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PROSPECTS FOR R MEASUREMENT AT *BABAR* USING RADIATIVE RETURN

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ABSTRACT

A precise measurement of the ratio of hadron to muon production in e^+e^- collisions, denoted by $R(s)$, is a necessary input for the interpretation of current precision electroweak measurements. We describe a method for measuring $R(s)$ with the *BABAR* detector at the PEP-II B-factory using initial-state radiation events.

1 Introduction

In recent years, precision electroweak measurements have probed some of the fundamental parameters of the Standard Model. Following the successful prediction of the mass of top quark, the precise measurement of electroweak parameters can now put significant constraints on the Higgs boson mass. Similarly, the unprecedented precision of the BNL measurement of the muon anomalous magnetic moment $(g-2)$ [1] could also offer sensitivity to beyond-the-Standard-Model physics.

However, interpreting those results requires precise theoretical predictions of Standard Model contributions. At present the leading source of uncertainty in these calculations arises from hadronic corrections, which cannot be computed from first principles. For the Higgs mass, this corresponds mainly to hadronic contributions to the running of α_{QED}, and hadronic corrections to the QED vertex for $g-2$. These contributions can be related through dispersion integrals to the cross-section for $e^+e^- \to$ hadrons, or equivalently to $R(s)$, defined as its ratio with the Born cross-section for $e^+e^- \to \mu^+\mu^-$. For the running of α_{QED}, and the muon magnetic moment, we have respectively

$$\Delta\alpha_{QED}^{Had}(M_Z^2) \propto \int_{4m_\pi^2}^{\infty} as\frac{R(s)}{s(s-M_Z^2)} \quad \text{and} \quad \Delta a_\mu^{Had} \propto \int_{4m_\pi^2}^{\infty} ds\frac{R(s)K(s)}{s} \tag{1}$$

where $K(s)$ is the QED kernel function. A precise measurements of $R(s)$ over a wide energy range would have a significant influence on the determination of both these quantities. It would also shed some light on recently discovered discrepancies between hadronic data from e^+e^- collisions and τ decays, which have significant impact on the interpretation of the $g-2$ measurement. [1] At present $R(s)$ can be reliably calculated above 10 GeV using perturbative QCD. It would therefore be particularly useful to provide a precise measurement for energies below 10 GeV.

2 The Radiative Return Method

There has recently been a renewed interest in the possibility that the measurement of $R(s)$ could be performed at fixed-energy colliders by using radiative return to lower energies [3, 4]. An especially attractive possibility would be to use the large event rates provided by the B-factories, where the fiducial cross-section is estimated to be of the order of 40 pb for events with a hadronic system invariant mass less than 7 GeV. , yielding about 3.6 million fiducial events in the current *BABAR* dataset of 90 fb^{-1}.

It would in particular be possible to perform an inclusive analysis, which would rely only on the identification of the tagged initial-state radiation (ISR) photon. A highly efficient hadronic selection would be performed, with minimal sensitivity to detector efficiency and event shape modelling. Alternatively, an exclusive analysis could be performed, in which each possible hadronic decay channel is analyzed separately. This would be especially advantageous for energies near to the ρ mass, which provide the largest contribution to the $g-2$ integral, since the measurement of $R(s)$ through $\sigma(e^+e^- \to \pi^+\pi^-\gamma)/\sigma(e^+e^- \to \mu^+\mu^-\gamma)$ benefits from the cancellation of radiative and efficiency corrections. The inclusive method would present the disadvantage that the photon energy resolution gives a large uncertainty on the effective center-of-mass energy s' in the deep ISR regime. This would however not be a significant problem in the case of the running of α_{QED}, for which the dispersion integral has little sensitivity to uncertainties on s'.

[1] See Andreas Hoecker's contribution in these proceedings.

3 Comparison With Other Methods

Using the radiative return offers several advantages over energy-scan methods. The entire energy range — for *BABAR*, from the ρ peak to about 7 GeV — can be covered in a single measurement. With the currently available datasets, the event rates in each energy region are expected to be competitive with other experiments: the latest BES measurement of $R(s)$ [5], in the energy range $2-5$ GeV is based on about $120,000$ events, while the current *BABAR* dataset should include about $950,000$ events in the same interval. The higher center-of-mass energy of the collision also leads to a different event geometry, with a collimated hadronic system recoiling at high momentum against the ISR photon. By selecting tagged photons well within the detector we can ensure high fiducial acceptance for the hadronic system. In addition, the boost imparted to the hadron system produces particles with higher transverse momentum, thus reducing the kinematic bias in the event selection due to limited p_T coverage. The high energy of the photon can also be used to reduce contamination from beam backgrounds such as beam-gas interactions, which form an important systematic uncertainty in the BES measurement. Finally, the situation with respect to final-state radiation (FSR) is improved, with a clear geometrical separation between ISR, mostly located in the vicinity of the collision axis, and FSR, which follows the directions of outgoing hadrons. This can furthermore be verified in data by studying the forward-backward asymmetry produced by ISR/FSR interference.

4 Conclusion

The radiative return method offers promising prospects at *BABAR* and other facilities. Competitive measurements can already be made based an available datasets and preliminary results are expected in the coming months.

References

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