Centre of Excellence in Quark Matter

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UNIVERSITY OF JYVÄSKYLÄ

Research Council of Finland

HELSINKI INSTITUTE OF PHYSICS

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Hymn D v1: New D-meson FF from LEP and LHC

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Overview

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The Heavy meson (Hymn) collaboration presents

1. Introduction

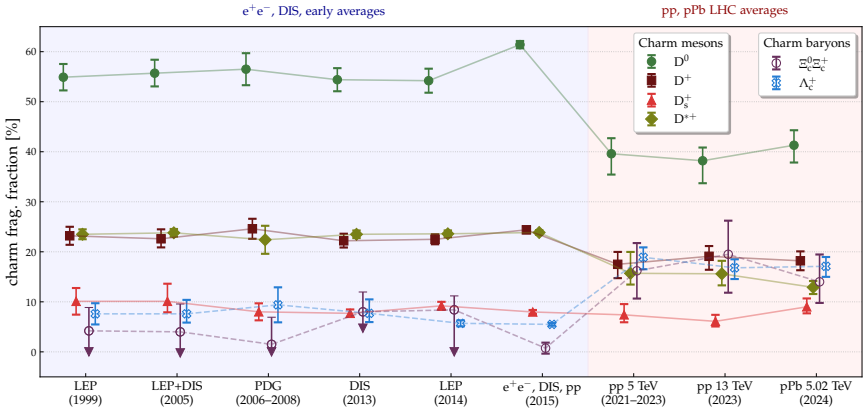
2. Fitting ingredients

3. Results for Fragmentation Functions

4. Summary

Introduction

Universality of charm fragmentation?



Meson ↘ + Baryon ↗ in pp and pPb - why?

plot from [in preparation D. d'Enterria, FH, I. Helenius, V. D. Lê, H. Paukkunen]

Factorization is universal!

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D-meson production in semi-inclusive annihilation (SIA):

$$\sigma^{e^+ + e^- \to \mathrm{D} + X}(q^2) = c(q^2) \otimes D_{\mathrm{D}}(q^2) + \mathcal{O}(1/q^2)$$

D-meson production in proton-proton collision:

$$\sigma^{p+p \to \mathrm{D} + X}(p_T^2) = \hat{\sigma}(p_T^2) \otimes D_{\mathrm{D}}(p_T^2) + \mathcal{O}(1/p_T^2)$$

$\Rightarrow$ Universality holds in the high-energy region!

$\Rightarrow$ Provide new FFs for D^0, D^+, and $\mathrm{D}^{*,+}$

Fitting collinear distributions

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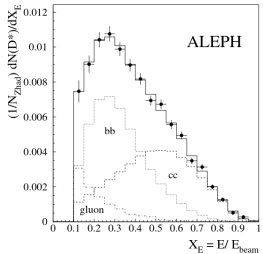
Experiment



taken from [EPJC16.597]

Methodology

xFitter

[EPJC75.304]

Theory

$$s^{x^2}\frac{d^2\sigma^{(1),H,fin}_{C,bf,g}}{dt_1 du_1} = \alpha\alpha_s\theta_W^{i_1}\eta_Q^{i_2}\eta_{\bar{Q}}^{i_3}K_{pr}N_C C_F\left[-\frac{2}{u_1}P^H_{ss,ag}(x_1)\right.$$
$$\left\{B^{(0)}_{e,\mathrm{QED}}(x_1k_1)\left(\ln\left(\frac{s_4^2}{m^2(s_4+m^2)}\right)-\ln(\mu_F^2/m^2)\right)-2B^{(1)}_{e,\mathrm{QED}}(x_1k_1)\right\}$$
$$+C_A\frac{s_4}{2\pi(s_4+m^2)}\left(\int d\Omega_4 R_{e,\mathrm{OK}}\right)^{finite}$$
$$\left.+2C_F\frac{s_4}{2\pi(s_4+m^2)}\int d\Omega_4 R_{e,\mathrm{QED}}\right]. \qquad (5.36)$$

taken from [1910.01536]

Strategy:

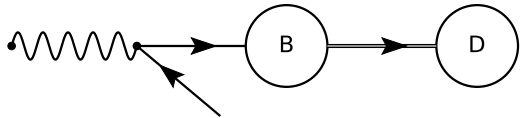
repeat until converged:

guess candidate FF $D(Q_0^2)$ $\rightarrow$ compute theory predictions $\rightarrow$ compare to data

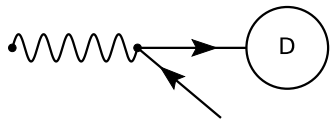
Fitting ingredients

Theory: non-prompt vs. prompt

non-prompt SIA: $e^+ + e^- \to V^* \to b + X \to \mathrm{B} + X' \to \mathrm{D} + X''$



prompt SIA: $e^+ + e^- \to V^* \to c + X \to \mathrm{D} + X'$



inclusive SIA = non-prompt SIA + prompt SIA

Experimental data

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semi-inclusive annihilation: $\sqrt{s} = M_Z$

- non-prompt: ALEPH [EPJC16.597], OPAL [ZPC72.1] [EPJC1.439]
- inclusive: ALEPH [EPJC16.597], DELPHI [ZPC59.533], OPAL [ZPC72.1] [EPJC1.439]

hadroproduction:

- prompt: ALICE [JHEP12.086], CMS [JHEP11.225] with $p_T > 10$ GeV

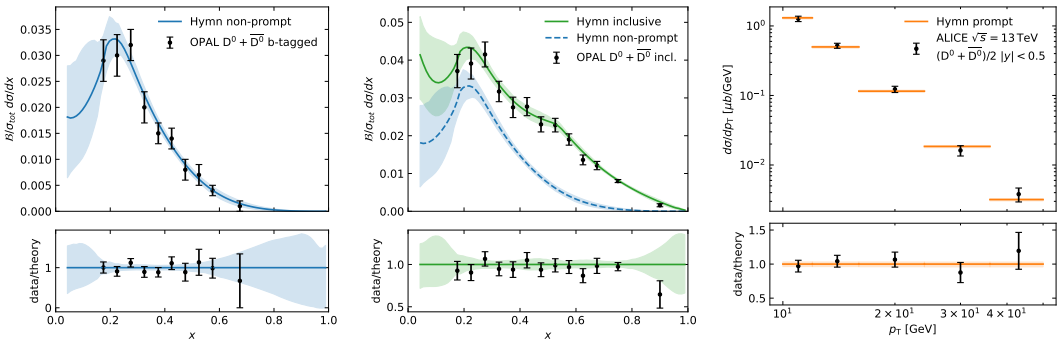
$\mathrm{D}^{*,\pm}$ has more SIA data (ALEPH)!

Methodology: Fitting strategy

1. Fit non-prompt

2. Compute non-prompt contributions

3. Fit prompt

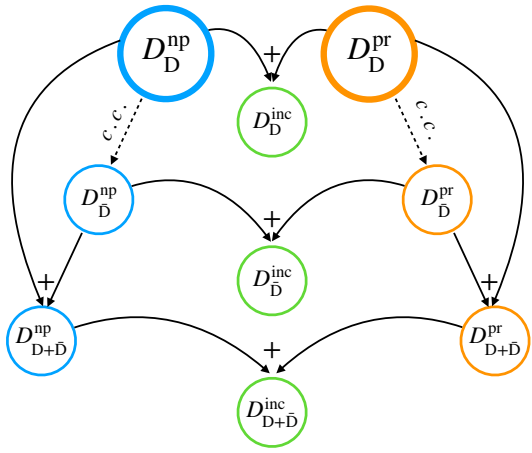


Generate (correlated) Monte Carlo replicas $\rightarrow$ 4. select “good” replicas

Methodology: Fitted and derived distributions

Use:

- charge conjugation
- inclusiveness
- final state summation



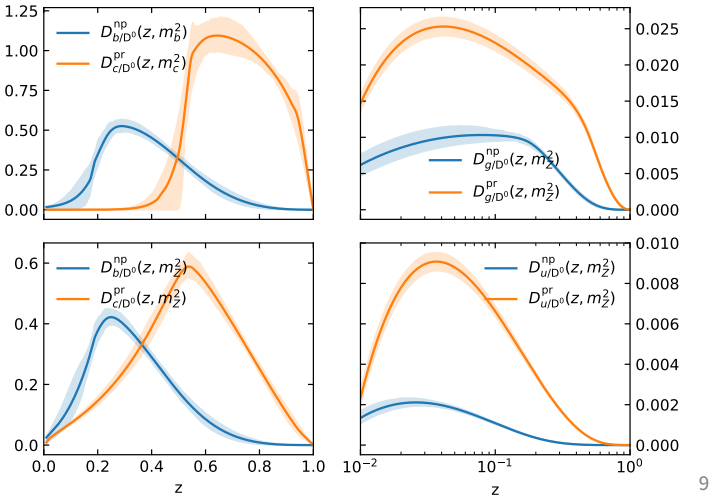
Results for Fragmentation Functions

Hymn D^0: FFs

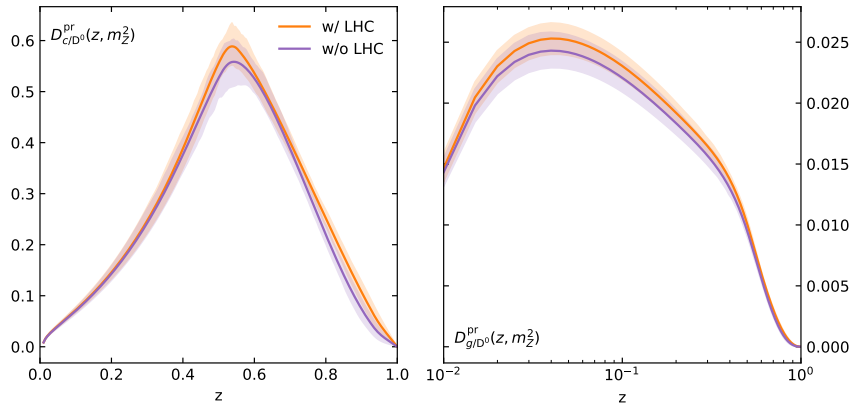
We parametrize only the favored quark:

- *b* in non-prompt
- *c* in prompt

Gluon, etc. contribute through evolution

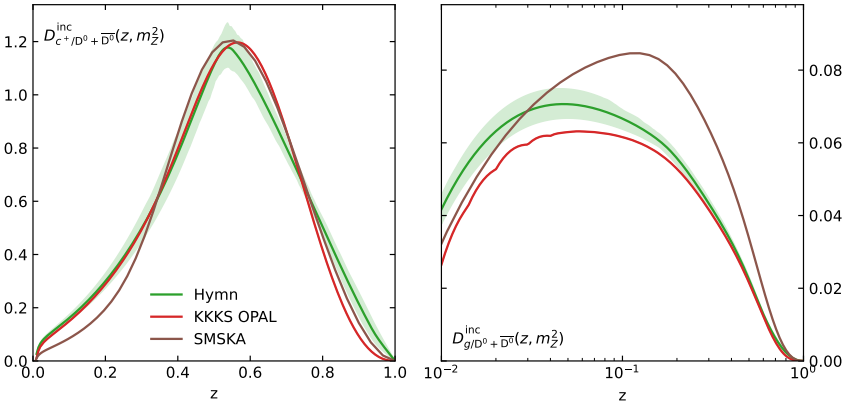


Hymn D^0: Impact of LHC data



LHC directly constraints gluons | distributions $\sim\nearrow$ | compatible within error

Hymn D^0: Comparison to others



KKKS [NPB799.34] | SMSKA [EPJC79.999]

Summary

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The Heavy meson (Hymn) collaboration presents new FF for D-mesons:

- $\mathrm{D}^0 \oplus \mathrm{D}^+ \oplus \mathrm{D}^{*,+}$
- non-prompt $\otimes$ prompt $\otimes$ inclusive
- $\mathrm{D} \otimes \overline{\mathrm{D}} \otimes \mathrm{D} + \overline{\mathrm{D}}$

Features:

- use only high-scale data ✓
- FF uncertainty (Monte Carlo) ✓
- LHAPDF6 format ✓ [EPJC75.132]

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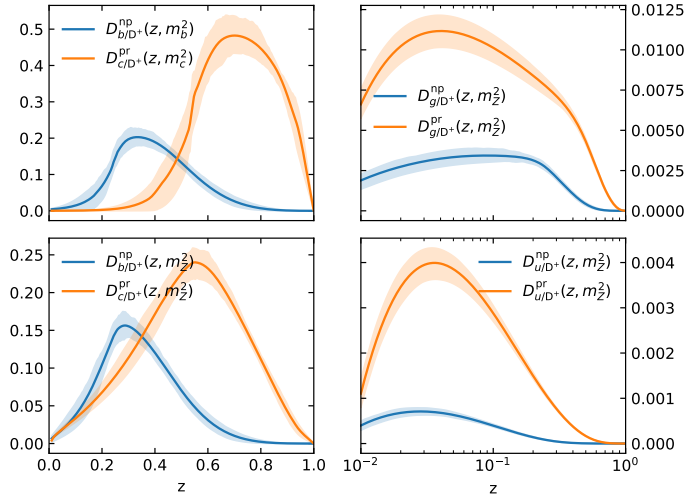
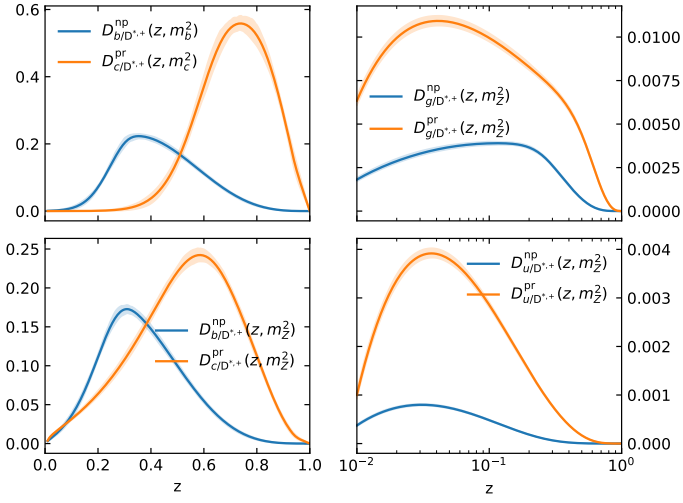
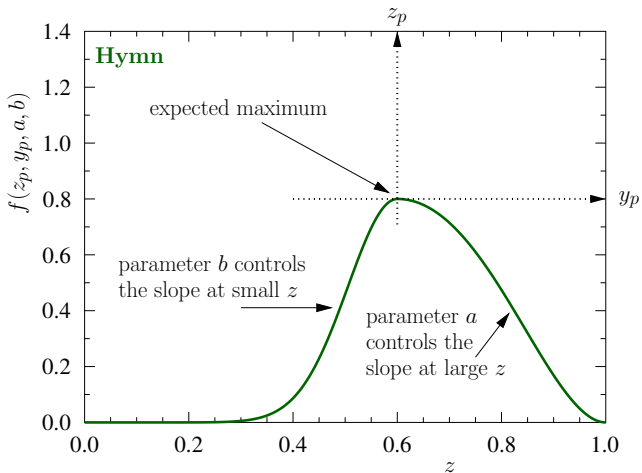
Danke! Thanks! Kiitos!

Backup slides

Hymn D^+: FFs



Hymn $\mathrm{D}^{*,+}$: FFs



Hymn fitting form