RESPONSE TO THE 2-4 PROJECT
Yale University Department of Physics – December 8, 2006

Introduction.

Jon Butler, Dean of the Graduate School, has asked every department to review and evaluate their PhD program this fall semester, concentrating on years 2 through 4. This is the 2-4 Project.

To oversee the physics department's review a faculty committee was established comprising Bonnie Fleming, Steve Girvin, Walter Goldberger, Dan McKinsey, Simon Mochrie, and Nick Read. Because we believe it is impossible to sensibly separate years 2 through 4 from year 1 and from later years, we took it upon ourselves to review and discuss all aspects of the program.

A key element of the 2-4 Project review was student input. To this end, both the Graduate School and the Physics Department's 2-4 Project Committee invited responses to questionnaires asking for students' opinions concerning various aspects of our graduate program. There were 9 responses to the GS questionaire and 15 to the committee's, out of a total of about 120 graduate students in the Physics Department. In addition, draft proposals were discussed at the Chairman's Town Meeting with graduate students on December 6, at which the attendence was about 50 students, and at a meeting of the Teaching Faculty on December 7. The proposed changes described in this document were approved by faculty vote at the December 7 meeting.

At these separate meetings, in essentially all cases, there was broad concensus among the students and among the faculty about how to modify the Physics PhD program. In addition, there was also good agreement between faculty and student opinion.

Proposals concerning course requirements and options

- Proposal 1: The department will implement "pass-out" examinations for the core courses, to be given at the start of each course, to determine whether a student has sufficient mastery of basic material to be excused that particular core course. (The core courses are here defined to be: PHYS 500 Dynamics, PHYS 502 Electromagnetic Theory, PHYS 506 Mathematical Methods of Physics, PHYS 508 Quantum Mechanics I, PHYS 512 Statistical Physics I, and PHYS 608 Quantum Mechanics II.) To be eligible to take this exam a student must have had a more-or-less equivalent-level course elsewhere. The exam will be administered by the DGS and the previous year's lecturer of the course in question. **This proposal was overwhelmingly popular amoung students.**

- Proposal 2: PHYS 500 Dynamics will remain a required course. Its content will be further updated in consultation with all interested parties. **The majority student opinion recognized that PHYS 500 had evolved in recent years to cover more advanced topics, but held that it should move even further in that direction, with even less of a review of of undergraduate material. The majority of students thought that such a more-advanced-topics PHYS 500 should remain a required course.**

- Proposal 3: PHYS 602 Classical Field Theory will no longer be a required course. All required electromagnetism will be covered in one semester in EM I. **This proposal was overwhelming popular among the experimental students. Theory students held mixed opinions.**

- Proposal 4: In consultation with the interested parties the 2-4 Project committee will decide on a proposal as to how best to present and coordinate classes in General Relativity.

- Proposal 5: The requirement to take QFT I or MBT I will become a requirement to take one of QFT I, MBT I, or a renormalization-group-based Statistical Mechanics II. QFT II and MBT II will also be satisfactory substitutes for the requirement, for students who have taken QFT or MBT, prior to coming to Yale. This proposal is predicated on second quantization being taught in QM II.

- Proposal 6: The department will specify what are the basic, essential concepts of physics at the graduate level. This will amount to guidelines for the topics covered in the core courses and the Qualifying Exam. The 2-4 Project Committee in consultation with the interested parties will provide a draft of these guidelines.

- Proposal 7: The requirement on first-year graduate students to take PHYS 504Lb will be modified to become a requirement to take either PHYS 504Lb or a laboratory-based special investigation (SI) (PHYS 991a,b), supervised by a particular faculty advisor. Either course must be completed in the first year of graduate study. To be able to chose the SI option, the student must have previously taken an advanced undergraduate laboratory class, and will be required to write a brief proposal specifying what the SI project is. The SI project must be approved by the DGS. In addition, a Powerpoint or similar presentation on the SI would be required at the end of the semester, graded by a 3 faculty panel. **This proposal was overwhelming popular proposal with students. Faculty opinion held that it was essential that this requirement be met in the first year of graduate study and that the option to do an SI only makes sense if the student has previously had an advanced undergraduate laboratory.**

- Proposal 8: If deemed necessary by the subfield, each subfield will determine a set of preferred courses, that represents a guide for the courses that students in that subfield will likely take beyond the core courses. At the same time, each subfield will examine the current slate of courses and if necessary develop new courses to present the material that will enable students to enter research effectively, and ensure they are regularly given. In some areas, collaboration with other departments will make a lot of sense. In other cases, there will be courses that are common to several subfields.

Rationale.

For many incoming students, the current core classes are appropriate. For better-prepared incoming students, however, repetition of material that they've previously mastered elsewhere delays the taking of more advanced and interesting courses and delays entry into research. It emerged in several of the questionnaire responses that students found some of the material of the core courses repetitive of undergraduate material, leading to considerable dissatisfaction.

Currently, it is possible at the discretion of the DGS for a student to replace a core course with an elective. However, this is a subjective judgement with lots of possibility for error either way. An exam, based on material from the previous years' course, that permits students to place out would be more objective and fairer. This motivates Proposal 1.

In the questionnaires, a significant fraction of the respondents indicated that some of material in PHYS 500 was repetitive of what they had already studied as undergraduates. This motivates Proposal 2.

Proposal 3 is motivated by the uncertain focus of CFT, and the opinion among student respondents that it was of doubtful value in later research.

Proposal 4 follows from the observation that, on one hand, General Relativity is increasingly important in a number of subfields, while, on the other, currently, the teaching of GR within the

department has become distributed among several courses, including Math. Methods, Classical Field Theory, PHYS 538a, and PHYS 680a.

In essence the QFT/MBT requirement is a requirement to have taken a class that involves Feynmann diagrams. Proposal 5 expands the list of courses that are consistent with this, but which may be preferable for some subfields, in particular, for soft-condensed matter physics.

At one level, Proposal 6 addresses the student-expressed concern that there is a mismatch between what is taught in the core courses and what is tested on the Qualifying Exam. Beyond this, however, in view of the increased diversity of Physics and the department, it seems valuable to indeed specify the essentials.

Since physics is based on experiments, it is imperative for all physics PhD students to have some laboratory experience. PHYS 504Lb is appropriate for incoming PhD students without sufficiently advanced undergraduate laboratory experience. Currently, students can be excused from PHYS 504Lb at the discretion of the DGS if they can demonstrate an equivalent previous class. This procedure too is fraught with objectivity and fairness issues. For students who have had prior laboratory experience, Proposal 7 propels them into a real research environment earlier than previously and it gives them credit for it. This is not a "soft option". The reason for insisting on a proposal and a final presentation is to ensure that the SI is a genuine educational experience, in which the student is invested in the research of the host group. Having a faculty group examine the outcome of the SI addresses one of the perceived weaknesses of the SI/rotation process in other science departments, namely that students who perform poorly in SIs are not given proper feedback, so that they remain unaware of what is expected of them in a research context. This problem was particularly emphasized in the Engelmann report. Such a group review also permits a wider range of potential advisors to get to know the student.

Proposals concerning the qualifying examination

- Proposal 1: The Qualifying Exam will remain unchanged in format and timing. Incoming students will be permitted to take the exam "for free", as currently, but will not be required to take it.

  The majority of students were more-or-less satisfied with the qualifying exam and by a ratio of about 3:1 would keep it as is rather than eliminate it.

- Proposal 2: Under exceptional circumstances, at the discretion of the faculty, students who fail the Qualifying Exam for the second time may be permitted to take a Special Oral Examination, the outcome of which will determine whether the student in question will be permitted to continue in the program. The purpose of any such Special Oral Examination is test whether the student, who has twice failed the written qualifying examination, is nevertheless sufficiently secure with the material of the core courses to eventually graduate with a Physics PhD. Any Special Oral Exam, therefore, should test whether this is the case by asking a number of questions at the level of and on the material of the written qualifying exam. The Special Oral Exam committee shall consist of 4 faculty nominated by the DGS.

Rationale. The student questionnaires overall did NOT reveal any great dissatisfaction with the current Qualifying Exam procedure, except a possible mismatch between material on the exam and that taught in the core courses. This motivates Proposal 1, and our earlier proposal to create guidelines for the topics appearing in the core courses and the qualifying exam. However, students

agreed with the concern, expressed by several, that the current administration/grading of the exam was too opaque. On balance, there was no faculty concensus on a satisfactory means to address this concern.

Proposal 2 formalizes an ad-hoc procedure that has been followed occasionally.

Proposals concerning research mentoring and feedback

- Proposal 1: For the special project carried out in the summer between the first and second years, students will be required to make a Powerpoint or similar presentation, and will be provided with written feedback concerning their overall research performance by the summer research advisor, that will be reviewed by the DGS.

- Proposal 2: A core thesis committee, consisting of 3 faculty members, will be appointed for each student at the earliest opportunity, either in the second semester of the second year or in the first semester of the third year. The student will present his/her 2-to-3 summer research and research plans to this committee early in the the first semester of the third year. *The committee composition can be changed later.*

- Proposal 3: Each student will meet periodically with her/his core thesis committee in closed session to discuss progress. These meetings will occur at least once per year, but could be more frequently at the discretion of the committee.

- Proposal 4: Each student will present his/her thesis Prospectus in an oral presentation to their core thesis committee (before the end of their third year). In addition, the committee will review the written prospectus, and will approve or suggest modifications to the Prospectus. The current system of review of the Prospectus by the entire faculty will be discontinued.

- Proposal 5: In addition, students will periodically give presentations (at least once per year) in a public forum, which the core thesis committee members are expected to attend and concerning which provide written feedback to the student. Possible forums for such presentations could include the Weak Interaction Discussion Group, the Monday Evening Seminar, the Single Molecule Discussion Group, collaboration presentations, group meeting presentations, *etc.*. The format of the presentation should be a a talk that lasts 40 minutes or more.

- Proposal 6: After admission to candidacy, each student will be provided with yearly written feedback from the Department, prepared by the student's advisor and reviewed and approved or disapproved by the student's core thesis committee.

- Proposal 7: The current format of a formal Field Oral Exam will be replaced by a requirement on the thesis committeee to ensure a sufficiently broad knowledge of the student's subfield.

Rationale. An important recommendation of the Engelman report, that the GS is emphasizing, was that students' research experiences should be formally evaluated and the evaluation results communicated to students in writing. Thus, substantive feedback to a student concerning his/her progress at the end of each year will shortly be required of us by the graduate school. This motivates re-evaluation of the department's formal procedures for monitoring a student's progress towards their PhD, and mentoring her/him along the way. Indeed, in the questionnaires, the reaction of most students was that they had never received any feedback concerning their research

performance, and that they would like feedback. Students particularly mentioned lack of feedback after talks, and a few bemoaned the absence of instruction in how to give a good talk. Some students, however, who were already making a number of research presentations to collaborators, disdained the idea of having to do an additional, special presentation for the thesis committee.

The Graduate School is especially concerned that research performance and potential be evaluated early on. This motivates Proposal 1.

A student's thesis prospectus is a very important document, representing an initial vision for the student's thesis. Currently, the prospectus is prepared by the student, in collaboration with the student's advisor. It is then submitted to the DGS and, if the DGS approves, it is posted on the Departmental web site for review by the entire faculty. The weaknesses in this procedure are two-fold. First, the DGS is not expert across subfields – certainly not the current one. Second, in most cases, expert faculty do not read the posted prospecti. Thus, the current procedure provides an inadaquate review of the thesis prospectus. By contrast, the proposed procedure provides the opportunity for mentoring and advice from more than solely the student's advisor. In this context, it is worth noting that Physics seems to be unique at Yale in not establishing a thesis committee essentially until the thesis is finished. These considerations lead to Proposals 2 and 4.

Proposals 3, 5 and 6 are designed to more closely monitor progress and mentor students beyond Year 3, and also provide detailed written feedback to the student about their progress as required by the Graduate School. The allowable format and content for the "public presentations" should be viewed broadly, subject only to the participation of the core thesis committee. Especially early on in her/his research career, to satisfy this requirement, it may be that it makes most sense for a student to make a journal club-type presentation in the context of a group meeting, later on progressing to a research-based presentation in one of the regularly scheduled series. Yearly private meetings with the core thesis committee, in addition to yearly public presentations which the core thesis committee attends will provide ample opportunity for the core thesis committee to determine that a student has a sufficiently broad knowledge of the subfield and to insist on steps to correct any important gaps. These extensive meetings will include any function that the Field Oral plays currently, leading to Proposal 7.

Preparing for presentations is likely to improve students' presentation skills and the ongoing monitoring of a student's research progress will diminish the chances of surprises at the thesis defense. Such monitoring will also provide a protection to both the student and advisor that is presently lacking: First, if a student has sufficient material for a PhD, why then the committee can push a reluctant advisor to agree to a thesis defence. (One questionnaire respondent complained that his/her advisor was reluctant to let him/her graduate, even though his/her thesis was really done, because as a senior student, he/she was less expensive and more skilled than a junior replacement would be.) Alternatively, if a student's research performance is inadequate, the committee can support academic sanctions on the student, *i.e.* that the student is not in good academic standing.

Finally, the use of a mutual assessment from, currently in use at Stanford, was considered but overwhelmingly rejected by the students.

Miscellaneous Proposals, Options, and Questions

- Proposal 1: The department will examine how students' teaching experience could be improved.

The questionnaires indicated that more contact time between TA and their students and less grading would be highly welcomed by many respondents. Some of our graduate students may want this and be suitable for this, some may not. However, there are many classes and we encourage a student-faculty discussion of how to accomodate graduate students who want to lecture/tutor, rather than grade. Perhaps, in some classes, there should be TA-led recitations?

One suggestions was the following, on a trial basis with willing faculty and willing TAs: Instead of having TAs grade all (6 or 8) problems on a problem set, they grade only 3 or 4 of the 6 or 8, chosen at random. In the remainder of their TF time, the students lead recitations down the hill the evening before the problem set is due.