Final Technical Report

Outstanding Junior Investigator Award DE-FG02-94ER40869
August 1, 1994 – July 31, 2001

Principal Investigator: Adam F. Falk, Johns Hopkins University

This report summarizes the research of the Principal Investigator, his postdoctoral research associates, and his students during the period of the award. The majority of the work concerns the behavior hadrons containing strange, charm, bottom and top quarks, with a particular focus on the extraction of Cabibbo-Kobayashi-Maskawa matrix elements from experiments performed on such systems.

DOE Patent Clearance Granted
Mark P. Dvorscak
Mark P. Dvorscak
(630) 252-2393
E-mail: mark.dvorscak@ch.doe.gov
Office of Intellectual Property Law
DOE Chicago Operations Office
1.7.03
Date

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Summary of Research Activities for 1994-2001

During this period, the grant supported in part the work of Falk, postdocs Alexey Petrov, Robert Fletcher, and Michael Booth, and students Alexander Kyatkin, Tom Mehen, George Chiladze and Adam Lewandowski. Before listing the publications, I discuss briefly the content of these investigations.

1. *Inconclusive Inclusive Nonleptonic B Decays*: Falk, M. Wise and I. Dunietz investigated the apparent conflict between calculations of the semileptonic branching ratio of the B meson and the experimentally measured rate. They recast the problem as a test of certain key hypotheses in the QCD calculation. They concluded that the discrepancy can be resolved within QCD by relaxing certain convenient assumptions, a disappointing but not unnatural scenario. Most importantly, they argued, in contrast to other authors, that this discrepancy provides *no* substantial evidence for new flavor-dependent interactions at the TeV scale.
2. *Another Source of Baryons in B Meson Decays*: Motivated by this “charm deficit”, I. Dunietz, P. Cooper, Falk and M. Wise suggested that the baryons which are produced in B decays arise primarily in channels with two charm quarks in the final state, rather than one. They found evidence for such a scenario in the energy spectrum of charmed baryons from B decays, and they suggested additional tests of their proposal. If substantiated by further data, this scenario would moderately enhance the experimental number of charm quarks observed per B decay, reducing the discrepancy discussed above.
3. *Instantons and the Endpoint of the Lepton Energy Spectrum in Charmless Semileptonic B Decays*: Falk and Kyatkin investigated whether instanton corrections could spoil an interesting relation between the endpoint spectra in charmless semileptonic and radiative B decays. This relation is of considerable phenomenological relevance for the extraction of the CKM matrix parameter V_{ub} from data, and it is important to know whether it holds when nonperturbative effects are included. They found that unless the theoretical spectrum is smeared over a region considerably larger than previously thought necessary (and perhaps larger than is experimentally available), the relation may well fail. This result affects the possibility of performing a reliable measurement of V_{ub} using inclusive decays.
4. *Excited Heavy Mesons Beyond Leading Order in the Heavy Quark Expansion*: In this paper, Falk and Mehen built on Falk’s earlier work on the application of heavy quark effective theory to the excited heavy mesons. The goal was to understand whether certain anomalies in the properties of excited charmed mesons could be understood within the heavy quark expansion, or whether they indicated a failure of this expansion in the case of charm. This question has important implications for the heavy quark program as a whole, since a clear failure in one context would lead one to view other results with suspicion. They found that a proper treatment of the subleading corrections to the theory leads precisely to the pattern of symmetry breaking which is observed in nature.
5. *Hadron Spectra for Semileptonic Heavy Quark Decay*: In this paper with M. Luke and M. Savage, Falk studied the mass and energy distributions of hadrons produced in semileptonic B and D decays. These distributions are theoretically interesting, because they di-

rectly probe physics beyond the parton model, or beyond leading order in perturbative QCD. Hence they are an excellent laboratory in which to investigate questions such as the convergence of the heavy quark and perturbative expansions, and the applicability of parton-hadron duality to inclusive heavy quark decays. Falk, Luke and Savage also showed how to organize the analysis in such a way as to reduce the dependence of the theoretical predictions on unknown infrared renormalon ambiguities.

6. *Phenomenology of the $1/m_Q$ Expansion in Inclusive B and D Decays:* Falk, M. Luke and M. Savage explored the phenomenological applications of the theoretical analysis of the previous paper. In particular, by analyzing the moments of the hadronic distributions simultaneously with the total semileptonic decay rate, they were able to extract new bounds on the CKM matrix element V_{cb} , as well as constrain the nonperturbative heavy quark parameters $\bar{\Lambda}$ and λ_1 and the heavy quark masses. They also extended the analysis to semileptonic charm decays, where they found no evidence for the failure of parton-hadron duality.

7. *Resumming Phase Space Logarithms in Inclusive Semileptonic Decays:* With C. Bauer and M. Luke, Falk studied the origin of phase space logarithms in inclusive B decays. These logarithms, which usually arise from the integration over the charm quark phase space, may alternatively be understood from the point of view of an operator product expansion. Their approach allows one to resum the leading perturbative corrections to the phase space logarithms, in a leading logarithm approximation. While the new contributions are not numerically dominant, this analysis clarifies the origin of the phase space logarithms and their relation to other logarithms which appear in the theory.

8. *A New Interpretation of the Observed Heavy Baryons:* Falk proposed a resolution to the problem of the apparent large violation of $SU(3)$ flavor and heavy quark symmetry observed in the charmed and bottom baryon systems. His solution was to posit the existence of additional heavy baryon resonances, too light to decay via pion emission, and to reassign certain quantum numbers of those heavy baryons which have already been observed. This proposal is currently being investigated by a number of experimental groups at Cornell and Fermilab.

9. *A Model for the $B \rightarrow X_s + \gamma$ Decay in the Chromomagnetic Background:* Hopkins student Kyatkin studied a background field model for the chromomagnetic interactions in the B meson, in order to study the endpoint of the photon energy in the decay $B \rightarrow X_s + \gamma$. He found that the model made an interesting prediction, that the photon energies near the endpoint would be split by an analogue of the Zeeman effect. This prediction is testable at the B Factories, where this spectrum will be measured precisely.

10. *Excited Heavy Mesons Beyond Leading Order in the Heavy Quark Expansion:* In this paper, Falk and Mehen built on Falk's earlier work which applied heavy quark effective theory to the excited heavy mesons. The goal was to understand whether certain anomalies in the properties of excited charmed mesons could be understood within the heavy quark expansion, or whether they indicated a failure of this expansion in the case of charm. This question has important implications for the heavy quark program as a whole, since a clear failure in one context would lead one to view other results with suspicion. They found that a proper treatment of the subleading corrections to the theory leads precisely to the pattern of symmetry breaking which is observed in nature.

11. *Scale Setting in Top Decays*: Hopkins student Mehen applied the Brodsky-Lepage-Mackenzie scale-setting analysis to the radiative corrections to inclusive top quark decay. He found that the perturbation series was surprisingly ill-behaved in certain regions of the phase space. However, this behavior was sensitively dependent on the choice of expansion variables; for example, it is straightforward to show that where the series was badly behaved when expressed in terms of the pole masses, it improved considerably when re-expressed in terms of the running masses. The analysis provides an important case study in how the BLM procedure can give misleading results if not applied and interpreted with care.

12. *Testing Quarkonium Production with Photoproduced $J/\psi + \gamma$* : Mehen computed the leading color-octet contributions to the process $\gamma + p \rightarrow J/\psi + \gamma(+X)$ within the non-relativistic QCD (NRQCD) factorization formalism. In the color-singlet model, $J/\psi + \gamma$ can only be produced when the photon interacts through its structure function, while the color-octet mechanism allows for production of $J/\psi + \gamma$ via direct photon-gluon fusion. This process provides a conclusive test of the color-octet mechanism. $J/\psi + \gamma$ production is particularly sensitive to the NRQCD matrix element which figures prominently in the fragmentation production of J/ψ at large $p_\perp$ in hadron colliders. He also examined the predictions of the color evaporation model of quarkonium production and found that this process can easily discriminate between the NRQCD factorization formalism and the color evaporation model.

13. *Quenched Chiral Perturbation Theory for Vector Mesons*: Falk, Booth and Chiladze developed quenched chiral perturbation theory for vector mesons made of light quarks, in the limit where the vector meson masses are much larger than the pion mass. They used this theory to extract the leading nonanalytic dependence of the vector meson masses on the masses of the light quarks. By comparing with analogous quantities computed in ordinary chiral perturbation theory, they estimated the size of quenching effects, and observed that in general these effects can be quite large. This estimate is relevant to lattice simulations, where the ρ mass is often used to set the lattice spacing.

14. *Hybrid Charmonium Production in B Decays*: Falk, Petrov and Chiladze studied the production of hybrid charmonium states in B meson decays. It had been suggested that such processes might help resolve the "missing charm puzzle" if the hybrids decay not to open charm but to light hadronic final states. This group developed an analysis of charm production based on the operator product expansion; they showed that the proposed effect gives too small a contribution to resolve the puzzle.

15. *Final State Interactions and New Physics in $B \rightarrow \pi K$ Decays*: Falk, Petrov, A. Kagan and Y. Nir used a phenomenological Regge model to study final state interactions in $B \rightarrow \pi K$ decays. In the absence of rescattering effects, this process provides important information about the CKM parameter γ ; the goal of this analysis was to probe the robustness of this information once rescattering was included. The conclusion was that in the absence of direct experimental bounds on rescattering effects, the information on γ to be obtained from $B \rightarrow \pi K$ is not reliable.

16. *Hadronic Spectral Moments*: Falk and M. Luke updated their earlier study of hadronic spectral moments in semileptonic B decays. The new moments incorporates modest lepton energy cuts which are integral to the CLEO analysis of these moments. This new measurement and calculation will permit the most sensitive determination of the HQET parameter

$\bar{\Lambda}$ to date, an analysis which is now being completed by CLEO. The computation includes the “BLM-type” two loop corrections, which are important for assessing the quality of the extraction of $\bar{\Lambda}$, as well as corrections of order $1/m_b^3$, which provide information about residual theoretical uncertainties.

17. *Charmless B Decays*: Falk, Z. Ligeti and M. Wise performed a study of the distribution of hadronic invariant masses in charmless semileptonic B decays. The goal was to understand, in a *model-independent* way, if the B decay rate to hadrons with invariant masses $s_H < m_D^2$ may be used to extract the CKM parameter V_{ub} . An accurate measurement of V_{ub} is possible, if the HQET parameter $\bar{\Lambda}$ is known to 100 MeV.

18. *Phenomenology of New Baryons with Charm and Strangeness*: Falk and Chiladze studied the spectrum and decays of baryons with the quark content csq . The analysis was inspired by the report by CLEO of the discovery of a new, excited csq resonance. They predicted its width and decay properties, and also suggested new decay channels, such as $\Xi_c K$, in which it would be productive to look for more such states.

19. *Quenched Chiral Perturbation Theory for Heavy Baryons*: Hopkins student Chiladze extended heavy baryon chiral perturbation theory to include the effects of quenching. In this framework the leading nonanalytic dependence of the heavy baryon masses on the light quark masses was studied. The size of quenching effects was estimated by comparing the results of quenched and ordinary chiral perturbation theories. It was found that in general they can be large. This estimate is relevant to lattice simulations of the heavy baryon masses.

20. *Leptoproduction of J/ψ* : Along with S. Fleming, Mehen studied leptoproduction of J/ψ at large Q^2 within the nonrelativistic QCD (NRQCD) factorization formalism. The cross section is dominated by color-octet terms that are of order α_s . The color-singlet term, which is of order α_s^2 , was shown to be a small contribution to the total cross section. They also calculated the tree diagrams for color-octet production at order α_s^2 in a region of phase space where there is no leading color-octet contribution. They found that in this regime the color-singlet contribution dominates. They argued that non-perturbative corrections arising from diffractive leptoproduction, higher twist effects, and higher order terms in the NRQCD velocity expansion should be suppressed as Q^2 is increased. Therefore, the color-octet matrix elements $\langle \mathcal{O}_8^\psi(1S_0) \rangle$ and $\langle \mathcal{O}_8^\psi(3P_0) \rangle$ can be reliably extracted from this process. Finally, they pointed out that an experimental measurement of the polarization of leptoproduced J/ψ will provide an excellent test of the NRQCD factorization formalism.

21. *Summing $O(\beta_0^n \alpha_s^{n+1})$ Corrections to Top Quark Decays*: Mehen computed QCD corrections of order $\beta_0^n \alpha_s^{n+1}$ to top quark decays into W^+ and H^+ bosons to all orders in perturbation theory. Predictions for the radiative corrections to the top quark width were compared with the estimates from BLM scale setting procedures. The results of the summation were shown to greatly improve understanding of higher order corrections in the limit $m_W, m_H \rightarrow m_t$, where the BLM scale setting method is known to fail. Attempts to reduce nonperturbative error by substituting the running mass for the pole mass in the expression for the decay were shown to fail in the limit $m_W, m_H \rightarrow m_t$ because of subtleties in the treatment of phase space.

22. *Radiative Leptonic B_c Decays in Effective Field Theory*: With Chiladze and Petrov,

Falk investigated the radiative leptonic decay $B_c \rightarrow \gamma l \nu$. This process is an important background to the annihilation process $B_c \rightarrow l \nu$, which will be used to extract the B_c decay constant. We performed a model-independent calculation, based on QCD, of the partial width and various kinematic distributions. We also examined the decay within the framework of NRQCD, an effective field theory of nonrelativistic quarks, generalizing the NRQCD Lagrangian to include external sources for the weak and electromagnetic currents.

23. *Precision Observables and Electroweak Theories:* With Hopkins professors M. Swarz and J. Bagger, Falk computed the bounds from precision observables on alternative theories of electroweak symmetry breaking. They showed that a cut-off as large as 3 TeV can be accommodated by the present data, without unnatural fine tuning.

24. *SIBYLL: An Event Generator for Simulation of High Energy Cosmic Ray Cascades:* Along with T. Gaisser, Lipari, and T. Stanev, Hopkins postdoc Fletcher described the physical basis and some applications of an efficient event generator designed for Monte Carlo simulations of atmospheric cascades at ultra-high energies. The event generator (SIBYLL) emphasized the fragmentation region and the production of minijets in both hadron-hadron and hadron-nucleus interactions. Examples of applications are the calculation of coincident muons observed in deep underground detectors and the simulation of the longitudinal development of air shower components in the atmosphere. The model is now being used by the MACRO, AMANDA, Auger, and other collaborations in detector design and data analysis.

25. *The Hadronic Interactions and the Development of High Energy Air Showers.* As part of the Pierre Auger Project Design Report, assembled at Fermilab, Fletcher worked with members of the Auger Project to study the sensitivity of measurements of high energy air showers to uncertainties in our understanding of high energy cosmic rays. The Auger Project hopes to measure the composition, energy, and arrival direction of cosmic rays in the region of the GKZ cutoff. As part of the design proposal, comparisons were made of the SIBYLL Monte-Carlo program for hadronic interactions to previous models. The use of this more realistic interaction model substantially changes the density of muons in very high energy air showers.

26. *Measurement of γ in B_s decays:* Falk and Petrov proposed that the CKM phase γ be extracted by comparing the decays of flavor and CP-tagged B_s mesons to the final states $D^\pm K^\mp$. While the measurement of flavor-tagged decays will be done at the Tevatron, the identification of CP-tagged initial states requires an e^+e^- collider operating at the $\Upsilon(5S)$ resonance. This method for extracting γ is entirely theoretically clean. The more complicated case of CP-tagging in the B_d system was also investigated.

27. *Extraction of V_{ub} from $b \rightarrow u\bar{c}d$:* Falk and Petrov proposed that the CKM matrix element $|V_{ub}|$ be extracted by studying the inclusive nonleptonic decay $B \rightarrow X_c$. They identified a ratio of physical observables which could be computed with small theoretical uncertainties, and which is directly sensitive to the ratio $|V_{ub}/V_{cb}|$. In a follow-up to this paper, Falk, Petrov, J. Chay and M. Luke worked out this proposal in more detail, proposing new observables to study and refining the theoretical analysis by calculating additional radiative and nonperturbative corrections.

28. *Strong phases in D decays:* Falk, Petrov and Y. Nir investigated the strong phase

difference between the decay $D^0 \rightarrow K^+\pi^-$ and $\bar{D}^0 \rightarrow K^+\pi^-$. The phase difference δ vanishes in the flavor $SU(3)$ limit, so it has always been assumed that it is small. However, a large phase difference could affect the interpretation of a recent CLEO analysis of $D^0 - \bar{D}^0$ mixing. With a model in which the decay receives a large contribution from intermediate excited K^* resonances, they found that a value as large as $\sin \delta \sim 0.3$ is quite natural, and should be allowed for in the CLEO analysis.

29. *Interpretation of $D^0 - \bar{D}^0$ mixing experiments*: Petrov, Y. Nir, S. Bergmann, Y. Grossman, and Z. Ligeti examined the seemingly contradictory recent results on $D^0 - \bar{D}^0$ mixing from the CLEO and FOCUS experiments. They found that in the presence of very large final state interactions in $D^0 \rightarrow K^+\pi^-$, it is possible for the central values of the two measurements to be consistent with each other, since they are sensitive to $D^0 - \bar{D}^0$ mixing in different ways. They also explored the implications of the scenario $\Delta\Gamma \gg \Delta M$ in the D^0 system.

30. *Production of charmonium at neutrino factories*: Petrov and T. Torma studied production of charmonium states in an experiment in the beam of high-luminosity neutrino source such as has recently been proposed. The process of charmonium production is calculable in QCD, once the nature of the target is known. The rates turn out to be quite significant, and the process is sensitive to hadronic matrix elements which are difficult to measure in other experiments such as at the Tevatron.

31. *CP violation in models with right-handed couplings*: Hopkins student Lewandowski studied CP violation in a class of models in which the b couples only via right-handed interactions. After showing that such models are in fact highly constrained by collider limits and existing data on K decays, he went on to explore the pattern of CP violating asymmetries which would be observed in B and B_s decays. It turns out that this scenario is quite different in its predictions from the standard CKM picture.

32. *CP tagging in B_d and B_s decays*: Falk and Hopkins postdoc Petrov proposed that the CKM phase γ could be extracted from CP-tagged B and B_s decays at future high-luminosity e^+e^- B Factories. For example, one may compare the decays of flavor and CP-tagged B_s mesons to the final states $D^\pm K^\mp$. While the measurement of flavor-tagged decays will be done at the Tevatron, the identification of CP-tagged initial states requires an e^+e^- collider operating at the $\Upsilon(5S)$ resonance. This method for extracting γ is entirely theoretically clean. In a follow-up paper, Falk developed the formalism for the more complicated case of CP-tagging in the B_d system.

33. *Effects from the charm scale in $K^+ \rightarrow \pi^+\nu\bar{\nu}$* : Falk, Hopkins student A. Lewandowski, and former Hopkins postdoc A. Petrov studied contributions to the rare decay $K^+ \rightarrow \pi^+\nu\bar{\nu}$ which become nonlocal at the charm scale. Compared to the leading term, such amplitudes are suppressed by powers of m_K^2/m_c^2 and could potentially give corrections at the level of 15%. They computed the leading coefficients of the subleading dimension eight operators in the effective theory below the charm mass. The matrix elements of these operators cannot all be calculated from first principles and some must be modeled. They found that these contributions are likely to be small, but the estimate is sufficiently uncertain that the result may be as large as the existing theoretical uncertainty from other sources.

34. *$SU(3)$ Breaking and $D^0 - \bar{D}^0$ Mixing*: Falk, Y. Grossman, Z. Ligeti and Y. Nir studied

the Standard Model calculation of the mass and width difference in the $D^0 - \bar{D}^0$ system. They proved that D meson mixing occurs in the Standard Model only at second order in $SU(3)$ violation. Considering the possibility that phase space effects may be the dominant source of $SU(3)$ breaking, they found that $y = \Delta\Gamma/2\Gamma$ of the order of one percent is natural in the Standard Model. This result potentially reduces the sensitivity to new physics of measurements of D meson mixing.

Publications resulting from DOE grant support, 1994-2001

Publications in refereed journals:

1. "SU(3) Breaking and $D^0 - \bar{D}^0$ Mixing",
A. F. Falk, Y. Grossman, Z. Ligeti and Y. Nir, *Phys. Rev. D* 65, 054034 (2002).
2. "CP Tagged Decays at SuperBaBar",
A. F. Falk, *Phys. Rev. D* 64, 093011 (2001).
3. "Effects From the Charm Scale in $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ ",
A. F. Falk, A. Lewandowski and A. A. Petrov, *Phys. Lett. B* 505, 107 (2001).
4. "Measuring γ Cleanly with CP-Tagged B_s and B_d Decays",
A. F. Falk and A. A. Petrov, *Phys. Rev. Lett.* 85, 252 (2000).
5. "Precision Observables and Electroweak Theories",
J. A. Bagger, A. F. Falk and M. Swartz, *Phys. Rev. Lett.* 84, 1385 (2000).
6. "Phenomenology of V_{ub} from Ratios of Inclusive B Decays",
J. Chay, M. Luke, A. F. Falk and A. A. Petrov, *Phys. Rev. D* 61, 34020 (2000).
7. "Measuring V_{ub} in Inclusive B Decays to Charm",
A. F. Falk and A. A. Petrov, *Phys. Rev. D* 61, 33003 (2000).
8. "Strong Phases and $D^0 - \bar{D}^0$ Mixing Parameters",
A. F. Falk, Y. Nir and A. A. Petrov, *J. High Energy Phys.* 12, 019 (1999).
9. "Radiative Leptonic B_c Decays in Effective Field Theory",
G. Chiladze, A. F. Falk and A. A. Petrov, *Phys. Rev. D* 60, 34011 (1999).
10. "Hybrid Charmonium Production in B Decays",
G. Chiladze, A. F. Falk and A. A. Petrov, *Phys. Rev. D* 58, 34013 (1998).
11. "Final State Interactions and New Physics in $B \rightarrow \pi K$ Decays",
A. F. Falk, A. L. Kagan, Y. Nir and A. A. Petrov, *Phys. Rev. D* 57, 4290 (1998).
12. "Hadronic Spectral Moments in Semileptonic B Decays with a Lepton Energy Cut",
A. F. Falk and M. Luke, *Phys. Rev. D* 57, 424 (1998).
13. "Phenomenology of New Baryons with Charm and Strangeness",
G. Chiladze and A. F. Falk, *Phys. Rev. D* 56, R6738 (1997).
14. " V_{ub} from the Hadronic Invariant Mass Spectrum in Semileptonic B Decay",
A. F. Falk, Z. Ligeti and M. B. Wise, *Phys. Lett. B* 406, 225 (1997).
15. "Quenched Chiral Perturbation Theory for Vector Mesons",
M. Booth, G. Chiladze and A. F. Falk, *Phys. Rev. D* 55, 3092 (1997).
16. "A New Interpretation of the Observed Heavy Baryons",
A. F. Falk, *Phys. Rev. Lett.* 77, 223 (1996).
17. "Resumming Phase Space Logarithms in Inclusive Semileptonic Decays",
C. Bauer, A. F. Falk and M. Luke, *Phys. Rev. D* 54, 2097 (1996).
18. "Phenomenology of the $1/m_Q$ Expansion in Inclusive B and D Decays",
A. F. Falk, M. Luke and M. J. Savage, *Phys. Rev. D* 53, 6316 (1996).

19. "Hadron Spectra for Semileptonic Heavy Quark Decay",
A. F. Falk, M. Luke and M. J. Savage, *Phys. Rev. D* 53, 2491 (1996).
20. "Excited Heavy Mesons Beyond Leading Order in the Heavy Quark Expansion",
A. F. Falk and T. Mehen, *Phys. Rev. D* 53, 231 (1996).
21. "Instantons and the Endpoint of the Lepton Energy Spectrum in Charmless Semi-leptonic B Decays",
A. F. Falk and A. Kyatkin, *Phys. Rev. D* 52, 5049 (1995).
22. "Inconclusive Inclusive Nonleptonic B Decays",
A. F. Falk, M. B. Wise and I. Dunietz, *Phys. Rev. D* 51, 1183 (1995).
23. "Another Source of Baryons in B Meson Decays",
I. Dunietz, P. S. Cooper, A. F. Falk and M. B. Wise, *Phys. Rev. Lett.* 22, 1075 (1994).
24. "A Model for the $B \rightarrow X_s + \gamma$ Decay in the Chromomagnetic Background",
A. Kyatkin, *Phys. Lett. B* 361, 105 (1995).
25. "Scale Setting in Top Quark Decays",
T. Mehen, *Phys. Lett. B* 382, 267 (1996).
26. "Testing Quarkonium Production with Photoproduced $J/\psi + \gamma$ ",
T. Mehen, *Phys. Rev. D* 55, 4338 (1997).
27. "Quenched Chiral Perturbation Theory for Heavy Baryons",
G. Chiladze, *Phys. Rev. D* 57, 5586 (1998).
28. "Leptoproduction of J/ψ ",
S. Fleming and T. Mehen, *Phys. Rev. D* 57, 1846 (1998).
29. "Summing $O(\beta_0^n \alpha_s^{n+1})$ Corrections to Top Quark Decays",
T. Mehen, *Phys. Lett. B* 417, 353 (1998).
30. "Lessons From CLEO and FOCUS Measurements of $D^0 - \bar{D}^0$ Mixing Parameters",
S. Bergman, Y. Grossman, Z. Ligeti, Y. Nir and A. A. Petrov, *Phys. Lett. B* 486, 418 (2000).
31. "Charmonium Production at Neutrino Factories",
A. A. Petrov and T. Torma, *Phys. Rev. D* 60, 093009 (1999).
32. "Constraints on a Model With Pure Right-Handed Third Generation Couplings",
A. Lewandowski, hep-ph/0002104, *Phys. Rev. D* 62, 055007 (2000).

Book chapters:

1. "Introduction to CP Violation",
A. F. Falk, Y. Grossman, Y. Nir and H. Quinn, *B Physics at the Tevatron, Run II and Beyond*, Fermilab Report Pub-01/197, 2001.
2. "Introduction to Hadronic B Physics",
A. F. Falk, *The BaBar Physics Book: Physics at an Asymmetric B Factory*, SLAC Report R-504, 1998.

Publications in Conference Proceedings:

1. "Measuring ϕ_3 Cleanly with CP-tagged B_s Decays",
A. F. Falk, Proceedings of BCP4, *International Workshop on B Physics & CP Violation*, Ise-Shima, Japan, February 19-23, 2001, World Scientific: Singapore, 2001.
2. "Precision in V_{ub} as a Function of Luminosity at e^+e^- B Factories (Theoretical Issues)",
A. F. Falk, Proceedings of BCP4, *International Workshop on B Physics & CP Violation*, Ise-Shima, Japan, February 19-23, 2001, World Scientific: Singapore, 2001.
3. "Unraveling the Mystery of Flavor",
A. F. Falk, Proceedings of the Twenty-fourth Johns Hopkins Workshop on Current Problems in Particle Theory, *Non-Perturbative QFT Methods and Their Applications*, Budapest, Hungary, August 19-21, 2000, World Scientific: Singapore, 2001.
4. "The CKM Matrix and the Heavy Quark Expansion",
A. F. Falk, Proceedings of the Theoretical Advanced Study Institute in Elementary Particle Physics (TASI-2000), *Flavor Physics for the Millenium*, University of Colorado, June 4-30, 2000, World Scientific: Singapore, 2001.
5. "B Physics, the Unitarity Triangle, and the Universe",
A. F. Falk, Proceedings of the XIX *International Symposium on Lepton and Photon Interactions at High Energies*, Stanford University, August 9-14, 1999, World Scientific: Singapore, 2000.
6. "Final State Interactions in Hadronic B Decays",
A. F. Falk, Proceedings of *Continuous Advances in QCD 1998*, Theoretical Physics Institute, University of Minnesota, April 16-19, 1998, World Scientific: Singapore, 1998.
7. "Heavy Quark Effective Theory and Inclusive B Decays",
A. F. Falk, Proceedings of the *Fifth International Workshop on Physics in Hadron Machines (Beauty '97)*, University of California, Los Angeles, October 12-16, 1997, in *Nucl. Instr. and Meth. in Phys. Res. A*408, 7 (1998).
8. "Extraction of V_{ub} From the Hadronic Invariant Mass Spectrum in Semileptonic B Decays",
A. F. Falk, Proceedings of the *International Europhysics Conference on High Energy Physics*, Jerusalem, Israel, August 19-26, 1997, Springer: Berlin, 1999.
9. "The Theory of Heavy Baryons",
A. F. Falk, Proceedings of the *Second International Conference on B Physics and CP Violation*, Honolulu, March 24-27, 1997, World Scientific: Singapore, 1998.
10. "The Heavy Quark Expansion of QCD",
A. F. Falk, Proceedings of the XXIVth SLAC Summer Institute on Particle Physics, *The Strong Interaction, from Hadrons to Partons*, Stanford, August 19-30, 1996, SLAC Publication Office, SLAC Report 508, 1997.
11. "The Many Uses of Excited Heavy Hadrons",
A. F. Falk, Proceedings of the Twentieth Johns Hopkins Workshop on Current Problems in Particle Theory, *Nonperturbative Particle Theory and Experimental Tests*, Heidelberg, Germany, June 27-29, 1996, World Scientific: Singapore, 1997.

12. "New Predictions for Charmed and Bottom Baryons",
A. F. Falk, Proceedings of the Quarkonium Physics Workshop, *Experiment Confronts Theory*, University of Illinois at Chicago, June 13-15, 1996, in *Int. J. Mod. Phys. A* 12, 4079 (1997).
13. "Theory of Rare B Decays",
A. F. Falk, Proceedings of the *International Symposium on Vector Boson Self-Interactions*, University of California, Los Angeles, February 1-3, 1995, American Institute of Physics Press: New York, 1996.
14. "Possible Puzzles in Nonleptonic B Decays",
A. F. Falk, Proceedings of the Eighteenth Johns Hopkins Workshop on Current Problems in Particle Theory, *Theory Meets Experiment*, Florence, Italy, August 31-September 2, 1994, World Scientific: Singapore, 1995.
15. "The Use of Neutrino Beams From Muon Storage Rings",
A. A. Petrov, Proceedings of the *23rd Johns Hopkins Workshop on Current Problems in Particle Theory: Neutrinos in the Next Millennium*, Baltimore, June 10-12, 1999.
16. "Final State Interactions: From Strangeness to Beauty",
A. A. Petrov, Proceedings of the *1999 Chicago Conference on Kaon Physics*, Chicago, June 21-26, 1999.