Preparation to B-physics ETMC programm

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- Purpose of the analysis
- Finding the most convenient interpolating field
- A comparison with HQET data

Purpose of the analysis

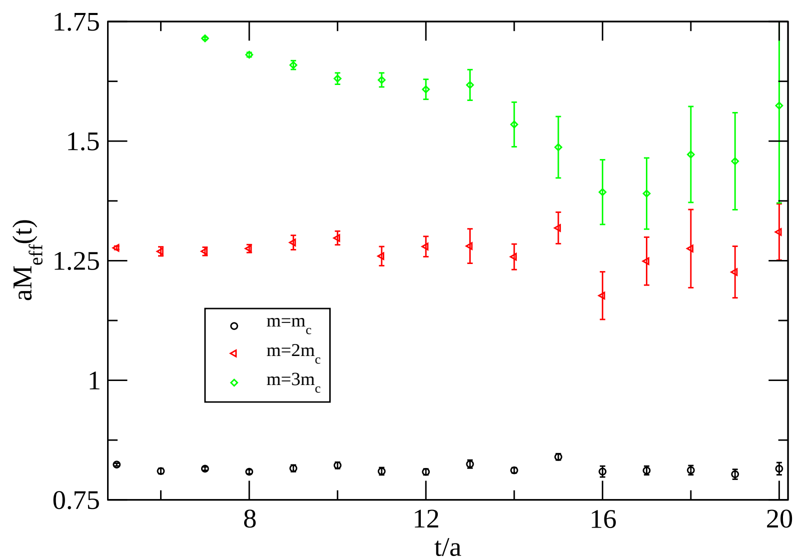
The ETM Collaboration has decided to make an important effort (computer time, man power) to measure relevant quantities in B-physics $\longrightarrow$ theoretical counterpart of the on-going and forthcoming experiments in flavour physics (LHCb, Super B).

The idea is to use the method proposed recently to obtain $F(m_b)$ from a series of ratios $F(m_i)/F(m_{i-1})$ and the initial point $F(m_c)$: Step Scaling in Masses [P. Dimopoulos *et al*, '11]

An issue is to isolate correctly the ground states on 3-pt correlators (extraction of B_B, $\mathcal{F}^{B\to D^*}$,...), especially at $m_i \sim m_b$.

Test on the ETM ensemble "B_3" ($\beta = 3.9, a\mu = 0.0085, V = 24^3 \times 48$)

Effective mass of local-local 2-pt PP correlators



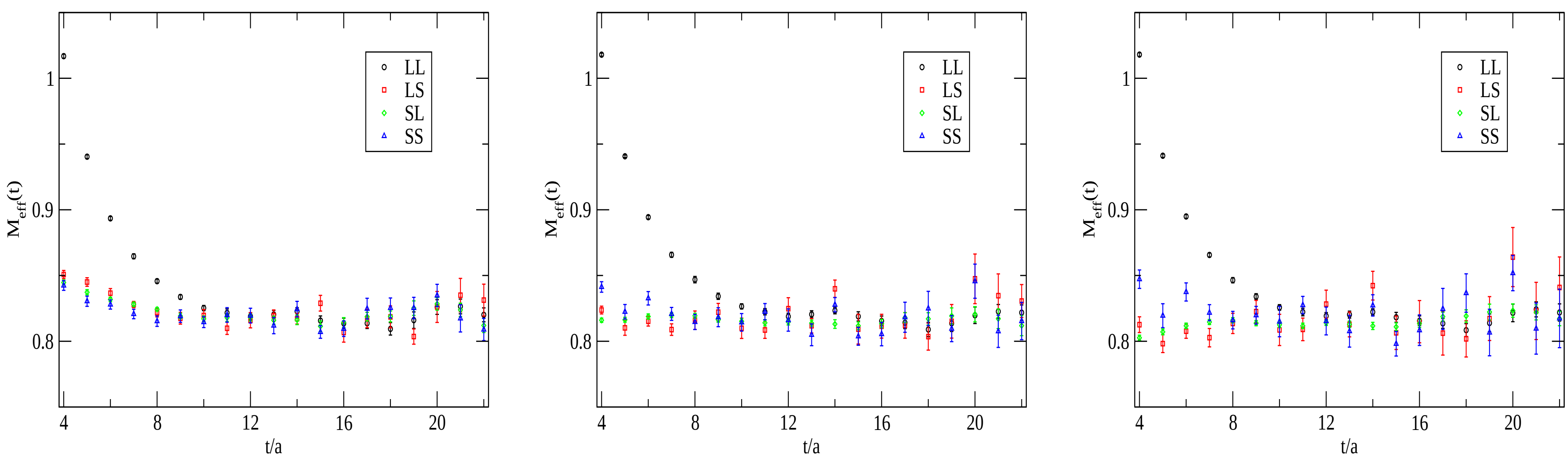
Very strong coupling of the local operator to excited states at high mass.

Finding the most convenient interpolating field

Use of Gaussian smeared fields: $\psi^S = (1 + \kappa_G a^2 \Delta^F)^{N_G} \psi_l$: $\kappa_G = 0.4$, Δ^F covariant Laplacian of APE-Blocked links ($\alpha_{\rm APE} = 0.5$, $N_{\rm APE} = 10, 30$); radius of the “wave function”: $R = 2a\sqrt{\kappa_G N_G}$

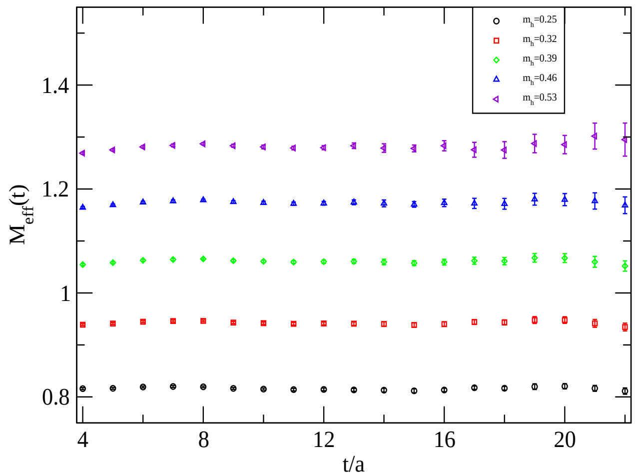
Effective mass of PP correlators with different N_G at $m = m_c$
(starting point of the Step Scaling in masses)

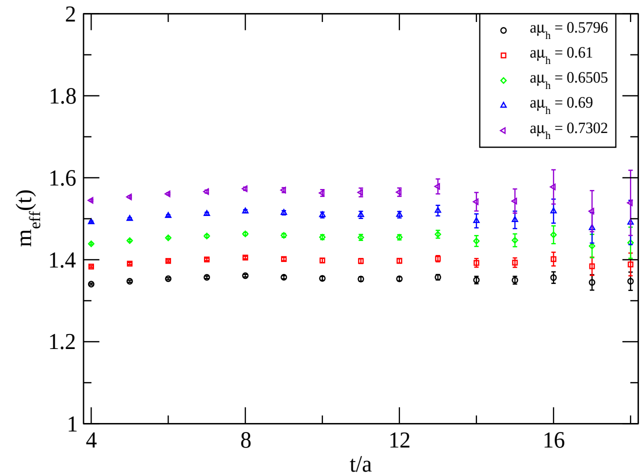
$N_G = 30 \;\; R = 0.6$ fm $\qquad N_G = 60 \;\; R = 0.85$ fm $\qquad N_G = 90 \;\; R = 1$ fm



Smearing improves well the situation with respect to local operators: plateaus appear much earlier in time, signal especially good for smeared-local correlators.

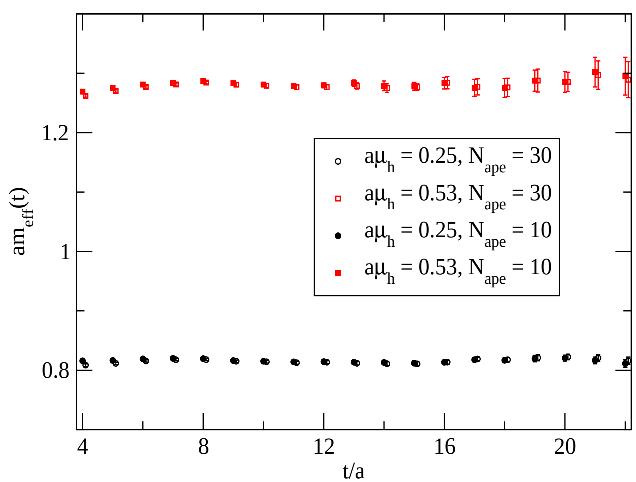
Effective mass of smeared-local correlators at different heavy masses (various points of the Step Scaling in masses); $N_G = 60$

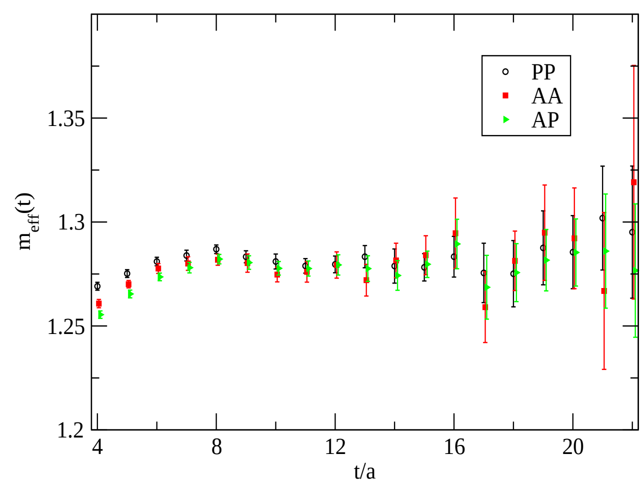




Smeared-local operators are very promising in the whole mass range.

Some more tests on the effective mass of smeared-local correlators; N_{APE} dependence, various Dirac structures of the interpolating fields





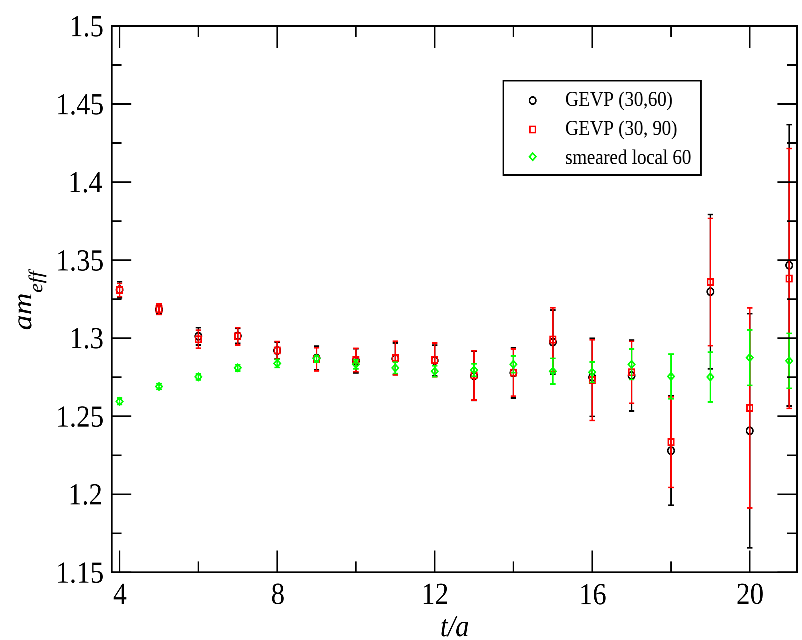
Everything seems to be under control from that point of view. A common fit of PP, AP and AA is allowed.

Solve a GEVP: $C(t)v^{(n)}(t) = \lambda^{(n)}(t,t_0)C(t,t_0)v^{(n)}(t,t_0)$

A non-biased approach is to include only SS correlators in the matrix of correlators C (with possibly different smearing iterations N_G at the source and the sink).

3×3 system ($N_G = 30, 60, 90$) is unstable (large error bars in the effective mass).

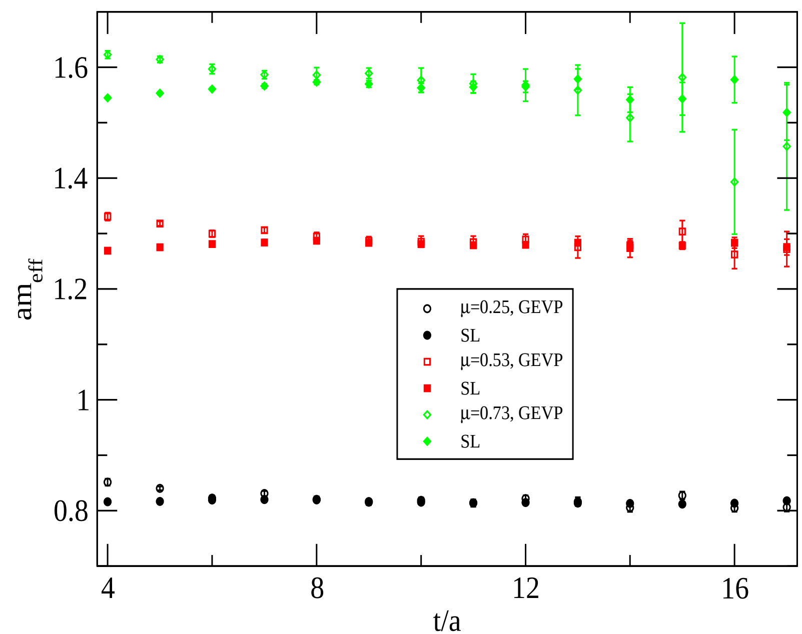
Effective mass obtained by GEVP at $m = 2m_c$



2×2 subsystem with $N_G = 30$ are stable, the subsystem ($N_G = 60, 90$) is not; $N_G = 60$ and $N_G = 90$ are excellent candidates to be the most convenient parameter.

To be confirmed by solving GEVP on the 2×2 system (LL, LS, SL SS).

Comparison between the effective masses of SL correlator and GEVP solution ($N_G = 60$)



From this analysis it seems that the ground state is dominating the smeared-local correlator at $t/a \geq 8$ in the whole mass range.

Our conclusion is that $\kappa_G = 0.4$, $N_G = 60$, $N_{\rm APE} = 10$, $\alpha_{\rm APE} = 0.5$ are appropriate parameters for the smearing.

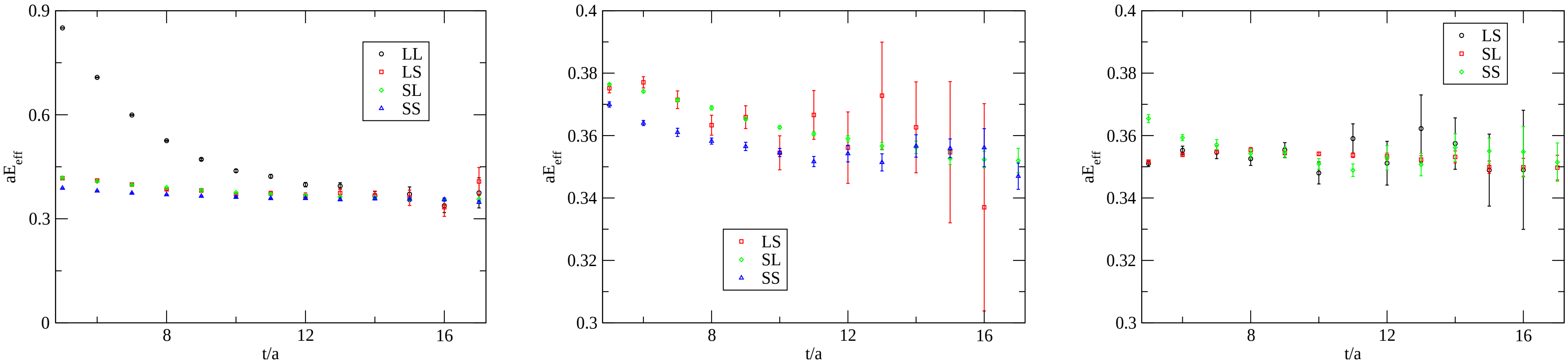
Smeared-local correlators are the most convenient to isolate the ground state
$\Longrightarrow$ particularly welcome to measure B_B.

A comparison with HQET data

Lattice set-up: CLS ensemble “E5g” ($a \sim 0.07$ fm, $m_\pi \sim 350$ MeV), static limit of HQET for the heavy quark, 1 stochastic source per timeslice (ETM data: 4 sources per configuration); $\alpha_{\rm APE} = 0.4$, $N_{\rm APE} = 3$.

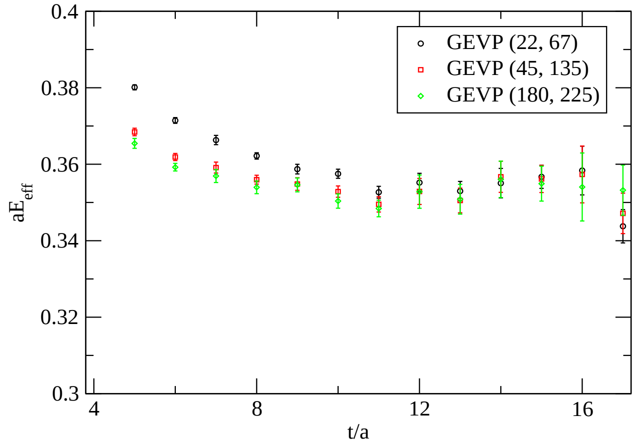
Effective mass for different wave function radii

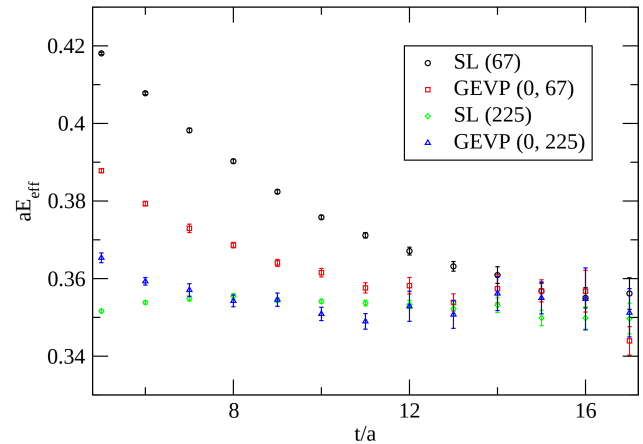
$R = 0.35$ fm | $R = 0.5$ fm | $R = 0.65$ fm



Once again analyse the local correlator only is not recommended. If a smeared interpolating field is weakly coupled to excited states, the smear-local correlator shows the best signal.

Solving the GEVP on different 2×2 subsystems





Similar conclusions to the previous analysis are derived concercing the SL correlator.

Solving a GEVP helps to extract the decay constant f_B in HQET
[B. Blossier *et al*, ALPHA, '09 and '10]:

$$f_B \sim \frac{\tilde{C}_{LS}(t,t_0)}{\sqrt{\tilde{C}_{SS}(t,t_0)}} = \frac{C_{lj}(t)v_j^{(1)}(t,t_0)}{\sqrt{v_i^{(1)}(t,t_0)C_{ij}(t,t_0v_j^{(1)}(t,t_0)}} \left(\sqrt{\frac{\lambda^{(1)}(t_0+1,t_0)}{\lambda^{(1)}(t_0+2,t_0)}}\right)^t$$

is it also possible to measure in that way f_D?

	HQET	QCD
$\delta C_{SS}/C_{SS}(t=0.85\,\mathrm{fm})$	0.35 %	3.38 %
$\delta v_1^{(1)}/v^{(1)}(t=0.35\,\mathrm{fm}, t_0=0.25\,\mathrm{fm})$	4 %	100%
$\delta\tilde{C}_{LS}/\tilde{C}_{LS}(t=0.85\,\mathrm{fm}, t_0=0.25\,\mathrm{fm})$	1%	28%
$\delta\tilde{C}_{SS}/\tilde{C}_{SS}(t=0.85\,\mathrm{fm}, t_0=0.25\,\mathrm{fm})$	1%	33%

Unfortunately it seems prohibitive to extract f_D from GEVP, unless multiply the number of stochastic sources by a factor 20.