Résumé des conférences d'été

Laurent Schoeffel (CEA Saclay) 22/10/07

-- End of HERA

-- Impressive improvement in the systematic understanding
@ the Tevatron : EW physics, top quark + tests analysis @ LHC

-- Single top evidence @ D0 (plausible due to the « item » above)

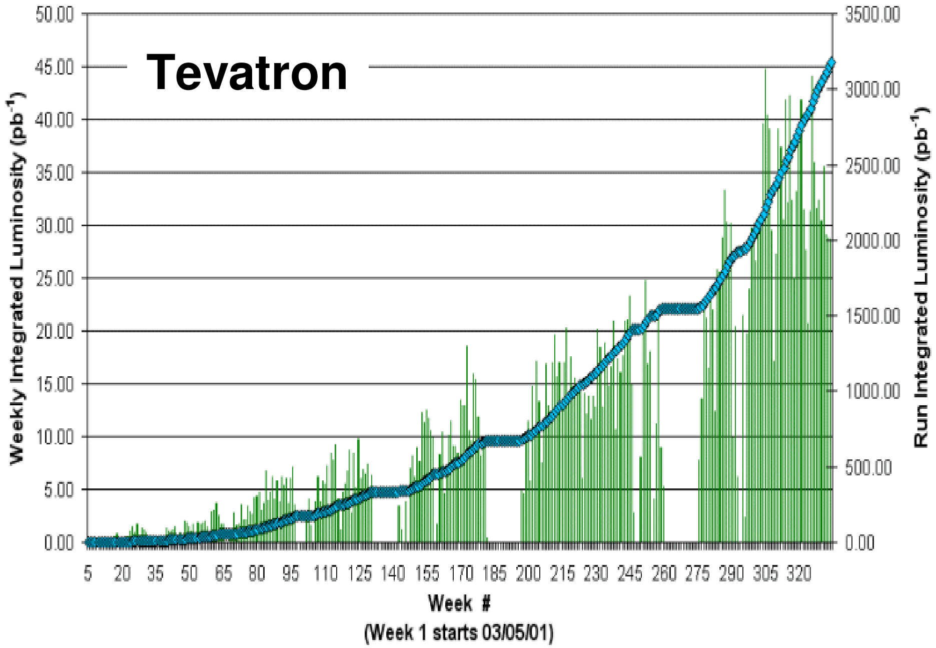
-- New limits on the Higgs boson (SM)

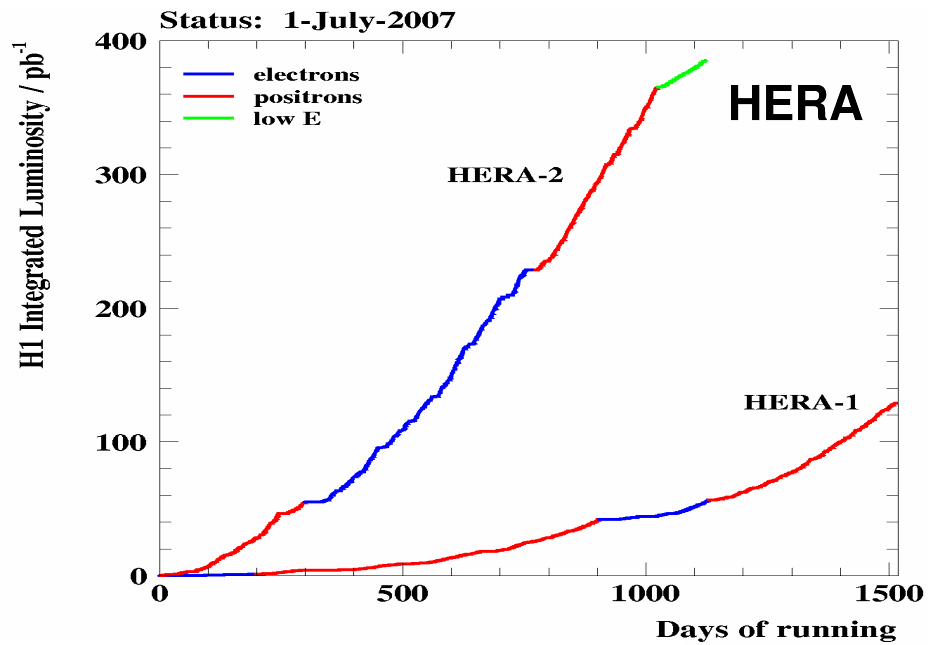
-- Some words on the BSM pseudo-world and prospects @ LHC

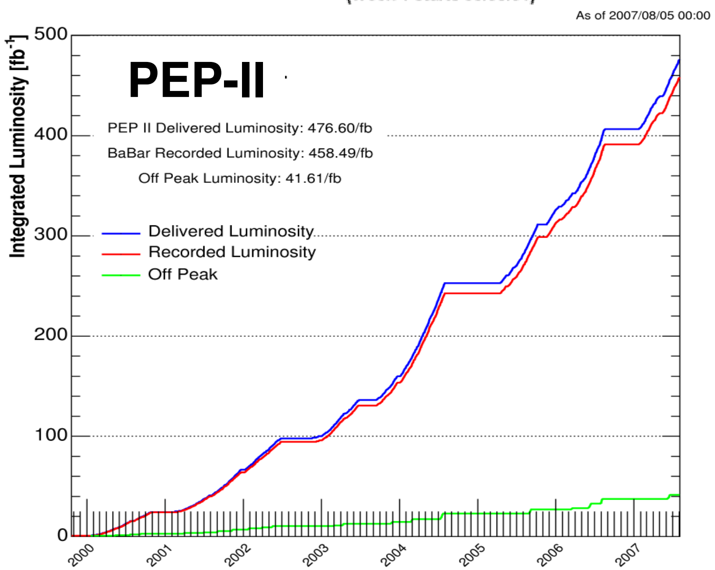
-- D0/D0bar mixing @ BABAR & BELLE

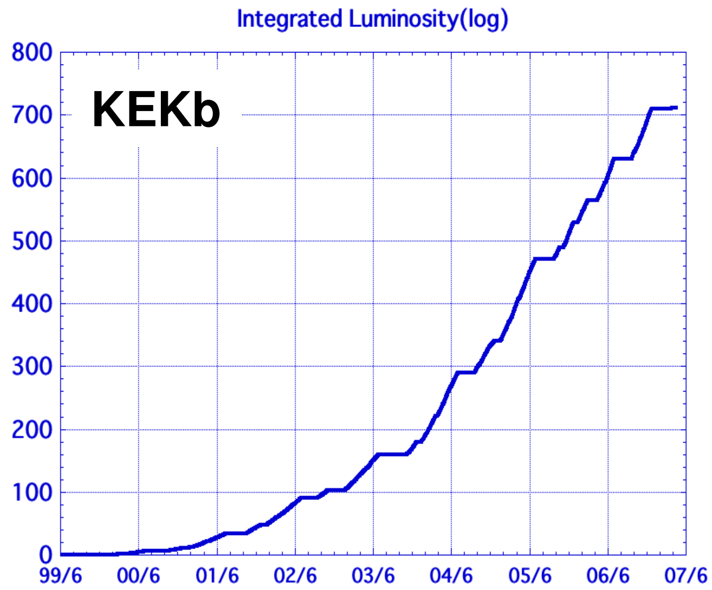
-- Neutrinos : an essential part of SM with interesting open questions

Colliders and luminosities

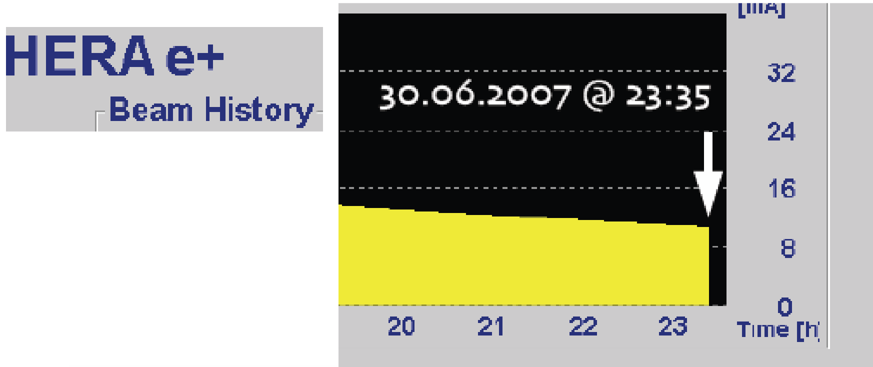


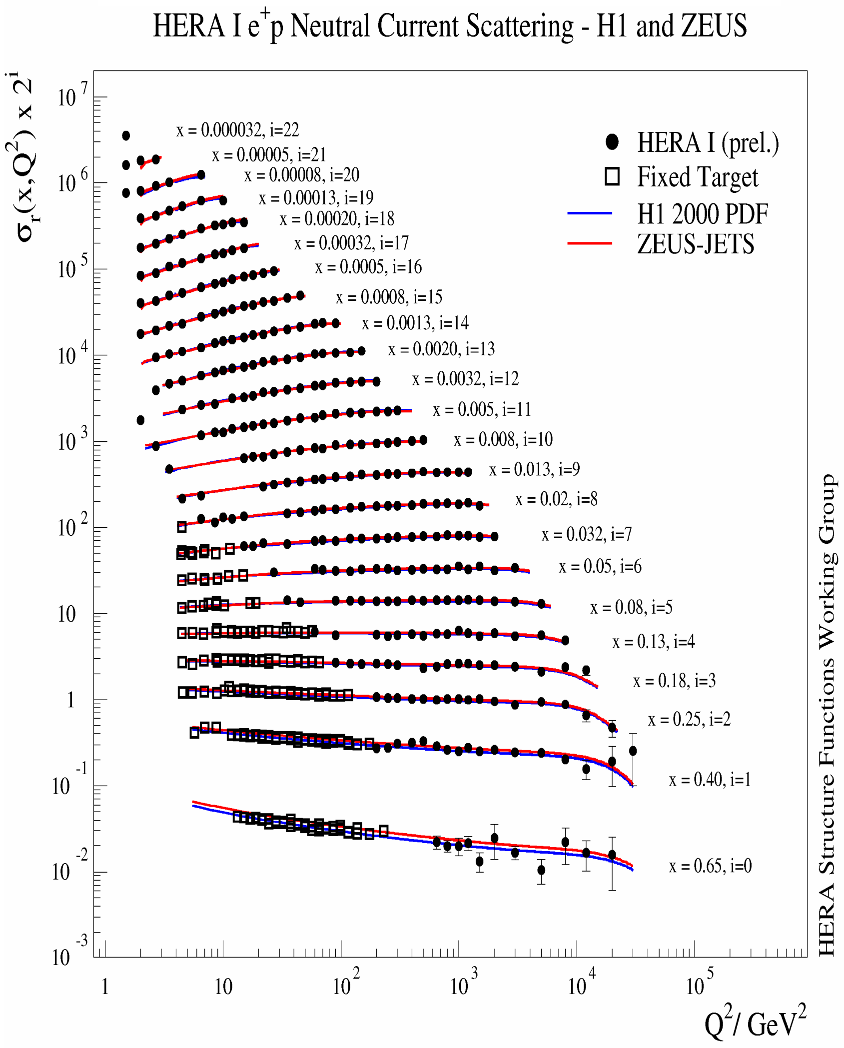


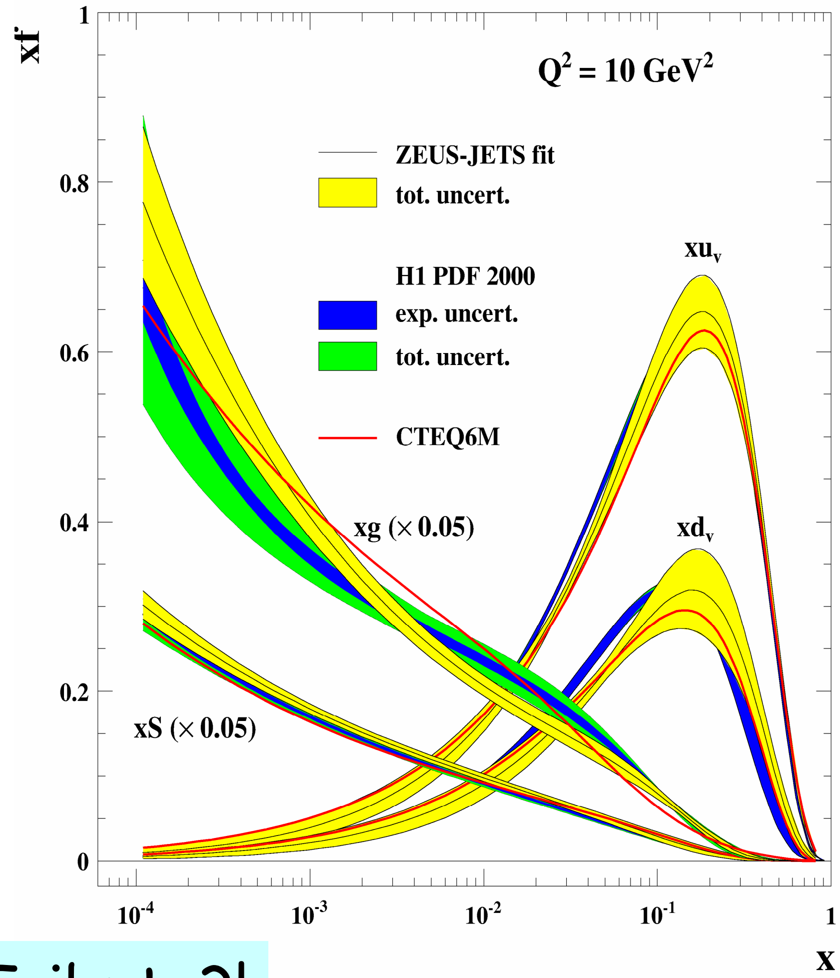




END of HERA

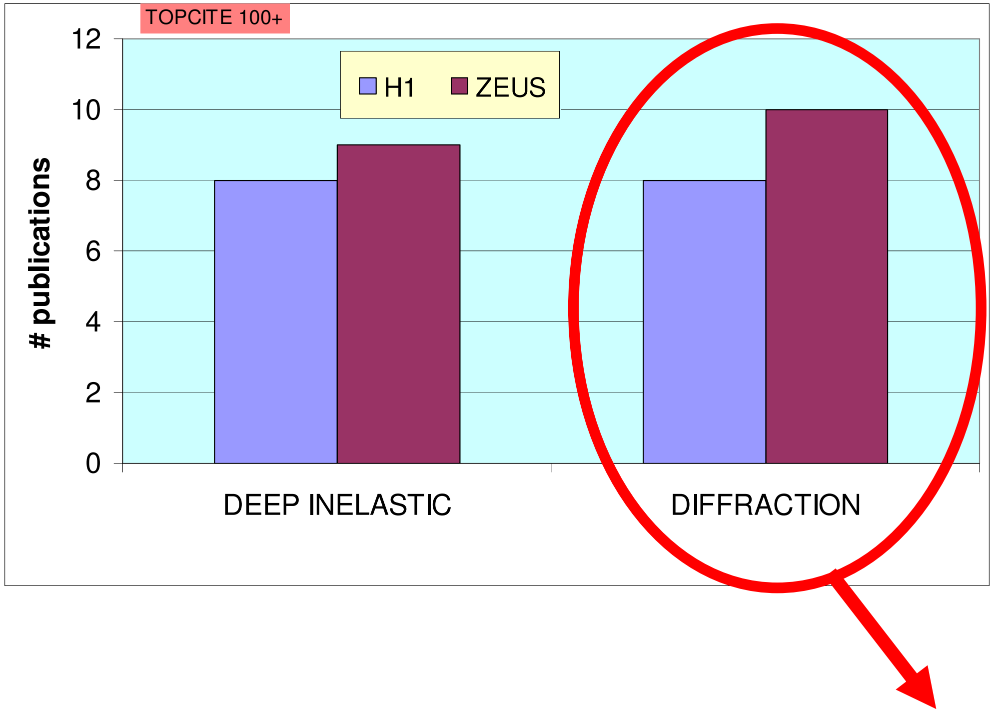


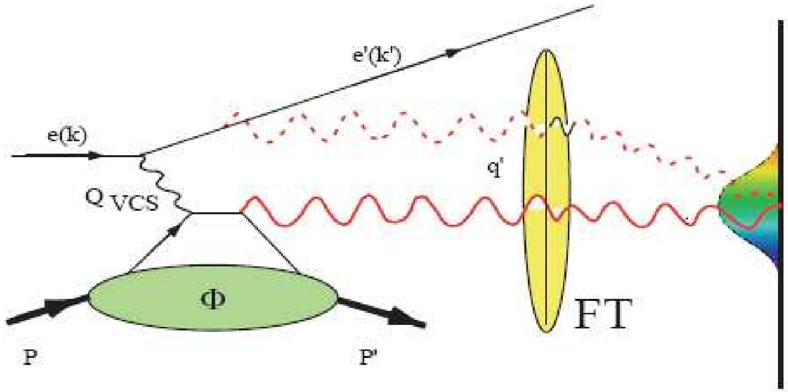


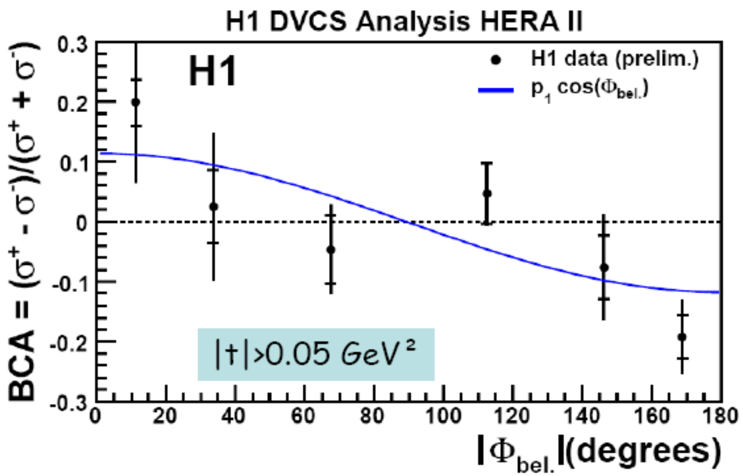


Tribute?!

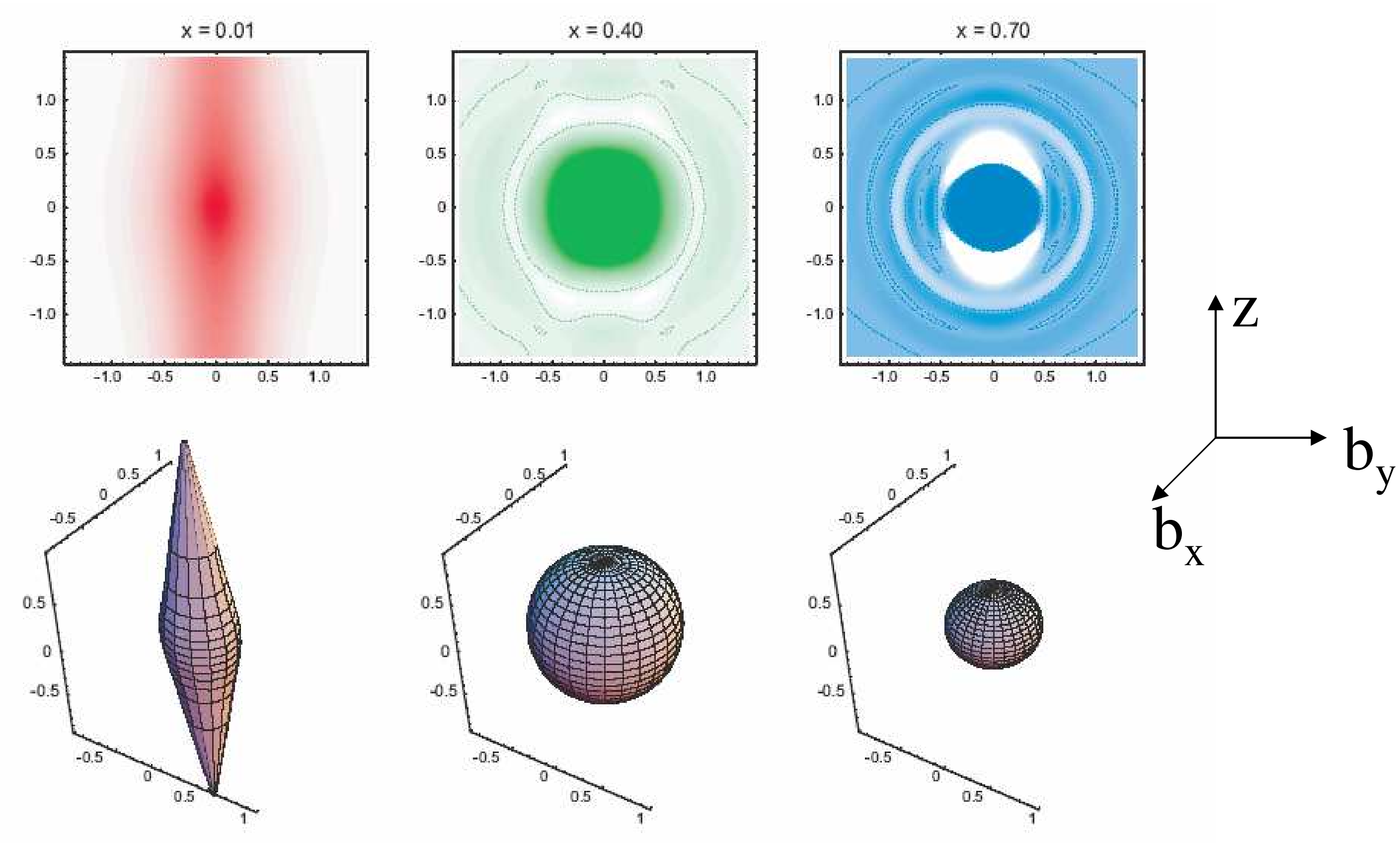
Impact of HERA on the community







diffraction & imaging the partons (x)



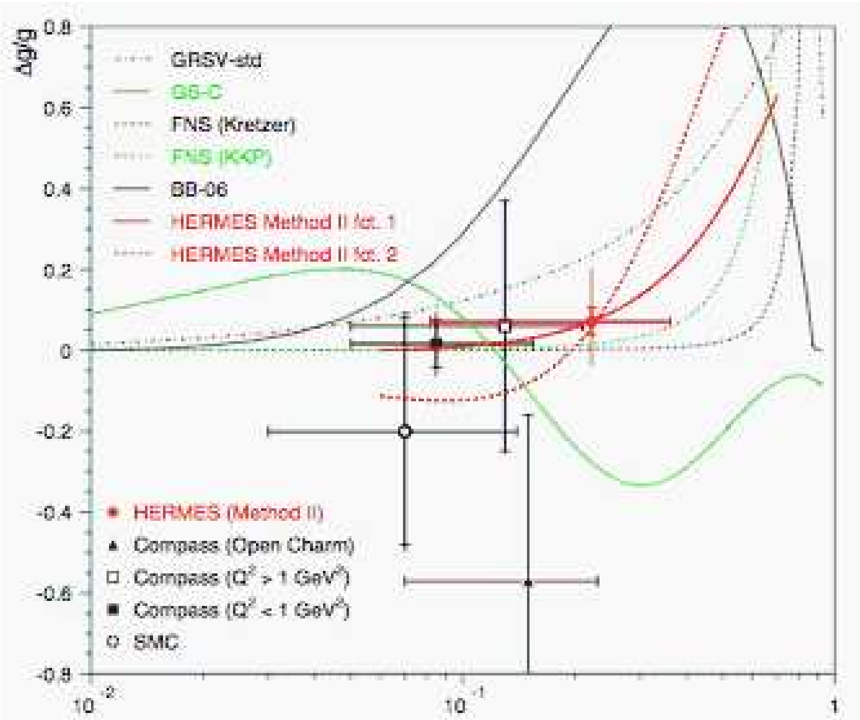
diffraction & orbital momentum

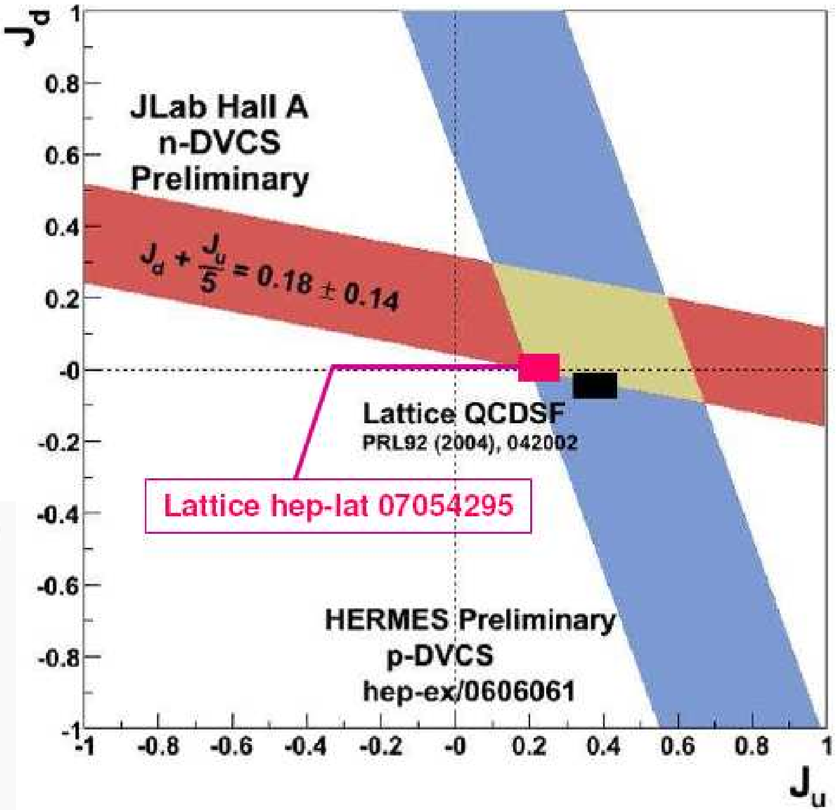
Contribution to the nucleon spin knowledge

$\frac{1}{2} = \frac{1}{2}\,\Delta\Sigma + \Delta G + \langle L_z^q \rangle + \langle L_z^g \rangle$

$2J_q = \int x\,(H^q(x,\xi,0) + E^q(x,\xi,0))\,dx$

=> *J can be accessed with GPDs*





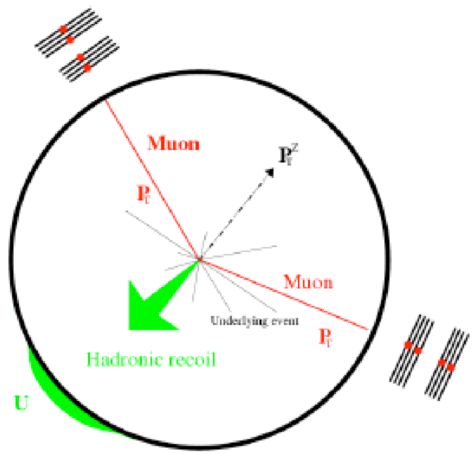
=> Orbital momentum of quarks

On going

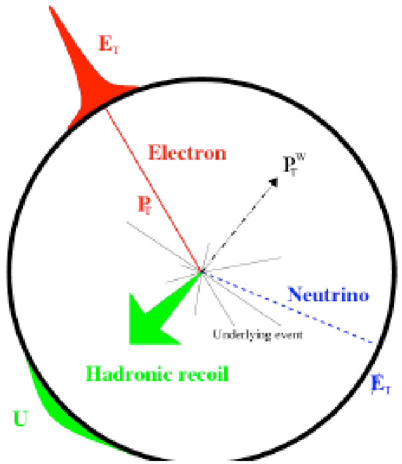
EW physics @ Tevatron

- Proton-antiproton collisions
- $\sqrt{s} = 1.96$ TeV

Signatures of W and Z Production at the Tevatron



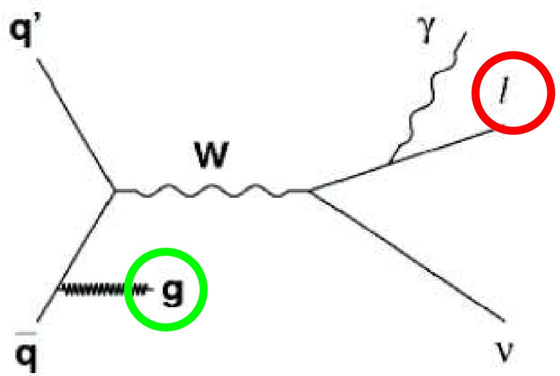
- Z: pair of charged leptons:
  - high p_T
  - isolated
  - opposite-charge



- W: single charged lepton:
  - high p_T
  - isolated
- E_T^{miss} (from neutrino)

transverse mass: $m_T = \sqrt{2 p_T^{\,l} p_T^{\,\nu} (1 - \cos\phi_{l\nu})}$

W Mass Strategy



Detector Calibration

- Tracking momentum scale
- Calorimeter energy scale
- Recoil

↓

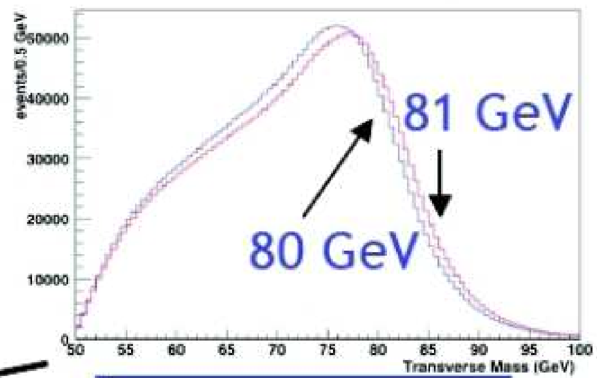
Data

Fast Simulation

- NLO event generator
- Model detector effects

↓

W Mass templates



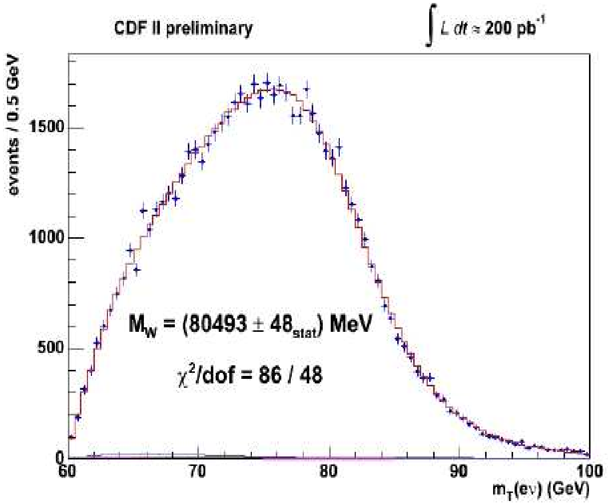
+ Backgrounds

Binned likelihood fit

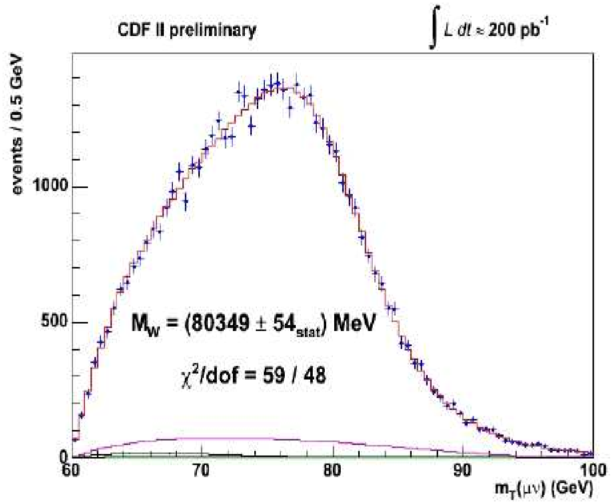
↓

W Mass

W boson mass & width



Electron m_T



Muon m_T

M_W uncertainties

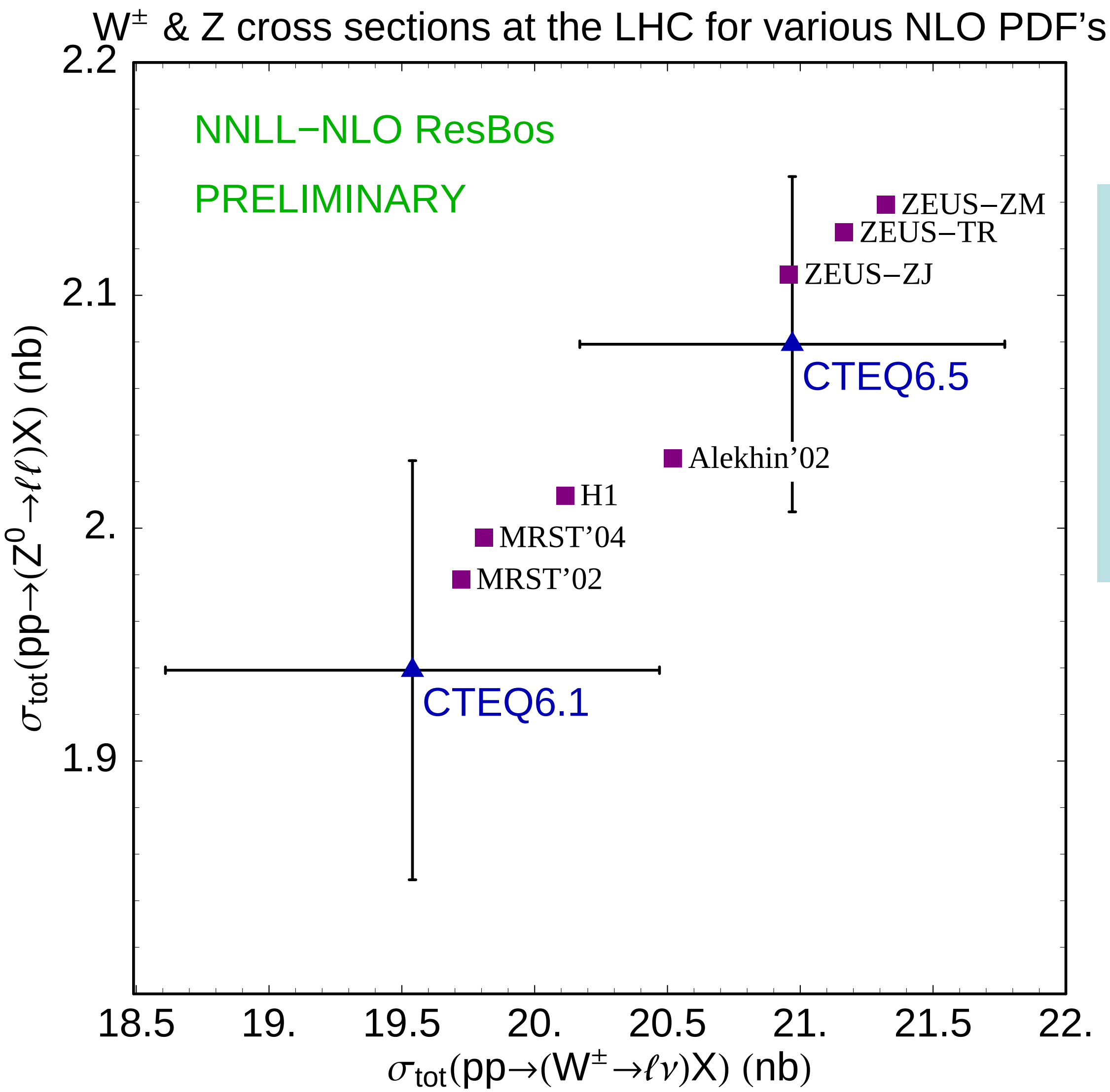
CDF II preliminary $L = 200\ pb^{-1}$

m_T Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	9	9	9
Recoil Resolution	7	7	7
$u_{\parallel}$ Efficiency	3	1	0
Lepton Removal	8	5	5
Backgrounds	8	9	0
$p_T(W)$	3	3	3
PDF	11	11	11
QED	11	12	11
Total Systematic	39	27	26
Statistical	48	54	0
Total	62	60	26

Γ_W uncertainties

CDF Run II Preliminary (350 pb^{-1})

	$\Delta\Gamma_W$ [MeV]		
	Electrons	Muons	Common
Lepton Scale	21	17	12
Lepton Resolution	31	26	0
Simulation	13	0	0
Recoil	54	49	0
Lepton ID	10	7	0
Backgrounds	32	33	0
$p_T(W)$	7	7	7
PDF	16	17	16
QED	8	1	1
W mass	9	9	9
Total systematic	78	70	23
Statistical	60	67	0
Total	98	97	23

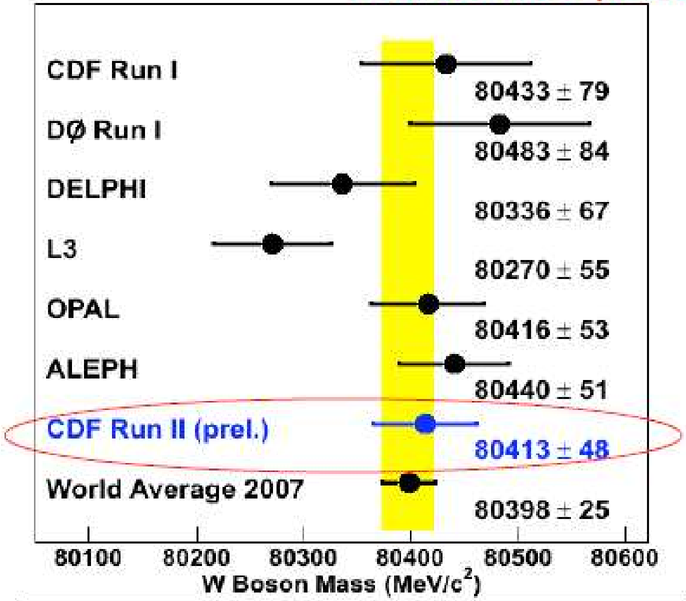


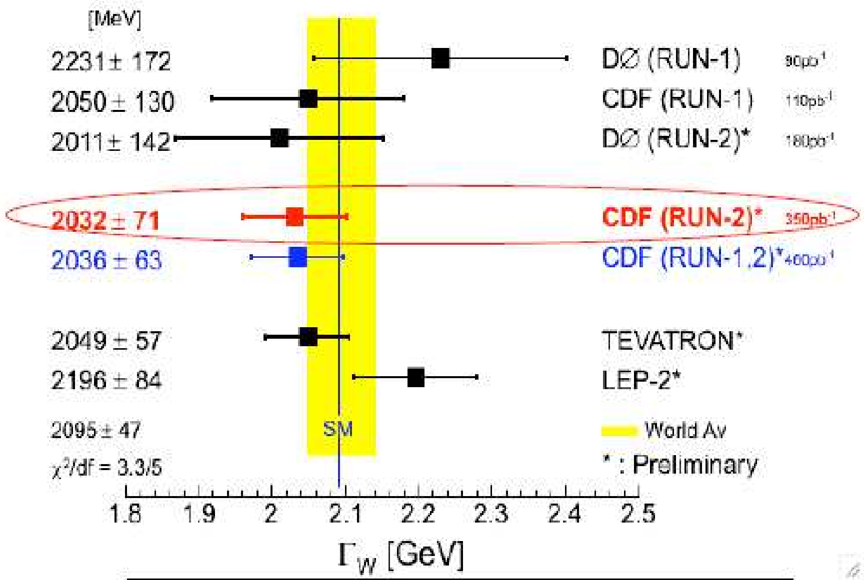
PDF uncertainty still large

~ 10% spread @ LHC on EW cross sections

W boson mass and width : global view

World's most precise single measurements!





Central value increases by 6 MeV:
80392 → 80398 MeV

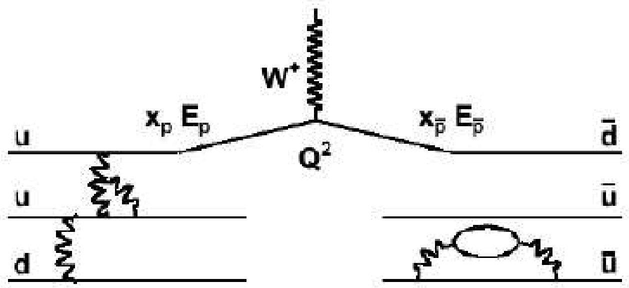
Central value decreases by 44 MeV:
2139 → 2095 MeV

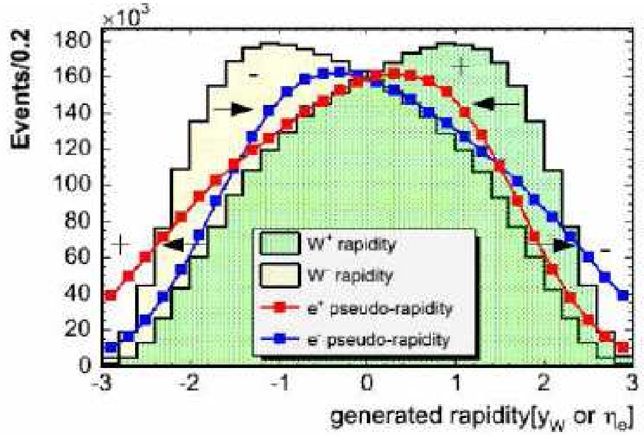
Uncertainty reduced by 15%:
29 → 25 MeV

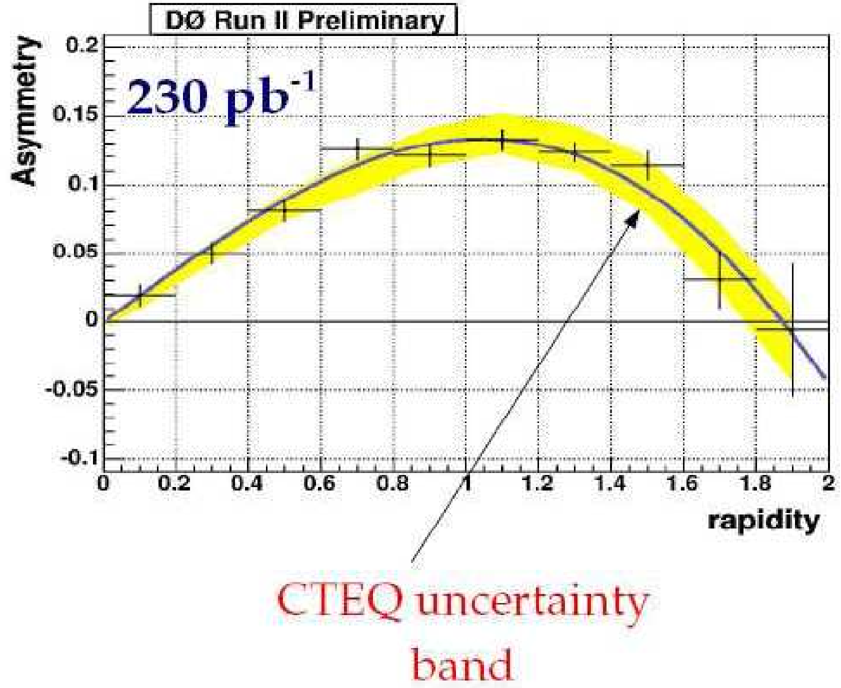
Uncertainty reduced by 22%:
60 → 47 MeV

A good exercice with PDFs : W^+ / W^-

Asymmetric u, d PDFs ⟶ Asymmetric W^+, W^- rapidity distributions

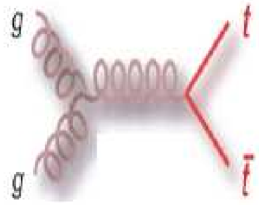


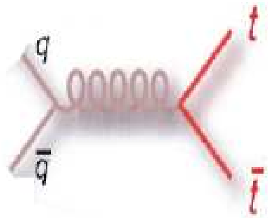


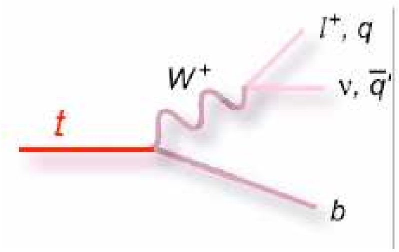


Top quark @ Tevatron

Top Quark Pair Production and Decay at Tevatron

- Production: 85% 

15% 

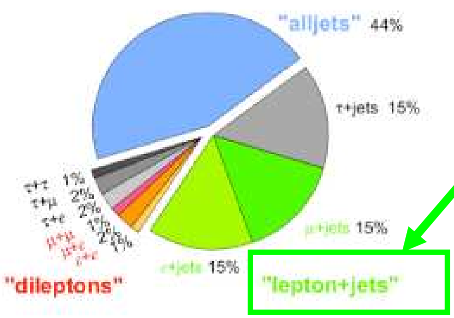
- Decay 

CDF measurement

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = 0.01 \pm 0.16(stat) \pm 0.07(syst)$$

- Final state determined by decay of the two Ws

Top Pair Branching Fractions



"lepton+jets"

(e or μ), υ, W→qq, two b-jets
30% of tt decays
moderate background
→ usually yields most precise measurements

Top Mass Measurement

Example Technique: Matrix Element (ME)

- Form event probability P_{evt}

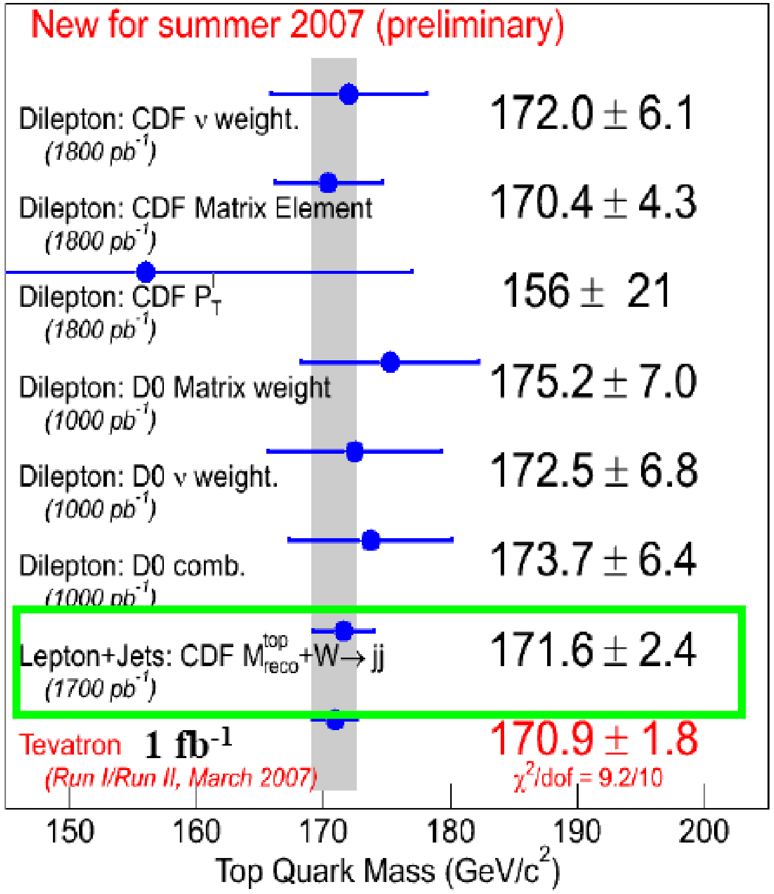
$$P_{evt} = f_{sgn} P_{sgn}(x; m_{top}, JES) + (1 - f_{sgn}) P_{bkg}(x)$$

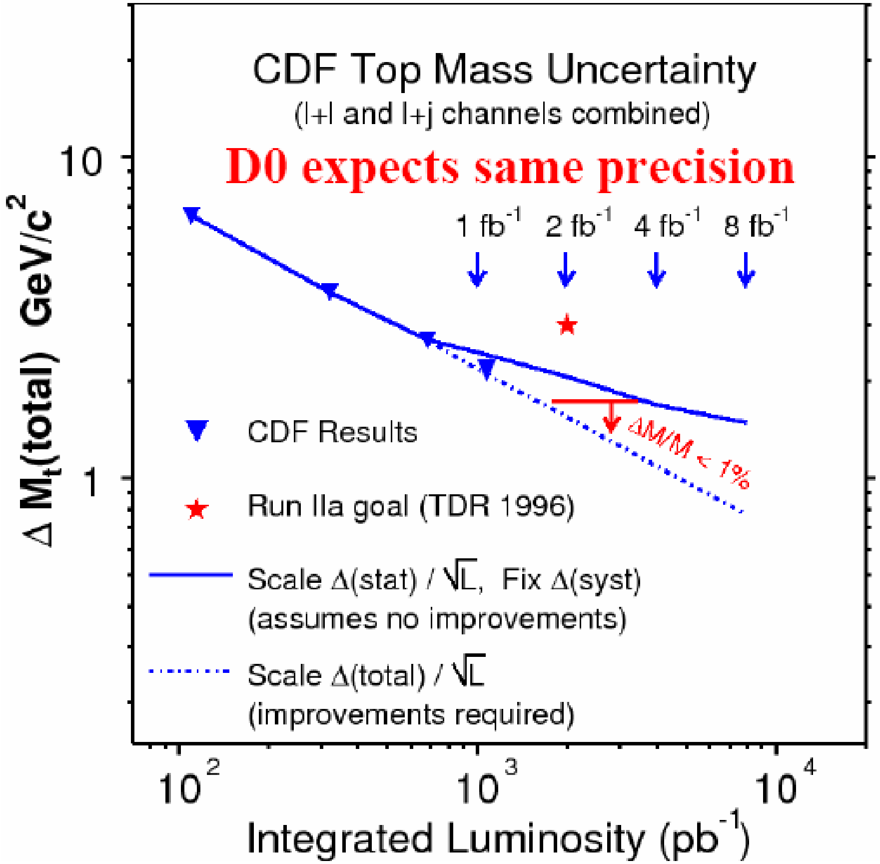
- Where P_{sgn} is the probability to observe x for given values of m_{top} and JES (Jet Energy Scale calibration factor)

$$P_{sgn}(x; m_{top}, JES) = \frac{1}{\sigma} \underbrace{\sum w_i}_{\text{b-tag weights}} \int \underbrace{T(x, y, JES)}_{\text{transfer function}} \underbrace{d\sigma^n(y, m_{top})}_{\text{from ME}} \underbrace{f(q_1) f(q_2)}_{\text{PDFs}} dq_1 dq_2$$

- Integrate over all unmeasured quantities and experimental resolutions
- Fit simultaneously m_{top} and JES
  - using m_W constraint

Results/near future (top mass)



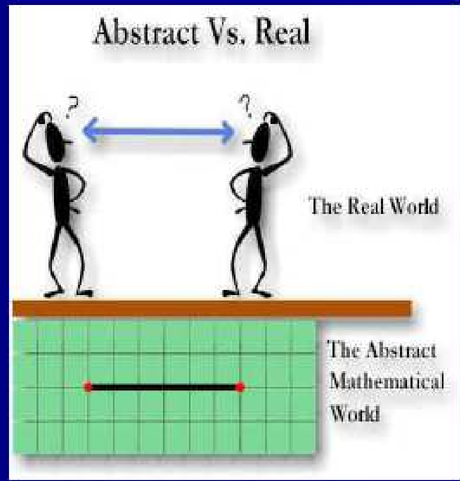


What have we measured?

Using the top quark mass in this manner begs the question — what quantity have we actually measured? There are several options:

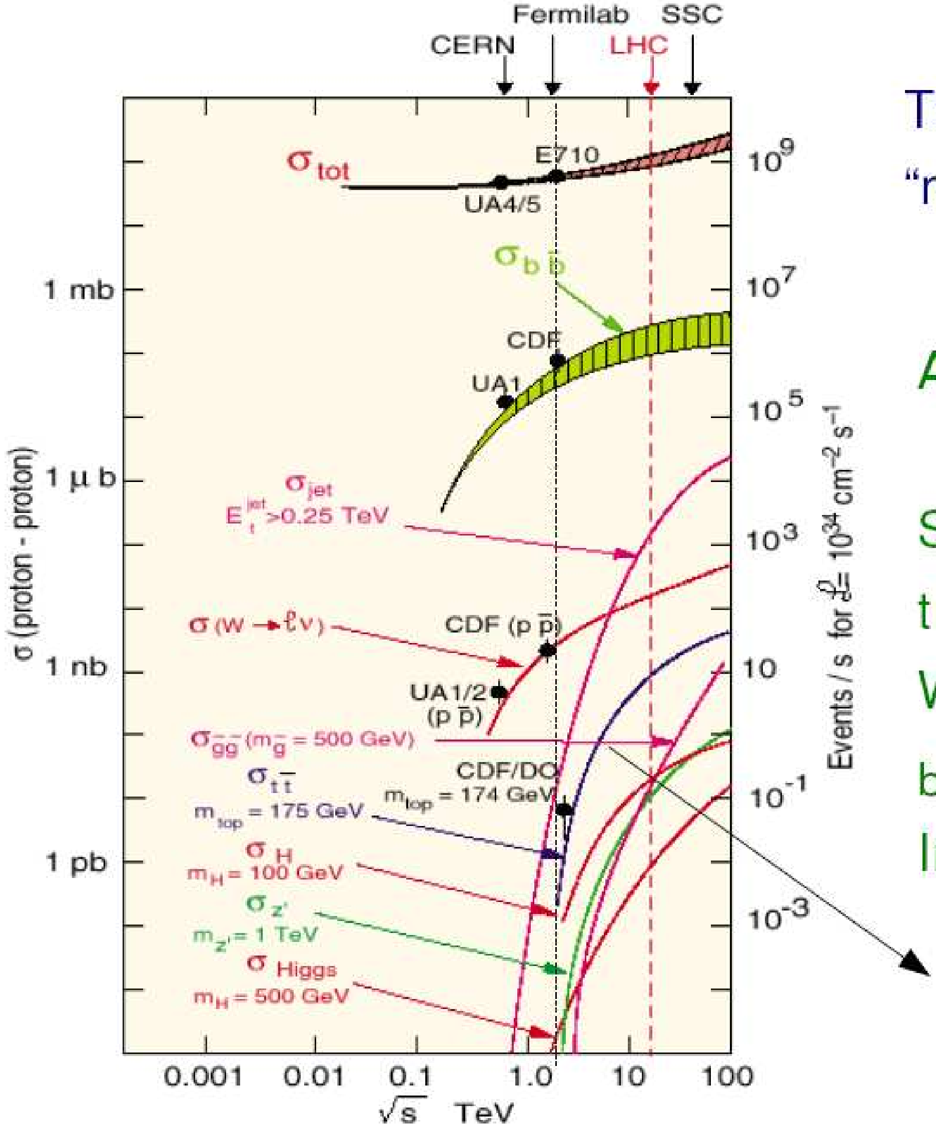
- pole mass
- $\overline{\mathrm{MS}}$ mass
- PMAS(6,1) in PYTHIA
- etc

probably closest given analysis techniques (transfer functions, calibration), but what does this quantity represent within PYTHIA?



CDF and DØ use the same paradigm to measure the top quark mass so the world average is consistent. Deciding what this means theoretically, however, is the subject of some debate.

The LHC case (for EW)



The first goal of LHC will be to "rediscover the Standard Model".

At Luminosity (10^{32} cm^{-2} s^{-1})

SM Higgs (115 GeV/c^2)	→0.001 Hz
t t production:	→0.1 Hz
W→ ℓ ν:	→1 Hz
bb production:	→ 10^4 Hz
Inelastic:	→10^7 Hz

For example, tt cross-section is multiplied by 170 !

With the first physics data in 2008 - 2009....

$1\ fb^{-1}$ ($100\ pb^{-1}$) $\equiv$ 1 (m)year (1 (m)month) at $L = 10^{32}\ cm^{-2}s^{-1}$
$\rightarrow$ may collect a $O(100\ pb^{-1})$ per experiment by end 2008 - early 2009

EW
top
QCD
BSM

Channels (examples ...)	Events to tape for $100\ pb^{-1}$ (per expt: ATLAS, CMS)	Total statistics from some of previous Colliders
$W \rightarrow \mu\nu$		$\sim 10^6$
$\sim 10^4$ LEP, $\sim 10^6$ Tevatron		
Z	$\sim 10^5$	$\sim 10^6$ LEP, $\sim 10^5$ Tevatron
$t\bar{t} \rightarrow WbWb \rightarrow \mu\nu + X$	$\sim 10^4$	$\sim 10^4$ Tevatron
QCD jets $p_T > 1$ TeV	$> 10^3$	---
$\tilde{g}\tilde{g}$ m = 1 TeV	~ 50	---

With these data:

- Understand and calibrate detectors in situ using well-known physics samples
  e.g. - $Z \rightarrow ee, \mu\mu$ tracker, ECAL, Muon chambers calibration and alignment, etc.
  - $t\bar{t} \rightarrow bl\nu\ bjj$ jet scale from $W \rightarrow jj$, b-tag performance, etc.

- "Rediscover" and measure SM physics at $\sqrt{s}$ = 14 TeV : W, Z, $t\bar{t}$, QCD jets ...
  (also because omnipresent backgrounds to New Physics)

W boson @ LHC

- Constrain PDF using $W \to \ell\nu$ ATLAS early data

$$u\bar{d} \to W^+ \to e^+\nu$$

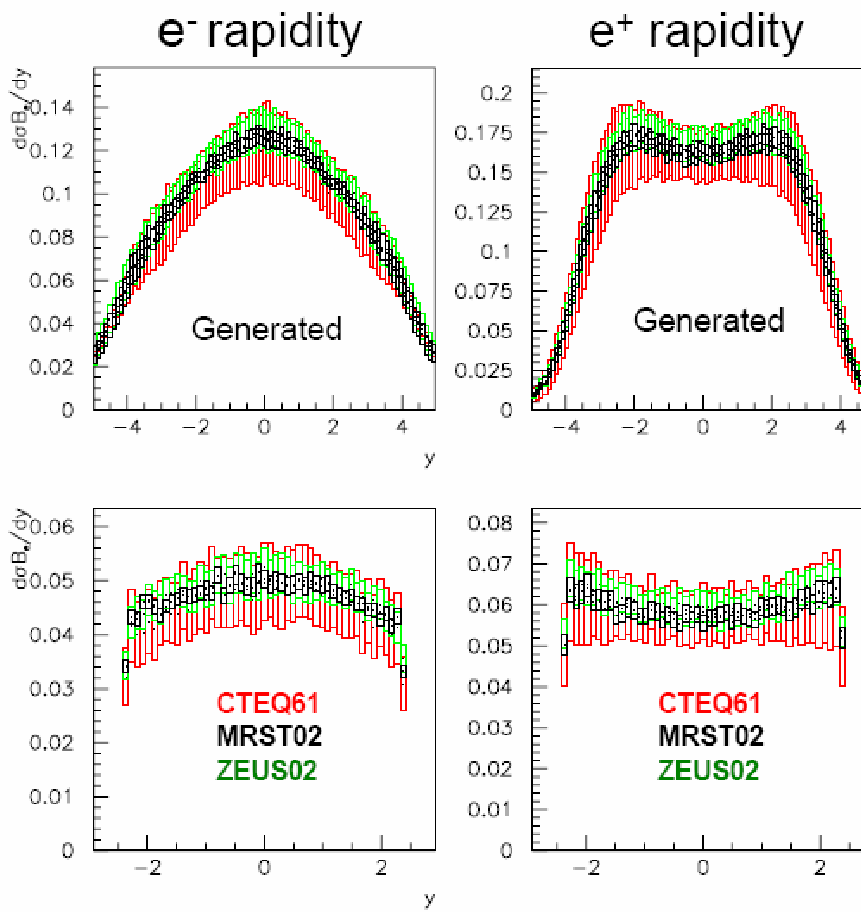
$$d\bar{u} \to W^- \to e^-\bar{\nu}$$

  – $e^\pm$ rapidity spectrum shape: sensitive to gluon shape parameter - valence quark density

- Probe low-x gluon PDF at $Q^2=M_W^2$

The selection:

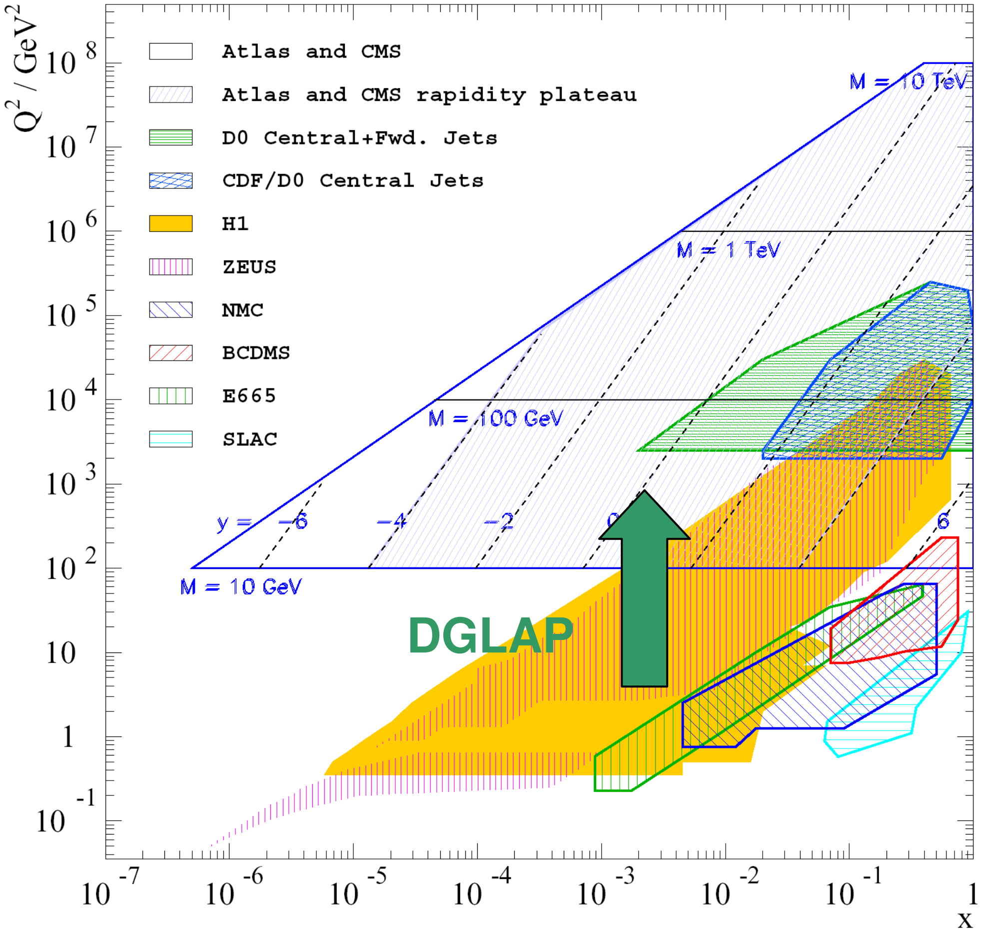
- Isolated electron p_T>25 GeV, $|\eta|$<2.4
- E_T^{miss}>25 GeV
- no jets with E_T>30 GeV
- p_T^{recoil}<20 GeV
- BKG <1% $W/Z \to \tau$, $Z \to e^+e^-$, QCD

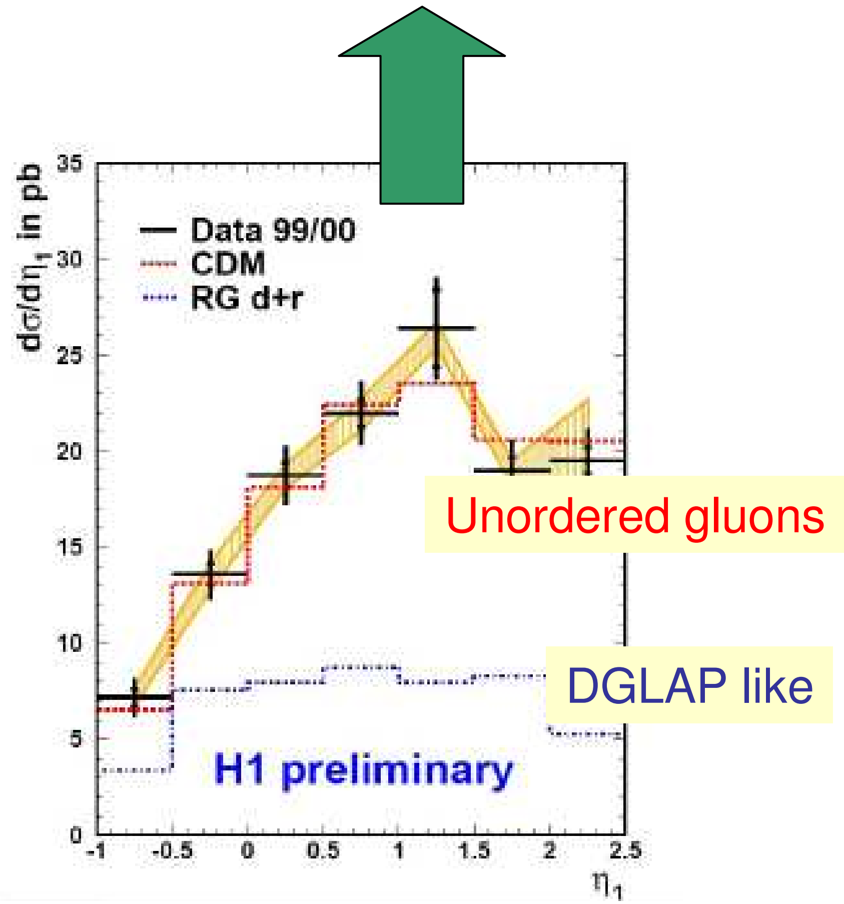


Low x @ LHC ?

Not so obvious that MC would (in their present forms) would be useful?!

We have evidence for unordered gluon radiation at low x and large rapidities



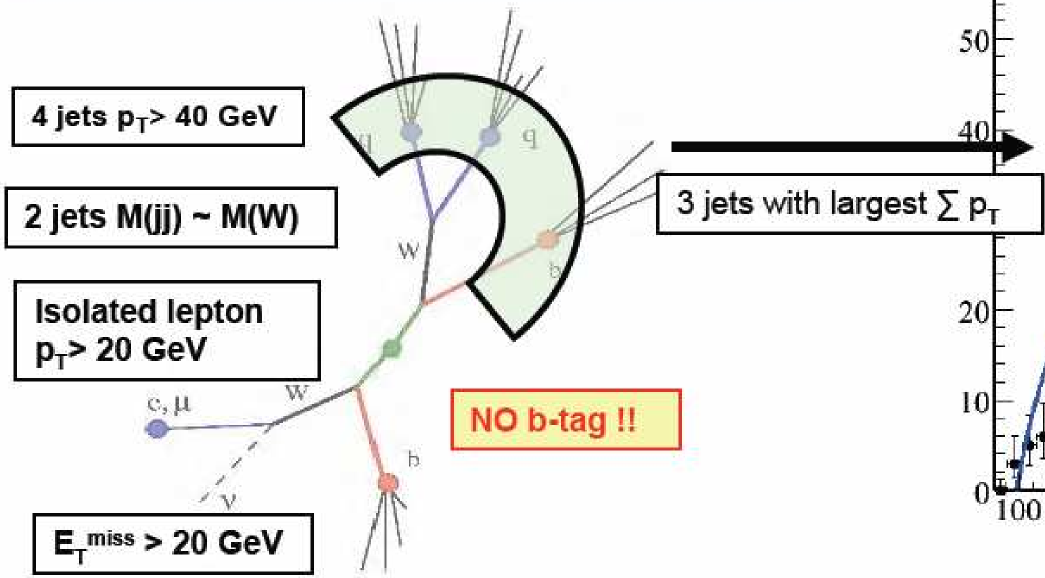


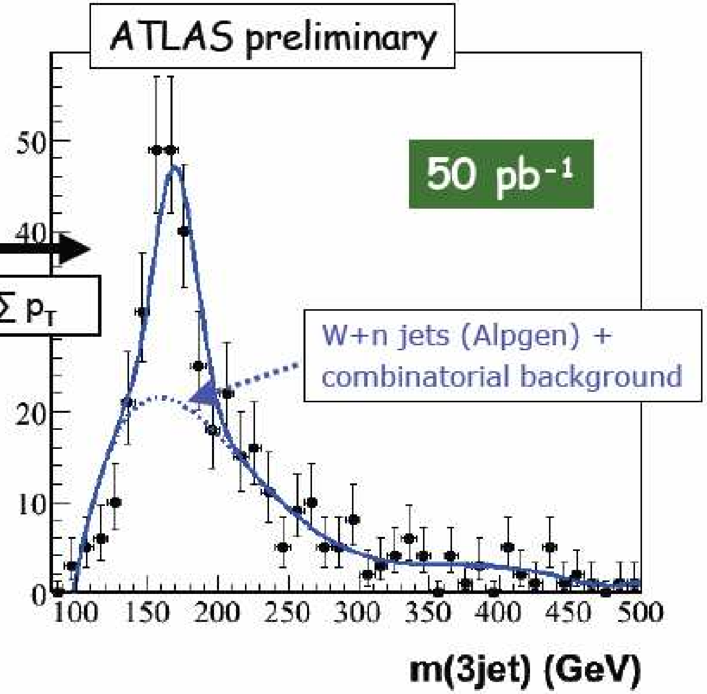
Top quark @ LHC

Example of initial measurement: understanding detector and physics with top events

Can we observe an early top signal with limited detector performance ?
And use it to understand detector and physics ?

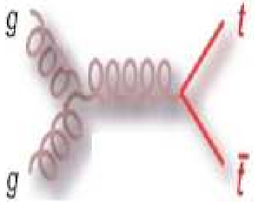
$\sigma_{t\bar{t}} \approx 250$ pb for $t\bar{t} \rightarrow bW\ bW \rightarrow bl\nu\ bjj$



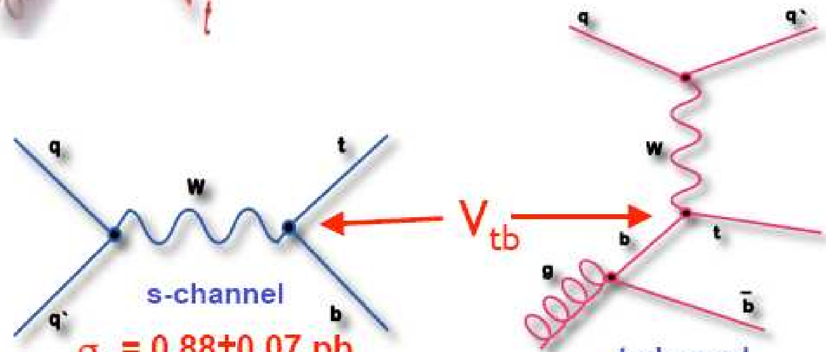


Top signal observable in early days with no b-tagging and simple analysis
(100 ± 20 evts for 50 pb^{-1}) → measure $\sigma_{t\bar{t}}$ to 20%, m to 10 GeV with ~100 pb^{-1} ?
In addition, excellent sample to:
- understand detector performance for e, μ, jets, b-jets, missing E_T, …
- understand / constrain theory and MC generators using e.g. p_T spectra

Single top @ Tevatron(/LHC)

- Top pairs: 

  σ_{tt} = 6.7 ± 0.8 pb

- Single top: 

  σ_s = 0.88±0.07 pb

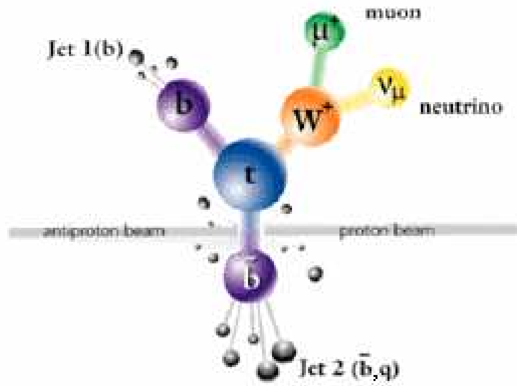
  σ_t = 1.98±0.21 pb

- Motivation
  - Top pairs
    - can measure only ratio of couplings to kinematically allowed final states

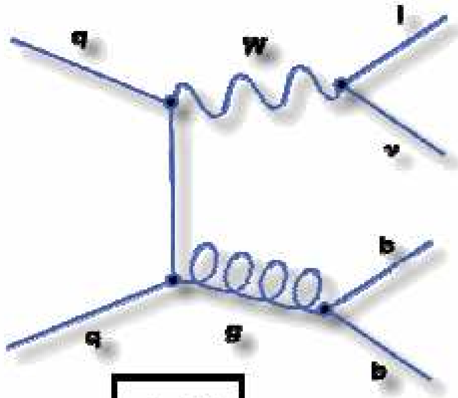
$$R = \frac{Br(t \to Wb)}{Br(t \to Wq)} = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2}$$

  - Single top
    - $\sigma_{s+t} \propto |Vtb|^2$
    - $|Vtb|^2$ can be determined with assumptions of 3 generations, unitarity

Backgrounds to Single Top

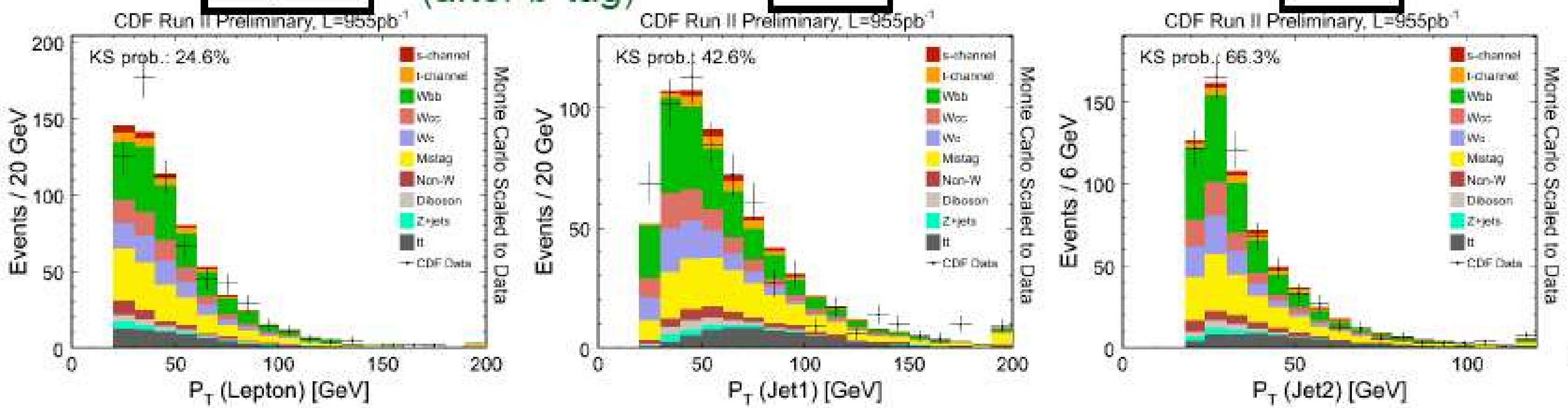


- σ_{s+t} only a factor of two lower than σ_{tt}
  - signal event signature less pronounced
    - fewer high p_T objects

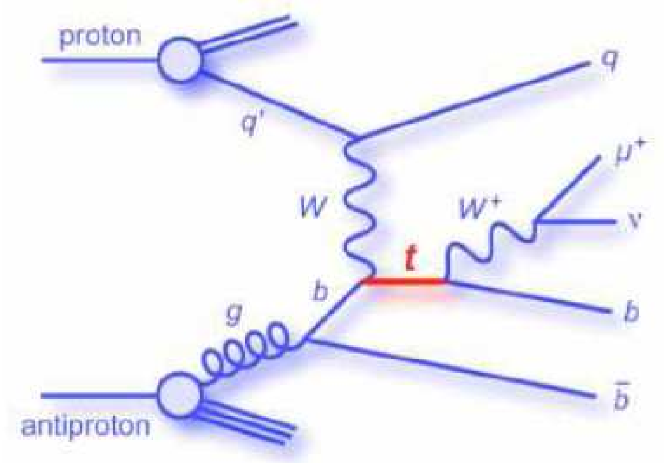


OK with what we have seen on W boson measurements

- Backgrounds much more of a challenge!
- W+jets poorly understood
  - especially W+heavy flavour
  - considerable tuning of MC to data required
  - Lepton (after b-tag) Jet1 Jet2



Signal for single top production

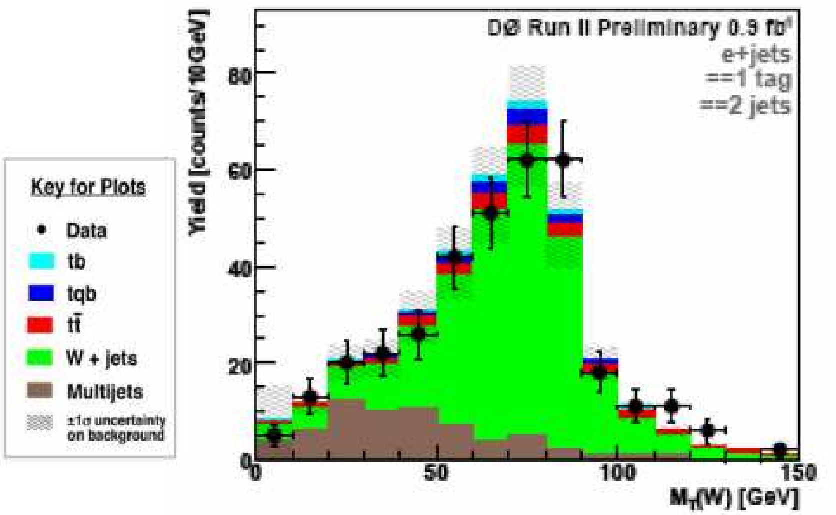


- High p_T jet
- High p_T lepton
- Missing transverse energy
- High p_T jet ("*b*-tagged")
- High p_T jet ("*b*-tagged")

- One isolated high transverse momentum lepton
- Missing transverse energy
- Two to four high transverse momentum jets
- One or two jets associated with *b*-quark:
  - Labeled as a "*b*-tagged" jet

Analysis selection (« first » step)

Source	Event Yields in 0.9 fb^{-1} Data Electron+muon, 1tag+2tags combined		
	2 jets	3 jets	4 jets
tb	16 ± 3	8 ± 2	2 ± 1
tqb	20 ± 4	12 ± 3	4 ± 1
$t\bar{t} \rightarrow ll$	39 ± 9	32 ± 7	11 ± 3
$t\bar{t} \rightarrow l$+jets	20 ± 5	103 ± 25	143 ± 33
$W+b\bar{b}$	261 ± 55	120 ± 24	35 ± 7
$W+c\bar{c}$	151 ± 31	85 ± 17	23 ± 5
$W+jj$	119 ± 25	43 ± 9	12 ± 2
Multijets	95 ± 19	77 ± 15	29 ± 6
Total background	686 ± 41	460 ± 39	253 ± 38
Data	697	455	246



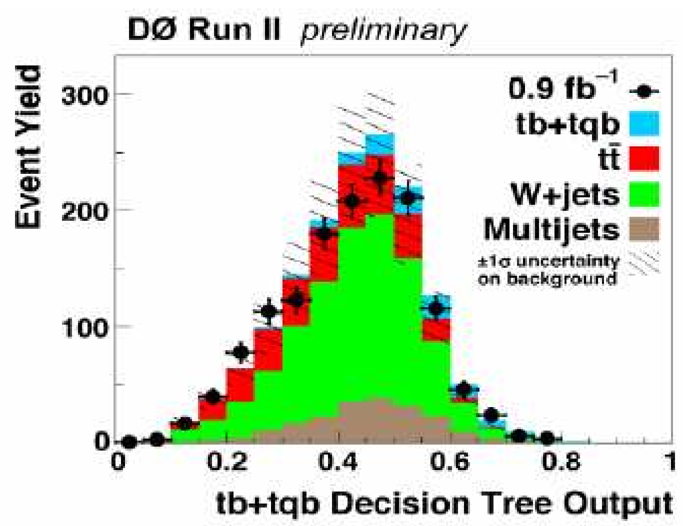
- Signal acceptances:
  tb=(3.2 ± 0.4)%   tqb=(2.1 ± 0.3)%
- Single top signal smaller than total background uncertainty
- Cross section uncertainty dominated by statistical uncertainty

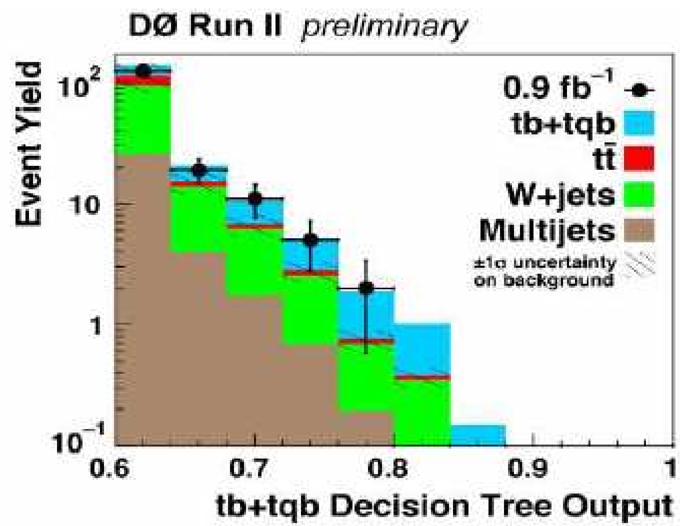
Source of Uncertainty	Size
Top pair normalization	18%
W+jet & multijet norm.	18-28%
Integrated luminosity	6%
Trigger modeling	3-6%
Lepton ID corrections	2-7%
Other small components	Few%
Jet energy calibration	1-20%
"*b*"-tagged jet modeling	2-16%

tricky buisness then

Statistical analysis : decision trees

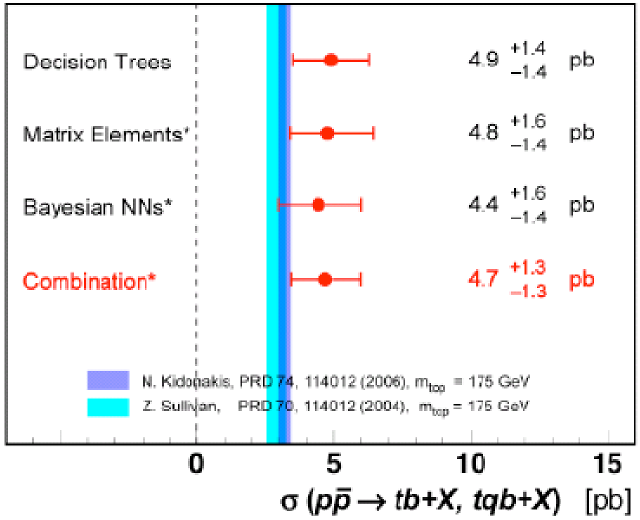
- Goal: recover events that fail a simple cut-based analysis
- Use 49 variables for training: most discriminating variables
  M(alljets), M(W,b-tag1), cos(b-tag1,lepton), Q(lepton)*η(untagged1)
- Decision tree output for each event = leaf purity: $N_S/(N_S+N_B)$
- Train network on signal and background simulated events:
  - Signal tends to one and background tends towards zero
- Boosting: retrain 20 times to improve "weak classifier"





Results : evidence for single top (D0)

- Combined result
  - σ_{s+t} consistent with SM
  - 3.6σ significance
  - 2.4σ expected significance



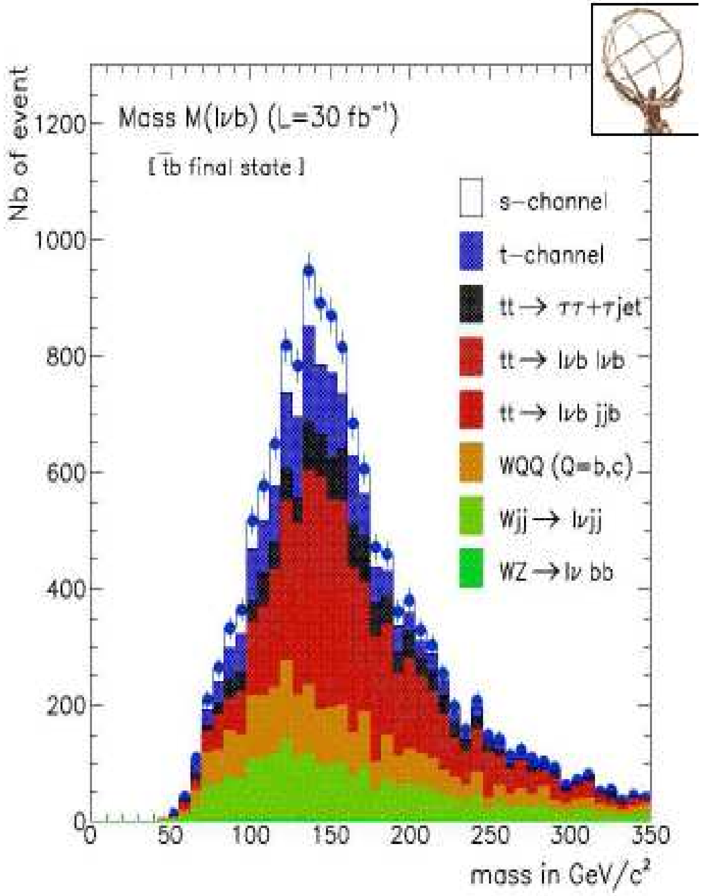
D0	Bayesian NN		Matrix Element		Decision Trees	
	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.
σ(tb+tqb)[pb]	$3.2^{+2.0}_{-1.8}$	5.0 ± 1.9	$3.0^{+1.8}_{-1.5}$	$4.6^{+1.8}_{-1.5}$	$2.7^{+1.6}_{-1.4}$	4.9 ± 1.4
Significanc	1.3σ	2.4σ	1.8σ	2.9σ	2.1σ	3.4σ

CDF	Matrix Element	Neural Network	Likelihood ratio
	2.3 σ excess	No evidence.	No evidence.
σ(tb+tqb)[pb]	$2.7^{+1.5}_{-1.3}$	< 2.6	< 2.7

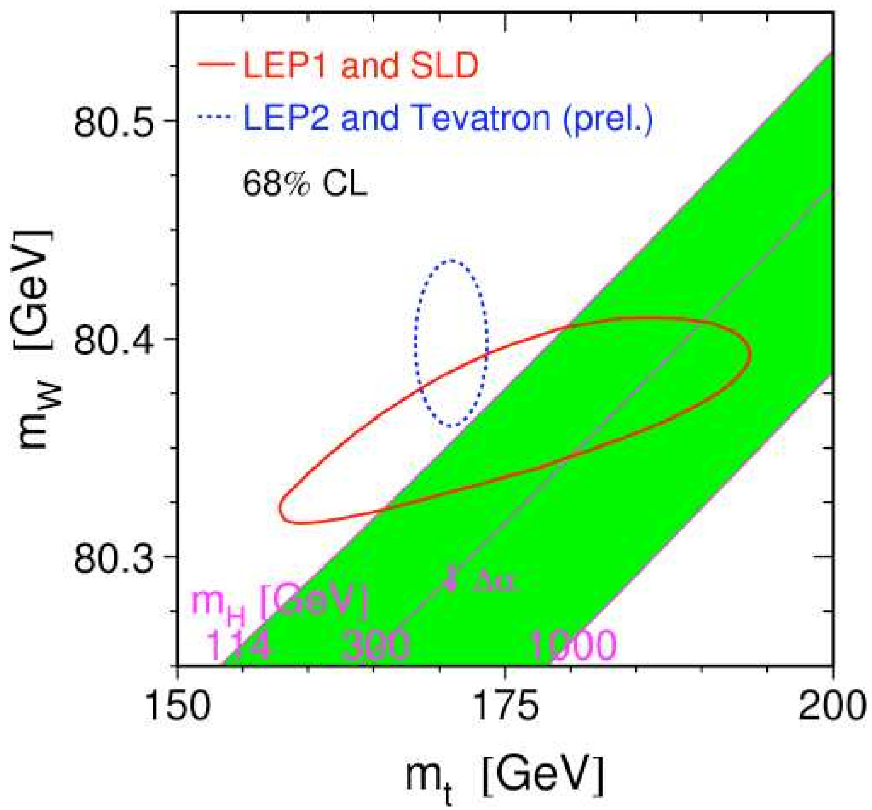
+ $|V_{tb}| = 1.3 \pm 0.2$ or $0.68 < |V_{tb}| < 1$ at 95%CL

Single top @ LHC for 30 fb^{-1}

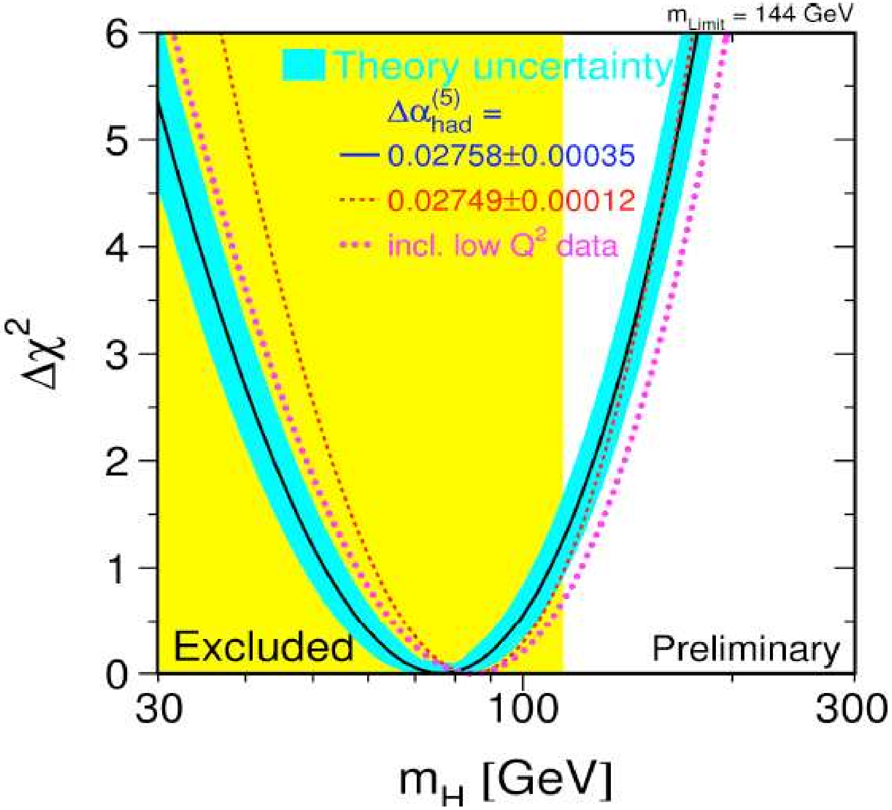
- Typical Selection cut:
  - 1 lepton, p_T>25GeV
  - High Missing E_T
  - ≥2 jets (at least 1 bJet)
- Separate Channels by $(N_J;N_B)$ in final state:
  - t Channel → $(N_J;N_B)=(2,1)$
  - Wt Channel → $(N_J;N_B)=(3,1)$
  - s Channel → $(N_J;N_B)=(2,2)$



EW physics & impact on Higgs boson



Data prefer light Higgs



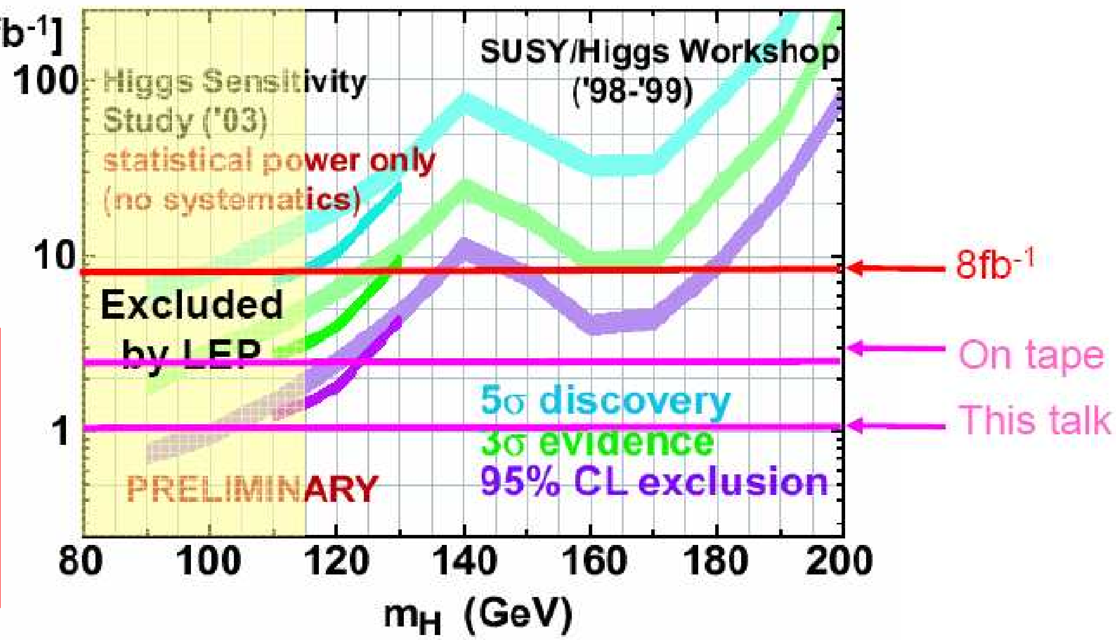
Probability M_H>114 GeV:
15%

Renormalise probability
for m_H>114 GeV to 100%:
m_H < 182 GeV (95%CL)

Higgs searches : last results (LP07)

- Previous studies
  - Sensitivity above LEP starts at $2fb^{-1}$
  - $8fb^{-1}$: Exclusions from 115-135GeV & 145-180GeV

TeV GOAL

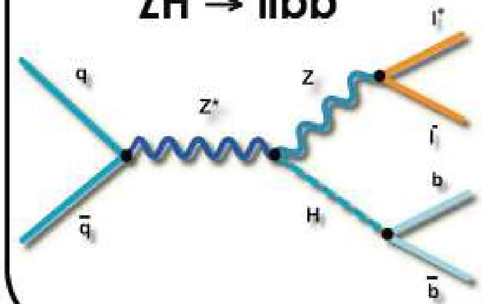


- Now:
  - Measuring SM backgrounds (tt, Zbb, Wbb, WZ, ZZ, single top !)
  - Optimizing analysis techniques
  - 1st combined Higgs limits & comparing to predictions

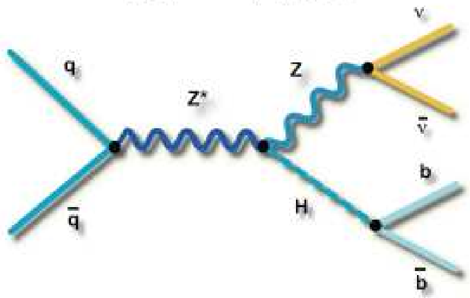
Strategies (Higgs boson) @ Tevatron

- For low mass Higgs : 3 main channels

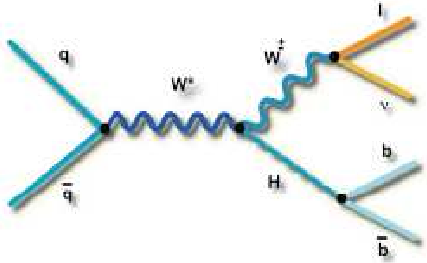
$ZH \to llbb$



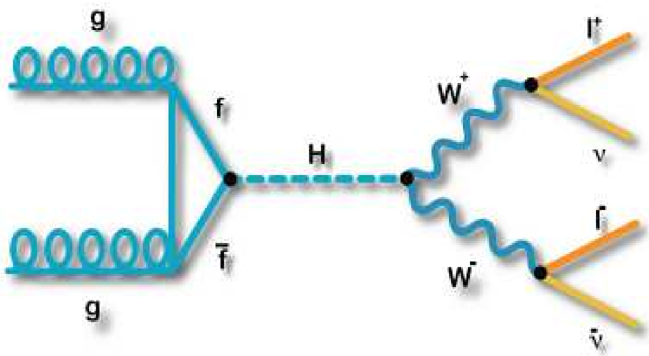
$ZH \to \nu\nu bb$



$WH \to l\nu bb$



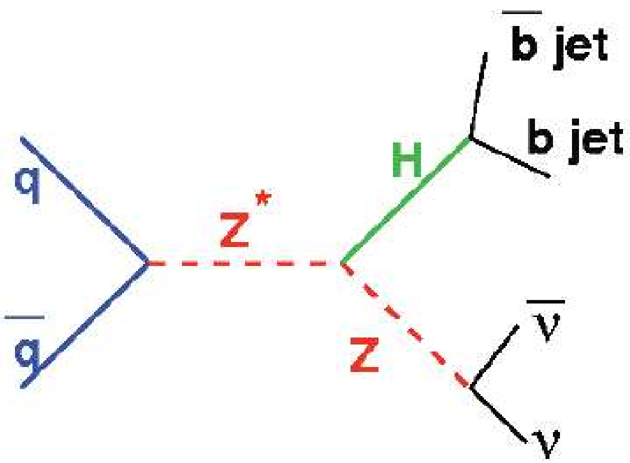
- For high mass Higgs : 1 main channel

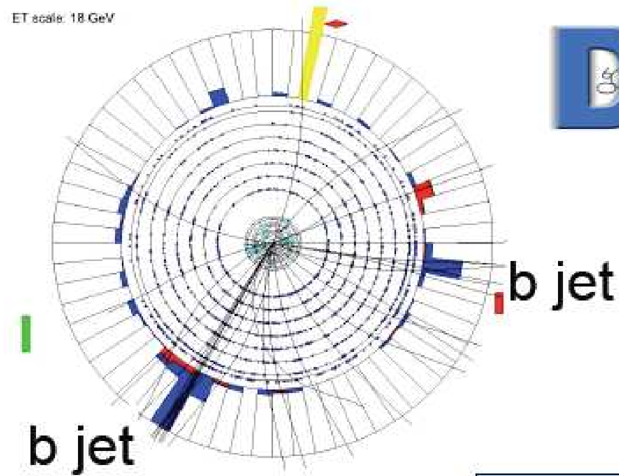


$gg \to H \to WW \to l\nu l\nu$

Examples of analysis status

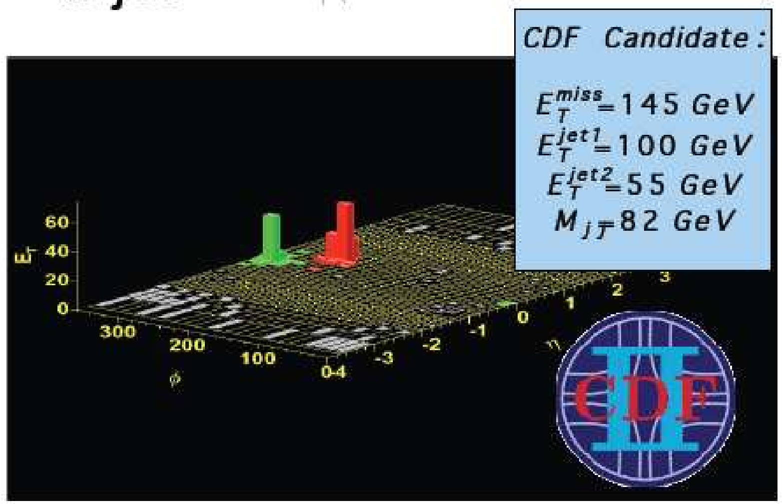
$ZH \rightarrow \nu\nu bb \quad \not{E}_T$ 힉스



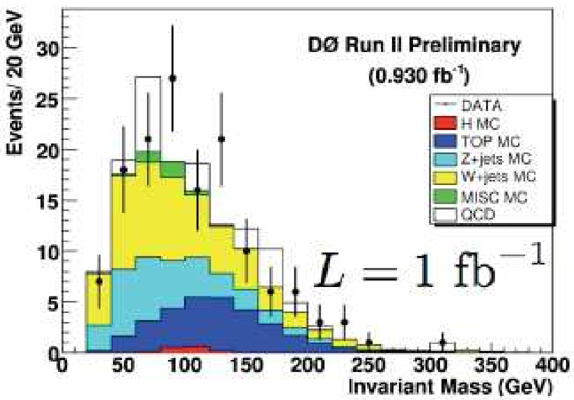


Basic selection:

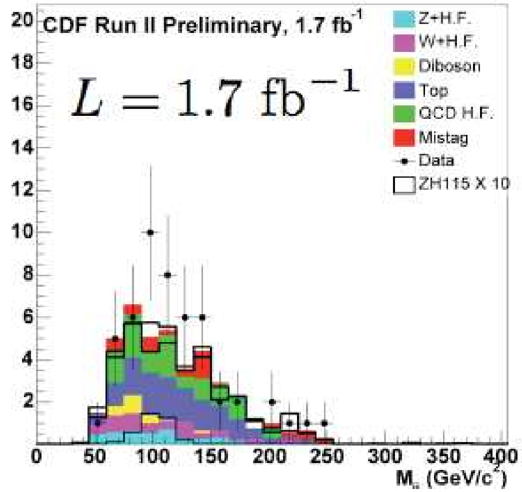
- two acoplanar jets
- ≥ 1 tagged b-jets (CDF)
  2 tagged b-jets (DØ)
- E_T^{miss} > 70 GeV (CDF)
  50 GeV (DØ)



$ZH \rightarrow \nu\nu bb$ 힉스



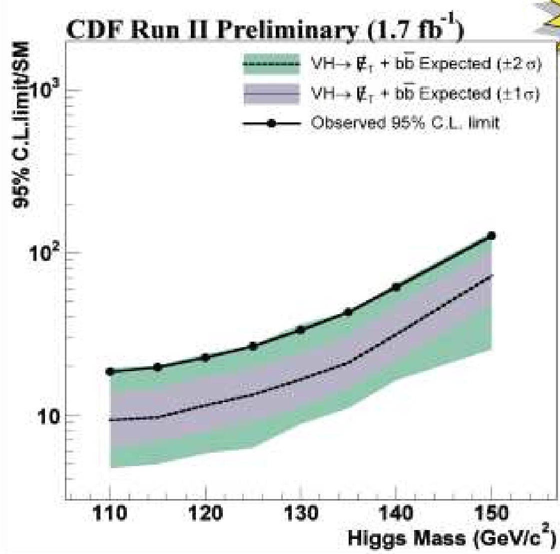
Dijet Mass, SR, L+L



Backgrounds :

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

NEW

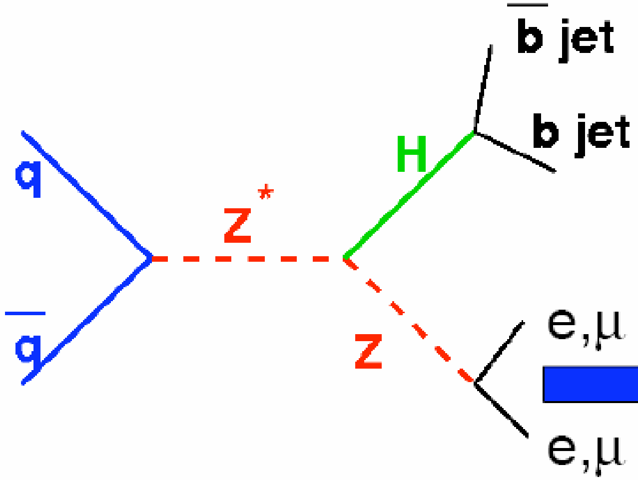


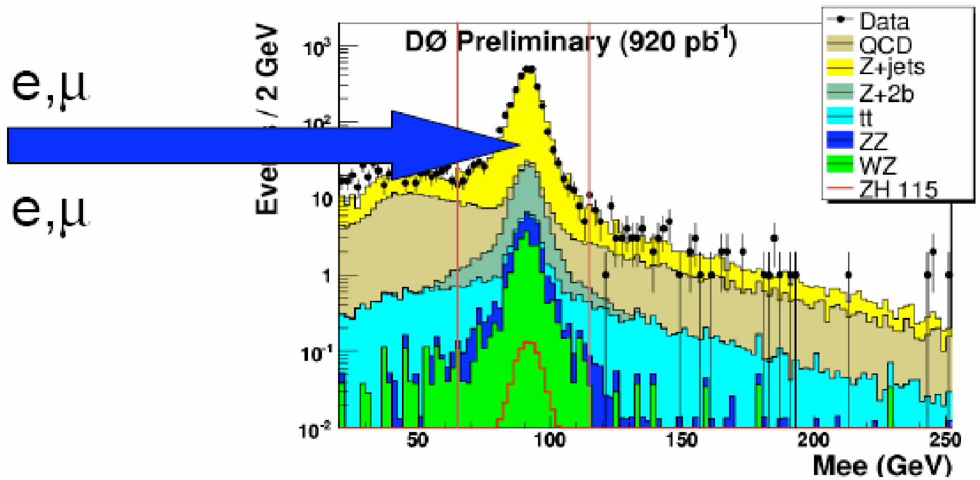
same sensitivity as WH channel:

m_H=115 GeV: σ_{95}/SM=9.7(exp),19.7(obs)

$ZH \to \ell^+\ell^- bb$

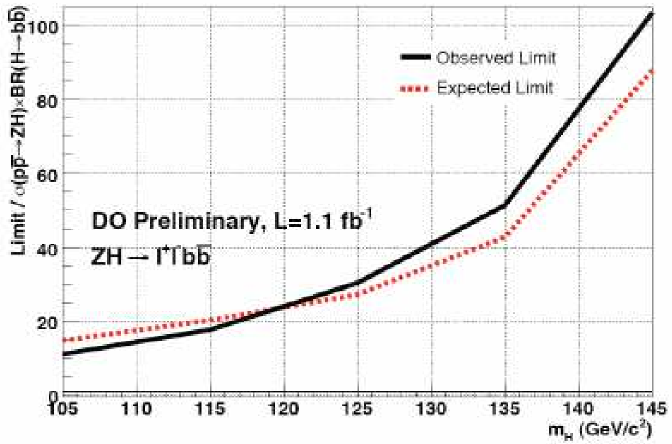
힉스

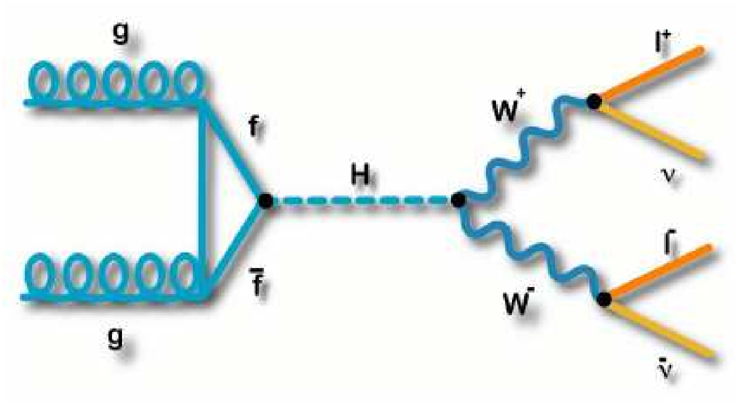




Basic selection:

-require two isolated muons or electrons in Z mass window
-one or two tagged b jets



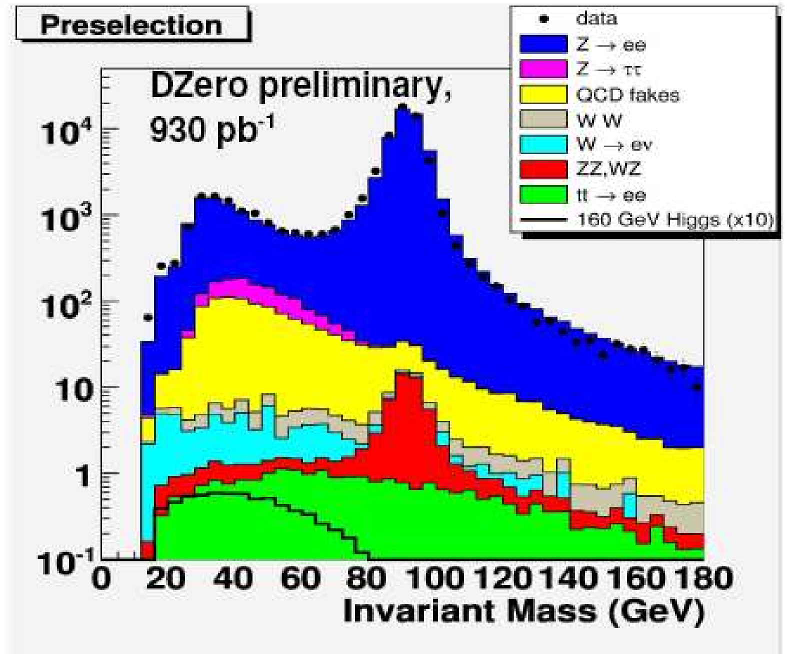


Main search channel for mass > 135 GeV

Study ee, mumu and emu channels

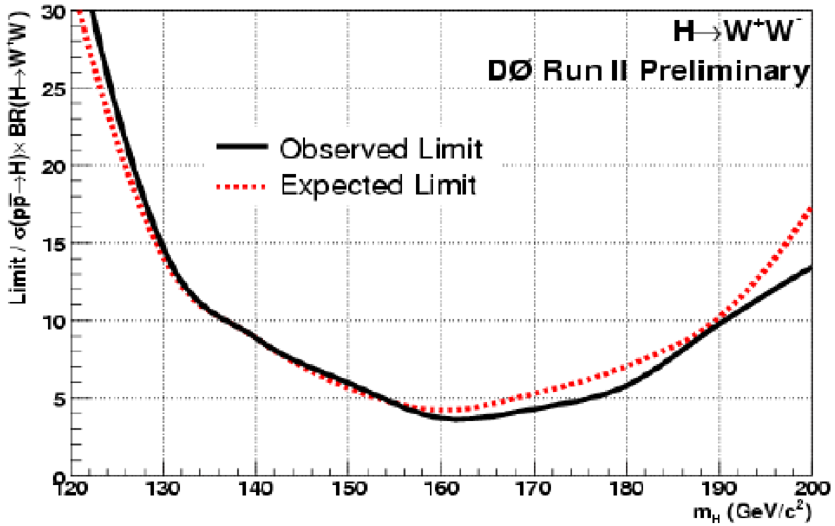
Signature:

- opposite sign leptons (10 - 20 GeV)
- missing energy



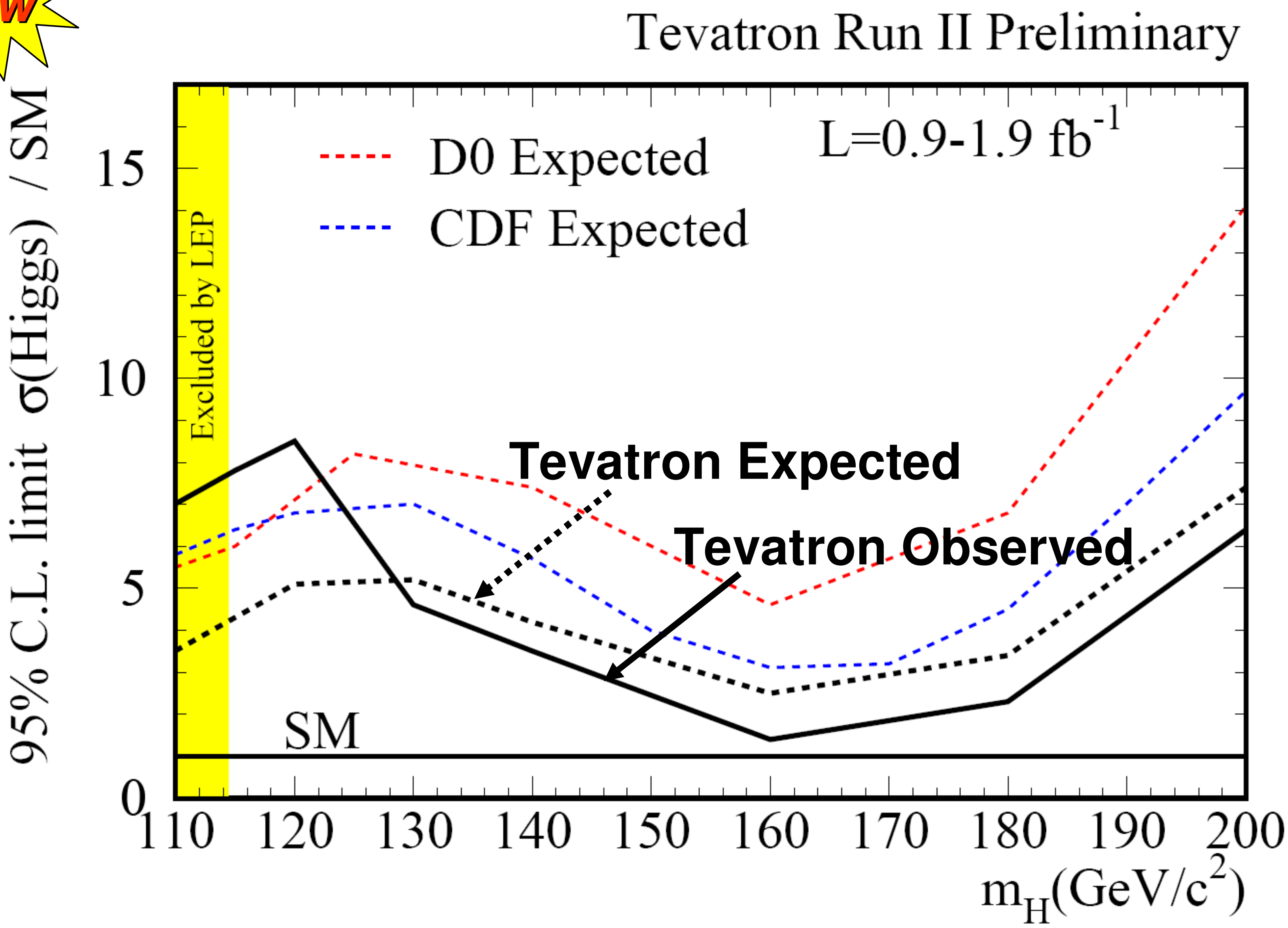
Main backgrounds are:

- Drell-Yan
- QCD: semi-leptonic decays
  jets faking electrons
- Diboson (WW, WZ, ZZ)
- top



New

Results / last limits

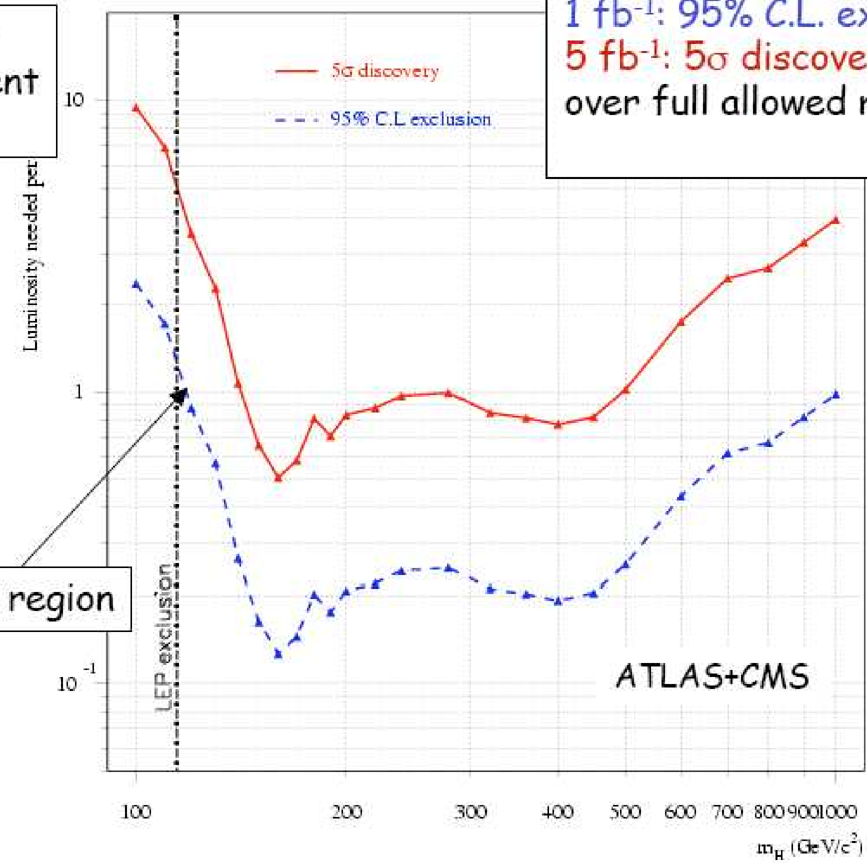


Higgs boson searches @ LHC

1 summary plot

Needed ∫Ldt per experiment (fb^{-1})

With
1 fb^{-1}: 95% C.L. exclusion
5 fb^{-1}: 5σ discovery
over full allowed mass range



Most difficult region

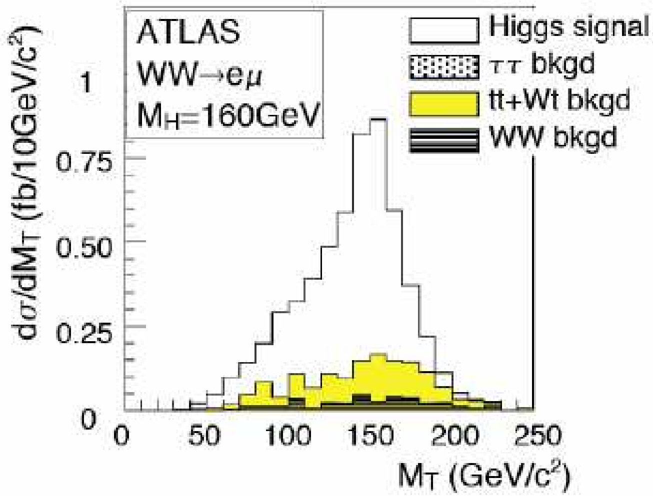
Production rate :
2 orders of magnitude
larger than @ TeV

If Higgs found, mass can be measured to 0.1%, couplings to ~ 10-20%
→ major insight into electroweak symmetry breaking mechanism

Higgs boson @ Tev/LHC (in numbers)

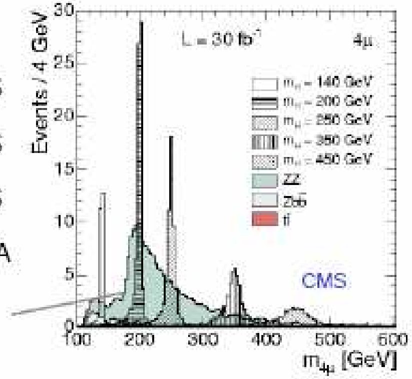
Tevatron

	Produced	Selected	Background
ZH-->llbb	5	1	100
ZH-->ννbb	15	2	300
WH-->lνbb	30	3	500
H-->WW-->llνν	20	4	300



LHC

	Produced	Selected	Background	
H(135)-->γγ	86	30	300	CMS
H(140)-->ZZ*-->llll	13	3	500	CMS
H(160)-->WW-->llnn	2300	45	30	CMS
qqH(160)-->qqWW-->qqllnn	280	4	1	ATLA

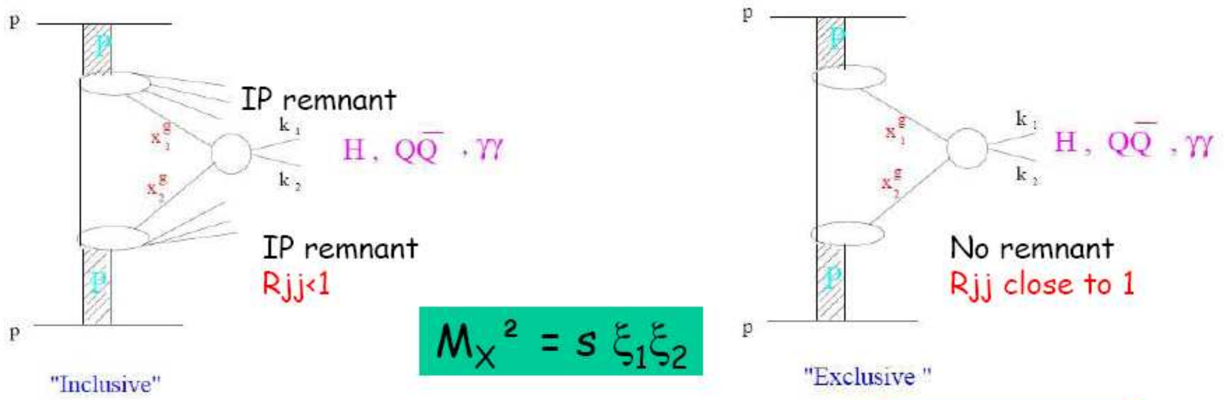


Higgs boson
@ Tev/LHC

Alternative search

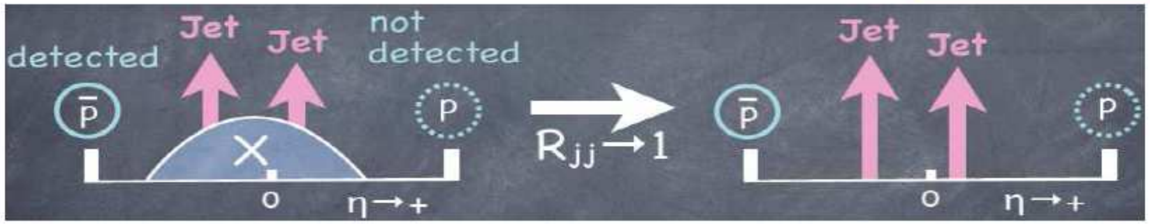
clean but low rate

Double Diffractive exchange

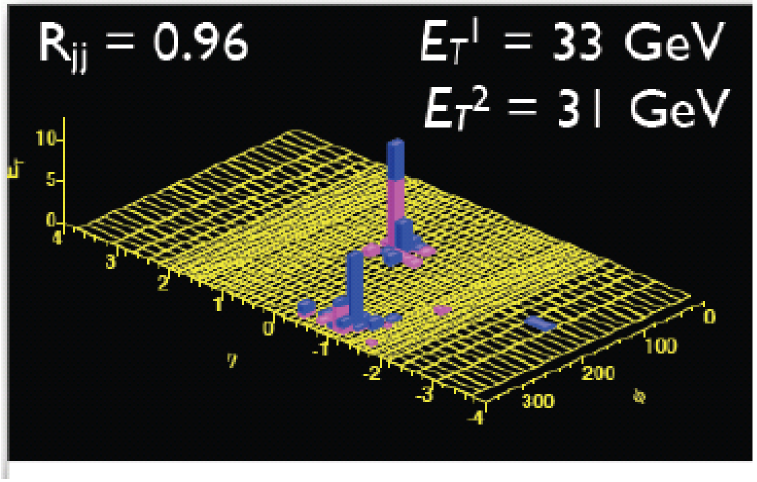


Measurement of the Dijet Mass Fraction @ TeV

$$R_{jj} = \frac{M_{jj}}{M_X}$$



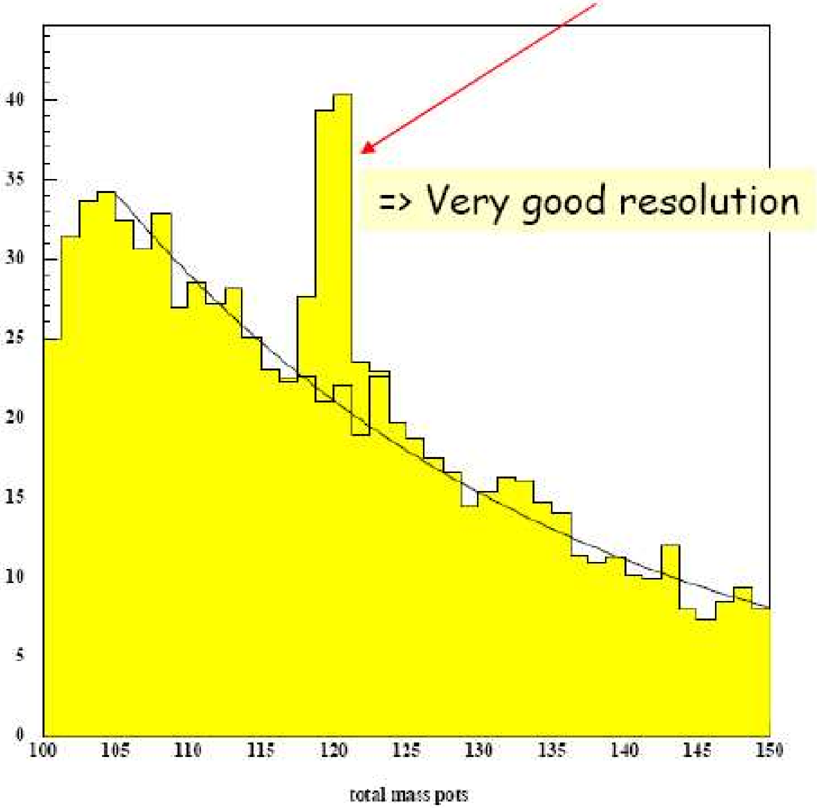
CDF Run II Preliminary

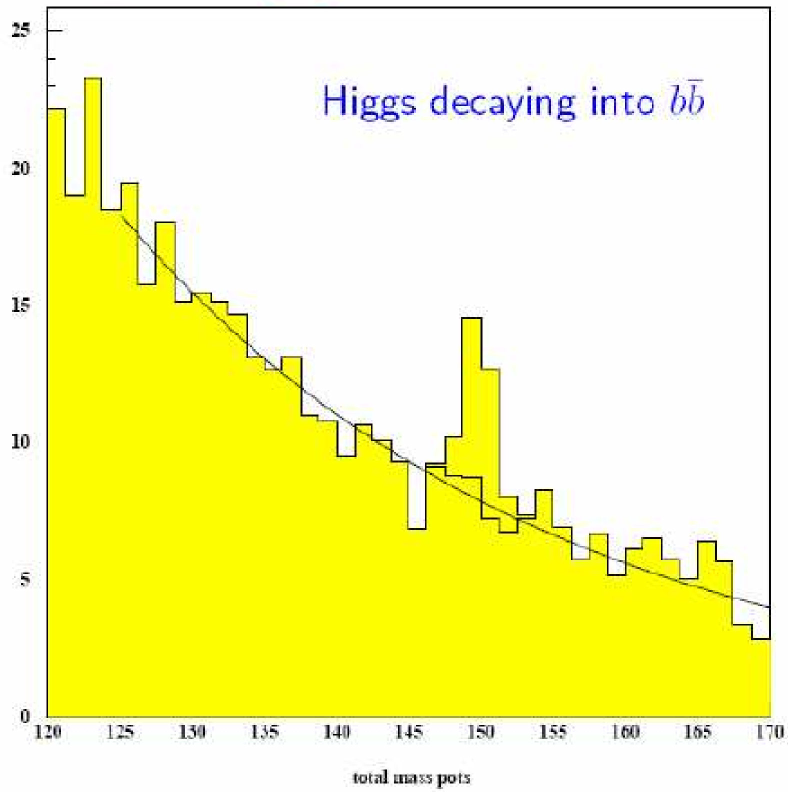


Exclusive Higgs production @ LHC

After the hints from the TeV, let's come back on the Higgs exclusive production @ LHC : **simul for a 120 & 150 GeV mass Higgs!**

Measurement of the mass from : $M_X^2 = s\,\xi_1\xi_2$



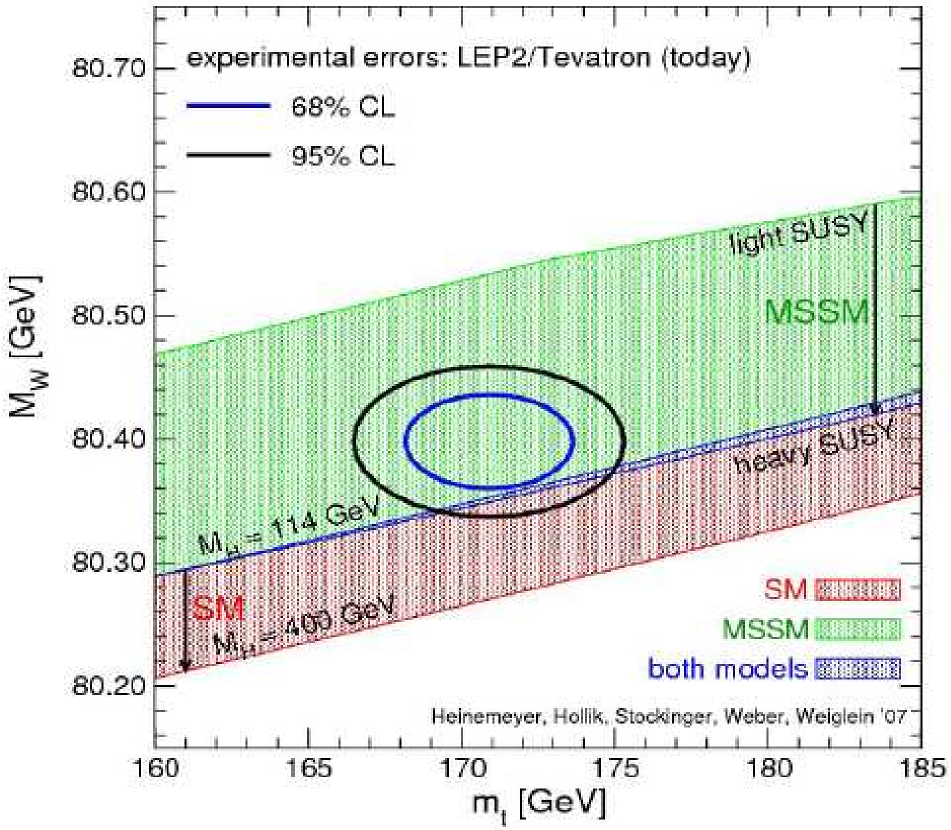


Signal and background for different Higgs masses for 100 fb^{-1}

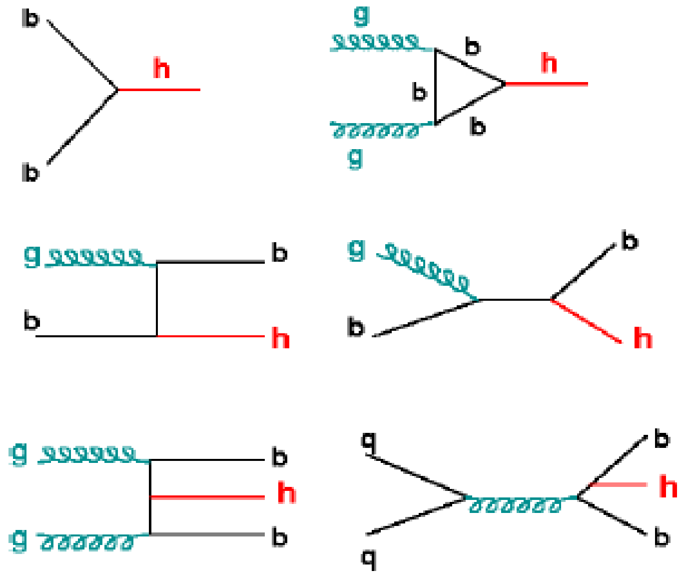
BSM (light) Higgs

Higgs sector with 2 doublets

$$H_U, H_D \longrightarrow h, H, A, H^{\pm}$$



Measured top and W masses favor low values for M_H
(dangerously entering MSSM regime)

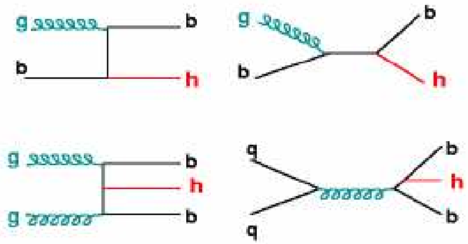


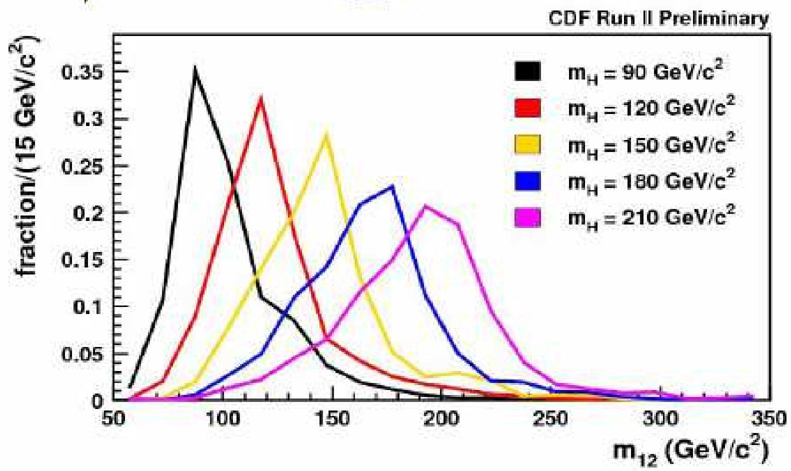
At low masses

$$Br(h \to bb) \sim 90\% , Br(h \to \tau\tau) \sim 10\%$$

ϕb(b)->bb b(b)

NEW





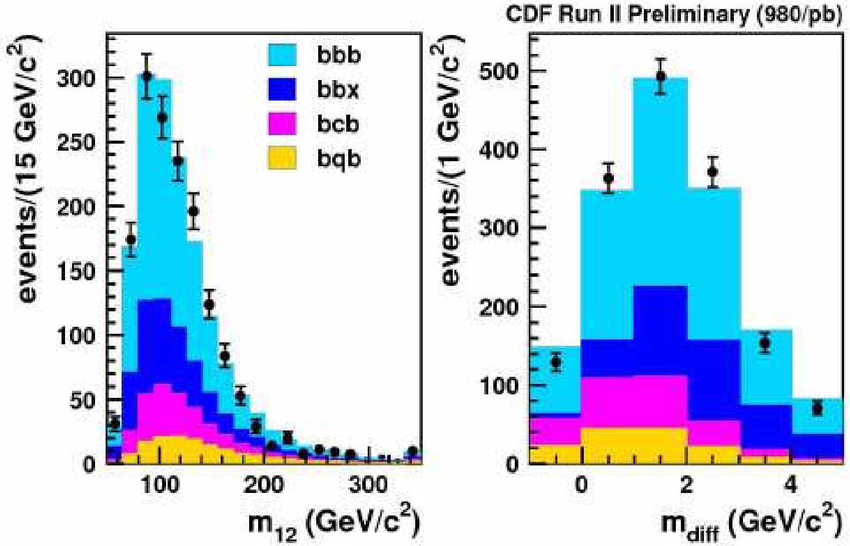
3 b-tagged jets in the final state

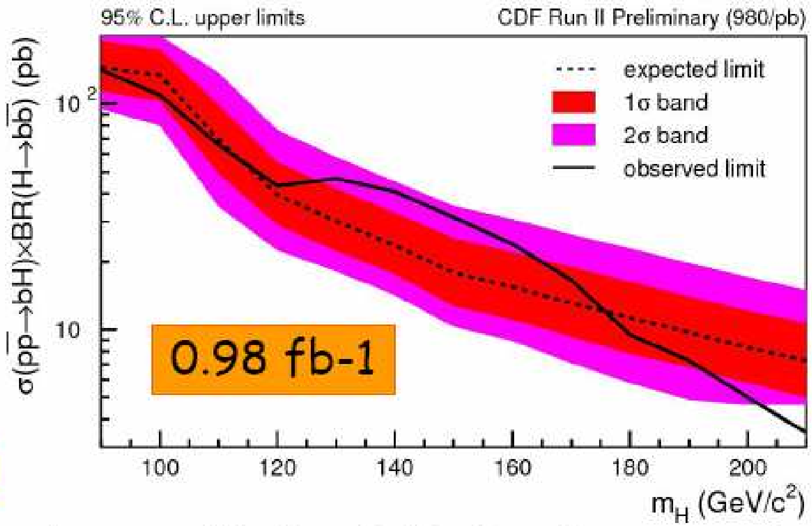
Two variables for discrimination

M_{12} (invariant mass two leading jets)

$M_{diff} \equiv M^{jet1}_{vertex} + M^{jet2}_{vertex} - M^{jet3}_{vertex}$

Data fitted to templates for flavor mixing

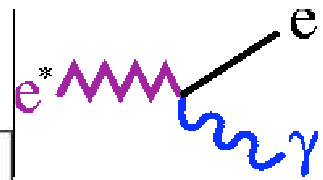




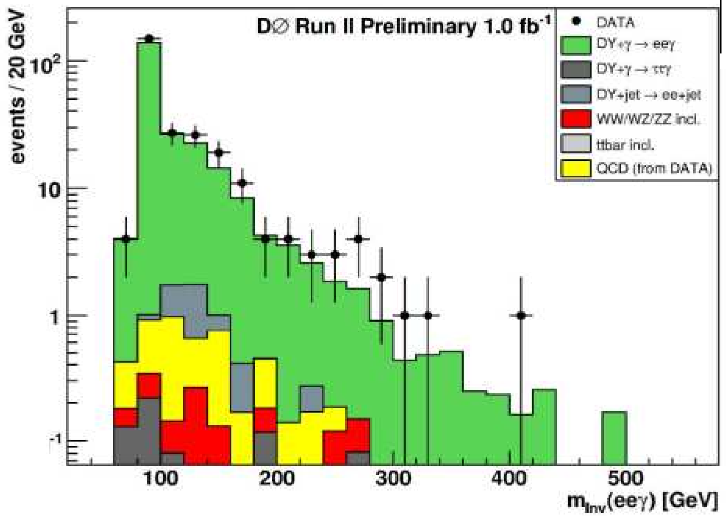
observed limit within 2σ of expected

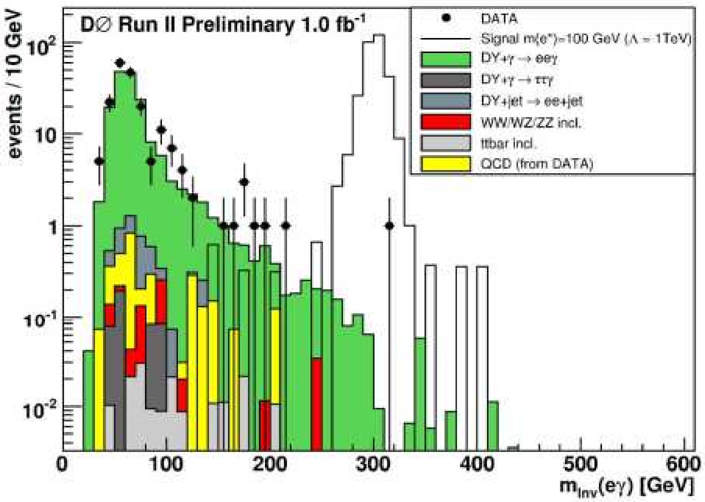
BSM continued TeV/HERA(/LHC)

Compositness @ TeV

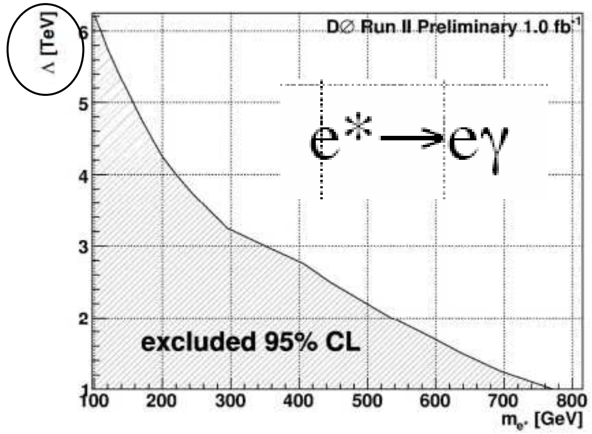


- Possible lepton structure → could observe excited states
- D0's e* search looks for eeγ events from ee* production, resonance in eγ mass





No evidence for e* production



Similar analysis @ H1

$$\mathcal{L}_{CI} = \frac{g^2}{2\Lambda^2} j^{\mu} j_{\mu}$$

General search @ HERA

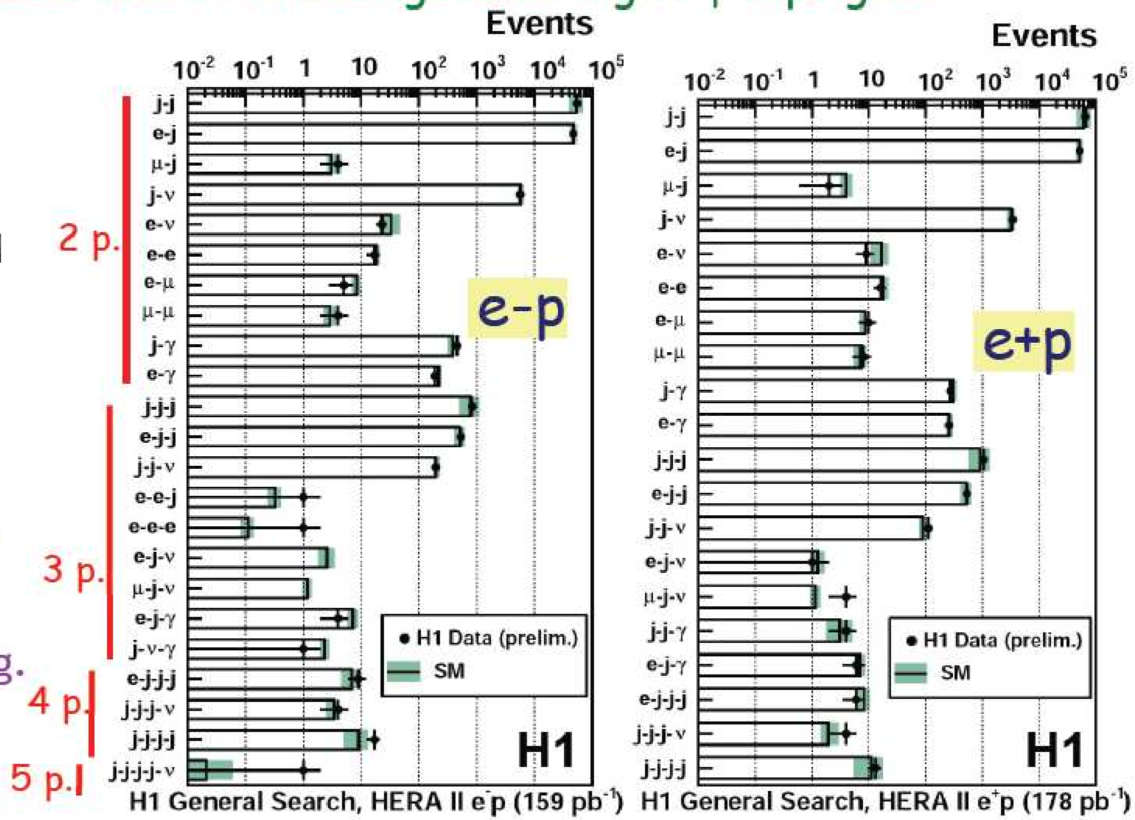
➘ A signature based search: investigate all high P_T topolgies

- H1, full HERA II data (337 pb^{-1})

  HERA I data published (117 pb^{-1}) [PLB 602(2004)14]

- Isolated particles
  - ➔ e, γ, μ, jet, ν

- A common phase space
  - ➔ P_T^{part} > 20 GeV
  - ➔ 10 < θ^{part} < 140 deg.



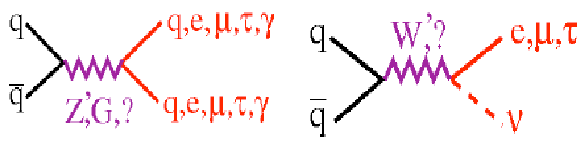
➔ Good agreement with SM in most classes

➘ Good understanding of the detector and of SM processes

Similar analysis @ CDF : no excess observed (also)

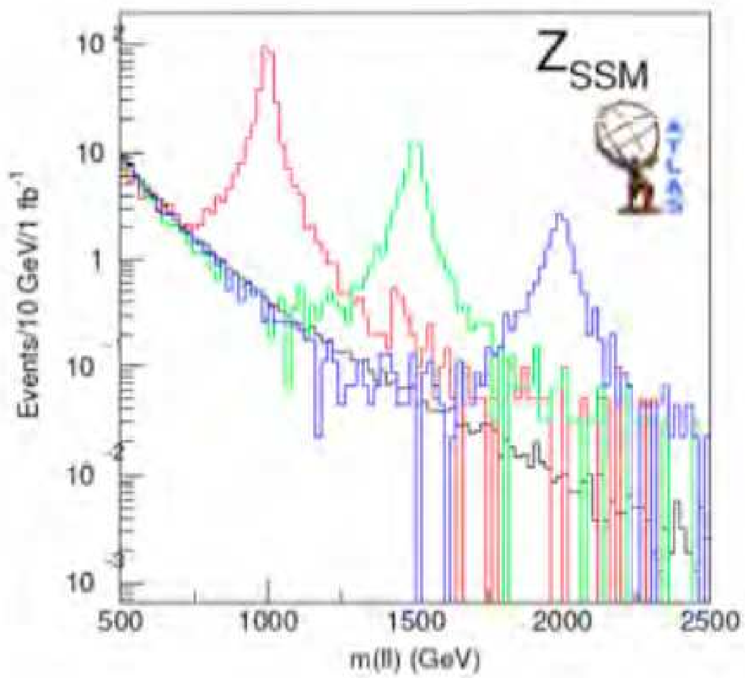
ATLAS study
Z' -> e⁺ e⁻

Probes new resonances: Z', W', Extra Dimensions

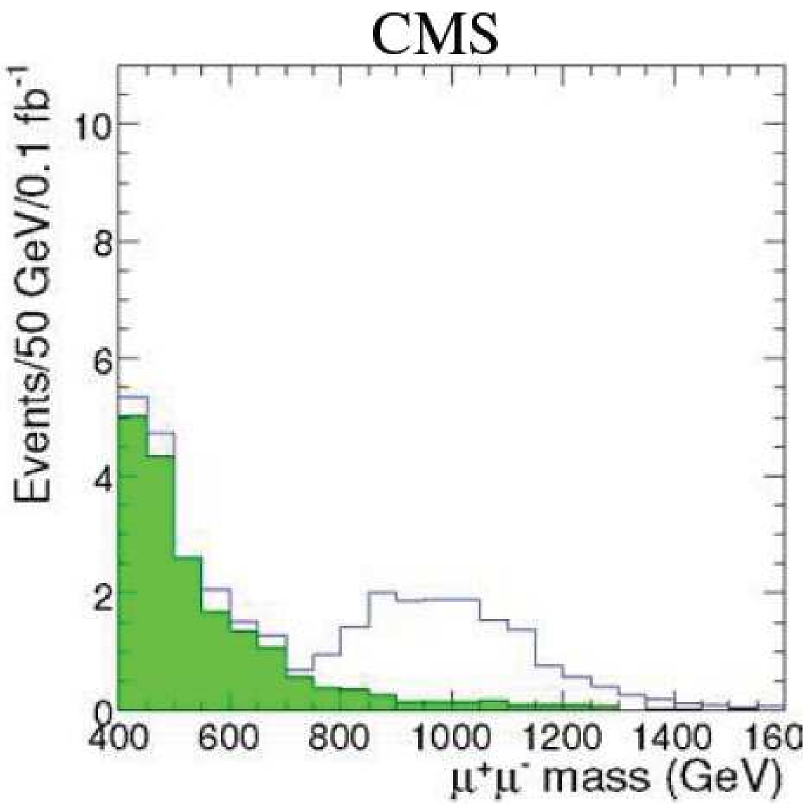


Mass	Expected events for 1 fb^{-1} (after all analysis cuts)	Integrated luminosity needed for discovery (corresponds to 10 observed evts)
1 TeV	~ 160	~ 70 pb^{-1}
1.5 TeV	~ 30	~ 300 pb^{-1}
2 TeV	~ 7	~ 1.5 fb^{-1}

- large enough signal for discovery with ~100 pb^{-1} up to m > 1 TeV
- small SM background
- signal is (narrow) mass peak above background



CMS study : Z' -> $\mu^+ \mu^-$

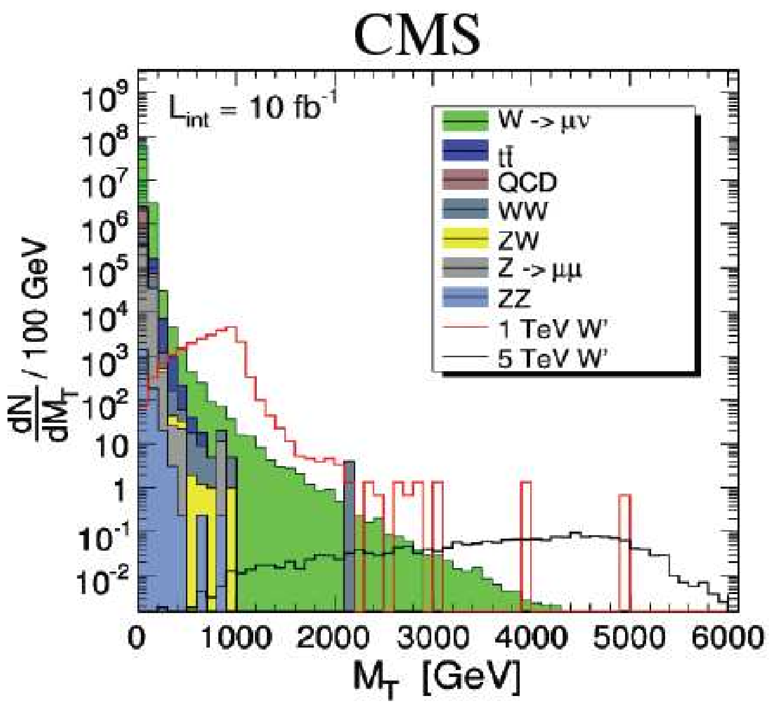


CMS Physics TDR CERN/LHCC 2006-021

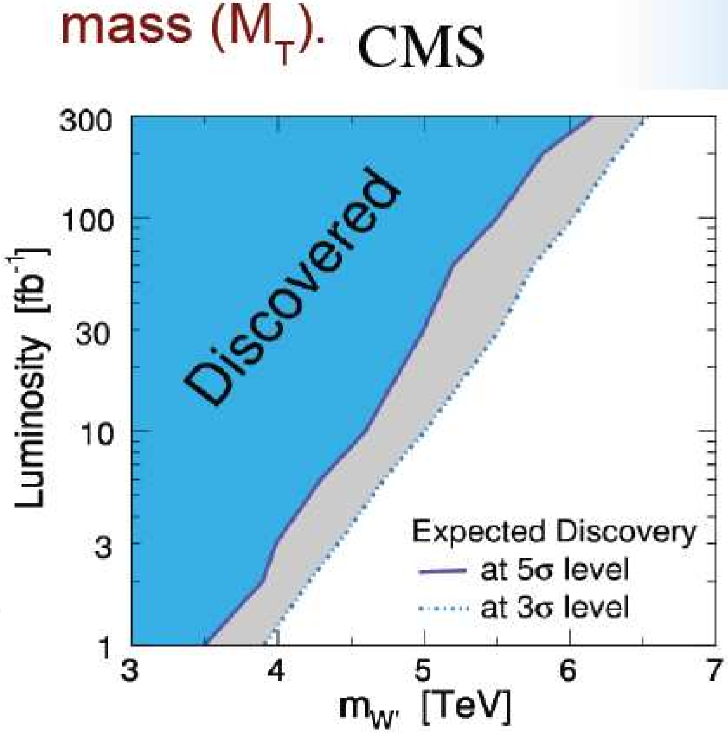
- Search for $\mu^+\mu^-$ resonance above the Drell-Yan background
- Example: E6/ SO(10) Z_η
- 0.1 fb-1 data for normalisation
- Assumes perfect detector
- If include realistic "$100pb^{-1}$" detector alignment.
- Less clear, but still observable.

CMS study : lepton + missing pt

- Benchmark against W' models, as in the dilepton case for Z'.
- Discovery based on transverse mass (M_T).



CMS Physics TDR CERN/LHCC 2006-021.
Hof, Hebbeker, Hoepfner, CMS NOTE-2006/117.
W' reference model, Altarelli , Mele, Ruiz-Altaba, Z. Phys. C45 (1989) 109.



BABAR & BELLE

D^0-$\bar{D}^0$ Mixing in $D^0 \to K\pi$

Why is observing charm mixing interesting?

It *completes the picture* of quark mixing already seen in the K, B_d, and B_s systems.

K — PR 103, 1901 (1956); PR 103, 1904 (1956).

B_d — PL B186, 247 (1987); PL B192, 245 (1987).

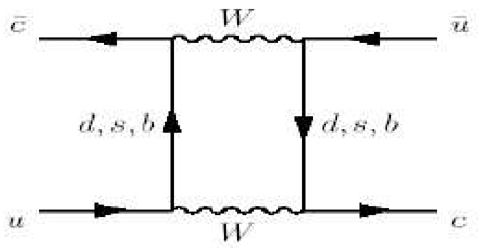
B_s — PRL 97, 021802 (2006); PRL 97, 242003 (2006).

Standard Model:

short distance

~ x ~ Δm

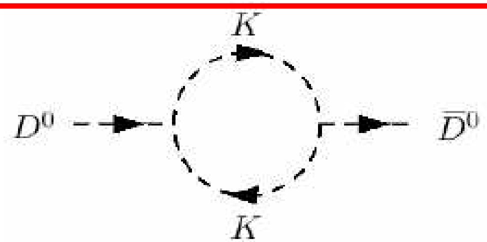
$O(10^{-5})$



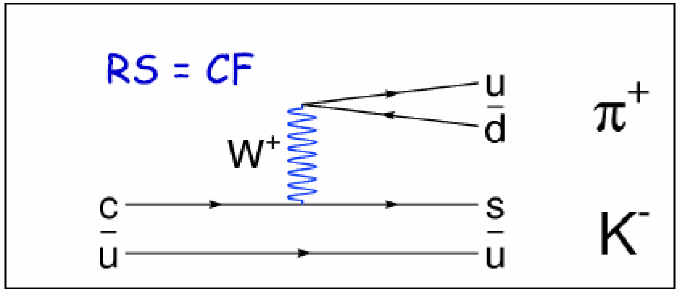
long distance

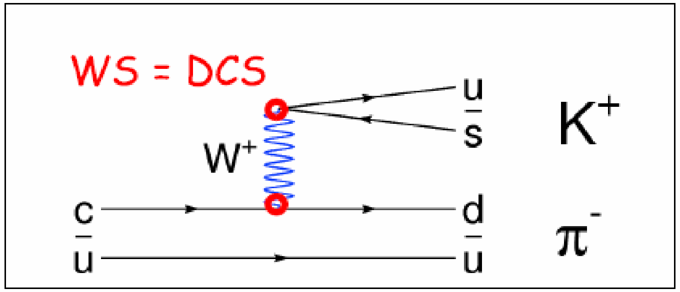
~ y ~ $\Delta\Gamma$

$O(10^{-3} - 10^{-2})$

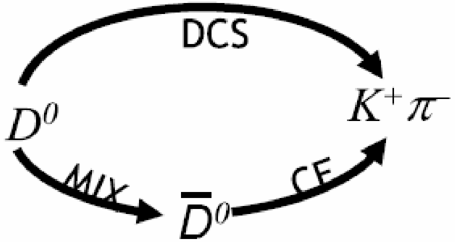


Analysis strategy





DCS and mixing amplitudes interfere to give a "quadratic" WS decay rate (x, y << 1):

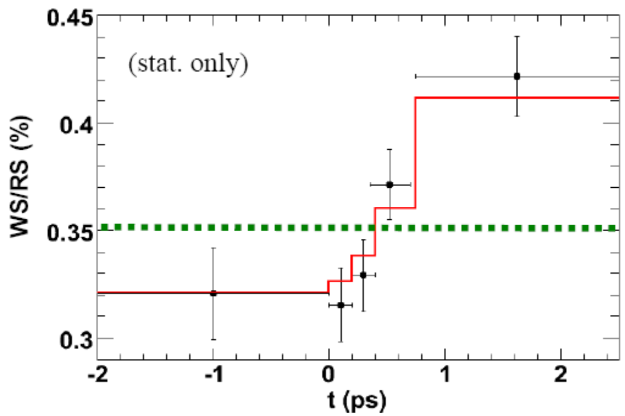


$$\frac{\Gamma_{WS}(t)}{e^{-t/\tau}} \propto R_D + \sqrt{R_D}y'\left(\frac{t}{\tau}\right) + \left(\frac{x'^2+y'^2}{4}\right)\left(\frac{t}{\tau}\right)^2$$

where $x' = x\cos\delta + y\sin\delta$ $\quad y' = y\cos\delta - x\sin\delta$

and δ is the phase difference between DCS and CF decays.

Simplified Fit Strategy & Validation



Results

Average Kπ Mixing Results

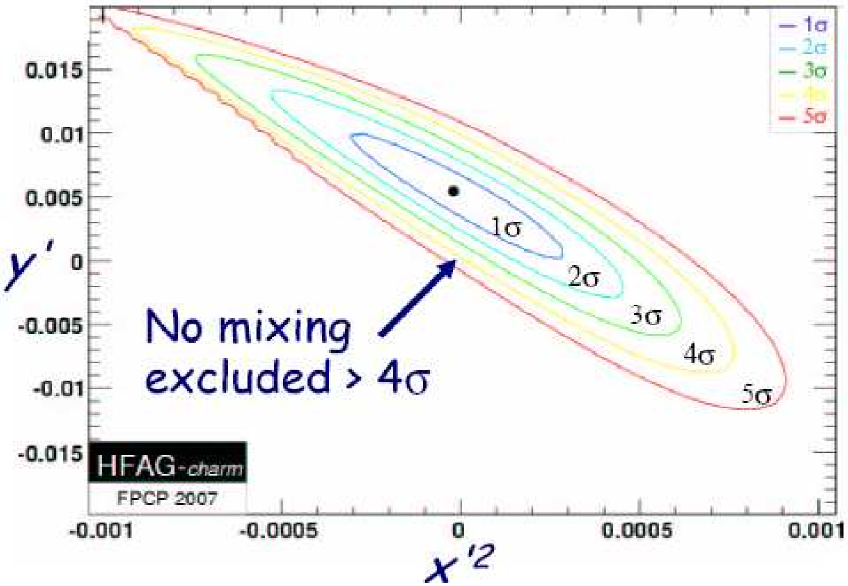
Combine BaBar and Belle likelihoods in 3 dimensions (R_D, x'^2, y')

May 2007 Averages:

R_D: $(3.30^{+0.14}_{-0.12}) \times 10^{-3}$

x'^2: $(-0.01 \pm 0.20) \times 10^{-3}$

y': $(5.5^{+2.8}_{-3.7}) \times 10^{-3}$



Interests : Observed mixing may (not) be arising from SM
+ So far no evidence of CP Violation in D^0

Neutrinos : experiments & questions

News from ν Flavor Oscillations

Neutrino oscillation experiments have revealed that neutrinos change flavor after propagating a finite distance. The rate of change depends on the neutrino energy E_ν and the baseline L.

- $\nu_\mu \to \nu_\tau$ and $\bar{\nu}_\mu \to \bar{\nu}_\tau$ — atmospheric experiments [“indisputable”];
- $\nu_e \to \nu_{\mu,\tau}$ — solar experiments [“indisputable”];
- $\bar{\nu}_e \to \bar{\nu}_{\text{other}}$ — reactor neutrinos [“indisputable”];
- $\nu_\mu \to \nu_{\text{other}}$ from accelerator experiments [“really strong”].

The simplest and **only satisfactory** explanation of **all** this data is that neutrinos have distinct masses, and mix.

+ LSND anomaly ruled out by miniBooNE (no need for a « sterile » part)

Phenomenological Understanding of Neutrino Masses & Mixing

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{e\tau 2} & U_{\tau 3} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix} \begin{pmatrix} \cos\theta_{13} & 0 & e^{-i\delta}\sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta}\sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix} \begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

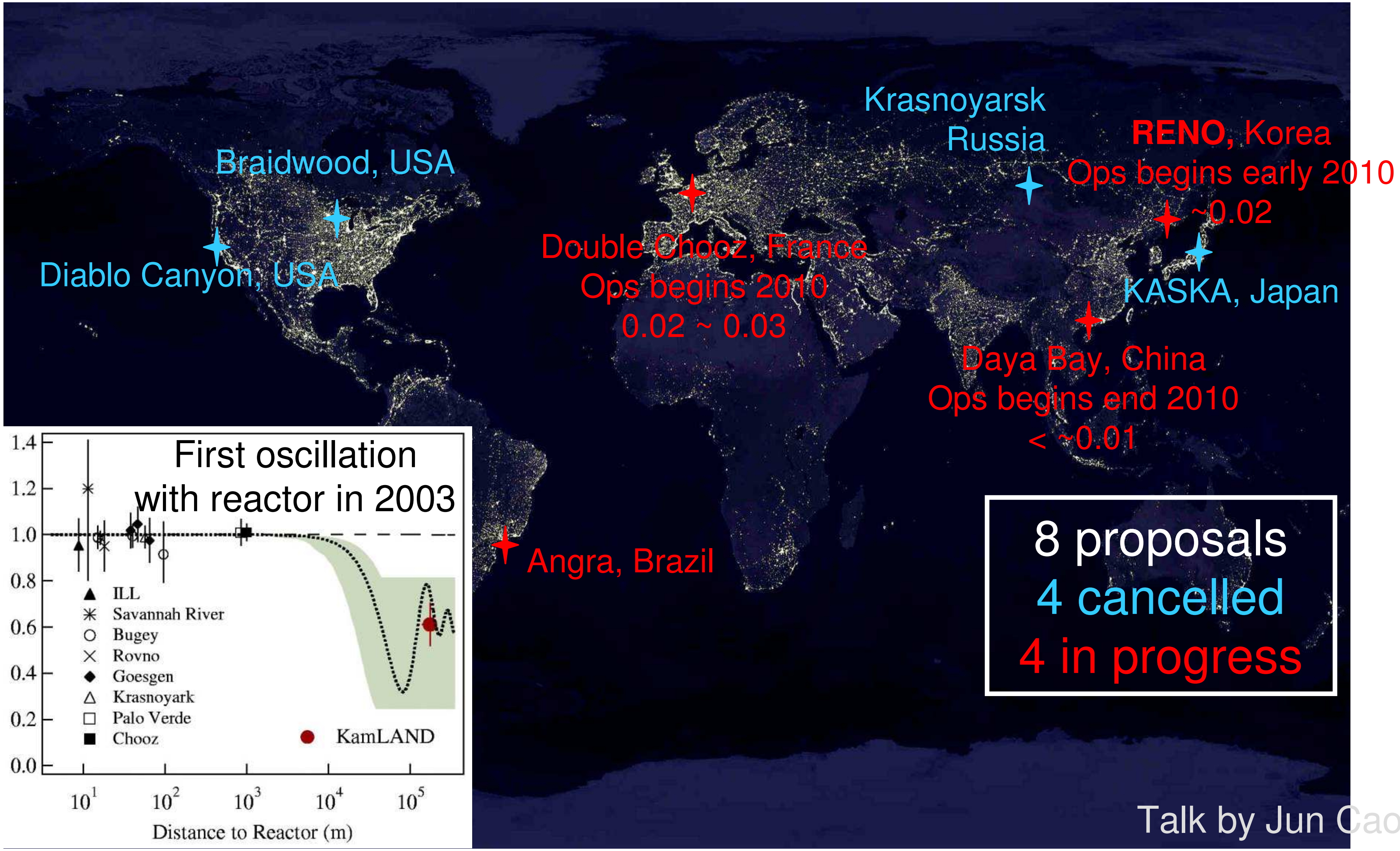
Atmospheric, K2K, MINOS, T2K, etc. $\theta_{23} \sim 45^\circ$	Reactor Accelerator $\theta_{13} < 12^\circ$	Solar KamLAND $\theta_{12} \sim 30^\circ$

Known: $|\Delta m^2_{32}|$, $\sin^2 2\theta_{23}$, Δm^2_{21}, $\sin^2 2\theta_{12}$

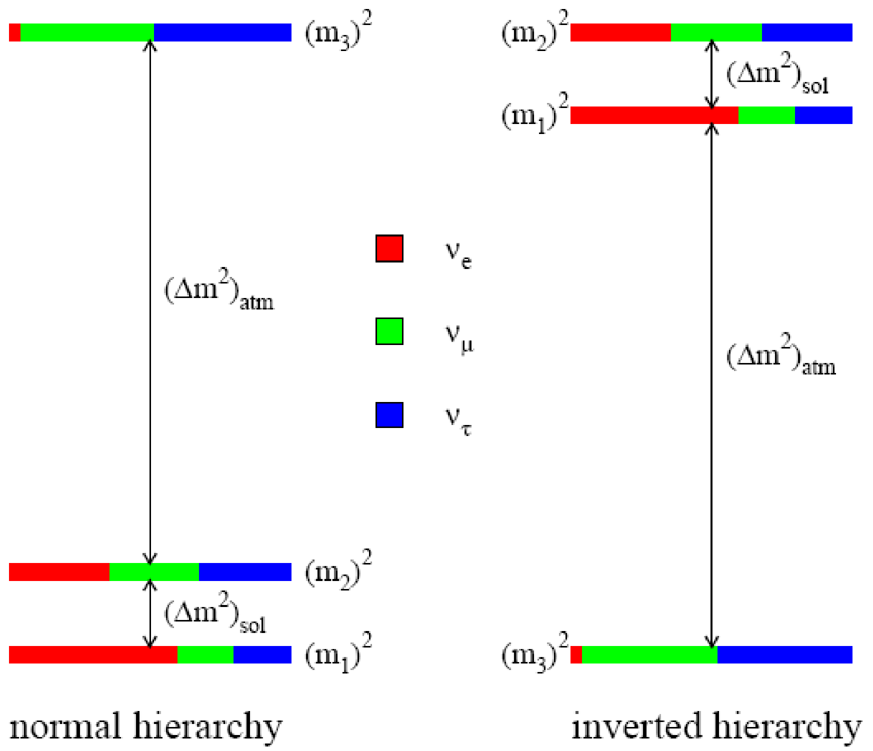
Unkown: $\sin^2 2\theta_{13}$, δ_{CP}, Sign of Δm^2_{32}

Reactor Neutrino experiments

Sensitivity to measure $\sin^2 2\theta_{13} < 0.01$



What We Know We Don't Know : Missing Oscillation Parameters



- What is the ν_e component of ν_3? ($\theta_{13} \neq 0$?)
- Is CP-invariance violated in neutrino oscillations? ($\delta \neq 0, \pi$?)

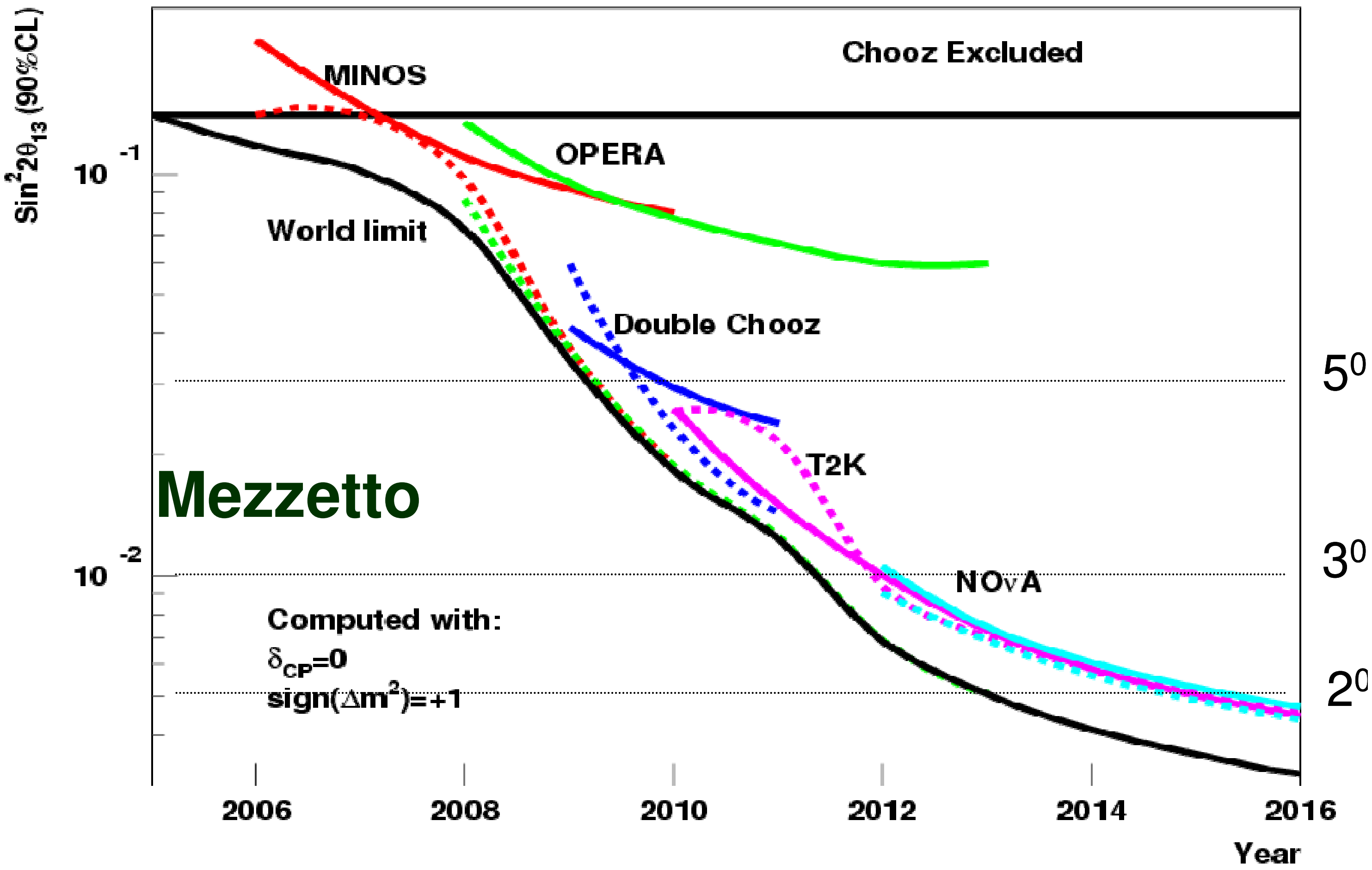
⇒ All of the above can be addressed in neutrino oscillation experiments if we get lucky, that is if θ_{13} is large enough.

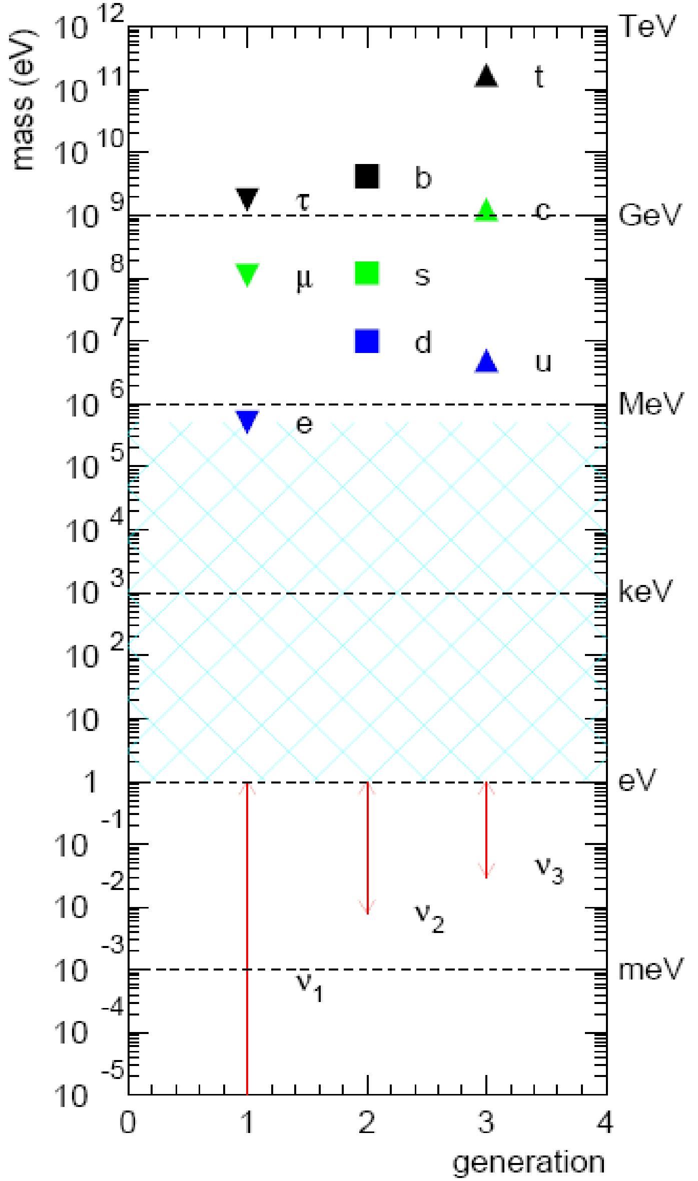
CP-invariance Violation in Neutrino Oscillations

The most promising approach to studying CP-violation in the leptonic sector seems to be to compare $P(\nu_\mu \to \nu_e)$ versus $P(\bar{\nu}_\mu \to \bar{\nu}_e)$.

Outlook of Accelerator Based n Programs

$\sin^2 2\theta_{13}$ (next decade)



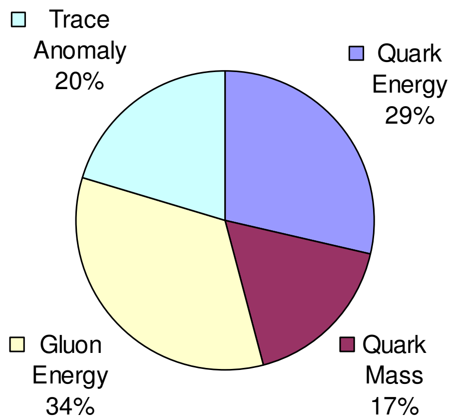


NEUTRINOS HAVE MASS

[albeit very tiny ones...]

Essential *ingredient* for the Standard Model

Questions of « mass » are driving HEP : neutrinos, Higgs, but also proton (DIS)



Short words to conclude

**

END of H1 (1/07/07) : important successful investment for the lab & large impact on the community : **topcite 100+ : 30 papers**
In comparison :
topcite 100+ (D0) : 22 papers
topcite 100+ (Babar) : 13 papers

**

Very interesting : each community (EW, CP violation, neutrinos, QCD) has a lot of issues (open problems) on going
=> very rich environment in HEP for the next years.
pb of mass (EW, H), hierarchy (neutrino), CPV in neutrinos, quark imaging in nucleon etc.
+ others that we have not discussed : how does behave a gluon cloud in a certain medium [proton or nucleus(A)] : a strong community also.