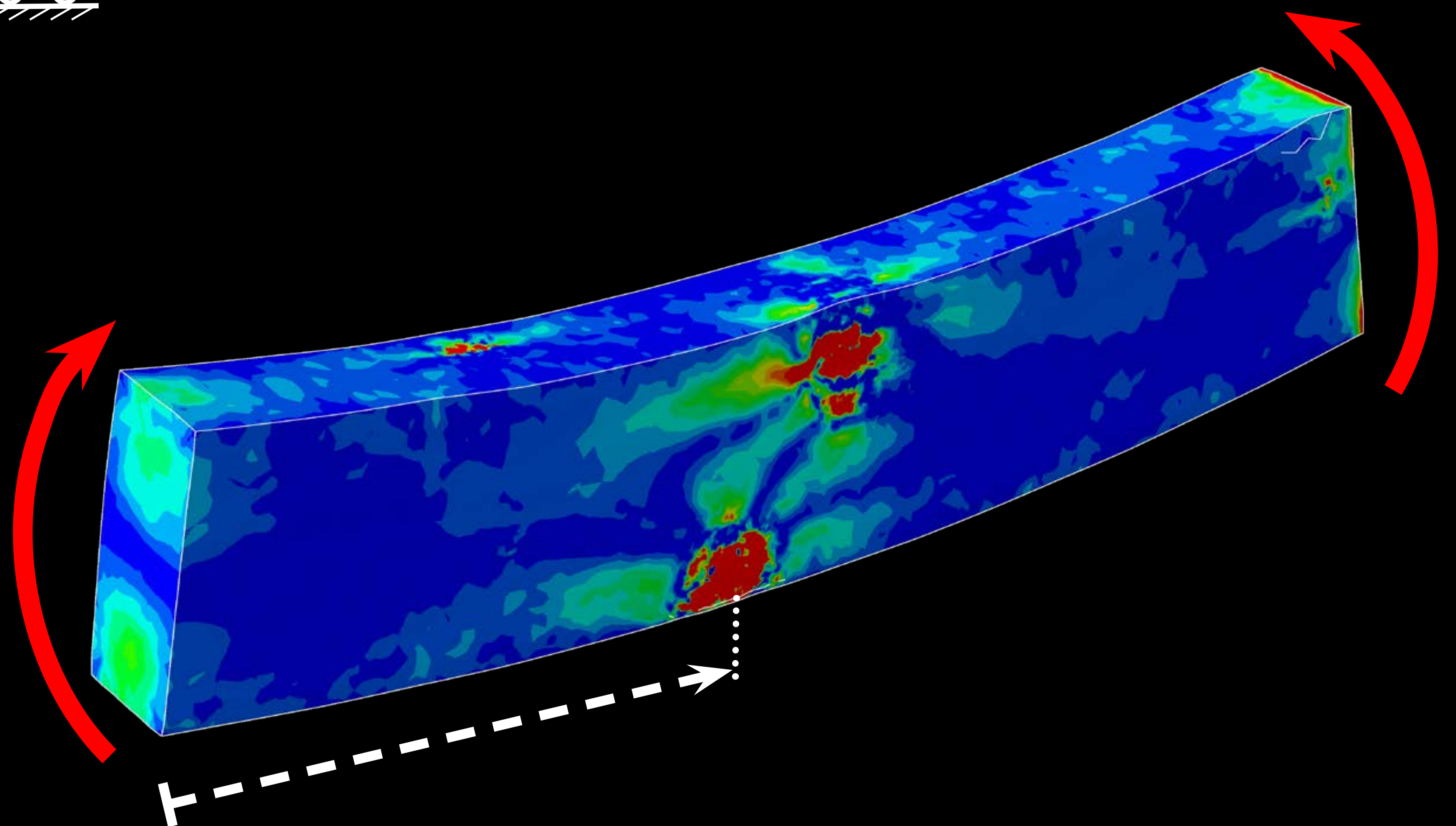
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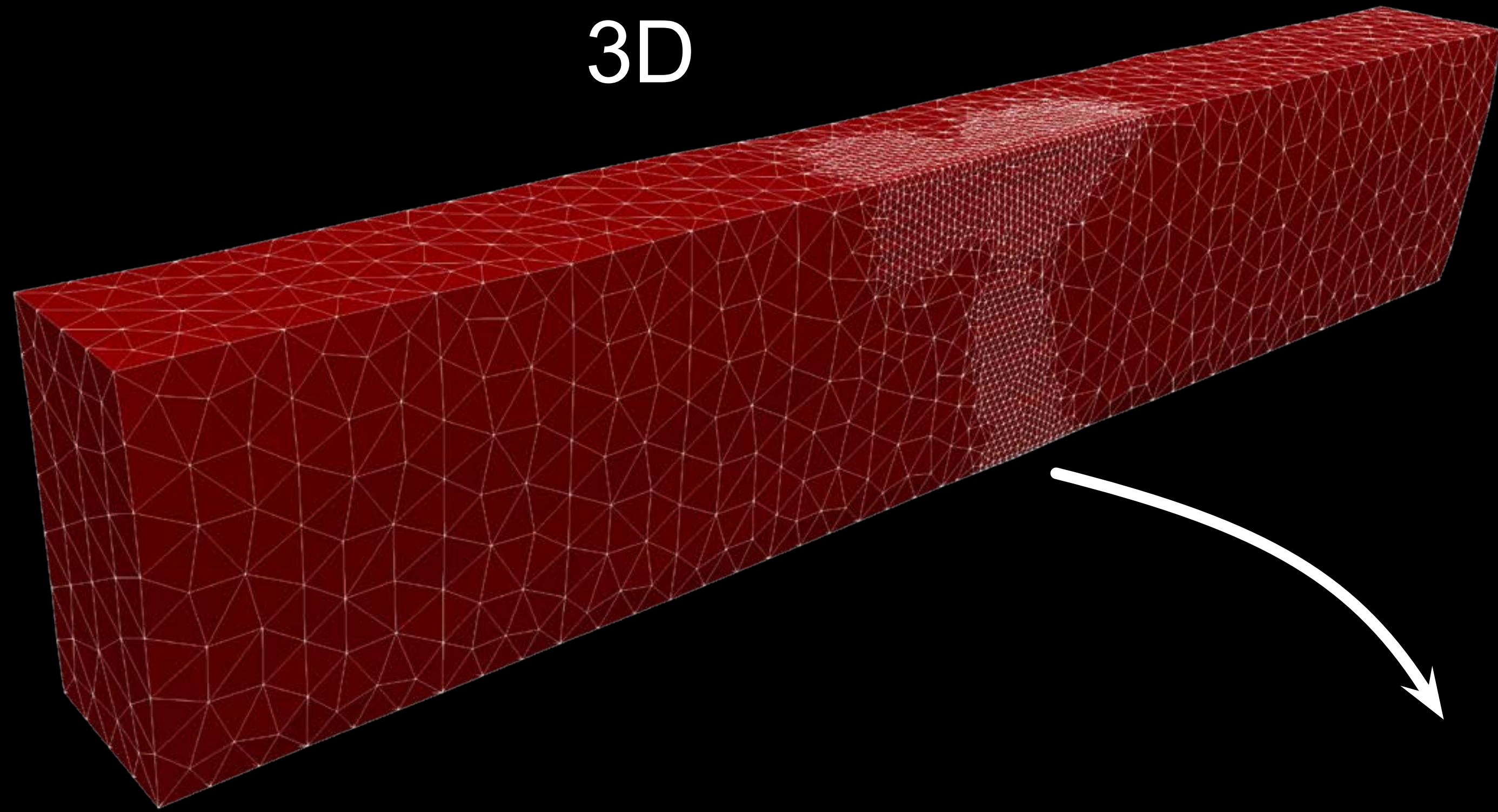




Styvhet  
Styrka  
Initialspricka



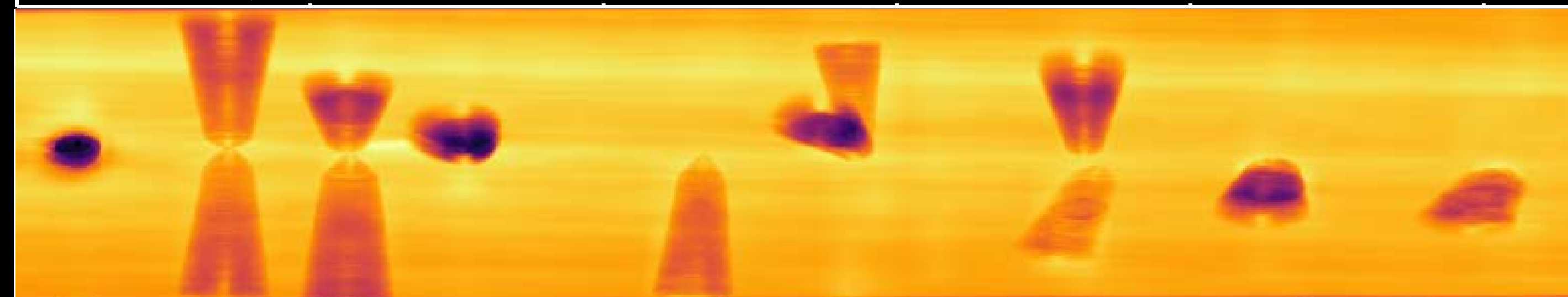
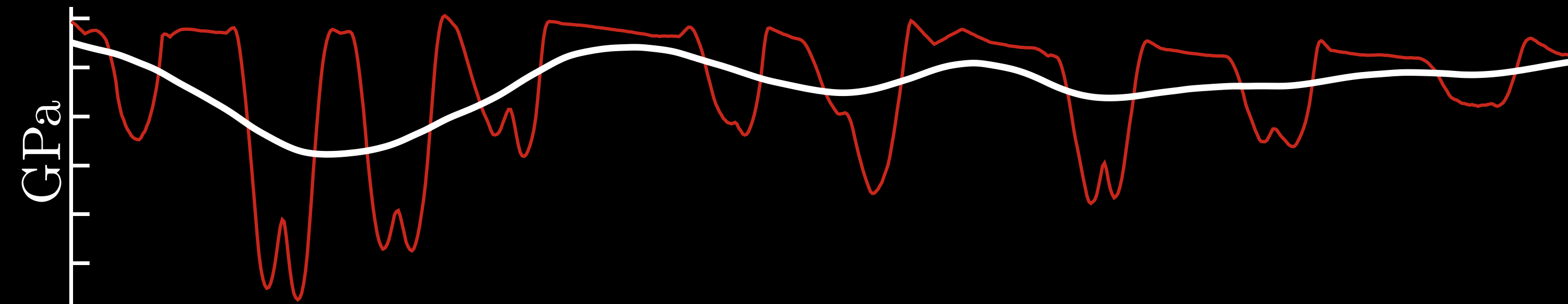
3D



FÖRENKLINGAR

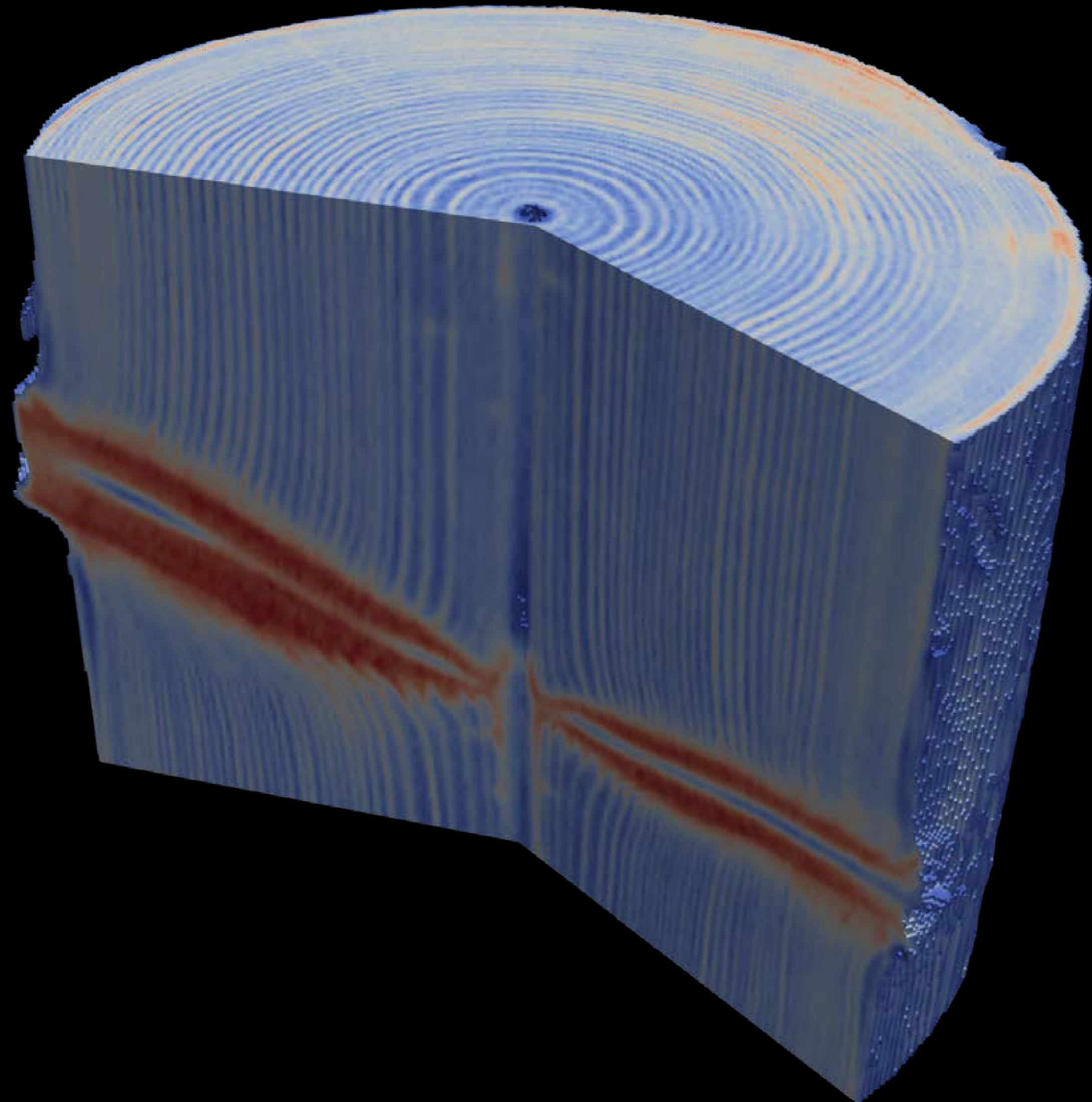
1D

Styvhetsprofil

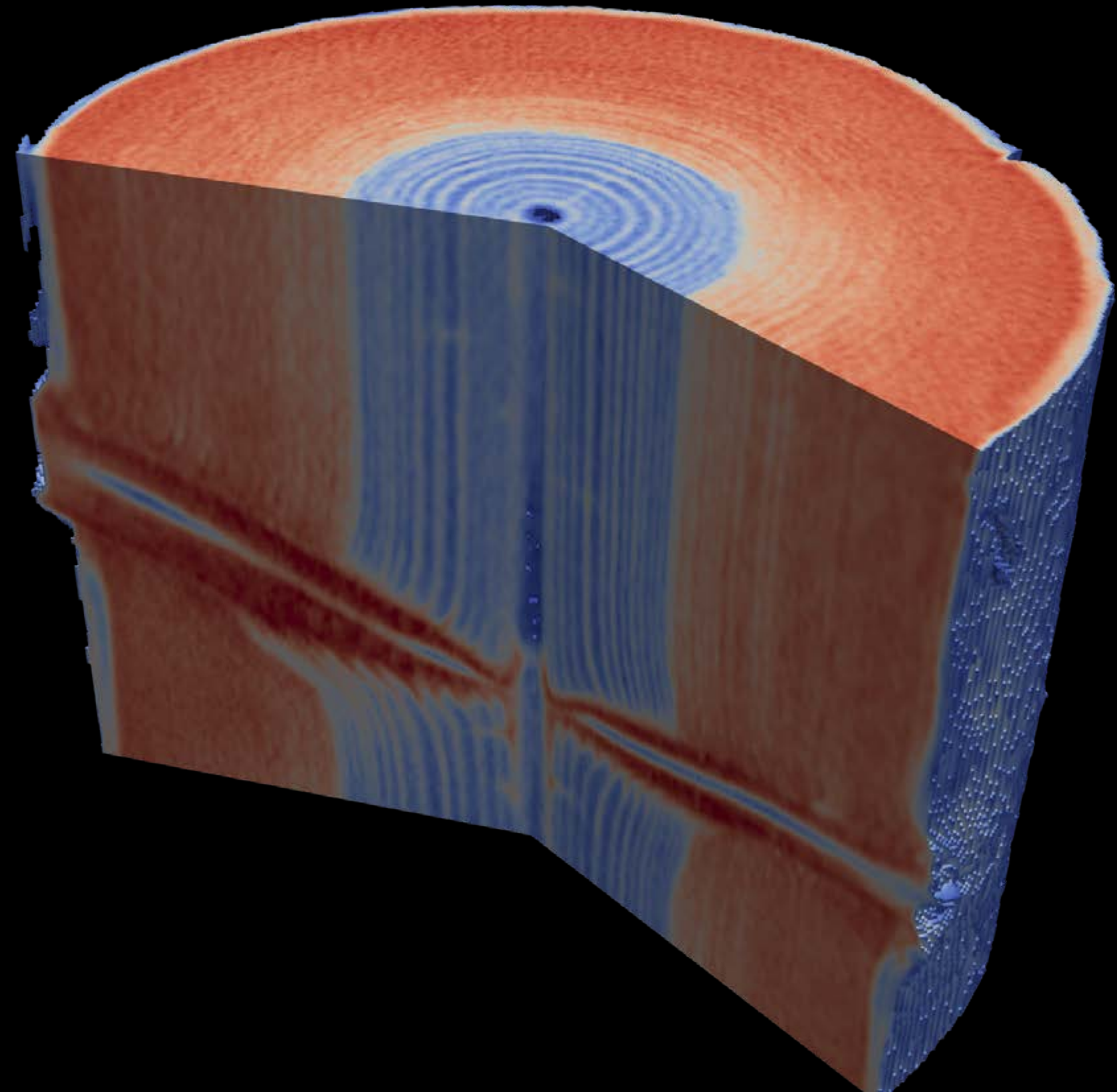


**UTMANINGAR**

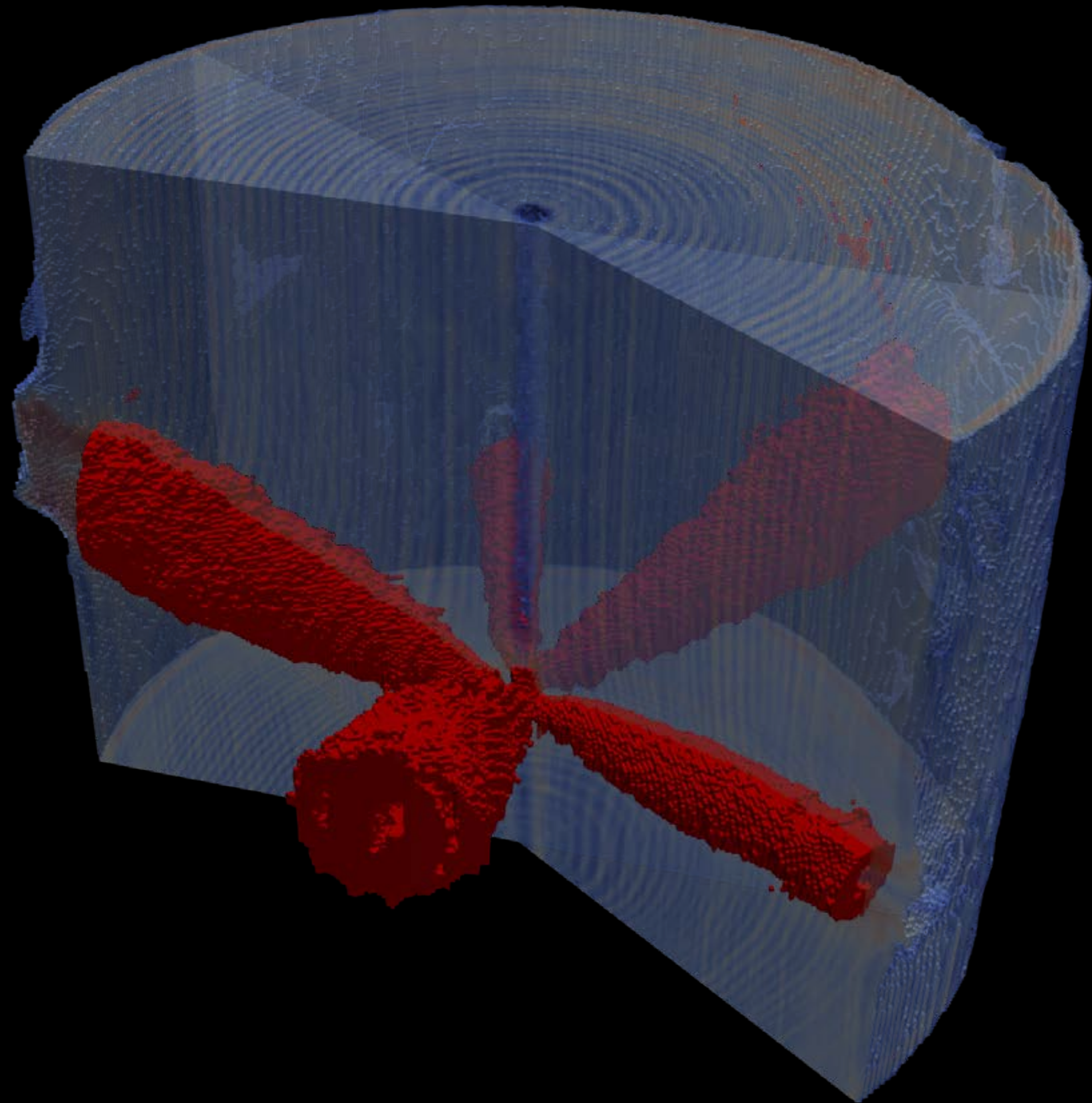
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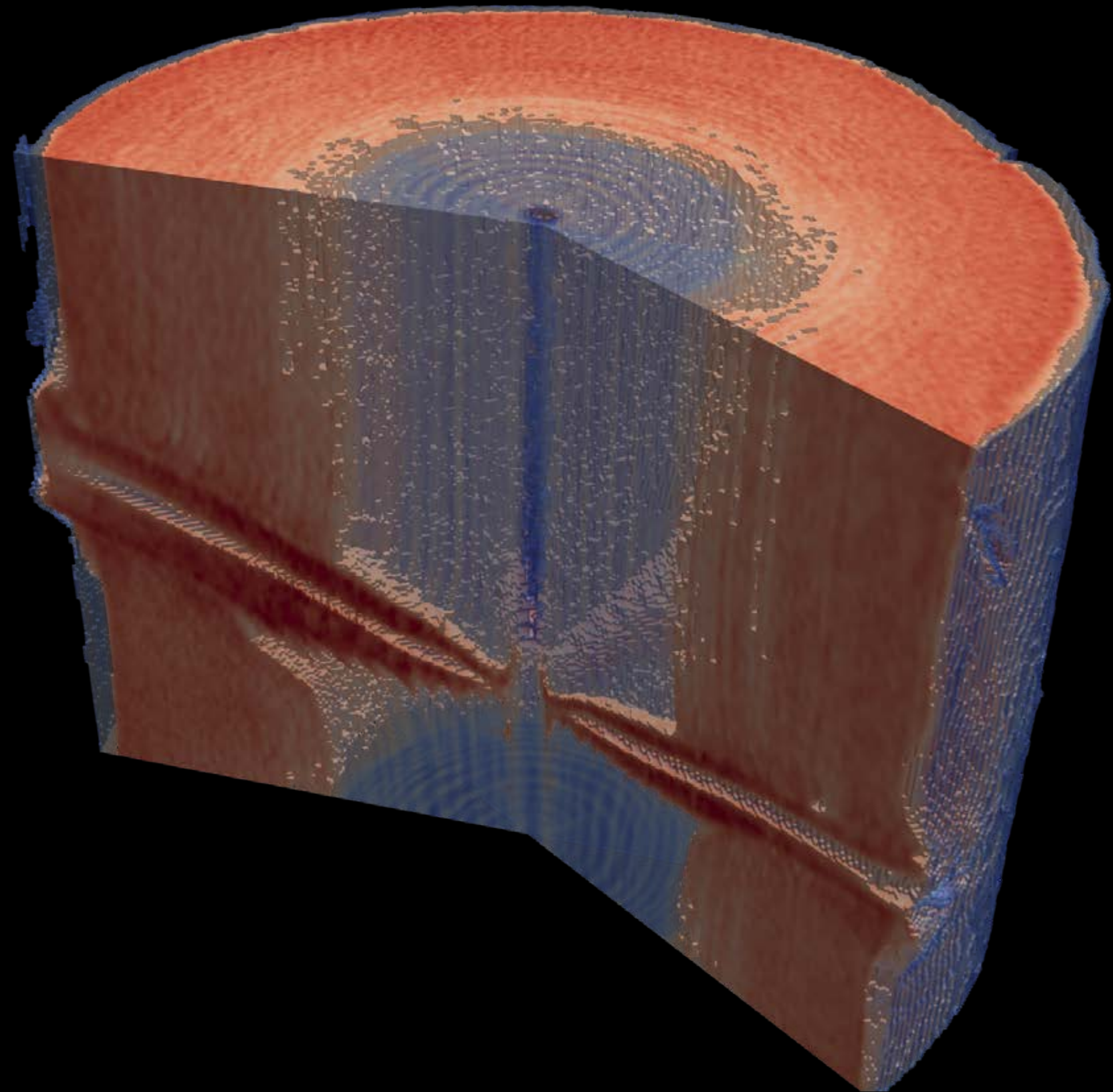
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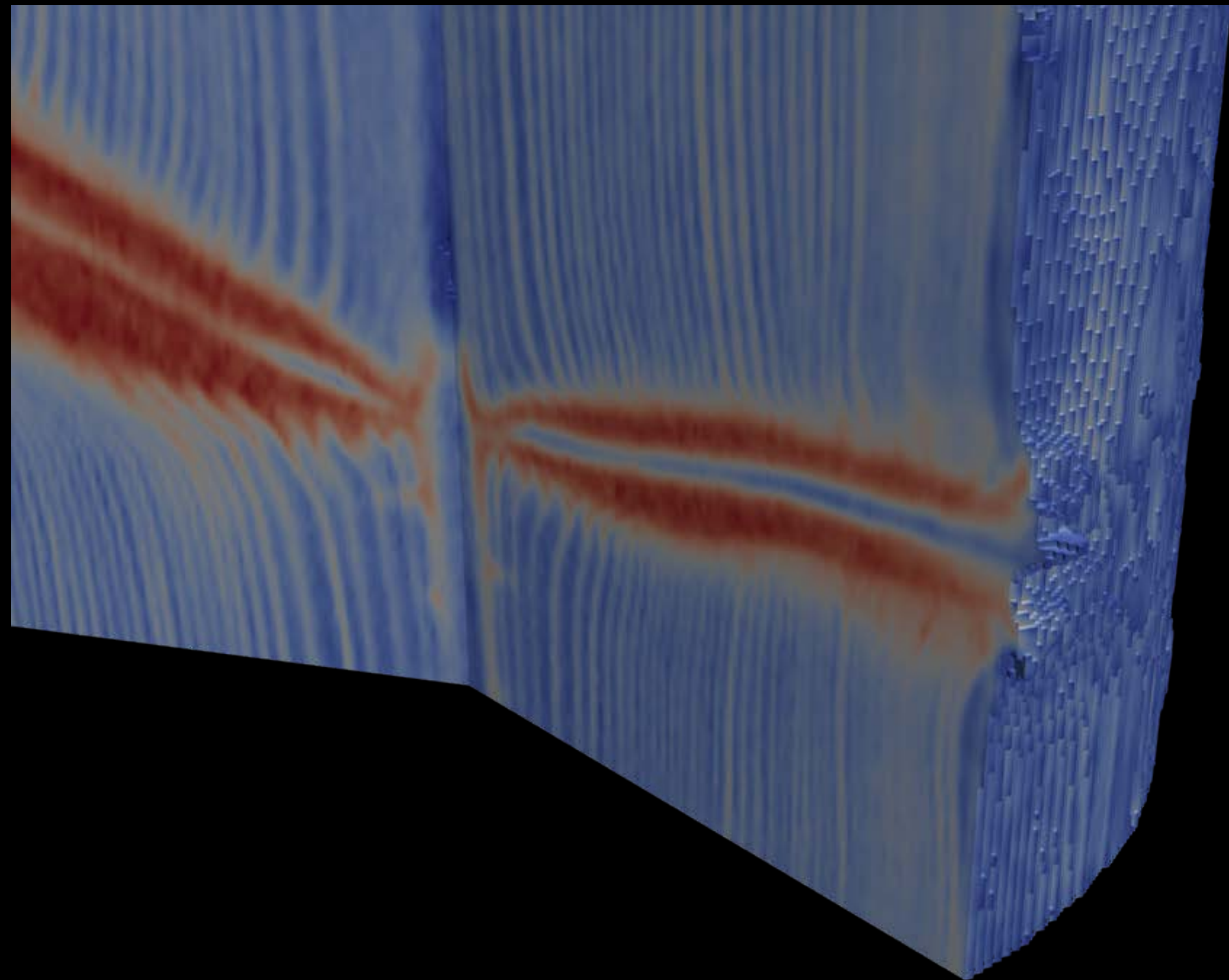
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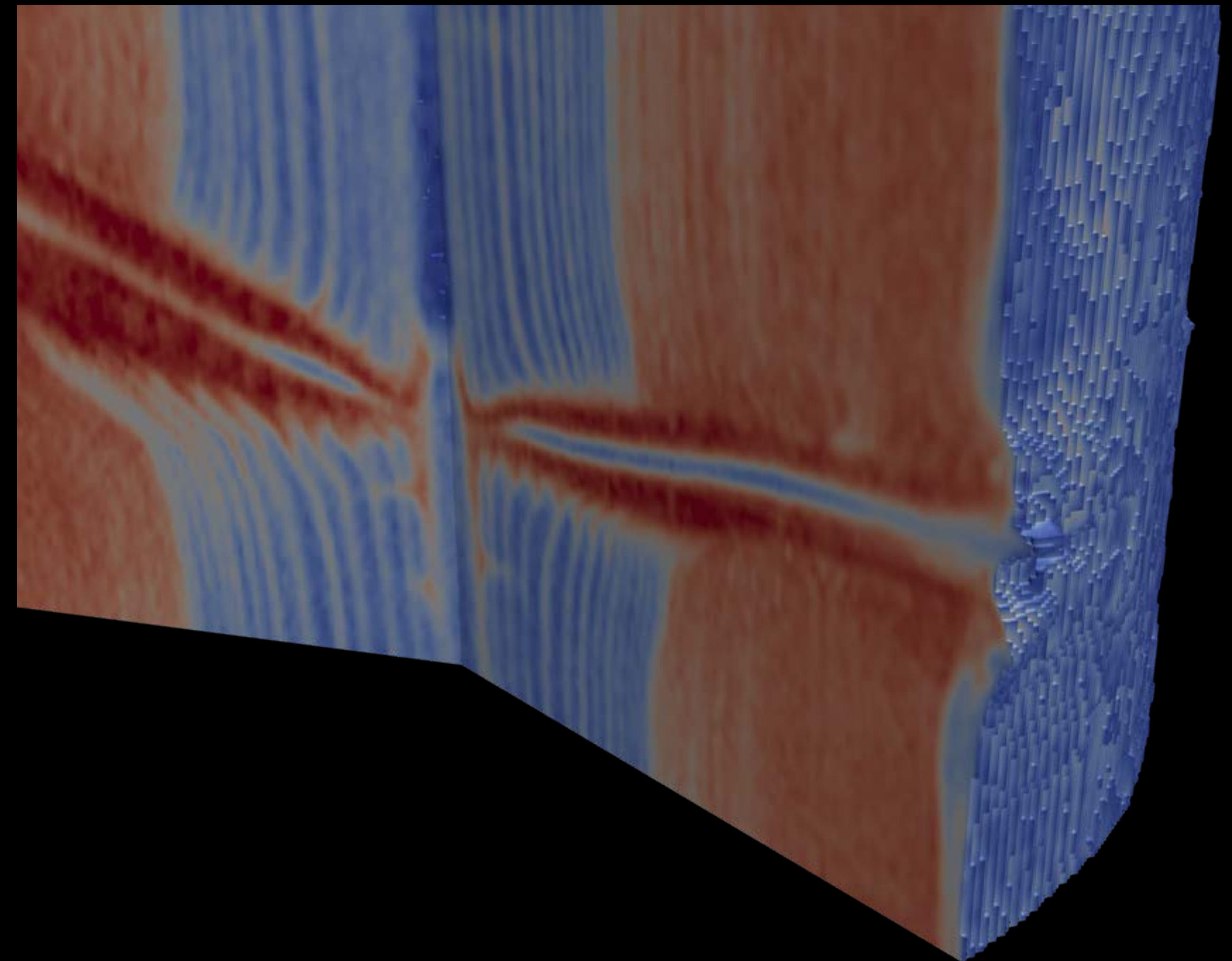
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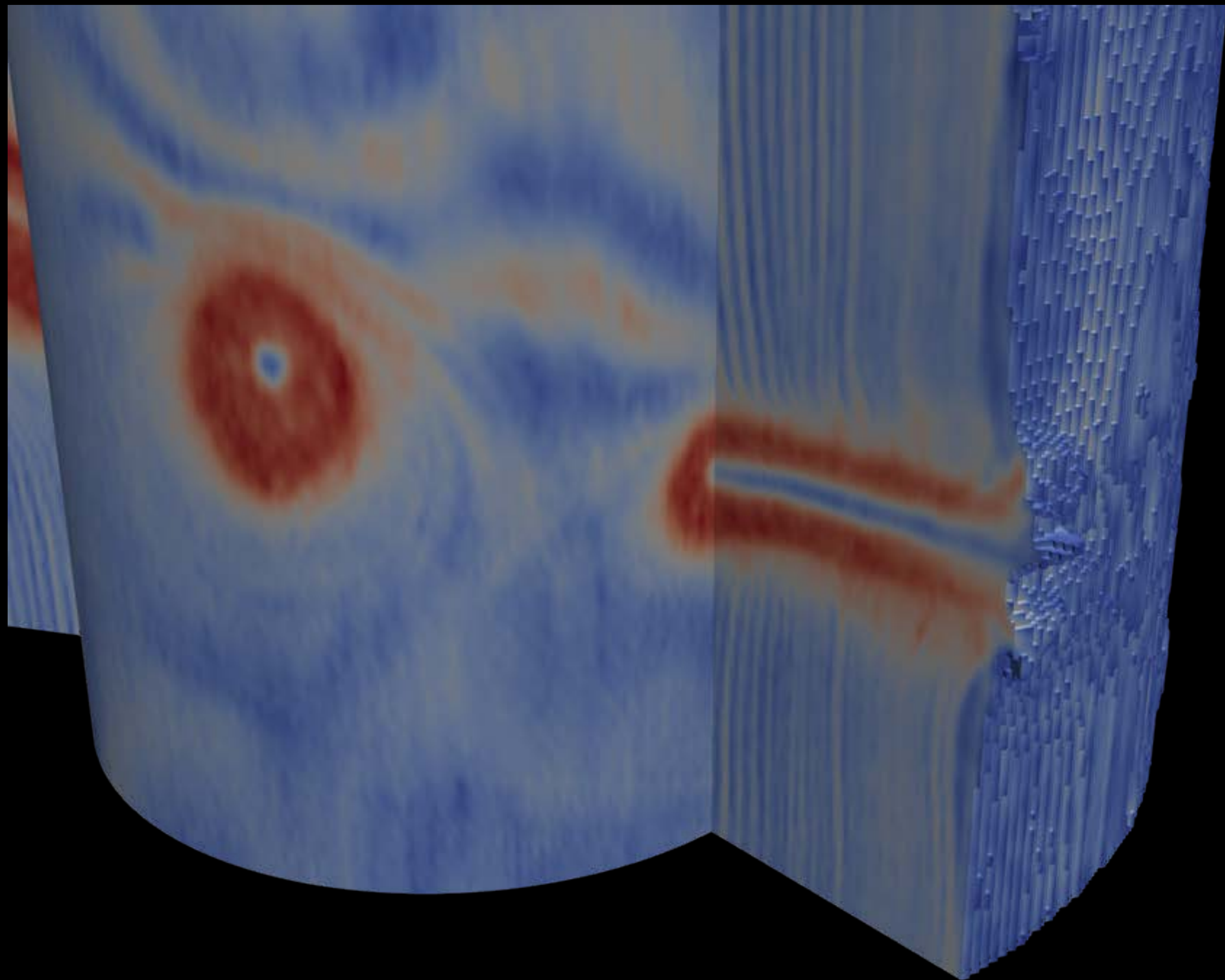
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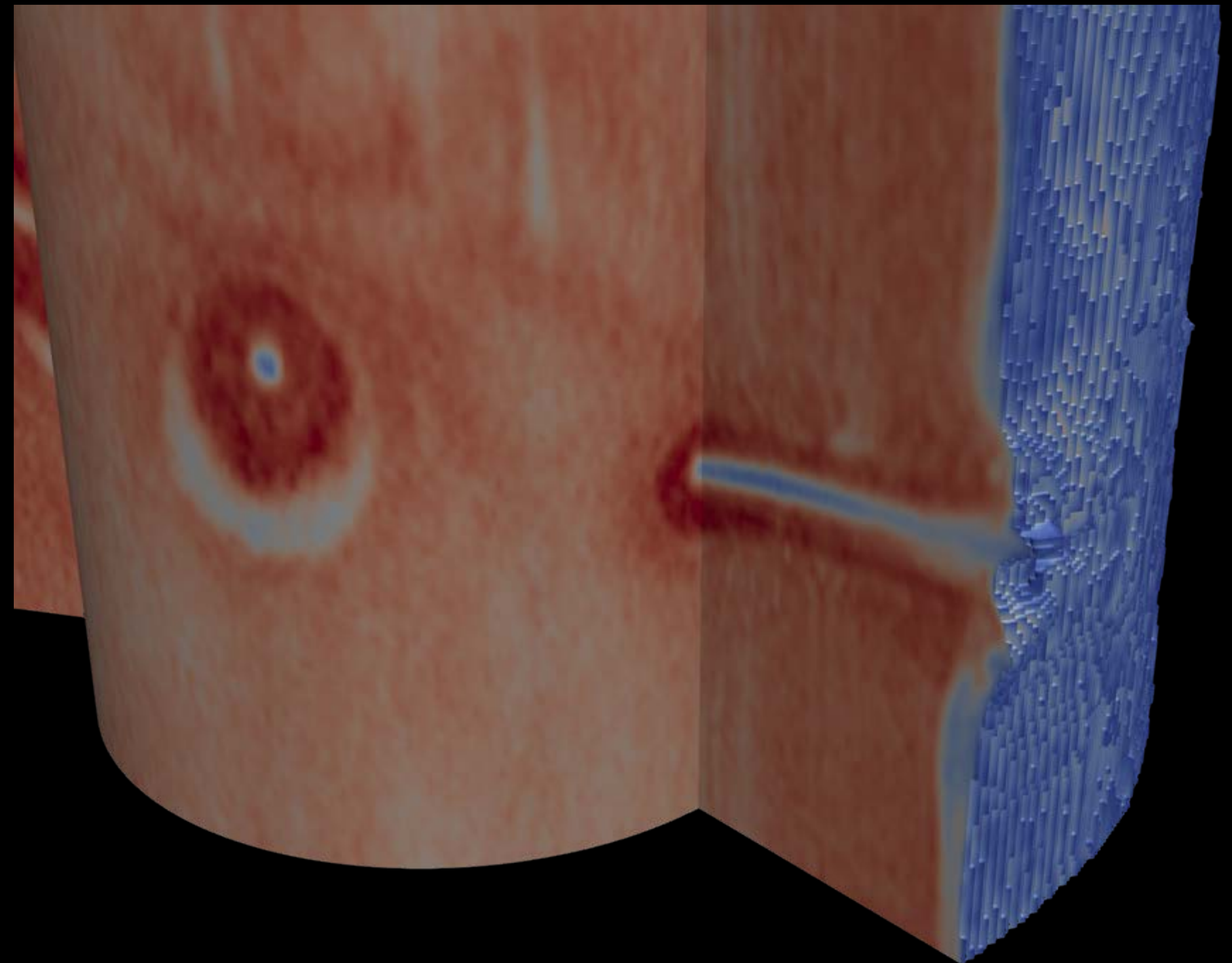
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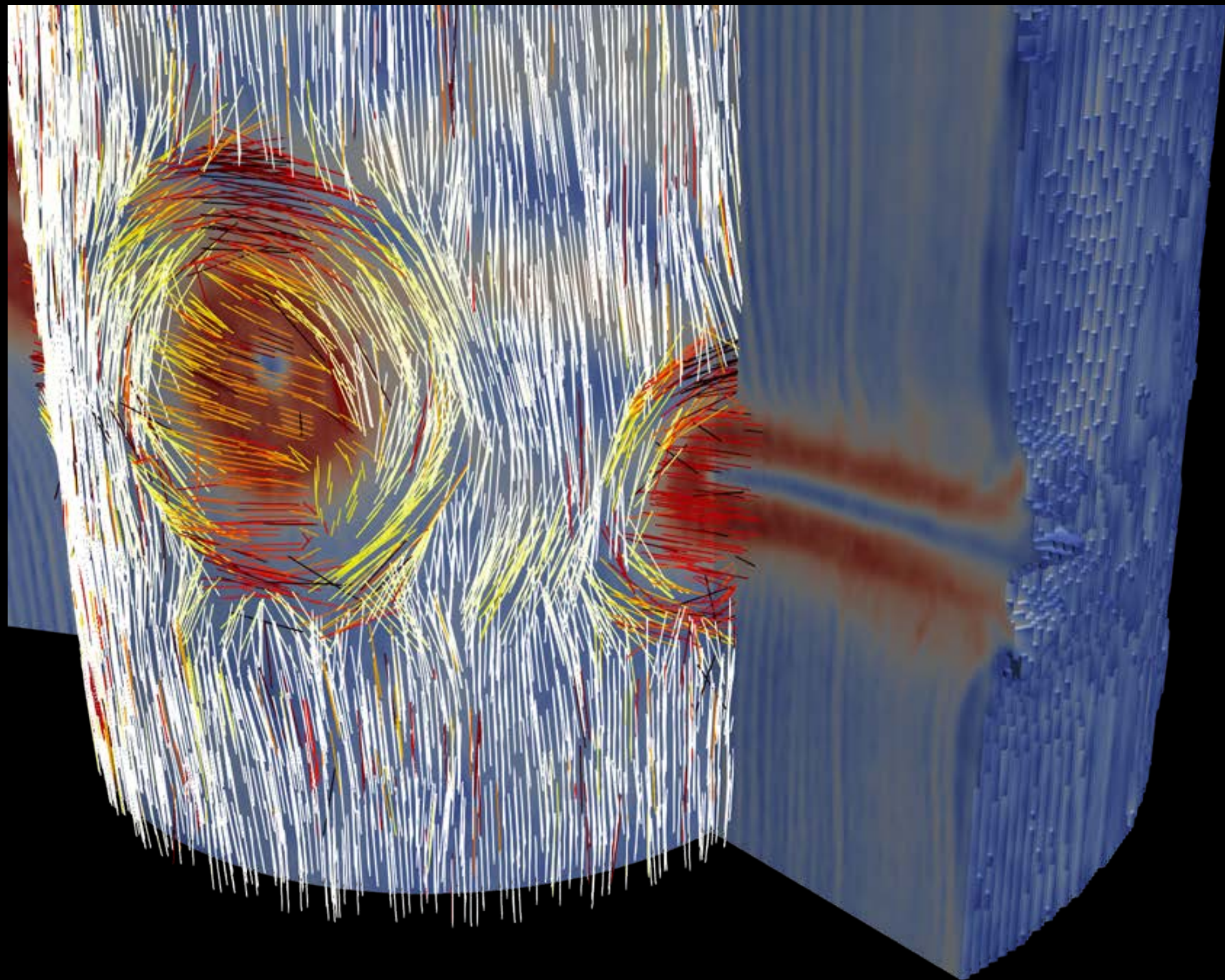
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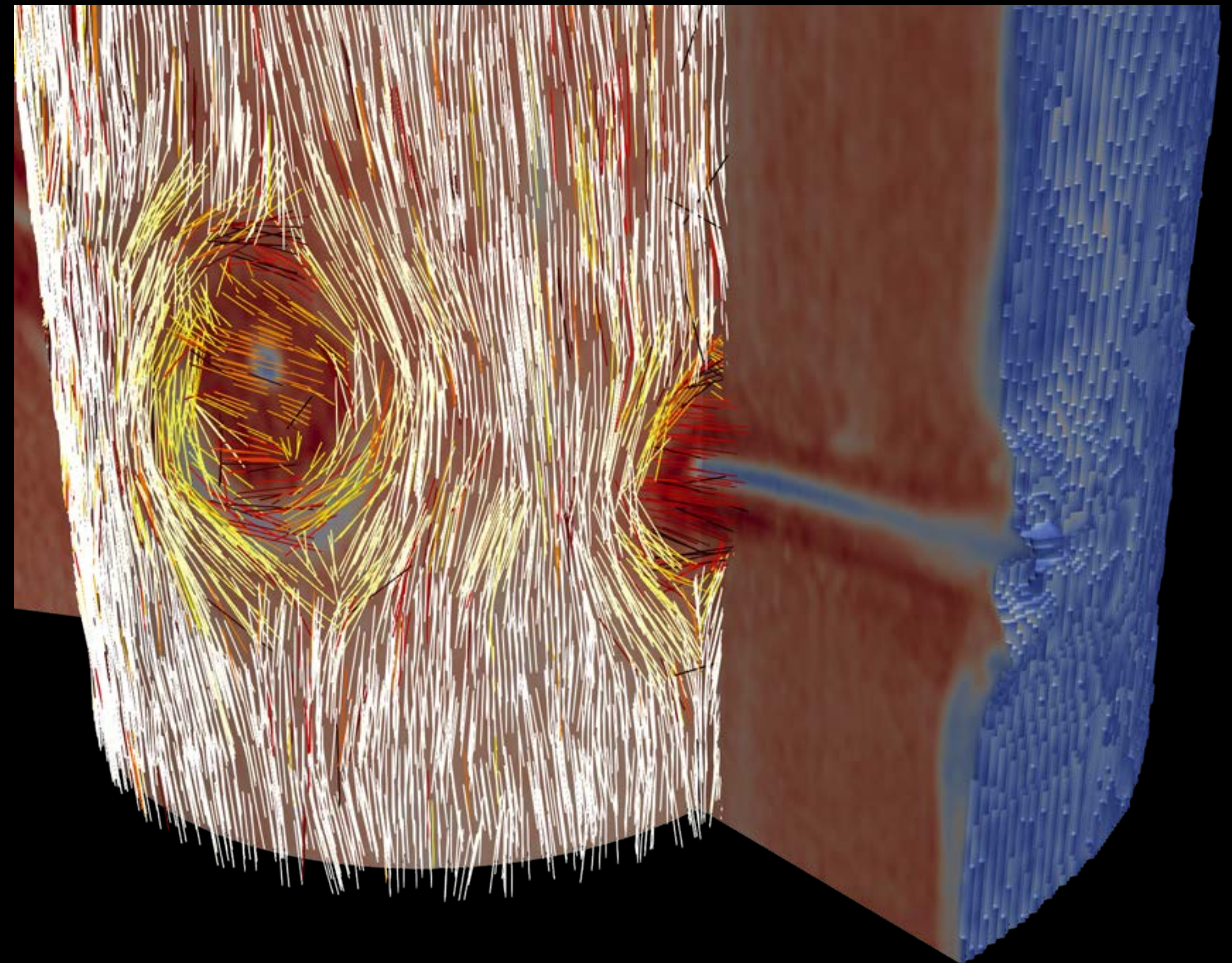
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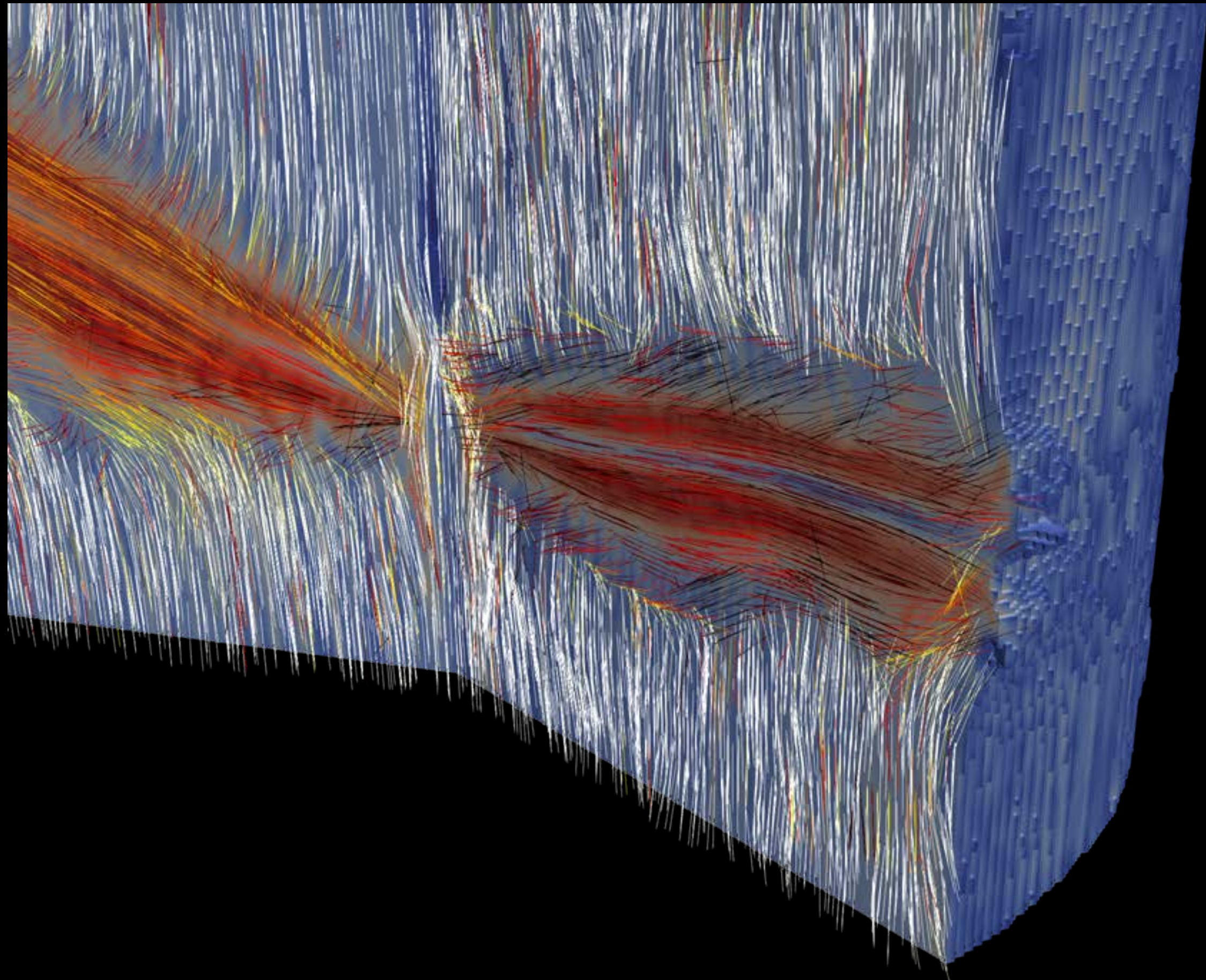


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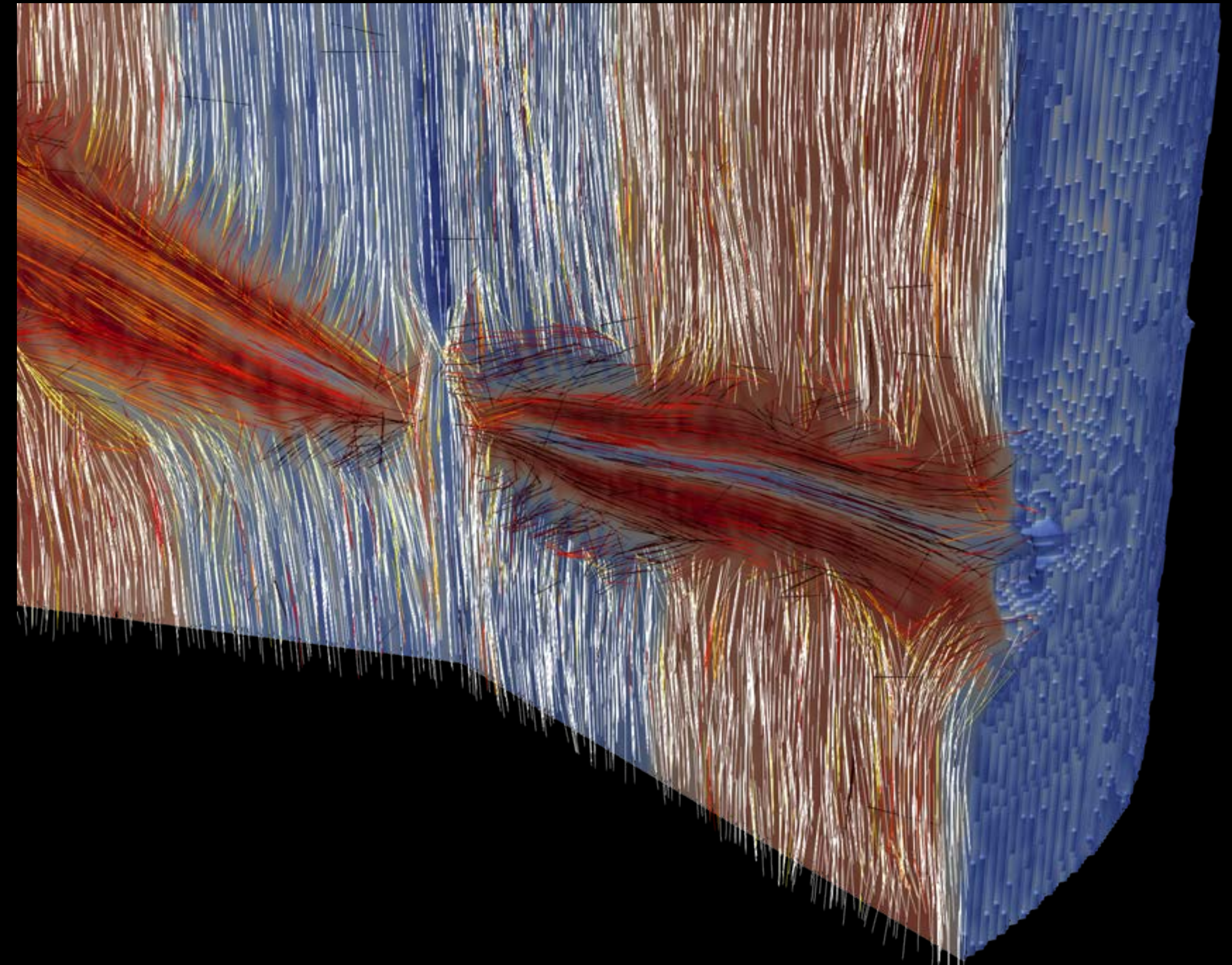




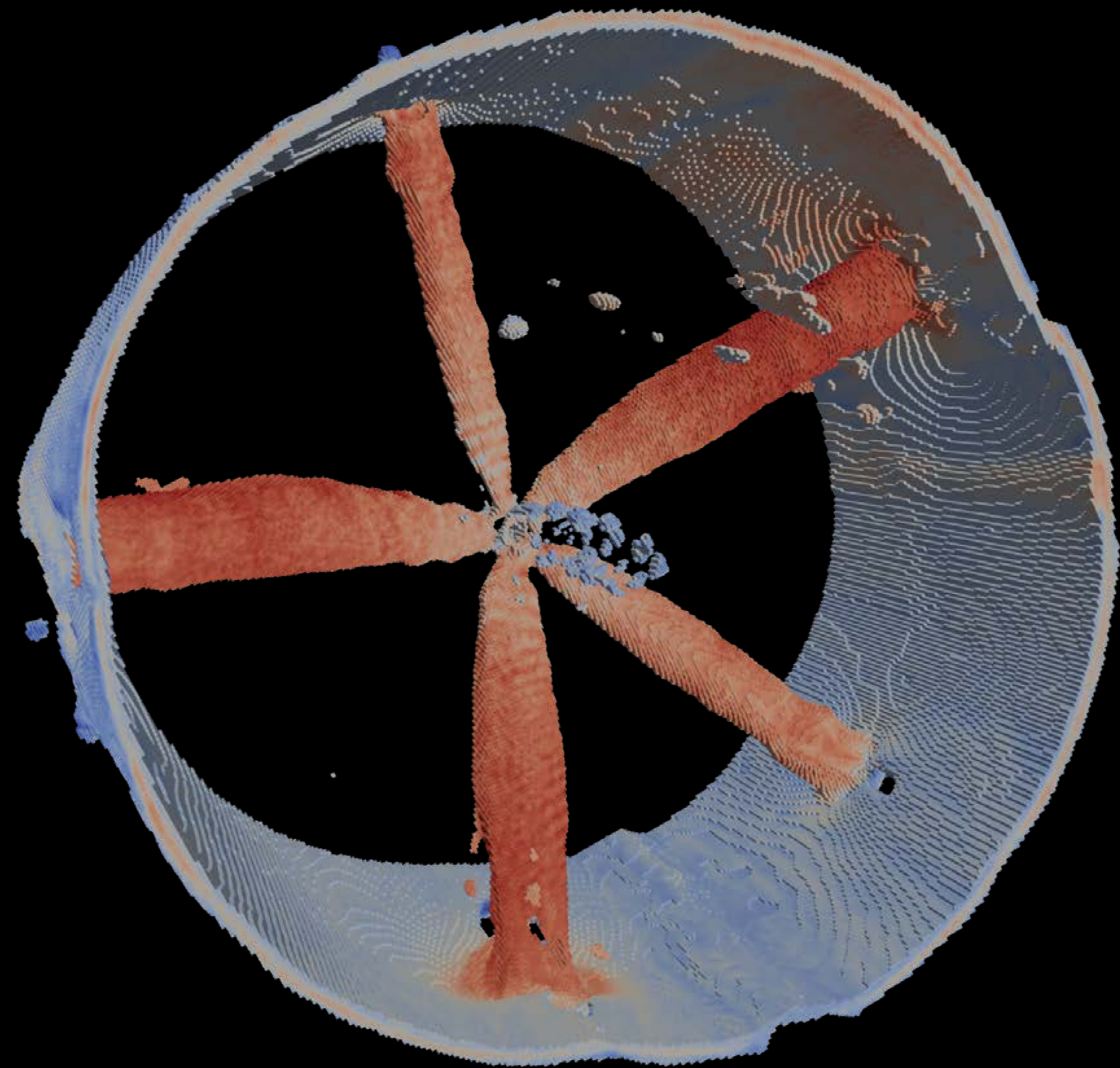
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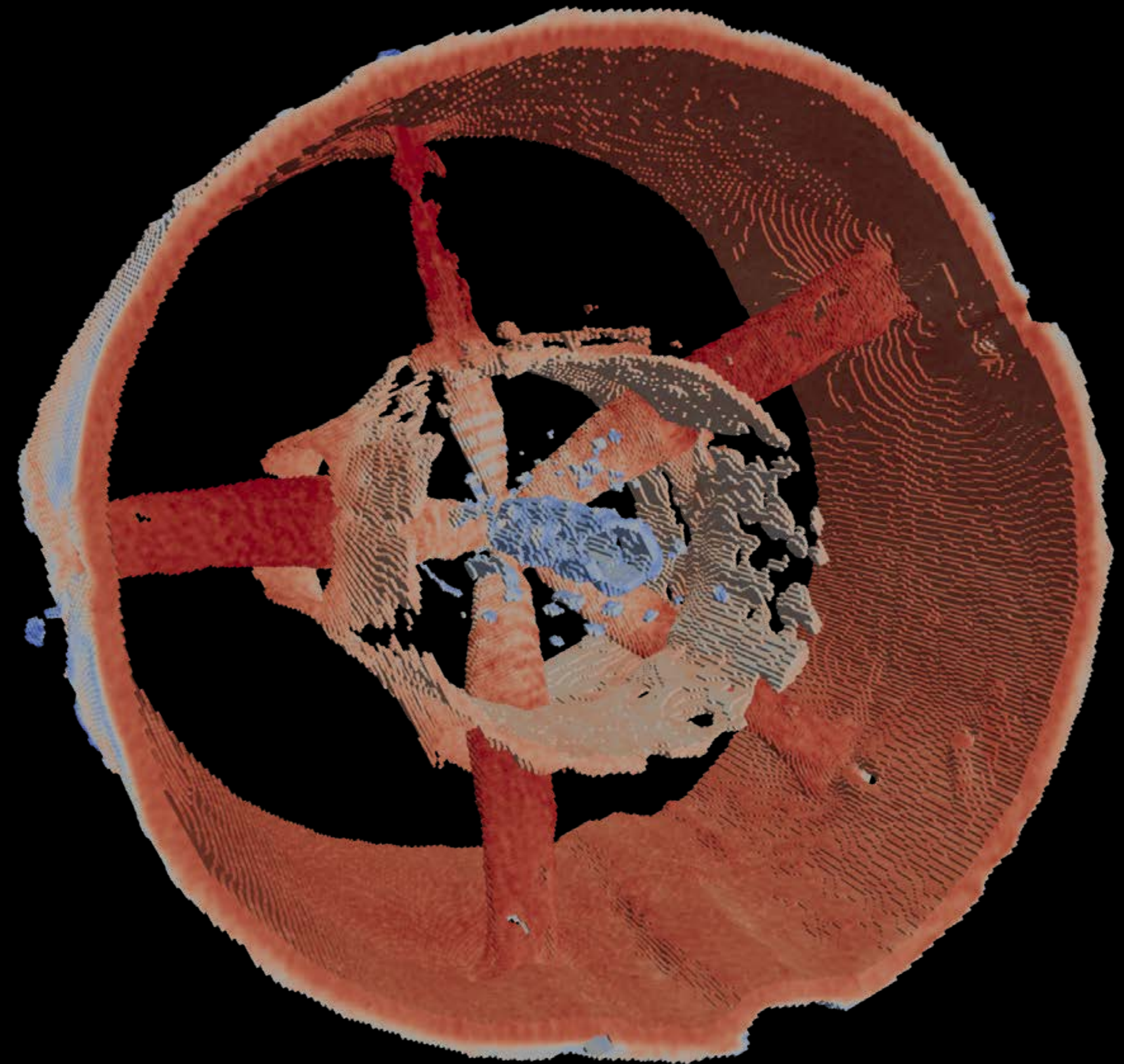
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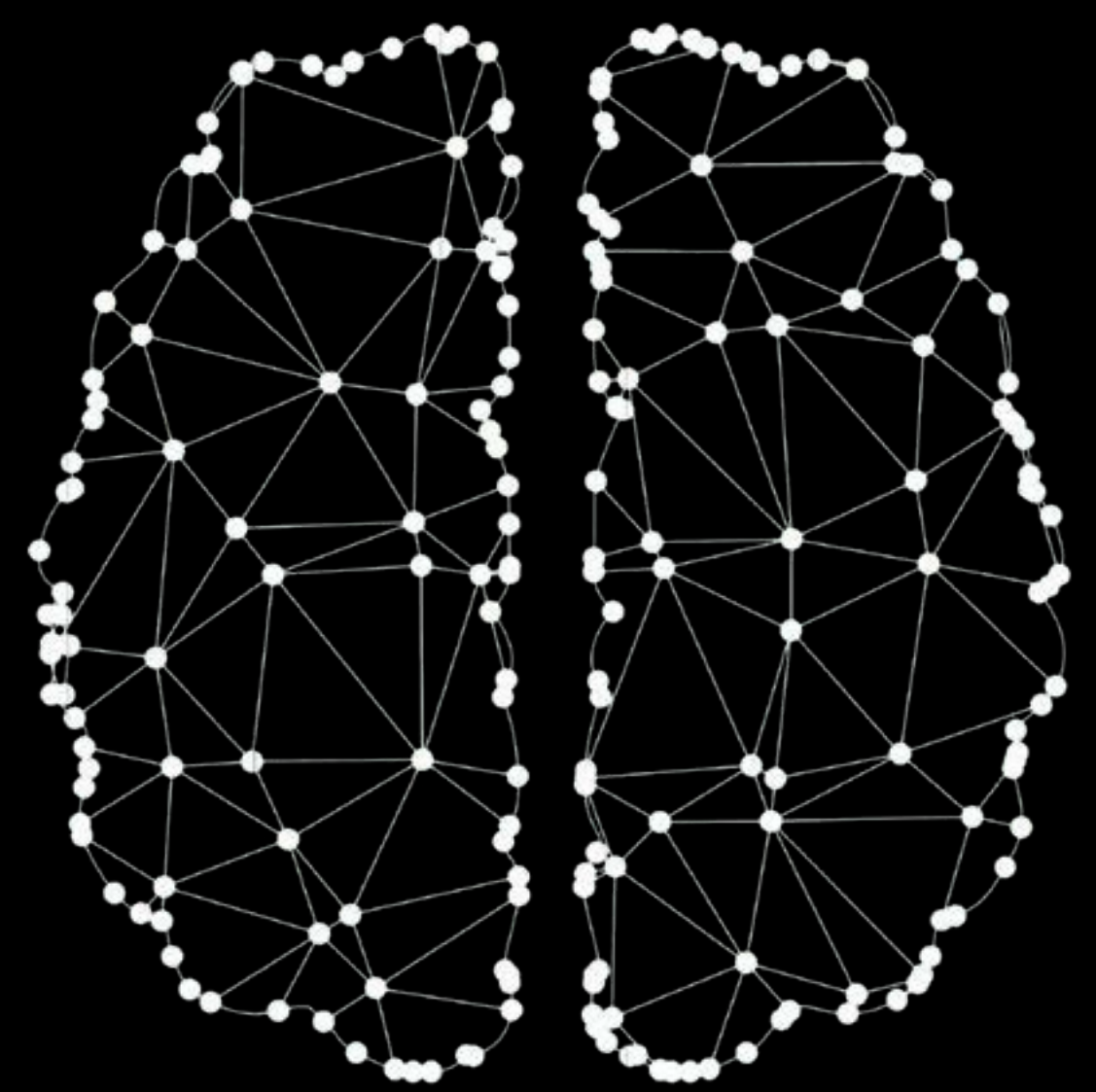
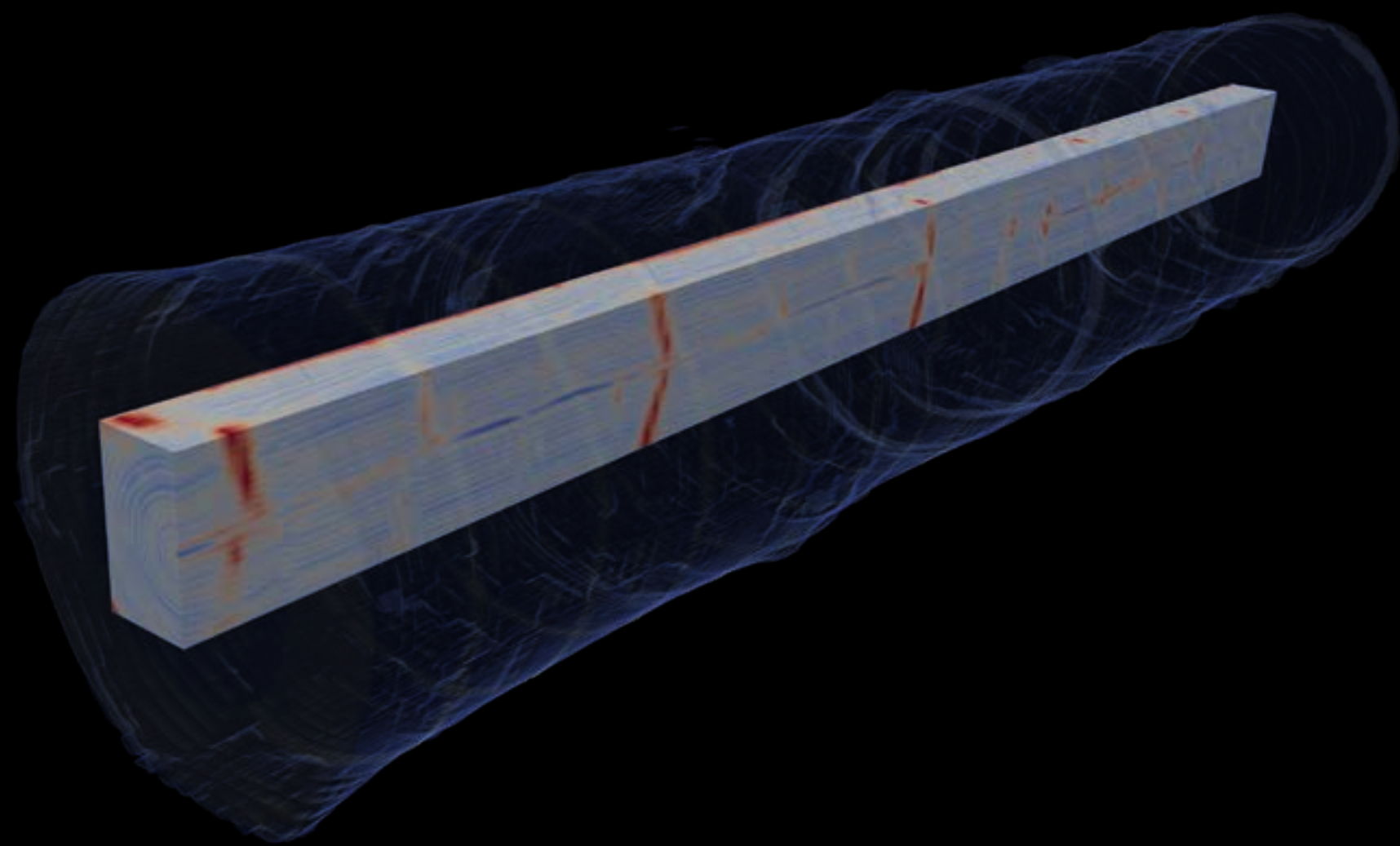
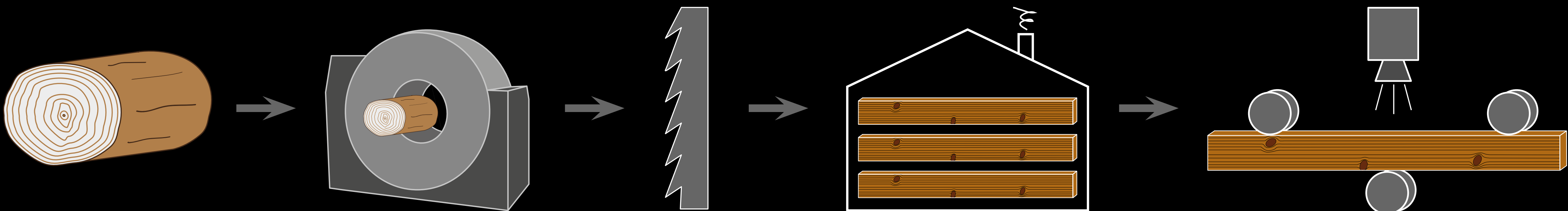


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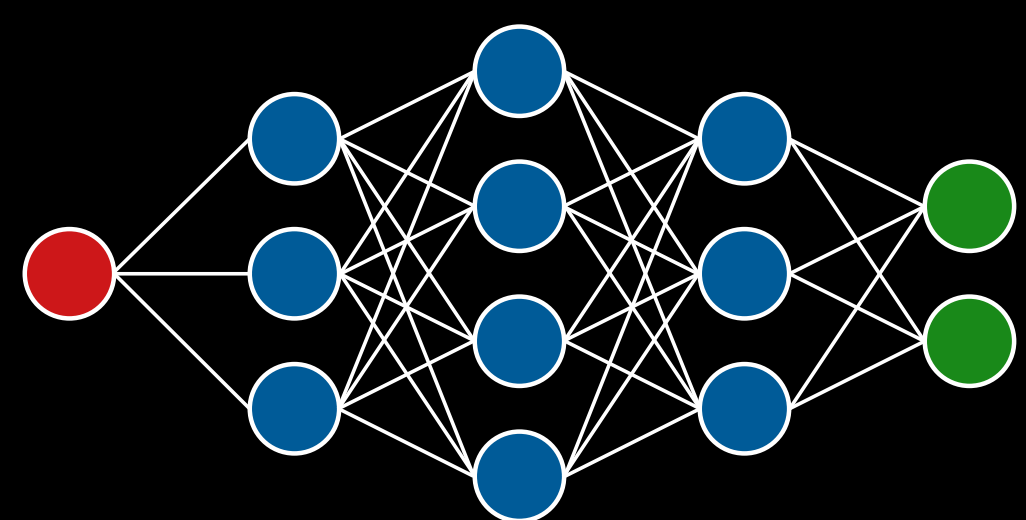
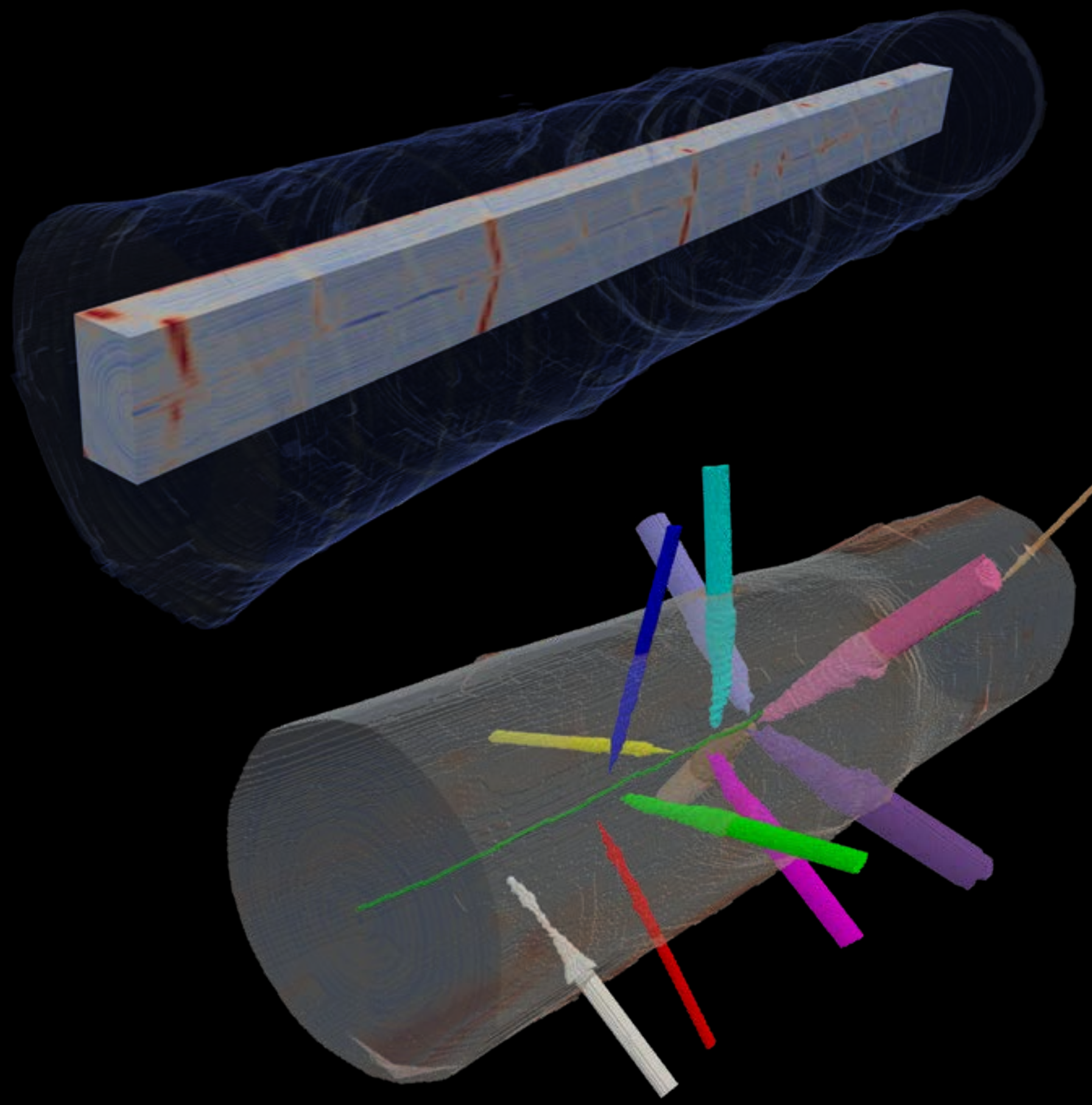
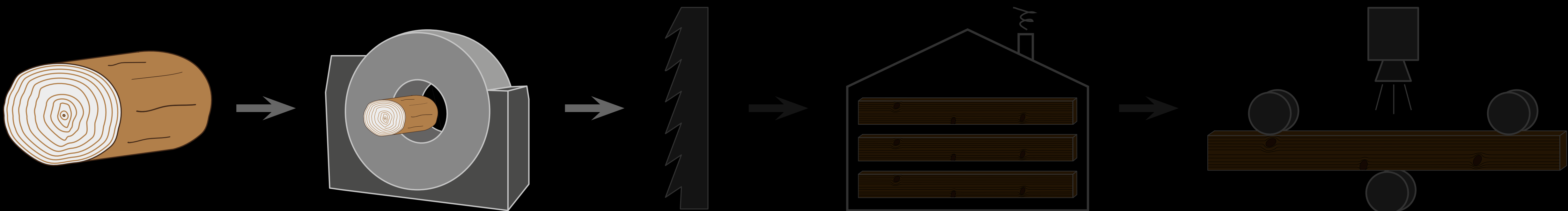


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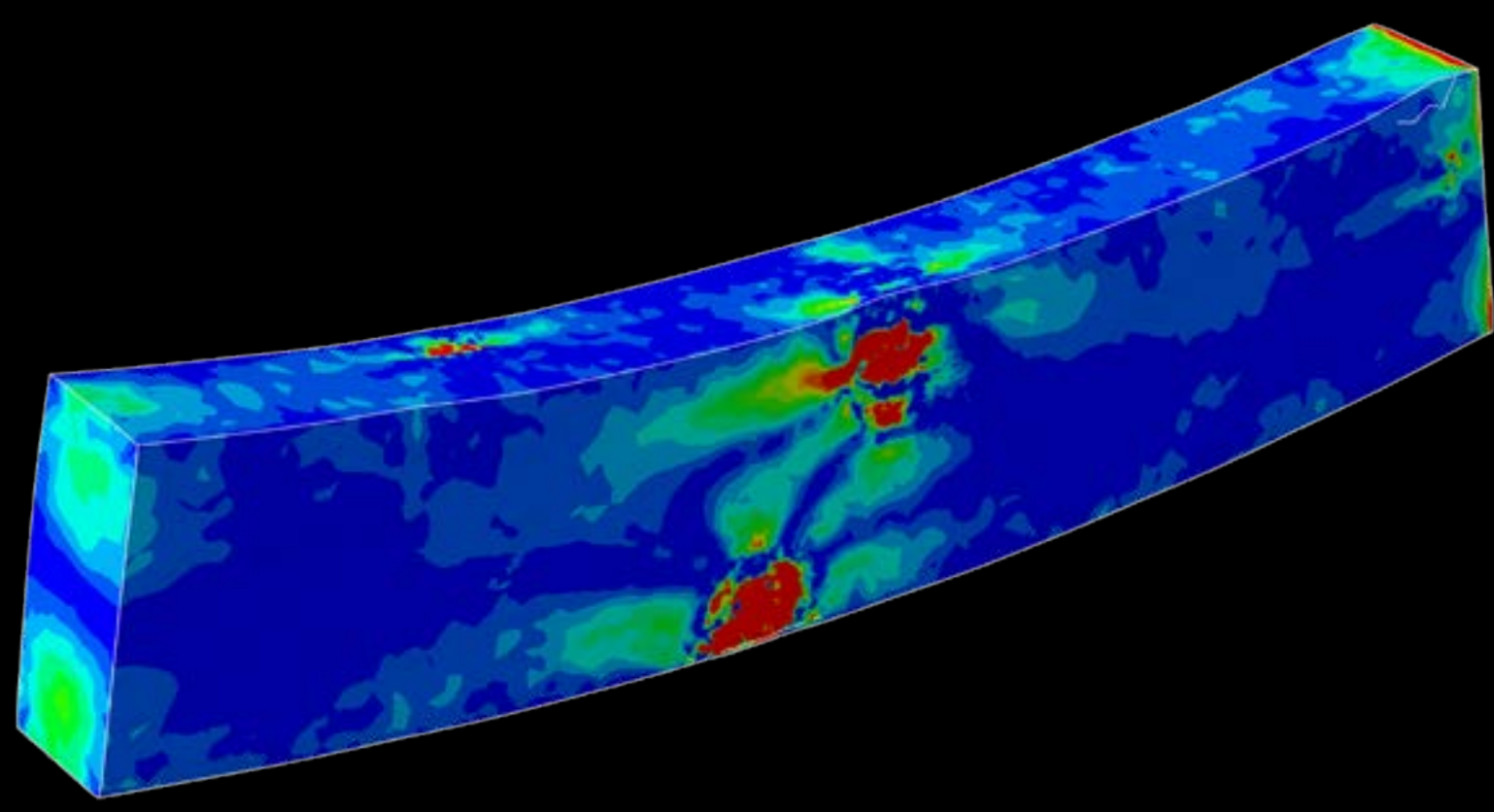
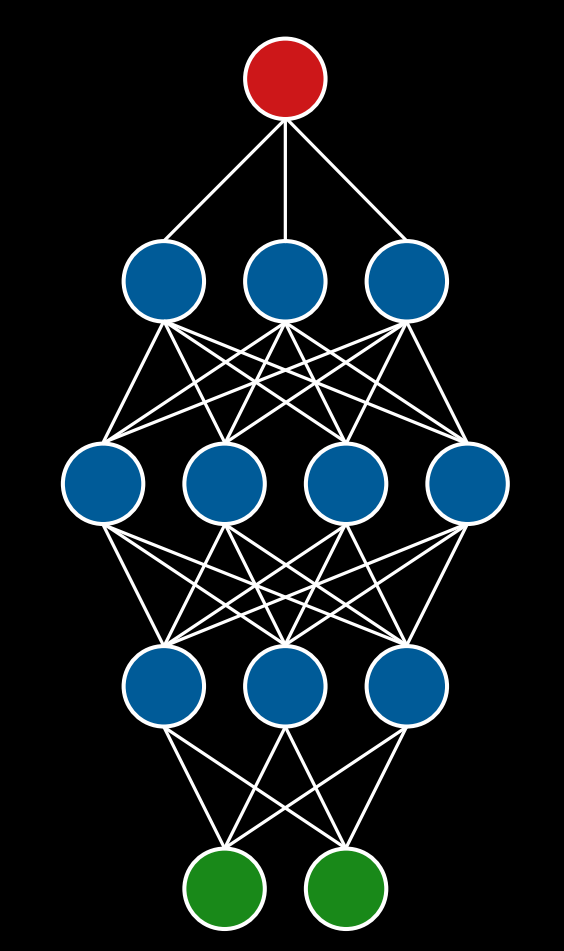
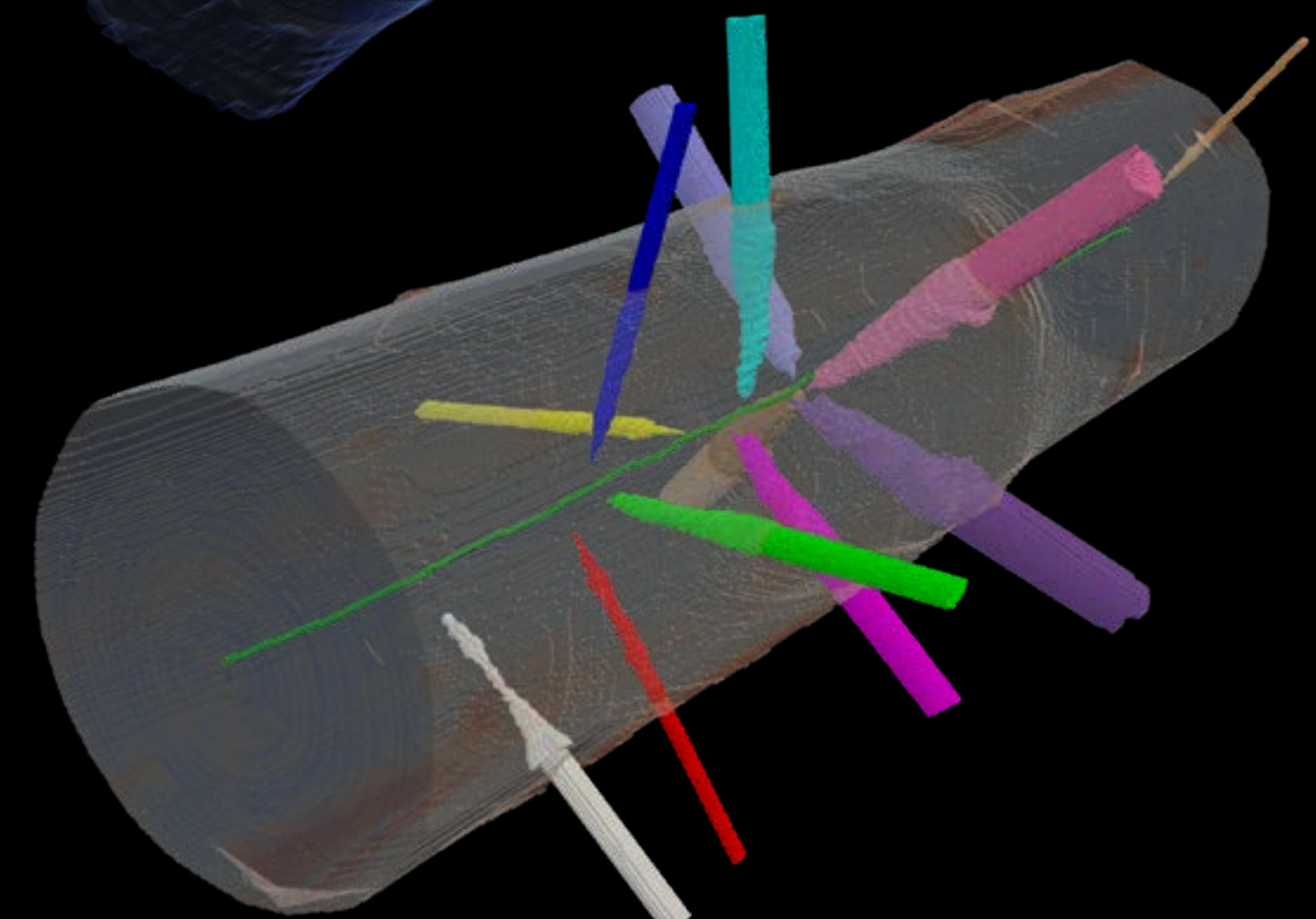
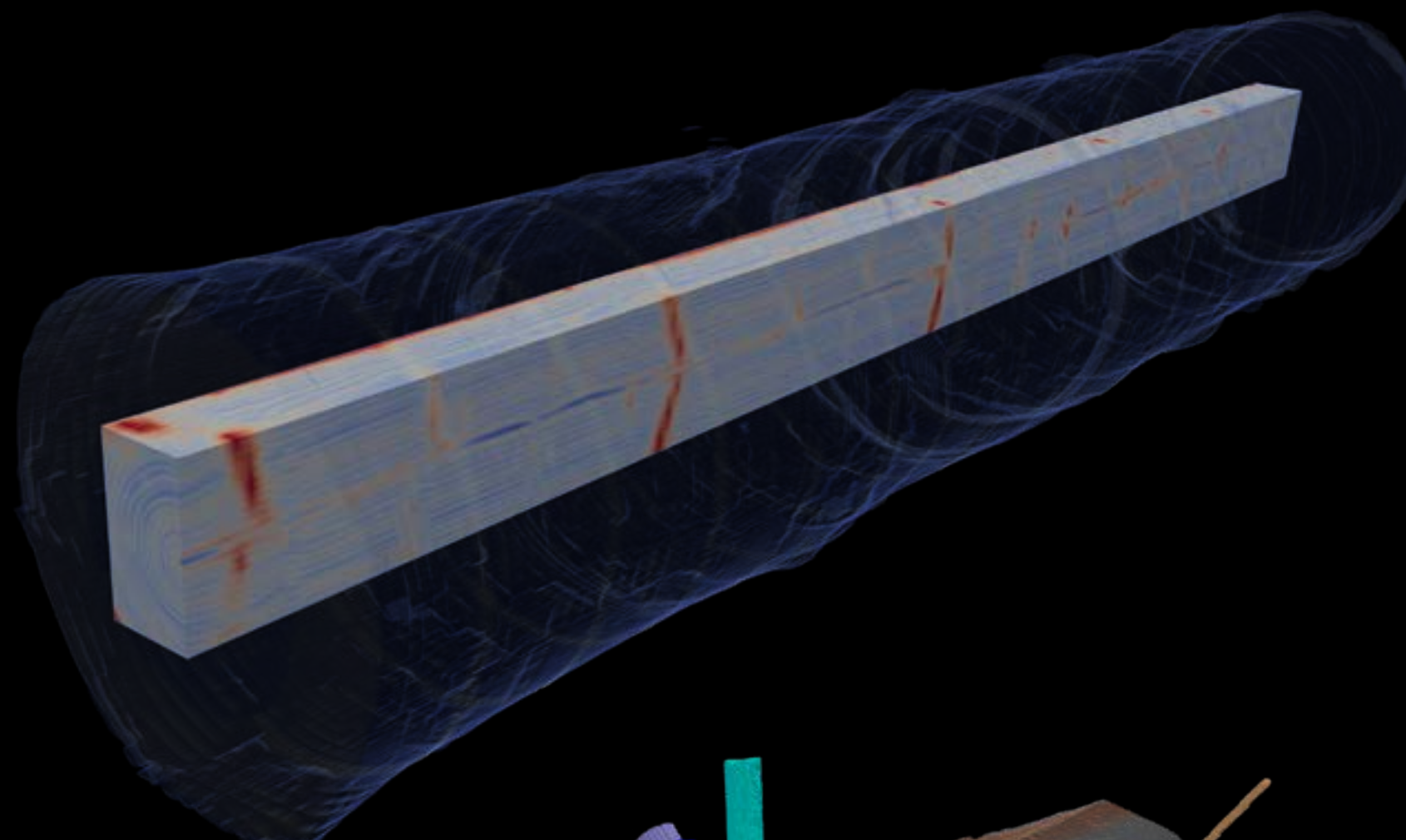
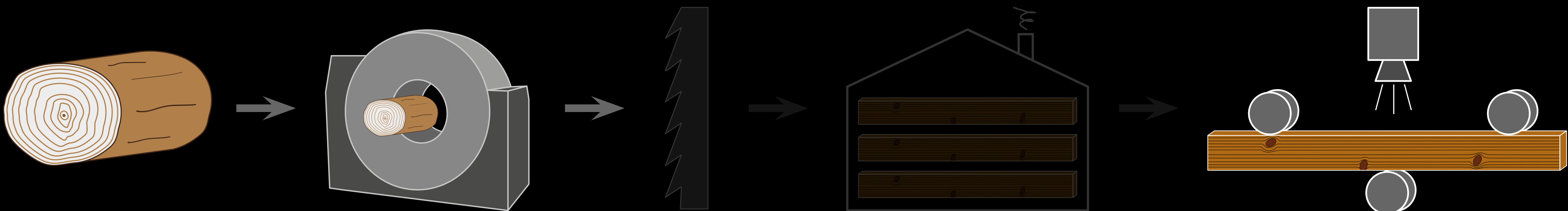


AI



DJUPINLÄRNING

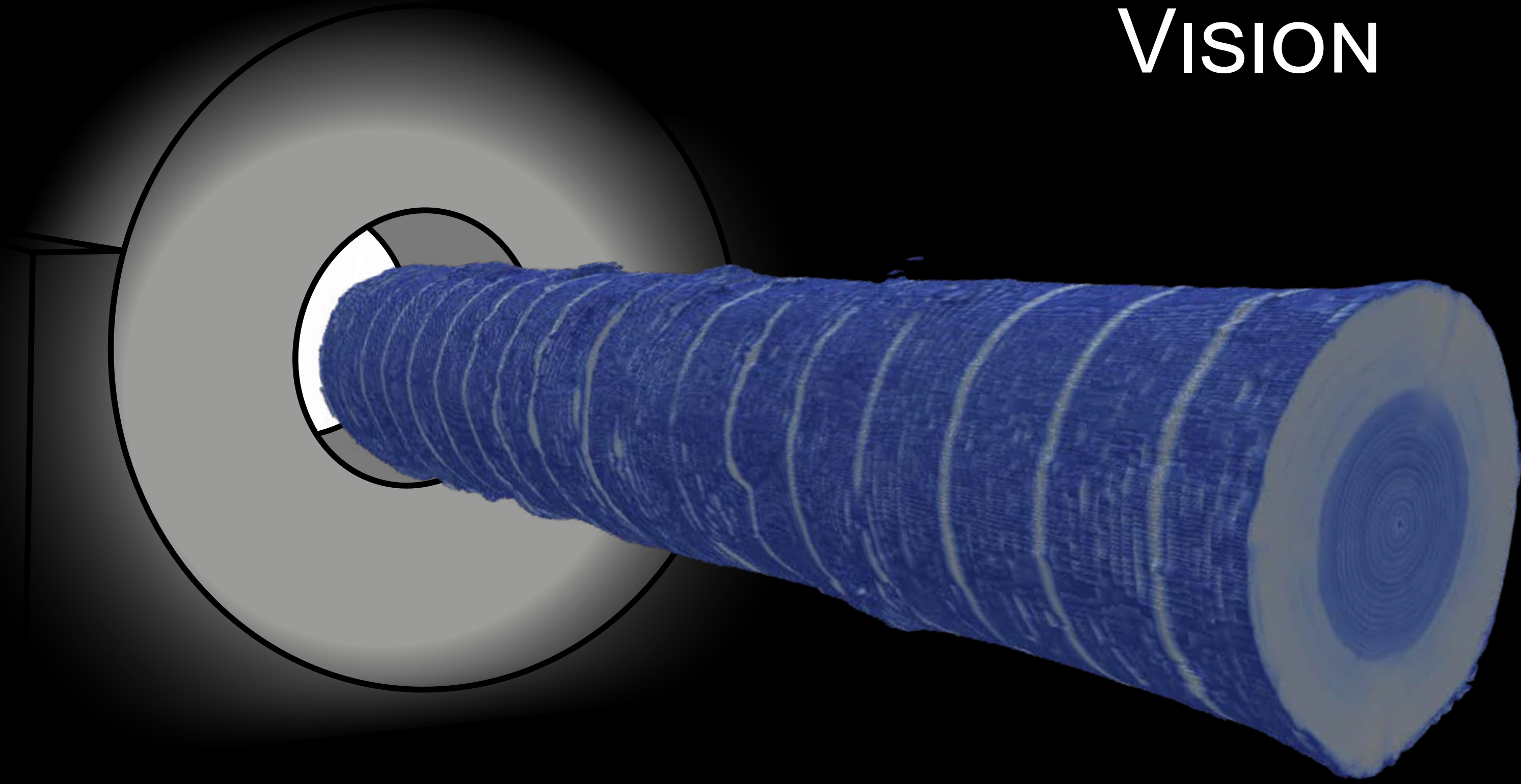
- 3D bilder:  
rekonstruktion  
segmentering  
klassificering



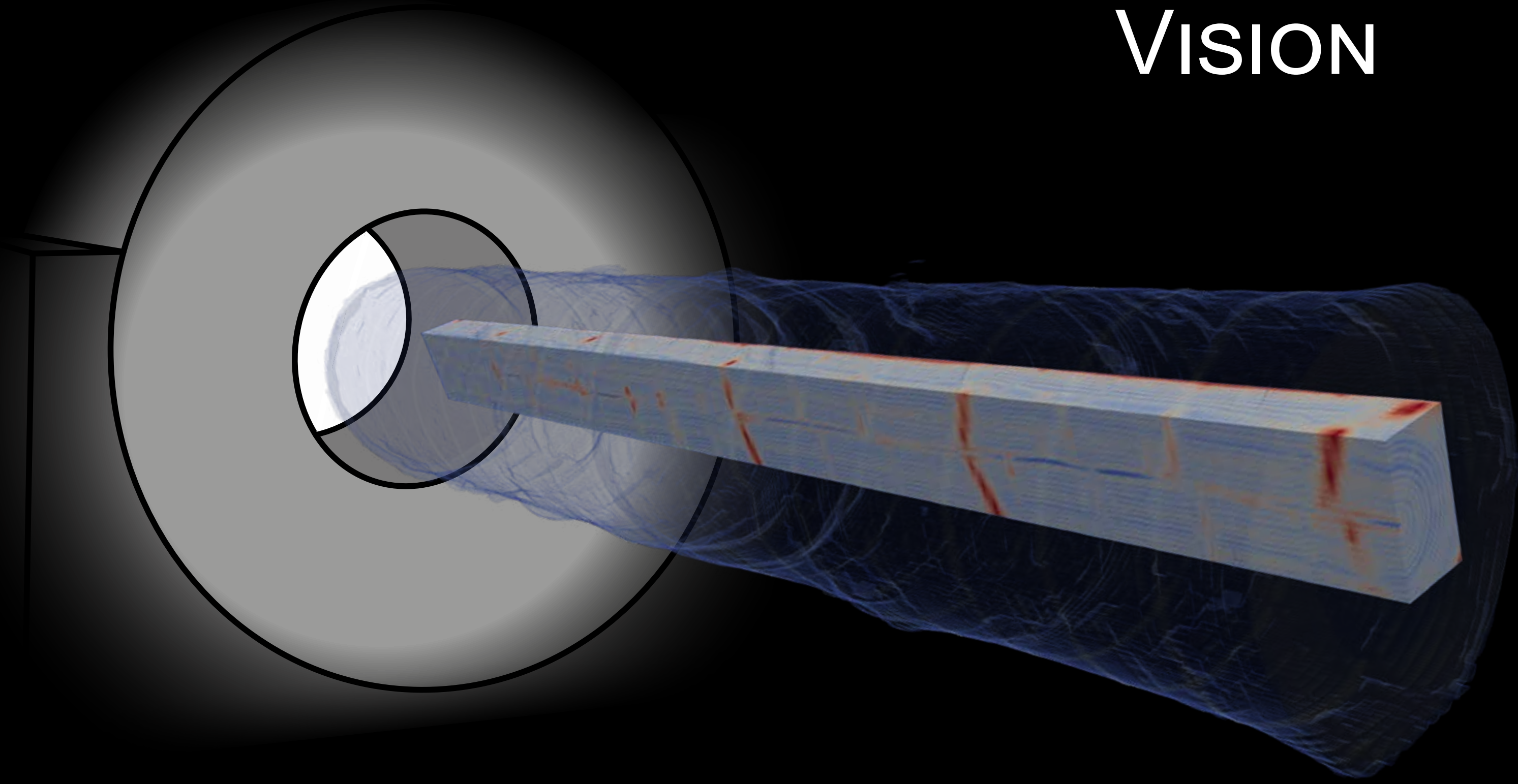
$$\frac{\partial \sigma_{ij}}{\partial x_j} + b_i = 0$$

physics-informed machine learning  
(PINNs)

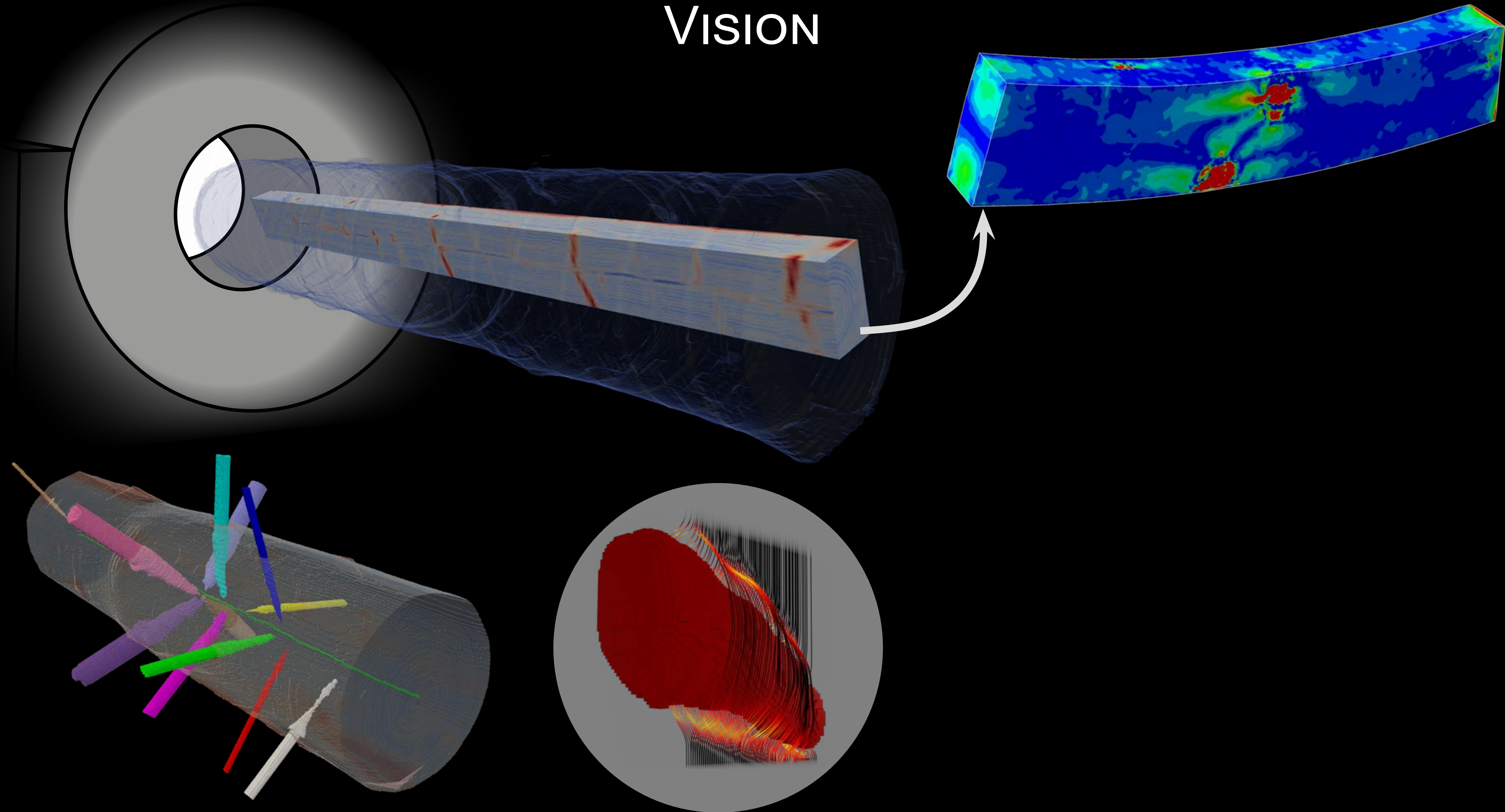
# VISION



# VISION

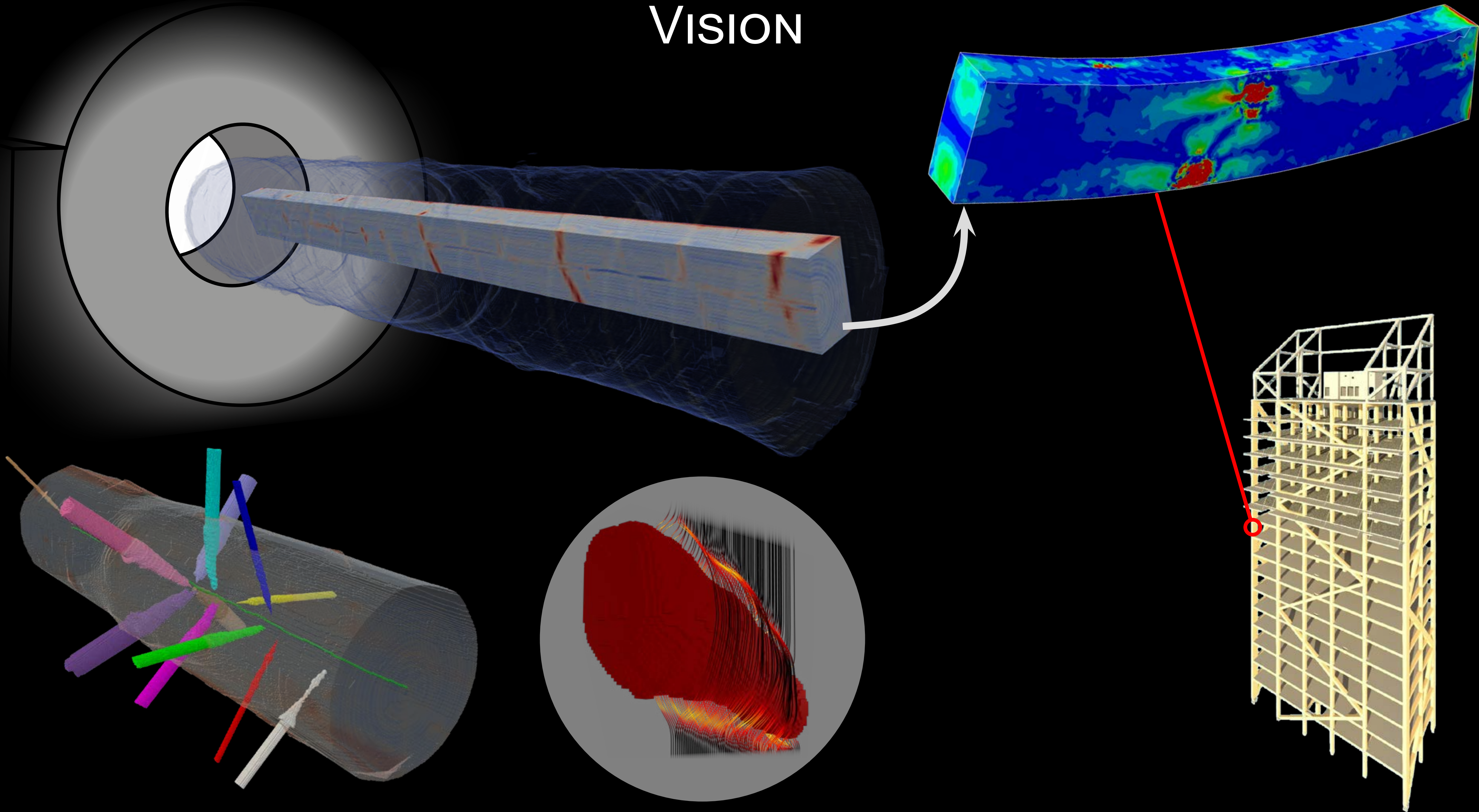


# VISION

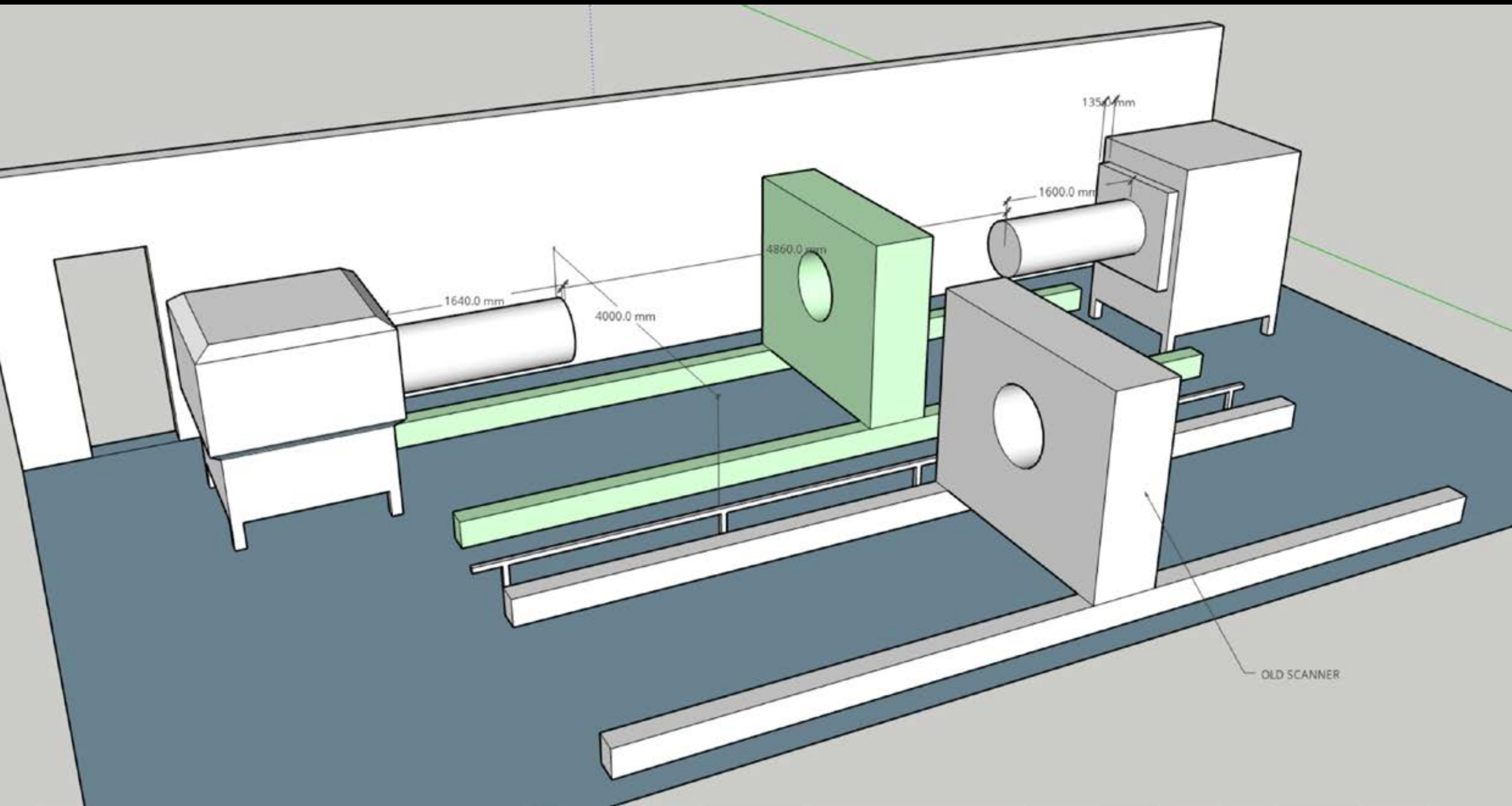




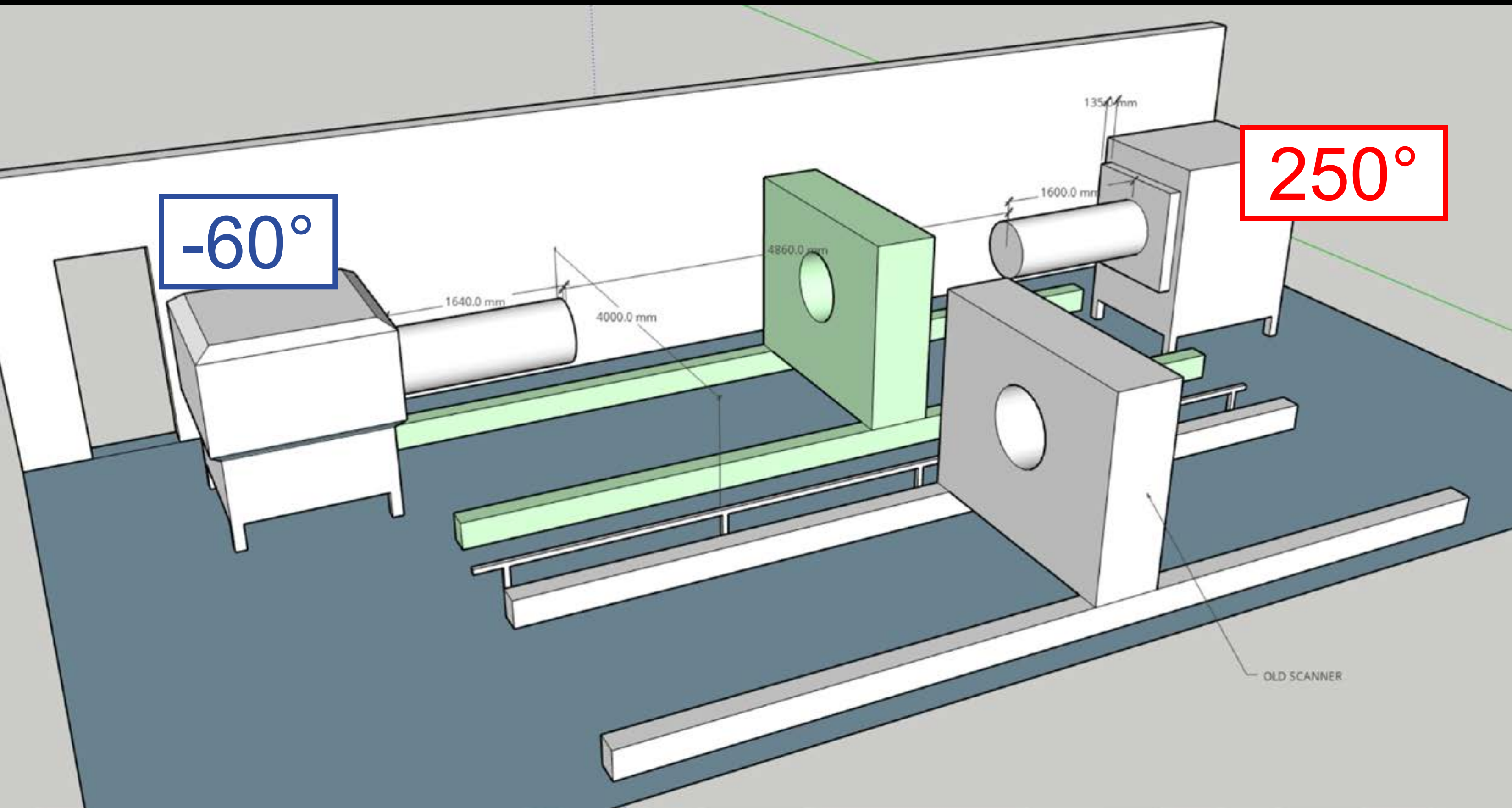
# VISION



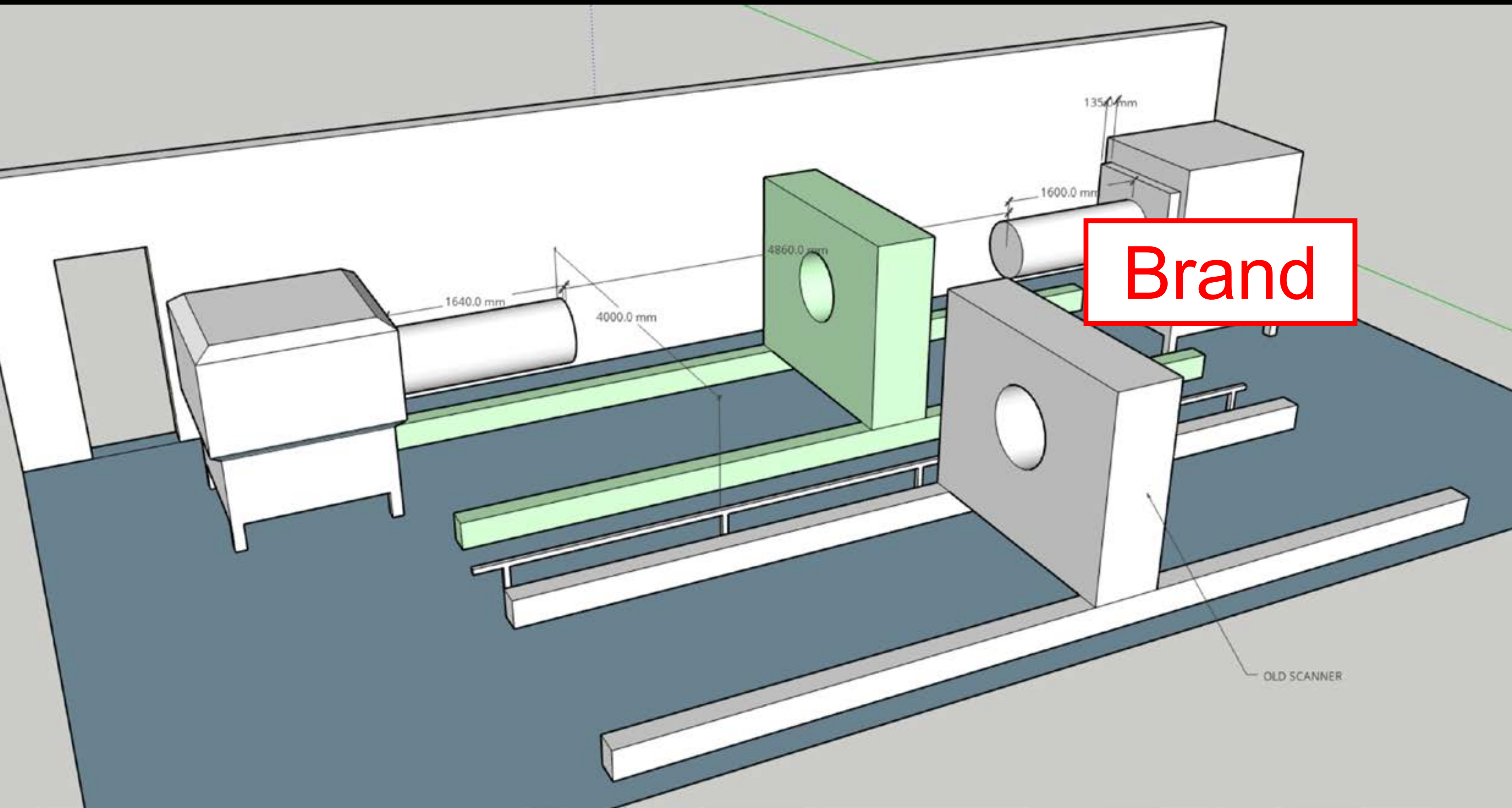
# LTU SKELLEFTEÅ



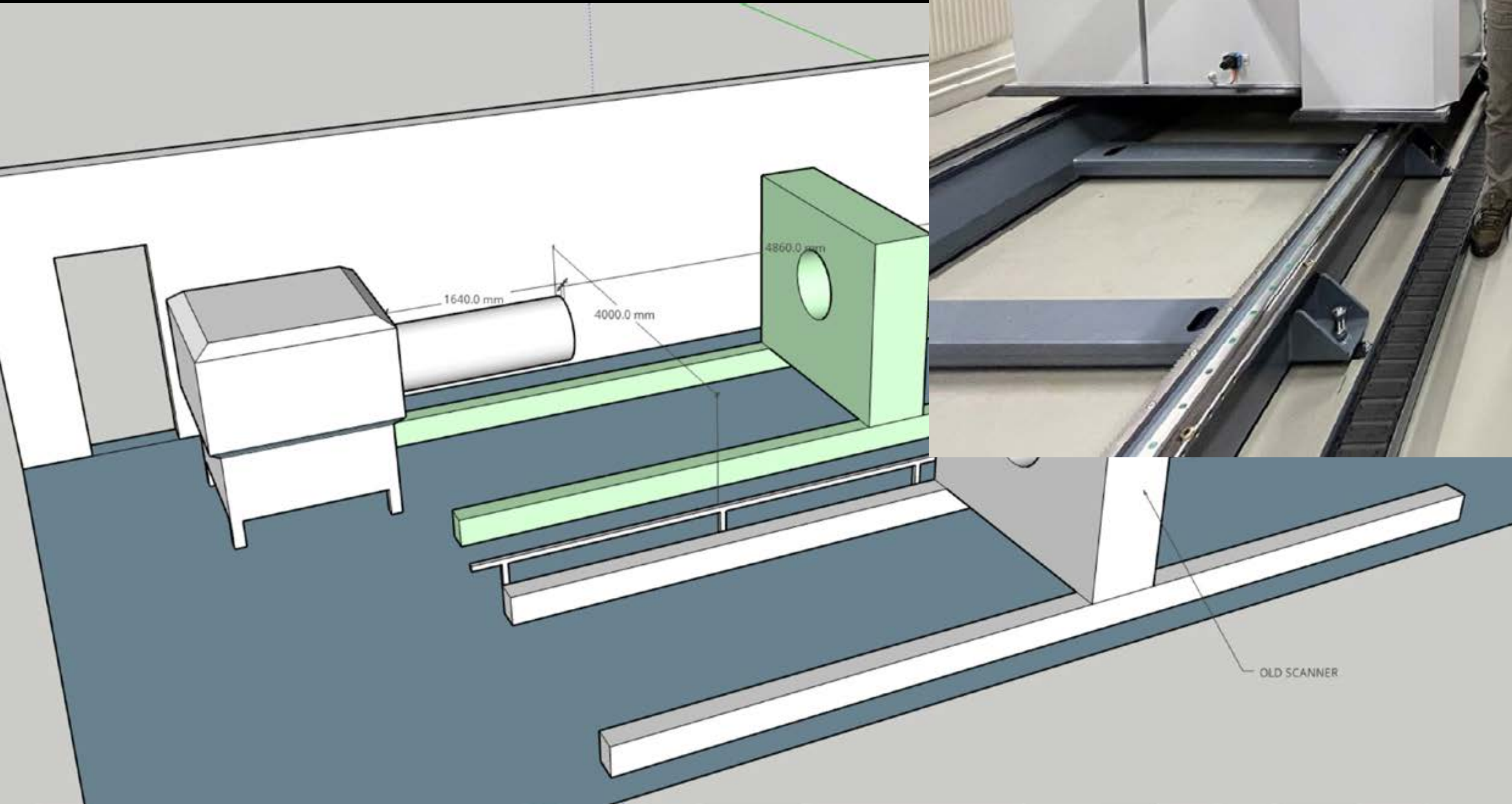
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TACK!



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