Computation of QCD meson screening masses at high temperature

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Screening masses

Screening masses are the inverse of the correlation length which is related to the response of the quark and gluon plasma when a meson is put in the system. They encode fundamental properties of the plasma and characterize the long distance behaviour of fermionic bilinears.

State of the art

- One-loop perturbation theory for $T \longrightarrow \infty$
  [M. Laine, M. Vepsalainen (2010)]
- Non perturbative calculations for $T \leq 2.5$ GeV [B. Brandt et al. (2019), A. Bazavov et al. (2019)]

Aim of the study

Fill the gap between the high and low temperature regimes

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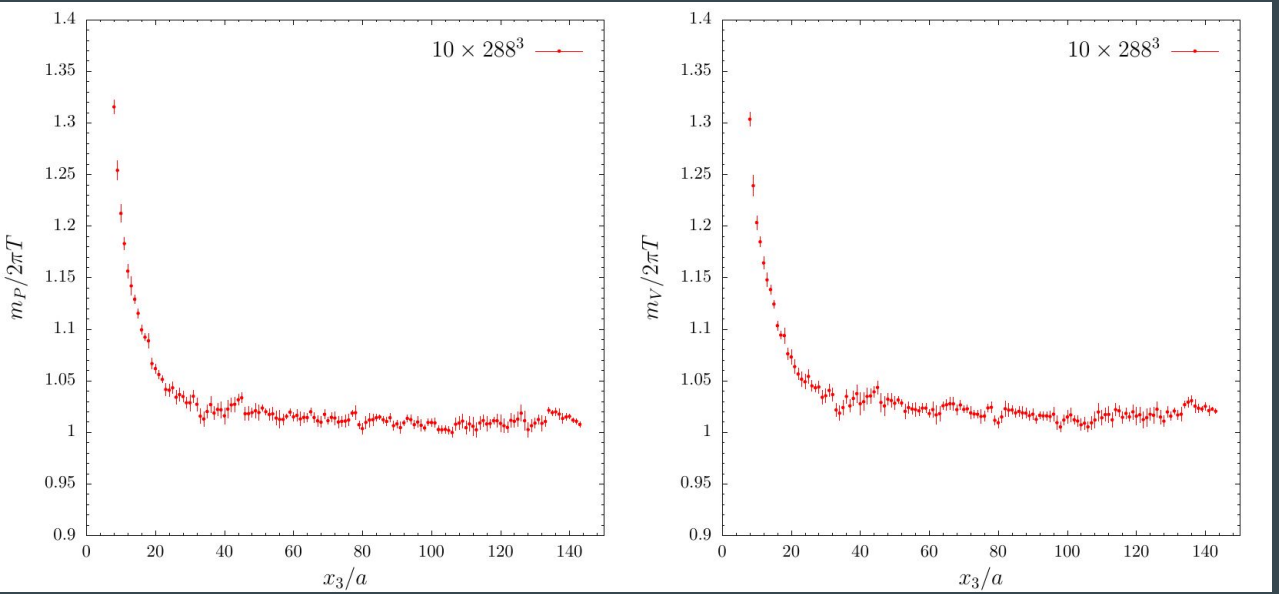
First computation between T = 1 GeV up to the electroweak scale

Numerical study: parameters

- Simulations performed using the **Hybrid Monte Carlo** algorithm
- Calculation carried out with $\mathbf{N_f = 3}$ in the **chiral limit** with **O(a)-improved Wilson quarks**
- **11 Temperatures** simulated over 3 or 4 different lattice spacings between T = 1.16 GeV and T = 82 GeV
- **Large volumes** to keep finite volume effects under control
- **Lines of constant physics** were fixed from the ALPHA collaboration [ALPHA Collaboration (2016-2018)]

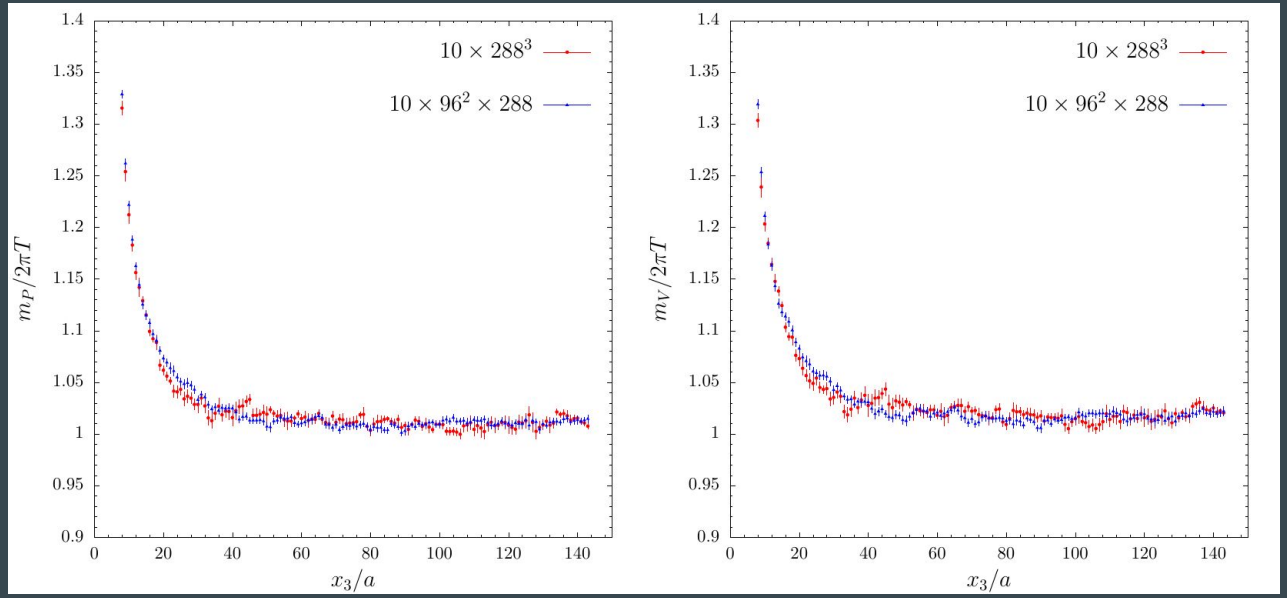
Temperature (GeV)	
T_0	164.6
T_1	82.3
T_2	51.4
T_3	32.8
T_4	20.63
T_5	12.77
T_6	8.03
T_7	4.91
T_8	3.040
T_9	2.833
T_{10}	1.821
T_{11}	1.167

Numerical study: effective masses



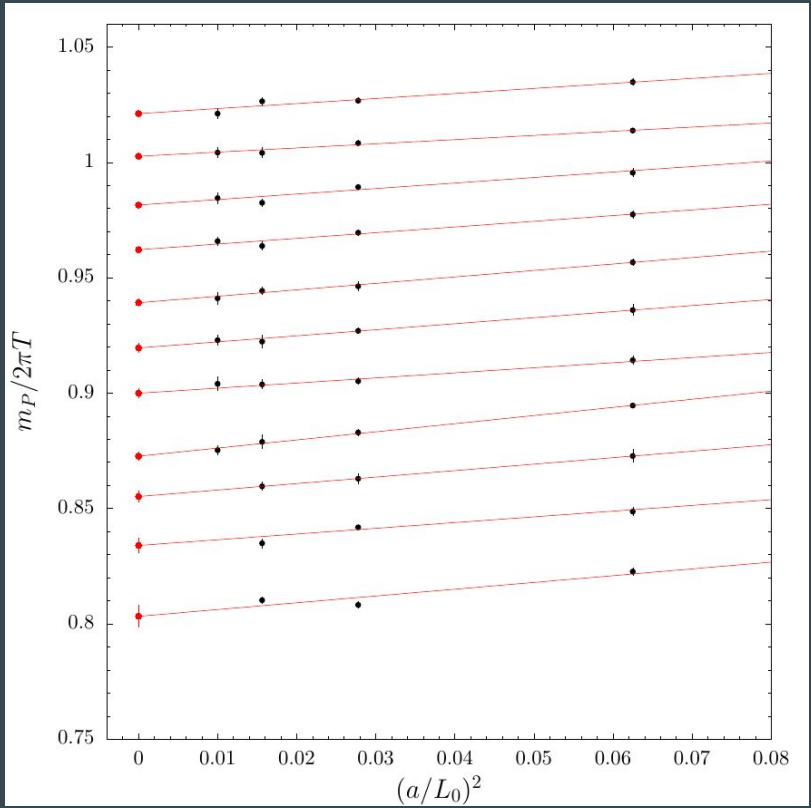
The inversion of the quark propagator was performed using a distance-preconditioned version of the Dirac equation [G.M. de Divitiis, R. Petronzio, N. Tantalo (2010)]

Numerical study: finite volume effects



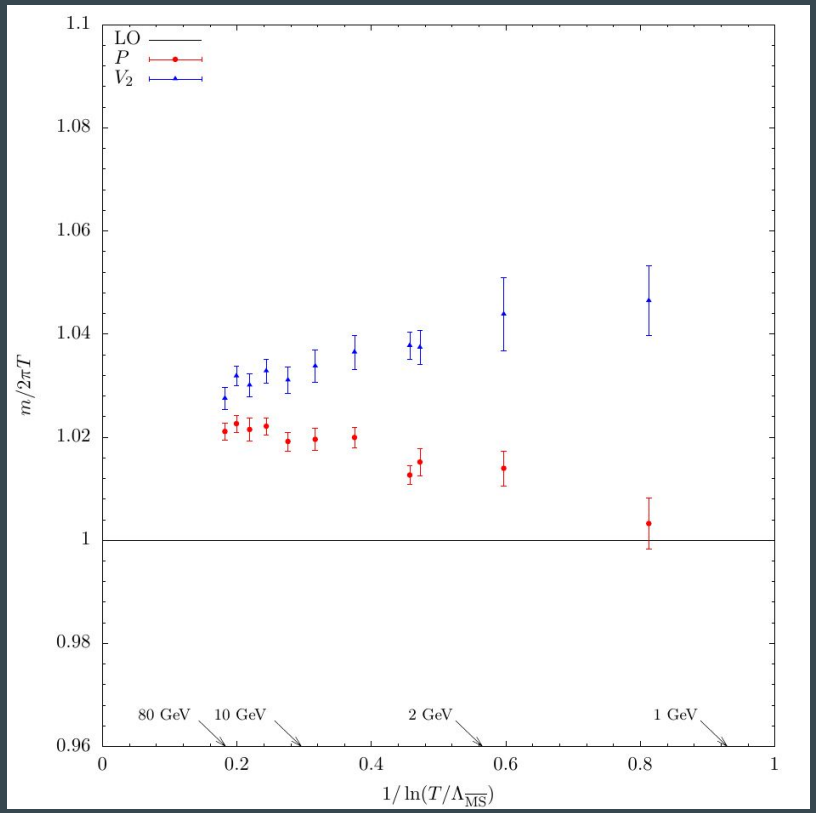
A preliminary analysis on two different volumes at the highest and the lowest temperature shows finite volume effects are negligible.

Numerical study: continuum limit (preliminary)



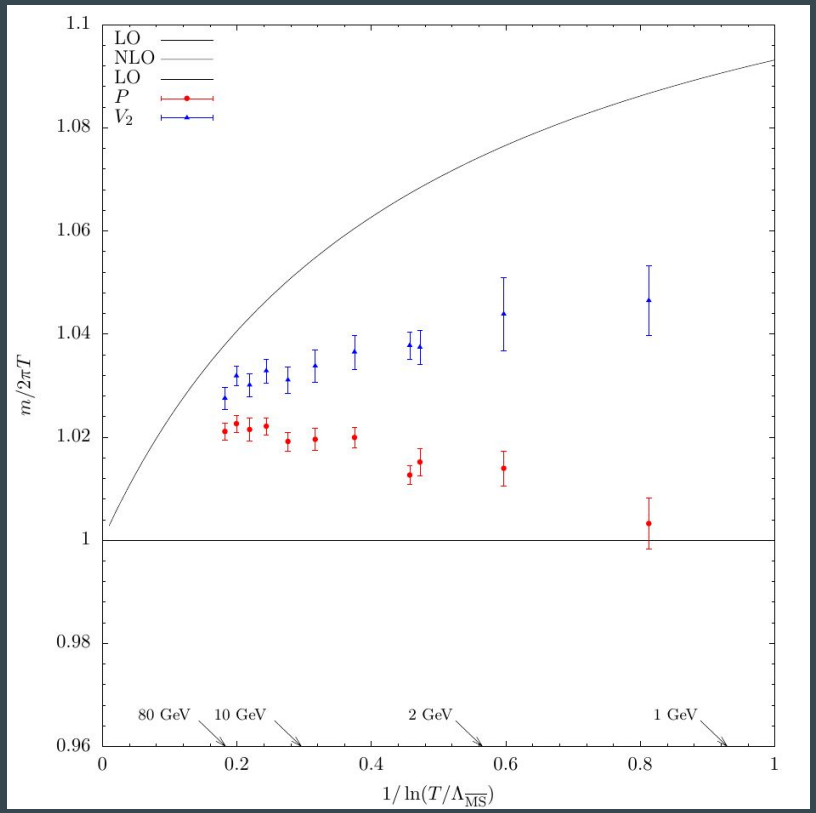
- The analytic calculation of the free theory contribution on the lattice was used to reduce discretization effects.
- The continuum limit was performed with confidence
- Screening masses were determined with a few **per mille-accuracy** in the continuum limit

Numerical study: temperature dependence (preliminary)



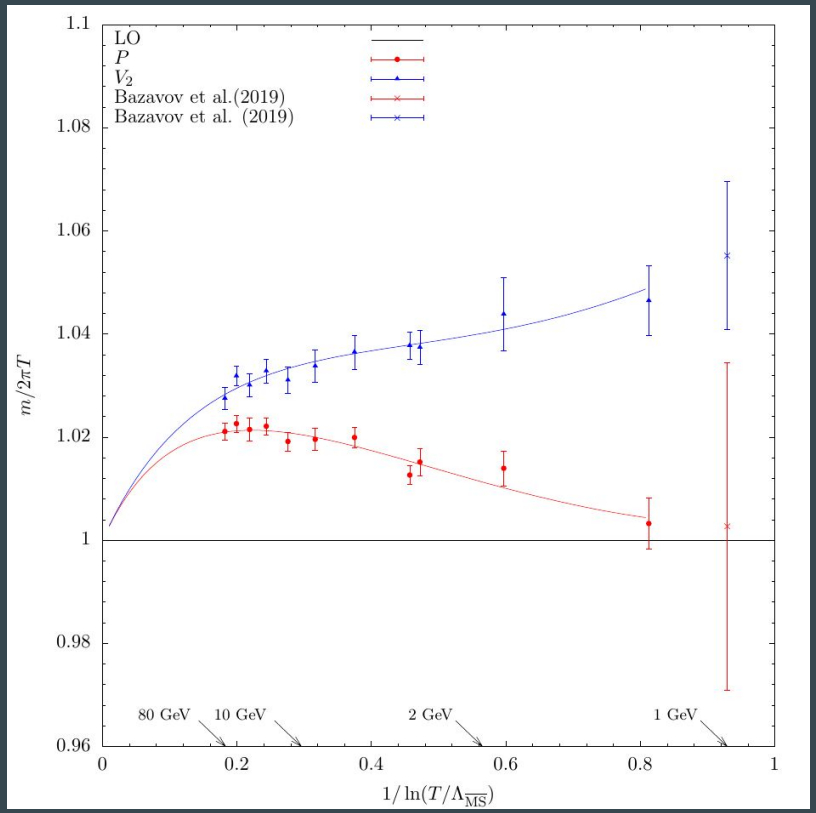
- The bulk of the masses is given by the free theory result with a few percent positive deviations

Numerical study: temperature dependence (preliminary)



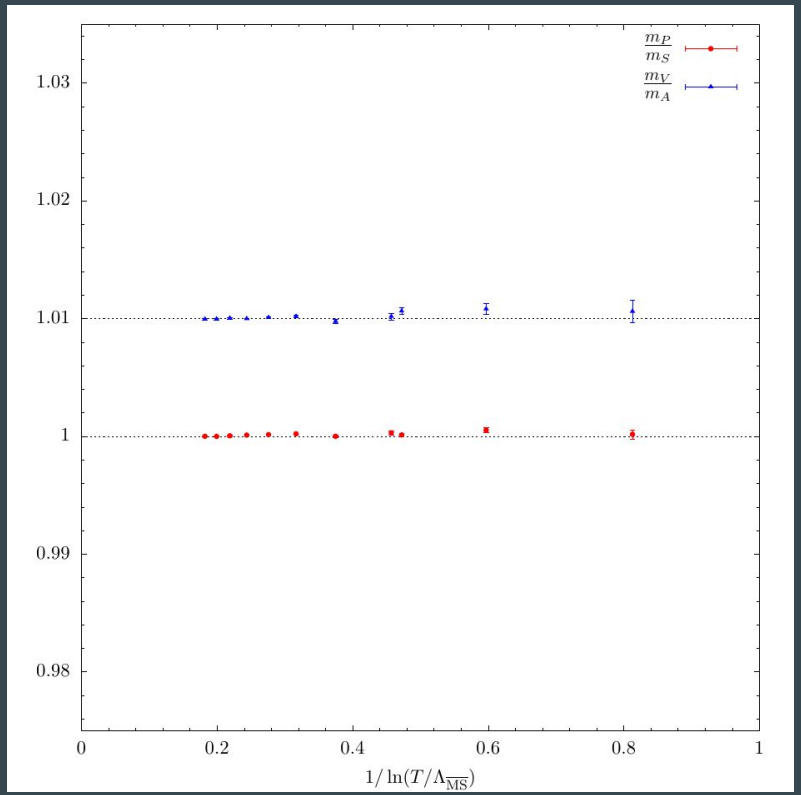
- The bulk of the masses is given by the free theory result with a few percent positive deviations
- At T ≃ 80 GeV the 1-loop perturbative calculation is **not compatible** within our precision: Vector and Pseudoscalar screening masses are **still not degenerate**

Numerical study: temperature dependence (preliminary)



- The bulk of the masses is given by the free theory result with a few percent positive deviations
- At T ≃ 80 GeV the 1-loop perturbative calculation is **not compatible** within our precision: Vector and Pseudoscalar screening masses are **still not degenerate**
- Data are well described by a phenomenological polynomial fit in the renormalized coupling
- The linear coefficient of the polynomial is compatible with the leading perturbative correction

Numerical study: chiral symmetry restoration (preliminary)



- **Chiral symmetry restoration** exhibits itself through the degeneracy of the axial and vector channels and the degeneracy of the scalar and pseudoscalar channel (m_V/m_A is shifted upward by 0.01 to improve readability)

Summary

- Screening masses were determined with a few per mille-accuracy between T = 1 GeV up to the electroweak scale
- The bulk of the masses is the free value with a few percent positive deviations
- Preliminary results show 1-loop perturbation theory is not satisfactory within our precision at the highest temperatures simulated and unreliable below T $\lesssim$ 10 GeV
- The linear coefficient in the perturbative expansion is compatible with our findings
- Chiral symmetry restoration is observed in the entire range of temperature