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# Unbinned measu for new phy

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Jet I

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### Overview of unbinned measurements

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## Motivation - why unbinned?

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### Motivation I: Inference-aware binning



### Motivation I: Inference-aware binning



## Motivation I: Inference-aware binning



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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).

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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.

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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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#### 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<sup>-1</sup>. 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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#### <sup>11</sup>-binned Deep Learning Jet Substructure Measurement in High $Q^2 ep$ collisions at HERA

Jul

18

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July 19, 2023

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.

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