Final Project

PHY494 Computational Methods in Physics (2016)

Requirements

- team (3)
- GitHub repository
- keep “lab notebook” on wiki page
- final poster presentation
  - abstract, poster as PDF
  - description of contributions (PDF)
  - individual Q&A

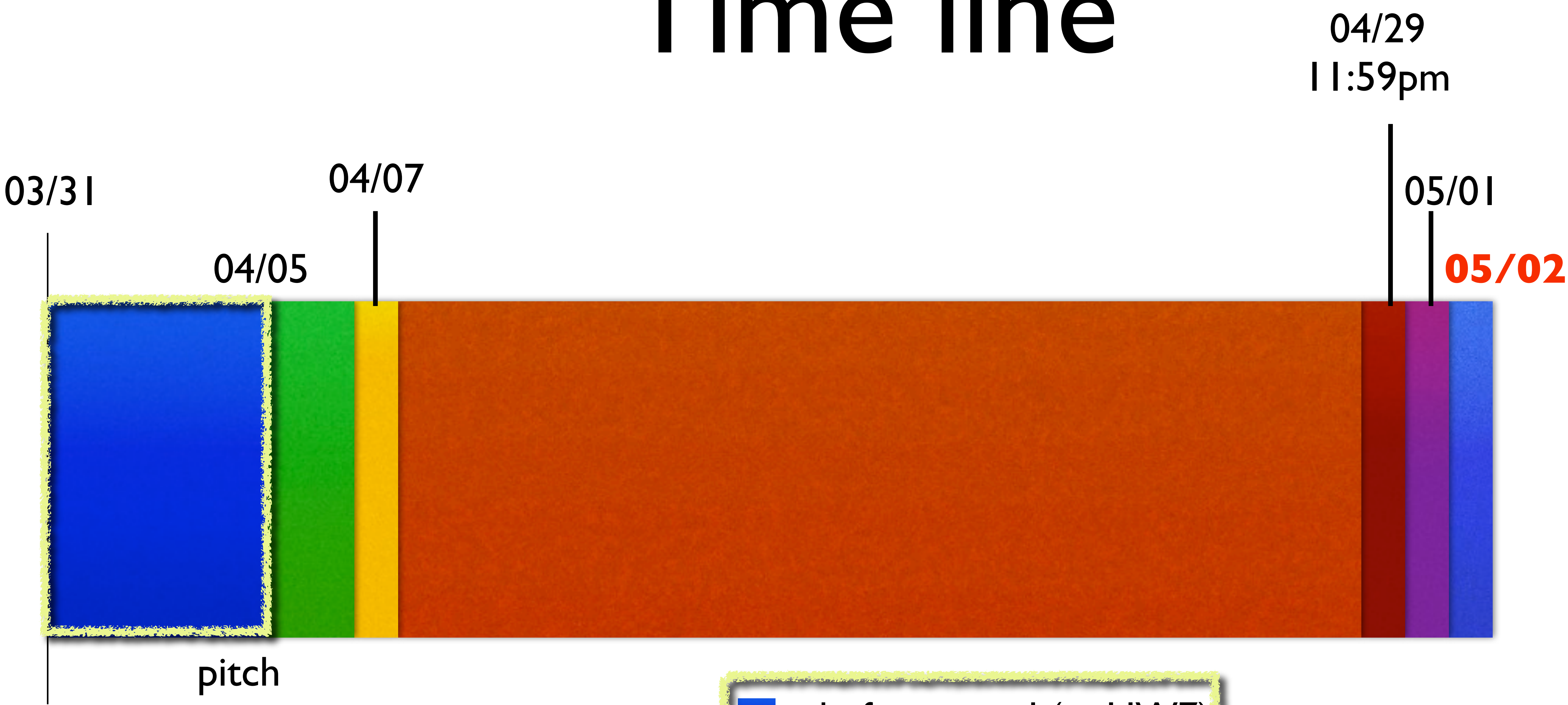
Grading

- code, achieves objectives (30%)
- teamwork (contributions, commits, evidence of communication) (10%)
- keep "lab notebook" on wiki page (5%)
- final poster presentation
  - abstract (5%)
  - poster (20%)
  - individual Q&A (30%)

Projects

1. Select from list (see HW7)
2. Propose your own.

Time line



- draft proposal (as HW7)
- finalize teams and proposal
- announce teams
- work on project
- abstract + contributions due
- poster PDF due
- poster symposium

proposal = HW7
due Monday
6pm!

Project Proposal

- 1 page
- title
- *Problem:* Describe the problem to be solved.
- *Approach:* Algorithms, outline of how you will solve the problem, requirements (e.g. what data needs to be collected?)
- *Objectives*: List 3–6 measurable non-trivial outcomes that you want to achieve; your grade will depend on achieving these objectives

as HW7: due Monday 6pm!

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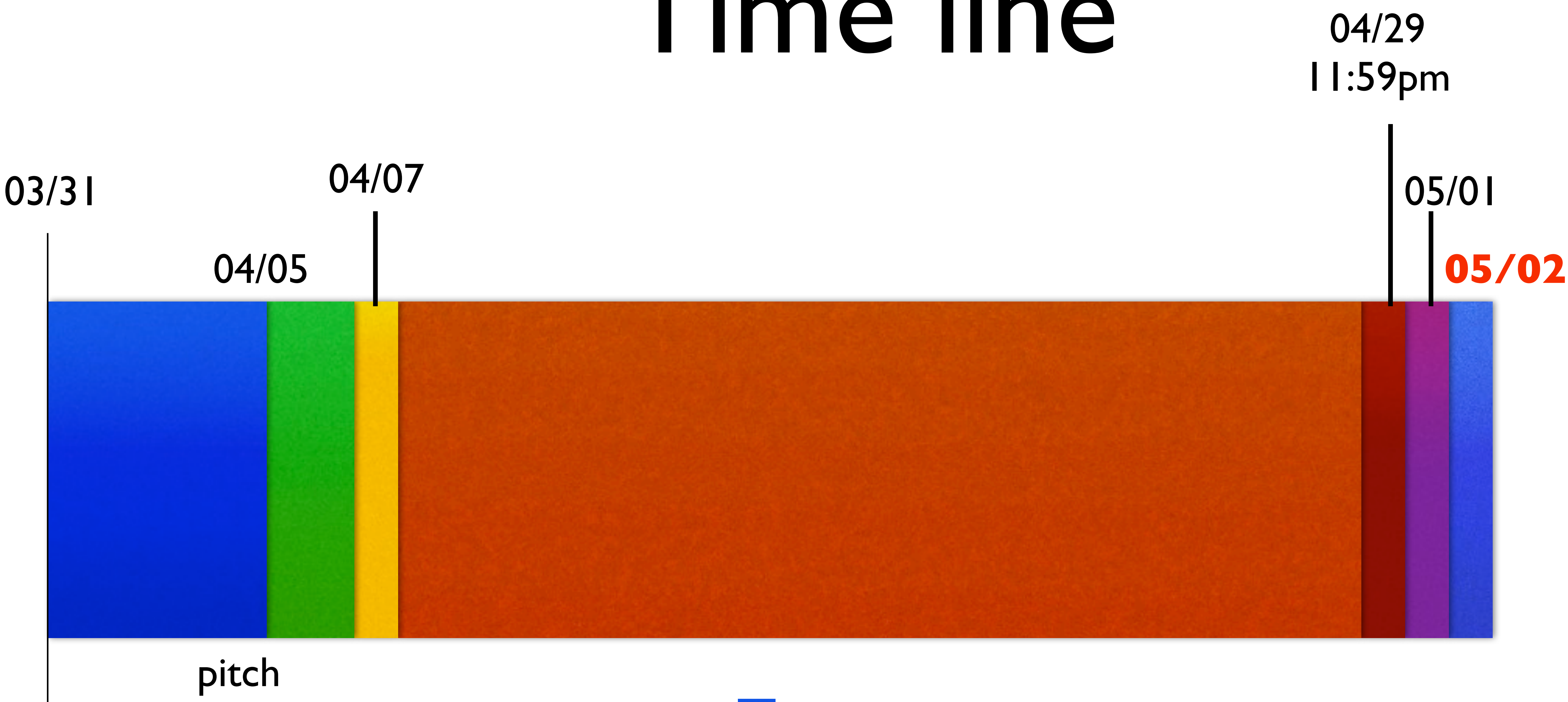
Project Pitch

- ~5 min presentation (next Tuesday)
    - email any slides as PDF in advance
- introduce project (*Problem*, *Approach*, *Objectives*)
- attract a team!
- You can only *choose* a project that was pitched… so be prepared to pitch yourself!

Time line



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team size: 3

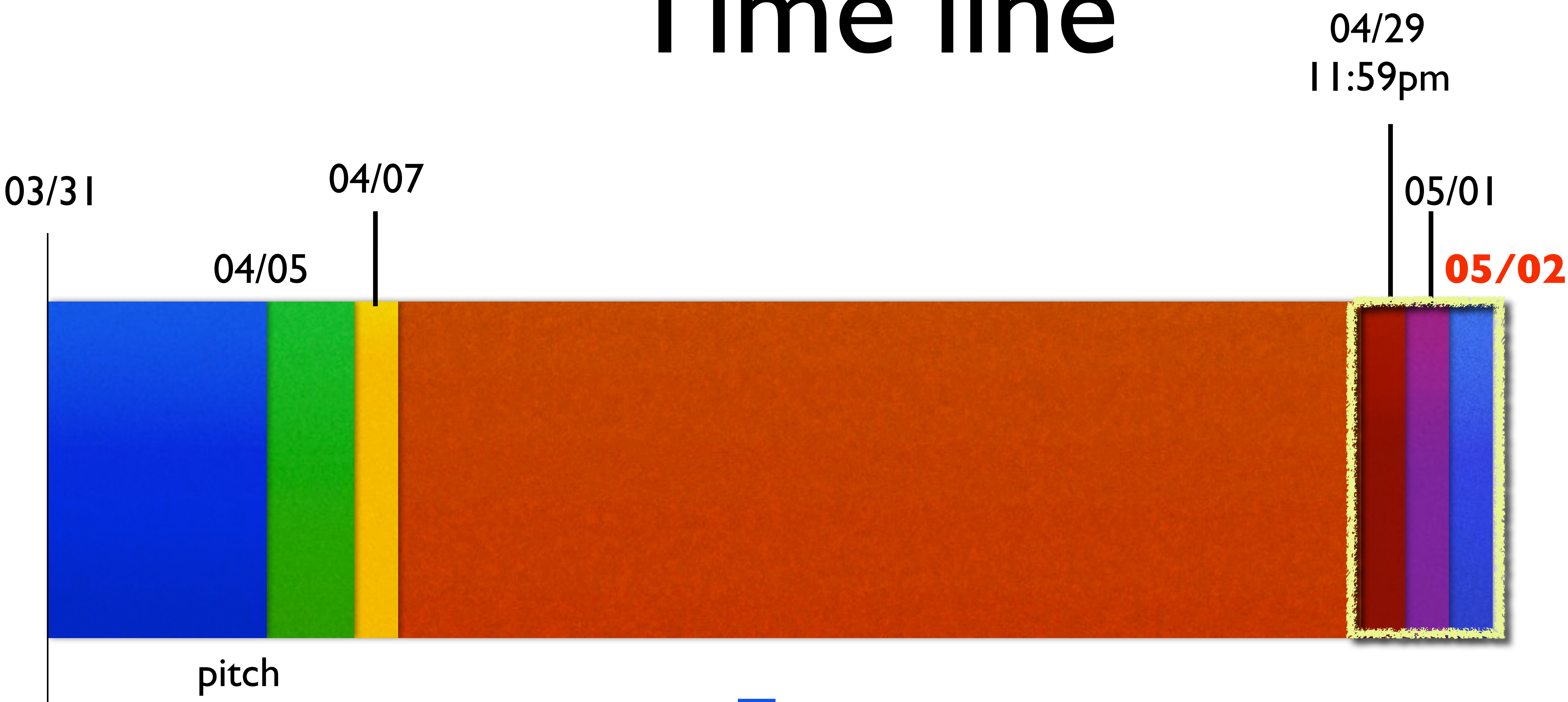
You have 2d to form teams; I will assign anyone not in a team.

Work on project

- use GitHub repo for code
- use GitHub Wiki for organization, notes on algorithms, preliminary results
- optional: use GitHub issue tracker for assigning tasks and keeping track of bugs and objectives
- Create abstract and poster together.

Start early!

Time line



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Poster Symposium...
more details later

Projects

- rough outline: expand in your proposal
- see also *Computational Physics*

1. Monte Carlo Simulation of liquid Argon

- difficulty: 1
- implement basic MC for liquid Argon in *NVT*
  - analyze at different temperatures (phase transition?)
  - calculate equation of state $P(T, \rho)$
- visualize
- extra: implement *NPT* (volume moves)

2. Monte Carlo simulation of the Ising magnet

- difficulty: 2–3
- implement MC for Ising spin system in 1D, 2D, possibly 3D
- compute magnetization as function of *T* (phase transition?)
- visualize
- compare to 2D exact result

3. Classical chaotic scattering

- difficulty: 1
- Problem 9.4 in *Computational Physics*
- integrate equations of motions of particles scattering from “4-peak” potential (e.g. with RK4)
- vary parameters
- analyze cross section
- visualize

4. Classical billiard

- difficulty: 2
- Simulate elastic collisions between "2D balls" (disks) confined within walls.
- Implement a collision-based algorithm (fully elastic collisions between balls and balls/walls) and remove balls through "pockets" (holes)
- What is the smallest number of turns needed to get rid of 1, 2, … 15 balls?
- visualize
- extra: friction; "computer player"

5. Quantum Mechanics: Wave packet propagation

- difficulty: 3
- See 22.2 and 22.3 in *Computational Physics*
- solve the time-dependent Schrödinger equation for a Gaussian wave packet in different potentials (Visscher or Maestri/Askar&Cakmak algorithm)
- 1D: step barrier, harmonic well, square well; 2D: slit
- calculate transmission/reflection, wave velocity, ...
- visualize

6. Fluid mechanics: 2D Navier-Stokes

- difficulty: 2 (3 without CP…)
- See Ch 25 in *Computational Physics*
- solve Navier-Stokes for incompressible 2D flow (finite difference with SOR algorithm)
- velocity (flow) field and vorticity for submerged beam, cylinder, drop shape
- visualize
- vary parameters (e.g. Reynolds number, velocities, boundary conditions)

7. Energy efficient houses

- difficulty: 4
- solve the heat equation for a 2D house
- implement house plan with realistic parameters for walls, windows, doors and typical shapes and sizes
- How much energy is needed to maintain interior at constant T throughout a Phoenix year?
- What is the effect of increasing insulation, shading windows, changing target temperature?

8. Solar system

- difficulty: 2 (?)
- simulate the solar system (planets + sun + Halley's comet) using classical Newtonian mechanics
- obtain realistic parameters from e.g. NASA
- stability over time?
- extra: design a two-sun system and find "life-friendly" orbits for an earth-like planet

9. Stock market forecasting with wavelets

- difficulty: 3
- See e.g. Yousefi et al (2005), doi:10.1016/j.chaos.2004.11.015
- implement a wavelet analysis (Daubechies wavelets) for stock market and commodity prices timeseries
- test how well you can forecast (correlation between "predicted" data and data not used for the wavelet analysis)
- vary forecast range

10. Predicting winning sports teams

- difficulty: 2
- Carry out repeated stochastic simulations of a sports tournament (e.g. March Madness, World Cup) to determine likelihoods of individual teams winning.
- Derive simple quantifiers for probability to win a match from existing data (historical match data, rankings, …).
- Report statistics and compare to historical results.