Ttbar + Dark Matter Kinematic Reconstruction

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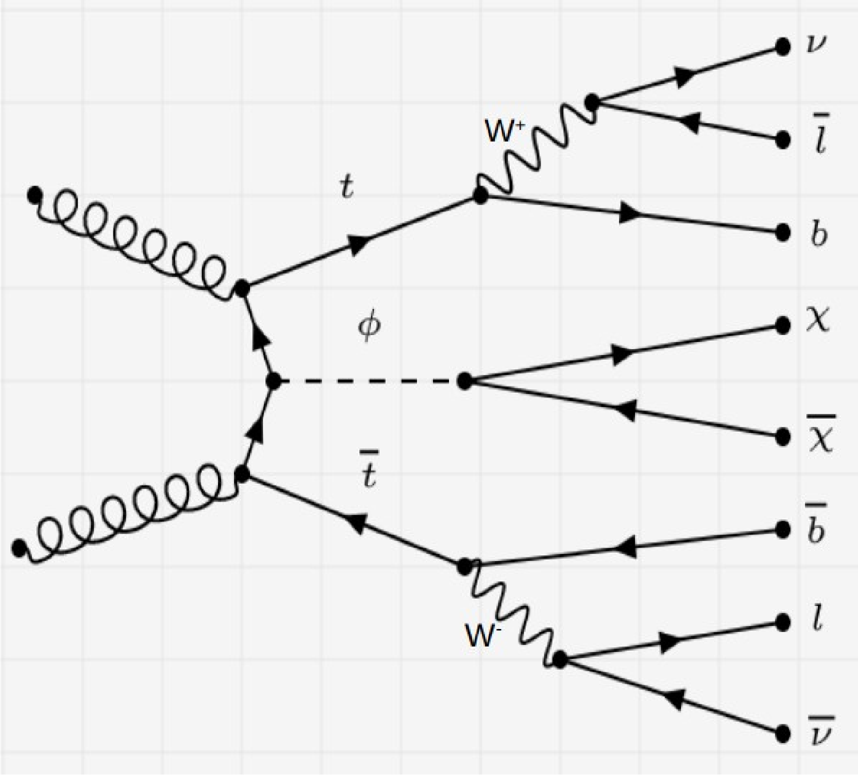
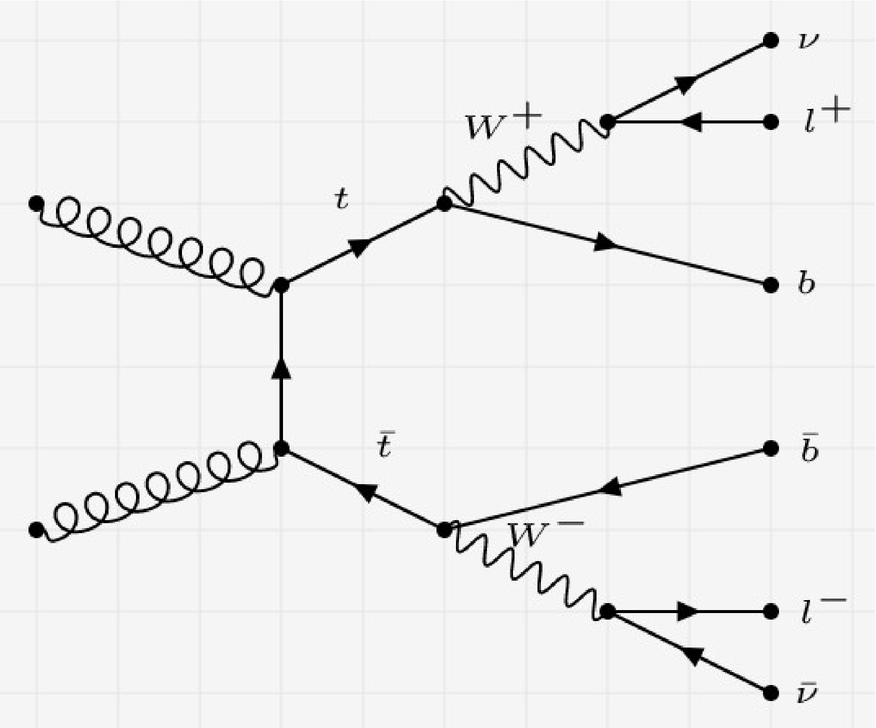


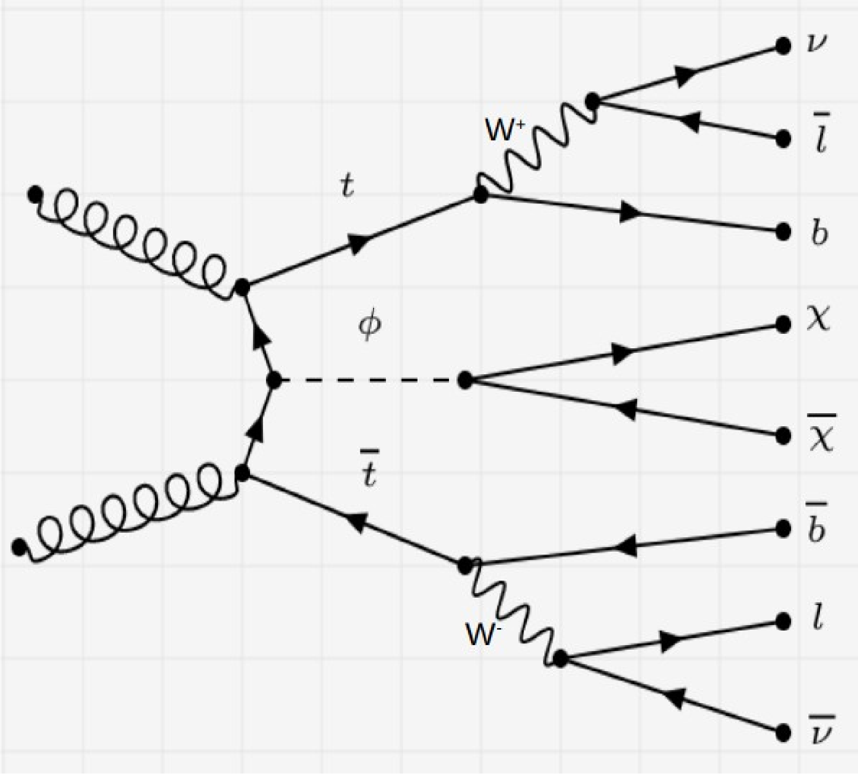
Top pair Kinematic Reconstruction

- Standard Model top quark pair production in the dileptonic channel features two neutrinos, which are not observed and so have to be inferred using a Kinematic Reconstruction algorithm
- System has eight degrees of freedom
- Can obtain six constraints from on-shell conditions for top quarks, W bosons and neutrinos, and a further two from assumption that missing transverse energy is due to neutrinos
- These conditions give up to four solutions for the neutrino momenta and thus the t quark pair; there are well-develop algorithms to calculate these (see later)



Ttbar + Dark Matter production

- Associated production with a top quark pair is an important channel for DM searches at the LHC
- However, the addition of the dark matter invalidates the assumption that the missing transverse energy is solely due to neutrinos
- Currently just perform standard Kinematic reconstruction (ignoring p_T from DM), unless this fails, in which case use minimum DM p_T necessary to obtain a solution.



Existing Algorithms

Sonnenschein's algorithm:

- Reduce standard eight constraints to a single 4th order polynomial, and solve algebraically
- Often doesn't give a solution, even for SM $t\bar{t}$ due to mismeasurement, but can smear the measured values and average the result to recover most solutions
- However can't handle cases with a further source of MET (i.e. DM)

Betchart et al.:

- Construct top and W mass constraints as ellipsoids in momentum space, and intersect these to obtain ellipses
- The intersection of these for a given MET displacement gives the solution
- If there is no intersection (either due to mismeasurement or DM) can find the point of closest approach, so can always find a solution
- However only assigns the minimum necessary pt to DM, and so DM MET is zero if one gets a solution immediately

Possibilities for ML Algorithms

- Could ML do better than traditional algorithms, e.g. by not using MET constraint?
- Could potentially leverage "soft" information, such as z-components of missing momentum and energy of the entire system from PDFs, or correlations of top directions with lepton and bottom directions?
- So far we have tried using ML to reconstruct a standard $t\bar{t}$ system, but not yet a $t\bar{t}$ + DM system