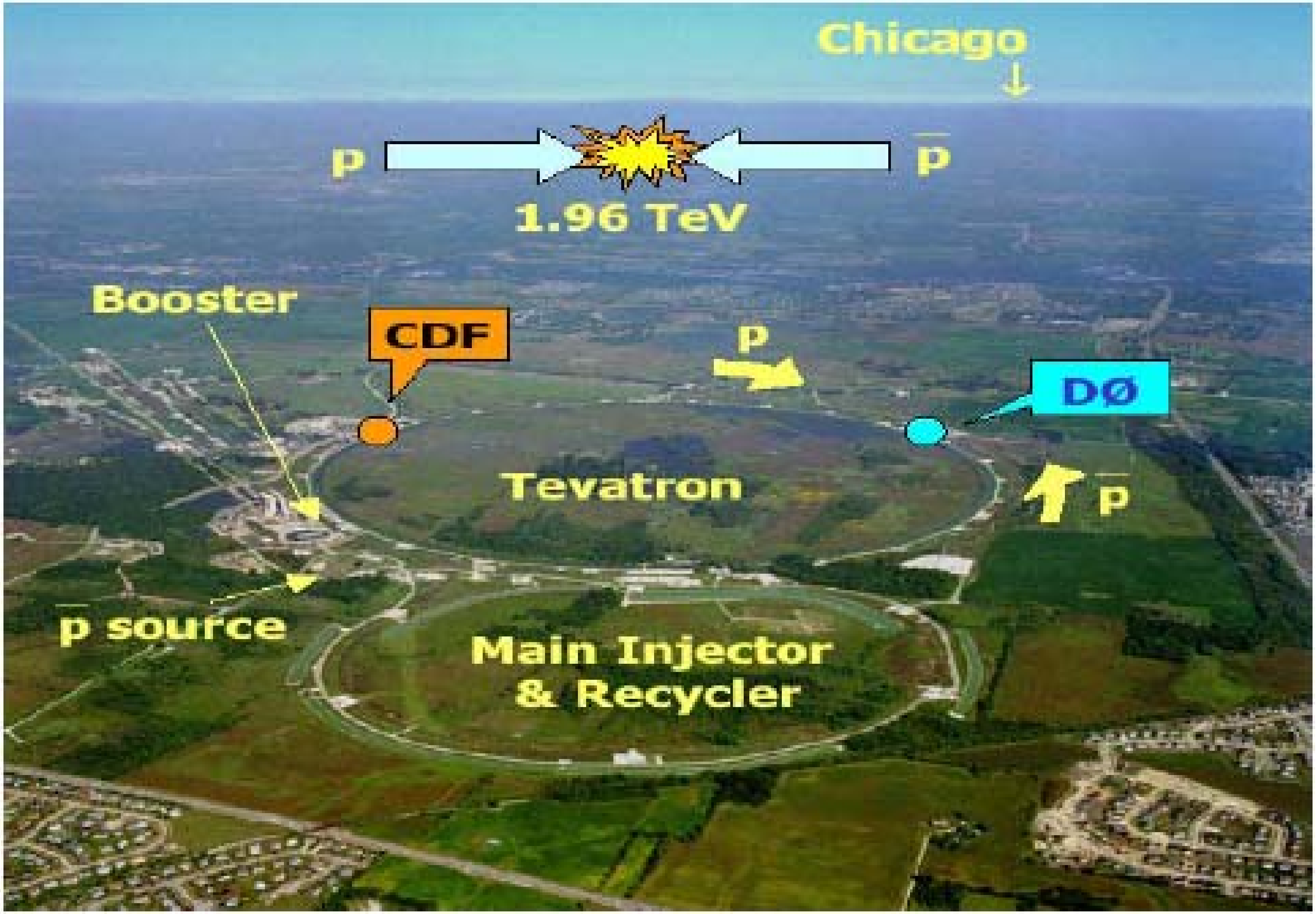
DZero experiment

Recent results


United States
Department of Energy
Fermilab
Operated By
Universities Research Association



Run II started in March 2001

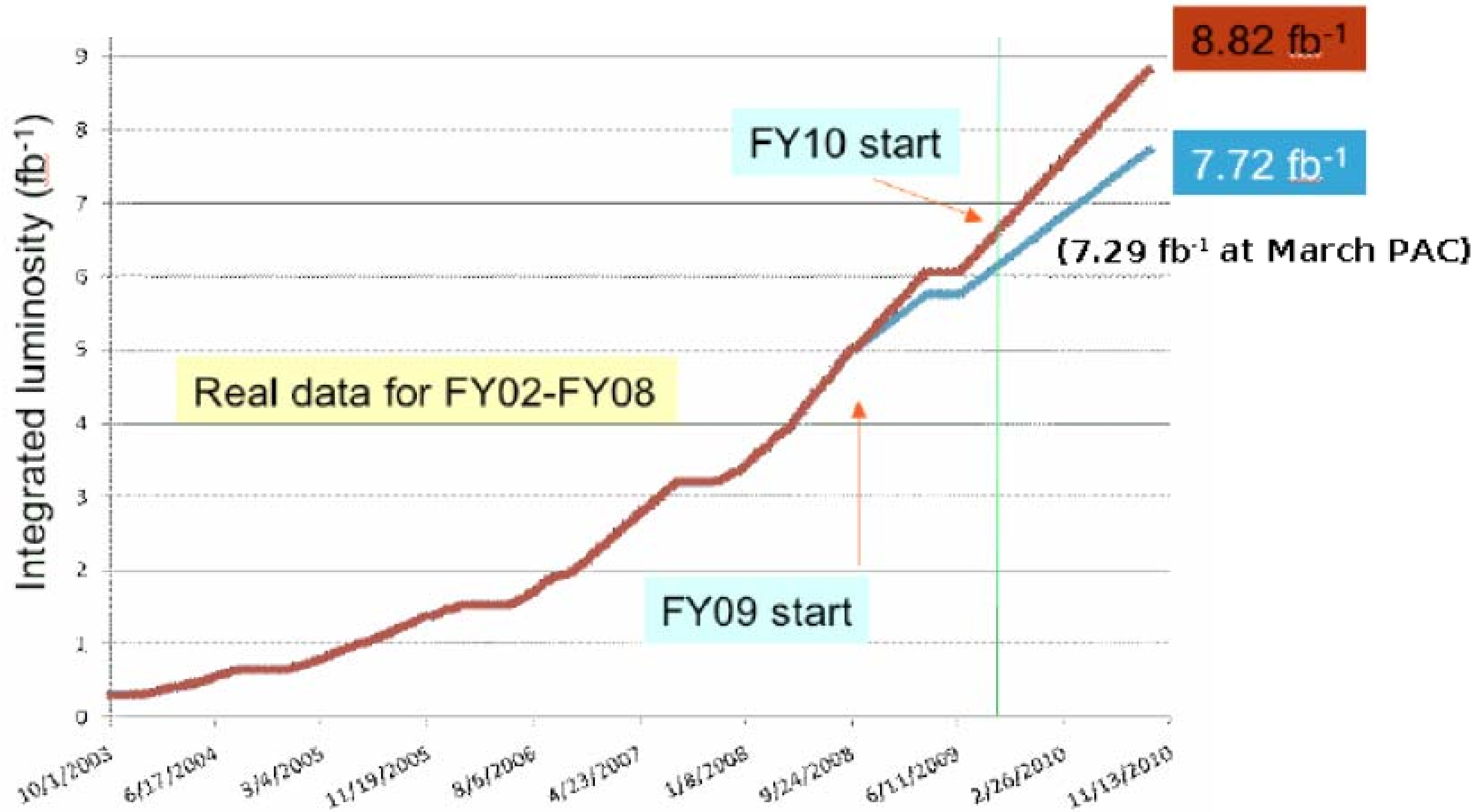
Peak Luminosity: $3.2 \cdot 10^{32}$ cm^{-2}s^{-1}

Delivered: > 4.8 fb^{-1} (Run I: 0.16 fb^{-1})


D-ZERO
ASSEMBLY
BUILDING

Теватрон вышел на проектную светимость,
и в настоящее время за 1 месяц работы набирается интегральная светимость больше чем во всём Run I.

Сейчас интегральная светимость – ~ 5 fb^{-1},
к концу 2009 г. – 6-7 fb^{-1}, 2010 – 8-9 fb^{-1}, 2011 ?




The
DØ
Collaboration

The DØ Collaboration

DØ is an international collaboration of
600 physicists from 18 nations who have designed, built and operate the DØ detector at the Tevatron and perform data analysis

Institutions: 82 total, 38 US, 44 non-US

Collaborators:
~ 50% from non-US institutions
(note strong European involvement)
~ 100 postdocs, 140 graduate students

Physics Goals

Precision tests of the Standard Model
- Weak bosons, top quark, QCD, B-physics

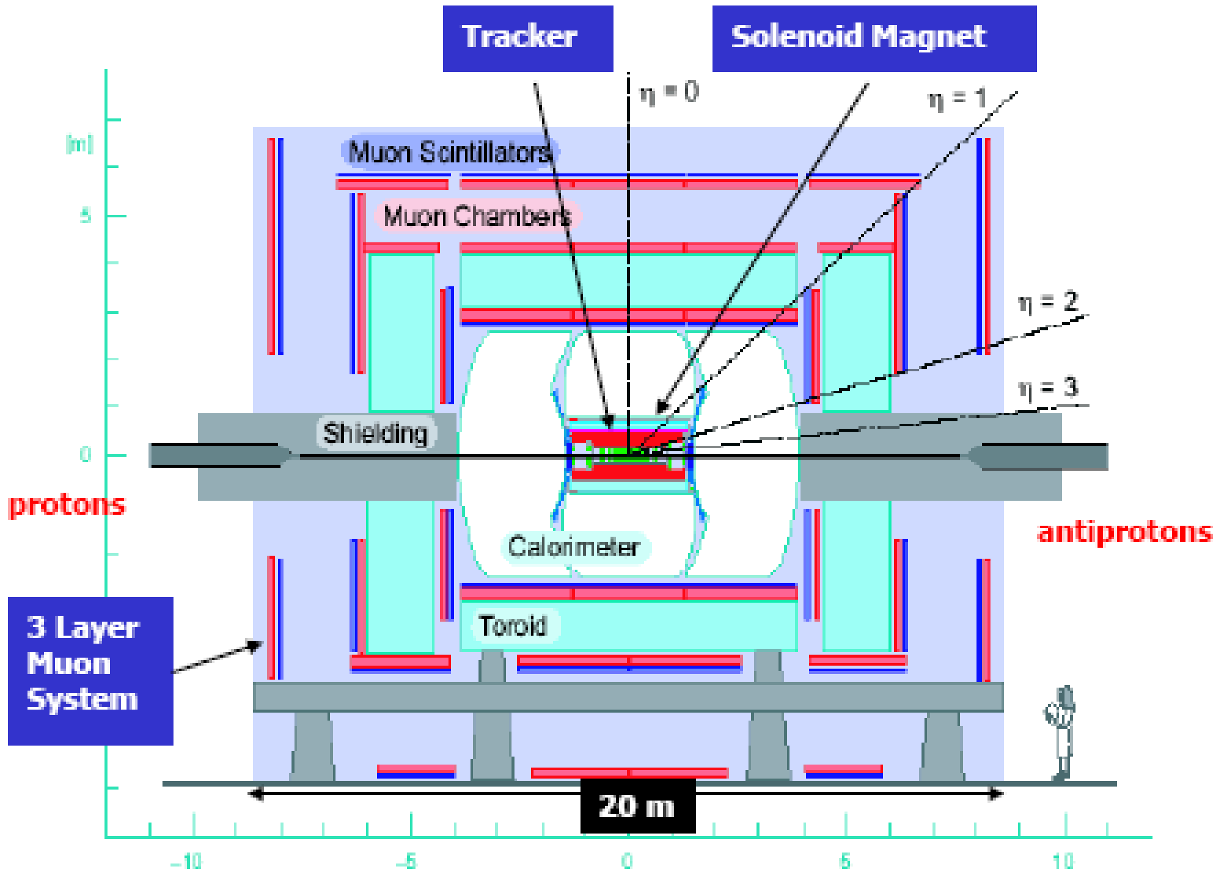
Search for particles and forces beyond those known
- Higgs, supersymmetry, extra dimensions....

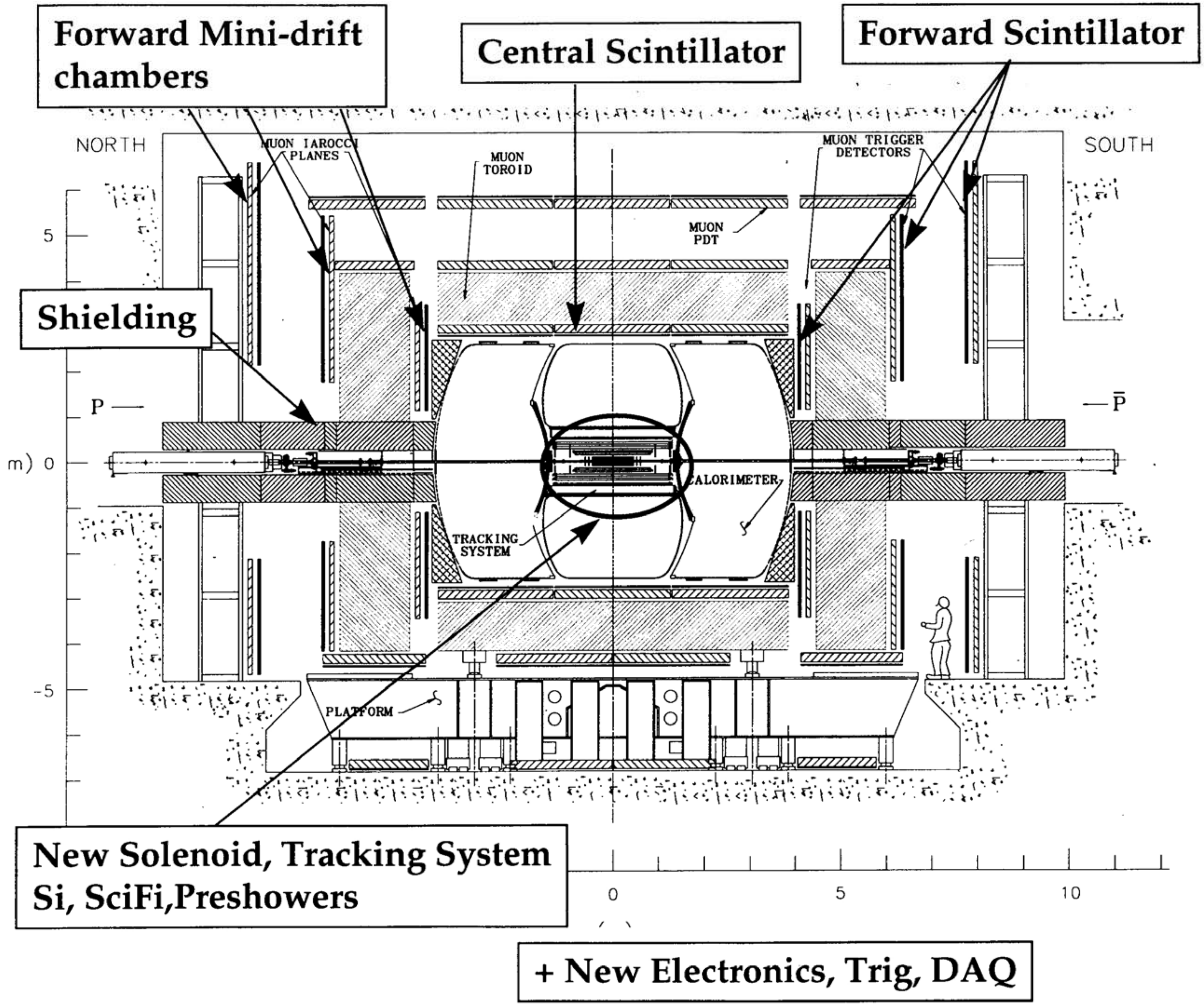
Driven by these goals, the detector emphasizes

Electron and muon identification

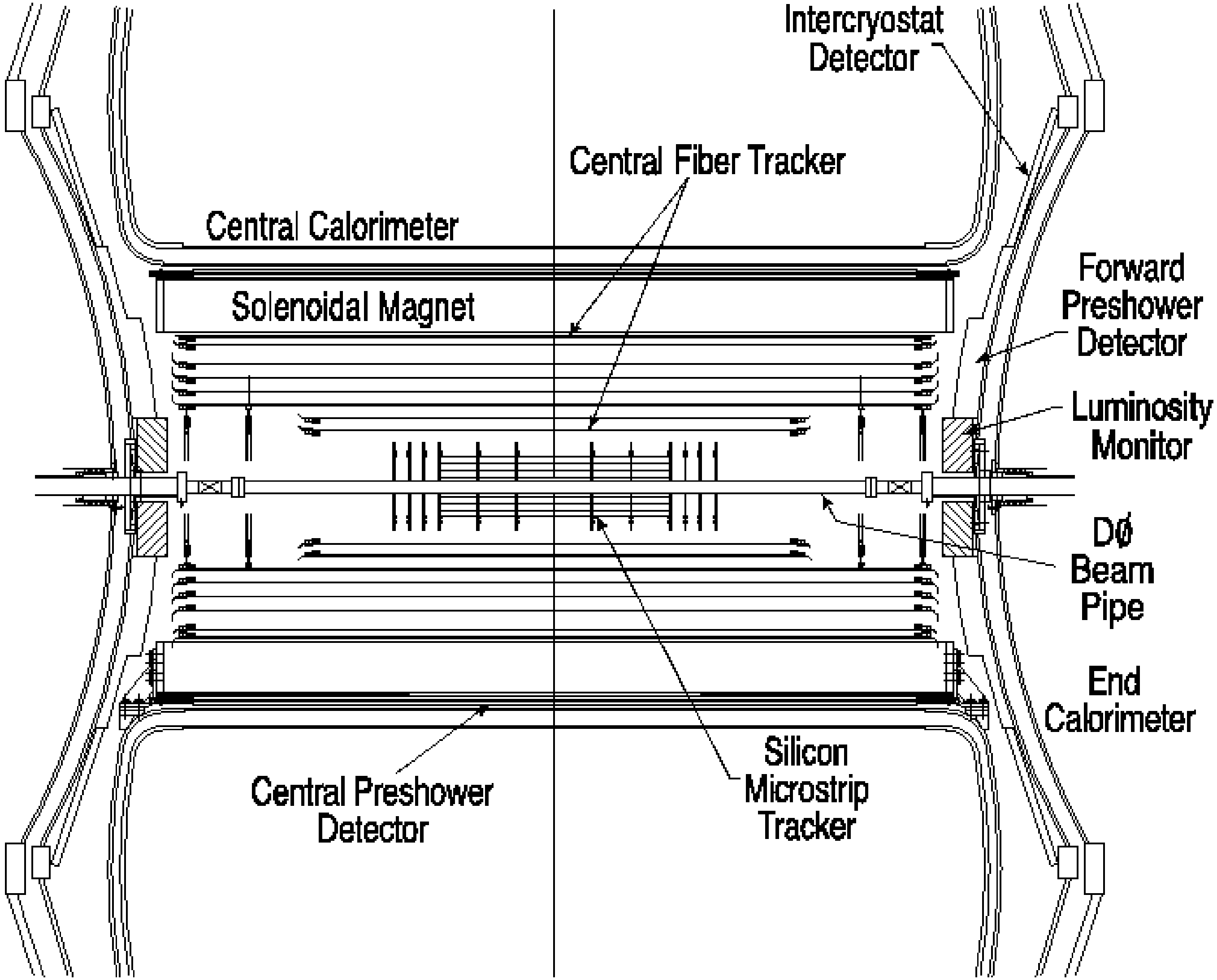
Jets and **missing transverse energy**

Flavor tagging through **displaced vertices** and **leptons**

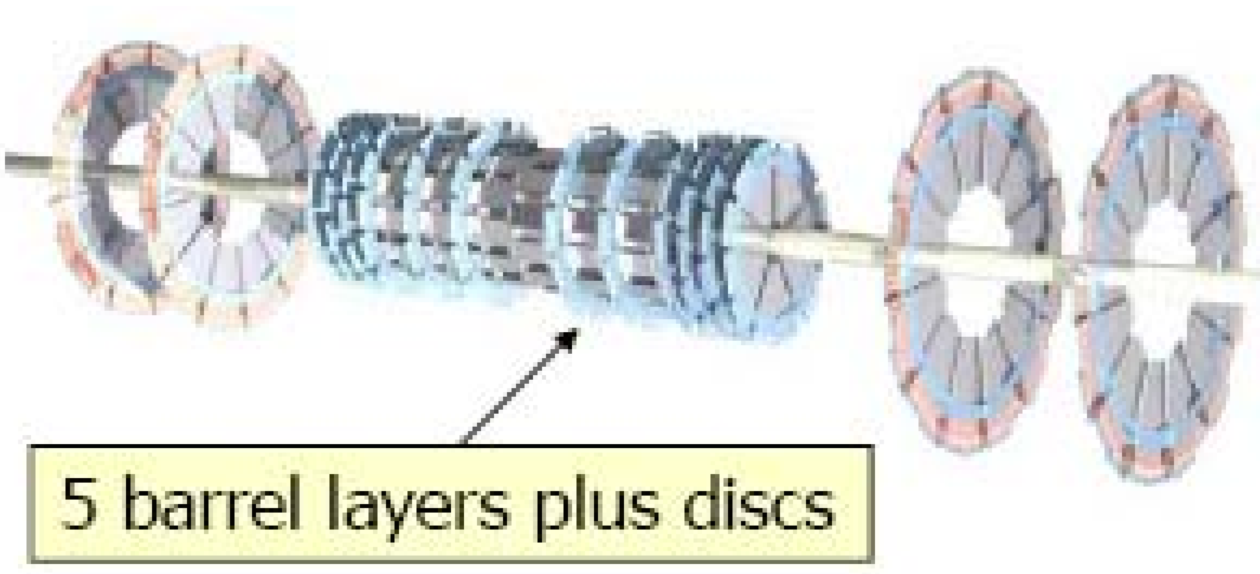




Forward Mini-drift chambers
Central Scintillator
Forward Scintillator
NORTH
SOUTH
MUON IAROCCI PLANES
MUON TOROID
MUON TRIGGER DETECTORS
MUON PDT
Shielding
P
P̄
CALORIMETER
TRACKING SYSTEM
PLATFORM
5
0
-5
5
10
New Solenoid, Tracking System
Si, SciFi,Preshowers
+ New Electronics, Trig, DAQ


Intercryostat
Detector
Central Fiber Tracker
Central Calorimeter
Solenoidal Magnet
Forward
Preshower
Detector
Luminosity
Monitor
DØ
Beam
Pipe
End
Calorimeter
Silicon
Microstrip
Tracker
Central Preshower
Detector

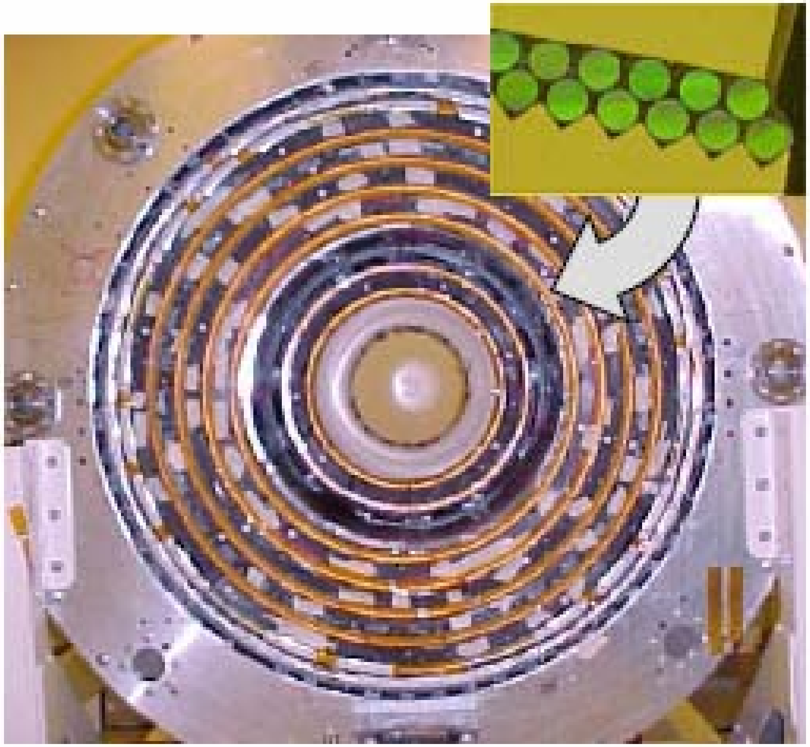
Silicon Microstrip Tracker



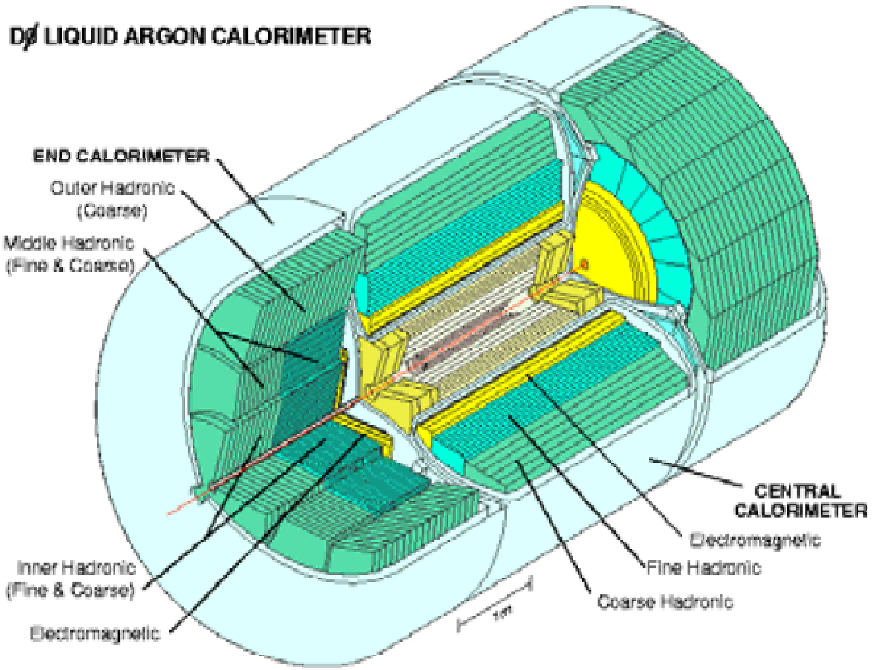
800 000 micro strips, $\Delta x = 50 - 70\ \mu m$

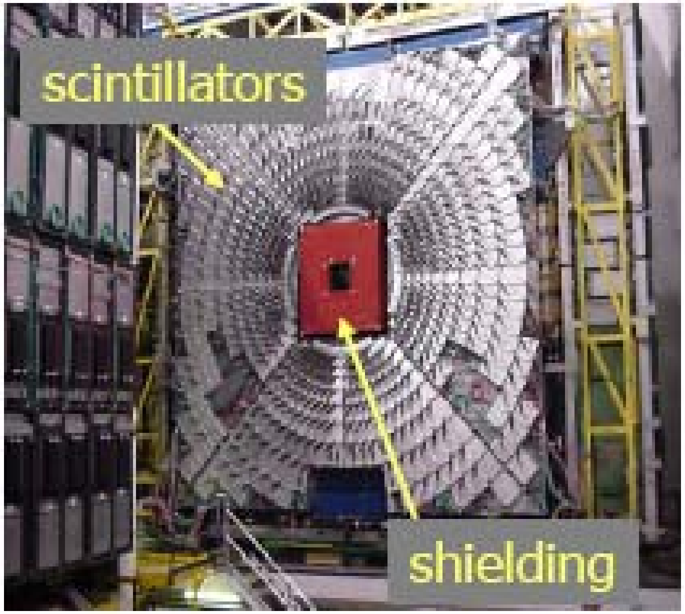
Scintillating Fiber Tracker

- 8 axial and 8 stereo fibers double layers
- Performing well
  - Light yield of ~7 pe/mip
  - Number of operating channels > 98%
- Substantially improved readout electronics – AFEII boards - since late 2006
  - Excellent amplitude resolution and no saturation up to highest luminosity
  - Provide hits longitudinal coordinate measurement capability



Calorimeter and Muon System



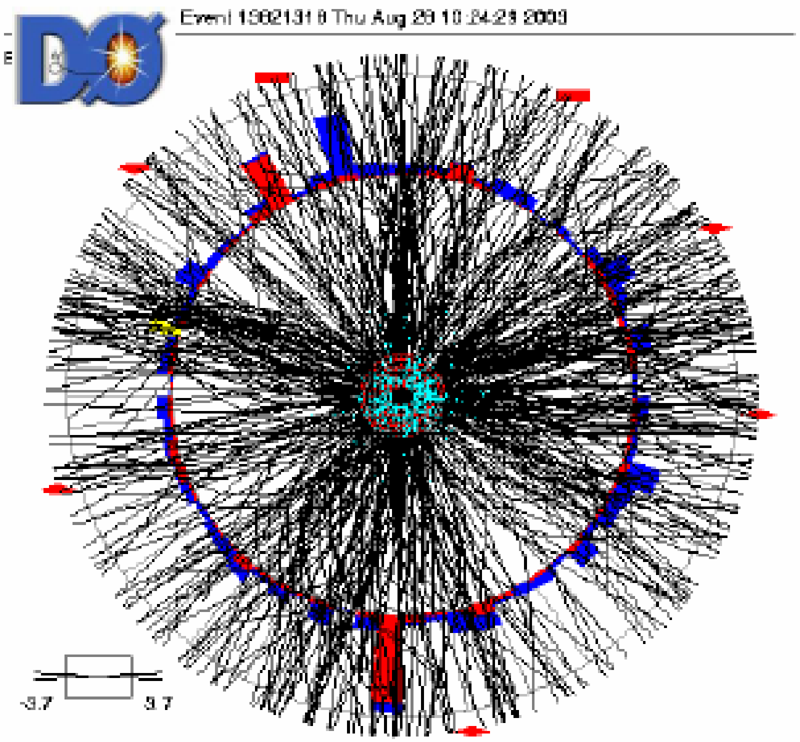


Uranium Liquid Argon calorimeter
Drift tubes and scintillation counters based muon system

Stable and reliable operation

- Less than 0.1% of non-working channels in the calorimeter and 0.5% in the muon system
- No detectors radiation damage issues
- Stable operation since early Run II

“Typical” event display at the Tevatron:



Physics Program

- Limit on the B_s to $\mu\mu$ branching ratio
- CP violation studies in B_s system
  - Mass difference Δm_s
  - Lifetime Γ and lifetime difference $\Delta\Gamma$
  - CP-violating phase ϕ_s
- High precision measurement of W boson mass
- High precision measurement of the top quark mass
- Studies of the top quark production and properties
- Precision measurements of the top quark production cross sections
- Search for SM Higgs boson
- Search for non-SM Higgs boson(s)
- Search for SUSY in many modes
- Search for high mass resonances (Z′, extra dimensions, etc.)
- Highest energy QCD jets studies
- Di-boson production and studies of anomalous couplings

PNPI

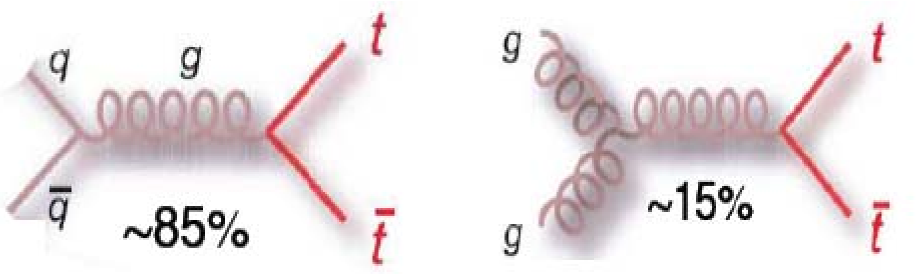
Readout electronics for 50 000 mini drift tubes
Software for the data acquisition by our electronics
Software for the electronics interface
Determination of the D0-Tevatron luminosity
Calibration of the D0 Calorimeter
Calibration of the D0 ICD
Reprogramming of the electronics
Estimation of the D0 SM background for top quark and Higgs boson physics

Publications

~ 20 in 2007
~ 40 in 2008
~ 100 in total during Run II
Our contribution - 1 paper

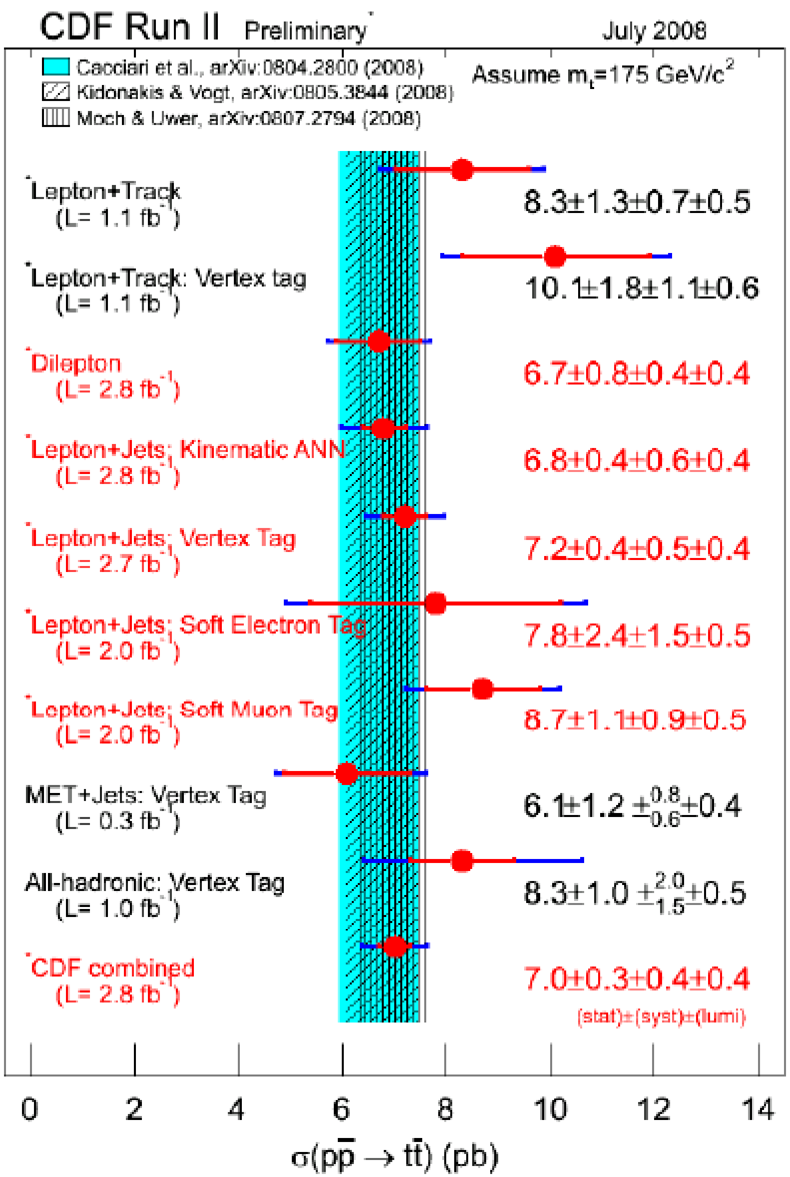
Top quark Pair Production & Decay

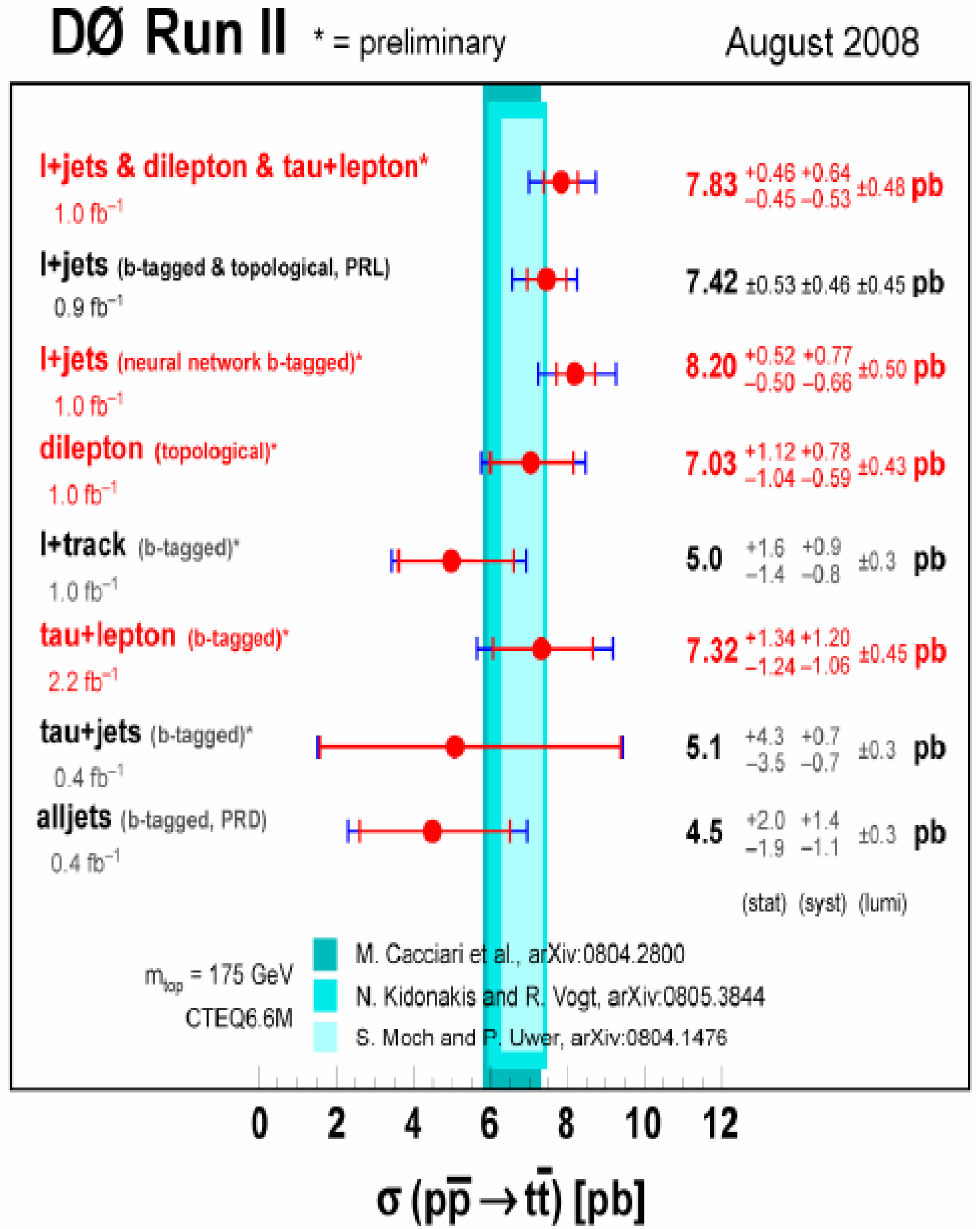
Top quarks are mainly produced in pairs, via the strong interaction



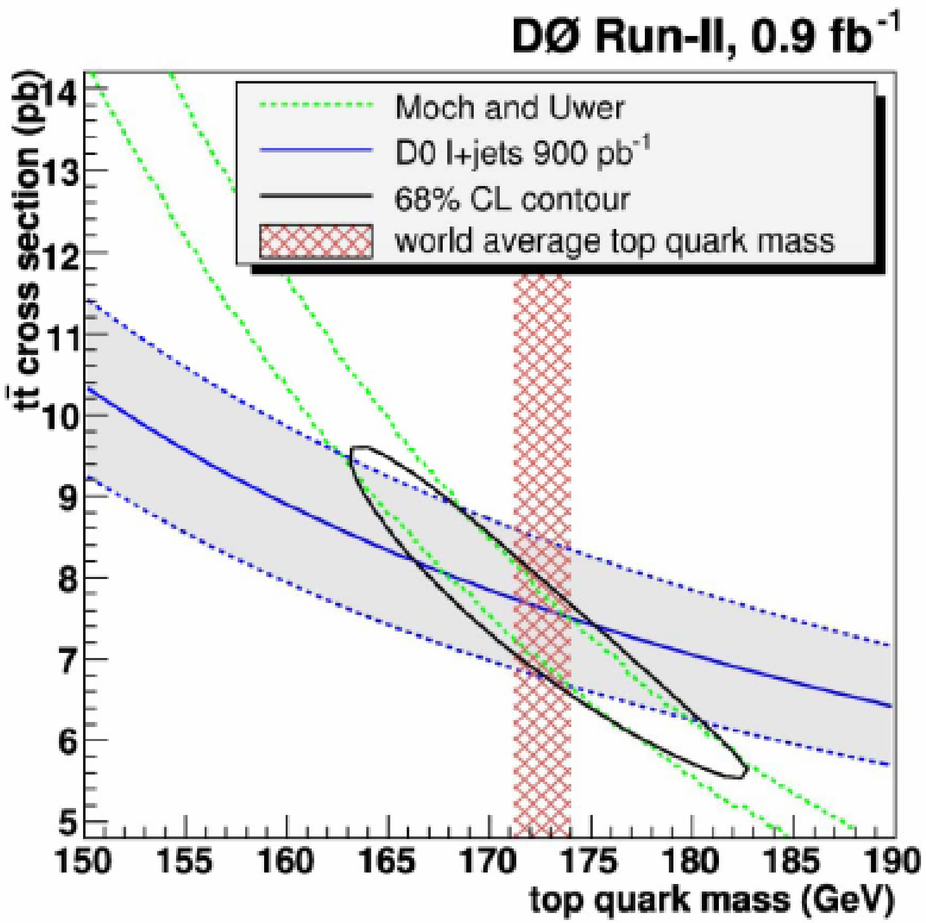
$m_t > m_W + m_b \Rightarrow$ dominant 2-body decay $t \rightarrow Wb$

$\Gamma_t^{SM} \approx 1.4$ GeV at $m_t = 175$ GeV





Top quark cross section production: σ = 6.8 +/- 0.6 pb

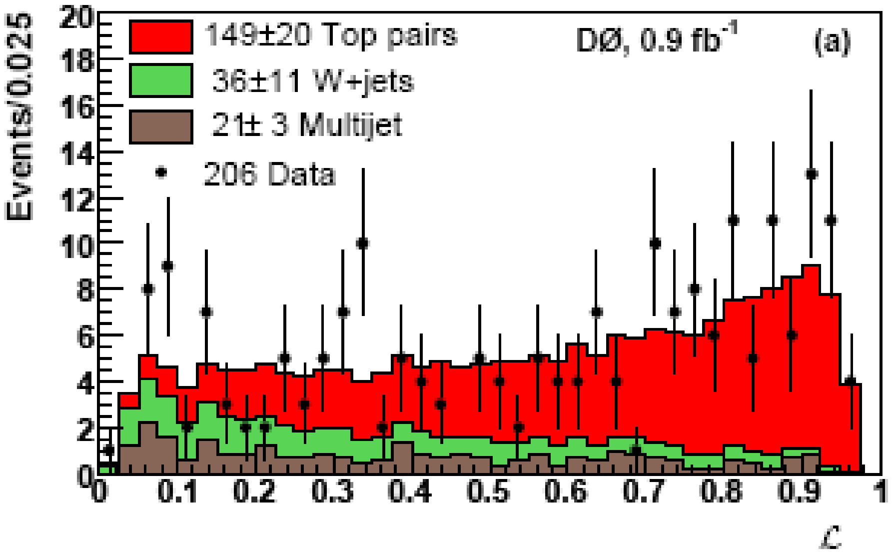


Assuming that production is governed by the SM, Top quark mass can be extracted comparing the measured cross section with theory

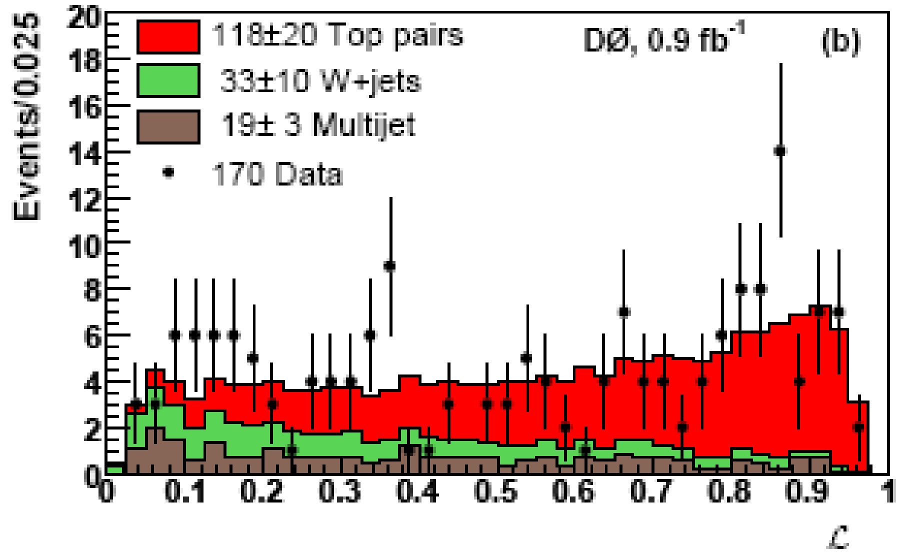
M(top)=169.1±6.5 GeV

t - anti-t forward-backward asymmetry

$pp \rightarrow tt + X$



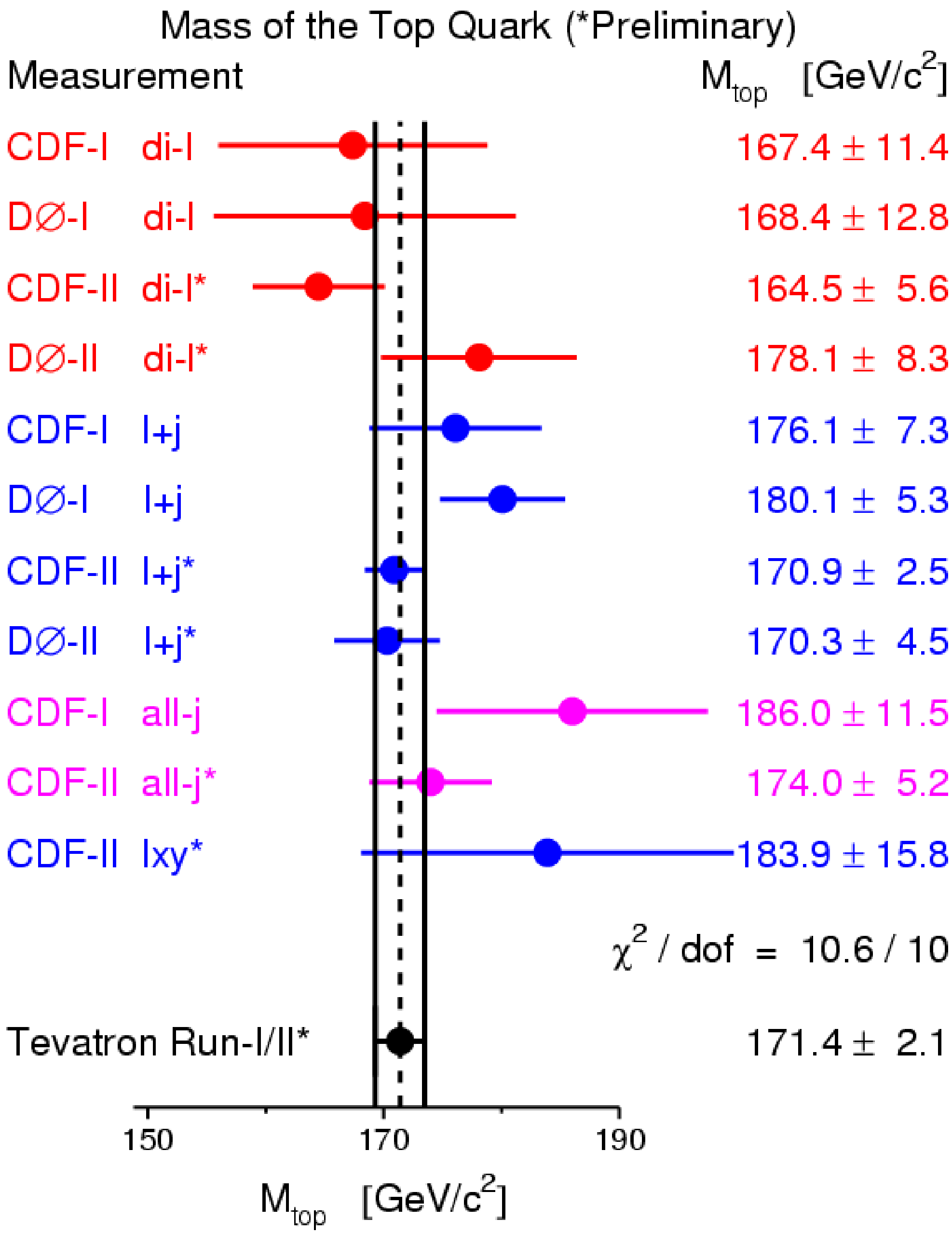
Events where the top quark is more forward with respect to the p-beam



Events where the anti-top quark is more forward with respect to the p-beam

The SM NLO QCD – A_{bf} = 5-10%
First measurement (D0): A_{bf} = 12 +/- 8 %

The measured A_{bf} is consistent with the MC NLO SM predictions

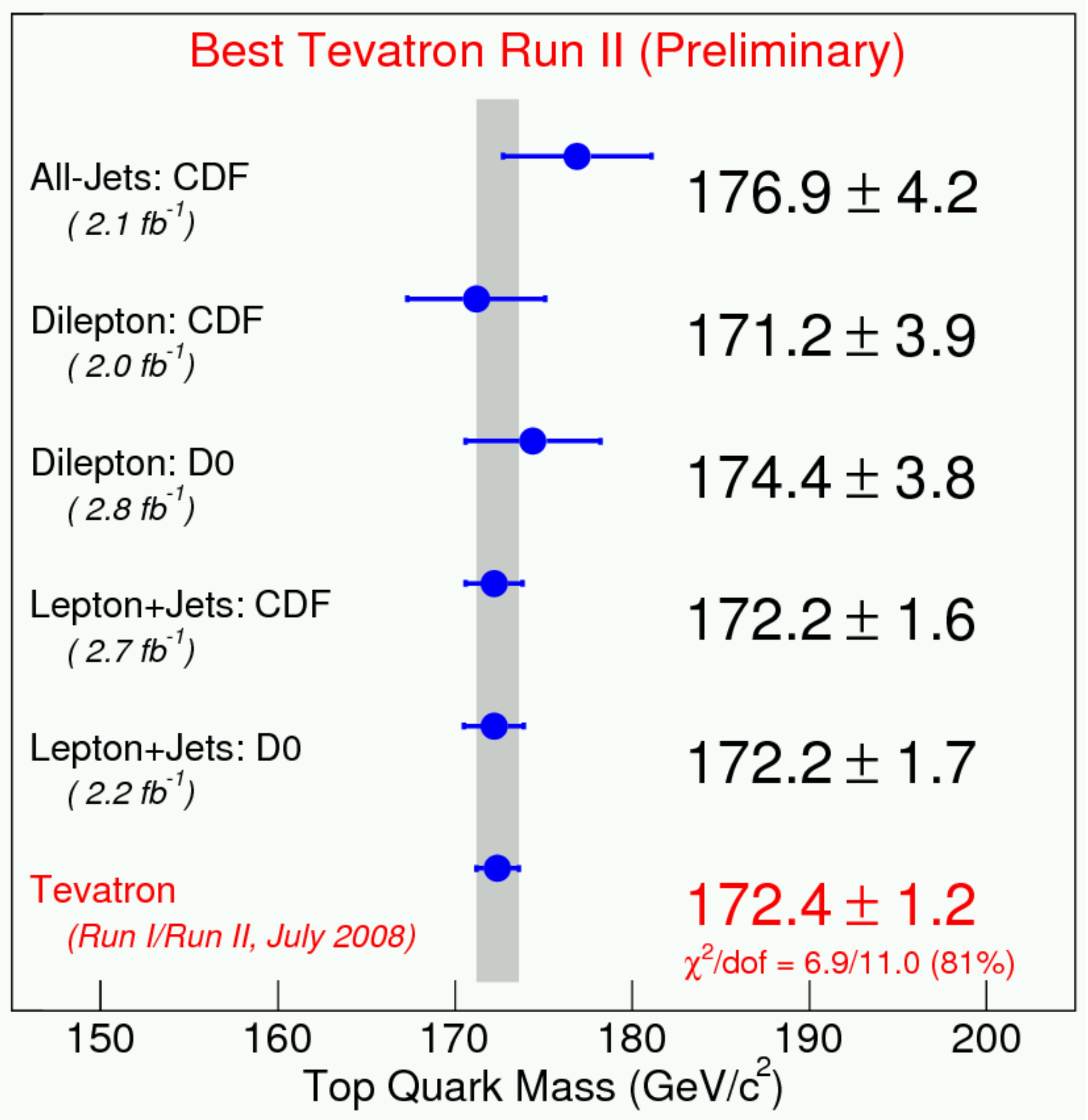


$m_t \sim 170$ GeV vs $m_b \sim 5$ GeV

m_t ~ gold atom

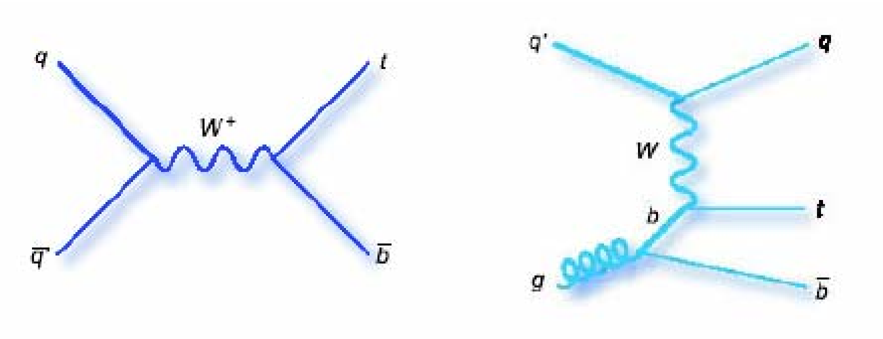
It is the only bare quark. It decays so quickly that the strong force does not confine it.

M_t & $M_W \rightarrow M_H$



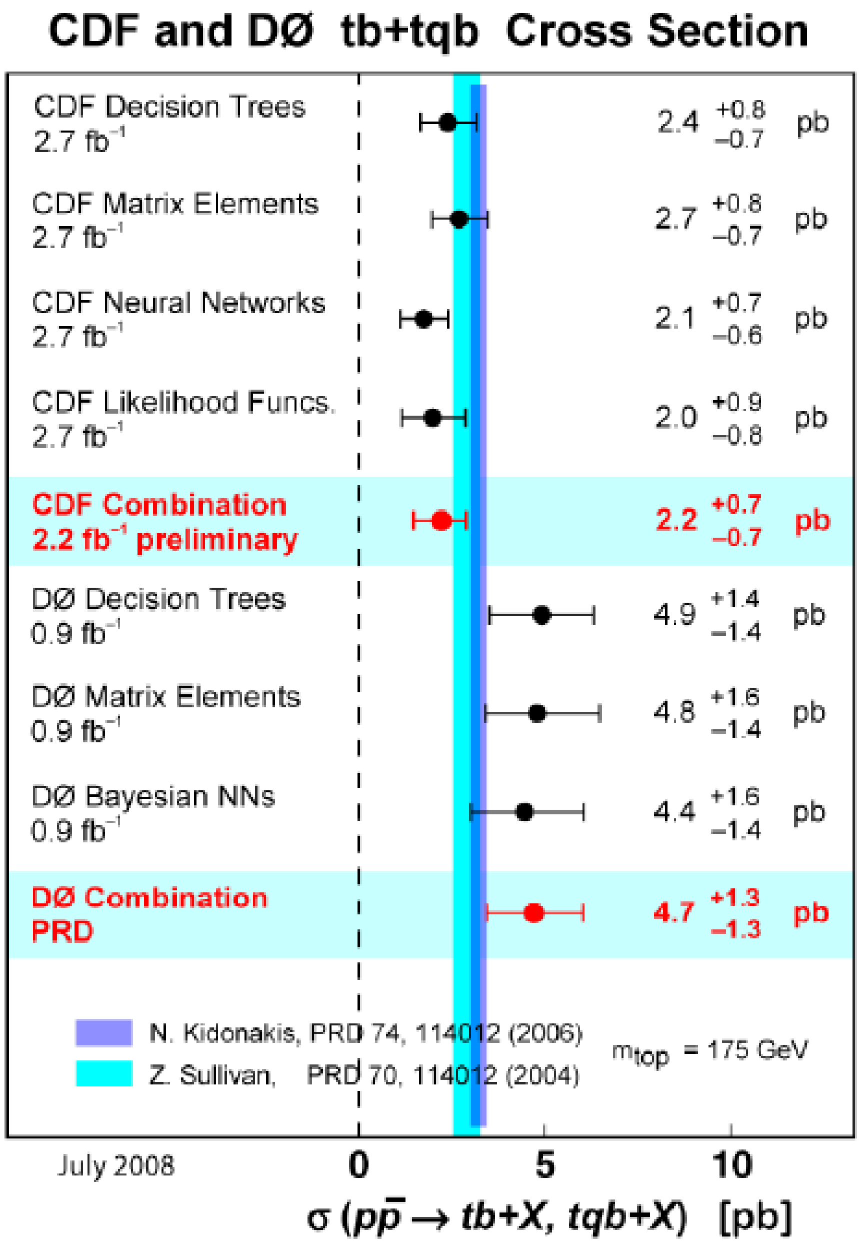
$M(top)=172.4\pm0.7\pm1.0$ GeV

Single Top Production



***s*-channel**	***t*-channel**
$\sigma = 0.88 \pm 0.11$ pb	$\sigma = 1.98 \pm 0.25$ pb

Single top quark production for the first time was observed at D0



SM → $V_{tb} \approx 1.0$ (6 quarks)

D0

|Vtb| = 1.31 + 0.25 - 0.21

$0.68 \leq |V_{tb}| \leq 1.0$

CDF

|Vtb| = 0.88 ± 0.12± 0.07

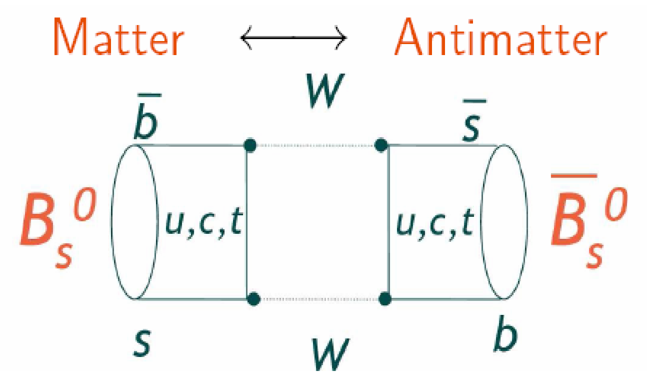
B – B mixing and oscillations

$|B_1\rangle = (|B\rangle + |B\rangle) / \sqrt{2} = |B_H\rangle$ $B_H \rightarrow M_H, \Gamma_H$

$|B_2\rangle = (|B\rangle - |B\rangle) / \sqrt{2} = |B_L\rangle$ $B_L \rightarrow M_L, \Gamma_L$

$\Delta m = M_H - M_L$

$\Delta\Gamma = \Gamma_L - \Gamma_H$

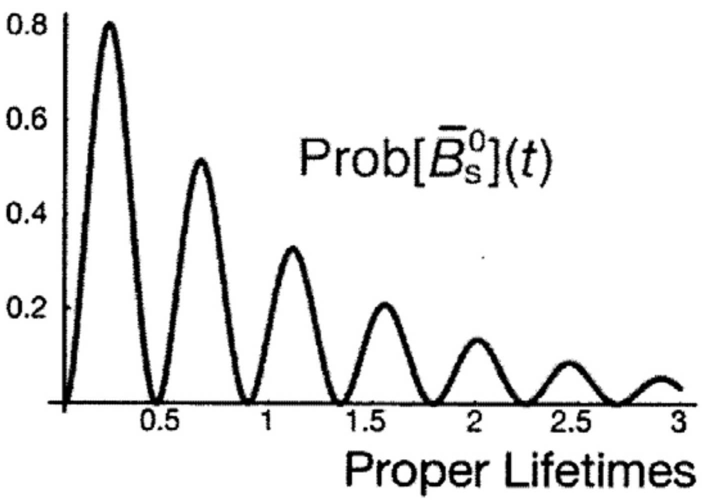


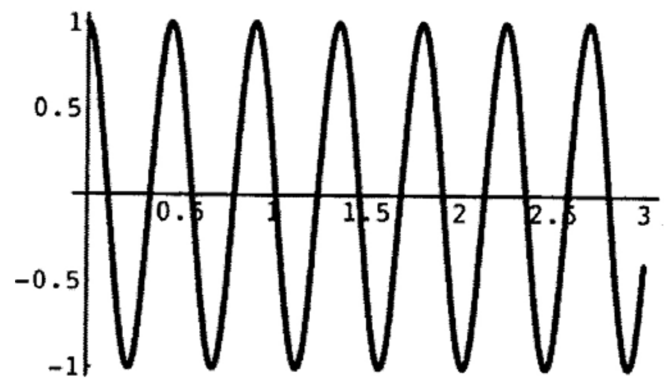
If initially start with a B →

Prob[B](t) = [exp(-Γ_1t) + exp(-Γ_2t) **+** 2 exp(-Γt) cos(Δmt)]

Prob[B](t) = [exp(-Γ_1t) + exp(-Γ_2t) **-** 2 exp(-Γt) cos(Δmt)]

A={N[B](t) – N[B](t)}/{N[B](t) + N[B](t)} ≈ cos(Δmt)





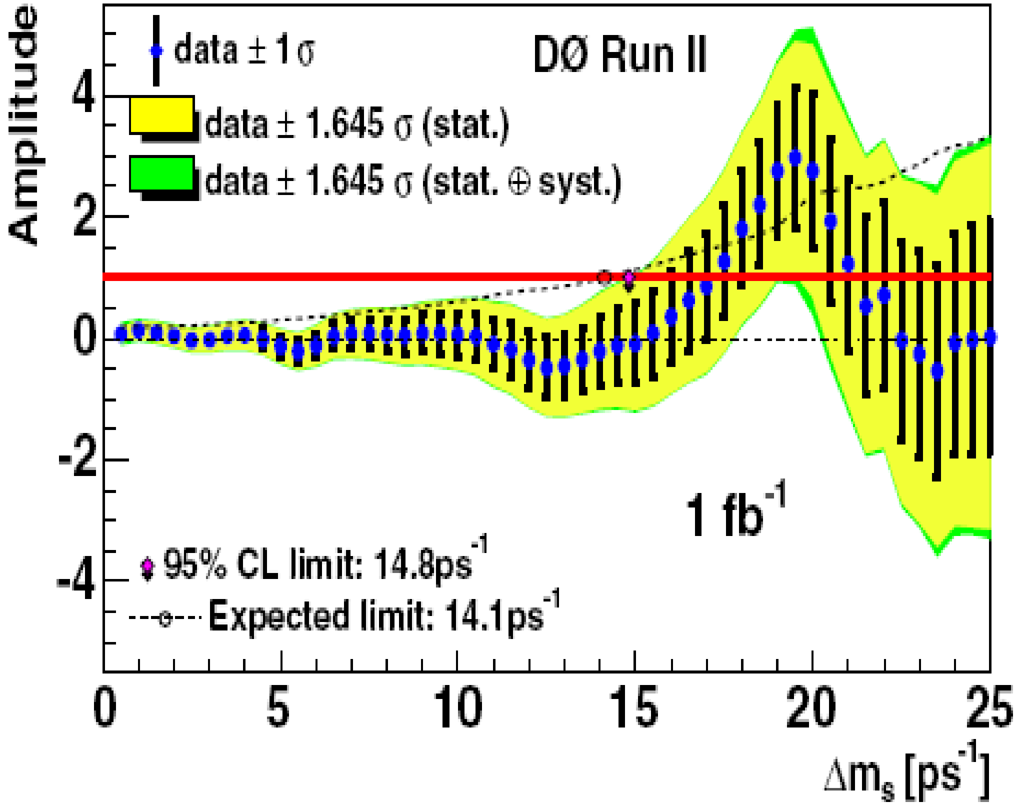
Asymmetry **A**

B_s^0 oscillations

$B_s^0 - (bs)$ $\tau(B_s) \approx 1.5$ ps

$B_s^0 \rightarrow \mu^+ D_s^- X$,
$D_s^- \rightarrow \varphi\pi^-$, $\varphi \rightarrow K^+ K^-$

$\Delta m_s \sim |V_{tb}V_{ts}|^2$, $\Delta m_d \sim |V_{tb}V_{td}|^2$



SM: $\Delta m_s = 21 +5 -4\ ps^{-1}$
D0: $17 \le \Delta m_s \le 21\ ps^{-1}$
CDF: $\Delta m_s = 17.3 +0.4 - 0.2\ ps^{-1}$

$|V_{td}|/|V_{ts}|=0.21 +/- 0.01$

This result rules out some versions of the SUSY theory which predict faster rates of oscillations

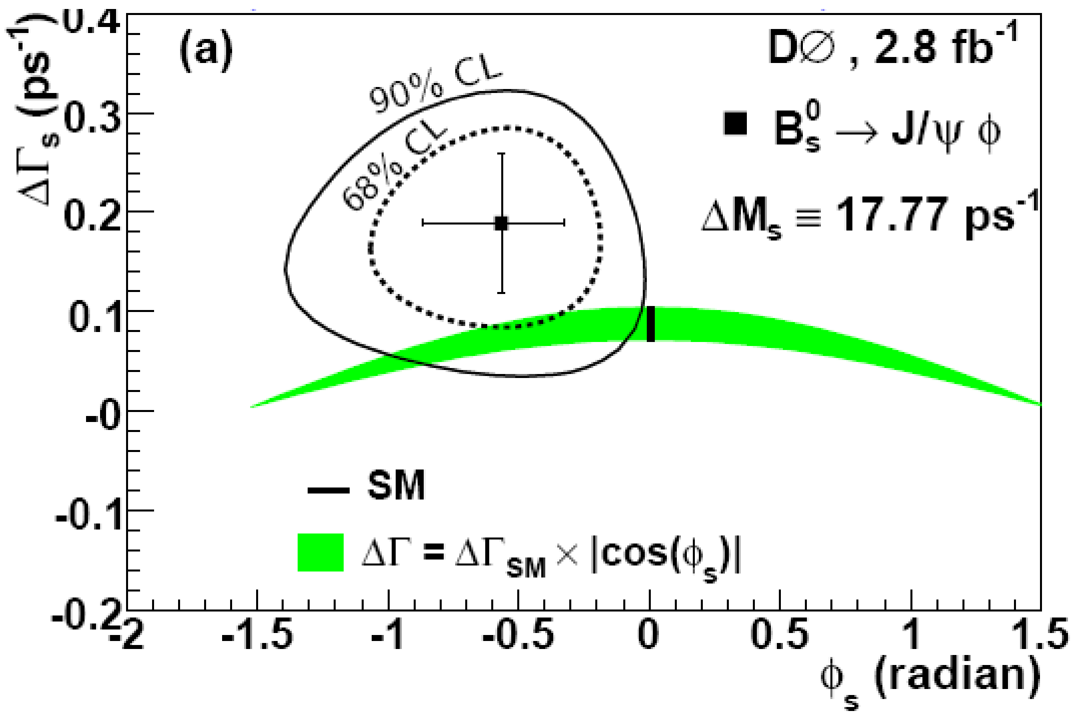
B_s^0 mixing parameters

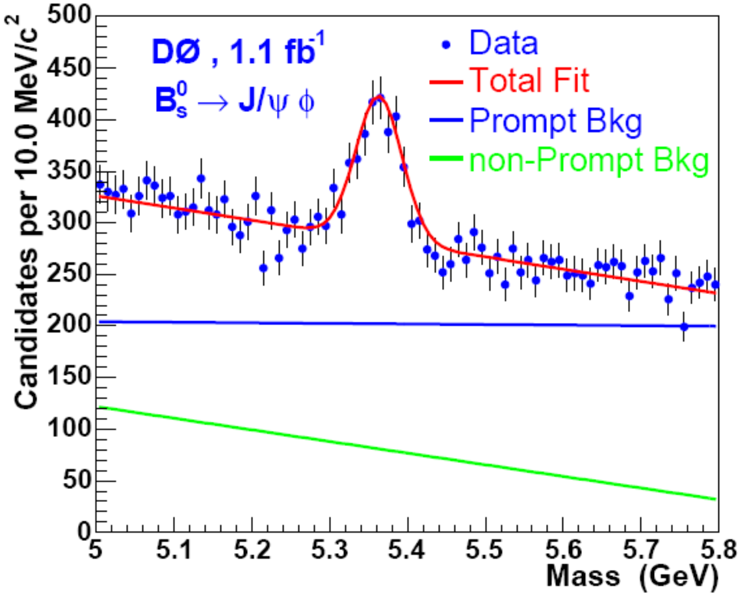
$B_s^0 \to J/\psi\ \varphi$

$J/\psi \to \mu^+\mu^-$

$\Phi \to K^+K^-$

Time-dependent angular distributions of μ^+, μ^-, K^+, K^-





SM → $\Phi_s = -0.04 \pm 0.01$

$\overline{\tau}(B_s^0) = 1.52 \pm 0.05$ (stat) ± 0.01 (syst) ps

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

CP violating phase:

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

- Probability of SM 6.6% $\Rightarrow\ \sim 1.8\sigma$

First direct observation of the strange b baryon Ξ_b^-

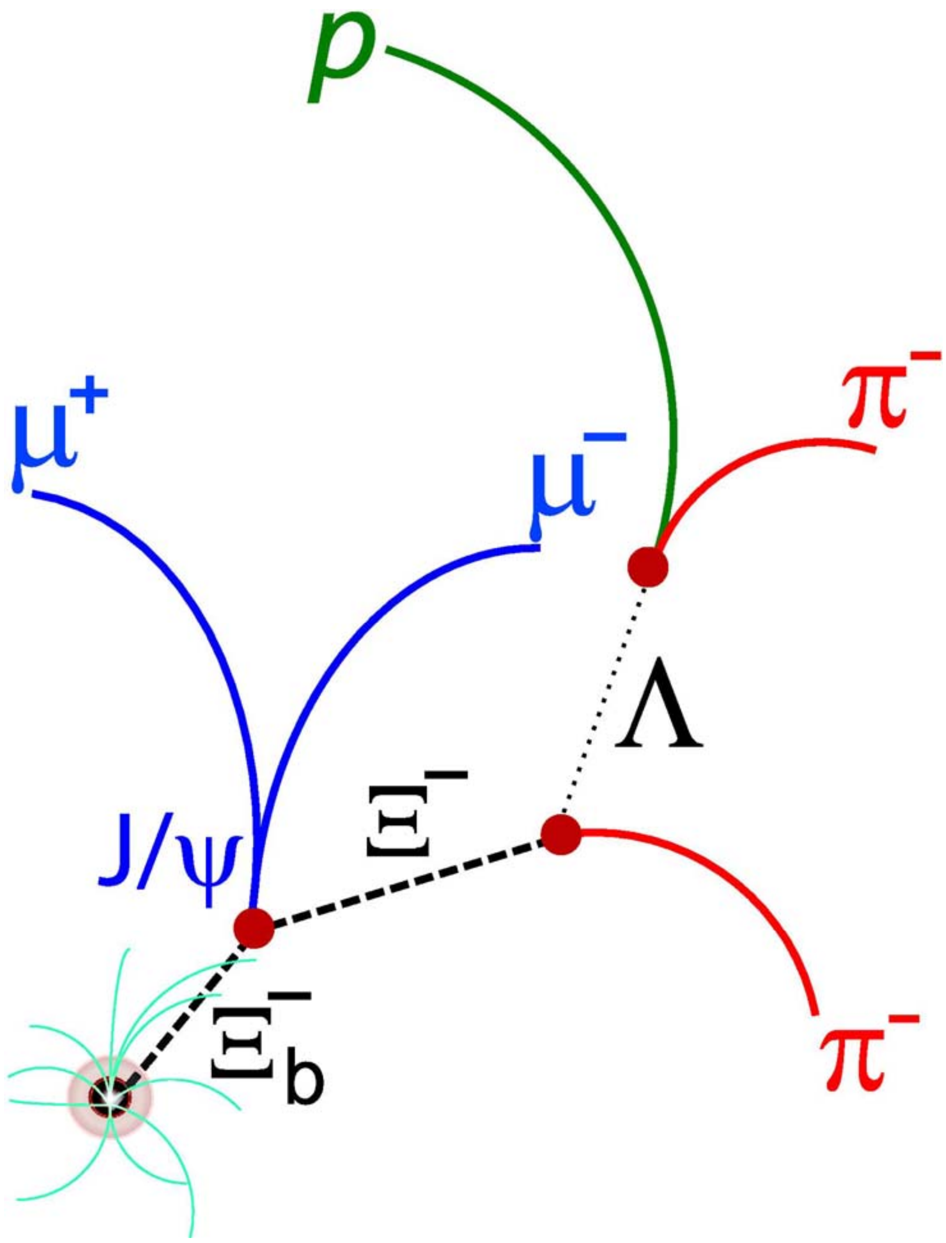
The **STANDARD MODEL**

d u	M_d=6 MeV, M_u=3 MeV,
s c	M_s=100 MeV, M_c=1.2 GeV,
b t	M_b=4.4 GeV, M_t=173 GeV

Λ_b(udb) was observed previously

Ξ_b^-(dsb) - ? – indirect evidence was obtained at the CERN LEP collider
An excess of Ξ^- events was observed in jets.
This excess was interpreted as due to $\Xi_b^- \rightarrow \Xi^- \ell^- \nu X$
The lifetime of Ξ_b^- was estimated to be 1.4 +/- 0.3 ps.
The mass of Ξ_b^- is expected to be 5.7 – 5.8 GeV

DELPHI 1995, ALEPH 1996, DELPHI 2004.
D0 – first direct observation of Ξ_b^- -- Phys. Rev. Lett. 99, 052001 (2007)



$\Xi_b^- \rightarrow J/\Psi + \Xi^-$

$J/\Psi \rightarrow \mu^+ \mu^-$

$\Xi^- \rightarrow \Lambda\ \pi^-$

$\Lambda \rightarrow p\ \pi^-$

J/Ψ (cc) M=3.097 GeV

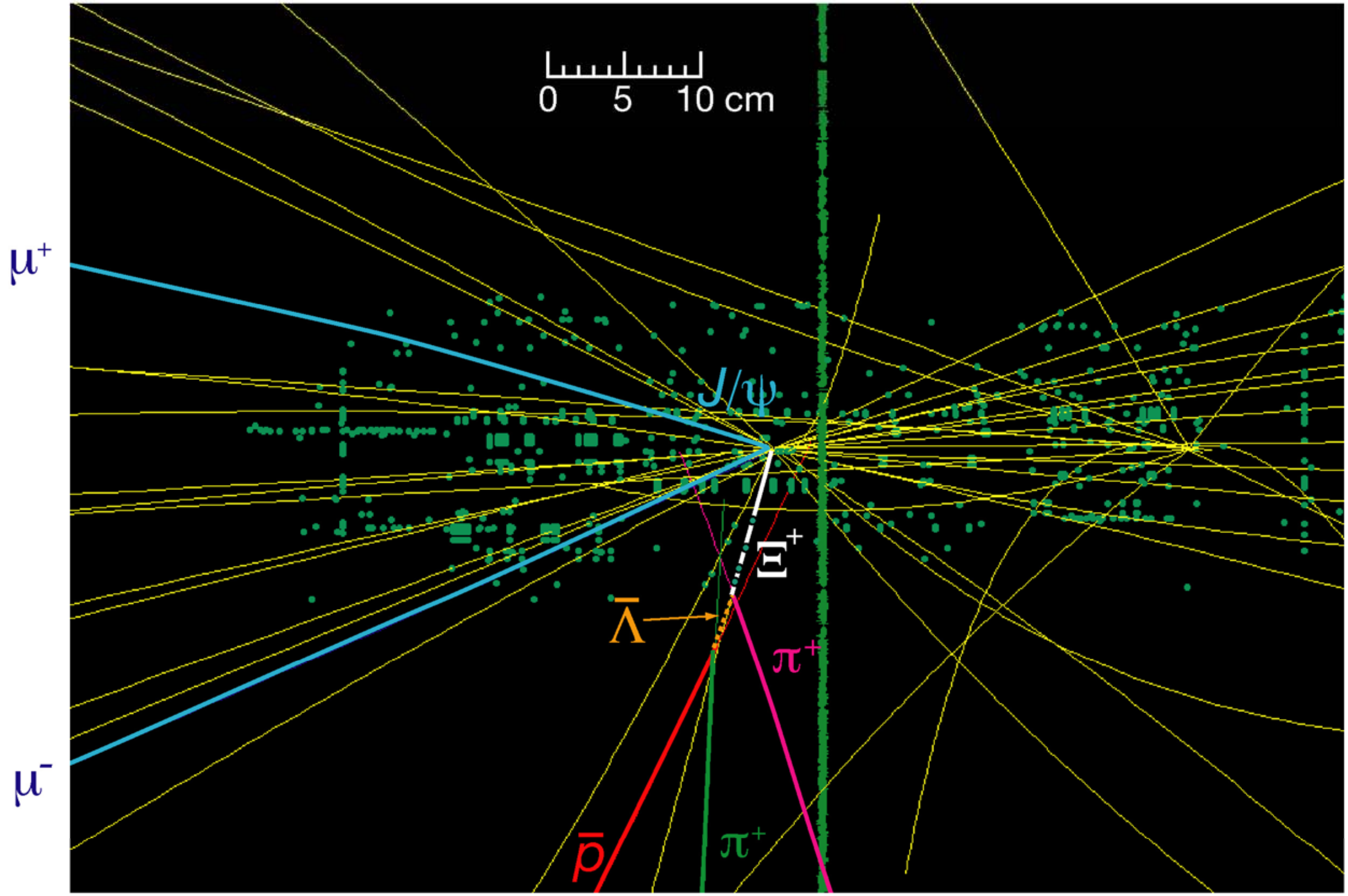
Ξ^- (dss) M=1.315 GeV, τ = 290 ps.

Λ (uds) M=1.116 GeV, τ = 263 ps.

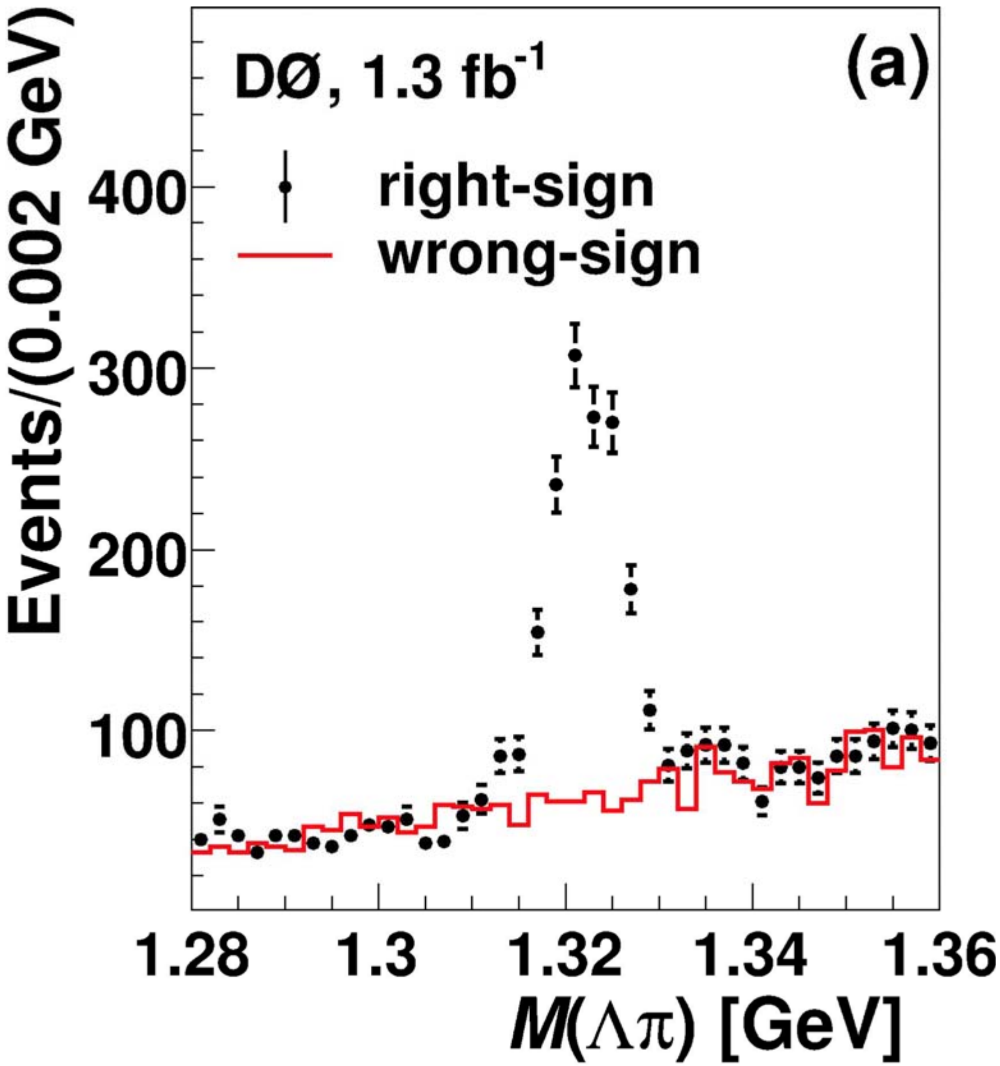
$\lambda(\Xi_b^-)$ = ~ mm

$\lambda(\Xi^-)$ = ~ 5 cm

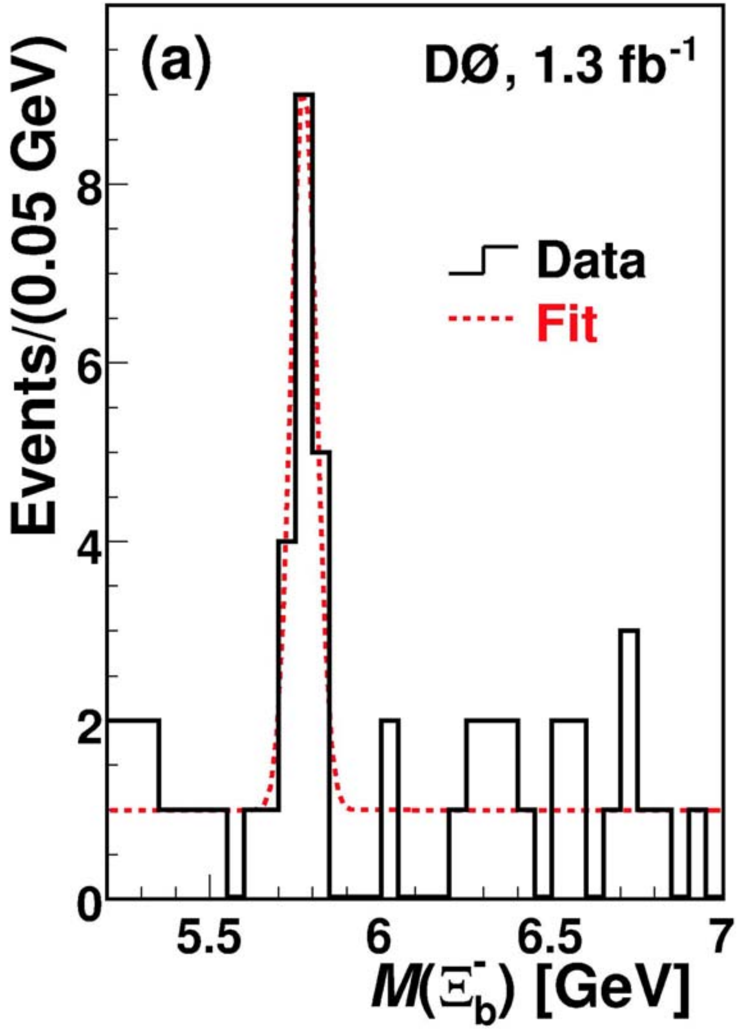
$\lambda(\Lambda)$ = ~ 5 cm



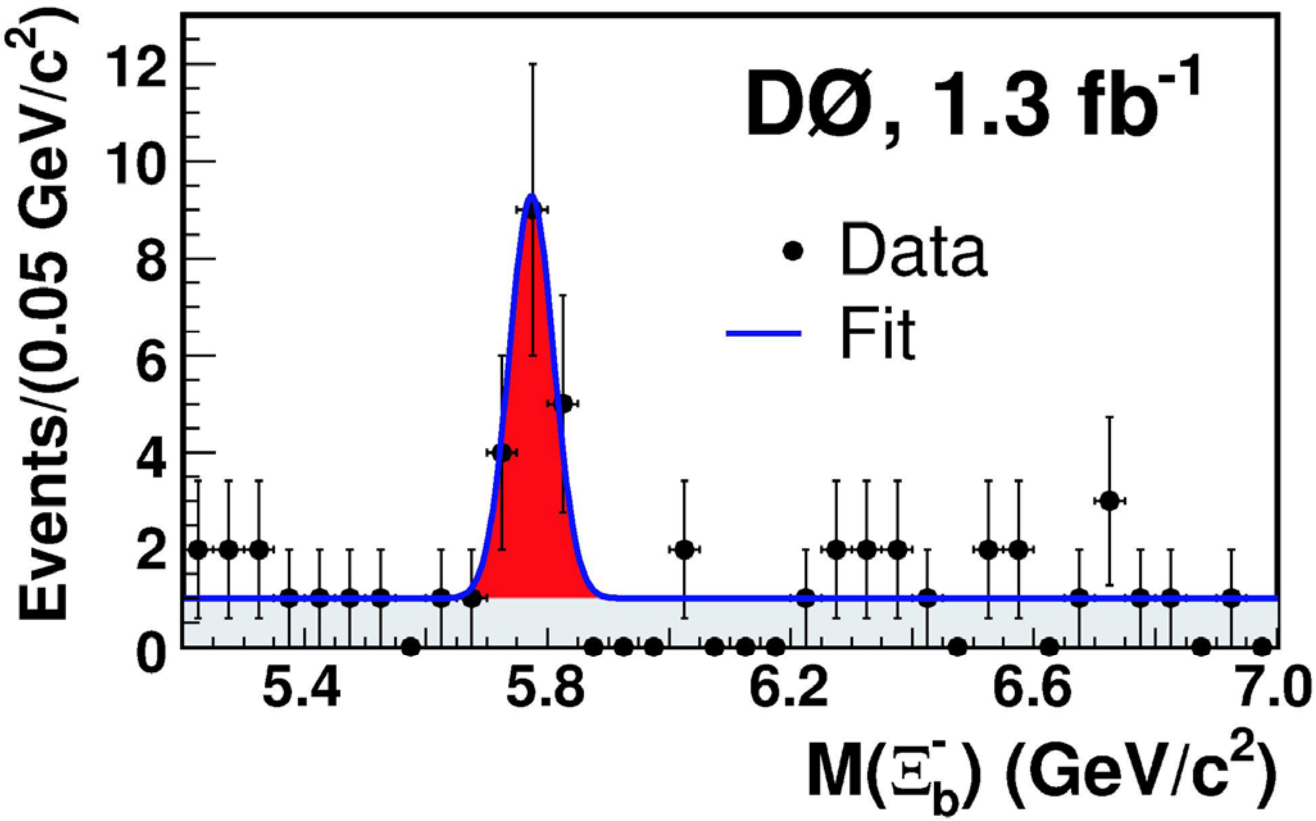
Run 179200, Event 55278820, $M(\Xi_b)$ = 5.788 GeV



Mass spectrum of Ξ^-



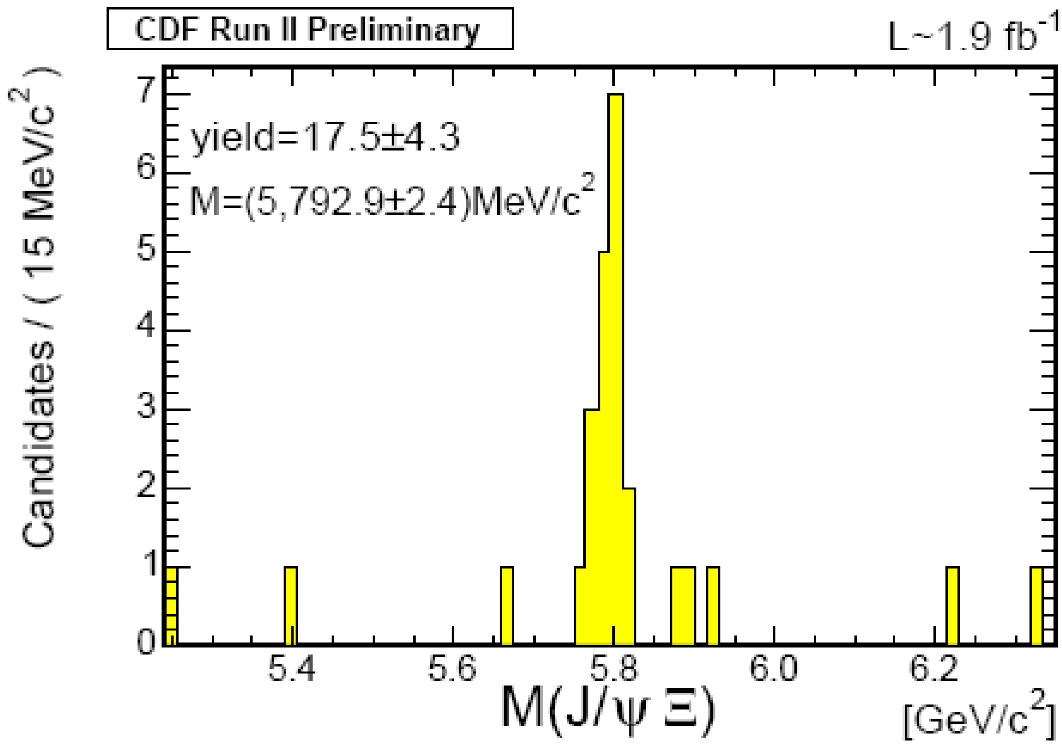
Mass spectrum of Ξ_b^-



M(Ξ_b^-)=5.774 +/- 0.19 GeV

15 событий над фоном в 3 события.

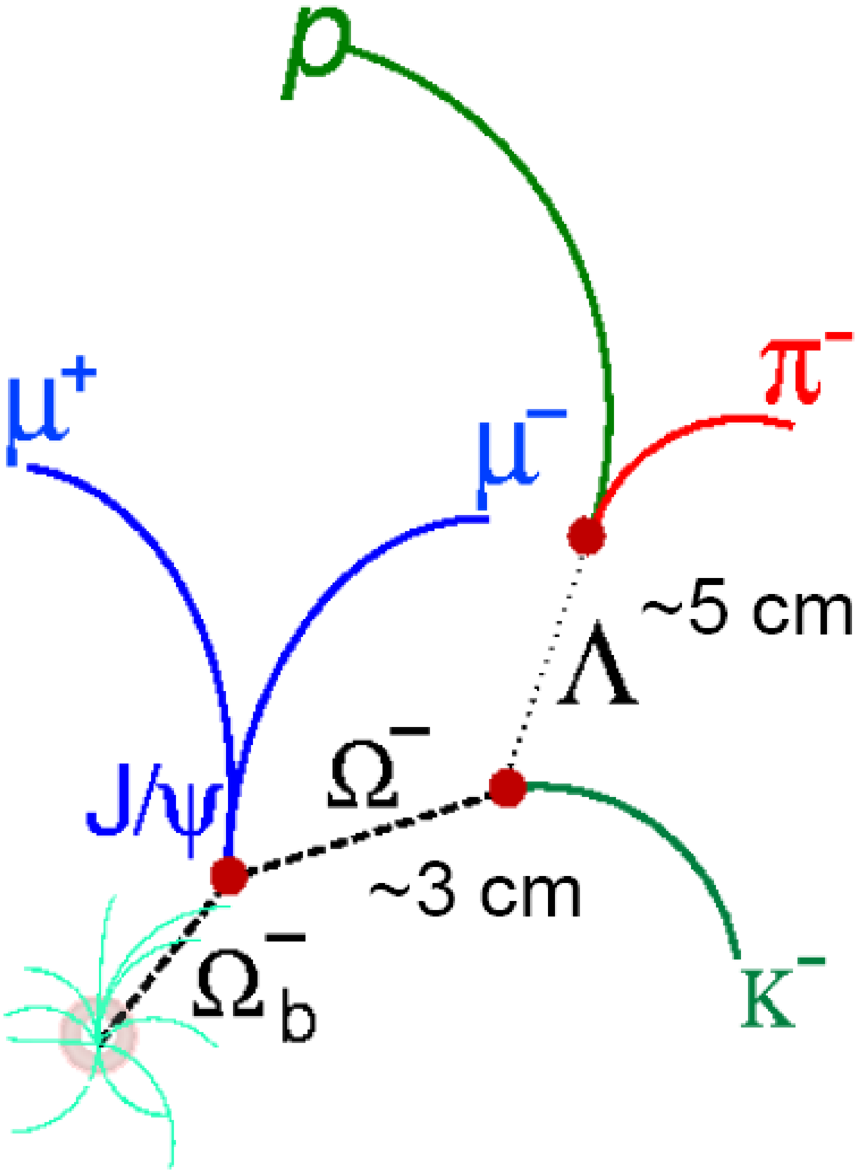
Significance - 5.5 σ.

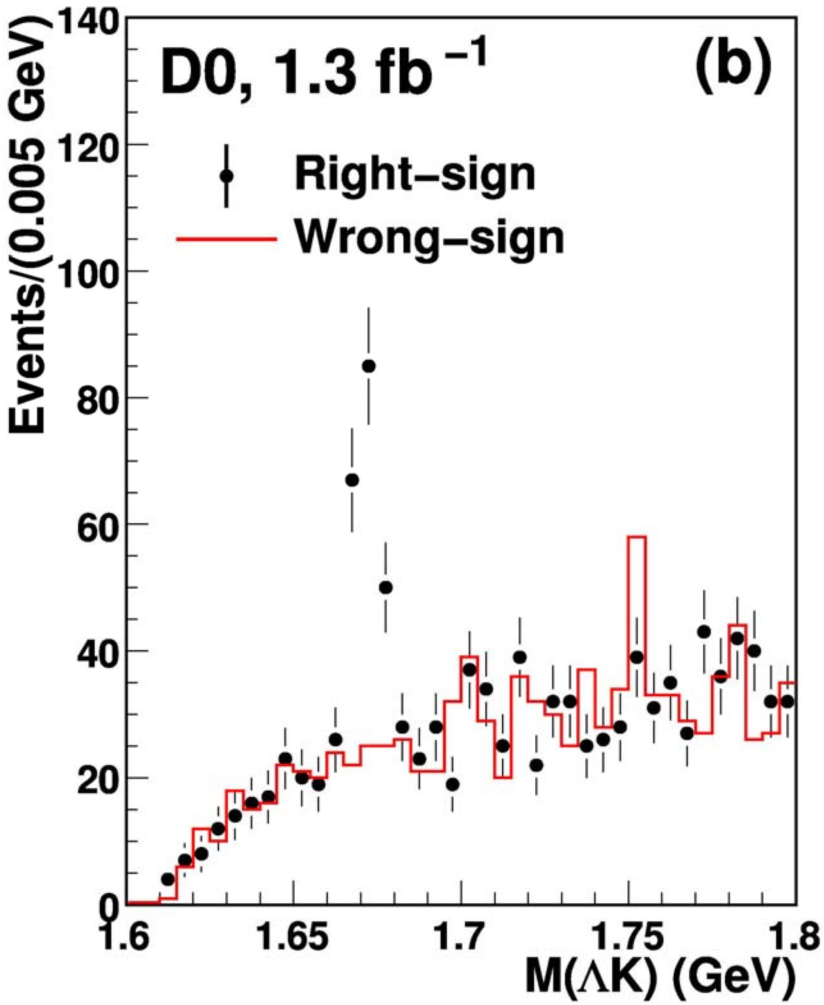


$$M(\Xi_b^-) = (5,792.9 \pm 2.4(stat.) \pm 1.7(syst.))\ \mathrm{MeV}/c^2$$

CDF observes Ξ_b. Significance is 7.8σ

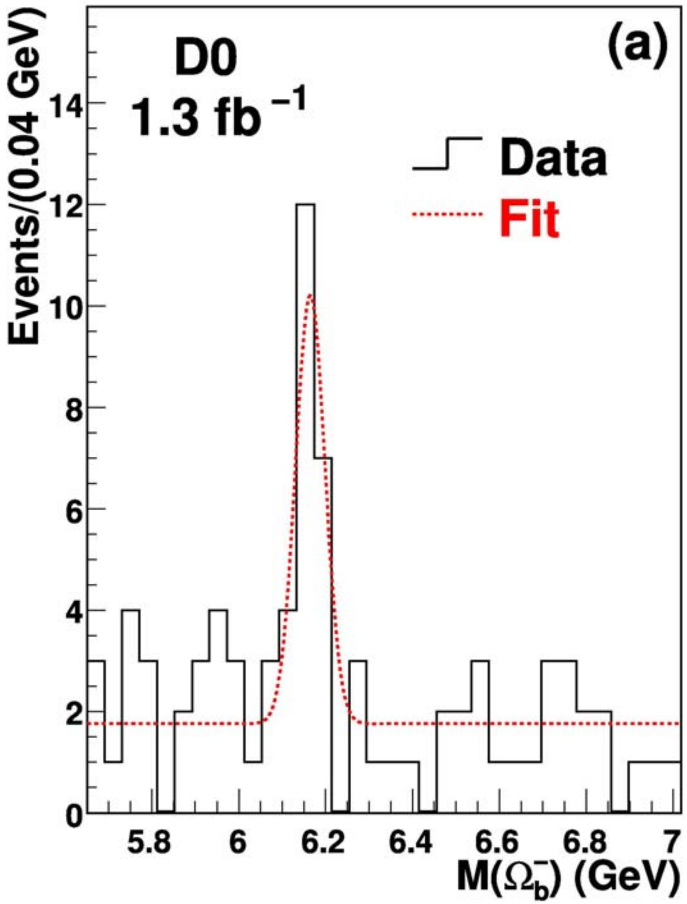
First observation of the doubly strange b baryon Ω_b^-





$M(\Omega^-) = 1.672$ Gev/c^2

Mass spectrum of Ω^-



Mass spectrum of Ω_b^-

17.8 ± 4.9 (stat) ± 0.8 (syst) events

Mass: 6.165 ± 0.010(stat) ± 0.013(syst) GeV

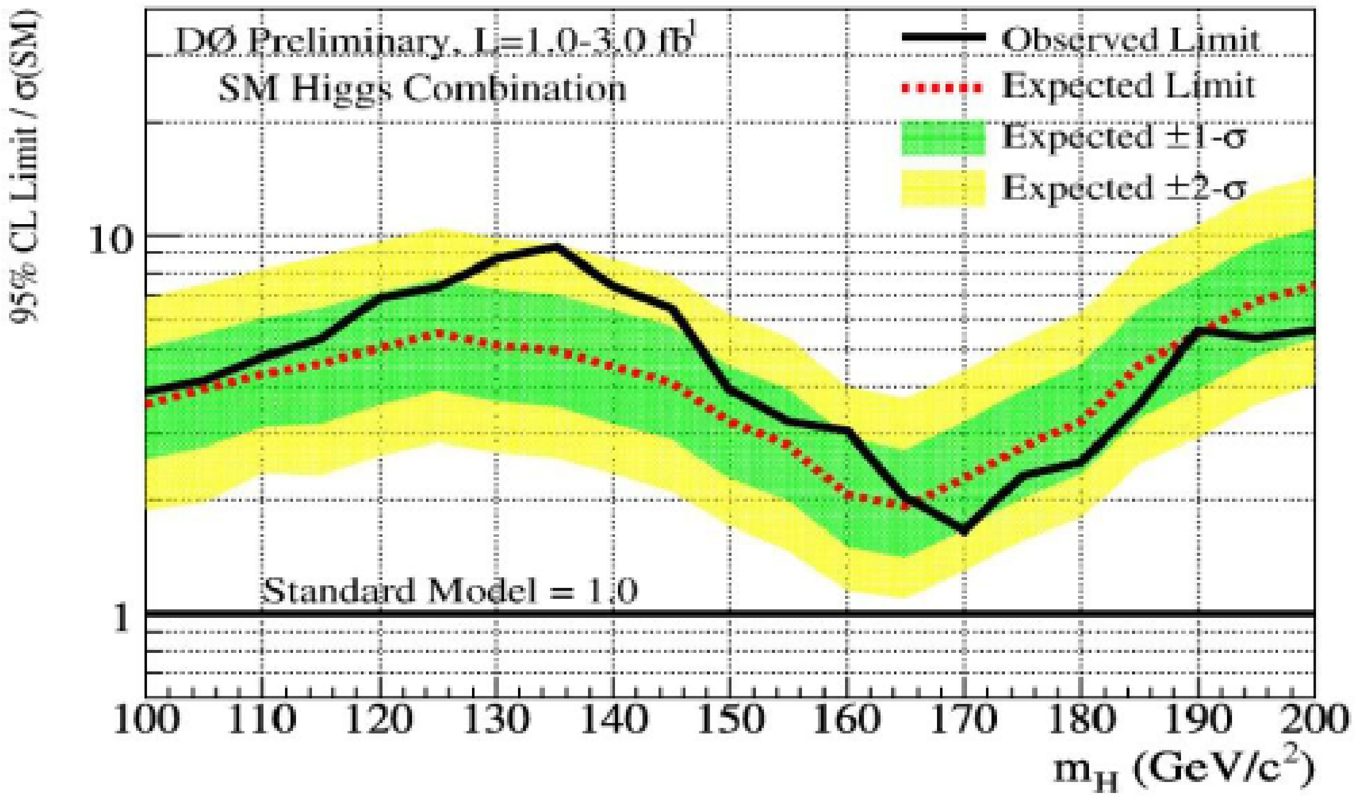
Significance: 5.4σ

$M(\Omega_b^-)$, theory: 5.9 – 6.1 GeV/c^2

probability of background fluctuation - < $7*10^{-8}$

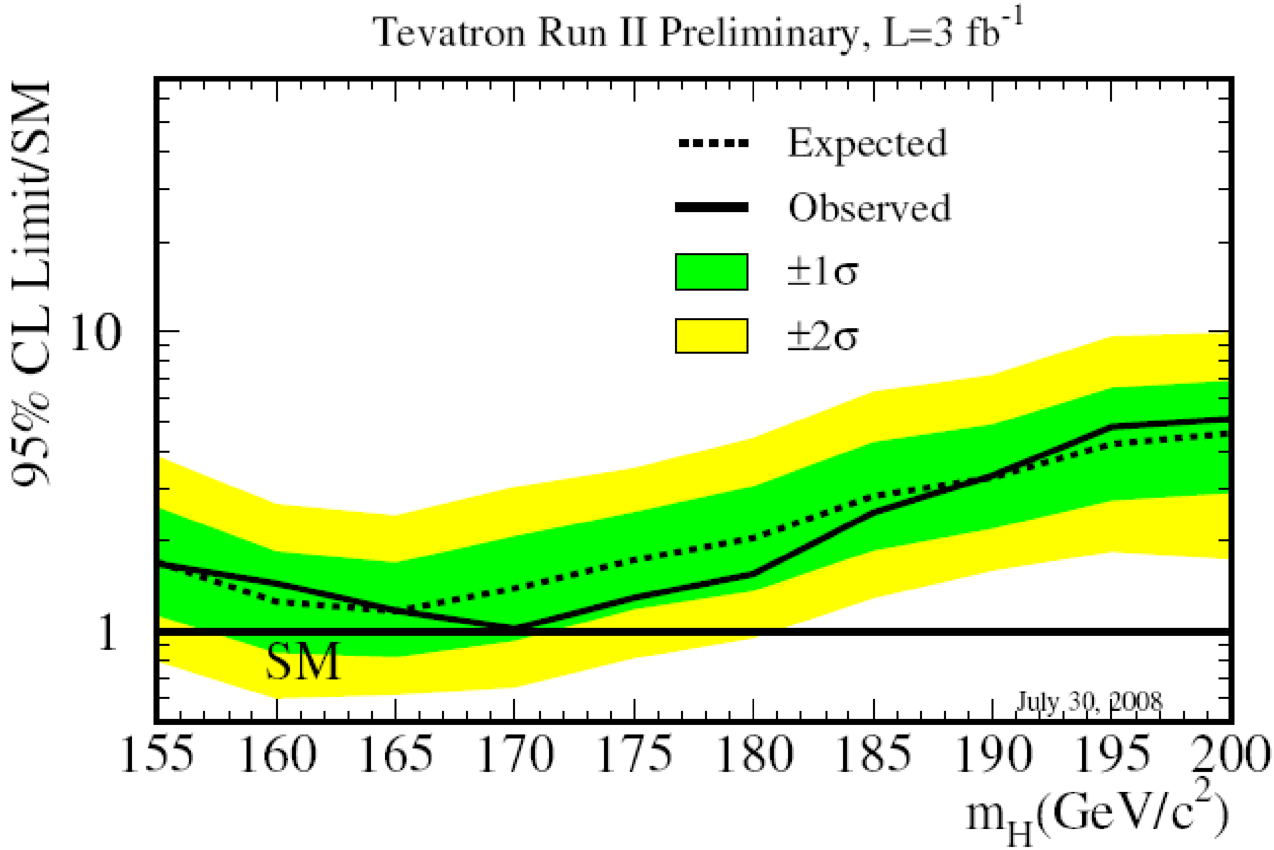
Higgs search at DZero

Previous studies – M_{Higgs} > 114 GeV   Indirect evidence – M_{Higgs} < 180 GeV



Higgs production rate excluded on the 95% C.L.

Combined D0 and CDF result



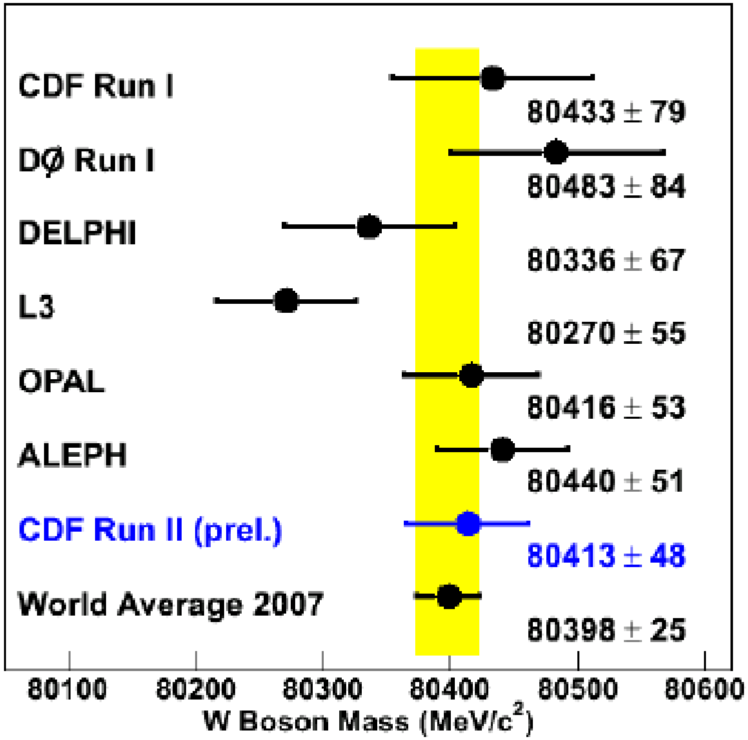
D0+CDF exclude a Higgs boson with a mass of ~170 GeV at the 95% confidential level.

W Boson Mass

Constraint on SM Higgs mass is now dominated by the W mass uncertainty:

Δm_t = 1.2 GeV ➔ ΔM_H = +9/-8 GeV

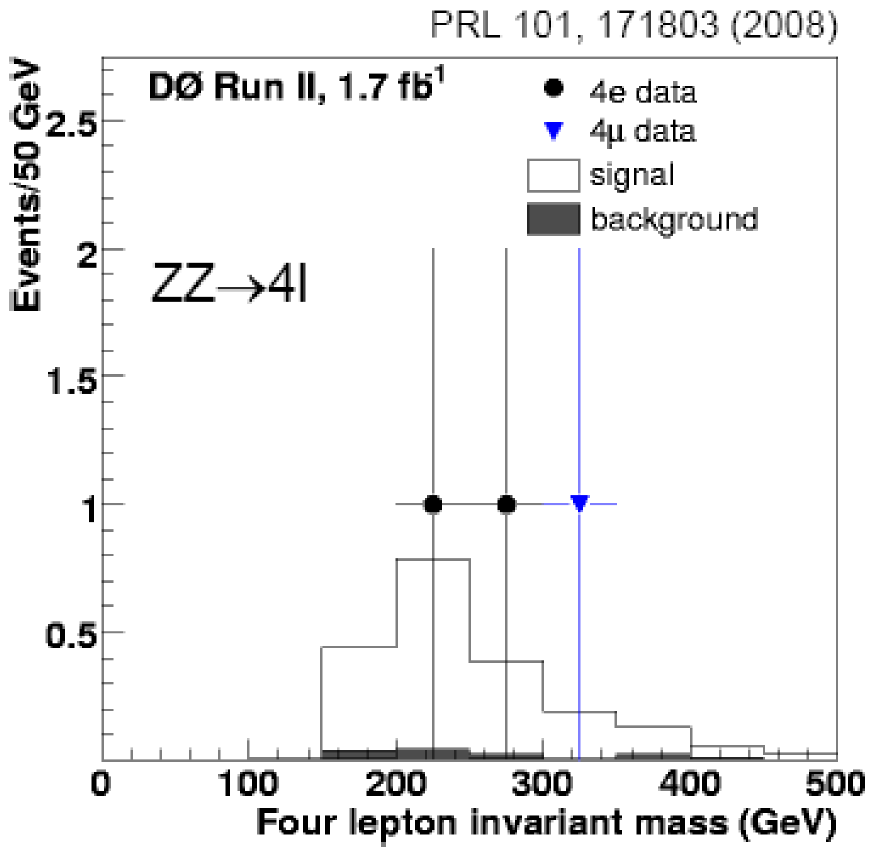
ΔM_W = 25 MeV ➔ ΔM_H = +17/-13 GeV



New results expected soon!

- CDF working on 2.4 fb-1 measurement
- DØ working on 1 fb-1 measurement

First observation of double Z production



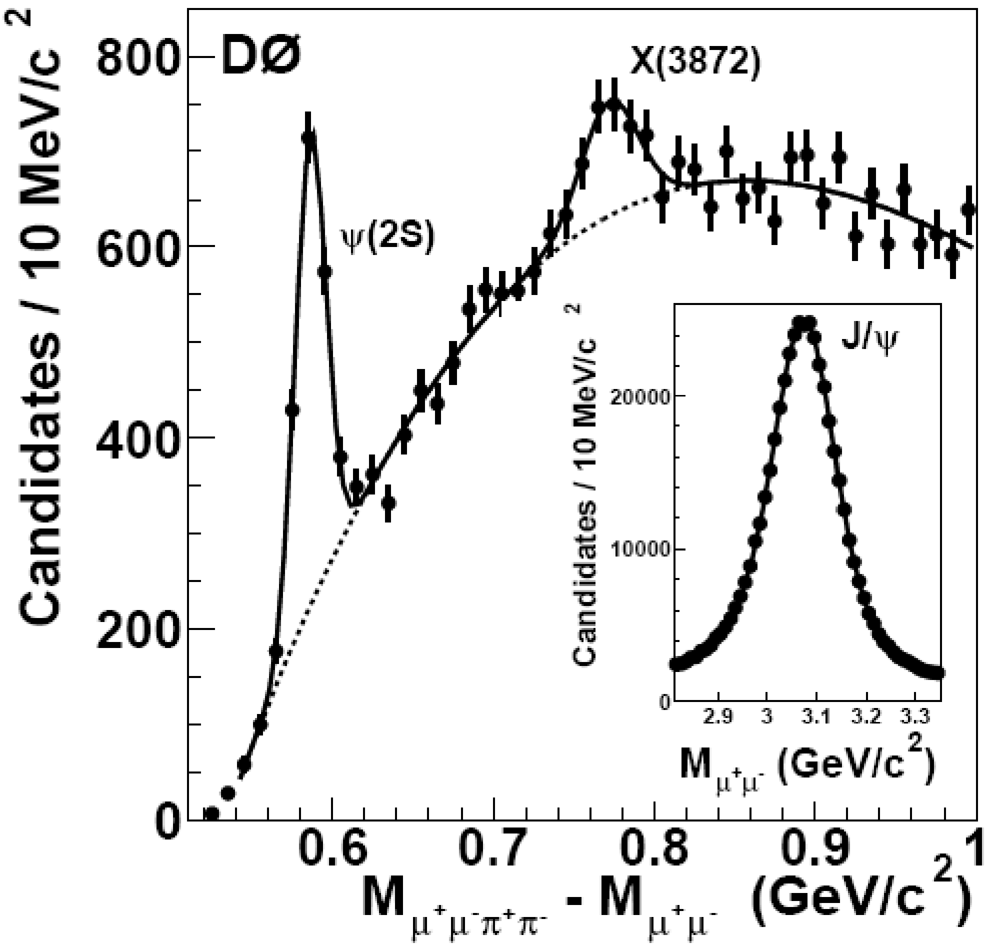
pp → **ZZ** ZZ → 4e, 4μ, 2e2μ Observed 3 events, the background being 0.14 events.

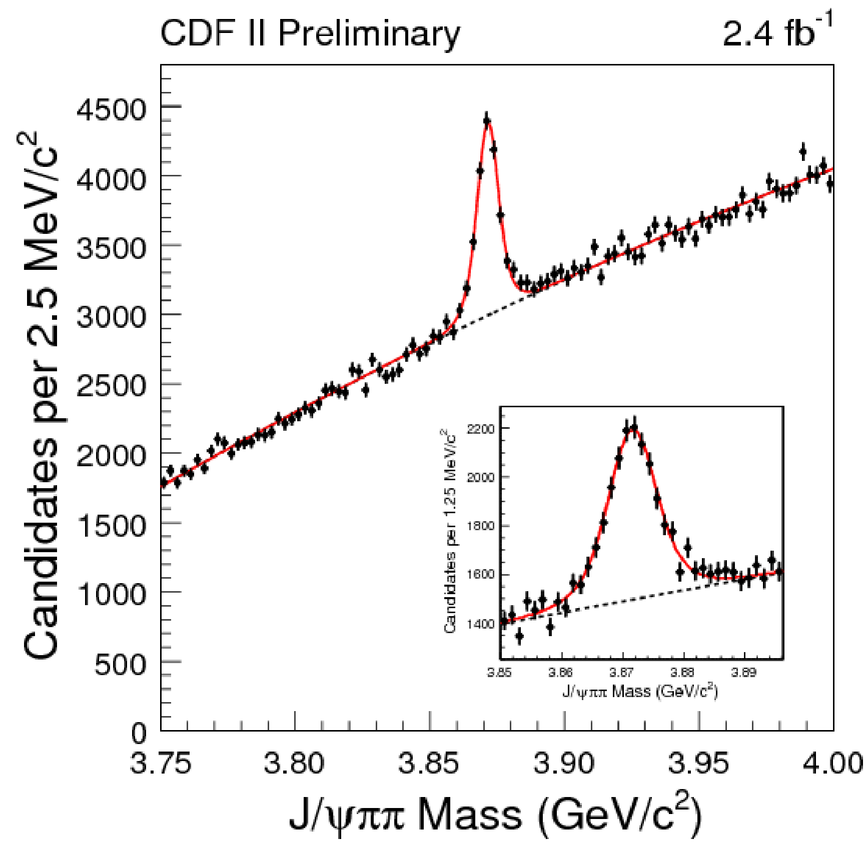
Theory: **σ = 1.4 +/- 0.1 pb**. The significance is 5.7 σ

Experiment D0: **σ = 1.6 +/- 0.6 pb**,

Experiment CDF: σ = 1.4 +/- 0.7 pb.

X(3872) – (cc), (ccqq), (D^0D^{0*}) ?

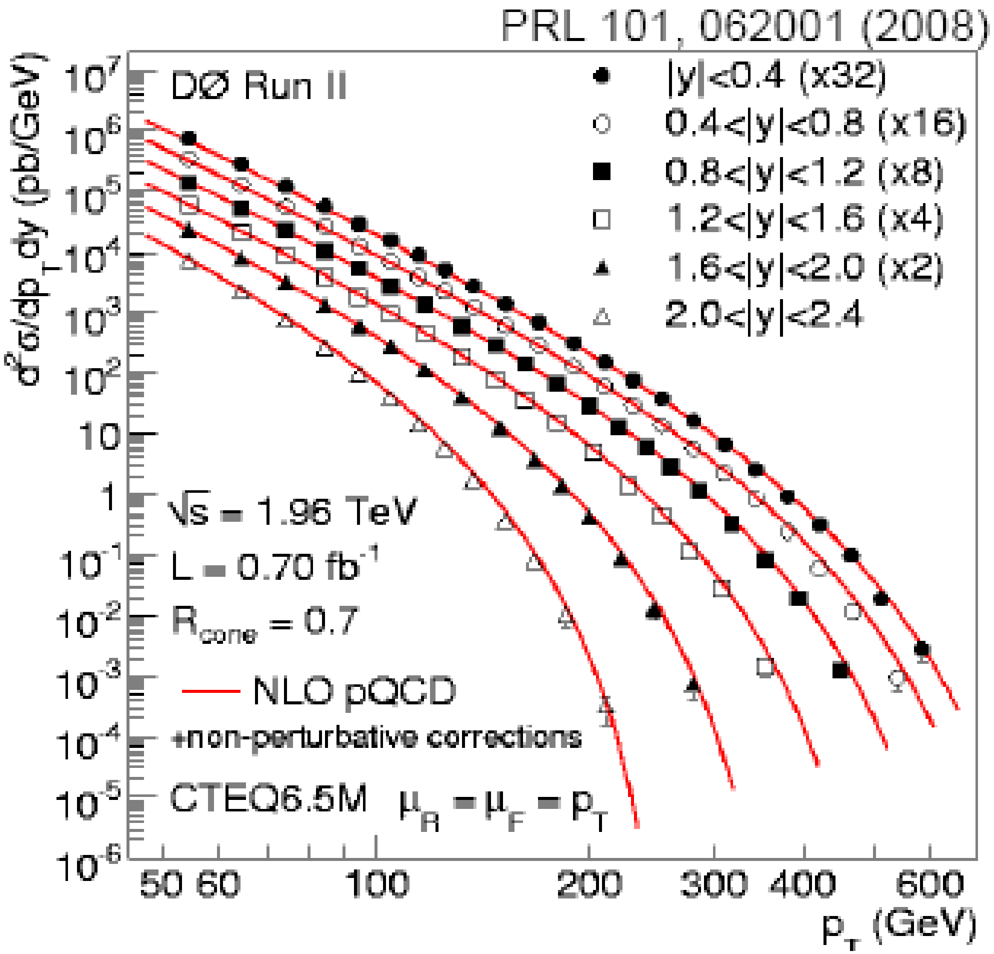




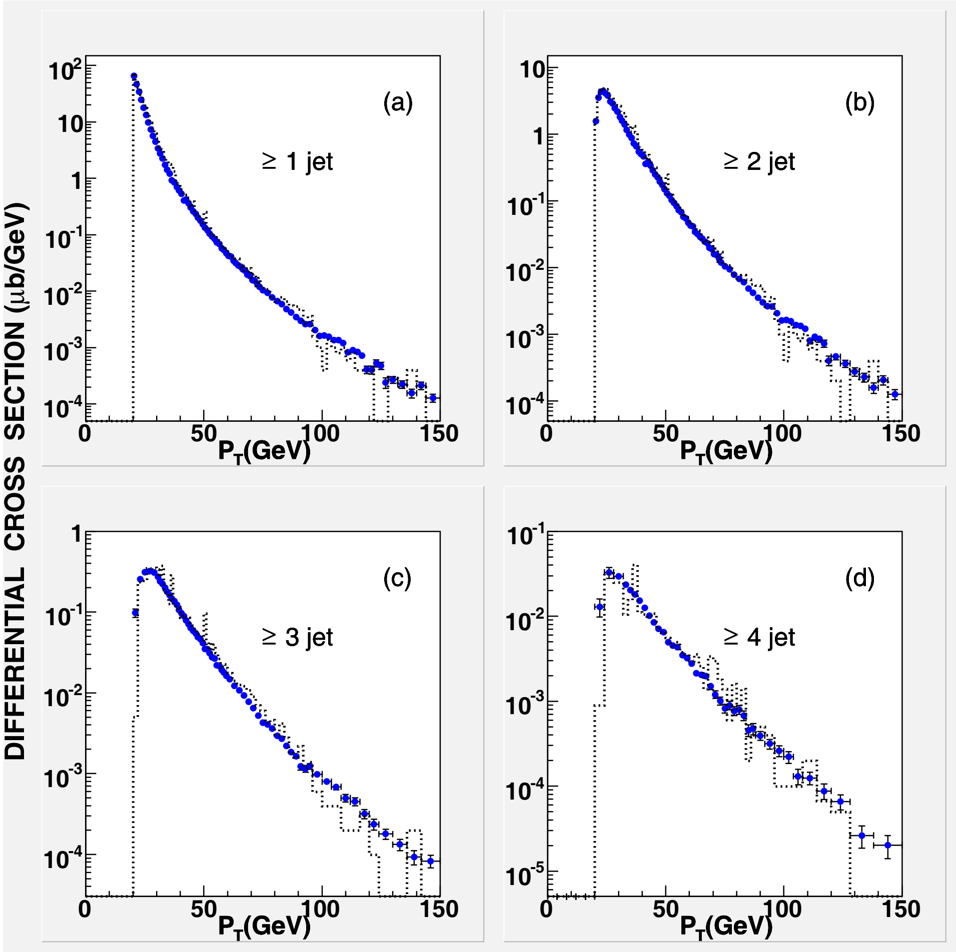
X(3872) → J/ψ ππ   ψ(2S) → J/ψ ππ   X(3872) is not a 4 quark state

M[X(3872)] = 3871.61 +- 0.16 (stat) +- 0.19 (syst) MeV/c2; M[D^0] + M[D^{0*}] = 3.871.81

Inclusive jet production



pQCD – perturbative QCD



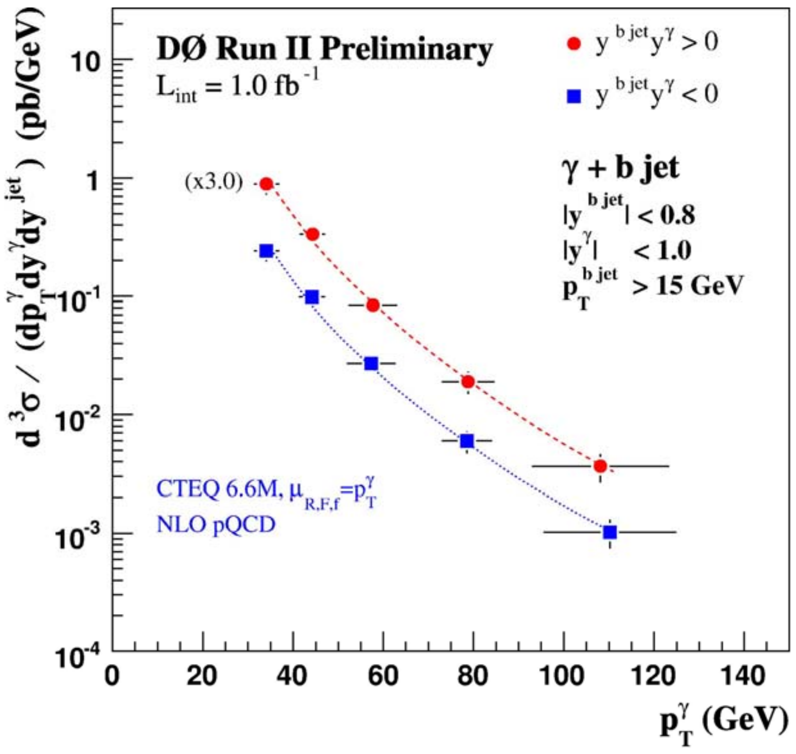
Г. Обрант

Данные свидетельствуют
о большом (~50%) вкладе
в сечение множественных
партонных взаимодействий

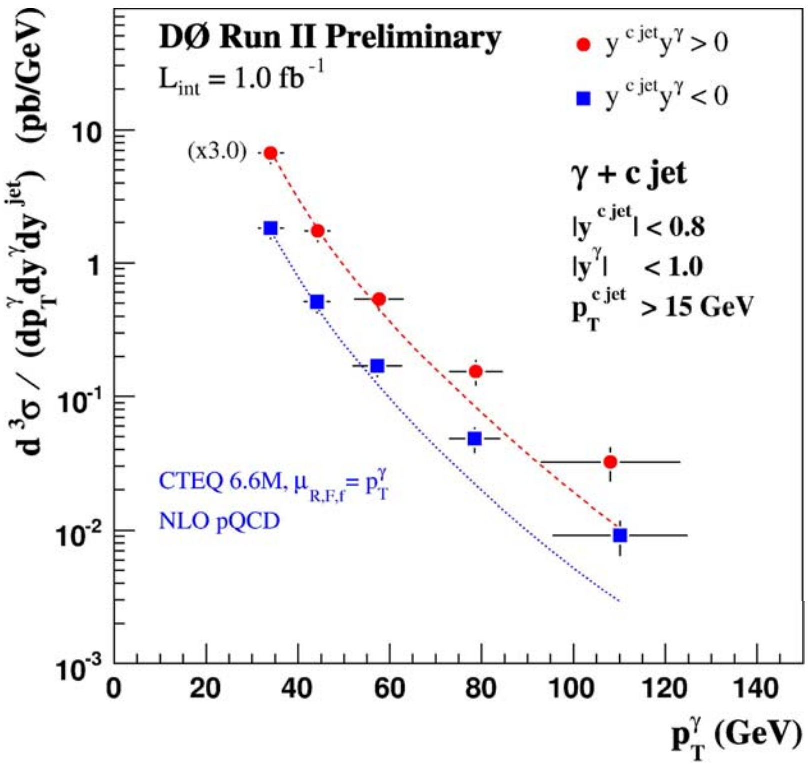
Распределения по поперечному импульсу лидирующей струи для одно- , дважды- , трижды- и четырежды инклюзивным событиям: (a), (b), (c) и (d), соответственно. Гистограммы показывают результаты моделирования PYTHIA.

b and c quarks in the proton

$p\bar{p} \rightarrow \gamma + b$

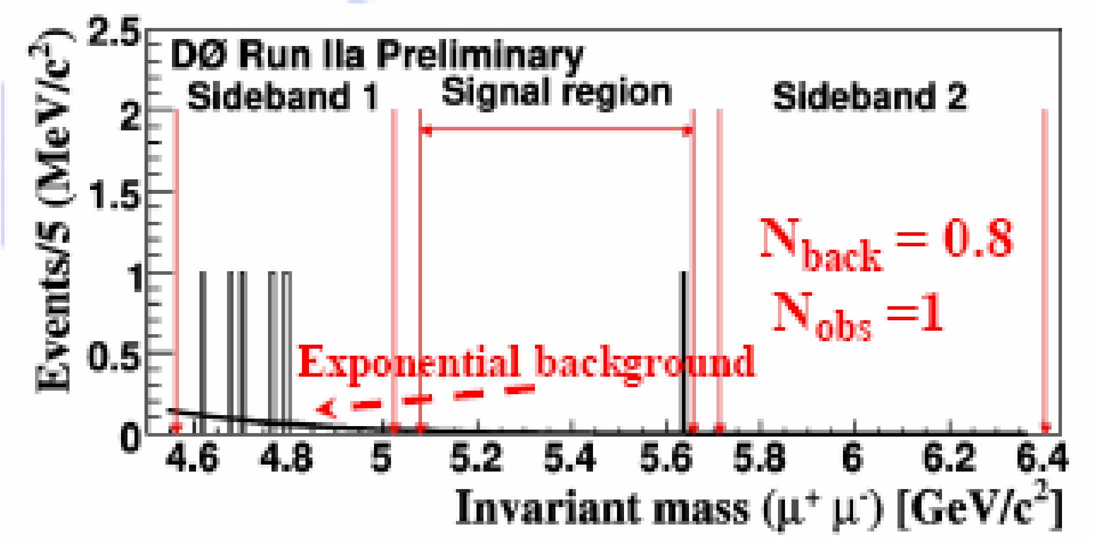


$p\bar{p} \rightarrow \gamma + c$



Production rate for photons in association with a **b** quark (left) or a **c** quark (right) versus the photon transverse momentum

$B_s \to 2\mu$

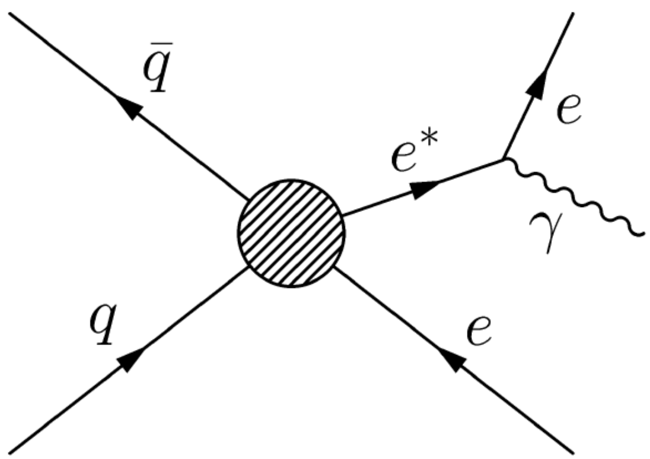


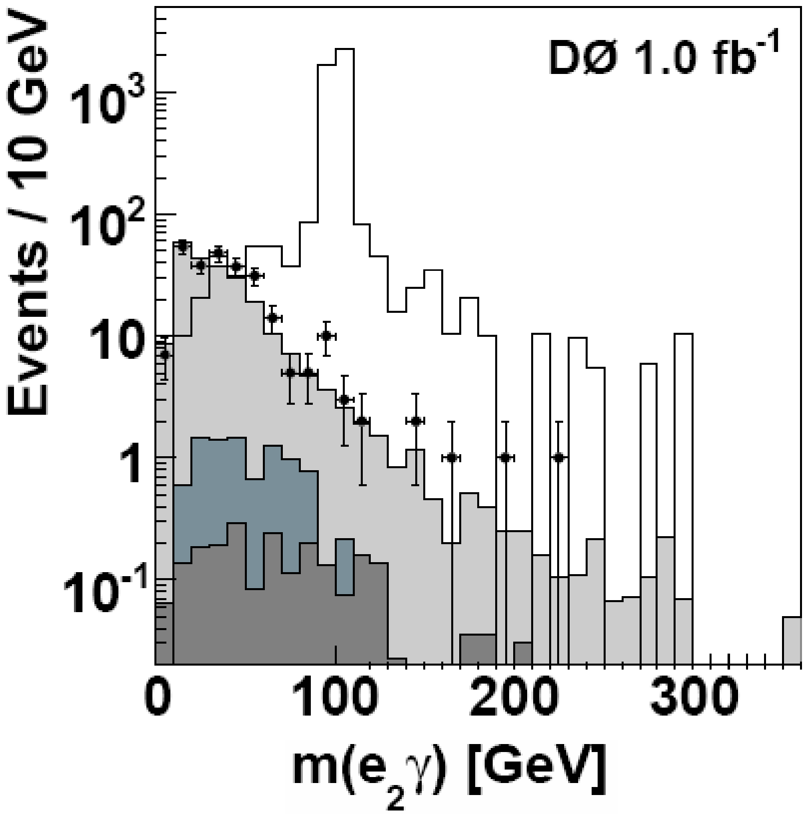
Димюонный спектр в области инвариантной массы $\mathbf{B_s \to 2\mu}$

$Br(B_s \to 2\mu) = 5.1 \to 0.9*10^{-7}$ 95% CL $\to 10^{-8}$?

(SM - $3*10^{-9}$)

Search for excited electrons





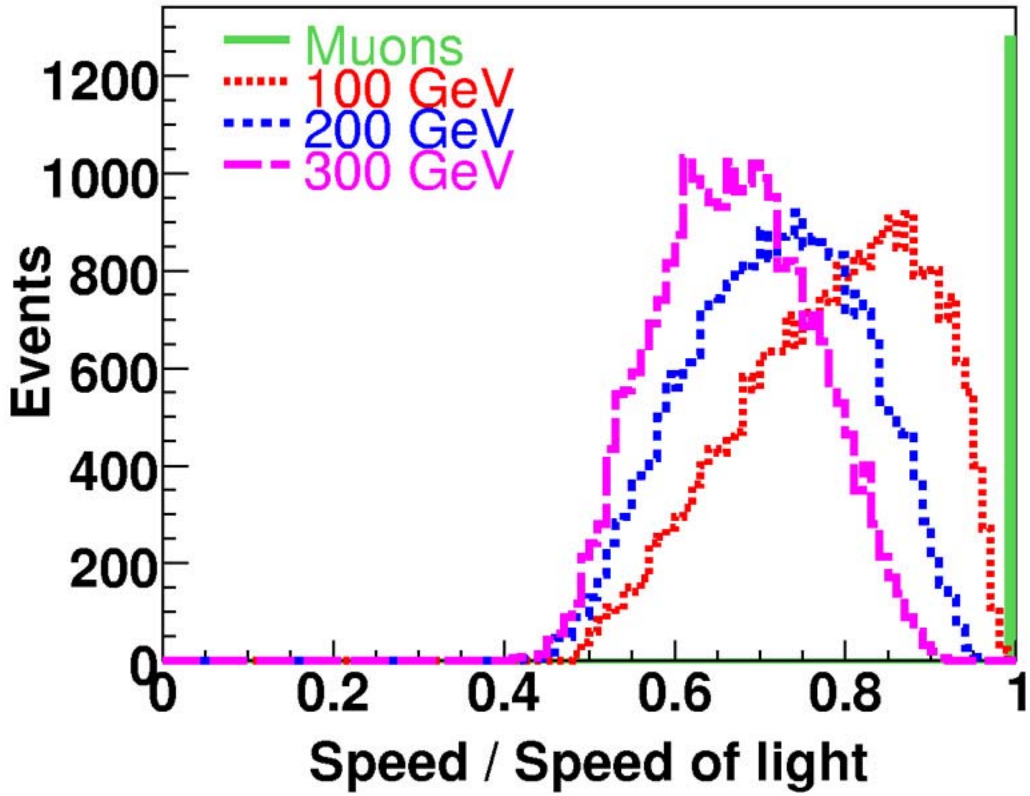
Leptons and quarks consist of
3 fermions or a boson and a fermion ?

D0 → no evidence of e* with
m[e*] ≤ 800 GeV

The distribution of the $e_2\gamma$ invariant mass compared with the SM expectation and a possible e* signal for m_{e*} = 100 GeV

Search for charged massive "stable" particles

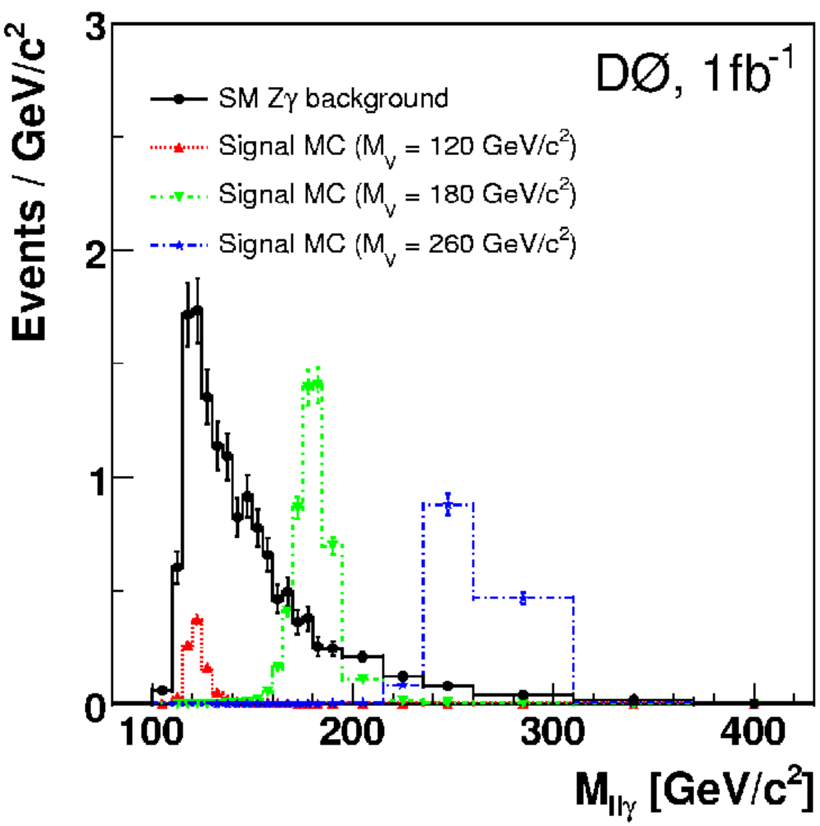
(tau sleptons, gaugino-like charginos, higgsino-like charginos, candidates for dark matter)

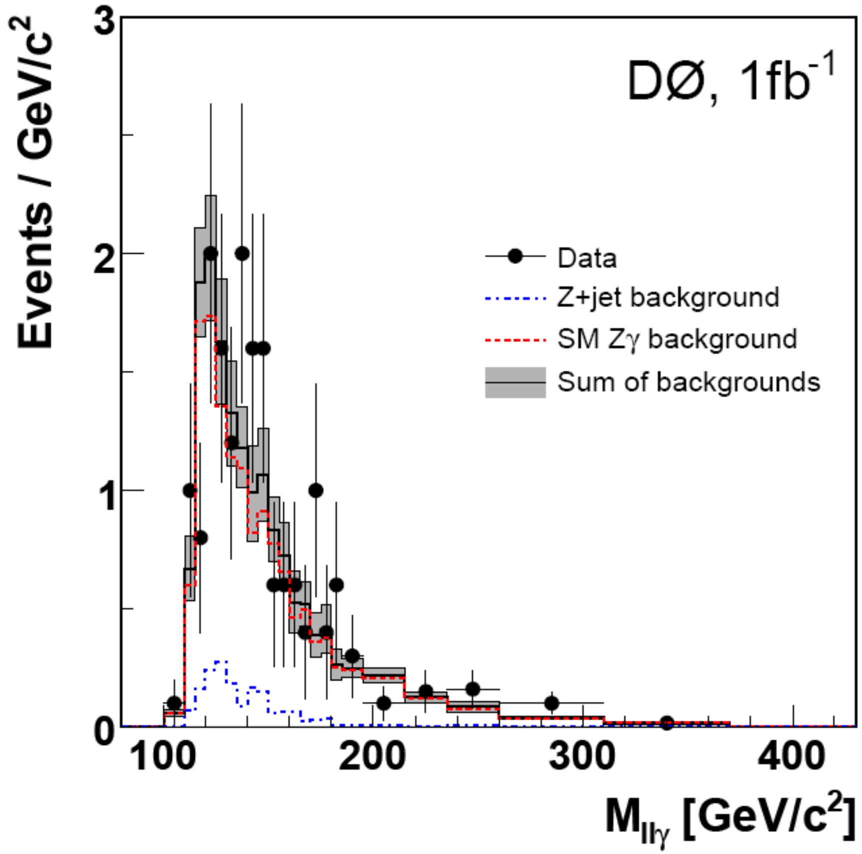


Mass (GeV)	Signal Acceptance	Predicted Background	Observed Events
	(a) stau		
60	$0.064 \pm 0.001 \pm 0.005$	$30.9 \pm 2.2 \pm 1.9$	38
80	$0.038 \pm 0.001 \pm 0.005$	$2.6 \pm 0.6 \pm 0.4$	1
100	$0.056 \pm 0.001 \pm 0.004$	$1.6 \pm 0.5 \pm 0.3$	1
150	$0.123 \pm 0.002 \pm 0.013$	$1.7 \pm 0.5 \pm 0.2$	1
200	$0.139 \pm 0.002 \pm 0.011$	$1.7 \pm 0.5 \pm 0.5$	1
250	$0.133 \pm 0.002 \pm 0.013$	$1.7 \pm 0.5 \pm 0.3$	1
300	$0.117 \pm 0.002 \pm 0.013$	$1.9 \pm 0.5 \pm 0.2$	2
	(b) gaugino-like charginos		
60	$0.032 \pm 0.001 \pm 0.003$	$23.6 \pm 1.9 \pm 1.4$	24
80	$0.024 \pm 0.001 \pm 0.003$	$1.9 \pm 0.5 \pm 0.3$	1
100	$0.046 \pm 0.001 \pm 0.004$	$1.6 \pm 0.5 \pm 0.3$	1
150	$0.085 \pm 0.001 \pm 0.009$	$1.2 \pm 0.4 \pm 0.1$	1
200	$0.089 \pm 0.001 \pm 0.007$	$1.9 \pm 0.5 \pm 0.0$	1
250	$0.074 \pm 0.001 \pm 0.007$	$1.7 \pm 0.5 \pm 0.3$	1
300	$0.059 \pm 0.001 \pm 0.007$	$1.7 \pm 0.5 \pm 0.1$	2
	(c) higgsino-like charginos		
60	$0.029 \pm 0.001 \pm 0.002$	$17.9 \pm 1.7 \pm 1.1$	21
80	$0.024 \pm 0.001 \pm 0.003$	$1.6 \pm 0.5 \pm 0.3$	1
100	$0.049 \pm 0.001 \pm 0.004$	$1.6 \pm 0.5 \pm 0.3$	1
150	$0.089 \pm 0.001 \pm 0.009$	$1.4 \pm 0.5 \pm 0.1$	1
200	$0.096 \pm 0.001 \pm 0.008$	$1.9 \pm 0.5 \pm 0.0$	1
250	$0.081 \pm 0.001 \pm 0.008$	$1.7 \pm 0.5 \pm 0.3$	1
300	$0.064 \pm 0.001 \pm 0.007$	$1.7 \pm 0.5 \pm 0.1$	1

No evidence for such particles. $\sigma < 0.3 – 0.04$ pb for stau masses 60 – 300 GeV

Search for scalar or vector particles decaying into Zγ

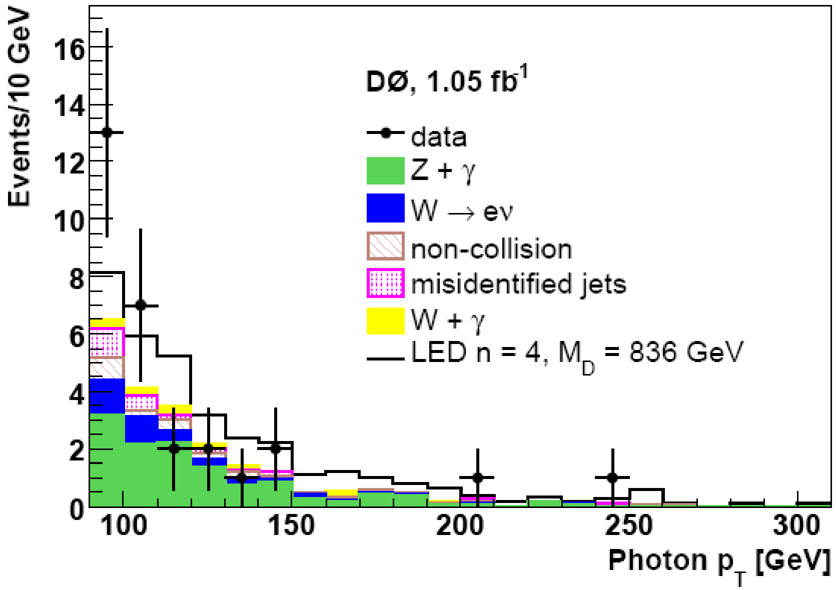


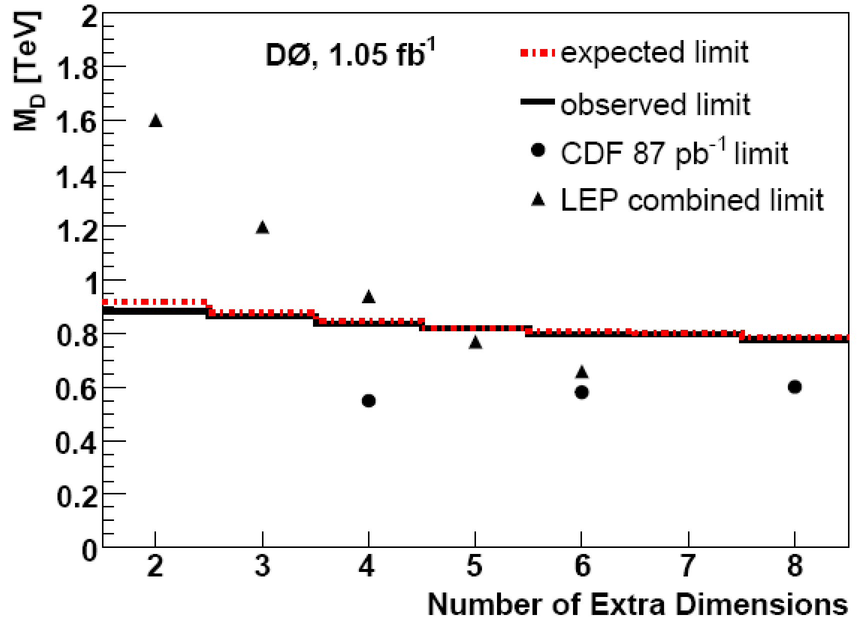


$Z \rightarrow l^+l^-$

Experimental limits on the production cross section:
M = 140 GeV – σ ≤ 3 pb,   M = 600 GeV – σ ≤ 0.2 pb.

Search for large extra dimensions





Kaluza-Klein graviton

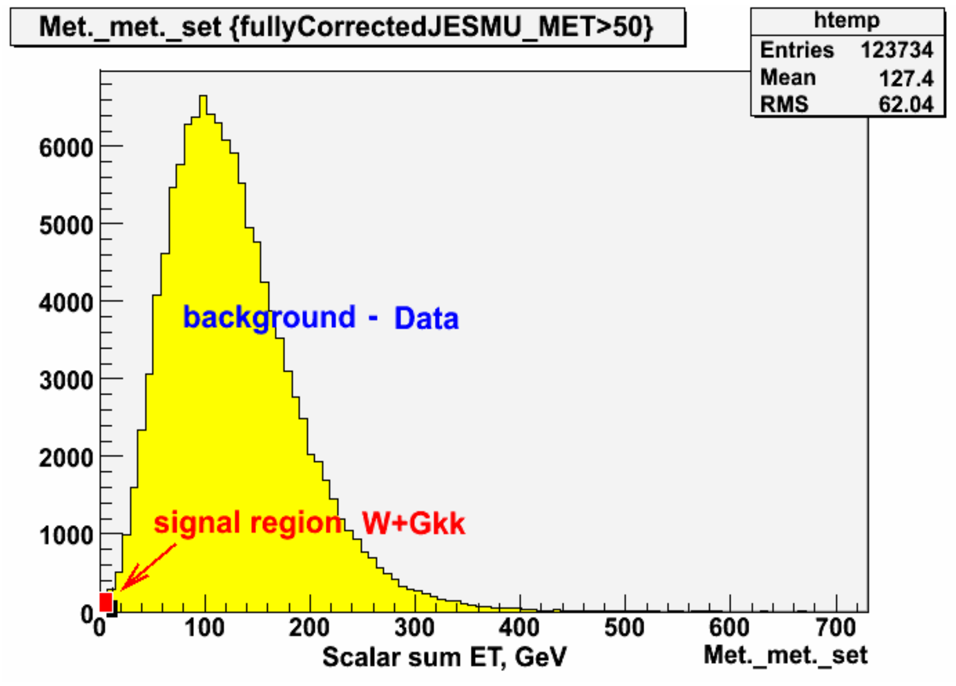
Lower limits on the fundamental mass scale M_D

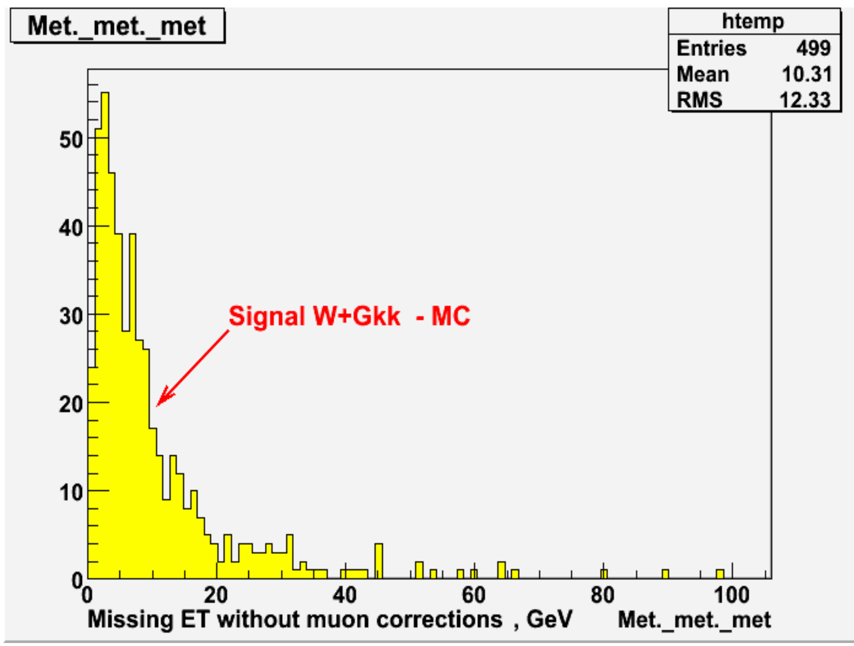
pp → g + γ   register a photon with p_t > 90 GeV and E_t_miss > 70 GeV

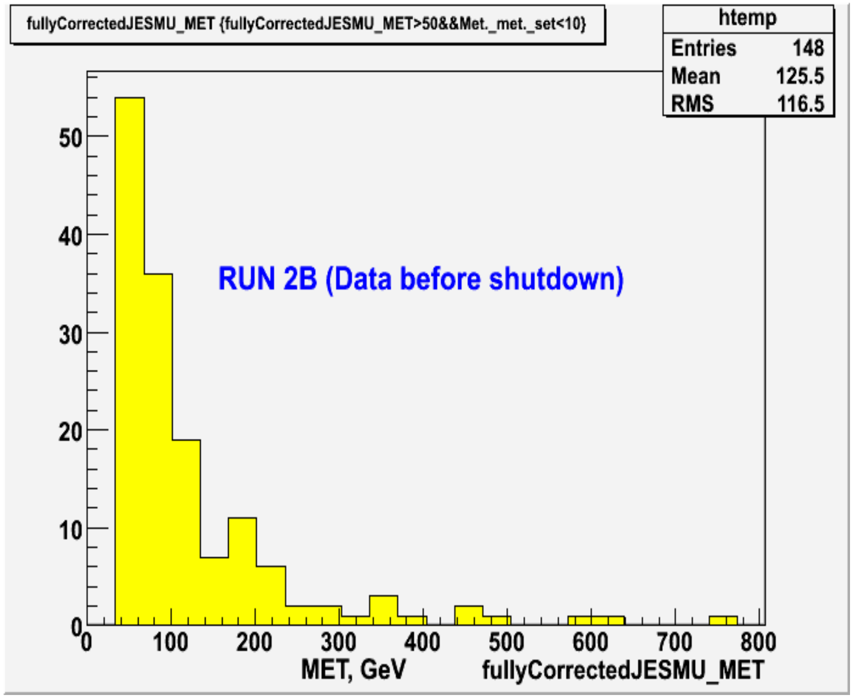
Поиск квантовой гравитации

pp → W(Z) + g   W → μ + ν   g – Kaluza-Klein graviton

Отбор: малая суммарная энергия в калориметре, большой поперечный импульс μ – мезона, большая недостающая поперечная энергия.
pp → W(Z) + g   modernized generator has been included to Pythia 8.3





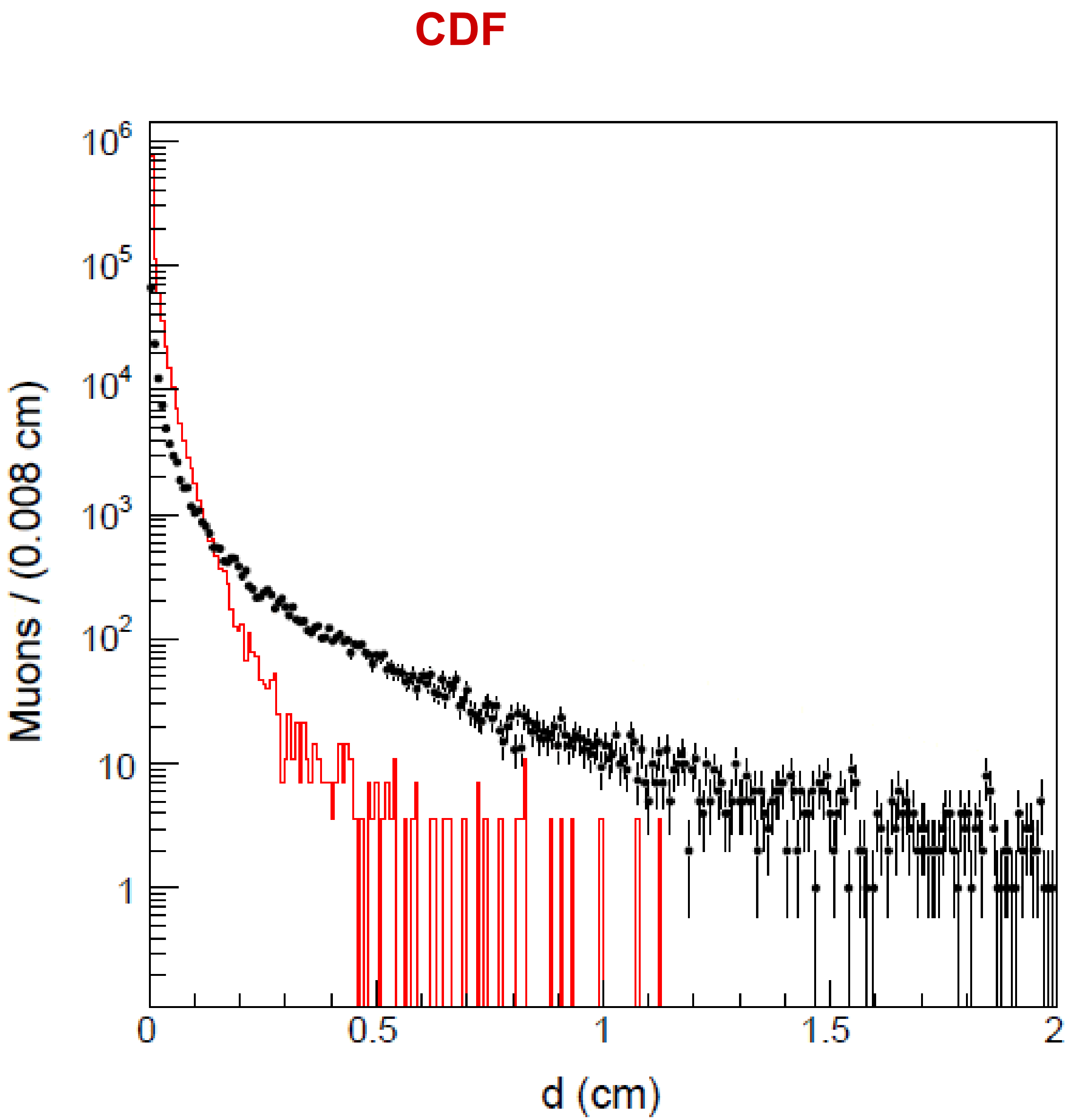


MET distribution of the data for $p_t(\mu) > 15$ GeV,

ΣE_t (calorimeter) < 15 GeV.

In 2009, simulations of the MET spectrum for the signal,

simulations of the background processes.


CDF
Muons / (0.008 cm)
d (cm)
10^6
10^5
10^4
10^3
10^2
10
1
0
0.5
1
1.5
2