Introduction

Goal of the course:

We aim to educate our students to be independent and well capable scientists, as demanded by MIT's hallmark "Mens and Manus" , i.e. intellect and hands.
MIT graduate students will be among the future leaders in Nuclear and Particle Physics. They are expected to recognize essential physics ideas and be able to substantiate them by designing realistic experiments. Remember: an experiment firstly is a question to nature which has to be designed to produce a clear answer and only secondly often a collaboration to work in. To carry on research for a thesis or beyond, you must master the instrumentation to understand natures answer. The course combines Physics ideas with instrumentation of modern techniques. Many of the ingrediences are common to your research later. They include analyzing techniques and error estimates. The course is designed to give graduate students an experience in experimental measuring and analyzing techniques from nuclear and particle physics in preparation for their research.

Prerequisite: 8.701 or equivalent

Organization: Start: at IAP Jan.4, 2010 in room 3-358
Each experiment will take~ five working days in the laboratories from 9-4pm

Credit units: 12

Staff: ….. Ulrich Becker 3-5822, Bldg 44-123B, becker@mit.edu,
Sean Robinson

Locations: 4-359 and 44-007

You will carry out accurate measurements for 3 experiments from the list below. In preparation literature will be consulted and preparatory questions answered, before the "hands on" measurements. Students may work in pairs or alone. Using the measured data with errors, including proper propagation, you will analyze results. This will involve Monte Carlo calculations and Feynman graph evaluations.
A laboratory guide will contain the preparatory questions for each specific experiment and specify the proceeds for the results to be obtained. The preparatory questions including theoretical prediction will be graded and are required before experimental work canstart. A five page paper in APS style describes each experiment after a 20 min oral presentation.

Description:
Graduate Laboratory is meant to give "hands on experience" and acquaint students with a variety of different experimental methods of modern detection. Wherever possible, a concrete fundamental quantity in physics will be measured. We expect theoretical calculation before

the measurement is carried out. Detailed error analysis will be emphasized, which is also necessary to evaluate the merits of future measurements in Nuclear and Particle Physics. To gain lasting experience in detail, one of the three experiments will require design, manual construction and subsequent test evaluation.

List of experiments:

1. Compton scattering
2. Fermi constant from muon decay
3. Tunnel effect in decays of nuclei
4. Time of flight measurements
5. Angular distribution of cosmics
6. Rutherford and Multiple scattering
7. Cerenkov radiation
8. Gamma – gamma correlations
9. Proportional counter/ chambers

Place: 4-358 for experiments 1., 2., 3., 6., 8.

Experiments 4., 5., 7. 9.will take place in building 44 - 004.

A named and dated log book for recording the measurements is mandatory.

Ethics in Science

Reading a published report about an experiment you must expect:

- an honest description of what was done
- exactly what was observed
- proper referencing of previous work
- all “quotes” and websites used are marked, no copying ever
- an error estimate specifying the significance of the result obtained.
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Nature ultimately enforces the truth in science. If fraud is involved, a career may be ruined.

Grades:

Attendance, Lab performance, log book : 30%
Preparatory assignments: 10%
Oral 20' presentation for 3 experiments 30%
Papers describing theory and data 30%

Safety:
The safe handling and accurate accounting of the radioactive sources is under the authority of the MIT Radiation Protection Office (N52-496). On the first day an officer will instruct you in the safe use of radioactive material. Every source must meticulously signed out and put back into the repository. Inescapable is the dose from cosmic radiation: 360mrem/year at sea level. Our sources
Compton Scattering: 137Cs 0.4mCi
Calibration sources: 133 Ba, 22Na .005, .002 mCi
Gamma-Gamma 60 Co (.0005)

are way to weak to contribute much to the recommended<=100mren/year.
Precaution: ALARA = as low as reasonably achievable. (D'ont handle more than necessary. Transfer quickly. Keep away from body. Never borrow a source, leave in lab storage.)
High Voltage: All our power supplies have current limits set low. Always check that the return line (ground) is connected before you apply HV. U.Becker will give a safety instruction.

Have Fun -and know what is at the other end of the cable to your computer !