# GPUnit

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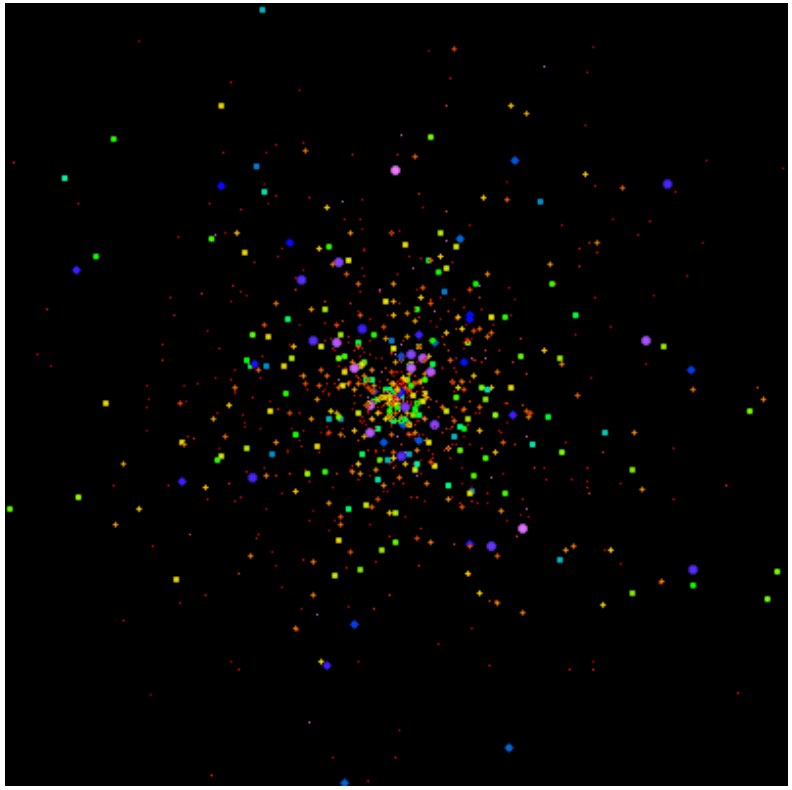
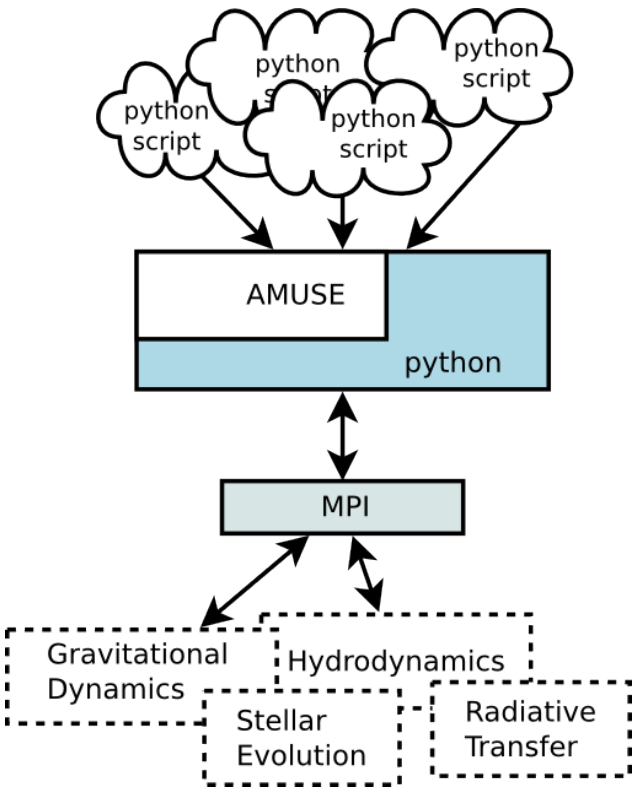
# Overview

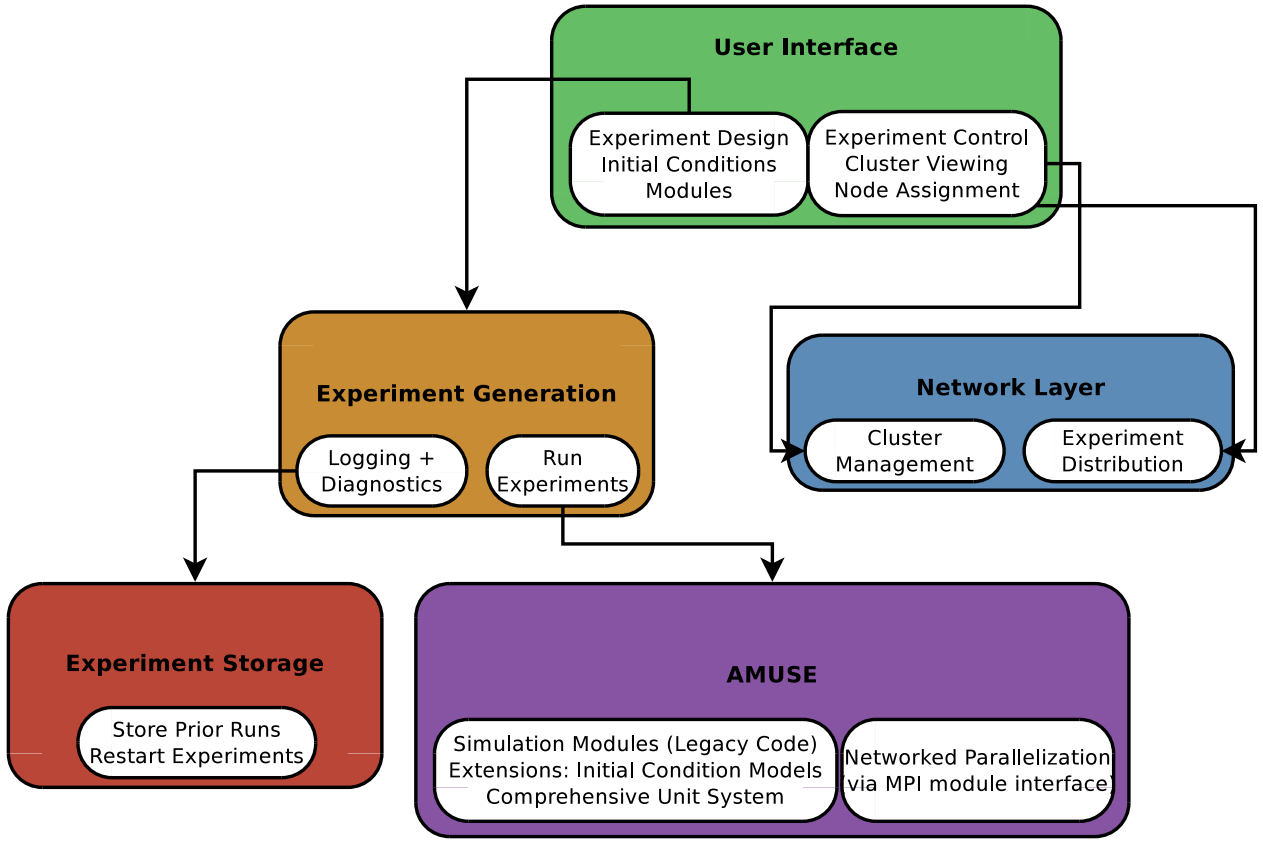
# Motivation

- Astrophysics researchers need to simulate movement and evolution of star clusters and galaxies.
- Every star pulls on all of the others: $O\left(n^2\right)$ for the simplest algorithm.
- Stars evolve over time, mass and size changes.



# Astrophysical Multipurpose Software Environment (AMUSE)




http://www.amusecode.org

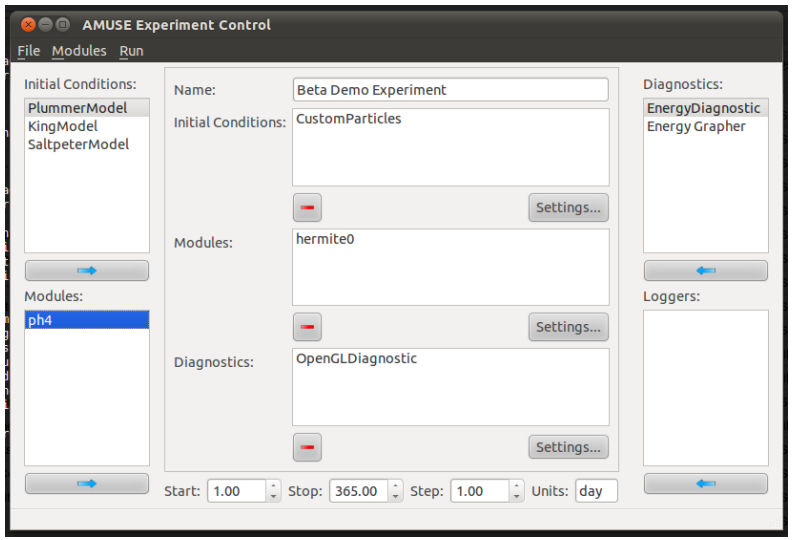
# State of AMUSE

- Currently used by researchers to run large-scale simulations.
- Scripts, diagnostics, logging are all written by hand.
- AMUSE API/programming knowledge is required to create experiments.
- Still better than separated and opaque FORTRAN codes.

```
case 219539042:
  for (int i = 0 ; i < request_header.len; i++){
    ints_out[i] = get_number_of_stopping_conditions_set(
      &ints_out[( 1 * request_header.len) + i]
    );
  }
  reply_header.number_of_ints = 2;
  break;

case 243588422:
  doubles_out[0] = par_getd(
    characters + ( 0- 1 < 0 ? 0 :strings_in[0 - 1] + 1) ,
    characters + ( 1- 1 < 0 ? 0 :strings_in[1 - 1] + 1)
  );
  reply_header.number_of_doubles = 1;
  break;

case 271440754:
  for (int i = 0 ; i < request_header.len; i++){
    ints_out[i] = is_stopping_condition_set(
      ints_in[i] ,
      &ints_out[( 1 * request_header.len) + i]
    );
  }
  reply_header.number_of_ints = 2;
  break;

case 280123374:
  for (int i = 0 ; i < request_header.len; i++){
    ints_out[i] = esys_roe_adb_hydro(
      &ints_out[( 1 * request_header.len) + i] ,
      &doubles_out[i] ,
```

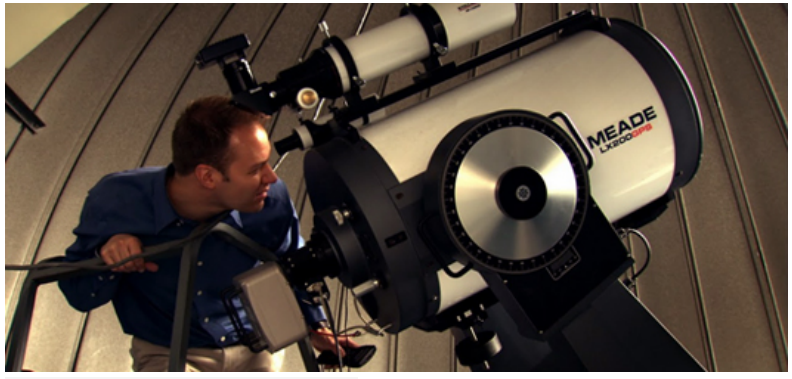
# Purpose of GPUnit

- Ease the use of AMUSE
- Create/Design/Modify experiments
- Select, configure, swap out modules and initial conditions
- Store and restore progress of running experiments.



# Target Audiences

- Physics Students
- Observational Astrophysicists
- Theoretical Astrophysicists




$$\ddot{X}+\frac{C}{M}\dot{X}+\omega_n^2\left[1-\frac{f(\Phi)}{2}(\Delta k_1+\Delta k_2\cos 2\Phi)\right]X$$
$$-\frac{\omega_n^2 f(\Phi)\Delta k_2\sin 2\Phi}{2}\left(Y_m-\frac{P}{K}\right)$$
$$=\varepsilon(\Omega+\dot{\phi})^2\cos(\Phi+\delta)+\varepsilon\ddot{\phi}\sin(\Phi+\delta),$$
$$\ddot{Y}_m+\frac{C}{M}\dot{Y}_m-\frac{\omega_n^2 f(\Phi)\Delta k_2\sin 2\Phi}{2}X$$
$$+\omega_n^2\left[1-\frac{f(\Phi)}{2}(\Delta k_1-\Delta k_2\cos 2\Phi)\right]Y_m$$
$$=\varepsilon(\Omega+\dot{\phi})^2\sin(\Phi+\delta)-\varepsilon\ddot{\phi}\cos(\Phi+\delta)$$
$$-\frac{Pf(\Phi)}{2M}(\Delta k_1-\Delta k_2\cos 2\Phi),$$
$$\ddot{\theta}+\frac{K_t+K_c}{I_0}\theta-\frac{K_t}{I_0}\varphi=-\frac{C_t+C_c}{I_0}\dot{\theta}+\frac{C_t}{I_0}\dot{\varphi},$$
$$\ddot{\varphi}+\frac{C_t}{I}\dot{\varphi}-\frac{C_t}{I}\dot{\theta}+\frac{K_t}{I}\varphi-\frac{K_t}{I}\theta$$
$$=\frac{P\varepsilon f(\Phi)}{2I}(\Delta k_1\cos(\Phi+\delta)-\Delta k_2\cos(\Phi-\delta))$$
$$+\frac{P^2}{2KI}\left[\frac{1}{2}\frac{\partial f(\Phi)}{\partial\Phi}(\Delta k_1-\Delta k_2\cos 2\Phi)\right.$$
$$\left.+f(\Phi)\Delta k_2\sin 2\Phi\right]+\Gamma_c,$$

# Features

- Configurable experiments that can be saved and shared.
- Diagnostic tools that compute useful metrics.
- Storage of experiment state in case of crashes.
- Custom diagnostics and code generation.
- Provides a display of cluster usage to aid in scheduling.

# Design

- Written in Python using the PyQt4 GUI toolkit.
- AMUSE is written in Python, streamlines interaction.
- C++ was considered as it supports Qt as well.
  - Communication w/AMUSE would be cumbersome.
  - AMUSE would be in a separate process.
- Designed APIs for diagnostics, logging and experiment persistence.
  - Users can create new diagnostics easily.
  - Experiments can be stored in a file structure, a remote DB etc...


# Tests

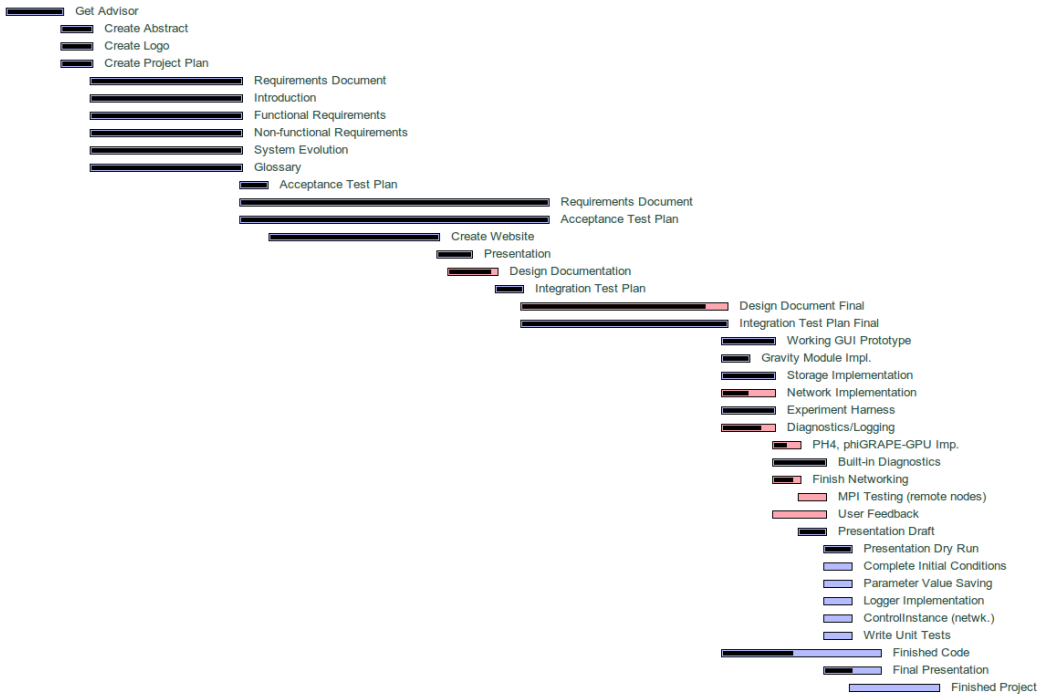
- Table of tests that pass.

# User Testing

- Tested with customers (Steve/Tim)

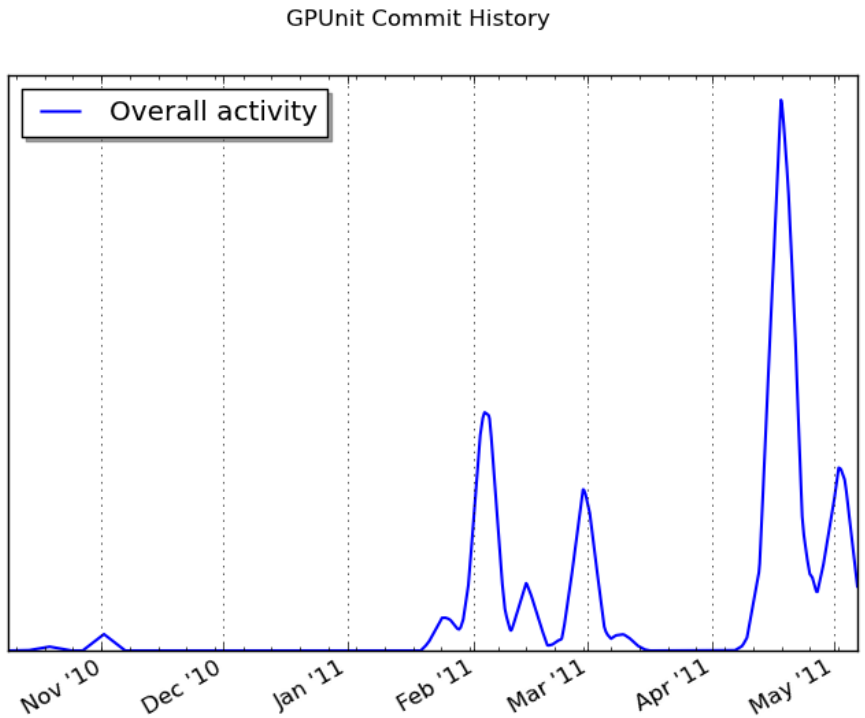
# Project Plan

- Mostly waterfall design process.
- Initial phases were spent learning the domain (Physics/AMUSE).
- Needed more knowledge before making a plan.



# Team Management

- Used Mercurial as our version control system.
  - Distributed, allows off-line commits.
- Team met weekly.
  - Once to plan work, once to code.
- Bi-weekly advisor meetings.



# Potential Benefits

# Demo

- Demonstration of a simulation.

# Questions

- Questions?