CLEO-c & CESR-c: A New Frontier in Weak & Strong Interactions

CLEO-c Collaboration:
CLEO-c: The Context

This Decade
Flavor Physics is now in “the sin2β era”, akin to Weak Physics & “the precision Z era” in the ’90s. B-factories will overconstrain CKM matrix with precision measurements. The discovery potential is limited by systematic errors from non-perturbative QCD.

The Future
LHC may uncover strongly coupled sectors in the physics that lies beyond the Standard Model. The LC will study them. Strongly-coupled field theories are an outstanding challenge to theoretical physics. Critical need for reliable theoretical techniques & detailed data to calibrate them.

The Lattice is a complete definition of perturbative & non-perturbative QCD & therefore the premier example of a strongly coupled FT. In the next few years the expectation is for calculations at the few % level in B, D, ψ, &ϒ.

Charm at threshold can provide the data to test & calibrate QCD techniques such as the Lattice. Hence CLEO-c/CESR-c.
Precision theory + charm = dramatic increase in the potential of quark flavor physics to discover new physics

Theoretical errors dominate width of bands

precision QCD calculations tested with precision charm data from CLEO-c ➔ theory errors of a few % on B system decay constants & semileptonic form factors

500 fb⁻¹ @ BABAR/Belle
CLEO-c Physics Program

- **Flavor Physics:** overcome the hadronic road block
  - Precision charm absolute branching ratio msmts needed for precision B msmts... can be the limiting systematic error

- **Tests QCD techniques in c-sector**...
  - decay constants, form factors, $V_{cs}$, $V_{cd}$, unitarity

- ... And apply to b-sector
  - Precision $V_{ub}$, $V_{cb}$, $V_{td}$, & $V_{ts}$
  - Maximizes sensitivity to new physics

- **Lattice testing ground**
  - Precise measurements of quarkonia spectroscopy & decay

- **Physics beyond the Standard Model**
  - D-mixing, CPV, rare decays, + measure strong phases

**The CLEO-c program will enable this decade’s flavor physics & the next decade’s new physics**
Detectors: CLEO III → CLEO-c

Minor modifications:
- Silicon → 6-layer low mass inner drift chamber
- B-field: 1.5T → 1.0T
Status

**CESR upgraded to CESR-c**
- 12 wigglers for damping
  - 6 installed in summer '03, 6 installed summer '04
- Luminosity tuning monitor (high rate) installed
- ~50% time commitment to CHESS (Cornell High Energy Synchrotron Source) @ ~5 GeV
  - No more simultaneous CLEO/CHESS running

**Sept '03-Mar '04**
- 6-wiggler Pilot Run
- $L_{\text{PEAK}} = 4.6 \times 10^{31}$
- 57 pb$^{-1}$ @ $\psi(3770)$ (6×Mark III, 3×BES II)
- 5.5 pb$^{-1}$ @ $\psi(2S)$ (3686)
- 20 pb$^{-1}$ @ 3670 (continuum just below $\psi(2S)$)

**Preliminary results at ICHEP on many high priority topics (as well as “niche” physics like quarkonia decays)**
Luminosity: Going up...

Daily Integrated Luminosity (nb$^{-1}$/day)

- 6 wigglers
- 12 wigglers

Peak Luminosity ($10^{31}$ cm$^{-2}$/sec)

- 6 wigglers
- 12 wigglers
D-hadronic BRs

\[ \sigma(DD) = (6.06 \pm 0.13 \pm 0.23) \text{ nb} \]
$f_{D^+}$ from Absolute $\text{Br}(D^+ \to \mu^+ \nu)$

Hadronic tag

$D^- \xrightarrow{} D^+ \to \mu^+ \nu$ 1 track, $\mu$ consistent, no showers

$$MM^2 = \left( E_{beam} - E_\mu \right)^2 - \left( -P_{Diag}^{D^+} - P_\mu \right)^2$$

CLEO-c Proposal:

MC $1\text{ fb}^{-1}$

$D^+ \to K^0 \pi^+$

$MM^2 (\text{GeV}^2)$
$f_{D^+}$ from Absolute $\text{Br}(D^+ \to \mu^+\nu)$

**CLEO data**

$D^+ \to K^0\pi^+$

- Tags 28575
- Signal 8 events
- Bkgd $1.07 \pm 1.07$

$$B = (3.5 \pm 1.4 \pm 0.6) \times 10^{-4}$$

$$f_{D^+} = (201 \pm 41 \pm 17) \text{MeV}$$

- $\sim 57 \text{ pb}^{-1}$
- 8 signal candidates

$$MM^2 (\text{GeV}^2)$$

Charged $D$ Decay Constant (MeV)

- BES
- Lattice 2004
- CLEO-c
- Isospin Mass Splittings
- Potential Model
- Rel. Quark Model
- QCD Sum Rules
- QCD Spectral Sum Rules
- MILC
- UKQCD

QWG3 B Heltsley Oct 2004
Run Plan

**CESR-c**
- Components in place, including fast luminosity tuning monitor
- Improvements seen already. Factor of ~5 to design performance.

**Big Picture: Now – 2007**
- "Yellow Book" priorities have not changed
- Year 1: D physics: 3 fb⁻¹ @ ψ(3770)
- Year 2: Dₛ physics: 3 fb⁻¹ @ ~4140: DₛDₛ threshold
- Year 3: QCD w/10⁹ J/ψ (20×BES)

**Other c.m. energies potentially of interest...**
- Will be taken so as to not compromise above goals
- ψ(2S)
  - Physics: h_c studies, 12% rule, η_c BRs, J/ψ BRs, ...
  - Even in small doses, useful for calibration, systematic checks
- Continuum @ 3670
- R scan
- 3770 scan
- ??

**Exciting years ahead!**