To B^0 or $\overline{B}^0$:
An Experimentalist's View of Mixing

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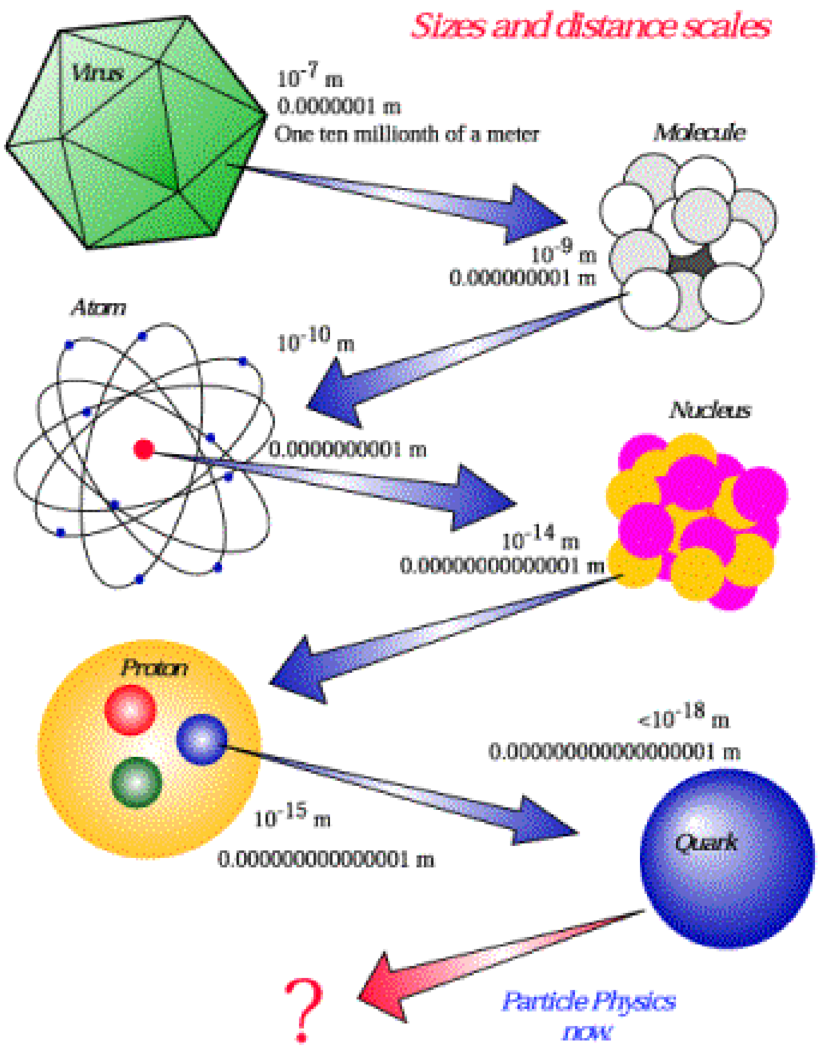
Sept 26, 2003

(Presented at SUNY, Albany)

Outline:

- Introduction
- Quarks and Particle-AntiParticle Mixing
- D0 detector
- Progress and Outlook
- Conclusions



What's the Point?

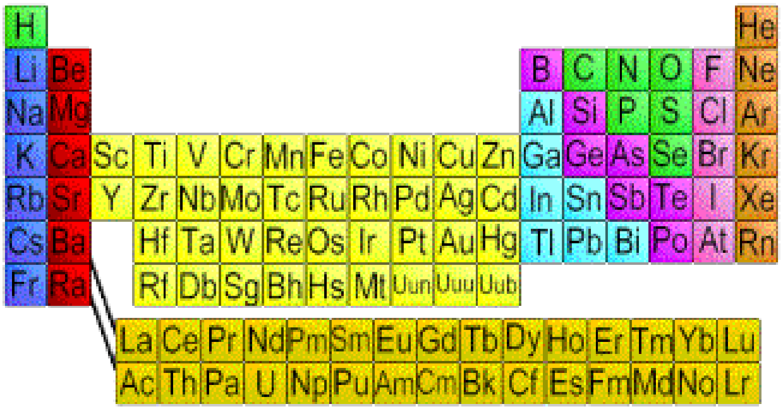
High Energy Particle Physics is a study of the smallest pieces of matter.

It investigates (among other things) the nature of the universe immediately after the Big Bang.

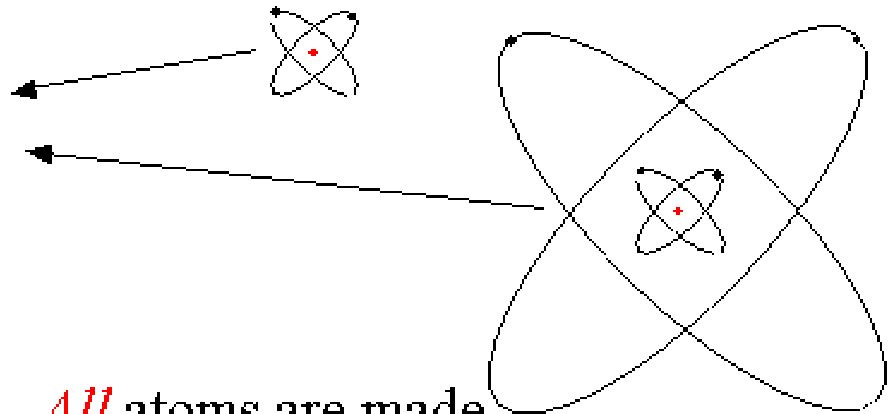
It also explores physics at temperatures not common for the past 15 billion years (or so).

It's a lot of fun.

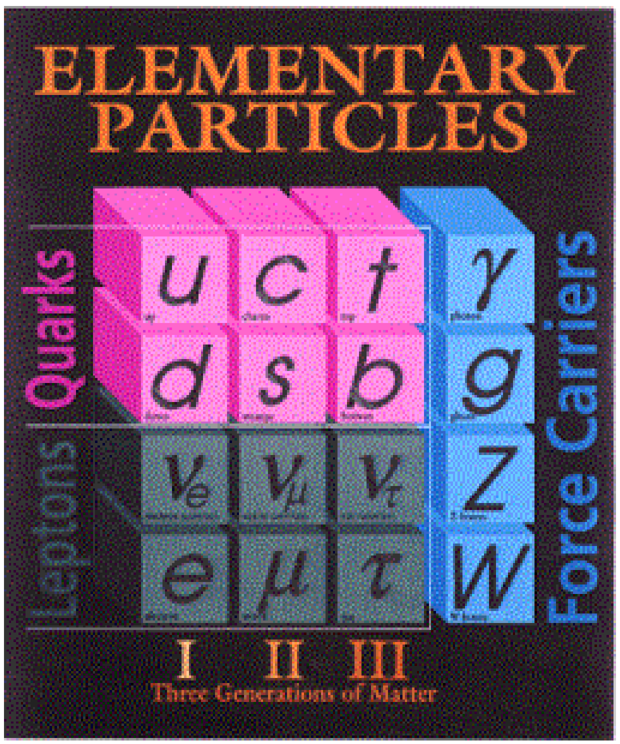
Periodic Table

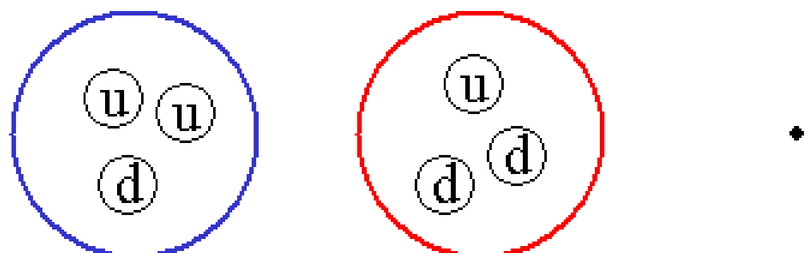


Helium Neon



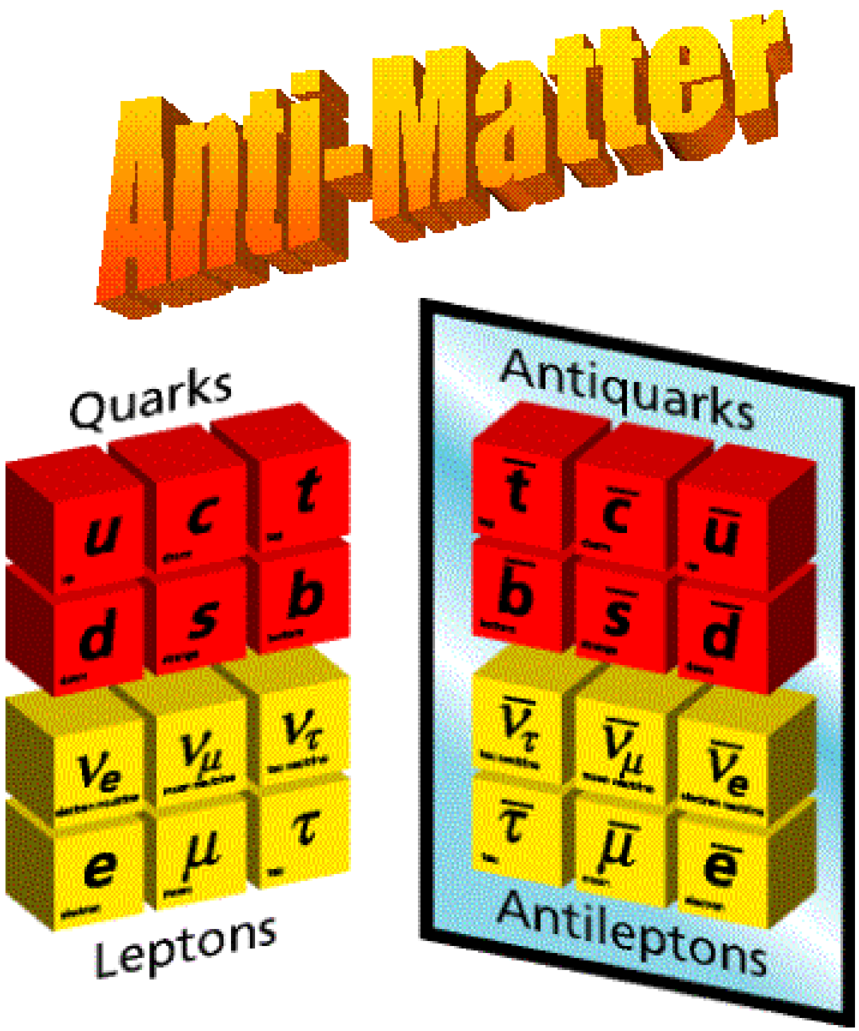
All atoms are made of protons, neutrons and electrons





Proton Neutron Electron

Gluons hold quarks together
Photons hold atoms together



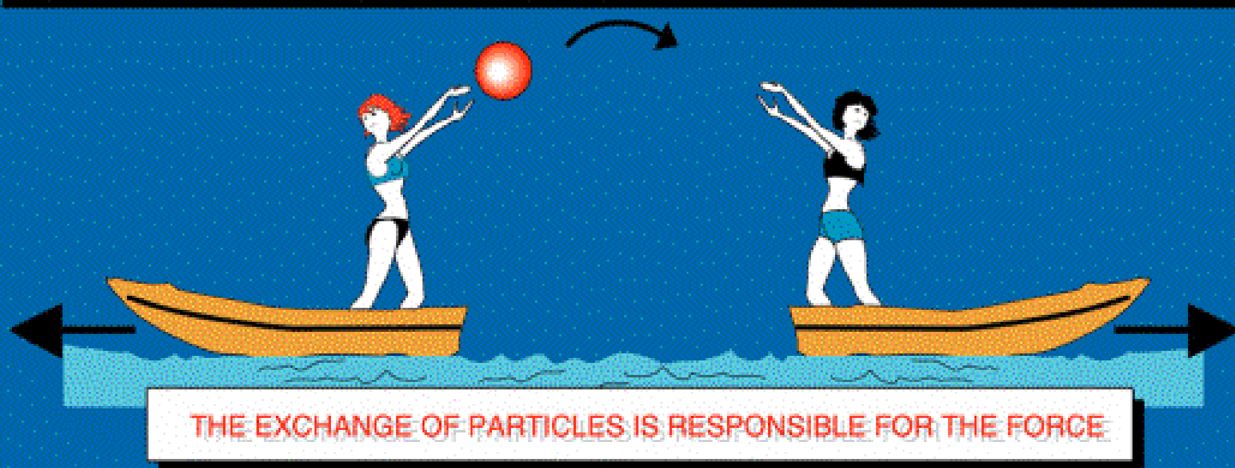
- All particles have ‘anti-particles’, which have similar properties, but opposite electrical charge

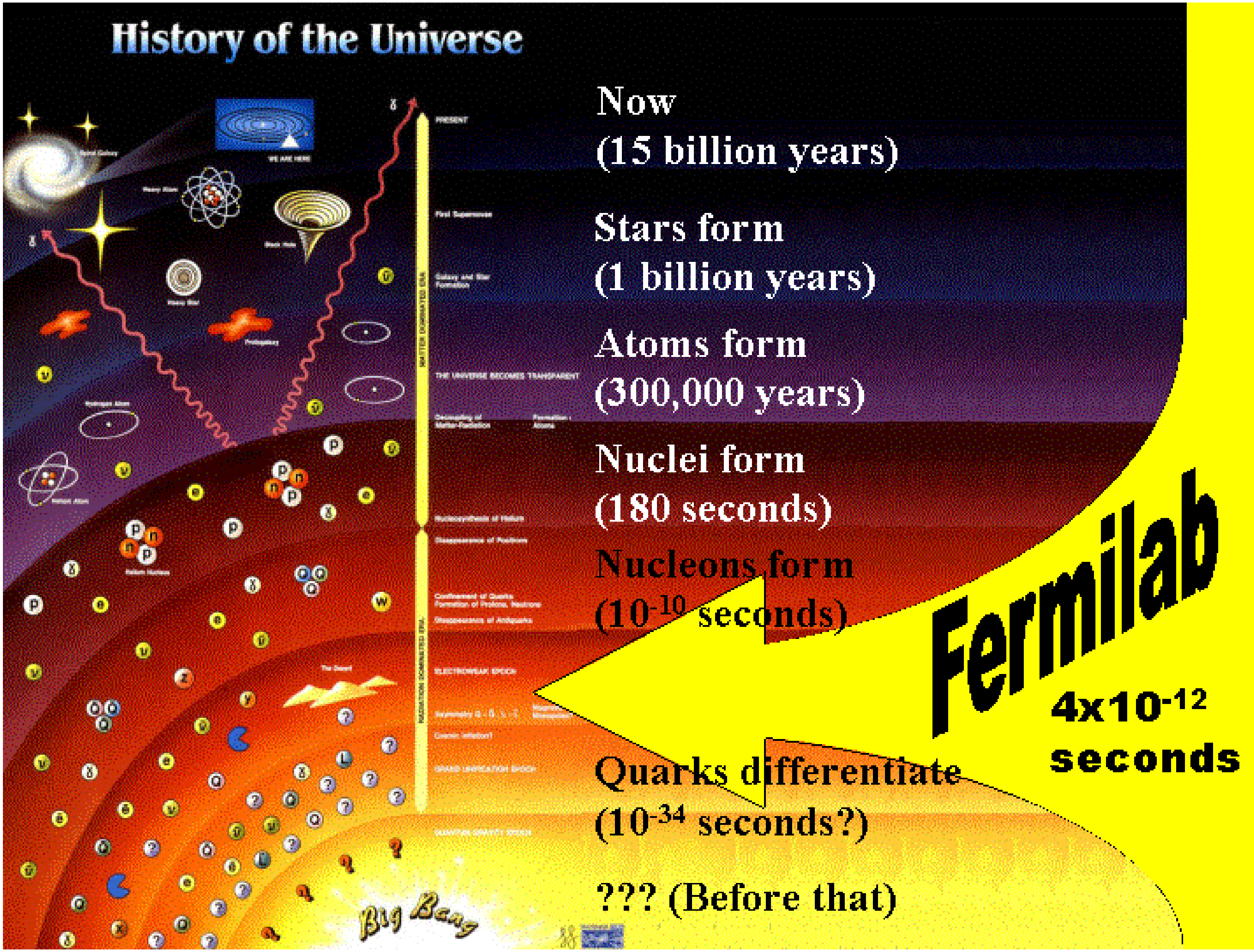
→ Particles
  - u,c,t +2/3
  - d,s,b -1/3
  - e,μ,τ -1

→ Anti-particles
  - u,c,t -2/3
  - d,s,b +1/3
  - e,μ,τ +1

The forces in Nature

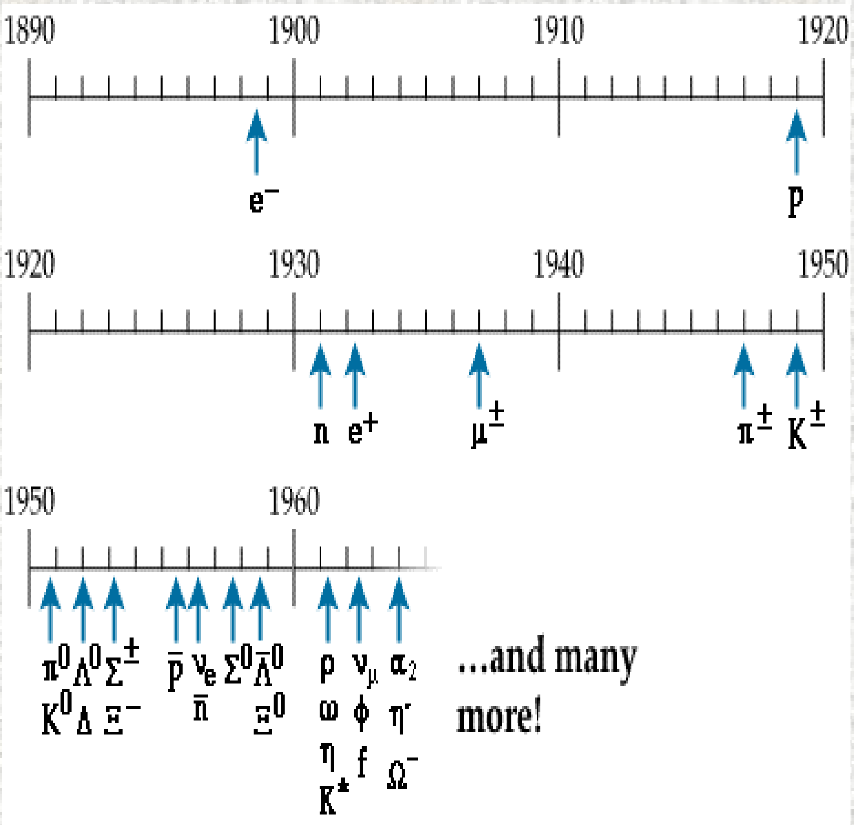
TYPE	INTENSITY OF FORCES (DECREASING ORDER)	BINDING PARTICLE (FIELD QUANTUM)	OCCURS IN :
STRONG NUCLEAR FORCE	~ 1	GLUONS (NO MASS)	ATOMIC NUCLEUS
ELECTRO -MAGNETIC FORCE	~ 10^{-3}	PHOTONS (NO MASS)	ATOMIC SHELL ELECTROTECHNIQUE
WEAK NUCLEAR FORCE	~ 10^{-5}	BOSONS Z^0 , W+ , W- (HEAVY)	RADIOACTIVE BETA DESINTEGRATION
GRAVITATION	~ 10^{-38}	GRAVITONS (?)	HEAVENLY BODIES



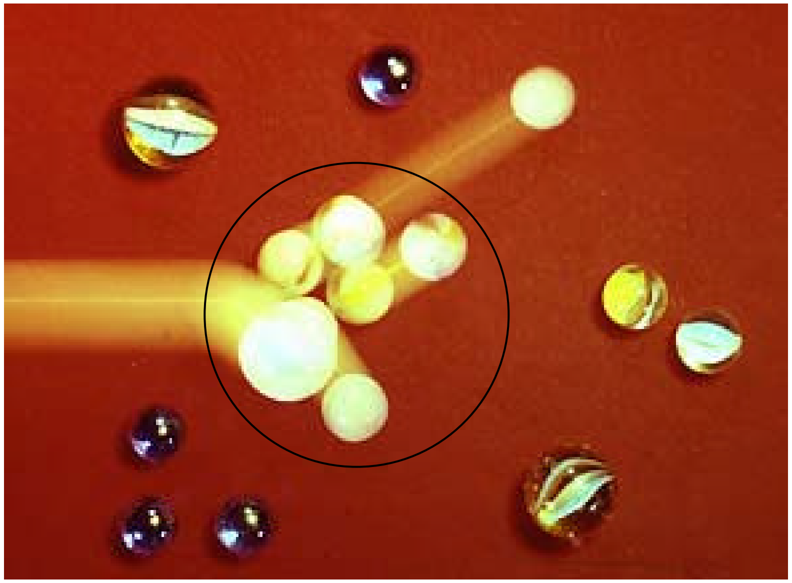

History of the Universe
Now
(15 billion years)
Stars form
(1 billion years)
Atoms form
(300,000 years)
Nuclei form
(180 seconds)
Nucleons form
(10^-10 seconds)
Quarks differentiate
(10^-34 seconds?)
??? (Before that)
Fermilab
4x10^-12
seconds
Big Bang

A Brief History of Quarks

- By the 1960's, many particles had been discovered
- In 1964, Gell-Mann and Zweig put forward the concept of quarks – 3 quarks, with fractional charges: u, d and s
- Quarks more of a mathematical entity than actual physical objects



- In 1968-69 experiments at SLAC, showed that when electrons scattered off protons, they behaved as if bouncing off small hard cores.



- Bjorken and Feynman analyzed this in terms of constituents inside protons – evidence of quarks

OBSERVED BEHAVIOR OF HIGHLY INELASTIC ELECTRON-PROTON SCATTERING

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and

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(Received 22 August 1969)

Results of electron-proton inelastic scattering at 6° and 10° are discussed, and values of the structure function W_2 are estimated. If the interaction is dominated by transverse virtual photons, νW_2 can be expressed as a function of $\omega = 2M\nu/q^2$ within experimental errors for $q^2 > 1$ (GeV/c)^2 and $\omega > 4$, where ν is the invariant energy transfer and q^2 is the invariant momentum transfer of the electron. Various theoretical models and sum rules are briefly discussed.

In a previous Letter,[1] we have reported experimental results from a Stanford Linear Accelerator Center–Massachusetts Institute of Technology study of high-energy inelastic electron-proton scattering. Measurements of inelastic spectra, in which only the scattered electrons were detected, were made at scattering angles of 6° and 10° and with incident energies between 7 and 17 GeV. In this communication, we discuss some of the salient features of inelastic spectra in the deep continuum region.

One of the interesting features of the measurements is the weak momentum-transfer dependence of the inelastic cross sections for excitations well beyond the resonance region. This weak dependence is illustrated in Fig. 1. Here we have plotted the differential cross section divided by the Mott cross section, $(d^2\sigma/d\Omega dE')/(d\sigma/d\Omega)_{\rm Mott}$, as a function of the square of the four-momentum transfer, $q^2 = 2EE'(1-\cos\theta)$, for constant values of the invariant mass of the recoiling target system, W, where $W^2 = 2M(E-E') + M^2 - q^2$. E is the energy of the incident electron, E' is the energy of the final electron, and θ is the scattering angle, all defined in the laboratory system; M is the mass of the proton. The cross section is divided by the Mott cross section

$$\left(\frac{d\sigma}{d\Omega}\right)_{\rm Mott} = \frac{e^4}{4E^2}\frac{\cos^2\frac{1}{2}\theta}{\sin^4\frac{1}{2}\theta}$$

in order to remove the major part of the well-known four-momentum transfer dependence arising from the photon propagator. Results from both 6° and 10° are included in the figure for each value of W. As W increases, the q^2 dependence appears to decrease. The striking difference between the behavior of the inelastic and elastic cross sections is also illustrated in Fig. 1, where the elastic cross section, divided by the Mott cross section for $\theta = 10°$, is included. The q^2 dependence of the deep continuum is also consider-

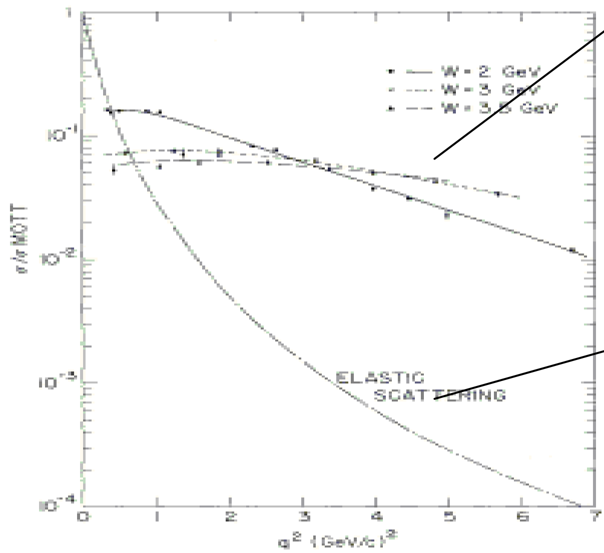
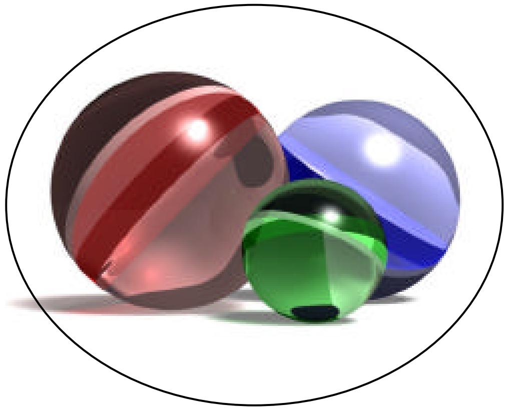


FIG. 1. $(d^2\sigma/d\Omega dE')/\sigma_{\rm Mott}$, in GeV^{-1}, vs q^2 for W = 2, 3, and 3.5 GeV. The lines drawn through the data are meant to guide the eye. Also shown is the cross section for elastic e-p scattering divided by $\sigma_{\rm Mott}$, $(d\sigma/d\Omega)/\sigma_{\rm Mott}$, calculated for $\theta = 10°$, using the dipole form factor. The relatively slow variation with q^2 of the inelastic cross section compared with the elastic cross section is clearly shown.

Quarks

No Quarks

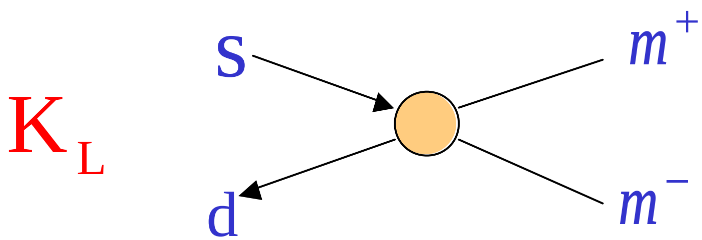
- After the discovery of quarks, belief was that particles could be constructed out of the 3 quarks



$$\begin{bmatrix} u \\ d' \end{bmatrix} \quad \text{and} \quad s$$

- However, this led to a theoretical problem: following transitions were allowed

Proton = uud



- However, experimentally, $K_L \rightarrow m^+ m^- \leq 10^{-8}$

- Proposal by Glashow, Iliopoulos, Maiani saved the day!!

- In 1964, Bjorken and Glashow had proposed the existence of a fourth quark

- In 1970, the GIM mechanism recognized the importance of the fourth quark, and used it to explain the K_L puzzle

- The four quarks can be arranged as,

$$\begin{bmatrix} u \\ d' \end{bmatrix} \qquad \begin{bmatrix} c \\ s' \end{bmatrix}$$

- The decay, $K_L \to mm$, can be written as a sum of 2 terms, which cancel

$$s \to u \to d \;\oplus\; s \to c \to d$$

November Revolution

- In Nov. 1974, experiments at BNL/SLAC, (simultaneously) found the same particle!!
- BNL experiment led by Sam Ting:

$$pp \to X \to e^{+}e^{-}$$

- SLAC experiment led by Burt Richter:

$$e^{+}e^{-} \to X \to m^{+}m^{-} \text{ (and other particles)}$$

BNL

$M_{e^+e^-}$

Experimental Observation of a Heavy Particle J†

J. J. Aubert, U. Becker, P. J. Biggs, J. Burger, M. Chen, G. Everhart, P. Goldhagen, J. Leong, T. McCorriston, T. G. Rhoades, M. Rohde, Samuel C. C. Ting, and Sau Lan Wu
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(Received 12 November 1974)

We report the observation of a heavy particle J, with mass $m = 3.1$ GeV and width approximately zero. The observation was made from the reaction $p + \mathrm{Be} \to e^+ + e^- + x$ by measuring the e^+e^- mass spectrum with a precise pair spectrometer at the Brookhaven National Laboratory's 30-GeV alternating-gradient synchrotron.

This experiment is part of a large program to study the behavior of timelike photons in $p + p \to e^+ + e^- + x$ reactions[1] and to search for new particles which decay into e^+e^- and $\mu^+\mu^-$ pairs.

We use a slow extracted beam from the Brookhaven National Laboratory's alternating-gradient synchrotron. The beam intensity varies from 10^{10} to 2×10^{12} p/pulse. The beam is guided onto an extended target, normally nine pieces of 70-mil Be, to enable us to reject the pair accidentals by requiring the two tracks to come from the same origin. The beam intensity is monitored with a secondary emission counter, calibrated daily with a thin Al foil. The beam spot size is 3×6 mm^2, and is monitored with closed-circuit television. Figure 1(a) shows the simplified side view of one arm of the spectrometer. The two arms are placed at 14.6° with respect to the incident beam; bending (by $M1$, $M2$) is done vertically to decouple the angle (θ) and the momentum (p) of the particle.

The Cherenkov counter C_0 is filled with one atmosphere and C_e with 0.8 atmosphere of H_2. The counters C_0 and C_e are decoupled by magnets $M1$ and $M2$. This enables us to reject knock-on electrons from C_0. Extensive and repeated calibra-

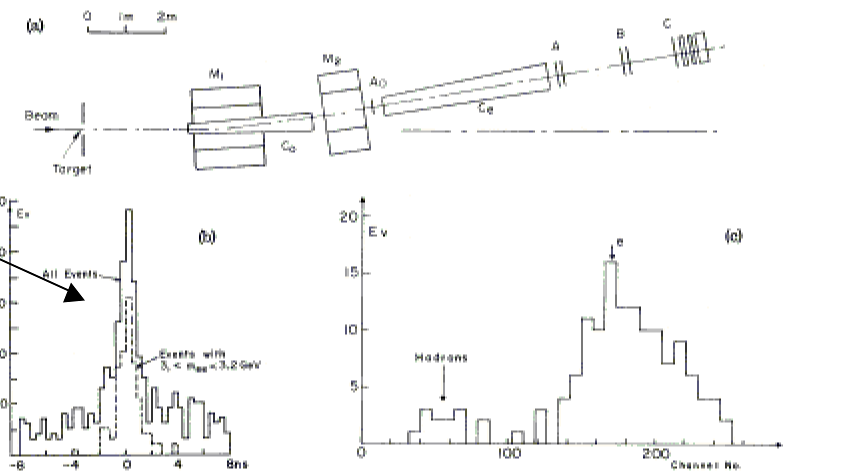

FIG. 1. (a) Simplified side view of one of the spectrometer arms. (b) Time-of-flight spectrum of e^+e^- pairs and of those events with $3.0 < m < 3.2$ GeV. (c) Pulse-height spectrum of e^- (same for e^+) of the e^+e^- pair.

SLAC

DISCOVERY OF A NARROW RESONANCE IN e^+e^- ANNIHILATION*

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ABSTRACT

We have observed a very sharp peak in the cross section for $e^+e^- \rightarrow$ hadrons, e^+e^-, and possibly $\mu^+\mu^-$ at a center-of-mass energy of 3.105 ± 0.003 GeV. The upper limit to the full width at half maximum is 1.3 MeV.

(Submitted to Phys. Rev. Letters)

*Work supported by the U. S. Atomic Energy Commission.

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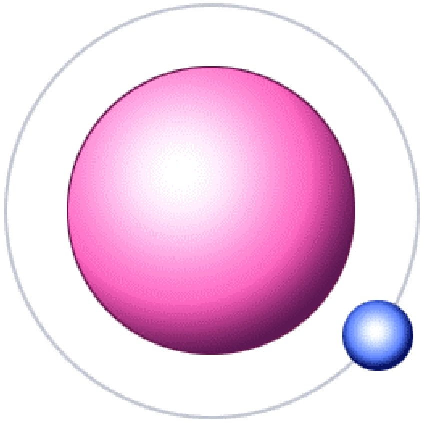
- X explained to be a bound state of charm and anti-charm quarks called J/Psi - (only particle to have two names!)

- Imagine a Hydrogen atom, and replace the proton and electron by charm and anti-charm



- Charm quark turned out to be the same as one proposed by the GIM mechanism

- Now everyone believed in quarks

- In 1979, the fifth quark, bottom, was discovered at Fermilab, in

$pp \rightarrow X \rightarrow m^{+}m^{-}$

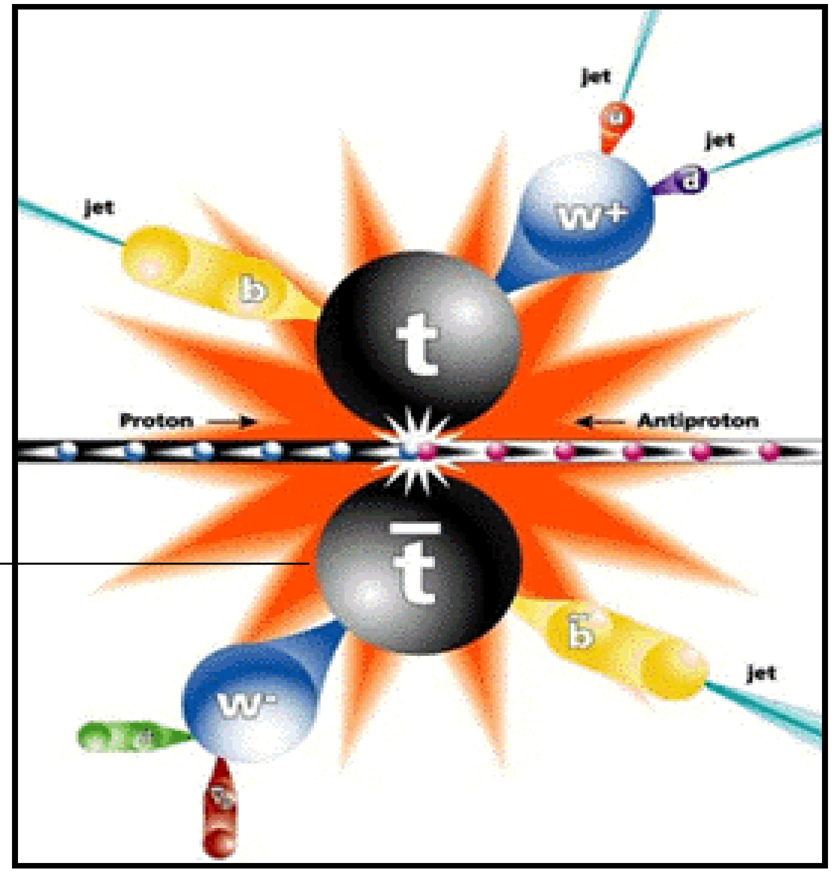
Heavier cousin of the J/Psi

- In 1995, the sixth quark, top, was discovered at Fermilab in

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

175x mass of a proton!!

Existed freely in the early Universe



Disclaimer:

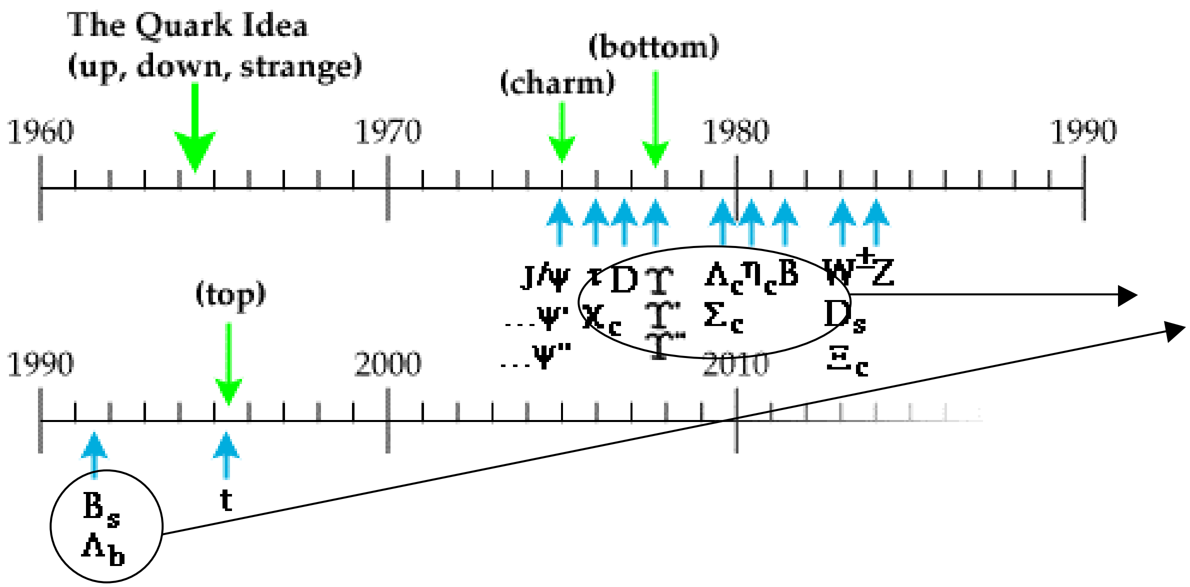
I have completely skipped other "revolutions" in Particle Physics

- The unification of Electro-magnetic and Weak forces: Weinberg-Glashow-Salam model

- The emergence of the "Standard Model" to explain the Electro-Weak and Strong force (latter by Quantum Chromo Dynamics)

- Have not even talked about leptons, i.e., e, m, n

- Only talking about Weak Interactions



Most particles can be explained in terms of quarks

➢The six quarks are arranged as,

$$\begin{bmatrix} u \\ d' \end{bmatrix}_L \quad \begin{bmatrix} c \\ s' \end{bmatrix}_L \quad \begin{bmatrix} t \\ b' \end{bmatrix}_L \quad \ldots$$

are there more?

don’t know!!

➢A 3x3 matrix known as the Cabibbo-Kabayashi-Maskawa (1974) matrix describes the Weak Interactions in the six quark case

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

V_{ub}: ≈ 0.004

V_{ts}: ≈ 0.04

V_{tb}: ≈ 1

These constants cannot be calculated and have to be measured experimentally

- Elements decrease as we go away from the diagonal
- If there are three generations, CKM matrix is unitary, i.e.,

$$VV^{+} = 1$$

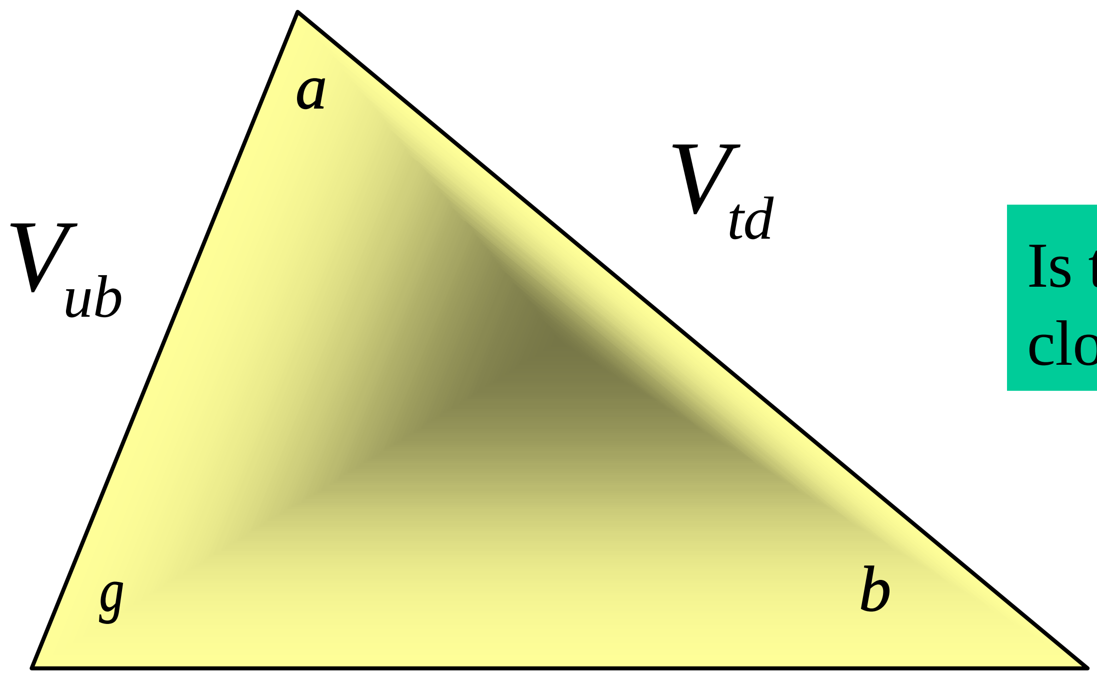
- One way to check for unitarity is to measure each element precisely

- If matrix is unitary one can write the following expression,

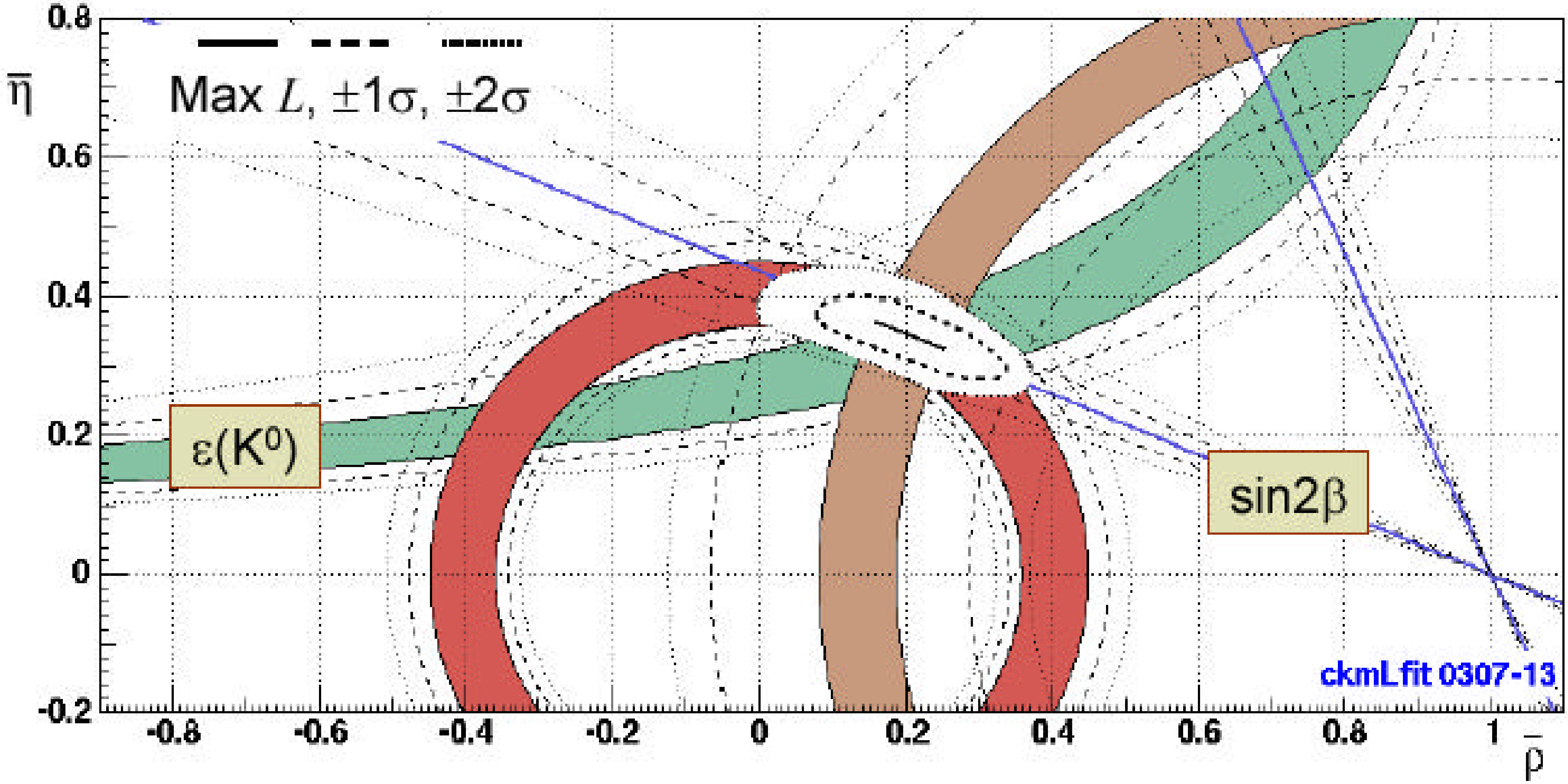
$$V_{ud}V_{ub}^{*}+V_{cd}V_{cb}^{*}+V_{td}V_{tb}^{*}=0$$

(one can do this for any two rows/columns)

- This can also be expressed as a triangle



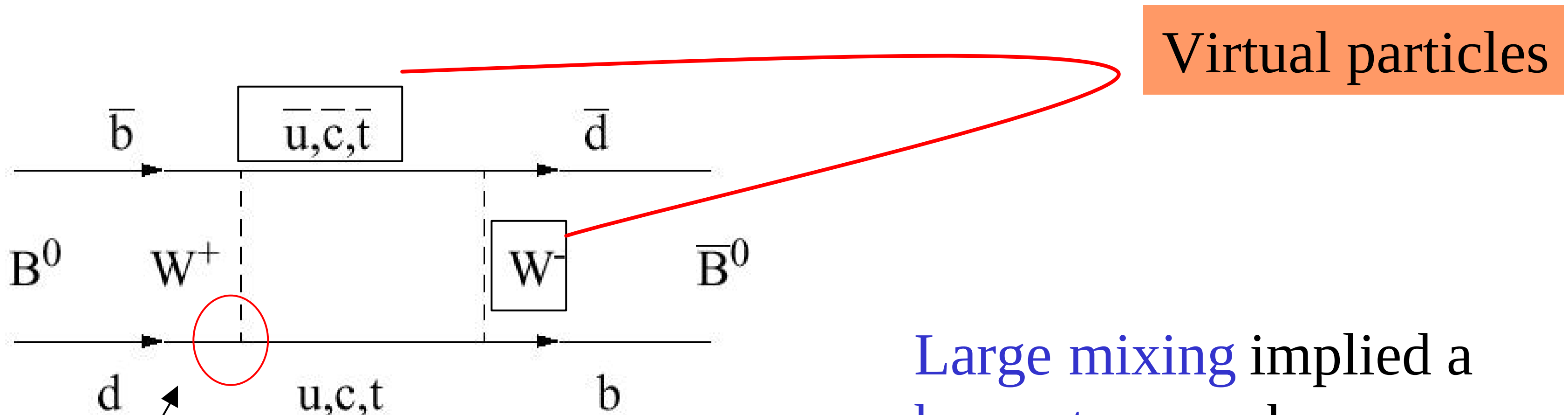
Is the triangle closed?



Getting there…

Schubert – LeptonPhoton’03

Particle-Antiparticle Mixing



Large mixing implied a heavy top quark

Top quark mass was inferred before it was discovered in 1995!!

$|V_{td}|$ describes the tdW vertex

Not well measured – error is 16%

$B\overline{B}$ Mixing:

An initially pure B^0 can oscillate into $\overline{B}^0$:

- We produce a B^0 or a $\overline{B}^0$ $p\overline{p} \rightarrow b\overline{b}, \quad b + \overline{d} \Rightarrow \overline{B}^0$

- Since $B^0/\overline{B}^0$ mix, the physical states are linear combinations

$$|B_L\rangle = p|B^0\rangle + q|\overline{B}^0\rangle$$

$$|B_H\rangle = p|B^0\rangle - q|\overline{B}^0\rangle$$

→ Physical states

B_L, B_H $\Delta m = M_H - M_L$

$$\left| B_{H,L}(t) \right\rangle = e^{-(iM_{H,L} + \Gamma_{H,L}/2)t} \left| B_{H,L} \right\rangle$$

Propagation of physical states

$$\left| B^0(t) \right\rangle = g_+(t) \left| B^0 \right\rangle + \frac{q}{p} g_-(t) \left| \overline{B}^0 \right\rangle$$

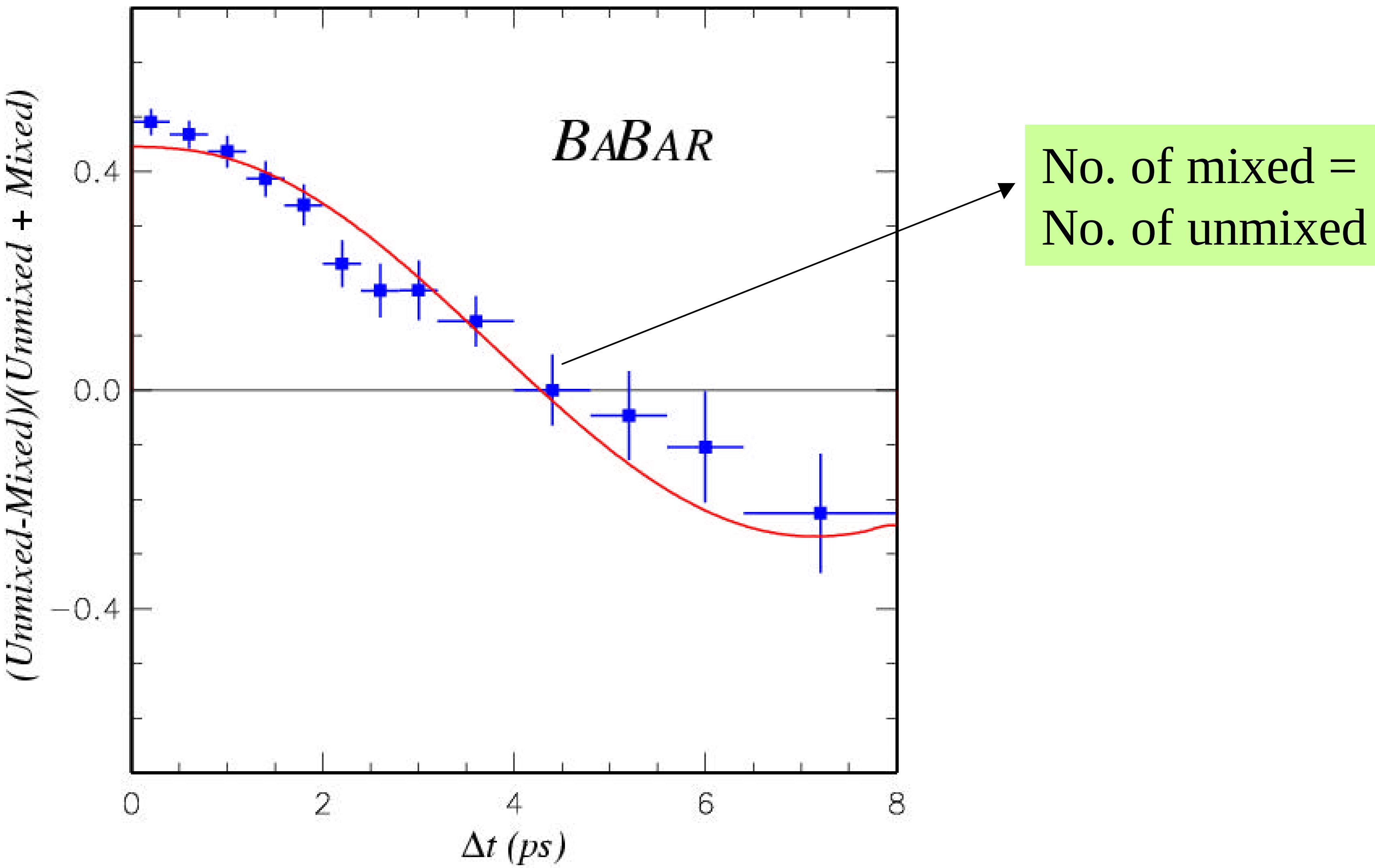
$$\left| \overline{B}^0(t) \right\rangle = \frac{p}{q} g_-(t) \left| B^0 \right\rangle + g_+(t) \left| \overline{B}^0 \right\rangle$$

- The probability an initial B^0 remains a B^0 or becomes a $\overline{B}^0$,

$$\langle B^0 | B^0(\overline{B}^0)(t) \rangle \equiv P_{U,M}(t) \propto \frac{\Gamma_d e^{-\Gamma_d t}}{2}\left[1 \pm \cos(\Delta m_d t)\right]$$

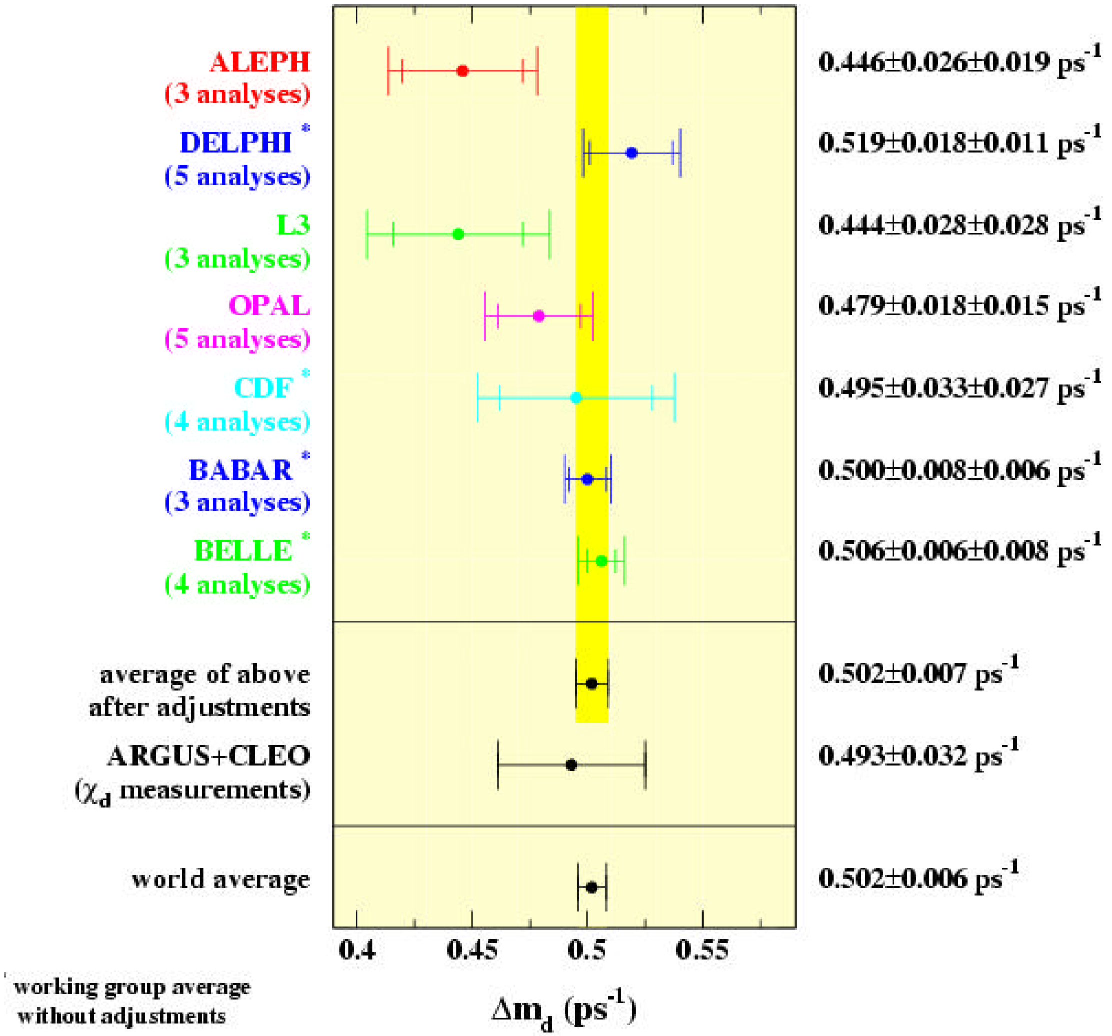
- Measure difference between mixed and unmixed states:

$$A(t) = \frac{P_U - P_M}{P_U + P_M} \propto \cos(\Delta m_d t)$$



$$\langle \Delta m_d \rangle = (0.512 \pm 0.017(\text{stat.}) \pm 0.022(\text{syst.}))\ \hbar\ \text{ps}^{-1}$$

ICHEP2000



HFAG – 7/2003:

$$\langle \Delta m_d \rangle = (0.502 \pm 0.006)\ \hbar\ \mathrm{ps}^{-1}$$

- $B_d^0 \overline{B}_d^0$ mixing is characterized by Δm_d

- $$\Delta m_d = \frac{G_F^2 m_{B_d}^2 f_{B_d}^2 B_{B_d} h_B}{6p^2} \cdot |V_{td}|^2 \cdot |V_{tb}|^2 \cdot f(m_t^2, m_W^2)$$

between 0 and 1

≈ 1

describes structure of meson

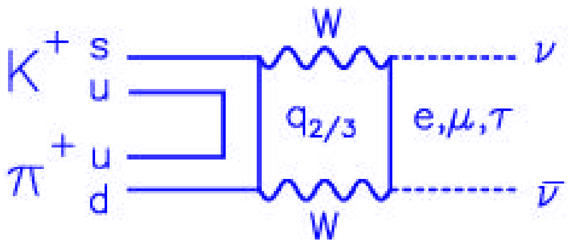
- $$\sqrt{f_{B_d}^2 B_{B_d}} = (223 \pm 35)$$ MeV – from theory

- $$|V_{td}| \cdot |V_{tb}| = (9.2 \pm 1.4 \pm 0.5) 10^{-3}$$

- Even though Δm_d is known to 1%
  V_{td} is known to 16%

Box diagram is used to describe other phenomena

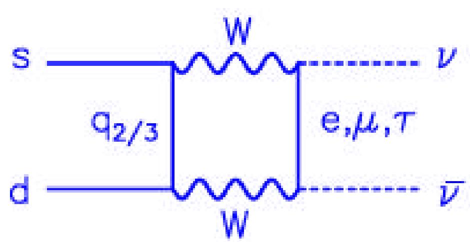
V_{td} plays a key role in these decays



$K^+ \to p^+ n\bar{n}$

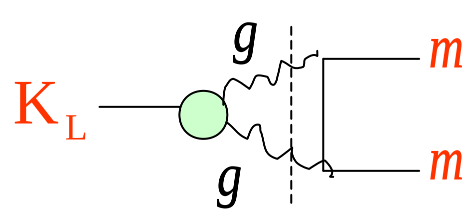
low statistics

$BR \approx 10^{-10}$



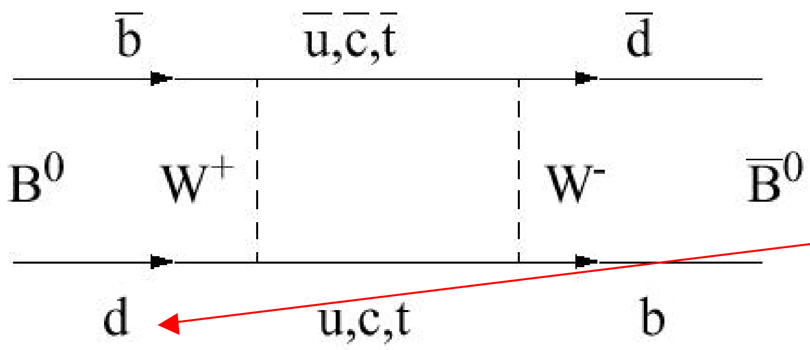
(flip e, m, t, n)

$K_L \to m^+ m^-$



long distance effects complicate things

g real or virtual



if we replace d with s, then we are talking about

$B_s\bar{B}_s$ mixing

Side of the Unitarity triangle ($\propto |V_{td}|$)can also be written as

$$\propto \sqrt{\frac{?\,m_d}{?\,m_s}}$$

from 17% to 5%

If we can measure Δm_s, significantly reduce errors on $|V_{td}|$

OK, So what am I going to do about this?

650 collaborators:
110 graduate students
85 post-docs

80 institutions, 18 countries

Approx. half the collaboration is Non-US


Chicago
Booster
CDF
p
DØ
Tevatron
p̄
p̄ source
Main Injector
(new)

B Physics at the Tevatron

$s\,(p\bar{p} \rightarrow b\bar{b}) \approx 150\,mb$ at $\sqrt{s} = 1.96\,\mathrm{TeV}$

Copious production rate

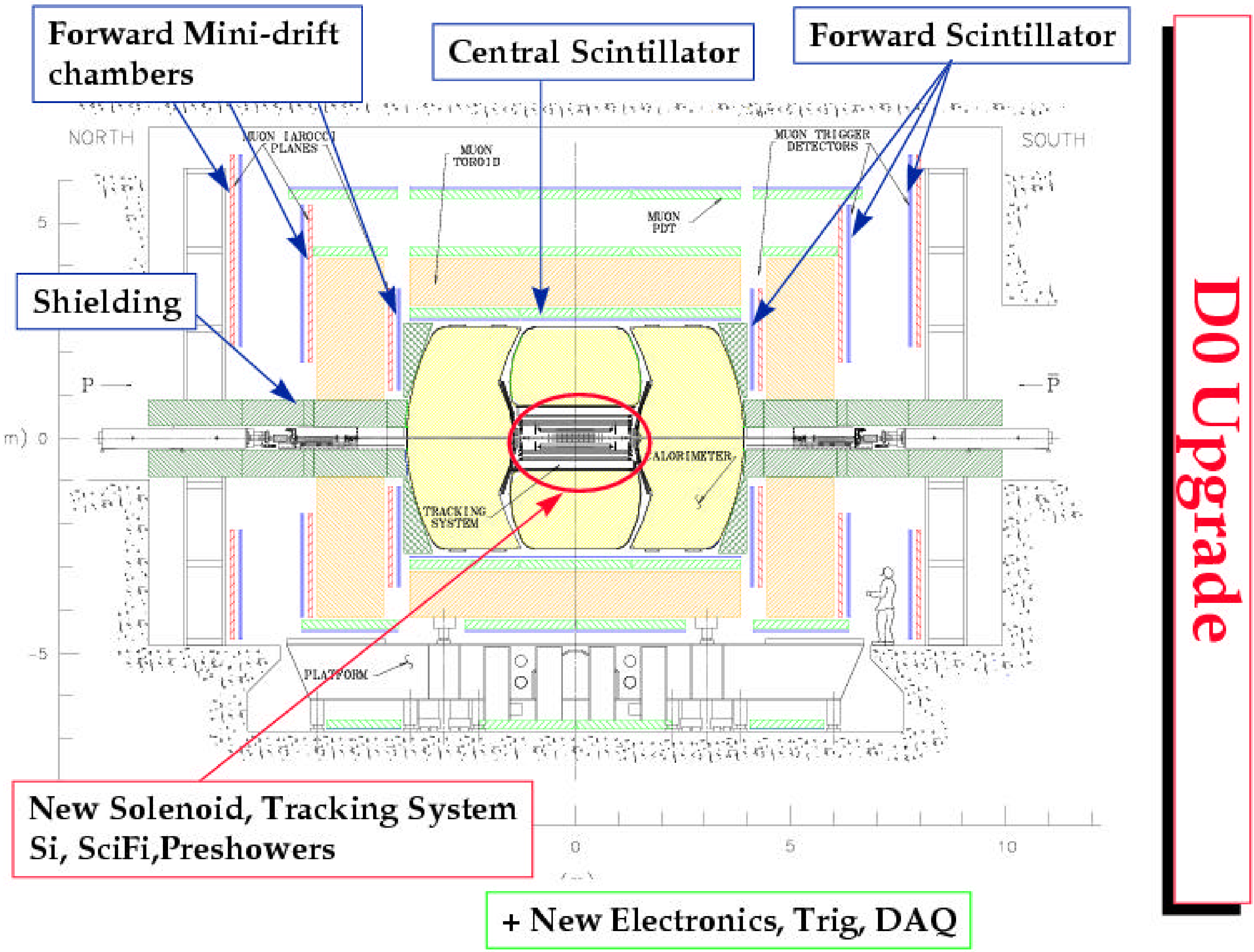
6000 such evts/sec

$s\,(e^{+}e^{-} \rightarrow b\bar{b}) \approx 1\,\mathrm{n}b$

At SLAC/KEK, 1-10 events/sec

Pros: All B species produced: $\mathrm{B_s}, \mathrm{B_c}, \Lambda_b \ldots$

Cons: b-production is 1000 smaller than the total rate


Forward Mini-drift chambers
Central Scintillator
Forward Scintillator
Shielding
NORTH
SOUTH
MUON IAROCCI PLANES
MUON TOROID
MUON TRIGGER DETECTORS
MUON PDT
CALORIMETER
TRACKING SYSTEM
PLATFORM
P
P̄
New Solenoid, Tracking System
Si, SciFi,Preshowers
+ New Electronics, Trig, DAQ
D0 Upgrade

D0 Run II Detector - Tracking

Silicon Tracker

- Four layer barrels (double/single sided)
- Interspersed double sided disks
- 840,00 channels

Fiber Tracker

- Eight layers sci-fi ribbon doublets (z-u-v, or z
- 77,800 835um fibers w/ VLPC readout

Central Preshower

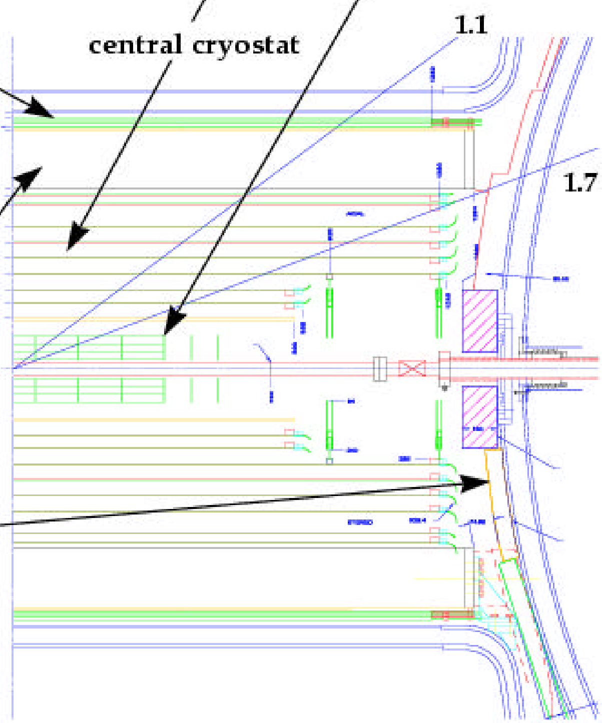
- Scintillator strips, WLS fiber readout
- 7,680 channels
- VLPC readout

Solenoid

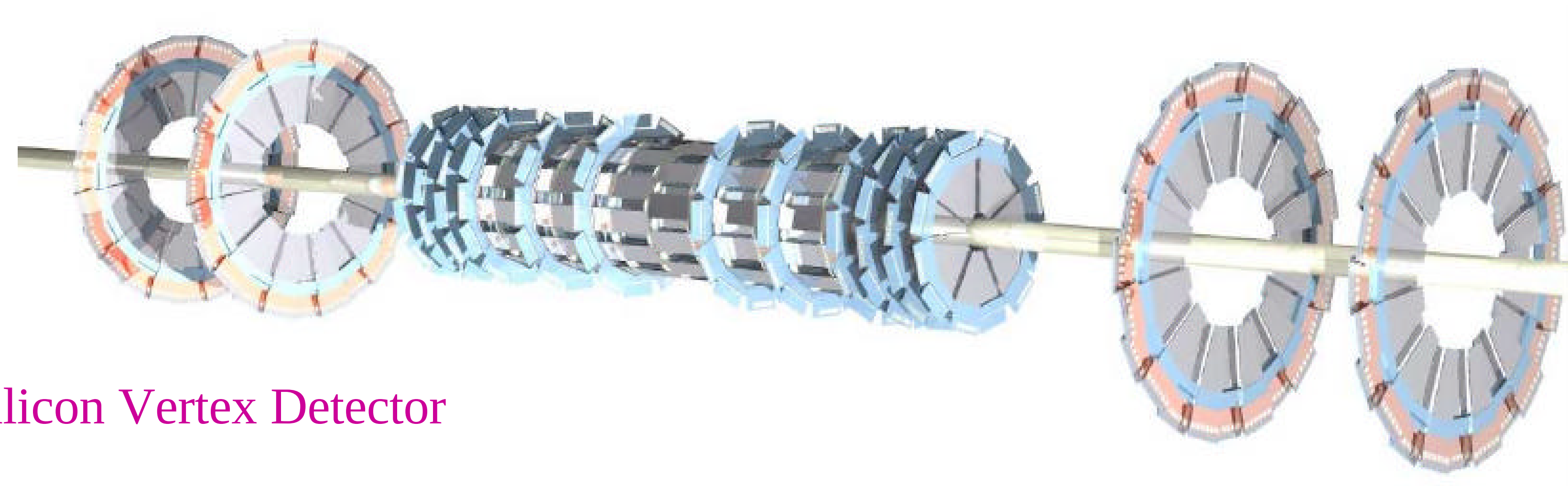
- 2T superconducting

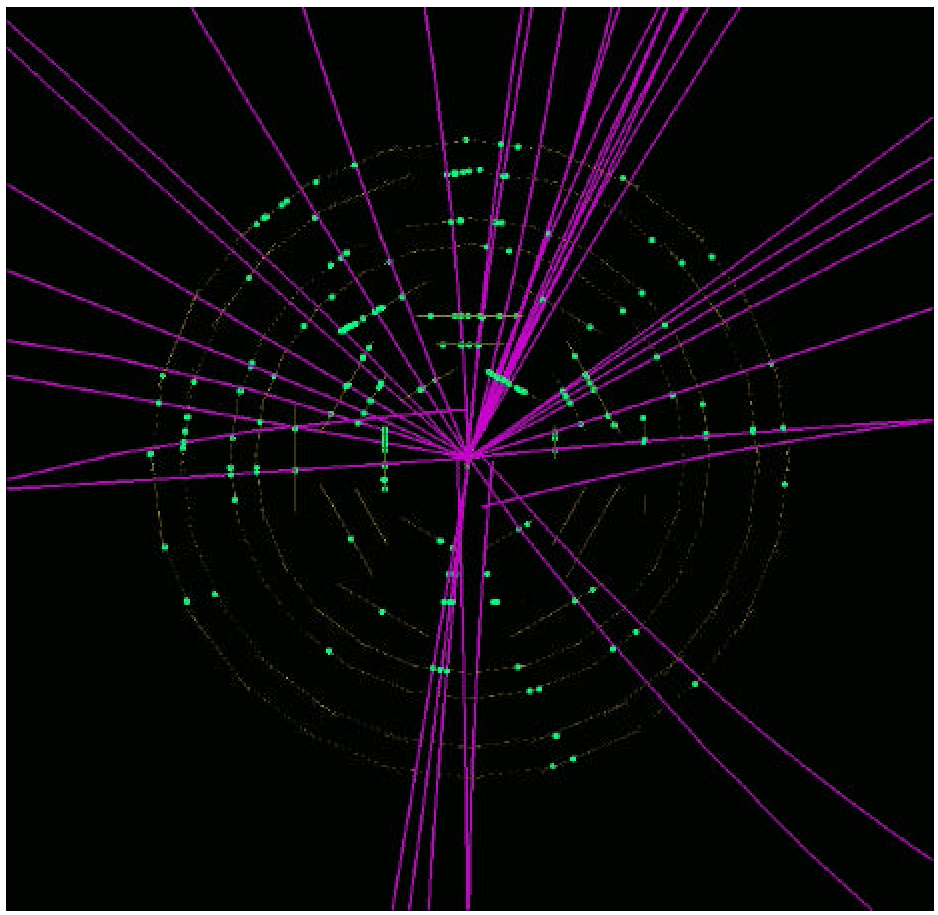
Forward Preshower

- Scintillator strips, stereo, WLS readout
- 14,968 channels
- VLPC readout

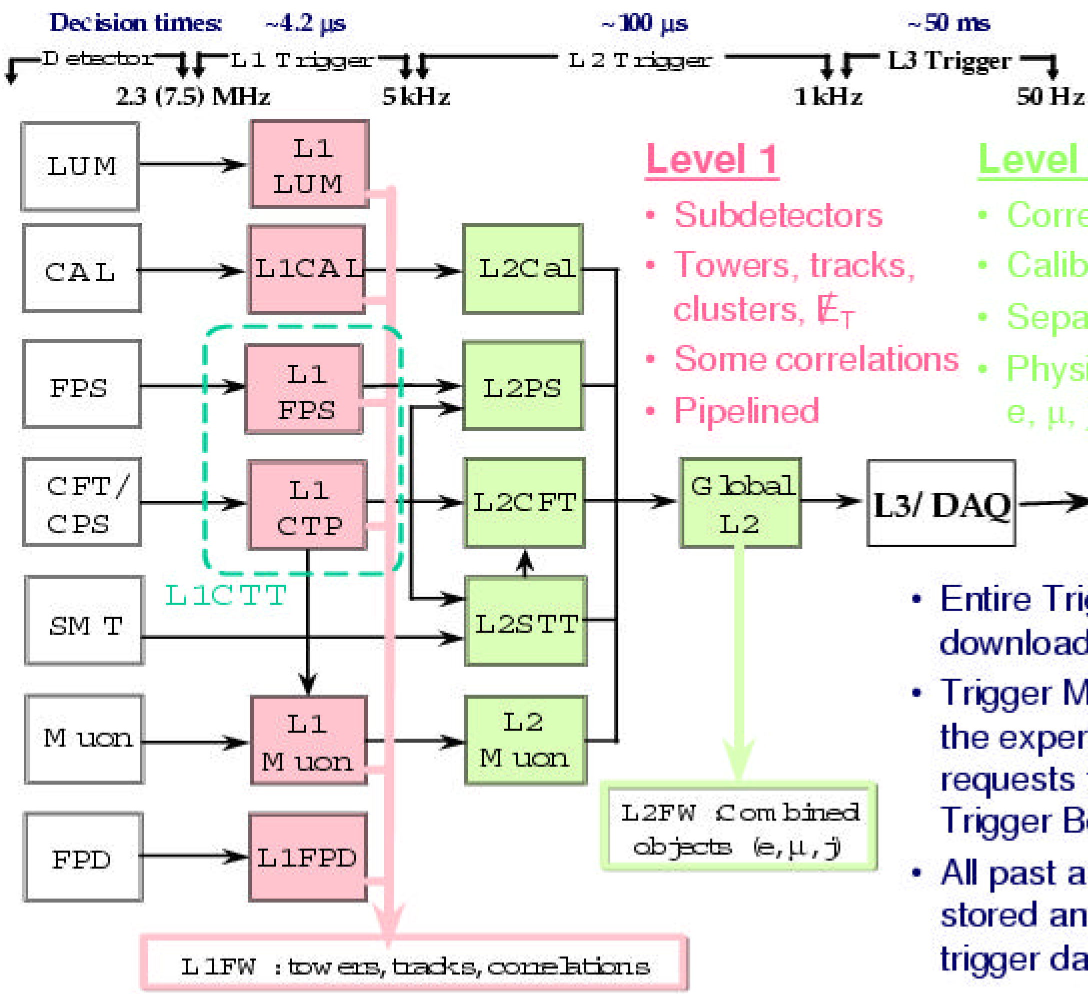


Silicon Vertex Detector





DØ Trigger System



Level 1
- Subdetectors
- Towers, tracks, clusters, $\not\!\!E_T$
- Some correlations
- Pipelined

Level 2
- Correlations
- Calibrated Data
- Separated vertex
- Physics Objects e, μ, j, τ, $\not\!\!E_T$

Level 3
- Simple Reconstruction
- Physics Algorithms

- Entire Trigger Menu configurable and downloadable at Run start
- Trigger Meisters provide trigger lists for the experiment by collecting trigger requests from all physics groups in the Trigger Board
- All past and present trigger lists are stored and maintained in the dedicated trigger database

All trigger components are simulated in software

Accelerator performance

	Run Ib	Run IIa	Run IIb
# bunches	6X6	36X36	140X133
$\sqrt{s}$ (TeV)	1.8	1.96	1.96
L cm^{-2} s^{-1}	1.6E31	8E31	2-5E32
Bunch x-ing (ns)	3500	396	132(?)
Int./x-ing	2.8	2.4	2-5

Currently $L_{inst} \approx 3-4\text{E}31\,\text{cm}^{-2}\ \text{s}^{-1}$

We now have $\int L \approx 215\ \text{pb}^{-1}$

Run IIa > 1-2000 pb^{-1} (2005)

For mixing measurements, we need the following ingredients:

- Reconstruction of final states, e.g.,

$$B_S \rightarrow D_S^{(*)-} p^+, B_S \rightarrow D_S^{(*)-} m^+ n_m, \; J/y \; X, ...$$

- Measurement of (proper) decay distance

- Knowing the flavour of the B at production and decay, i.e., is the B under study a B^0 or $\overline{B}^0$

- Jet reconstruction for b-production studies

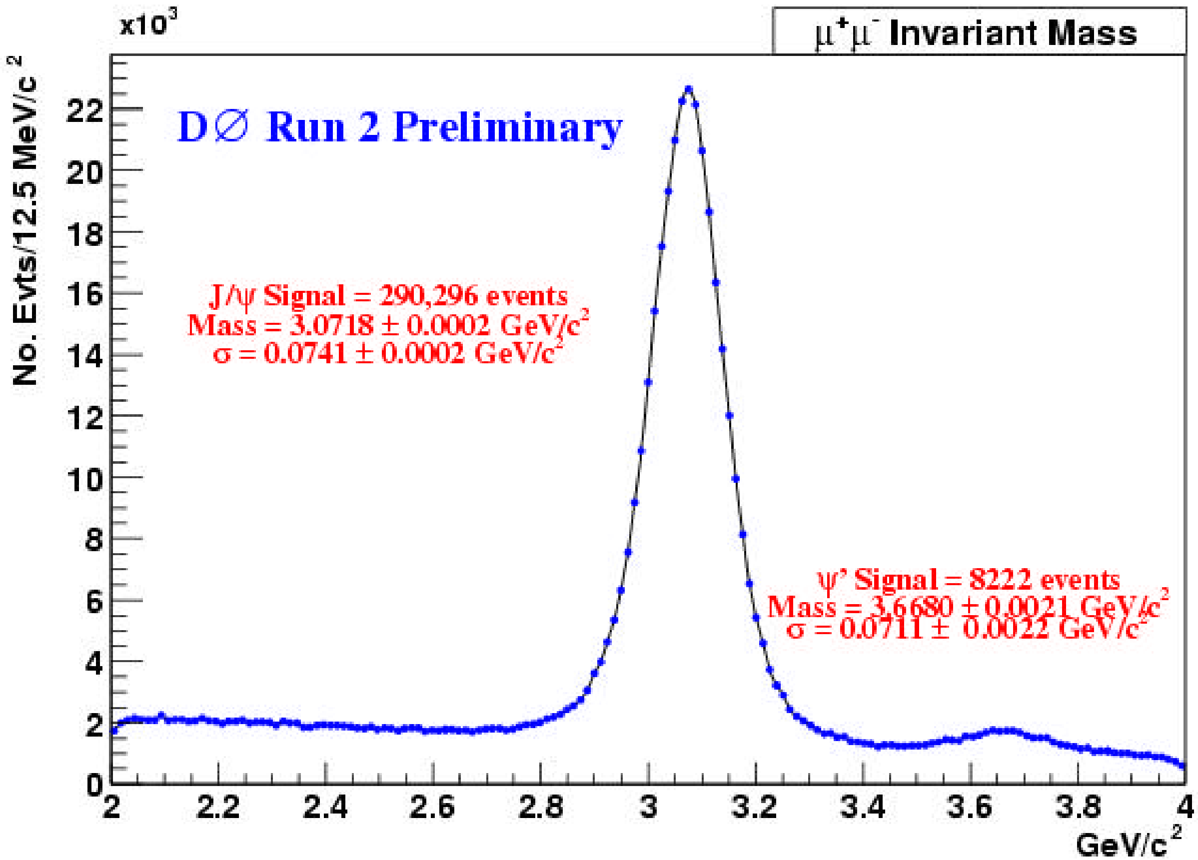
Where do all the events go?

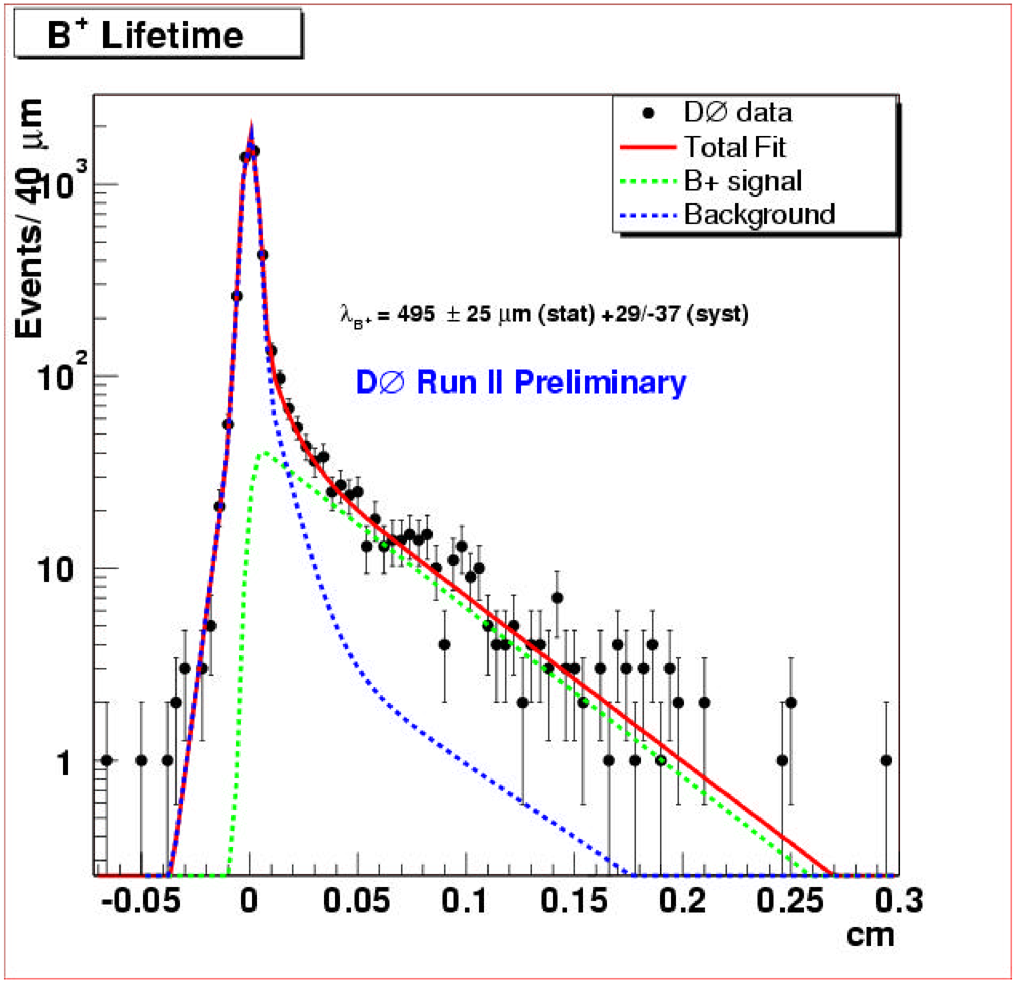
Factor	No. of events in 2 fb^{-1}
$\sigma_{b\bar{b}} \approx 158\, mb$	3.16E11
No. of b quarks/evt = 2	6.32E11
$BR(b \to B_S) \approx 0.1$	6.32E10
$BR(B_S \to D_S^{(*)-} \pi^+) \approx 2 * (3 * 10^{-3})$	3.8E8
$BR(D_S \to \phi\pi) = 0.04$	1.5E7
$BR(\phi \to K^+ K^-) = 0.5$	7.6E6
$\varepsilon_{trig} \leq 1\% *$	<7.4E4
Reconstruction ε = 0.135	<10000

* Highly dependent on trigger

Recent Results

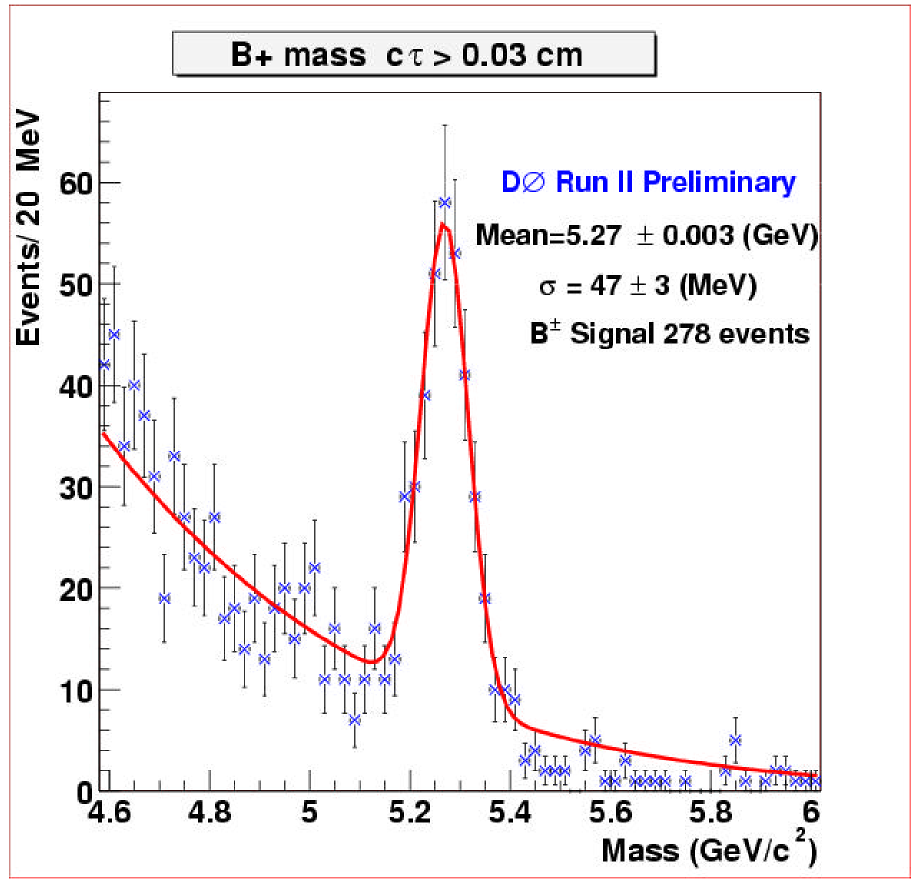
Following results are based on the J/ψ sample ($\approx 115\ \mathrm{pb}^{-1}$)



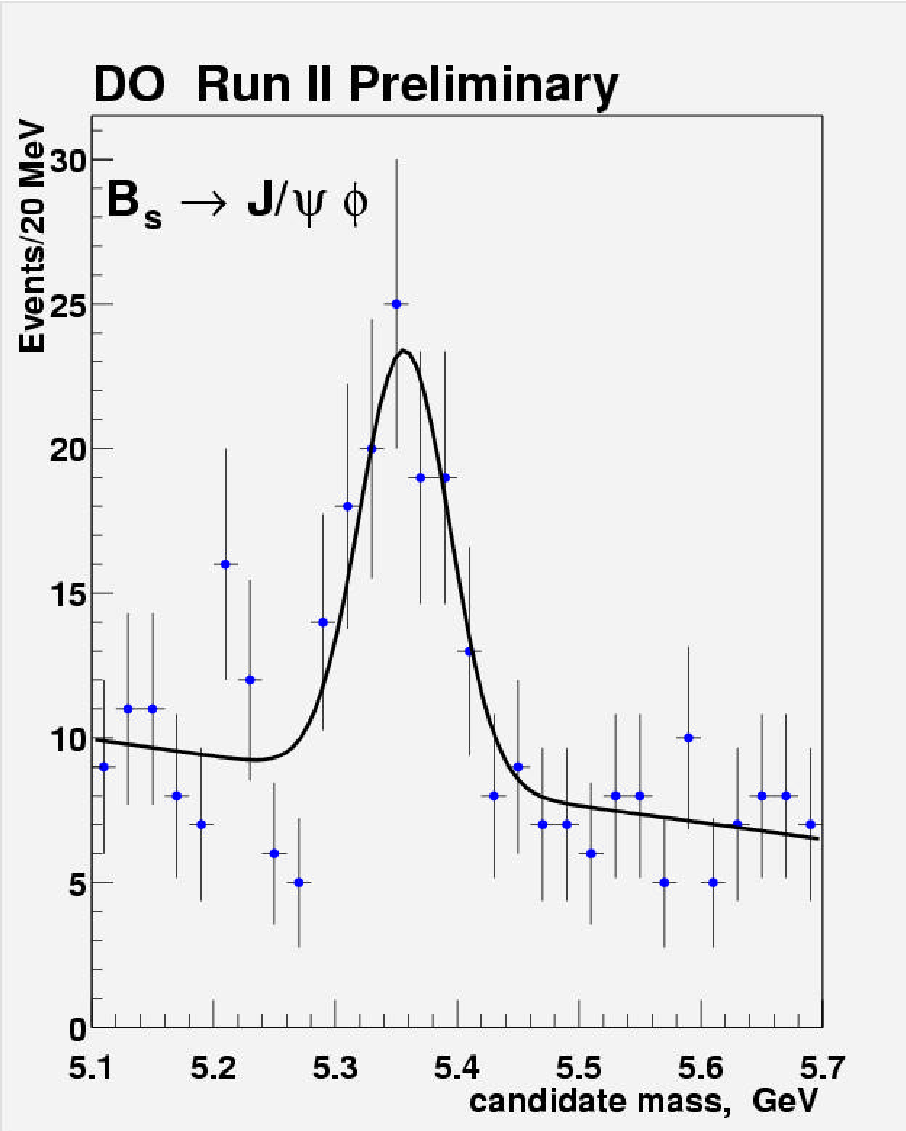


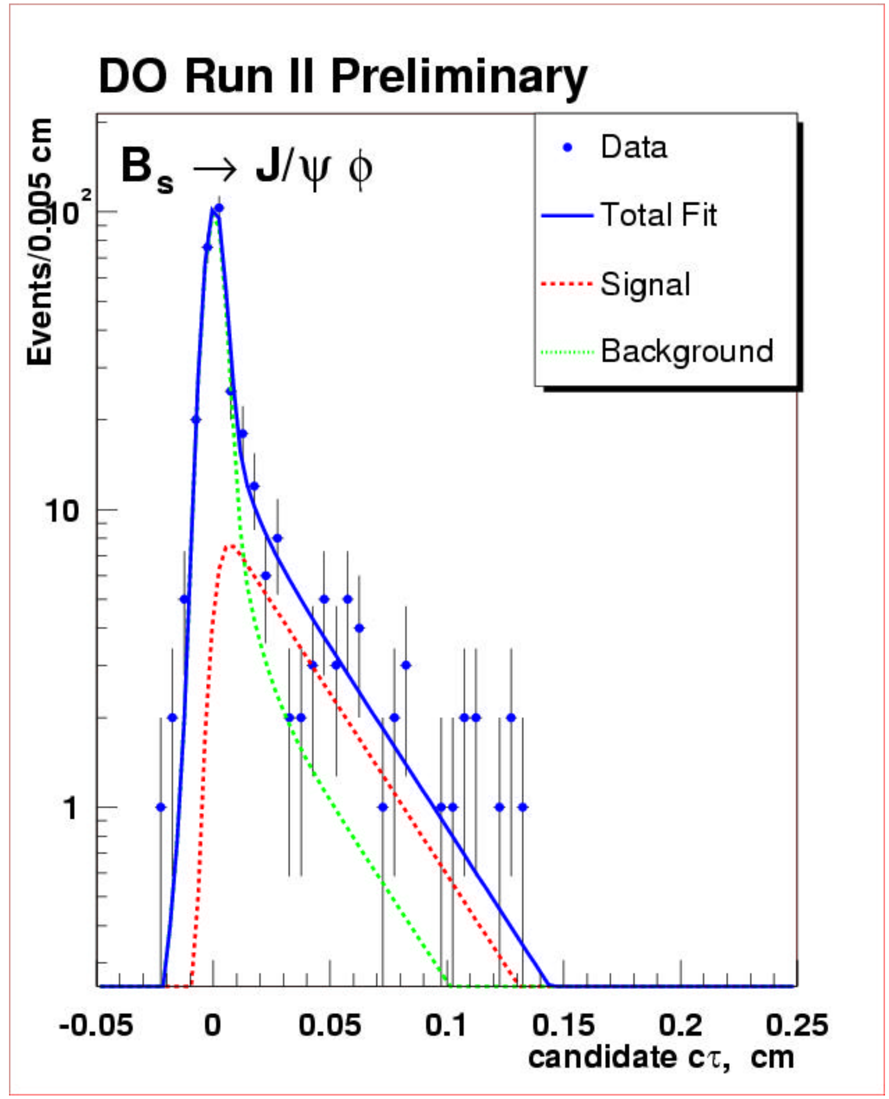
(PDG) Average: $502 \pm 5\ m$

Our result: $495 \pm 25(\text{stat})^{+29}_{-37}(\text{syst})\ m$



Check B mass after cuts →

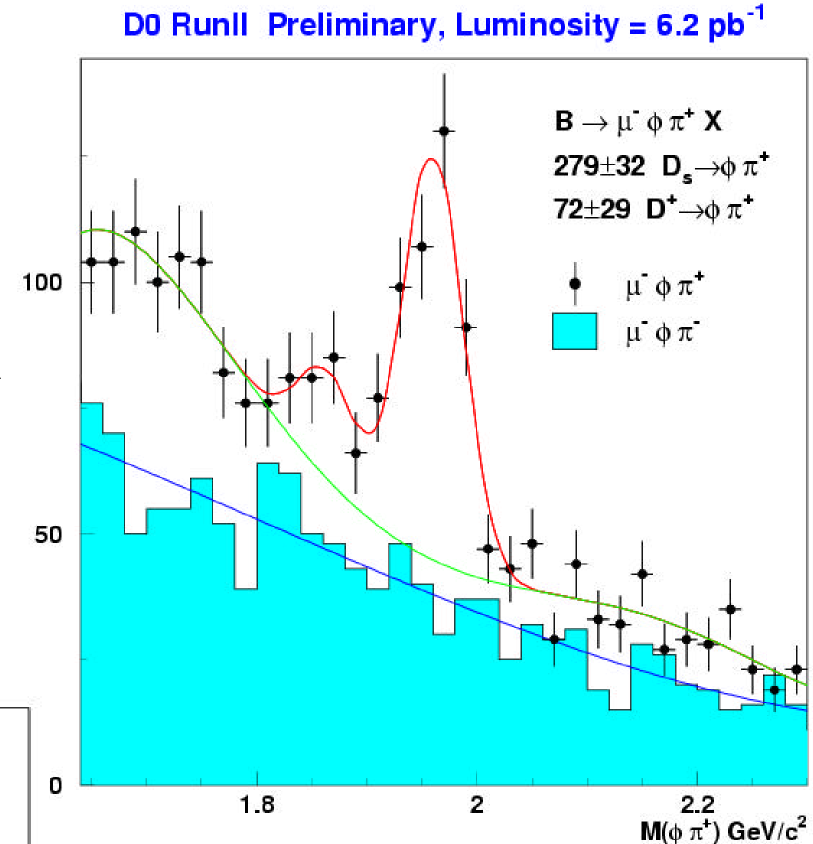


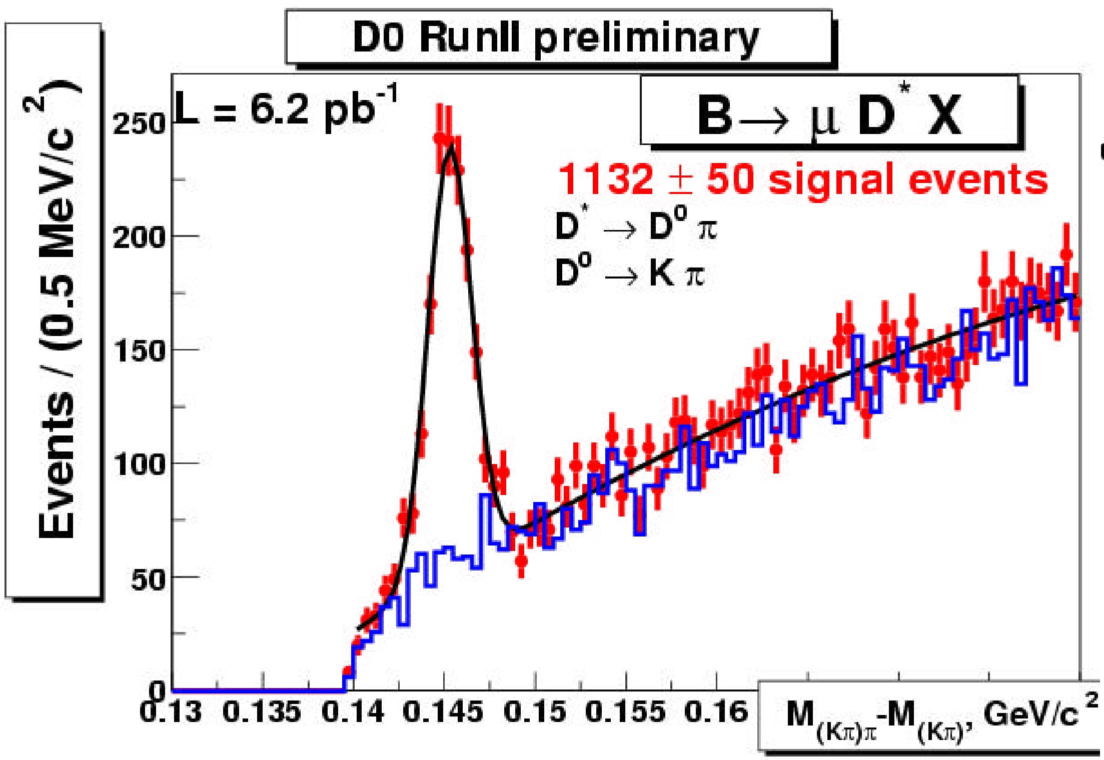


Our result $357^{+30}_{-48}(\text{stat}) \pm 42(\text{syst})\ m$

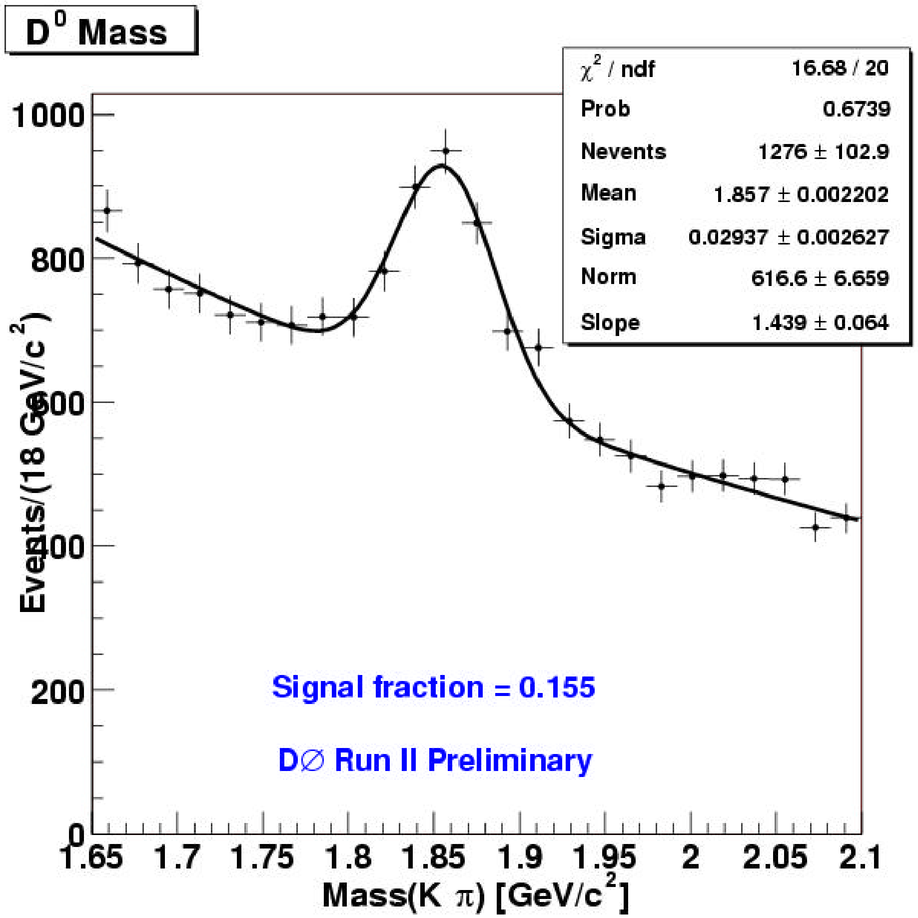
(PDG) Average $438 \pm 17\ m$

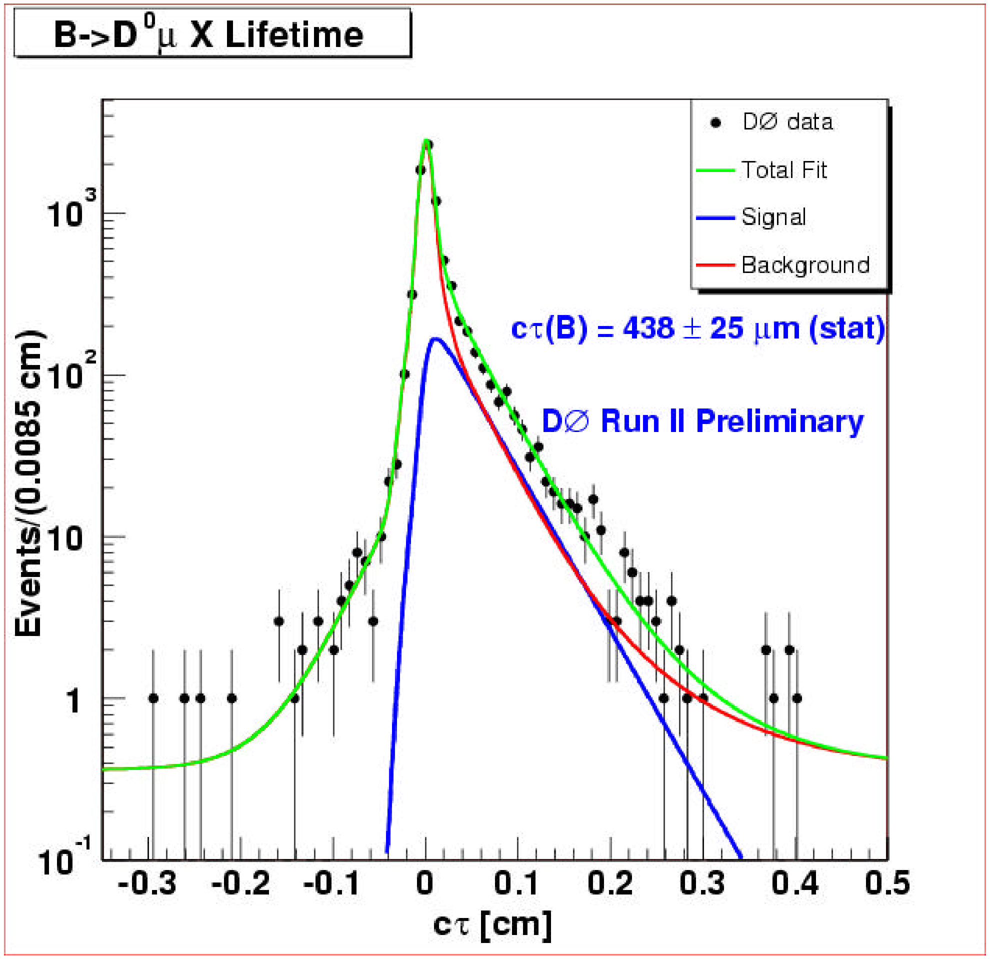
Dominated by B_S





Dominated by B^0/B^+





Have to correct for missing particles, e.g., ν

- Previous results should have convinced you that we can measure lifetimes and hence proper decay distances and can reconstruct final states

- For mixing studies, we also need to tag the B flavour at decay and production

- By choosing appropriate decays, we can get the flavour at decay:
  $B_S \rightarrow D_S^{(*)-} \mu^+ \nu_\mu$ whereas $\overline{B}_S \rightarrow D_S^{(*)+} \mu^- \overline{\nu}_\mu$

- What about at production?

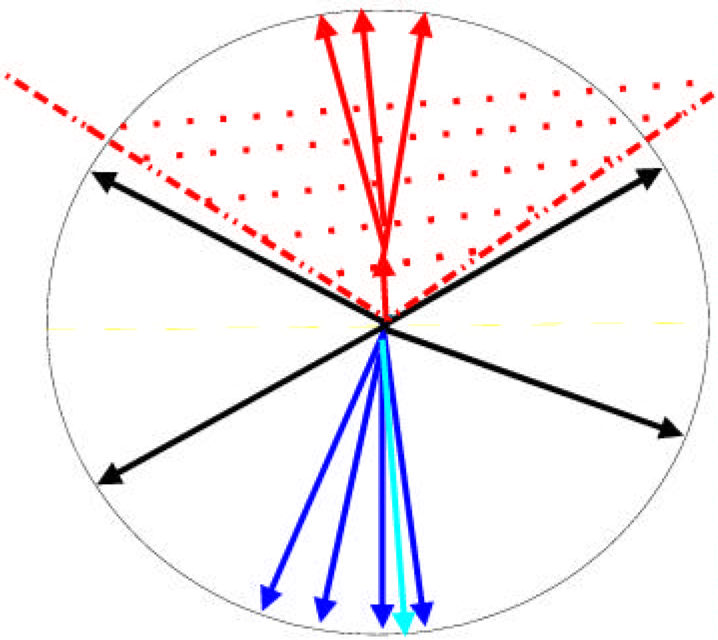
How do we know whether we produced a B^0 or a $\overline{B}^0$?
At the Tevatron, we use the following techniques:

- Soft-lepton tagging:
  Look at semi-leptonic decay of the other B
  Muon/electron charge is related to the B flavour
  Pros: High correlation, Cons: Low efficiency

- Jet Charge Tagging:
  Look at all tracks on the other side and measure charge
  Pros: High efficiency, Cons: Lower correlation

- Same Side Tagging:
  Tracks from fragmentation of b quark and B**
  Look at all tracks on the same side as the decaying B
  Pros: High efficiency, Cons: Lower correlation

Make the jet for the jet charge tagging



bbbar events on the transverse plane.

See the drawing on the left, taking all the tracks

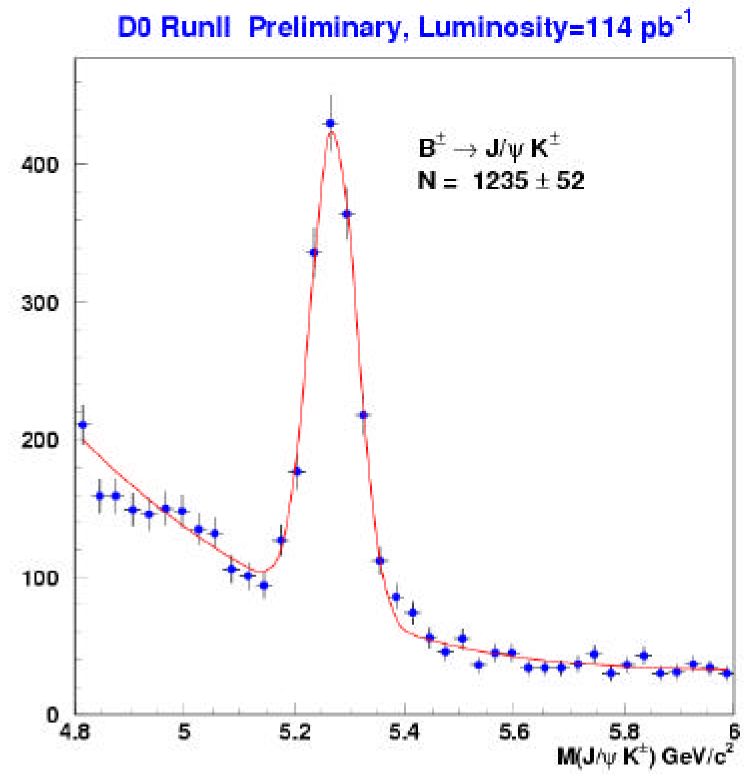
- Remove decay products from the B^+ meson
- Remove all other tracks in the red shaded area, $\Delta\phi = 2.4$ radians.
- Remove tracks with pt < 0.5 GeV.
- Remove tracks having the track fit chi square greater than 9.9.
- Remove tracks having z vertex displacement from the primary vertex of greater than 2 cm.
- Use the remaining tracks, calculate the jet charge Q weighting by track p_T

$$Q = \frac{\sum P_T^i \cdot q_i}{\sum P_T^i}$$

- Q > 0.2 tags b_bar containing hadron, Q < –0.2 tags b containing hadron, |Q| < 0.2 is untagged.

Use our B^+ signal to study flavour tagging techniques:

Method	Epsilon e	Tagging power or Dilution (D)	Figure of Merit eD^2 (%)
Soft Muon	5%	57%	1.6±1.1
Jet Charge	47%	27%	3.3±1.7
Same Side	Not done	as yet	-



$$e = \frac{N_R + N_W}{N_R + N_W + N_{notag}}$$

$$D = \frac{N_R - N_W}{N_R + N_W}$$

Significance of Mixing Measurement

$$\text{Sig.} = \sqrt{\frac{N\epsilon D^2}{2}}\, e^{-(\Delta m * \sigma_t)^2/2} \sqrt{\frac{S}{S+B}}$$

Cleanliness Of signal

σ_t Proper time resolution (crucial to reduce this)

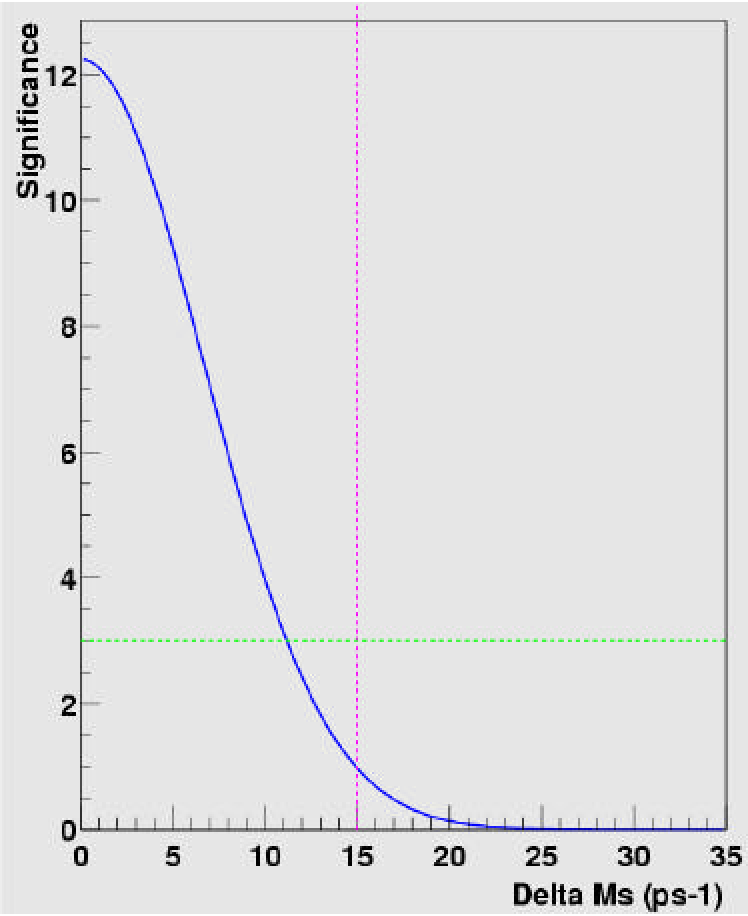
- Semi-leptonic decays:

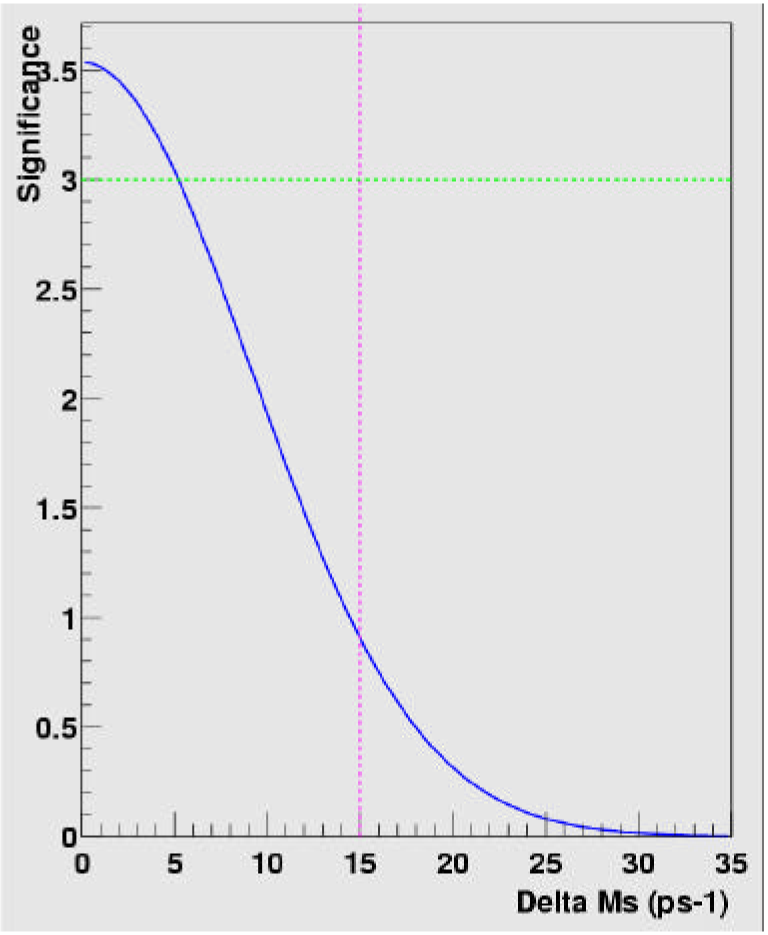
  Pros: Large yields (BR $\approx$ 10%), Cons: σ_t is large

- Hadronic decays:

  Pros: σ_t is lower, Cons: Small yields (BR $\leq$ 1%)

Projections for B_S Mixing: $\int L = 150\, pb^{-1}$





Semi-Leptonic:

Yield $\approx$ 6000, $eD^2 = 0.1,\ s_t \approx 150\, fs$

Hadronic:

Yield $\approx$ 100, $eD^2 = 0.1,\ s_t \approx 110\, fs$

Projections for B_S Mixing: $\int L = 150\, pb^{-1}$

Decay Mode	Yield	3 s value for Δm_S (ps^{-1})	Signif. If $\Delta m_S = 15$
Semi-Muon	6000	11	0.8
Semi-Elec.	750	10	0.8
Semi-Muon	750	11	0.8
Hadronic	100	5	0.9
Hadronic	200	9	1.3
Semi-Muon	1300	6	0.8
Hadronic	200	-	1.0

D0

CDF
200 pb

Triggers

Single Mu

Di-Muon

Single Mu

Silicon based

We can combine different modes – current limit is ave. of 13 expts

Conclusions and Outlook

- We are making lot of progress in understanding the D0 detector

- We have data in hand and more coming!

- Exciting times… B physics, Top/Higgs/New Phenomena/QCD