PWG/DWG common questions

1.- Common set of energies, beam species, luminosities, and polarization

Based on the current BNL design, we suggest, as a starting point for our physics simulations, to study one or several of the following beam energy combinations:

- p-e:	275 on 18 GeV,	100 on 10 GeV,	100 on 5 GeV	and	41 on 5 GeV
- Au-e:	110 on 18 GeV,	110 on 10 GeV		and	41 on 5 GeV

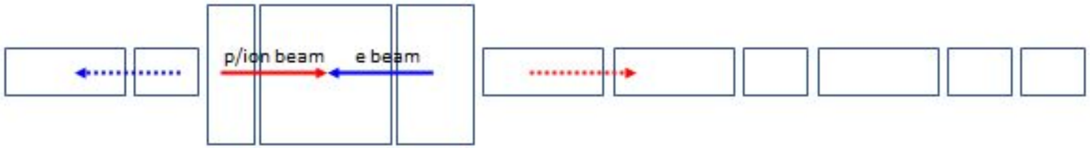
For integrated luminosity, we could follow similar assumptions as in the White Paper, i.e.: 10 fb^{-1} and 100 fb^{-1}.

A polarization of 70% can be assumed for electrons and light ions as a baseline (including polarized d?)

2.- What physics processes drive each detector component the most, and what are these requirements?

Cartoon/Model of the Extended Detector and IR

- ❑ EIC physics covers the entire region (backward, central, forward)
- ❑ Many EIC science processes rely on excellent and fully integrated forward detection scheme



far-backward e detection	e final-focus quads	"Central detector", includes e endcap, central, and p/ion endcap detectors	Ion final-focus quads	far-forward h detection	forward dipole	far-forward h detection	forward dipole	far-forward h detection
Low-Q^2 spectroscopy		Inclusive Structure Functions, TMDs, heavy flavors and jets, electrons for GPDs		Baryon decay π/K structure evaporated n		GPDs/DVCS, tagging, diffraction		lowest-t, diffraction
GEMs Diamond detectors?		Vertex and Tracking detectors, particle identification detectors, calorimetry detectors, muon detectors, etc.		GEMs ZDCs e/γ calorim.		GEMs Roman pots e/γ calorim.		Roman pots GEMs?

physics examples (green row) | detector examples (yellow row)

2.- What physics processes drive each detector component the most, and what are these requirements?

Measurement/ process	Main detector requirements	Anticipated plot	Physics topic/goal
SIDIS	• η acceptance for hadrons • angular resolution • granularity of the detector (central to forward -1 to 4), • pi/K/p identification •Comments: PID↔Tracking, B −field → δp/p, min p	• pseudo-3D Sivers function as a function kt for various x bins, • Value of Tensor charge uncertainties + plot vs x, • Q2 dependence of Sivers function or A_{UT} at fixed x	Quark Sivers, 3D momentum structure, TMD evolution
SIDIS, di-jets/dihadrons	acceptance for back-to back dihadrons	Size of the asymmetry as a function of x	Gluon Sivers
SIDIS: Spectroscopy possibilities	• dilepton identification for J/psi • displaced vertex • pi/K separation for open charm • forward proton/neutron recoils from diffractive production (similar to DVCS reqs)	Kinematic coverage for decay particles in representative channels Possibly expected limits on coupling vs mass for J/Ψππ, DD* final states	Representative spectroscopy channel : X,Y → J/Ψππ, DD*
SIDIS: Sea quark helicity measurements	hadron momentum and energy resolution in forward direction (2 < η < 4) for CC events	Update of previous sea quark helicity PDF uncertainty plots	flavor separated (anti)quark helicity distributions over wide range of x

2.- What physics processes drive each detector component the most, and what are these requirements?

Measurement/ process	Main detector requirements	Anticipated plot	Physics topic/goal
FFs/nFFs/nPDFs via single hadron FF	See TMD SIDIS reqs	nPDF uncertainty expectation, (n)FF expectation	Single hadron fragmentation functions for ep and eA for FFs, nFFs, nPDFs
Di-hadron correlations in eA at low x	backward hadron acceptance, granularity	decorrelation plot as in white paper	onset of saturation phenomenon

Polarized reactions

Physics goals + channel	Money plots	Bonus plots	Detector requirements
Nucleon structure, helicity distributions Jet and dijet A_{LL}	A_{LL} vs jet p_T and for various η bins	Δq and Δg vs x and Q^2	Polarimetry Luminosity, Forward, central and backward acceptance, Calorimetry,Tracking
Nucleon structure, 3D, Sivers asymmetry, TMD evolution, transversity Jets, di-jets, lepton-jets	Quark sivers function of x, k_T Q^2 dependence of the Sivers function	A_N as a function of angle (away from back-to-back) Gluon Sivers function	Polarimetry, Luminosity, Forward, central and backward acceptance, Calorimetry, Tracking

Jets & HF

Unpolarized reactions, light flavor jets

Physics goals + channel	Money plots	Bonus plots	Detector requirements
TMD physics, Nuclear broadening Di-jets, photon/lepton-jet correlations	Dijet angular distributions Lepton-jet angular distributions. Different rapidity, $p_{T,}$ bins	TEEC vs azimuthal angle Photon-jet correlations and asymmetries in eA, comparison to ep	Detector acceptance; Calorimetry, Tracking, Particle ID (lepton, photon)
Fragmentation (TMD, longitudinal), fundamental QCD splitting processes Inclusive jet substructure, hadron in jet	Hadron distribution in jets vs k_T (relative to jet axis) and vs z	Light flavor jet momentum sharing distributions vs angle r, splitting fraction z Modification of shapes and fragmentation functions (vs r, z), angularities	Detector coverage; Calorimetry, Tracking, Particle ID, Granularity, Tracking resolution

Heavy flavor

Physics goals + channel	Money plots	Bonus plots	Detector requirements
Hadronization and energy loss D, B meson production, modification in eA	D, B meson and light h R_{eA} vs z_h D, B meson cross sections vs p_T	D, B meson and light h R_{eA} vs Q^2, v Also vs k_T	Tracking, Vertexing, Particle ID, Calorimetry, Forward coverage
Charm and bottom content of nucleons and nuclei Heavy-flavor tagged jet cross section	Charm - tagged jet cross sections vs $p_{T,}$ Charm F_2 (vs x Q^2)	Bottom tagged jet cross sections vs $p_{T,}$ Bottom F_2 (vs x Q^2)	Tracking, Vertexing, Particle ID, Calorimetry, Forward, Central, and Backward coverage
Mass dependence of parton showers Heavy flavor jet substructure	Heavy flavor splitting functions vs r (angle) and z Heavy flavor jet shapes vs r	Fragmentation in jets to heavy mesons vs z and p_T (relative to jet axis) Substructure modification in eA Quarkonia in jets	Tracking, Vertexing, Particle ID, Calorimetry

EW and angularities

Physics goals + channel	Money plots	Bonus plots	Detector requirements
Electroweak structure functions Parity violating reactions with jets, Charge currents	Charge current cross sections vs Jet p_T , rapidity $F_1^{\gamma Z}$, $F_3^{\gamma Z}$ vs x in bins of Q^2 (polarized x polarized) $g_1^{\gamma Z}$, $g_5^{\gamma Z}$ vs x in bins of Q^2 (unpolarized x polarized)	$\sin^2\theta_W$ vs scale Q Present structure functions vs x, Q	Polarimetry, Luminosity, Tracking, Calorimetry
Extraction of α_s, hadronization parameters Global event shapes	Thrust distribution as a function of τ for several x and Q^2 bins Angularity vs τ for several α parameters	α_s and hadronization parameter Ω_1 scatter plot	Forward, central and backward coverage, Calorimetry, Tracking.

Inclusive

Measurement	Main Detector Requirements	Anticipated Plot	Physics Topic/goal	Responsible persons	Additional Comment
$A_\parallel$, $A_\perp$ for p, d, ^{3}He	Standard inclusive	$A_\parallel$, $A_\perp$, $g_{1,2,\perp}$, Δg	Gluon & Quark Helicity and HT	TBA	Global fit with SIDIS?
$A^e_{\rm PV}$, $A^h_{\rm PV}$ for p, d	Standard inclusive	$A^e_{\rm PV}$, $A^h_{\rm PV}$, $F^{\gamma Z}_{2,3}$, $g^{\gamma Z}_{1,5}$, $F^{W^-}_{2,3}$, $g^{W^-}_{1,5}$, $(\Delta)s^+$	Pol. & Unpol. strange	TBA	Will SIDIS do the Kaon tagging channel?
$d\sigma^{\rm NC}/dxdy$ (inc, HQ) for p, d	Standard inclusive + heavy quark	$\sigma^{\rm inc.,HQ}_{\rm red}$, $F^{\rm inc.,HQ}_{2,L}$, g, d/u	Proton PDFs	TBA	Global fit with SIDIS?
$d\sigma^{\rm NC}/dxdy$ (inc, HQ) for A	Standard inclusive + heavy quark	$\sigma^{\rm inc.,HQ}_{\rm red}$, $F^{\rm inc.,HQ}_{2,L}$, F^A_2/F^N_2, g,	Nuclear PDFs	TBA	
$d\sigma^{\rm NC}/dxdy$ (inc) for p, A	Standard inclusive	$\sigma^{\rm inc.,HQ}_{\rm red}$, $F^{\rm inc.,HQ}_{2,L}$	Non-linear QCD dynamics	TBA	Global fit with SIDIS?
$A^e_{\rm PV}$ for d	Standard inclusive	$\sin^2(\theta_W)$	BSM & precision EW physics	TBA	Need ~100 fb^{-1} CLFV via $e \to \tau$?
$d\sigma^{\rm NC}/dxdyd\phi$	Standard inclusive	Updated Fig.6 in PhysRevD.98.115018 for CM energies smearing	Lorentz and CPT Violating Effects	Lunghi and Sherrill	

Topics under consideration: DVCS

	Requires detection of:
Protons	
Cross-section and polarisation asymmetries	e, p, γ
π^0 as DVCS background In e+p	$e, p, (\gamma\gamma)$
Neutrons	
In e+d: require tagging of the spectator proton in addition to the recoil neutron	e, n, γ, p_s
Coherent on light ions	
In e+d and e+ He: tagging of the light nuclei	e, d, γ e, He, γ
Within heavy nuclei	
On the proton within heavy nuclei, with leading twist nuclear shadowing	e, p, γ

3.- Considerations/constraints from the detector design side that must be included into baseline physics simulations

The Detector Handbook provides initial guidance on possible detector capabilities, however, since the goal of the YR exercise is to optimize the detectors for physics, it would be most useful to come up with performance constraints based on current state-of-the-art technologies. For example:

- Tracking performance vs. p_T and rapidity
- PID capabilities for pi, K, p separation (vs. p_T, η)
- Vertex resolution
- Jet reconstruction/energy resolution (particularly forward/backward)
- ....

3.- Considerations/constraints from the detector design side that must be included into baseline physics simulations

DWG Interactive Map

https://physdiv.jlab.org/DetectorMatrix/

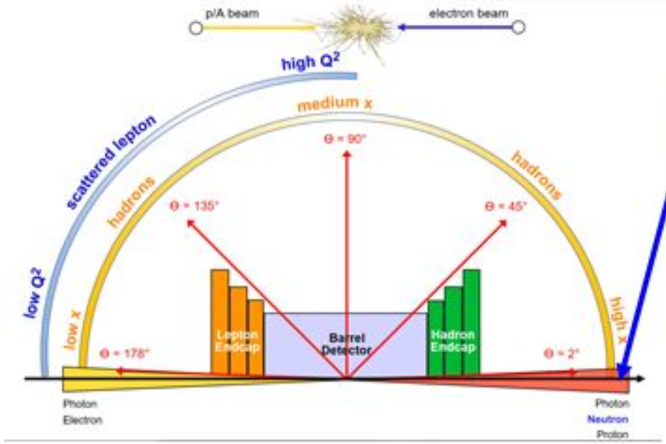
- ❑ Goal: work out requirements to carry out the EIC physics
- ❑ Goal: Integrate technologies to meet the requirements

Details for Zero-Degree Neutron Detection

Abstract:
Geometry needs for zero-degree calorimeter used to detect neutrons from incoherent nuclear breakup reactions.

Referenced Files:
- ZDC neutron angle as function of energy.
- Zero-Degree High Precision Hadronic Calorimetry.

Notes:
ZDC: size 60x60x200cm



Example of zero-degree neutron detection

Interactive Map: to guide and document the efforts towards these goals

Thanks to: Walt Akers, Elke Aschenauer, Rolf Ent, Thomas Ullrich

3.- Considerations/constraints from the detector design side that must be included into baseline physics simulations

DWG Interactive Map

https://physdiv.jlab.org/DetectorMatrix/

- ❑ Interactive table of detector requirements for each region of physics

Details for the Barrel Calorimeter HCAL

Abstract:

The resolution was determined in a study, which looked to the energy-resolution of jets using a the information of a hadron calorimeter in the unfolding.

Referenced Files:

- Jet study in Barrel HCAL

Notes:

Barrel HCAL: 75%/sqrt(E) + 15%

Example of Barrel Calorimeter HCAL

η	Nomenclature			Tracking			Electrons		π/K/p		HCAL	Muons
				Resolution	Allowed X/X_0	Si-Vertex	Resolution σ_E/E	PID	p-Range (GeV/c)	Separation	Resolution σ_E/E	
-6.9 to -5.8			low-Q2 tagger	$\delta\theta/\theta < 1.5\%$; $10^{-6} < Q^2 < 10^{-2}$ GeV^2								
…	↓ p/A	Auxiliary Detectors										
-4.5 to -4.0			Instrumentation to separate charged particles from photons									
-4.0 to -3.5							2%/√E					
-3.5 to -3.0												
-3.0 to -2.5				$\sigma_p/p \sim 0.1\% \times p + 2.0\%$								
-2.5 to -2.0			Backward Detector	$\sigma_p/p \sim 0.05\% \times p + 1.0\%$		TBD			≤ 7 GeV/c		~50%/√E	
-2.0 to -1.5				7%/√E				π suppression up to 1:10^4				
-1.5 to -1.0												
-1.0 to -0.5												
-0.5 to 0.0		Central Detector	Barrel	$\sigma_p/p \sim 0.05\% \times p + 0.5\%$	~5% or less	$\sigma_{xyz} \sim 20$ μm, $d_0(z) \sim d_0(r\Phi) \sim 20/p_T$ GeV μm + 5 μm			≤5 GeV/c	≥ 3 σ	TBD	TBD
0.0 to 0.5												
0.5 to 1.0												
1.0 to 1.5									≤ 8 GeV/c			
1.5 to 2.0				$\sigma_p/p \sim 0.05\% \times p + 1.0\%$			(10-12)%/√E					
2.0 to 2.5			Forward Detectors			TBD			≤ 20 GeV/c		~50%/√E	
2.5 to 3.0				$\sigma_p/p \sim 0.1\% \times p + 2.0\%$								
3.0 to 3.5									≤ 45 GeV/c			
3.5 to 4.0			Instrumentation to separate charged particles from photons									
4.0 to 4.5												
…			Neutron Detection									
> 6.2	↑e	Auxiliary Detectors	Proton Spectrometer	$\sigma_{intrinsic}(\lvert t \rvert)/\lvert t \rvert < 1\%$; Acceptance: $0.2 < p_T < 1.2$ GeV/c								

Thanks to: Walt Akers, Elke Aschenauer, Rolf Ent, Thomas Ullrich

4.- How do we organize the various steps of the work that require interactions and feedback between PWG and DWG ?

- Define and agree on the steps, here a preliminary list:
  - Define the reference beam energies (question 1)
  - Define the benchmark process (the whole TEMPLE meeting ?)
  - Establish the characteristics of the event samples
  - Produce the event samples and make them available
  - Get the feedback from detectors: resolutions, constrains
  - Understand the impact resolution and constrains on the physics reach

- Timelines for the steps
- Who does what
- A mechanism to update in real time the indications coming from detector studies

4.- How do we organize the various steps of the work that require interactions and feedback between PWG and DWG ?

Straw-man plan of attack:

a. Review previous existing work related to your subgroup.
b. Converge on a set of important and representative measurements for your subgroup.
c. Break-down physics deliverables into “physics objects” (PO) [electron, hadron (ID/noID), muon, jet]; map out kinematics for each PO.
d. Cross-check PO maps across physics subgroups to determine the most challenging constraints in terms of detector design; resolve overlaps [decide who runs what].
e. Focus on fast simulations for the most demanding measurements first; determine the optimal/acceptable detector performance; confirm/check resulting impact on the rest of the measurements.