Recent D0 Results at Run II

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4th International Conference on Physics Beyond the Standard Model
Beyond the Desert '03
Schloss Ringberg, Tegernsee, Germany, 9-14 June 2003

A first look at the Run II data

- The status of DØ
- W and Z production
- Searches for new physics (Leptoquarks, Extra Dimensions, SUSY)
- Searches for the Higgs (SM Higgs, H-> WW*)
- Top cross-sections
- Summary

The DØ Collaboration

U. of Arizona
U. of California, Berkeley
U. of California, Riverside
Cal State U., Fresno
Lawrence Berkeley Nat. Lab
Florida State U.
Fermilab
U. of Illinois, Chicago
Northern Illinois U
Northwestern U
Indiana U.
U. of Notre Dame
Iowa State U.
U. of Kansas
Kansas State U
Louisiana Tech U
U. of Maryland
Boston U.
Northeastern U.
U. of Michigan
Michigan State
U. of Nebraska U.
Princeton U.
Columbia U.
U. of Rochester
SUNY, Stony Brook
Brookhaven Nat. Lab.
Langston U.
U. of Oklahoma
Brown U.
U. of Texas, Arlington
Texas A&M U.
Rice U.
U. of Virginia
U. of Washington

U. de Buenos Aires

LAFEX, CBPF, Rio de Janeiro
State U. do Rio de Janeiro
State U. Paulista, São Paulo

IHEP, Beijing

U. de los Andes, Bogotá

Charles U., Prague
Czech Tech. U., Prague
Academy of Sciences, Prague

U. San Francisco de Quito

ISN, IN2P3, Grenoble
CPPM, IN2P3, Marseille
LAL, IN2P3, Orsay
LPNHE, IN2P3, Paris
DAPNIA/SPP, CEA, Saclay
IReS, Strasbourg
IPN, IN2P3, Villeurbanne

U. of Aachen
Bonn U.
IOP, U Mainz
Ludwig-Maximilians U, Munich
U. of Wuppertal

Panjab U., Chandigarh
Delhi U., Delhi
Tata Institute, Mumbai

University College, Dublin

KDL, Korea U., Seoul

CINVESTAV, Mexico City

FOM-NIKHEF, Amsterdam
U. of Amsterdam/NIKHEF
U. of Nijmegen/NIKHEF

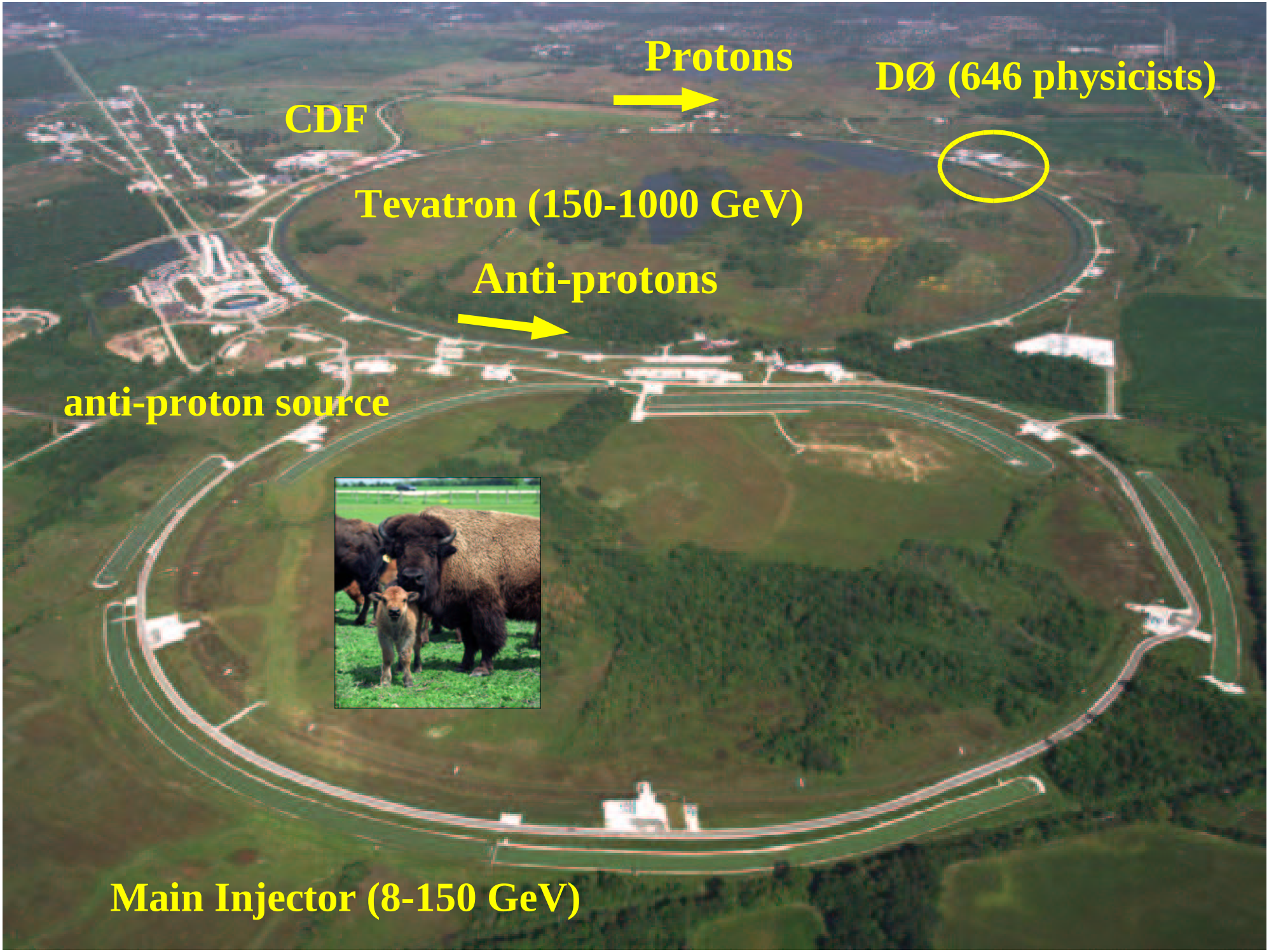
JINR, Dubna
ITEP, Moscow
Moscow State U.
IHEP, Protvino
PNPI, St Petersburg

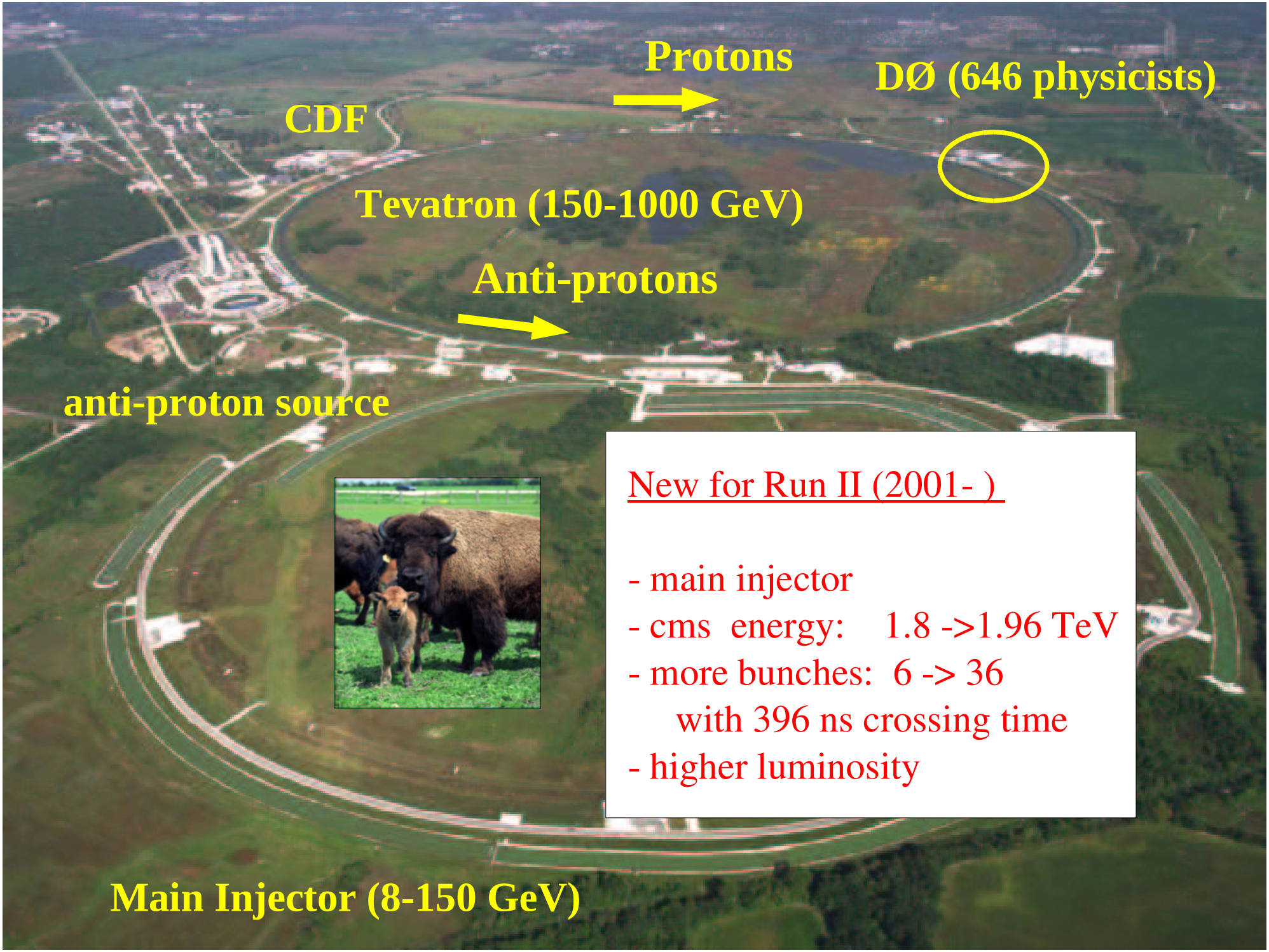
Lund U.
RIT, Stockholm
Stockholm U
Uppsala U.

Lancaster U.
Imperial College, London
U. of Manchester

HCIP, Hochiminh City

Ann Heinson, UC Riverside

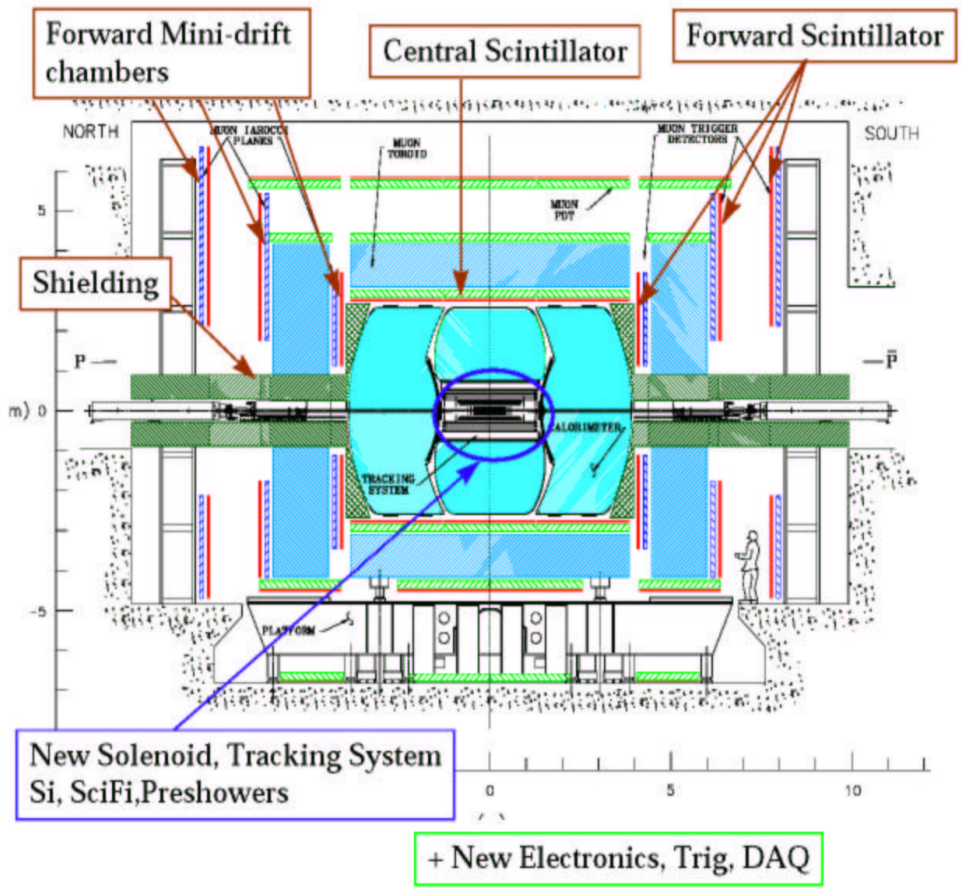

Protons
DØ (646 physicists)
CDF
Tevatron (150-1000 GeV)
Anti-protons
anti-proton source
Main Injector (8-150 GeV)



New for Run II (2001-)

- main injector
- cms energy: 1.8 ->1.96 TeV
- more bunches: 6 -> 36
  with 396 ns crossing time
- higher luminosity

The upgraded DØ Detector



Retained from Run I:

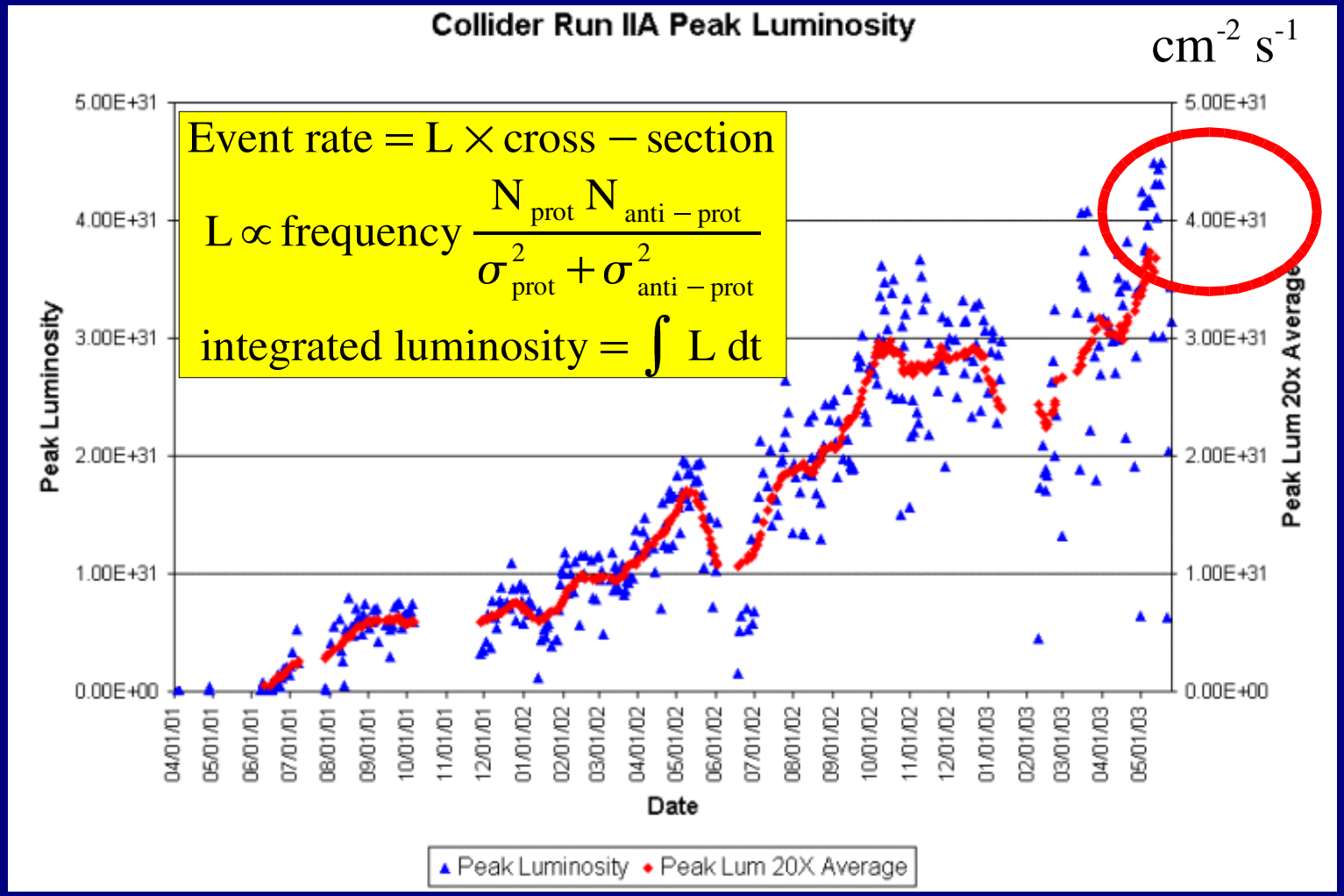
LAr calorimeter
Central muon detector
Muon Toroid

New for Run II:

Magnetic Tracker
- 2 Tesla Solenoid
- Silicon Microvertex Tracker (SMT)
- Central Fiber Tracker (CFT)

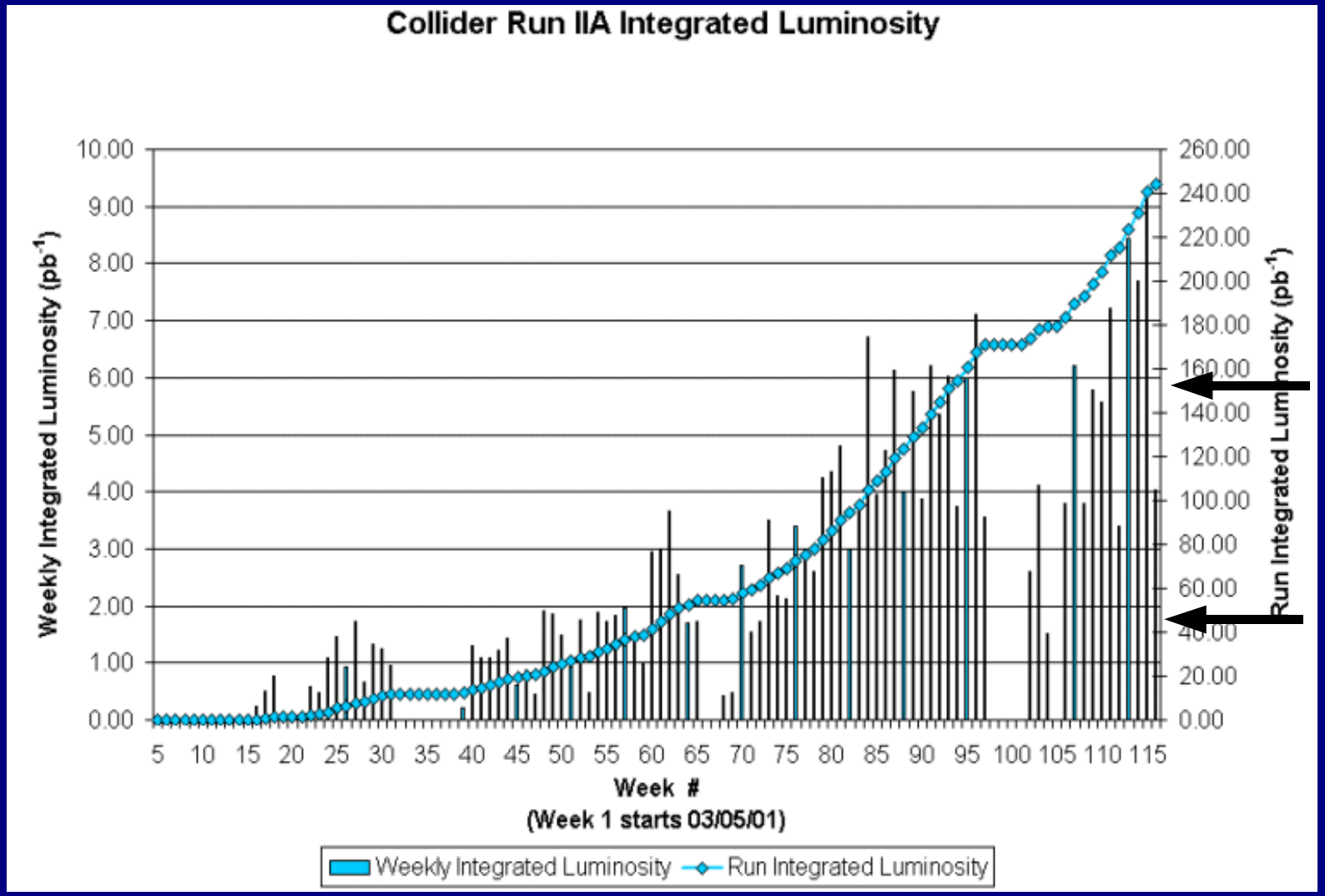
Preshower detectors
Forward muon detector
Forward proton detector
FE electronics, Trigger &DAQ
(50 Hz to tape)

Tevatron Peak Luminosity



factor two higher than Run I record
goal for Run II: another order of magnitude..

Integrated Luminosity



on tape

spring 2003

Run I about 100 pb^{-1}

Production of W and Z Bosons

Calibration of detector with standard process

↓

Measure luminosity with small experimental and theoretical uncertainty

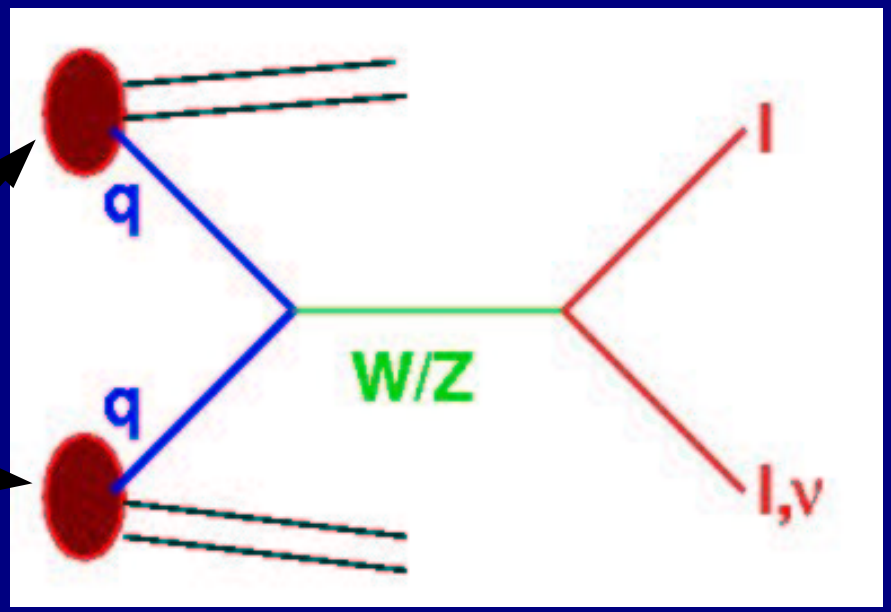
↓

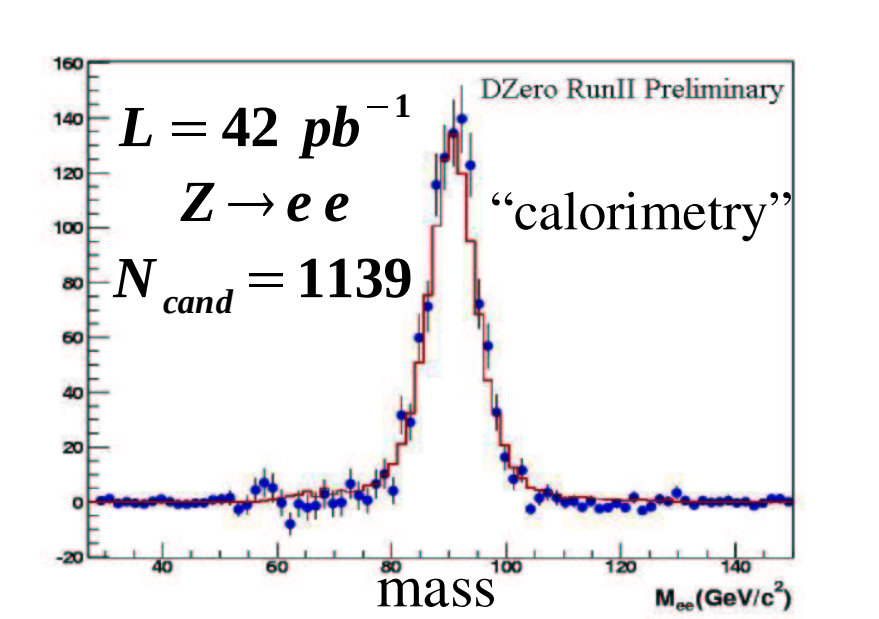
Constraint parton densities

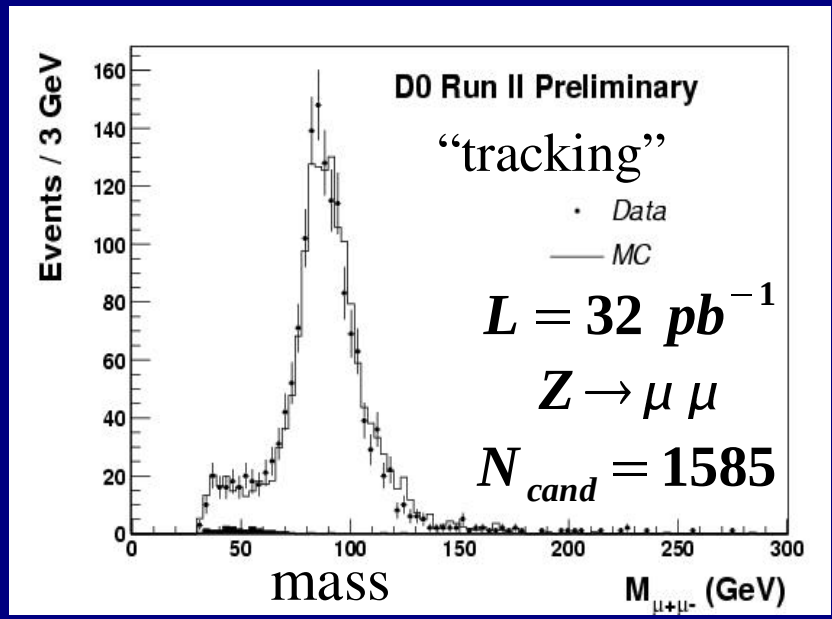
↓

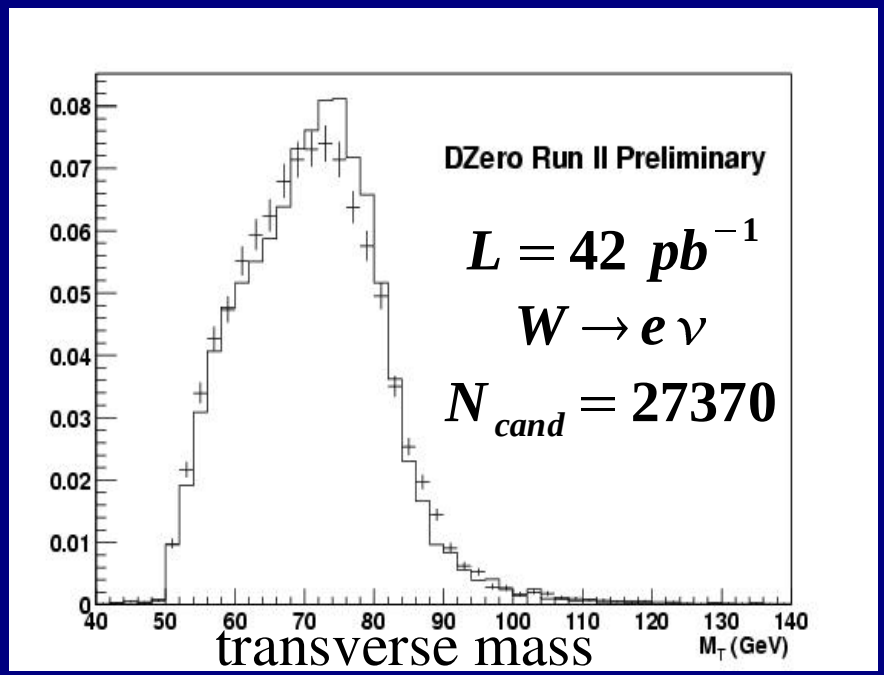
Perform precision measurement of electroweak parameters (e.g. W mass and width, gauge couplings..)

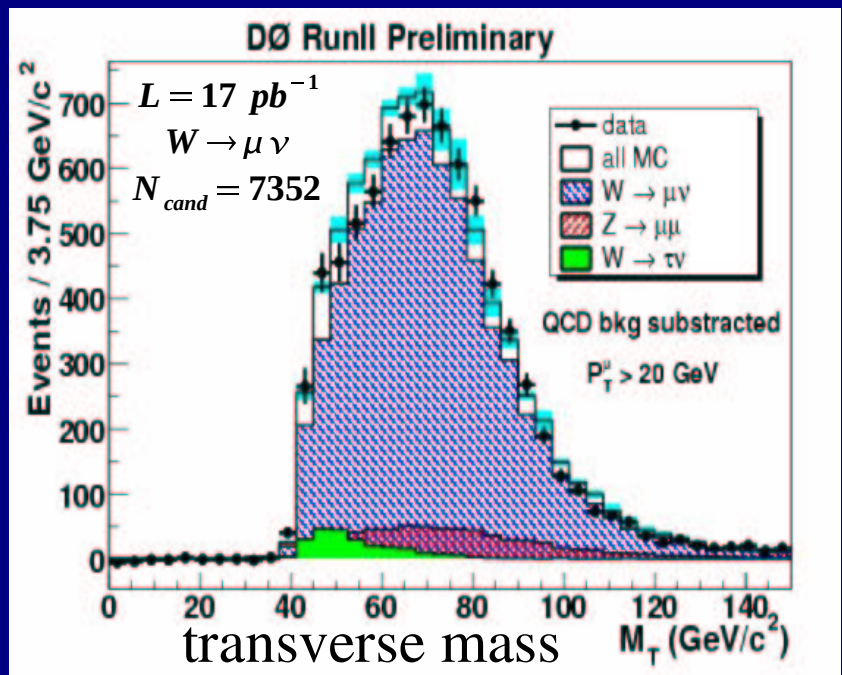
dominant W/Z production process




DZero RunII Preliminary
$L = 42\ pb^{-1}$
$Z \to e\,e$
$N_{cand} = 1139$
"calorimetry"
mass
M_{ee}(GeV/c^2)


D0 Run II Preliminary
"tracking"
Data
MC
$L = 32\ pb^{-1}$
$Z \to \mu\,\mu$
$N_{cand} = 1585$
Events / 3 GeV
mass
$M_{\mu+\mu-}$ (GeV)

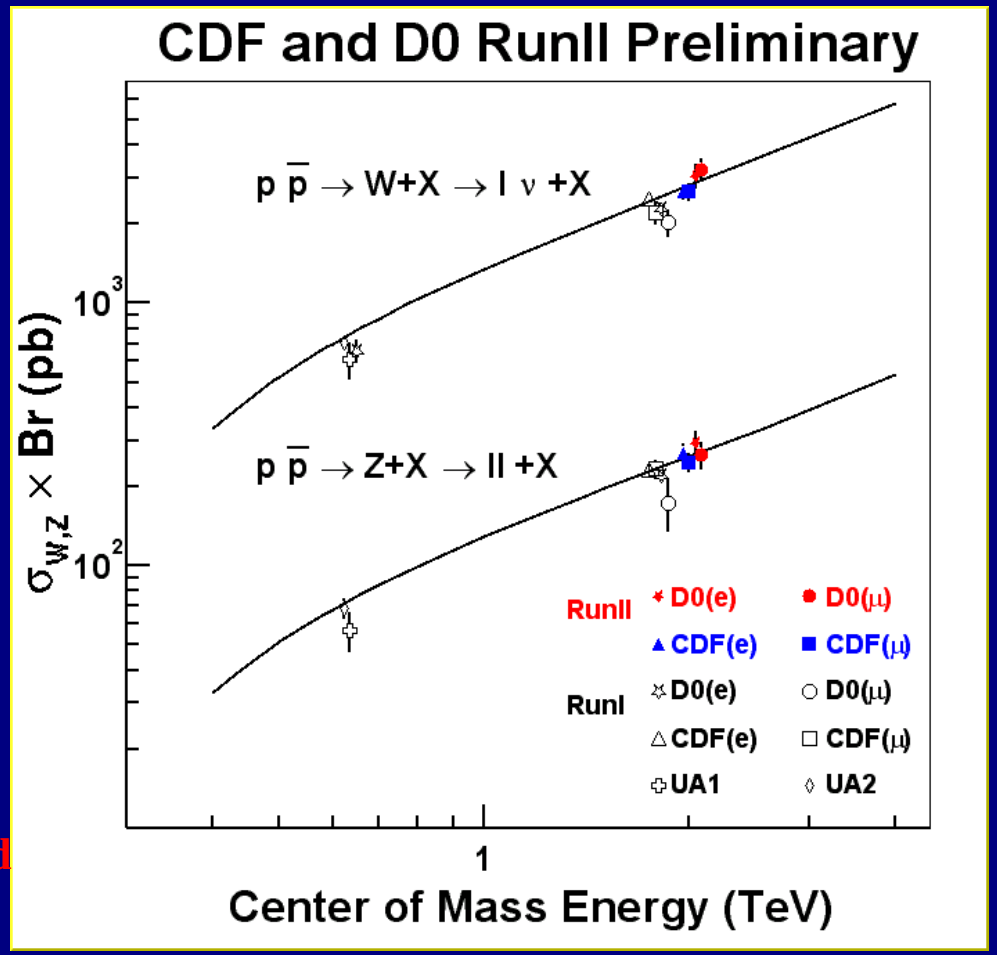

DZero Run II Preliminary
$L = 42\ pb^{-1}$
$W \to e\,\nu$
$N_{cand} = 27370$
transverse mass
M_T (GeV)


DØ RunII Preliminary
$L = 17\ pb^{-1}$
$W \to \mu\,\nu$
$N_{cand} = 7352$
data
all MC
$W \to \mu\nu$
$Z \to \mu\mu$
$W \to \tau\nu$
QCD bkg substracted
$P_T^{\mu} > 20$ GeV
Events / 3.75 GeV/c^2
transverse mass
M_T (GeV/c^2)

Luminosity uncertainty of about 10 % is dominant

The luminosity is determined using total inelastic p-pbar cross-section

will be improved...



NLO:
C. R. Hamberg, W.L. van Neerven and T. Matsuura, Nucl. Phys. B359 (1991) using CTEQ4M PDF

$$\sigma(W)\times BR(W\to e) = 3054\pm100\,(stat)\pm 86\,(sys)\pm305\,(lumi)\,pb$$
$$\sigma(Z)\times BR(Z\to ee) = 294\pm 11\,(stat)\pm 8\,(sys)\pm 29\,(lumi)\,pb$$
$$\sigma(W)\times BR(W\to \mu) = 3226\pm128\,(stat)\pm100\,(sys)\pm323\,(lumi)\,pb$$
$$\sigma(Z)\times BR(Z\to \mu\mu) = 264\pm 8\,(stat)\pm 17\,(sys)\pm 26\,(lumi)\,pb$$

Large Extra Dimensions

- inspired by string theory

- one popular model: Arkani-Hamed, Dimopoulos, Dvali (ADD)

- gravity exists in extra dimensions, it only appears weak to us

$$M_{Planck} = M_s^{n+1} R^n$$

n : number of extra dimensions

$M_S \simeq 1\,TeV$: fundamental Planck scale

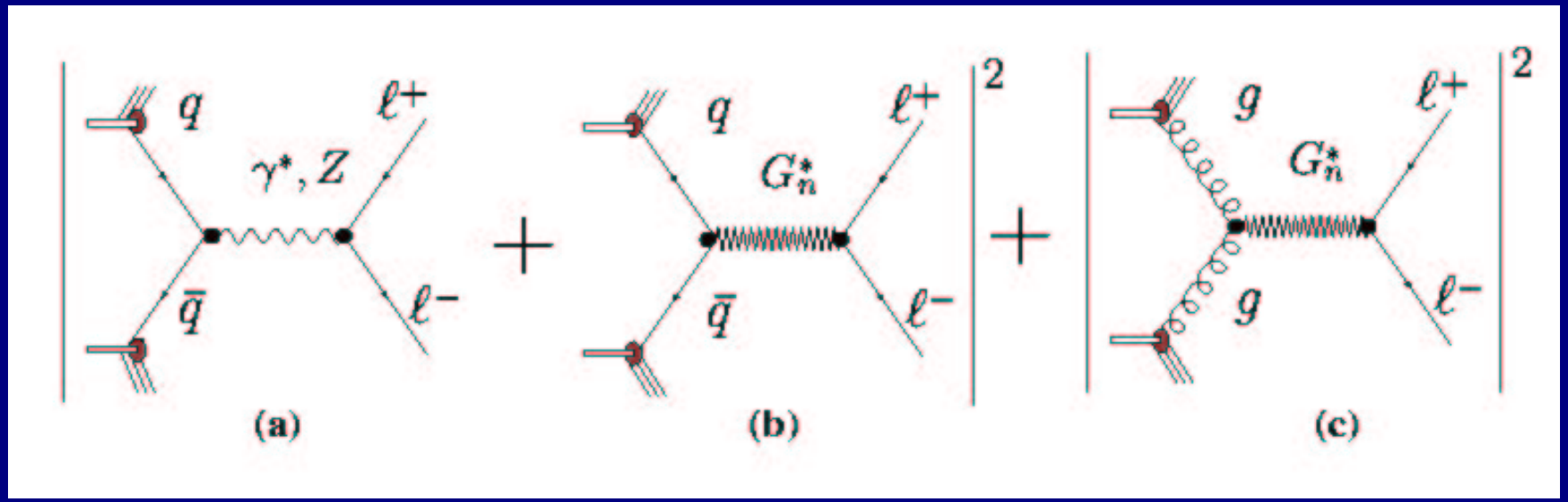
R : radius of extra dimensions

- n = 2 corresponds to R about 1 mm, i.e. it is accessible to gravity experiments

- n > 2 can only be excluded by accelerators

- observation of effects due to Kaluza-Klein excitations of graviton, G_{KK}

Search for Large Extra Dimensions

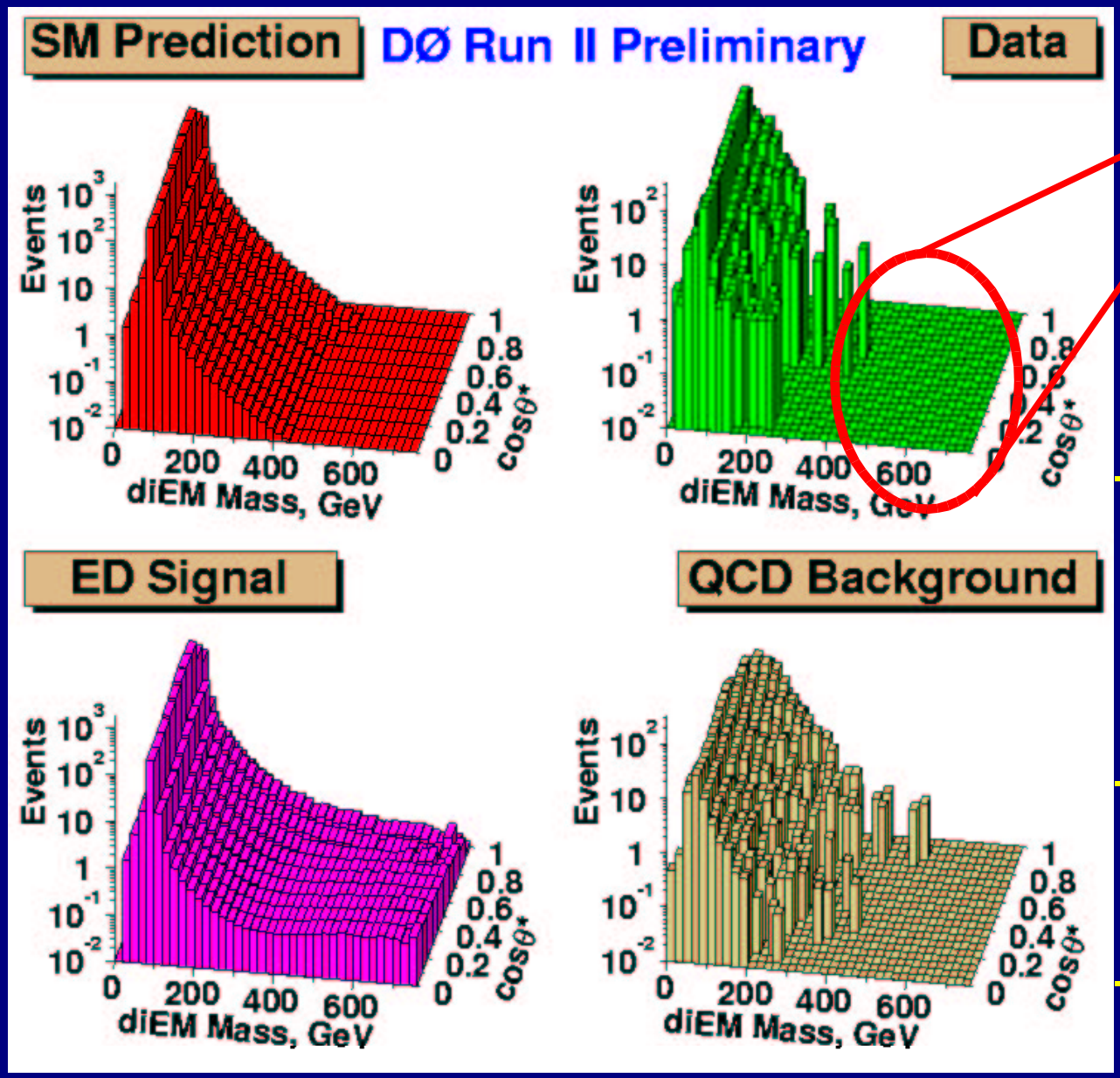


$$\frac{d^2\sigma}{dM\, d\cos\theta^*} = f_{SM} + f_{interference}\,\eta_G + f_{Kaluza-Klein}\,\eta_G^2 \qquad (\eta_G = F/M_S^4)$$

F is dimensionless parameter of order unity (depends on formalism)

Graviton exchange would modify distribution of mass and cos θ∗

ee and γγ final state



No signal

- Two objects in calorimeter consistent with electron or photon hypothesis (EM object)
- Both EM objects have $p_T > 25$ GeV
- Missing tranverse energy < 25 GeV

Fit the distributions in the M_{ll} - $\cos\theta^*$ plane to determine the value of η_G ($\eta_G = 0$ in SM)

Electron/Photon analysis: $\eta_G = 0.00 \pm 0.27$ TeV^{-4}

Muon analysis: $\eta_G = 0.02 \pm 1.35$ TeV^{-4}

Translate to 95% CL lower limits on Planck scale M_S

using different formalisms for F:

	GRW	HLZ for n=2	HLZ for n=7	Hewett $\lambda = 1$
Electron/Photon Channel	1.12	1.16	0.89	1.00
Muon Channel	0.79	0.68	0.63	0.71

TeV

Close to Run I and LEP limits

Leptoquarks

- LQ mediates interactions between quarks and leptons

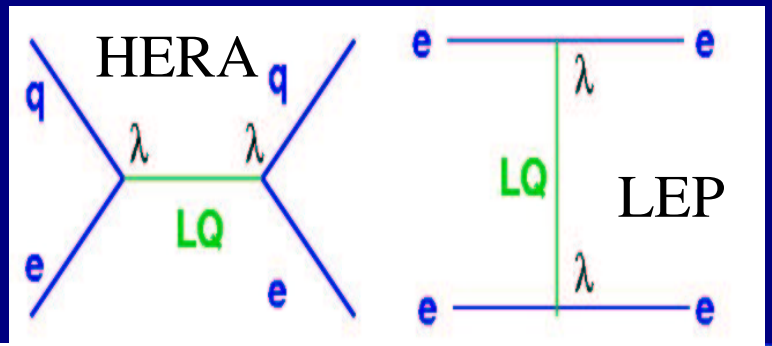
- LQ carries lepton number, baryon number, and colour

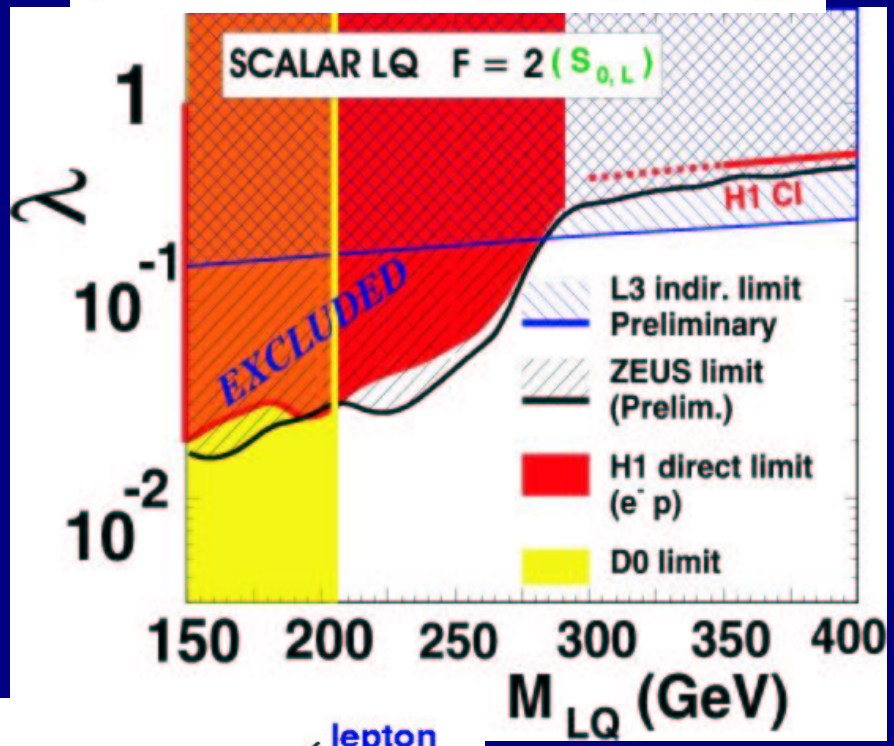
- Scalar (S) or Vector (V) states

- Charges +- 1/3, 2/3, 4/3, 5/3

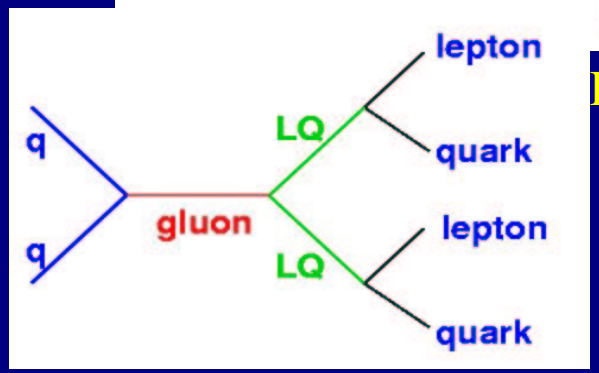
- Branching Ratio into charged leptons β=BR(eq->eq) = 0, 0.5, 1 (Buchmüller-Rückl-Wyler model)

- pair production (LEP,Tevatron) (nearly) independent of λ





R.McPherson, ICHEP02



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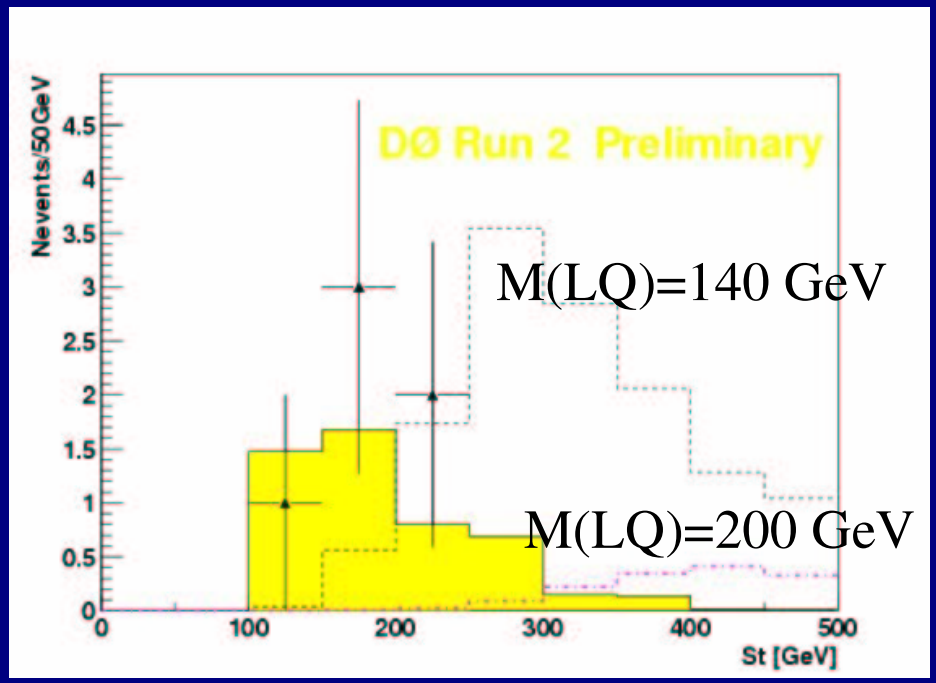
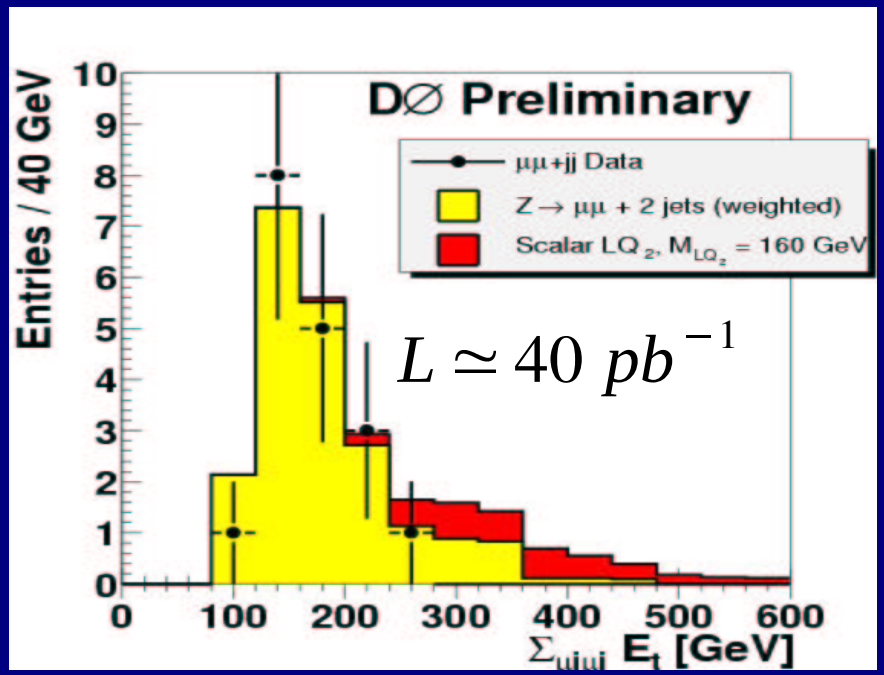
$LQ_1 LQ_1$ -> e q e q



$LQ_2 LQ_2$ -> μ q μ q



Good signal-background separation using sum over the transverse energy of all leptons and jets

Cuts: **Two jets with P_T > 20 GeV**

Two electrons with P_T> 25 GeV or two muons with P_T> 15 GeV

Limits for scalar LQ assuming 100% branching ratio into charged leptons

$M(LQ_1)$ > 179 GeV **$M(LQ_2)$ > 157 GeV**

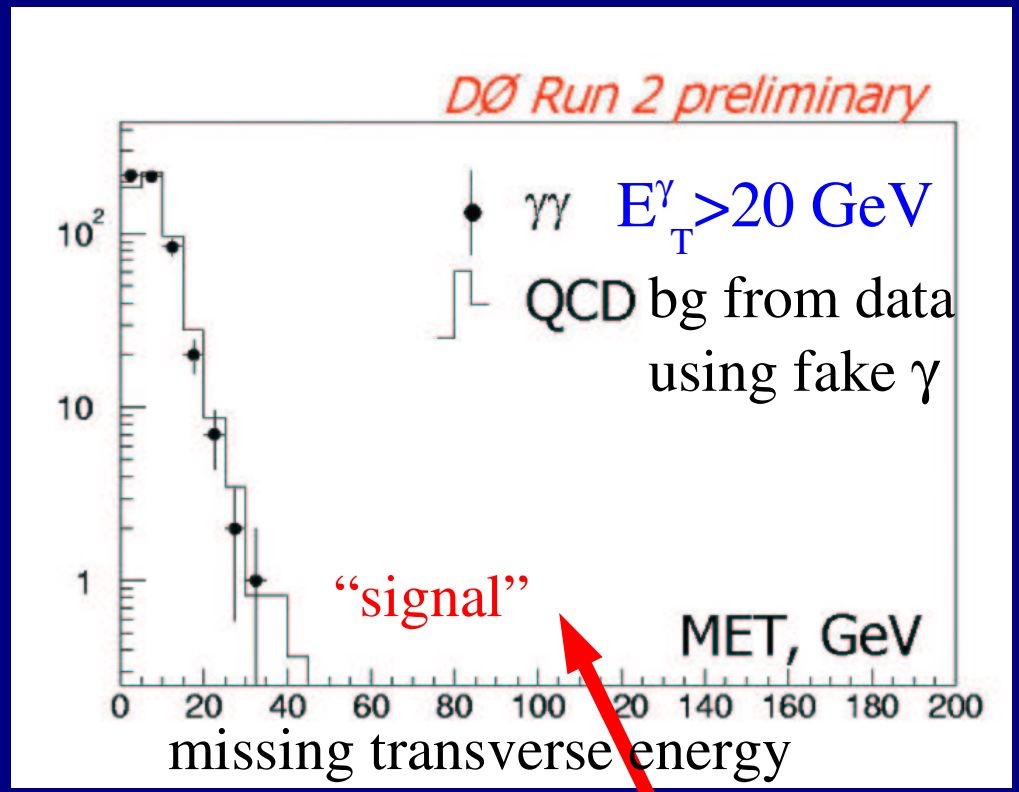
Gauge Mediated Supersymmentry (GMSB)

Signatures:

- **Gravitino is lightest super-symmetric particle (LSP)**

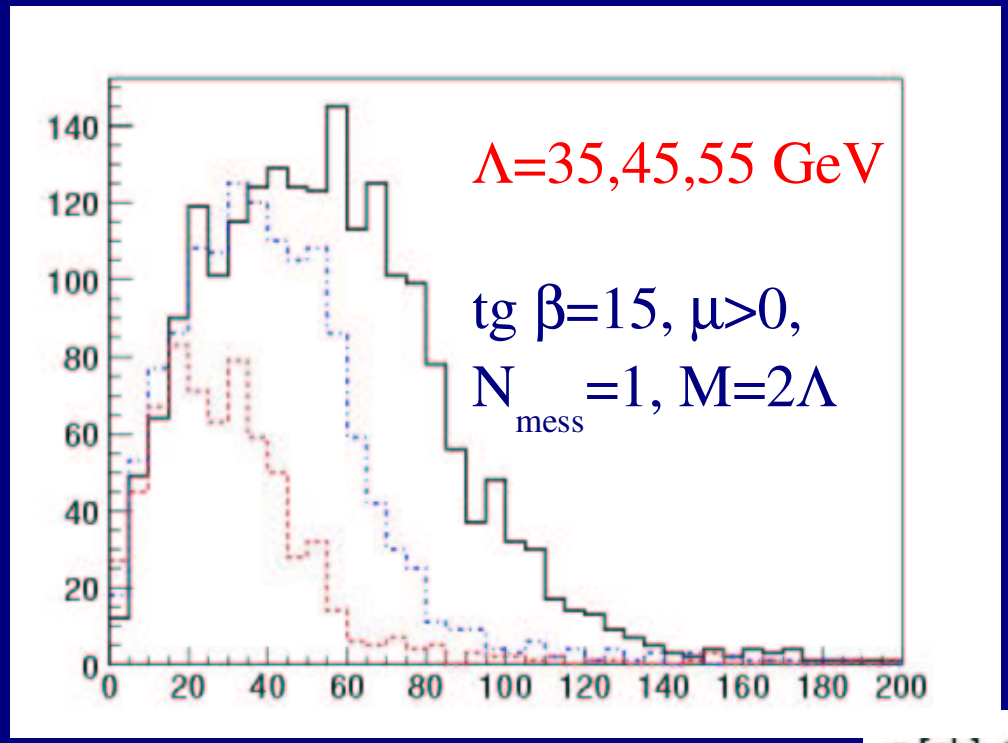
- **Neutralino is the NLSP**

$$\widetilde{\chi}_1^0 \rightarrow \widetilde{G}\,\gamma$$



- **typical process:**

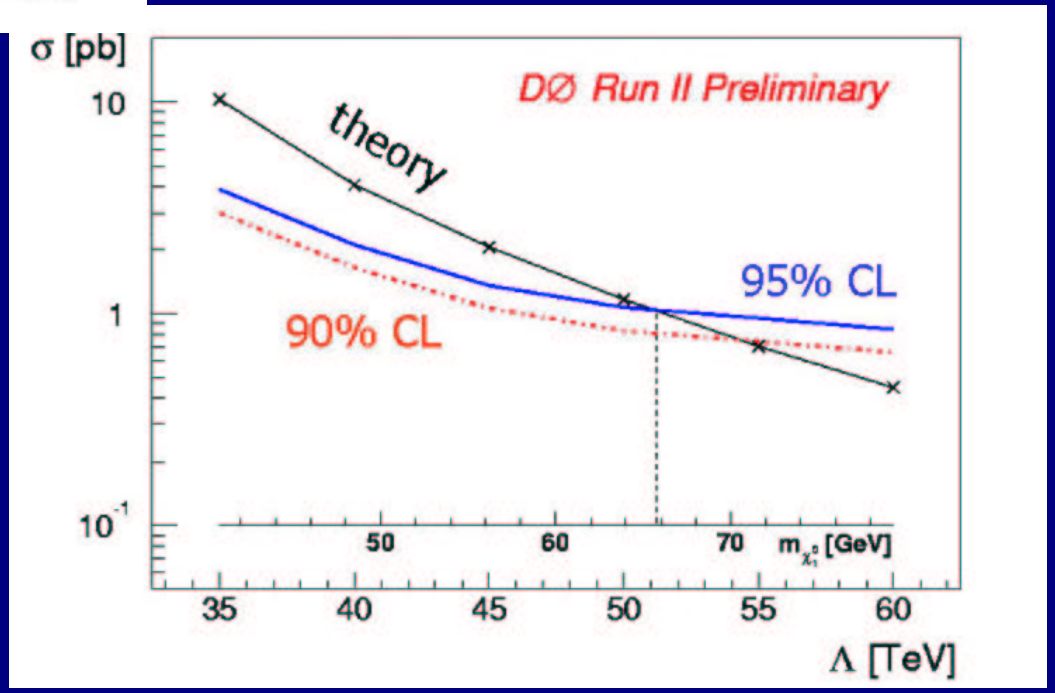
$$p\,\overline{p} \rightarrow \textbf{gauginos} \rightarrow W\,,Z\,,\gamma + \widetilde{\chi}_1^0\,\widetilde{\chi}_1^0 \rightarrow \gamma\,\gamma + \widetilde{G}\,\widetilde{G} + X$$



Cut at E_T>30 GeV:

SUSY particle mass scale:
Λ < 51 TeV

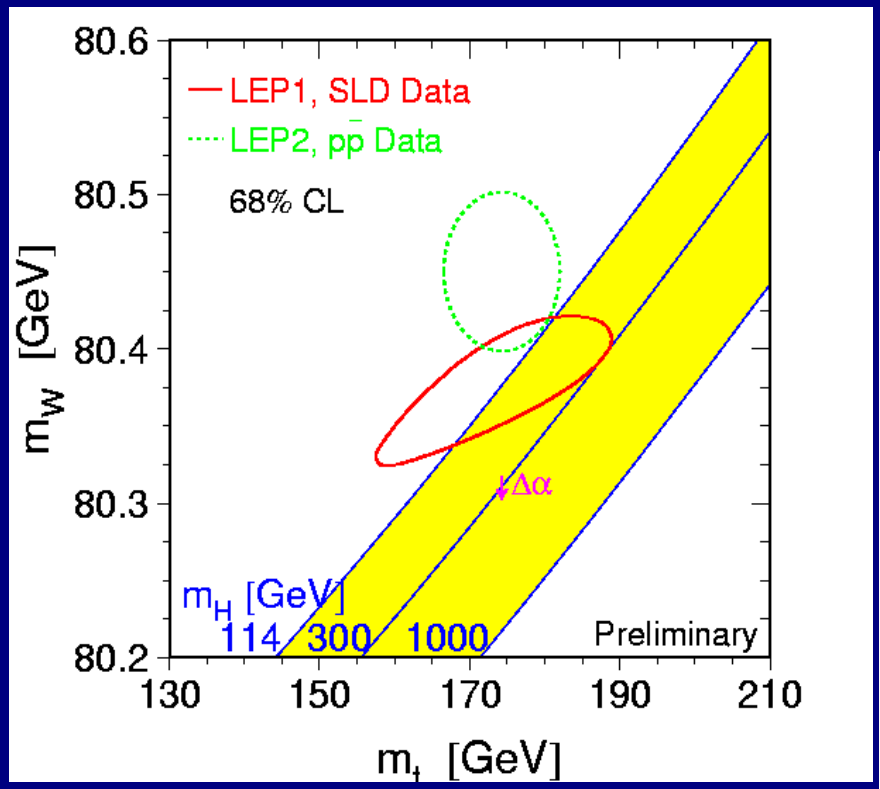
M(neutralino)< 66 GeV



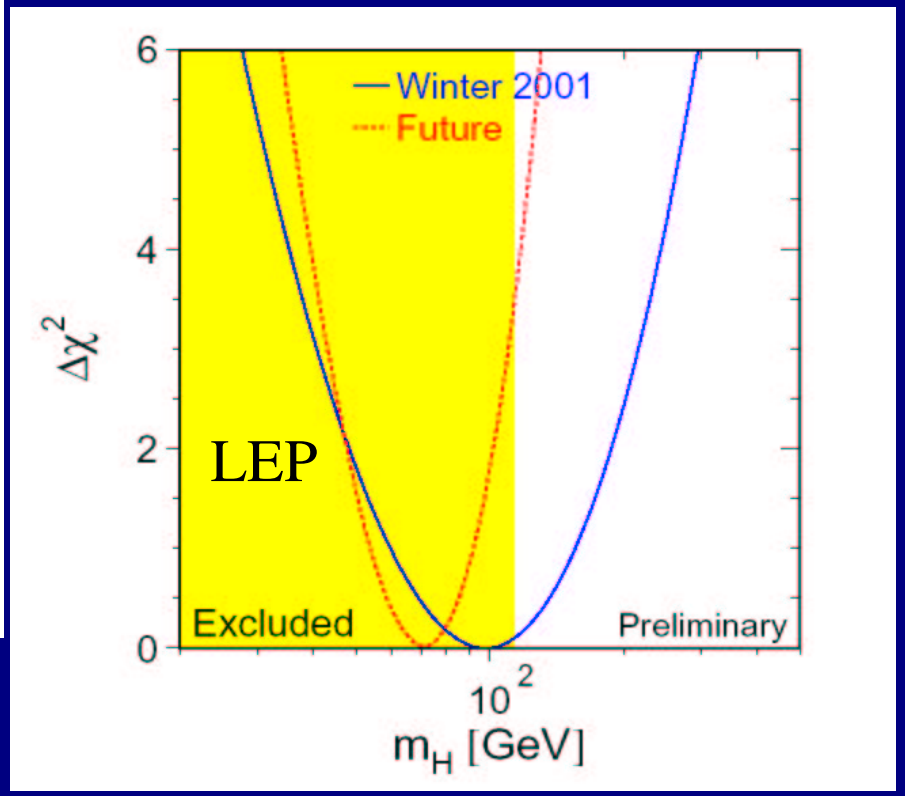
Close to Run I limits
Lower than LEP 2 limits
..just starting...

many ongoing searches
(e.g. tri-leptons)

Cornering the Standard Model .....



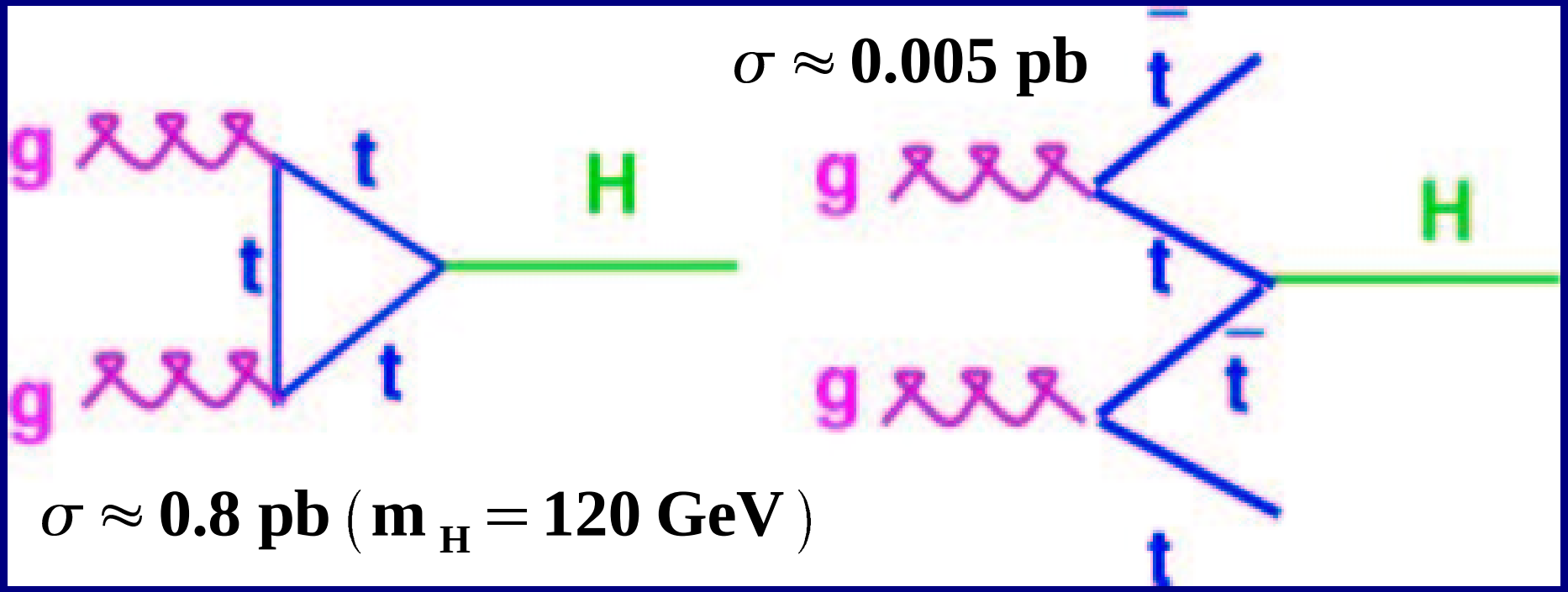
expected uncertainties:
W mass 20 MeV
Top mass 1 GeV

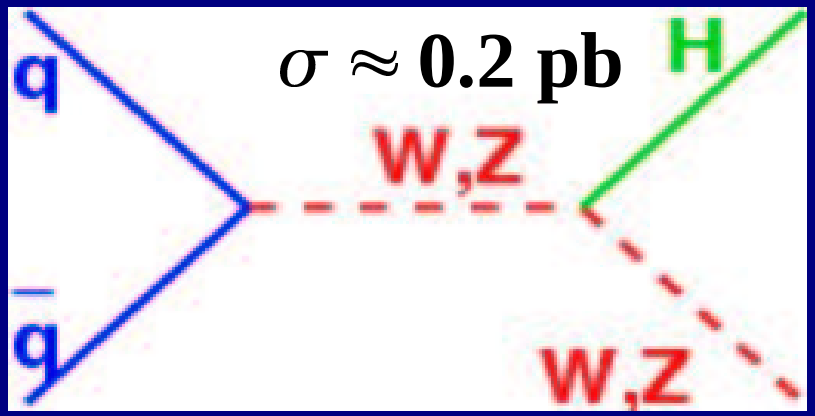


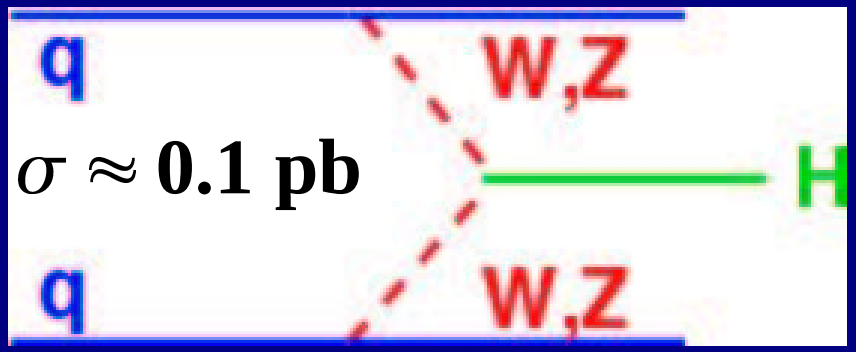
world average : $m_W = 80451 \pm 33$ MeV
expected uncertainty : 27 MeV
with $L = 15\ fb^{-1}$ per experiment

M.Grünewald et al, hep-ph/0111217

Higgs production at the Tevatron (and the LHC)



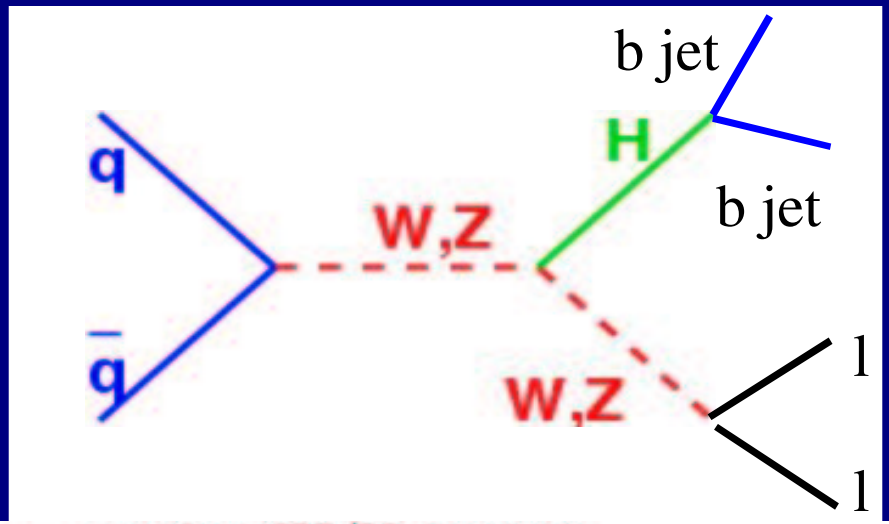


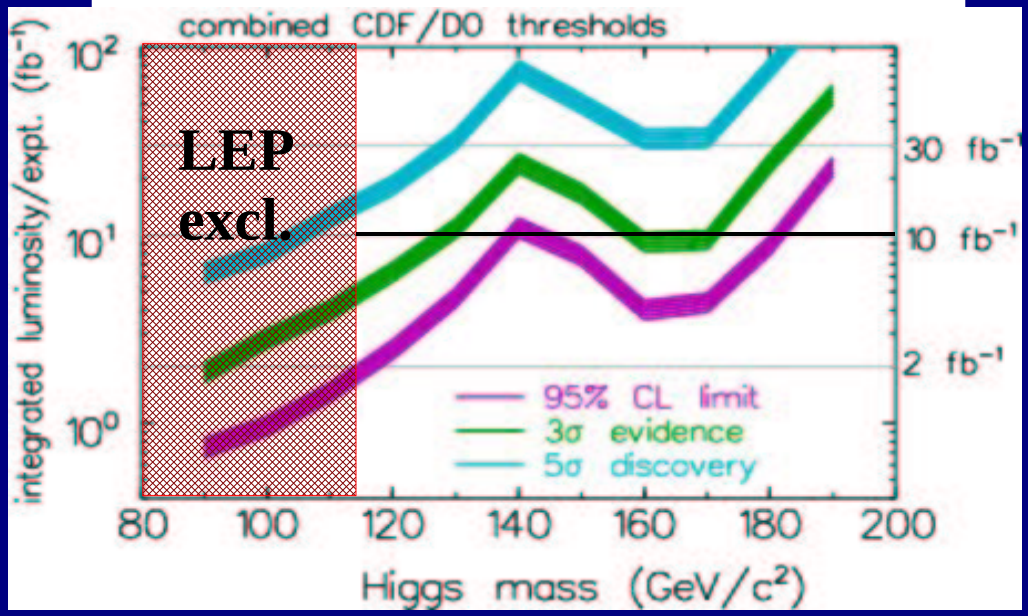


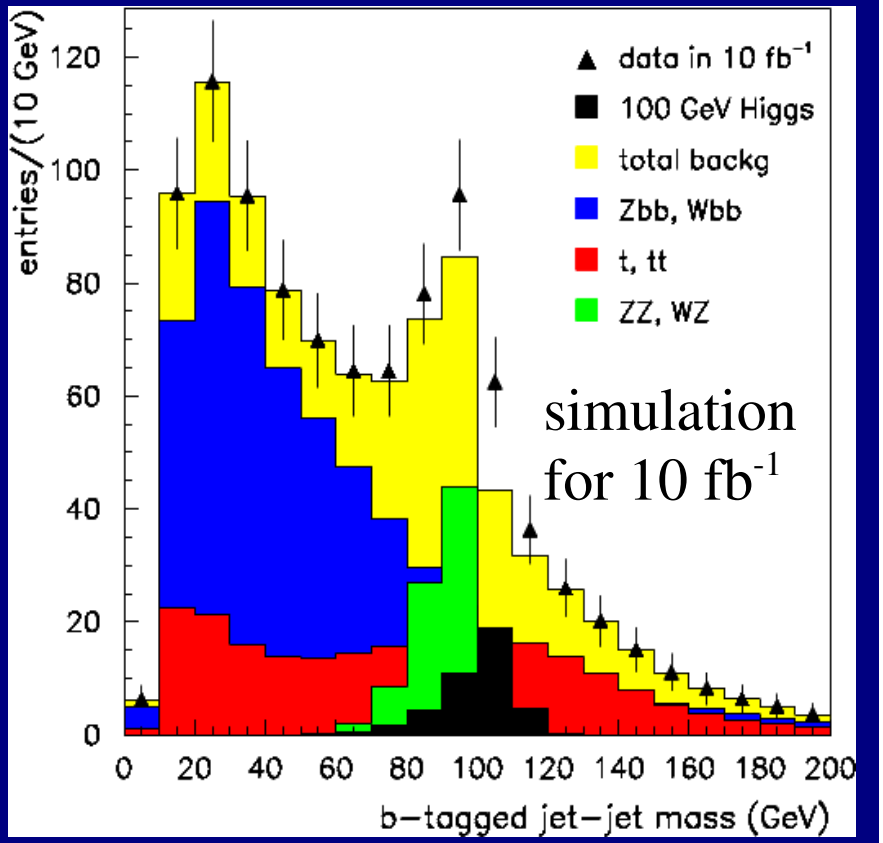
The Search for the Standard Model Higgs Boson

$$\sigma_{\text{eptonic}} \simeq \sigma \times \mathrm{BR}_{W \to l\nu} \approx 0.2 * 0.1 \text{ pb} = 20 \text{ fb}$$

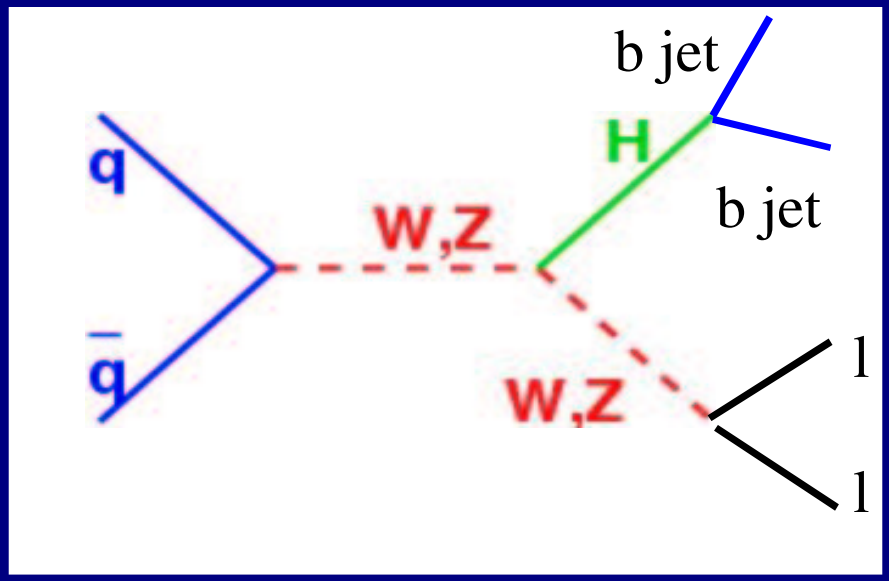
m=100 GeV







The Road to the Higgs:



Identifiy W and Z bosons

↓

Understand jets
(W + 2 jets, Z + 2 jets)

↓

Identify b jets (b tagging)

The Road to the Higgs:

Identifiy W and Z bosons

↓

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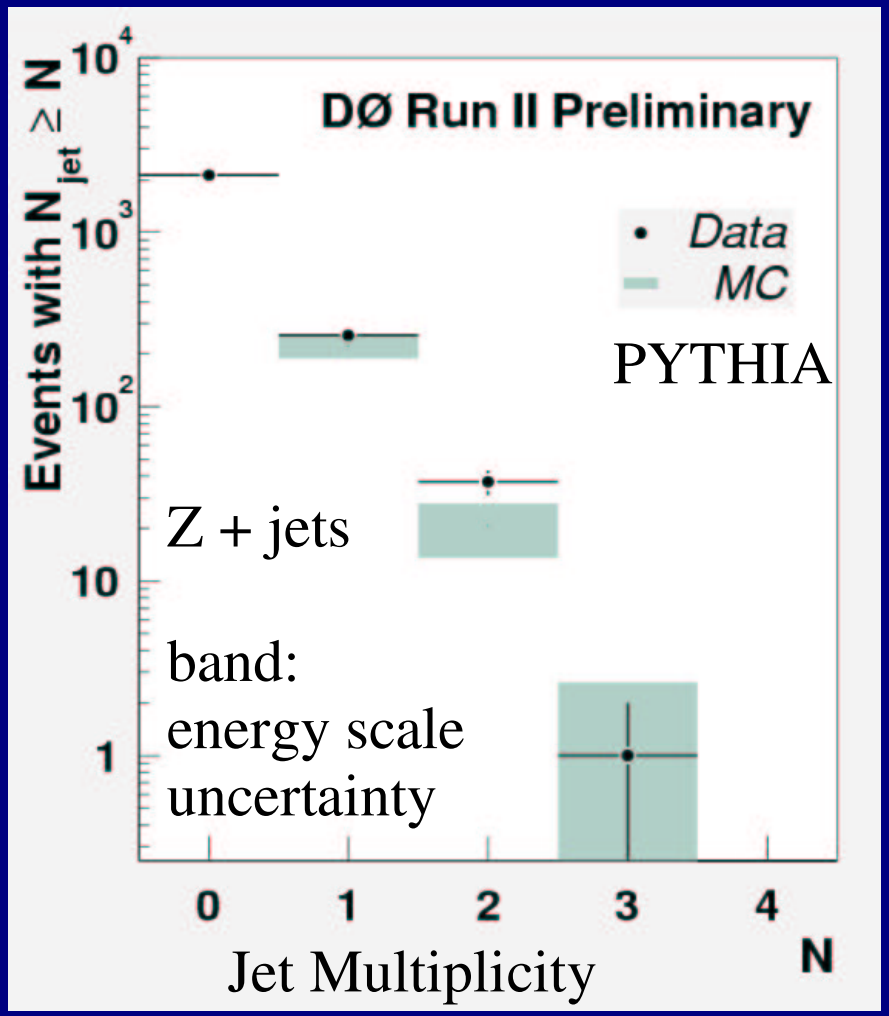
(W + 2 jets, Z + 2 jets)

↓

Identify b jets (b tagging)

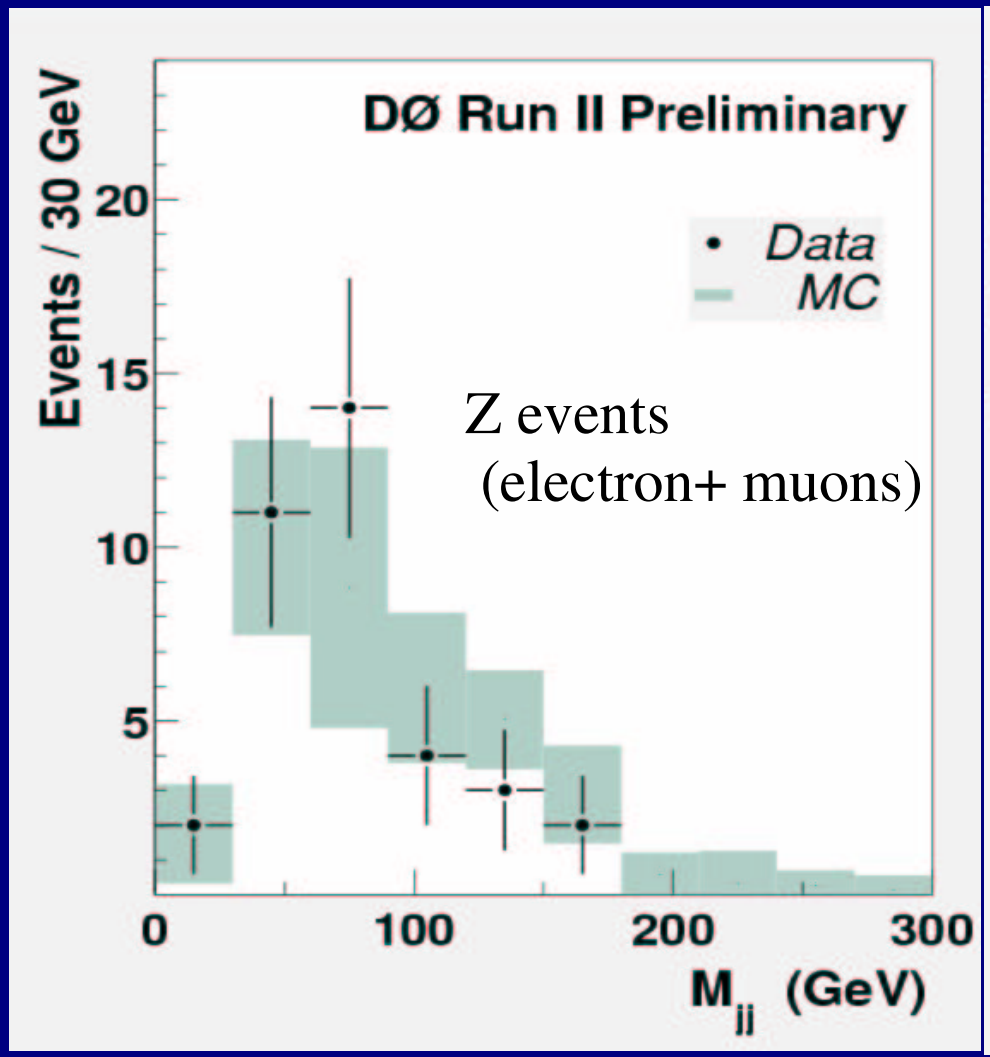


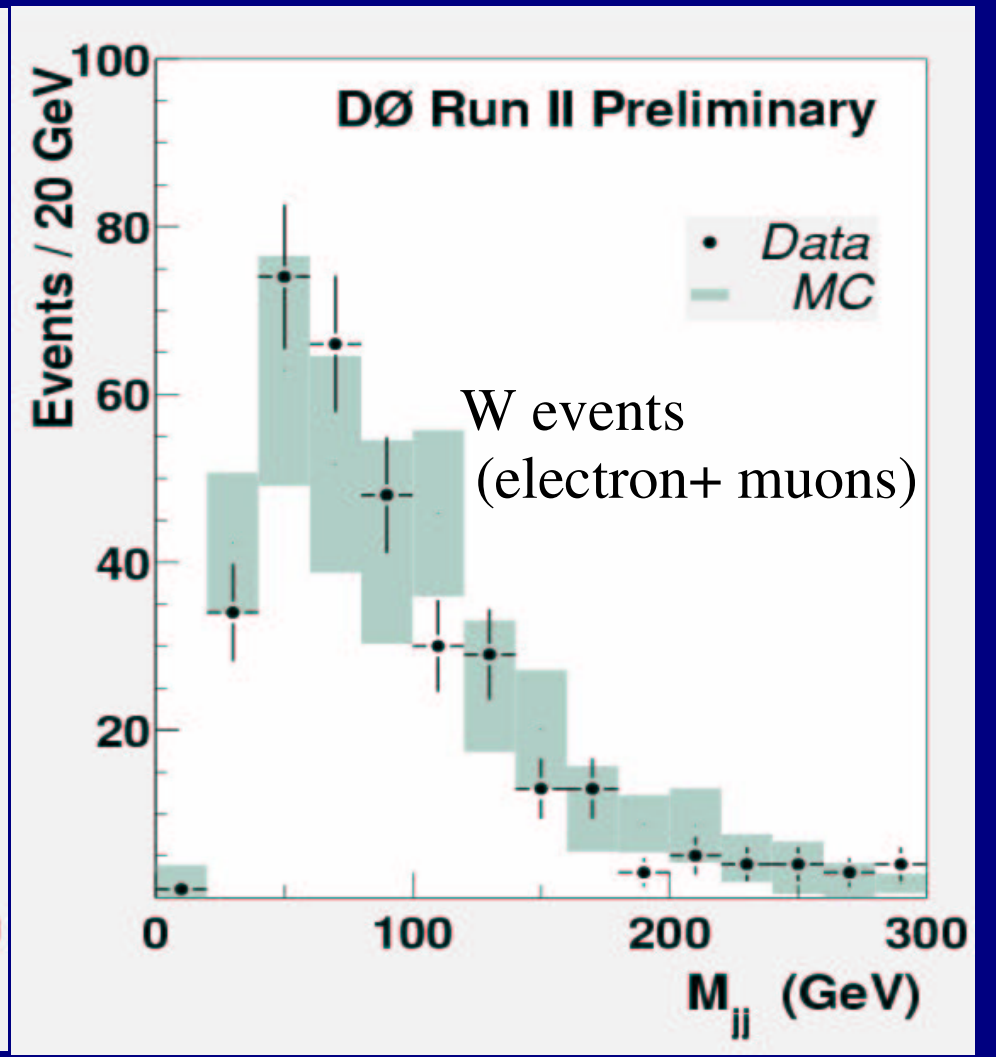
Jet Selection:

$p_T > 20$ GeV

$|\eta| < 2.5$

Di-jet mass spectrum

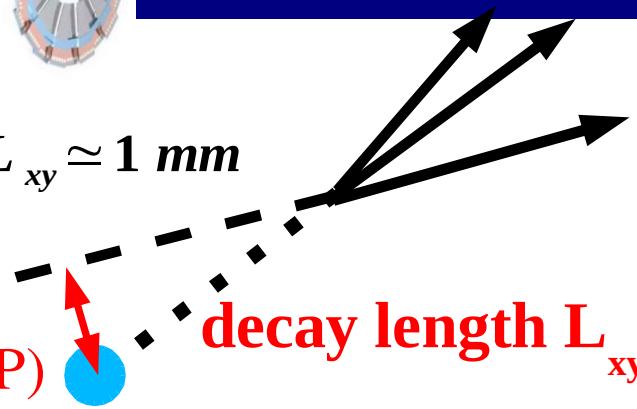




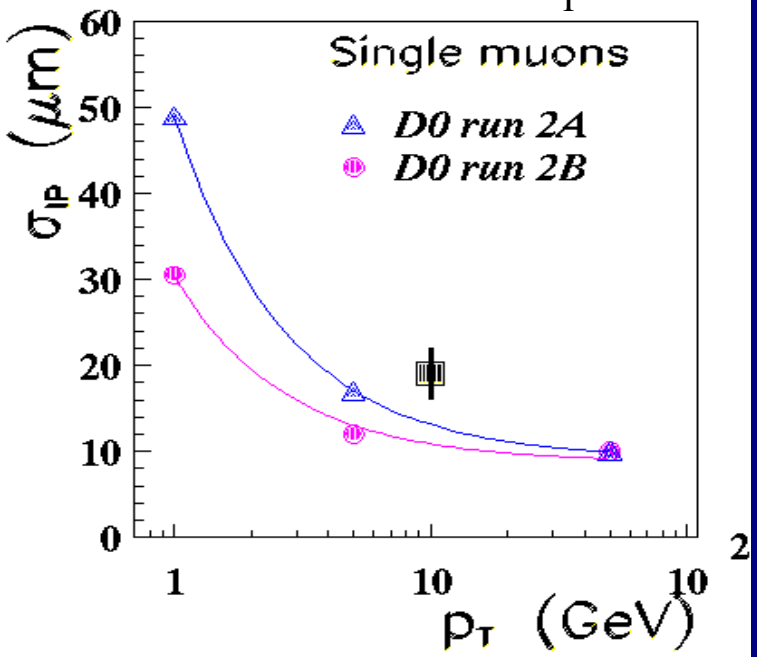
Monte Carlo normalised to data

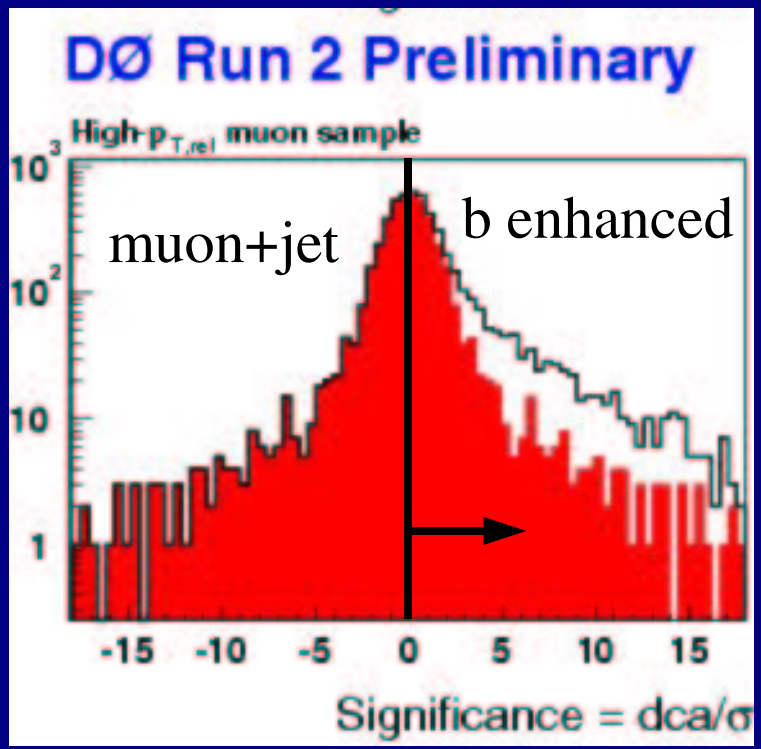
Tagging of b jets

$\tau \simeq 1.5\ ps \rightarrow L_{xy} \simeq 1\ mm$

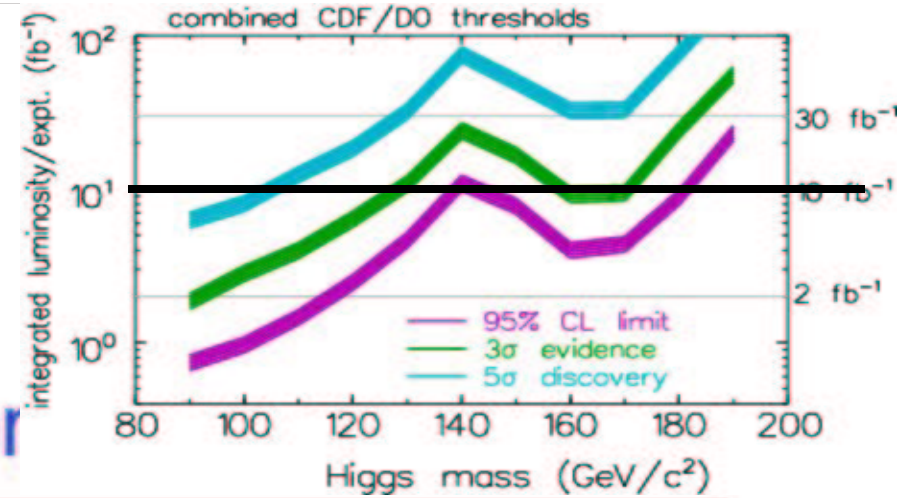


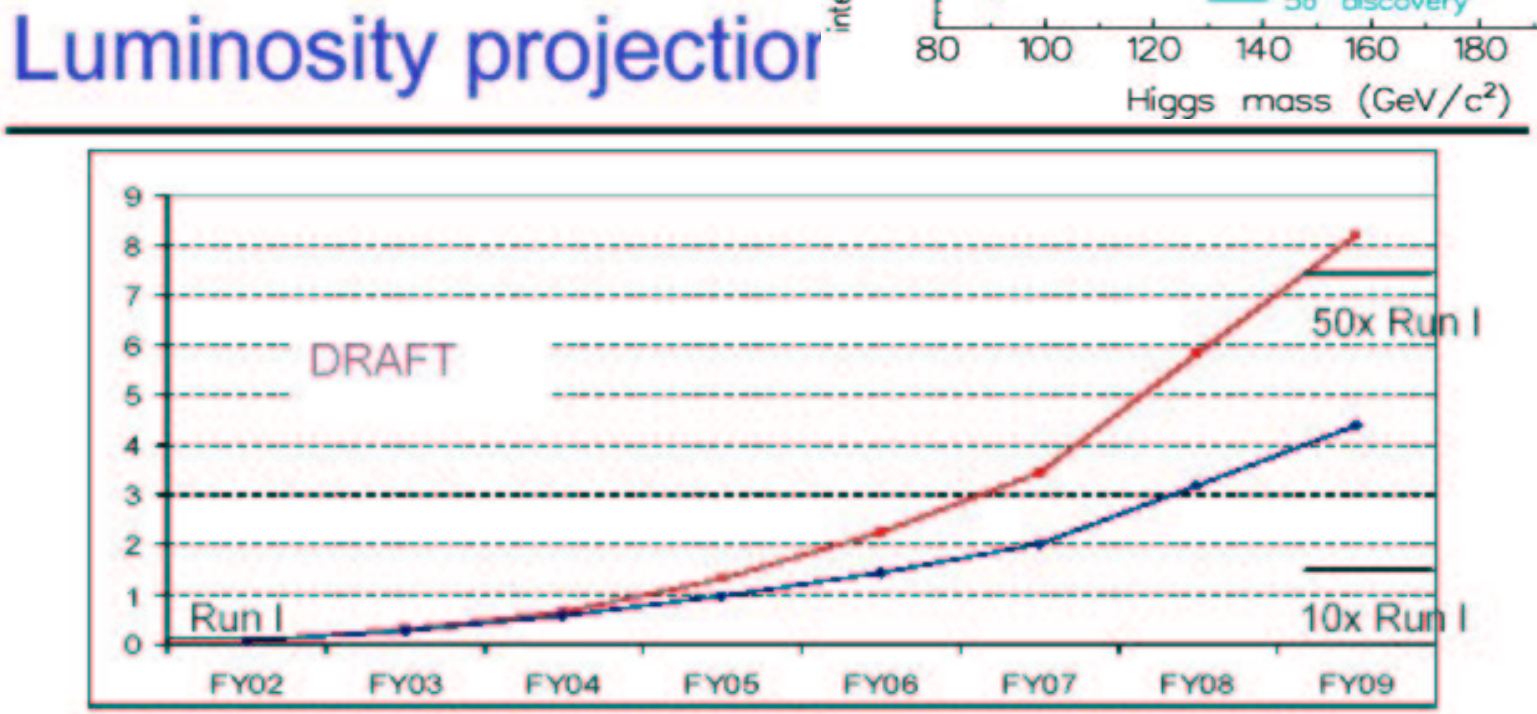
IP resolution vs track p_T





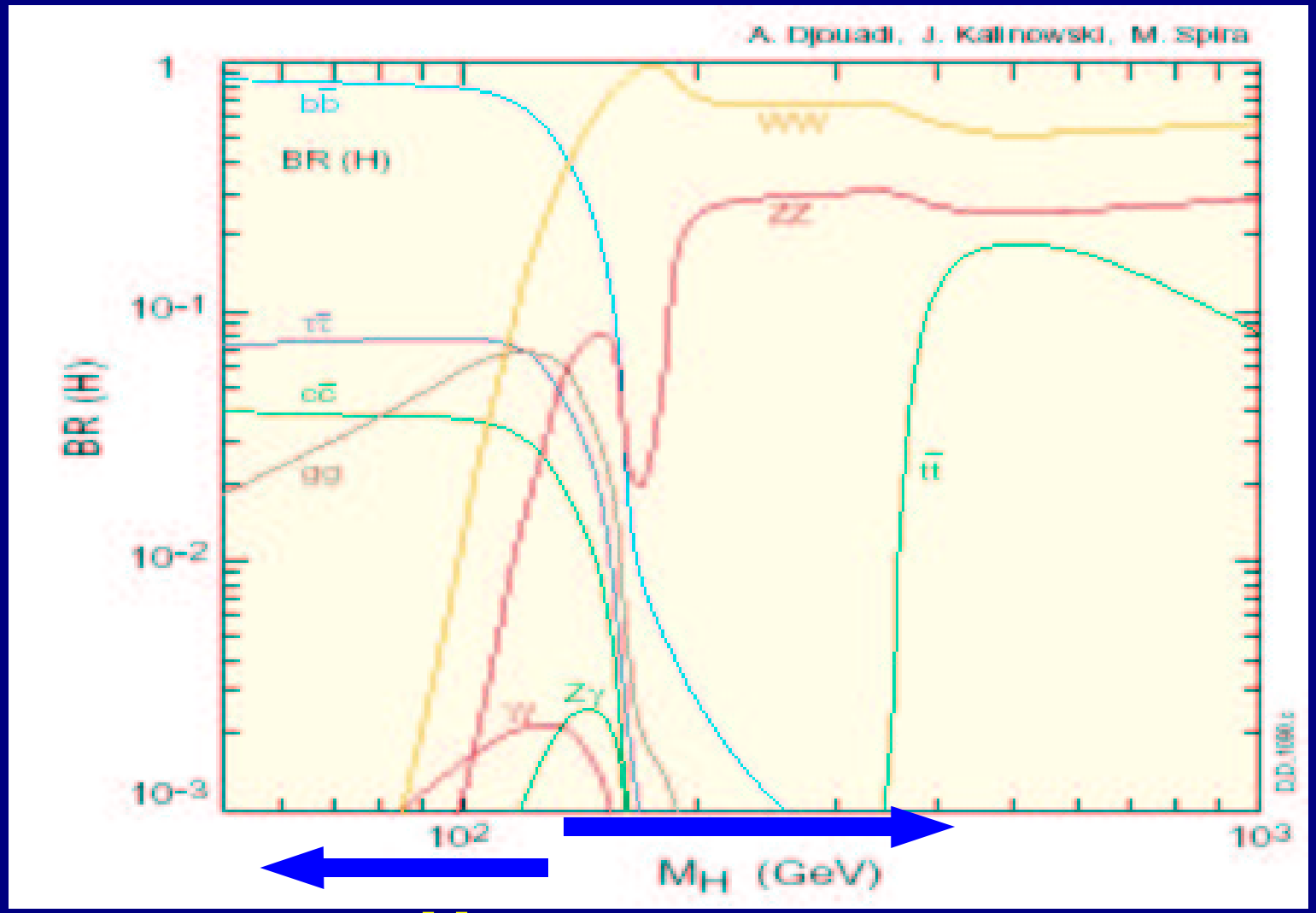
Presentation by Mike Witherell (Fermilab Director) at the FNAL User's Meeting last week:





still in flux: depends on success of technical improvements for the Tevatron

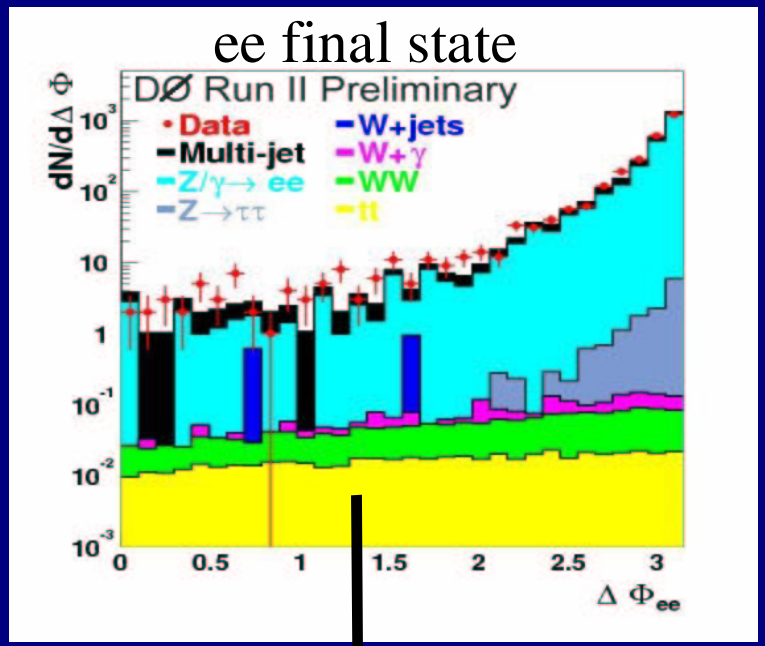
Branching ratio of SM Higgs boson

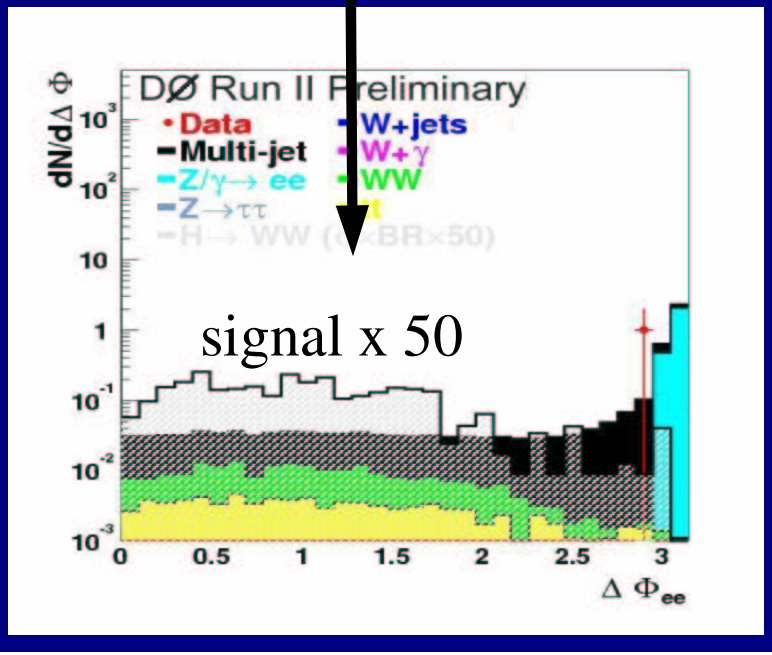


bb WW

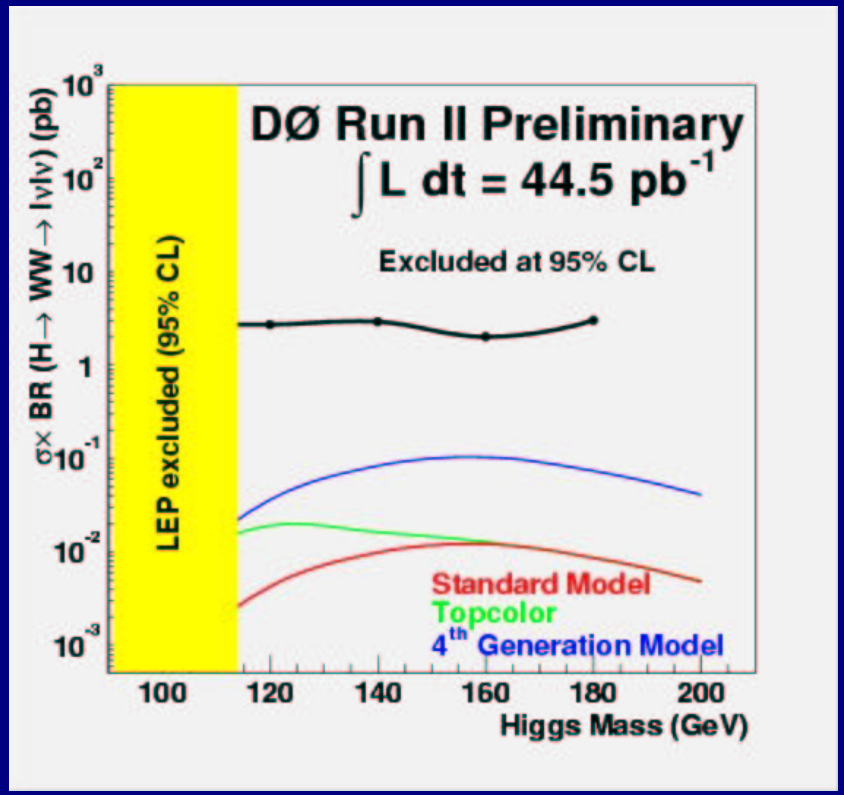
Higgs mass (GeV)

$H \rightarrow W W^{*} \rightarrow l^{+} l^{-} \nu \nu$



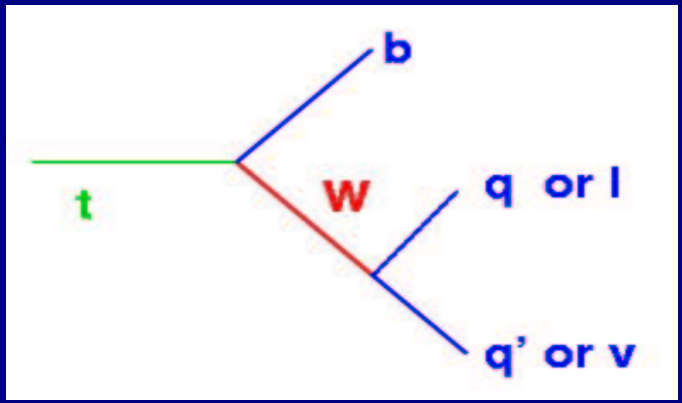


eμ and ee final state combined:



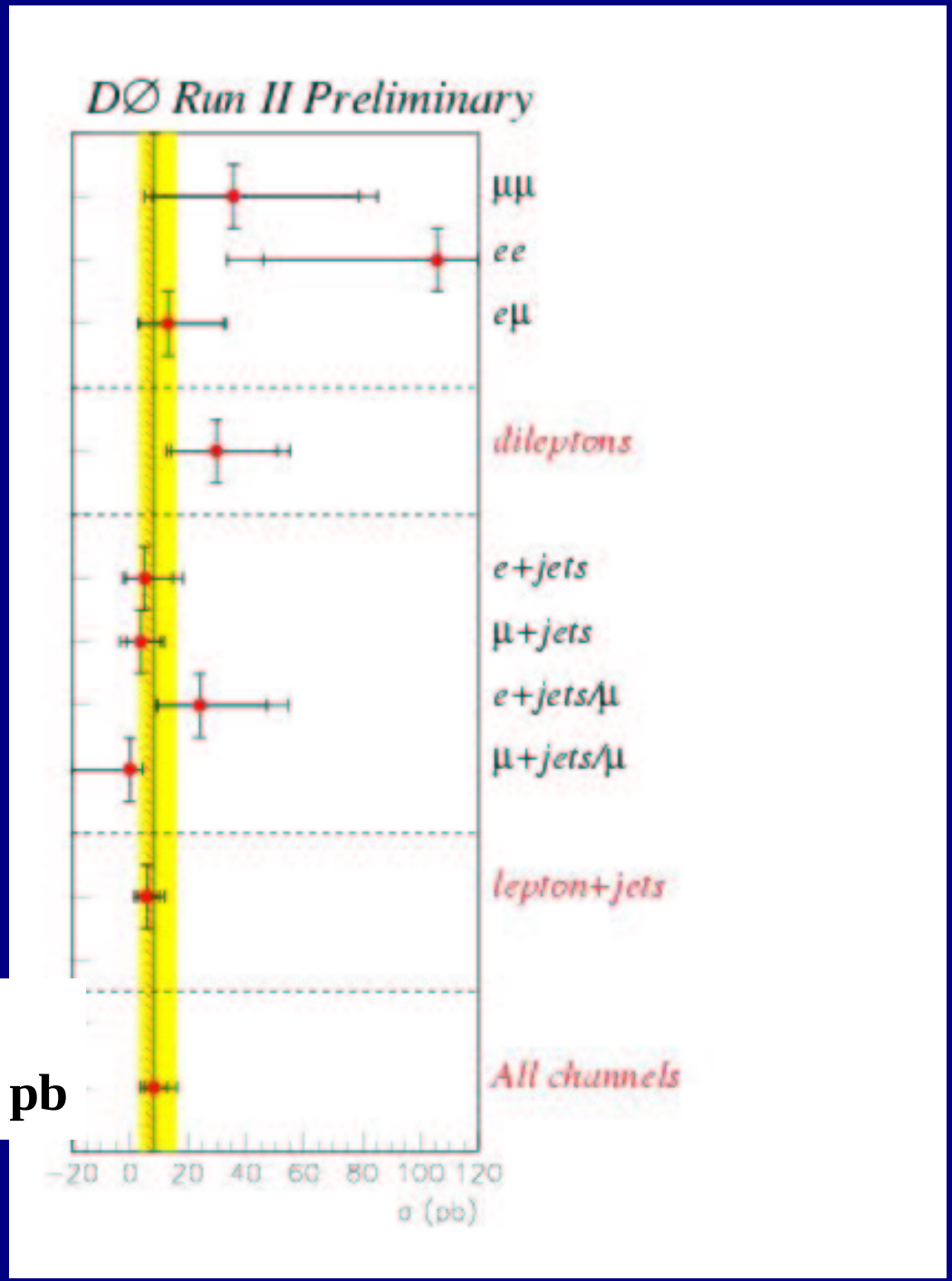
Many other searches for non-SM Higgs (H^{++}, H->γγ...)

$p\,\bar{p} \rightarrow t\,\bar{t}$



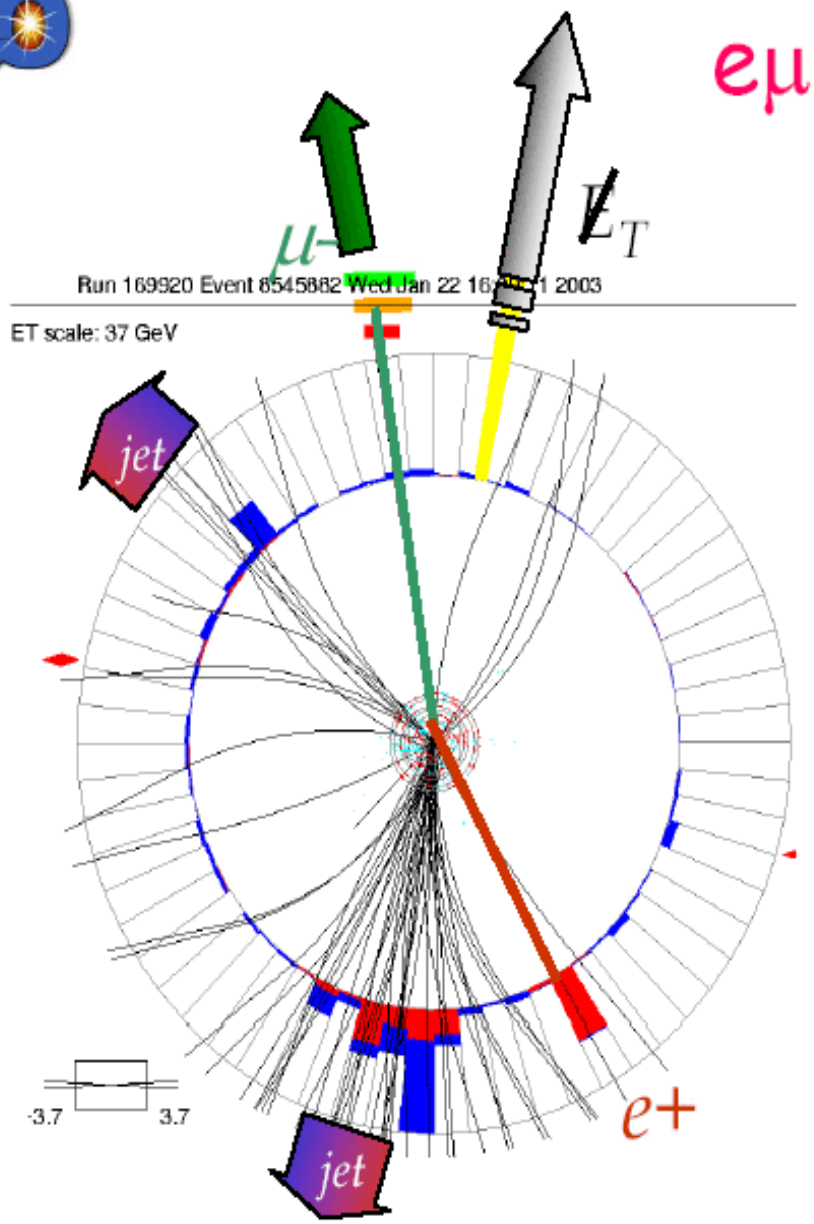
Run II cross-section about 30% higher than in Run I

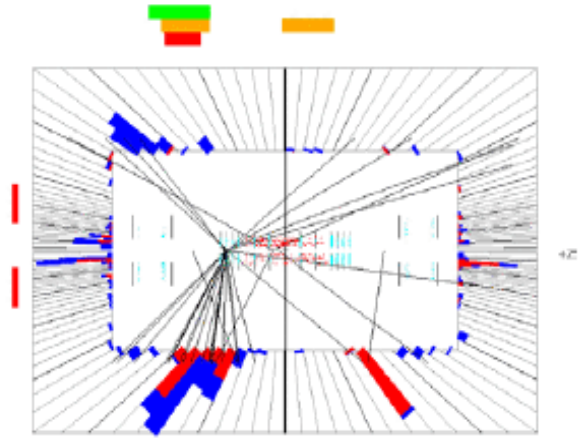
No Run II mass measurement yet



$$\sigma(t\,\bar{t}) = 8.5^{+4.5}_{-3.6}(\text{stat})^{+6.3}_{-3.5}(\text{sys}) \pm 0.8\,(\text{lumi})\,\text{pb}$$

eμ Top candidate





e+	P_T= 20.3
μ−	P_T= 58.1
j	P_T= 141.0
j	P_T= 55.2
$\not{E}_T$	91 GeV

0.5 events expected, 1 event observed
expected background: 0.07 +- 0.01

C. Gerber (UIC)

Summary

- First DØ Run II results with L=40-50 pb^{-1} (about half of Run I)
- >140 pb^{-1} on tape -> more at summer conferences
- With about 300 pb^{-1} we expect to significantly improve on many LEP results
- Basic objects (jets, tracks, electrons, muons) are well understood
- In high energy collider physics this will be the decade of the Tevatron