Search for Supersymmetry in Vector Boson Fusion Topology using proton-proton collisions at √s = 8 TeV

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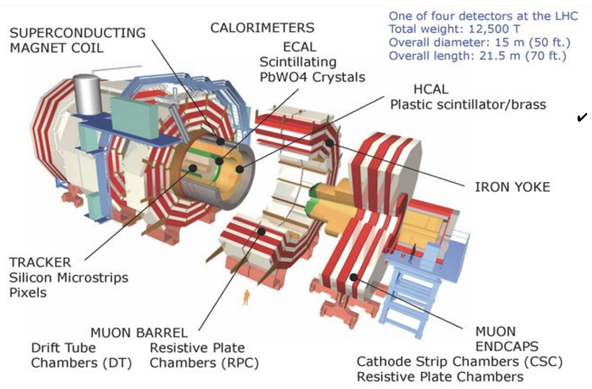
- The biggest success of Standard Model(SM) is the discovery of **Higgs Boson.**
- Some mysteries are yet to be explained : **Neutrino oscillations, Matter-antimatter asymmetry, Dark Matter, weakness of gravity .**
- Possible extension of symmetry beyond Lie symmetries : **Supersymmetry** relates every SM particle to its corresponding superpartner.
- In R-Parity conserving models, SUSY particles are produced in pairs.

$$R_p = (-1)^{3(B-L)+2S} \begin{cases} = 1 & \text{-> SM particles} \\ = -1 & \text{-> SUSY particles (produced in pairs)} \end{cases}$$

- SUSY searches focus on colored sectors due to large x-section.
- Limits the gluions / 1st and 2nd generation squarks to few TeV.
- Limits on charginos/neutralinos are relatively weaker in compressed mass spectra
- Lightest Supersymmetric particle is stable and gives rise to imbalance in E_T^{miss} .

CMS Detector

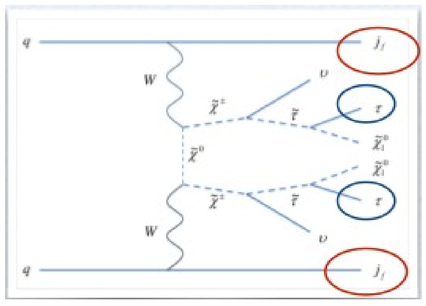


- Multipurpose detector to search for new physics at √s = 13 TeV.
- Designed to measure the energy and momentum of particles.
- Detecting Muons is crucial task of CMS.
- Measure charged particles in $|\eta| < 2.5$.

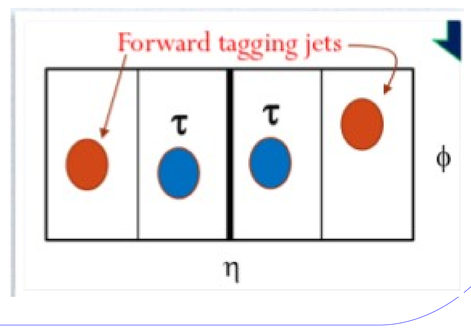
Vector Boson Fusion (VBF) Topology

- **Experimental Signature of VBF processes are :**

- 2 lepton/Jets in final state.
- Large Missing transverse energy.
- Two highly energetic jets with large dijet mass in opposite hemispheres (large pseudorapidity gap).



- VBF topology provides a complementary probe to look for compressed mass spectra.
- Suppress backgrounds by a large factor.



Analysis Strategy

- Search performed with 8 TeV data corresponding to an intergrated luminosity used is **19.7 fb^{-1}.**

2 leptons + 2 jets and E_t^{miss} (final state)

8 Final States
1.) eμjj (OS/LS)
2.) μμjj (OS/LS)
3.) μ$\tau_h$jj (OS/LS)
4.) $\tau_h\tau_h$jj (OS/LS)

Single Muon Trigger

Double hadronic τ Trigger

Central Selections

- Lepton pair with $|\eta| < 2.1$ GeV $\Delta R(l_1, l_2) > 0.3$.
- E_t^{miss} > 75 GeV (> 30 GeV only for $T_h\tau_h$jj .)
- No B-jet .

VBF Selections

- ≥ 2 jets with pt > 30/50 GeV (loose/Tight) and $|\eta| < 5.0$
- $\Delta\eta > 4.2$ and $(\eta_1 * \eta_2) < 0$
- $M_{jj} > 250$ GeV.

Background Estimation

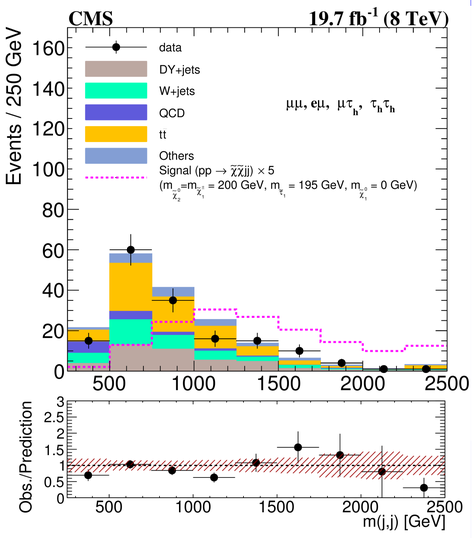
- Main backgrounds are : **W+jets, Ttbar, VV and QCD.**
- Control and signal regions are defined in order to reduce backgrounds with some modification in nominal selections cuts.

- Isolate control regions to measure VBF efficiency and M_{jj} shapes from data and validate central selections.
- Control Regions should not bias M_{jj} distribution.
- Backgrounds in signal region are estimated by data using the equation :

$$N_{BG}^{Data} = N_{BG}^{MC}(central) \cdot SF_{central}^{CR1} \cdot \epsilon_{VBF}^{CR2}(m_{jj})$$

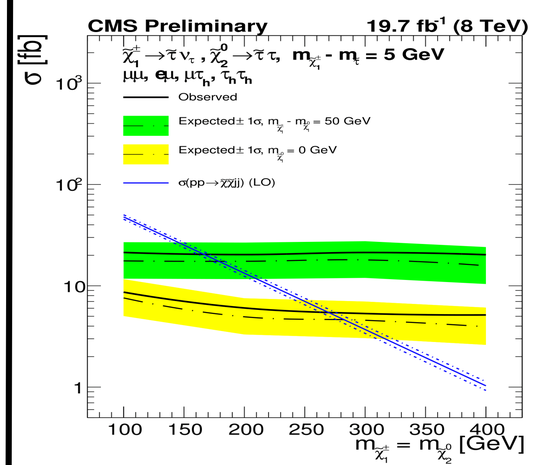
- VBF efficiency is measured in CR after central selections .

- Observed Dijet invariant mass consistent with BG's predictions



Combined Mjj for all final states

Results & Conclusio



Combined 95% C.L. upper limits on signal cross-section as a function of

$$m_{\tilde{\chi}_2^0} = m_{\tilde{\chi}_1^\pm}.$$

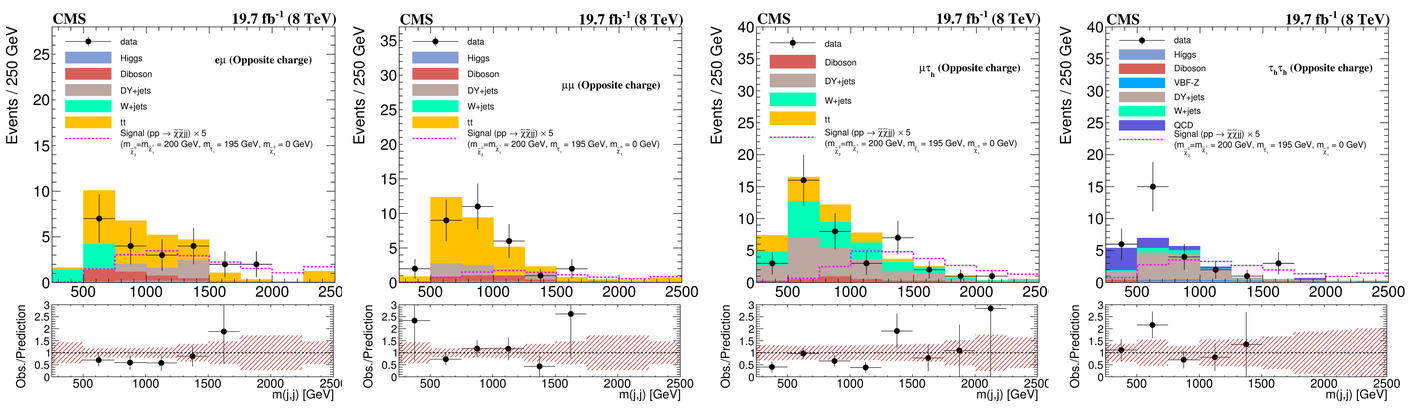
OS event yield

Process	$\mu^\pm\mu^\mp jj$	$e^\pm\mu^\mp jj$	$\mu^\pm\tau_h^\mp jj$	$\tau_h^\pm\tau_h^\mp jj$
Z+jets	4.3 ± 1.7	$3.7^{+2.1}_{-1.9}$	19.9 ± 2.9	12.3 ± 4.4
W +jets	<0.1	$4.2^{+3.3}_{-2.5}$	17.3 ± 3.0	2.0 ± 1.7
VV	2.8 ± 0.5	3.1 ± 0.7	2.9 ± 0.5	0.5 ± 0.2
$t\bar{t}$	24.0 ± 1.7	$19.0^{+2.3}_{-2.4}$	11.7 ± 2.8	–
QCD	—	—	—	6.3 ± 1.8
Higgs boson	1.0 ± 0.1	1.1 ± 0.5	—	1.1 ± 0.1
VBF Z	—	—	—	0.7 ± 0.2
Total	32.2 ± 2.4	$31.1^{+4.6}_{-4.1}$	51.8 ± 5.1	22.9 ± 5.1
Observed	31	22	41	31

LS event yield

Process	$\mu^\pm\mu^\pm jj$	$e^\pm\mu^\pm jj$	$\mu^\pm\tau_{\tau_h}^\pm jj$	$\tau_{\tau_h}^\pm\tau_{\tau_h}^\pm jj$
Z+jets	<0.1	$0^{+1.7}_{-0}$	0.5 ± 0.2	<0.1
W +jets	<0.1	$0^{+3.0}_{-0}$	9.3 ± 2.3	0.5 ± 0.1
VV	2.1 ± 0.3	$1.9^{+0.4}_{-0.2}$	1.1 ± 0.2	$0.1 \pm 6.5 \times 10^{-2}$
$t\bar{t}$	3.1 ± 0.1	$3.5^{+0.7}_{-0.9}$	6.7 ± 2.8	$0.1 \pm 1.2 \times 10^{-2}$
Single top	—	—	—	<0.1
QCD	—	—	—	7.6 ± 0.9
Higgs boson	—	—	—	<0.1
Total	5.4 ± 0.3	$5.4^{+3.5}_{-0.9}$	17.6 ± 3.8	8.4 ± 0.9
Observed	4	5	14	9

Invariant Mass distribution in various final states



References

[1] CMS Collaboration, Search for supersymmetry in the vector-boson fusion topology in proton-proton collisions at √s = 8 TeV (JHEP11 189, 2015).

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