B Leptonic Decays and $B-\bar{B}$ Mixing with 2+1 Flavors of Dynamical Quarks

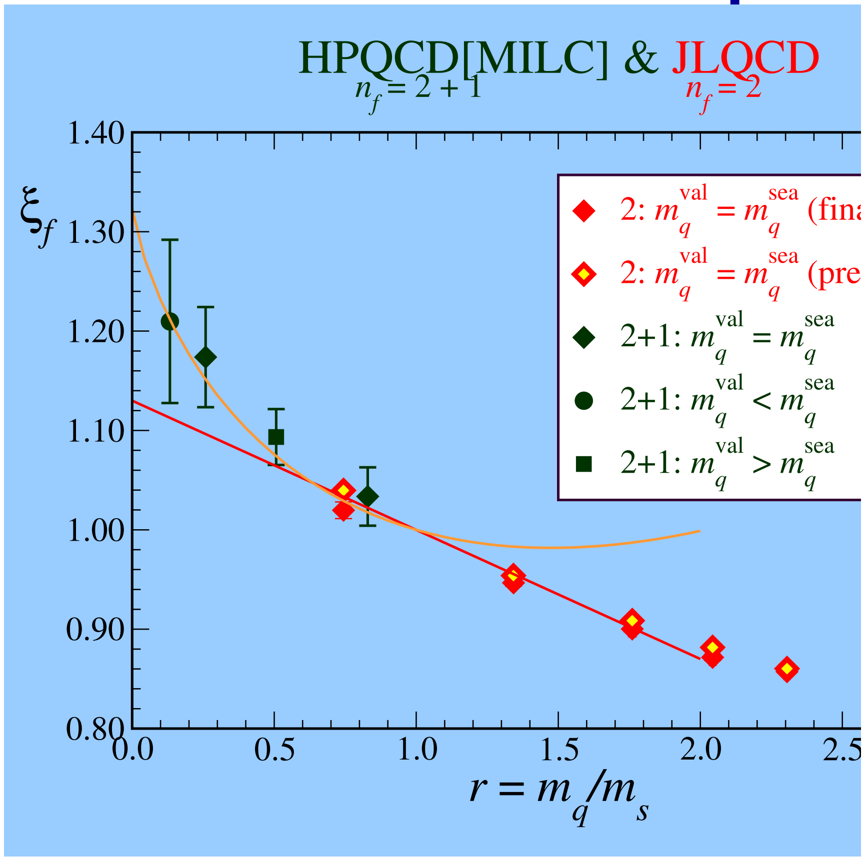
C. Davies[a], A. Gray[b], E. Gulez[b], P. Lepage[c], J. Shigemitsu[b], M. Wingate[d]

[a]*University of Glasgow* [b]*The Ohio State University* [c]*Cornell University*
[d]*University of Washington*

Introduction

- Need precision calculation of f_B and B_B in order to pin down CKM parameters. In particular need combination $\frac{f_{B_s}\sqrt{B_{B_s}}}{f_B\sqrt{B_B}}$.
- Aim is to reduce theory errors to a few percent otherwise will dominate uncertainties from experiment.
- Improved staggered formulation (fast - simulations been done with m_f as low as $m_s/8$) has allowed precise determination of a number of quantities - gives confidence that above calcs now possible.

B Leptonic Decays



M. Wingate, A. Kronfeld review Lattice 2003

- $$\xi_f = \frac{f_{B_s}\sqrt{m_{B_s}}}{f_B\sqrt{m_B}}$$
- Hint of chiral logs but stat. errors large. Aim is to reduce stat. errors.
- We have used smearing to succesfully do this.

Simulation details

- MILC coarse $20^3 \times 64$, $2+1$ flavour dynamical configs (with $am_s = 0.05$). For light quarks use asqtad action.

$am_f \equiv am_{u/d}$	n_{conf}	a^{-1}(GeV)	am_q
0.01	568	1.59	$0.005, 0.01, 0.02, 0.04$
0.02	486	1.60	$0.02, 0.04$

Red$\equiv$fully unquenched, Blue$\equiv B_s$, rest partially quenched.

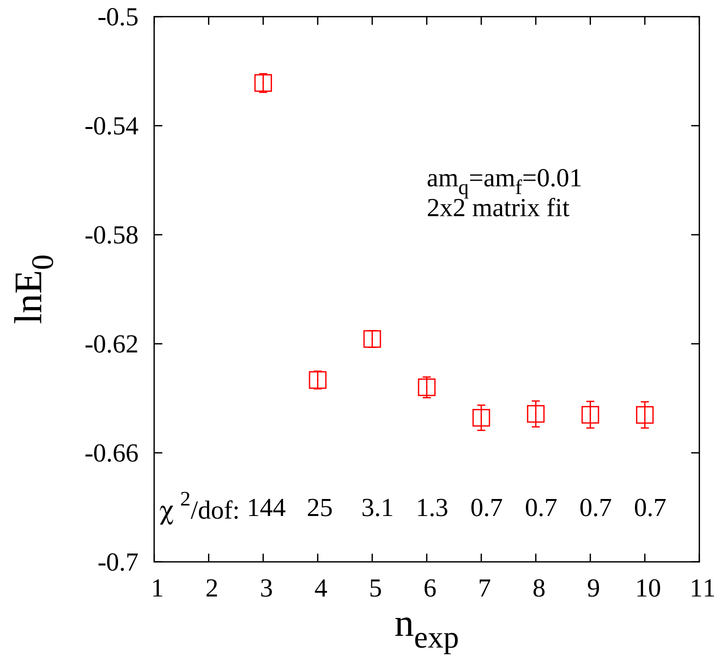
- For heavy b quarks use standard tadpole improved Lattice NRQCD action correct through $1/am_b^2$ at $am_b = 2.8$.

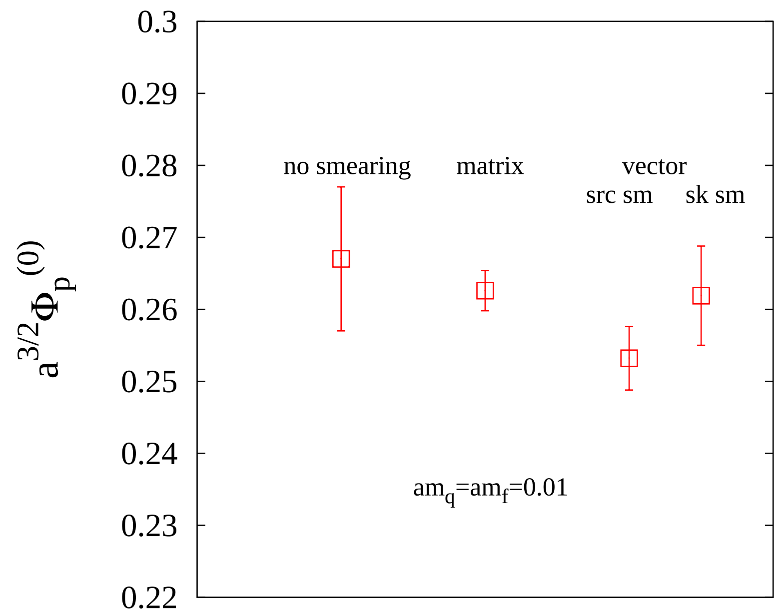
- a^{-1} and m_b fixed by Υ,
  $m_{u,d}$ and m_s fixed by π and K.

Smearing & Fitting

- Smear heavy quark at source and sink. Use ground state hydrogenic style wavefunctions as have been used for Υ.
- Find optimal radius: that which minimises fit errors while maintaining reasonable $\chi^2/$dof
- Do Bayesian multi exponential fits. Compare single correlator fits to simultaneus *vector* 2×1 (source or sink smearing only) and *matrix* 2×2 (source and sink smearing) fits.
- Fit function is $G(t) = \sum_{j=0}^{n_{exp}-1} C^{(0j)}(-1)^{jt} e^{-m_j t}$
- Extract $\Phi^{(0)} = f_B^{(0)} \sqrt{m_B} = 2\sqrt{C^{(00)}}$. Similarly get next order in $1/m_b$ parts: $C^{(10)}, \Phi^{(1)}$ and combine through 1-loop (See talk by E. Gulez for PT).

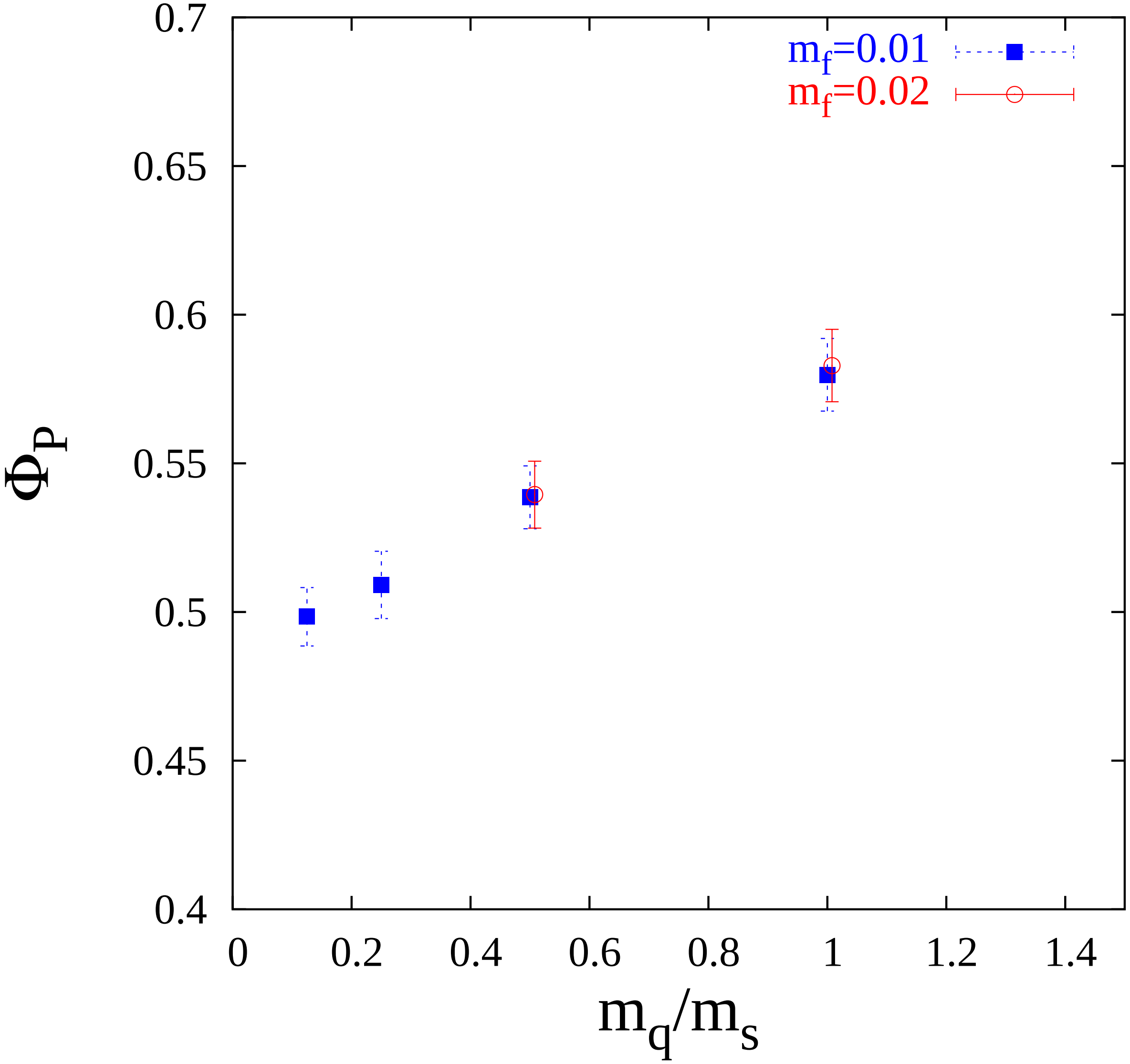
Smearing Results



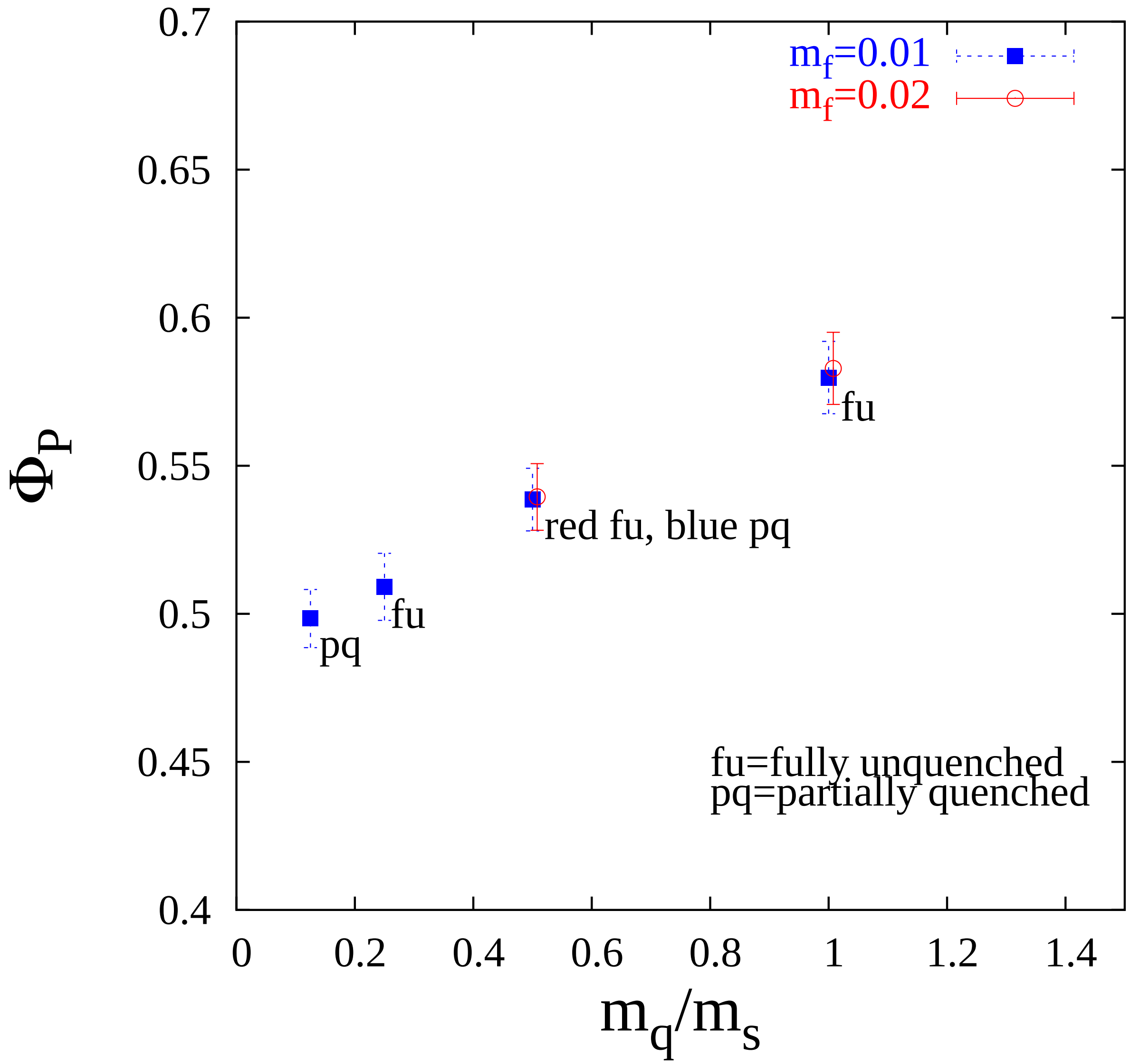


- Fit good for $n_{exp} \geq 7$
- Matrix fit substantially reduces stat. errors.

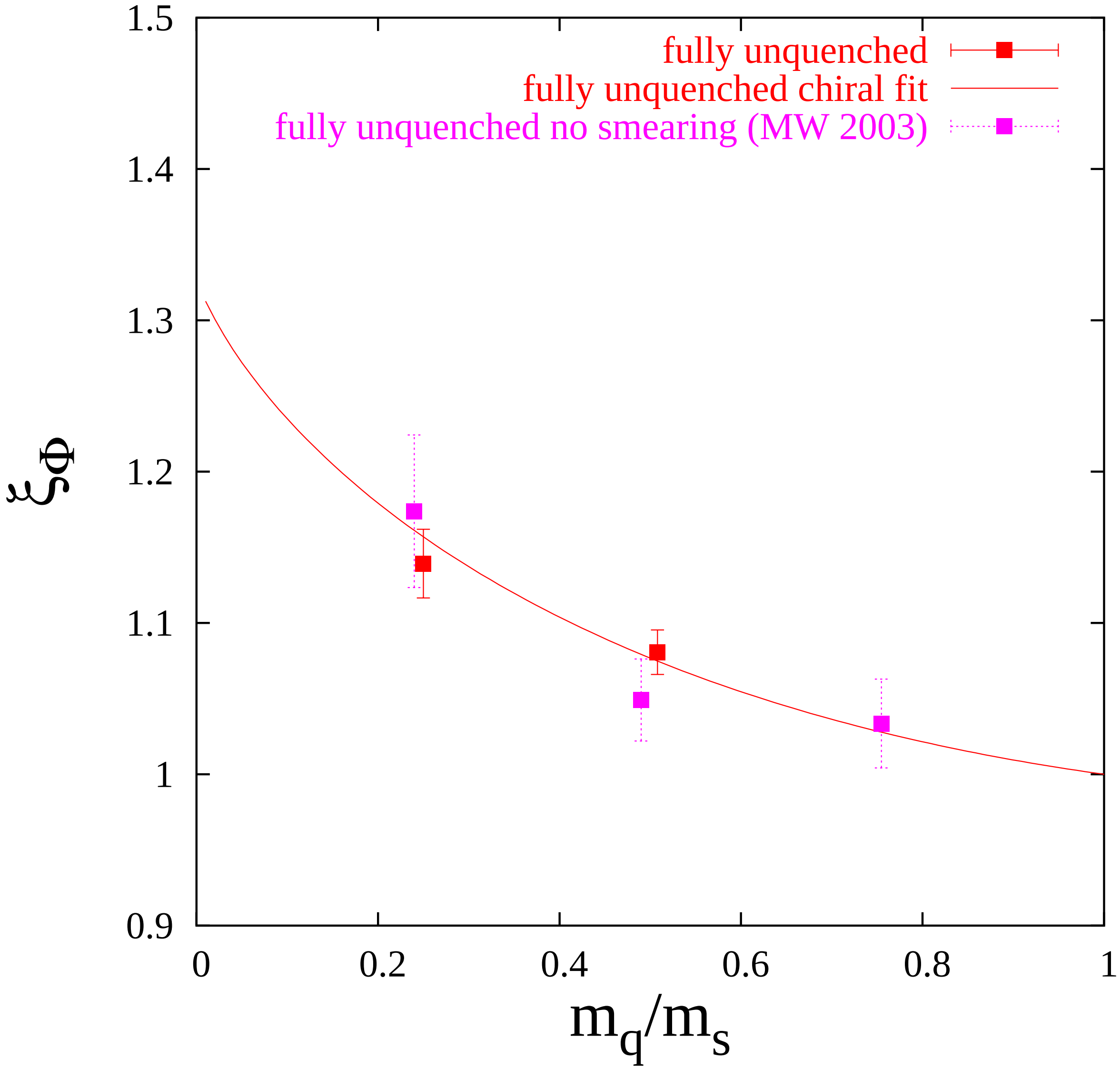
Φ Results



Φ Results

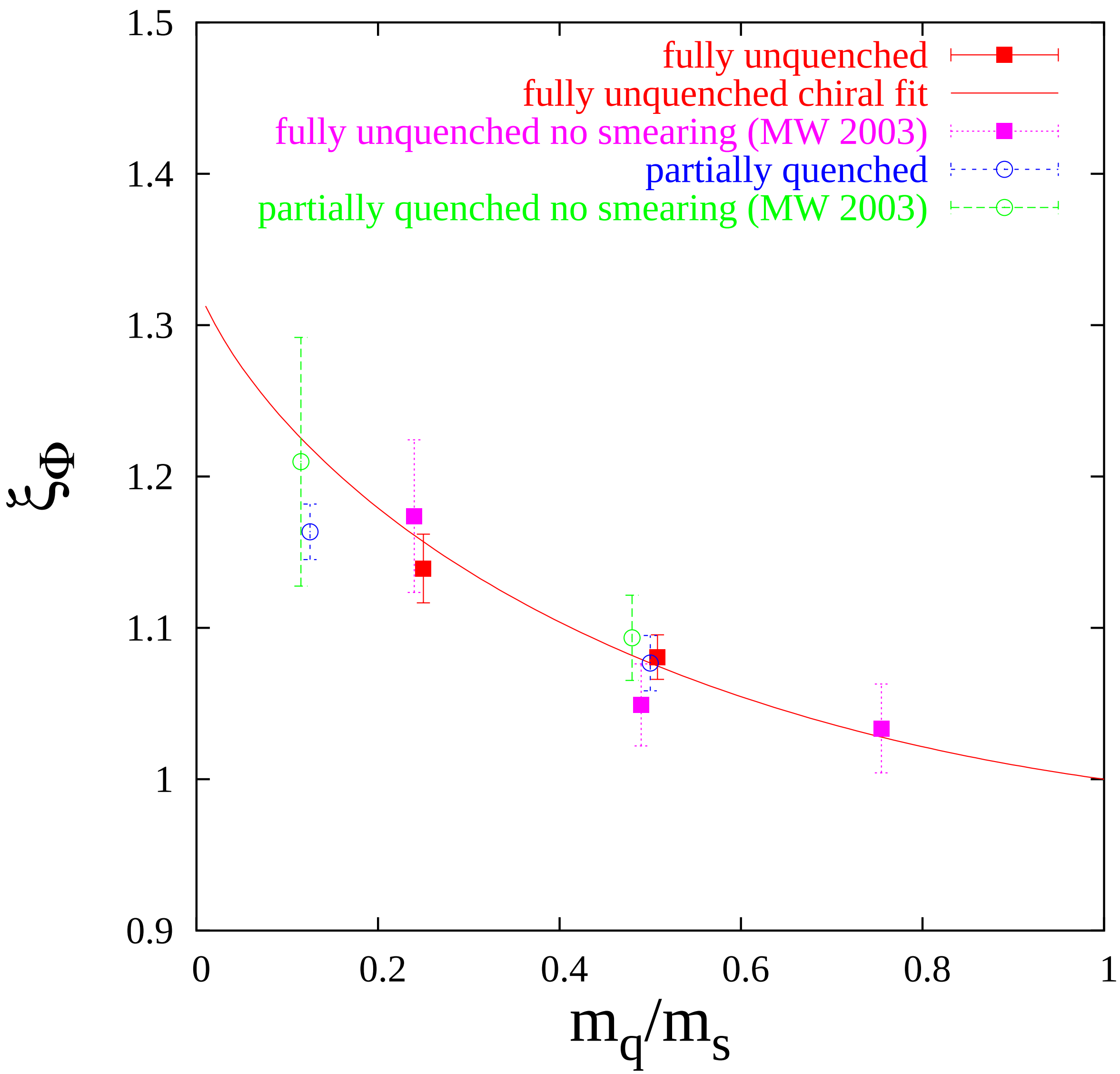

0.7
0.65
0.6
0.55
0.5
0.45
0.4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Φ_P
m_q/m_s
m_f=0.01
m_f=0.02
fu
red fu, blue pq
fu
pq
fu=fully unquenched
pq=partially quenched

ξ Results



- $\xi_\Phi = \frac{\Phi_{B_s}}{\Phi_B} \equiv \frac{f_{B_s}\sqrt{m_{B_s}}}{f_B\sqrt{m_B}}$
- Systematics cancel in ratio.

ξ Results



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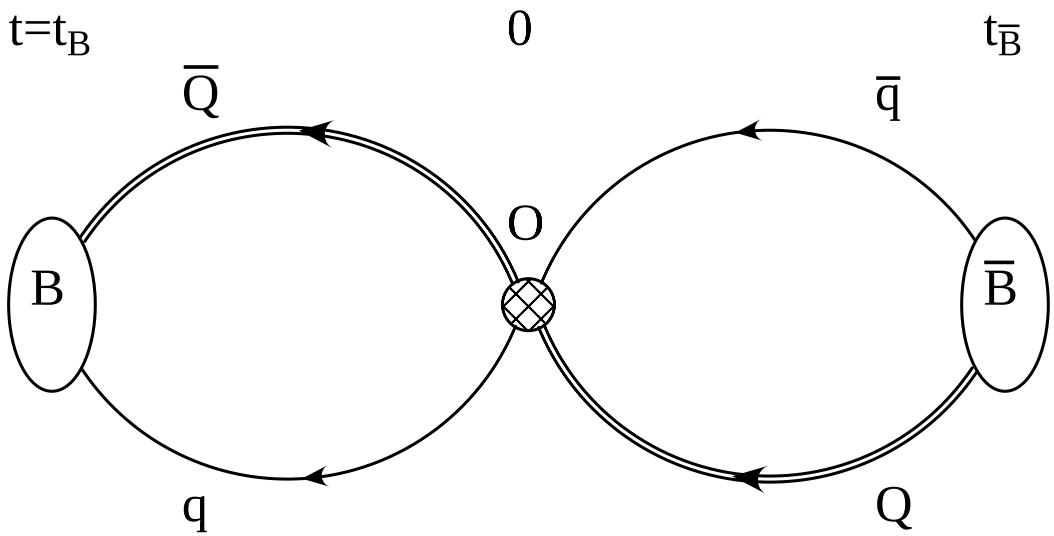
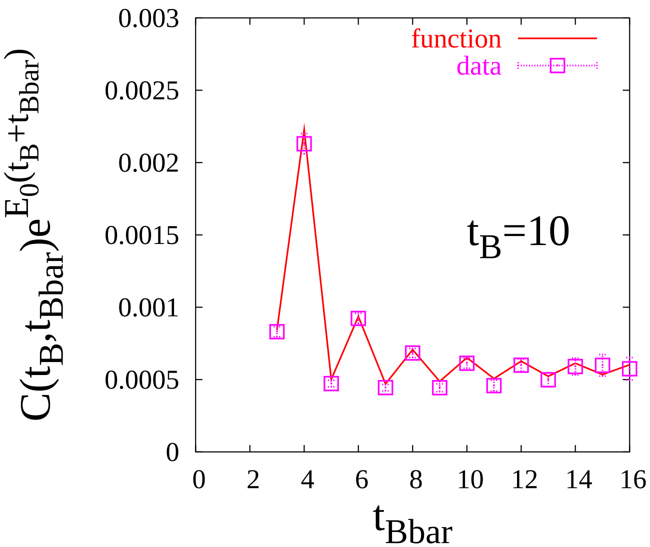
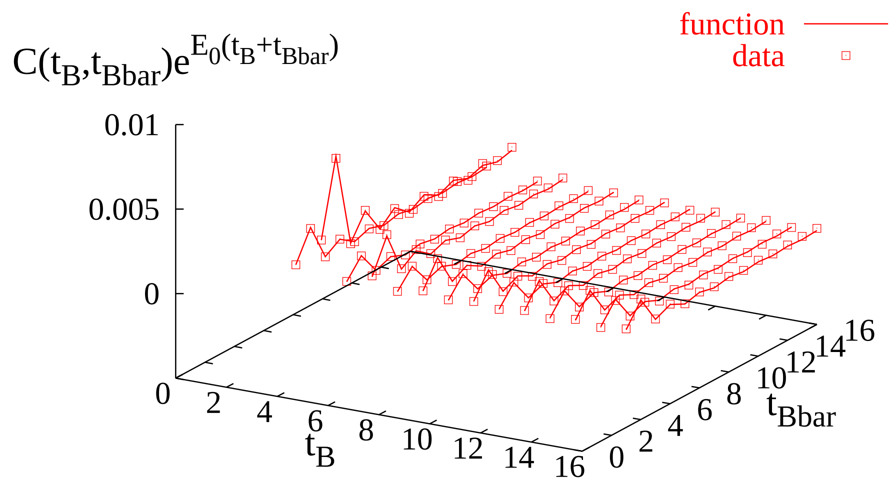
$B - \bar{B}$ Mixing



- Continuum $\langle O_L \rangle^{\overline{MS}}$ has contribution from lattice $\langle O_L \rangle_{lat}$ and $\langle O_S \rangle_{lat}$ at 1-loop:
  $O_L = [\,\overline{\psi}_Q\,\gamma^\mu(1-\gamma_5)\,\psi_q\,]\,[\,\overline{\psi}_{\overline{Q}}\,\gamma_\mu(1-\gamma_5)\,\psi_q\,]$
  $O_S = [\,\overline{\psi}_Q\,(1-\gamma_5)\,\psi_q\,]\,[\,\overline{\psi}_{\overline{Q}}\,(1-\gamma_5)\,\psi_q\,]$
- Same simulation params as B leptonic decay but only so far with $m_f = 0.01$, $m_q = 0.04$ (i.e B_s).

Fitting





- Corr has form $C(t_B, t_{\bar{B}}) = \sum_{j,k=0}^{n_{exp}-1} A_{jk}(-1)^{jt_B} e^{-m_j t_B} (-1)^{kt_{\bar{B}}} e^{-m_k t_{\bar{B}}}$
- Have done prelim. Bayesian $n_{exp} = 4$ fit to this complicated oscillating function with good $\chi^2/$dof but need to work on getting fits with other n_{exp}.

$f_B\sqrt{B_B}$

- $$a^6\langle O_L\rangle^{\overline{MS}} = [1+\rho_{LL}\,\alpha_s]\,\langle O_L\rangle_{lat} \quad + \quad \rho_{LS}\,\alpha_s\,\langle O_S\rangle_{lat}$$
  $$O_L = [\,\overline{\psi}_Q\,\gamma^\mu(1-\gamma_5)\,\psi_q\,]\,[\,\overline{\psi}_{\overline{Q}}\,\gamma_\mu(1-\gamma_5)\,\psi_q\,]$$
  $$O_S = [\,\overline{\psi}_Q\,(1-\gamma_5)\,\psi_q\,]\,[\,\overline{\psi}_{\overline{Q}}\,(1-\gamma_5)\,\psi_q\,]$$
- ρ_{LS},ρ_{LL} calculated pertubatively.
- In terms of 3-pnt (A_{00}) and B 2-pnt (ξ_{BB}) correlator groundstate amplitudes,
  $$\frac{A_{00}^{(OL,S)}}{\xi_{BB}}2 = \frac{1}{2M_Ba^3}\,\langle O_{L,S}\rangle_{lat}$$
- Note: we fit directly to 3-point without first taking ratio over 2-point. Don't need to wait for plateau - fit at low t where error is still small by including ex states.
- B_B is defined through $\langle O_L\rangle^{\overline{MS}} = \frac{8}{3}f_B^2M_B^2B_B$
- prelim result $f_{B_s}\sqrt{B_{B_s}(m_b)} = 0.197(16)(28)$ GeV
  errors are fitting (fits still prelim) and systematic (Λ_{QCD}/m_b, α_s^2 etc.).

Conclusions

- Have implemented smearing in B simulations to substantially reduce statistical errors of parameters needed for f_B.
- Must do more fully unquenched runs at low m_q and do full staggered chiral fits.
- Preliminary fit to $B - \bar{B}$ mixing correlator looks good but more work needs done to make sure fit is solid. Then include $1/M$ currents and repeat with different $m_{q,f}$.