

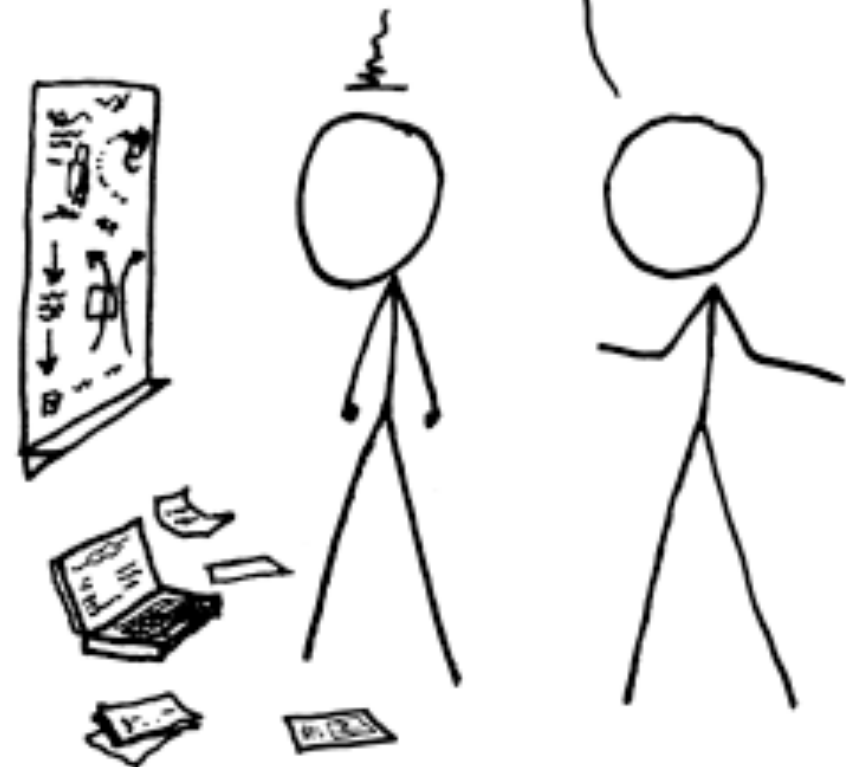
# Computational Modeling with VPython

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YOU'RE TRYING TO PREDICT THE BEHAVIOR  
OF <COMPLICATED SYSTEM>? JUST MODEL  
IT AS A <SIMPLE OBJECT>, AND THEN ADD  
SOME SECONDARY TERMS TO ACCOUNT FOR  
<COMPLICATIONS I JUST THOUGHT OF>.

EASY, RIGHT?


SO, WHY DOES <YOUR FIELD> NEED  
A WHOLE JOURNAL, ANYWAY?



LIBERAL-ARTS MAJORS MAY BE ANNOYING SOMETIMES,  
BUT THERE'S *NOTHING* MORE OBNOXIOUS THAN  
A PHYSICIST FIRST ENCOUNTERING A NEW SUBJECT.






# What is Computational Modeling?



# WolframAlpha



WolframAlpha<sup>®</sup> computational knowledge engine

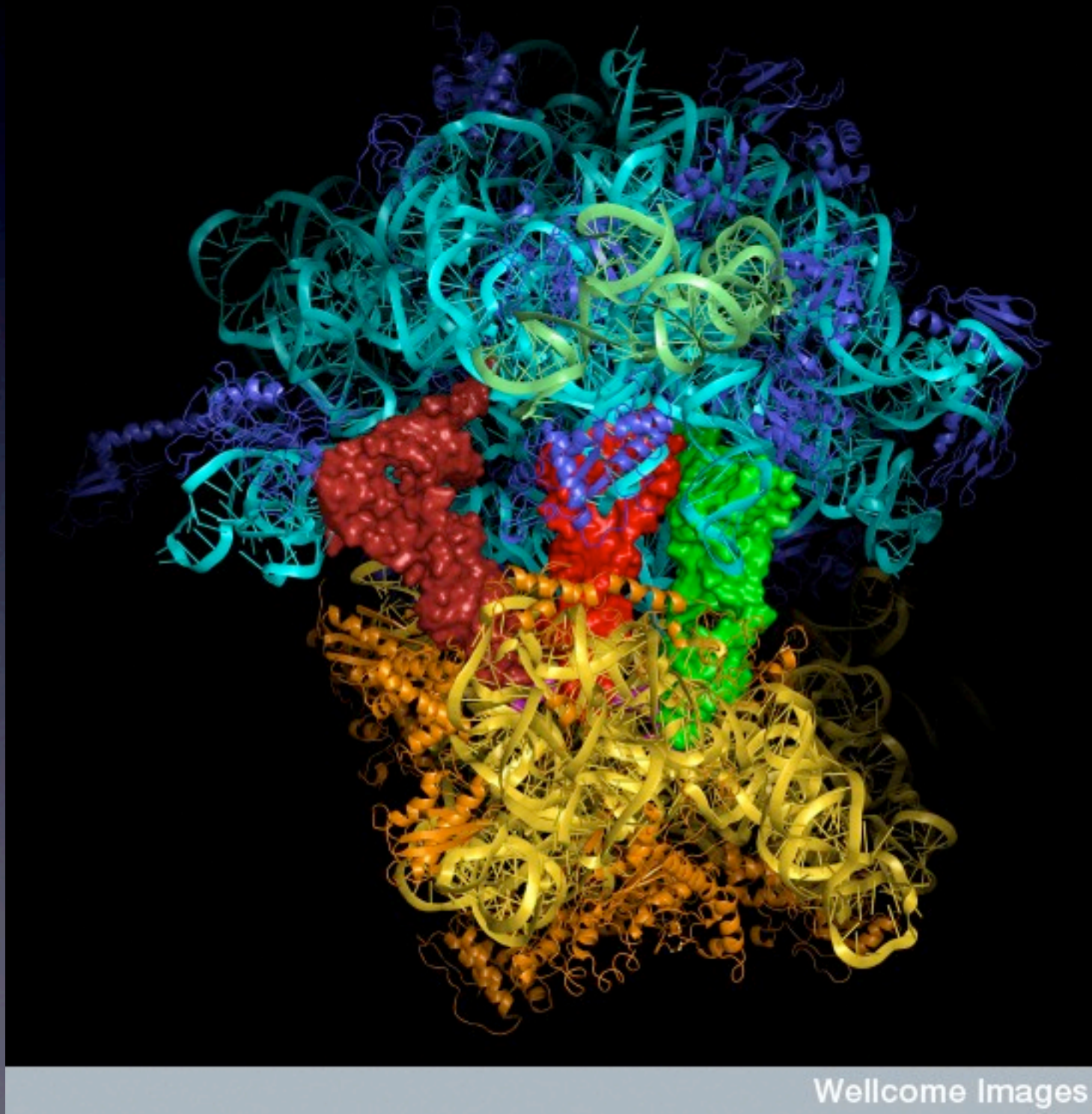
Enter what you want to calculate or know about:



 Examples  Random



# Molecular Models





# Examples from Fermilab

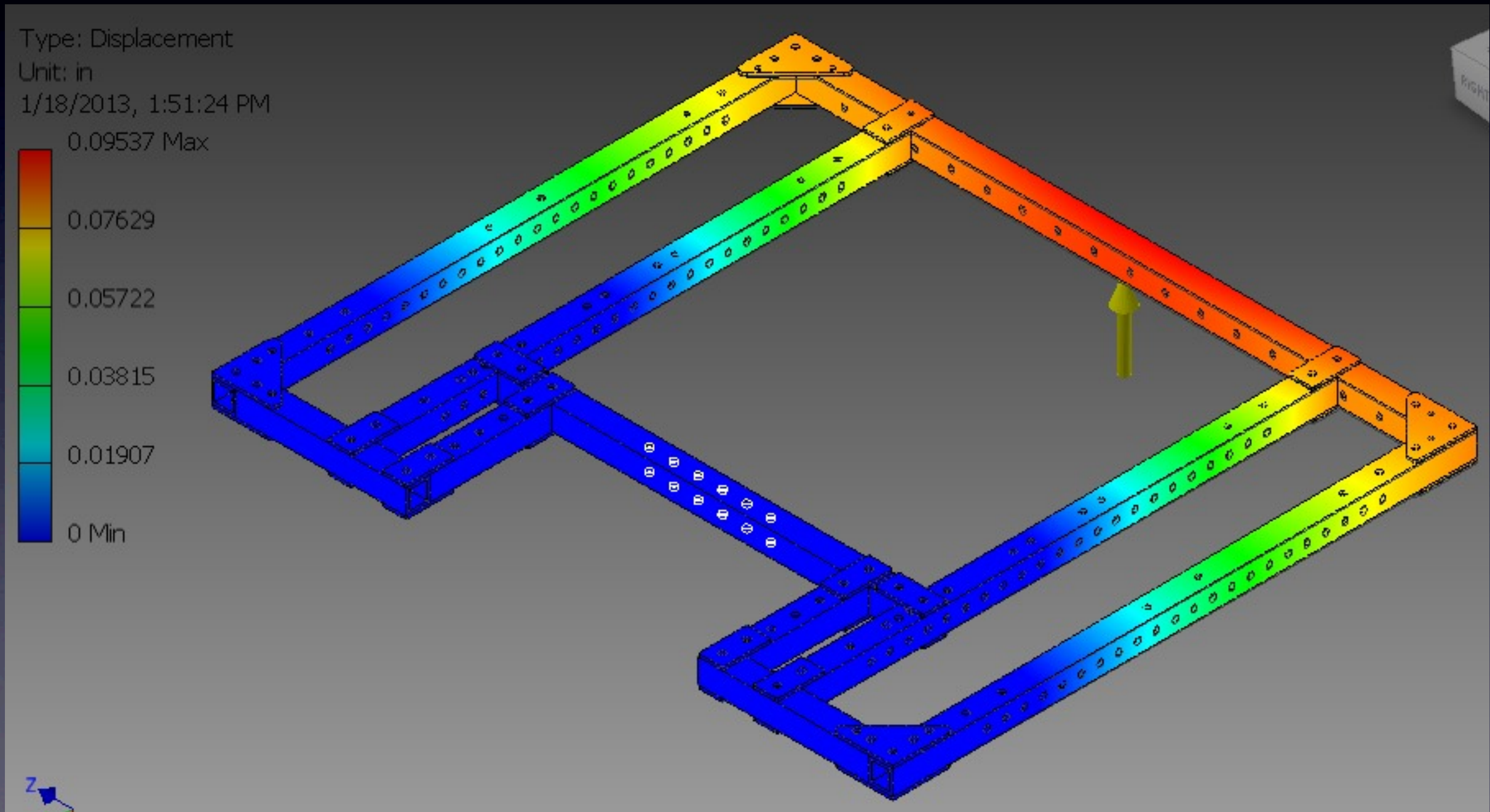
- Monte Carlo simulations to predict frequency of decay products from other particles when looking for Higgs
- dark matter distribution throughout the Milky Way simulations
- design and tuning of 40-m long interferometer



# High-Altitude Balloon Path

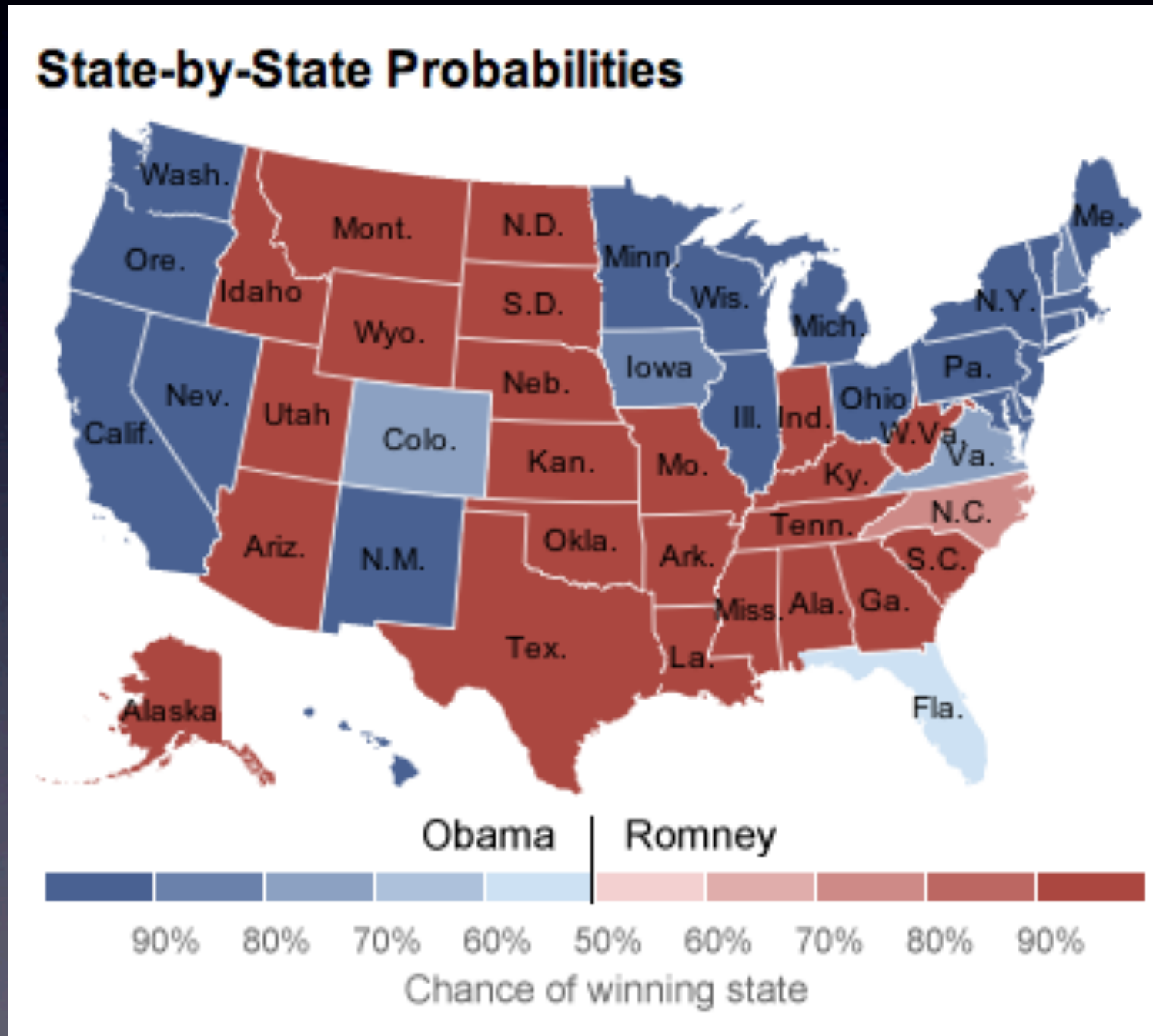


# Finite Element Analysis



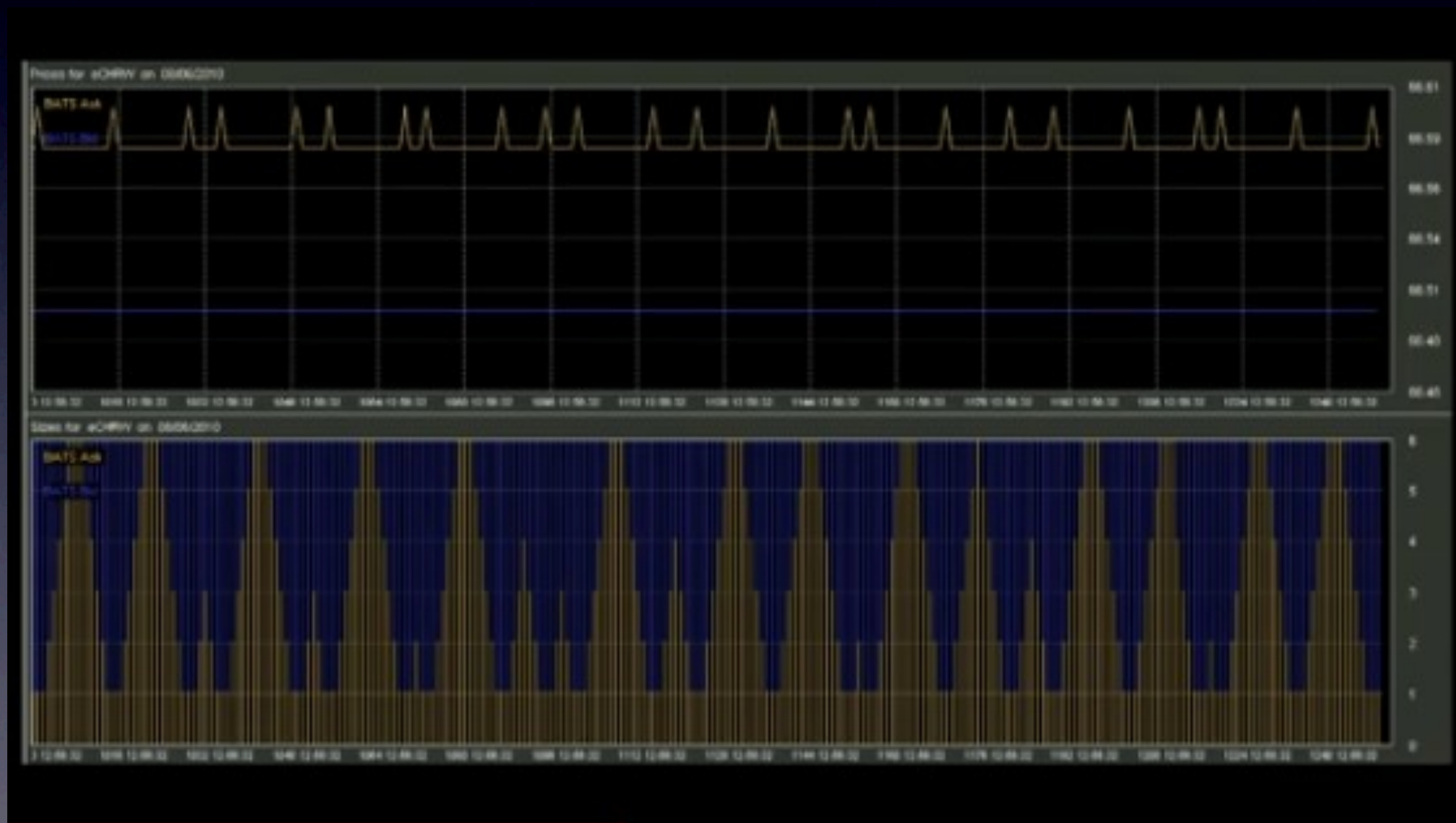


# Politics

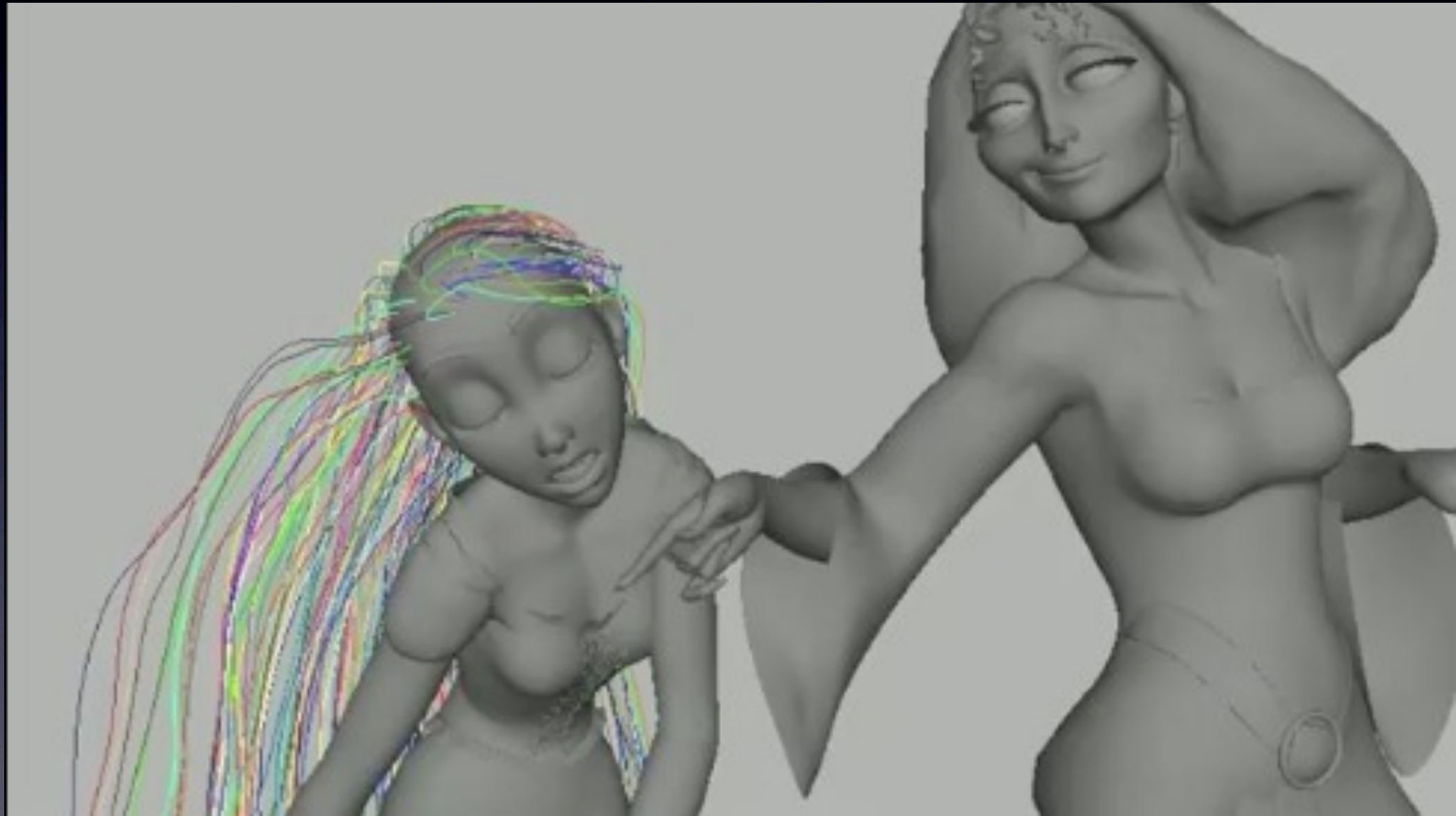




# Black Box Trading (Algo Trading)



# Rapunzel's Hair





# More Than Programming

- computational thinking is
  - knowing when and how to use a computer to solve a problem
  - mapping from the problem space to the solutions space by creating an algorithm
- programming is just one part

# More Than Running Simulations

- not sufficient to develop computational thinking
- students need to modify, extend, and create their own computational models



# Why Teach Computational Modeling?

# Increase Understanding

- multiple representations of concepts
  - verbal, mathematical, graphical, diagrammatical, and computational
- reinforce key idea of models predicting the future and explaining the past
- encourages exploration (what if?)



# Authenticity

- enable students to explore more complex problems whose solutions are beyond the scope of their current course

# Next Generation Science Standards

- Science and Engineering Practices
  - Analyzing and Interpreting Data
  - Using Mathematics and Computational Thinking
  - Developing and Using Models
- refer to computational thinking and students using and creating computational models and simulations



# I -dMotionSimulation.py

# Resources

- Georgia Tech PER Group
  - <https://per.gatech.edu/wiki/doku.php?id=projects:hscomp:physutil>
- my GitHub
  - <https://github.com/gcschmit/vpython-physics>
- John Burk's blog
  - <https://quantumprogress.wordpress.com/computational-modeling/>



# Papers

- Integrating Numerical Computation into the Modeling Instruction Curriculum
  - Caballero, Burk, et al.
  - <http://arxiv.org/abs/1207.0844>