DESY

Team:

DESY @ Zeuthen :
J. Blümlein (TH) (Chair Training Board), I. Bloch, Th. Naumann (ATLAS), S. Riemann (ILC), S. Moch (TH)
DESY @ Hamburg :
A. Raspereza (CMS), J. Reuter, F. Tackmann (TH), K. Tackmann (ATLAS), G. Weiglein (Convener WP1), A. Weiler (TH)

- Higgs-boson search (ATLAS, CMS)
- Improvement of QCD and electro-weak corrections: signal and background, α_s, PDFs, heavy quark corrections, MCs, SUSY-Higgs
- Determine the detailed nature of the observed boson: SM and/or MSSM, little Higgs, other BSM scenarios, global fits
- measurement of t-quark, Drell-Yan and weak-boson production at LHC (backgrounds and source to refine PDFs and fundamental parameters).

Work-packages

- WP 1: Interpretation of Data
  Milestones: 1.2.1, 1.2.2. [Measurement Higgs properties], 1.3.1. [Interpretation of data], 1.4.1 [European Strategy]
- WP 2: Predictions and simulations of signal and background
  Milestones: 2.2.3 [Non-standard Higgs bosons]
- WP 3: Tools
  Milestones: 3.3.3, 3.3.4 [PDFs]

Cooperation with other nodes:

- Durham: special functions
- Granada/Santander: SM/MSSM and other BSM analyses
- Zurich: secondment of ESR: data analysis
- CERN: secondment of ESR: phenomenology
- Milano/UCL: improved PDFs

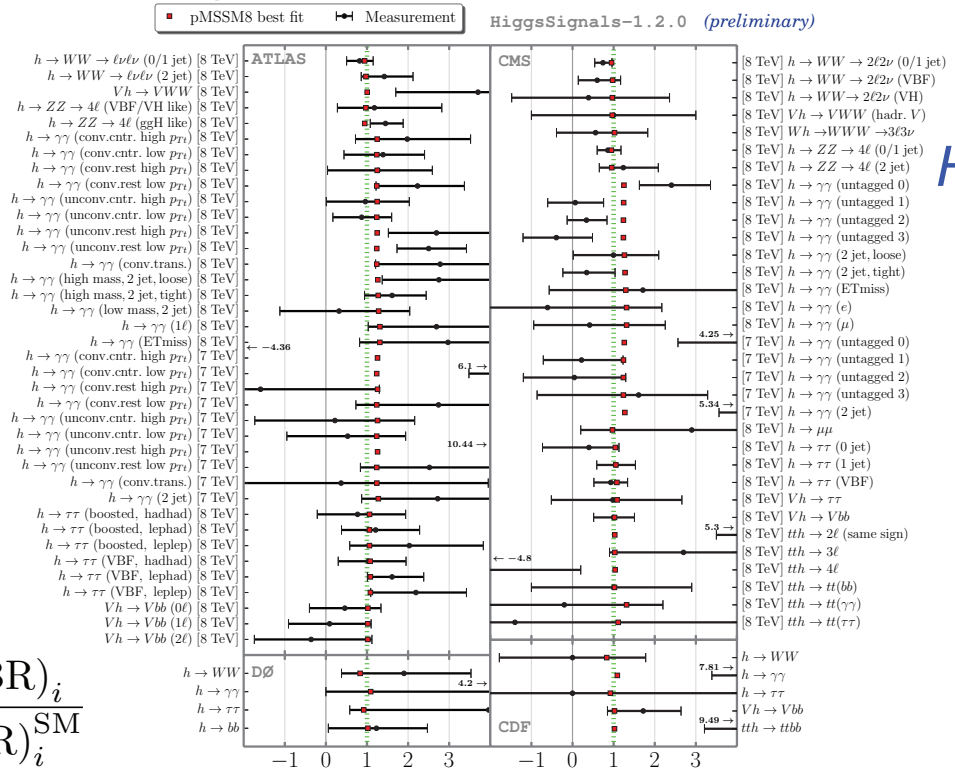
Research: Some Examples

G. Weiglein et al.:

SUSY interpretation of the observed Higgs signal: light Higgs h?

Fit to LHC data, Tevatron, precision observables: SM vs. MSSM

Observables:



HiggsSignals

$$\mu_i = \frac{(\sigma \times \mathrm{BR})_i}{(\sigma \times \mathrm{BR})_i^{\mathrm{SM}}}$$

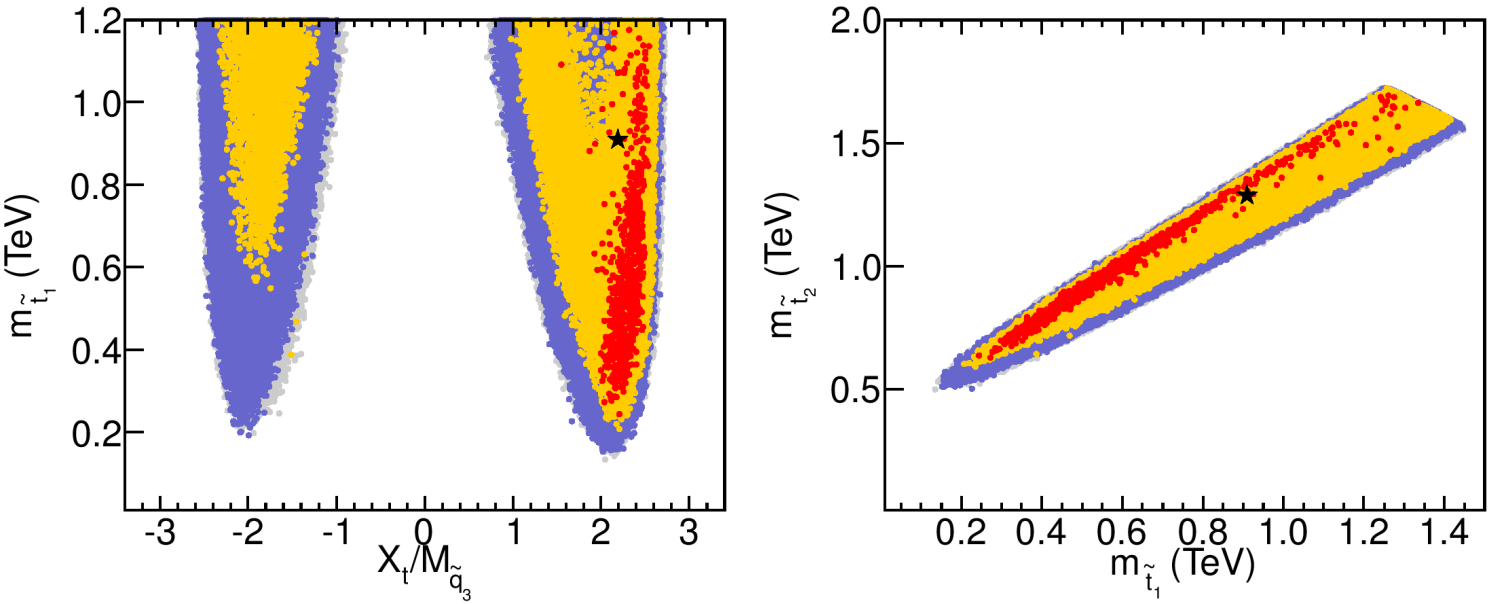
⇒ χ^2 reduced compared to the SM, (slightly) improved fit quality

Higgs as a portal to physics beyond the Standard Model, dark matter, ...?

MSSM interpretation of the signal at 126 GeV in terms of the light Higgs h of the MSSM

MSSM fit, preferred values for the stop masses:

P. Bechtle, S. Heinemeyer, O. Stål, T. Stefaniak, G. Weiglein, L. Zeune [1211.1955]

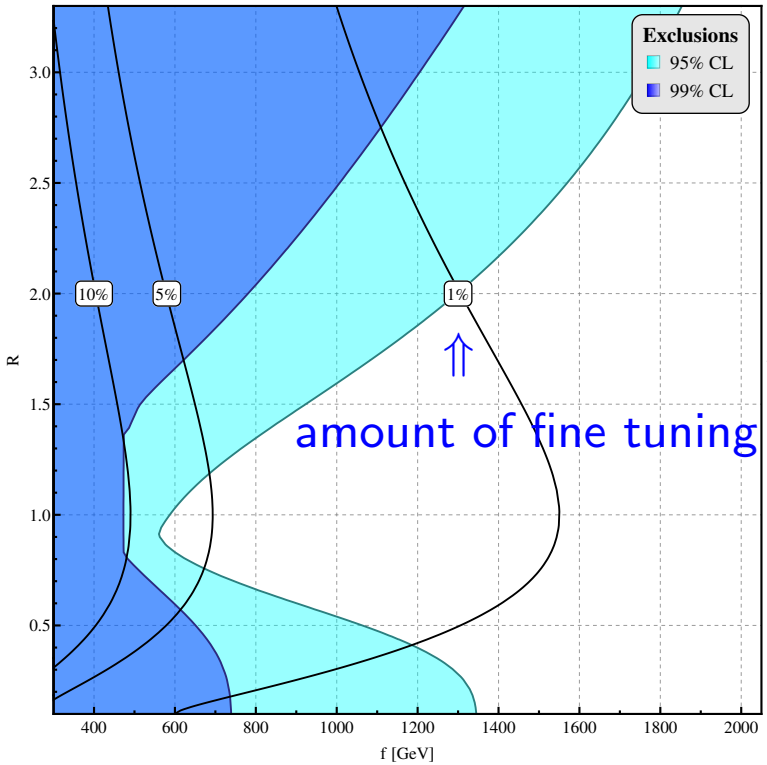


$\Longrightarrow M_h \sim 126$ GeV requires large stop mixing, but stop masses can still be light.

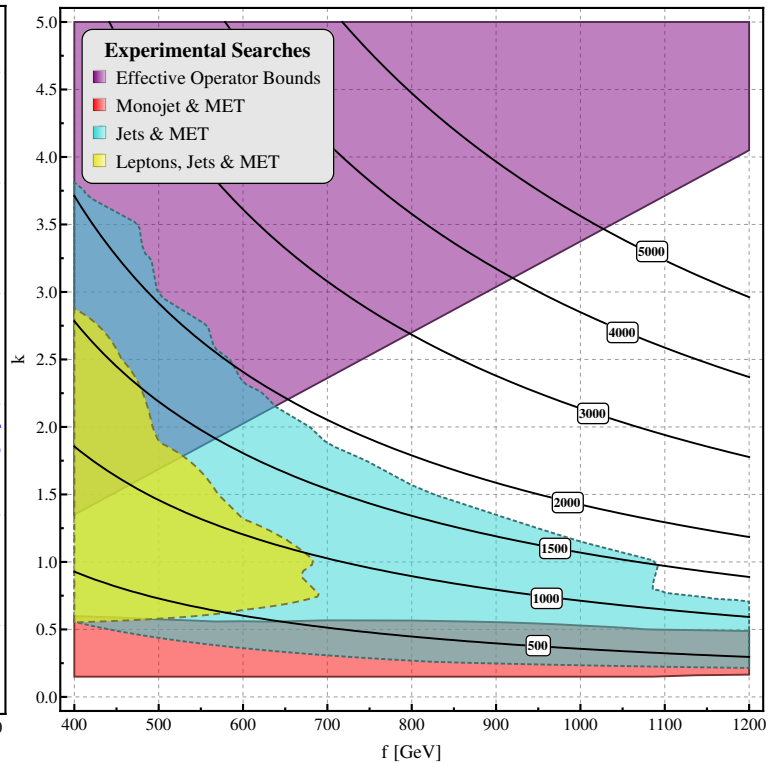
Littlest Higgs with T parity vx. LHC results and electroweak precision data

J. Reuter, M. Tonini, M. de Fries, [1310.2918]

Higgs and e.w. precision data



Direct LHC searches for new particles



f = collective symmetry breaking scale; boxes: heavy masses

k = Yukawa coupling; R = ration of Yukawa couplings.

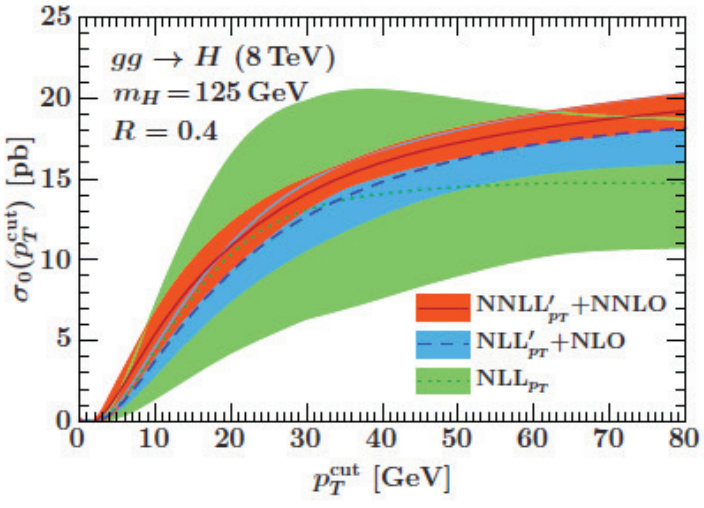
Predictions for Higgs + jet production

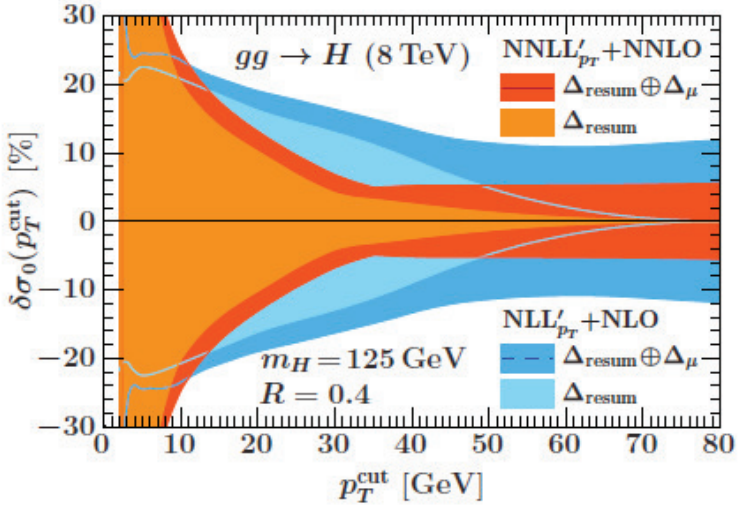
Higgs measurements divide data into exclusive categories

based on number of jets, decay kinematics, etc.

- $H + 0$ jets cross section $\sigma_0(p_T^{\text{jet}} < p_T^{\text{cut}})$ important in $H \to WW$ and $H \to \tau\tau$ analyses
- resum $\log(p_T^{\text{cut}}/m_H)$ terms using SCET

[Stewart, Tackmann, Walsh, Zuberi; arXiv:1307.1808]





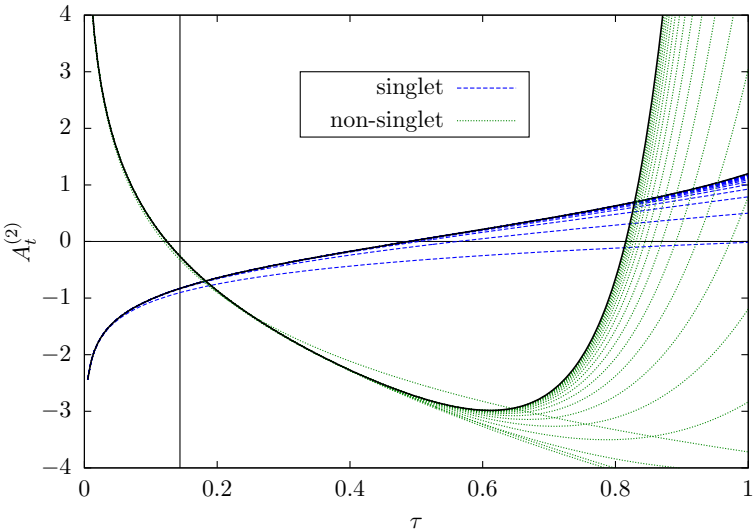
Systematic and careful uncertainty analysis required for reliable predictions

- Jet binning analyses require full theory correlation matrix for $\{\sigma_0, \sigma_{\geq 1}\}$

$$C = \begin{pmatrix} \Delta_{\mu 0}^2 & \Delta_{\mu 0}\,\Delta_{\mu \geq 1} \\ \Delta_{\mu 0}\,\Delta_{\mu \geq 1} & \Delta_{\mu \geq 1}^2 \end{pmatrix} + \begin{pmatrix} \Delta_{\text{resum}}^2 & -\Delta_{\text{resum}}^2 \\ -\Delta_{\text{resum}}^2 & \Delta_{\text{resum}}^2 \end{pmatrix}$$

Complete 3-loop QCD corrections to the decay $H \to \gamma\gamma$

P. Maierhöfer, P. Marquard [1212.6233]



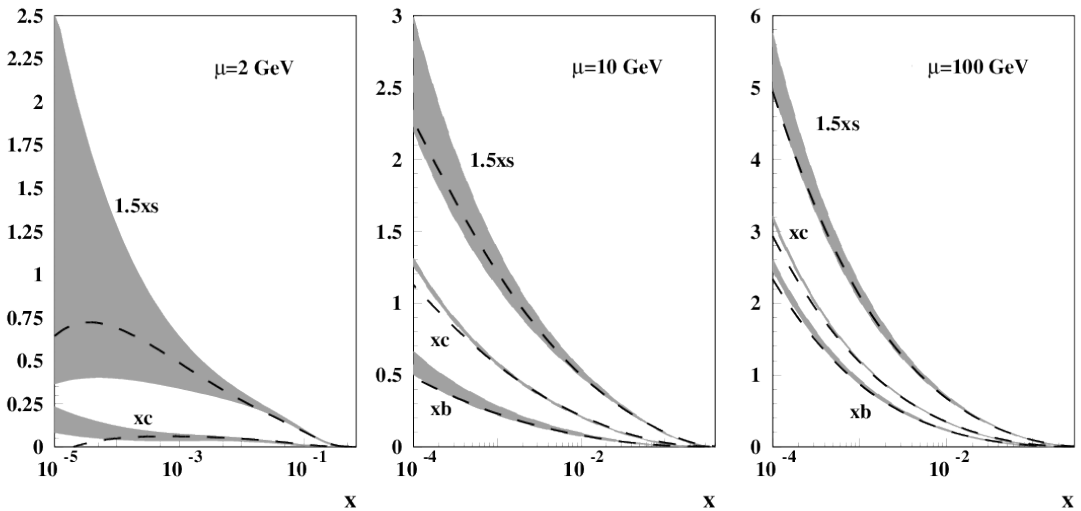
The singlet contributions reach the size of the non-singlet terms.

Heavy quark parton distribution function, precision PDFs and $\alpha_s(M_Z^2)$

Higgs cross section: $\propto \quad \alpha_s^2(M_H)[xG(x,Q^2)]^2$

$\Longrightarrow$ High sensitivity to both quantities.

ABKM 09, ABM 12 PDFs :



- Improvement needed for: s, c, b-PDFs
- Bounce-back effects on the gluon density and α_s

Heavy quark parton distribution function, precision PDFs and $\alpha_s(M_Z^2)$

- Inclusion of LHC-data into the current world data PDF analyses: Drell-Yan data, $W^{\pm}, Z$-production, inclusive and di-jet data, $t\bar{t}$-data to better constrain xG and the sea quarks.
- Here NNLO accuracy is requested.
- VFNS to 3-loops: calculation of the remaining OMEs.
- Refine the $\alpha_s(M_Z^2)$ measurement to reduce the present systematics
- Is the value of $\alpha_s(M_Z^2) = 0.1175$ or $\alpha_s(M_Z^2) = 0.1140$?
  $\Longrightarrow$ 7% error on $\sigma_{\rm Higgs}$.

Regular Workshops and Schools

- Helmholtz Alliance Schools (several schools per year)
- Loops and Legs in Quantum Field Theory (2014, 2016)
- DESY Theory Workshop (2014, 2015, 2016, 2017)
- CAPP - School (2015, 2017)

Further activities outside the network

- cooperation: Higgs cross section WG; Signals of electroweak symmetry breaking WG
- cooperation: European Strategy for Particle Physics
- cooperation: Particle Data Group
- Helmholtz Alliance Cooperations
- SFB & Graduate Schools at Hamburg and Berlin & mutual cooperation with nearby University groups
- Mutual special Lectures at Hamburg and Berlin +3 other sites (including Particle Phenomenology QFT, String TH, Cosmology, math. Physics)
- Numerous weekly seminars on theoretical and experimental particle physics
- other EU networks: LHCPHENOnet