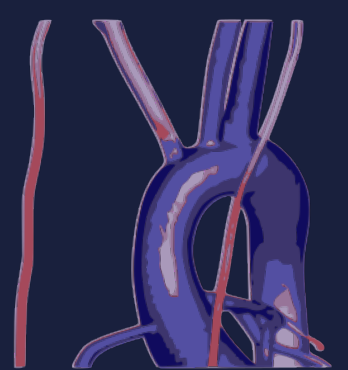
TUBULAR PARTITIONS

PEER-TIMO BREMER
SHANE SCOTT
AUGUST 2017



MOTIVATION
HARVEY

models blood flow in patient-specific geometries
uses 1.6 million computational cores
potential to detect strokes and vascular disorder
informs next generation drug delivery

CHALLENGE
LOAD BALANCING

spatial density of vascular geometry varies wildly
may assign cores an uneven number of computation
unbalanced load bottlenecks simulation speed
boundary and interior elements require uneven computations

PROBLEM

given an embedding of the sphere into 3-space

$$\mathbb{S}^2 \hookrightarrow \mathbb{R}^3$$

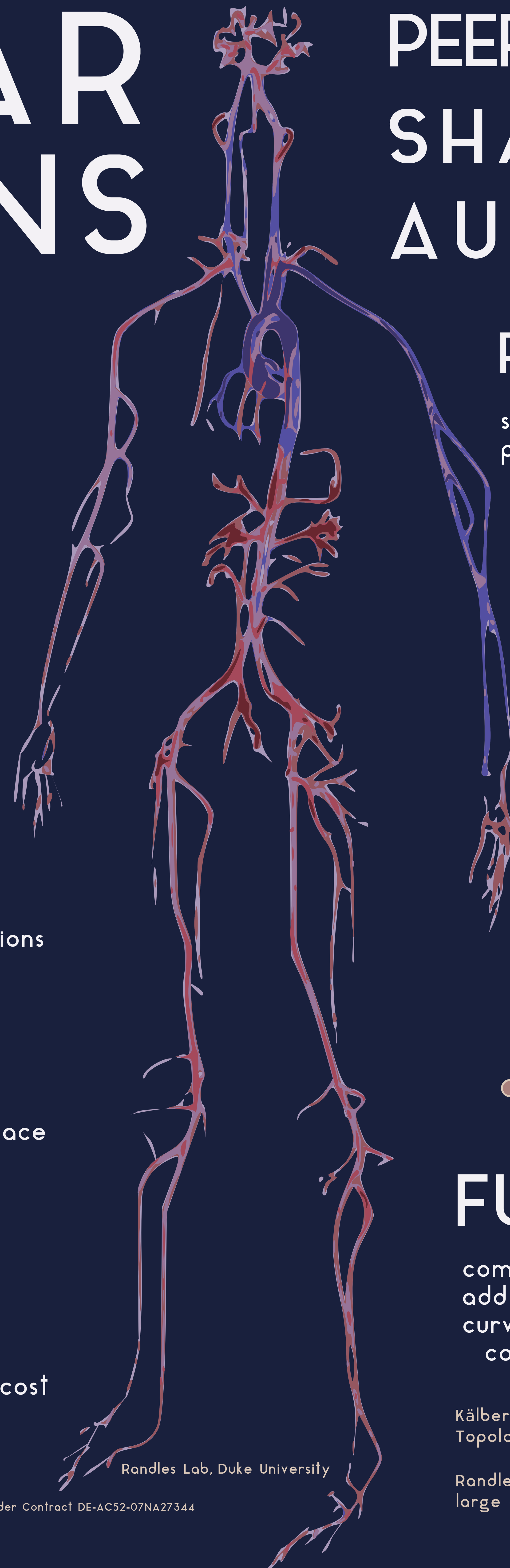
costs associated to area and volume

$$c_A \quad c_V$$

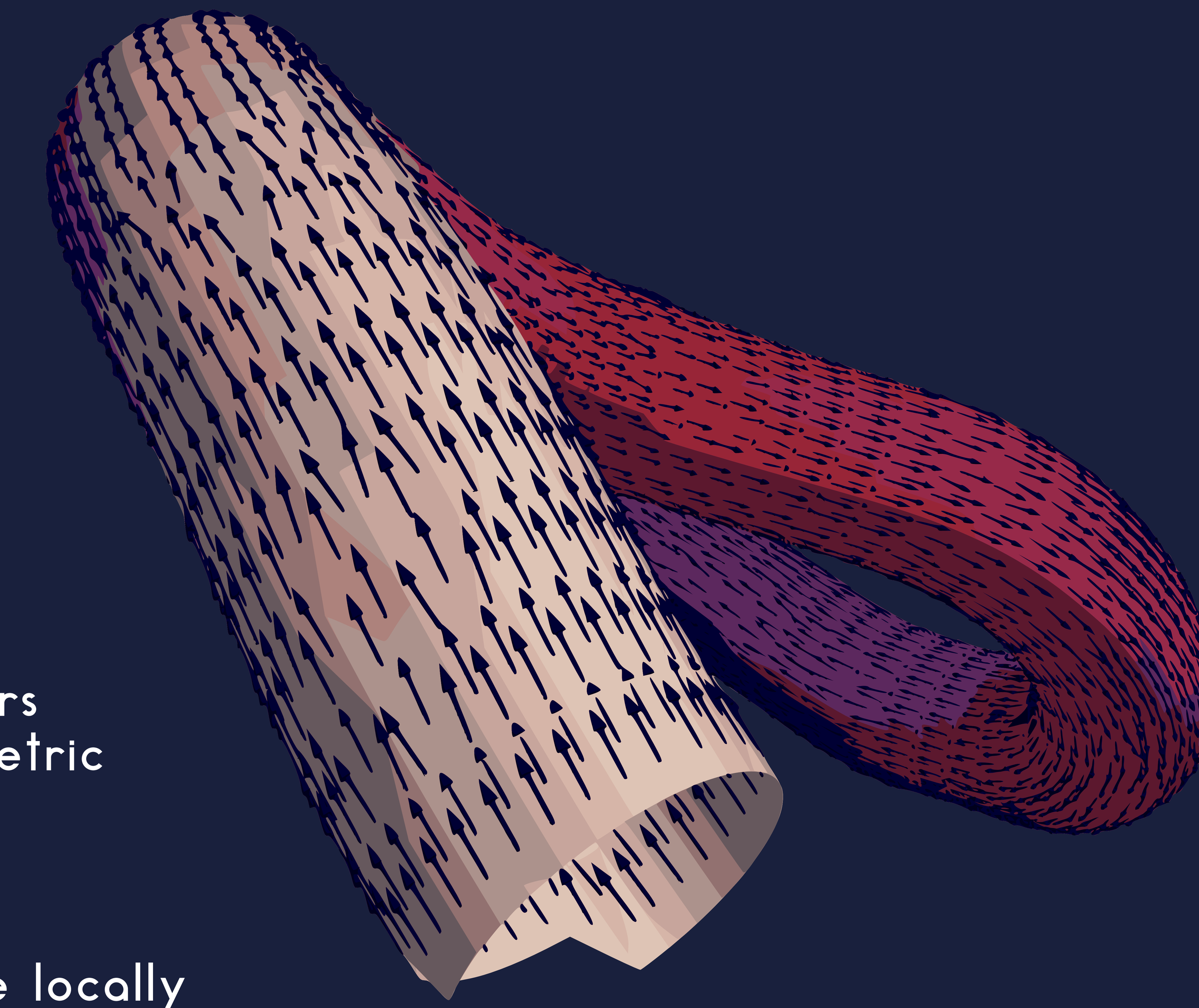
and an integer

$$N$$

partition the sphere into N pieces of equal cost



Randles Lab, Duke University

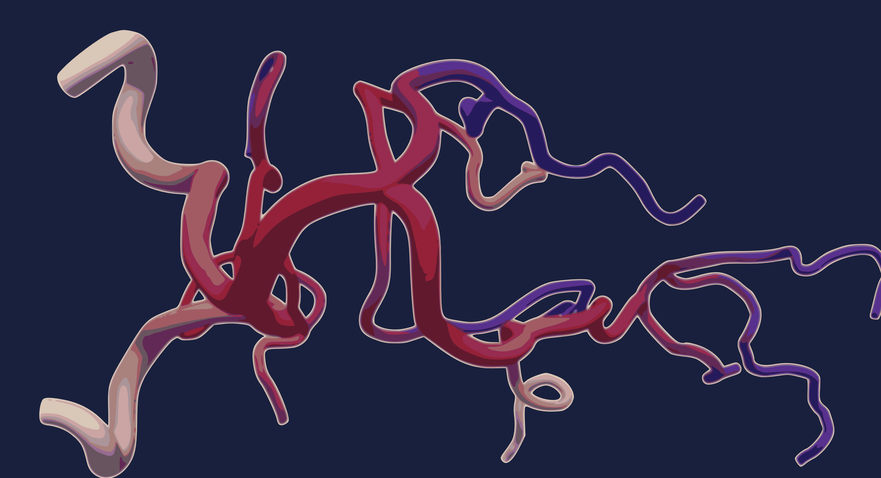


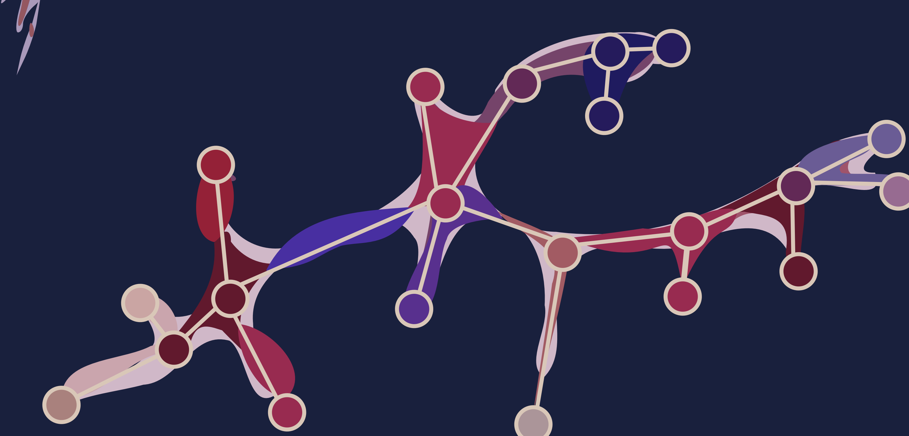
PARAMETRIZATION

surface is approximately a union of cylinders
parametrize surface as the product of a metric
tree and a circle away from vertices

$$T \times \mathbb{S}^1$$

compute the direction of least curvature locally
integrate to obtain a function parametrizing T
connected components of level sets give circles





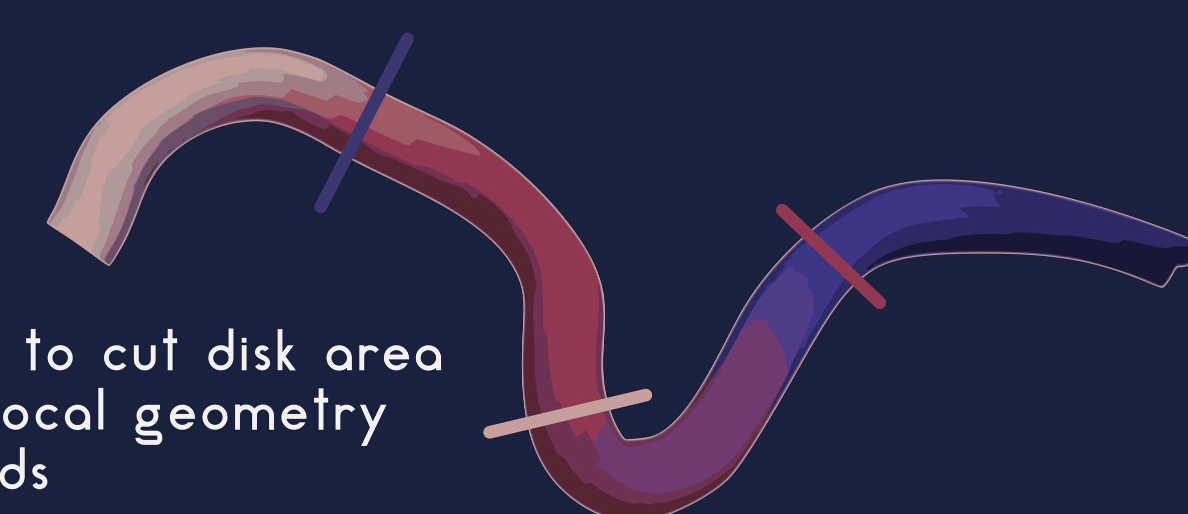
PARTITION

compute length l_x and bounding area A_x of level
set component at x
obtain a measure on the edges of T

$$dm = (c_A l_x + c_V A_x)\ dx$$

integrate along paths from a root to partition the tree
into components of measure $1/N$
partition of the tree lifts to partition of the surface
cutting along closed curves

FUTURE WORK



comparison to current load balancing
add cost of core communication proportional to cut disk area
curvature computation is sensitive to noisey local geometry
consider alternative parametrization methods

Kälberer, Felix, Matthias Nieser, and Konrad Polthier. "Stripe parameterization of tubular surfaces." Topological Methods in Data Analysis and Visualization. Springer Berlin Heidelberg, 2011. 13-26.

Randles, Amanda, Erik W. Draeger, and Peter E. Bailey. "Massively parallel simulations of hemodynamics in the primary large arteries of the human vasculature." Journal of Computational Science 9 (2015): 70-75.

Release Number: LLNL-POST-735267
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344