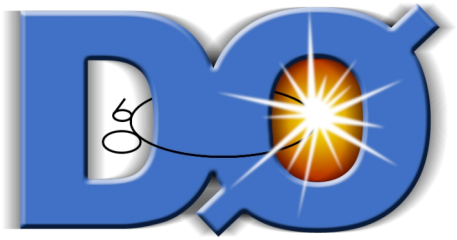
MANCHESTER 1824

The University of Manchester

Dzero Physics Highlights from Moriond



Stefan Söldner-Rembold

University of Manchester

Fermilab Joint Experimental-Theoretical Seminar

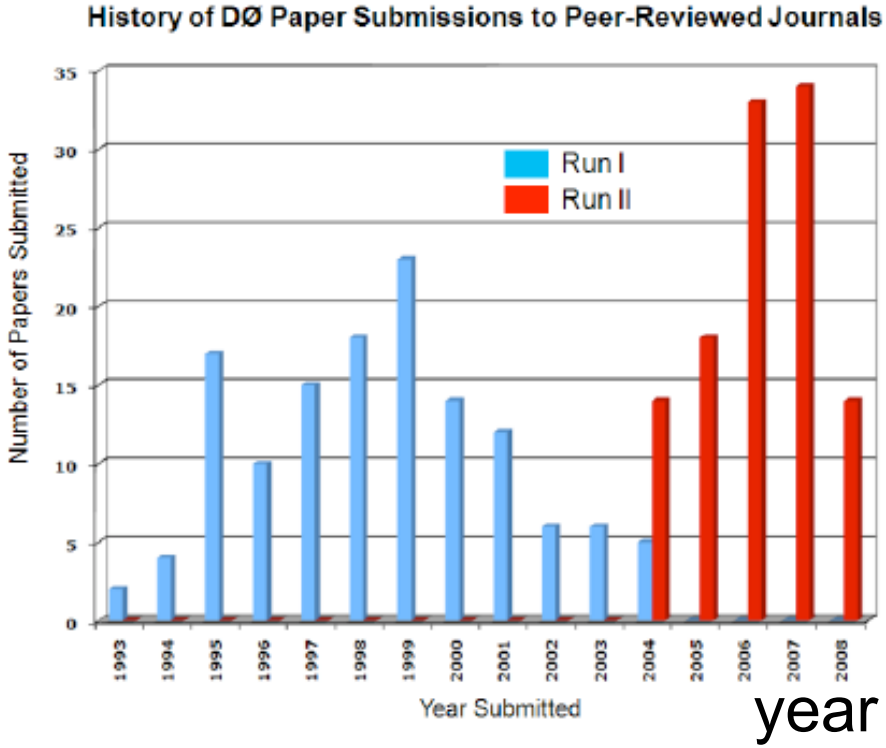
'Wine & Cheese'

Since September 2007, we have released

- 14 preliminary results
- 28 journal papers (~ 1/week)

covering

- QCD
- B Physics
- Electroweak Physics
- Top Physics
- Higgs Searches
- New Phenomena

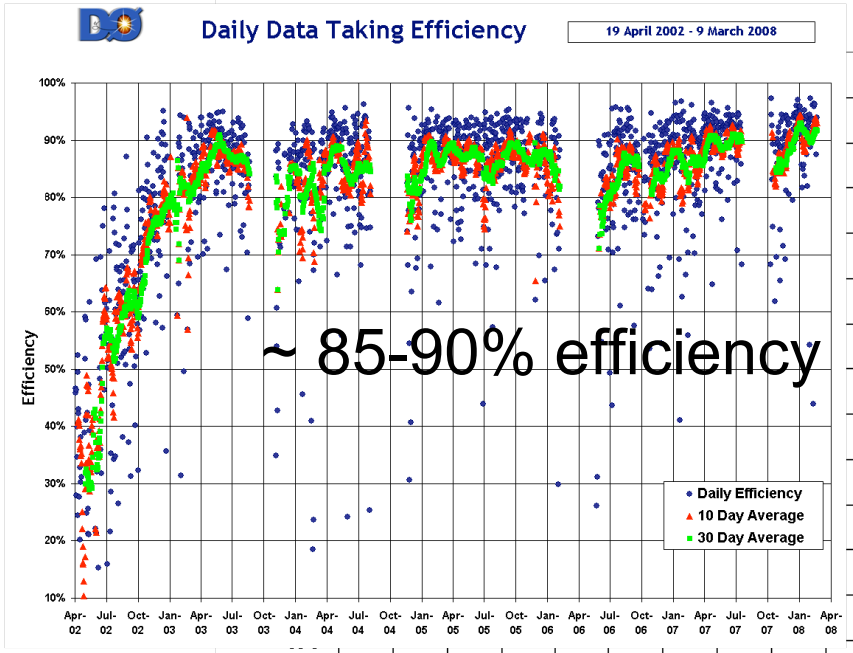


year

http://www-d0.fnal.gov/Run2Physics/WWW/results.htm

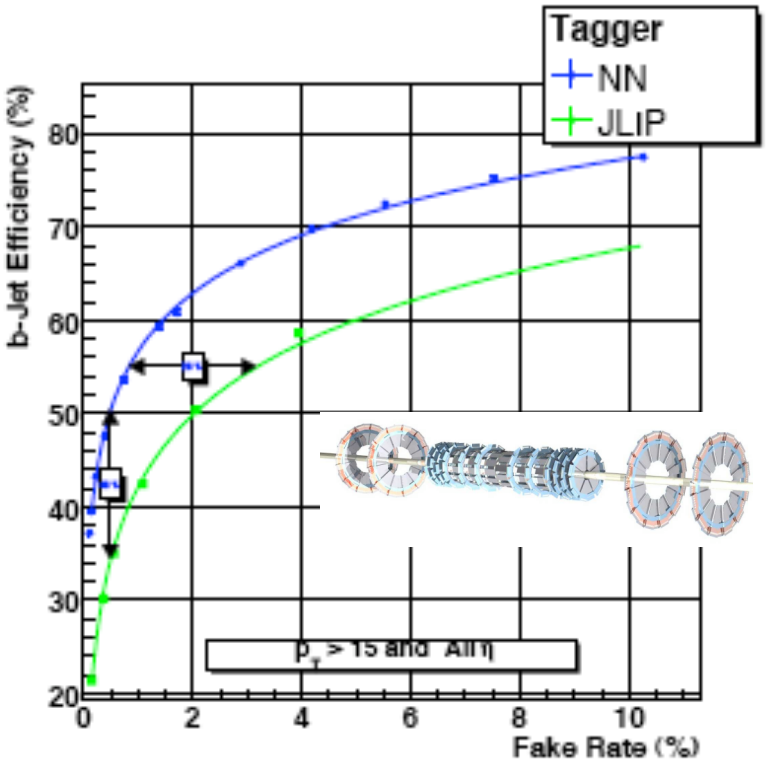
Data Set

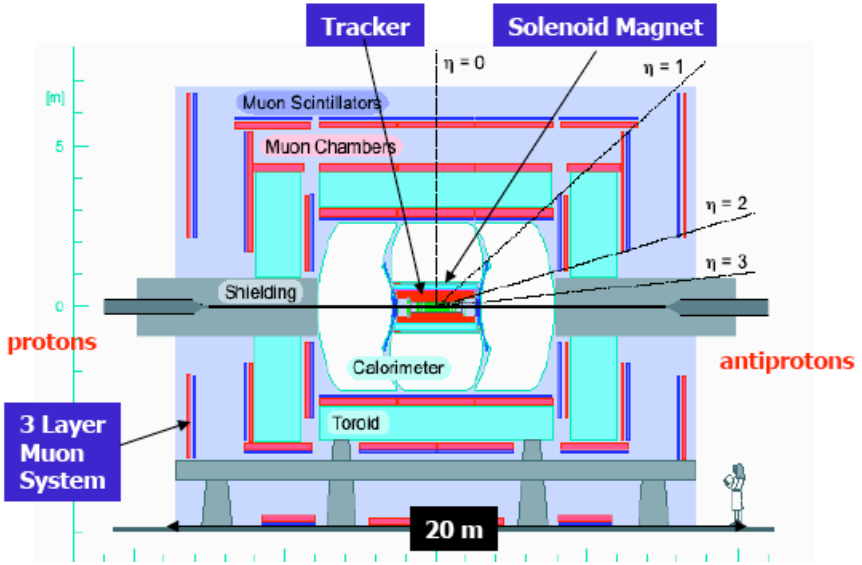
A big thank you to the Accelerator Division !

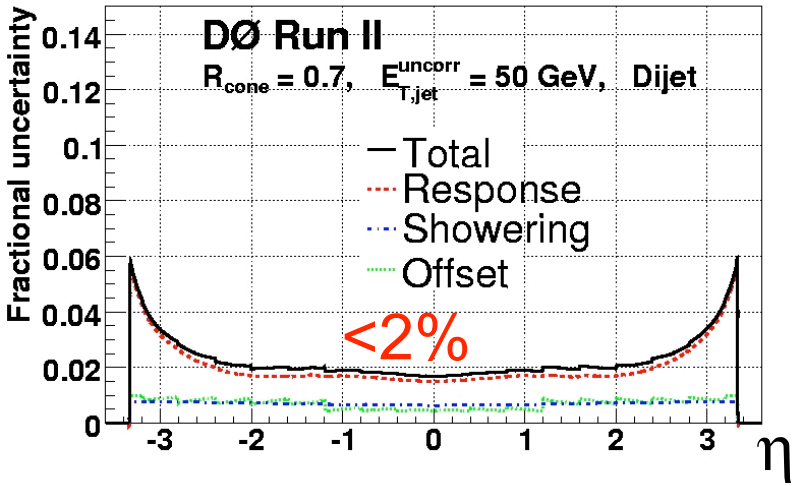


3.2 fb^{-1}

Performance of the Detector

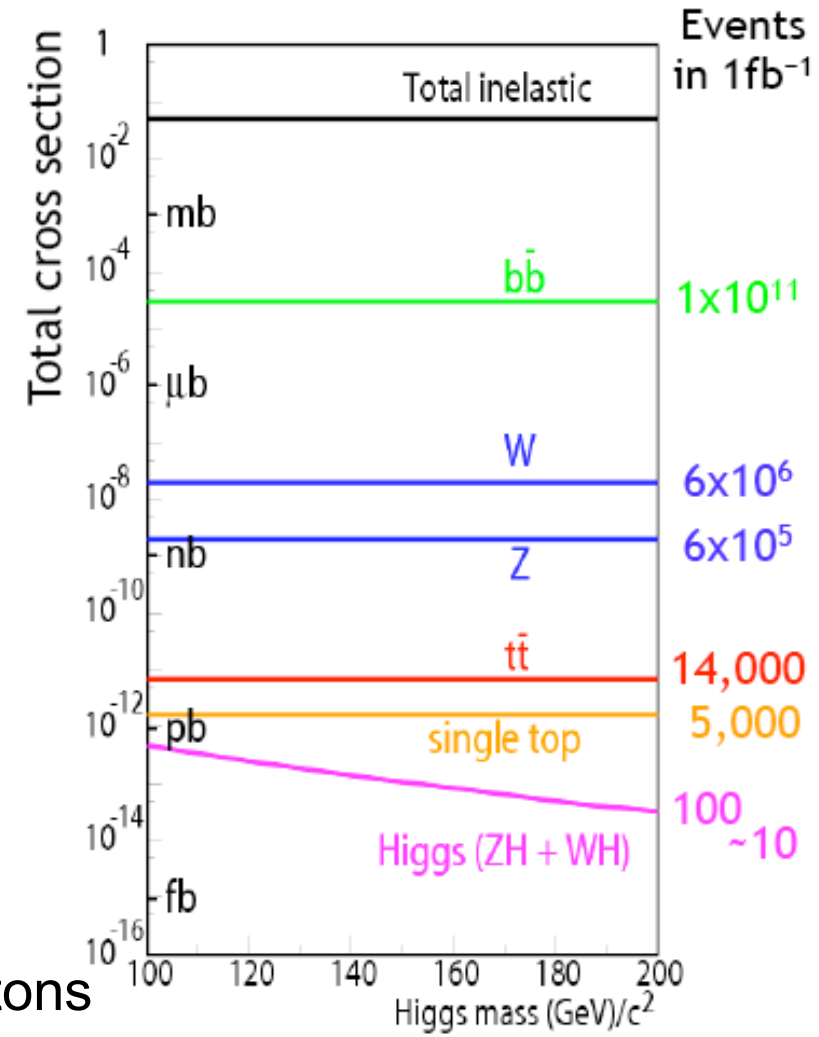




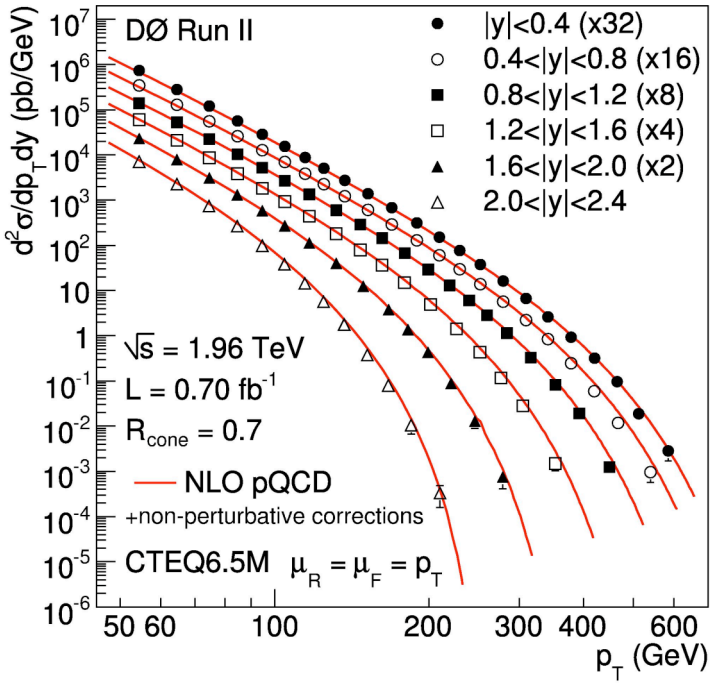


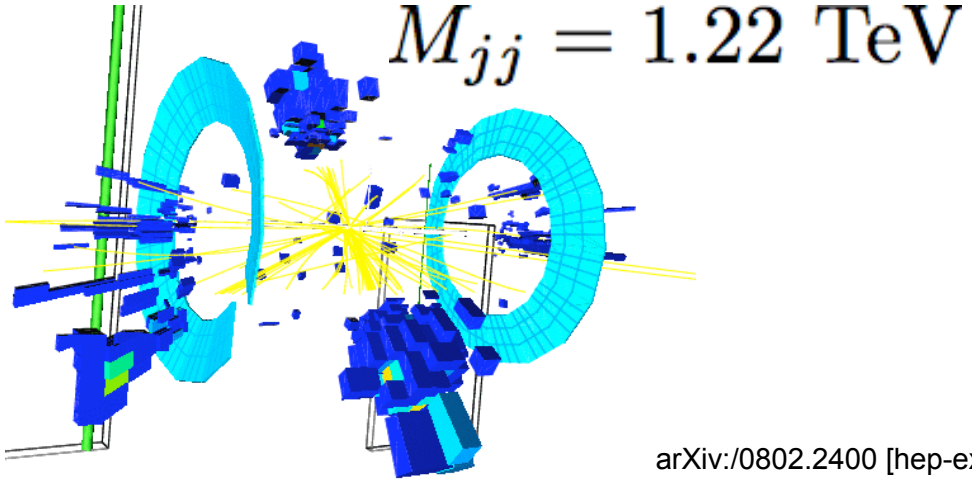
Today's Programme

- inclusive jets
- W + charm jets
- Z transverse momentum
- B_c mass and lifetime
- B_s mixing parameters
- CPV in B+ decays
- Top cross-section and mass
- Top resonances
- Wγ & radiation amplitude zero
- ZZ production
- low and high mass SM Higgs
- fermiophobic Higgs
- squarks and gluinos
- stop in charm plus missing E_T
- large extra dimensions in mono-photons

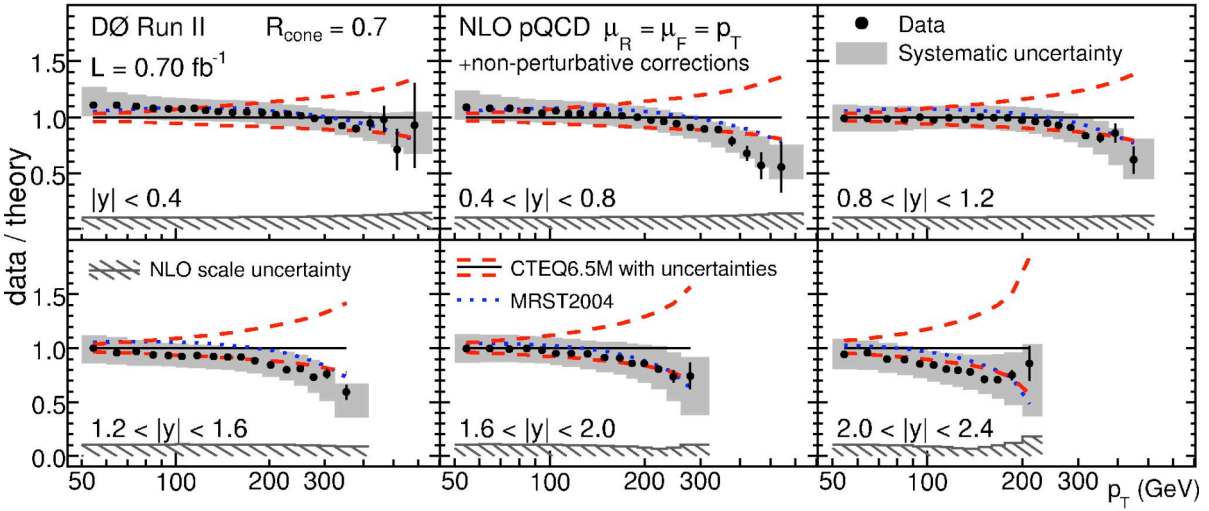


Understanding the basics: inclusive jets





arXiv:/0802.2400 [hep-ex]

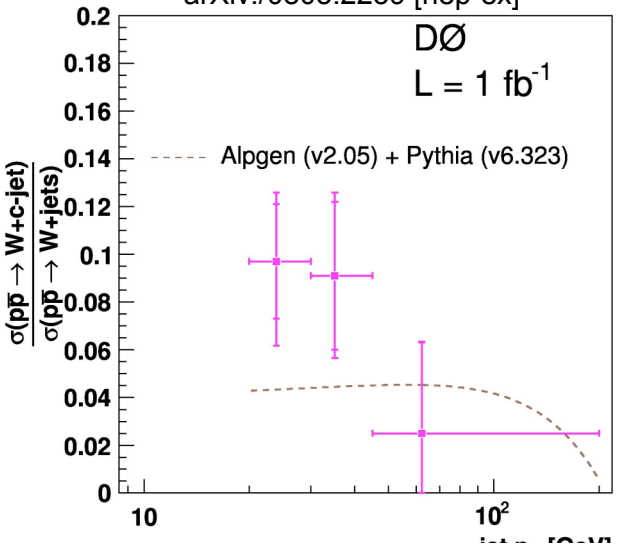


constrain pdf's
test QCD calculations

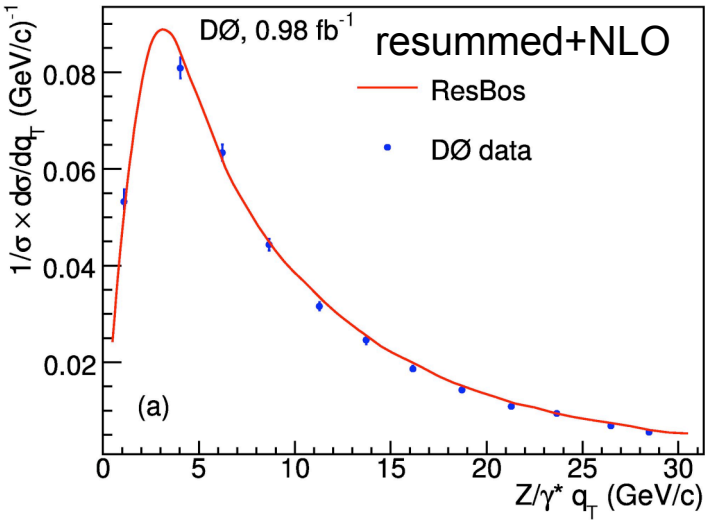
most precise measurement and over widest kinematic range to date

Understanding the basics: W and Z

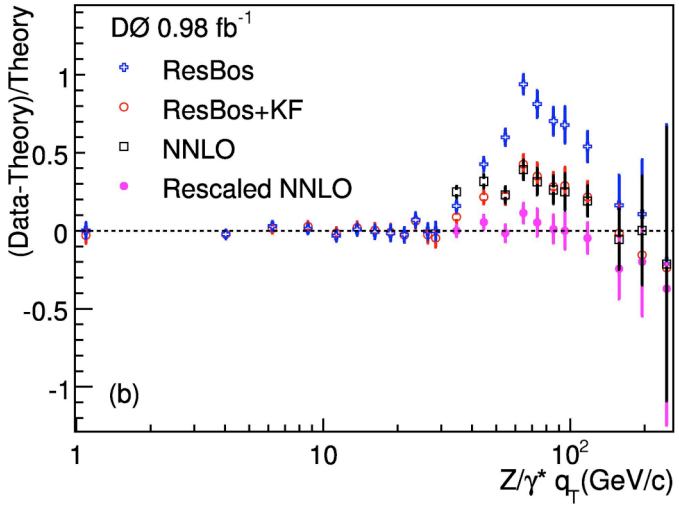
arXiv:/0803.2259 [hep-ex]



Phys. Rev. Lett. 100 , 102002 (2008)

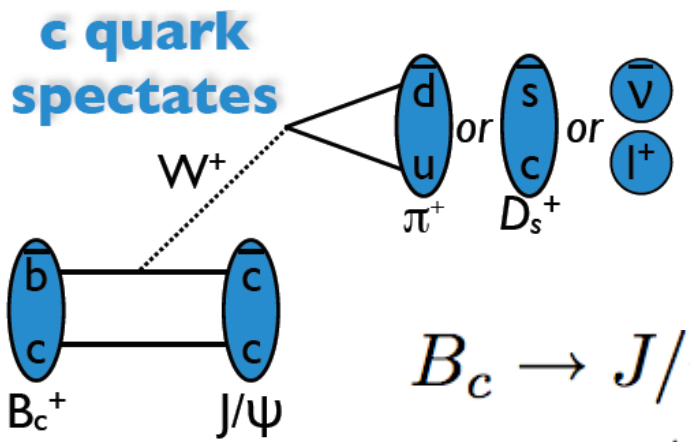


$$\frac{\sigma\,[W + c\text{-jet}]}{\sigma\,[W + \text{jets}]} = 0.074 \pm 0.019(\text{stat.})^{+0.012}_{-0.014}(\text{syst.})$$



-many systematics cancel in ratio
-3.5σ significance
-sensitive to s(x,Q^2)
-important for many searches

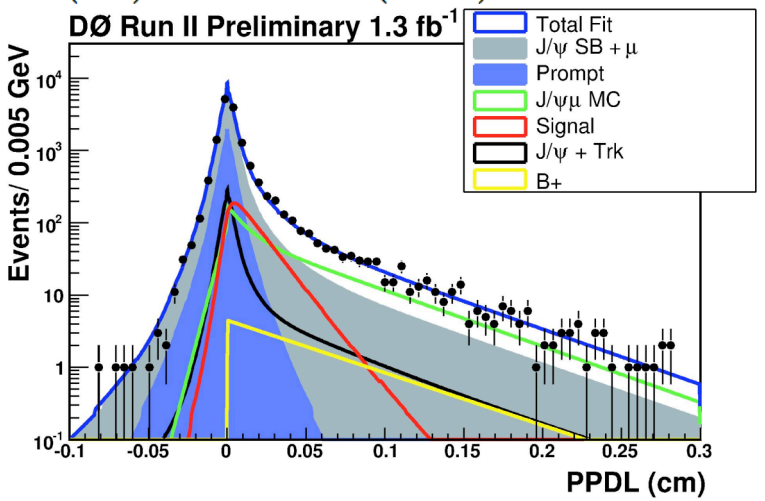
Mass and lifetime of the B_c Meson



$$B_c \to J/\psi\mu\nu$$

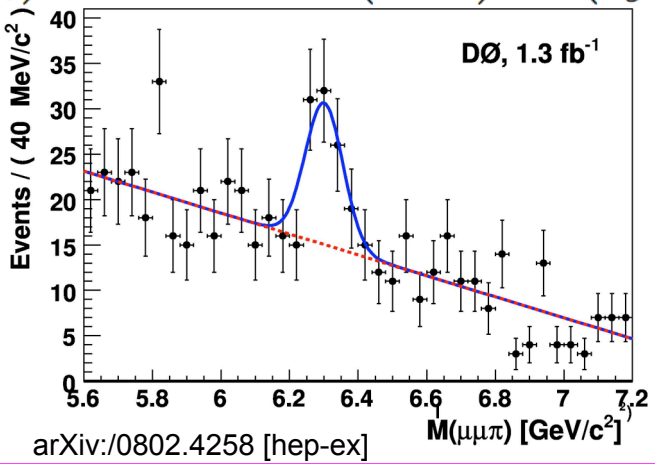
$$B_c \to J/\psi\pi^+$$

$$N(B_c) = 856 \pm 85(stat.)$$



Pseudo Proper Decay Length (PPDL)

$$m(B_c) = 6300.7 \pm 14(stat.) \pm 5(syst.)\ \text{MeV}$$



arXiv:/0802.4258 [hep-ex]

$$\lambda = L_{xy}\frac{m(B_c)}{p_T(J\psi\mu)} = c\tau\ \frac{1}{K}$$

$$L_{xy} = c\tau\frac{p_T}{m} \qquad K = \frac{p_{T(J\psi\mu)}}{p_{T(B_c)}}$$

most precise result

$$\tau(B_c) = 0.444^{+0.039}_{-0.036}(stat.)^{+0.039}_{-0.033}(syst.)\ \text{ps}$$

many results on B spectroscopy, lifetimes

B_s^0 mixing parameters from $B_s^0 \to J/\psi\phi$

see W&C by B.Hoeneisen

If CPT is a symmetry,

$$i\frac{d}{dt}\begin{pmatrix} B_s(t) \\ \bar{B}_s(t) \end{pmatrix} = \left(\begin{bmatrix} m & M_{12}^s \\ M_{12}^{s*} & m \end{bmatrix} - \frac{i}{2}\begin{bmatrix} \Gamma & \Gamma_{12}^s \\ \Gamma_{12}^{s*} & \Gamma \end{bmatrix} \right) \begin{pmatrix} B_s(t) \\ \bar{B}_s(t) \end{pmatrix}$$

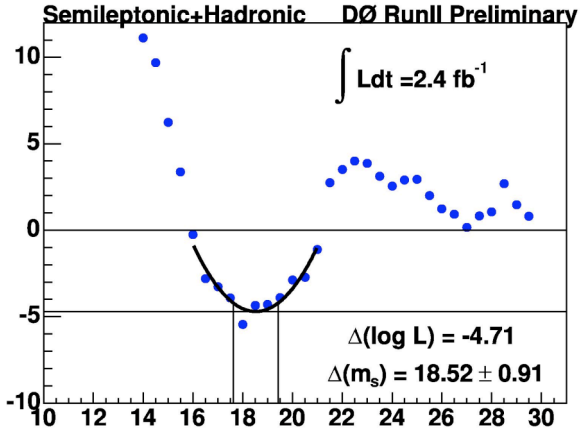
The eigenvalues are

$$M_s + \frac{1}{2}\Delta M_s - \frac{i}{4}(\Gamma_s - \Delta\Gamma_s),$$
$$M_s - \frac{1}{2}\Delta M_s - \frac{i}{4}(\Gamma_s + \Delta\Gamma_s),$$

where $\Delta M_s > 0$ by definition.

The CP-violating phase is

$$\phi_s \equiv \arg\left(\frac{\Gamma_{12}^s}{M_{12}^s}\right).$$



$\Delta M_s(ps^{-1})$

$\Delta M_s = 17.77 \pm 0.12\ \text{ps}^{-1}$ CDF

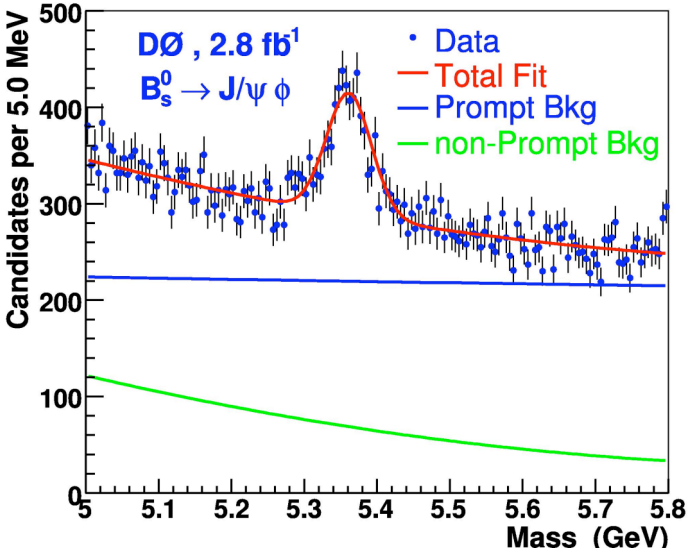
New physics may alter ϕ_s (SM ϕ_s = - 0.038 ± 0.002)

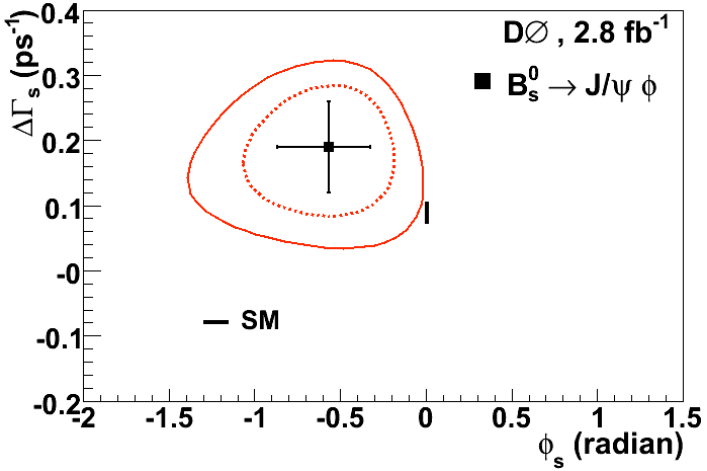
B_s^0 mixing parameters from $B_s^0 \to J/\psi\phi$

Simultaneous unbinned maximum likelihood fit to distribution of

- proper decay time
- three decay angles
- mass

Events are flavour tagged (opposite and same side)





CP violating phase

$$\Delta\Gamma_s = 0.19 \pm 0.07(stat.)^{+0.02}_{-0.01}(syst.)\ \mathrm{ps}^{-1}$$

$$\phi_s = -0.57^{+0.24}_{-0.30}(stat.)^{+0.07}_{-0.02}(syst.)$$

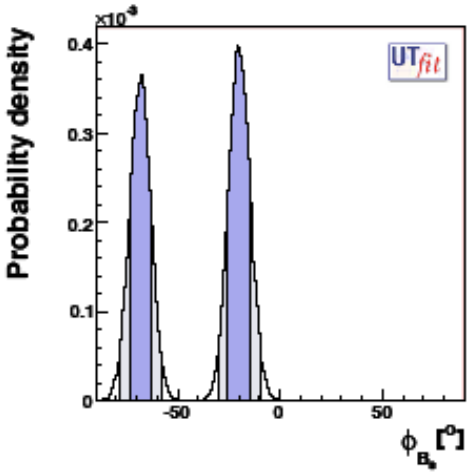
$$P_{SM}(\phi_s) = 6.6\%$$

FIRST EVIDENCE OF NEW PHYSICS IN b ↔ s TRANSITIONS

(**UT***fit* Collaboration)

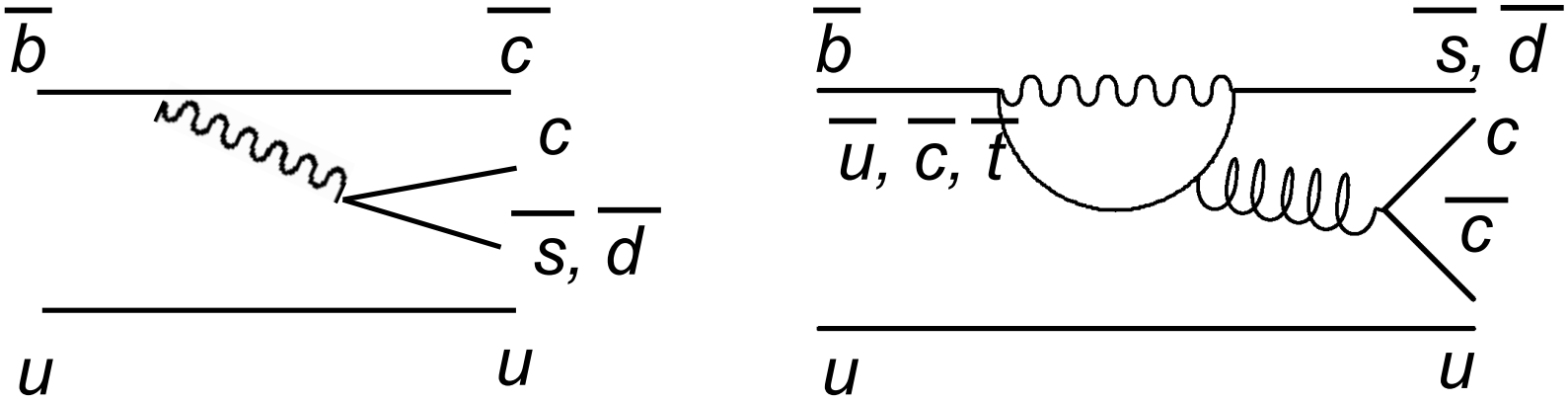
M. Bona,[1] M. Ciuchini,[2] E. Franco,[3] V. Lubicz,[2,4] G. Martinelli,
P. Roudeau,[7] C. Schiavi,[6] L. Silvestrini,[3] V. Sordini,[7] A. Sto

[1] *CERN, CH-1211 Geneva 23, Switzerlan*
[2] *INFN, Sezione di Roma Tre, I-00146 Roma,*
[3] *INFN, Sezione di Roma, I-00185 Roma, I*
[4] *Dipartimento di Fisica, Università di Roma Tre, I-001*
[5] *Dipartimento di Fisica, Università di Roma "La Sapienza",*
[6] *Dipartimento di Fisica, Università di Genova and INFN, I*
[7] *Laboratoire de l'Accélérateur Linéaire, IN2P3-CNRS et Université de Paris-Sud*
[8] *INFN, Sezione di Bologna, I-40126 Bologna,*



We combine all the available experimental information on B_s mixing, including the very recent tagged analyses of $B_s \to J/\Psi\phi$ by the CDF and DØ collaborations. We find that the phase of the B_s mixing amplitude deviates more than 3σ from the Standard Model prediction. While no single measurement has a 3σ significance yet, all the constraints show a remarkable agreement with the combined result. This is a first evidence of physics beyond the Standard Model. This result disfavours New Physics models with Minimal Flavour Violation with the same significance.

Direct CPV in $B^{\pm} \to J/\psi K^{\pm}(\pi^{\pm})$



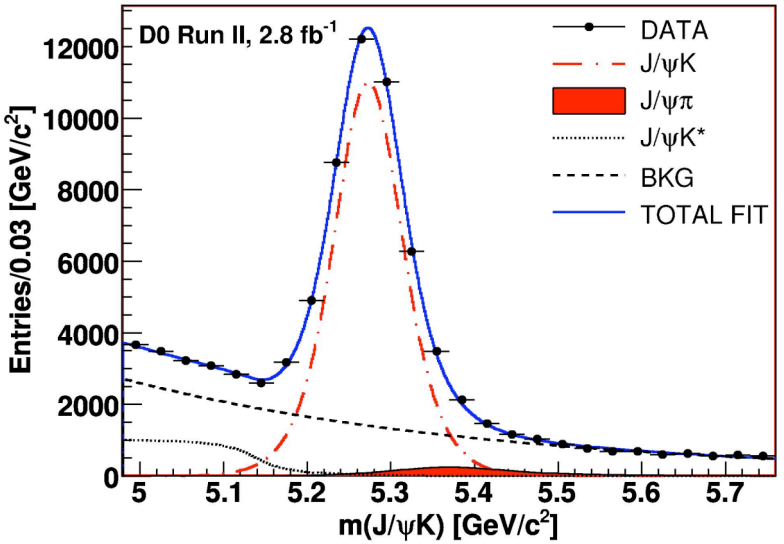
CPV in SM due to different phases

Charge asymmetries:

$$A(B^+ \to J/\psi K^+) \sim 0.003$$

$$A(B^+ \to J/\psi \pi^+) \sim 0.01$$

New phases may enter through new physics



~ 40k signal events

Direct CPV in $B^{\pm} \to J/\psi K^{\pm}(\pi^{\pm})$

$$A = \frac{N(J/\psi(K^-,\pi^-) - N(J/\psi(K^+,\pi^+))}{N(J/\psi(K^-,\pi^-)) + N(J/\psi(K^+,\pi^+))} = \frac{n_- - n_+}{n_- + n_+} \Rightarrow n_{\pm} = \frac{1}{2} N(1 \pm qA)$$

- We need to correct for A_{FB} (K^+ in p direction) and detector asymmetries
- Divide sample into eight mass samples according to signs of
  - solenoid polarity
  - sign of pseudorapidity
  - kaon charge
- Solve the model for all asymmetries to obtain charge asymmetry A
- finally correct for A_K from $\sigma(K^+ D\emptyset) \neq \sigma(K^- D\emptyset)$

$$A(B^+ \to J/\psi K^+) = +0.0074 \pm 0.0061(stat.) \pm 0.0027(syst.)$$

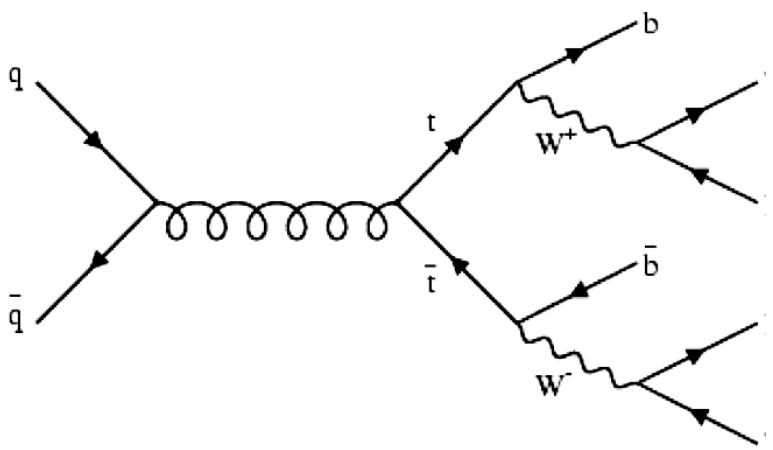
~ 3 times more precise than PDG average

$$A(B^+ \to J/\psi \pi^+) = -0.09 \pm 0.08(stat.) \pm 0.03(syst.)$$

The TevatrOn Particle (TOP)

We are now performing precision tests of the SM in the top sector:

- top cross-section
- top mass
- charge, width, lifetime
- decays, couplings
- CKM elements, Vtb
- spin correlations, charge and FB asymmetries
- W helicity in decays
- charged Higgs, resonances



electron/ muon

neutrino

jet

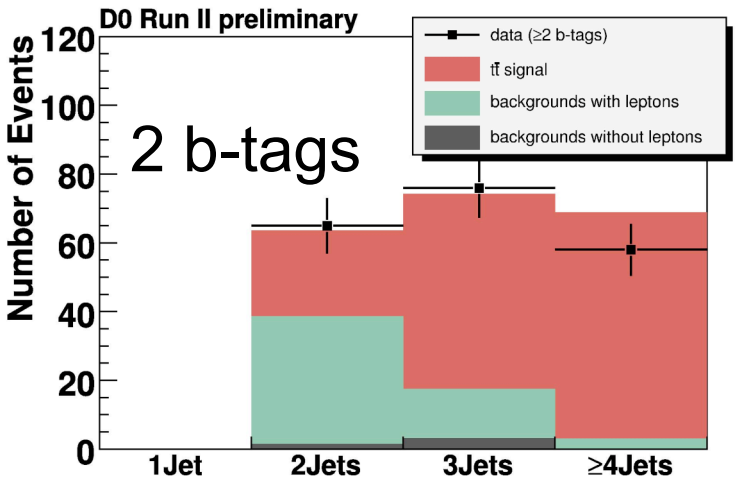
jet

this talk: lepton plus jets

$\sigma(t\bar{t})$ using ℓ + jets

(1) b-tagging

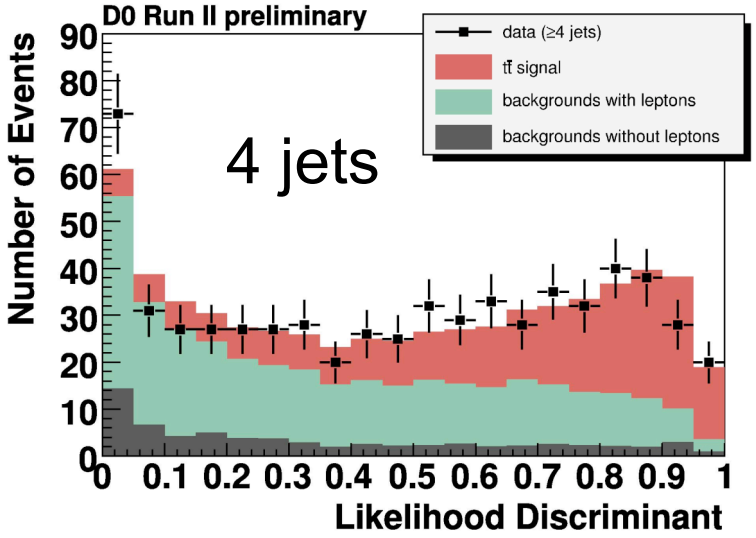
- 1 or 2 b-tags



$L = 0.9\ \mathrm{fb}^{-1}$

(2) likelihood discriminant

- jet transverse momenta (3 and 4 jets)
- angular correlations
- sphericity/aplanarity



arXiv:/0803.2779 [hep-ex]

$\sigma(t\bar{t})$ using ℓ + jets

combination of both analysis with statistical correlation 0.31

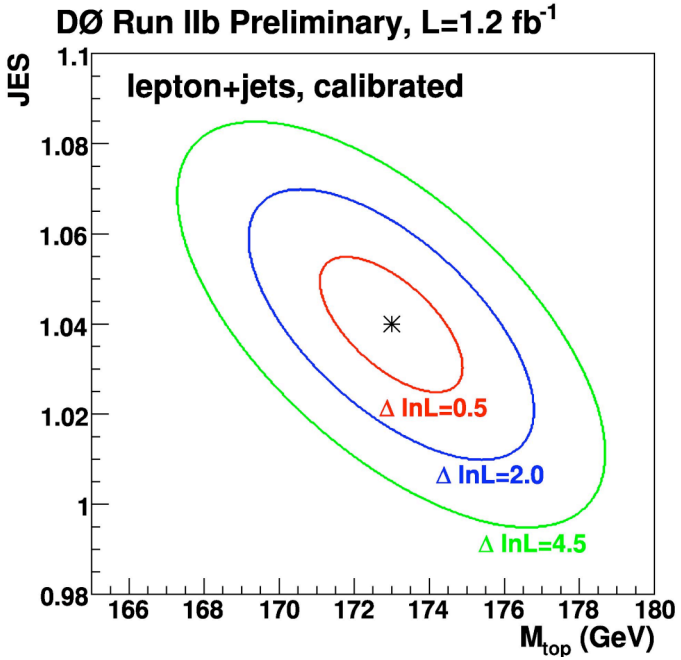
most precise cross section value to date

$$\sigma(t\bar{t}) = 7.62 \pm 0.85 \text{ pb for } m_{top} = 172.6 \text{ GeV}$$

Top Mass (lepton + jets)

$$P_{sig}(x; m_{\rm top}, JES) = \frac{1}{\sigma_{\rm obs}(p\overline{p} \to t\overline{t}; m_{\rm top}, JES)}$$
$$\times \sum_{\rm perm} w_i \int_{q_1,q_2,y} \sum_{\rm flavors} dq_1 dq_2 f(q_1) f(q_2) \frac{(2\pi)^4 \left|\mathcal{M}(q\overline{q} \to t\overline{t} \to y)\right|^2}{2q_1 q_2 s} d\Phi_6 W(x, y; JES).$$

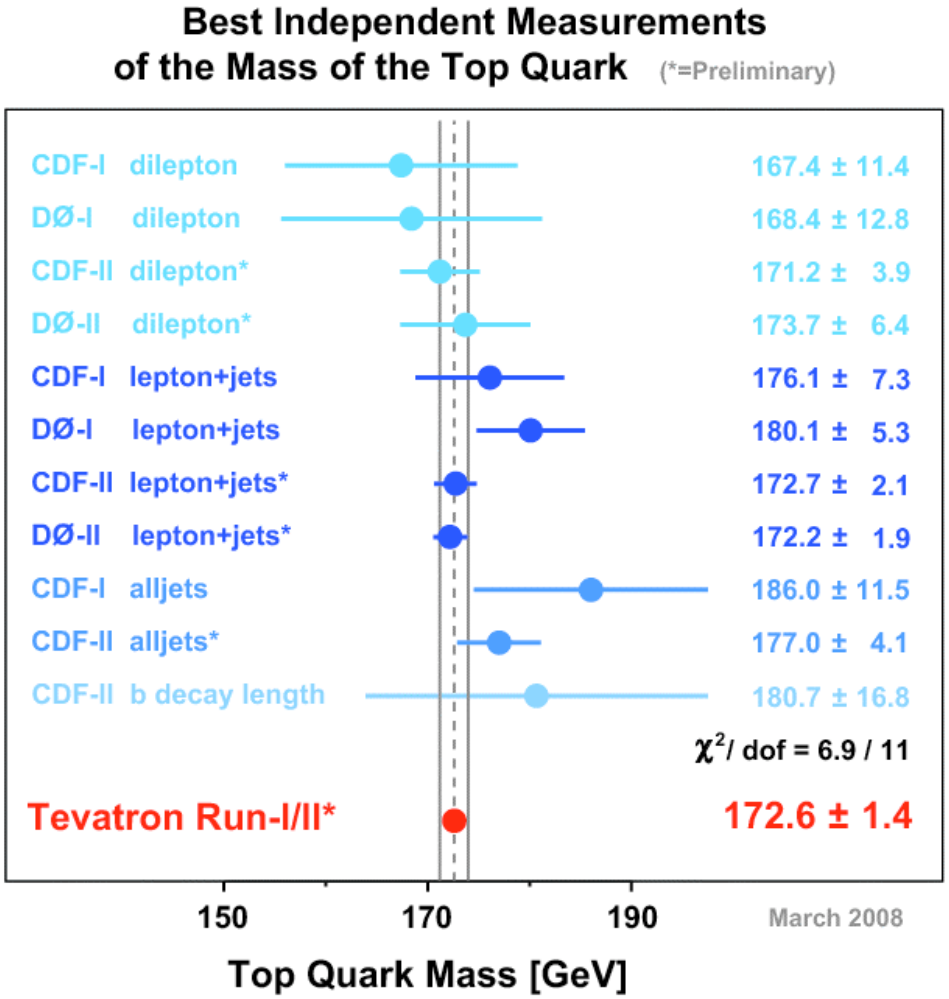
JES fitted in situ using m_W



$$m_{\rm top} = 172.2 \pm 1.1({\rm stat}) \pm 1.6({\rm syst})\ {\rm GeV/c^2} \qquad L = 2.1\ {\rm fb}^{-1}$$

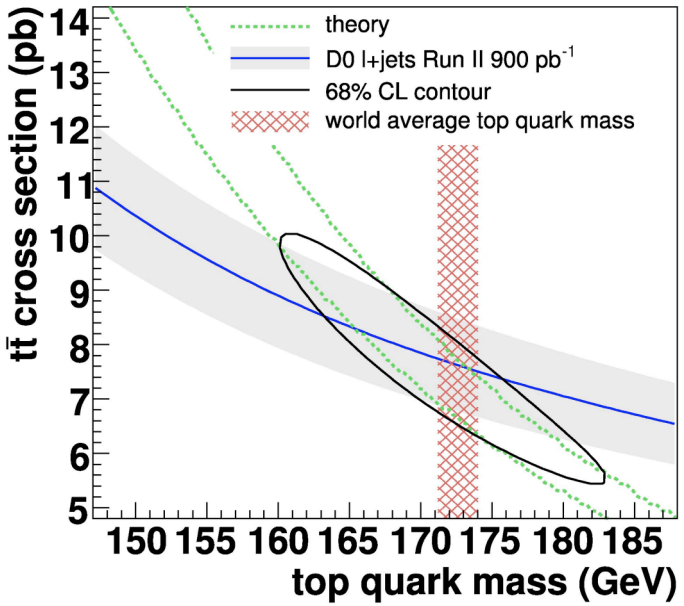
most precise value to date

Top Mass Combination



extract top mass from cross-section with different experimental and theoretical uncertainties

consistent with directly measured m(top)

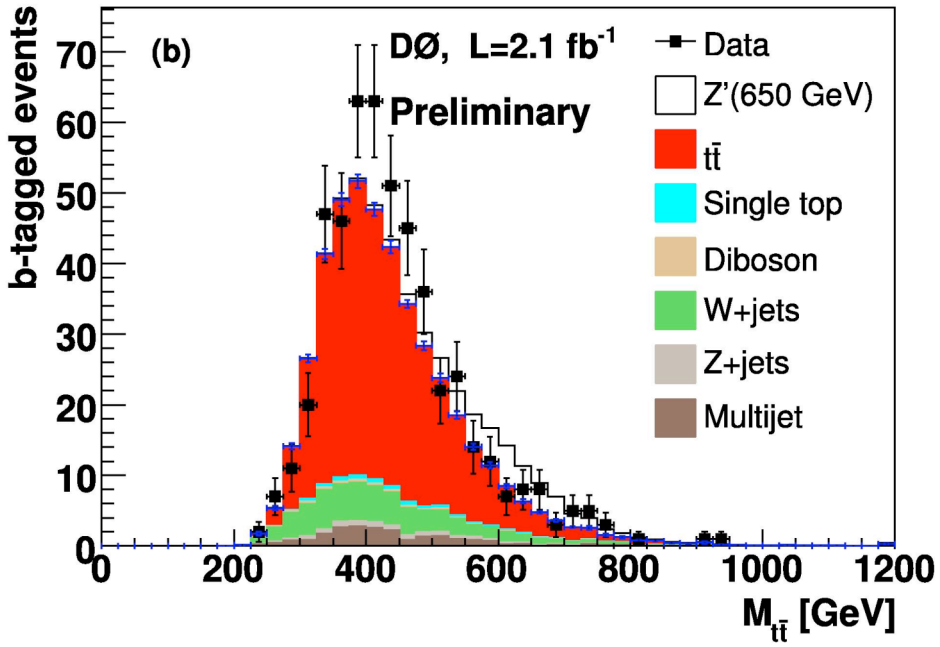


$$m_{top} = 170 \pm 7 \text{ GeV}$$

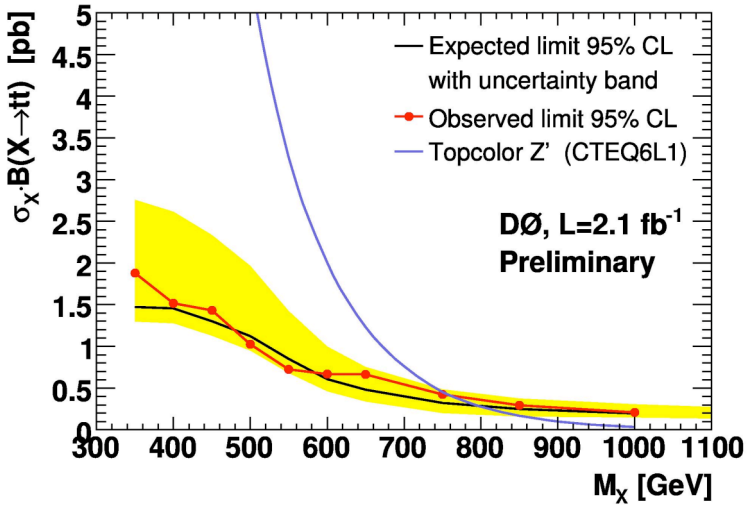
$t\bar{t}$ Resonances

Search for narrow resonance optimised at high masses

$\ell + 4$ jets

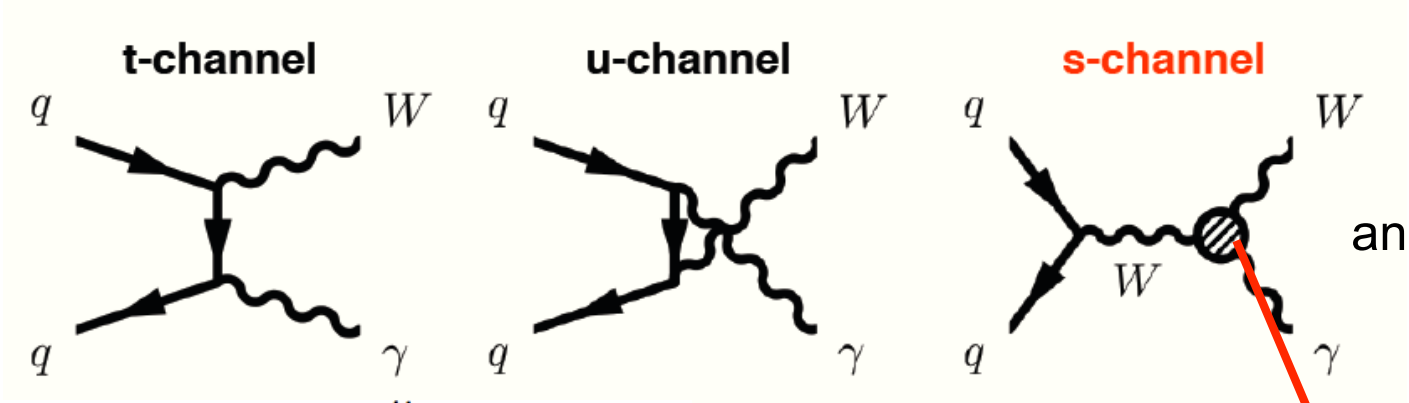


top-colour assisted technicolour: leptophobic heavy boson couples mainly to 3rd generation



$M_{Z'} > 765$ GeV (expected 795 GeV)

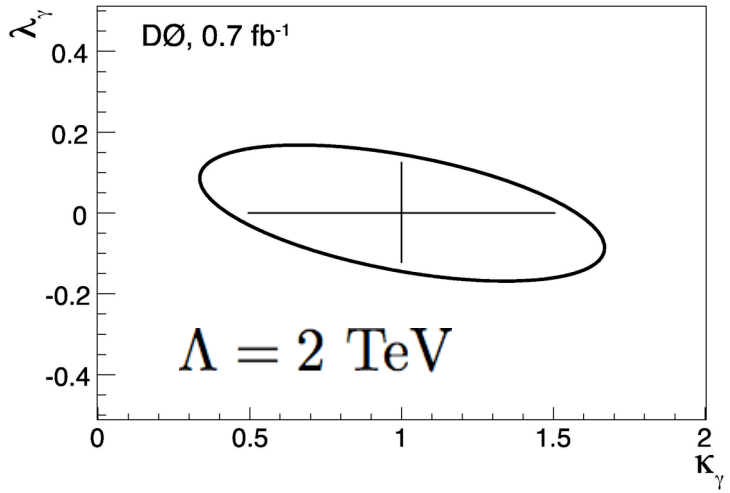
Wγ and Radiation Amplitude Zero (RAZ)

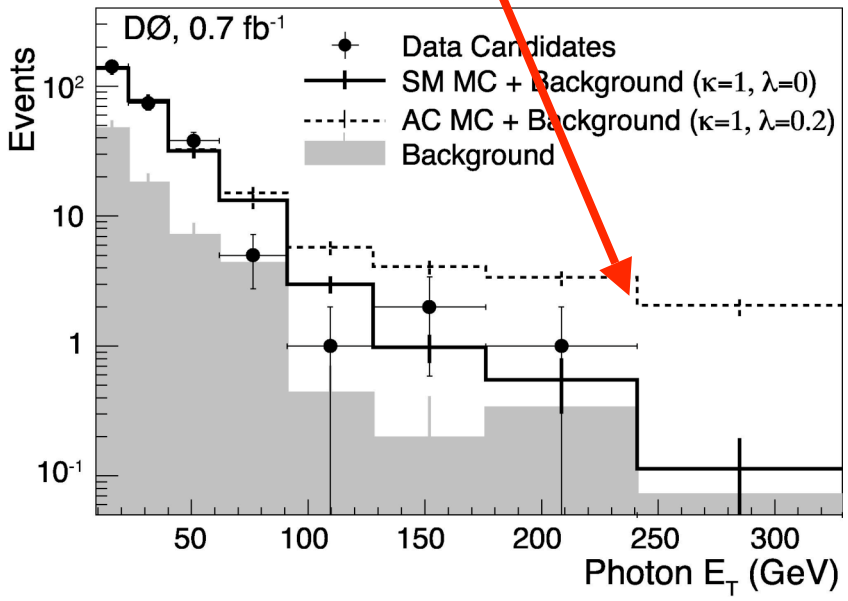


anomalous TGC

$$W \to \mu\nu : \not{E}_T, p_T^{\mu} > 20 \text{ GeV}$$

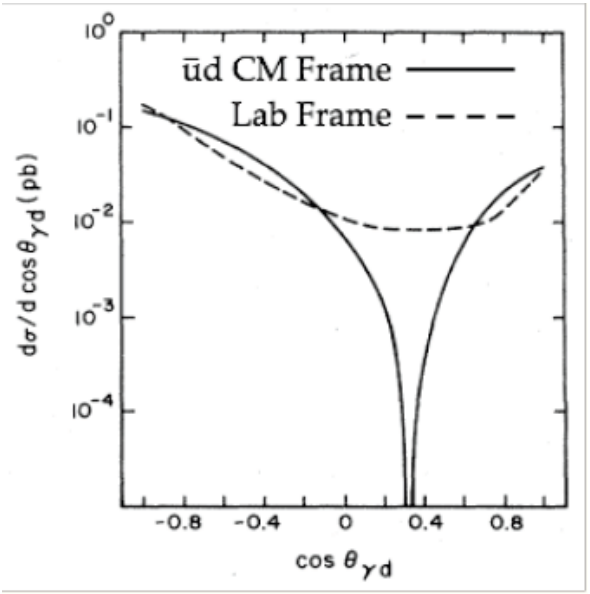
$$W \to e\nu : \not{E}_T, p_T^{e} > 25 \text{ GeV}$$



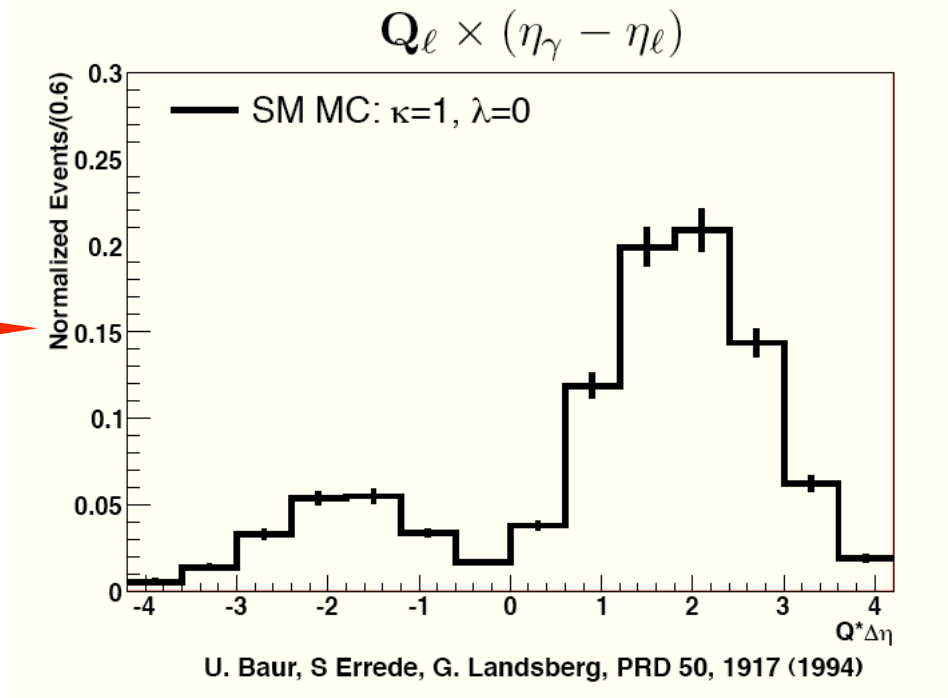


Wγ and Radiation Amplitude Zero (RAZ)

$$d\bar{u} \rightarrow W^{-}\gamma$$



Valenzuela & Smith, PRD 31:2787, 1985



U. Baur, S Errede, G. Landsberg, PRD 50, 1917 (1994)

property of gauge theory

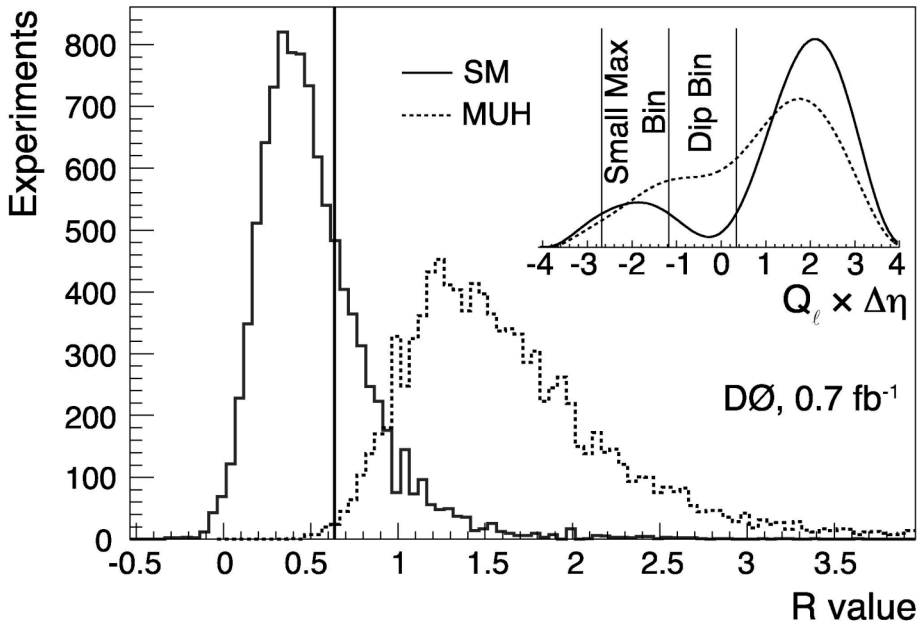
$$\cos(\theta_{\gamma d}) = \frac{q_d + q_u}{q_d - q_u} = -\frac{1}{3}$$

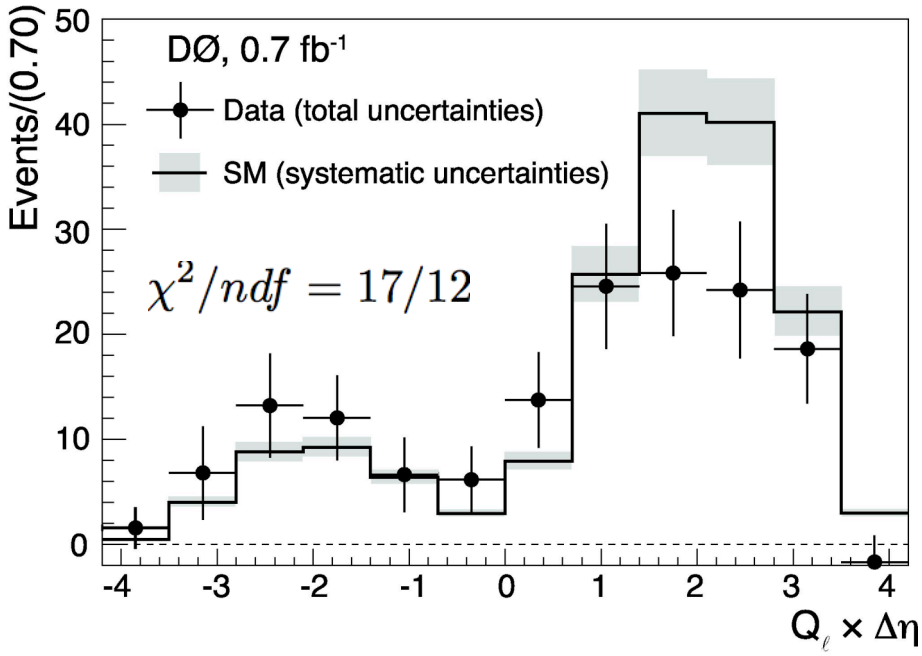
dip diluted by
- final state radiation (FSR) off leptons
- NLO corrections
- background
- anomalous couplings

Wγ and Radiation Amplitude Zero (RAZ)

$$R = \frac{N_{\text{small max bin}}}{N_{\text{dip bin}}}$$

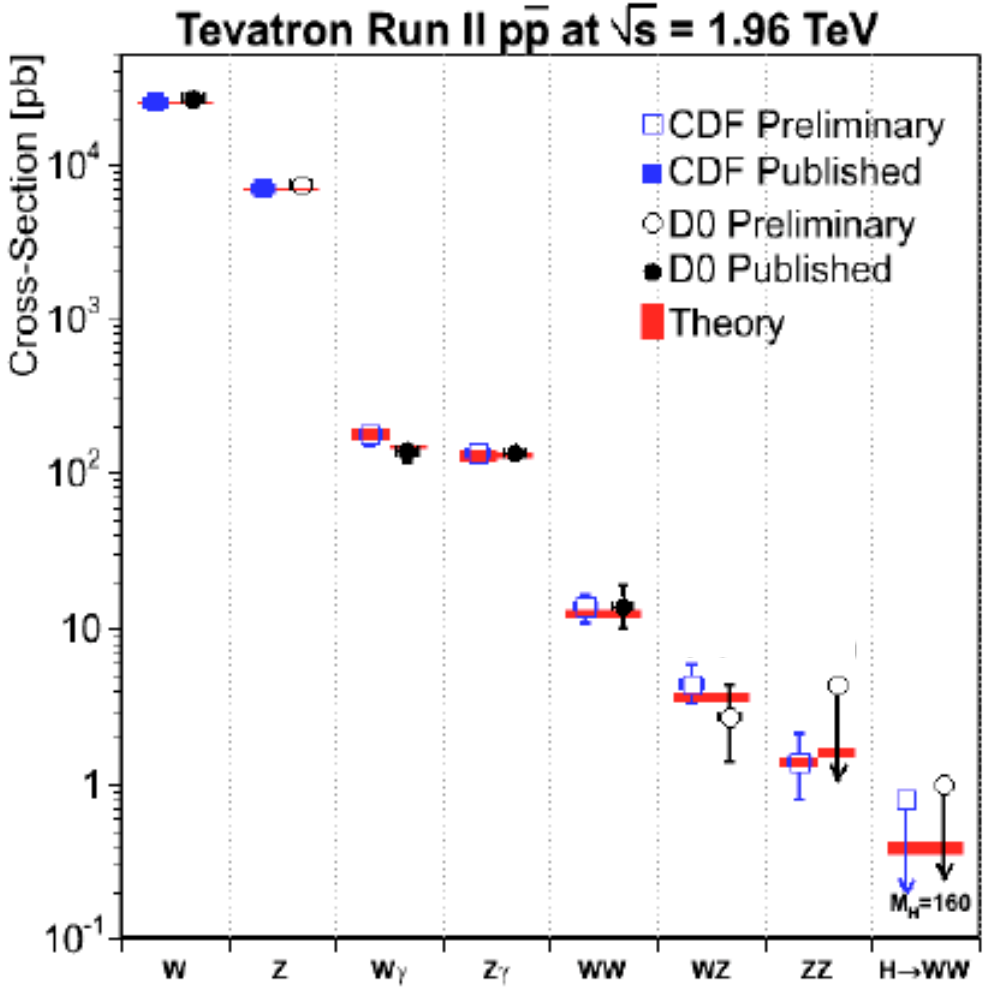
arXiv:/0803.0030 [hep-ex]





$$p_{\text{uni modal}} < (4.5 \pm 0.7) \times 10^{-3}$$

first indication of Radiation Amplitude Zero


Tevatron Run II pp̄ at √s = 1.96 TeV
Cross-Section [pb]
10^4
10^3
10^2
10
1
10^-1
CDF Preliminary
CDF Published
D0 Preliminary
D0 Published
Theory
M_H=160
W
Z
Wγ
Zγ
WW
WZ
ZZ
H→WW

$ZZ \to \ell\ell\nu\nu$

Define a variable $\hat{\not\!\!E}_T$ sensitive to 'true' $\not\!\!E_T$:

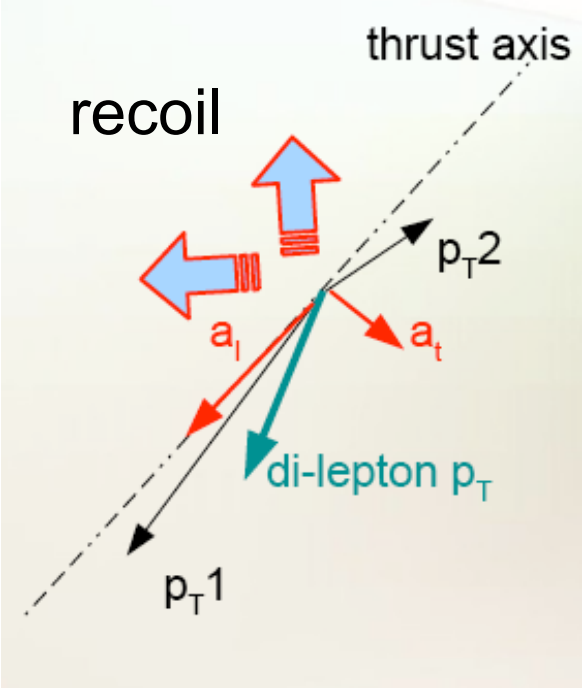
Decompose lepton p_T into a_l and a_t using thrust axis.

Construct $\hat{\not\!\!E}_T$ giving more weight to a_t

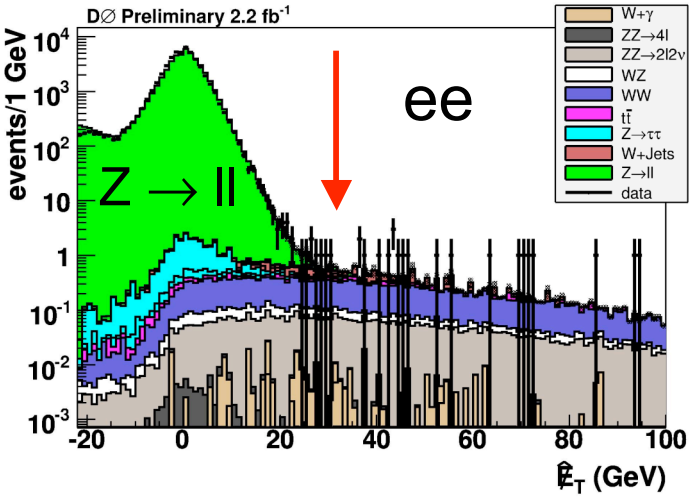
Corrections due to
- lepton mis-measurements
- hadronic recoil (tracks & calorimeter)

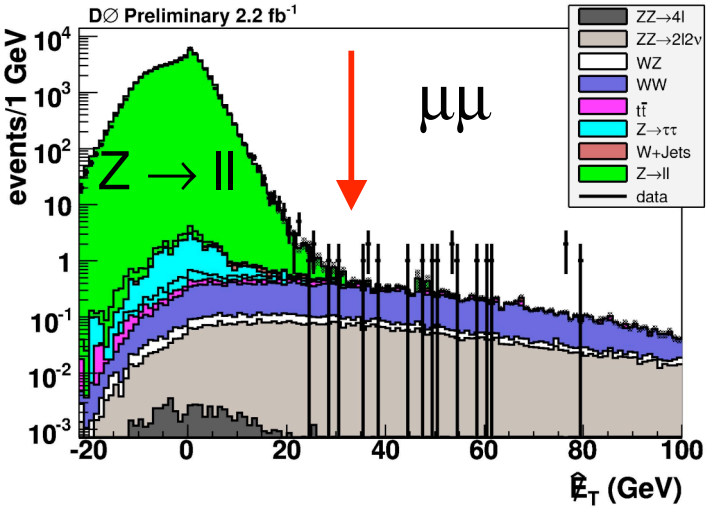
are applied if they reduce $\hat{\not\!\!E}_T$

By construction, all corrections reduce $\hat{\not\!\!E}_T$



$ZZ \to \ell\ell\nu\nu$

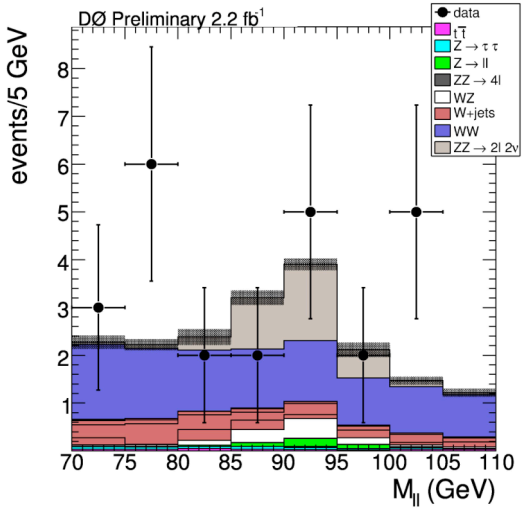




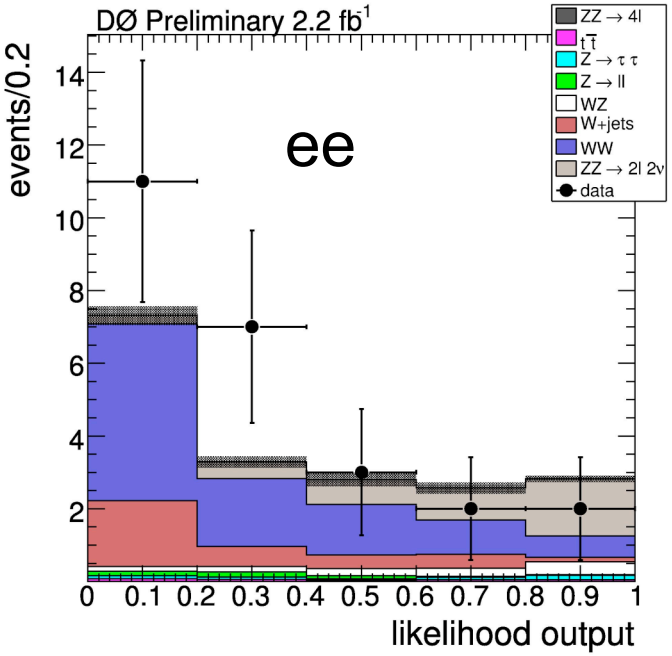
WW

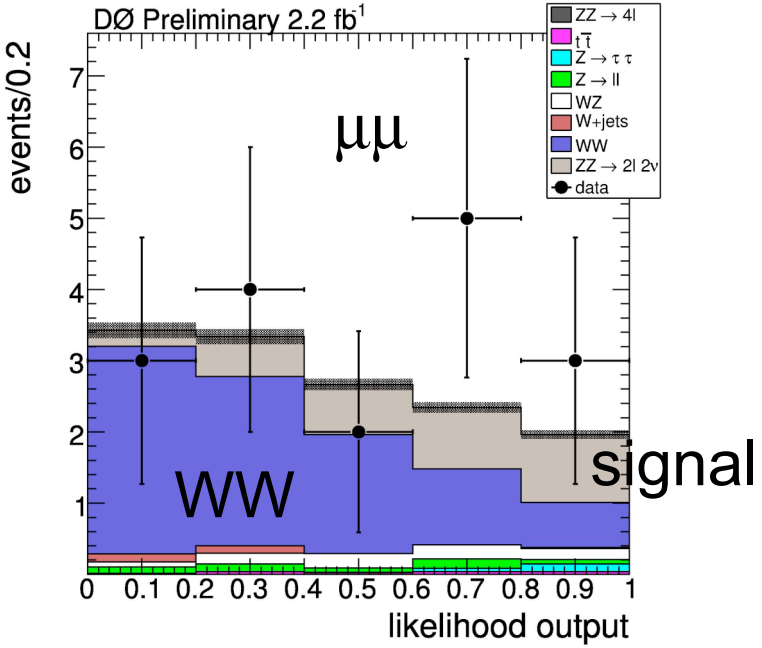
Likelihood discriminant:

- di-lepton mass
- p_T of the leading lepton
- scattering angle of the negative lepton in the di-lepton rest frame
- angle between the leading lepton and the di-lepton system



$ZZ \to \ell\ell\nu\nu$





$$\sigma(ZZ) = 2.1 \pm 1.1(stat.) \pm 0.4(syst.)\ \text{pb}$$

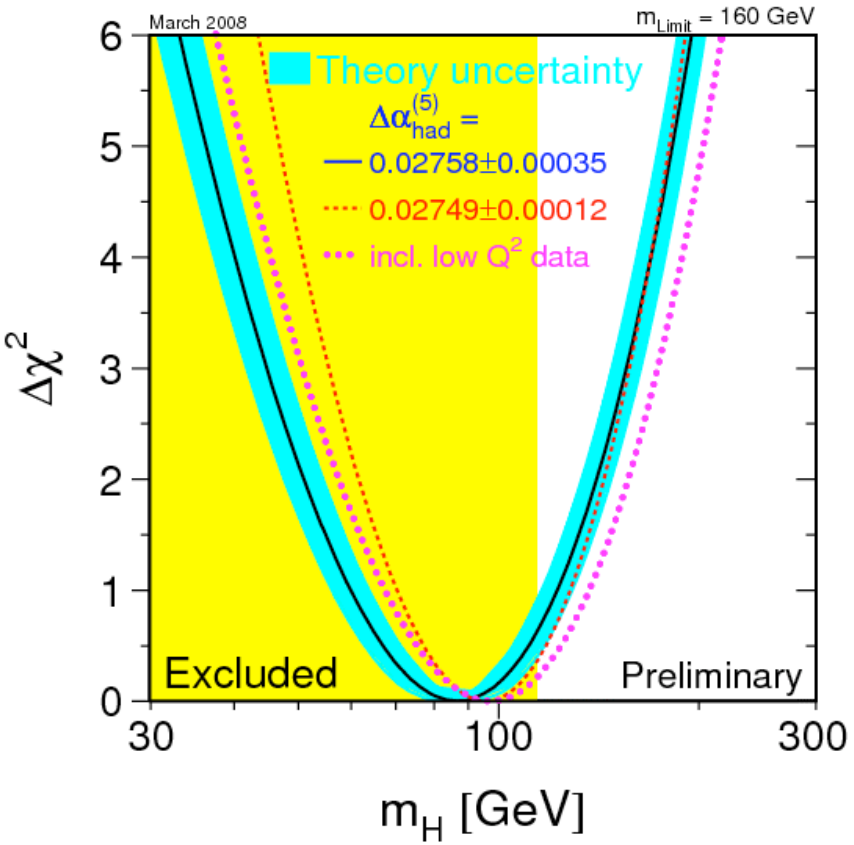
significance: 2.4σ observed, 1.8σ expected

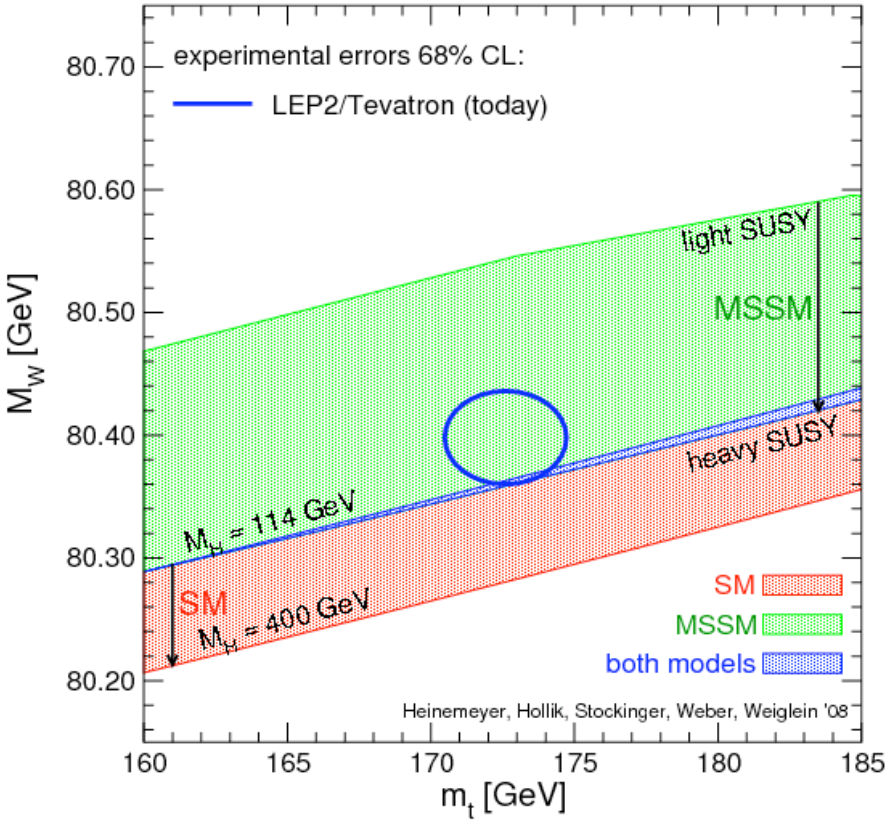
$$\sigma(ZZ) = 1.6 \pm 0.1\ \text{pb}\ (\text{SM})$$

Stalking the Higgs

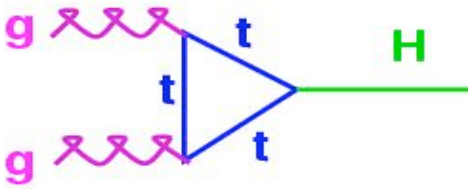
A light Higgs might be around the corner (if the SM is correct)

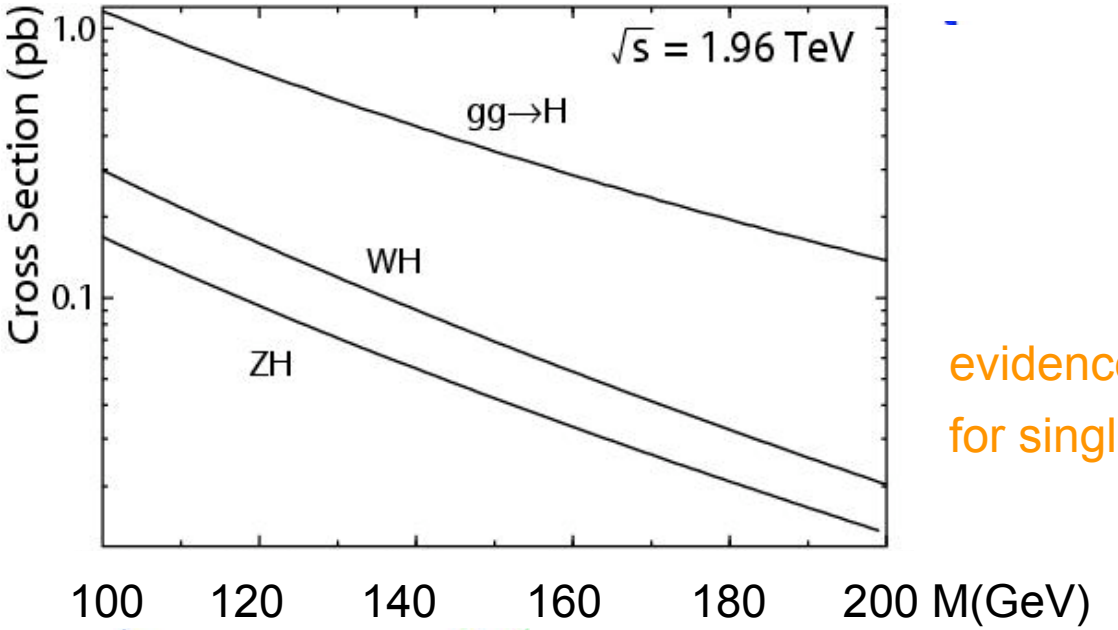
$$m_H = 87 \pm {}^{36}_{27}\ \text{GeV}$$



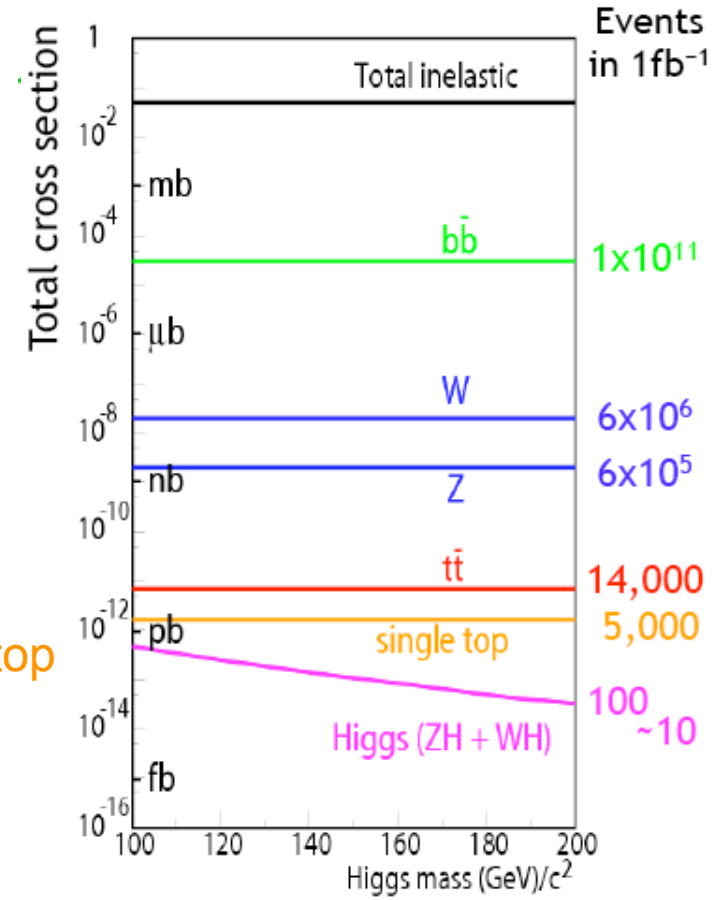


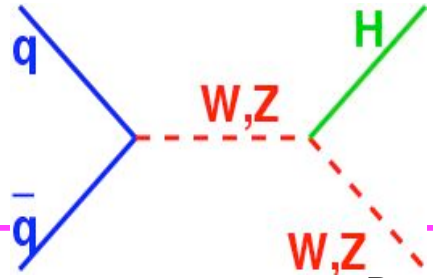
Production at the Tevatron..





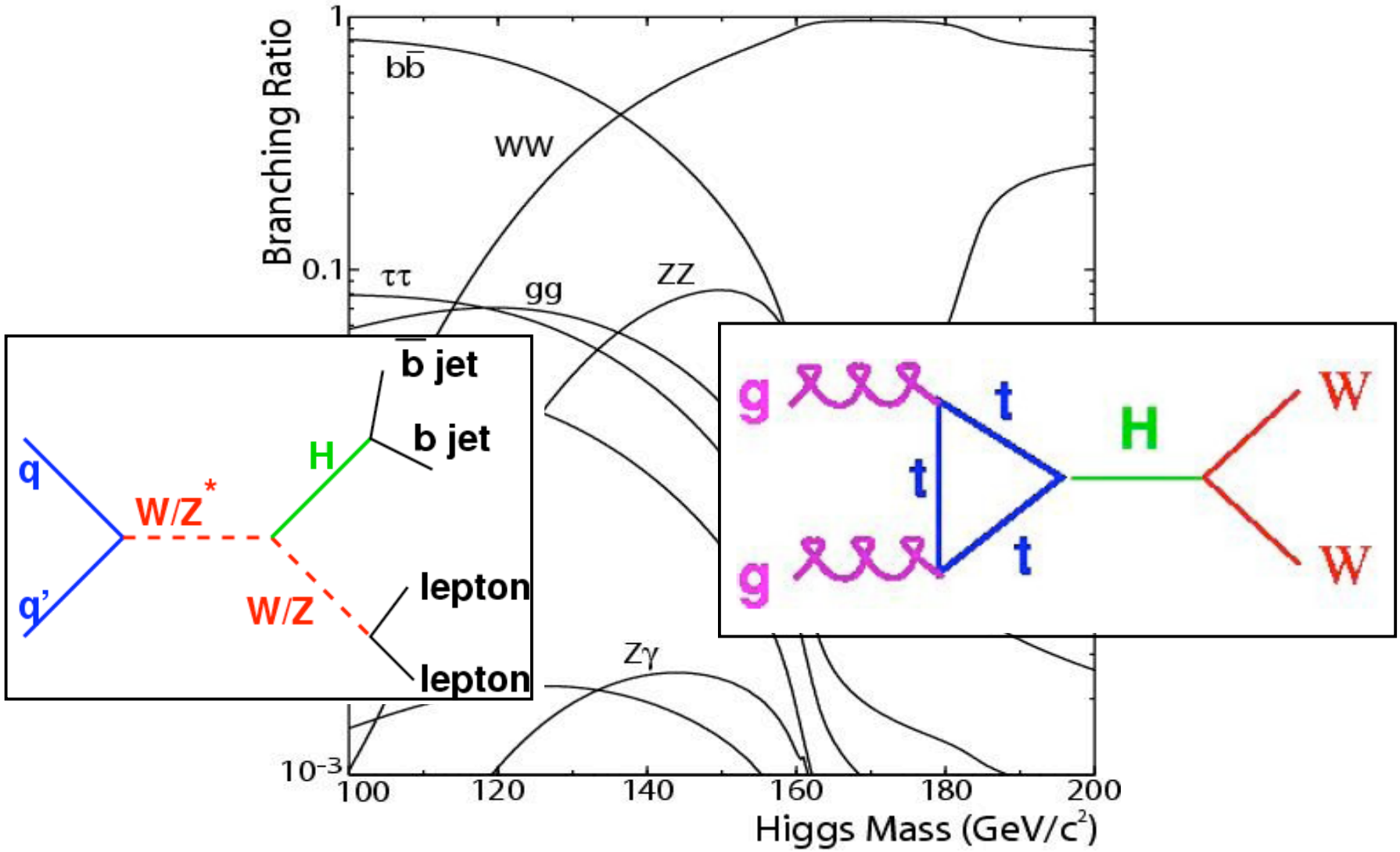
evidence for single top



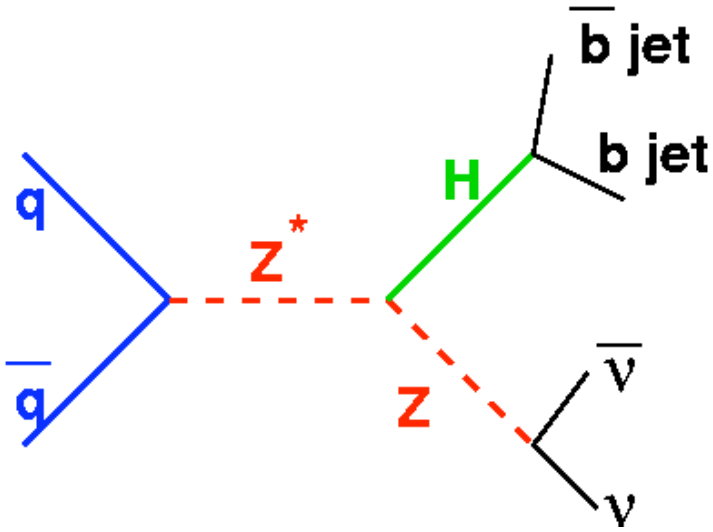


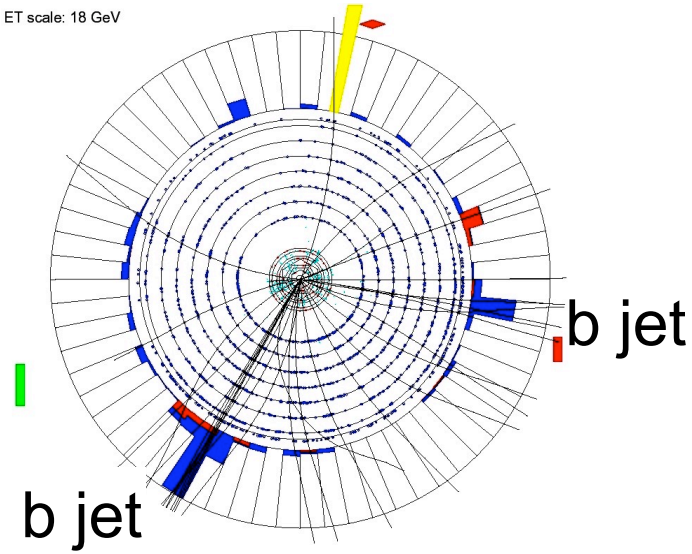
one in ~10^{12} events will be a Higgs boson

Search Strategy at the Tevatron



$ZH \rightarrow \nu\nu bb$ $\not\!\!E_T$

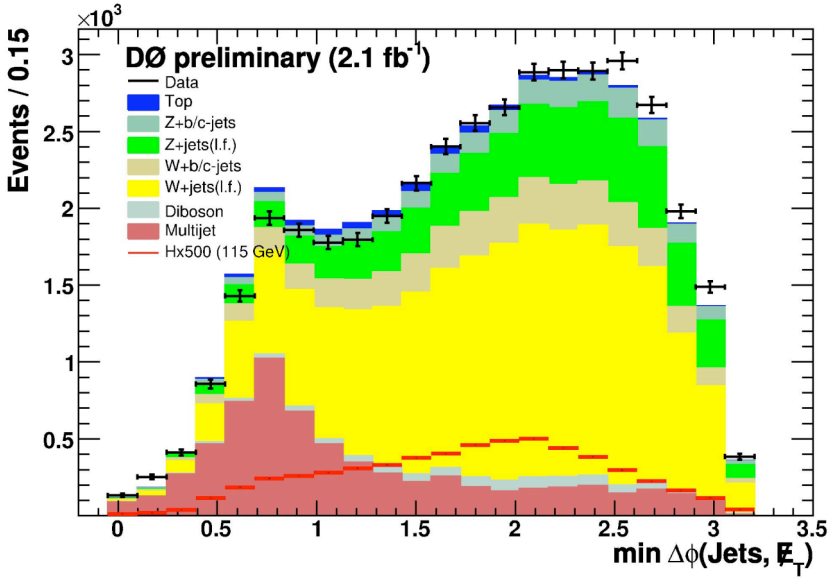




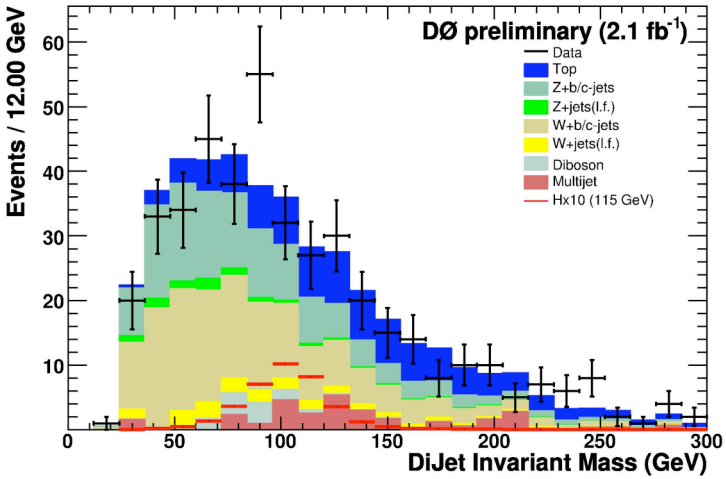
Typical selection:

two acoplanar jets

$\not\!\!E_T > 50$ GeV



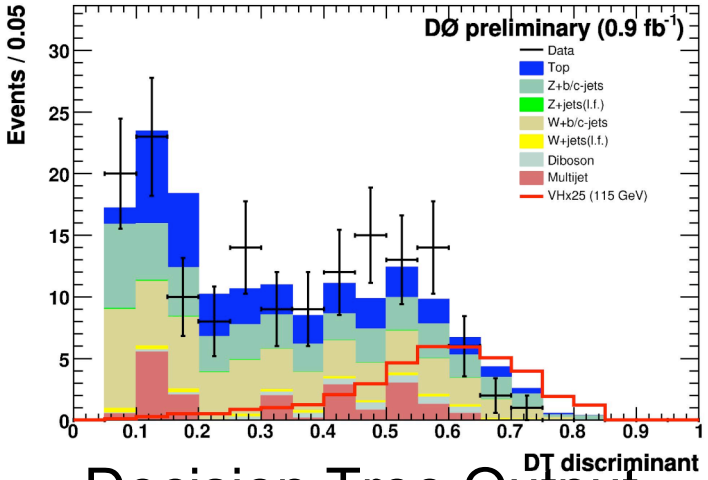
$ZH \rightarrow \nu\nu bb$



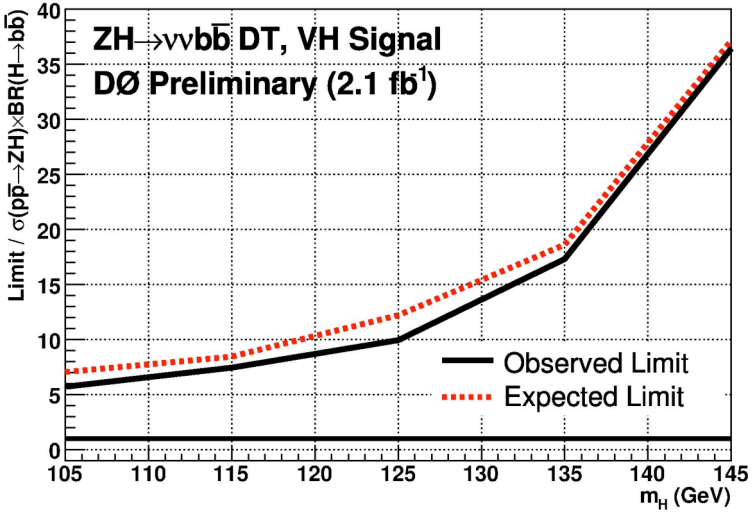
Two asymmetric b tags (one loose, one tight)

Backgrounds :

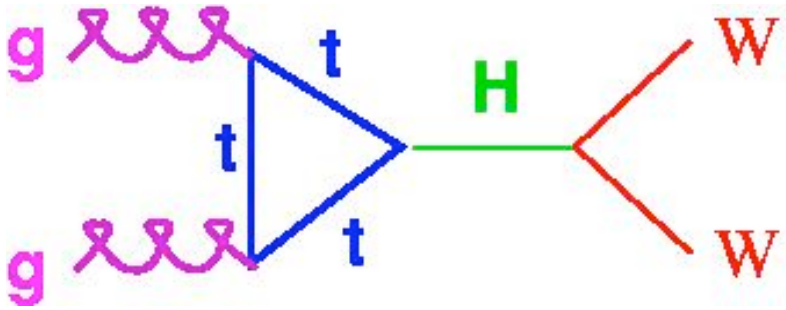
- W+heavy flavour jets
- Z +heavy flavour jets
- top pairs

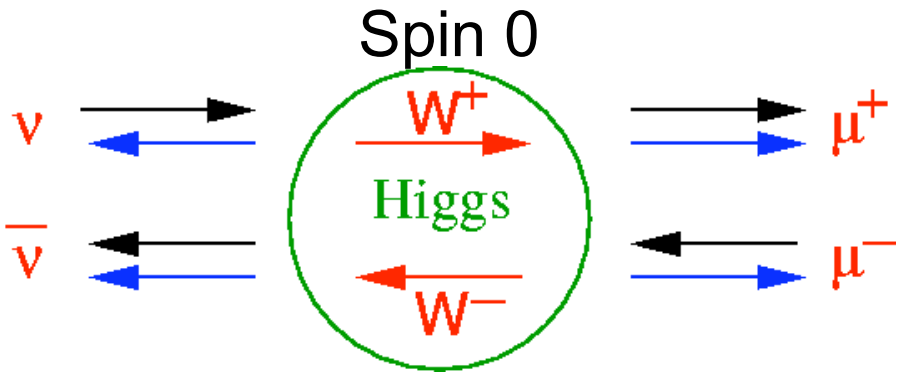


Decision Tree Output



$H \rightarrow WW \rightarrow \ell\nu\ell\nu$





Higgs: small $\Delta\varphi_{ll}$
WW: large $\Delta\varphi_{ll}$

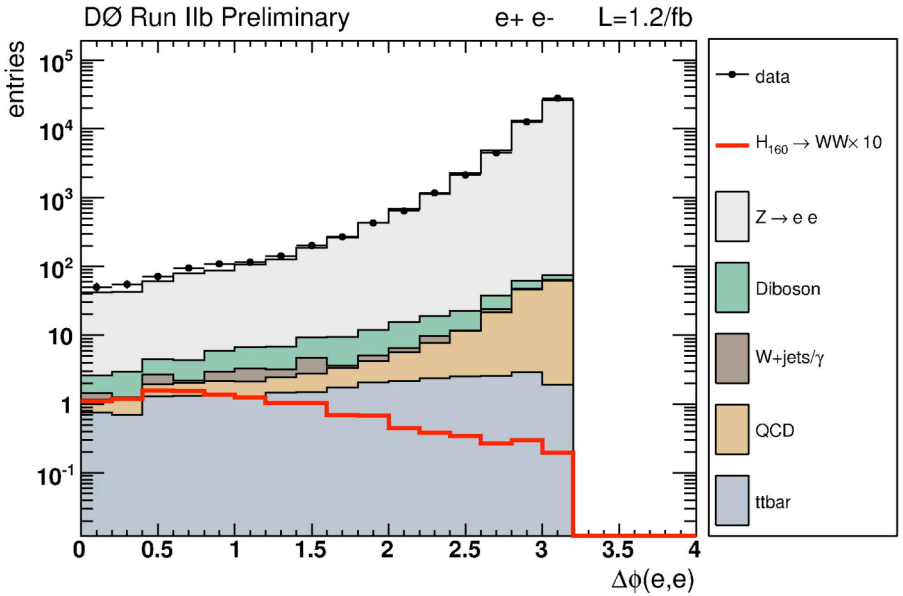
Typical selection:

two isolated leptons

$$p_T^{\ell} > 10 \text{ GeV}$$

$$\not\!\!E_T > 20 \text{ GeV}$$

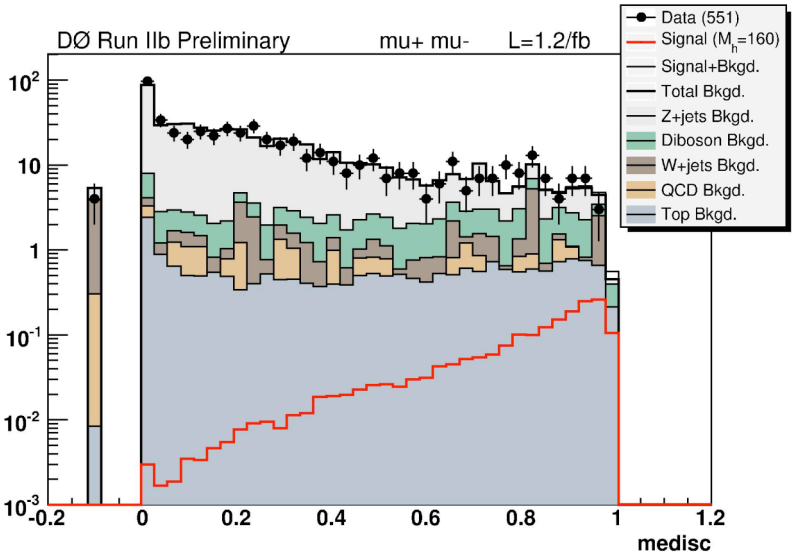
$$\Delta\phi_{\ell\ell} < 2.5$$

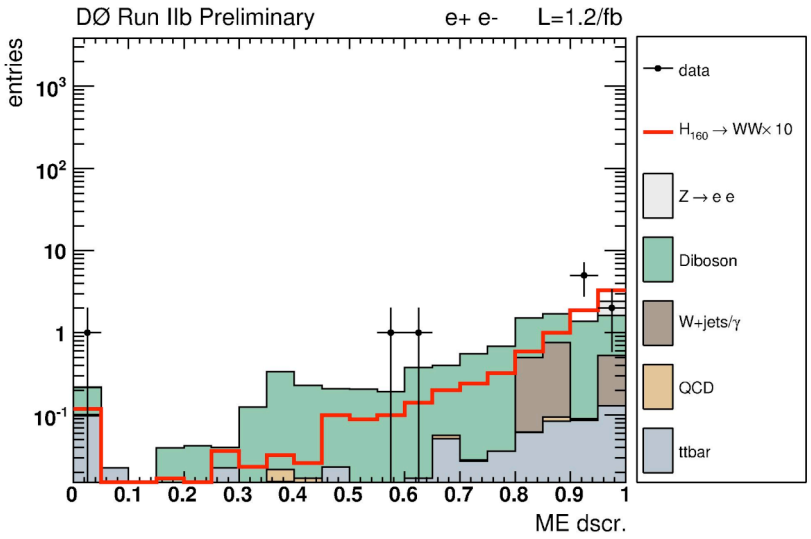


$H \rightarrow WW \rightarrow \ell\nu\ell\nu$

$$P_m(\vec{x}_{obs}) = \frac{1}{\langle\sigma_m\rangle} \int d^n\sigma_m^{theory}(y)\epsilon(y)G(\vec{x}_{obs}, y)$$

P_m : Event-by-event probability for process m
y : true lepton kinematics, incl. neutrinos
$\vec{x}_{obs}$: observed kinematics
ϵ : lepton efficiencies
G : detector resolution function



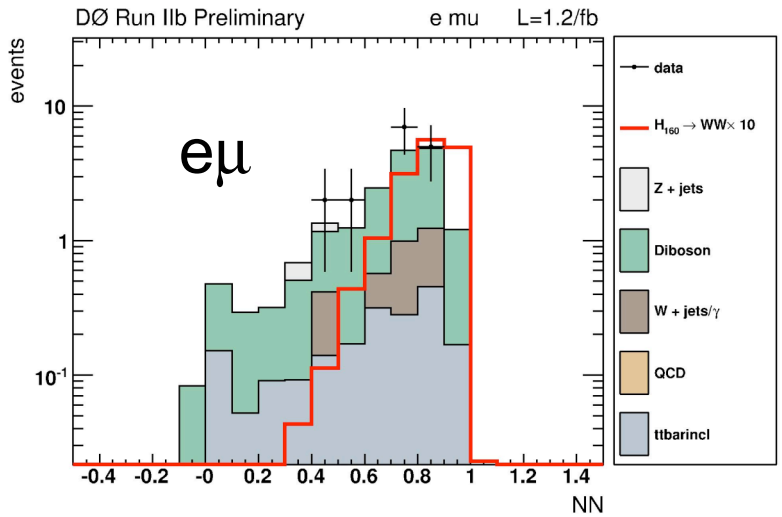


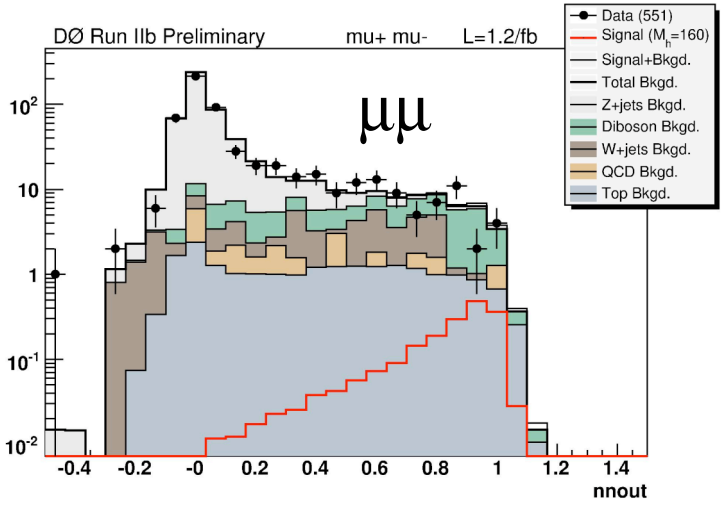
Matrix Element (ME) discriminant used as additional NN input variable

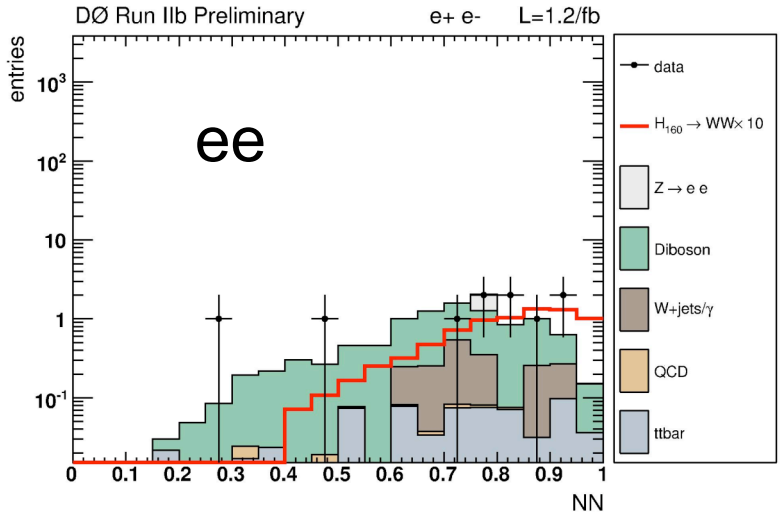
ee: 12 variables

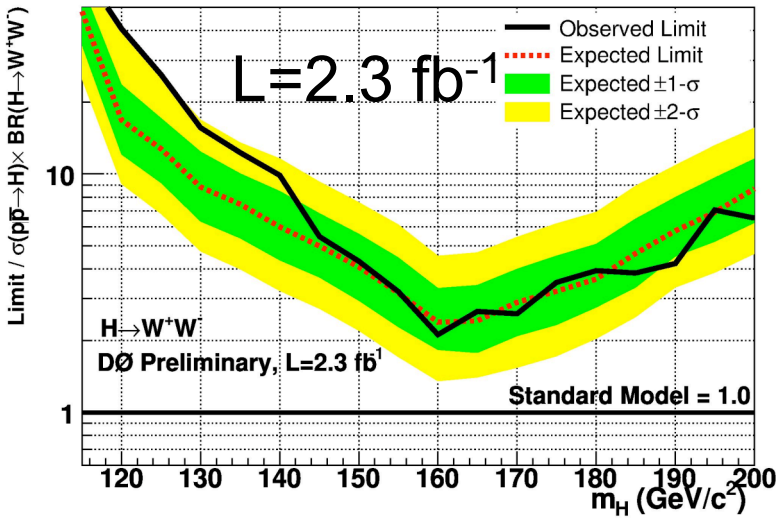
μμ: 15 variables

$H \rightarrow WW \rightarrow \ell\nu\ell\nu$





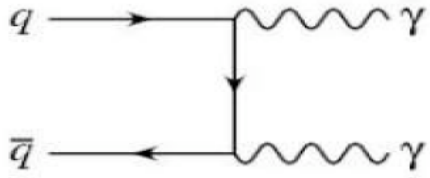




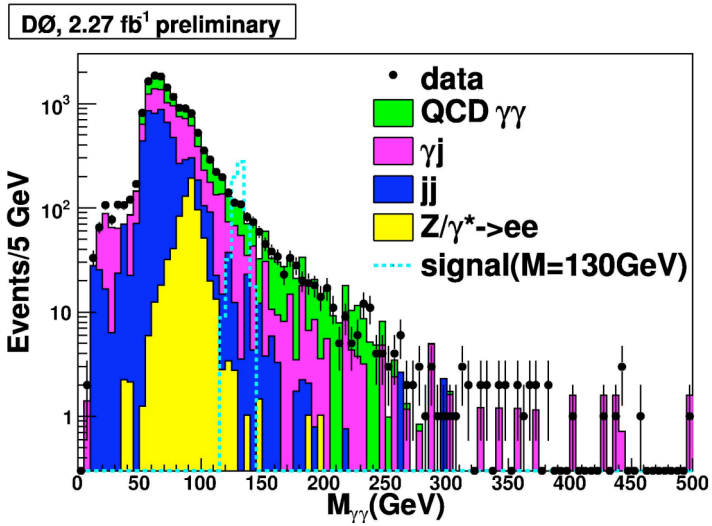
$gg \rightarrow H \rightarrow \gamma\gamma$

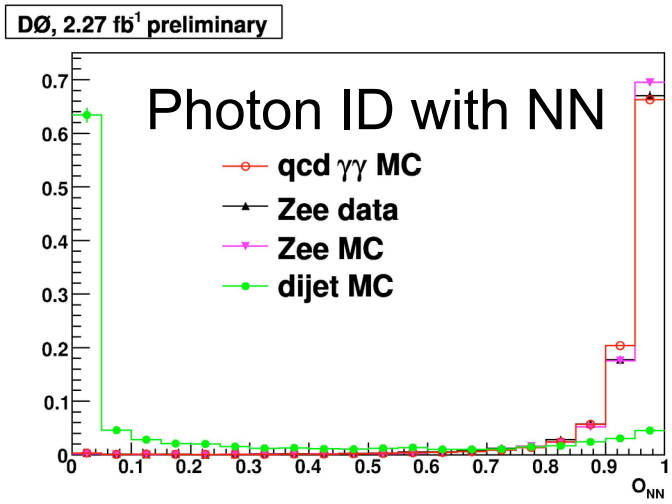
small BR ~ 0.002, but clear signature not only at the LHC !

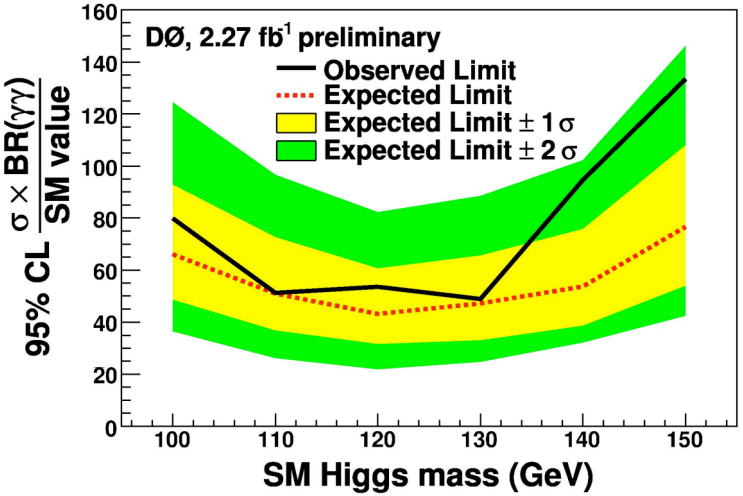
simulation + NLO cross section:



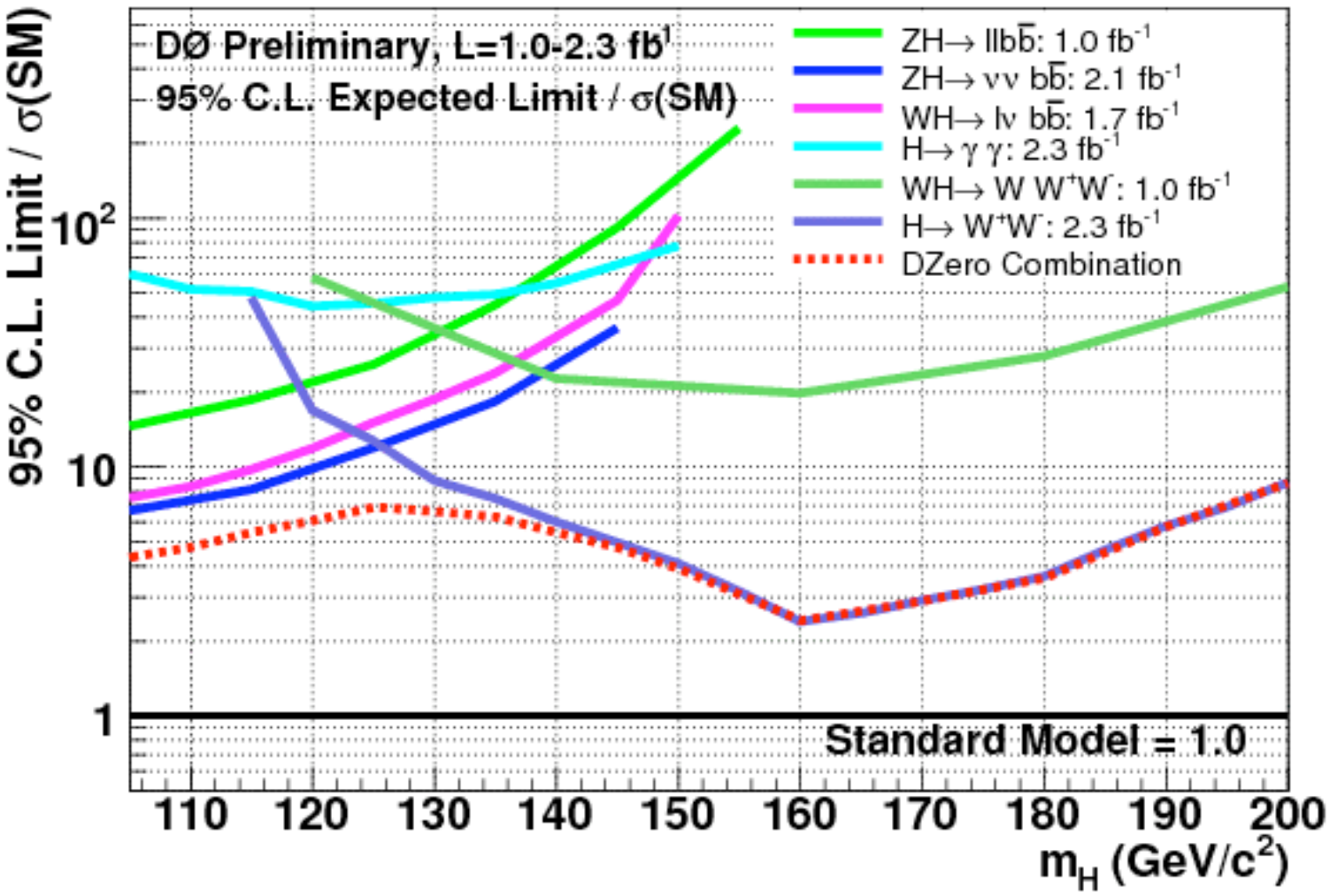
from data: - photon + jet (π^0)
- jet (π^0) + jet (π^0)



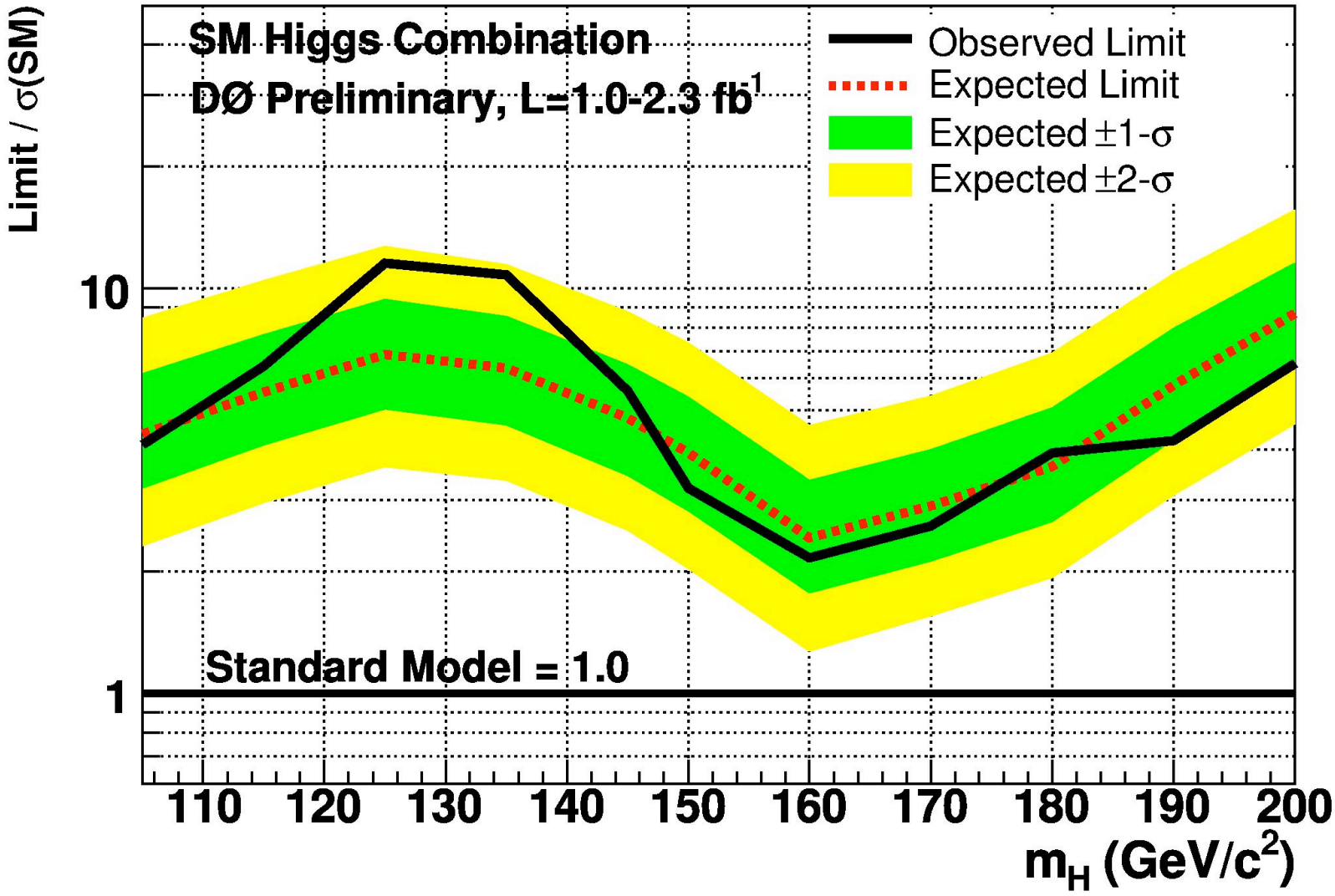




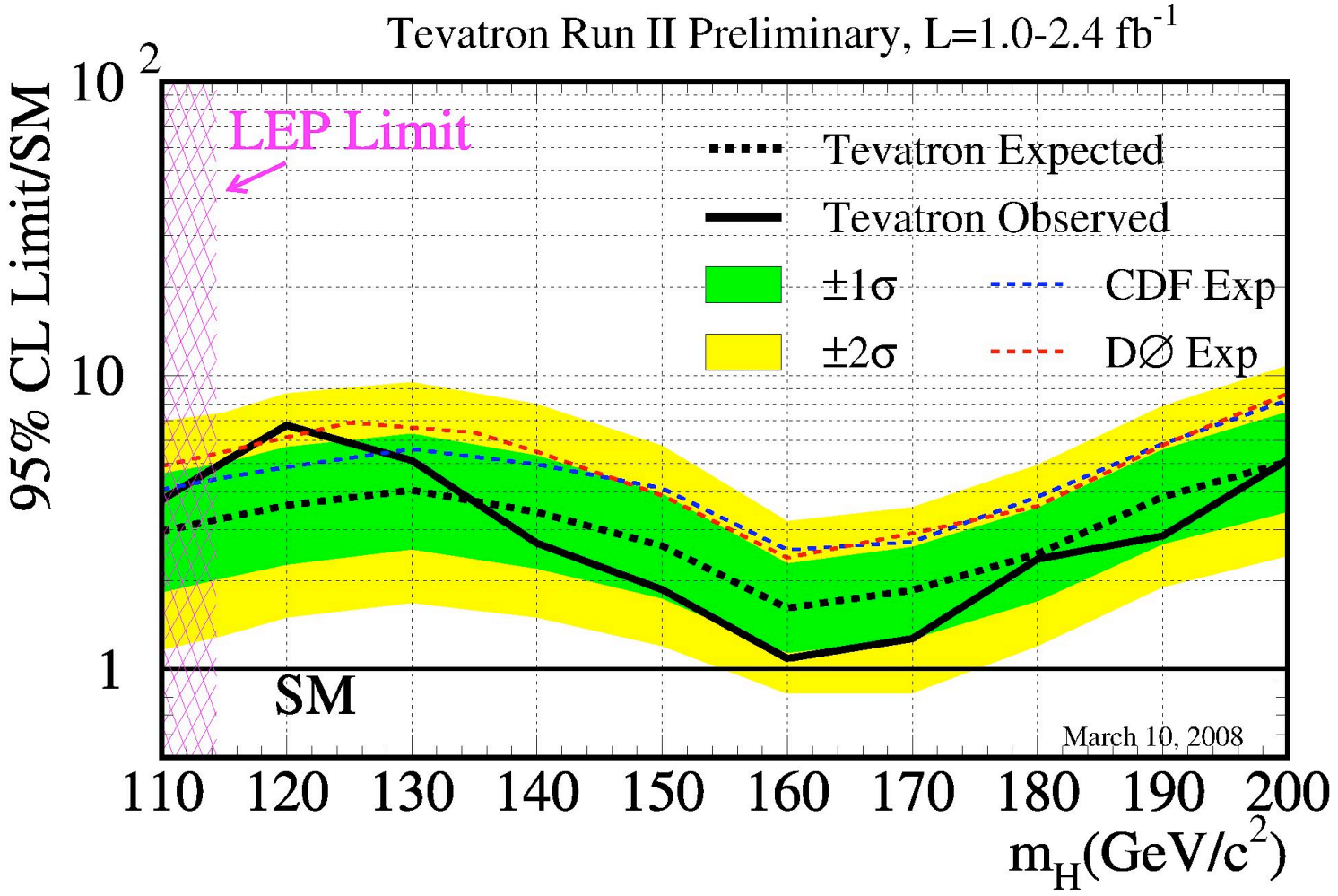
Expected Sensitivities



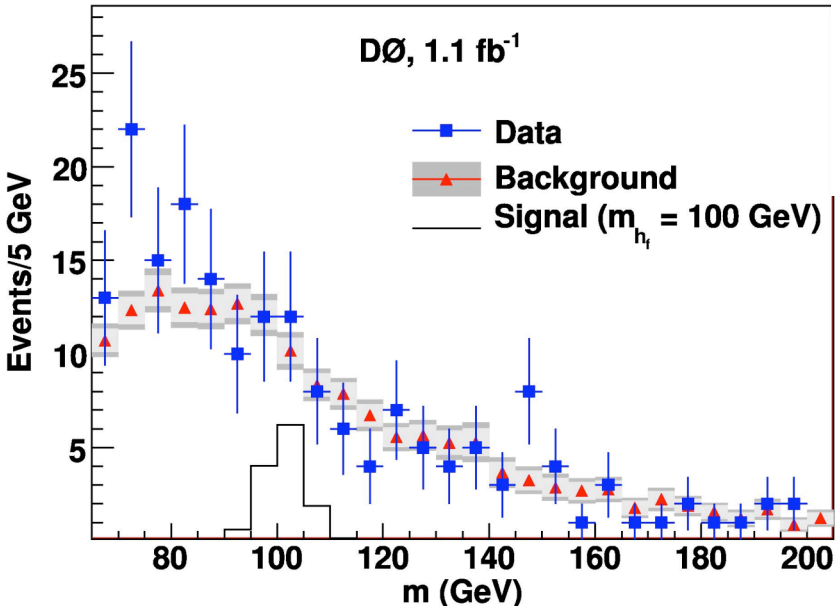
Dzero Combination

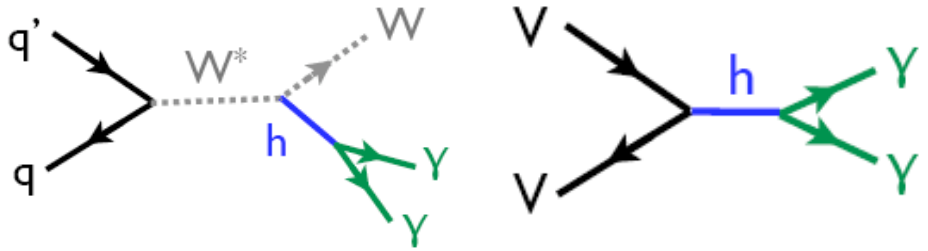


Tevatron Combination

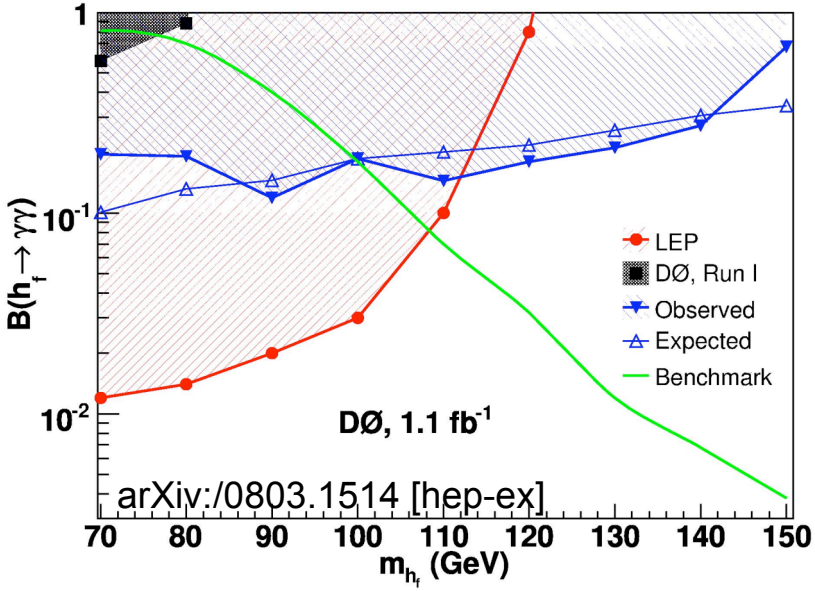


Fermiophobic Higgs





$$q_T^{\gamma\gamma} > 35 \text{ GeV}$$



Benchmark model:

- SM Higgs coupling to W,Z
- no coupling to fermions

$$m(h_f) > 100.0 \text{ GeV (D0)}$$

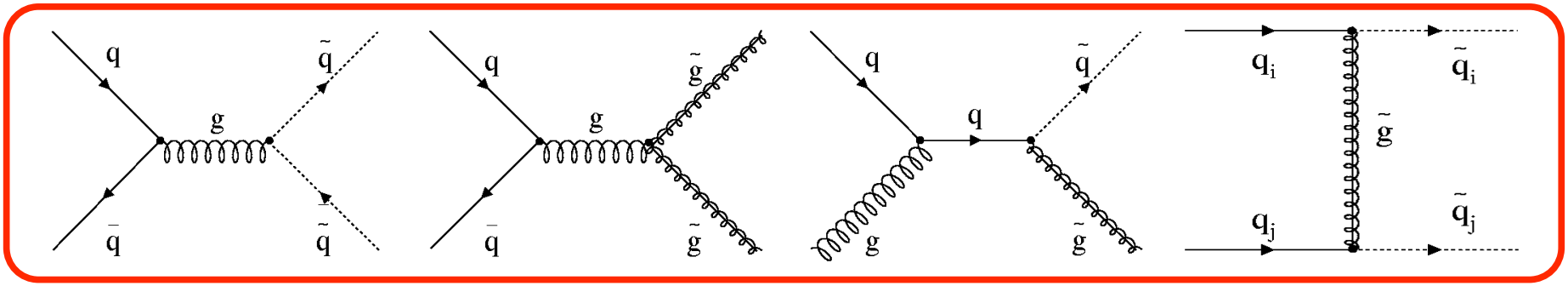
$$m(h_f) > 109.7 \text{ GeV (LEP)}$$

If you can think of it, we can search for it…!

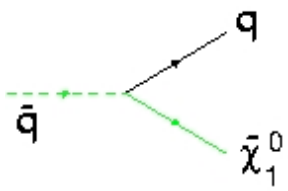
Examples:

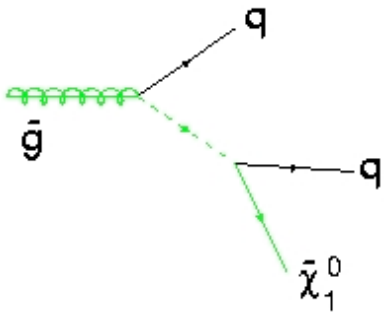
- first, second, third generation leptoquarks
- extra gauge bosons (Z',W')
- Large Extra Dimensions (LED)
- excited quarks and leptons (q*, e*)
- Supersymmetry
- Technicolour
- charged massive stable particles
- monopoles
- ….

Squark and Gluino Limits



2 jets 4 jets 3 jets 2 jets





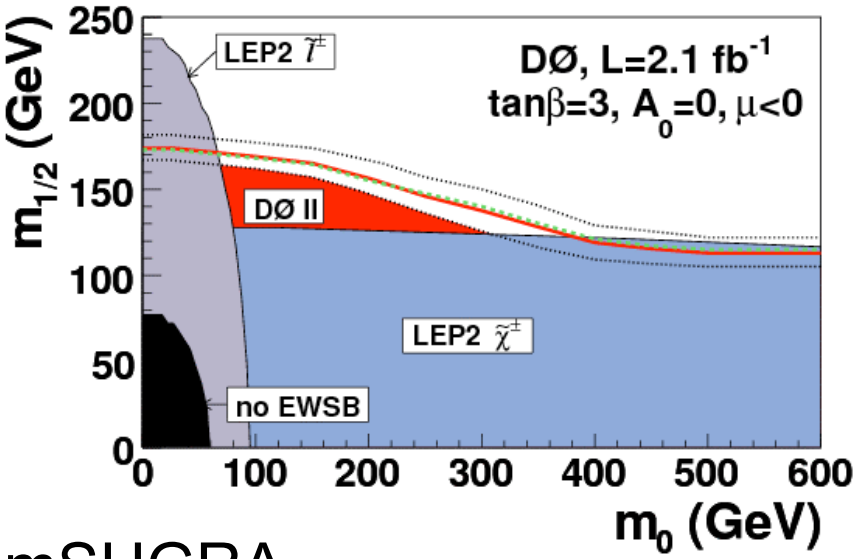
+ cascade decays

Three overlapping analyses optimised for different topologies combined for final limit

$$\not\!\!E_T > 100 - 225 \text{ GeV}$$
$$p_T^{jet} > 35 \text{ GeV}$$
$$\text{large } \Delta\phi(jets, \not\!\!E_T)$$
$$\text{lepton veto}$$

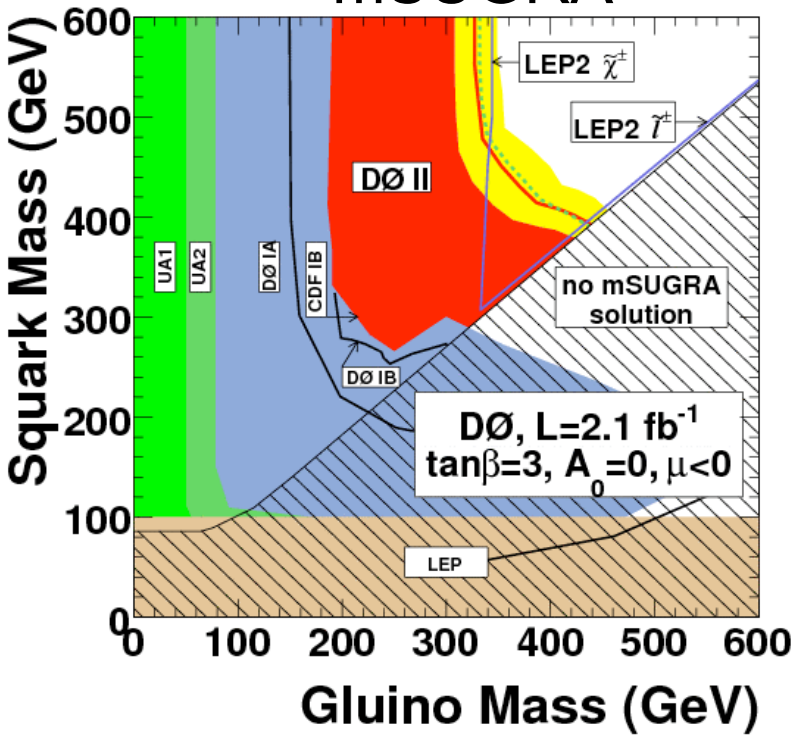
Squark and Gluino Limits

m_0: universal scalar mass
$m_{1/2}$: universal gaugino mass
A_0: trilinear coupling
all at GUT scale



mSUGRA

mSUGRA

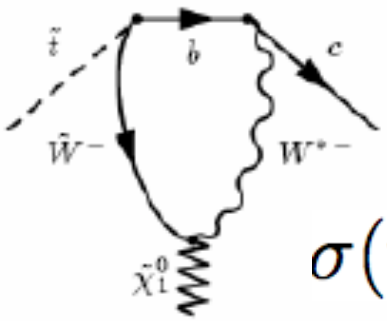


$$m(\tilde{g}) > 327 \text{ GeV}$$

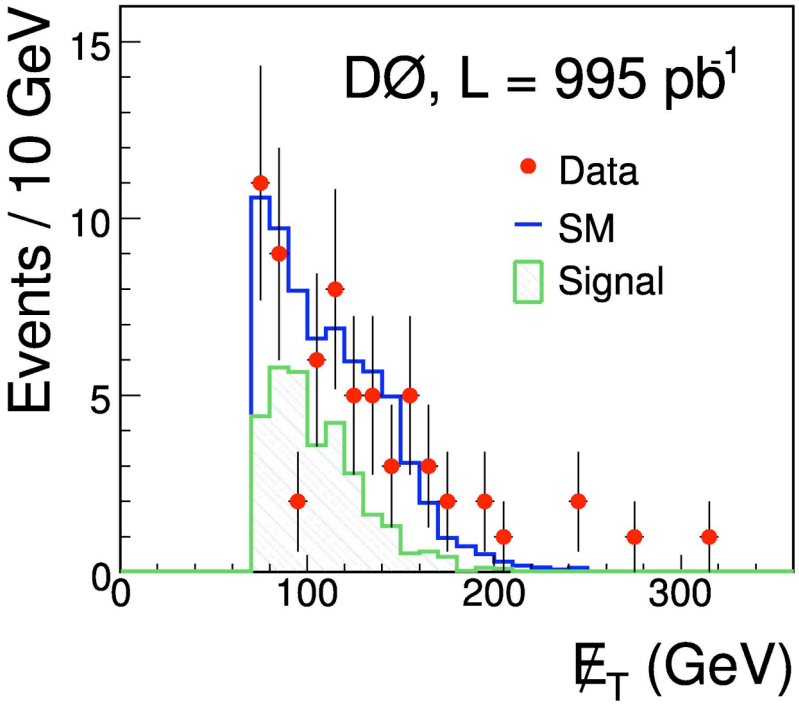
$$m(\tilde{q}) > 392 \text{ GeV}$$

most constraining limits

$\tilde{t} \rightarrow c\tilde{\chi}_1^0$



$$\sigma(\tilde{t}\bar{\tilde{t}}) \simeq 0.1\sigma(t\bar{t})$$



Assumption:

$$BR(\tilde{t} \rightarrow c\tilde{\chi}_1^0) = 100\%$$

Selection:

$$p_T^{jet1} > 40 \text{ GeV}$$

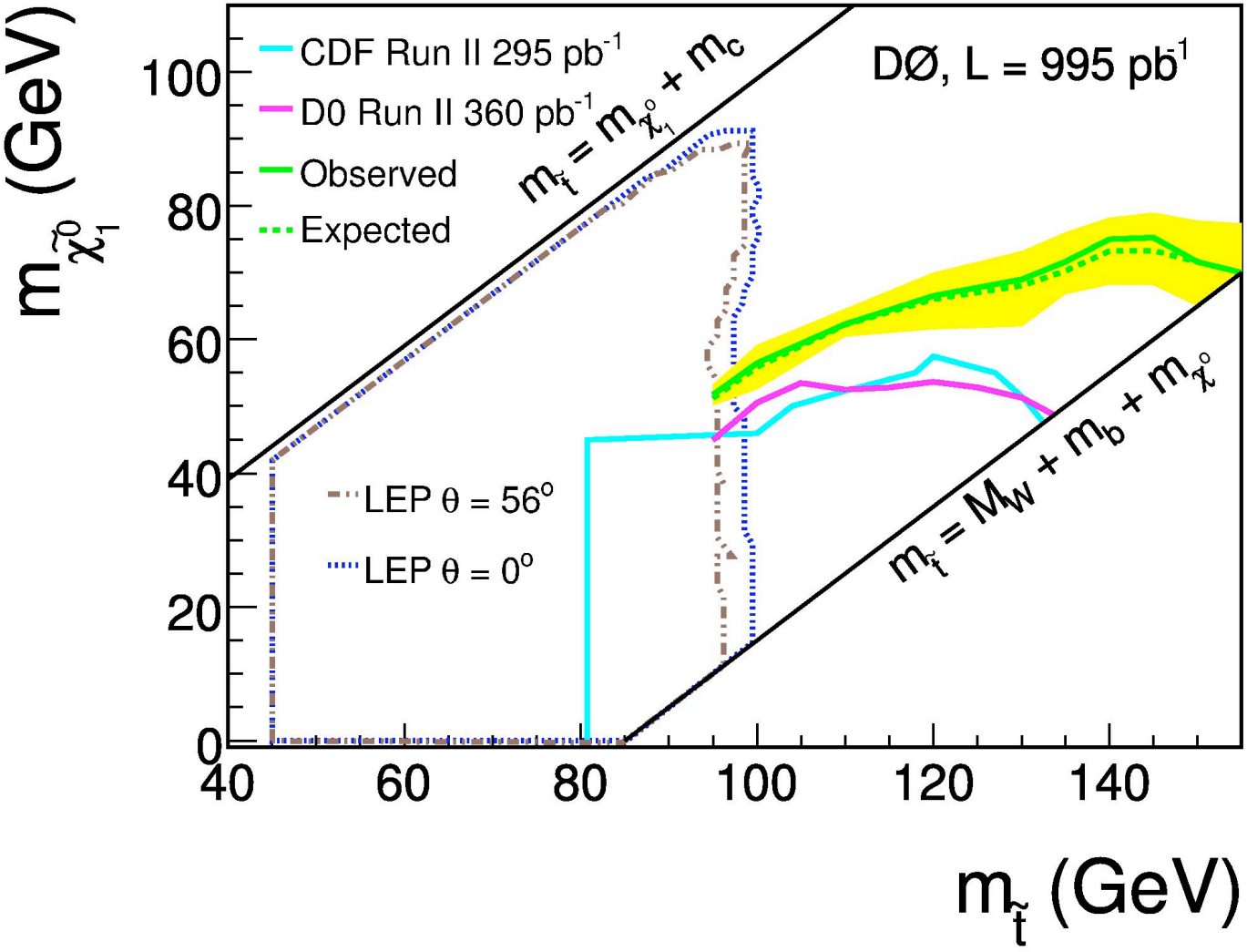
$$p_T^{jet2} > 20 \text{ GeV}$$

$$\not\!\!E_T > 60 \text{ GeV}$$

charm tagging

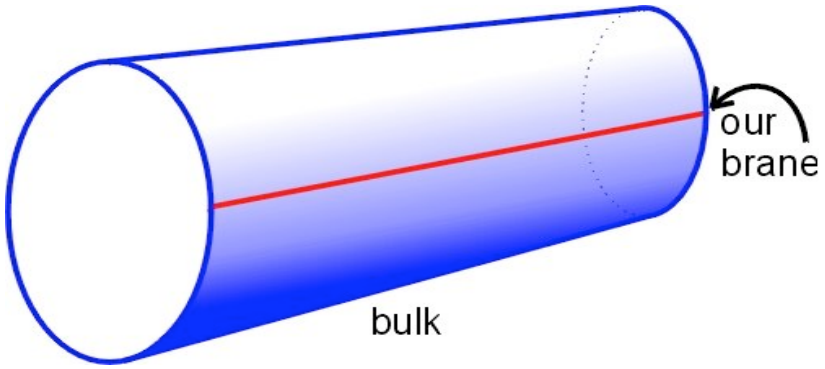
$\tilde{t} \rightarrow c\tilde{\chi}_1^0$

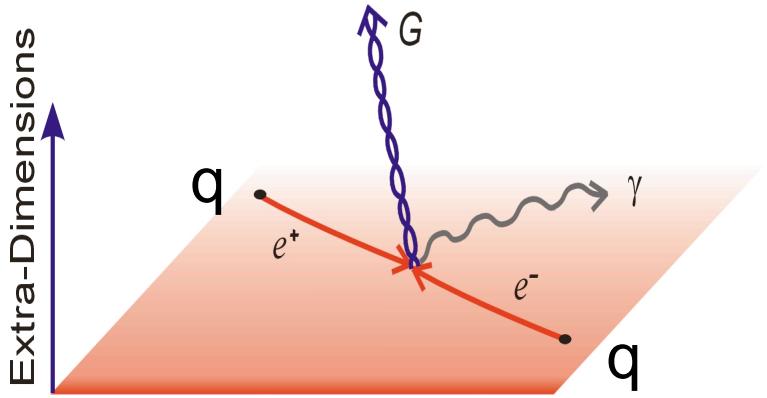
arXiv:/0803.2263 [hep-ex]



Large Extra Dimensions (mono-photons)

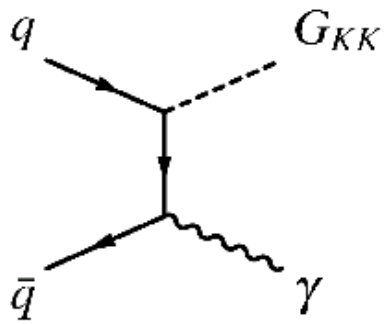
Hierarchy problem: Why is gravity so weak ?





$$M_{Pl}^2 = 8\pi M_D^{\delta+2} R^{\delta}$$

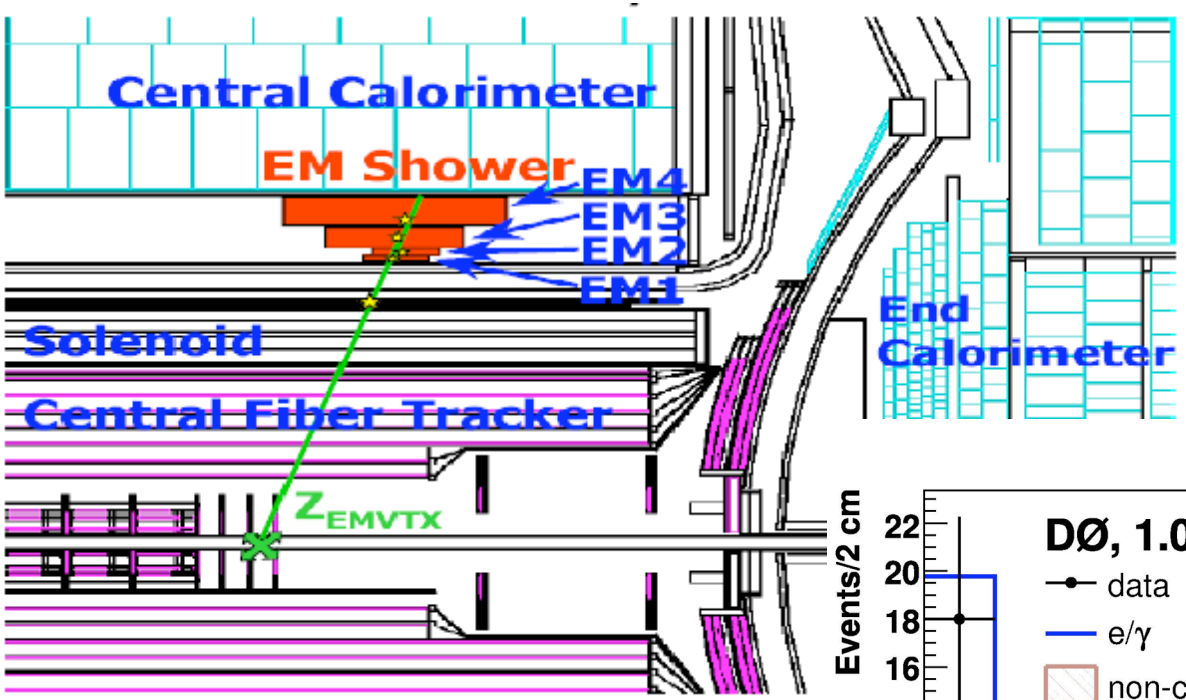
$$\not{E}_T > 70 \text{ GeV}$$



$$p_T^{\gamma} > 90 \text{ GeV}$$

Tower of Kaluza-Klein Gravitons G_{KK}
massive, non-interacting, stable

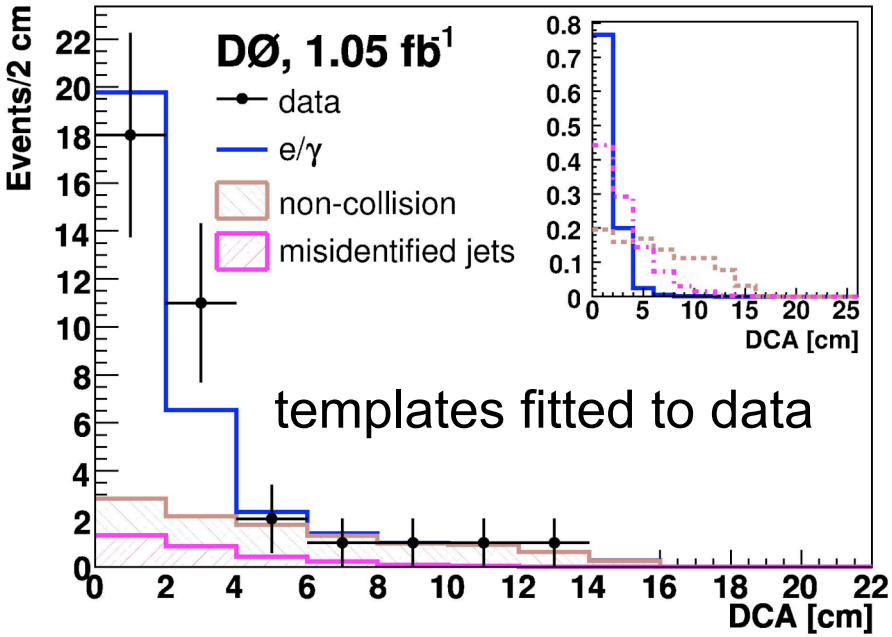
Large Extra Dimensions (mono-photons)



EM pointing:

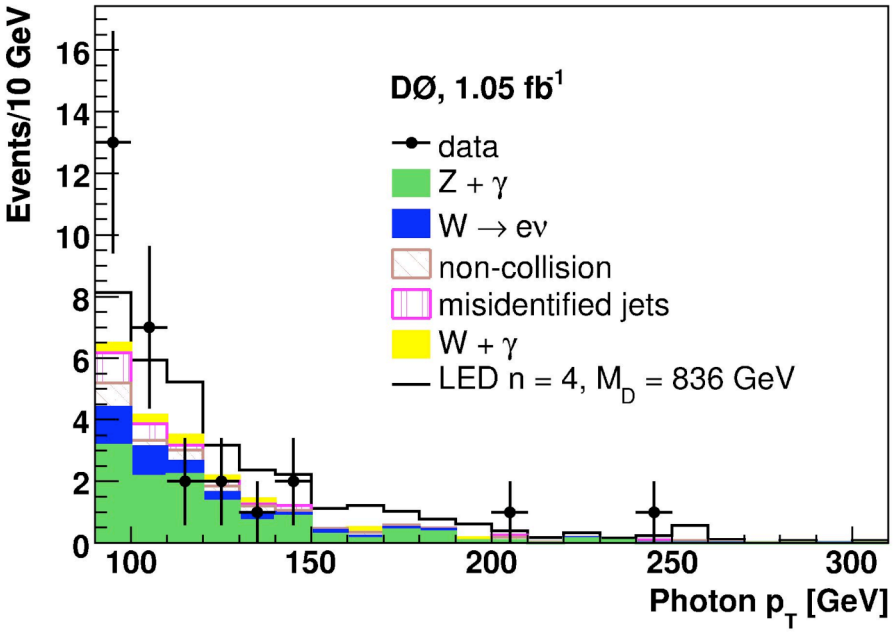
- $|z_{PV}-z| < 10$ cm
- distance of closest approach (dca) to z axis, $\sigma_{dca} \approx 2$ cm

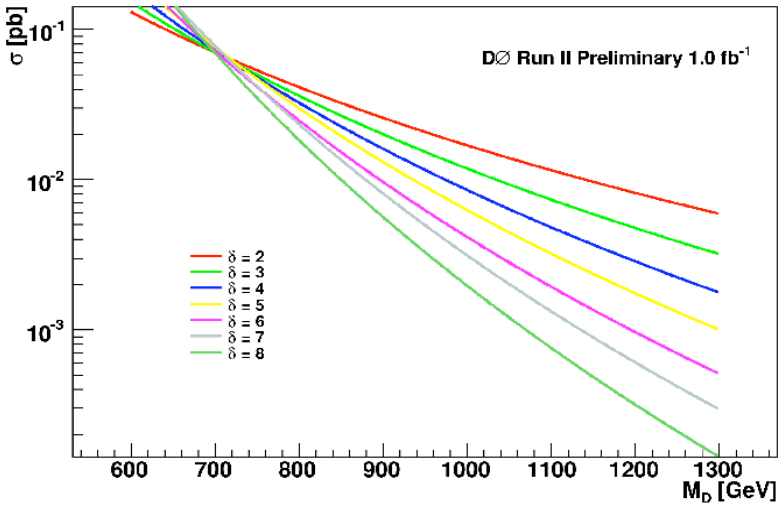
Background	Number of expected events
$Z+\gamma \to \nu\bar{\nu}\gamma$	12.1 ± 1.3
$W \to e\nu$	3.8 ± 0.3
Non-collision	2.8 ± 1.4
Misidentified jets	2.2 ± 1.5
$W+\gamma$	1.5 ± 0.2
Total Background	22.4 ± 2.5
Data	29

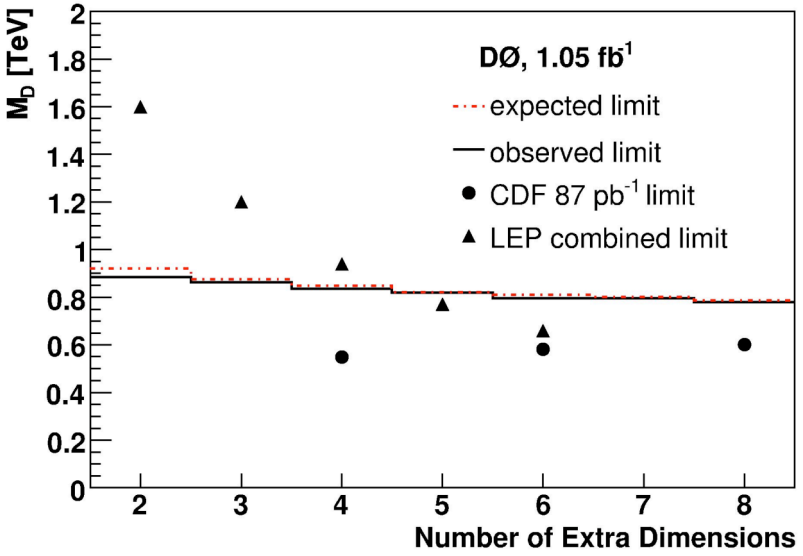


Large Extra Dimensions (mono-photons)

$$\sigma \propto \frac{1}{M^{\delta+2}}$$



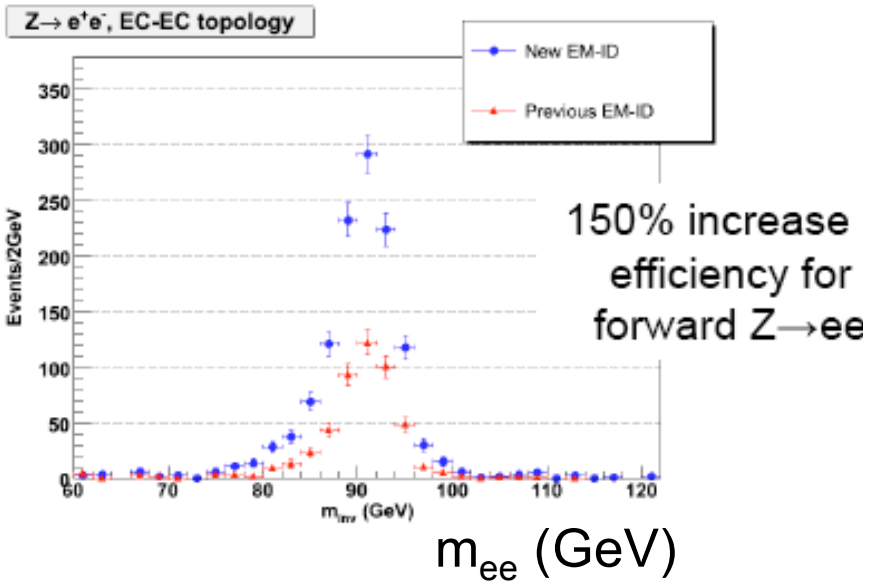




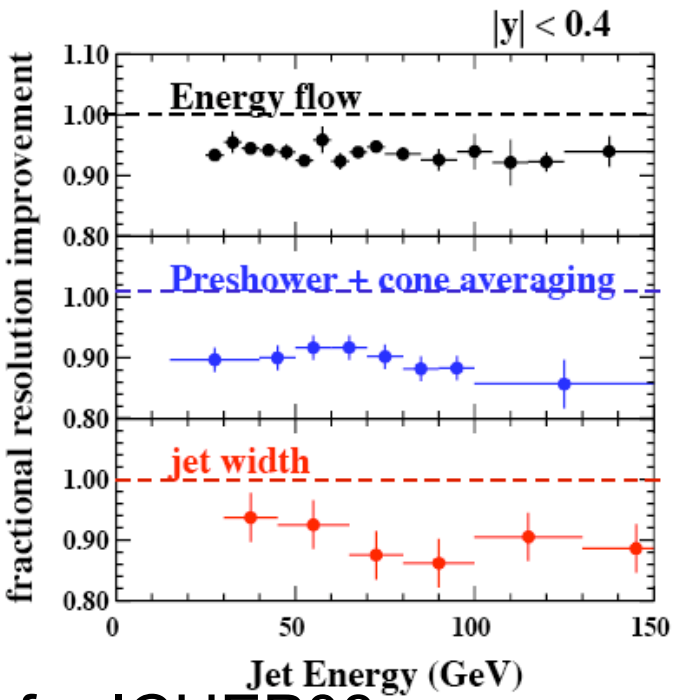
From Moriond to ICHEP

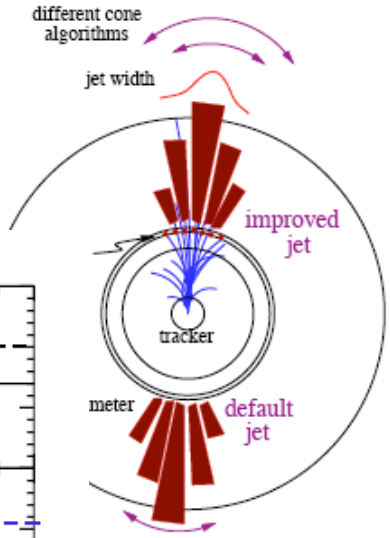
The key to future discoveries and high precision measurements are more luminosity and continuing improvements

electrons



jets





many new results expected for ICHEP08

Summary

DØ is producing a wide range of high quality results both testing the Standard Model and searching or new physics; these results represent a large fraction of the new results presented at the winter conferences.

The challenges of the future are not just adding more data; we are improving analysis techniques and increasing our sensitivies faster than $\sqrt{L}$.

Summary

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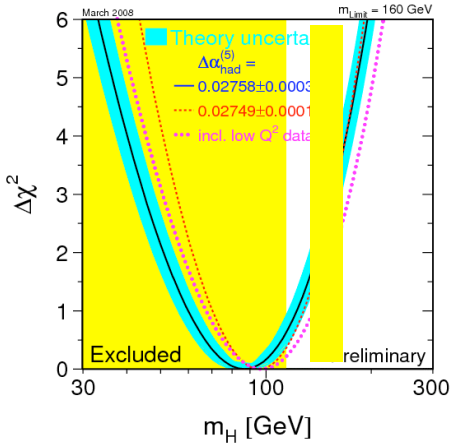
And here is a preview of the next SM fit:



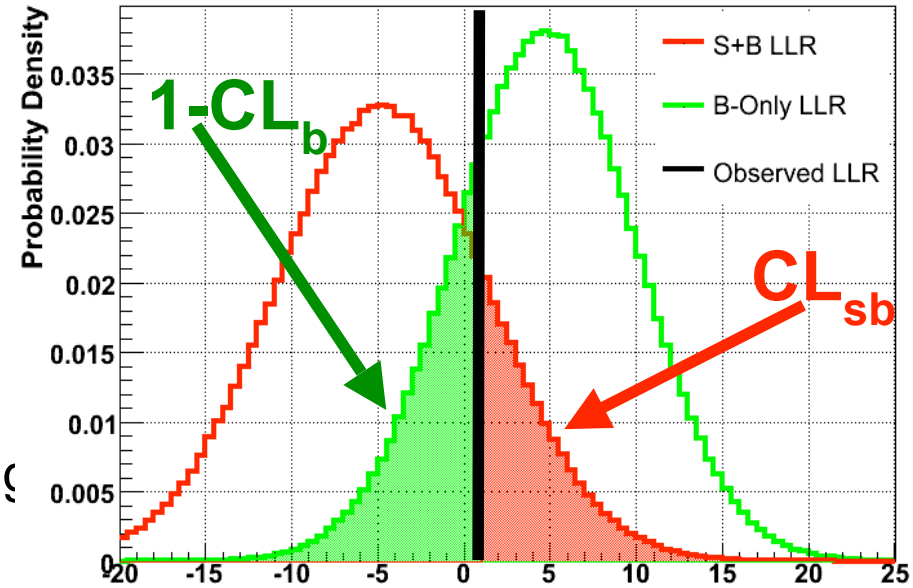
Limit Setting (CLs method)

Background only (b) and signal plus background (s+b) hypotheses are compared to data using Poisson likelihoods.

Probability density function is obtained through Gaussian smearing

Systematic uncertainties are included in the likelihood ('profile likelihood')

Background is constrained by maximising profile likelihood ('sideband fitting').



LLR = -2 ln Q

$$Q(m_H) = \frac{L_{s+b}}{L_b}$$