vvh 1TeV study
# h→WW* channel study

ILD Analysis meeting

Nov. 06 2012

H.Ono (NDU)

Current status

- h→bb, cc, gg channel
  - Update with all the available BGs (2f, 4f, 6f)
    →Still majority is singleZnunu_sl channel
    Ask Jan to increase statistics to reduce fluctuation
  - γγ→hadron BG study is still on-going to improve the the mass separation
- h→WW*→4j channels
  - Check background rejection and flavor tagging performance

Request to simulate/reconstruct samples

Invariant mass after pre selection
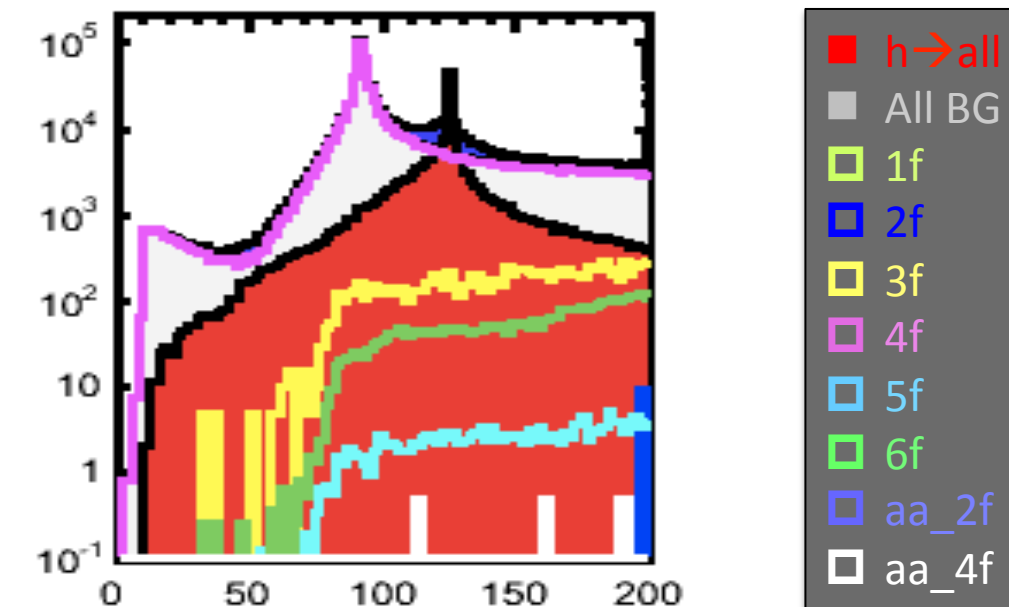
3f samples are not simulated at all

			Cross section	Request
3f	ae_vxy	eB.pR.I35369	15311.4	10,000
3f	ae_vxy	eW.pR.I35368	6126.4	10,000

Generator level check
L=500 fb^{-1}, (e$^-$,e$^+$)=(-0.8, 0.2)

| Type	evis<500	pt>15	-450<pl<300	15<NPFO<150	100<Mh<150
H->all	198,659	191,456	185,578	169,119	118,037
bb	114,217	111,144	107,452	107,447	80,008
cc	5,340	5,210	5,014	5,014	3,897
gg	16,876	16,495	15,832	15,831	12,245
WW	43,027	41,292	40,223	35,987	19,157
1f	85,873	0	0	0	0
2f	59,425	39,582	38,631	812	0
3f	2,200,210	1,524,950	257,754	57,931	4,024
4f	2,817,240	2,493,310	1,876,850	833,577	144,232
5f	5,454	4,936	2,150	1,013	64
6f	21,299	20,799	19,441	18,455	1,154
aa_2f	169,421	11,464	10,289	3	0
aa_4f	1,987	1,703	1,529	271	1
BG all	5,360,900	4,096,740	2,206,650	912,062	149,474

H→WW* channel

h→WW* (one on-shell W) from Higgs decay
h→WW*→qqqq fully hadronic decay channel is considered
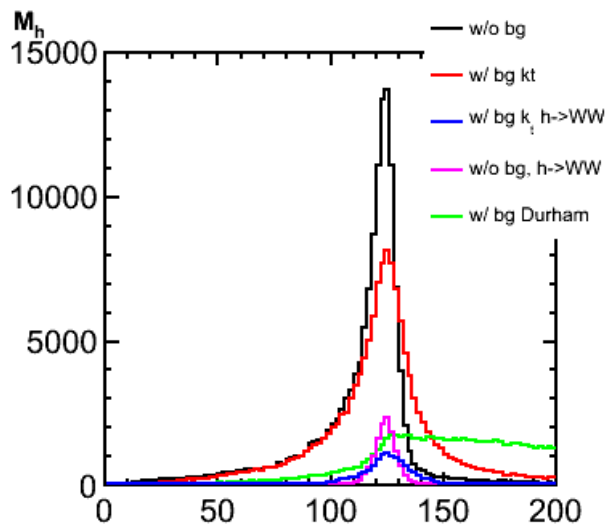
1. Apply forced <u>four jet clustering</u> with <u>k_t jet clustering</u> (R=1.1)
2. Apply flavor tag for jet associated particles with LCFIPlus
3. Jet clustering and paring for W_1, W_2 (W_1 is on-shell with J_1, J_2)
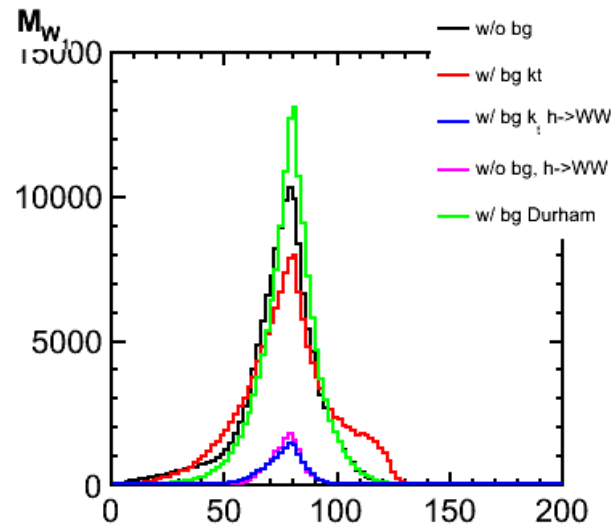4. Select best candidate with minimizing χ^2
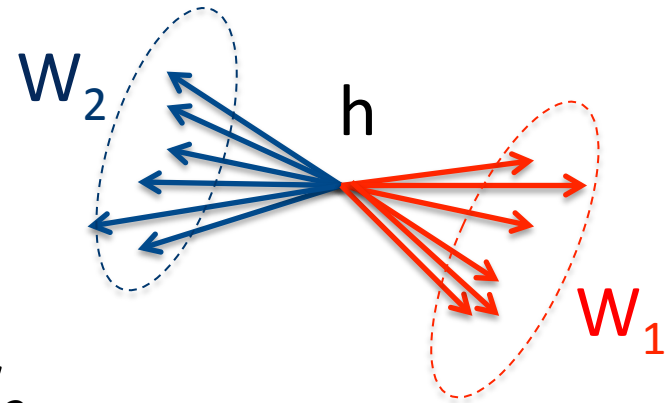
$$\chi^2 = \left(\frac{M_{12} - M_W}{\sigma_W} \right)^2 + \left(\frac{M_{4j} - M_h}{\sigma_H} \right)^2$$

L=500 fb^{-1}
(e$^-$,e$^+$)=(-+0.8, +-0.2)

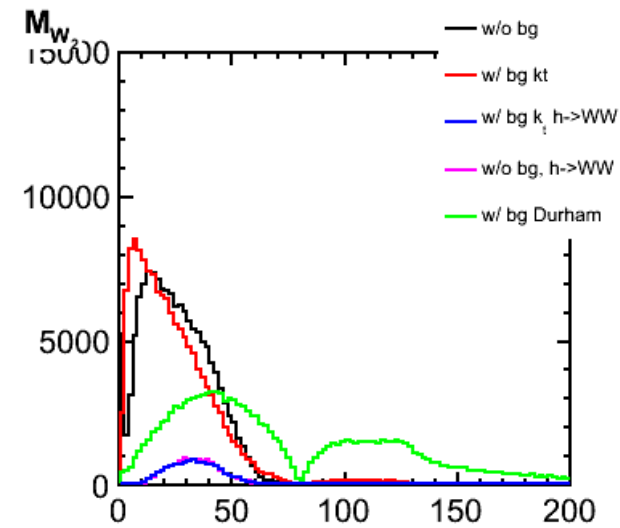# h→WW* analysis with kt jet clustering
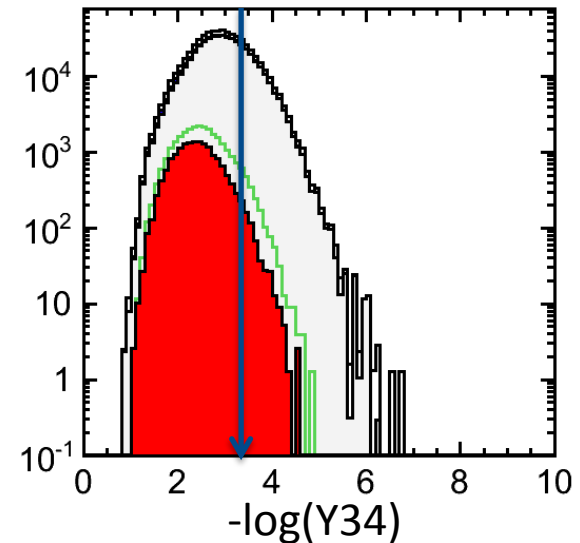
Higgs mass (GeV)

W_1 mass (GeV)

W_2 mass (GeV)

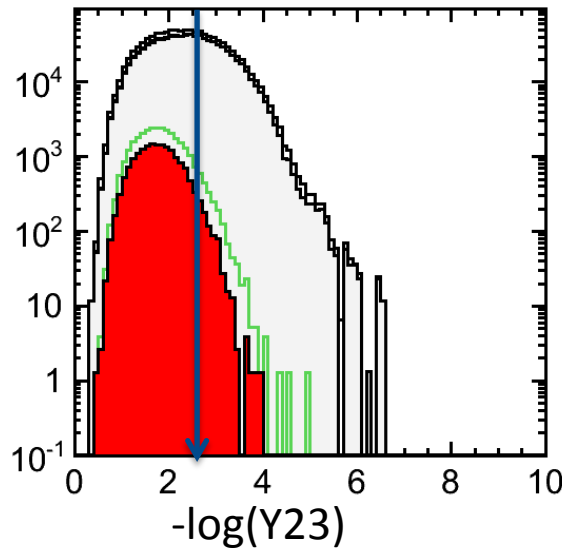- γγ→hadron is suppressed with kt jet clustering with R=1.1 but still remaining this effect
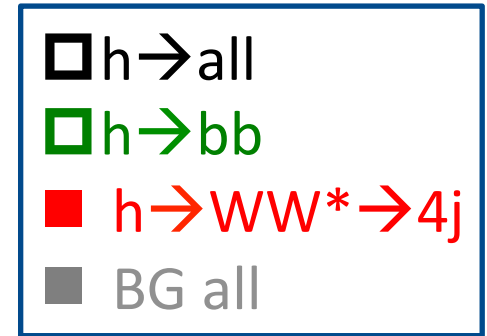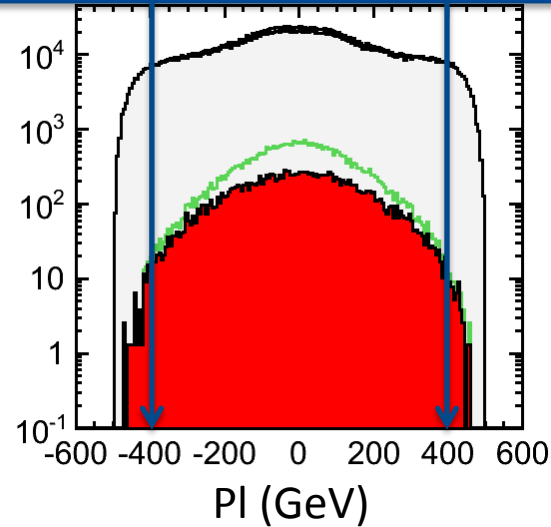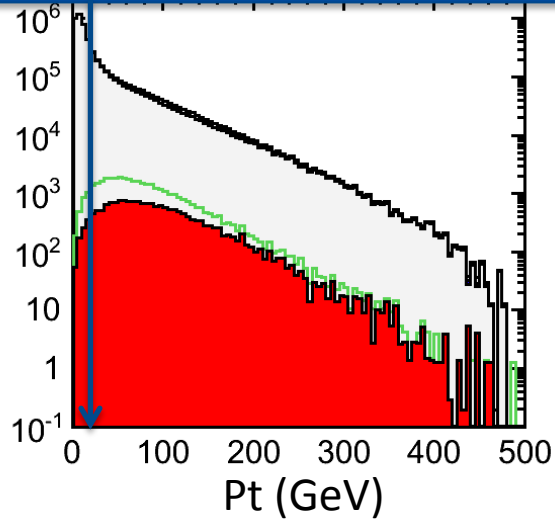
  →Still working this issue to improve BG reduction
- h→bb can be a background for h→WW*→4j channel.

  →Suppress with b-tagging information

Background reductions

1. $100 < \text{Evis} < 500$ GeV
2. $Pt > 20$ GeV: Suppress 2f backgrounds
3. $|Pl| < 400$ GeV
4. $50 < \text{Npfos}$: Suppress leptonic decay channel
5. $-\text{Log}(Y23) < 2.5$: suppress 2 jet like background
6. $-\text{Log}(Y34) < 2.8$: suppress 2 jet like background
7. b-likness < 0.2 : Suppress h$\rightarrow$bb backgrounds
8. $50 < M_{W1} < 100$ GeV
9. $M_{W2} > 15$ GeV
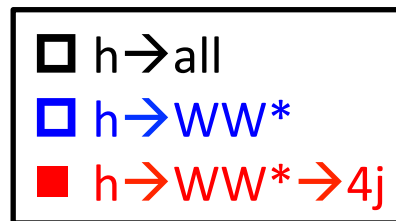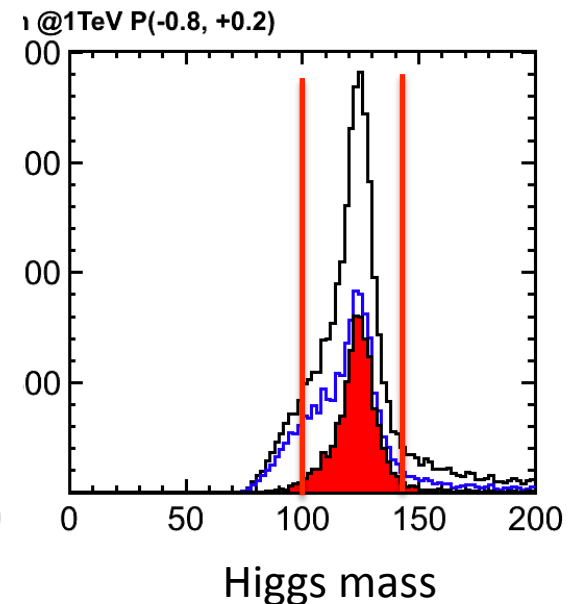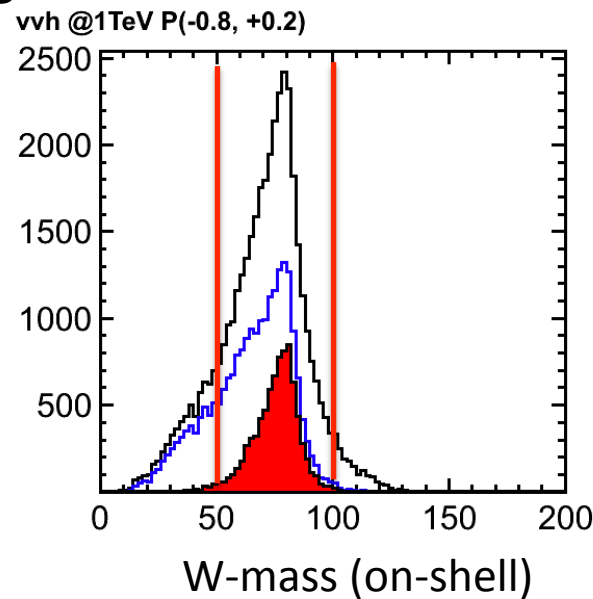10. $100 < M_h < 140$ GeV

Cut positions are still under optimization

Cut variables to suppress BGs

Legend:
- □ h→all (black)
- □ h→bb (green)
- ■ h→WW*→4j (red)
- ■ BG all (gray)
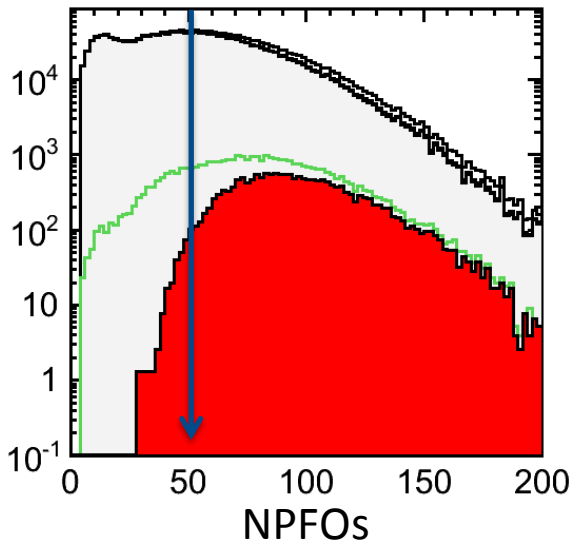
After kt four jets clustering
apply cuts and b-tagging

Cut on b-likeness<0.2

vvh @1TeV P(-0.8, +0.2)

10^4

10^3

10^2

10

1

10^{-1}

0   0.2   0.4   0.6   0.8   1

b-likeness (for two jets)

vvh @1TeV P(-0.8, +0.2)

2500

2000

1500

1000

500

0   50   100   150   200

W-mass (on-shell)

n @1TeV P(-0.8, +0.2)

00

00

00

00

00

0   50   100   150   200

Higgs mass
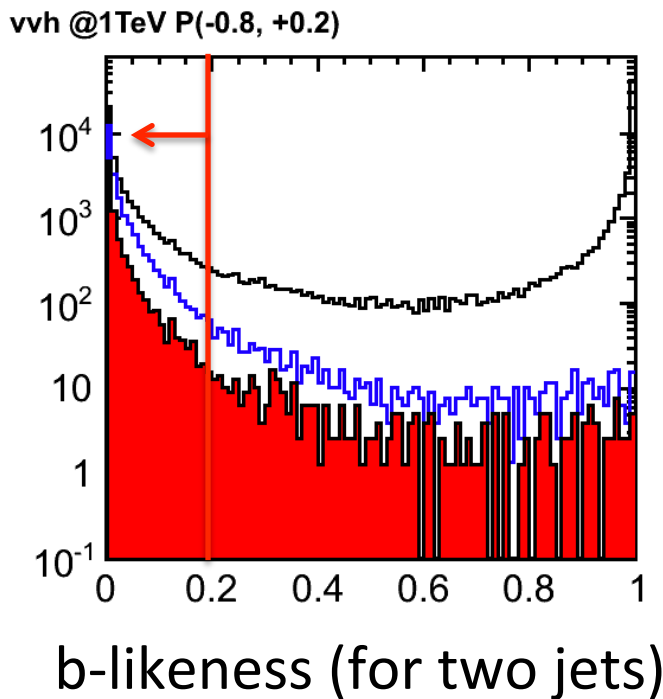
☐ h→all
☐ h→WW*
■ h→WW*→4j

h→bb is suppressed
by b-likeness cut
but still remaining
other channels contribution

Reduction summary

	Gen.	Evis	Pt	Pl	Npfo	Y23	Y34	btag	Mw1	Mw2	Mh
h→all	223,408	190,885	180,050	179,364	157,945	101,827	52,327	29,594	27,142	25,826	18,632
h→WW	48,277	40,686	38,083	37,947	30,940	28,055	20,406	18,895	17,147	16,384	12,079
h→WW →4j	22,020	18,846	18,005	17,894	17,627	16,507	13,165	12,206	11,967	11,772	9,732
h→bb	128,662	111,606	106,202	105,789	99,513	53,757	20,541	1,357	1,270	1,154	680
2f	3,890,180	1,151,010	184,654	156,306	68,506	26,721	7,153	5,586	3,930	3,540	696
4f	9,982,390	4,109,680	1,664,780	1,567,490	809,964	454,116	180,552	146,810	123,657	103,379	39,083
6f	346,419	42,824	38,787	38,379	30,845	28,121	19,985	11,828	11,553	11,402	1,056
BG all	14,219,000	5,303,520	1,888,220	1,762,170	909,314	508,958	207,690	164,224	139,140	118,321	40,835
Signif.	5.8	8.0	12.5	12.8	17.1	21.1	25.8	27.7	29.3	31.0	39.9

h→WW*→4j, Efficiency=44.2%, Significance=39.9
Still h→other channels contributions are remaining.
Need to improve for further reduction

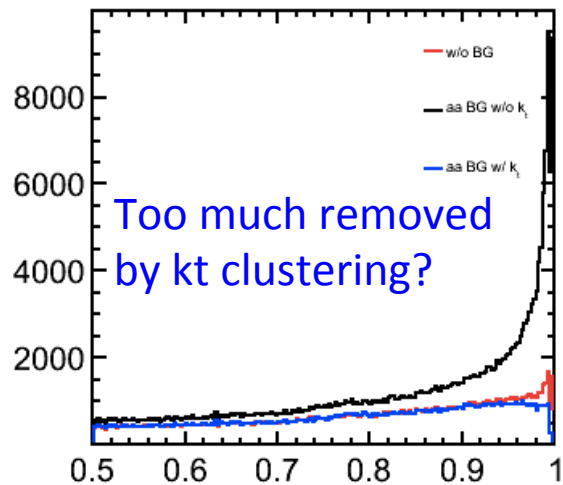# Reconstructed Higgs mass distribution

Reconstructed Higgs mass
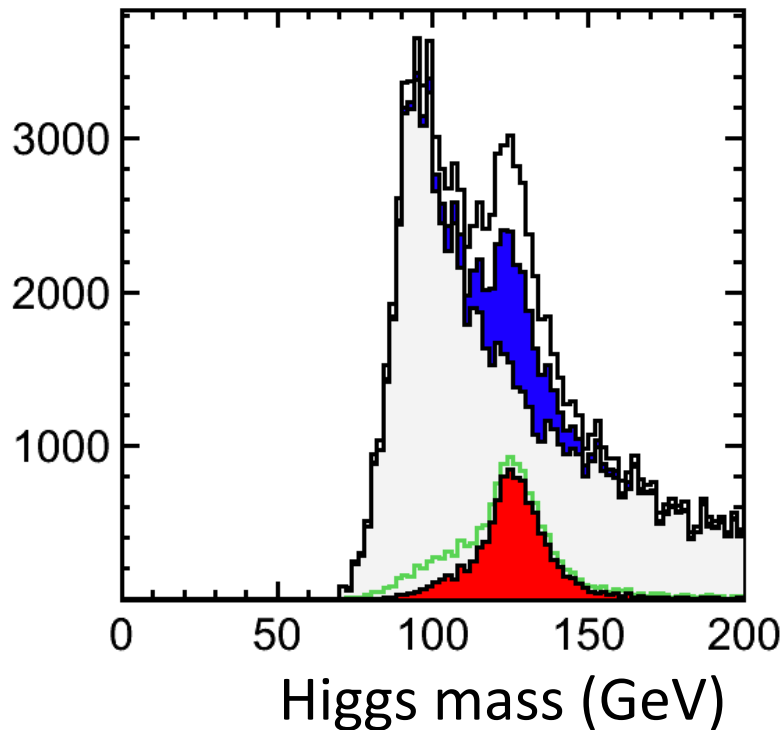
- ☐ h→All + BG
- ■ h→WW→4j + BG
- ■ All BG
- ■ h→WW→4j
- ☐ h→WW

h→bb contribution is well suppressed with b-tagging cut,
but other Higgs decay channels need to be improved.
→Consider to use TMVA
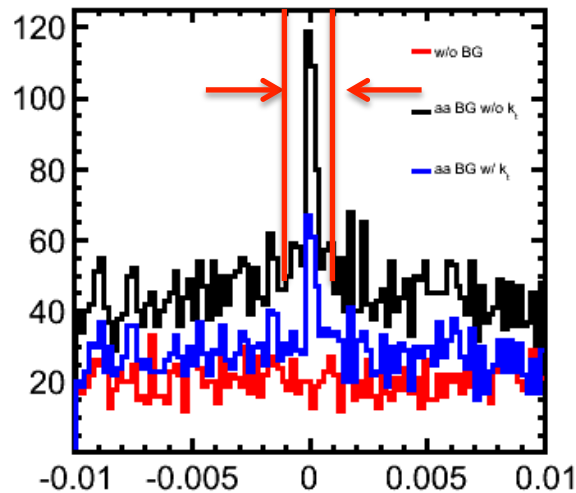to improve the reduction power.

γγ→hadron BGs PFO distributions

cosθ distribution
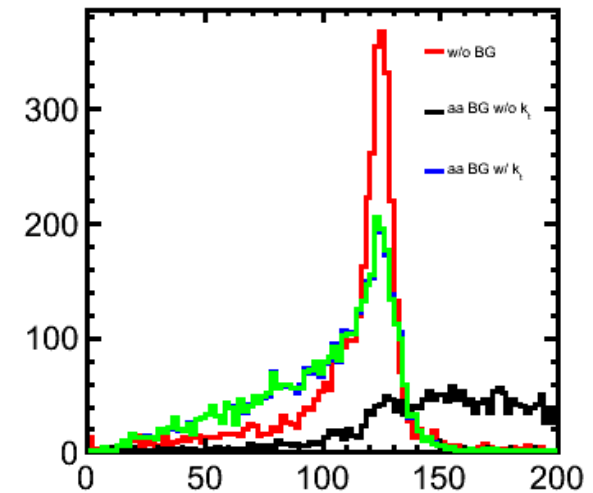
TMath::Abs(cos)

Too much removed
by kt clustering?

- w/o BG
- aa BG w/o k_t
- aa BG w/ k_t

Pz distribution

pz

- w/o BG
- aa BG w/o k_t
- aa BG w/ k_t

Invariant mass

Invariant mass

- w/o BG
- aa BG w/o k_t
- aa BG w/ k_t
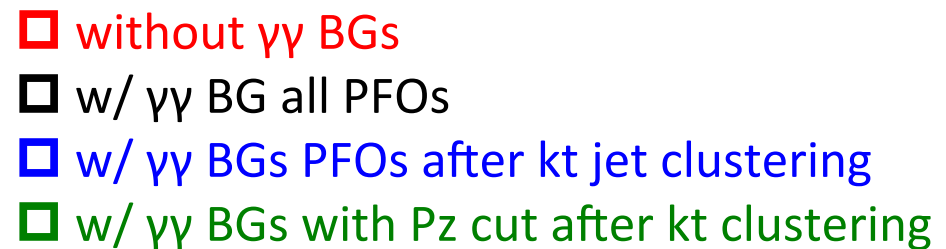
Kt jet clustering : R=1.1

- Forward PFOs are removed after kt clustering
- Too much removed?
  Need to check with R value

☐ **without γγ BGs**
☐ w/ γγ BG all PFOs
☐ w/ γγ BGs PFOs after kt jet clustering
☐ w/ γγ BGs with Pz cut after kt clustering

Next step

- Very preliminary results are obtained with only apply the kt jet clustering to suppress γγ→hadron BGs.

- Try to improve γγ→hadron BGs reduction
  - Add PFO based cut (not well improved for now)

- Cut optimization
  - For 2 jets and four jets both channel
  - Consider to use TMVA?