Physics 741
Experimental Nuclear Physics – Course Projects

Assignment
The goal of the course project is to have you research a topic in nuclear physics research or related areas, discuss its physics motivation, and present its status and open questions to the class.

Timeline
By October 5
Pick three topics of interest from the list (ranked by preference) or define your own topic for the research project and email those to me. If more than one person is interested in a given subject, I will assign a topic based on your preferences.

By October 17
Establish a reading list of at least three readable references on the subject that is finally assigned to you, and go over the reading list with me so we agree on what you will read and research for the project.

By November 21
Prepare a conference-style presentation in PowerPoint, Keynote, PDF, or in some other electronic presentation format. Let me know if you do not have access to a computer to prepare the presentation. Email me the electronic file of your presentation so I can look it over.

November 24 - December 3
Arrange a time to meet with me to go over the draft presentation, and then refine your presentation based on our individual discussions.

December 5 (or some other day)
Project presentations to the class. We will schedule an afternoon or evening with pizza to hear everyone’s presentation.

Presentation
- You will have about 20min for your presentation plus 5-10min of questions and discussions. This corresponds to about 20 slides depending on how fast or slow you talk.
- Talks will be posted in electronic form on the course website.
- Talks will be graded based on content, clarity of presentation and explanation, background knowledge and discussion of particular topic within broader research context.

Questions?
Come by my office or mail me: heeger@wisc.edu
Some Electronic Resources and Archives

Preprint arXive http://arxiv.org/

SPIRES HEP http://www.slac.stanford.edu/spires/

Particle Data Group http://pdg.lbl.gov/

National Nuclear Data Center http://www.nndc.bnl.gov/

Department of Energy, Office of Science Nuclear Physics http://www.er.doe.gov/Program_Offices/NP.htm

University of Wisconsin, Physics Library http://physics.library.wisc.edu/

Suggested Topics

1. Describe the solar neutrino problem and how it was resolved. What can we learn from the study of solar neutrinos about neutrinos and the Sun?

2. Describe the techniques and challenges in measuring the neutrino mass with laboratory experiments, and in astrophysics and cosmology. What are the current results and experiments?

3. Describe the physics and techniques of neutron electric dipole experiments. How do they probe physics beyond the Standard Model?

4. Describe the history in measuring the lifetime of the neutron, including recent results and discrepancies. What are the experimental techniques used in the current experiments?

5. Describe the origin of the supernova relic neutrino background and experimental efforts to measure it.

6. What is dark matter? How do we know it exists and how are experiments trying to detect it?

7. Describe recent results and proposals for a precision measurement of the anomalous magnetic moment of the muon (g-2 experiments) and their tests of the Standard Model.

8. The experiments at the Relativistic Heavy Ion Collider have discovered a new state of matter at extreme temperature and density—a quark-gluon plasma that exhibits
unexpected, almost perfect liquid dynamical behavior. Describe the physics of the quark gluon-plasma and what it tells us about neutron stars and the early Universe.

9. Describe the physics of neutrinos in supernovae and what they can tell us about the supernova mechanism and the neutrino.

10. Describe baryogenesis, leptogenesis and some of the leading theories to explain the observed matter-antimatter difference in the Universe. What are the experimental limits on antimatter in the Universe? What are Sakharov’s conditions?

11. Why do some experiments go underground? Describe the basic physics of underground laboratories: how are penetrating muons produced, what happens to their spectrum and flux as they propagate through the earth, what measurements exist that can be used to calibrate simulations, what is the difference between a “mountain” site like Gran Sasso and a flat site like Homestake, what absolute limits to backgrounds exist underground.

12. Describe long-baseline neutrino oscillations to determine the neutrino hierarchy or to see CP violation. Describe the ideas behind off-axis and broad-band beams.