



Feasibility Study on Higgs Pair Production in Muon Collider

Summer plan

Kenny Jia

May 6th, 2021





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



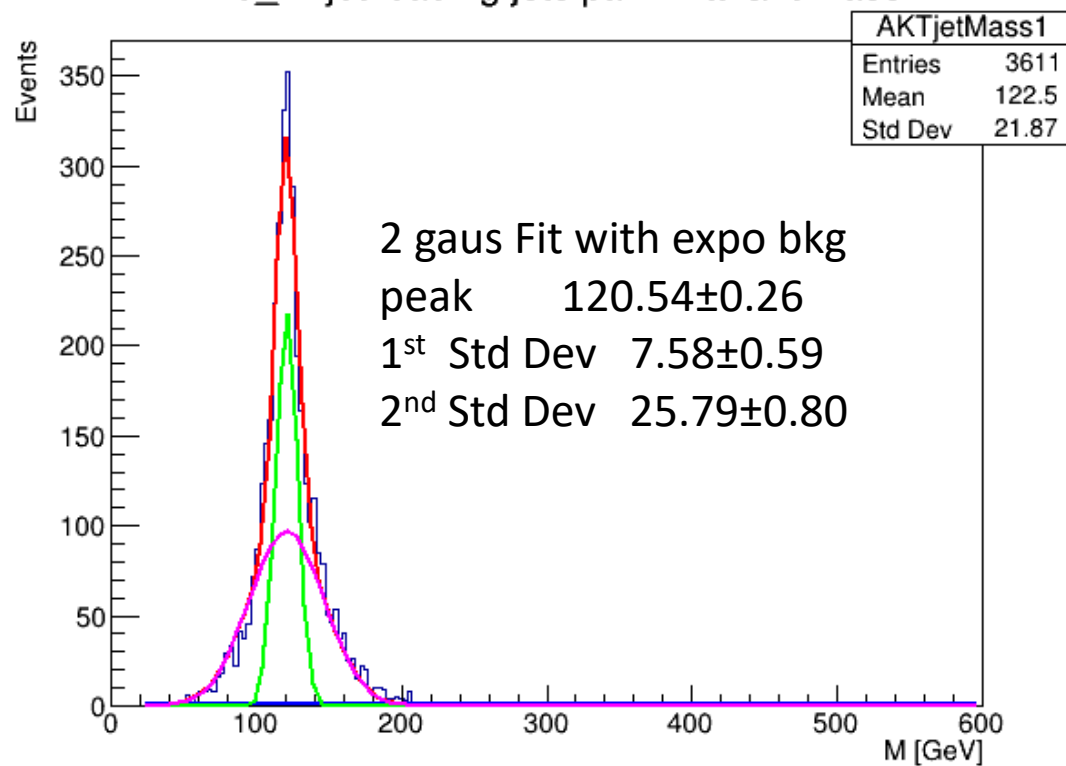
Reconstructing two Higgs bosons

- 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**

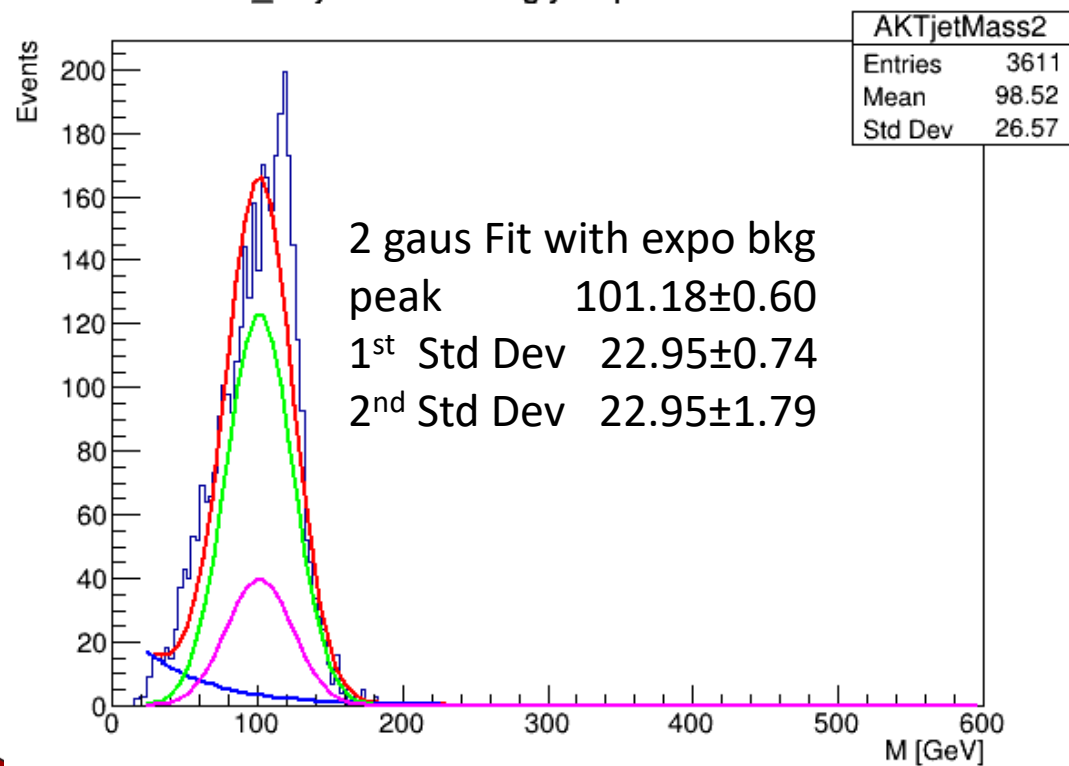


Anti- k_t jet for 10k events ($n_{\text{Jets}} \geq 4$)

Anti_KTjet leading jets pair invariant mass

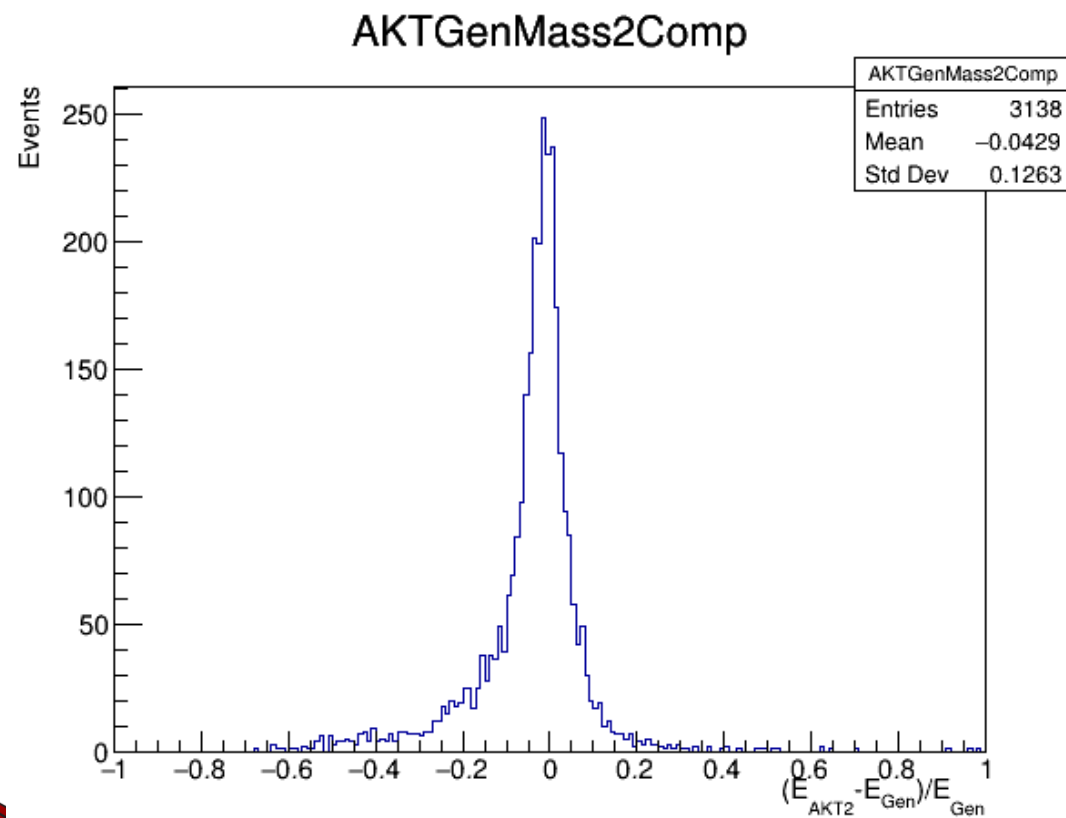
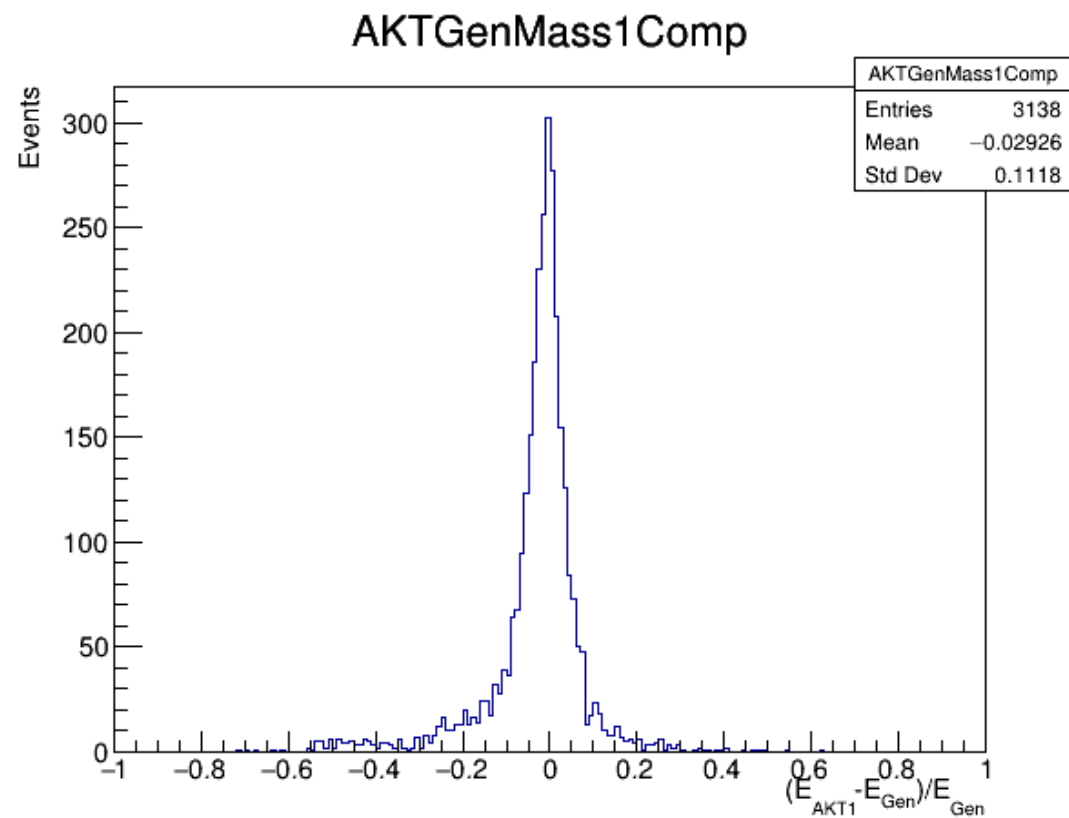


Anti_KTjet sub-leading jets pair invariant mass





Resolution





Summer plan

- Research side:
 - Continue on jets pairing algo
 - kinematic fitting
- Personal side:
 - Prepare GRE from late June to July, might be a little busy but I think there will be enough time for research
 - Maybe going back home early August depends on policies, so far it seems impossible.



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 }
```



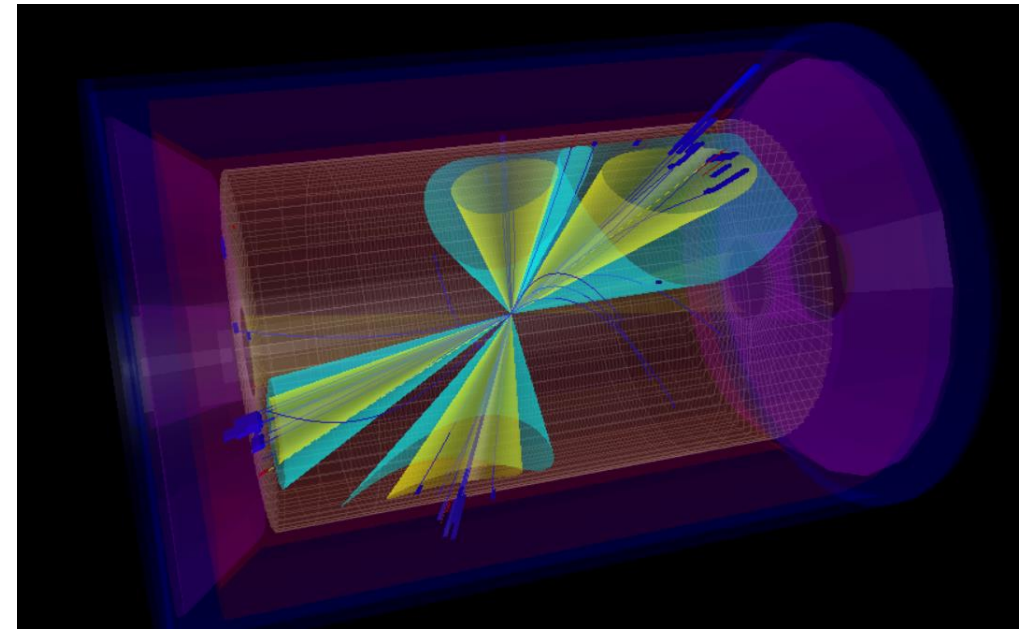
Appendix: Dual jets pair optimize

- 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



Appendix: For exactly for 4 jets in one event

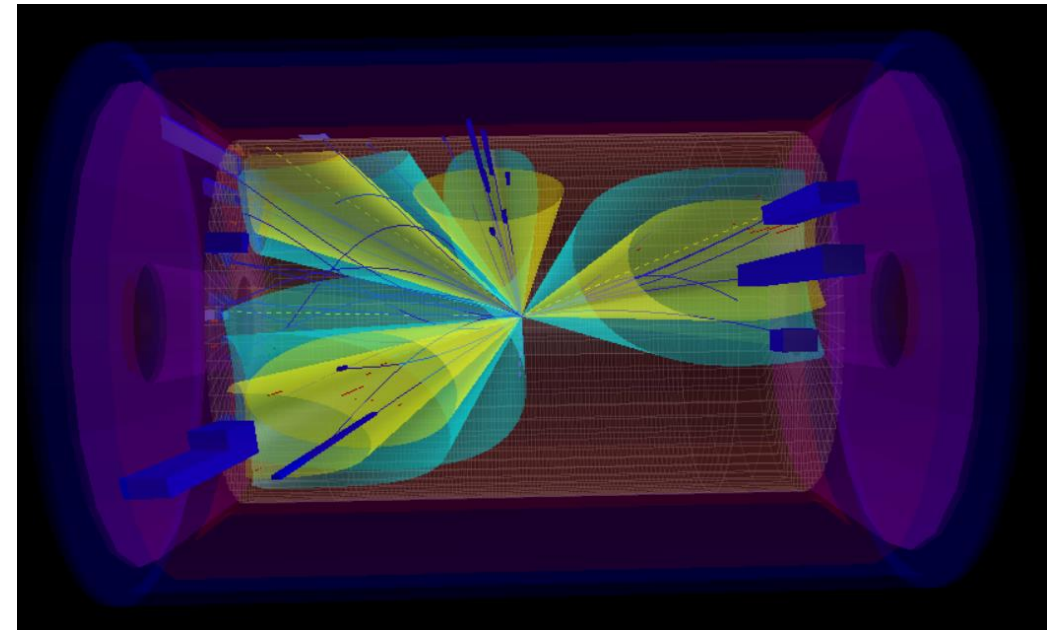
1. C_2^4 different choices for picking the “leading” jets pair, then the remain two just forms the “sub-leading” jets pair.
2. Store the invariant masses and entry info into a 2d array AKTjetspair[C_2^4] [6].
3. Final decision is the one that minimize the sum of the distance from 125GeV





Appendix: 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 `AKTjetpair[ $C_2^n$ ]` [6].
4. Final decision is the one that minimize the sum of the distance from 125GeV





Appendix: Double gaussian fit with exponential background

- Fit to curve:

- $f(x) = A_1 \exp[-\frac{1}{2}(\frac{x-\mu_1}{\sigma_1})^2] + A_2 \exp[-\frac{1}{2}(\frac{x-\mu_2}{\sigma_2})^2] + \exp(A_3 - \lambda x)$
- Tight bound on almost all parameters

```
TF1 *jetpair1fit = new TF1("jetpair1fit", "gaus+gaus(3)",25,600);
TF1 *jetpair2fit = new TF1("jetpair2fit", "gaus+gaus(3)+expo(6)",25,600);
TF1 *fSignal = new TF1("fSignal","gaus+gaus(3)",20,600);
TF1 *fBackground = new TF1("fBackground","expo", 20,600);
Double_t param[8];
```

```
jetpair2fit->SetParameters(200,133,10,20,100,10,2,-0.0001);
jetpair2fit->SetParLimits(0,80,200);
jetpair2fit->SetParLimits(1,110,130);
jetpair2fit->SetParLimits(2,5,25);
jetpair2fit->SetParLimits(6,0,8);
jetpair2fit->SetParLimits(7,-1,-0.0001);
jetpair2fit->SetParLimits(4,50,109);
jetpair2fit->SetParLimits(5,5,30);
```

```
jetpair1fit->SetParameters(300,120,10,40,125,10,2,-0.0001);
jetpair1fit->SetParLimits(0,100,400);
jetpair1fit->SetParLimits(1,110,120);
jetpair1fit->SetParLimits(2,5,30);
/*jetpair1fit->SetParLimits(6,0,8);
jetpair1fit->SetParLimits(7,-1.5,-0.0001);*/
jetpair1fit->SetParLimits(4,120,140);
jetpair1fit->SetParLimits(5,5,40);
```



Kinematic fitting

