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LHC Reinterpretation Forum (RIF) Aug. 29, 2023

Overview of unbinned measurements

2	Motivation		2109.13243	3
	2.1	Inference-Aware Binning	2100.10240	3
	2.2	Derivative Measurements		4
	2.3	Extension to Higher Dimensions		4
3	Overview of Unbinned Methods		5	
	3.1	Experimental Measurements		5
		3.1.1 Density-Based Models		5
		3.1.2 Classifier-Based Models		6
	3.2	Theoretical Calculations		6
4	Statistics of Unbinned Spectra		7	
	4.1	Acceptance Effects		7
	4.2	Background Subtraction		7
	4.3	Local Statistical Uncertainty		7
5	5 Systematic Uncertainties		9	
6	Pro	posed Format and Storage		9
	6.1	Structure		9
	6.2	Uncertainties		11
	6.3	Storage		11
	6.4	Common Tools		11
7	Example		11	
8	Conclusions and Outlook			16

Motivation - why unbinned?

2109.13243 Motivation $\mathbf{2}$ 3 Inference-Aware Binning 2.1**Derivative Measurements** 2.22.3Extension to Higher Dimensions **National Methods Overview** of 3 5 3.1 Experime Measurements 3.1.1 D Rased Models used Models 3.1.2 C 3.2 Theoretic ons Statistics of U 4 Acceptance 4.1 Backgroun 4.2 Local Sta 4.3 Inference-Aware Binning **Systematic** 5 Proposed 6 Derivative Measurements Structi 6.1 6.2 Uncert Extension to Higher Dimensions 6.3 Storage 6.4 Commo Example 7

3

8 Conclusions and O

Motivation I: Inference-aware binning



Motivation I: Inference-aware binning



Motivation I: Inference-aware binning



6

Related: makes comparison with other experiments much easier ... do not need to coordinate on binning ahead of time!

Say you measure the observables x, but you later want to measure f(x).

If the original measurement is binned, then you can only make a crude approximation of f using bin centers. Say you measure the observables x, but you later want to measure f(x).

8

If the original measurement is binned, then you can only make a crude approximation of f using bin centers.

Optimal f (and the binning) may depend with time as more data are available for global fits - this is enabled by unbinned data! Many of the proposals for unbinned measurements make use of machine learning and readily extend to many (and even variable) dimensions.

9

While not a direct benefit of unbinned results, this would be a clear game changer for how we do measurements !!

With enough (internal) information, can build correlation matrices between measurements post-hoc, but this comes for free if originally done multidimensional

Unbinned Methods



There are other examples, but these ones (and their extensions) are particularly well studied.

Can these approaches preserve BSM?



MultiFold: 10d cross section, OmniFold: all particles.

BSM: H->Za

Answer: sort of ... preserves anomaly when big enough (>1%). Precision continues to improve!

see also 1912.00477

Can these approaches preserve BSM?



Step towards improving: add BSM to prior during unfolding.

Has little effect when no signal (bottom) but makes it much easier to preserve signal when present (top)

2105.09923



This breaks HEPData!

2109.13243 proposed a solution, but it has not been applied yet, despite the fact that OmniFold has been used in a few places now (H1, LHCb, STAR)

...stay tuned!

Conclusions and Outlook

New methods for unbinned unfolding are here! We should be ready to use them also for BSM!

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Measurement of lepton-jet correlation in deep-inelastic scatterin with the H1 detector using machine learning for unfolding

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+<u>CMS open data study</u>

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CERN-EP-2022-161 LHCD LHCb-PAPER-2022-013 August 25, 2022 Multidifferential study of identified charged hadron distributions in Z-tagged jets in proton-proton collisions at $\sqrt{s} = 13$ TeV

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

Abstrac

Jet fragmentation functions are measured for the first time in proton-proto collisions for charged pions, kaons, and protons within jets recoiling against a Z boson. The charged-hadron distributions are studied longitudinally and transversely to the jet direction for jets with transverse momentum $20 < p_T < 100$ GeV and in the pseudorapidity range $2.5 < \eta < 4$. The data sample was collected with the LHCb experiment at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 1.64 fb⁻¹. Triple differential distributions as a function of the hadron longitudinal momentum fraction, hadron transverse momentum, and jet transverse momentum are also measured for the first time. This helps constrain transverse-momentum-dependent fragmentation functions. Differences in the shapes and magnitudes of the measured distributions for the different hadron species provide insights into the hadronization process for jets predominantly initiated by light quarks

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¹¹-binned Deep Learning Jet Substructure Measurement in High $Q^2 ep$ collisions at HERA

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Measurement of CollinearDrop jet mass and its correlation with SoftDrop groomed jet substructure observables in $\sqrt{s} = 200 \text{ GeV} pp$ collisions by STAR.

YOUQI SONG (WRIGHT LABORATORY, YALE UNIVERSITY)

on behalf of the STAR Collaboration

Jet substructure variables aim to reveal details of the parton fragmentation and hadronization processes that create a jet. By removing collinear radiation while maintain ing the soft radiation components, one can construct CollinearDrop jet observables, which have enhanced sensitivity to the soft phase space within jets. We present a CollinearDrop jet measurement, corrected for detector effects with a machine learning method, Multi-Fold, and its correlation with groomed jet observables, in pp collisions at $\sqrt{s} = 200$ GeV at STAR. We demonstrate that the population of jets with a large non-perturbative contribution can be significantly enhanced by selecting on higher CollinearDrop jet mass fractions. In addition, we observe an anti-correlation between the amount of grooming and the angular scale of the first hard splitting of the jet.

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