


# Vector boson scattering at CMS (LHC)

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# Why WW-fusion?

$V_L V_L$ scattering is very sensitive to EWSB:

SM predicts that without a Higgs the scattering amplitude violates unitarity at about ~1.2 TeV:

- Higgs case: resonance at $M_{WW} = M_H$
- No Higgs case: new dynamics MUST appear

<u>Model Independent Study of the VV-fusion channel:</u>

- Which resolution on $\sigma$ vs $M_{WW}$ ?
- What is the range of $M_{WW}$ that we can explore?

# Preliminary study

$pp \rightarrow qqWW \rightarrow qq\mu\nu qq$ (Highest BR + clear signature)

Signal generated with PYTHIA (50k):

- $M_H$ = 500 GeV – 750 GeV – 1000 GeV
- No Higgs case ($M_H$ = 2000 GeV – 10000 GeV)
- $\sigma \approx 2 \times 10^{-2} \div 6 \times 10^{-2}$ pb

Fast Detector Simulation: CMSJET (No PU)

Considered background:

| | | |
|---|---|---|
| • ttbar | (PYTHIA) | $\sigma \approx 624$ pb |
| • WW | (PYTHIA) | $\sigma \approx 11$ pb |
| • W+jj | (CompHEP) | $\sigma \approx 77$ pb |
| • Single W | (PYTHIA) | $\sigma \approx 185 \times 103$ pb |

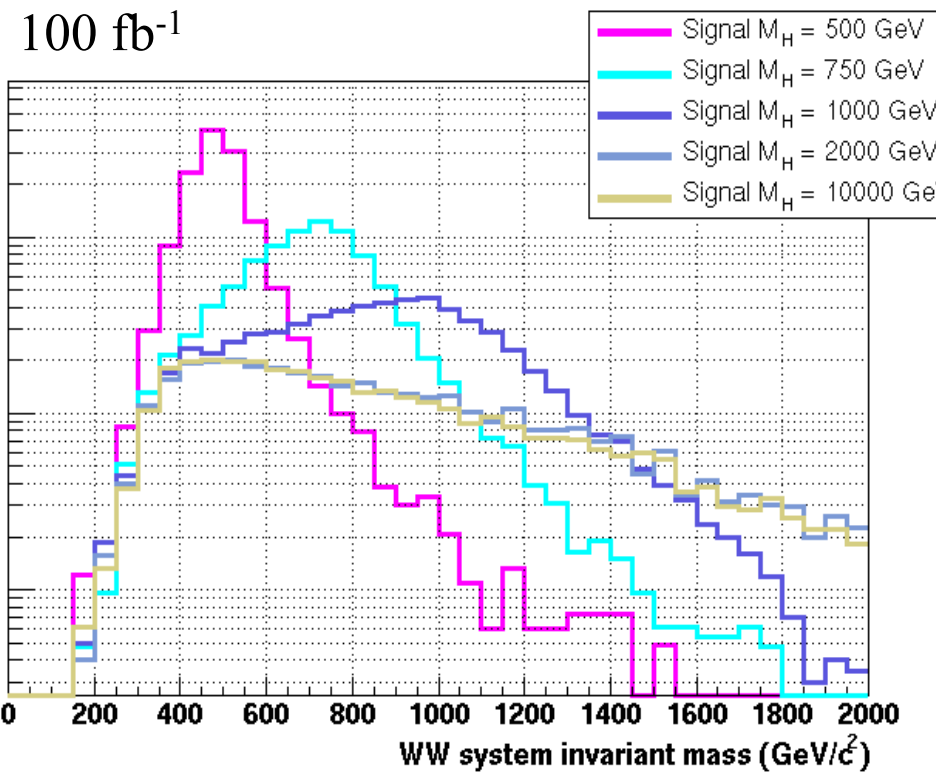
# Event selection

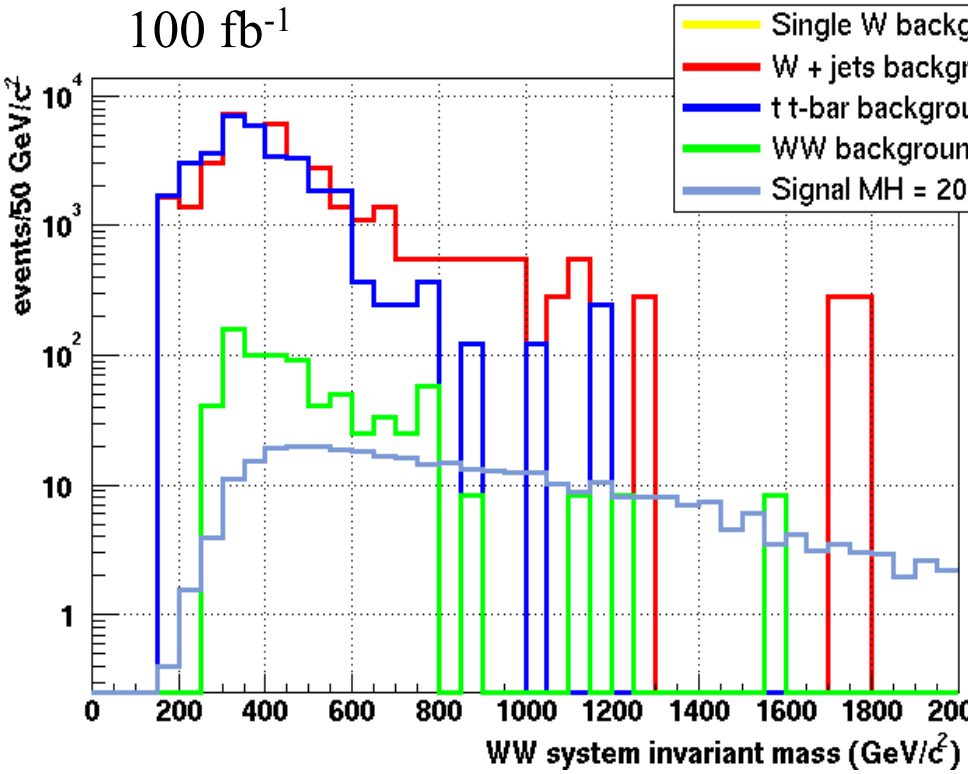
- Muon: $p_t > 30$ GeV
- Neutrino:
  - $p_t > 30$ GeV
  - $p_z$ calculated using the constraint: $(p^{\mu} + p^{\nu})^2 = m_W^2$
- Jets from W decay:
  - $p_t > 30$ GeV
  - $|\eta^{jet}| < 3$
  - $60$ GeV $< M^W < 110$ GeV
- Forward jet tagging: $p_t > 20$ GeV
  - 2 jets: $\eta^{j1} \times \eta^{j2} < 0$ $|\eta^{j1} - \eta^{j2}| > 3$ at least one with $1.5 < |\eta^{j1}| < 5$

  or:
  - 1 jet: $|\eta| > 2$ + central jet veto: (NO JETS with $|\eta| < 3$ and $p_t > 20$ GeV)
- Additional requirements:
  - M(jet tag system) > 550 GeV
  - $p_t^W > 100$ GeV
  - Rapidity gap: $\Delta\eta^{jt-\mu} > 1$
  - $\Delta\eta^{jt-jW} > 1$

# Preliminary results (1)

- High luminosity needed to explore up to $M_{WW} \approx 2$ TeV
- Good sensitivity to $M_H$ dependences:

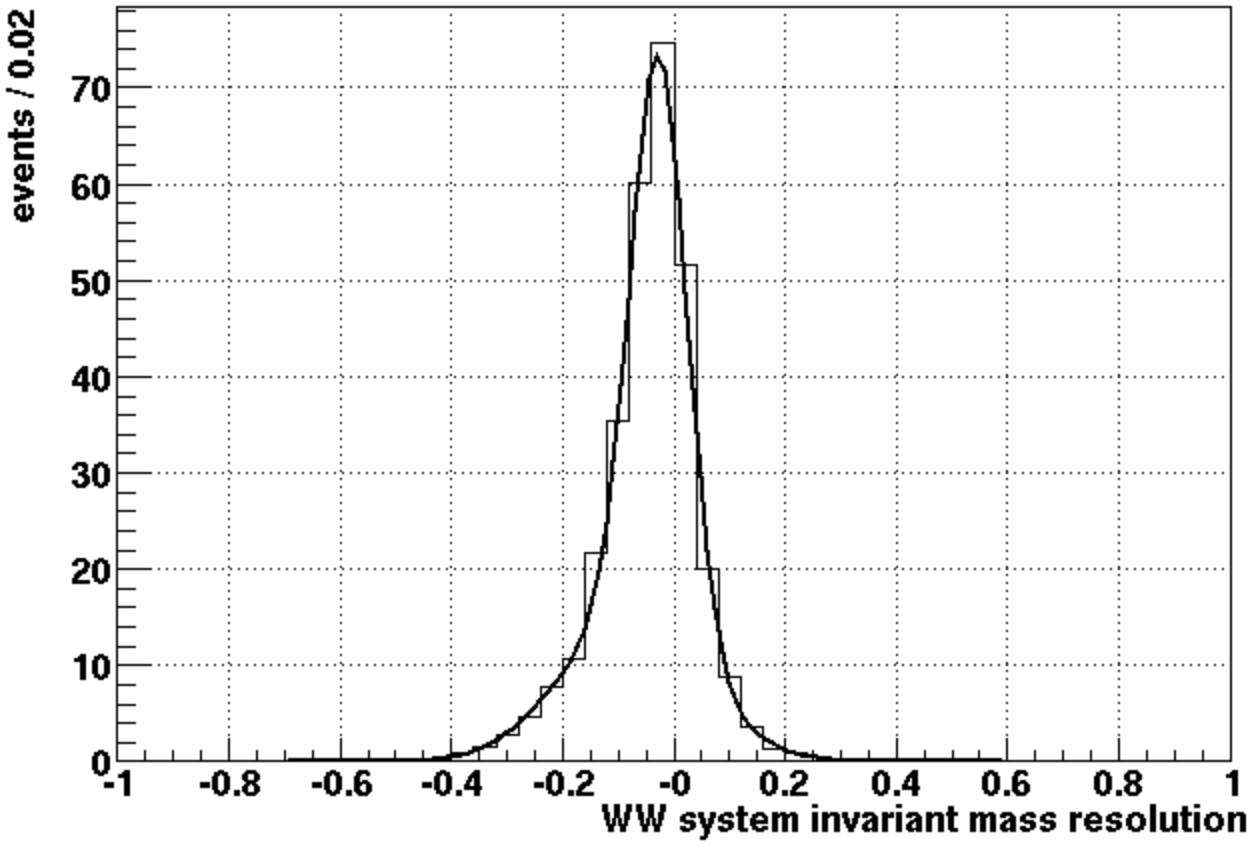



S/B to be improved

# Preliminary results (2)

- Flat efficiency above ~ 800 GeV: ~40 – 50%
- Good resolution on $M_{WW}$: $\sigma \approx 10\%$




**BUT**: NO Pileup, FAST detector simulation

# What we are doing now

- First cross checks Fast-Full Simulation for channel:

$$pp \rightarrow qqWW \rightarrow qq\mu\nu qq$$

- CMSJET + PileUp preliminary studies for ZZ and WZ final states.
- Full Simulation studies (OSCAR+ORCA) for ZZ, ZW, WW
- Test of 6 fermion final state MC (PHASE) in CMS (summer?)

# PHASE

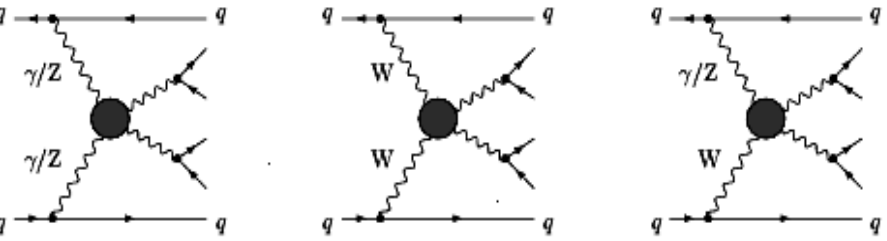
## PHact Adaptive Six Fermion Event Generator

(E. Accomando, A. Ballestrero, E. Maina)

**Monte Carlo** for **LHC** dedicated studies and full physics and detector simulation of

**Boson Boson Fusion and scattering**
**Higgs Production in this channel**
**$t\bar{t}$ production**
**Triple and Quadruple Boson Couplings**
**Three Boson Production**

**Present analyses** on the possibility of defining **boson boson scattering** signal in presence of **strong gauge cancellations**




## Features

**All** processes with 6 fermions final stat

$q_1 q_2 \to q_3 q_4 q_5 q_6 l\bar{\nu}$ $O(\alpha^6)$ **up to now**

**Complete helicity matrix elements**

Possible selection of particular set of diagrams soon

**New adaptive multi-channel method**

for efficient mapping of all possible pea

**One shot :** Unweighted event generation all processes (several hundreds) or any subset in a single run

**Parton shower and hadronization**

via Les Houches Protocol (Pythia up to now)

# Full simulation studies

Institute for Theorethical and Experimental Physics (ITEP) Moscow

- Full simulation vs Parton level study
- Particular focus on Central Jet Veto:
  - Good ttbar background rejection

  but
  - Low signal efficiencies (because of PU and detector effects)
  - Possible to improve the efficiency using vertex constraint on jets.

See talk: Andrei Krokhotine -CMS Week- 16 March 2004

# Conclusions

- WW-scattering is a promising channel (especially if no (light) Higgs is found)
- Preliminary studies:
  - High luminosity required in order to study $\sigma$ vs $M_{WW}$ up to ~ 2 TeV
- More complete study is NEEDED:
  - Full Detector Simulation
  - PileUp simulation
  - More complete study of backgrounds
  - New MC Generator (for 6 fermions final states)