Remarks on top reconstruction from low to high p_t

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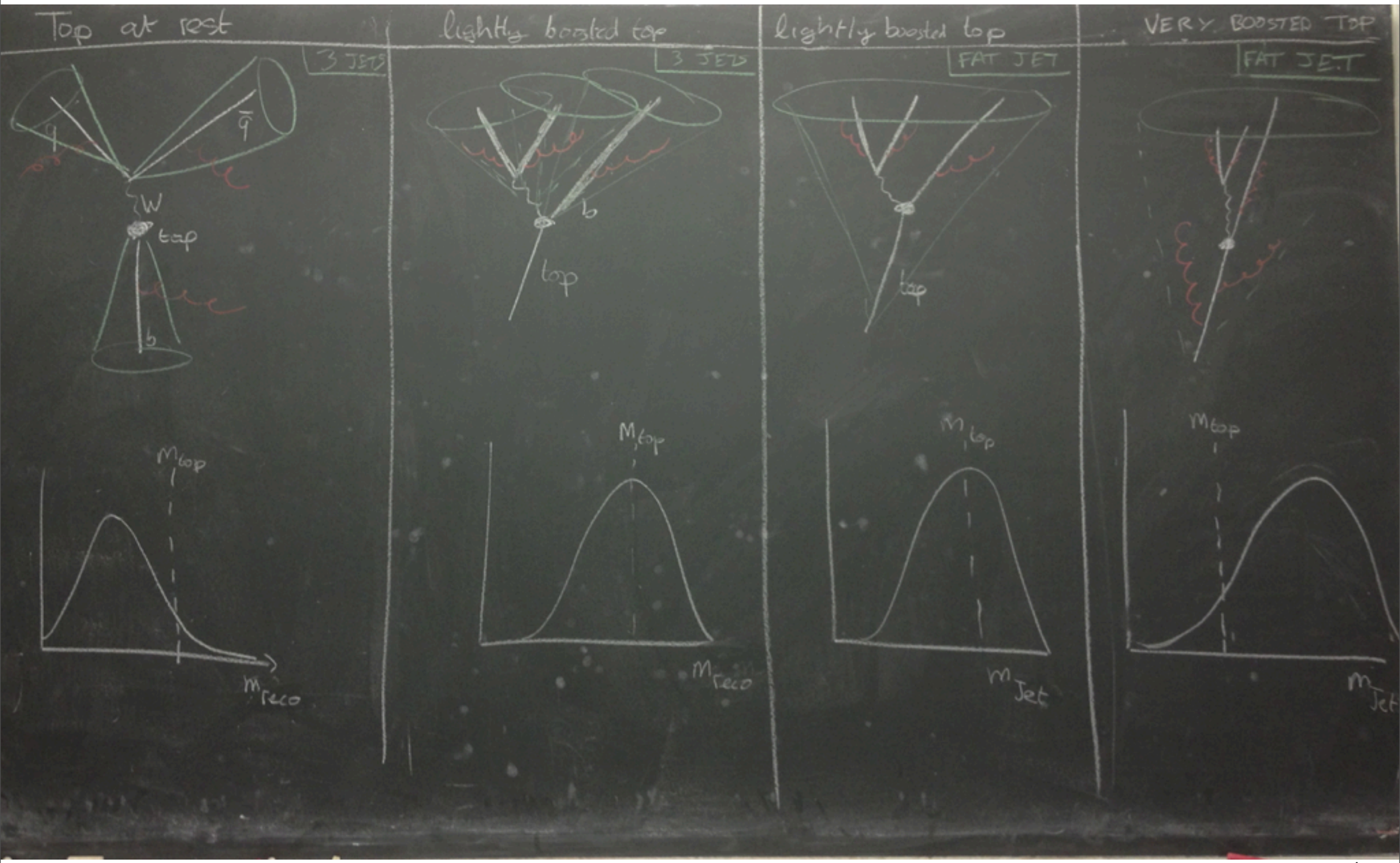
for ATLAS top WG

Outline

- Top quarks v. top jets, as a function of p_t
- Understanding taggers
- Pileup and boosted tops
- Top kinematics at high p_t

Top quarks,
Tops from quark-jets &
Top fat-jets

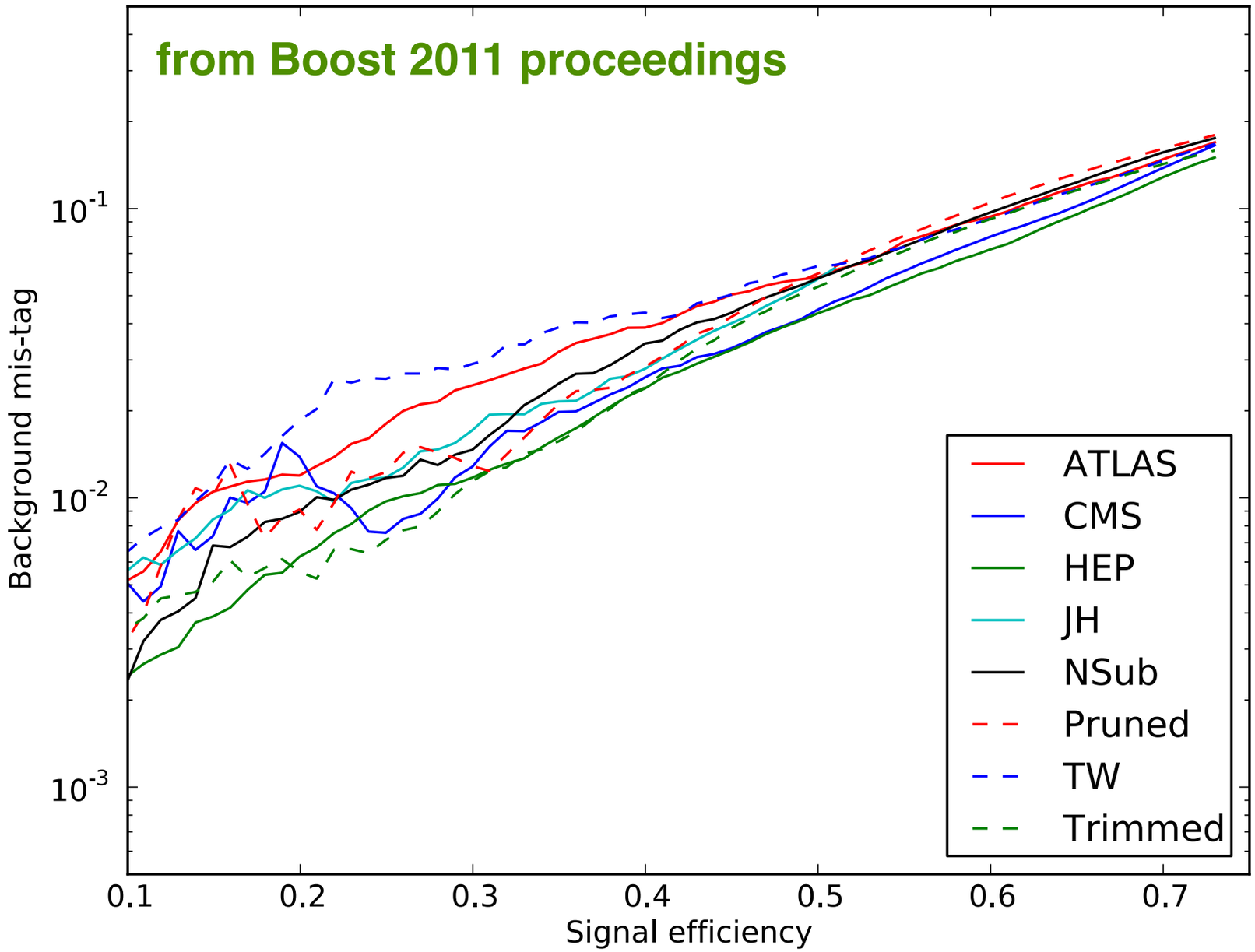
3-jet mass or fat-jet mass v. boost



Which boosted top tagger?

Some elements to think about when choosing

Many different top taggers



(c) HERWIG++

Different fat-jet tagger types

Prong based

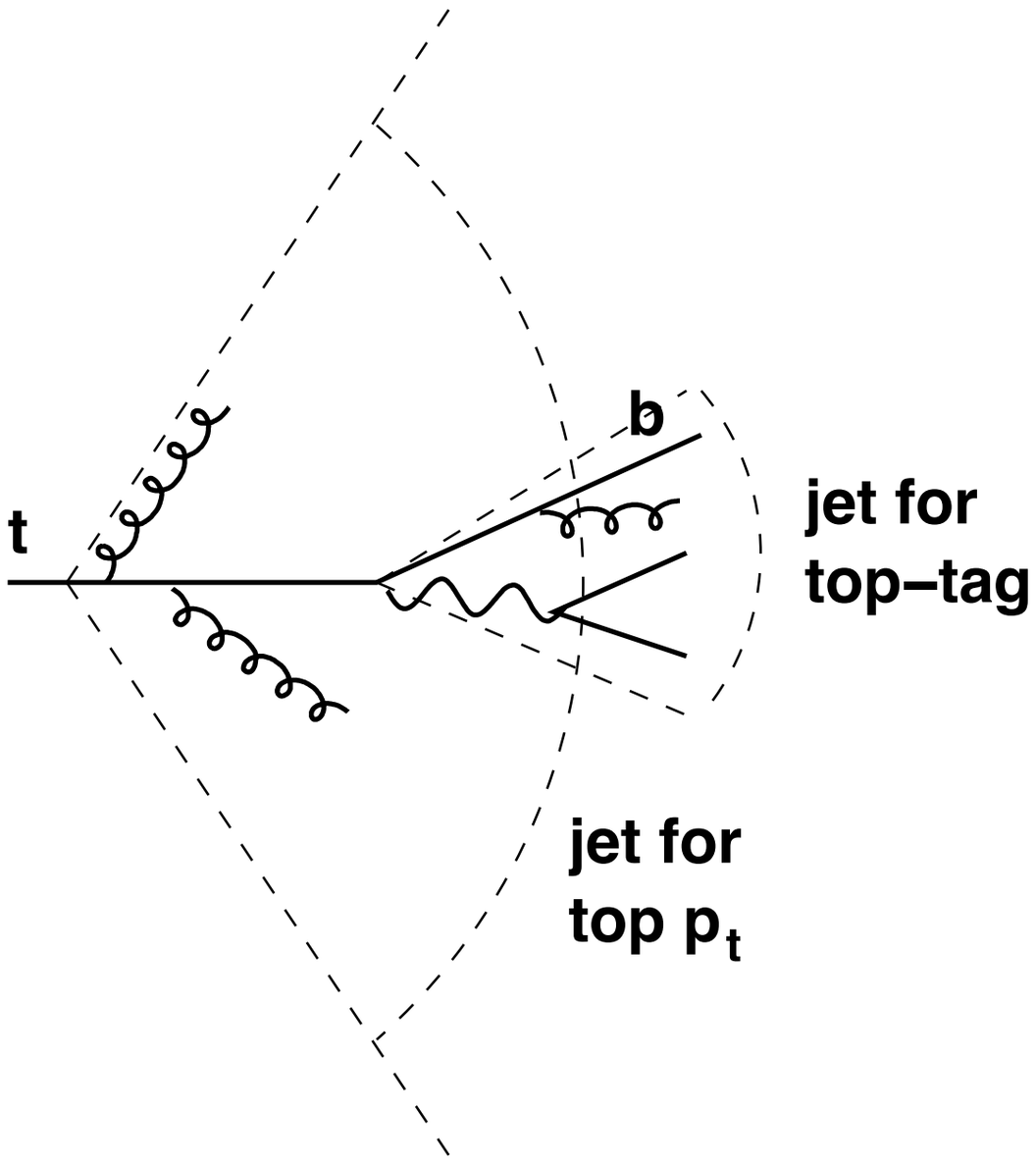
(e.g. HEPTopTagger, Template Tagger)

- Identifies prongs
- Requires prongs be consistent with kinematics of t→Wb→ 3 quarks

Radiation based

(e.g. N-subjettiness = τ_3/τ_2 + mass cut)

- Requires top-mass consistency (maybe with some grooming)
- Exploits weaker radiation from top (3 quarks) than background (1q+2g or 3g)



In boosted regime

Use output of a 3-pronged tagger when checking for consistency with the top mass

Use the original fat jet as an input to the di-“top” mass spectrum in searches

Understanding Taggers

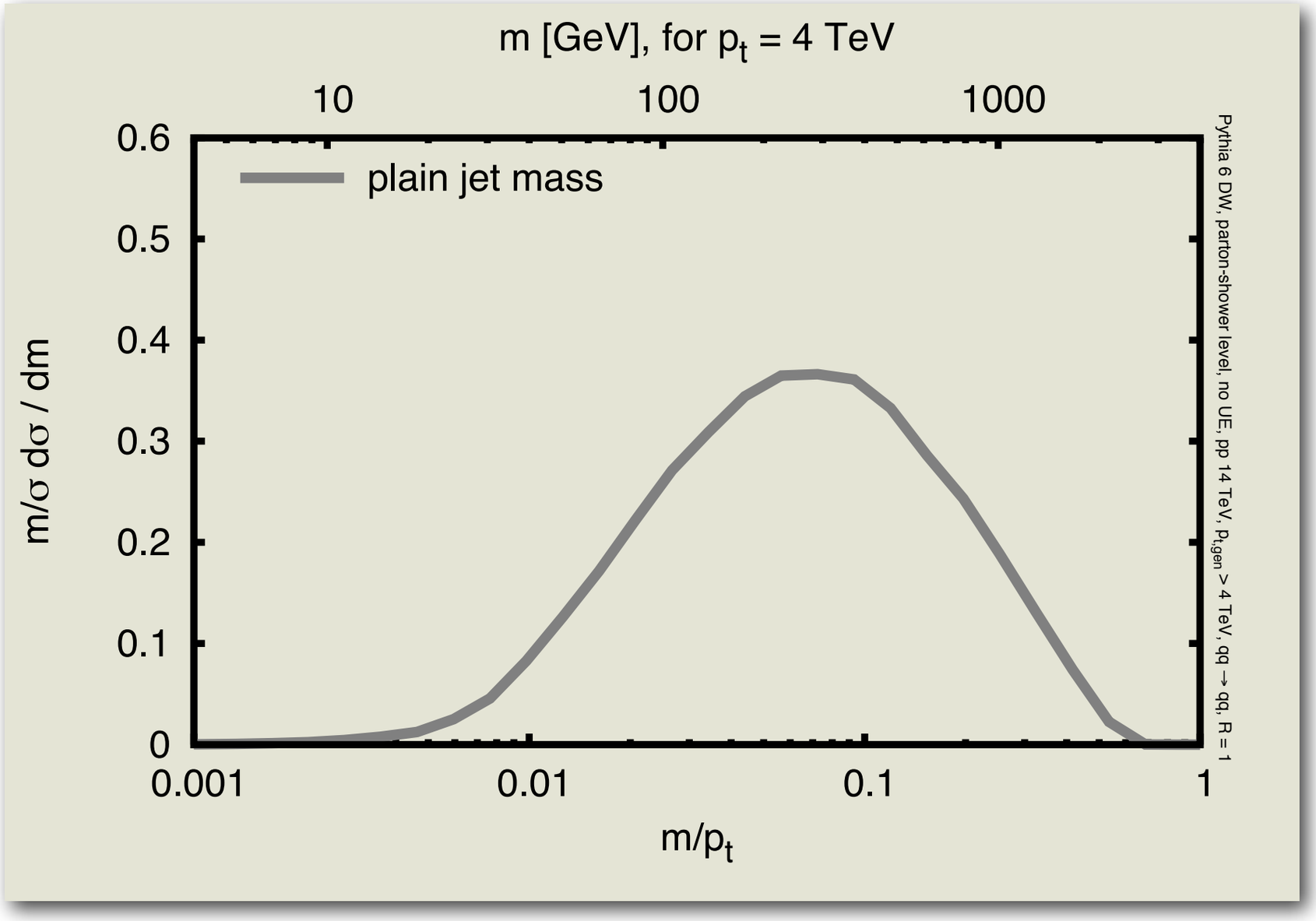
It's becoming clear that even simple taggers can be complicated objects.

They need to be understood and stress tested:

- Over a broad range of p_t and mass scales
- For different kinds of:
  event (signal, background),
  calculation (parton shower, NLO, NNLO) &
  experimental conditions (e.g. pileup)

An example in the context of 2-pronged taggers

(testing on background [quark] jets)



Dasgupta, Fregoso, Marzani & GPS, forthcoming

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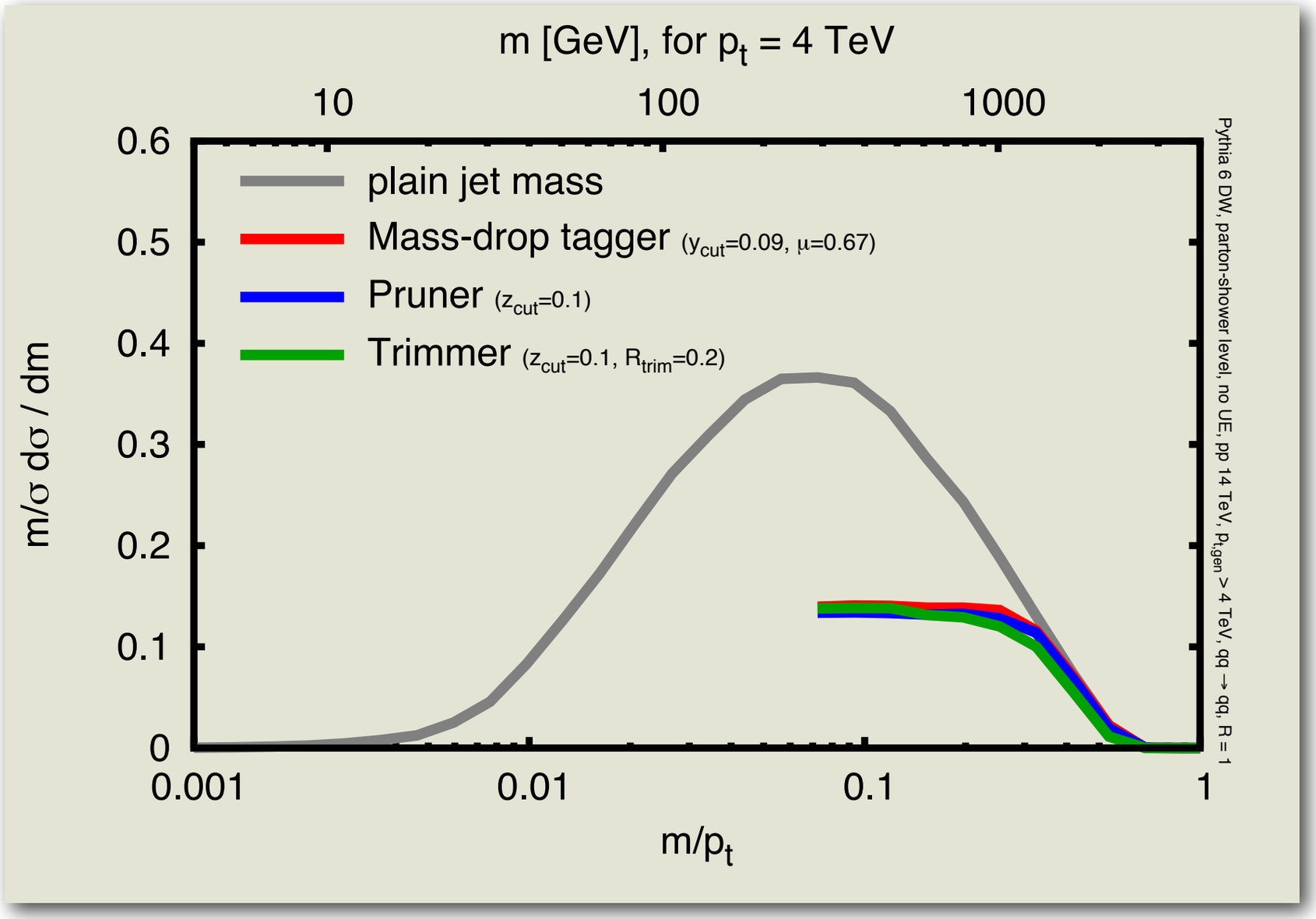

Different taggers are apparently quite similar

Dasgupta, Fregoso, Marzani & GPS, forthcoming

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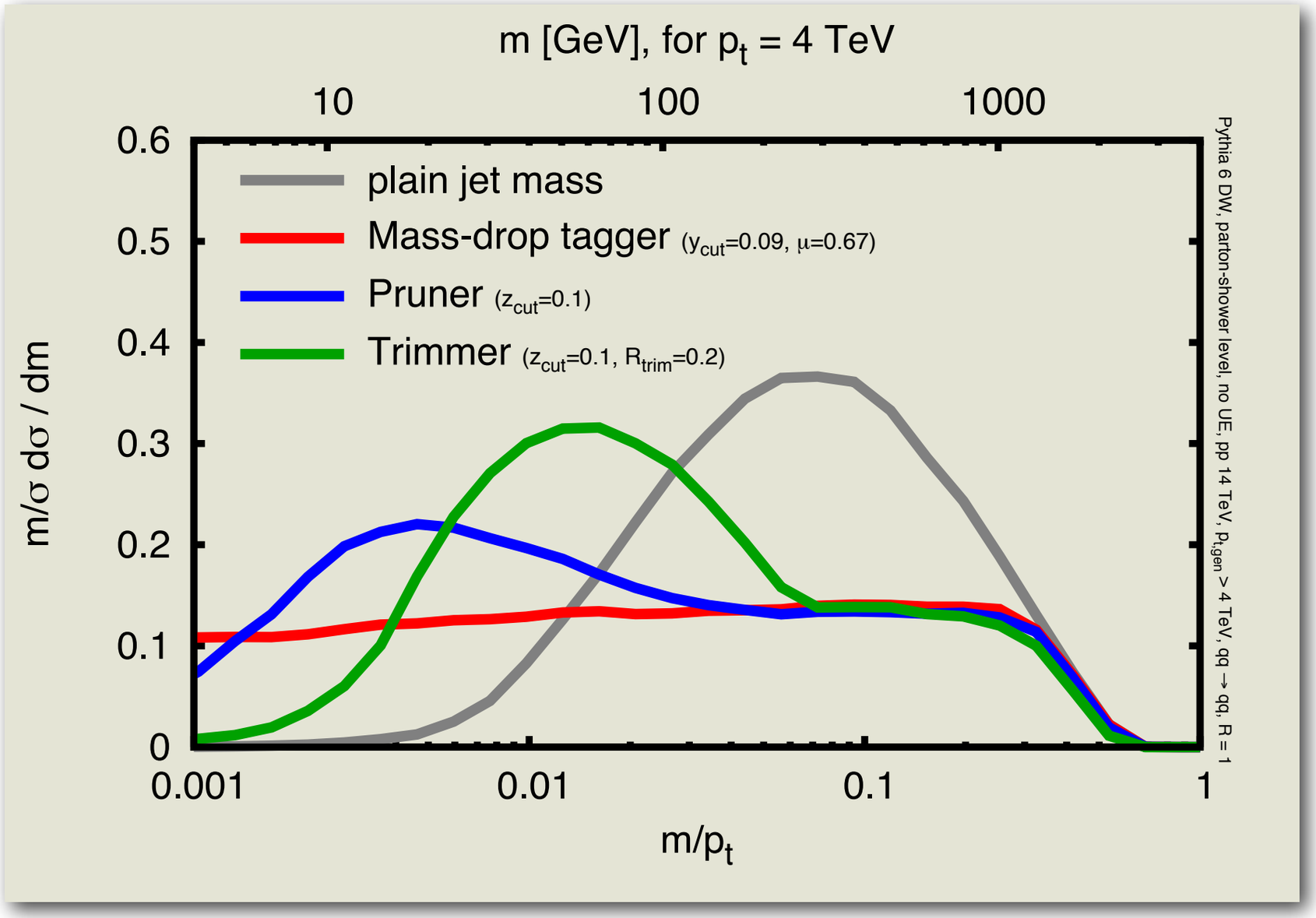


But only for a limited range of masses

Dasgupta, Fregoso, Marzani & GPS, forthcoming

Infrared safety

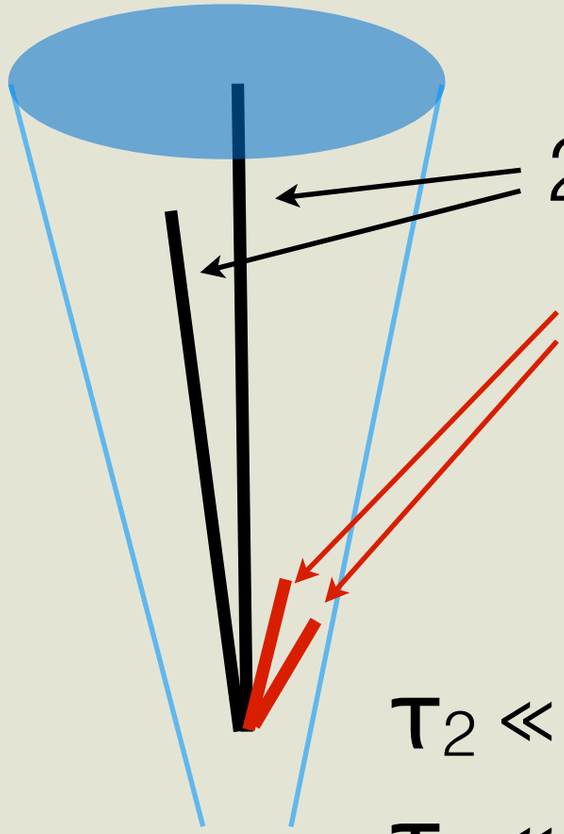
The IR safety problem was a long-standing one for basic jet finding.

Let's make sure it doesn't sneak back in for boosted-object tagging.

N-subjettiness τ_3 / τ_2:

τ_2 measures departure from 2-parton energy flow

τ_3 measures departure from 3-parton energy flow



$\tau_2 \ll 1$

$\tau_3 \ll 1$

$\tau_3/\tau_2 \sim 1$

} However soft the two gluons, you get finite τ_3/τ_2

That's IR unsafe

Cacciari et al '12: easily cured with extra cut on τ_2 / τ_1

Pileup in the boosted regime

Pronged top taggers

Some have pileup-***reduction*** built in (HEPTopTagger, Template), essentially by using small (R~0.2–0.3) sub-cones, sometimes dynamically adjusted to the top p_t

For heavy pileup you will need to supplement them with full pileup ***subtraction*** (e.g. area-based).

[Technically trivial, but so far studied only for filtering & trimming]

Shape-based taggers

Until recently, no clear way of subtracting pileup.

Pileup subtraction for shapes

Cacciari, Dutta, JH Kim, GPS & Soyez '12

n^{th} **derivative of shape** wrt ghost momenta

Shape as a function of particle momenta in jet

$$V_{\text{jet}}^{[n]} \equiv A_g^n \, \frac{d^n}{dr_{t,g}^n} V(\{p_i\}_{\text{jet}})$$

Ghost area

Pileup subtraction for shapes

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$$V_{\rm jet}^{[n]} \equiv A_g^n \, \frac{d^n}{dr_{t,g}^n} V(\{p_i\}_{\rm jet})$$

Ghost area

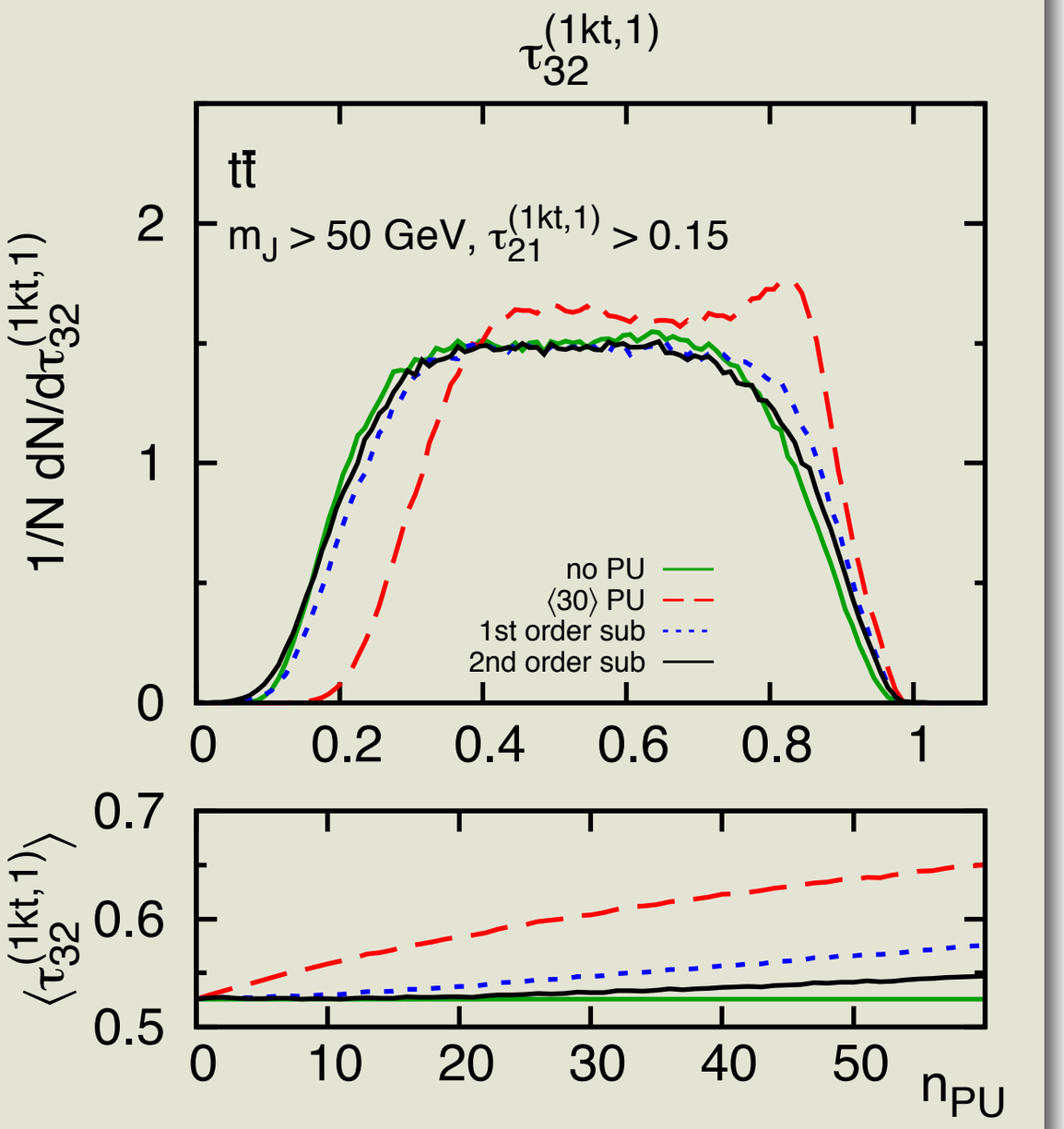
$$V_{\rm jet,sub} = V_{\rm jet} - \rho V_{\rm jet}^{[1]} + \frac{1}{2}\rho^2 V_{\rm jet}^{[2]} + \cdots$$

Subtracted shape

pileup density

Practical test: τ_{32} and top tagging

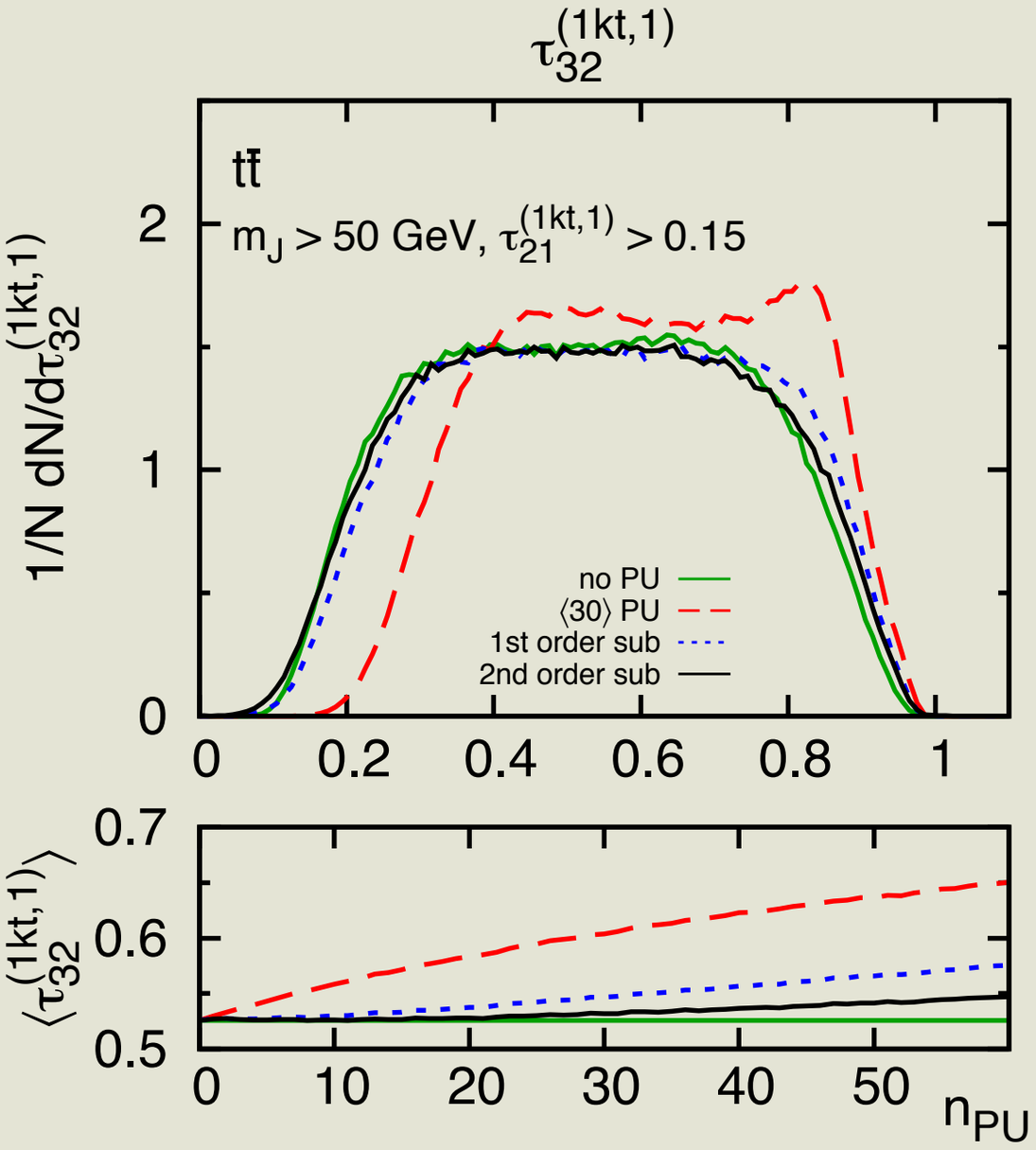
Correcting the τ_{32} distribution



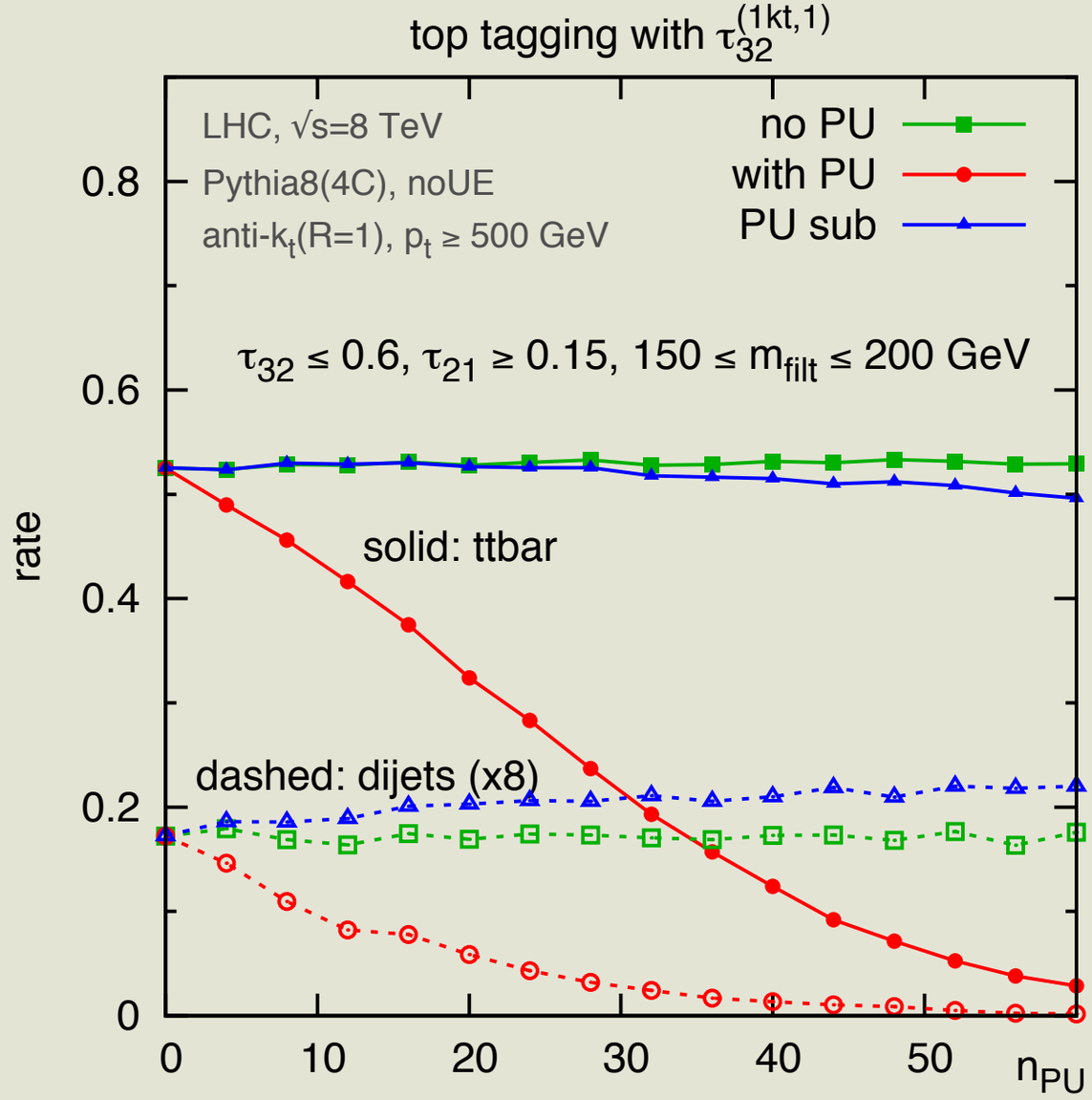
Green: no PU **Red: with PU** **Blue/Black: subtracted**

Practical test: τ_{32} and top tagging

Correcting the τ_{32} distribution



Tagging efficiency



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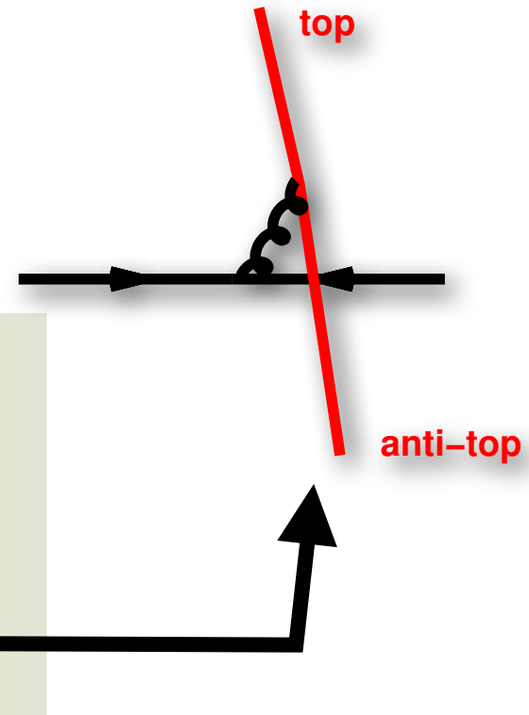
Are top pairs in high-p_t events always back-to-back?

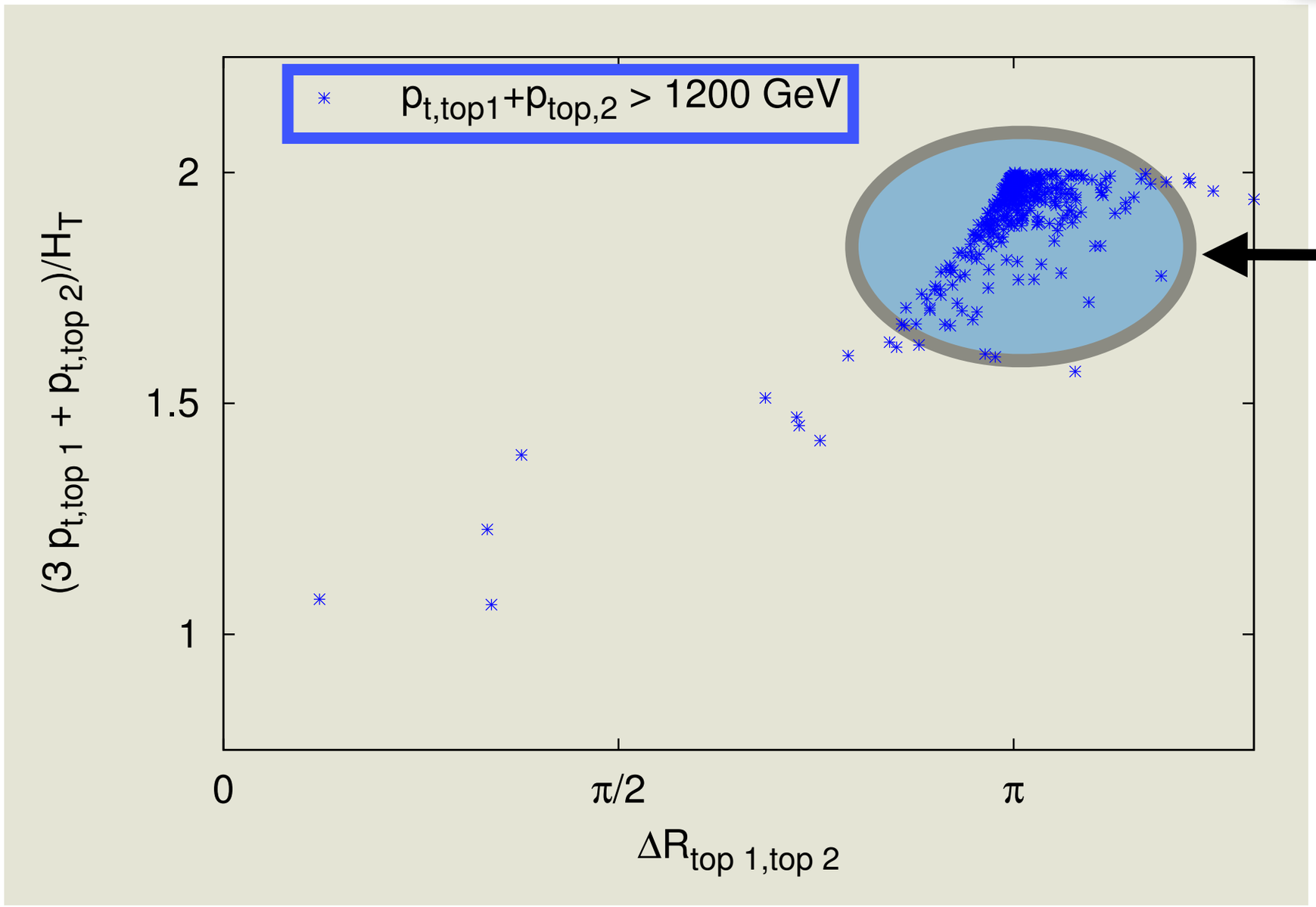
A reminder that top-quarks at LHC are almost “light”

An 8 TeV study with POWHEG, top-pair production, no decay and no parton showering (to keep things simple)

top topology v. cuts

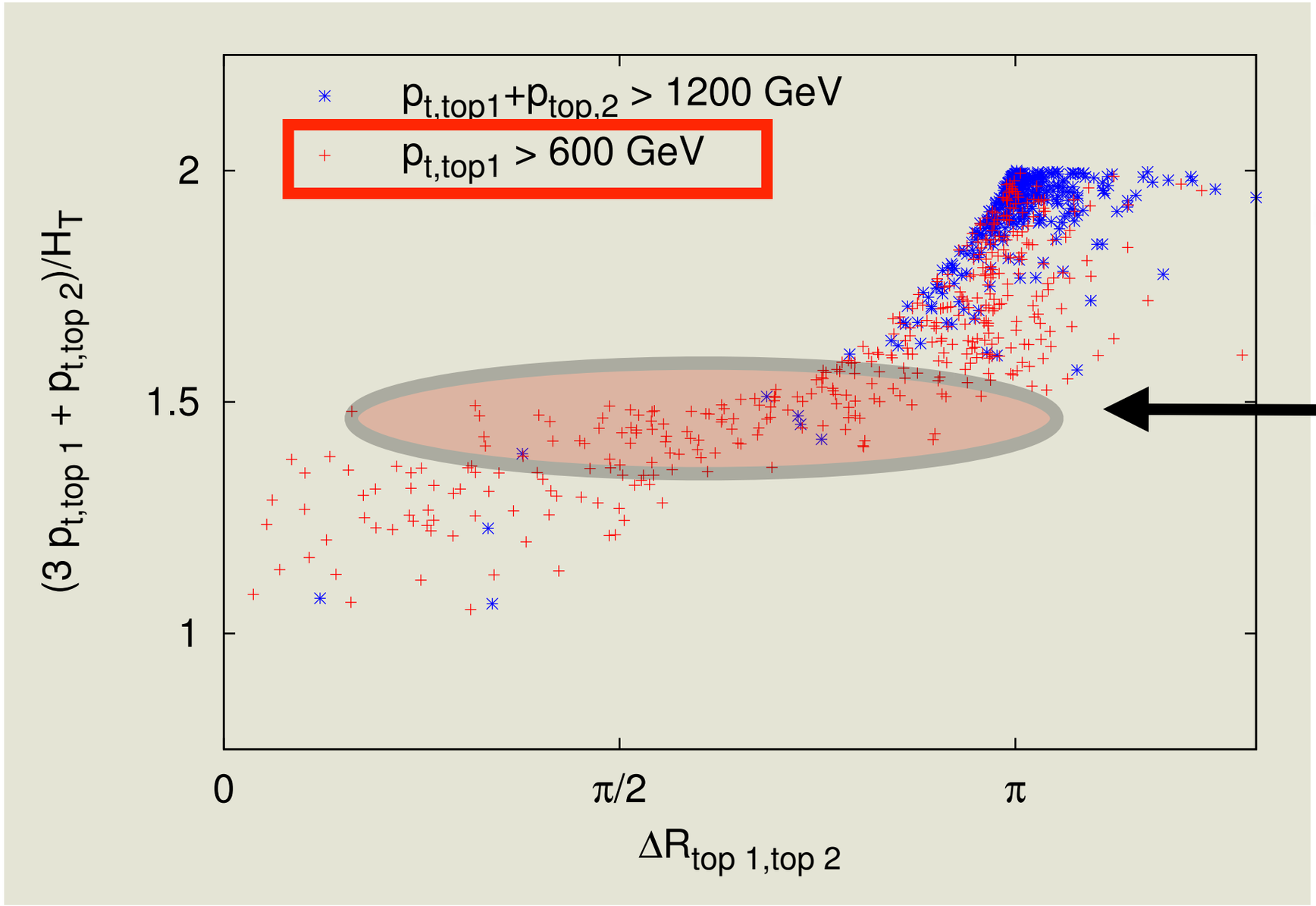
Flavour Creation

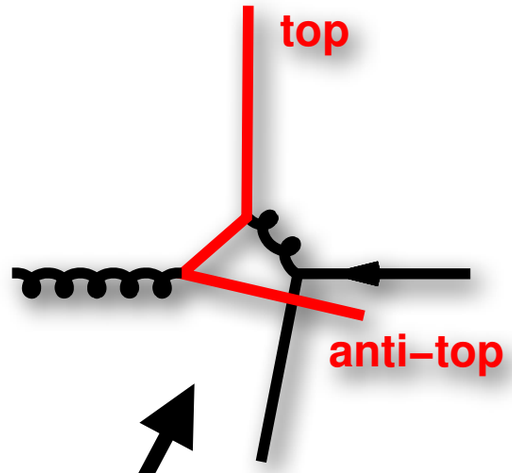




top topology v. cuts

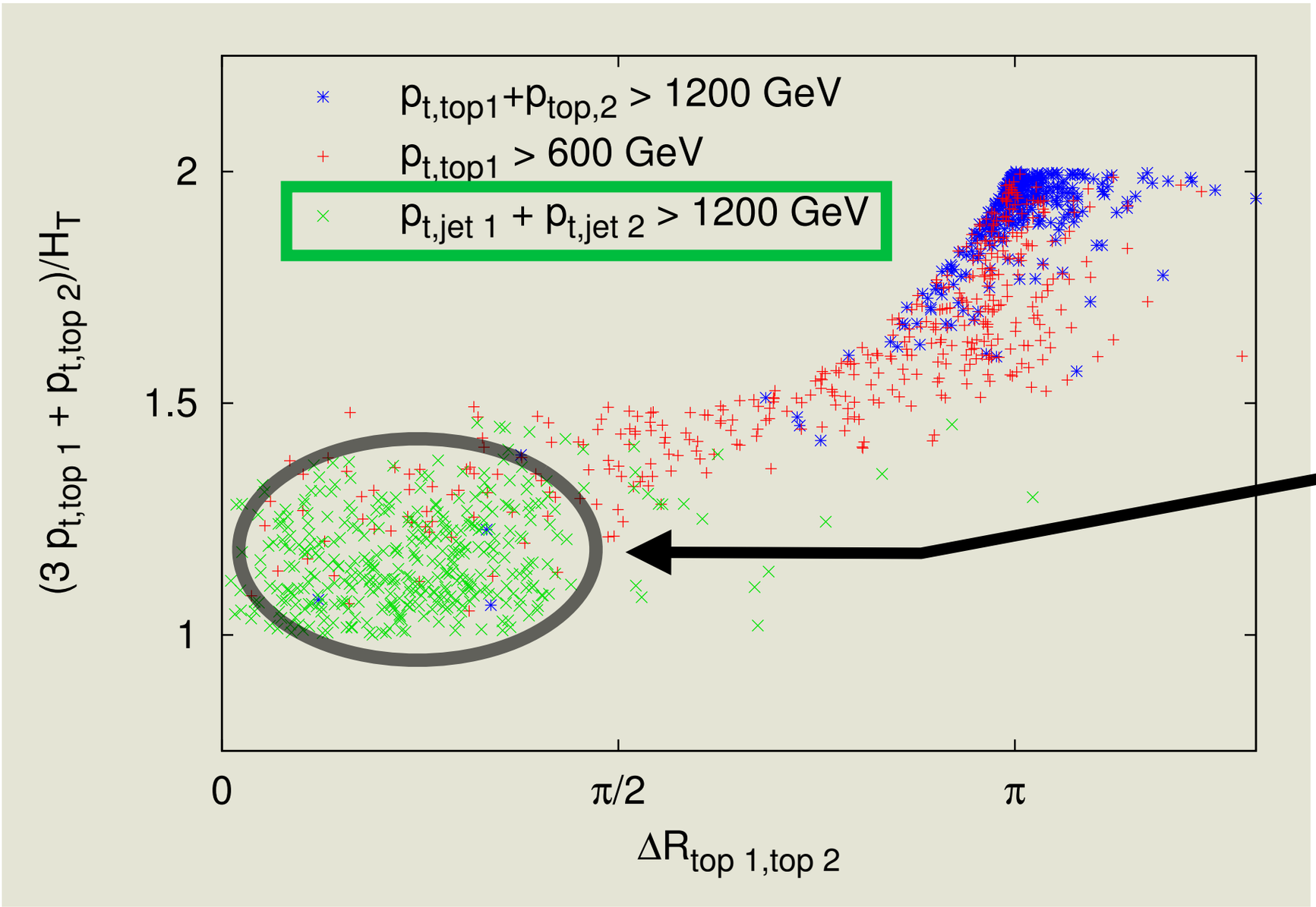
Flavour Excitation – tops inside your PDFs

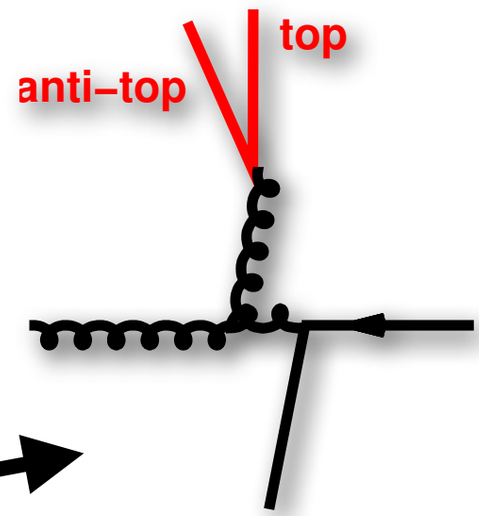




top topology v. cuts

Gluon Splitting





Concluding remarks

We're at a stage where we know it's feasible to study and use tops across a range of p_t's, from low to high

But we shouldn't forget the field is still young:

- connection between low and high-p_t regions still delicate
- taggers work, but still have surprises in store for us
- high-p_t top-physics is rich – differences between top jets and top quarks; new top-pair topologies