Status update on $A \to Zh \to \ell\ell b\bar{b}$ analysis.

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Introduction

Introduction

- Interesting channel in 2HDM
- Neutral SUSY pseudoscalar higgs A, $m_h + m_Z \lesssim m_A \lesssim 2m_{top}$, decay $A \to Zh_{125} \to \ell\ell b\bar{b}$
  - also in MSSM at low $\tan\beta$, not allowed in m_h^{max} benchamrk scenario given $m_h = 125\ GeV$
  - possible in other scenarios if $M_{SUSY} \gg 1\ TeV$
- Production via gluon fusion process.
  - Also $b\bar{b}$ associated production possible (not yet considered)

signature two resonant ℓ;
- two resonant $b-tag$ jets;
- reconstruct $\ell\ell b\bar{b}$ invariant mass;

background mostly Z+bb, $t\bar{t}$

What's new

- Moved to CMSSW_5_3_11
  - Jet energy scale fixed
  - new b-tagger: CSV retrained and the "supercombined"
- Moved to Data ReReco22Jan13
- Some new MC samples,
  - including $A \to Zh \to \ell\ell bb$ signals from full simulation
  - more statistics for $Z+$jets background
- Consolidated control regions
  - Simultaneous scale factor fit from 3 CR
- Preliminary cuts optimization.

2HDM Scan

- Rui Santos kindly provided the 2HDM (type-I [left] and type-II [center]) scans for $\sigma \times \mathcal{B}$ for $A \to Zh$ modes.
- https://twiki.cern.ch/twiki/bin/view/CMS/Higgs/HiggsExotics2HDM
  - $\sigma \times \mathcal{B}(A \to Zh) \sim \mathcal{O}(1 \div 10pb)$
  - $\times \mathcal{B}(Zh \to \ell\ell bb) \approx 0.07$
  - $\sigma \times \mathcal{B}(A \to Zh \to \ell\ell bb) \sim \mathcal{O}(10 \div 100fb)$
- We are in the correct ballpark [right] expected sensitivity for this analysis

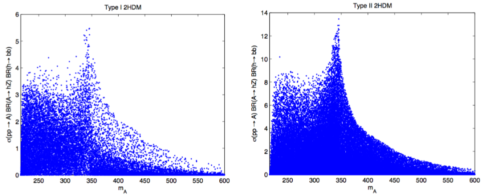
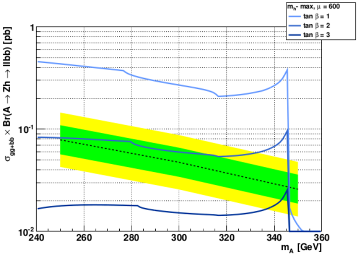


FIG. 7: The pseudoscalar scalar mass *versus* $\sigma(pp \to A)BR(A \to hZ)BR(h \to bb)$. Left - type I and right - type II. Cross sections in pbarn and masses in GeV. The peak at $\sim$ 375 GeV, corresponding to the "opening" of the $t\bar{t}$ channel in the gluon-gluon production of A



Data ReReco 22Jan

CMSSW_5_3_11

HLT paths: HLT_Mu17_Mu8 OR

HLT_Ele17_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL_Ele8_CaloIdT_CaloIsoVL_TrkIdVL_TrkIso

Dataset	Triggers	$L[fb^{-1}]$
/DoubleMuParked/Run2012A-22Jan2013-v1	567 697	0.912
/DoubleMuParked/Run2012B-22Jan2013-v1	12 313 533	4.508
/DoubleMuParked/Run2012C-22Jan2013-v1	13 922 018	7.228
/DoubleMuParked/Run2012D-22Jan2013-v1	12 636 904	7.446
Total DoubleMuParked	39 440 152	20.094
/DoubleElectron/Run2012A-22Jan2013-v1	1 167 639	0.912
/DoubleElectron/Run2012B-22Jan2013-v1	5 905 466	4.511
/DoubleElectron/Run2012C-22Jan2013-v1	9 357 957	7.267
/DoubleElectron/Run2012D-22Jan2013-v1	6 226 511	7.446
DoubleElectron Total	22 657 573	20.136

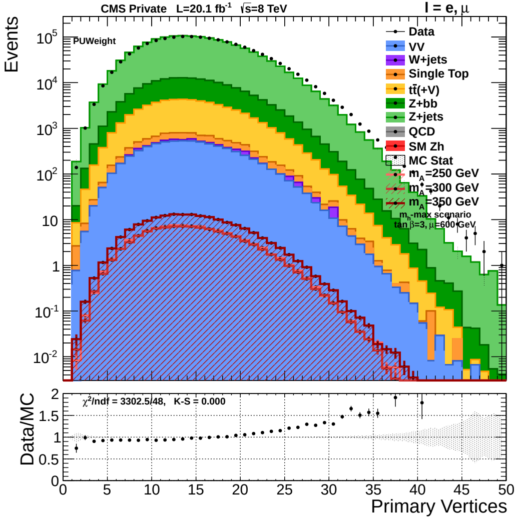
MonteCarlo samples

Dataset	Events	Triggers	Trigger ϵ	σ
QCD_Pt_20_MuEnrichedPt_15_TuneZ2star_8TeV_pythia6	21 484 602	338,281	1.59%	$364 \cdot 10^6$
DYJetsToLL_M-50_TuneZ2Star_8TeV-madgraph-tarball	30 459 503	8,880,856	29.16%	3,503.71
DYJetsToLL_M-10To50_TuneZ2Star_8TeV-madgraph	37 835 275	331,795	0.88%	11,050.00
DY1JetsToLL_M-50_TuneZ2Star_8TeV-madgraph	24 045 248	7,692,924	31.99%	666.30
DY2JetsToLL_M-50_TuneZ2Star_8TeV-madgraph	21 852 156	7,404,195	33.88%	214.97
DY3JetsToLL_M-50_TuneZ2Star_8TeV-madgraph	11 015 445	3,872,159	35.15%	60.69
DY4JetsToLL_M-50_TuneZ2Star_8TeV-madgraph	6 402 827	2,320,782	36.25%	27.36
ZbbToLL_massive_M-50_TuneZ2star_8TeV-madgraph-pythia6_tauola	14 129 304	5,916,544	41.87%	76.75
WJetsToLNu_TuneZ2Star_8TeV-madgraph-tarball	57 709 905	85,365	0.15%	37,509.00
T_s-channel_TuneZ2star_8TeV-powheg-tauola	259 961	6,221	2.39%	3.79
T_t-channel_TuneZ2star_8TeV-powheg-tauola	99 876	1,631	1.63%	56.40
T_tW-channel-DR_TuneZ2star_8TeV-powheg-tauola	497 658	34,417	6.92%	11.10
Tbar_s-channel_TuneZ2star_8TeV-powheg-tauola	139 974	3,265	2.33%	1.76
Tbar_t-channel_TuneZ2star_8TeV-powheg-tauola	1 935 072	33,047	1.71%	30.70
Tbar_tW-channel-DR_TuneZ2star_8TeV-powheg-tauola	493 460	34,328	6.96%	11.10
TTJets_FullLeptMGDecays_8TeV-madgraph-tauola	12 011 428	4,886,110	40.68%	23.64
TTWJets_8TeV-madgraph	196 046	32975	16.82%	0.23
TTZJets_8TeV-madgraph_v2	210 160	35763	17.02%	0.21
WW_TuneZ2star_8TeV_pythia6_tauola	10 000 431	330,481	3.30%	33.61
WZ_TuneZ2star_8TeV_pythia6_tauola	10 000 283	475,852	4.76%	12.63
ZZ_TuneZ2star_8TeV_pythia6_tauola	9 799 908	830,053	8.47%	5.20
ZH_ZToLL_HToBB_M-125_8TeV-powheg-herwigpp	999 462	455,572	45.58%	0.02
GluGluToAToZhToLLBB_mA-250_mh-125_8TeV-pythia6-tauola	300 000	147653	49.22%	-
GluGluToAToZhToLLBB_mA-300_mh-125_8TeV-pythia6-tauola	300 000	154646	51.55%	-
GluGluToAToZhToLLBB_mA-350_mh-125_8TeV-pythia6-tauola	299 272	159499	53.30%	-
Total	272 697 805			

Blue=new dataset

all datasets Summer12_DR53X-PU_S10_START53_V7A

PileUp reweight

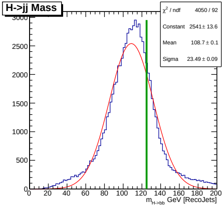


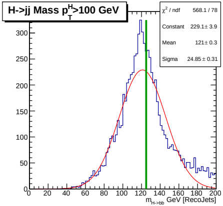
Jets energy scale issues (solved)

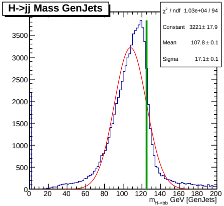
- With the last PAT productions (based on 52X) we had a problem in the Jet energy scale.
  - $< m_{125}^{h \to bb} >= 103\ GeV$, $< m_{Z \to jj} >= 78\ GeV$
- Problem tracked down to incorrect PU treatment
  - many thanks to Michele for his suggestion!
- Furthermore, there is a very clear correlation between the reconstructed invariant mass and the pt of the H/W/Z the jets come from
- given our cuts, the heavy object is less boosted than the analogous in the standard VH analysis, so care must be taken in comparing the results.
- Following slides: jets used comes from H/W/Z (MC truth)

$H_{125} \to bb$ mass distribution

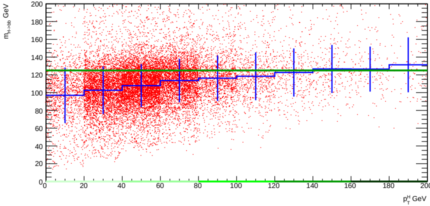
Invariant mass bb: all events, $p_T^h > 100\ GeV$, using `GenJets`

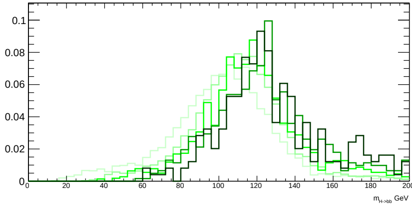






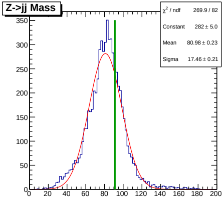
Invariant mass bb vs p_T^h: error bar are σ of Gaussian fit

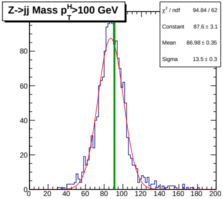


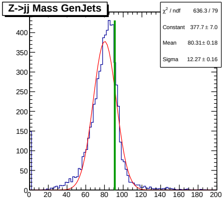


$Z \rightarrow jj$ mass distribution

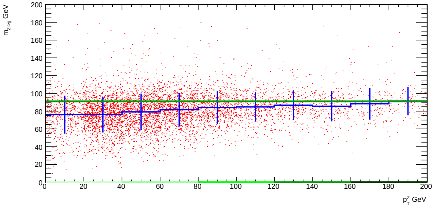
Invariant mass jj: all events, $p_T^Z > 100\ GeV$, using `GenJets`

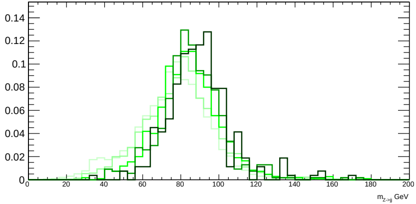






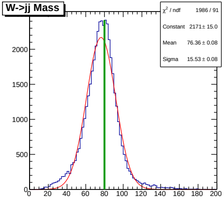
Invariant mass bb vs p_T^Z: error bar are σ of Gaussian fit

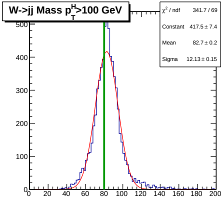


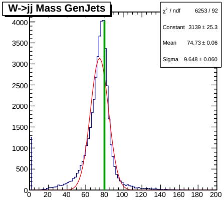


$W \to jj$ mass distribution

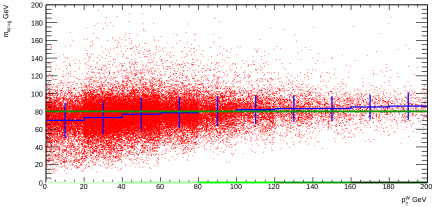
Invariant mass jj: all events, $p_T^W > 100\ GeV$, using GenJets

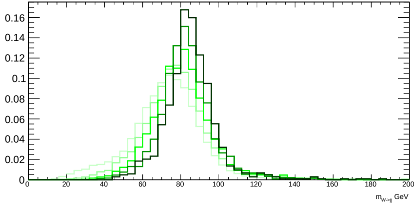






Invariant mass bb vs p_T^W: error bar are σ of Gaussian fit

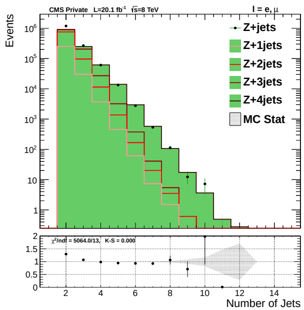


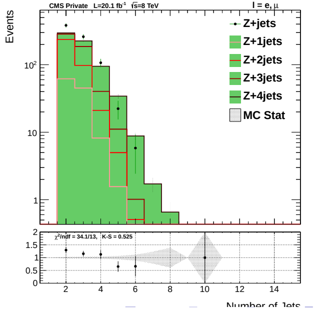


Z+light jets statistics in MC

DYJets vs $\Sigma_{N=1}^{4}$DY**N**Jets

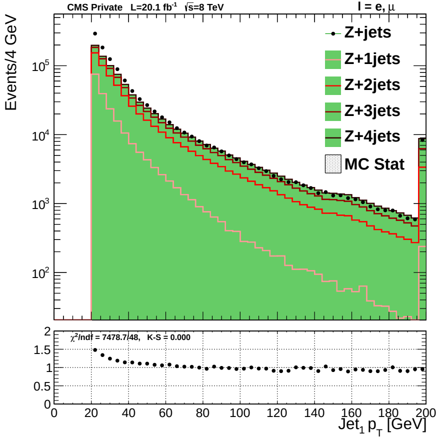
- The events reduction for Z+light jets background is very large, especially when b-tagging is required. There is a statistical problem in the MC.
- We can use the exclusive `DYNJets with` `N=1,2,3,4` instead of the inclusive `DYJets`.
- Question: do the two samples behave equally for our phase space? `DY0Jets` is missing;
- Look at N_{jets} (normalized) distribution all events (top) and 2 b-tag (bottom);
- The $N_{jets} = 2$ is 30% under-populate in $\Sigma_{N=1}^{4}$DY**N**Jets
- Should we add the `DY0Jets` from `DYJets`? How?



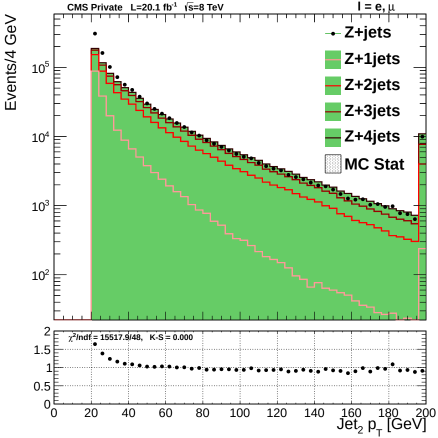


Jet p_T DYJets vs $\Sigma_{N=1}^{4}$DY**N**Jets

Jet1 (ZJets CR)



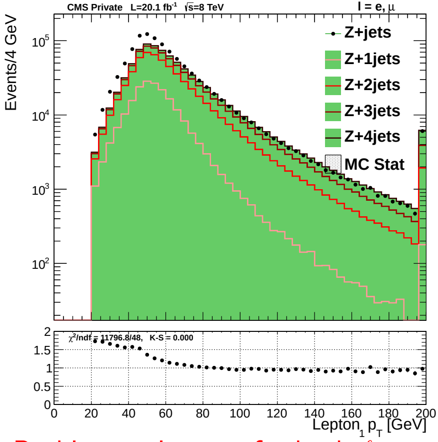
Jet2 (ZJets CR)



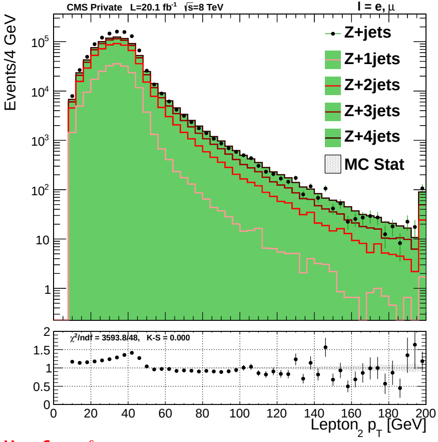
Problem at low p_T for both jets

ℓ p_T DYJets vs $\Sigma_{N=1}^{4}$DY**N**Jets

ℓ_1 (ZJets CR)



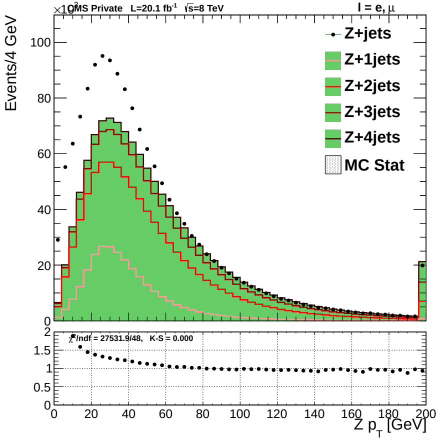
ℓ_2 (ZJets CR)



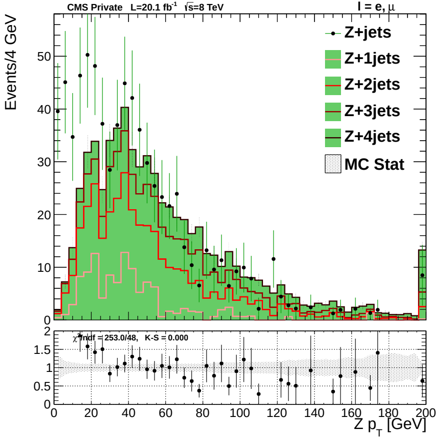
Problem at low p_T for both ℓ, especially for ℓ_1

p_T^Z DYJets vs $\Sigma_{N=1}^{4}$DY**N**Jets

All events



2 b-tag

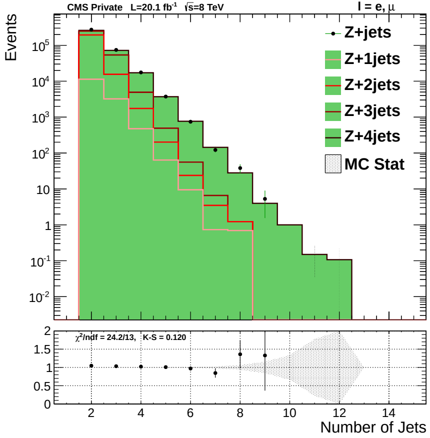


Clearly events at low p_T^Z are missing in the $\Sigma_{N=1}^{4}$DY**N**Jets sample.

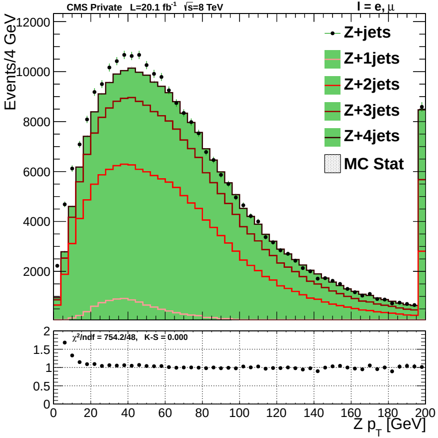
What if we ask $p_T^{jets} > 30\ GeV$?

p_T^Z DYJets vs $\Sigma_{N=1}^{4}$DY**N**Jets

N_{jets}



p_T^Z



Better but not perfect

Conclusions for DYJets vs $\Sigma_{N=1}^{4}$DY**N**Jets

Bottomline is:

- we cannot just use $\Sigma_{N=1}^{4}$DY**N**Jets in place of DYJets!
- with higher jet threshold agrrement is better;
- We have to find a way to get DY**0**Jets from DYJets
- add to $\Sigma_{N=1}^{4}$DY**N**Jets so to have $\Sigma_{\mathbf{N=0}}^{4}$DY**N**Jets

Analysis overview

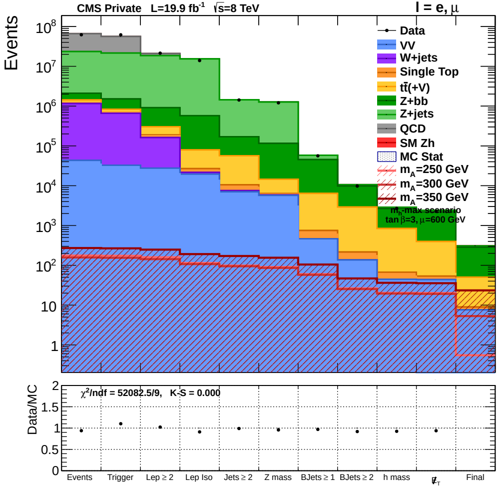
Preselection

- either HLT_Mu17_Mu8 or HLT_Ele17[...]Ele8[...] trigger fired;
- $N_\ell \geq 2$: $p_T > 20(10)\ GeV$, $\pm$, same flavour, isolated ($PF^{rel}_{iso} < 0.15$);
- $N_{jets} \geq 2$: $p_T > 20\ GeV$, $\Delta R_{jet,\ell} > 0.5$;

Analysis cuts

- Z Selection: $80 < m_{\ell\ell} < 100\ GeV$;
- b-tagging (CSV): jet_1 is CSVT, jet_2 CSVM;
- h selection: $90 < m_{bb} < 140\ GeV$;
- top: $MET < 60\ GeV$
- Final selection is m_A dependent.

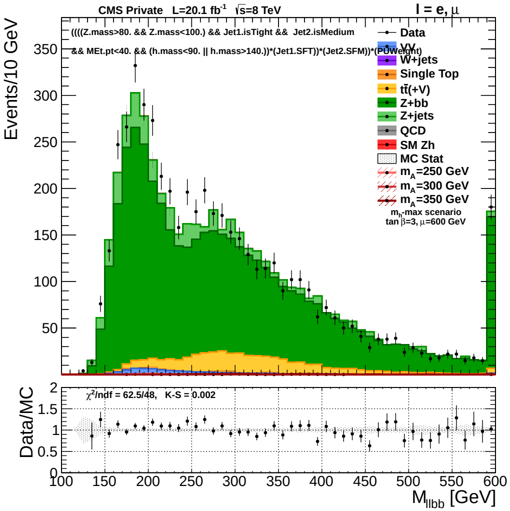
Events reductions



After preselection dominating backgrounds are:

1. $Z + bb$
2. $t\bar{t}$
3. $Z +$ light jets reducible asking b-jets
4. other: singleTop, VV

Zbb control region

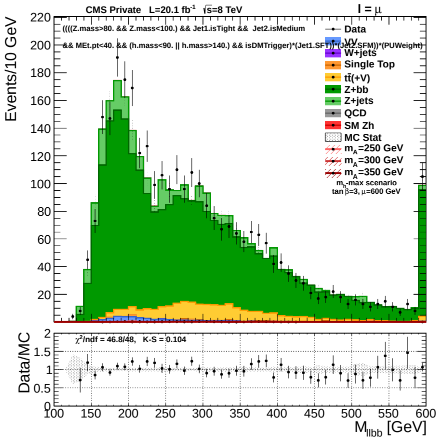


Zbb CR cuts

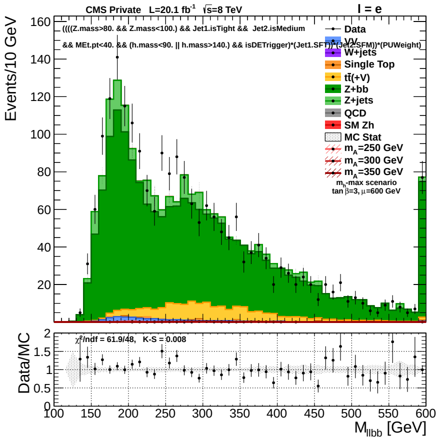
- Preselection
- Z selection: $80 < m_{\ell\ell} < 100\ GeV$;
- B-tag: Jet_1 CSVT, Jet_2 CSVM
- top veto: $MET < 40\ GeV$
- Data/Bkg= 1.076±0.017

Zbb control region

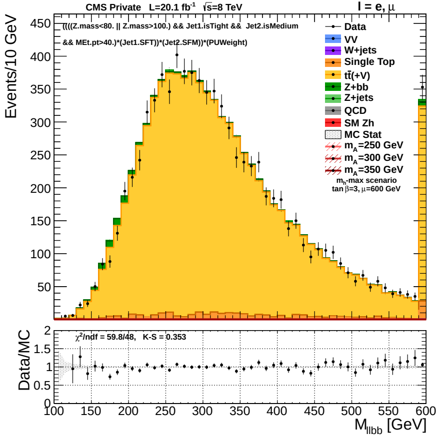
$\ell = \mu$



$\ell = \mathbf{e}$



TTbar control region

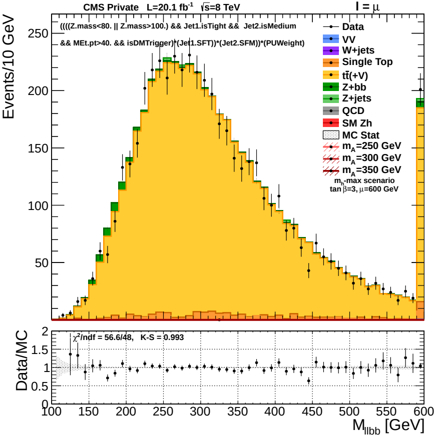


TTbar CR cuts

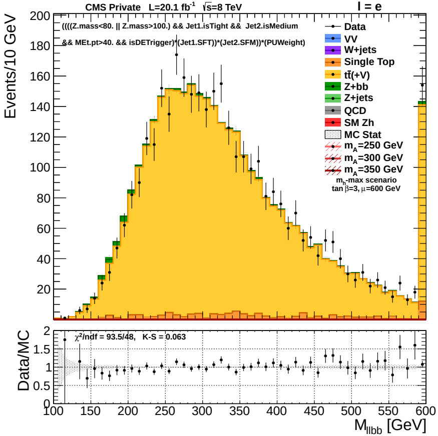
- Preselection
- Z veto $m_{\ell\ell} < 80$ OR $m_{\ell\ell} > 100$ GeV;
- B-tag: Jet_1 CSVT, Jet_2 CSVM
- top selection $MET > 40$ GeV
- Data/Bkg= 1.052±0.012

TTbar control region

$\ell = \mu$

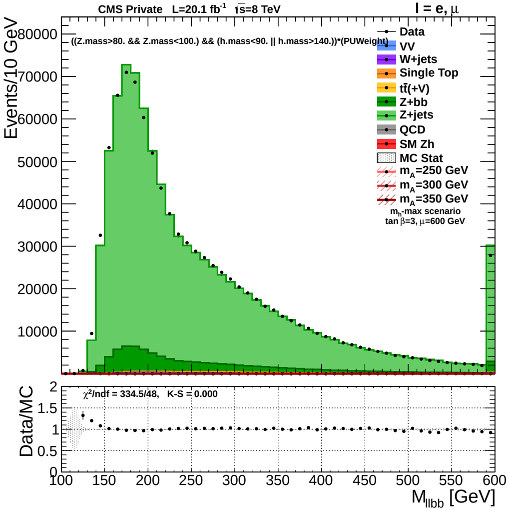


$\ell = \mathbf{e}$



ZJets control region

$m_A = m_{\ell\ell bb}$



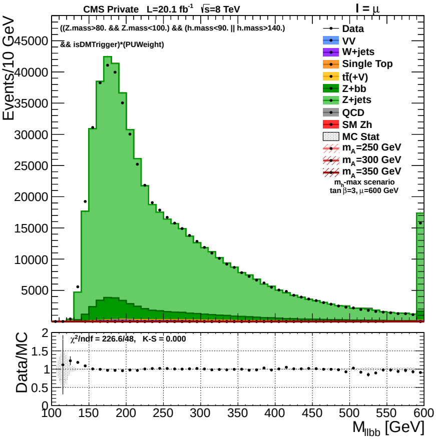
ZJets CR cuts

- Preselection
- Z selection: $80 < m_{\ell\ell} < 100\ GeV$;
- h veto: $m_h < 80$ or $m_h > 140\ GeV$
- top veto: $MET < 40\ GeV$
- Data/Bkg= 1.032 ± 0.002

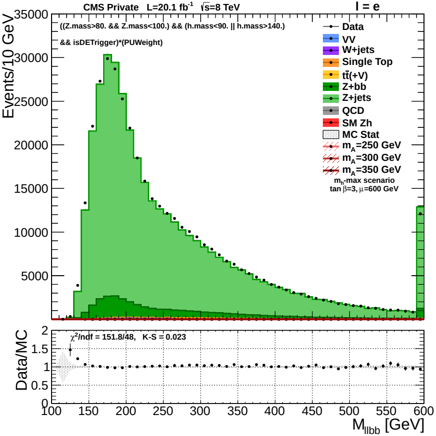
ZJets control region

$m_A = m_{\ell\ell bb}$ for μ and e separately

$\ell = \mu$

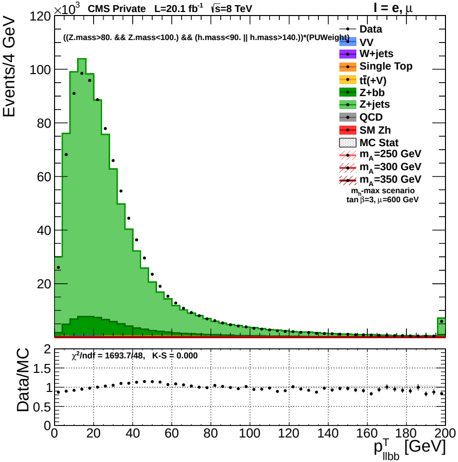


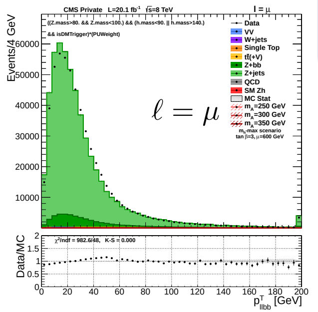
$\ell = \mathbf{e}$

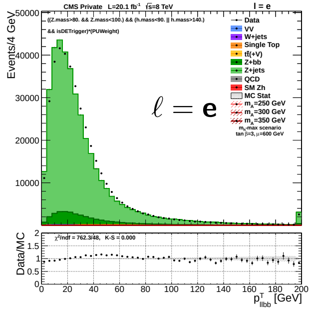


ZJets control region

$p_T^A = p_T^{\ell\ell bb}$



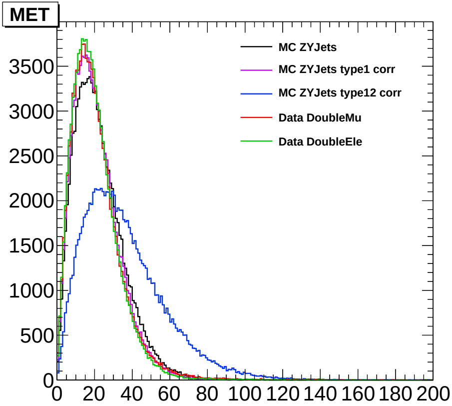




Type0 and 1 MET corection **NOT** applied!

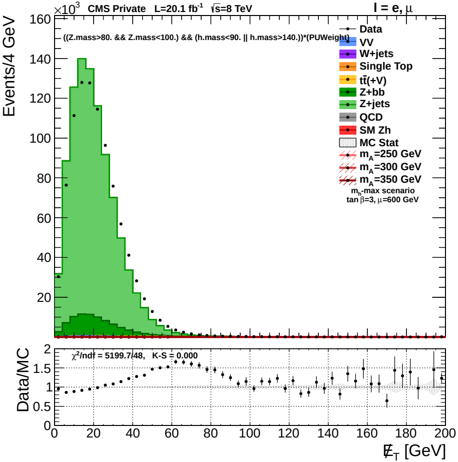
MEt type-I and type-II corrections test

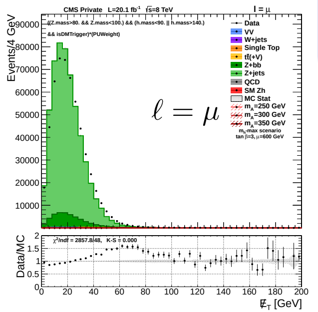
- Small PAT production with type-I and type-II MET correction
- Data: DoubleMu and DoubleEle dataset, RunA
- MC: DYJets
- Type-I corrected MET shows good agreement data-MC (type-II does not!)

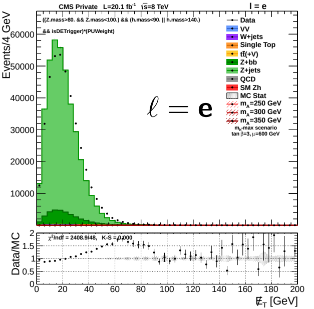


ZJets control region

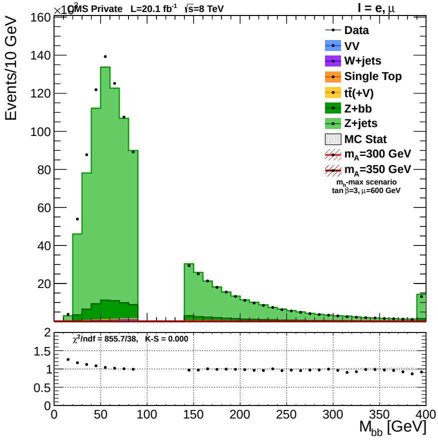
MET

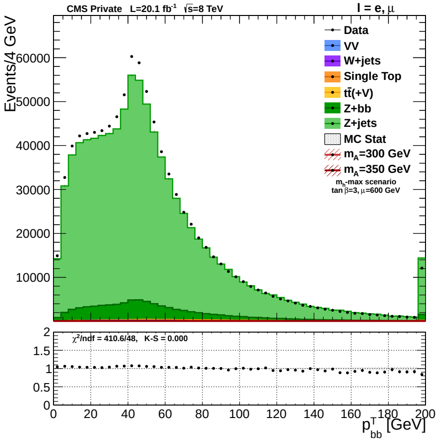






ZJets control region



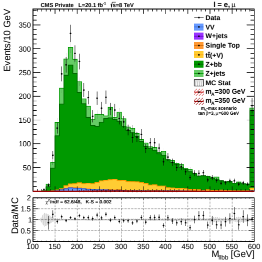


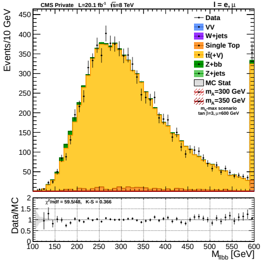
Control Region simultaneous fit

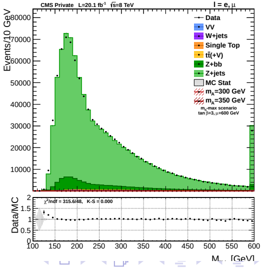
- We have three control region for the three major background source.
- Do a simultaneous likelihood of MC on Data in order to get the CM scale factor.
- The normalization of the other minor backgrounds are kept fixed.

Scale factors

Control Region	Scale Factor simultaneous fit	Scale Factor single CR ratio
Zbb	1.042 ± 0.018	1.076 ± 0.017
TTbar	1.058 ± 0.012	1.052 ± 0.012
ZJets	1.032 ± 0.002	1.032 ± 0.002







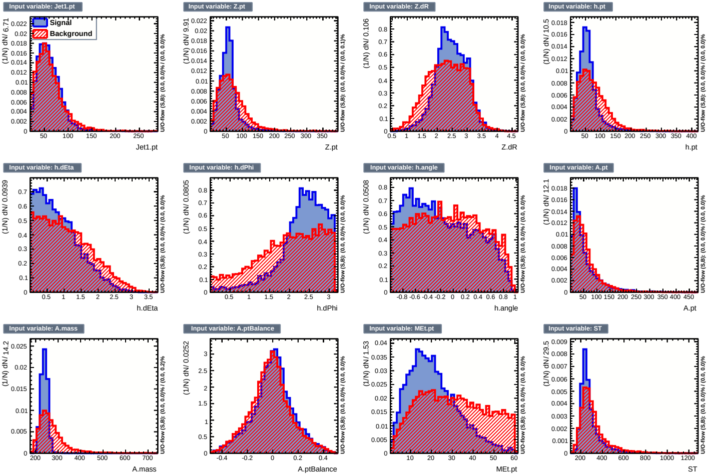
Final selection

Variable considered

- p_T^Z $Z = \ell\ell$
- $\Delta(R, \eta, \phi)^Z$ between the ℓ from $Z \to \ell\ell$
- α^Z angle between the ℓ from $Z \to \ell\ell$
- $p_T^{Balance}(Z) = \frac{p_T^{\ell_1} - p_T^{\ell_2}}{p_T^{\ell_1} + p_T^{\ell_2}}$
- $\text{Centrality}_Z = \frac{p_T^{\ell_1} + p_T^{\ell_2}}{p^{\ell_1} + p^{\ell_2}}$
- likewise for $h = bb$
- likewise for $A = Zh$ $(\Delta R, \eta, \phi^A, \alpha^A$ between $Z = \ell\ell$ and $h = bb)$
- MET an its significance
- HT, ST, Centrality, Aplanarity, EventShape C/D
- ...

variable distributions: signal $M_A = 250\ GeV$

showing only most discriminating variables



Linear correlation coefficient

Correlation Matrix (signal)

Linear correlation coefficients in %

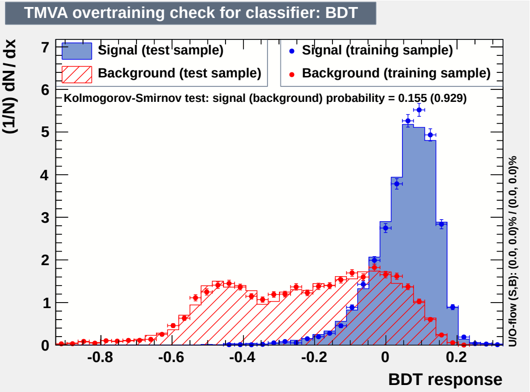
	Jet1.pt	Z.pt	Z.dR	h.pt	h.dEta	h.dPhi	h.angle	A.pt	A.mass	A.ptBalance	MEt.pt	ST
ST	33	53	-37	60	-13	-36	23	86	15	-7	21	100
MEt.pt	1	6	-4	3	-3	-3	2	10	-6	2	100	21
A.ptBalance	-27	57	-47	-64		48	-22	-7	-16	100	2	-7
A.mass	23	5	-3	24	1	-6	1	6	100	-16	-6	15
A.pt	30	54	-35	62	-1	-44	23	100	6	-7	10	86
h.angle	15	1		32	-17	-27	100	23	1	-22	2	23
h.dPhi	-10	-6	2	-70	-37	100	-27	-44	-6	48	-3	-36
h.dEta	-26			-1	100	-37	-17	-1	1		-3	-13
h.pt	44	10	-4	100	-1	-70	32	62	24	-64	3	60
Z.dR	-2	-74	100	-4		2		-35	-3	-47	-4	-37
Z.pt	5	100	-74	10		-6	1	54	5	57	6	53
Jet1.pt	100	5	-2	44	-26	-10	15	30	23	-27	1	33

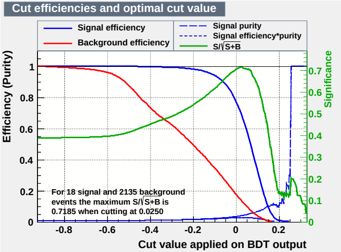
Correlation Matrix (background)

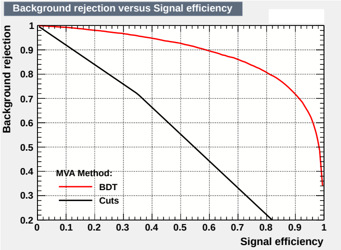
Linear correlation coefficients in %

	Jet1.pt	Z.pt	Z.dR	h.pt	h.dEta	h.dPhi	h.angle	A.pt	A.mass	A.ptBalance	MEt.pt	ST
ST	36	59	-46	57	-26	-25	29	72	49		18	100
MEt.pt	6	4	-7	9	-13	-5	8	18	-1	-4	100	18
A.ptBalance	-22	42	-41	-45	5	38	-23	-6	1	100	-4	
A.mass	32	62	-47	61	-8	-36	31	22	100	1	-1	49
A.pt	27	36	-25	44	-12	-23	21	100	22	-6	18	72
h.angle	27	23	-22	50	-31	-38	100	21	31	-23	8	29
h.dPhi	-16	-31	30	-70	-30	100	-38	-23	-36	38	-5	-25
h.dEta	-33	-9	8	-16	100	-30	-31	-12	-8	5	-13	-26
h.pt	52	46	-39	100	-16	-70	50	44	61	-45	9	57
Z.dR	-19	-81	100	-39	8	30	-22	-25	-47	-41	-7	-46
Z.pt	23	100	-81	46	-9	-31	23	36	62	42	4	59
Jet1.pt	100	23	-19	52	-33	-16	27	27	32	-22	6	36

BDT

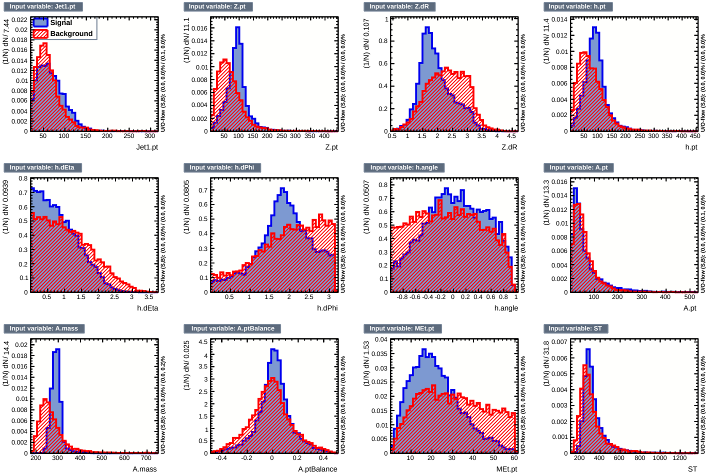

TMVA overtraining check for classifier: BDT
Signal (test sample)
Background (test sample)
Signal (training sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.155 (0.929)
(1/N) dN / dx
BDT response
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%


Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/√S+B
Efficiency (Purity)
Significance
For 18 signal and 2135 background events the maximum S/√S+B is 0.7185 when cutting at 0.0250
Cut value applied on BDT output


Background rejection versus Signal efficiency
Background rejection
MVA Method:
BDT
Cuts
Signal efficiency

variable distributions: signal $M_A = 300\ GeV$

showing only most discriminating variables



Linear correlation coefficient

Correlation Matrix (signal)

Linear correlation coefficients in %

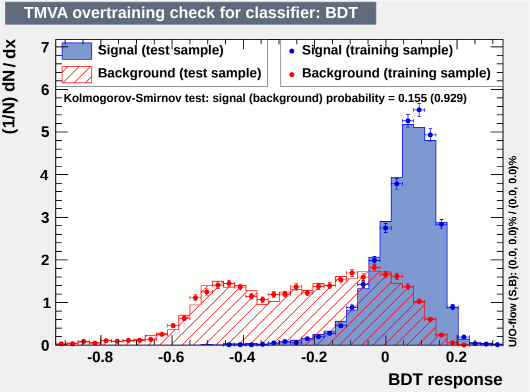
	Jet1.pt	Z.pt	Z.dR	h.pt	h.dEta	h.dPhi	h.angle	A.pt	A.mass	A.ptBalance	MEt.pt	ST
ST	27	50	-29	54	-14	-23	19	86	17	-5	20	100
MEt.pt		7	-5	5	-4	-3	4	13	-7	1	100	20
A.ptBalance	-29	59	-48	-66	6	44	-30	-3	-13	100	1	-5
A.mass	22	21	-15	33	-2	-11	7	4	100	-13	-7	17
A.pt	22	43	-21	47	-4	-22	16	100	4	-3	13	86
h.angle	13	-2	2	38	-15	-34	100	16	7	-30	4	19
h.dPhi	-10	-7	8	-63	-43	100	-34	-22	-11	44	-3	-23
h.dEta	-22	2	-2	-6	100	-43	-15	-4	-2	6	-4	-14
h.pt	44	6	-5	100	-6	-63	38	47	33	-66	5	54
Z.dR	-2	-74	100	-5	-2	8	2	-21	-15	-48	-5	-29
Z.pt	2	100	-74	6	2	-7	-2	43	21	59	7	50
Jet1.pt	100	2	-2	44	-22	-10	13	22	22	-29		27

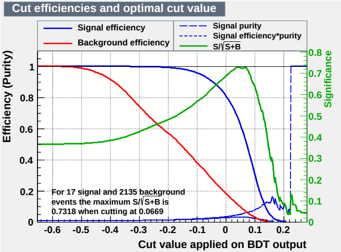
Correlation Matrix (background)

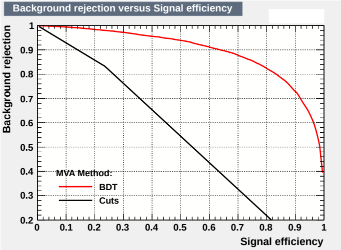
Linear correlation coefficients in %

	Jet1.pt	Z.pt	Z.dR	h.pt	h.dEta	h.dPhi	h.angle	A.pt	A.mass	A.ptBalance	MEt.pt	ST
ST	36	59	-46	57	-26	-25	29	72	49		18	100
MEt.pt	6	4	-7	9	-13	-5	8	18	-1	-4	100	18
A.ptBalance	-22	42	-41	-45	5	38	-23	-6	1	100	-4	
A.mass	32	62	-47	61	-8	-36	31	22	100	1	-1	49
A.pt	27	36	-25	44	-12	-23	21	100	22	-6	18	72
h.angle	27	23	-22	50	-31	-38	100	21	31	-23	8	29
h.dPhi	-16	-31	30	-70	-30	100	-38	-23	-36	38	-5	-25
h.dEta	-33	-9	8	-16	100	-30	-31	-12	-8	5	-13	-26
h.pt	52	46	-39	100	-16	-70	50	44	61	-45	9	57
Z.dR	-19	-81	100	-39	8	30	-22	-25	-47	-41	-7	-46
Z.pt	23	100	-81	46	-9	-31	23	36	62	42	4	59
Jet1.pt	100	23	-19	52	-33	-16	27	27	32	-22	6	36

BDT

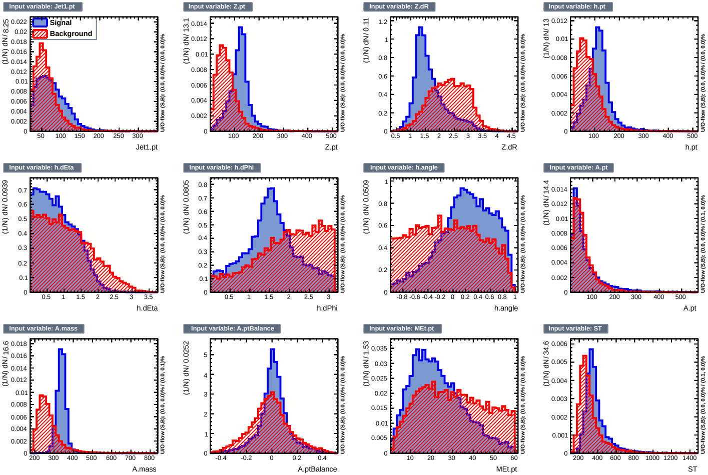

TMVA overtraining check for classifier: BDT
Signal (test sample)
Background (test sample)
Signal (training sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.155 (0.929)
(1/N) dN / dx
BDT response
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%


Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/√S+B
Efficiency (Purity)
Significance
For 17 signal and 2135 background
events the maximum S/√S+B is
0.7318 when cutting at 0.0669
Cut value applied on BDT output


Background rejection versus Signal efficiency
Background rejection
MVA Method:
BDT
Cuts
Signal efficiency

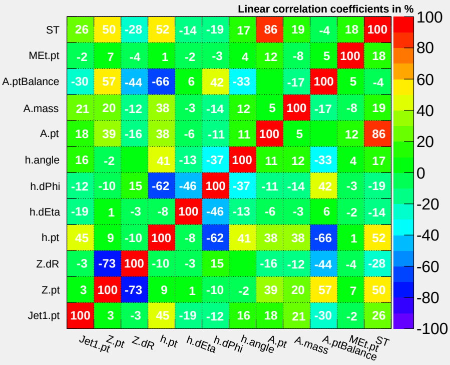
variable distributions: signal $M_A = 350\ GeV$

showing only most discriminating variables

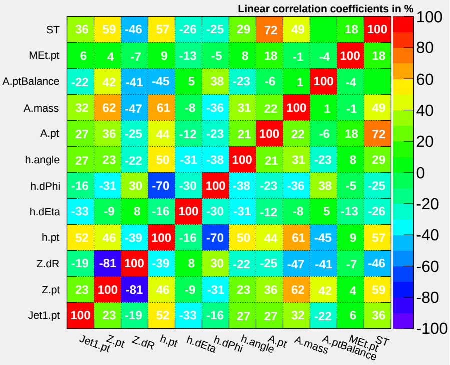


Linear correlation coefficient

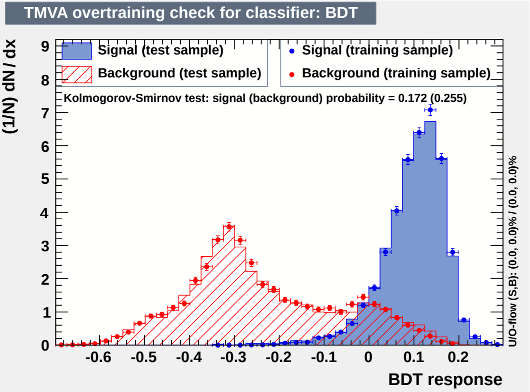
Correlation Matrix (signal)

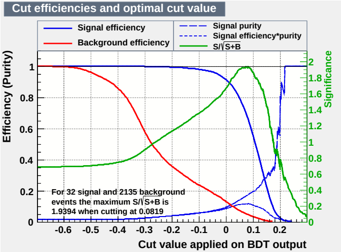


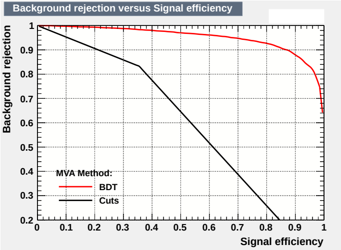
Correlation Matrix (background)



BDT

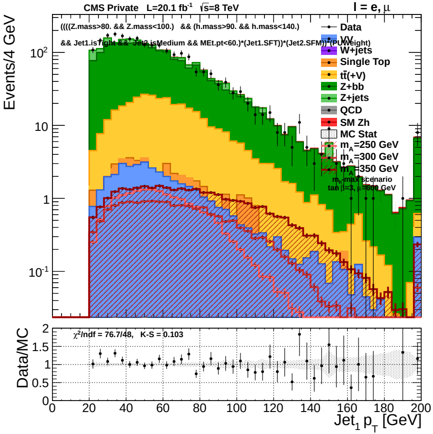

TMVA overtraining check for classifier: BDT
Signal (test sample)
Background (test sample)
Signal (training sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.172 (0.255)
(1/N) dN / dx
BDT response
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%

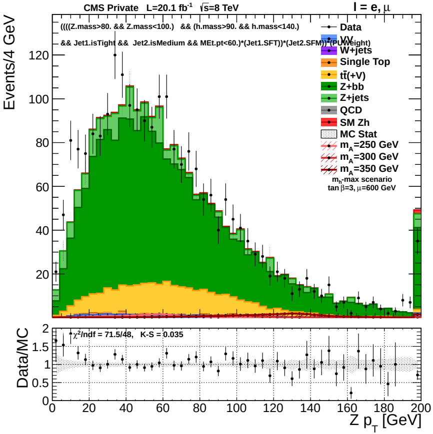

Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/√S+B
Efficiency (Purity)
Significance
For 32 signal and 2135 background events the maximum S/√S+B is 1.9394 when cutting at 0.0819
Cut value applied on BDT output


Background rejection versus Signal efficiency
Background rejection
MVA Method:
BDT
Cuts
Signal efficiency

Data - MC for discriminating variables (1)

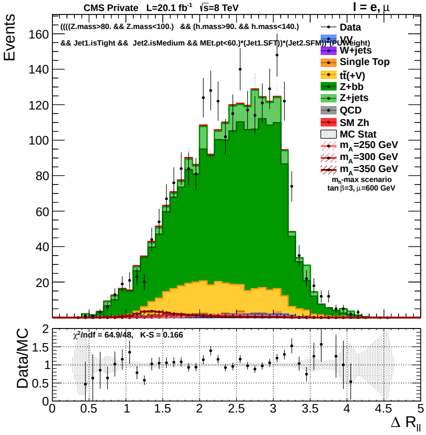
Before final selection

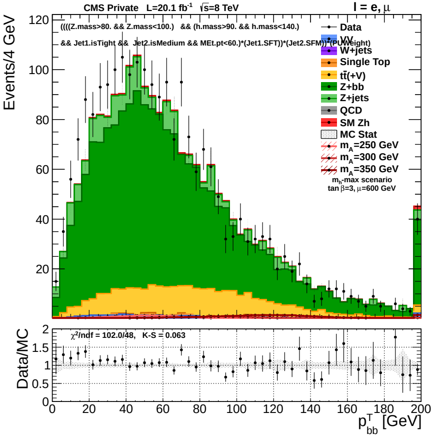




Data - MC for discriminating variables (2)

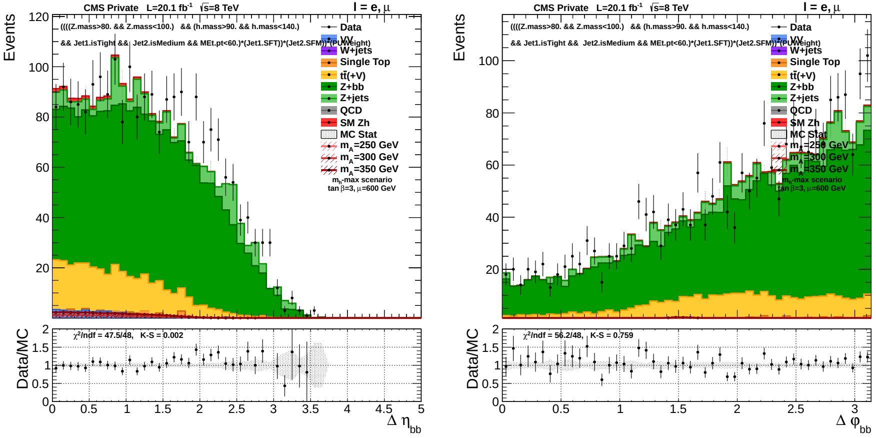
Before final selection





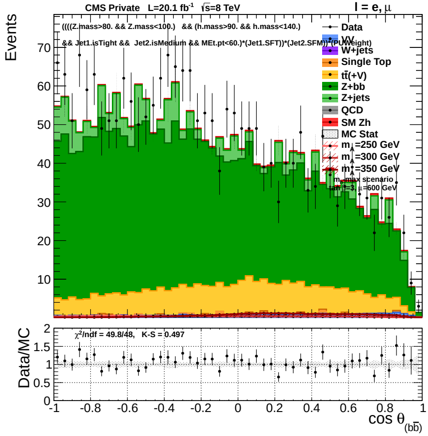
Data - MC for discriminating variables (3)

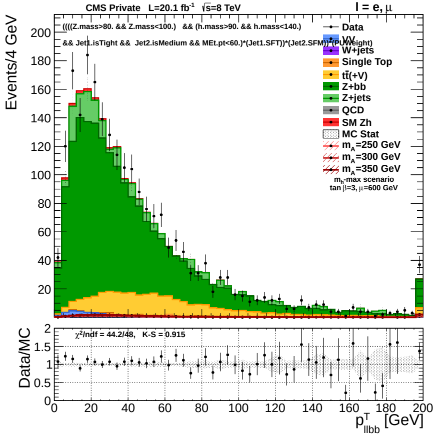
Before final selection



Data - MC for discriminating variables (4)

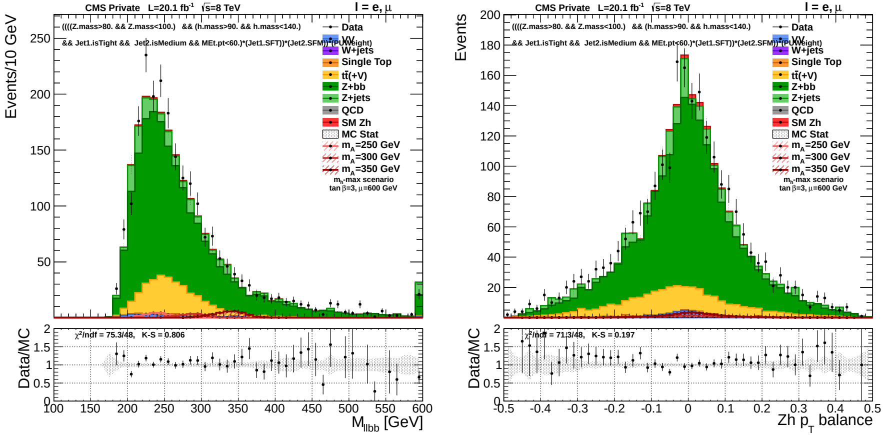
Before final selection





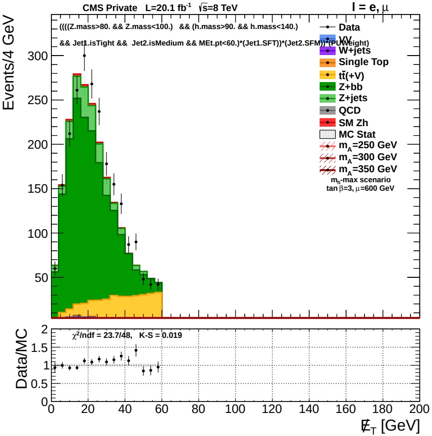
Data - MC for discriminating variables (5)

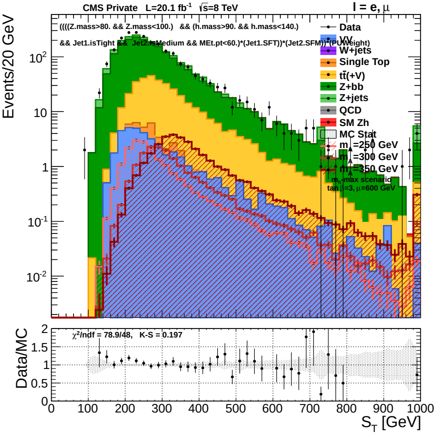
Before final selection



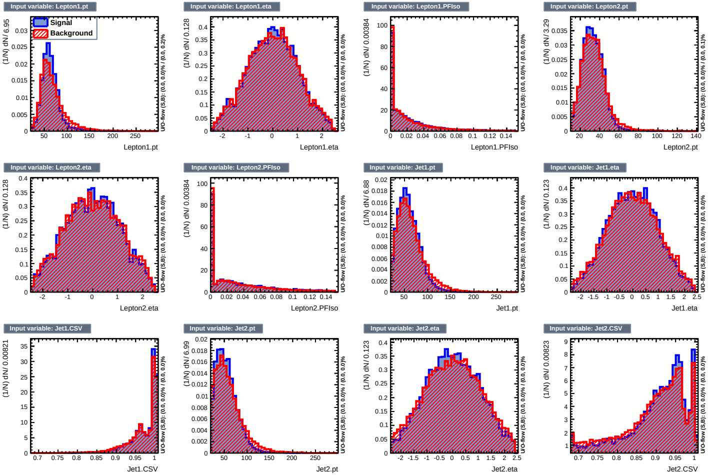
Data - MC for discriminating variables (6)

Before final selection

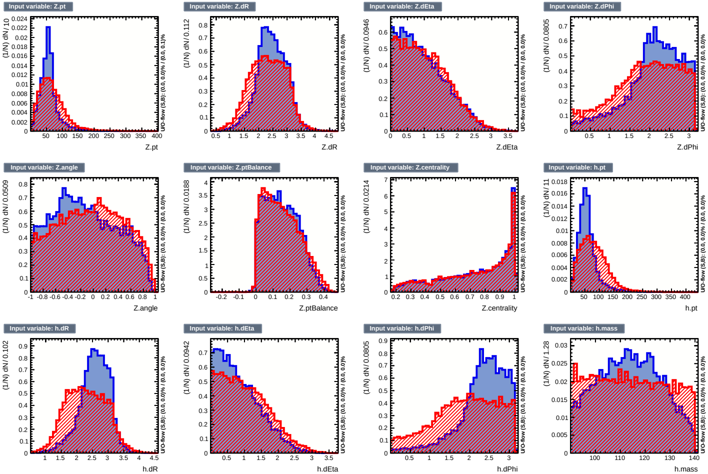




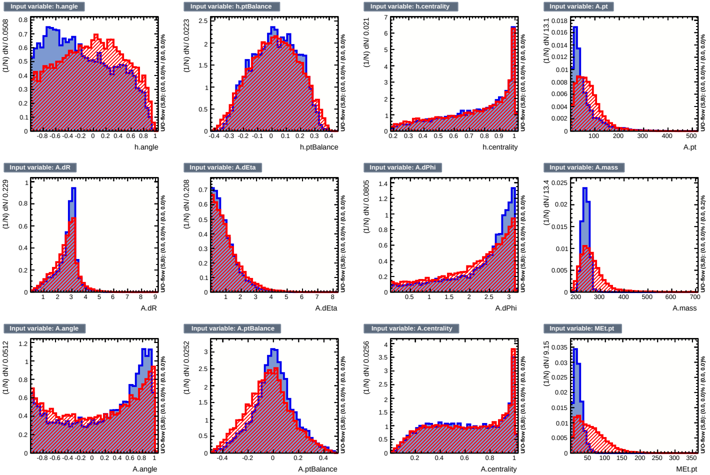
All variable distributions: signal vs background (I)



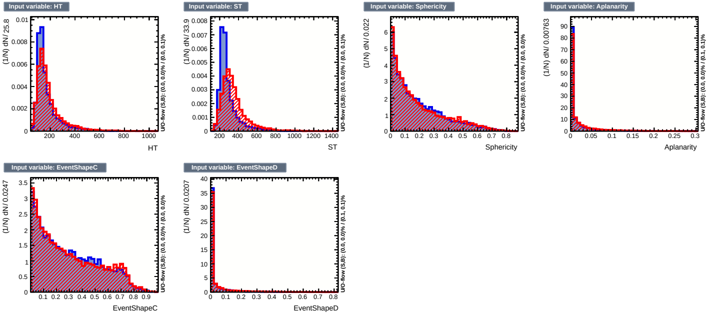
All variable distributions: signal vs background (II)



All variable distributions: signal vs background (III)



All variable distributions: signal vs background (IV)



Final selection

$M_A = 250\ GeV$

- $p_T^Z > 20\ GeV$
- $\Delta R^h > 2$
- $\Delta\eta^h < 1.75$

$M_A = 300\ GeV$

- $p_T^Z > 80\ GeV$
- $\Delta R^Z > 1$
- $p_T^h > 20\ GeV$
- $1.5 < \Delta R^h < 3.5$
- $\Delta\eta^h < 2.0$

$M_A = 350\ GeV$

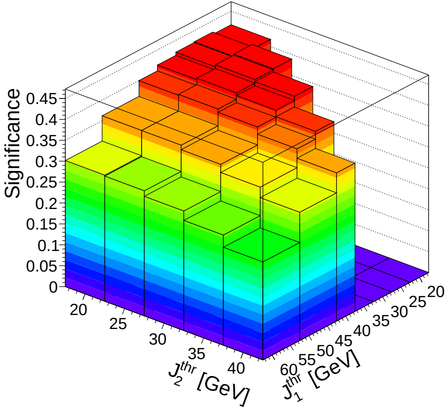
- $p_T^Z > 100\ GeV$
- $p_T^h > 60\ GeV$
- $1 < \Delta R^h < 2.75$
- $\Delta\eta^h < 2.0$

- ΔR^h is the ΔR between the jets from $h \to bb$.
- likewise for $\Delta\eta^h$ and for Z

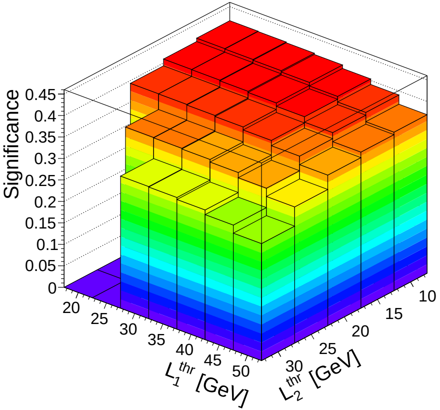
Cut optimization: Lepton and jet thresholds

$M_A = 250\ GeV$

Significance vs jet_1 vs jet_2 with
$\ell_1 > 20 \quad \& \quad \ell_2 > 10 GeV$



Significance vs ℓ_1 vs ℓ_2 with
$jet_1 > 25 \quad \& \quad jet_2 > 25 GeV$



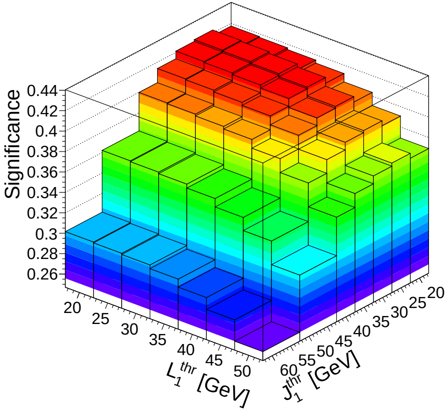
Significance is $S = 2. \cdot \left(\sqrt{N_S + N_B} - \sqrt{N_B}\right)$ as per Stat.Comm. recipe

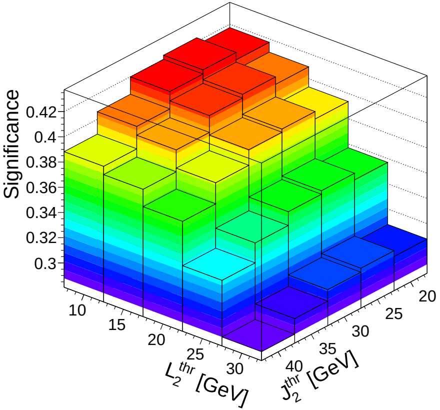
Cut optimization: Lepton and jet thresholds

$M_A = 250\ GeV$

Significance vs ℓ_1 vs jet_1 with $\ell_2 > 10$ & $jet_2 > 25\,GeV$

Significance vs ℓ_2 vs jet_2 with $\ell_1 > 20$ & $jet_1 > 25\,GeV$



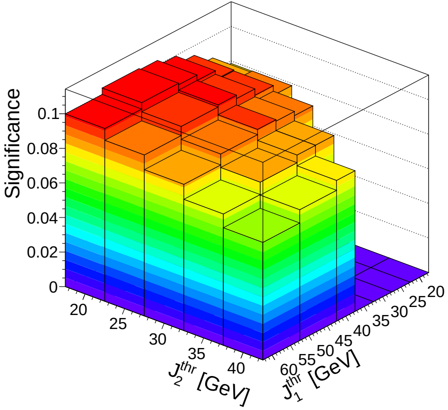


Significance is $S = 2.\cdot\left(\sqrt{N_S + N_B} - \sqrt{N_B}\right)$ as per Stat.Comm. recipe

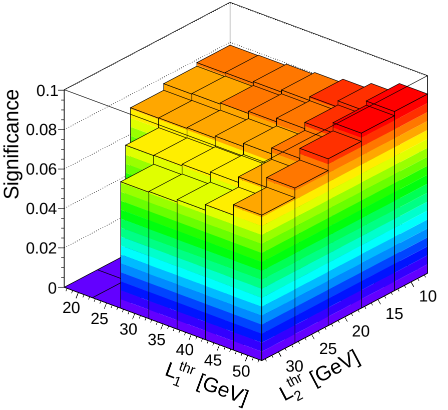
Cut optimization: Lepton and jet thresholds

$M_A = 300\ GeV$

Significance vs jet_1 vs jet_2 with
$\ell_1 > 20 \quad \& \quad \ell_2 > 10\,GeV$



Significance vs ℓ_1 vs ℓ_2 with
$jet_1 > 25 \quad \& \quad jet_2 > 25\,GeV$

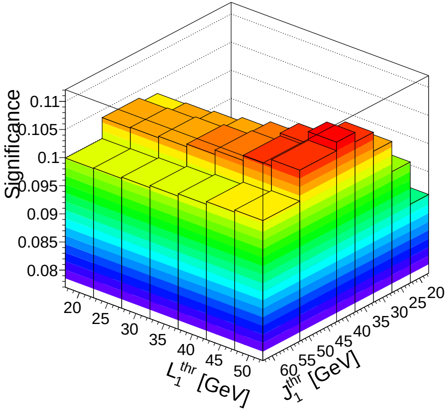


Significance is $S = 2. \cdot \left(\sqrt{N_S + N_B} - \sqrt{N_B}\right)$ as per Stat.Comm. recipe

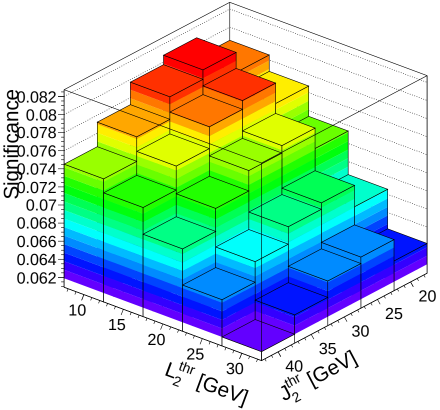
Cut optimization: Lepton and jet thresholds

$M_A = 300\ GeV$

Significance vs ℓ_1 vs jet_1 with $\ell_2 > 10$ & $jet_2 > 25\,GeV$



Significance vs ℓ_2 vs jet_2 with $\ell_1 > 20$ & $jet_1 > 25\,GeV$

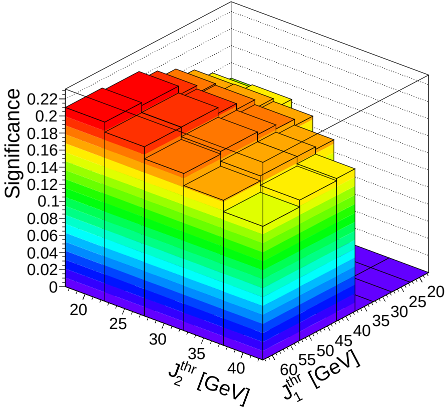


Significance is $S = 2. \cdot \left(\sqrt{N_S + N_B} - \sqrt{N_B}\right)$ as per Stat.Comm. recipe

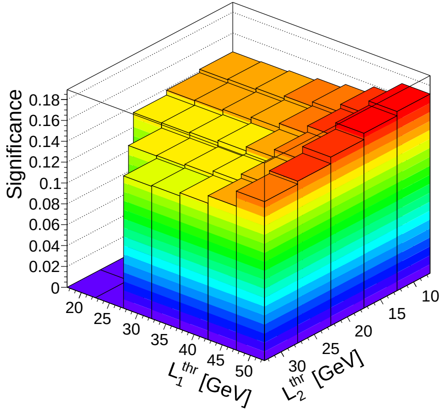
Cut optimization: Lepton and jet thresholds

$M_A = 350\ GeV$

Significance vs jet_1 vs jet_2 with
$\ell_1 > 20 \quad \& \quad \ell_2 > 10\,GeV$



Significance vs ℓ_1 vs ℓ_2 with
$jet_1 > 25 \quad \& \quad jet_2 > 25\,GeV$

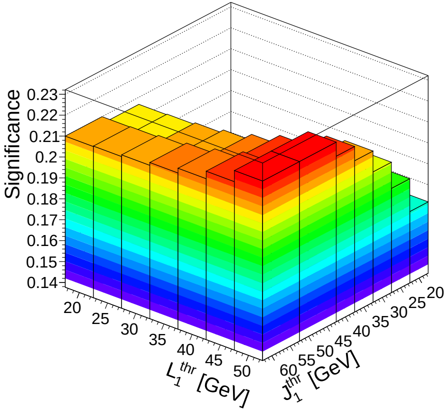


Significance is $S = 2. \cdot \left(\sqrt{N_S + N_B} - \sqrt{N_B}\right)$ as per Stat.Comm. recipe

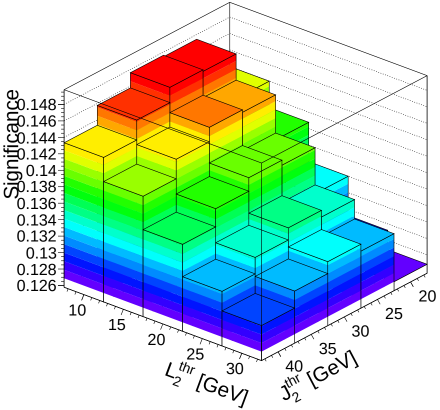
Cut optimization: Lepton and jet thresholds

$M_A = 25\ GeV$

Significance vs ℓ_1 vs jet_1 with $\ell_2 > 10$ & $jet_2 > 25\,GeV$



Significance vs ℓ_2 vs jet_2 with $\ell_1 > 20$ & $jet_1 > 25\,GeV$



Significance is $S = 2. \cdot \left(\sqrt{N_S + N_B} - \sqrt{N_B}\right)$ as per Stat.Comm. recipe

Summary and TODO

Summary

- being there
  - done this
  - and that
- Something important

TODO

- Use `DYNJets` correctly
- blah
- blah