non-leptonic

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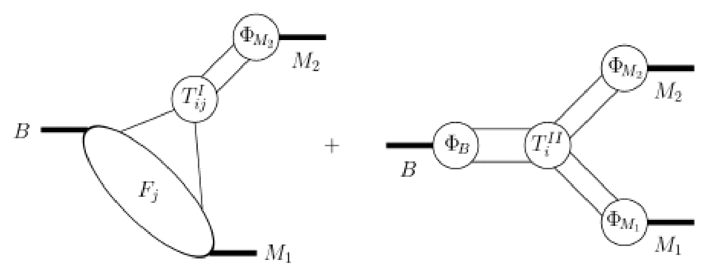
Non-leptonic B decays

- B→ππ, Kπ, …
  - Too hard. Maybe much harder than K→ππ. So, naturally, no progress so far.
  - But, there is a clue: reduce the problem to a simpler one by the QCD factorization, namely a calculation of the *light-cone distribution amplitude*

$$\Phi^B_{\alpha\beta}(k_+) = \int dz_- e^{ik_+z_-} \langle 0|\bar{q}_\beta(z)[z,0]b_\alpha(0)|B\rangle|_{z_+,z_\perp=0}$$

  - Its inverse moment appears

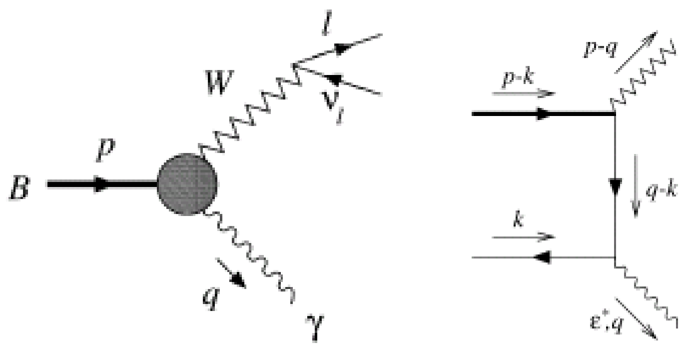
$$\frac{\sqrt{2}}{\lambda_B} = \int_0^\infty \frac{dk_+}{k_+}\Phi^B_+(k_+)$$



    - Poorly known so far: λ_B = 200~600 MeV.

B→lνγ

- Light-cone distribution amplitude
  - Still, no idea on how to implement the light-like separation on the lattice. Theoretically simpler to calculate a *physical* process.
  - B→lνγ is governed by the same quantity.



$$\frac{1}{\sqrt{4\pi\alpha}}\langle\gamma(\varepsilon^*,q)|\bar{u}\gamma_\mu(1-\gamma_5)b|\bar{B}(p)\rangle$$
$$= \epsilon_{\mu\nu\rho\sigma}\varepsilon^{*\nu}v^\rho q^\sigma F_V(E_\gamma)$$
$$+i[\varepsilon^*_\mu(v\cdot q)-q_\mu(v\cdot\varepsilon^*)]F_A(E_\gamma)$$

$$F_V = F_A = \frac{f_B m_B Q_u}{2\sqrt{2}E_\gamma}\int_0^\infty dk_+ \frac{\Phi_+^B(k_+)}{k_+}$$

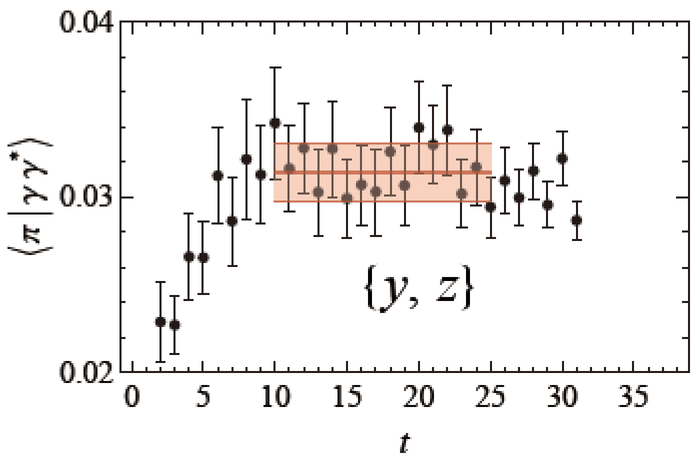
- Two problems
  - On-shell photon final state
  - Large momentum transfer

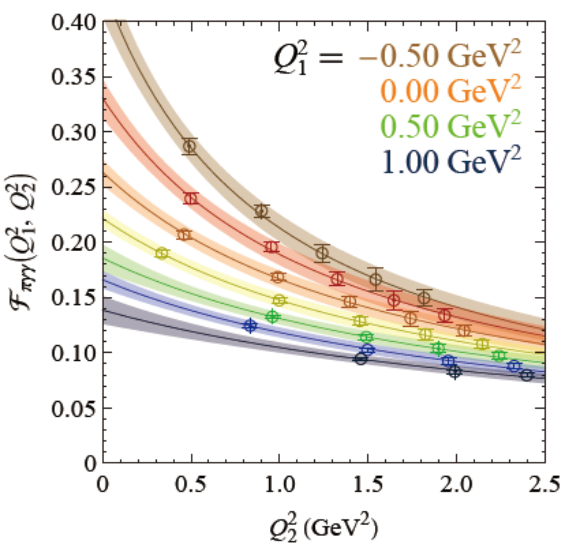
On-shell photon

- A proto-type calculation: $\pi^0 \to \gamma\gamma$
  - Cohen at Lattice 2008
  - LSZ reduction; final equation is simply like this

$$\frac{e^2 \varepsilon_\mu^{(1)} \varepsilon_\nu^{(2)}}{\frac{Z_\Phi(p)}{2E_\Phi(p)} e^{-E_\Phi(p)(t_f - t)}} \int dt_i e^{-\omega_1(t_i - t)} \left\langle T \left\{ \int d^3\vec{z} e^{-i\vec{p}\cdot\vec{z}} \varphi_\Phi(\vec{z}, t_f) \int d^3\vec{y} e^{i\vec{q}_2\cdot\vec{y}} j^\nu(\vec{y}, t) j^\mu(\vec{0}, t_i) \right\} \right\rangle,$$

    - three-point function with one leg integrated over time with a weight determined by the photon energy.
  - Beautiful results





Large momentum transfer

- Charmonium done already
  - $\eta_c \to \gamma^{(*)} \gamma^{(*)}$
    - Dudek-Edwards, Phys Rev Lett 97, 172001 (2006)
- Or, use the "moving" HQET (or NRQCD)
  - Boost the initial B meson, such that the photon becomes soft.
  - Should be possible, but need more study.
- Also, $\pi \to \gamma^{(*)} \gamma^{(*)}$ is interesting for its LCDA