Kinematic constraints in the SIDIS WG

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Single hadron SIDIS for quark TMDs, helicities, (n)FFs, etc

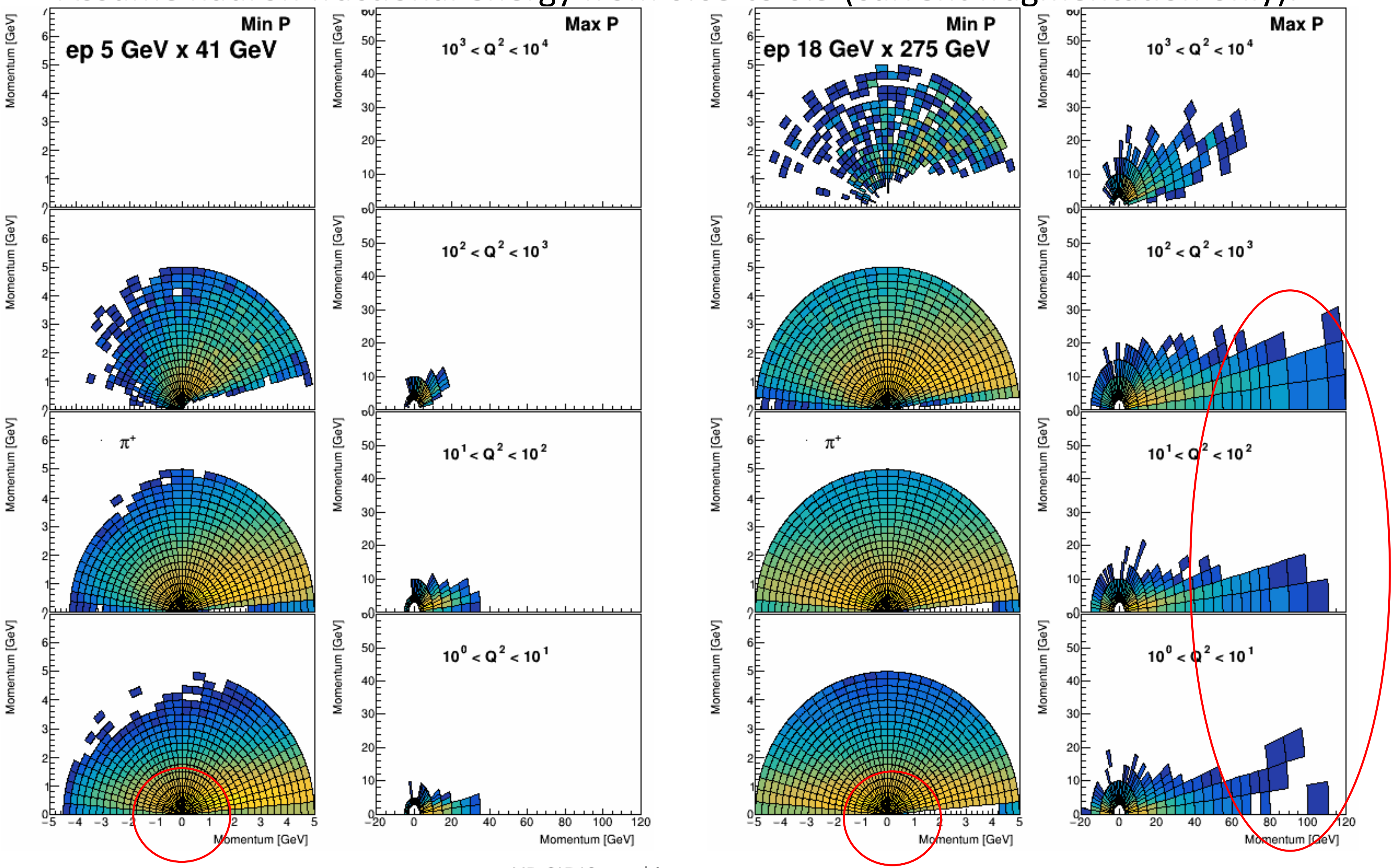
η	Nomenclature		Tracking Resolution	Allowed X/X_0	Si-Vertex	Electrons Resolution σ_E/E	PID	π/K/p p-Range (GeV/c)	Separation	HCAL Resolution σ_E/E	Muons
-6.9 to -5.8		low-Q2 tagger									
...											
-4.5 to -4.0	Auxiliary Detectors	Instrumentation to separate charged particles from photons									
-4.0 to -3.5											
-3.5 to -3.0											
-3.0 to -2.5											
-2.5 to -2.0		Backward Detector						≤ 7 GeV/c		~50%/√E	
-2.0 to -1.5							π suppression up to $1:10^4$				
-1.5 to -1.0											
-1.0 to -0.5	Central Detector								≥ 3 σ		
-0.5 to 0.0		Barrel						≤ 5 GeV/c			TBD
0.0 to 0.5											
0.5 to 1.0											
1.0 to 1.5								≤ 8 GeV/c			
1.5 to 2.0											
2.0 to 2.5		Forward Detectors								~50%/√E	
2.5 to 3.0								≤ 20 GeV/c			
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	Auxiliary Detectors										
...		Neutron Detection									

Hadron momentum from as low as possible (magnet), lowest z reach

Slightly higher would be preferable

Single hadron SIDIS for quark TMDs, helicities, (n)FFs, etc

- Assume hadron fractional energy from 0.05 to 0.9 (current fragmentation only):



Polar angle in steps of 5 degrees

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Di-hadrons for Tensor charge/BM/Higher Twist

η	Nomenclature		Tracking Resolution	Allowed X/X_0	Si-Vertex	Electrons Resolution σ_E/E	PID	π/K/p p-Range (GeV/c)	Separation	HCAL Resolution σ_E/E	Muons
-6.9 to -5.8	Auxiliary Detectors	low-Q2 tagger									
...											
-4.5 to -4.0		Instrumentation to separate charged particles from photons									
-4.0 to -3.5											
-3.5 to -3.0	Central Detector	Backward Detector									
-3.0 to -2.5											
-2.5 to -2.0								≤ 7 GeV/c		~50%/√E	
-2.0 to -1.5							π suppression up to 1:10^4				
-1.5 to -1.0											
-1.0 to -0.5		Barrel									
-0.5 to 0.0								≤ 5 GeV/c	≥ 3 σ		TBD
0.0 to 0.5											
0.5 to 1.0											
1.0 to 1.5		Forward Detectors						≤ 8 GeV/c			
1.5 to 2.0											
2.0 to 2.5										~50%/√E	
2.5 to 3.0								≤ 20 GeV/c			
3.0 to 3.5								≤ 45 GeV/c			
3.5 to 4.0	Auxiliary Detectors	Instrumentation to separate charged particles from photons									
4.0 to 4.5											
...		Neutron Detection									

Hadron momentum from as low as possible (magnet), partial wave extraction

Important for pi-K pairs from Mis-ID pion pairs

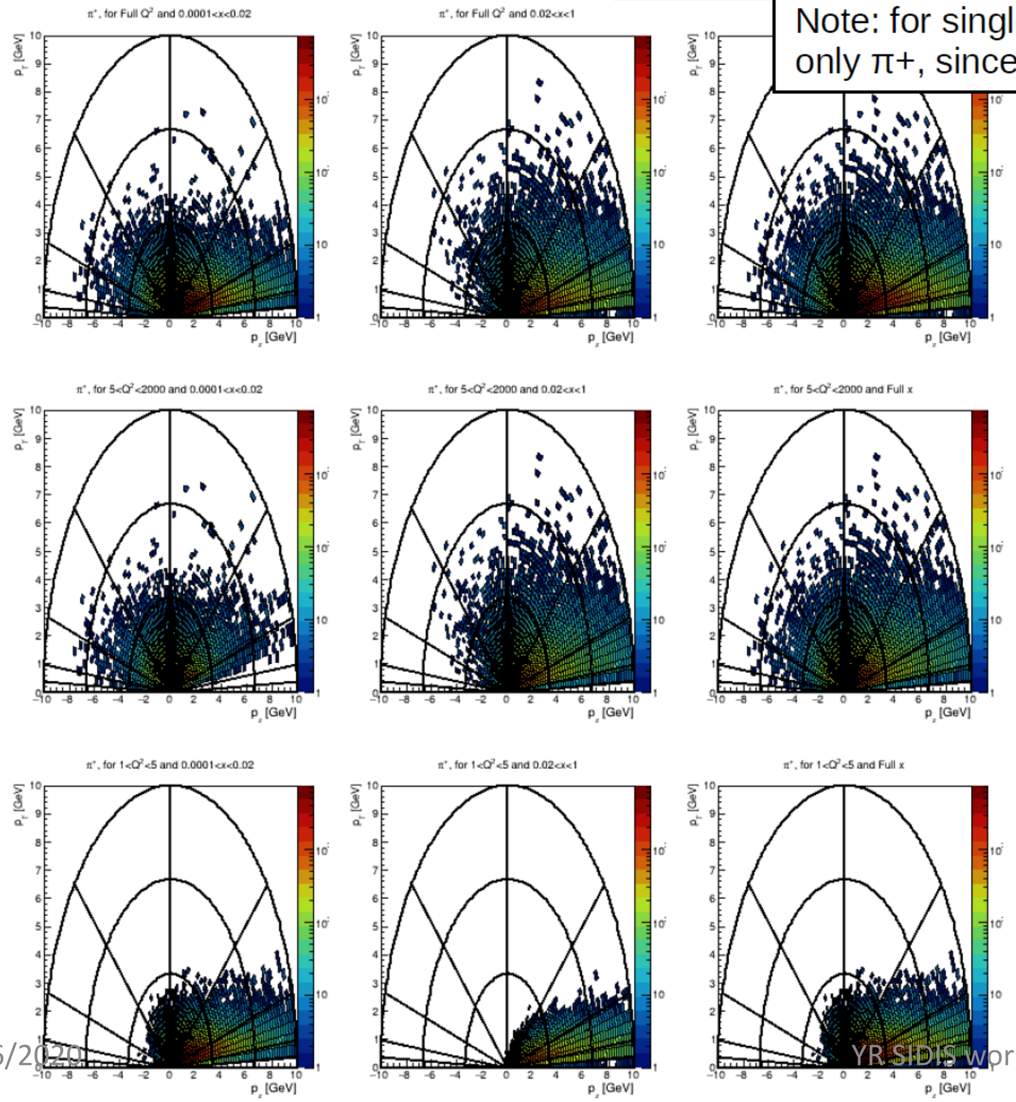
Chris Dilks, et. al

Di-hadrons for Tensor charge/BM/Higher Twist

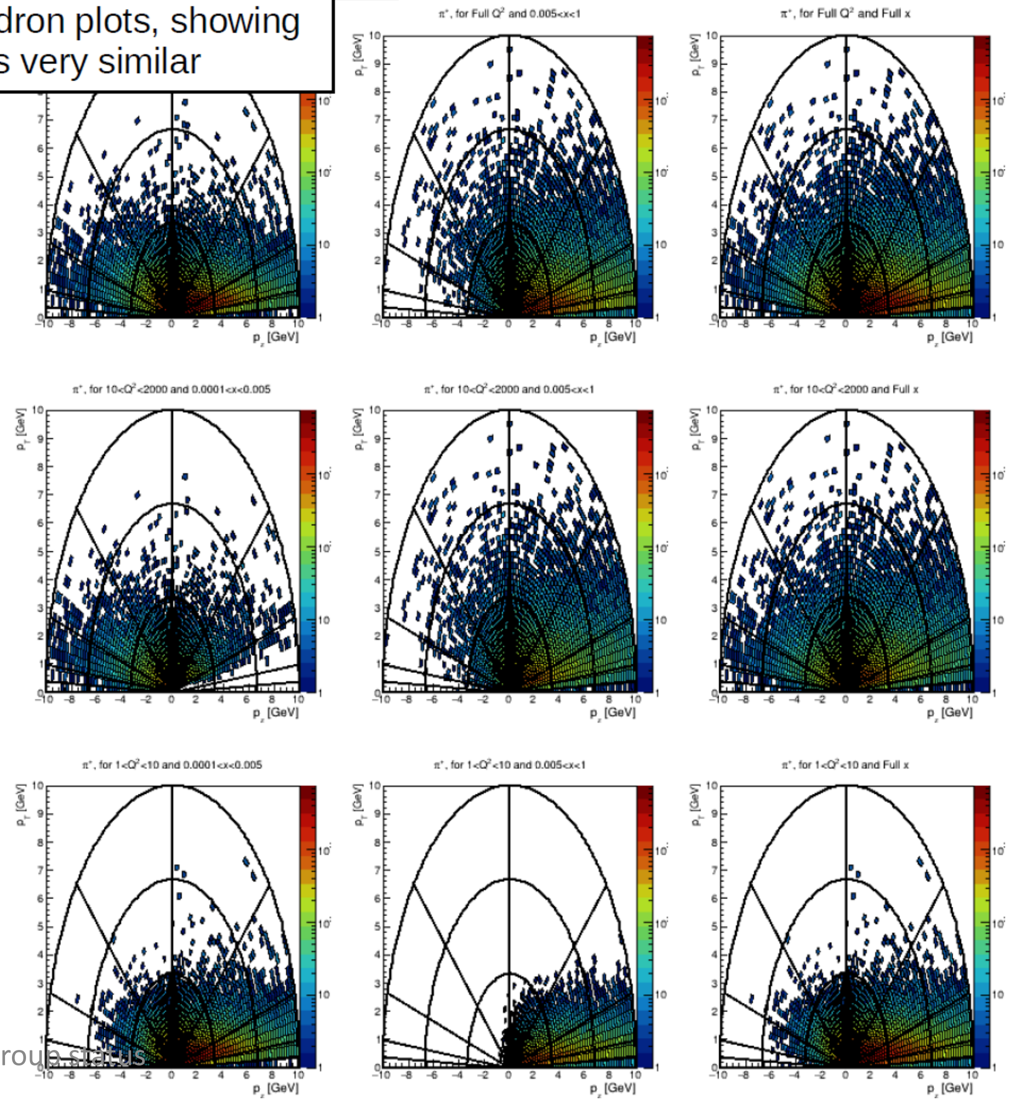
π^+ p_T vs. p_z Polar Plots

Note: for single hadron plots, showing only π+, since π- is very similar

10x100 GeV

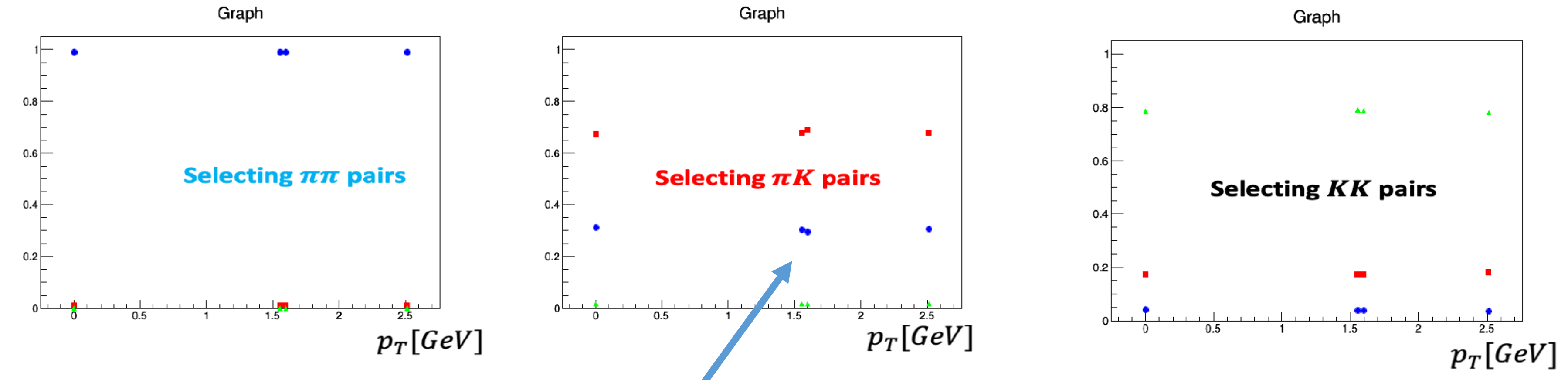


18x275 GeV



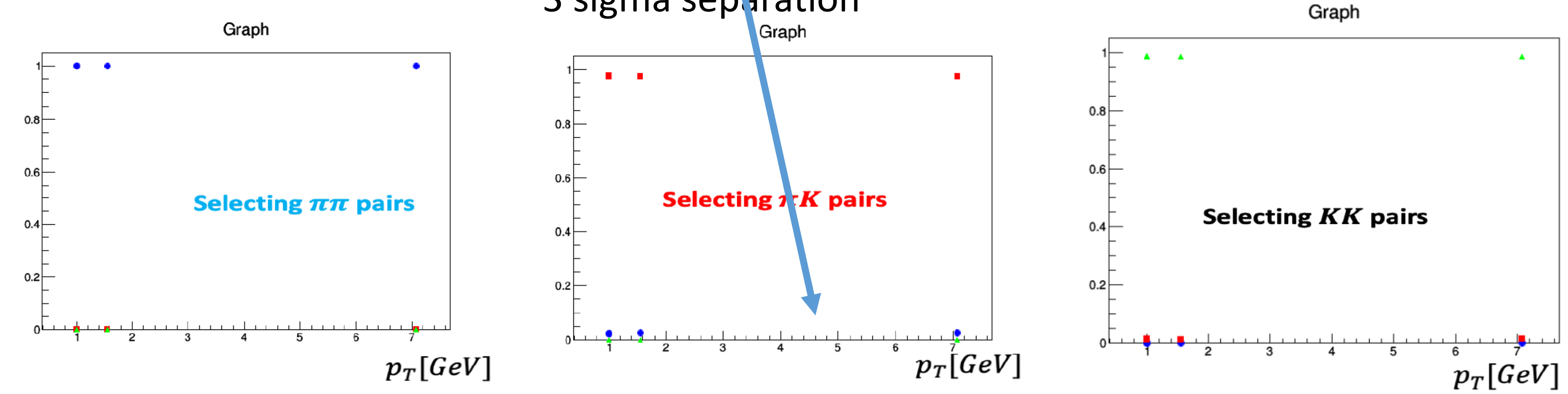
Anselm Vossen, et. al

2 sigma separation



- **Fraction of reconstructed $\pi\pi$ pairs**
- **Fraction of reconstructed πK pairs**
- **Fraction of reconstructed KK pairs**

3 sigma separation



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Di-hadrons(jets,HF) for low-x and gluon Sivers

η	Nomenclature		Tracking Resolution	Allowed X/X_0	Si-Vertex	Electrons Resolution σ_E/E	PID	π/K/p p-Range (GeV/c)	Separation	HCAL Resolution σ_E/E	Muons
-6.9 to -5.8	Auxiliary Detectors	low-Q2 tagger	σθ/θ < 1.5%; 10-6 < Q2 < 10-2 GeV2								
...											
-4.5 to -4.0		Instrumentation to separate charged particles from photons									
-4.0 to -3.5						2%/√E					
-3.5 to -3.0		Backward Detector	σ_p/p ~ 0.1%⊕0.5%								
-3.0 to -2.5											
-2.5 to -2.0			σ_p/p								
-2.0 to -1.5			σ_p/p 0.05								
-1.5 to -1.0											
-1.0 to -0.5	Central Detector	Barrel	σ_p/p ~0.0								
-0.5 to 0.0											
0.0 to 0.5											
0.5 to 1.0											
1.0 to 1.5		Forward Detectors	σ_p/p ~0.0								
1.5 to 2.0											
2.0 to 2.5											
2.5 to 3.0			σ_p/p 0.1%								
3.0 to 3.5											
3.5 to 4.0	Auxiliary Detectors	Instrumentation to separate charged particles from photons									
4.0 to 4.5											
...		Neutron Detection									
> 6.2		Proton Spectrometer	σ_{intri} 1%; Acceptance: 0.2 < p_t < 1.2 GeV/c								

Generally similar to single hadron measurements:

gluon Sivers: forward region (higher x)

Saturation: central/backward region (low x)

- High tracking resolution needed at higher momenta
- full azimuthal coverage for azimuthal correlation needed

Gluon Sivers measurement requirement from charged dihadron channel

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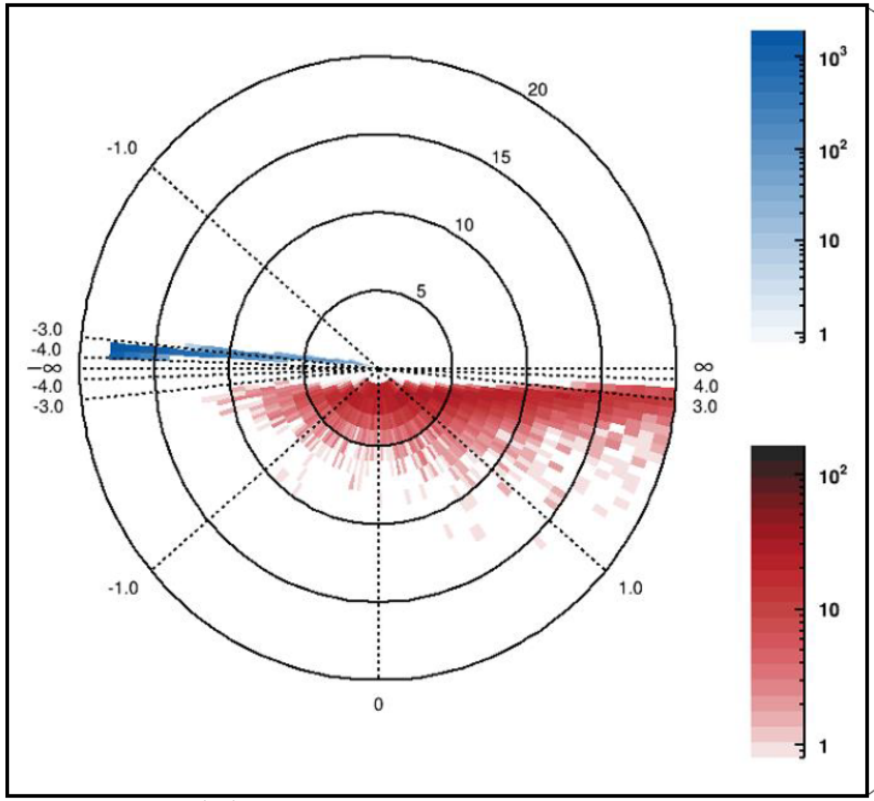
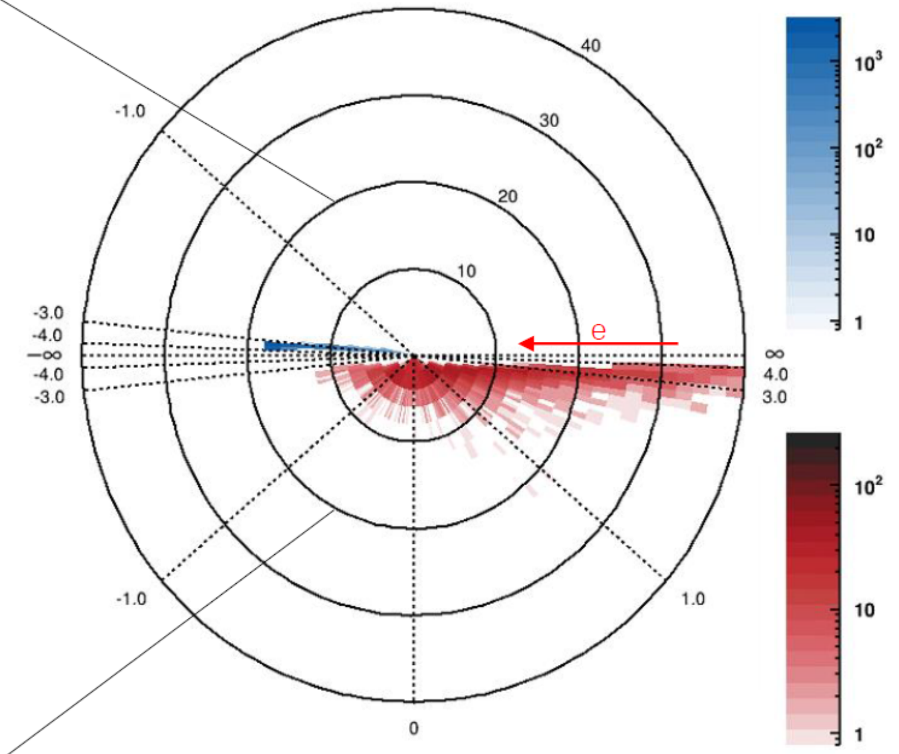
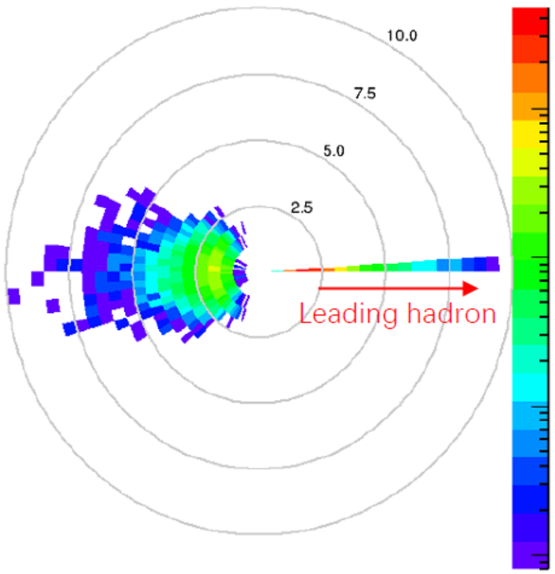
ep 18x275 GeV
$0.01<y<0.95$, $1<Q^2<2$ GeV^2
charged hadron, $|\eta|<4.5$, $p_T^*>1.4$ GeV, $z_h>0.1$,
$k^*_T/P^*_T<0.7$, * indicates $\gamma^*\mathrm{p}$ c.m.s frame



p vs η for scattered electron and charged hadron pairs



p_T vs $\Delta\phi$ for associate hadron relative to leading hadron



Gluon Saturation from charged dihadron channel

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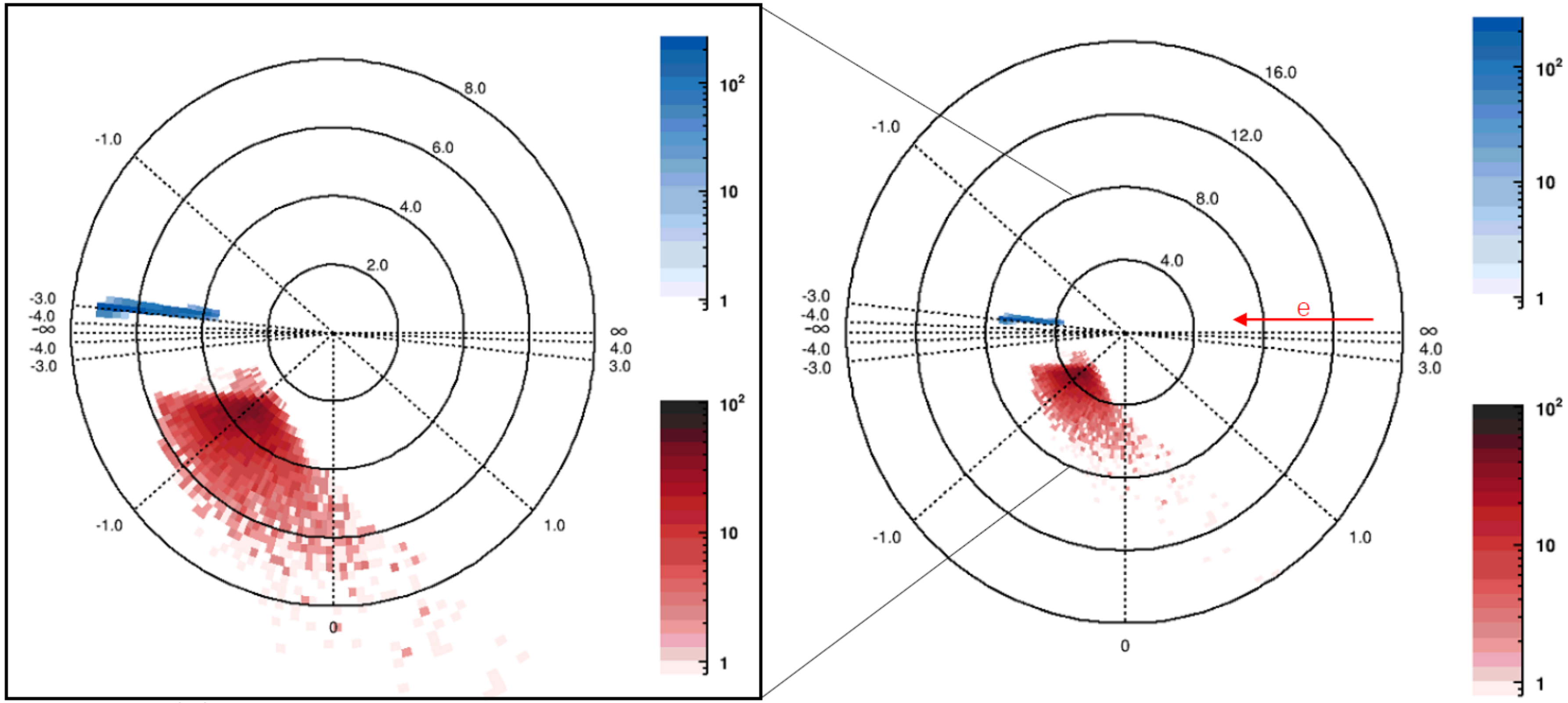
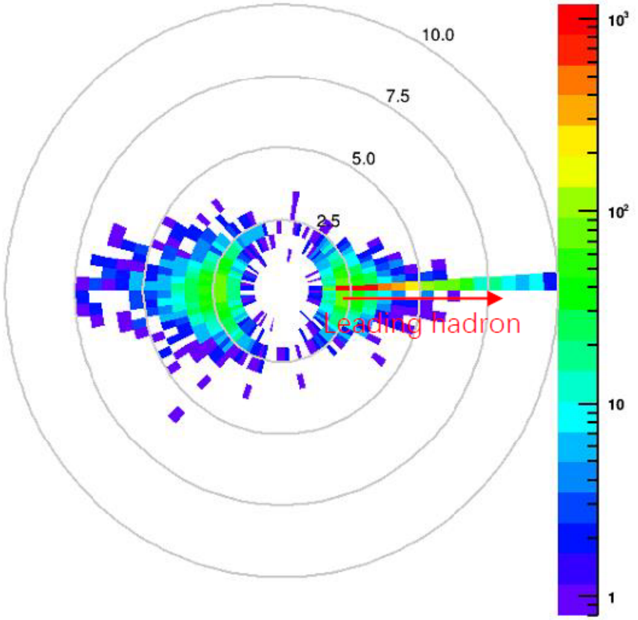
ep 18x110 GeV
$0.6<y<0.8$, $1<Q^2<2$ GeV^2
charged hadron, $|\eta|<4.5$, $p_{T\,trig}^{*}>2$ GeV, $p_{T\,assc}^{*}>1$ GeV,
$0.2<z_h<0.4$, * indicates $\gamma^{*}\mathrm{p}$ c.m.s frame

p vs η for scattered electron and charged hadron pairs



p_T vs $\Delta\phi$ for associate hadron relative to leading hadron



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Lambda measurements

η	Nomenclature		Tracking Resolution	Allowed X/X_0	Si-Vertex	Electrons Resolution σ_E/E	PID	π/K/p p-Range (GeV/c)	Separation	HCAL Resolution σ_E/E	Muons
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-3.5 to -3.0											
-3.0 to -2.5											
-2.5 to -2.0		Backward Detector						≤ 7 GeV/c		~50%/√E	
-2.0 to -1.5											
-1.5 to -1.0											
-1.0 to -0.5	Central Detector								≥ 3 σ		
-0.5 to 0.0		Barrel						≤ 5 GeV/c			TBD
0.0 to 0.5											
0.5 to 1.0											
1.0 to 1.5								≤ 8 GeV/c			
1.5 to 2.0											
2.0 to 2.5		Forward Detectors						≤ 20 GeV/c		~50%/√E	
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3.0 to 3.5								≤ 45 GeV/c			
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4.0 to 4.5											
...		Neutron Detection									

Slow decay pion determines Λ statistics. Mass resolution via tracking and vertex resolution

Precise Photon energy measurement from Σ decays to separate Λ and Σ

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Momentum vs theta

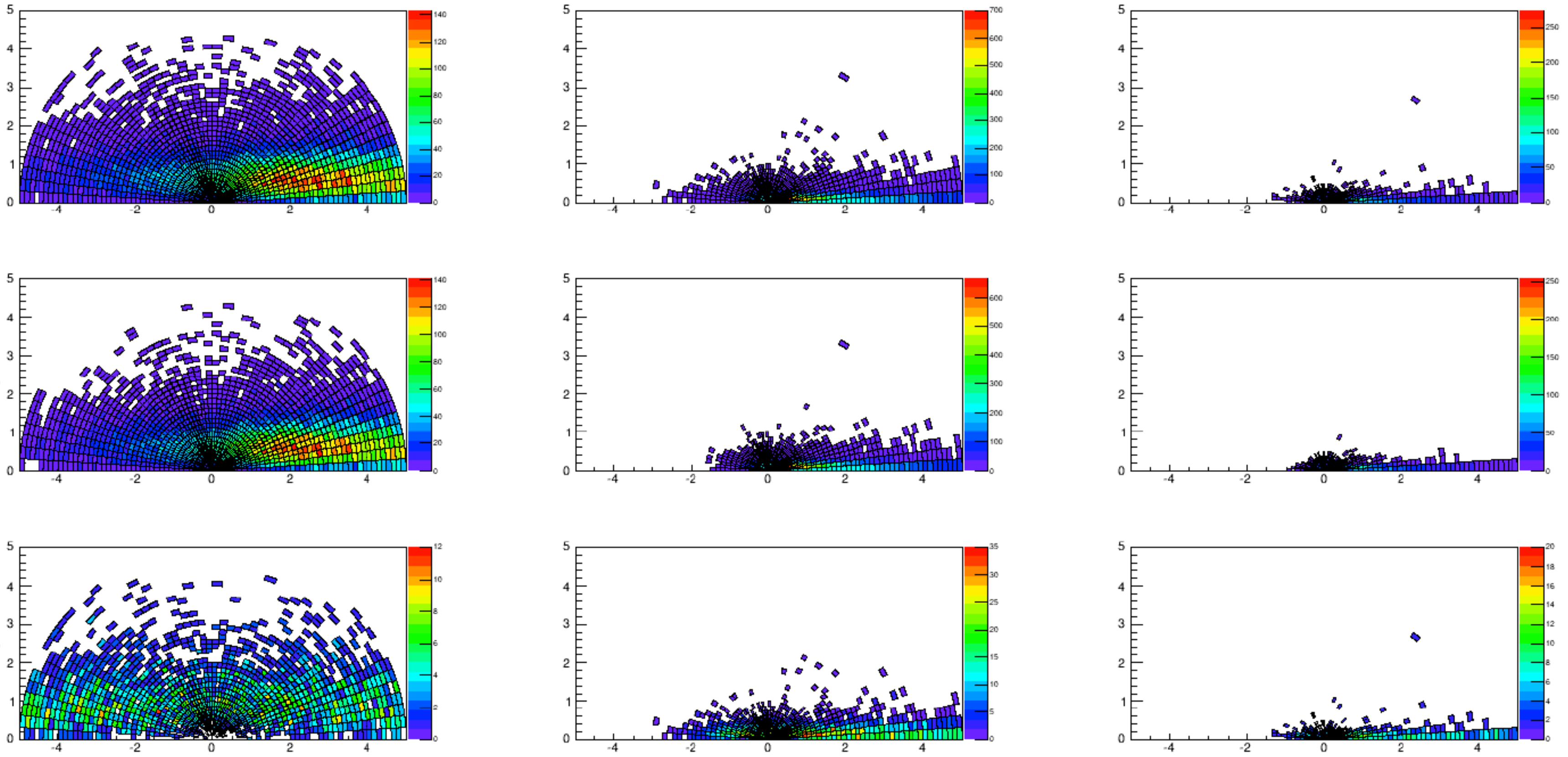
275 GeV → ← 18 GeV

Proton from Lambda | Pion from Lambda | Gamma from Sigma0

All

z_h < 0.4

z_h > 0.4



Angle for theta, radius for momentum/energy

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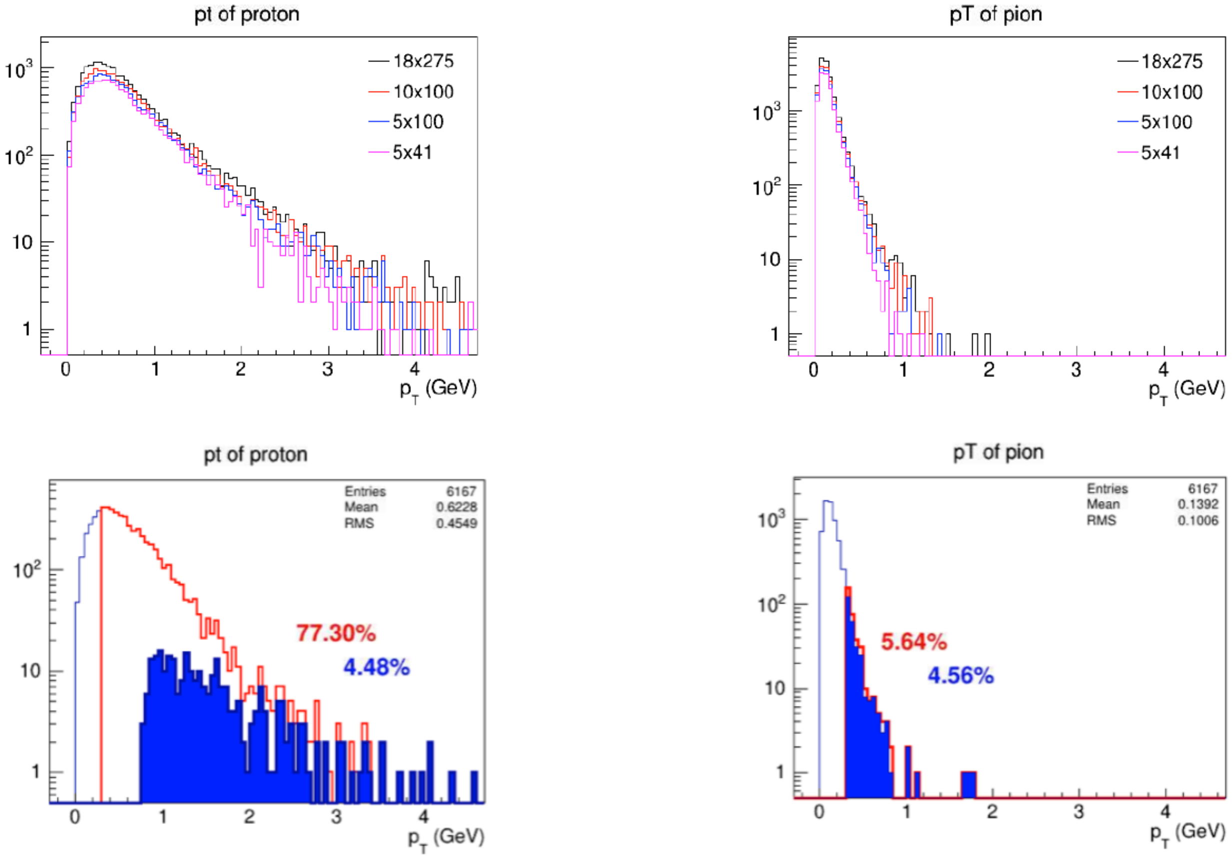
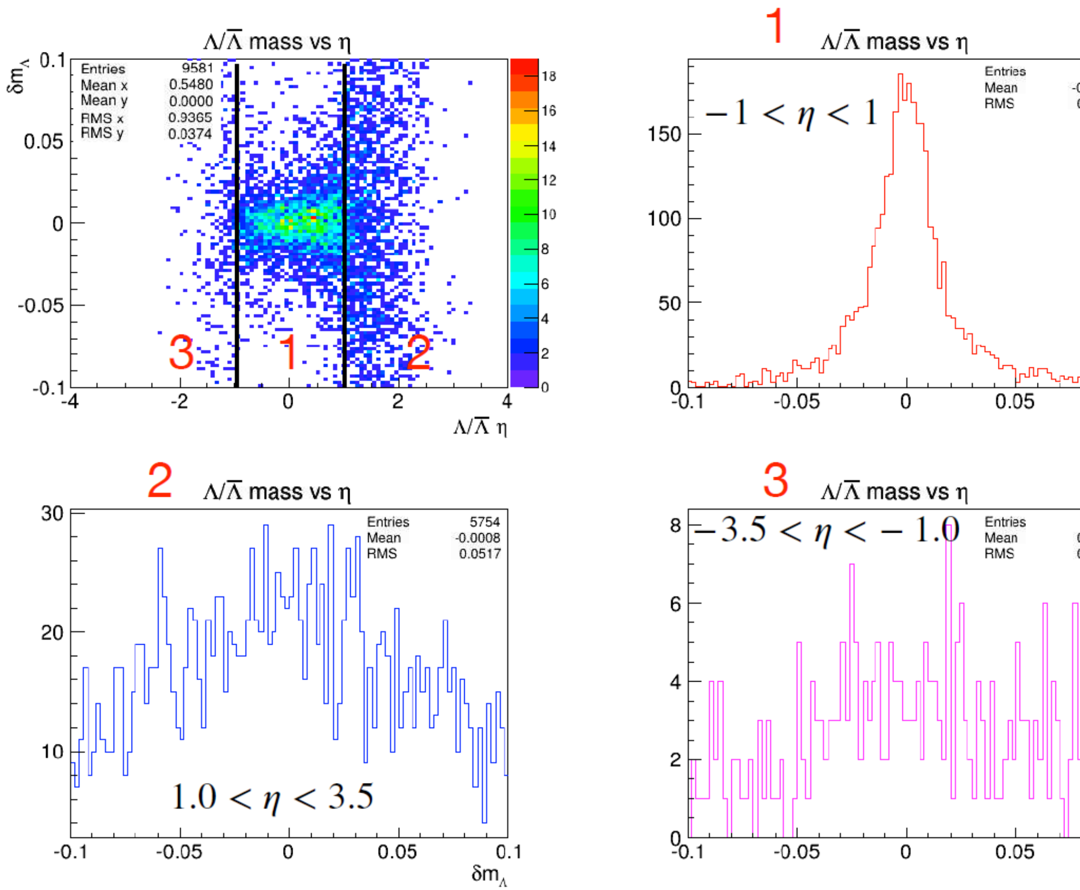
Final p_T limits



- p_T of pion and proton > 0.3 GeV
- Red is independent 0.3 GeV cut
- Blue filled is combined eta and pT cut

Lambda mass vs eta



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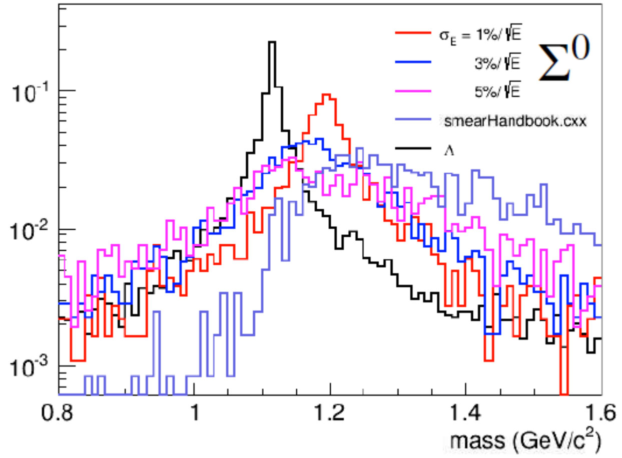
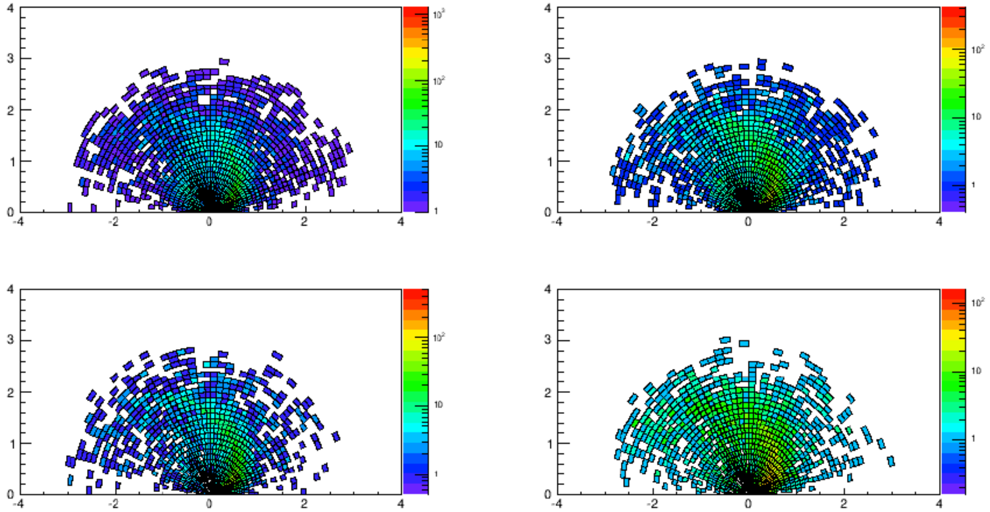
Smearing photon E for Sigma0

- In addition to the tracking smearing (handbook)
- Handbook setup push mass to larger side
- Lambda and sigma peak start merging at 3%/√E



Angle for theta, radius for open angle between lambda and photon



Spectroscopy measurements: **ep → Zc+n, Zc+ → J/ψπ+**

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

Even more forward than SIDIS channels, requires higher momenta

+ forward neutron tagging

Polar detector maps

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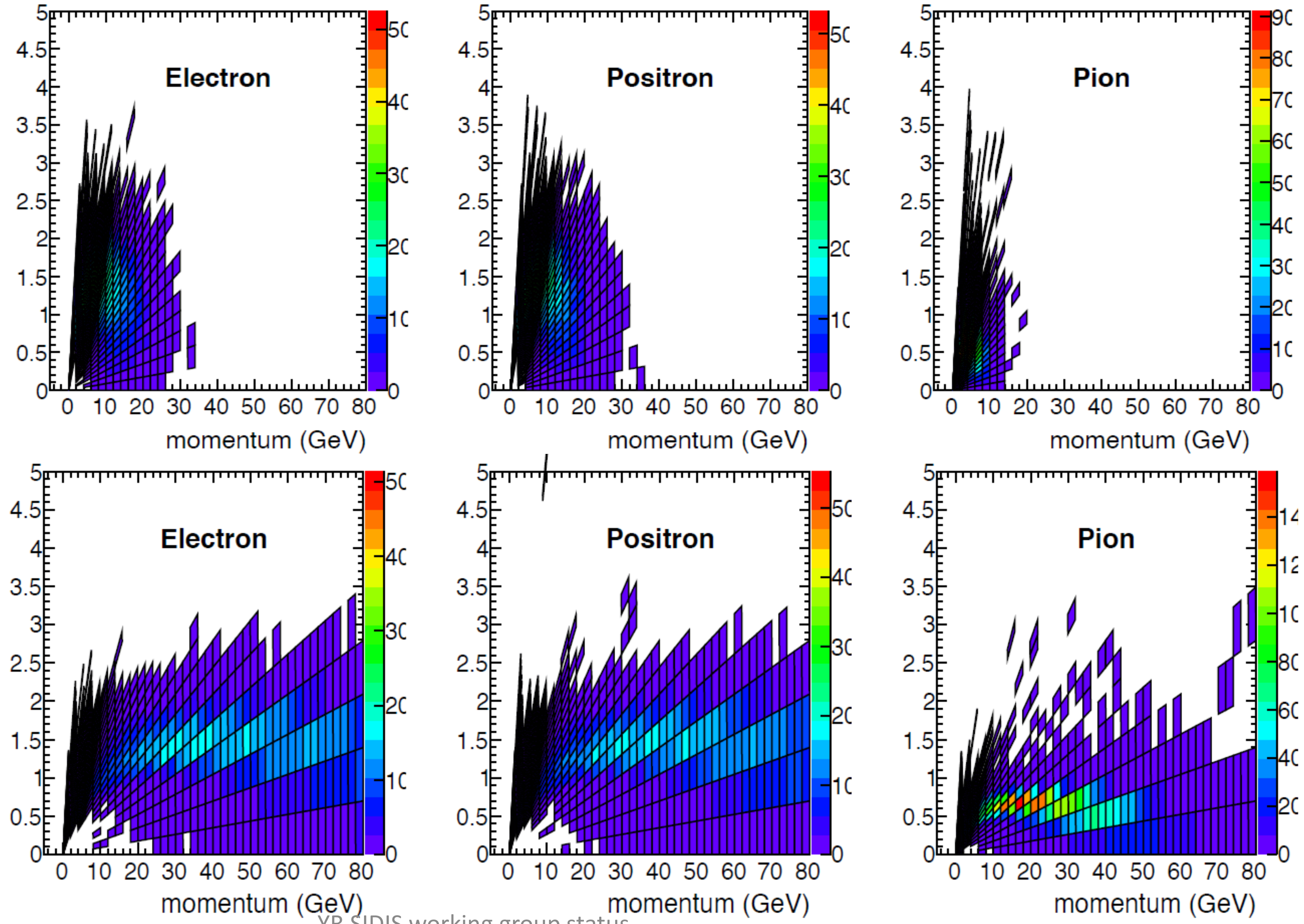
5 x 41

18 x 275



Overall status

- All channels are progressing well, all have produced some simulation data (mostly pythiaerhic+eicsmear, some dedicated generators and Pythia8)
- Application of latest smearing package (from Kolja’s mail) ongoing
- Some pseudo-data already with theorists for impact studies

- Requests for Pavia meeting: Maybe again joint SIDIS/HFjets session.

Golden channels I

Measurement/process	Main detector requirements	Anticipated plot	**Comments**
Quark Sivers, 3D momentum structure, TMD evolution from single hadrons →3D image (x, kT) of the Sivers Function, Evolution test of Sivers at intermediate x, Tensor charge via Collins Alexey Vladimirov	• 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$$%at fixed x	• Use of existing simulations at Elke's group + smearing + weights originating from theorists, weights for Sivers asymmetries prepared • Work on common database ongoing, integrate in SW environment • Theory work on fits/parameterizations. First tests for unpol TMD data
Gluon Sivers via di-jets/dihadrons →Probing the size of the gluon Sivers function Bowen Xiao	acceptance for back-to-back Dihadrons	Size of the asymmetry as a function of x	• Continuation of study based on **arXiv:1805.05290** together with current EIC detector design • consideration of different jet algorithms Elke, Zheng, Lee and Yin • Possible different parametrizations of gluon Sivers function inputs from Pavia

Golden channels II

Measurement/process	Main detector requirements	Anticipated plot	**Comments**
Spectroscopy possibilities →Representative spectroscopy channel : X,Y → J/Ψππ, DD* Justin Stevens	• 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	Generator, EICsmear for mass resolution etc., bkgd. estimation

Silver channels I

Measurement/process	Main detector requirements	Anticipated plot	**Comments**
Sea quark helicity measurements →flavor separated (anti)quark helicity distributions over wide range of x Ralf Seidl	hadron momentum and energy resolution in forward direction (2 < η < 4) for CC events	Update of previous sea quark helicity PDF uncertainty plots	Work will follow ongoing sensitivity studies by Elke's group + Argentinian global fitters. • Implementation of detector smearing, etc needs to be added to existing studies. • Concentration on CC and $D/3He$.
FFs/nFFs/nPDFs via single hadron FF →Single hadron fragmentation functions for ep and eA for FFs, nFFs, nPDFs Ralf Seidl	See TMD SIDIS reqs	nPDF uncertainty expectation, (n)FF Expectation	Simulations prepared using official 4 ep and 3 eAu beam energy combinations, for smeared simulation BeAST resolutions were used in eicsmear. • reweighted eAu multiplicitis using nFFs from SSZ fit • Not implemented: magnetic field and PID (hadron, momentum, rapidity) impact.

Silver+New channels

Measurement/process	Main detector requirements	Anticipated plot	**Comments**
Di-hadron correlations in eA →low x →Probing the onset of saturation phenomenon Bowen Xiao	backward hadron acceptance, granularity	decorrelation plot as in white paper	Continuation of work based on **arXiv:1403.2413** with extension to jets with different algorithms using the new collisional energies at eRHIC.
Di-hadron FF for Tensor charge/Boer-Mulders Anselm Vossen	Single hadron reqs+min z for partial wave expansion	• Impact on tensor charge/transversity extraction • Projected BM asymmetries	Initial simulations prepared for kin. Ranges, Reweighting of asymmetries next
Lambda related spin measurements →L/T spin transfer, polarizing FFs (universality), jet structure Anselm Vossen	• Λ acceptance • Slow pion →low momentum cutoff, displaced vertex	• Precision of Λ polarization measurements	Detailed study of acceptances and momentum requirements