



Delphes Simulation Studies on Higgs Pair Production in Muon Collider

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- Signal: $\mu^+ + \mu^- \rightarrow \nu_\mu + \bar{\nu}_\mu + H + H$
- Background:
 - $\mu^+ + \mu^- \rightarrow \nu_\mu + \bar{\nu}_\mu + b + \bar{b} + Z$
 - $\mu^+ + \mu^- \rightarrow \nu_\mu + \bar{\nu}_\mu + b + \bar{b} + H$
 - $\mu^+ + \mu^- \rightarrow \nu_\mu + \bar{\nu}_\mu + b + \bar{b} + b + \bar{b}$



Reconstructing two Higgs bosons

- Anti- k_t Jets:
 1. Single jets pair optimize:
 - Simply leading and sub-leading jets pair, ordering by how far it is from 125GeV
 2. Dual jets pair optimize:
 - Minimize the sum of the distance from jets pair to 125GeV



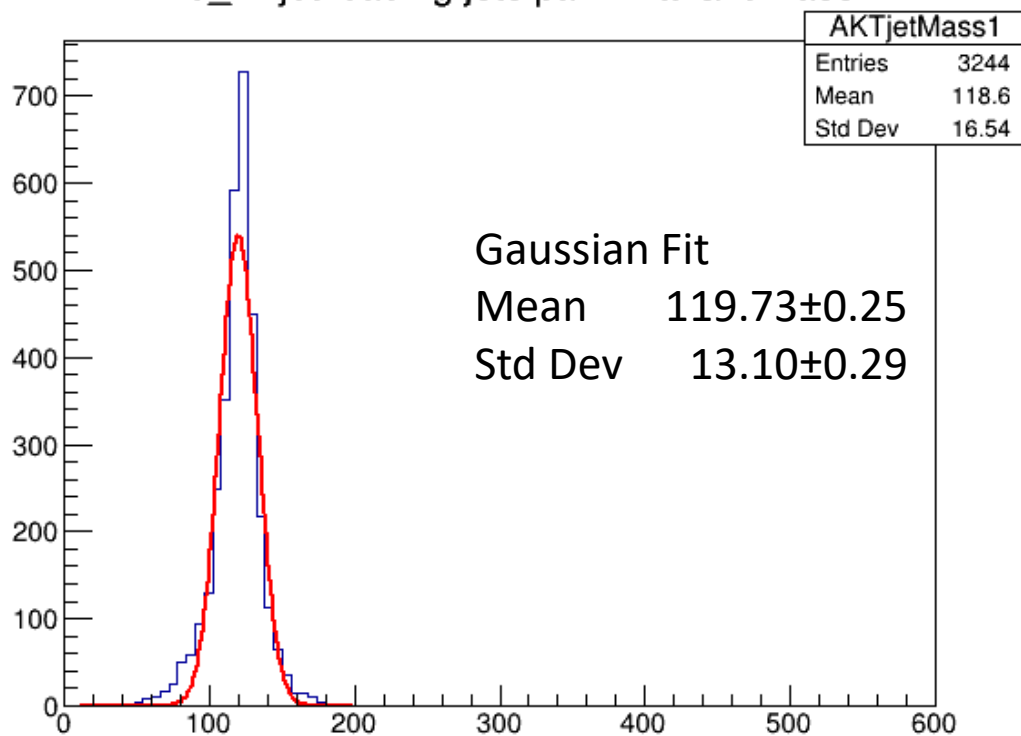
Single jets pair optimize

- Anti- k_t Jets:
 - Only studied the events with at least 4 jets (or exactly 4), ordering the leading and sub-leading jets pair by distance to 125GeV. Then truth matching with GenJet ($|\eta| < 2.25$).
 - 32.4% pass check (nJets \geq 4)
 - 26.4% pass check (nJets = 4)
 - Invariant mass of sub-leading jets pair
 - 79.33GeV (nJets \geq 4)
 - 85.80GeV (nJets = 4)
 - Gaussian fit with an exponential background

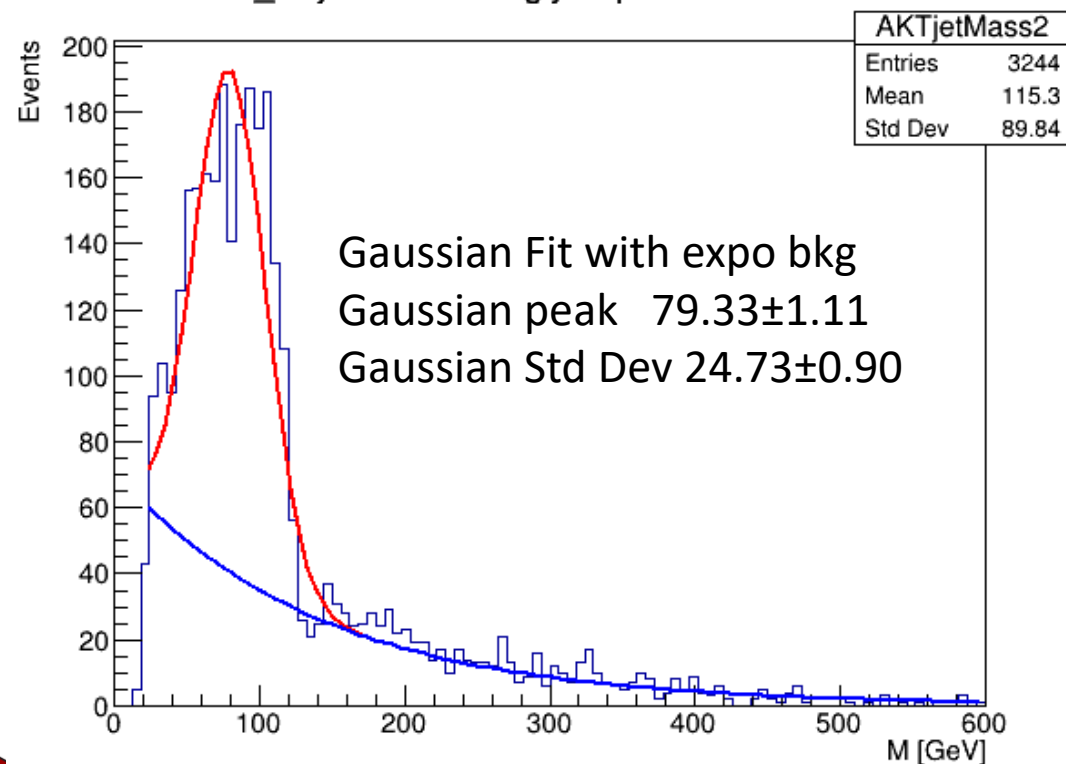


Anti- k_t jet for 10k events ($n_{\text{Jets}} \geq 4$)

Anti_KTjet leading jets pair invariant mass



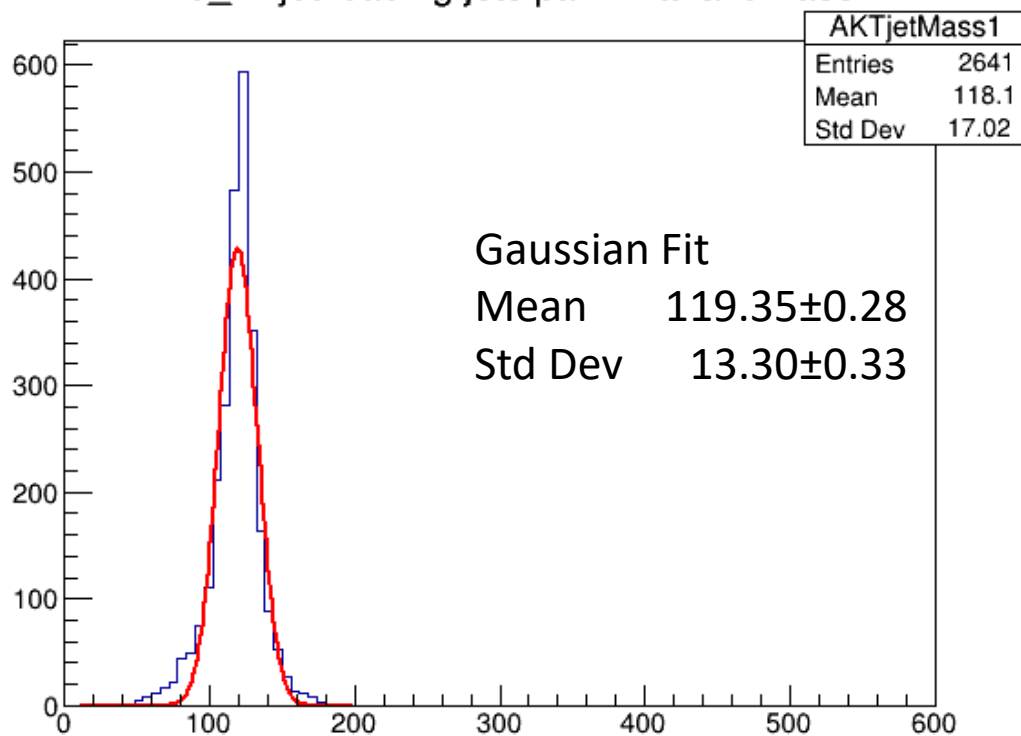
Anti_KTjet sub-leading jets pair invariant mass



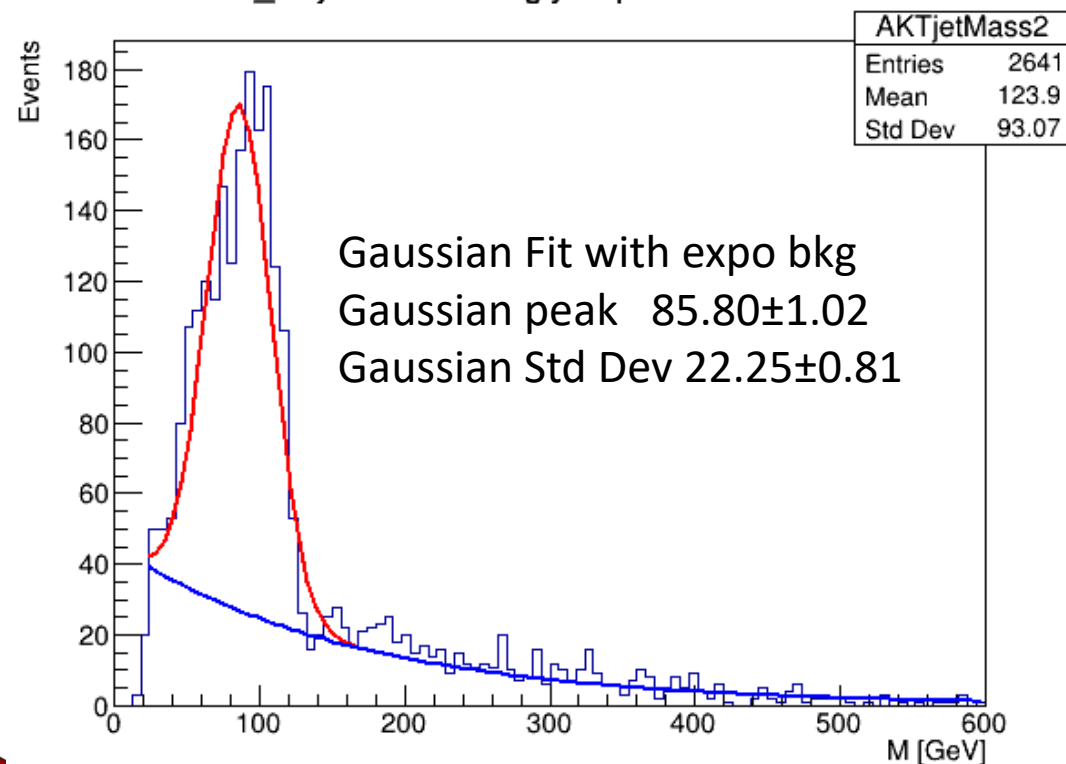


Anti- k_t jet for 10k events (nJets = 4)

Anti_KTjet leading jets pair invariant mass



Anti_KTjet sub-leading jets pair invariant mass





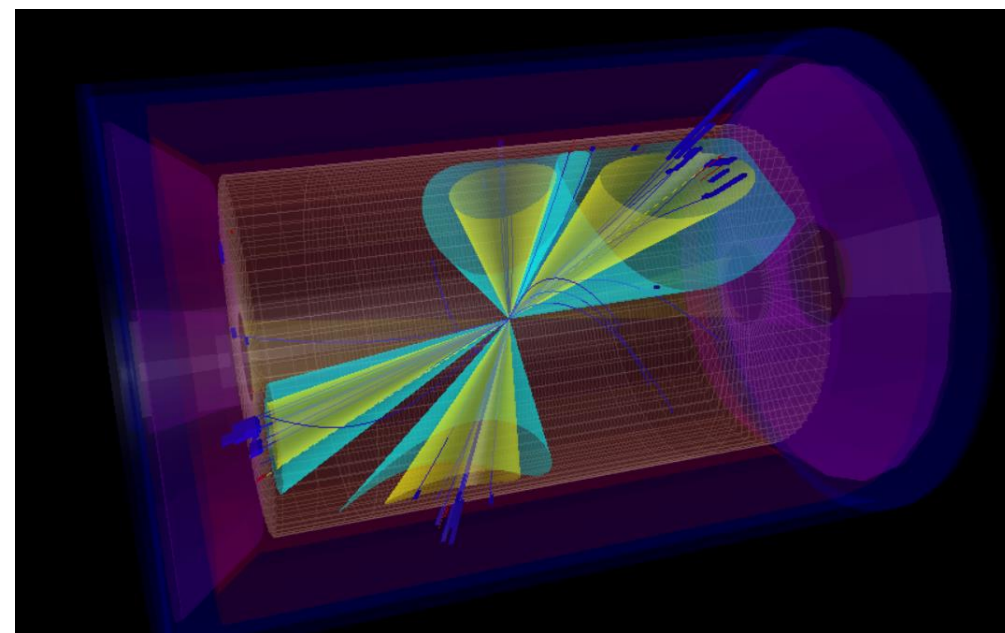
Dual jets pair optimize

- Anti- k_t Jets:
 1. Arbitrarily pick two from all jets
 2. Choosing one pair that is closest to 125GeV from the rest to be the respective sub-leading jets pair.
 3. Stored all info in a 2d array. Finally choosing the choice with smallest sum of distance from 125GeV



For exactly for 4 jets in one event

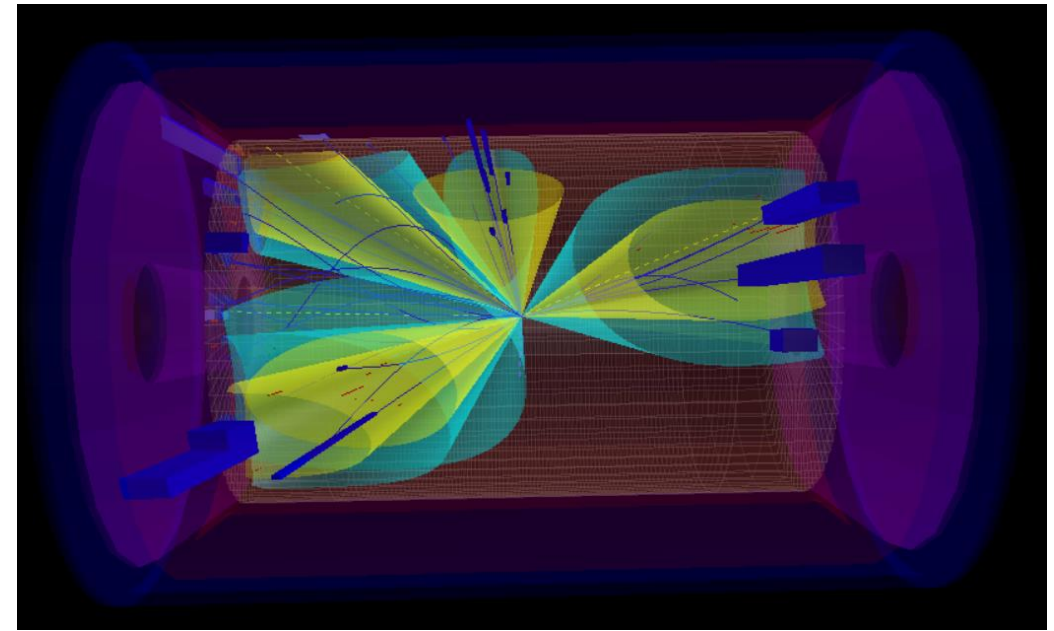
1. C_2^4 different choices for picking the “leading” jets pair, then the remain two just forms the “sub-leading” jets pair.
2. Store the invariant masses and entry info into a 2d array `AKTjetspair[C24] [6]`.
3. Final decision is the one that minimize the sum of the distance from 125GeV





For at least 4 jets ($n_{\text{Jet}} = n$) in one event

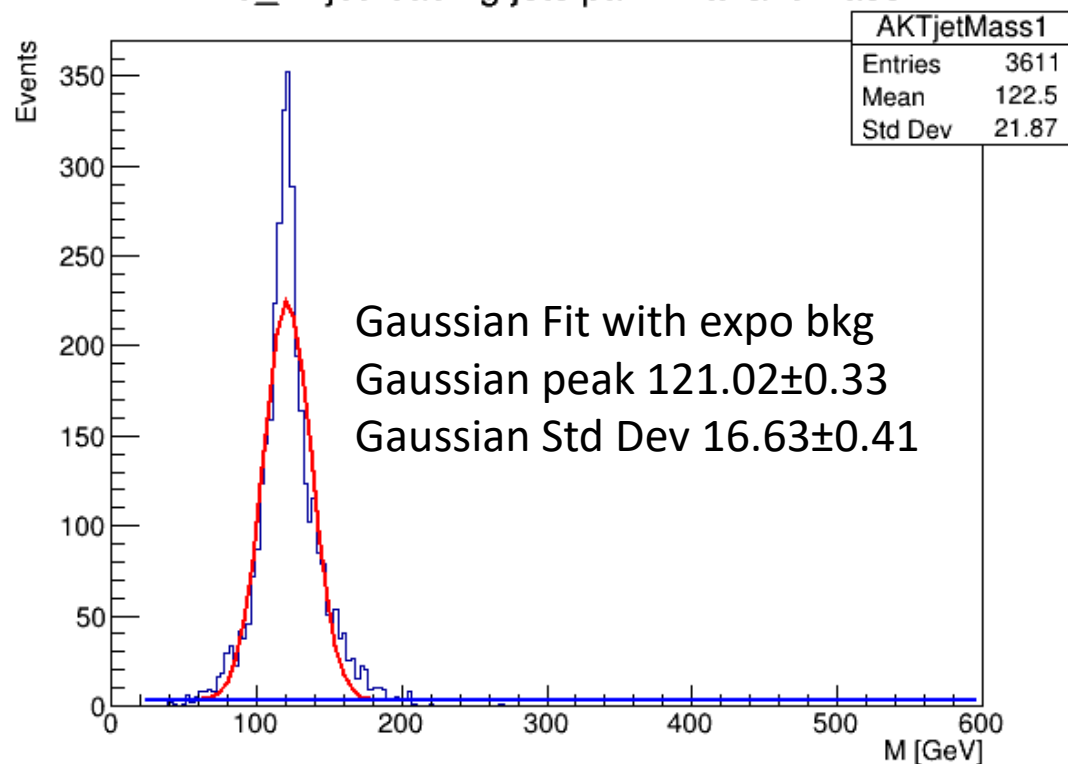
1. C_2^n choices for the “leading” jets pair.
2. Loop through remain C_2^{n-2} choice for “sub-leading” jets pair choosing the one which closest to 125GeV
3. Store the invariant masses and entry info into a 2d array `AKTjetspair[C_2^n]` [6].
4. Final decision is the one that minimize the sum of the distance from 125GeV



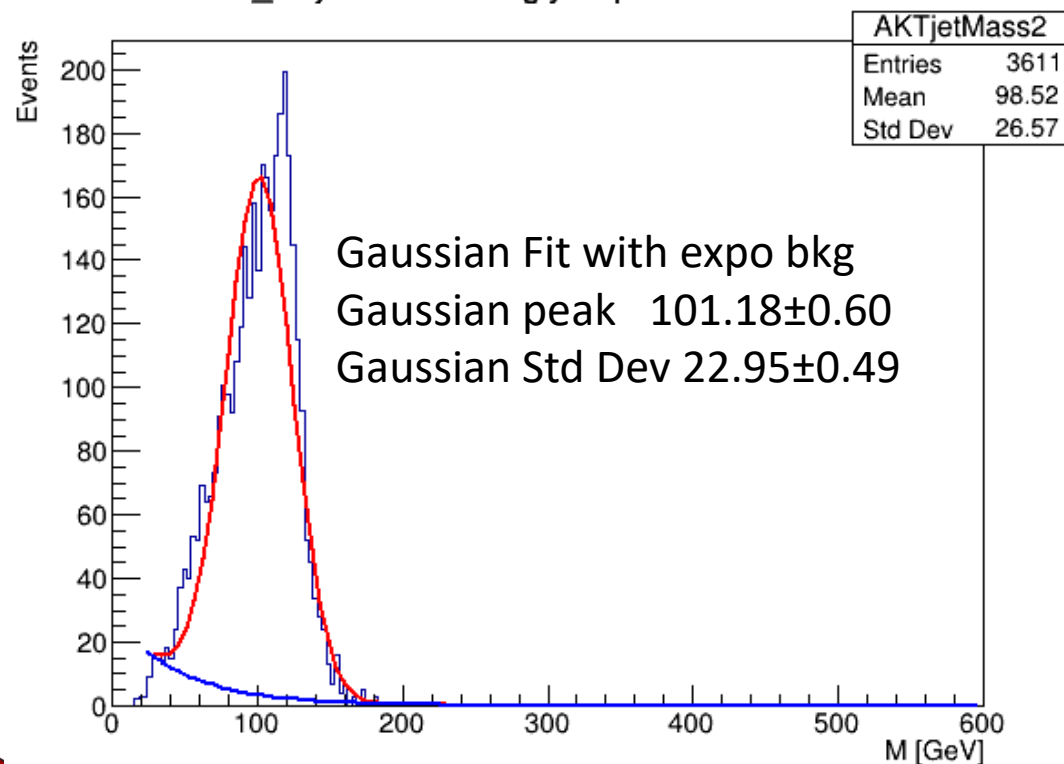


Anti- k_t jet for 10k events ($n_{\text{Jets}} \geq 4$)

Anti_KTjet leading jets pair invariant mass



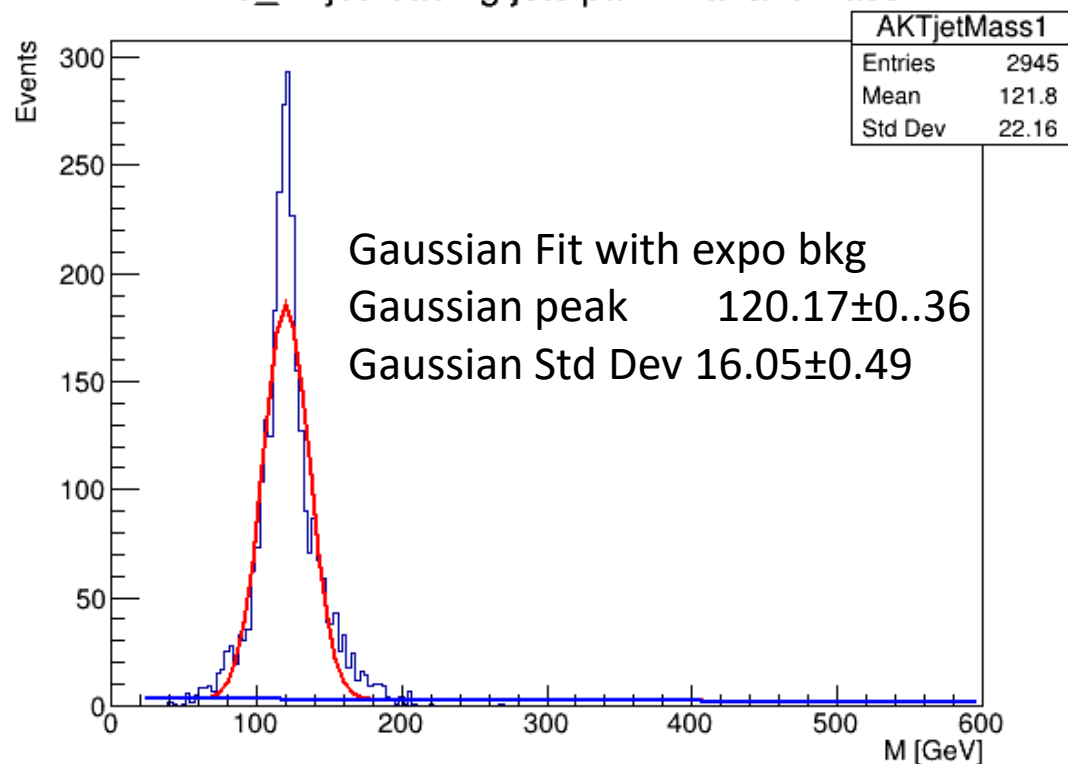
Anti_KTjet sub-leading jets pair invariant mass



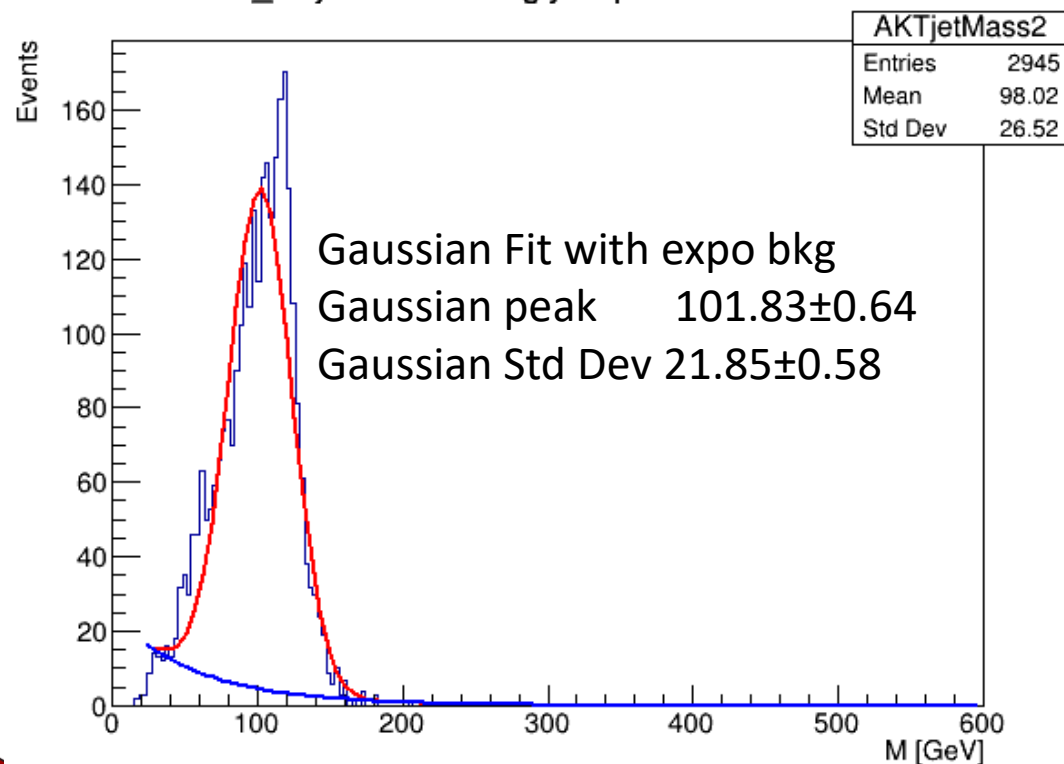


Anti- k_t jet for 10k events (nJets = 4)

Anti_KTjet leading jets pair invariant mass



Anti_KTjet sub-leading jets pair invariant mass





Appendix: data card for run anti- k_t jet algo

```
1633 #####
1634 # Jet finder AKT
1635 #####
1636
1637 module FastJetFinder FastJetFinderAKT {
1638     # set InputArray Calorimeter/towers
1639     set InputArray EFlowMerger/eflow
1640
1641     set OutputArray AKTjets
1642
1643     # algorithm: 1 CDFJetClu, 2 MidPoint, 3 SIScone, 4 kt, 5 Cambridge/Aachen, 6 antikt.
1644     set JetAlgorithm 6
1645     set ParameterR 0.5
1646
1647     set JetPTMin 20.0
1648 }
```