



Analysis Coordinator Update

Rosi Reed



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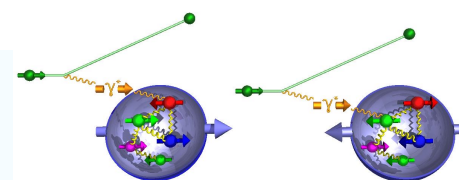
ePIC General Meeting

September 22, 2023

Introduction

- Attempt was to have analysis meetings opposite weeks from the general meeting
 - Not working well in practice → Doodle poll and pick a permanent time that does not conflict with other ePIC meetings
- Four reconstruction tasks being reorganized with efficiency in mind:
 - Regular technical updates related to these tasks will be presented in the S&C meetings only
 - Initiate joint meetings between Analysis and S&C -> once a month on Wednesday 12:00pm ET
 - This will replace the standard S&C meeting → no additional meetings required 😊
 - Focus: interplay of physics analysis and S&C, with regular reports on both the progress on reconstruction tasks and the status of physics benchmarks
- TDR is coming, let's get ready! Need to showcase detector performance
 - STEP 1 - start with reproducing key results from ECCE+ATHENA+CORE
 - Reconstruction task tools on the horizon to facilitate
 - Some examples to follow

Proton's helicity structure



$$\Delta g(x, Q^2) = g_{\rightarrow}(x, Q^2) - g_{\leftarrow}(x, Q^2)$$

○ **Observable:** Longitudinal double spin asymmetries (A_{LL})

○ **DIS** scaling violations determine **gluons** at small x



Inclusive double spin asymmetry $A_1(x)$

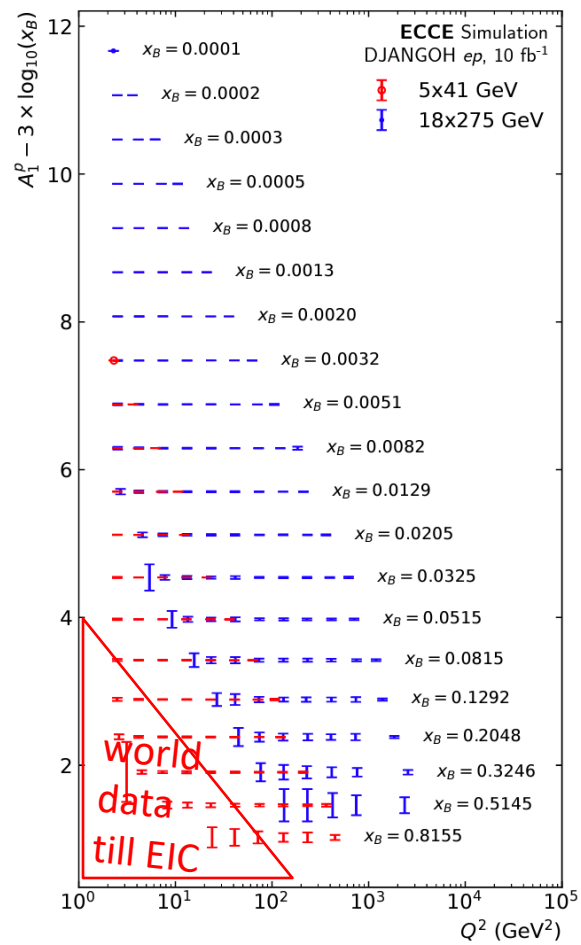
$$\frac{dg_1}{d\log(Q^2)}$$

g_1 scaling violation

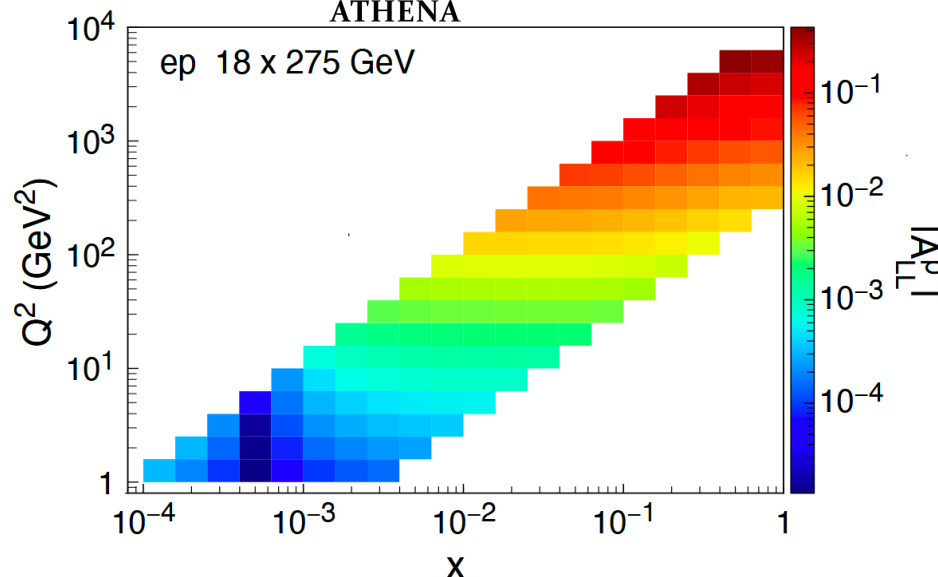
$$\propto -\Delta g$$

Key:

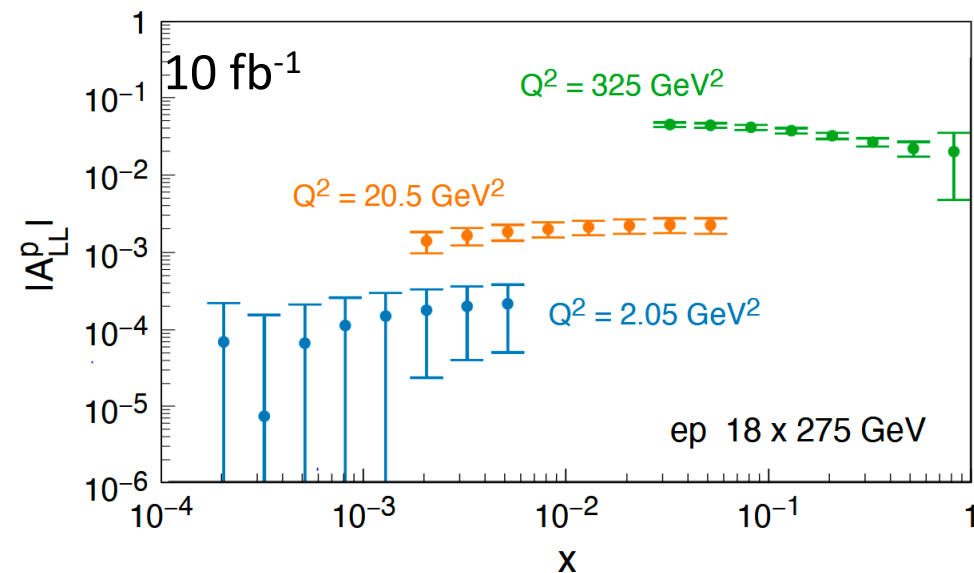
- Acceptance
- electron id



- Double spin asymm. in NC DIS



S. Fazio (University of Calabria & INFN Cosenza)



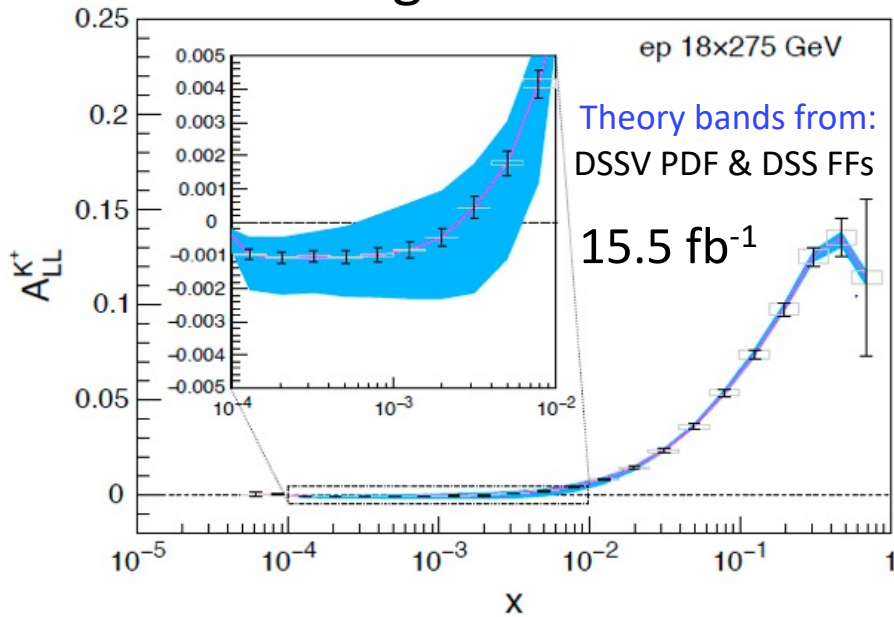
Proton's helicity structure from SIDIS

- **Observable:** Longitudinal double spin asymmetries (A_{LL})
- Furthermore, **SIDIS** data provide detailed **separation of sea quark**
 - Do sea quark helicities vanish at small x ?

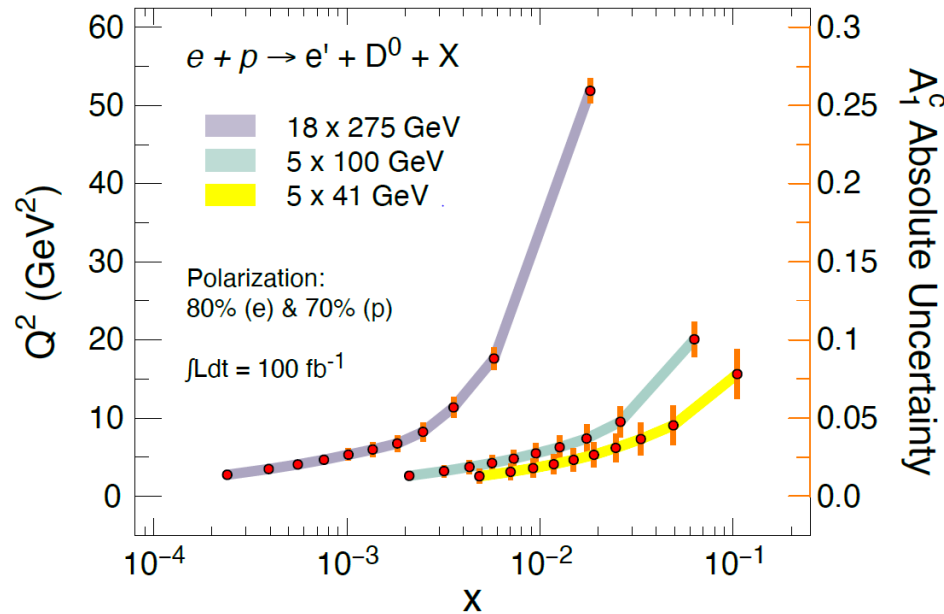
Key:

- PID (barrel, forward)
- Vertexing for charm tagging

Charged kaons



Charm production



g helicity from c production
 $(e + p \rightarrow e' + D^0 + X):$

$$A_1^c \sim g_1^c / F_1^c$$

A_1^c Absolute Uncertainty

The spin sum rule

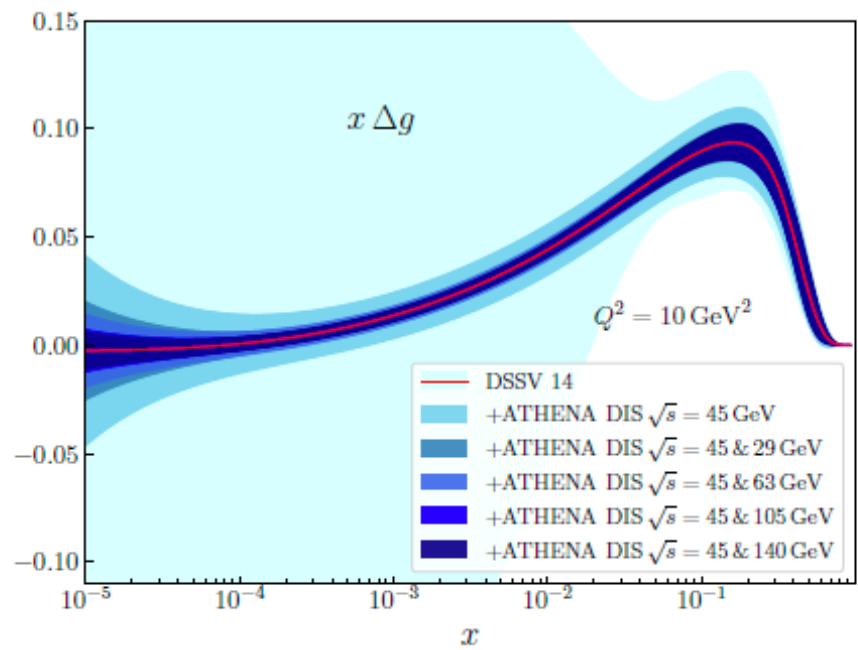
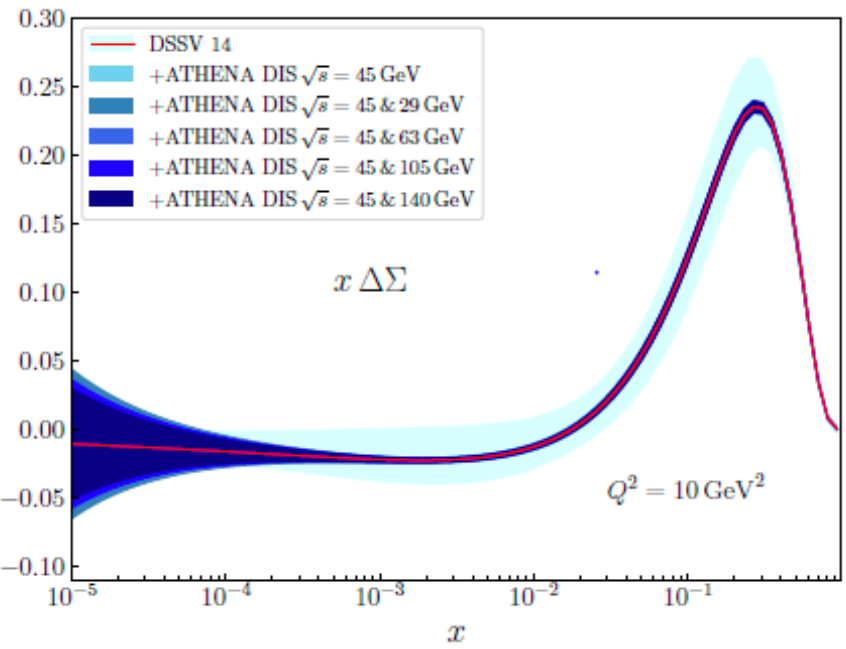
New global fit by
JAM/DSSV collaboration

$$\frac{1}{2}\hbar = \left\langle P, \frac{1}{2} \left| J_{QCD}^z \right| P, \frac{1}{2} \right\rangle = \underbrace{\sum_q \frac{1}{2} S_q^z}_{\text{q spin } \Delta\Sigma} + \underbrace{S_g^z}_{\text{g spin } \Delta g} + \underbrace{\sum_q L_q^z + L_g^z}_{\text{orb. angular momentum}}$$

1/2 - Quarks

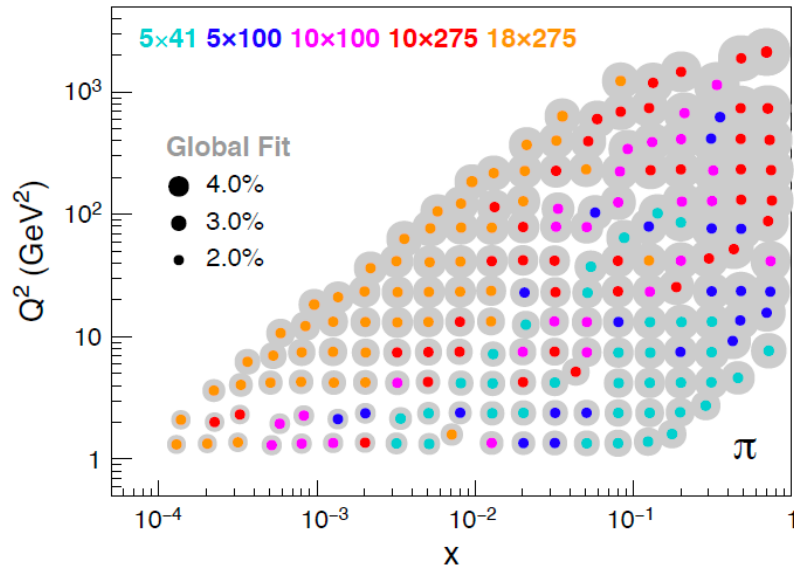
Gluons

= orb. angular momentum

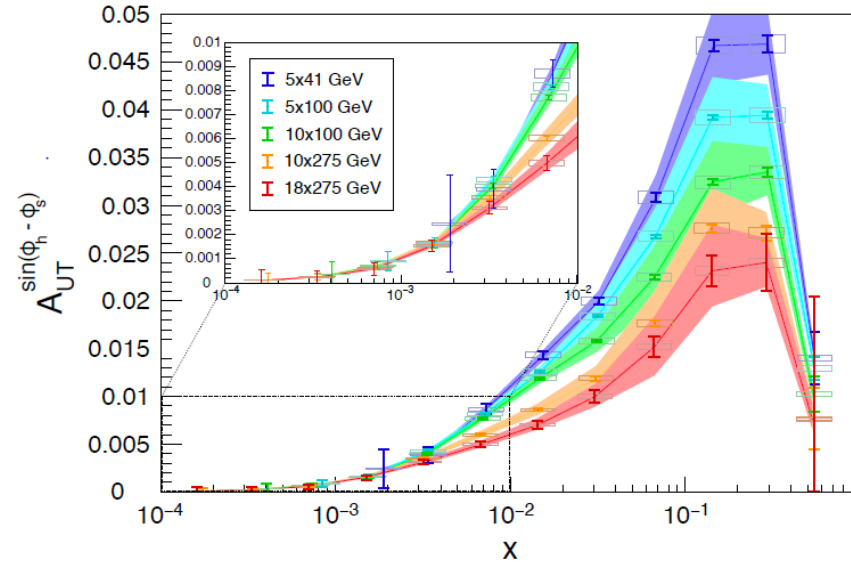


Momentum tomography – SIDIS, Heavy Flavor, Jets

Unpolarized cross section uncertainties

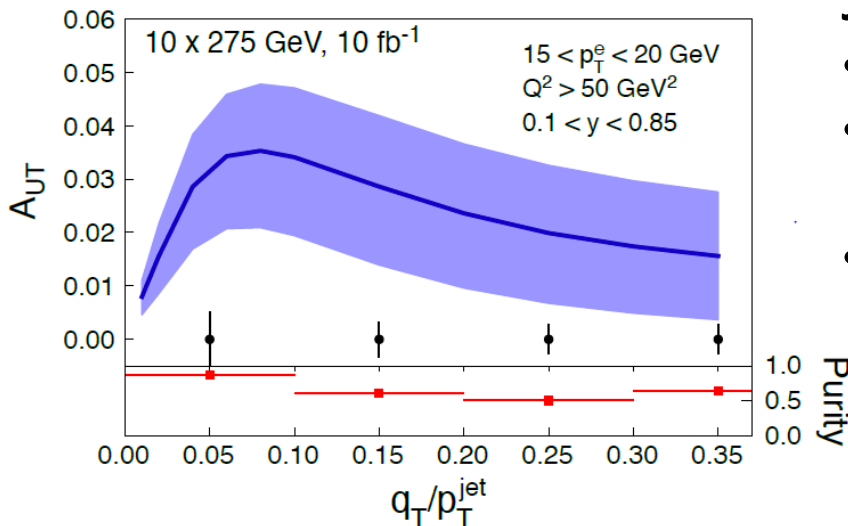
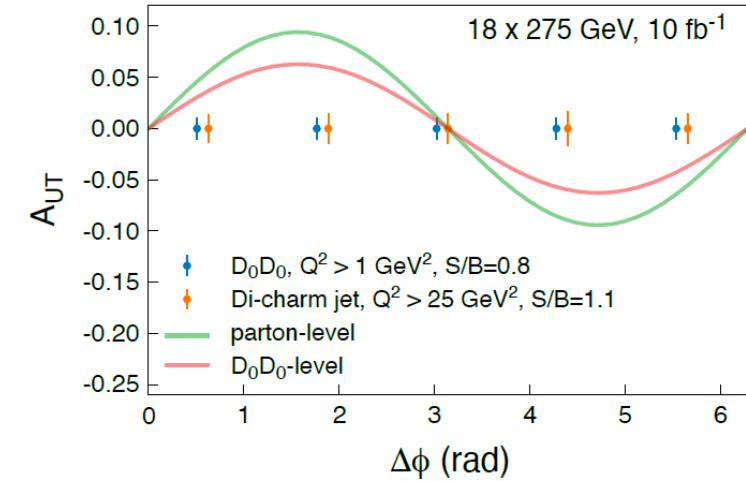


Projected Sievers asymmetries



Heavy flavor

Sensitivity for Sievers in di-charm



Jets:

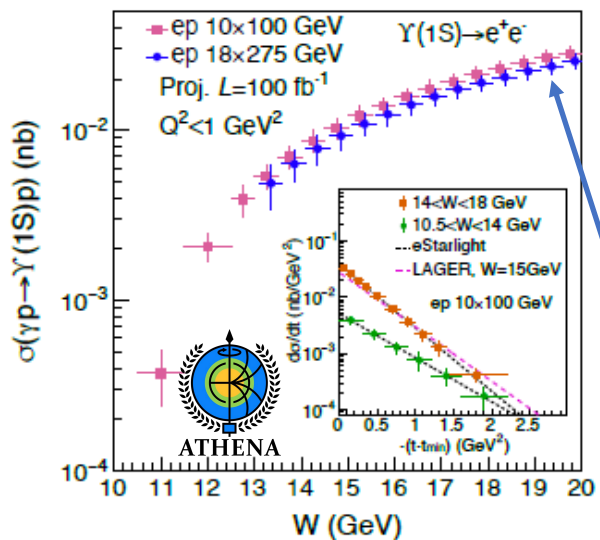
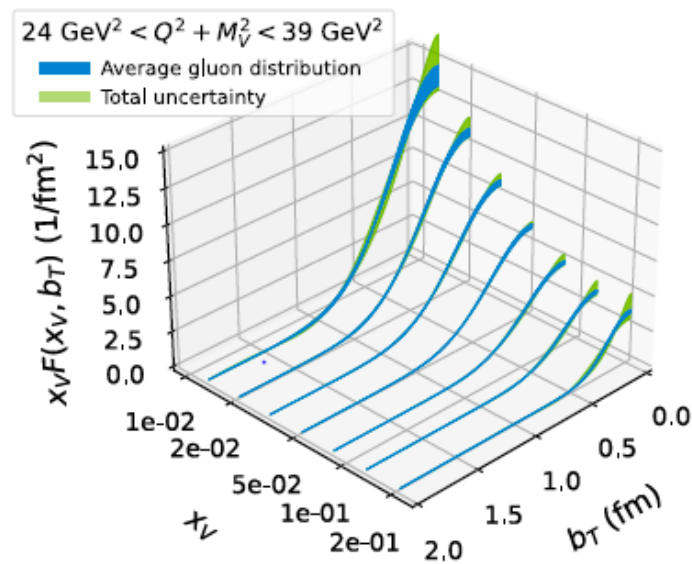
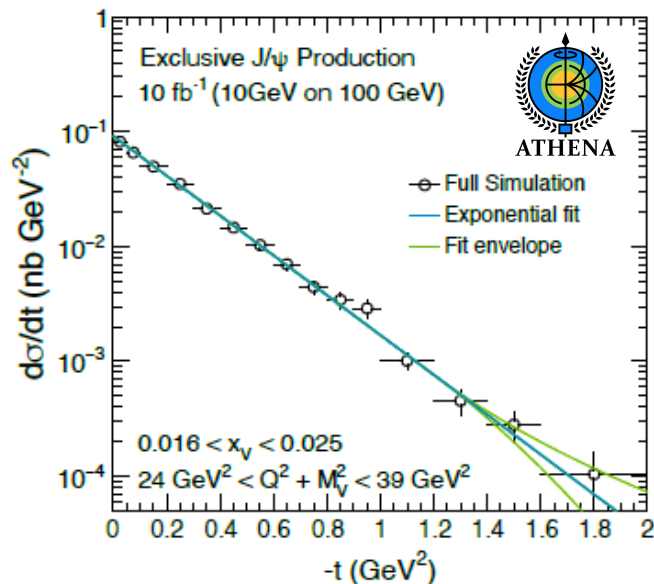
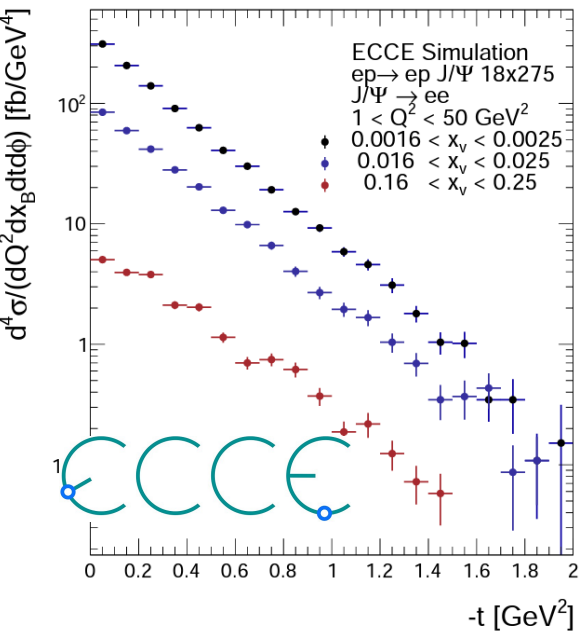
- excellent proxies for partons
- probe **quark TMDs** without convolution with FF
- di-jets can probe **gluon Sievers**

Key:

- Azimuthal acceptance
- PID
- Acceptance
- Vertexing (heavy flavor)
- Quality of tracking
- HCal (for jets)

VMs in ep

$$\vec{e} + \vec{p} \rightarrow e + p + \vec{V}$$



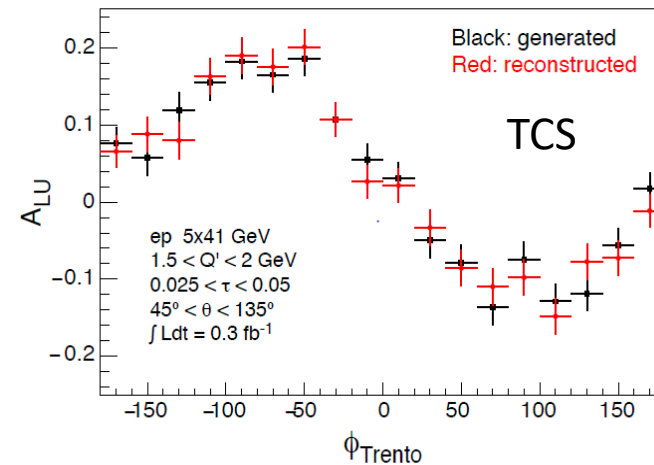
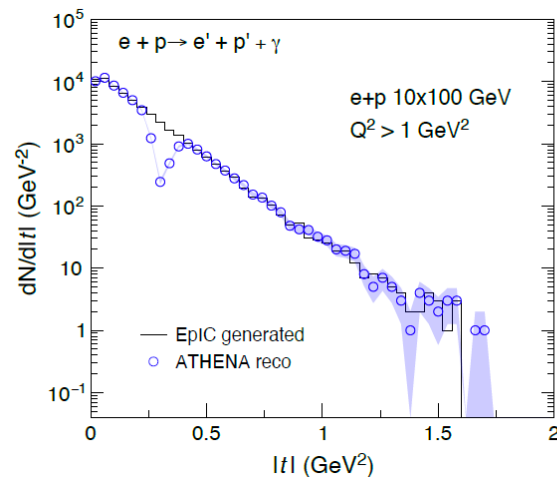
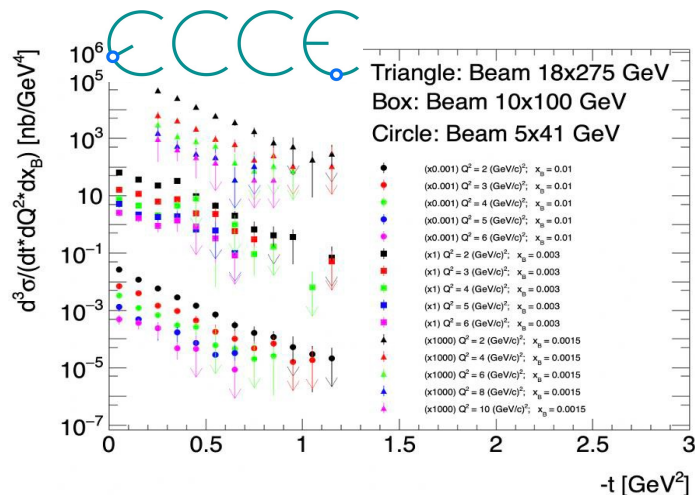
$$\int L = 100 \text{ fb}^{-1}$$

γ Photoproduction near threshold and electro-production ($Q^2 < 1 \text{ GeV}^2$)
 -> origin of p -mass

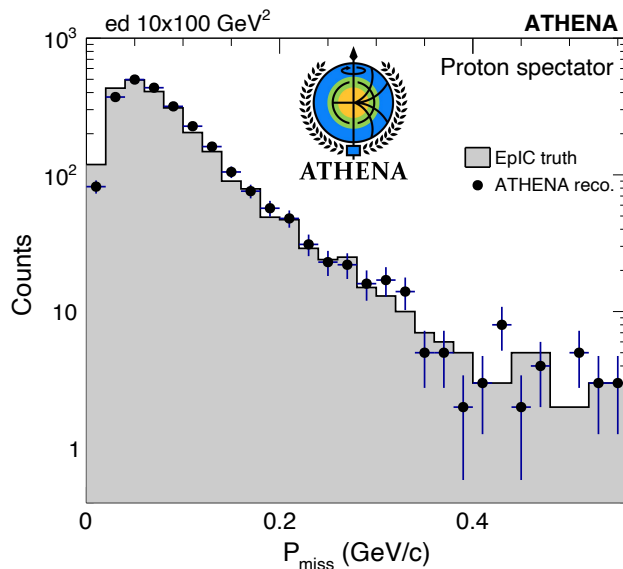
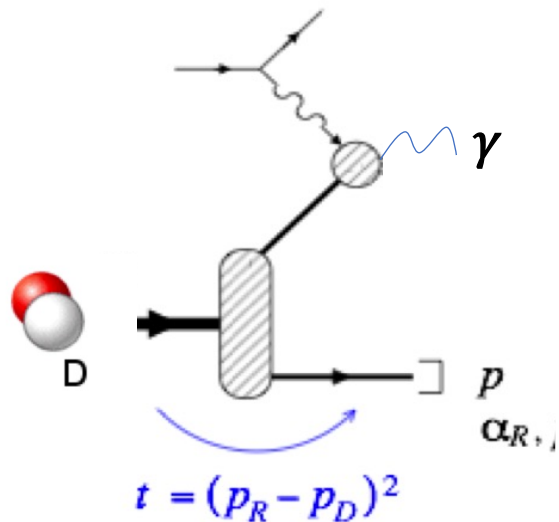
Key:

- γ/π^0 separation in ECAL for DVCS
- Acceptance and low material for VM decay leptons
- Resolution of lepton pair inv. mass
- Muon id
- Scattered electrons over full kinem.
- t - lever arm in FF spectrometers

DVCS & TCS in ep



Study of neutrons with light nuclei

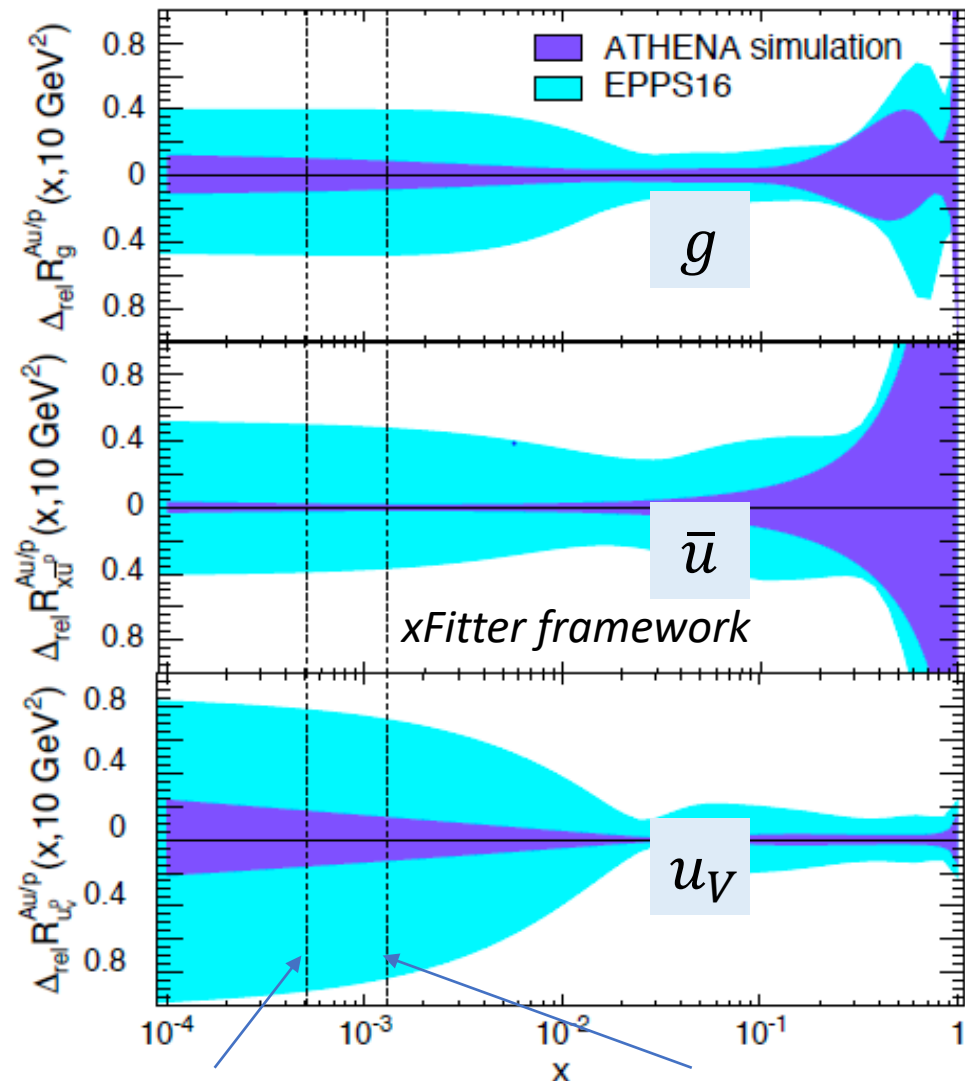


ATHENA – DVCS on e+D:

- 80-90% acceptance at low $|t|$,
- $|t|$ -acceptance loss at higher value mostly due to the loss in tagging the active neutron in ZDC.
- Alternatively, $|t|$ can be measured via scattered e and $\gamma \rightarrow$ higher acceptance at large $|t|$.
- Proton momentum is well reconstructed

Collinear nuclear PDFs

nPDFs: Au/p

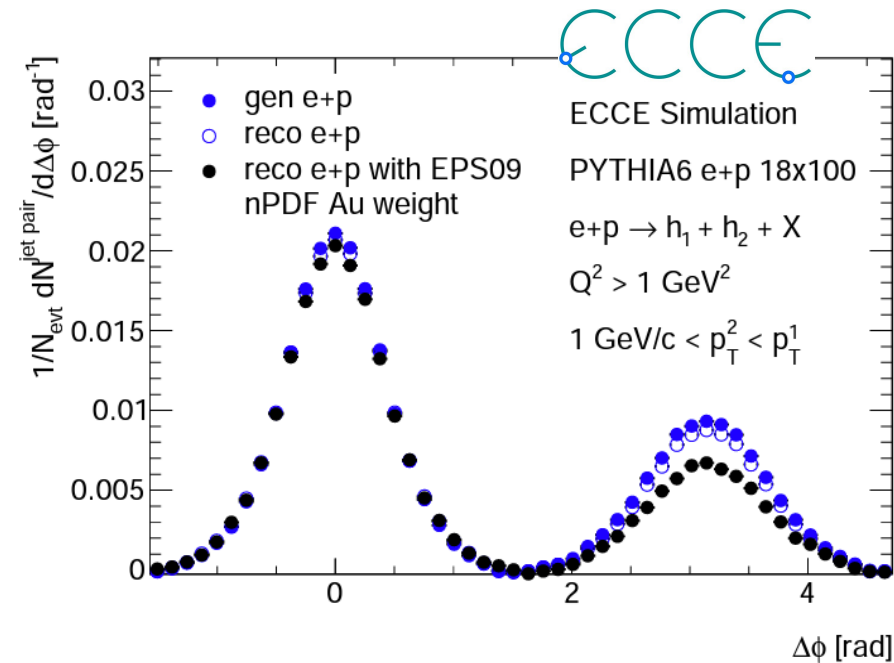


Key:

- Fine resolution in y over a large phase space

S. Fazio (University of Calabria & INFN Cosenza)

Saturation via Di-hadron correlations



Key:

- Quality detection at mid rapidity
- Reconstruction of dijets sensitive to saturation effects

Brief Working Group Update

SiDIS

- Conveners: Charlotte Van Hulse (U Alcalá), Stefan Diehl (JLU Giessen and UConn)
- Wiki of the SIDIS PWG: <https://wiki.bnl.gov/EPIC/index.php?title=SIDIS>
- PWG meetings: Tuesday 2.30 pm (~ every 2 weeks)
- Status of most physics analyses:
 - Analysis framework → see talk by C. Dilks:
<https://indico.bnl.gov/event/17018/contributions/67903/attachments/43129/72509/sidis-eic.pdf>
 - Github: <https://github.com/eic/epic-analysis>
 - This framework needs to be properly implemented as a benchmark which needs personpower!
- Next steps:
 - Realistic PID (priority: high)
 - Radiative effects (priority: high)
 - Inclusion of realistic simulations with background (priority: medium-high)
 - Inclusion of new PDF/FF set to study variation of outcome (priority: medium)
 - Implementation of unfolding (priority: medium, sufficient simulation needed)
 - Study impact of tracking resolution for some analyses

SiDIS

- An overview on detailed studies done so far can be found here:
 - https://indico.bnl.gov/event/17621/contributions/70630/subcontributions/2135/attachments/45495/76765/2023_01_11_ePIC_SIDIS.pdf
 - https://indico.bnl.gov/event/15342/contributions/65968/attachments/42422/71057/WG_SIDIS_EICUGJuly22.pdf
- Planned (partly ongoing) activities:
 - Definition and implementation of detector benchmarks:
 - (SI)DIS resolutions and coverages / acceptances (x_B , Q^2 , z , P_T , Φ_h)
 - purity of pions and kaons vs. momentum (e/π K/π separation)
 - Reconstruction efficiencies for Lambdas and maybe others [maybe in combination with exclusives]

SiDIS: Task List

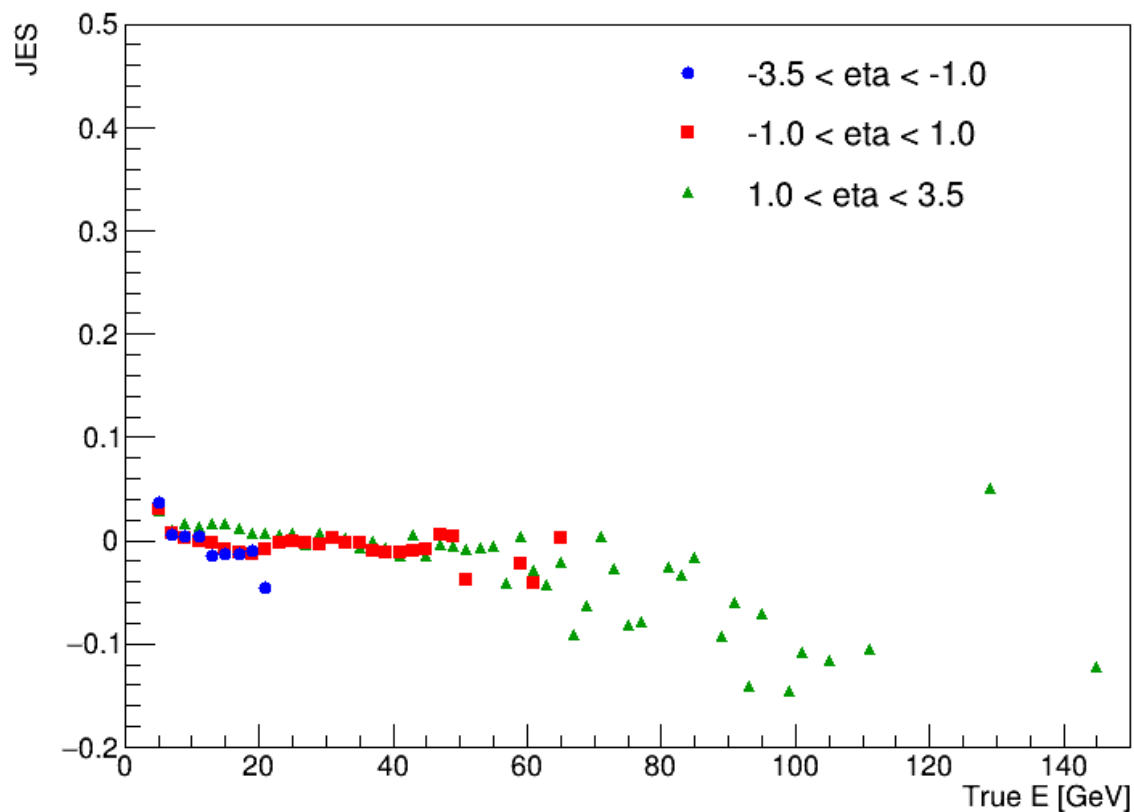
- Monitoring plots (priority):
 - Resolution (and acceptance) plots for SIDIS variables: z , PhT , ϕ , ϕ_S
- Software implementations and monitoring:
 - Cross work with the PID related detectors: implementation of a realistic PID to be used in analysis instead of truth
 - Implementation of a PID monitoring after the last point is done (e/π and π/K separation as a function of the kinematic variables)
- Analysis related tasks:
 - Study of radiative effects via DJANGO
 - New analyses: high PhT hadrons (sensitive to saturation, gluons Sivers, ...)
 - Feasibility of the reconstruction of quarkonium, J/ψ to start with, in SIDIS via $e+e^-$ and $\mu+\mu^-$
 - if feasible, simulation and reconstruction of various SIDIS processes with quarkonia so that we get information on gluon TMD PDFs, which at present are not known.

Jets and HF

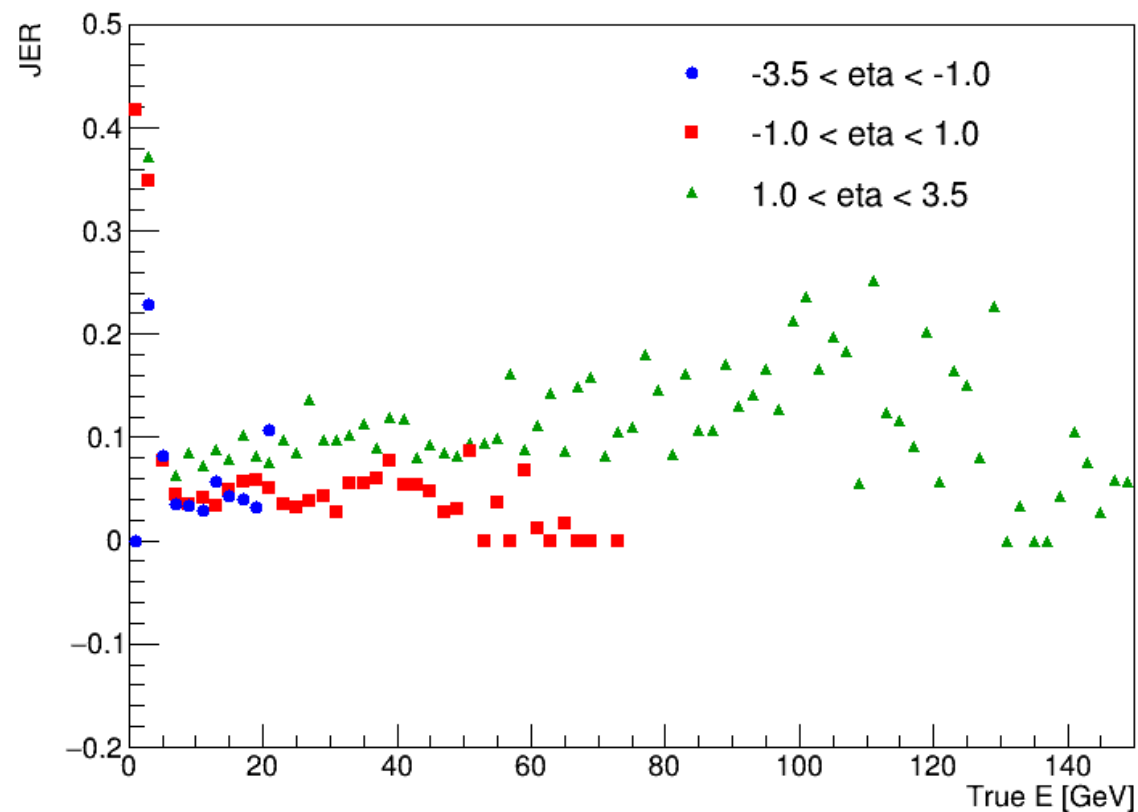
- Mailing List: eic-projdet-jethf-l@lists.bnl.gov
 - <https://lists.bnl.gov/mailman/listinfo/eic-projdet-jethf-l>
- Meeting Indico Pages: <https://indico.bnl.gov/category/420/>
- Wiki Page: <https://wiki.bnl.gov/eic-project-detector/index.php/JetsHF>
- Mattermost Chat: (sign-up link) - https://eic.cloud.mattermost.com/signup_user_complete/?id=i8gnmob4stdrpjfrezhegxs3ew
- Conveners
 - Olga Evdokimov – evdolga@uic.edu
 - Brian Page – bpage@bnl.gov
- Meetings - Wednesdays 12 pm time slot - Biweekly

Jets and HF: Example Benchmark

Jet Energy Scale Vs True Energy



Jet Energy Resolution Vs True Energy

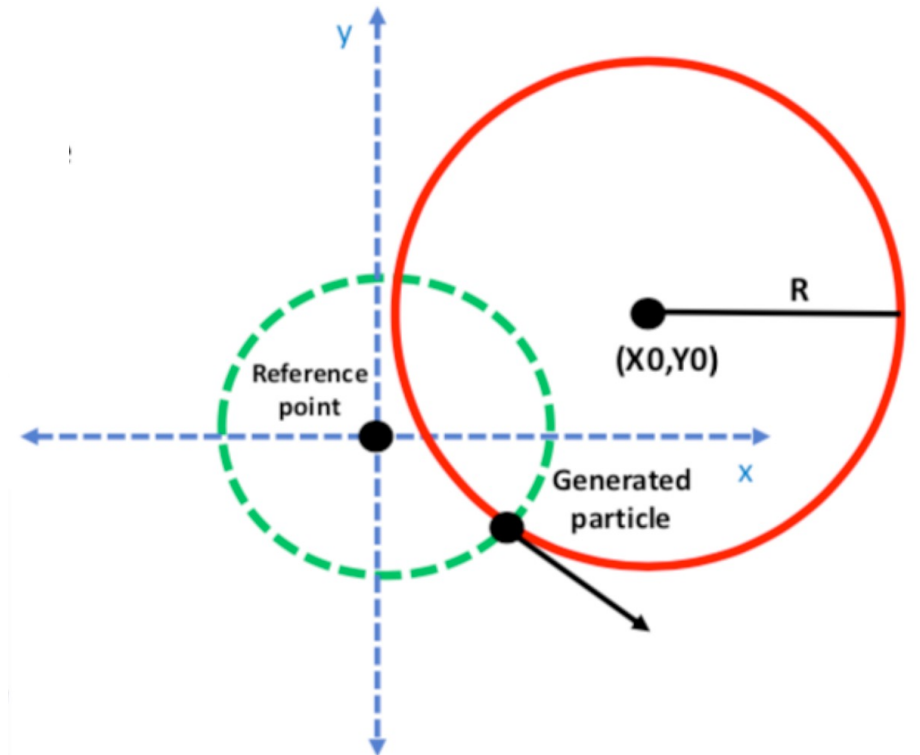


Jets and HF

- Initial jet reconstruction benchmarks are ~done
 - Will need updates as jet factory is modified
 - Evolve as calorimeter information is added to jet finding
- Beginning to look at track performance
 - Efficiency and resolution for tracks and also Lambdas and D⁰s
 - Explore quantities needed for track QA
- Updates to Jet Factory (Reconstruction task for Particle Flow): See [PR #767](#) and [issue #724](#)
- Jet Data structure
 - Currently, jets in EICrecon are stored as a ReconstructedParticle type → this structure does not allow for the storage of useful information (area, background, etc)
 - One idea is to create a dedicated jet type which can store this 'non-kinematic' information
 - Investigating needs (jet info, calibrations, etc)
- Stay tuned for potential Workfests!

Jets and HF: Update on Track Parameters and Truth Seeding

- Recent update to truth seeding that should be checked
 - For particles with a generation vertex on the z-axis, should be no change between versions
 - For non-zero (x,y) generated vertices
 - Old version gives specific point in space
 - New version gives specific z and specifies a circle in xy plane
- For secondary particles, since the particle is generated far from the z-axis, there may be differences between old new
 - Depends on CKF treatment of input



Exclusive, Diffractive and Tagging PWG

- Meet Mondays at noon ET roughly every couple of weeks
 - Mailing list: eic-projdet-excldiff-l@lists.bnl.gov
 - Indico: <https://indico.bnl.gov/category/419/>
- Conveners
 - Raphael Dupre - raphael.dupre@ijclab.in2p3.fr
 - Rachel Montgomery - Rachel.Montgomery@glasgow.ac.uk
- Wiki will be updated
 - Complex to assess how "alive" are the analysis
- See Kong's talk (next) for a spotlight update from this working group

Inclusive PWG

- Conveners:
 - Claire Gwenlan (claire.gwenlan@physics.ox.ac.uk)
 - Tyler Kutz (tkutz@mit.edu)
- Meeting time: Mondays (biweekly) at 12pm ET
- Mailing list: eic-projdet-Inclusive-I@lists.bnl.gov
- Indico: <https://indico.bnl.gov/category/417/>
- Mattermost: <https://eic.cloud.mattermost.com/main/channels/inclusive-physics>
- Short update:
 - Track propagation factory merged into EICrecon
 - Next efforts will be split between:
 - Track-cluster matching studies (outside of EICrecon at first, but eventually migrated into an EICrecon factory)
 - Kinematic variable resolution benchmarks (initially based on MC truth information, later using real electron/particle ID)

Beyond Standard Model + Precision Electro-Weak PWG

- Conveners:
 - Ciprian Gal (ciprian@jlab.org)
 - Michael Nycz (df3ks@virginia.edu)
- Meeting time: Tuesdays (biweekly) at 8:30am ET
- Mailing list: eic-projdet-semiincl-1@lists.bnl.gov
- Indico: <https://indico.bnl.gov/category/421/>
- Mattermost: <https://eic.cloud.mattermost.com/main/channels/ew-bsm>
- TBD the best time for the WG meetings
- Short Physics update
 - Andrew Hurley (UMass) has started analyzing LQGENEP events to see the distribution of the 1 prong tau decays
 - We plan to use these distributions around the detector to plan single muon simulations
 - Expectation is the simulations will start running in the first week of Oct

Conclusions

- Will be picking a new time for our biweekly analysis meeting based on polling → stay tuned!
- Considerable progress has been made on all 4 reconstruction task forces, soon tools will be available for high-level physics analysis
- Working on a master task list from all PWGs with open items that need additional person-power
- All PWGs are in need of personpower, please join!
- Efforts will ramp up for preparing for the TDR
 - With new reconstruction tools on the horizon, the first step will be to remake plots produced for DPAP w/ePIC framework
 - Good opportunity for folks to get involved with physics analysis!