WWU MÜNSTER

IJCLab Irène Joliot-Curie

A lattice QCD extraction of $B_s \longrightarrow D_s^{(*)}$ form factors

Explorative study of the mass step-scaling method with N_f=2

Based on arXiv:2110.10061 (hep-lat)

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The Form Factors

-**Semileptonic** decay.

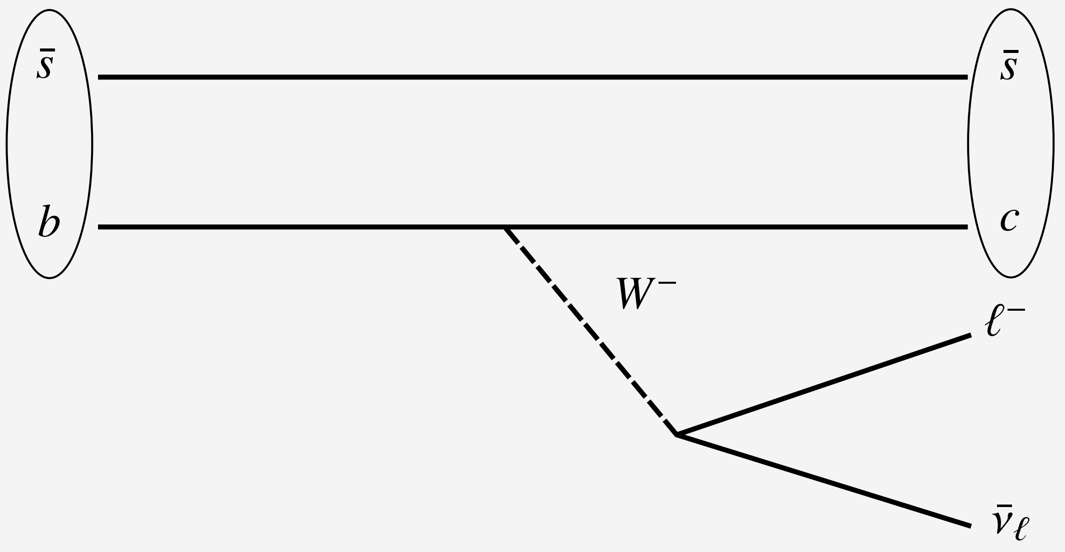
-**Strong and weak** contributions.

$$\frac{d\Gamma_{B_s \to D_s}}{dw} \propto |V_{cb}|^2 \cdot |G(w)|^2$$

$$w = \frac{E_{D_s}}{m_{D_s}}$$

Can be extracted

from **Lattice QCD.**



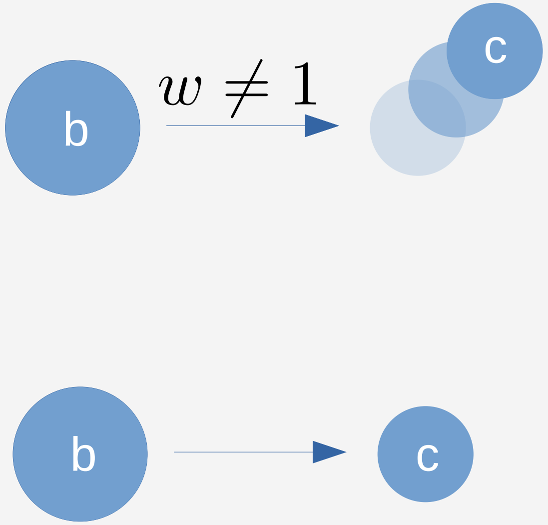
Schematic of the decay in question.

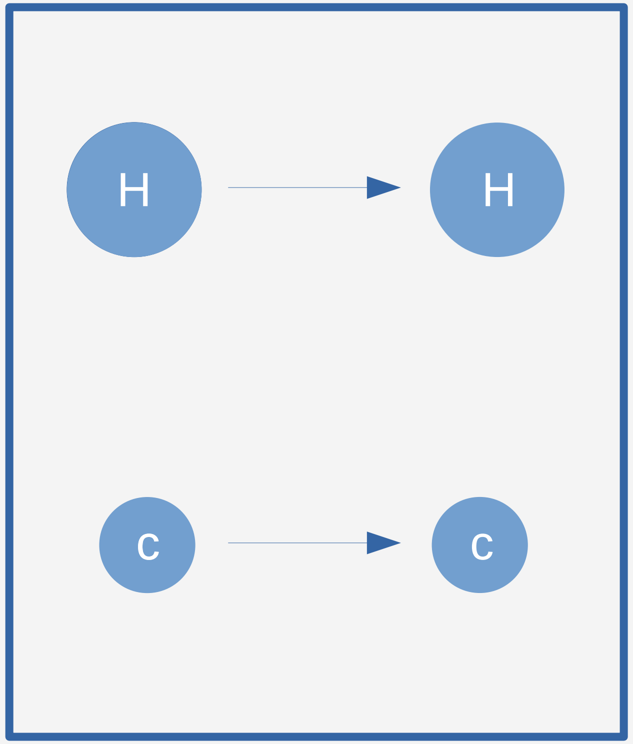
The Form Factors

-**G** only **depends** on **w.**

-We are interested in **zero recoil** (w=1)

-This is **not** directly **accessible** on the lattice.





$G = 1$

$$\langle D_s(k)|\bar{b}\gamma_\mu c|B_s(p)\rangle$$
$$= A_\mu(p,k)G(w) + B_\mu(p,k)f_0(w)$$

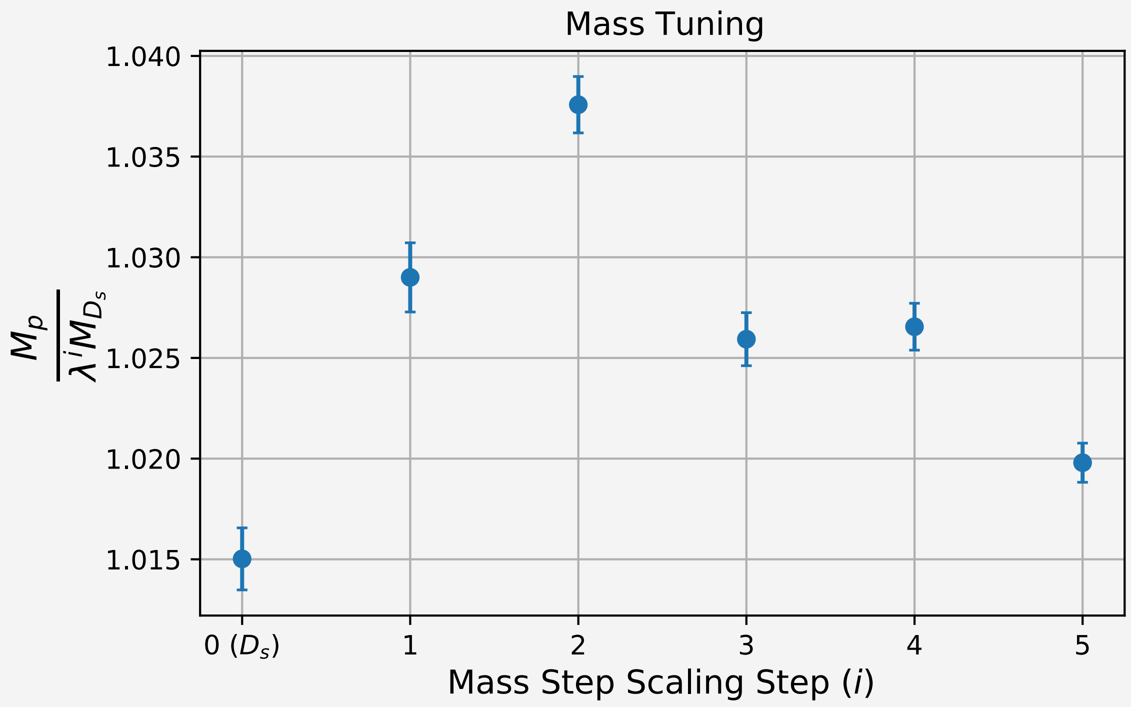
Mass Step-Scaling

-No measurements at b-scale (cutoff effects)

-Instead **extrapolation to Bs** mass.

$$m_{h_0 s} = m_{D_s}$$

$$\frac{m_{h_{i+1} s}}{m_{h_i s}} = \lambda \quad \text{with} \quad \lambda = \sqrt[6]{\frac{m_{B_s}}{m_{D_s}}}$$



Example from one ensembe used in our analysis.

Mass Step-Scaling

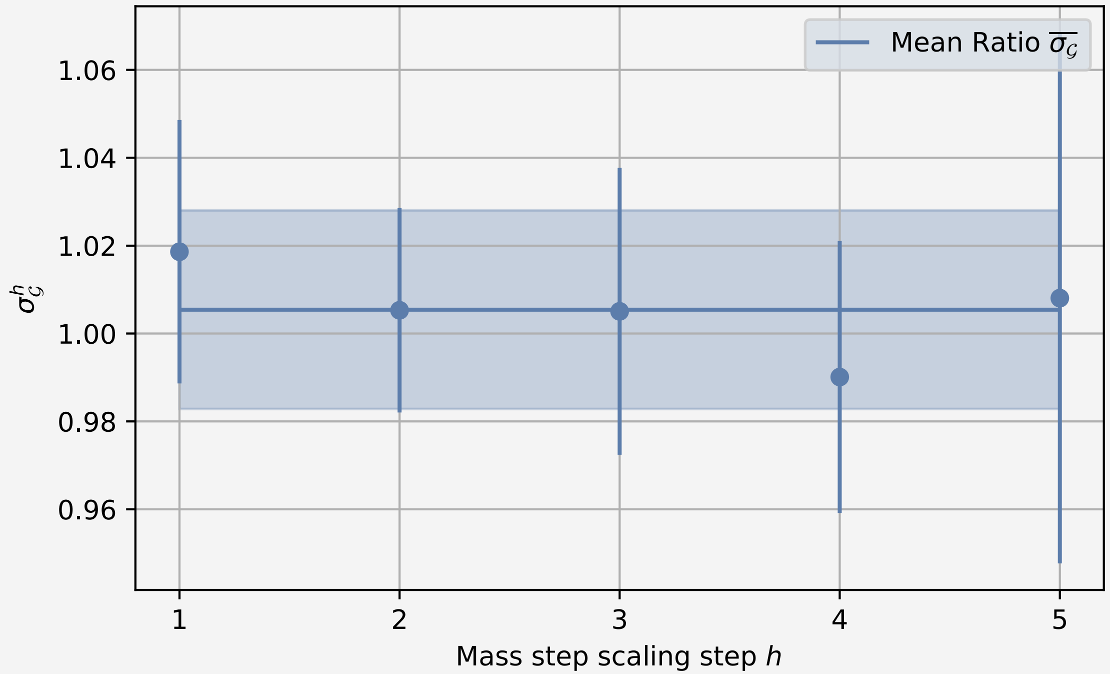
-Only consider **ratios** of G‘s between steps.

-Exploit G=1 for Ds → Ds.

$$G^{B_s \to D_s}(w=1) = G_{i=6}(1)$$

$$= \frac{G_6(1)}{G_5(1)} \cdot \frac{G_5(1)}{G_4(1)} \cdot \ldots \cdot \frac{G_1(1)}{G_0(1)} \cdot G_0(1)$$

$$= \sigma_6 \cdot \sigma_5 \cdot \ldots \cdot \sigma_1 \quad \text{with} \quad \sigma_i = \frac{G_i(1)}{G_{i-1}(1)}$$



-Method used by M. Atoui et al. (arXiv: 1310.5238)

On the Lattice

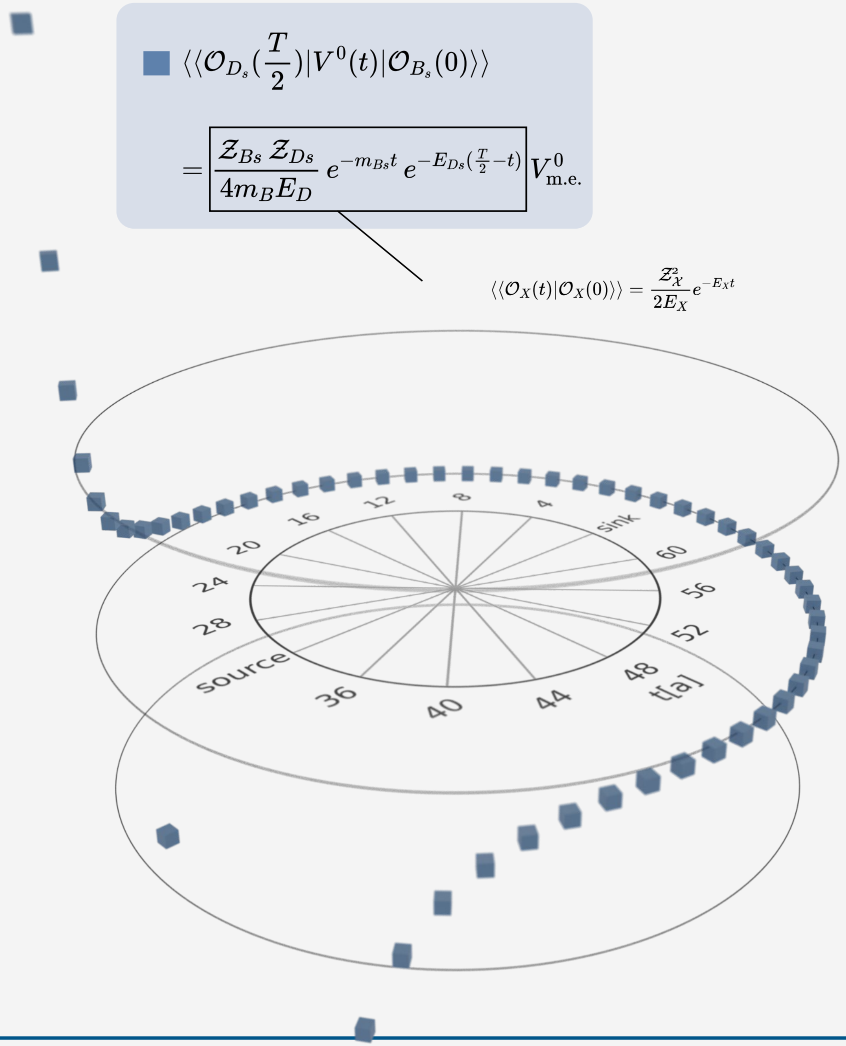
-**Three point** correlation function $< O_{H_2}(t2)\Gamma(t1)O_{H_1}(0) >$

-Extract matrix element

-**Twisted** boundary conditions for (unquantized) **momenta.**

$$\Psi(x + L\vec{e_i}) = e^{i\theta_i}\Psi(x)$$

-4x4 smeared sources.



Analysis

-Get **ground state** projection.

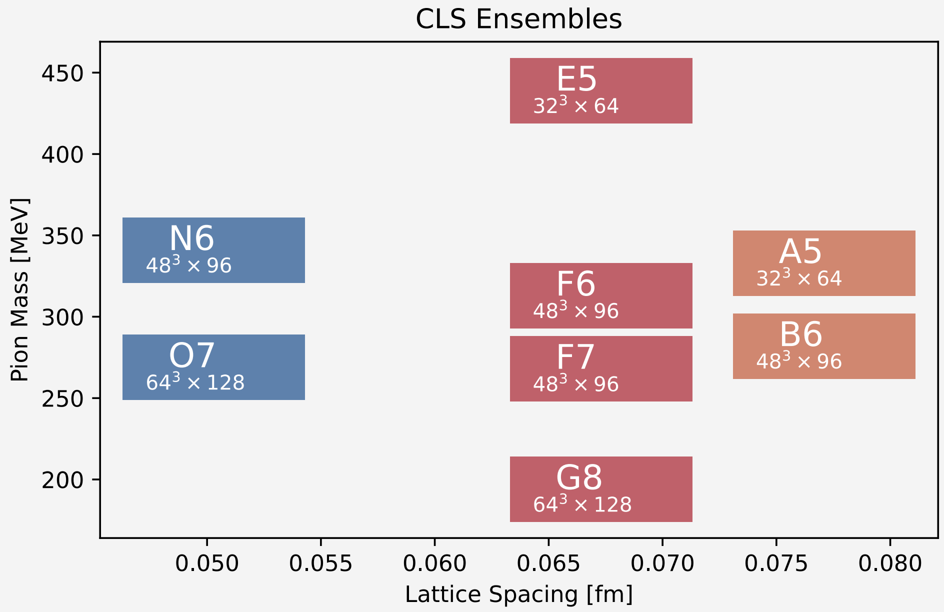
-**Masses** and amplitudes from **2pt correlators.**

-Extract **matrix element** and calculate G.

-Extrapolate to zero recoil (linear in (w-1)).

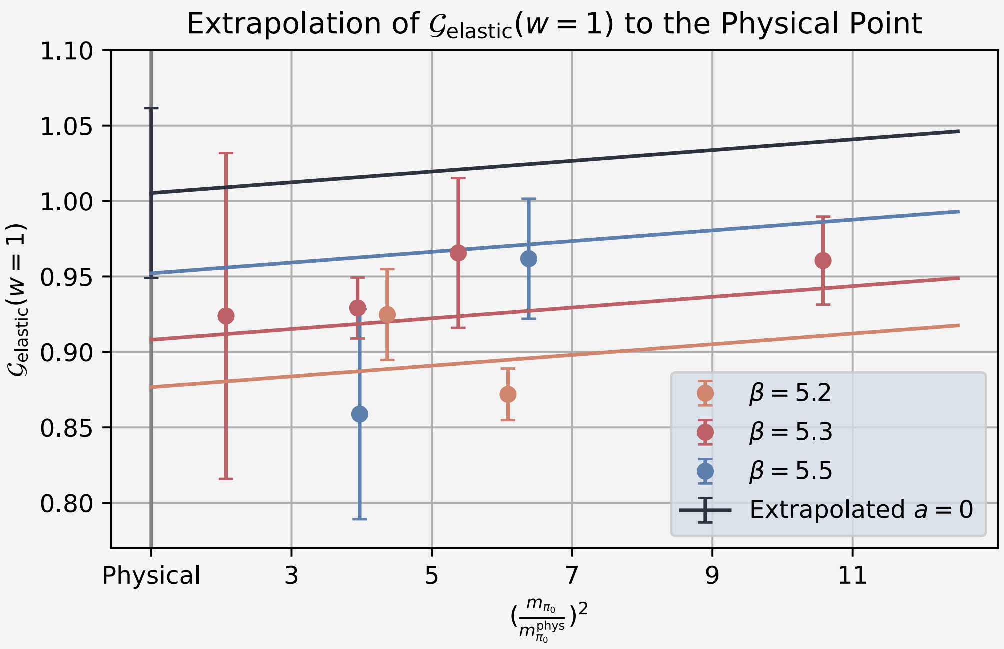
-Take ratios between masses.

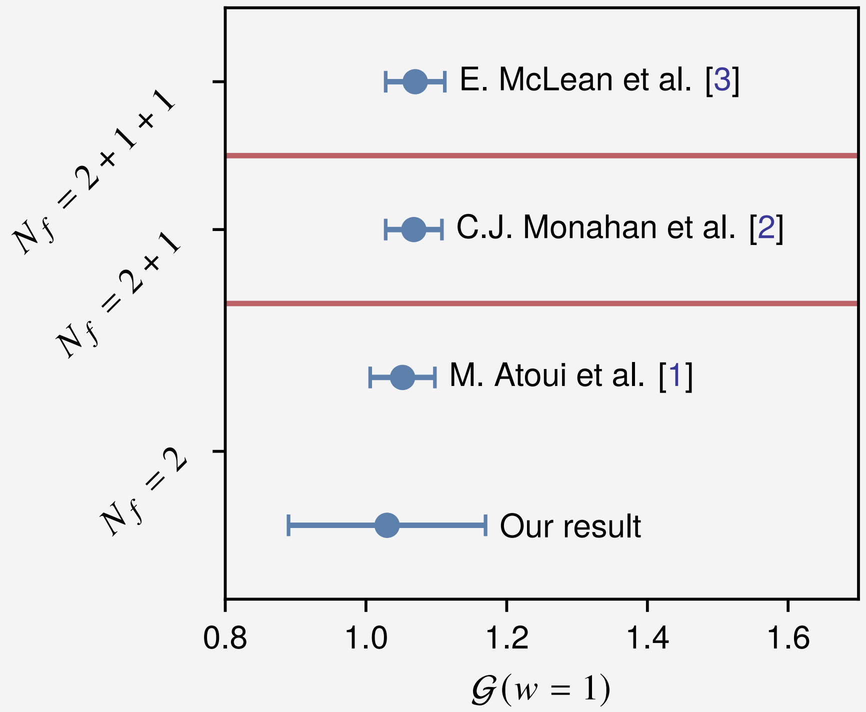
-Extrapolate to the physical point.



Ensembles used in this analysis.

Results





[1] M. Atoui, D. Becirevic, V. Morénas and F. Sanfilippo, *Lattice QCD study of $B_s \to D_s \ell \bar{\nu}_\ell$ decay near zero recoil*, *PoS* **LATTICE2013** (2014) 384, [1311.5071].

[2] C. J. Monahan, H. Na, C. M. Bouchard, G. P. Lepage and J. Shigemitsu, *$B_s \to D_s \ell \nu$ Form Factors and the Fragmentation Fraction Ratio f_s/f_d*, *Phys. Rev. D* **95** (2017) 114506, [1703.09728].

[3] E. McLean, C. T. H. Davies, J. Koponen and A. T. Lytle, *$B_s \to D_s \ell \nu$ Form Factors for the full q^2 range from Lattice QCD with non-perturbatively normalized currents*, *Phys. Rev. D* **101** (2020) 074513, [1906.00701].