Working with jets in a high background environment

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Definition of Jets in a Large Background

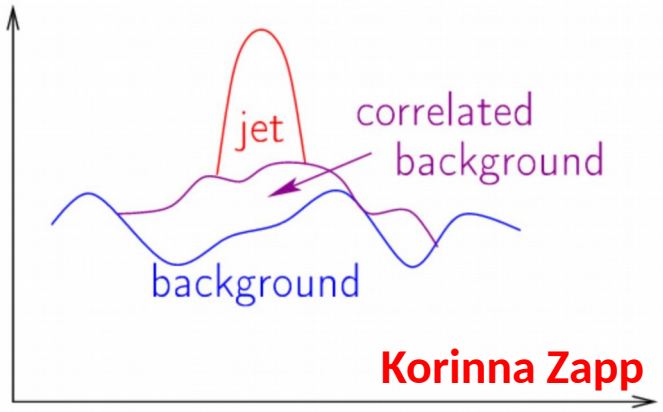
- **Organizers:** M. Connors, G. Milhano, C. Nattrass, R. Reed, S. Salur
- **Spectra conveners:** R. Kunnawalkam Elayavalli, Y. Mehtar-Tani (R. Bertens)
- **Correlation conveners:** J. Noronha-Hostler, J. Huang
- **Substructure conveners:** Y. Lee, Y. Chien

62 Registered but due to various visa & travel complications: 45 + several BNL employees attended.

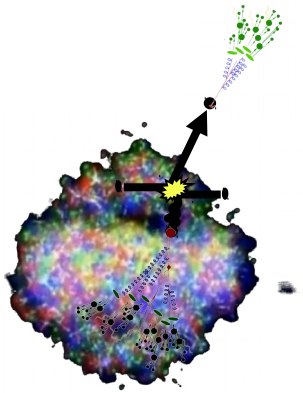
GOAL

Extensively discussed the interplay between experimental techniques and theoretical calculations with the aim of **reaching an agreement*** on the way forward for extracting jet measurements from large background events such as those in heavy ion collisions and high luminosity p-p or electron-ion collisions.

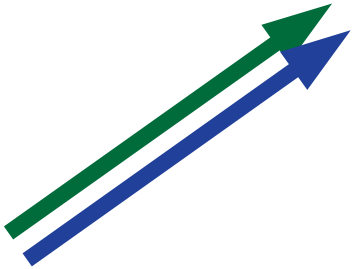
*Consensus on some points



Include anything correlated in definition of jet



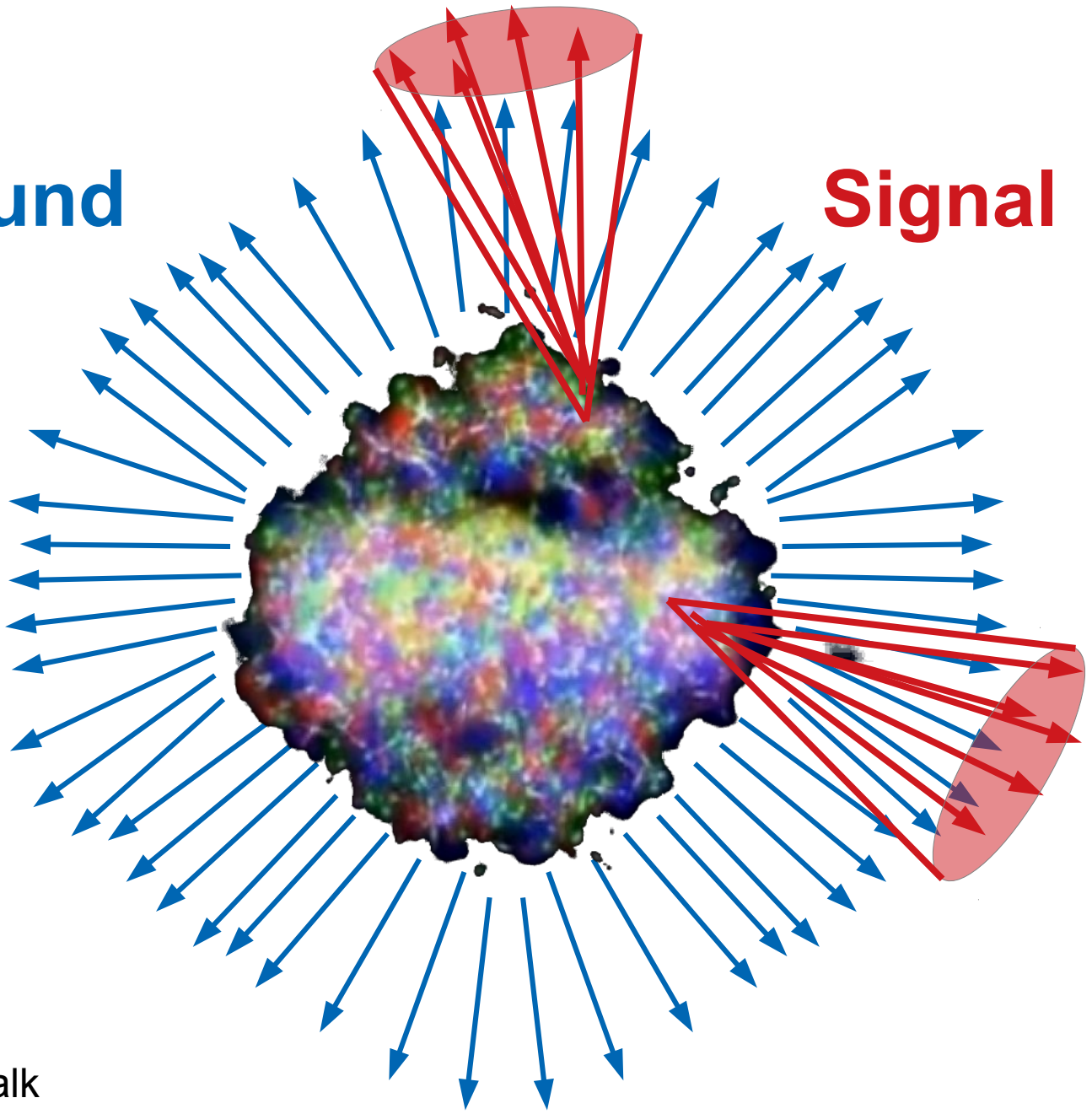
Provide enough details to make comparisons between data and models



Reconsider role of collinear safety

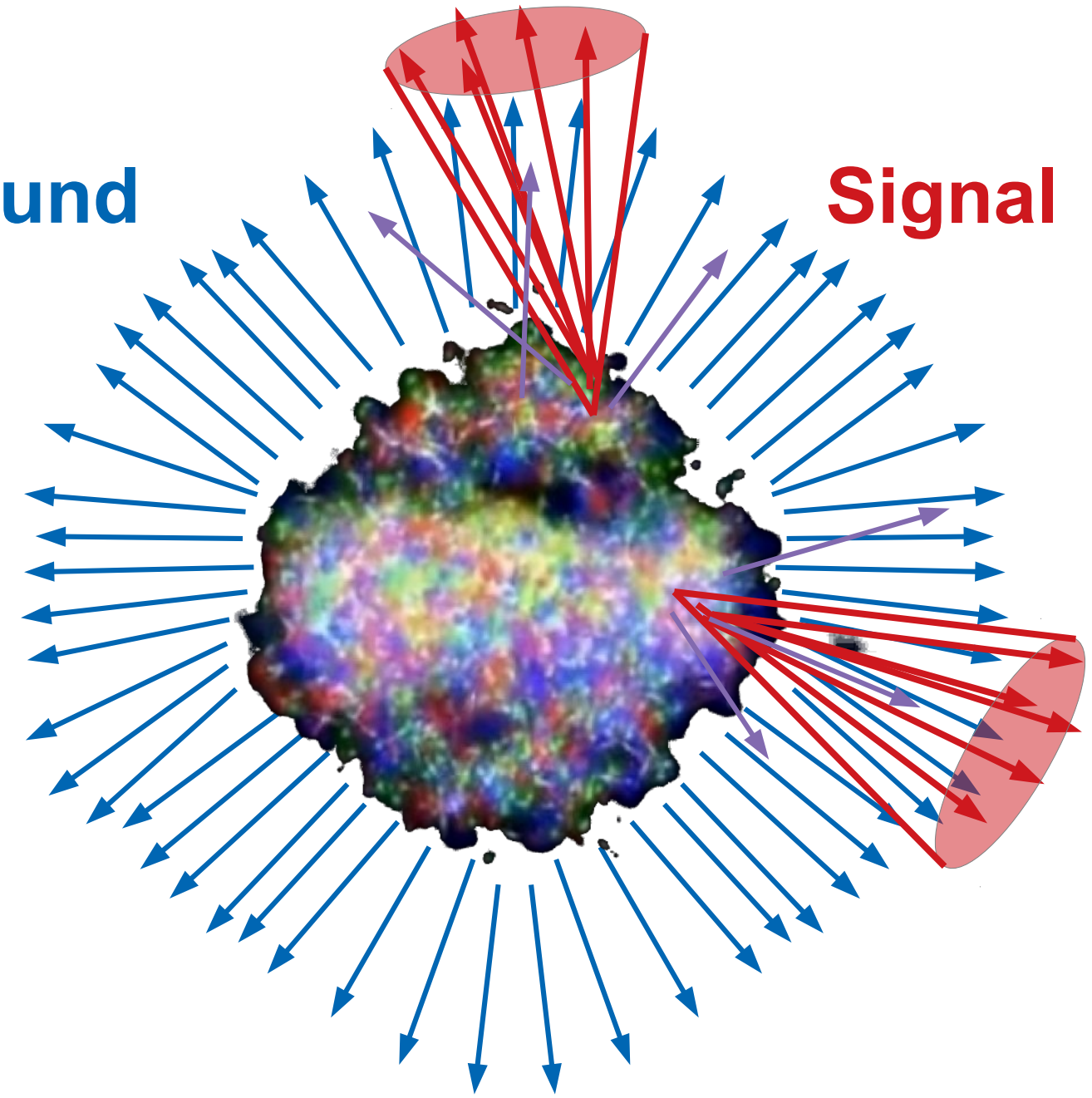
Discuss and put effort into the problem

Signal vs Background: the standard paradigm

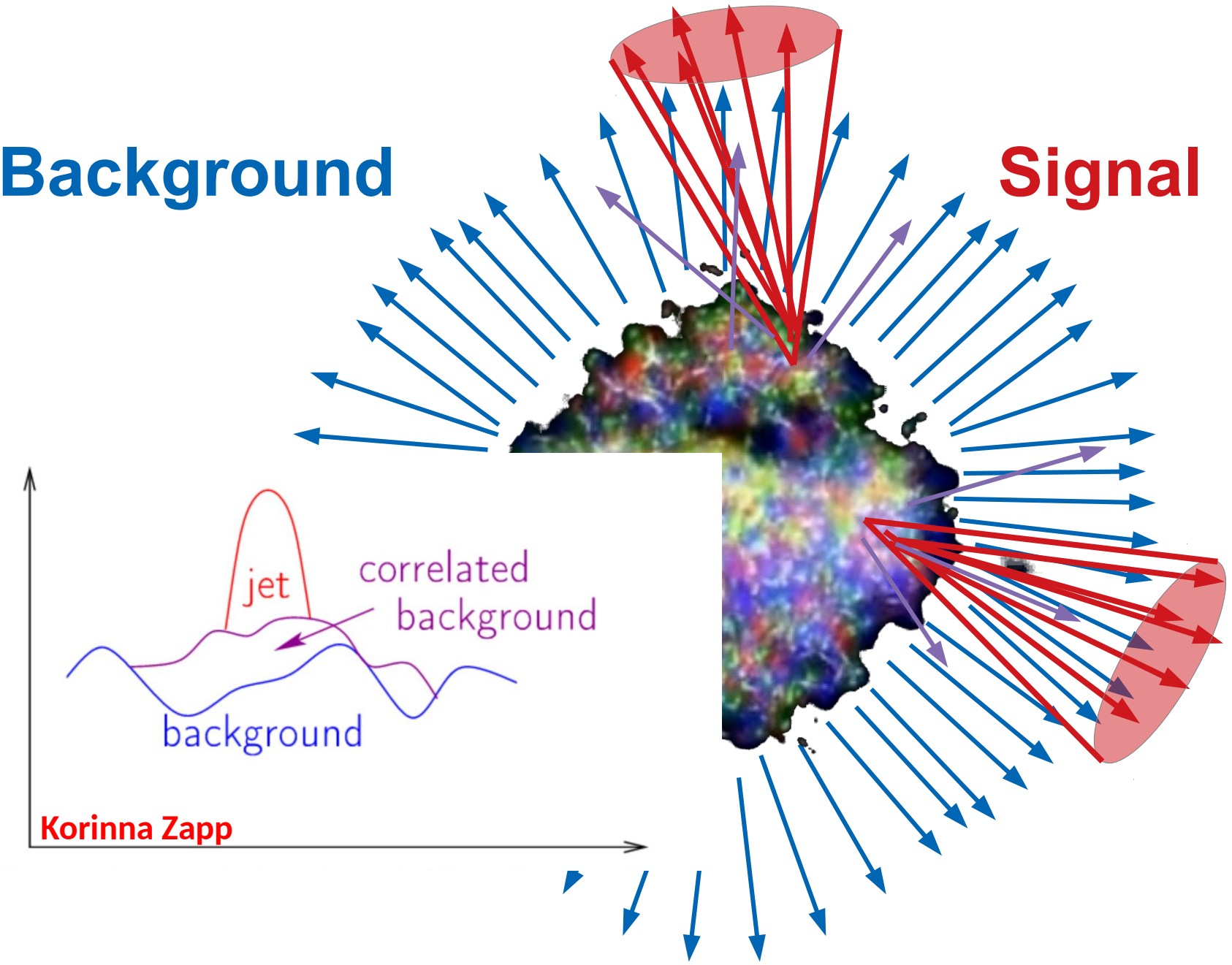


See Peter Jacob's talk

Problem 1: what about medium interactions?



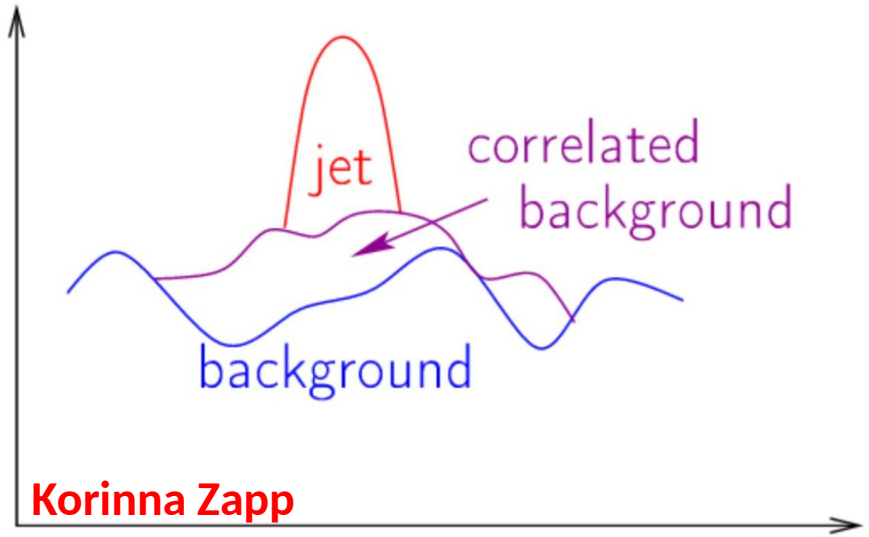
Problem 1: what about medium interactions?



Problem 1: what about medium interactions?

Background

Signal

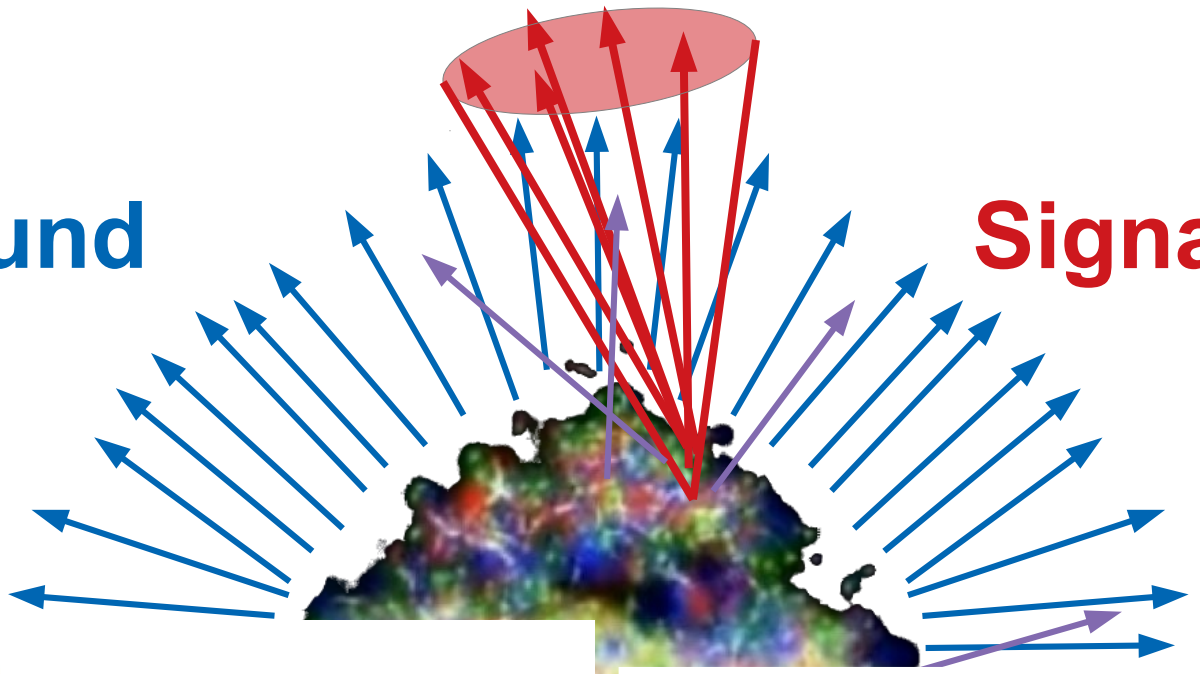


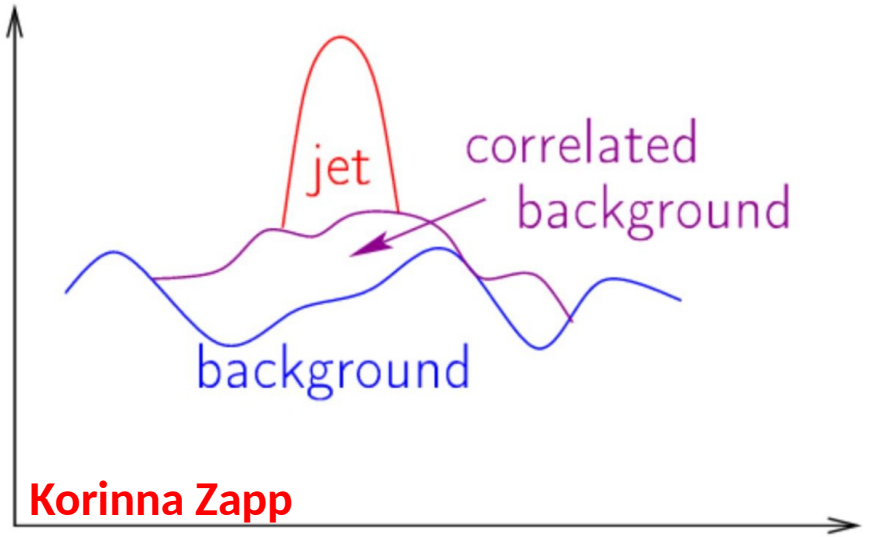
Solution: Particles which are correlated with the jet are part of the signal.

Problem 1: what about medium interactions?

Background

Signal



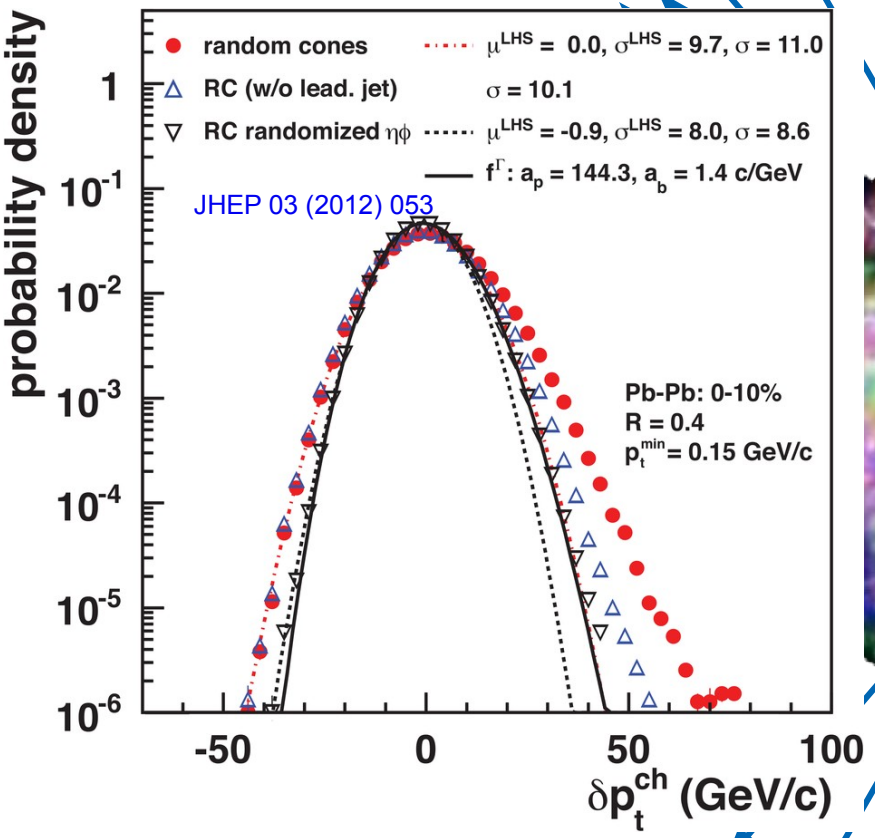


Solution: Particles which are correlated with the jet are part of the signal.

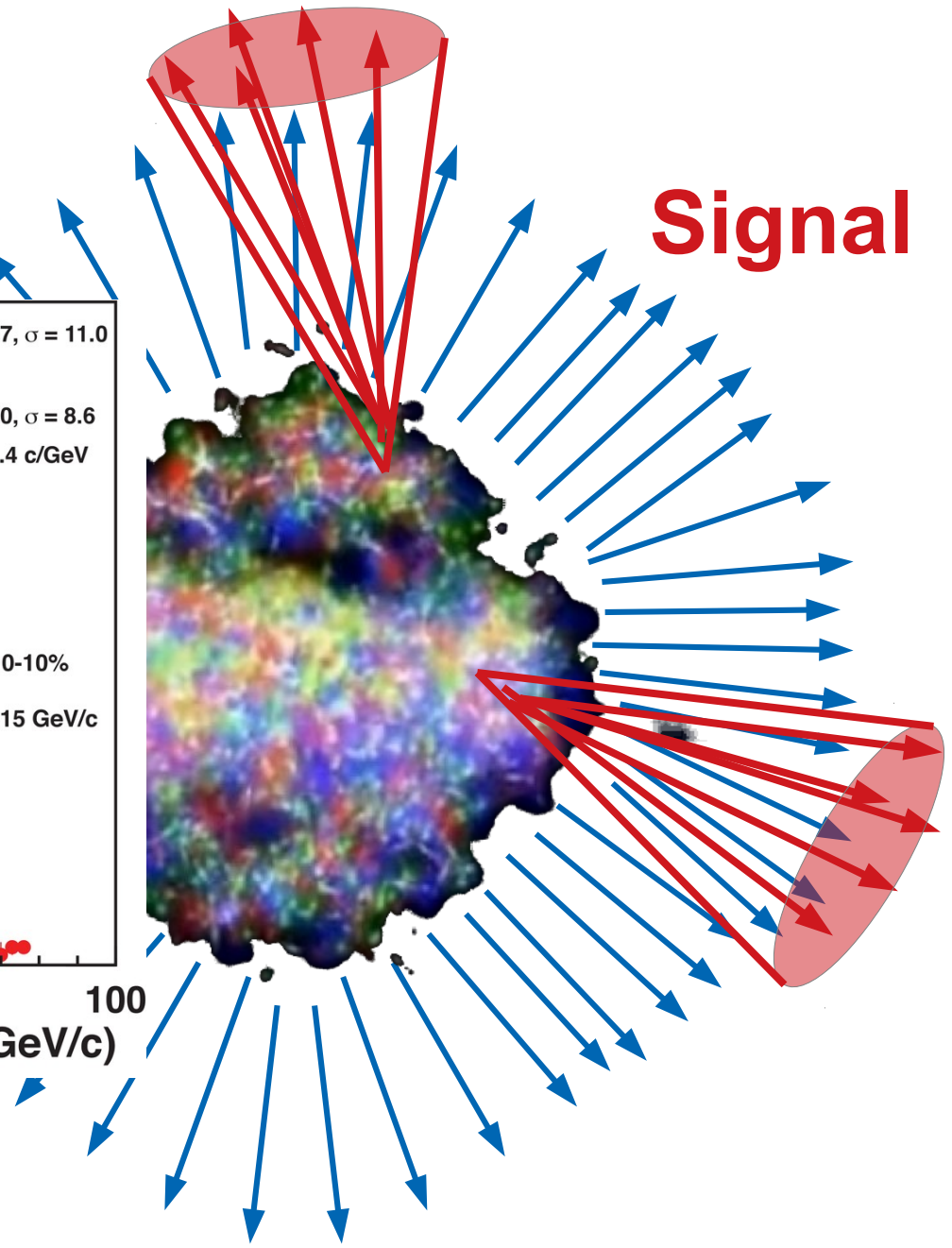
Problem 1a: May need to apply the same background on data and models to make sure we use the same definition of background.

Problem 2: The background fluctuates

Background



Signal



Problem 2: The background fluctuates

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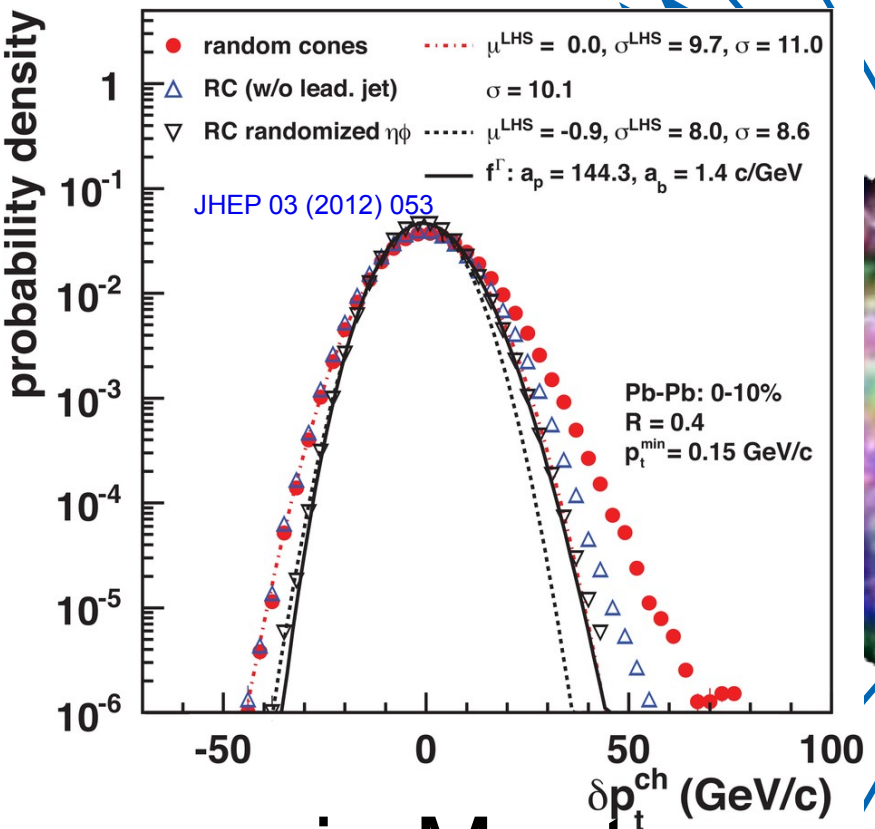
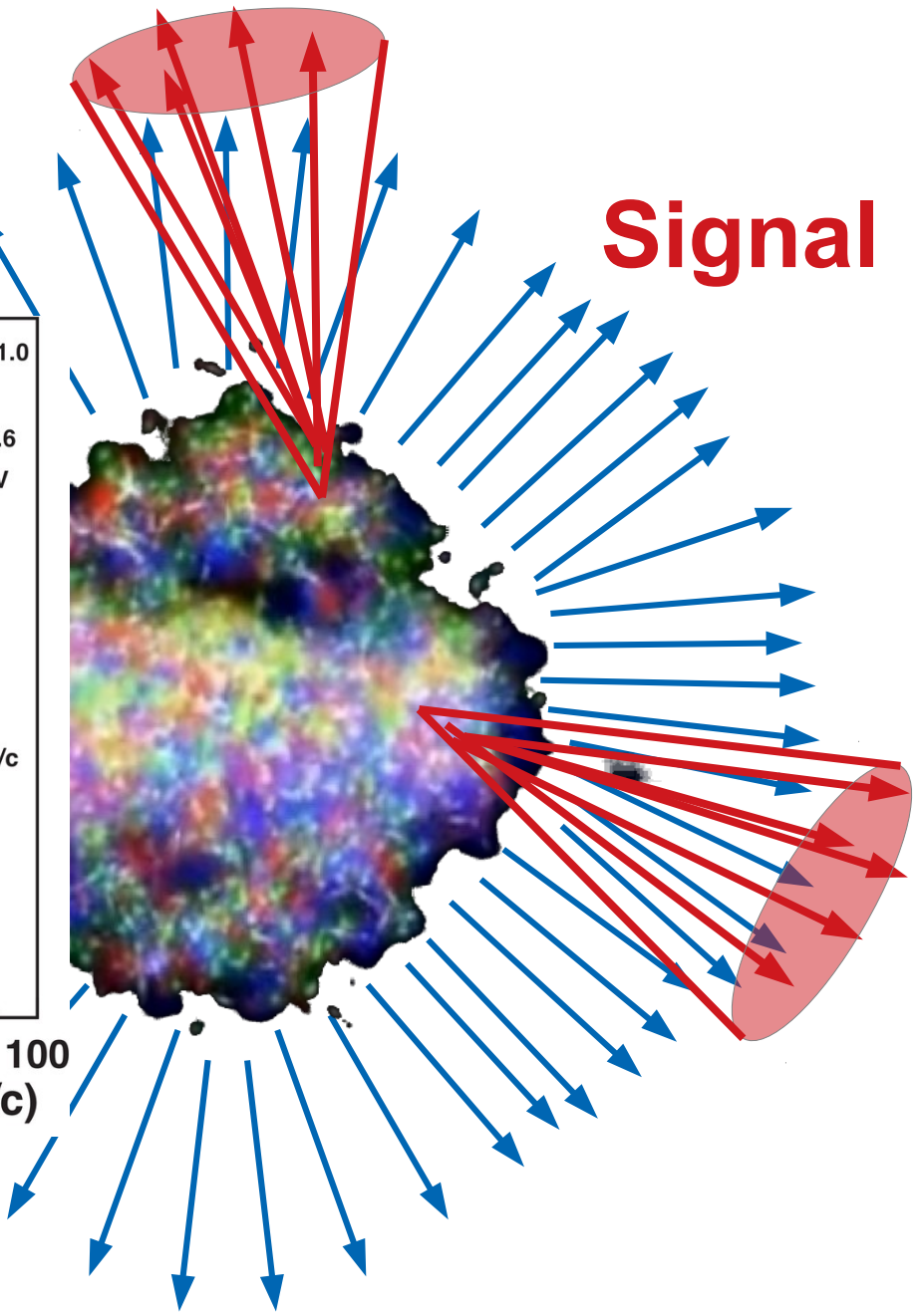


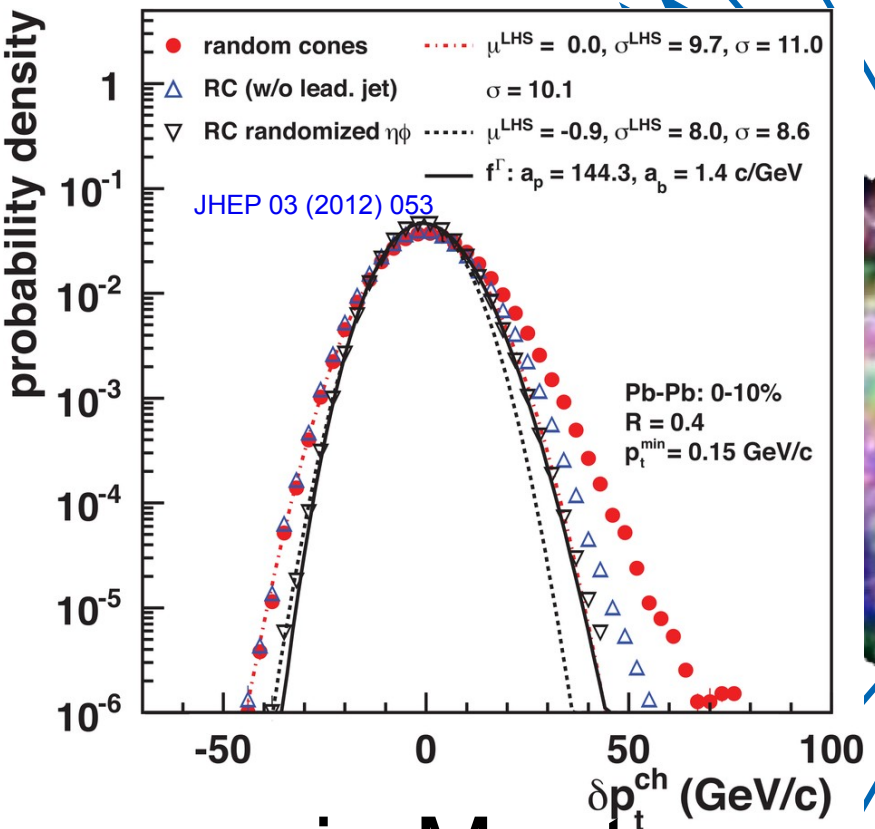
Signal



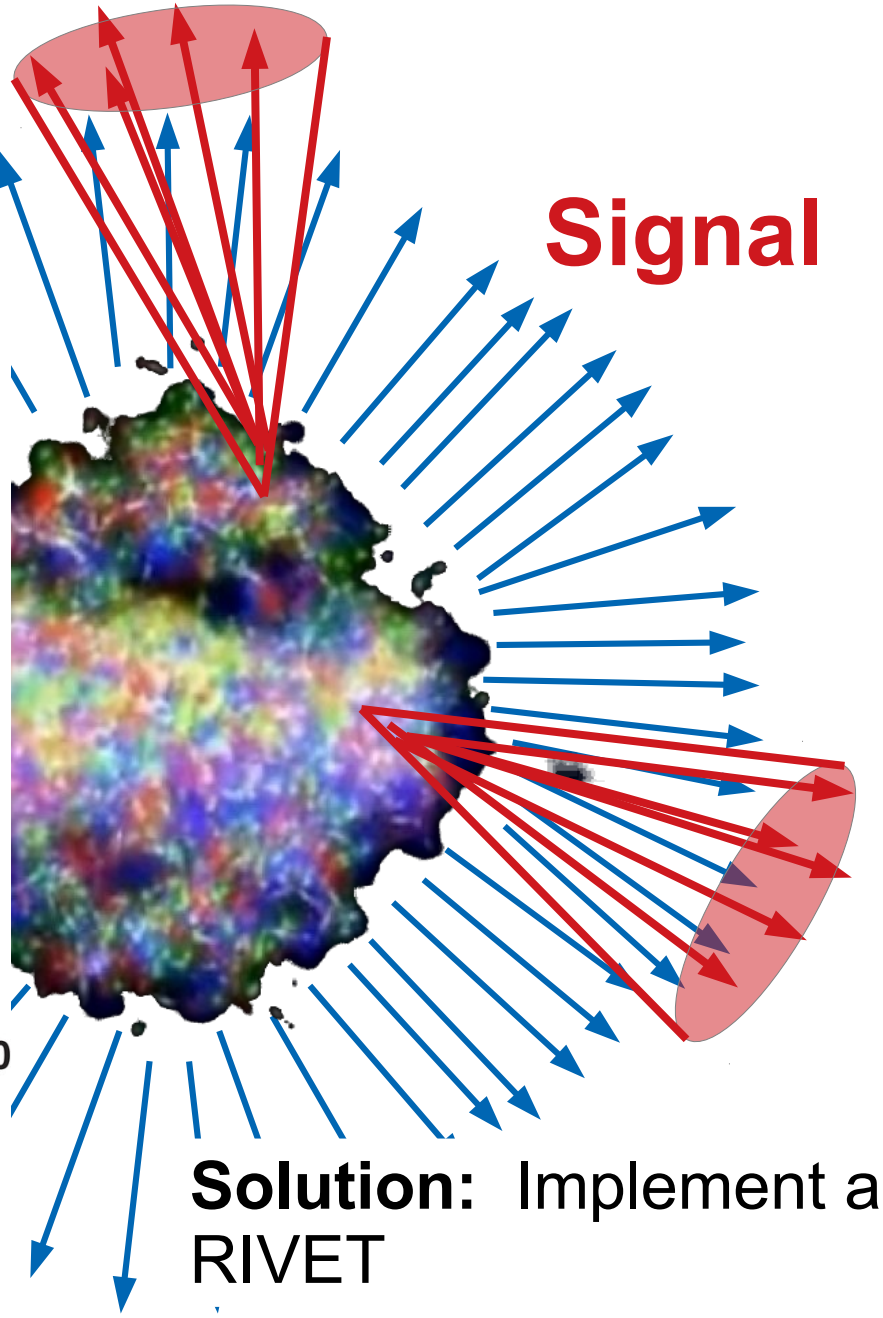
...even in Monte Carlo!

Problem 2: The background fluctuates

Background

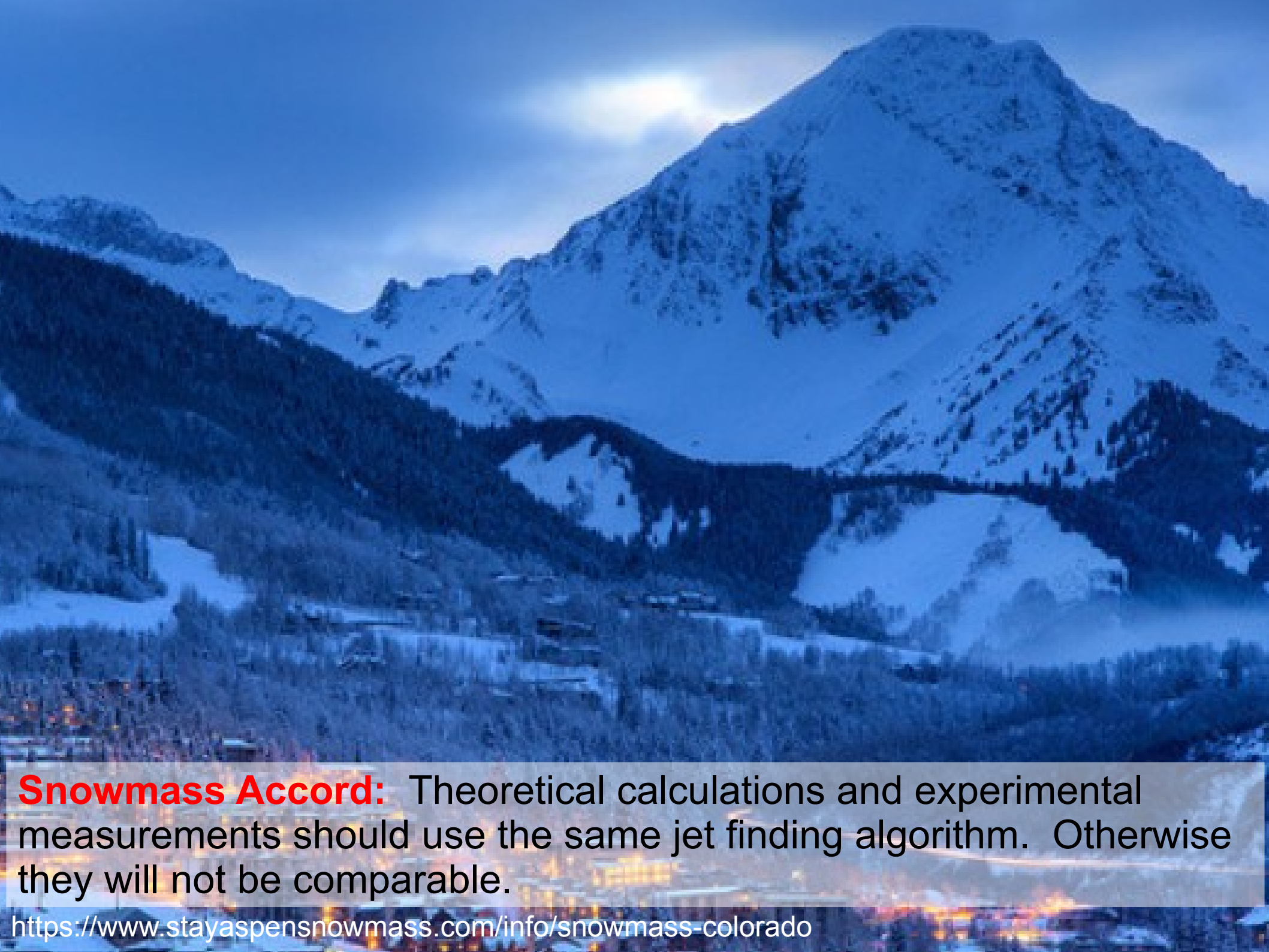


Signal



...even in Monte Carlo!

Solution: Implement analyses in RIVET

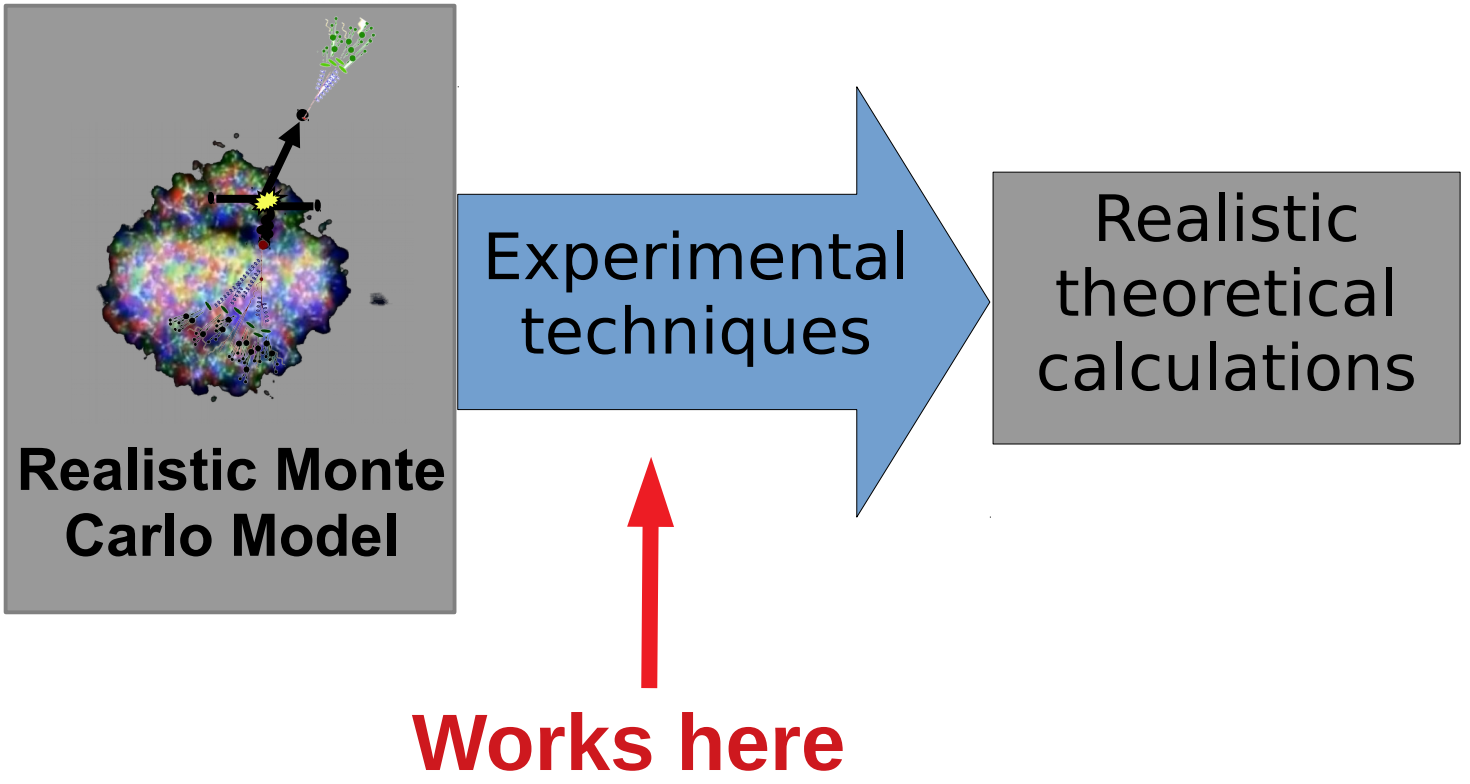


Snowmass Accord: Theoretical calculations and experimental measurements should use the same jet finding algorithm. Otherwise they will not be comparable.

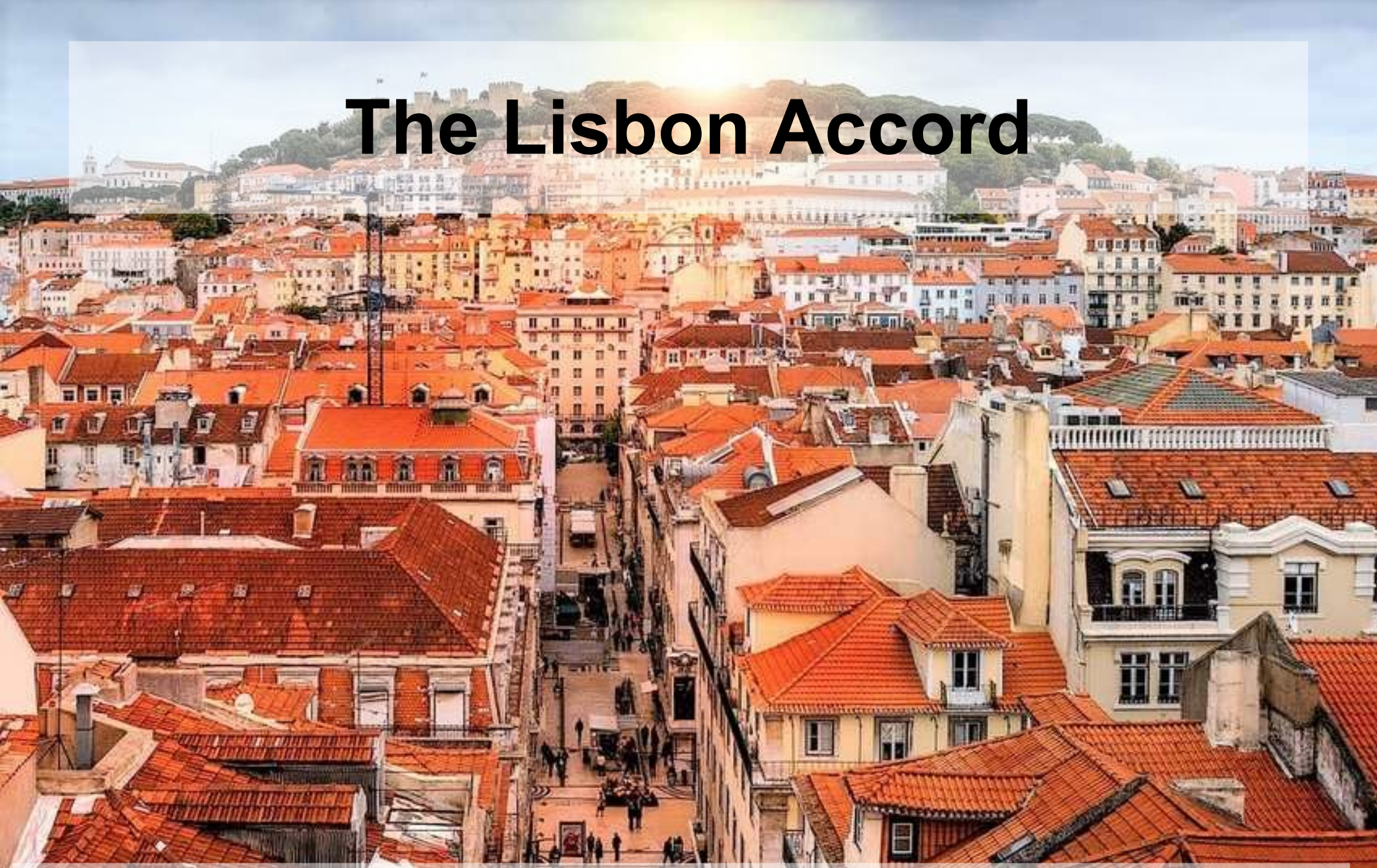
https://www.stayaspensnowmass.com/info/snowmass-colorado

RIVET

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



The Lisbon Accord



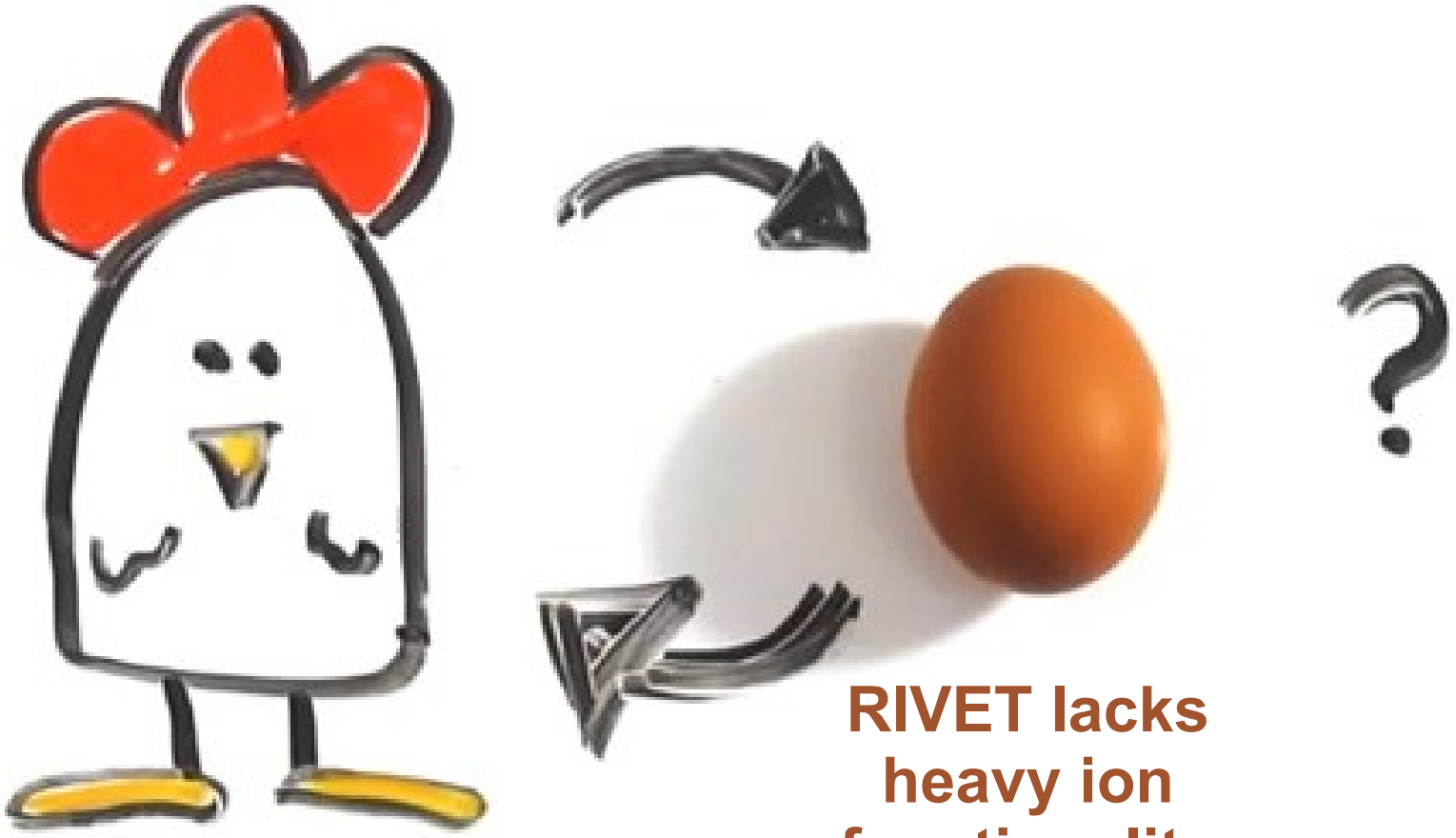
- Lisbon Accord proposed that heavy ion analyses adopt RIVET in July 2014
- Workshop position paper will second this recommendation

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

Problems with RIVET

- Not all heavy ion functionality exists
- Very few heavy ion analyses exist
- Only takes in HEPMC 2.0 input
- No way to deal with fluctuations

Few heavy ion analyses in RIVET



RIVET lacks heavy ion functionality

http://iterated-reality.com/en/2015/03/17/the-chicken-or-the-egg-causality-dilemma-solved-by-unity-consciousness/

RIVET-HI

https://github.com/alisw/rivet-hi

- ALICE extended RIVET to enable heavy ion analyses (*Przemyslaw Karczmarczyk*, *Jochen Klein, Jan Fiete Grosse-Oetringhaus)*
- Adds centrality determination
- No option to fit functions

Undergraduates!*
JETSCAPE
REU
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

RIVET-HI

https://github.com/alisw/rivet-hi

- ALICE extended RIVET to enable heavy ion analyses (*Przemyslaw Karczmarczyk*, *Jochen Klein, Jan Fiete Grosse-Oetringhaus)*
- Adds centrality determination
- No option to fit functions
- UTK clone of RIVET-HI
  https://github.com/cnattras/rivet-hi
  - Implementation of STAR/ALICE, CMS, and ATLAS background subtraction methods for jets
  - Calculation of v_n from thrown particles

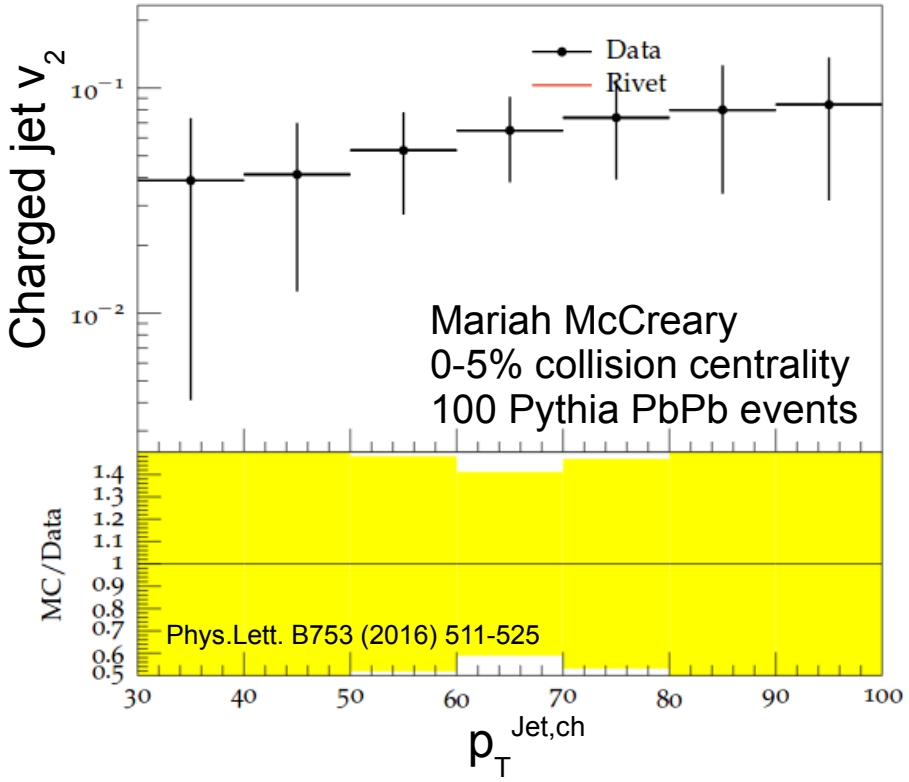
Problems with RIVET

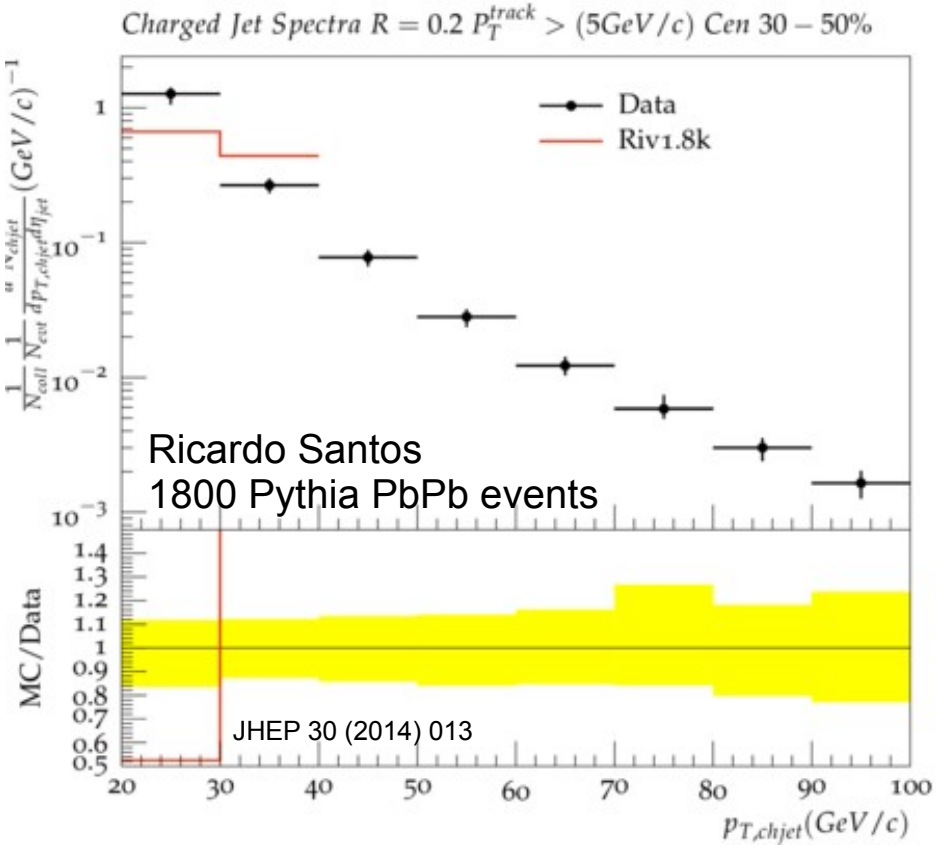
- Not all heavy ion functionality exists ✔
- Very few heavy ion analyses exist
- Only takes in HEPMC 2.0 input
- No way to deal with fluctuations

Implementing analyses in RIVET-HI*

*Not yet checked in to RIVET-HI but in a UTK mirror

Progress

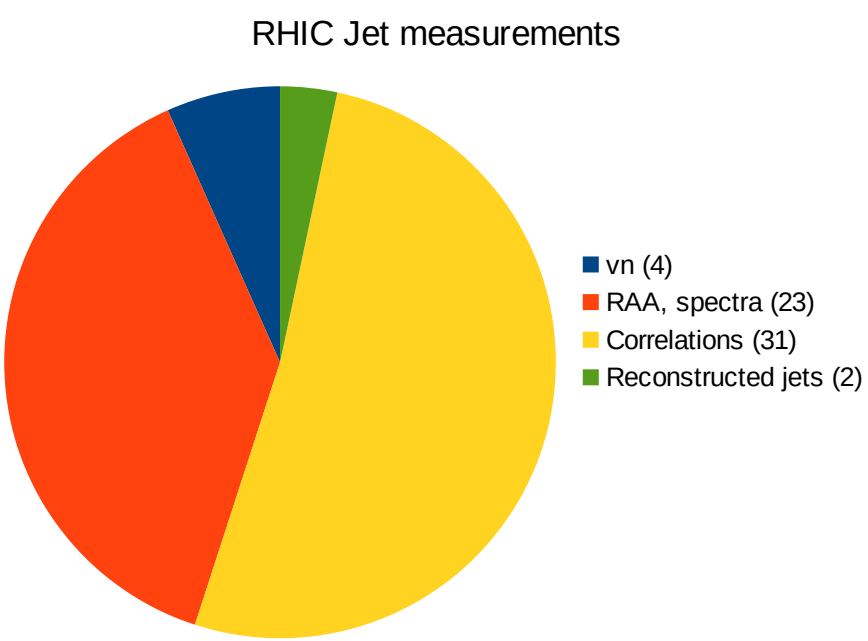


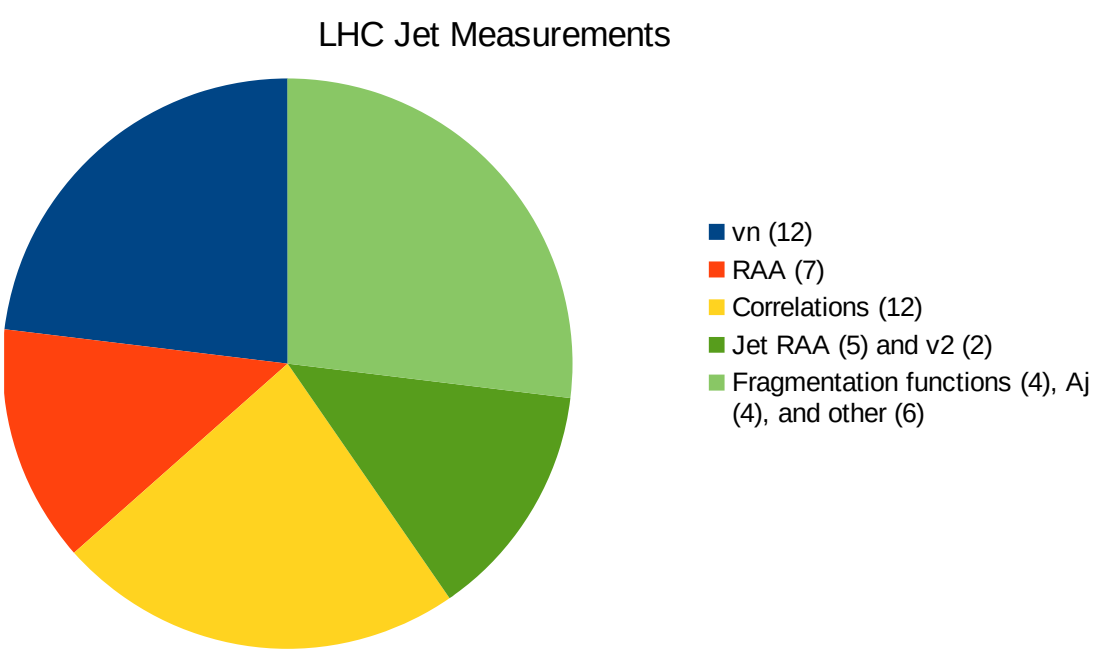


WARNING: Very small sample size, highly biased results, need to coordinate with Przemyslaw, Jochen, & Jan Fiete to ensure code can eventually be committed. Fluctuations in combinatorial background not subtracted.

Undergraduates *Mariah McCreary (UTK)*, James Neuhaus (UTK), Jerrica Wilson (UTK), *Ricardo Santos (Berea);* Graduate student Austin Schmier (UTK); Post doc Redmer Bertens (UTK)
Mariah and Ricardo implementing ALICE analyses, James and Redmer providing key support.
Funding from JETSCAPE, Berea, and the UTK physics department.

Available data





RHIC: High-p_T hadron correlations 52%, reconstructed jets 3%
LHC: High-p_T hadron correlations 23%, reconstructed jets 40%

Analysis about 1 year old, some may disagree with classifications, but the gist holds

Course-based undergraduate research experience

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

Free Access

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

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Abstract

National efforts to transform undergraduate biology education call for research experiences to be an integral component of learning for all students. Course-based undergraduate research experiences, or CUREs, have been championed for engaging students in research at a scale that is not possible through apprenticeships in faculty research laboratories. Yet there are few if any studies that examine the long-term effects of participating in CUREs on desired student outcomes, such as graduating 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

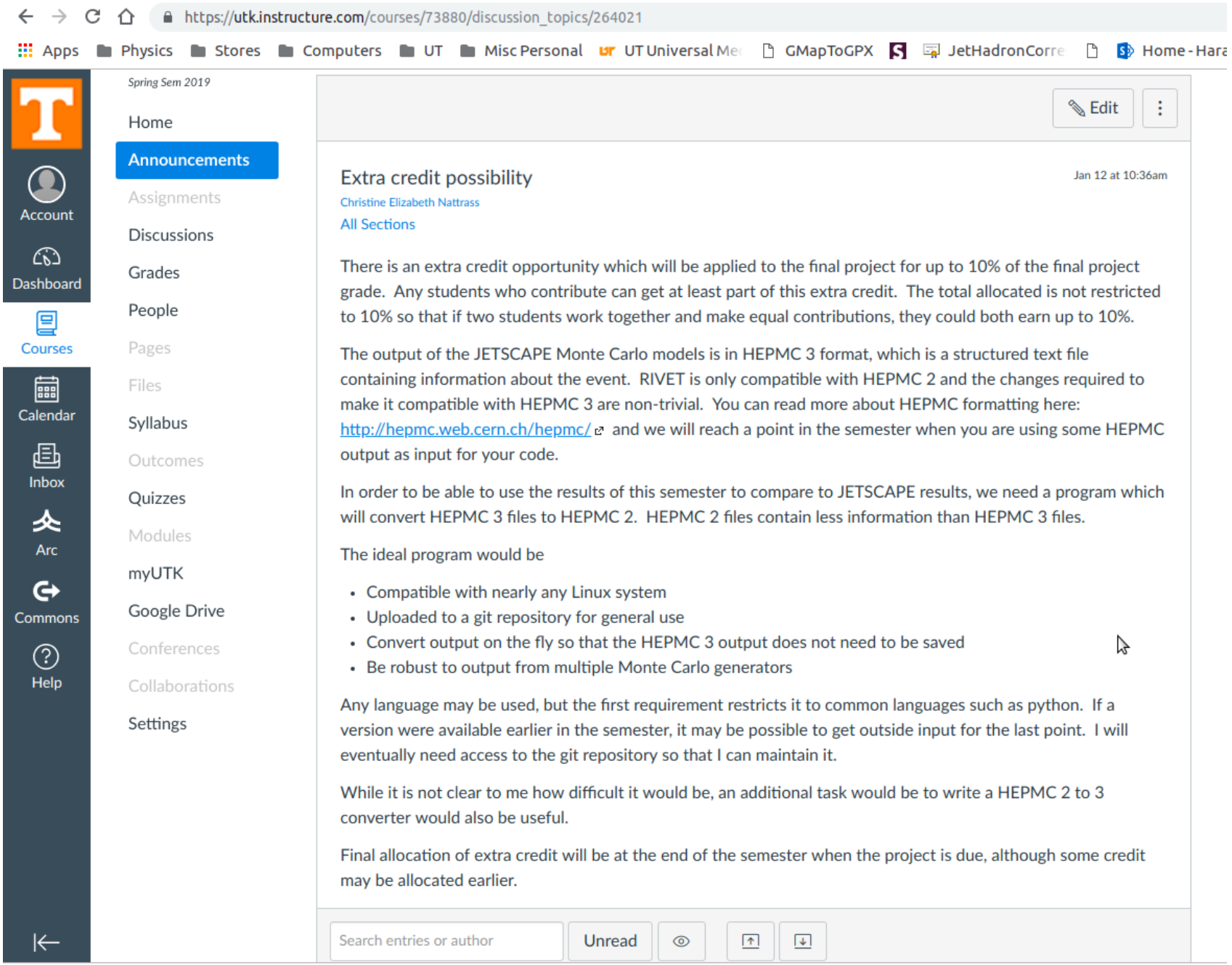
Class time & Location: TR 12:40-1:55 SERF 210

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.

https://i.ytimg.com/vi/mZnv6LXD9qs/maxresdefault.jpg

Problems with RIVET

- Not all heavy ion functionality exists ✔
- Very few heavy ion analyses exist ✔ (in progress)
- Only takes in HEPMC 2.0 input
- No way to deal with fluctuations


https://utk.instructure.com/courses/73880/discussion_topics/264021
Apps
Physics
Stores
Computers
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UT Universal Me
GMapToGPX
JetHadronCorre
Home - Hara
Spring Sem 2019
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Courses
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Discussions
Grades
People
Pages
Files
Syllabus
Outcomes
Quizzes
Modules
myUTK
Google Drive
Conferences
Collaborations
Settings
Edit
Extra credit possibility
Jan 12 at 10:36am
Christine Elizabeth Nattrass
All Sections
There is an extra credit opportunity which will be applied to the final project for up to 10% of the final project grade. Any students who contribute can get at least part of this extra credit. The total allocated is not restricted to 10% so that if two students work together and make equal contributions, they could both earn up to 10%.
The output of the JETSCAPE Monte Carlo models is in HEPMC 3 format, which is a structured text file containing information about the event. RIVET is only compatible with HEPMC 2 and the changes required to make it compatible with HEPMC 3 are non-trivial. You can read more about HEPMC formatting here: http://hepmc.web.cern.ch/hepmc/ and we will reach a point in the semester when you are using some HEPMC output as input for your code.
In order to be able to use the results of this semester to compare to JETSCAPE results, we need a program which will convert HEPMC 3 files to HEPMC 2. HEPMC 2 files contain less information than HEPMC 3 files.
The ideal program would be
Compatible with nearly any Linux system
Uploaded to a git repository for general use
Convert output on the fly so that the HEPMC 3 output does not need to be saved
Be robust to output from multiple Monte Carlo generators
Any language may be used, but the first requirement restricts it to common languages such as python. If a version were available earlier in the semester, it may be possible to get outside input for the last point. I will eventually need access to the git repository so that I can maintain it.
While it is not clear to me how difficult it would be, an additional task would be to write a HEPMC 2 to 3 converter would also be useful.
Final allocation of extra credit will be at the end of the semester when the project is due, although some credit may be allocated earlier.
Search entries or author
Unread

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- Very few heavy ion analyses exist ✔ (in progress)
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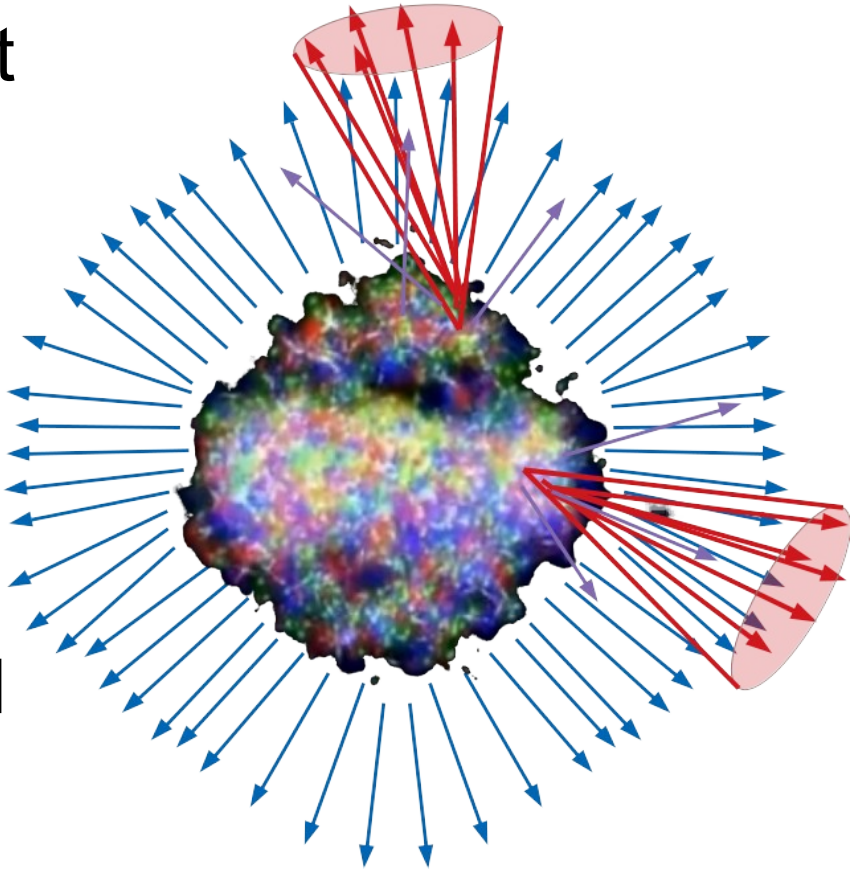
- No way to deal with fluctuations

Ways to deal with fluctuations

- Tag final state hadrons as part of signal or background and only put these into jet finder
  - May work OK but conceptually suboptimal
- Compare to data which have not been corrected for fluctuations in the background
- Unfold Monte Carlo results
  - Treating MC just like data
  - Unfolding is highly non-trivial



Conclusions

- Jet background is tricky
- It will be an issue for JETSCAPE
  - Especially fluctuations!
- RIVET(-HI) is progressing
- Undergraduates are great!

13th International Workshop on High-p_T Physics in the RHIC/LHC Era

The Past, Present, and Future of Heavy Ion Collisions
March 18

A symposium in celebration of Miklos Gyulassy's 70th birthday

Registration deadline: Jan. 19, 2019
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Student support available
Participants requiring a visa strongly encouraged to apply early

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