SnowMass EF05-07: QCD

Draft ideas of LoI

Zhao Li, on behalf of Group of EF05-07, Jun-28-2020

近期的活动

SnowMass EF05-07: QCD 碰头会

24 June 2020
Asia/Shanghai timezone

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https://meeting.tencent.com/s/fa8f863cH9Sd

会议 ID：248 543 429
会议密码：271828

1. Exclusive Z decays (radiative and non-leptonic, test of factorization theorem free of power corrections), Qin Qin

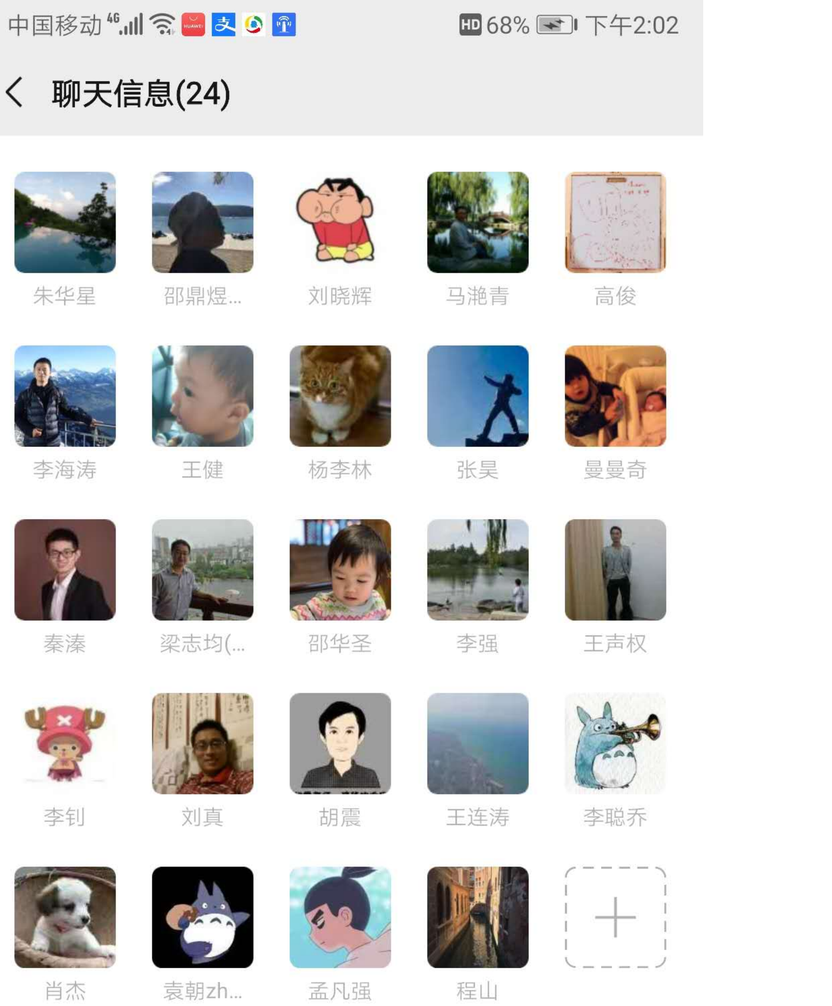
2. Exotic hadrons, Zhen Hu

3. Alpha_s projection (c.f. FCC-ee).

4. Gluon/quark differentiation

Starts 24 Jun 2020 21:00
Ends 24 Jun 2020 23:00
Asia/Shanghai

No material yet



Exclusive Z decays at the CEPC

Proposed by Shan Cheng and Qin Qin

CEPC as a Tera-Z factory

$10^{12}\ Z$

Decay mode	Branching ratio	CEPC Uncertainty
$Z \to J/\psi\gamma$	8.02×10^{-8} [29]	$\sim 1.8\%$
$Z \to \Upsilon(1S)\gamma$	5.39×10^{-8} [29]	$\sim 3.4\%$
$Z \to \rho^0\gamma$	4.19×10^{-9} [29]	$\sim 1.8\%$
$Z \to \omega\gamma$	2.82×10^{-8} [29]	$\sim 0.8\%$
$Z \to \phi\gamma$	1.04×10^{-8} [29]	$\sim 1.6\%$
$Z \to \pi^0\gamma$	9.80×10^{-12} [29]	$< 3.4 \times 10^{-8}$
$Z \to \eta\gamma$	$0.1 - 1.7 \times 10^{-10}$ [30]	$\sim 12\% - 50\%$
$Z \to \eta'\gamma$	$3.1 - 4.8 \times 10^{-9}$ [30]	$\sim 2.7 - 3.4\%$

[Grossman,Konig,Neubert,1501.06569]
[Alte,Konig,Neubert,1512.09135]

$$\mathcal{B}(Z \to \pi^+\pi^-) = (0.83 \pm 0.06) \times 10^{-12}$$

$$\mathcal{B}(Z \to K^+K^-) = (1.74 \pm 0.06) \times 10^{-12}$$

[Cheng,Qin,1810.10524]

Test of Factorization

- In B meson decays, **dirty**:

  large, but unknown power corrections

  $$\sim \mathcal{O}(\Lambda_{\rm QCD}^n/m_b^n)$$

- In Z decays, **clean**:

  power corrections are ignorable

  $$\sim \mathcal{O}(\Lambda_{\rm QCD}^n/M_Z^n)$$

Extraction of Distribution Amplitudes

proton PDF ✓

meson DAs ✗

$$\phi_M(x,\mu) = 6x(1-x)\left[1+\sum_{n=1}^{\infty} a_n^M(\mu) C_n^{(3/2)}(2x-1)\right]$$

$a_2^M(\mu)$	Theoretical value	CEPC precision
ρ^0	0.17 ± 0.07	± 0.02
ω	0.15 ± 0.12	± 0.01
ϕ	0.23 ± 0.08	± 0.02

Proposals

- study **more non-leptonic channels** like $\pi\rho$, $\rho\rho$ via different theoretical methods
  - to find channels with bigger branching ratios
  - to test consistency between different theoretical methods
- **NLO calculations**

Exotic Hadrons

Proposed by Zhen Hu

Exotic Hadrons

夸克模型是标准模型的一个重要组成部分，其传统的介子（两夸克）和重子（三夸克）框架取得了巨大的成功。夸克模型同时预言了奇特介子（四夸克）、奇特重子（五夸克）、更多夸克组成的复合粒子、或者有胶子的直接参与的复合粒子等，统称奇特强子。对奇特强子的深入探索可以揭示多体低能强相互作用的性质，促进非微扰强相互作用理论的进展，帮助我们理解物质世界的多种构成形式，因此对强子和奇特强子的研究本身具有十分重要的意义。

Exotic Hadrons

中国近年来在奇特强子理论和实验研究中均取得了一些重要成果。理论方面，赵光达院士早在1980年就提出了四夸克模型，迄今为止，中国理论家已经在格点QCD、QCD求和规则、有效场论等多个方面讨论了多夸克态粒子的性质。实验方面，中国LHCb组对于五夸克态的发现做出了重要贡献，中国CMS组对于全重味四夸克态的寻找也取得了关键进展。因此，在CEPC上开展奇特强子的研究，有助于继续加强中国在理论和实验方面的贡献。

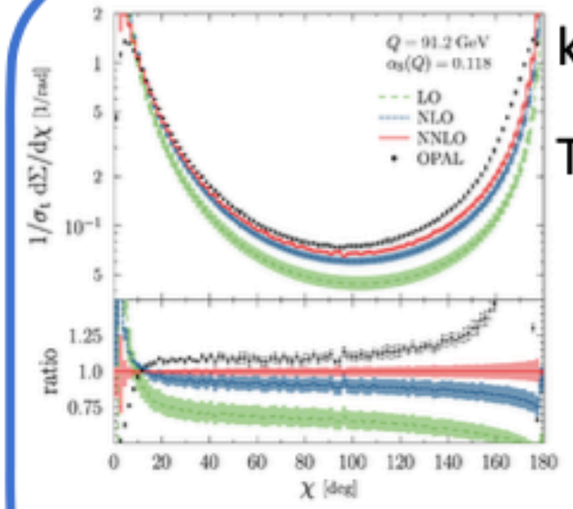
Exotic Hadrons

下一步的计划是联合中国相关领域的理论家和实验家，挑选一两个适合在CEPC上进行研究的奇异强子态及衰变道，对ee对撞下的产生机制和产生截面做更深入的理解和计算，对实验测量方法做更细致的分析和模拟，如反冲质量法等。同时与HL-LHC，FCC，ILC等做横向比较。

α_s determination and non-perturbative modeling with energy-energy correlator

Proposed by Jun Gao and Hua-Xing Zhu

α_s determination and non-perturbative modeling with energy-energy correlator



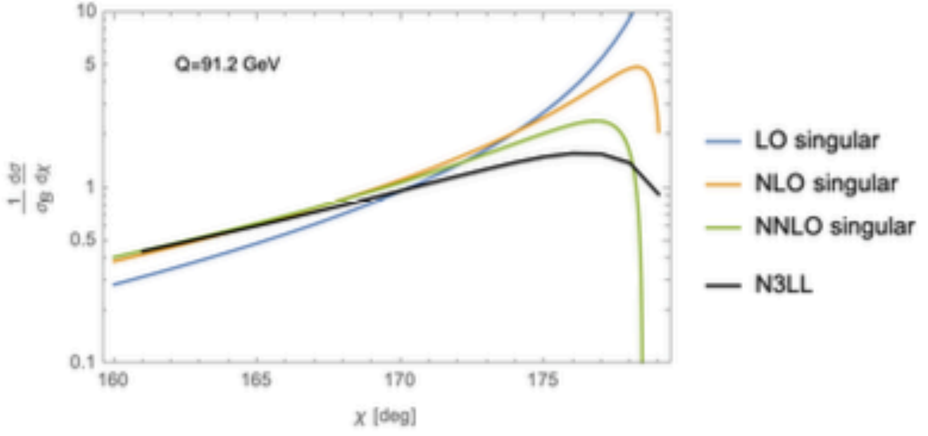
kardos, Kluth, Somogyi, Tulipant, Verbytskyi, 1804.09146

Theoretical accuracy: NNLO + NNLL (back-to-back)

Hadronization corrections:

non-perturbative modeling/Monte Carlo

$$\alpha_s(m_Z) = 0.11750 \pm 0.00018\,(exp.) \pm 0.00102\,(hadr.) \pm 0.00257\,(ren.) \pm 0.00078\,(res.),$$

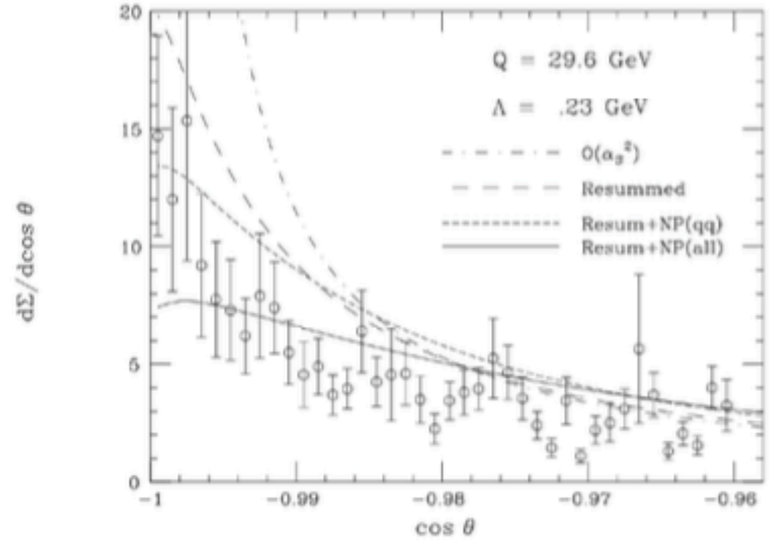


Towards ultimate theory accuracy:

NNLO + N3LL resummation

高俊，朱华星，in progress

α_s determination and non-perturbative modeling with energy-energy correlator



Sensitive to non-perturbative modeling

in the back-to-back limit

Dokshitzer, Marchesini, Webber,

hep-ph/9905339

log(Q) dependence from perturbative corrections

Power corrections in Q from non-perturbative hadronization

Goal: (a) Investigating better non-perturbative modeling of hadronization, with energy conservation sum rule incorporated;

(b) Disentangle perturbative and non-perturbative corrections with data from multiple Q: important to have energy scan in a wide range at CEPC

高俊，朱华星，in progress

Gluon/quark differentiation

By using substructure of jets or Machine Learning, one can discriminate gluon jet and quark jet, or even different flavors.

Proposed by unknown

Thank you!