Summary: Diffraction and Tagging physics working subgroup

Wim Cosyn, Or Hen, Douglas Higinbotham, Spencer Klein, Anna Stasto

2nd EIC Yellow Report Workshop at Pavia University, May 22, 2020

Diffraction and Tagging sessions Thursday, May 21

Morning session:

Wojciech Slominski: Inclusive diffraction in ep DIS
Vadim Guzey: Diffractive dijet photoproduction at EIC
Richard Trotta: Meson structure at EIC
Florian Hauenstein: SRC measurements at EIC
Ivica Frsicic: ^{3}He measurements

Morning session joint with Exclusive group:

Barak Schmookler: Elastic Hydrogen and Deuteron scattering
Charles Hyde: Initial state radiation as a probe of ep and eA scattering
Mark Strikman: Coherent gamma* ^{4}He scattering emphasizing t-range for 4He detection
Sylvester Joosten: VM production: electrons vs muons
Sam Heppelmann: Vector meson production simulations
Wan Chang: Suppression of incoherent background in VM production
Vadim Guzey: Diffractive dijet photoproduction at the EIC
Farid Salazar: Diffractive dijets in DIS
Wenliang Li: u-channel pi0 production

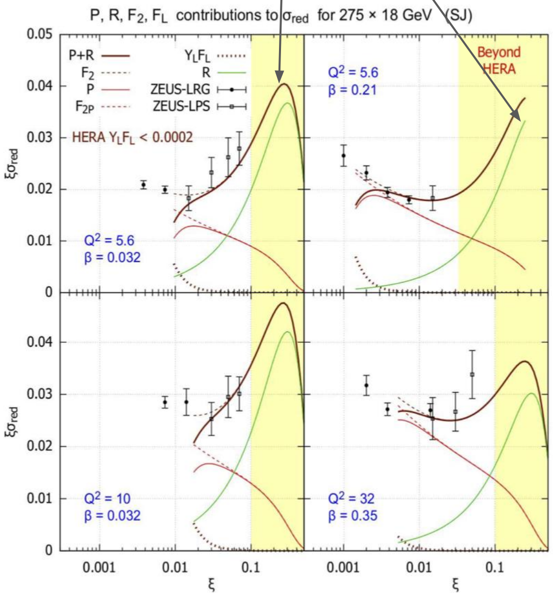
Afternoon session joint with Exclusive and DWG:

Alex Jentsch: DVCS and e+D spectator tagging in the FF region
Douglas Higinbotham: Magic beam energies for polarized deuteron

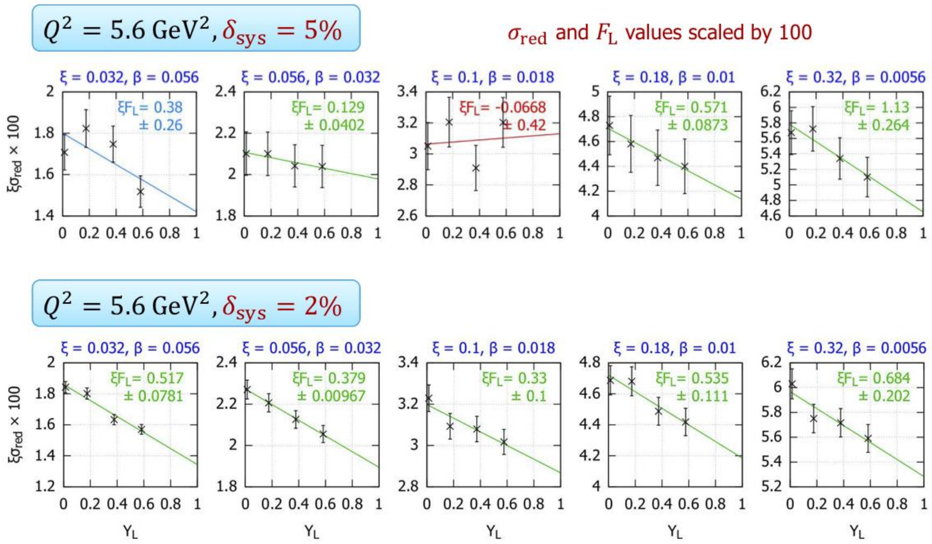
Thanks to all the speakers for their contributions and work and all participants for lively discussions!

Wojciech Slominski: Inclusive diffraction in ep

Possibility of measurement of $\sigma^{D(4)}$ if |t| is measured up to 2 GeV^2: **proton tagging angle 0.5-10 mrad**
Determination of Reggeon contribution: **x_L down to 0.6 or less**
Possibility of measurement of F_L^D : **additional intermediate c.m.s energies**



100×10, 120×10, 165×10, 275×18 GeV

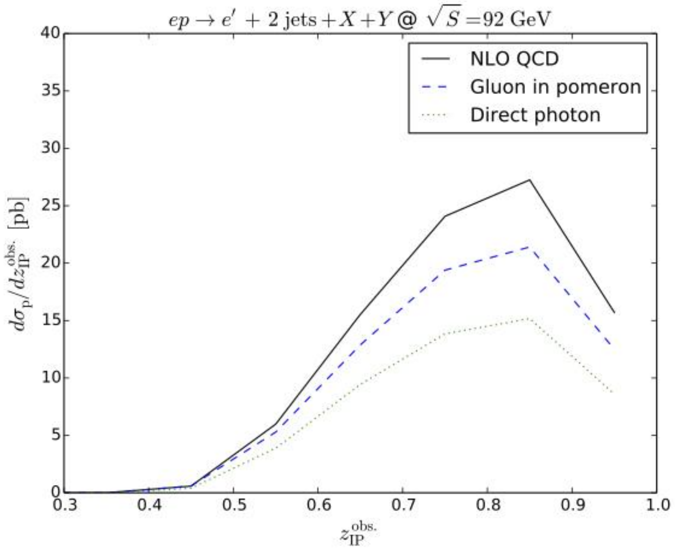


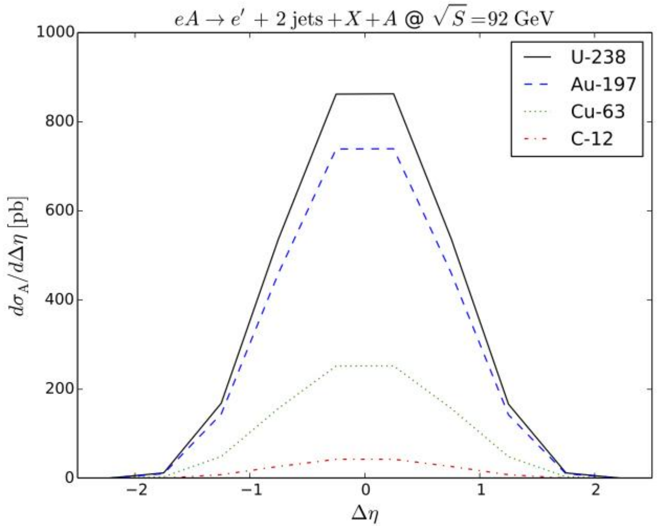
F_L contributions are often smaller than 5% sys. error

Significant improvement wrt. δ_{sys} = 5%

Vadim Guzey: Diffractive dijet photoproduction at an EIC

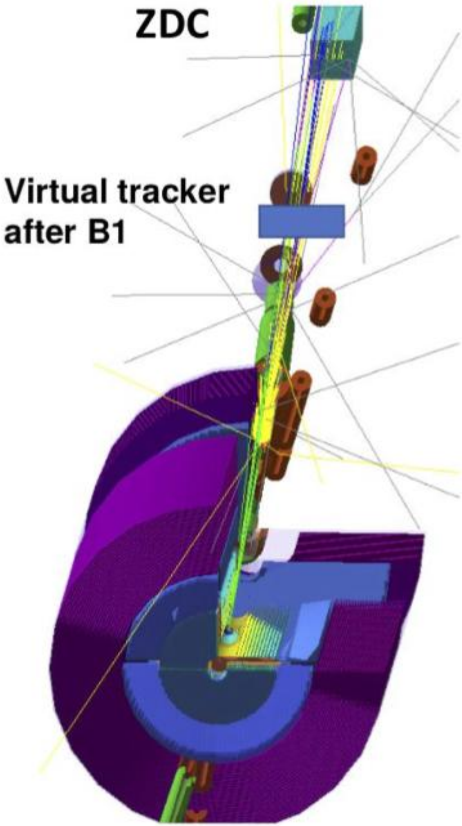
Diffractive dijet production sensitive to the gluon density at large z
Large cross section for **p_T<8 GeV (lower energy 21+100) p_T<14 GeV (higher energy 18+275)**
Tests of factorization breaking : **need high energy and good coverage in x_γ**
Diffractive dijet photoproduction on nuclei





Summary of Detector Requirements

- For π^+/n...
  - For all energies, the neutron detection efficiency is ~100% with planned ZDC
  - Lower energies [5 on 41, 5 on 100], **require at least 60cmx60cm size** to access wider range of energies
- For π^+/n and K^+/Λ...
  - All energies need good ZDC angular resolution for the required t resolution
  - High energies [10 on 100, 10 on 135, 18 on 275] **require resolution of 1 cm or less**
- K^+/Λ benefits from low energies [5 on 41, 5 on 100] and also need...
  - $\Lambda \rightarrow n+\pi^0$: additional high-res/granularity
    - **EMCal+tracking before ZDC** (seems doable)
  - $\Lambda \rightarrow p+\pi^-$: additional trackers/veto in opposite charge direction on path to ZDC (more challenging)
- Standard detection requirements
- [In progress] Good hadronic calorimetry to obtain good x resolution at large x

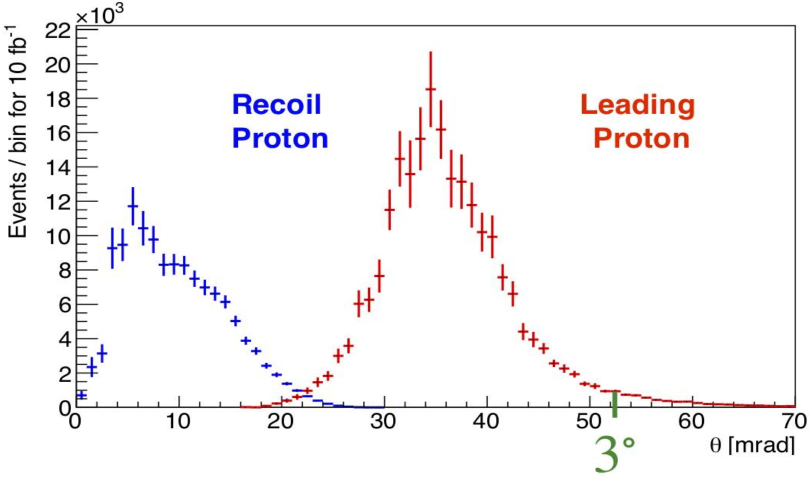


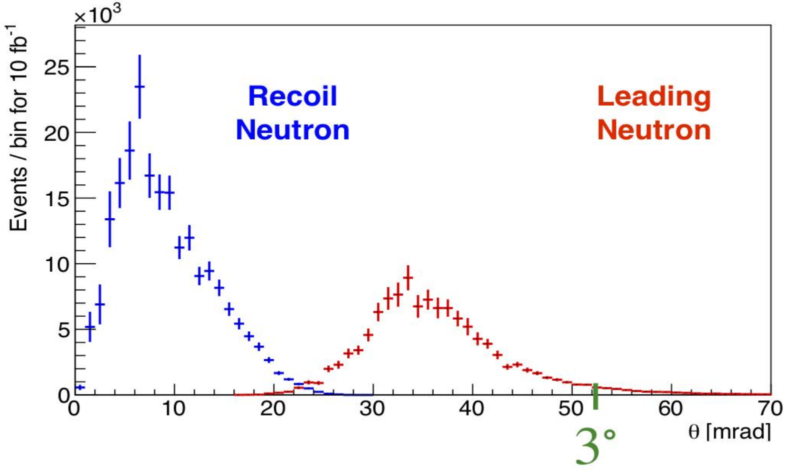
Florian Hauenstein: SRC measurements

Measurements of short range correlated pairs of nucleons

Leading and recoil nucleons well separated, e+C,e+D similar,
good separation for higher energies as well

e+C 10+41GeV/nucleon





Detailed acceptance study:

Good acceptance for recoils

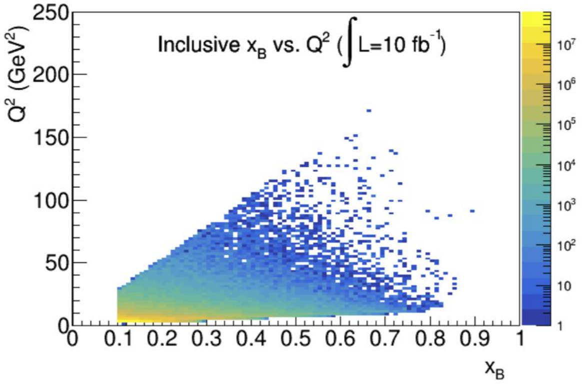
Leading protons with high acceptance

Leading neutrons acceptance under investigation

Ivica Friscic: 3He measurements

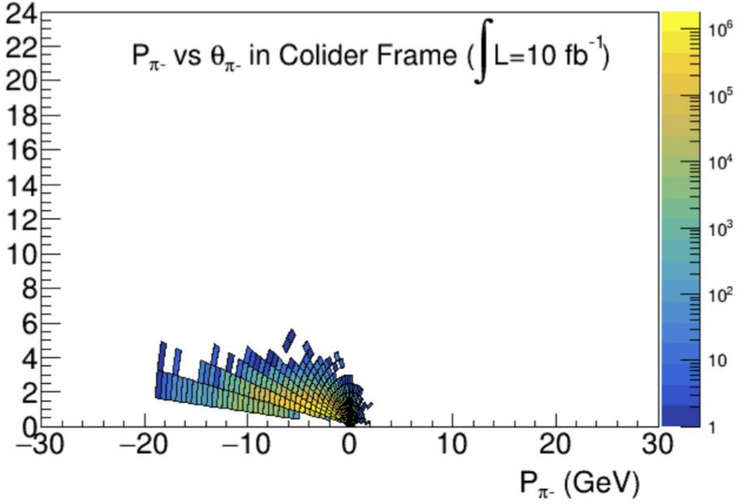
Simulations for DIS and SIDIS using CLASDIS generator: change from target to collider frame

$E_e^{Col} = 2.5$ GeV and $E_{3He}^{Col} = 81.9$ GeV

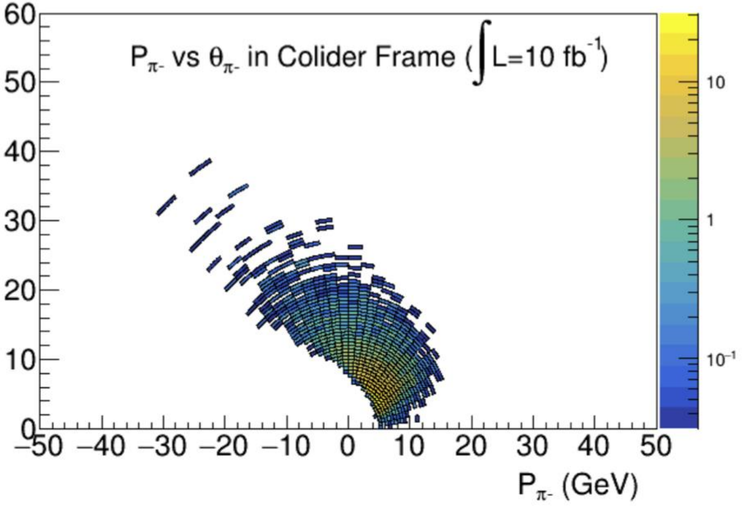


- SIDIS cuts : $W^2 > 4$ GeV^2, $Q^2 > 2$ GeV^2, $x_B > 0.1$, $Z > 0.3$

$E_e^{Col} = 2.5$ GeV and $E_{3He}^{Col} = 81.9$ GeV



$E_e^{Col} = 18$ GeV and $E_{3He}^{Col} = 550$ GeV



Douglas Higinbotham: Magic beam energies for polarized deuteron

- Longitudinal deuteron polarization at the interaction regions in the EIC can be achieved relatively easily with the spin rotators included in the baseline project by going to "magic" energies. (see https://doi.org/10.1103/PhysRevLett.84.3855 and references therein for the physics behind the magic)
- Scanning an EIC deuteron energy range of 20.5 to 137.5 GeV/nucleon, there are a total of 17 magic energies for one IR. Of these, there are 5 energies where the deuteron polarization can be made longitudinal at both planned interaction points: **39.4**, 59.0, 78.7, 98.4 and **118.1** GeV/nucleon.
- Two of those are very close to the yellow report energies of 41 and 110 GeV/nucleon.
- Assuming 39.4 GeV/nucleon is possible and not risky to the project, changing the lower energy from 41 to 39.4 GeV/nucleon looks like an item for the accelerator teams to look at very closely and is certainly an interesting finding of yellow report exercise.

Summary of studied channels:

Measurement/process	Main detector requirement (if known/anticipated)	Expected plot for the YR	Physics goal/topic	Contact person	Comments and next steps
Sullivan process ep/d -> e + pi/K/X + nucleon	-detection of forward p/n -detection of forward decay products of Λ,Σ -hadronic calorimetry in forward region, constraints on ZDC	-pion and kaon SF projections a la HERA proton structure function plots -pion form factor at large Q^2	Meson structure	T.Horn	Advanced analysis. Fast simulations in progress

Summary of studied channels:

Measurement/process	Main detector requirement (if known/anticipated)	Expected plot for the YR	Physics goal/topic	Contact person	Comments and next steps
ep/A-> e + X+p/A	Instrumentation (roman pot and other detectors) for leading protons	Roman pot acceptance, diffractive kinematics, structure function pseudodata, diffractive PDFs	diffractive structure functions and PDFs in protons and nuclei	N.Armesto P.Newman, W.Slominski A.Stasto	Pseudodata, PDF fits, longitudinal structure function. To do: more detailed anaysis on F_L^D, PDFs in nuclei
ep/A-> e + VM+rapidity gap+Y diffraction of vector mesons with proton dissociation	excellent acceptance for forward region for measurement of large rapidity gaps	cross section growth with rapidity gap size, dependence on t, angular vs pT acceptance	Pomeron trajectory, energy and t-dependence of the cross section on the rapidity gap size	M. Deak, M.Strikman, A.Stasto	Cross section level calculation, rapidity gap estimates completed. To do: angular acceptance plots, simulations

Summary of studied channels:

Measurement/process	Main detector requirement (if known/anticipated)	Expected plot for the YR	Physics goal/topic	Contact person	Comments and next steps
Electro/Photo-production J/ψ Upsilon 1S, 2S, 3S	Central Detector Scattered Electron Forward Detector for nuclear fragments to separate coherent/incoherent Requires less than 1% momentum resolution	Gluon distributions as a function of x and $b_\perp$	Gluon Dist. 3D Gluon imaging	S. Klein S. Heppelmann	EICRoot Framework Detector Setups:(LBNL All-Si,BeAST) Studies on reconstruction efficiency and detector resolution with different fields
Diffractive deuteron breakup in J/ψ production	deuteron internal momenta up to 0.8–1 GeV/c can be detected with good acceptances and excellent resolutions with current far forward design	number of events vs p_miss with p and n spectators	Various: study is proxy for processes with single and double nucleon tagging in deuteron	K.Tu A.Jentsch	arXiv imminent Beagle + current far forward detectors

Summary of studied channels:

Measurement/process	Main detector requirement (if known/anticipated)	Expected plot for the YR	Physics goal/topic	Contact person	Comments and next steps
eA QE 2N knockout	Acceptance for far forward nucleons	number of events vs p_miss of struck nucleon for 2N knockout reactions	SRC studies	F. Hauenstein	fast simulations Beagle + g4e. simulations GCF-DIS for tagged DIS
e-p/d elastic scattering	small angle scattered electron detection	FF projections as a function of Q^2	elastic FF	B.Schmookler	work to separate elastic from high-x inelastic. Simulation for elastic e-d ongoing

Other channels

Measurement/process	Main detector requirement (if known/anticipated)	Expected plot for the YR	Physics goal/topic	Contact person	Comments and next steps
Hadron spectroscopy	central barrel tracking and calorimetry down to 100 MeV	Invariant mass distribution (state TBD)	exotic hadron spectroscopy (i. e. XYZ states)	TBD	manpower
Bethe-Heitler	Acceptance for small-angle photons	elastic FF projections	(transition) FF measurements at variable energies exploiting initial state radiation	Ch. Hyde Ch. Weiss	kinematic plots forthcoming
Coherent production of VM in 4He scattering	$0.01 < -t < 0.5$ GeV^2	Evolution of t-dependence of VM production as a function of Q^2	Color transparency, rescattering, color opacity at various Q^2,	M. Strikman	Need more calculations for the detector requirements

Other channels

Measurement/ process	Main detector requirement (if known/anticipated)	Expected plot for the YR	Physics goal/topic	Contact person	Comments and next steps
nucleon fragmentation e+p -> e+h(p,n, π)[TF]+X e+p ->e+h+π/dijet[CF]+X	Far forward: -p/n: x_L range down to 0.1; p_T range: 0 <p_T <0.7 GeV/c -Delta production: detection of pions with xL range from 0.3 to 0.1	leading hadron cross sections as a function of xL (normalized to inclusive)	fracture functions, multiparton nucleon structure, formation time	M. Strikman	acceptance plots
ep/A-> e + 2 jets + X + Y	Roman pot for leading protons, forward neutron calorimeter for pion exchange, nuclei	Differential diffractive cross section for jet production, i.e. Figs. 5d, 6d; 8b and 9d from 2004.06972	diffractive PDFs in protons and nuclei, pion PDFs, nuclear excitation	M. Klasen V.Guzey	NLO calculations finished, must still optimise YR plot(s) Pass through simulations

Final remarks:

- Many well advanced studies with clear requirements for detectors.
  - Other studies, on important physics topics, are just getting started.
- Next steps: start to summarize/put details of results in Wiki and/or overleaf document(s) (in many cases papers are already being written and/or near completion)
- If you would like to contribute/participate please join our mailing list and group meetings (usually on Thursdays at 1pm/EDT)
- New ideas always welcome, even if the full studies cannot be completed in time for YR. Manpower needed.

Thank you!