

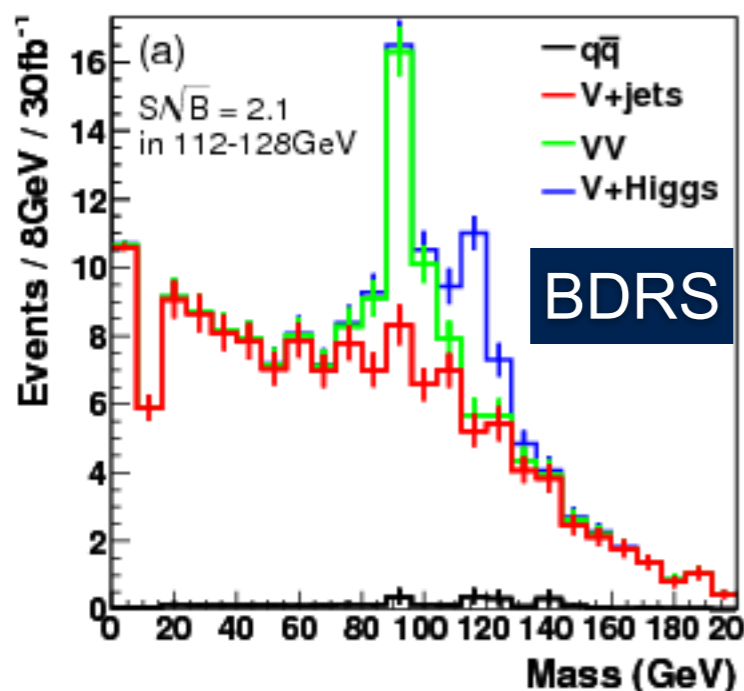
# BOOST 2014 Summary

BOOST 2015 : University of Chicago

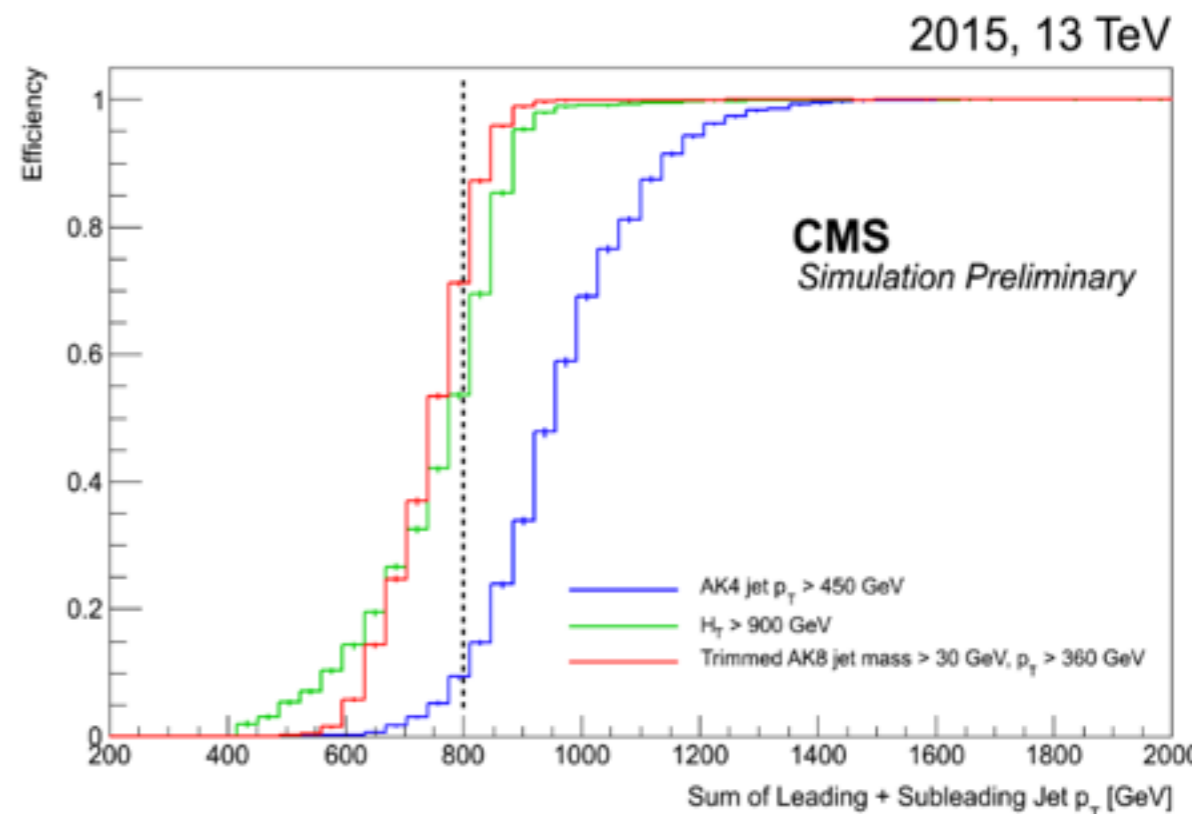
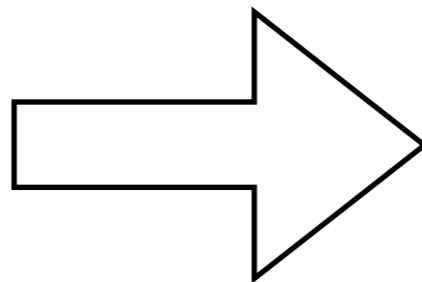
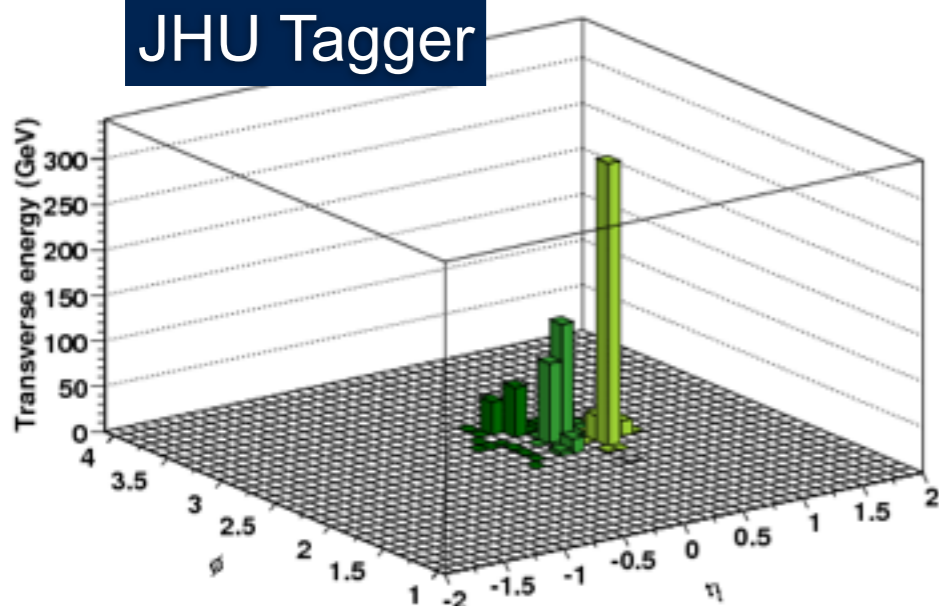
Salvatore Rappoccio  
(State University of New York at Buffalo)



# All About That Boost!



**JHU Tagger**



**See Dylan's Talk!**

- Gone from “neat idea, I wonder if it will work in real life” to “critical tool, used even in Run 2 triggers” in ~7 years (modulo Mike Seymour’s foresight in 1993)



# 'Bout That Boost

Very active research field

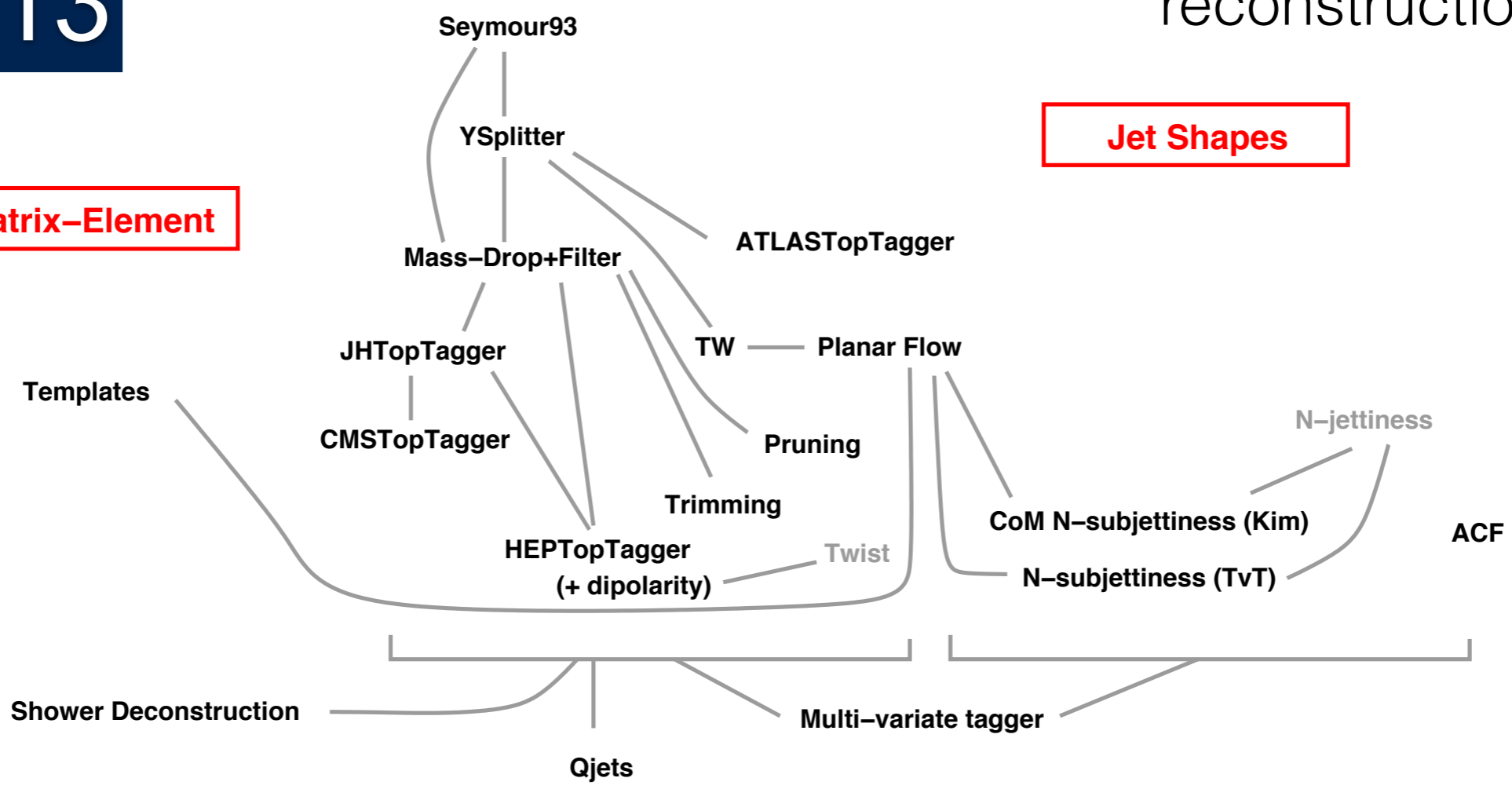
Some of the tools developed for boosted W/Z/H/top reconstruction

2013

Matrix-Element

Jet Declustering

Jet Shapes



apologies for omitted taggers, arguable links, etc.



# 'Bout That Boost

Very active research field

And growing rapidly!

for boosted  $W/Z/H/top$  reconstruction

2015

Matrix-Element

Jet Shapes

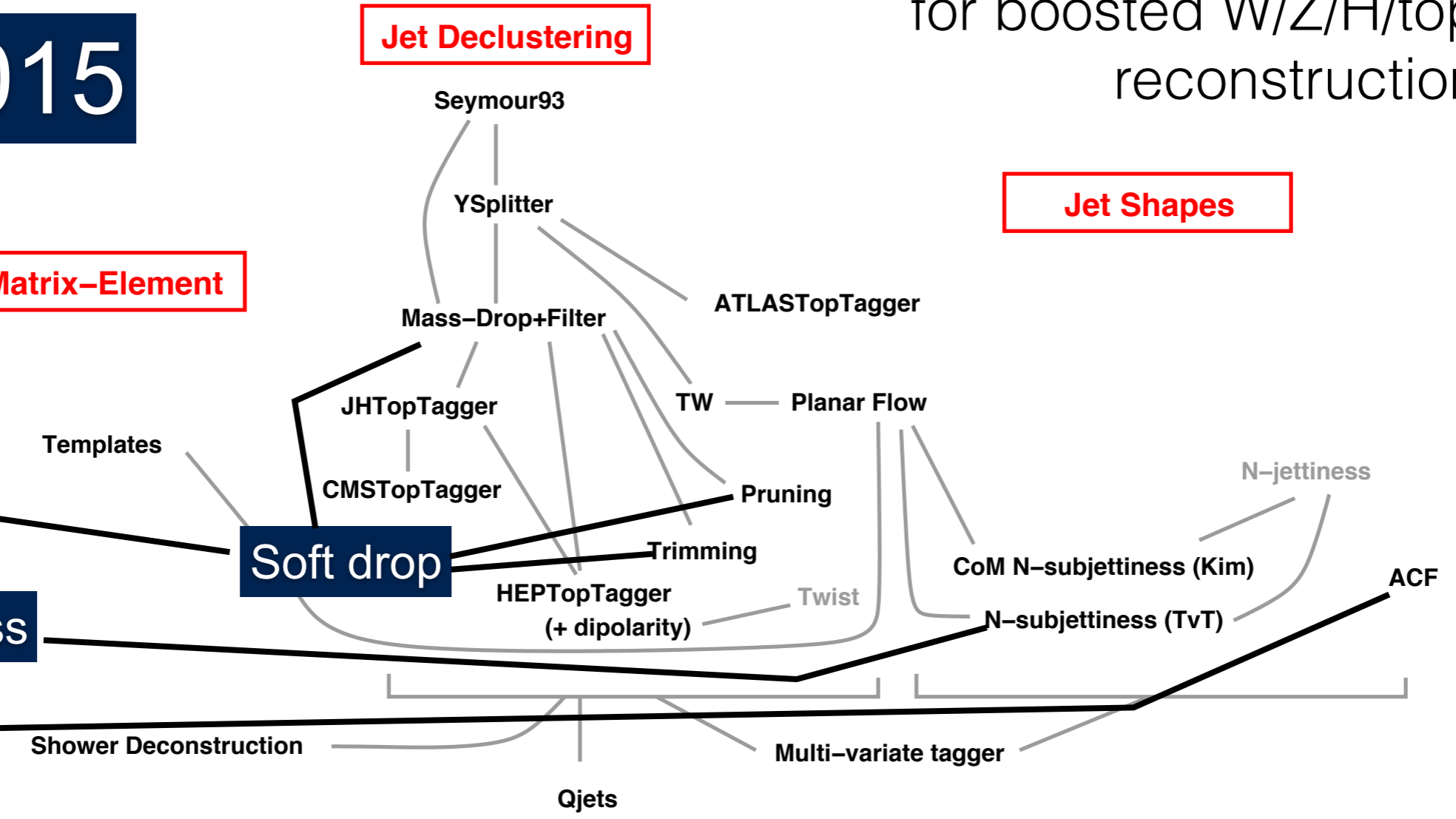
Analytics

Mass

Soft drop

N-subjettiness

Angularities

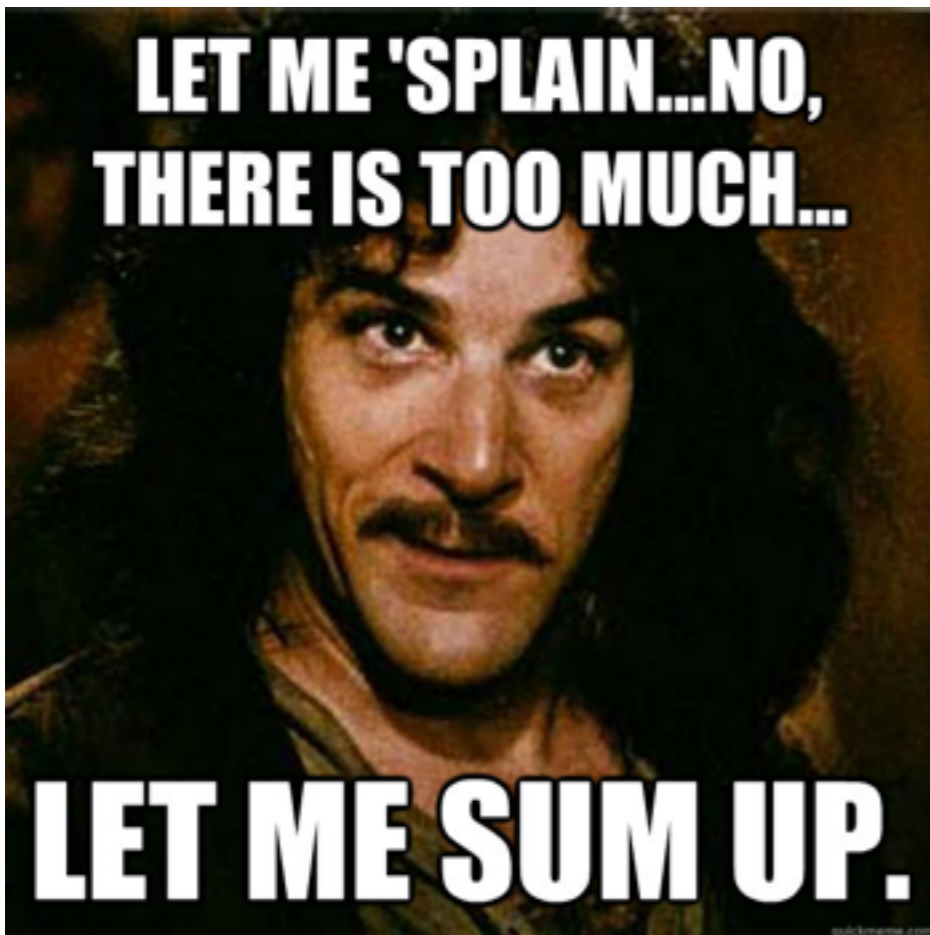


apologies for omitted taggers, arguable links, etc.





# 'Bout That Boost



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- D. Krohn, M. Low, M. D. Schwartz, and L.-T. Wang, arXiv:1309.4777
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- This list is by no means exhaustive
- If you can read this, you have passed your eye exam. Congratulations.

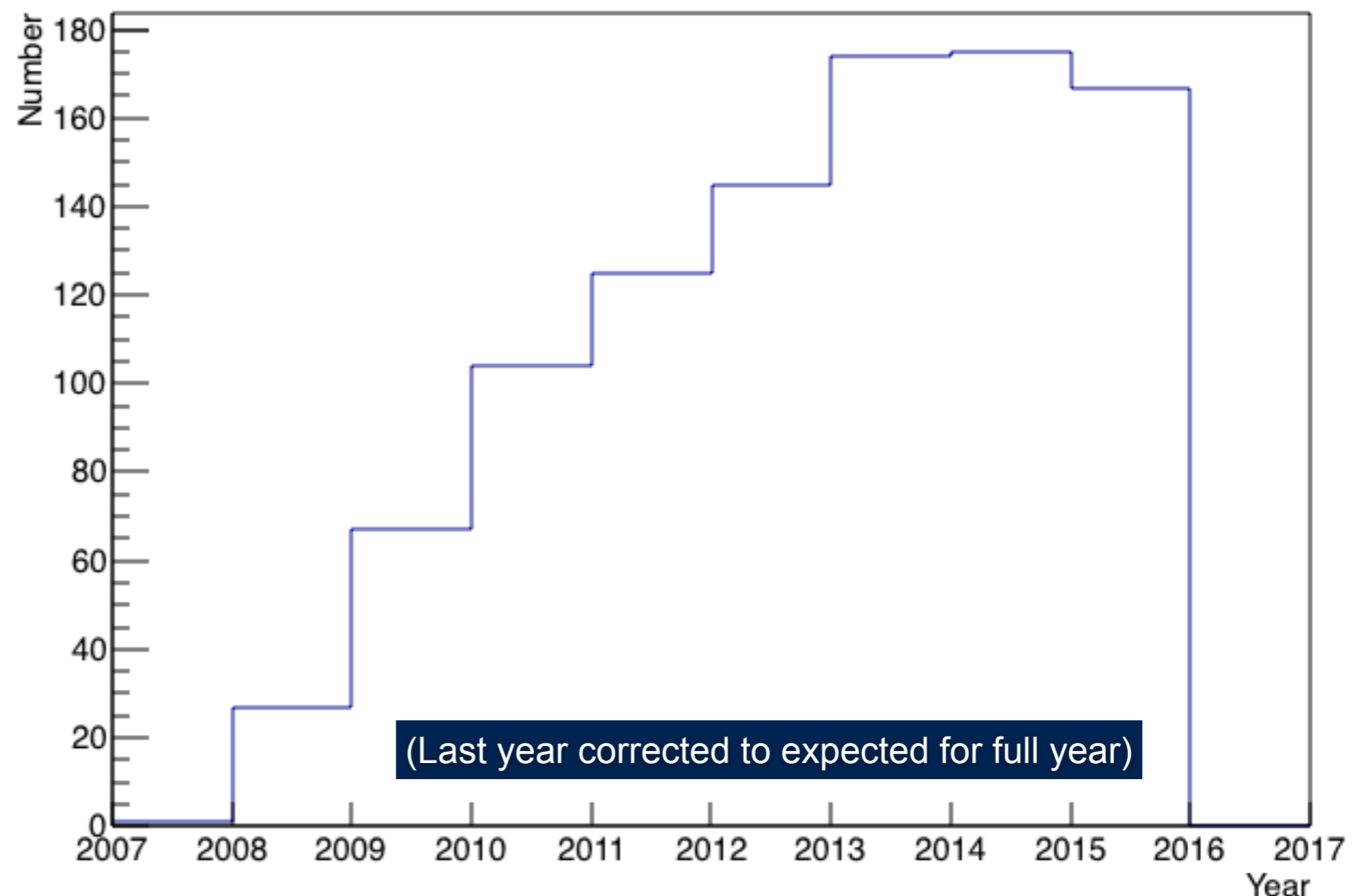


# 'Bout That Boost

- Results with boosts or jet substructure : ~760 to date
  - Cites one of Seymour 93, BDRS, JHU tagger, HEP tagger, n-subjettiness, pruning, filtering, trimming
  - 2015 : 111 so far, expect ~70 more?
  - 12 ATLAS, 13 CMS, rest theory)

**Extremely  
mature yet  
dynamic field!**

Boosted or Substructure Citations Per Year

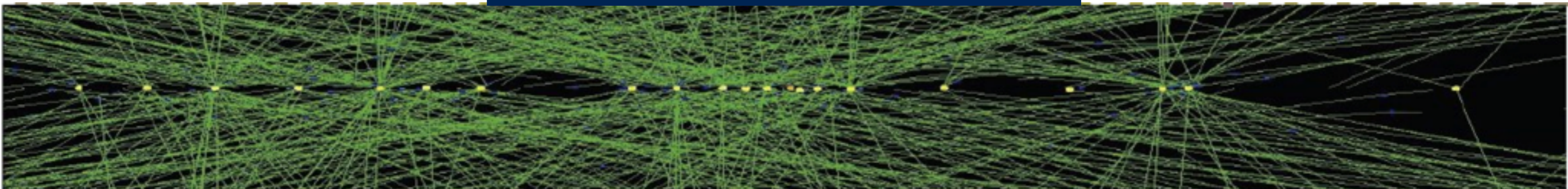






# Pileup

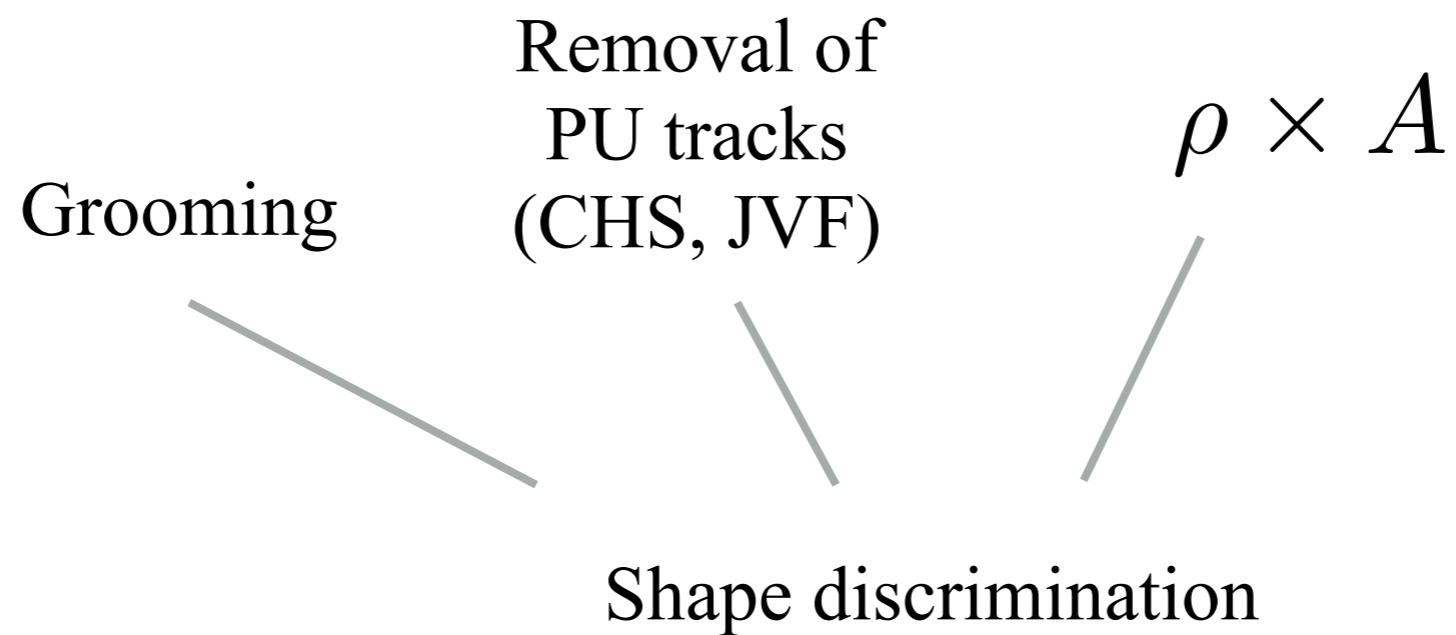
#MoCollisionsMoProblems





# Pileup

- Run 1 : Set the baseline

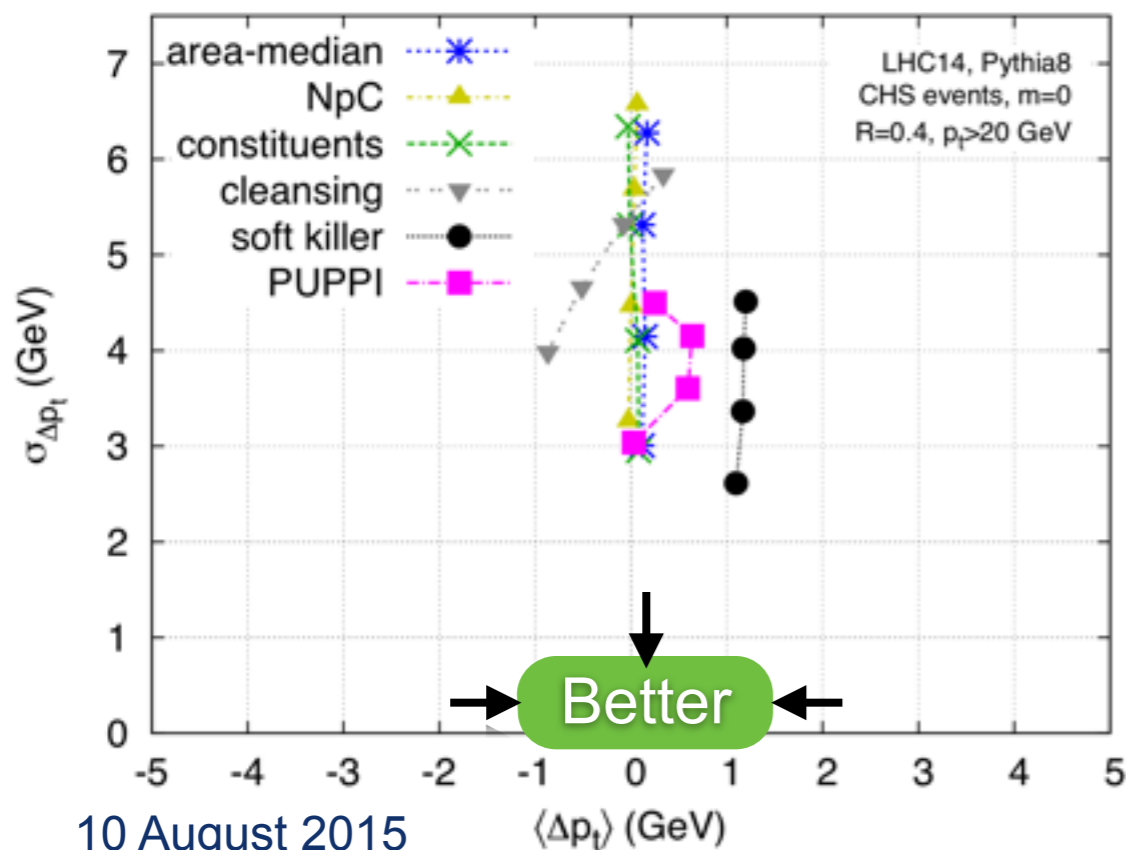
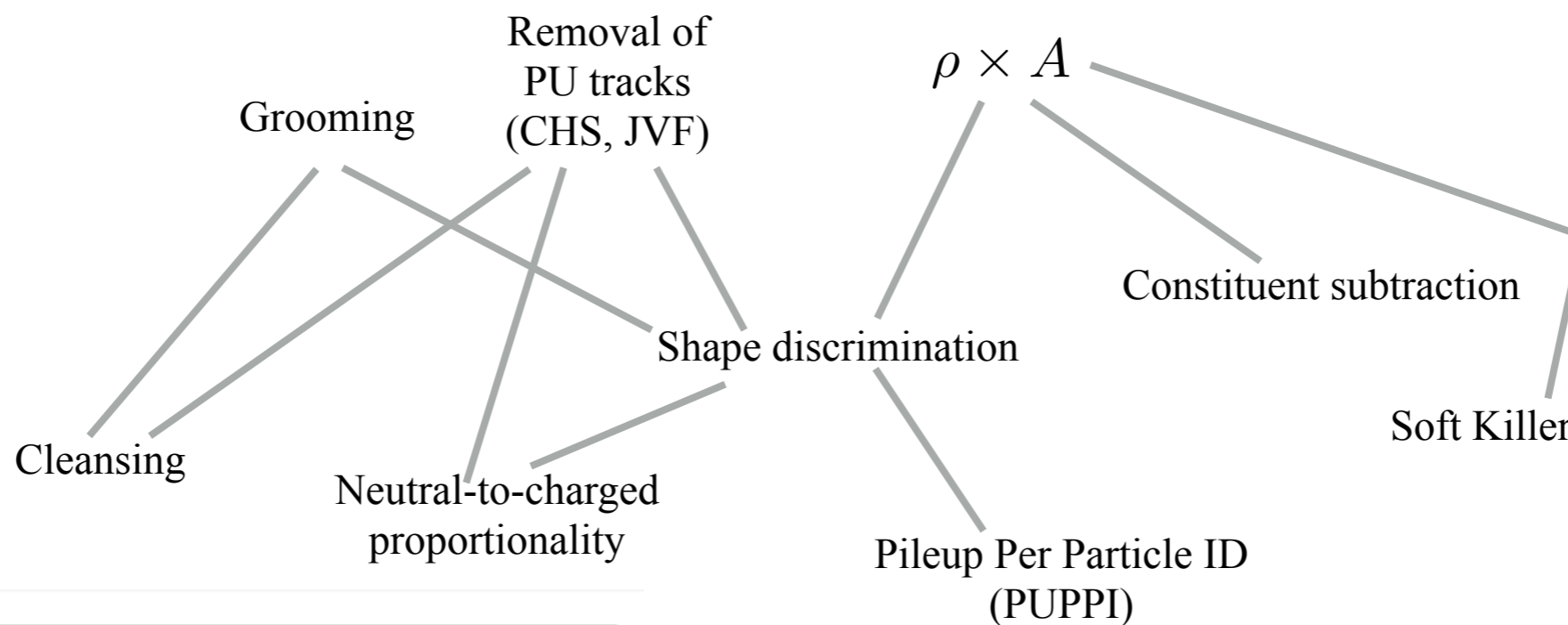






# Pileup

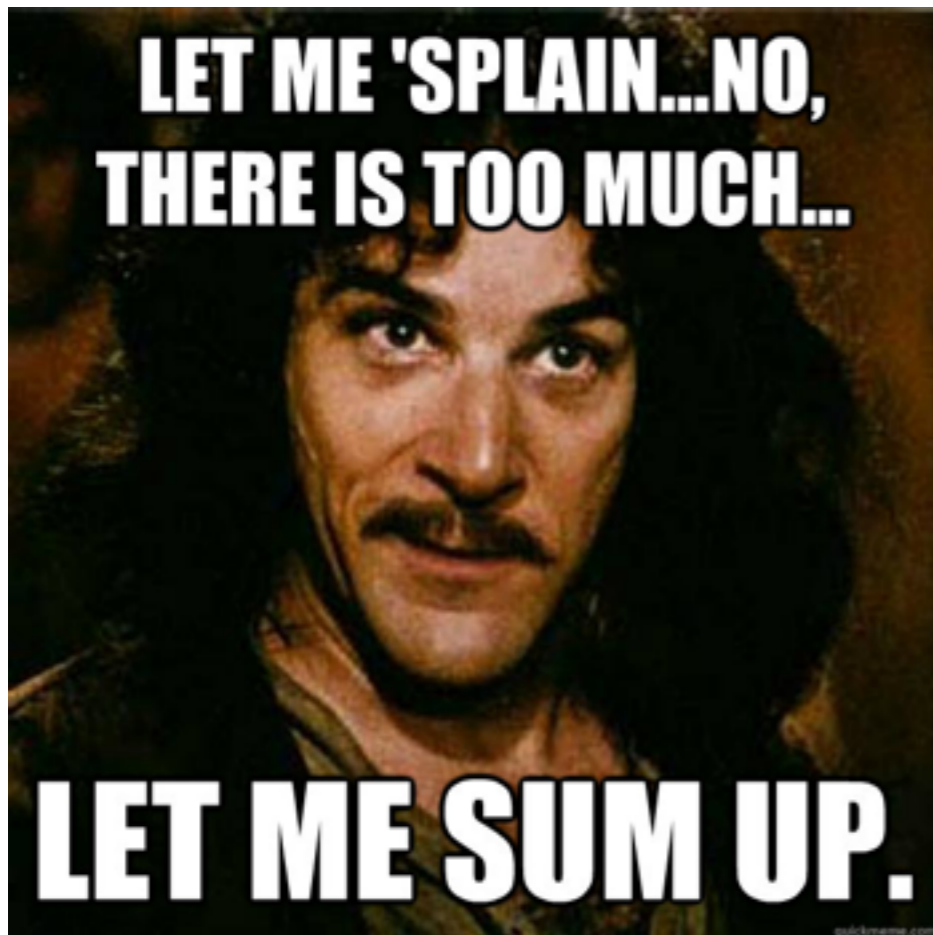
- Run 2 : Kick it up a notch



From pileup mitigation workshop at CERN



# Pileup



- Cacciari, Salam, Soyez JHEP 0804 (2008) 005
- Butterworth, Davison, Rubin, Salam, Phys. Rev. Lett. 100 (2008) 242001
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- CMS-PFT-10-002
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- CMS-JME-14-001
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- Berta, Spousta, Miller, Leitner, JHEP 1406 (2014) 092
- Cacciari, Salam, Soyez, CERN-PH-TH-2014-052
- Bertolini, Harris, Low, Tran, JHEP 1410 (2014) 59
- Cacciari, Salam, Soyez, Eur.Phys.J. C75 (2015) 59



# From Nhan's Summary : BOOST 2014

**BOOST 2010: These aren't your daddy's jets**

**BOOST 2011: "First" data**

**BOOST 2012: Kids in a candy store**

**BOOST 2013: Bringing substructure into the mainstream**

**BOOST 2014: If you ain't boostin', you ain't livin'**





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**BOOST 2015:** ???



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**BOOST 2010: These aren't your daddy's jets**

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**BOOST 2012: Kids in a candy store**

**BOOST 2013: Bringing substructure into the mainstream**

**BOOST 2014: If you ain't boostin', you ain't livin'**

**BOOST 2015: ???**

**BOOST 2016: Make Profit!**

**(Characterization of the  $X(2036 \text{ GeV})$  E6.321 Resonance with Boosted Jets)**



# Teaser

- This is not intended to be comprehensive, but just a short list of highlights from 2014
  - No sense in reiterating the theory+exp summary talks by Nhan and Mrinal, they're already very good!
- Just going over a couple of points that generated a lot of discussion and interest over the year
- Don't be offended if I left you out, this is a teaser for the week!





# Jet Analytics

- First need to understand jet mass...

At "NLL" :

$$\frac{\rho}{\sigma} \frac{d\sigma}{d\rho} \simeq \frac{\alpha_s C_F}{\pi} \left( \ln \frac{1}{\rho} - \frac{3}{4} \right) e^{-\frac{\alpha_s C_F}{2\pi} \left( \ln^2 \frac{1}{\rho} - \frac{3}{2} \ln \frac{1}{\rho} + \mathcal{O}(1) \right)}$$

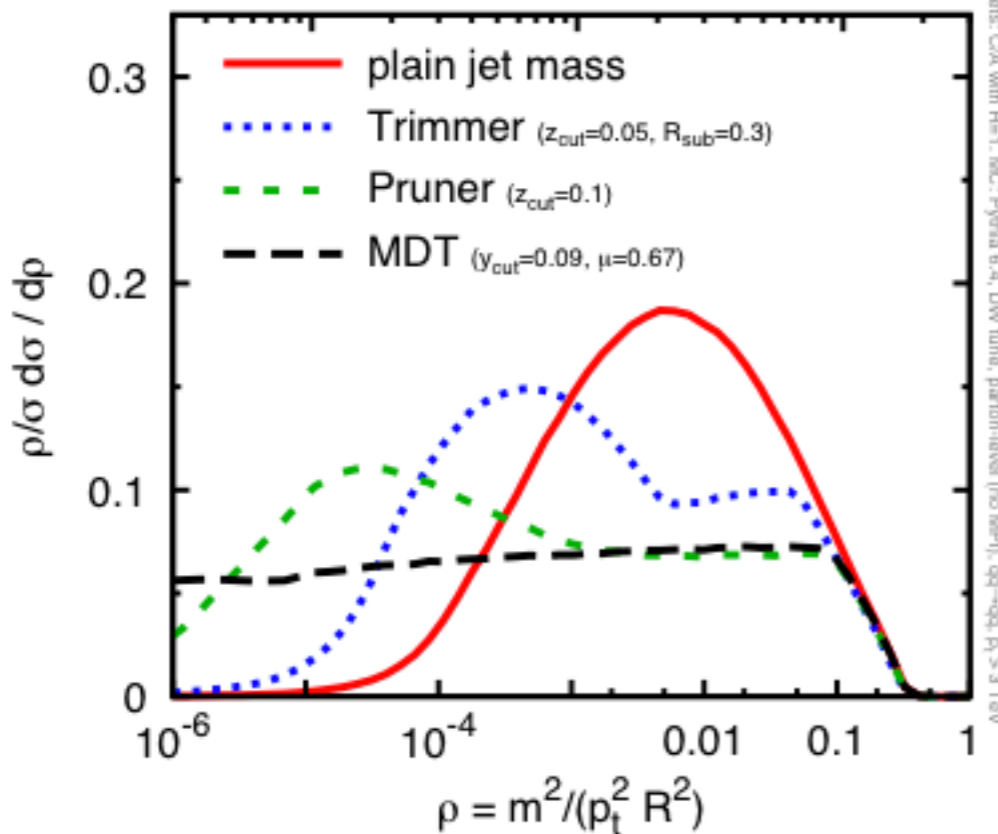
$$\rho \equiv \frac{m^2}{p_t^2 R^2}$$

Slide from G. Soyez

quark jets (Pythia 6 MC)

m [GeV], for  $p_t = 3$  TeV, R=1

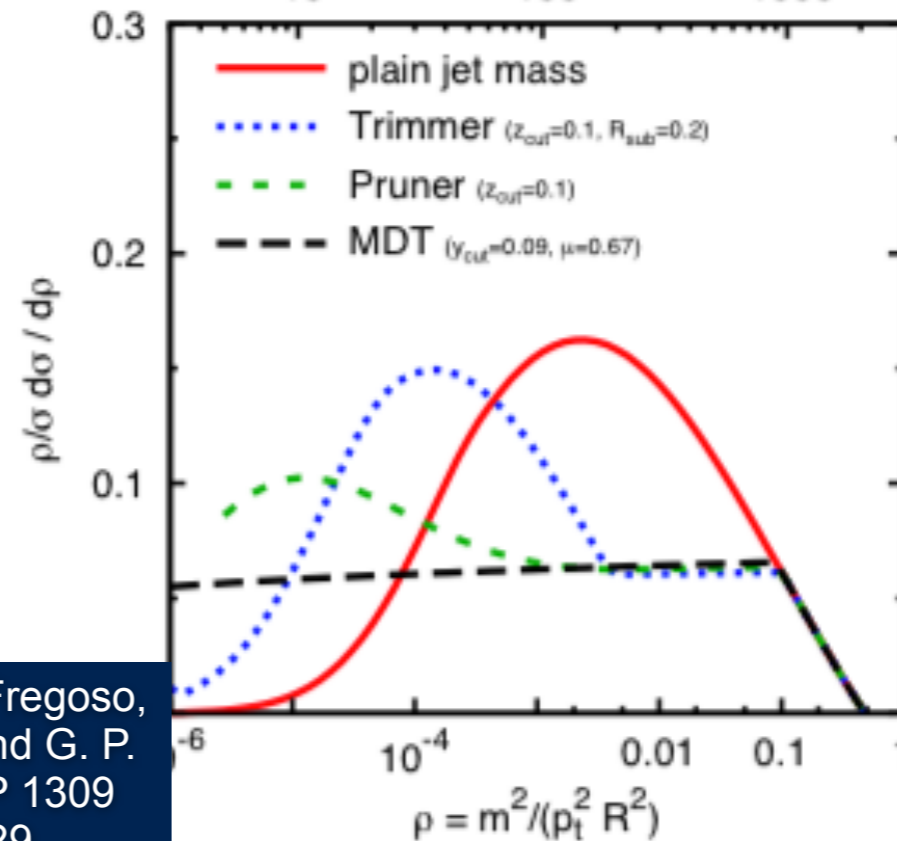
10 100 1000



Analytics

analytics quark jets: m [GeV], for  $p_t = 3$  TeV

10 100 1000



Dasgupta, A. Fregoso,  
S. Marzani, and G. P.  
Salam, JHEP 1309  
(2013) 029,

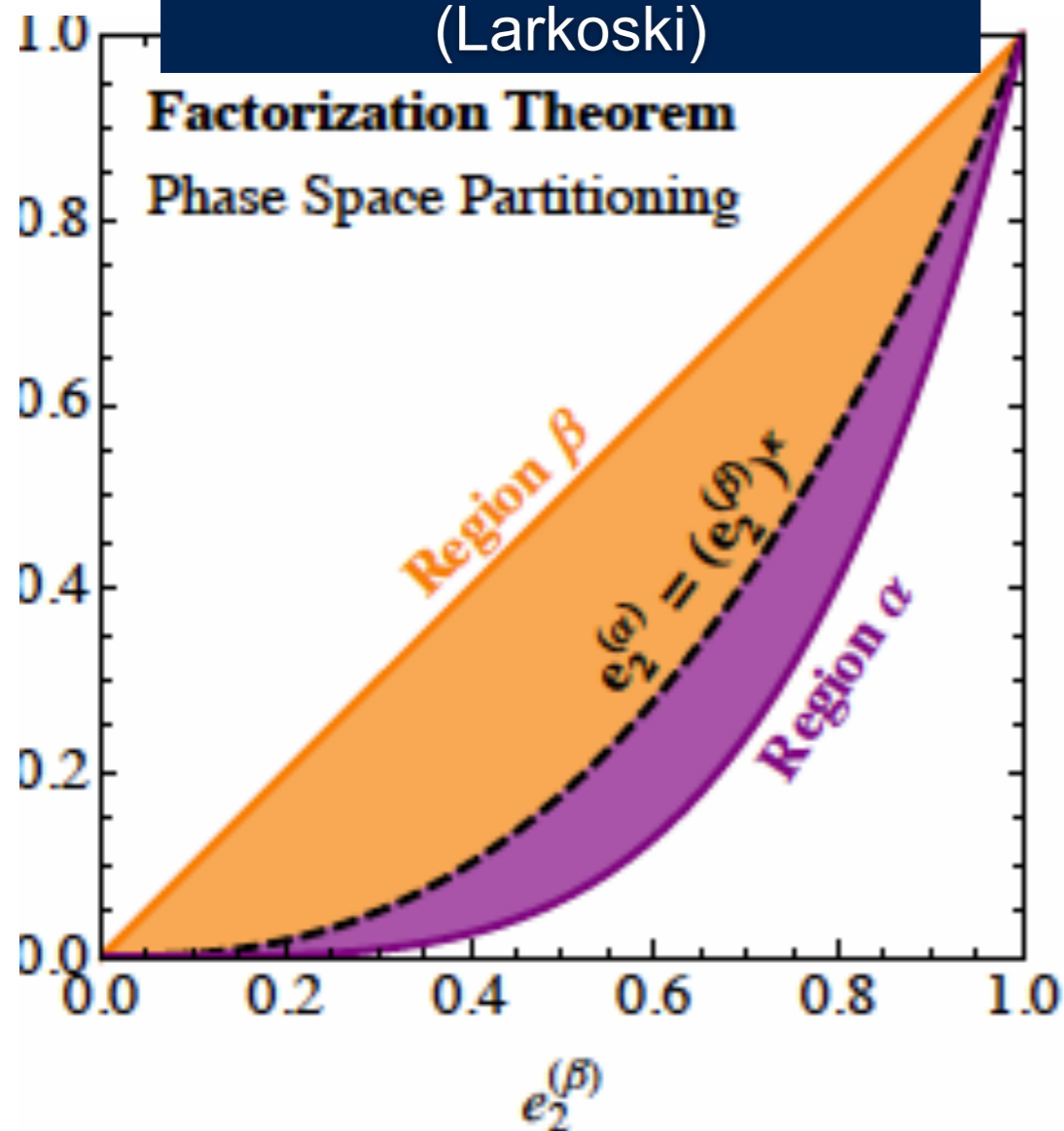


# Jet Analytics

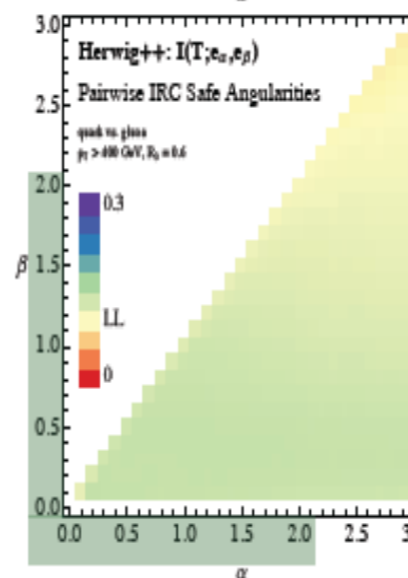
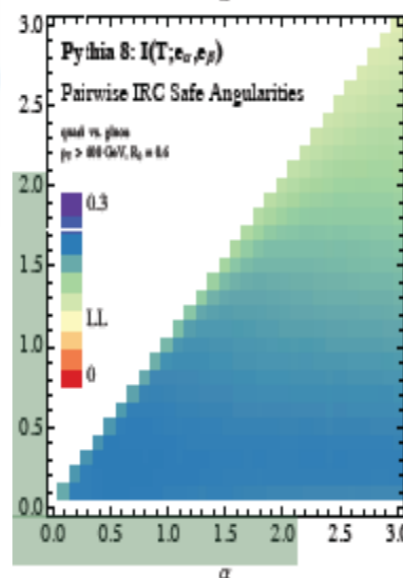
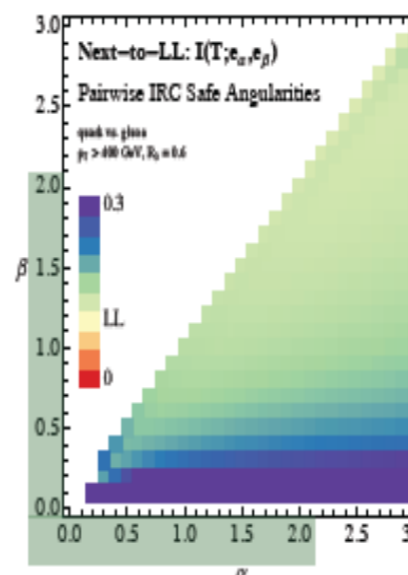
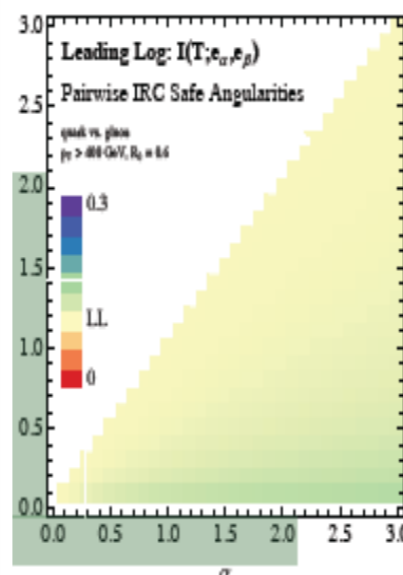
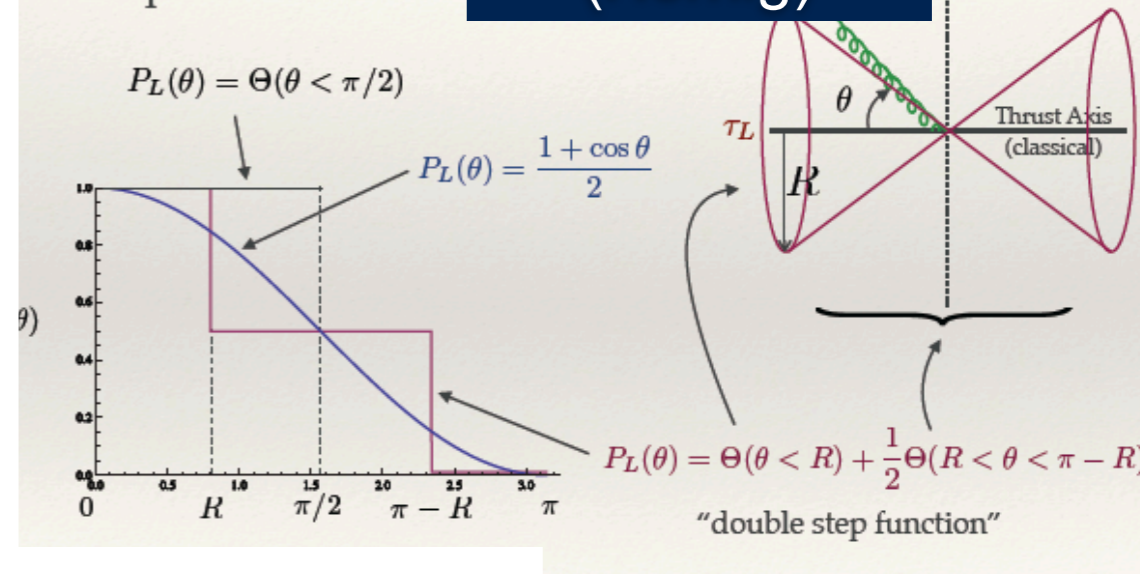
## QJets in SCET (Hornig)

- ...and going beyond!

### Multi-differential calculations (Larkoski)

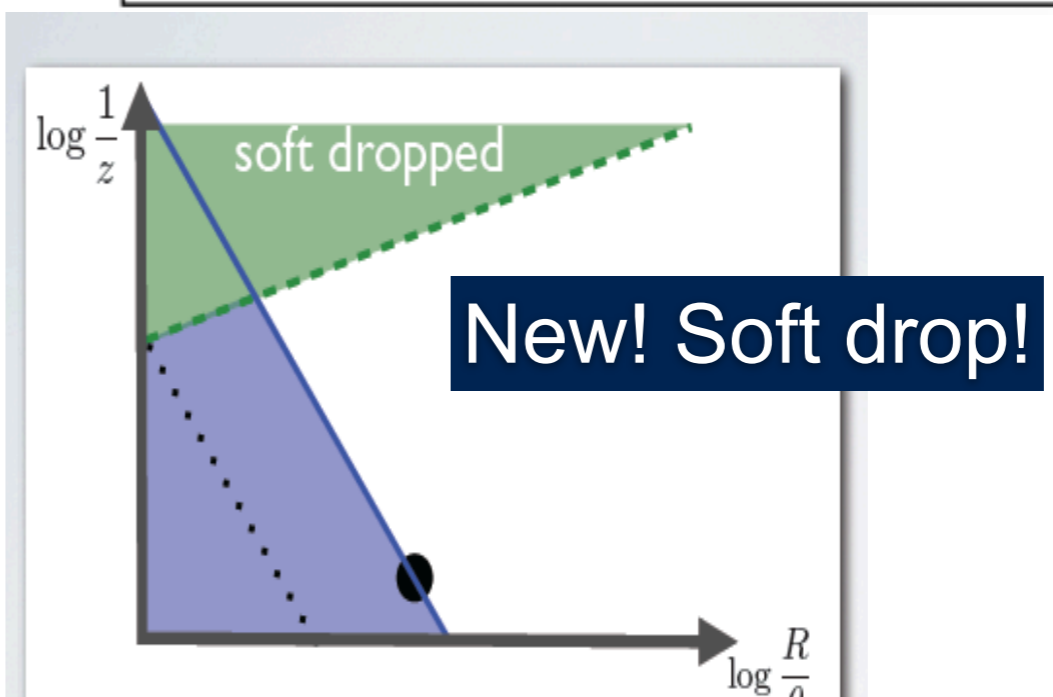
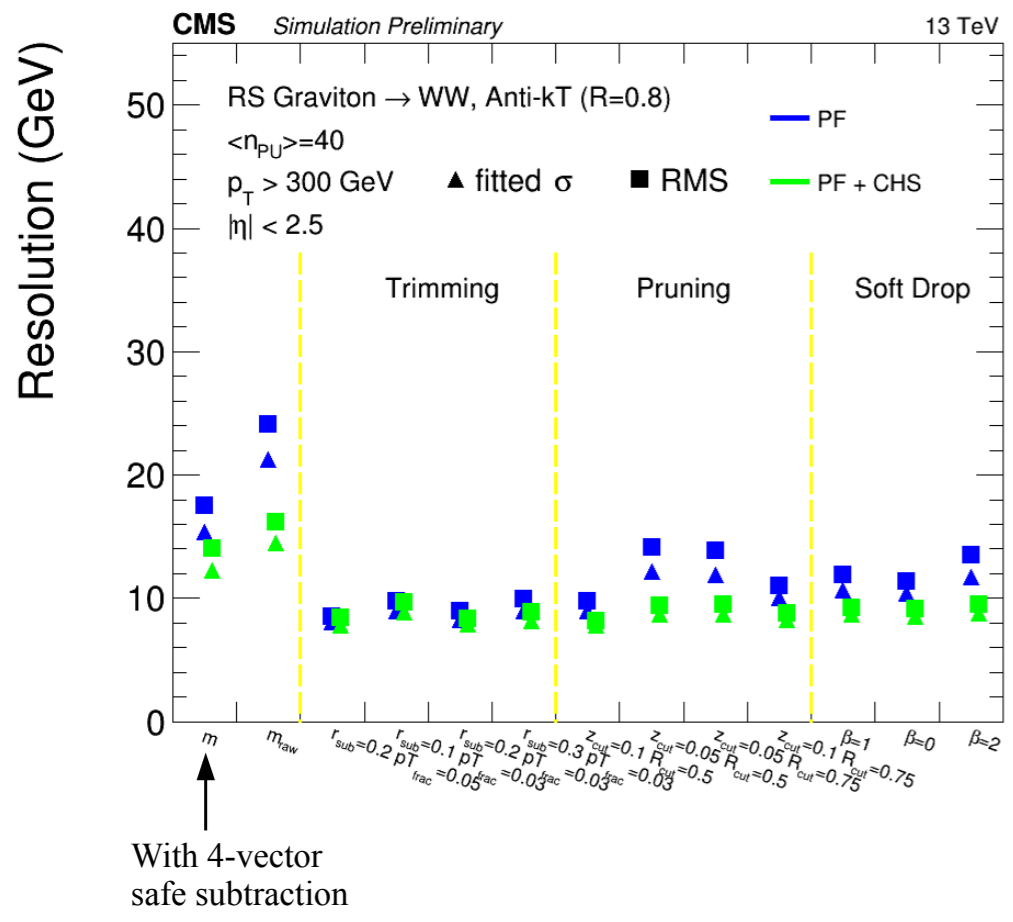
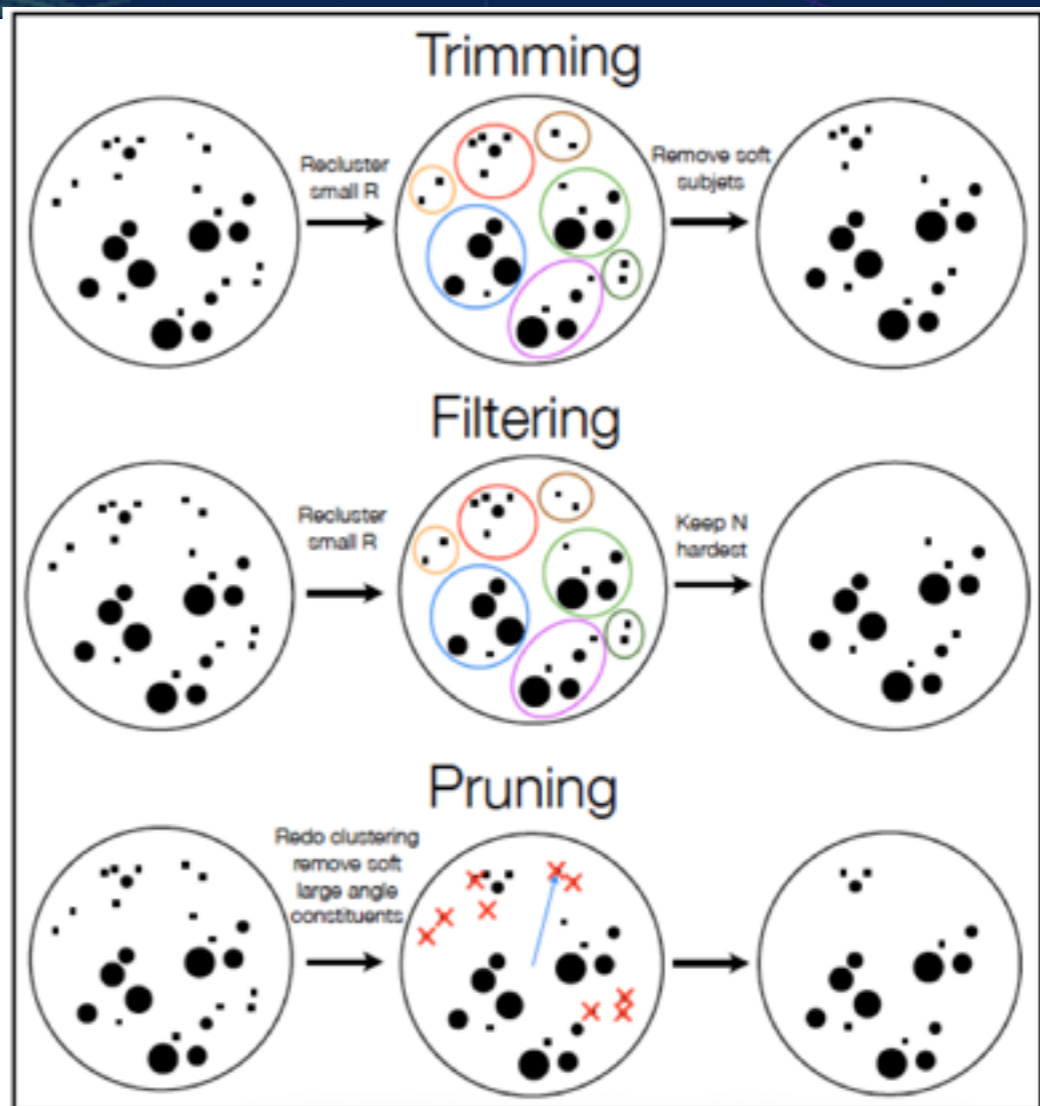
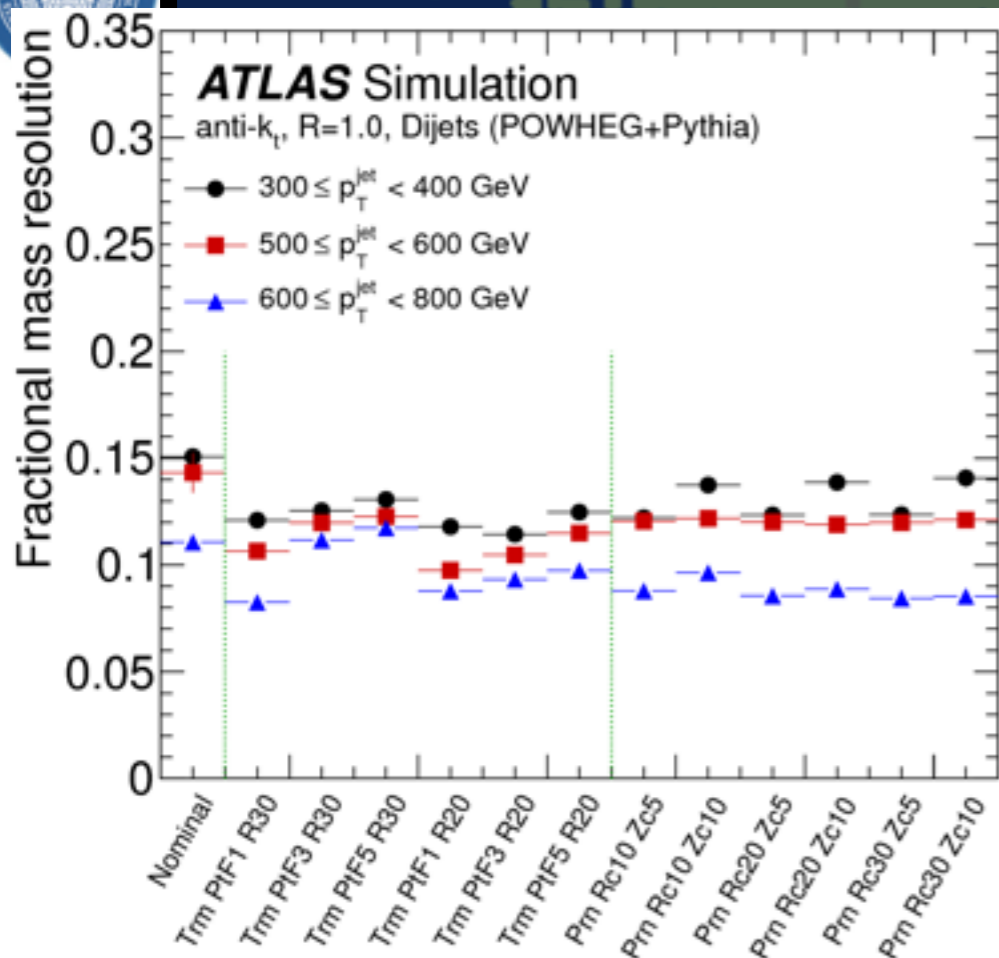


Examples:



### Mutual information (Thaler)

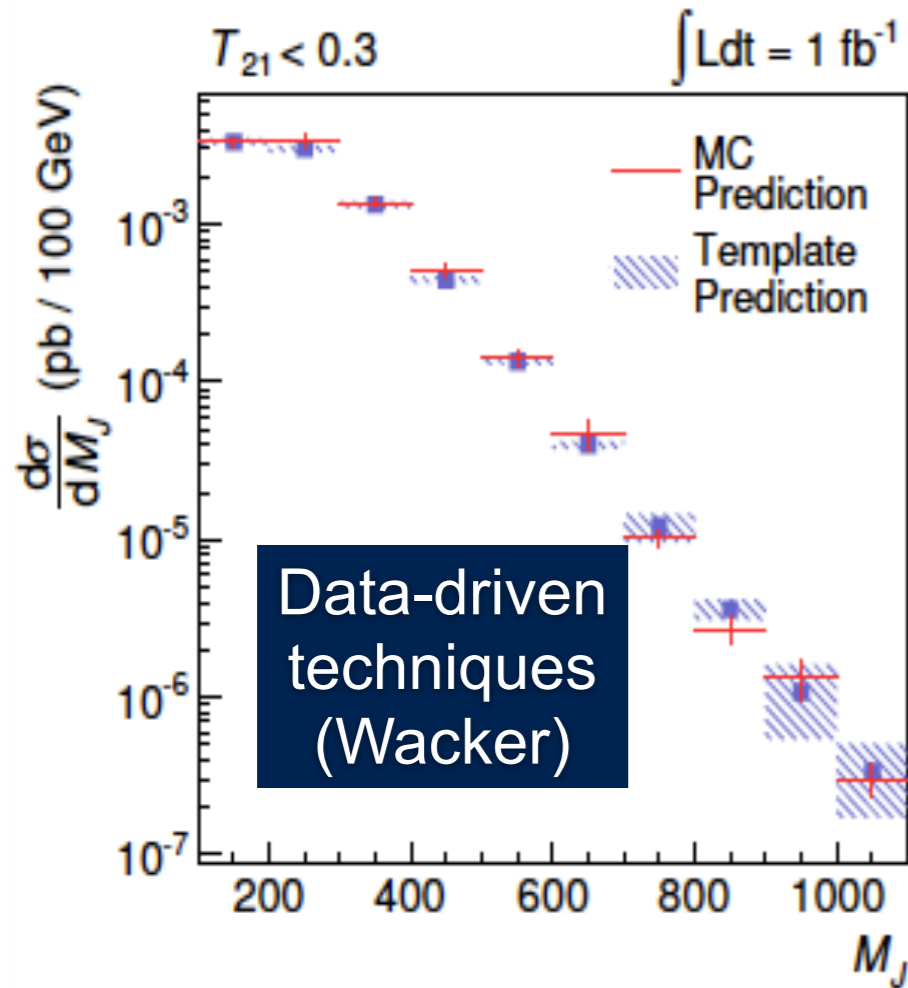
# Tools, Tools...



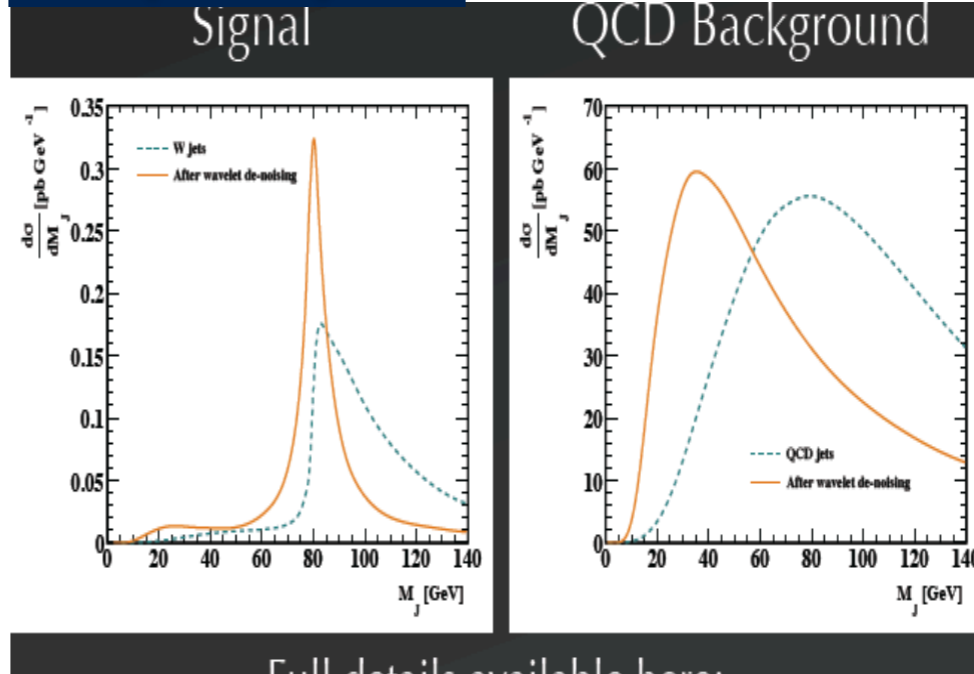




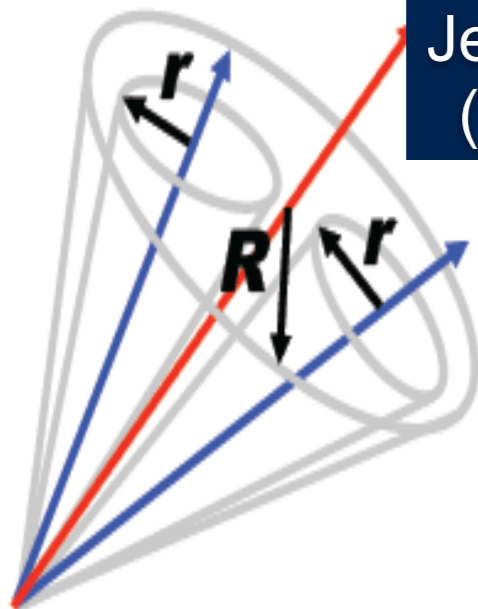
# And More Tools



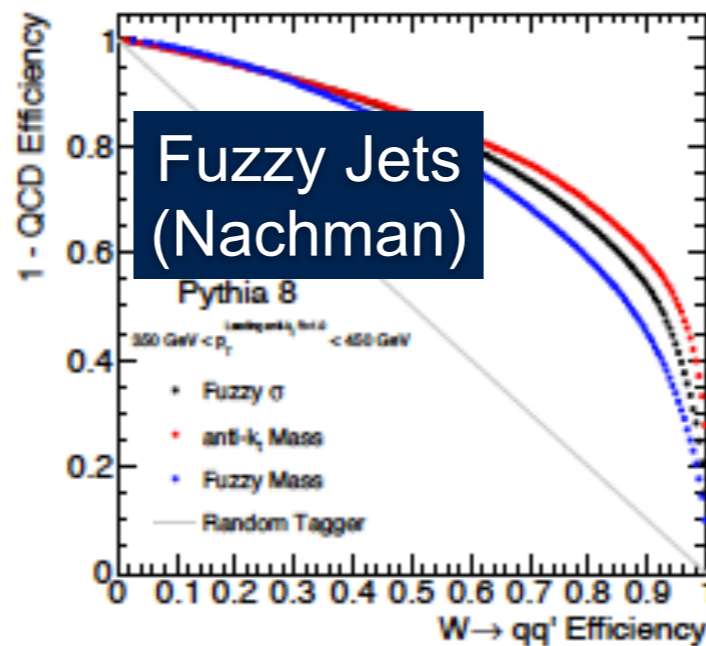
## Wavelet decomposition (Monk)



Full details available here:



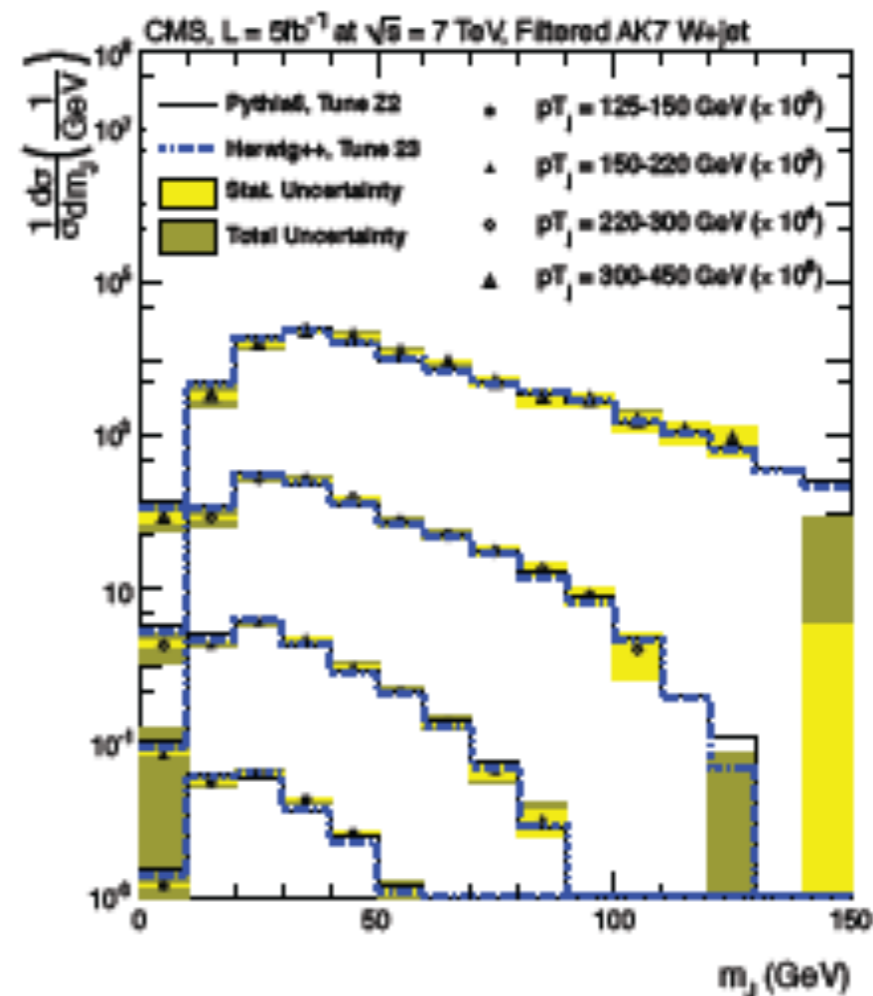
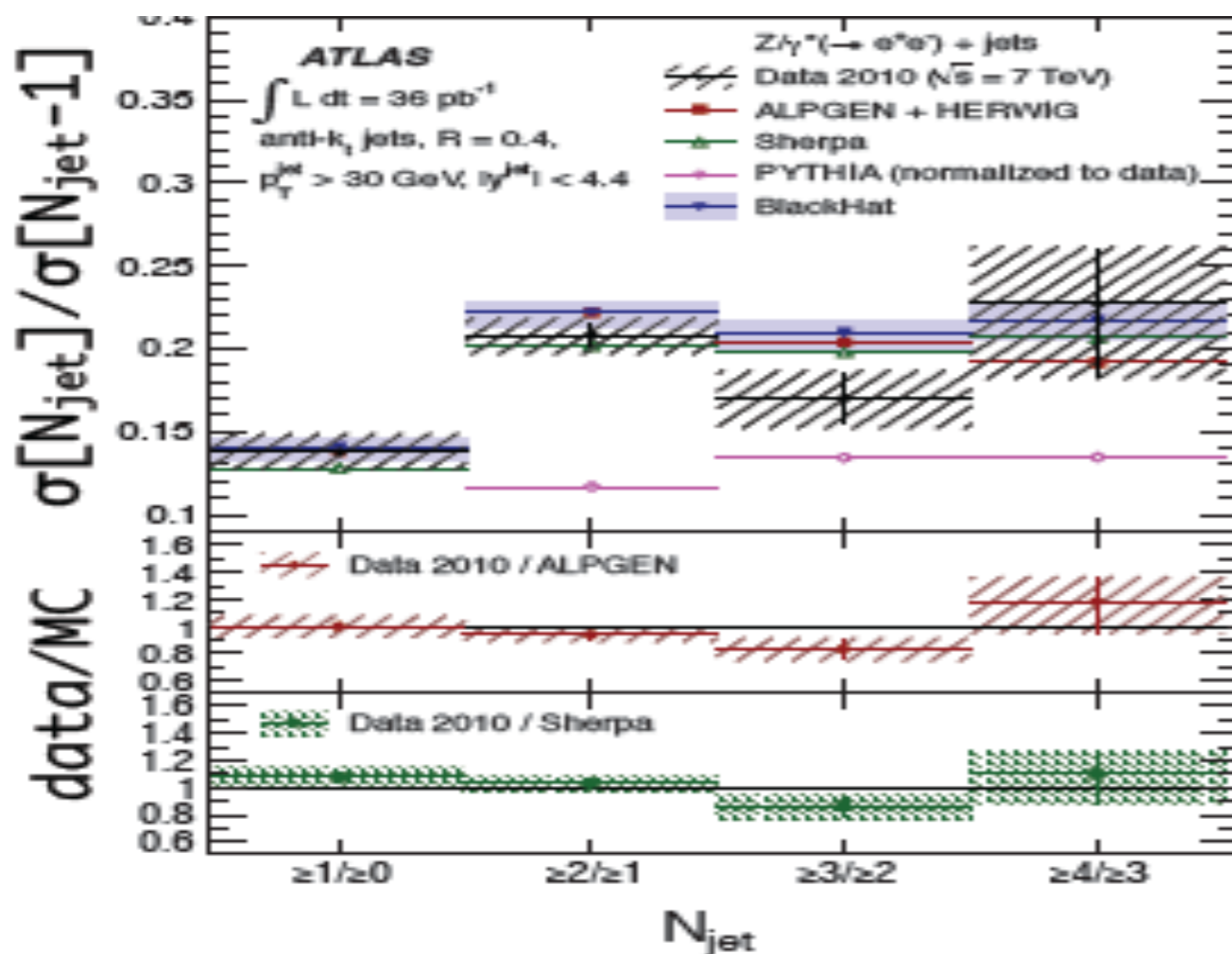
## Jets from jets (Nachman)



## Fuzzy Jets (Nachman)



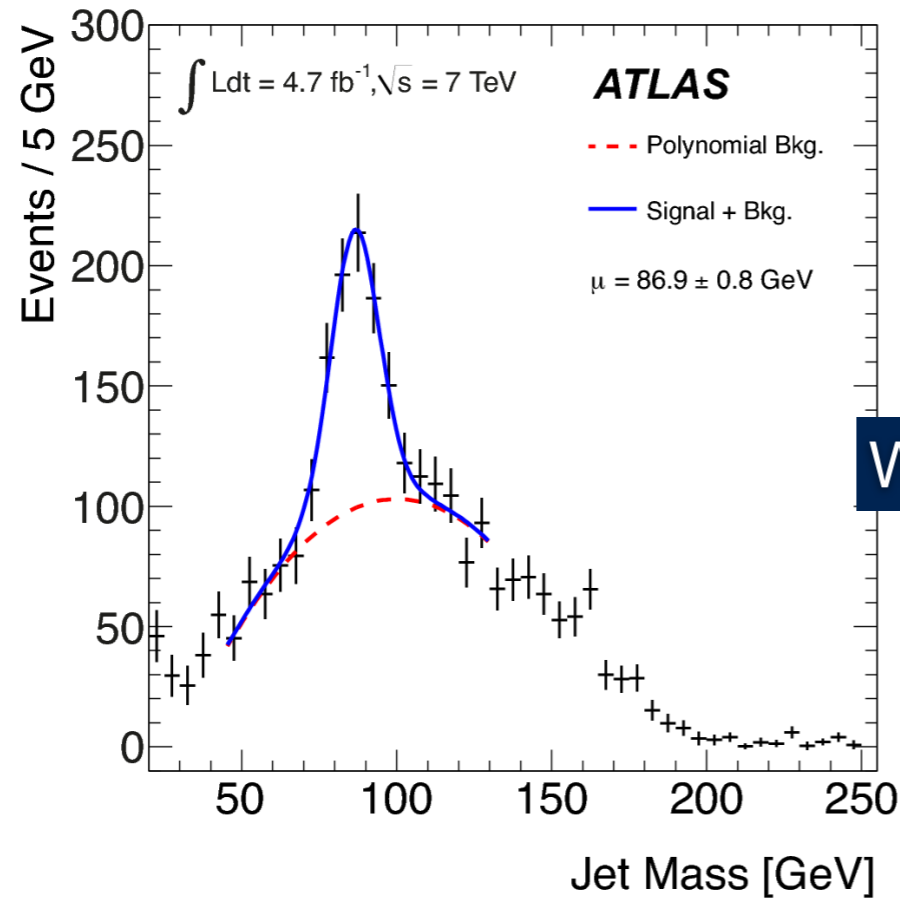
# Extensive Contact with MC Community



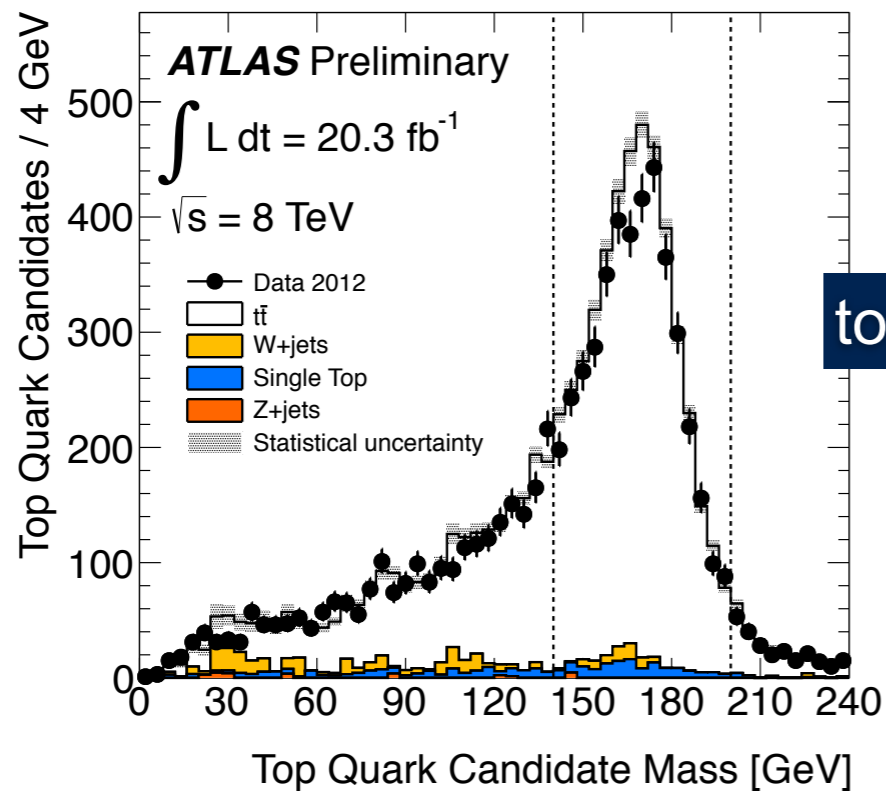
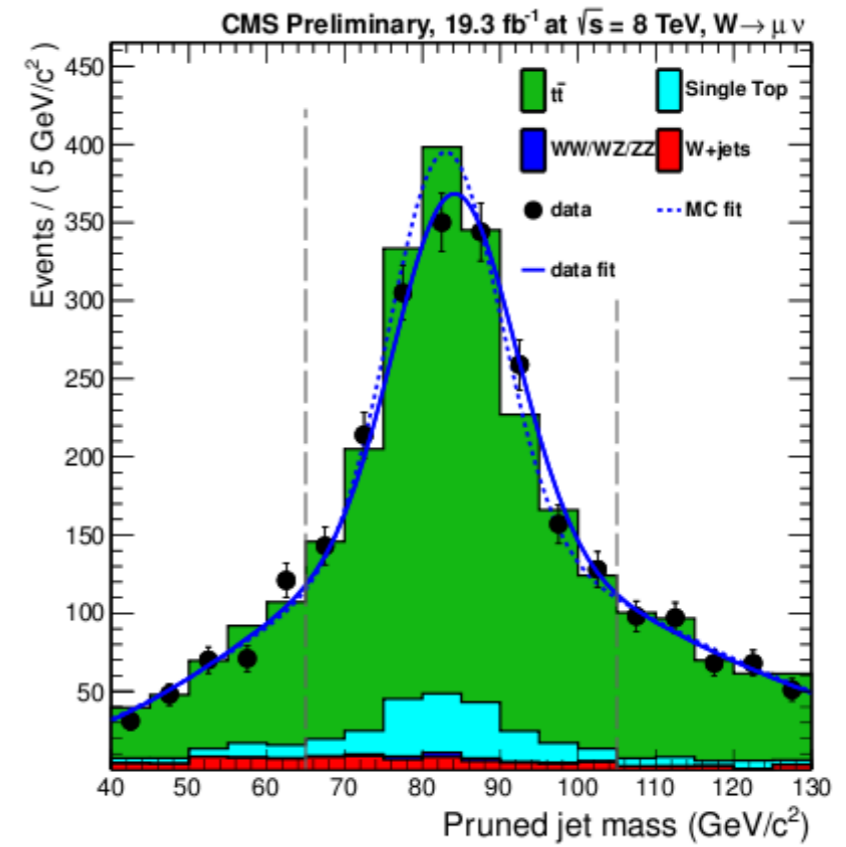
- Also informing decisions about which generators to use!
  - E.G. CMS switching to PYTHIA8 for most analyses driven by agreement in substructure variables!



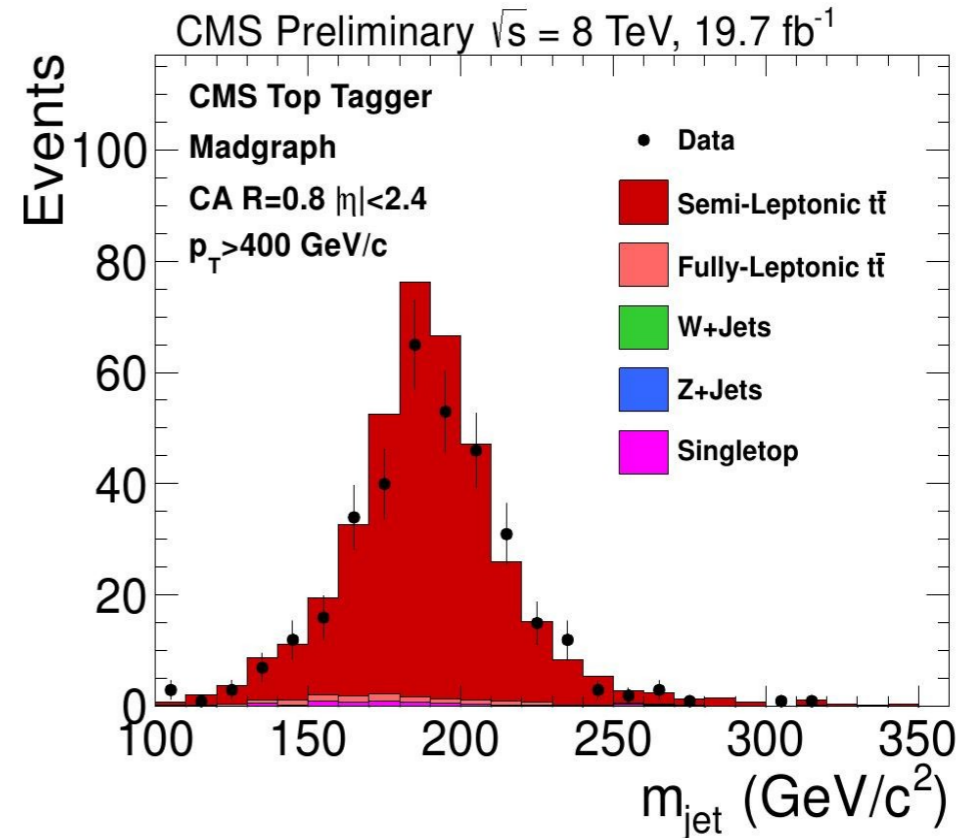
# Jet Tagging



W tagging



top tagging

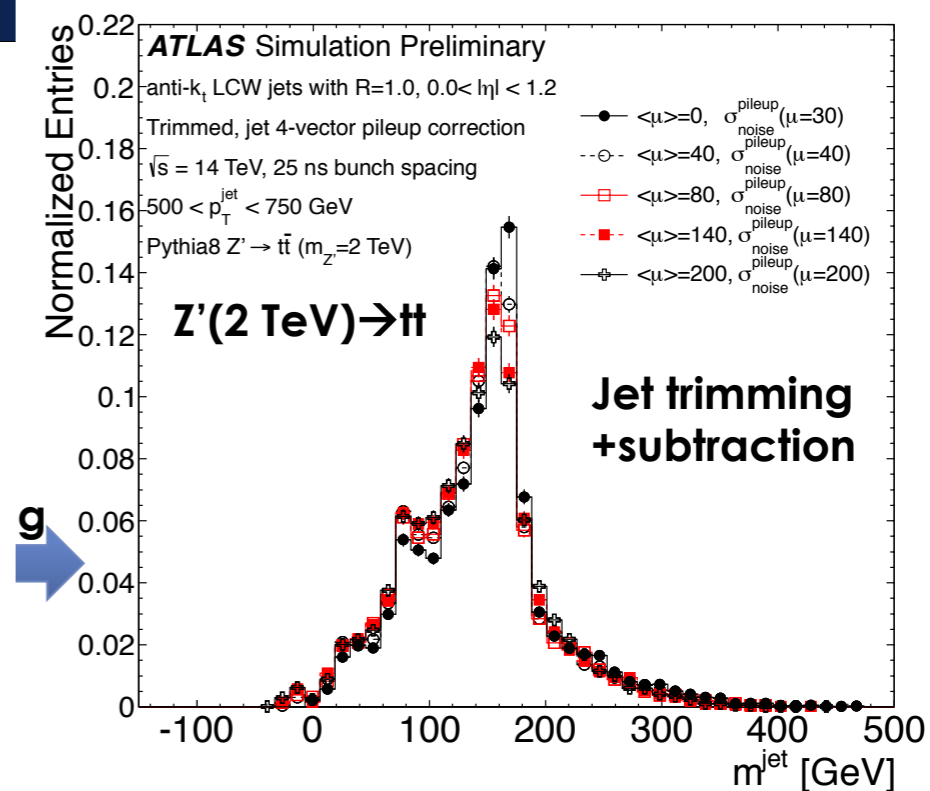
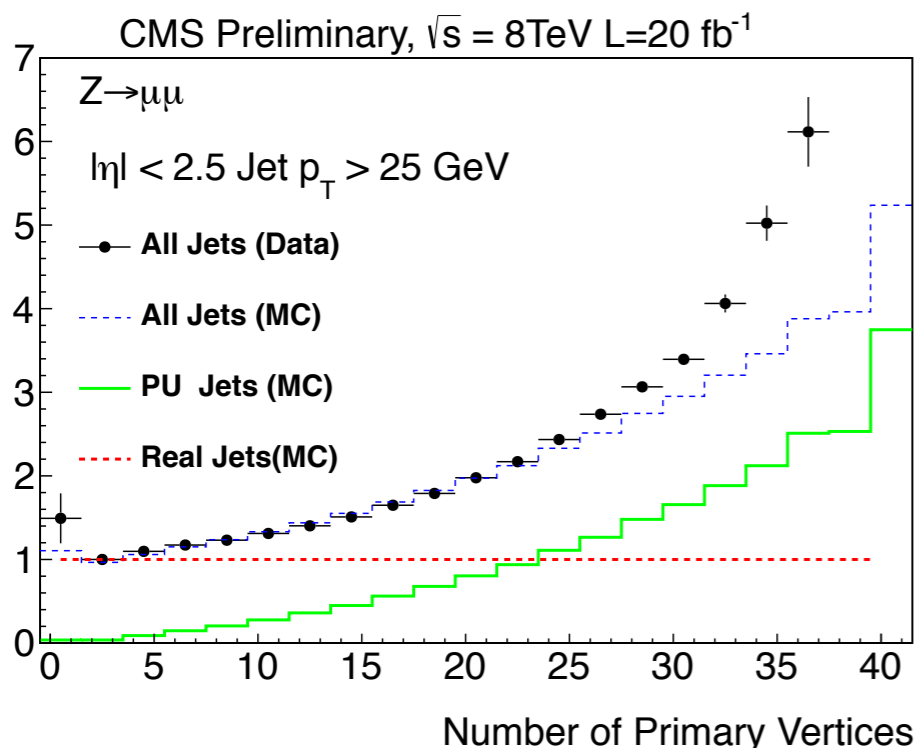




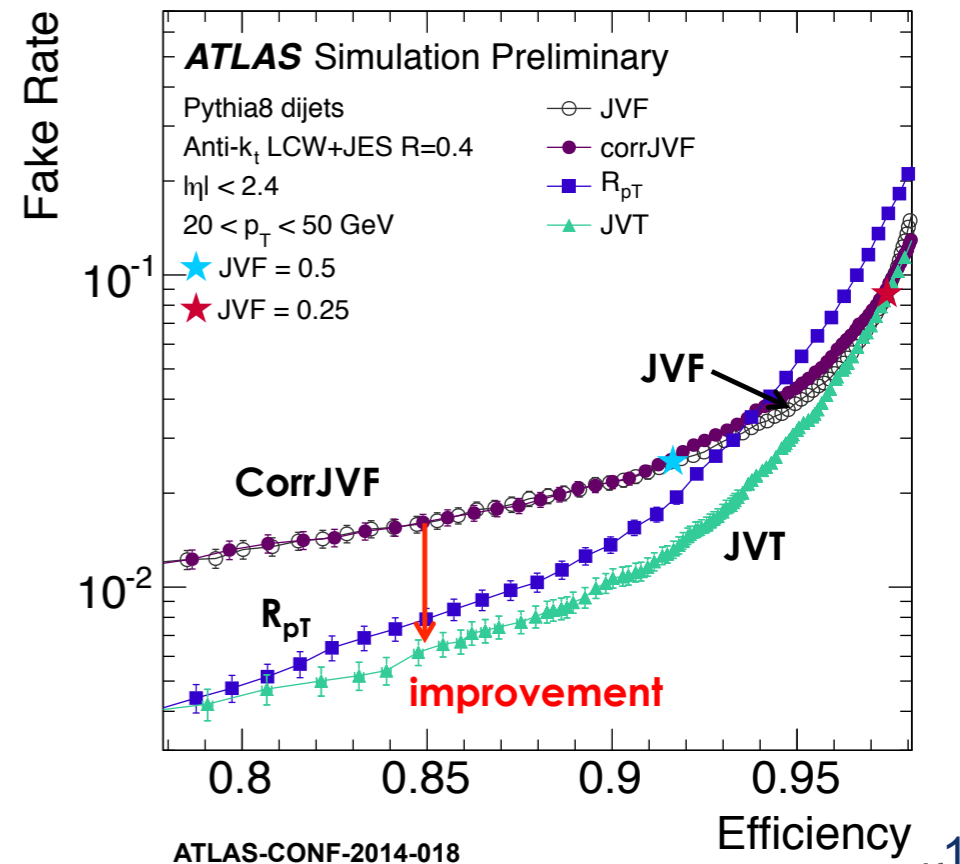
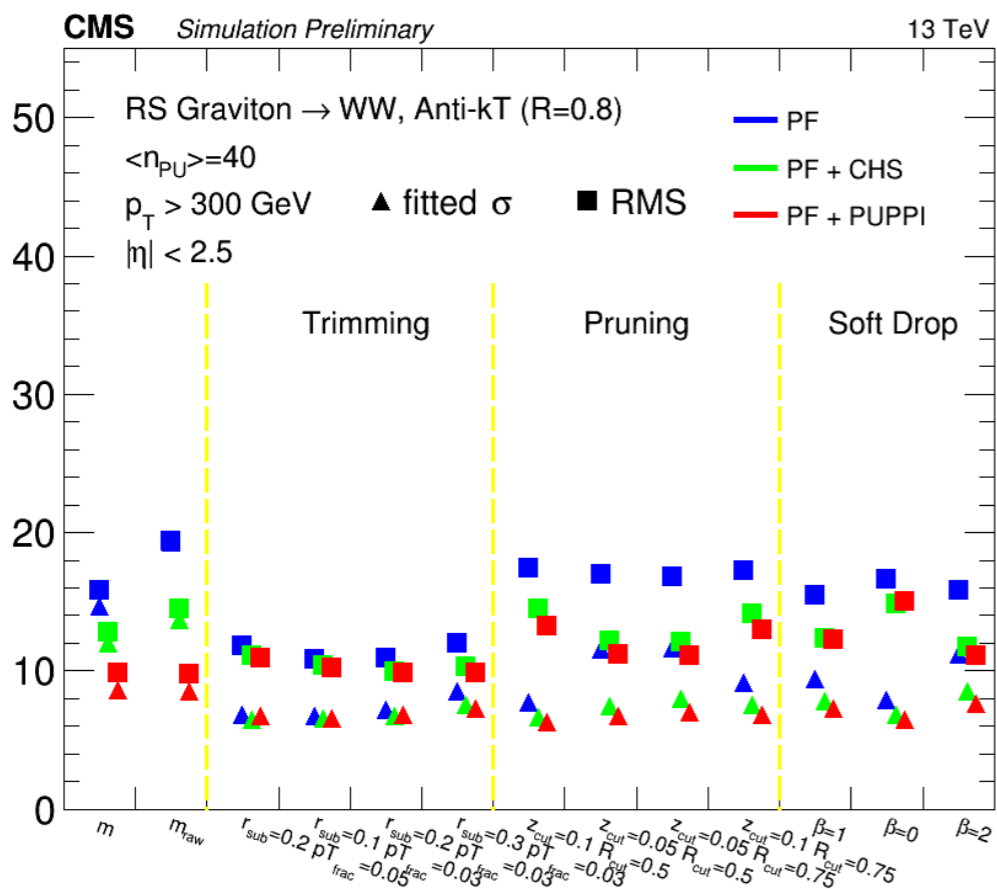


# Pileup Mitigation

All/Real Jet Rate



Resolution (GeV)

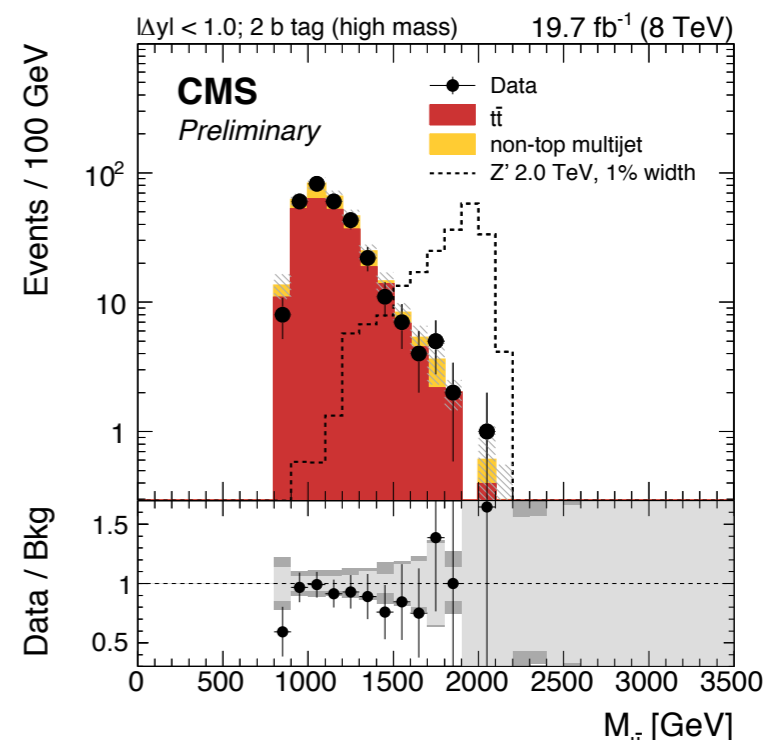
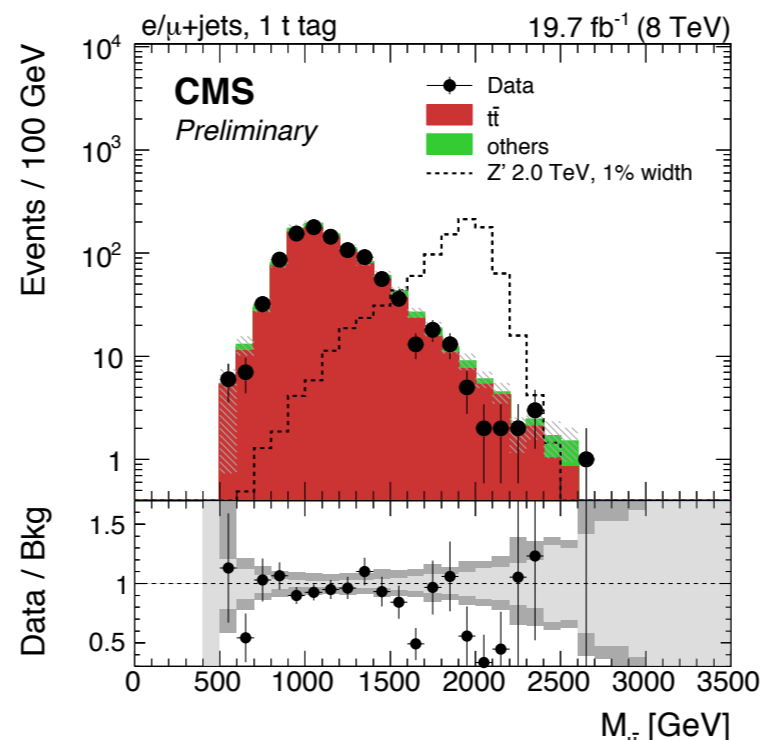
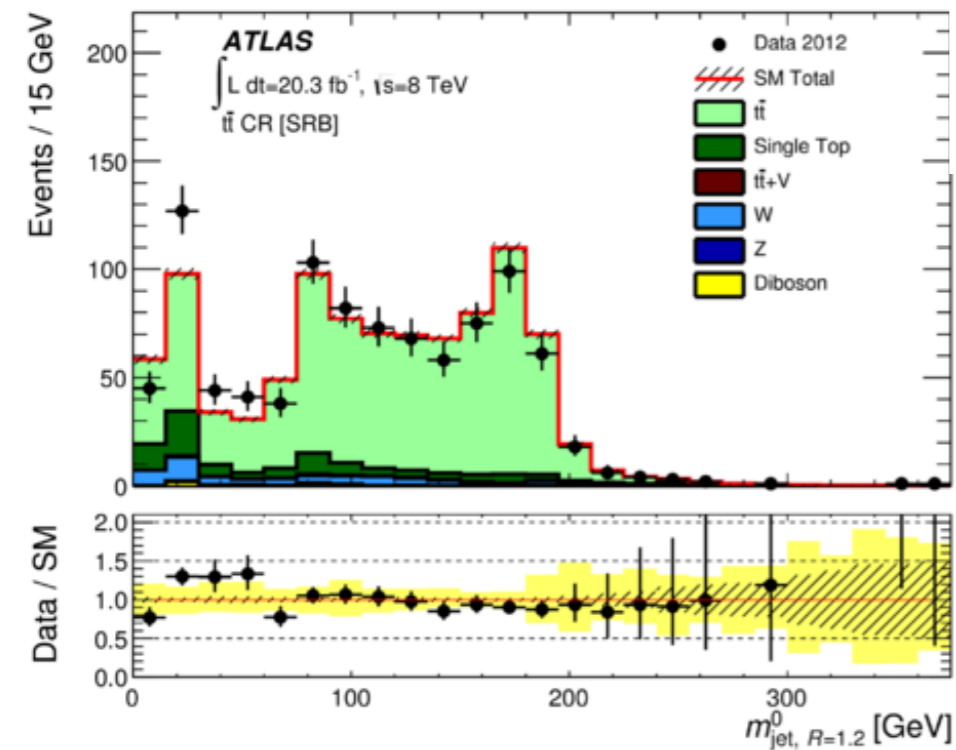
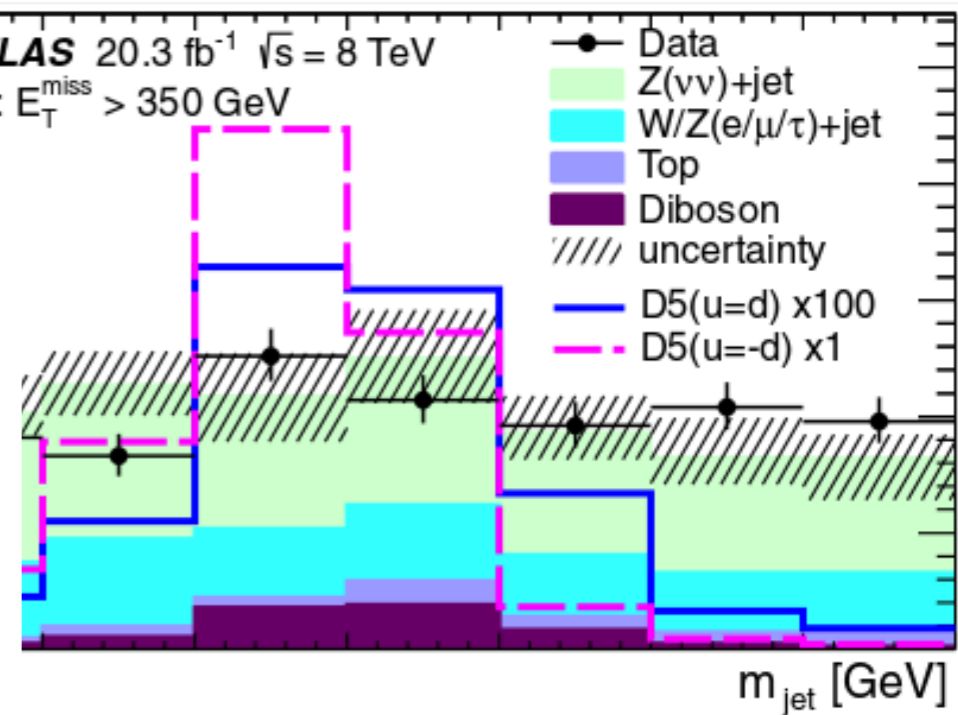
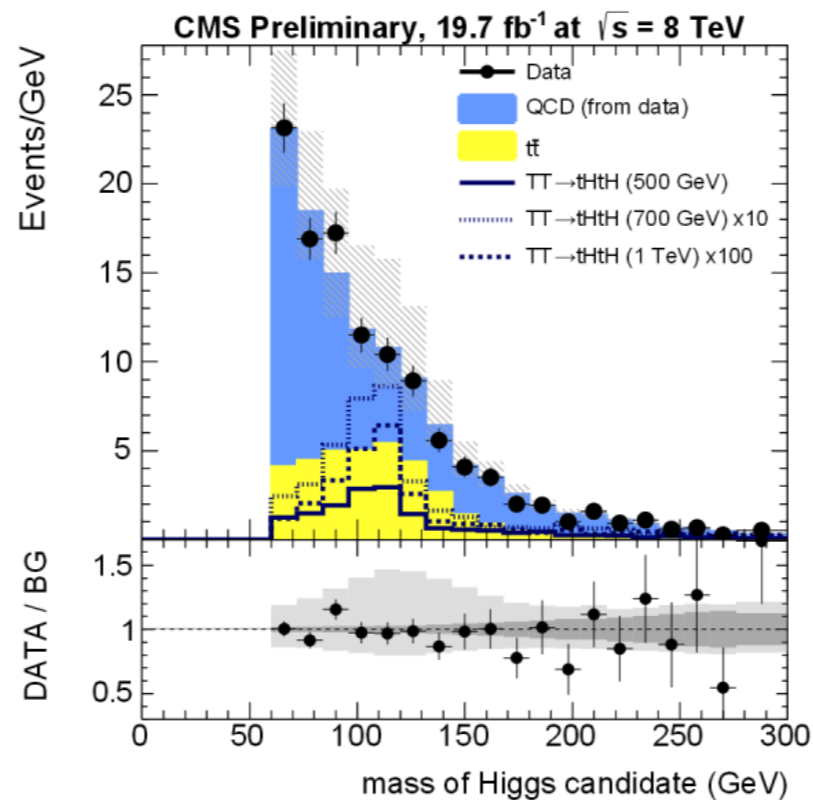
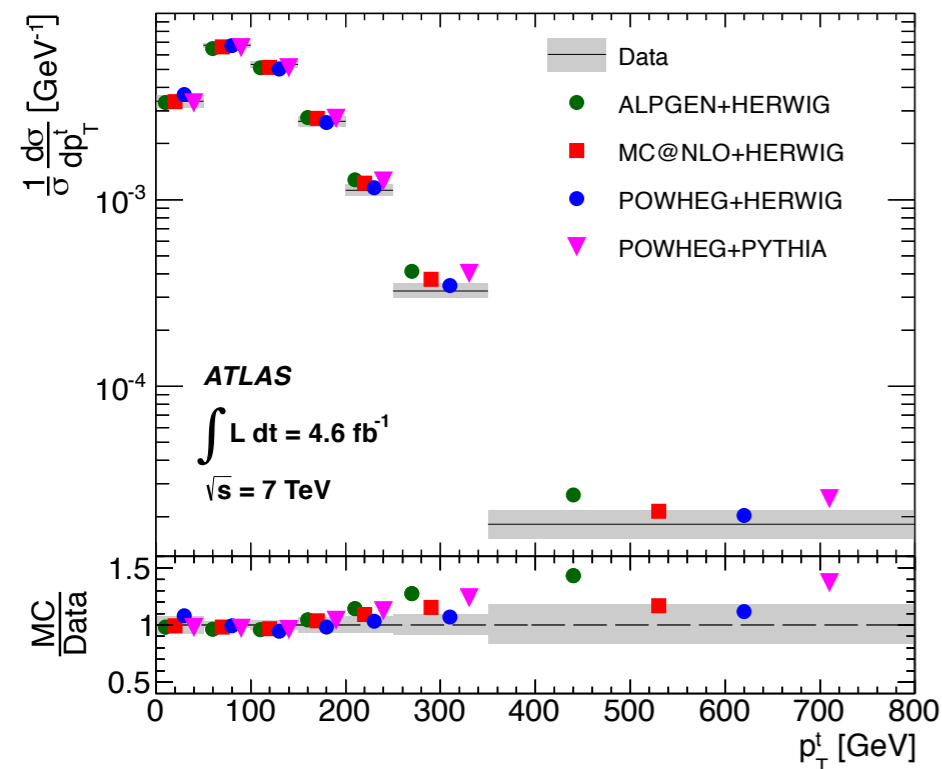






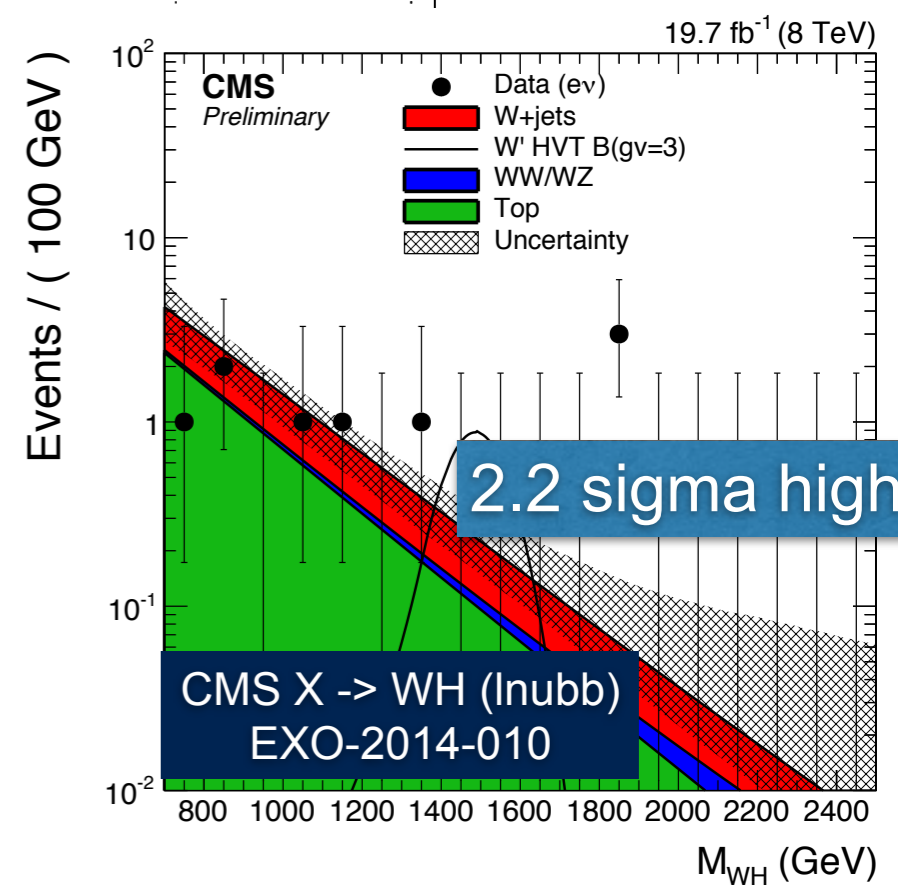
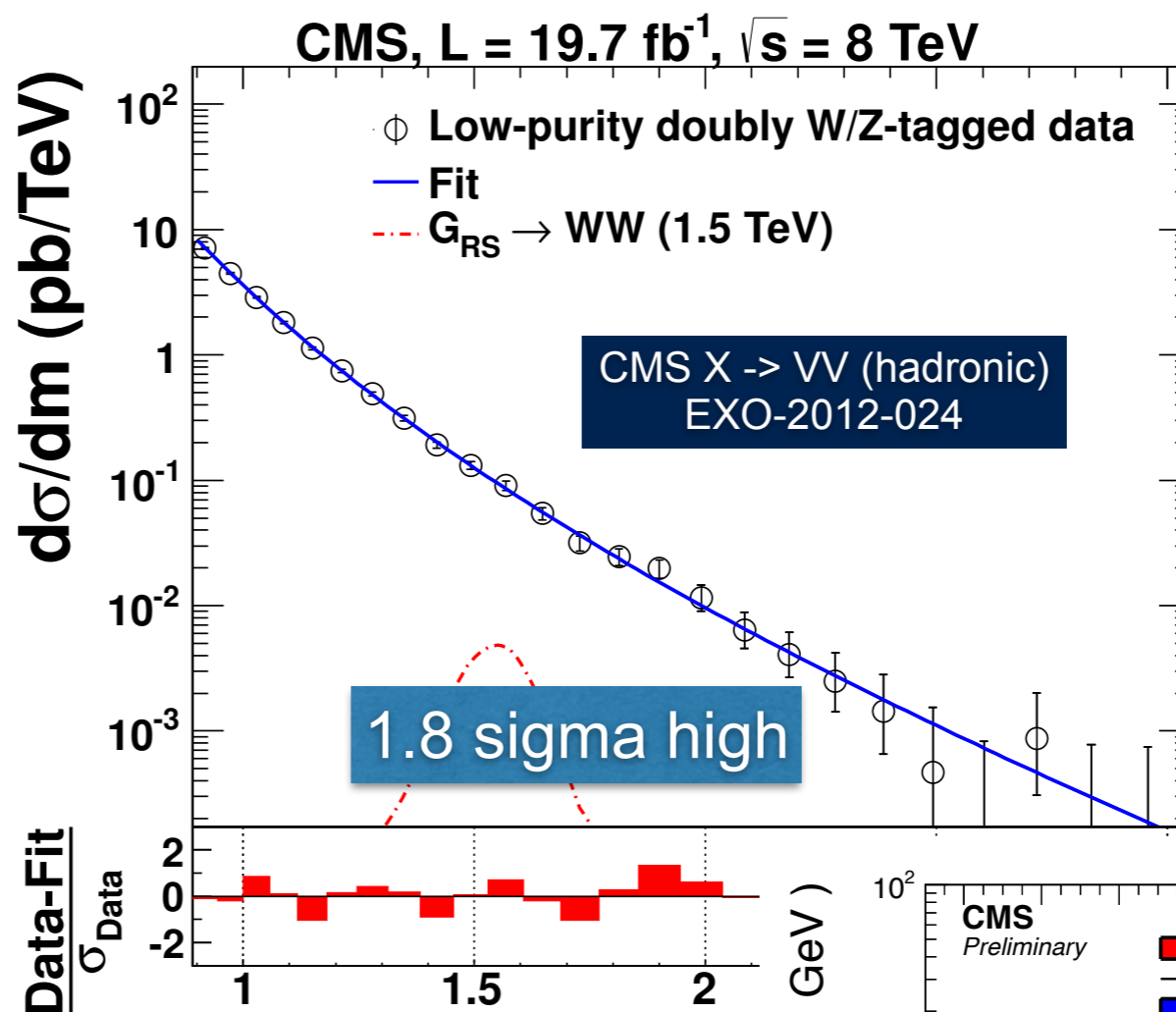
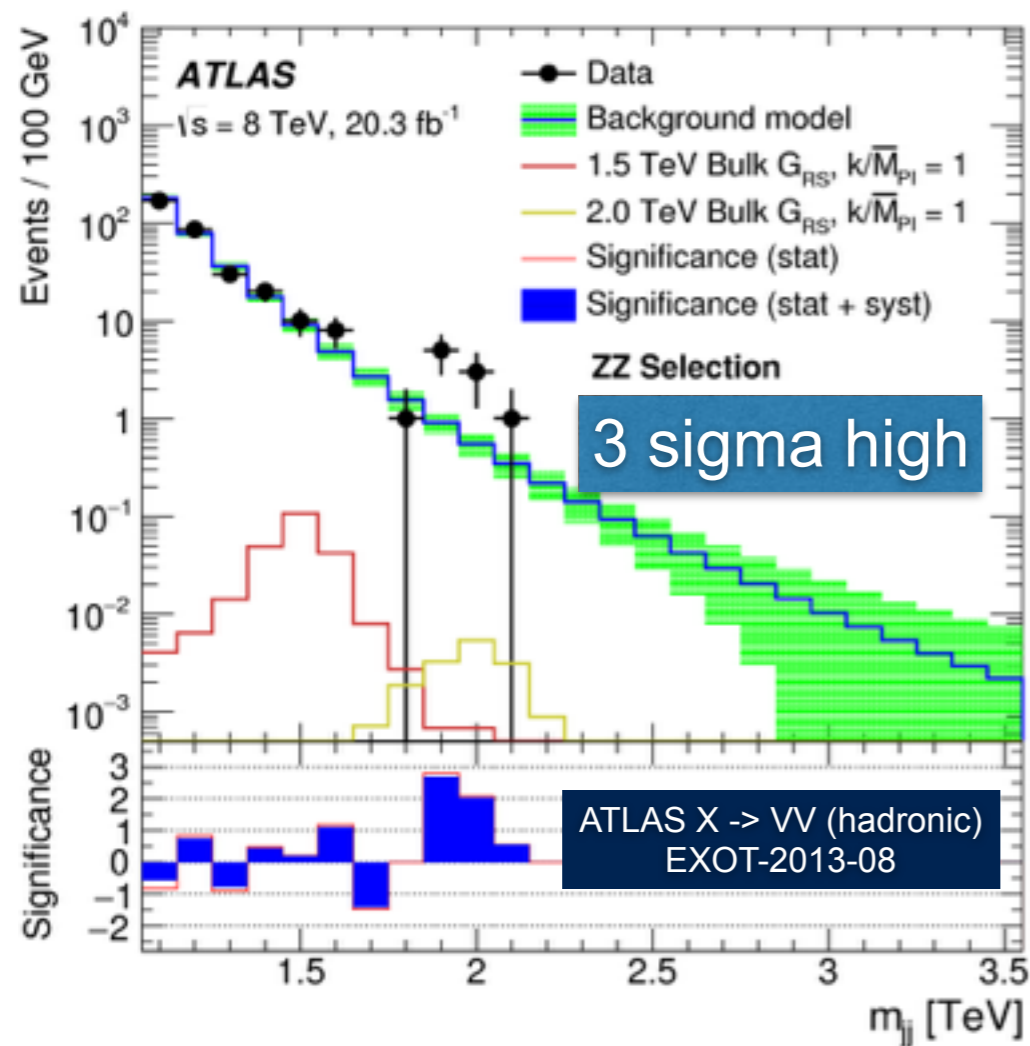
# Applications : Too Many To List!

$$\frac{1}{\sigma} \frac{d\sigma}{dp_T^t} :$$





# Diboson Excitement?



All of Tuesday afternoon devoted to this!



# The BOOST Series Reports

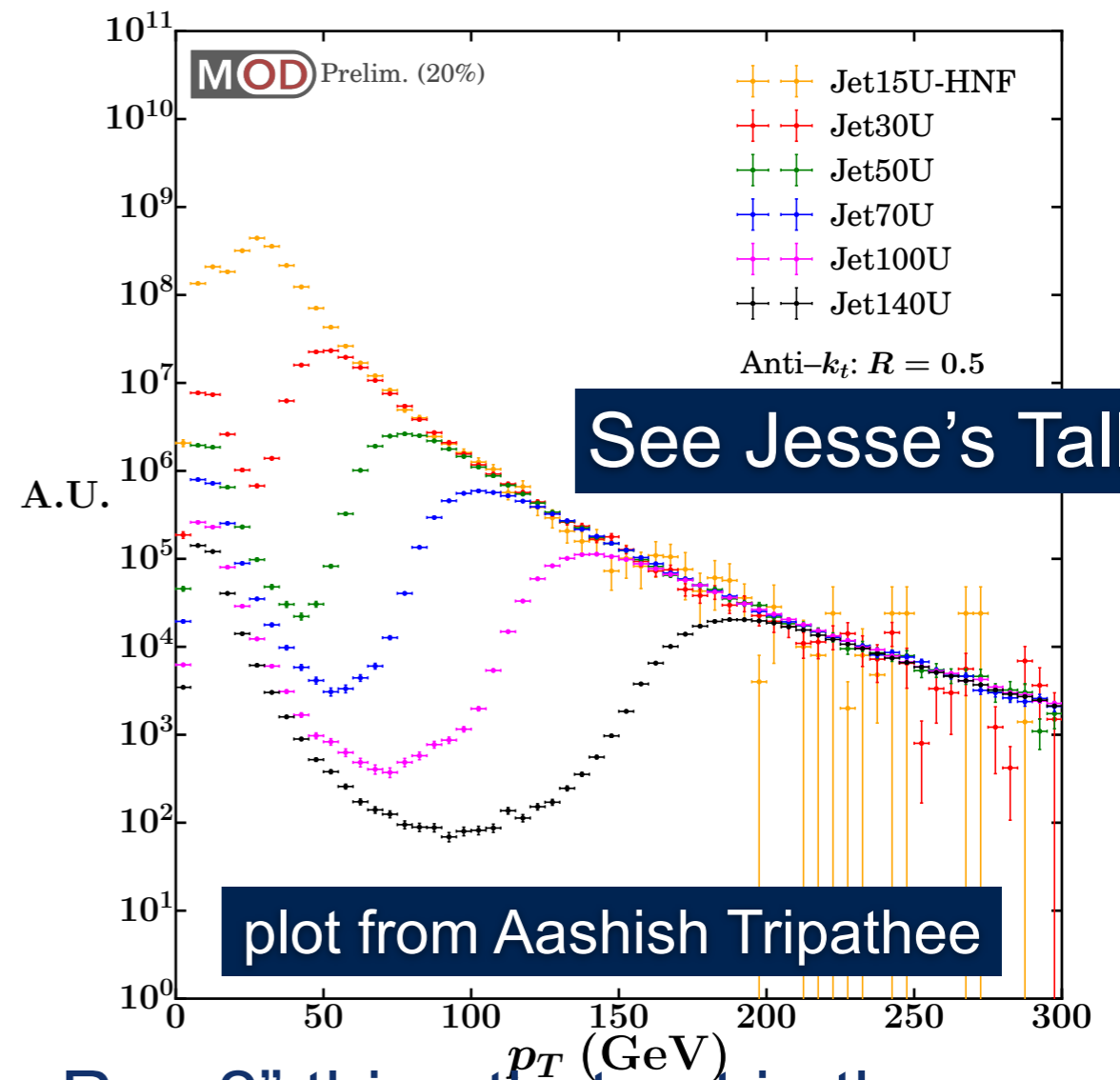
- 2010 :
  - Boosted objects: A Probe of beyond the Standard Model physics
- 2011:
  - Jet Substructure at the Tevatron and LHC: New results, new tools, new benchmarks
- 2012 :
  - Boosted objects and jet substructure at the LHC
- 2013 :
  - Towards an Understanding of the Correlations in Jet Substructure





# BOOST 2014 Report?

- The interest was low to write a BOOST report from the community
  - In retrospect, need to have the “working sessions” before people leave to get motivated and organized
- Partially people’s time was split with the Pileup Mitigation Workshop
  - The idea of combined proceedings was kicking around
- A few ideas were kicking around, but not enough for a full paper :
  - “Riveted” boosted tools
  - Using CMS open data
- Also, there’s that pesky “Get ready for Run 2” thing that got in the way of many people ;)







# BOOST 2014 Report?

- Proposal 1 : add the BOOST 2014 and 2015 reports together, do actual work
  - Goals :
    - Pileup mitigation technique overview? Combine with PU mitigation workshop?
    - Combined theoretical and experimental ideas?
- Proposal 2 : 2014 report is “review” of field, no original work
  - Goals :
    - Highlight, compare, contrast, educate
  - Also add 2015?
- Discuss at session Friday!
  - Great opportunity for young people
  - Lots of visibility “outside” of experimental collaborations
  - High citation counts
  - **But we need people to do the work!**



# Boostamos

- Without further ado...

Let's boost!