# QUICK UPDATE

## 8 TeV–13 TeV comparisons

~~G. Aad et. al.~~ Number 6, Number 1

University of Glasgow

2016-09-14

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# a single, big image

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# an animated image (compatible with Adobe Reader)

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# a video (compatible with Okular)

# itemized list

- item
- item
  - subitem
  - subitem
    - subitem
- item
- item

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# enumerate list

1. item
2. item
    1. subitem
    2. subitem
        1. subitem
3. item
4. item

# description list

**A** item

**B** item

  **A** subitem

  **B** subitem

    **A** subitem

**C** item

**D** item

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# description list with checkmarks

- ✓ item
- ✓ item
  - ✓ subitem
  - • subitem
    - • subitem
- ✓ item
- ✗ item

# links

- URL: `http://info.cern.ch/hypertext/WWW/TheProject.html`
- hyperlink: TheProject
- hyperlink: ATL-COM-PHYS-2014-1471

# mathematics

- $H^+ \to tb$
- lepton $p_T$ and $\eta$

# mathematics

Jet pull is a variable that can be constructed from particles within a jet cone. The procedure is as follows:

- Select a pair of jets in an event.
- Build a vector sum of calorimater cells within each jet.

$$\vec{p} = \sum_i \frac{E_T^i \, |r_i|}{E_T^{\text{jet}}}$$

- $\vec{r_i}$: position of jet cell $i$ relative to jet centre
- $E_T^i$: transverse energy of cell $i$
- $E_T^{\text{jet}}$: transverse energy of jet

Each cell is assigned to the closer jet in $(\eta, \phi)$ space.

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# jet shape and pull

Jet shape is influenced by color flow. The pull vectors are different for the singlet and octet cases. For the singlet case the pull vector of one jet points towards the centre of the other jet and for the octet case the pull vector of one jet points somewhat away from the centre of the other jet.
The relative angle of the pull vector with respect to the connection line between the jet centres is a useful measure.

# emoticons

- smiley: ☺
- frownie: ☹
- neutralie: 😐



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# centered text

some centered text

some more centered text

# blocks

### block 1

- item
- item

### block 2

- item
- item

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# columns (2)

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# multiple columns (2)

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# multiple columns (4)

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# positioning by textblock

- item 1
- item 2
- item 3

- item 1
- item 2
- item 3

- item 1
- item 2
- item 3

- item 1
- item 2
- item 3

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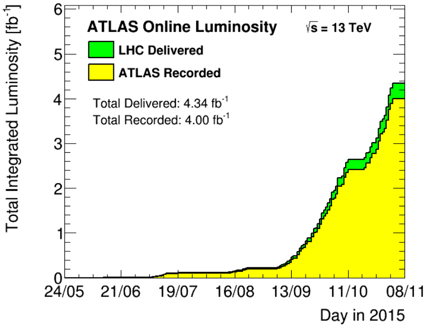
# positioning by textblock

- suppressed with respect to other Higgs modes
- $H \to b\bar{b}$ has the largest branching ratio (0.577 for $m_H$ 125 GeV)
- irreducible background from $t\bar{t}b\bar{b}$
- other backgrounds: $t\bar{t}$ production in association with light quarks ($u$, $d$, $s$) or gluon jets
  (called $t\bar{t}$ + light), and $t\bar{t} + c\bar{c}$




| $\sqrt{s}$ (TeV) | 7 | 8 | 13 | 14 |
|---|---|---|---|---|
| $t\bar{t}H$ ($m_H = 125$ GeV) (pb) | 0.086 | 0.130 | 0.5085 | 0.611 |
| $t\bar{t}$ (pb) | 177 | 253 | 832 | 950 |
| $S/\sqrt{B}$ | 0.00646 | 0.0082 | 0.0176 | 0.0198 |

7 TeV $\to$ 13/14 TeV: $S/\sqrt{B}$ changes by factor of $\simeq 3$

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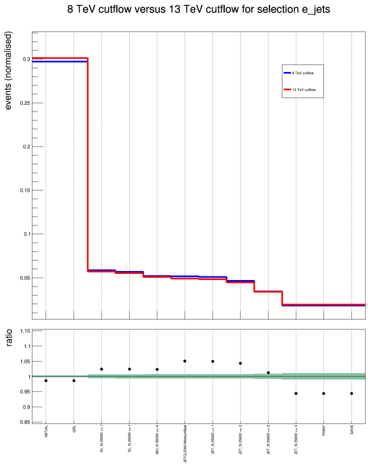
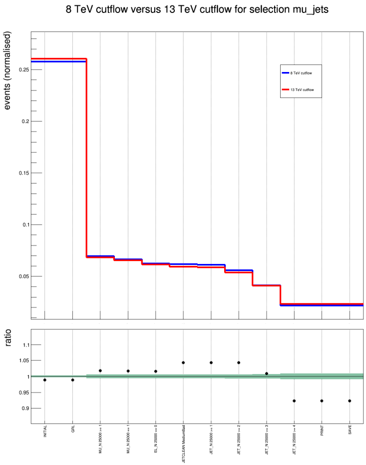
# 8 TeV vs. 13 TeV: cutflow for $l + \text{jets}$

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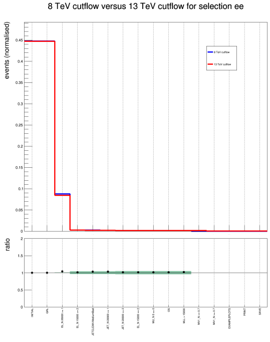
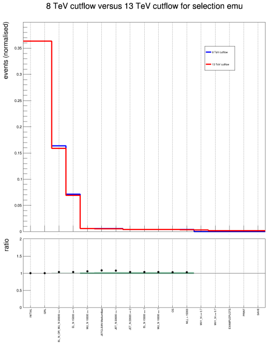
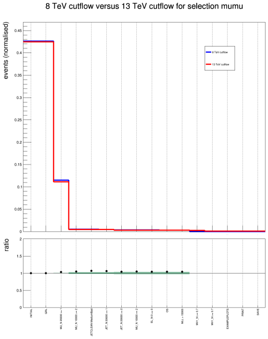
# 8 TeV vs. 13 TeV: cutflow for dilepton




I3PD+SV1: https://indico.cern.ch/event/387410/contribution/9/material/slides/0.pdf

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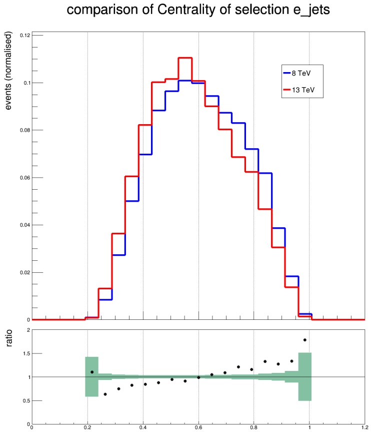
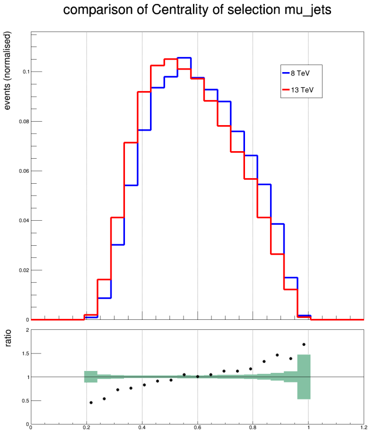
# 8 TeV vs. 13 TeV: centrality

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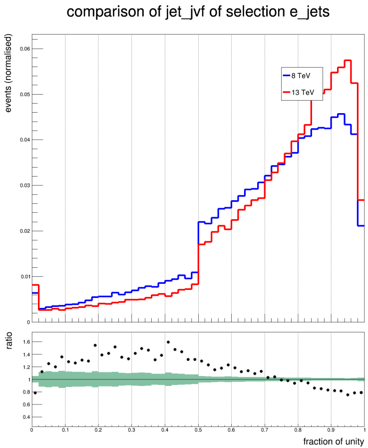
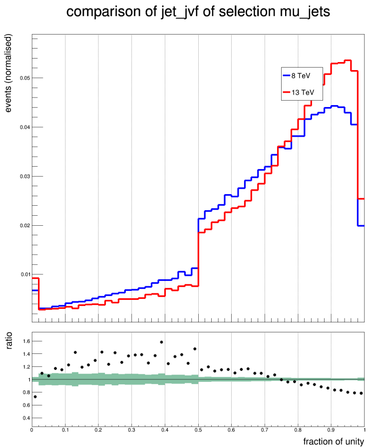
# 8 TeV vs. 13 TeV: JVF

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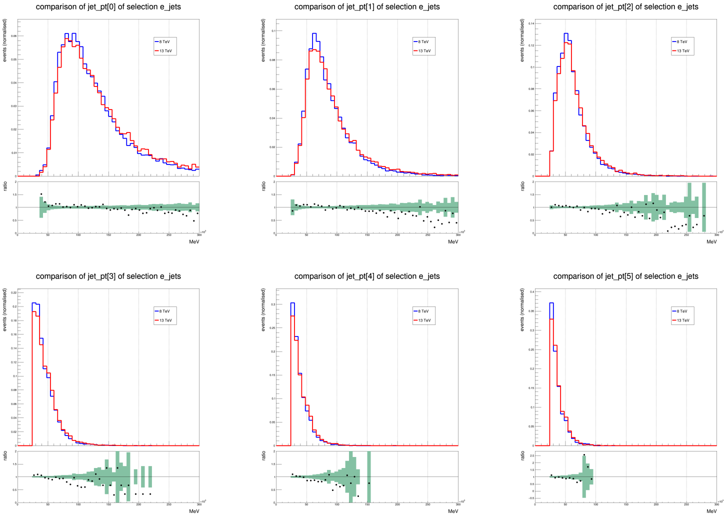
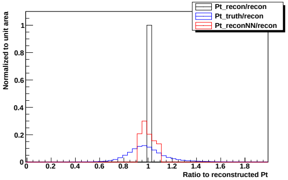
# 8 TeV vs. 13 TeV: subleading jets $p_T$ of $e$ selection

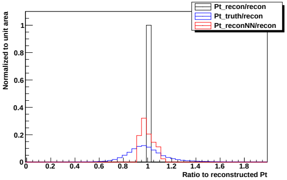


# $p_T$ ratio results for training with epochs of interest

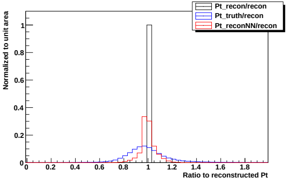
## 40 epochs:



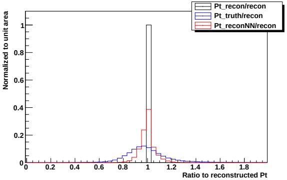

## 100 epochs:




## 145 epochs:




## 300 epochs:

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# neural networks and input variables

Four neural networks with progressively increasing input information were defined, all trained through 250 epochs (training cycles). NN0 comprises only the $\mu$-in-jet and $p_T$-only NN corrections, as opposed to further NN corrections.

| neural network designation | input variables |
|---|---|
| NN0 | no new neural network applied |
| NN1 | Et, SumPtTrk, Width |
| NN2 | Et, SumPtTrk, Width, MET |
| NN3 | Et, SumPtTrk, Width, MET, METPhi, JetPhi |

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# per-event $M_{b\bar{b}}$ resolutions with use of MET direction

$M_{b\bar{b}}$ resolutions for $VH_{b\bar{b}}$ for progressively decreasing MET energy cut requirements for various neural networks, shown to 3 significant figures:

| selection | events | NN0 | NN1 | NN2 | NN3 |
|---|---|---|---|---|---|
| $VH_{b\bar{b}}$ | 23686 | 0.133 | 0.129 | 0.131 | 0.131 |
| $VH_{b\bar{b}} + \mathrm{MET} < 100\ \mathrm{GeV}$ | 22654 | 0.132 | 0.130 | 0.129 | 0.131 |
| $VH_{b\bar{b}} + \mathrm{MET} < 70\ \mathrm{GeV}$ | 21094 | 0.131 | 0.128 | 0.129 | 0.129 |
| $VH_{b\bar{b}} + \mathrm{MET} < 40\ \mathrm{GeV}$ | 15050 | 0.128 | 0.126 | 0.126 | 0.126 |
| $VH_{b\bar{b}} + \mathrm{MET} < 20\ \mathrm{GeV}$ | 6174 | 0.130 | 0.127 | 0.126 | 0.127 |

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# per event $M_{b\bar{b}}$ resolutions with use of MET direction

Here, the physical processes are ranked according to the effectiveness of the corresponding behaviour they induce in NN3, where a greater effectiveness is taken to mean a smaller resolution value. *Caveat:* Systematic uncertainties are not given their due consideration.

| selection | events | NN0 | NN1 | NN2 | NN3 |
|---|---|---|---|---|---|
| $VH_{b\bar{b}} + \mathrm{MET} > 100$ GeV | 1032 | 0.121542 | 0.129038 | 0.13072 | 0.116975 |
| $VH_{b\bar{b}} + \mathrm{MET} < 40$ GeV | 15050 | 0.128387 | 0.125939 | 0.125637 | 0.125963 |
| $VH_{b\bar{b}} + \mathrm{MET} < 20$ GeV | 6174 | 0.129539 | 0.127454 | 0.126029 | 0.127043 |
| $VH_{b\bar{b}} + \mathrm{MET} < 70$ GeV | 21094 | 0.131248 | 0.128119 | 0.128908 | 0.128825 |
| $VH_{b\bar{b}} + \mathrm{MET} < 100$ GeV | 22654 | 0.132004 | 0.129924 | 0.129095 | 0.130467 |
| $VH_{b\bar{b}}$ | 23686 | 0.132823 | 0.129032 | 0.131202 | 0.131303 |
| $VH_{b\bar{b}} + \mathrm{MET} > 20$ GeV | 17512 | 0.135974 | 0.13137 | 0.13366 | 0.132341 |
| $VH_{b\bar{b}} + \mathrm{MET} > 40$ GeV | 8636 | 0.140116 | 0.135415 | 0.140013 | 0.140551 |
| $VH_{b\bar{b}} + \mathrm{MET} > 70$ GeV | 2592 | 0.143505 | 0.15228 | 0.151469 | 0.155914 |

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# $m_{b\bar{b}}$ value results for training with epochs of interest

$m_{b\bar{b}}$ resolution results (Gaussian fit) for training with epochs of interest:

| | | epochs | | | |
|---|---|---|---|---|---|
| | | 40 | 100 | 145 | 300 |
| subset | training | 0.137 | 0.138 | 0.138 | 0.138 |
| | training test | 0.139 | 0.139 | 0.139 | 0.139 |

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# $m_{b\bar{b}}$ resolutions with and without MET

comparison of $m_{b\bar{b}}$ resolutions for various channels both excluding and including the MET variable with various epochs:

| number of epochs | | $l\nu bb$ | $llbb$ | $\nu\nu bb$ | all |
|---|---|---|---|---|---|
| 50 | without MET | 0.135159 | 0.138616 | 0.135159 | 0.137488 |
| | with MET | 0.130047 | 0.137266 | 0.136842 | 0.138516 |
| | change | -3.78% | -0.97% | +1.24% | +0.75% |
| 100 | without MET | 0.134537 | 0.138781 | 0.13656 | 0.13743 |
| | with MET | 0.129719 | 0.137265 | 0.136247 | 0.138948 |
| | change | -3.58% | -1.09% | -0.22% | +1.1% |
| 150 | without MET | 0.13676 | 0.138464 | 0.137943 | 0.13747 |
| | with MET | 0.138292 | 0.137261 | 0.137344 | 0.138948 |
| | change | +1.12% | -0.87% | -0.43% | +1.07% |
| 500 | without MET | 0.139041 | 0.139451 | 0.13849 | 0.13827 |
| | with MET | 0.139225 | 0.137261 | 0.136398 | 0.138948 |
| | change | +0.13% | +1.6% | -1.51% | -0.48% |

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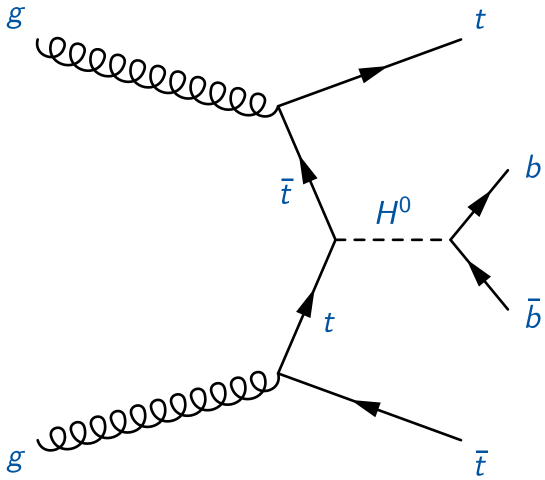
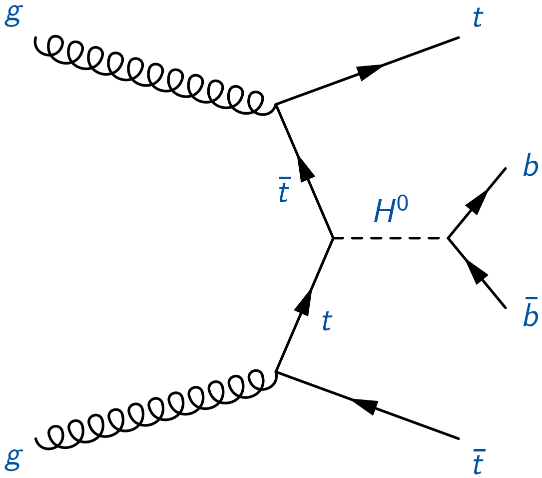
# Feynman diagram



# Feynman diagram with text

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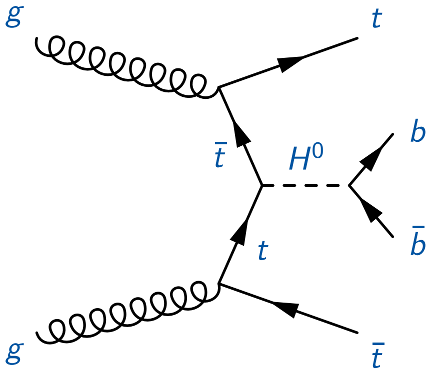
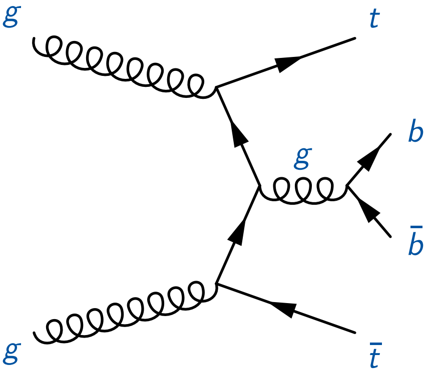
# Feynman diagrams

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# embedded data

The following is an embedded data file:

↓ data.root

The following is an embedded sound file:

Omnichord.wav

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# TTHbbLeptonic development team

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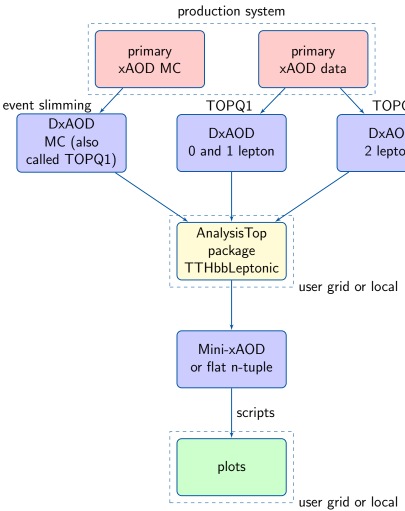
# analysis framework



# questions?

Sarah
Boutle

Andrea
Knue

Johnny
Raine

Will
Breaden Madden

questions?

Georges
Aad

Michele
Pinamonti

Snezana
Nektarijevic

Royer Edson
Ticse Torres

END