humility

/hjʊˈmɪlɪti/

noun

the quality of having a modest or low view of one's importance.
"he needs the humility to accept that their way may be better"
synonymer: modesty, humbleness, modestness, meekness, lack of pride, lack of vanity, diffidence, unassertiveness
"he needs the humility to accept that their way may be better"

I do not care about jets.

Paraphrased from Sevil Salur

I want to learn about the QGP.

First part paraphrased from Sevil Salur. The cartoon is my fault.

What should we measure?

What should we measure?

Jupiter and the Monkey

Jupiter promised a royal reward to the one whose offspring should be deemed the handsomest.

The monkey came with the rest, and presented a flat-nosed, hairless, ill-featured young monkey.

A general laugh saluted her on the presentation of her son.

She resolutely said; "He is at least in the eyes of me, his mother, the dearest, handsomest, and most beautiful of all."

http://aesopsfables.org/F9_Jupiter-and-the-Monkey.html
Abbreviated

Jet measurement madlibs!

[Adjective] [noun] [observable] in [collision system]

[Adjective]	[noun]	[observable]	[collision system]
Groomed	Top quark	Correlations	Proton-lead
Unfolded	B-jet	Di-jet asymmetries	Ultra-central collisions
Event-engineered	Z-boson	v_1, v_2, v_3, v_4...	
	D meson		

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Groomed top quark di-jet asymmetries in ultracentral collisions

Jet measurement madlibs!

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Groomed top quark di-jet asymmetries in ultracentral collisions

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Groomed top quark di-jet asymmetries in ultracentral collisions

Unfolded Z-boson correlations in proton-lead

Groomed top jet v_4 in ultra-central collisions

Jet measurement madlibs!

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	D meson		

Groomed top quark di-jet asymmetries in ultracentral collisions

Unfolded Z-boson correlations in proton-lead

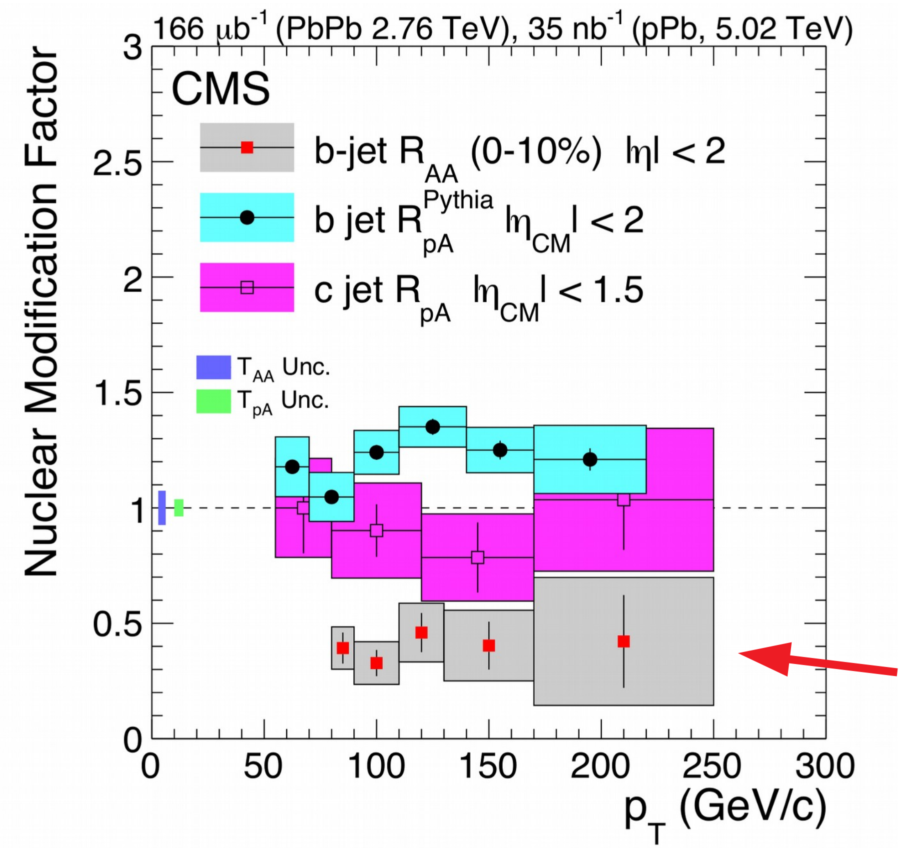
Groomed top jet v_4 in ultra-central collisions

Event-engineered groomed b-jet top quark di-jet asymmetries in ultra-central collisions

Error bars matter

- Simple measurements with small error bars may offer stronger constraints than better/more intuitive/more clever observables with large error bars
- Sometimes it's surprising which measurements provide greatest constraints
- Examples:
  - Single particle spectra with small error bars constrain uncertainty on properties of the medium well Phys.Rev. C89 (2014) no.3, 034917
  - Relatively low Q, large x DIS and Drell-Yan data provide comparable constraints on Higgs production to LHC jet measurements PoS DIS2018 (2018) 024
- Correlations between uncertainties are also important. ***Experiments should publish them*.**

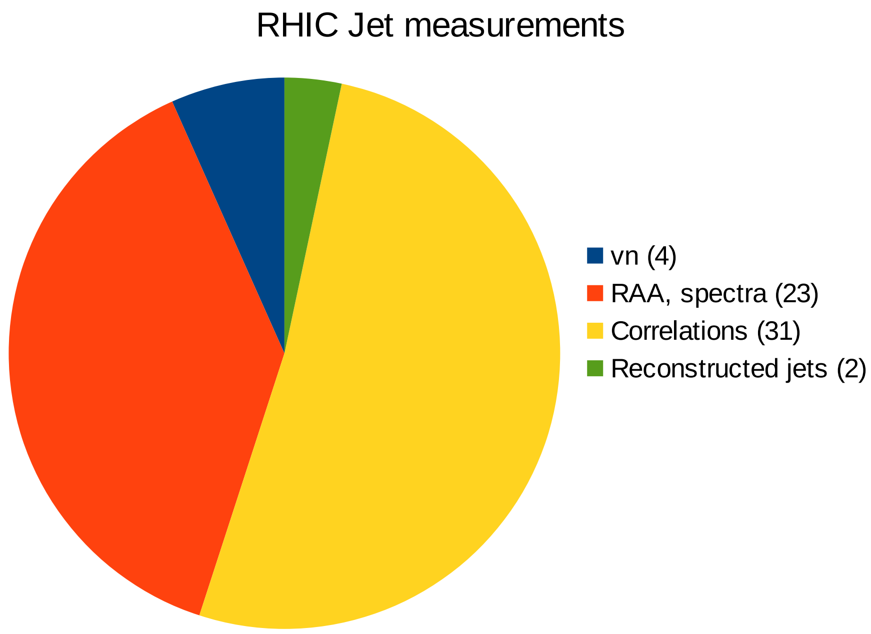
Do we really learn anything from this?*

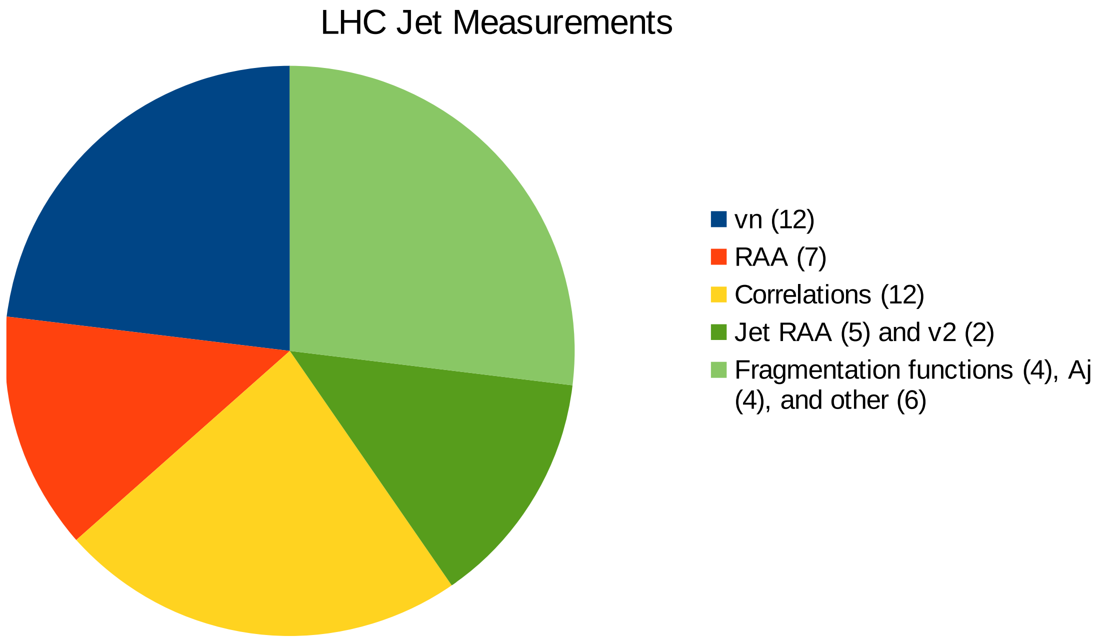


HUGE error bars!

*I really do like this measurement. It's nothing personal. I ask the same thing about the measurements I'm working on.

Available data





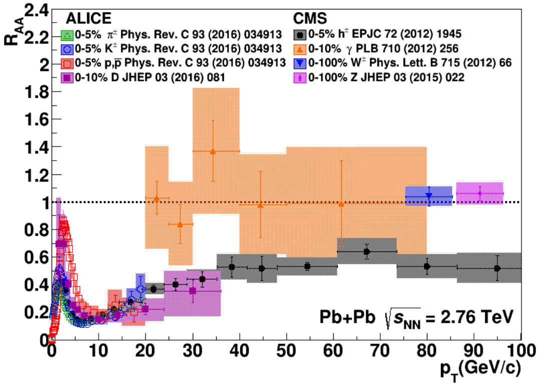
RHIC: High-p_T hadron correlations 52%, reconstructed jets 3%

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

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

What should we measure?

What should we measure?



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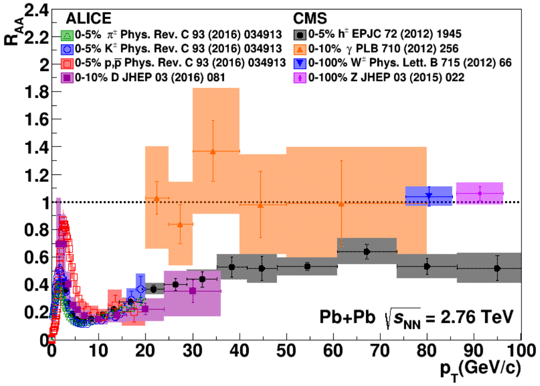

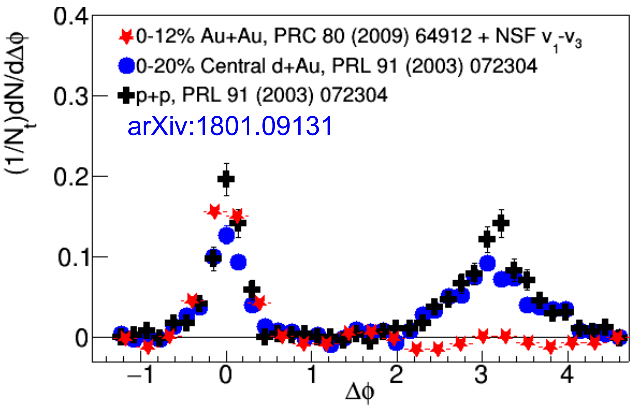

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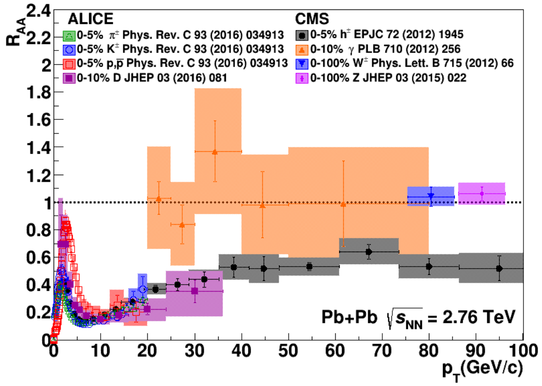

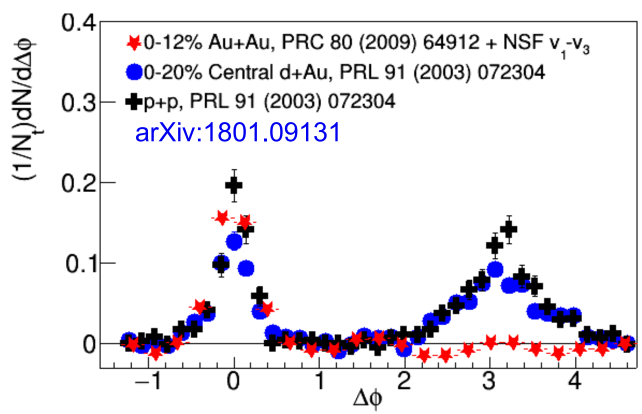

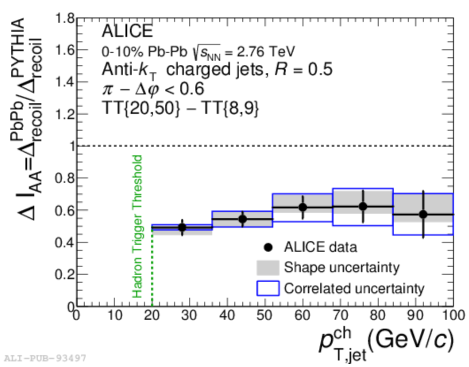

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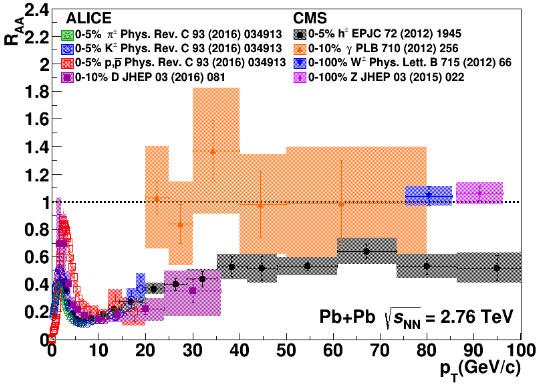

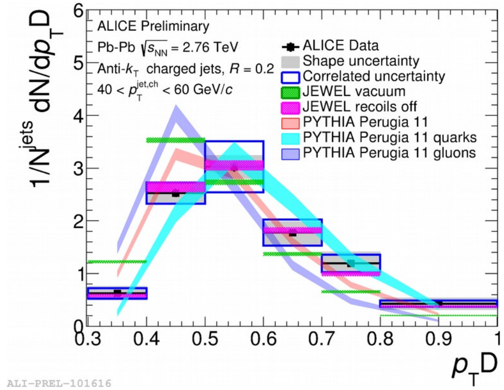

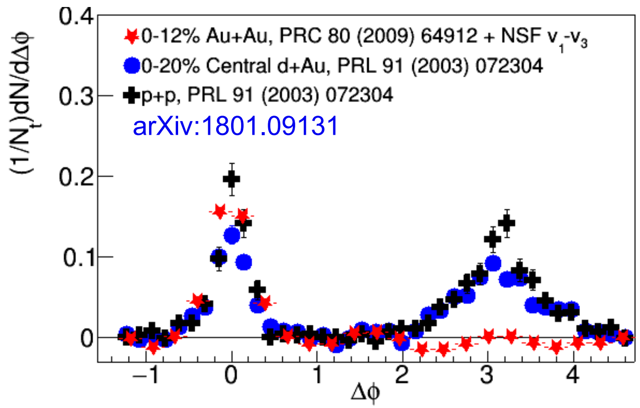

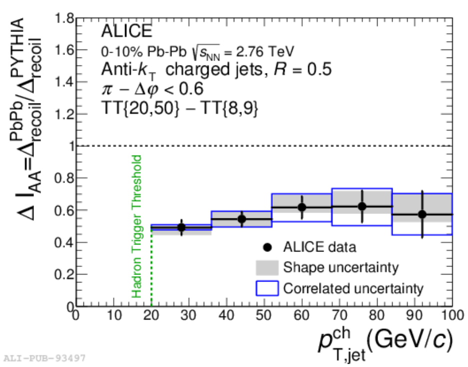

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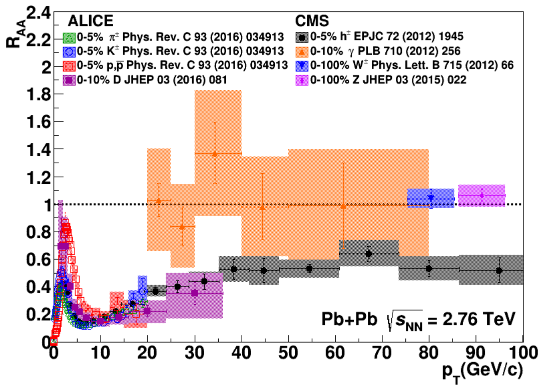
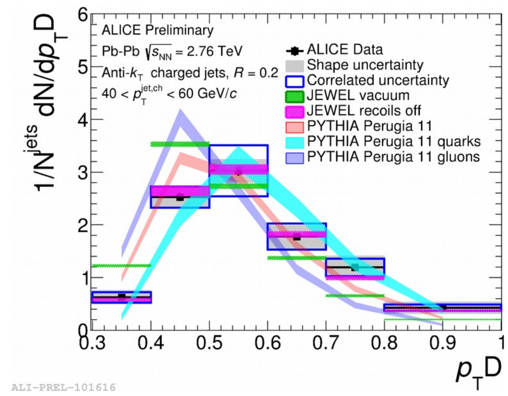
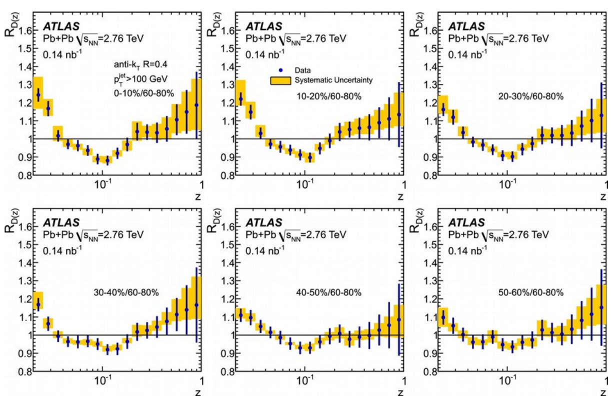
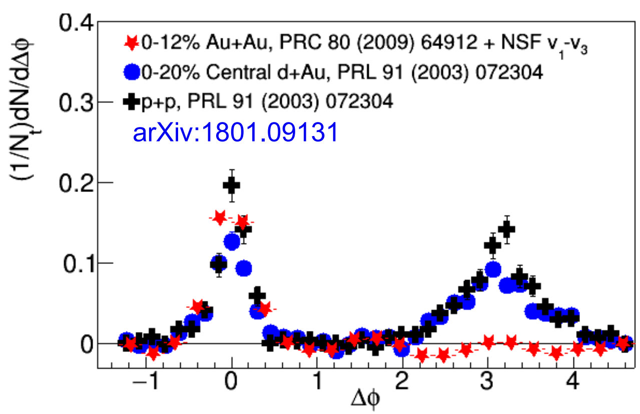
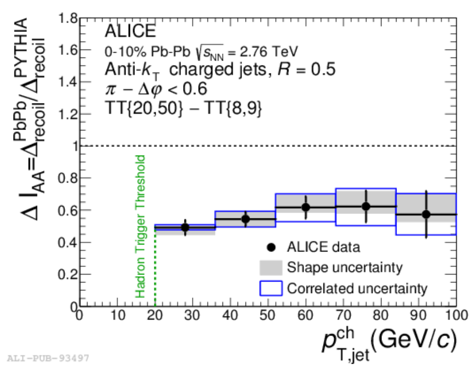


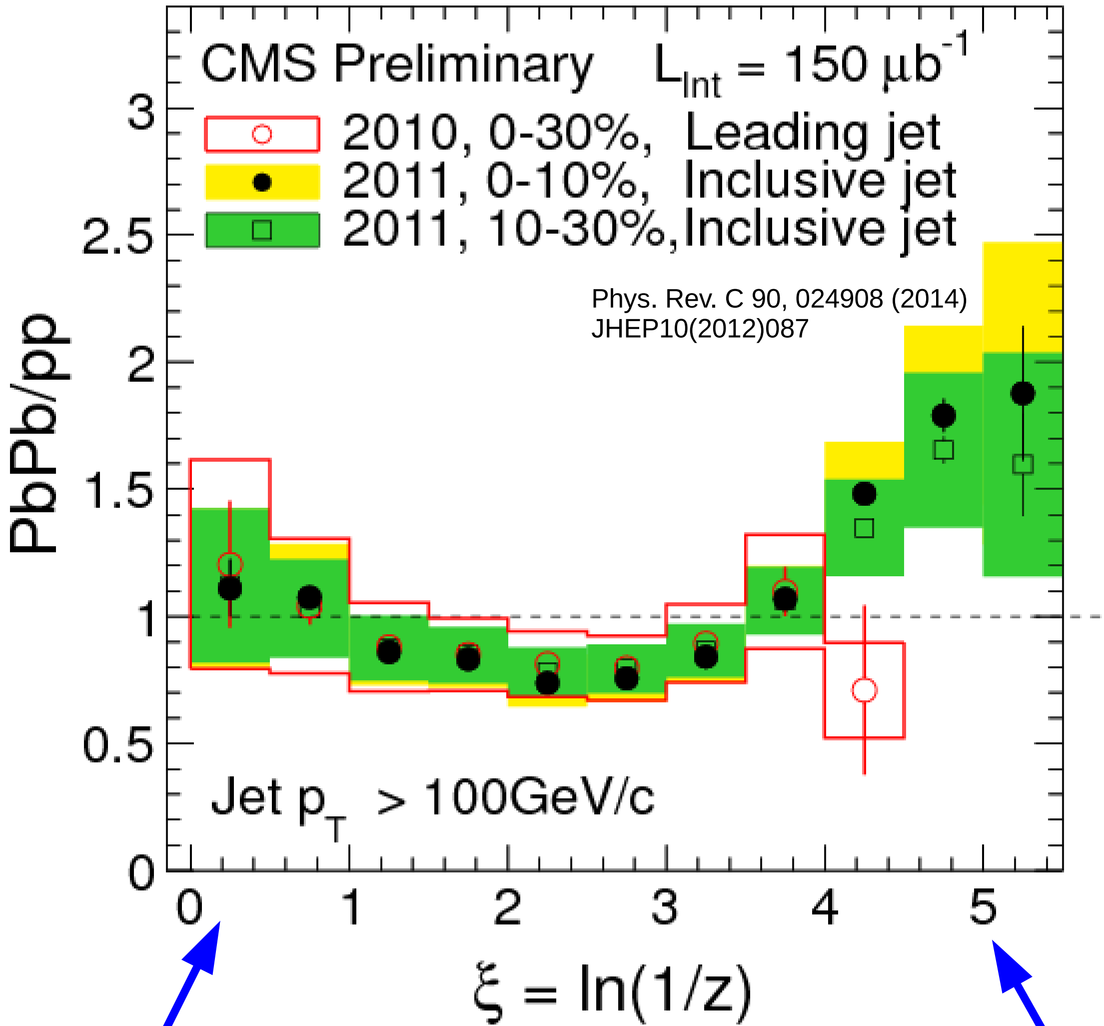


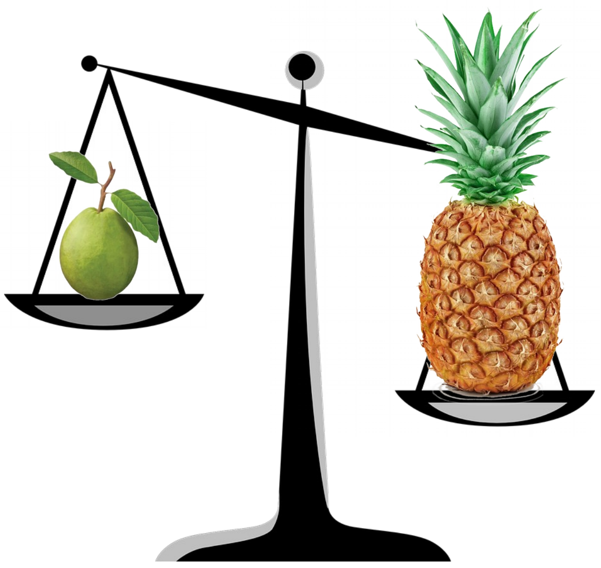






What you don't see matters



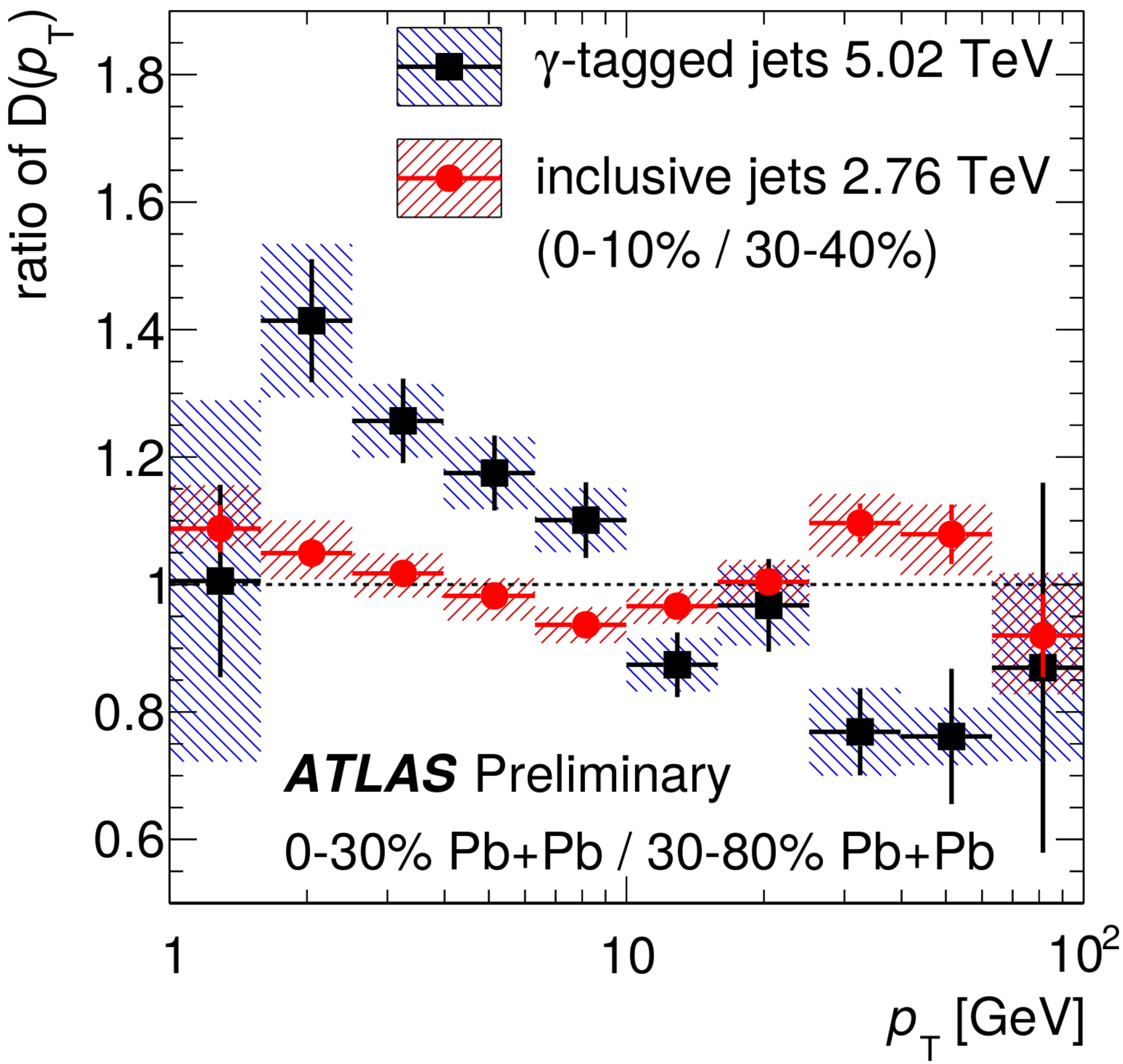


High p_T

$z = p_T/E_{jet}$

Low p_T

What you don't see matters

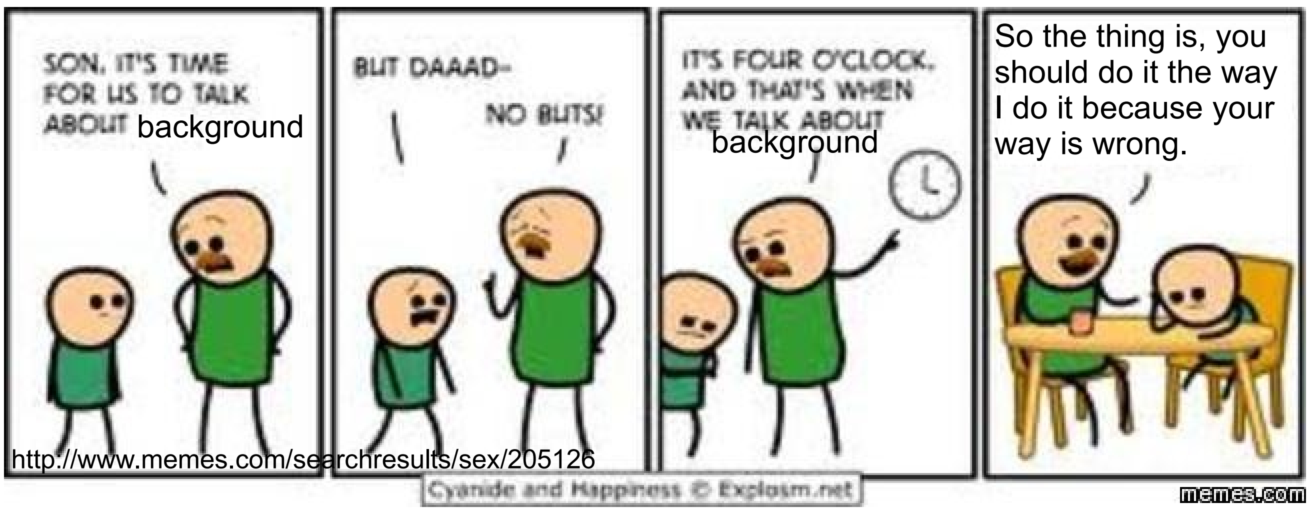


What should we measure?

Some of my answers

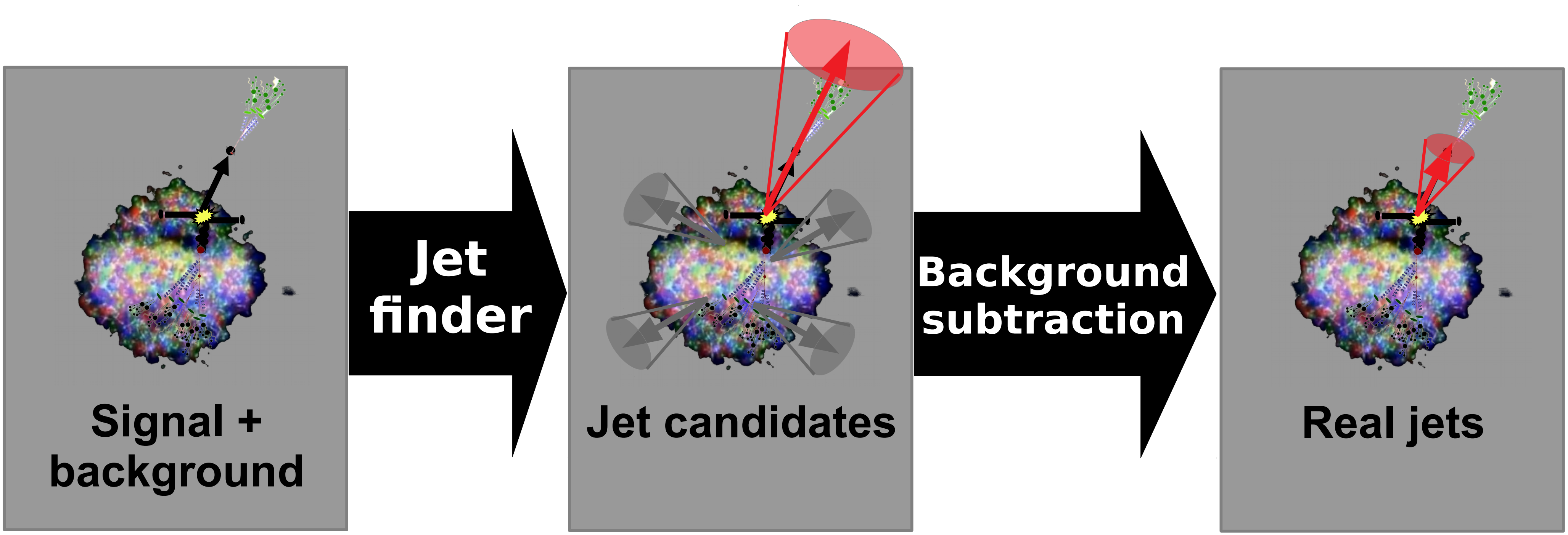
- Everything!
  - Martin Spousta: But we can't measure everything! We should focus!
  - Yen-jie Lee: We should measure things which are sensitive to different properties of the medium and which are human understandable.
- "Simple" measurements with small error bars
- Beware complicated measurements and black boxes.
- Have an open mind – your (my!) pet observable may not be the best

Background

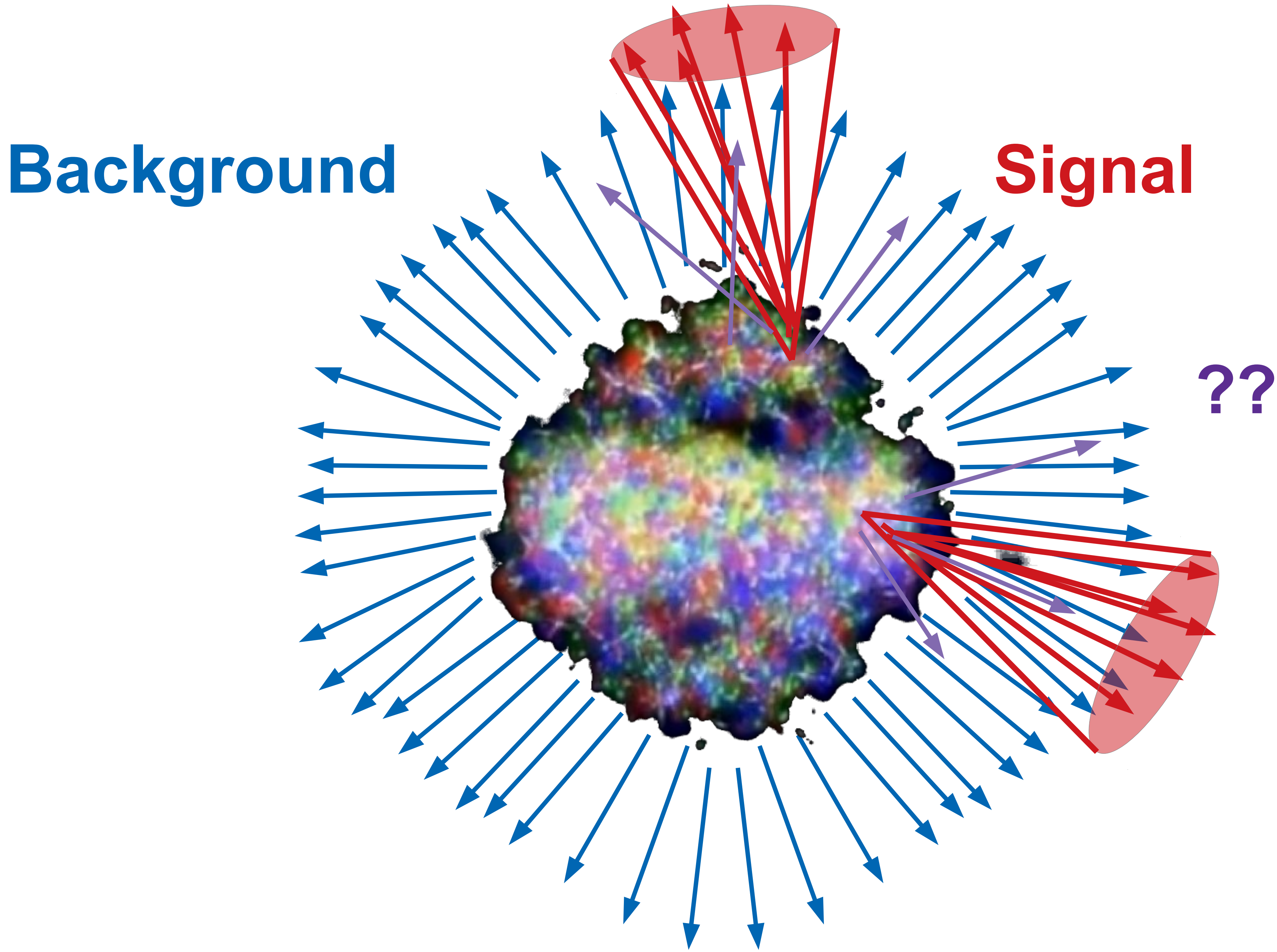


http://www.memes.com/searchresults/sex/205126

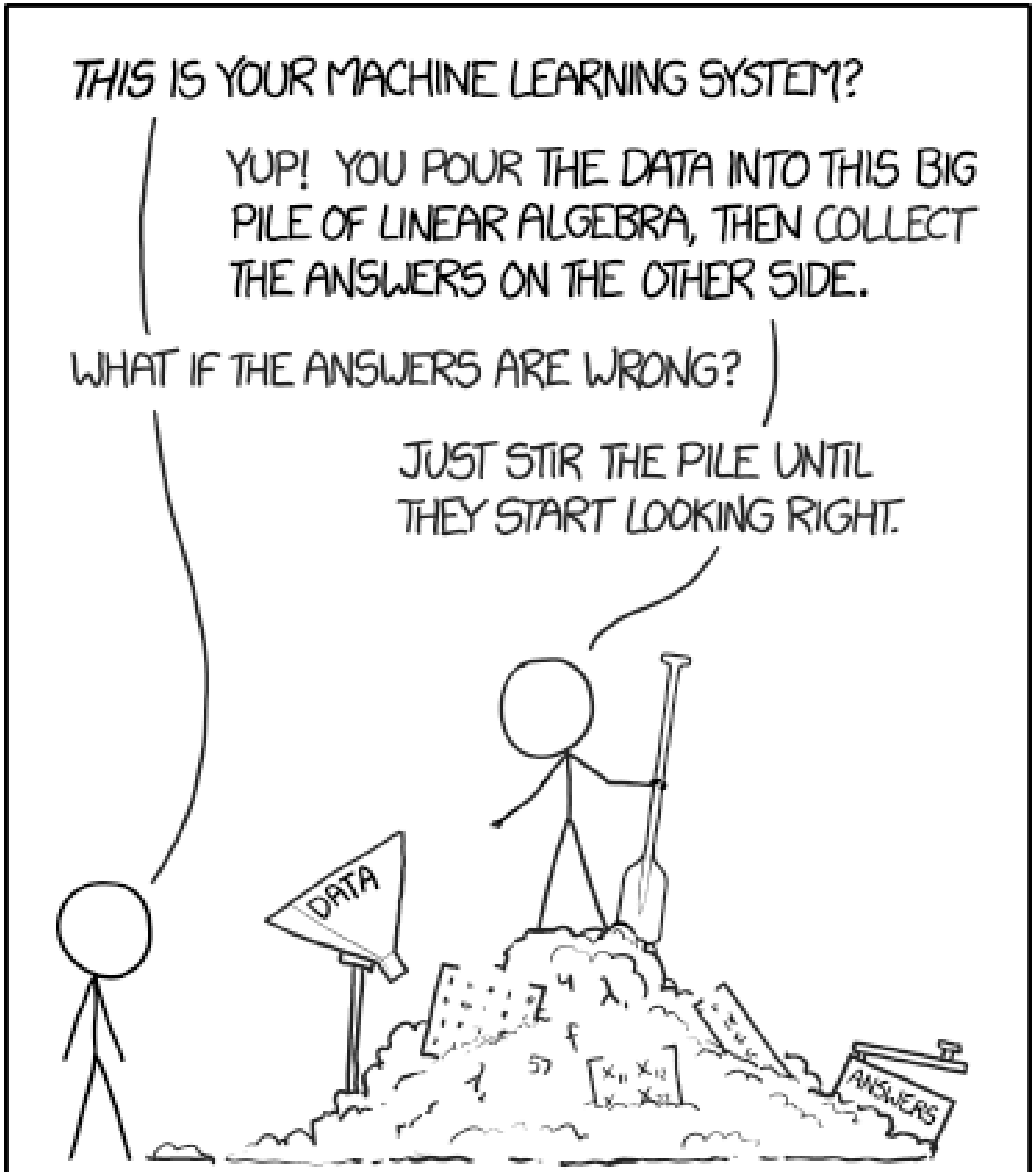
Discussion of analysis technique in a typical jet paper/talk



Signal vs Background



Beware black boxes!



https://xkcd.com/1838/

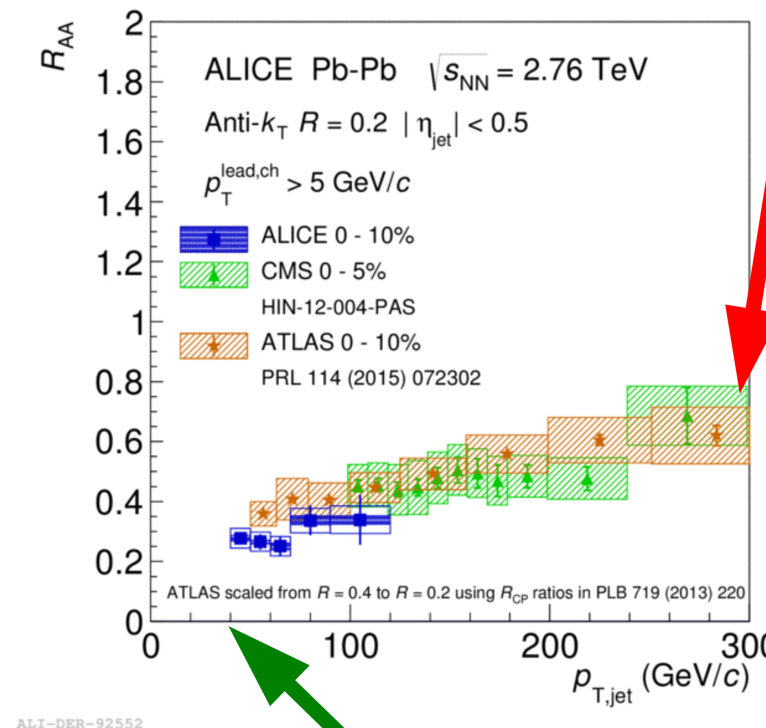
Beware black boxes!

ATLAS

Background subtraction method:

- Iterative procedure
  - **Calorimeter jets:** Reconstruct jets with R=0.2. v_2 modulated <Bkgd> estimated by energy in calorimeters excluding jets with at least one tower with $E_{tower} > \langle E_{tower} \rangle$
    Track jets: Use tracks with p_T>4 GeV/c
  - Calorimeter jets from above with E>25 GeV and track jets with p_T>10 GeV/c used to estimate background again.
- Calorimeter tracks matching one track with p_T>7 GeV/c or containing a high energy cluster E >7 GeV are used for analysis down to E_{jet} = 40 GeV

Constituent biases don't matter that much up here



But they do matter down here!

→ Background subtraction in use by experiments is not benign!

Phys. Lett. B 719 (2013) 220-241

Definition of Jets in a Large Background

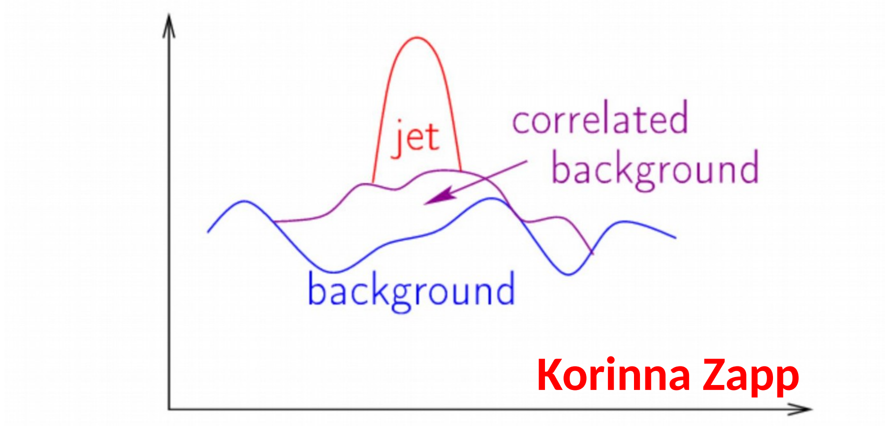
- **Organizers:** M. Connors, G. Milhano, C. Nattrass, R. Reed, S. Salur
- **Spectra conveners:** R. Kunnawalkam Elayavalli, Y. Mehtar-Tani (R. Bertens)
- **Correlation conveners:** J. Noronha-Hostler, J. Huang
- **Substructure conveners:** Y. Lee, Y. Chien

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.

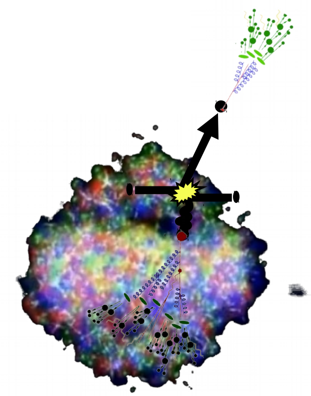
*Consensus on some points

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

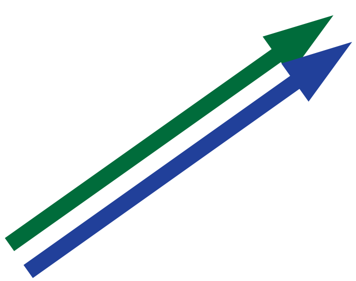
Recommendations



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

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~~ **RIVET 2.7**
- Very few heavy ion analyses exist → **Use undergraduates!**
- Only takes in HEPMC 2.0 input → **Write a converter**
- No way to deal with fluctuations
- No option to fit functions
- Cannot run in batch mode

Few heavy ion analyses in RIVET

RIVET isn’t useful for heavy ion analyses

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


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.
We acknowledge substantial support from the US NSF and the JETSCAPE Collaboration

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

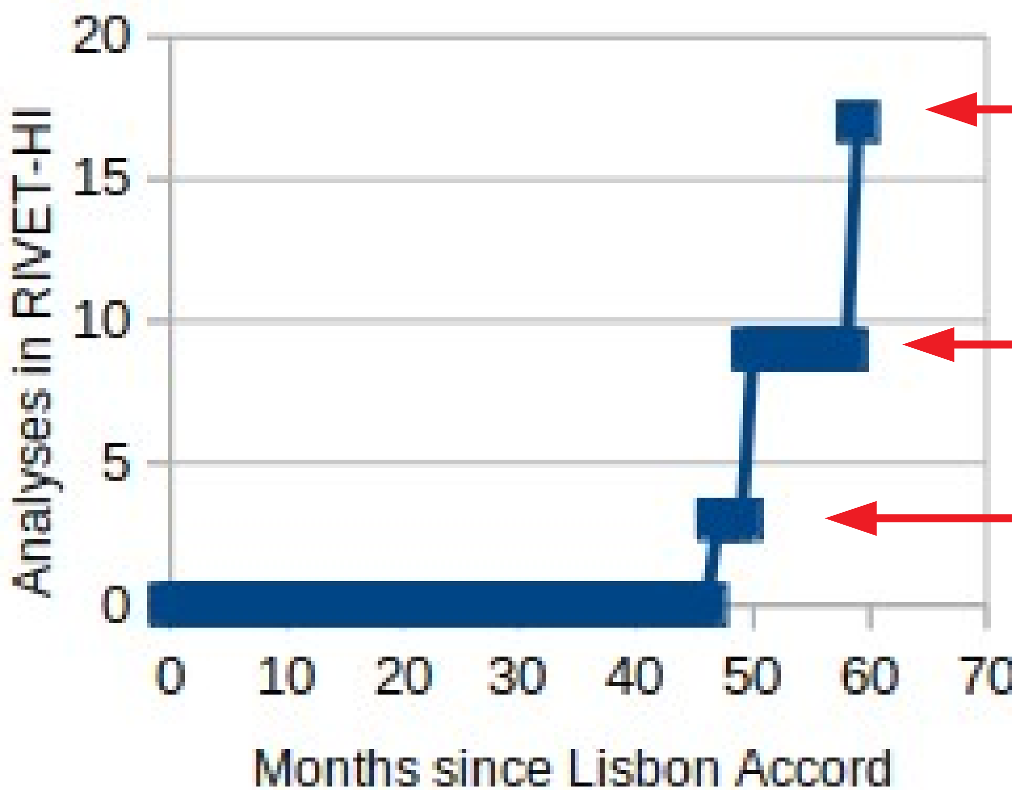
Teaching assistant: N/A

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

Analyses (almost) implemented in UTK copy of RIVET



Spring 2019 UTK research class, RHIC dihadron and gamma hadron analyses

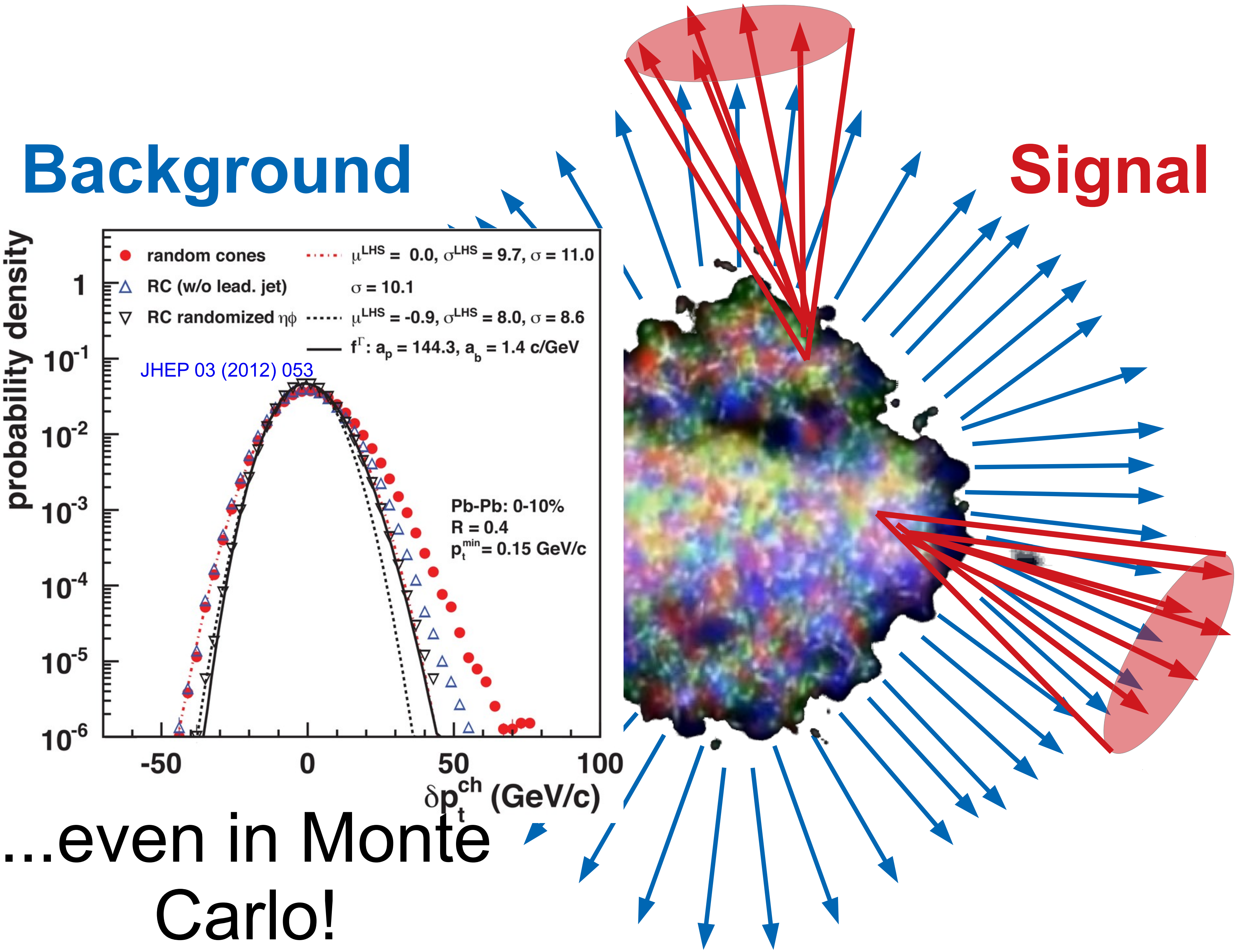
2018 UTK summer students, reconstructed jet analyses

ALICE implementations

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

Need to be finalized! Hold me to it!

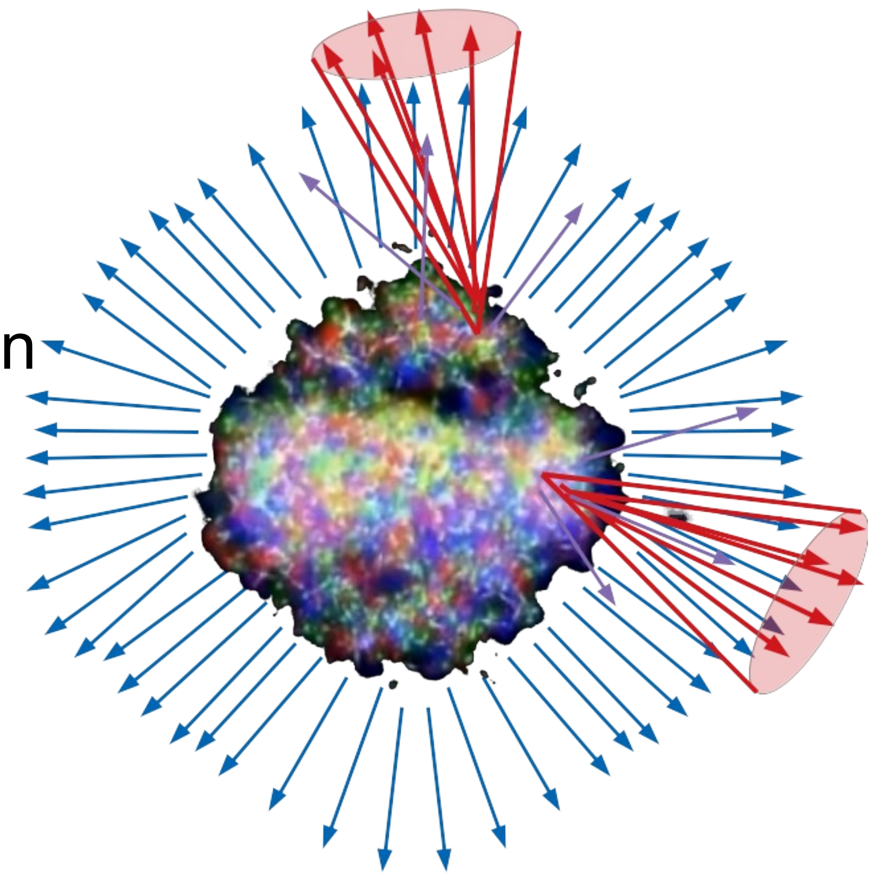
Problem: The background fluctuates



...even in Monte Carlo!

How to address 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
  - Technically feasible but jet measurements would not be physically meaningful, would be sensitive to our understanding of soft physics
- Unfold Monte Carlo results
  - Treating MC just like data
  - Unfolding is highly non-trivial



Conclusions

- We need to be humble
- Focus on reduced uncertainties
- Publish correlations between uncertainties!
- Treat MC like data
  - Implement analyses in RIVET!
  - Warning: fluctuations in full MC
- Beware black boxes

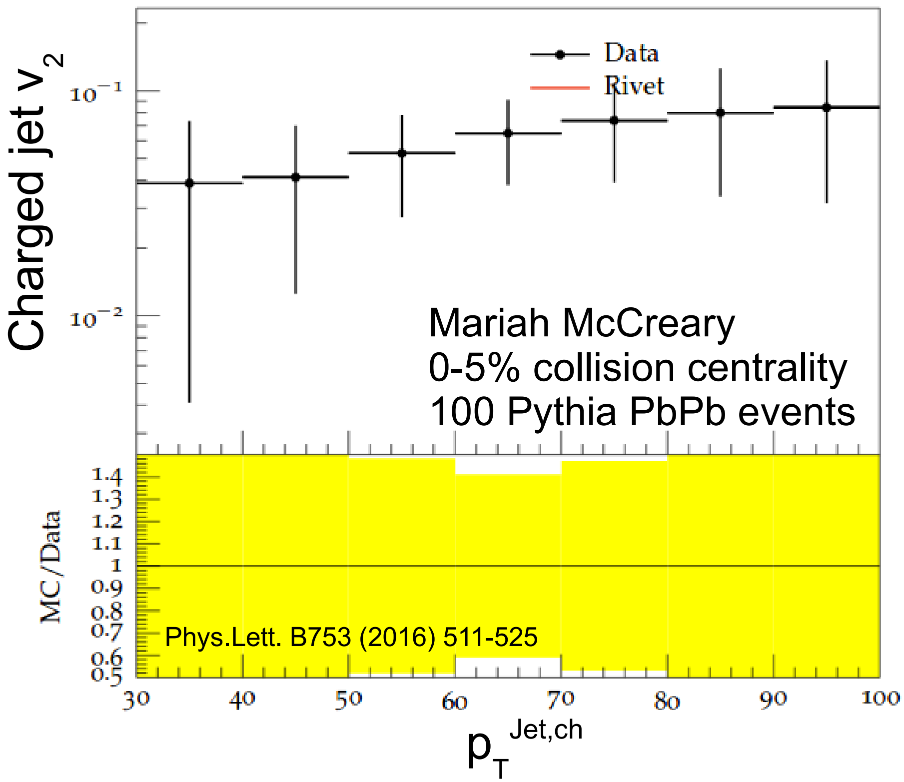
humility

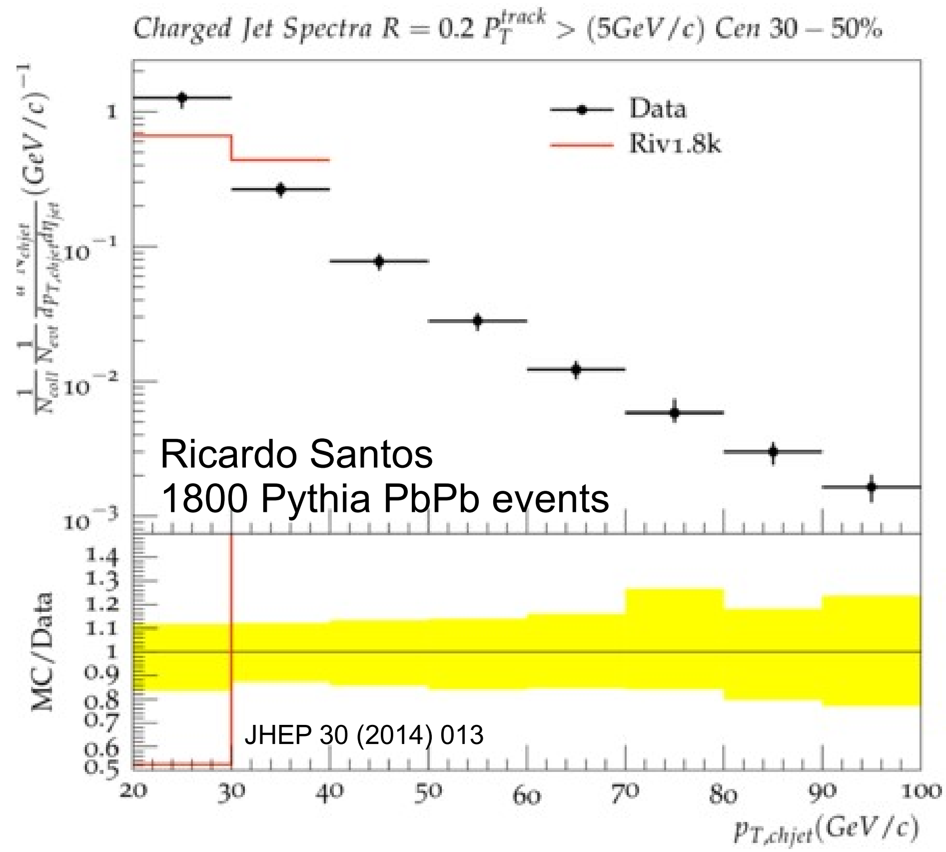
/hjʊˈmɪlɪti/

noun

the quality of having a modest or low view of one's importance.
"he needs the humility to accept that their way may be better"
synonymer: modesty, humbleness, modestness, meekness, lack of pride, lack of vanity, diffidence, unassertiveness
"he needs the humility to accept that their way may be better"

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.

Summary of existing heavy ion analyses

- STAR
  - 6 analyses but none of them instantiated by STAR, some validated but none heavy ion
  - I am an “author” on one and I have no recollection of this whatsoever so I’m not sure how official they are
  - 2 implemented in my class this semester, 2 in progress
- PHENIX
  - 4 implemented in my class this semester
- ALICE
  - 10 pp analyses
  - 3 heavy ion analyses in RIVET-HI (multiplicity, charged spectra, dihadron correlations)
  - 2 jet spectra analyses and one jet v2 analysis in UTK copy of RIVET-HI, still require management of fluctuations
- ATLAS - 0
  - 1 jet spectra analysis in UTK copy of RIVET-HI, one in jet spectra analysis and one jet v2 analysis in progress, still require management of fluctuations
- CMS - 0
  - 1 jet fragmentation function analysis in UTK copy of RIVET-HI, jet fragmentation function analysis and jet spectra analysis in progress, still require management of fluctuations
- LHCb - 0