기초과학연구원
Institute for Basic Science

Higgs Decay to Light Jets

Zhuoni Qian (IBS)

July 5th, 2018

Photo from https://www.internationaltraveller.com

Linda M. Carpenter, Tao Han, Khalida Hendricks, ZQ, Ning Zhou. Phys. Rev. D 95, no. 5, 053003 (2017)

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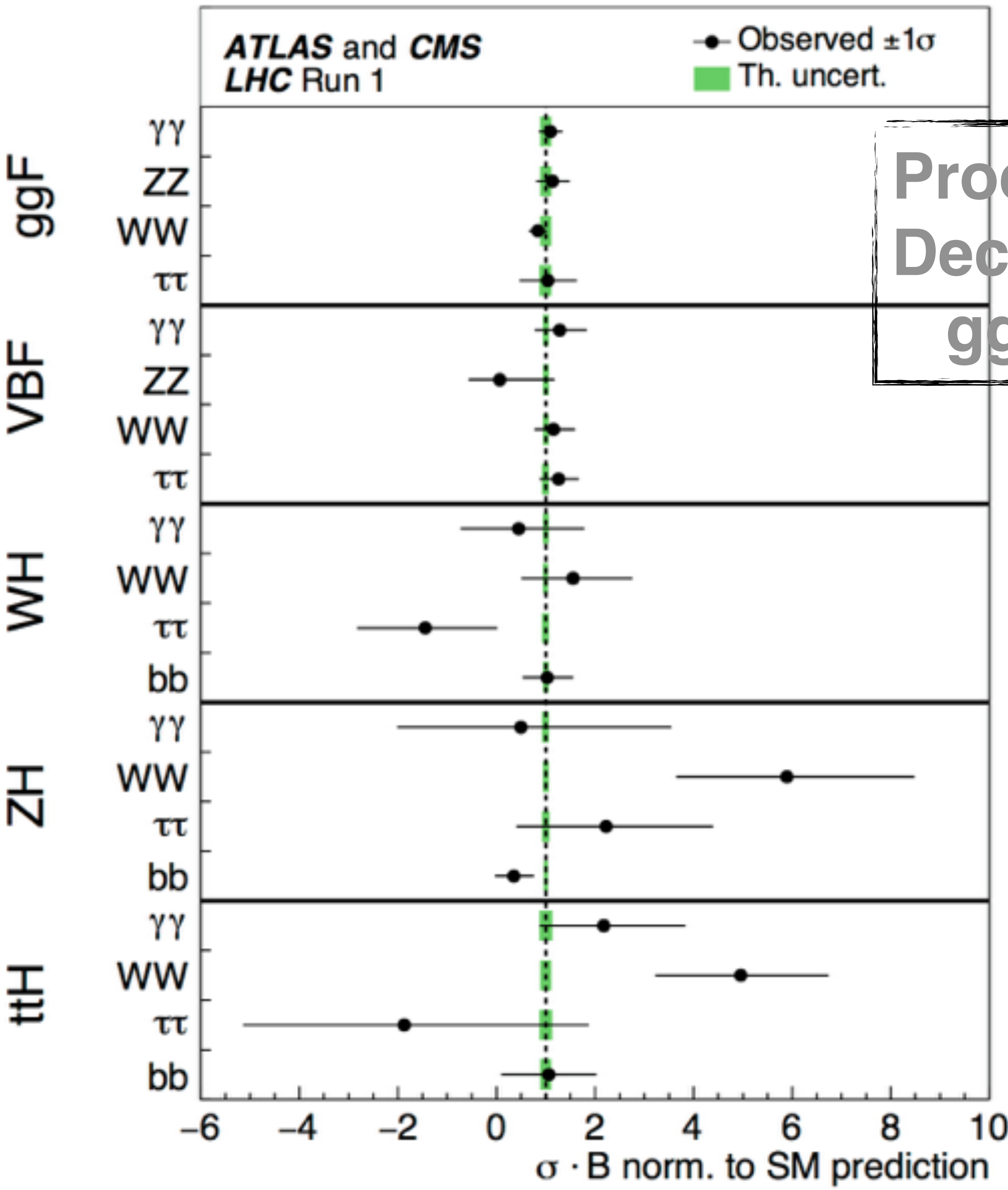
Current Status

ATLAS+CMS combined analysis 7&8 TeV (2015):



Production: ggF, VBF, WH, ZH, ttH
Decay: ZZ, γγ, WW, ττ, μμ, Zγ, bb, gg, cc, ss, uu, dd, ee

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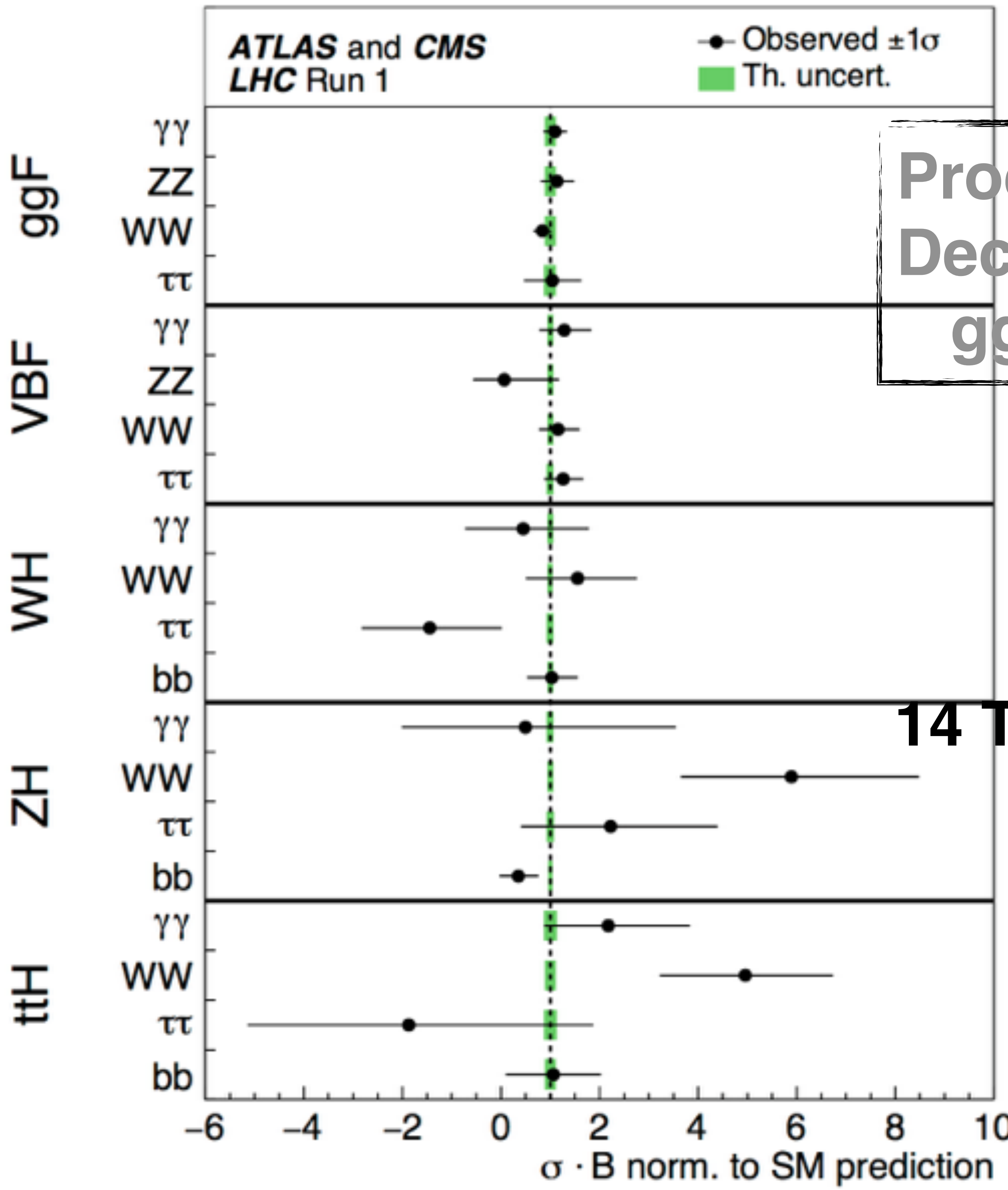

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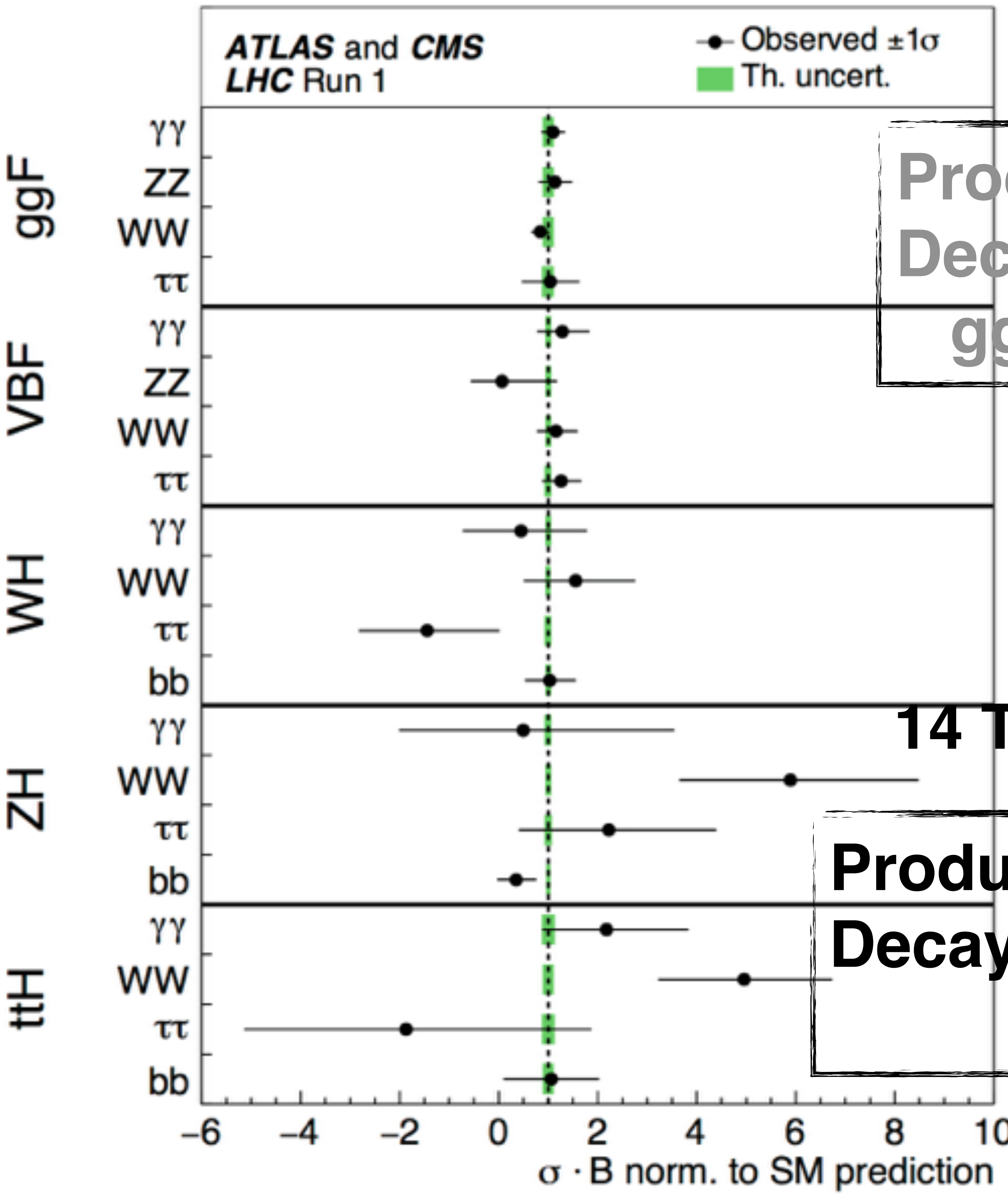

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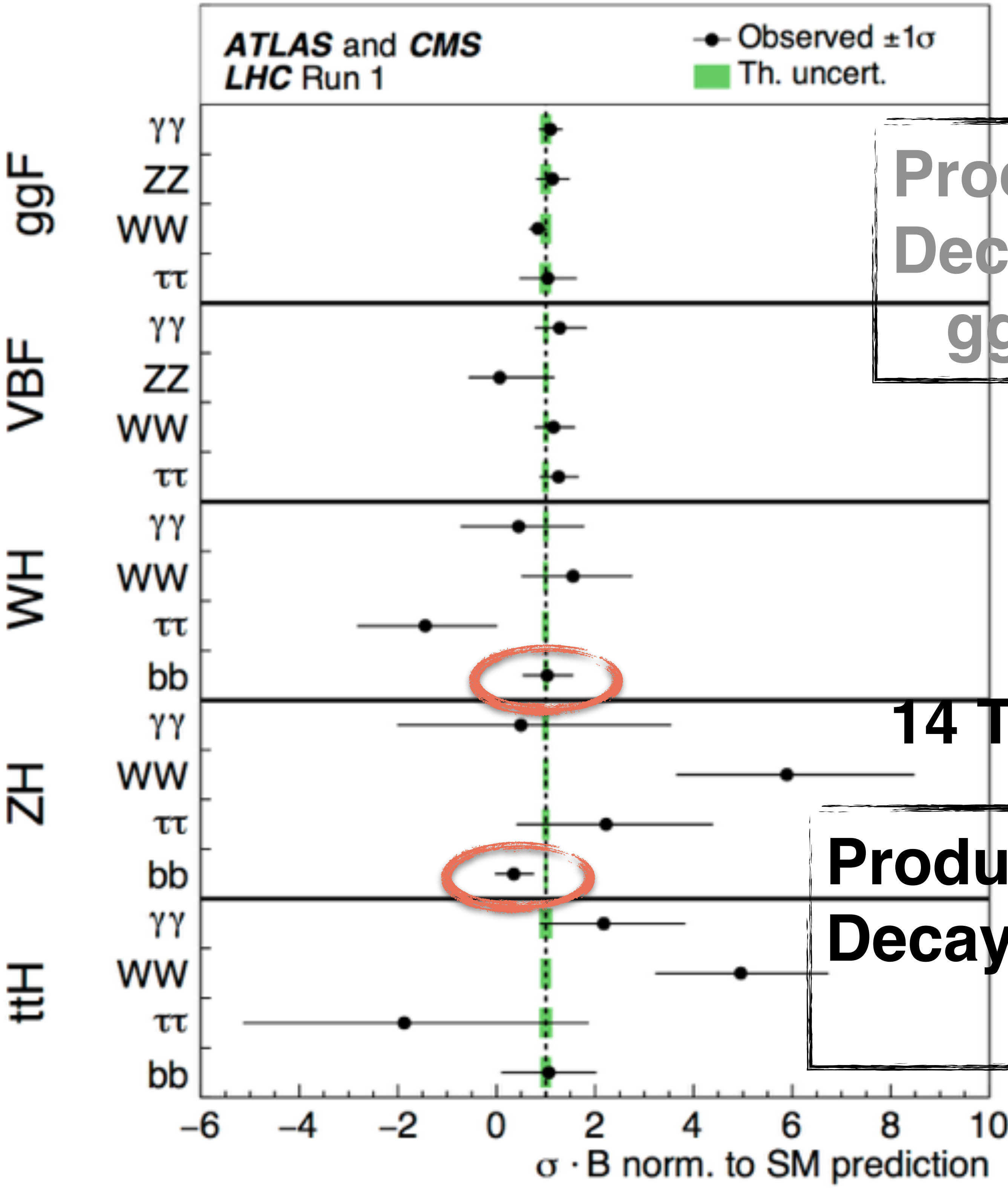

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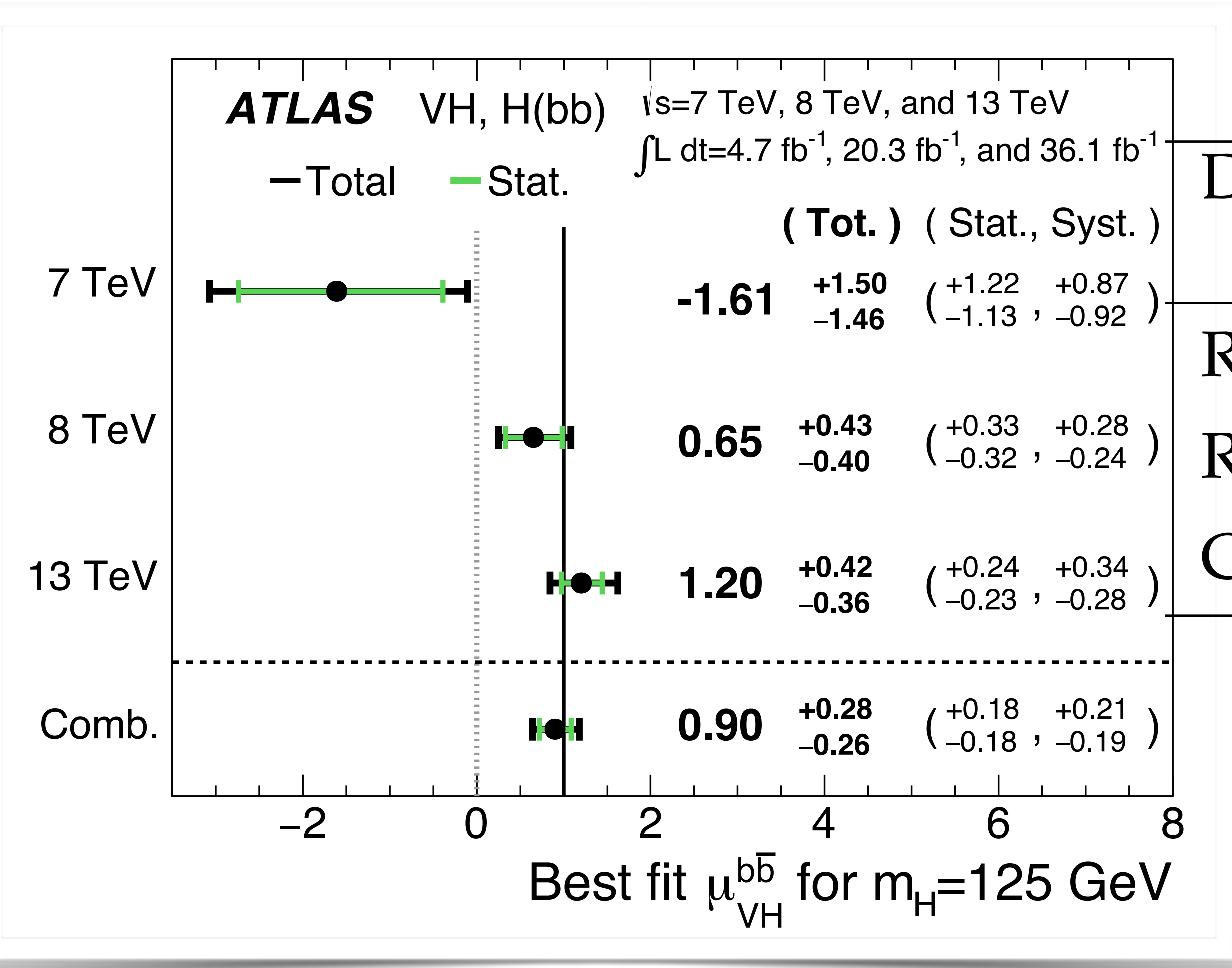

Data used	Significance expected	Significance observed	Signal stren observe
Run 1	2.5	2.1	$0.89^{+0.44}_{-0.42}$
Run 2	2.8	3.3	$1.19^{+0.40}_{-0.38}$
Combined	3.8	3.8	$1.06^{+0.31}_{-0.29}$

- arXiv: 1709.15543, 1709.07497, 1708.03299
- Nuclear and Particle Physics Proceedings 273–275 (2016) 733–739

2405-6014/Published by Elsevier B.V.

ww

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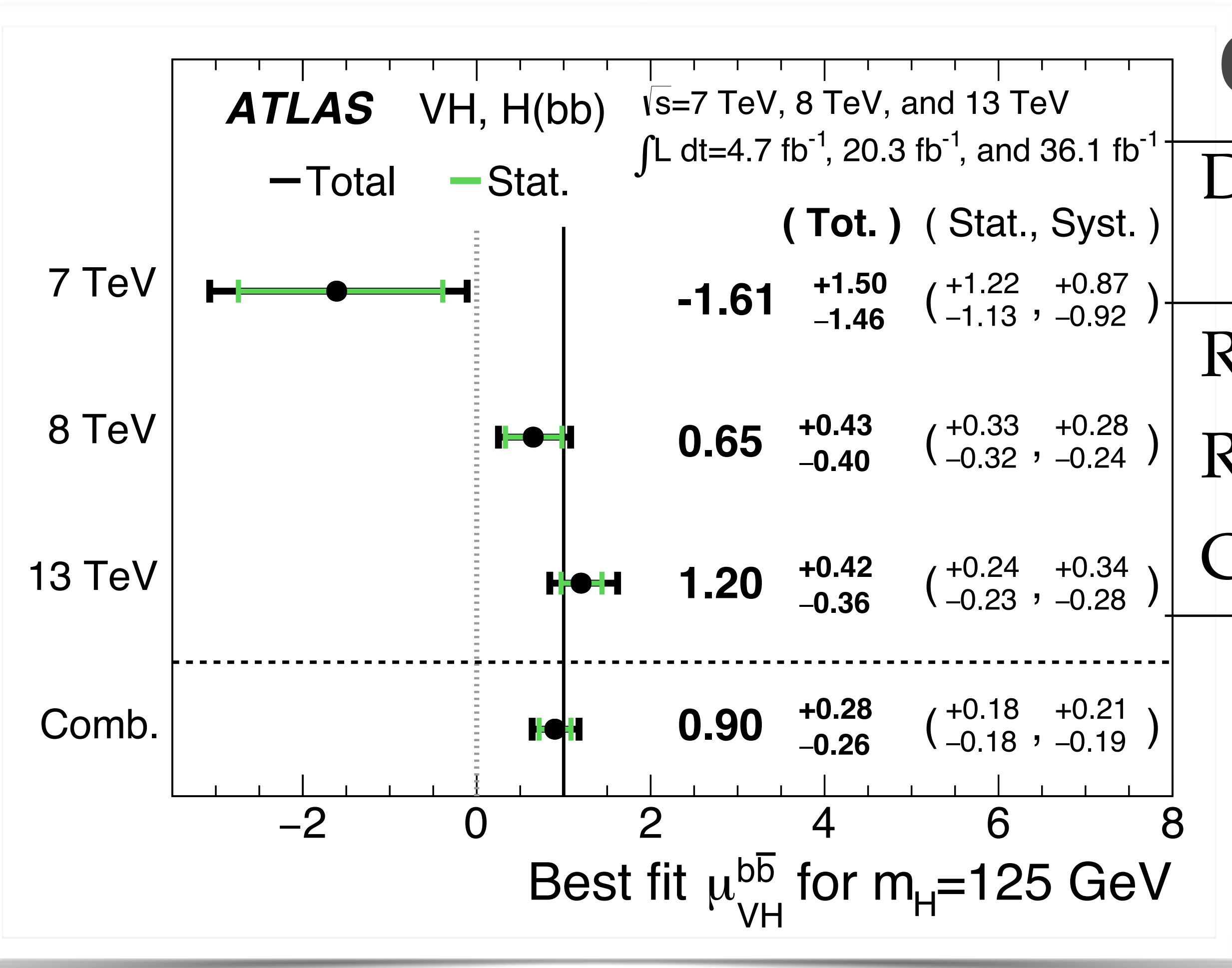

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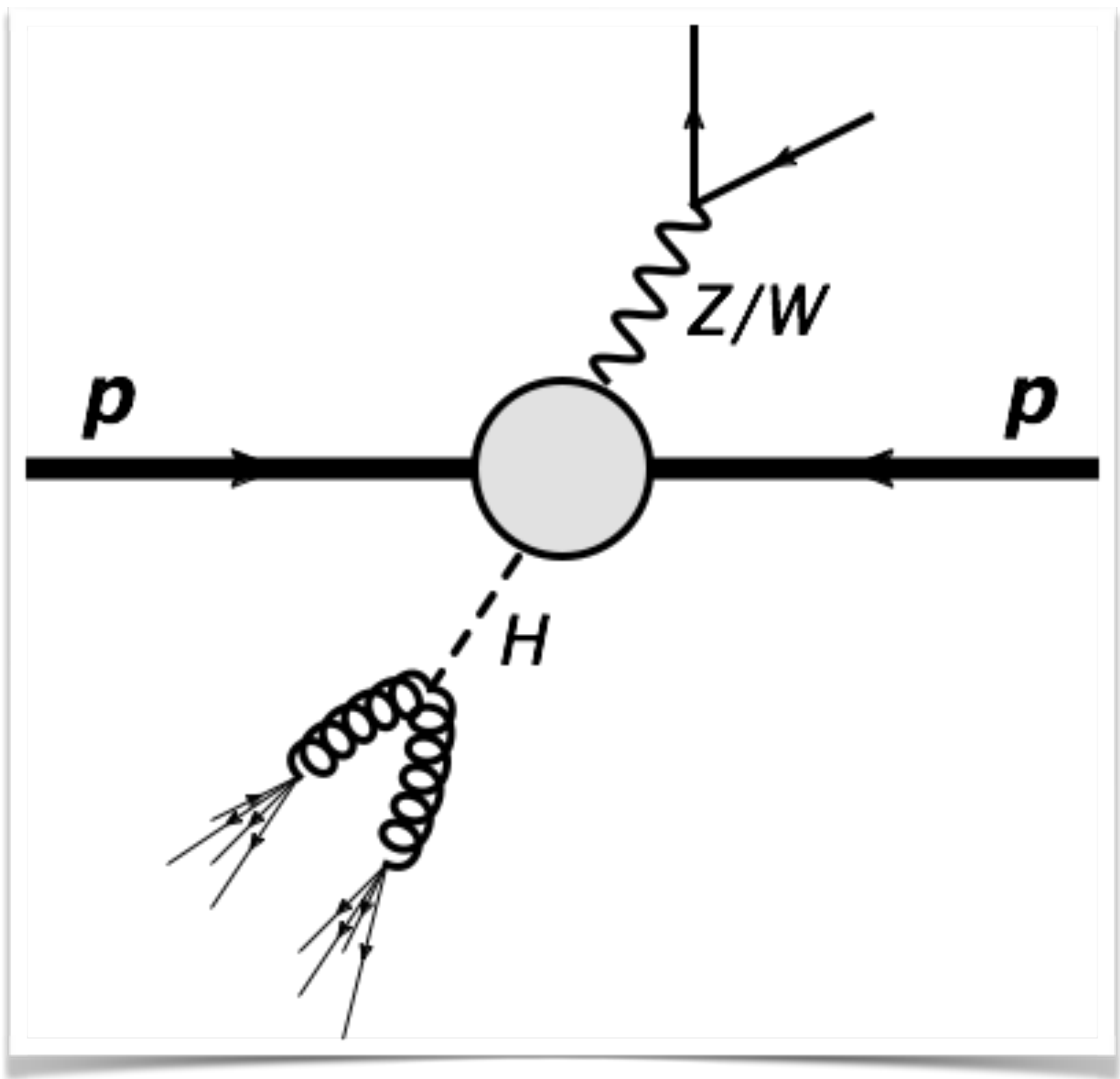
Higgs Decay to Light Jets

Signal Process



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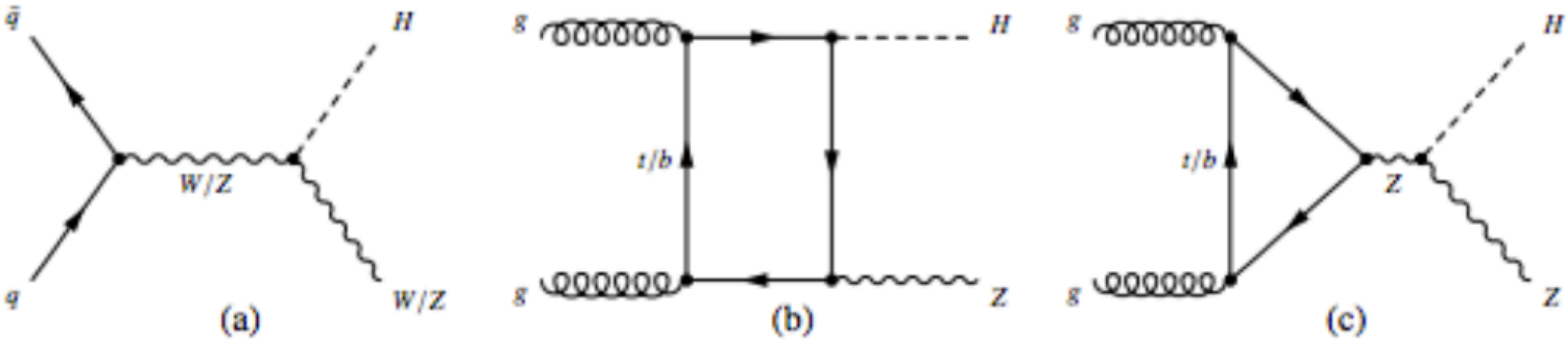

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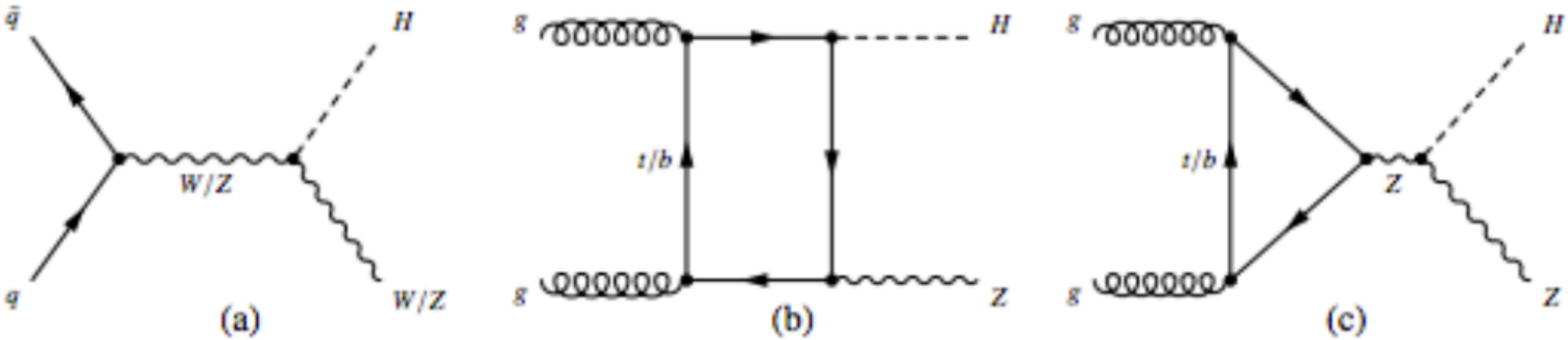

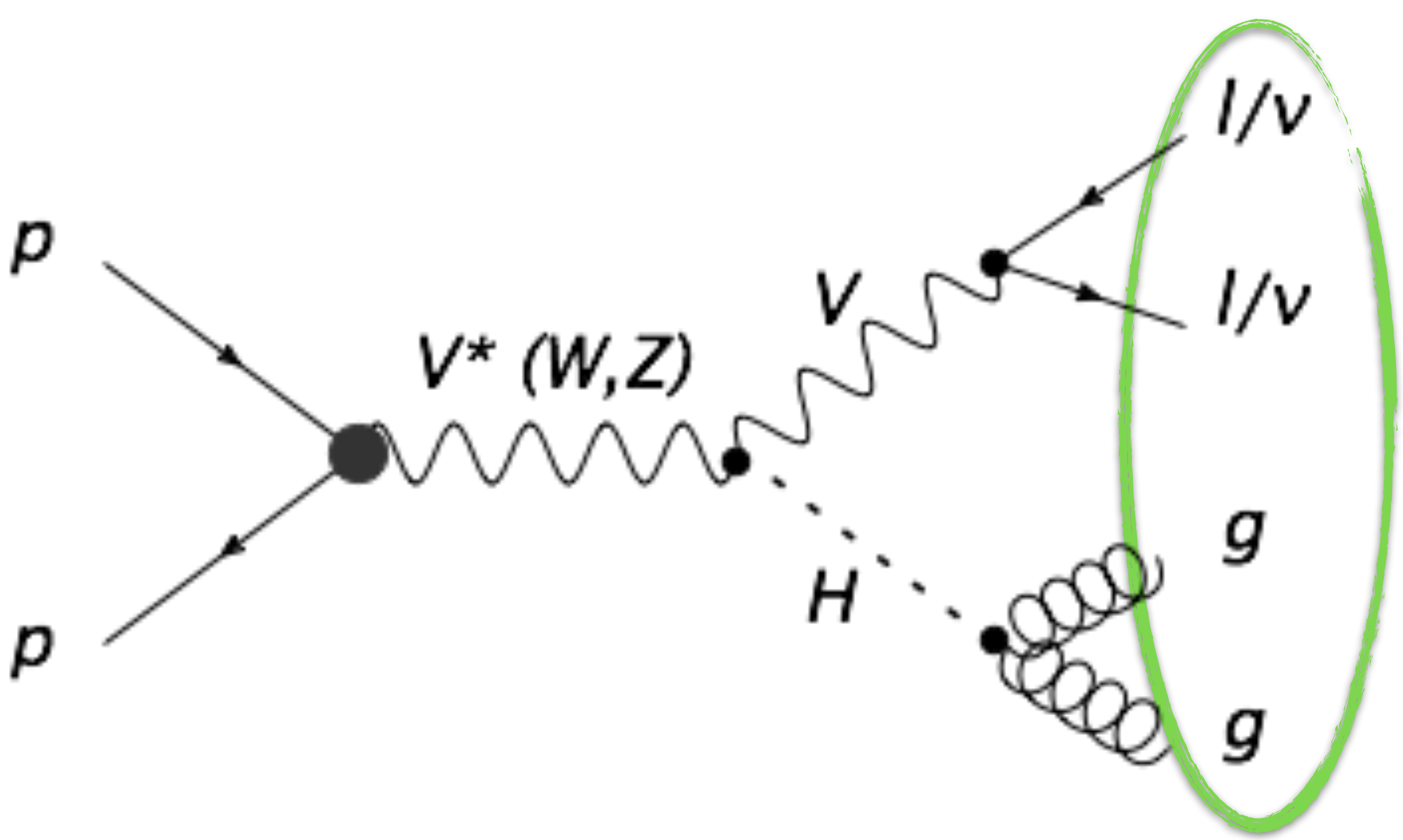

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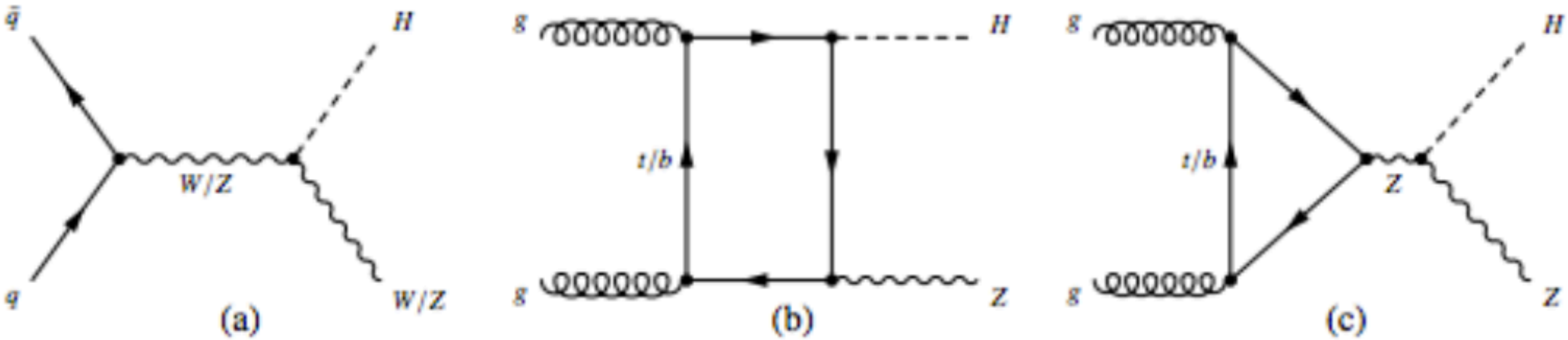

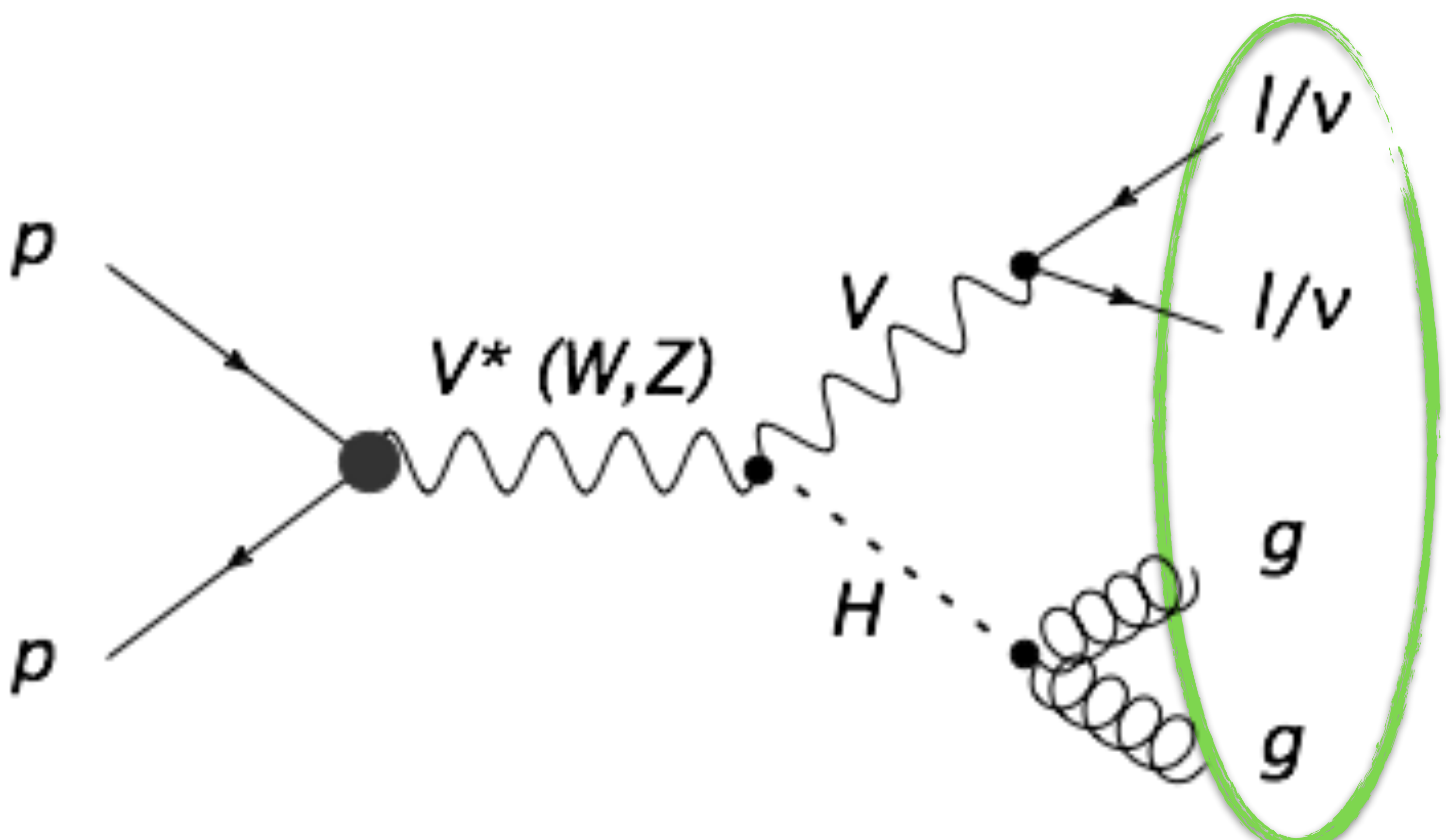

3 Channels:

2 leptons, 2 jets

1 lepton + MET, 2 jets

MET, 2 jets

Higgs Decay to Light Jets

Background Process

σ (fb)	cuts Eq. (2.3)
$q\bar{q} \to Zh \to \ell^+\ell^- \; gg$	3.5
$gg \to Zh \to \ell^+\ell^- \; gg$	0.71
$q\bar{q} \to Zjj \to \ell^+\ell^- \; jj$	2.5×10^5
$q\bar{q} \to Wh \to \ell\nu \; gg$	20
$q\bar{q} \to Wjj \to \ell\nu \; jj$	2.5×10^6
$pp \to t\bar{t} \to \ell\nu jjb\bar{b}$	1.1×10^5
$q\bar{q} \to Zh \to \nu\nu \; gg$	11
$gg \to Zh \to \nu\nu \; gg$	2.1
$q\bar{q} \to Zjj \to \nu\nu \; jj$	7.4×10^5

$$\mathbf{cut0}: \quad \mathbf{p_{T(j)} > 20}\mathrm{GeV}, \quad |\eta_\mathbf{j}| < \mathbf{3}, \quad \mathbf{R_{jj} > 0.4} \qquad (2.3)$$

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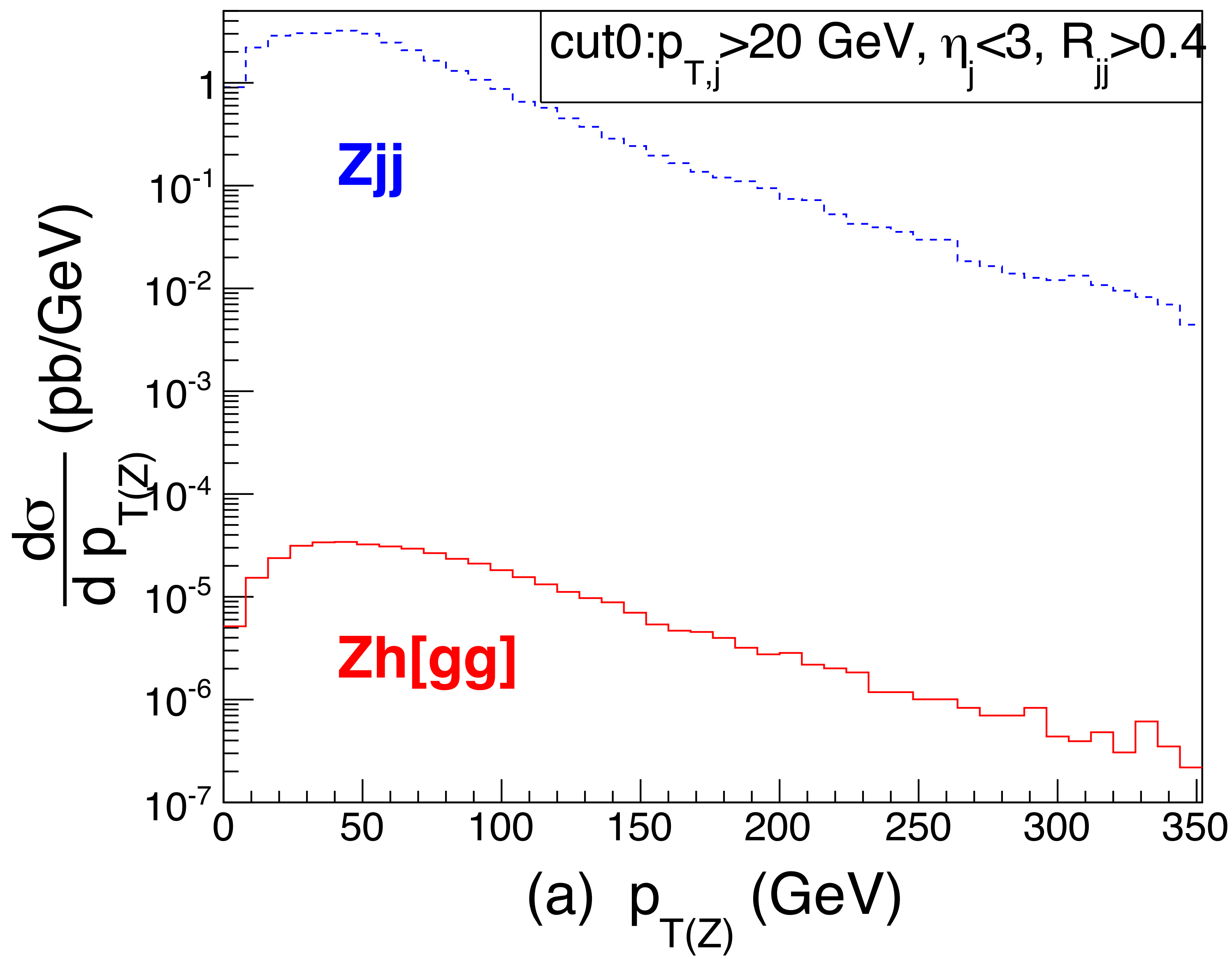
Kinematics



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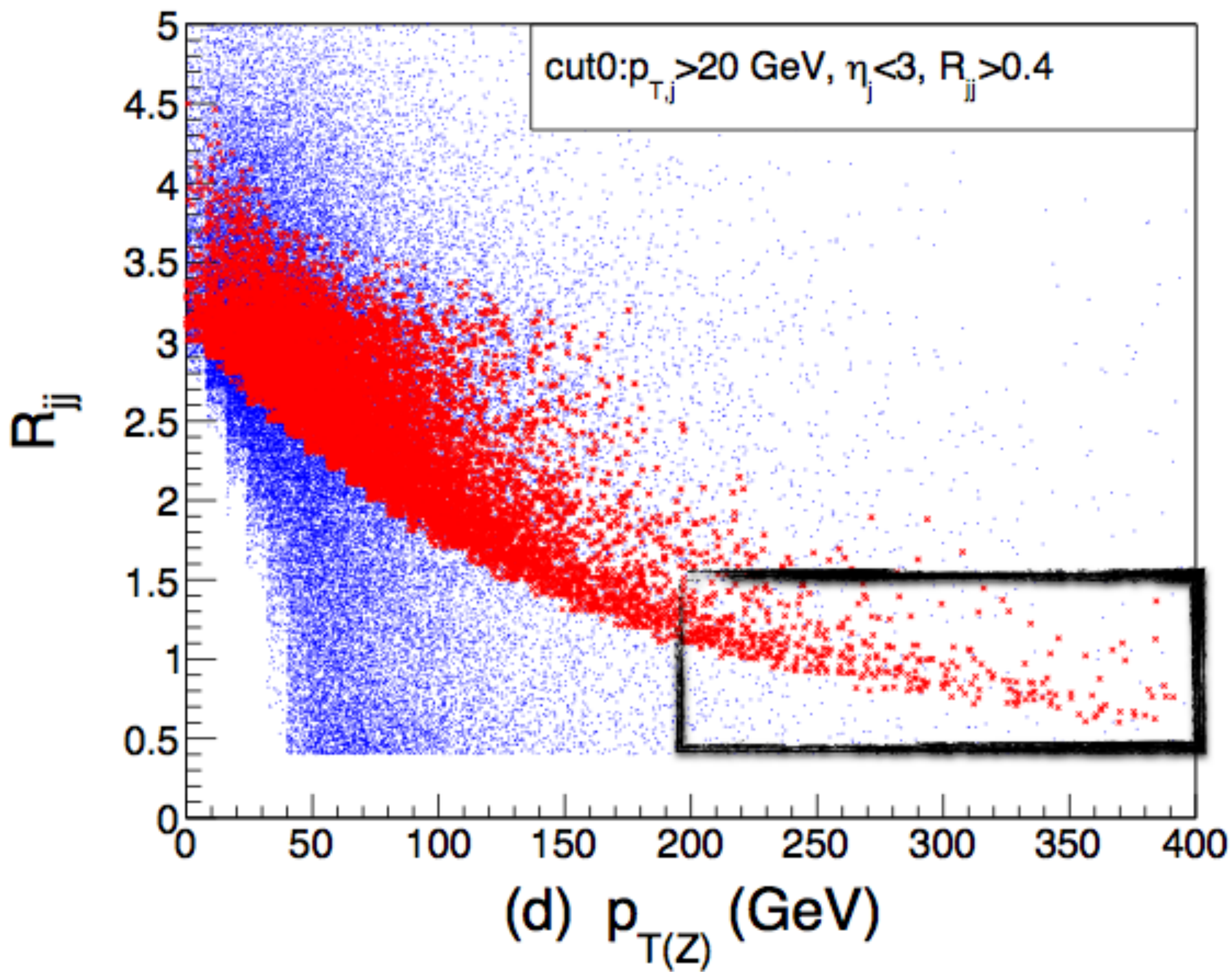

$$R_{jj} \approx \frac{1}{\sqrt{z(1-z)}} \frac{m_h}{p_{T(h)}},$$

$$p_{T(j,\ell)} > 30\text{GeV}, \quad |\eta_{j,\ell}| < 2.5$$

$$p_{T(\ell\ell,\ell\nu,\nu\nu)} > 200\text{GeV}, \quad R_{jj} < 1.4$$

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Higgs Decay to Light Jets

Mass Reconstruction

Boosted or Resolved: arxiv:1506.04973 (2015) Jon M. Butterworth et al.

Wh[bb] over pT (200-1000) GeV

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Wh[bb] over pT (200-1000) GeV

Resolved^{+} : Two Leading jets & additional jets within R<1.4

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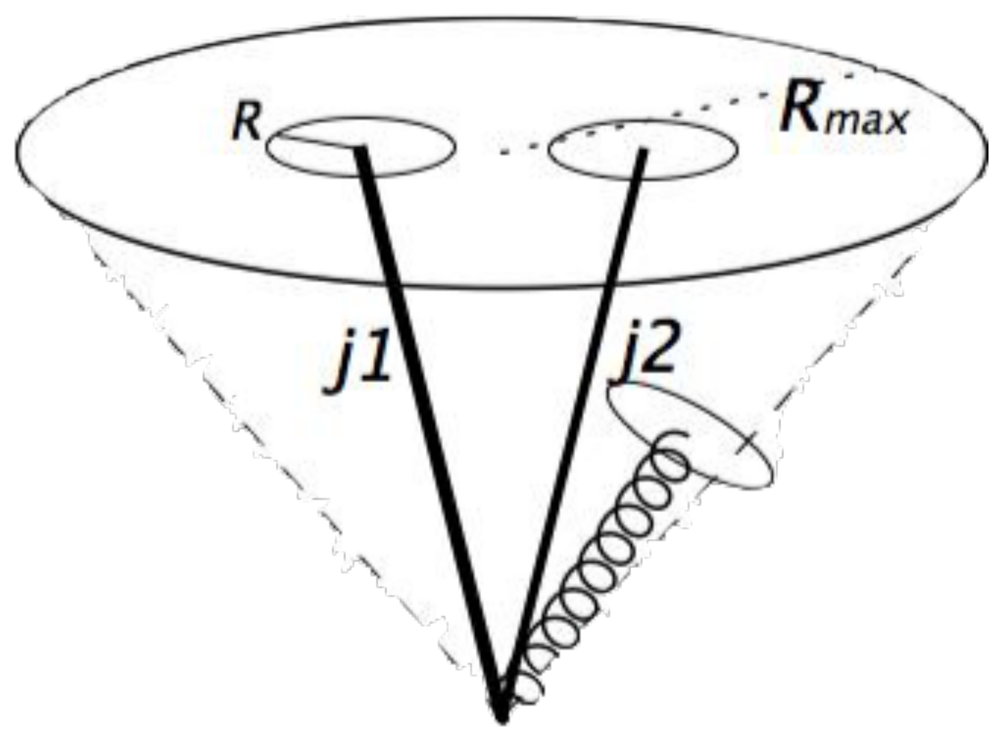

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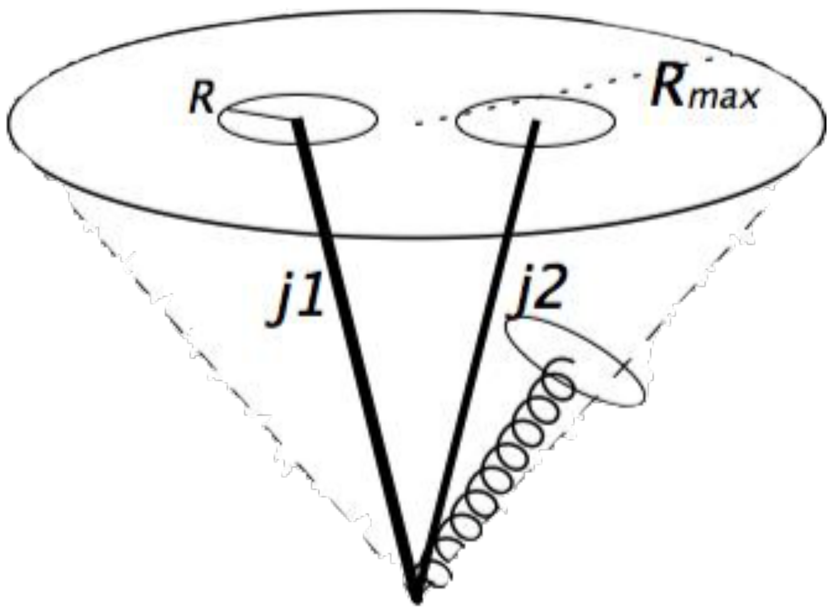

Two Leading jets
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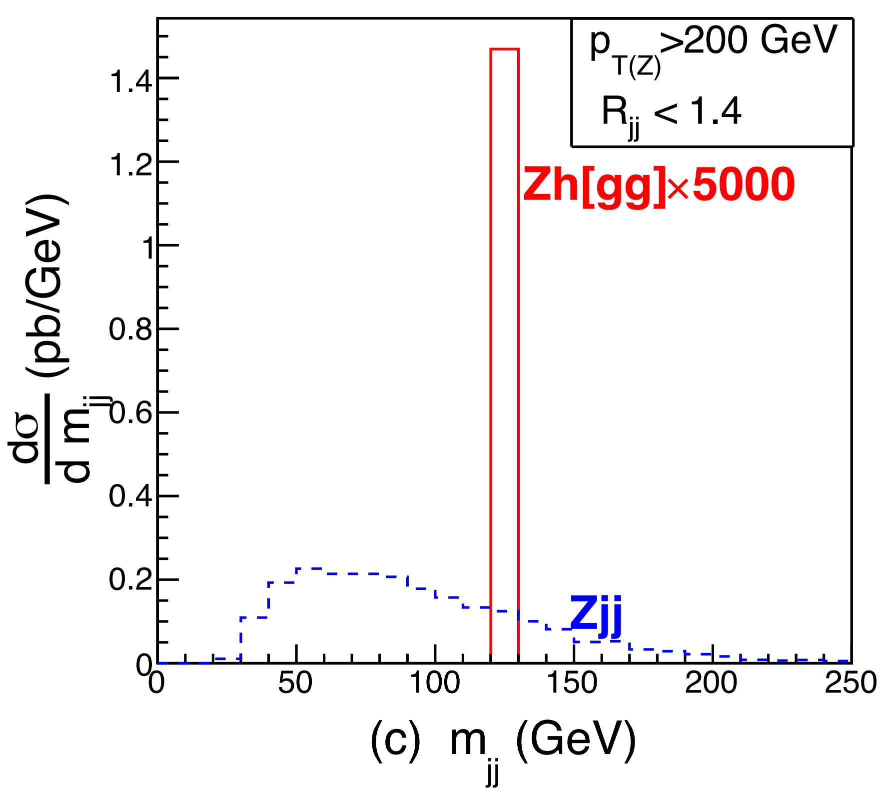

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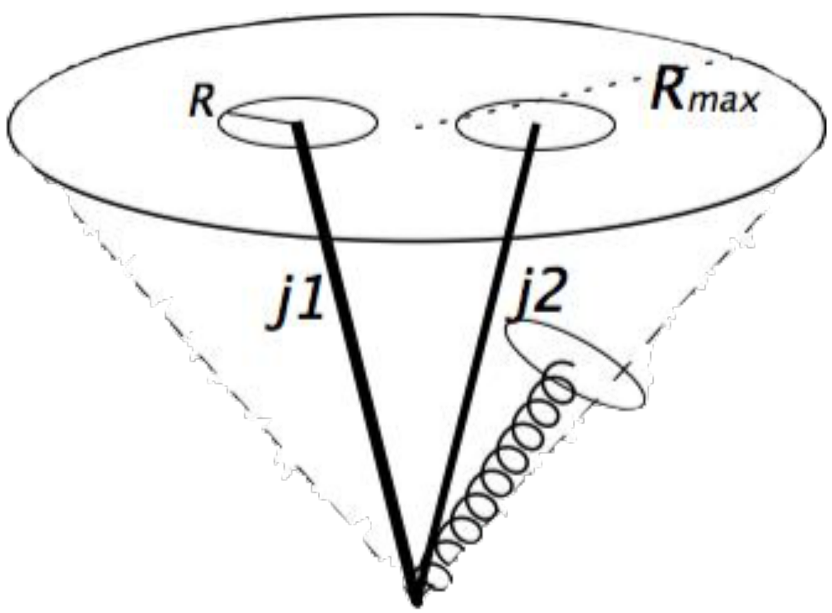

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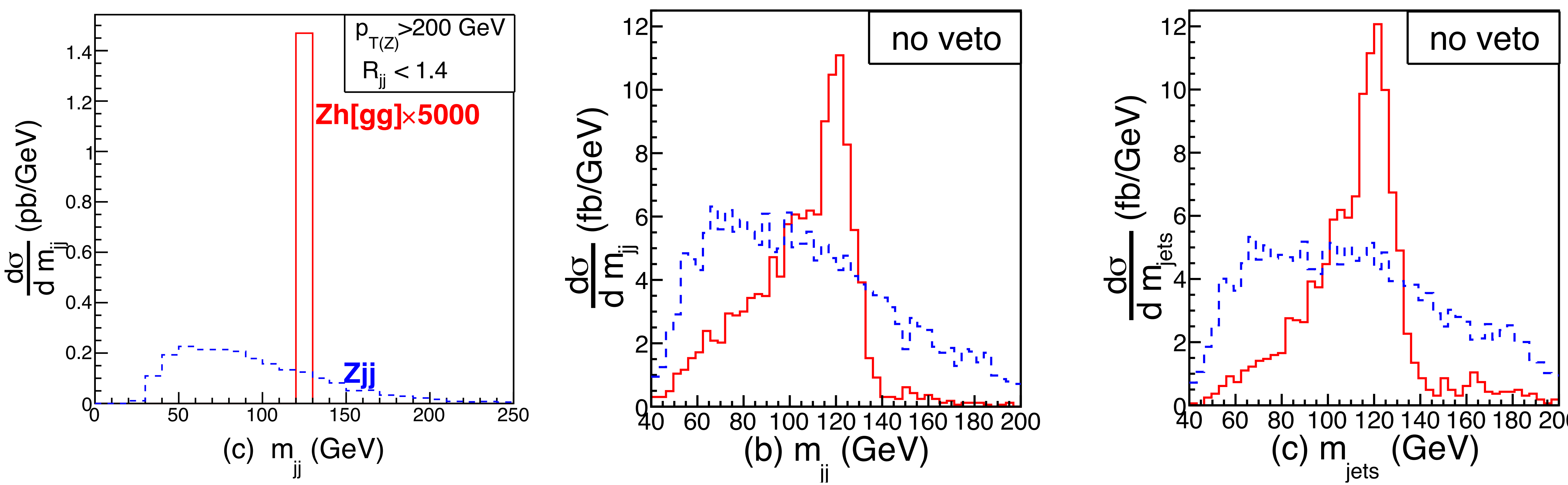

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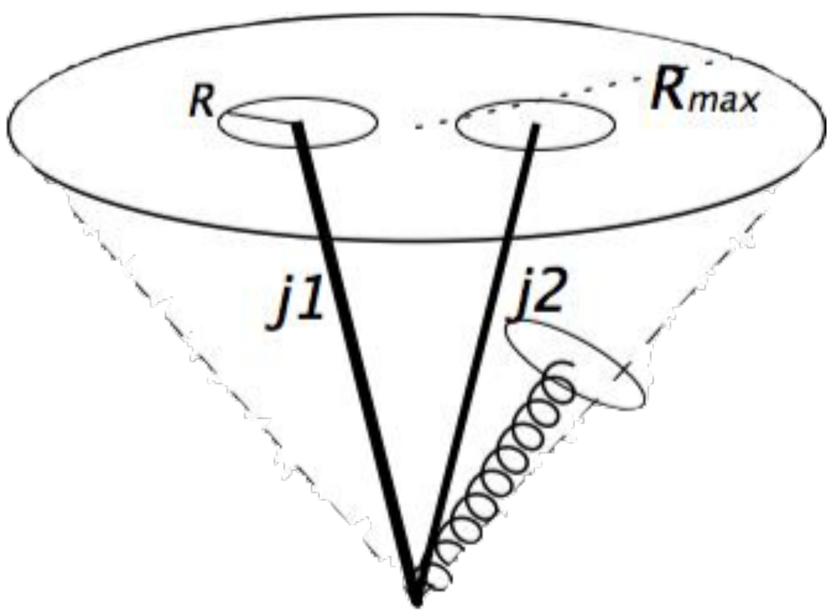

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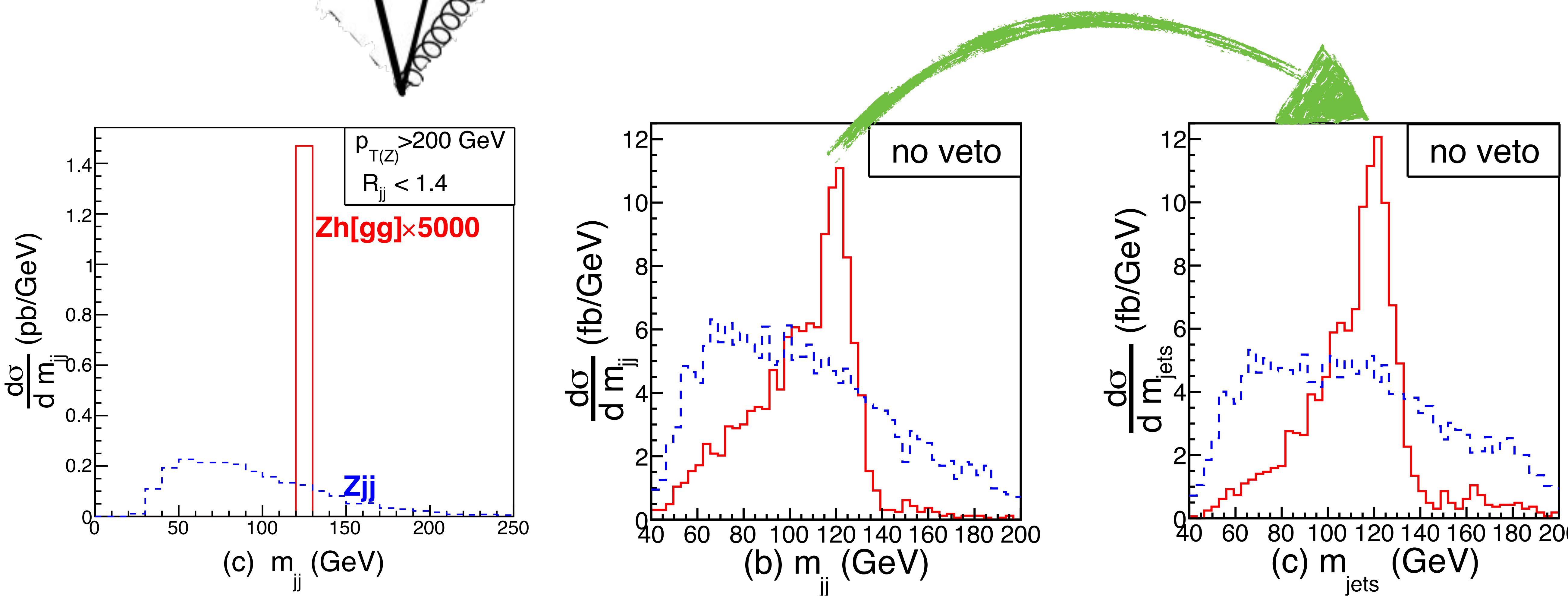

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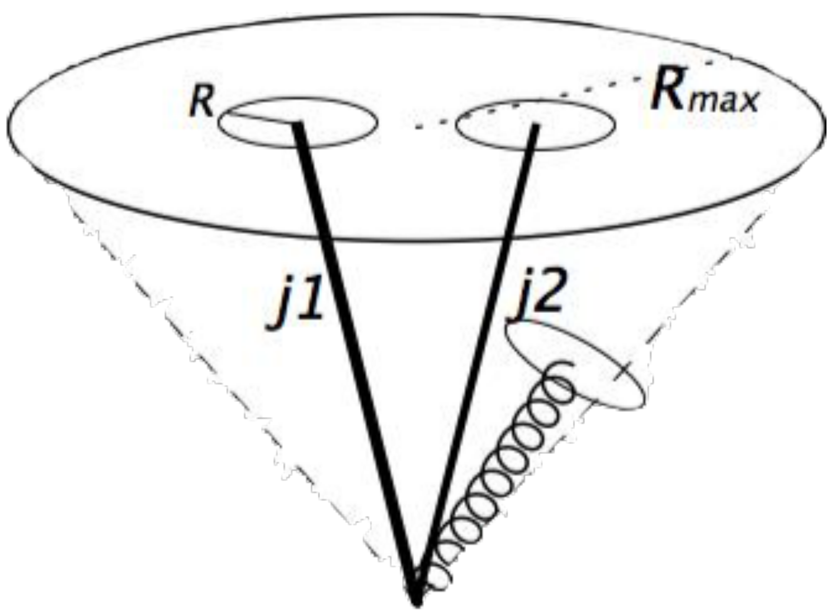

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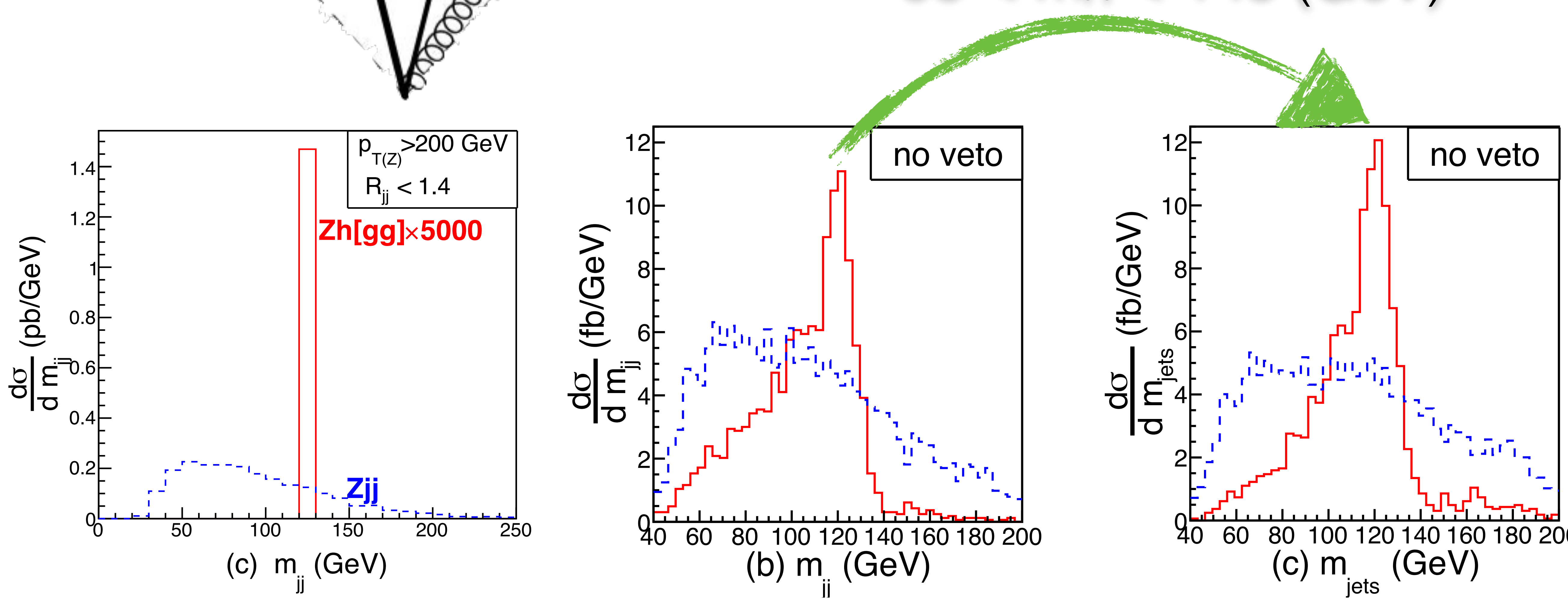
$95 < m_H < 145$ (GeV)



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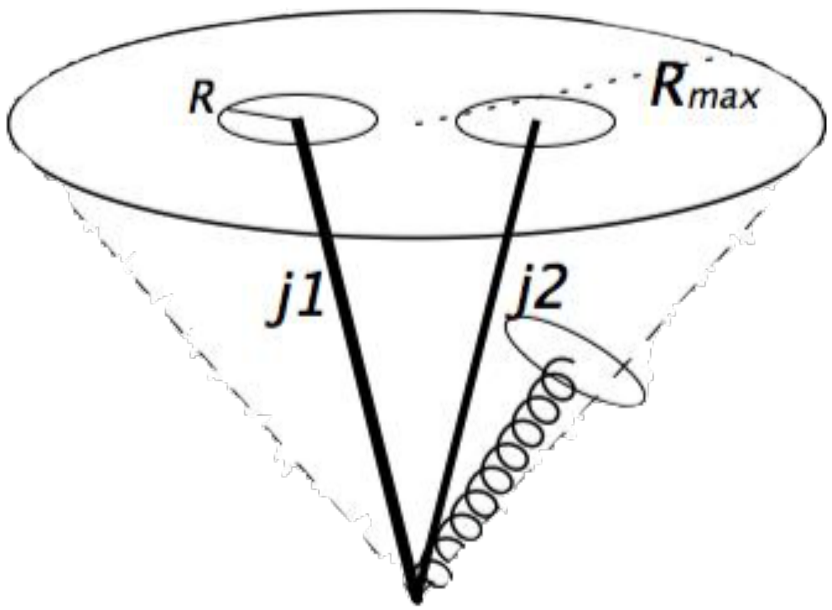

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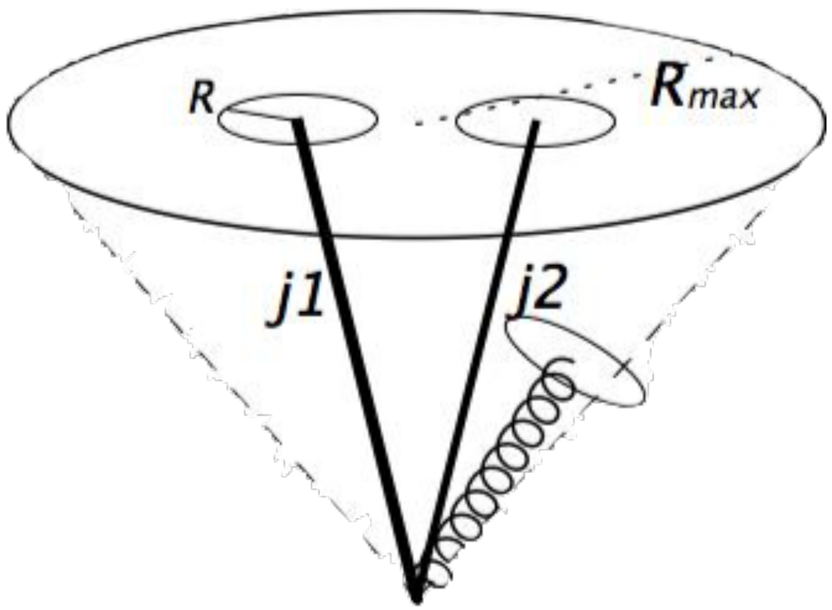

Robustness with pileup

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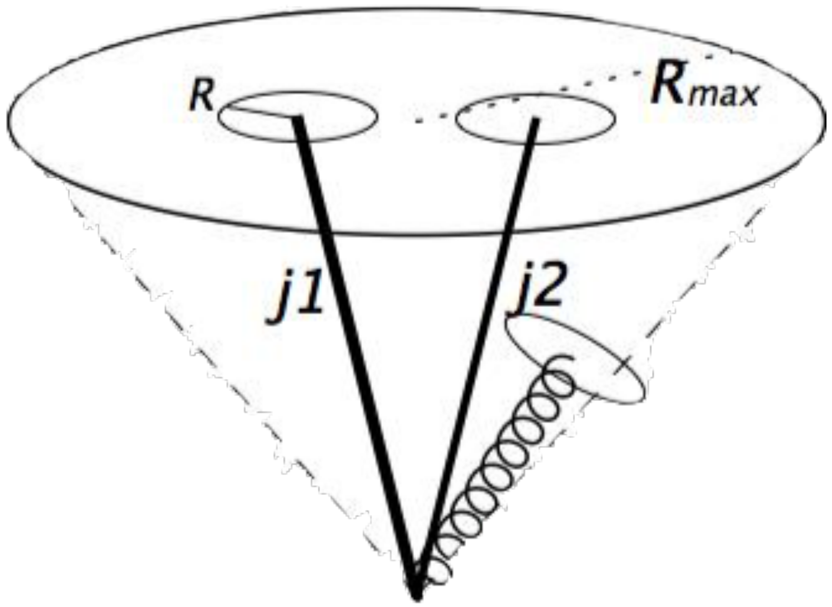

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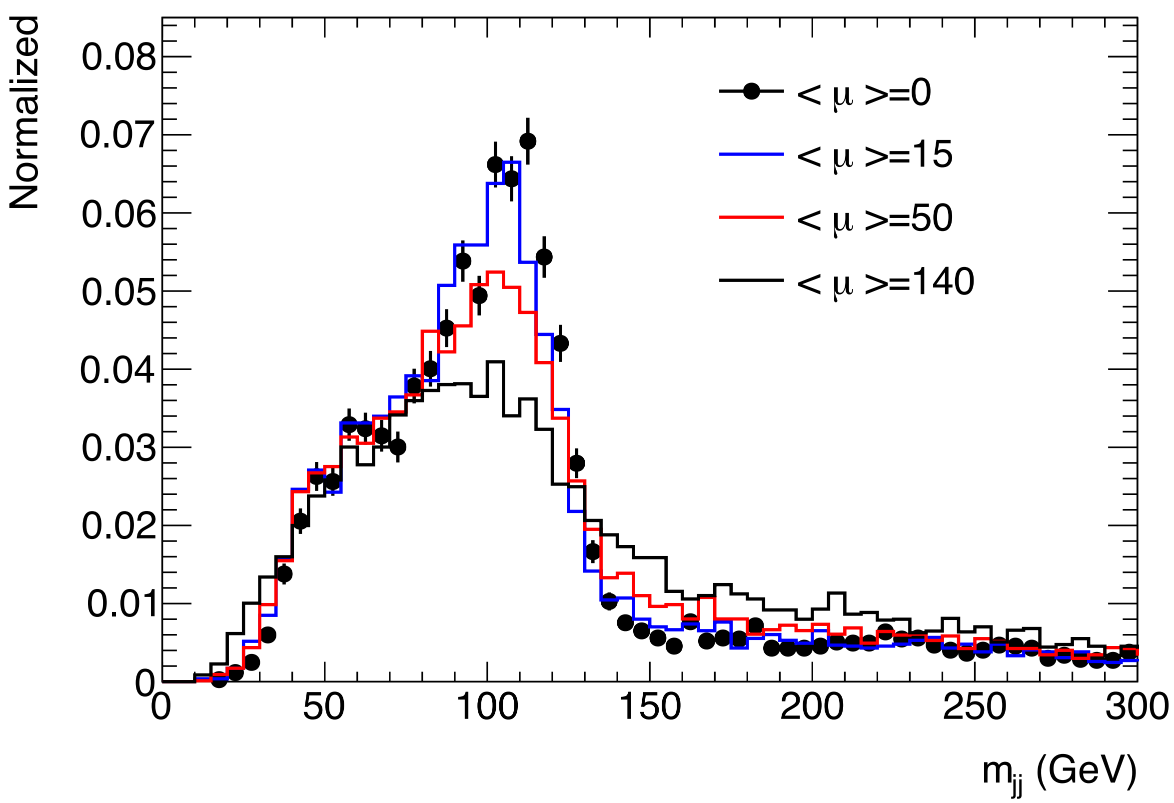

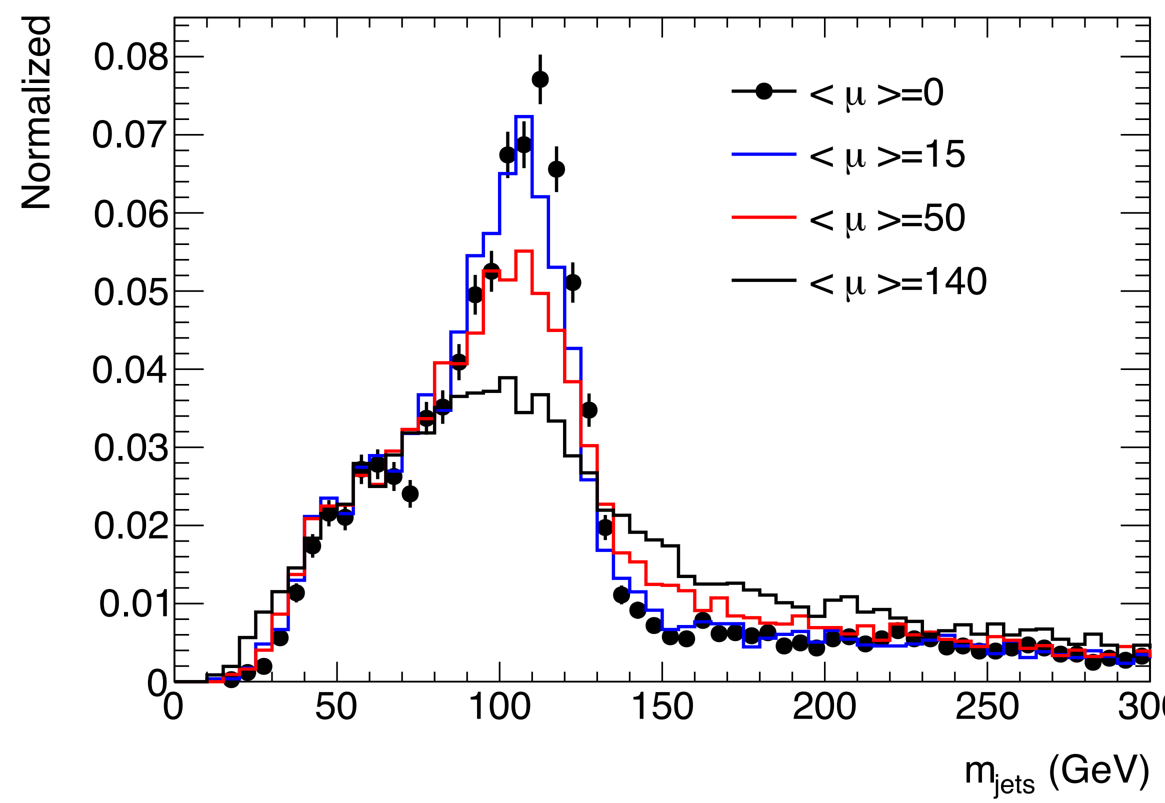

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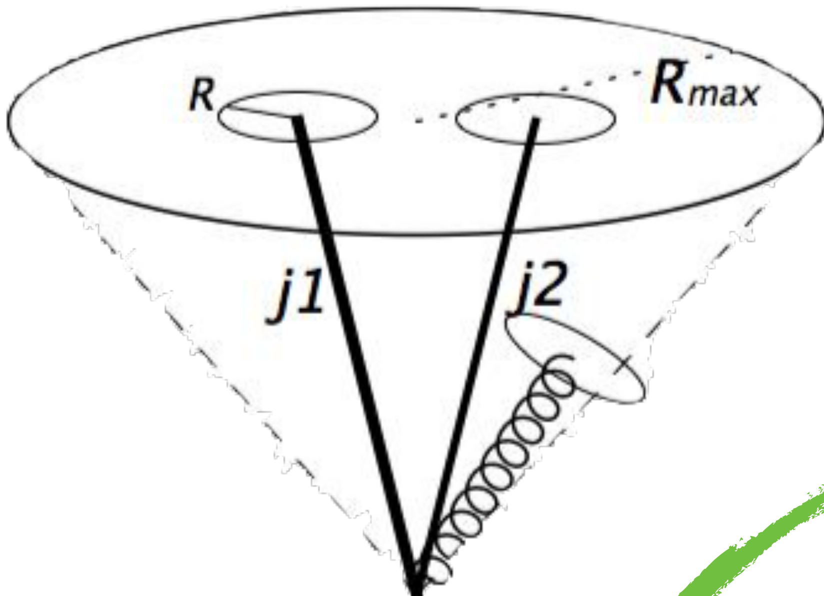

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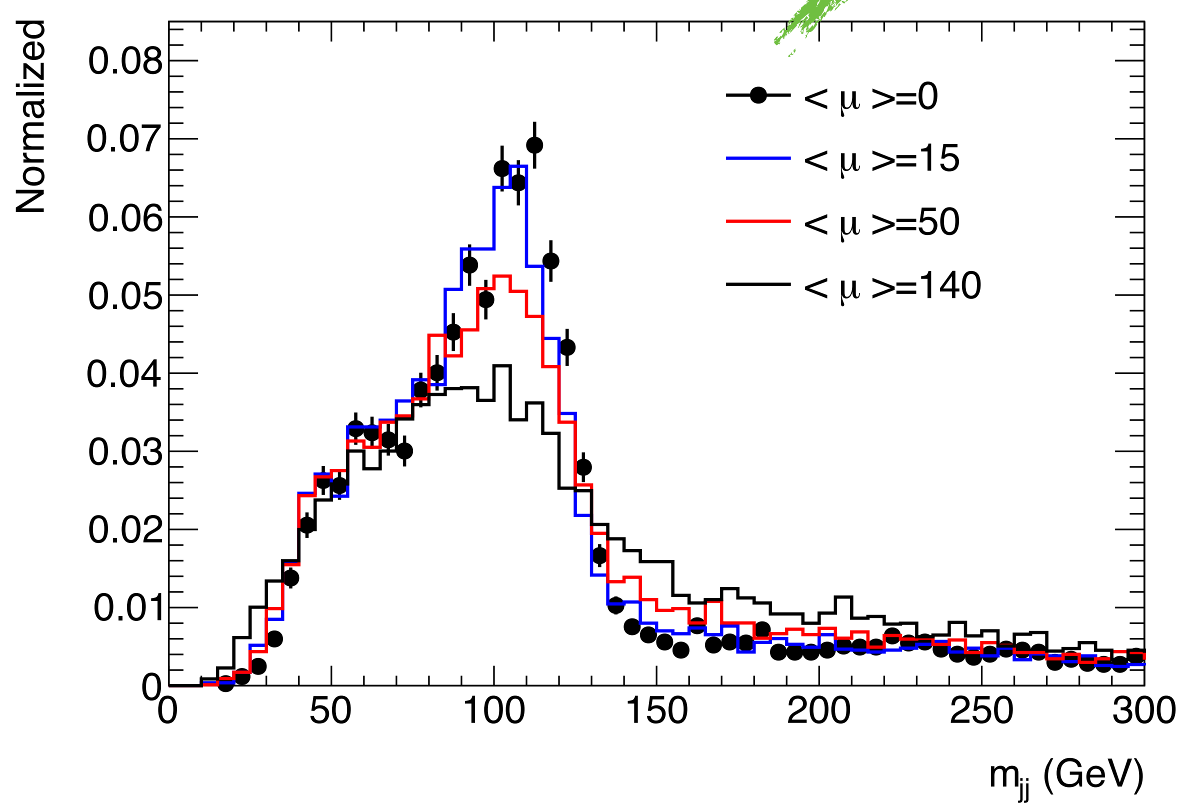

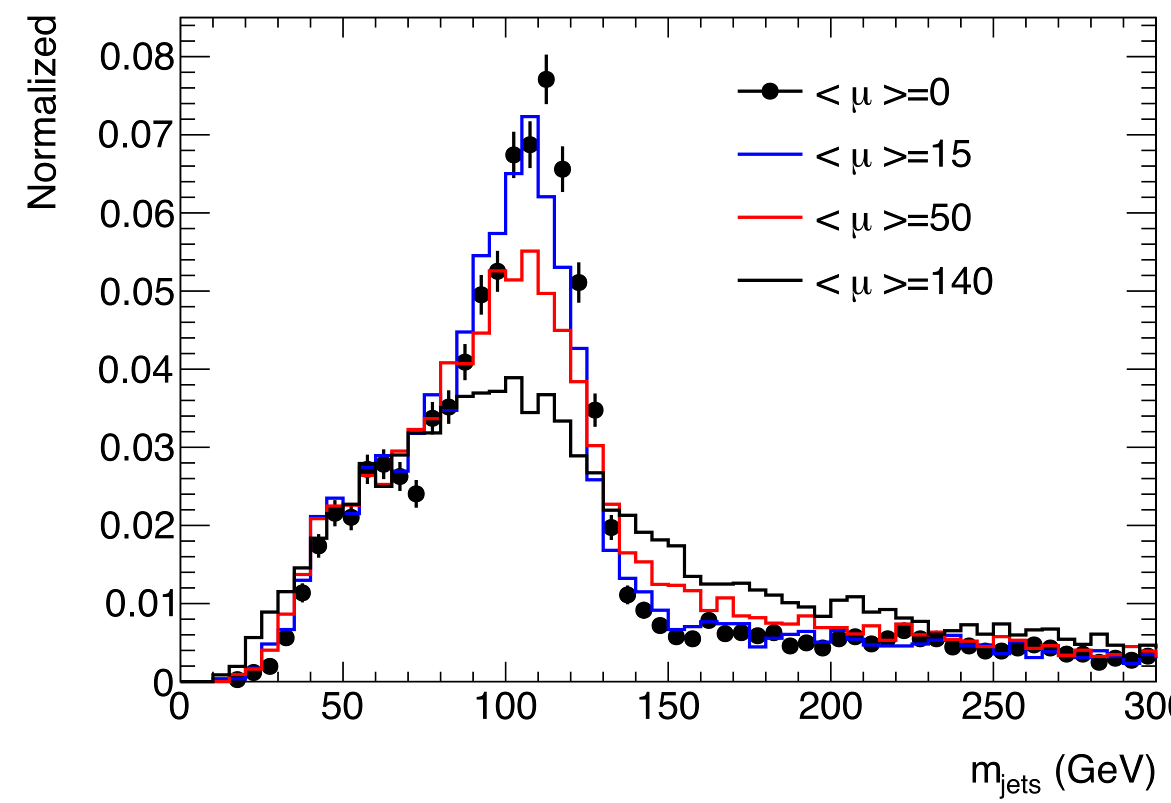

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Higgs Decay to Light Jets

Results

$$N = \sigma \times 3000\text{fb}^{-1}$$

σ (fb)	$\ell^+\ell^- + jj$	$\ell^\pm + \not{E}_T + jj$	$\not{E}_T + jj$	combined
Vh signal	7.0×10^{-2}	4.1×10^{-1}	3.6×10^{-1}	
Vjj background	2.4×10^{2}	2.5×10^{3}	1.6×10^{3}	
$\mathcal{S}$	0.25	0.61	0.49	0.82
$\mathcal{S}_{\text{sys}}$	0.09	0.17	0.17	0.26

$$\mathcal{S} = \frac{N_{\text{sig}}}{\sqrt{N_{\text{bkg}}}} \qquad \mathcal{S}_{\text{sys}} = \frac{N_{\text{sig}}}{\epsilon_B \times N_{\text{bkg}}}$$

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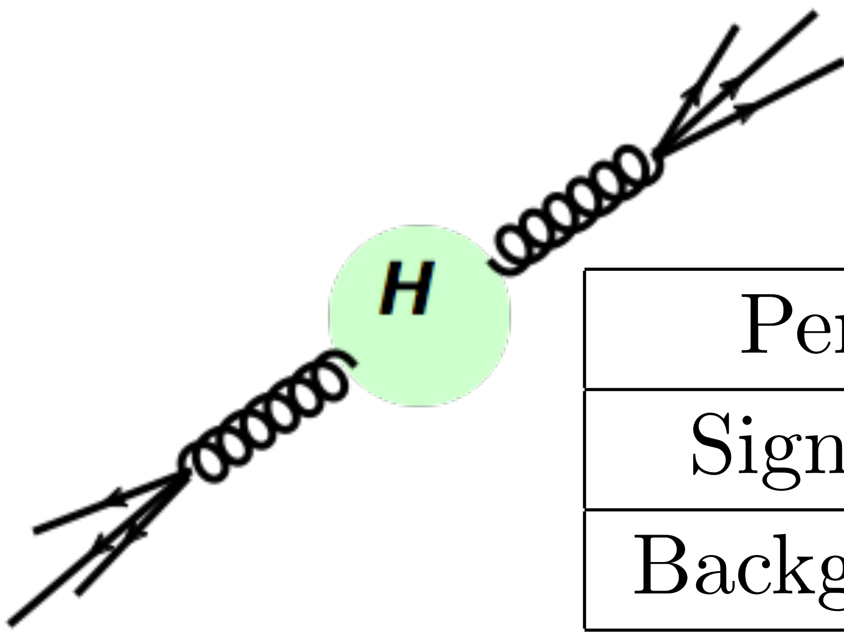
Higgs Decay to Gluon Pair

Improvements



Quark/Gluon Tagging

Percentage	qq	qg	gg
Signal $Zh[gg]$	0	0	100%
Background Zjj	9%	77%	14%

LO

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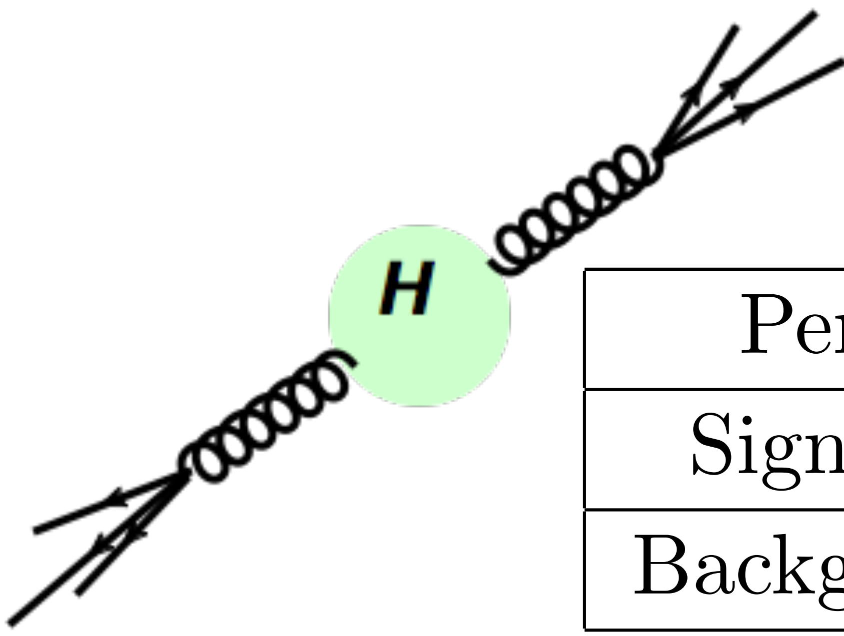
Improvements



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"Quark Jet Veto"

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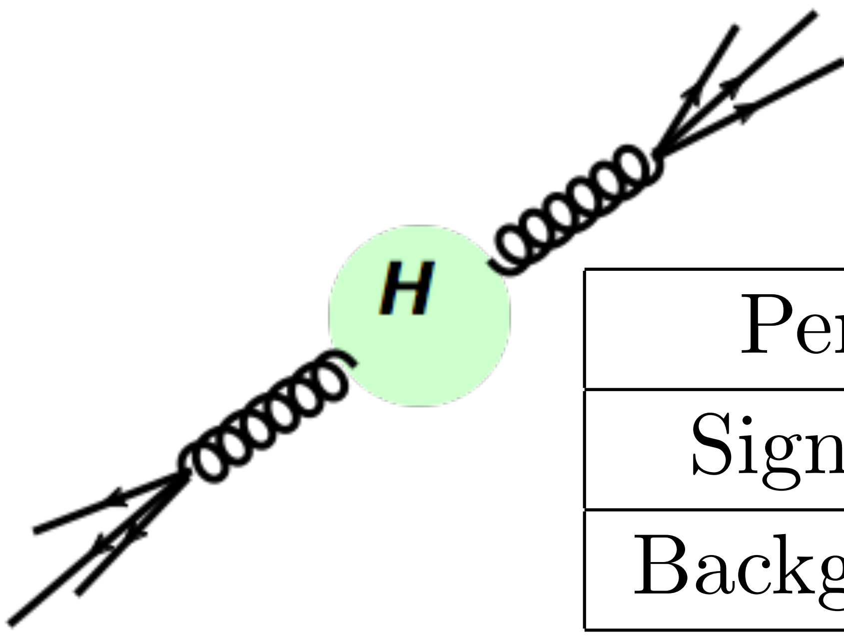

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LO

"Quark Jet Veto"

q-tagger	q	g	S	B	$S/\sqrt{B} - 1$
A	20%	5%	90%	77%	+3%
B	40%	10%	81%	56%	+8%
C	50%	15%	72%	45%	+8%
D	60%	25%	56%	32%	-1%
E	80%	50%	25%	12%	-26%

Thanks!

- Alone in pp>VH, H>jj channel, we expect ~1 sigma significance with 3000 fb-1 data (HL-LHC)

Thanks!