Implementation of heavy ion measurements in Rivet

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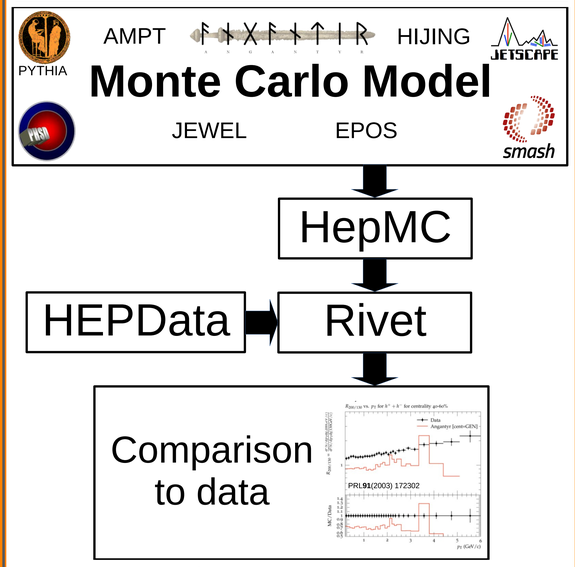
1. Robust Independent Validation of Experiment and Theory



1.1 What is Rivet?

- C++ framework for physics analyses (over 900 and growing!)
- Validates Monte Carlo event generators
- Runs analysis over simulated data, then plots with published data pulled from HEPData

1.2 Implementing heavy ion collisions

- Format your data for HEPData (See [1]). Make sure to use bins for the relevant histograms.
- Write a class for defining centrality or use an existing class. (See [2] for STAR and PHENIX centrality classes.)
- Identify similar analyses.

2. Undergraduate Participation

- Course-based Undergraduate Research Experiences (CUREs) linked to increased retention in the major, continuation to graduate studies [3], esp. among Under-Represented Minorities (URMs) and women
- 19 independent students: 8 Summer students, one independent study, 12 in CURE
- 7 URMs, 8 women, 4 non-traditional students

3. Models

3.1 PYTHIA Angantyr

PYTHIA Angantyr [4] is a Monte Carlo model for heavy ion collisions included in PYTHIA 8[4, 5].

- No flow, no jet quenching
- Used the centrality class implemented in Rivet [6]
- Simulates both jets and an underlying event

3.2 JEWEL

JEWEL [7] is a Monte Carlo model for partonic energy loss.

- Treats the interplay of QCD radiation and re-scattering microscopic dynamics
- Consistent perturbative framework with minimal assumptions.
- Output contains only particles from the jet or from interactions with the medium

4. Single Hadron R_{AA}

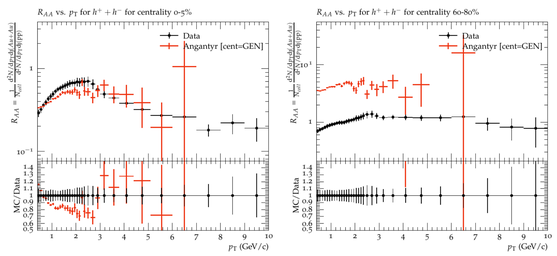
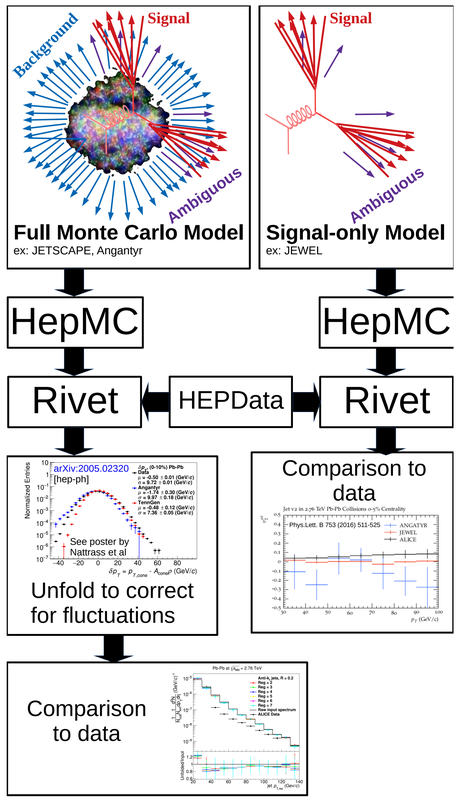


Figure 1: *Comparison of R_{AA} in 0–5% (left) and 60–80% (right) central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV [8] with Angantyr.*

- Required implementation of centrality
- Code available here [2]

5. Implementation of jet measurements



- Rivet philosophy: Treat Monte Carlo *exactly* like data. Reduces dependence of data/model comparison on model- or method-dependent assumptions.
- Full Monte Carlo has fluctuating background. Published measurements correct for this → needs to be corrected in Monte Carlo → unfold using RooUnfold [9], as in data.
- Some models provide only "Signal" particles. These models do not require unfolding.
- Options for full or signal-only Monte Carlo programmed into analysis.

5.1 Jet R_{AA} from ALICE

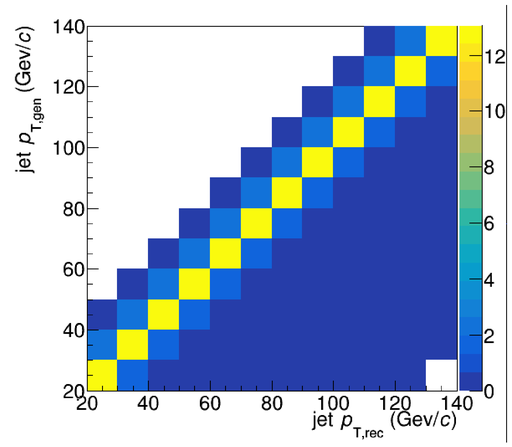


Figure 2: *Response matrix generated using random cones as described in [10] with two leading jets excluded.*

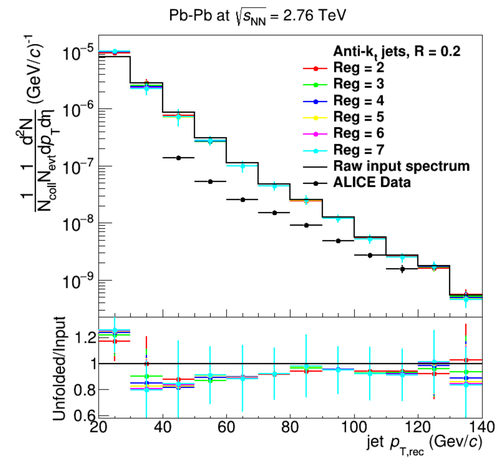


Figure 3: *Comparison of charged jet R_{AA} in 0–10% central Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [11] with Angantyr.*

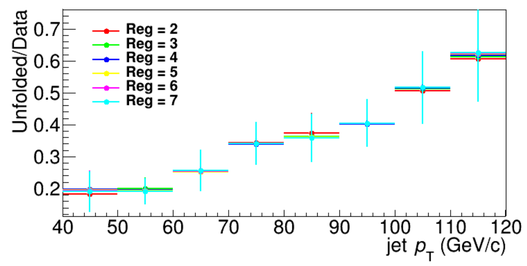


Figure 4: *Ratio of charged jet R_{AA} in 0–10% central Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [11] to Angantyr.*

5.2 Jet v_2 from ALICE

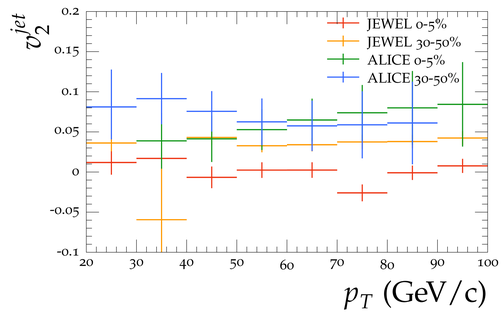


Figure 5: *Comparison of charged jet v_2 in 0–5% and 30–50% central Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [12] with JEWEL.*

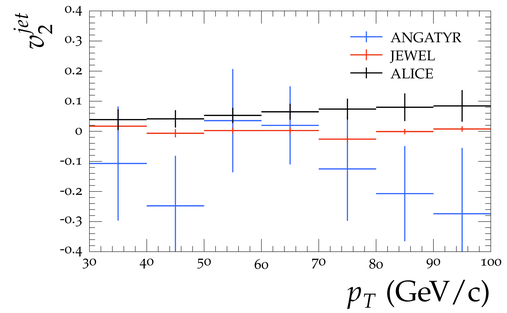


Figure 6: *Comparison of charged jet v_2 in 0–5% central Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [12] with Angantyr and JEWEL.*

- JEWEL predicts $v_2 = 0$ in central collisions, missing fluctuations in initial state
- Angantyr expected to have $v_2 = 0$, but provides test of this approach in full Monte Carlo

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