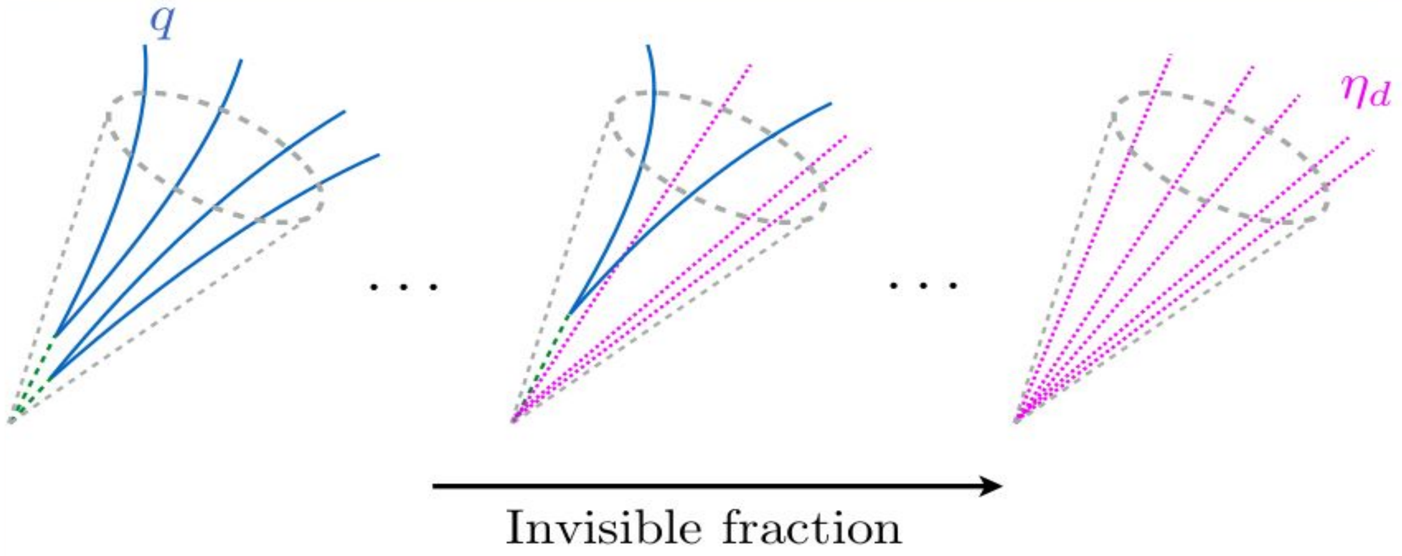
Dark Matter search using Semi-Visible jets

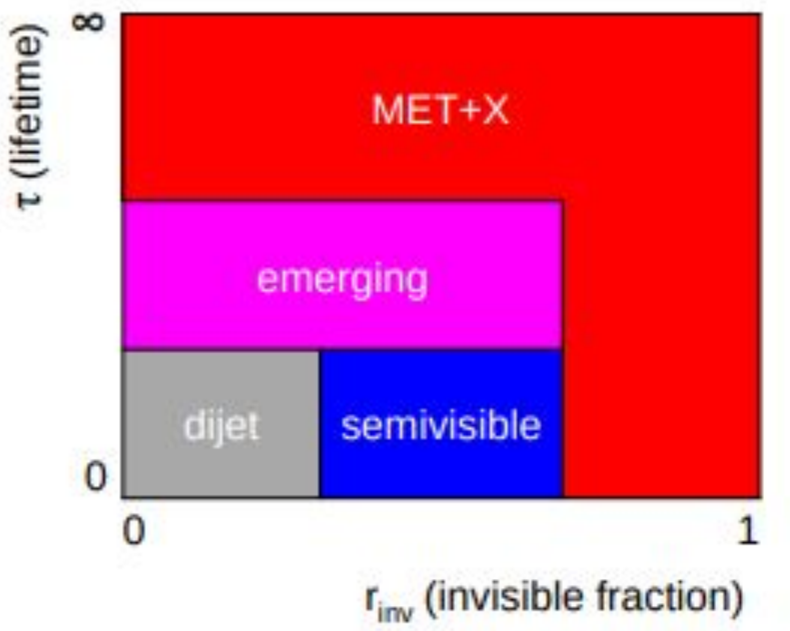
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Deepak Kar & Sukanya Sinha

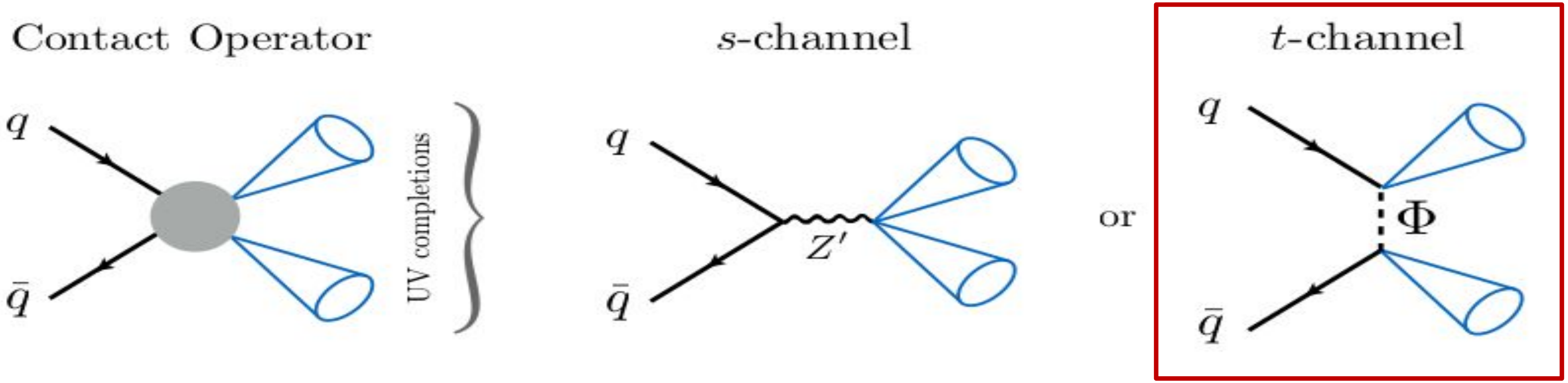
19/11/2019

Semi visible jet production





Link to the paper: https://arxiv.org/abs/1707.05326



Model Parameters:

1. M_ϕ = Mass of Scalar Bi - fundamental
2. M_d = Mass of dark hadrons
3. r_{inv} = no. of stable dark hadrons/ no. of hadrons

If the dark hadrons decay entirely to visible states: $r_{inv} \rightarrow 0$.
If none of the dark hadrons decay back to the SM (on collider timescales) : $r_{inv} \rightarrow 1$.
In intermediate r_{inv} scenario, 2 back-to-back semi-visible jets produced : MET points in the direction of the jet containing most stable mesons.

Characteristic mass scale for the dark hadrons, $\mathbf{M_d}$, and the dark strong coupling, $\boldsymbol{\alpha_d}$ affect the number of dark hadrons produced during dark shower → impacts jet multiplicity.

Higher M_d and M_ϕ values lead to a decrease in the cross-section since overall dark hadrons in the shower decreases, and hence we chose these particular values of M_d (= 10GeV) and M_{phi} (= 1500GeV).

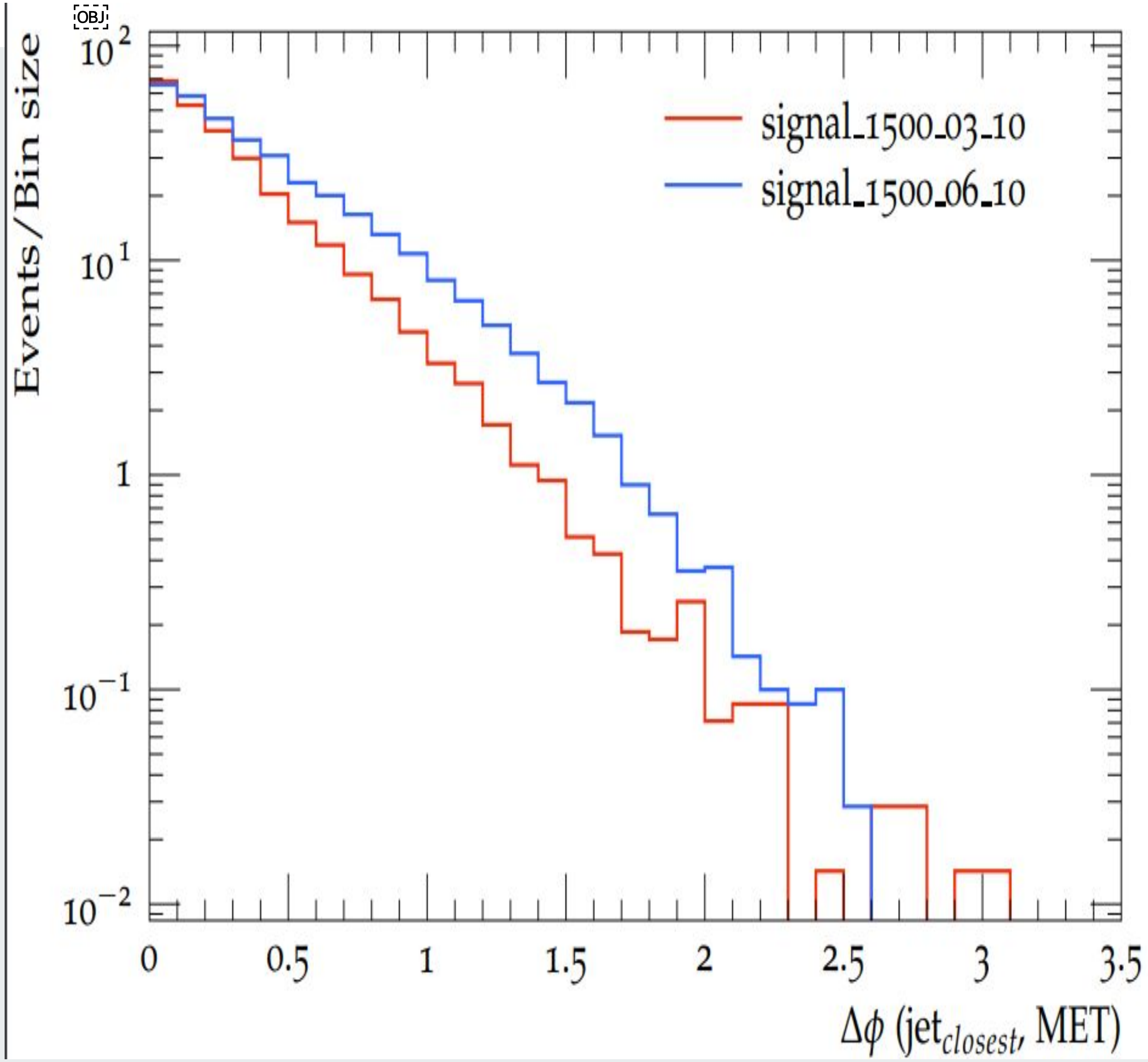
Particle Level Studies with standalone samples

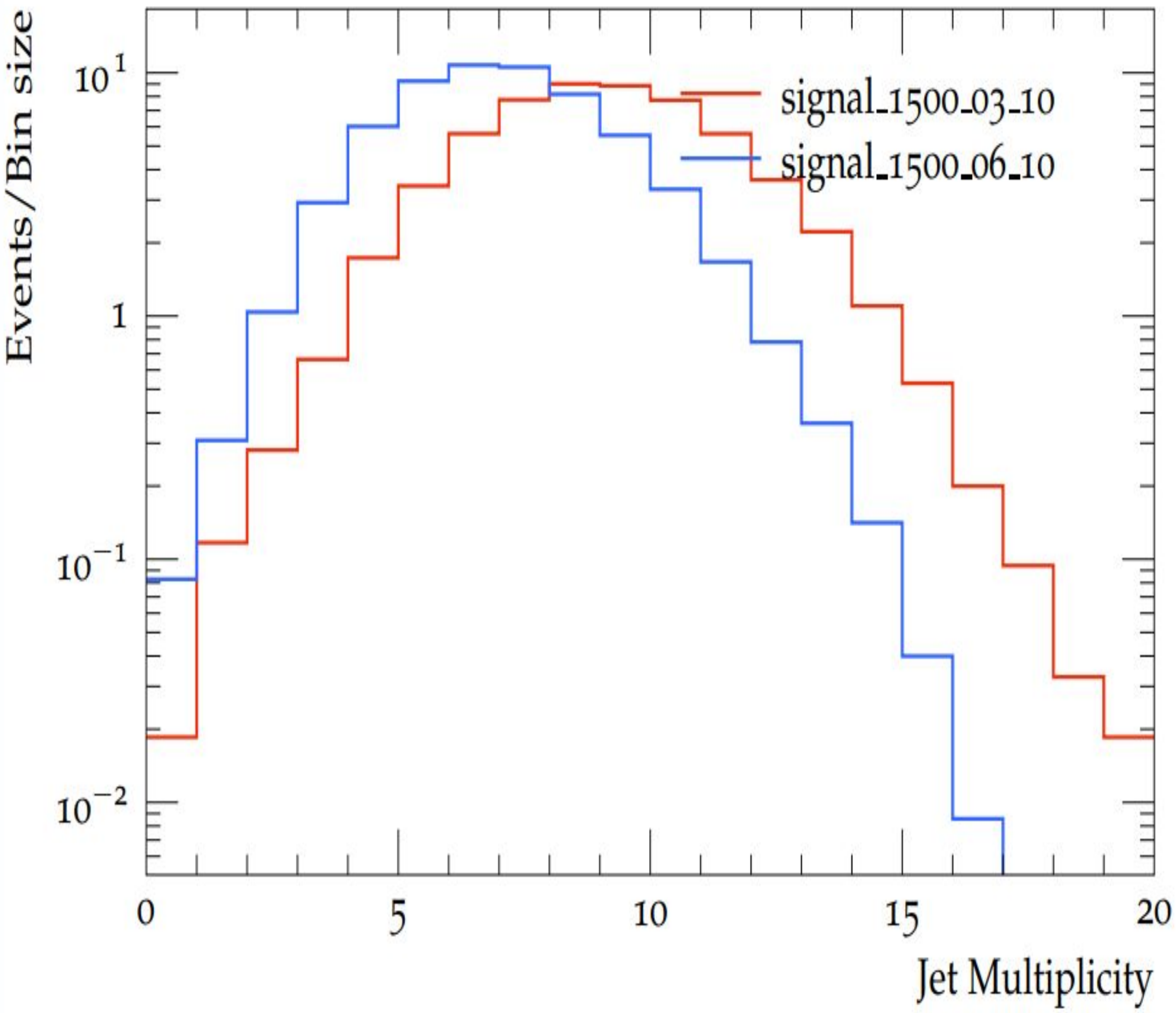
- Signal: Madgraph+Pythia8 using UFO provided by authors (using hidden valley module to simulate dark shower) (https://github.com/smsharma/SemivisibleJets)
- Znunu: MadGraph+Pythia8 Np0 to Np4
- Multijets: Pythia8 multijet sliced sample

Observables used for the generator level studies:

1. **$\Delta\phi$** : Angle between the closest jet and the MET, looking at **$\Delta\phi$** < 0.4
2. H_T : Scalar sum of jet p_T
3. M_T and M_{T2}: computed using the leading two jets
4. Looking at High MET (for truth level studies MET > 200GeV)

Comparison of signals for different values of r_{inv} :

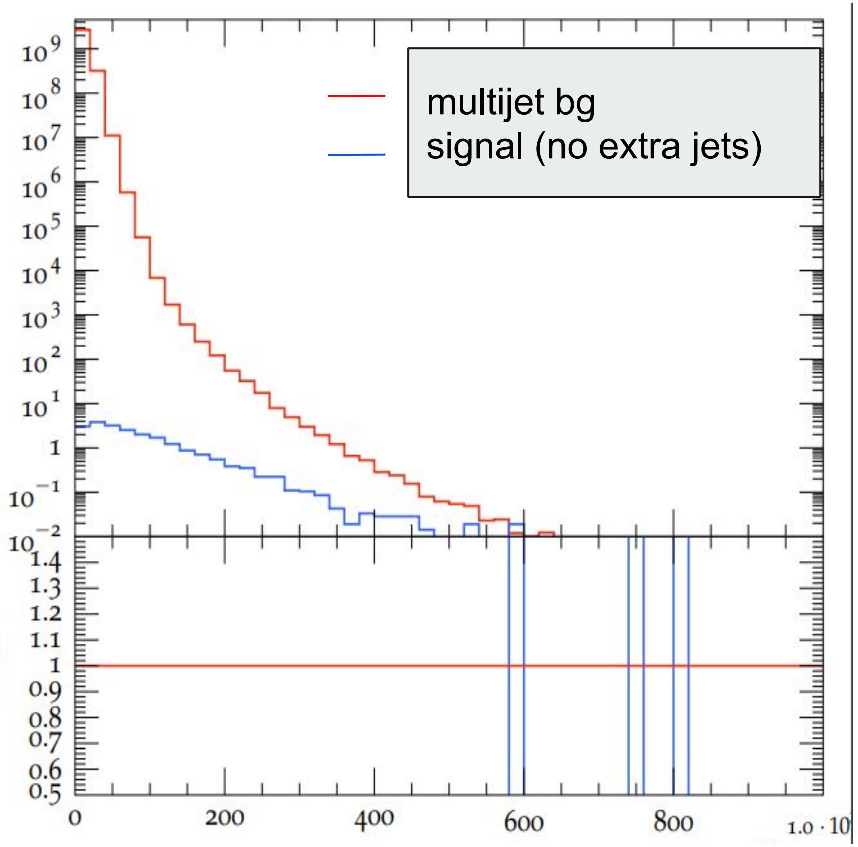




Semi visible jets have MET aligned closely to the jet

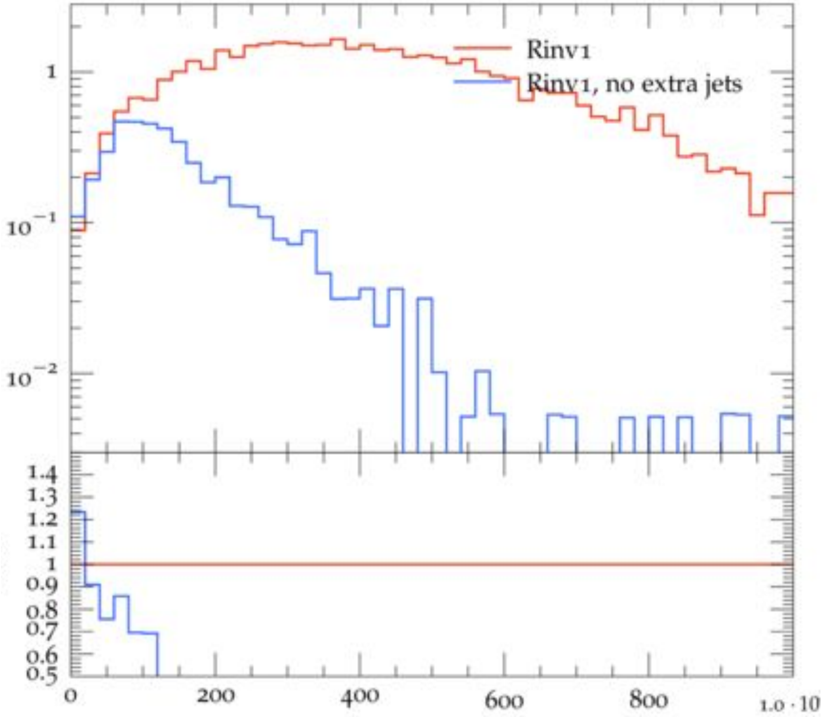
Most no.of events have more than 5 jets

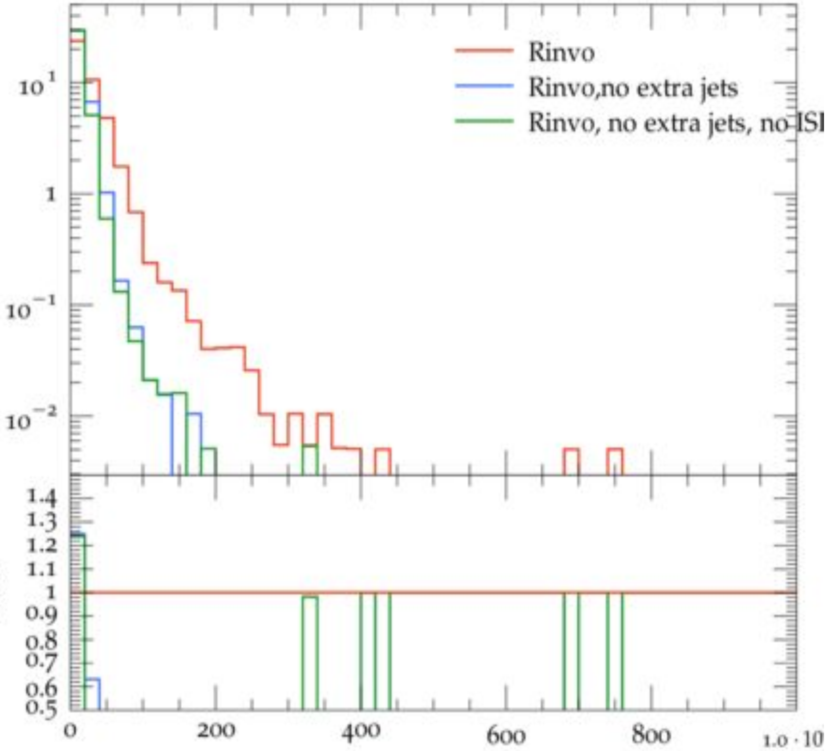
Why we need two extra jets in the MG Production?



MET plots for 3 scenarios:

1. **signal (no extra jets) vs multijet background**
2. **$r_{inv} = 0$**
3. **$r_{inv} = 1$**





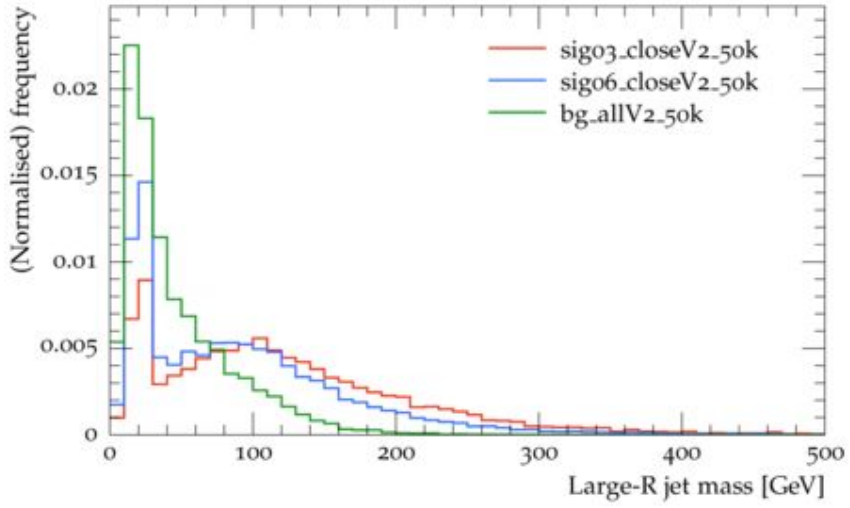
Were asked to check why jet multiplicity is so high (6-7 jets)?

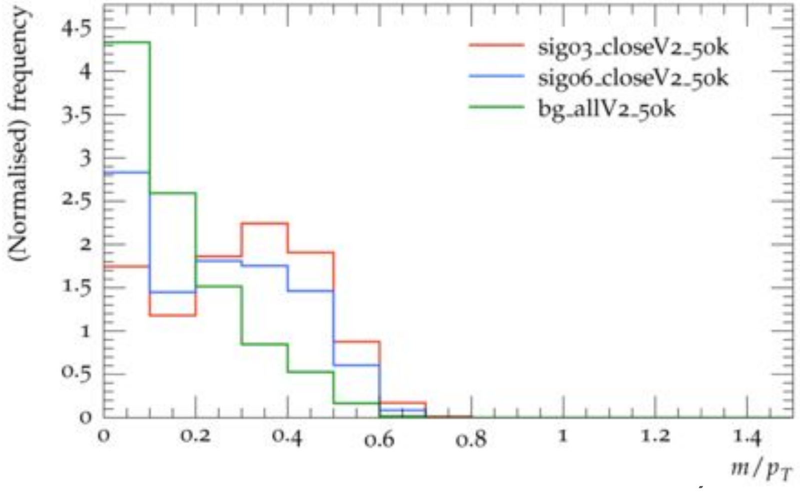
2 extra jets are required in order to obtain a proper signal which is visible over the QCD background, unlike the no extra jet case (fig above).

XS also increases on adding the 2 jets, which makes the search more powerful.

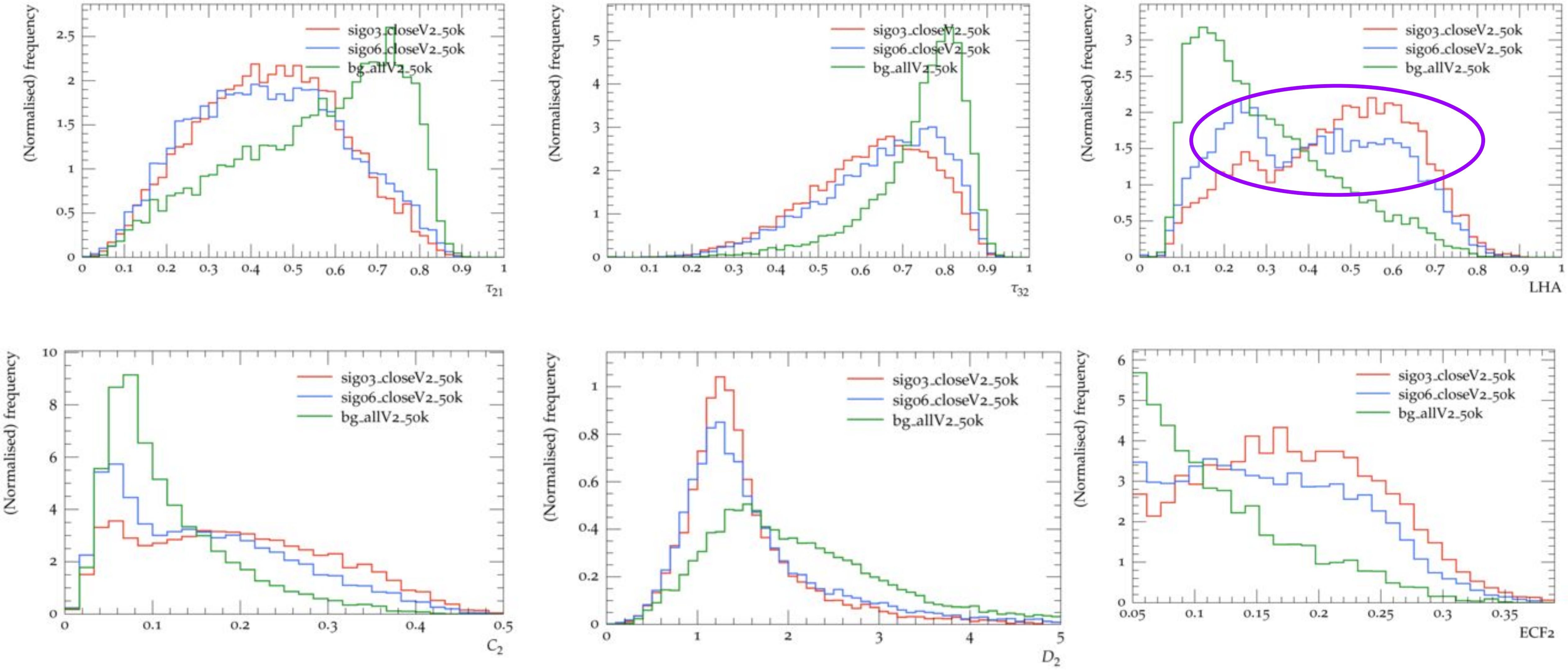
Very preliminary look at substructure of SVJ

- Setup: Leading trimmed antikt R=1.0 jets are used. For SVJ, the jet closest to MET and for background leading jet from a Pythia8 multijet sample.
- Looked at some common jss variables
- The SVJ's look more two-prongy! (with the usual caveat that the mass distribution is rather different)
- Can use a BDT to come up with an optimal classifier





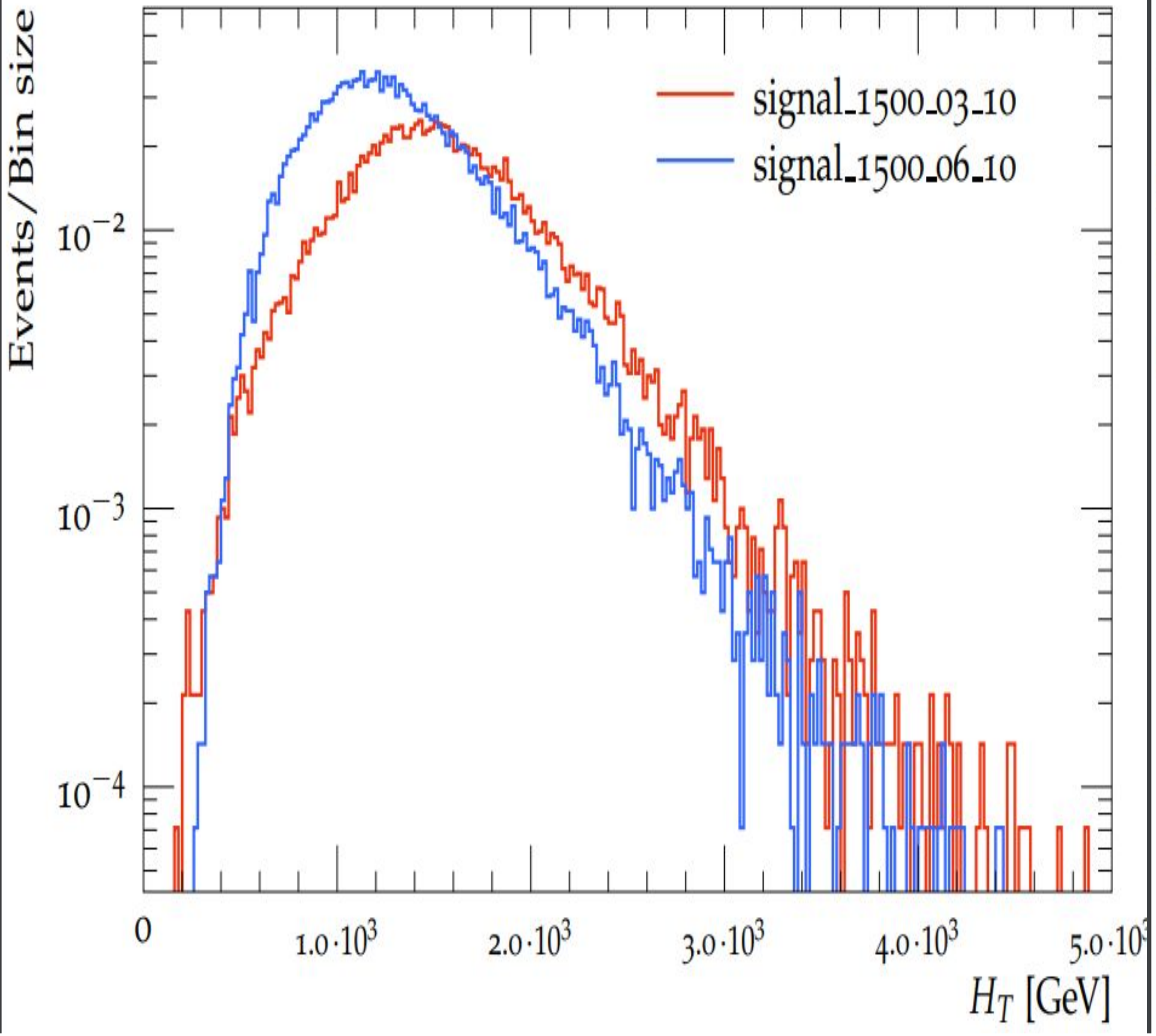
Red: SVJ with R_{inv} = 0.3
Blue: SVJ with R_{inv} = 0.6
Green: Multijet



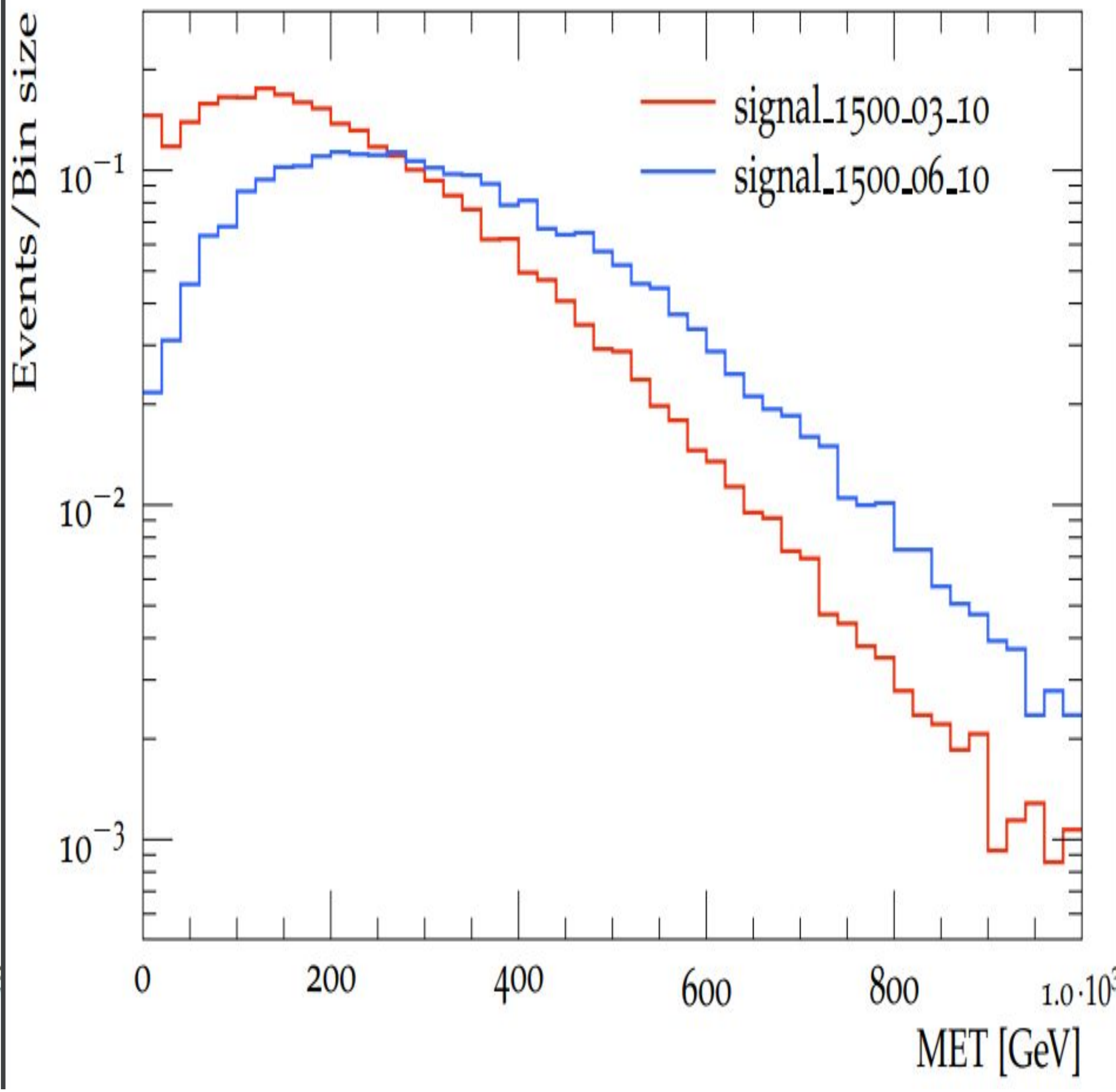
Pronounced difference,
not sure we understand it yet!

Red: SVJ with R_{inv} = 0.3
Blue: SVJ with R_{inv} = 0.6
Green: Multijet

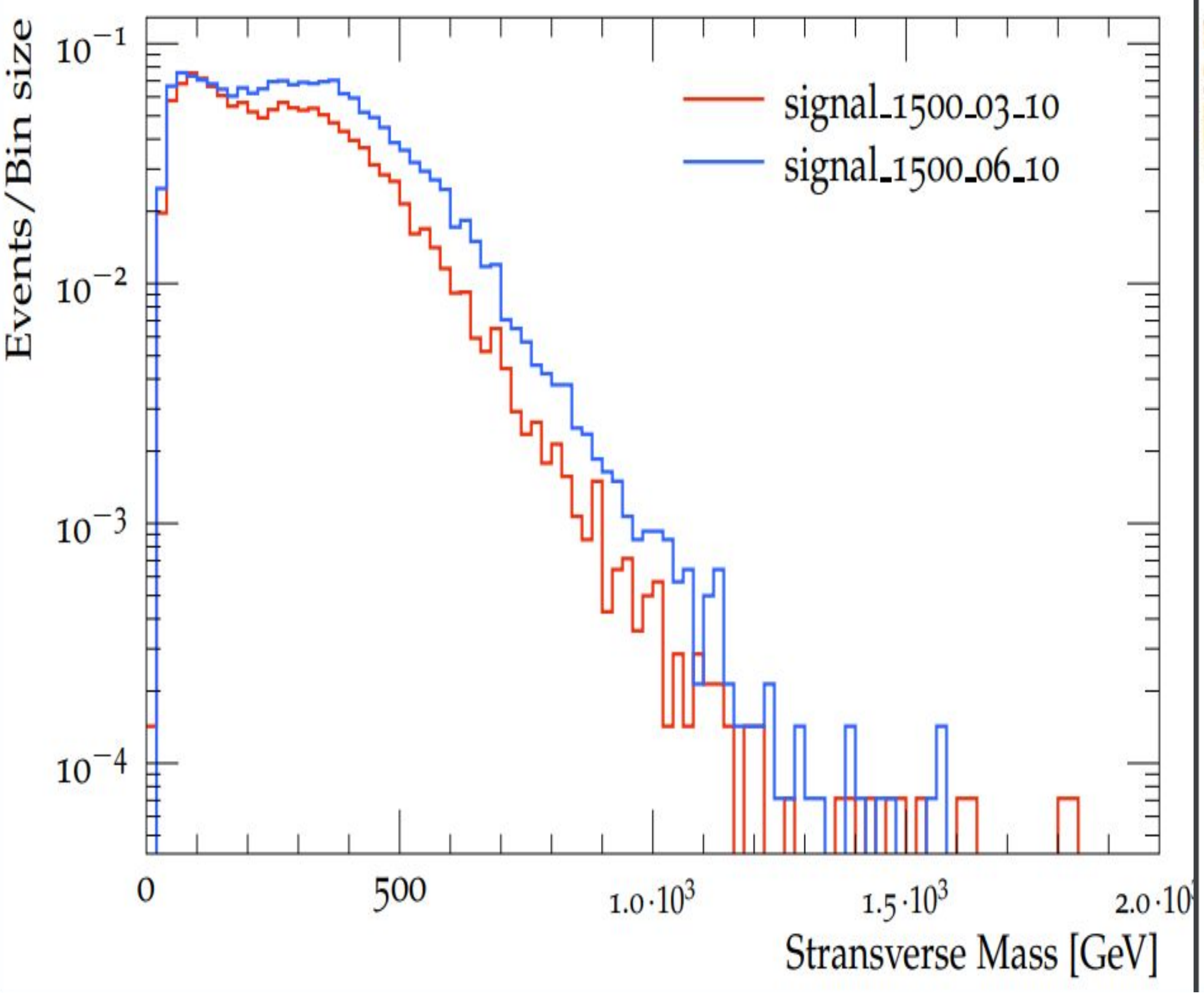
BACK UP

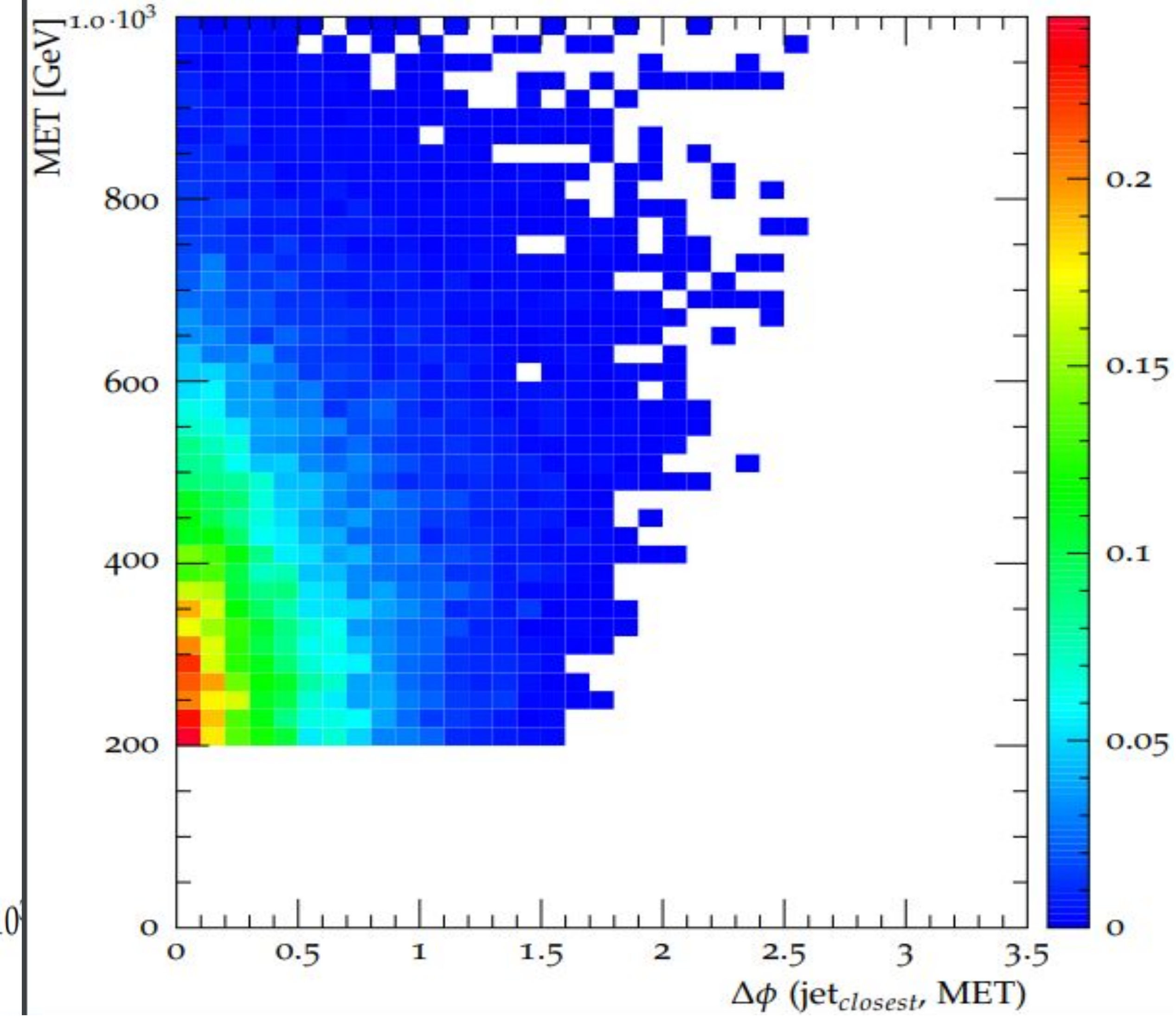


Signal with more dark hadrons have a lower H_T



The signal with more dark hadrons have a higher MET

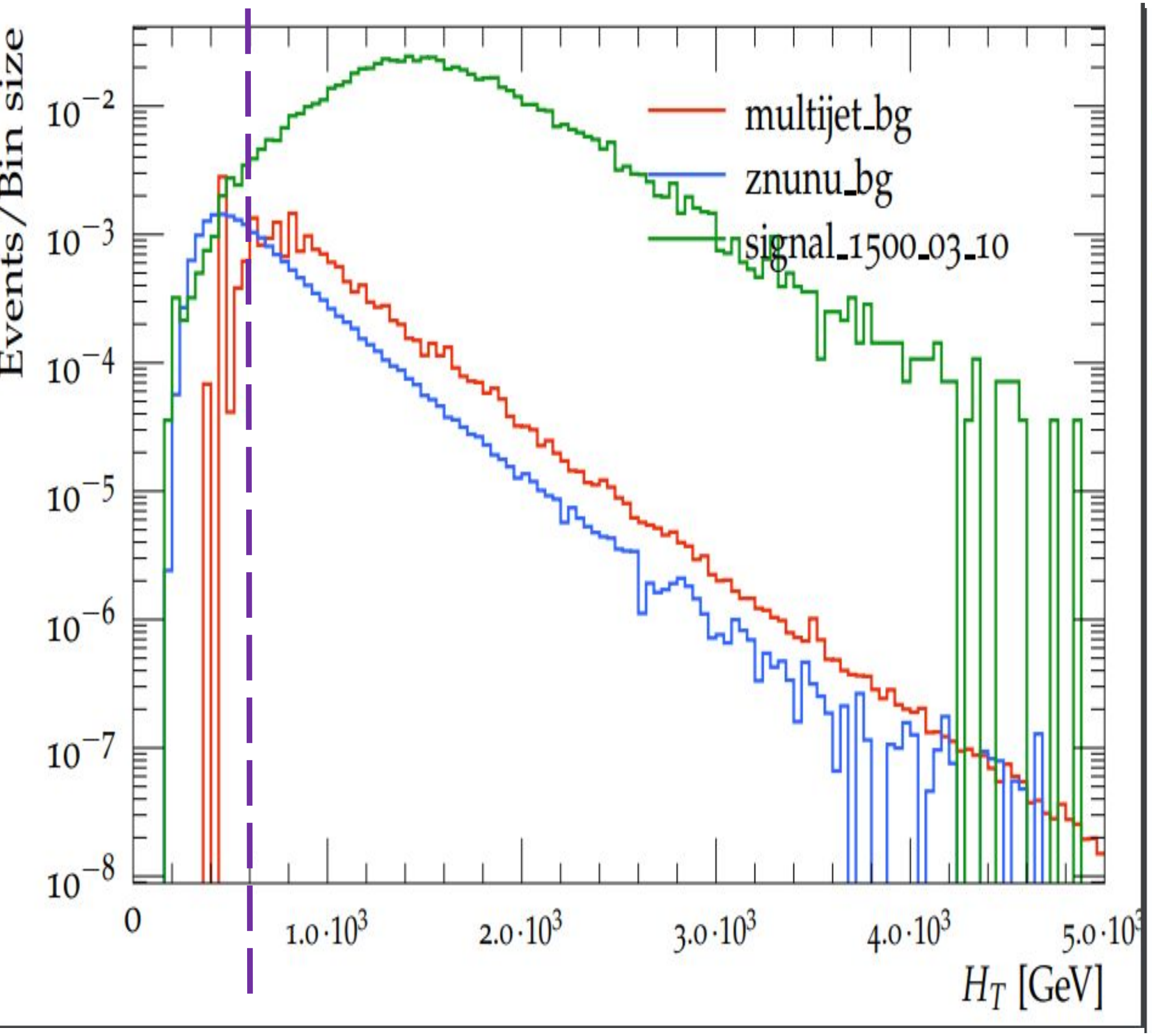




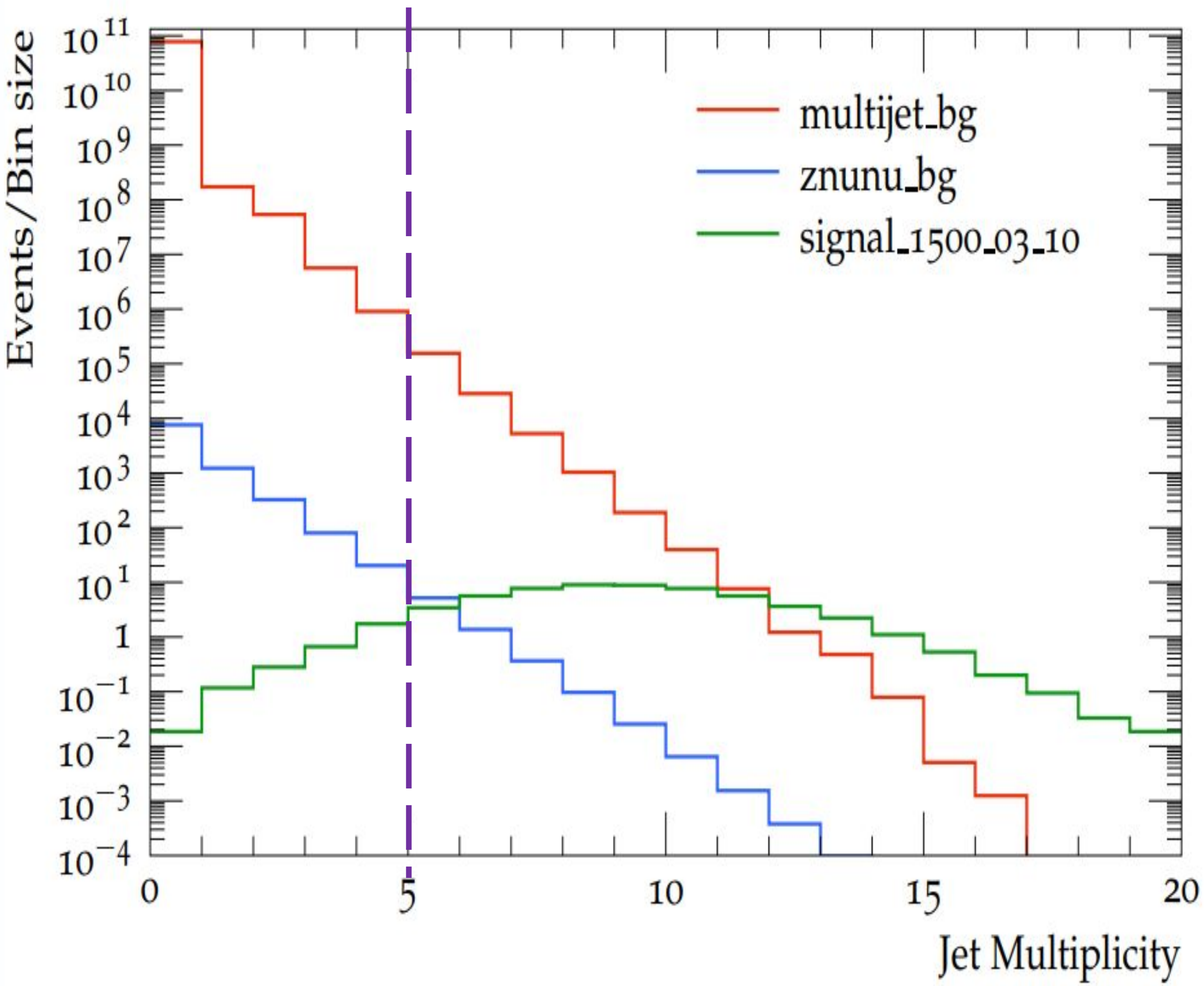
The signals behave as expected for M_{ϕ} = 1500GeV!

High MET is mostly aligned with the closest jets (for Sig_1500_06_10)

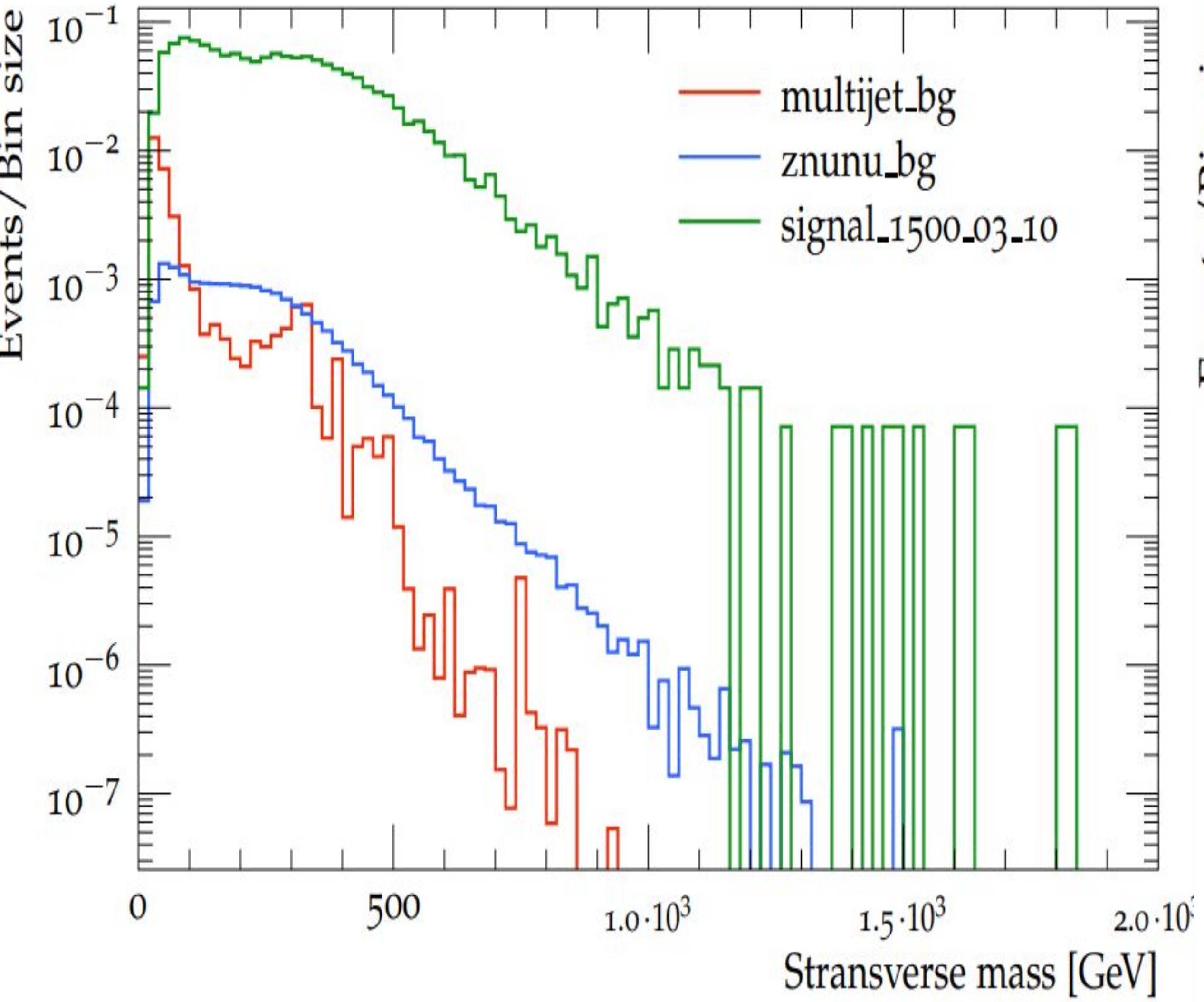
Signal(1500_03_10) and Background (multijet and znunu) plots

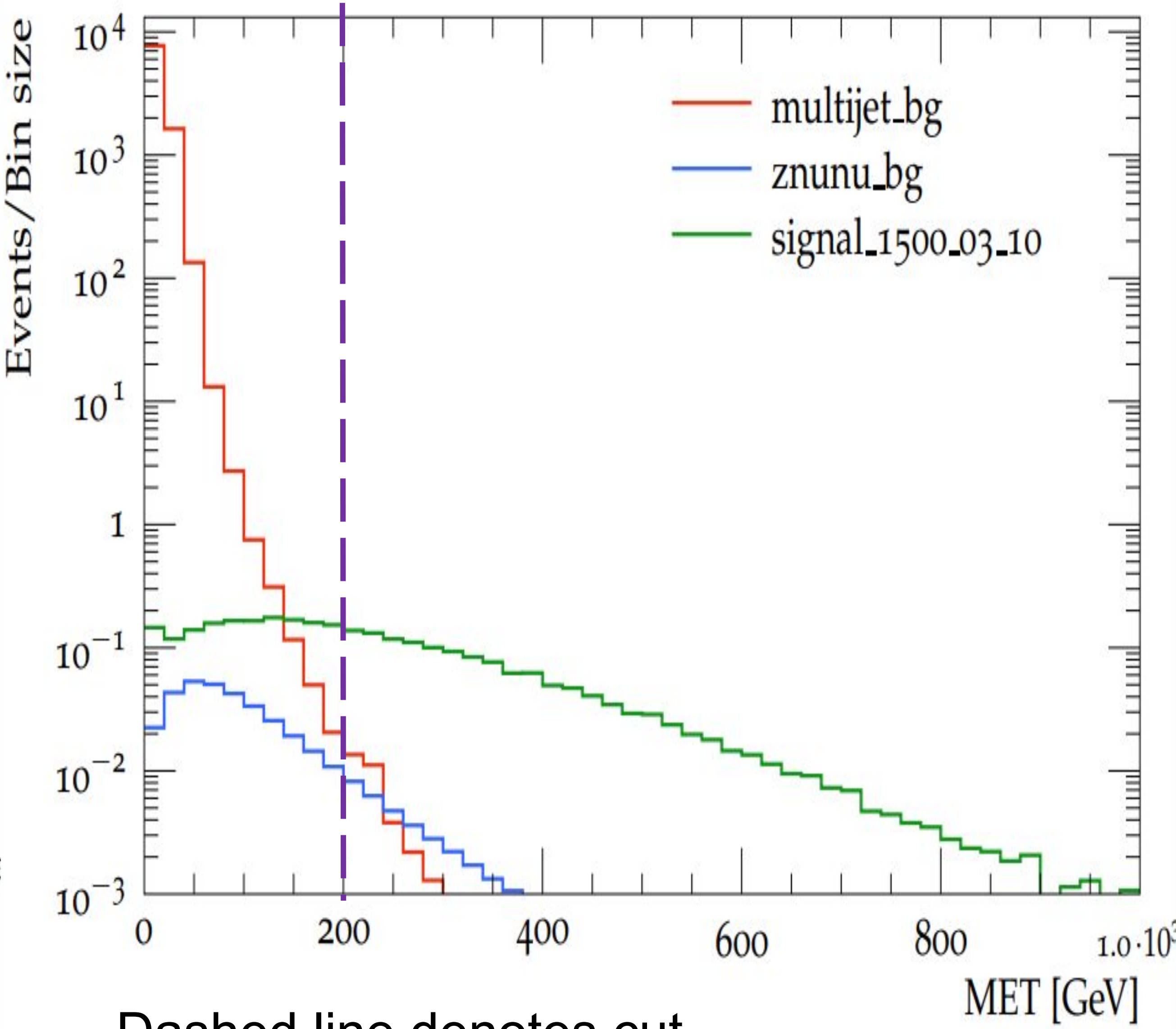


Dashed line denotes cut $H_T > 600$ GeV



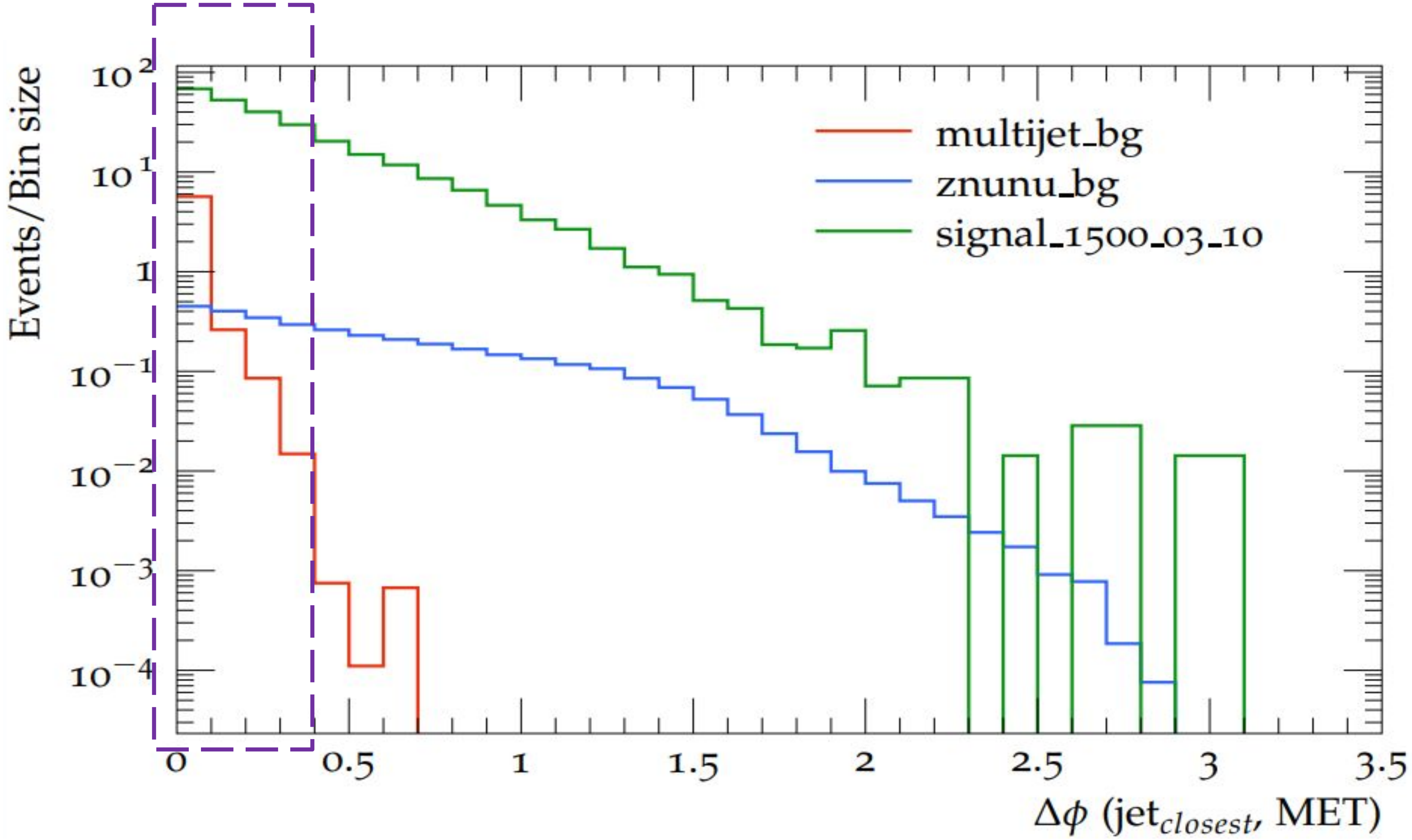
Dashed line denotes cut jet multiplicity > 5





After all applied cuts, signal is higher and this hints at a possible cut and count approach for the analysis

Dashed line denotes cut
MET > 200GeV
Adding this cut helps to reduce the background contribution



Purple dashed box highlights deltaphi < 0.4 region