Physics Working Group Requirements Overview

Nov 19, 2020

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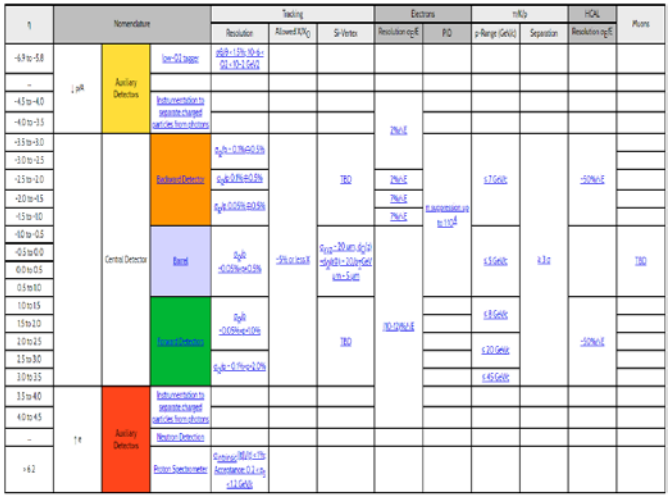
Miami->DC-> Berkeley: Collaboration with DWG

- ✔ Document studies/results in the wiki: https://wiki.bnl.gov/eicug/index.php
- ✔ Prepare updates for the detector matrix!



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

To summarize emerging requirements from each group: update (excel) table.
The “color-coding”/updating scheme is as follows:

- Unchanged cell -- only if this parameter has not yet been considered but it may have an impact on your processes
- Fill **green** -- if listed performance is sufficient and/or will have no impact on your processes. If known, add an updated performance quantifier of what your measurements could “tolerate” without loss of physics
- Fill **red** & update the cell -- if improvements are shown necessary

Summary of PWG Detector Requirements @ DC

Documentation:
https://wiki.bnl.gov/eicug/index.php/Yellow_Report_Physics_Common

- Inclusive Reactions (Renee Fatemi, Nobuo Sato, Barak Schmookler)
- Semi-inclusive Reactions (Ralf Seidl, Justin Stevens, Alexey Vladimirov, Anselm Vossen, Bowen Xiao)
- Jets, Heavy Quarks (Leticia Mendez, Brian Page, Frank Petriello, Ernst Sichtermann, Ivan Vitev)
- Exclusive Reactions (Raphaël Dupré, Salvatore Fazio, Tuomas Lappi, Barbara Pasquini, Daria Sokhan)
- Diffractive Reactions & Tagging (Wim Cosyn, Or Hen, Doug Higinbotham, Spencer Klein, Anna Stasto)

Summary of PWG Detector Requirements @ DC

Documentation: https://wiki.bnl.gov/eicug/index.php/Yellow_Report_Physics_Common

Tracking resolution **p_T^{min}** **PID** **HCAL resolution**

η	Nomenclature			Tracking				Electrons and Photons			π/K/p		HCAL		Muons
				Resolution	Allowed	minimum-pT	SI-Vertex	Resolution	PID	min E	p-Range (GeV/c)	Separati	Resolution σE/E	Energy	
-6.9 to -5.8	↓ p/A	Auxiliary Detectors	low-Q2 tagger	σθ/θ < 1.5%; 10-6 < Q2 < 10-2 GeV2											
-5.0 to -4.5						300 MeV pions									
-4.5 to -4.0			Instrumentation to separate charged particles from photons			300 MeV pions		2%/√E(+1-3%)		50 MeV					
-4.0 to -3.5						<100MeV pions, 135MeV kaons				50 MeV			~50%/√E + 6%		
-3.5 to -3.0		Central Detector	Backward Detector	σp/p ~ 0.1%⊕0.5%	~5% or less X	<100MeV pions, 135MeV kaons			π suppression up to 1:1E-4	50 MeV	≤ 7 GeV/c	≥ 3 σ		~500 MeV	muons useful for bkg, improve resolution
-3.0 to -2.5						<100MeV pions, 135MeV kaons	σ_xy ~ 30/pT μm + 40 μm	2%/√E(+1-3%)		50 MeV			~45%/√E+6%		
-2.5 to -2.0				σp/p 0.1%⊕0.5%		<100MeV pions, 135MeV kaons	σ_xy ~ 30/pT μm + 20 μm	7%/√E(+1-3%)		50 MeV					
-2.0 to -1.5				σp/p 0.05%⊕0.5%		<100MeV pions, 135MeV kaons		7%/√E(+1-3%)		50 MeV					
-1.5 to -1.0						<100MeV pions, 135MeV kaons				50 MeV					
-1.0 to -0.5			Barrel	σp/p ~0.05%⊕0.5%		<100MeV pions, 135MeV kaons	σxyz ~ 20 μm, dD(z) ~dD(rφ) ~ 20/pTGeV μm + 5 μm			50 MeV	≤ 10 GeV/c		~85%/√E+7%		
-0.5 to 0.0						<100MeV pions, 135MeV kaons				50 MeV			~85%/√E+7%		
0.0 to 0.5						<100MeV pions, 135MeV kaons				50 MeV			~85%/√E+7%		
0.5 to 1.0						<100MeV pions, 135MeV kaons				50 MeV	≤ 15 GeV/c		~85%/√E+7%		
1.0 to 1.5			Forward Detectors	σp/p ~0.05%⊕1.0%		<100MeV pions, 135MeV kaons	σ_xy ~ 30/pT μm + 20 μm	(10-12)%/√E (+1-3%)	3σ e/π	50 MeV	≤ 30 GeV/c		35%/√E		
1.5 to 2.0						<100MeV pions, 135MeV kaons				50 MeV	≤ 50 GeV/c				
2.0 to 2.5						<100MeV pions, 135MeV kaons				50 MeV					
2.5 to 3.0				σp/p ~ 0.1%⊕2.0%		<100MeV pions, 135MeV kaons	σ_xy ~ 30/pT μm + 40 μm			50 MeV	≤ 30 GeV/c				
3.0 to 3.5						<100MeV pions, 135MeV kaons	σ_xy ~ 30/pT μm + 60 μm			50 MeV	≤ 45 GeV/c				
3.5 to 4.0	↑ e	Auxiliary Detectors	Instrumentation to separate charged particles from photons			<100MeV pions, 135MeV kaons				50 MeV					
4.0 to 4.5						300 MeV pions				50 MeV					
4.5 to 5.0			Neutron Detection			300 MeV pions		4.5%/√E for photon energy > 20 GeV	<= 3 cm granularity	50 MeV			35%/√E (goal), <50%/√E (acceptable)*, 3mrad/√E (goal)		
> 6.2			Proton Spectrometer	σintrinsic/|t| < 1%; Acceptance: 0.2 < pt < 1.2 GeV/c											

Intensive discussions with the DWG

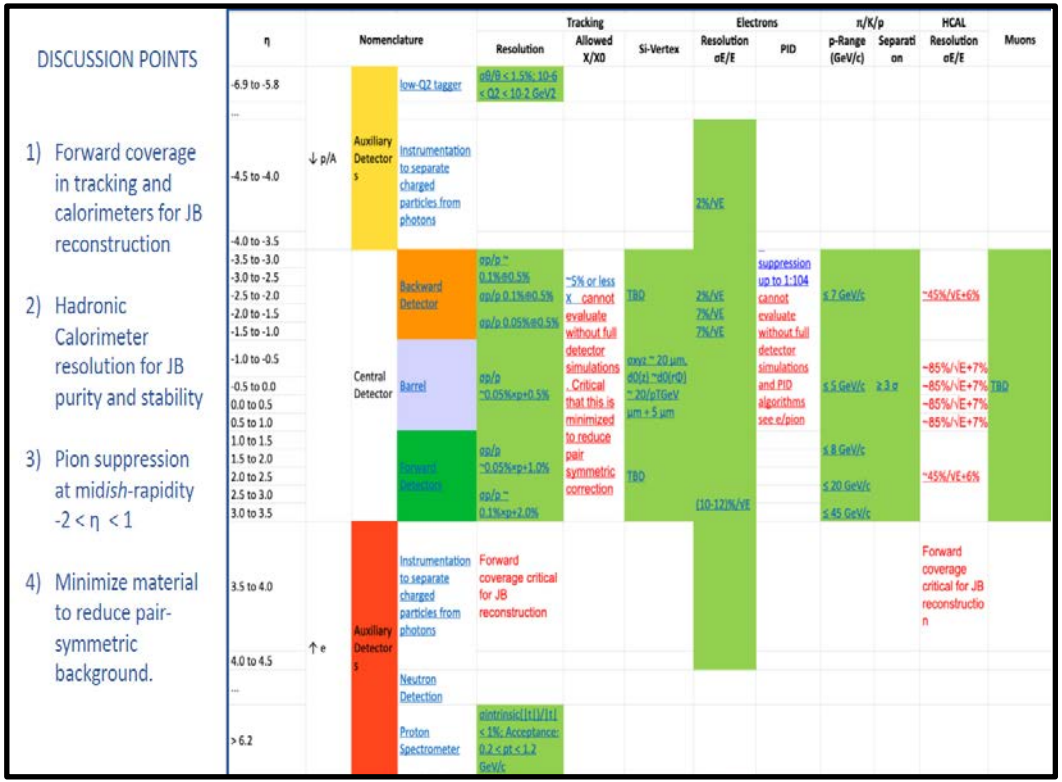
Tension points/emerging constraints:

1) Central detectors optimal on $|\eta| < 3.5$

2) PID in $|\eta| < 1$ (K and π) up to 6 GeV

3) HCAL only $\frac{50\%}{\sqrt{E}} + 10\%$ for $1 < \eta < 3.5$

Inclusive Reactions



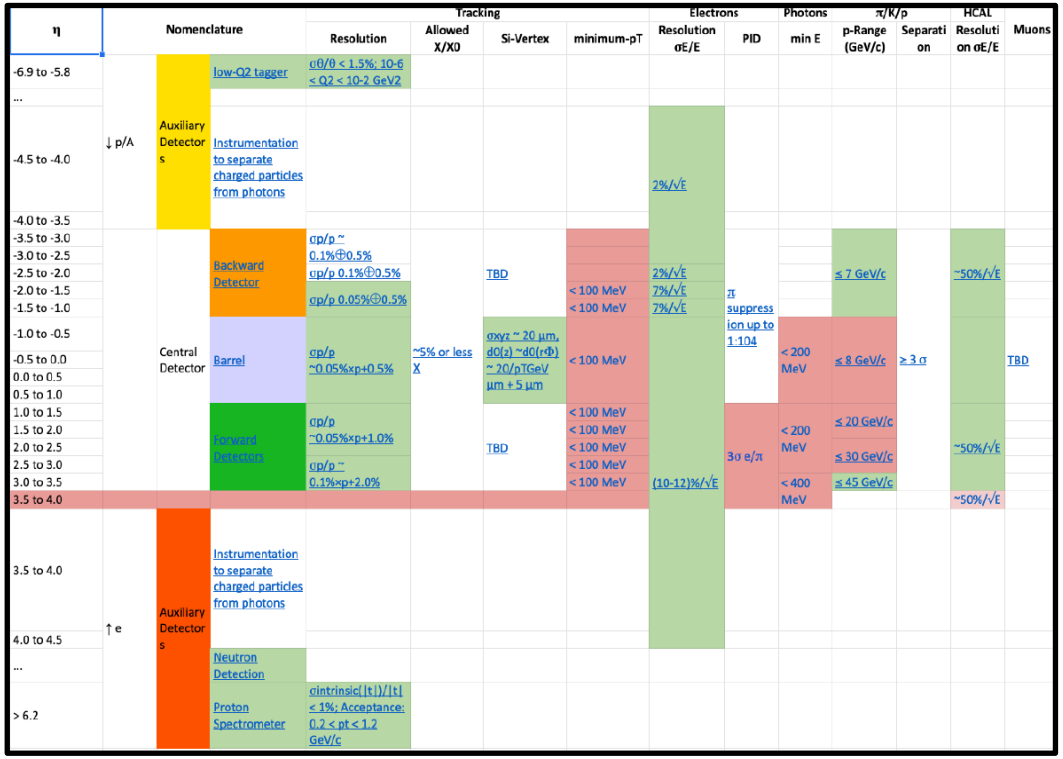
tracking, PID, HCAL

1) Central region constraints: loss of phase-space coverage; some loss in resolution in the JB reconstruction method, but no loss of physics capabilities per se.

2) PID cut-off at 6 GeV: no major effect

3) HCAL resolution: loss in resolution in the JB reconstruction method, but no loss of physics.

Semi-Inclusive Reactions

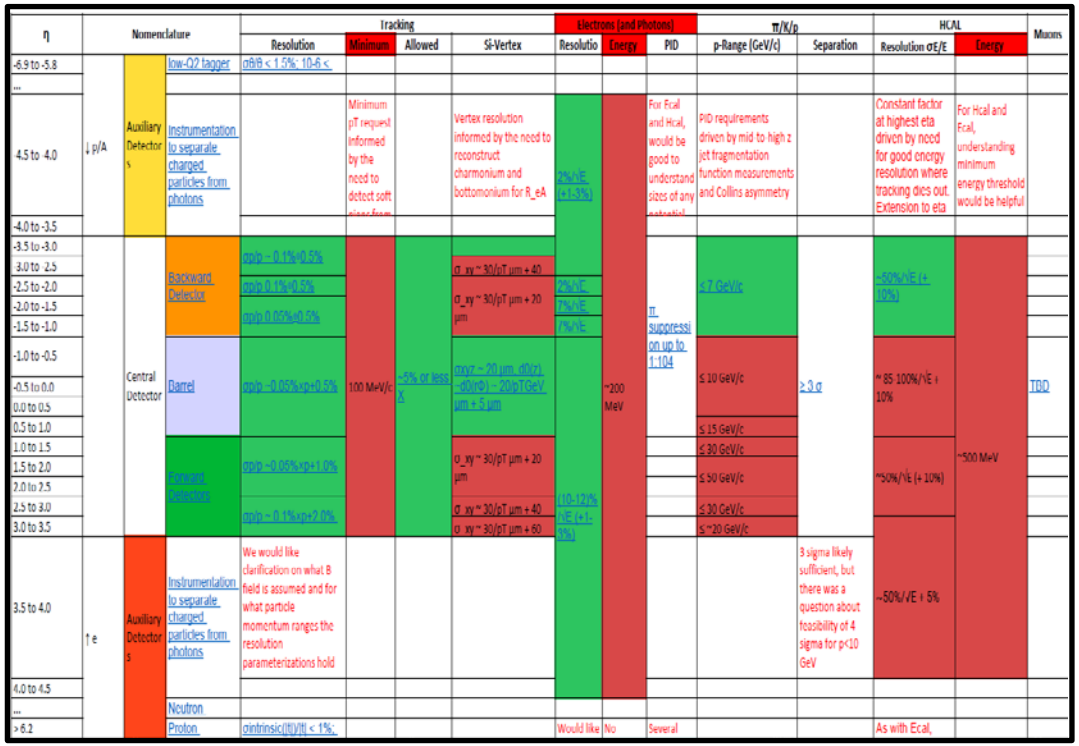


η	Nomenclature			Tracking				Electrons		Photons	π/K/p		HCAL	Muons
			Resolution	Allowed X/X0	Si-Vertex	minimum-pT	Resolution σE/E	PID	min E	p-Range (GeV/c)	Separation	Resolution σE/E	
-6.9 to -5.8			low-Q2 tagger	σθ/θ < 1.5%; 10-6 < Q2 < 10-2 GeV2									
...													
-4.5 to -4.0	↓ p/A	Auxiliary Detectors	Instrumentation to separate charged particles from photons				2%/√E						
-4.0 to -3.5													
-3.5 to -3.0													
-3.0 to -2.5			Backward Detector	σp/p ~ 0.1%⊕0.5%									
-2.5 to -2.0				σp/p 0.1%⊕0.5%	TBD		2%/√E			≤ 7 GeV/c		~50%/√E	
-2.0 to -1.5				σp/p 0.05%⊕0.5%		< 100 MeV	7%/√E	π suppression up to 1:10^4					
-1.5 to -1.0						< 100 MeV	7%/√E						
-1.0 to -0.5					σxyz ~ 20 μm, d0(z) ~d0(rΦ) ~ 20/pTGeV μm + 5 μm								
-0.5 to 0.0		Central Detector	Barrel	σp/p ~0.05%xp+0.5%	~5% or less X	< 100 MeV			< 200 MeV	≤ 8 GeV/c	≥ 3 σ		TBD
0.0 to 0.5													
0.5 to 1.0													
1.0 to 1.5						< 100 MeV				≤ 20 GeV/c			
1.5 to 2.0			Forward Detectors	σp/p ~0.05%xp+1.0%		< 100 MeV			< 200 MeV				
2.0 to 2.5					TBD	< 100 MeV		3σ e/π		≤ 30 GeV/c		~50%/√E	
2.5 to 3.0				σp/p ~ 0.1%xp+2.0%		< 100 MeV							
3.0 to 3.5						< 100 MeV	(10-12)%/√E		< 400 MeV	≤ 45 GeV/c			
3.5 to 4.0												~50%/√E	
3.5 to 4.0			Instrumentation to separate charged particles from photons										
4.0 to 4.5	↑ e	Auxiliary Detectors											
...			Neutron Detection										
> 6.2			Proton Spectrometer	σintrinsic(|t|)/|t| < 1%; Acceptance: 0.2 < pt < 1.2 GeV/c									

minimum p_T threshold, PID

1) Central region constraints: loss of phase-space coverage (x-range for gluon Sivers); loss in resolution in the JB for charged current or Double Angle for neutral current; visible effects, but no dramatic loss of physics.
2) PID cut-off at 6 GeV: modest impact on TMD extraction (model dependent).
3) HCAL resolution: loss in resolution in the JB reconstruction method, but no loss of physics.

Jets and Heavy Quarks

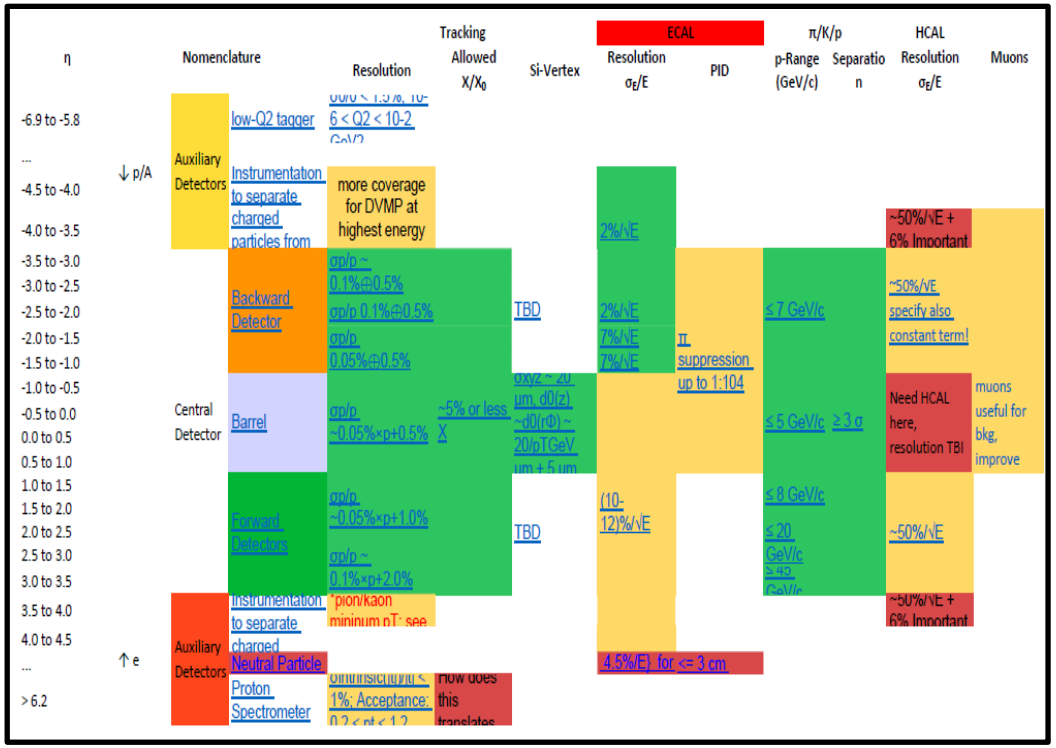


η	Nomenclature			Tracking				Electrons (and Photons)			π/K/p		HCAL		Muons
				Resolution	Minimum	Allowed	Si-Vertex	Resolutio	Energy	PID	p-Range (GeV/c)	Separation	Resolution σE/E	Energy	
-6.9 to -5.8	↓ p/A	Auxiliary Detectors	low-Q2 tagger	σθ/θ < 1.5%; 10-6 <											
...															
4.5 to -4.0			Instrumentation to separate charged particles from photons		Minimum pT request informed by the need to detect soft		Vertex resolution informed by the need to reconstruct charmonium and bottomonium for R_eA	2%/√E (+1-3%)	~200 MeV	For Ecal and Hcal, would be good to understand sizes of any potential	PID requirements driven by mid to high z jet fragmentation function measurements and Collins asymmetry		Constant factor at highest eta driven by need for good energy resolution where tracking dies out. Extension to eta	For Hcal and Ecal, understanding minimum energy threshold would be helpful	
-4.0 to -3.5															
-3.5 to -3.0		Central Detector	Backward Detector	σp/p ~ 0.1%⊕0.5%	100 MeV/c	~5% or less X	σ_xy ~ 30/pT μm + 40	2%/√E		π suppression up to 1:104	≤ 7 GeV/c		~50%/√E (+ 10%)	~500 MeV	
-3.0 to -2.5				σp/p 0.1%⊕0.5%											
-2.5 to -2.0							σ_xy ~ 30/pT μm + 20 μm								
-2.0 to -1.5				σp/p 0.05%⊕0.5%				2%/√E							
-1.5 to -1.0								2%/√E							
-1.0 to -0.5			Barrel	σp/p ~0.05%⊕p⊕0.5%			σxyz ~ 20 μm ⊕(z) ~d0(rΦ) ~ 20/pTGeV μm + 5 μm	(10-12)% /√E (+1-2%)			≤ 10 GeV/c	≥ 3 σ	~ 85 100%/√E + 10%		TBD
-0.5 to 0.0											≤ 15 GeV/c				
0.0 to 0.5											≤ 30 GeV/c				
0.5 to 1.0											≤ 50 GeV/c		~50%/√E (+ 10%)		
1.0 to 1.5			Forward Detectors	σp/p ~0.05%⊕p+1.0%			σ_xy ~ 30/pT μm + 20 μm								
1.5 to 2.0															
2.0 to 2.5															
2.5 to 3.0				σp/p ~ 0.1%⊕p+2.0%			σ_xy ~ 30/pT μm + 40				≤ 30 GeV/c				
3.0 to 3.5							σ_xy ~ 30/pT μm + 60				≤ ~20 GeV/c				
3.5 to 4.0	↑ e	Auxiliary Detectors	Instrumentation to separate charged particles from photons	We would like clarification on what B field is assumed and for what particle momentum ranges the resolution parameterizations hold								3 sigma likely sufficient, but there was a question about feasibility of 4 sigma for p<10 GeV	~50%/√E ⊕ 5%		
4.0 to 4.5															
...			Neutron												
> 6.2			Proton	σintrinsic(|t|)/|t| < 1%;				Would like	No	Several			As with Ecal,		

vertex, PID, HCAL

1) Central region constraints: loss of x-Q^2 coverage can be partially compensated by beam energy scan;
2) PID cut-off at 6 GeV: will severely cut into the z-j_T phase-space for identified hadrons; degradation studies underway; larger impact expected for kaons
3) HCAL resolution: should suffice

Exclusive Reactions



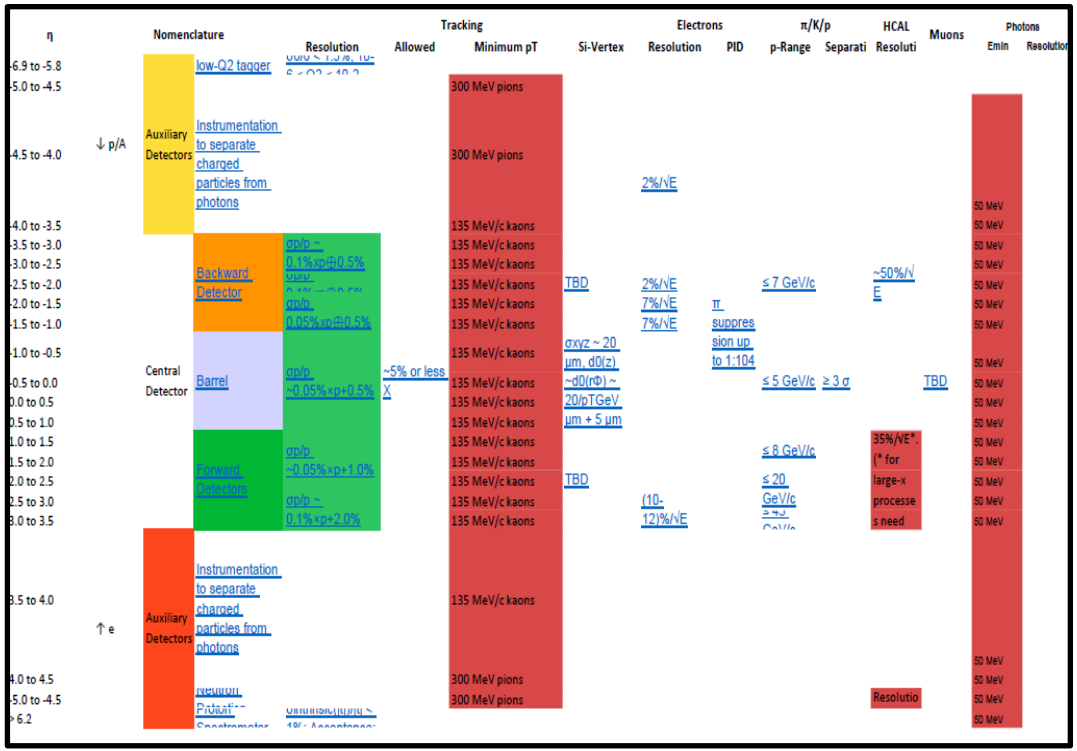
neutral detection @ forward, π0 and γ for DVCS, HCAL coverage

1) Central region constraints: loss of exclusivity, impact on resolution/precision;

2) PID cut-off at 6 GeV: n/a

3) HCAL resolution: resolution? large coverage required for jets

Diffractive Reactions & Tagging



minimim p_T, HCAL

1) Central region constraints: forward losses limit high-x studies (near-threshold production, pentaquarks, high-x gluons); backward losses limit low-x studies (gluons).

1) PID cut-off at 6 GeV: n/a (PID required in soft sector)

2) HCAL resolution: acceptable