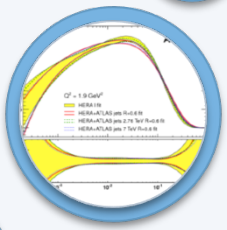
Atlas: Il gruppo e la Fisica

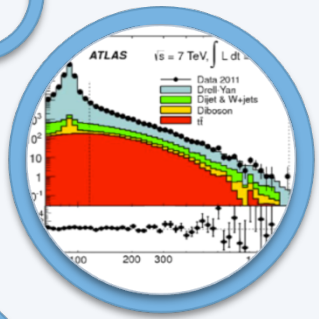
Atlas: Standard Model EW and QCD

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/StandardModelPublicResults

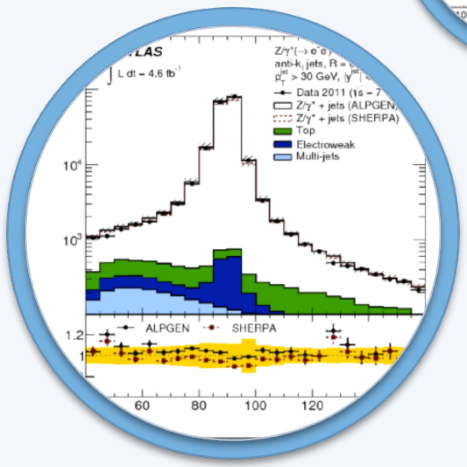


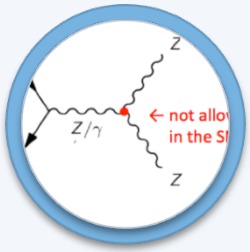
Pdf (W+c, Z+bb, jet ratio x-sec)

Relevant bkgs (Z+jets, diboson production, photon + jets)



QCD (W+b jets, high mass Drell-Yan, jet x-section ratio)





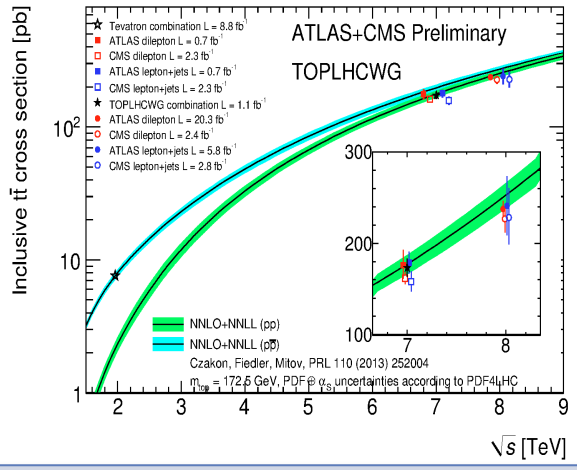
New physics (diboson TGC anomalous coplings

Atlas: Top Physics

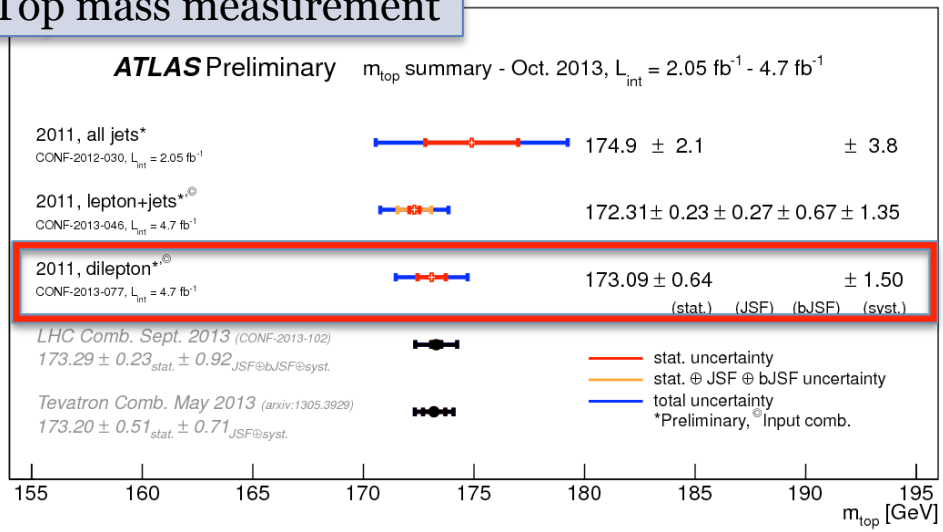
ATLAS-CONF-2013-077

- Heaviest particle in the SM: special role in EW symmetry breaking; large coupling to Higgs
- Most important background to many New Physics signatures and Higgs.
- Unprecedented sample of top quarks: ~6M top pairs and ~3M single top
- Tool for precise test of SM (NLO, NNLO QCD) and search for new physics
- Enough statistics to measure differential cross sections as a function of observables sensitive to QCD predictions

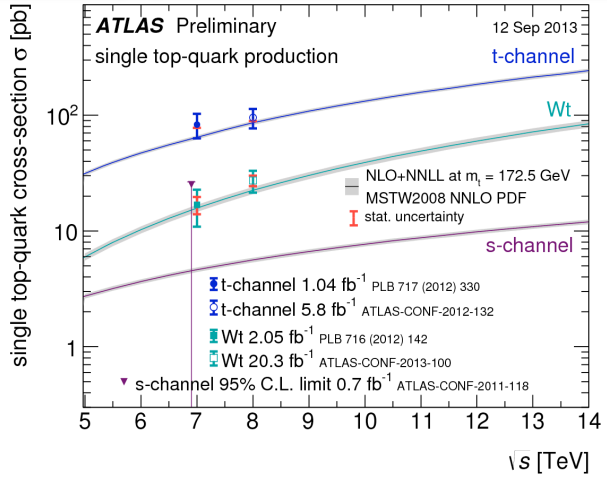
ttbar production cross section



Top mass measurement

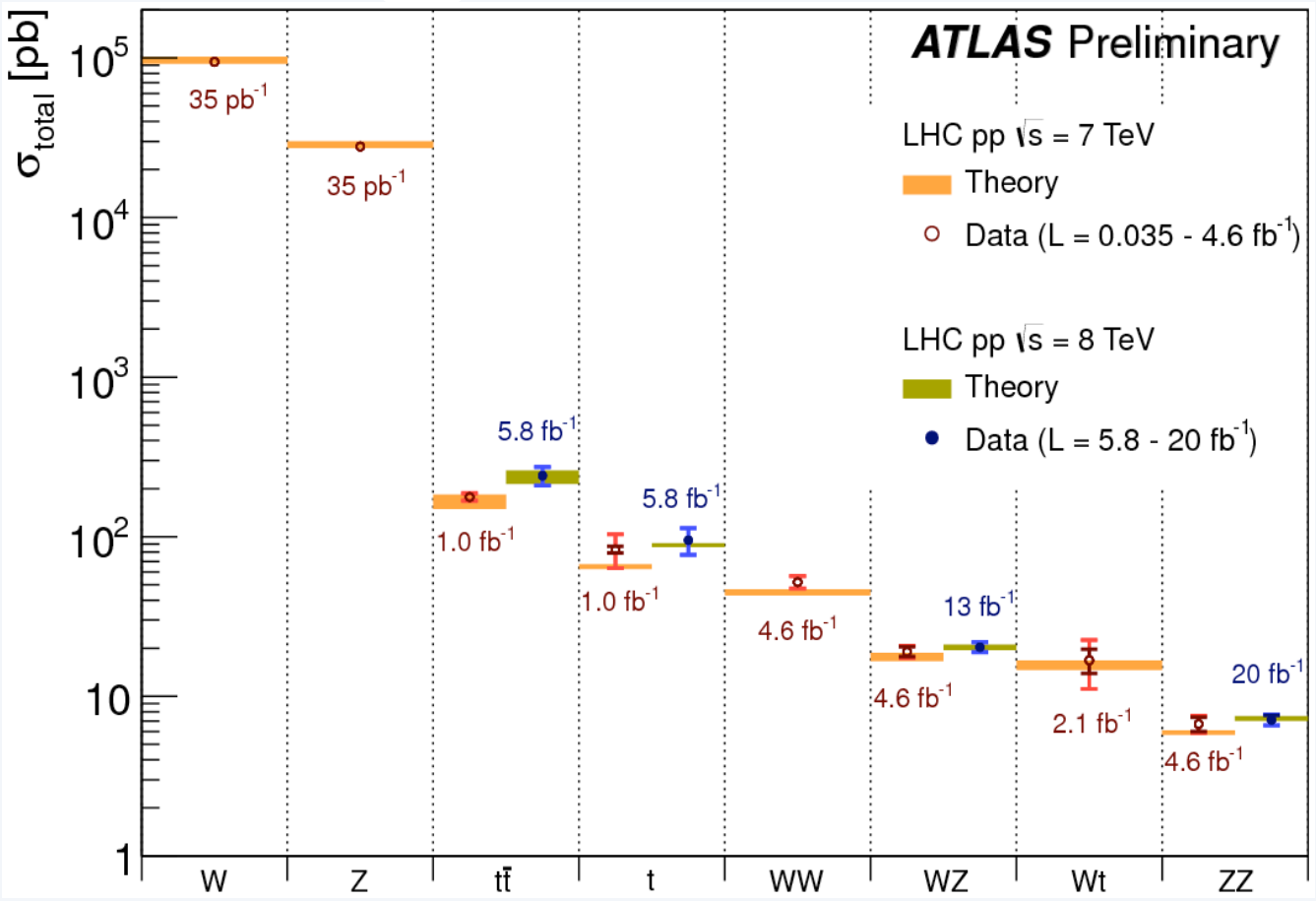


single top production cross section



Atlas: Standard Model

- Validate SM in new energy regime
- Constrain new physics contributions (like anomalous couplings)
- Improve precision of known SM parameters
- Understand processes which are backgrounds for other studies/searches



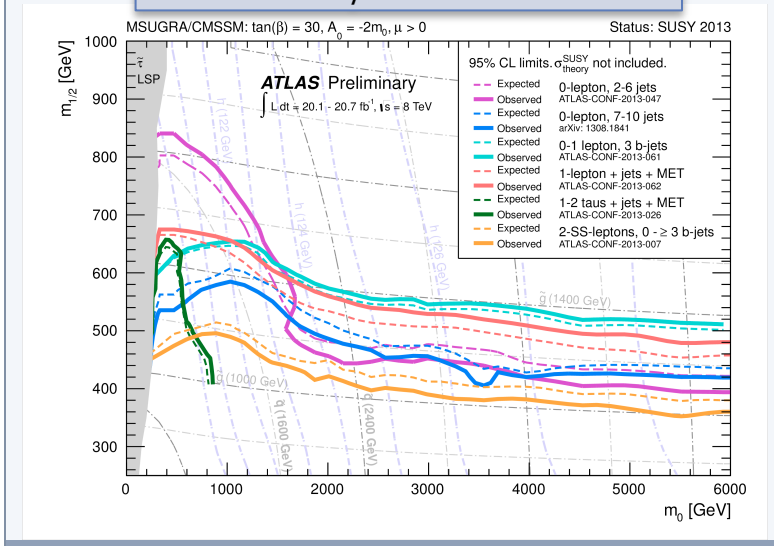
About 70 out of 280 atlas physics papers on SM, more results at https://twiki.cern.ch/twiki/bin/view/AtlasPublic/StandardModelPublicResults

Atlas: SUSY

24 results with 20fb^{-1}:

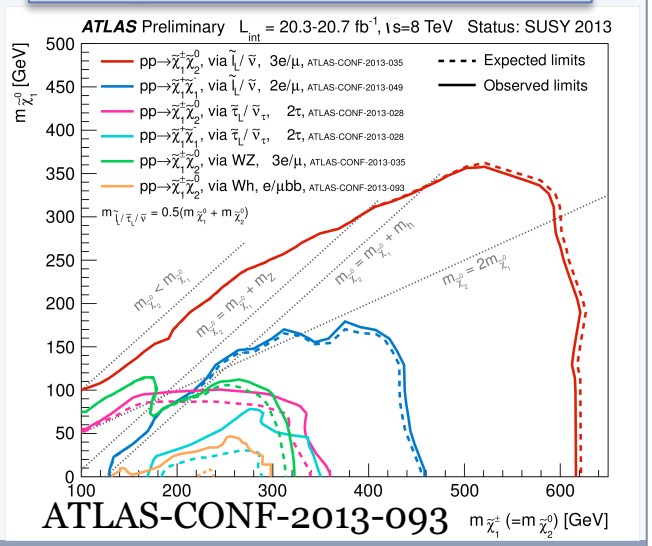
- Gluino and 1st/2nd generation squarks → 6 CONF - 1 paper
- 3rd generation (top & bottom) squarks → 6 CONF - 1 paper
- Electroweak SUSY (charginos, neutralinos, sleptons) → 5 CONF
- R-parity Violating scenarios & long-lived particles→ 5 CONF - 2 papers

(m_0, $m_{1/2}$) plane for the MSUGRA/CMSSM model



Exclusion limits at 95% CL for 8 TeV analyses

Chargino & neutralino searches



Exotics Searches at Atlas (non-SUSY)

- Plethora of BSM "exotics" models:
  - Extra-dimensions, GUT, Technicolor(s), Leptoquarks, Hidden Valley, Compositeness, SeeSaw mechanism, etc…
- Searches for final state signature:
  - Heavy Resonances, monojet, multileptons, same-sign dileptons, long-lived particles, lepton jets…
- Results can be interpreted in the context of predictions of multiple models

See also: NON-SUSY session @ HB2013 07/06/2013

Dilepton resonances

Full 8TeV dataset

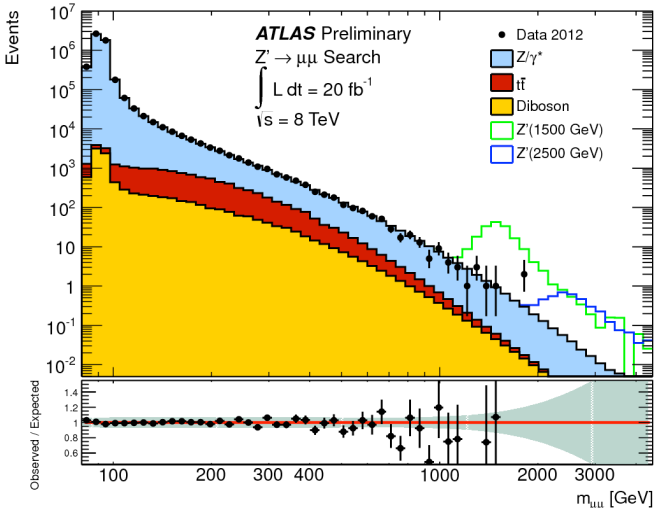
[ATLAS-CONF-2013-017]

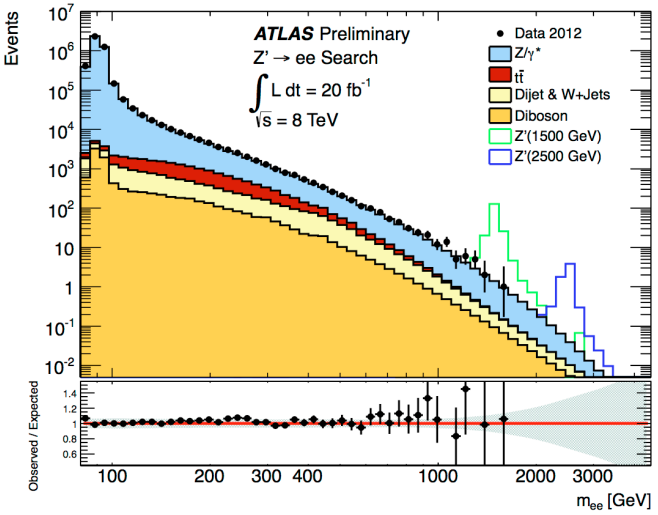
BSM extensions:

- Z' from GUT E6, SSM
- Randall-Sundrum graviton

Event selection:

- Single (double) muon (electrons) trigger
- 2 Same Flavor (Opposite sign for muons) leptons
- *Main backgrond:*
  - tt, Drell-Yan, Diboson
  - QCD multijets and W+jets (in electron channel)
- Number of events for most backgrounds from MC using SM predicted cross section (using NNLO K-factors)
- Jets background and Multi-jets from data template



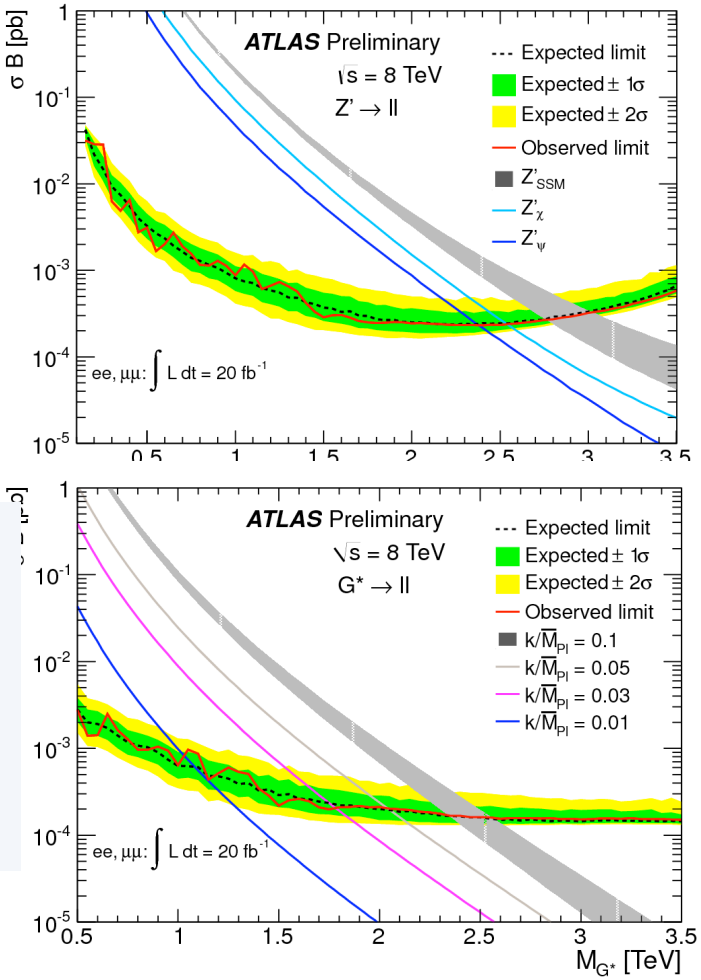


Dilepton resonances

Full 8TeV dataset

[ATLAS-CONF-2013-017]

- Upper limit on the number of signal events is determined at the 95% C.L. using a Bayesian approach



Exclusion regions:

$M_{Z'} < 2.86$ TeV @ 95% CL (SSM)
$M_{Z'} < 2.38$-2.54 TeV @ 95% CL (E_6 models)
$M_{G^*} < 2.47$ TeV @ 95% CL (RS gravitons, $k/M_{Pl}=0.1$)

Atlas Experiment: Papers

	Bphys	Top	SM	Higgs	Susy	Exotic	HI	
2013	1 (10%)	6 (18%)	9 (12%)	4 (15%)	5 (9%)	12 (17%)	3 (27%)	40 (15%)
2012	5 (56%)	24 (73%)	25 (34%)	16 (59%)	33 (60%)	34 (49%)	4 (36%)	141 (50%)
Overall (since 2010)	9	33	73	27	55	70	11	**278**

Atlas Conference Talks

- Nel 2013 circa 100 conferenze con talks Atlas

(Atlas international conference policy: http://atlas-speakers-committee.web.cern.ch/atlas-speakers-committee/)

- **International Conference Talks Atlas-Napoli:**
  - *F. Conventi "Summary of Higgs and BSM physics at ATLAS" (Higgs and Beyond 2013, Sendai June 2013)*
  - *E. Rossi "Production cross section of B-meson in ATLAS" (DIS2013, Marsiglia Apr 2013)*
  - *A. Sanchez "Determination of the Higgs boson spin at ATLAS " SPIN2013, Praga Jul 2013*

Atlas Conference Talks and posters

- Atlas-IT Conference Talks:
  - N. Bruscino " Misura della massa del candidato bosone Higgs nel canale H→ZZ→4l", IFAE2013, Cagliari Apr 2013
  - N. Bruscino " Test d'ipotesi per differenti stati di spin-parita nel decadimento *H→ZZ*→4l* per la nuova risonanza osservata dall'esperimento ATLAS a LHC", *" XCIX Congresso Nazionale della SIF, Trieste, 23-27/9/2013.*
  - F. Cirotto "Risultati e prospettive nello studio della struttura tensoriale del veritce HZZ con l'esperimento Altas ad LHC", IFAE2013, Cagliari Apr 2013 **(miglior presentazione)**
  - F. Cirotto "Risultati e prospettive nello studio della struttura tensoriale del vertice H→ZZ(*) : Ricerca di effetti di violazione di CP con discriminate 1D basato sul metodo Matrix Element*" XCIX Congresso Nazionale della SIF, Trieste, 23-27/9/2013.*
  - A. Sannino "Ricerca del decadimento raro Bs→mumu in Atlas", IFAE2013, Cagliari Apr 2013
  - A. Sanchez "Quark-gluon tagging: Applicazioni nella ricerca del bosone di Higgs nell'esperimento Atlas ad LHC: IFAE2013, Cagliari Apr 2013
  - E. Rossi "Risultati di ATLAS nella ricerca di H->ZZ->4l", IFAE2013, Cagliari Apr 2013

Analisi: In&Out 2013

- **Laurea magistrale:**

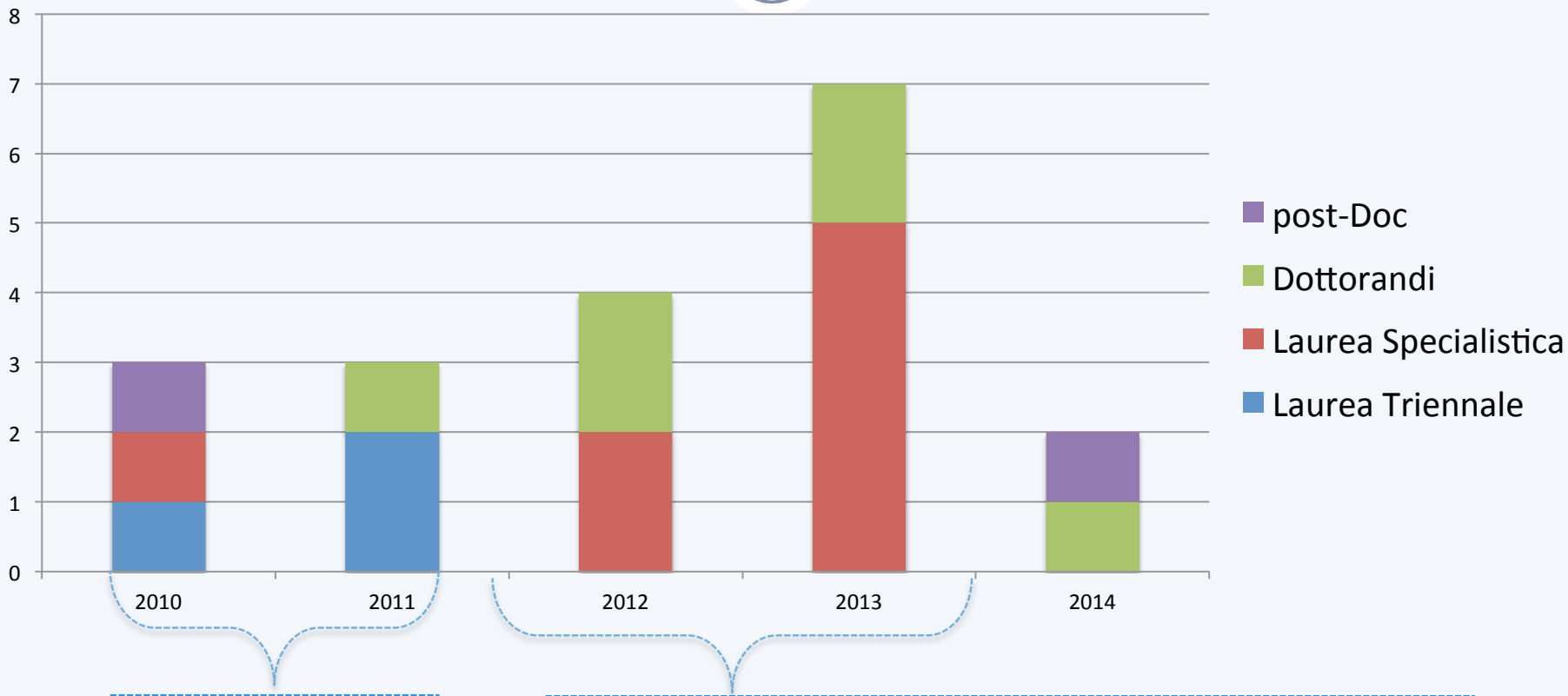
☑ A. Sannino (Bs→mumu, marzo 2013)
☑ F. Cirotto (Higgs spin-CP, ottobre 2013)
☑ N Bruscino (Higgs spin-CP, ottobre 2013)
☑ C. Savarese (High mass H→ZZ→qqll, novembre 2013)
☐ N. Calace (W+jets, marzo 2014)
☐ L. Paolillo (Low mass H→ZZ→qqll, meta' 2014)

- **Dottorandi/ti:**

☑ A. Sanchez (high mass H→ZZ→qqll Aprile 2013, assegnista)
☐ G. Zurzolo → termine del II anno → tesi ☺
☑ N.Bruscino inziera' a breve il suo PhD in Bonn (ttH)

- *Concorso dottorato a Napoli Febbraio 2014!!*

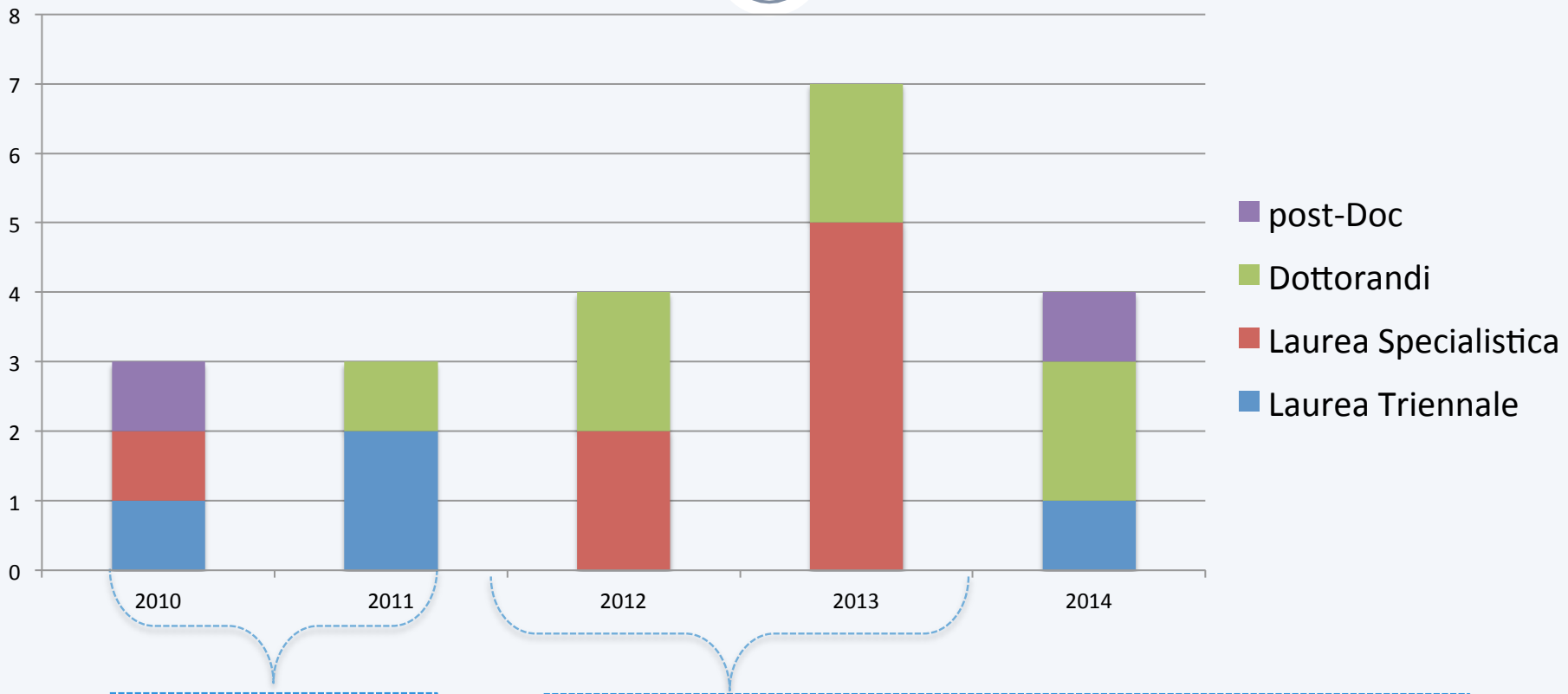
Analisi: In&Out 2013



J/ψ→μμ and B-Physics

Higgs→ZZ→4l: Discovery and Spin-CP
Higgs→ZZ→qqll: High mass resonance
B-Physics

Analisi: In&Out 2013



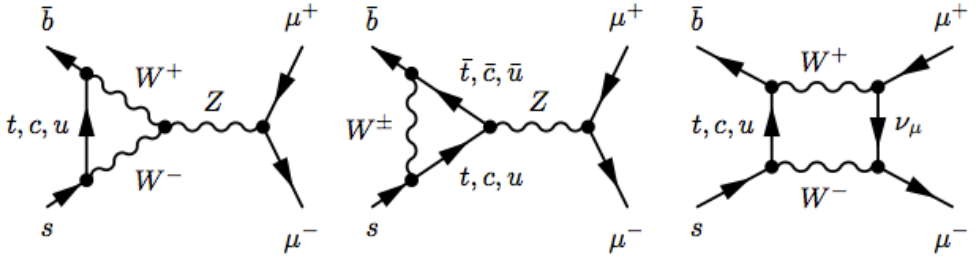
J/ψ→μμ and B-Physics

Higgs→ZZ→4l: Discovery and Spin-CP
Higgs→ZZ→qqll: High mass resonance
B-Physics

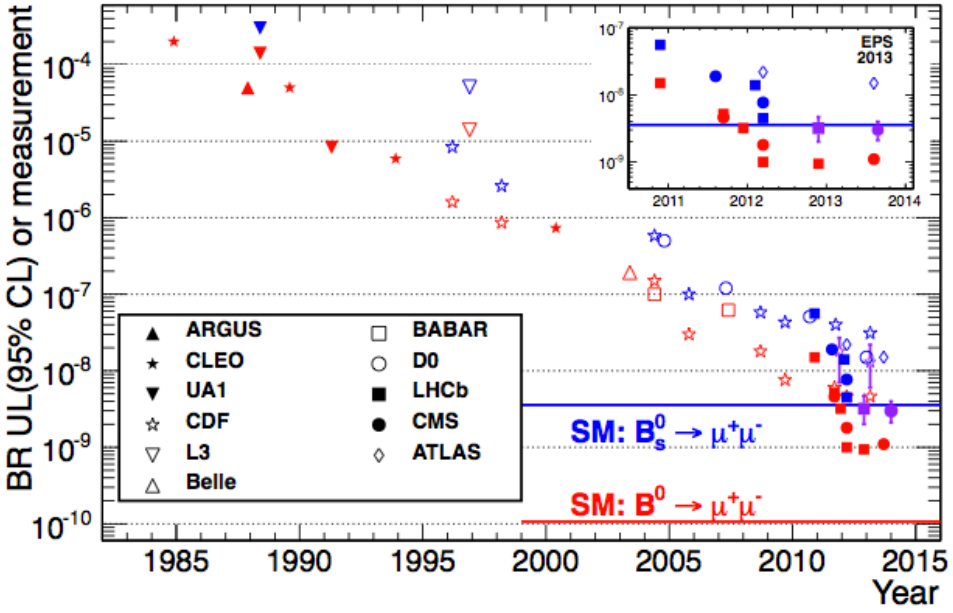
$B_s \rightarrow mu+mu-$

V. Canale, P. Iengo,
A. Sannino
(Laurea on March 2013)

- FCNC process → suppressed at tree level in SM
- SM BR=(3.46±0.18) x 10^{-9} (with time integration effect)



First observation of Bs→mumu decay from LHCb (Summer 2013)

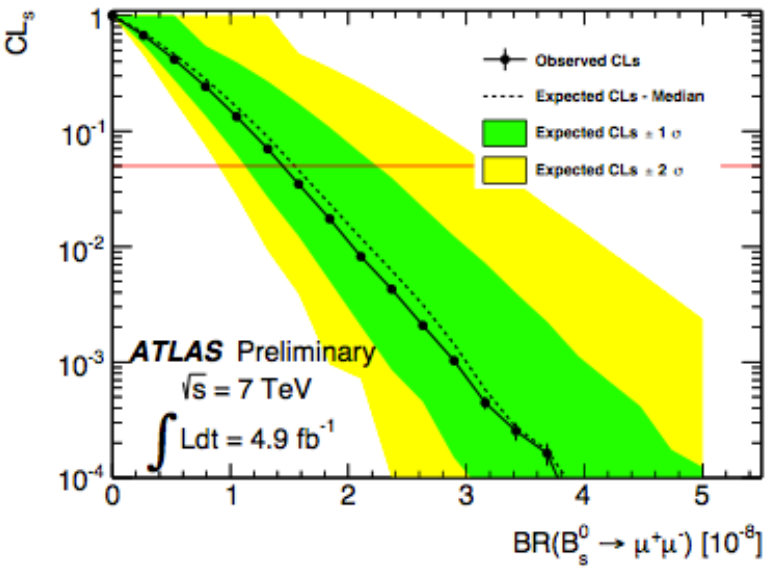


ATLAS suffers from historical lack of manpower in this analysis:
In 2013 finalized analysis of data collected in 2011 (4.9 fb^{-1}) → Br<1.5x10^{-8} @ 95%CL
Analysis on full data set 2011+2012 (25 fb^{-1}) ongoing

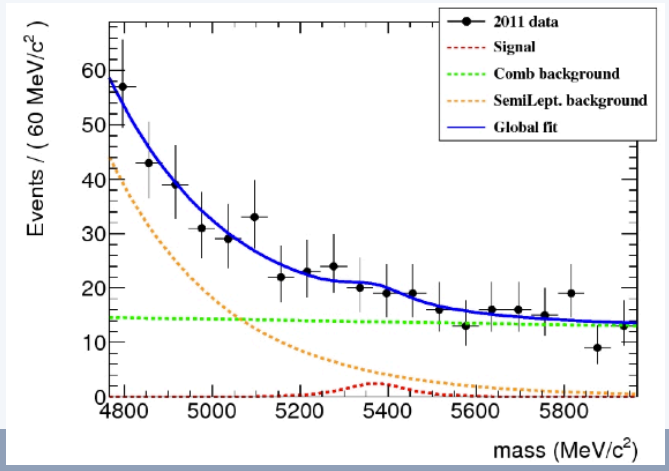
V. Canale, P. Iengo, A. Sannino
(Laurea on March 2013)

$B_s \rightarrow mu+mu-$

- Contributo del gruppo di Napoli
  - Trattamento statistico dei dati
  - Definizione ed implementazione delle procedure per l'estrazione del limite superiore
  - Estrazione del limite
  - Combinazione del limite con LHCb e CMS (2012) → prima combinazione in assoluto dei tre esperimenti LHC
  - Editor degli articoli e note di ATLAS e della combinazione ATLAS/CMS/LHCb
  - Proposte e studio per migliorare l'analisi in vista dell'estensione a tutta la statistica 2011+2012 (tesi di A. Sannino)



- Tecnica SWAP: consente di ottimizzare l'utilizzo del campione di dati disponibile per la valutazione del fondo e quindi di ridurre una parte dell'errore sistematico sul limite → tecnica poi esportata in altre analisi di ATLAS
- Implementazione di un fit unbinned alla mass shape per sostituire il fit di event counting effettuato in precedenza



Entrambe le proposte portano ad un aumento di sensibitilta' della misura

V. Canale, P. Iengo, A. Sannino
(Laurea on March 2013)

$B_s \rightarrow mu+mu-$

- Finalizzazione dell'analisi su 25 fb^{-1} entro l'estate → speriamo di passare dal limite alla misura
- Nonostante il ristretto numero di persone coinvolte il gruppo di Napoli e' riuscito ad avere un impatto notevole sull'analisi
- Negli ultimi mesi l'attivita' e' andata riducendosi per la mancanza di studenti ed e' destinata a scomparire
  - 1 dottorando avrebbe consentito al gruppo di guidare l'analisi e finalizzarla in tempi ragionevoli
  - 1 laureando avrebbe consentito di mantere l'attuale livello di coinvolgimento

Analisi Higgs

- **H→ZZ→4l spin-CP**

test d'ipotesi, MEGA fit: Francesco C., Elvira, Nello, Francesco Cirotto, Arturo

- Elvira co-editor nota 4leptoni spin-CP

- **2HDM (BSM) and SM H→ZZ→qqll**
- Francesco C., Arturo, Claudio, Giovanni, Lorena

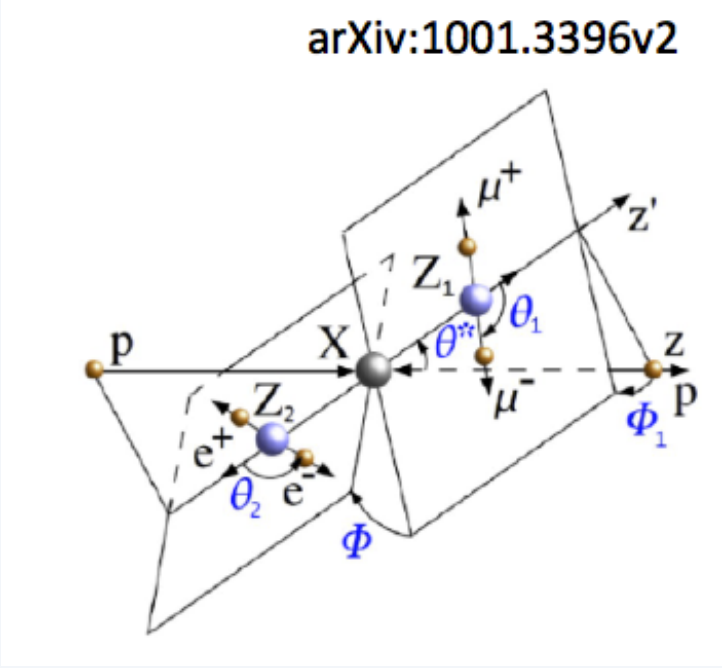
H→ZZ→4l

Modifiche rilevanti per spin-CP nella selezione H→ZZ→4l:

- Electron likelihood-ID (reduces by 50% Z+jets background)
- Cluster-track combination to improve electron resolution at low pT
- Analisi è "frozen" ma non si guarda ancora ai dati (8 e 7 TeV) →"blind"

Attesi 5 papers (2-3 mesi da ora)

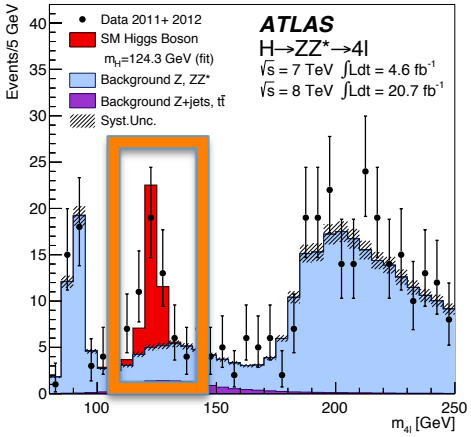
- Massa (combined con gamma-gamma)
- Couplings
- Spin-CP (Elvira co-editor)
- Fiducial and differential x-section
- High mass searches



H→ZZ→4l

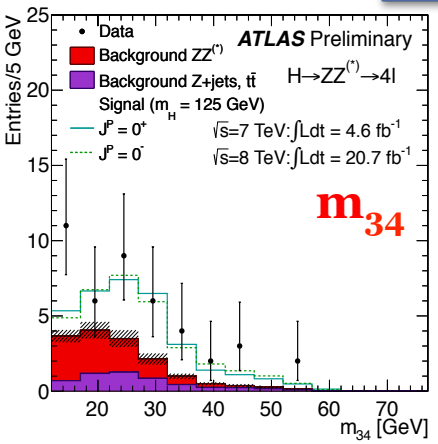
Stato finale con 4 leptoni completamente ricostruito

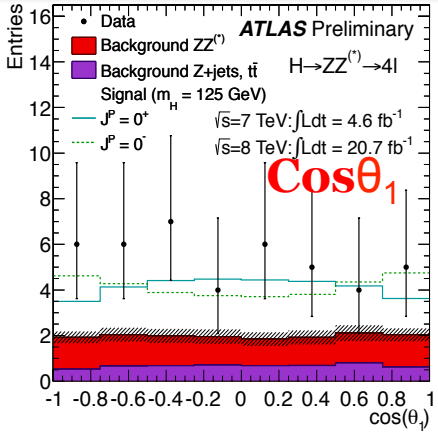
- Gli osservabili sensibili per la misura di spin-CP sono: le masse delle due Z, l'angolo di produzione (Θ*) e 4 angoli di decadimento
- Identificazione dei leptoni e selezione degli eventi come per l'analisi nominale
- Divisione in 4 canali finali per aumentare la sensibilita': 4e, 4μ, 2e2μ, 2μ2e
- Selezione eventi con m4l [115-130] GeV: divisione in due regioni (low S/B (115-121) e (127-130) GeV e high S/B: (121-127) GeV)
- Test d'ipotesi 0-, 1+, 1- e spin-2

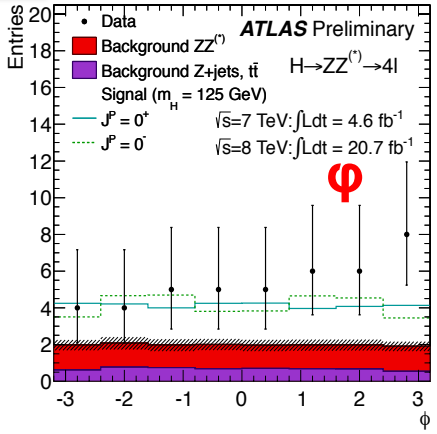


Osservabili sensibili

Unico canale in grado di studiare il caso di spin 0-







H→ZZ→4l spin-CP: Test d'ipotesi

Tesi Nello B.

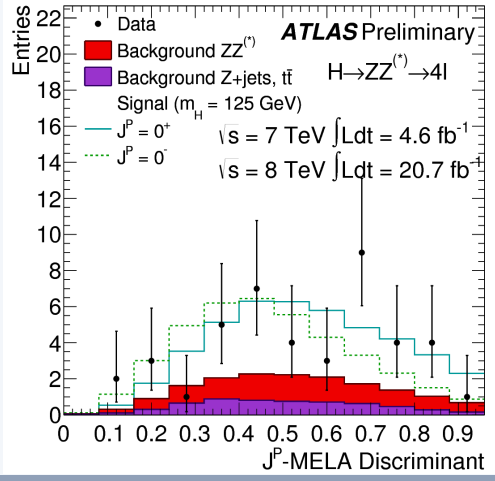
Evidence for the spin-0 nature of the Higgs boson using ATLAS data
Phys. Lett. B 726 (2013), pp. 120-144

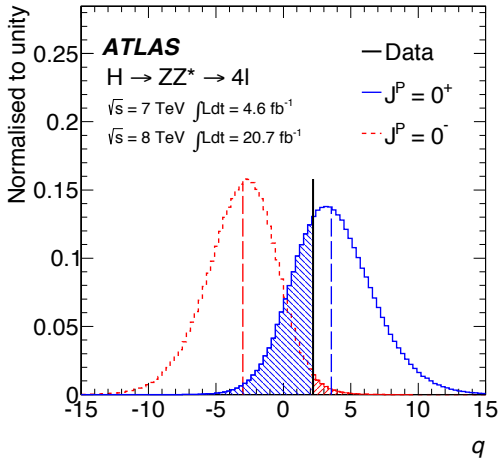
Eventi osservati	**43**
Eventi attesi BKG	**16**
Eventi attesi SM Higgs	**18**

MELA: approccio Matix Element per la costruzione di un discriminante a 8 dimensioni per distiguere tra le diverse ipotesi di spin-CP

Modifiche nell'analisi principale si ripercuotono sull'analisi spin-CP

Esclusione dell'ipotesi 0- and 2+ (CL >98% con il solo H→ZZ→4l)



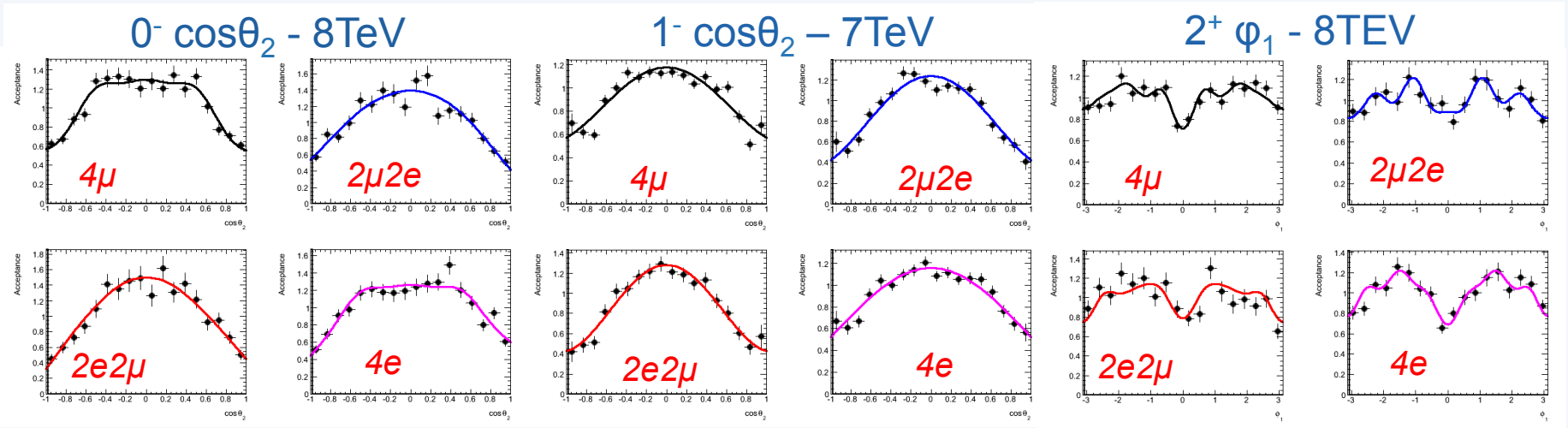


Systematics:

- shape of the observables
- normalisation of the high/low S/B mass bins (±10%)
- overall variations of the bkg yields + 10% for migration of events

H→ZZ→4l spin-CP: Test d'ipotesi

- Update dei test d'ipotesi per la nota:
  - Inclusione delle modifiche nella selezione 4l + update MC signal sample (spin2 MadGraph5)
  - Ri-ottimizzare fit di accettanza
  - Estrazione dei limiti e separazioni (0^-,1^+,1^-,2^+,2^{-h}, 0^{-h}??)
  - Nuova stima delle sistematiche



Studio della struttura tensoriale del vertice H→ZZ

(Napoli, RomeI and ANL & Chicago)

- "MEGA": Metodo Matrix Element usato per misurare Spin-CP dell'Higgs nel canale in H→ZZ→4l
- Stato 0^- escluso dal test di ipotesi ma stati misti possibili (SUSY and 2HDM models)
- Termini CP-odd implicano violazione di CP→ meccanismo bariogenesi (matter-antimatter asymmetry)
- Uno studio completo richiede esclusione della frazione CP-odd ad un livello del 10% che però corrisponde ad un contributo in ampiezza dell'ordine 10^{-5} (accoppiamento HZZ in CP-odd e' soppresso ad 1 loop)

Studio della struttura tensoriale del vertice H→ZZ

$$A(X \to V_1 V_2) = v^{-1}\left(g_1^{(0)} m_V^2 \epsilon_1^* \epsilon_2^* + g_2^{(0)} f_{\mu\nu}^{*(1)} f^{*(2),\mu\nu} + g_3^{(0)} f^{*(1),\mu\nu} f_{\mu\alpha}^{*(2)} \frac{q_\nu q^\alpha}{\Lambda^2} + g_4^{(0)} f_{\mu\nu}^{*(1)} \tilde{f}^{*(2),\mu\nu}\right),$$

$$= v^{-1} \epsilon_1^{*\mu} \epsilon_2^{*\nu} (a_1 g_{\mu\nu} m_X^2 + a_2 q_\mu q_\nu + a_3 \epsilon_{\mu\nu\alpha\beta} q_1^\alpha q_2^\beta).$$

in terms of coefficients a_1, a_2, a_3 (i.e. g_1, …, g_4):

$$a_1 = g_1^{(0)} \frac{m_V^2}{m_X^2} + \frac{s}{m_X^2}\left(2g_2^{(0)} + g_3^{(0)} \frac{s}{\Lambda^2}\right),$$

$$a_2 = -\left(2g_2^{(0)} + g_3^{(0)} \frac{s}{\Lambda^2}\right), \qquad a_3 = -2g_4^{(0)},$$

where s is defined as

$$s = q_1 q_2 = \frac{m_X^2 - m_1^2 - m_2^2}{2}.$$

Coupling of CP-even Higgs boson (h or H) to ZZ pair expected at tree level

Coupling of CP-odd Higgs boson (A) to ZZ pair expected through loops (greatly suppressed)

Notice that a_1 can be identified with g_1 (i.e. characterizes CP fraction) *only if* g_2=g_3=0

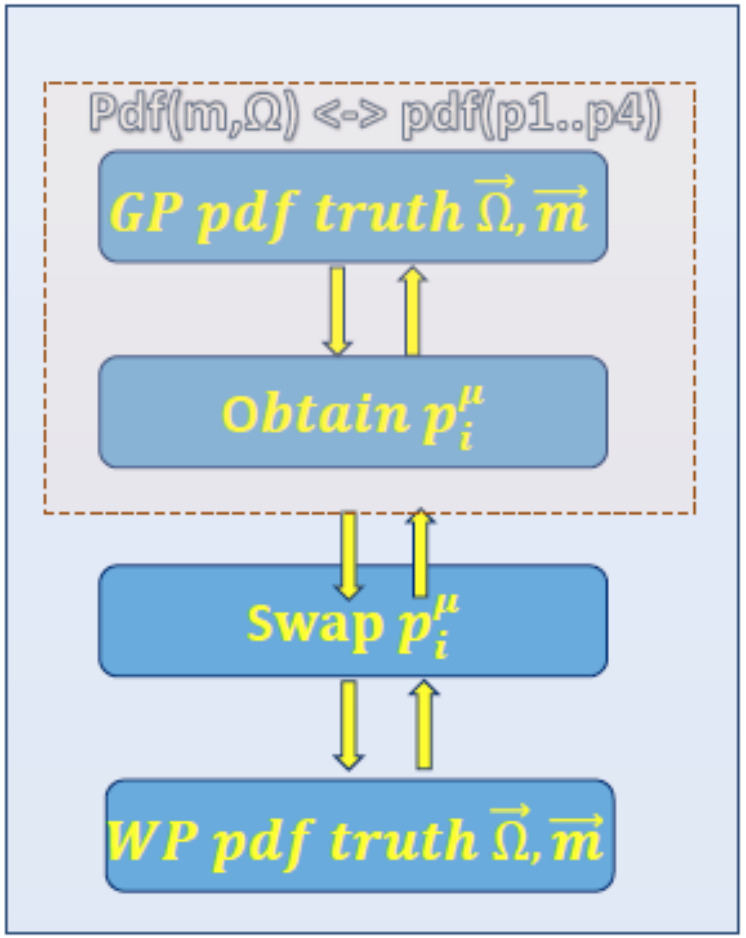
SM: g_1=1, g_2=g_3=g_4=0

Studio della struttura tensoriale del vertice H→ZZ

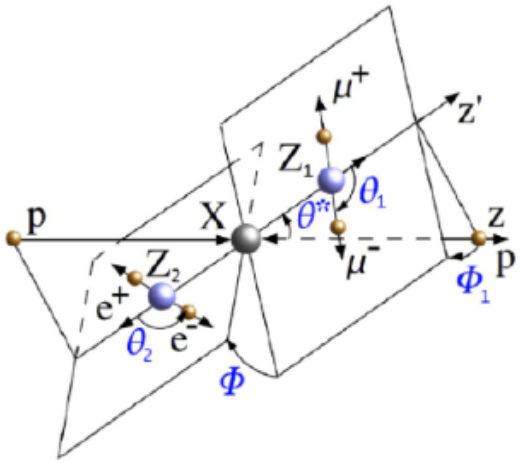
- Primi risultati su g_2 e g_4 gia' con i dati di Run-I (sensitivita' limitata)
- Prospettive per Run-II e oltre (gia' inlcuse nelle note ECFA di Ottobre 2013)
- Fit 8 dimensionale (m_{4l}, m_1, m_2, Ω)
- Diverse problematiche sperimentali da affrontare:
  - Good-Wrong paired events (10-15% del totale)
  - Effetti di accettanza del detector e della procedura di selezione sulla pdf

Mela and MEGA ++

Francesco C.
Elvira
Francesco Cirotto



arXiv:1001.3396v2



defined as

$$\Phi = \frac{\boldsymbol{q}_1 \cdot (\hat{\boldsymbol{n}}_1 \times \hat{\boldsymbol{n}}_2)}{|\boldsymbol{q}_1 \cdot (\hat{\boldsymbol{n}}_1 \times \hat{\boldsymbol{n}}_2)|} \times \cos^{-1}(-\hat{\boldsymbol{n}}_1 \cdot \hat{\boldsymbol{n}}_2) ,$$
$$\Phi_1 = \frac{\boldsymbol{q}_1 \cdot (\hat{\boldsymbol{n}}_1 \times \hat{\boldsymbol{n}}_{sc})}{|\boldsymbol{q}_1 \cdot (\hat{\boldsymbol{n}}_1 \times \hat{\boldsymbol{n}}_{sc})|} \times \cos^{-1}(\hat{\boldsymbol{n}}_1 \cdot \hat{\boldsymbol{n}}_{sc}) , \quad (2)$$

where the normal vectors to the three planes are defined as

$$\hat{\boldsymbol{n}}_1 = \frac{\boldsymbol{q}_{11} \times \boldsymbol{q}_{12}}{|\boldsymbol{q}_{11} \times \boldsymbol{q}_{12}|} , \qquad \hat{\boldsymbol{n}}_2 = \frac{\boldsymbol{q}_{21} \times \boldsymbol{q}_{22}}{|\boldsymbol{q}_{21} \times \boldsymbol{q}_{22}|} , \quad \text{and} \quad \hat{\boldsymbol{n}}_{sc} = \frac{\hat{\boldsymbol{n}}_z \times \boldsymbol{q}_1}{|\hat{\boldsymbol{n}}_z \times \boldsymbol{q}_1|} . \quad (3)$$

In the above equations, $\boldsymbol{q}_{i1(2)}$ is the three-momentum of a fermion (antifermion) in the decay of the V_i, and $\boldsymbol{q}_1 = \boldsymbol{q}_{11} + \boldsymbol{q}_{12}$ is the V_1 three-momentum, where all three-momenta are defined in the X rest frame.

- Finally, the angles θ_1 and $\theta_2 \in [0, \pi]$ are defined as

$$\theta_1 = \cos^{-1}\left(-\frac{\boldsymbol{q}_2 \cdot \boldsymbol{q}_{11}}{|\boldsymbol{q}_2||\boldsymbol{q}_{11}|}\right) , \quad \theta_2 = \cos^{-1}\left(-\frac{\boldsymbol{q}_1 \cdot \boldsymbol{q}_{21}}{|\boldsymbol{q}_1||\boldsymbol{q}_{21}|}\right) , \quad (4)$$

where all three-momenta are taken in the rest frame of V_i for the angle θ_i.

Mela and MEGA ++

$$\text{Acceptance}\,(x) = \frac{\text{JHU reco distribution of x}}{\text{MELA truth pdf for x}}$$

At each point in observable space, calculate parton-level p_T and η of the 4 leptons

↓

Determine the acceptance of each lepton from a pre-derived p_T vs. η template

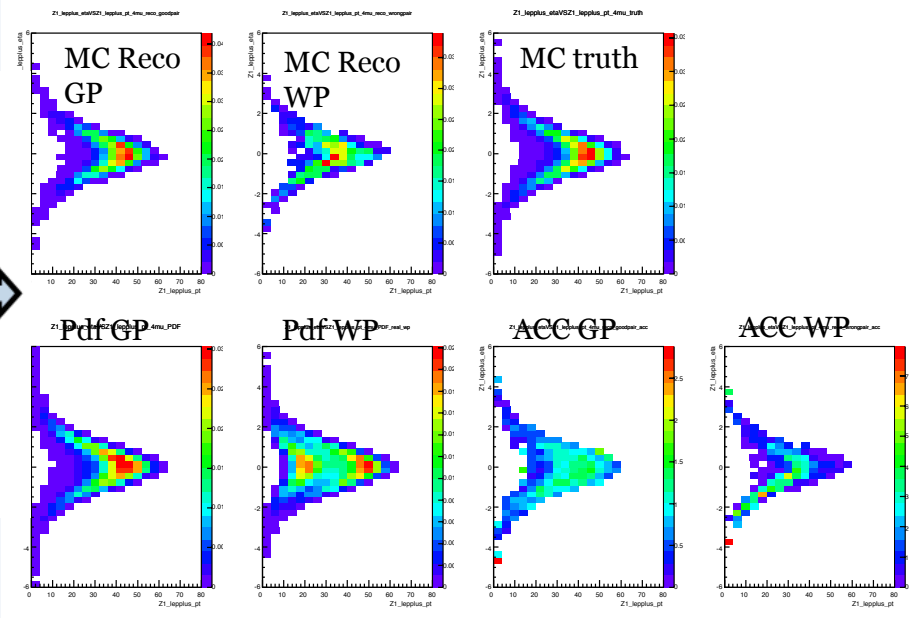
↓

Assign a detector correction weight:

$$Acc_1(p_{T1},\eta_1) \times Acc_2(p_{T2},\eta_2) \times Acc_3(p_{T3},\eta_3) \times Acc_4(p_{T4},\eta_4)$$

4μ channel:

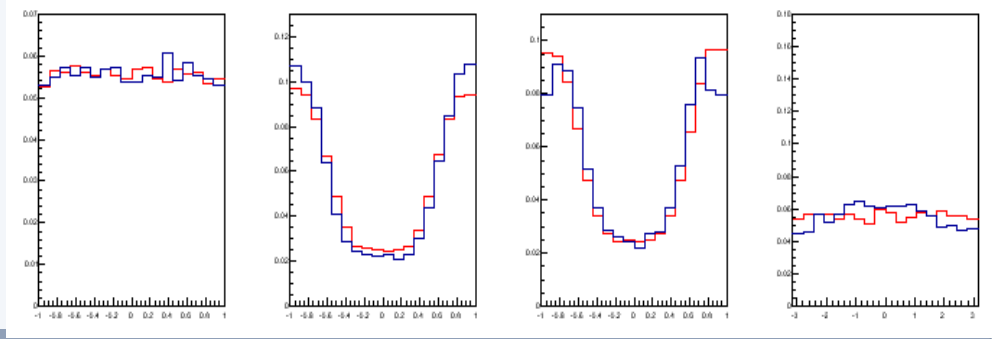
Positive lepton from Z_1 (l_1^+)



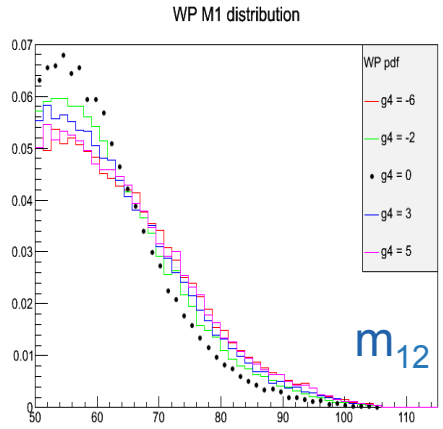
Wrong Pair events → from reco MC

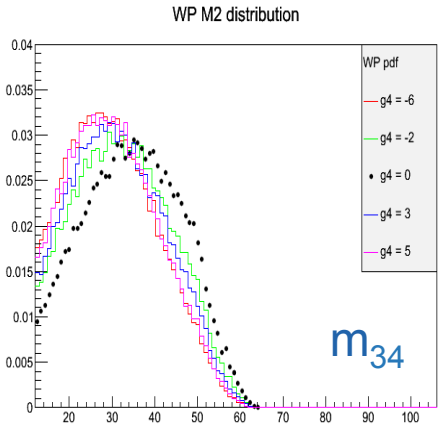
RED: MC Wrong Paired events truth distributions

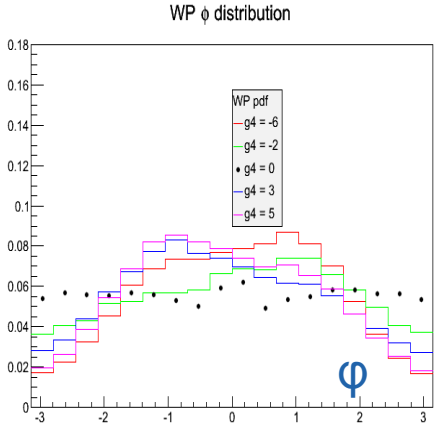
BLU: Wrong Paired events truth pdf

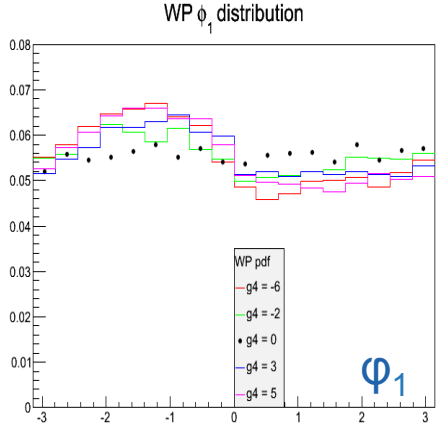


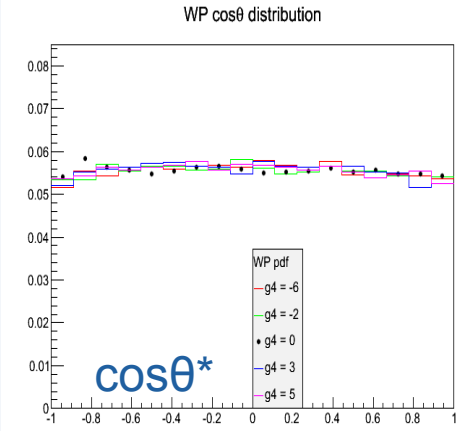
WP pdf for g4≠0

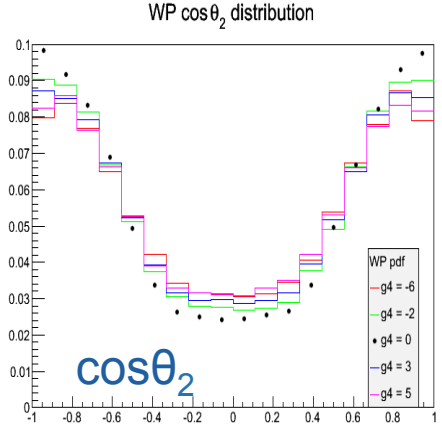


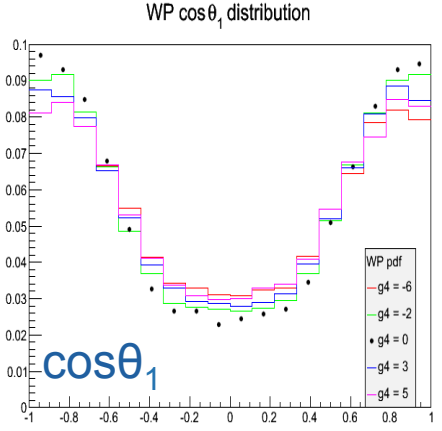




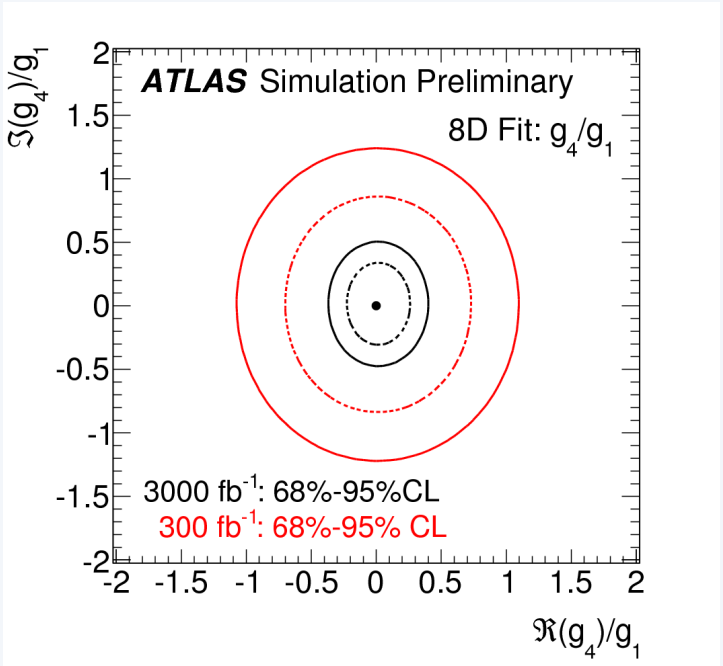


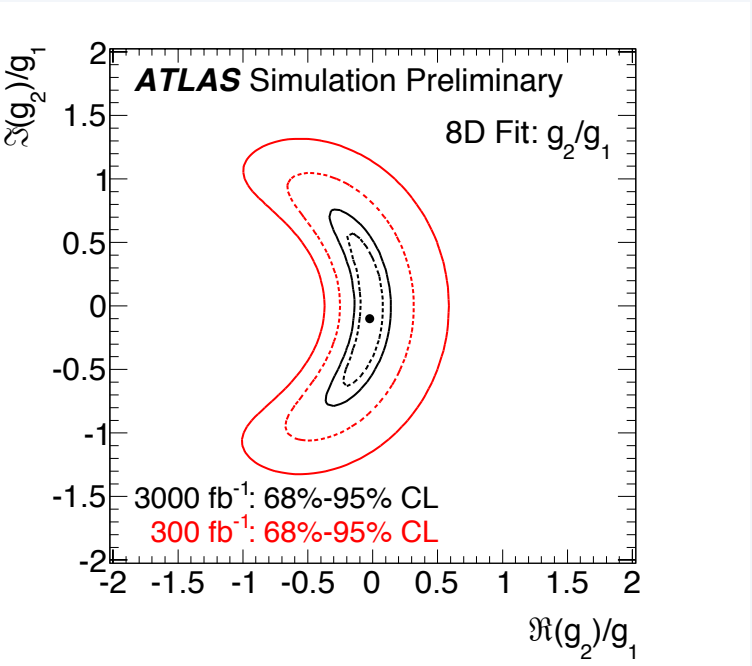






Studio della struttura tensoriale del vertice H→ZZ



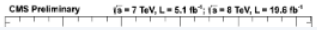


- CP-fraction is defined as fractional *event yield* from CP-odd source:

$$f_{CP} = f_{a3} = \frac{|a_3|^2\sigma_3}{|a_1|^2\sigma_1 + |a_2|^2\sigma_2 + |a_3|^2\sigma_3}; \qquad \phi_{a3} = \arg\left(\frac{a_3}{a_1}\right)$$

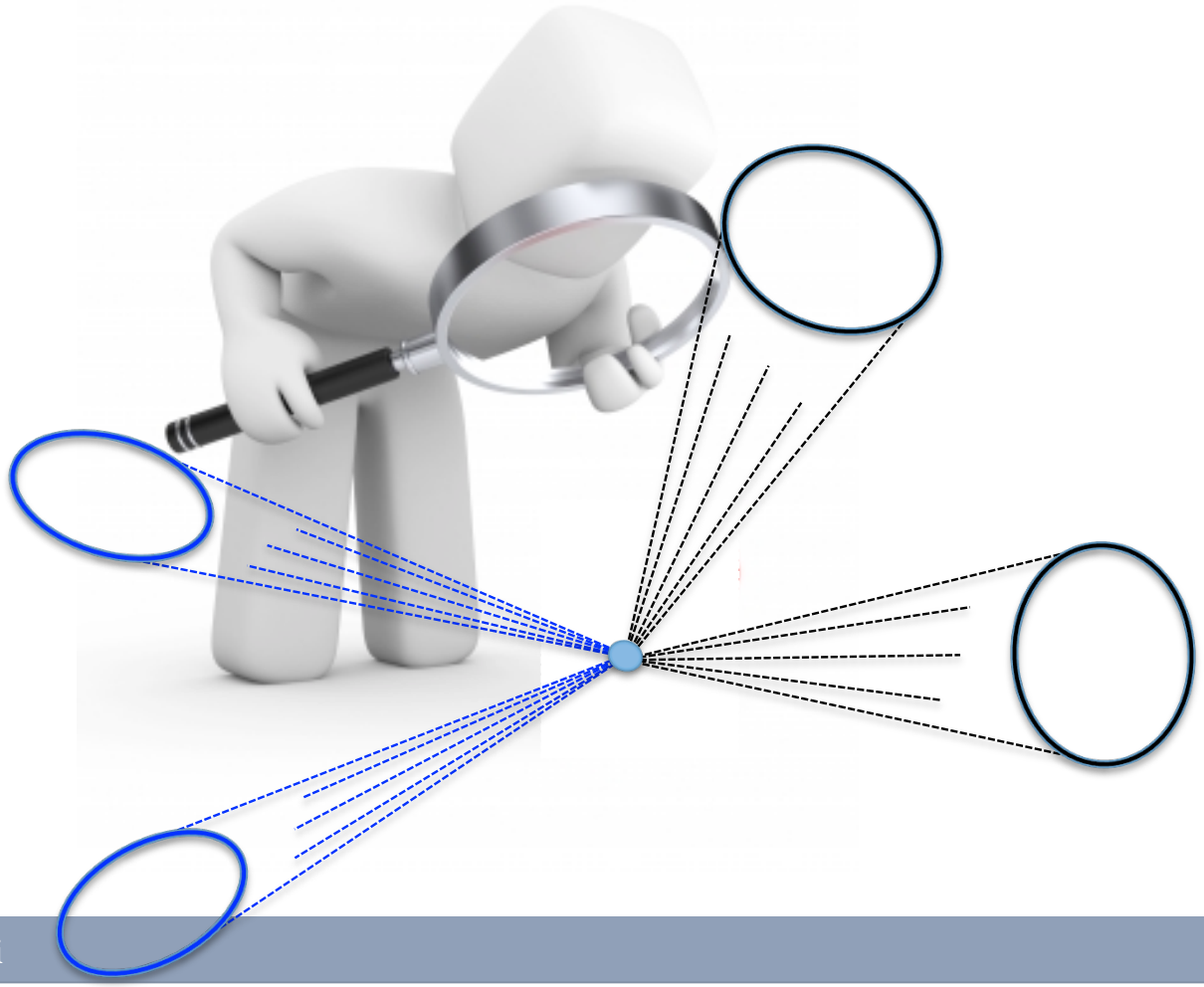
$$f_{a2} = \frac{|a_2|^2\sigma_2}{|a_1|^2\sigma_1 + |a_2|^2\sigma_2 + |a_3|^2\sigma_3}; \qquad \phi_{a2} = \arg\left(\frac{a_2}{a_1}\right)$$

$$\sigma_i = \int d\Omega\, |A_{VV}(a_i = 1, a_{j\neq i} = 0)|^2$$



8D fit		
Luminosity	f_{g4}	f_{g2}
300 fb^{-1}	0.2	0.29
3000fb^{-1}	0.06	0.12

The ZZ→llqq Analysis



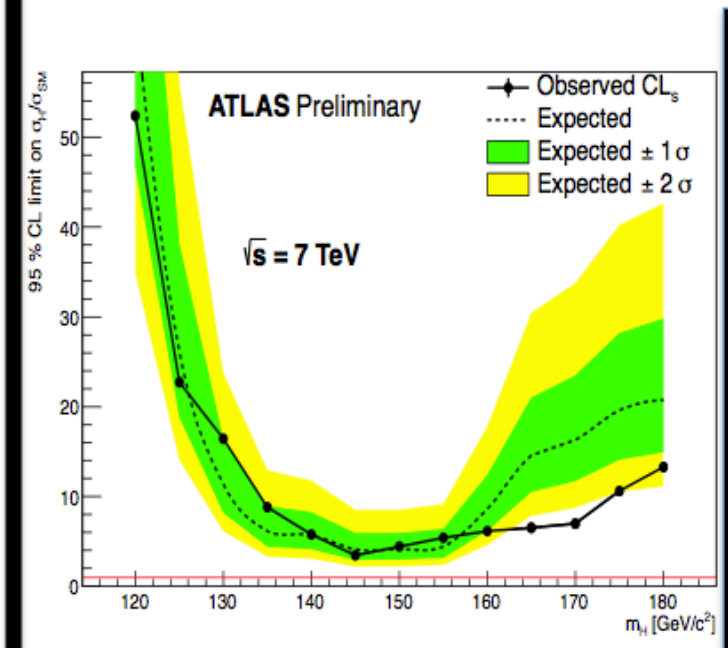
Introduction

The focus of the llqq-group activities is the implementation and improvement of the High Mass Analysis and Low Mass Analysis using the 2012 data recorded by the ATLAS detector at $\sqrt{s}$ = 8 TeV (20.3 fb^{-1}).

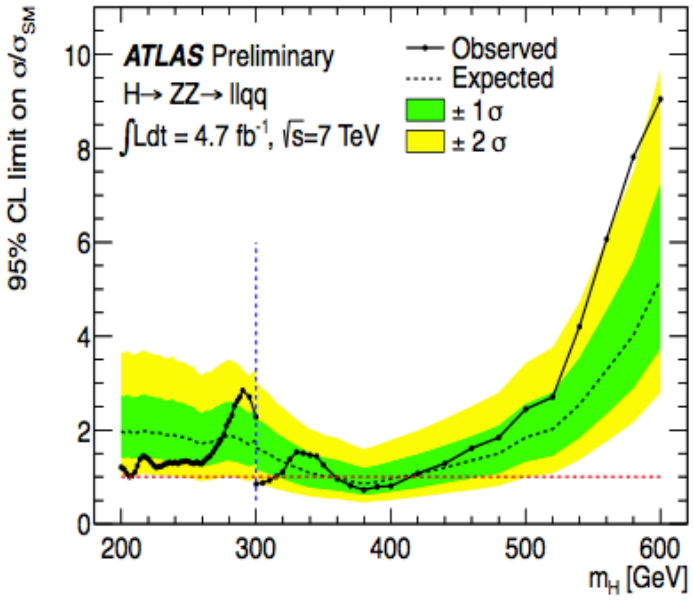
Knowing the Higgs decays H→ZZ→llqq is one of the most sensitive channels in the very high mass region: A search for a Higgs-like particle doing a scan of mass and width with no assumptions on production cross section, but with SM prediction as central value and on separate production mechanisms (ggH and VBF) is ongoing.

The goal is to produce a complete analysis into the mass range
120 GeV -1 TeV using the 2011+2012 data
$\sqrt{s}$ = 7 TeV (4.71 fb^{-1}) + $\sqrt{s}$ = 8 TeV (20.3 fb^{-1})

The H→ZZ(*)→llqq
Analyses with 2012 data at √s = 8 TeV



?



Extending the Mass search

!

120 GeV

2011:
[120-180] + [200-600] GeV

600 GeV

1000 GeV

2012:
120 GeV to 1TeV

The High Mass analyses

The goal is to use the VV channels search/constraint models with multiple Higgs bosons

- $H \to ZZ \to 4\ell$
- $H \to ZZ \to \ell\ell\nu\nu$
- $H \to ZZ \to \ell\ell qq$
- $H \to ZZ \to b\bar{b}\nu\nu$
- $H \to ZZ \to \ell\ell\tau\tau$
- $H \to WW \to \ell\nu\ell\nu$
- $H \to WW \to \ell\nu qq$

Plan: **paper** combining the $H \to ZZ \to \ell\ell XX$ channels early next year using 8 TeV data
The $H \to ZZ \to b\bar{b}\nu\nu$ would then be included for the combination with other searches ($H \to WW/\gamma\gamma$, $A \to Zh$, ...)

Two benchmarks are planned to be explored (HSG6 Int Note):

- **125 GeV Higgs + High mass real electroweak singlet**
- **2HDM**
- Higgs triplet models ? $\to$ future
- Degenerated states (125 GeV) ? $\to$ future

Knowledge ($m_h = 125$ GeV mass/signal-strength/couplings) included accordingly.
Agreement within ATLAS (and at some point with CMS) also with the "blessing" of the theory community (under the LHC XSEC BSM Heavy Higgs WG)

125 GeV Higgs + Real Electroweak 125 Singlet

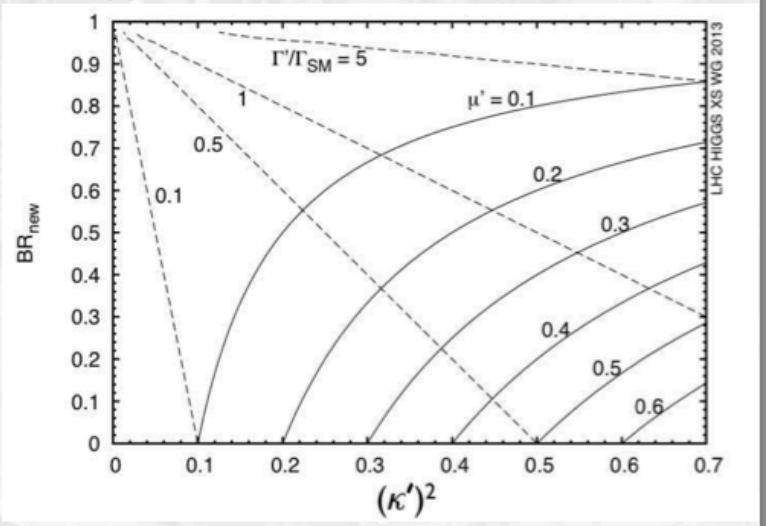
- Upper-limit on $\sigma \times$BR **CPS like and NWA** (partially done for the 4ℓ channel)
- Heavy real singlet couplings rescaled wrt SM
- $h_{125\text{GeV}}$ coupling: κ, H_{new} coupling: κ'
- H constrained by: $\kappa'^2_V + \kappa^2_V = 1.$ $\kappa \equiv \kappa_V = \kappa_f = \sqrt{\mu}$
- Search in 2 parameters space for each m_H hypothesis:

$$\mu' = \frac{\sigma' \times \text{BR}'}{\sigma_{\text{SM}} \times \text{BR}_{\text{SM}}} = \kappa'^2(1 - \text{BR}_{\text{new}})$$

$$\sigma' = \kappa'^2 \sigma_{\text{SM}}$$

$$\Gamma' = \frac{\kappa'^2}{1 - \text{BR}_{\text{new}}} \Gamma_{\text{SM}}$$

$$\text{BR}' = (1 - \text{BR}_{\text{new}})\text{BR}_{\text{SM}}$$



Width may be narrower or larger than SM, we restrict ourselves to

$\Gamma'_{\text{NWA}} \leq \Gamma' \leq \Gamma'_{\text{SM}}$

Two Higgs Doublet Model potential

- Natural path to explore → two identical complex scalar fields($SU(2)$)
- The 2HDM scalar potential is a Z_2 broken symmetry

$$V(\Phi_1,\Phi_2) = m_1^2\Phi_1^\dagger\Phi_1 + m_2^2\Phi_2^\dagger\Phi_2 + (m_{12}^2\Phi_1^\dagger\Phi_2 + \text{h.c}) + \frac{1}{2}\lambda_1(\Phi_1^\dagger\Phi_1)^2 + \frac{1}{2}\lambda_2(\Phi_2^\dagger\Phi_2)^2 + \lambda_3(\Phi_1^\dagger\Phi_1)(\Phi_2^\dagger\Phi_2) + \lambda_4(\Phi_1^\dagger\Phi_2)(\Phi_2^\dagger\Phi_1) + \frac{1}{2}\lambda_5[(\Phi_1^\dagger\Phi_2)^2 + \text{h.c}]$$

- We are interested in the CP-conserving case. Parameters are:
  3 masses $m_h, m_H, m_{H^\pm}, m_A$,, 2 angles α, β and 1 potential parameter m_{12}^2
- Scan over m_H, $\cos(\beta-\alpha)$ and $\tan\beta$ planes
- For the VV final states we only focus in the type I and II where there are not FCNC

- For each parameters choice there are specific predictions for σ and BR for both light and heavy Higgs

Draft version 0.01

ATLAS NOTE

November 13, 2013

Search for a Standard Model Higgs in the mass range 120–1000 GeV in the channel $H \to ZZ \to \ell\ell qq$

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[3] *University of Liverpool, Liverpool*
[4] *Brookhaven National Laboratory, Brookhaven*
[5] *Academia Sinica, Taiwan*
[6] *Università di Napoli, Federico II*

Datasets

- Muon/Egamma streams: 20.3 fb^{-1} @ $\sqrt{s} = 8$ TeV
- Signal: Powheg ggF and VBF
  - From 200–1000 GeV in 20 (50) GeV steps below (above) 600 GeV
  - Both narrow width approx (NWA) and complex-pole scheme (CPS)
  - Reweight CPS to include interference (ggF:Passarino/VBF: REPOLO)
- Background MC:
  - Z/W+jets:
    - ggf: Inclusive + boosted Sherpa $l/c/b$ samples
    - VBF: Alpgen+Pythia (better describes VBF vars due to N_p samples)
  - $t\bar{t}$: Powheg
  - Single top: Powheg (Wt/s-chan) / Acer (t-chan)
  - Diboson ($ZZ/WZ/WW$): Herwig
    - Unfiltered WW/WZ samples
    - ZZ lepton filer/MET veto + MET filter/lepton veto
  - QCD multijet from data in ee channel (negligible in $\mu\mu$)
    - loose++ lepton ID + reversed track isolation

Event Selection

- Preselection
  - GRL, LAr/tile error veto, jet cleaning, LAr hole veto, $N_{trk}(PV) > 2$
- Recommended single/dilepton triggers
- Exactly 2 electrons/muons (no additional lepton with $p_T > 10$ GeV)

Electron

- VeryLooseLH
- $p_T > 25/10$ GeV
- $|\eta| < 2.47$
- $\sum p_T(\Delta R = 0.2)/p_T < 0.10$
- OQ cuts
- Trigger matched

Muon

- CB/ST + CB/ST/SA/Calo
- $p_T > 25/10$ GeV
- $|\eta| < 2.7$
- $\sum p_T(\Delta R = 0.2)/p_T < 0.10$
- MCP + IP cuts
- Trigger matched

- $83 < m_{ll} < 99$ GeV
- `MET_RefFinal` < 60 GeV
- Separate ggF and VBF categories ...
  - ggF has merged sub-category optimised for high m_H

Event Selection

VBF

- ≥ 4 jets (EM+GSC)
  - $p_T > 20/30$ GeV
  - $|\eta| < 4.5$
- $\eta_1 \times \eta_2 < 0$
- Pick highest m_{jj} pair
- $m_{jj} > 500$ GeV
- $\Delta\eta > 4$
- Follow ggF cuts
  - $+ p_T^{jj} > a + bm_{llqq}$

ggF

- Veto VBF events
- ≥ 2 signal jets
  - $p_T > 45/20$ GeV
  - $|\eta| < 2.5$
- $70 < m_{jj} < 105$ GeV
- Optimised cuts
  - $P_T^{\text{jet}} > 0.1 m_{llqq}$
  - $p_T^{ll} > a + bm_{llqq}$
  - $\Delta\phi_{ll} > a/m_{llqq}^b + 1$

Merged

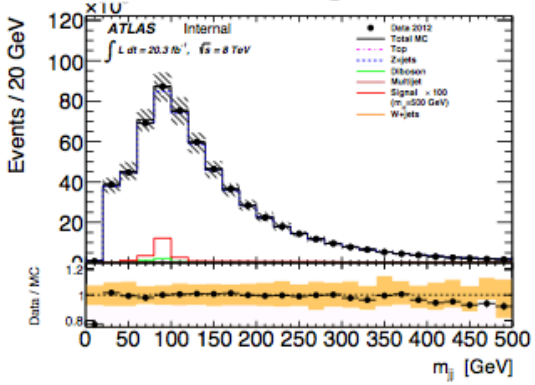
- ≥ 1 jets (anti-k_T4)
- $m_{jj} \notin [50, 150]$ GeV
- Highest p_T jet
- $m_J > 70$ GeV
- Optimised cut:
  - $p_T^{ll} > a + bm_{llqq}$

- Exclusive b-tag categories for ggF and VBF (TBC)
  - 0/1/2 b-tags using MV1c @ 70% (may merge 0/1 tag as in 7 TeV result)
  - Pick highest b-weight jets, then highest p_T

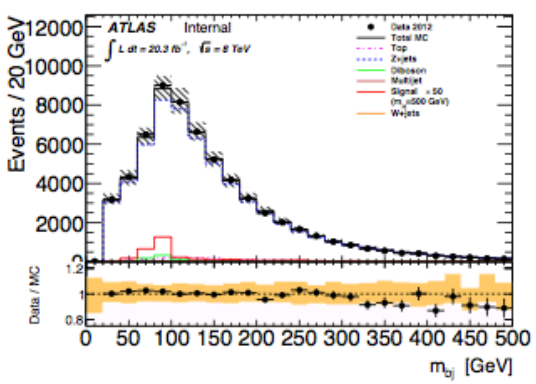
Mjj

- Before (top) and after (bottom) optimised cuts
  - b-jets corrected for semi-lep μs and $p_T^{\text{reco}}/p_T^{\text{true}}$ when forming m_{bb}
  - Some slope in ratio for 0/1 tag but SB only up to $m_{jj} = 150$ GeV

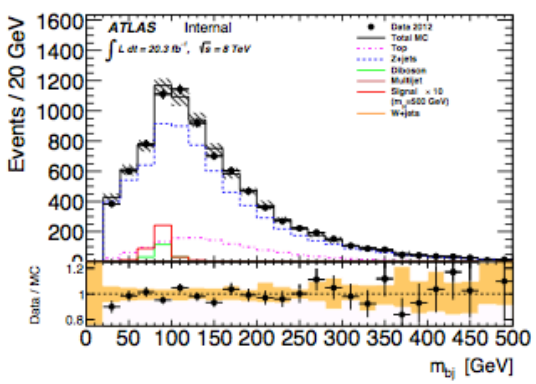
0 b-tag

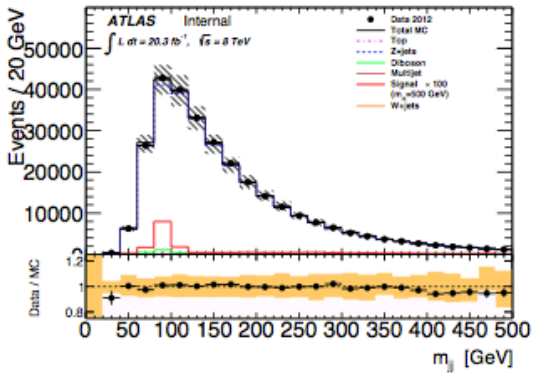


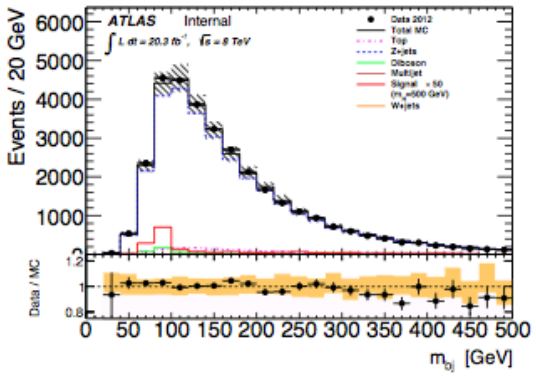
1 b-tag

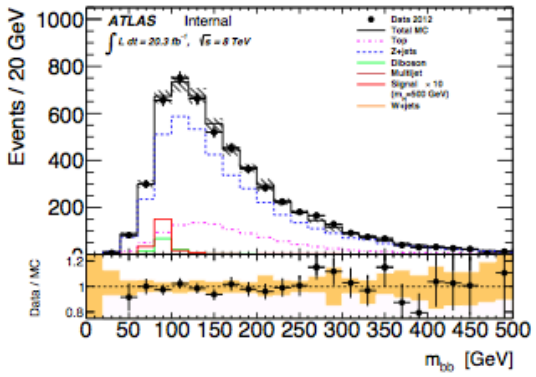


2 b-tag







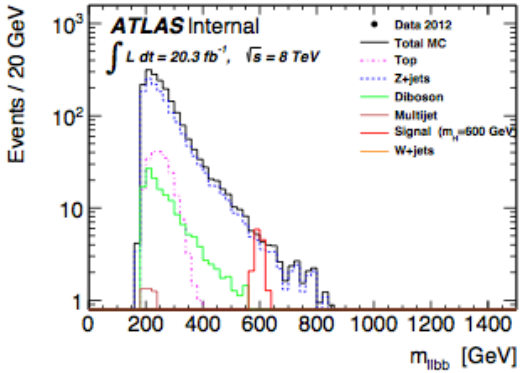


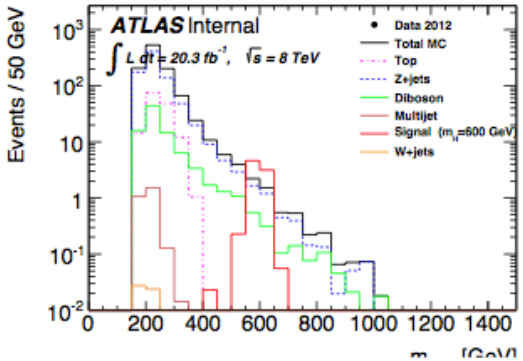
Blinded Mjjll (H mass = 600 GeV)

- m_{lljj} before (top) & after (bottom) opt. cuts
  - Constrain m_{jj} to m_Z
  - Good sensitivity, especially 2 tag (SM NWA)

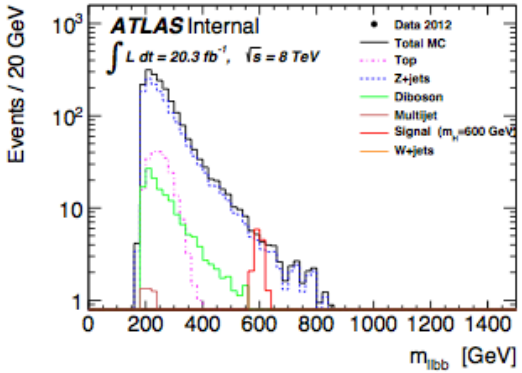
Tag	S/B	signif
0	0.05	1.72
1	0.10	1.08
2	0.57	2.90

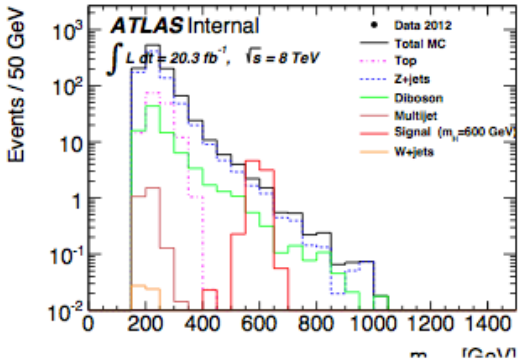
0 *b*-tag



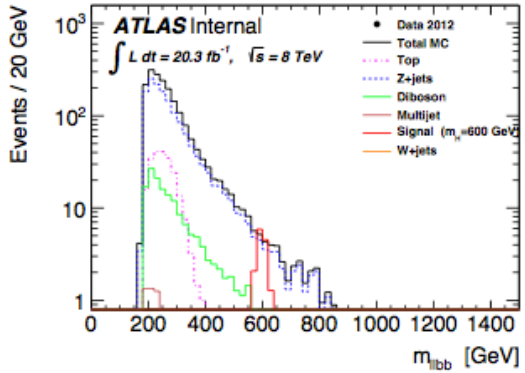


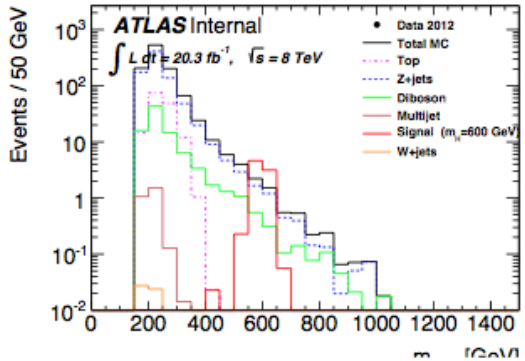
1 *b*-tag





2 *b*-tag



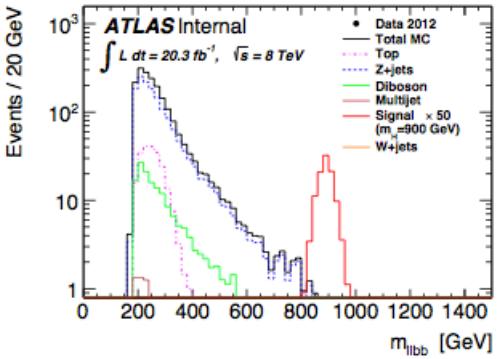


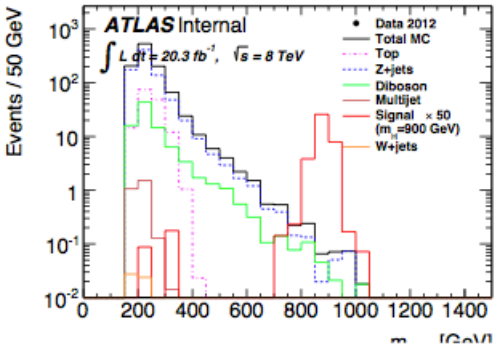
Blinded Mjjll (H mass = 900 GeV)

- m_{lljj} before (top) & after (bottom) opt. cuts
  - Constrain m_{jj} to m_Z
  - Good sensitivity, especially 2 tag (SM NWA)

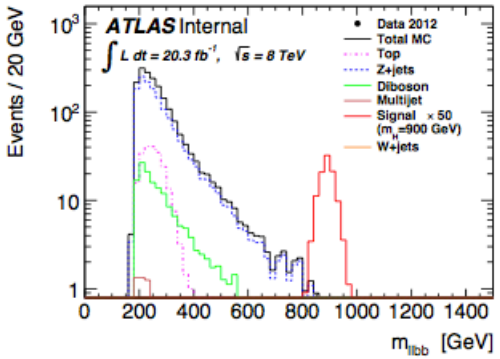
Tag	S/B	signif
0	0.01	0.71
1	0.01	0.48
2	0.14	0.97

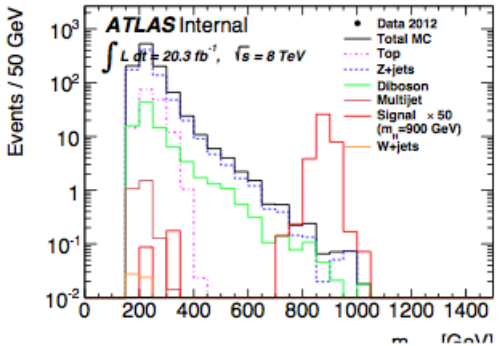
0 *b*-tag



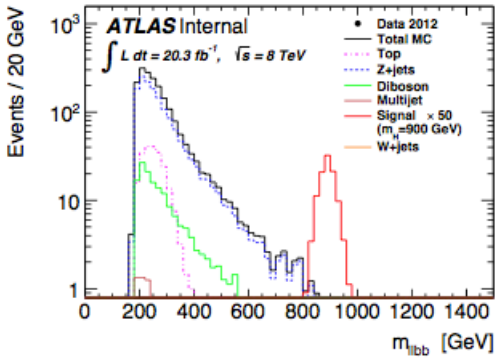


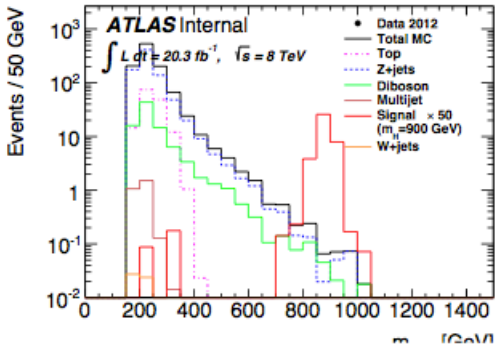
1 *b*-tag





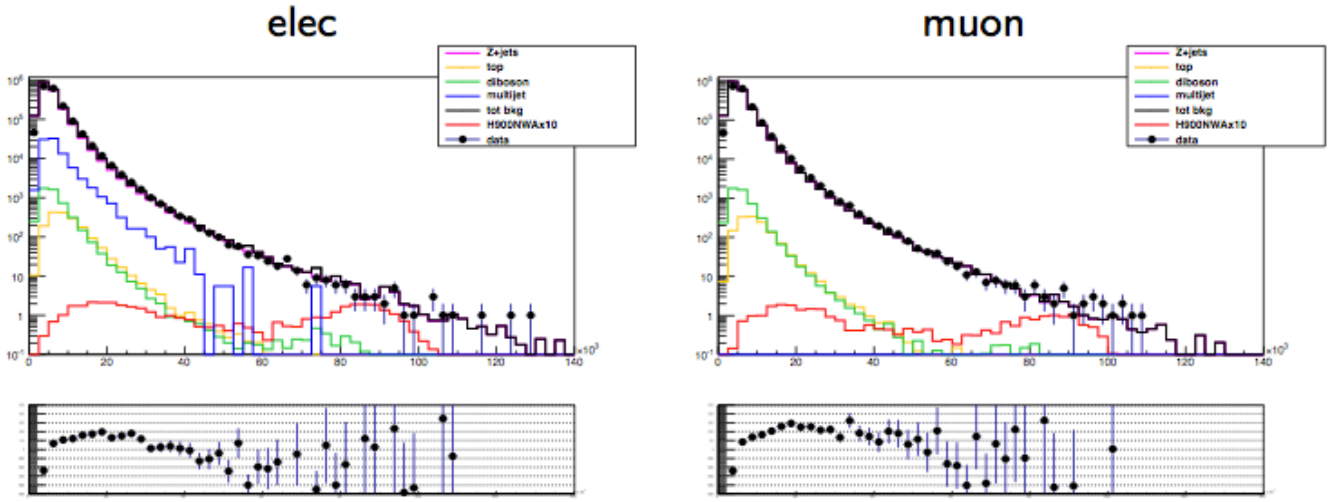
2 *b*-tag





Merged Regime

- At high m_H ($>$ 700 GeV) the qs from the Z become close enough to start merging into a single jet $\rightarrow$ exploit this using a merged channel
  - For this mass range, CA fat jets give little improvement over anti-k_T 0.4
- Signal peaks at $m_J \sim m_Z \rightarrow$ select $m_J > 70$ GeV and form m_{llJ}
  - Use $m_J < 60$ GeV SB to normalise/check background



- Need to understand discrepancy in jet mass + assign systematics

Expected Limits

- Limit setting machinery mostly in place
  - Based on standard HSG2 4*l* framework to aid combination of *ZZ* channels
- Systematics
  - **Lepton:** energy scale/resolution + efficiency
  - **Jet:** JES (14 NP + multijes) + JER + ptreco syst + JVF syst
  - ***b*-tag:** 10 EV variations for $l/c/b$ SFs (check which negligible)
  - E_T^{miss}**:** Propagate object uncertainties to E_T^{miss} + soft scale/resol
  - **Lumi + pileup:** 2.8% lumi uncertainty + vary μ scale
  - **MC Modeling:**
    - **Signal:** Acceptance uncertainty + error on width/interference reweight
    - **top:** linear m_{jj} uncertainty from comparing different generators
    - ***Z*+jets:** linear m_{jj} uncertainty from comparing data/MC in SB
      50% uncertainty on $\Delta\phi_{jj}$ reweight (uncorrelated between flavours)
    - **Diboson:** linear m_{jj} uncertainty from comparing different generators
      uncertainty on p_T^V by comparing MC and NLO MCFM prediction
    - **Normalisation:** uncertainty on *Z*+jets/top fit; theory error for *VV*/Signal;
      50% for mulitjet
- Still investigating VBF/merged-specific uncertainties

Summary

- Status:
  - Analysis in good shape and progressing fast
  - **ggF channel:** close to complete
  - **VBF channel:** finalising selection + background modeling
  - **Merged channel:** investigating background modeling
  - Work ongoing on INT note draft
- To do
  - Fix VBF cuts
  - Recheck cutflows with latest selection (
  - Background modeling for VBF/Merged channels (
  - Systematic implementation for VBF/Merged (in progress) + finalise all systematic treatments
  - VBF/ggF reweights for varying width and corresponding interference effect needed for EW singlet interpretation (
  - INT note
  - Full expected limit results (early-mid January)

Summary and Short term plans

IX ATLAS Italia Physics and Upgrade Workshop

14-16 January 2014 *Bologna - Dipartimento di Fisica e Astronomia*
Europe/Rome timezone

Wednesday, 15 January 2014

09:00 - 11:50 **Higgs**

Convener: Roberto Di Nardo (LNF), Ruggero Turra (MI)

09:00 **Introduzione** *20'*
Speakers: Roberto Di Nardo (LNF), Ruggero Turra (MI)

09:20 **Misura delle proprietà dell'Higgs (15+5 min)** *20'*
Speaker: Andrea Gabrielli (ROMA1)

09:40 **Determinazione della Spin-Parità (15+5 min)** *20'*
Speaker: Ms. Elvira Rossi (Universita' Federico II di Napoli)

10:00 **Evidenza del decadimento dell'Higgs in due tau (15+5 min)** *20'*
Speaker: Sofia Maria Consonni (MI)

10:20 **Ricerca della produzione associata dell'Higgs con un bosone vettore (13+5 min)** *18'*
Speaker: Ms. MONICA TROVATELLI (ROMA3)

10:38 **Ricerca della produzione associata dell'Higgs con quark top (13+5)** *18'*
Speaker: Michele Pinamonti (UD)

10:56 **Ricerca di produzione dell'Higgs mediante VBF nel canale in due b quark (13+4 min)** *17'*
Speaker: Elisa Guido (GE)

11:16 **Ricerche di Higgs BSM ad alta massa (13+4 min)** *17'*
Speaker: Giovanni Zurzolo (NA)

Summary and Short term plans

- Presenza napoletana nelle analisi Higgs e' in questo momento consolidata in Italia con visibilita' molto buona al CERN..
- Analisi Mela/MEGA and BSM-qqll quasi ultimate per RUN-I, approvazione attesa per fine Gennaio- Febbraio 2014 forte impegno per tutto il gruppo nei prossimi 1-2 mesi (sindrome PXD..)
- Diverse idee/proposte gia' in cantiere per prossime analisi Higgs and BSM..(ad esempio A→Zh in 2HDM) quali requirements?
  - No students no party (ovvio...) (meccanismo PhD e borse nn funziona...)
  - Non ci sono analisi sostanzialmente "scoperte" → clusterizzazione all'interno del gruppo locale (e non) che conducano analisi fino all'approval →necessario contributo opportuno da laureandi/PhD/post-doc/ricercatori/ senior...altrimenti si rischia..
  - Presenze al CERN (meccanismo OK tra missioni e simil-fellow)
  - Bilanciamento attivita' di gruppo sw/hw/analisi & OTP