Testing Jet Azimuthal Correlations in VBF Topology:

with Tops & Bottoms

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Motivation in Brief

- Azimuthal correlations of tagged jets in Gluon fusion processes probe the tensor structure of the effective Hgg vertex and thus the CP nature of the dominant quark couplings (Htt). (Plehn, Rainwater, Zeppenfeld, Del Duca, Kilgore, Oleari, Schmidt, Figy....)

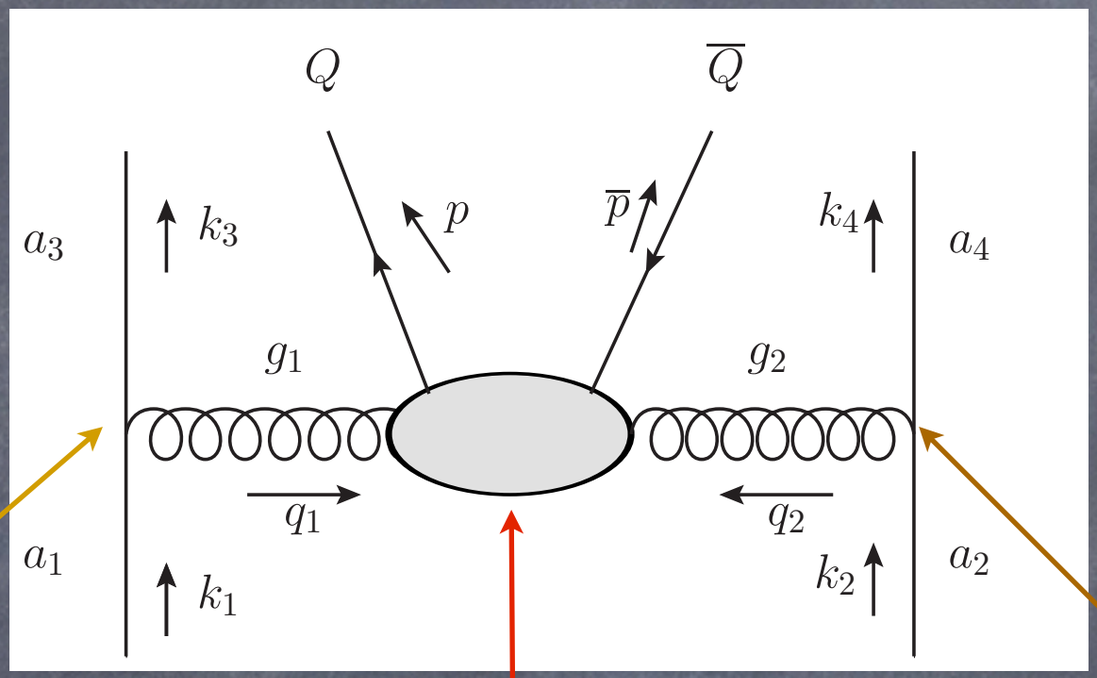
- Can we test this technique in standard QCD processes (sufficient cross-section @ 8 TeV) ?

- Bonus: useful in New Physics search

Which correlations to expect?

Use on-shell Gluon approximation

For Higgs and Massive Graviton: Hagiwara, Li, Mawatari



$$\hat{\mathcal{J}}^{+}_{++} = \frac{1}{z_1} e^{-i\phi_1}$$

$$\hat{\mathcal{J}}^{-}_{++} = -\frac{1-z_1}{z_1} e^{i\phi_1}$$

q/g current

q/g current

Central process:

Q=t,b

$$gg \to Q\overline{Q}$$

Use helicity amplitudes with on-shell gluons

Interference of intermediate gluon helicities

$\rightarrow$ correlations

General Azimuthal Correlation

$\varphi 1, \varphi 2$: azimuthal angles of j1,j2

$$\overline{\sum_{s,c}}|\mathcal{M}|^2 \propto [A_0 + A_1\cos(2\phi_1) + A_2\cos(2\phi_2)$$

$$+A_3\cos 2(\phi_1-\phi_2) + A_4\cos 2(\phi_1+\phi_2)]$$

$$A_i = f_i(\beta)g_i(\theta)F_i(z_1,z_2)$$

1. In the $\beta \to 0$ or 1 limit, $A_{1,2} \to 0$, and only one of A_3 or A_4 survives

2. $F_3=F_4$, same for qq,qg and gg initial states

Very simple limits

Threshold : $\beta \to 0$

$$\overline{\sum_{s,c}}|\mathcal{M}|^2 \propto [F_0 - 4F_3 \cos 2(\phi_1 - \phi_2)]$$

Relativistic : $\beta \to 1$

$$\overline{\sum_{s,c}}|\mathcal{M}|^2 \propto [F_0 - 4F_4 f(\theta) \cos 2(\phi_1 + \phi_2)]$$

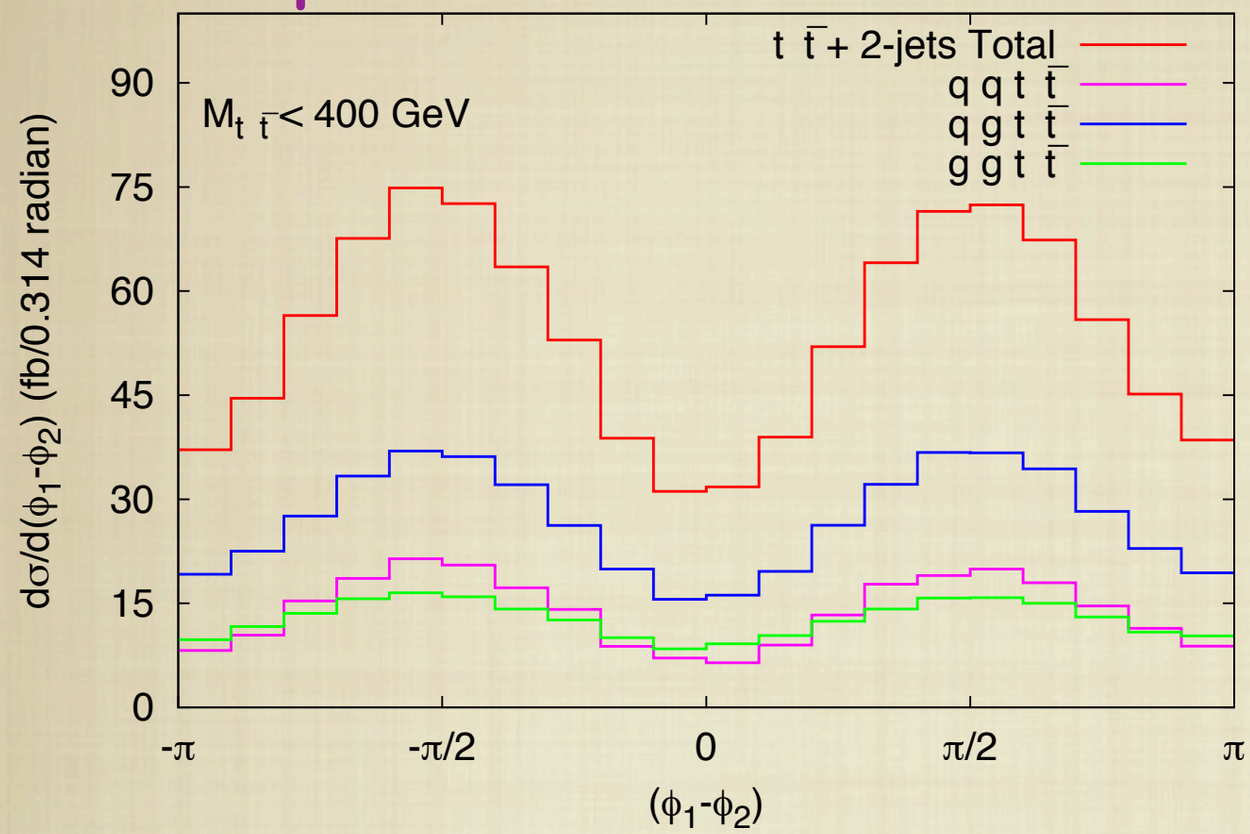
And, in soft t-channel gluon limit : $z_1, z_2 \to 0$

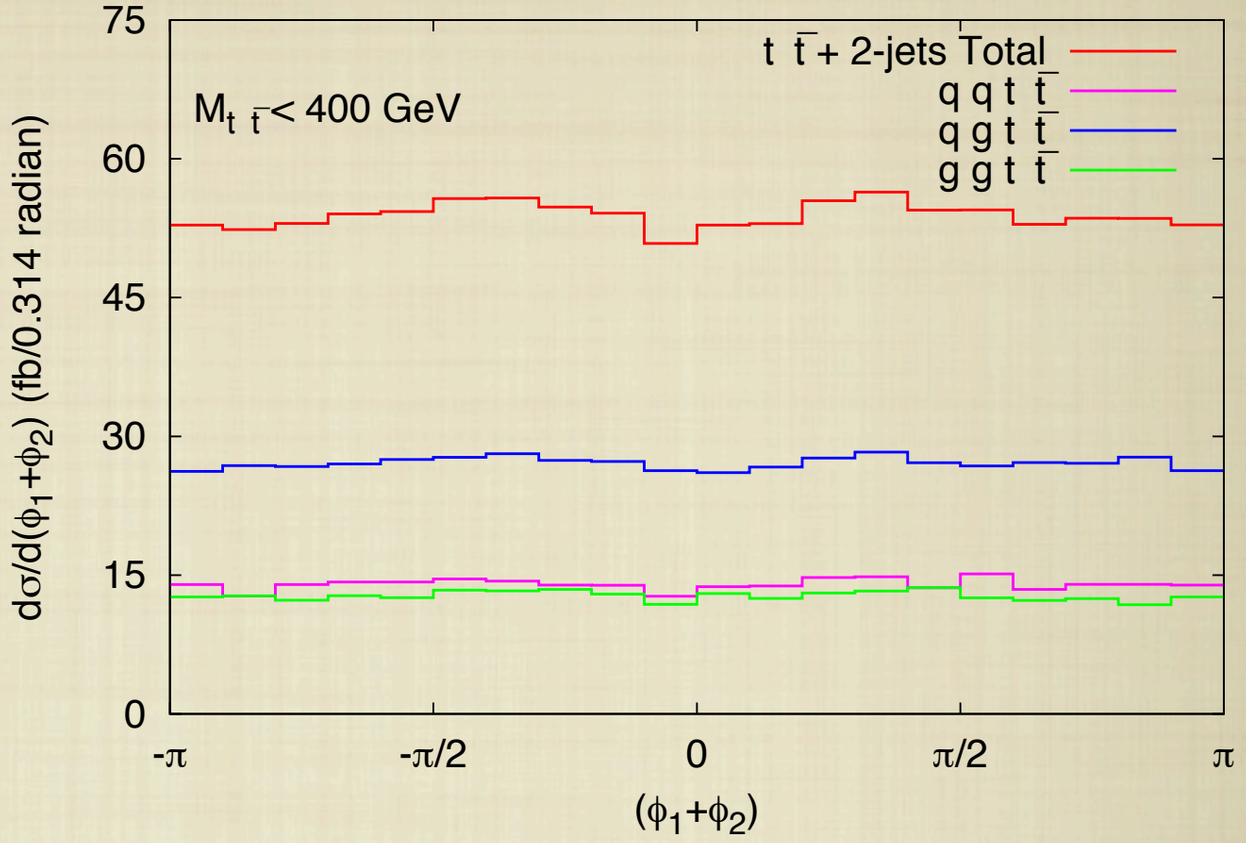
$$\frac{4F_3}{F_0}, \frac{4F_4}{F_0} \to 1$$

Hence, strong correlations expected

$t\bar{t}+2$-jets, 8 TeV LHC, Exact Matrix Element (Madgraph5)

Like Spin-0, CP-odd





$$\eta_{j_1} > 0 > \eta_{j_2}, \quad \Delta\eta_{jj} = \eta_{j_1} - \eta_{j_2} > 4$$

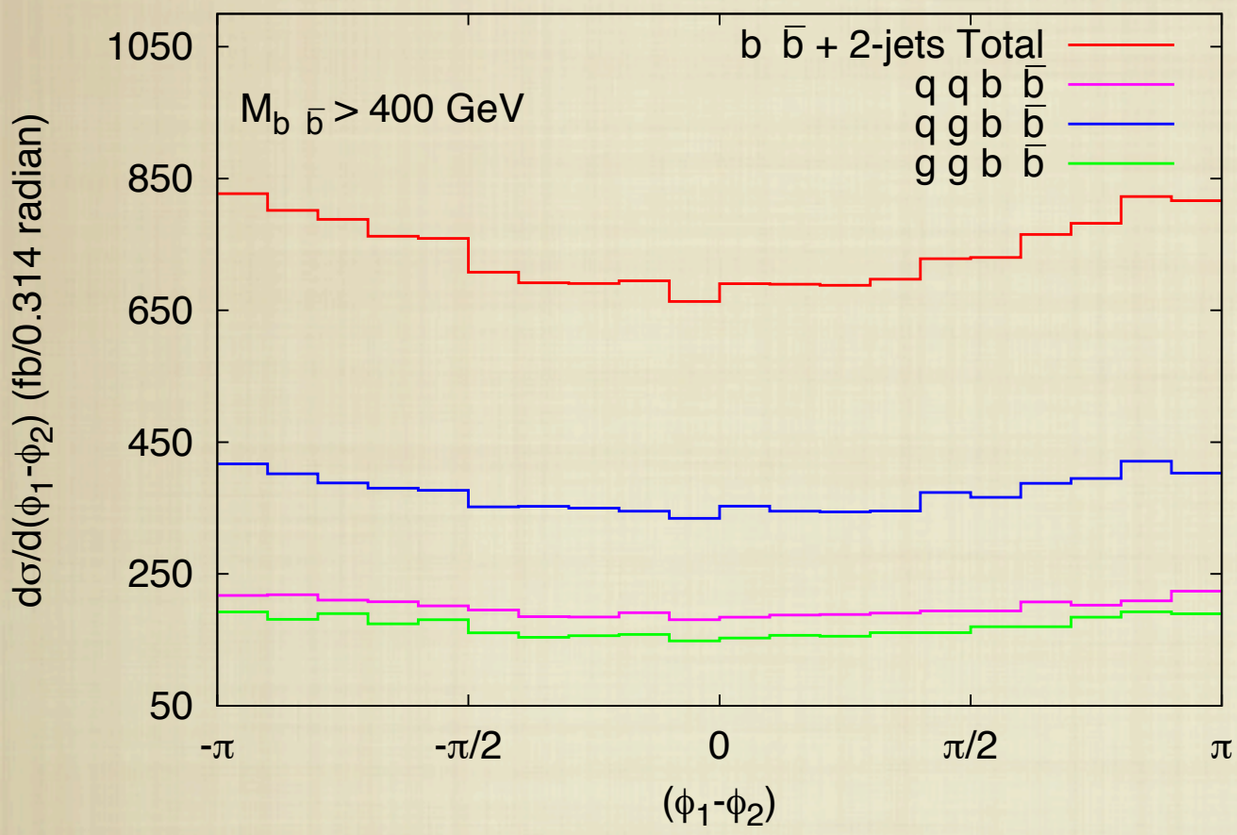
$$20\ \text{GeV} \leq p_T^j \leq 60\ \text{GeV}, \quad E_j \geq 250\ \text{GeV},$$

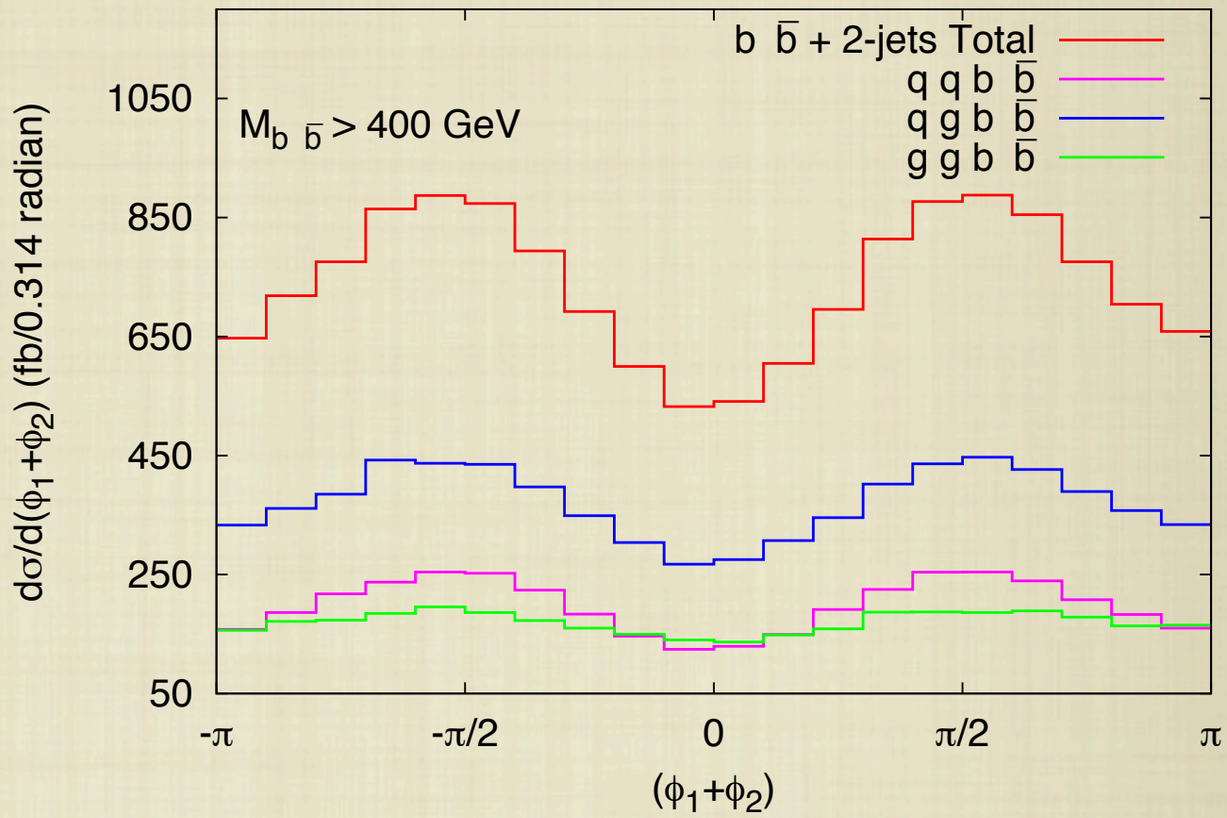
$$|\eta_j| \leq 5, \quad \Delta R_{j_1 j_2} \geq 0.6$$

σ~340 fb

$b\bar{b}$ + 2-jets, 8 TeV LHC, Exact Matrix Element (Madgraph-5)

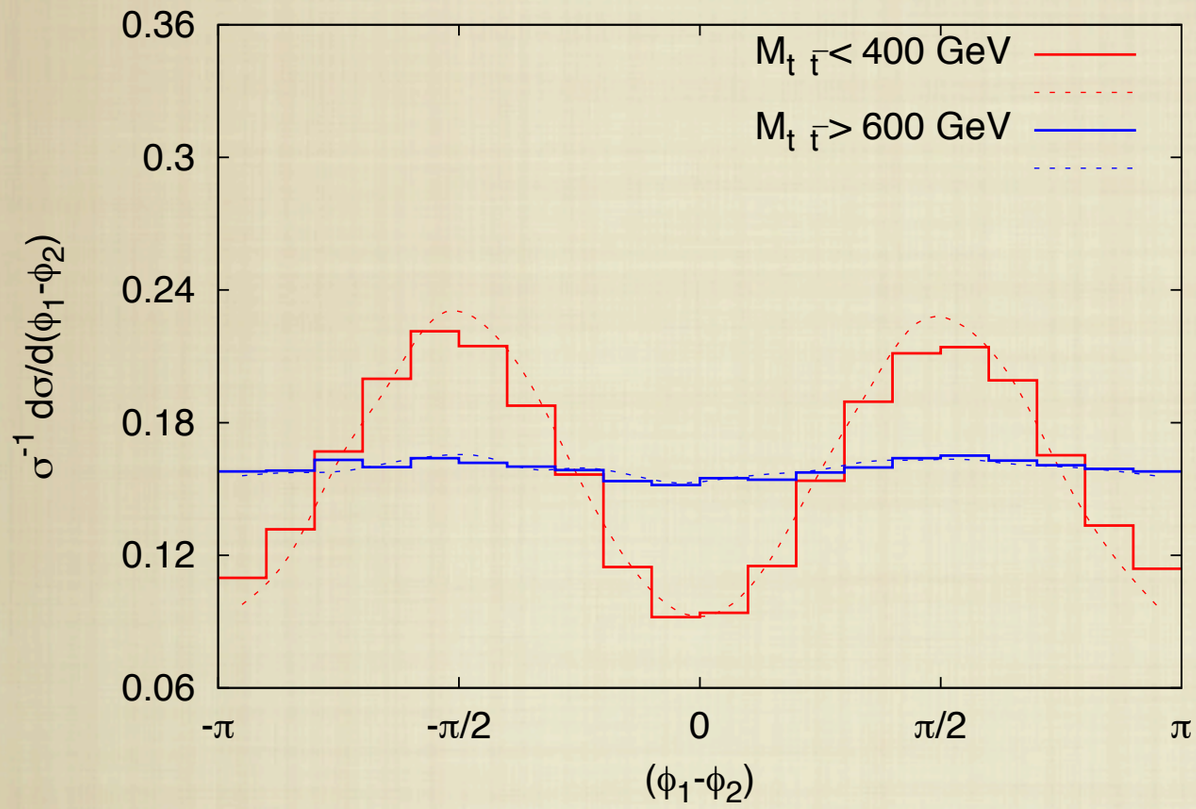
σ~4.6 pb

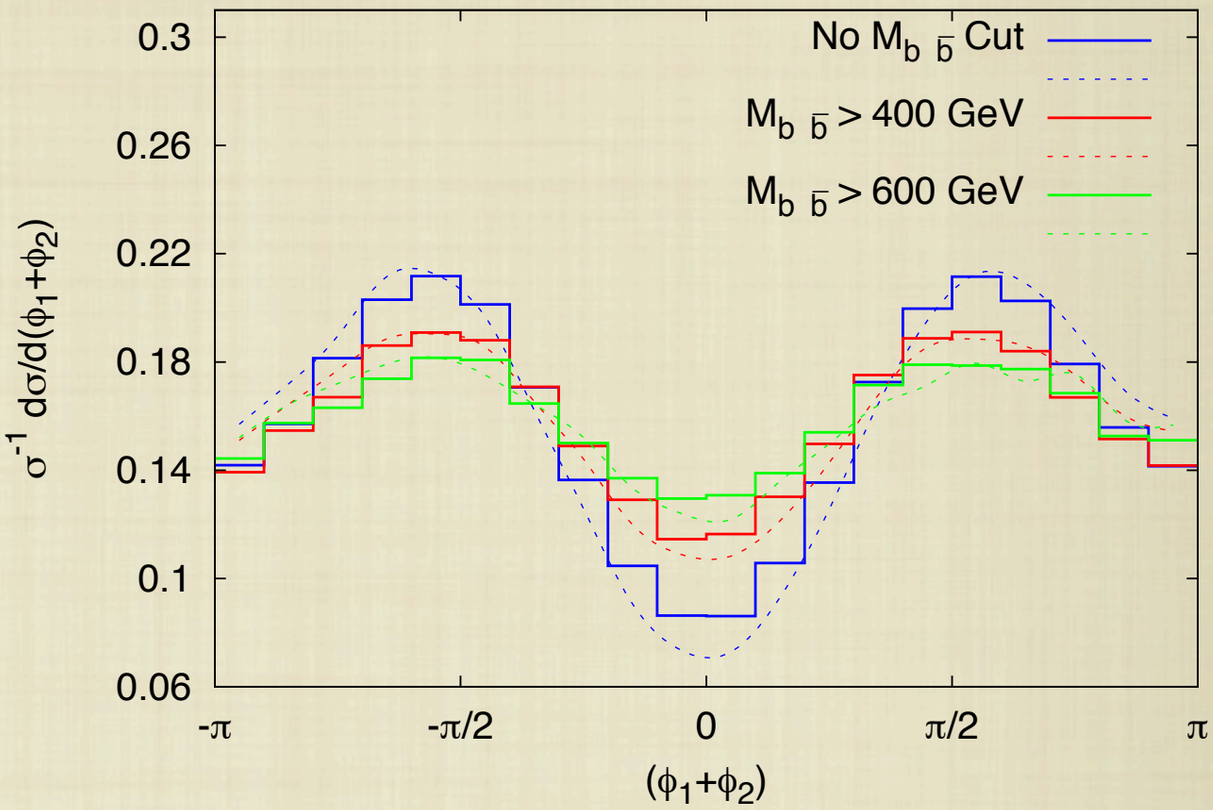




1. Distinct from spin-0 CP-odd or even
2. For $\varphi_1 + \varphi_2$, need to measure from the bottom quark reference azimuthal angle

Comparing the exact Matrix Element and On-shell Gluon Approximation





1. On-shell gluon approximation can predict the shapes very well in VBF topology
2. Total cross-section approaches the exact answer in the limit of low jet p_t

Next steps: ongoing work

- In the low-p_T region for the tagged jets, parton shower is important
- The exact ME is necessary to have the interference effects and hence correlations
- Working on the ME+PS matching
- Useful for background reduction in SUSY search: work in progress