SLAC-PEP-NOTE--161

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STUDY OF THE REACTION $e^+e^- \to \mu^+\mu^-$ WITH AN IRON SOLENOID SPECTROMETER

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AUG [illegible]

Abstract

An iron core solenoid spectrometer is considered which will measure $e^+e^- \to \mu^+\mu^-$ and other final states such as e^+e^- (elastic) and $\gamma\gamma$. Other processes including hadron production an $e\,\mu$ production may also be studied. The spectrometer magnet is assembled from two independent rectangular parts of which the inner contains drift chambers and shower counters.

1. Primary Physics Goals:

(1) Measure the charge asymmetry in $e^+e^- \to \mu^+\mu^-$ over essentially 4π sr. solid angle.

(2) Measure σ ($e^+e^- \to \mu^+\mu^-$) by detecting the muons over essentially 4π s solid angle and monitoring the luminosity using two or three independent processes:

- (a) small angle Bhabha scattering
- (b) large angle Bhabha scattering ($35° < \theta < 145°$; no charge identification)
- (c) $e^+e^- \to \gamma\gamma$ which is weak interaction independent

Both (1) and (2) give information on weak interactions as discussed in detail in the group report. To use the $e^+e^- \to 2\gamma$ reaction as a monitor, spark chambers for the localization of photons need to be added to the attached design.

2. Secondary Physics Goals:

The primary goal of studying weak interaction - electromagnetic interaction interference effects in both charge asymmetry and σ ($ee \to \mu\mu$) requires acquisition of a large number of muon pairs ($\gtrsim 10^4$), near 4π solid angle acceptance, and careful monitoring of luminosity. This involves a substantial amount of beam time. It seems therefore very sensible to include other experiments into the program as long as they do not add significantly to the complexity of the experiment or interfere otherwise with the primary goals.

Within these guidelines, the following additional experiments can be carried out in parallel:

(1) Comparison of the detailed angular distribution in the 3 Q.E.D. reactions $e^+e^- \rightarrow e^+e^-, \mu^+\mu^-, \gamma\gamma$ between $35° < \theta < 145°$.

(2) Look with high efficiency for non-collinear (eμ), (μμ), (ee) and lepton-photon signatures of new particles.

Other secondary experiments such as a measurement of the total hadronic production cross section, or of π° final hadron states, would require substantially more complex (but not necessarily heavier!) apparatus and/or abandonment of small angle muon detection.

3. General Design Considerations

(1) The iron solenoid geometry is used so that the magnetic deflection is in a plane ⊥ to the beam direction where it can be measured accurately with cylindrical chambers surrounding the beam pipe (ϕ is measured well, θ is not) and drift chambers surrounding the iron box.

(2) The "flux returns" are arranged so as to serve as muon filters in the forward and backward directions. In these regions leakage from other particles may be more important; the filter is naturally twice as thick as at $\theta = 90°$.

(3) $(\mu^+\mu^-)$ pairs are measured down to small angles ($\theta \gtrsim \sim 5°$) to measure accurately σ ($ee \rightarrow \mu\mu$) and to have an additional check of the radiative corrections to the charge asymmetry (the corrections dominate the effect of weak interactions at small angles).

(4) At the price of bulkiness (i.e. lots of iron!) the iron structure is geometrically simple: it is composed of a few large, rectangular pieces. The counters and spark chamber are all simple and considering the size of the magnet, few in numbers.

(5) The apparatus fits easily into a "high luminosity" interaction region with a 10 m total length

4. Specific Design Considerations

(1) The shortest path length through the iron is 1 m. Assuming 15 Kgauss average magnetic field in the iron (which requires driving some portion of the iron into saturation) this means that $(\phi^2_{magn} / \phi^2_{scatt})^{1/2} = 4.0$ for the shortest path.

(2) The magnetic deflection for 15 GeV particles is $\phi_{magn} = 3 \times 10^{-2}$ rad. Thus we want to measure ϕ to $\sim 3 \times 10^{-3}$ radians. This can be done in cylindrical chambers ∼20cm thick and drift chambers about 20cm thick.

(3) A 10 rad. length thick shower counter (5.6 cm Pb + 10 cm scint)

can be fitted into a 20 cm thick cylinder outside of the cylindrical spark chamber.

(4) The initial direction of particles is measured in the cylindrical spark chamber in the region ~25° < θ < 155°, in end cap flat chambers for ~ 7° < θ < 25°, 155 < θ < 173°

(5) The trigger consists of coincidences between 2 muon signatures or 2 electron (photon) signatures or 1 muon + 1 electron (photon) signature.

A muon signature consists of a coincidence between an inside and an outside counter. An electron (photon) signature consists of a large pulse in one of the shower counters. Time of flight discriminates against Cosmic Ray triggers.

(6) For access to the interior detectors, the sides of frame B should be movable on rails.

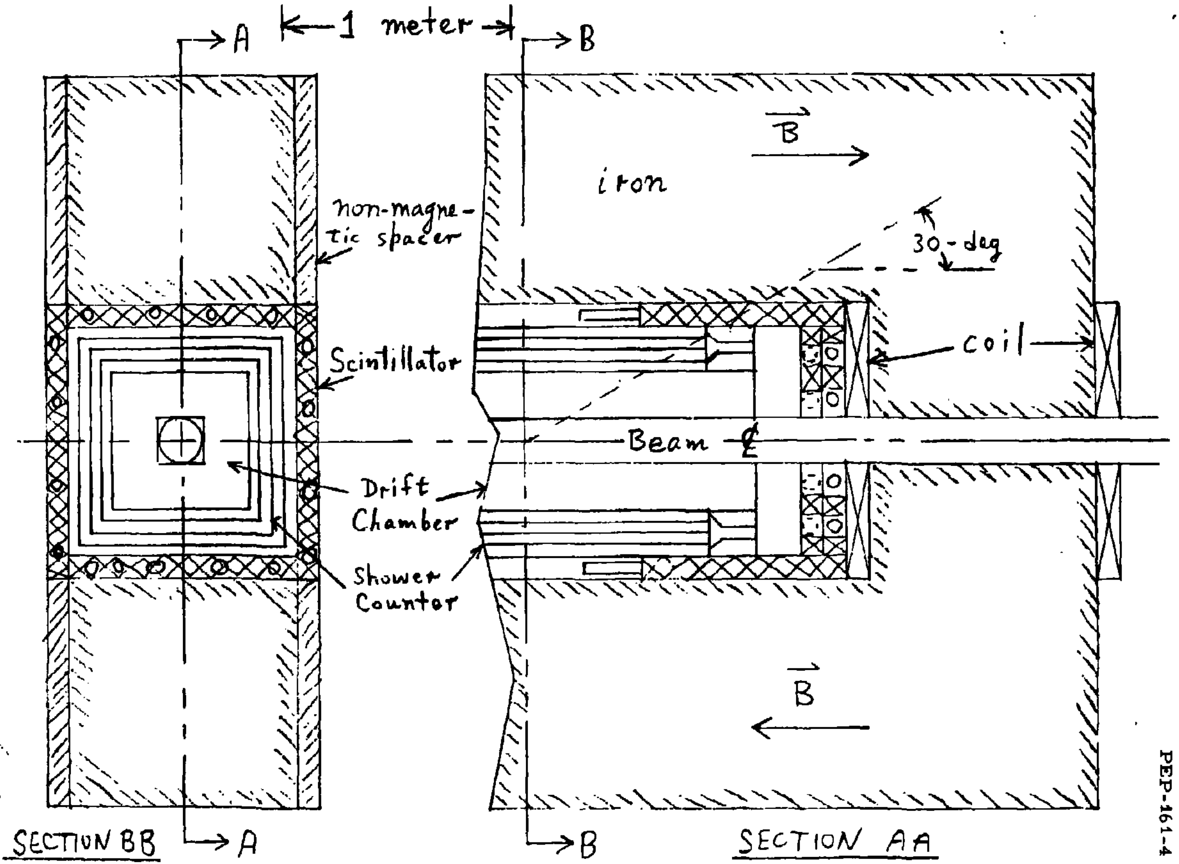
(7) Some of the remaining questions that need further study:

- (a) coils-size and power
- (b) shielding of beams when passing through end caps.
- (c) small separation of frames A and B to decouple the two magnetic circuits.
- (d) radiative corrections

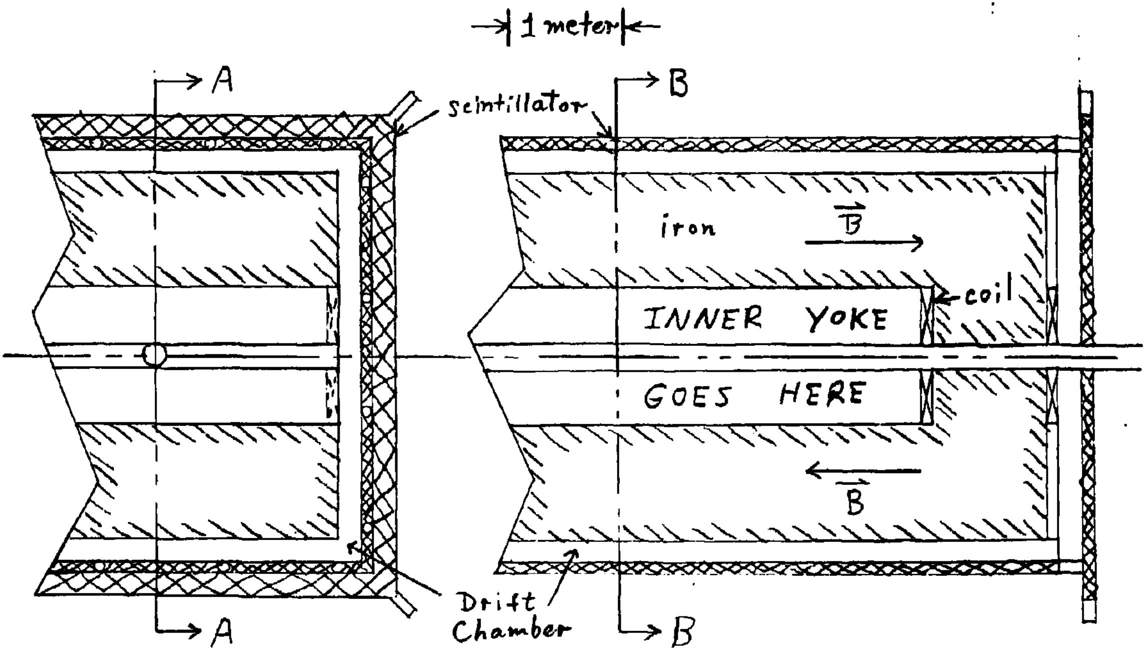
(a), (b), (c) require studies with a magnetic field program.

DISCLAIMER

IRON SOLENOID SPECTROMETER - INNER YOKE



IRON SOLENOID SPECTROMETER — OUTER YOKE



SECTION BB

SECTION AA