PHY6860
Computational Physics
Final Project(s) Discussion

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Relativistic Resonance Decays
Predator Prey Extension
Quantum Circuit simulator

Final Project(s)

1. Relativistic Resonance Decays
2. Predator - Prey Extension
3. Quantum Circuit simulator

<u>**Timeline:**</u>

- April 4th: Group forming
- April 13th: Short group presentation/discussion of the project
- Last week of Finals: Presentation TBC

Final Projects: Goal

Goals:

All projects are intended to make use what we learned over the course; in particular all projects will require you to implement an “event-like” ROOT Class and usage of container classes of your own ROOT object classes (depends on the problem).

In particular the resonance problems (2-3 groups), since you should be able to analyze the resonance of the other group(s), requires that you discuss beforehand on a common event class interface. In principle you could implement it as you wish, but the interface should be in a generic way the you can use the resonance simulation data of the other group(s).

Relativistic Resonance Decay

$\ast$ Cons. of $\left\{ \begin{matrix} E \\ \vec{p} \end{matrix} \right\}$

Implement a <u>relativistic</u> resonance decay Monte Carlo Simulation:

- Pick a resonance (will be assigned)

$$\Lambda \rightarrow \underset{uud}{p} + \underset{\bar{u}d}{\pi^-}$$

- Implement decay in resonance rest frame (isotropic decay)

3D decay, 2 θ's

same $P(\theta)$

- Boost in the center-of-mass frame of the collision use for example sqrt(sNN)=200 GeV

$\underbrace{200\text{ GeV}}_{CM} = \dfrac{p}{\sqrt{1 - v^2/c^2}}$

$v/c = \beta$

- Save this event (of course lots of them)

- Write an analysis macro: Invariant Mass calculation (to identify/confirm the resonance)

$M_\Lambda^2 = M_p^2 + M_{\pi^-}^2$?

- <u>Additions:</u>

i) You can implement gaussian smearing of uncertainties in momentum (mimic detector resolution)

ii) Add uncorrelated background

Relativistic Resonance Decay Cont.

Preparations:

What is needed and how do you want to store/generate? Track class, Event class, containers/trees ... ?

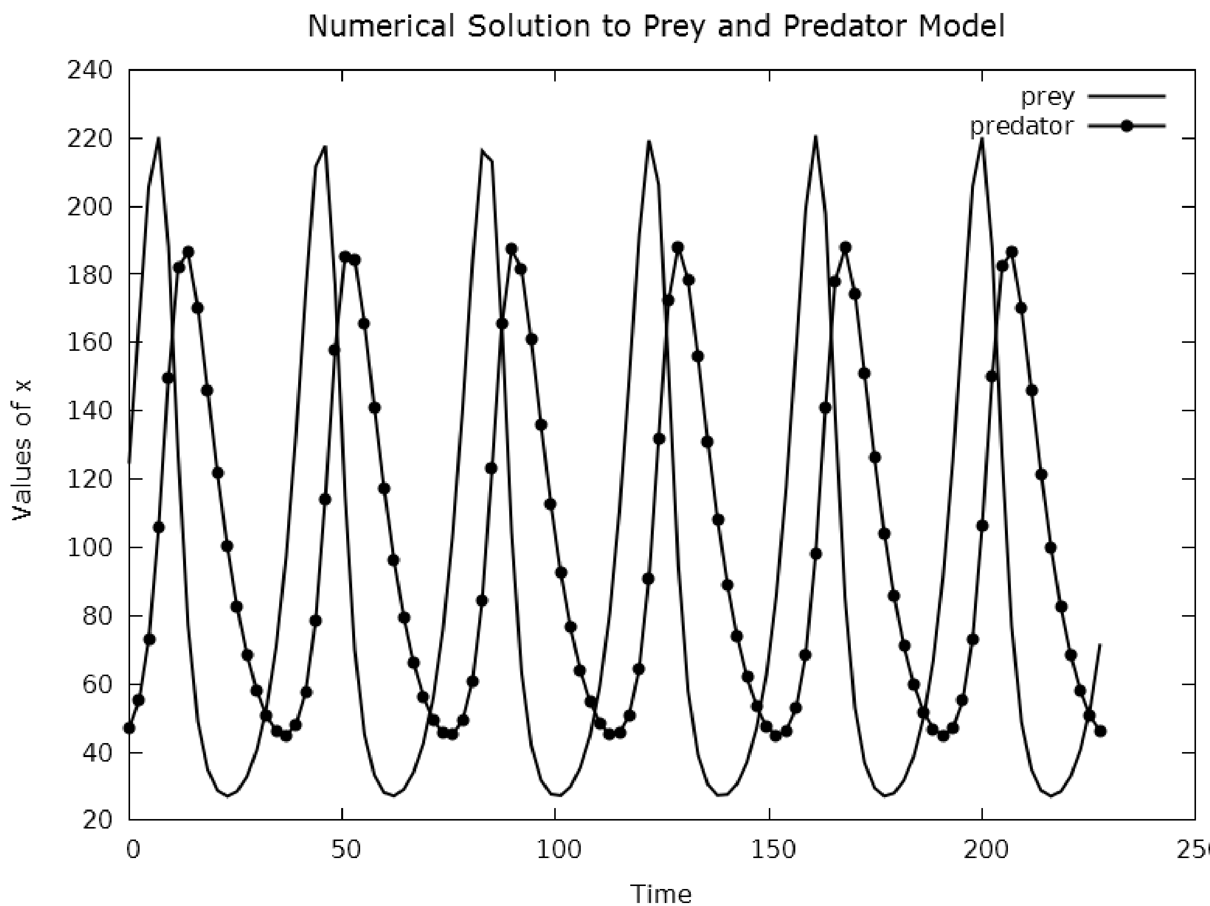
Prepare a short outline of what functionalities the classes need and a quick flow chart of the project itself! We will discuss it in class accordingly (April 13th)!

Hints:

You clearly need a 4 mom. vector (look at TLorentzVector), but it would be beneficial to extend this by creating your own track class allowing to store further information like particle type ...

A good starting point for an event class we did in Lecture 10 ...

Intro: Predator-Prey Model



Try to implement/solve the model using GSL
and use ROOT and the root functionalities
to create similar plots (more details later)

Project Tasks

- Write a code solving the Pred-Prey ODE system
- Create a root output file saving a TGraph (TH1) for the pred-prey population as function of time (allow for meaning file names and TGraph names depending on what parameters you used; in particular important ones we include population fluctuations)
- Allow for pred-prey gaussian population fluctuations for each time step (Use ROOT TF1 in order create these fluctuations)
- Write a separate plotting macro (reading in the different root files you created) and show several figures comparing the different solutions by varying the amount of population fluctuations). The figures should contain axis labeling a figure legend (use ROOT TLegend) …
(make it look pretty and professional!)
- Additional: Think about other ways to characterize the distributions, mean, rms, ratios, 2d plots … !?
- Prepare a short presentation discussing your findings and an explanation of your code …

Use the remaining weeks/InClass time to implement and prepare your final project; ideally we could have the presentations on the last day of class!

Remark

This project is intended for you to learn how to define and outline a more complex computing program and in addition how to organize and work with other people on such a problem (so using OO programing you can think about that you can, once an interface is defined, indeed split work).

It would be of course great if all projects will indeed be successful, but even if not, in the presentation you can discuss/point out the obstacles/problems and this is certainly part of the intended learning experience!