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Physikalisches Institut
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Experimental Methods in Elementary Particle Physics

Course Nr. 6794

Summer Semester 1999

Course Outline

I. General Introduction
   - A. Units
   - B. Cross section, Interaction length

II. Particles and Forces

III. Relativistic Kinematics

IV. Energy Loss Mechanisms in Matter
   - A. Ionization
   - B. Bethe-Bloch formula
   - C. Density effect
   - D. Landau distribution

V. General Detector Properties
   - A. Sensitivity, noise, least significant bit
   - B. Response function, acceptance, linearity, saturation, dynamic range
   - C. Resolution
   - D. Efficiency
   - E. Dead time

VI. Ionization Chambers

A. Generalities
   1. Parallel-plate capacitor
   2. Charge collection time
   3. Primary, secondary ionization
   4. Avalanche, gas gain

B. Proportional chambers
   1. Cylindrical geometry
   2. Gain dependence on operating voltage
   3. Relative contributions to signal from electrons and ions
   4. Signal readout
   5. Plateau curve
   6. Multiwire proportional chamber
   7. Position resolution

C. Planar drift chambers
   1. Drift velocities, Ramsauer cross section
   2. Diffusion
   3. Contributions to position resolution
   4. Drift time distributions
   5. Magnetic field, Lorentz angle

D. Cylindrical drift chambers

E. Time projection chambers (omitted)

F. Momentum resolution

VII. Scintillation Detectors

A. Generalities
   1. Organic, inorganic scintillators
   2. History, ZnS, Crookes (1903), photomultipliers (1944)
   3. Associated topics
      a. Emission and absorption spectra
      b. Light yield, photostatistics, energy loss, saturation
      c. Decay time
      d. Light transport, attenuation length
      e. Light-sensitive detectors

B. Organic scintillators

1. Light emission, absorption
2. Light yield, photostatistics
3. Decay time
4. Attenuation length
5. Light-sensitive detectors, photomultiplier tubes
6. Time measurement, constant-fraction timing
7. Example: Scintillating fibers
8. Time-of-flight detectors

C. Inorganic scintillators

1. NaI(Tl), CsI(Tl), BGO
2. Energy resolution

VIII. Cerenkov and Transition Radiation Detectors

A. Theoretical treatment

1. Dispersion formula
2. Optical, absorption and X-ray regions

B. Cerenkov detectors

1. Threshold counters
2. Ring-imaging detectors

C. Transition radiation

IX. Calorimetry

A. Generalities

B. Physical processes

1. Multiple scattering
2. Energy loss by electrons
   a. Ionization
   b. Bremsstrahlung
3. Interactions of photons with matter
   a. Photo-effect
   b. Compton scattering
   c. Pair production

C. Electromagnetic calorimeters

1. Shower formation
2. Inorganic scintillating crystals
3. Lead glass
4. Sampling calorimeters

D. Hadronic calorimeters

1. Shower development
2. Energy loss mechanisms
3. Compensation
4. Energy resolution