Tracking the Identities of Boosted Particles

Zhenyu Han
Harvard University
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Outline

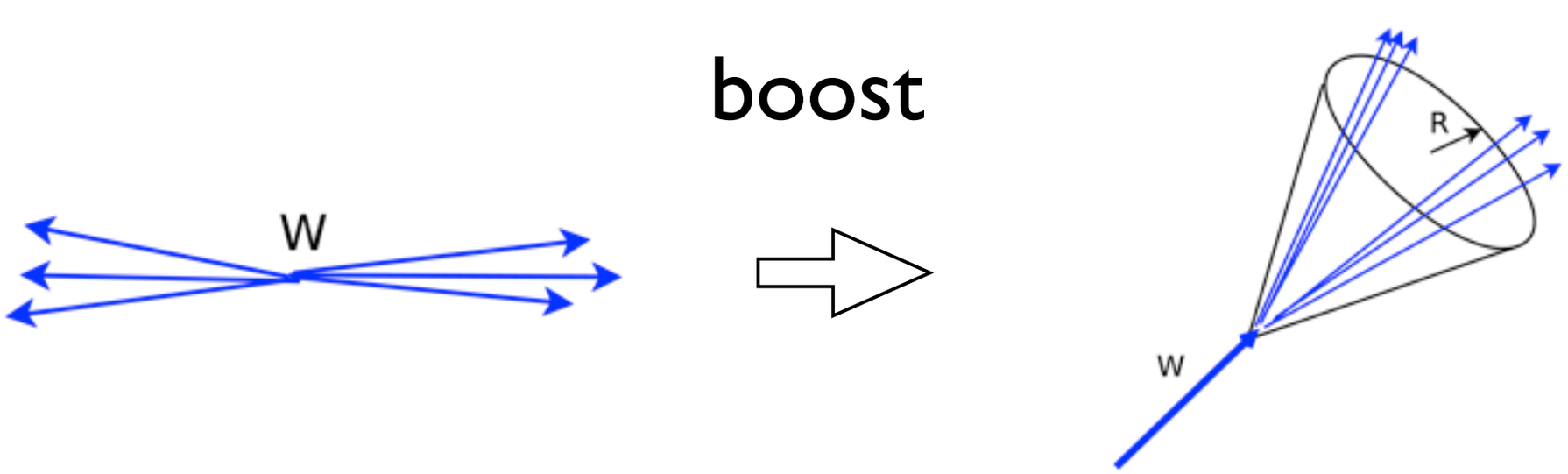
- Motivation: tagging boosted massive SM particles
  - W-jet as an example (top)
- Variables sensitive to jet radiation patterns
  - Orthogonal to jet grooming variables
  - Use tracking information
- Conclusion

Boosted particles at the LHC

- LHC probes TeV scale physics
- 'Heavy' SM particles become probes to new physics
  - W: 80GeV, Z: 91GeV, top: 175GeV, Higgs: 125GeV(?) << 1TeV
  - Need to standardize W/Z/top/(Higgs) tagging

The problem

- When highly boosted, hadronically decaying particles look like a single jet in a detector.



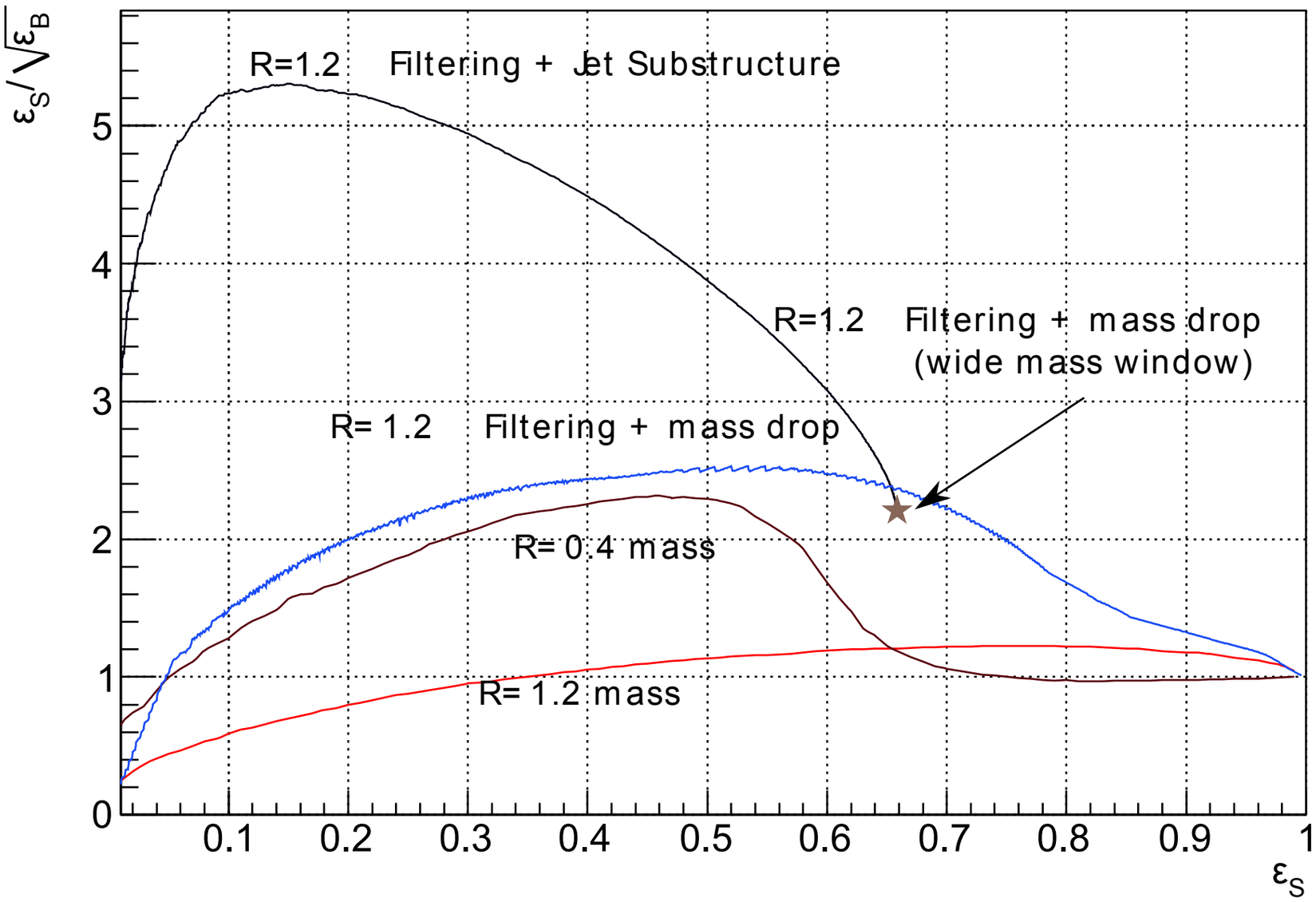
How to distinguish W-jet from QCD jets?

Same problem for Z/top/Higgs.

Jet substructure

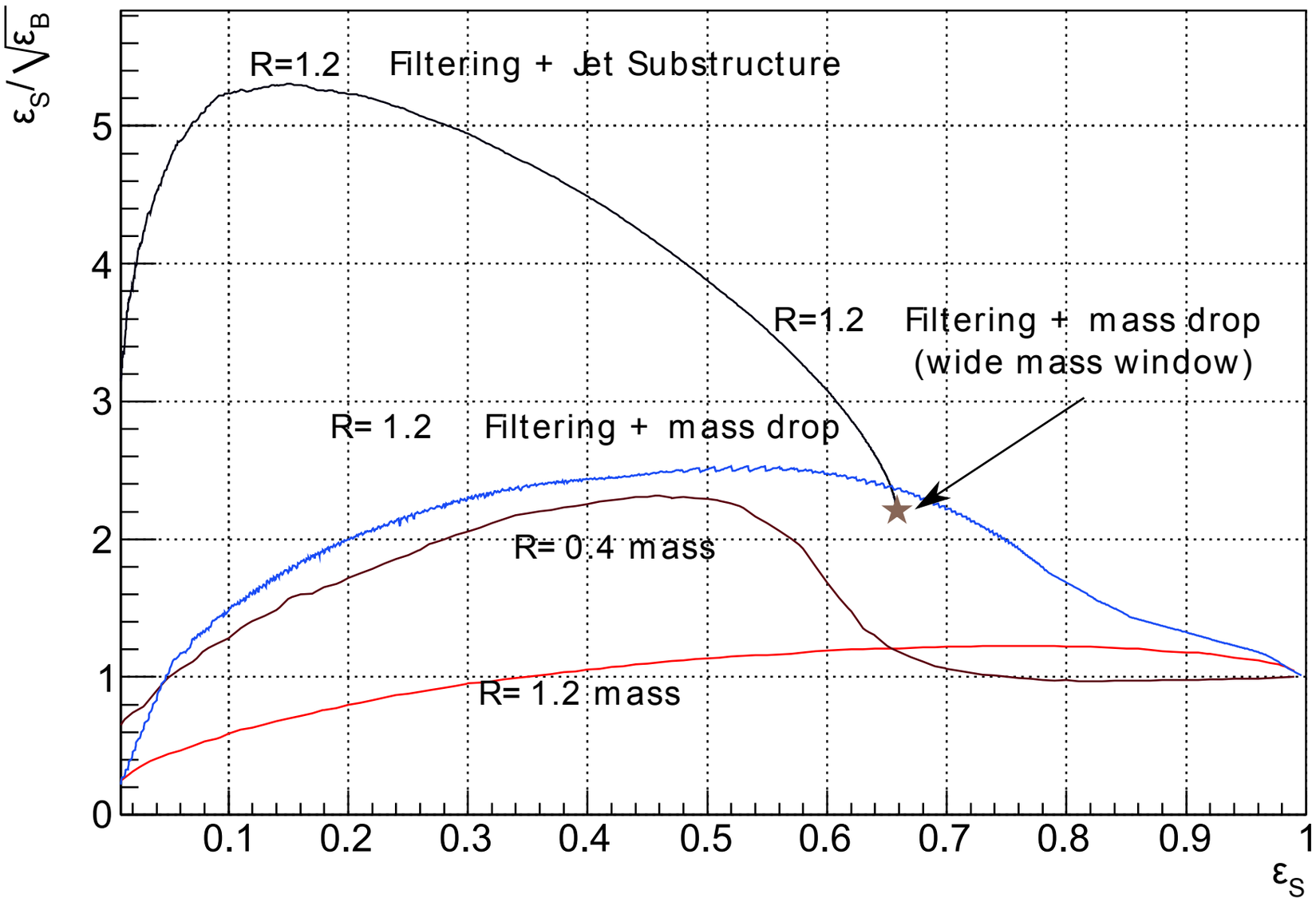
- Hard subjets
  - Filtering/pruning/trimming
- Jet shape variables
  - Jet mass, planar flow, N-subjettiness...
- Multivariate analysis

W-jet tagging (Cui, Han &Schwartz)



Significance improvement as a function of signal efficiency, PT=500GeV

W-jet tagging (Cui, Han &Schwartz)



20 variables used in multivariate tagger

Can we simplify? What are the best variables?

W jets vs QCD jets

- W jet: a hard spitting at 80 GeV

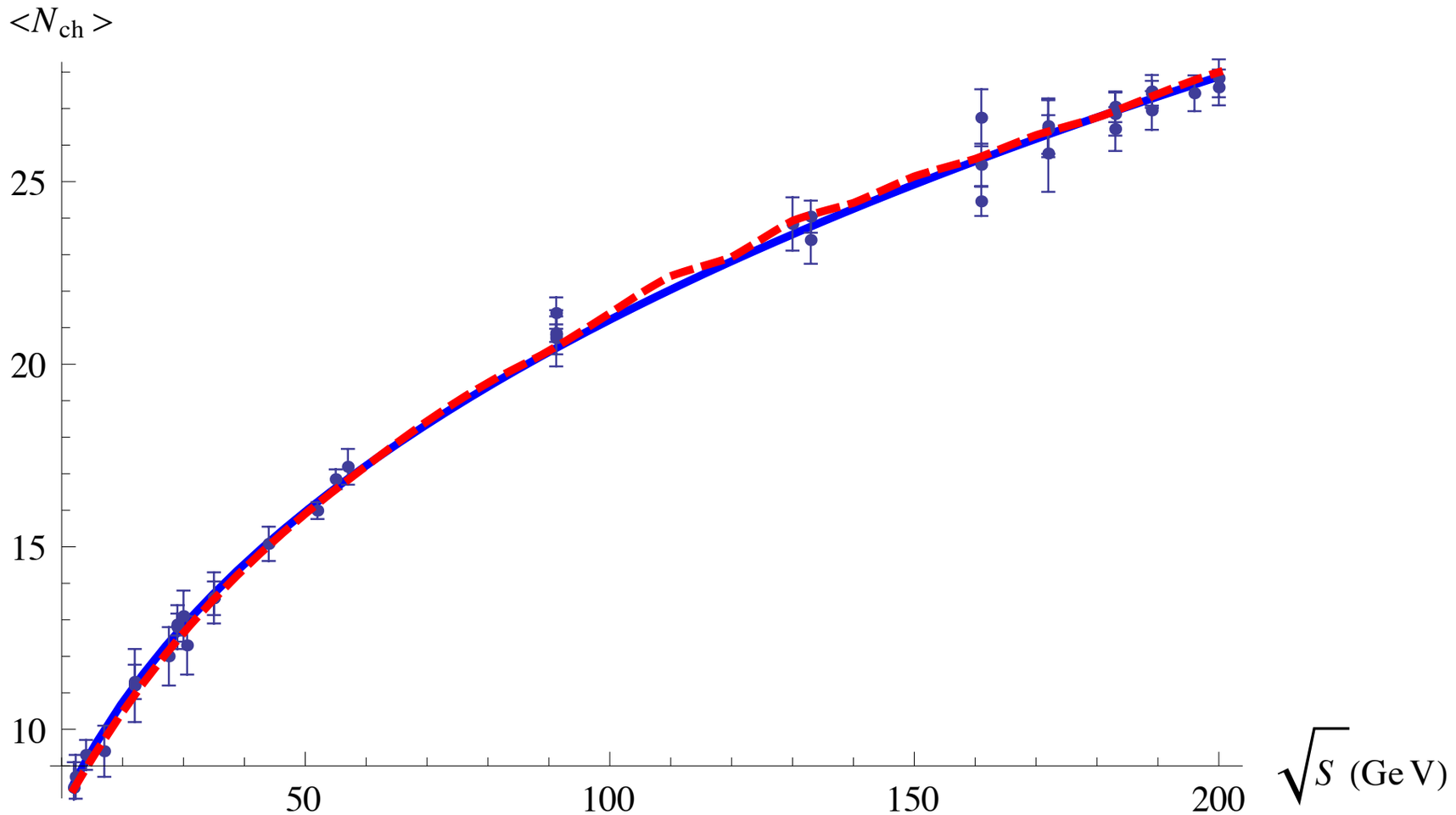
  QCD jets: colinear and soft splittings

  - Identify with jet grooming algorithms

- Radiation pattern: color singlet vs color octet/triplet

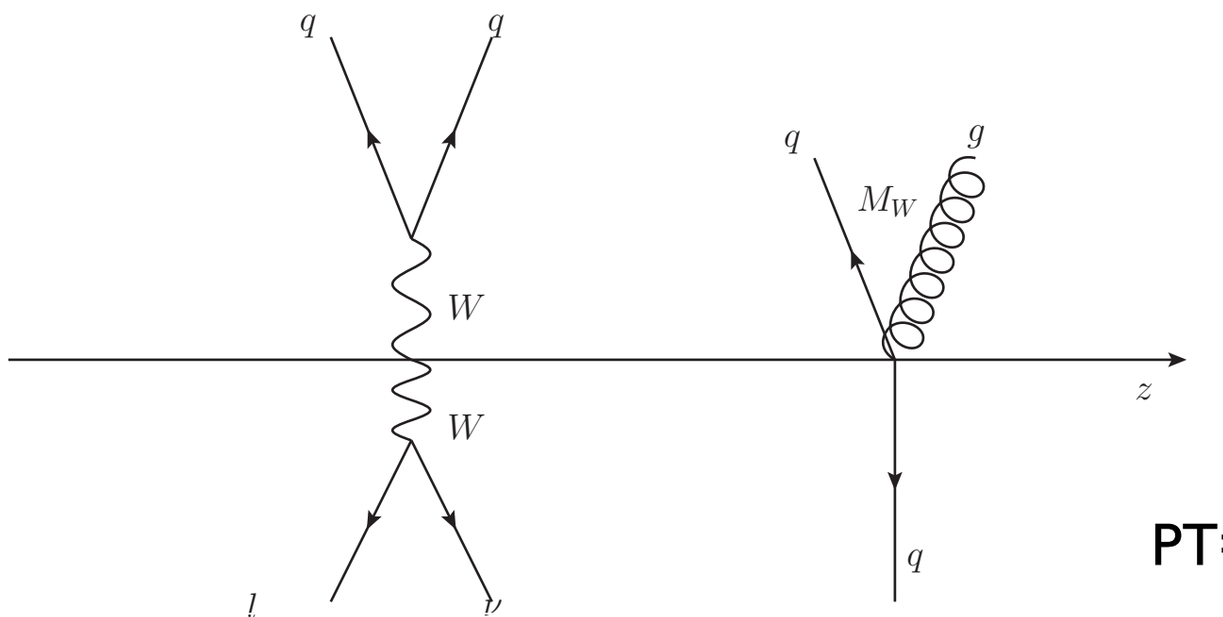
  - Charged particle multiplicity
  - N-subjettiness

Charged particle multiplicities at e+e- machines



Well understood
<Nch> grows slowly with CM energy

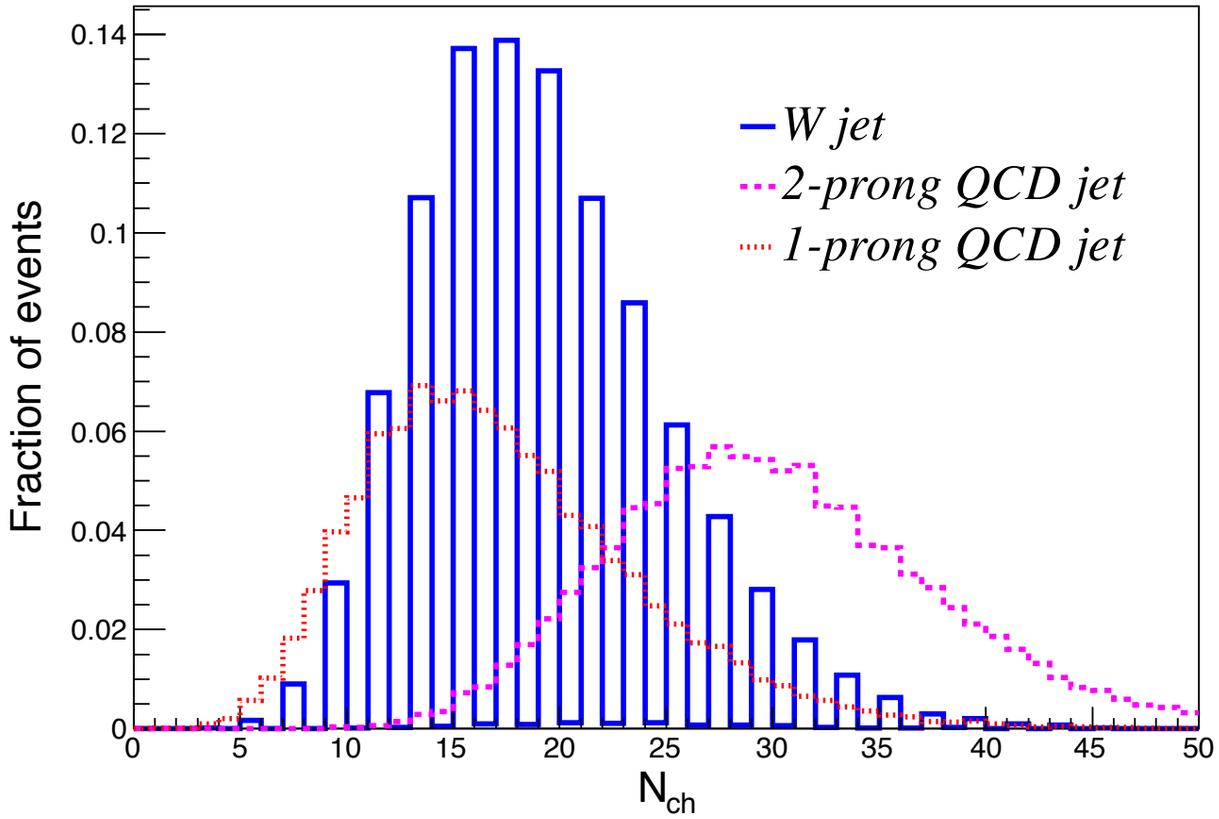
Special configuration

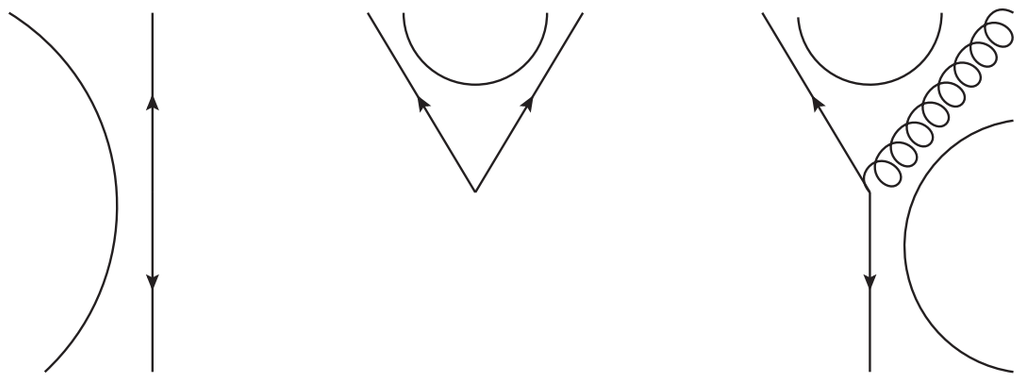


PT=500GeV

- W jets vs QCD jets with a hard splitting
  - Charged particle multiplicity
  - N-subjettiness

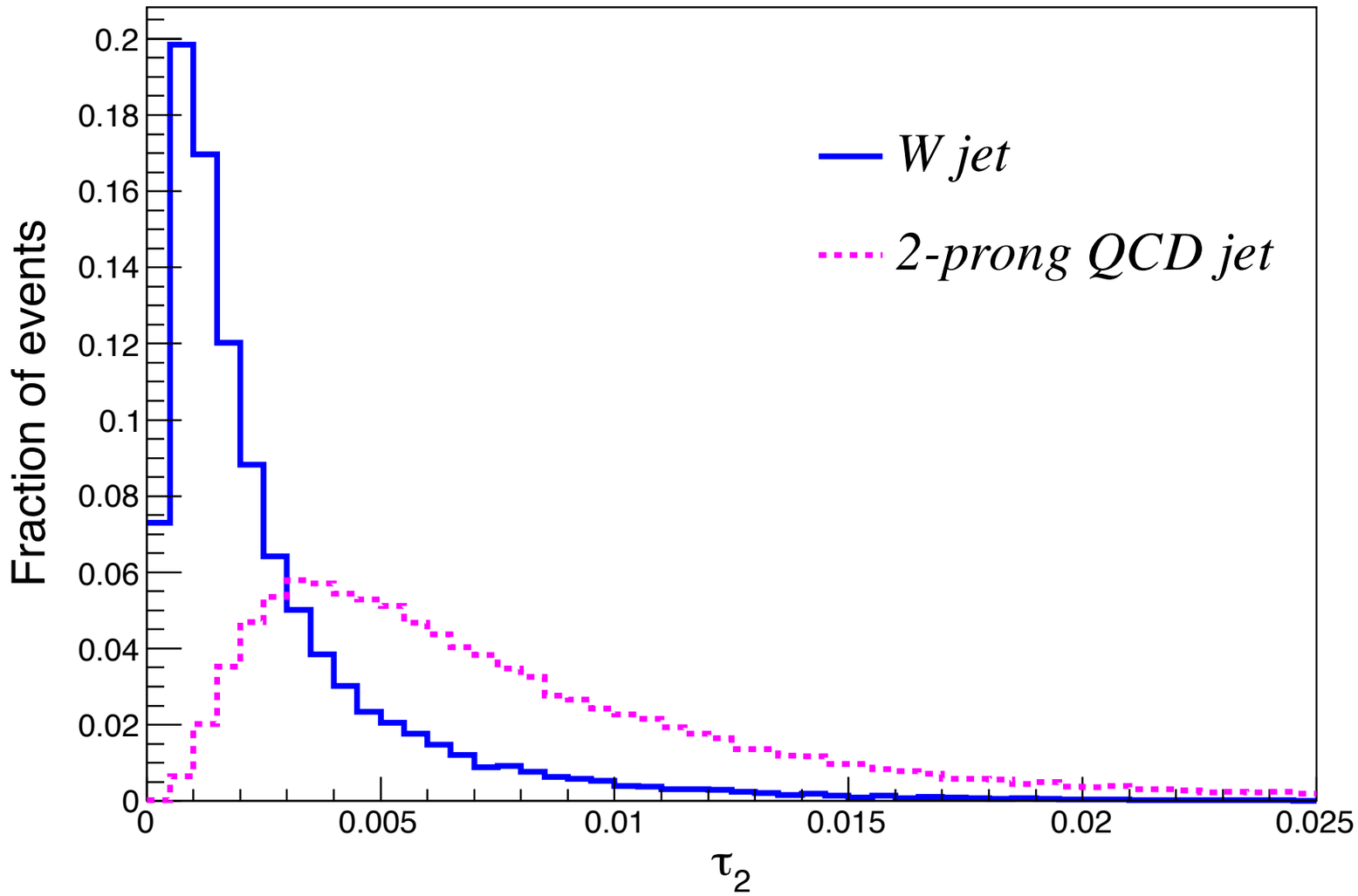
Charged particle multiplicity in special configuration





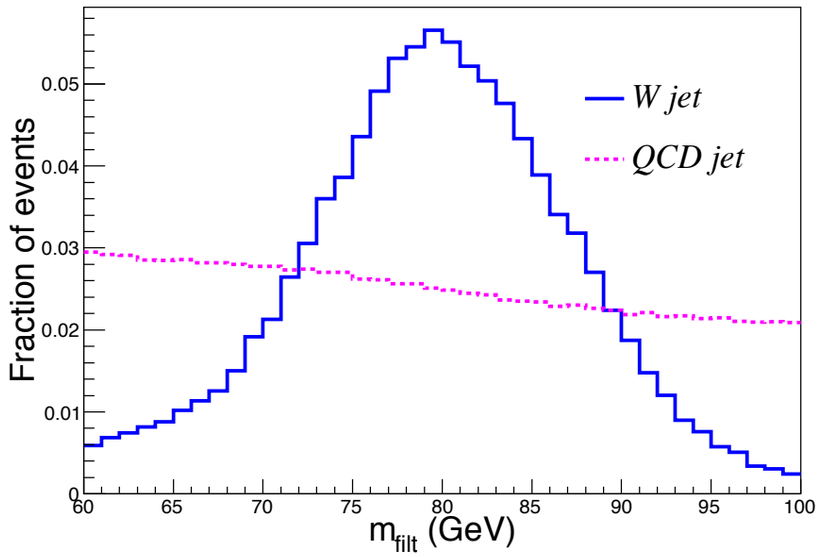
Nch ‘proportional’ to the number of dipoles

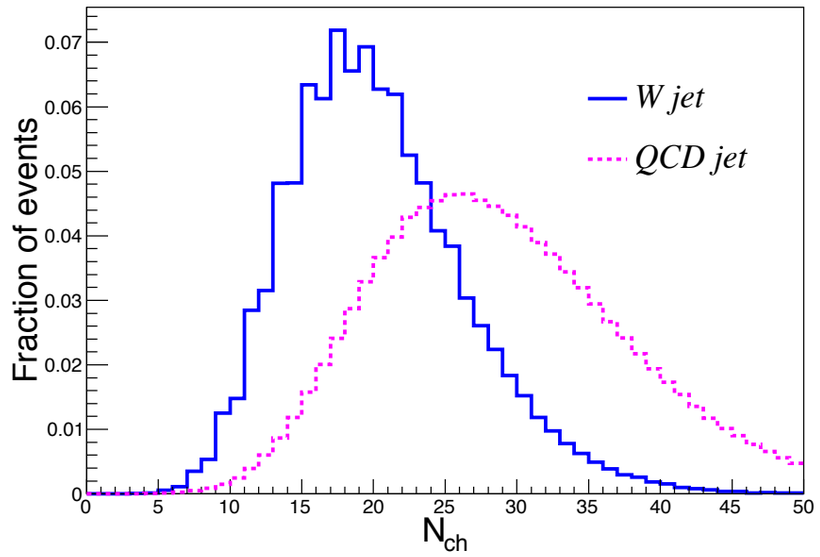
2-subjettiness in special configuration

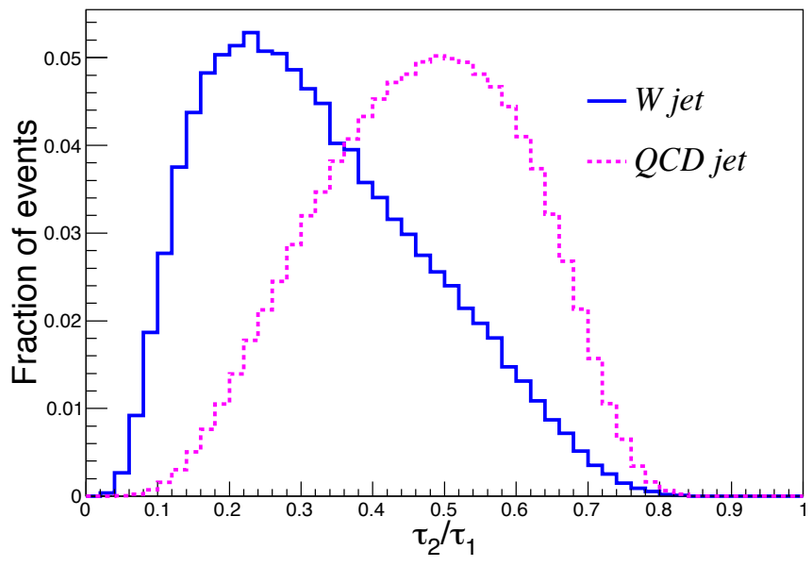


Used charged particles to calculate tau2

Application at the LHC





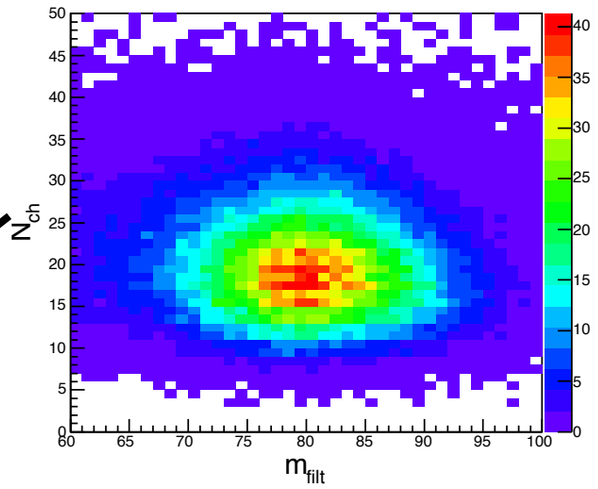


500 GeV jets, hard splitting identified with filtering.

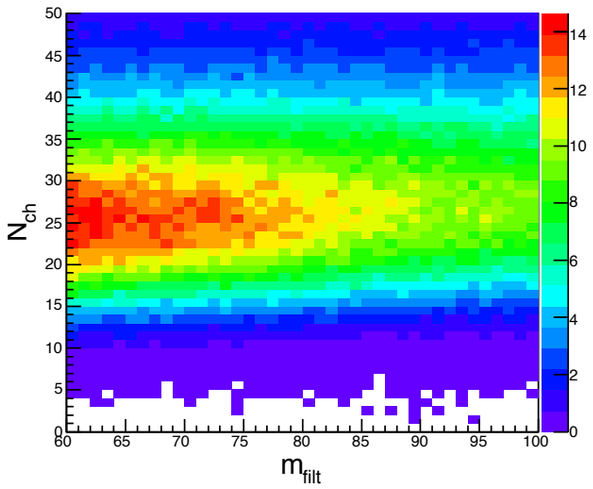
Correlations

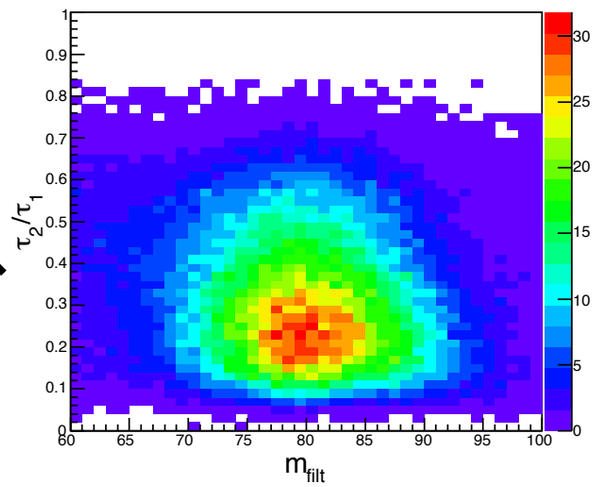
small correlation

large correlation

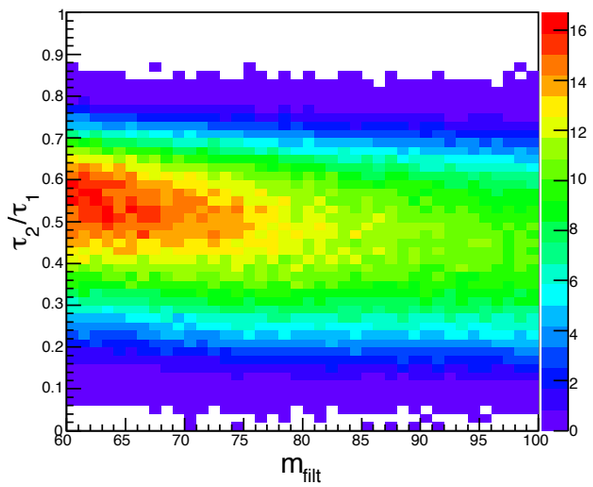


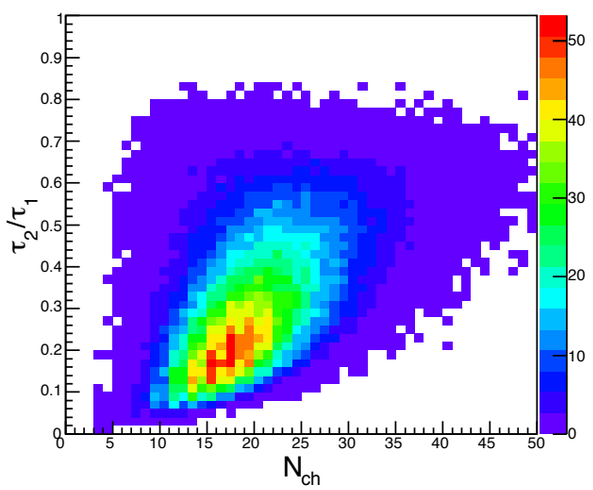
Mfilt vs Nch



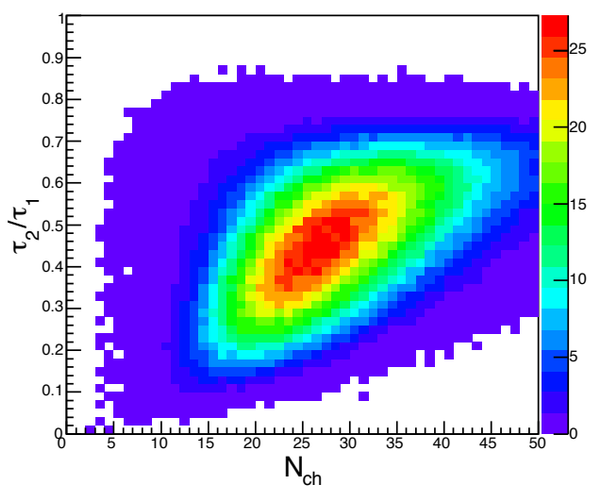


Mfilt vs tau2/tau1





Nch vs tau2/tau1



W

QCD

Improvement in significance

	m_{filt}	N_{ch}	τ_2/τ_1
m_{filt}	1.15	1.66 (1.59)	1.67 (1.58)
N_{ch}	-	1.34	1.55 (1.50)
τ_2/τ_1	-	-	1.39
all:	1.85		

Significance improvement over filtering (mfilt ~(60, 100) GeV)

What we learn?

- Classify jet substructure variables to those sensitive to the hard splitting scale and those sensitive to the radiation pattern, which are largely uncorrelated.
- To obtain the best discriminating power, we should combine the two different kinds of variables.

What about top jets?

- Z and Higgs very similar: color singlet
- Top more tricky: W within the jet, but top itself is colored. Work in progress.
  - The idea: simplify and relax the kinematic cuts, add charged multiplicity or other variables sensitive to radiation patterns.
  - preliminary results showing improvement

Conclusion

- To best distinguish W/Z/Higgs/top jets from QCD jets, combine variables sensitive to hard splitting and those sensitive to radiation patterns (color structure)
- Tracking is very useful for studying jet radiation pattern
  - Charged particle multiplicity unique to tracking
  - Other variables can be also defined with charged particles