

DBD •  • Higgs
Branching Ratio Analysis

Presented by
H. Neal (SLAC)

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The August 2012 SiD Workshop

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Analysis work in progress by
A. Grohsjean, M. Stanitzki & H. Neal
and much support from

T. Barklow, N. Graf,

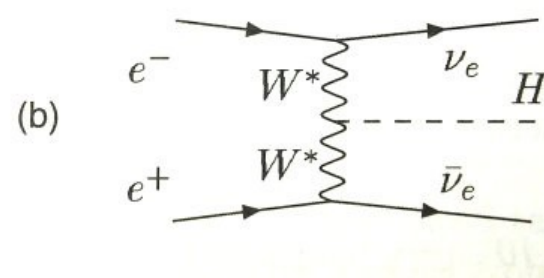
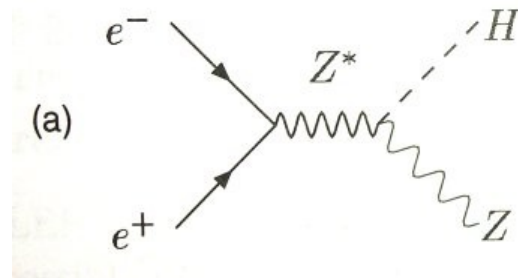
C. Grefe, J. McCormick, S. Poss, P. Roloff & J. Strube

Motivation for using $e^+e^- \rightarrow \nu\nu H$

Goal is to measure BR errors for gg, WW^* using $e^+e^- \rightarrow \nu\nu H$
@ 1 TeV

WW fusion cross-section rises with E_{COM}

Higgstrahlung



WW fusion
 σ grows
as $\ln(s)$

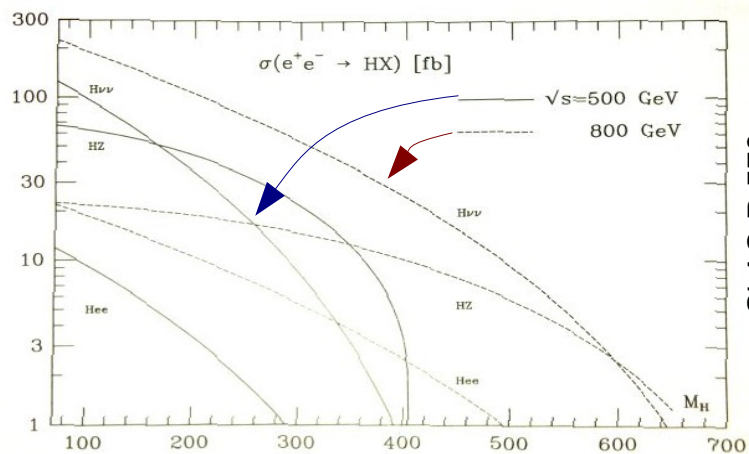


Figure 3.4: Cross sections for Higgstrahlung ($e^+e^- \rightarrow Zh_{\text{SM}}$) and Higgs production via W^+W^- fusion ($e^+e^- \rightarrow \nu\bar{\nu}h_{\text{SM}}$) and ZZ fusion ($e^+e^- \rightarrow e^+e^-h_{\text{SM}}$) as a function of $m_{h_{\text{SM}}}$ for two center-of-mass energies, $\sqrt{s} = 500$ and 800 GeV [5].

\sqrt{s} (GeV)	e_{pol}^+ (%)	Higgs Mass (GeV)			
		120	140	160	200
350	0	110280	89150	69975	37385
350	+50	159115	128520	100800	53775
1000	0	386550	350690	317530	259190
1000	+50	569750	516830	467900	382070

arXiv:hep-ph/0312268v2 21 Jan 2004

Elements of the $\nu\nu H$ Benchmark

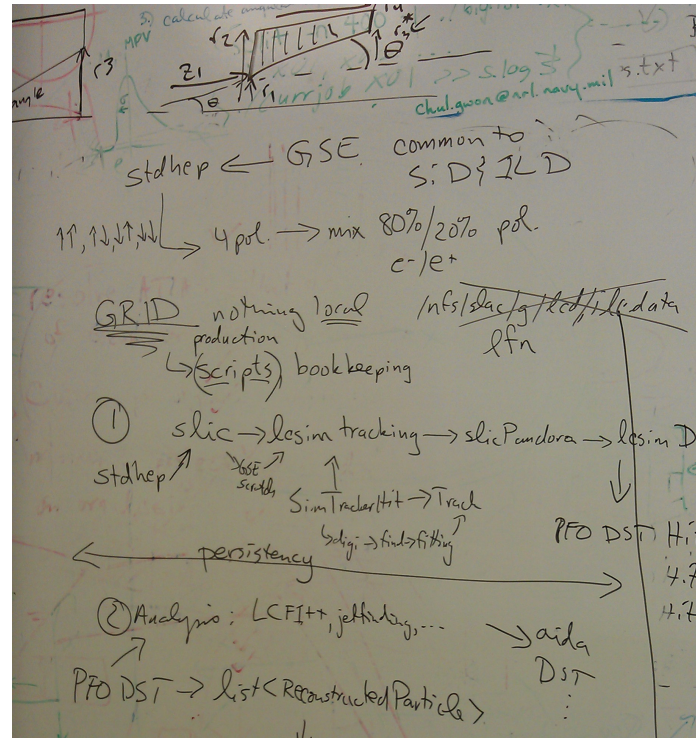
- flavor/anti-flavor tagging using LCFI+
- Include extra background
- Full simulation using SLIC
- Mixed stdhep from Whizard with various polarizations (+80%,-20%),(-80%,+20%)
- Beam spot simulation
- Pandora PFA

Continuing the work of Ron and Tim

SiD Workshop August 2012

Production Steps

Initial orientation from Jeremy and Norman was extremely useful in getting started.



Use of the GRID tools has been productive as well as fun.

Thanks to Jan and Philipp for development of recoChain

System ▾ Jobs ▾ Views ▾ Tools ▾ Selected setup: ILC-Production ▾

JobMonitoring [Refresh] [Select All] [Select None] [Reschedule] [Kill] [Delete]

JobId	Status	MinorSt...	ApplicationStatus	Site	JobName	LastUpdate [UTC]	Las	SubmissionTim...
<input type="checkbox"/> 5105922	Running	Application	SLIC v3r0p3 step 1	LCG.CERN.ch	ilc_higg...	2012-08-22 00:...	201	2012-08-21 23:51
<input type="checkbox"/> 5103255	Running	Application	SLIC v3r0p3 step 1	LCG.DESY-HH.de	ilc_hiss...	2012-08-21 22:12	201	2012-08-21 21:44

JobMonitoring [Refresh] [Select All] [Select None] [Reschedule] [Kill] [Delete]

JobId	Status	MinorStatus	ApplicationStatus	Site	JobName	LastUpdate [UTC]	Las	SubmissionTim...
5105922	Running	Application	SLIC v3r0p3 st...	LCG.CERN.ch	ilc_higgs_ffh...	2012-08-22 00:...	201	2012-08-21 23:51
5103255	Running	Application	LCSIM DBD_TE...	LCG.DESY-HH.de	ilc_hiss_ffh-...	2012-08-22 03:53	201	2012-08-21 21:44

Signal Samples

The following signal samples were generated thanks to Tim Barklow:

Process	Ecm(GeV)	# Events	Lumi (ab ⁻¹)	Mixed File Creation Date
<i>ffH H → bb, cc, WW*, gg</i>	1000	3.1e6	7.4	26Jul2012 Mh=125 GeV

/nfs/slac/g/lcd/ilc_data4/DBD/ILC1000/higgs_ffh_nomu/stdhep/

Uploaded to:

/ilc/user/j/jstrube/SID_DBD/ILC1000/mixed/higgs_ffh_nomu/stdhep/:

500 Event samples

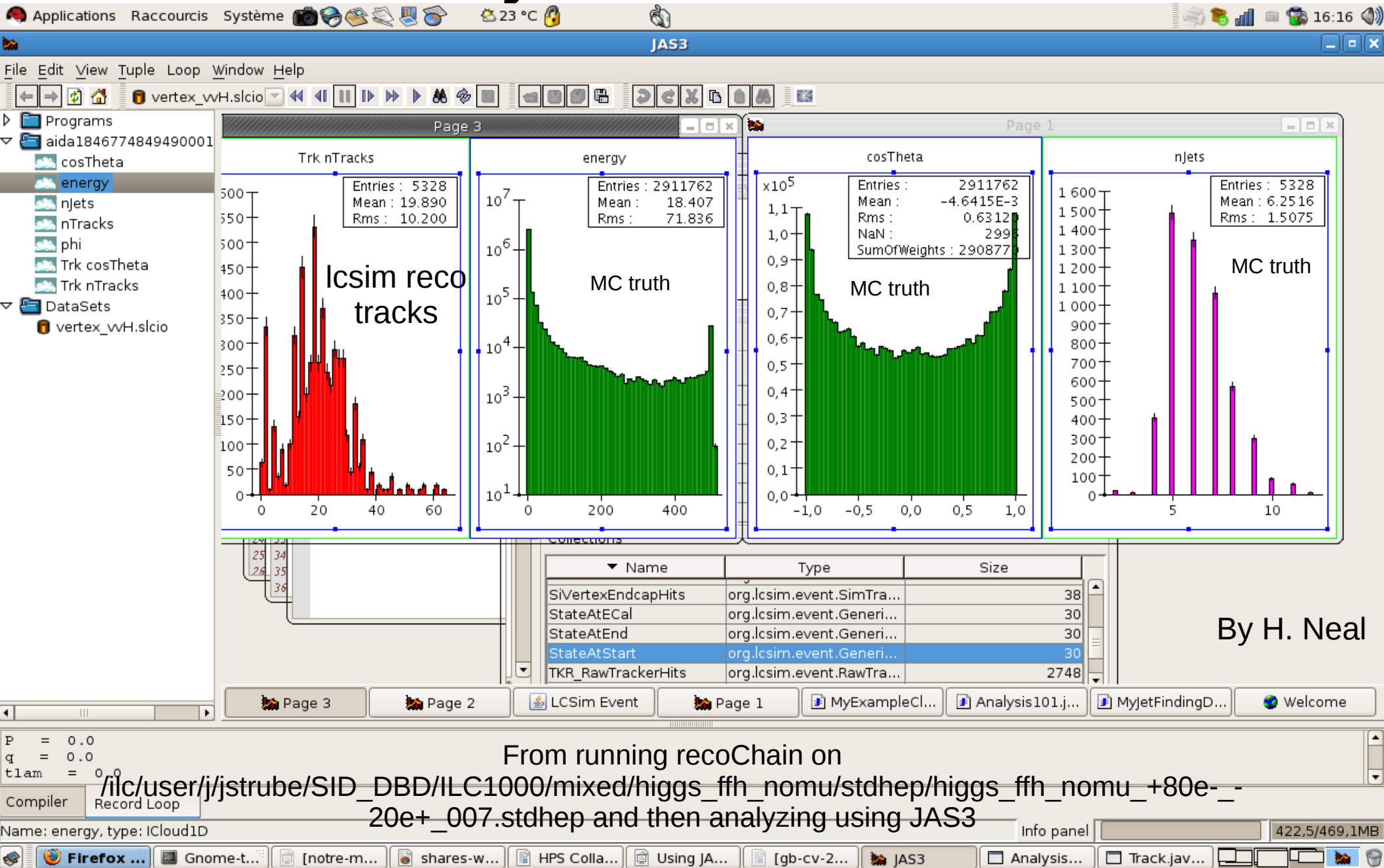
#Files Filename prefix

3089 higgs_ffh_nomu_+80e-_-20e

3089 higgs_ffh_nomu_-80e-_+20e



Analyzable $\nu\nu H$ Data



Higgs event selection

PreSelection:

- no isolated electron or muon
- $|\cos \theta_{\text{thrust}}| < 0.95$,
- $100 < E(\text{visible}) < 400 \text{ GeV}$
- $20 < p_{\text{T}}(\text{visible}) < 500 \text{ GeV}$

Previously used selection variables with cuts depending on the mode: (see [arXiv:hep-ph/0312268](https://arxiv.org/abs/hep-ph/0312268))

- visible mass $M(\text{visible})$
- $N(\text{chg})$
- $N(\text{imp})$ - # large impact parameter tracks
- $N(\text{jet})$ as determined by the PYCLUS algorithm of PYTHIA with parameters $\text{MSTU}(46)=1$ and $\text{PARU}(44)=5$.

Mode Specific Selection Cuts

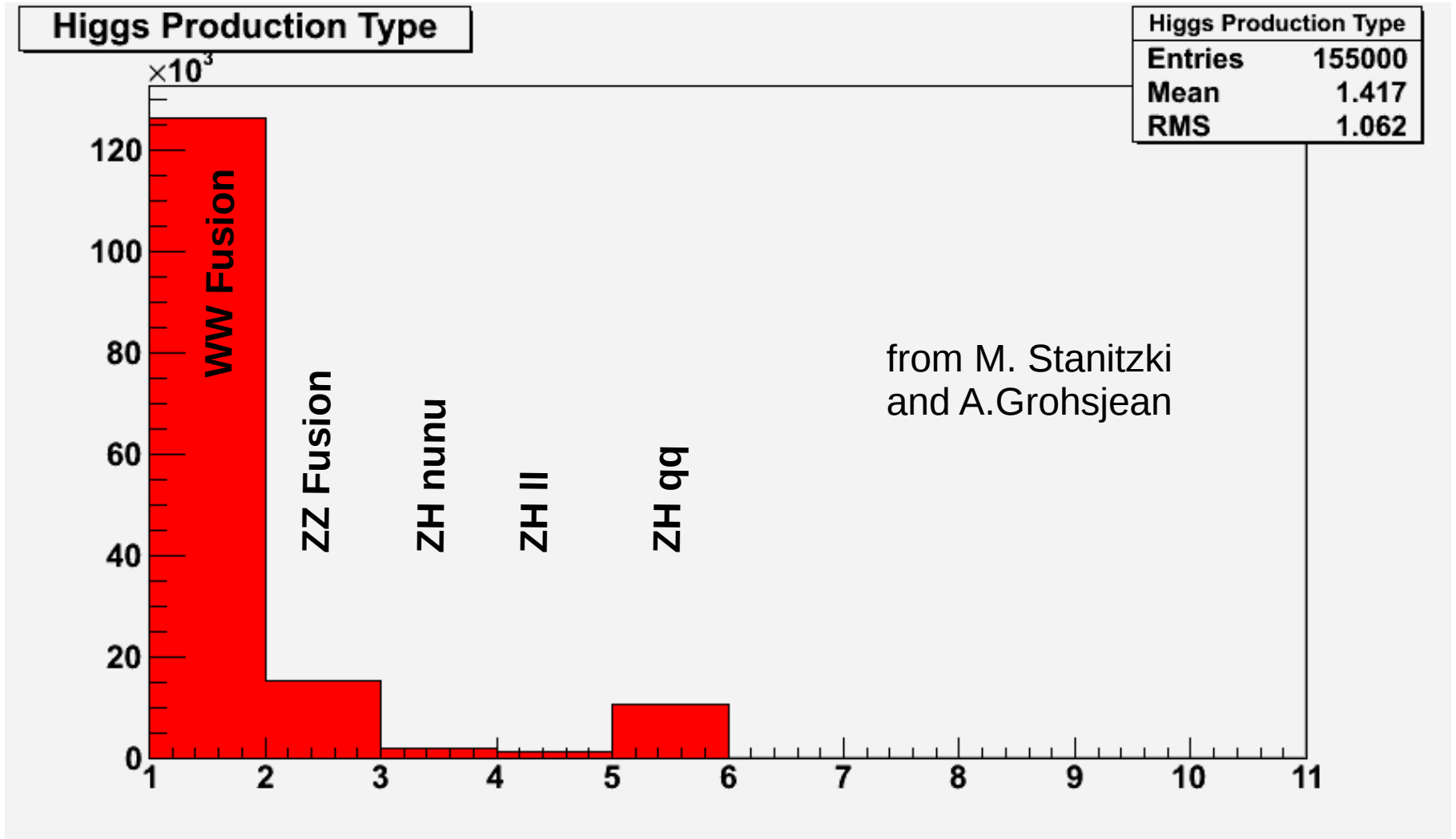
based on arXiv:hep-ph/0312268

$h \rightarrow bb$				
	$6 \leq N(\text{chg}) \leq 19$	$7 \leq N(\text{imp}) \leq 19$	$2 \leq N(\text{jet}) \leq 3$	$M_h - 10 \text{ GeV} < M(\text{vis}) < M_h + 6 \text{ GeV}$
$h \rightarrow \gamma\gamma$				
	$N(\text{chg})=0$	$N(\text{imp})=0$	$N(\text{jet})=2$	$M_h - 2 \text{ GeV} < M(\text{vis}) < M_h + 1 \text{ GeV}$
$h \rightarrow WW$				
	$16 \leq N(\text{chg}) \leq 44$	$N(\text{imp}) \leq 6$	$4 \leq N(\text{jet}) \leq 5$	$M_h - 10 \text{ GeV} < M(\text{vis}) < M_h + 6 \text{ GeV}$
$h \rightarrow gg$				
	$11 \leq N(\text{chg}) \leq 49$	$N(\text{imp}) \leq 6$	$2 \leq N(\text{jet}) \leq 4$	$M_h - 10 \text{ GeV} < M(\text{vis}) < M_h + 6 \text{ GeV}$

$N(\text{imp})$ will be replaced with LCFI+ flavor/anti-flavor tagging and the other cuts will need to be retuned due to new backgrounds.

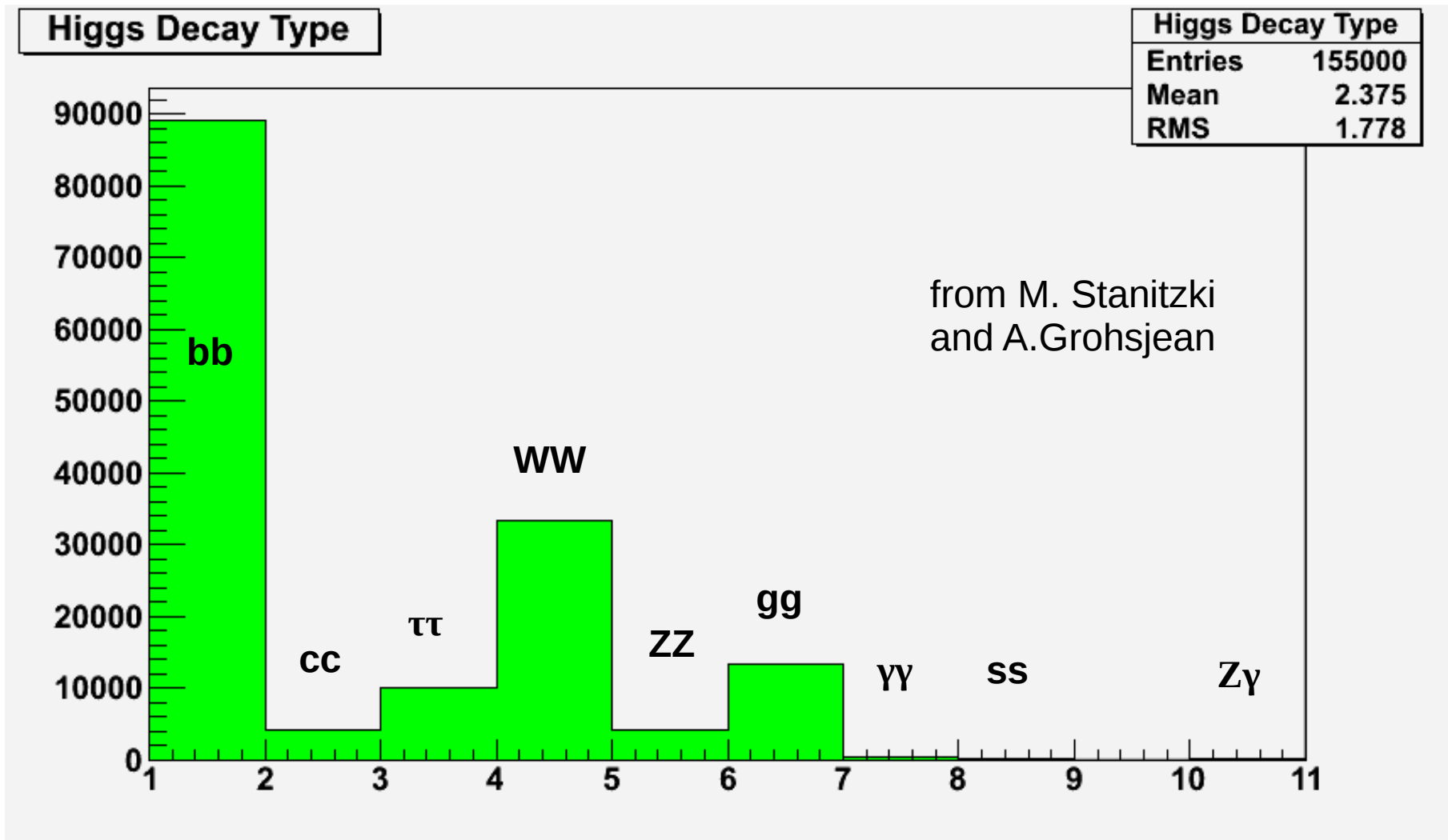
Higgs Production Mode

Higgs to gg and WW*



Fusion includes ZH + Interference

Decay Modes

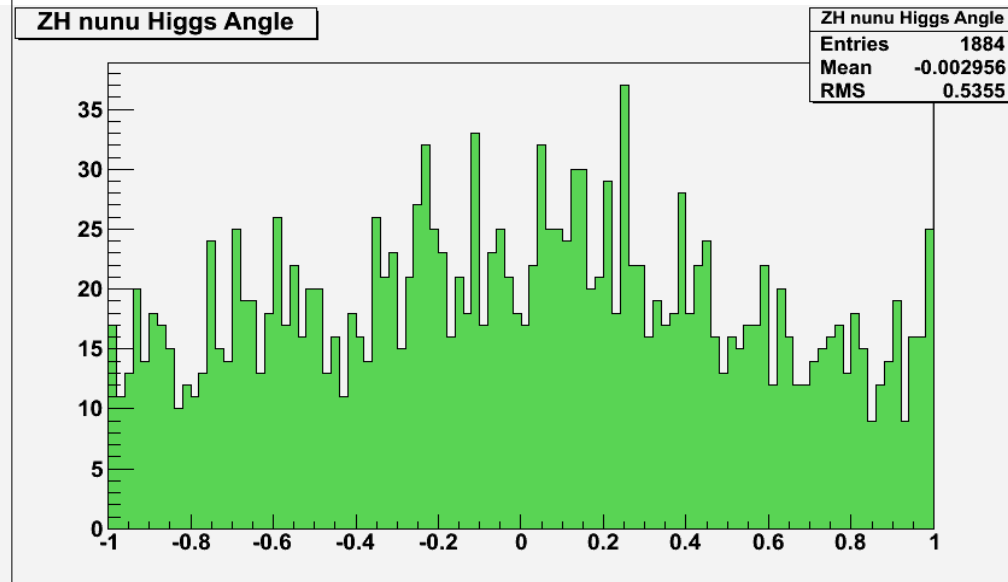
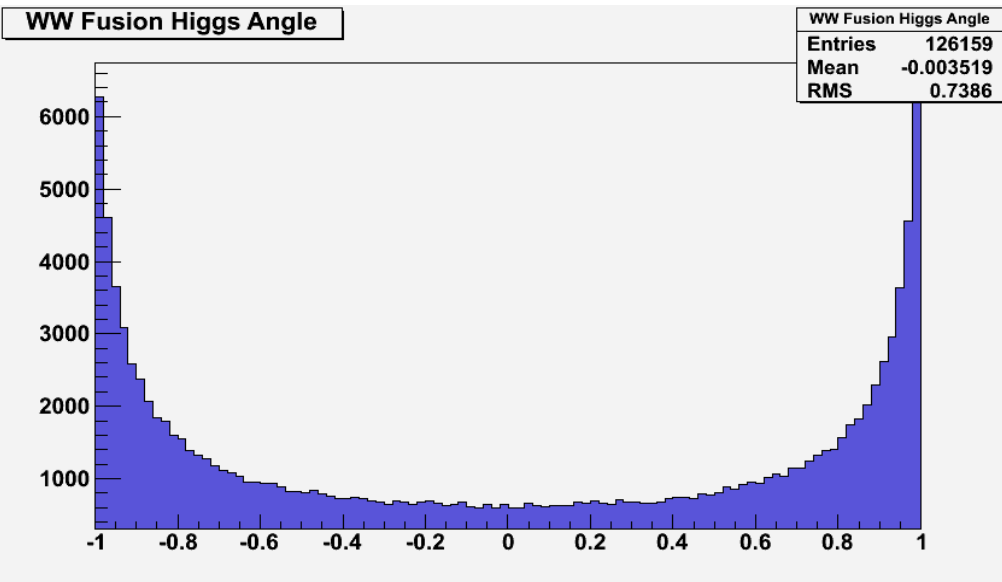
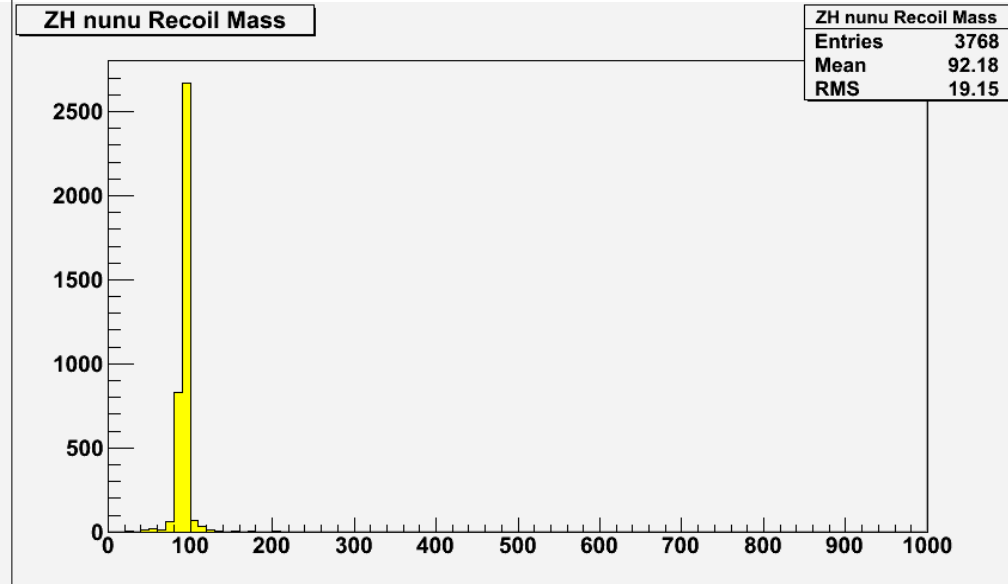
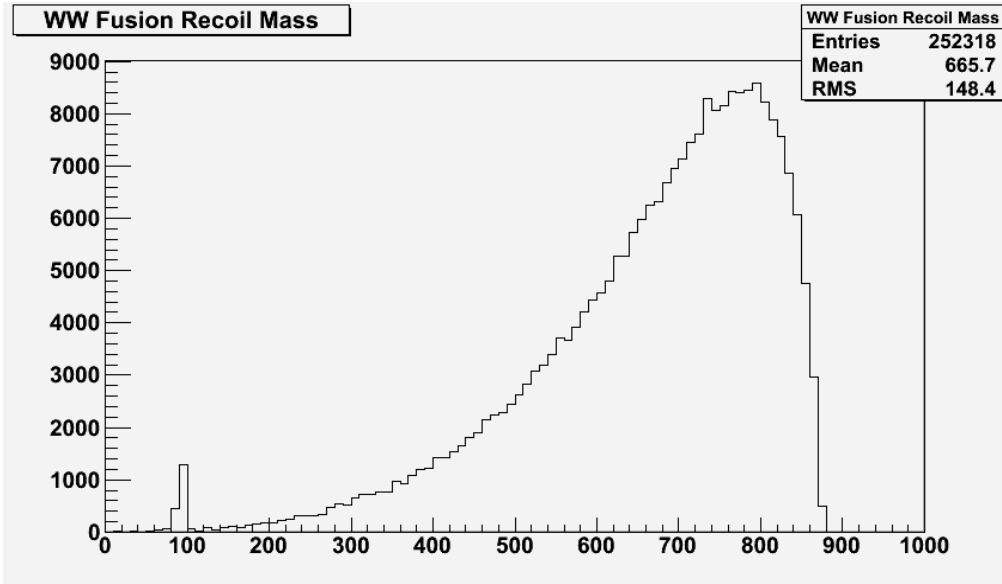


Recoil Mass and Higgs Angle

in WW Fusion and ZH Events

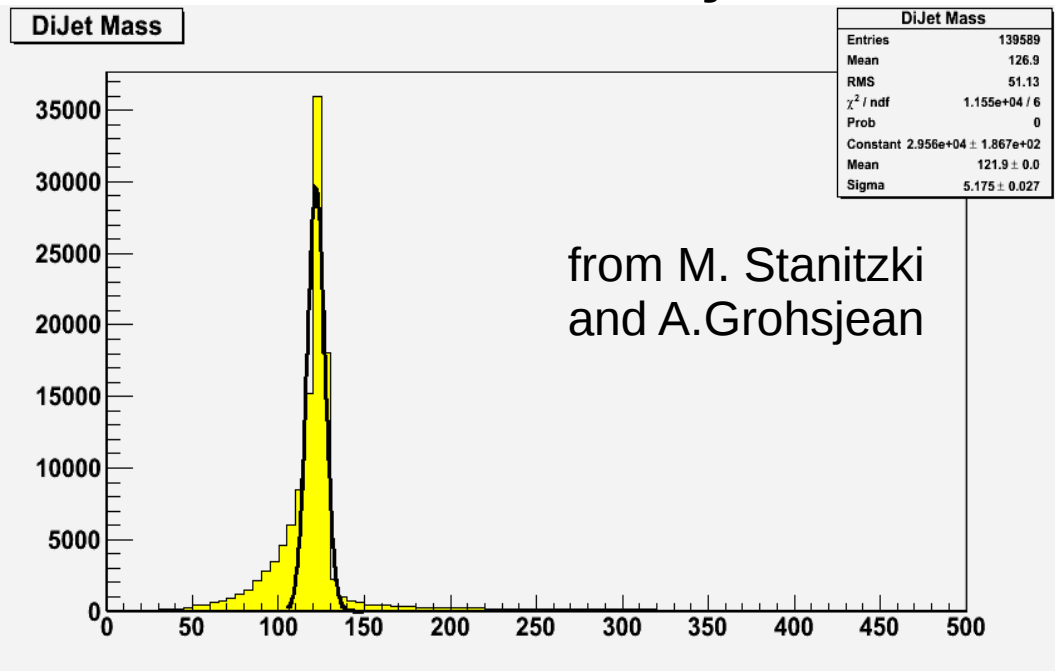
from M. Stanitzki
and A. Grohsjean

WW Fusion \longleftrightarrow ZH



From Simulation

- Durham
- Select Events > 9 Tracks
- Force into two jets
- Works most of the time
- They are getting with an adhoc-fit
 - 121.9 ± 5.1 GeV
 - Tail pulls it downwards



Known work to be done

- Add backgrounds
- Validate DSTs
- train flavor/anti-flavor taggers and apply to DSTs
- Apply improved electron ID
- Handle overlap between bb, cc, gg and WW
- Exactly define what is the signal (*ZH* included or not?)
- Alexander is working on the gluon tagging

Signal Production in Progress

System Jobs Data Views Tools Selected setup: ILC-Development

MetadataCatalog Metadata Query

Metadata tags

Path to start from: c:/sid/1000_p80m20/higgs_ffh_nomu

Select All Select None Save

File Name

- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4002.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4003.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4004.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4005.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4006.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4007.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4008.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4009.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4010.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4011.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4012.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4013.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4014.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4015.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4016.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4017.slcio
- /ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4018.slcio

Refresh Submit Reset

Data > MetadataCatalog homer@ ilc_user (/DC=org/DC=doe grids/OU=People/CN=Homer Alfred Neal 86449)

```
bash-3.2$ dirac-dms-get-file
/ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4002.slcio
{'Failed': {},
 'Successful':
 {'/ilc/prod/ilc/sid/1000_p80m20/higgs_ffh_nomu/sidloi3/SIM/00001729/004/higgs_ffh_nomu_p80m20_sim_1729_4002.slcio':
  '/afs/slac.stanford.edu/u/ey/homer/sid/grid_vvh/higgs_ffh_nomu_p80m20_sim_1729_4002.slcio'}}}
```

Summary

- Preparing to expediently complete the DBD Higgs BR Benchmark with updated simulation and flavor/anti-flavor tagging
- Production output of signals and backgrounds soon becoming available
- Analysis tools and data reduction being exercised
- Looking forward to having preliminary results soon.
- Many thanks to the help of the production experts

LCSIM output from running on Current Sim. Production Output

The screenshot shows the JAS3 application window. The title bar reads "JAS3". The menu bar includes "File", "Edit", "View", "Tuple", "Loop", "Window", and "Help". The toolbar contains various navigation and simulation control icons. The main window is titled "higgs_ffh_nomu_p80m20_sim_1729_4003_sidloi3_0_digi_rec.slcio".

On the left, there is a "DataSets" tree view showing "higgs_ffh_nomu". Below it, a list of event collections is displayed under the heading "Event".

The main area shows the "LCIO Event Header" for Run:17294003, Event: 0. The header information is as follows:

Run	17294003
Event	0
Time Stamp	Sat Aug 18 12:58:50 PDT 2012
Detector Name	sidloi3
Event Weight	0.023597
IDRUP	36151
SLIC Version	v3r0p2
Geant4 Version	v9r5p1

Below the header is a "Collections" table with the following data:

Name	Type	Size
MuonEndcapHits	org.lcsim.event.SimCalorimeterHit	0
PandoraPFOCollection	org.lcsim.event.ReconstructedPart...	45
ReconClusters	org.lcsim.event.Cluster	45
SiTrackerBarrelHits	org.lcsim.event.SimTrackerHit	622
SiTrackerEndcapHits	org.lcsim.event.SimTrackerHit	607
SiTrackerForwardHits	org.lcsim.event.SimTrackerHit	13
SiVertexBarrelHits	org.lcsim.event.SimTrackerHit	144
SiVertexEndcapHits	org.lcsim.event.SimTrackerHit	7
StateAtECal	org.lcsim.event.GenericObject	25
StateAtEnd	org.lcsim.event.GenericObject	25
StateAtStart	org.lcsim.event.GenericObject	25
TKR_RawTrackerHits	org.lcsim.event.RawTrackerHit	861
TKR_TrackerHits	org.lcsim.event.TrackerHit	251
Tracks	org.lcsim.event.Track	25
VXD_RawTrackerHits	org.lcsim.event.RawTrackerHit	330
VXD_TrackerHits	org.lcsim.event.TrackerHit	160

At the bottom of the window, the status bar displays "ConditionsReader.create - sidloi3".

Tracks

JAS3

File Edit View Tuple Loop Window Help

higgs_ffh_nomu_p80m20_sim_1729_4003_sidloi3_0_digi_rec.slcio

DataSets
higgs_ffh_nomu

Welcome LCSim Event ×

Run:17294003 Event: 0

Collection: Tracks size:25 flags:80000000

	D0	Phi	Omega	Z0	TanLambda	Track States	Momentum	Chi2	NDF
HelicalTrackHitRelations									
HelicalTrackHits									
HelicalTrackMCRelations									
INPUT_FILE	-.0067674	2.2213	5.0898E-4	-.010684	-.33828	1	[-1.7834,2.3436,-.99623]	8.6907	10
LumiCalHits	.66795	2.0812	-.0028255	.93933	-.51272	1	[-.25917,.46291,-.27201]	.33299	6
MCParticle	.97068	2.0634	-5.8816E-4	-1.6938	-.029763	1	[-1.2053,2.2455,-.075852]	2.1014	10
MCParticleEndPointEnergy	1.8901	1.9339	.0020507	2.2180	-.62683	1	[-.25965,.68328,-.45819]	1.7692	8
MUON_BARREL	.0098451	6.0883	.0015254	-.0049193	-.67604	1	[.96405,-.19025,-.66431]	.46699	9
MUON_ENDCAP	.010855	6.0057	-.0010058	.0094600	-.33235	1	[1.4334,-.40826,-.49533]	3.3514	9
MuonBarrelHits	-.22795	5.9992	-2.6097E-4	.90977	-.41440	1	[5.5138,-1.6094,-2.3803]	2.7639	10
MuonEndcapHits	-.0057357	5.9656	1.7283E-4	.0079121	-.23739	1	[8.2391,-2.7087,-2.0588]	1.7695	10
PandoraPFOCollection	-.019654	5.7004	-.0024796	.076189	.34142	1	[.50473,-.33268,.20639]	.20362	6
ReconClusters	-.0064504	2.3525	-6.1368E-4	.0068093	-.48841	1	[-1.7207,1.7336,-1.1930]	2.3323	10
SiTrackerBarrelHits	-.94240	6.0584	-2.7233E-4	.11792	-.31027	1	[5.3658,-1.2268,-1.7078]	8.8206	10
SiTrackerEndcapHits	-6.1188E-4	1.6359	.0014114	.0064128	-.039829	1	[-.069126,1.0598,-.042299]	1.0915	9
SiTrackerForwardHits	-.0057256	5.9796	-6.2787E-4	8.0856E-4	-.10427	1	[2.2782,-.71362,-.24894]	2.0690	10
SiTrackerHits	-.0034061	6.0472	-4.3921E-4	.0048781	-.21213	1	[3.3183,-.79797,-.72398]	1.1955	10
SiVertexBarrelHits	-.070832	5.9819	4.3442E-4	.13953	-.31673	1	[3.2951,-1.0239,-1.0929]	1.4502	10
SiVertexEndcapHits	.20188	5.9534	2.1226E-4	-.14565	-.28452	1	[6.6813,-2.2871,-2.0093]	2.2305	10
StateAtECal	.76814	5.9004	2.3825E-4	.098215	-.30785	1	[5.8361,-2.3498,-1.9368]	4.0862	10
StateAtEnd	-.0022184	6.0371	4.0117E-4	-.0078517	.090465	1	[3.6239,-.91025,.33802]	2.6412	10
StateAtStart	-.50428	2.3168	1.9748E-4	.36857	-.39839	1	[-5.1518,5.5742,-3.0239]	1.8602	10
TKR_RawTrackerHits	-.85960	2.3344	5.4153E-4	-1.6530	-.035152	1	[-1.9142,1.9994,-.097301]	2.5309	10
TKR_TrackerHits	-.0032334	5.9879	2.9043E-4	-.0072107	-.17288	1	[4.9378,-1.5019,-.89228]	3.3342	10
Tracks	.0090074	5.6512	.0011553	-9.0808E-4	.26375	1	[1.0468,-.76647,.34220]	2.0493	10
VXD_RawTrackerHits	.12419	2.1957	-2.5784E-4	1.0338	-.52227	1	[-3.4010,4.7148,-3.0362]	2.0611	10
VXD_TrackerHits	.0063048	5.9696	-8.8899E-4	.052541	-.30286	1	[1.6039,-.52013,-.51066]	.63633	10
MCParticleTree	.0035778	6.1540	-6.4900E-4	-.0087470	-.51423	1	[2.2904,-.29747,-1.1877]	5.0679	10

ConditionsReader.create - sidloi3