Measurement of the top quark mass at D0 using all hadronic events

(work in progress)

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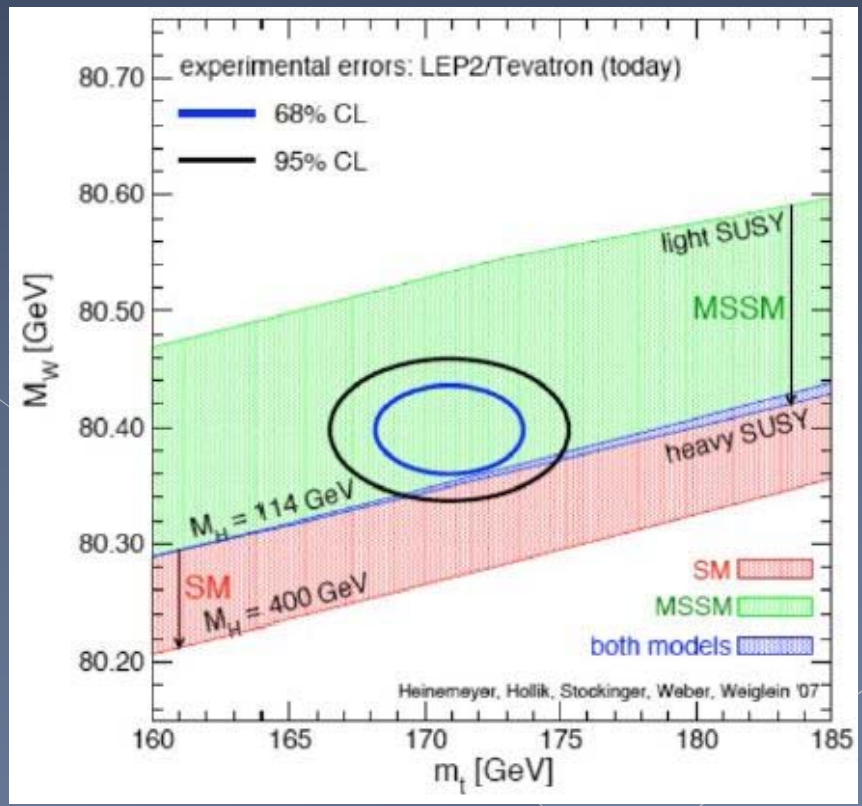
Outline

- Introduction
- Preselection
- Analysis strategy
- Background model
- Likelihood development
- Ensemble test
- Outlook

Motivation

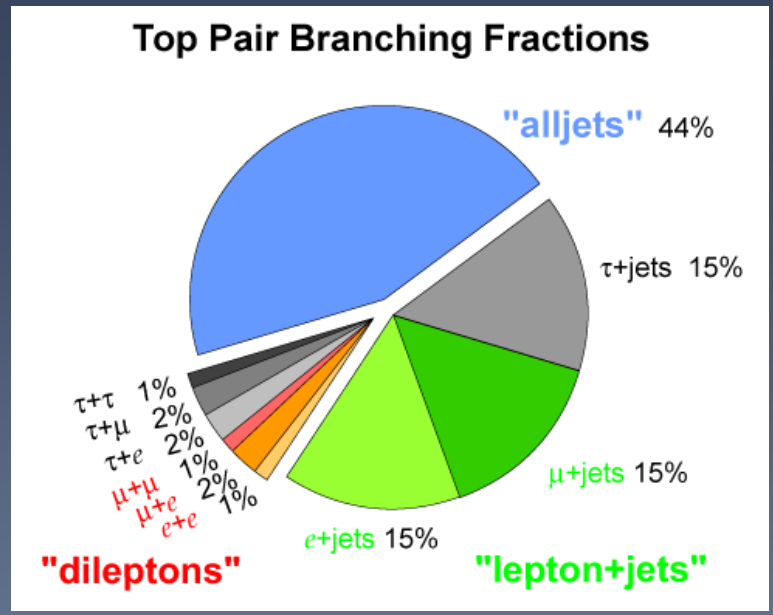
- Top mass is an important parameter in SM which still needs to be determined with better accuracy.
- A more accurate top mass measurement helps to narrow the Higgs mass range.
  - Which could change the Higgs search strategy.

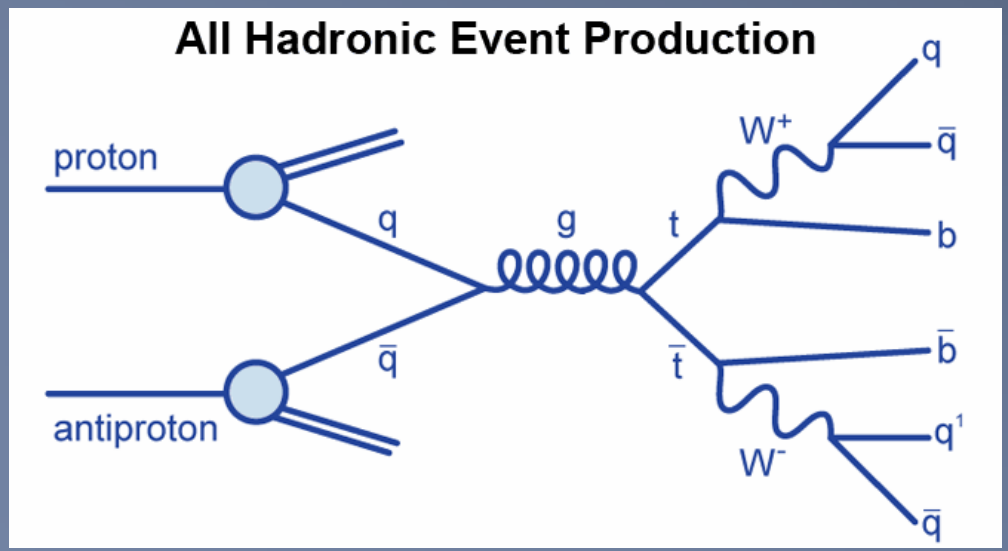
SM Higgs prediction

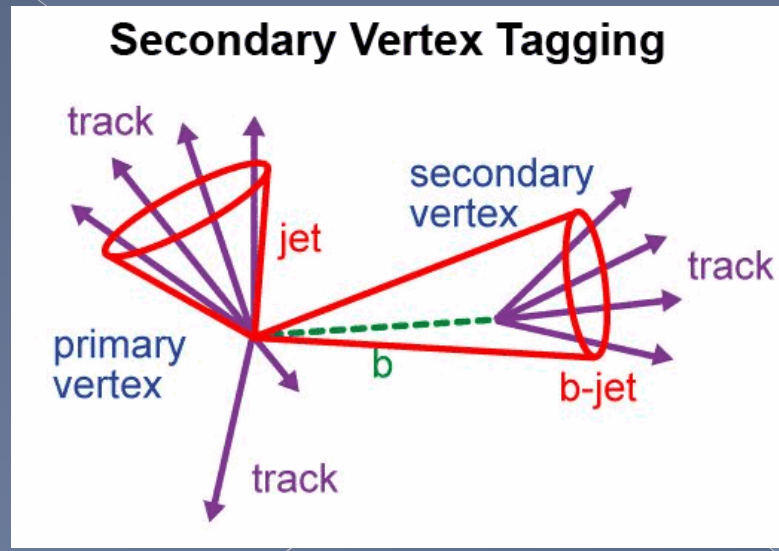


All Hadronic Channel

- All hadronic channel has the largest branching fraction of the top pair events.
- Decay products contain 2 *b* quarks and 4 light quarks.
- Use secondary vertex tag (SVT) to identify the *b* quark jet to reduce the number of combinations.







Preselection for the Hadronic Events

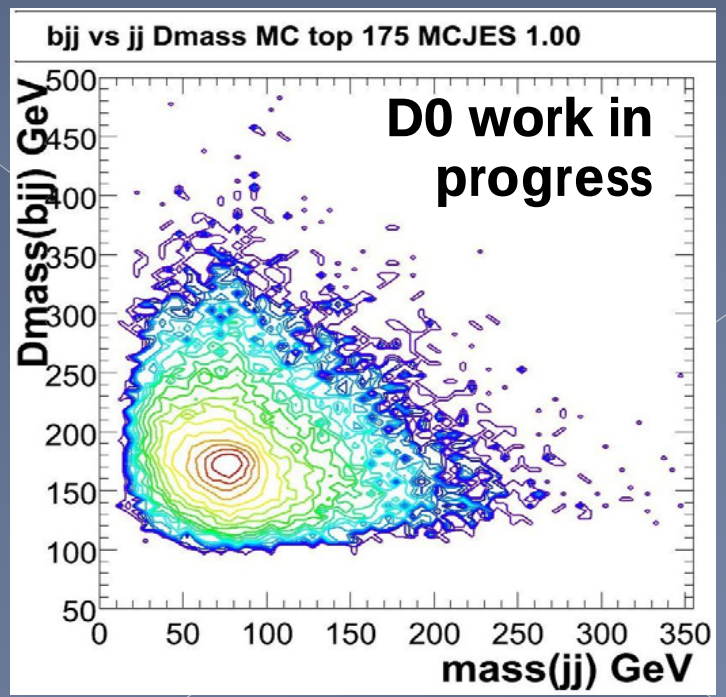
- Exactly 6 jets, $|\eta_{det}| < 2.5$
- 2 leading jets pT > 40 GeV/c
- 3rd jet pT > 30 GeV/c
- 4th-6th jet pT > 15 GeV.
  - Avoid bias by cutting above the turn-on region of the trigger system.
- 2 secondary vertex tagged jets (*b*-jets)
- *b*-jets pT > 40 GeV
- Mass(*bb*) > 80 GeV
  - gluon splitting g→*bb* have 2 *b*-jets close together, likely to yield mass < 80 GeV
  - Reject event from gluon splitting

Analysis Strategy

- Determine both top mass and JES (Jet Energy Scale) simultaneously based on the signal/background shape of di-jets (jj) mass (W mass) vs. b+di-jets mass.
- Reduce correlation between top and W mass with

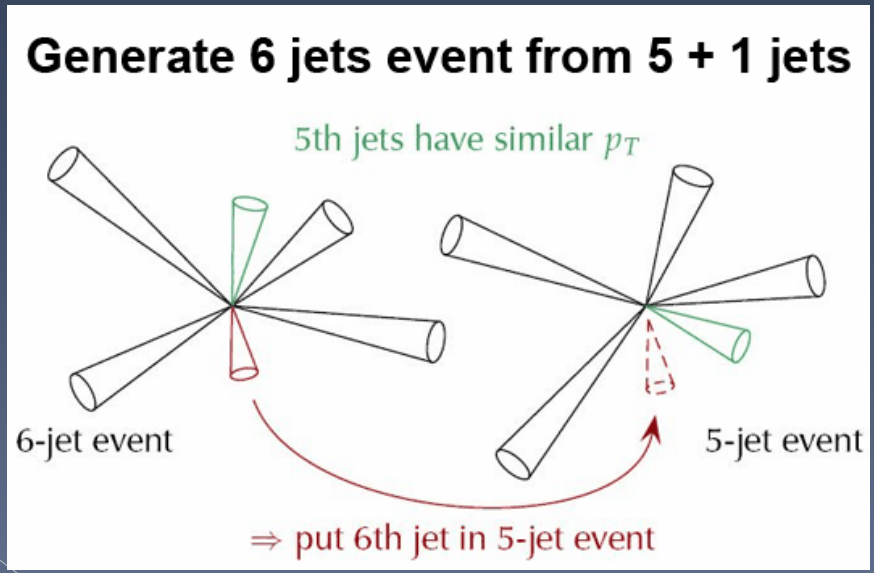
$$Dmass\,(\,bjj\,) = mass\,(\,bjj\,) - mass\,(\,jj\,) + 80.423GeV$$

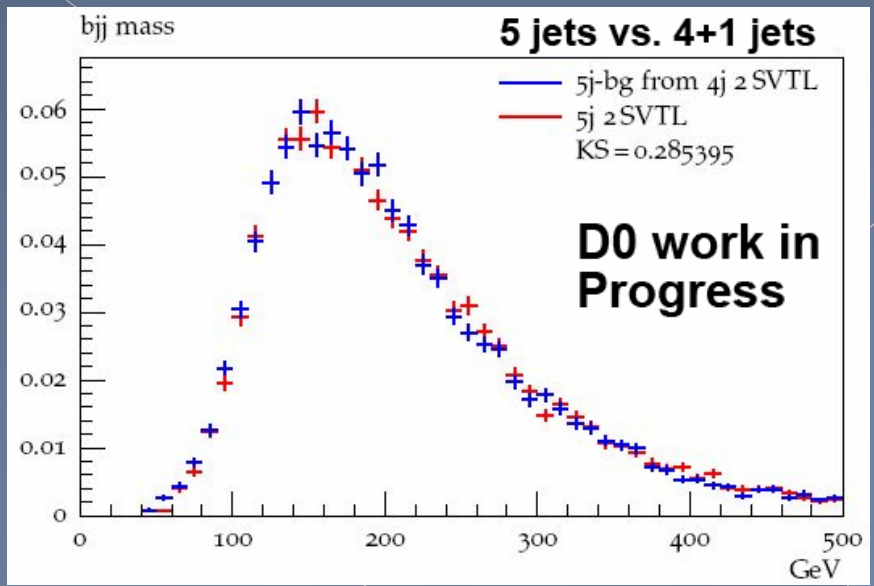
- In addition to all jet combinations, can also enhance the mass peak using:
- Best $\chi^2 = [mass(j_1 j_2) - mass(j_3 j_4)]^2 + [mass(b_1 j_1 j_2) - mass(b_2 j_3 j_4)]^2$
- Probability of signal based on topological likelihood



Background Model

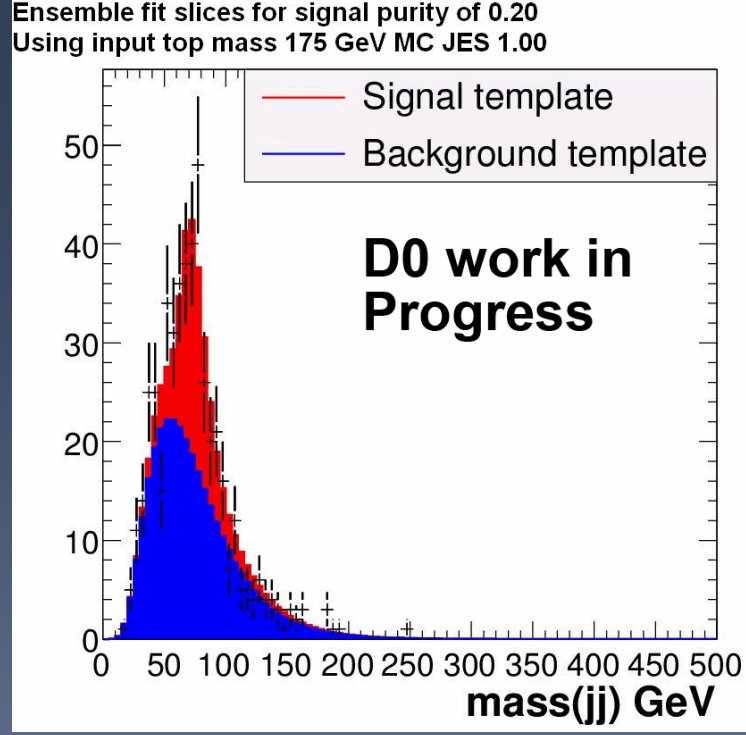
- Majority background of all-hadronic channels are QCD multi-jets events.
- MC simulation of multi-jets not sufficient to be trusted.
- Therefore need to extract the background shape from data.
- Add 1 jet to 5 jets events to get pure background
- Model works well with current background.

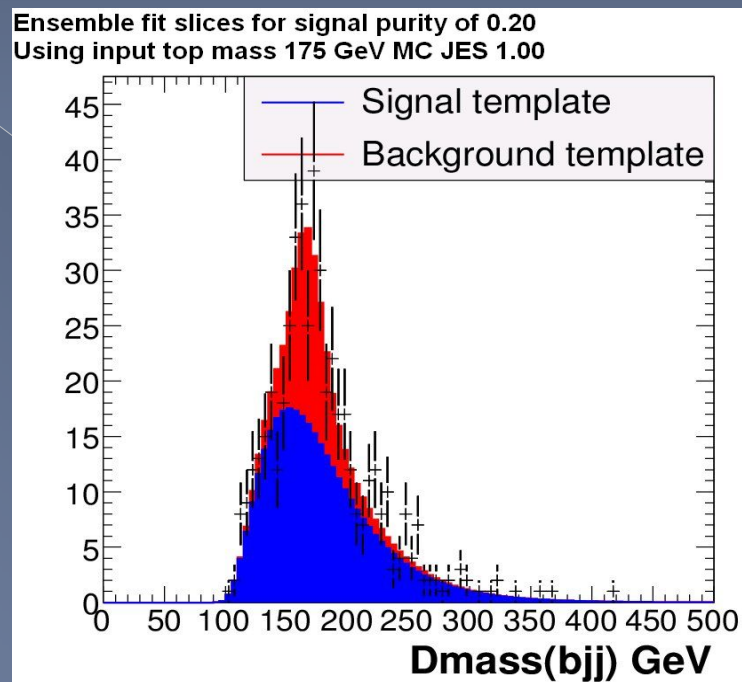




Template Fit

- The signal comes from Monte Carlo (MC), with different input top mass and Jet Energy Scale.
- Signal Fit function consist of 2 parts, for the correct/wrong jet combinations.
- Background function use the wrong jet combination part only.
- Fit works with pseudo-experiments of combining MC signal and background events.





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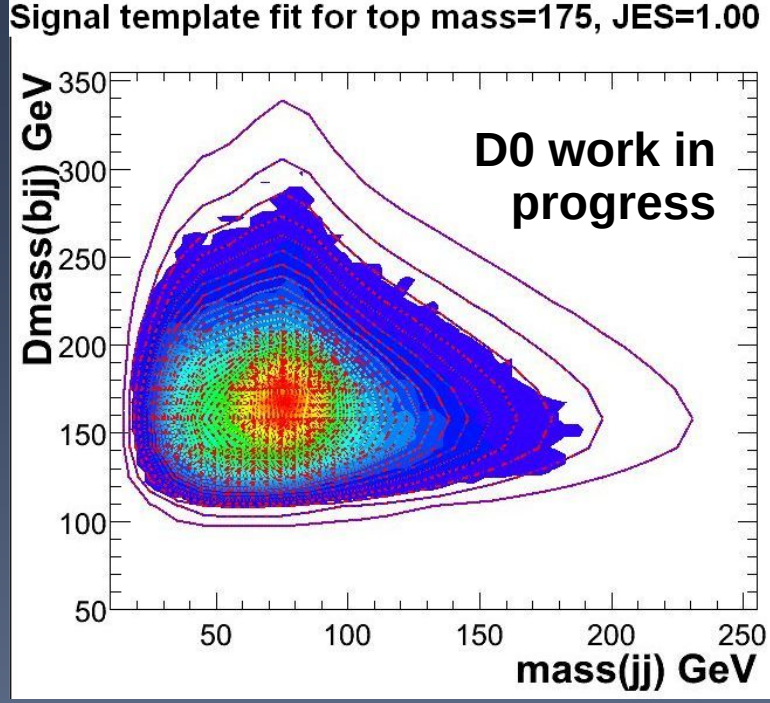
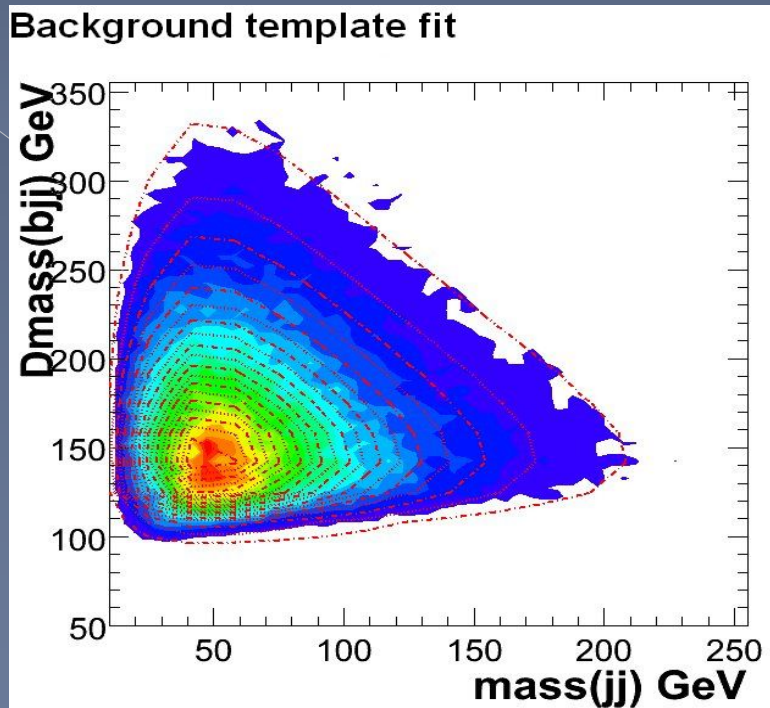


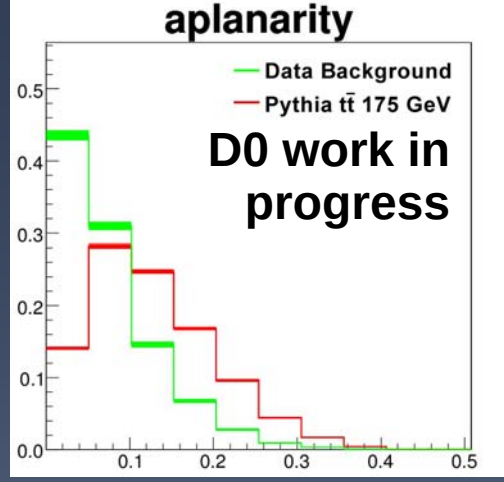


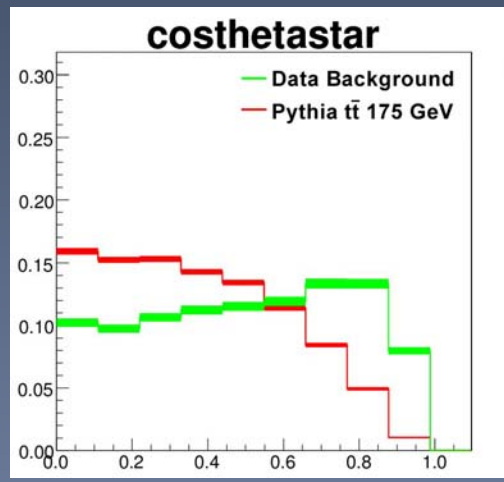
Topological Likelihood

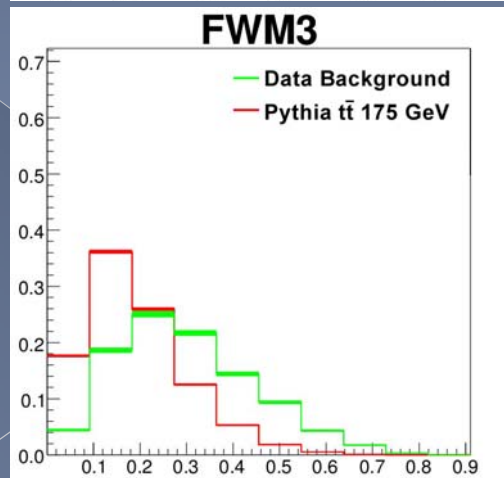
- Need to improve the signal fraction in the sample.
- Look into a set of topological variables that differ between Background and signal.
- dY01: rapidity difference between first 2 leading pT jets
- Aplanarity
- Cos(theta*)
- dY_{max}(among all 6 jets)
- El liptical flow(v2) = <cos(jet phi)>
- Fox-Wolfram Moments – a measure of the moments in the phase space.

$$H_k = \left(\frac{4\pi}{2l+1}\right) \sum_{m=-k}^{k} \left| \sum_{j}^{jets} Y_k^m(\Omega_j) \frac{|\vec{p}_j|}{E_{tot}} \right|^2$$

- Use 3rd – 9th moment.





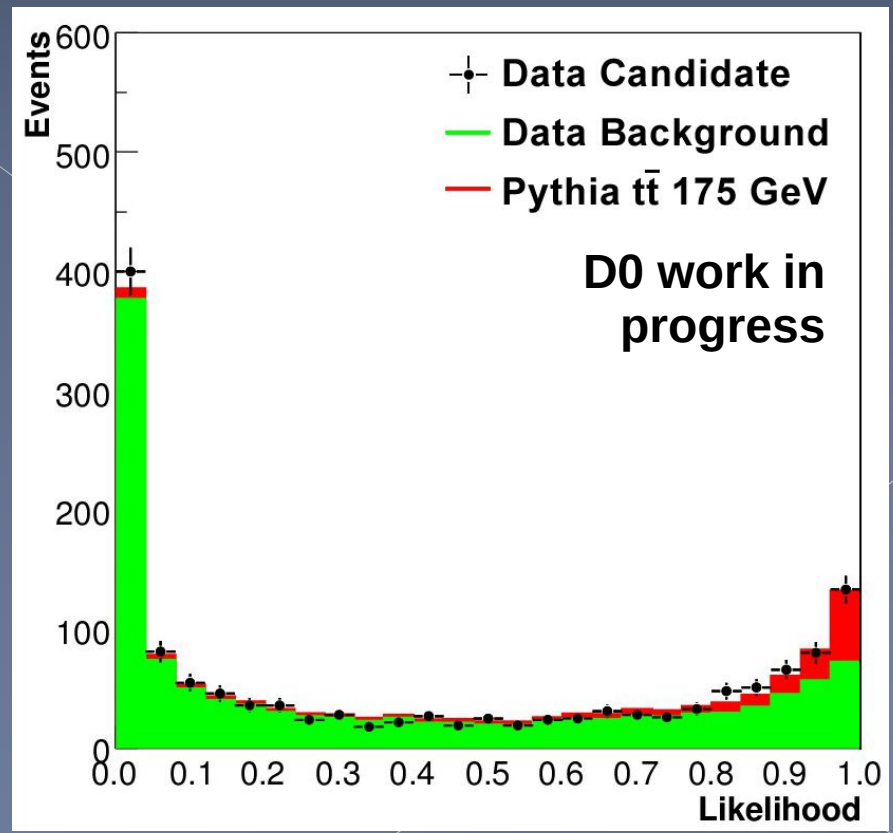


Topological Likelihood

- The chosen set variables are only loosely correlated to each other.
- Then we can develop a likelihood discriminant using chosen set of variables $\{x_i\}$:

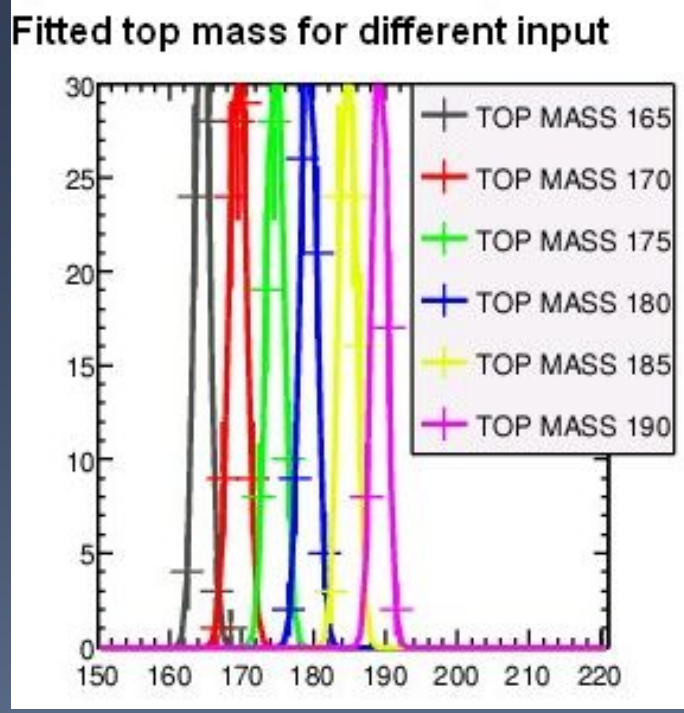
$$\frac{\prod_i Sig(x_i)}{\prod_i Sig(x_i) + \prod_i Bkg(x_i)}$$

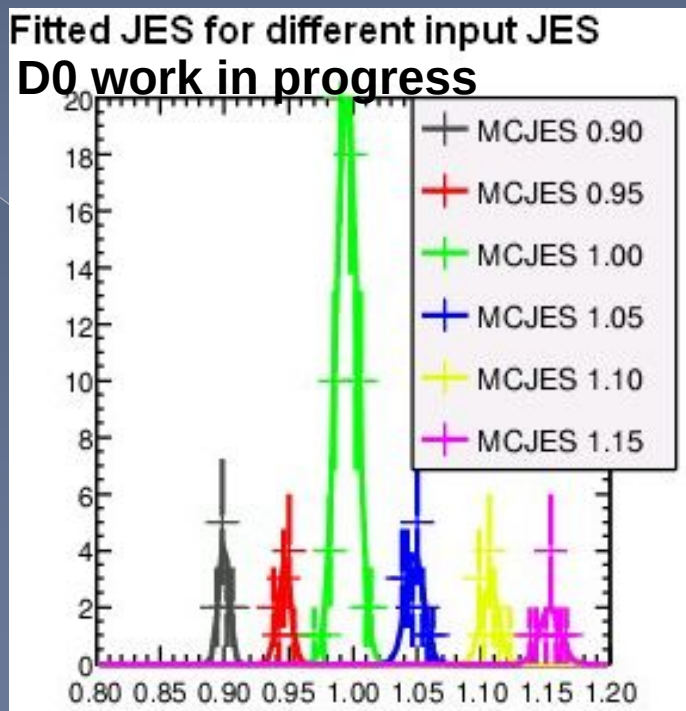
- Likelihood shows good separation between signal and background.
- Can be applied to event selection/ mass weighting



Ensemble Test

- Perform many pseudo-experiments by generating ensembles from MC events of different input top mass, JES + data background events, with different signal/background ratio.
- The test can also provide calibration of the output values of our method.





Outlook

- If the method is stable, then the pseudo-experiments will yield correct results in average.
- Ensemble test gives promising results that the template method is feasible.
- Looking forward for a better mass measurement from this channel!