Electroweak Measurements and Beyond the Standard Model: Session Summary II

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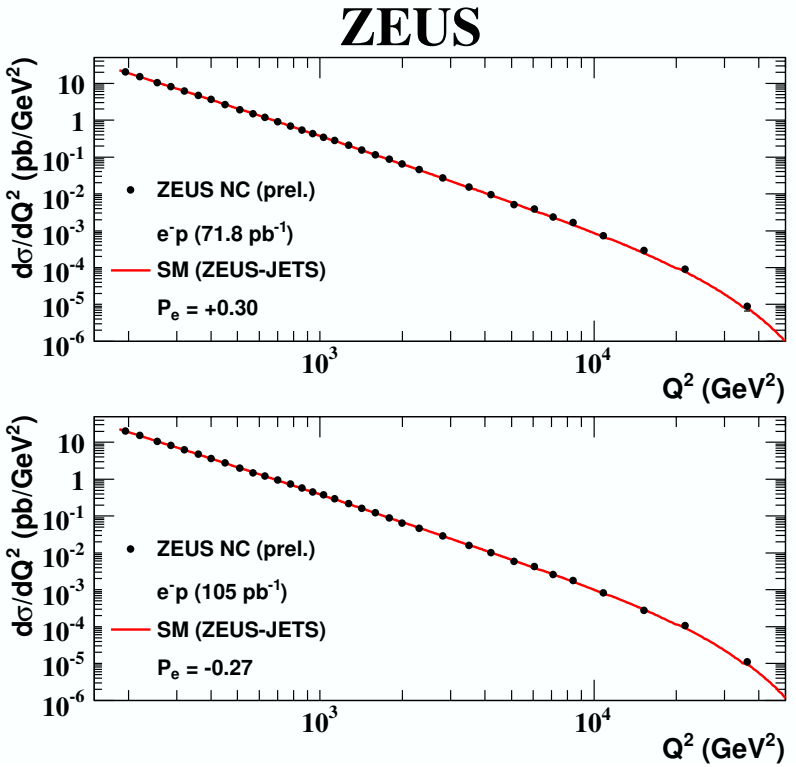
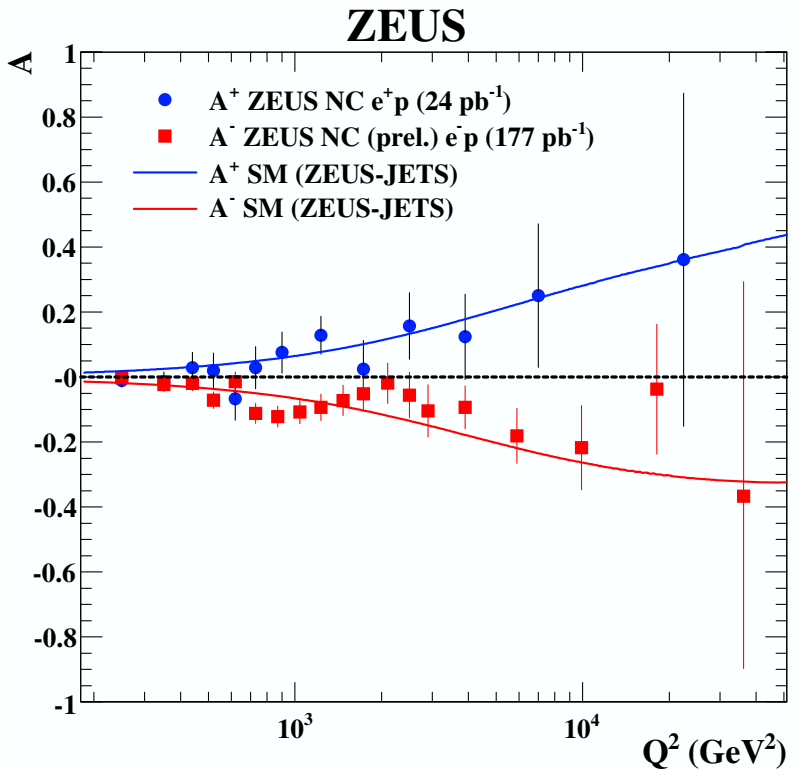
DIS 2007, Munich, 09.04.2007

The EW and BSM Parallel Sessions

- probably most exotic group at this conference as dominated by non-DIS experiments
- broad range of physics covered
  - electroweak boson production and properties
  - top quark physics
  - flavour physics
  - Searches for:
    - Higgs-Boson
    - Supersymmetry
    - Non-SUSY BSM
- Apologies for omissions in the following slides!

σ(NC) with polarized e^+/e^- (S. Bhadra)

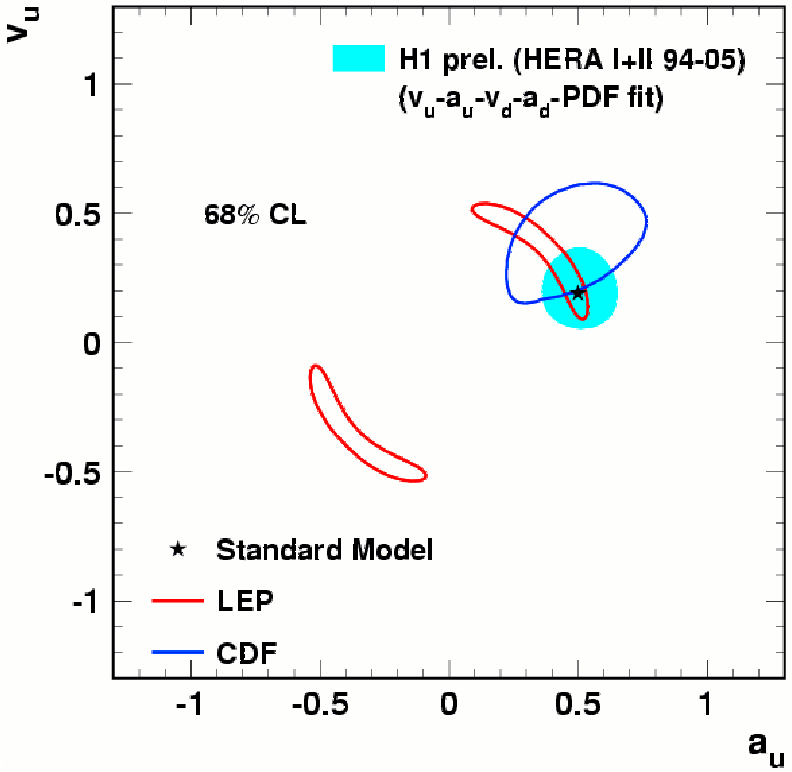


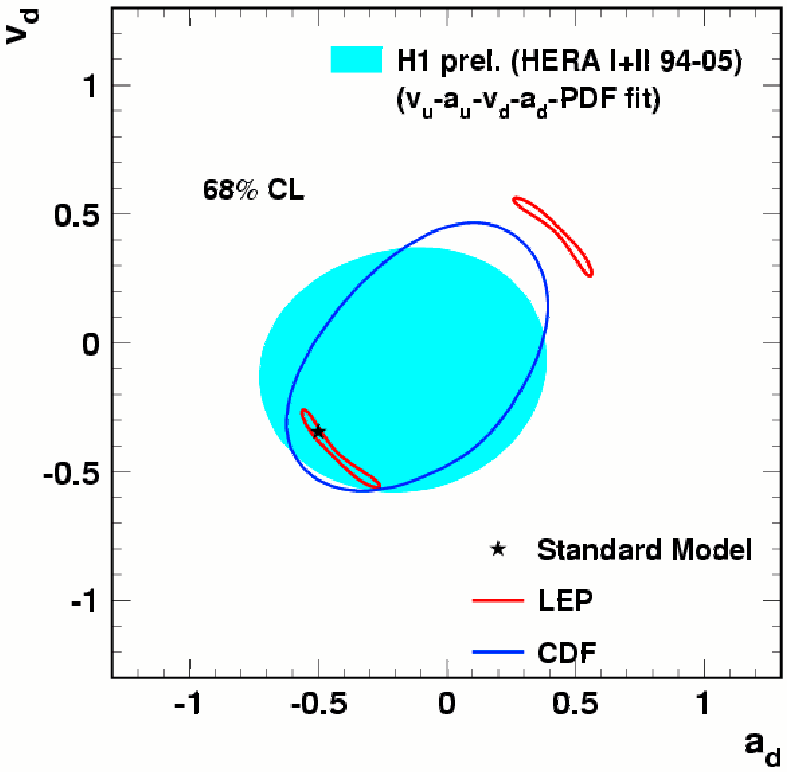


$$A^{\pm} = \frac{2}{P_e^+ - P_e^-} \frac{\sigma^{\pm}(P_e^+) - \sigma^{\pm}(P_e^-)}{\sigma^{\pm}(P_e^+) + \sigma^{\pm}(P_e^-)} \propto a_e \frac{F_2^{\gamma Z}}{F_2^{\gamma}} \propto a_e v_q$$

$\Rightarrow$ directly see effect of parity violation due to $a_e v_q$ term

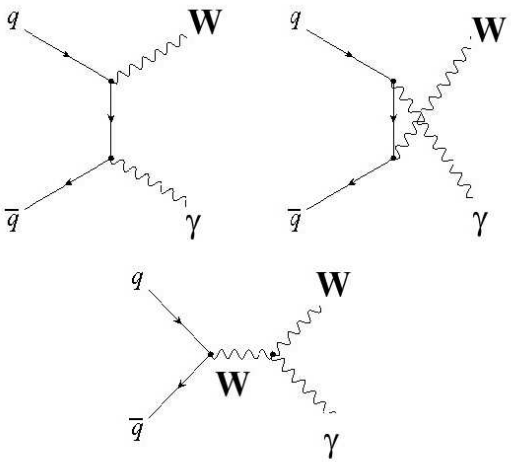
EW couplings of Z boson (G. Li)

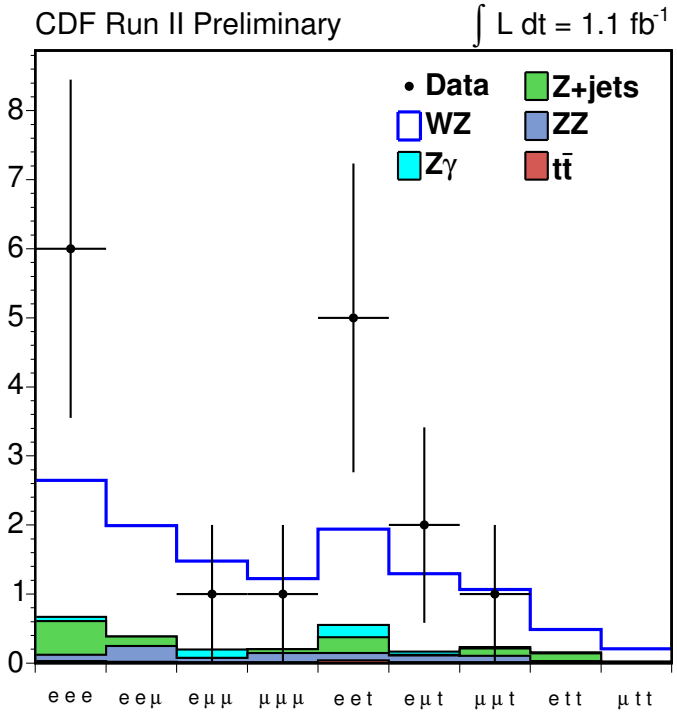




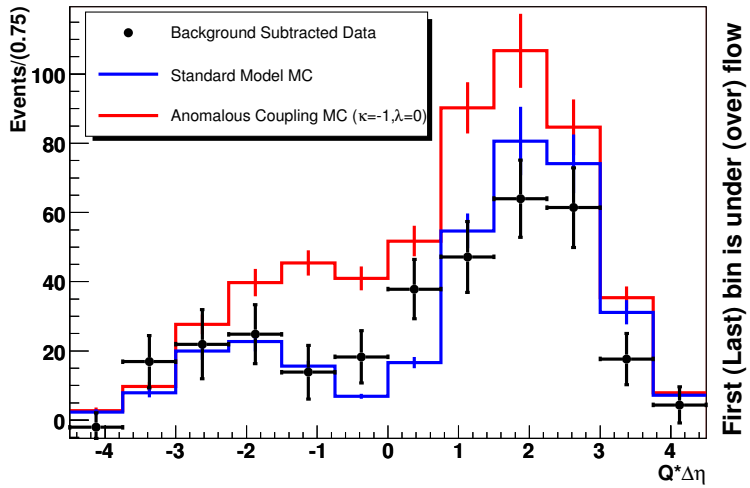
- NC+CC DIS included in fits
- $\frac{\sigma^{NC}}{\mathrm{d}x\mathrm{d}Q^2} \propto \sigma^{\gamma} + \sigma^{\gamma Z} + \sigma^{Z}$
  $\sigma^{\gamma} \propto \alpha^2$, $\sigma^{\gamma Z} \propto \alpha G_F \times v_q$, $\sigma^{Z} \propto G_F^2 \times (v_q^2 + a_q^2)$
- additional sensitivity w.r.t. published HERA-I fit due to polarization
- CDF ($72\,\mathrm{pb}^{-1}$): A_{FB} in lepton pair production

Diboson production at the Tevatron (Y. Maravin)





DØ: $0.9\,\mathrm{fb}^{-1}$



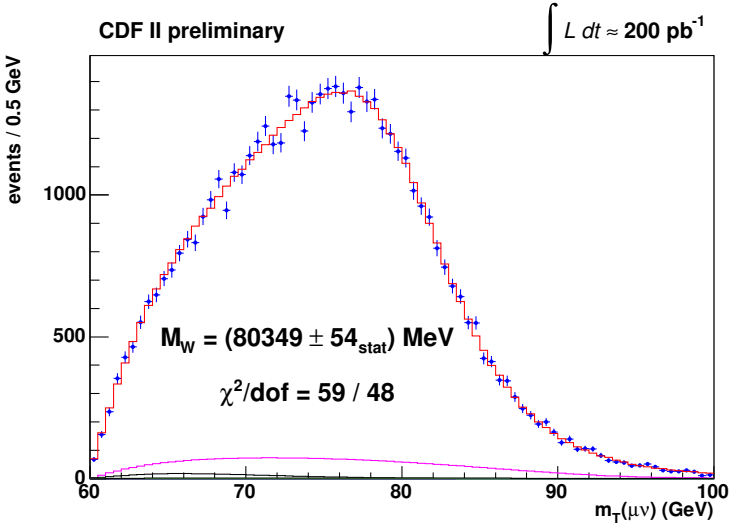
- $Q \times \Delta\eta$: first hint of radiation amplitude zero

- *WZ*: observation (CDF, $1.1\,\mathrm{fb}^{-1}$)
  $\sigma(WZ) = 5.0^{+1.8}_{-1.6}$ (stat+syst) pb (5.9σ)

- *ZZ*: evidence (CDF, $1.5\,\mathrm{fb}^{-1}$)
  $\sigma(ZZ) = 0.75^{+0.71}_{-0.54}$ (stat+syst) pb (3.0σ)

$M(W)$ and ΓW from CDF (S. Malik)

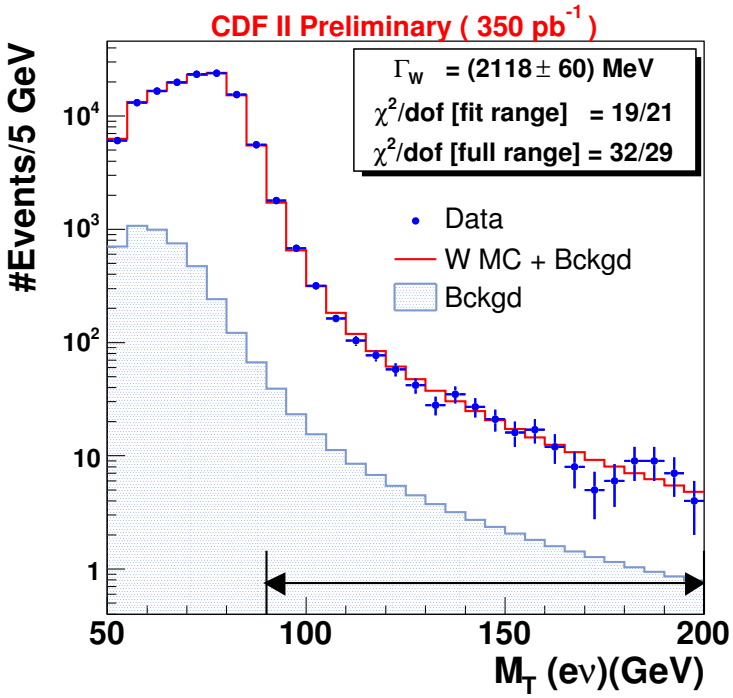
W mass



combination ($W \to e\nu$, $\to \mu\nu$, $M_T(W)$, $p_T(\ell)$, $p_T(\nu)$):

$M_W =$
80413 ± 48 (stat+syst) MeV

W width

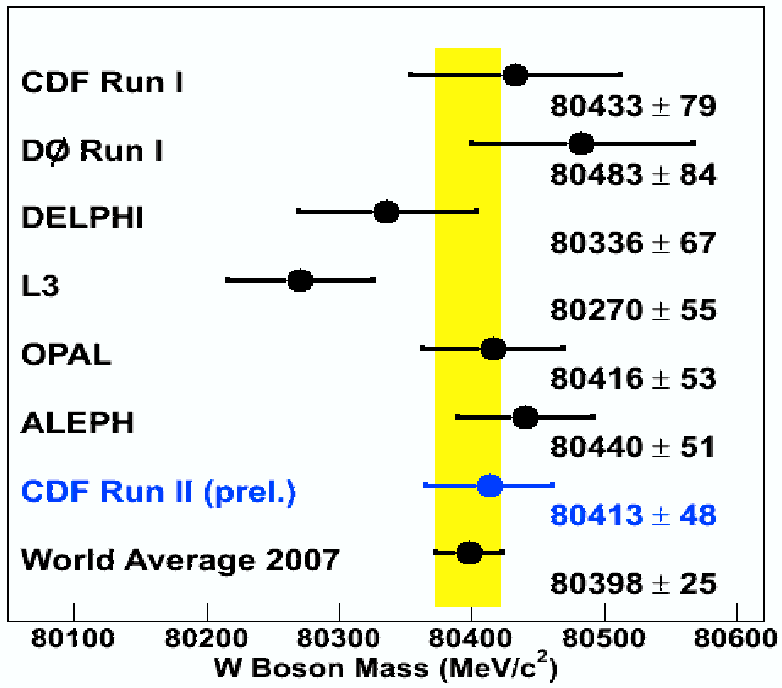


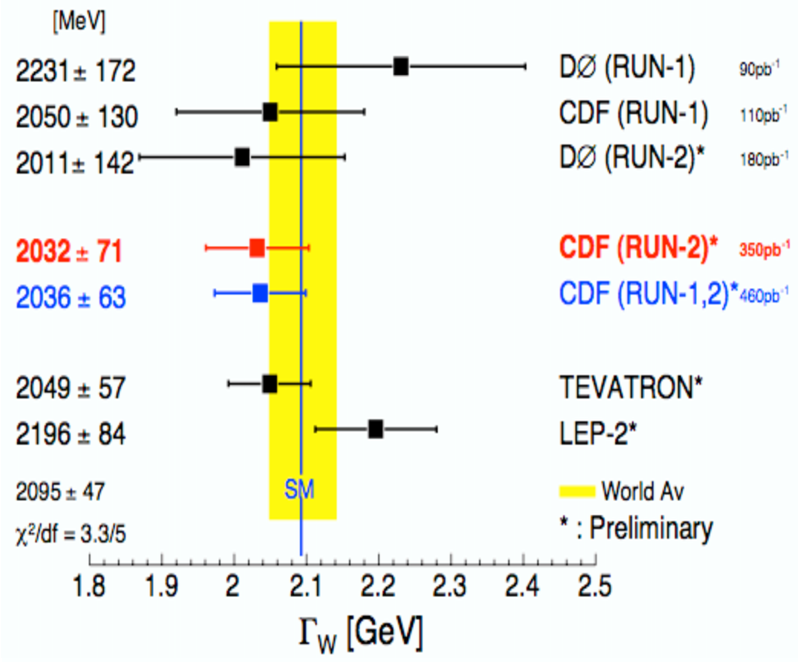
combination (e, μ):

$\Gamma(W) =$
2032 ± 71 (stat+syst) MeV

$\Rightarrow$ most precise single measurements

$M(W)$ and $\Gamma(W)$: new world averages



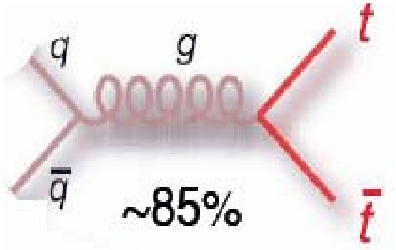


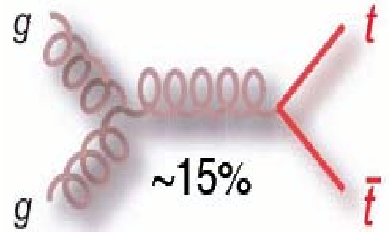
before: 80392 ± 29 MeV
now: 80398 ± 25 MeV

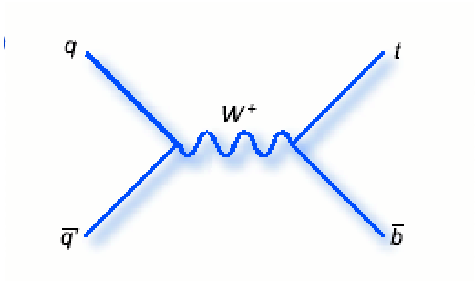
before: 2139 ± 60 MeV
now: 2095 ± 47 MeV
(only direct measurements)

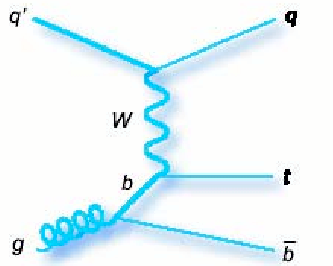
Top quark production at Tevatron

σ_{tt}=6.8±0.6 pb (Kidonakis, Vogt)
σ_{tt}=6.7+0.7-0.9 pb (Cacciari et al.)





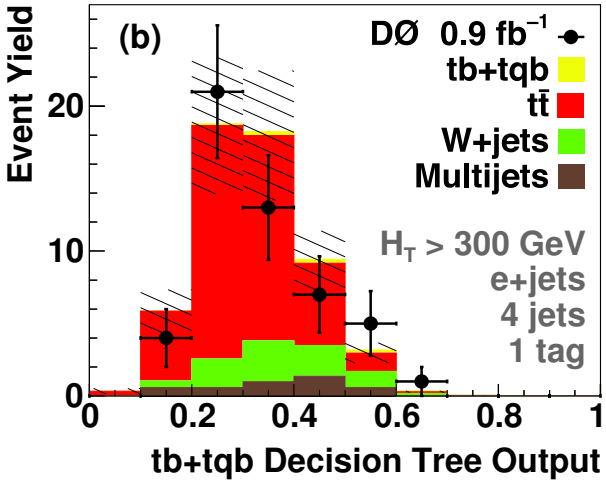


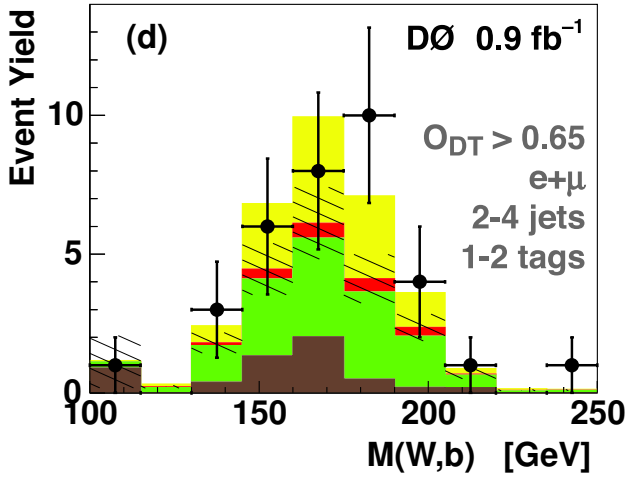


***s*-channel**	***t*-channel**
σ = 0.88 ± 0.11 pb	σ = 1.98 ± 0.25 pb

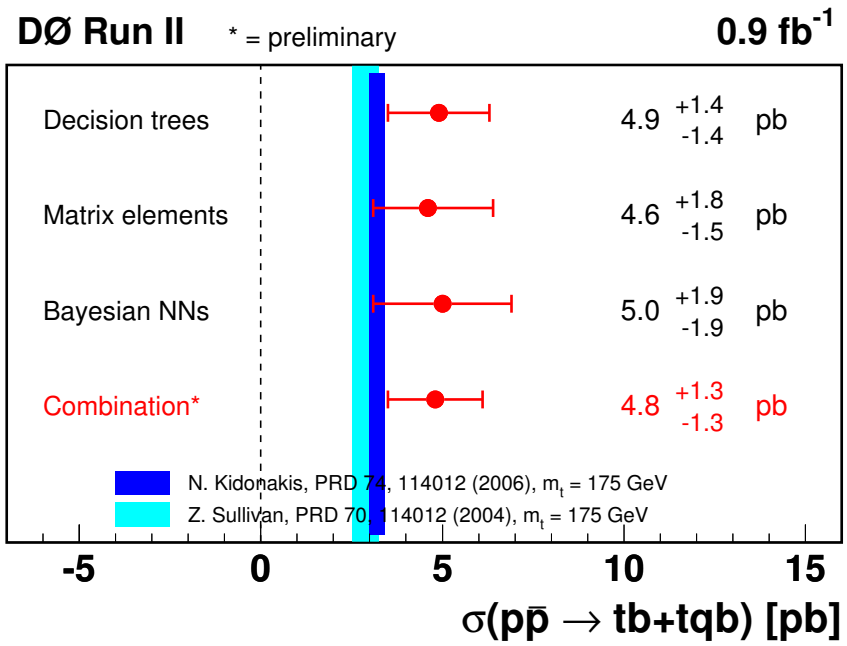
Evidence for single top quark prod. at DØ (S. Jabeen)

- validation of background model in side-band regions



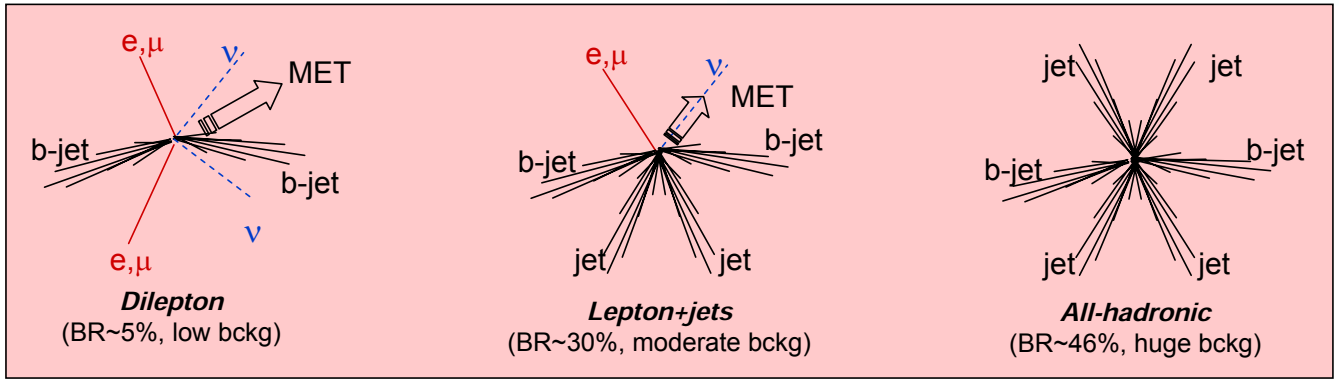


- large background from W+jets and $t\bar{t}$
- largest sensitivity with boosted decision tree analysis
- combined significance: 3.5σ

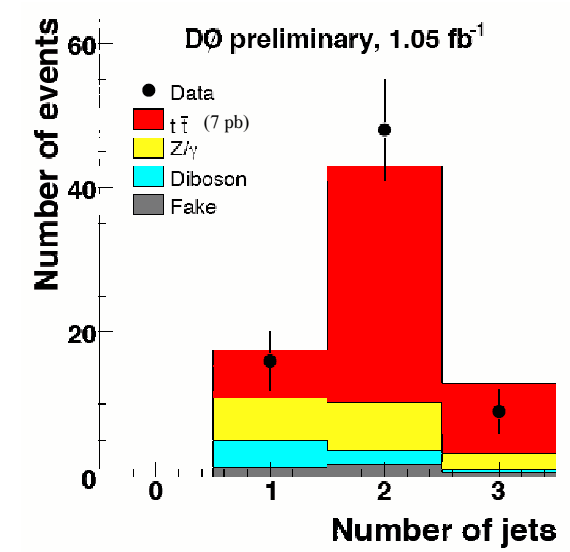


$\Rightarrow$ first direct measurement of $|V_{tb}|$: $0.68 < |V_{tb}| \leq 1$ (95% C.L.)

$t\bar{t}$ production cross sections (C. Gerber)



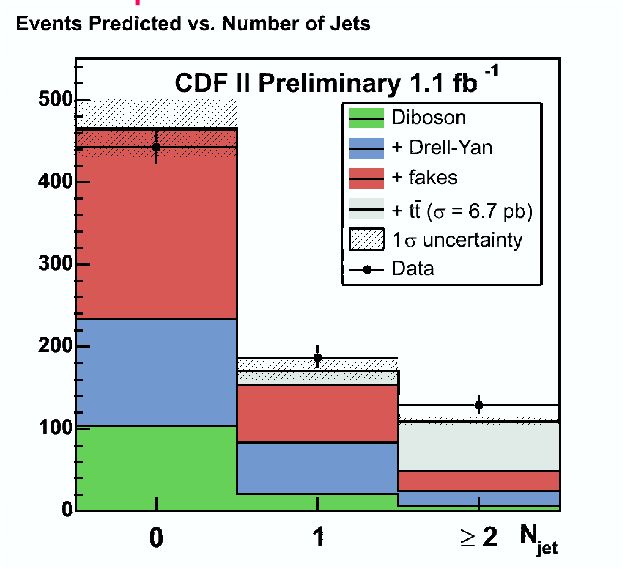
Dileptons



$\sigma_{tt} = 6.8^{+1.2}_{-1.1}$ (stat) $^{+0.9}_{-0.8}$ (syst) ± 0.4 (lumi) pb

$\delta\sigma/\sigma = 22\%$ (excluding luminosity)

Lepton + Track



$\sigma_{tt} = 9.0 \pm 1.3$(stat) ± 0.5(sys) ± 0.5(lumi) pb

$\delta\sigma/\sigma = 15\%$ (excluding luminosity)

⇒ experimental results reaching theoretical precision of ∼12%

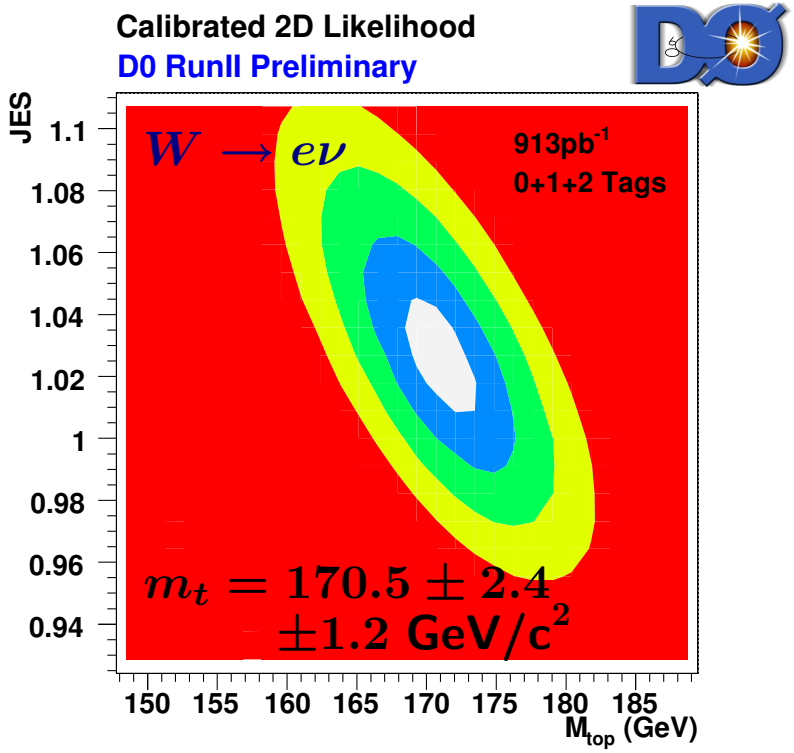
Top mass measurements (J. Wagner)

- best precisions obtained with Matrix-Element method

$$\mathcal{P}_{t\bar{t}}(\vec{x}_i, M_t) \propto \int \underbrace{\mathrm{d}p_q \mathrm{d}p_{\bar{q}} f(p_q) f(p_{\bar{q}})}_{\text{PDF}} \underbrace{\mathrm{d}\sigma_{t\bar{t}}(\vec{y}, M_t)}_{\propto\ \text{matrix-el.}} \underbrace{W(\vec{x}_i, \vec{y})}_{\text{transfer fnct.}}$$

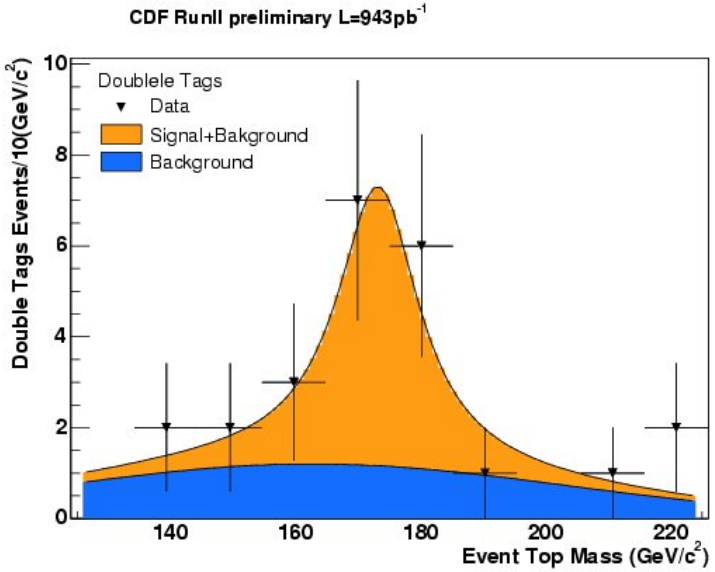
$l+$ jets channel:

ME technique



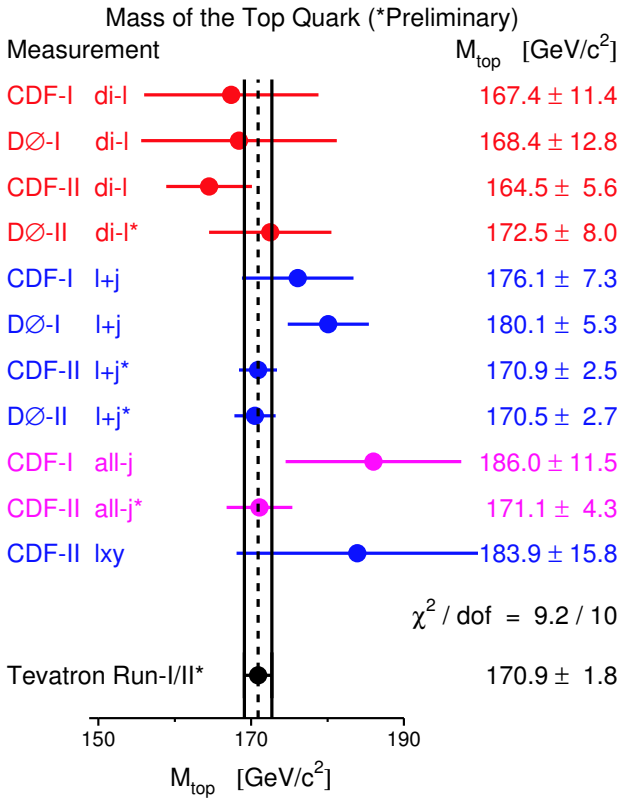
all hadronic decays:

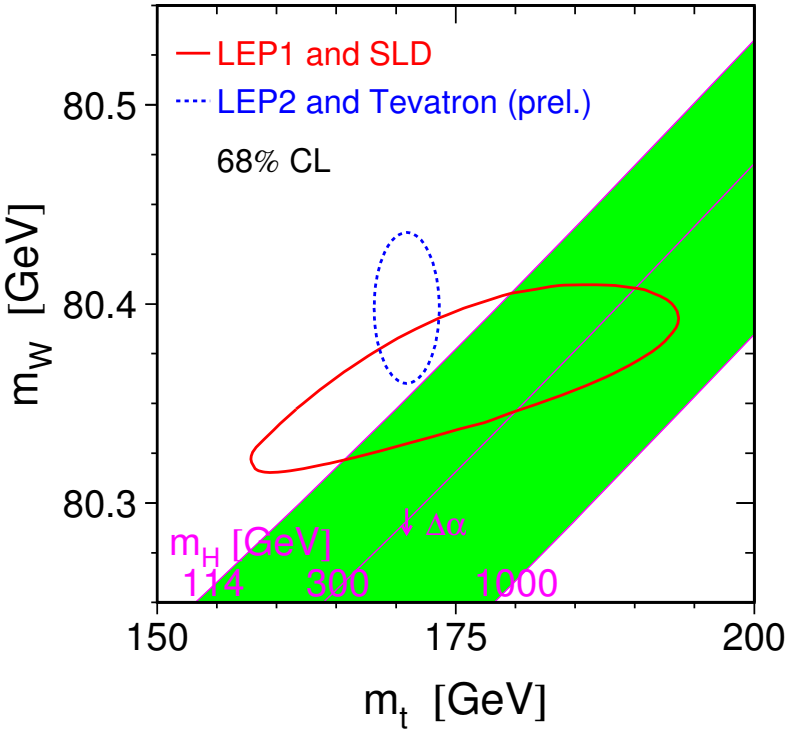
2D templates



$$m_t = 171.1 \pm 3.7 \pm 2.1 \text{ GeV}$$

Top Mass Combination

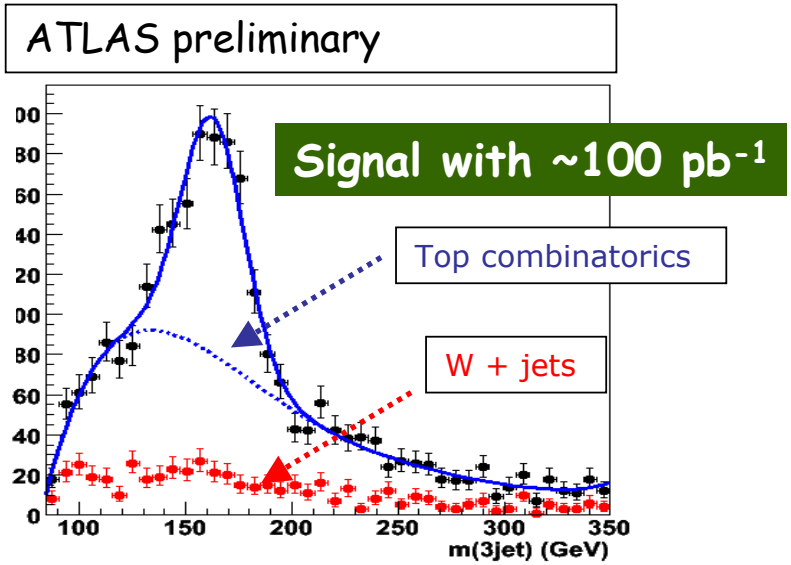


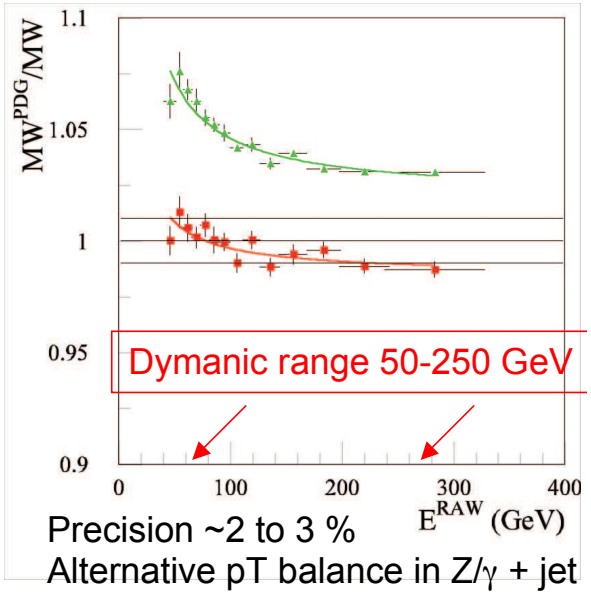


- relative uncertainty ∼1%
- new ambitious goal $\Delta m_t \sim 1\,\mathrm{GeV}$
- for Higgs mass constraint Δm_t corresponds to $\Delta m_W \sim 10$ MeV

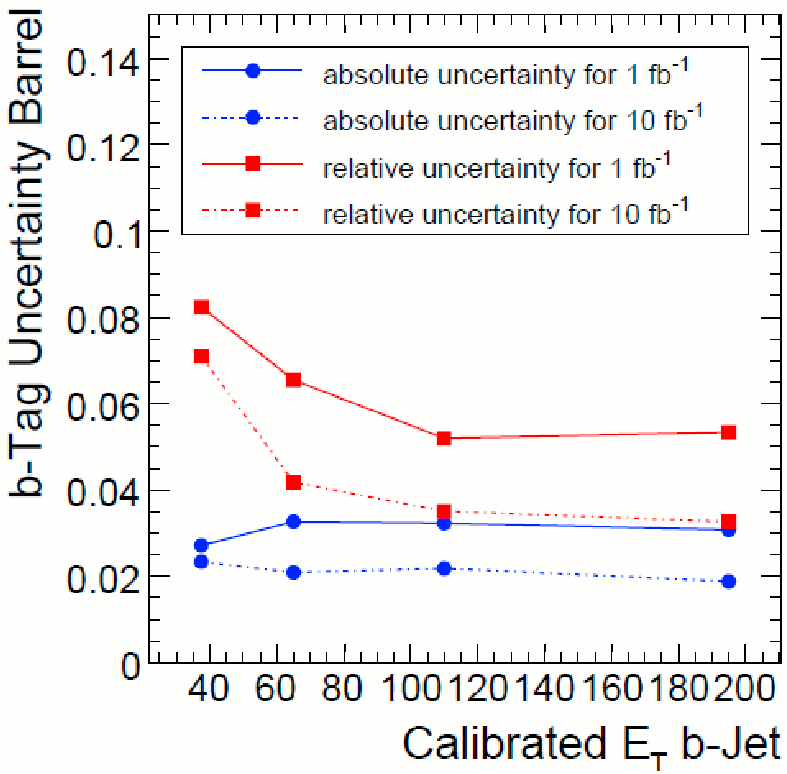
LHC: Top as Commissioning Tool

A.-C. Le Bihan, F.-P. Schilling



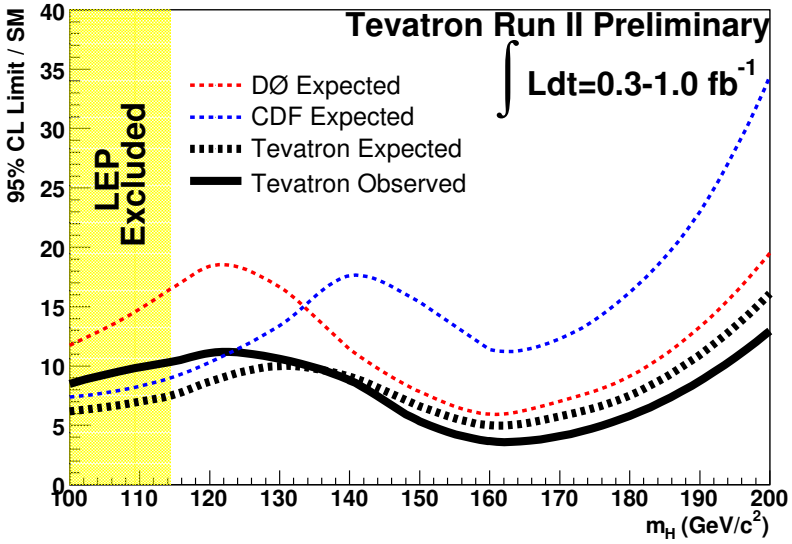


- ATLAS: jet energy scale calibration through $M(W)$ (l+jets)
- CMS: b-tagging efficiency (dilepton)

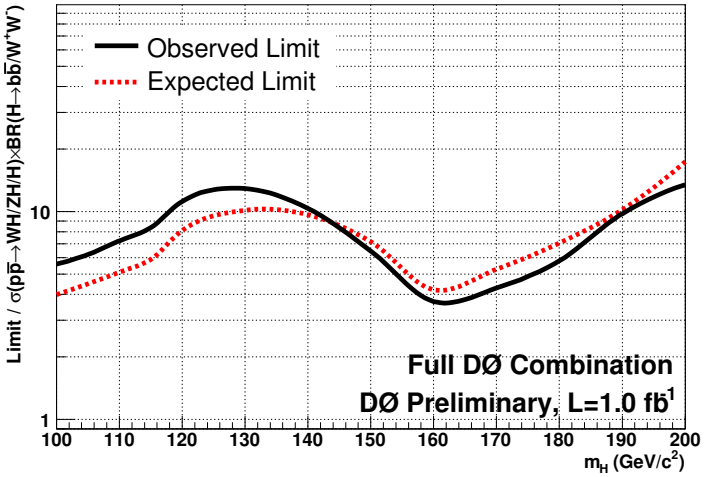


Higgs Searches at the Tevatron R. Vilar

Tevatron combination 07.06



DØ combination 04.07

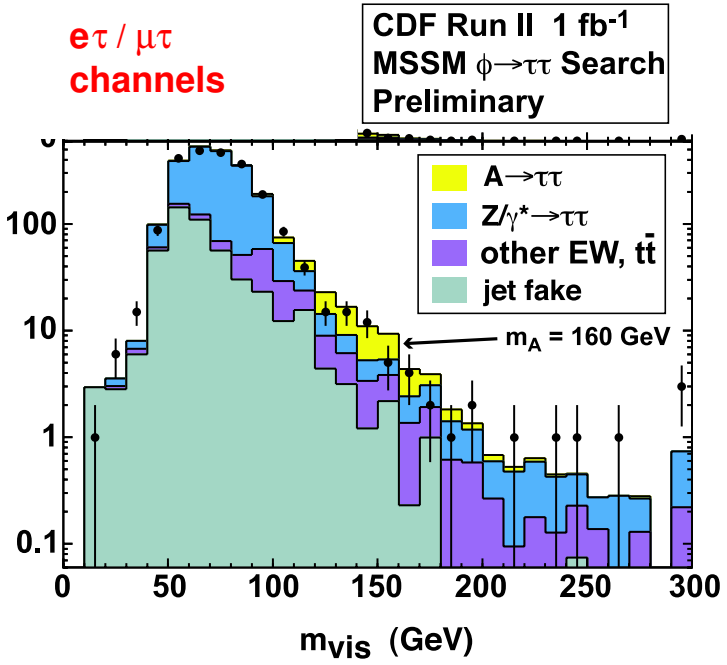


- many new results not yet included in Summer 06 Tevatron combination
- new results are scaling much better than just the luminosity factor

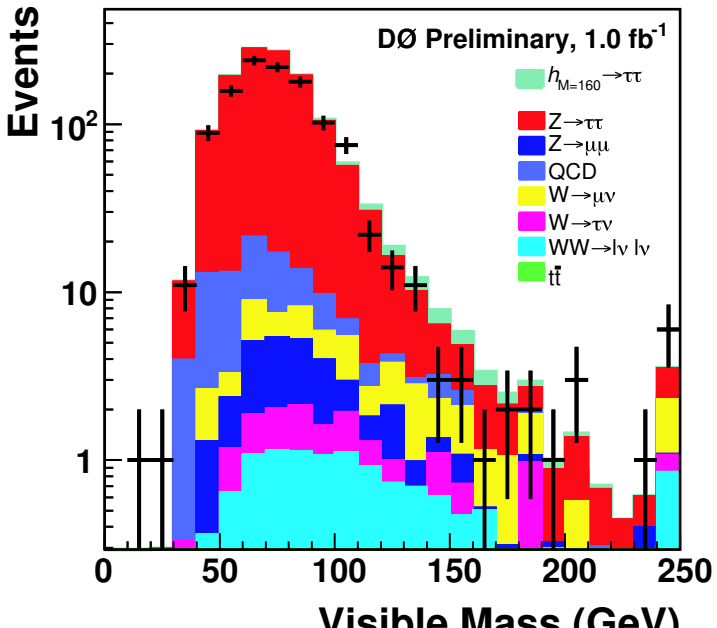
SUSY Higgs: $\phi \to \tau\tau$

(R. Ströhmer)

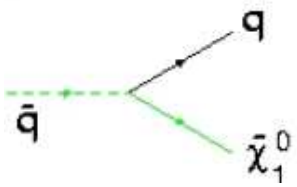
- MSSM: 2-Higgs-doublet model:
  - 5 H-bosons: h^0, H^0, A^0, $H^\pm$
  - all $^0 = \phi^0$
- $\sigma(gg \to H)$ and $\sigma(b\bar{b}H)$ enhanced at large $\tan\beta$
- CDF: some excess seen (only $e\tau$, $\mu\tau$), but significance $< 2\sigma$
- DØ: no excess



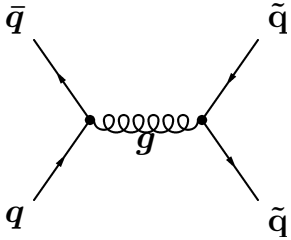
$\mu\tau$ channel

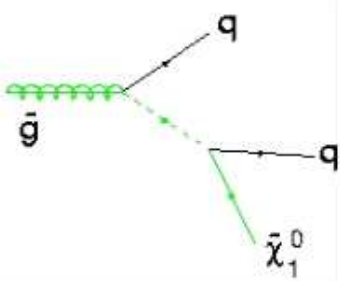


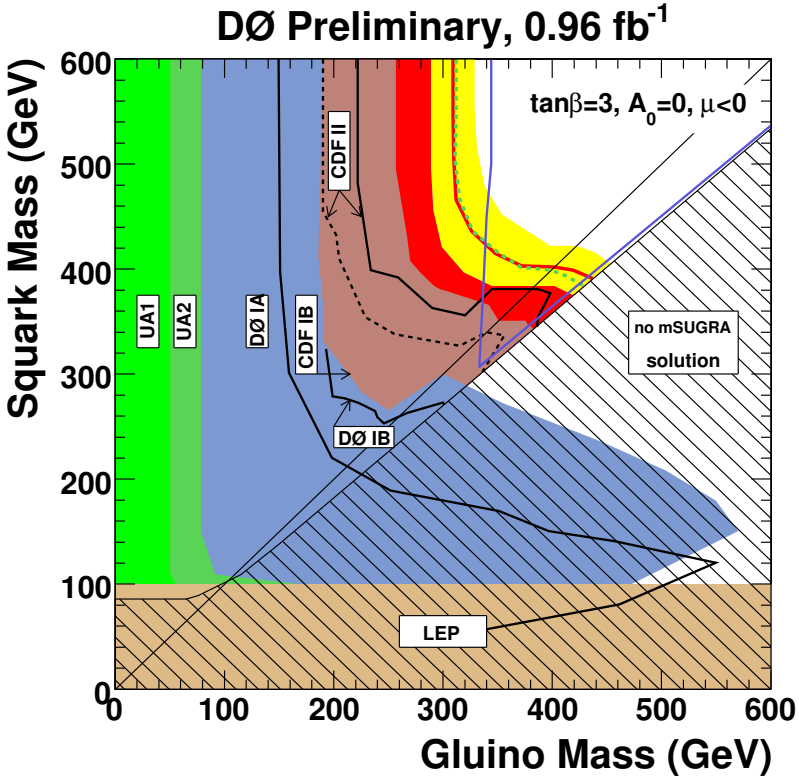
Search for $\tilde{q}$, $\tilde{g}$ at the Tevatron (R. Ströhmer)



- combination of different jets $+ \not{E}_t$ selections, optimized for different $m(\tilde{g}) - m(\tilde{q})$
- most conservative limits (for $\tan\beta = 3, A_0 = 0, \mu < 0$):
  $M_{\tilde{g}} > 289\,\mathrm{GeV}$
  $M_{\tilde{q}} > 375\,\mathrm{GeV}$
- interpretation within mSUGRA:
  improved limits w.r.t. LEP for
  $m_0 \sim 75 - 250\,\mathrm{GeV}$ and
  $m_{1/2} \sim 125 - 165\,\mathrm{GeV}$







Prospects for BSM Searches at LHC D. Rebuzzi

SUSY early searches 1 fb^{-1}

SUSY most popular template for exploration of new physics at the LHC

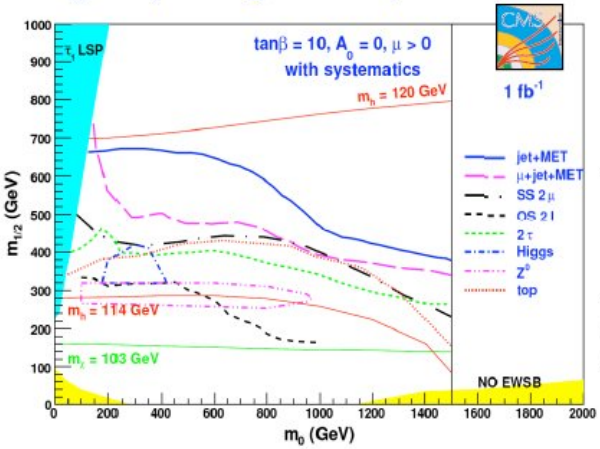
SUSY is a broken symmetry (no sparticles observed to date)→ several models of SUSY breaking (mSUGRA, GMSB, AMSB)

Minimal SUSY Standard Model (MSSM) with R-parity conservation

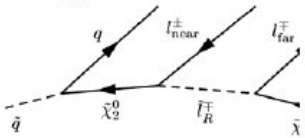
- *sparticles are produced in pairs*
- *the Lightest SUSY Particle (LSP) is stable*

sparticles → lighter sparticles + SM particles down to stable, undetected LSP

large E_T^{miss} + jets + leptons

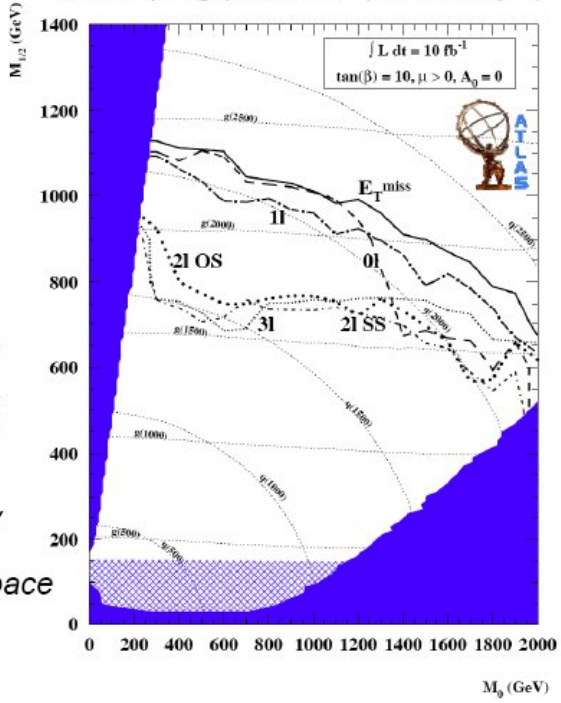


Typical SUSY event



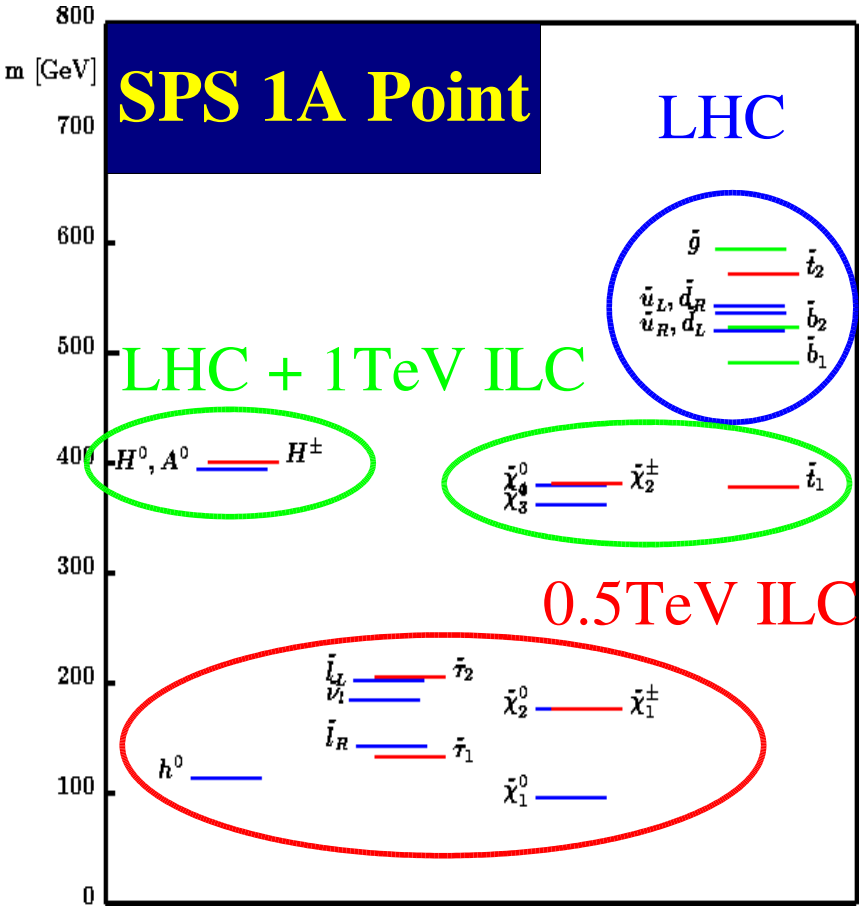
Rich phenomenology
Multiple signature on most of parameter space

Inclusive signatures in mSUGRA parameter spaces - 5σ discovery reach for ATLAS (below) and CMS (bottom-left)



A. Raspereza

Exploring SUSY
Complementarity of LHC & ILC

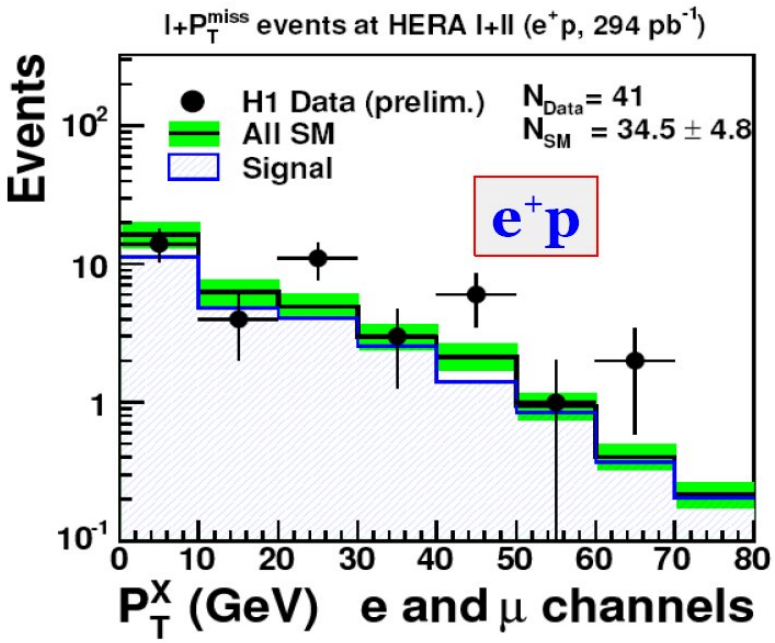


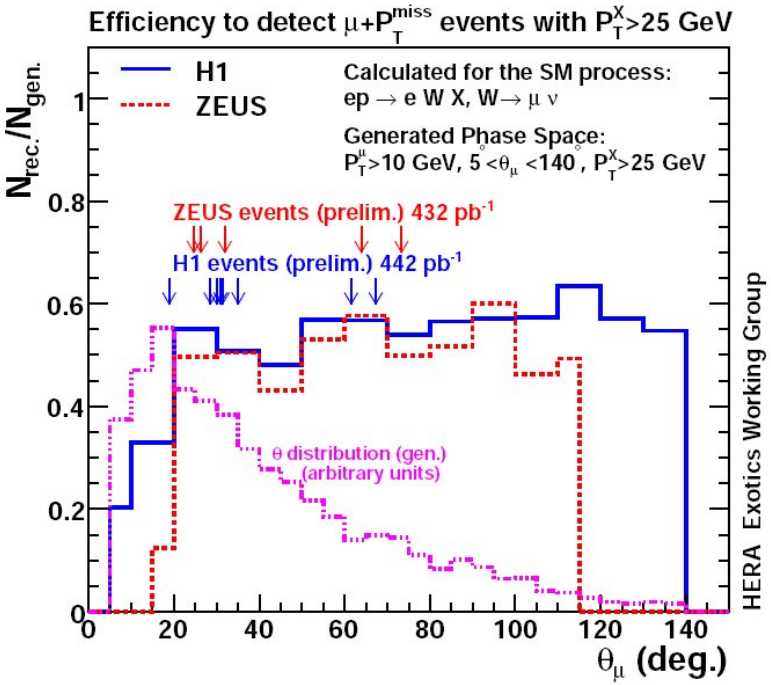
- **LHC explores in detail strongly interacting SUSY sector (squarks, gluinos)**
- **Most of other SUSY particles are within reach of sub-TeV ILC**
  - Big chance to observe SUSY particles at early stage of ILC operation (√s=500 GeV)
  - Clean signatures, low backgrounds precise SUSY spectroscopy (EW-interacting sector)
- **From physical observables to SUSY Lagrangian**
  - $M_1, M_2, M_3, \tan\beta, \mu, m_0$ ...etc

(Joint LHC & LC effort)

Events with Isolated Leptons and $\not{E}_t$ at HERA

(K. Korcak-Gorzo, Y. de Boer)



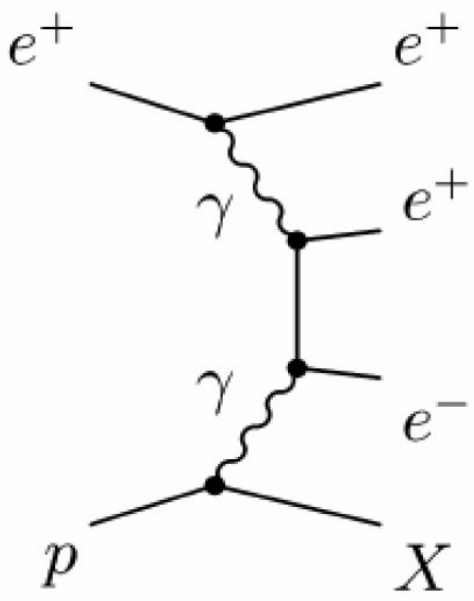


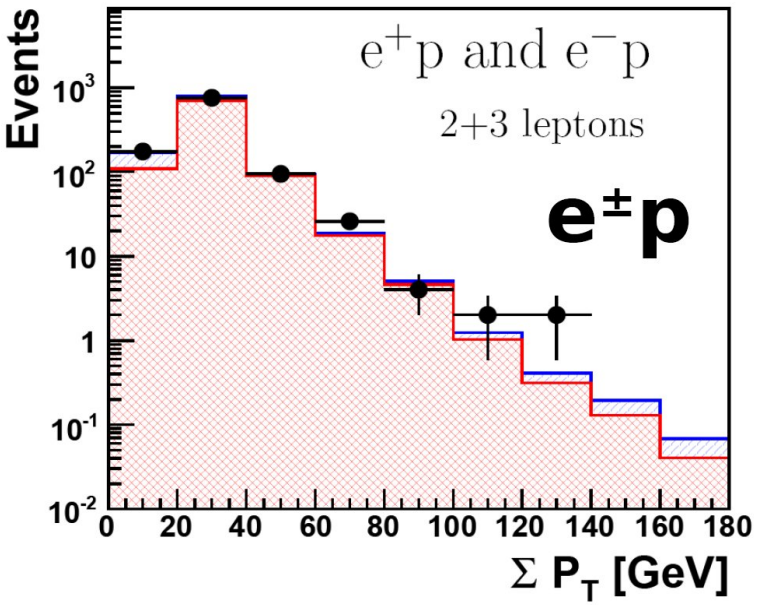
	P_T^X> 25 GeV		electrons Data/SM	muons Data/SM
e^+p	H1	294 pb^{-1}	11/4.7±0.9	10/4.2±0.7
	ZEUS	228 pb^{-1}	1/3.2±0.4	3/3.1±0.5
e^-p	H1	184 pb^{-1}	3/3.8±0.6	0/3.1±0.5
	ZEUS	204 pb^{-1}	5/3.8±0.6	2/2.2±0.3

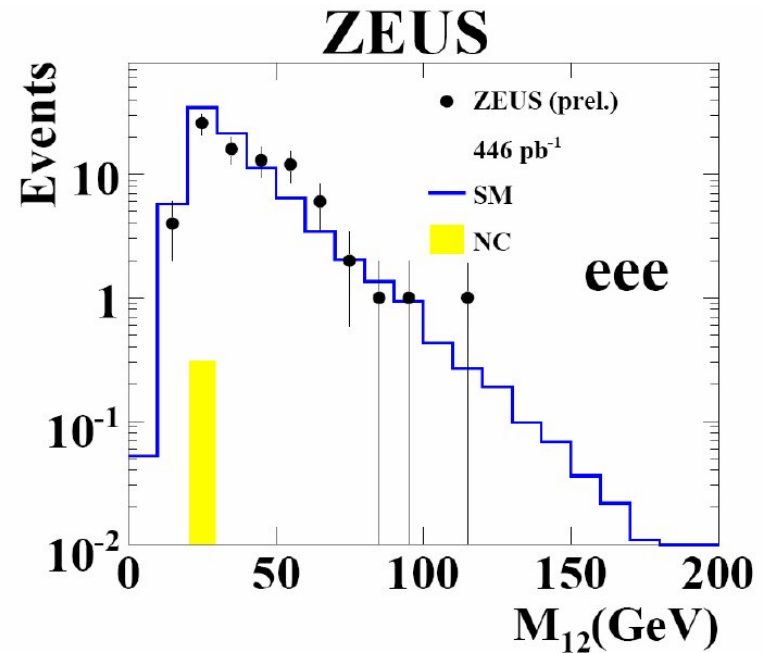
$\Rightarrow$ H1 excess still at 3.0σ

Multi-Lepton Production at HERA

G. Brandt, Osamu Ota

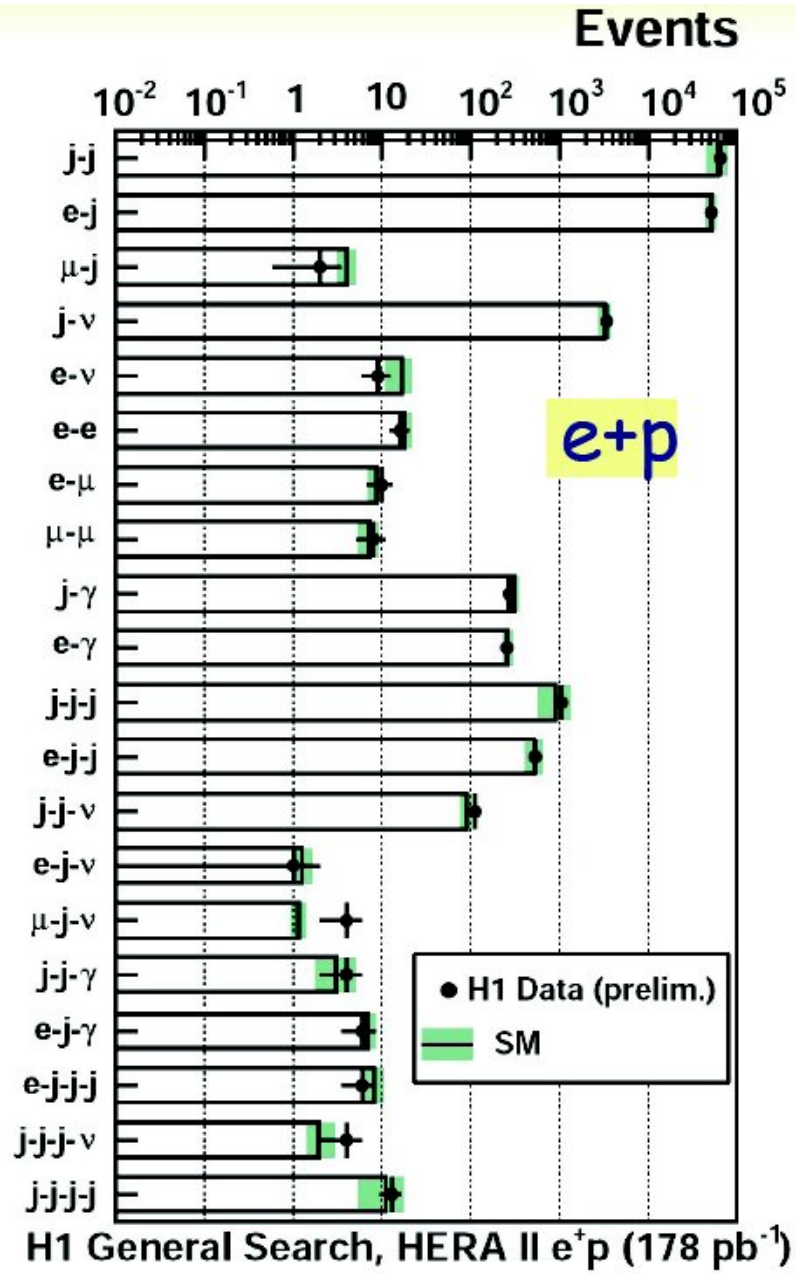




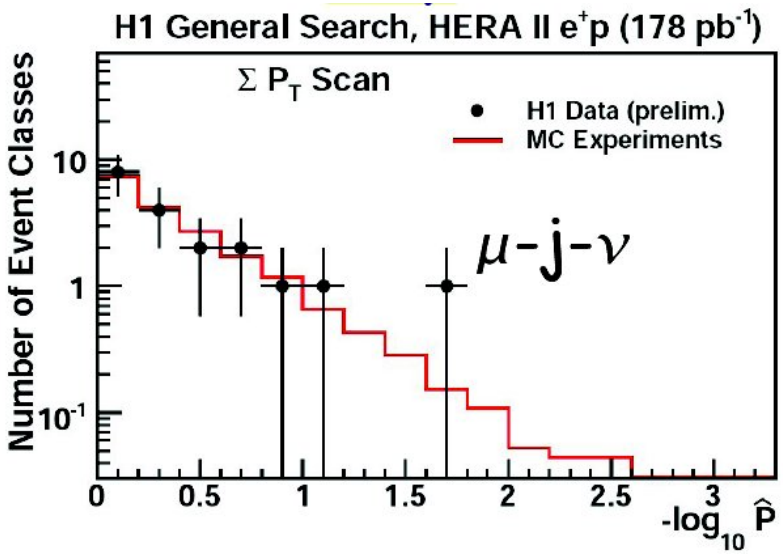


- Excess of *ee* and *eee* events at high M_{12} observed in H1 at HERA-1 vanished!

General Search for BSM at HERA (E. Sauvan)

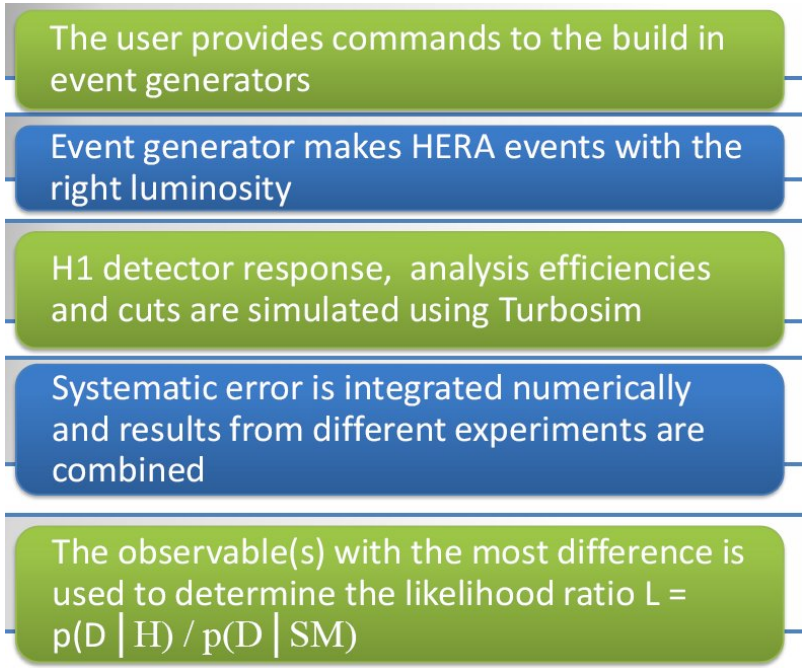


- event yields: good agreement with SM in most classes
- search for deviations in $\sum P_T$ and M_{all}
- quantify significance by comparing with random histograms from SM
- most deviating $\mu - j - \nu$ (cf. excess in isolated lepton search)



Automated Model Testing (S.Caron)

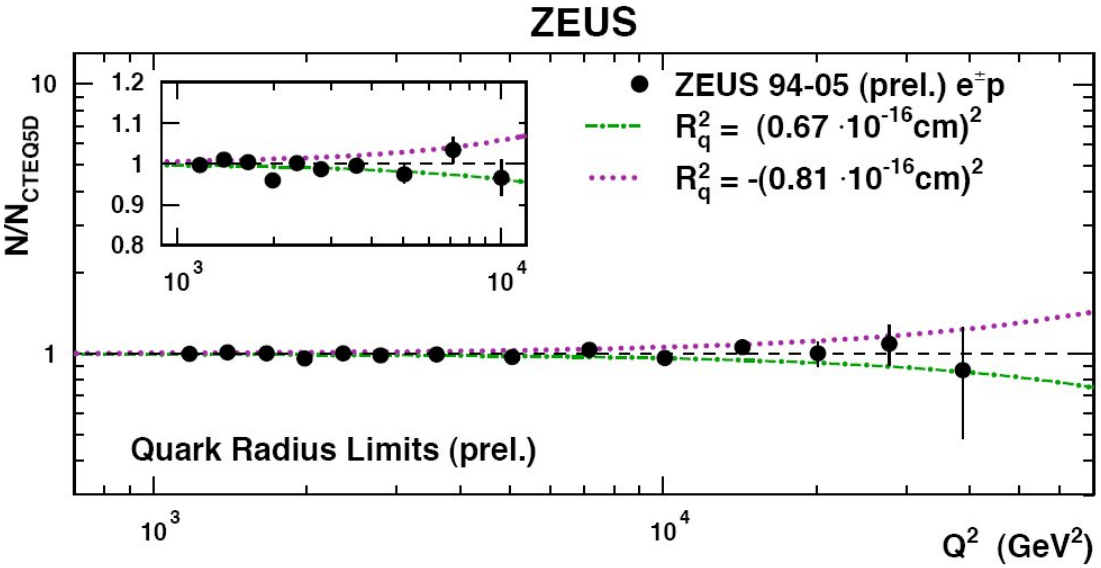
- Quaero@H1
- compare to published data
  - H1 general search HERA-I (histograms of all channels)
  - DØ Quaero samples (3 channels, with 4-vectors)
- provide fast simulation of detector response



Limits on BSM with NC DIS (S.Schlenstedt)

limits on EW quark radius

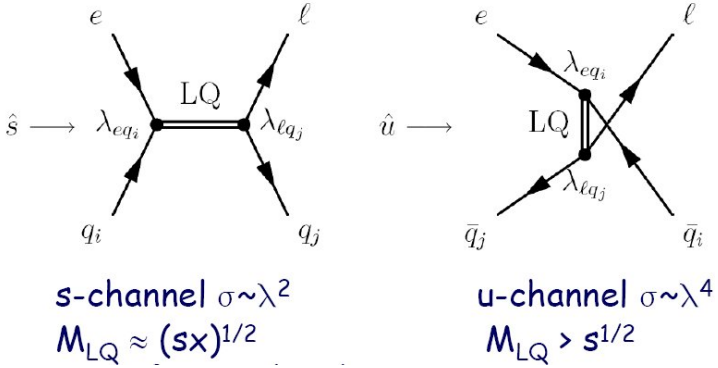
$$\frac{\mathrm{d}\sigma}{\mathrm{d}Q^2} = \left(\frac{\mathrm{d}\sigma}{\mathrm{d}Q^2}\right)_{SM} \left(1 - \frac{1}{6} R_q^2 Q^2\right)^2$$

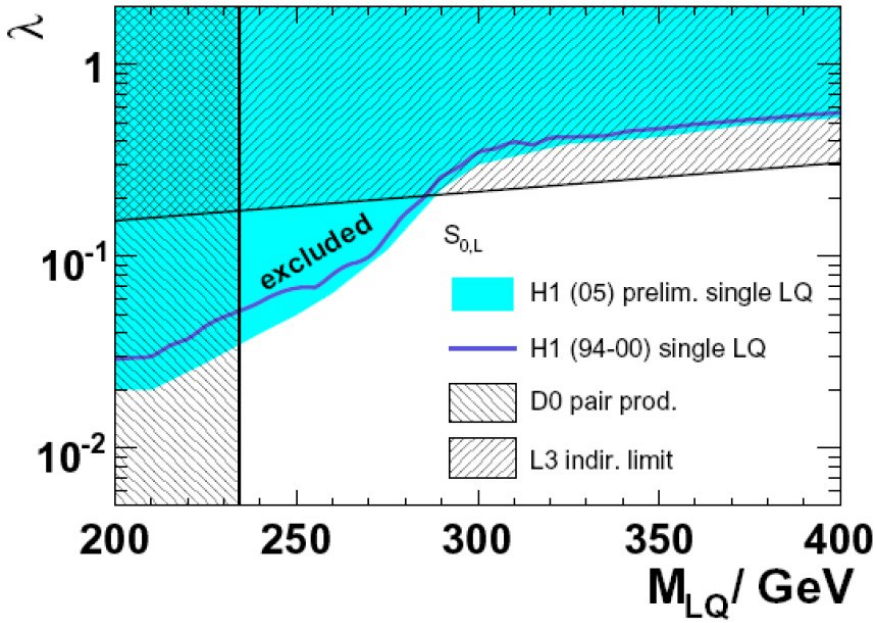


$\Rightarrow R_q < 0.67 \times 10^{-3}$ fm

also derived: limits on contact interactions, heavy leptoquarks and large extra dimensions

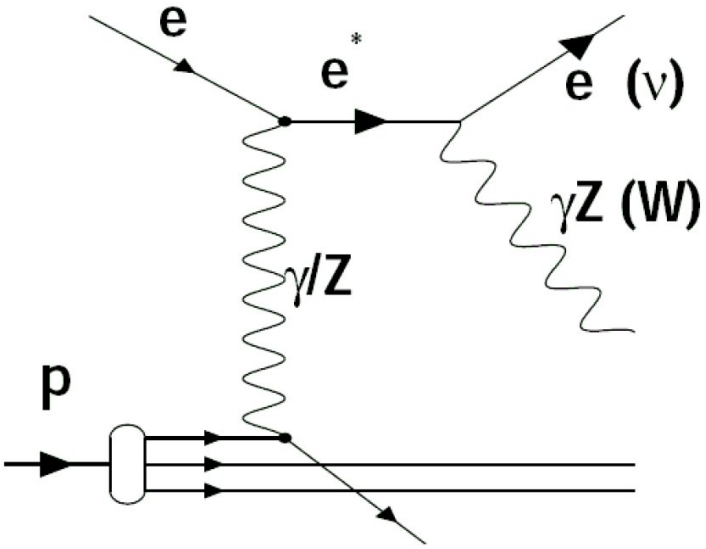
Search for Leptoquarks at H1 (A. Dubak)

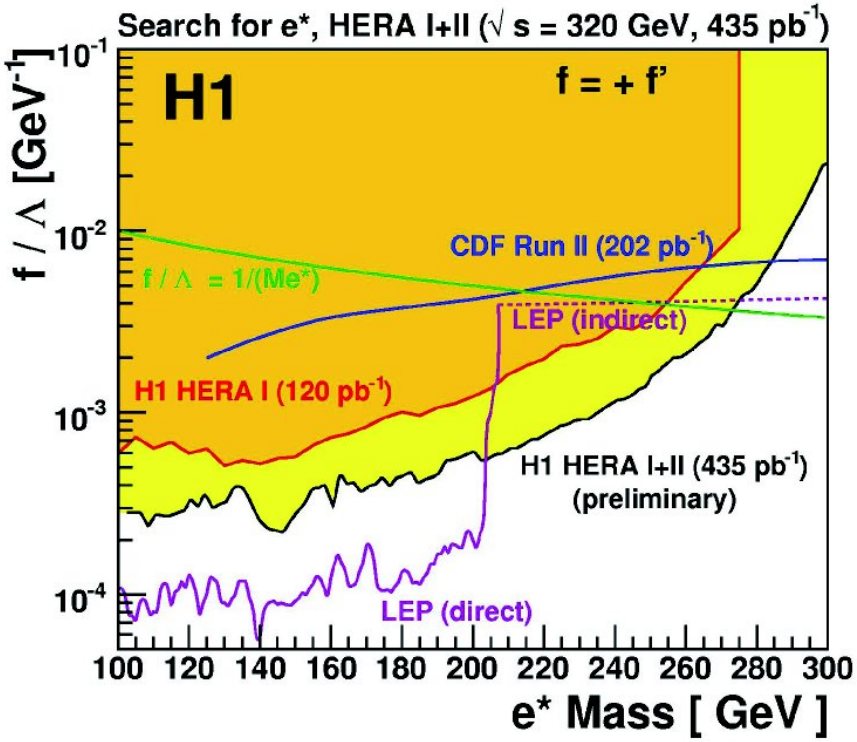




- new: increased $e^- p$ statistics
- $S_{O,L} \rightarrow \beta = Br(LQ \rightarrow eq) = 0.5$
  (Tevatron has higher sensitivity at $\beta = 1$)
- complementarity HERA $\leftrightarrow$ Tevatron

Search for excited leptons at H1 (T. Trinh)

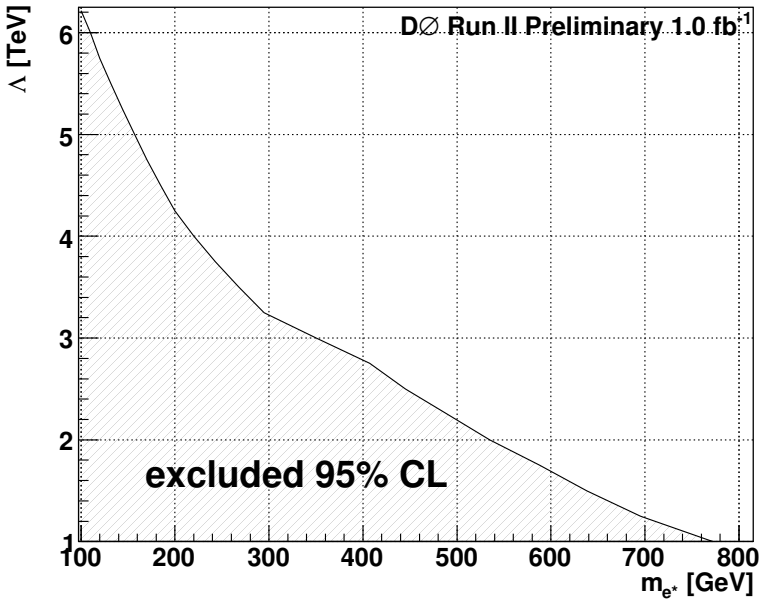




- also new results on excited neutrinos
- excited leptons couple to gauge bosons (Gauge Mediated Interaction)
- Note: at Tevatron the production cross section via Contact Interaction is about a factor 100 higher than GMI (not included here)

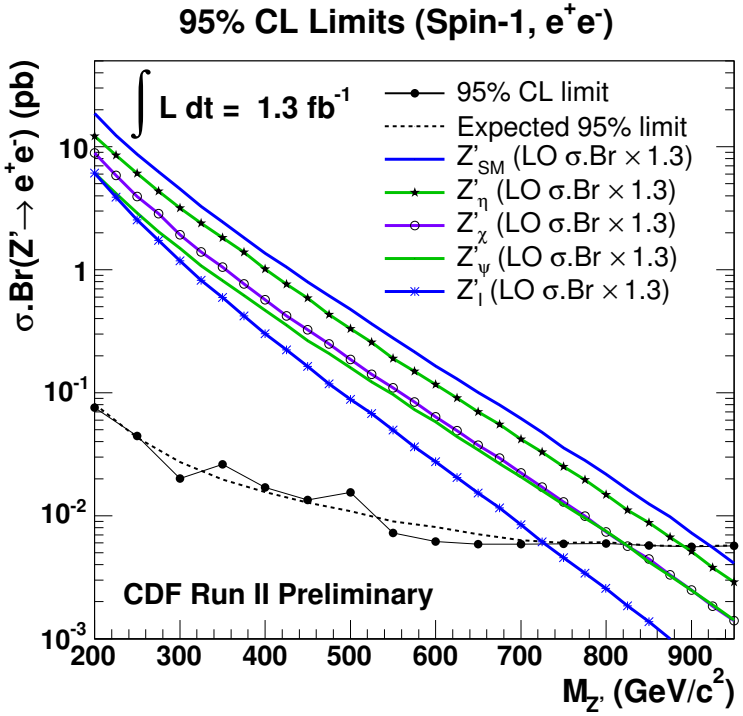
Non-SUSY BSM Searches at Tevatron (D. Stuart)

DØ: $Z \to ee^* \to ee\gamma$



including CI and GMI

CDF: $Z' \to ee$



- many model and signature driven searches at Tevatron:
  - extra dimensions, leptoquarks, 4th generation quarks, ...
  - $Z + X$, $\gamma\gamma + X$, ...

Summary of the Summary

- many, many new interesting results, too much to be able to give appropriate credits here
- Thanks for the speakers of our session for the very high quality of the presentations!
- Also thanks to the other participants in the sessions for the lively discussions!