



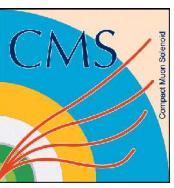
# Strategy for an early observation of the $ZZ^{(*)}$ di-boson production in four-lepton final states at CMS

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on behalf of the CMS Collaboration

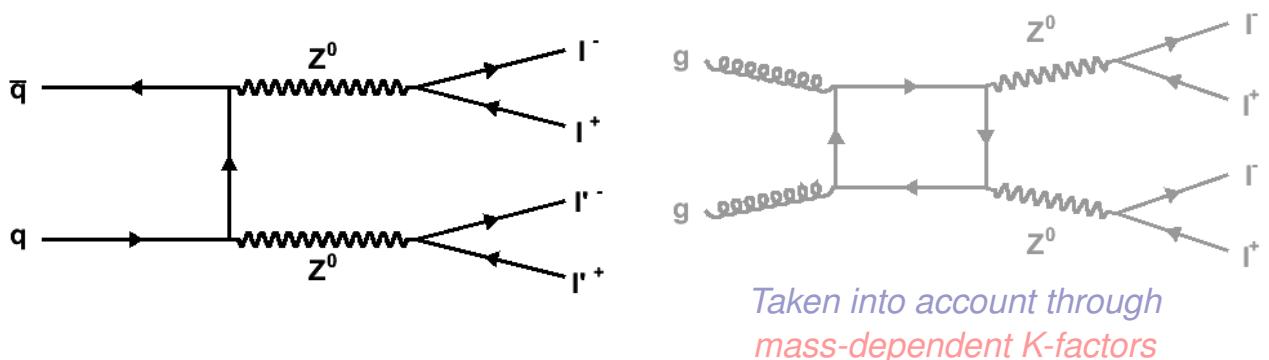
XLV Rencontres de Moriond on Electroweak Interactions and Unified Theories  
6-13 March 2010 – La Thuile (Italy)



# Introduction and Main Ideas

Aim: provide a full analysis for the measurement of  $pp \rightarrow ZZ \rightarrow 4\ell$  using the same *framework* and *strategies* developed in CMS for the discovery of the **SM Higgs boson** in the 4 leptons channel

- adjust and simplify cuts, making them clearer and more suitable for first data



Signatures:  $4\mu$ ,  $4e$ ,  $2\mu 2e$

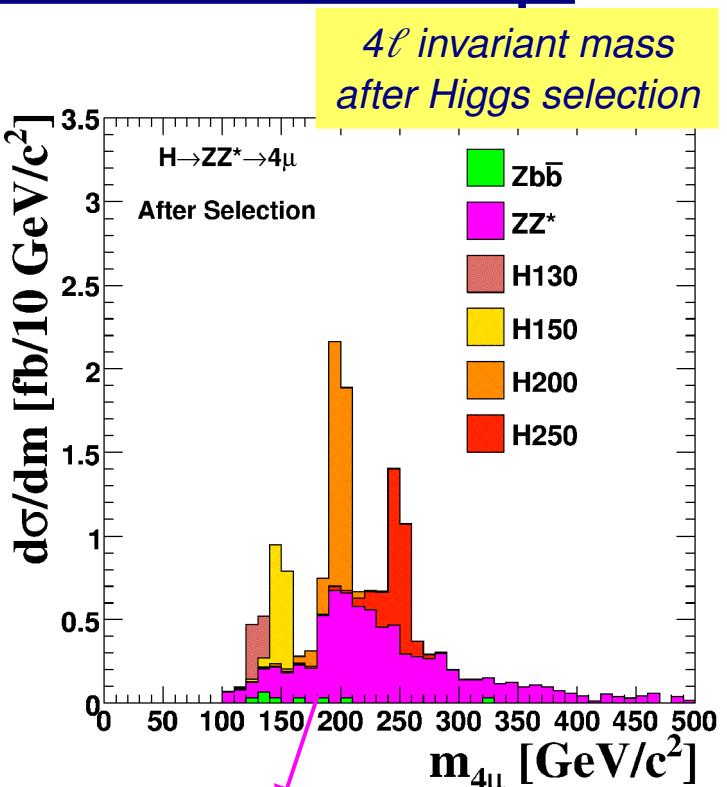
Backgrounds:  $Zb\bar{b}$ ,  $t\bar{t}$   
and multi-jet,  $Z+jets$ ,  $W+jets$

Luminosity:  $1 \text{ fb}^{-1}$  – Developed for **14 TeV** energy

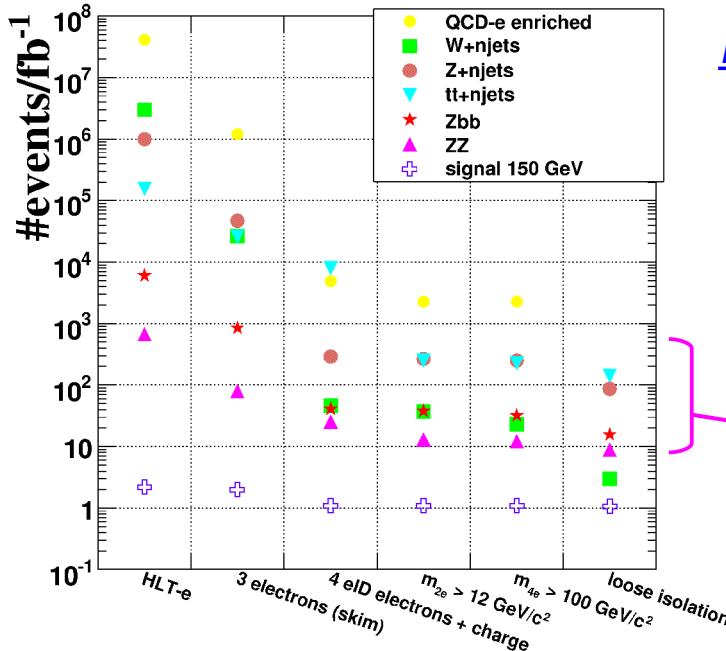
(projections for **10 TeV** and **7 TeV** in last slide)

Reference to the  $H \rightarrow ZZ$  analysis:

Search strategy for the Higgs boson in the  $ZZ^{(*)}$  decay channel with the CMS experiment, CMS PAS HIG-08-003



# Preselection & Z Mass Constraints



## Preselection

- based on  $p / p_T$  and invariant mass cuts
- reduce the amount of data to a manageable level
  - QCD background suppressed
  - all backgrounds reduced by orders of magnitude
  - $ZZ^{(*)}$  reduced ( $\gamma\gamma^*$ ,  $\gamma^*Z^*$ ,  $Z^*Z^*$  rejected)

same as in  
 $H \rightarrow ZZ$  analysis

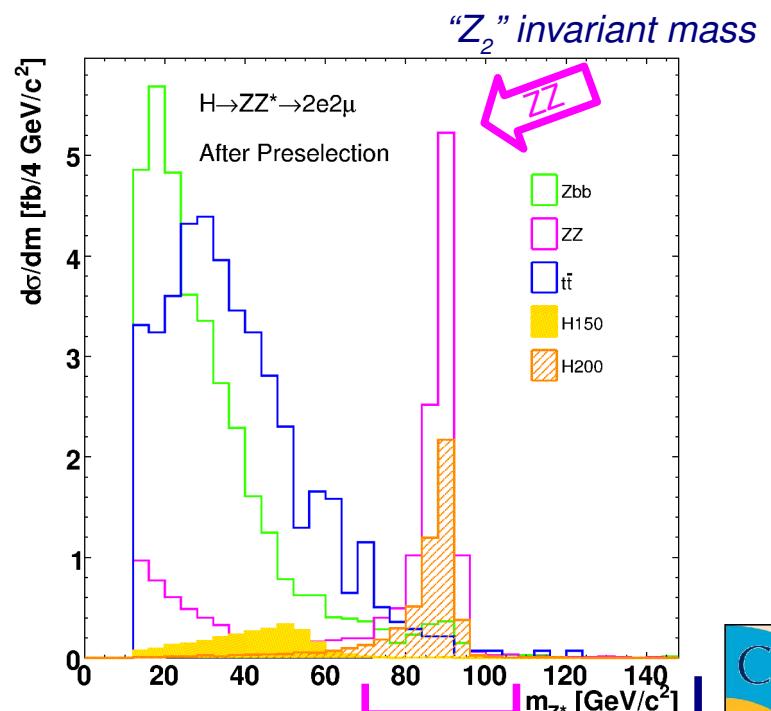
## Z mass cuts

Mass constraints are applied to *both* reconstructed Z's:  
strong suppression of *all* backgrounds + remaining off-shell Z

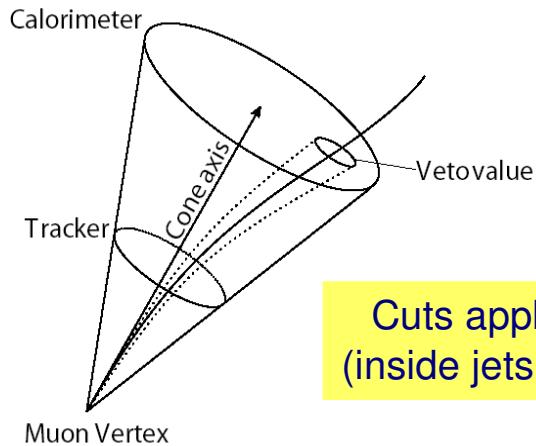
## Definition of Z:

$Z_1$  : the lepton pair **closest** to the nominal Z mass

$Z_2$  : the 2 remaining leptons with **highest**  $p_T$

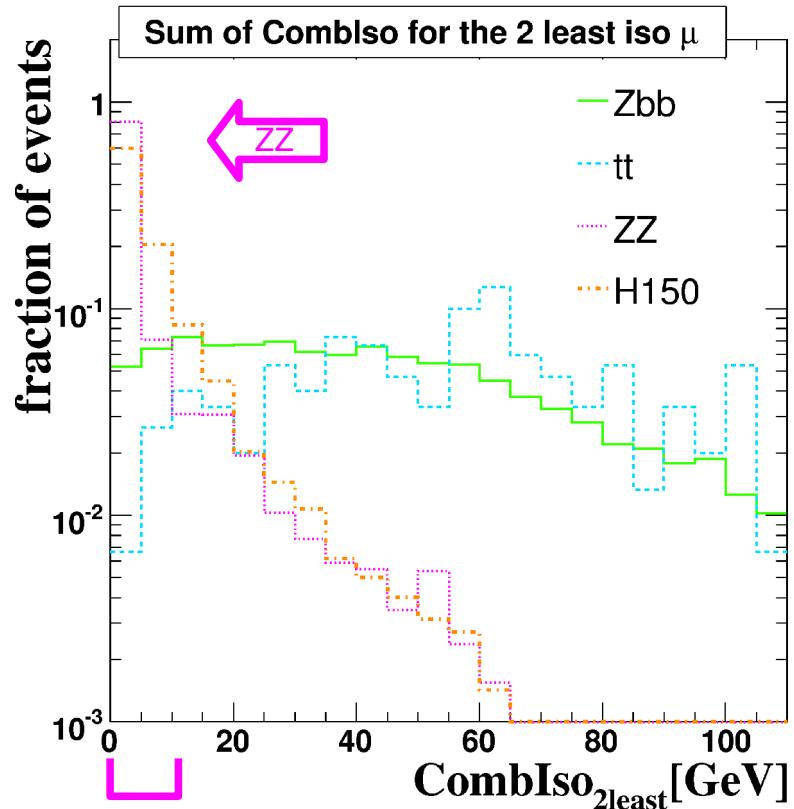
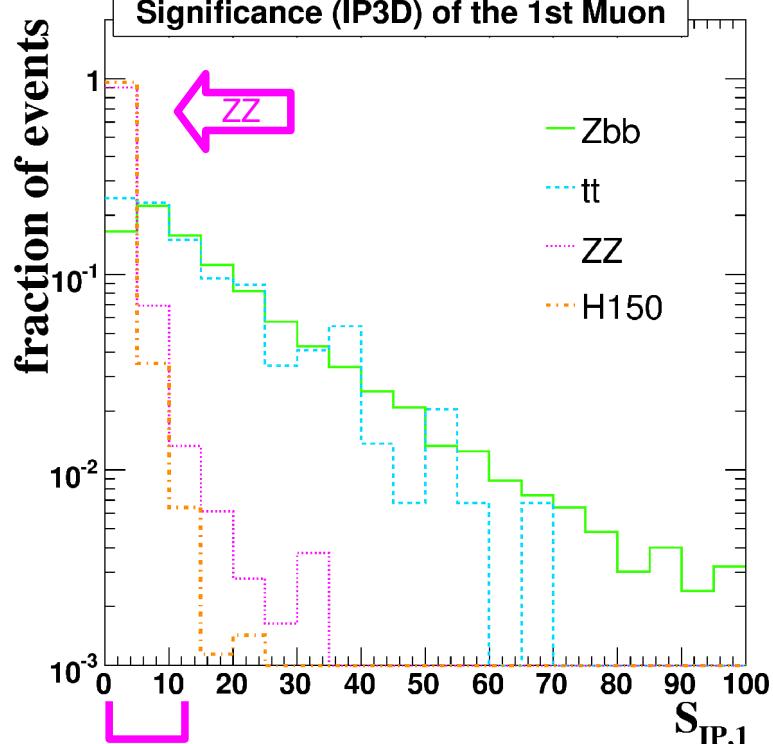


# Isolation and IP Cuts



Isolation variable  
momentum / energy of tracks  
inside a cone around the lepton

Cuts applied to the 2 least isolated leptons  
(inside jets in Zbb, tt and Z+jets backgrounds)

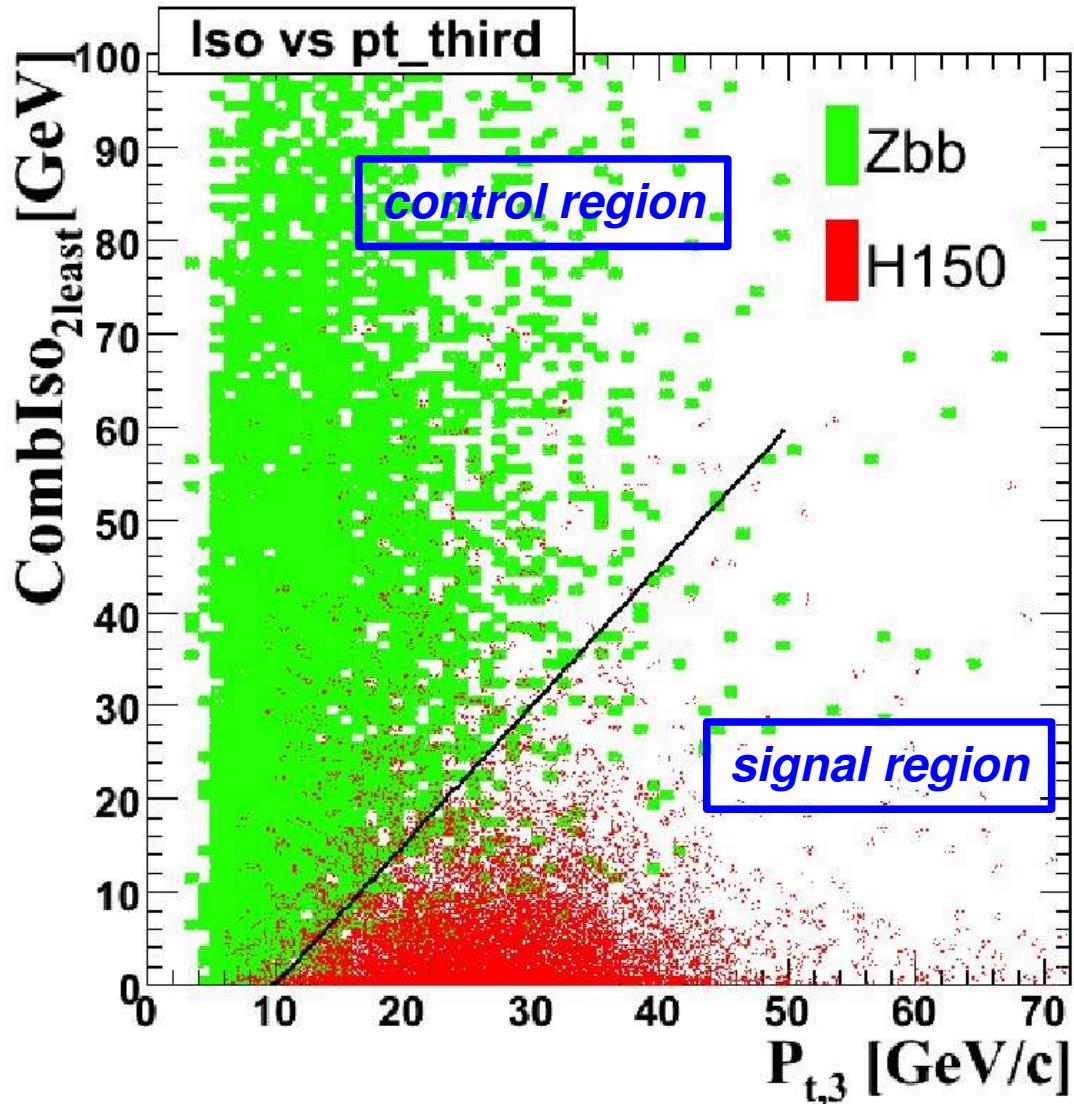


Impact parameter significance:

$$S_{IP} = \frac{IP^{3D}}{\sigma_{IP^{3D}}}$$

Cuts applied to the 2 highest  $S_{IP}$  leptons  
(leptons from  $b$ -jets have a higher  $S_{IP}$ )

# Isolation vs $p_T$



Isolation variable vs  $p_T$  of third highest- $p_T$  lepton

(here shown for a Higgs signal; very similar distributions and cuts for ZZ)

The *bidimensional* distributions isolation variable vs  $p_T$  of leptons show a very strong rejection power

Used for

- suppression of remaining Zbb events
- control of background from data

contamination in the *signal region*  
extrapolated from  
measurements in the *control region*

Estimated uncertainty ~35%

# Preliminary Results and Conclusions



From the results of the Higgs analysis (energy 14 TeV, luminosity 1  $\text{fb}^{-1}$ )

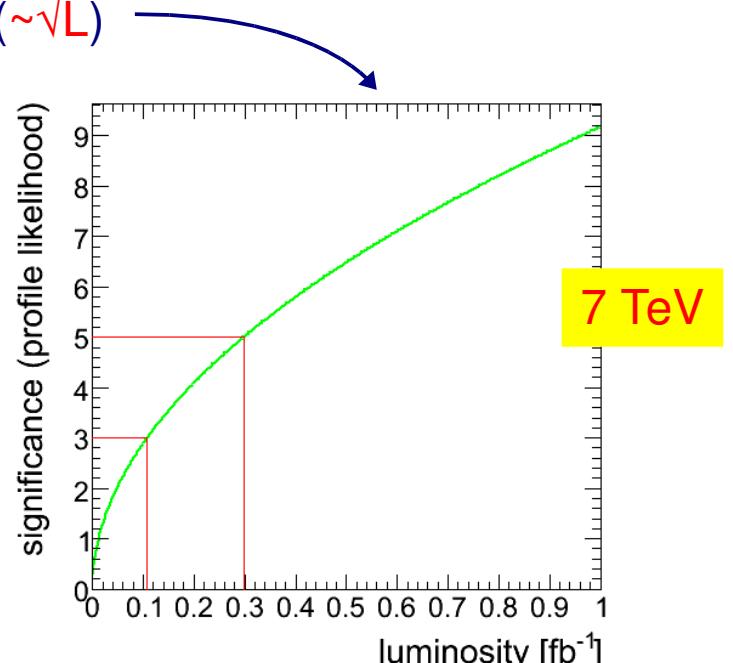
- rescaling the cross sections for 10 TeV and 7 TeV
- extrapolating the significance to lower luminosities ( $\sim \sqrt{L}$ )

we can foresee a ZZ<sup>(\*)</sup> observation with

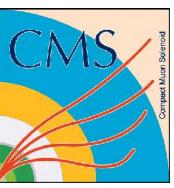
~190 pb<sup>-1</sup> at 10 TeV and ~300 pb<sup>-1</sup> at 7 TeV

rough estimation!

*Example of extrapolation  
of the significance*



- *full analysis* is being finalised for 10 TeV and 7 TeV
- great effort spent on **systematic uncertainties**:
  - estimate main systematics *from MC*
  - develop strategies to determine systematics *from data*



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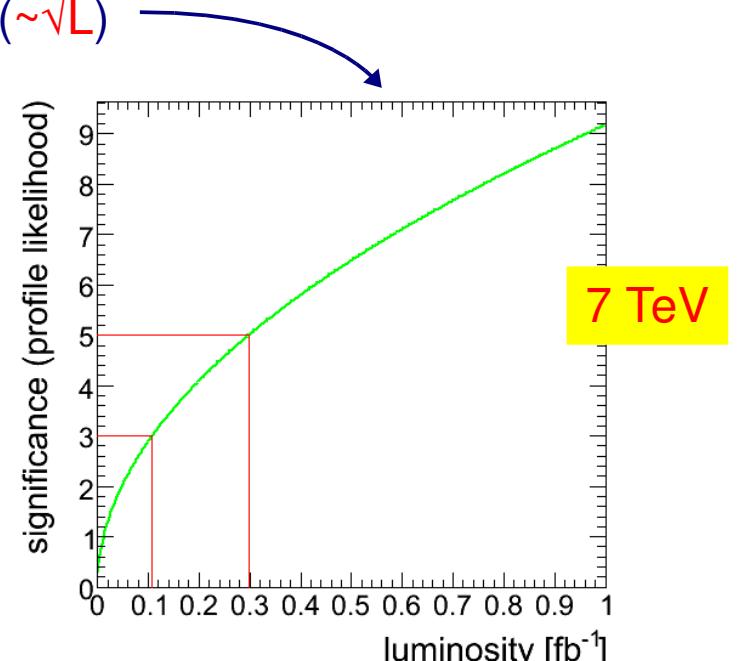
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$\sim 190 \text{ pb}^{-1}$  at **10 TeV** and  $\sim 300 \text{ pb}^{-1}$  at **7 TeV**



*Example of extrapolation  
of the significance*



*Thanks for the attention!*

