



Property Measurements of Higgs-like Single Resonance at LHC

MELA and Spin Hypothesis Separation

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On behalf of CMS++

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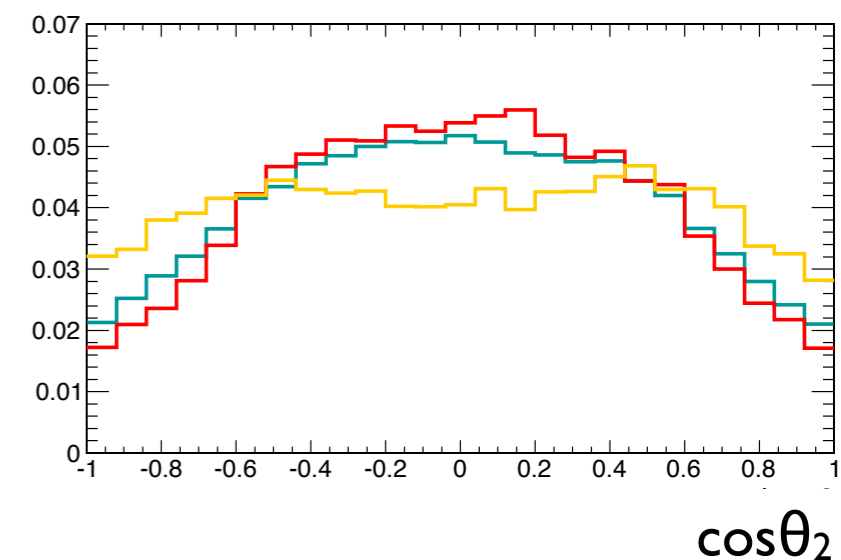
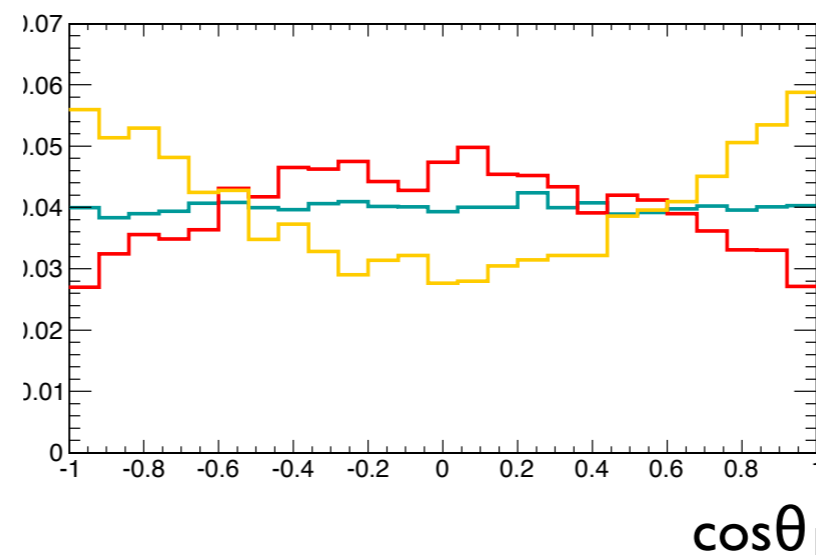
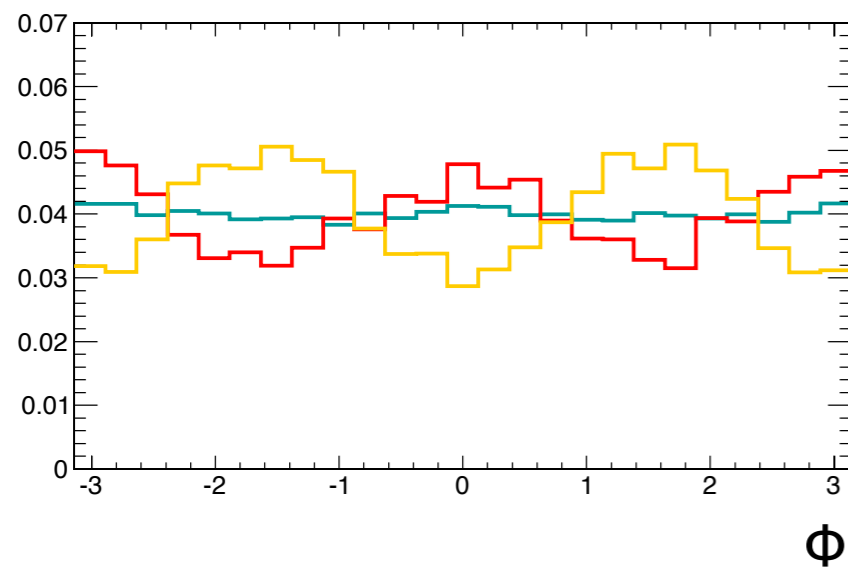
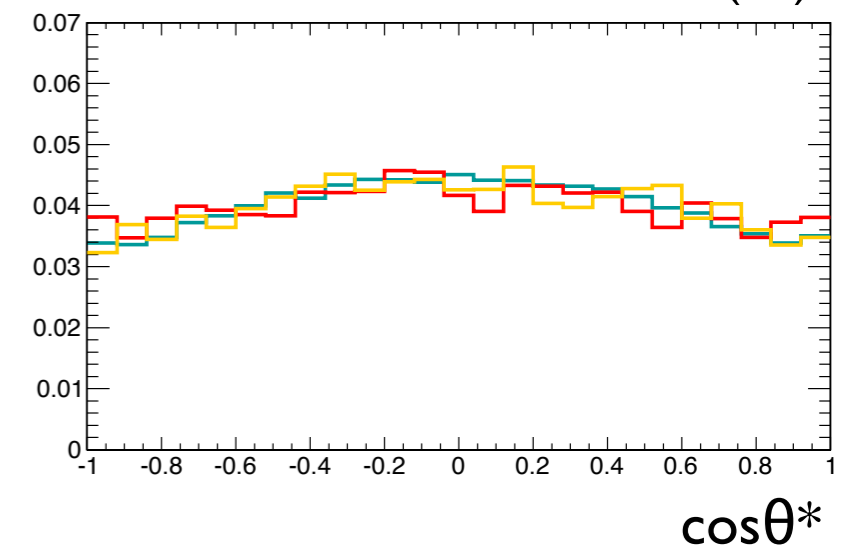
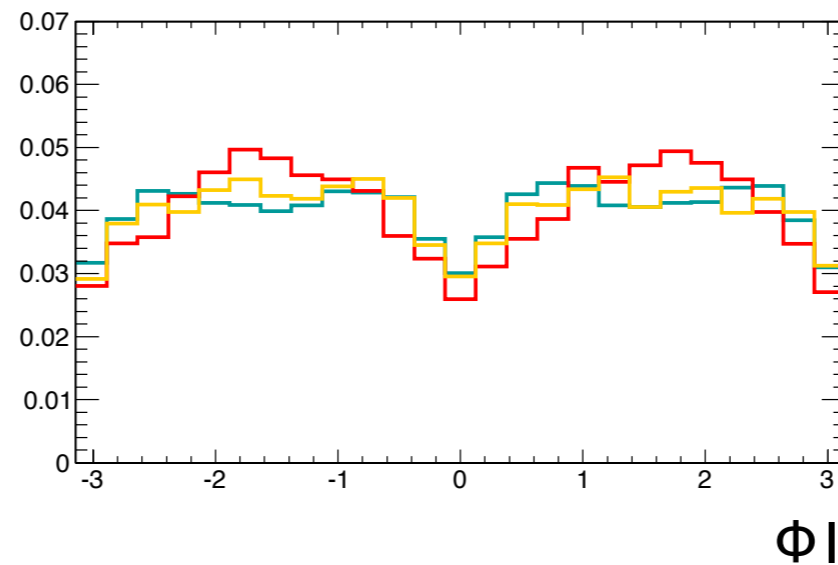
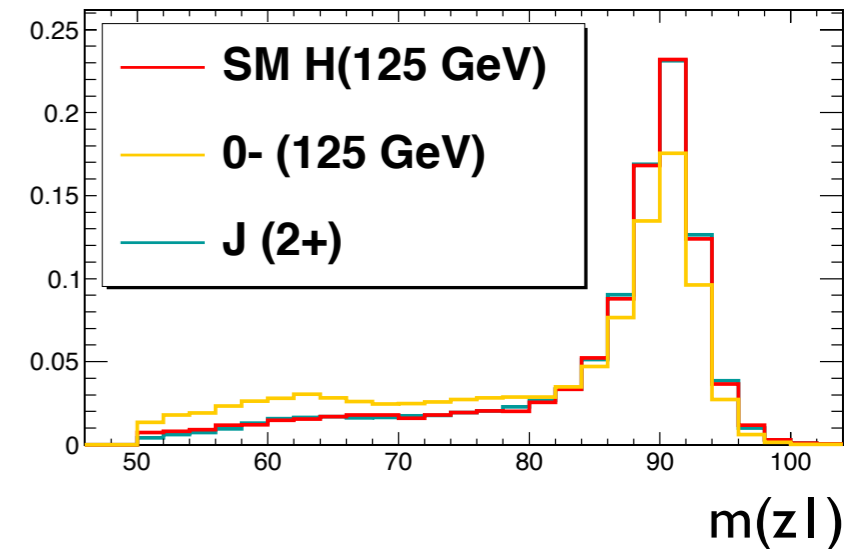
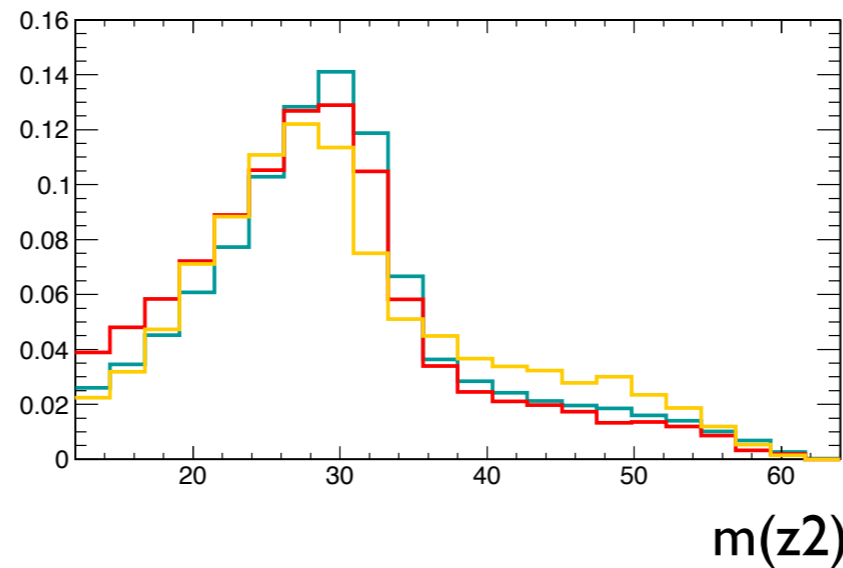
Spin/Parity Hypothesis Separations

$X \rightarrow ZZ \rightarrow 4l$ in CMS

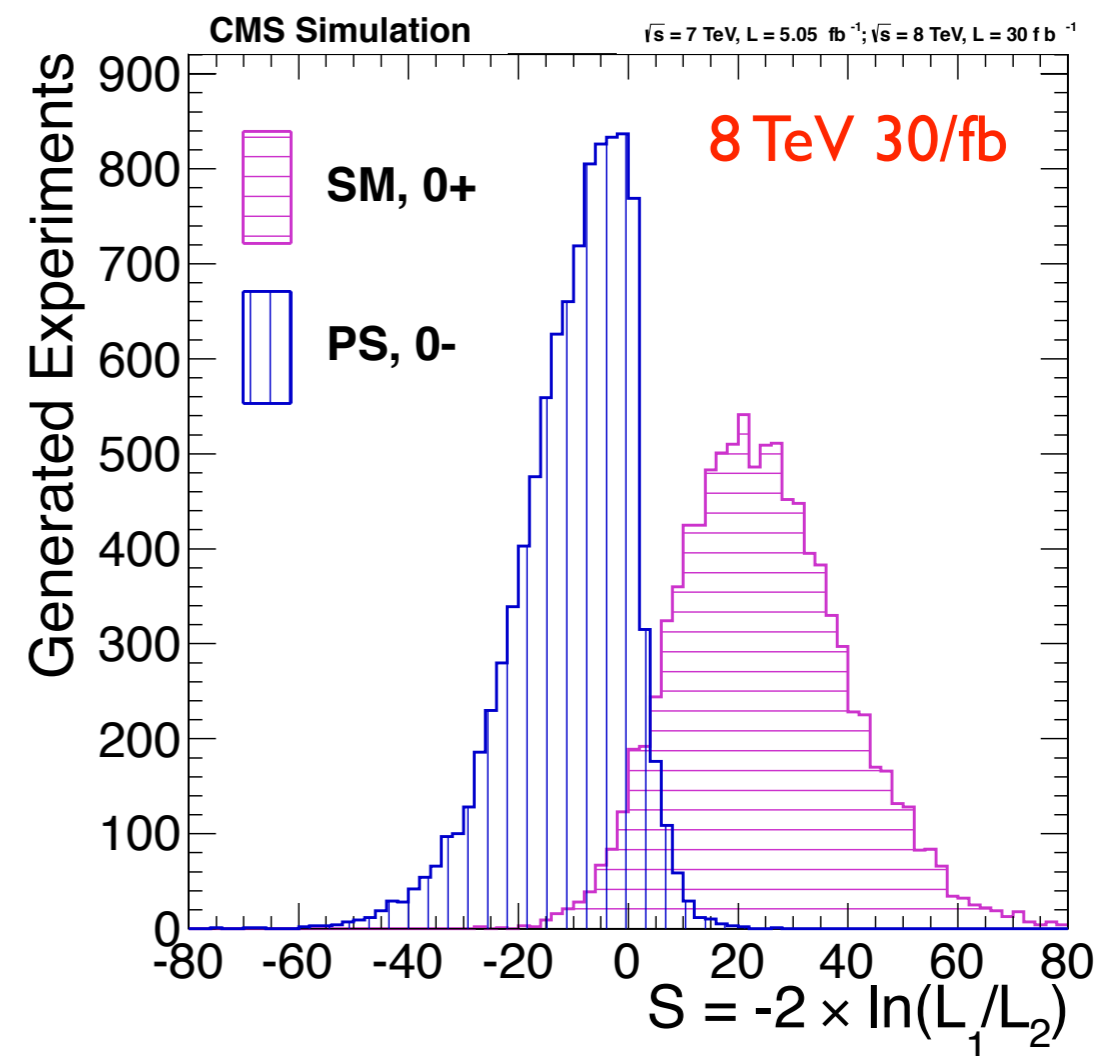
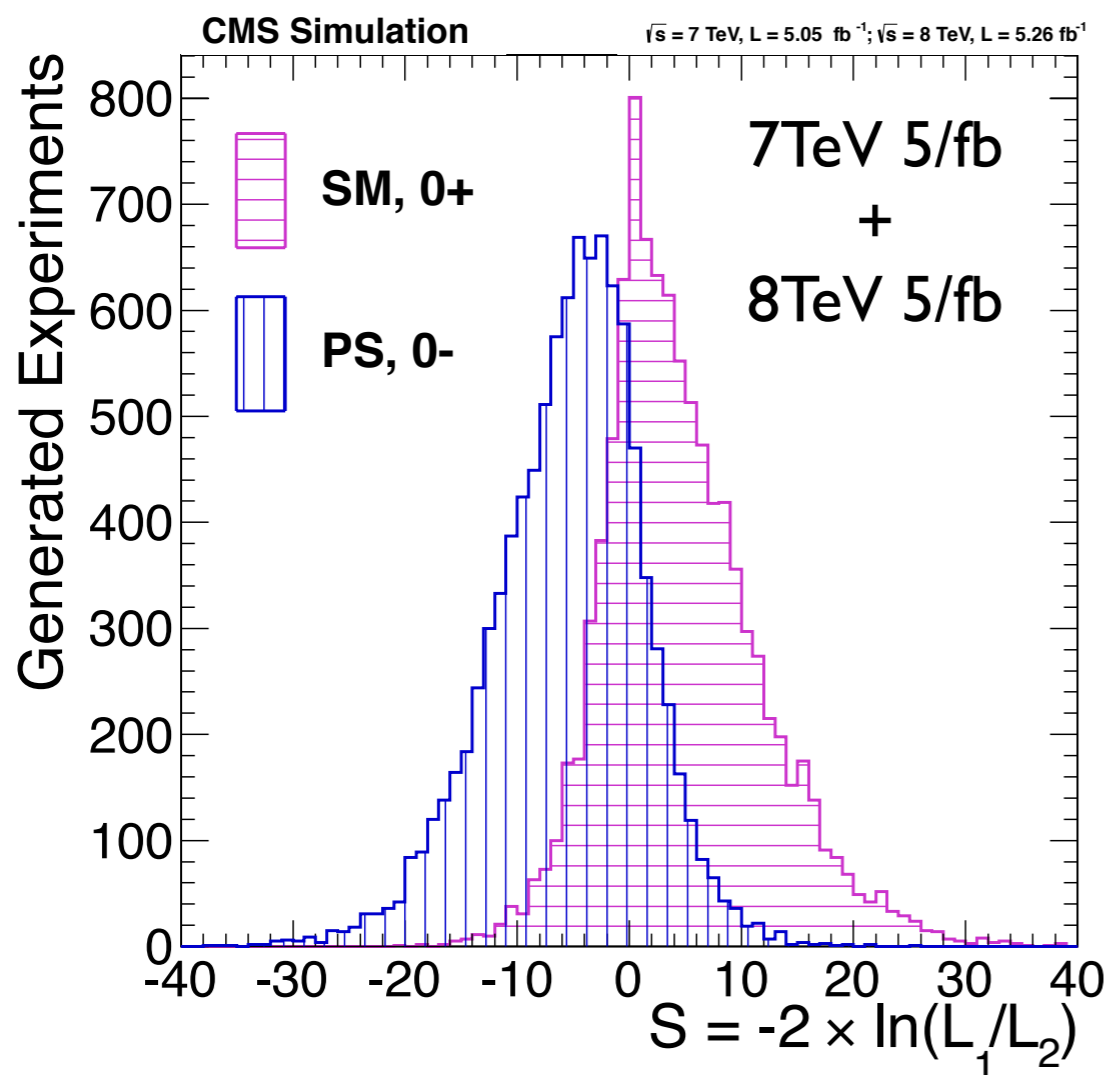
Kinematics for different spin/parity

- The full 7-D variables
 - Good separations between 0^+ and 0^-

Pseudo-data with CMS like detector resolutions



- PseudoMELA is fully implemented in CMS
 - **Current status:** 1.6 σ expected separation using 5/fb 7 TeV + 5/fb 8 TeV data
 - **Projections for 30/fb at 8 TeV:** $\sim 3 \sigma$ separation



Spin/Parity Hypothesis Separations

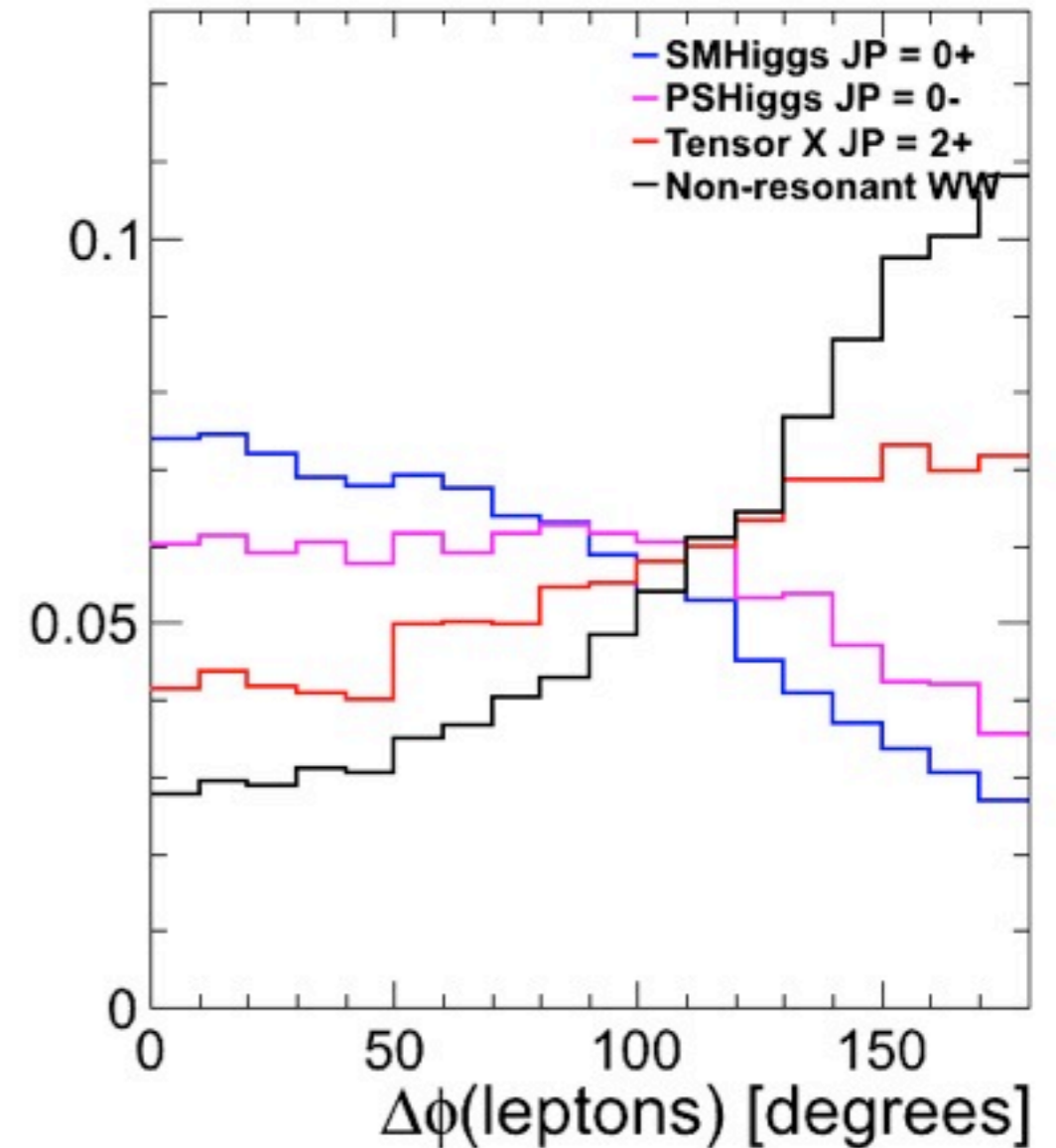
$$X \rightarrow WW \rightarrow (IV)(IV)$$

Generator level phenomenological studies

(not a CMS analysis)

The $X \rightarrow WW$ Analysis

- Due to the missing ν s, the WW final state is not fully reconstructible
 - No reconstructed resonance mass
 - The full angular distributions are not available
- Experimental variables can still be used to distinguish different spin/parity
 - For instance the **opening angle between the two leptons** carry important message
 - See also J.Ellis et al. [arXiv:1202.6660](https://arxiv.org/abs/1202.6660)
- The CMS/ATLAS analyses are optimized for the scalar resonance
 - The selections may not be suitable for the hypothesis tests



For spin-2 we consider the minimal coupling model

Explore more kinematic observables

- Select dilepton events with $p_T[20,10]$ and within $|\eta| < 2.5$

- Plots are normalized by area for the shape comparison

- Arrows indicate the shape-based analysis cuts in CMS

- For the XWW analysis

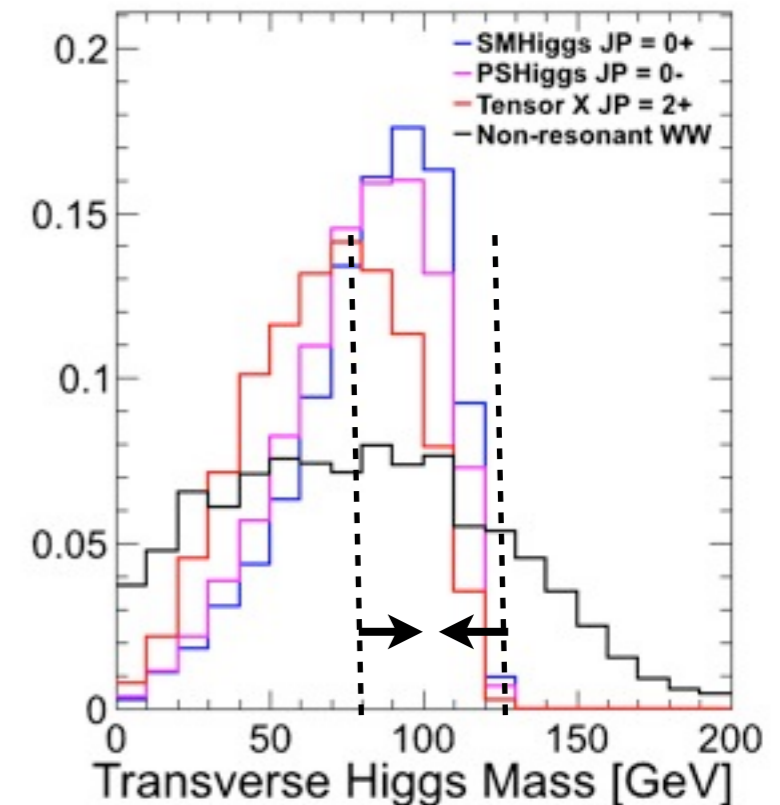
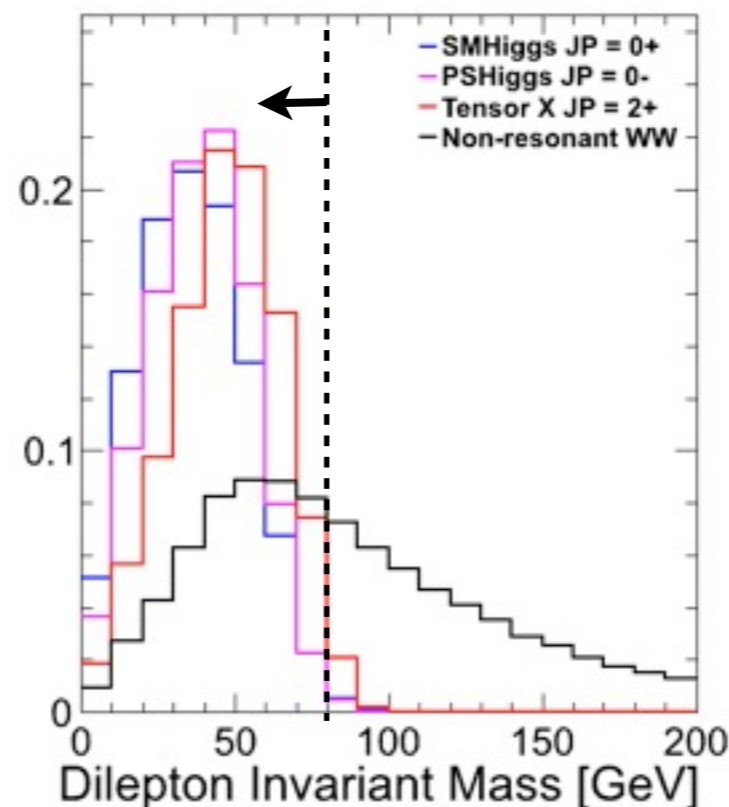
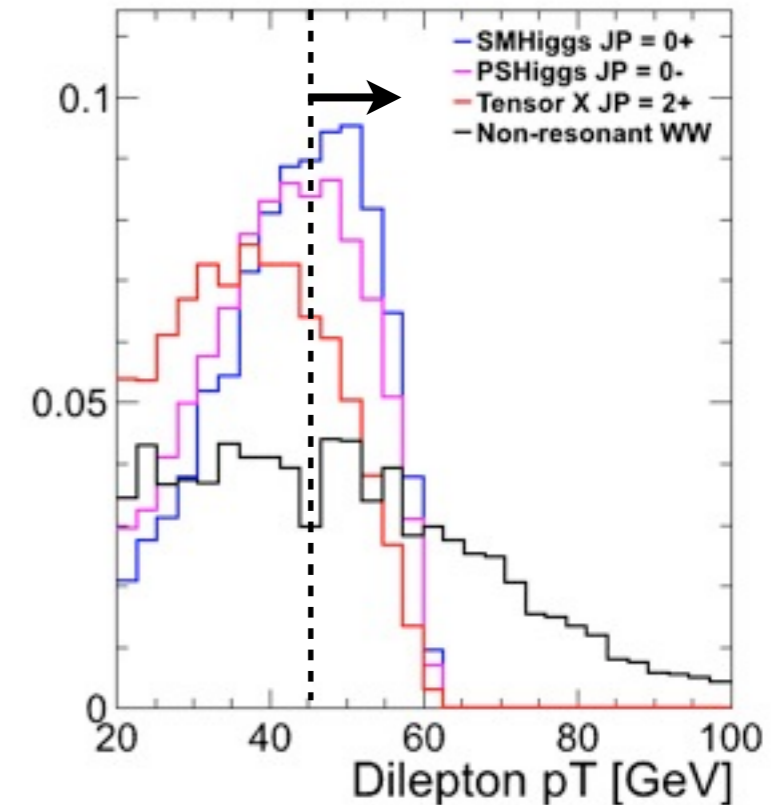
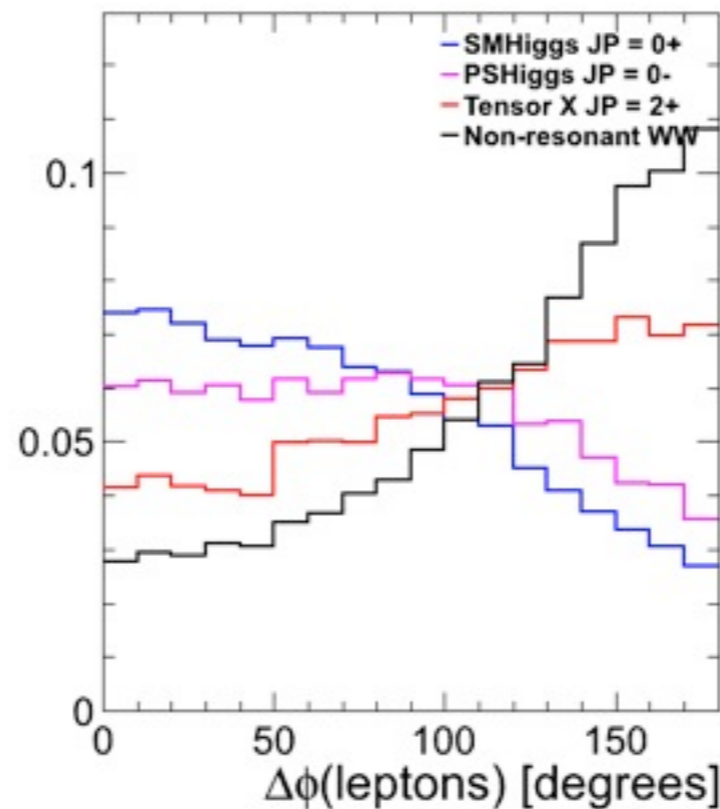
- Use only the purest channel, $e\mu$ events with 0 jets

- Relax cuts on dilepton p_T and MET and m_T

- For 10/fb at 8 TeV, we expect

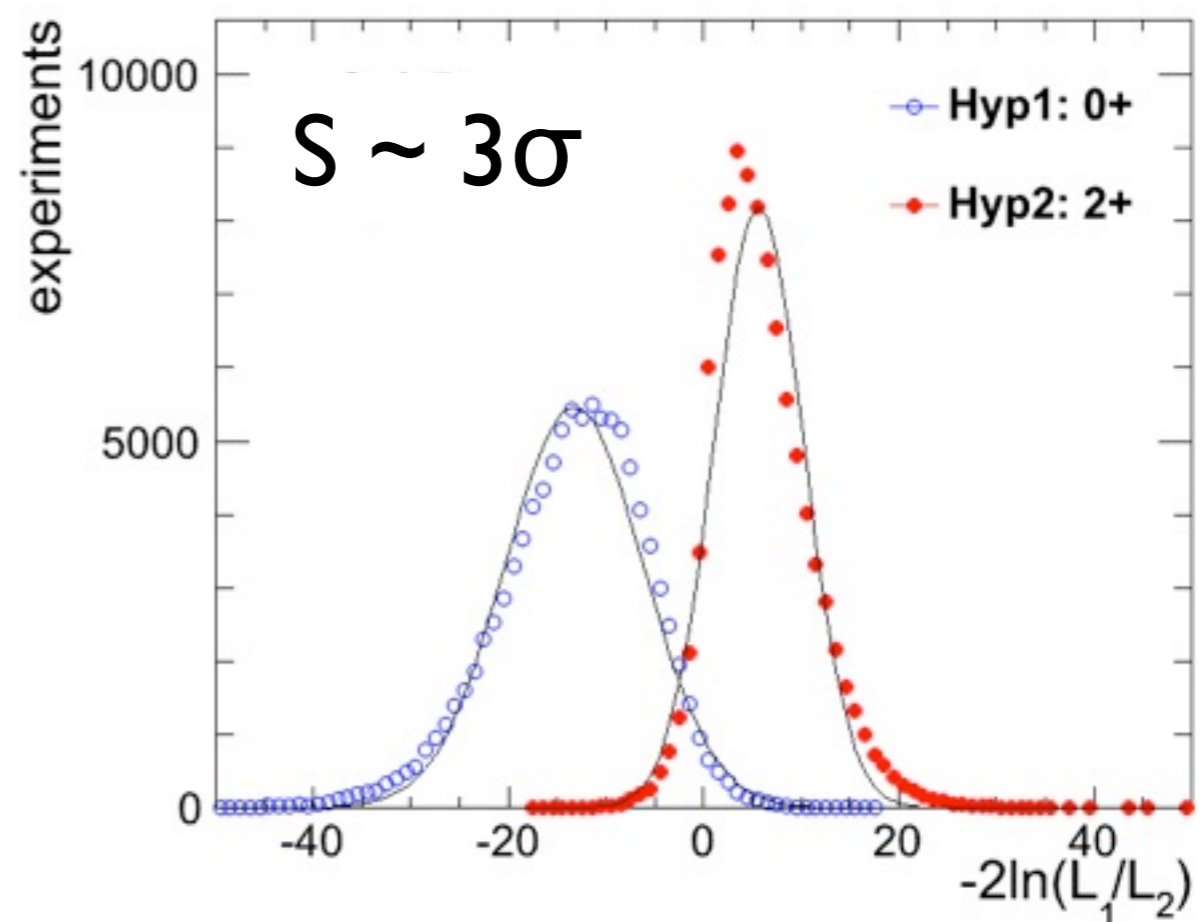
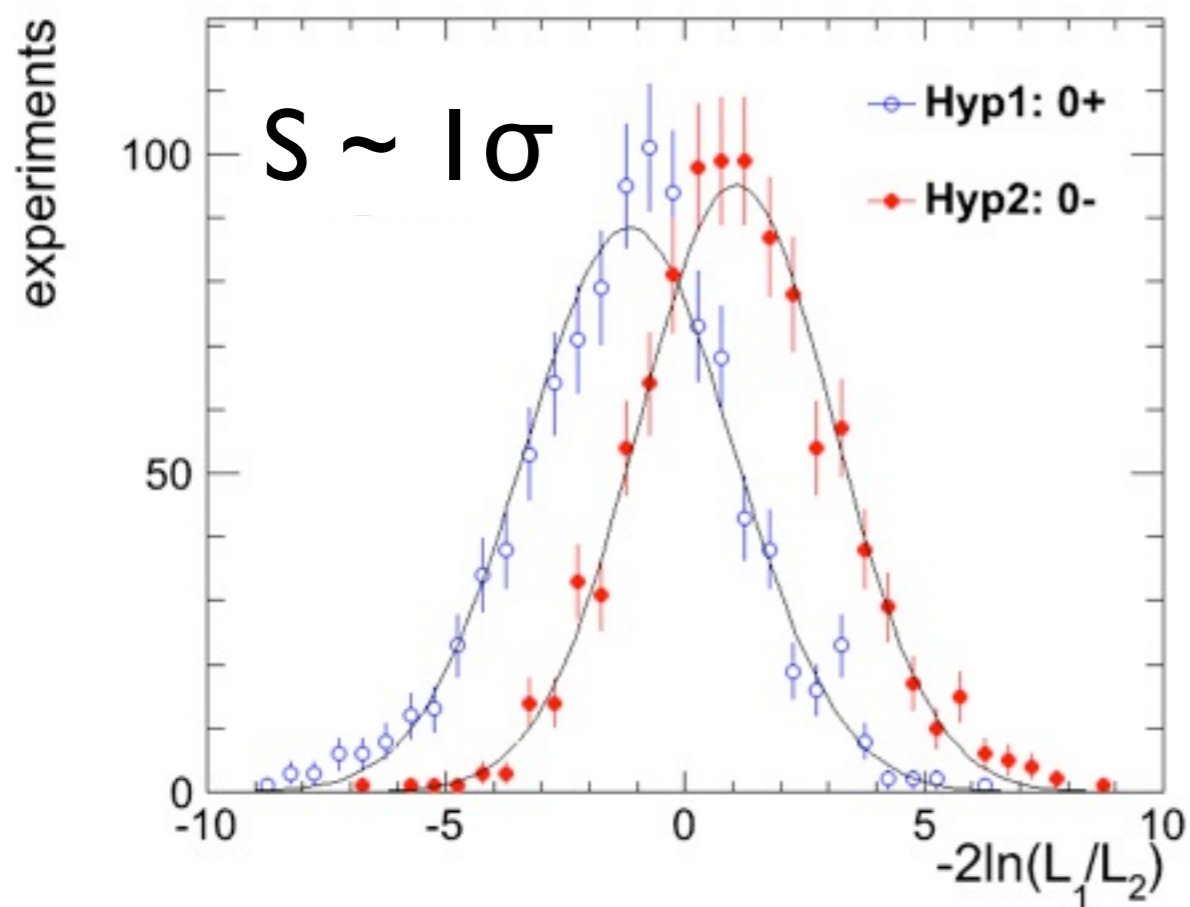
- 25 signal
- 250 background

- Assume it is all WW



Hypothesis Separation Results

- Consider an **ideal/optimistic scenario**
 - Ignore the systematics and assume the background is all WW
- Use the 2D template based on (mll, mT)
- For 10/fb we project $\sim 1\sigma$ separation for $0+$ vs $0-$, and $\sim 3\sigma$ for $0+$ vs $2+$
 - The separation between $0+/2+$ can reach $\sim 5\sigma$ with $\sim 30/\text{fb}$ data in this optimistic case
 - **Systematics and other bkgd will degrade the performance. By how much needs future studies.**



Summary and Conclusions

- We reviewed the status of hypothesis separations for $X \rightarrow ZZ \rightarrow 4l$ using MELA in CMS
 - Expected 0^+ vs 0^- separation at 1.6σ with current data, and $\sim 3 \sigma$ for 30/fb data
- We introduced similar analysis for the $X \rightarrow WW \rightarrow (lv)lv$ based on GEN quantities
 - Using variables (m_{ll} , m_T) this channel has promising sensitivity of 0^+ and $2m^+$ separations
 - With 30/fb data with ideal condition, we expect $\sim 5\sigma$ separation
 - **WARNING: consider only GEN quantities and ignore non-WW background or systematics**
 - The sensitivity is expected to get significantly degraded including the systematics and other non-WW background
 - The extent of how much needs to be evaluated carefully in a realistic LHC analysis