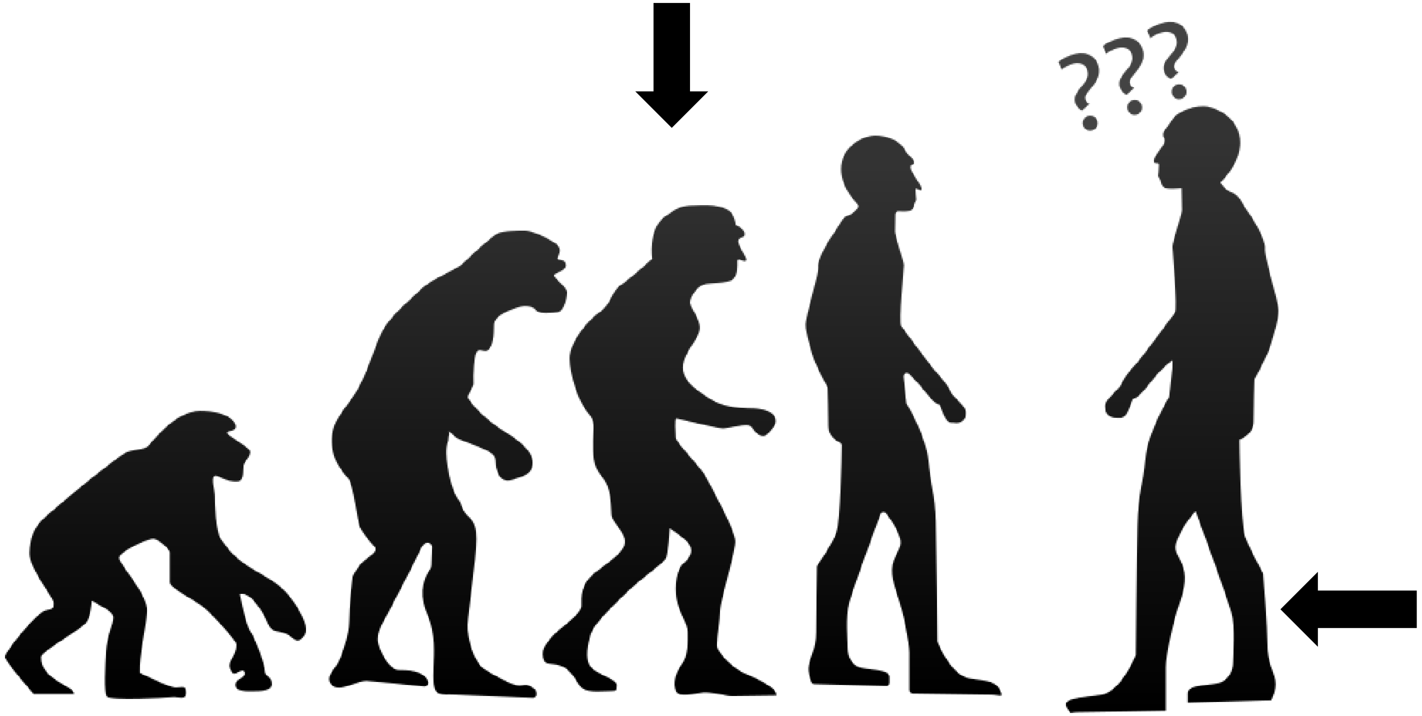
Evolution of Dihadron Fragmentation function

Kazuki Makino*



*my advisor,
Ted Rogers

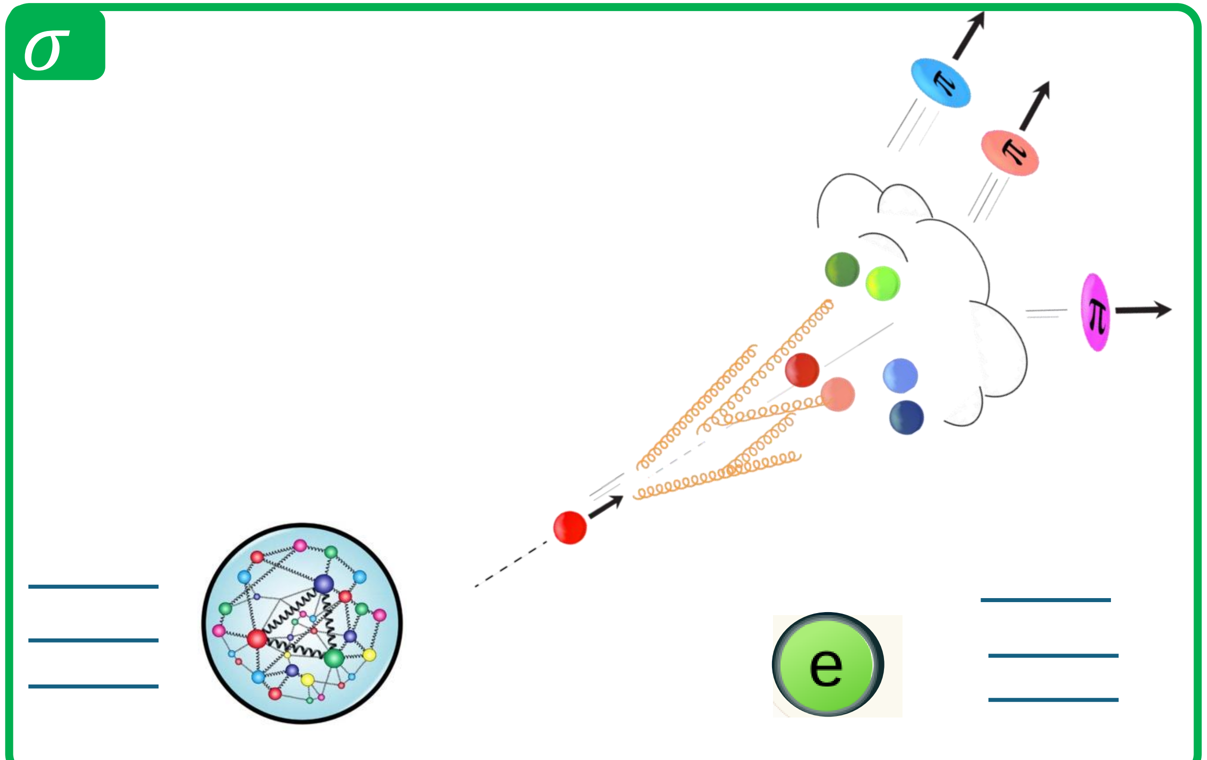
Factorization

Isolate perturbative & nonperturbative QCD

Factorization formula

$$\sigma \sim \hat{\sigma} \otimes d \otimes f$$

σ



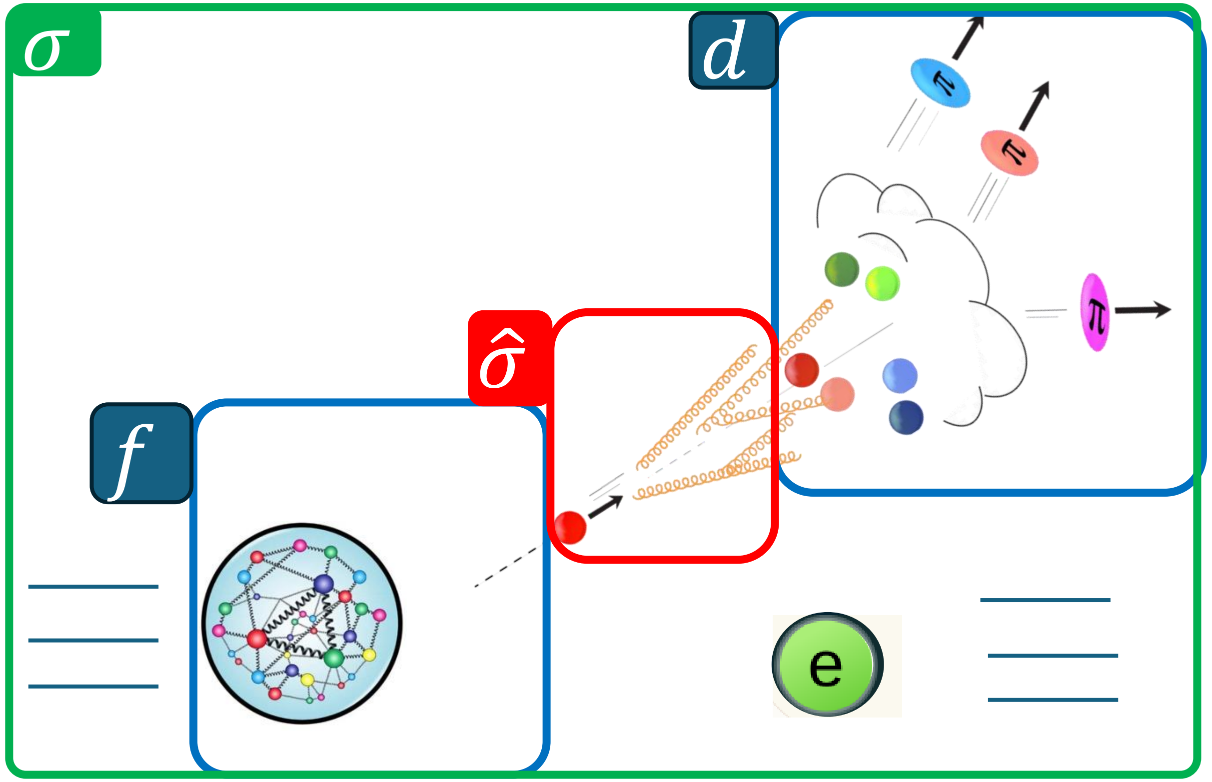
Factorization

Isolate perturbative & nonperturbative QCD

Factorization formula

$$\sigma \sim \hat{\sigma} \otimes d \otimes f$$

d **Fragmentation Function (FF)**



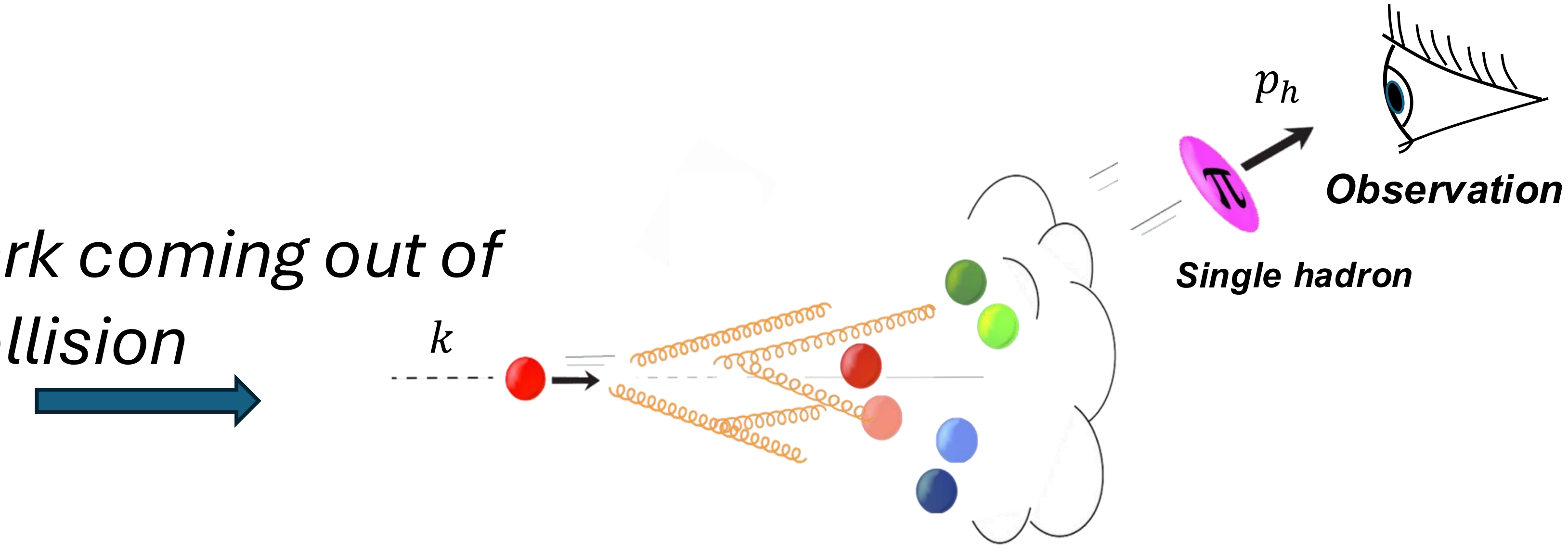
Fragmentation function (FFs)

How does a quark turn into the hadron?

$d(\xi)$ **Fragmentation function (FFs)**

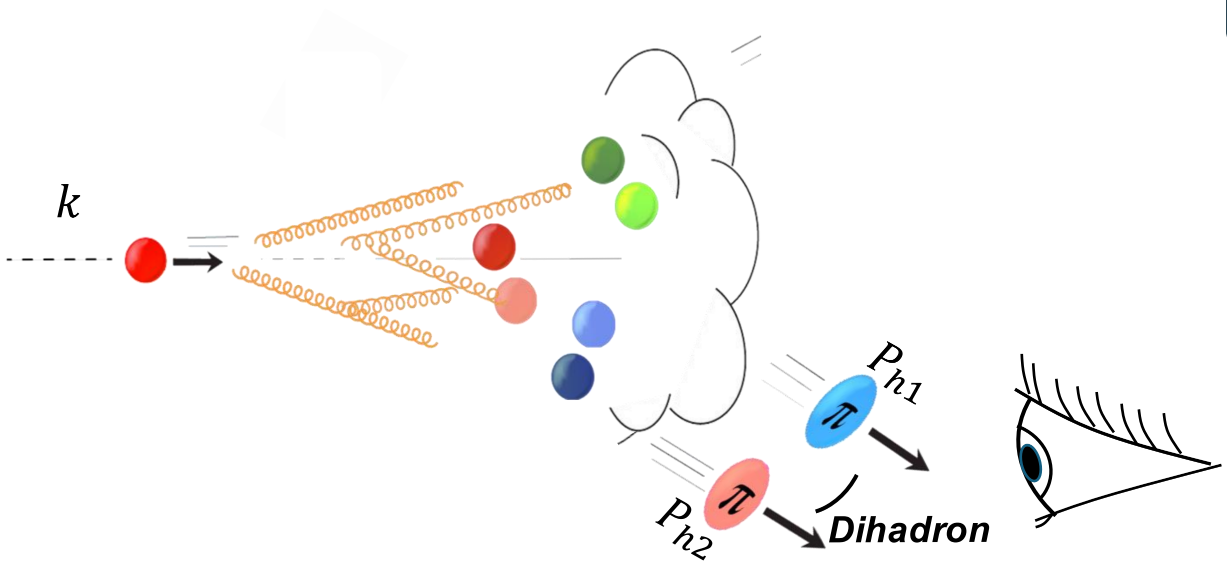
Probability of finding a hadron in a quark as a function of $\xi = p_h^+/k^+$

Quark coming out of a collision



(Dihadron) Fragmentation function (FFs)

How does a quark turn into the ***pair of*** hadron?



$d(\xi)$ **Fragmentation function (FFs)**

Probability of finding a hadron in a quark as a function of $\xi = p_h^+/k^+$

$d(\xi)$ **<u>Dihadron</u> Fragmentation function (DiFFs)**

Probability of finding a <u>pair</u> of hadrons in a quark as a function of $\xi = p_h^+/k^+$

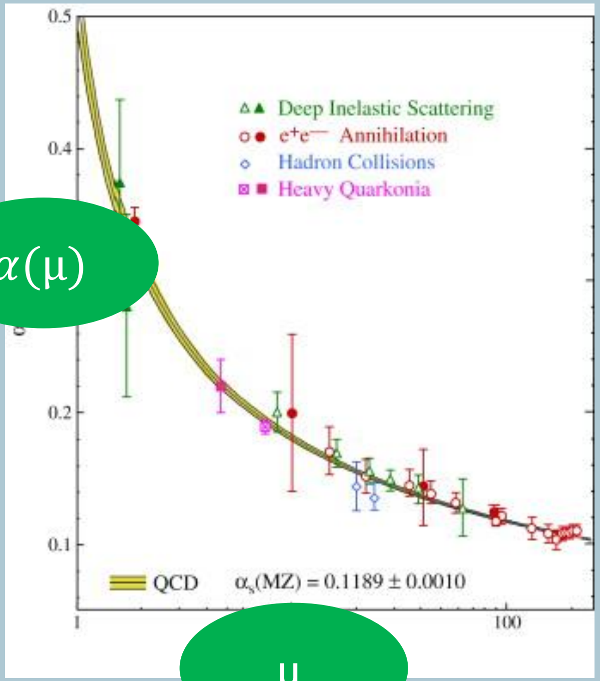
$P_h = P_{h1} + P_{h2}$

Evolution

$\alpha(\mu)$ evolves in (energy) scale μ

Fragmentation functions evolves in energy scale μ

Asymptotic freedom



$\alpha(\mu)$

μ

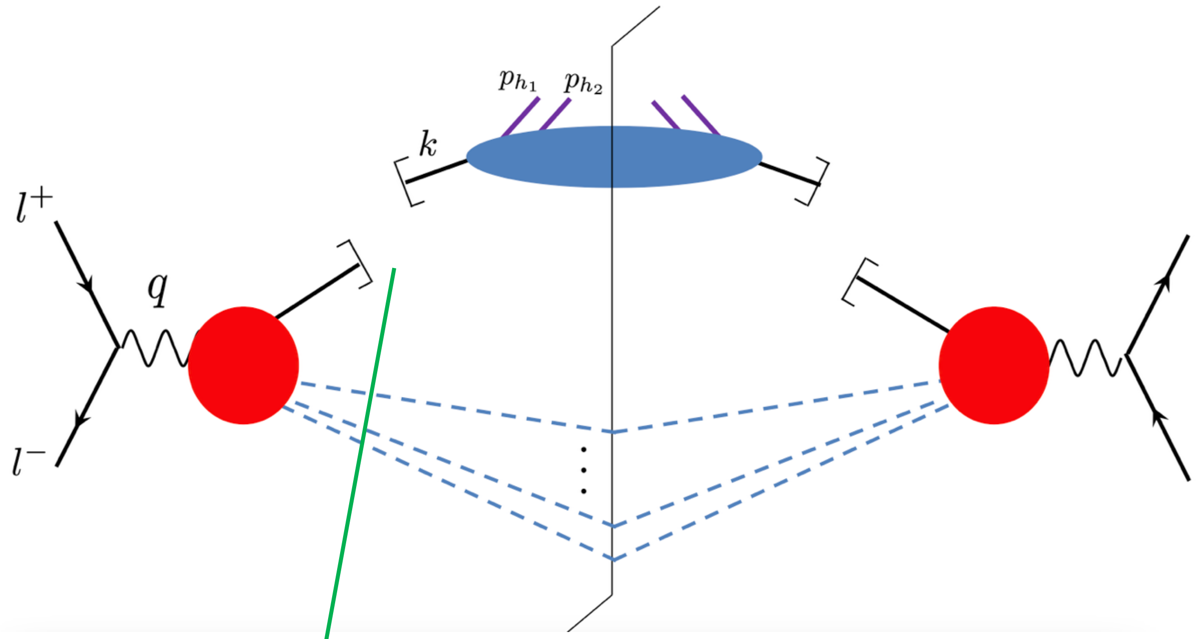
Coupling

$$\frac{\mathrm{d}}{\mathrm{d}\ln\mu} g_s(\mu) = \beta g_s(\mu)$$

Fragmentation function (DGLAP)

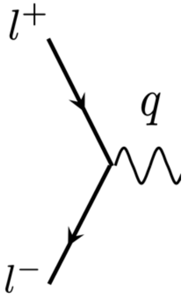
$$\frac{\mathrm{d}}{\mathrm{d}\ln\mu} d(\xi;\mu) = \left[P \otimes d\right](\xi;\mu)$$

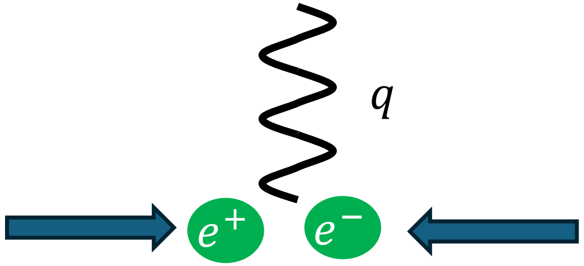
Dihadron Fragmentation function (DiFF)



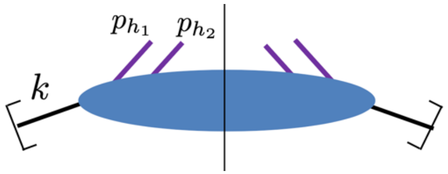
Hooks][to indicates factorization

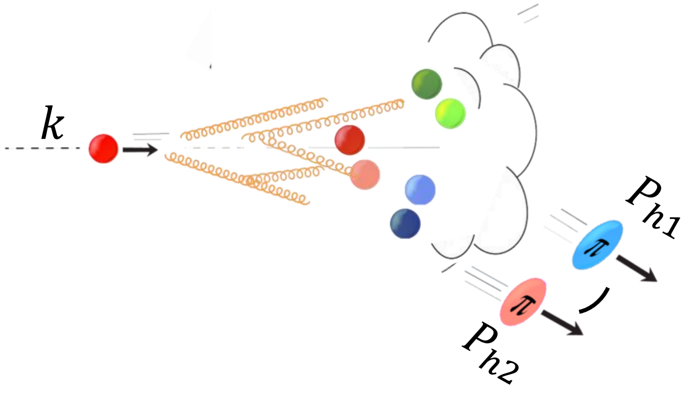
Q^2 controls how much energy is put into the system



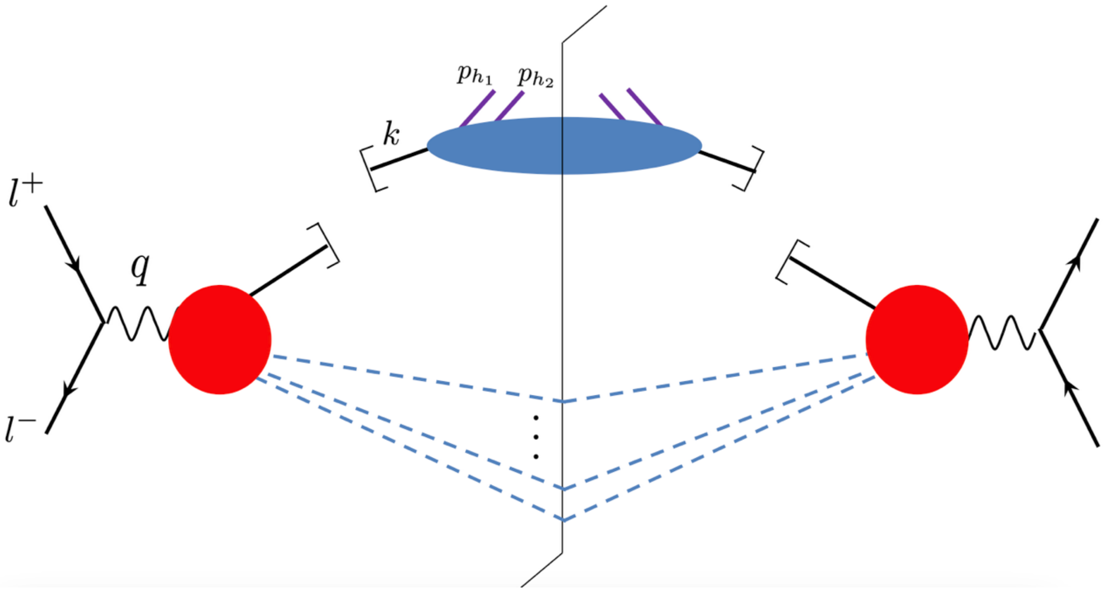


For DiFFs, invariant mass:
$M_h^2 = (P_{1h} + P_{h2})^2$



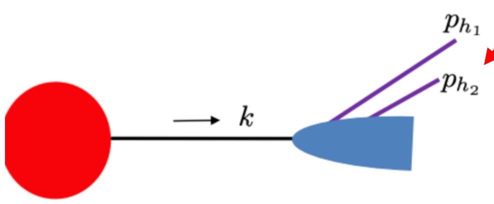


Evolution of Dihadron Fragmentation function (DiFF) in M_h^2

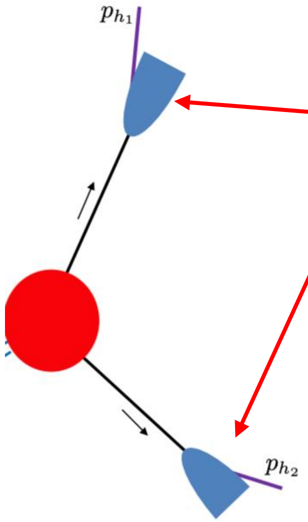


Evolution in M_h^2 and Q^2
to cover full phase space

Dihadron fragmentation function

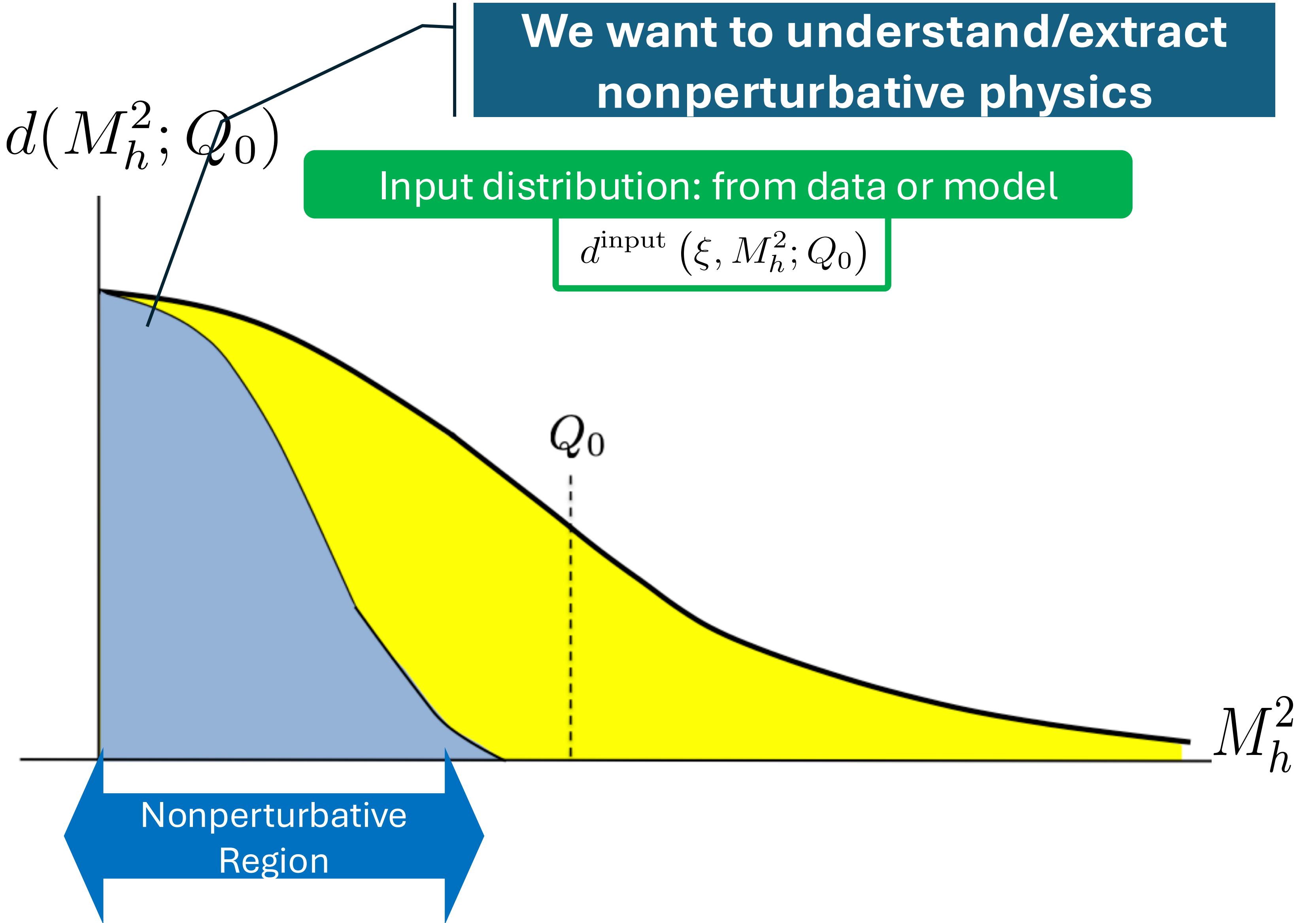


Larger M_h

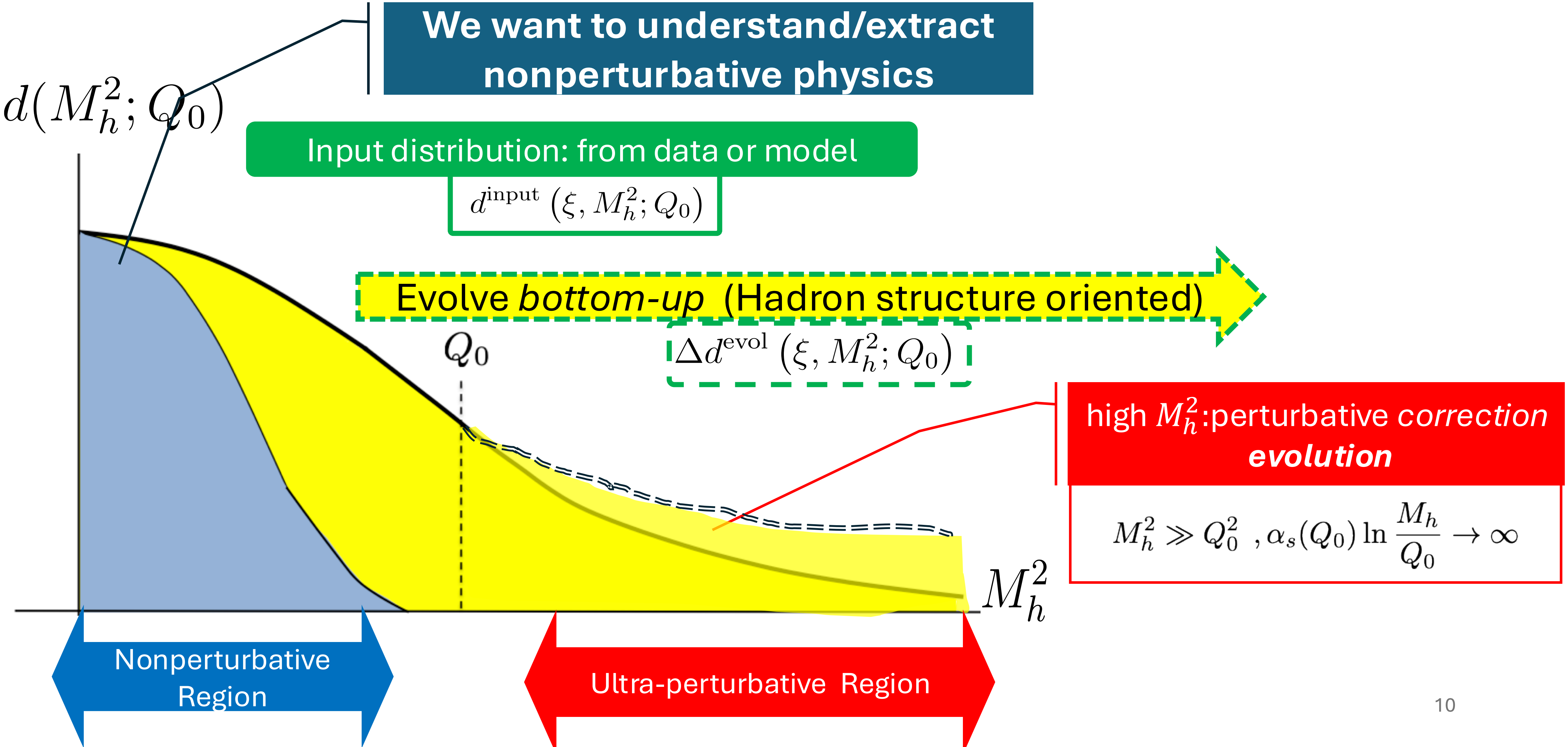


two single hadron fragmentation functions

Evolution from small to large M_h^2



Evolution from small to large M_h^2



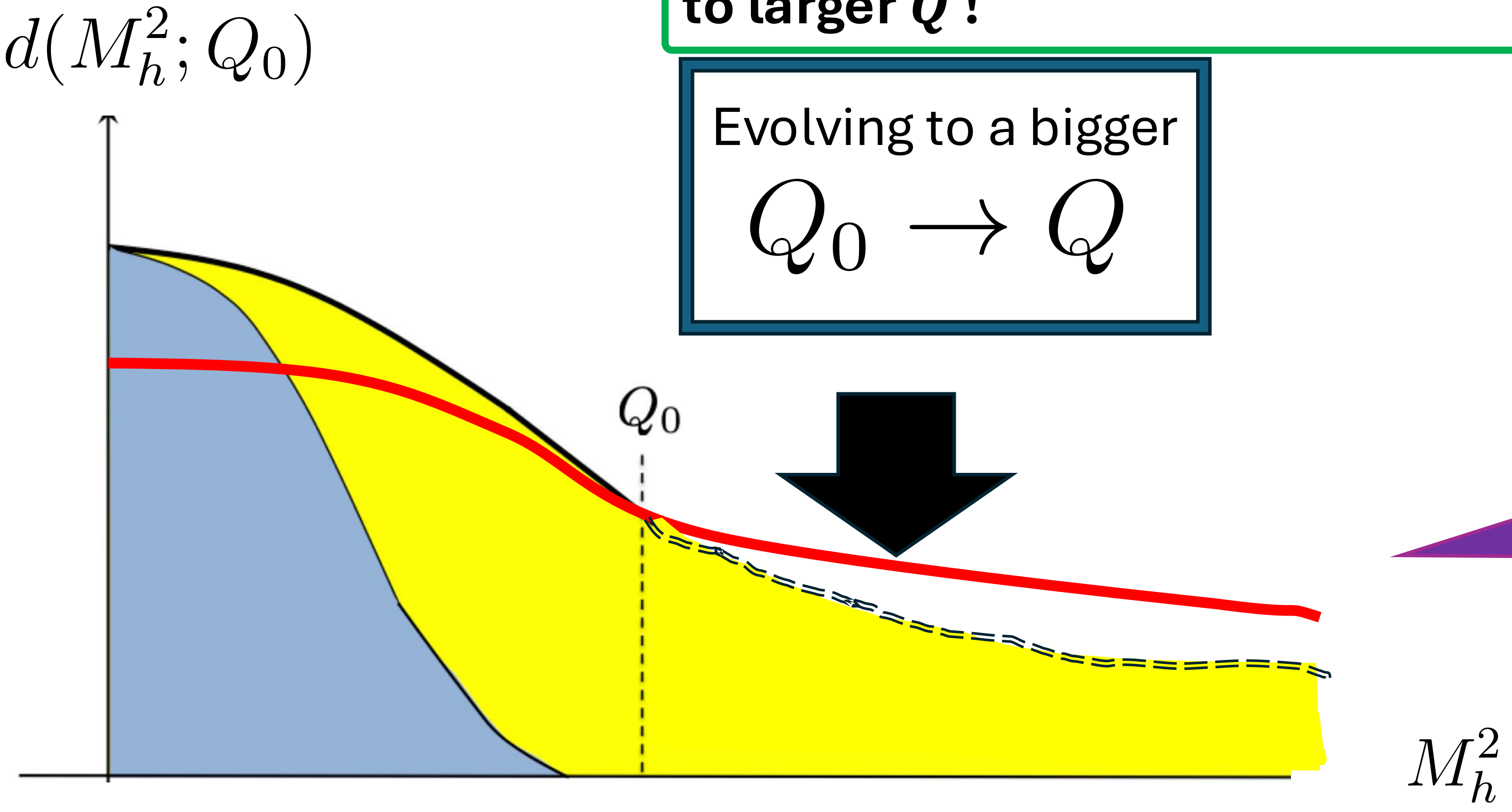
Final DIFF

Evolution into high Q^2

Needed to evove in full range of M_h to get evolution to larger Q !

Evolving to a bigger

$$Q_0 \to Q$$



Fit with experiments

DIFF evolution in a nutshell

Coupling evolution

$$\frac{\mathrm{d}}{\mathrm{d}\ln\mu} g_s(\mu) = \beta g_s(\mu)$$

Recall

Normal FF evolution in Q

$$\frac{\mathrm{d}}{\mathrm{d}\ln\mu} d\left(\xi, M_h^2; \mu\right) = P(\xi, \alpha(\mu)) \otimes d\left(\xi, M_h^2; \mu\right)$$

Recall

Independent of M_h

Separate evolution with additional scale M_h

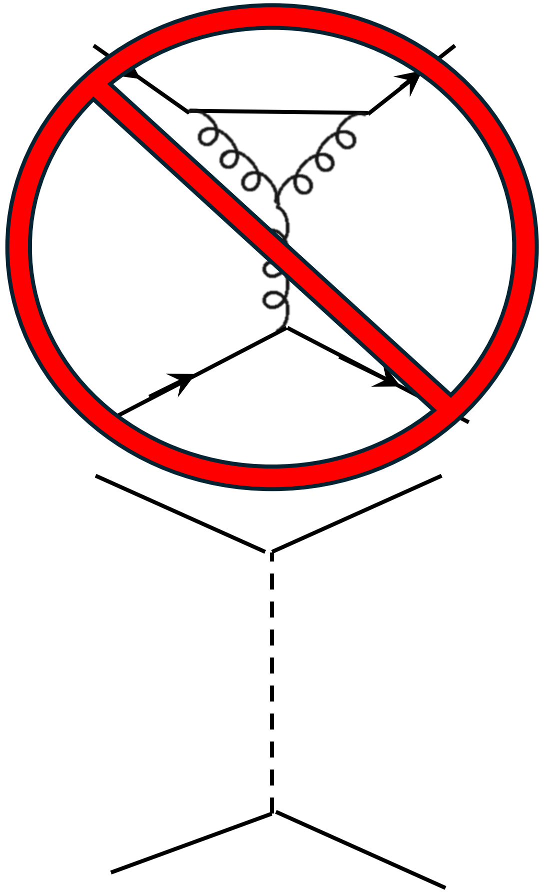
New!

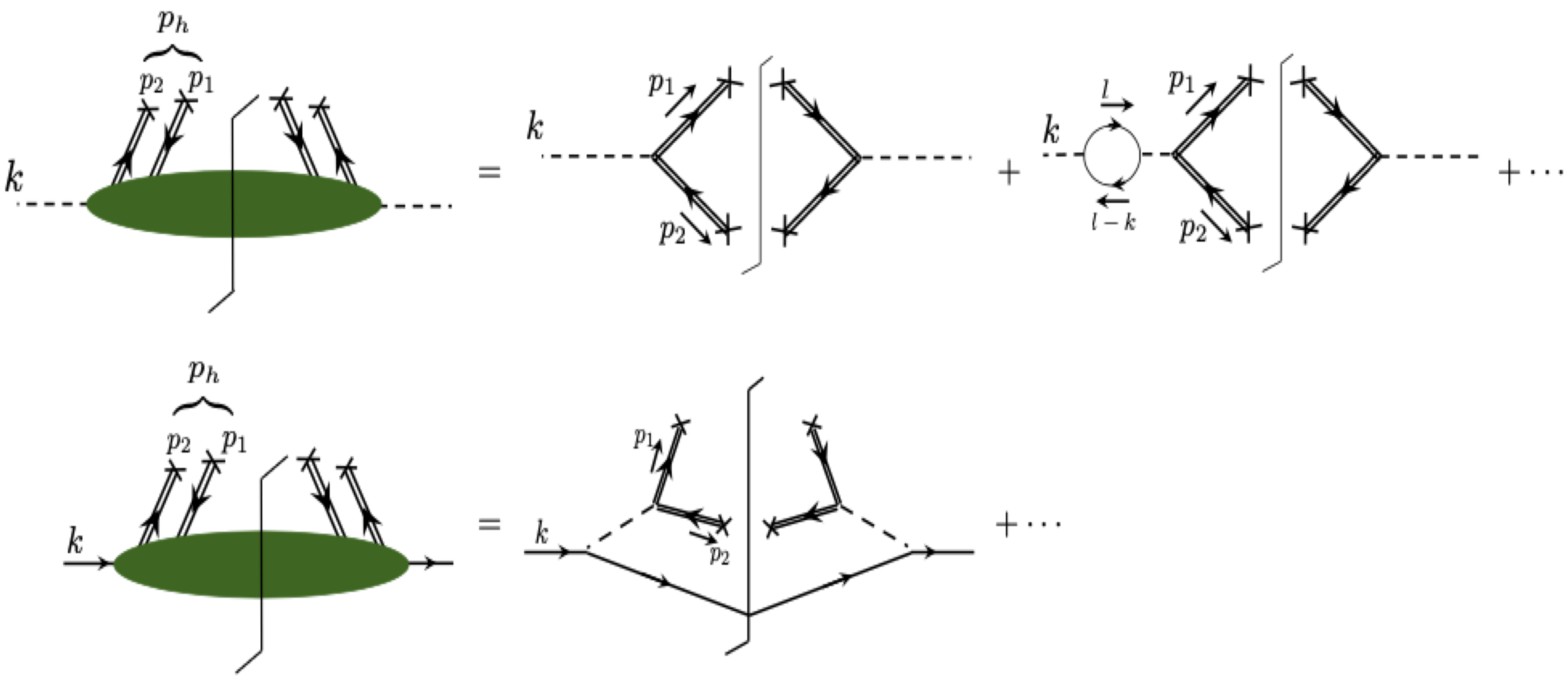
$$\frac{\partial}{\partial \ln M_h^2} d\left(\xi, M_h^2; \mu\right) = K(\xi, M_h^2) \otimes d\left(\xi, M_h^2; \mu\right)$$

Independent of μ

(DiFFs) in Yukawa theory

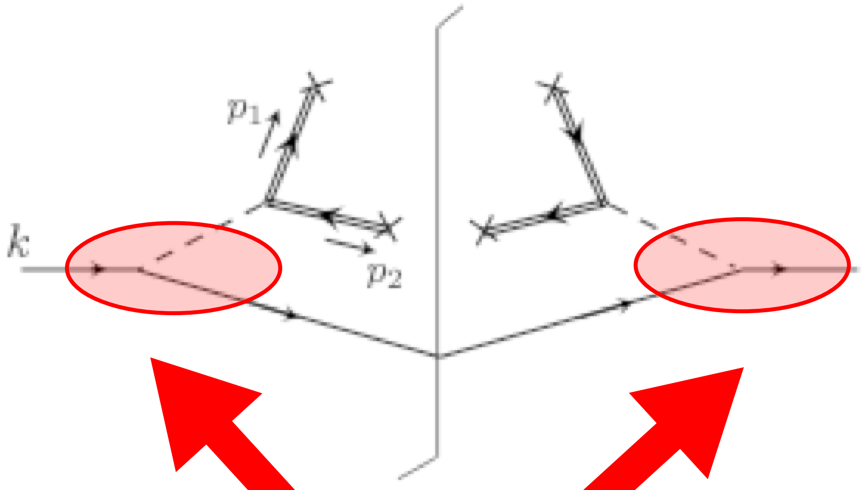
Proof of principle in a theory where everything is easily calculable





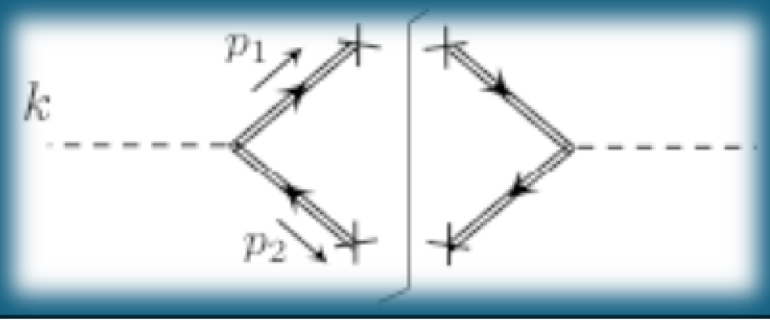
(DiFFs) in Yukawa theory

Evolution in M_h



$$\frac{\partial}{\partial \ln M_h^2} d^{\text{evol}}_{q \to h\bar{h}}\left(\xi, M_h^2; Q_0\right) = d^{\text{evol}}_{s \to h\bar{h}}\left(\xi, M_h^2; Q_0\right) \otimes K^{\text{pert}}_{q \to s}\left(\xi, M_h^2\right)$$

$$+ \ldots$$



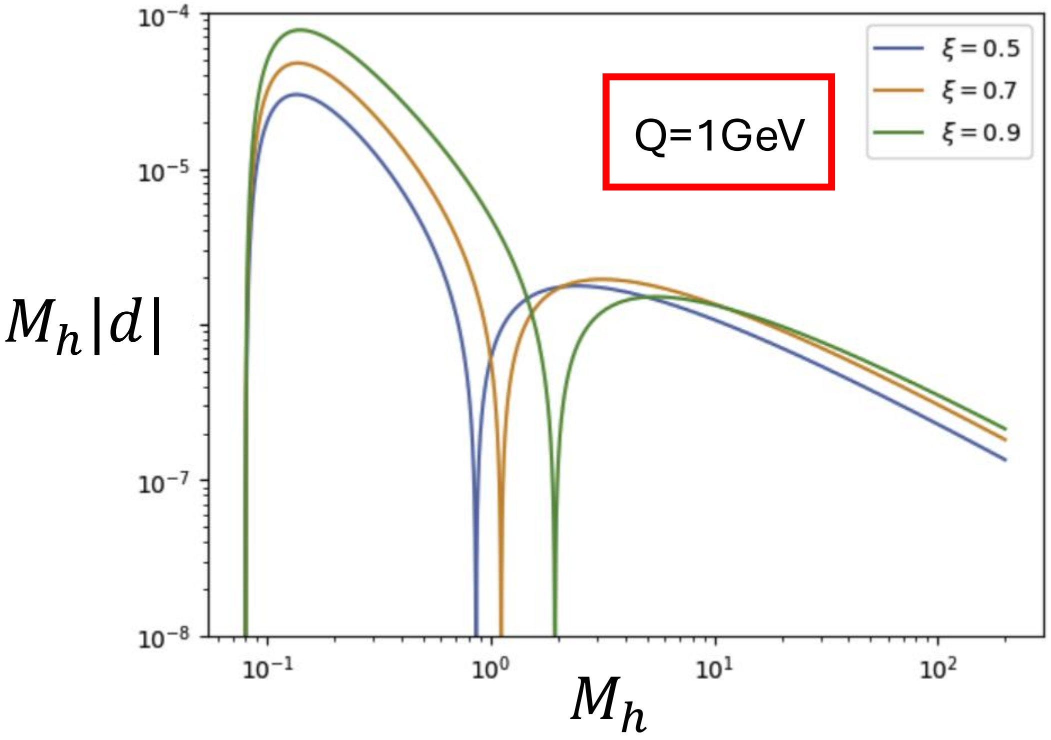
Perturbative calculable

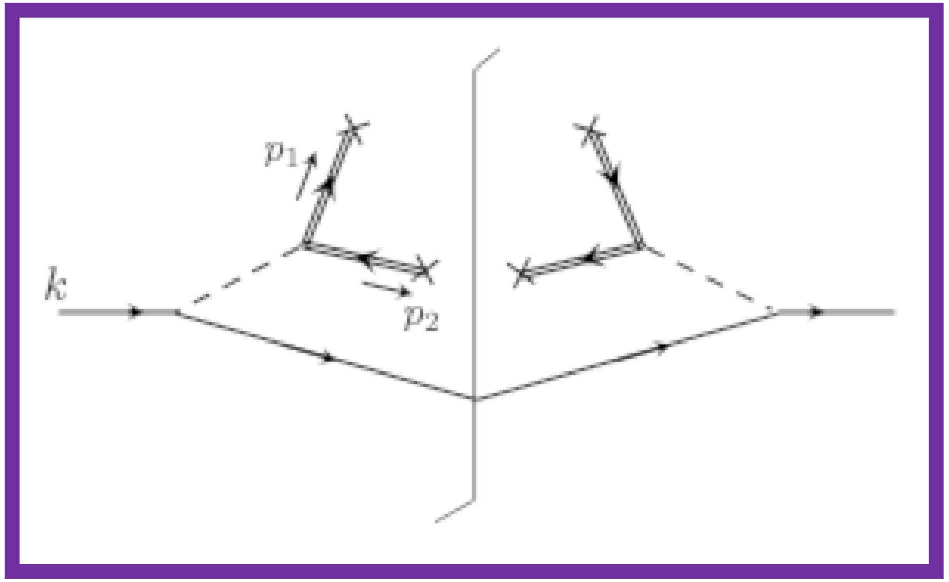
- at large M_h^2 in QCD
- at all M_h^2 in Yukawa theory

evolution in M_h

DiFFs in Yukawa theory

$$d\left(\xi, M_h^2; Q_0\right) = d^{\text{input}}\left(\xi, M_h^2; Q_0\right) + \Delta d^{\text{evol}}\left(\xi, M_h^2; Q_0\right)$$





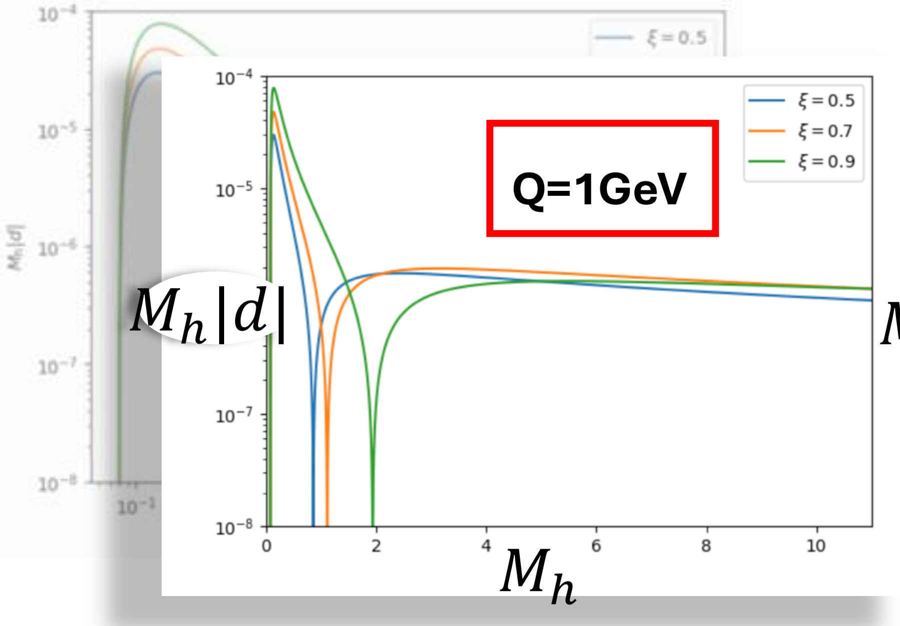
Numerical evolution in Q

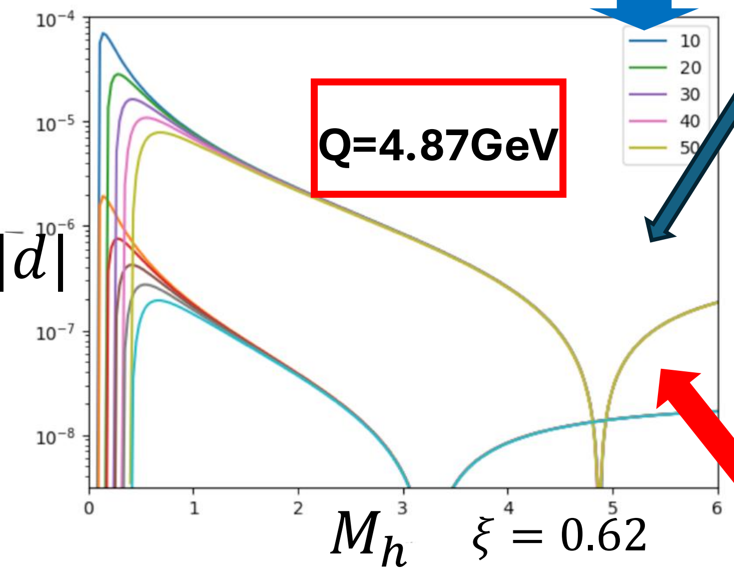
DiFF in Yukawa theory

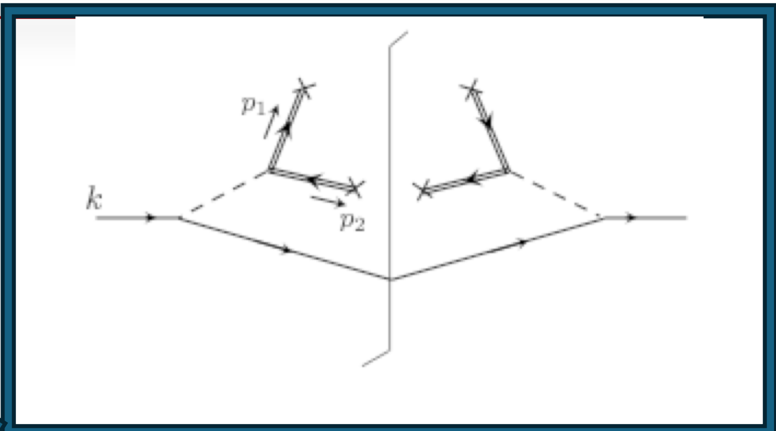
$$\frac{\mathrm{d}}{\mathrm{d}\ln Q^2} d_{s\to h\bar{h}}\left(\xi, M_h^2; Q\right) = \int_\xi^1 \frac{\mathrm{d}z}{z} \mathrm{d}_{f\to h\bar{h}}\left(\xi/z, M_h^2; Q\right) P_{sf}(z) + \int_\xi^1 \frac{\mathrm{d}z}{z} \mathrm{d}_{s\to h\bar{h}}\left(\xi/z, M_h^2; Q\right) P_{ss}(z)$$

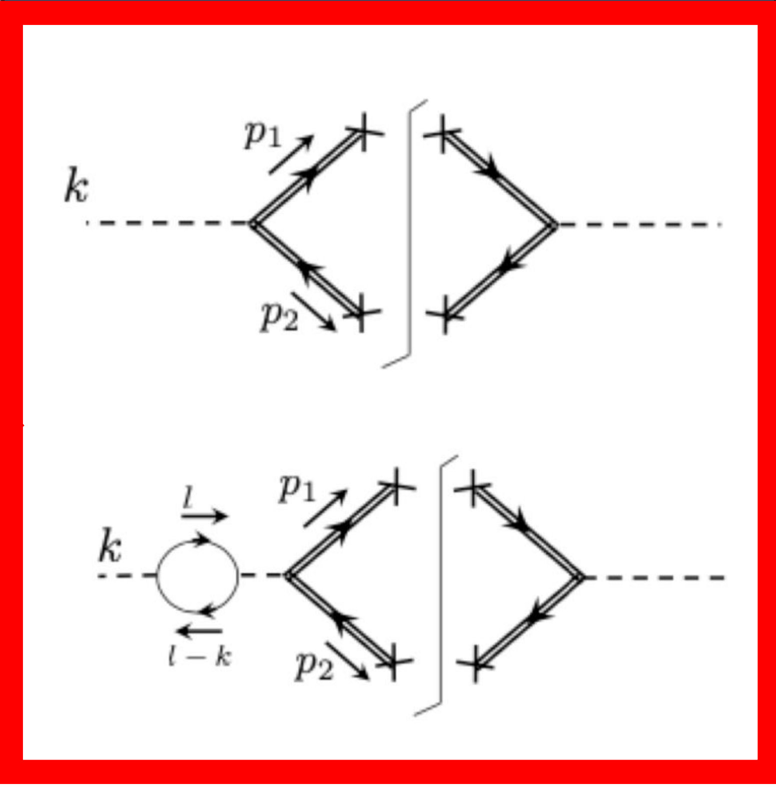
$$\frac{\mathrm{d}}{\mathrm{d}\ln Q^2} d_{f\to h\bar{h}}\left(\xi, M_h^2; Q\right) = \int_\xi^1 \frac{\mathrm{d}z}{z} \mathrm{d}_{f\to h\bar{h}}\left(\xi/z, M_h^2; Q\right) P_{sf}(z) + \int_\xi^1 \frac{\mathrm{d}z}{z} \mathrm{d}_{s\to h\bar{h}}\left(\xi/z, M_h^2; Q\right) P_{fs}(z)$$

Different particle mass scales



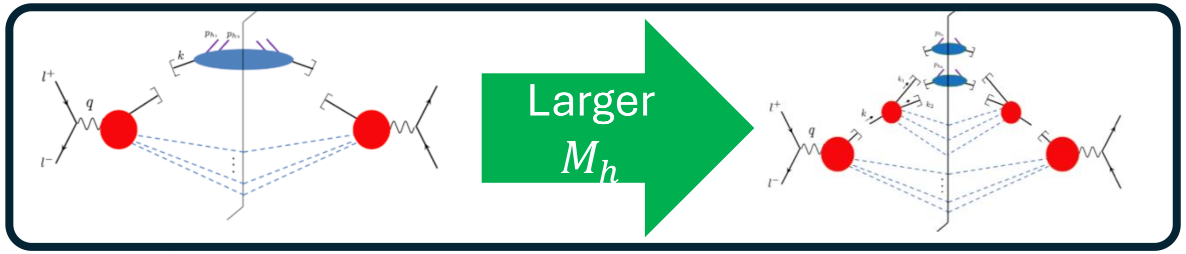


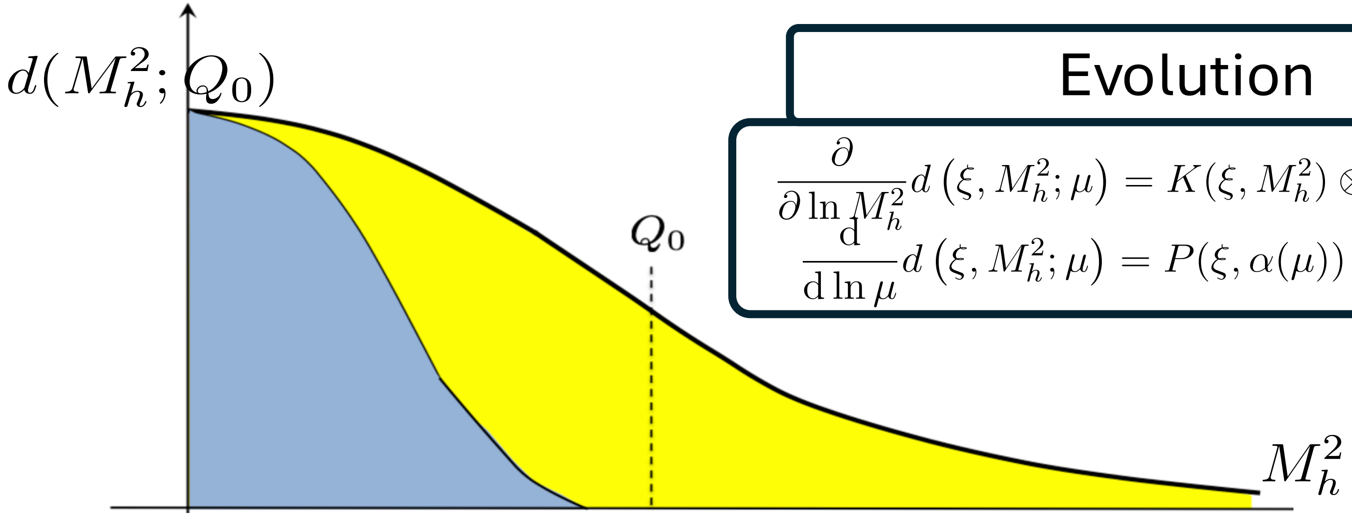




DiFFs: summary

- ➢ Defining d in all region of M_h^2 and Q^2
  - Using separate evolution for M_h^2 and Q^2
- ➢ Proof of principle in Yukawa theory



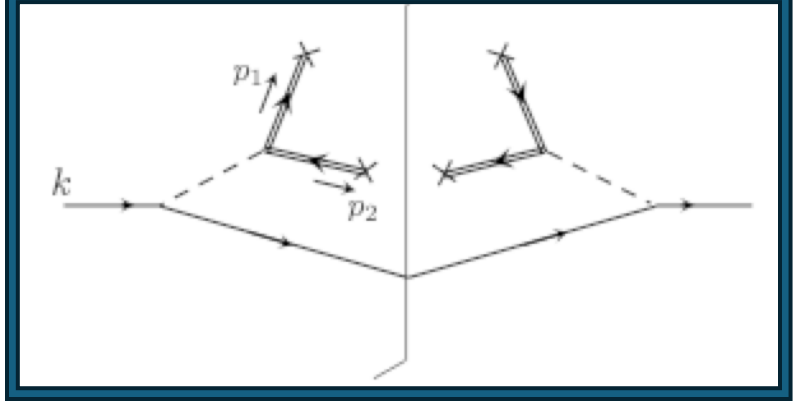


Evolution

$$\frac{\partial}{\partial \ln M_h^2} d\left(\xi, M_h^2; \mu\right) = K(\xi, M_h^2) \otimes d\left(\xi, M_h^2; \mu\right)$$

$$\frac{\mathrm{d}}{\mathrm{d}\ln \mu} d\left(\xi, M_h^2; \mu\right) = P(\xi, \alpha(\mu)) \otimes d\left(\xi, M_h^2; \mu\right)$$

Yukawa theory



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