WG 1: THEORY PART

- EWSB:
  J. Hosek Dynamical Fermion Mass Generation by a strong Yukawa Interaction
  A. Strumia Little Higgs and Precision Data after LEP2
  P. Langacker Global Fits to Precision elw. Data

- Dark Matter:
  G. Belanger SUSY Dark Matter

- Higgs + Bckgs.:
  M. Spira Higgs @ future Colliders
  M. Ciccolini W pairs @ LHC

- Automatic Tools:
  T. Gleisberg AMEGIC++ amd SHERPA
  M. Moretti ALPGEN

DYNAMICAL FERMION MASS GENERATION BY A STRONG YUKAWA INTERACTION

Jiří Hošek, NPI Řež (Prague)

Tomáš Brauner and Jiří Hošek, hep-ph/0505231

$$\mathcal{L} = \bar{\psi}_L i\partial\!\!\!/ \psi_L + \bar{\psi}_R i\partial\!\!\!/ \psi_R + (\partial_\mu\phi)^\dagger\partial^\mu\phi - M^2\phi^\dagger\phi - -\frac{1}{2}\lambda(\phi^\dagger\phi)^2$$

$$+y\bar{\psi}_L\psi_R\phi + y\bar{\psi}_R\psi_L\phi^\dagger$$

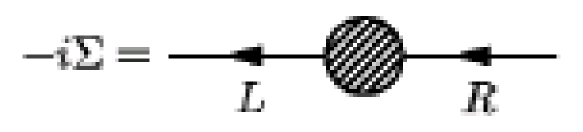
- Global chiral $U(1)_L \times U(1)_R$ symmetry

  $\psi_{L,R} \to \exp[i\alpha_{L,R}]\,\psi_{L,R}$, $\Phi \to \exp[i(\alpha_L - \alpha_R)]\,\Phi$

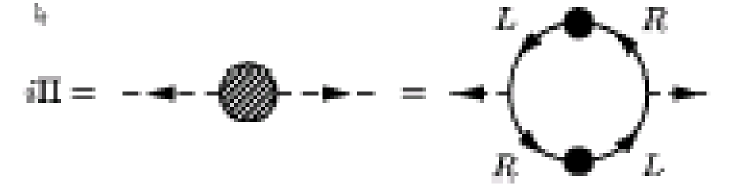
  FERMION MASS TERM PROHIBITED

  NO SCALAR-FIELD CONDENSATION ($M^2 > 0$)

Assume chirality-changing Σ is dynamically generated



- Σ induces generically new chiral-symmetry breaking Π in the scalar sector



$$\mathcal{L}'_{\phi\phi} = (\phi^\dagger, \phi)\, D^{-1}(p) \begin{pmatrix} \phi \\ \phi^\dagger \end{pmatrix} = \frac{1}{2}\phi_1 (p^2 - M^2 - \Pi)\phi_1 + \frac{1}{2}\phi_2 (p^2 - M^2 + \Pi)\phi_2$$

$$D(p) = \frac{1}{(p^2 - M^2 - \Pi(p^2))(p^2 - M^2 + \Pi(p^2))} \begin{pmatrix} p^2 - M^2 & i\Pi \\ -i\Pi & p^2 - M^2 \end{pmatrix}$$

CONCLUSIONS

- Massless pseudoscalar Nambu-Goldstone boson is a collective excitation of both fermion and boson fields with couplings calculable in terms of Σ and Π.
- Detailed knowledge of Σ and Π in Minkowski space is necessary.
- Gauging $U(1)_A$ (with care due to anomaly) should result in massive axial-vector field with mass calculable in terms of Σ and Π.
- Generalization to anomaly-free gauge SU(2)xU(1) chiral electroweak theory in
- Tomáš Brauner and Jiří Hošek, hep-ph/0407339 (with bosonic admixture of the 'would-be' NG bosons regrettably omitted).

Little Higgs
and precision data
after LEP2

1) The little hierarchy problem
2) Relevance of LEP2
3) Universal: $S, T, U \to \hat{S}, \hat{T}, W, Y$
4) Little Higgs models

Alessandro Strumia – WIN 05, $\Delta\epsilon\lambda\phi o\iota$ – 7/6/05

From works with Barbieri, Marandella, Pomarol, Rattazzi, Schappacher

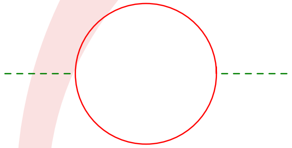
The hierarchy problem

Recent experimental progress:

1) Direct and indirect data showed that the **top is heavy**, $m_t \approx 180\,\text{GeV}$
2) Indirect data suggest the existence of a **light higgs**, $m_h \lesssim 200\,\text{GeV}$

This shifts ‘solutions’ to the hierarchy problem towards lower energies.
In the SM, cut-offing top loop at $E < \Lambda_{\text{UV}}$

$$\delta m_h^2 \approx \delta m_h^2(\text{top}) =$$



$$\approx \frac{12\lambda_{\text{top}}^2}{(4\pi)^2}\Lambda_{\text{UV}}^2$$

$$\delta m_h^2 \lesssim m_h^2 \qquad \text{if} \qquad \boxed{\Lambda_{\text{UV}} \lesssim 400\,\text{GeV}} \qquad \text{no longer few TeV!}$$

(Bigger Λ_{UV} needs fine-tuning, which is only a plausibility problem).

But at the same time

3) direct: no new detectable particles, $\tilde{m} \gtrsim 100\,\text{GeV}$.
4) indirect: no new non-renormalizable-operators, $\Lambda \gtrsim 10\,\text{TeV}$. →

$\mathscr{L}_{\text{eff}} = \mathscr{L}_{\text{SM}} + \mathcal{O}/\Lambda^2$

- Coefficients $g^2_{\text{new}}/\Lambda^2$: $g_{\text{new}} = 1$ chosen in hep-ph/0007265 because $\lambda_t, g_{\text{SM}} \sim 1$

- Only $\text{SU}(2)_L \otimes \text{U}(1)_Y$, B, L, B_i, L_i, CP symmetric operators $\mathcal{O}$.

operator $\mathcal{O}$	affects	constraint on Λ
$\frac{1}{2}(\bar{L}\gamma_\mu\tau^a L)^2$	μ-decay	10 TeV
$\frac{1}{2}(\bar{L}\gamma_\mu L)^2$	LEP 2	5 TeV
$\lvert H^\dagger D_\mu H\rvert^2$	θ_{W} in M_W/M_Z	5 TeV
$(H^\dagger\tau^a H)W^a_{\mu\nu}B_{\mu\nu}$	θ_{W} in Z couplings	8 TeV
$i(H^\dagger D_\mu\tau^a H)(\bar{L}\gamma_\mu\tau^a L)$	Z couplings	10 TeV
$i(H^\dagger D_\mu H)(\bar{L}\gamma_\mu L)$	Z couplings	8 TeV
$H^\dagger(\bar{D}\lambda_D\lambda_U\lambda_U^\dagger\gamma_{\mu\nu}Q)F^{\mu\nu}$	$b \to s\gamma$	10 TeV
$\frac{1}{2}(\bar{Q}\lambda_U\lambda_U^\dagger\gamma_\mu Q)^2$	B mixing	6 TeV

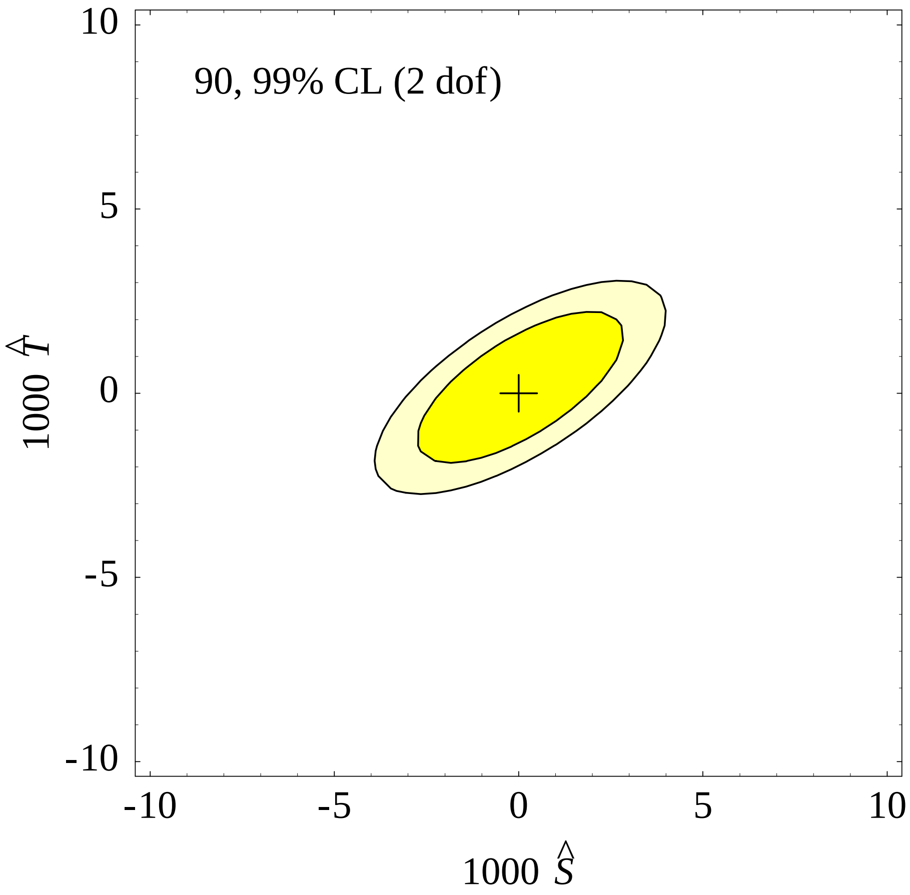
Cut-off above 10 TeV leaves $\delta m_h^2 \sim 500 m_h^2$: **‘little hierarchy problem’**

An important message behind boring successes of the SM?

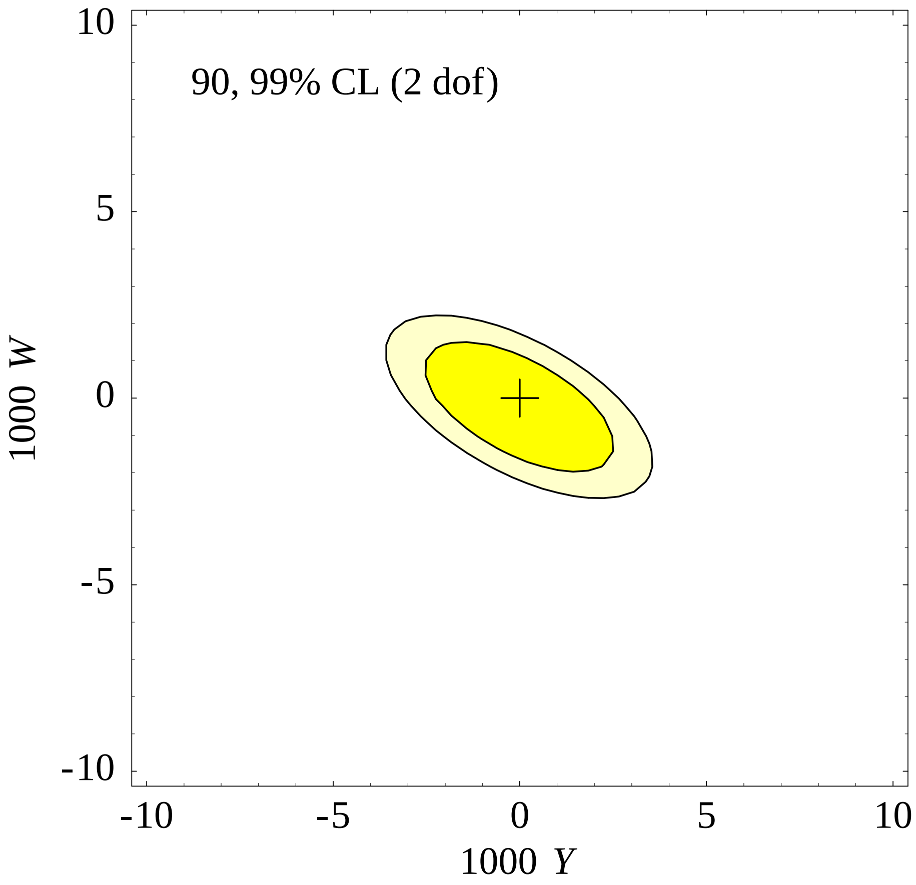
Global fit after LEP2

All $\hat{S}, \hat{T}, W, Y$ parameters must vanish within few $\cdot 10^{-3}$

$$\chi^2(\hat{S},\hat{T}) = \min_{W,Y} \chi^2(\hat{S},\hat{T},W,Y)$$



$$\chi^2(W,Y) = \min_{\hat{S},\hat{T}} \chi^2(\hat{S},\hat{T},W,Y)$$



Hard time for Higgsless, little-Higgs etc.

Conclusions

- **Little hierarchy problem**:
  successes of SM so boring that could contain important message.

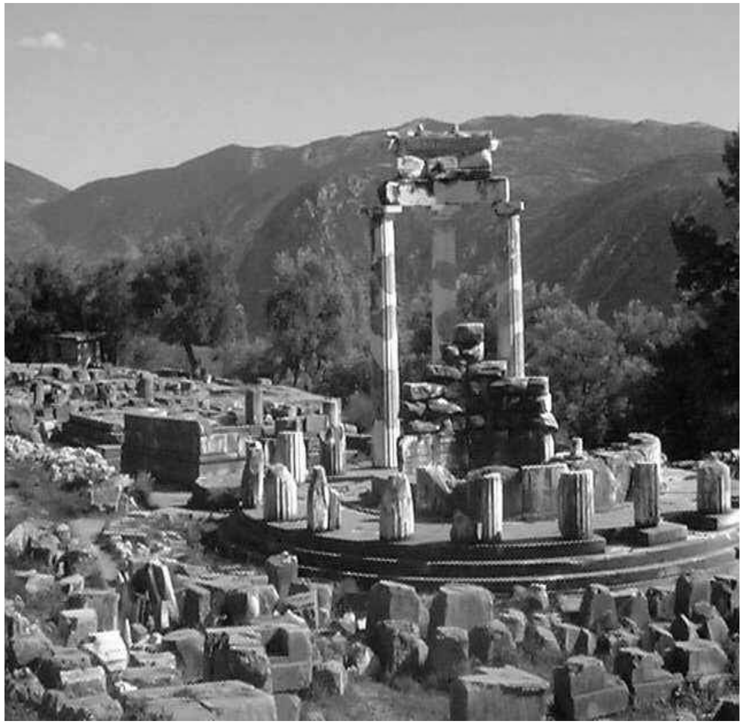
- **LEP2** $e\bar{e} \to f\bar{f}$ are relevant precision data

- **Heavy universal models**: $\hat{S}, \hat{T}, W, Y$ (not S, T, U)

- Little Higgs: $f >$ few TeV. Realize the little hierarchy problem.
  $\hat{S} > (W + Y)/2$, $W, Y > 0$ in all universal models.
  New model proposed and analyzed.

- Generic Z' approximated with leptonic $\hat{S}, \hat{T}, W, Y$.

Global Fits to Precision Electroweak Data



- Precision Experiments: Historical Perspective
- LEP/SLC Physics
- Probing the Standard Model
- Beyond the Standard Model

The Z Pole Observables: LEP and SLC (01/03)

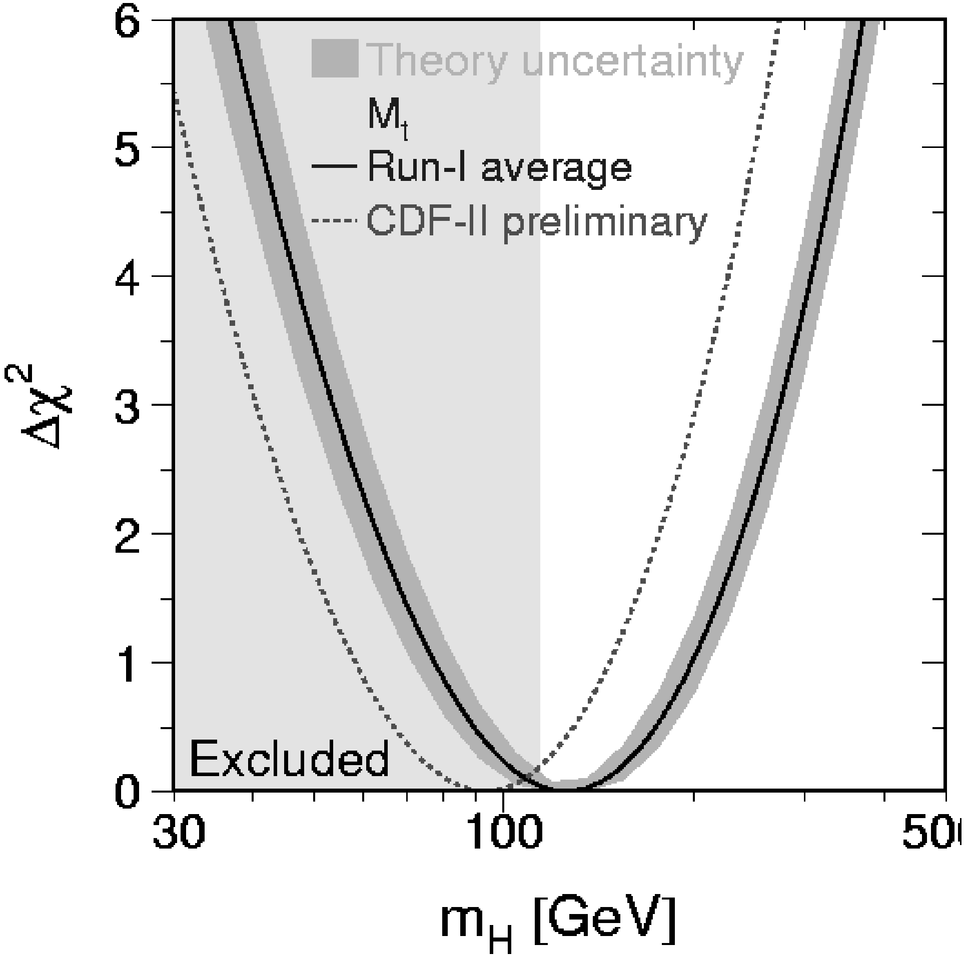
Quantity	Group(s)	Value	Standard Model	pull
M_Z [GeV]	LEP	91.1876 ± 0.0021	91.1874 ± 0.0021	0.1
Γ_Z [GeV]	LEP	2.4952 ± 0.0023	2.4972 ± 0.0011	−0.9
$\Gamma(\text{had})$ [GeV]	LEP	1.7444 ± 0.0020	1.7436 ± 0.0011	—
$\Gamma(\text{inv})$ [MeV]	LEP	499.0 ± 1.5	501.74 ± 0.15	—
$\Gamma(\ell^+\ell^-)$ [MeV]	LEP	83.984 ± 0.086	84.015 ± 0.027	—
σ_{had} [nb]	LEP	41.541 ± 0.037	41.470 ± 0.010	1.9
R_e	LEP	20.804 ± 0.050	20.753 ± 0.012	1.0
R_μ	LEP	20.785 ± 0.033	20.753 ± 0.012	1.0
R_τ	LEP	20.764 ± 0.045	20.799 ± 0.012	−0.8
$A_{FB}(e)$	LEP	0.0145 ± 0.0025	0.01639 ± 0.00026	−0.8
$A_{FB}(\mu)$	LEP	0.0169 ± 0.0013		0.4
$A_{FB}(\tau)$	LEP	0.0188 ± 0.0017		1.4

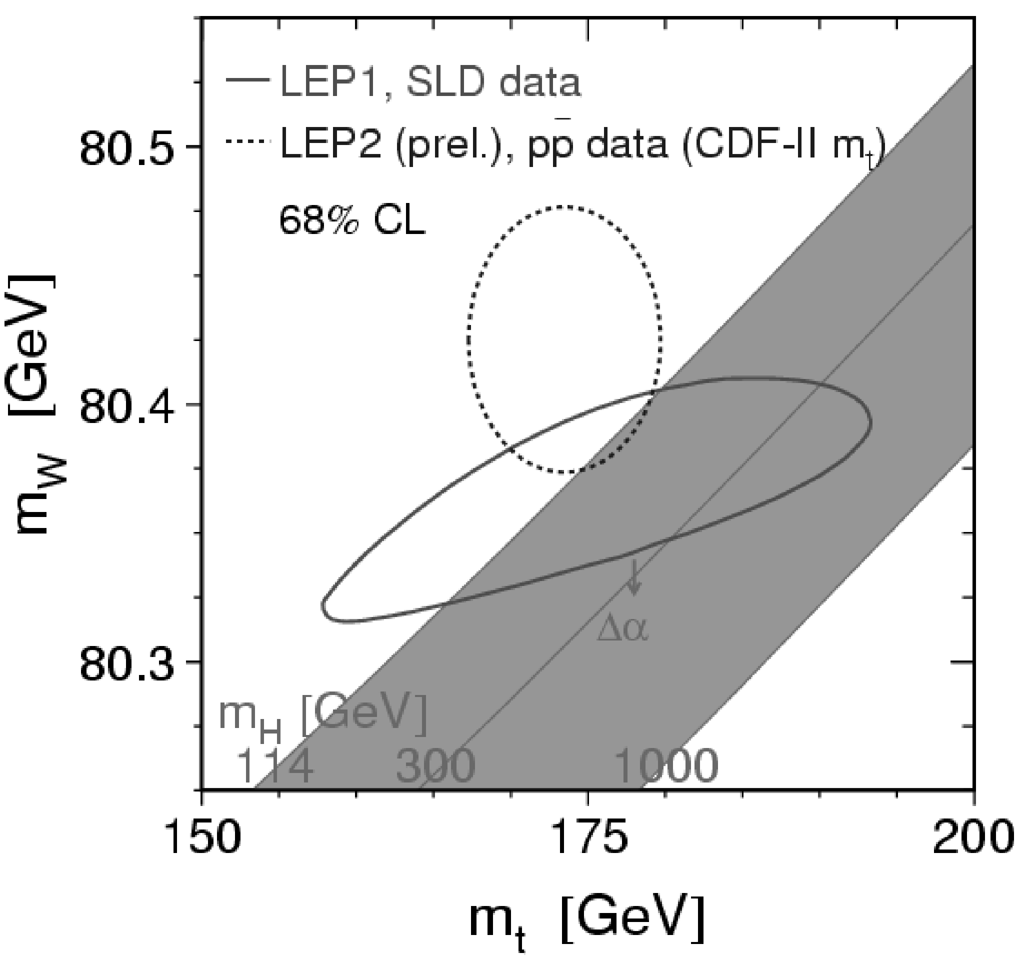
Quantity	Group(s)	Value	Standard Model	pull
R_b	LEP/SLD	0.21664 ± 0.00065	0.21572 ± 0.00015	1.1
R_c	LEP/SLD	0.1718 ± 0.0031	0.17231 ± 0.00006	-0.2
$R_{s,d}/R_{(d+u+s)}$	OPAL	0.371 ± 0.023	0.35918 ± 0.00004	0.5
$A_{FB}(b)$	LEP	0.0995 ± 0.0017	0.1036 ± 0.0008	-2.4
$A_{FB}(c)$	LEP	0.0713 ± 0.0036	0.0741 ± 0.0007	-0.8
$A_{FB}(s)$	DELPHI/OPAL	0.0976 ± 0.0114	0.1037 ± 0.0008	-0.5
A_b	SLD	0.922 ± 0.020	0.93476 ± 0.00012	-0.6
A_c	SLD	0.670 ± 0.026	0.6681 ± 0.0005	0.1
A_s	SLD	0.895 ± 0.091	0.93571 ± 0.00010	-0.4
A_{LR} (hadrons)	SLD	0.15138 ± 0.00216	0.1478 ± 0.0012	1.7
A_{LR} (leptons)	SLD	0.1544 ± 0.0060		1.1
A_μ	SLD	0.142 ± 0.015		-0.4
A_τ	SLD	0.136 ± 0.015		-0.8
$A_e(Q_{LR})$	SLD	0.162 ± 0.043		0.3
$A_\tau(\mathcal{P}_\tau)$	LEP	0.1439 ± 0.0043		-0.9
$A_e(\mathcal{P}_\tau)$	LEP	0.1498 ± 0.0048		0.4
Q_{FB}	LEP	0.0403 ± 0.0026	0.0424 ± 0.0003	-0.8

Non-Z Pole Precision Observables (1/03)

Quantity	Group(s)	Value	Standard Model	pull
m_t [GeV]	Tevatron	174.3 ± 5.1	174.4 ± 4.4	0.0
M_W [GeV]	LEP	80.447 ± 0.042	80.391 ± 0.018	1.3
M_W [GeV]	Tevatron /UA2	80.454 ± 0.059		1.1
g_L^2	NuTeV	0.30005 ± 0.00137	0.30396 ± 0.00023	-2.9
g_R^2	NuTeV	0.03076 ± 0.00110	0.03005 ± 0.00004	0.6
R^ν	CCFR	$0.5820 \pm 0.0027 \pm 0.0031$	0.5833 ± 0.0004	-0.3
R^ν	CDHS	$0.3096 \pm 0.0033 \pm 0.0028$	0.3092 ± 0.0002	0.1
R^ν	CHARM	$0.3021 \pm 0.0031 \pm 0.0026$		-1.7
$R^{\bar\nu}$	CDHS	$0.384 \pm 0.016 \pm 0.007$	0.3862 ± 0.0002	-0.1
$R^{\bar\nu}$	CHARM	$0.403 \pm 0.014 \pm 0.007$		1.0
$R^{\bar\nu}$	CDHS 1979	$0.365 \pm 0.015 \pm 0.007$	0.3816 ± 0.0002	-1.0

Quantity	Group(s)	Value	Standard Model	pull
$g_V^{\nu e}$	CHARM II	-0.035 ± 0.017	-0.0398 ± 0.0003	—
$g_V^{\nu e}$	all	-0.041 ± 0.015		-0.1
$g_A^{\nu e}$	CHARM II	-0.503 ± 0.017	-0.5065 ± 0.0001	—
$g_A^{\nu e}$	all	-0.507 ± 0.014		0.0
$Q_W(\mathrm{Cs})$	Boulder	-72.69 ± 0.44	-73.10 ± 0.04	0.8
$Q_W(\mathrm{Tl})$	Oxford/Seattle	-116.6 ± 3.7	-116.7 ± 0.1	0.0
$10^3\ \frac{\Gamma(b\rightarrow s\gamma)}{\Gamma_{SL}}$	BaBar/Belle/CLEO	$3.48^{+0.65}_{-0.54}$	3.20 ± 0.09	0.5
τ_τ [fs]	direct/$\mathcal{B}_e/\mathcal{B}_\mu$	$290.96 \pm 0.59 \pm 5.66$	291.90 ± 1.81	-0.4
$10^4\ \Delta\alpha^{(3)}_{\rm had}$	e^+e^-/τ decays	$56.53 \pm 0.83 \pm 0.64$	57.52 ± 1.31	-0.9
$10^9\ (a_\mu - \frac{\alpha}{2\pi})$	BNL/CERN	$4510.64 \pm 0.79 \pm 0.51$	4508.30 ± 0.33	2.5


Theory uncertainty
M_t
Run-I average
CDF-II preliminary
Excluded
$\Delta\chi^2$
0
1
2
3
4
5
6
30
100
50
m_H [GeV]


LEP1, SLD data
LEP2 (prel.), $p\bar{p}$ data (CDF-II m_t)
68% CL
$\Delta\alpha$
m_H [GeV]
114
300
1000
m_W [GeV]
80.3
80.4
80.5
150
175
200
m_t [GeV]

Conclusions

- WNC, Z, W are primary predictions and test of electroweak unification
- SM correct and unique to first approx. (gauge principle, group, representations)
- SM correct at loop level (renorm gauge theory; m_t, α_s, M_H)
- Watershed: TeV physics severely constrained (unification vs compositeness)
  - unification (decoupling): expect 0.1%
  - TeV compositeness: expect several % unless decoupling
- Precise gauge couplings (gauge unification)

Supersymmetric dark matter

G. Bélanger
LAPTH-Annecy

Theoretical ideas

- Lots of candidates for cold dark matter
- Favourites:
  - Supersymmetry with R parity conservation
    - Neutralino LSP
    - Gravitino
    - Axino
  - Kaluza-Klein dark matter
    - UED (LKP)
    - LZP is neutrino-R (in Warped Xdim models with matter in the bulk)
  - Little Higgs with T-parity
- Will concentrate on the neutralino LSP in different models

WMAP and SUSY dark matter

- In mSUGRA might conclude that the model is fine-tuned (either small ΔM or Higgs resonance) but in fact what WMAP is telling us might be rather that a good dark matter candidate is a mixed bino/Higgsino or mixed bino/wino….
  - In particular, main annihilation into gauge boson pairs works well for Higgsino (or wino) fraction ~25%

- What does that tell us about models?
- Some examples
  - mSUGRA –focus point
  - Non-universal SUGRA
  - String inspired moduli dominated
  - Split supersymmetry
  - AMSB
  - NMSSM

Conclusion

- Complementarity direct/indirect detection and collider searches to probe models with neutralino dark matter
- If SUSY is correct within a few years good potential for signal from SUSY AND dark matter – which SUSY model?
- From determination of parameters might have enough precision to confront cosmological model
- Of course many other candidates for dark matter…
- Expect new exciting results soon

HIGGS PHYSICS @ FUTURE COLLIDERS

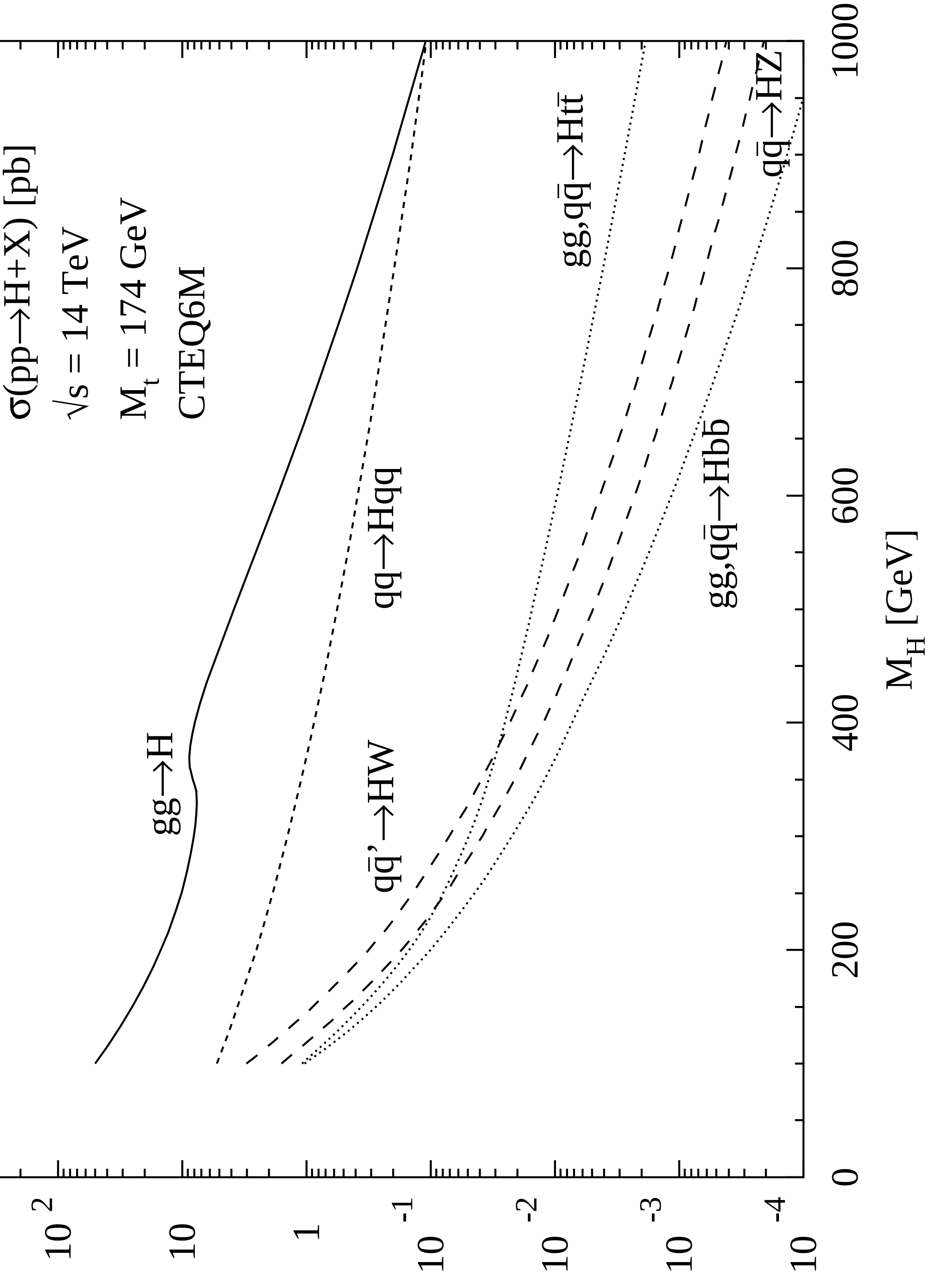
Michael Spira (PSI)

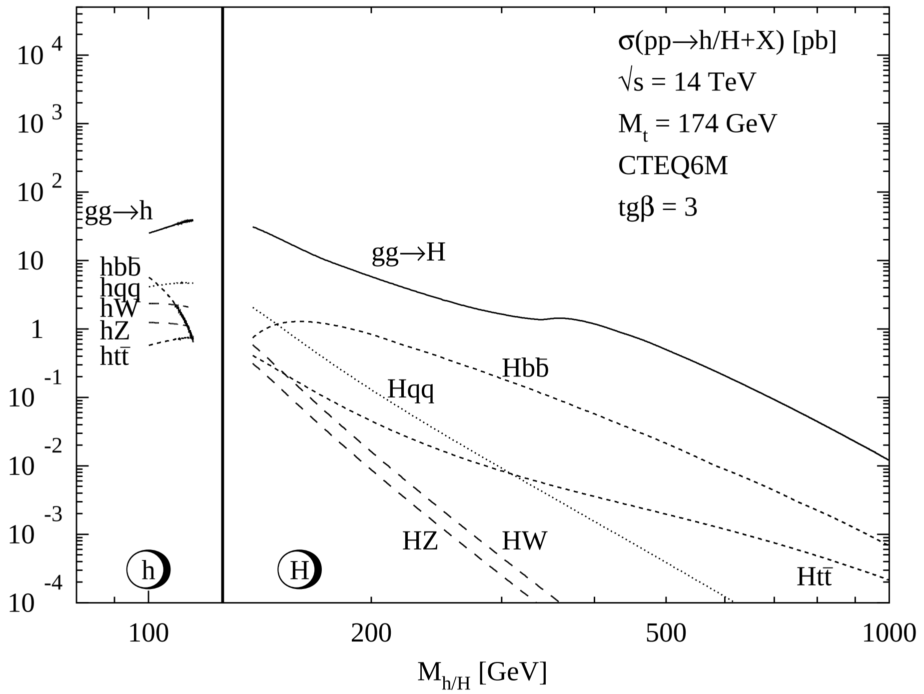
I Introduction

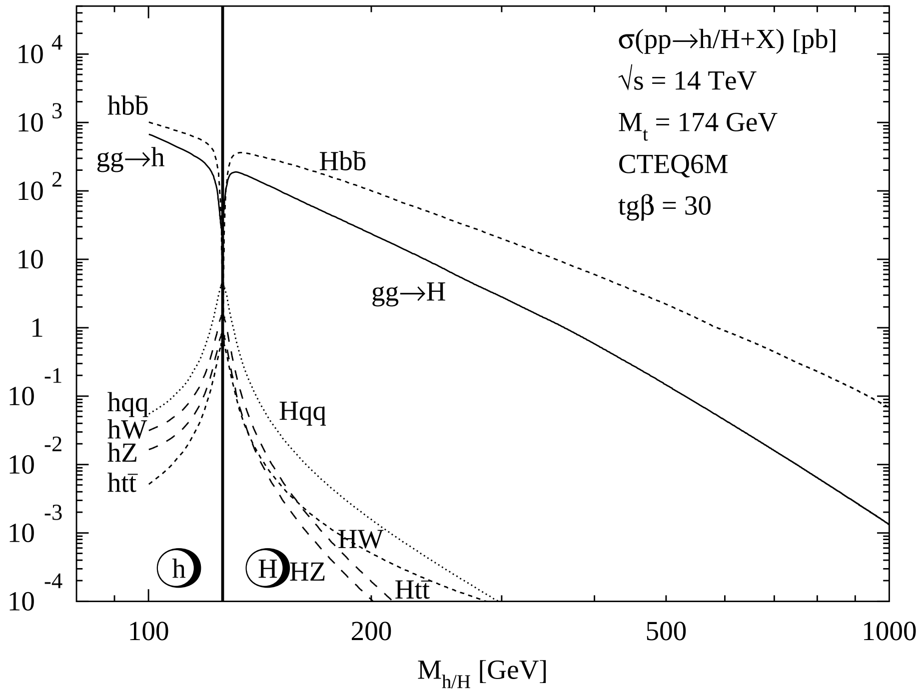
II Higgs Boson Production @ LHC

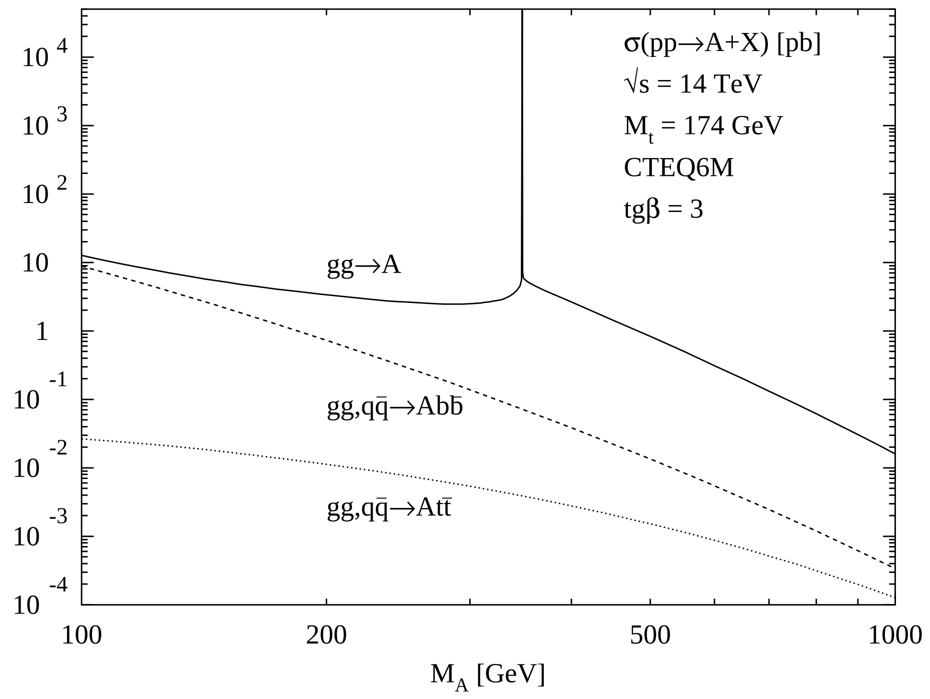
III Higgs Boson Production @ ILC

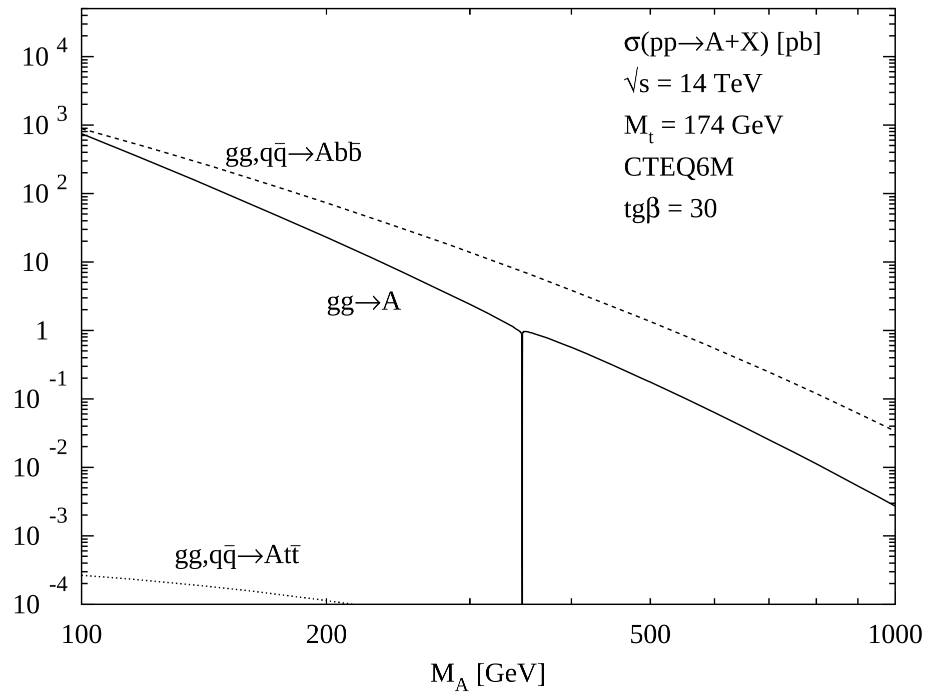
IV Conclusions


σ(pp→H+X) [pb]
√s = 14 TeV
M_t = 174 GeV
CTEQ6M
gg→H
qq→Hqq
qq̄'→HW
gg,qq̄→Htt̄
gg,qq̄→Hbb̄
qq̄→HZ
M_H [GeV]
0
200
400
600
800
1000
10^2
10
1
10^-1
10^-2
10^-3
10^-4

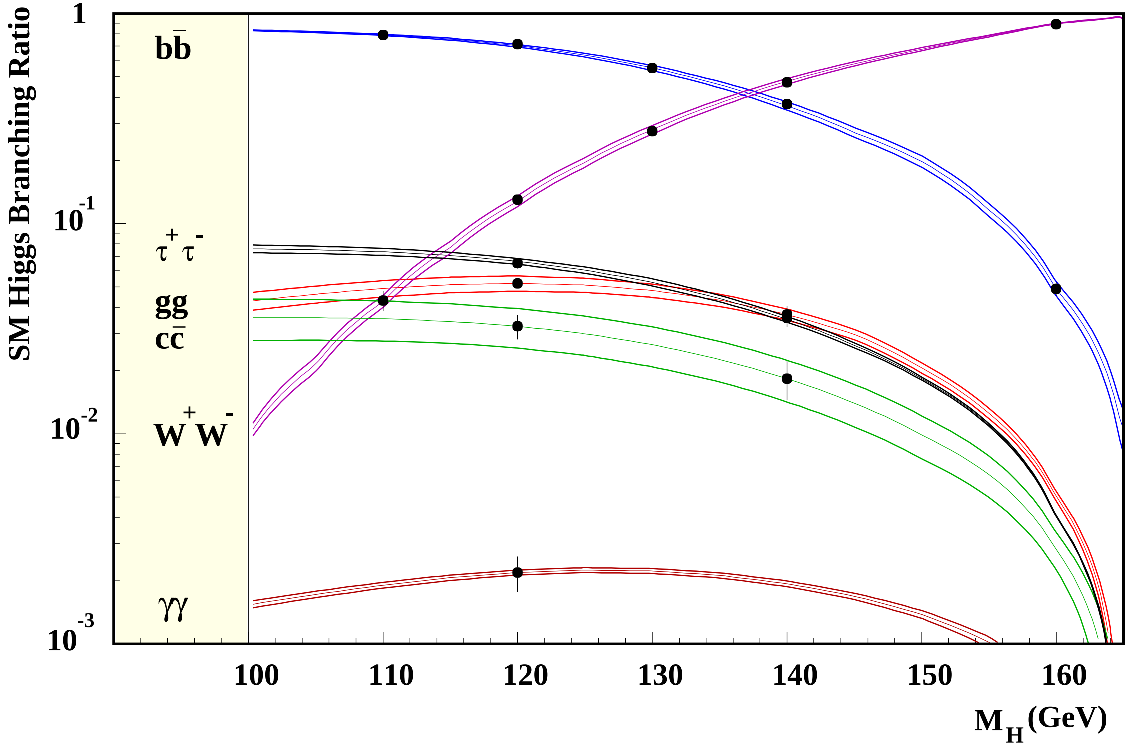

σ(pp→h/H+X) [pb]
√s = 14 TeV
M_t = 174 GeV
CTEQ6M
tgβ = 3
gg→h
hbb̄
hqq
hW
hZ
htt̄
gg→H
Hbb̄
Hqq
HZ
HW
Htt̄
h
H
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
100
200
500
1000
M_h/H [GeV]


σ(pp→h/H+X) [pb]
√s = 14 TeV
M_t = 174 GeV
CTEQ6M
tgβ = 30
hbb̄
gg→h
Hbb̄
gg→H
hqq
hW
hZ
htt̄
Hqq
HW
HZ
Htt̄
h
H
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
100
200
500
1000
M_h/H [GeV]


σ(pp→A+X) [pb]
√s = 14 TeV
M_t = 174 GeV
CTEQ6M
tgβ = 3
gg→A
gg,q$\bar{q}$→Ab$\bar{b}$
gg,q$\bar{q}$→At$\bar{t}$
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
100
200
500
1000
M_A [GeV]


σ(pp→A+X) [pb]
√s = 14 TeV
M_t = 174 GeV
CTEQ6M
tgβ = 30
gg,q$\bar{q}$→Ab$\bar{b}$
gg→A
gg,q$\bar{q}$→At$\bar{t}$
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
100
200
500
1000
M_A [GeV]

- Yukawa couplings: from branching ratios



Battaglia

$\Rightarrow \delta BR/BR \sim$ few % $\Rightarrow$ Test $g_f \propto m_f$

III *CONCLUSIONS*

- Higgs searches at the LHC and ILC belong to major endeavours

- LHC will find at least one Higgs boson [light scalar]

- most QCD and elw. corrections known
  $\Rightarrow$ large corrections in several cases
  remaining theoretical uncertainties:
  $\sim 100\% \longrightarrow \lesssim 15 - 20\%$

- profile of the Higgs bosons can be studied partially @ LHC
$\rightarrow$ completed @ LC with much higher accuracy

- LHC: problematic distinction SM $\leftrightarrow$ MSSM for large M_A $\rightarrow$ can be solved @ LC

$\Rightarrow$ $\boxed{\text{We need both colliders}}$

- close collaboration of experimentalists and theorists necessary

Gluon induced W-boson pair production as SM Higgs boson discovery background at the LHC

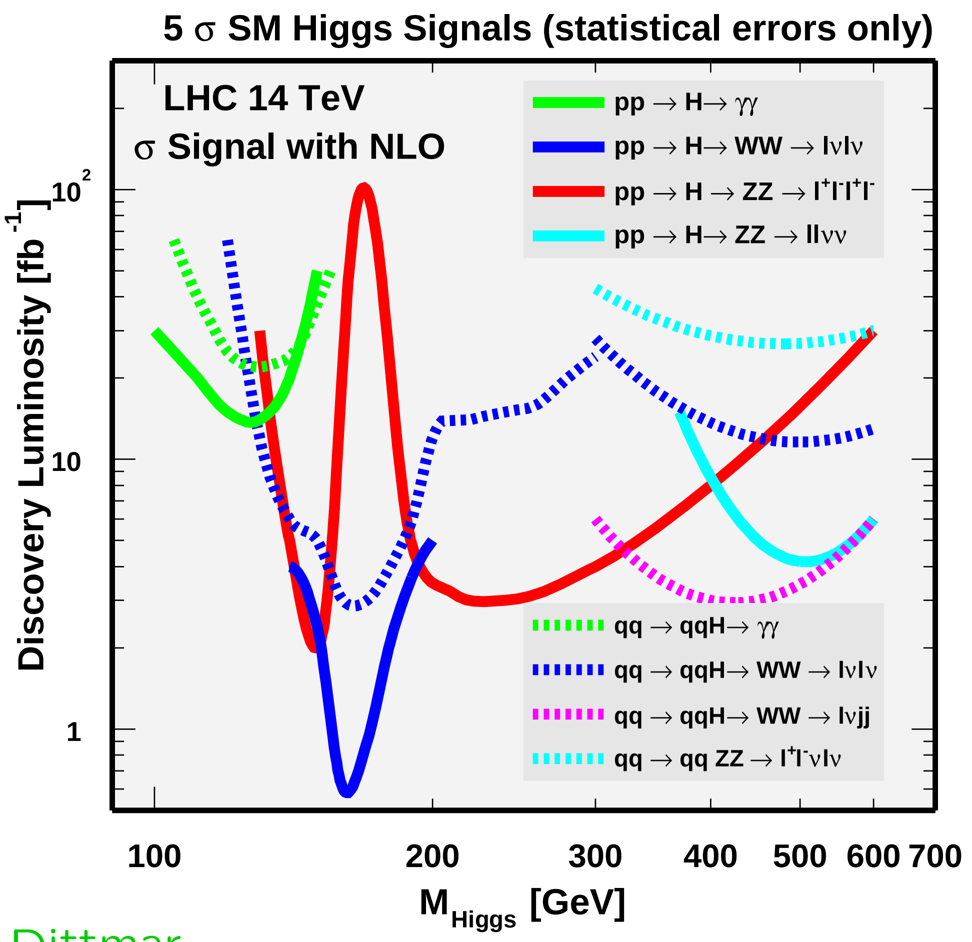
M. Ciccolini

In collab. with T. Binoth, N. Kauer and M. Krämer

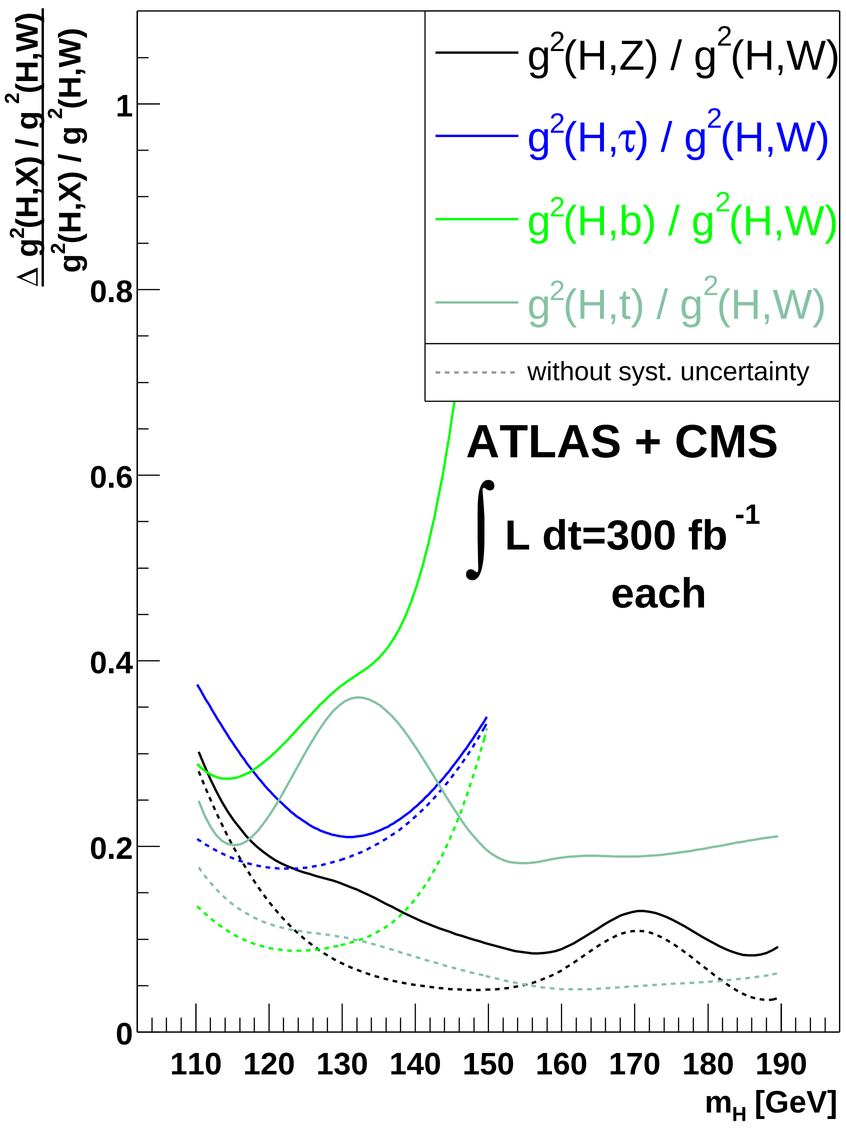
Paul Scherrer Institut
Villigen, Switzerland

Weak Interactions and Neutrinos 2005
Delphi, Greece

June 6 - June 11, 2005



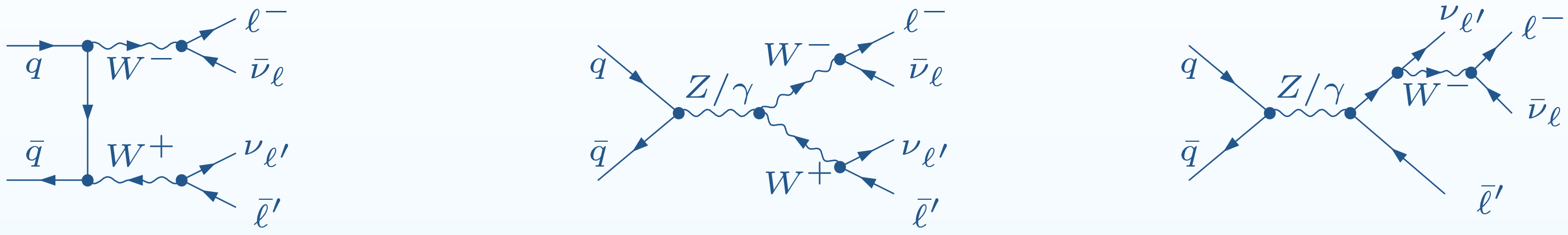
Dittmar



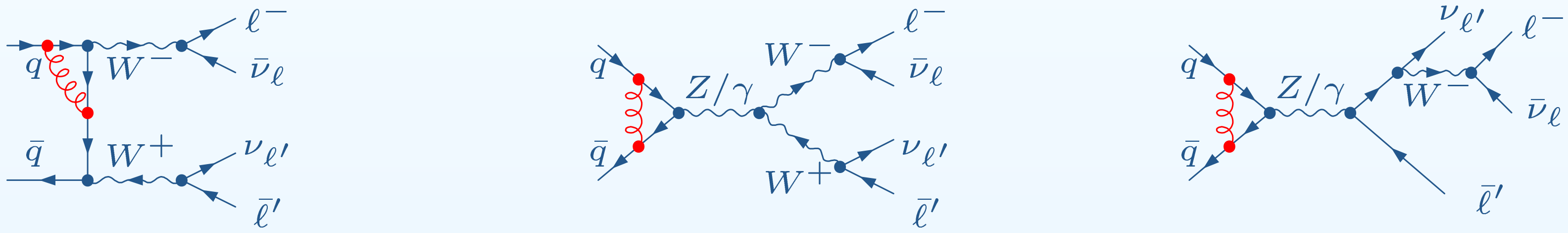
Dührssen,. . .

Hadronic W-pair production status

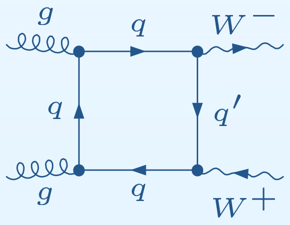
- LO (J. M. Campbell, R. K. Ellis) :



- QCD NLO (L. Dixon, Z. Kunszt, A. Signer; S. Frixione; J. Ohnemus; J. M. Campbell, R. K. Ellis) :



- Log. EW $\mathcal{O}(\alpha)$ corrections (E. Accomando, A. Denner, A. Kaiser)
- Gluon-induced contribution (E. W. N. Glover, J. J. van der Bij; C. Kao, D. A. Dicus) :



- $gg \to Z^* Z^*$ (C. Zecher, T. Matsuura, J. J. van der Bij)
- Tree level $gg \to W\, Z/\gamma\, q\bar{q}$ (K. L. Adamson, D. de Florian, A. Signer)

Conclusions

- $gg \to H \to W^- W^+ \to l\,\bar{\nu}_l\,\bar{l}'\,\nu_{l'}$ important Higgs search channel
- W-boson pair production: main background
- Gluon induced offshell W-boson pair production calculation
- $gg \to W^- W^+$ contribution:
  - No cuts: 5%
  - Higgs selection cuts: 30%
- Gluon induced contribution must be taken into account.
- `gg2WW` code
- Future Work
  - Massive b and t loops
  - Incorporate modifications into `gg2WW` code
  - Implement the ZZ mediated process into `gg2WW` (`gg2VV`?)

Construction of new tools for automatic calculation of cross sections

Tanju Gleisberg [a]

Institute for Theoretical Physics
Dresden University of Technology

- Event generation with SHERPA
- The matrix elements generator AMEGIC++
  - Features
  - Optimization and phase space integration
- Physics implementation and applications

---

[a] The SHERPA collaboration: T. G., S. Höche, F. Krauss, S. Schumann, J. Winter

The event generator Sherpa

SHERPA (**S**imulation of **H**igh **E**nergy **R**eactions of **PA**rticles) is a new multipurpose event generator entirely written in C++.

T. Gleisberg, S. Höche, F. Krauss, A. Schälicke, S. Schumann and J. Winter, JHEP **0402** 056 (2004).

The Scope:

- Full simulation of high energy particle reactions at existing and future collider experiments, including e^+e^-, $\gamma\gamma$, $e\gamma$, $p\bar{p}$ and pp collisions
- Account for multi-jet production by using tree level matrix elements combined with the parton shower using the CKKW prescription

Features:

- Modular structure of independent physics modules
- Modules are interfaced through abstract handler classes
- Bottom-up approach (slim overhead that can be easily adapted)

Matrix elements

Tame the factorial growth:"Super-amplitudes"

$e^+e^- \longrightarrow$	Feynman diagrams	Super-amplitudes
e^+e^-	4	4
$e^+e^-\mu^+\mu^-$	50	10
$e^+e^-e^+e^-$	144	9
$e^+e^-e^+e^-\mu^+\mu^-$	3690	261
$e^+e^-e^+e^-e^+e^-$	13896	323

- So far only for amplitudes with equal color structure

SM applications

Validation for LHC purposes during and after the MC4LHC workshop at CERN, summer 2003 ...

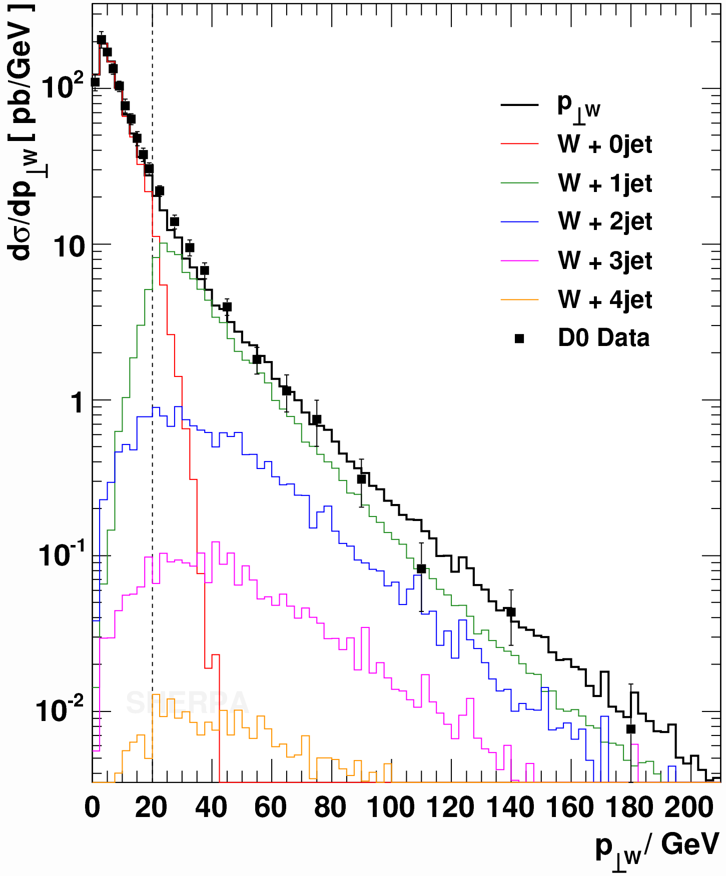
X-sects (pb)	Number of jets						
$e^- \bar{\nu}_e$ + n QCD jets	0	1	2	3	4	5	6
Alpgen	3904(6)	1013(2)	364(2)	136(1)	53.6(6)	21.6(2)	8.7(1)
CompHEP	3947.4(3)	1022.4(5)	364.4(4)				
MadEvent	3902(5)	1012(2)	361(1)	135.5(3)	53.6(2)		
Amegic++/Sherpa	3908(3)	1011(2)	362.3(9)	137.5(5)	54(1)		

X-sects (pb)	Number of jets				
$e^- \bar{\nu}_e$ + $b\bar{b}$	0	1	2	3	4
Alpgen	9.34(4)	9.85(6)	6.82(6)	4.18(7)	2.39(5)
CompHEP	9.415(5)	9.91(2)			
MadEvent	9.32(3)	9.74(1)	6.80(2)		
Amegic++/Sherpa	9.37(1)	9.86(2)	6.87(5)	4.31(6)	

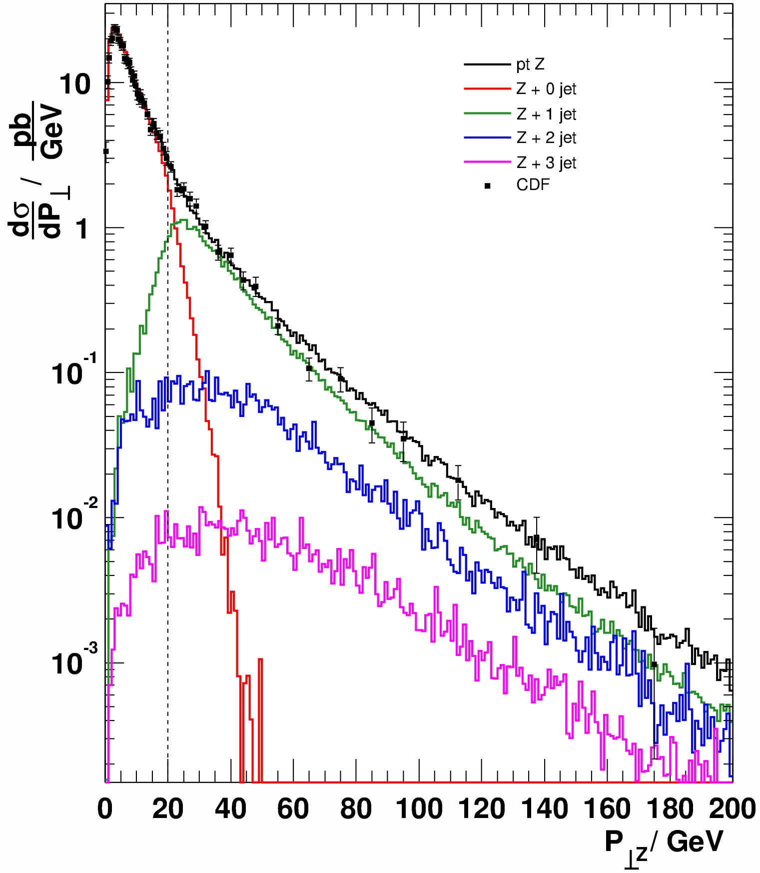
SHERPA vs. Data

Inclusive W and Z transverse momentum distributions from Tevatron Run I

- ME’s with up to four (W) or three (Z) extra jets



D0: Phys. Lett. B **513**, 292 (2001)



CDF: Phys. Rev. Lett. **84**, 845 (2000)

distributions multiplied by constant K factors: 1.25 and 1.6

Conclusion and outlook

- AMEGIC++ is an automatic tool to generate tree-level matrix elements
- Tested for up to six-particle production processes
- Beyond SM the MSSM and the ADD model of large extra dimensions have been implemented
- As a module of the event generator SHERPA AMEGIC++ allows a huge variety for studies of signal and background processes in SM and BSM
    - Extension to further models is rather straightforward
      → in progress or planned in near future:
        - R-parity violating supersymmetry
        - anomalous EW gauge coupling
- Soon available: ME for production + fully correlated decay processes
  e.g. $p\bar{p} \;\rightarrow\; t\left[\,\rightarrow b\,W^{+}[\rightarrow ...]\right]\,\bar{t}\left[\rightarrow \bar{b}\,W^{-}[\rightarrow ...]\right]\; h[\rightarrow b\bar{b}]$

Mauro Moretti
Dipartimento di Fisica, Università di Ferrara
INFN, Sezione di Ferrara

ALPGEN

http://mlm.home.cern.ch/mlm/alpgen

M. Mangano, M. Moretti, R. Pittau, F. Piccinini and A. Polosa

JHEP 0307:001,2003.

- Ready-to-use exact LO calculation (based on the ALPHA code) for multiparton final states in hadronic collisions (SM)

  ALPHA: F. Caravaglios and M. Moretti, Phys. Lett. B **358** (1995) 332

- Parton-level event generation (weighted and unweighted)
  - mass term included
  - stable/unstable heavy particles avaliable.
  - routines for decays of heavy particles avaliable. full spin correlation in the narrow width approximations
  - coulor structure of the event in the leading $1/N_c$ approximation
- Interface to Herwig/Pythia for the evolution of the partonic final state through parton shower (jets and hadrons)

Up to now available processes

- $W^* Q\bar{Q} + n\text{-}jets$
    1. $W^* = l\nu_l$ only $O(\alpha_W)$ contibutions,
    2. $Q = top, bottom$
    3. description of top quark decay with spin correlation taken fully into account (infinitely narrow width approximation, $\Gamma_t = 0$).
    4. option for anomalous $V + A$ interaction in top decay.
- $W^* + n\text{-}jets$
- $Z^*/\gamma^* Q\bar{Q} + n\text{-}jets$ $(Z^*/\gamma^* = l\bar{l}, \nu\bar{\nu})$
- $Z^*/\gamma^* + n\text{-}jets$
- $Q\bar{Q} + n\text{-}jets$
- $Q\bar{Q}Q\bar{Q} + n\text{-}jets$
- $Q\bar{Q} + H + n\text{-}jets$
- $n\text{-}jets$
- $n_W + n_Z + n_H + n\text{-}jets$
    1. description of V-boson and top quark decay with spin correlation taken fully into account (infinitely narrow width approximation, $\Gamma = 0$).
    2. Z decay channel can be selected
    3. Higgs decay: to be released (v.2.0).
    4. $\Gamma_V = 0$ and a 'tuned' slice in $m_{jj'}$ cutted away to preserve gauge invariance
    5. four EW scheme provided (four free parameters, including higgs sector, others from tree-level relationships to preserve gauge invariance). Experienced users can override defaults.

- Single Top: to be released (v.2.0)
- $H + n$-*jets* :to be released (v.2.0) (gluon fusion, $m_t \to \infty$ limit)

Up to 8 final partons allowed (although not all the contributing partonic process are always accounted for). This restriction can be removed if required from physics studies.

Validation

An extended series of comparisons among avaliable packages (AMEGICC++, ComHEP, HELAC/PHEGAS/JetI, MadEvent) has been performed in MC_4 Wshop. See the web page *http://agenda.cern.ch/displayLevel.php?fid=152* for full detayls.

Validation against data

Tevatron W + multi-jet data

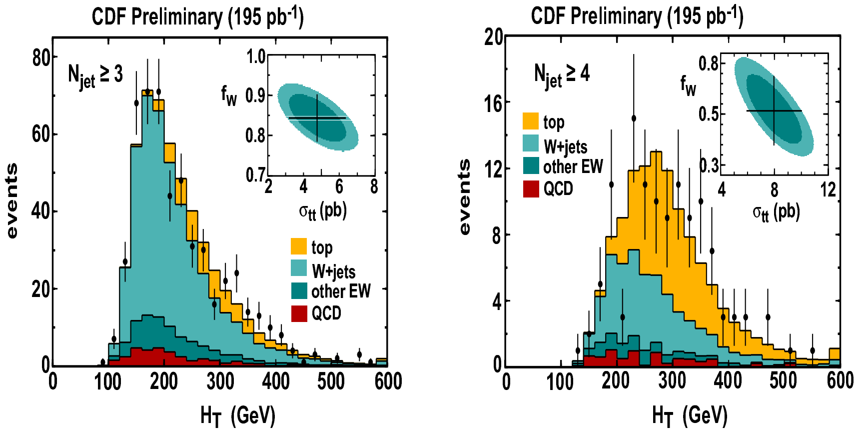


Figure 1:

The CKKW procedure has been successfully tested on LEP data

e.g. S. Catani et al., JHEP 0111 (2001) 063

R. Kuhn et al., hep-ph/0012025

F. Krauss, R. Kuhn and G. Soff, J. Phys. G26 (2000) L11

Recent work for hadronic collisions

- `Herwig` (P. Richardson)
- `Pythia` (S. Mrenna)

  S. Mrenna and P. Richardson, hep-ph/0312274
- `SHERPA with APACIC++/AMEGIC++` (F. Krauss and A. Schälicke)

An alternative proposal

- generate event sample ($p_T > p_{T\,min}$ $\Delta R > \Delta R_{min}$
- shower the event and reconstruct particle clusters (jets) with a cone algorithm
  - Note: these clusters are just a computational device to define the sample. they don't need to coincide with "experimental" jet Namely you can input $p_{T\,min} = 20$GeV and $\Delta R > 0.5$ as cuts for the partonic ME and then analize the sample requiring $p_{T\,min} = 40$GeV and $\Delta R > 0.7$ for final jets.
- define the matching of a parton (LO matrix element) and a cluster as follows: a parton match a cluster if the separation ΔR between the parton and the cluster is smaller than $\Delta \bar{R}$ (an arbitrary fixed quantity $\Delta \bar{R} \sim \Delta R_{min}$
- reject the event if more than one parton match the same cluster or if a parton doesn't match any cluster
- for *exclusive* samples also events with number of clusters different (larger) from number of partons are rejected
- Let's stress again that we have different parameters: a) $p_T^{(partons,matching)}$ $\Delta R^{(partons,matching)}$ which should not affect σ and distributions (efficiency can however depend on the choice made). b) $p_{T\,jets}$, ΔR_{jets} and any other cuts