Physics 198

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Introduction to Radiation Detectors and Electronics

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course notes in pdf format at www-physics.LBL.gov/~spieler

WHY?

Radiation is the only observable in processes that occur on a scale that is either too brief or too small to be observed directly.

Originally developed for atomic, nuclear and elementary particle physics, radiation detectors now are applied in many diverse areas of science, engineering and everyday life.

Progress in science is driven not just by the interplay of theory and experiment, but also by breakthroughs in instrumentation.

Types of Radiation:

a) charged particles

electrons, protons, atomic nuclei
+ many elementary particles

b) neutral particles

neutrons
+ many elementary particles

c) photons

light
x-rays
gamma rays

Emphasis of this course:

detection of individual particles or photons

The development of detector systems is an interdisciplinary mix of physics and electronics.

For example, understanding of a modern tracking detector in high-energy physics or a medical imaging system requires knowledge of

- solid state physics
- semiconductor device physics
- semiconductor fabrication technology
- low-noise electronics techniques
- analog and digital microelectronics
- high-speed data transmission
- computer-based data acquisition systems

Some examples as introduction….

- imaging in astronomy
  (thanks to Steve Holland, Engineering Div. LBNL)

- medical imaging –
  positron emission tomography
  (thanks to Bill Moses, Life Sciences Div. LBNL)

- detection of trace elements by x-ray fluorescence
  (thanks to Joe Jaklevic, Engineering Div. LBNL)

- tracking detectors in high-energy physics

- failure analysis in silicon integrated circuits

Course Content

1. Energy Loss Mechanisms and Spectrum Formation
2. Scintillation Detectors

   Use a “simple” detector system to
   explain basic requirements and functional blocks of
   complete system
3. Semiconductor Detectors (ionization chambers)

   signal formation

   electronic noise

   optimization of signal-to-noise ratio

   pulse processing electronics

   amplification and pulse shaping
   amplitude digitization
   time measurements
4. A Semiconductor Device Primer
5. Photodiodes
6. Gaseous Detectors
7. Position Sensitive Detectors
8. Detectors for Weakly Ionizing Radiation
9. Development of a System Concept
10. Why Things Don’t Always Work

Open to change as required.

The course does not follow a specific text, but a useful book is

Radiation Detection and Measurement
by Glenn F. Knoll, Wiley, 1989,

QC787.C6K56
ISBN 0-471-81504-7

Additional literature will be specified for specific topics.

Course notes and homework problems will be posted on the World Wide Web (www-physics.LBL.gov/~spieler)

Homework will provide basis of pass/fail.

Questions …

Scheduling?

Office hours?

I'll be available after each lecture,

or contact me and we can meet some other time

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