Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft

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Exploration of hybrid fermion formulations

Work in collaboration with
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Outline

- Motivation
- Production
  - Details
  - Pion mass
  - Performance of algorithm
  - Comment on metastability
  - Performance of code
- Setting the strange quark mass
- Matching sea and valence sector
- Conclusions

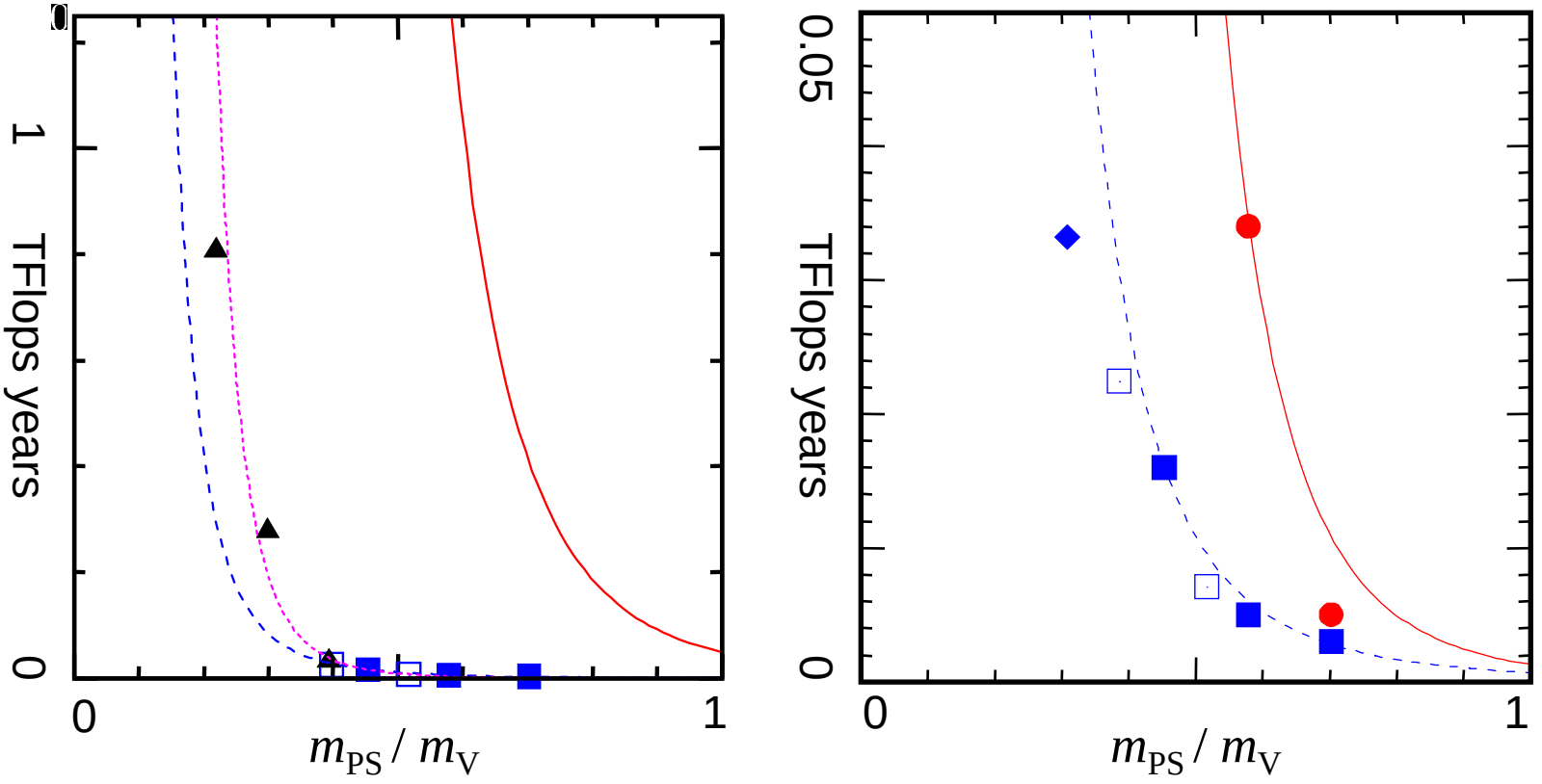
Motivation: Why hybrid?

- Dynamical Simulations with Wilson type fermions suffer from lack of chiral symmetry → complicated operator mixing in valence sector
- Overlap valence calculation are simplified by the exact chiral symmetry
- Dynamical Overlap calculations are extremely computationally demanding → on presently available TFlop scale computers only production of small lattices is possible
- TFlops scale machines enough for production with dynamical Wilson type fermion formulations
- Experience with quenched overlap calculations exist
- Matching of sea and valence sector is possible

Production: Details

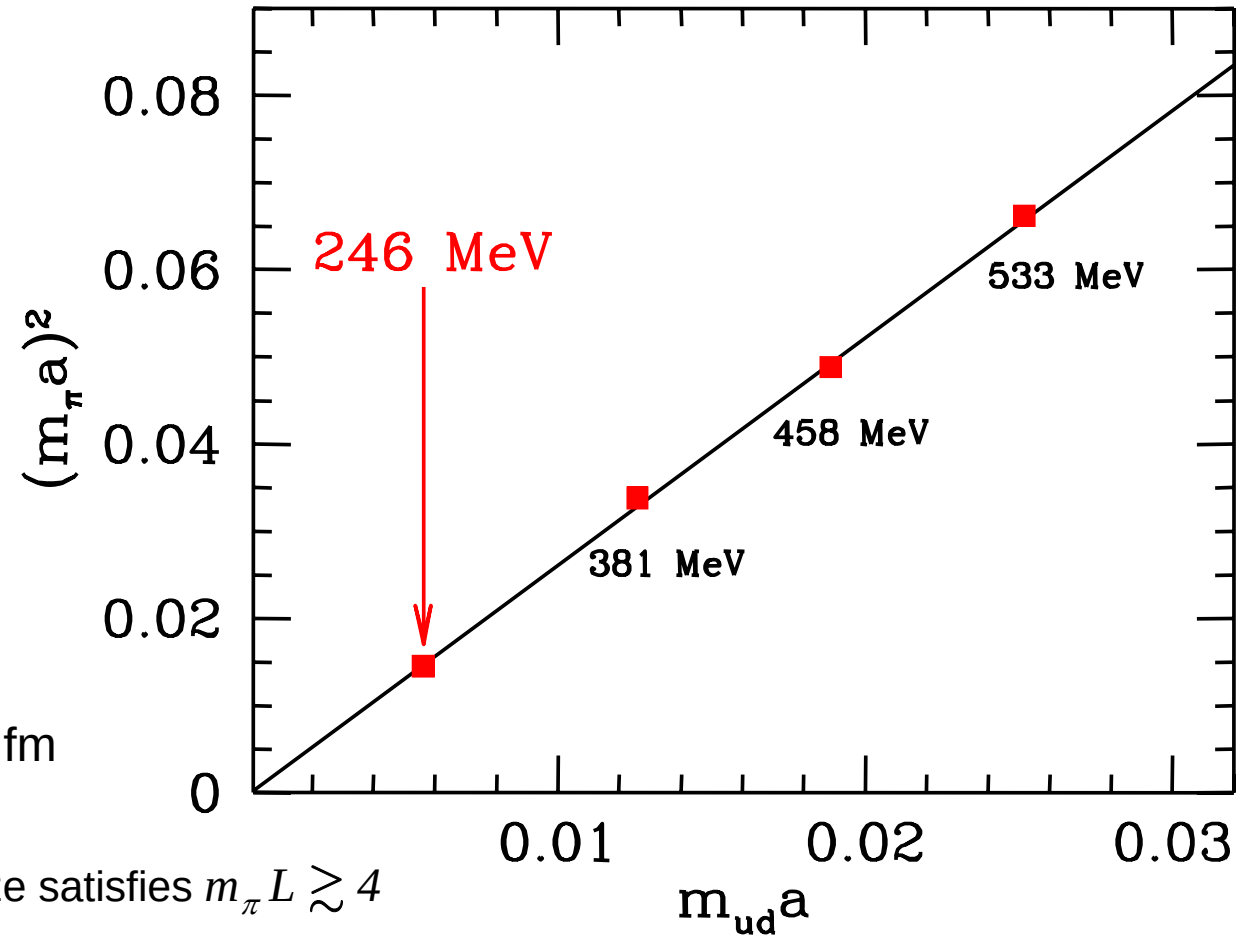
- Action
  - Clover improved Wilson fermions
  - Symanzik improved gauge action
  - Stout links
  - Rational HMC for strange quark
  - Mass preconditioning (“Hasenbusch trick”)
  - Multiscale integration scheme
  - Omelyan integrator
- Machines
  - PC-Clusters (ALiCEnext: 1024CPU, ..) at Wuppertal University
  - BlueGene/L (“Jubl”) at FZ-Juelich (NIC)

Production: Performance of algorithm ("Berlin Wall plot")



Plots taken from K. Jansen et al. hep-lat/0511013 (■), this work (□), staggered (▲)

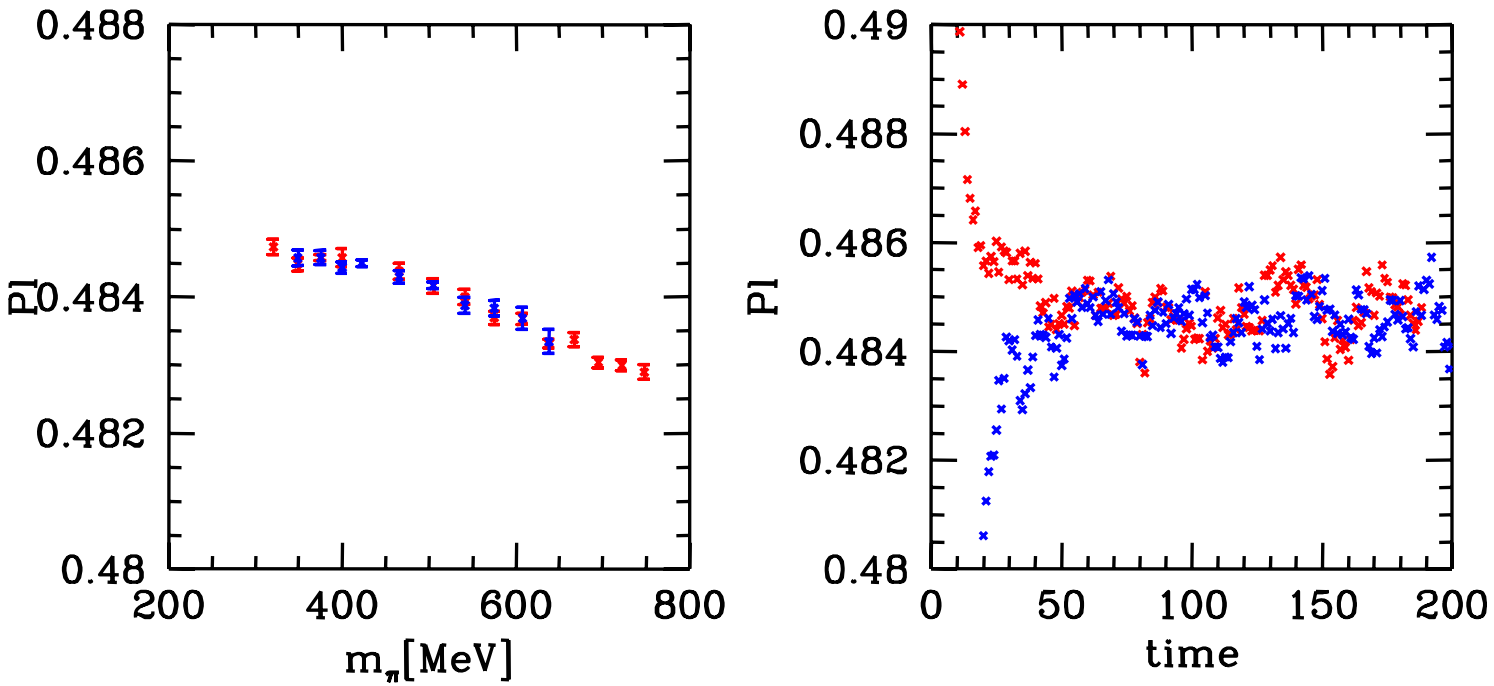
Production: Pion mass (sea)



a=0.095 fm

Lattice size satisfies $m_\pi L \gtrsim 4$

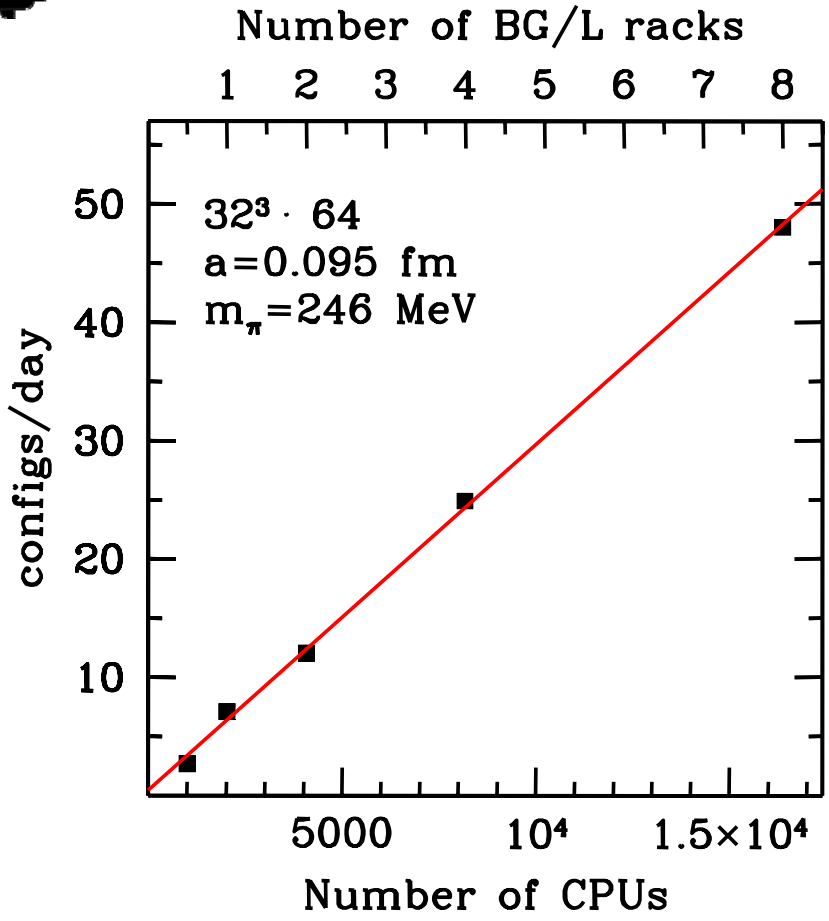
Production: Comment on metastability



O(a) improved Wilson + improved gauge action →

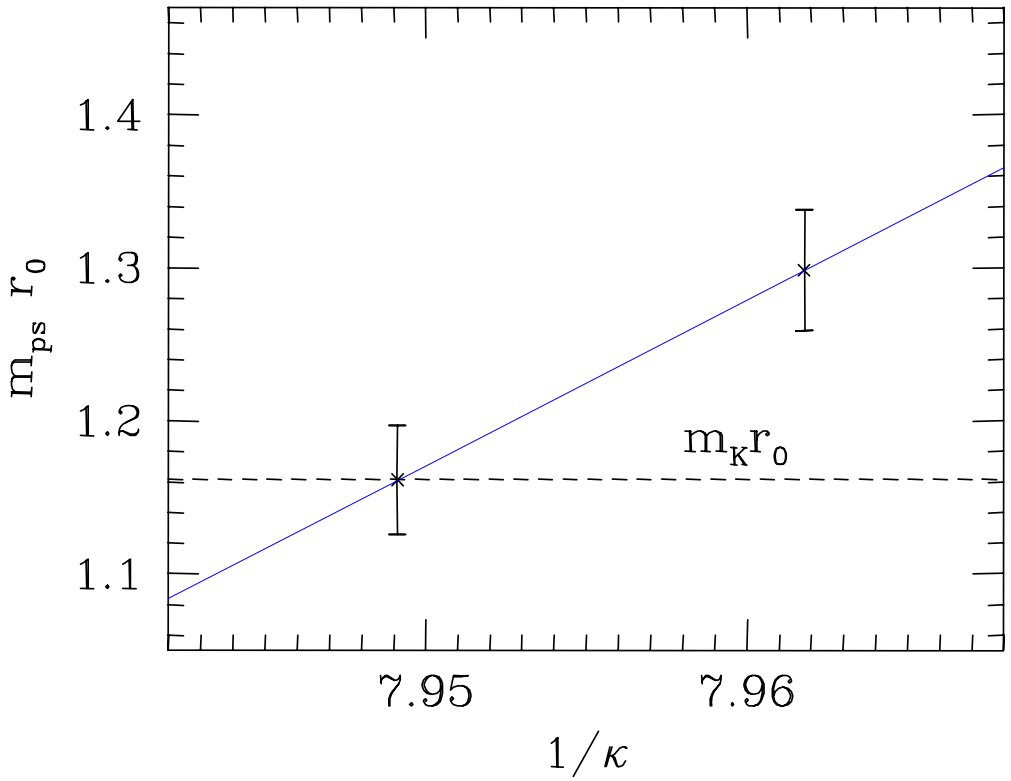
No metastability: cold/hot-start plaquettes agree after ca. 50 trajectories

Production: Performance of code



- Code written using inline assembly for core routines
- Low level communication (no mpi)
- 3 dimensions mapped onto torus network
- 4^{th} dimension along the 2 cores of a node
- Kernel reaches above 20% peak

Setting the strange quark mass



- To simulate 2+1 flavors the strange quark mass has to be set
- In 3 flavour theory the strange quark mass is given by the hopping parameter κ where

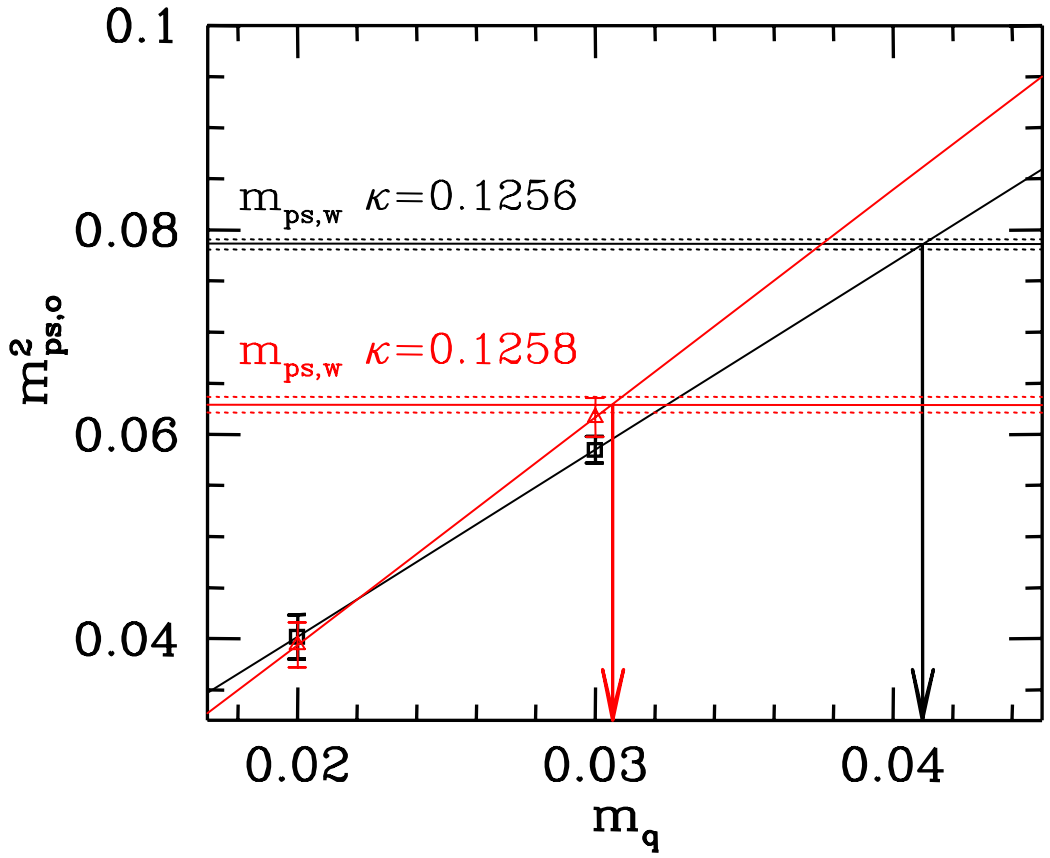
  $m_{ps} \cdot r_0 = m_K \cdot r_0$

  is fullfilled. Alternatively:

  $m_{ps}/f_{ps} = m_K/f_K$

- This κ gives roughly half the strange quark mass.

Matching of sea and valence sector



- For each κ we calculate the pion mass with the Wilson type fermions
- Then we calculate the pion mass with the overlap fermions (valence)
- Since

$$m_{ps,o}{}^2(m_q) \propto m_q$$

only 2 datapoints are needed in principle

- The same procedure for the kaon gives the strange quark mass

Conclusions

- Using present TFlops scale computers large lattices with dynamical Wilson type fermions can be generated
- Experience and tested algorithms for valence calculations using overlap fermions exist

→ With a hybrid action calculation the advantages of both formulations can be combined