Experimental summary

Hiro Aihara
University of Tokyo

41st Rencontres de Moriond QCD and High Energy Hadronic Interactions
La Thuile, Aosta valley, Italy March 18-25, 2006
First of all, I wish to thank

• all the speakers who brought great new results to this conference and gave excellent talks (~60 experimental talks).
• the organizers who once again made this conference a success.
• Tran Thanh Van for his dedication to “Moriond” conference for 40 long years.
• Many of us grew up with this institution.
I owe a lot to excellent overviews by

A. Golutvin : Heavy Flavors
H. Kowalski : Small x and Diffraction
F. Yuan : Spin physics
C. Salgado : Heavy Ions
The Status of the EW Standard Model
$P(t) \sim (1 \pm AD \cos \Delta m_s t)$

CDF 355pb$^{-1}$

$\Delta m_s > 8.6 \text{ ps}^{-1}$ @ 95% CL

Sensitivity: 13.0 ps$^{-1}$ @ 95% CL

A deviation of $\sim 2.5 \sigma$ from 0 at $\Delta m_s \sim 19$ ps$^{-1}$

Md. Naimuddin
Likelihood analysis

DØ Run II, 1 fb\(^{-1}\)

\[ \Delta \log(L) \]

\[ \Delta m_s \text{ [ps}^{-1}] \]

- \( \Delta m_s < 21 \text{ ps}^{-1} \) @ 90% CL

Most probable value of \( \Delta m_s = 19 \text{ ps}^{-1} \)

For a true value of \( \Delta m_s = 19 \text{ ps}^{-1} \), the probability is 15% for measuring a value in the range of \( 17 < \Delta m_s < 21 \text{ ps}^{-1} \) with a \(- \Delta \log L\) lower by at least 1.9 than the corresponding value at \( \Delta m_s = 25 \text{ ps}^{-1} \).
The Standard Model still in good shape.
CDF should see it soon.

\[
\text{D0 : } \varepsilon_{\text{effective}} = \varepsilon D^2 = (2.44 \pm 0.21^{+0.08}_{-0.06})\%
\]

\[
\text{CDF : } \varepsilon_{\text{effective}} = (1.55 \pm 0.020 \pm 0.014)\% \text{ (opposite side)}
= (4.0^{+0.9}_{-1.2})\% \text{ (same side Kaon tag)}
\]
**Bs oscillations @ LHCb**

- One of the first LHCb physics goals
  - important measurement
  - aiming for $5\sigma$ observation for $\Delta m_s < 68$ ps$^{-1}$ [in one year]
  - LHCb could exclude full SM range
  - Once observed, precise value is obtained: $\sigma_{\text{stat}}(\Delta m_s) \sim 0.01$ ps$^{-1}$ in one year of data taking

$$\mathcal{E}_{\text{effective}} \sim 6\%$$

\[ \Delta m_s = 15 \text{ ps}^{-1} \]
\[ \Delta m_s = 25 \text{ ps}^{-1} \]

Tomáš Laštovička (CERN)
D. Whiteson

Mass of the Top Quark (*Preliminary)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>M_{top} [GeV/c^2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDF-I di-l</td>
<td>167.4 ± 11.4</td>
</tr>
<tr>
<td>DØ-I di-l</td>
<td>168.4 ± 12.8</td>
</tr>
<tr>
<td>CDF-II di-l*</td>
<td>164.5 ± 5.5</td>
</tr>
<tr>
<td>DØ-II di-l*</td>
<td>176.6 ± 11.8</td>
</tr>
<tr>
<td>CDF-I l+j</td>
<td>176.1 ± 7.3</td>
</tr>
<tr>
<td>DØ-I l+j</td>
<td>180.1 ± 5.3</td>
</tr>
<tr>
<td>CDF-II l+j*</td>
<td>173.4 ± 2.8</td>
</tr>
<tr>
<td>DØ-II l+j*</td>
<td>170.6 ± 4.6</td>
</tr>
<tr>
<td>CDF-I all-j</td>
<td>186.0 ± 11.5</td>
</tr>
</tbody>
</table>

Tevatron Run-I/II*

\[ M_{top} = 172.5 \pm 1.3 \text{ (stat)} \pm 1.9 \text{ (syst)} \text{ GeV} \]

\[ \chi^2 / \text{dof} = 8.1 / 8 \]

W-Boson Mass [GeV]

- TEVATRON: 80.452 ± 0.059
- LEP2: 80.388 ± 0.035
- NuTeV: 80.136 ± 0.084
- LEP1/SLD: 80.363 ± 0.032
- LEP1/SLD/m_t: 80.364 ± 0.021

Average: 80.404 ± 0.030

\[ m_w = 80.383 \pm 0.026 \text{(stat)} \pm 0.024 \text{(syst)} \text{ GeV} \]

Precision measurements!!

top mass + W mass \Rightarrow SM Higgs mass
$m_H < 175$ GeV @95%CL
Direct search for the SM Higgs at Tevatron

Tevatron Run II Preliminary

95% CL Limit/SM

$95\% \text{ CL Limit}/\text{SM}$

$10^3$

$10^2$

$10$

$1$

$110$  $120$  $130$  $140$  $150$  $160$  $170$  $180$  $190$

$m_H \text{ (GeV)}$

$ZH\rightarrow vvbb$

CDF 289 pb$^{-1}$

$WH\rightarrow lvbb$

CDF 319 pb$^{-1}$

$WH\rightarrow WWW$

CDF 194 pb$^{-1}$

$WH\rightarrow lll$

CDF 360 pb$^{-1}$

$H\rightarrow WW^{(*)}\rightarrow lll$

CDF 300-325 pb$^{-1}$

$D0 \text{ combined}$

261-385 pb$^{-1}$

$D0 \text{ combined with updated } H\rightarrow WW$

950 pb$^{-1}$

March 20, 2006

P. Jonsson
Direct search for SM Higgs at LHC

pp → $WH \rightarrow WW$

Discovery if $153 < M_H < 178$ GeV
Measuring Higgs properties @ LHC
H.Prysiezniak

→ Mass 0.1%-1% precision over whole mass range

→ Spin-CP can be ruled out
  \( J=1 \)
  for \( m_H > 230 \text{ GeV/c}^2 \) - 100 fb\(^{-1}\) and for \( m_H = 200 \text{ GeV/c}^2 \) - 300 fb\(^{-1}\).
  
  \( (J,\text{CP}) = (0,-1) \)
  for \( m_H \geq 200 \text{ GeV/c}^2 \) - <100 fb\(^{-1}\).

→ Couplings (depending on assumptions)
  10%-45% precision on \( g_Z^2, g_W^2, g_\tau^2, g_t^2 \) \( \Gamma_H \)
  for 110<\( m_H \)>190 GeV/c\(^2 \) and 300 fb\(^{-1}\).

→ Self-coupling
  \( \Delta \lambda_{HHH} = (\lambda - \lambda_{SM})/\lambda_{SM} = -1 \) excluded with at least 95% CL
  with 300 fb\(^{-1}\),
  \( \lambda \) determined to -60% to +200%. 

Single top production

**s-channel**

\[ q\bar{q} \rightarrow W^{*} \rightarrow t\bar{b} \]

**t-channel**

\[ qb \rightarrow q't \]

**tW associated production**

\[ bg \rightarrow tW^- \]

<table>
<thead>
<tr>
<th>( m_{top} = 175 \text{ GeV/c}^2 )</th>
<th>s-channel</th>
<th>t-channel</th>
<th>Associated tW</th>
<th>Combine (s+t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tevatron ( \sigma_{NLO} )</td>
<td>0.88 ± 0.11 pb</td>
<td>1.98 ± 0.25 pb</td>
<td>~ 0.1 pb</td>
<td></td>
</tr>
<tr>
<td>LHC ( \sigma_{NLO} )</td>
<td>10.6 ± 1.1 pb</td>
<td>247 ± 25 pb</td>
<td>62^{+17}_{-4} \text{ pb}</td>
<td></td>
</tr>
</tbody>
</table>

95\% C.L. limits on single top cross-section

<table>
<thead>
<tr>
<th>Channel</th>
<th>CDF (696 pb(^{-1}))</th>
<th>DØ (370 pb(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>3.4 pb</td>
<td></td>
</tr>
<tr>
<td>s-channel</td>
<td>3.2 pb</td>
<td>5.0 pb</td>
</tr>
<tr>
<td>t-channel</td>
<td>3.1 pb</td>
<td>4.4 pb</td>
</tr>
</tbody>
</table>

Tevatron by A.Gresele

LHC Study by M.M.Najafabadi
**W polarization in top decay**

**Tevatron result by J. Leveque**

![Tevatron result graph](image)

\[ W_R \text{ fraction} \]

\[ f^+ = 0.08 \pm 0.08 \text{ (stat)} \pm 0.06 \text{ (syst)} \]

\[ f^+ < 0.24 \text{ @ 95\% C.L.} \]

**LHC study by F. Hubault**

![LHC study graph](image)

\[ 2 \text{ parameter fit with } F_0 + F_L + F_R = 1 \]

<table>
<thead>
<tr>
<th>SM (M_T=175 GeV)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(± stat ± syst)</td>
</tr>
<tr>
<td>( F_0 )</td>
<td>0.703</td>
</tr>
<tr>
<td></td>
<td>± 0.004 ± 0.015</td>
</tr>
<tr>
<td>( F_L )</td>
<td>0.297</td>
</tr>
<tr>
<td></td>
<td>± 0.003 ± 0.024</td>
</tr>
<tr>
<td>( F_R )</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>± 0.003 ± 0.012</td>
</tr>
</tbody>
</table>

[hep-ex/0508061]
**B_c Lifetime Measurement**

- B_c lifetime extracted from B_c → J/ψ e νX sample

![Graph showing pseudo-proper decay length distribution with various decay modes and fits.](image)

- More stat than hadronic mode
- But also more background too

- B_c lifetime measured with J/ψ+e channel
  
  $0.474 \pm 0.074/0.066 \pm 0.033 \text{ ps}$

(CDF: Best in the world)

- Theoretical prediction: $0.55 \pm 0.15 \text{ ps}$

  V. Kiselev, hep-ph/0308214
The Status of pQCD
Combined cross section from 6 channels, up to 760 pb$^{-1}$

CDF: $7.3 \pm 0.5 \text{(stat)} \pm 0.6 \text{(syst)} \pm 0.4 \text{(lumi)}$ pb

12% relative uncertainty!

15% better than the best single measurement

03/21/06

E. Shabalina 41$^{st}$ Recontres de Moriond QCD
Diboson production

$W^+W^- \rightarrow \ell^+\ell^- E_T$

CDF 825 pb$^{-1}$

$\sim 57$ signal events

$\sigma(pp \rightarrow WW) = 13.6 \pm 2.3 \pm 1.6 \pm 1.2$(lum) pb

$\Delta\Phi_{\text{min}}(\ell, E_T) = 74^\circ$
$M_{\ell\ell} = 81.9$ GeV/c$^2$
$E_T/\sqrt{\Sigma E} = 6.1$
$\Sigma E_T = 113$ GeV
Inclusive jet cross section at Tevatron

A. Messina

Good agreement with NLO pQCD.
Direct photon production at Tevatron

M. Wobisch

L = 326 pb

agree with NLO within 7%

Dṣ

CDF Diphoton

207 pb⁻¹

|y| < 0.9

L = 326 pb⁻¹

pₜγ (GeV)

pₜ (GeV)

Eₜ¹ > 14 GeV, Eₜ² > 13 GeV

|η₁,₂| < 0.9

PYTHIA norm to data
Determination of $\alpha_s$ by inclusive jet cross section at HERA

$\alpha_s(M_Z) = 0.1196 \pm 0.0011^{\text{stat}} \pm 0.0025^{\text{exp}} \pm 0.0019^{\text{th}}$

ZEUS

$\alpha_s(M_Z) = 0.1197 \pm 0.0016^{\text{exp}}$ (th)

H1

$\alpha_s(M_Z) = 0.1196 \pm 0.0011^{\text{stat}} \pm 0.0025^{\text{exp}} \pm 0.0017^{\text{th}}$

$\alpha_s(M_Z) = 0.1187 \pm 0.0020$

C. Wissing
Two-photon physics at LEP

Open charm and beauty production in two-photon collisions

3 times larger than QCD prediction.

\[ \sigma(e^+e^- \to e^+e^-cc) \approx 1000 \text{ pb (± 10%)} \]

\[ \sigma(e^+e^- \to e^+e^-bb) \approx 13 \text{ pb (± 30%)} \]
Beauty production at HERA $\sqrt{s} = 320$ GeV

More Beauty than Expected

- All measurements consistent with a ratio data/NLO of 1.5
- Theory error (not shown) typically $\sim 10\%$
- Improved theoretical understanding needed
- ... and underway:
  - NNLO calculations coming
  - Calculations taking gluon $k_t$ into account
The Status of SUSY
Search for non-SM Higgs at Tevatron

A. Safonov

Neutral MSSM Higgs to \( \tau \tau \)
Direct search for squark and gluino

Generic squarks and gluinos strongly produced
Cross section @ Tevatron: ~ a few pb
Expect cascade decays
Signature: Large Missing $E_T$ and $\geq 2$ jets

Results from D0: (310 pb$^{-1}$) 2, 3, or 4 jets
CDF: (250 pb$^{-1}$) $\geq 3$ jets
Dominant backgrounds
- Z+jets, W+jets, tt, QCD
- QCD fitted or cross checked with data
- MET cut > [75;175] GeV
Both experiments see no hints of SUSY
Purely leptonic decays of Bs,d mesons

<table>
<thead>
<tr>
<th>Experiment</th>
<th>CDF Bs→μμ</th>
<th>DØ Bs→μμ</th>
<th>DØ Bs→μμ</th>
<th>CDF Bs→μμ</th>
<th>CDF Bs→μμ</th>
<th>CDF Bd→μμ</th>
<th>CDF Bd→μμ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>176 pb⁻¹</td>
<td>240 pb⁻¹</td>
<td>300 pb⁻¹</td>
<td>364 pb⁻¹</td>
<td>780 pb⁻¹</td>
<td>364 pb⁻¹</td>
<td>780 pb⁻¹</td>
</tr>
<tr>
<td></td>
<td>7.5×10⁻⁷</td>
<td>5.1×10⁻⁷</td>
<td>4.0×10⁻⁷</td>
<td>2.0×10⁻⁷</td>
<td>1.0×10⁻⁷</td>
<td>4.9×10⁻⁸</td>
<td>3.0×10⁻⁸</td>
</tr>
<tr>
<td></td>
<td>Published</td>
<td>Published</td>
<td>Prelim.</td>
<td>Published</td>
<td>Prelim.</td>
<td>Published</td>
<td>Prelim.</td>
</tr>
</tbody>
</table>

SM: \( \text{Br}(B_s^+ \rightarrow \mu^+ \mu^-) = 3.4 \times 10^{-9} \)
Inclusive Signatures

SUSY events dominated by \( \text{jets} + E_T^{\text{miss}} + n\text{-leptons} \)

Effective Mass variable: \( M_{\text{eff}} = \Sigma |p_T| + E_T^{\text{miss}} \).
- discriminate SM and SUSY
- correlated with SUSY mass scale

\[ M_{\text{eff}} \propto M_{\text{SUSY}} = \min(m_{\tilde{g}}, m_{\tilde{q}}) \]

General selection cuts -
- 2 jet with \( p_T > 100 \text{ GeV} \), 4 jets with \( p_T > 50 \text{ GeV} \)
- \( E_T^{\text{MISS}} > \max(100 \text{ GeV}, 0.2 M_{\text{eff}}) \)
- Transverse sphericity \( S_T > 0.2 \)
- No isolated muon or electron with \( p_T > 20 \text{ GeV} \) (0-lepton case)
Beyond-SUSY at Tevatron

Extra Dimensions

$qq, qg, gg \rightarrow gG, qG$: a single energetic jet + large $\not{E}_T$

CDF

<table>
<thead>
<tr>
<th>Background</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z \rightarrow \nu\bar{\nu}$</td>
<td>$130 \pm 14$</td>
</tr>
<tr>
<td>$W \rightarrow \tau\nu$</td>
<td>$60 \pm 7$</td>
</tr>
<tr>
<td>$W \rightarrow \mu\nu$</td>
<td>$36 \pm 4$</td>
</tr>
<tr>
<td>$W \rightarrow e\nu$</td>
<td>$17 \pm 2$</td>
</tr>
<tr>
<td>$Z \rightarrow \ell\ell$</td>
<td>$3 \pm 1$</td>
</tr>
<tr>
<td>QCD</td>
<td>$15 \pm 10$</td>
</tr>
<tr>
<td>Non-collision</td>
<td>$4 \pm 4$</td>
</tr>
<tr>
<td>Total predicted</td>
<td>$265 \pm 30$</td>
</tr>
<tr>
<td>Data observed</td>
<td>$263$</td>
</tr>
</tbody>
</table>

Uncertainties:
- stat+syst: 11%
  (bckgd from data)

World Best Limit

CDF II Preliminary ($368 \text{ pb}^{-1}$)

$n$: number of Extra Dimensions
$M_D$: effective Planck scale

$n=5$ $M_D>0.85 \text{ TeV}$

$n=6$ $M_D>0.83 \text{ TeV}$
Heavy Spin-2 Object Search at LHC

V. Litvin

[Diagram showing coupling parameter vs. graviton mass with discovery limits and simulation results]
The Status of the Structure Functions and Parton Density Functions
• Still large uncertainties on gluon density and on d density at large x
Collins fragmentation: transverse quark spin observable in azimuthal hadron distributions

- 29 fb\(^{-1}\) of off-resonance data
- 60 MeV below \(\Upsilon(4S)\) resonance
- Submitted to PRL, [hep-ex/0507063]
- Significant non-zero asymmetries
- Rising behavior vs. \(z\)
- \(\cos(\phi_1 + \phi_2)\) double ratios only marginally larger
- First direct measurement of the Collins function
- Integrated results:
  - \(\cos(2\phi_1)\) method
    - \((3.06 \pm 0.65 \pm 0.55)\%\)
  - \(\cos(2\phi_1 + \phi_2)\) method
    - \((4.26 \pm 0.78 \pm 0.68)\%\)
Spin-dependent PDF from HERMES

Collins Amplitudes

\[ A_C \propto \delta q \cdot H_1^+ \]

Results of 2002–2004 data

- Collins amplitude positive for \( \pi^+ \) and negative for \( \pi^- \).
- First evidence for non-vanishing Collins FF
- Large negative \( \pi^- \) moment unexpected → important role of unfavoured FF (e.g., same size, opposite sign)
- Extraction of \( \delta q \): additional information on \( H_1^+ \) needed
- BELLE data are analysed, extraction of FF in progress
- Contribution from exclusive elastic vector mesons → uncertainty in interpretation

\( \delta q \): transversity
The Status of Quark model & non-pQCD
X(3872) \( J^{PC}=1^{++} \)

\[ N = 13.6 \pm 4.4, \ 4.0 \sigma \]

X(3940) \( \rightarrow DD^* \)

Y(3940) \( \rightarrow J/\psi \omega \)

significant deviation from phase-space, 8.1\( \sigma \)

\( \gamma \gamma \rightarrow Z(3930) \rightarrow DD \)

64\( \pm 18 \) ev.

\[ M=3929 \pm 5 \pm 2 \]

\[ \Gamma=29 \pm 10 \pm 2 \]

5.3\( \sigma \)

D side band
S.Gowdy/BABAR

$Y(4260)$

Hybrid (qqbar+g)?

T.Ferguson/CLEO

$Y(4260)$

$11\sigma$

$5.1\sigma$

$3.7\sigma$

BaBar

$e^+e^- \rightarrow \pi^+ \pi^- J/\psi$

$m(\pi\pi J/\psi)$ (GeV/c$^2$)

Events / 20 MeV/c$^2$

Data taken @ $\sqrt{s} = 4.26$ GeV.
Solid line histogram from MC simulation.
Results from BES at Beijing $e^+e^-$ Collider

X.U.Zhuang

$\chi(1835)$

The $\pi^+\pi^-\eta'$ mass spectrum for $\eta'$ decaying into $\eta' \rightarrow \pi^+\pi^-\eta$ and $\eta' \rightarrow \gamma\rho$

$N_{\text{obs}} = 264 \pm 54$

$M = 1833.7 \pm 6.1 \pm 2.7\text{MeV}$

$\Gamma = 67.7 \pm 20.3 \pm 7.7\text{MeV}$

$B(J/\psi \rightarrow \gamma X)B(X \rightarrow \pi^+\pi^-\eta') = (2.2 \pm 0.4 \pm 0.4) \times 10^{-4}$

J.Chen

Substantial non-DDbar decay of $\psi(3770)$ by inclusive measurements. BR~14%-16%
Observation of $\Xi_{cx}(2980)^+$ and $\Xi_{cx}(3077)^+$

Instead of seeing the $\Xi_{cc}$...

Two new excited charm strange baryons observed

$\chi_c^{(c,s)} \rightarrow \Lambda_c K \pi$

$\rightarrow c$ and $s$ quarks are carried away by different final state particles

**Preliminary**

**Background:** threshold function £ third order polynomial

<table>
<thead>
<tr>
<th>New State</th>
<th>Mass, (MeV/c²)</th>
<th>Width, (MeV/c²)</th>
<th>Yield, (events)</th>
<th>Significance, ($\sigma$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Xi_{cx}(2980)^+$</td>
<td>2978.5 ± 2.1 ± 2.0</td>
<td>43.5 ± 7.5 ± 7.0</td>
<td>405.3 ± 50.7</td>
<td>6.3</td>
</tr>
<tr>
<td>$\Xi_{cx}(3077)^+$</td>
<td>3076.7 ± 0.9 ± 0.5</td>
<td>6.2 ± 1.2 ± 0.8</td>
<td>326.0 ± 39.6</td>
<td>9.7</td>
</tr>
</tbody>
</table>
$\Lambda_c(2880)^+ \& \Lambda_c(2940)^+$

- New charm baryon found decaying to $D^0 p$
  - $\Lambda_c(2880)^+$ also measured in this mode
  - $D^0$ decays to $K\pi^+$ and $K\pi^+\pi^-\pi^+$ in 288 fb$^{-1}$ used
  - No signal in $D^+ p$, not $\Sigma_c$ state

- $\Lambda_c(2880)^+$ confirmed;
  - $m = [2881.9 \pm 0.1 \text{ (stat.)} \pm 0.5 \text{ (syst.)}] \text{ MeV}/c^2$
  - $\Gamma = [5.8 \pm 1.5 \text{ (stat.)} \pm 1.1 \text{ (syst.)}] \text{ MeV}$

- $\Lambda_c(2940)^+$ results are;
  - $m = [2939.8 \pm 1.3 \text{ (stat.)} \pm 1.0 \text{ (syst.)}] \text{ MeV}/c^2$
  - $\Gamma = [17.5 \pm 5.2 \text{ (stat.)} \pm 5.9 \text{ (syst.)}] \text{ MeV}$
Baryonic B decays

S.W. Lin / Belle

\[ B^0 \rightarrow \bar{\Lambda}_c^- \Lambda_c^+ K^0 \]

Large branching fraction!

\[ Br = (7.9^{+2.9}_{-2.3} \pm 1.2 \pm 4.2) \times 10^{-4} \]
Pentaquark saga continues.

Search for $\theta_c \rightarrow D^* p$

charmed pentaquark

Comparison of H1 and ZEUS in similar phase space region

ZEUS do not observe $\theta_c$ signal in a DIS data sample 1.7 times of H1 data sample (H1 see the signal also in PHP, ZEUS neither in photoproduction)
# B → D(*)D(*) : Results

[preliminary]

<table>
<thead>
<tr>
<th>Mode</th>
<th>Branching Fraction / 10^{-4}</th>
<th>\sqrt{2 \log \left( \frac{L_{\text{max}}}{L(0)} \right)}</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^0 \to D^0 \bar{D}^0$</td>
<td>&lt;0.59 [90% C.L.]</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>$B^0 \to D^{*0} \bar{D}^0$</td>
<td>&lt;2.92 [90% C.L.]</td>
<td>0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>$B^0 \to D^{*0} \bar{D}^{*0}$</td>
<td>&lt;0.92 [90% C.L.]</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>$B^0 \to D^{+} D^-$</td>
<td>2.81 ± 0.43 ± 0.45</td>
<td>5.5</td>
<td>3.1</td>
</tr>
<tr>
<td>$B^0 \to D^{*+} D^-$</td>
<td>5.72 ± 0.64 ± 0.71</td>
<td>7.3</td>
<td>7.1</td>
</tr>
<tr>
<td>$B^0 \to D^{<em>+} \bar{D}^{</em>-}$</td>
<td>8.11 ± 0.57 ± 0.99</td>
<td>12.0</td>
<td>9.1</td>
</tr>
<tr>
<td>$B^- \to D^- D^0$</td>
<td>3.76 ± 0.57 ± 0.45</td>
<td>4.9</td>
<td>3.3</td>
</tr>
<tr>
<td>$B^- \to D^{*-} D^0$</td>
<td>3.56 ± 0.52 ± 0.40</td>
<td>5.2</td>
<td>4.5</td>
</tr>
<tr>
<td>$B^- \to D^- \bar{D}^{*0}$</td>
<td>6.30 ± 1.32 ± 0.95</td>
<td>3.8</td>
<td>3.1</td>
</tr>
<tr>
<td>$B^- \to D^{*-} \bar{D}^{*0}$</td>
<td>8.14 ± 1.17 ± 1.21</td>
<td>5.3</td>
<td>9.8</td>
</tr>
</tbody>
</table>

| stat. | syst. | *previously measured by Belle |

211/fb, 232x10^6 B\bar{B} pairs

Rare Hadronic B Decays  J. Kroseberg (BaBar)  Moriond QCD, March 19'06
Observation of $B^0 \rightarrow a_1(1260)^+ \pi^-$

**Motivation:**
Can be used to give a new measurement of $\alpha$ by time-dependent $A_{CP}$ analysis

**Branching Fractions:**

$$BF(B^0 \rightarrow a_1(1260)^+ \pi^-) = 40.2 \pm 3.9 \pm 3.9 \times 10^{-6}$$

**Fitted $a_1(1260)$ resonance parameters:**

Next step:
Measure $\alpha$ using time-dependent CP analysis

$ma_1 = 1.22 \pm 0.02 \text{ GeV/c}^2$

$\Gamma_{a_1} = 0.423 \pm 0.050 \text{ GeV/c}^2$
Exclusive (C=+1) final state $e^+e^- \rightarrow \rho^0 \rho^0 / \phi \rho^0$

First observation!!
Opens a new full range of possible studies

- Searching for exotic states, rare processes...
  - Selecting $e^+e^- \rightarrow 4\text{ch. Trk} @ 10.58 \text{ GeV}$
  - Clean $\pi^+\pi^-\pi^+\pi^-$ and $K^+K^-\pi^+\pi^-$ sample
  - Clear $\rho$ (and more) signal in $m(\pi^+\pi^-)$
  - Clear $\phi$ signal in $m(K^+K^-)$

On-peak data

Strong $\rho\rho$ and $\rho\phi$ correlation found...
forbidden in usual 1 VP process!
Purely leptonic D decay by CLEO

\[ D^+ \rightarrow \mu^+ \nu_\mu \] and \[ f_{D^+} \]

\[ \Gamma (D^+ \rightarrow l^+ \nu) = \frac{G_F^2}{8\pi} f_{D^+}^2 M_{D^+}^2 \left( 1 - \frac{m_l^2}{M_{D^+}^2} \right)^2 |V_{cd}|^2 \]

\[ Br(D^+ \rightarrow \mu^+ \nu_\mu) = (4.40 \pm 0.66^{+0.09}_{-0.12}) \times 10^{-4} \]
Pion form factor from $\sigma(e^+e^- \rightarrow \gamma\pi^+\pi^-)$ at DAΦNE

$|F_\pi(s)|^2$

KLOE 2001
140pb$^{-1}$
PLB606(2005)12

CMD-2
VEPP-2M
Energy scan

\[ \rho - \omega - \text{interference} \]

Standard model prediction:

\[ a_{\mu}^{\text{theo}} = a_{\mu}^{\text{QED}} + a_{\mu}^{\text{weak}} + a_{\mu}^{\text{hadr}} \]

CMD-2 and KLOE are averaged in hadronic contribution

NEW

preliminary

50$^o$<$\theta_\pi$<130$^o$
50$^o$<$\theta_\gamma$<130$^o$
L = 240 pb$^{-1}$
2002 data

$\mu - 11.659 \times 10^{-10}$

2.7\sigma deviation
The Status of proton spin

\[
\frac{1}{2} = \Delta S_q \text{ (quark)} + \Delta G \text{ (gluon)} + L_q \text{ (orbital)} + L_G \text{ (gluon)}
\]

\[
\begin{align*}
\frac{1}{2} &= \frac{1}{2} \times (0.2 - 0.3) + 0.4 + 0 + 0 \\
\frac{1}{2} &= \frac{1}{2} \times (0.2 - 0.3) + 0.0 + 0.4
\end{align*}
\]
 Eyser /PHENIX

\[ \int \Delta G(x_g) = \text{Small } \Delta G \text{ preferred} \]

Fatami /STAR

\[ \int \Delta G(x_g) = 2.5 \]

\[ \int \Delta G(x_g) = 0.62 \]

\[ \int \Delta G(x_g) = 0.16 \]

COMPASS /Procureur
The Status of colorless exchange (a.k.a. diffraction) process
Diffraction at HERA

Diffractive PDF's

DGLAP evolution NLO fits allow extraction of 3 dPDF's sets:
- ZEUS-LPS fit to ZEUS 1997 LPS data
- H1 2002 fit to H1 1997 LRG data
- GLP (Groys-Levy-Proskuryakov) fit to ZEUS 1998-99 $M_\chi$ data

- Discrepancies evident and larger than experimental errors
- Not fully understood
- Estimate of the uncertainty on dPDF's

Need more work for precise and consistent determination of dPDF's
Exclusive $\gamma\gamma$ Candidates

3 candidate events observed
no background estimate yet

$1^{+3}_{1}$ events predicted by
ExHuME Monte Carlo
(based on Khoze, Martin, Ryskin,

Look forward to bkgd. estimation
LHC very forward detector

**Exclusive Central Higgs Production**

Exclusive central Higgs production $pp \rightarrow p\ H\ p : \quad 3-10 \text{ fb}$
Inclusive central Higgs production $pp \rightarrow p+X+H+Y+p : \quad 50-200 \text{ fb}$

Advantages Exclusive production:
- $J_z=0$ suppression of $gg \rightarrow bb$ background
- Mass measurement via missing mass

$$M_H^2 = (p + \overline{p} - p' - \overline{p'})^2$$

$\Delta M = O(1.0 - 2.0) \text{ GeV}$
The Status of Heavy Ion Physics
$\rho$ width broadens in medium

$J/\psi$ suppression in medium

Floris / NA60

In-In SemiCentral
all $p_T$

$\frac{dN_{ch}}{d\eta}_{3,8} = 133$

excess data
RW (norm.)
BR (norm.)
Vac.$\rho$ (norm.)
cockt.$\rho$ (dashed)
D$\bar{D}$ (dashed)

Tram / PHENIX

PHENIX expected

NA50 expected 4.2mb

1mb

3mb

PHENIX preliminary

$N_{part}$
Heavy flavour QGP probes:
Dissociation/regeneration of quarkonia

SPS  RHIC  LHC

$J/\Psi$ regeneration

$J/\Psi$ melting

energy density

Belikov /ALICE
Direct photon

\[ \gamma_{\text{direct}} = \gamma_{\text{incl}} \cdot \frac{\gamma_{\text{direct}}}{\gamma_{\text{incl}}} \]

Prompt electrons

Au+Au 0-5% \( \sqrt{s_{\text{NN}} = 200 \text{ GeV}} \)

Armesto et al. \texttt{hep-th/0511257}
van Hess et al. \texttt{hep-th/0508055}
Wicks et al. (DVGL) \texttt{hep-th/0512076}

\[ \frac{\text{d}N_{\text{e+e-}}}{\text{d}y} \]

\[ R_{\text{AA}} \]

Sahlmuller / PHENIX

Bielcik / STAR
Di-haron correlation due to medium

$P_t$ suppression

Shape modification

Mishke / STAR

Isobe / PHENIX
Summary of summaries

• Tevatron is back in business!
• Power of statistics by B, Charm, phi-factory machines
• Steady progress at HERA, RHIC
• Thorough preparation for LHC

• Yes, we are doing OK. Therefore,
We are bound to make more discoveries.