Rivet

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What is Rivet?

Robust **I**ndependent **V**alidation of **E**xperiment and **T**heory

AMPT HIJING JETSCAPE

PYTHIA

Monte Carlo Model

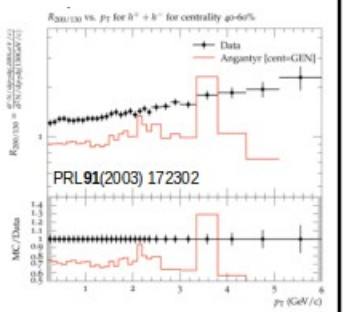
JEWEL EPOS

smash

HepMC

HEPData → Rivet

Comparison to data



The Lisbon Accord

- Lisbon Accord proposed that heavy ion experiments adopt Rivet in July 2014
- Fully heavy ion capable with June 2019 release of Rivet 3.0

https://www.aworldtotravel.com/things-lisbon-is-famous-for/

Why use Rivet?

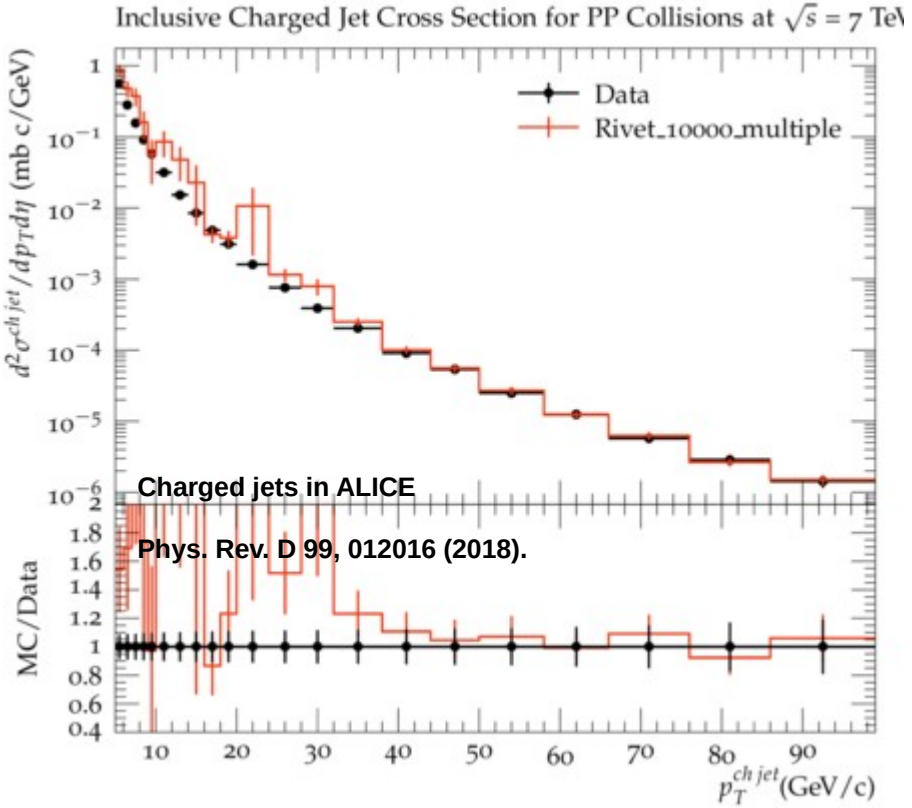
- Facilitates comparisons between Monte Carlos and data
- It’s not that hard
- It preserves analysis details
- You can treat Monte Carlo like data

Steps

- Format data for HEPData or fix issues with Rivet compatibility of HEPData
  Short tutorial Long tutorial
- Install Rivet or load it on an existing farm
- Follow a Rivet tutorial
  - Slides and recordings from
    Rivetizing Heavy Ion Collisions at RHIC

Jet spectra in 7 TeV pp collisions

- Justin Piel – Undergraduate at Stetson
- First learned about jets this summer
- Learned how to run JETSCAPE at this school
- Implemented analysis



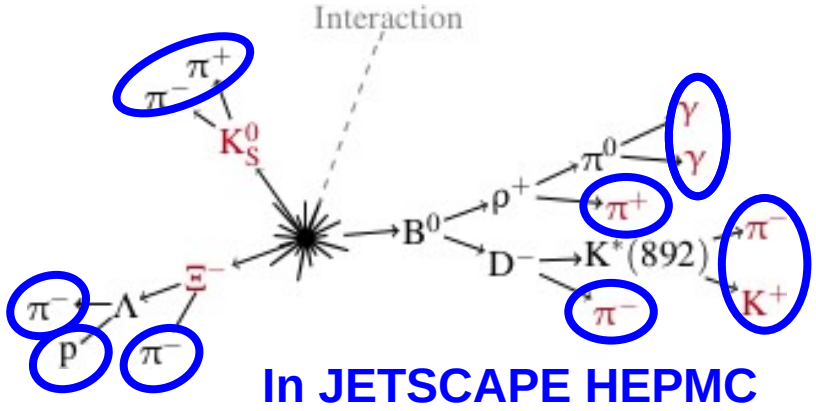
Other undergrads working with me on Rivet this summer: Ralph Davenport, Kip Hunt, Jason Spriggs, Taylor Sussmane, Adam Tilley

What does it take to get everyone doing this?

- Experiments need to have a validation procedure
- Manage issues with heavy ion Monte Carlo models
- Define “primary particles” in Rivet
- Deal with background in models
- Get a critical mass of heavy ion analyses

Status of heavy ion Monte Carlos

Compatibility with HEPMC/Rivet



In JETSCAPE HEPMC

HIJING - unknown

HIJING++ - Compatible, code should be public soon.

EPOS – Mostly compatible. Treatment of decays may need improvement.

PHSD – Mostly compatible. Treatment of decays may need improvement.

SMASH – Mostly compatible. Treatment of decays may need improvement.

JETSCAPE – Treatment of decays needs improvement. Only contains final state particles.

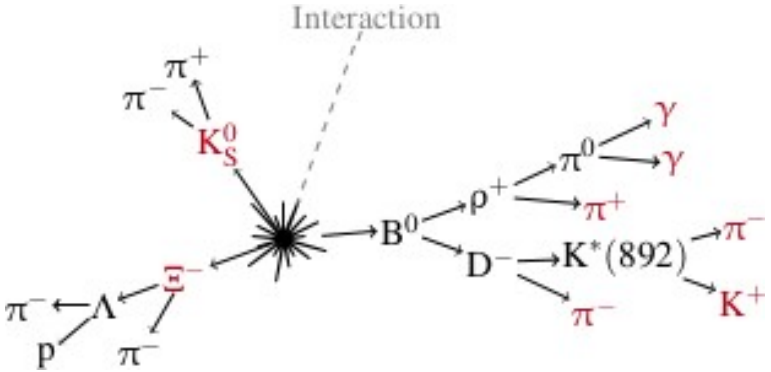
AMPT - Converter to HEPMC available internally in ALICE. Working on making this publicly available

Status of beams: may need to run with options to ignore beams

Draft from HEPMC in Heavy Ion Collisions workshop

Primary Particles

Primary Particles



Experimental definition:
Looks like it comes from the interaction vertex, cτ> 1 cm
Slight variations by experiment

Definition for each experiment

Needs particle decays in MC

Needs experiment approval

Specie	Width Γ (GeV)	Mean proper lifetime τ (ps)	(cm/c)
p^+	0	∞	∞
γ	0	∞	∞
K^0	0	∞	∞
e^-	0	∞	∞
n	7.478×10^{-28}	$8.861 \times 10^{+14}$	$2.656 \times 10^{+13}$
μ^-	2.996×10^{-19}	$2.212 \times 10^{+06}$	$6.63 \times 10^{+04}$
K^0_L	1.287×10^{-17}	$5.148 \times 10^{+04}$	1543
π^+	2.528×10^{-17}	$2.621 \times 10^{+04}$	785.7
K^+	5.317×10^{-17}	$1.246 \times 10^{+04}$	373.6
Ξ^0	2.27×10^{-15}	291.9	8.751
Λ	2.501×10^{-15}	264.9	7.943
Ξ^-	4.02×10^{-15}	164.8	4.941
Σ^-	4.45×10^{-15}	148.9	4.464
K^0_S	7.351×10^{-15}	90.14	2.702
Ω^-	8.071×10^{-15}	82.1	2.461
Σ^+	8.209×10^{-15}	80.72	2.42

Theoretical definition

in Rivet projection - ALICE public note
Christian Holmes Christiansen (cholm@nbi.dk)

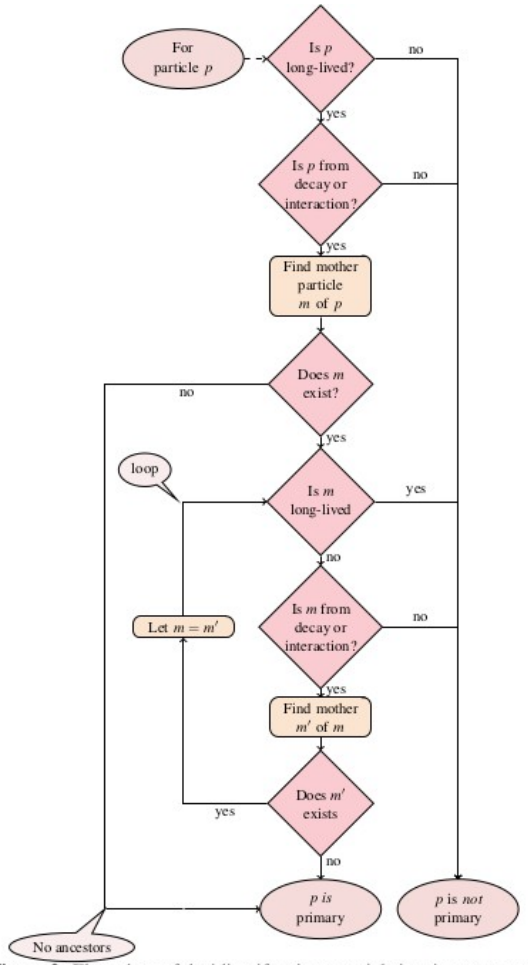
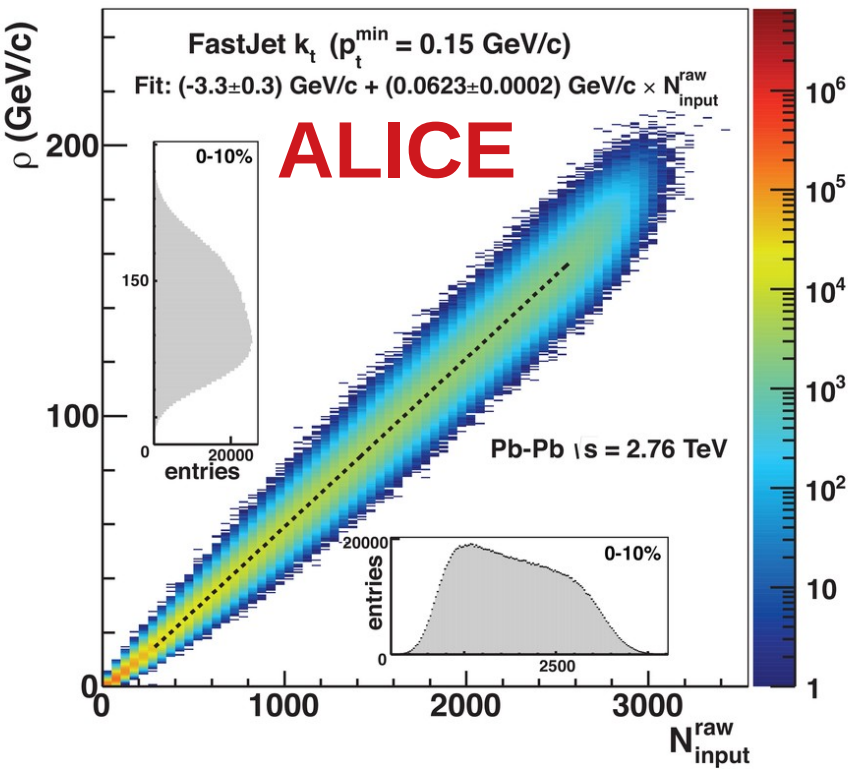
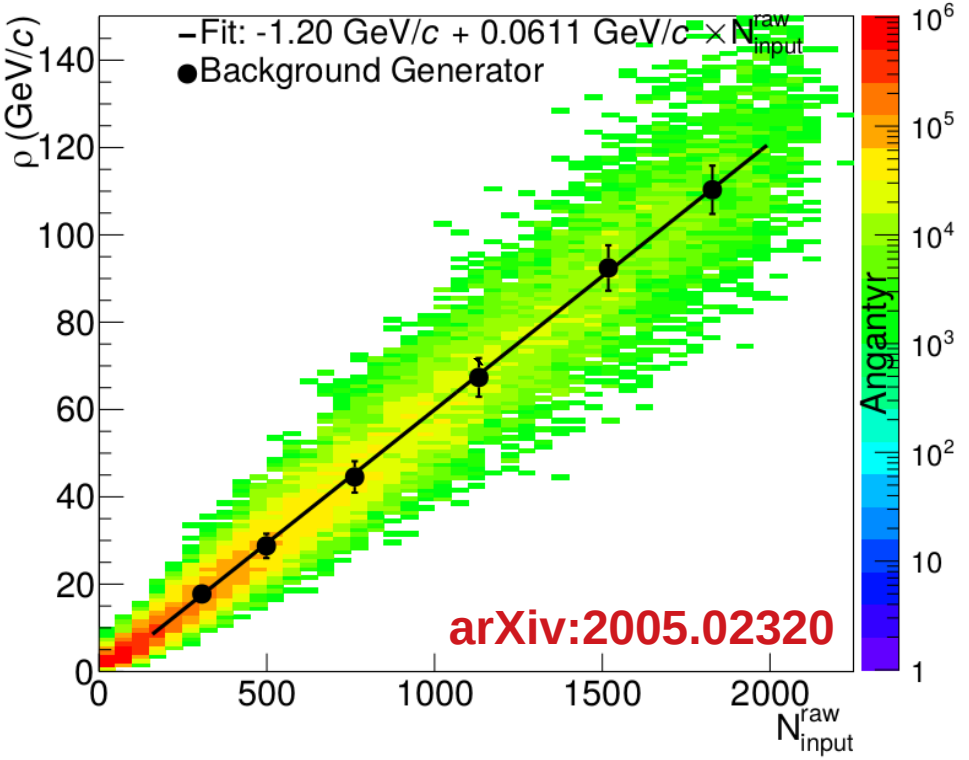


Figure 2: Flow chart of deciding if a given particle is primary or not.

Background for jet analyses

Background density ρ





Snowmass Accord: Apply the same algorithm to data and your model. Then the measurement and the calculation are comparable.

Rivet: Apply the same algorithm to data and your model. Then the measurement and the calculation are comparable.

Analysis steps

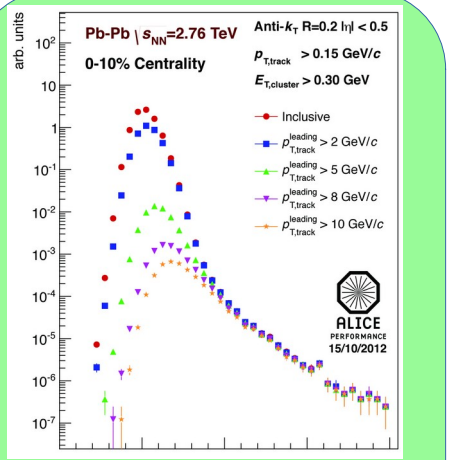
Tracks

Clusters

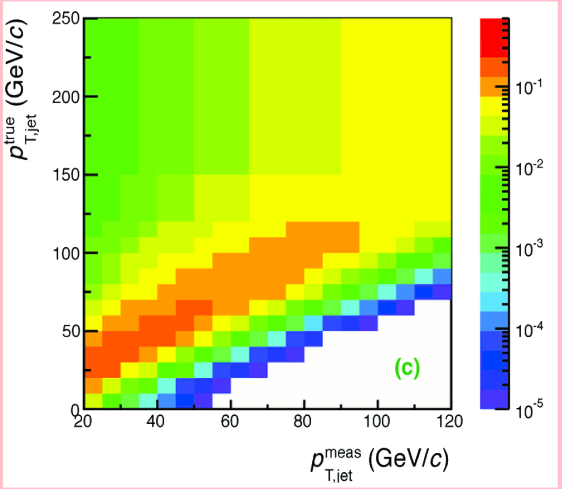
Jet finding algorithm

Jet candidates

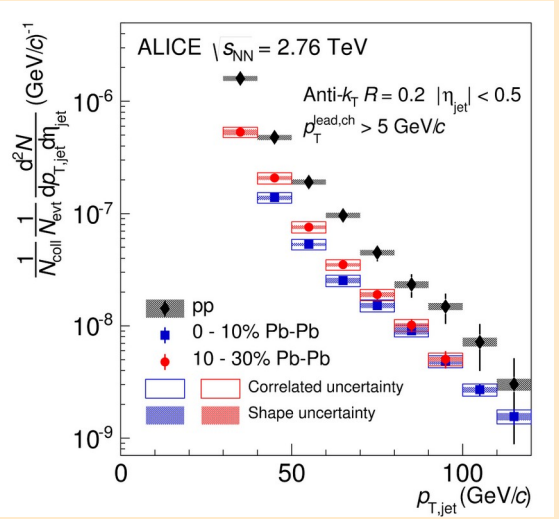
Background subtraction



Jet spectrum smeared by energy resolution, background fluctuations



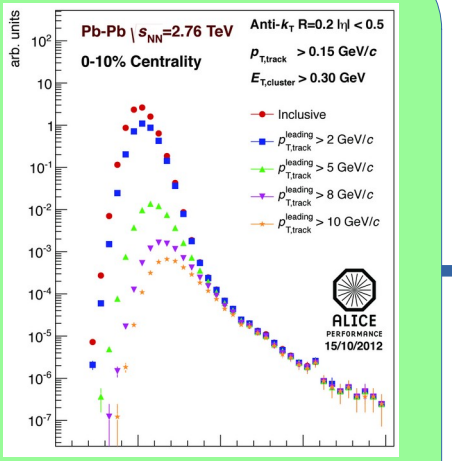
Unfolding – corrects for single track reco ε, E resolution, background fluctuations



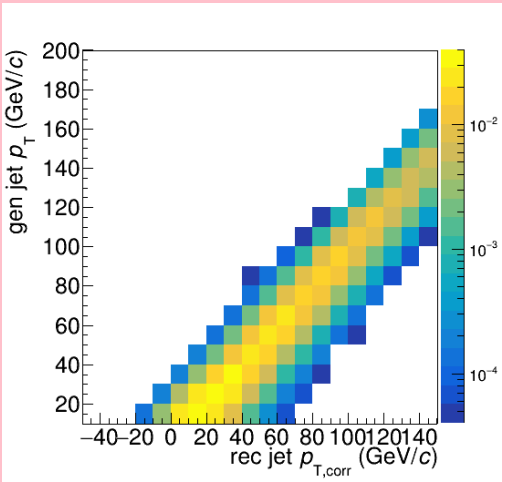
Corrected spectra

Analysis steps: Full Monte Carlo

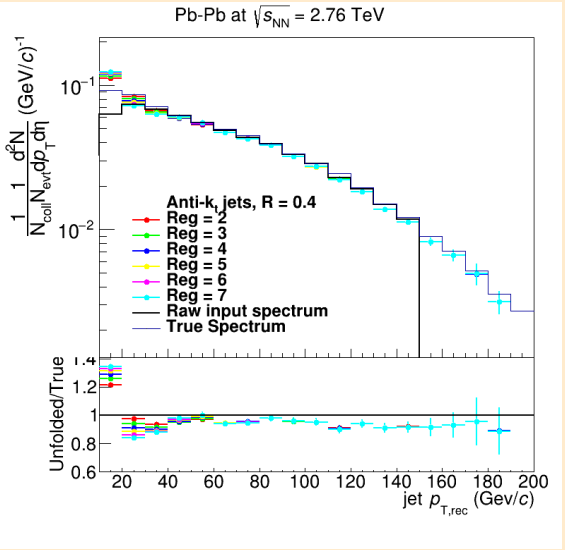
Particles → Jet finding algorithm → Jet candidates → Background subtraction



Jet spectrum smeared by energy resolution

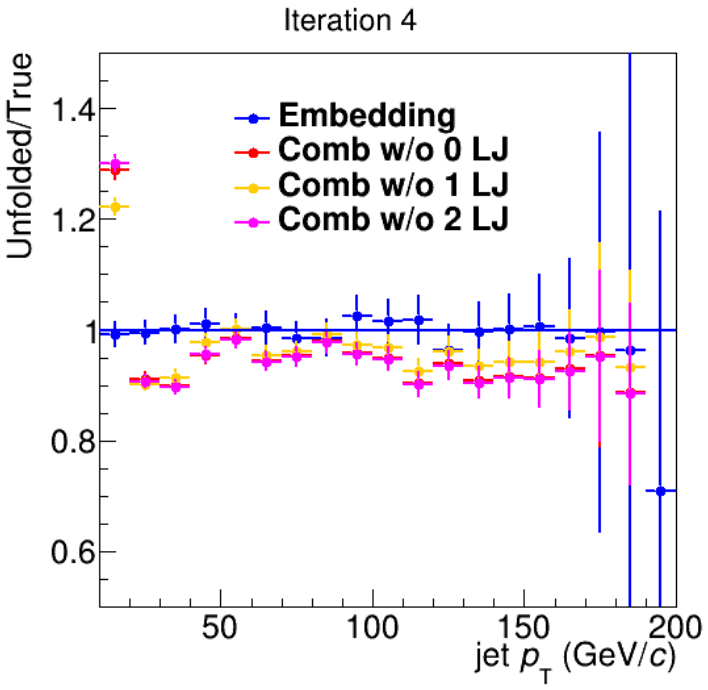


Unfolding – ***corrects for background fluctuations and other effects***

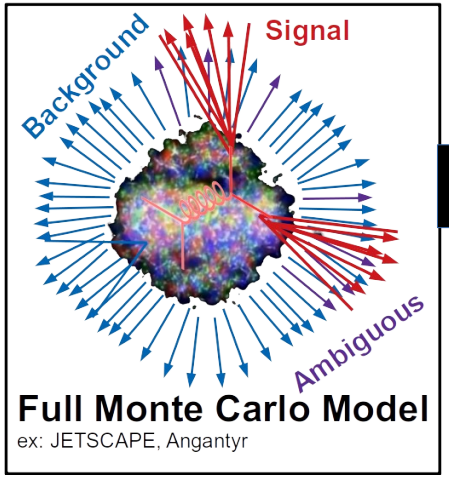


Corrected spectra

Closure



- Methods
  - Use δp_T method to measure width of fluctuations with varying numbers of leading jets (LJ) discarded
  - Embed PYTHIA event into heavy ion event
- Only embedding leads to full closure



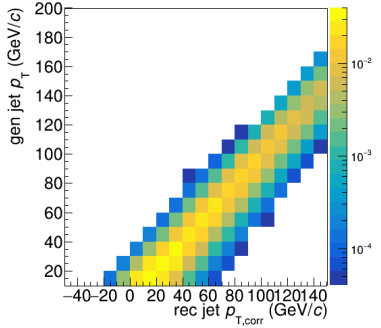
Full Monte Carlo Model

ex: JETSCAPE, Angantyr

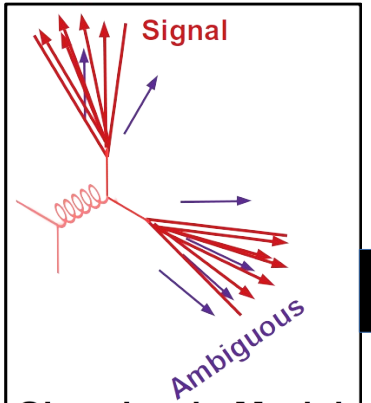
HepMC

Rivet

HEPData



Unfold to correct for fluctuations



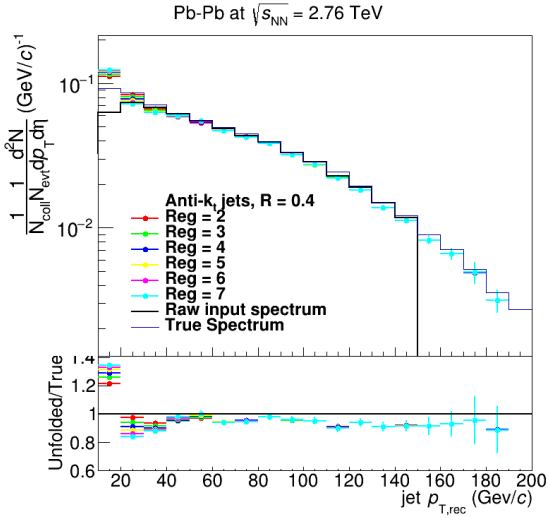
Signal-only Model

ex: JEWEL

HepMC

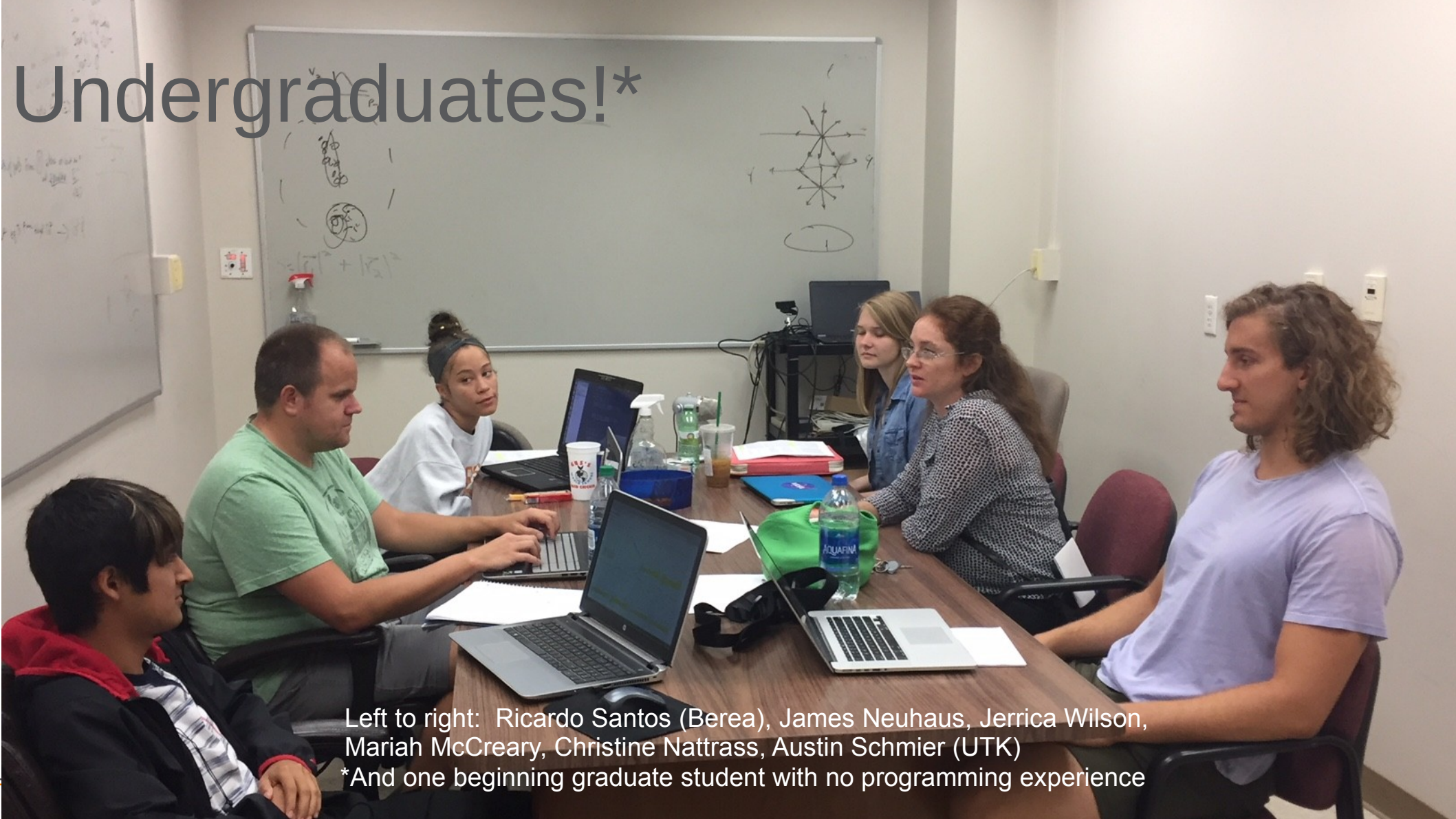
Rivet

Comparison to data



How do you get a lot of Rivet analyses done?

Undergraduates!*



Left to right: Ricardo Santos (Berea), James Neuhaus, Jerrica Wilson, Mariah McCreary, Christine Nattrass, Austin Schmier (UTK)

*And one beginning graduate student with no programming experience

Course-based undergraduate research experience

Ask me if you want more info!

CBE—Life Sciences Education, Vol. 15, No. 2 | Articles

Early Engagement in Course-Based Research Increases Graduation Rates and Completion of Science, Engineering, and Mathematics Degrees

Stacia E. Rodenbusch, Paul R. Hernandez, Sarah L. Simmons, and Erin L. Dolan

Jennifer Knight, Monitoring Editor:

Published Online: 13 Oct 2017 | https://doi.org/10.1187/cbe.16-03-0117

Abstract

National efforts to transform undergraduate biology education call for research experiences to be an integral component learning for all students. Course-based undergraduate research experiences, or CUREs, have been championed for engagi students in research at a scale that is not possible through apprenticeships in faculty research laboratories. Yet there are f if any studies that examine the long-term effects of participating in CUREs on desired student outcomes, such as graduatir from college and completing a science, technology, engineering, and mathematics (STEM) major. One CURE program, the Freshman Research Initiative (FRI), has engaged thousands of first-year undergraduates over the past decade. Using propensity score–matching to control for student-level differences, we tested the effect of participating in FRI on students' probability of graduating with a STEM degree, probability of graduating within 6 yr, and grade point average (GPA) at graduation. Students who completed all three semesters of FRI were significantly more likely than their non-FRI peers to earn a STEM degree and graduate within 6 yr. FRI had no significant effect on students' GPAs at graduation. The effects were similar for diverse students. These results provide the most robust and best-controlled evidence to date to support calls for early involvement of undergraduates in research.

Phys 494 – Course-based Undergraduate Research Experience in Relativistic Heavy Ion Physics

Instructor:
Dr. Christine Nattrass
Office: SERF 609
Phone: 974-6211
Email: christine.nattrass@utk.edu
Office hours: TBA

Teaching assistant: N/A

Class time & Location: TR 12:40-1:55 SERF 210

Course Description:
This course will incorporate undergraduates into a research project in high energy nuclear physics in a course setting. Each student will be responsible for implementing a heavy ion analysis in the program RIVET so that it can be used by the JETSCAPE collaboration to make comparisons between Monte Carlo models and data. Each student's project will be incorporated into a public software repository so that it is available to the field and, if possible, it will be validated by the relevant experiment and incorporated into the official RIVET software.

4 semesters	**All Rivet students**
17 students	28 students
8 women	12 women
4 minorities	9 minorities
3 non-traditional	5 non-traditional

Since Summer 2019:
- 32% of UTK ugrad
- 42% of female UTK ugrads
- 50% of non-white UTK ugrads worked on Rivet

Resources

- Output - github
  - Unvalidated, work in progress
  - About 45 analyses, mostly R_{AA} & dihadron correlations
  - May have issues with some models (see #5)
  - May need primary particle, centrality definition approval (see #3)
- Course-based undergraduate research experience
  - Designed for ~135 hours of effort by undergraduate students with one intro computing class and no previous Linux experience
  - Flipped pedagogy → extensive out-of-class activities, interactive class sessions
  - Possible alternative for diploma students?
  - Syllabus
  - Schedule with links to resources
  - Tutorial slides Part 1 UTK-specific Part 2 Universal
- Workshop
  - Slides
  - Recordings

Contact me!

Conclusions

- Rivet
  - Is ~~easy~~ straightforward
  - Allows comparisons to multiple models
- Lots of resources available!

Acknowledgements

Antonio Da Silva

Christal Martin

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