Was there a case for muons made at the *"Kick-Off Meeting - Synergies between the Electron-Ion Collider and the Large Hadron Collider"* on Jun 20-21, 2022 at CERN?

https://indico.ph.tum.de/event/7014/

Thomas Ullrich

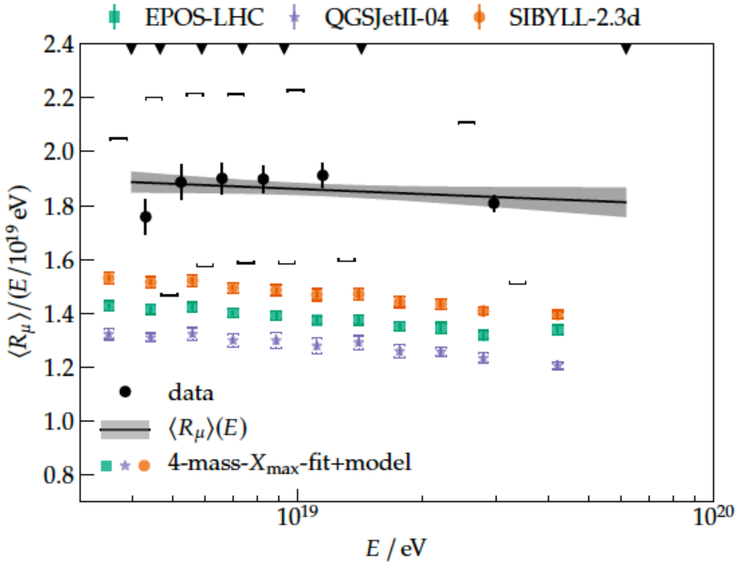
(someone who did not attend but went through all slides)

October 14, 2022

BROOKHAVEN NATIONAL LABORATORY

Muon puzzle in air showers (Hans Dembinski, TU Dortmund)

- Muon puzzle in cosmic-ray included air showers
  - Unresolved physics discrepancy in simulated vs. measured showers: Muon deficit in simulated air showers
  - Bottleneck for progress in cosmic ray and astroparticle physics
- Puzzle potentially caused by unexpected effect in soft-QCD
  - Forward light hadron production (soft QCD) drives air shower development
- LHC outlook
  - Fully exploit LHCb data
  - Measurements with p-O collisions in 2023/24
  - Forward physics facility (FPF)
  - FoCal, forward calorimeter for ALICE?
  - Forward calorimeter for LHCb?



Muon puzzle in air showers (Hans Dembinski, TU Dortmund)

- Muon puzzl
  - Unresolve
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- LHC outlook
  - Fully explo
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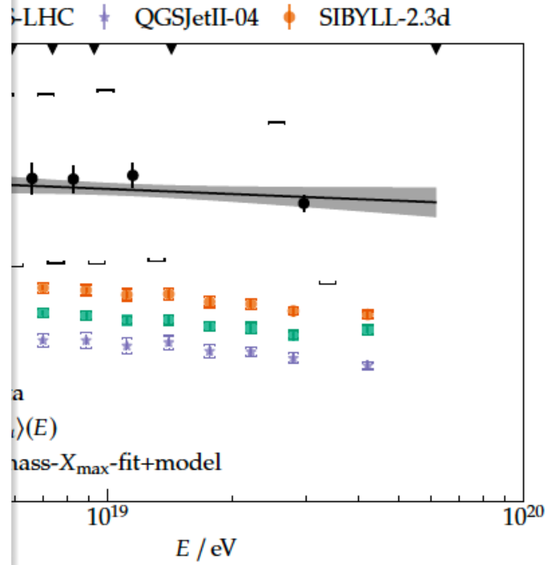
  - Forward p
  - FoCal, forward calorimeter for ALICE?
  - Forward calorimeter for LHCb?

Not clear how much LHC will/can do and how much EIC could potentially contribute given the lack of energy to get close to air shower energies that matter.
Still if it's a softQCD effect it might be worth pursuing!?

Not a strong argument for muons IMHO



Quarkonium production (J.P. Lansberg Orsay/Saclay)

Synergies between LHC and EIC already at work

HL-LHC and EIC quarkonium physics case from "Quarkonia as Tools" workshops

Progress in Particle and Nuclear Physics 122 (2022) 103906

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Review

Prospects for quarkonium studies at the high-luminosity LHC

Émilien Chapon [1,a], David d'Enterria [2,a], Bertrand Ducloué [3,a], Miguel G. Echevarria [4,a], Pol-Bernard Gossiaux [5,a], Vato Kartvelishvili [6,a], Tomas Kasemets [7,a], Jean-Philippe Lansberg [8,a,b], Ronan McNulty [9,a], Darren D. Price [10,a], Hua-Sheng Shao [11,a], Charlotte Van Hulse [3,a], Michael Winn [12,a], Jaroslav Adam [13], Liupan An [14], Denys Yen Arrebato Villar [5], Shohini Bhattacharya [15], Francesco G. Celiberto [16,17,18,19], Cvetan Cheshkov [20], Umberto D'Alesio [21], Cesar da Silva [22], Elena G. Ferreiro [23], Chris A. Flett [24,25], Carlo Flore [3], Maria Vittoria Garzelli [26,14,27], Jonathan Gaunt [28,10], Jibo He [29], Yiannis Makris [12], Cyrille Marquet [30], Laure Massacrier [5], Thomas Mehen [31], Cédric Mezrag [32], Luca Micheletti [32], Riccardo Nagar [33], Maxim A. Nefedov [34], Melih A. Ozcelik [8], Biswarup Paul [21], Cristian Pisano [21], Jian-Wei Qiu [35], Sangem Rajesh [29], Matteo Rinaldi [36], Florent Scarpa [8,37], Maddie Smith [8], Pieter Taels [38], Amy Tee [6], Oleg Teryaev [39], Ivan Vitev [37], Kazuhiro Watanabe [15], Nodoka Yamanaka [35,40], Xiaojun Yao [41], Yanxi Zhang [7,42]

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Physics case for quarkonium studies at the Electron Ion Collider

Editors: Daniël Boer[a,1], Carlo Flore[b,1], Daniel Kikoła[c,1], Jean-Philippe Lansberg[b,1], Charlotte Van Hulse[b,1]

[a] Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, 9747 AG Groningen, The Netherlands
[b] Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France
[c] Faculty of Physics, Warsaw University of Technology, ul. Koszykowa 75, 00-662 Warsaw, Poland

Abstract

The physics case for quarkonium-production studies accessible at the future US Electron Ion Collider is described.

First big question we encountered: can one afford the absence of an EIC muon detector ?

Strong words but … J.P. made predictions and worked with NA60, CMS etc data that all measure quarkonia through muon channels.

- This has clear advantages
  - better mass resolution
  - less radiation effect
  - no combinatorial background from scattered electron
  - same BR as in e^+e^- channels
- But this is a quantitative issue
  - low mass, good e/h mitigate issues
  - e^+e^- allows lower p_T reach

Quarkonium production (J.P. Lansberg Orsay/Saclay)

Synergies between LHC and

HL-LHC and EIC quarkonium physics case fr

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First big question we encountered: can on

It is a valid argument that quarkonia measurements are superior with muons in colliders than with electrons. It also doubles the statistics and allows for systematic cross checks. It is not opening new doors.

A solid argument for muons IMHO

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- e^+e^- allows lower p_T reach

Lepton flavour violation searches (Giulia Frau, Heidelberg)

- Standard Model (SM) predicts same electroweak couplings for all the three lepton flavours => Lepton Flavor Universality (LFU)
  - LFU violation generally implies Lepton Flavour Violation (LFV)
- Observation of LFV => clear sign of new physics (NP)
  - Tension with SM recently reported by LHCb in $b \to s\ell\ell$ transitions
- Studies/Techniques
  - $B^+ \to K^+ J/\psi(\to \mu^\pm e^\mp)$ with $B^+ \to K^+ J/\psi(\to \mu^+\mu^-)$ as normalization channel, $B^+ \to K^+ J/\psi(\to e^+e^-)$ as control channel
  - Upper limits in many channels by ATLAS, CMS, LHCb, and Belle

Lepton flavour violation searches (Giulia Frau, Heidelberg)

- Standard Model (SM) predicts same electroweak couplings for all the three lepton flavours => Lepton Flavor Universality (LFU)
  - LFU viola
- Observatic
  - Tension v
- Studies/Te
  - $B^+ \to K$ channel,
  - Upper lim

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Not really in scope of EIC. LHC & BELLE-II will set upper limits that will be hard to match

Not an argument for muons IMHO

Conclusion

Was there a case for muons made at the “Kick-Off Meeting - Synergies between the Electron-Ion Collider and the Large Hadron Collider” on Jun 20-21, 2022 at CERN?

Conclusion

Was there a case for muons made at the “Kick-Off Meeting - Synergies between the Electron-Ion Collider and the Large Hadron Collider” on Jun 20-21, 2022 at CERN?

➟ Not really …

Likely triggered by JPs talk - but no meat