Jet/HF/EW/BSM

Weekly meetings: Tuesday's starting at 13:30 EDT

Indico: https://indico.bnl.gov/category/367

Mailing list:
https://lists.bnl.gov/mailman/listinfo/eic-ip6-phys-jet-hq-l
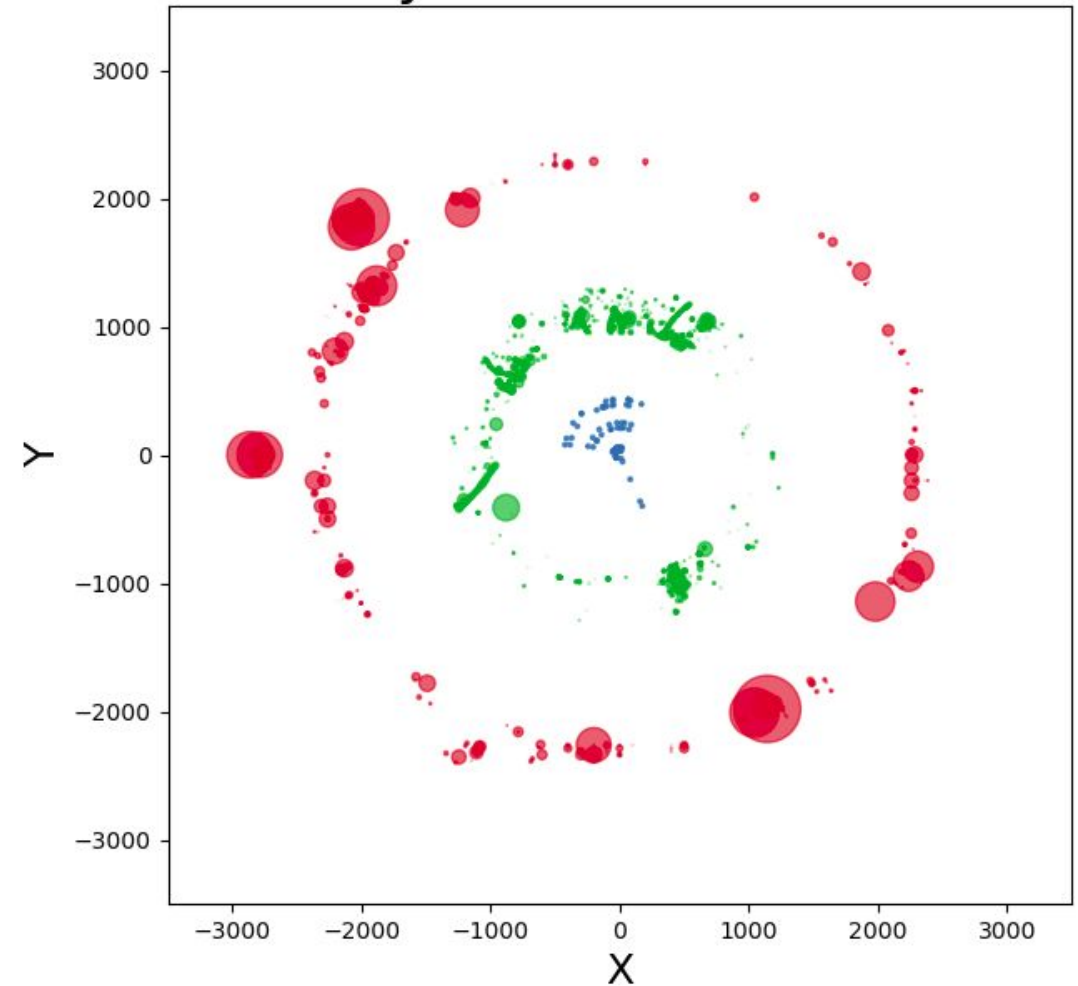
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ATHENA Bi-weekly Meeting, June 24th 2021

ATHENA simulation
Pythia8 + Geant4

The Proposals should include two parts:

1. A description of the science addressed and performance estimated through simulation including, but not limited to, e/γ, jets, π/K/p separation, vertex, and tracking, and how the simulated performance compares to the requirements detailed in the YR. The realization of the conceptual detector design given the technology choices, the R&D needs, risks, and, if applicable, adoption of emerging new technologies.

Performance plots relevant for this group (there is overlap with other groups)

❏ We have identified some of the 'low-level' plots , which seem required by proposal, that are relevant for our group

1 Secondary vertex performance (resolution)

2 Hadronic-final-state reconstruction (energy-flow algorithm)

2 Jet performance (resolution and bias) with energy-flow, calorimetric reco. PID for 4-vectors (?).

3 Charm-jet performance (tagging efficiency/mis-id)

Golden channels

❑ Golden Channel = Important results that we need to demonstrate that we can measure well

❑ We have identified several golden channels candidates– obviously not all of these can make it into proposal plots, but we need to prove we can do them and describe any issues in the proposal text

- **Heavy-flavour channels**
    - F_2^c
    - A_{LL} heavy quark
    - charm meson and charm-jet R_{eA}.

- **Lepton-jet and dijet correlations:**
    - quark-Sivers and gluon-Sivers [DIS]
    - low-x, Wigner function [diffractive DIS]
    - ΔG, photon structure [photo-production, DIS]
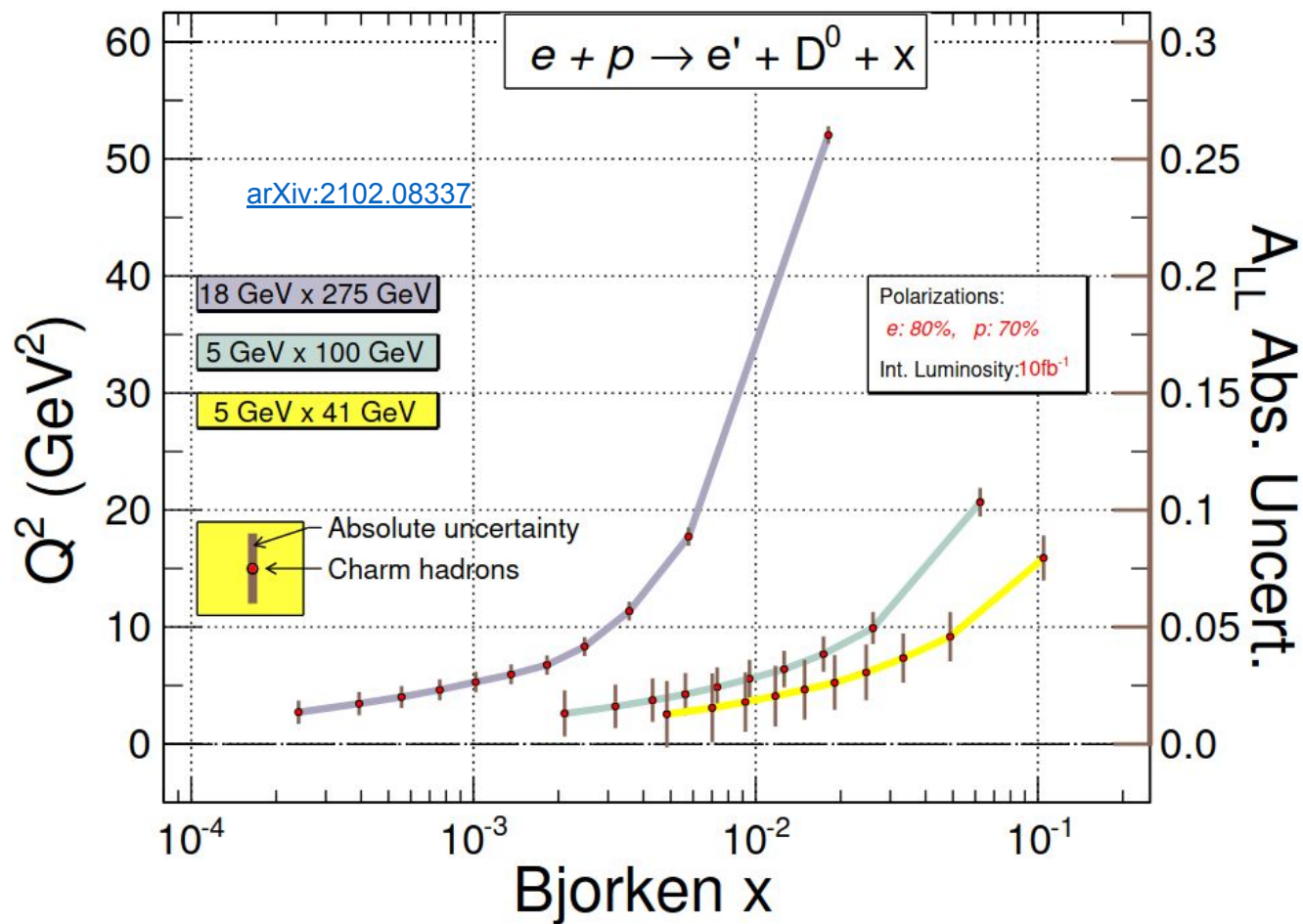   - Cold-nuclear matter [(n)DIS]

- **Jet substructure and event-shapes**
    - Hadron-in-jet Collins [DIS].
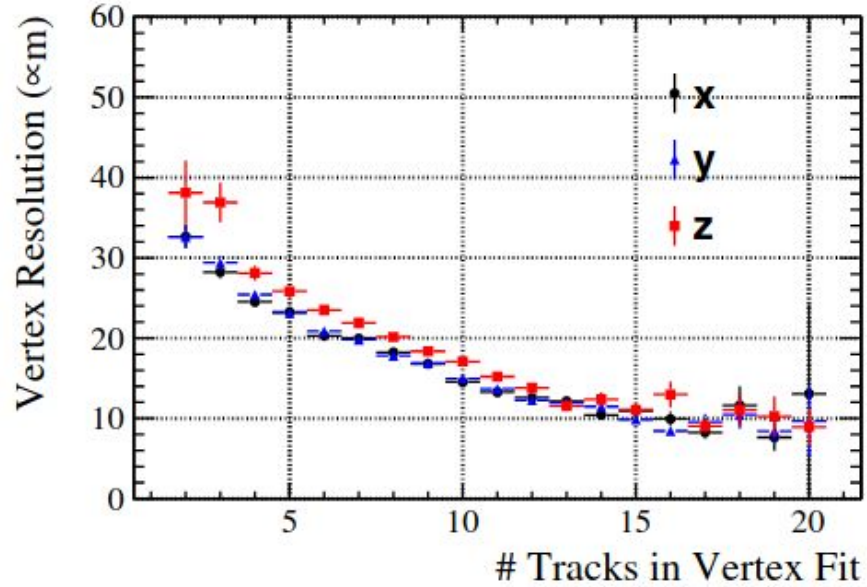   - Hadronization studies with angularities, correlations. [(n)DIS]

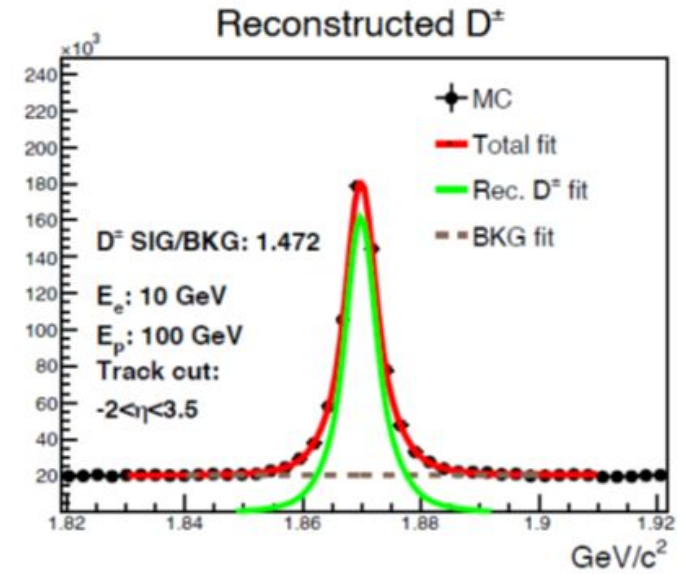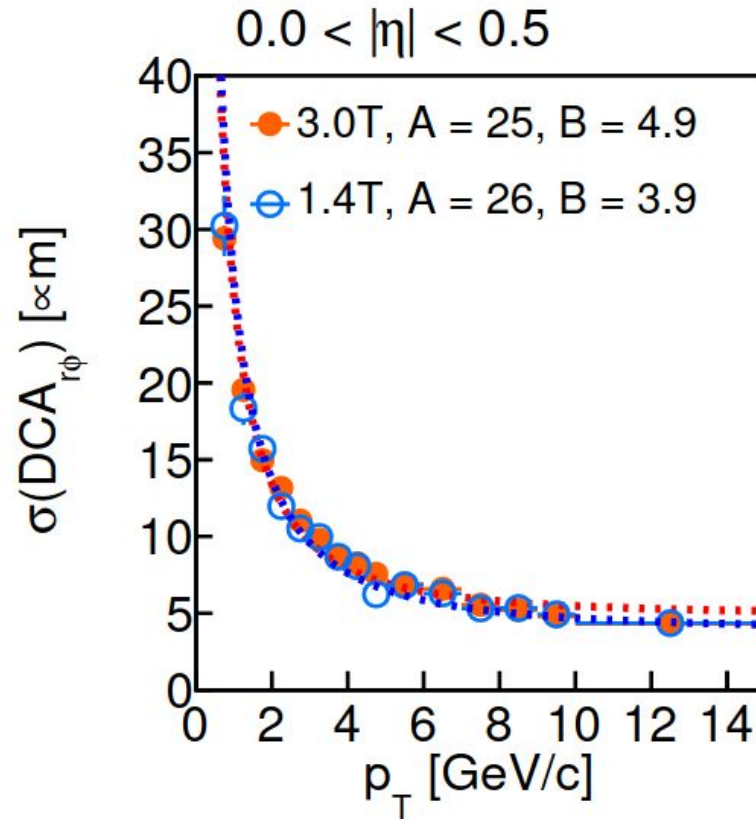- **Electroweak/BSM**
    - EW Structure functions [CC DIS].

Heavy-flavour

$e + p \rightarrow e' + D^0 + x$

arXiv:2102.08337

18 GeV x 275 GeV

5 GeV x 100 GeV

5 GeV x 41 GeV

Polarizations:
e: 80%, p: 70%
Int. Luminosity:10fb^{-1}

Absolute uncertainty
Charm hadrons

Q^2 (GeV^2)

A_{LL} Abs. Uncert.

Bjorken x

e+Au

√s = 31.6 GeV
√s = 44.7 GeV
√s = 89.4 GeV
CT14NLO+EPPS16

arXiv:1708.01527

∫Ldt = 10 fb^{-1}/A

$Q^2 = 139$ GeV^2

$Q^2 = 4.4$ GeV^2

$\sigma_{red}^{c\bar{c}}(x,Q^2)$

x
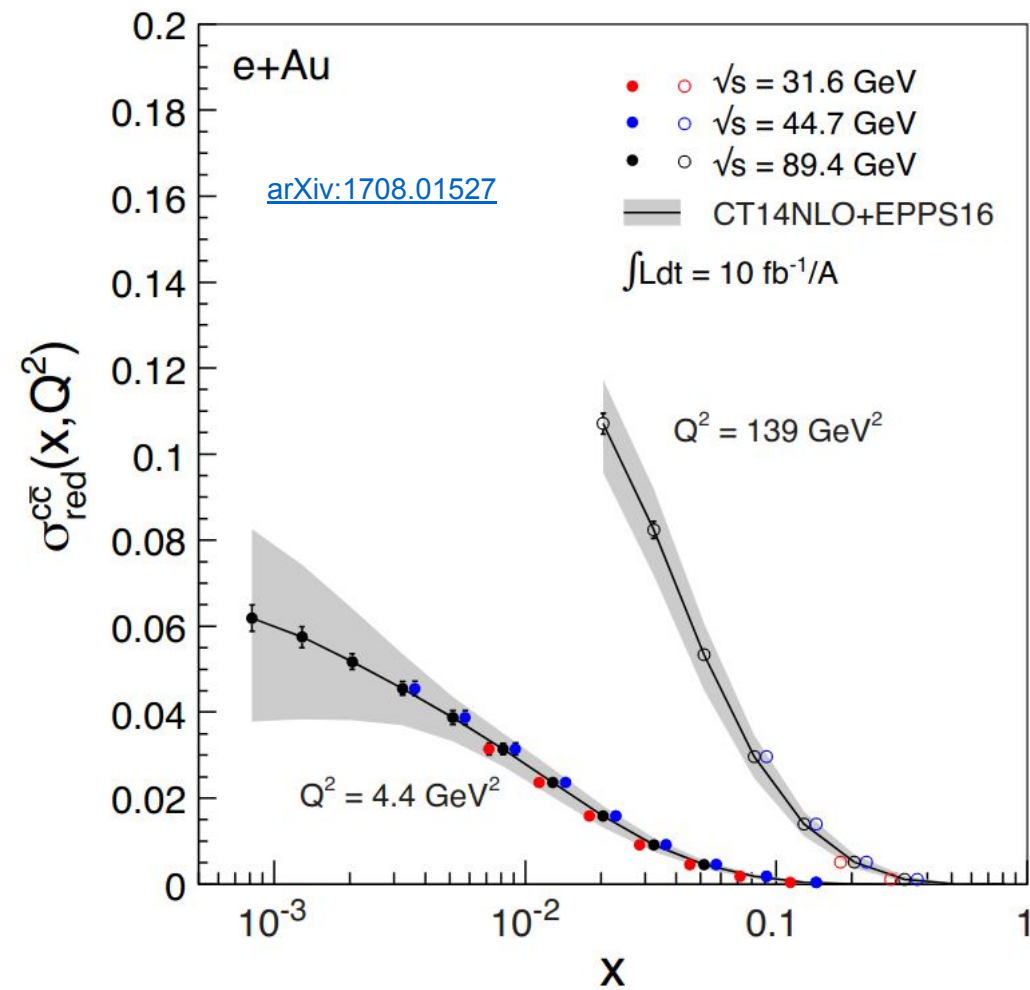
Tracking, vertexing performance plots, e.g.

arXiv:2102.08337
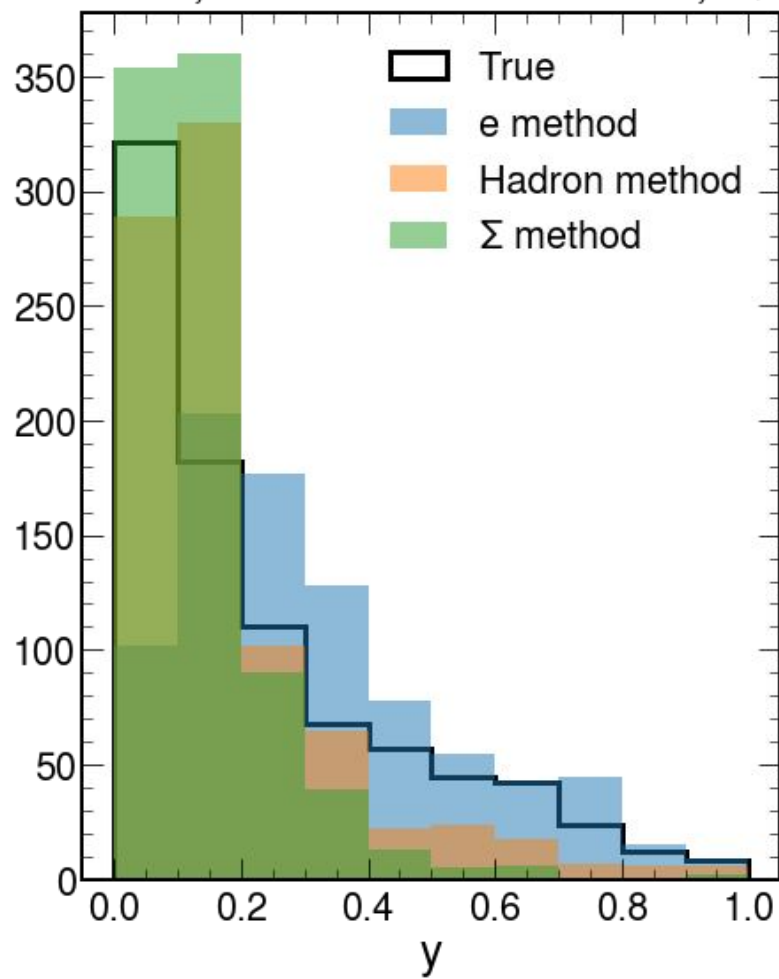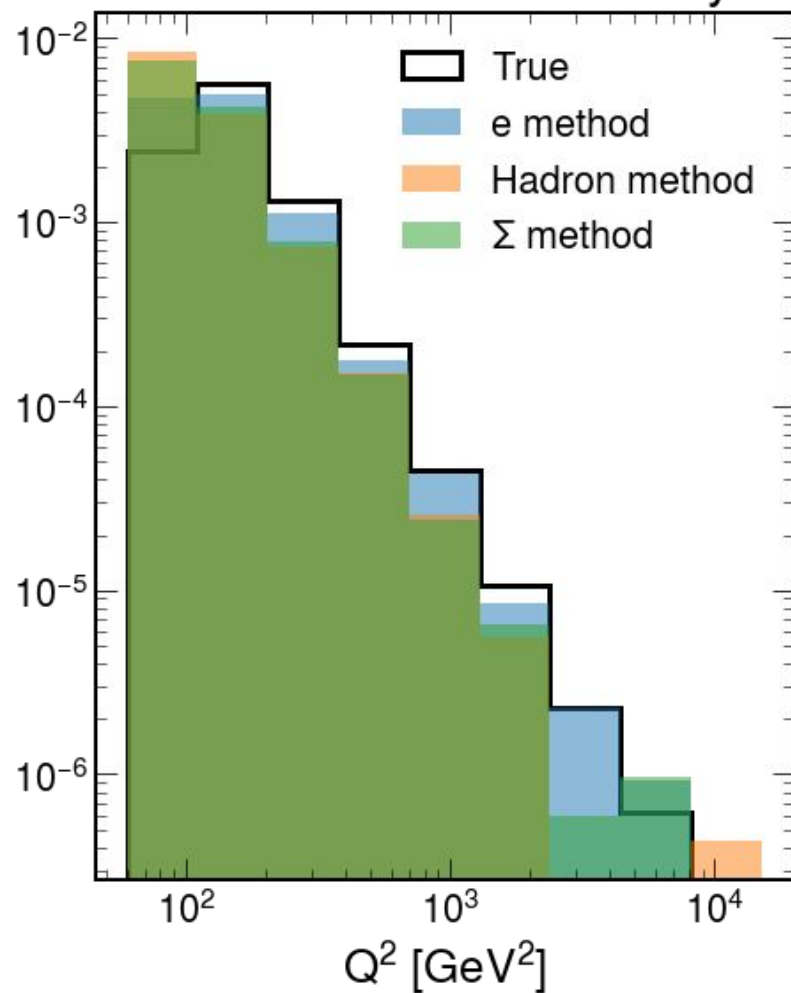
Measuring the "hadronic final state" is essential to

1) Reconstruct DIS variables in neutral-current DIS (lepton alone not enough)
2) Reconstruct DIS variables in charged-current DIS (neutrino in final state)
3) Jets, Missing energy, event shapes, rapidity gaps, etc.

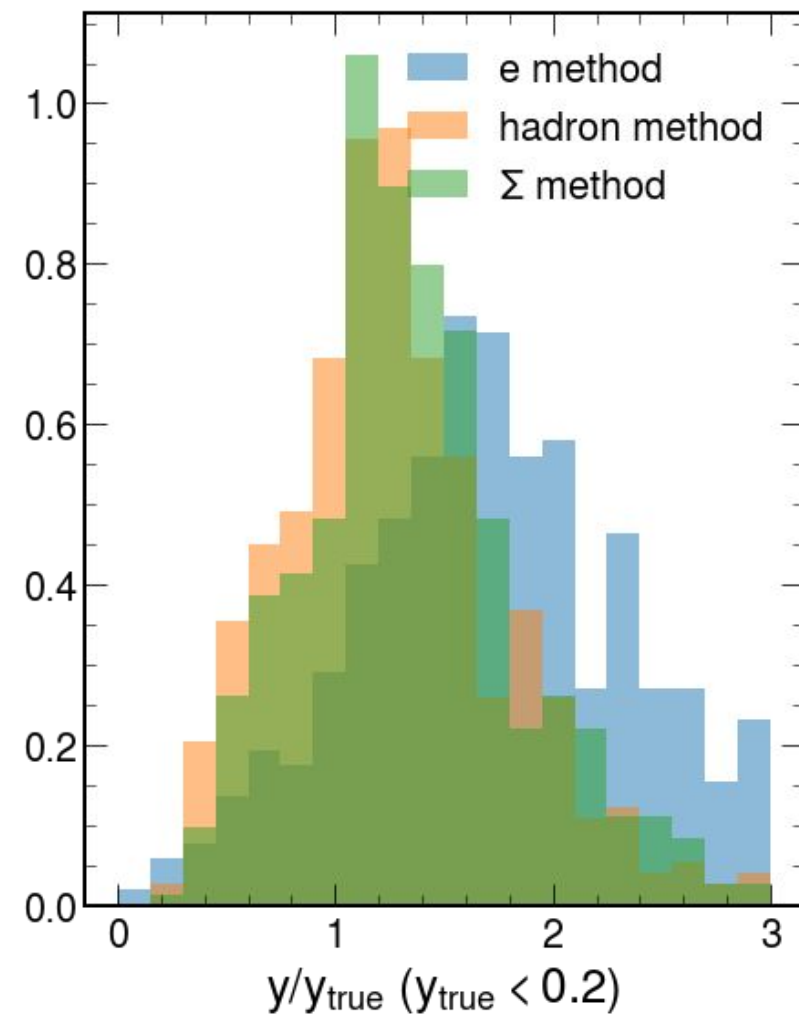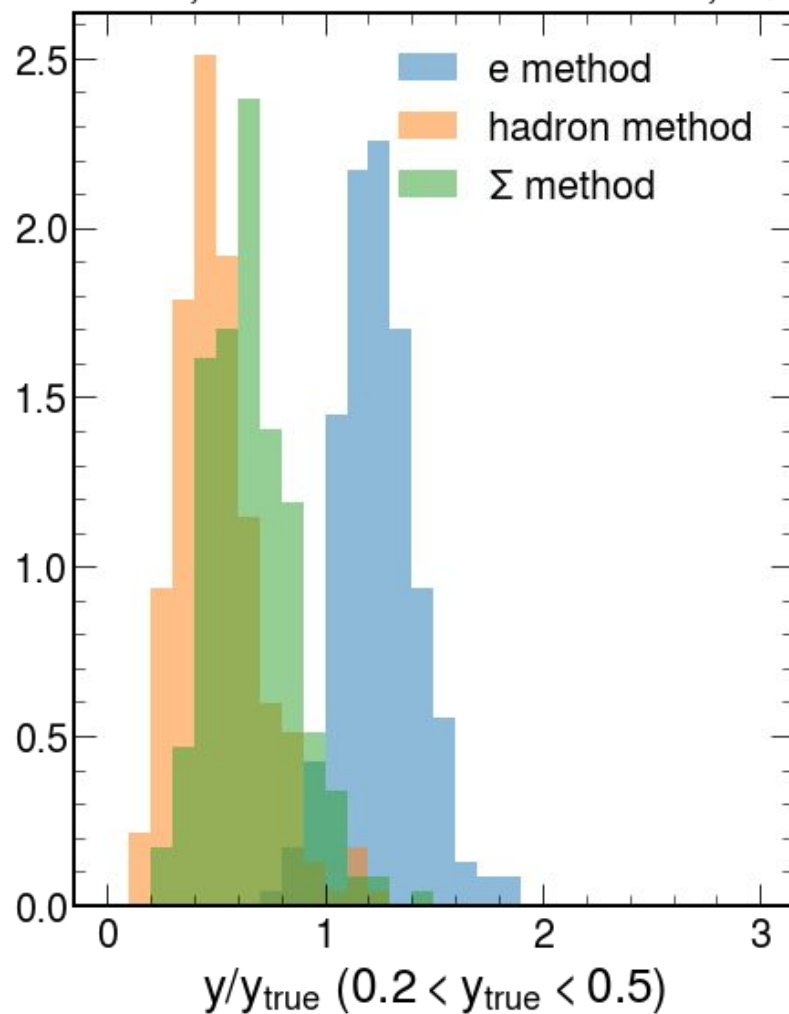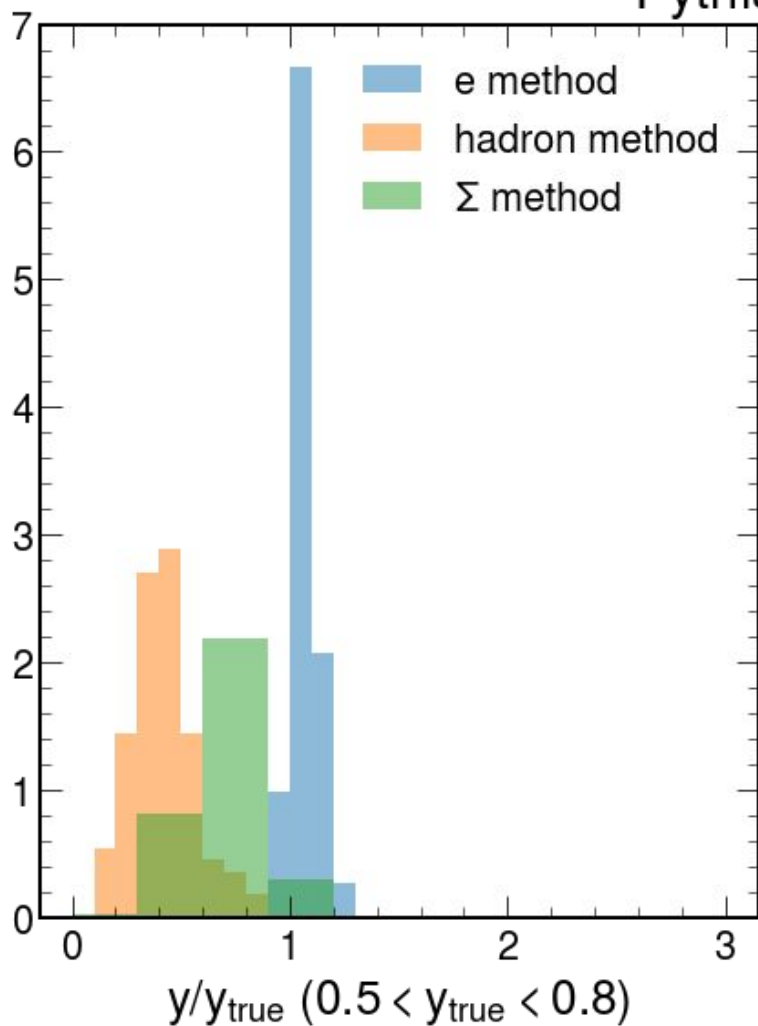**All of these are HFS measurements.**
Jets are subset of HFS.
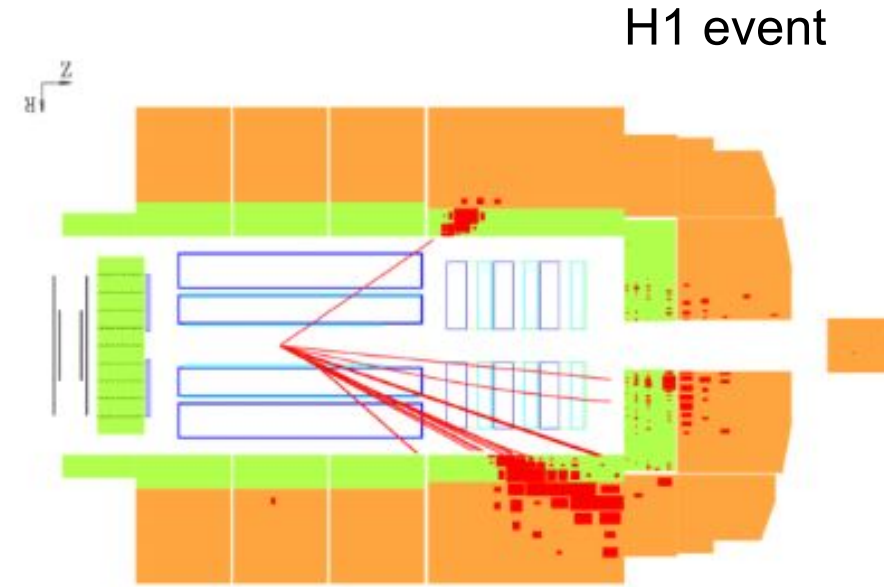
ATHENA full simulation [DD4hep]
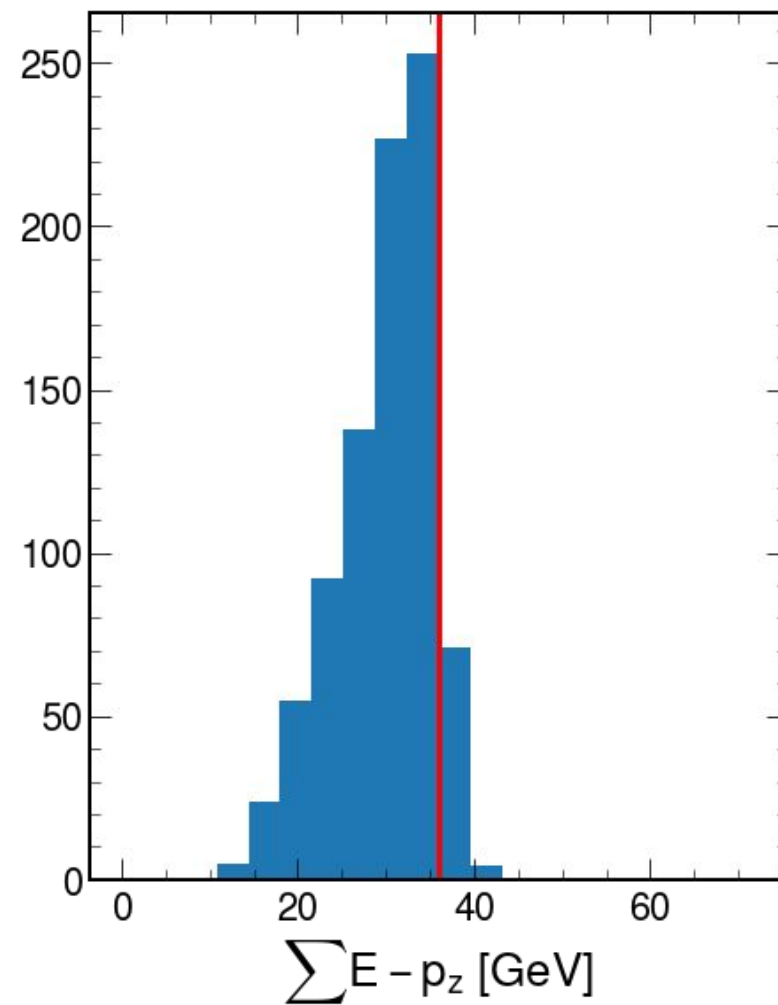
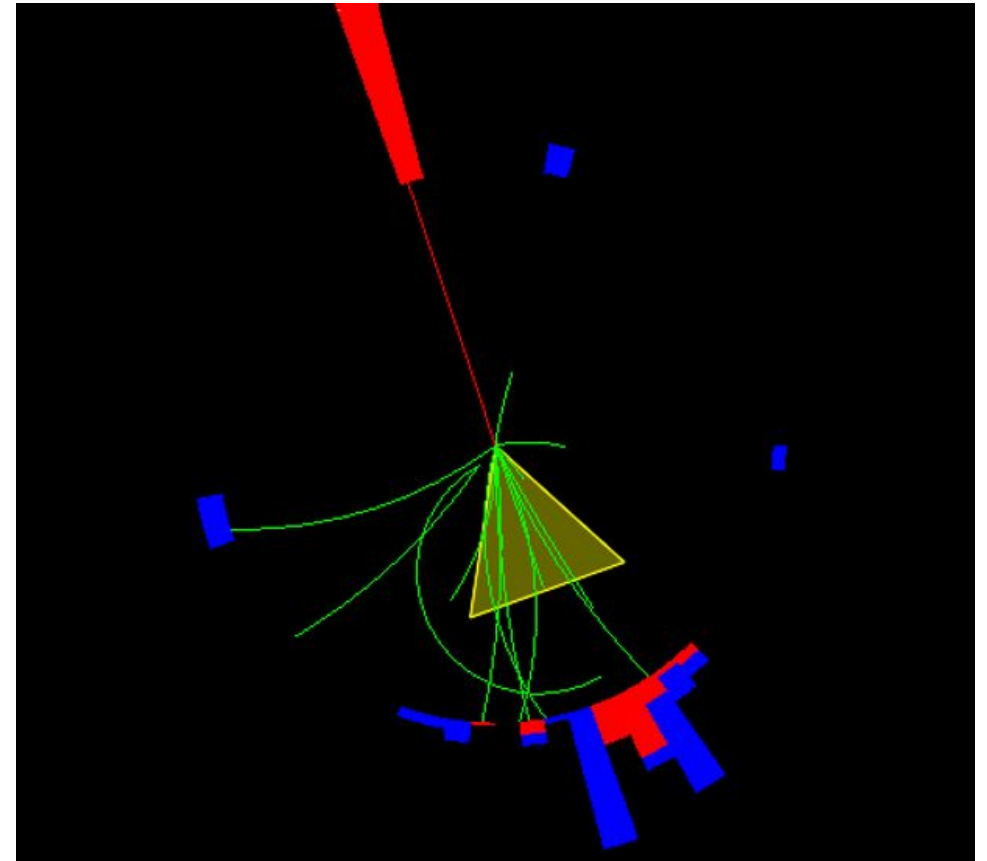Pythia8+Geant4, NC DIS 18x275 GeV, $Q^2 > 100$ GeV^2

Left panel legend:
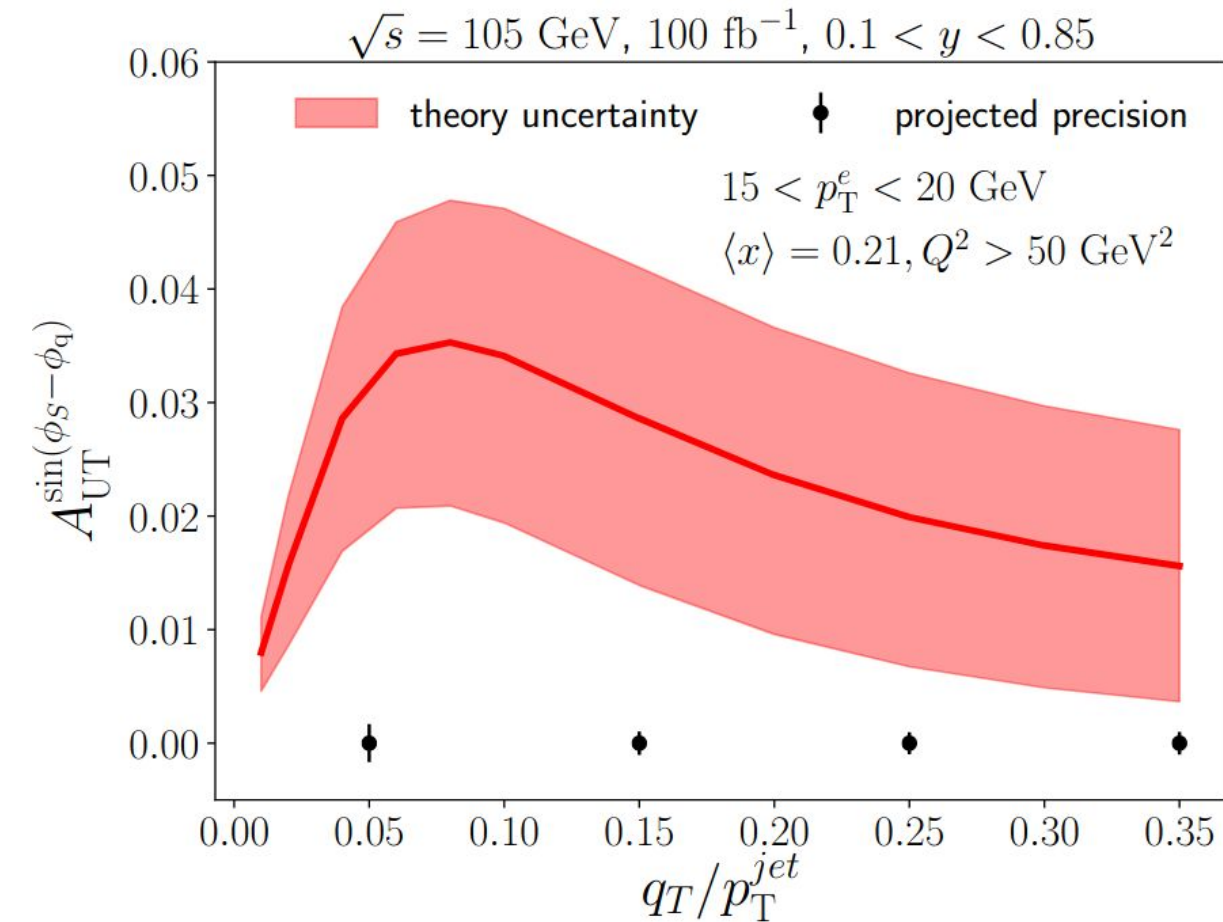- True
- e method
- Hadron method
- Σ method

x-axis: Q^2 [GeV^2]

Middle panel legend:
- True
- e method
- Hadron method
- Σ method

x-axis: y

Right panel x-axis: $\sum E - p_z$ [GeV]

ATHENA full simulation [DD4hep]

Pythia8+Geant4, NC DIS 18x275 GeV, $Q^2 > 100$ GeV^2

y/y$_{true}$ (0.5 < y$_{true}$ < 0.8)

y/y$_{true}$ (0.2 < y$_{true}$ < 0.5)

y/y$_{true}$ (y$_{true}$ < 0.2)

e method
hadron method
Σ method

Jet kinematics measurements, e.g. **Lepton- Jet Sivers asymmetry**

$\sqrt{s} = 105$ GeV, 100 fb^{-1}, $0.1 < y < 0.85$

theory uncertainty   projected precision

$15 < p_T^e < 20$ GeV

$\langle x \rangle = 0.21$, $Q^2 > 50$ GeV^2

$A_{UT}^{\sin(\phi_S - \phi_q)}$

q_T / p_T^{jet}

-
- Addresses NAS/White-Paper with new tools
- Requires energy and angle of jets (4-vector)

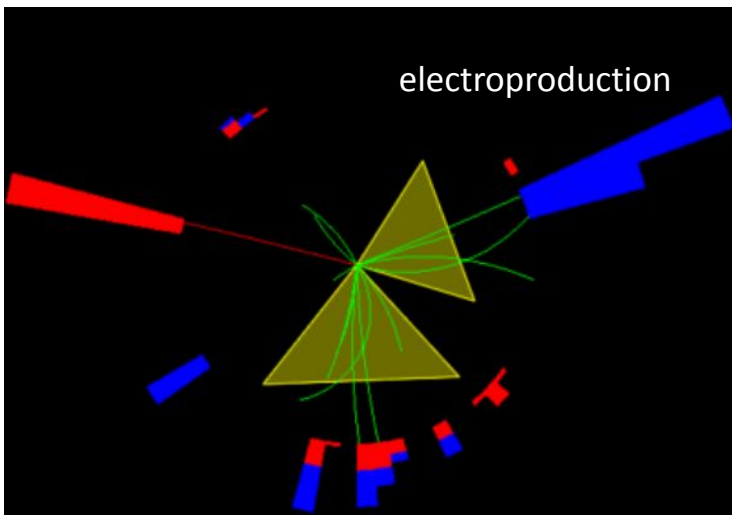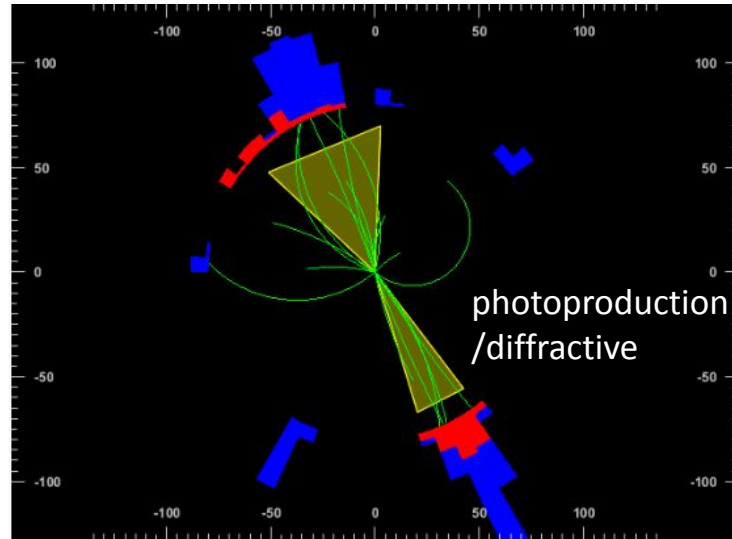FYI, we are very close to get first performance metrics for this channel!
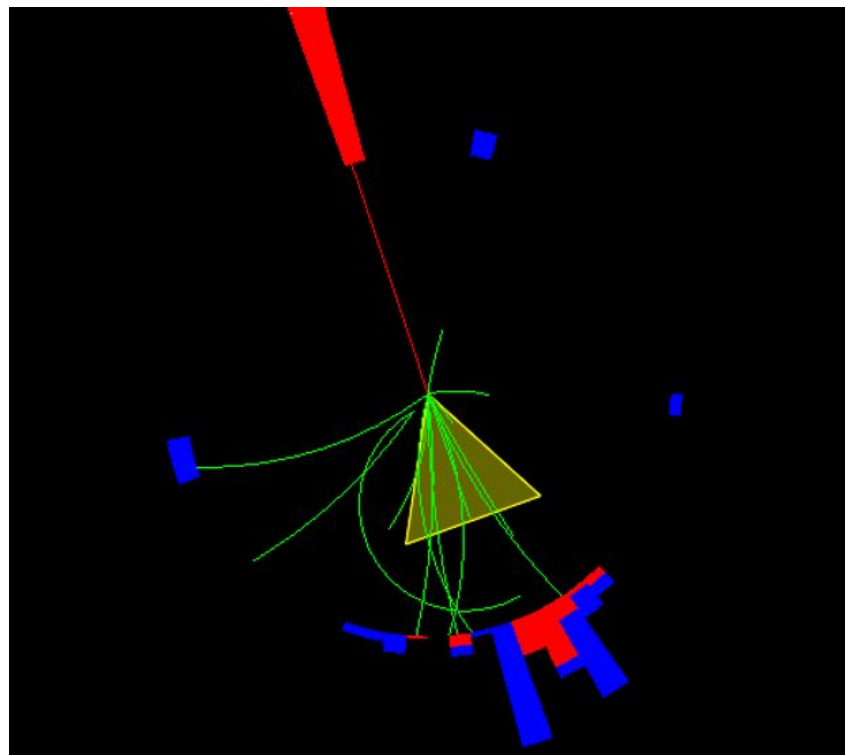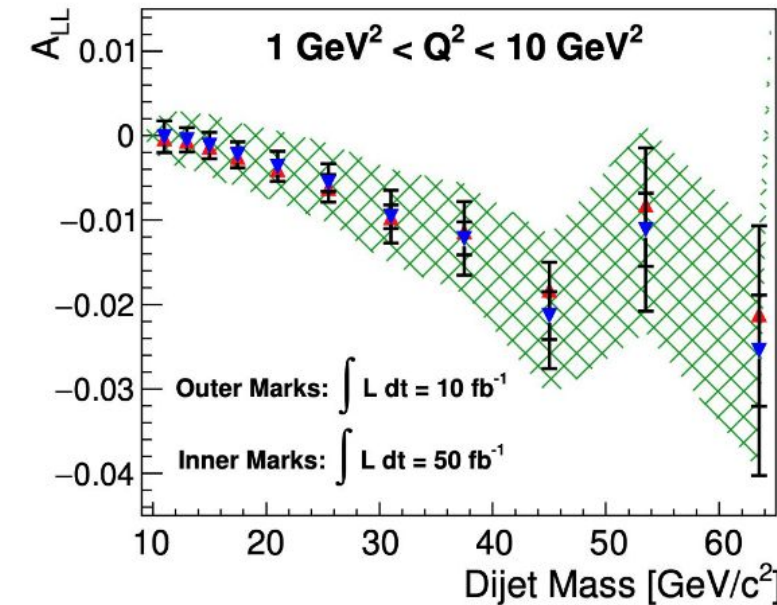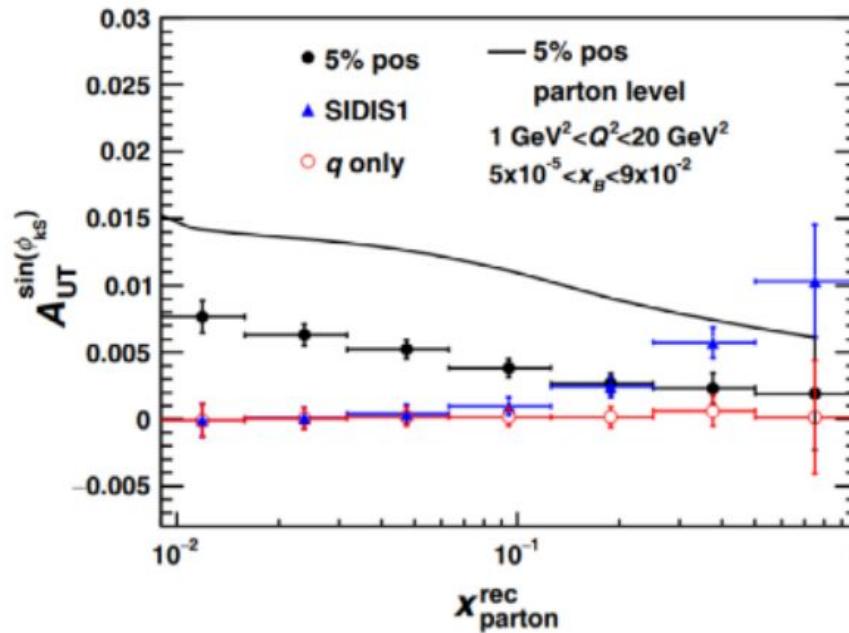

ATHENA full simulation [DD4hep]
Pythia8+Geant4, NC DIS 18x275 GeV, $Q^2 > 100$ GeV^2

E^{jet} [GeV]

η^{jet}_{lab}

ϕ^{jet}_{lab}

E^e [GeV]

η^e_{lab}

ϕ^e_{lab}

Missing Transverse Energy [GeV]

p_T^{jet}/p_T^e

$\Delta\phi_{electron-jet}$ [rad]
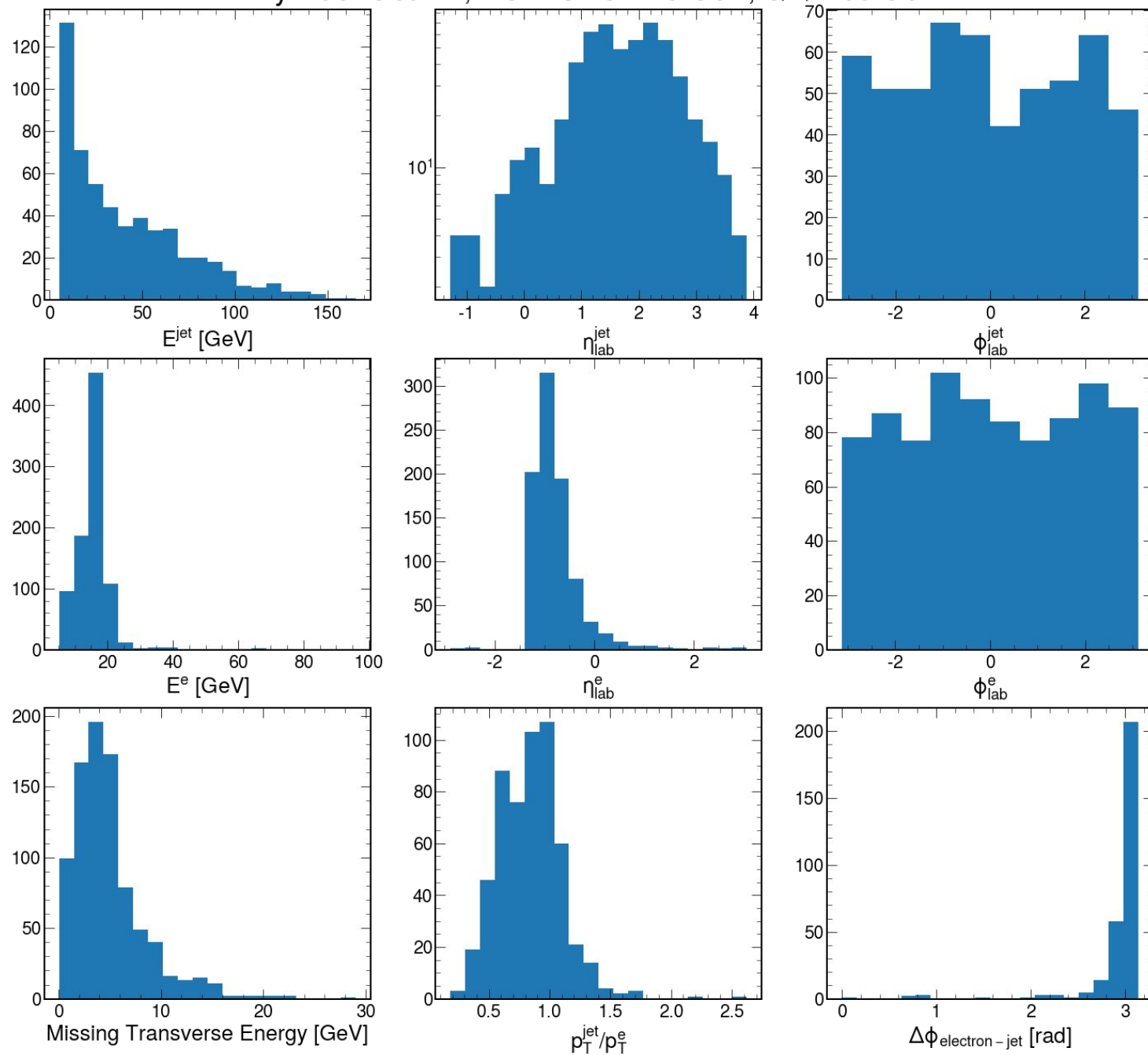
Jet kinematics measurements, e.g. **Dijets correlations (gluon Sivers, Wigner, delta-G)**

photoproduction /diffractive

electroproduction

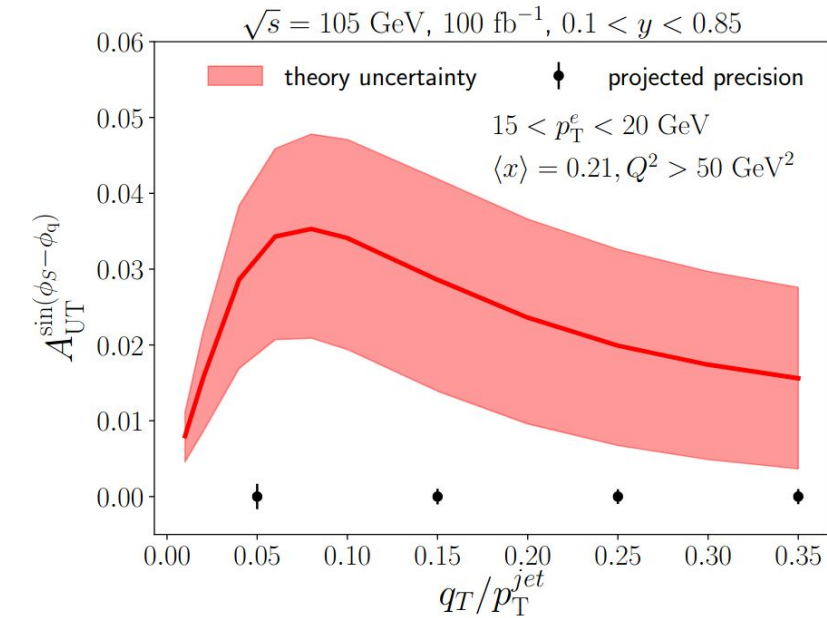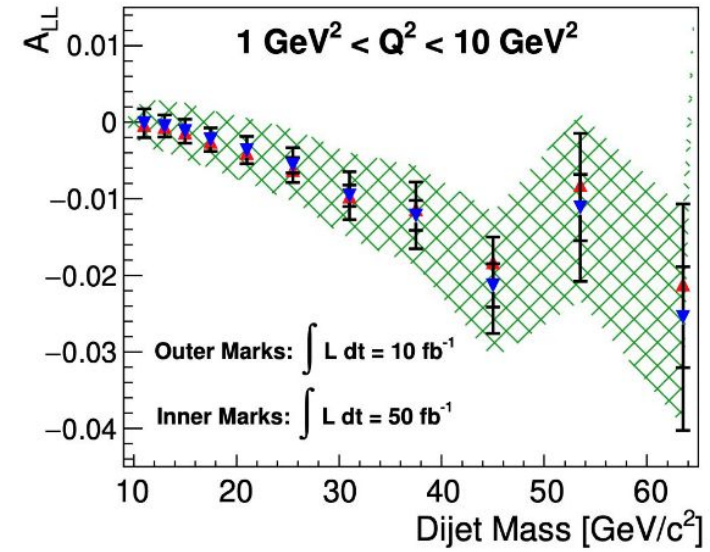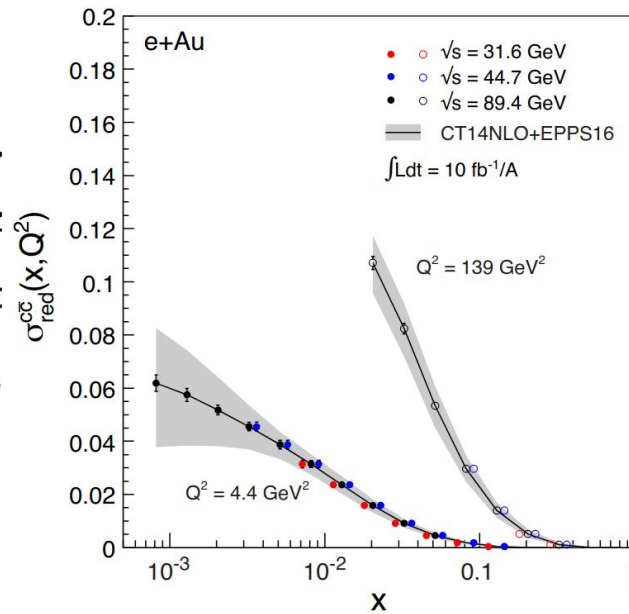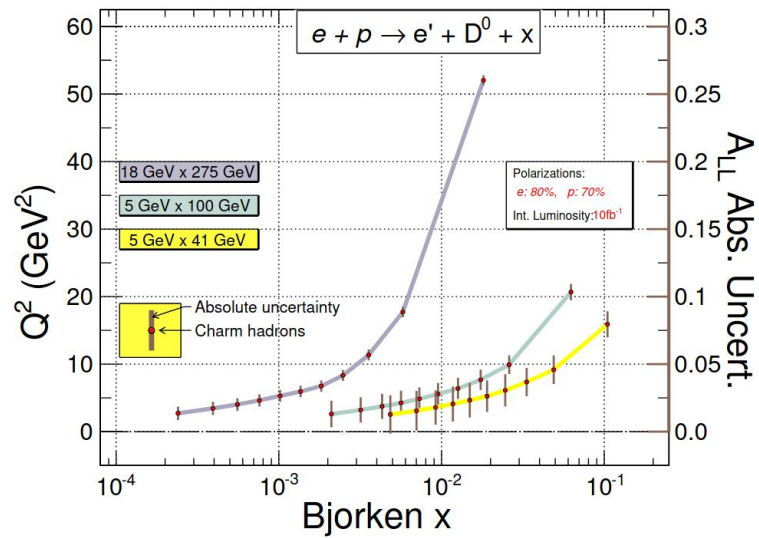**gluon Sivers:**

- Addresses core EIC science with jets
- Requires energy and angle of jets (4-vector)

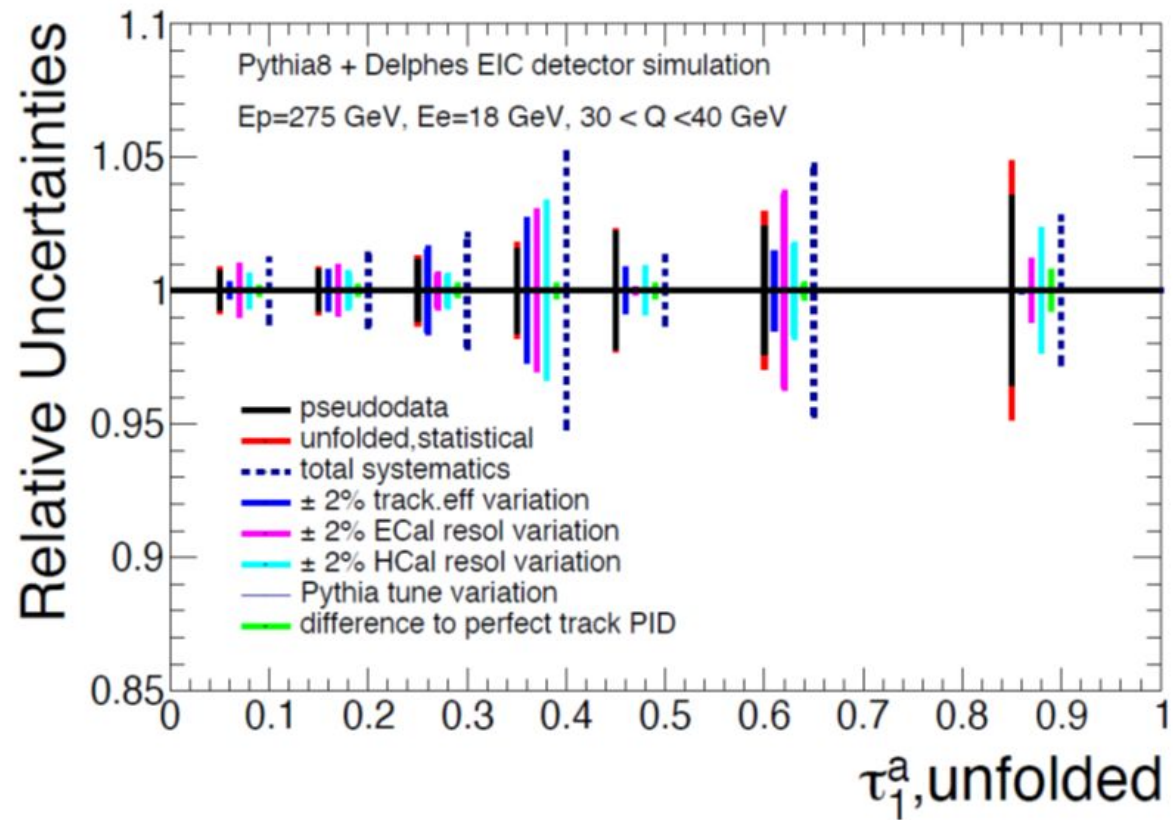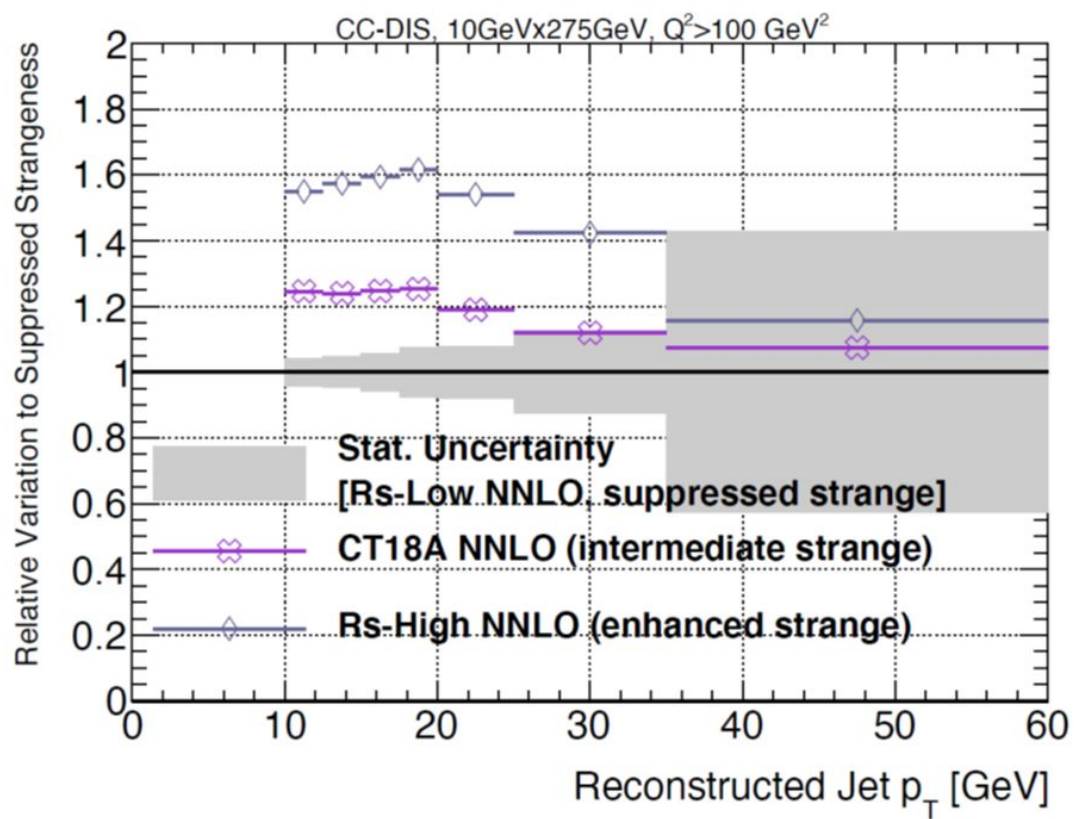# Jet-substructure measurements: e.g. Collins asymmetry
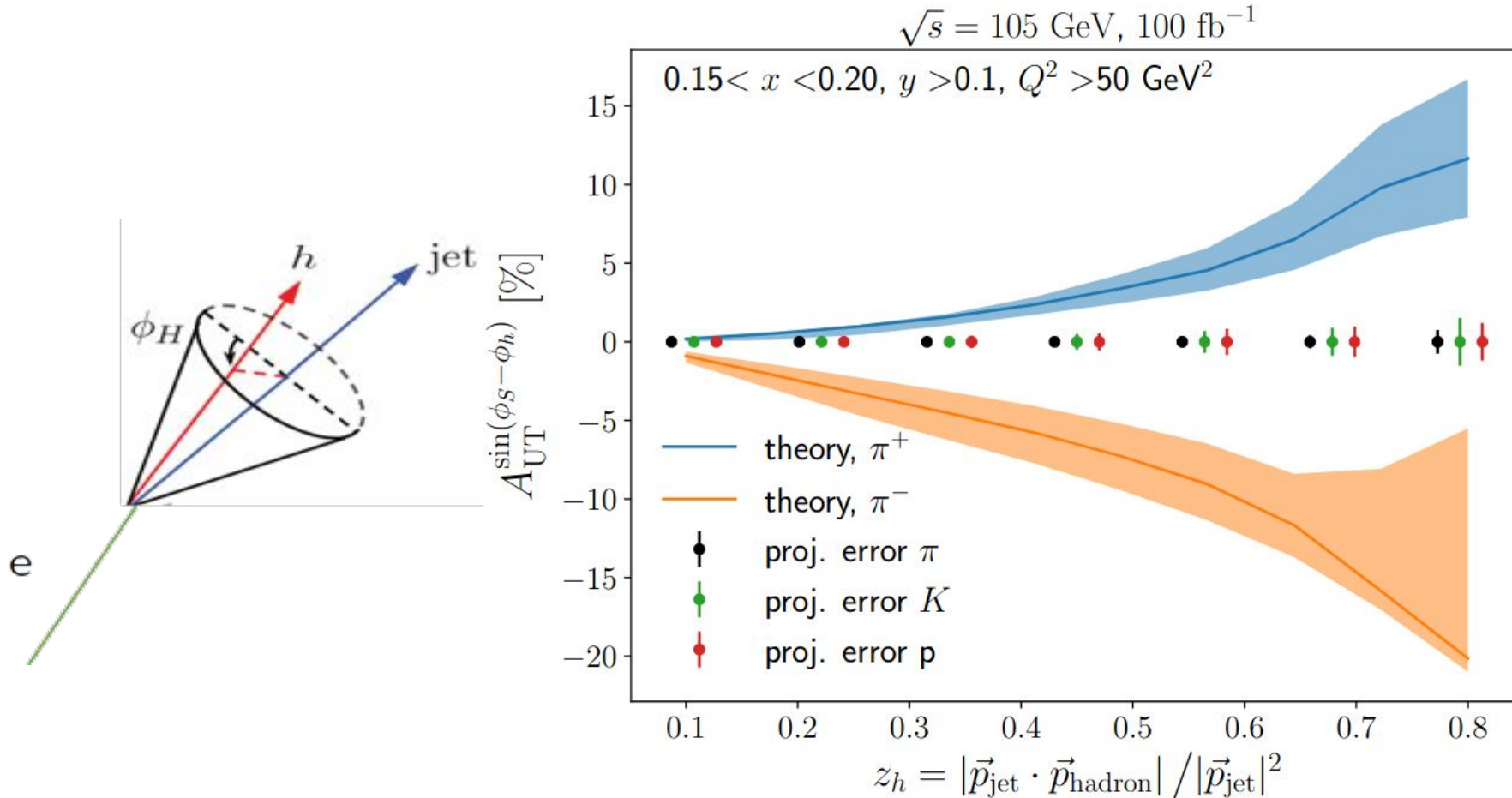
- Identification of hadrons inside jets.
- This is an example of an entire class of substructure measurements
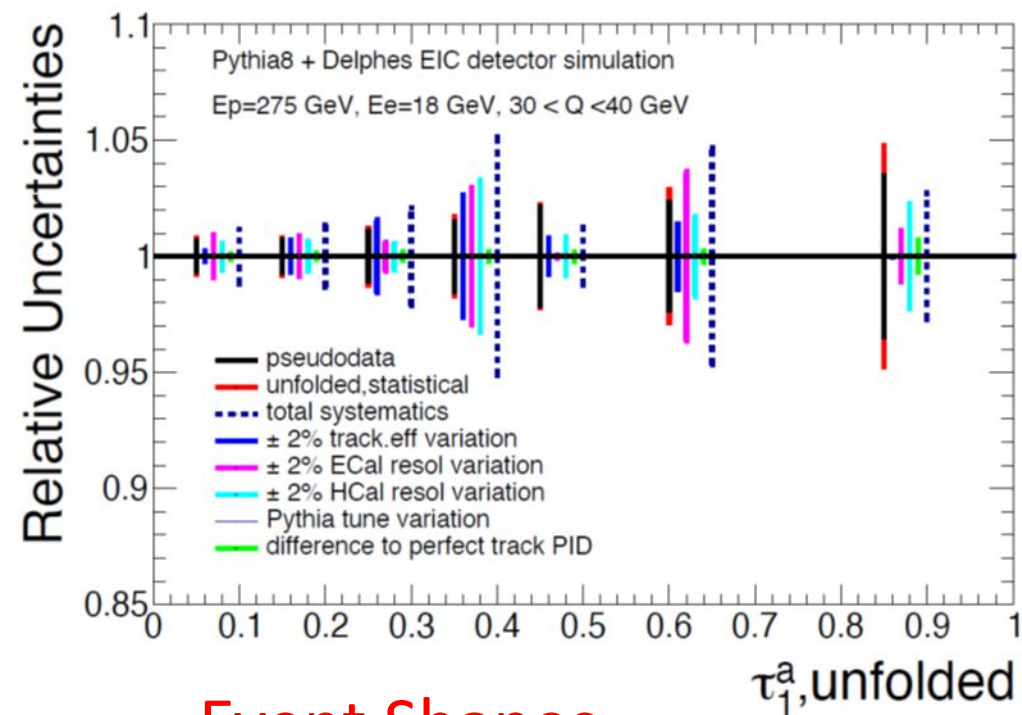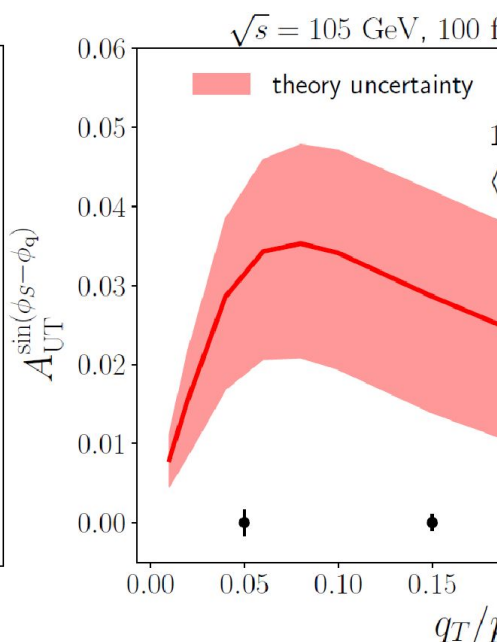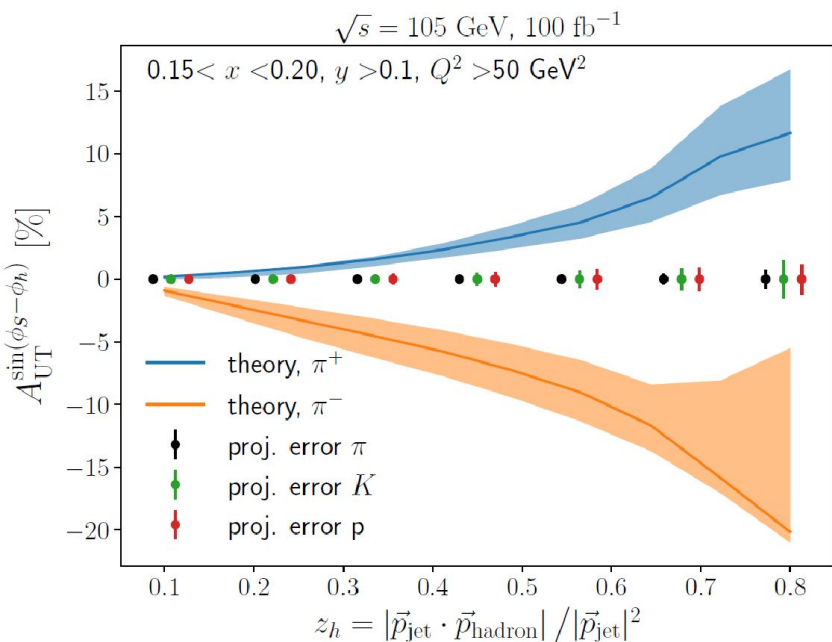- Require PID, angular resolution

Summary (some of our golden channels)

BACKUP

CC-DIS, 10GeVx275GeV, $Q^2 > 100$ GeV²

Relative Variation to Suppressed Strangeness

Stat. Uncertainty
[Rs-Low NNLO, suppressed strange]

CT18A NNLO (intermediate strange)

Rs-High NNLO (enhanced strange)

Reconstructed Jet p_T [GeV]

Pythia8 + Delphes EIC detector simulation

Ep=275 GeV, Ee=18 GeV, 30 < Q <40 GeV

Relative Uncertainties

pseudodata
unfolded,statistical
total systematics
± 2% track.eff variation
± 2% ECal resol variation
± 2% HCal resol variation
Pythia tune variation
difference to perfect track PID

τ_1^a,unfolded

15

Golden Physics Channels

Event Shapes

TMD M   Fragmentation