

The determination of f_{D_s} and f_D in $2 + 1$ flavor lattice QCD

Fermilab, MILC and HPQCD Collaborations

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A precision test

New CLEO-c result (9 signal events)

$$f_D = 230 \pm 42 \pm 10 \text{ MeV} \quad [\text{J. Yelton, HQ\&L 2004}]$$

60× dataset “Soon”.

$$f_{D_s} = 285 \pm 19 \pm 40 \text{ MeV} \quad [\text{ALEPH 2002}]$$

Opportunity for a LQCD prediction.

Same methods apply to f_{B_s} and f_B determinations.

Our toolkit

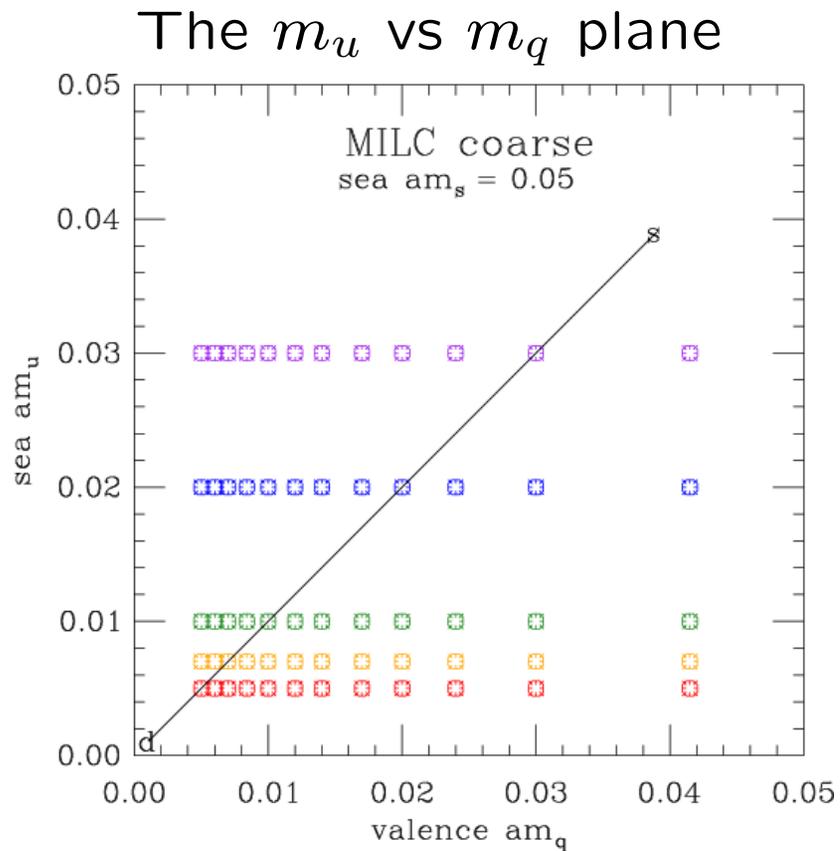
- Asqtad gluons with realistic $N_f = 2 + 1$ sea quarks [MILC].
- Fermilab and NRQCD approaches for heavy quarks.
- Improved staggered valence light quarks.
- Automated PT for 1-loop (2-loop) matching [Nobes, Trotter].
- Staggered χ PT [Aubin, Bernard]; f_K and f_π [MILC].

Apply these tools to the determination of f_{D_s} and f_D .

Focus on the extrapolation to f_D using $S\chi$ PT.



— Partially quenched simulations —



Simulations for every point.

Diagonal line indicates the “full” QCD extrapolation.

Better constraints on chiral behavior by using all simulation results in a single fit.

Include results at other lattice spacings in the fit to better control discretization effects.

Calculations using the MILC fine lattices are underway.



SχPT overview

C. Aubin talk for details.

Leading order in $1/m_Q$ expansion and χ PT,

$$f_{Qq}\sqrt{m_{Qq}} = \alpha \left[1 + \frac{1}{16\pi^2 f^2} \Delta f_q + \dots \right]$$

where ... are powers terms in sea and light valence quark masses; up to 3rd order in fit.

Chiral log terms

$$\Delta f_q = -\frac{1 + 3g^2}{2} (h^{av} + h^I + a^2 \delta'_A h^A + a^2 \delta'_V h^V)$$

Discretization effects from taste violations in pion masses and h^A and h^V terms.

■ The $S\chi PT$ fit and extrapolation ■

Single fit to all the coarse lattice results.

Six fit parameters; one is coeff. of chiral log terms.

Priors for six all parameters.

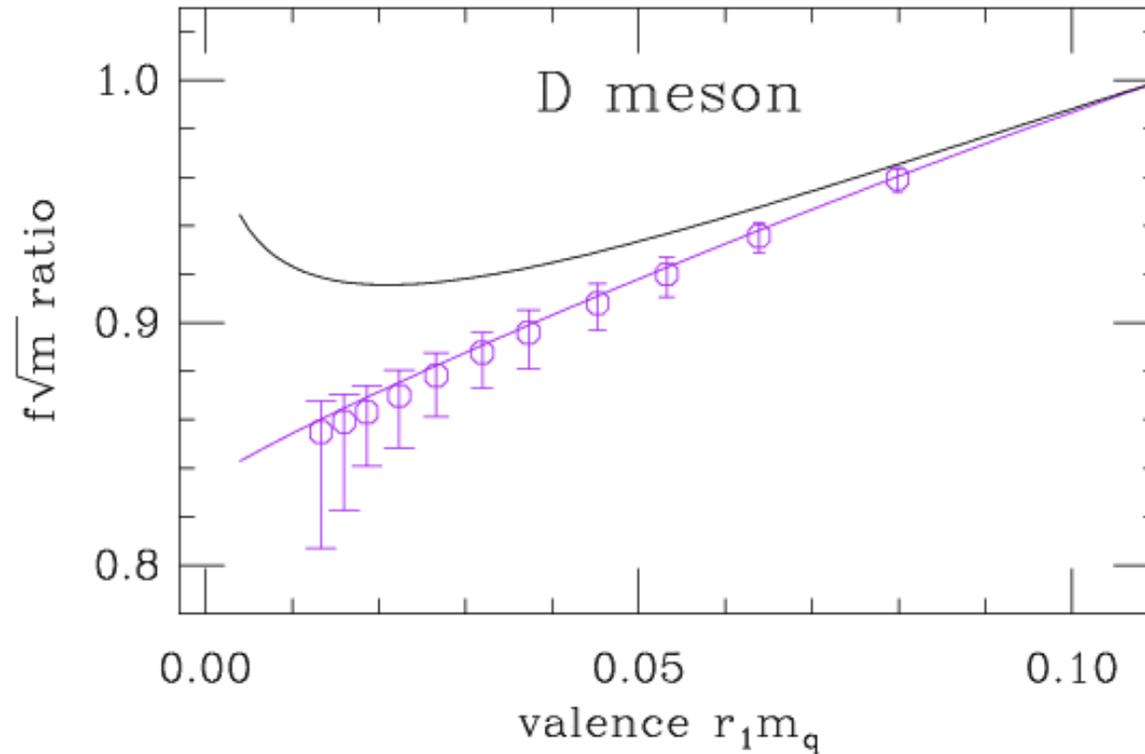
Reasonable $\chi^2/dof = 0.2$.

Correlations propagated through the fits (bootstrap).

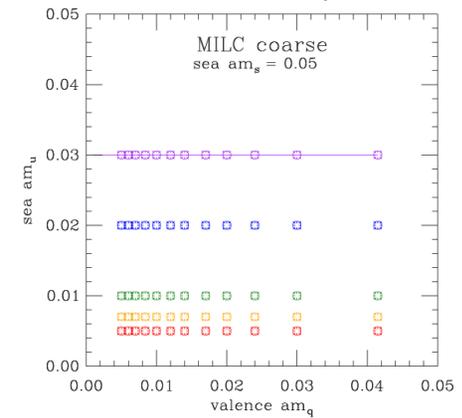


The $S\chi$ PT fit

Ensemble 0.030/0.05



The mass plane

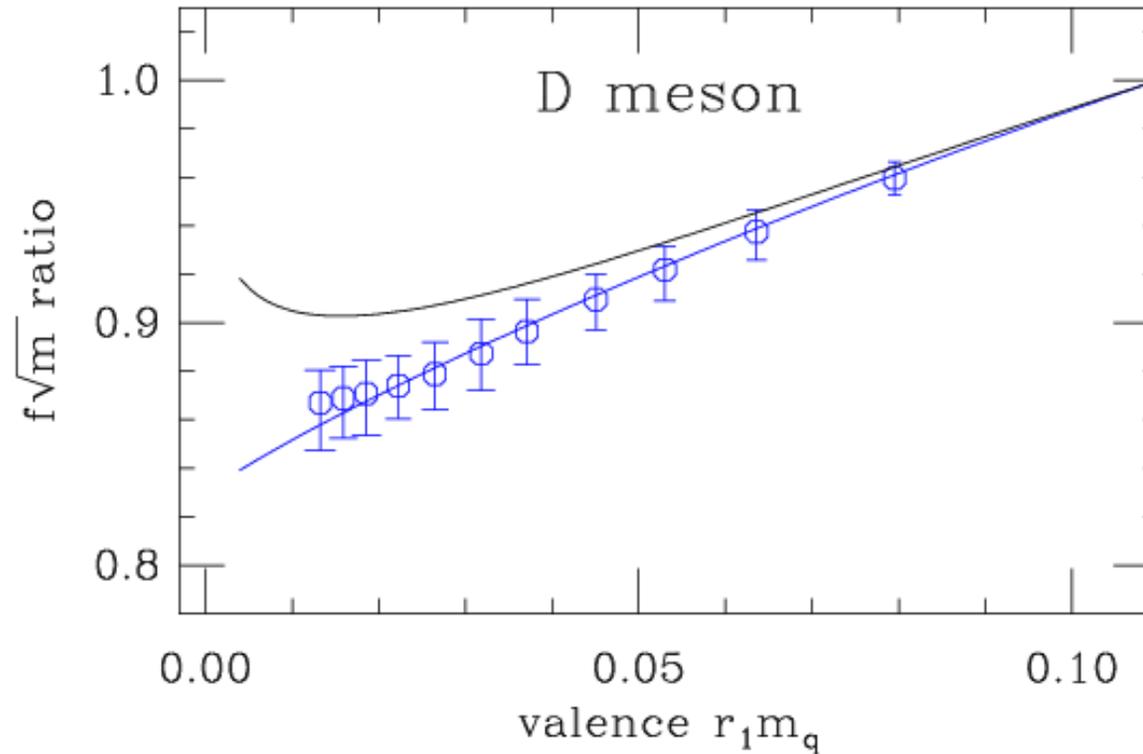


Fit including staggered discretization effects.

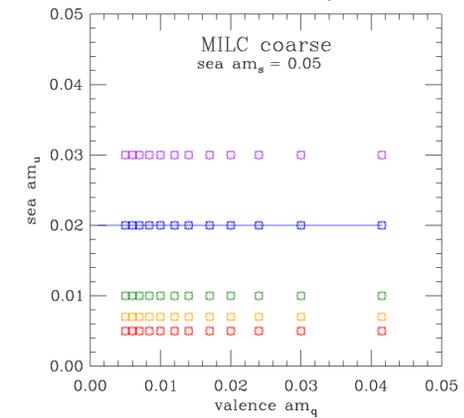
Fit without discretization effects.

The $S\chi PT$ fit

Ensemble 0.020/0.05



The mass plane

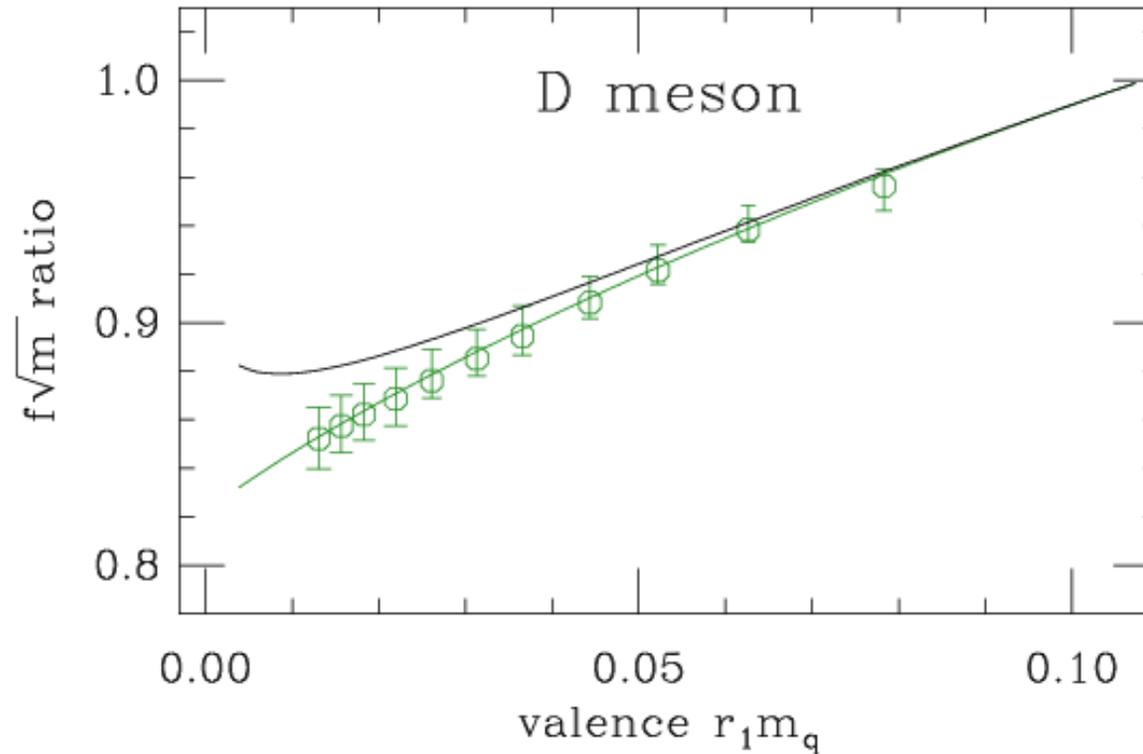


Fit including staggered discretization effects.

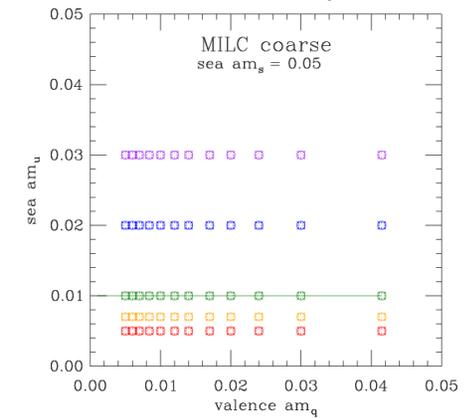
Fit without discretization effects.

The $S\chi PT$ fit

Ensemble 0.010/0.05



The mass plane

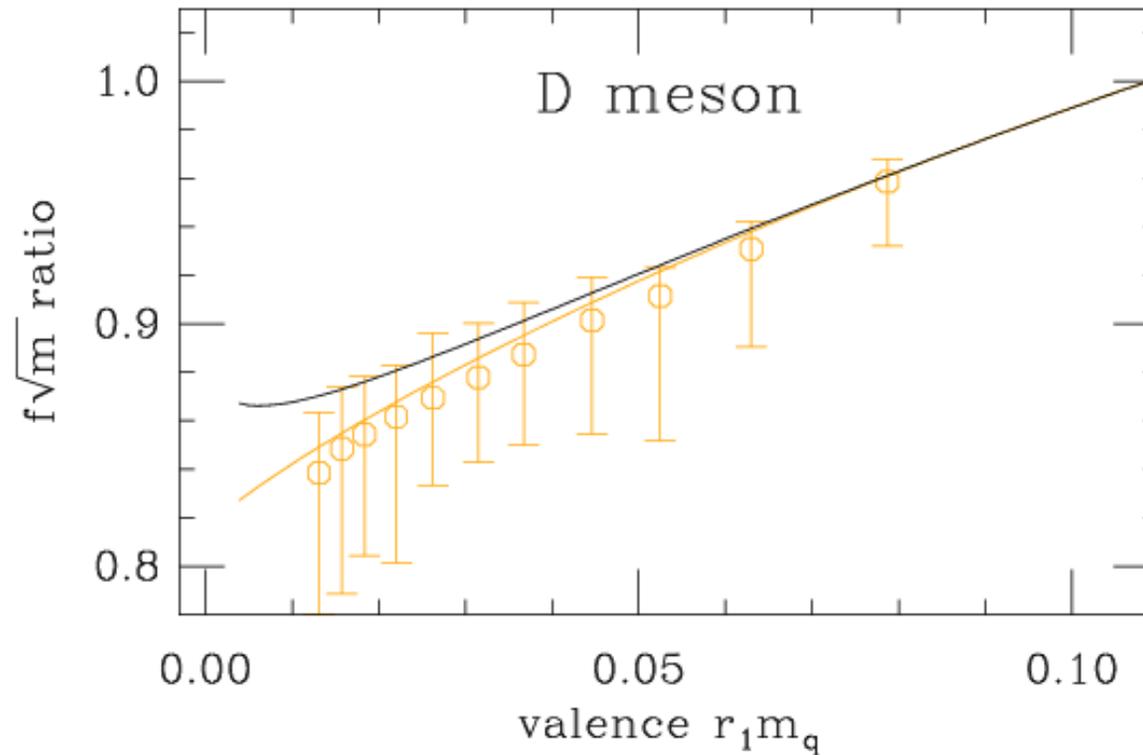


Fit including staggered discretization effects.

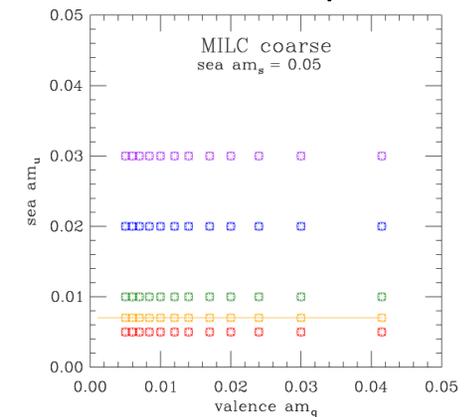
Fit without discretization effects.

The $S\chi$ PT fit

Ensemble 0.007/0.05



The mass plane

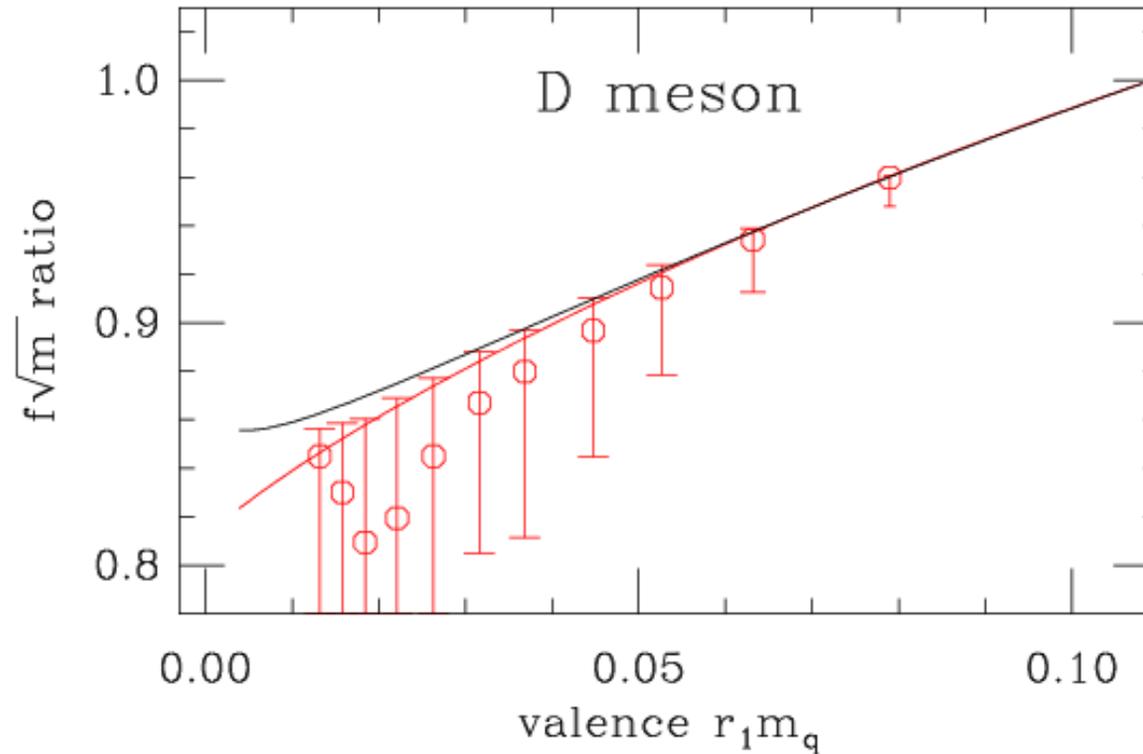


Fit including staggered discretization effects.

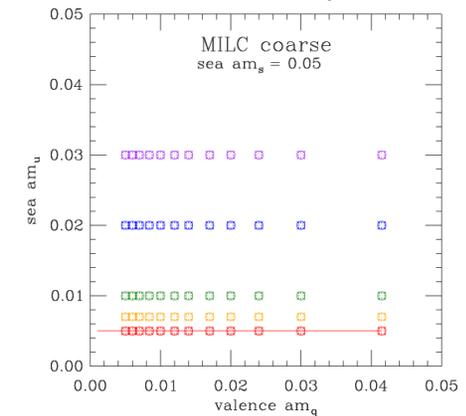
Fit without discretization effects.

The $S\chi$ PT fit

Ensemble 0.005/0.05



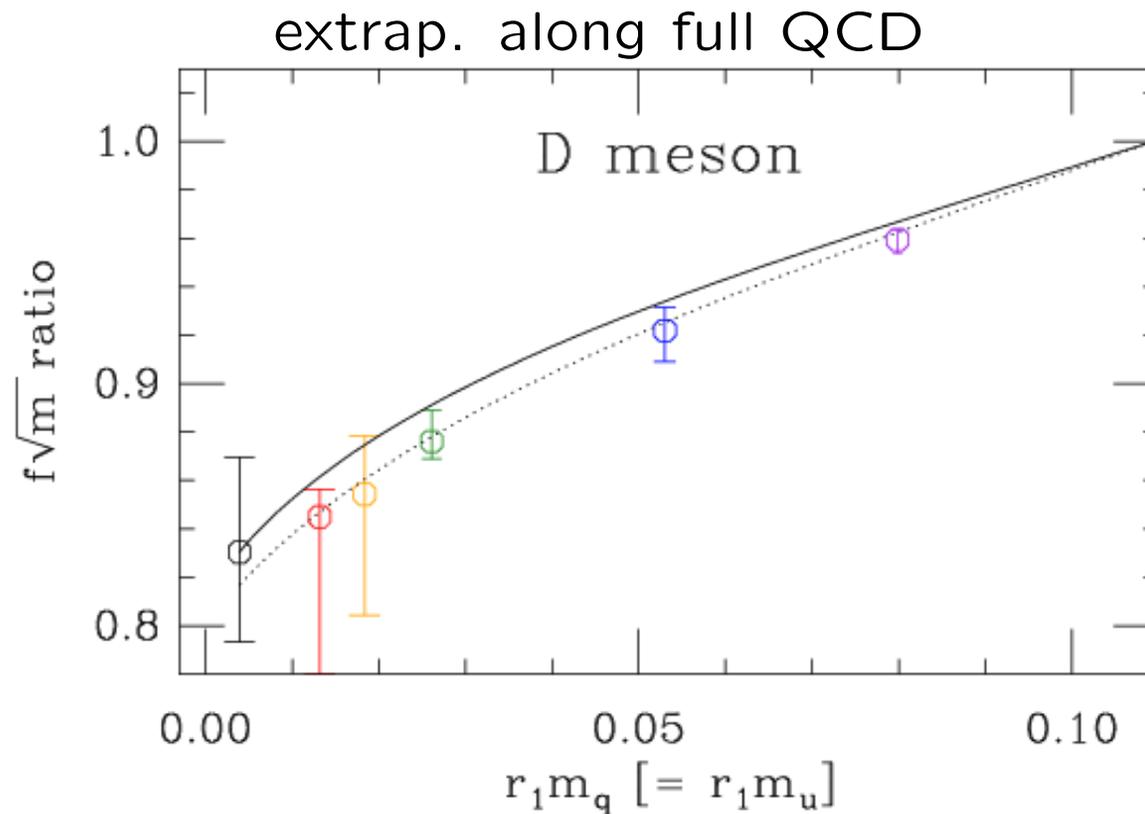
The mass plane



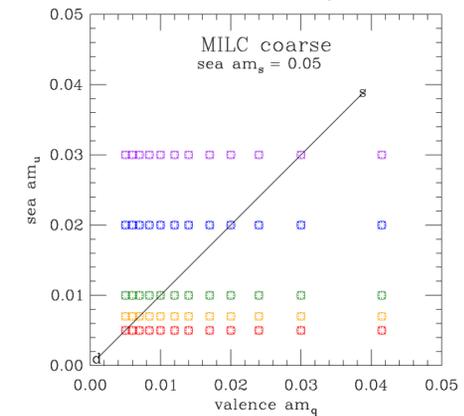
Fit including staggered discretization effects.

Fit without discretization effects.

The full QCD view



The mass plane



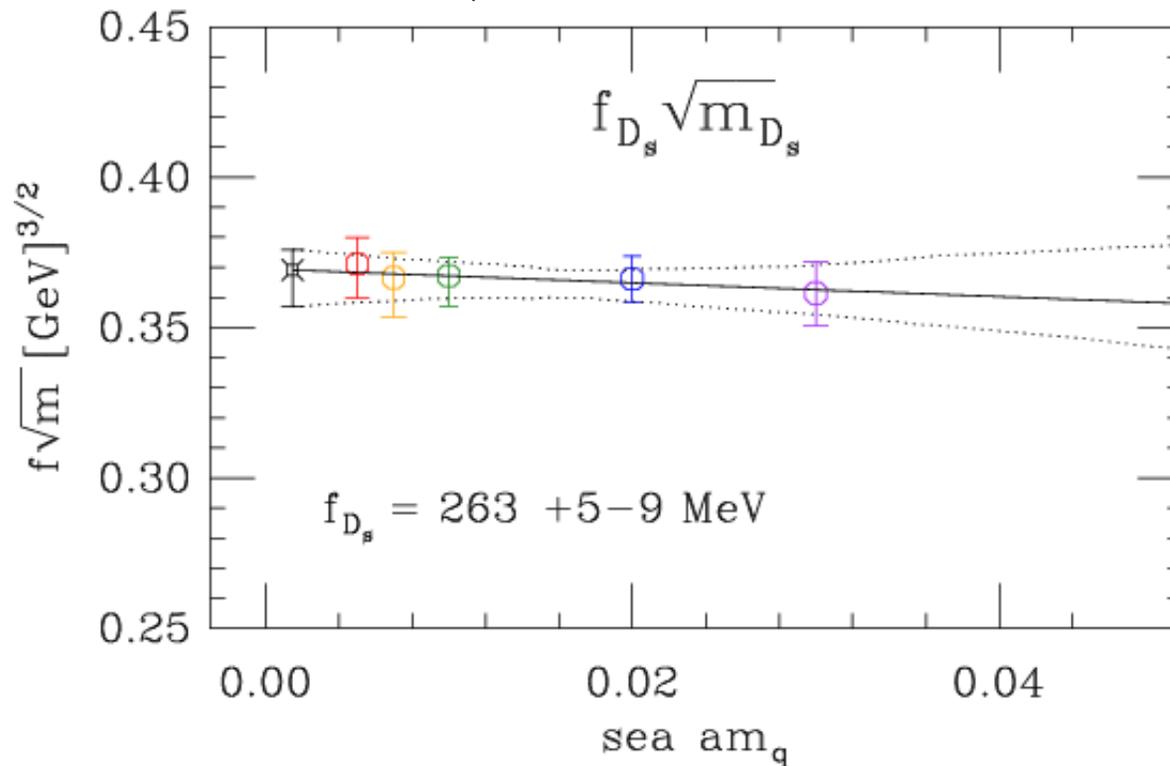
Solid curve no taste violations; dotted includes effects.

$$\frac{f_D \sqrt{m_D}}{f_{D_s} \sqrt{m_{D_s}}} = 0.830_{-0.037}^{+0.039} \quad (\text{stat.} + \text{extrap.})$$

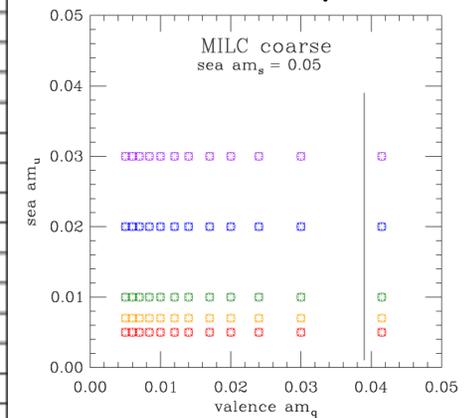
$f_{D_s} \sqrt{m_{D_s}}$ determination

$f_{D_s} \sqrt{m_{D_s}}$ currently obtained in a separate (linear) extrap.

$f_{D_s} \sqrt{m_{D_s}}$ extrap.



The mass plane



$$f_{D_s} \sqrt{m_{D_s}} = 0.369_{-0.012}^{+0.007} (\text{stat.} + \text{extrap.})$$

Error budget

PRELIMINARY

source	uncertainty as percent of:		
	d/s ratio	$f_{D_s} \sqrt{m_{D_s}}$	$f_D \sqrt{m_D}$
stat.+extrapolation	4.7	3.3	6.2
HQ matching to QCD	<1	11	11
LQ discret. effects	4	4	4
m_{charm} determination	<1	4	4
valence m_s, m_d det.	2	1	2.2
lat. spac. & sea quark	<1	2	2

Results

PRELIMINARY

Combining systematic errors in quadrature,

$$\frac{f_{D_s} \sqrt{m_{D_s}}}{f_D \sqrt{m_D}} = 1.20 \pm .06 \pm .06$$

$$f_{D_s} = 263_{-9}^{+5} \pm 24 \text{ MeV}$$

$$f_D = 224_{-14}^{+10} \pm 22 \text{ MeV}$$

Future

Matching now the dominant uncertainty. Need matching beyond tree level for action.

Include results from second lattice spacing.

Higher statistics.