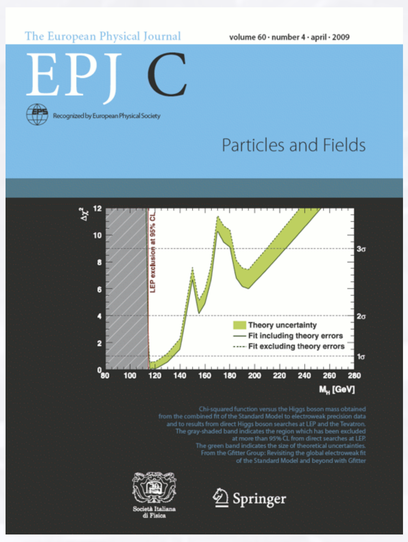
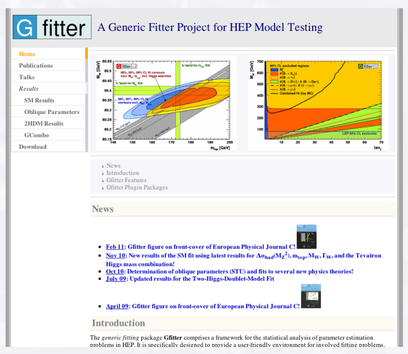
The global electroweak fit and constraints on new physics with the latest LHC results

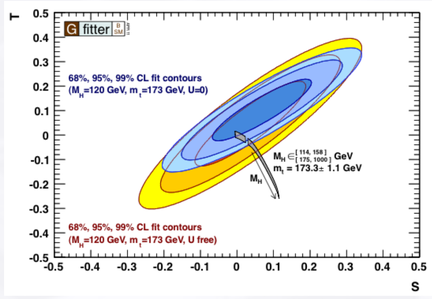
The Gfitter Package

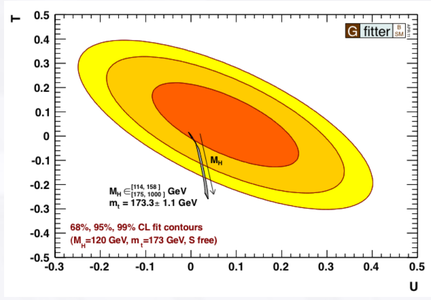
- Gfitter = state-of-the-art HEP model testing tool for LHC era
- **Gfitter software and features**
  - Modular, object-oriented C++, relying on ROOT, XML, python, …
  - Core package with data-handling, statistics tools, and fitting
  - Various fitting tools: Minuit, Genetic Algorithms, Simulated Annealing, etc.
  - Consistent treatment of statistical, systematic, theoretical uncertainties (Rfit prescription), correlations, and inter-parameter dependencies
  - Theoretical uncertainties included in c^2 with flat likelihood in allowed ranges
  - Full statistics analysis: goodness-of-fit, p-values, parameter scans, MC analyses.
  - Independent "plug-in" libraries: SM, 2HDM, oblique parameters, SUSY, ...
- Updates and new results available at: www.cern.ch/Gfitter





Oblique Corrections





Latest Results for STU

$S = 0.02 \pm 0.11$

$T = 0.05 \pm 0.12$

$U = 0.07 \pm 0.12$

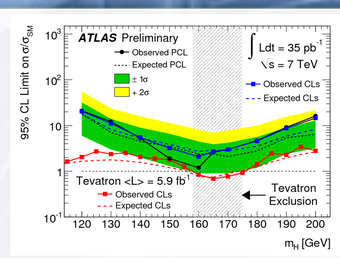
	S	T	U
S	1	0.879	-0.469
T		1	-0.716
U			1

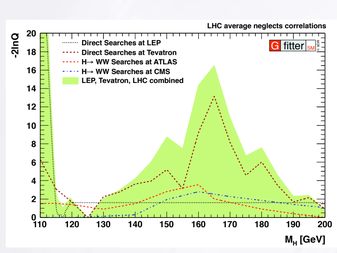
- At low energies, BSM physics appears dominantly through vacuum polarization corrections (oblique corrections)
- **Oblique corrections** reabsorbed into electroweak parameters: Δr, Δk, Δr parameters, appearing in: M_W^2, $\sin^2 q_{eff}$, G_F, a, etc
- Electroweak fit sensitive **to BSM physics** through oblique corrections
- Oblique corrections from New Physics described through STU parametrization $O_{meas} = O_{SM,REF}(m_H, m_t) + c_S S + c_T T + c_U U$
- S : New Physics contributions to **neutral currents**
- T : Difference between neutral and charged current processes - sensitive to **weak isospin violation**
- U : (+S) New Physics contributions to charged currents. U only sensitive to W mass and width, usually very small in NP models (often: U=0)

Experimental Input

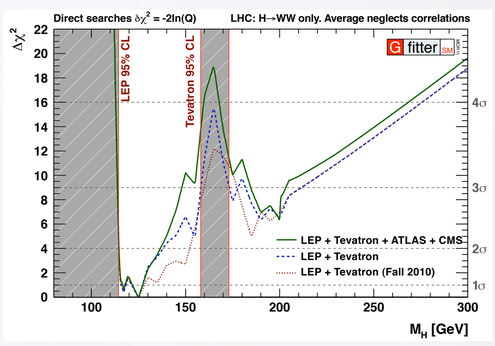
- **Z-pole** observables: LEP/SLC
- **m_W** and **Γ_W** latest from LEP/Tevatron (03/2010)
- **m_{top}** latest Tevatron average (07/2010)
- **m_c, m_b** world averages 2006
- $\Delta a_{had}^{(5)}(M_Z^2)$ including a_S dependency (10/2010)
- Direct **Higgs searches** from LEP/Tevatron/LHC (2011)
  - Discussion of stat. Treatment in next section

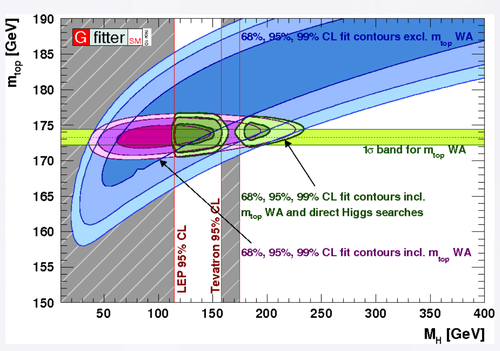
M_Z [GeV]	91.1875 ± 0.0021
Γ_Z [GeV]	2.4952 ± 0.0023
σ^0_{had} [nb]	41.540 ± 0.037
R^0_ℓ	20.767 ± 0.025
$A^{0,\ell}_{FB}$	0.0171 ± 0.0010
A_ℓ (*)	0.1499 ± 0.0018
A_c	0.670 ± 0.027
A_b	0.923 ± 0.020
$A^{0,c}_{FB}$	0.0707 ± 0.0035
$A^{0,b}_{FB}$	0.0992 ± 0.0016
R^0_c	0.1721 ± 0.0030
R^0_b	0.21629 ± 0.00066
$\sin^2\theta^\ell_{eff}(Q_{FB})$	0.2324 ± 0.0012
M_H [GeV] (o)	Likelihood ratios
M_W [GeV]	80.399 ± 0.023
Γ_W [GeV]	2.085 ± 0.042
$\overline{m}_c$ [GeV]	$1.27^{+0.07}_{-0.11}$
$\overline{m}_b$ [GeV]	$4.20^{+0.17}_{-0.07}$
m_t [GeV]	173.3 ± 1.1
$\Delta\alpha^{(5)}_{had}(M_Z^2)$ (†Δ)	2749 ± 10
$\alpha_s(M_Z^2)$	–

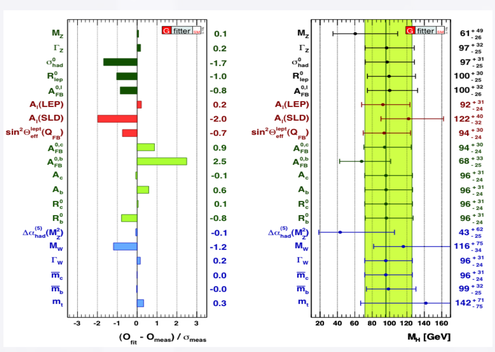




Electroweak Fit – SM Fit Results



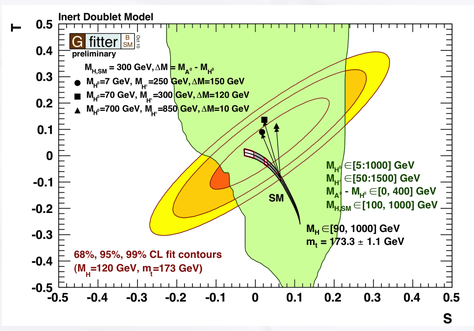


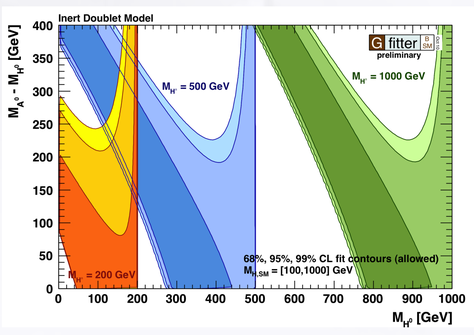


- Gfitter package for the global EW fit
  - new implementation of the SM prediction of the EW observables
  - The calculation of the partial and total widths of the Z have been taken from the ZFITTER package
- Stat. interpretation in global fit:
  - 2-sided CL_{S+B} when applicable
    - transform 1-sided CL_{S+B} into 2-sided CL^{2s}_{S+B}
    - measure both down- and up-ward deviations from SM !
  - If CL_{S+B} info not public use χ^2 contribution which is -2lnQ where $Q=L_{S+B}/L_B$
  - Note that combination of ATLAS and CMS H→WW results ignores for now the correlations between x-section theory and lumi. unc.
- Results with **LHC Higgs** searches
  - Goodness of fit: χ^2_{min}=17.5, i.e. Prob(χ^2_{min}, 14) = 0.23
  - Central value : $M_H = 120.2^{+12.3}_{-4.7}$ GeV
  - 2σ interval: $-2\ln Q$: $[115,137]$ GeV

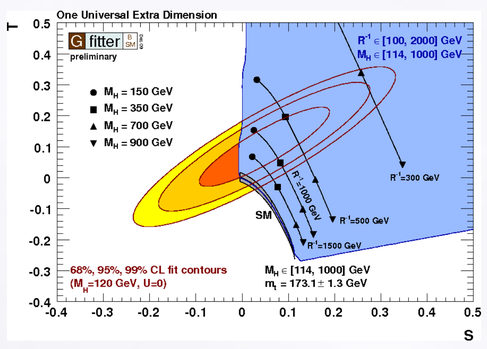
Test of BSM Models

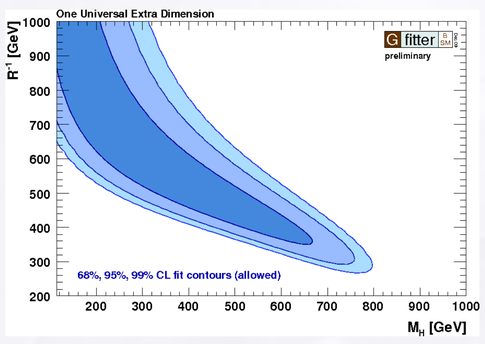
- **Inert Doublet Model**
  - Introduction of extra Higgs doublet to help solve hierarchy problem
  - Does not couple to fermions ("inert"). Does not acquire a VEV.
  - Three new Higgses: Two neutral (M_H, M_A), one charged (M_H+)
  - Lightest inert particle ("LIP") is stable (ML), assumed neutral.
  - Natural dark matter candidate
  - Contributions to:
    - T: isospin violation between neutral and charged Higgses.
    - S: H+H- and HA loop corrections to self energy of Z/γ propagator
  - **Results: large SM Higgs mass allowed**





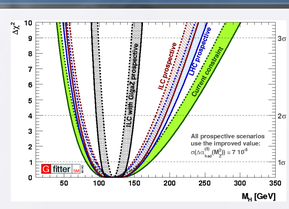
- **Universal Extra Dimensions**
  - SM particles can propagate into ED
  - Compactification → KK excitations
  - Conservation of KK parity
  - Phenomenology similar to SUSY
  - Lightest stable KK state: DM candidate
  - Model parameters: dED = number of ED (fixed to dED=1) and R-1 = compactification scale (mKK~n/R)
  - Contribution to vac. polarisation (STU): From KK-top/bottom and KK-Higgs loops, Dependent on R-1, M_H (and mt)
  - **Results: Excluded: R-1<300GeV and M_H > 800 GeV**

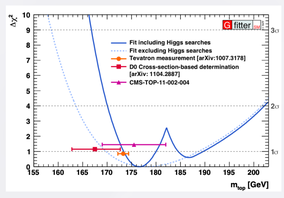




Conclusion and outlook

- New and updated global fit of the electroweak SM
- **First LHC Higgs results included in EW fit**
- SM Higgs mass strongly constrained. Light Higgs very much preferred by SM.
- Oblique parameters (still!) a powerful method to constrain BSM theories
- The future: Maintain and extend existing fits. Update with laterst Tevatron and LHC results
  - Looking forward to new **Higgs results** and precision measurements of m_t and m_W at LHC





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