Reconstruction and Visualization of Fiber and Laminar Structure of the Human Heart

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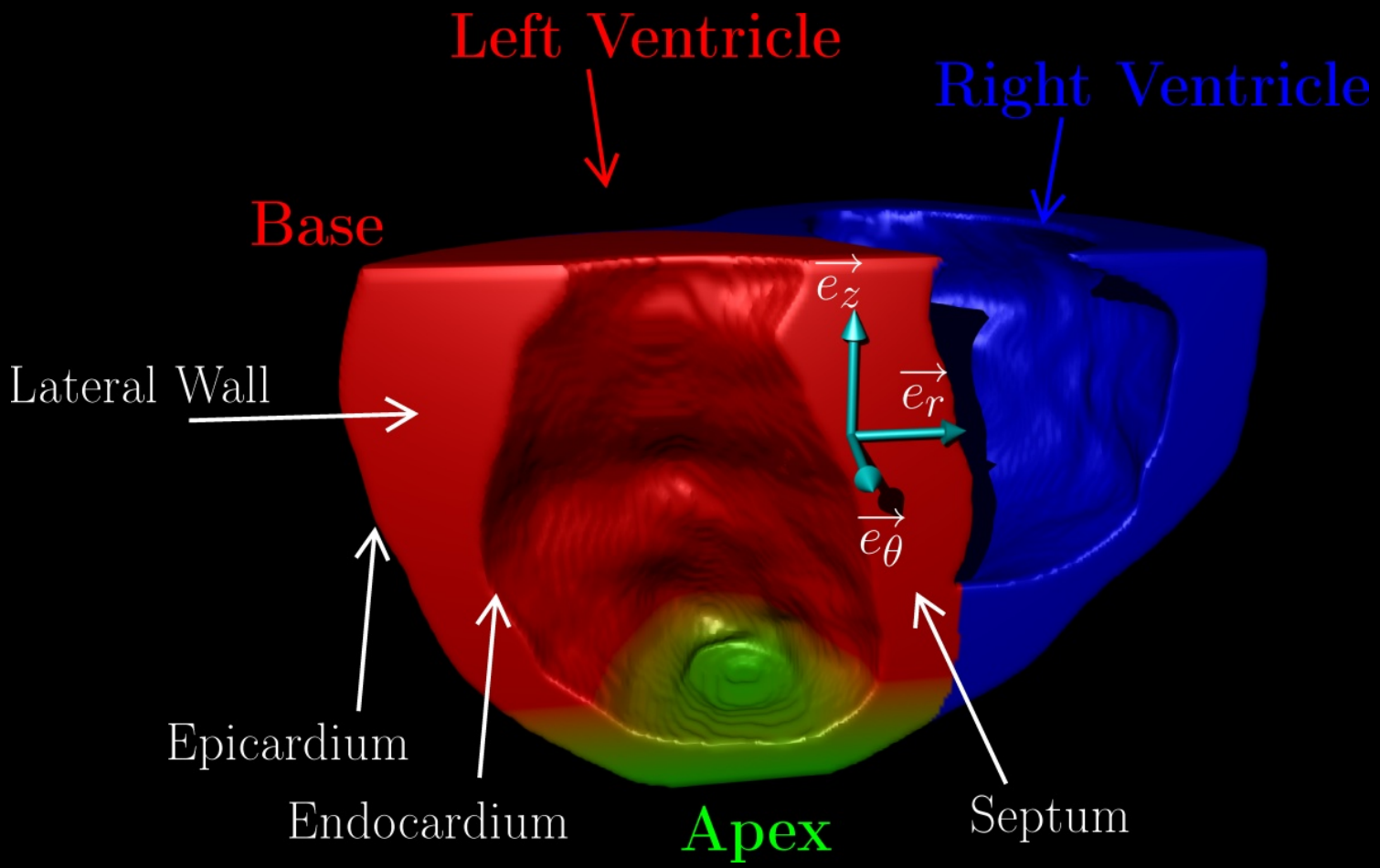
Summary

1. Structure of the heart
2. Diffusion Tensor
3. Fiber Tracking
4. Sheet Structure
5. Conclusion

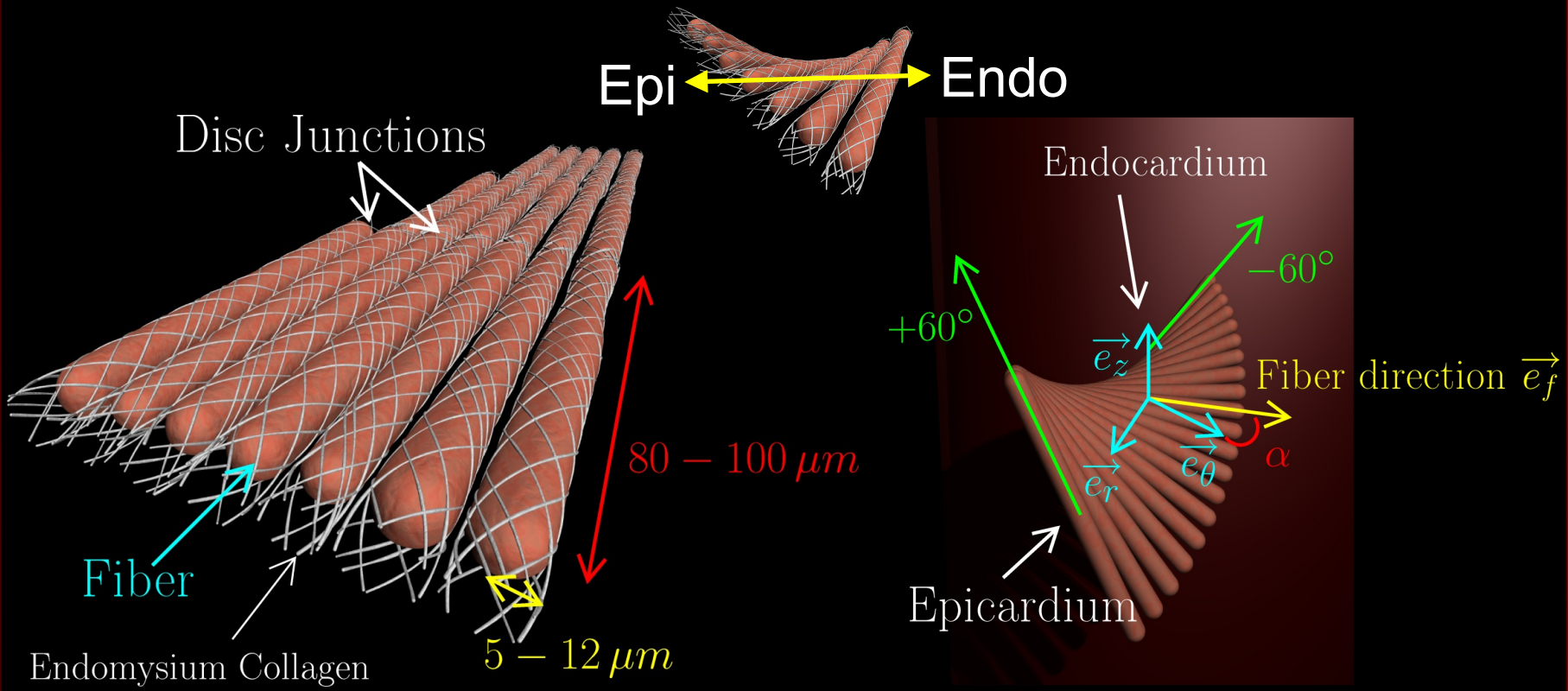
1. Structure of the heart

- **1. Introduction**



1. Structure of the heart

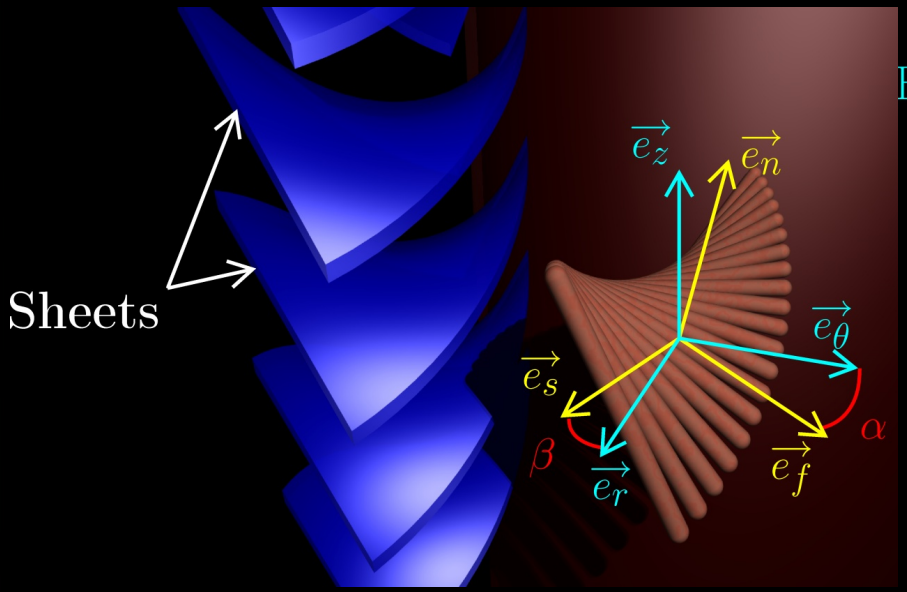
- **2. Fiber Structure**
  - **Physical Constitution**

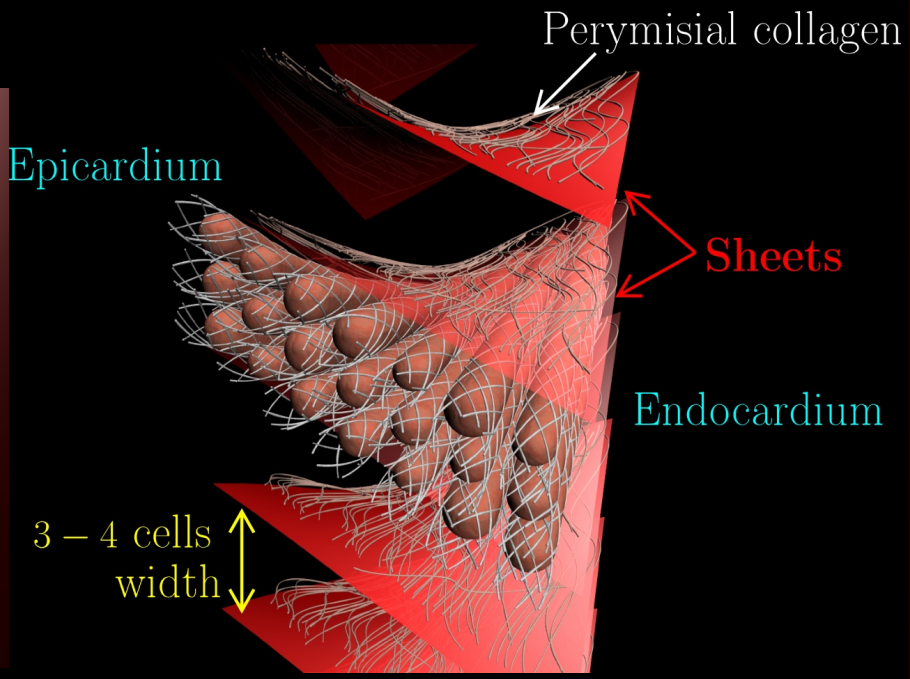


Collagen : Prevent Slippage rupture and overstretch. Mainly type I and III (62%).

1. Structure of the heart

- **3. Sheet Structure**
  - **General Orientation**





Arrangement of fibers in sheets stacked from apex to base.

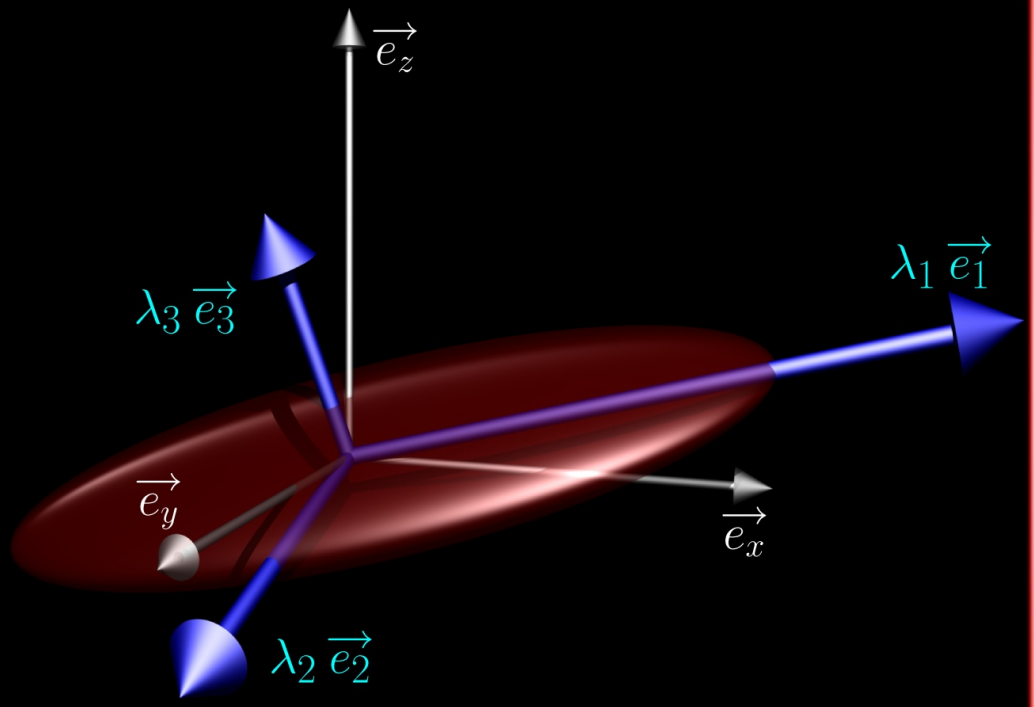
Physical separation by Perimysial collagen, Mainly Type I (72%) and III.

2. Diffusion Tensor

- **1. Introduction**

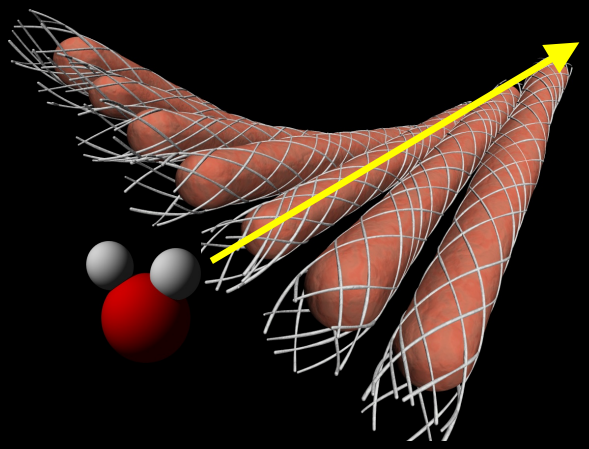
$$D = \begin{pmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{xy} & D_{yy} & D_{yz} \\ D_{xz} & D_{yz} & D_{zz} \end{pmatrix}$$

$$D = R\,\Lambda\,R^T$$
$$\Lambda = \mathrm{diag}\,(\lambda_1, \lambda_2, \lambda_3)$$
$$R = \left[\overrightarrow{e_1}, \overrightarrow{e_2}, \overrightarrow{e_3}\right]$$

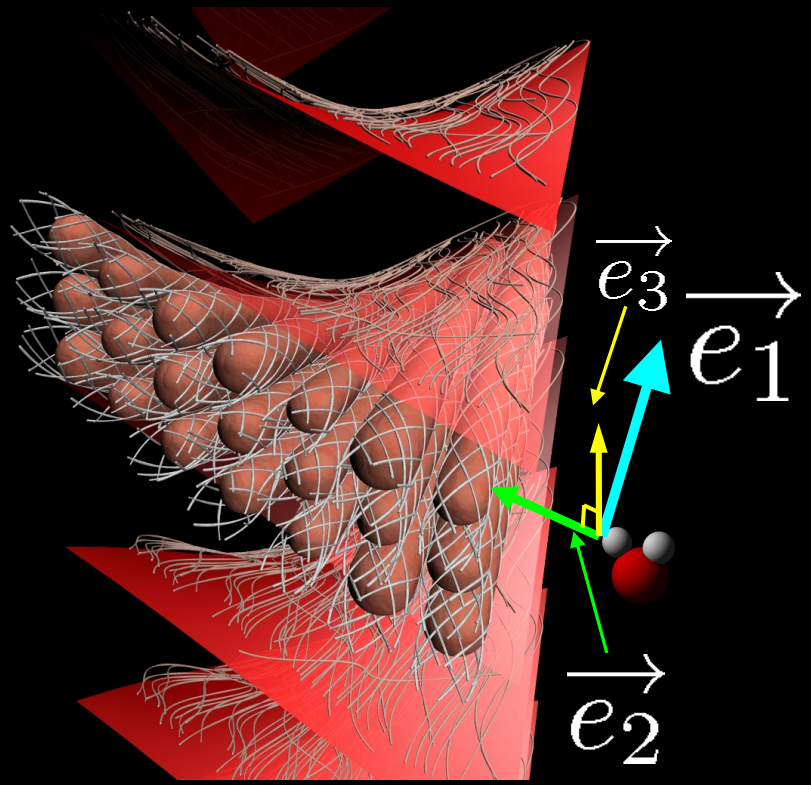


2. Diffusion Tensor

- **2. Link with Heart Structure**



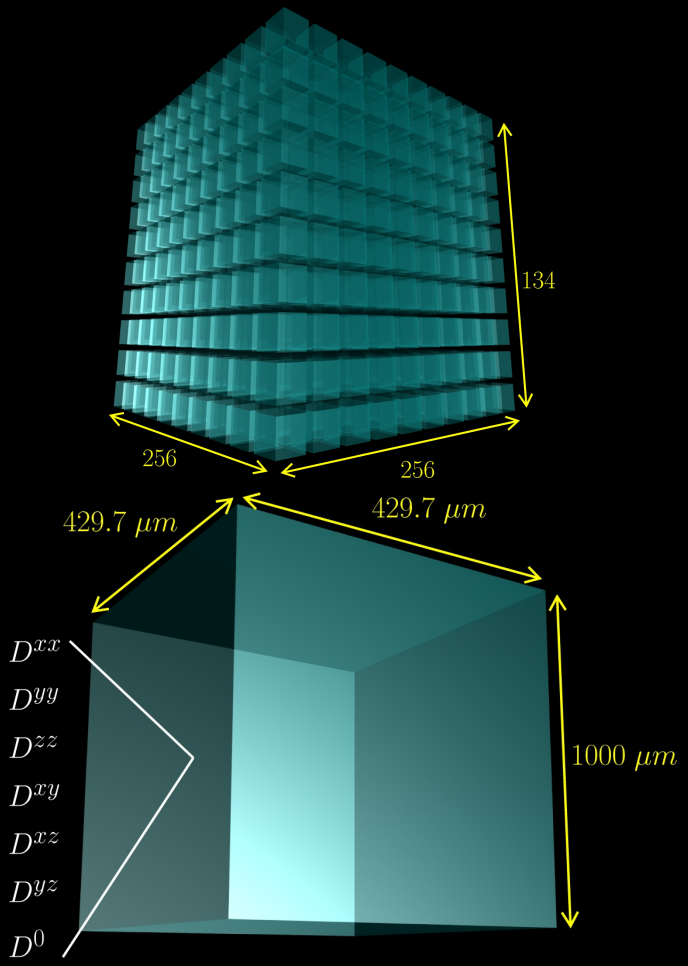
$$\overrightarrow{e_1} = \overrightarrow{e_f}$$

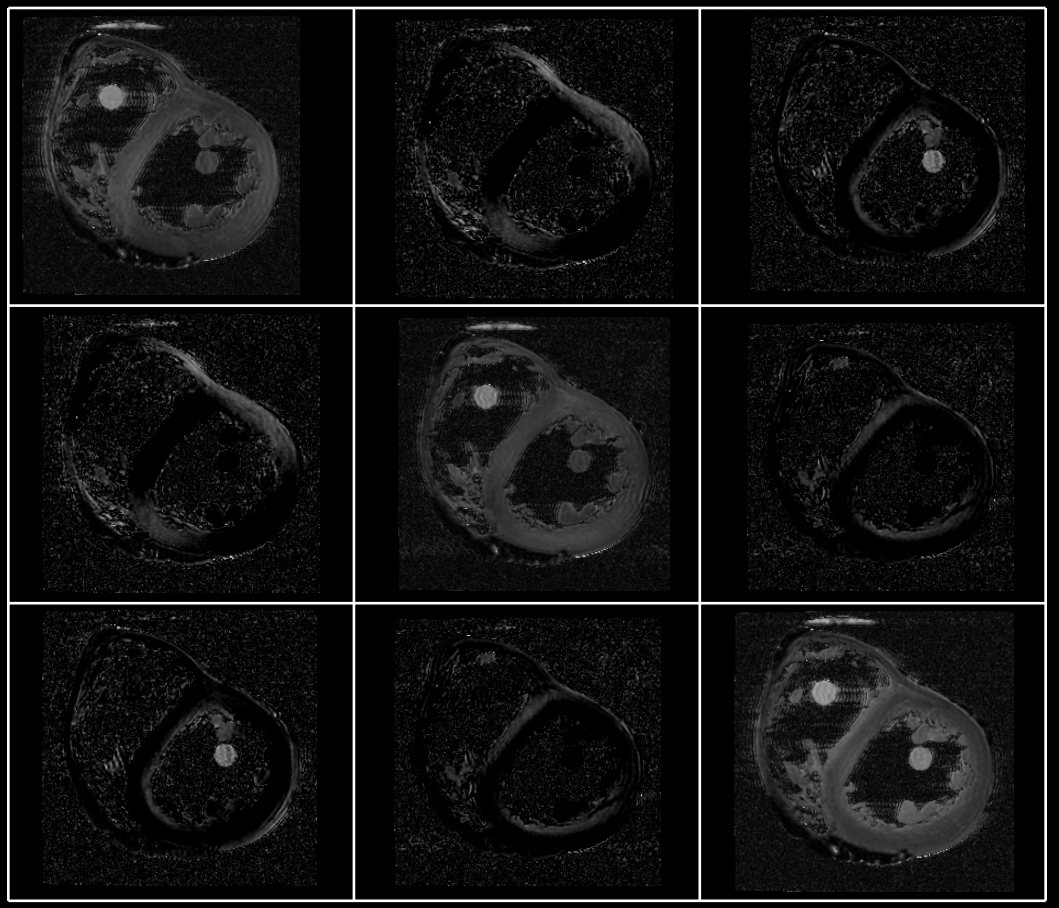


First Eigenvector is the Fiber Direction
Second Eigenvector is Inside the Sheet
Third Eigenvector is Normal to the Sheet

2. Diffusion Tensor

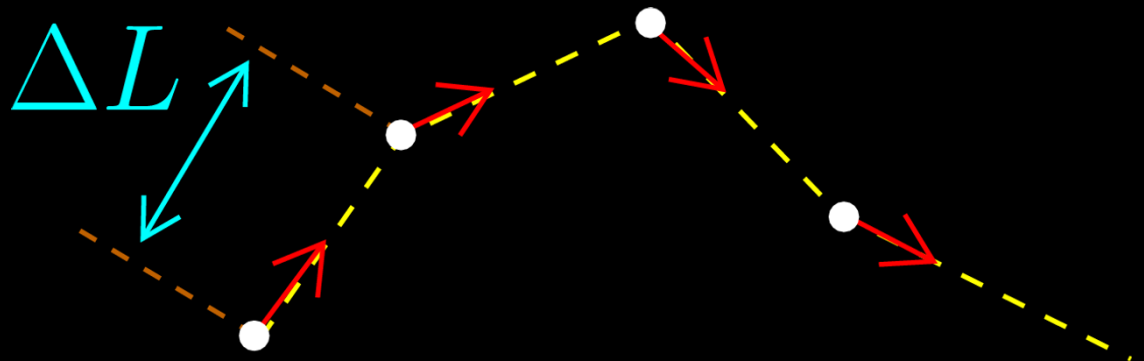
- **3. Data** Raimond Winlsow at The Center for Cardiovascular Bioinformatics and Modeling. Johns Hopkins.

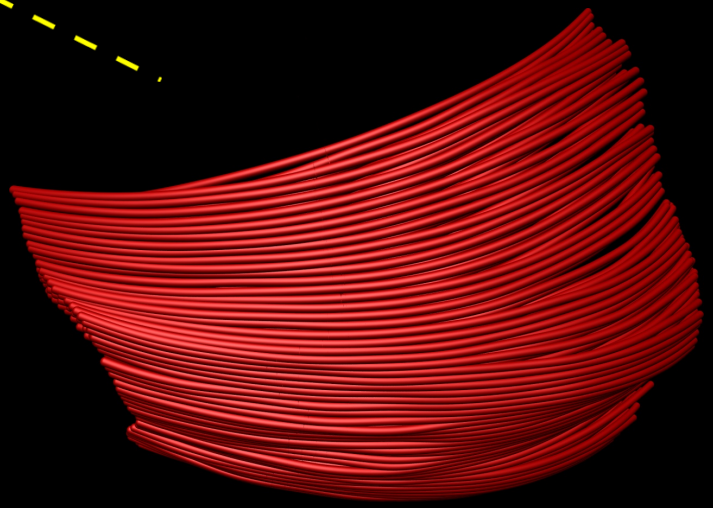




3. Fiber Tracking

- **1. Introduction**



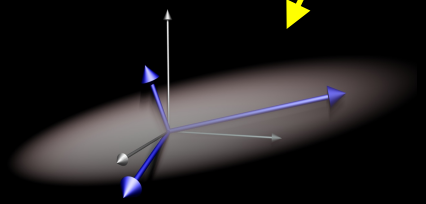


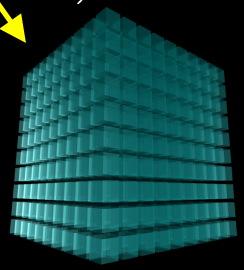
$$s(t) = s(0) + \int_0^t \mathbf{e}_1\Big(s(\tau)\,\mathrm{d}\tau\Big)$$

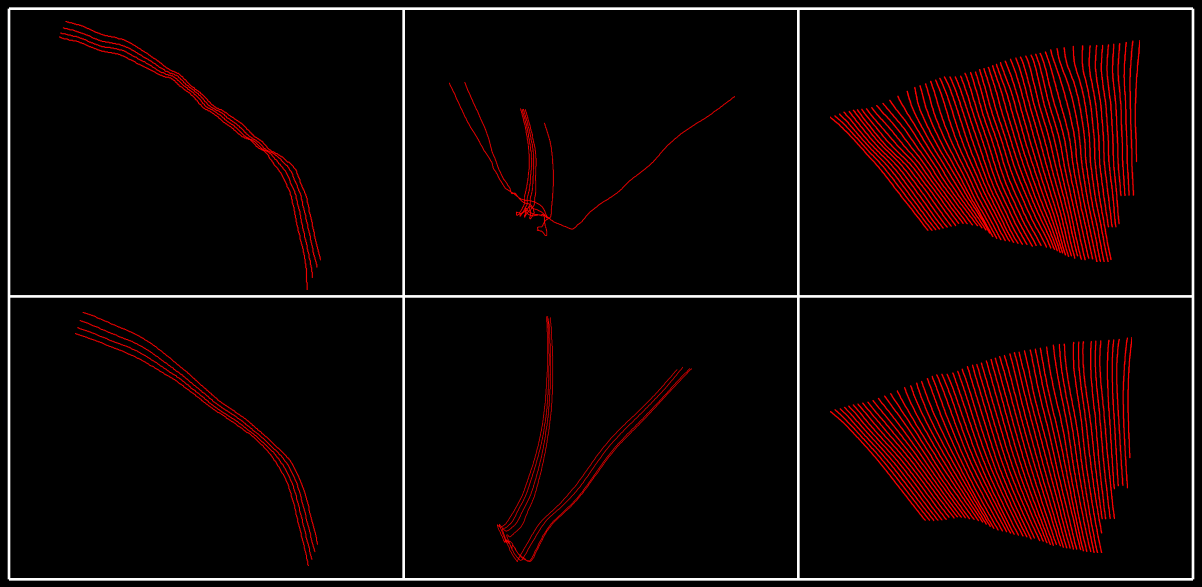
3. Fiber Tracking

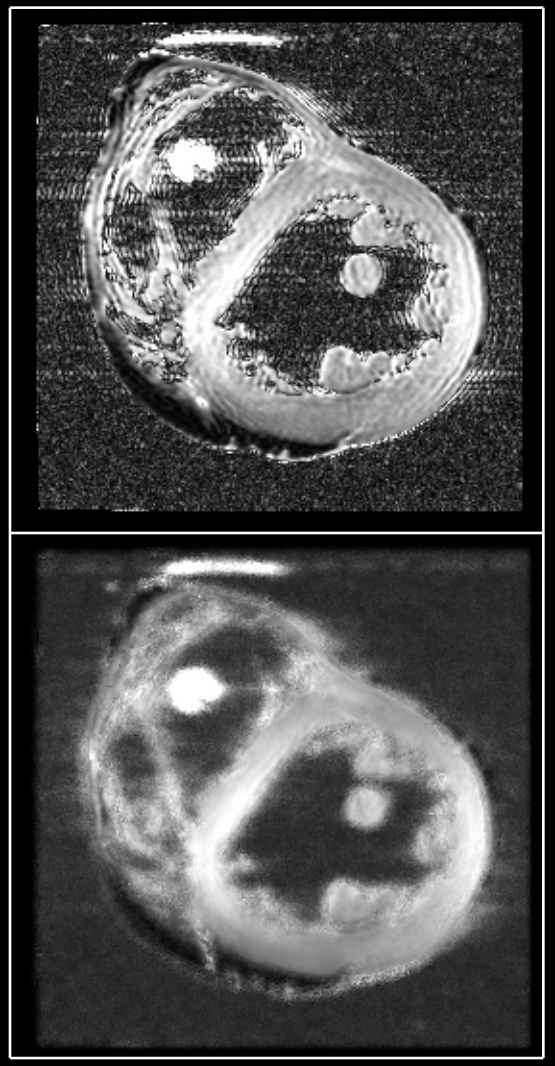
- **2. Regularization MLS**

$$E(\mathbf{x}) = \int_{\mathbf{y}\in\mathbb{R}^3} G(\mathbf{y}-\mathbf{x})\left(\tilde{D}(\mathbf{y}-\mathbf{x}) - D(\mathbf{y})\right)^2 \mathrm{d}\mathbf{y}$$



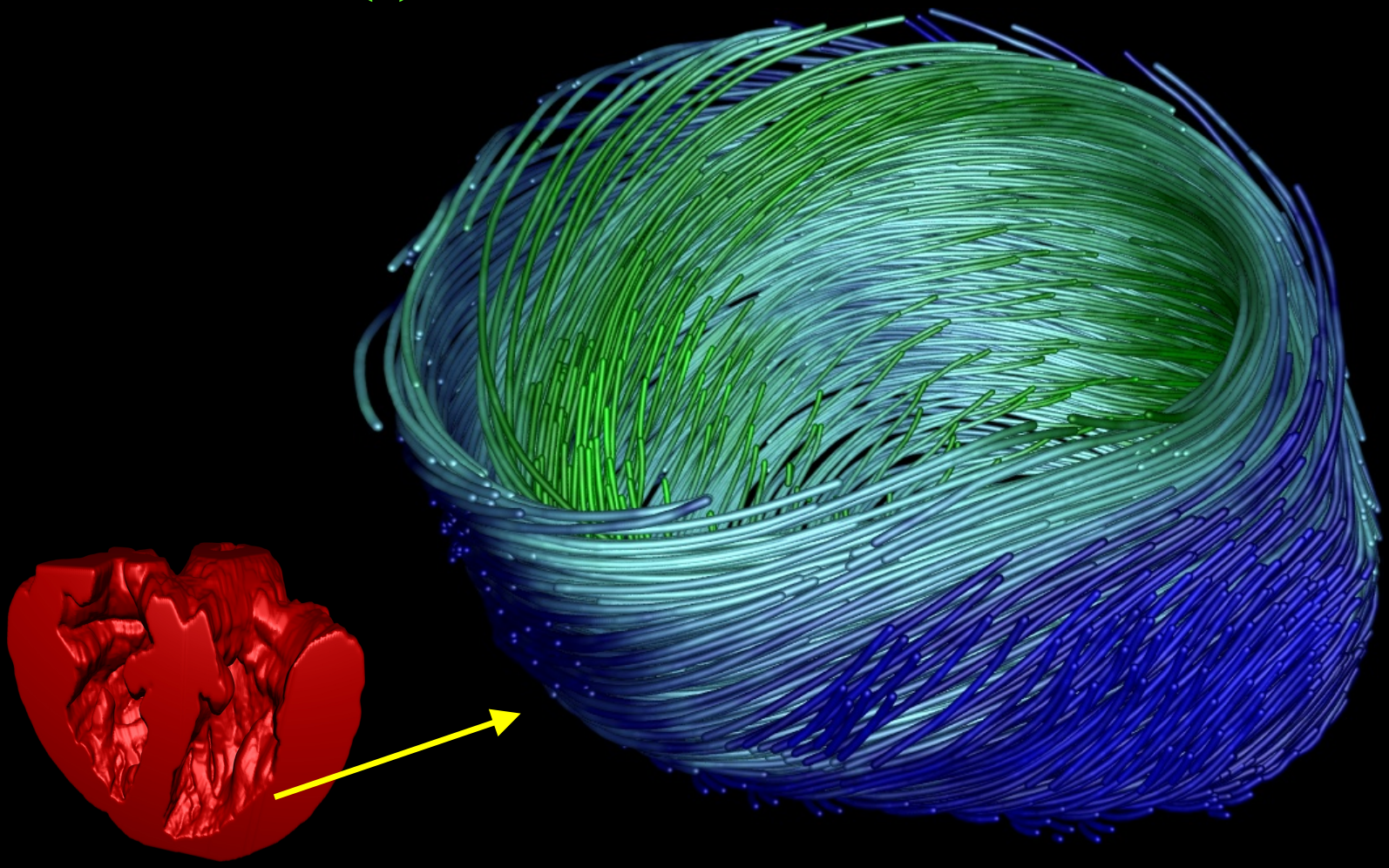






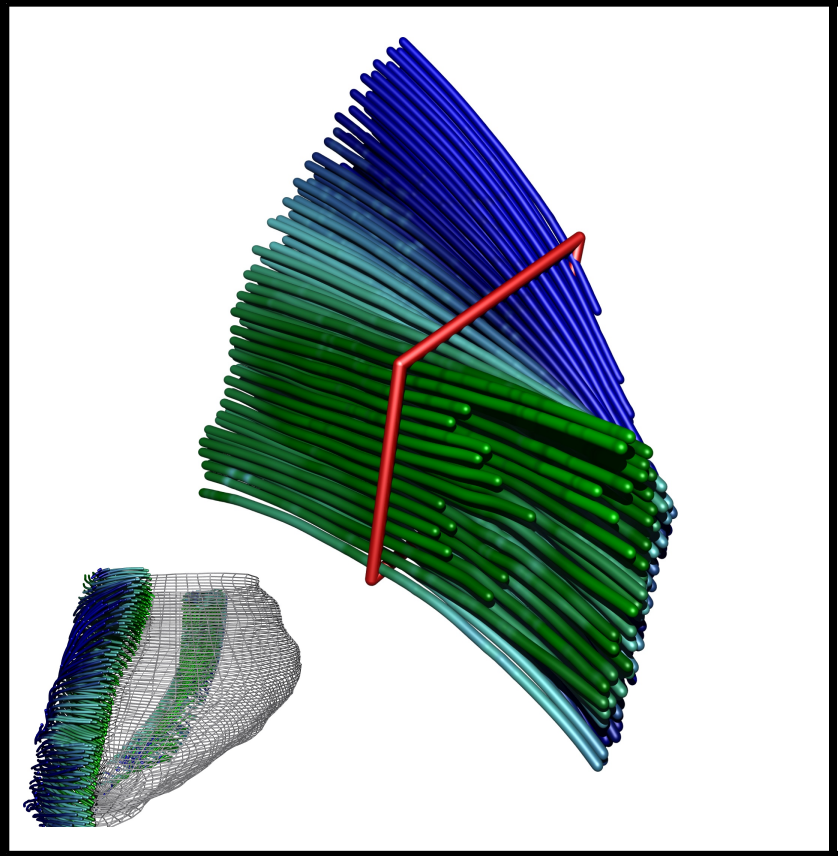
3. Fiber Tracking

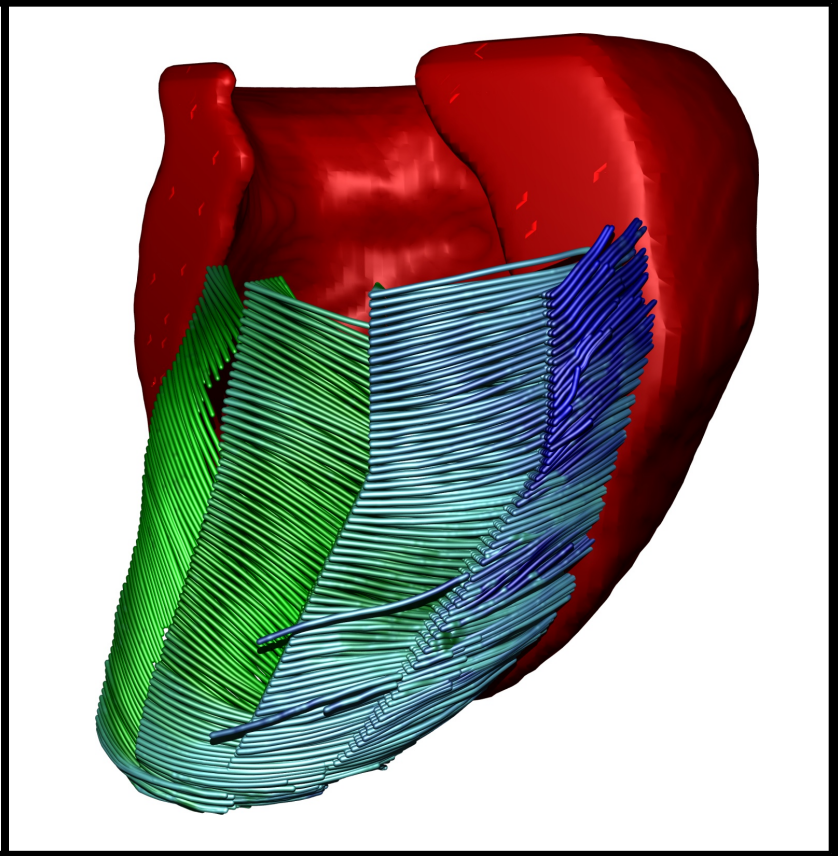
- **3. Results (I)**



3. Fiber Tracking

- 3. Results (II)

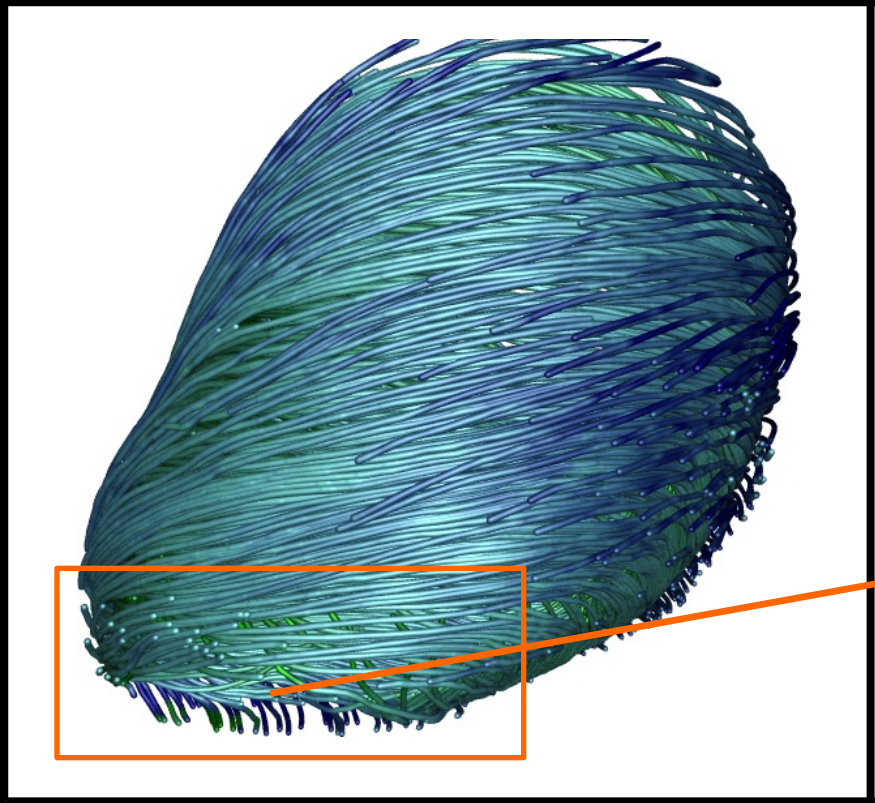


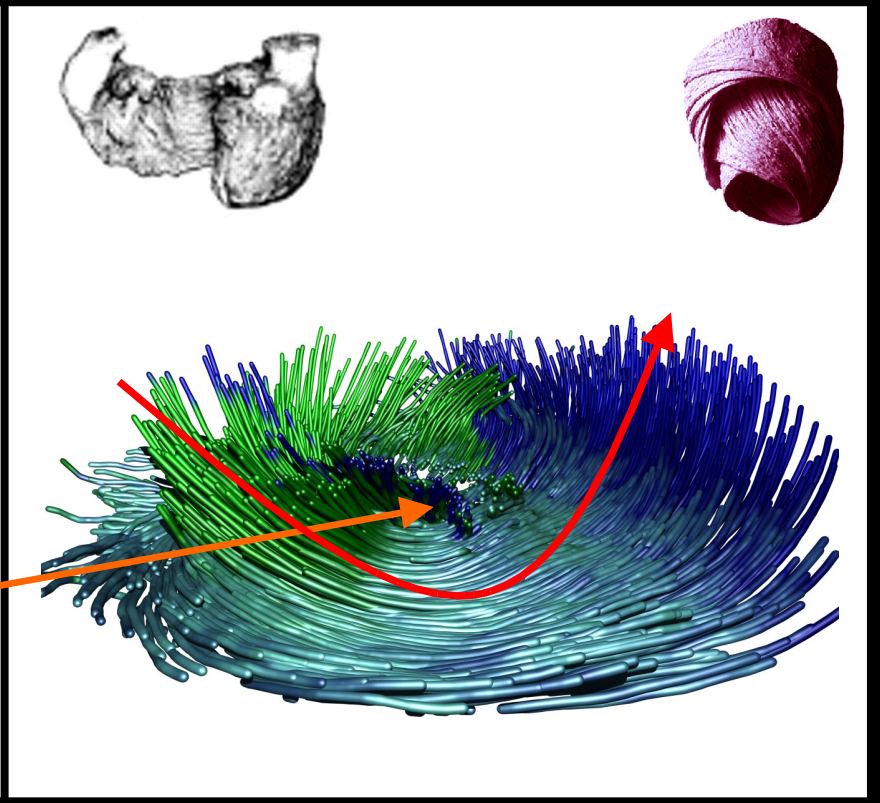


3. Fiber Tracking

- **3. Results (III)**

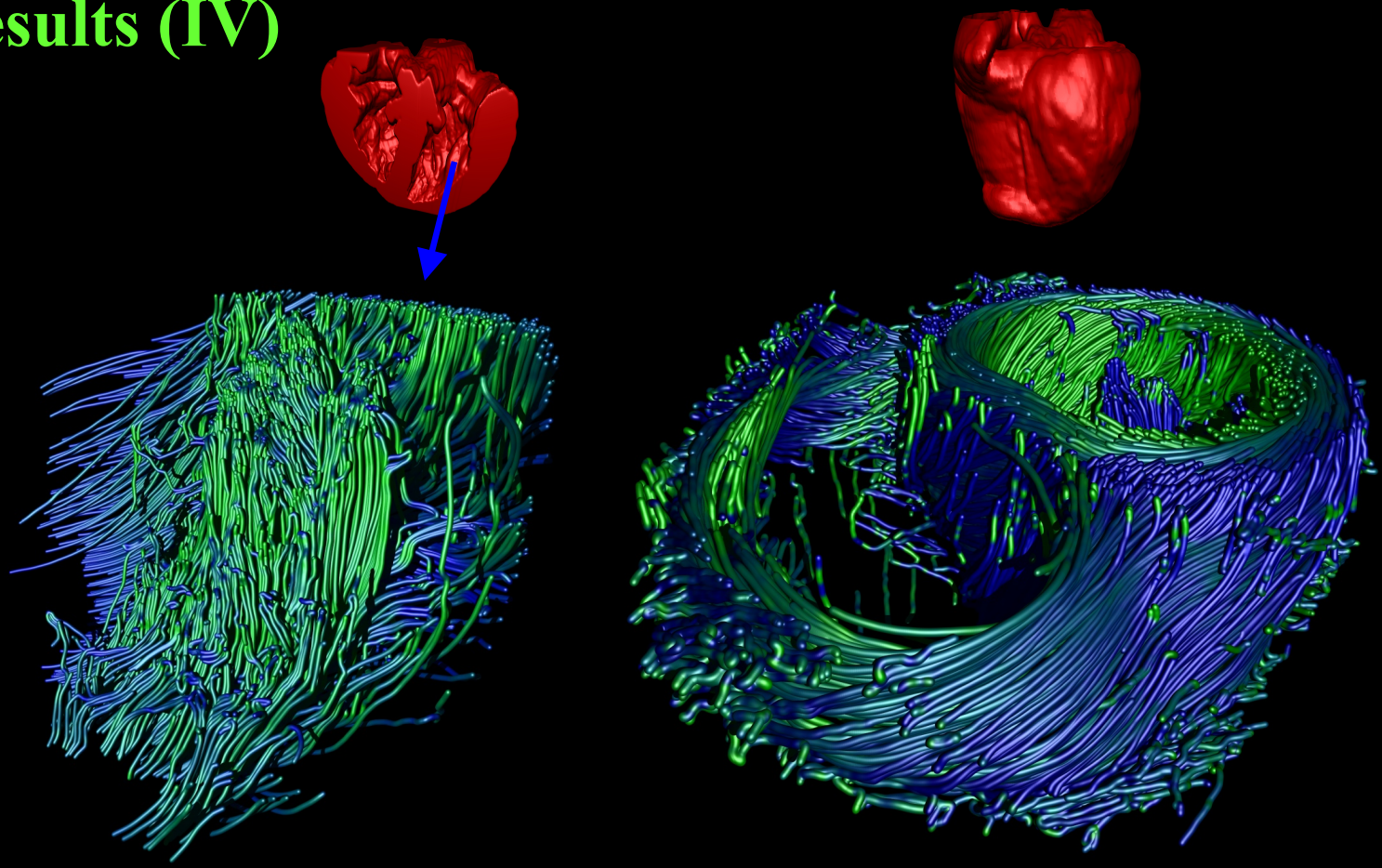
Hypothesis : Torrent-Guasp et al.
Cardio-Thoracic surgery 2005





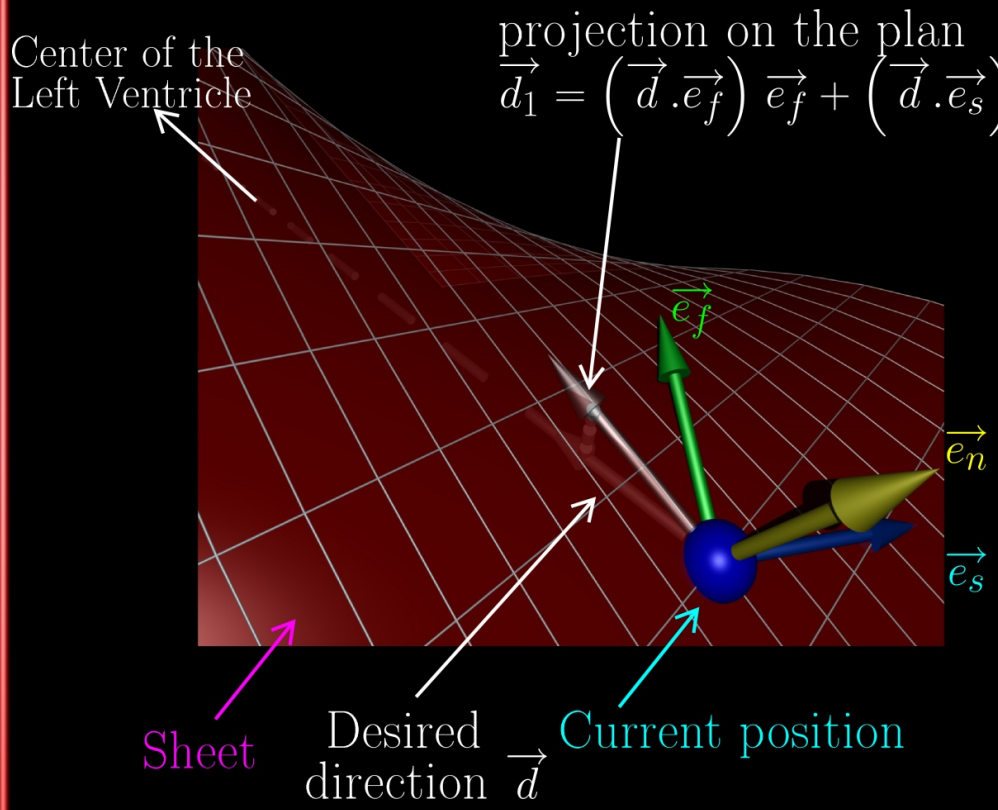
3. Fiber Tracking

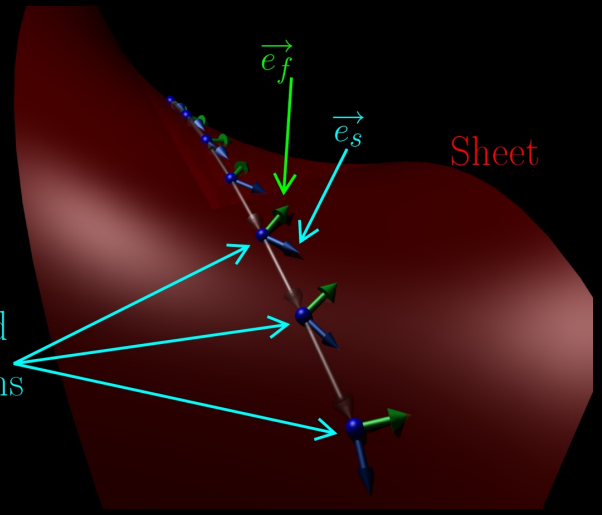
- **3. Results (IV)**

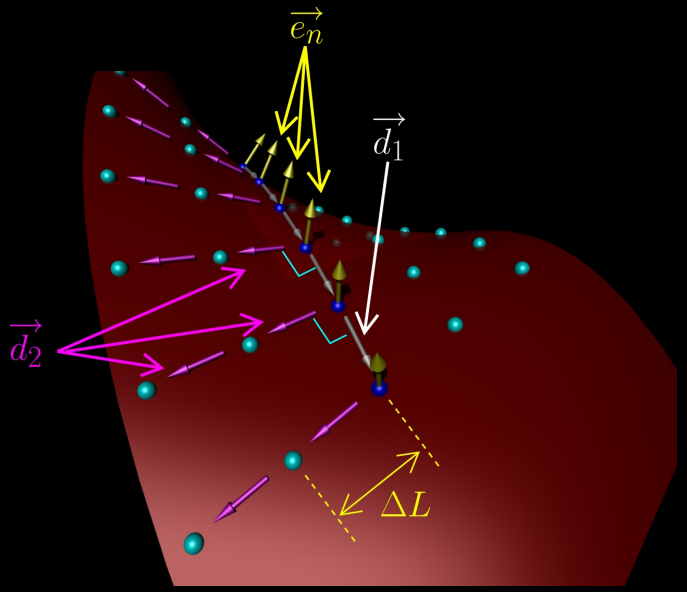


3. Sheet Structure

- **1. Reconstruction**

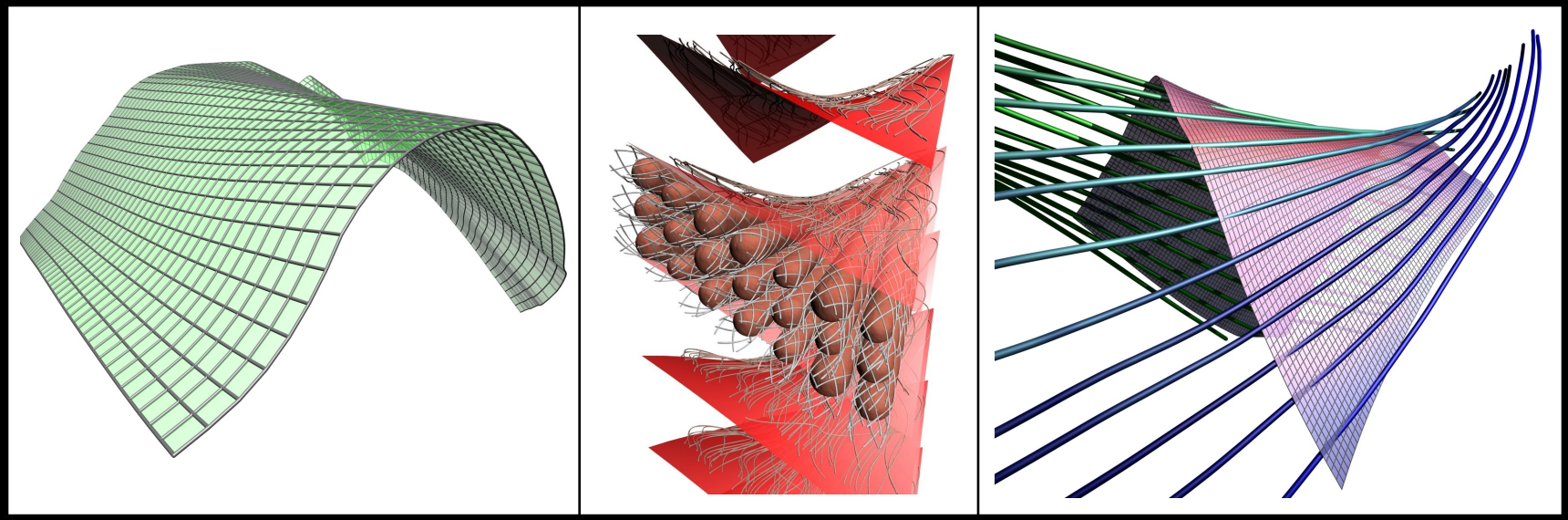






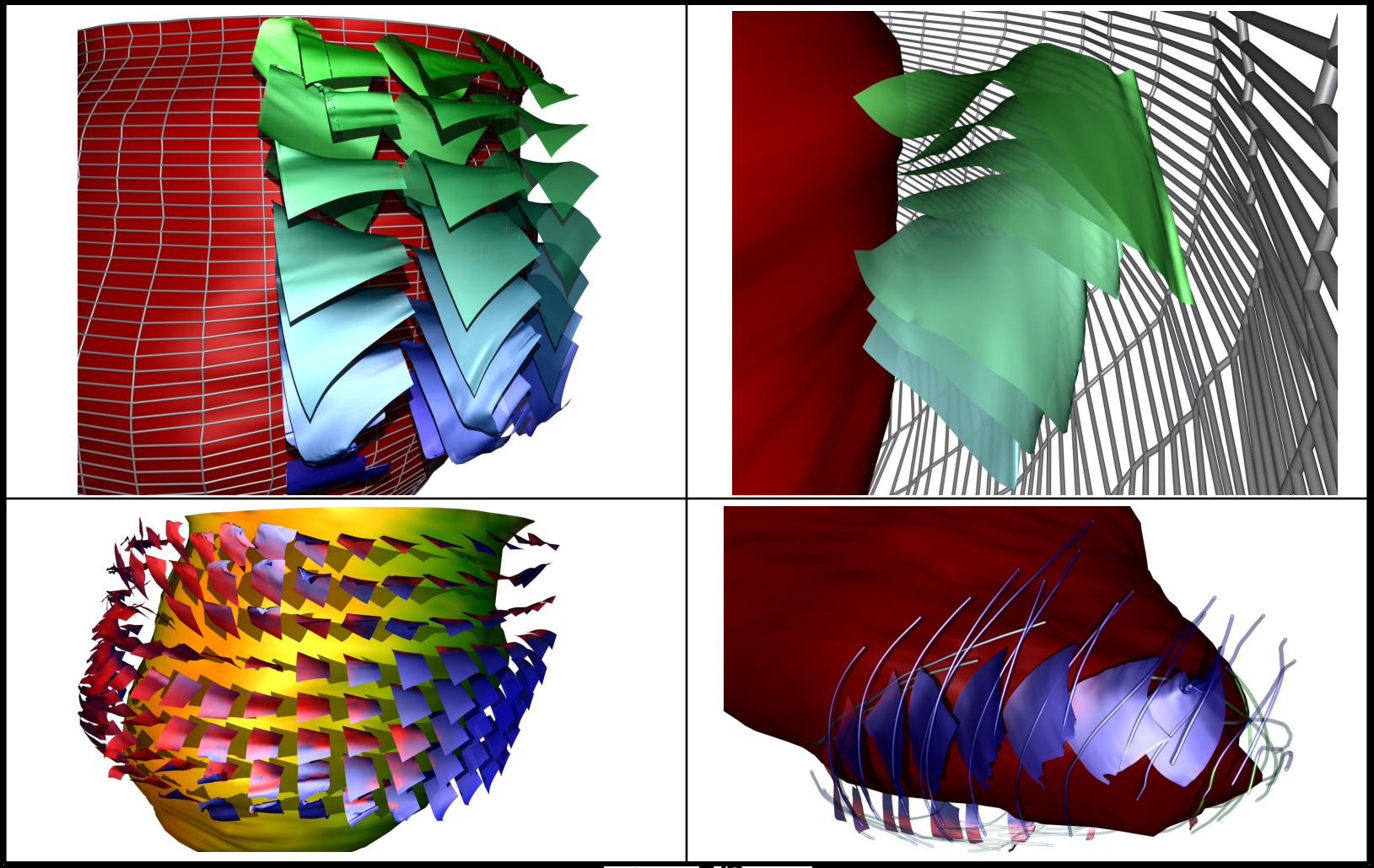
3. Sheet Structure

- 2. Results (I)

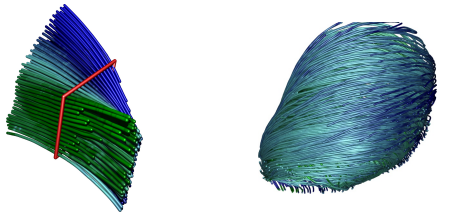
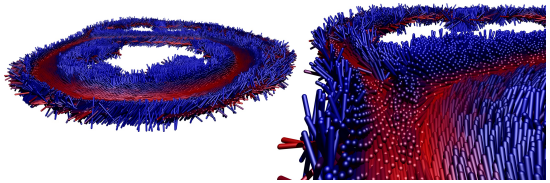


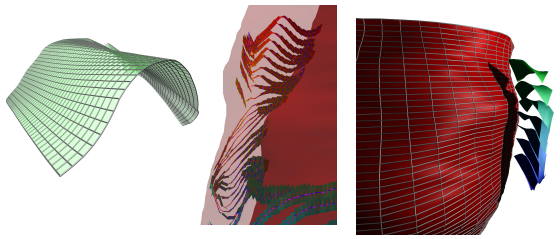
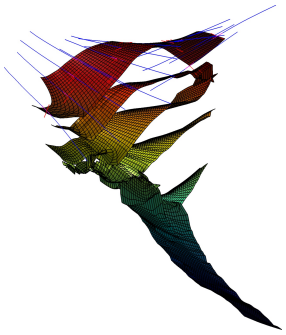
3. Sheet Structure

- 2. Results (II)



4. Conclusion

Results	•Smooth Results with MLS •Fit to the model (goes to +90º to -90º)	
Future Work	•Fiber tracking in the whole heart (papillary muscles, right ventricle) •Validation of the Band Theory (Torrent-Guasp)	

Results	•Smooth in the some regions •Correspond to the measurements in those regions	
Future Work	•Geometry is complex (cross section is not always the best direction) •Noise level (inversion, noise at the boundaries) •Need a check on the normal direction	

Acknowledgment

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