

Exclusive semileptonic B -decays from QCD Light-Cone Sum Rules: a brief status report

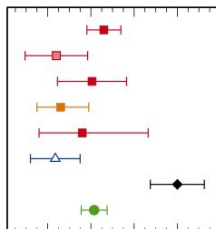
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Workshop: Flavour Physics with High-Luminosity Experiments ,
MIAPP, Garching, 03.11.2016

□ Current status of exclusive $|V_{ub}|$ determination

figures from [J. A. Bailey *et al.* [Fermilab Lattice and MILC Collaborations], arXiv:1503.07839 [hep-lat].]



This work + BaBar + Belle, $B \rightarrow \pi l \nu$

Fermilab/MILC 2008 + HFAG 2014, $B \rightarrow \pi l \nu$

RBC/UKQCD 2015 + BaBar + Belle, $B \rightarrow \pi l \nu$

Imsong *et al.* 2014 + BaBar12 + Belle13, $B \rightarrow \pi l \nu$

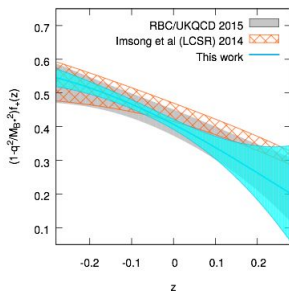
HPQCD 2006 + HFAG 2014, $B \rightarrow \pi l \nu$

Detmold *et al.* 2015 + LHCb 2015, $\Lambda_b \rightarrow p l \nu$

BLNP 2004 + HFAG 2014, $B \rightarrow X_u l \nu$

UTFit 2014, CKM unitarity

$\Leftarrow B \rightarrow \pi$ FF from LCSR (*)



(*) I.S.Imsong, A.K., T.Mannel and D.van Dyk,

[arXiv:1409.7816 [hep-ph]]

□ Schematic expression of LCSR for $B \rightarrow \pi$ form factor:

quark-hadron duality

Borel transf. $(p+q)^2 \rightarrow M^2 \sim m_b \chi$

$$f_{B\pi}^+(q^2; \vec{\theta}) = \frac{e^{m_B^2/M^2}}{2m_B^2 [f_B]_{2\text{ptSR}}} \int_{m_b^2}^{s_0^B} ds \frac{1}{\pi} \text{Im} F(s, q^2, \alpha_s, \mu, m_b, \vec{\theta}_{DA}^{(2,3,4)}) e^{-s/M^2}$$

$f_B(\bar{M}^2, \bar{s}_0^B, \alpha_s, \mu, m_b, \vec{\theta}_{\text{cond}})$

calculated from light-cone OPE

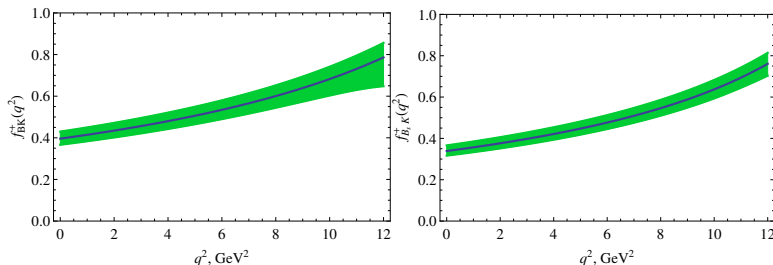
- set of input parameters

$$\vec{\theta} \equiv \left(\alpha_s(M_Z), \bar{m}_b(m_b), \vec{\theta}_{DA}^{(2,3,4)}, \vec{\theta}_{\text{cond}}, M^2, s_0^B, \bar{M}^2, \bar{s}_0^B \right).$$

- statistical (Bayesian) analysis of the sum rules (within adopted theory approx.)

□ Update of LCSRs for $B \rightarrow K$, $B_s \rightarrow K$ form factors

PRELIMINARY !, errors not correlated [AK, A.Rusov, work in preparation]



$$f_{BK}^+(0) = 0.396^{+0.034}_{-0.029}$$

$$f_{B_s K}^+(0) = 0.339^{+0.029}_{-0.024}$$

- $|V_{ub}|$ from $B_s \rightarrow K l \nu_\ell$ decay

$$\Delta\zeta(0, 12 \text{ GeV}^2) = \frac{1}{|V_{ub}|^2} \int_0^{12 \text{ GeV}^2} dq^2 \frac{d\Gamma}{dq^2}(B_s \rightarrow K l \nu_\ell) = 6.92^{+1.09}_{-0.90} \text{ ps}^{-1}$$

□ Possible improvements of LCSRs for $B \rightarrow \pi$, $B \rightarrow K$ form factors

- confirmed to be very small:
 - NNLO $O(\alpha_s^2 \beta_0)$ correction to the twist-2 part [A. Bharucha (2012)]
 - twist 5,6 term in factorizable approximation [A. Rusov, paper in preparation]
- missing NLO, $O(\alpha_s)$ correction to the twist-3 part **challenging !**
- quantifying the "systematic" uncertainty of semi-local duality ?
(suppressed with Borel transformation, controlled by the m_B calculation)
- pion, kaon DAs from LCSRs for e.m. pion and kaon form factors
BESS and Belle-2 data on $\gamma^* \gamma \rightarrow \pi^0$; JLab data on the pion, kaon e.m. FFs
- future Belle-2 data on the q^2 -shape of $B \rightarrow \pi \ell \nu_\ell$
will provide additional constraints on the DA parameters

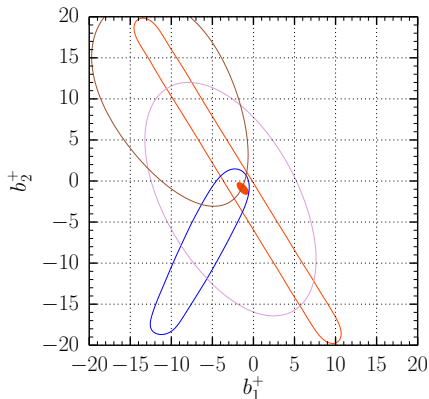
□ Other semileptonic heavy-light form factors from LCSRs

- LCSRs for $B \rightarrow \rho, K^*$ form factors (zero-width ρ, K^*)
at $0 < q^2 \lesssim 15 \text{ GeV}^2$ at the same level of accuracy as $B \rightarrow \pi, K$
[A.Bharucha, D.Straub, R.Zwicky (2015)]
- $\Lambda_b \rightarrow \rho$ FFs , much less accurate, limited by proton DAs
[AK, Th.Mannel, Ch. Klein, Y.-M. Wang (2011)]
- $B \rightarrow \pi\pi\ell\nu_\ell$ form factors see also Danny's contribution to this session
 - LCSRs with light-cone dipion DAs
- to assess ρ -width effects, ρ -dominance, partial -wave pattern
(so far only leading twist , LO) [Ch. Hambrock, AK, arXiv:1511.02509]
 - using B -meson DAs and dipion interpolating current
[S.Cheng, AK, J.Virto, in progress]

BACKUP SLIDES

□ Comparison of shape parameters (preliminary !)

- z-parameterizations of experiment (lattice) fitted (transformed) to the $N = 3$ BCL (modified) form to compare with our results



orange: LCSR
(full with derivatives; lines without)
blue : Lattice with 3 data points
violet: 2010 BaBar+Belle
brown: 2013 BaBar+Belle

- only parametrical uncertainties of LCSR result are taken into account
future Belle-2 data on the q^2 -shape of $B \rightarrow \pi \ell \nu_\ell$ will be crucial

- purely LCSR prediction
(no parametrization/extrapolation involved)

$$\Delta\zeta(0, 12\text{GeV}^2) = \frac{1}{|V_{ub}|^2} \int_0^{12\text{GeV}^2} dq^2 \frac{d\Gamma}{dq^2}(B \rightarrow \pi \ell \nu_\ell)$$

$$\equiv \frac{G_F^2}{24\pi^3} \int_0^{12\text{GeV}^2} dq^2 p_\pi^3 |f_{B\pi}^+(q^2)|^2 = (5.25_{-0.54}^{+0.68}) \text{ps}^{-1},$$