Electroweak & Beyond the Standard Model (theory)

C.-P. Yuan
Michigan State University

- W/Z (P. Nadolsky, Q.-H. Cao)
- Top (F. Larios)
- Higgs
  - SM $\gamma\gamma$ background (C. Balazs)
  - MSSM (A. Belyave, H. Baer, N. Kidonakis)
- Extra boson (L. T. Wang)
- Extra fermion (T. Tait)
- B-physics (S. Gopalakrishna)

W/Z physics

P. Nadolsky

Tevatron Run 2 expectation:

$\Delta M_W \sim 40$ MeV , $\Delta\Gamma_W \sim 50$ MeV (Per Experiment)

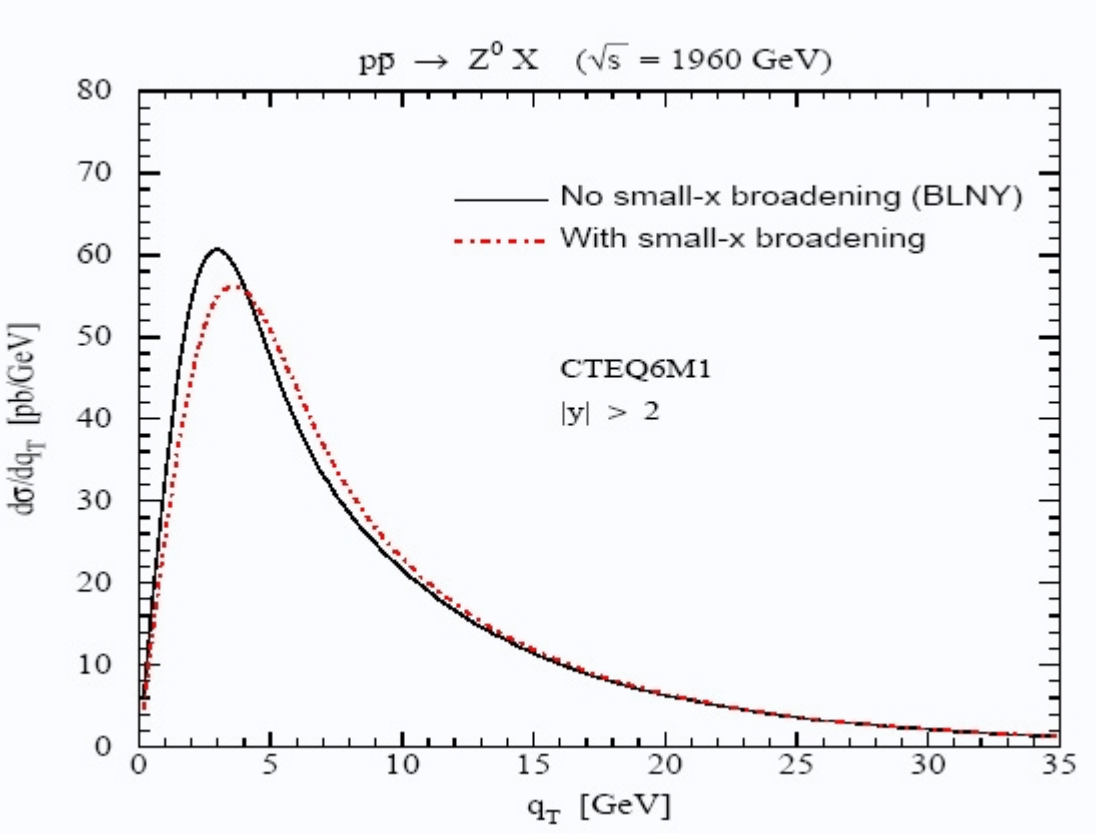
➡ Need to resum initial state multiple soft gluon emission

(1) A better fit to the non-perturbative function of Collins-Soper-Sterman resummation formalism for predicting $p_T(W)$ from a global fit to Drell-Yan data.

(2) Need improved

semi-inclusive DIS energy flow data from HERA

to explore $p_T(Z)$ distribution at large rapidity region.

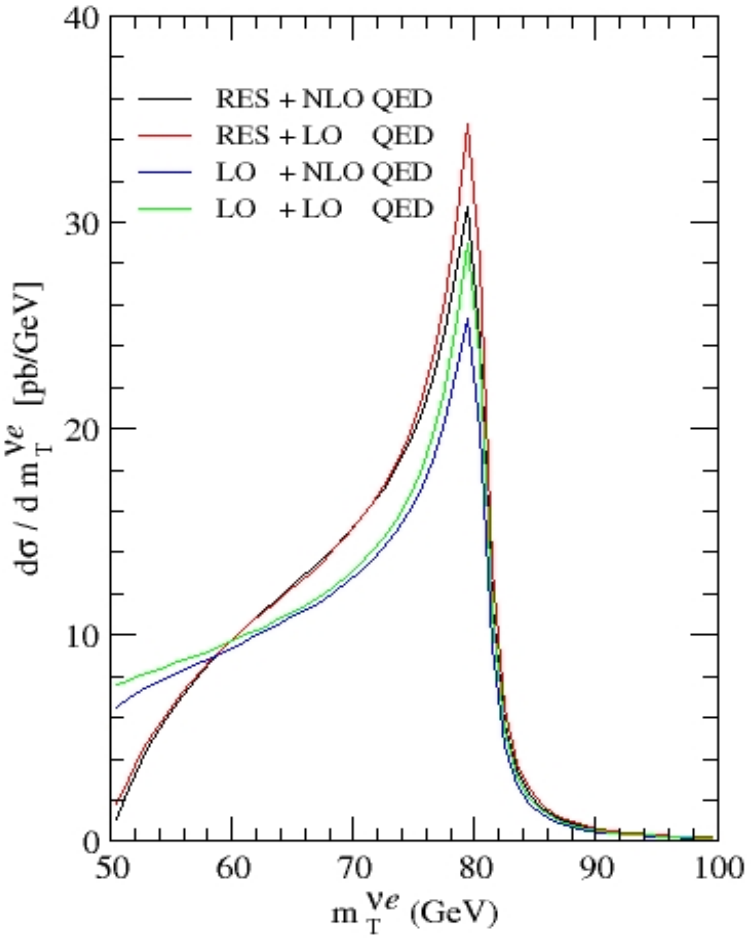


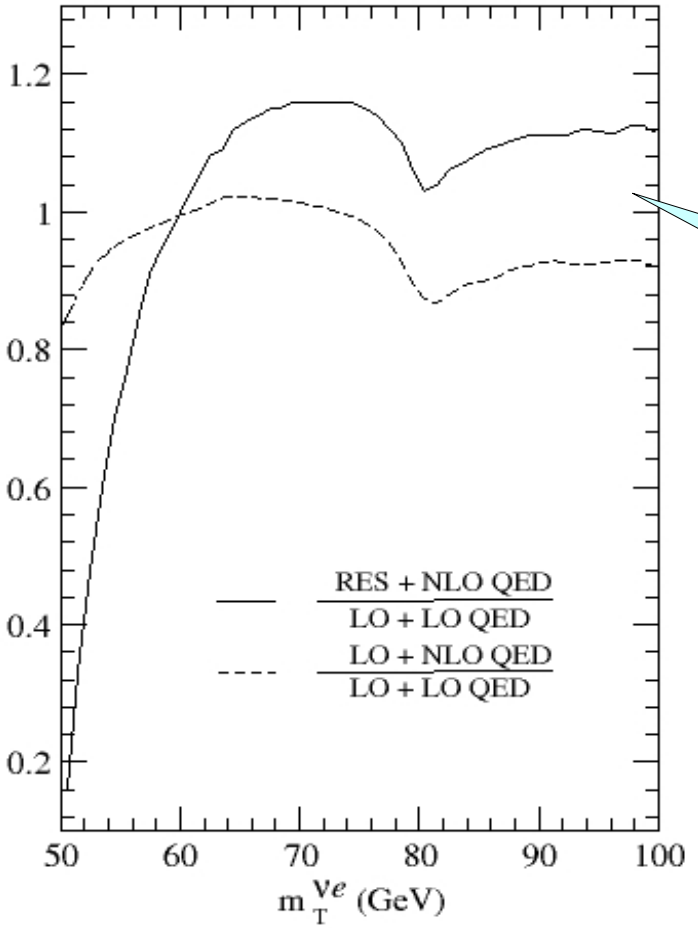
W/Z physics

Q.-H. Cao

Final state QED correction cause W mass shift ~100 MeV

➡ Need to incorporate initial state QCD resummation and final state QED correction into one Monte Carlo code : ResBos-A





$\Delta\Gamma_W$ is dominated by the initial state QCD resummation effect.

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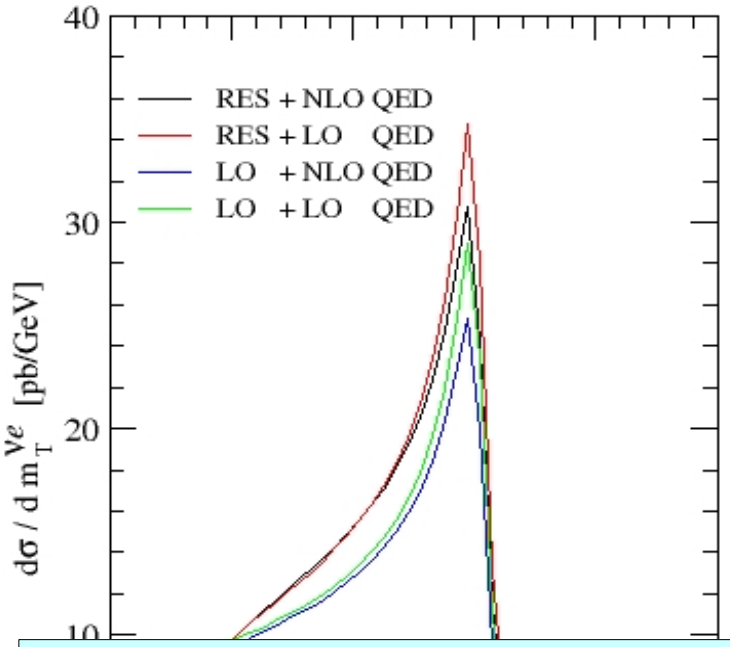
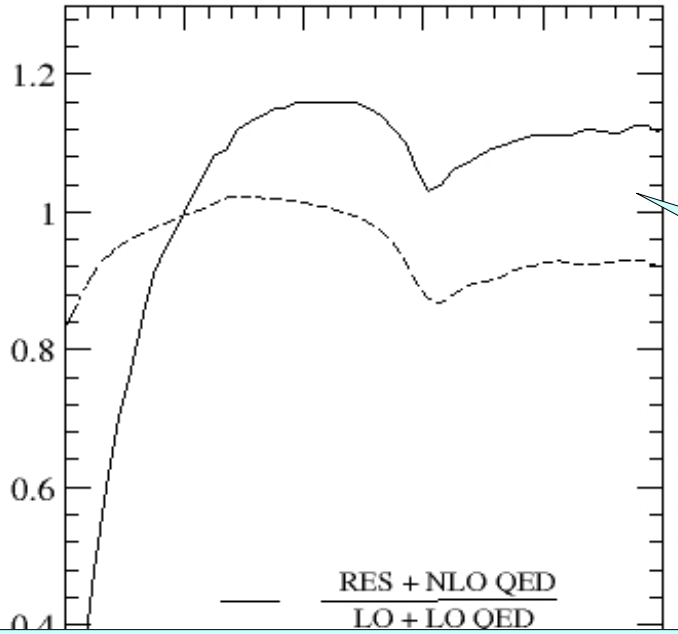




$\Delta\Gamma_W$ is dominated by the initial state QCD resummation effect.

ResBos-A

including $\gamma - Z$ interference effect to study Drell-Yan pair production for the whole invariant mass range.

➡ can pin down $p_T(W)$ and $p_T(Z)$ distributions at large rapidity

➡ improve the determination of m_W and $\frac{u}{d}$ (PDF)

Top

F. Larios

Propose a general analysis to study the t-b-W coupling from direct measurements

- From $t\bar{t}$ data:

  measure W polarization from top decay

  - longitudinal f_0
  - left-handed f_-

  $$(f_+ = 1 - f_0 - f_-)$$

- From single-top cross section:
  - t-channel: σ_t
  - s-channel: σ_s

➡ 4 independent exp. data (to determine 4 general couplings of t-b-W)

$$\mathcal{L}_{tbW} = \frac{g}{\sqrt{2}} W_\mu^- \bar{b} \gamma^\mu (f_1^L P_L + f_1^R P_R) t$$

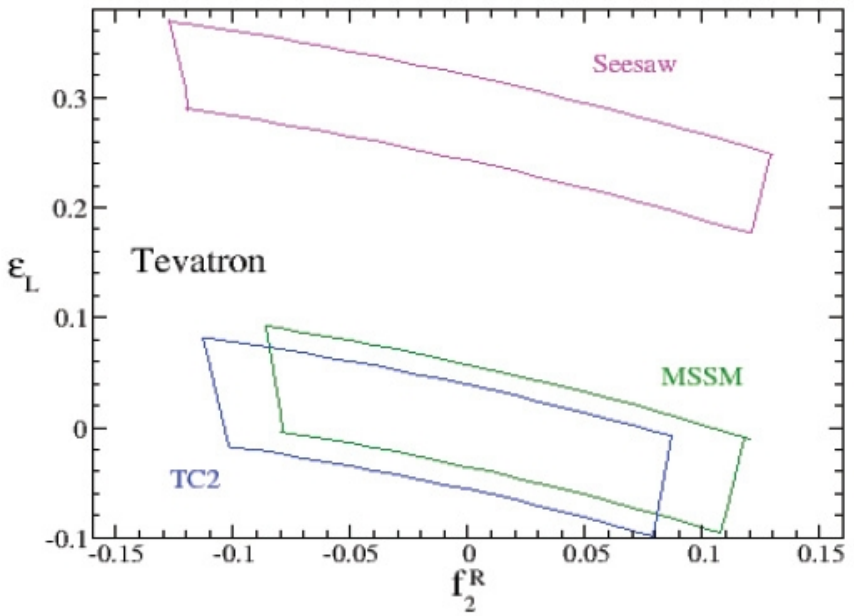
$$- \frac{g}{\sqrt{2} m_W} \partial_\nu W_\mu^- \bar{b} \sigma^{\mu\nu} (f_2^L P_L + f_2^R P_R) t + h.c.$$

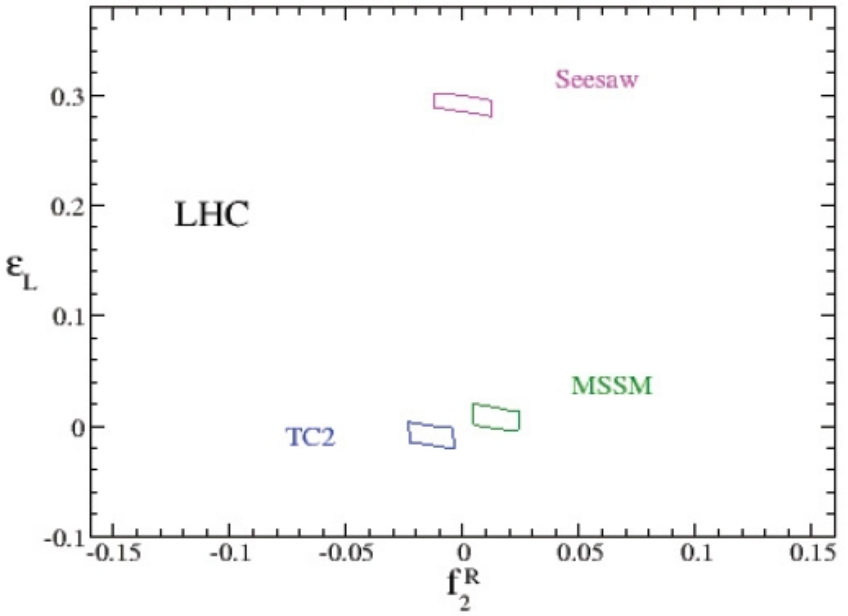
Top

F. Larios

Propose a general analysis to study the t-b-W coupling from direct measurements

➡ Distinguish different EWSB models:
- Top Seesaw
- TopColor Assisted Technicolor (TC2)
- MSSM





Higgs

C. Balazs

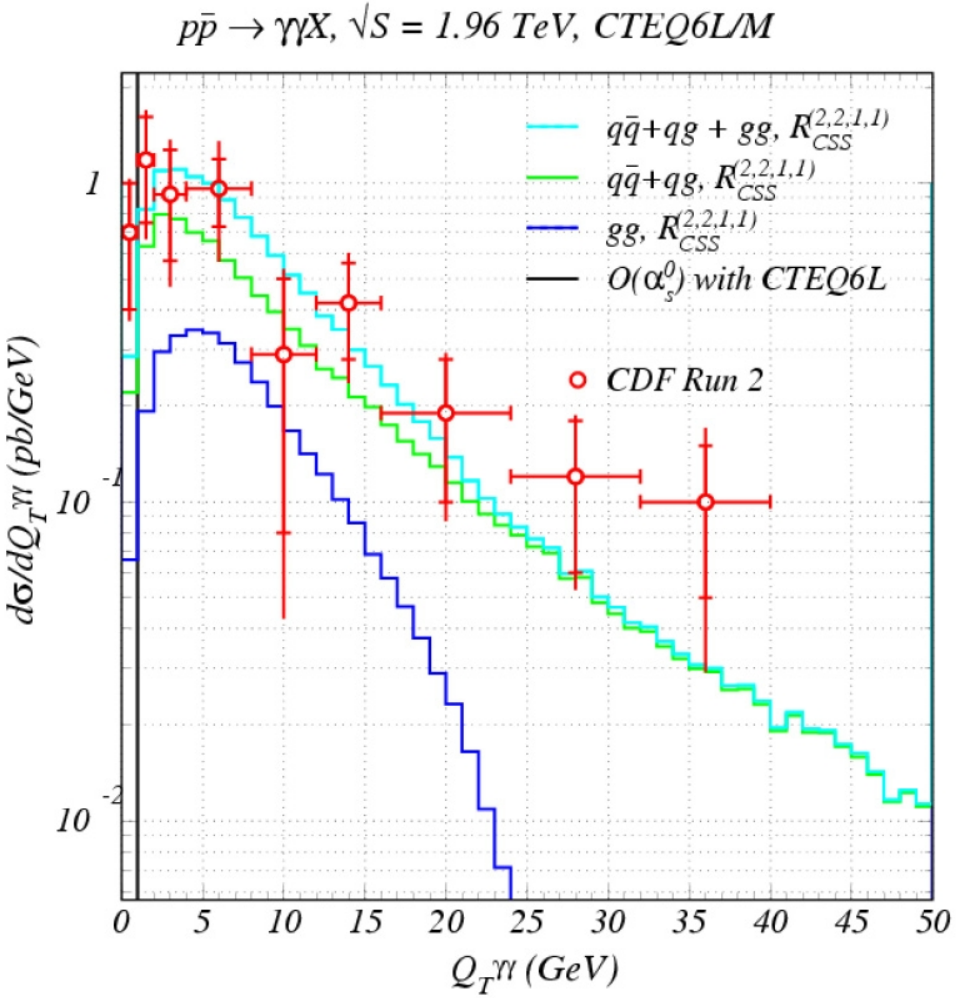
Standard Model $\gamma\gamma$ background:

need accurate $p_T(\gamma\gamma)$ distribution

to model the background for

$$PP, P\bar{P} \to H(\to \gamma\gamma)X$$

➡ ResBos code



MSSM

H. Baer

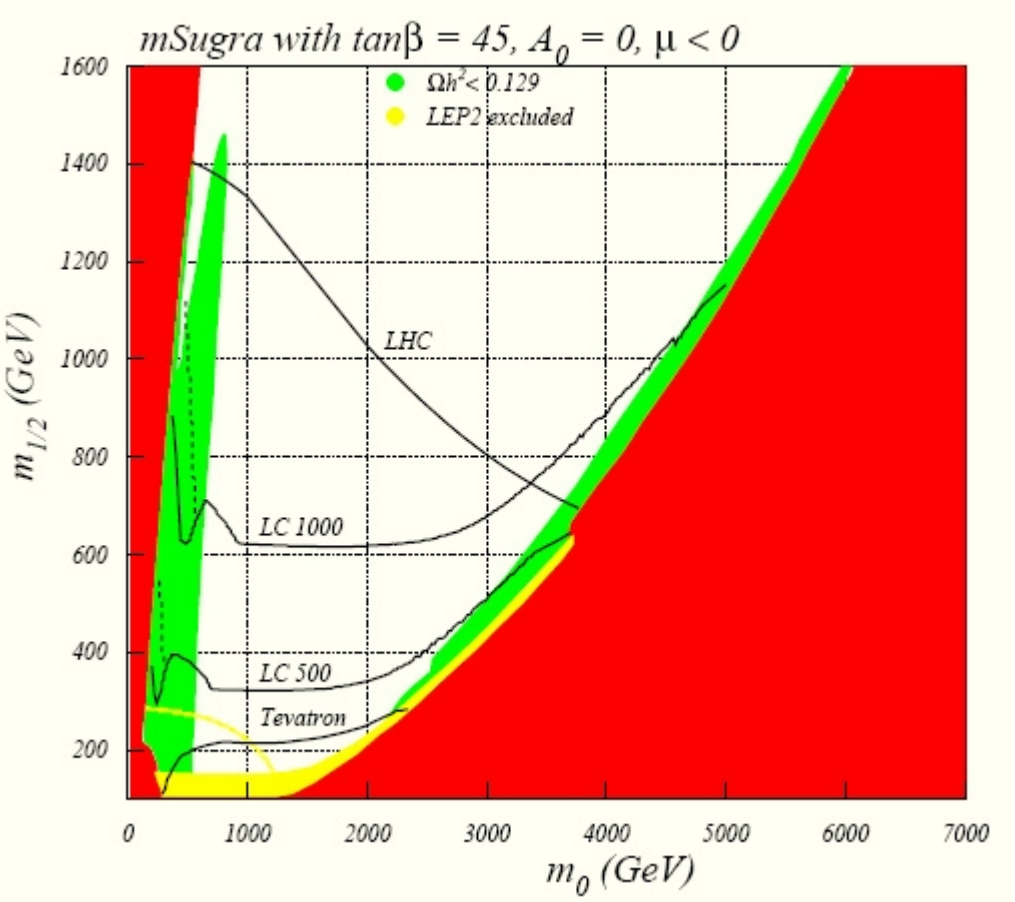
- ⋆ Spontaneous breaking of SUSY phen. inconsistent within MSSM
- ⋆ Hidden sector models (HS)
- ⋆ HS is arena for SUSY breaking; how to communicate SUSY breaking to visible sector (VS)?
  - gravity mediation: supergravity (SUGRA) and local SUSY: minimal messenger sector: $m_{3/2} \sim$ TeV: LSP=bino/higgsino/wino/gravitino?
  - gauge mediation (GMSB): introduce messenger sector fields as intermediary between HS and VS: $m_{3/2} \ll$ TeV: LSP=gravitino
  - anomaly mediation (AMSB): $m_{3/2} >$ TeV: LSP=wino
- ⋆ role of extra dimensions? compactification? sequestered sector and AMSB; gaugino mediation; GUTs; $\cdots$

Discovery Potential

H. Baer

Relic density measurement impose strong constraint on mSugra model.

➡ Complementary to collider search for sparticles (Tevatron, LHC, LC)



Prospects for SUSY at HERA

★ $ep \to \tilde{e}\tilde{q}$ pre-empted by LEP2+Tevatron?

- not so for Higgs split models where just 2 light squarks $(\tilde{u}_R, \tilde{c}_R)$!
- occurs in models with split Higgs at $Q = M_{GUT}$
- hep-ph/0407165, hep-ph/0504001

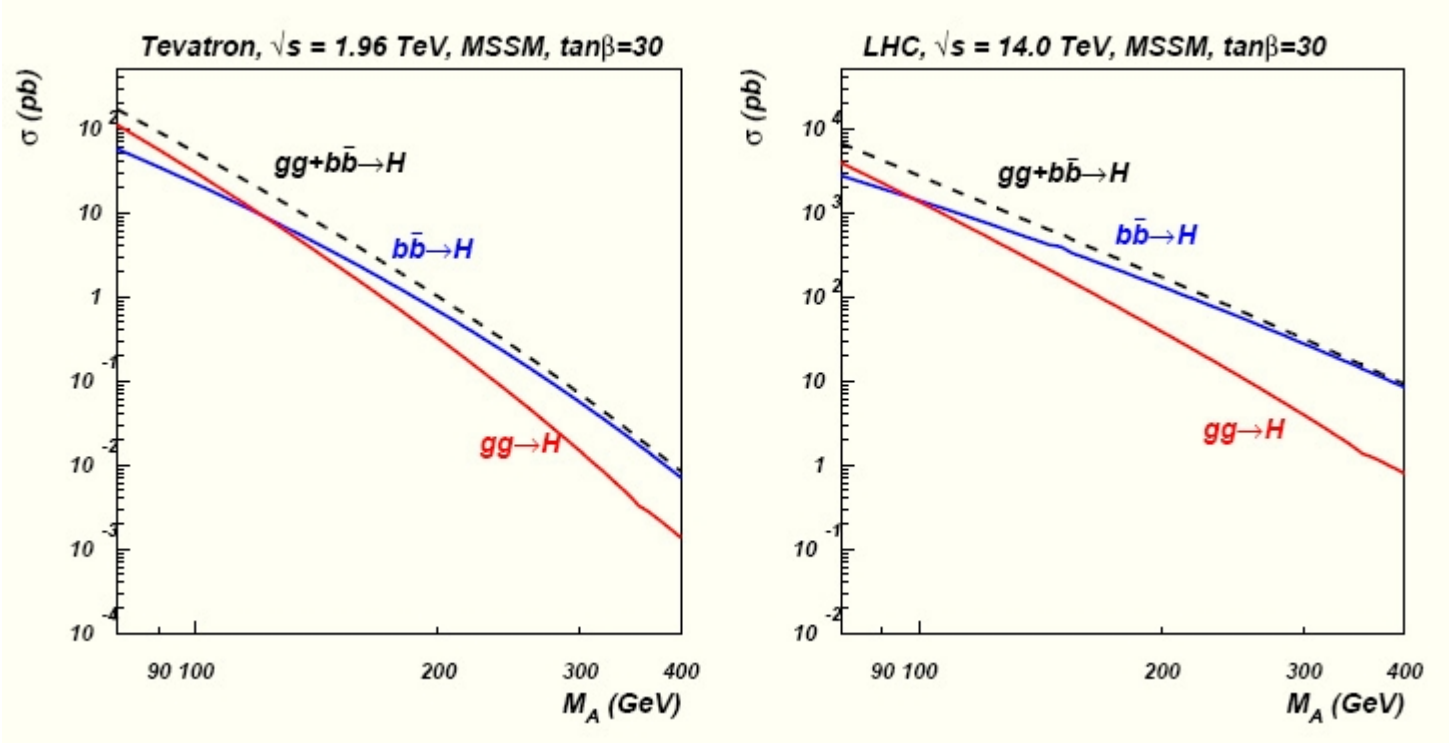
★ Direct squark/slepton production via RPV couplings

- $\hat{f}_{TRV} =$
  $\sum_{i,j,k} \left[\lambda_{ijk} \epsilon_{ab} \hat{L}_i^a \hat{L}_j^b \hat{E}_k^c + \lambda'_{ijk} \epsilon_{ab} \hat{L}_i^a \hat{Q}_j^b \hat{D}_k^c + \lambda''_{ijk} \epsilon_{lmn} \hat{U}_i^{cl} \hat{D}_j^{cm} \hat{D}_k^{cn} \right]$
- $\hat{f}_{BRV} = \sum_i \mu'_i \epsilon_{ab} \hat{L}_i^a \hat{H}_u^b$

$\sigma(b\bar{b} \to H)$ in MSSM

A. Balyaev

Study PDF uncertainty in $\sigma(b\bar{b} \to H)$ and compare with its scale uncertainty



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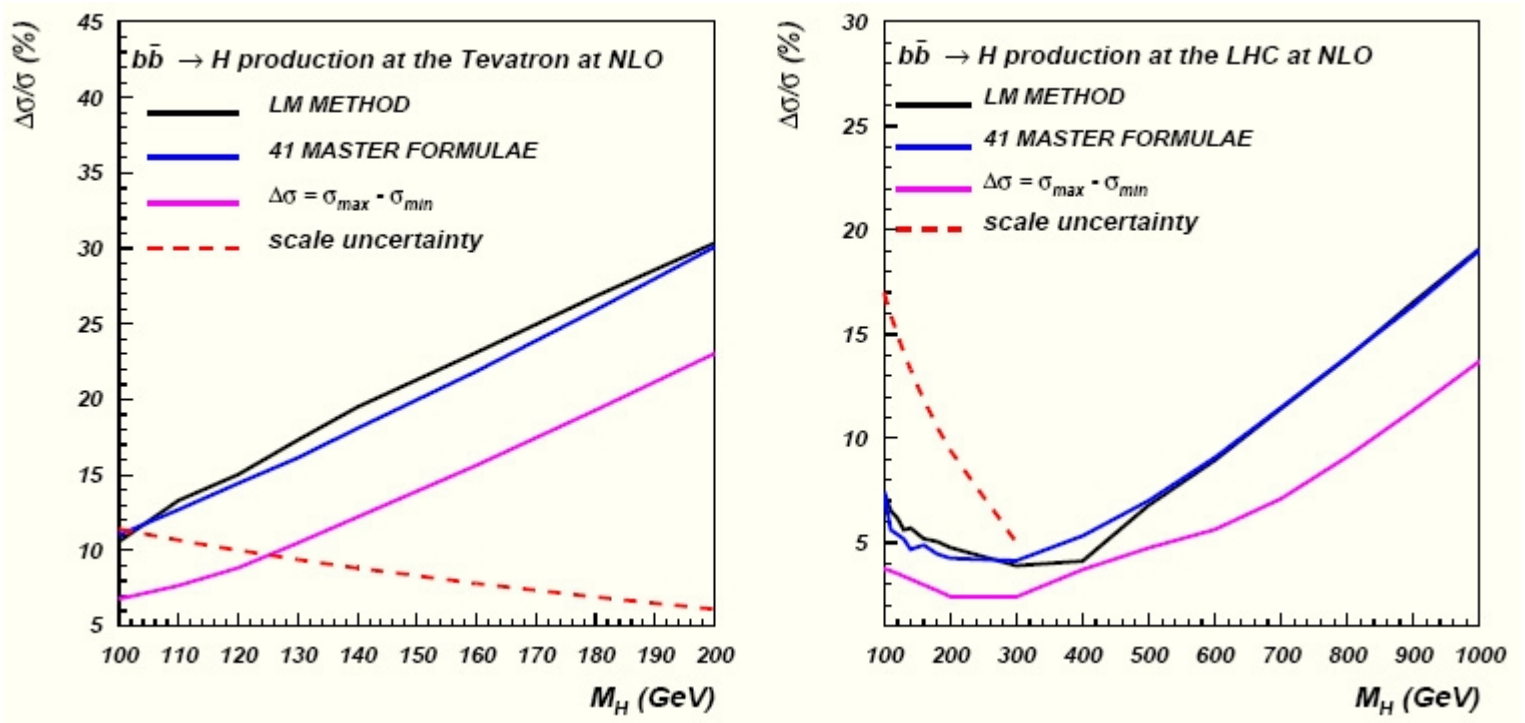


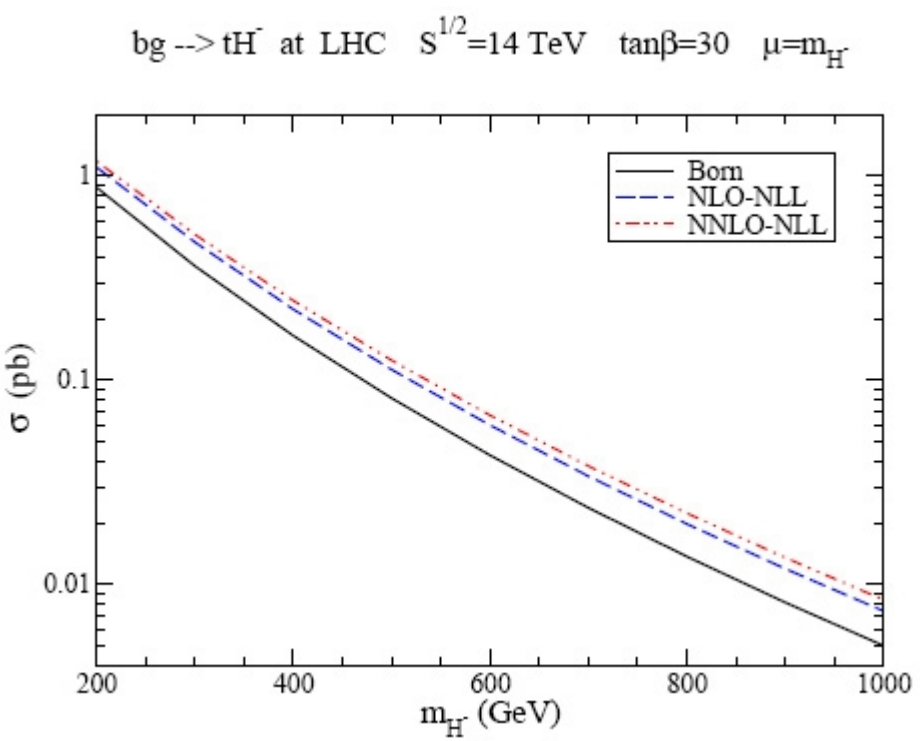
- *opposite trend for PDF and scale uncertainties!*
- *LM and Hessian results are in a good agreement (CTEQ6.1)*
- *"$\sigma_{max} - \sigma_{min}$" method underestimates PDF uncertainty by about factor 2*

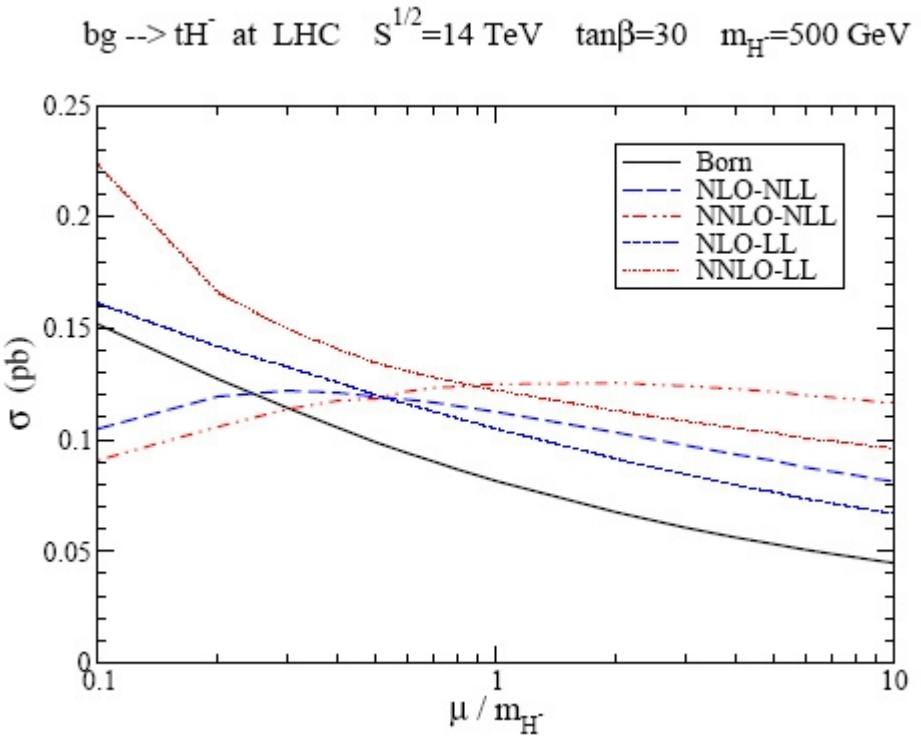
LM: Lagrangian Multiplier

$\sigma(gb \to H^- t)$ in MSSM

N. Kidonakis

- $\sigma(gb \to H^- t)$ was calculated to higher orders with less scale dependence
- K-factor increases by 10~15%, compared to exact NLO.





Extra bosons

with EW gauge quantum number are well motivated L. T. Wang

Hierarchy problem of SM

$\delta m_H^2 \sim \Lambda^2$ ➡ "big" hierarchy problem

➡ SUSY, Extra dimension, ...

$v^2 \ll \Lambda^2_{\rm GUT},\ M^2_{\rm planck}$ ➡ sfermions, extended Higgs sector, KK modes, ...

Little hierarchy problem

EW precision data and Flavor physics

↓

$\Lambda > 5 - 10$ GeV in high dimensional operators

$$\frac{1}{\Lambda^2} H^\dagger \tau^a H W^a_{\mu\nu} B^{\mu\nu}$$

$v^2 < \Lambda^2$

➡ "little" hierarchy problem

➡ Little Higgs model, Higgsless model, ...

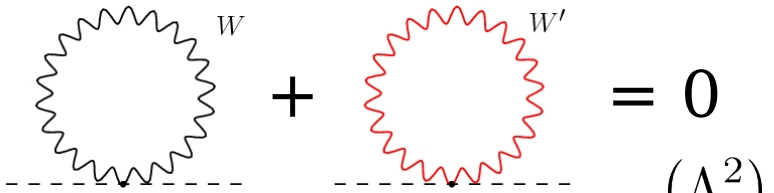
➡ W', Z', ...

Extra bosons

with EW gauge quantum number are well motivated

L. T. Wang

New gauge bosons W', Z'

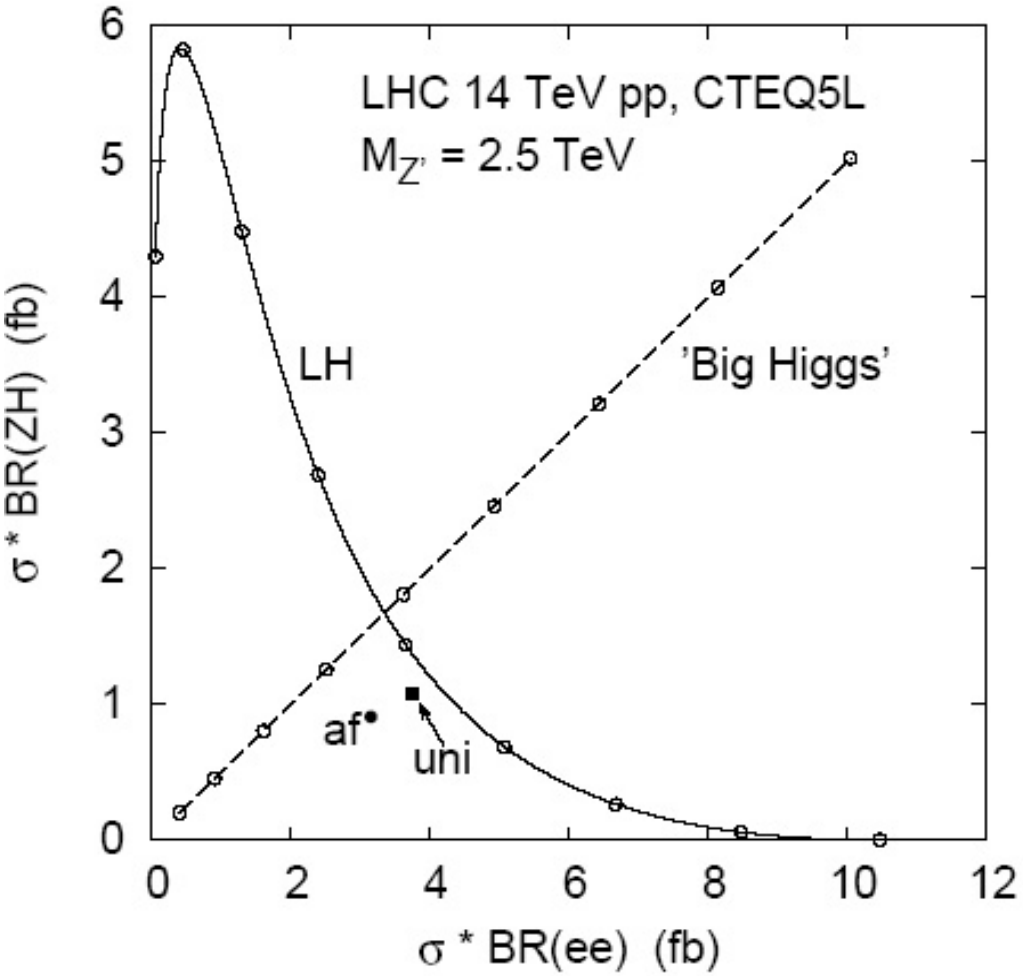


$W' \to f\bar{f}'$ $\quad$ $Z' \to \ell\bar{\ell}$

$\to Wh$ $\quad$ $\to Zh$

➡ Relation between $\sigma(Z' \to Zh)$ v.s. $\sigma(Z' \to \ell\bar{\ell})$

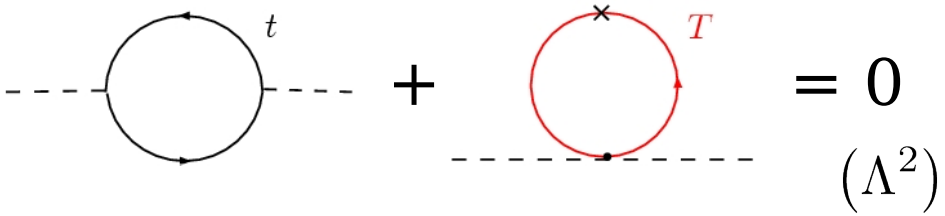
➡ LHC phenomenology



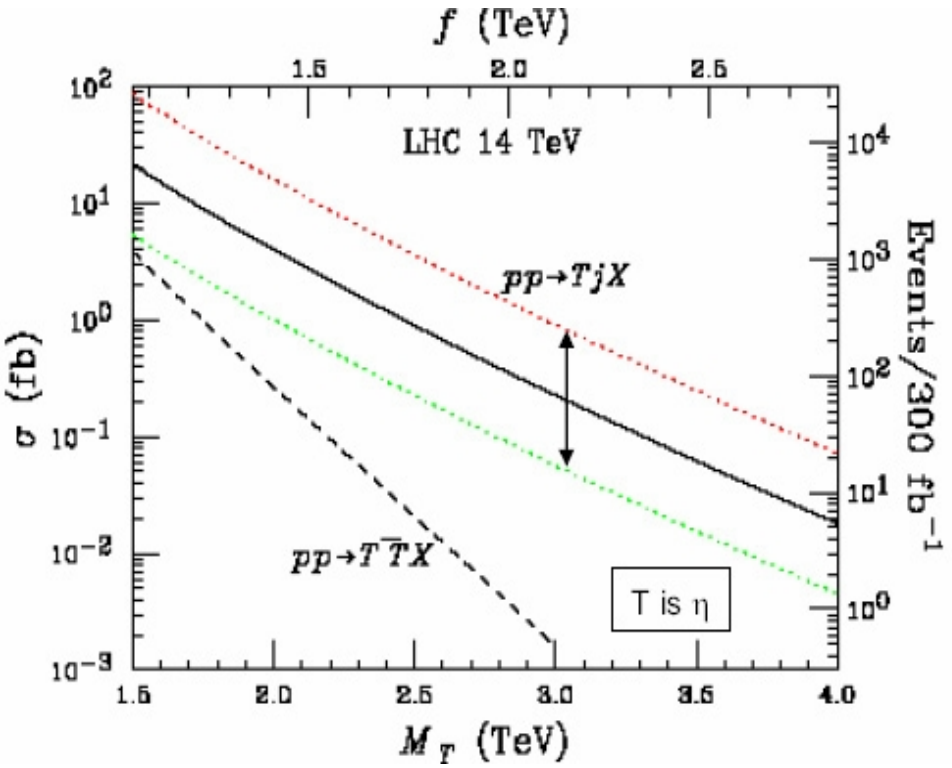
Vector-like quarks

T. Tait

"little" hierarchy problem motivates the existence of vector-like quarks



- Little Higgs model
  (Higgs boson is renormalized as a pseudo-Goldstone boson from a broken global symmetry)
- Vector-like T
  (with same quantum number as t)
- T can be produced either singly or in pairs



Similarly, Top seesaw, Top Flavor, Higgsless,
Extra dimension models with quarks in the bulks, ...

➡ vector-like quarks

Vector-like quarks

T. Tait

Precision EW data motivates the existence of vector-like quarks

The 2.4σ deviation in precision EW data $A_{\rm FB}^b$ motivated

"Beautiful Mirrors" model

➡ vector-like b'

➡ modify mostly ($\sim 26\%$)
right-handed Zbb coupling

Question from the floor:

Can HERA probe some parameter space of this model ($m_{b'}$, mixing, ...) via $b' \to bZ$?

New Physics in the Flavor Sector

S. Gopalakrishna

Motivated by

- Gauge hierarchy problem

$$\delta m_H^2 \sim \Lambda^2$$

- Flavor problem

  Quark / lepton masses,

  CKM elements, ...

- Non-zero neutrino mass

Look for them in

- Flavor changing neutral current (FCNC)

  (... since SM contribution is

  loop suppressed)

- CP violation observables

→ $B - \bar{B}$ mixing

$b \to s\gamma$

$b \to s\bar{s}s$

$s \to d\nu\bar{\nu}$

(MSSM, Extra dimension, ...)

Quark Flavor Sector in MSSM

S. Gopalakrishna

$u(2)$ flavor symmetry in MSSM model, with

$$m^u = m_t \begin{pmatrix} 0 & -\epsilon' & 0 \\ \epsilon' & \epsilon & \epsilon \\ 0 & \epsilon & 1 \end{pmatrix} \qquad m^d = m_b \begin{pmatrix} 0 & -\epsilon' & 0 \\ \epsilon' & \epsilon & \epsilon \\ 0 & \epsilon & 1 \end{pmatrix}$$

$$\epsilon \approx 0.02,\ \epsilon' \approx 0.004$$

- Consistent with known data
- Can explain $B_d \to \phi k_s$
- Await $B_d \to \phi k_s, A_{\rm CP}(B_d \to X_s\gamma), \Delta m(B_s),\ ...$

Finally

- More topics were covered in the individual (posted) talk.
- Thanks to all the speakers and the lively discussions from the floor.