Jet Calibration in sPHENIX

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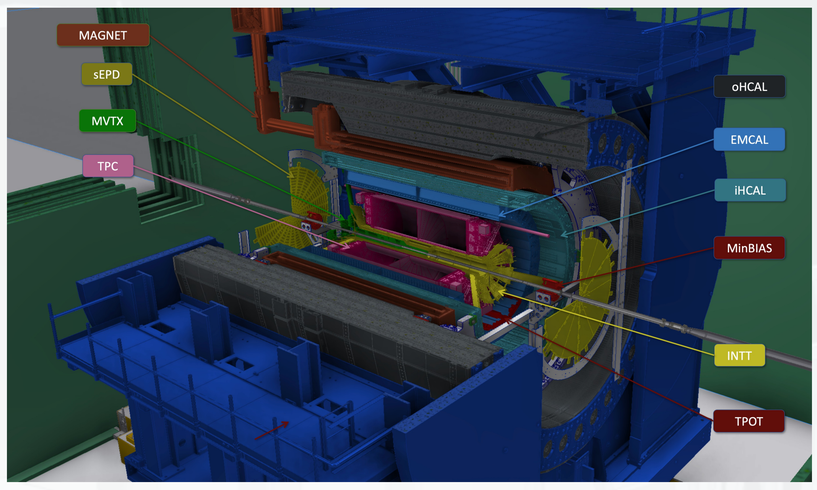
Abstract

The sPHENIX detector at the Relativistic Heavy Ion Collider (RHIC) is designed to study the small-scale structure of the quark-gluon plasma (QGP) created in collisions of heavy ions. Jets, produced in hard scatterings early in the collisions, provide an ideal probe for the full evolution of the QGP. sPHENIX is the first detector at RHIC with full coverage electromagnetic and hadronic calorimetry at mid-rapidity up to $|\eta|$ = 1.1, allowing for precise measurements of jet kinematics and physics effects such as jet energy loss. The sPHENIX calorimeter system consists of three sampling calorimeters: a tungsten and scintillating fiber electromagnetic calorimeter, and an aluminum (steel) and scintillating tile inner (outer) hadronic calorimeter. These calorimeters must be calibrated to reconstruct the full electromagnetic and hadronic energy deposited by jets. The jet level calibration combines Monte Carlo-based corrections and data-driven techniques to provide fully calibrated calorimeter jets for measurements of jet quenching in sPHENIX. This poster will present the status and plans for jet calibration using Au+Au data at 200 GeV measured in sPHENIX in 2023.

The sPHENIX Detector



Calorimeters: Inner hadronic calorimeter (iHCAL), outer hadronic calorimeter (oHCAL), electromagnetic calorimeter (EMCAL)

Tracking: Time projection chamber (TPC), TPC outer tracker (TPOT), intermediate silicon tracker (INTT), MAPS-based vertex detector (MVTX)

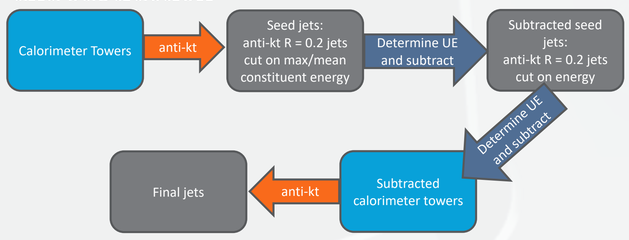
Event characterization: minimum bias detector (MinBIAS), event plane detector (sEPD) , zero-degree calorimeter (ZDC)

Calorimeter jets in sPHENIX

Jets reconstructed using calorimeter towers

Method from: *Phys.Rev.C* 86 (2012) 024908

Event-by-event underlying event determination and subtraction

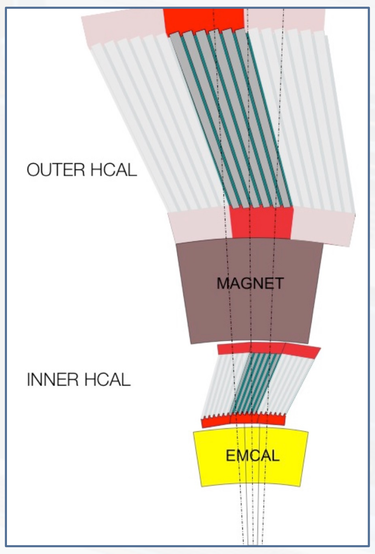


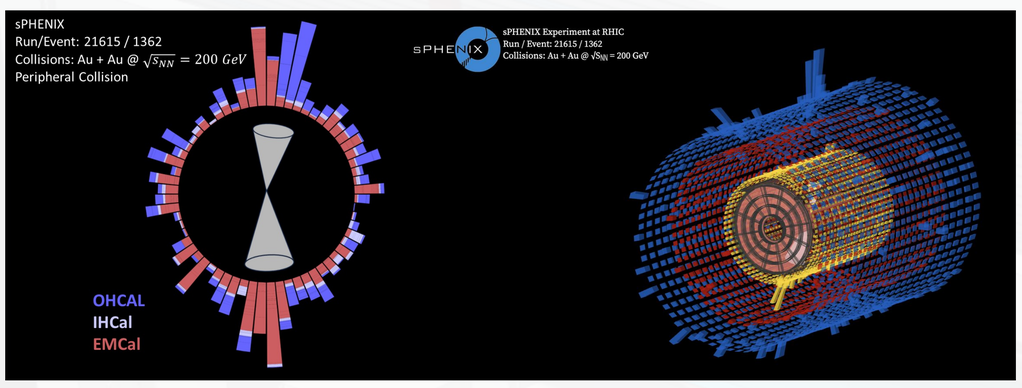
Planned UE determination:

$$\frac{d^2E_T}{d\eta d\phi} = \frac{dE_T}{d\eta}\left(1 + 2\sum_n v_n \cos(n(\phi - \psi_n))\right)$$

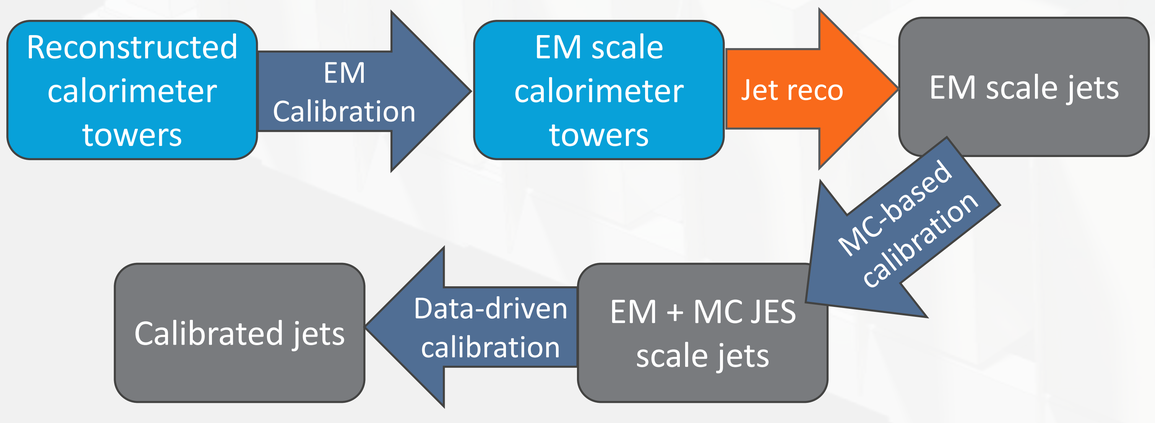
Average energy density, excluding regions with jet candidates

Flow modulation: v_2 (not included in this poster)





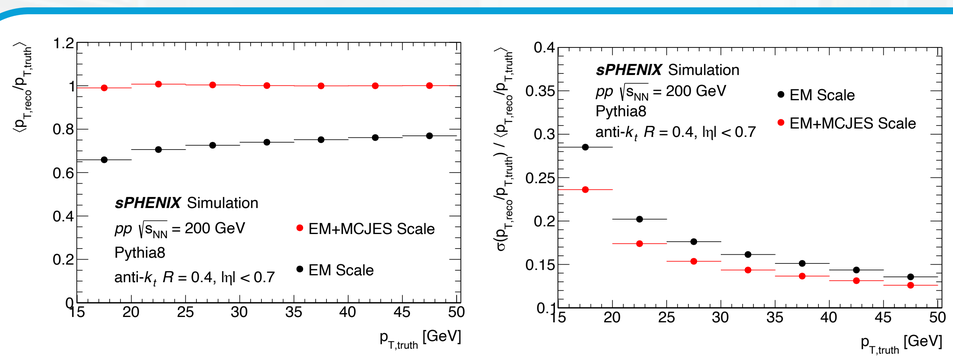
Calorimeter Jet Calibration



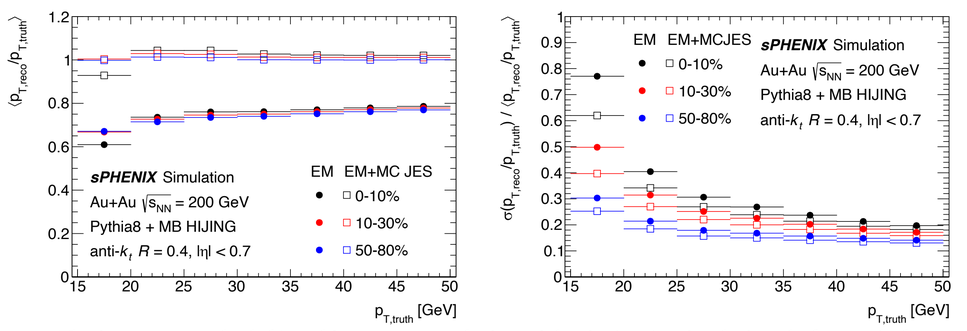
MC-based Calorimeter Jet Calibration

- Calibration follows numerical inversion method outlined in **[1]**
- Response in Monte Carlo simulation of *pp* dijets using Pythia8 is inverted to obtain calibration factors
- Calibration corrects from EM scale to full EM + hadronic scale jets in simulation
- Additional calibration required in data to account for MC/data differences

[1] A. Cukierman and B. Nachman,
Mathematical Properties of Numerical Inversion for Jet Calibrations,
Nucl. Instrum. Meth. A 858 (2017) 1, arXiv: 1609.05195 [physics.data-an]



The jet energy scale (left) and jet energy resolution (right) in *pp* simulations before and after applying the MC JES calibration



The jet energy scale (left) and jet energy resolution (right) in Au+Au simulations before and after applying the MC JES calibration

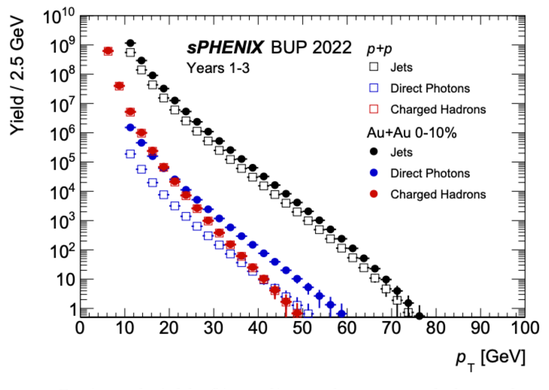
Conclusion & Outlook

Can reconstruct and calibrate jets in simulations of sPHENIX Au+Au and *pp* collisions

Commissioning efforts ongoing for real sPHENIX data collection – initial studies of calorimeter jets ongoing

Fully calibrated jets in data require data driven corrections. Run 2024 *pp* data will be ideal for these in-situ calibrations

Full jet calibration is crucial to sPHENIX physics program measuring jets and jet substructure to understand small-scale structure of QGP



Projected yield of jets, direct photons, and charged hadrons for the nominal sPHENIX three year run plan

Acknowledgements

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