EIC Detector Requirements

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Credits: Material by the EICUG Yellow Report Initiative, Physics WG & Detector WG; A. Bazilevsky, Y. Furletova, A. Kiselev

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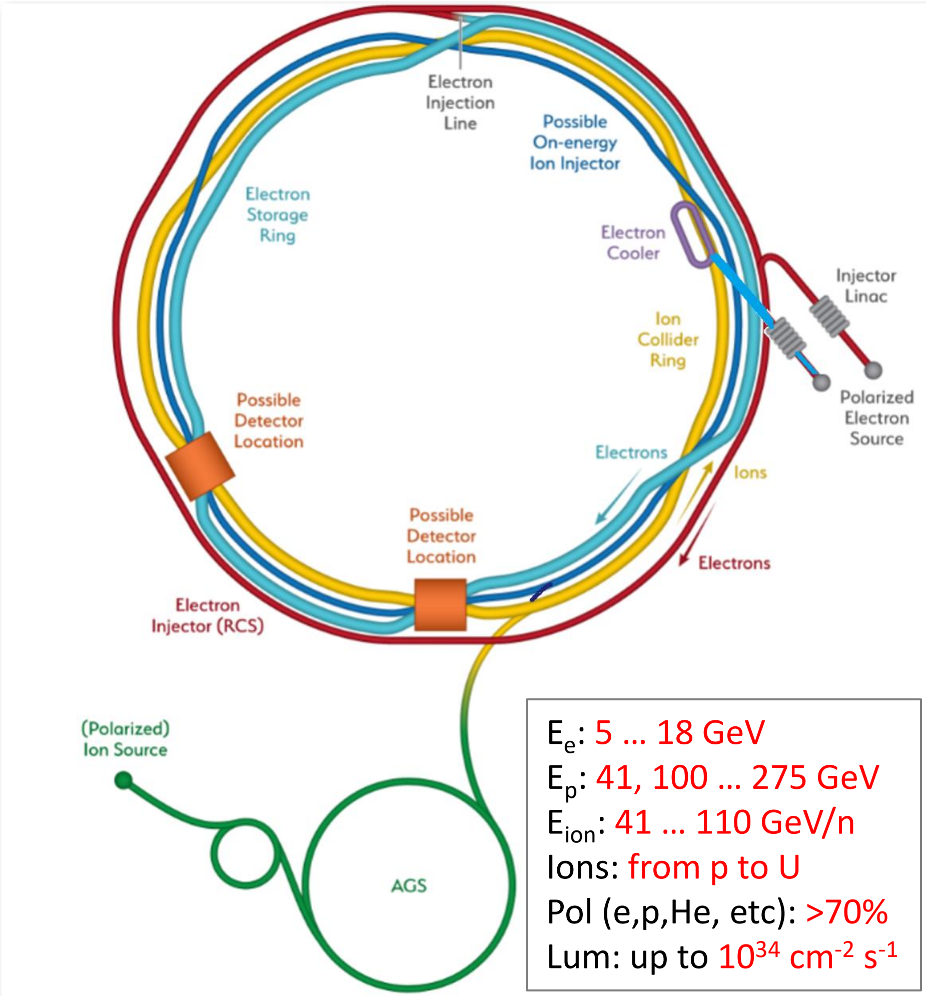
National Academy of Science Report: AN ASSESSMENT OF U.S.-BASED ELECTRON-ION COLLIDER SCIENCE:



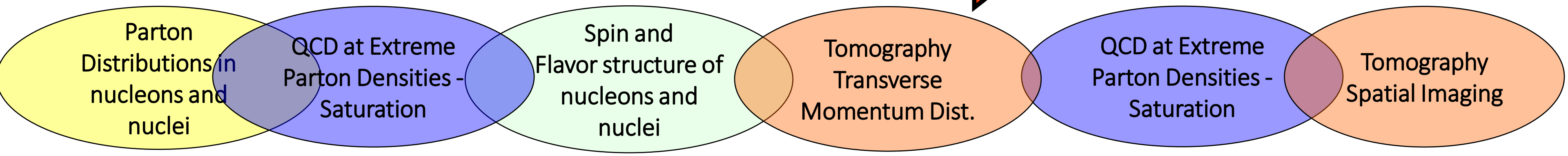
"An EIC can uniquely address three profound questions about nucleons - neutrons and protons - and how they are assembled to form the nuclei of atoms:

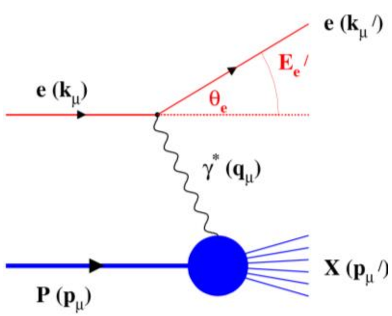
- **How does the mass of the nucleon arise?**
- **How does the spin of the nucleon arise?**
- **What are the emergent properties of dense systems of gluons?"**

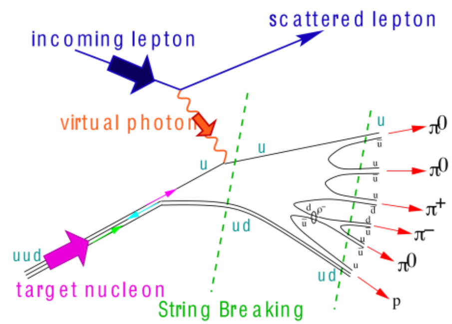
Overview EIC Physics Categories

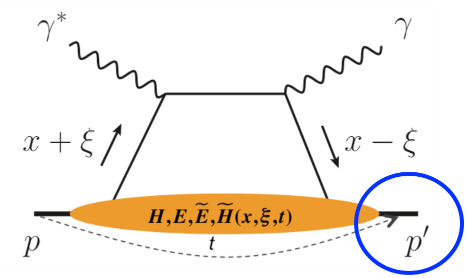
See talk by Or Hen for more detail

machine & detector requirements →









Inclusive DIS

- measure scattered lepton
- multi-dimensional binning: x, Q^2
  - → reach to lowest x, Q^2 impacts Interaction Region design
  - → low mass detectors, excellent e/h separation

Semi-inclusive DIS

- measure scattered lepton and hadrons in coincidence
- multi-dimensional binning: x, Q^2, z, p_T, ϕ
  - → particle identification over entire region is critical

Exclusive processes

- measure all particles in event
- multi-dimensional binning: x, Q^2, t, ϕ
- proton p_t: 0.2 - 1.3 GeV
  - → cannot be detected in main detector
  - → strong impact on Interaction Region design

$\int Ldt$: 1 fb^{-1} | 10 fb^{-1} | 10 - 100 fb^{-1}

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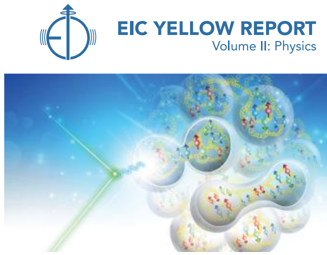
EIC Detector General Requirements

EIC physics measurements require a detector with unique capabilities

- ❑ Large rapidity ($-4 < \eta < 4$) coverage; and far beyond in especially far-forward detector regions
- ❑ High precision low mass tracking
  - small (μ-vertex) and large radius tracking
- ❑ Electromagnetic and Hadronic Calorimetry
  - equal coverage of tracking and EM-calorimetry
- ❑ High performance PID to separate p, K, π on track level
  - also need good e/π separation for scattered electron
- ❑ Large acceptance for diffraction, tagging, neutrons from nuclear breakup: critical for physics program
  - Many ancillary detector integrated in the beam line: low-Q^2 tagger, Roman Pots, Zero-Degree Calorimeter, ….
- ❑ High control of systematics
  - luminosity monitor, electron & hadron Polarimetry

⮎ **Integration into Interaction Region is critical**

EICUG: Yellow Report (YR) Initiative



http://www.eicug.org/web/content/yellow-report-initiative

Detector requirements and design driven by EIC Physics program and defined by EIC Community

Physics Topics → Processes → Detector Requirements

Physics Working Group:

- Inclusive Reactions
- Semi-Inclusive Reactions
- Jets, Heavy Quarks
- Exclusive Reactions
- Diffractive Reactions & Tagging

See talk by Or Hen

Detector Working Group:

- Tracking + Vertexing
- Particle ID
- Calorimetry
- Far-Forward Detectors
- DAQ/Electronics
- Polarimetry/Ancillary Detectors
- Central Detector: Integration/Magnet
- Forward Detector: IR Integration

Handoff between Physics & Detector Working Groups in "**interactive detector matrix**": Collects physics requirements "real time", lists all technologies for a given region, and links to studies that established the numbers

EIC YR Detector Working Group

- Conveners: Ken Barish (UC Riverside), Tanja Horn (CUA), Peter Jones (U. Birmingham), Silvia Dalla Torre (Trieste/INFN), Markus Diefenthaler (Jlab, ex-officio)

- Eight Working groups

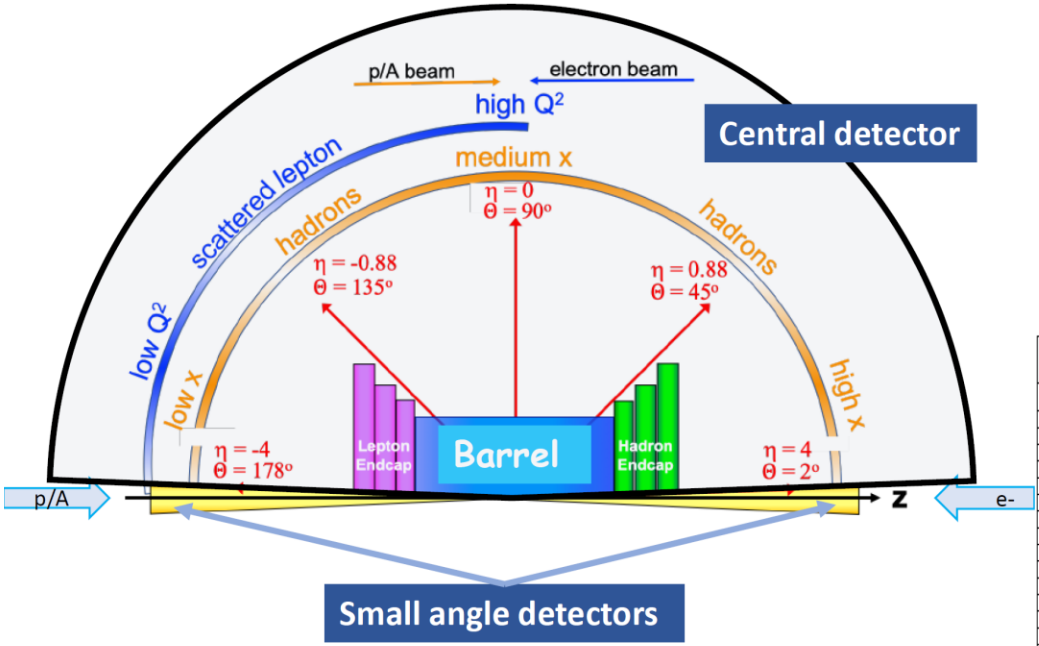
  - **Tracking (+vertexing),** Conveners: Kondo Gnanvo (UVA), Leo Greiner (LBNL), Annalisa Mastroserio (INFN), Domenico Elia (INFN)
  - **Particle ID**, Conveners: Tom Hemmick (SBU), Patrizia Rossi (JLab)
  - **Calorimetry (EM and Hadronic),** Conveners: Vladimir Berdnikov (CUA), Eugene Chudakov (JLab)
  - **Far-Forward Detectors**, Conveners: Alexander Jentsch (BNL), Michael Murray (Kansas)
  - **DAQ/Electronics**, Conveners: Andrea Celentano (INFN), Damien Neyret (CEA Saclay)
  - **Polarimetry/Ancillary Detectors**
    - Conveners: Elke Aschenauer, Dave Gaskell
  - **Central Detector/Integration & Magnet,** Conveners: Willliam Brooks, Alexander Kiselev (BNL)
  - **Forward Detector/IR Integration,** Convener: Yulia Furletova (JLab)
  - **Infrastructure and Installation,** Convener: TBA
  - **Detector Complementarity,** Conveners: Elke Aschenauer (BNL), Paul Newman (Birmingham)

- Webpage: http://www.eicug.org/web/content/yellow-report-detector-working-group

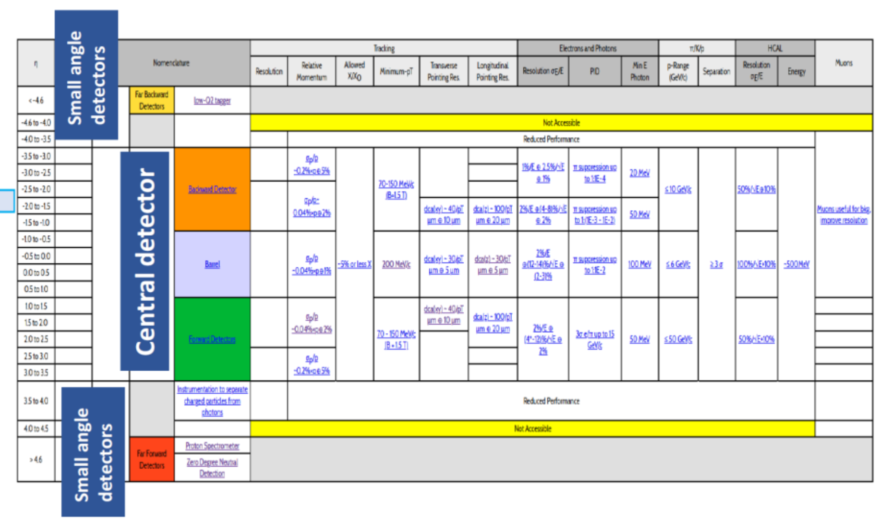
EIC YR Detector Requirements Overview: Interactive Matrix

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

The detector matrix takes care of the whole EIC phase space !



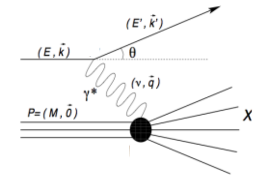
Yellow Report, Volume 3, 1/13/21 snapshot, Fig. 9.1



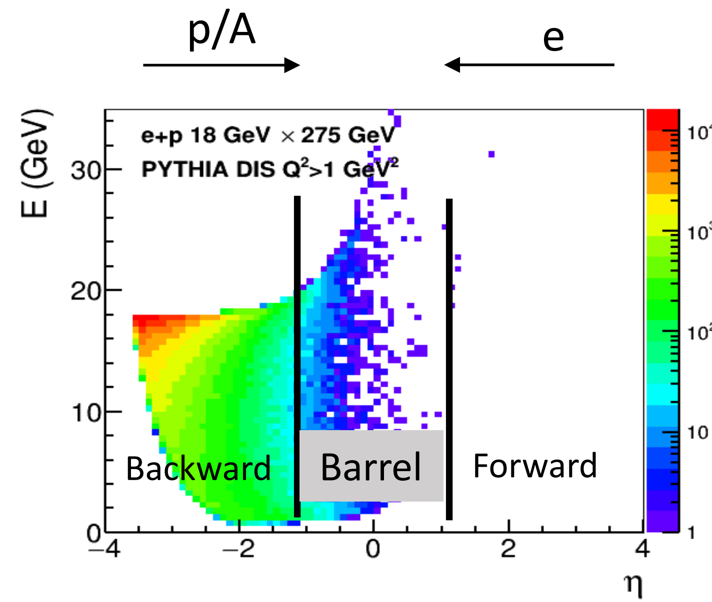
η	Nomenclature		Tracking: Resolution	Tracking: Relative Momentum	Tracking: Allowed X/X0	Tracking: Minimum-pT	Tracking: Transverse Pointing Res.	Tracking: Longitudinal Pointing Res.	Electrons and Photons: Resolution σE/E	Electrons and Photons: PID	Electrons and Photons: Min E Photon	π/K/p: p-Range (GeV/c)	π/K/p: Separation	HCAL: Resolution σE/E	HCAL: Energy	Muons
< -4.6	Far Backward Detectors	low-Q2 tagger														
-4.6 to -4.0			Not Accessible													
-4.0 to -3.5				Reduced Performance												
-3.5 to -3.0	Backward Detector			σp/p ~0.2%⊕5%	~5% or less X	70-150 MeV/c (B=1.5T)			1%/E ⊕ 2.5%/√E ⊕ 1%	π suppression up to 1E-4	20 MeV	≤10 GeV/c	≥3σ	50%/√E⊕10%	~500 MeV	Muons useful for bkg, improve resolution
-3.0 to -2.5																
-2.5 to -2.0				σp/p ~0.04%×p⊕2%												
-2.0 to -1.5							dca(xy) ~ 40/pT µm ⊕ 10 µm	dca(z) ~ 100/pT µm ⊕ 20 µm	2%/E ⊕ (4-8)%/√E ⊕ 2%	π suppression up to 1/(1E-3 - 1E-2)	50 MeV					
-1.5 to -1.0																
-1.0 to -0.5	Barrel			σp/p ~0.04%×p⊕1%		200 MeV/c	dca(xy) ~ 30/pT µm ⊕ 5 µm	dca(z) ~ 30/pT µm ⊕ 5 µm	2%/E ⊕ (12-14)%/√E ⊕ (2-3)%	π suppression up to 1E-2	100 MeV	≤6 GeV/c		100%/√E⊕10%		
-0.5 to 0.0																
0.0 to 0.5																
0.5 to 1.0																
1.0 to 1.5	Forward Detectors			σp/p ~0.04%×p⊕2%		70 - 150 MeV/c (B = 1.5 T)	dca(xy) ~ 40/pT µm ⊕ 10 µm	dca(z) ~ 100/pT µm ⊕ 20 µm	2%/E ⊕ (4*-12)%/√E ⊕ 2%	3σ e/π up to 15 GeV/c	50 MeV	≤50 GeV/c		50%/√E+10%		
1.5 to 2.0																
2.0 to 2.5																
2.5 to 3.0				σp/p ~0.2%⊕5%												
3.0 to 3.5																
3.5 to 4.0		Instrumentation to separate charged particles from photons		Reduced Performance												
4.0 to 4.5			Not Accessible													
> 4.6	Far Forward Detectors	Proton Spectrometer; Zero Degree Neutral Detection														

Inclusive DIS

$$Q^2 = 4EE'\sin^2\left(\frac{\theta}{2}\right) \qquad y = 1 - \frac{E'}{E}\cos^2\left(\frac{\theta}{2}\right) \qquad x = \frac{Q^2}{sy}$$



DIS kinematics through electron measurements

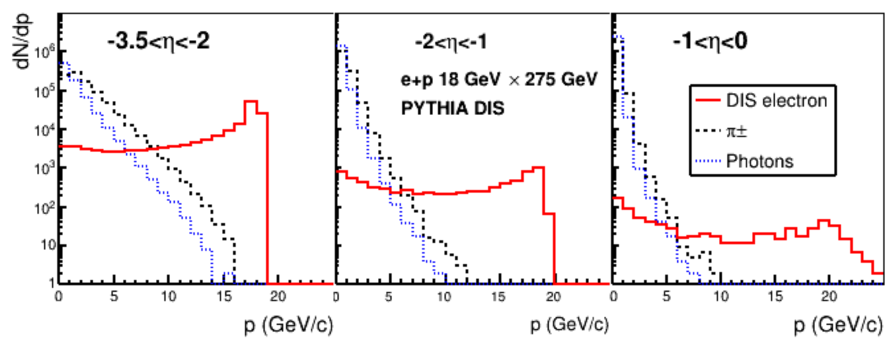


EMCal + Tracking + Electron ID

- Mainly barrel and backward
- Hadron suppression up to a factor of 10^4
- Energy/Momentum measurement is critical:
  $\frac{\sigma_{Q2}}{Q^2} \sim \frac{\sigma_{E'}}{E'}$; $\frac{\sigma_x}{x} \sim \frac{1}{y}\frac{\sigma_{E'}}{E'}$
- Highest resolution EMCal in the most backward region (due to degraded tracking mom. res.)
- Lowest material budget (to minimize Bremsstrahlung)

dN/dp vs p

Yellow Report, Volume 3, 1/13/21 snapshot, Fig. 11.69 and 11.70



Low Q^2 tagger

(far backward EMCal+Tracking)

- To measure reactions with $Q^2 < 0.1$ GeV^2
- **Minimize the gap with central detector**

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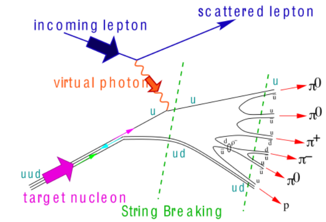
Semi-Inclusive DIS (SIDIS)



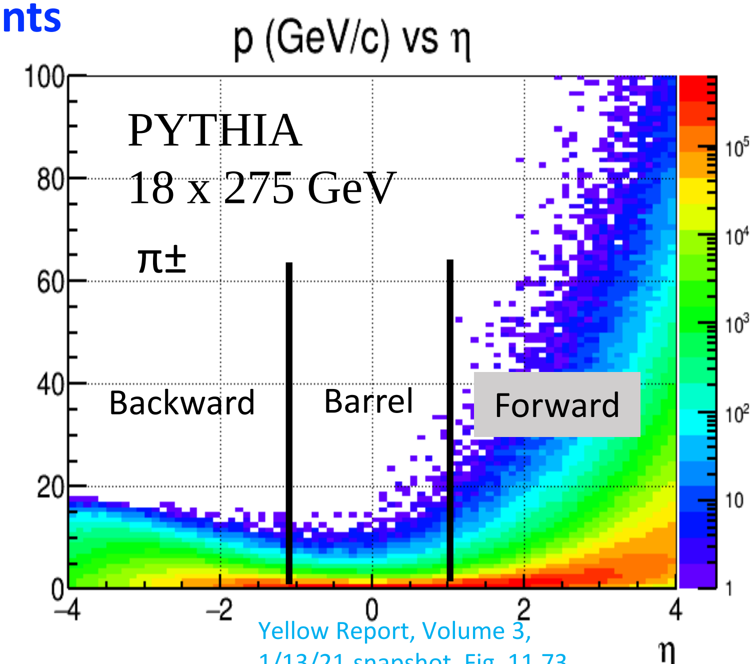
Flavor tagging through identified hadron measurements

EMCal + Tracking + Particle ID

- Coverage at least |η|<3.5
- Charged PID: π/K/p, e/h
- π^0/γ discrimination => EMCal granularity
- Particle decays (e.g. Λ→πp) => Minimal momentum threshold

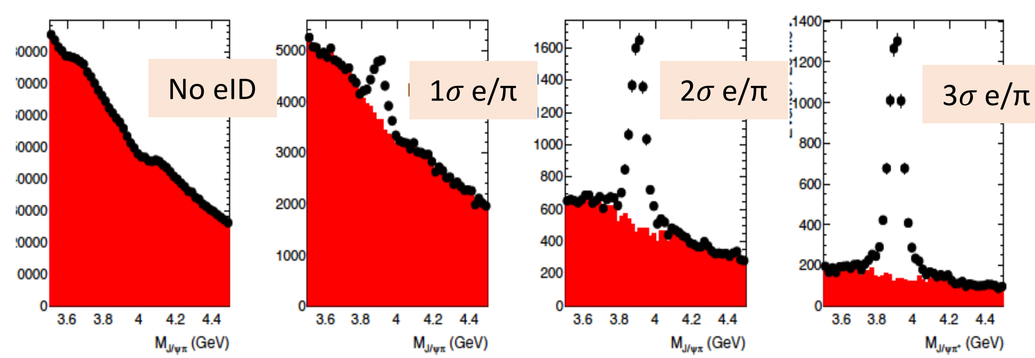
Rapidity	π/K/p and π0/γ	e/h	Min pT (E)
-3.5 – -1.0	7 GeV/c	18 GeV/c	100 MeV/c
-1.0 – 1.0	8-10 GeV/c	8 GeV/c	100 MeV/c
1.0 – 3.5	50 GeV/c	20 GeV/c	100 MeV/c

Yellow Report, Volume 2,
1/13/21 snapshot, Table 8.2



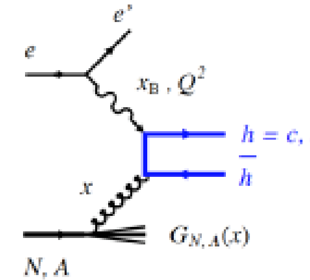
Yellow Report, Volume 3,
1/13/21 snapshot, Fig. 11.73

e/h impact on $Z_c^+ \rightarrow J/\psi$+π

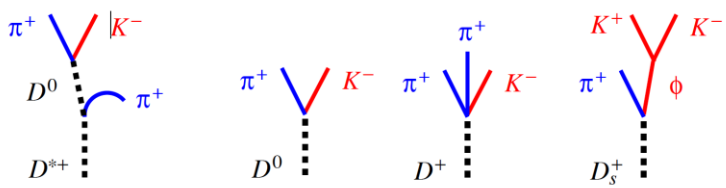


Yellow Report, Volume 2,
1/13/21 snapshot, Fig. 8.38

Heavy Quarks



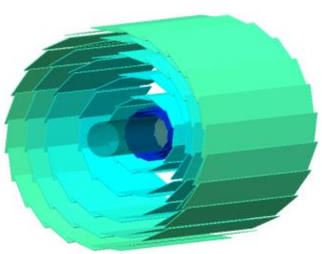
Gluon tagging

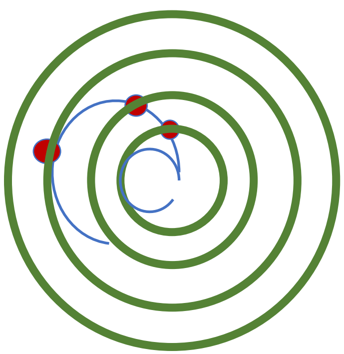


	Mass	$c\tau$
D0	1864,8 MeV	123 μm
D*	2010.2 MeV	-
D+	1869.5 MeV	315 μm
Ds+	1967 MeV	147 μm
Λc	2286.5 MeV	60μm

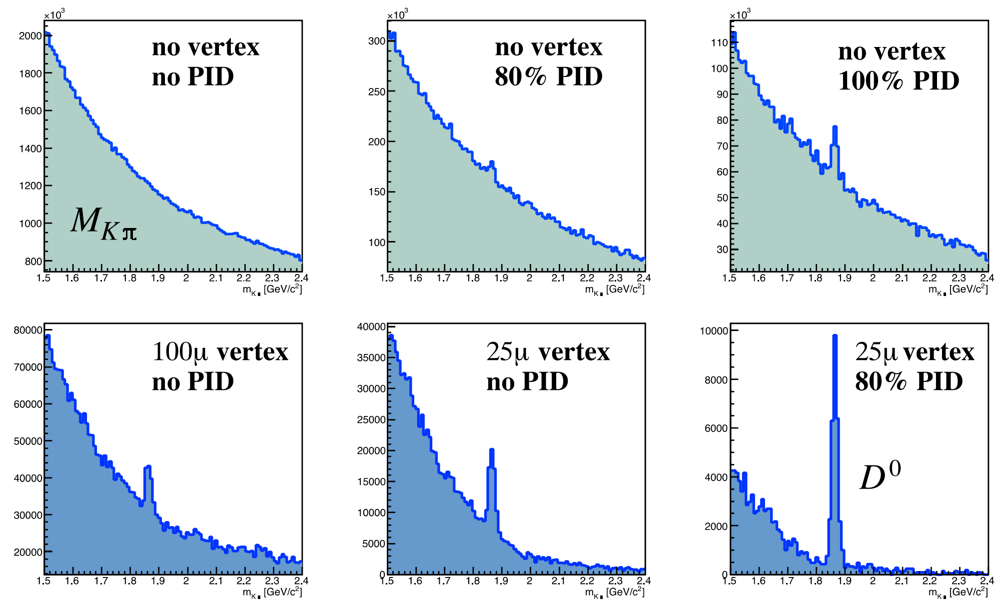
+ Vertex tracker

- Resolution ~20 μm
- Also, provides stand-alone measurements of low p_T particles

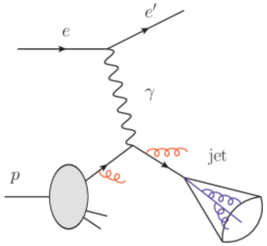




$D^0 \rightarrow K\pi$



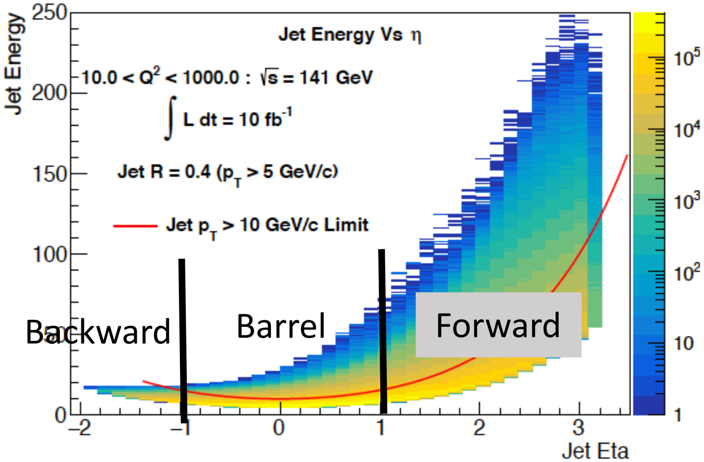
Jets



Hadronization in vacuum and in nuclear medium

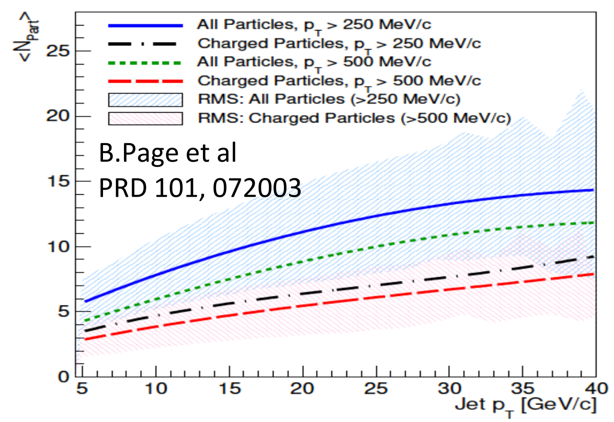
+ HCal

- Continuous coverage at least |η|<3.5
  - Minimize gap between barrel and endcap
- Important to measure neutral hadrons (n, K_L)
- Important for DIS kin. reconstruction with JB approach (via hadronic final state)
  - The only method for CC events
- Tag jets with no neutrals
  - Significantly improve jet resolution
- Would benefit from higher HCal energy resolution at η>2.5 for charged hadron measurements
  - Because of degraded track momentum res.

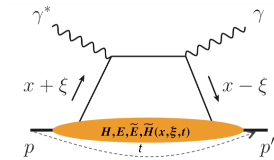


Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 8.41

Particle multiplicity in a Jet



Exclusive Reactions

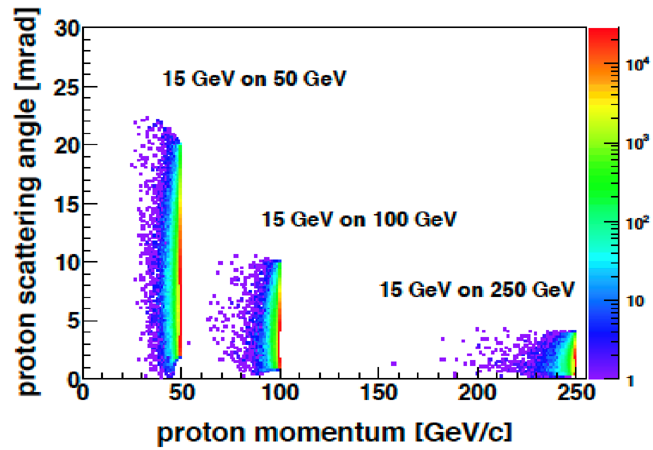


Parton tomography

+ Far-Forward proton tagger (Roman Pots)

- Dedicated detector(s) close to the beam line is required
- Need to cover at least $0.18<p_T<1.3$ GeV/c
- Integration in the Interaction Region is critical
- Exclusiveness => hermetic coverage from central to far-forward (see next slide)

DVCS: scattered proton



$0.18<p_T<1.3$ GeV/c

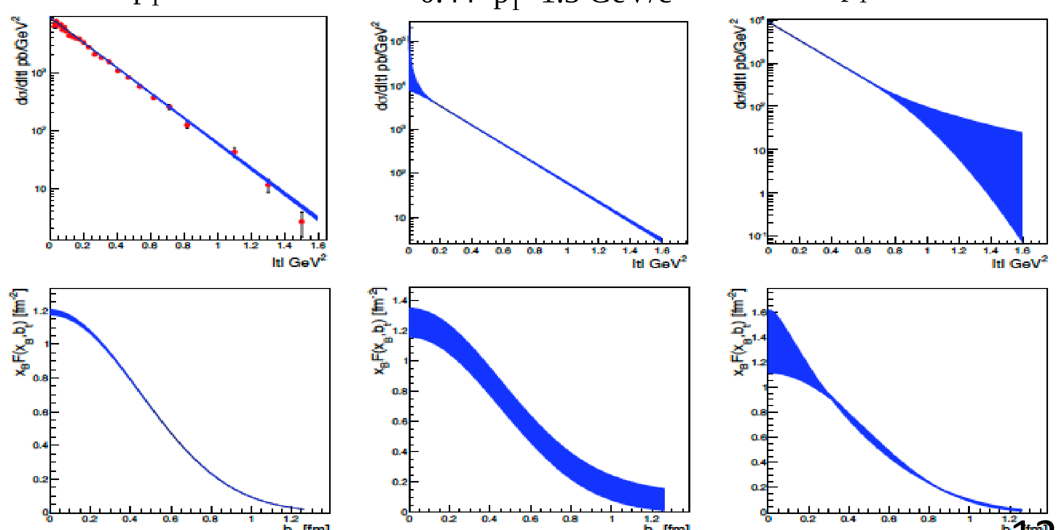
$0.44<p_T<1.3$ GeV/c

$0.18<p_T<0.8$ GeV/c

Fourier Transform

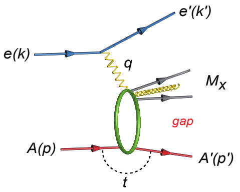
DVCS $\sigma(t)$

PDF(b_T)

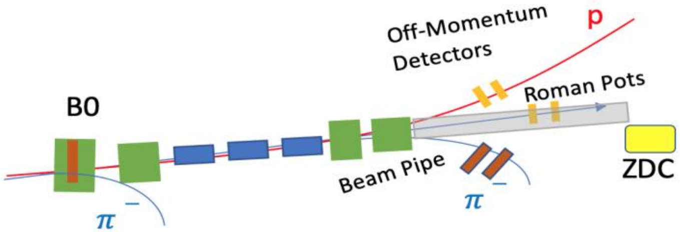


Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 7.46

Diffractive Reactions & Tagging



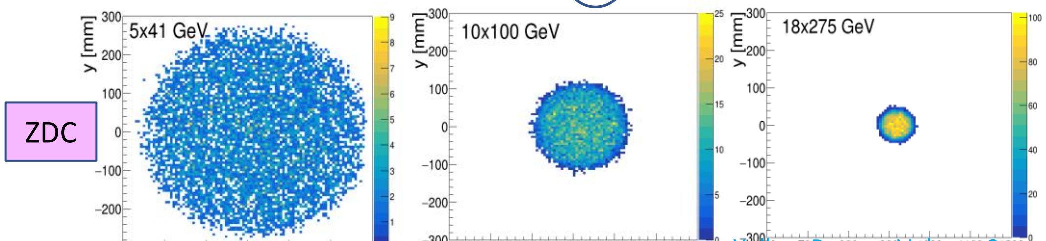
Free neutron structure and nuclear modification
Meson structure
High gluon density matter



+ Zero Degree Calorimeter

- Neutrons from nuclear break up, nucleon tagging in light ion reactions, and $p \rightarrow n$ processes
- HCal+EMCal: Coverage 60x60 cm^2

$$e + p \rightarrow e' + X + n \text{ (for pion structure)}$$

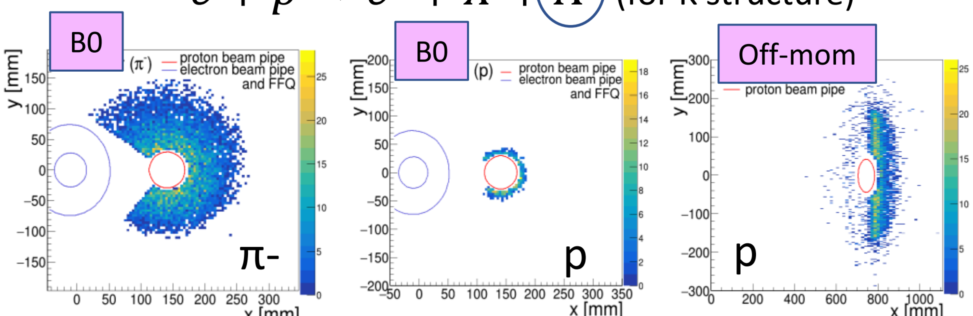


Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 8.104

+ Additional tracker(s) between central detector and proton tagger ("B0" and "OFF mom")

- Rapidity Gap measurements
- Forward decay products
- Hermetic coverage from central to far-forward region

$$e + p \rightarrow e' + X + \Lambda \text{ (for K structure)}$$



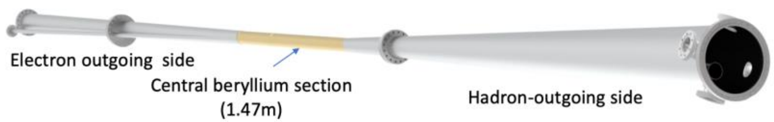
Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 8.106

Integration in the Interaction Region is critical

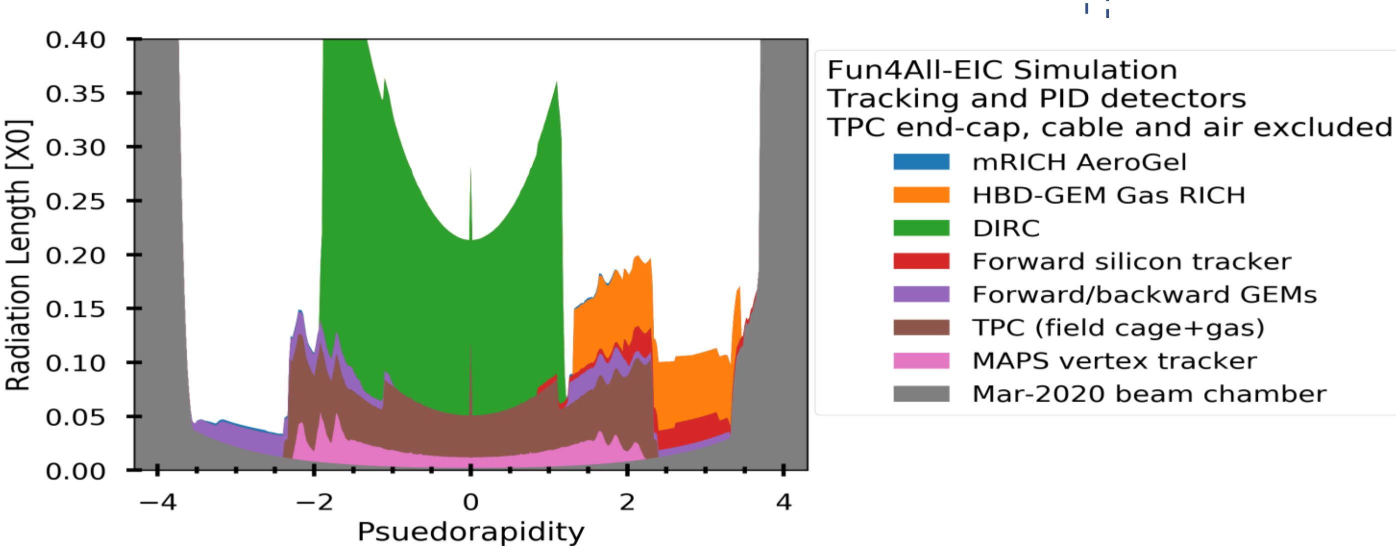
Tracking/Material Budget

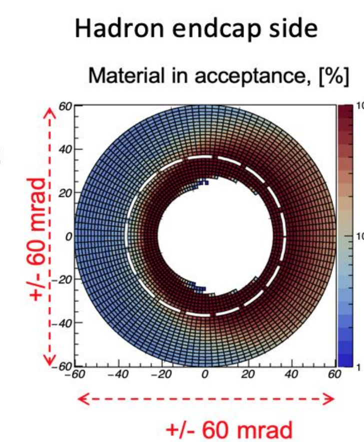
See talk by Y. Furletova, and talks by R. Cruz Torres, L. Gonella

- Vertex + central + forward / backward tracker layout (moderate momentum resolution, vertex resolution ~20 μm)
- At most 3T central solenoid field (maximize B*dl integral at high |η|)
- Low material budget
  - Minimize bremsstrahlung and conversions for primary particles
  - Improve tracking performance at large |η| by minimizing multiple Coulomb scattering
  - Minimize the dead material in front of the high resolution e/m calorimeters



- ❑ Central area of beampipe (around IP): ~1.5m of beryllium to minimize multiple scattering for low Pt particles
- ❑ Low-mass exit window for far-forward particles
- ❑ Few % radiation length material thickness for the required angular range (low angle)





Particle ID

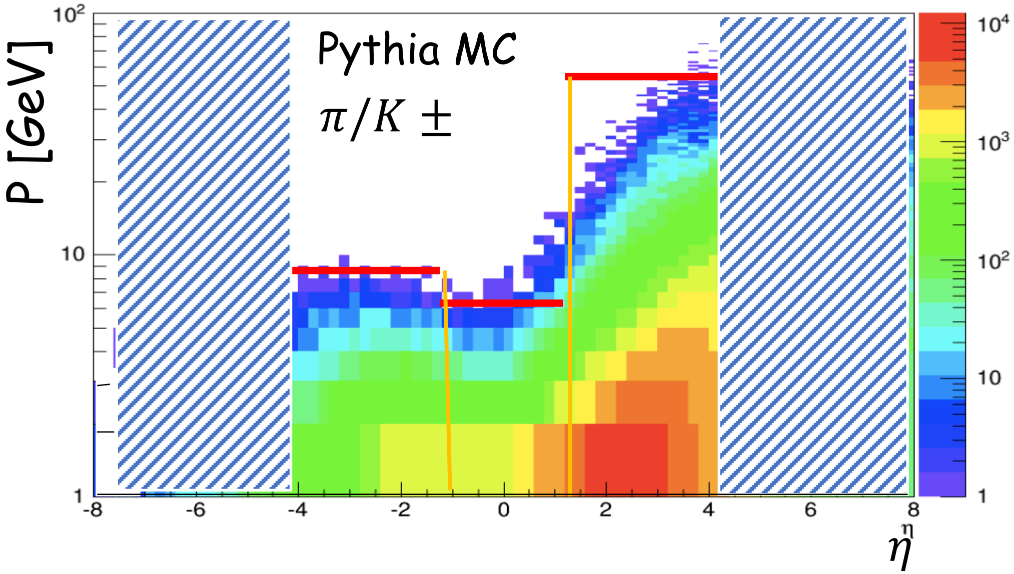
See talk by T. Hemmick

- In general, need to separate:
  - Electrons from photons -> 4π coverage in tracking
  - Electrons from charged hadrons -> mostly provided by calorimetry
  - Charged pions, kaons and protons from each other -> Cherenkov detectors

Physics requirements:

Rapidity	π/K/p and π0/γ	e/h	Min pT (E)
-3.5 – -1.0	7 GeV/c	18 GeV/c	100 MeV/c
-1.0 – 1.0	8-10 GeV/c	8 GeV/c	100 MeV/c
1.0 – 3.5	50 GeV/c	20 GeV/c	100 MeV/c

Illustration of PID detectors achievements:



Cherenkov detectors, complemented by other technologies at lower momenta

Electromagnetic Calorimeter

See talk by A. Bazilevsky

- Applications
  - Scattered electron kinematics measurement at large |η| in the e-endcap
  - Photon detection and energy measurement
  - e/h separation (via E/p & cluster topology)
  - π^0/γ separation -> may also consider a highly segmented preshower

- Anticipated stochastic term in energy resolution & available space

η	[-4 .. -2]	[-2 .. -1]	[-1 .. 1]	[1 .. 4]
σ_E/E	~2%/√E	~7%/√E	~10-12%/√E	~10-12%/√E
space	~50 cm	~50 cm	~30 cm	~40 cm

- Other considerations
  - Fast timing
  - Compactness (small X_0 and R_M)
  - Tower granularity
  - Readout immune to the magnetic field

#	Type	sampling, mm	f_{samp}	X_0 mm	R_M mm	λ_I mm	cell mm^2	$\frac{X}{X_0}$	ΔZ cm	σ_E/E, % α	β
1	W/ScFi**	⌀0.47 ScFi W powd.	2%	7.0	19	200	25^2	20	30	2.5	13
2	$PbWO_4$***	-	-	8.9	19.6	203	20^2	22.5	35	1.0	2.5
3	Shashlyk***	0.75 W/Cu[a] 1.5 Sc	16%	12.4	26	250	25^2	20	40	1.6	8.3
4	W/ScFi** with PMT	0.59^2 ScFi W powd.|	12%	13	28	280	25^2	20	43	1.7	7.1
5	Shashlyk***	0.8 Pb 1.55 Sc	20%	16.4	35	520	40^2	20	48	1.5	6
6	TF1 Pb glass***	-	-	28	37	380	40^2	20	71	1.0	5-6
7	Sc. glass*[b]	-	-	26	35	400	40^2	20	67	1.0	3-4

EIC Yellow Report

Yellow Report, Volume 3, 1/13/21 snapshot, Table 11.28

Hadron Calorimeter

See talk by A. Bazilevsky
and talk by N. Schmidt

- Main purpose: hadron/jet energy measurement
  - Particle Flow Algorithm usage anticipated (where HCal role is identification and energy measurements of the neutral hadrons, namely neutrons and K_L)

- "Conventional" hadronic calorimetry has been considered per default

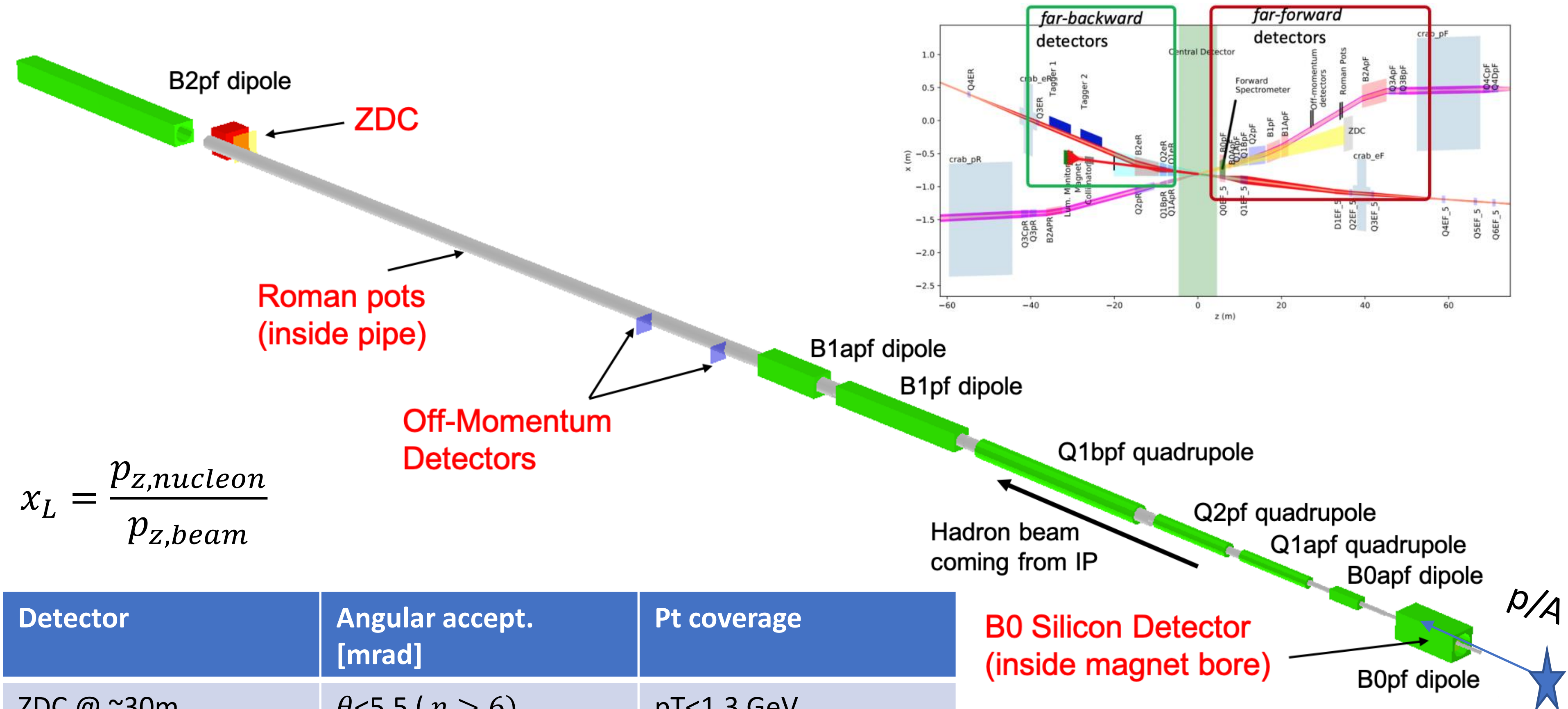
- Anticipated stochastic term in energy resolution & depth

η	[-4 .. -1]	[-1 .. 1]	[1 .. 4]
σ_E/E	~50%/√E + 10%	~100%/√E + 10%	~50%/√E + 10%
depth	~5 λ_I	~5 λ_I	~6-7 λ_I

- Other considerations
  - Space!
  - Interplay with EmCal in a "binary" EmCal+HCal configuration
  - Tower granularity (~10 x 10 cm^2 suffices)
  - Readout immune to the magnetic field

Far forward (hadron going) region

See talks by A. Jentsch and B. Schmookler



$$x_L = \frac{p_{z,nucleon}}{p_{z,beam}}$$

Detector	Angular accept. [mrad]	Pt coverage
ZDC @ ~30m	θ<5.5 ($\eta > 6$)	pT<1.3 GeV
Roman Pots	0*<θ<5.0 ($\eta > 6$)	*Low pT(t) cutoff (beam optics)
Off-Momentum Detectors	0.0< θ < 5.0 ($\eta > 6$)	Low-rigidity particles from nuclear breakups
B0 forward spectrometer	$5.5 < \theta < 20.0$ (4.6< $\eta < 5.9$)	High pT(t)

Yellow Report, Volume 3, 1/13/21 snapshot, Fig. 9.4 and 11.83

THE CATHOLIC UNIVERSITY OF AMERICA Jefferson Lab

A possible EIC Detector

ECCE

The EIC Collider dEtector (ECCE) consortium comprises 36 institutions assembled around the idea of building on the foundation of existing infrastructure available at RHIC IP8 and experimental equipment available there and elsewhere at JLab and RHIC.

Central Barrel Detector:
- ❑ Hadronic Calorimetry - possibly based on the existing sPHENIX magnet flux return.
- ❑ Electromagnetic Calorimetry
- ❑ Central Tracker
- ❑ Pre-shower

Hadron Endcap
- ❑ Forward Calorimetry
- ❑ Particle ID
- ❑ Forward Tracking

Lepton Endcap:
- ❑ Electromagnetic Calorimetry
- ❑ Hadronic Calorimeter
- ❑ Particle ID

Far Forward Detectors
Far Backward Detectors
Polarized Beam and polarimetry
Electronics
Computing

Much of the EIC physics can be done with this field

Parameter	New Magnet	BABAR/sPHENIX Magnet
Maximum Central Field (T)	3	1.5
Coil length (mm)	3600	3512
Warm bore diameter (m)	3.2	2.8
Uniformity in tracking region ($z = 0$, $r < 80$ cm) (%)	3	3
Conductor	NbTi in Cu Matrix	Al stabilized NbTi
Operating Temperature (K)	4.5	4.5

Table 11.1: Summary of some of the main requirements of the EIC detector solenoid magnet.

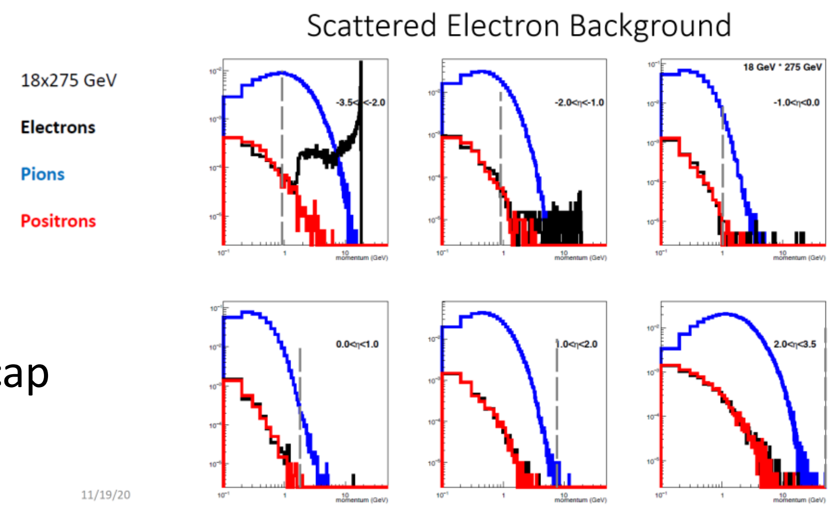
Example of Physics possible with ECCE: Spin

Major requirements:

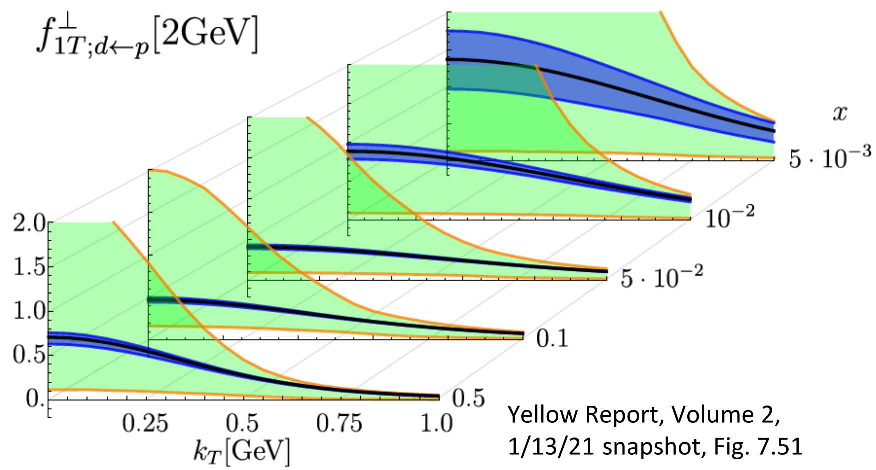
- ❑ Precision calorimetry in lepton endcap
- ❑ PID in barrel

ECCE:

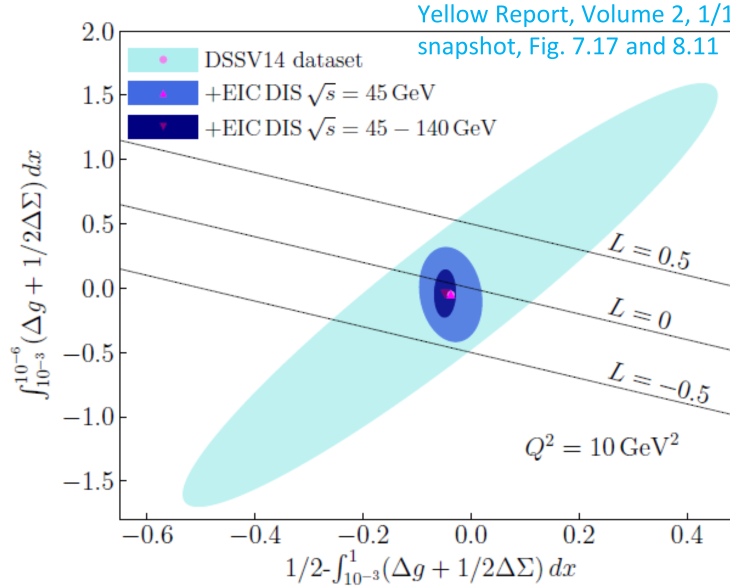
- ❑ High resolution calorimetry in lepton endcap
- ❑ PID in barrel
- ❑ PID in forward endcap enables also TMDs



Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 7.17 and 8.11



Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 7.51



Physics WG (https://wiki.bnl.gov/eicug/index.php/Yellow_Report_Physics_Common)

Yellow Report, Volume 2, Chapter 7

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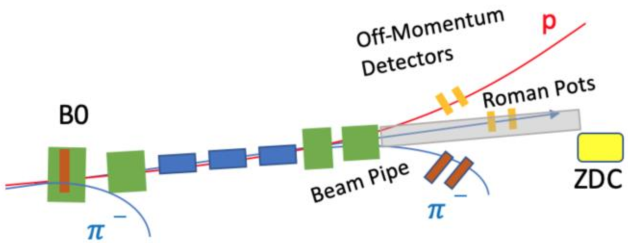
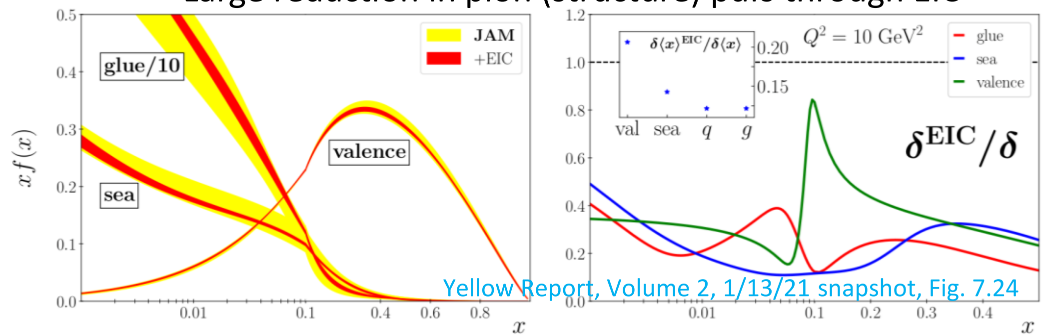
Example of Physics possible with ECCE: Origin of Hadron Mass



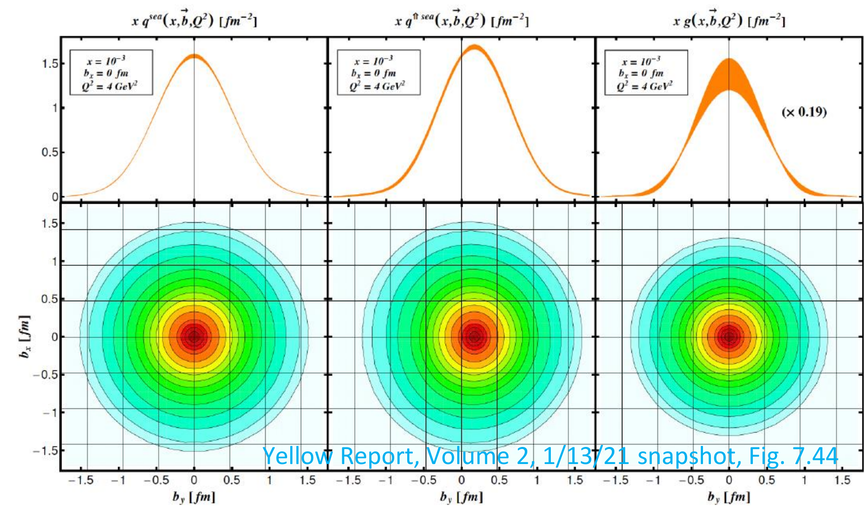
Major requirements

- Far Forward detection to tag n and Λ (or Σ^o) (meson structure) and to tag p (for DVCS/3D).
- Scattered electron detection in electron endcap
- Good hadron endcap and far-forward calorimetry (goal: 35%/E, <50%/E acceptable)
- For pion form factor: pion in hadron endcap

Large reduction in pion (structure) pdfs through EIC



Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 7.24



Yellow Report, Volume 2, 1/13/21 snapshot, Fig. 7.44

ECCE – physics reach enhanced in x_L and x_B with beam focus with dispersion – relevant for diffraction (e-p, e-A) and tagging (e-d, e-3He, etc), and exclusive measurements

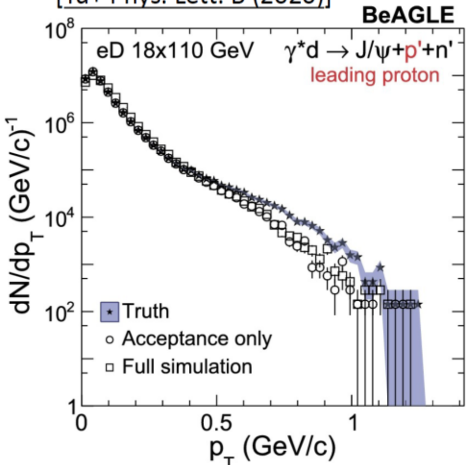
#	Parameter	EIC IR #1	EIC IR #2	Impact
8	Minimum $\Delta(B\rho)/(B\rho)$ allowing for detection of $p_T = 0$ fragments	0.1	0.003 – 0.01	Beam focus with dispersion, reach in x_L and p_T resolution, reach in x_B for exclusive processes

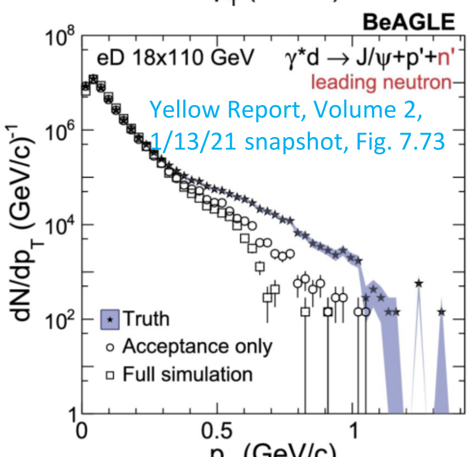
From 4th YR Workshop – talks on complementarity (Y. Zhang, V. Morozov)

Example of Physics possible with ECCE: Nuclei

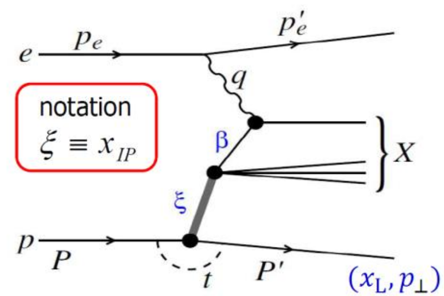
Incoherent diffractive J/Ψ production in e-d tagging

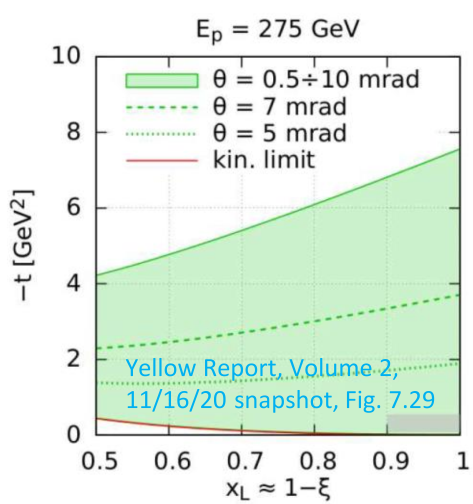
[Tu+ Phys. Lett. B (2020)]



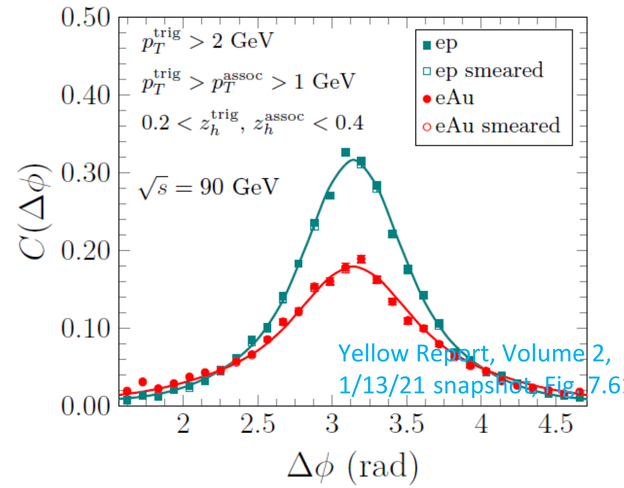


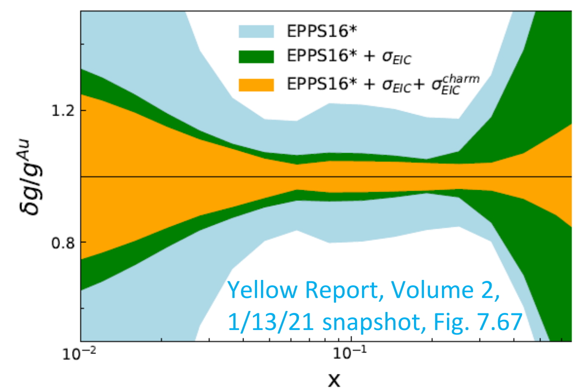
Inclusive diffraction in e-A





di-hadron azimuthal angle correlation, nuclear glue ratio through inclusive and open charm





ECCE – physics reach enhanced in x_L and x_B with beam focus with dispersion – relevant for diffraction (e-p, e-A) and tagging (e-d, e-3He, etc), and exclusive measurements

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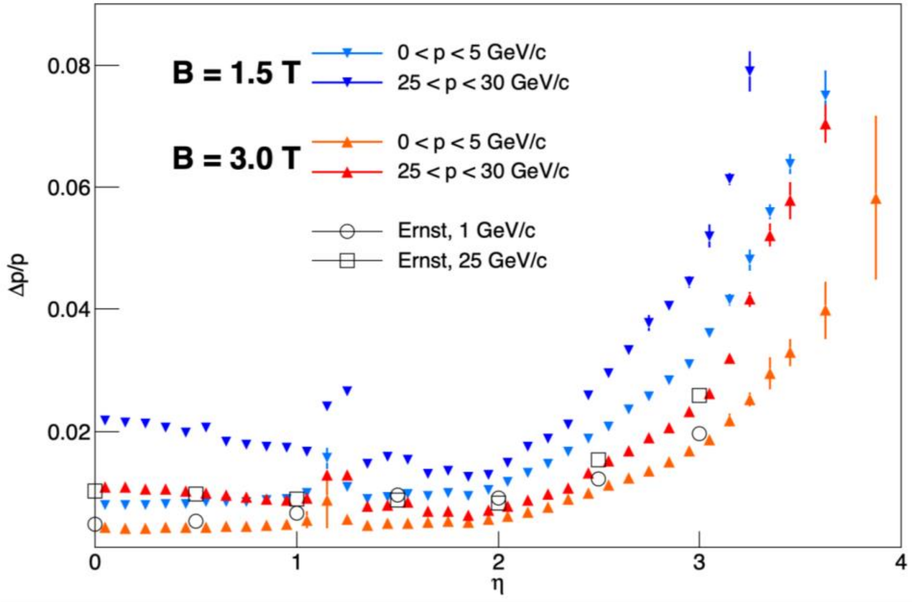
Challenges with B=1.5T

Resolution in forward region η > 2.5

- ❑ Jets and heavy flavor group requires higher resolution in forward hadron region.

Jets/HF WG (https://wiki.bnl.gov/eicug/index.php/Yellow_Report_Physics_Jets-HF)



Track Momentum Resolution

Eta Range	Default Resolution (σP/P)%	Requested (σP/P)%
-3.5 < η < -2.5	0.1%*P + 0.5%	Same
-2.5 < η < -2.0	0.1%*P + 0.5%	Same
-2.0 < η < -1.0	0.05%*P + 0.5%	Same
-1.0 < η < 1.0	0.05%*P + 0.5%	Same
1.0 < η < 2.5	0.05%*P + 1.0%	Same
2.5 < η < 3.5	0.1%*P + 2.0%	Same

- ❑ However, lower field can also be useful in tagging and reconstruction of certain heavy mesons (D*) – resolution vs. acceptance/efficiency balance

Pseudorapidity Range	Min p_T (3T) [MeV/c]	Min p_T (1.5T) [MeV/c]
$0.0 < \eta < 1.0$	400	200
$1.0 < \eta < 1.5$	300	150
$1.5 < \eta < 2.0$	160	70
$2.0 < \eta < 2.5$	220	130
$2.5 < \eta < 3.5$	150	100

Solenoid bore diameter & Barrel Detector Space needs

Tracking	all-Si maybe down to 50-60 cm,
	Si + TPC = 80 cm
Tracking support structure	5 cm
Hadron particle identification	DIRC only needs 10 cm,
	RICH 50 cm but better for uniformity
EM Calorimetry	50 cm for high-resolution,
	30 cm for less-resolution (or costly)
PID & EMCal support structure	10-15 cm likely enough

Function	Minimum [cm]	Maximum [cm]	Minimum [cm]	Maximum [cm]
Tracking (includes 5 cm support)	All-Si		Si + TPC	
	65		85	
Hadron particle identification	RICH		DIRC	
	50		10	
EM Calorimetry	30	50	High-Resolution to achieve P < 2 GeV	
			50	
PID & EMCal support structure	10	15	10	15
Total	145	165	155	160

Need to discuss the fit of all detectors in the existing magnet with bore 2.8 meter - will be a tour de force and it is possible some functionality has to give.

From 4th YR Workshop – talk on magnet

Technologies Matrix

system	system components	reference detectors	detectors, alternative options considered by the community			
tracking	vertex	MAPS, 20 um pitch	MAPS, 10 um pitch			
	barrel	TPC	TPC surrounded by a micro-RWELL tracker	MAPS, 20 um pitch	set of coaxial cylindrical MICROMEGAS	
	forward & backward	MAPS, 20 um pitch	GEMs with Cr electrodes			
ECal	barrel	Pb/Sc Shashlyk	SciGlass	W powder/ScFi	W/Sc Shashlyk	
	forward	W powder/ScFi	SciGlass	Pb/Sc Shashlyk	W/Sc Shashlyk	
	backward, inner	$PbWO_4$	SciGlass			
	backward, outer	SciGlass	PbWO4	W powder/ScFi	W/Sc Shashlyk	Pb/Sc Shashlyk
h-PID	barrel	High performance DIRC & dE/dx (TPC)	reuse of BABAR DIRC bars	fine resolution TOF		
	forward, high p	fluorocarbon gaseous RICH	double RICH combining aerogel and fluorocarbon	high pressure Ar RICH		
	forward, medium p	aerogel				
	forward, low p	TOF	dE/dx			
	backward	modular RICH (aerogel)				
e/h separation at low p	forward	TOF & areogel & gaseous RICH	adding TRD			
	backward	modular RICH & TRD	Hadron Blind Detector			
HCal	barrel	Fe/Sc	RPC/DHCAL	Pb/Sc		
	forward	Fe/Sc	RPC/DHCAL	Pb/Sc		
	backward	Fe/Sc	RPC/DHCAL	Pb/Sc		