

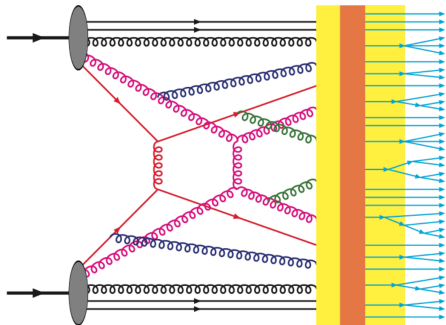
Exploring emergent properties of QCD with streaming data

Joe Osborn

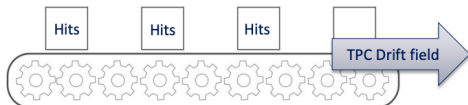
Early career retreat
September 9, 2022

Emergent Processes: Hadron Structure and Fragmentation

- Inherently emergent and dynamic processes - perturbatively defined objects collectively form complex bound states
- Multiple scales: perturbative and nonperturbative elements important
- Decades spent on initial state collinear, or 1-dimensional, structure of the proton
- Only recently has there been more exploration into 3-dimensional structure



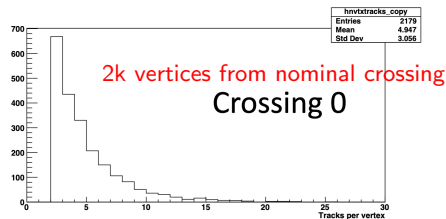
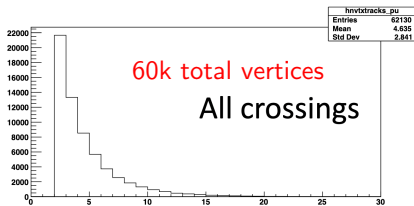
Streaming Data



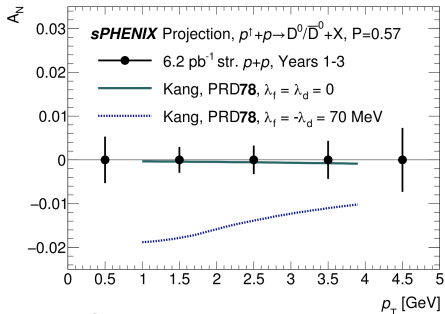
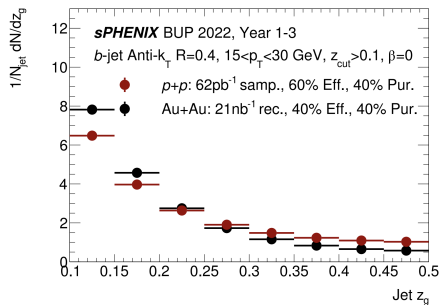
- Heavy flavor hadron production (e.g. in a jet) gives an additional scale
- However, lose many statistics at low p_T - no good trigger!
→ stream as much data as can fit on disk
- sPHENIX will collect $\mathcal{O}(100\times)$ more low p_T heavy flavor hadron statistics by streaming 10% of minimum bias cross section

Track Reconstruction in Streaming Data

- However, charged particle reconstruction in streaming environment difficult
- sPHENIX time projection chamber integration time $\sim 13\mu\text{s}$, beam crossing $\sim 100\text{ns}$
- $\sim 30\times$ number of collisions to reconstruct



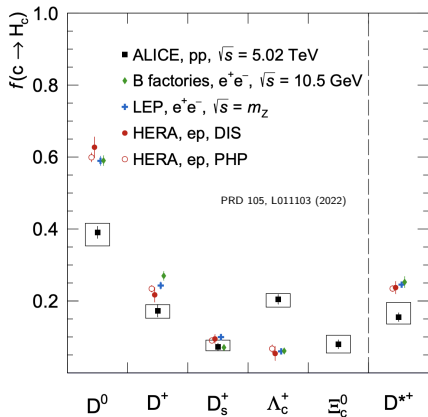
Physics Opportunities



- Enables many new physics opportunities utilizing rare heavy flavor probes
- Examples: D^0 transverse single spin asymmetry and heavy flavor hadronization
- First at RHIC, with potential to study at low p_T and hadron momentum fraction

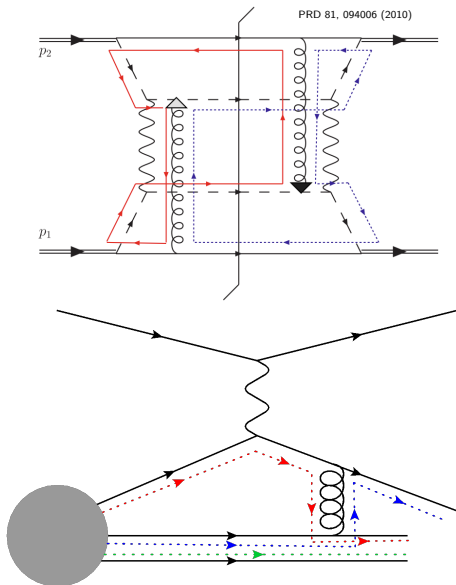
sPHENIX \rightarrow EIC

- Comparing results from different collision systems will be essential for maximizing physics interpretation!
- Many questions will benefit from both hadronic and DIS data
 - e.g. role of color in QCD interactions (PT odd TMD-PDFs, factorization breaking, etc.)



sPHENIX → EIC

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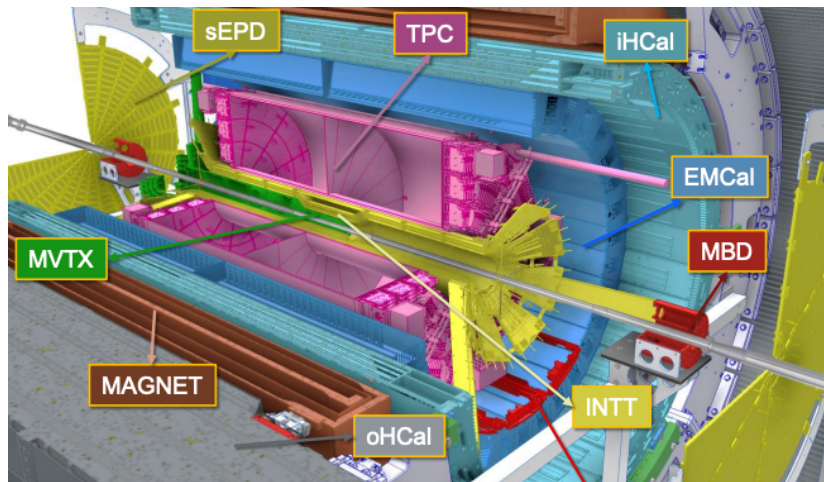
Backup

Transverse Momentum Dependence

- In recent decades, focus has moved to 3 dimensional structure functions
- However, focus has remained on initial state structure
- Only recently has there been increased interest in the final state
 - As well as how initial and final states are correlated

		Quark polarization		
		Un-Polarized	Longitudinally Polarized	Transversely Polarized
Nucleon Polarization	U	$f_1 = \odot$		$h_1^\perp = \uparrow - \downarrow$ Boer-Mulder
	L		$g_1 = \rightarrow - \leftarrow$ Helicity	$h_{1L}^\perp = \nearrow - \nwarrow$
	T	$f_{1T}^\perp = \uparrow \odot - \downarrow \odot$ Sivers	$g_{1T}^\perp = \uparrow \rightarrow - \downarrow \rightarrow$	$h_{1T}^\perp = \uparrow \downarrow - \downarrow \uparrow$ Transversity $h_{1T}^\perp = \nearrow \nwarrow - \nwarrow \nearrow$ Pretzelosity

sPHENIX



Other HF Opportunities

- Physics opportunities opened by streaming data:
 - D^0 transverse single spin asymmetry
 - Low p_T HF-in-jet (e.g. dead cone effect at RHIC)
 - HF jet cross sections and correlations
 - Charged hadron A_N in $p+Au$
 - Baryon-meson production ratios WRT to SIDIS and e^+e^-
 - HF multi-particle cumulants in $p+Au$

