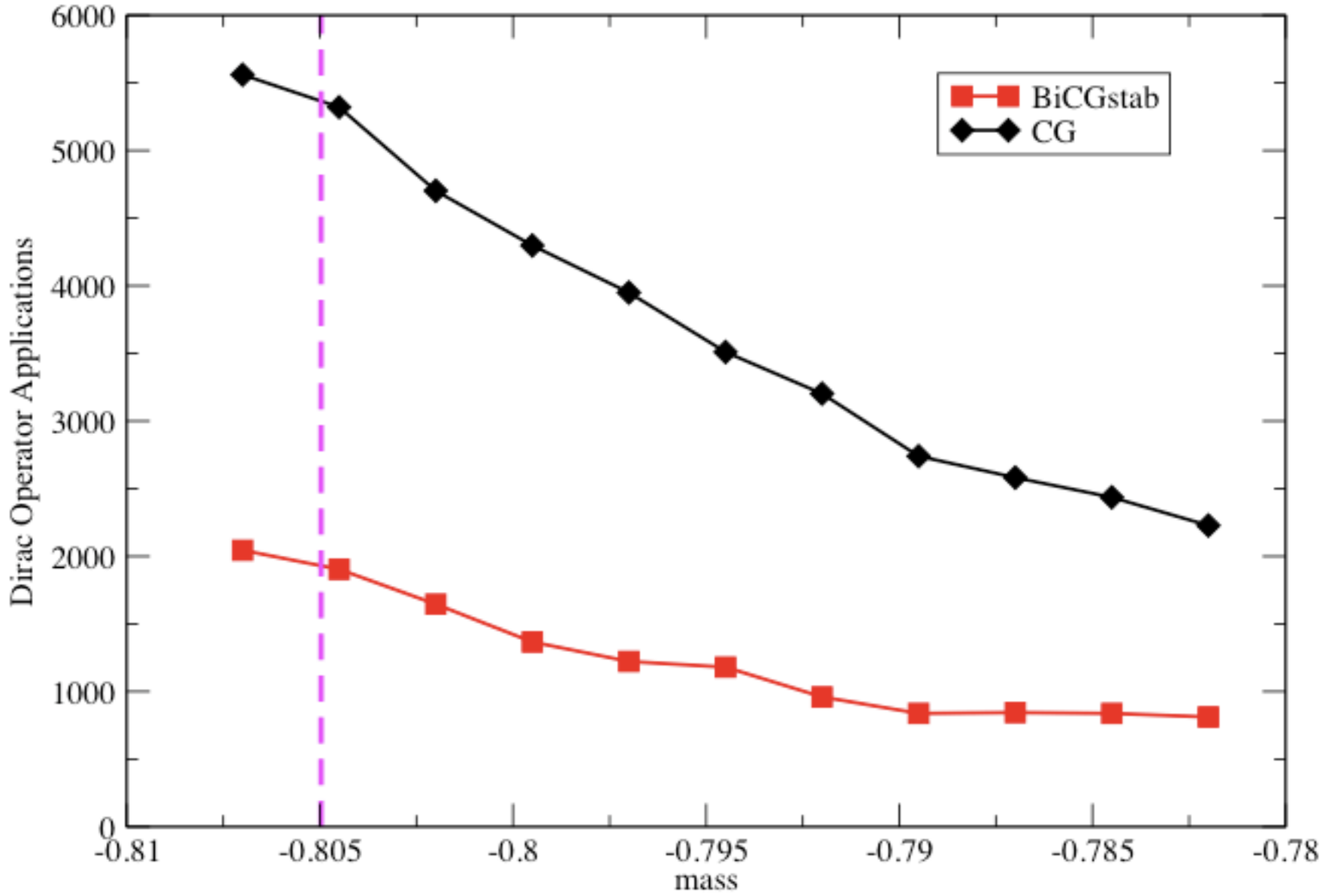
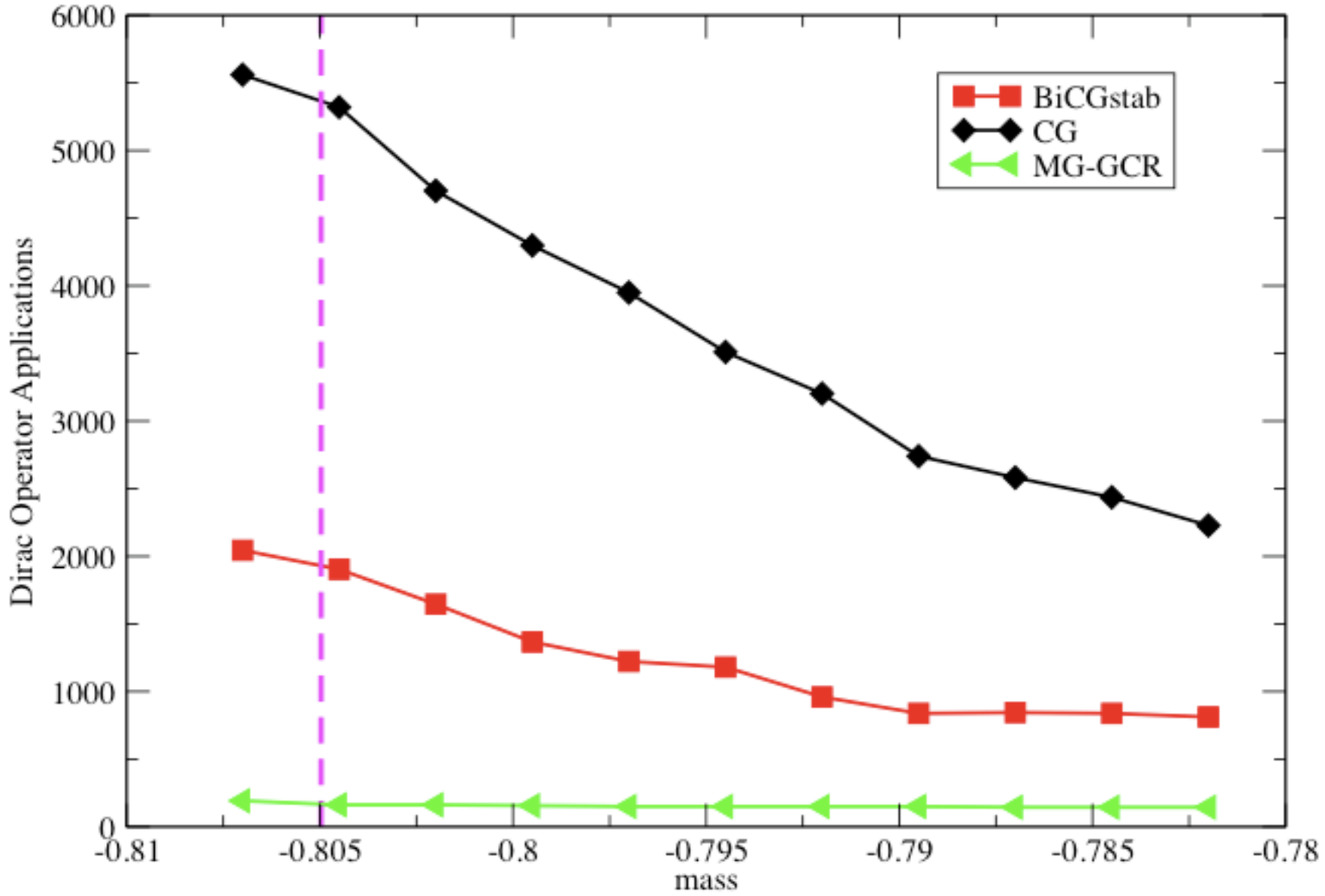
ADAPTIVE MULTIGRID

- Represent null space of Dirac operator on coarse grid
  - Less dof, can solve exactly on coarse grid
  - Use as a preconditioner for original problem
- Removal of critical slowing down
- New software requirements and performance challenges
  - Different lattice geometries
  - Arbitrary number of colours on coarse grid



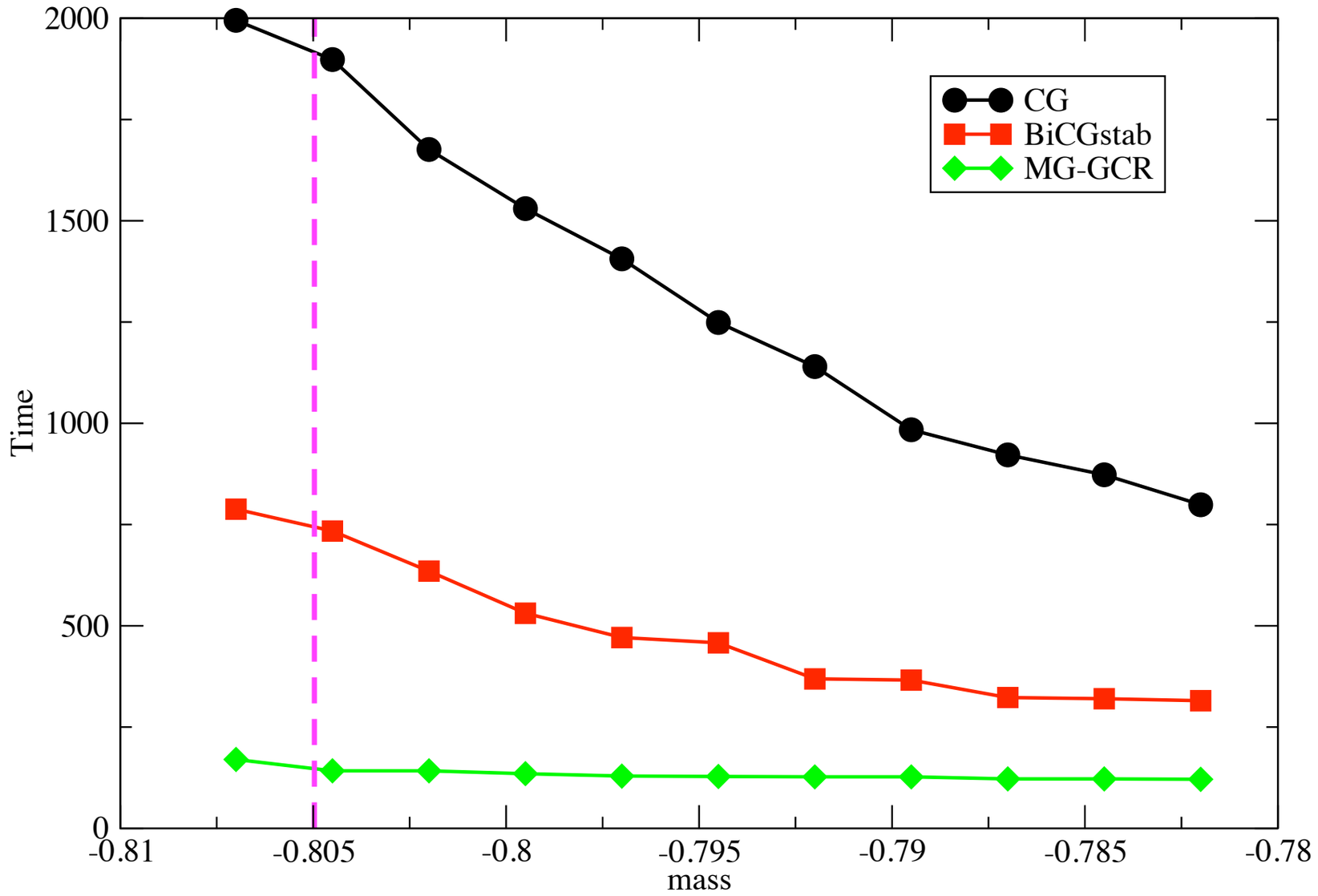
4D WILSON-DIRAC RESULTS: OPERATOR APPLICATIONS

$16^3 32$, $\beta=6.0$



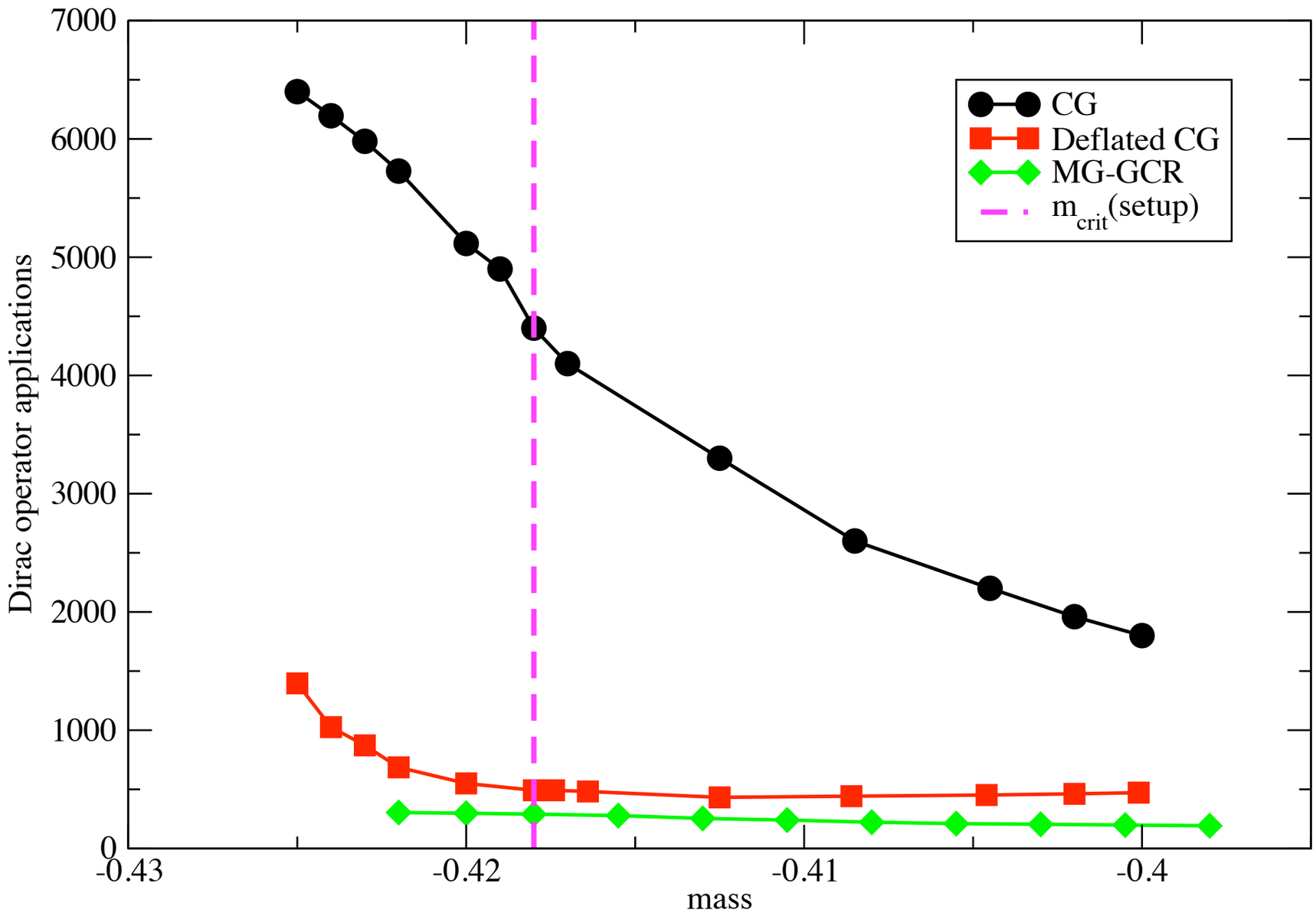
4D WILSON-DIRAC RESULTS: OPERATOR APPLICATIONS

$16^3 32$, $\beta=6.0$



4D WILSON-DIRAC RESULTS: TIME TO SOLUTION

$16^3 32$, $\beta=6.0$



4D WILSON-DIRAC RESULTS: OPERATOR APPLICATIONS

$16^3 64$, β=5.6

QCDMG

- No support for multi-lattices QDP(++)
- Code developed from scratch in C++
- Uses external libraries
  - Parallelized using QMP
  - Load and save data using QIO
  - Also need LAPACK and BLAS
- Initial version s...l...o...w

QCDMG: LINEAR ALGEBRA

- Replace linear algebra with QLA
  - SU(3) code much faster
- No optimization for the many multigrid specific operations
  - Inter-grid transfer operations (rectangular matrices)
  - Coarse-grid Wilson operator has arbitrary Nc (O(10-20))
  - 50% execution time spent on multigrid operations, 25% flops
- Open problem: extend QLA, QA0, BAGEL?

FUTURE

- Almost ready for production use
- Currently only supports Wilson and Laplace Operators
  - Add support for Clover and Staggered
  - Chiral fermions?
- Port QCDMG to CUDA
  - GPU ideal for MG since no scaling issues
- QDP support for multiple lattices (James / Andrew)

MULTI-PRECISION

- GPUs, Cell, etc. single >> double performance
- Structure algorithm to suit architecture
  - e.g. LAPACK mixed precision 6x speedup over double on Cell
- MG preconditioner accounts for ~90% flops
  - Krylov wrapper in double
  - Preconditioner in single
- Also thinking about multi-level multi-precision solvers
  - double <--> float <--> half