SiD
ffH, $H \rightarrow c\bar{c}$ @ E_{cm}=1 TeV
Branching Ratio Analysis
&
Total Higgs Width from
$e^+e^- \rightarrow ZH$, $H \rightarrow ZZ^*$ @ E_{cm}=250 GeV

14 October 2013

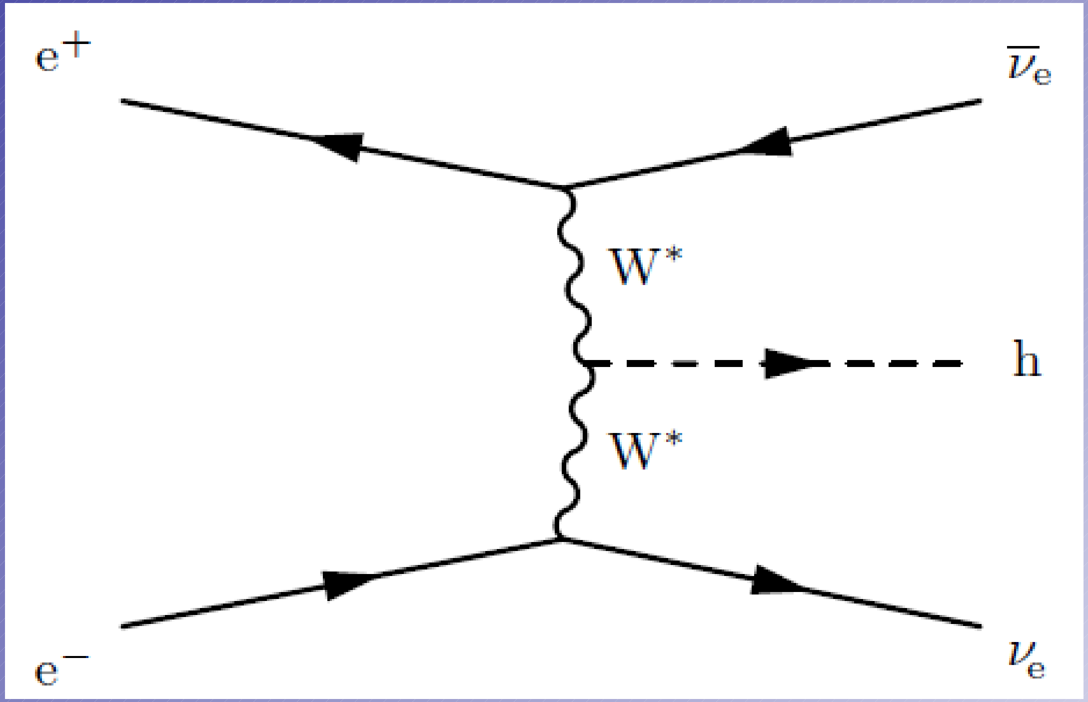
- H. Neal (SLAC NATIONAL ACCELERATOR LABORATORY)

Initial Goal

measure Higgs BR errors for bb, cc, gg, WW using

$e^+e^- \rightarrow \nu\nu H$

@ 1 TeV



Reason for continued focus on $H \rightarrow c\bar{c}$

Table 11.2.4: Relative uncertainties on the Higgs $\sigma \times BR$ expected at $\sqrt{s}$ =1 TeV using the SiD detector with integrated luminosities of 500 fb^{-1} and 1 ab^{-1} and polarisation sets $P(e^-)$ = -80%, $P(e^+)$ = +20% and $P(e^-)$ = +80%, $P(e^+)$ = -20%.

	$\mathscr{L}$ = 500 fb^{-1}		$\mathscr{L}$ = 1 ab^{-1}
	$P(e^-)$ = -80%, $P(e^+)$ = +20%	$P(e^-)$ = +80%, $P(e^+)$ = -20%	$P(e^-)$ = -80%, $P(e^+)$ = +20%
$h \rightarrow b\bar{b}$	0.0067	0.046	0.0047
$h \rightarrow c\bar{c}$	0.108	0.843	0.076
$h \rightarrow gg$	0.044	0.294	0.031
$h \rightarrow W^+W^-$	0.047	0.346	0.033

SiD DBD results comparable
to those of ILD
EXCEPT FOR $H \rightarrow c\bar{c}$!

ILD gets 0.057 for $H \rightarrow c\bar{c}$

Charm tagging stresses the vertexing capabilities so we need to see how good we can really do.

Outline of the SiD Higgs BR Analysis

- Jet clustering to four jet using exclusive kt algorithm w/ R=1.5 using the PFO objects from the jets obtained when using the kt algorithm with a jet size parameter, R, of 0.7 and clustering into six jets. This was found to improve the rejection of beam particles.
- flavour-tagging is used as implemented in the LCFIPlus package
- Preselection is applied based on the Higgs decay mode being studied
- After the preselection, an MVA is applied and the point which maximises the significance ($S/\sqrt{S+B}$) of the selection is used

What has changed since the DBD

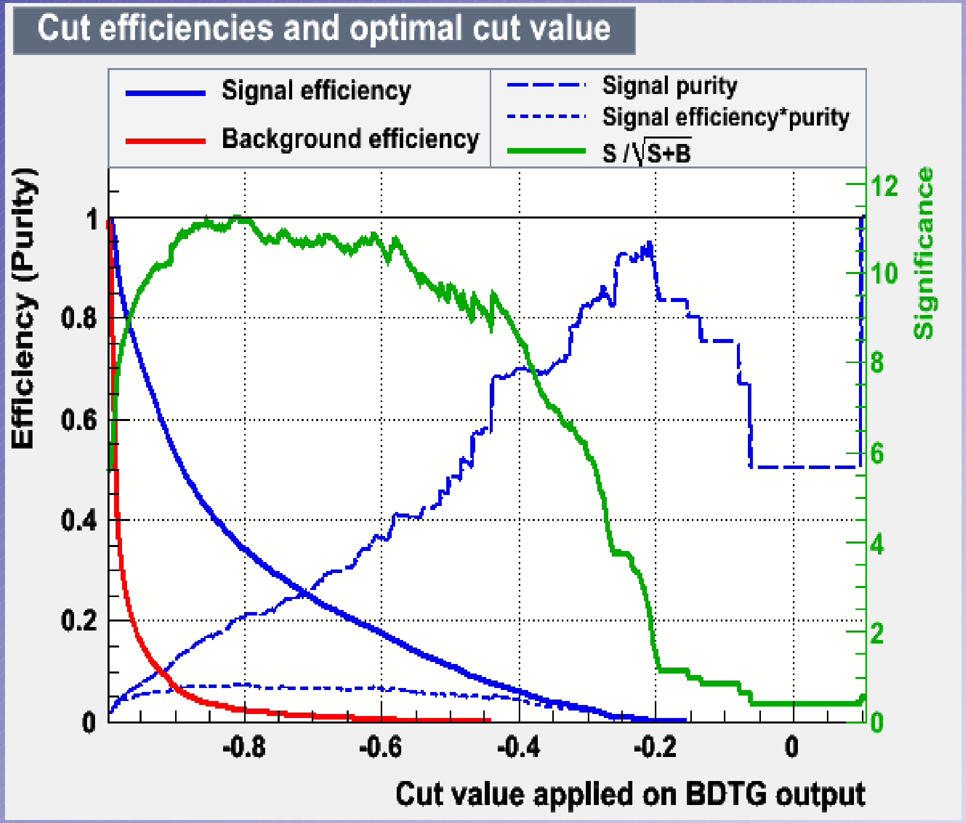
- **BDTG is used for the MVA instead of Fisher** ***(higher stats training eventually proved that this is better than Fisher, FisherG, and BDT)***
- **higher stats for decay mode selection training**
  - **About 30% more ffh_nomu events**
  - **Note: More (~20%) evW... and all_other_SM_backgrounds could be used if space allows.**
- **addition of B-likeness variable**
- **100K** ***(instead of ~20K)*** **250GeV Z->bb,cc,qq used for flavor tag training**
- **#vertices and thrust variables added** ***(for incorporating different performance cuts depending on the vertexing event category)***

MVA variables & new result

- the b-tag and c-tag values of both jets;
- the masses and energies of both jets;
- the number of reconstructed PFOs;
- the number of high-momentum isolated electrons;
- the visible energy, mass and transverse momentum;
- the cosines of the polar angles of both jets;
- the angle between both jets in the plane perpendicular to the beam axis.
- the c-tag value divided by the sum of the b-tag and c-tag values for each jet (for $h \to c\bar{c}$ only)

+

•b & c-likeness
•Number of vertices including/excluding single tracks
•thrust



- **S=11.25 is for -80/+20 500/fb with all backgrounds**
- **This corresponds to an uncertainty on σ x BR of 0.088**

- **clike = (ctag1*ctag2)/((ctag1*ctag2)+(1.0-ctag1)*(1.0-ctag2))**
- **blike = (btag1*btag2)/((btag1*btag2)+(1.0-btag1)*(1.0-btag2))**

Results for all channels with the current MVA variables

h->bbbar:

Classifier	(#signal, #backgr.)	Optimal-cut	S/sqrt(S+B)	NSig	NBkg	EffSig	EffBkg
Fisher:	(25277.664, 3124.481)	-1.3285	150.744	25192.95	2737.6	0.9966	0.8762
BDTG:	(25277.664, 3124.481)	0.0122	150.862	25109.4	2592.699	0.9933	0.8298

h->ccbar:

Classifier	(#signal, #backgr.)	Optimal-cut	S/sqrt(S+B)	NSig	NBkg	EffSig	EffBkg
Fisher:	(1763.6545,100502.62)	0.0731	11.1066	703.023	3303.616	0.3986	0.03287
BDTG:	(1763.6545,100502.62)	-0.8125	11.3024	631.2651	2488.226	0.3579	0.02476

h->gg:

Classifier	(#signal, #backgr.)	Optimal-cut	S/sqrt(S+B)	NSig	NBkg	EffSig	EffBkg
Fisher:	(4206.6636,77490.953)	0.0078	17.7274	2912.645	24082.33	0.6924	0.3108
BDTG:	(4206.6636,77490.953)	-0.8187	21.5904	2568.394	11583.14	0.6106	0.1495

h->WW:

Classifier	(#signal, #backgr.)	Optimal-cut	S/sqrt(S+B)	NSig	NBkg	EffSig	EffBkg
Fisher:	(3817.4458,33379.426)	-0.0700	20.8578	2964.736	17239.19	0.7766	0.5165
BDTG:	(3817.4458,33379.426)	-0.7862	22.8728	2674.263	10995.72	0.7005	0.3294

Results for all channels with the current MVA variables

- Only H $\rightarrow$ cc is significantly affected:

$$\mathscr{L} = 500\ \text{fb}^{-1}$$

$$P(e^-) = \text{-}80\%$$
$$P(e^+) = +20\%$$

	'-80/+20'	
	SiD DBD	SID now
H $\rightarrow$ bb	0.0067	0.0066
H $\rightarrow$ cc	0.108	0.088
H $\rightarrow$ gg	0.044	0.046
H $\rightarrow$ WW*	0.047	0.044

- Good improvement but still want to revisit vertexing performance.

The template Method

The ILD analysis doesn't use MVA's it uses what is called the template method after a general all channel selection.

The following shows what happens if we try something similar.

The template method
Excerpts from the ILD DBD

"

$$\sigma\mathrm{BR}(\mathrm{s}) = \mathrm{r_s} \times \sigma\mathrm{BR}^{\mathrm{SM}}(\mathrm{s}) \;\; (\mathrm{s} = \mathrm{b\bar{b}},\; \mathrm{c\bar{c}},\; \mathrm{gg},\; \mathrm{bkg}),$$

$$\frac{\Delta\sigma\mathrm{BR}(\mathrm{h}\to\mathrm{s})}{\sigma\mathrm{BR}} = \frac{\Delta\mathrm{r_s}}{\mathrm{r_s}}.$$

$\mathrm{r_s}$ is a fluctuation from the SM prediction

From: arXiv:0907.0917v2 [hep-ex] 7 Sep 2009

$$\chi^2 = \sum_{i=1}^{n_b}\sum_{j=1}^{n_c}\sum_{k=1}^{n_{bc}} \frac{(N_{ijk}^{data} - \sum_s r_s(\frac{N^{ZH}}{N^s})N_{ijk}^s - r_{bkg}N_{ijk}^{bkg})^2}{N_{ijk}^{all}}$$

Must minimize to get r_s , s=bb,cc,gg,WW

"

From ILD DBD

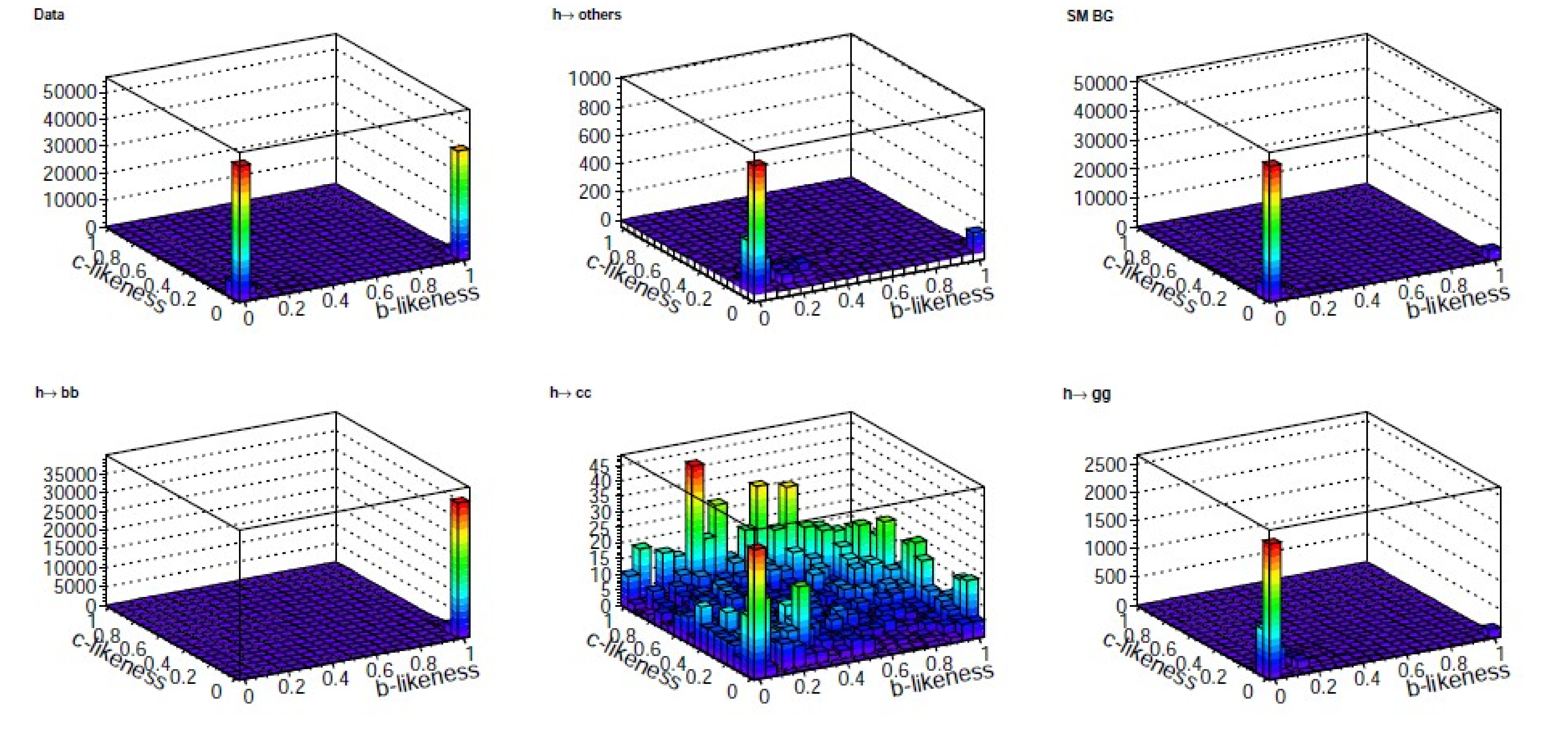


FIG. 8: 2D image of the 3D flavor template samples for Data, $h \to b\bar{b}$, $c\bar{c}$, gg, others, and SM BGs.

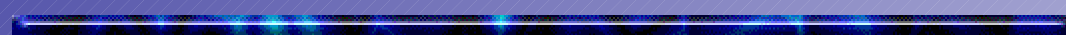
The full 3D templates

The full 3-D templates have also the axis of bc-likeness:

i,j,k axes are: b,c,**bc**-likeness

"bc-likeness is c-likeness whose neural-net training is done by using only Z-->bb events as background."

from: arXiv:0907.0917v2 [hep-ex] 7 Sep 2009



Hiroaki says that bc-likeness as defined in the excerpt above was available in LCFIVTX but is not available in LCFIPlus. Thus, BCTag is used.

BCTag1 = cTag1/(cTag1+bTag1)
BCTag2 = cTag2/(cTag2+bTag2) where the index is the jet#

bc-likeness = (BCTag1*BCTag2)/((BCTag1*BCTag2)+(1.0-BCTag1)*(1.0-BCTag2)) ;

Switch to ILD-like general preselection for template tests

SiD
$c\bar{c}$

$50. < pT_{vis} < 250.$

$150. < E_{vis} < 400.$

$115. < M_{vis} < 135.$

$|\theta jet_{1,2}| < 0.95$

$bTag_{1,2} < 0.8$

$10 <= \#Trks <= 50$

ILD
H.ONO
general
selection

$50. < pT_{vis}$

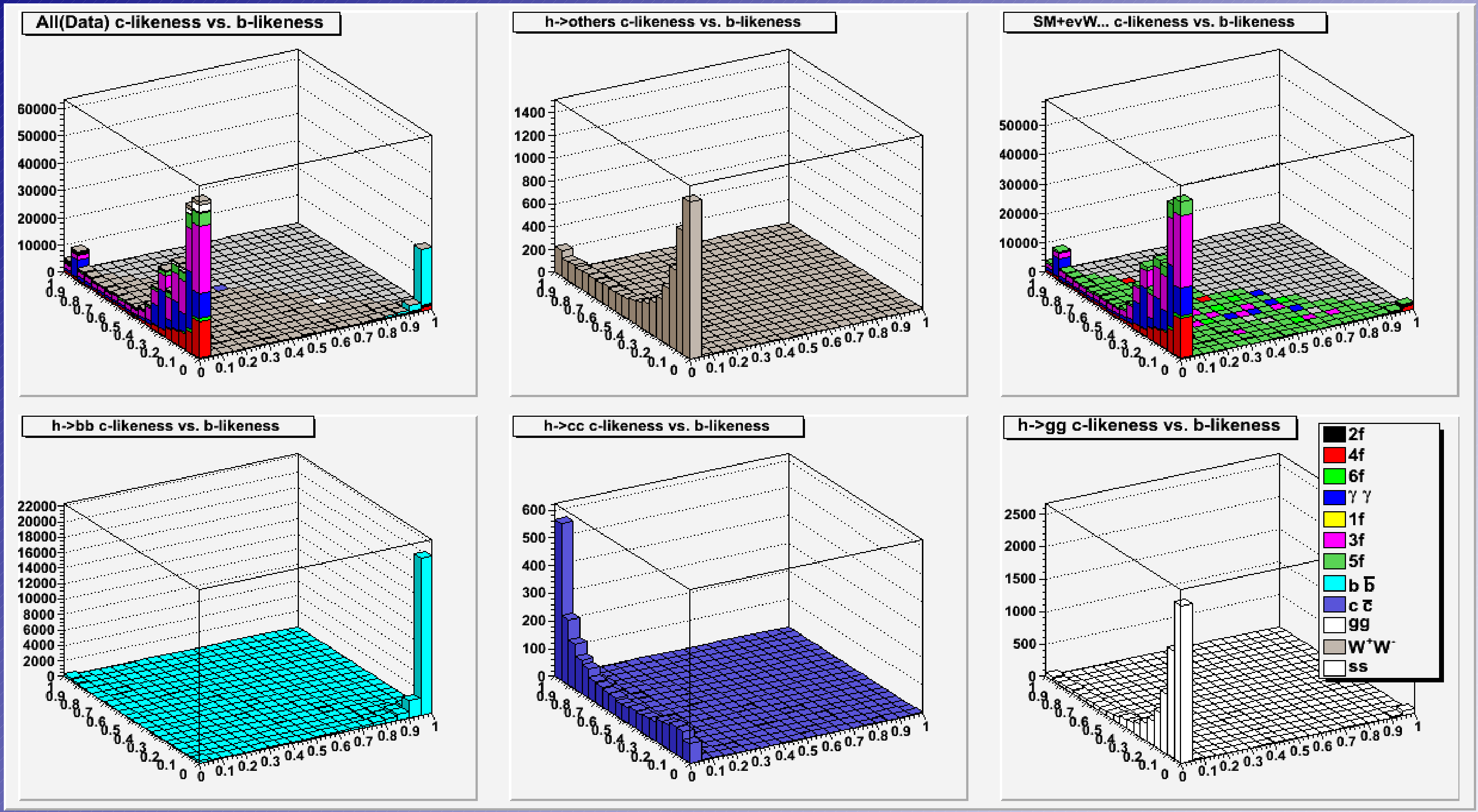
$100. < E_{vis} < 400.$

$110. < M_{vis} < 140.$

$|\theta thrust_{1,2}| < 0.95$ and $|\theta higgs_{1,2}| < 0.95$

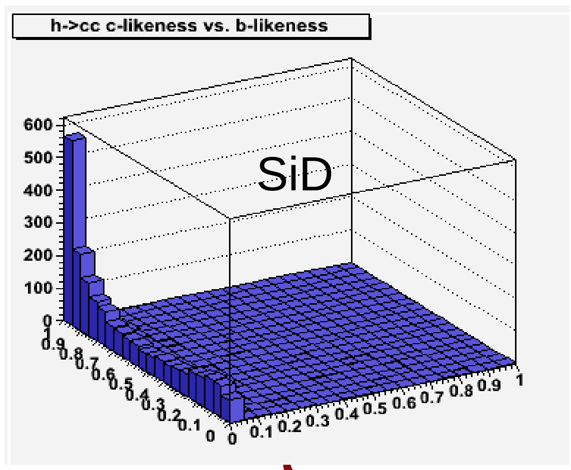
$15 <= \#charged\ Trks <= 50$

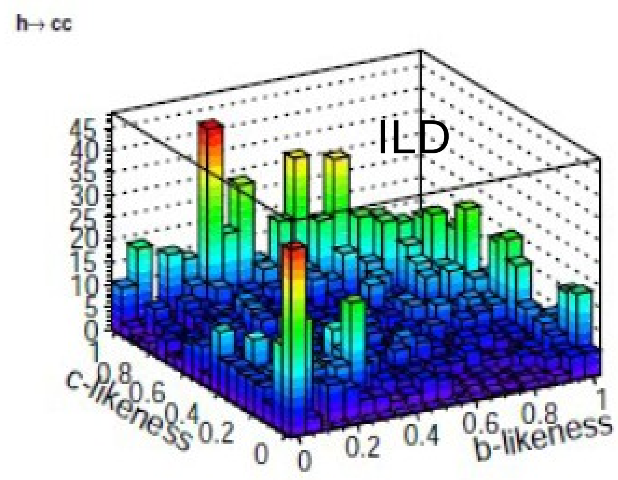
SiD templates after ONO-like presel



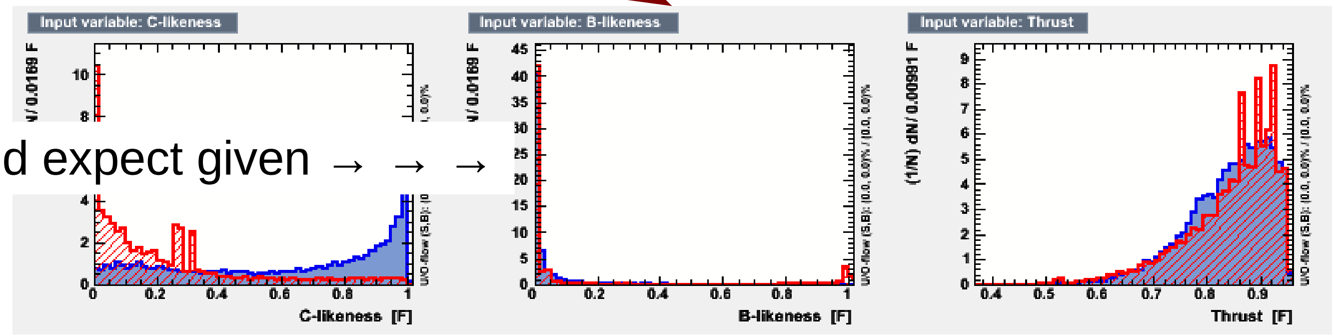
An initial discrepancy … resolved

-

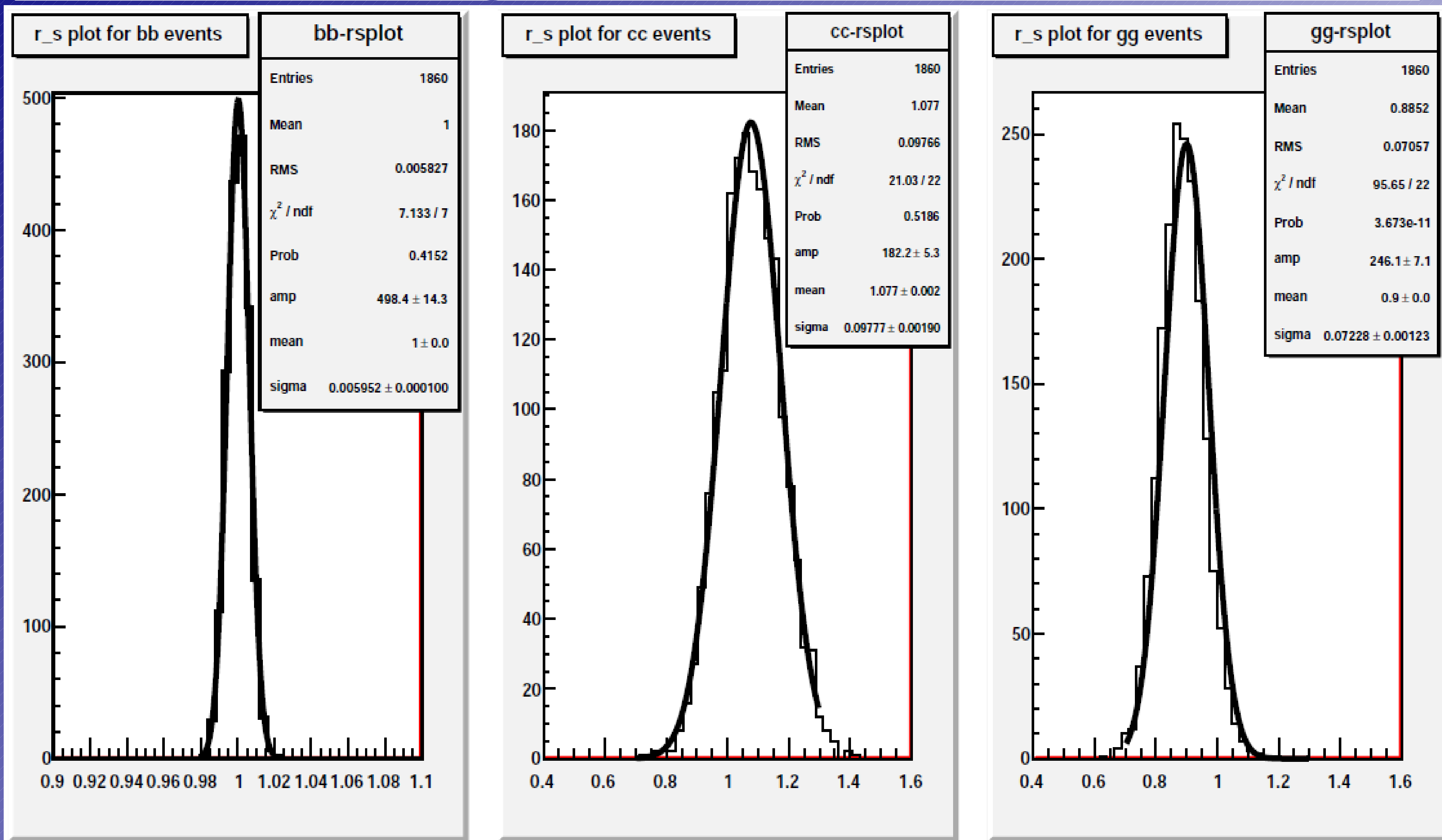




But my plot is what I'd expect given → → →



r_s distributions for 60x60x60 binning of the templates:



$\frac{\Delta(\sigma \cdot BR)}{\sigma \cdot BR}$ for different #bins templates

20x20x20 bins:

h->b$\bar{b}$	→	sigma	6.24714e-03	9.88073e-05
h->c$\bar{c}$	→	sigma	1.11379e-01	2.04201e-03
h->gg	→	sigma	9.92033e-02	1.73081e-03

25x25x25 bins:

h->b$\bar{b}$	→	sigma	6.32818e-03	1.00089e-04
h->c$\bar{c}$	→	sigma	1.12191e-01	2.06801e-03
h->gg	→	sigma	9.78997e-02	1.73164e-03

30x30x30 bins:

h->b$\bar{b}$	→	sigma	6.13841e-03	9.70885e-05
h->c$\bar{c}$	→	sigma	1.04590e-01	1.84549e-03
h->gg	→	sigma	9.43471e-02	1.70588e-03

60x60x60 bins:

h->b$\bar{b}$	→	sigma	5.95225e-03	1.00386e-04
h->c$\bar{c}$	→	sigma	9.77718e-02	1.89866e-03
h->gg	→	sigma	7.22824e-02	1.23449e-03

100x100x100 bins:

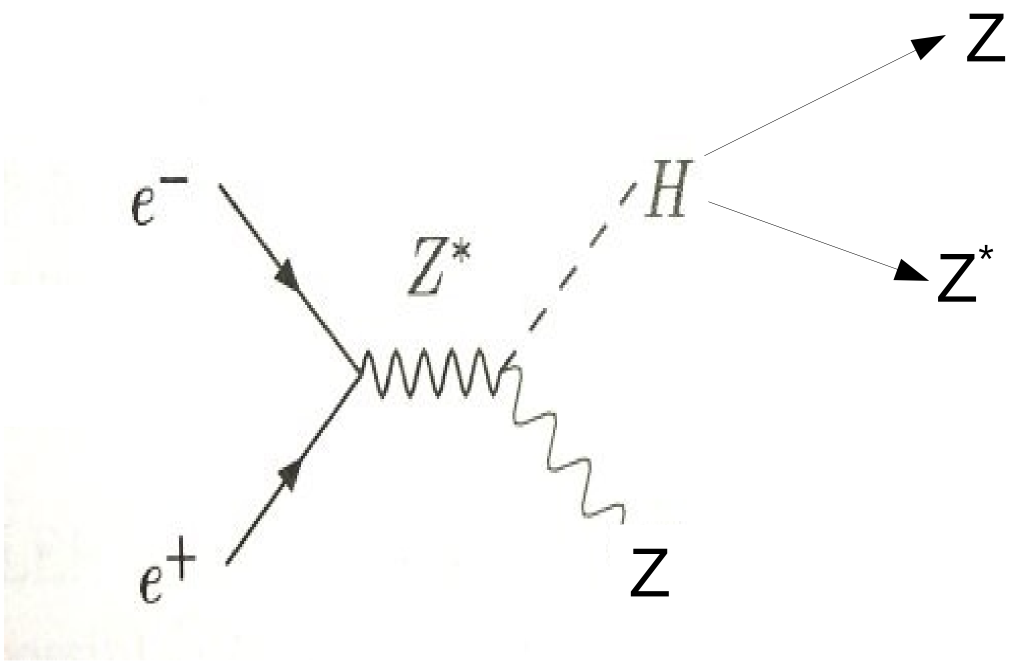
h->b$\bar{b}$	→	sigma	6.51439e-03	1.35240e-04
h->c$\bar{c}$	→	sigma	9.36110e-02	1.85658e-03
h->gg	→	sigma	6.48416e-02	1.06240e-03

Comparison to results using MVA's

	'-80/+20'	
	SiD DBD	SID now
H → bb	0.0067	0.0066
H → cc	0.108	0.088
H → gg	0.044	0.046
H → WW*	0.047	0.044

SiD Total Higgs Width from $e^+e^- \rightarrow ZH$, $H \rightarrow ZZ^*$ @ E_{cm}=250 GeV

Goal



to extract the total Higgs width running @ Ecm=250 GeV only

Topologies

higgs_ffh_zz_-80e-_+30e+_018_SLIC-v3r0p3_geant4-v9r5p1_QGSP_BERT_sidloi3_lcsimTracking_lcsim-2.9_pandora.slcio-flav.slcio

6 Jet

- gamma(E=1.3421 status=Intermediate)
- gamma(E=.081287 status=Intermediate)
- e-(E=46.709 status=Intermediate)
- e+(E=64.186 status=Intermediate)
- h0/H01(E=136.92 status=Intermediate)
  - h0/H01(E=136.92 status=Intermediate)
    - Zo(E=86.447 status=Intermediate)
    - Zo(E=50.470 status=Intermediate)

- gamma(E=.018825 status=Intermediate)
- gamma(E=1.4878 status=Intermediate)
- mu-(E=48.367 status=Intermediate)
- mu+(E=60.933 status=Intermediate)
- h0/H01(E=138.96 status=Intermediate)
  - h0/H01(E=138.96 status=Intermediate)
    - Zo(E=45.666 status=Intermediate)
    - Zo(E=93.293 status=Intermediate)

4 Jet

- gamma(E=2.7756E-14 status=Intermediate)
- gamma(E=1.4775E-5 status=Intermediate)
- nu_e(E=47.906 status=Intermediate)
- nu_e_bar(E=51.523 status=Intermediate)
- h0/H01(E=150.99 status=Intermediate)
  - h0/H01(E=150.99 status=Intermediate)
    - Zo(E=128.37 status=Intermediate)
    - Zo(E=22.613 status=Intermediate)

- gamma(E=1.4452E-5 status=Intermediate)
- gamma(E=5.8498E-8 status=Intermediate)
- u(E=80.005 status=Intermediate)
- u_bar(E=30.779 status=Intermediate)
- h0/H01(E=137.89 status=Intermediate)
  - h0/H01(E=137.89 status=Intermediate)
    - Zo(E=108.89 status=Intermediate)
    - Zo(E=28.993 status=Intermediate)

Overview

Data Preparation

- Steps of the job that prepares the data for being analyzed:

Fill hit counting values:
source /u/ey/homer/sidhome/sid/lcsim-homer/testrunsubDetHitNum $1 input_prejet.slcio

Clustering to 6 jets: (JetOut6Jets)
Marlin /u/ey/homer/sidhome/lcfi/mfast-all-batch-6jet-step1.xml

Clustering to 4 jets: (JetOut)
Marlin /u/ey/homer/sidhome/lcfi/mfast-all-batch-4jet-step2.xml

Vertexing:
Marlin /u/ey/homer/sidhome/lcfi/steering/revertex-all-batch.xml

Flavor tagging:
Marlin /u/ey/homer/sidhome/lcfi/steering/flavortag-all-batch-revtx-350-4jets.xml

- Inputs →

Process	$P(e^-)/P(e^+)$	N_{Events}
$f\bar{f}h$ w/ $h \to ZZ^*$	+80%/-30%	120,012
All SM background mix	+80%/-30%	2,058,374

Analysis Procedure:

- divide into 4 jet / 6 jet topologies using reconstructed variable(s)
  - 6 jet topology:
    - Find 2 exclusive jet pairs giving mass most consistent with m(Z)
    - Find pair that gives mass most consistent with m(H) when combined with the rest of the event
  - 4 jet topology:
    - Find jet pair giving mass most consistent with m(Z)
    - Form candidate m(H) from this and the rest of the event
- apply preselection depending on topology
- train/apply TMVAs
- validate outside of TMVA framework with a small c++ routine that reads the events/applies weights/applies preselection and then uses the MVA module (a routine produced by TMVA that you supply the inputs and returns the MVA output value) for applying the MVA cut

Jet Clustering

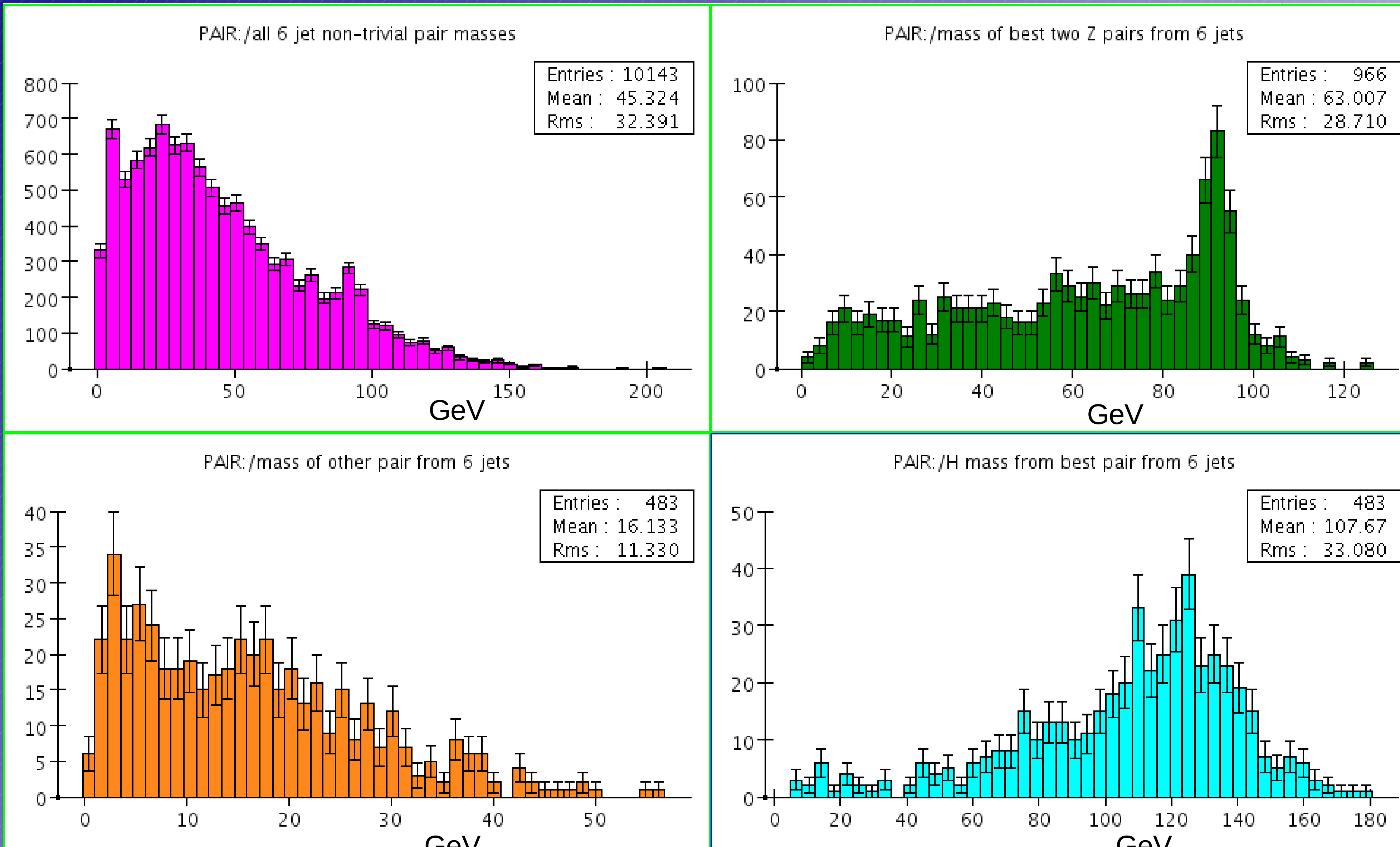
•The jet clustering size parameter used for the k_t exclusive algorithm was chosen to be 1.5 based on the visible mass resolutions.

•PFO objects are used from the jets obtained when using the k_t algorithm with a jet size parameter, R, of 0.7 and clustering into six jets. This was found to improve the rejection of beam particles.

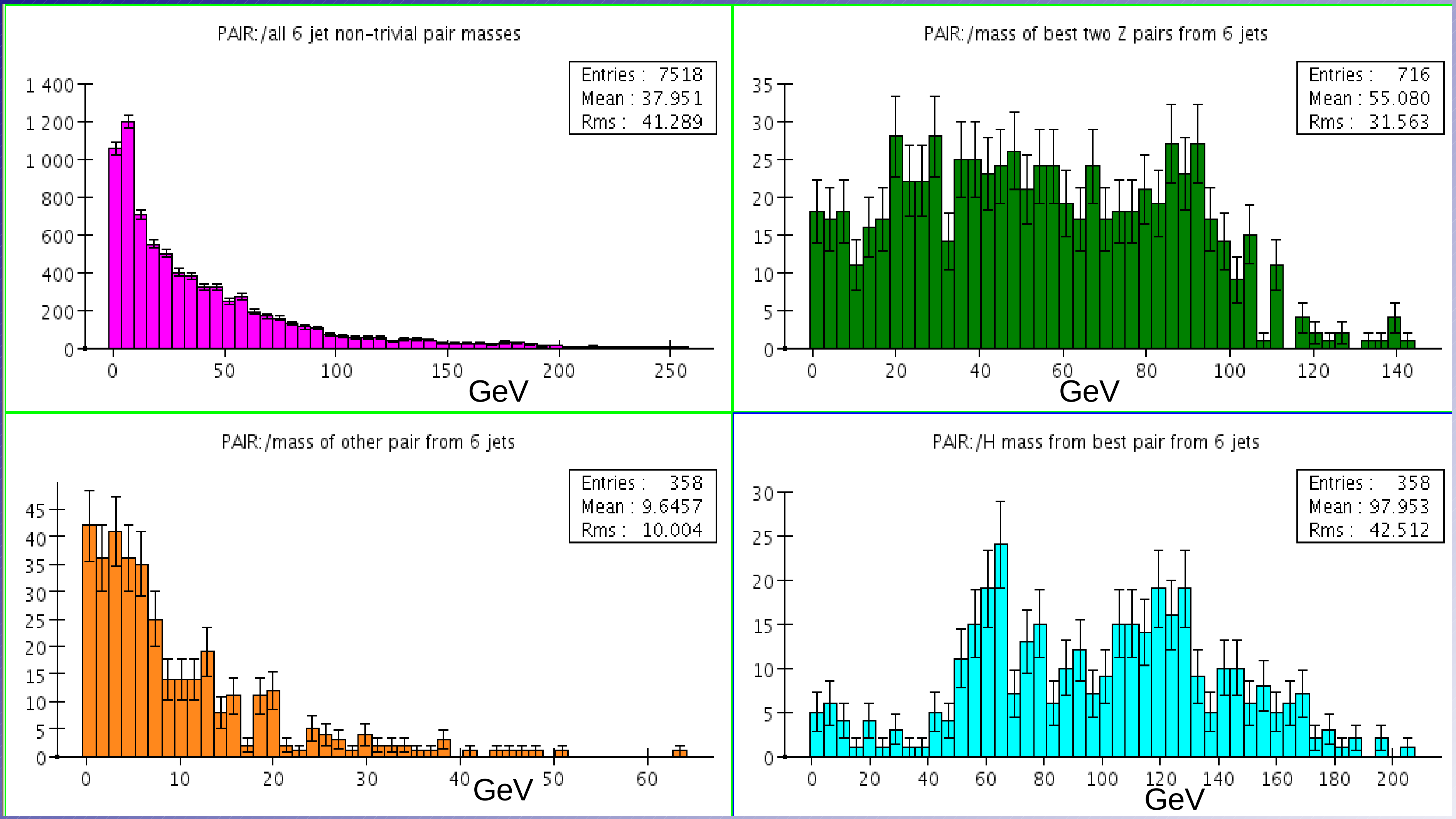
•These jets are directly used for the **6-jet** topology expected for the final states to qq ZZ and llZZ.

•For the **4-jet** decay topology consistent with ννh decays, events are clustered into four jets using the k_t exclusive algorithm and PFOs from the six jet clustering.

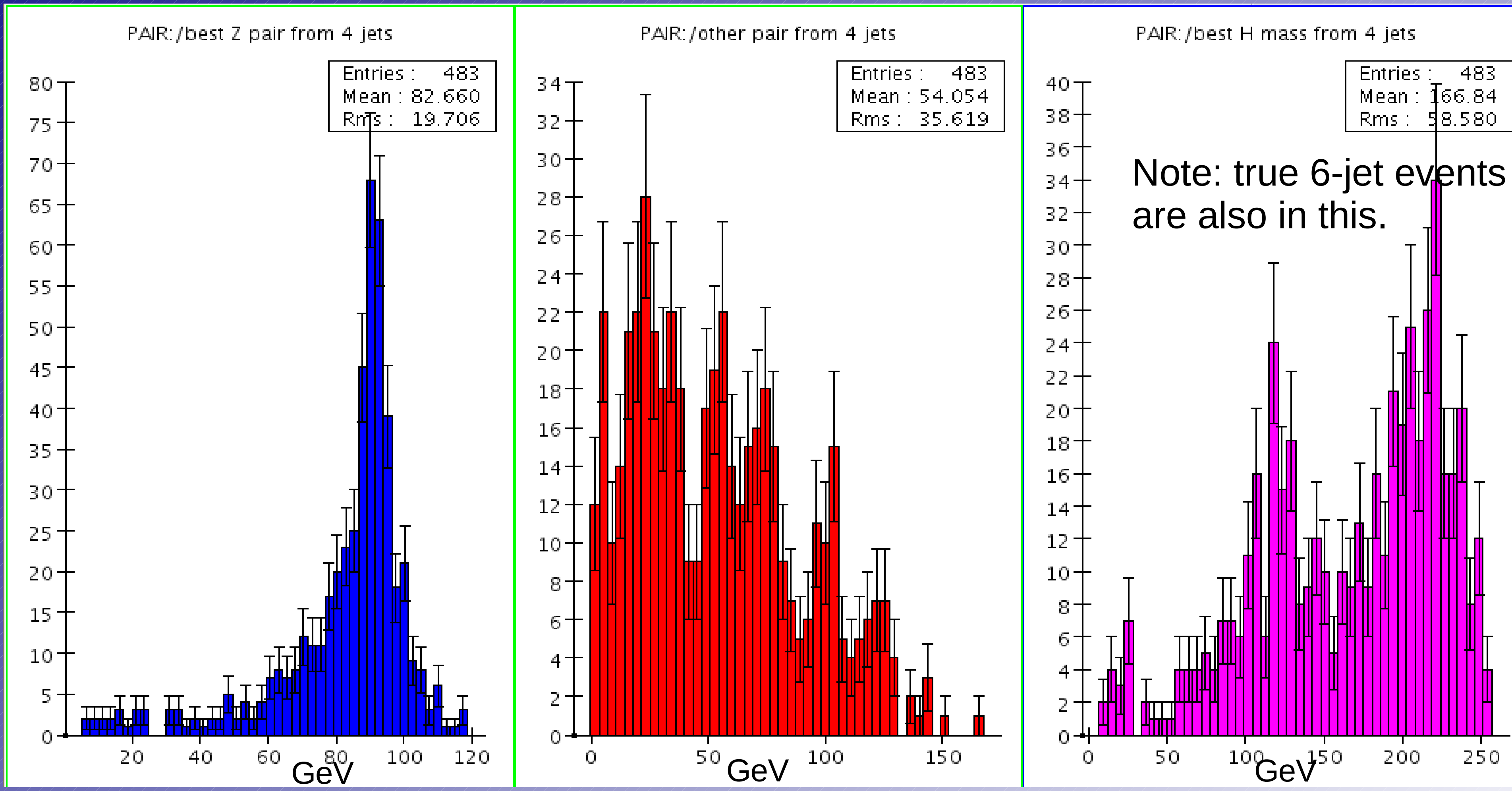
$e^+e^- \to ZH,\ H \to ZZ^*$
6 jet topology



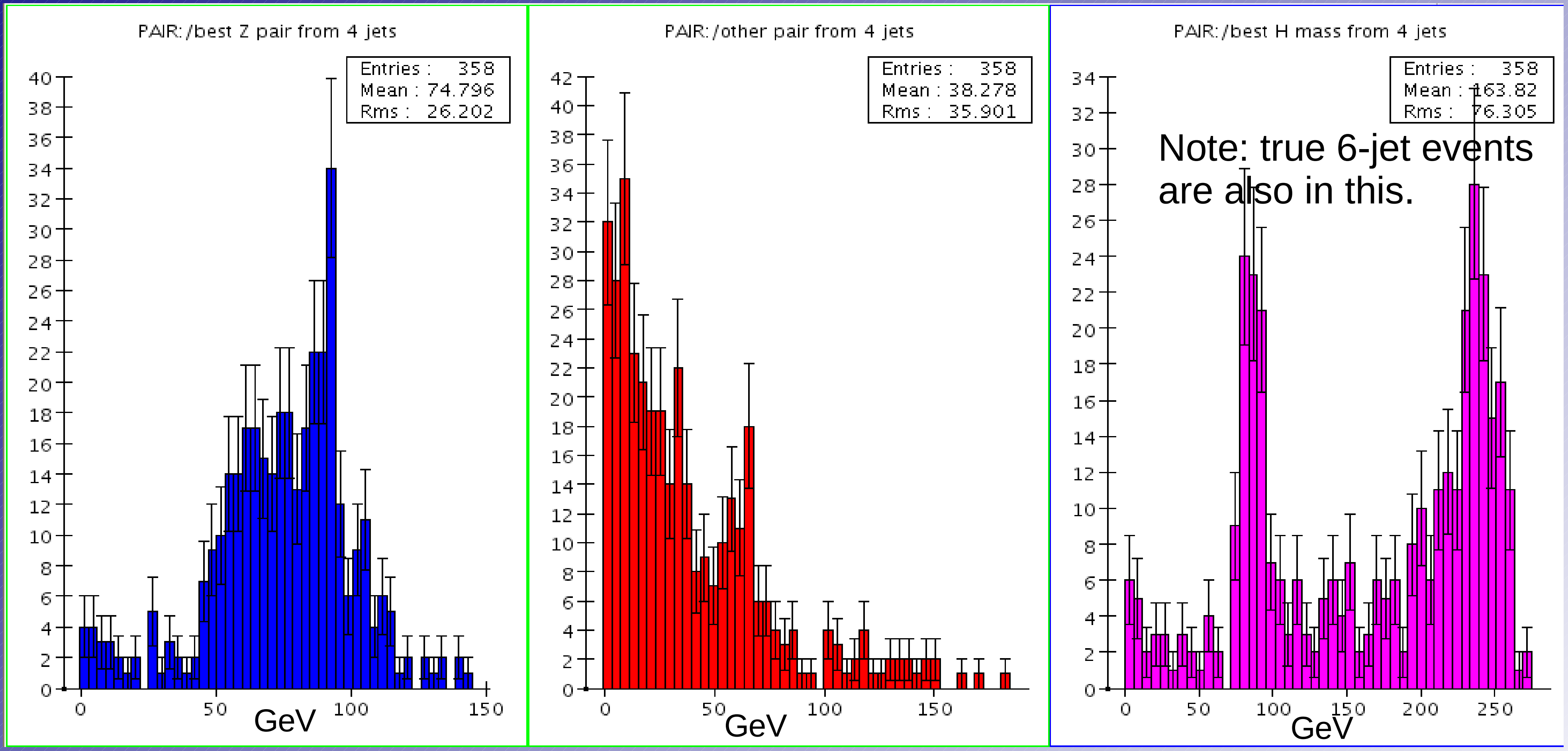
all_SM_background
6 jet topology
(NOT weighted yet)



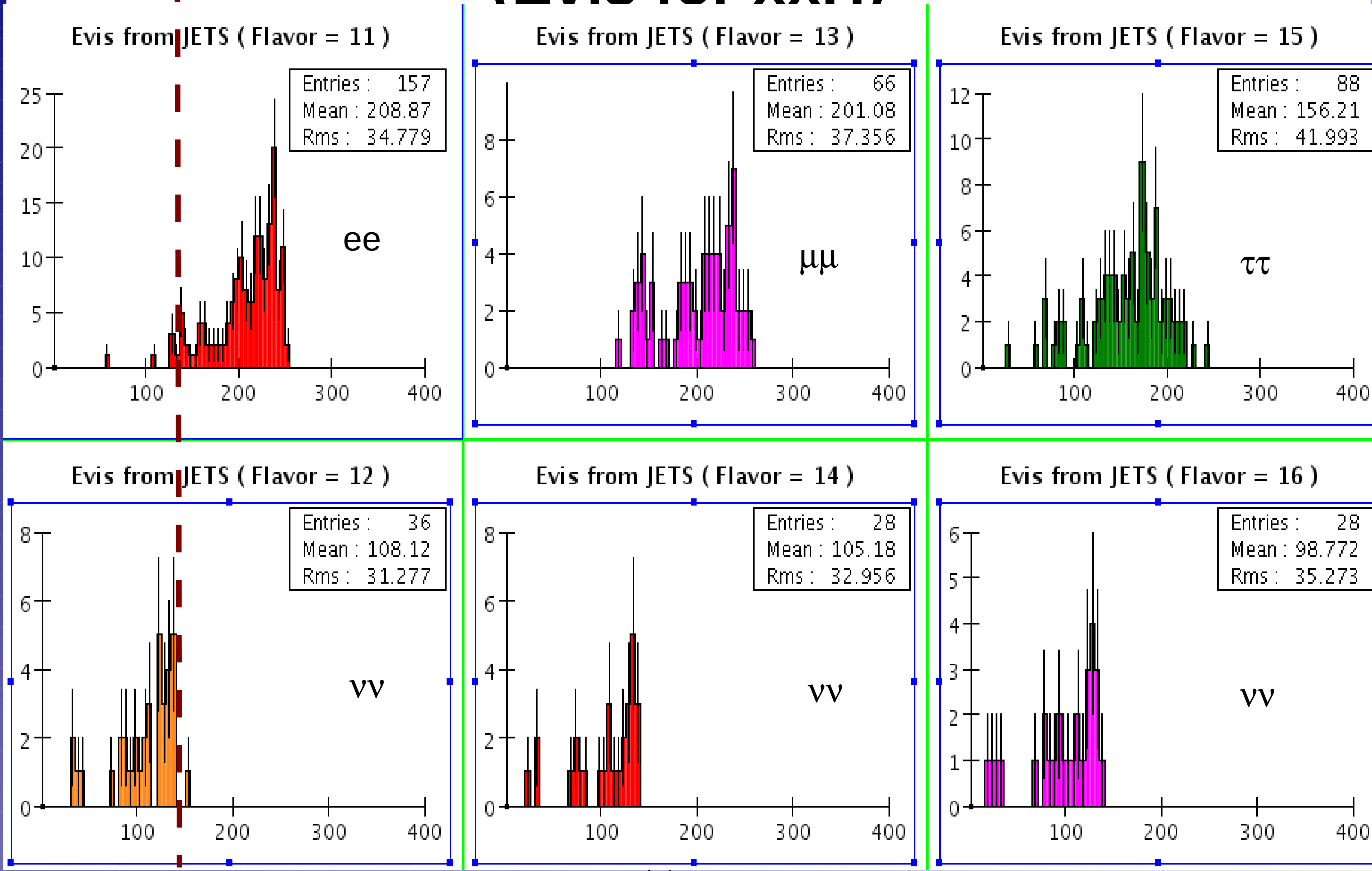
$e^+e^- \to ZH,\ H \to ZZ^*$
4 jet topology



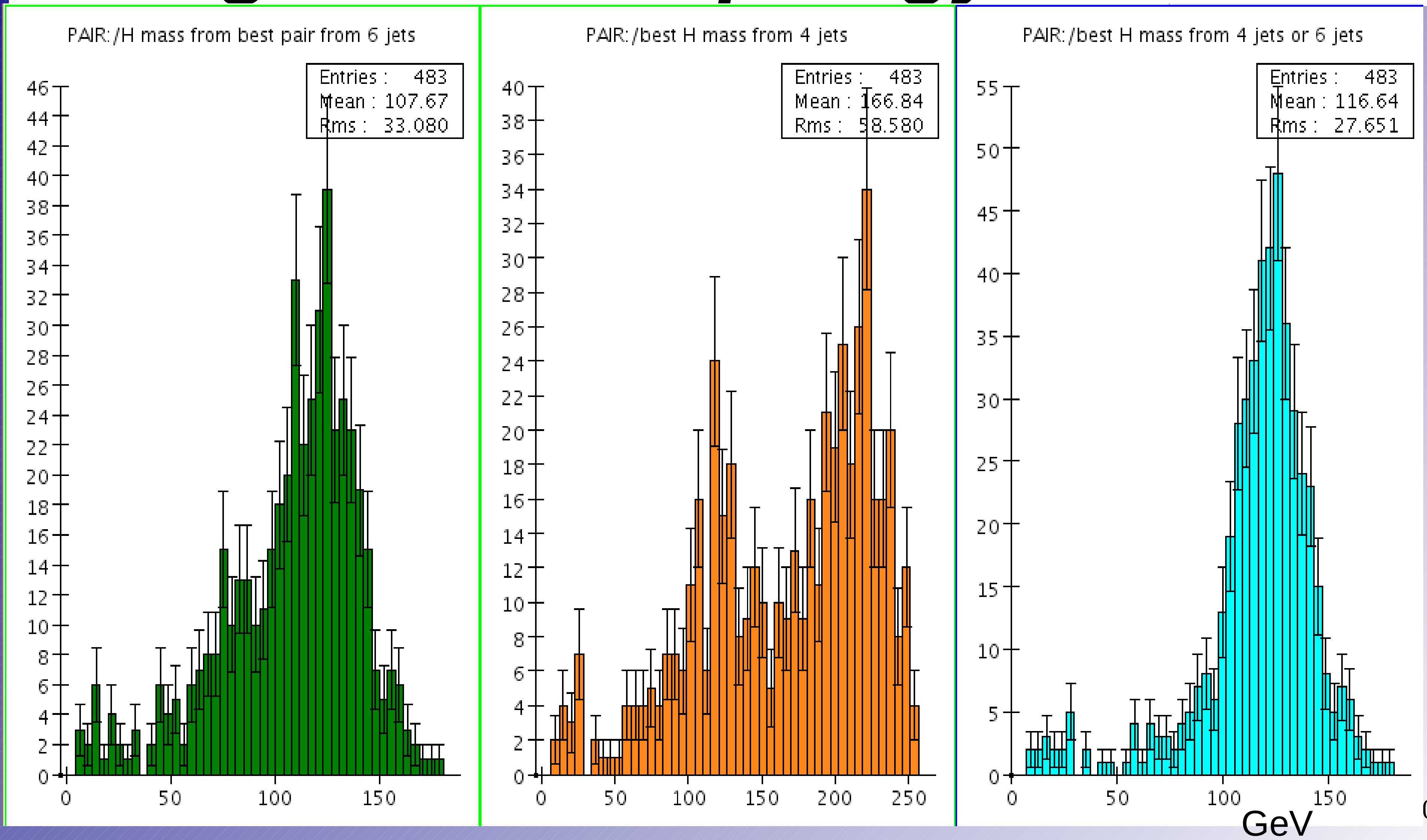
all_SM_background
4 ***jet topology***
(NOT weighted yet)



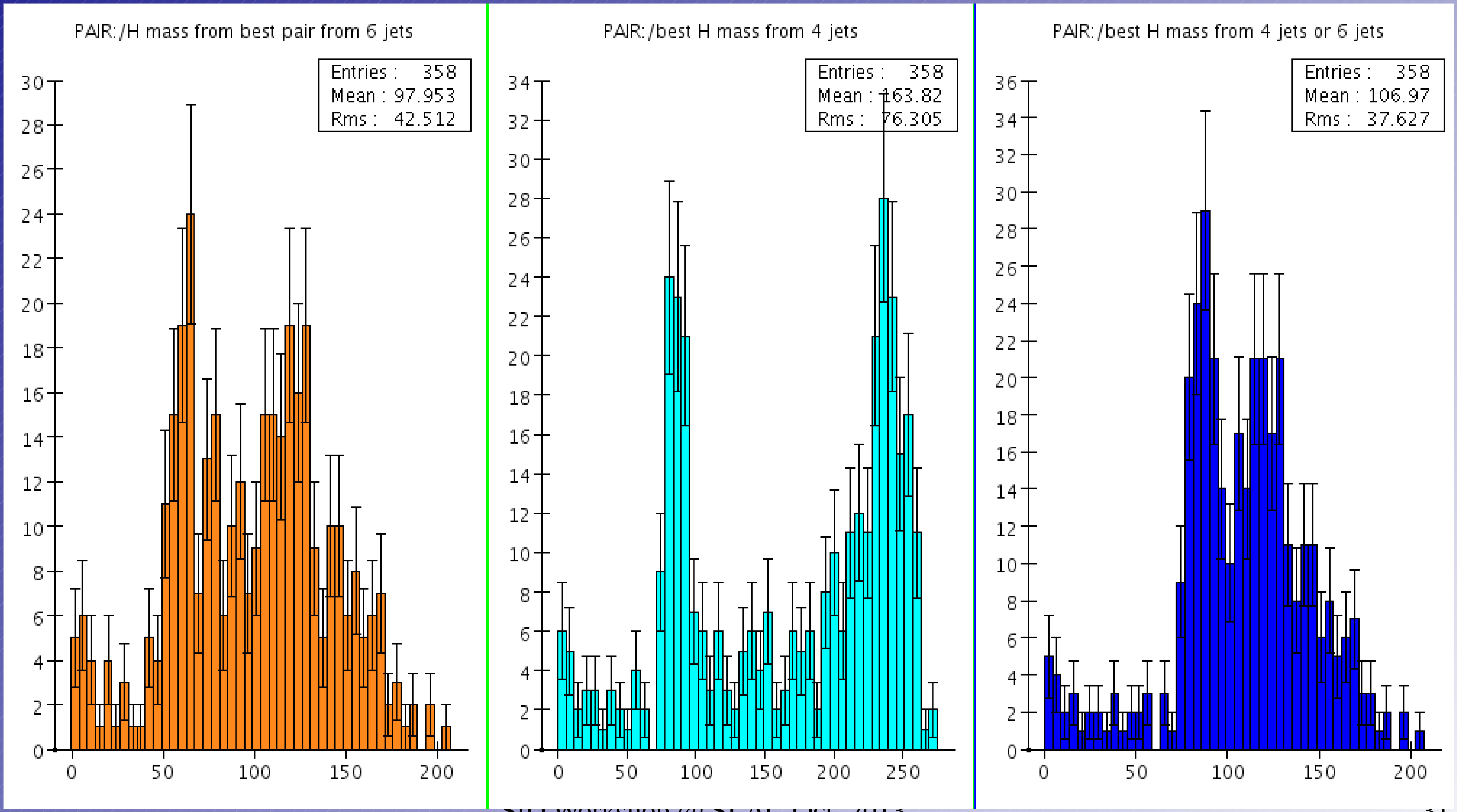
4/6 Jet Topology determination from Evis (Evis for $x\bar{x}$H)



$e^+e^- \to ZH,\ H \to ZZ^*$ best of 4/6 jet topology using Evis for topology selection

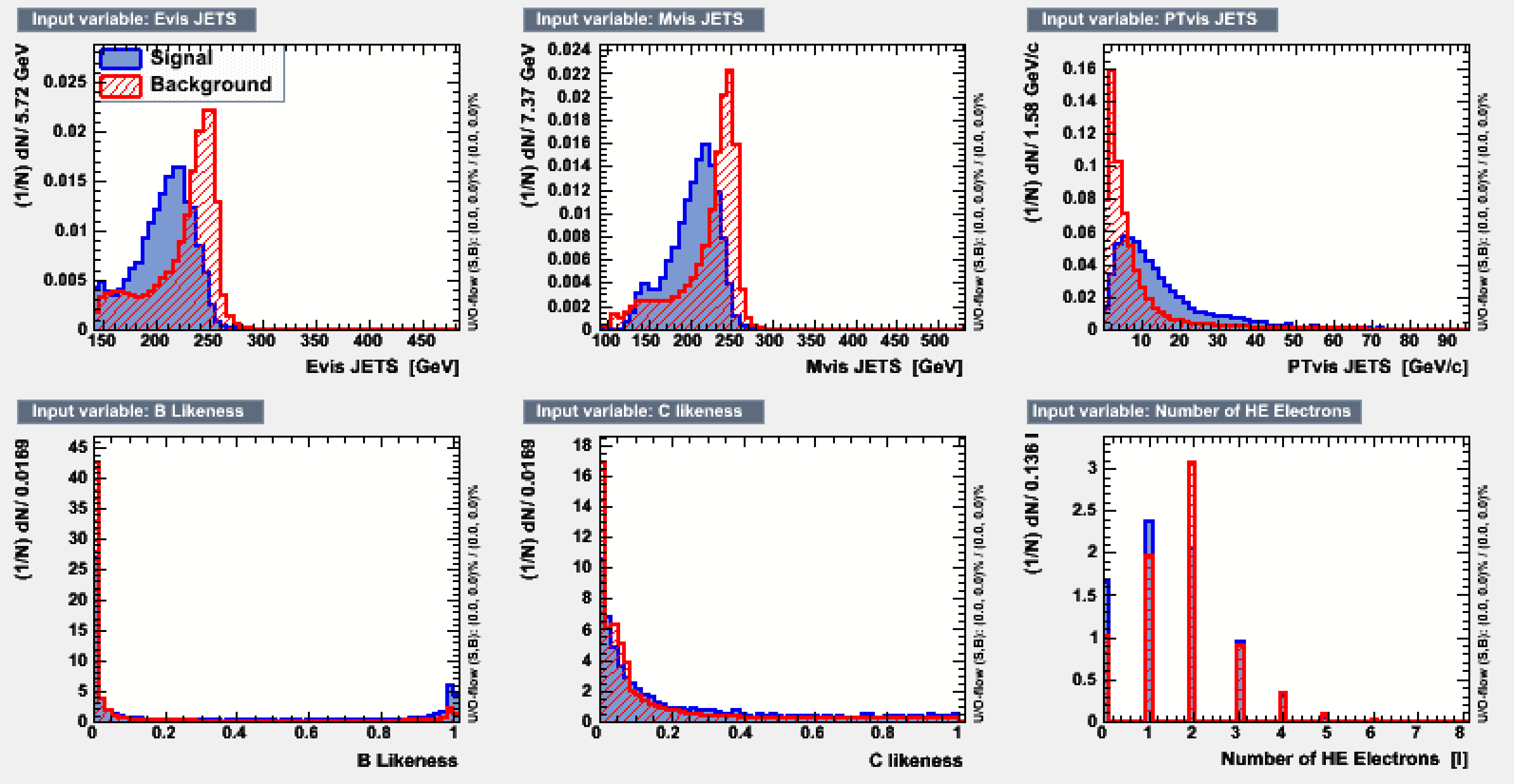


all_SM_background
best of 4/6 ***jet topology***
(NOT weighted yet)

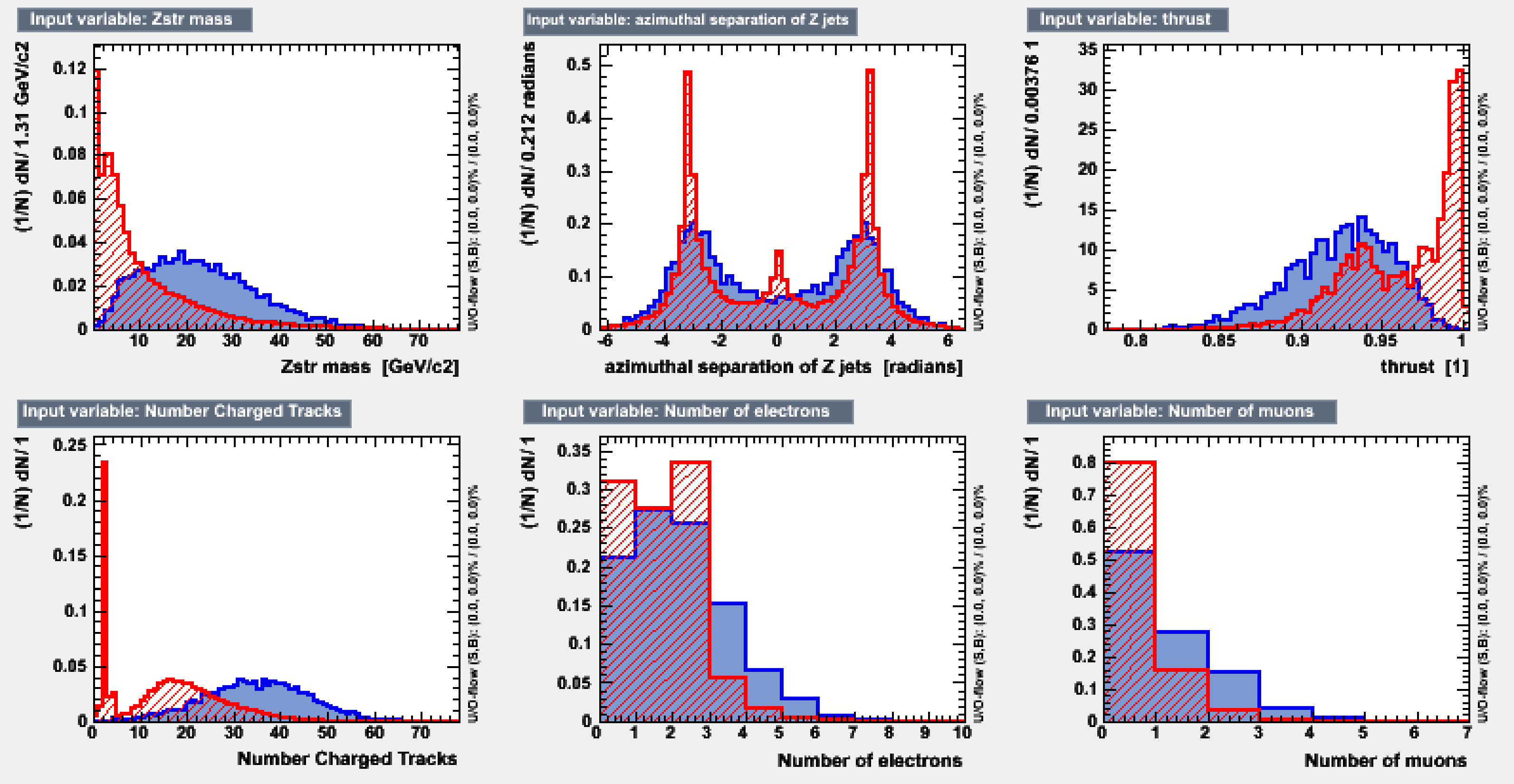


GeV

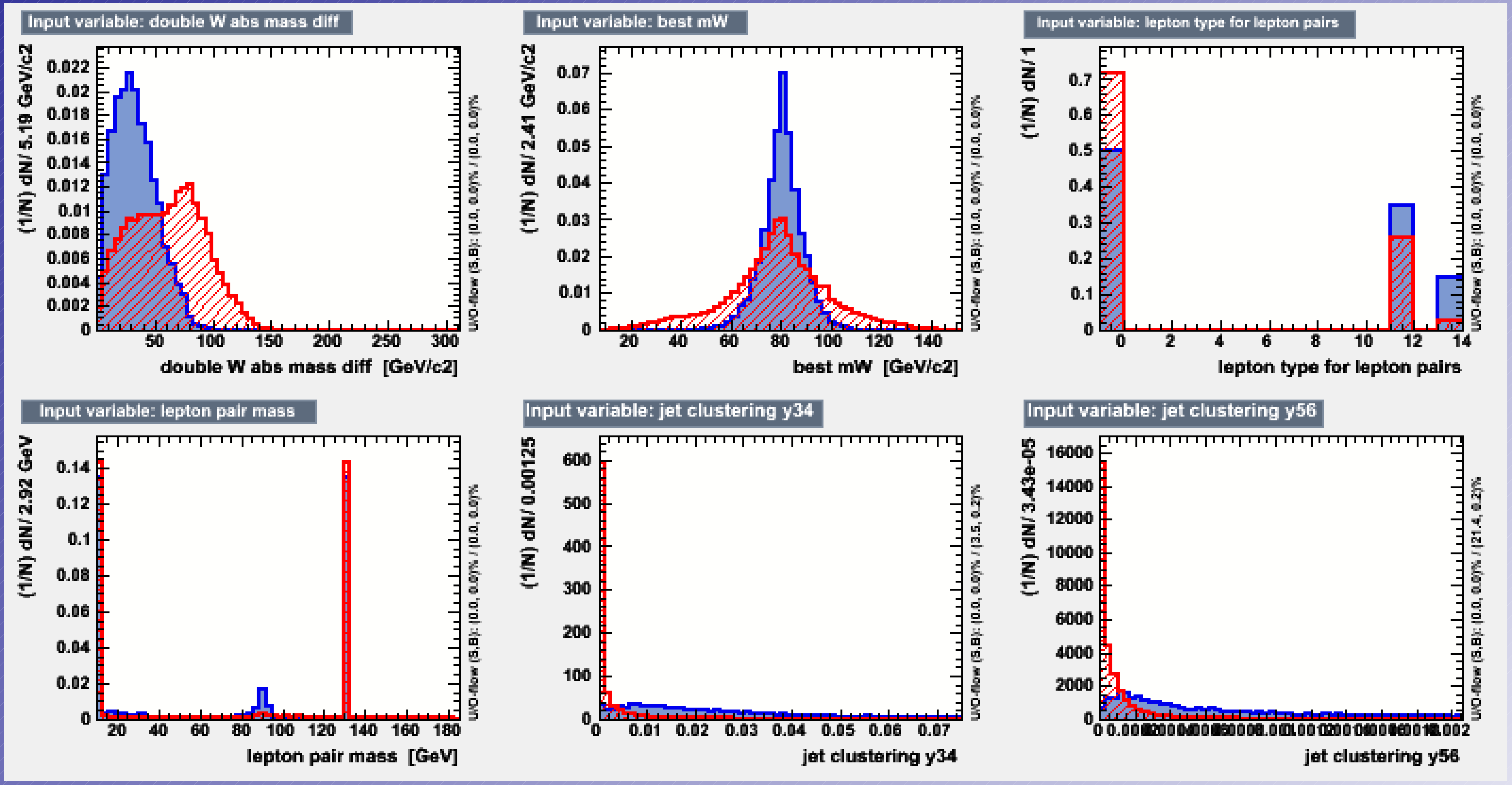
MVA Variables after only a Higgs mass window cut



MVA Variables after only a Higgs mass window cut

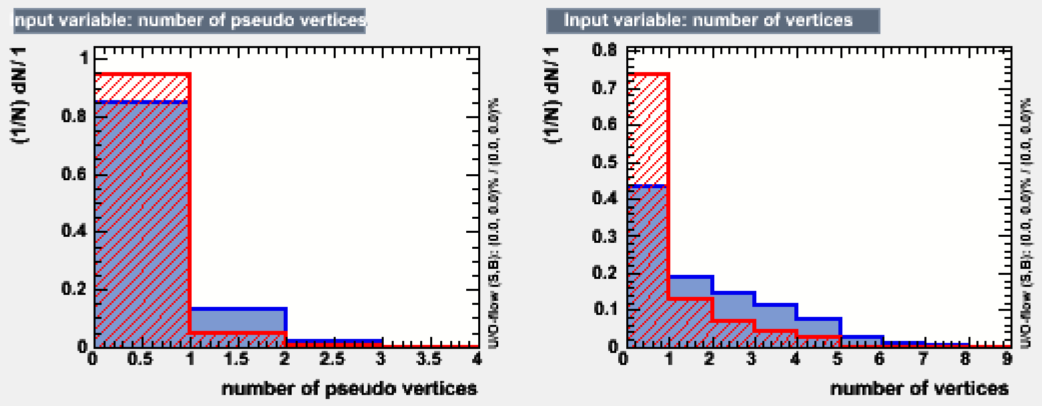


MVA Variables after only a Higgs mass window cut



(Note: the lepton pair mass plot has the entries at less than 10 GeV randomly set to 10 and 130 GeV so that the signal peak can be seen.)

MVA Variables after only a Higgs mass window cut



Preselection Choice

In the low visible energy signal events we expect a 4-jet topology if the Z and Z* decay visibly:

- One pair of jets must have a mass consistent with the Z mass.
- Events that have opposite signed electrons or muons with a mass consistent with the Z mass are unlikely to come from the WW background.
- Because of large missing energy and momentum from the invisible Z decay, it is unlikely that the reconstructed Z's are back-to-back and so we cut on the angle between them.
- Cutting on the number of tracks helps to remove much of the two-photon background.

The high visible energy signal events are largely true six jet events with all Z's decaying visibly:

- Backgrounds that come from ZZ and WW decays can be cut using the Durham jet clustering y34 and y56 variables.
- All pairs of jets are tried for the pair most consistent with the mass of the Z.
- Then from the remaining jets, the next pair most consistent with the mass of the Z is found and the remaining pair is taken as coming from the Z*.
- Each Z is then paired with the Z to see which one gives a mass most consistent with coming from a 125 GeV Higgs.
- The analysis then proceeds similarly to the 4 jet analysis using this pair of ZZ*.

Before applying an MVA selection, preselection cuts are applied seperately for Evis<140 GeV and Evis>140 GeV.
The preselection cuts exclude regions only where there is almost no signal.

Preselection

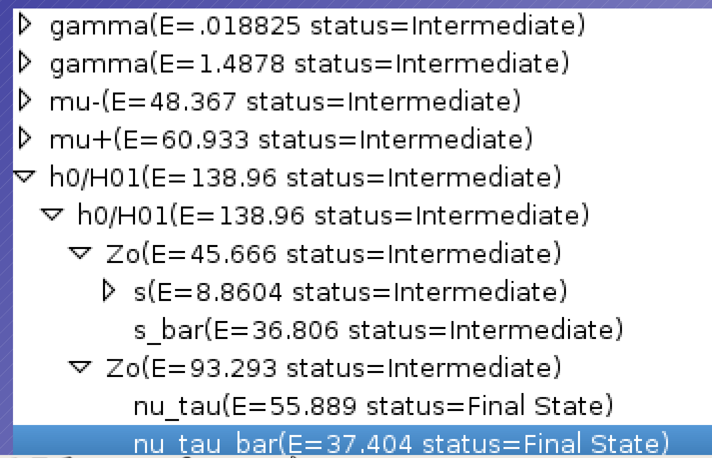
Higgs decay	Preselection cuts	Signal eff.	Background eff.
$h \to ZZ^*(E_{vis} < 140GeV)$	$25 < p^T_{\rm vis} < 70$ GeV $95. < M^{\rm higgs}_{\rm vis} < 140.$ GeV $\lvert\cos(\theta_{\rm jet})\rvert < 0.90$ $N_{\rm PFO} > 5$ $y_{34} > 0.$ $\mathrm{E}_Z > 120GeV$		
$h \to ZZ^*(E_{vis} > 140GeV)$	$90. < M^{\rm higgs}_{\rm vis} < 160.$ GeV $\lvert\cos(\theta_{\rm jet})\rvert < 0.90$ $N_{\rm PFO} > 5$ $y_{34} > 0.$ $\mathrm{E}_Z > 120GeV$ |thrust| ¡ 0.98		
Both		77%	1.5×10^{-2}

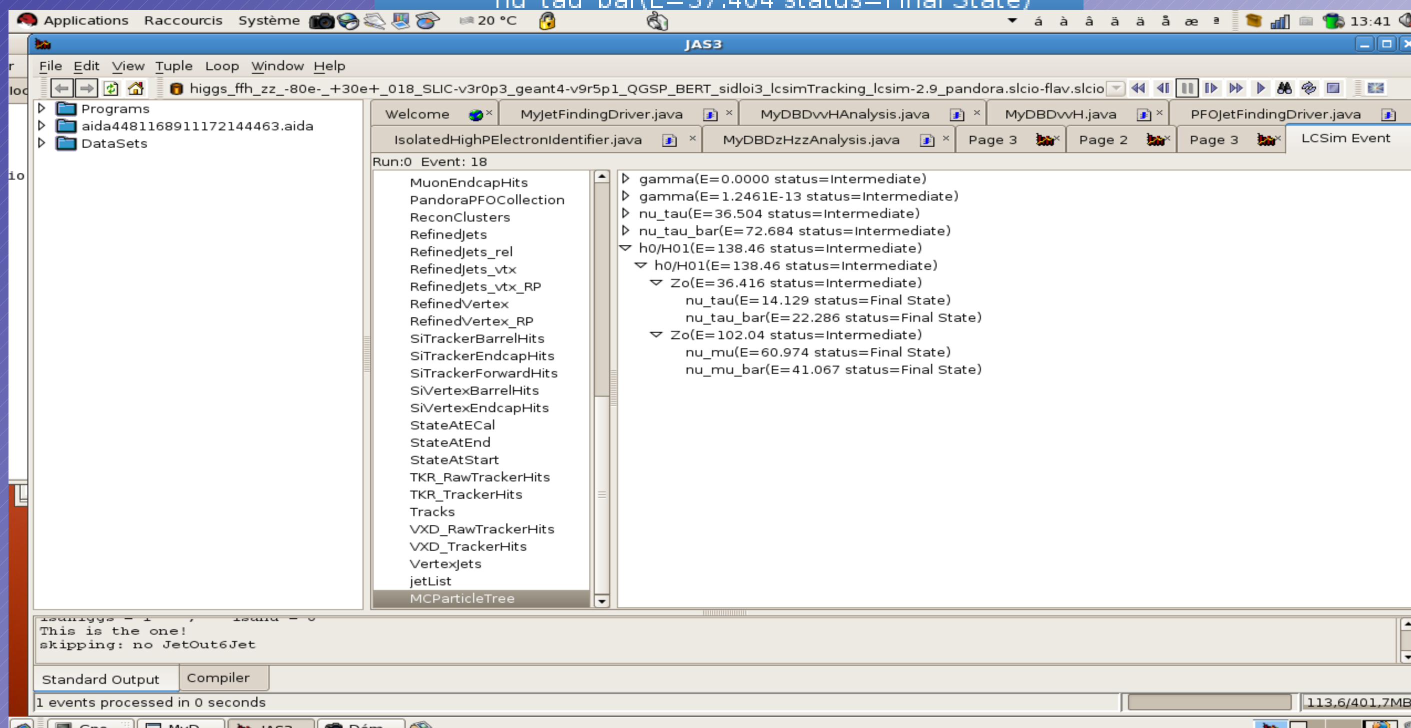
Mutli-Variate Analysis Variables

- visible mass of the event
- the visible energy, mass and transverse momentum
- B-Likeness from b-tag flavour tagging values
- C-likeness from c-tag flavour tagging values
- Number of High Energy Electrons

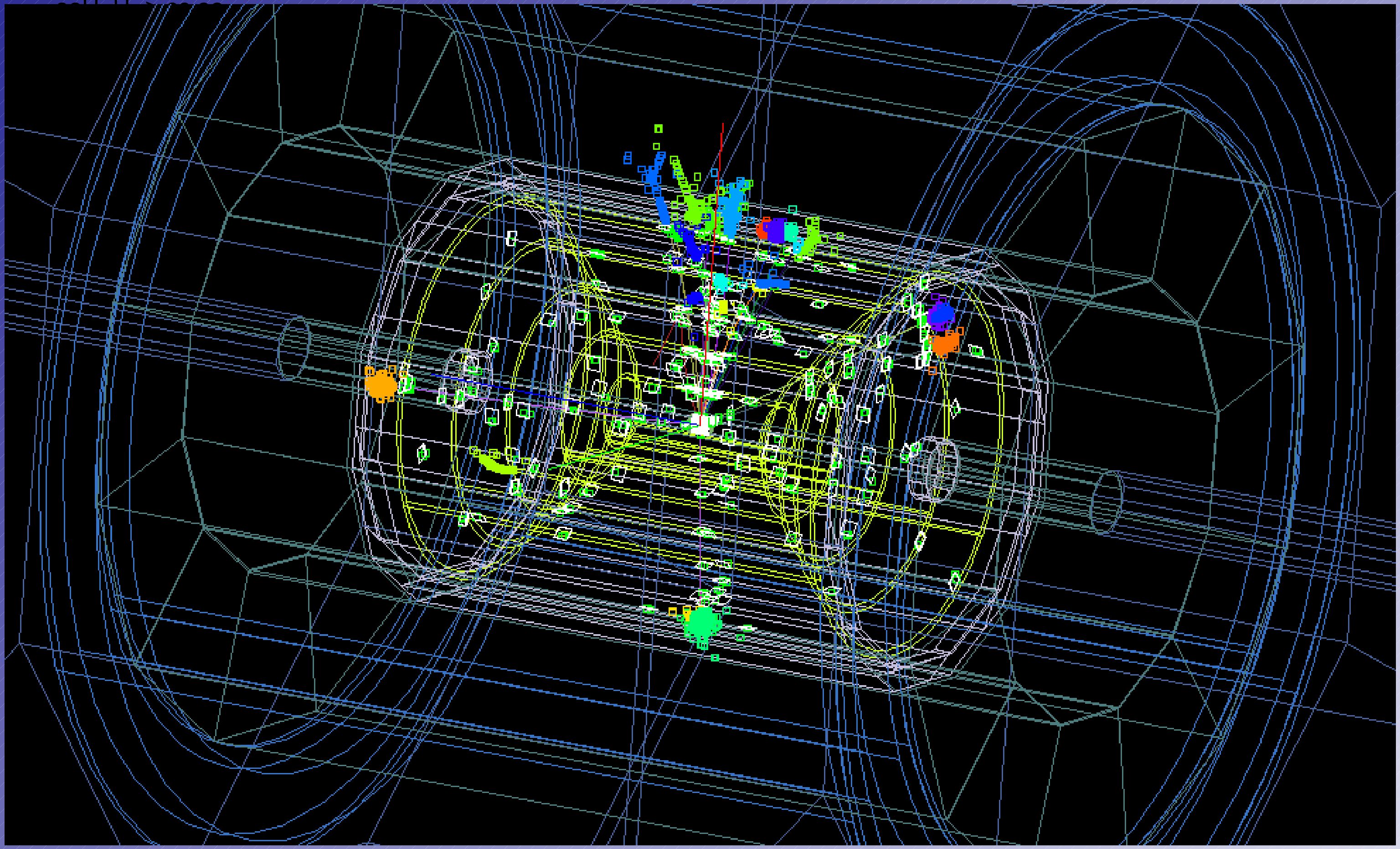
- Higgs Mass = mass of the reconstructed ZZ^*
- reconstructed Z energy
- reconstructed Z^* energy
- cosine of the reconstructed Z polar angle
- cosine of the reconstructed Z^* polar angle
- reconstructed Z mass
- reconstructed Z^* mass
- the angle between the reconstructed Z and Z^* in the plane perpendicular to the beam axis.
- the event thrust magnitude
- number Charged Tracks
- number of identified electrons
- number of identified muons
- Durham jet clustering y34 value
- Durham jet clustering y56 value
- lepton pair (PDG ID1 = -ID2) mass closest to m(Z)
- jet pair mass closest to m(W)
- sum of the absolute differences of the best W jet pair mass w.r.t. m(W)

Some Signals Too Hard/Impossible to select

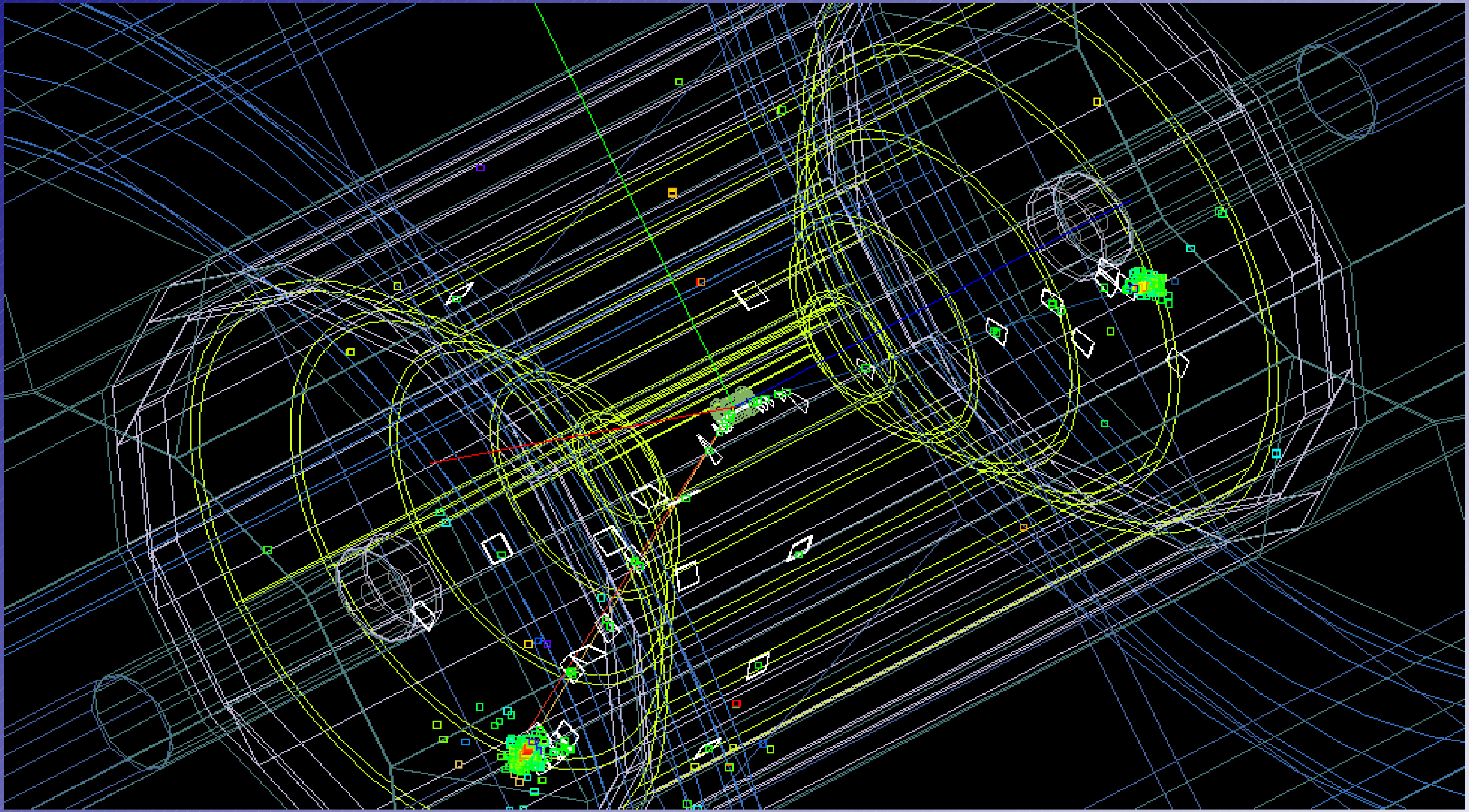




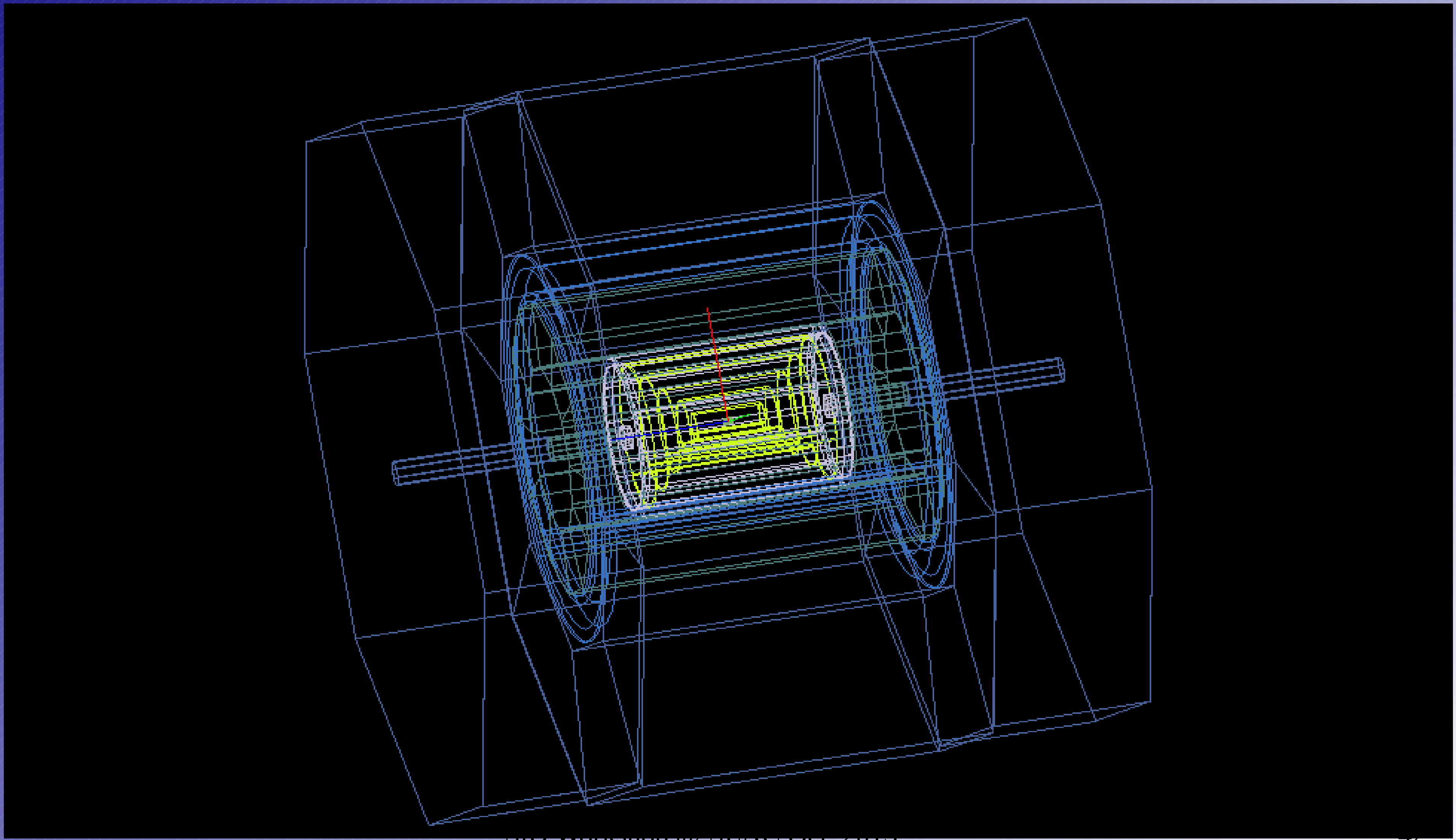
Now you see it: eeH, H -> cc ee



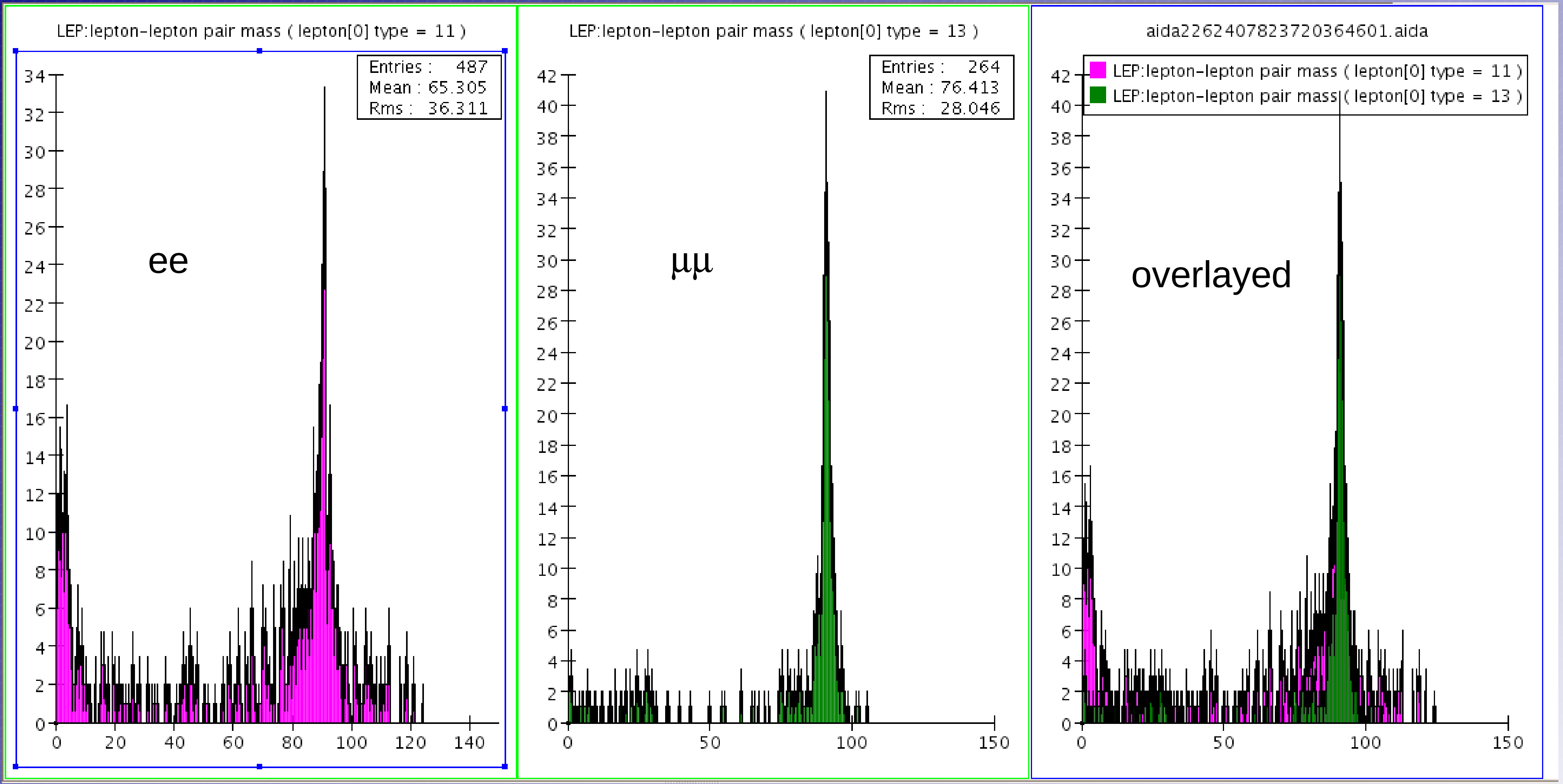
Almost gone: ee H, H -> $\nu\nu\nu\nu$



An invisible event: $\nu\nu H$, $H \rightarrow \nu\nu\nu\nu$

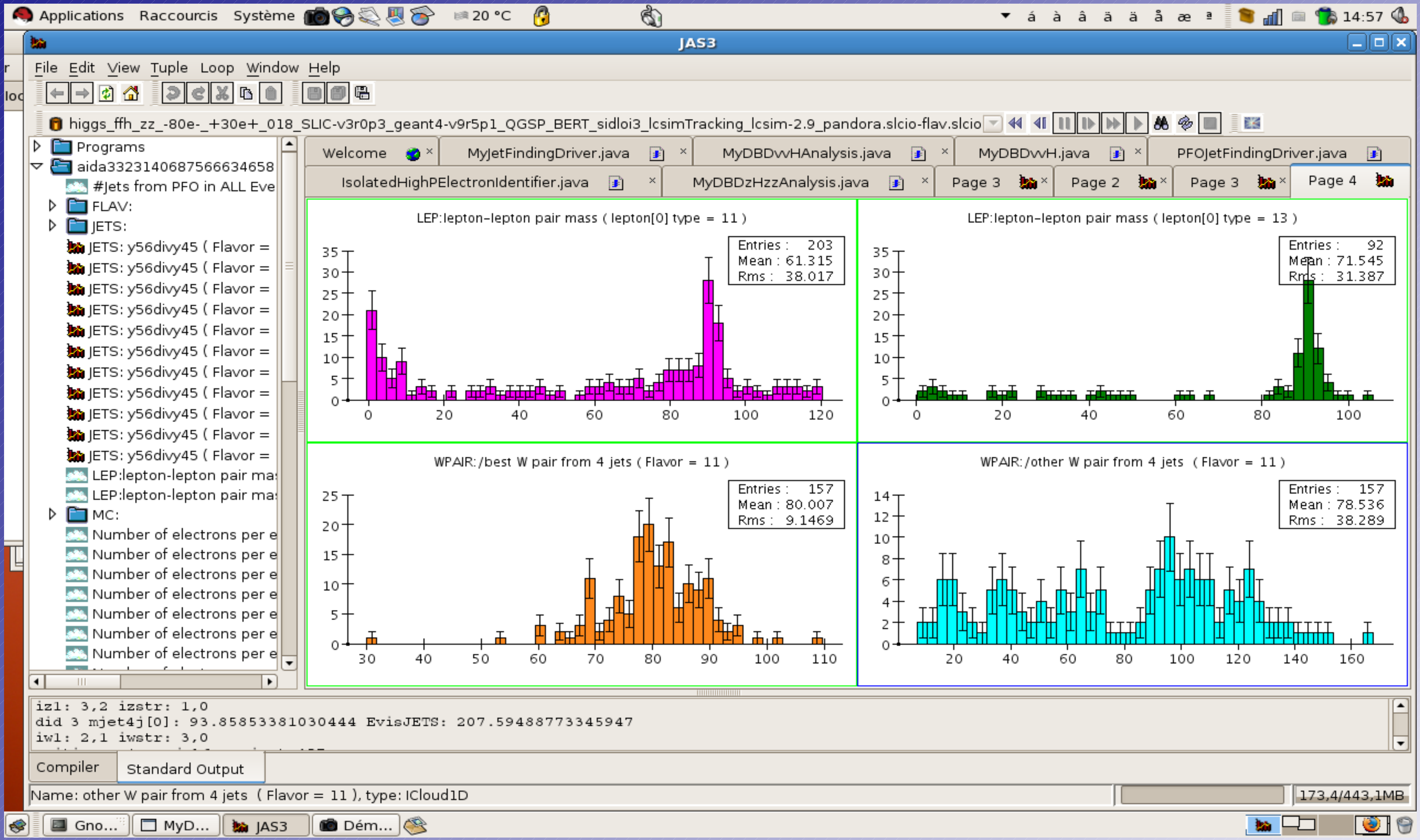


Mass of lepton pair with mass closest to mZ:

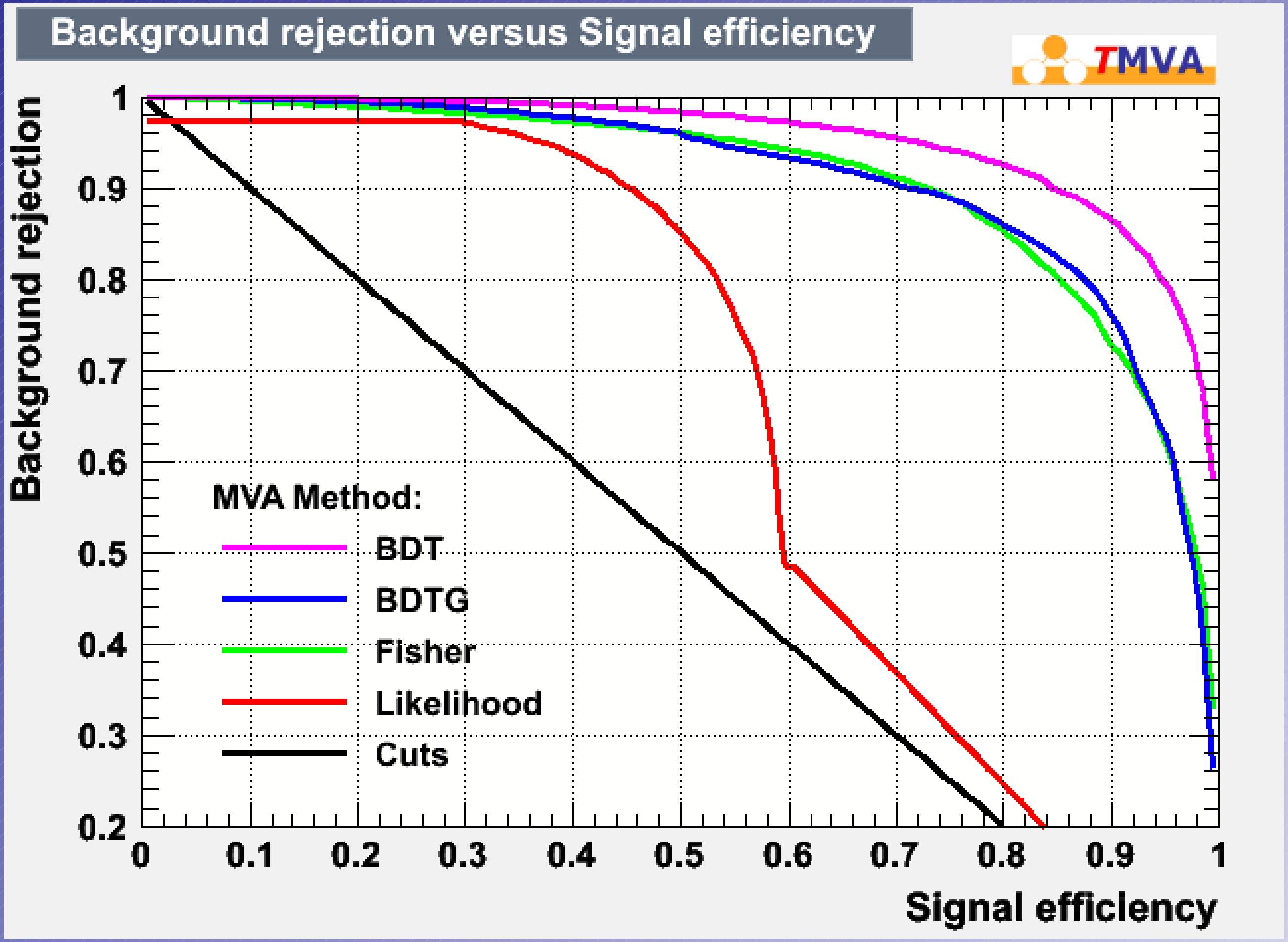


Note that these are all eeH events!

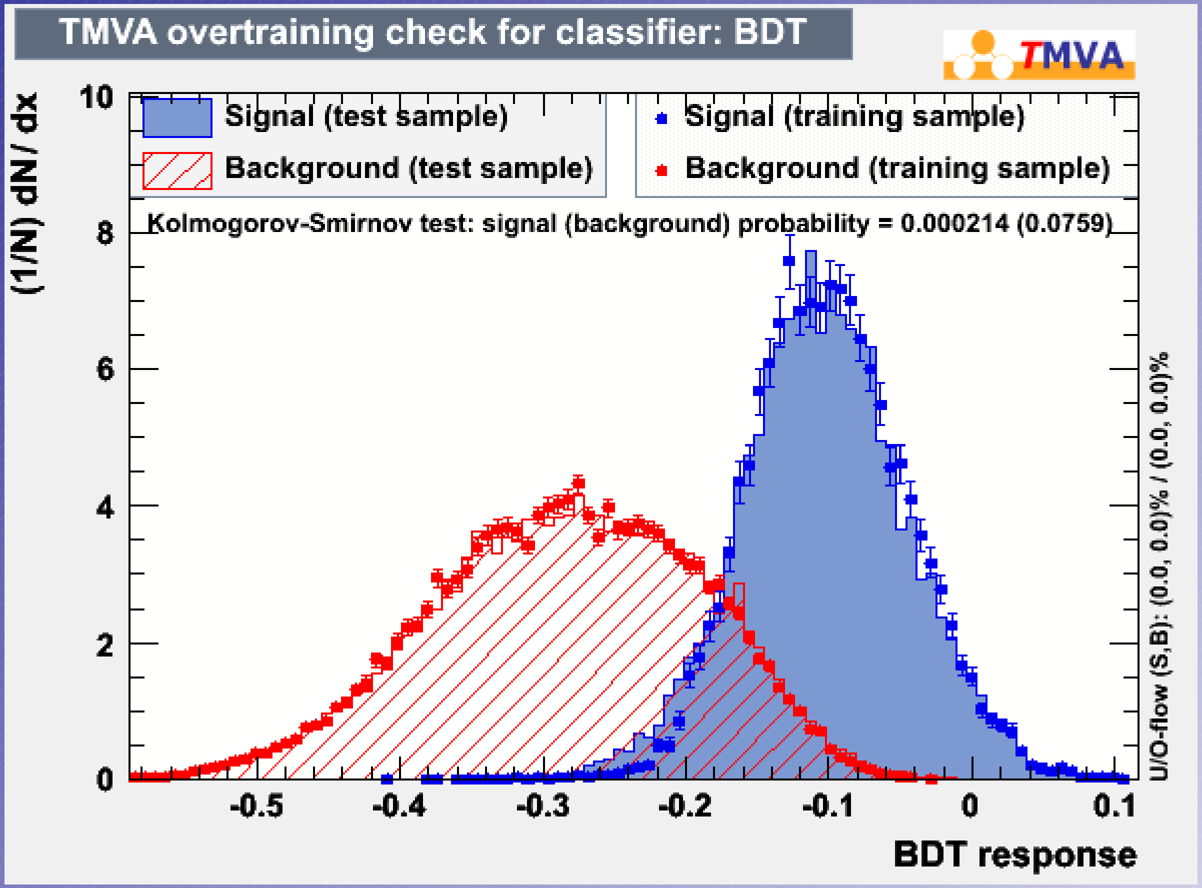
W? background rejection



MVA Performance



BDT response check



Results

For the polarisation P(e–) = +80%, P(e+) = -30% and 250 fb^{-1}.

The composition of the samples of events passing all selections of the analysis

	$h \to ZZ^*$ (%)
$e^+e^- \to 2$ fermions	50
$e^+e^- \to 4$ fermions	462
$e^+e^- \to 6$ fermions	0
$\gamma\gamma \to X$	0
$\gamma e^+ \to X$	0
$e^-\gamma \to X$	0
$qq\mathrm{h} \to ZZ^*$	68
$ee\mathrm{h}, \mu\mu\mathrm{h} \to ZZ^*$	24
$\tau\tau\mathrm{h} \to ZZ^*$	3
$\nu\nu\mathrm{h} \to ZZ^*$	49

$$\frac{\Delta(\sigma \cdot BR)}{\sigma \cdot BR}$$

this benchmark indicates that a precision of

$0.18+/-0.01$ can be obtained on the $\mathrm{f\bar{f}h} \to \mathrm{ZZ}^*$ branching ratio

The fraction of events passing all selections is
10.8% for the signal and 0.0008% for the background.

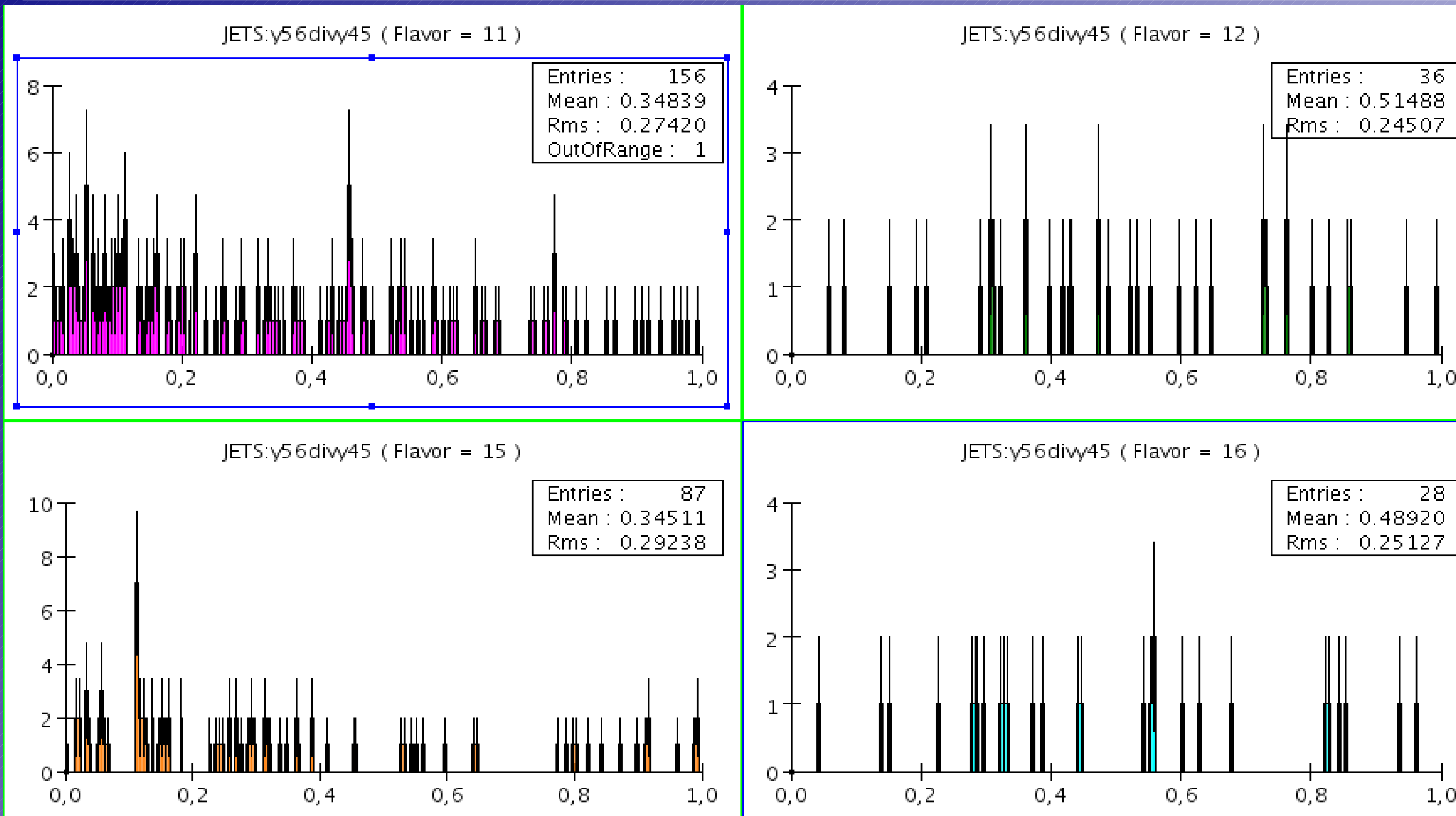
The significance of the signal after the preselection is 1.0.

After applying the cut on the BDT output, the significance is 5.6.

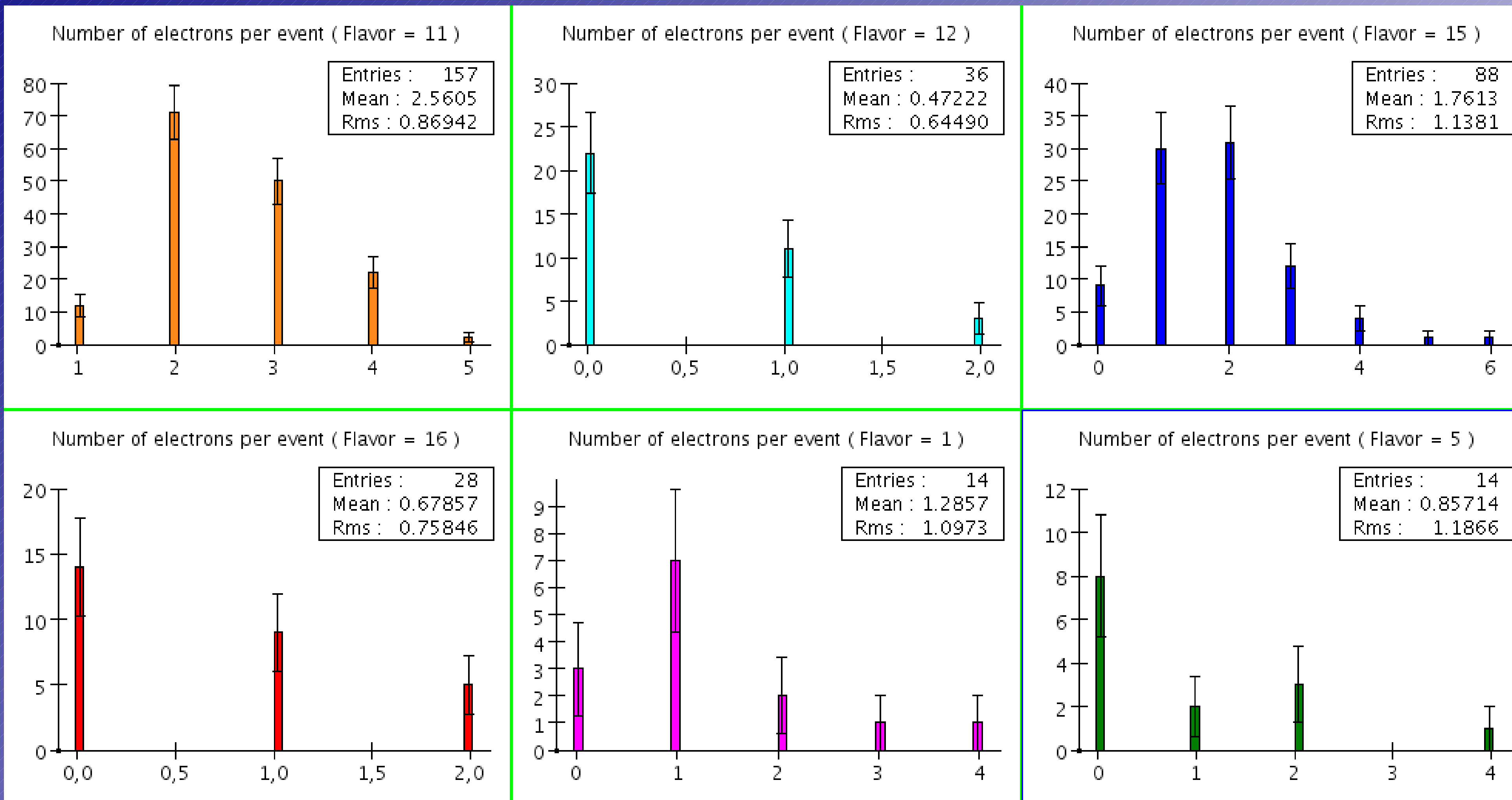
Plans

- Continue work on improving lepton tagging in $H \rightarrow ZZ^*$ analysis
- Examine pedestal cut in template method
- Verify that vertexing and flavour tagging are as good as they can be
- Prepare to take data!

RefinedJets: JetClustering y56/y45



#high energy electrons



No variation test

Start:

PARAMETER DEFINITIONS:

NO.	NAME	VALUE	STEP SIZE	LIMITS	
1	b	9.20000e-01	1.00000e-02	9.00000e-01	1.10000e+00
2	c	9.50000e-01	2.00000e-02	9.00000e-01	1.10000e+00
3	gg	1.02000e+00	2.00000e-02	9.00000e-01	1.10000e+00
4	Other	1.03000e+00	2.00000e-02	9.00000e-01	1.10000e+00
5	SM	9.30000e-01	1.50000e-02	9.00000e-01	1.10000e+00

Purposely starting away from the true values of 1.0

End:

PARAMETER CORRELATION COEFFICIENTS

NO.	GLOBAL	1	2	3	4	5
1	0.94197	1.000	0.117	-0.240	0.244	-0.541
2	0.57788	0.117	1.000	-0.551	0.568	0.335
3	0.95415	-0.240	-0.551	1.000	-0.931	-0.503
4	0.98412	0.244	0.568	-0.931	1.000	0.622
5	0.96512	-0.541	0.335	-0.503	0.622	1.000

EXTERNAL ERROR MATRIX. NDIM= 5 NPAR= 5 ERR DEF=0.5

2.625e-05	6.043e-06	-1.534e-04	1.496e-04	-3.089e-06
6.043e-06	1.019e-04	-6.955e-04	6.848e-04	3.764e-06
-1.534e-04	-6.955e-04	1.562e-02	-1.391e-02	-7.007e-05
1.496e-04	6.848e-04	-1.391e-02	1.428e-02	8.272e-05
-3.089e-06	3.764e-06	-7.007e-05	8.272e-05	1.240e-06

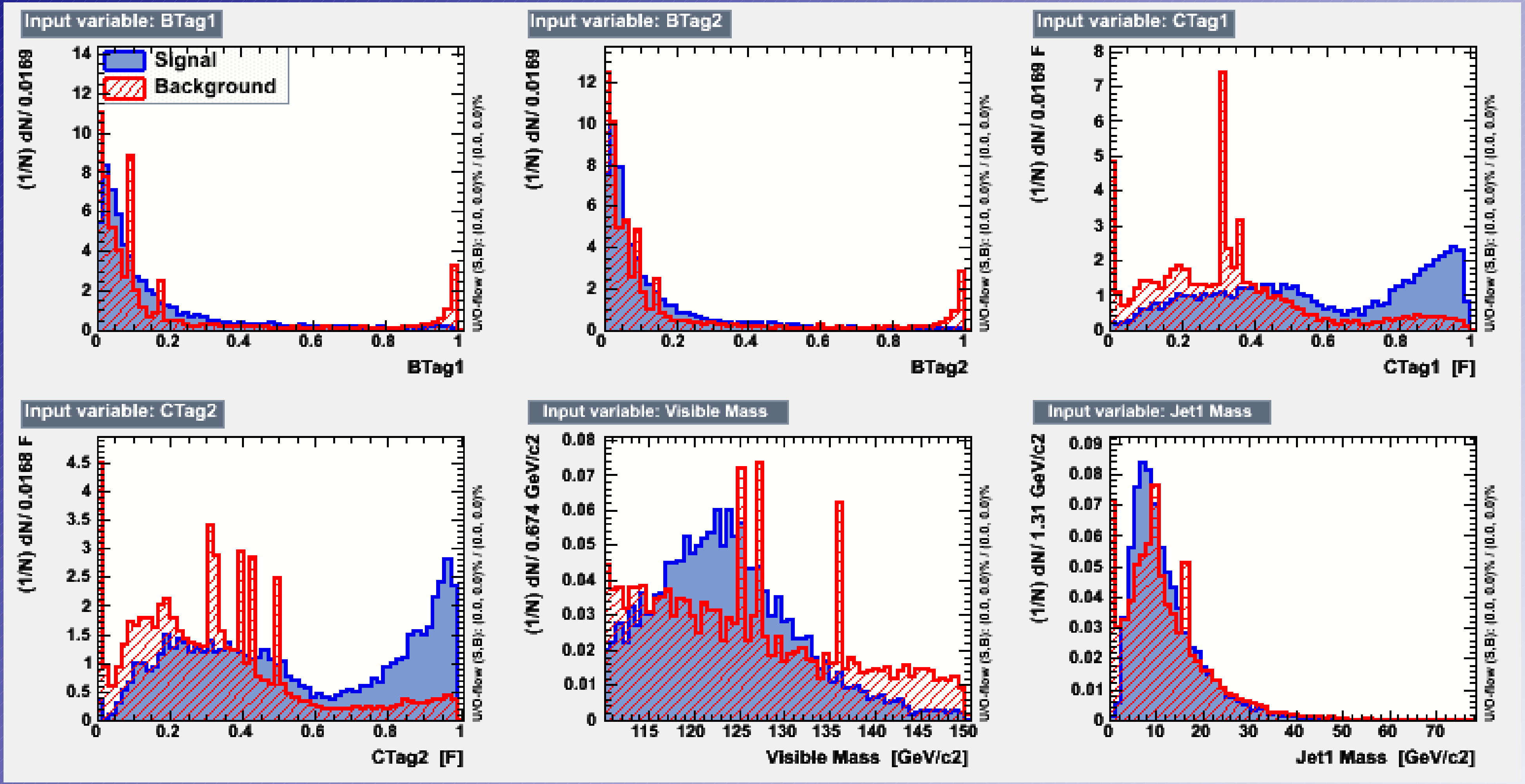
FCN=-2.92447e+06 FROM MIGRAD STATUS=CONVERGED 808 CALLS 809 TOTAL

EDM=0.107761 STRATEGY= 1 ERROR MATRIX UNCERTAINTY 8.2 per cent

EXT PARAMETER NO.	NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS NEGATIVE	POSITIVE
1	b	9.97798e-01	5.12162e-03		
2	c	1.09493e+00	9.92271e-03		
3	gg	1.06516e+00	1.72904e-01		
4	Other	9.32783e-01	1.01920e-01		
5	SM	9.99203e-01	1.11346e-03		

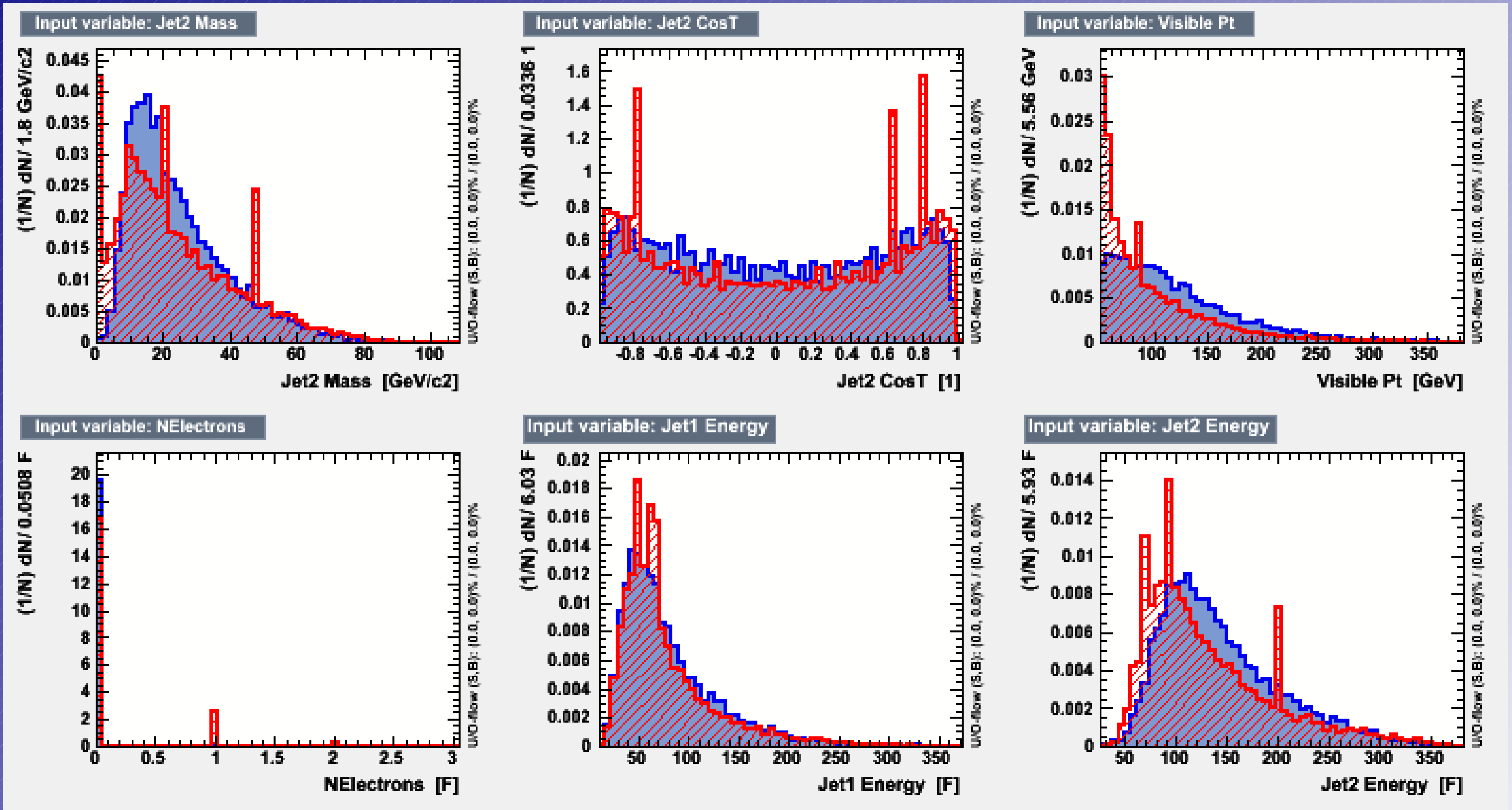
ERR DEF= 0.5

With Ono-like presel

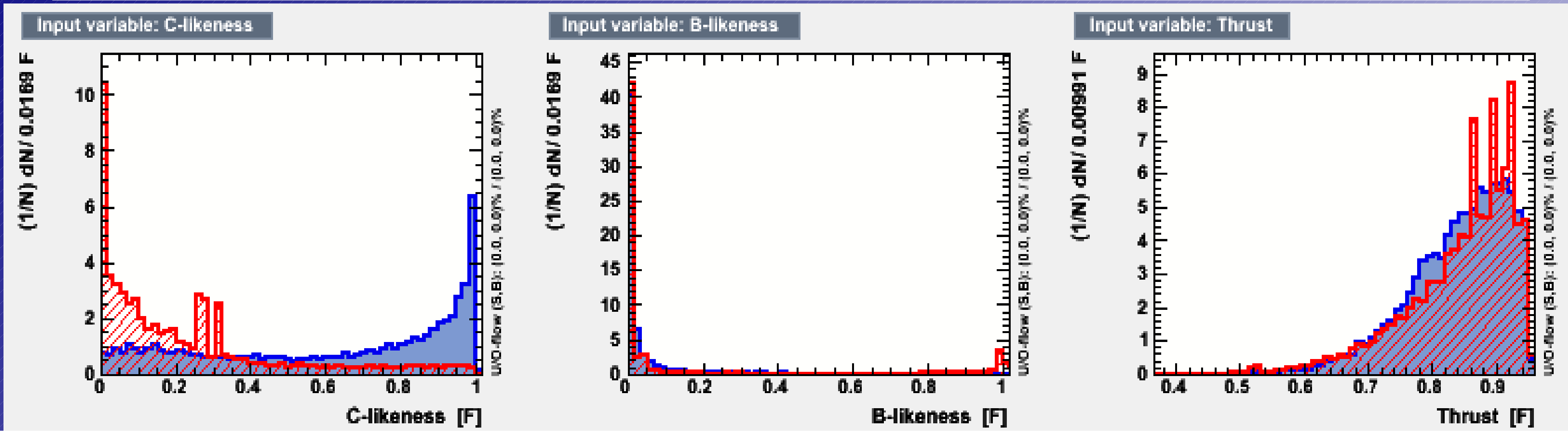


Spikiness due to high weight background events is a reason why I had always used tighter cuts.

With Ono-like presel



With Ono-like presel

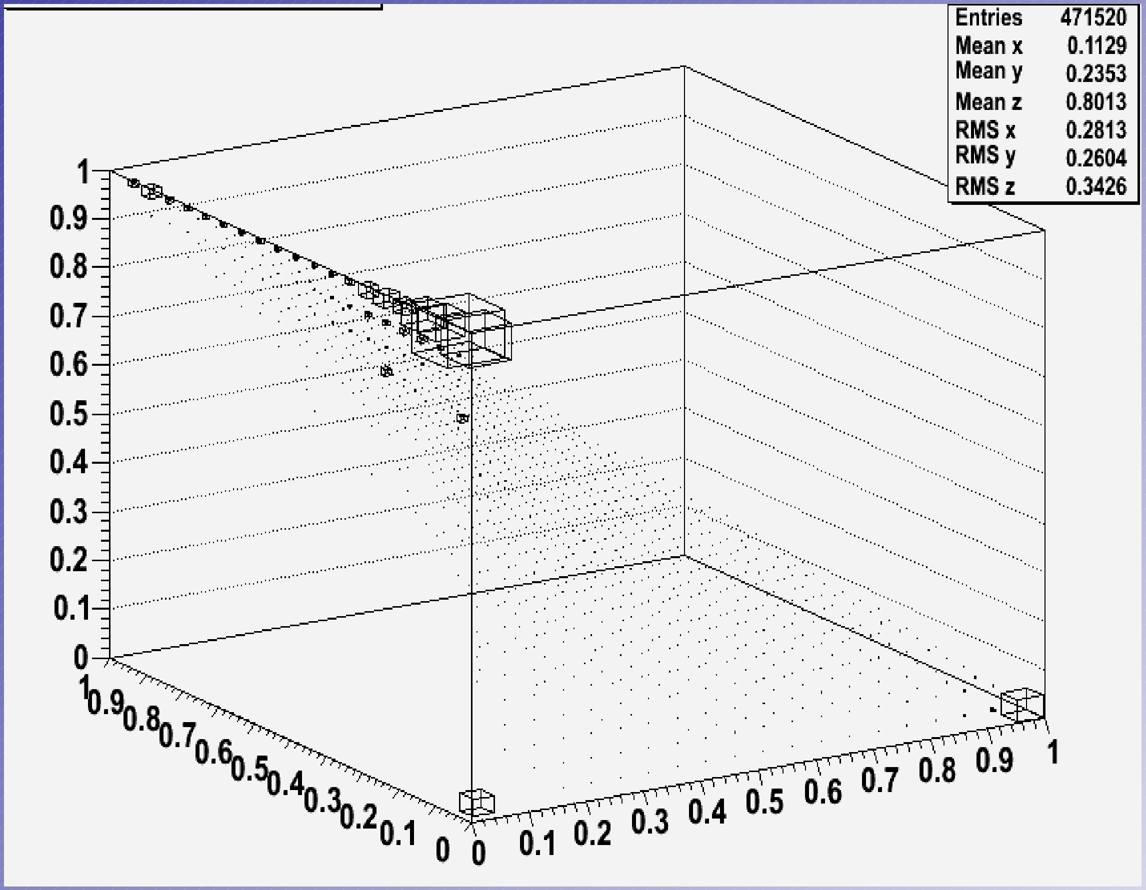


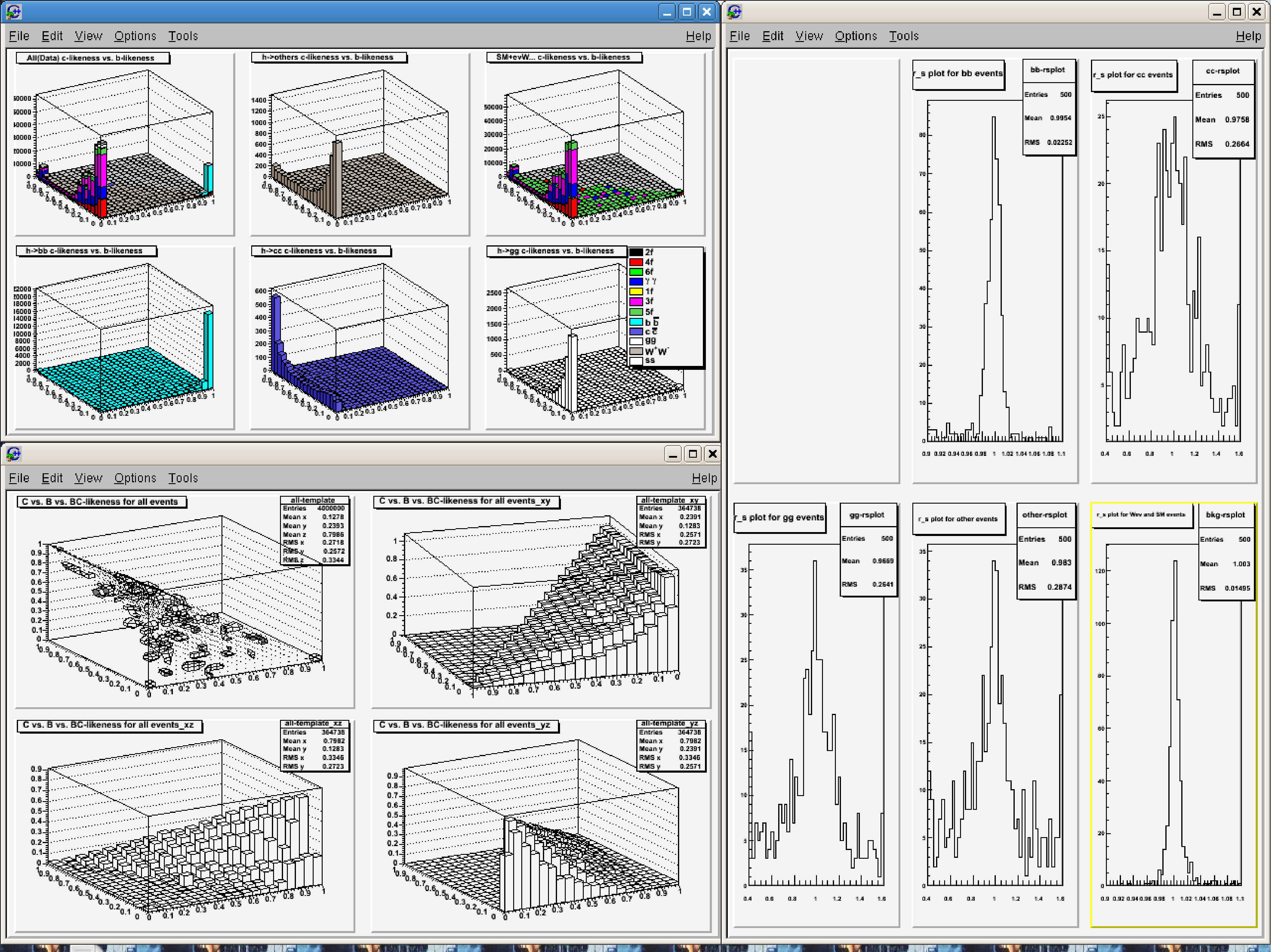
ILD

TABLE VI: Estimated measurement accuracies of σBR for $h \to b\bar{b}$, $c\bar{c}$, and gg channels at $\sqrt{s} = 1$ TeV with respect to the $\mathcal{L} = 500$ fb^{-1} for both $P(e^-, e^+) = (\mp 0.8, \pm 0.2)$ beam polarizations or accumulating $\mathcal{L} = 1$ ab^{-1} regarding $P(-0.8, +0.2)$ left-handed polarization. Here these results are taken only statistical uncertainties into account.

Integrated luminosity	500 fb^{-1}	500 fb^{-1}	1 ab^{-1}
Beam polarization $P(e^-, e^+)$	$P(-0.8, +0.2)$	$P(+0.8, -0.2)$	$P(-0.8, +0.2)$
$\Delta\sigma BR/\sigma BR(h \to b\bar{b})$	0.54%	2.1%	0.39%
$\Delta\sigma BR/\sigma BR(h \to c\bar{c})$	5.7%	36.8%	3.9%
$\Delta\sigma BR/\sigma BR(h \to gg)$	3.9%	25.7%	2.8%

c-likeness vs. b-likeness vs. bc-likeness




File Edit View Options Tools Help
All(Data) c-likeness vs. b-likeness
h->others c-likeness vs. b-likeness
SM+evW... c-likeness vs. b-likeness
h->bb c-likeness vs. b-likeness
h->cc c-likeness vs. b-likeness
h->gg c-likeness vs. b-likeness
2f
4f
6f
γ γ
1f
3f
5f
b b̄
c c̄
gg
W⁺W⁻
ss
File Edit View Options Tools Help
C vs. B vs. BC-likeness for all events
all-template
Entries 4000000
Mean x 0.1278
Mean y 0.2393
Mean z 0.7986
RMS x 0.2718
RMS y 0.2572
RMS z 0.3344
C vs. B vs. BC-likeness for all events_xy
all-template_xy
Entries 364738
Mean x 0.2391
Mean y 0.1283
RMS x 0.2571
RMS y 0.2723
C vs. B vs. BC-likeness for all events_xz
all-template_xz
Entries 364738
Mean x 0.7982
Mean y 0.1283
RMS x 0.3346
RMS y 0.2723
C vs. B vs. BC-likeness for all events_yz
all-template_yz
Entries 364738
Mean x 0.7982
Mean y 0.2391
RMS x 0.3346
RMS y 0.2571
File Edit View Options Tools Help
r_s plot for bb events
bb-rsplot
Entries 500
Mean 0.9954
RMS 0.02252
r_s plot for cc events
cc-rsplot
Entries 500
Mean 0.9758
RMS 0.2664
r_s plot for gg events
gg-rsplot
Entries 500
Mean 0.9669
RMS 0.2641
r_s plot for other events
other-rsplot
Entries 500
Mean 0.983
RMS 0.2874
r_s plot for Wev and SM events
bkg-rsplot
Entries 500
Mean 1.003
RMS 0.01495