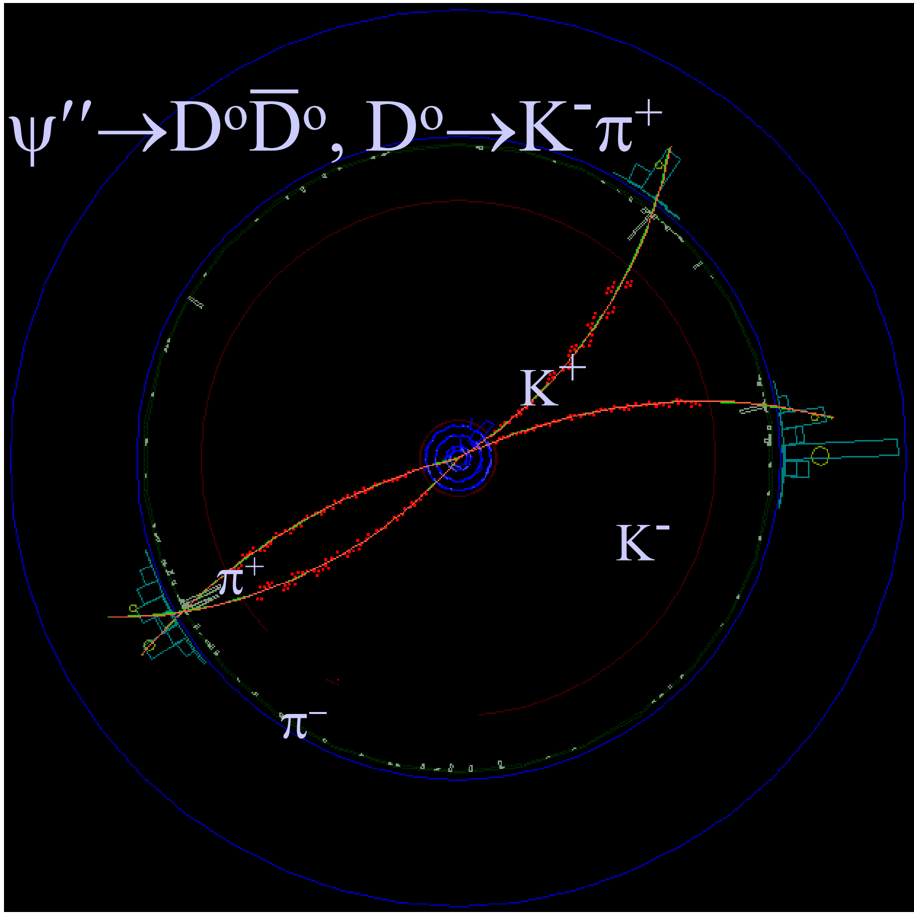
CLEO-c & CESR-c: A New Frontier in Weak and Strong Interactions

The CLEO-c Physics Program



The CLEO-c Collaboration
Caltech, Carnegie Mellon, Cornell, Florida, Illinois, Kansas, Northwestern, Minnesota, Oklahoma, Pittsburgh, Purdue, Rochester, SMU, Syracuse, Texas PM, Vanderbilt, Wayne State

Presented to HEPAP
August 5th, 2002

Ian Shipsey,
Purdue University

- I am completely deaf
- I communicate by lip reading
- BUT lip reading obeys an inverse square law
- Please write down your questions
- Pass them up to me
- I will read out your question before answering it

CLEO-c : the context

Thread #1

CLEO: Major contributions to B/c/τ physics. But, with the spectacular success of the B factories, CLEO is no longer competitive at the Υ(4S). Last run June 25 '01

This Decade Thread #2

Flavor Physics: is in "the sin2β era" akin to precision Z. Over constrain CKM matrix with precision measurements. Limiting factor: non-pert. QCD.

The Future Thread #3

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.

Example: The Lattice

Complete definition of pert & non. Pert.QCD. Matured over last decade, can calculate to 1-5% B,D,Υ,Ψ…

Charm at threshold can provide the data to calibrate QCD techniques $\rightarrow$ convert CESR/CLEO to a charm/QCD factory

CLEO-c Physics Program

•flavor physics: overcome the non pert. QCD roadblock

• CLEO-c: precision charm abs. branching ratio measurements

Leptonic decays : decay constants

Semileptonic decays: Vcs Vcd unitarity & form factors

Abs D hadronic Br's normalize B physics

Tests QCD techniques in c sector, apply to b sector

→Improved Vub, Vcb, Vtd & Vts

• strong coupling in Physics beyond the Standard Model

•CLEO-c: precise measurements of quarkonia spectroscopy & decay provide essential data to calibrate theory.

•Physics beyond the Standard Model in unexpected places:

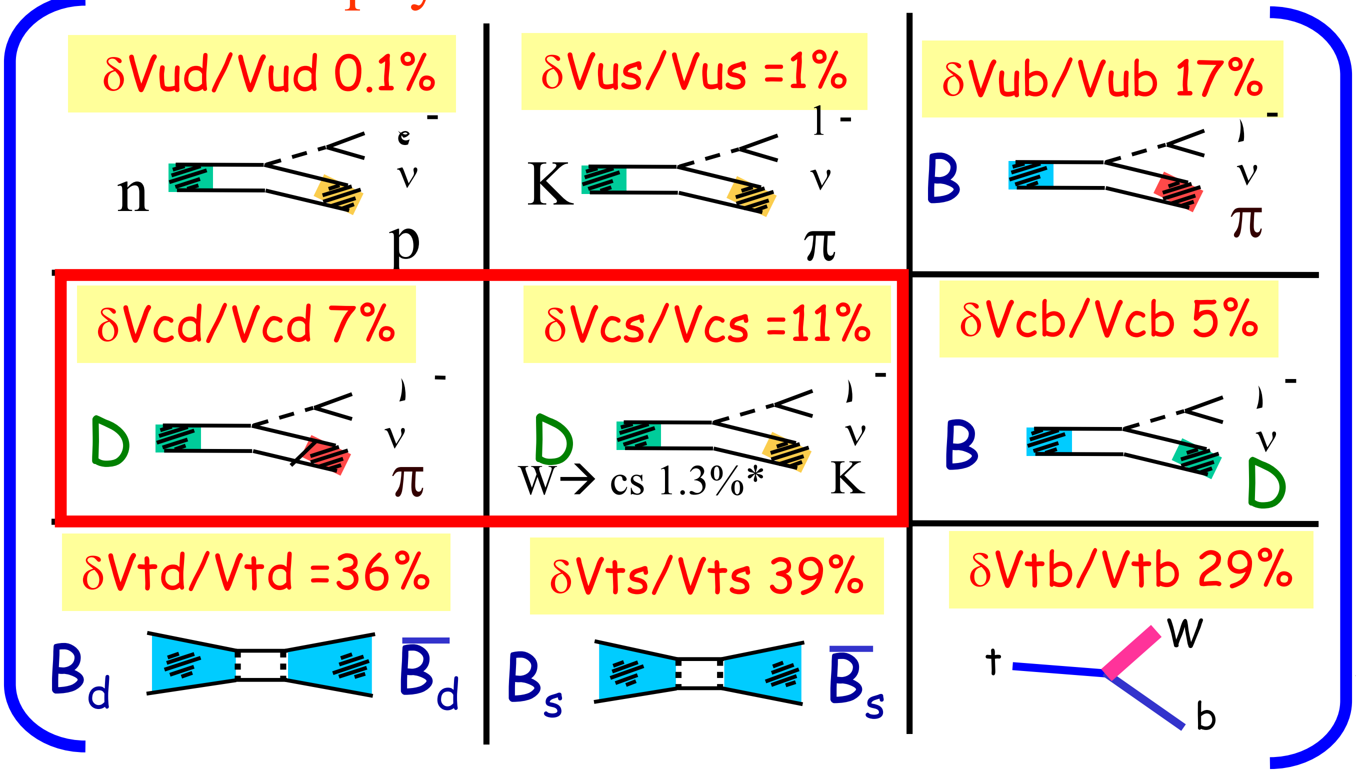
•CLEO-c: D-mixing, CPV, rare decays. + measure strong phases

CLEO-c will help build the tools to enable this decade's flavor physics and the next decade's new physics.

Precision Flavor Physics

Goal for the decade: high precision measurements of V_{ub}, V_{cb}, V_{ts}, V_{td}, V_{cs}, V_{cd}, & associated phases. Over-constrain the "Unitarity Triangles" - Inconsistencies → New physics !

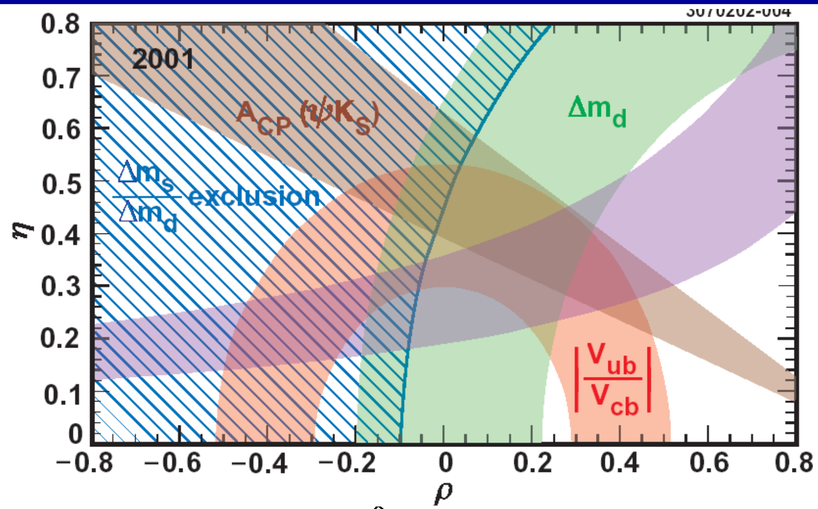
CKM Matrix Current Status:

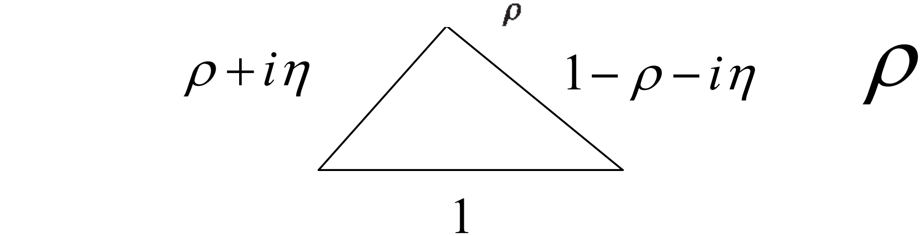


*Indirect determination

Many experiments will contribute. CLEO-c will enable precise new measurements to be translated into greatly improved CKM precision.

Importance of measuring f_D & f_{Ds}: Vtd & Vts





$$\Delta M_d = 0.50\,ps^{-1}\left[\frac{\sqrt{B_{B_d}}\,f_{B_d}}{200\,MeV}\right]^2\left[\frac{|V_{td}|}{8.8\times10^{-3}}\right]^2$$

$$\frac{\sigma(\rho)}{\rho} = 0.5\,\frac{\sigma(\Delta M_d)}{\Delta M_d} \oplus \frac{\sigma(f_B\sqrt{B_{B_d}})}{f_B\sqrt{B_{B_d}}}$$

(ICHEP02)1.2% ~15% (LQCD)

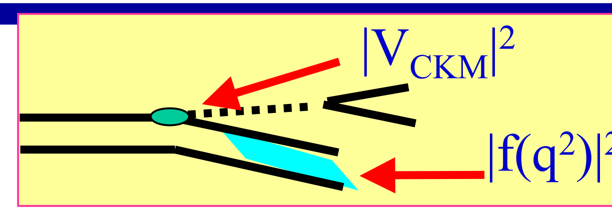
$$\frac{\Delta M_d}{\Delta M_s} \propto \left[\frac{\sqrt{B_{B_d}}\,f_{B_d}}{\sqrt{B_{B_s}}\,f_{B_s}}\right]^2\left[\frac{|V_{td}|}{|V_{ts}|}\right]^2$$

~5-7% (LQCD)

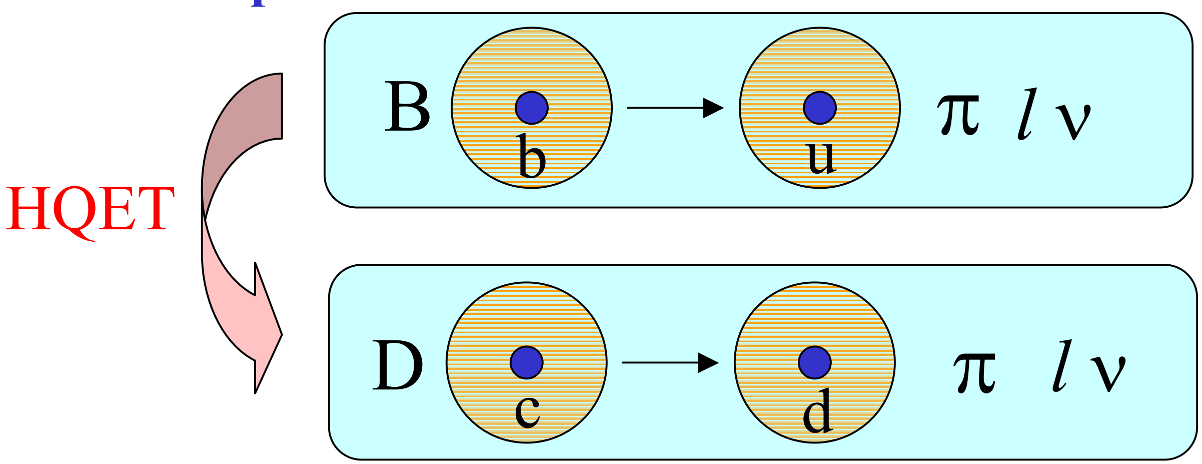
Lattice predicts f_B/f_D & f_{Bs}/f_{Ds} with small errors
if precision measurements of f_D & f_{Ds} existed (they do not)
We could obtain precision estimates of f_B & f_{Bs}
and hence precision determinations of Vtd and Vts
Similarly f_D/f_{Ds} checks f_B/f_{Bs}

Importance of absolute charm semileptonic decay rates.

$$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cs}|^2 p_K^3 |f_+(q^2)|^2$$



I. Absolute magnitude & shape of form factors are a stringent test of theory.
II. Absolute semileptonic rate gives direct measurements of V_{cd} and V_{cs}.
III Key input to ultra precise Vub vital CKM cross check of sin2β

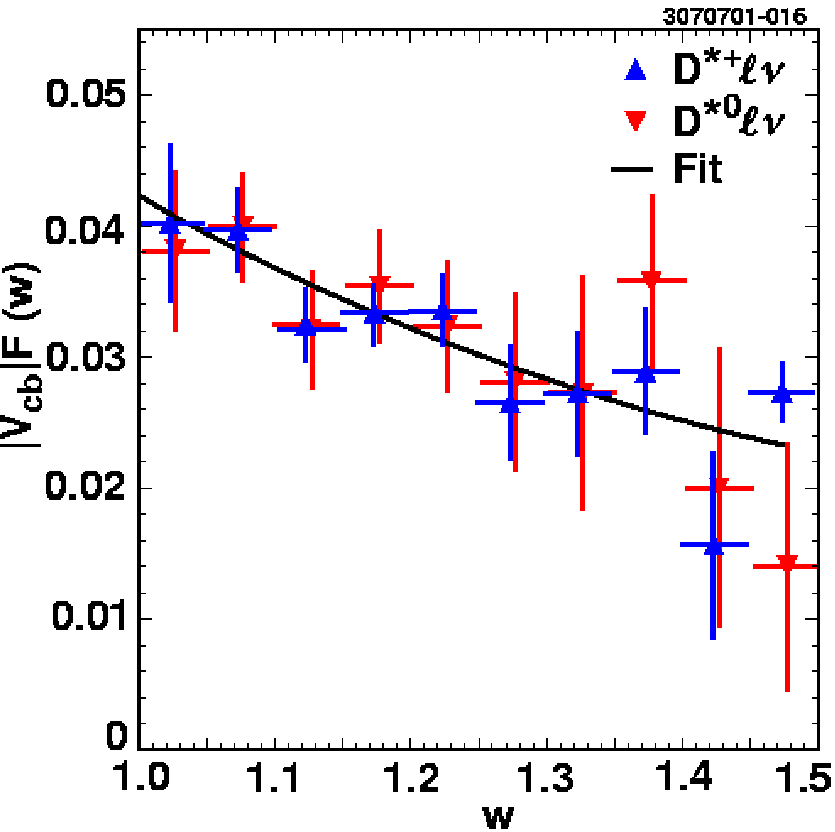


1) Measure D→π form factor in D→πlν. Calibrate LQCD uncertainties.
2) Extract V_{ub} at BaBar/Belle using *calibrated* LQCD calc. of B→π form factor.
3) But: need absolute Br(D →πlν) and high quality dΓ (D →πlν)/dEπ neither exist

The Importance of Precision Charm Absolute Branching Ratios I

V_{cb} from zero recoil in $B \to D^* l^+ \nu$

CLEO hep-ex/0203032



$$|V_{cb}| = (46.9 \pm 1.4 \pm 2.0 \pm 1.8) \times 10^{-3}$$

CLEO has single most precise Vcb by this technique

Stat: 3.0% Sys 4.3% theory 3.8%

Dominant Sys: ε_{π}slow, form factors

& B(D→Kπ) dB/B=1.3%

The importance of precision absolute Charm BRs II

HQET spin symmetry test
$$\frac{\Gamma\left(\bar{B}^o \to D^{*+} h^-\right)}{\Gamma\left(\bar{B}^o \to D^{+} h^-\right)} = 1$$

Test factorization with $B \to DD_s$

Understanding charm content of B decay (n_c)

Precision $Z \to bb$ and $Z \to cc$ (R_b & R_c)

At LHC/LC $H \to bb$ $H \to cc$

CLEO-c Proposed Run Plan

2002: Prologue: Upsilons ~1-2 fb^{-1} each at Υ(1S),Υ(2S),Υ(3S),…
Spectroscopy, matrix element, Γ_{ee}, η_B h_b
10-20 times the existing world's data (Fall 2001- Fall 2002)

CESR-c: Modify for low E operation: add wigglers for transverse cooling (talk of Dave Rice) Expect: 2-3.6 x 10^{32} cm^{-2} s^{-1})

2003: ψ(3770) – 3 fb^{-1}
30 million DD events, 6 million *tagged* D decays
(310 times MARK III)

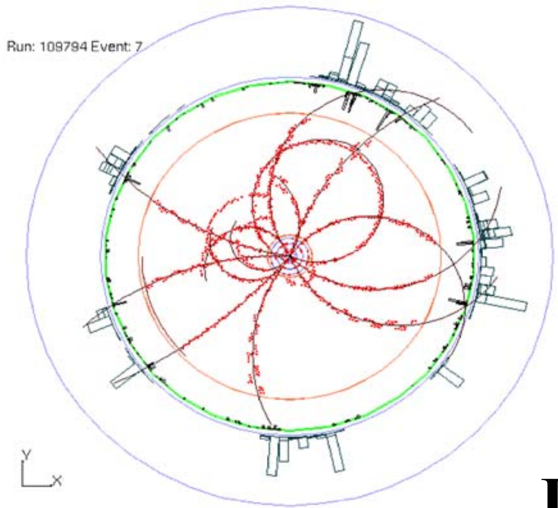
2004: $\sqrt{S} \sim 4140$ MeV – 3 fb^{-1}
1.5 million D_sD_s events, 0.3 million *tagged* D_s decays
(480 times MARK III, 130 times BES)

2005: ψ(3100), 1 fb^{-1} –1 Billion J/ψ decays
(170 times MARK III, 20 times BES II)

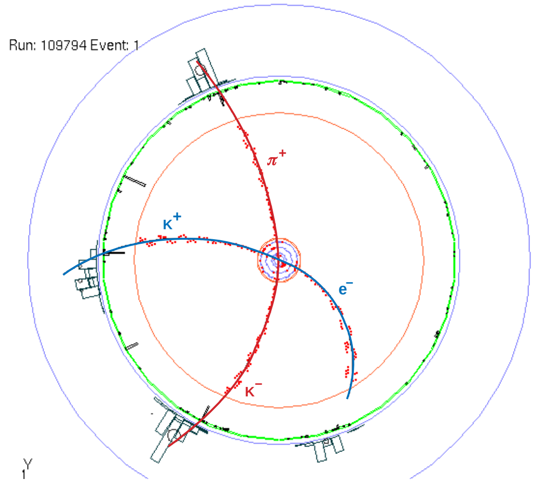
CLEO-c
A 3 year program

ψ(3770) events: simpler than Y(4S) events

Y(4S) event:



ψ(3770) event:



$D^0 \to K^-\pi^+$ $D^0 \to K^+e^-\nu$

- CLEO III works well,
- CLEO-c Replace Si with low mass drift chamber
- The demands of doing physics at 3-5 GeV are easily met by the existing detector.
- BUT: B Factories : 400 fb-1 ➔ ~500M cc by 2005, what is the advantage of running at threshold?

- Charm events produced at threshold are extremely clean
- Large σ, low multiplicity
- Pure initial state: no fragmentation
- Signal/Background is optimum at threshold

- Double tag events are pristine
  - These events are key to making absolute Br measurements
- Neutrino reconstruction is clean
- Quantum coherence aids D mixing & CP violation studies

Tagging Technique, Tag Purity

- $\psi(3770) \to D\bar{D}$ $\sqrt{s} \sim 4140 \to D_s D_s$

  Charm mesons have many large branching ratios (~1-15%)

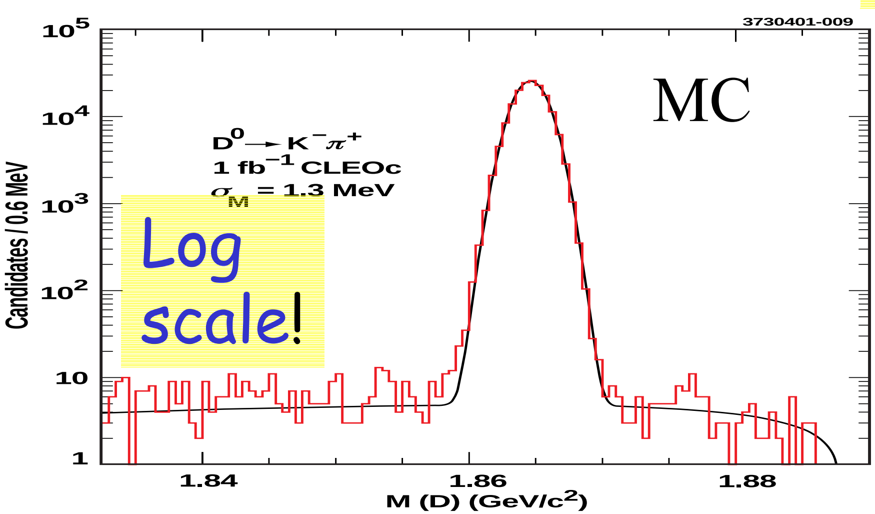
  High reconstruction eff

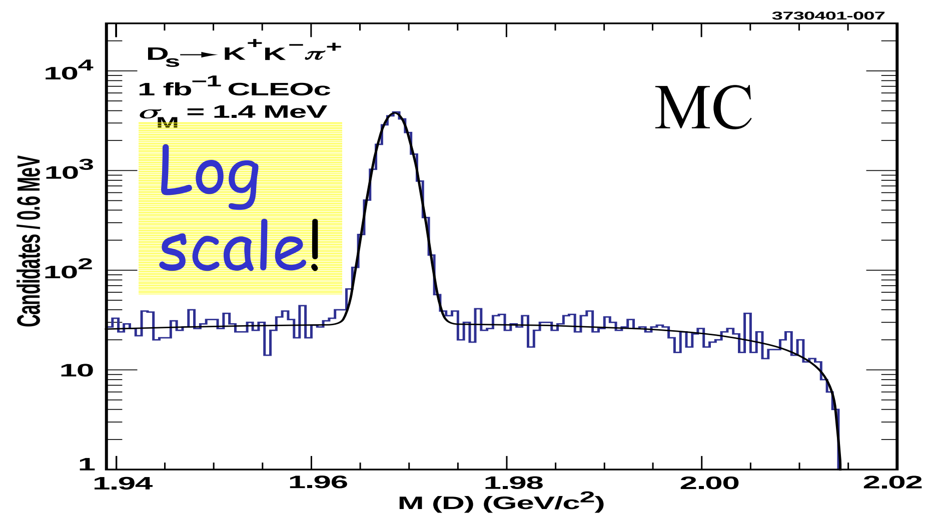
$\to$ high net tagging efficiency ~20% !

Anticipate 6M D tags 300K D_s tags:

$D \to K\pi$ tag. S/B ~5000/1 !

$D_s \to \phi\pi$ ($\phi \to KK$) tag. S/B ~100/1

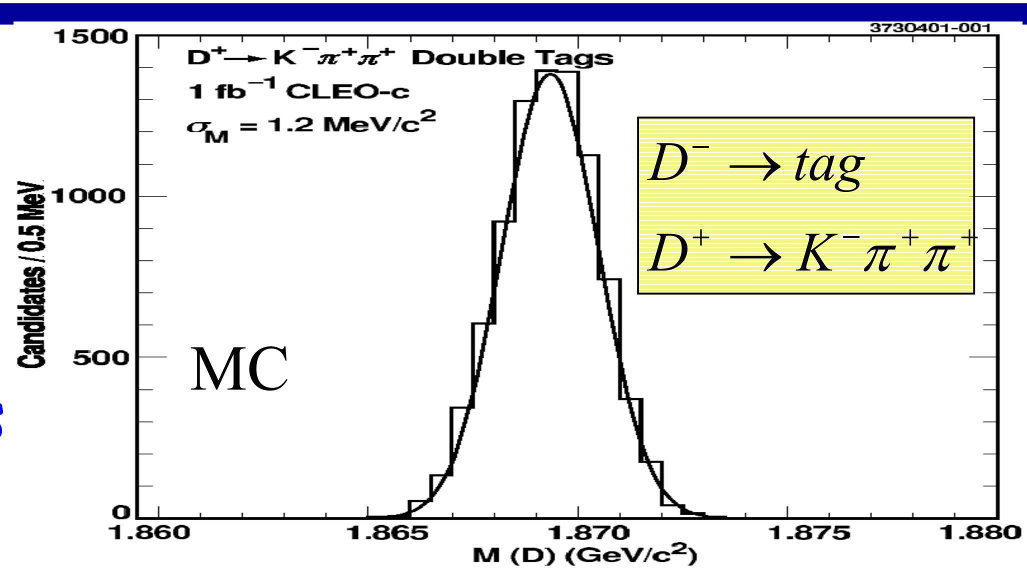




Beam constrained mass

Absolute Branching Ratios

~ Zero background in hadronic tag modes

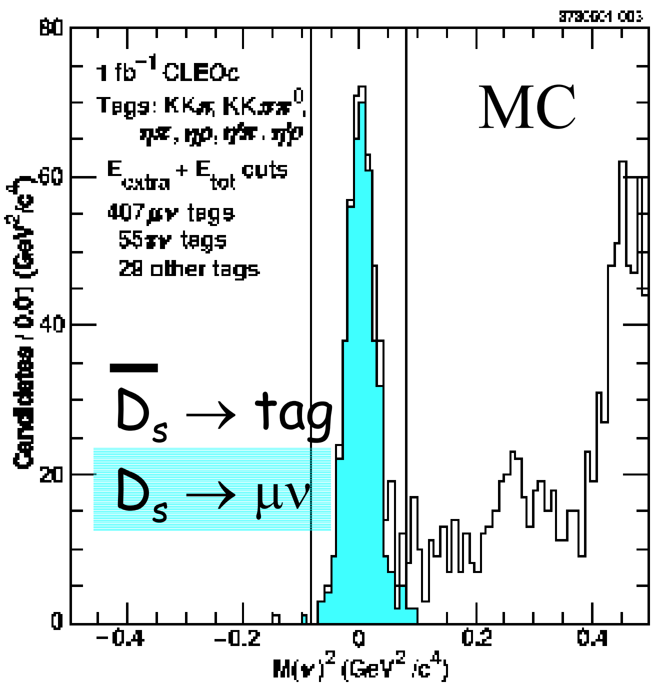


Measure absolute
Br (D→ X) with double tags
Br = # of X/# of D tags

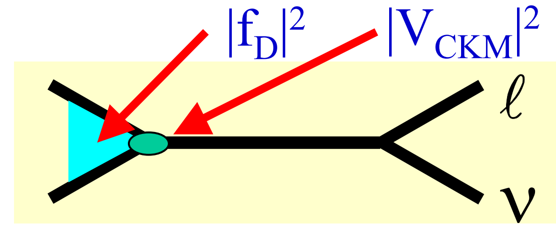
Decay	√s	L fb^{-1}	Double tags	PDG ($\delta B/B$ %)	CLEOc ($\delta B/B$ %)
$D^0 \to K^-\pi^+$	3770	3	53,000	2.4	0.6
$D^+ \to K^-\pi^+\pi^+$	3770	3	60,000	7.2	0.7
$D_s \to \phi\pi$	4140	3	6,000	25	1.9

CLEO-c sets absolute scale for all heavy quark measurements

f_{Ds} from Absolute Br($D_s \to \mu^+\nu$)



- Measure absolute Br ($D_s \to \mu\nu$)
- Fully reconstruct one D (tag)
- Require one additional charged track and no additional photons



•Compute MM^2

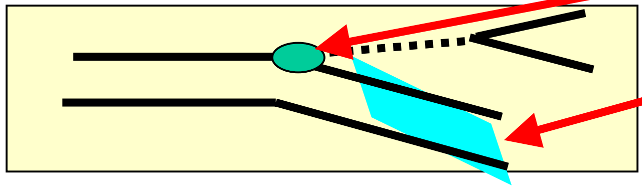
•Peaks at zero for $D_s^+ \to \mu^+\nu$ decay.

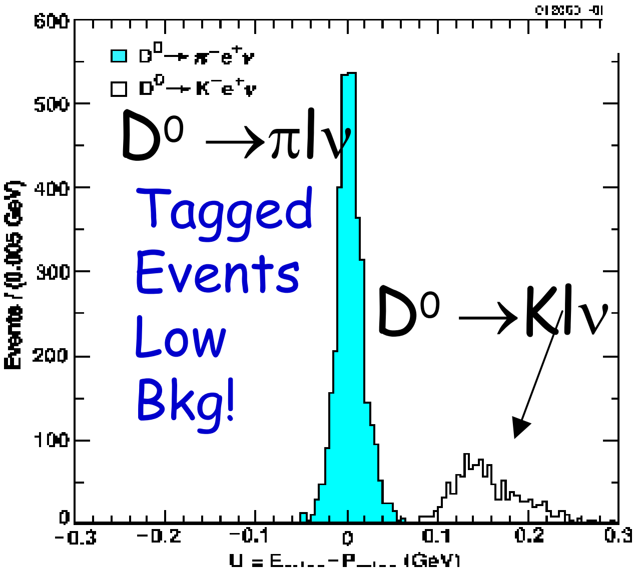
Expect resolution of ~M_{π^o}

Vcs, (Vcd) known from unitarity to 0.1% (1.1%)

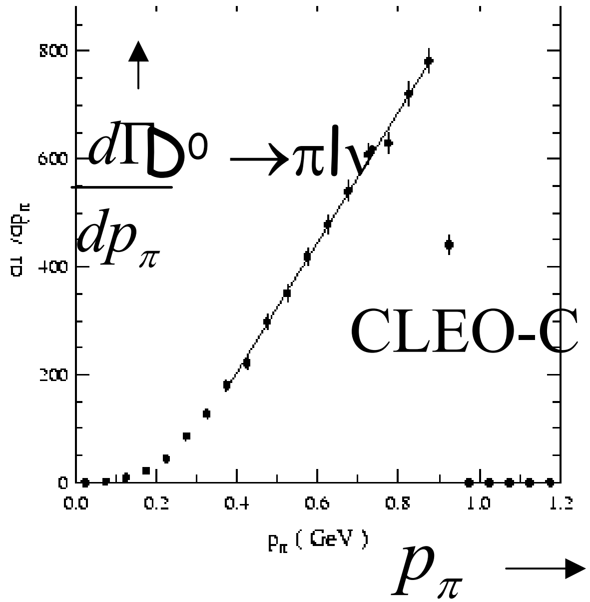
	Reaction	Energy(MeV)	L fb^{-1}	PDG	CLEO-c
f_{Ds}	$D_s^+ \to \mu\nu$	4140	3	17%	1.9%
f_{Ds}	$D_s^+ \to \tau\nu$	4140	3	33%	1.6%
f_{D+}	$D^+ \to \mu\nu$	3770	3	UL	2.3%

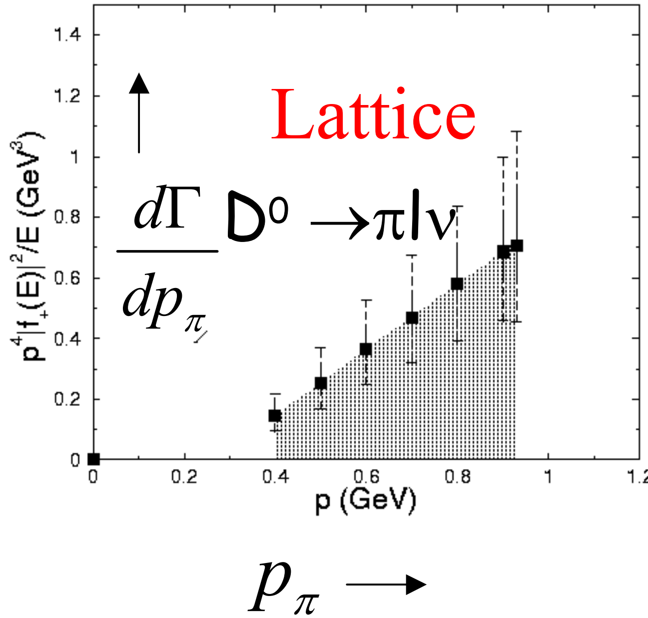
Semileptonic Decays $|V_{CKM}|^2 \, |f(q^2)|^2$





$U = E_{miss} - P_{miss}$





Assume 3 generation unitarity: for the first time measure complete set of charm PS → PS & PS → V absolute form factor magnitudes and slopes to a few% with ~zero bkgd in one experiment. Stringent test of theory!

CLEO-c Impact semileptonic dB/B

1 : $D^0 \to K^- e^+ \nu$

2 : $D^0 \to K^{*-} e^+ \nu$

3 : $D^0 \to \pi^- e^+ \nu$

4 : $D^0 \to \rho^- e^+ \nu$

5 : $D^+ \to \bar{K}^0 e^+ \nu$

6 : $D^+ \to \bar{K}^{*0} e^+ \nu$

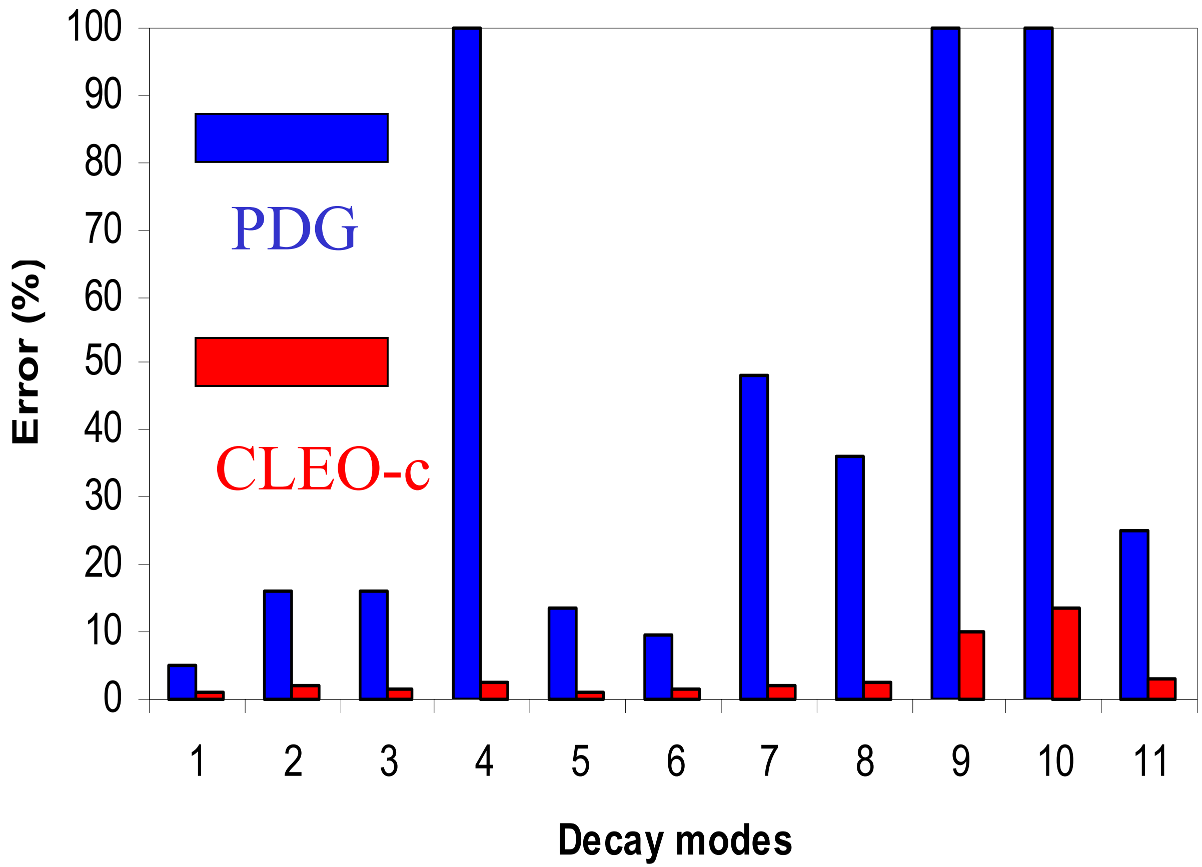
7 : $D^+ \to \pi^0 e^+ \nu$

8 : $D^+ \to \rho^0 e^+ \nu$

9 : $D_s \to K^0 e^+ \nu$

10 : $D_s \to K^{*0} e^+ \nu$

11 : $D_s \to \phi e^+ \nu$



CLEO-c will make significant improvements in the precision with which each absolute charm semileptonic branching ratio is known

Determining Vcs and Vcd

combine semileptonic and leptonic decays eliminating V CKM

$\Gamma(D^+ \to \pi l \nu) / \Gamma(D^+ \to l \nu)$ independent of Vcd
Test rate predictions at ~4%

$\Gamma(D_s \to \phi l \nu) / \Gamma(D_s \to l \nu)$ independent of Vcs
Test rate predictions at ~ 4.5%

Test amplitudes at 2%
Stringent test of theory! If theory passes the test.....

I

$D^0 \to K^- e^+ \upsilon$ δVcs /Vcs = 1.6% (now: 11%)

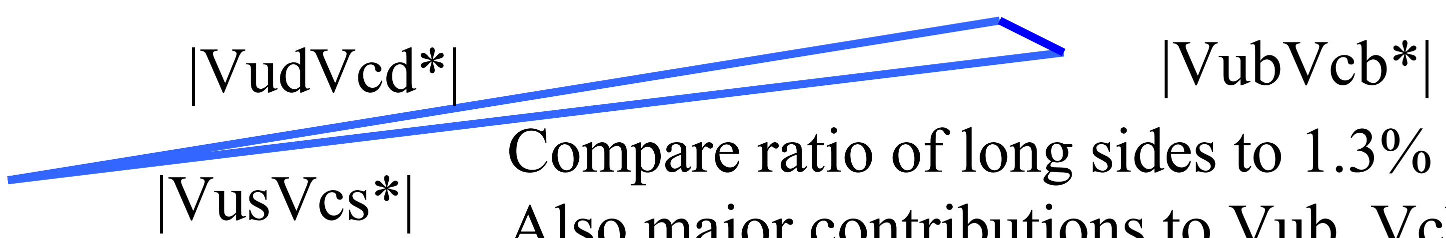
$D^0 \to \pi^- e^+ \upsilon$ δVcd /Vcd = 1.7% (now: 7%)

II Use CLEO-c validated lattice form factor + B factory
$B \to \rho/\pi/\eta/l\nu$ for ultra precise Vub

Unitarity Constraints

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

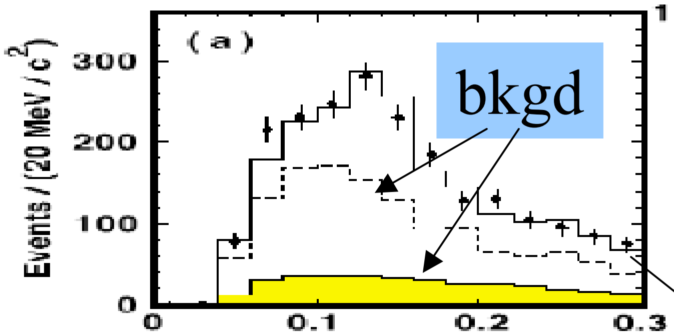
$$V_{CKM} = \begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4)$$

- $|Vud|^2 + |Vus|^2 + |Vub|^2 = 1$??
  With current values this test fails at ~ 2.7σ (PDG2002)
- $|Vcd|^2 + |Vcs|^2 + |Vcb|^2 = 1$??
  CLEO –c: test to ~3% (if theory D →K/πlν good to few %)
  Also 1st column
- 

Compare ratio of long sides to 1.3%
Also major contributions to Vub, Vcb, Vtd, Vts.

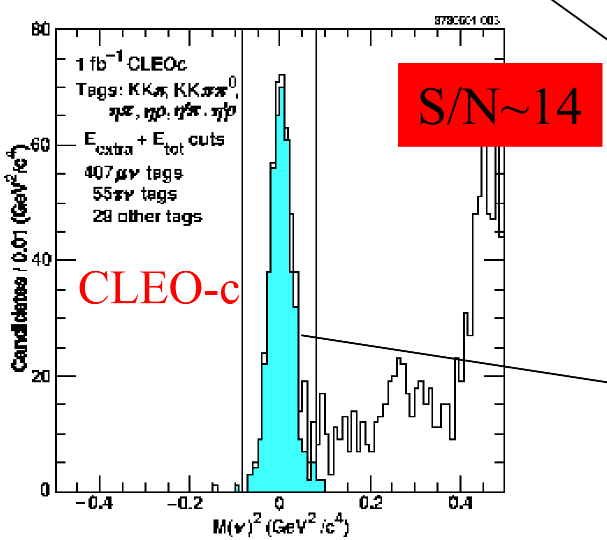
Compare B factories & CLEO-C

CLEO: f D_S : $D_S^* \rightarrow D_S \gamma$ $D_S \rightarrow \mu\nu$



$\Delta M = M(\mu\nu\gamma) - M(\mu\nu)$ GeV/c

B Factory CLEO technique with improvements



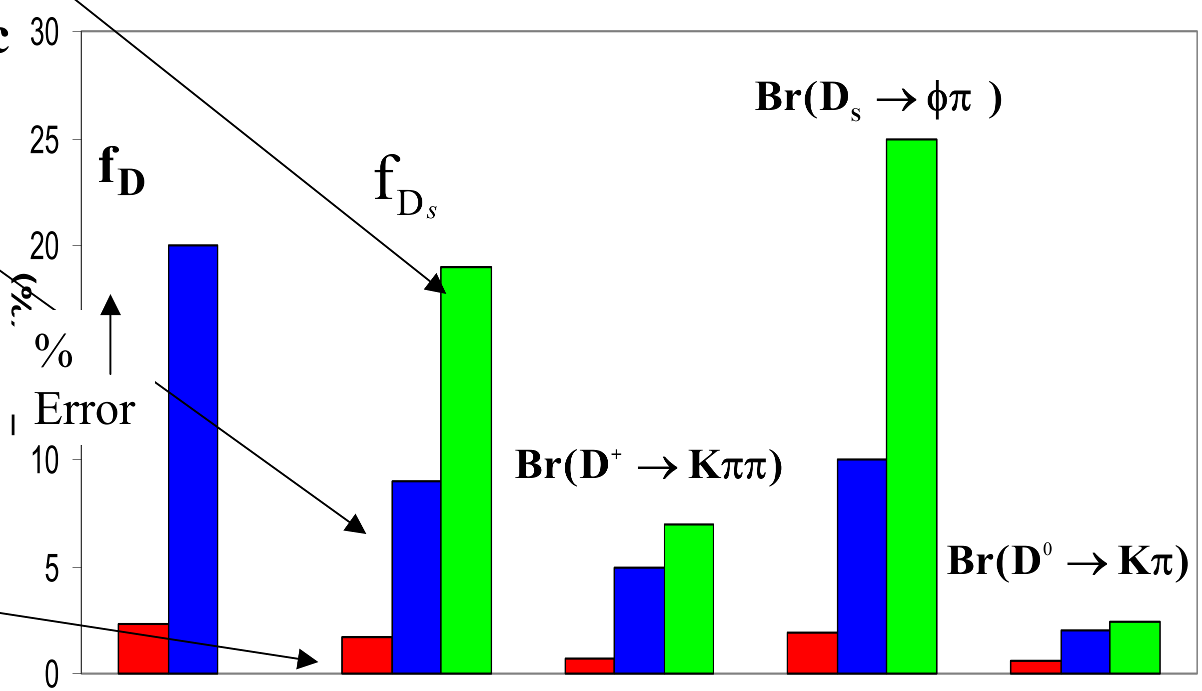
CLEO-c
3 fb^{-1}

Statistics limited

BFactory
400 fb^{-1}

Systematics & Background limited

PDG



CLEO-c Probes of New Physics

D mix & DCPV suppressed in SM – all the more reason to measure them

DD mixing $x = \Delta m/\Gamma$ $y = \Delta\Gamma/2\Gamma$ $\psi(3770) \to DD (C = -1)$

exploit coherence, no DCSD. $\psi(4140) \to \gamma DD$ $(C = +1)$

$\sqrt{r_D} = \sqrt{[(x^2+y^2)/2]} < 0.01$ @ 95%CL ($K\pi K\pi$, $Kl\nu, Kl\nu$)

- CP violating asymmetries
  - Sensitivity: $A_{cp} < 0.01$
  - Unique: $L=1, C=-1$ CP tag one side, opposite side same CP

$CP = \pm 1 \leftarrow \psi(3770) \to CP = \pm 1$ = CPV

- CP eigenstate tag X flavor mode

Gronau, Grossman, Rosner hep-ph/0103110

$K^+K^- \leftarrow D_{CP} \leftarrow \psi(3770) \to D_{CP} \to K^-\pi^+$

Measures strong phase diff. CF/DCSD

$\Delta\cos\delta \sim 0.05$. Crucial input for B factories

Needed for γ in $B \to DK$

$$\begin{cases} y' = y\cos\delta - x\sin\delta \\ x' = x\cos\delta + y\sin\delta \end{cases}$$

Rare charm decays. Sensitivity: 10^{-6}

Probing QCD

→Verify tools for strongly coupled theories
→ Quantify accuracy for application to flavor physics

- ψ and Υ Spectroscopy
  - Masses, spin fine structure
- Leptonic widths for S-states.
  - EM transition matrix elements
    - Υ resonances winter '01-summer'02 ~ 4 fb^{-1} total

Confinement, Relativistic corrections

Wave function
Tech: $f_{B,K}\sqrt{B_K}\ f_{D\{s)}$

Form factors

Rich calibration and testing ground for theoretical techniques → apply to flavor physics

J/Ψ running 2005 10^9 J/ Ψ x 20 BES II

- Uncover new forms of matter –gauge particles as constituents
  - Glueballs $G=|gg\rangle$ Hybrids $H=|gqq\rangle$

Study fundamental states of the theory

The current lack of strong evidence for these states is a fundamental issue in **QCD.** Requires detailed understanding of ordinary hadron spectrum in 1.5-2.5 GeV mass range.

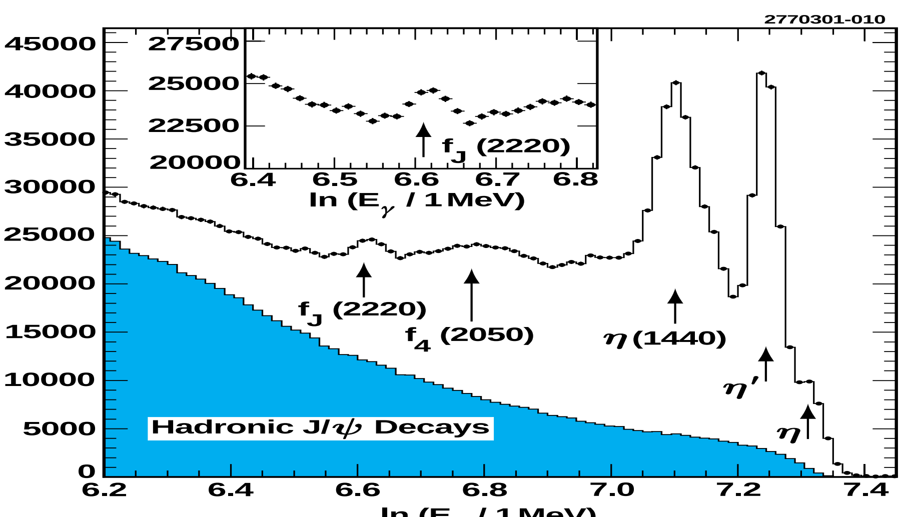
Gluonic Matter

- Gluons carry color charge: *should bind!*

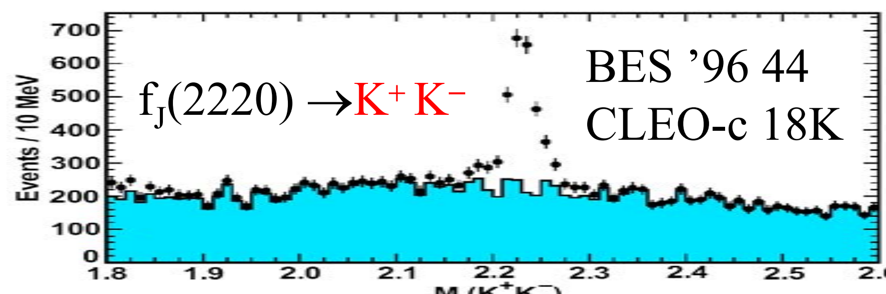
- But, like Jim Morrison, glueballs have been sighted too many times without confirmation....
- CLEO-c 1st high statistics experiment with modern 4π detector covering 1.5-2.5 GeV mass range.
- Radiative ψ decays:ideal glue factory:

- (60 M J/$\Psi \rightarrow \gamma$X)

Example: $f_J(2220)$ Inclusive γ



Exclusive:



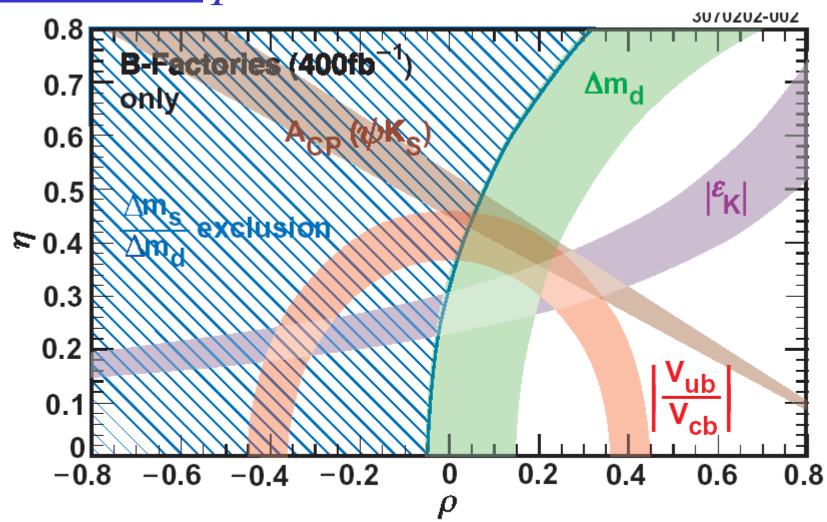
corroborating checks:

Anti-search in $\gamma\gamma$: /Search in Υ(1S)

Note: with more data BESII no longer see evidence of $f_j(2220)$

CLEO-c Physics Impact

- *Crucial Validation of Lattice QCD:* Lattice QCD will be able to calculate with accuracies of 1-2%. *The CLEO-c decay constant and semileptonic data will provide a "golden," & timely test. QCD & charmonium data provide additional benchmarks*. (E2 Snowmass WG)



B Factories only ~2005

Imagine a world Where we have theoretical mastery of non-perturbative QCD at the 2% level

CLEO-c Physics Impact

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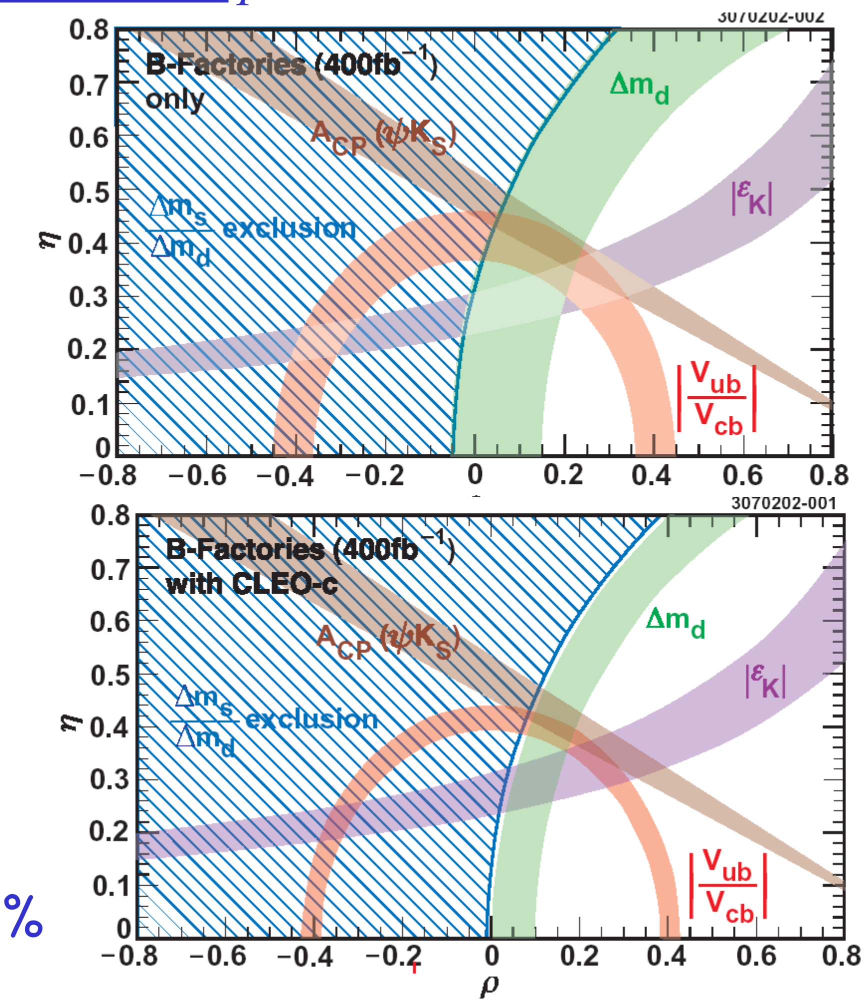
B Factories only ~2005

Imagine a world Where we have theoretical mastery of non-perturbative QCD at the 2% level

Theory errors = 2%



CLEO-c Physics Impact

- Knowledge of absolute charm branching fractions is now contributing significant errors to measurements involving b's. CLEO-c can also resolve this problem in a timely fashion
- Improved Knowledge of CKM elements, which is now not very good.

PDG

CLEO-c data and **LQCD**

Vcd	Vcs	Vcb	Vub	Vtd	Vts
7%	11%	3-5%	17%	36%	39%
1.7%	1.6%	3%	5%	5%	5%

PDG

B Factory/Tevartron Data & CLEO-c Lattice Validation

The potential to observe new forms of matter- glueballs & hybrids, and new physics D mixing/CPV/rare Provides a discovery component to the program

Competition? Complimentary to Hall D/HESR/BEPCII-BESIII (All late decade none approved)

(Snowmass E2 WG)

The Road to Approval

•CLEO-C workshop (5/ 01): successful ~120 participants, 60 non CLEO
•Snowmass working groups E2/P2/P5 : CLEO-c received strong support
• HEPAP LRPC "The sub-panel endorses CESR-c and recommends that it be funded."

CESR/CLEO Program Advisory Committee 9/01 endorsed CLEO-c
•Proposal submission (part of Cornell 5-year renewal) to NSF 10/ 01.
•External mail reviews uniformly excellent
• NSF Site visit panel; 3/2002 endorsed CLEO-c
• National Science Board (NSF) will meet in November.
• Expect approval shortly thereafter
•See http://www.lns.cornell.edu/CLEO/CLEO-C/ for project description
•We welcome discussion and new members

The CLEO-c Program: Summary

- Powerful physics case
  - Precision flavor physics – *finally*
  - Nonperturbative QCD – *finally*
  - Probe for New Physics

Direct: Vcs Vcd & tests QCD techniques aids BABAR/Belle/ CDF/D0/BTeV/LHC-b with Vub,Vcb,Vtd,Vts

- Unique: not duplicated elsewhere
- Highest performance detector to run @ charm threshold
- Flexible, high-luminosity accelerator
- Experienced collaboration

- Optimal timing
  - LQCD maturing
  - allows Flavor physics to reach
  - its full potential this decade
  - Beyond the SM in next decade

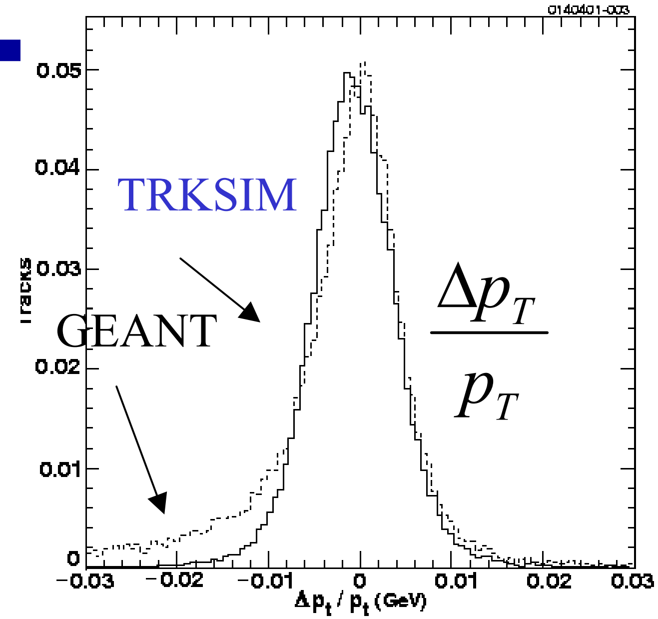
The most comprehensive & in depth study of non-perturbative QCD yet proposed in particle physics

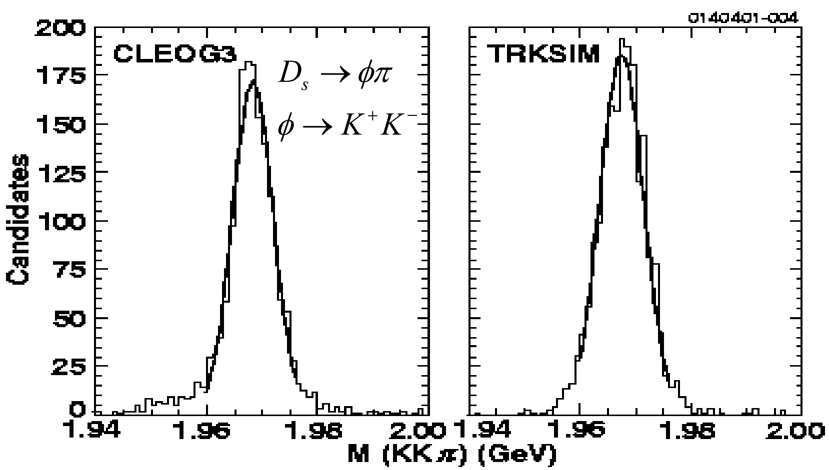
Analysis Tools

- Our estimate of CLEO-C reach has been evaluated using simulation tools developed during our long experience with heavy flavor physics

- Fast MC simulation: TRKSIM
- Parameterized resolutions and efficiencies
- Standard event generators
- Excellent modeling of resolutions, efficiencies and combinatorial bkgd
- No electronic noise or extra particles

- Performance validated with full GEANT simulation (CLEOG)





Compare to B factories, example f_{Ds}

FDs at a B factory Scale from CLEO analysis

–Search for $D_s^* \to D_s \gamma$, $D_s \to \mu\nu$

–Directly detect γ, μ, Use hermeticity of detector to reconstruct ν

–Plot mass difference but Backgrounds are LARGE!

•Use $D_s \to e\nu$ for bkgd determination but precision limited by systematics

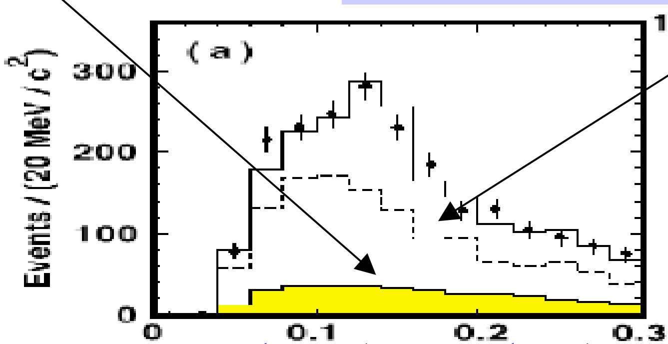
–FDs Error ~23% now (CLEO)

–400 fb^{-1} ~6-9%

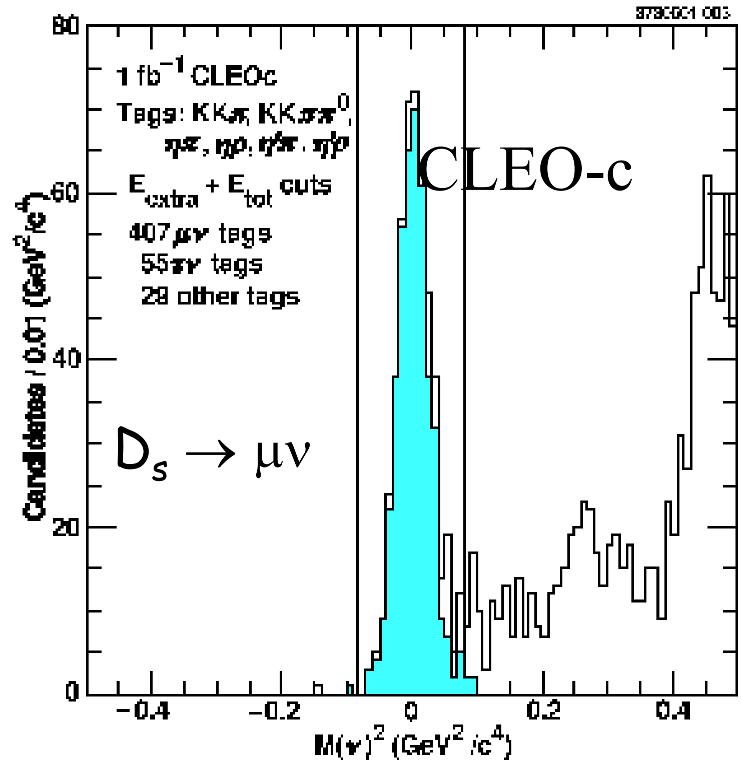
CLEO signal 4.8fb^{-1}

Excess of μ over e fakes

Background measured with electrons

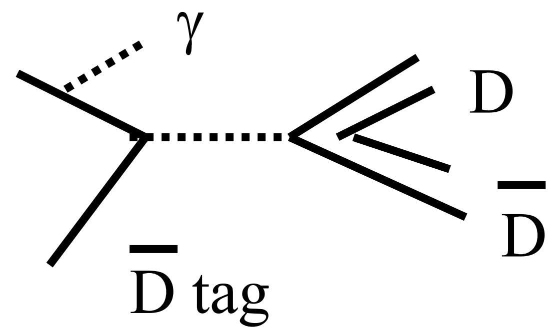


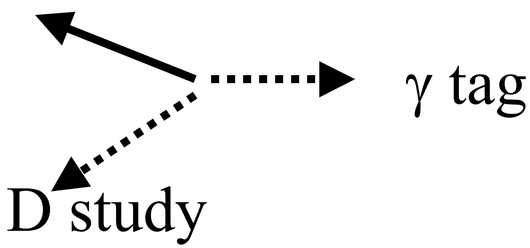
$\Delta M = M(\mu\nu\gamma) - M(\mu\nu)$ GeV/c



ISR Charm Events at B Factories

Initial State Radiation photon reduces $\sqrt{s}$



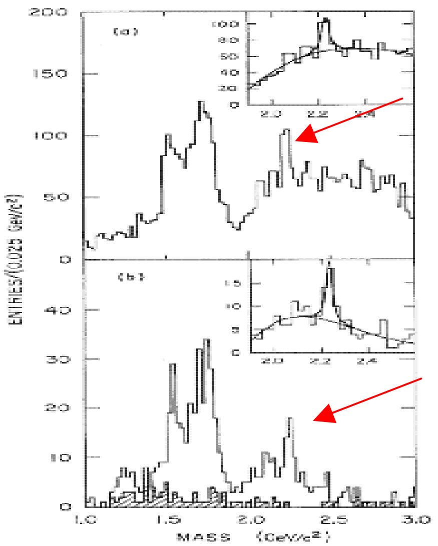


Measurement	#events	
	BaBar/Belle	CLEOc
	500 fb^{-1}	3fb^{-1}
$D_s^+ \to \mu\nu$	330	1,221
$D^+ \to \mu\nu$	50	672
$D^+ \to K^- \pi^+\pi^+$	6,750	60,000
$D_s^+ \to \phi\pi$	221	6,000

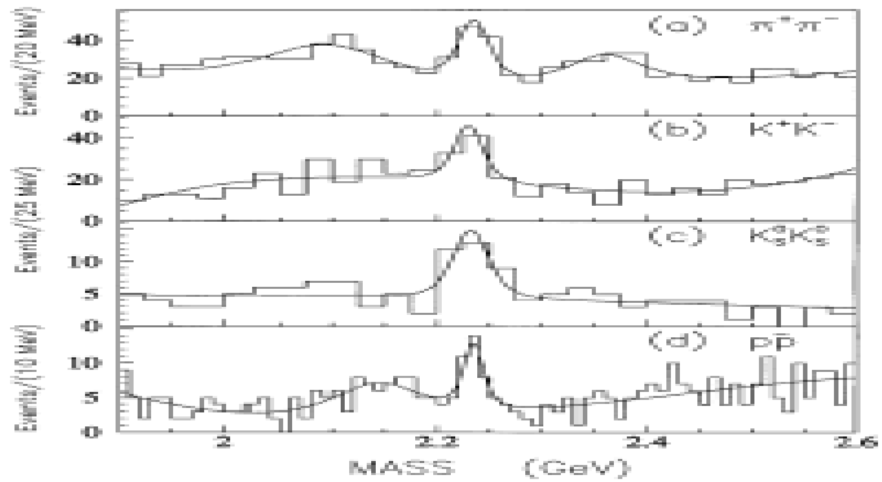
ISR projections made by BaBar show ISR technique is not statistically competitive with CLEO-c. Systematic errors are also much larger.

The $f_J(2220)$:A case study

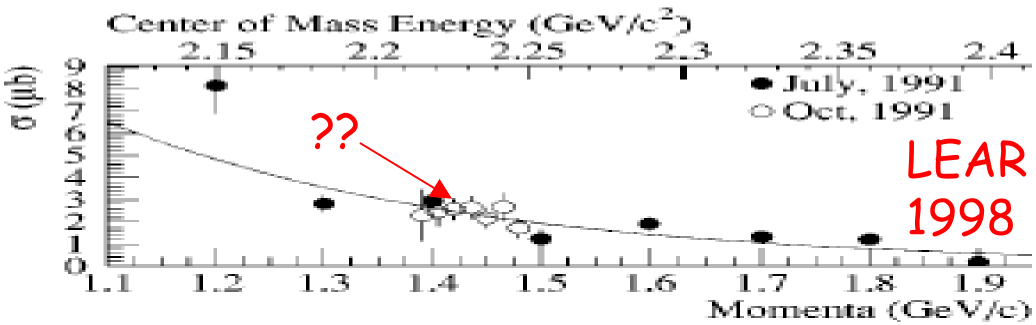
Glueballs are hard to pin down, often small data sets & large bkgds



MARKIII
(1986)



BES
(1996)

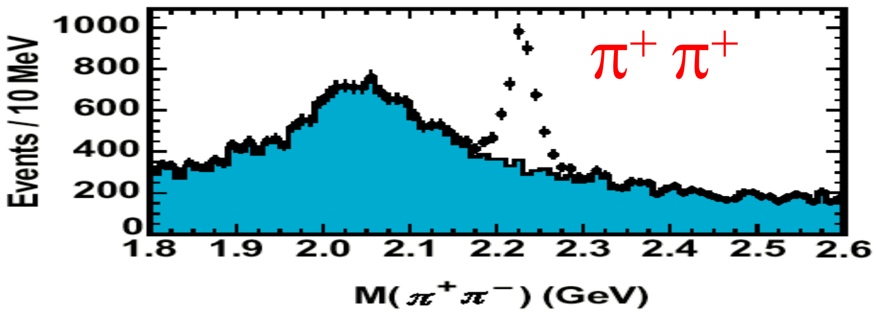


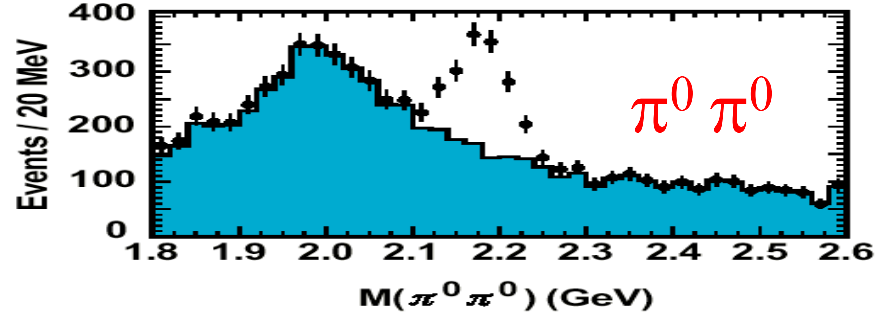
LEAR
1998

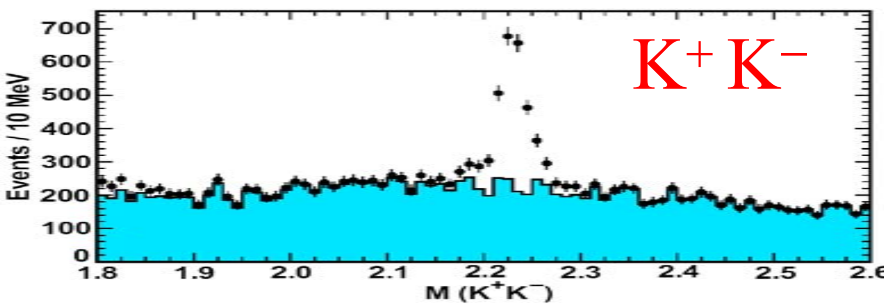
New BES data does not find the $f_J(2220)$!
(but not published)

Crystal barrel: $p\bar{p} \rightarrow K^0_s K^0_s$

$f_J(2220)$ in CLEO-c?







	BES	CLEO-C
$\pi^+\pi^-$	74	32000
$\pi^0\pi^0$	18	13000
K^+K^-	46	18600
K_SK_S	23	5300
pp	32	8500
$\eta\eta$	–	5000

CLEO-c has *corroborating checks:*

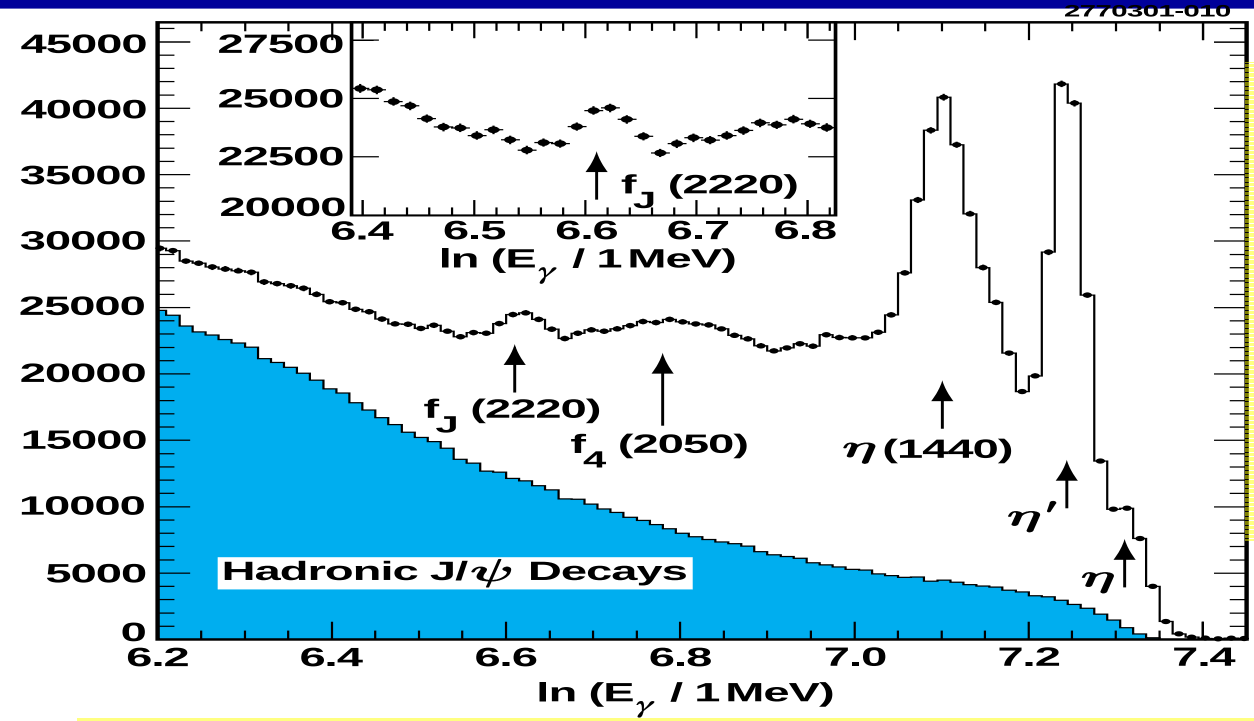
2 Anti-search in Two Photon Data: $\gamma\gamma \rightarrow f_J(2220)$:

- CLEO II: $\Gamma_{\gamma\gamma}B(f_J(2220) \rightarrow \pi\pi/K_SK_S) < 2.5(1.3)$ eV
- CLEO III: sub-eV sensitivity (new UL to appear ~1 week)

3

- Upsilonium Data: $\Upsilon(1S)$: Tens of events

Inclusive Spectrum J/ψ →γX



Inclusive photon spectrum a good place to search: monochromatic photons for each state produced

Unique advantages of CLEO-c
+ Huge data set
+Modern 4π detector (Suppress hadronic bkg: $J/\psi \rightarrow \pi^0 X$)
+Extra data sets for corroboration γγ, ϒ(1S):
Lead to Unambiguous determination of J^{PC} & gluonic content

Comparison with Other Expts

China:

BES II is running now.
BES II --> BES III upgrade
BEPC I --> BEPC II upgrade, ~10^{32}
2 ring design at 10^{33}under consideration (workshop 10/01)
(being proposed)
Physics after 2006? if approval & construction goes ahead.

BES III complimentary to CLEO-c if new detector is Comparable

Quantity	BES II	CLEO-C
J/psi yield	50M	> 1000M
dE/dx res.	9%	4.9%
K/pi separation up to	600 MeV	1500 MeV
momentum res. (500Mev)	1.3%	0.5%
Photon resolution (100 Mev)	70 MeV	4 MeV
Photon resolution (1000 Mev)	220 MeV	21 MeV
Minimum Photon Energy	80 MeV	30 MeV
Solid angle for Tracking	80%	94%

HALL-D at TJNAL (USA)

γp to produce states with exotic Quantum Numbers
Focus on light states with J^{PC} = 0+-, 1+-, …
Complementary to CLEO-C focus on heavy states with J^{PC}=0++, 2++, …
Physics in 2009?

+ HESR at GSI Darmstadt $\bar{p}$ p complementary, being proposed: physics in 2007?

Additional topics

- Ψ' spectroscopy (10^8 decays) $\eta'_c h_c$....
- $\tau^+\tau^-$ at threshold (0.25 fb^{-1})
  - measure m_τ to ± 0.1 MeV
  - heavy lepton, exotics searches
- $\Lambda_c\Lambda_c$ at threshold (1 fb^{-1})
  - calibrate absolute BR($\Lambda_c \rightarrow pK\pi$)
- $R=\sigma(e^+e^- \rightarrow \text{hadrons})/\sigma(e^+e^- \rightarrow \mu^+\mu^-)$
  - spot checks

Likely to be added to run plan

If time permits

HEPAP Sub-panel on Long Range Planning for U.S.High-Energy Physics

- Appendix A: Roadmap for Particle Physics

A.4.4 (pp 75-76.)

"The CLEO collaboration has proposed a program using electron-positron annihilation in the 3 to 5 GEV energy region, optimized for physics studies of charmed particles. These studies would use the CESR storage ring, modified for running at lower energies, and the upgraded CLEO detector. The storage ring would offer significantly higher luminosity and the CLEO detector would provide much better performance than has been available to previous experiments in this energy region."

"The improved measurements of charmed particle properties and decays are matched to theoretical progress in calculating charm decay parameters using lattice QCD. The conversion of the storage ring for low energy running would cost about $5M, and could be completed in a year, so that physics studies could begin sometime in 2003. The physics program would then require three years of running the modified CESR facility

"The sub-panel endorses CESR-c and recommends that it be funded."

- http://doe-hep.hep.net/home.html