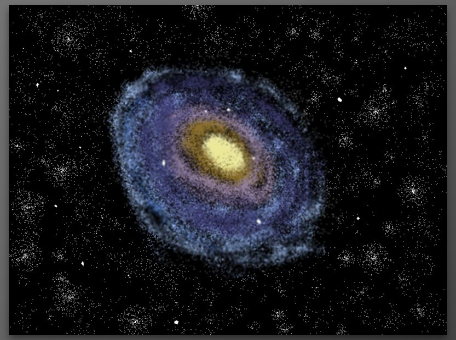
LOWELL OBSERVATORY

125 YEARS | 1894 - 2019



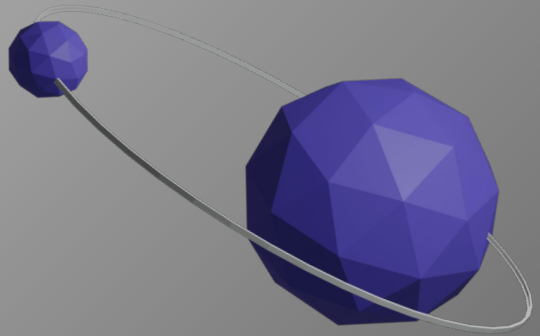
Three-Dimensional Simulation and Visualization of Binary Asteroids

Team Andromeda

Team Members: Matthew Amato-Yarbrough, Batai Finley, John Jacobelli, Bradley Kukuk, and Jessica Smith

Team Mentor: Isaac Shaffer

The Team



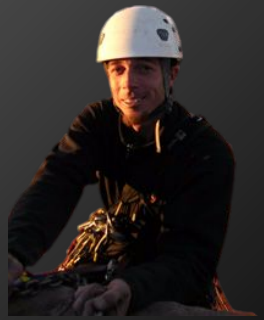
John Jacobelli
Team Lead
Recorder

Matthew Amato Yarbrough
Architect

Bradley Kukuk
Release Manager

Jessica Smith
Editor

Batai Finley
Team Communicator



Isaac Shaffer
Mentor

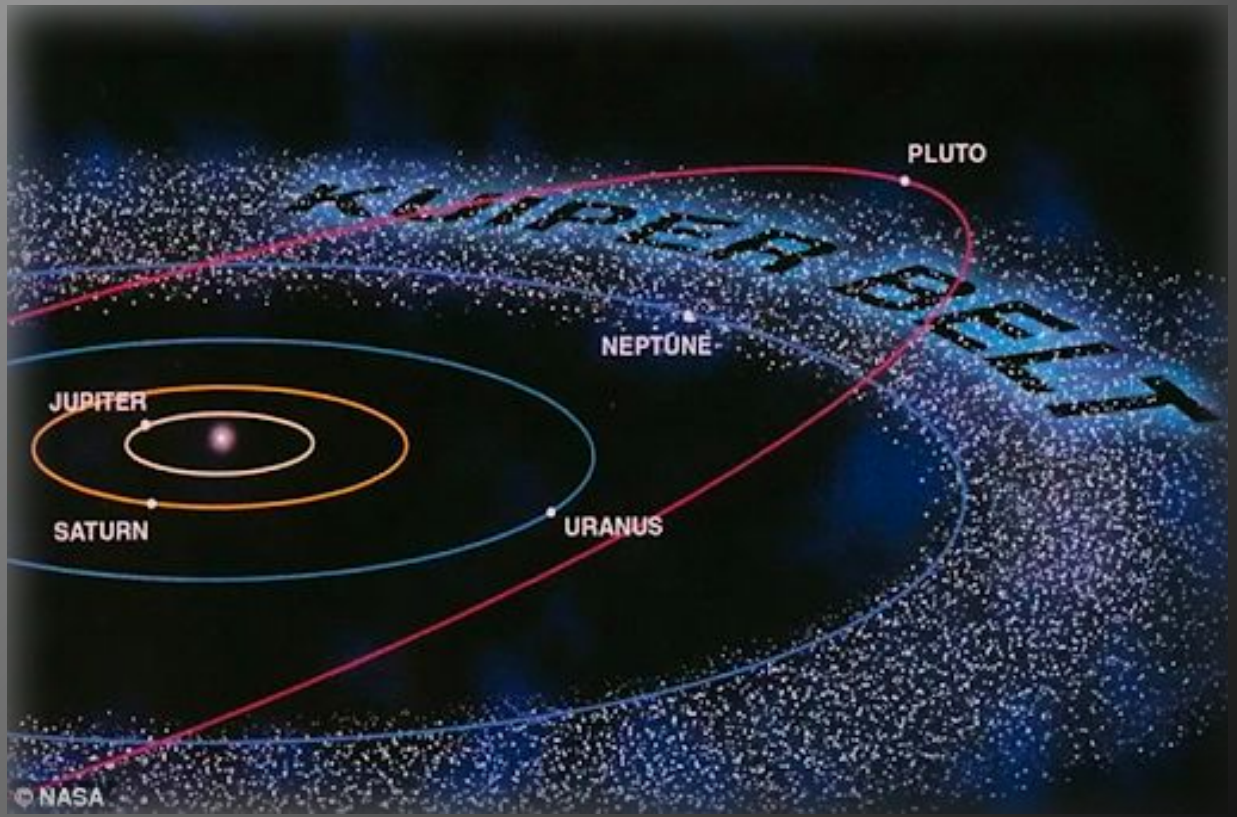
Dr. Audrey Thirouin

Studies binary objects

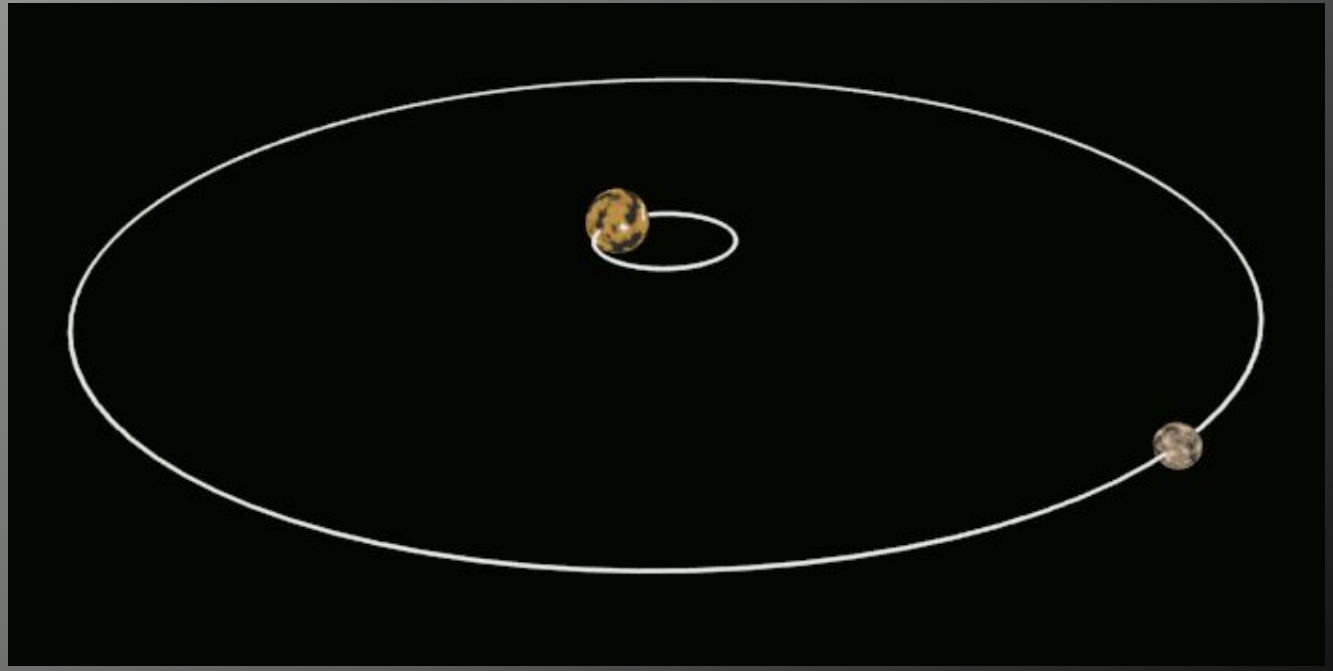
Dr. Will Grundy

Studies Kuiper Belt objects

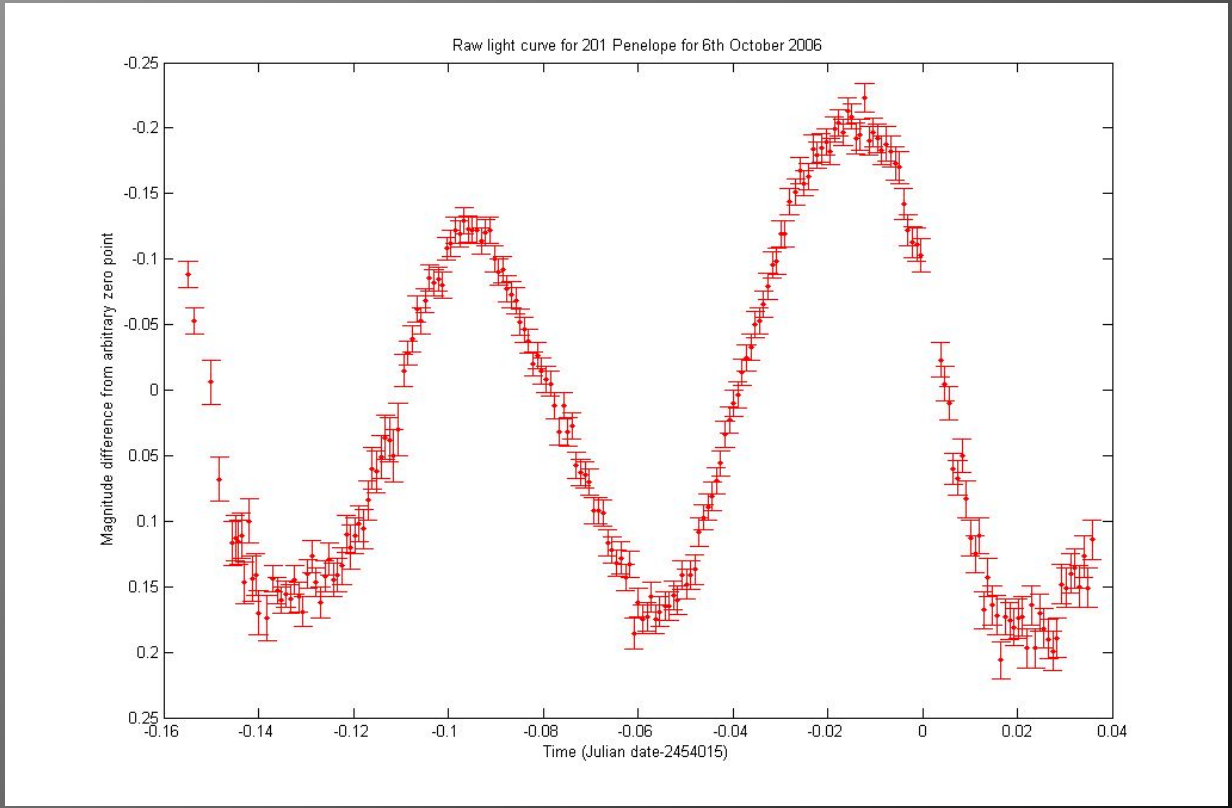
The Kuiper Belt



Model of a Binary System (Pluto and Charon)

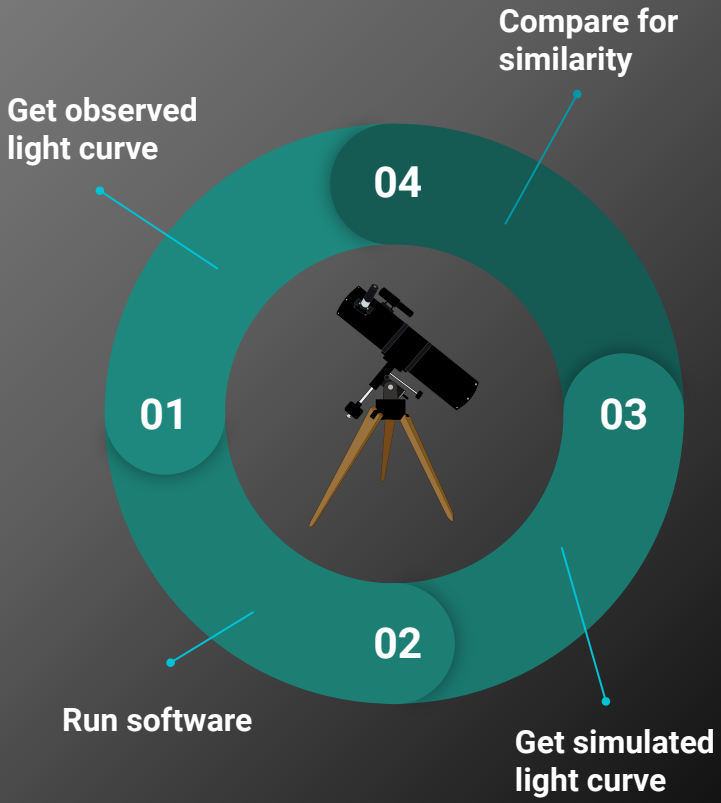


Light Curve


Raw light curve for 201 Penelope for 6th October 2006
Magnitude difference from arbitrary zero point
Time (Julian date-2454015)
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
-0.16
-0.14
-0.12
-0.1
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04

Problem Statement

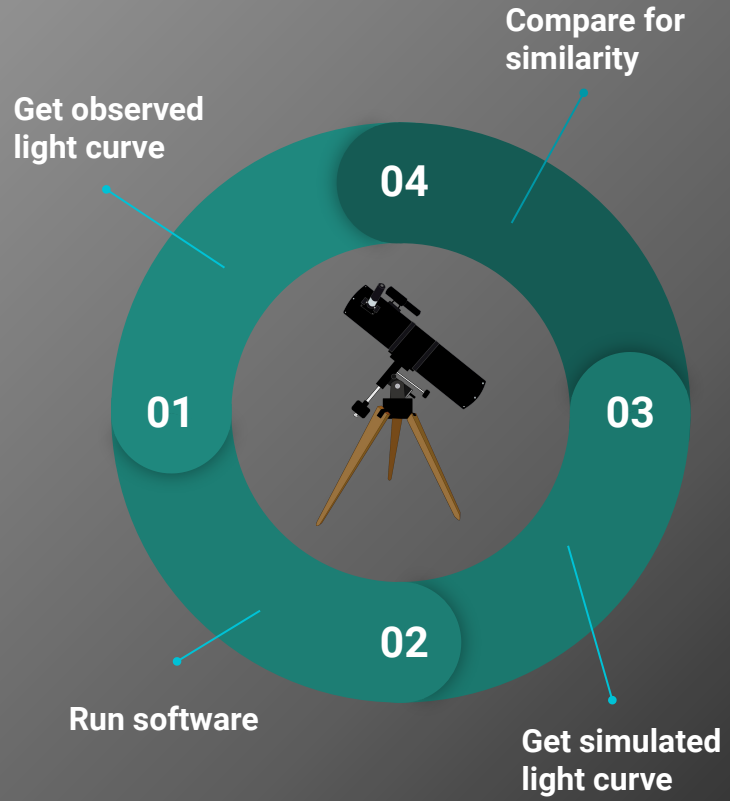
- 50+ parameters must be entered on a command line
- Current software lacks a mix of fast runtime and greater accuracy of simulations
- Our clients need a way to determine best fit parameters based upon observed data
- Current software generates rendered images, but not videos



Solution Overview

- Create GUI for parameter input
- Accelerate current software
- Implement Amoeba for parameter estimation
- Integrate video generator

Improved Workflow

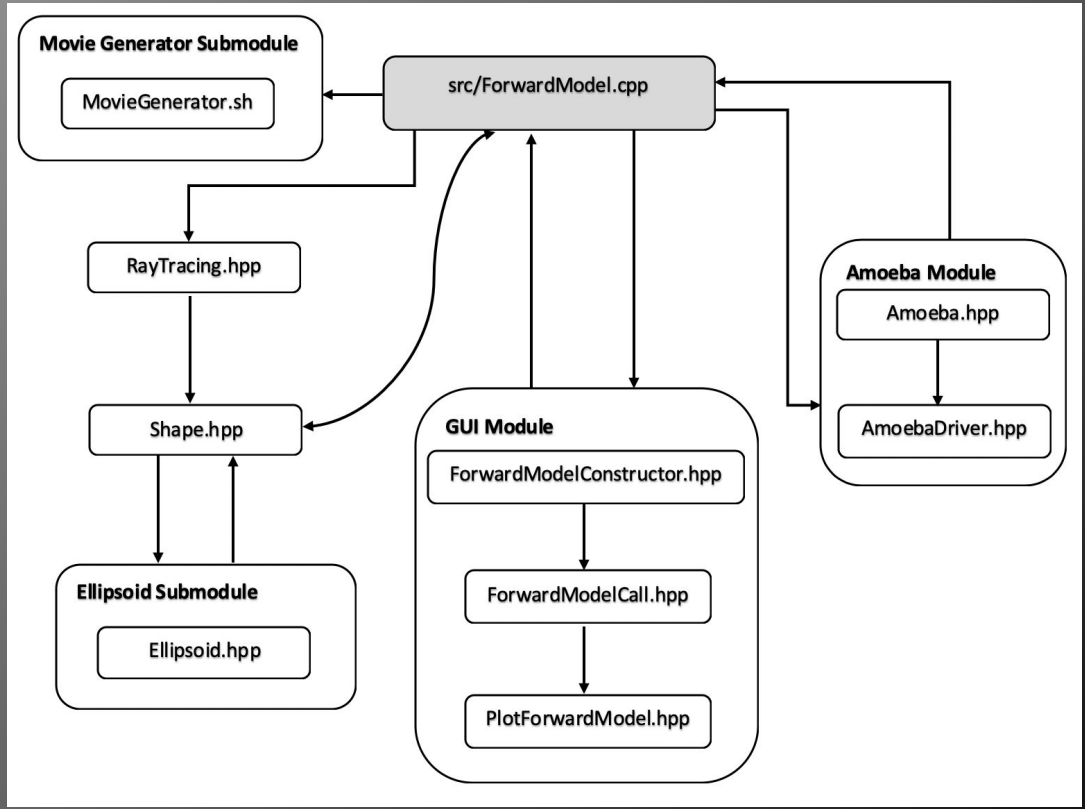


Key Requirements

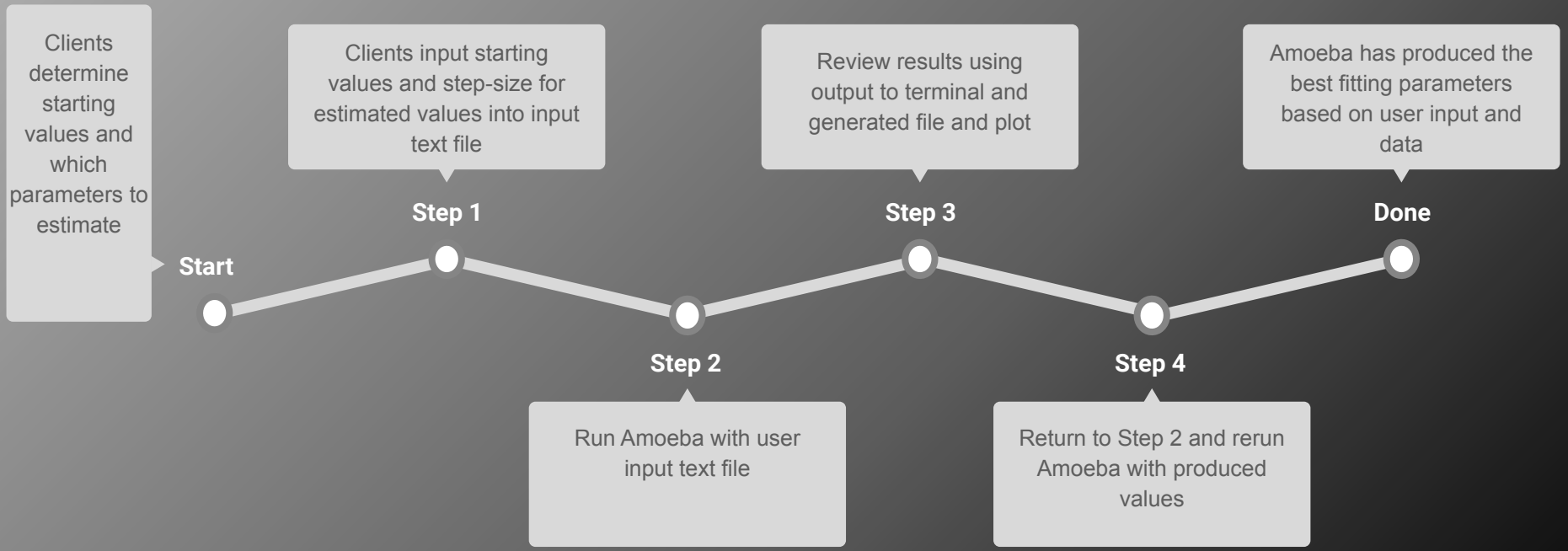
- Implementation of GUI
- Addition of Triaxial Ellipsoid shape
- Parameter Estimation
- Movie Generator

Solution Architecture and Implementation Review

- Movie Generator Submodule
  - Language: Bash
- Ellipsoid Submodule
  - Language: C++
- GUI Module
  - Language: C++
  - API: QT
- Amoeba Module
  - Language: C++

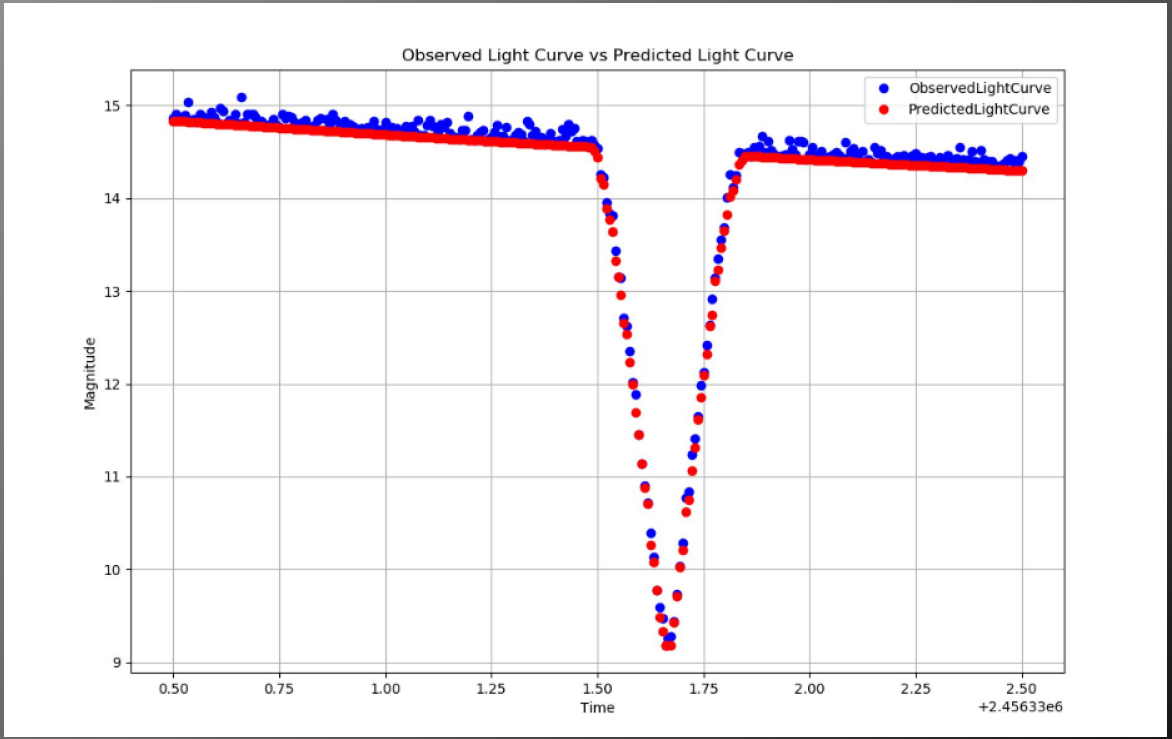


Prototype Review - Amoeba Steps

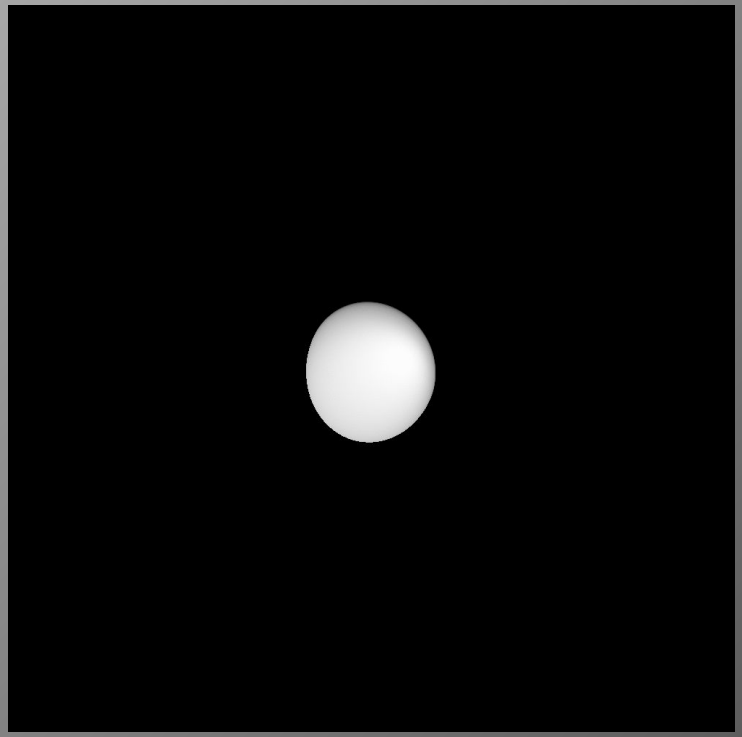


Prototype Review - Amoeba Use Case

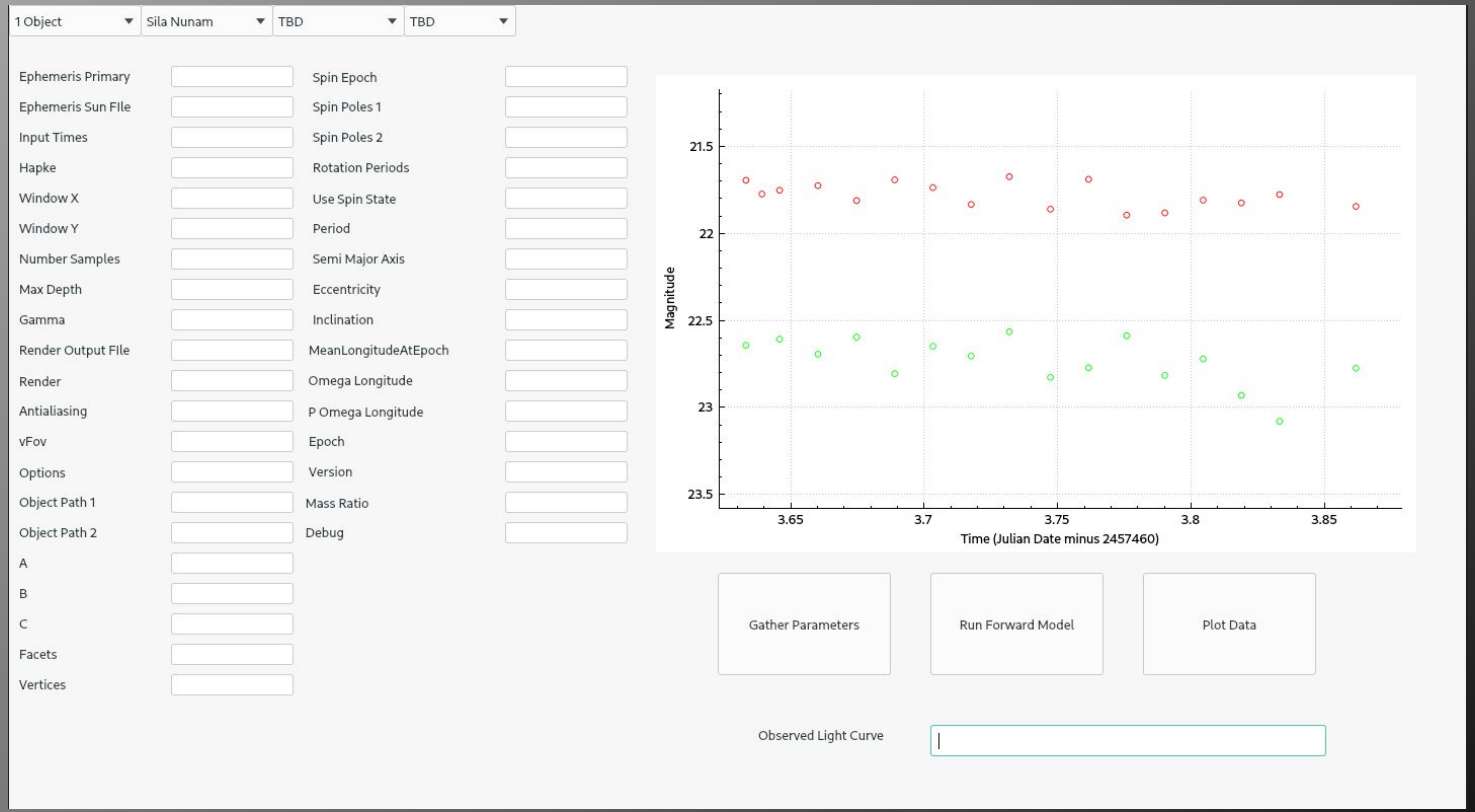
```
-------------------------------
Chi-square: 269.8568115234
aPrimary: 125.1066730200
aSecondary: 117.9214107083
-------------------------------
Chi-square: 269.7321472168
aPrimary: 125.1080035592
aSecondary: 117.9192492439
-------------------------------
Chi-square: 269.7720031738
aPrimary: 125.1066467637
aSecondary: 117.9217333452
-------------------------------
Chi-square: 538.5056152344
aPrimary: 125.1093078421
aSecondary: 117.9174104164
-------------------------------
Chi-square: 269.7459716797
aPrimary: 125.1073120333
aSecondary: 117.9206526130
-------------------------------


-----------------------------
Number of function evaluations: 113
-----------------------------
```



Prototype Review - Triaxial Ellipsoid



Prototype Review - GUI



Challenges and Resolution

Triaxial Ellipsoid

- Challenge: Rotation perspective issue
- Solution: Shift in camera perspective

- Challenge: Rendering a single ellipsoid
- Solution: Provide a second dummy object

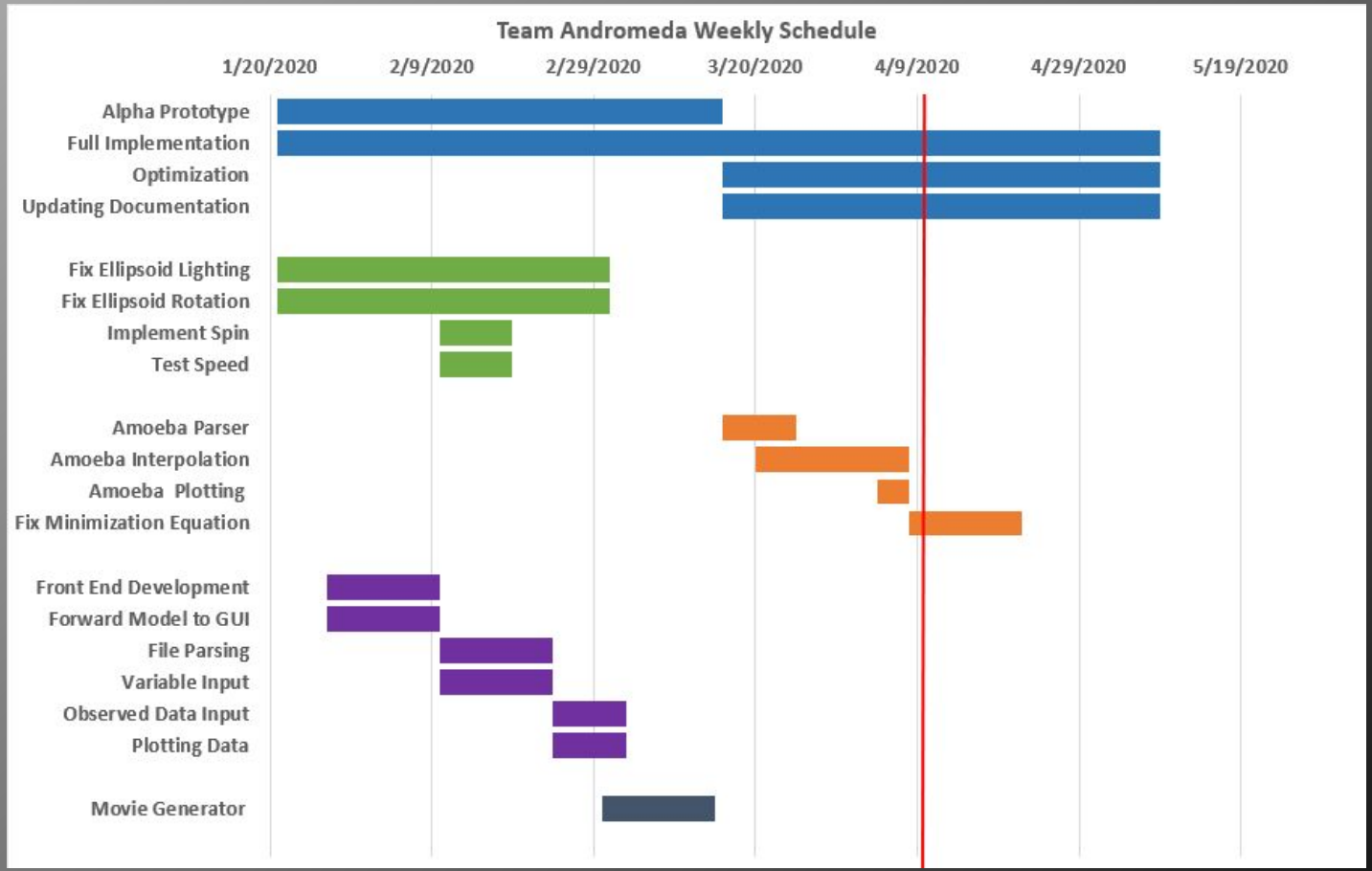
Amoeba

- Challenge: Accurate parameter estimations
- Solution: Fine tuning the minimization equation

GUI

- Challenge: GUI interpolation
- Solution: Additional testing

Schedule


Team Andromeda Weekly Schedule
1/20/2020
2/9/2020
2/29/2020
3/20/2020
4/9/2020
4/29/2020
5/19/2020
Alpha Prototype
Full Implementation
Optimization
Updating Documentation
Fix Ellipsoid Lighting
Fix Ellipsoid Rotation
Implement Spin
Test Speed
Amoeba Parser
Amoeba Interpolation
Amoeba Plotting
Fix Minimization Equation
Front End Development
Forward Model to GUI
File Parsing
Variable Input
Observed Data Input
Plotting Data
Movie Generator

Testing Plan

- Unit Tests
  - Individual functionality
- Integration Tests
  - Amoeba with Ellipsoids
  - GUI with Ellipsoids
- Usability Tests
  - Documentation

Conclusion

- Space and the Unknown
- Improve, Accelerate, Streamline
- Finishing up the final product

Discovery Channel Telescope

Thank you!

Questions?

https://www.cefns.nau.edu/capstone/projects/CS/2020/Andromeda-S20/