SCET-Q

Progress report

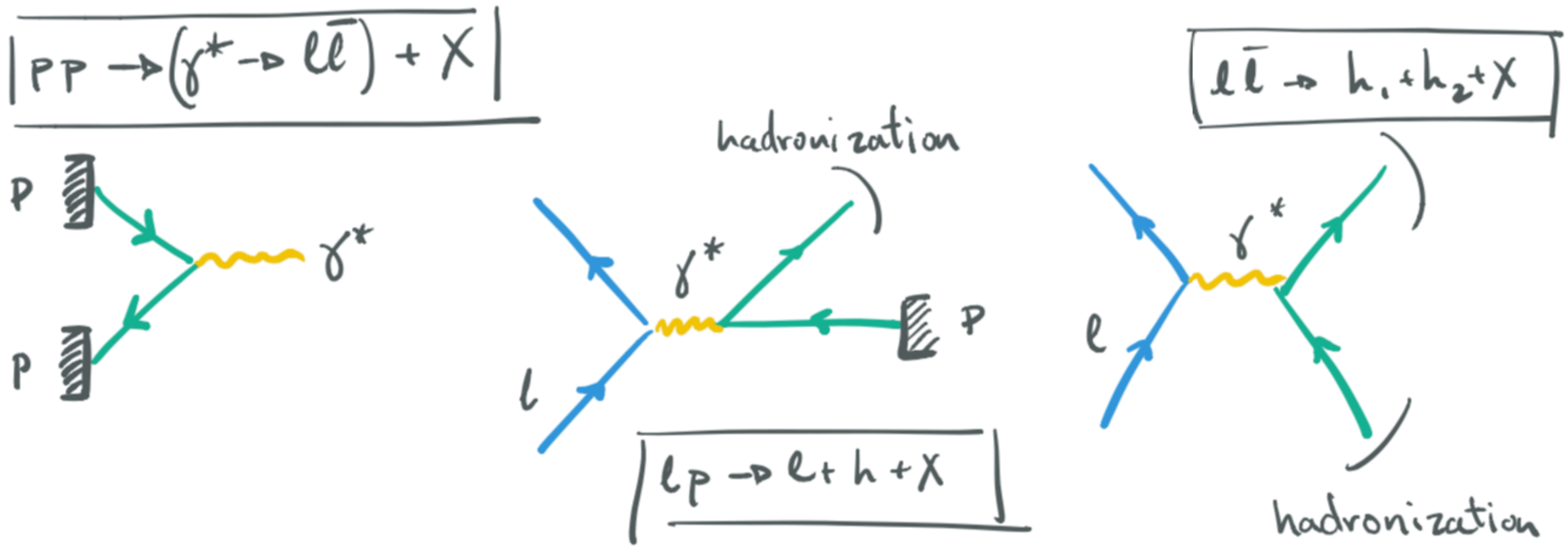
Yiannis Makris

INFN (Pavia)

Supported by the FELLINI project and the European Commission

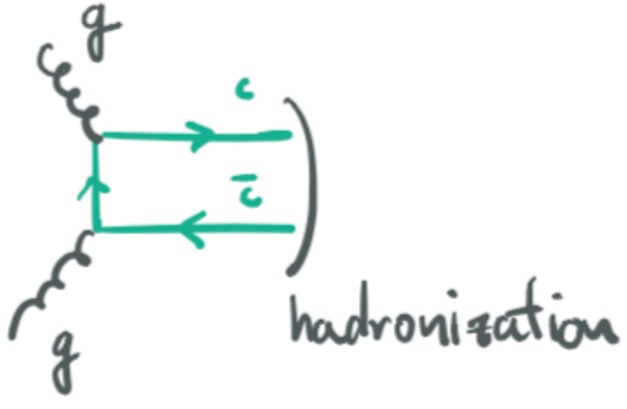
What ?

Transverse momentum dependent (TMD) observables, encode information about the three-dimensional distribution of partons in the nucleon. Extraction of TMDs rely on factorization theorems of hadronic cross section into universal QCD matrix elements.



How ?

$gg \to \eta_{c/b}$:

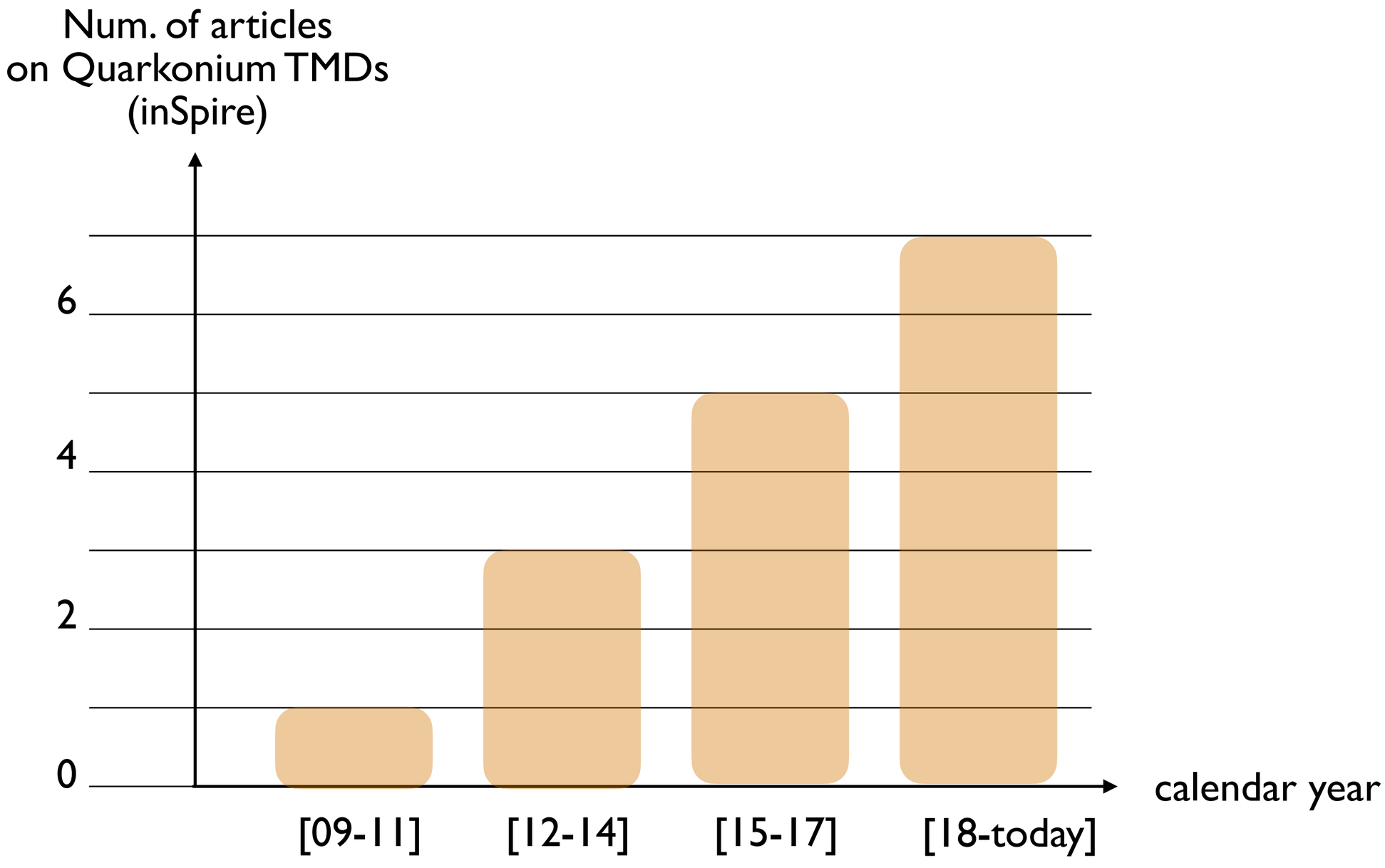


$eg \to \psi / \Upsilon(1S)$:

An effective field theory (EFT) framework for the description of quarkonium production at small transverse momentum. The EFT is considered a fusion of non-relativistic QCD (NRQCD) and soft collinear effective theory (SCET)

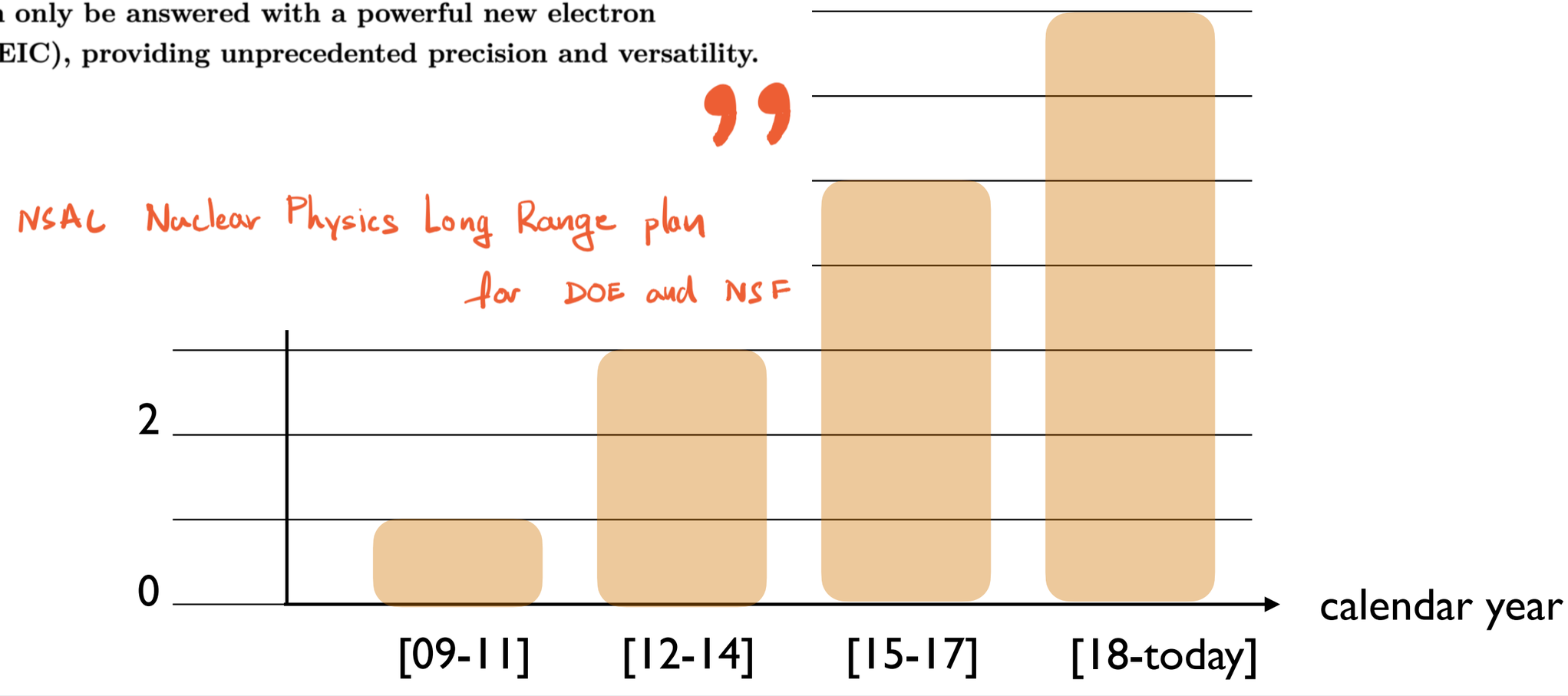
- Factorization of the relevant cross section into QCD matrix elements

Why ?


Num. of articles
on Quarkonium TMDs
(inSpire)
6
4
2
0
[09-11]
[12-14]
[15-17]
[18-today]
calendar year

Why ?

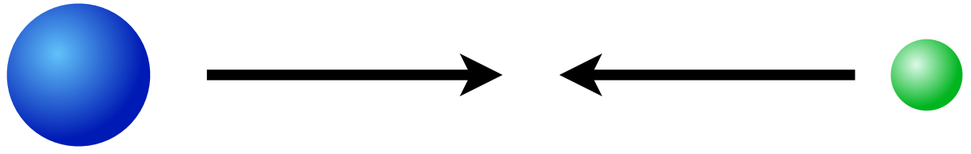
Gluons, the carriers of the strong force, bind the quarks together inside nucleons and nuclei and generate nearly all of the visible mass in the universe. Despite their importance, fundamental questions remain about the role of gluons in nucleons and nuclei. These questions can only be answered with a powerful new electron ion collider (EIC), providing unprecedented precision and versatility.



Why ?

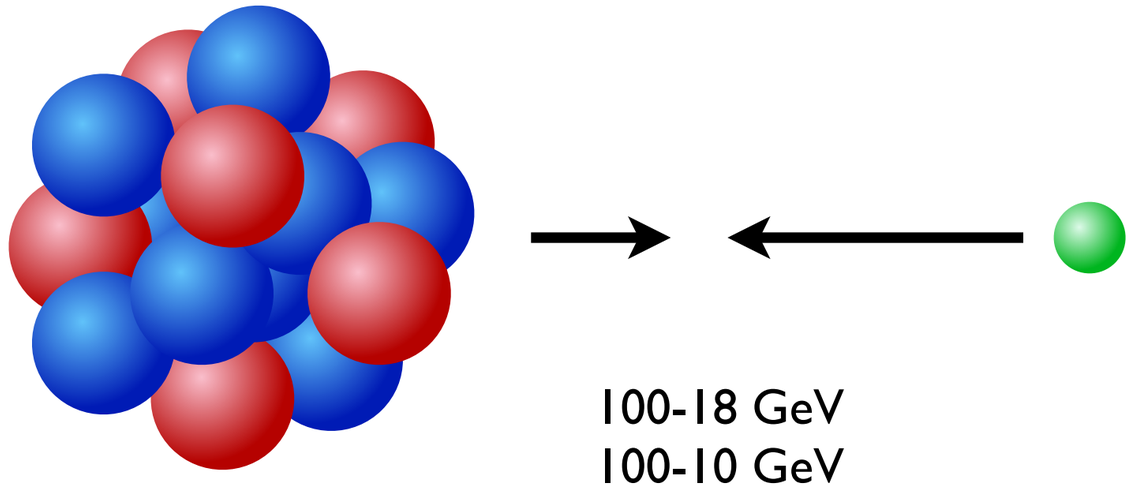
275-18 GeV
100-10 GeV
100-5 GeV
41-5 GeV

proton



electron

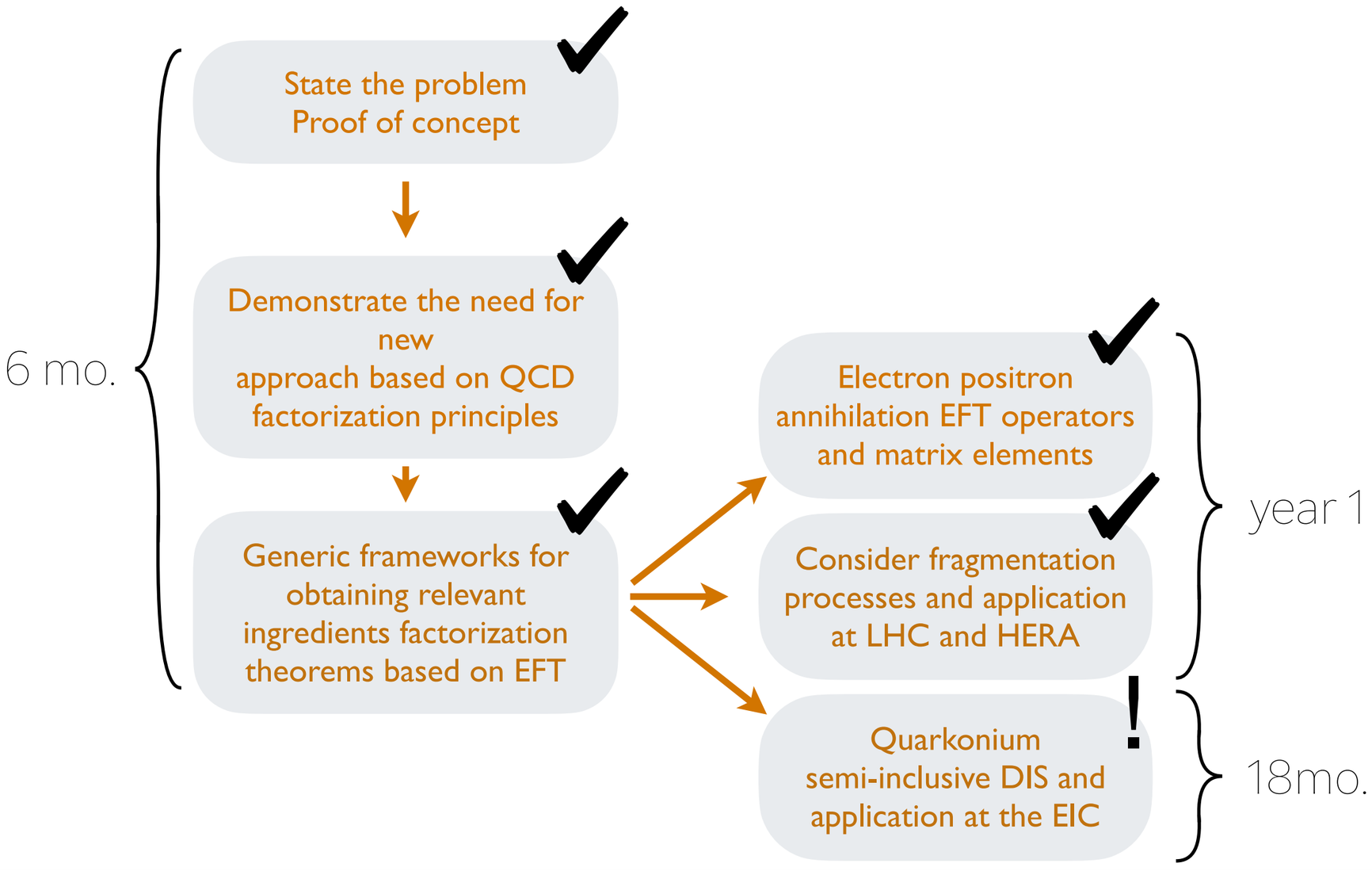
$d/\,^{3}\mathrm{He}/\,^{4}\mathrm{He}/\,\mathrm{C}/\,^{40}\mathrm{Ca}/\,\mathrm{Cu}/\mathrm{Au}$



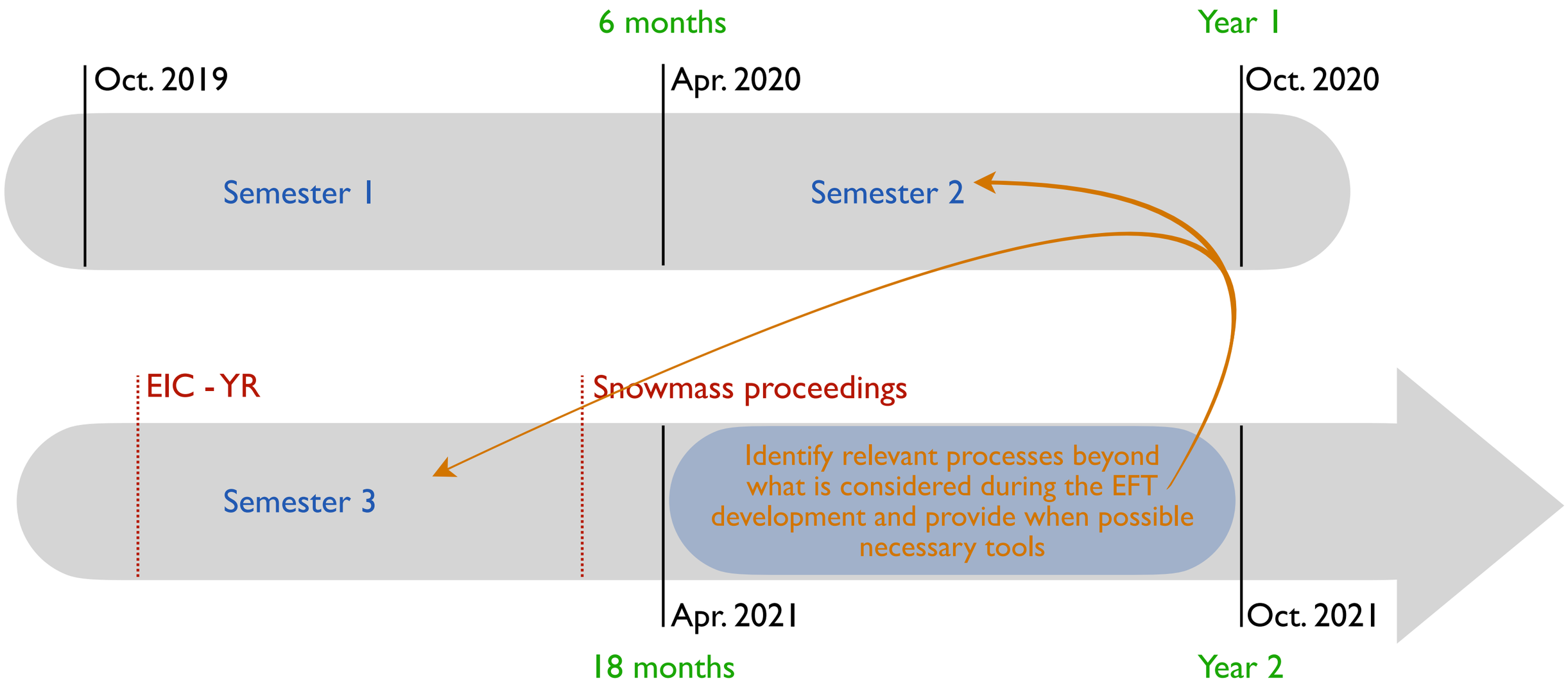
100-18 GeV
100-10 GeV
41-5 GeV
(Energy per nucleon)

When ?

EFT - Framework



When ?


6 months
Year 1
Oct. 2019
Apr. 2020
Oct. 2020
Semester 1
Semester 2
EIC - YR
Snowmass proceedings
Semester 3
Identify relevant processes beyond what is considered during the EFT development and provide when possible necessary tools
Apr. 2021
Oct. 2021
18 months
Year 2

What if ?

Centauro:
A jet algorithm for DIS

arXiv: 2006.10751 (M. Arratia, Y. Makris, D. Neill, F. Ringer, and N. Sato)

Revisiting grooming in DIS

arXiv: 2101.02708 (Y. Makris)

Open heavy flavor production

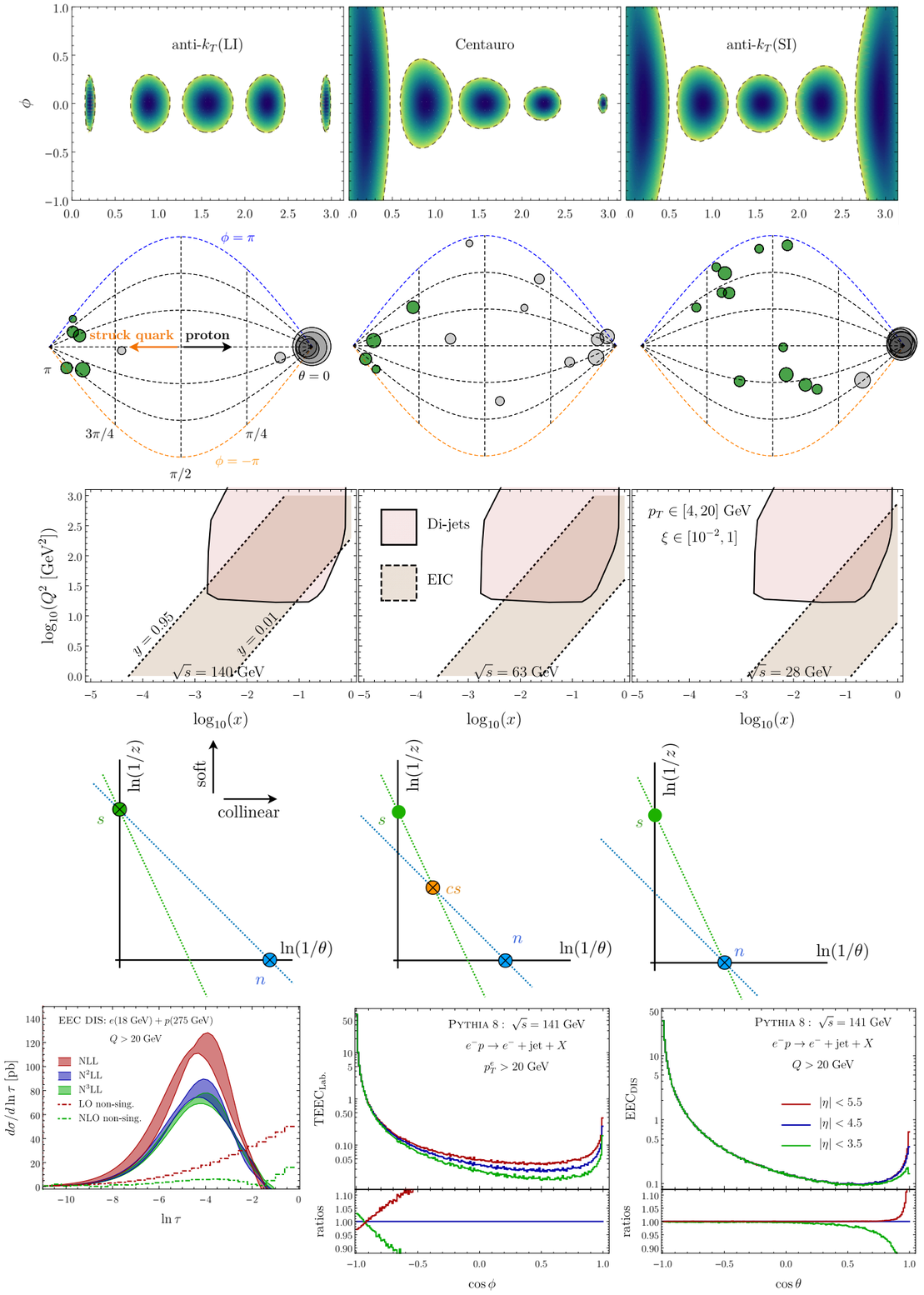
arXiv: 2008.07531 (R.F. del Castillo, M.G. Echevarria, Y. Makris, I. Scimemi)

Joint TMD resummation

arXiv: 2009.11871 (Y. Makris, F. Ringer, and W.J. Waalewijn)

Event shapes

arXiv: 2102.05669 (H.T. Li, Y. Makris, I.M. Vitev)



Publications and Pre-prints

Publications with range of collaborators

↕

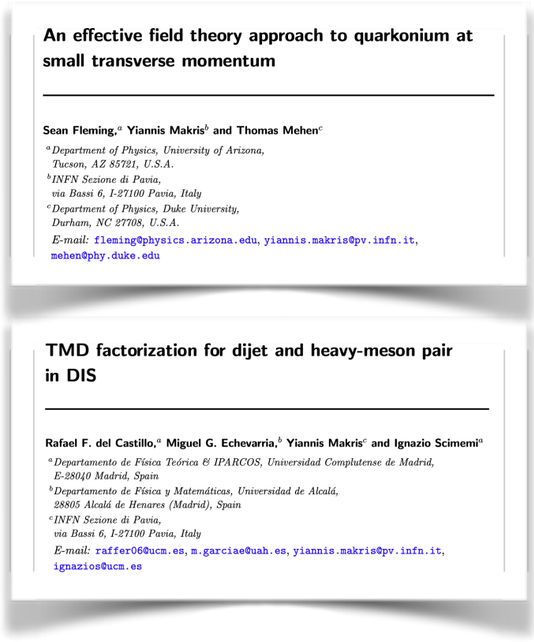
Talks and presentations in: International workshops and conferences Seminars

↕

Participate in community efforts and initiatives

↕

Public code for the numerical implementation



An effective field theory approach to quarkonium at small transverse momentum

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TMD factorization for dijet and heavy-meson pair in DIS

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Asymmetric jet clustering in deep-inelastic scattering

M. Arratia,[1,2,*] Y. Makris,[3,†] D. Neill,[4,‡] F. Ringer,[5,6,§] and N. Sato[7,¶]

[1] *Physics Department, University of California, Riverside, CA 92521, USA*
[2] *Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA*
[3] *INFN Sezione di Pavia, via Bassi 6, I-27100 Pavia, Italy*
[4] *Theoretical Division, MS B283, Los Alamos National Laboratory, Los Alamos, NM 87545, USA*
[5] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA*
[6] *Physics Department, University of California, Berkeley, CA 94720, USA*
[7] *Theory Center, Jefferson Laboratory, Newport News, Virginia 23606, USA*

(Dated: February 15, 2021)

Quarkonium TMD fragmentation functions in NRQCD

Miguel G. Echevarria,[a] Yiannis Makris[b] and Ignazio Scimemi[c]

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Joint thrust and TMD resummation in electron-positron and electron-proton collisions

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[b] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, U.S.A.*
[c] *Institute for Theoretical Physics Amsterdam and Delta Institute for Theoretical Physics, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands*
[d] *Nikhef, Theory Group, Science Park 105, 1098 XG, Amsterdam, The Netherlands*

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Perspectives for quarkonium studies at the high-luminosity LHC

Émilien Chapon[a,1], David d'Enterria[b,1], Bertrand Ducloué[c,1], Miguel G. Echevarria[d,1], Pol-Bernard Gossiaux[e,1], Vato Kartvelishvili[f,1], Tomas Kasemets[g,1], Jean-Philippe Lansberg[h,2], Ronan McNulty[i,1], Darren D. Price[j,1], Hua-Sheng Shao[k,1], Charlotte Van Hulse[l,1], Michael Winn[l,1], Jaroslav Adam[m], Liupan An[n], Denys Yen Arrebato Villar[o], Shohini Bhattacharya[p], Francesco G. Celiberto[q,r,s,1], Cvetan Cheshkov[n], Umberto D'Alesio[o], Cesar da Silva[w], Elena G. Ferreiro[x], Chris A. Flett[y,z], Carlo Flore[b], Maria Vittoria Garzelli[aa,n,ab], Jonathan Gaunt[ac,1], Jibo He[ad], Yiannis Makris[r], Cyrille Marquet[ae], Laure Massacrier[b], Thomas Mehen[af], Cédric Mezrag[l], Luca Micheletti[ag], Riccardo Nagar[ah], Maxim A. Nefedov[ai], Melih A. Ozcelik[b], Biswarup Paul[v], Cristian Pisano[y], Jian-Wei Qiu[aj], Sangem Rajesh[v], Matteo Rinaldi[ak], Florent Scarpa[h,al], Maddie Smith[f], Pieter Taels[am], Amy Tee[f], Oleg Teryaev[an], Ivan Vitev[w], Kazuhiro Watanabe[aj], Nodoka Yamanaka[an,ao], Xiaojun Yao[ap], Yanxi Zhang[b,aq]

Revisiting the role of grooming in DIS

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(Received 19 January 2021; accepted 15 February 2021)

Energy-energy correlators in Deep Inelastic Scattering

Hai Tao Li,[1,2,3,*] Yiannis Makris,[4,†] and Ivan Vitev[3,‡]

[1] *HEP Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[2] *Department of Physics & Astronomy, Northwestern University, Evanston, Illinois 60208, USA*
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[4] *INFN Sezione di Pavia, via Bassi 6, I-27100 Pavia, Italy*

Invited talks and Seminars

Publications with range of collaborators

Talks and presentations in: International workshops and conferences Seminars

Participate in community efforts and initiatives

Public code for the numerical implementation

Community efforts

Publications with range of collaborators

↕

Talks and presentations in: International workshops and conferences Seminars

↕

Participate in community efforts and initiatives

↕

Public code for the numerical implementation

Electron-Ion Collider User Group

The world's most powerful microscope for studying the "glue" that binds the building blocks of visible matter.

Open access code

Publications with range of collaborators

↕

Talks and presentations in: International workshops and conferences Seminars

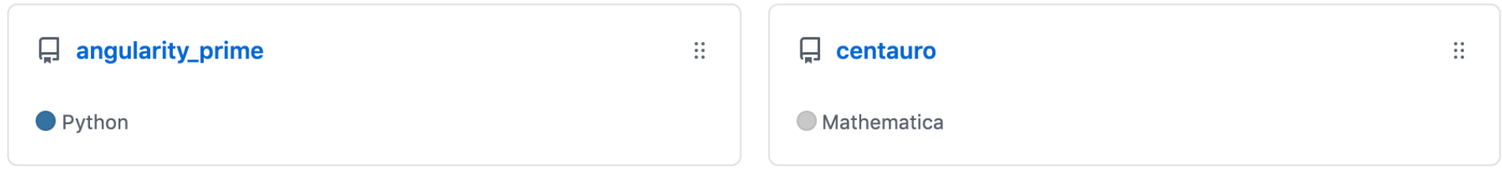
↕

Participate in community efforts and initiatives

↕

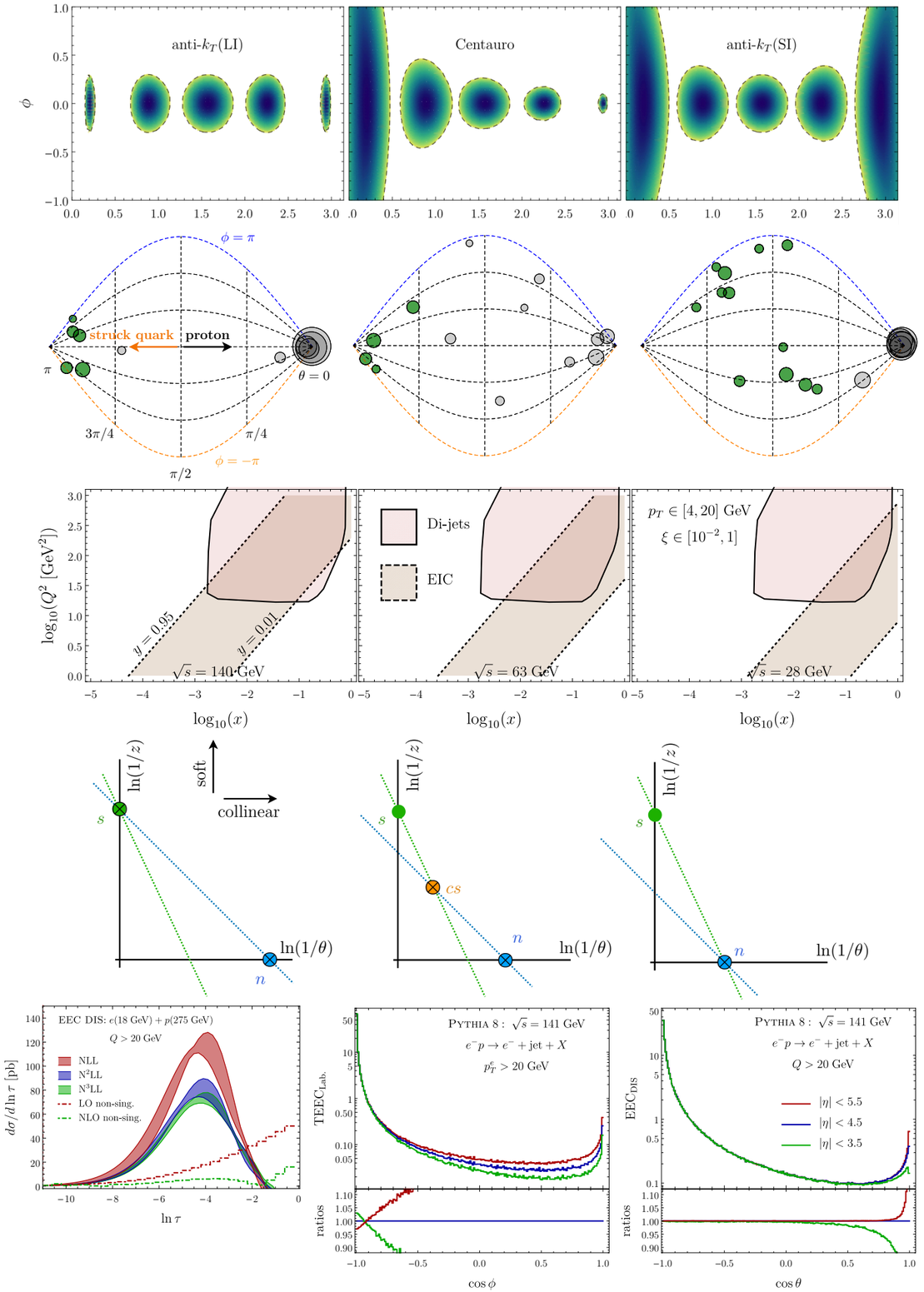
Public code for the numerical implementation

https://github.com/YiannisMakris



work in progress!
should be complete
by Oct. 2021

Thank you


anti-k_T(LI)
Centauro
anti-k_T(SI)
ϕ
$\phi = \pi$
$\phi = -\pi$
struck quark
proton
π
$\theta = 0$
$3\pi/4$
$\pi/4$
$\pi/2$
$\log_{10}(Q^2\ [\mathrm{GeV}^2])$
Di-jets
EIC
$y = 0.95$
$y = 0.01$
$\sqrt{s} = 140$ GeV
$\sqrt{s} = 63$ GeV
$\sqrt{s} = 28$ GeV
$p_T \in [4, 20]$ GeV
$\xi \in [10^{-2}, 1]$
$\log_{10}(x)$
soft
collinear
$\ln(1/z)$
$\ln(1/\theta)$
s
cs
n
EEC DIS: $e(18\ \mathrm{GeV}) + p(275\ \mathrm{GeV})$
$Q > 20$ GeV
NLL
N^{2}LL
N^{3}LL
LO non-sing.
NLO non-sing.
$d\sigma/d\ln\tau$ [pb]
$\ln\tau$
Pythia 8 : $\sqrt{s} = 141$ GeV
$e^- p \to e^- + \mathrm{jet} + X$
$p_T^e > 20$ GeV
$Q > 20$ GeV
$|\eta| < 5.5$
$|\eta| < 4.5$
$|\eta| < 3.5$
$\mathrm{TEEC}_{\mathrm{Lab.}}$
$\mathrm{EEC}_{\mathrm{DIS}}$
ratios
$\cos\phi$
$\cos\theta$