

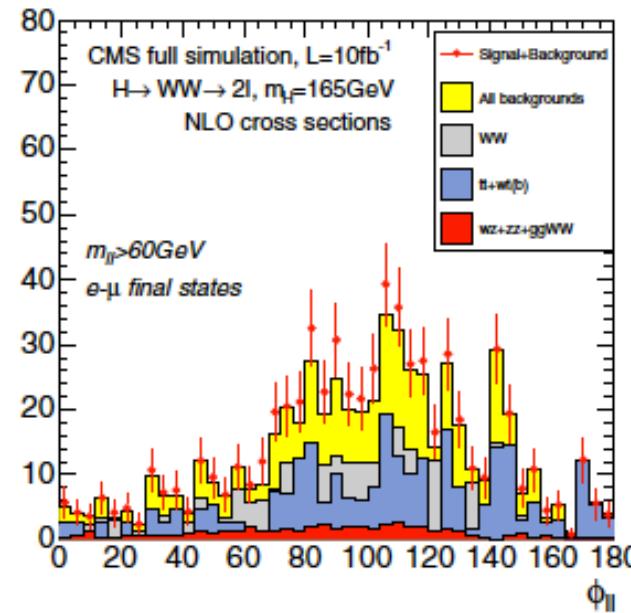
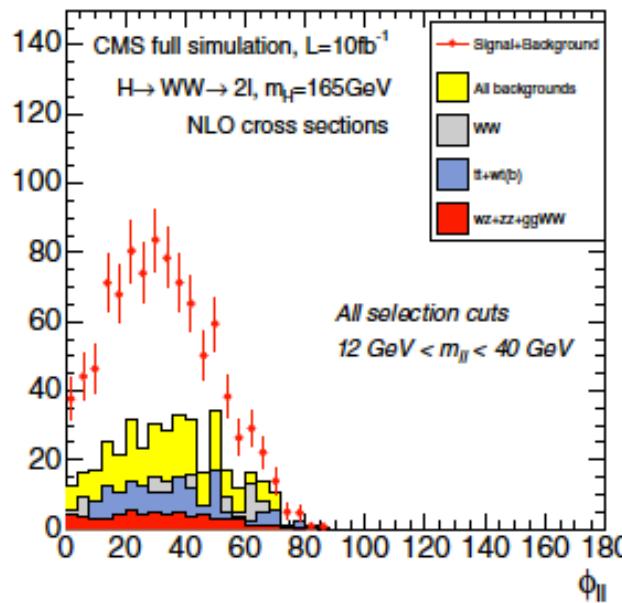
Research presentation

2006 - present

Rebeca Gonzalez Suarez

September 1st 2006

- Start of “**FPI**” **PhD grant** with University of Oviedo-IFCA, joined CMS
- Before that date:
 - Obtained **Physics degree** in June 2005 (Universidad de Oviedo)
 - Joined the HEP Oviedo group right after, contributing (unofficially) to the Physics TDR effort



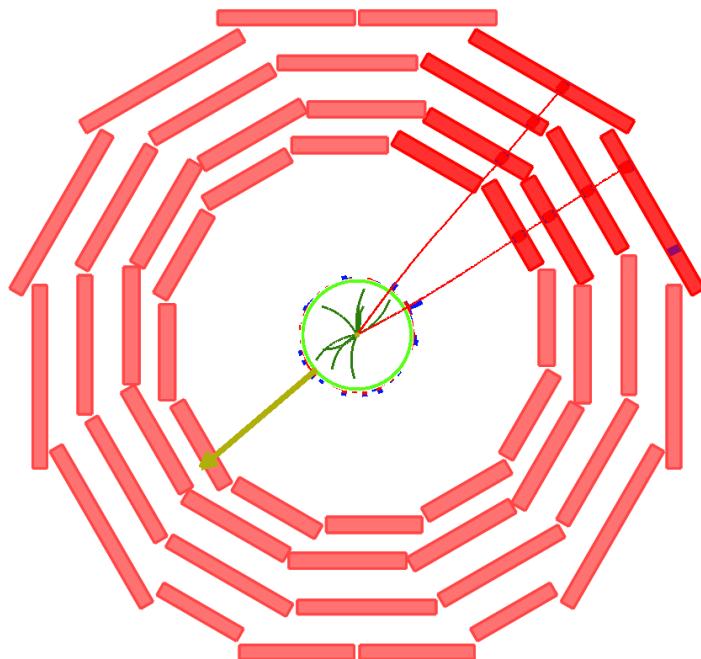
The starting point of my PhD studies was the Higgs to WW section of the TDR

Right after the TDR was done, I took over the Higgs to WW with two muons and two neutrinos in the final state

The CMS Collaboration 2007 J. Phys. G: Nucl. Part. Phys. 34 995 doi:10.1088/0954-3899/34/6/S01



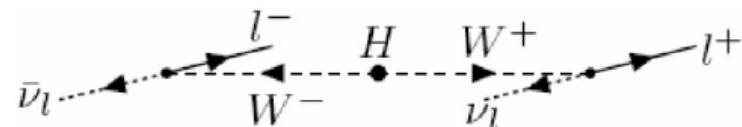
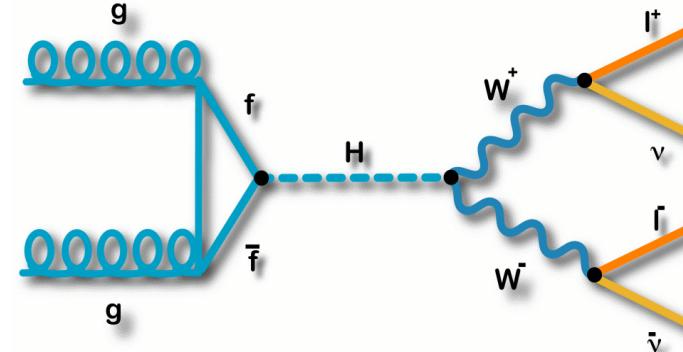
SM $H \rightarrow WW^* \rightarrow 2\mu 2\nu$



Backgrounds:

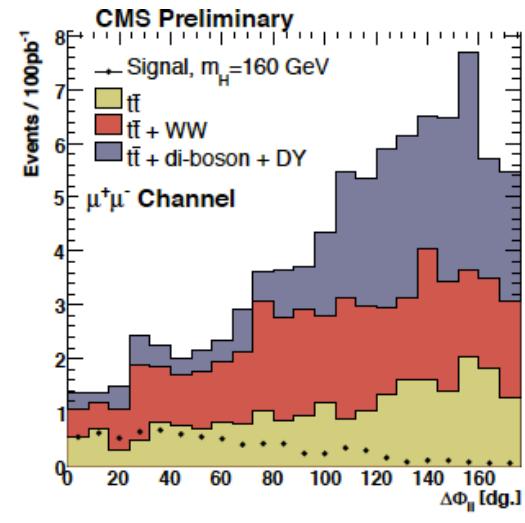
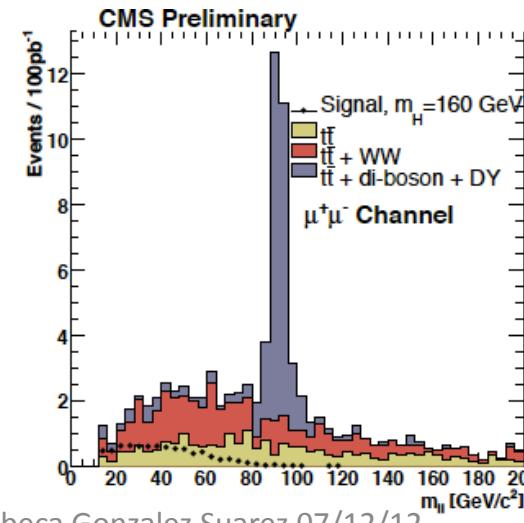
Real or fake multi-lepton final states + missing ET:
 'irreducible' **WW (WZ, ZZ), ttbar (tW), Drell-yan, W+jets...**

- $H \rightarrow WW^* \rightarrow 2l2\nu$, **discovery channel** for a SM Higgs boson in a wide mass range in the LHC
- Branching ratio close to 1 in $2m_W < m_H < 2m_Z$
- Clear **experimental signature**:
 - 2 high P_T leptons with opposite charge and a **small transverse opening angle** (spin correlations)
 - Missing ET
 - No jets (gluon fusion)



First contributions

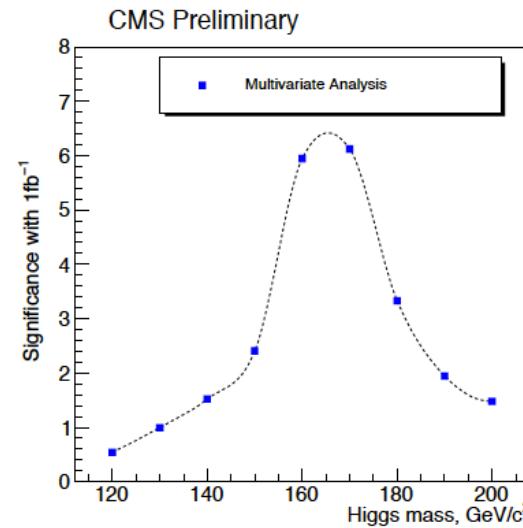
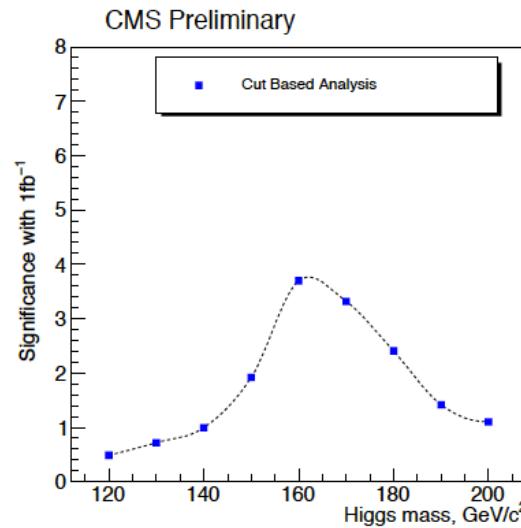
- **14 TeV studies** in Monte Carlo
- Study of the variables
- **Mass-dependent optimization of the cuts:**
 - low:(120, 130, 140) intermediate (150, 160, 170) and high (180, 190, 200)
 - First estimations of ttbar background (b-tagging)
- **PAS HIG-07-001**
 - First Higgs PAS in which I participated
 - 14 TeV, 100pb^{-1}
 - $m_H = 160 \text{ GeV}$



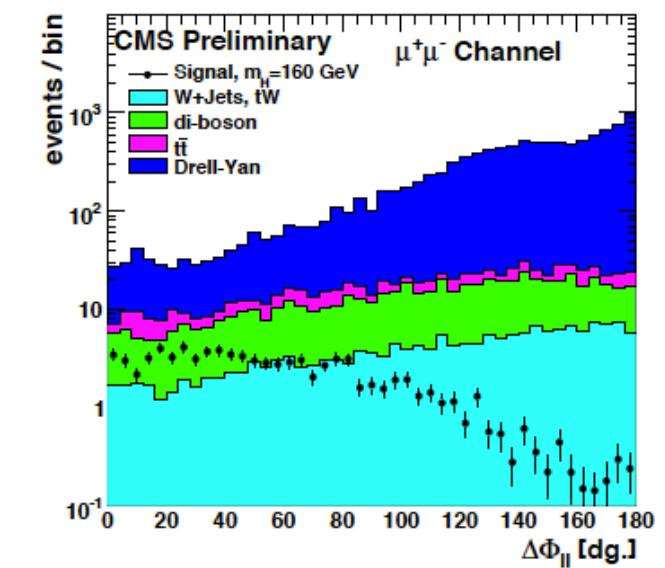
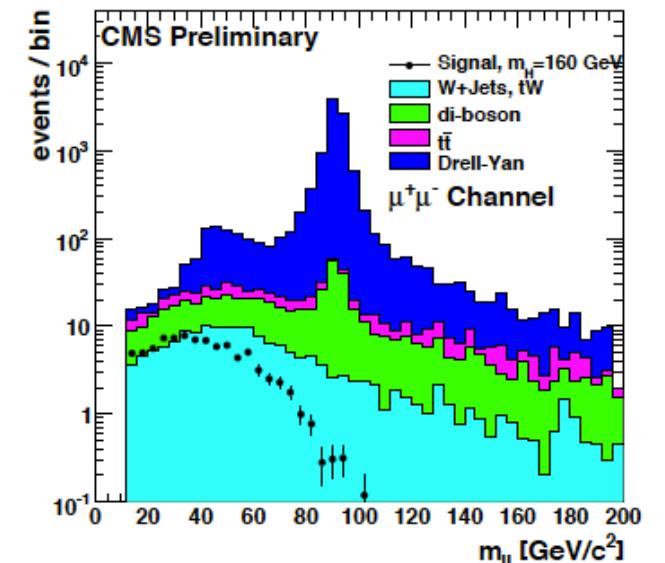


HIG-08-006

- Next public analysis, before the start of the data-taking:
14 TeV, 1fb⁻¹
- **Mass dependent cuts**, first multivariate analysis proposed
- **Control regions for WW and tt and first fake lepton studies**
- Prospective estimations of lepton and trigger efficiencies and systematic uncertainties



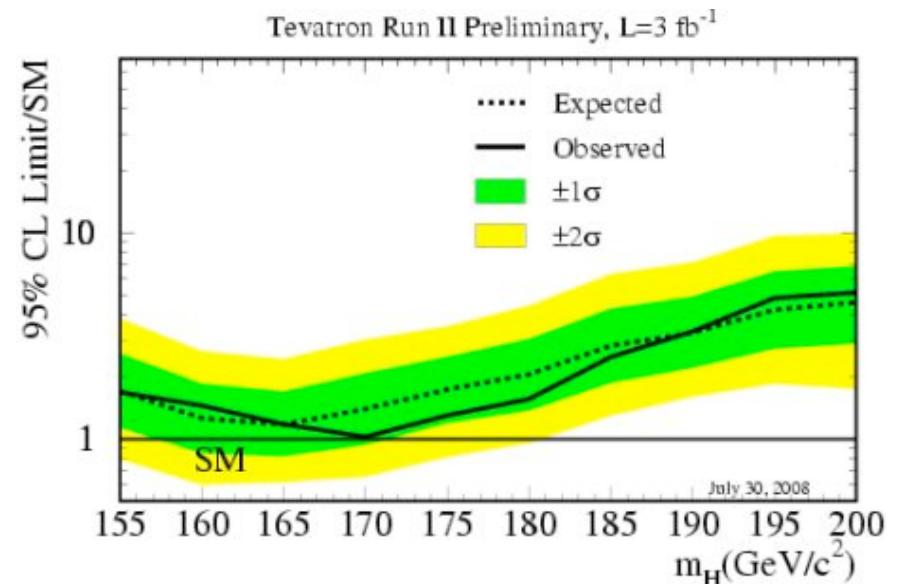
First significance estimations



2008: Tevatron exclusion LHC incident

In ICHEP2008, around one month before the startup of the LHC, the Tevatron experiments announce the exclusion of SM Higgs with $m_H \sim 170\text{GeV}$, close to our (then) favorite mass, 160GeV

(This was the first plot of many that followed)

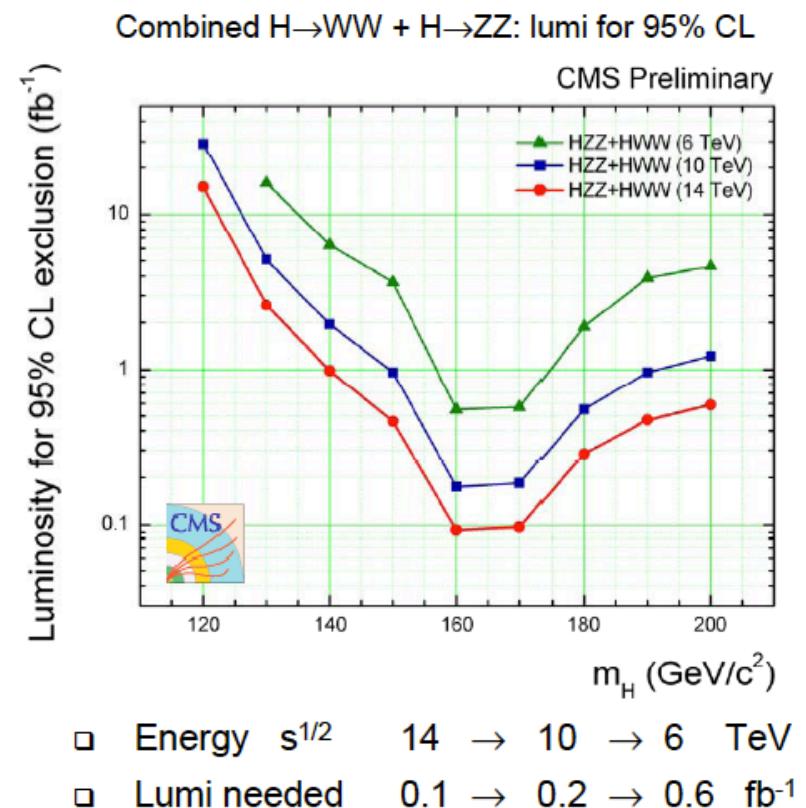


- In September, the LHC starts operation, to be stopped 9 days later after an incident.
- The LHC plans are altered in a big way, it means not only a **large delay**, but also a **change in the running conditions**.
- The center of mass energy of the collisions will no more be 14TeV, but lower. **Several scenarios are considered (initially 6 or 10 TeV)**



2009: Chamonix and 10 TeV

- We react rapidly by preparing **14 to 10 and 6 TeV estimations**, by scaling using the cross-section ratios and fast simulation
- A reduced group of people working tirelessly during Christmas 2008/Early 2009 to produce **public estimations for Chamonix 2009** (February)
- The estimations presented were only Higgs WW/ZZ and the combination



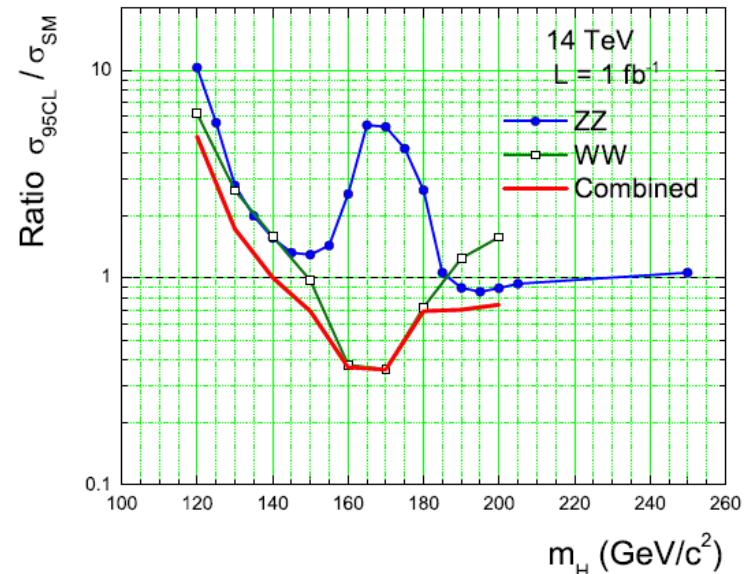
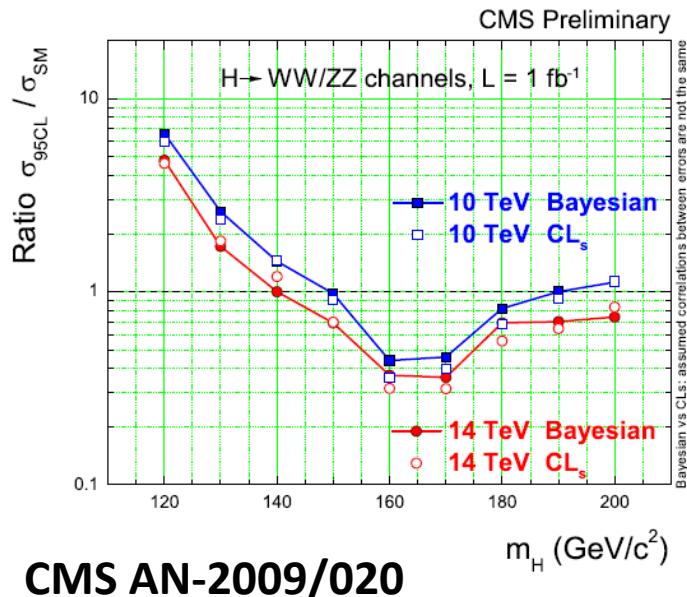
10 TeV is the most likely scenario, Monte Carlo samples are prepared and the full analysis is carried out (never made public, CMS AN 2009/139)

CMS projection for LHC@10TeV

- LHC 2009 - 2010 luminosity performance – estimate: ~ 200pb^{-1} of “good data”
- Strategy:**
 - First understand detectors,
 - do SM measurements,
 - then search for the Higgs...

Is that possible in the early running?

CMS: 10 TeV projection using the combination of HWW and HZZ results @ 14 TeV



Signal and bkgd yields re-scaled 14→10 TeV: loss of a factor of 1.5 in sensitivity, or a factor of ~2 in luminosity

With roughly $\sim 200 \text{ pb}^{-1}$, reach sensitivity for a SM Higgs with $m_H \sim 160\text{-}170 \text{ GeV}/c^2$ (comparable to the current Tevatron sensitivity)

⌚ region just excluded by Tevatron!!!

2010: data @ 7 TeV

- November 2009: Beams circulating again
- January 2010: Chamonix, decision to **run at 7 TeV** (bye, bye 10 TeV studies)
- February 2010: **First theoretical estimations of cross-section and branching ratios for all the SM Higgs channels at 7 TeV**

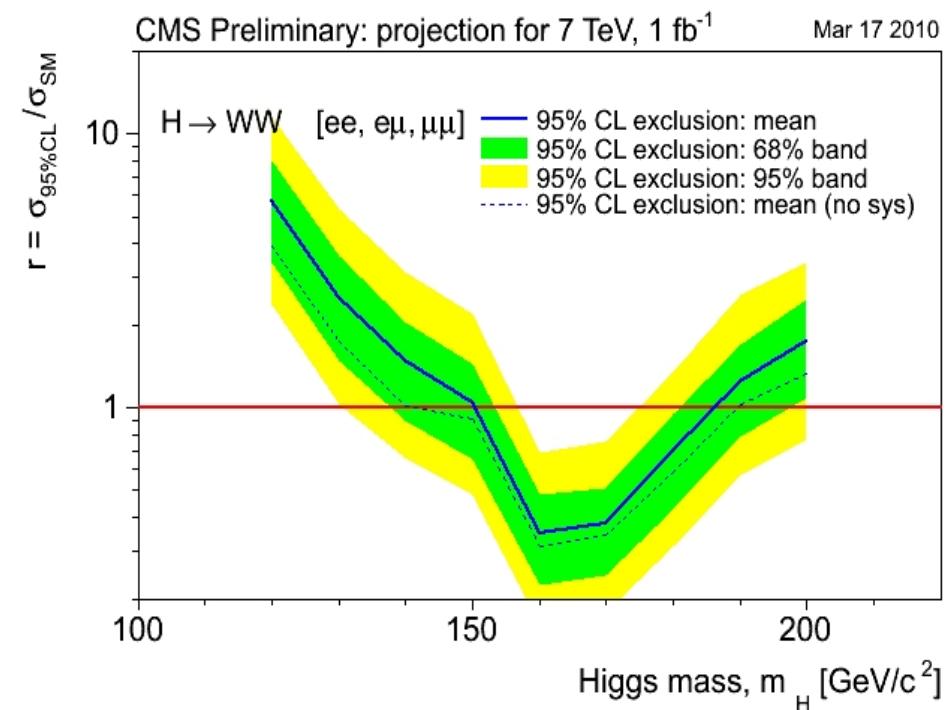
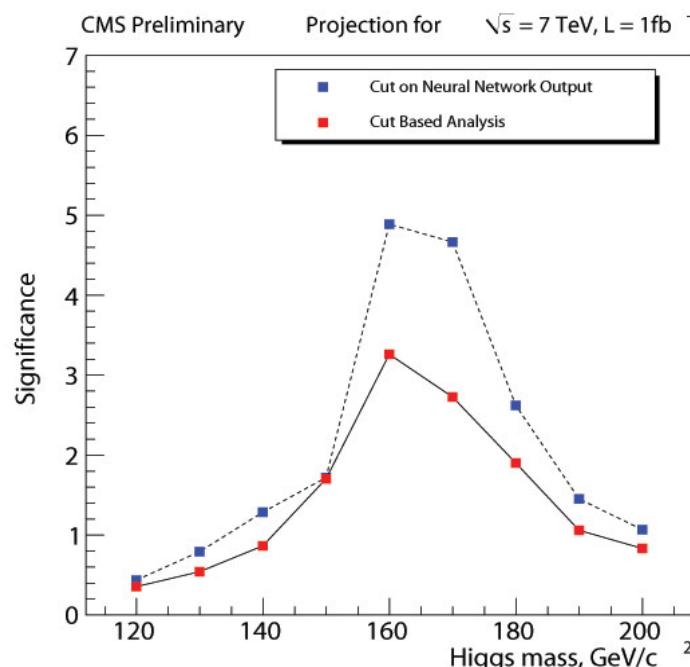
Fabian Stöckli and Rebeca Gonzalez Suarez, for the CMS Higgs Working-Group, "SM Higgs Production Cross-Section and Branching-Ratios at 10 TeV and 7 TeV"
<http://wwweth.cern.ch/HiggsCrossSections/> (obsolete)

- March 2010: **Collisions at 7 TeV**
- May 2010: **Estimations of the Higgs potential at 7 TeV** (from scaled 14 TeV results) made public (we also prepared **estimations at 8 TeV!**, plots are public)

7 TeV Monte Carlo ready, full analysis ready to perform (nothing public)

HWW projections @ 7TeV

CMS AN 2010/008 - 'The CMS physics reach for searches at 7 TeV'
 (CMS Collaboration) <http://cdsweb.cern.ch/record/1264099/>



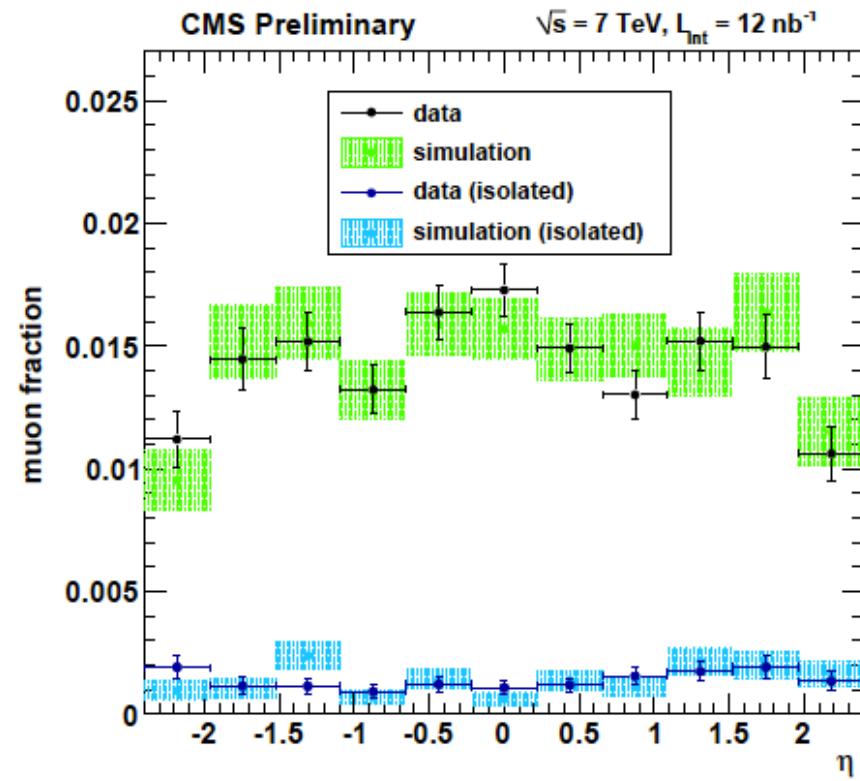
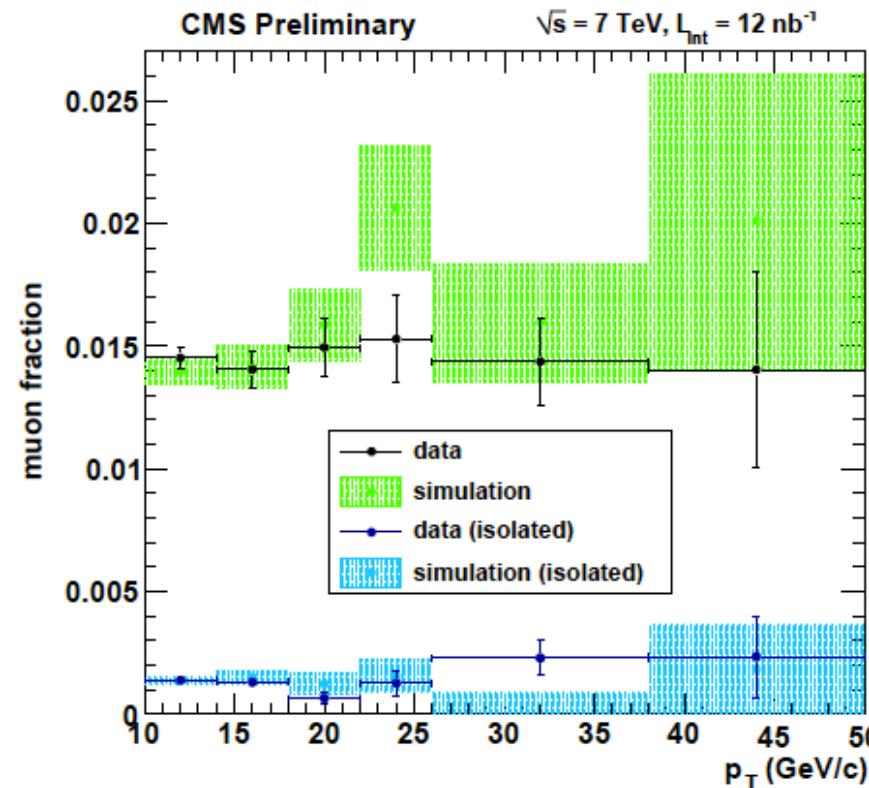
7 TeV, $\int L dt = 1 \text{ fb}^{-1}$ (projection)

Exclusion 95%CL: **$150 < m_H < 185 \text{ GeV}$**

Discovery level sensitivity ($\sim 5\sigma$): **$160 < m_H < 170 \text{ GeV}$**



Work with early data (ICHEP 2010)



Study of **tracks faking muons with 12nb^{-1}** (a part of the lepton fake rates studies made for Higgs to WW), appearing in the first muon public results with proton-proton collision data of CMS (**MUO-10-002**), presented in ICHEP 2010 (summer)

In parallel during my PhD

- Service work: Software **alignment of the DT chambers**
“A Software and Computing prototype for CMS Muon System alignment”, (Iban Cabrillo, Isidro Gonzalez Caballero, Rebeca Gonzalez Suarez...), Journal of Physics: Conference Series 119 (2008) 072008
- **Higgs to WW BDT analysis:** Gave the starting code for the implementation of BDT analysis in the HWW to $2\mu 2\nu$ channel. Starting from the same pre-selection, I contributed sharing and updating code.
- Helped in the analysis to measure the **W charge asymmetry** (CMS AN-2008/074) and slightly in the $t\bar{t}$ dilepton (CMS AN2010/406)
- **WW cross-section measurement:** set-up the starting analysis and proposed within my group to measure it together with HWW (CMS AN-2009/025, CMS AN-2009/185)

9 September 2010



Defense of PhD thesis:
**“Search for a SM Higgs Boson in the LHC with the CMS experiment using
the $H \rightarrow WW^* \rightarrow 2\mu 2\nu$ decay channel”**
<http://cdsweb.cern.ch/record/1296019/>

Dir. Javier Cuevas (Universidad de Oviedo) and Teresa Rodrigo (IFCA)
Sobresaliente Cum Laude



November 1st: Joined the VUB

- In November 2010 I joined the **Vrije Universiteit Brussel** (VUB) as a postdoc, in the group of Jorgen D'Hondt with **Freya Blekman** as supervisor
- I moved to **top physics**, in which the group has an important presence, starting by contributing to the e+jets cross-section analysis:

"Measurement of the tt Production Cross Section in pp Collisions at 7 TeV in Lepton + Jets Events Using b-quark Jet Identification", CMS Collaboration (Serguei Chatrchyan et al.), Phys.Rev. D84 (2011) 092004, arXiv:1108.3773
- Following that, I started my own analysis, studying the **single top tW associated production**:
 - Nobody was working on it
 - Process still to be observed
 - Only one rough early study made by CMS for the TDR (2006)
 - ATLAS already had results with data and a team formed
 - Most important: Very similar to HWW

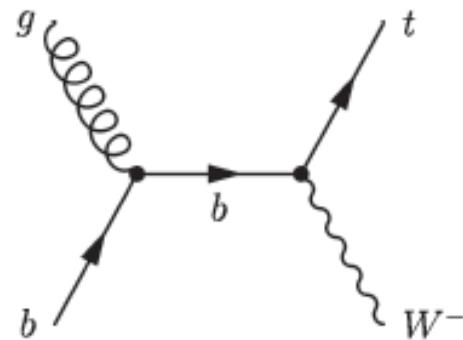
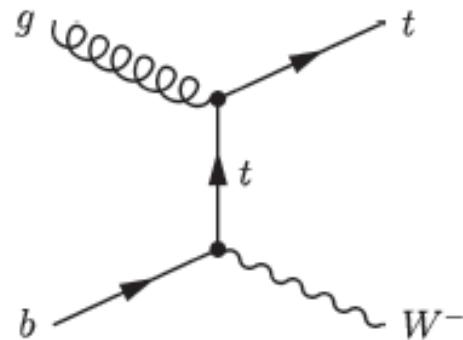


Single Top tW associated production

- First step towards the experimental study of the Single Top Associated tW in CMS:
 - Too difficult at the **Tevatron**, with no results from **CDF** and **D0**
 - At the **LHC**, **ATLAS** had already public results with **2010 and 2011** data (upper limits in the cross-section)
 - **CMS**'s latest analysis of the tW channel: part of the **physics TDR (2006)**
- It has a very interesting signature:
 - important background to **Higgs searches** (HWW)
- After the observation of the process, a lot of physics to do:
 - Measure EW properties of the top-quark:
 V_{tb} CKM matrix element, Wtb vertex
 - Sensitive to **BSM** processes, can be used to constrain the SM rate assuming lepton universality, etc.

tW dilepton topology

- tW leptonic final states (**ee/eμ/μμ**) studied



Signal signature:

2 opposite sign, isolated
leptons (e or μ)
Missing E_T (2 neutrinos)
1 jet (coming from a b-decay)

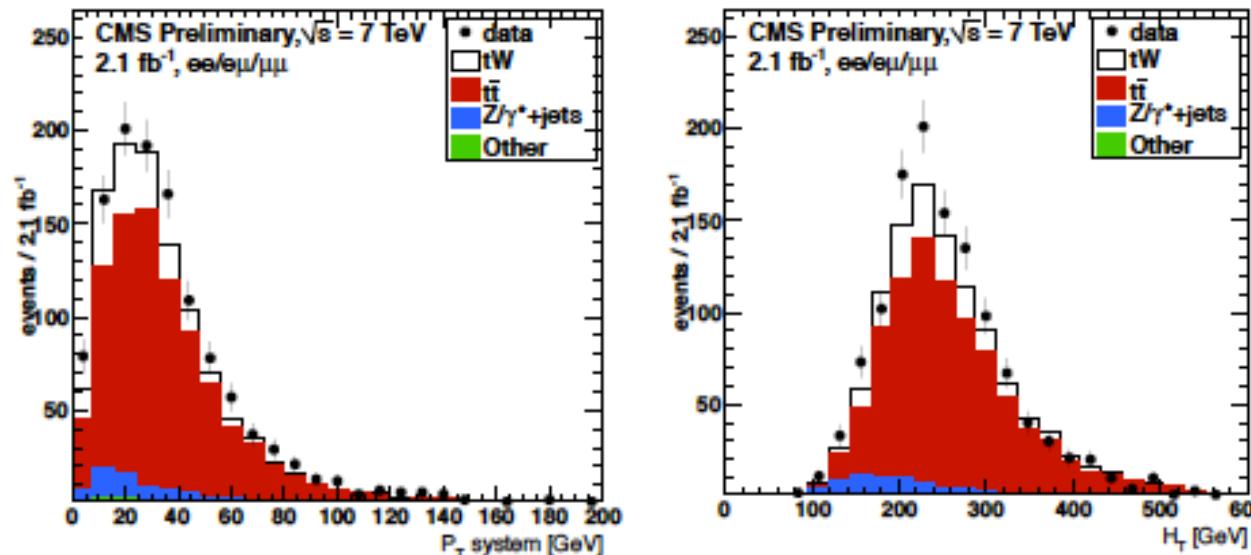
Similar signature
Higgs to WW + 1jet

Sources of background:

- ✓ **ttbar** (dominant background), **Z+jets**
- ✓ EWK di-boson production (**WW, WZ, ZZ**)
- ✓ **W+jets**, other **single top** processes (**t** and **s** channel) and **QCD**

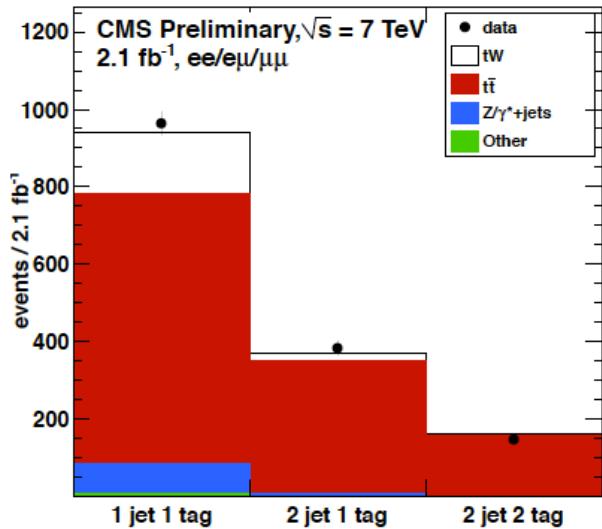
PAS TOP – 11 – 022

- Working from scratch I prepared the analysis in Monte Carlo and applied it to 2011 data (2.1fb^{-1} for the summer result, August 2011)
- Simple cut-based approach applying a couple of extra kinematic cuts on events with two leptons, 1 b-tag jet and Missing E_T



- After b-tagging only tt, a little Z+jets component, and tW signal remain
- Z+jets estimated in/out Z mass window; tt background is more complicated and requires the use of two control regions (2jets 1b-tag, 2jets 2 b-tags)

Summer result (2011)



Observed significance: 2.7σ

Expected significance: $1.8 \pm 0.9\sigma$

Cross section value: $22+9-7 \text{ (stat+syst) pb}$

(PAS TOP-11-022, manpower and editor)

Working alone I got a better result than ATLAS with higher sensitivity (by then, ATLAS had 1.2σ)

Result obtained using 9 final states (ee/e μ / $\mu\mu$ in signal and two tt control regions), multichannel statistical treatment (Higgs-like)

One of the highlights of TOP2011, the results appeared in many places after being made public (conferences, summary talks of CMS results, and the CERN courier – October 25-)



2012: tW paper

- People joined the tW effort, I still work in the analysis but I'm also coordinating
- ~10 people at the moment, 2 new institutions, **2 PhD students to write their thesis about tW**, +1 new student ready for 2012 data
- Next goal in reach: **PRL with CMS's tW evidence** (ATLAS just published the evidence just before ICHEP) using the full 2011 dataset
- Multivariate analysis (based on a BDT) and cut-based as cross-check
- To enter CWR very soon (next week hopefully!)
- Internal CMS notes:
 - **CMS AN-2011/465**
 - **CMS AN-2012/060**

Coming soon!

Service work and shifts

- Contact person for the local reconstruction of the strips
- Several developments of the code:
 - Automatic Peak-Deconvolution mode switch (before it was made “by hand”)
 - Removed possible occurrence of a mixed mode
 - Det Id information removal from the strip clusters
 - Reading information of FED errors from DQM files
- I maintain a shift quota of > 20 points/year (this year for example, 31)
 - DT offline (2008)
 - DT online (2008/2009)
 - DT on call (2009/2010)
 - Central DCS (2010/2011/2012)
 - Shift Leader (2012)





ARC activities

- Member of different analysis review committees (ARC) since Summer 2011
- SUSY analysis: multileptons + MET
 - **SUS-11-019:** “Search for Physics Beyond the Standard Model in Z + MET + Jets events at the LHC”
 - **SUS-11-021:** “Search for physics beyond the standard model in events with a Z boson, jets and missing transverse energy”

Search for physics beyond the standard model in events with a Z boson, jets, and missing transverse energy in pp collisions at $\text{sqrt}(s)= 7 \text{ TeV}$, CMS Collaboration (Serguei Chatrchyan et al.), Submitted to Physics Letters B, arXiv:1204.3774
- **SUS-12-006 (Ongoing): EWKino paper** “Search for electroweak production of charginos and neutralinos using leptonic final states in pp collisions at $\text{sqrt}(s) = 7 \text{ TeV}$ ” (6 supporting notes)
- **SUS-12-007 (merged with SUS-12-006): WZ, ZZ + MET**

Conferences

- **Poster** about Muon alignment sent to **CHEP07** (Victoria, Canada)
- Presented a **poster**, **ICHEP08** (Philadelphia, United States): "Discovery Potential for the SM Higgs Boson in the H to WW to 2l2 channel at LHC"
- **Talk** on behalf of **ATLAS and CMS, PASCOS 2009** (Hamburg, Germany): "EW symmetry breaking at the LHC"
- **Plenary talk** on behalf of **ATLAS and CMS, BEACH 2010** (Perugia, Italy): "Higgs Search Prospects at the LHC"
+ **Chair of the session** "Heavy Flavor Decays and Properties - I"
- **Invited Plenary talk**, **II CPAN days** (Valencia, Spain): "Higgs and SUSY searches in CMS"
- **Chair of the poster session** of the CMS Physics week in Brussels, 2011
- **Plenary Talk** on behalf of **ATLAS and CMS, Moriond 2012** (La Thuile, Italy): "Single Top Production at $\sqrt{s} = 7\text{TeV}$ "
- **Invited talk**, 4th generation and single-top Workshop 2012 (Leinsweiler, Germany): "tW production at CMS"

Outreach activities

- CERN guide
- CMS guide
- Meet high school students for Q & A in March 2009 (Doña Jimena High school, Gijón, Spain)
- Workshop leader of the "Questions without answers at the LHC" session in the Expanding your horizons (EYH) conference in Geneva, 12th November 2011 coordinating a group of 9 female LHC physicist receiving 3 groups of 45 girls (also from CMS in my session: Claudia Wulz, Bárbara Millán Mejías, María Cepeda)
<http://cms.web.cern.ch/news/cms-participates-expanding-your-horizons>



CAUTION

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