Tau – Charm Summary

Workshop on US/PRC Cooperation in HEP

Frederick A. Harris
June. 16, 2006
Workshop - Tau Charm

- There were many very and very useful presentations. I will not try to summarize all of them. Many thanks to all the authors.
- I will only make some general comments.

BEPCII/BESIII

Status: Approved and under construction; commissioning 2007.

There has been tremendous progress. See overview talk by Li Weiguo and other more detailed talks.

Design luminosity = $1 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$
Changing face of BESIII
BEPCII linac installation complete (new electron gun; new position source; new rf power (klystrons and modulators); and others. Most design specifications reached at 1st test run.
Two thirds of storage ring magnets have been installed
BESIII Detector

Muon Counter

SC magnet

TOF

Be beam pipe

Drift Chamber

CsI(Tl) calorimeter
### Year Event Production

Average Lum: $\mathcal{L} = 0.5 \times \text{Peak Lum.}$; data taking time: $T = 10^7 \text{s/yr}$

\[
\sigma_{\text{exp}}(W) = \int_0^\infty dW' \sigma_{r.c.}(W') G(W', W)
\]

\[
N_{\text{event/year}} = \sigma_{\text{exp}} \times \mathcal{L} \times T
\]

<table>
<thead>
<tr>
<th>Resonance</th>
<th>Energy (GeV)</th>
<th>Peak Lum. $(10^{33} \text{cm}^{-2}\text{s}^{-1})$</th>
<th>Physics Cross Section (nb)</th>
<th>Nevents/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>$J/\psi$</td>
<td>3.097</td>
<td>0.6</td>
<td>3400</td>
<td>$10 \times 10^9$</td>
</tr>
<tr>
<td>$\tau$</td>
<td>3.670</td>
<td>1.0</td>
<td>2.4</td>
<td>$12 \times 10^6$</td>
</tr>
<tr>
<td>$\psi(2S)$</td>
<td>3.686</td>
<td>1.0</td>
<td>640</td>
<td>$3.2 \times 10^9$</td>
</tr>
<tr>
<td>$D^0D^0\bar{\text{bar}}$</td>
<td>3.770</td>
<td>1.0</td>
<td>3.6</td>
<td>$18 \times 10^6$</td>
</tr>
<tr>
<td>$D^+D^-$</td>
<td>3.770</td>
<td>1.0</td>
<td>2.8</td>
<td>$14 \times 10^6$</td>
</tr>
<tr>
<td>$\text{DsDs}$</td>
<td>4.030</td>
<td>0.6</td>
<td>0.32</td>
<td>$1.0 \times 10^6$</td>
</tr>
<tr>
<td>$\text{DsDs}$</td>
<td>4.140</td>
<td>0.6</td>
<td>0.67</td>
<td>$2.0 \times 10^6$</td>
</tr>
</tbody>
</table>

Huge $J/\psi$ and $\psi(2S)$ samples at BESIII

Design luminosity = $1 \times 10^{33} \text{cm}^{-2} \text{s}^{-1}$
Physics: Importance of tau – charm region

Tremendous variety: taus at threshold, R, charm, charmonium, transition region between perturbative and non-perturbative QCD, etc.

Many new particles: X, Y, Z, etc. Hybrids? Glueballs?
Tau – charm physics

- Still much interest in this physics.
- Good turn out at Charm06, held June 5-7.
  - 64 registered participants, more than 100 attendees.
  - 47 from abroad and 20 from United States.
  - about 50 talks given.
- Much also being done at B factories and elsewhere.

- EXAMPLES:
Glueballs dramatically reflect QCD’s fundamental properties: local, unbroken, nonAbelian symmetry

• NonAbelian gauge th’y: gauge bosons carry charge
• Unbroken: charge confined in IR
  → Gauge bosons form singlet bound states

Cf QED: $Q_\gamma = 0 \Rightarrow$ IR free $\Rightarrow$ no lightballs

Prediction is simple and fundamental, but difficult to verify.

We expect a solution in the coming years:
  ✓ BES III $\Rightarrow$ definitive $\Psi$ decay data (especially $\Psi \rightarrow \gamma X$)
  ✓ LQCD $\Rightarrow$ unquenched results on spectrum, mixing, decays
  → Powerful combination of experiment & theory, sufficient to solve the problem.
Radiative $\psi$ decay is the ideal glueball hunting ground!
Conclusion

Important to know if chiral suppression is relevant:
Two old LQCD studies – of decays & of mixing – appear to be consistent with chiral suppression, but definitive LQCD studies are needed.

BES III is at the threshold of a very rich program, with unique capability to perform PWA in channels that are critical for the discovery of gluonic states:
- $\psi \rightarrow \gamma + \text{hadrons}$
- $\psi \rightarrow \text{hadrons}$
- $\gamma \gamma \rightarrow \text{hadrons, including (tagged) } \gamma \gamma^* \rightarrow \text{hadrons}$

Together with anticipated progress in LQCD, BEPC II/BES III can show the way to the gluonic sector of the QCD spectrum.
Conclusion

From Jim Napolitano

CLEO has had a long and fruitful life, running at CESR at Cornell for more than 25 years.

CLEO-c has produced many new results on charm physics, and many more results are on the way.

But CLEOc will not produce enough events to study quantum correlations.

BES III has a very bright future!
BESIII Upgrades

- Particle ID. Need R&D on improved PID for pi/K separation. Important for D D-bar mixing. See:
  - Alan Schwartz “Particle upgrade plans for Super Belle”.
  - Yeukun Heng “PID upgrade of BESIII”.
- Need beam energy measurement.
# BESIII and CLEOc comparison

<table>
<thead>
<tr>
<th>Detector</th>
<th>BES III</th>
<th>CLEOc</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDC</td>
<td>$\sigma_{\chi y} (\mu m) = 130$</td>
<td>90 $\mu m$</td>
</tr>
<tr>
<td></td>
<td>$\Delta P/P (0/0) = 0.5 % (1 \text{ GeV})$</td>
<td>0.5 %</td>
</tr>
<tr>
<td></td>
<td>$\sigma_{dE/dx} (0/0) = 6 - 7 %$</td>
<td>6%</td>
</tr>
<tr>
<td>EMC</td>
<td>$\Delta E/\sqrt{E} (0/0) = 2.5 % (1 \text{ GeV})$</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>$\sigma_z (\text{cm}) = 0.5 \text{cm}/\sqrt{E}$</td>
<td>0.3 cm $/\sqrt{E}$</td>
</tr>
<tr>
<td>TOF</td>
<td>$\sigma_T (\text{ps}) = 100-110/\text{layer}$</td>
<td>Rich</td>
</tr>
<tr>
<td></td>
<td>Double layer</td>
<td></td>
</tr>
<tr>
<td>$\mu$ counter</td>
<td>9 layers</td>
<td>----</td>
</tr>
<tr>
<td>magnet</td>
<td>1.0 T</td>
<td>1.0 T</td>
</tr>
</tbody>
</table>
**Tau mass measurement**

Novosibirsk performing a new tau mass measurement. (see “tau and psi mass measurement at KEDR”, talk at “e⁺ e⁻ collisions from phi to psi”, Feb. 28 – Mar. 2, Novosibirsk, Russia)

- Resonant depolarization
- Previously measured J/ψ and ψ(2S) masses.
- Very preliminary result:

\[
m_\tau = 1776.77^{+0.45}_{-0.35} \pm 0.10\text{MeV/c}^2
\]

Goal \(\delta(m) = 0.15\) to 0.20 MeV/c²

**BES** \[
m_\tau = 1776.96^{+0.18}_{-0.21}^{+0.25}_{-0.17}\text{MeV/c}^2
\]
Absolute Beam Energy Calibration at Novosibirsk

Alex Bondar, Budker Institute of Nuclear Physics, Novosibirsk, Russia

Motivation:

Precise mass measurement of the τ-lepton

$D^0, D^+, D_s$-mesons
Inverse Compton scattering of laser radiation ($\omega_0$) head-on the electron beam allows to measure the electron beam energy $\varepsilon$ through the sharp edge ($\omega_{max}$) of backscattered photon energy spectrum.

$$\omega_{max} = \frac{\varepsilon^2}{(\varepsilon + m^2/4\omega_0)}$$

in that way:

$$\varepsilon = \frac{\omega_{max}}{2} \left( 1 + \sqrt{1 + \frac{m^2}{\omega_0 \omega_{max}}} \right)$$

Accuracy:

$$\frac{\Delta \varepsilon}{\varepsilon} \approx \frac{1}{2} \cdot \frac{\Delta \omega_{max}}{\omega_{max}} \oplus \left( \frac{1}{2} \cdot \frac{\Delta \omega_0}{\omega_0} \oplus \frac{\Delta m}{m} \right)$$
Alex Bondar  

Beam Energy Calibration

- Carbon dioxide laser
- 25–50 W CW Power, RF discharge – long lifetime
- $\lambda=10.591 \ \mu m \ (\omega_0=0.117 \ eV)$
- $\Delta\omega_0/\omega_0 \approx 10^{-8}$
Alex Bondar

Beam Energy Calibration

Absolute calibration of energy scale

KEDR Collab., depolarization method:
Single energy scale at level of 0.8 keV, or $10^{-4}$ MeV
Total systematic error at level of 9 keV, or $10^{-3}$ MeV

Mo Xiaohu Slides
Fix, stable, regular, eliminate and controllable

UNSTABLE and IRREGULAR, uncontrollable

BESI: $\delta E = 0.2$ MeV
Summary

- Statistical and systematic uncertainties have been studied based on BESI performance experience.
- Monte Carlo simulation and sampling technique are adopted to obtain optimal data taking point for high accurate $\tau$ mass measurement. We found:
  1. optimal position is located at large derivative of cross section near threshold;
  2. one point is enough, and 45 pb$^{-1}$ is sufficient for accuracy up to 0.1 MeV.
- Many factors have been taken into account to estimate possible systematic uncertainties, the total relative error is at the level of $1.3 \times 10^{-5}$. However, the absolute calibration of energy scale may be a key issue for further improvement of $\tau$ mass.

Thanks!
Other Topics to prepare for:
(Besides R, tau, charm, and charmonium)

- ISR Physics – Nice talk from Genia Solodov.
- 2 gamma physics
Physics: Yellow Book

  

- Organized by Li Haibo.
- Contributors include D. Asner and I. Bigi.
- Questions to answer:
  - Physics opportunities relative to other experiments?
  - Priorities?
  - Time Scale?

Charm2006: Workshop on Tau-Charm Physics
June 5 – 7, 2006, Beijing, China
Workshop

- Proposed by TD to encourage collaboration with US.
- Many CLEOc people attended CHARM06 and left!
- Met with them during Charm06 and started dialogue. Other interested parties attended this workshop.
- Workshop a success in beginning discussions between interested groups and BES.
- But need a further meeting with BES, interested groups, and DOE and NSF.
- Workshop a great success. Many thanks to Fred Gilman and Chen Hesheng for organizing the workshop, to DOE, NSF, and CAS for sponsoring it, and to IHEP for hosting it.
Thanks