Guido Altarelli Award 2025

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Guido Altarelli Award 2025

The Guido Altarelli Award honors the memory
of the late Guido Altarelli, one of the founding fathers of QCD,
an outstanding communicator of particle physics,
and a mentor and strong supporter of Junior Scientists.

Some History

First IAC

Guido Altarelli

John Dainton

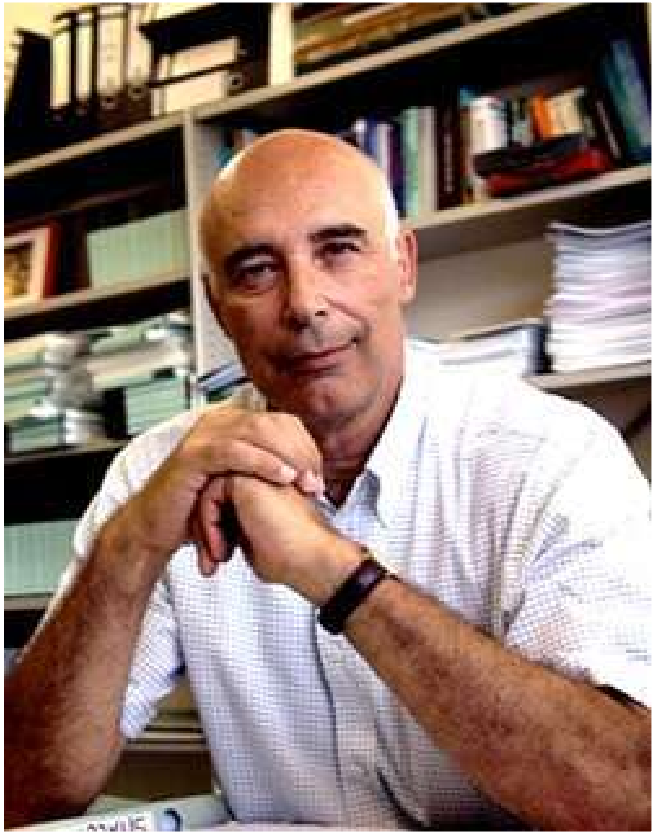
Joel Feltesse

Aharon Levy

Lev Lipatov

James Stirling

Gunter Wolf



Some History *… first hand*

Professor Yuri Dokshitzer

Yuri Dokshitzer and Guido Altarelli
are recognized as the "D" and "A"
in the well-known "DGLAP" equations.

Editor & Co-Author: "The Basics of QCD"

He is a visionary pioneer, responsible for numerous groundbreaking ideas that have reshaped our field.

Award History … 10th Year

Previous prize winners

Year	Theory winner	Experimental physics winner	Link to DIS page and indico
2024	Javier Mazzitelli	Holly Szumila-Vance	DIS2024 Grenoble, France
2023	Yong Zhao	Adinda de Wit	DIS2023 East Lansing, MI, (USA)
2022	Bernhard Mistlberger	Adi Ashkenazi	DIS2022 Santiago de Compostela (Spain)
2021	Eleni Vryonidou	Benjamin Nachman	DIS2021 online
2020	Pier Francesco Monni	Philip Ilten	DIS2020
2019	Jonathan Gaunt	Josh Bendavid	DIS2019 Torino (Italy)
2018	Jun Gao	Or Hen	DIS2018 Kobe (Japan)
2017	Maria Ubiali	Paolo Gunnellini	DIS2017 Birmingham (UK)
2016	Fabrizio Caola	Jan Kretzschmar	DIS2016 Hamburg (Germany)

See the webpage (linked from DIS2025)

https://www.physics.smu.edu/~olness/AltarelliAward/

Guido Altarelli Award 2025

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Thanks to all of you who nominated candidates.
This year we had impressive applications and difficult deliberations.

The selection committee in 2025:

Rolf Ent (JLAB), Aharon Levy (Tel Aviv, co-chair of DIS), Fred Olness (chair, SMU), Andrea Gabrielli (CREF), Marta Ruspa (INFN, Turin) Juan Terron (UAM), Yuji Yamazaki (Kobe), Maria Ubiali (Cambridge)

Miguel Arratia

Ph.D. University of Cambridge

B.Sc. M.Sc.

Universidad Técnica Federico Santa María, Chile

Postdoctoral Scholar,

University of California, Berkeley

Assistant Professor, University of California, Riverside

2024 U.S Department of Energy Early Career Award.

Guido Altarelli Award 2025

awarded to

Miguel Arratia

for advancing jet studies in deep inelastic scattering and developing high-granularity calorimetry for the Electron-Ion Collider.

Prof. Andrea Gabrielli (CREF Scientific Director)	**Dr. Christian Caron (Springer Executive Editor)**	**Prof. K.K. Puha (Chairman, WS Publishing)**	**Profs. Aharon Levy & Paul R. Newman (Chairs IAC of DIS2024)**

XXXII International Workshop on Deep-Inelastic Scattering and Related Subjects, 24-28 March 2025, Cape Town, South Africa

Rene Poncelet

Ph.D: RWTH Aachen University, Aachen, Germany

M.Sc., B.Sc.:

Georg-August University, Göttingen, Germany

Postdoc: Cambridge University

Assistant Professor: Institute of Nuclear Physics

Polish Academy of Sciences, Kraków, Poland

Leverhulme Early Career Fellow

Simons Foundation Grant

EPJ.org

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for outstanding contributions to precision calculations of the top quark and Higgs boson, which have profoundly influenced LHC analyses.

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			(Chairs IAC of DIS2024)

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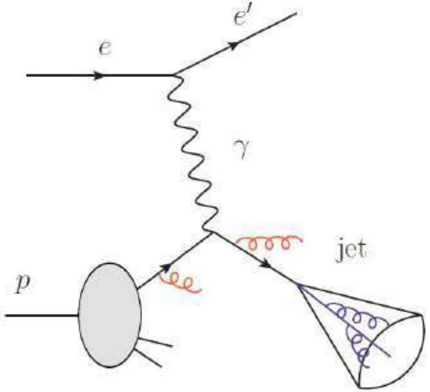
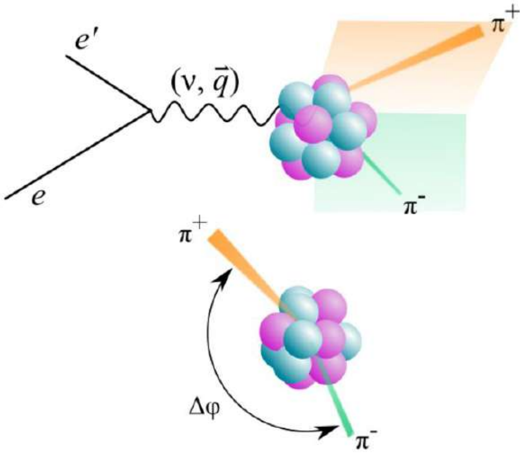
Jets in DIS 2.0

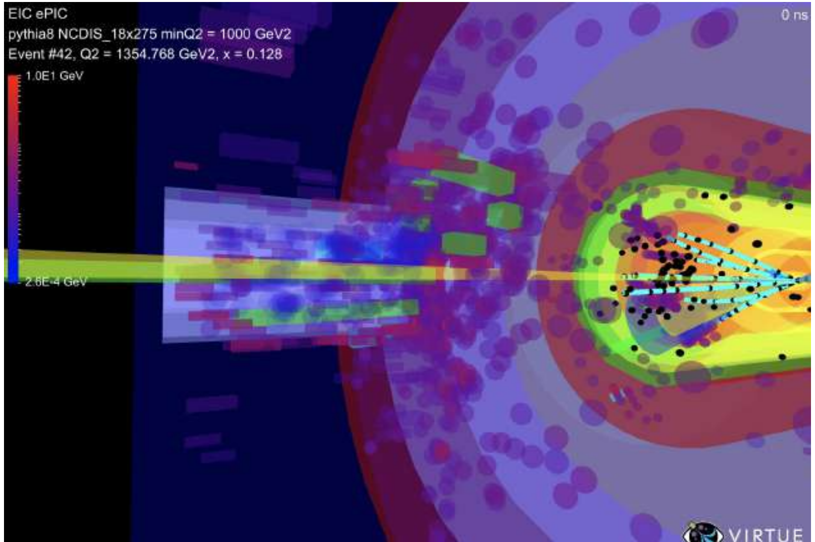
Miguel Arratia

UC RIVERSIDE

DIS 2025 @ Cape Town, March 24th 2025

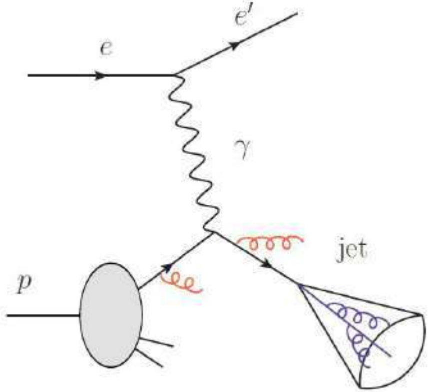




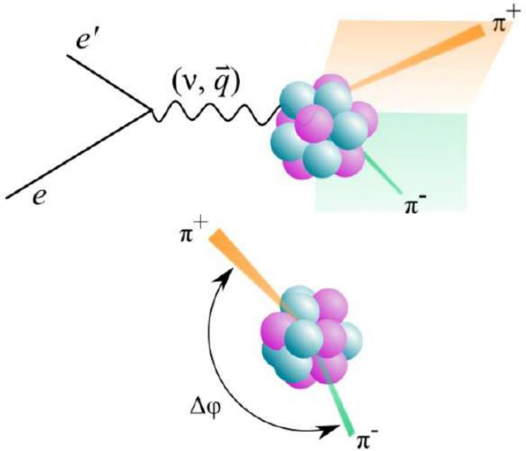


Overview of this talk

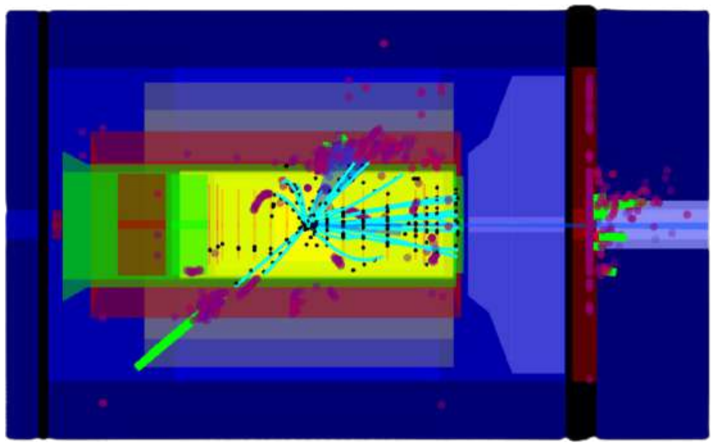
DIS Jets



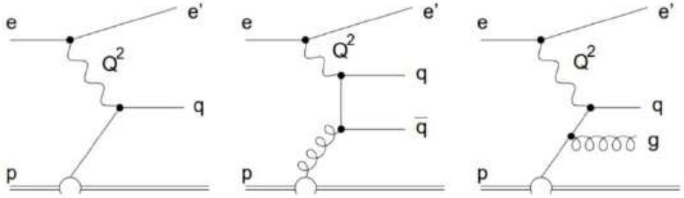
SIDIS eA



EIC



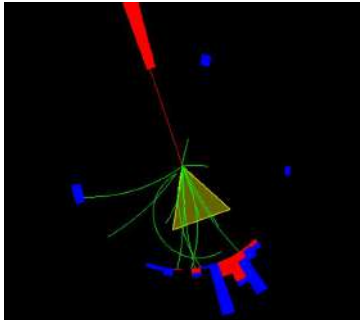
Context of Jet Physics in DIS 2.0



$$\gamma^{*} q \rightarrow q$$

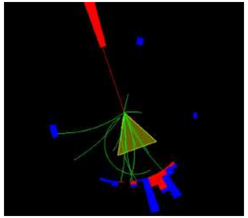
- Jets in DIS were recently proposed by theorists as novel tool to probe quark TMDs.
  Liu et al. PRL. 122, 192003 (2019) [Lab frame]
  Gutierrez et al. PRL. 121, 162001 (2018) [Breit frame]

- EIC "Yellow Report" Science gave us the chance to rethink the role of jets. Before it, they were barely mentioned.



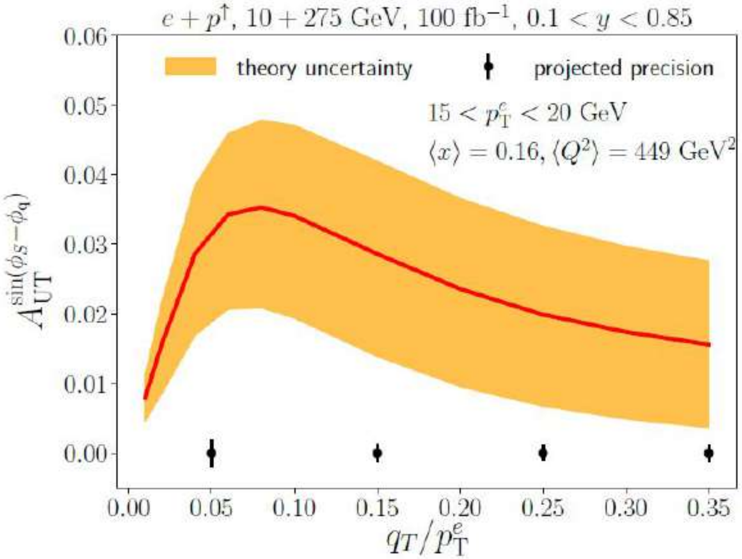
Yesterday's background,
Tomorrow's discovery

Experimental Projections & Phenomenology for EIC

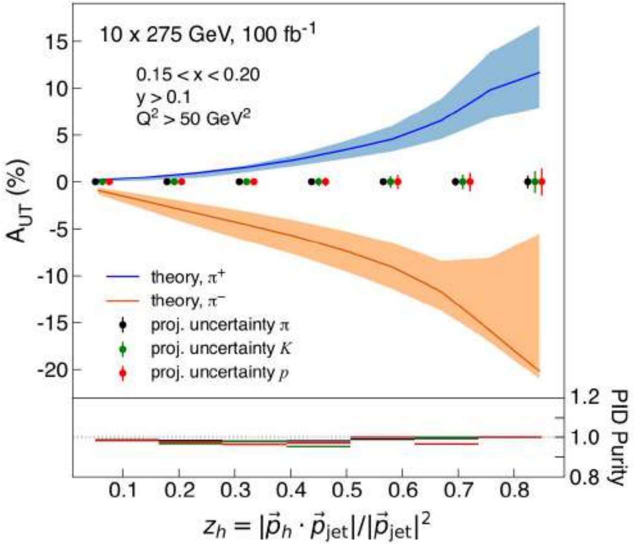


M. Arratia et. al.
PRD 102 (2020) 7, 074015
PRC 101 (2020) 6, 065204
PRD 104 (2021) 3, 034005
PRD 103 (2021) 7, 074023
PRD 107 (2023) 9, 094036
ATHENA, JINST 17 (2022) 10 P10019
EIC YR, NPA (2022) 122447

Jet Sivers

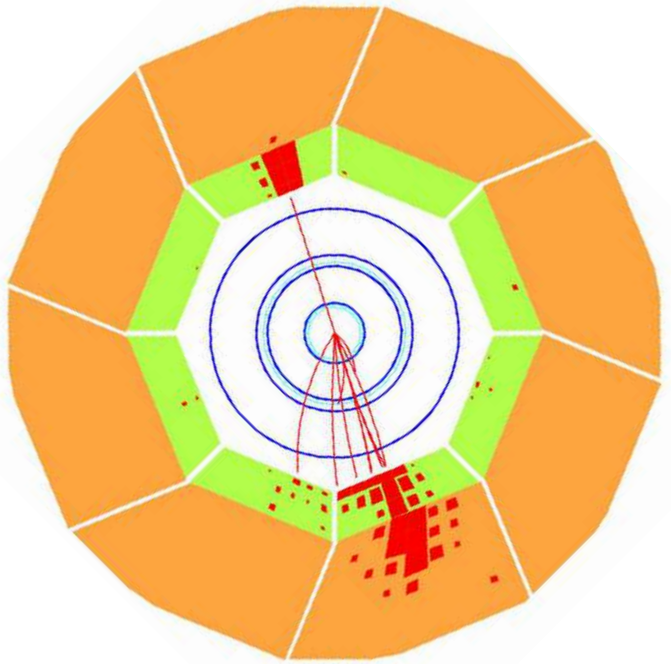


“Hadron-in-jet Collins

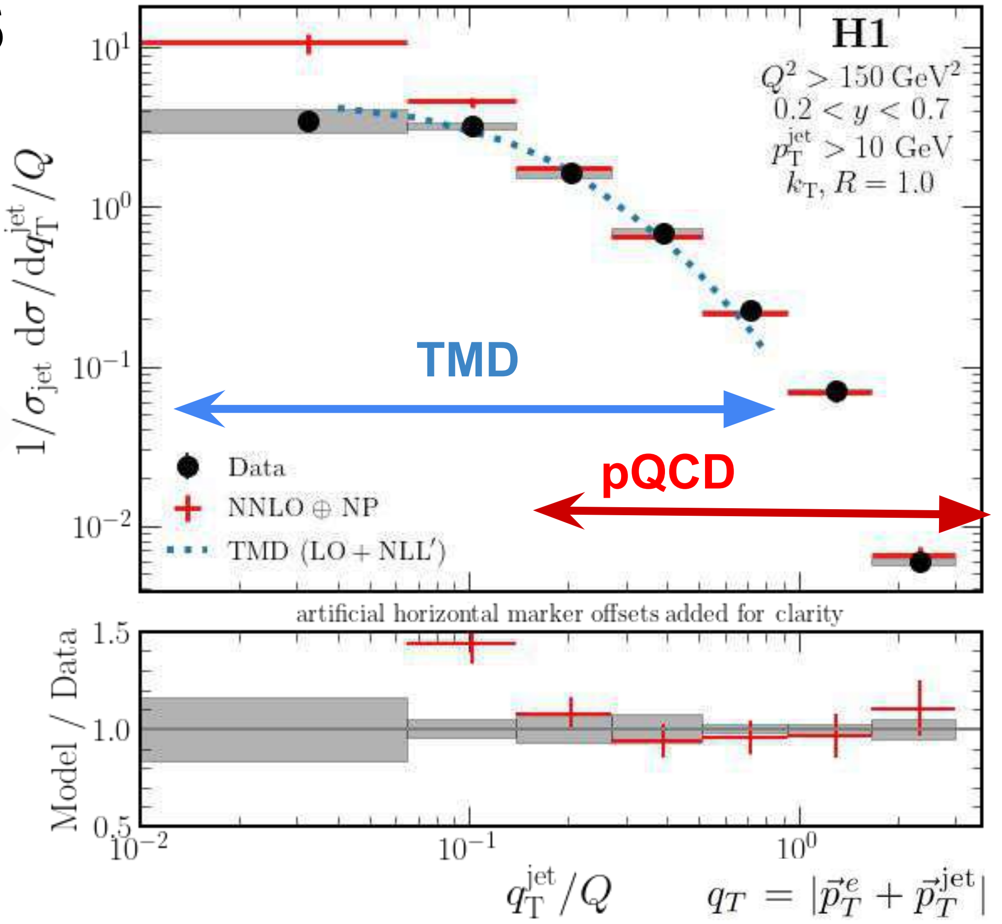


Jets = powerful tool to explore core EIC science (TMDs, spin, cold-QCD)

Jets in unpolarized ep DIS



H1 Collaboration, PRL 128 (2022) 132002;
PLB 844 (2023) 138101;
arXiv:2412.14902;
H1prelim-22-031
H1prelim-25-031



Textbook example of "matching" between collinear QCD and TMD frameworks **First time seen!**

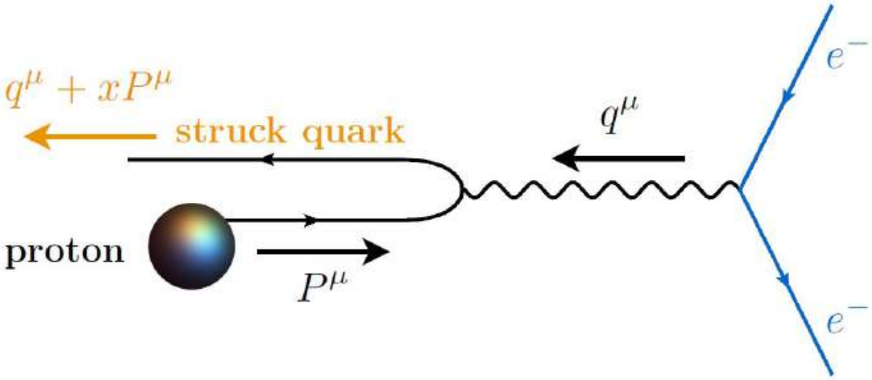
TMD studies in Breit frame need their own jet algorithm, beyond anti-kT

Centauro Jet Algorithm

M. Arratia et al. PRD 104, 034005 (2021)

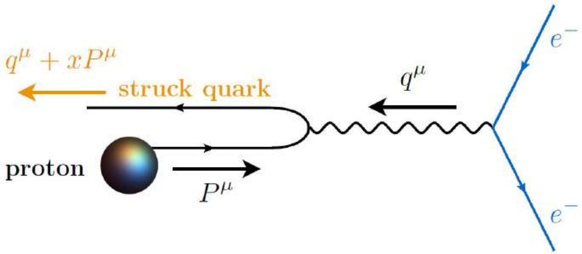
$$d_{ij} = \left[(\Delta\bar{\eta}_{ij})^2 + \bar{\eta}_i\bar{\eta}_j(1-\cos(\Delta\phi_{ij}))\right]/R^2$$

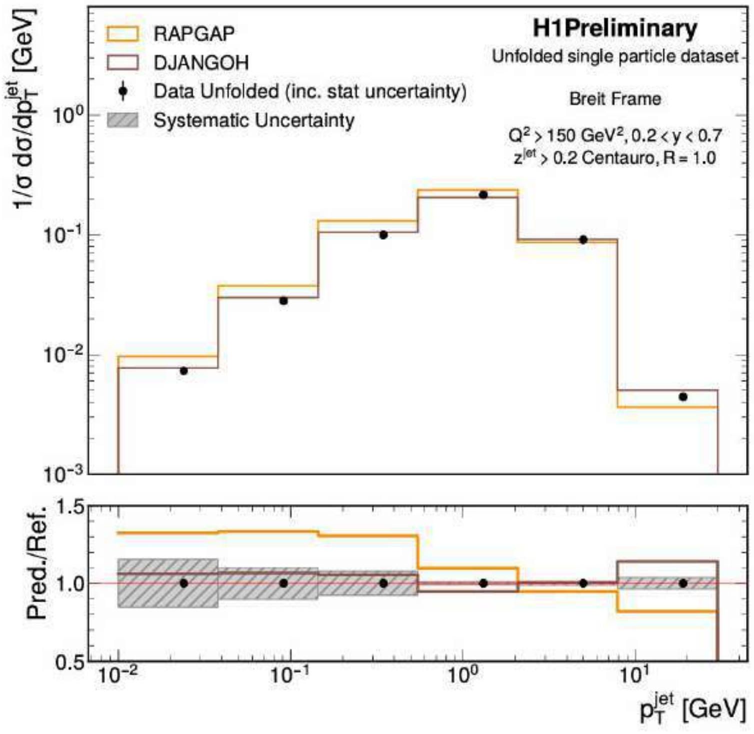
$$\bar{\eta}_i = \frac{p_{\mathrm{T},i}}{n_\mu \cdot p_i},\, n_\mu = (1,0,0,1)\; d_{i,B} = 1$$

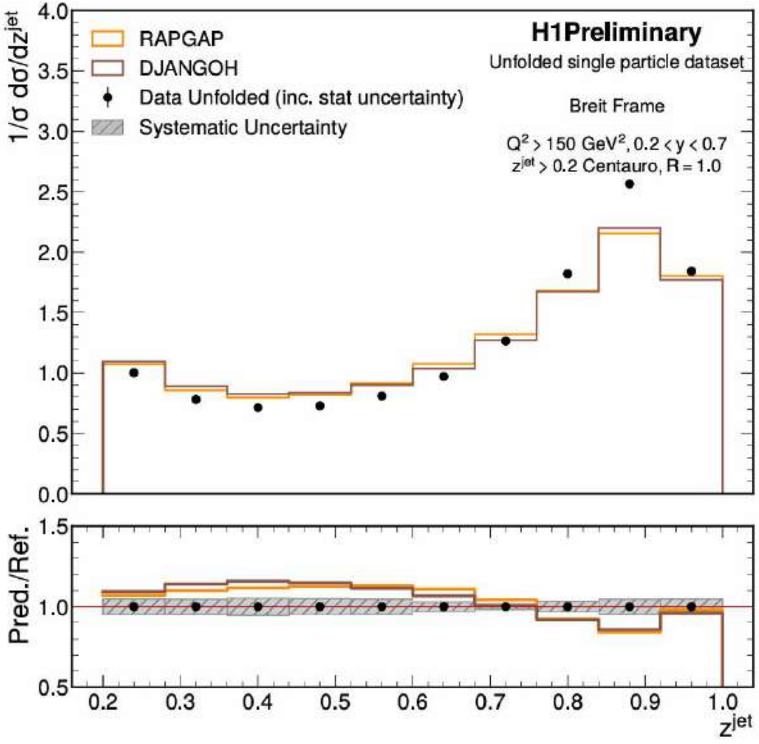


- First asymmetric clustering metric ever.
- Can cluster struck-quark jet (unlike anti-KT)
- Longitudinally invariant (like anti-kT)
- Avoids clustering beam-remnant (like anti-kT)

New: First Centauro Jet measurements

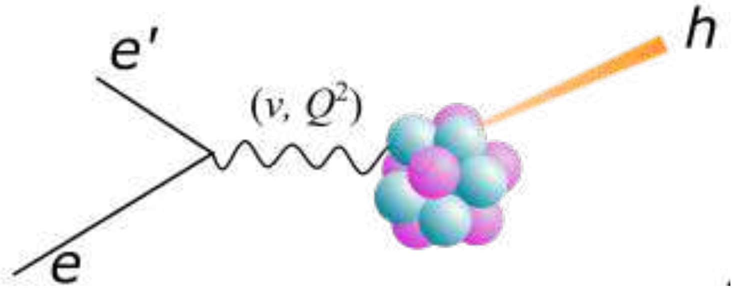


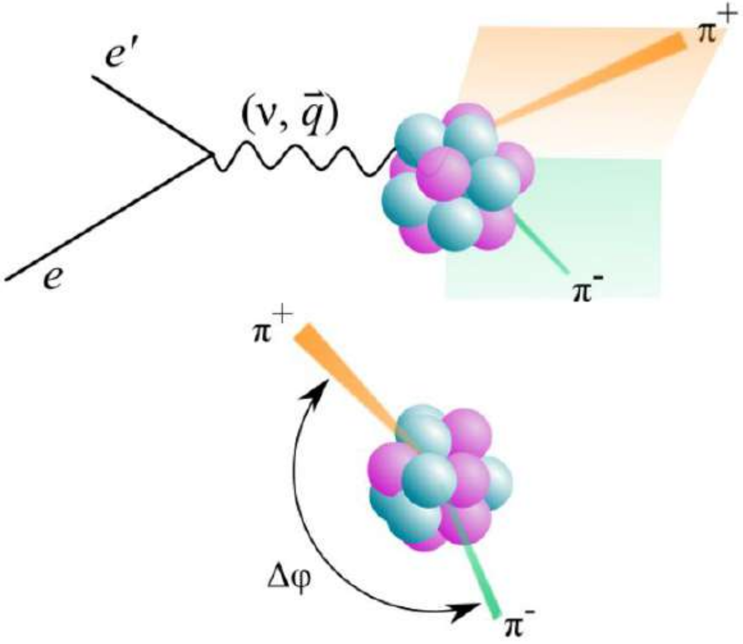




eA DIS at JLab

Fragmentation, correlations, cold-QCD, spin

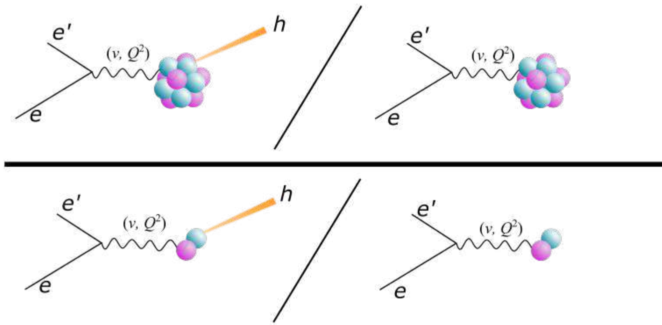




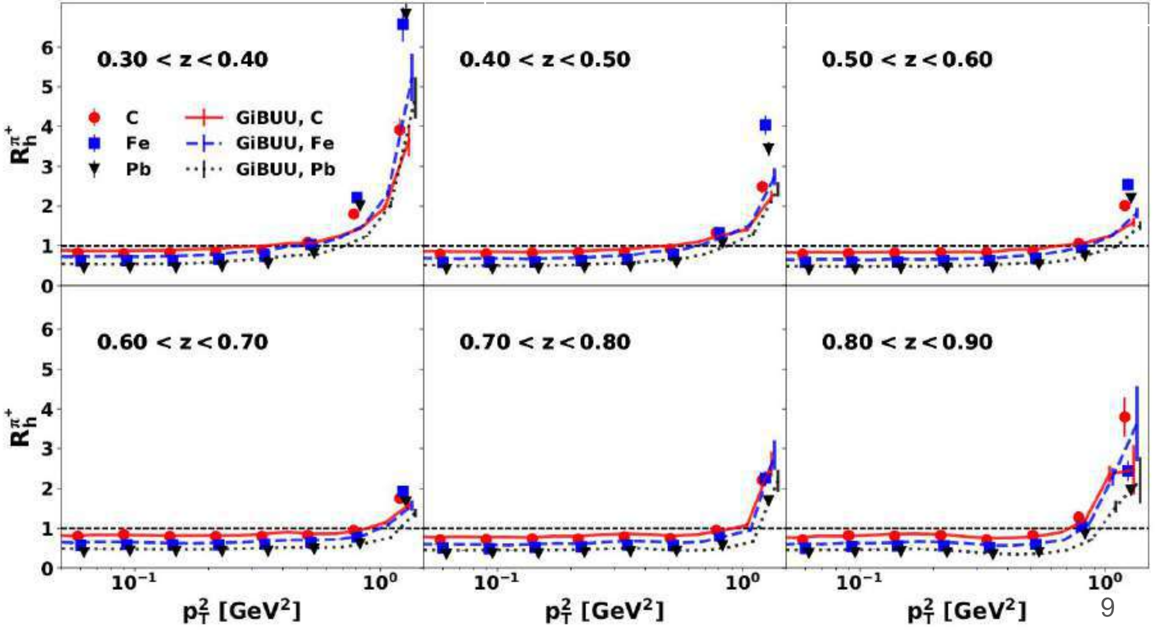
S. Moran et al. (CLAS) PRC 105 (2022) 1, 015201
S. Paul et al. (CLAS) PRL 129 (2022) 18, 18
S. Paul et al. (CLAS) NIMA 1049 (2023) 168032
S. Paul et a. (CLAS) PRC 111 (2025) 3, 035201
S. Moran et al. PRC 110 (2024) 2, 025202

eA SIDIS

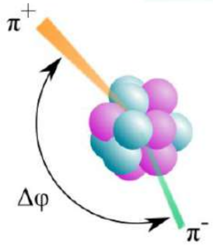
$$R_h^A =$$

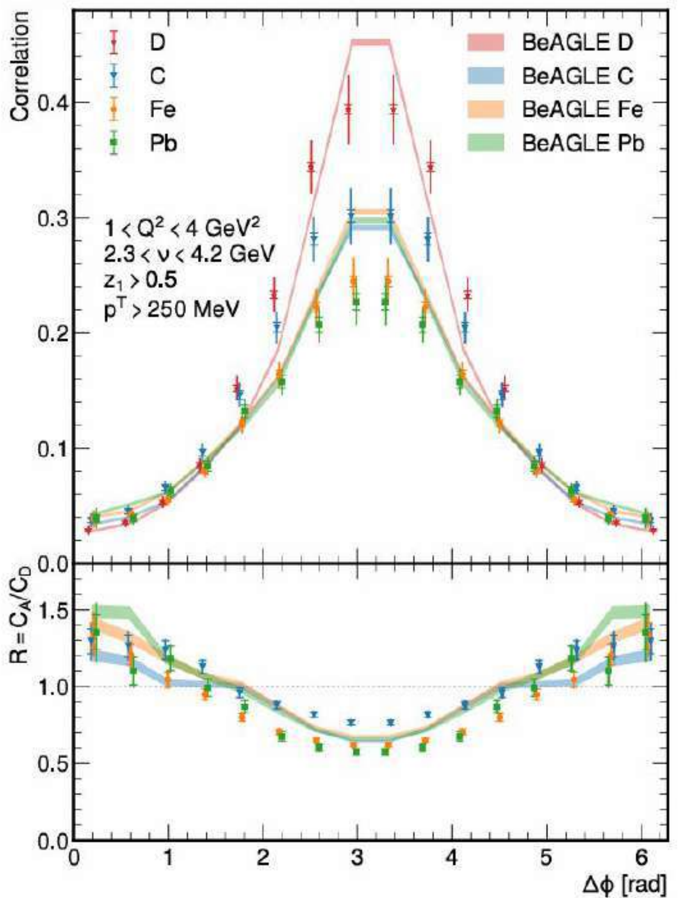


- TMD fragmentation to charged pions off heavy nuclei.
- Already used in:
  Fits nuclear TMD PDFs
  Fits nuclear FFs
  eA Monte Carlo tuning



Dihadron correlations in eA

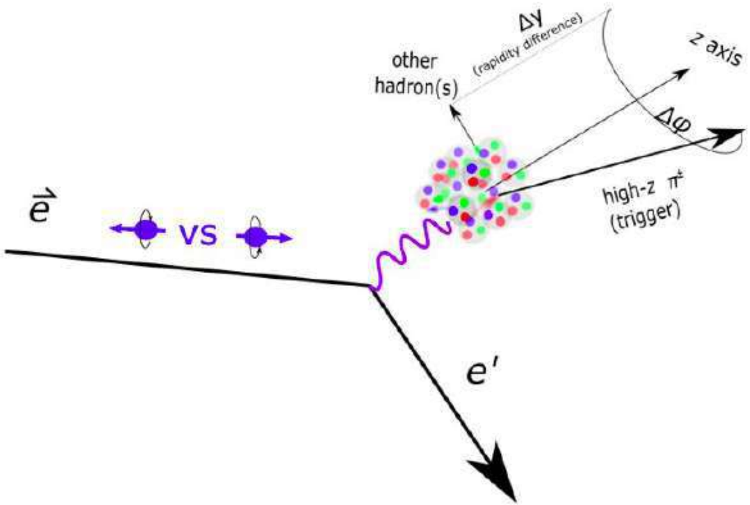


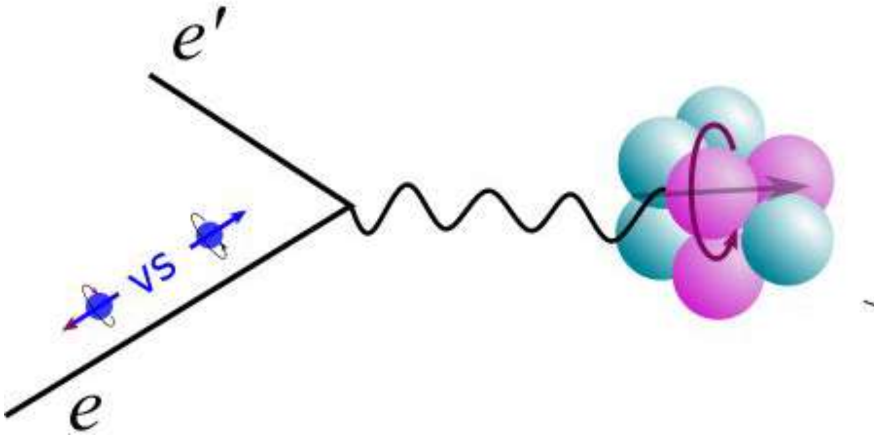


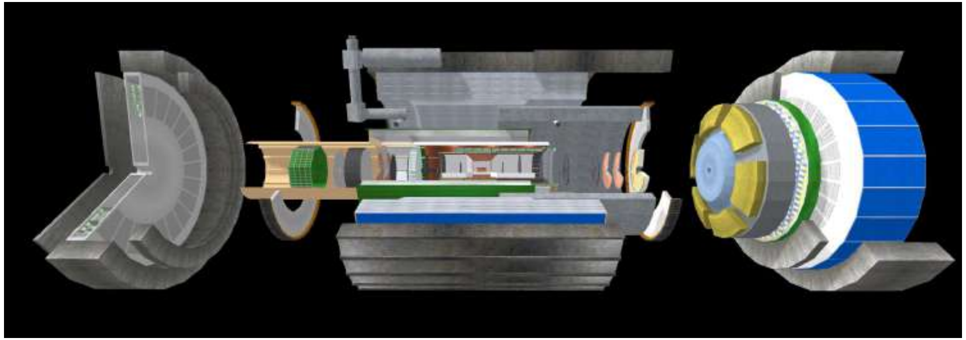
- First measurement of their type in eA
- Discovery of large nuclear effects that broaden azimuthal correlation (nuclear TMDs?)
- Indispensable reference for same measurements, at same Q2 but lower x at EIC

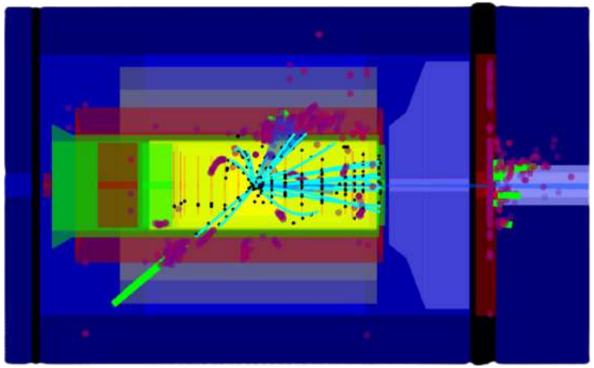
The next chapter in eA SIDIS

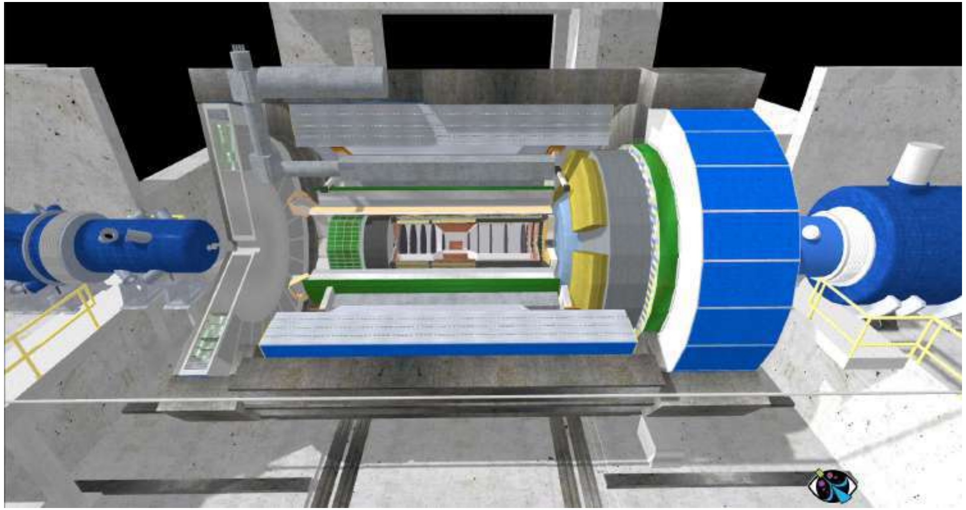
- Recent & Future experiments:
  - 11 GeV with polarized electron and heavy nuclear targets (50% in 2024)
  - 11 GeV polarized Li-7 & polarized electron (~2026)

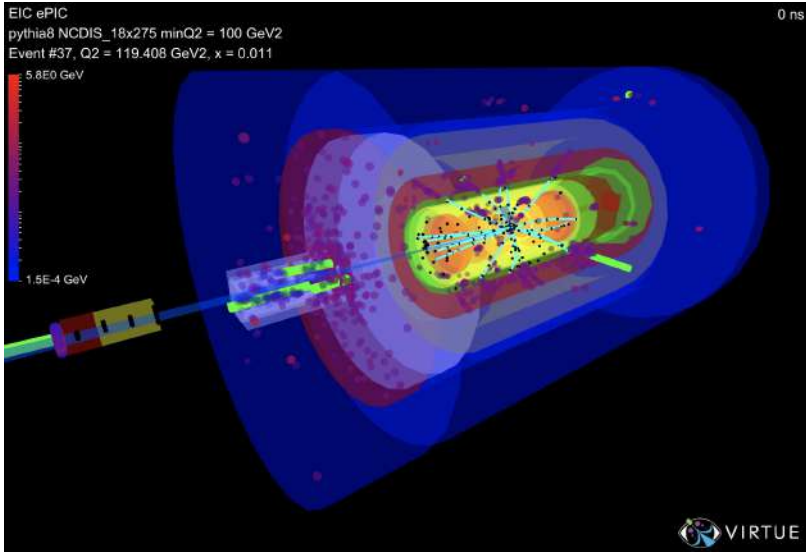






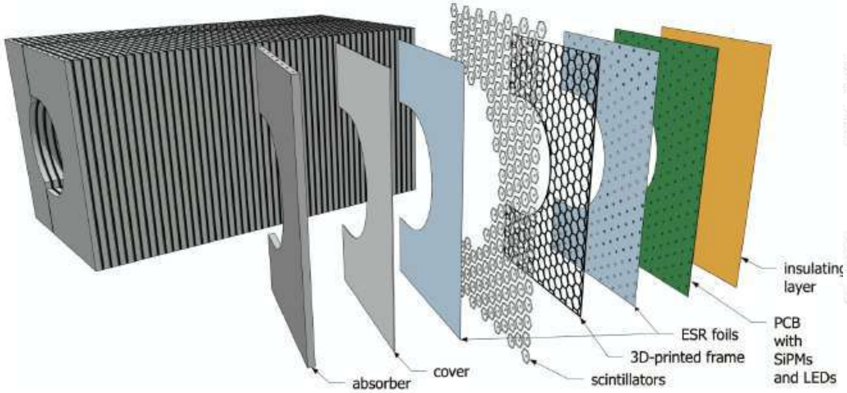


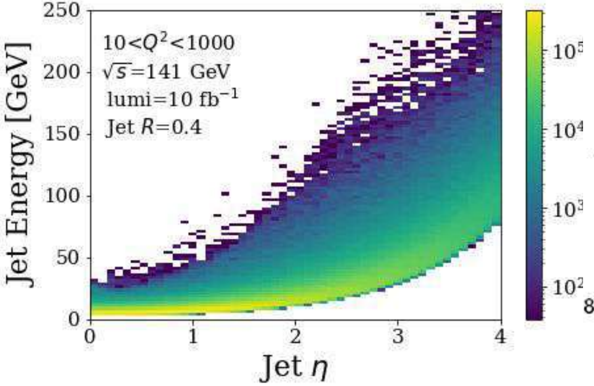


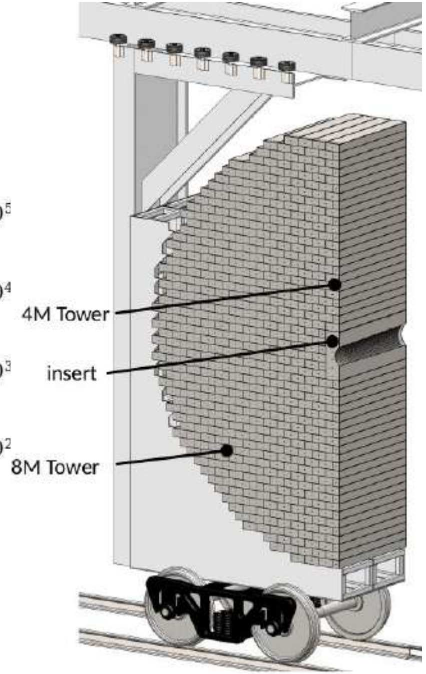

EIC ePIC
pythia8 NCDIS_18x275 minQ2 = 100 GeV2
Event #37, Q2 = 119.408 GeV2, x = 0.011
0 ns
5.8E0 GeV
1.5E-4 GeV
VIRTUE

The high-granularity Insert

The heart of forward HCAL covering 3.0<η<4.0







- First proposal of ePIC subdetector using SiPM-on-tile technology
- Key innovations:
  - Novel readout scheme avoids cooling in active volume,
  - Novel mechanical design achieves optimal acceptance,
  - Novel staggered-layer design improves angular resolution twofold.
- Spearheading high-granularity software reconstruction in ePIC

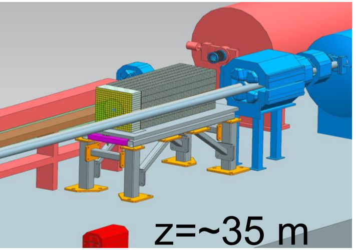
M. Arratia et al. NIMA 1047 (2023) 167866
S. Paul & M. Arratia, NIMA .A 1060 (2024) 169044
M. Arratia et al. JINST 18 (2023) 05, P05045
M. Arratia et al. Instruments 7 (2023) 43
F. Torales-Acosta et al. JINST 19 (2024) 06, P06002
F. Torales-Acosta et al. JINST 19 (2024) 05, P05003
M. Arratia et al. arXiv:2501.08586
J Huang et al. et al. arXiv:2503.14622

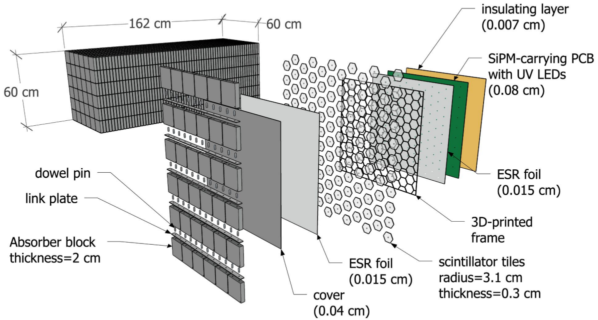
ZDC (η>6.0)

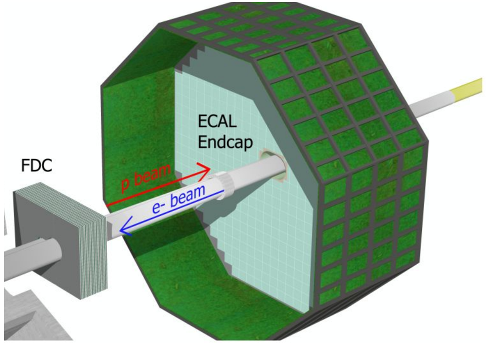
R. Milton et al. arXiv:2406.12877;
S. Paul et al. arXiv:2412.12346

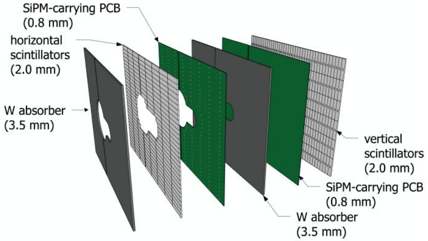
FDC (-4.7<η<-3.7)

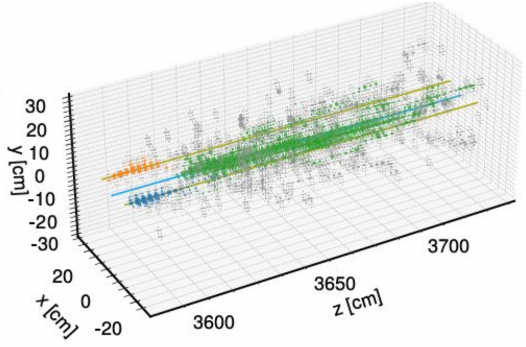
M. Arratia NIMA 1063 (2024) 169280

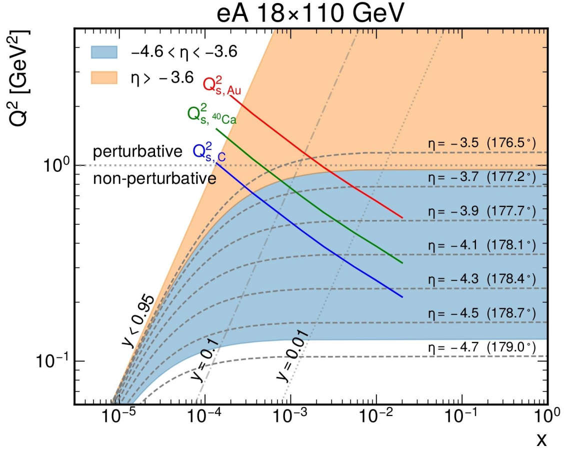












Thank you to my team at UCR, and to all my collaborators, and sponsors

clas ePIC H1

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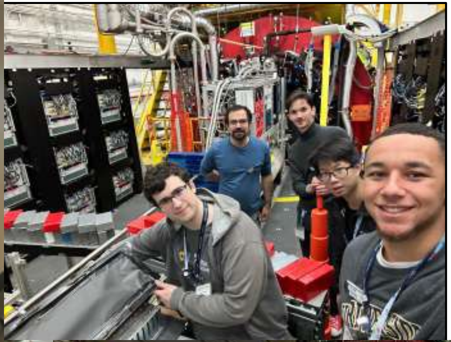
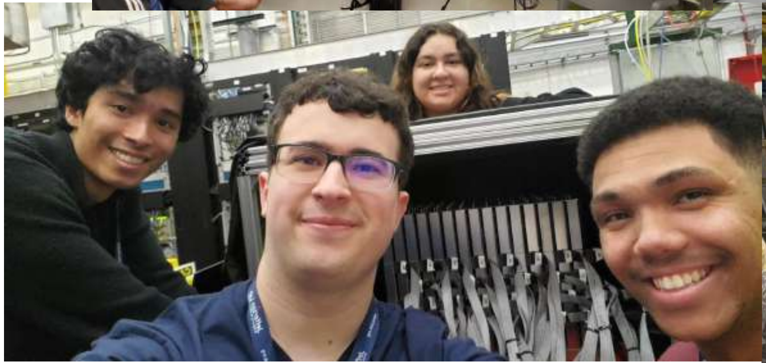
Brookhaven National Laboratory





Rene Poncelet

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Precision predictions for hadron collider physics

René Poncelet

THE HENRYK NIEWODNICZAŃSKI
INSTITUTE OF NUCLEAR PHYSICS
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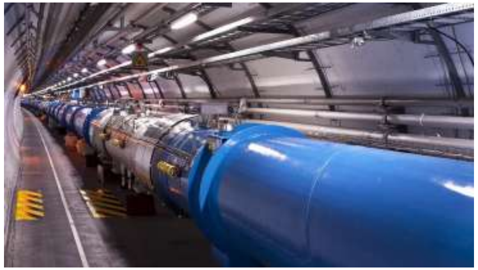
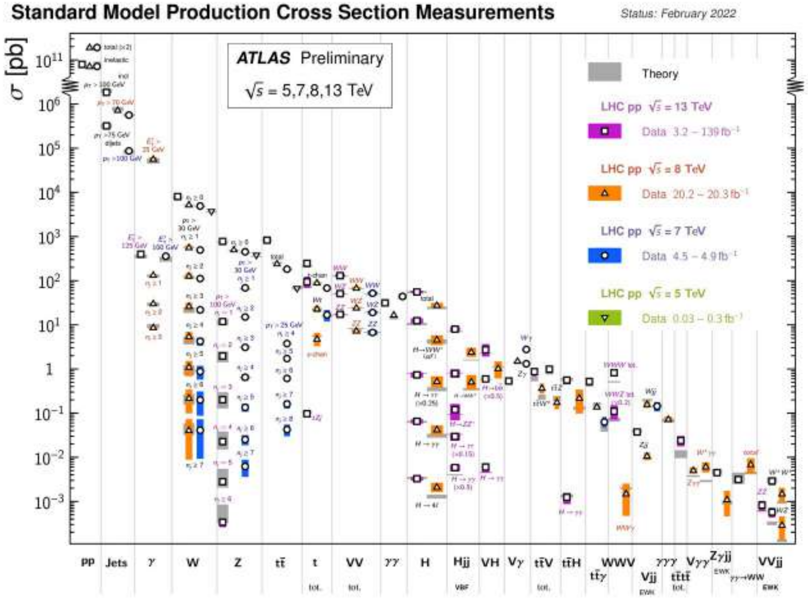
Standard Model phenomenology at the LHC

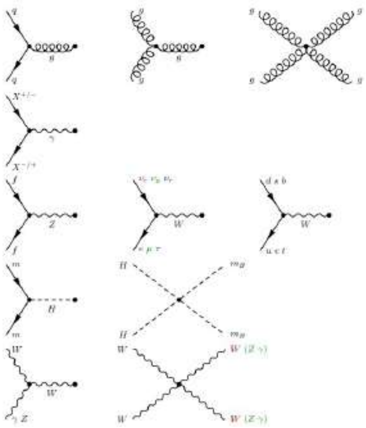
Scattering experiments



Credit: CERN

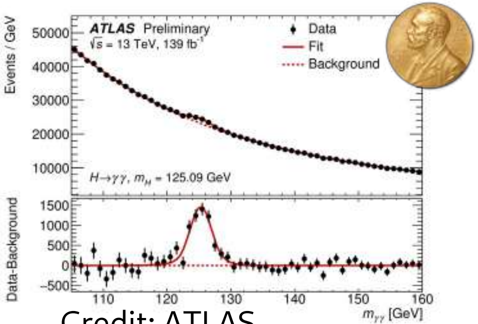


Theory/Model

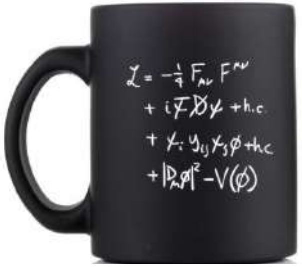


Credit: Jack Lindon, CERN

Higgs discovery 2012

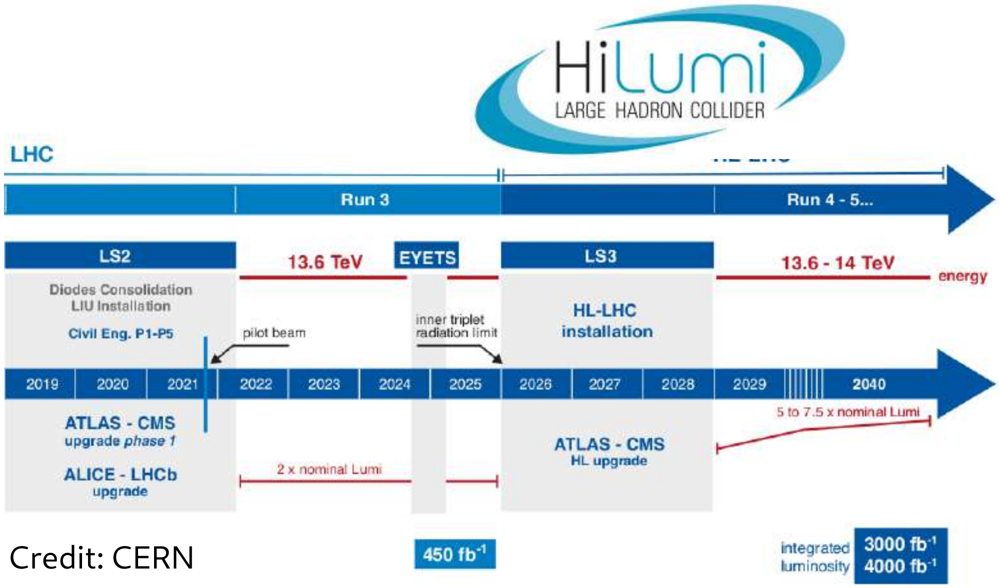


Credit: ATLAS



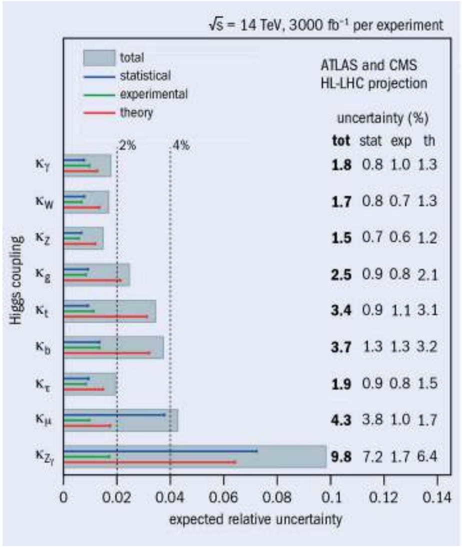
Credit: CERN

LHC Precision era and future experiments



Credit: CERN

Example:
projected Higgs couplings measurements



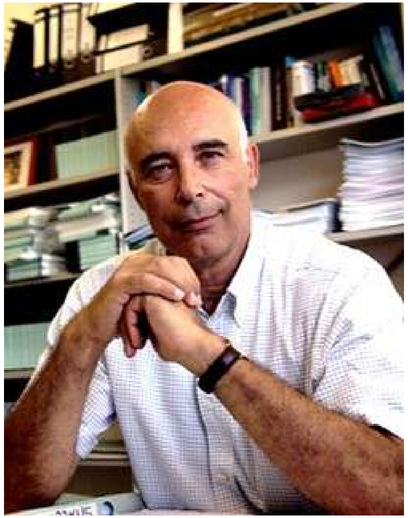
[1902.00134]

Theory input needed:

- Accurate → avoid wrong interpretation of excesses
- Precise → getting most out of our precious experiments

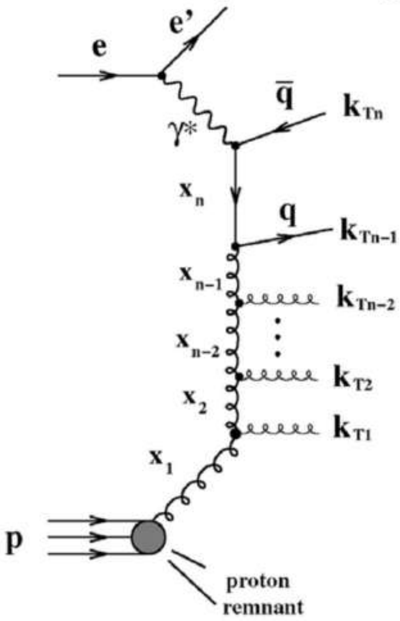
A pillar of precision phenomenology at hadron colliders

[Dokshitzer–Gribov–Lipatov–Altarelli–Parisi, ‘77]



DGLAP:

$$Q^2 \frac{\partial}{\partial Q^2} \begin{pmatrix} q_i(x,Q^2) \\ \bar{q}_i(x,Q^2) \\ g(x,Q^2) \end{pmatrix} = \frac{\alpha_s(Q^2)}{2\pi} \sum_j \int_x^1 \frac{d\xi}{\xi} \begin{pmatrix} P_{q_iq_j}(x/\xi) & 0 & P_{q_ig}(x/\xi) \\ 0 & P_{\bar{q}_i\bar{q}_j}(x/\xi) & P_{\bar{q}_ig}(x/\xi) \\ P_{gq_j}(x/\xi) & P_{g\bar{q}_j}(x/\xi) & P_{gg}(x/\xi) \end{pmatrix} \begin{pmatrix} q_j(\xi,Q^2) \\ \bar{q}_j(\xi,Q^2) \\ g(\xi,Q^2) \end{pmatrix}$$



[Zeus, hep-ph/0502029]

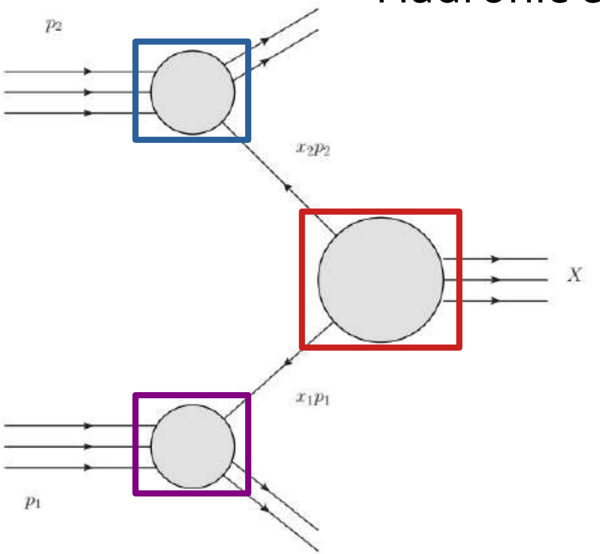
Evolution of the proton PDF with the energy:

→ Resummation of large logarithms from collinear emissions

→ correlation of processes at different energies
→ allows precise PDF determination

Basis of precision computation at hadron colliders today

Precision through higher orders



Hadronic cross section:

$$\sigma_{h_1h_2\to X} = \sum_{ij}\int_0^1\int_0^1 \mathrm{d}x_1\mathrm{d}x_2\phi_{i,h_1}(x_1,\mu_F^2)\phi_{j/h_2}(x_2,\mu_F^2)\hat{\sigma}_{ij\to X}(\alpha_s(\mu_R^2),\mu_R^2,\mu_F^2)$$

PDFs → DGLAP

Perturbative expansion of partonic cross section:

$$\hat{\sigma}_{ab\to X} = \underbrace{\alpha_s^0\hat{\sigma}^{(0)}_{ab\to X}}_{\text{Leading order}} + \underbrace{\alpha_s^1\hat{\sigma}^{(1)}_{ab\to X}}_{\text{Next-to-leading order}} + \underbrace{\alpha_s^2\hat{\sigma}^{(2)}_{ab\to X}}_{\text{Next-to-next-to-leading order}} + \mathcal{O}(\alpha_s^3)$$

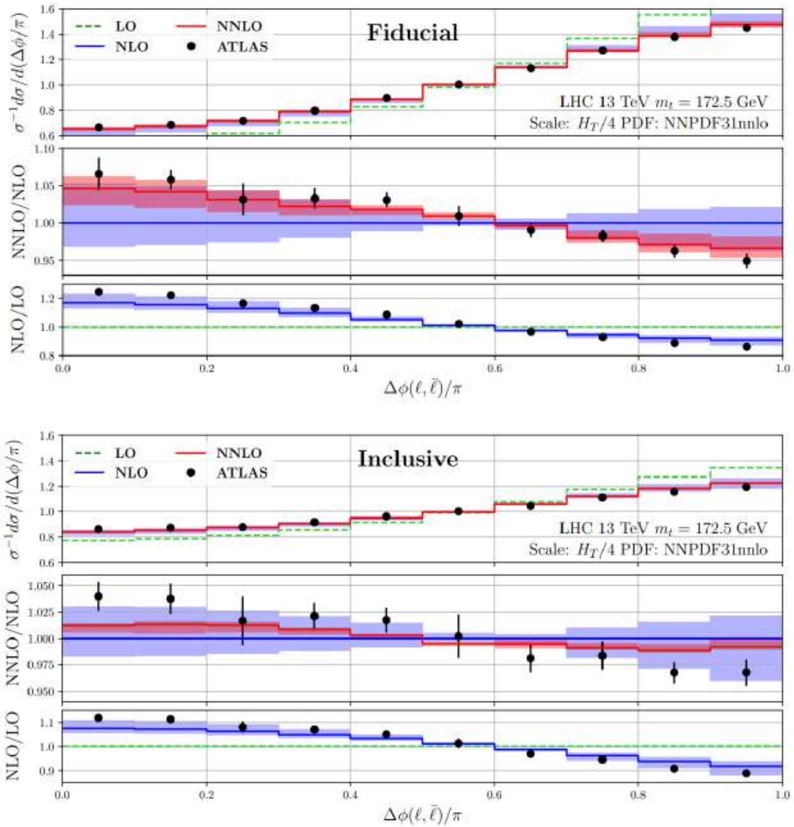
Uncertainty: $\alpha_s(m_Z) \approx 0.118$ | Order of magnitude | O(10%) | O(1%)

Next-to-next-to-leading order QCD needed to match experimental precision!
→ in some cases even next-to-next-to-next-to-leading order!

Accurate predictions, example: spin-correlations

[Behring, Czakon, Mitov, Papanastasiou, Poncelet'19
Czakon, Mitov, **Poncelet** '21]

Azimuthal correlations for leptons



Spin-density-matrix

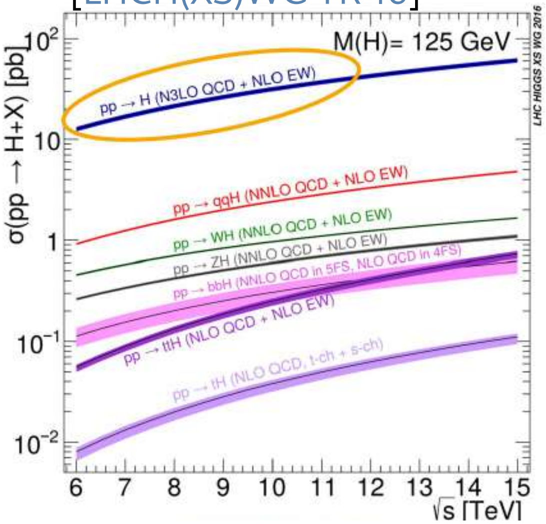
$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta_1^i\, d\cos\theta_2^j} = \frac{1}{4}\left(1 + B_1^i \cos\theta_1^i + B_2^j \cos\theta_2^j - C_{ij}\cos\theta_1^i \cos\theta_2^j\right)$$

Coefficient	LO ($\times 10^3$)	NLO ($\times 10^3$)	NNLO ($\times 10^3$)	CMS ($\times 10^3$)
B_1^k	1^{+0}_{-0} [sc] ± 1 [mc]	1^{+0}_{-1} [sc] ± 2 [mc]	-1^{+0}_{-1} [sc] ± 4 [mc]	5 ± 23
B_1^r	0^{+0}_{-0} [sc] ± 1 [mc]	0^{+1}_{-0} [sc] ± 2 [mc]	0^{+1}_{-2} [sc] ± 2 [mc]	-23 ± 17
B_1^n	0^{+0}_{-0} [sc] ± 1 [mc]	3^{+1}_{-1} [sc] ± 1 [mc]	4^{+1}_{-0} [sc] ± 3 [mc]	6 ± 13
B_2^k	0^{+0}_{-0} [sc] ± 1 [mc]	0^{+0}_{-1} [sc] ± 1 [mc]	-5^{+2}_{-3} [sc] ± 3 [mc]	7 ± 23
B_2^r	0^{+0}_{-0} [sc] ± 1 [mc]	0^{+2}_{-0} [sc] ± 1 [mc]	-2^{+0}_{-1} [sc] ± 2 [mc]	-10 ± 20
B_2^n	0^{+0}_{-0} [sc] ± 1 [mc]	-2^{+0}_{-1} [sc] ± 1 [mc]	-3^{+1}_{-0} [sc] ± 3 [mc]	17 ± 13
C_{kk}	324^{+7}_{-7} [sc] ± 1 [mc]	330^{+2}_{-2} [sc] ± 3 [mc]	323^{+2}_{-5} [sc] ± 6 [mc]	300 ± 38
C_{rr}	6^{+5}_{-5} [sc] ± 1 [mc]	58^{+18}_{-12} [sc] ± 2 [mc]	69^{+8}_{-7} [sc] ± 3 [mc]	81 ± 32
C_{nn}	332^{+1}_{-0} [sc] ± 1 [mc]	330^{+1}_{-1} [sc] ± 2 [mc]	326^{+1}_{-1} [sc] ± 4 [mc]	329 ± 20
$C_{nr} + C_{rn}$	1^{+0}_{-0} [sc] ± 1 [mc]	-1^{+1}_{-0} [sc] ± 3 [mc]	-4^{+4}_{-0} [sc] ± 6 [mc]	-4 ± 37
$C_{nr} - C_{rn}$	0^{+0}_{-1} [sc] ± 1 [mc]	-1^{+1}_{-0} [sc] ± 2 [mc]	2^{+4}_{-2} [sc] ± 8 [mc]	-1 ± 38
$C_{nk} + C_{kn}$	0^{+0}_{-0} [sc] ± 1 [mc]	2^{+1}_{-0} [sc] ± 1 [mc]	3^{+4}_{-1} [sc] ± 3 [mc]	-43 ± 41
$C_{nk} - C_{kn}$	1^{+0}_{-0} [sc] ± 1 [mc]	1^{+1}_{-1} [sc] ± 2 [mc]	6^{+0}_{-2} [sc] ± 7 [mc]	40 ± 29
$C_{rk} + C_{kr}$	-229^{+4}_{-4} [sc] ± 1 [mc]	-203^{+9}_{-7} [sc] ± 2 [mc]	-194^{+8}_{-6} [sc] ± 7 [mc]	-193 ± 64
$C_{rk} - C_{kr}$	1^{+0}_{-0} [sc] ± 1 [mc]	1^{+0}_{-1} [sc] ± 4 [mc]	-1^{+1}_{-3} [sc] ± 5 [mc]	57 ± 46

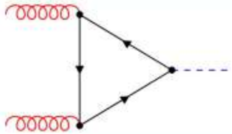
[CMS 1907.03729]

Precision example: Quark-mass effects in Higgs production

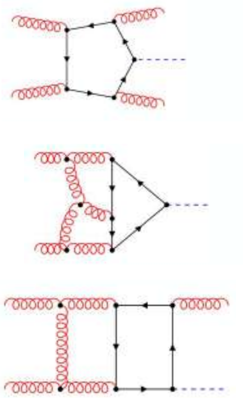
[LHCH(XS)WG YR'16]



Higgs-production in gluon fusion, main uncertainties:



δ(scale)	δ(trunc)	δ(PDF-TH)	δ(EW)	$\delta(t,b,c)$	$\delta(1/m_t)$
$+0.10$ pb -1.15 pb	± 0.18 pb	± 0.56 pb	± 0.49 pb	± 0.40 pb	± 0.49 pb
$+0.21\%$ -2.37%	$\pm 0.37\%$	$\pm 1.16\%$	$\pm 1\%$	$\pm 0.83\%$	$\pm 1\%$



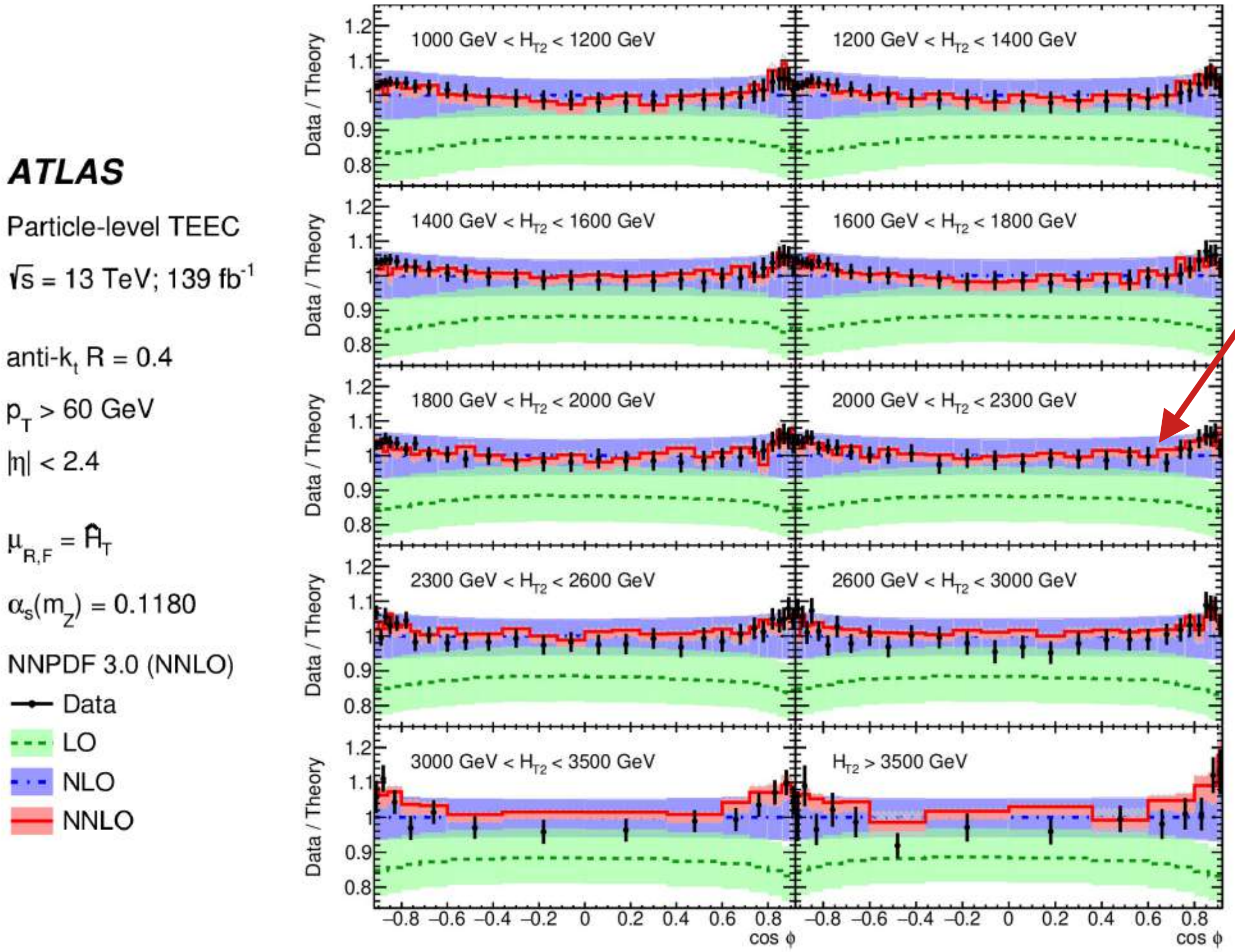
Renorm. scheme	$\overline{\text{MS}}$	on-shell
$\mathcal{O}(\alpha_s^2)$	-1.11	-1.98
LO	$-1.11^{+0.28}_{-0.43}$	$-1.98^{+0.38}_{-0.53}$
$\mathcal{O}(\alpha_s^3)$	-0.65	-0.44
NLO	$-1.76^{+0.27}_{-0.28}$	$-2.42^{+0.19}_{-0.12}$
$\mathcal{O}(\alpha_s^4)$	$+0.02$	$+0.43$
NNLO	$-1.74(2)^{+0.13}_{-0.03}$	$-1.99(2)^{+0.29}_{-0.15}$

Second-order corrections to top-bottom interference effects with full mass dependence!

[Czakon, Eschment, Niggetiedt, **Poncelet**, Schellenberger: 2312.09896, 2407.12413]

$\overline{\text{MS}}$ vs. on-shell scheme:
→ first agreement at NNLO!

Precision example: strong-coupling from TEEC



NNLO QCD for three jets

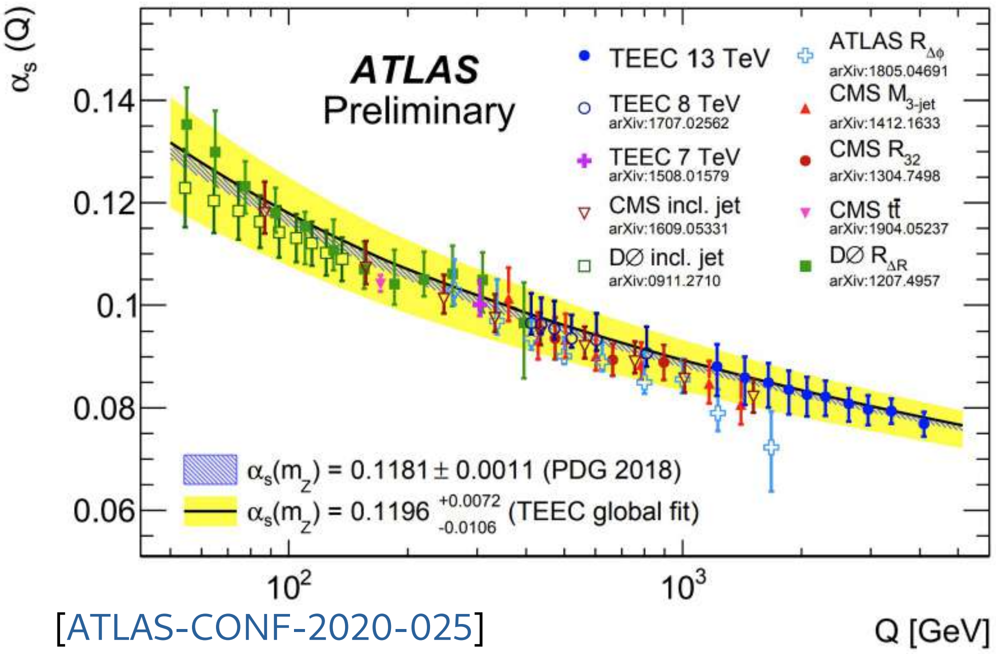
- [Czakon, Mitov, **Poncelet** 2106.05331]
- [Alvarez, Cantero, Czakon, Llorente, Mitov, **Poncelet** 2301.01086]

ATLAS: α_s extraction

- [ATLAS 2301.09351]

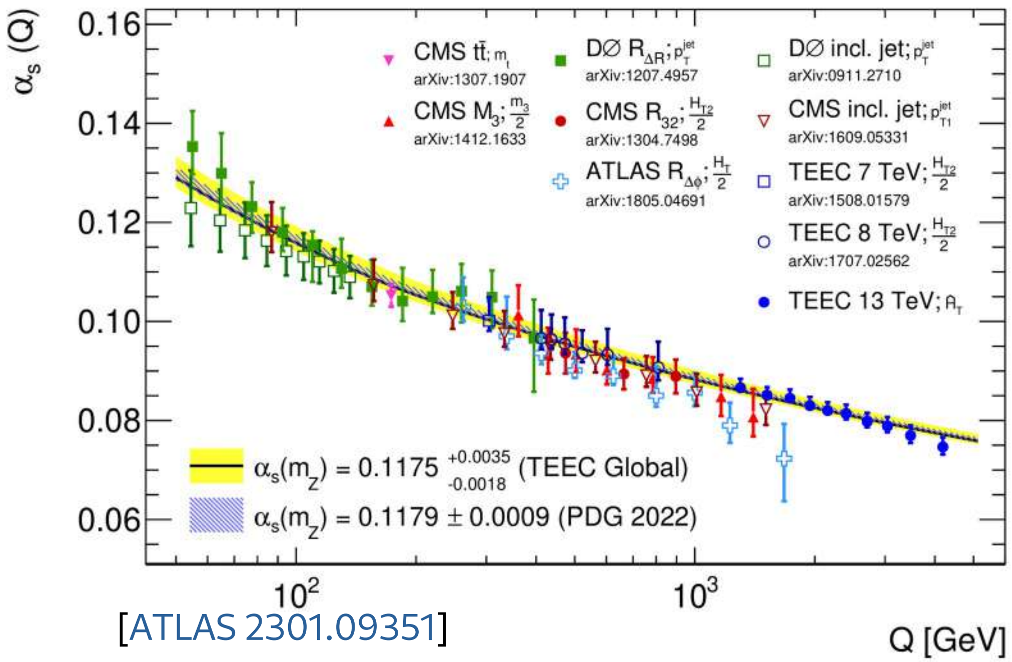
Precision example: strong-coupling from TEEC

NLO QCD



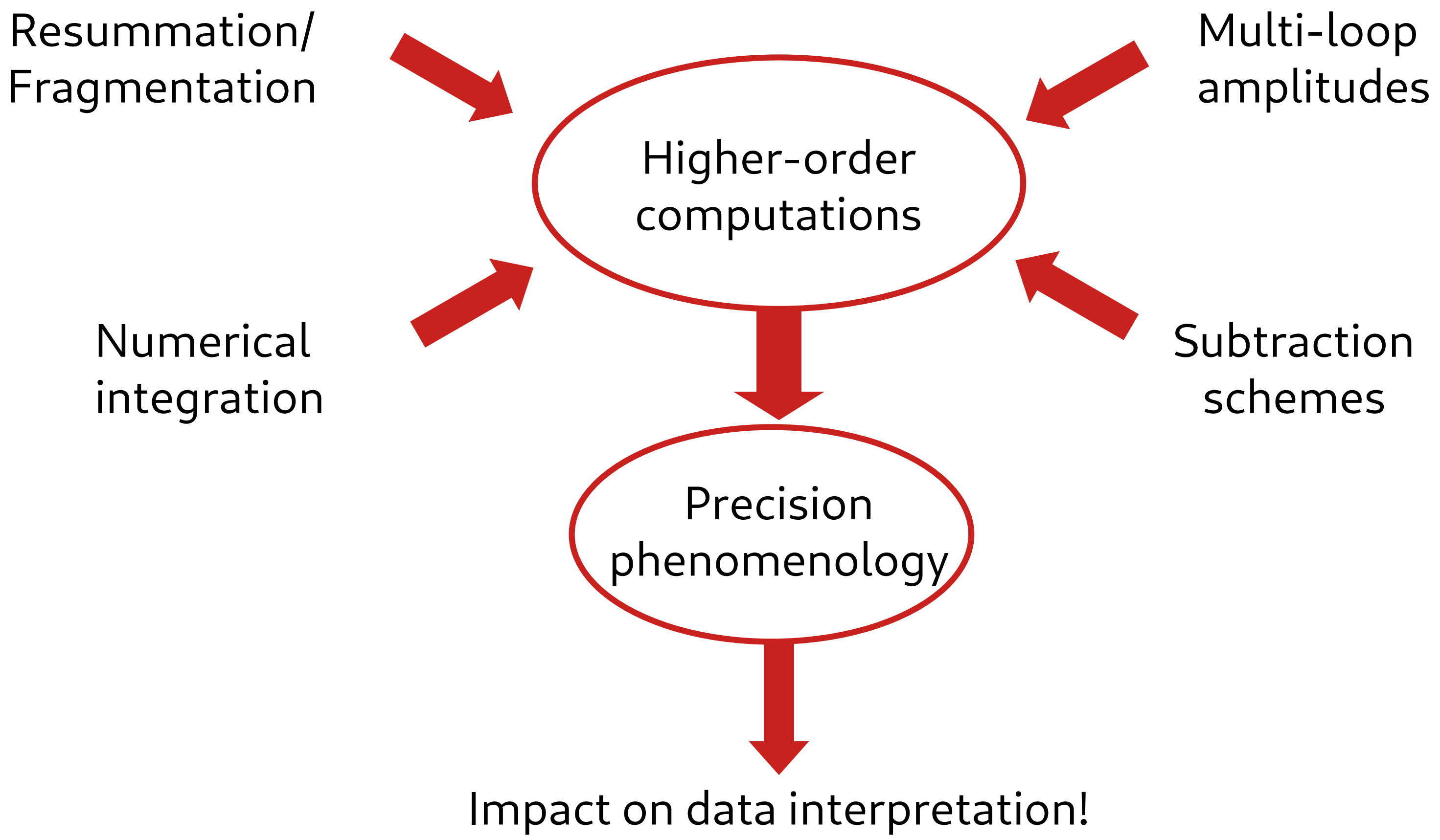
[ATLAS-CONF-2020-025]

NNLO QCD



[ATLAS 2301.09351]

From calculations to phenomenology



Conclusions

Predictions are essential for data interpretation. We need them

- accurate → avoid wrong interpretation of excesses
- precise → getting most out of our precious experiments

QCD calculations went a long way from ‘77 to today:

→ Miles stones like NNLO QCD multi-jet production and
N3LO QCD for simple inclusive processes

→ Next challenge: full automation of NNLO QCD and incorporation into Monte Carlos
(main bottlenecks: multi-loop amplitudes, parton-shower matching)

→ A lot of space for surprises and novel ideas!

Many thanks to all my collaborators,
in particular to my mentors Michal Czakon and Alexander Mitov!

Thank you!