Hirschegg 2007:

The Structure and Dynamics of Hadrons

Spectroscopy at CLEO

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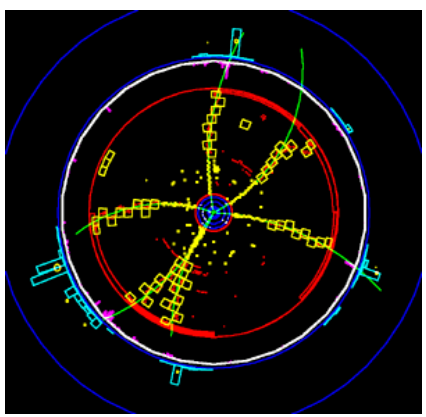


CLEO

Rensselaer

What does "hadron spectroscopy" tell us about the "hadron dynamics?"

The pattern of energy levels gives important clues to what are the relevant "degrees of freedom."

This pattern, and matrix elements, tell how a complicated system can be reduced to a "simple" one.

An example from nuclear physics: Dynamics of the samarium isotopes

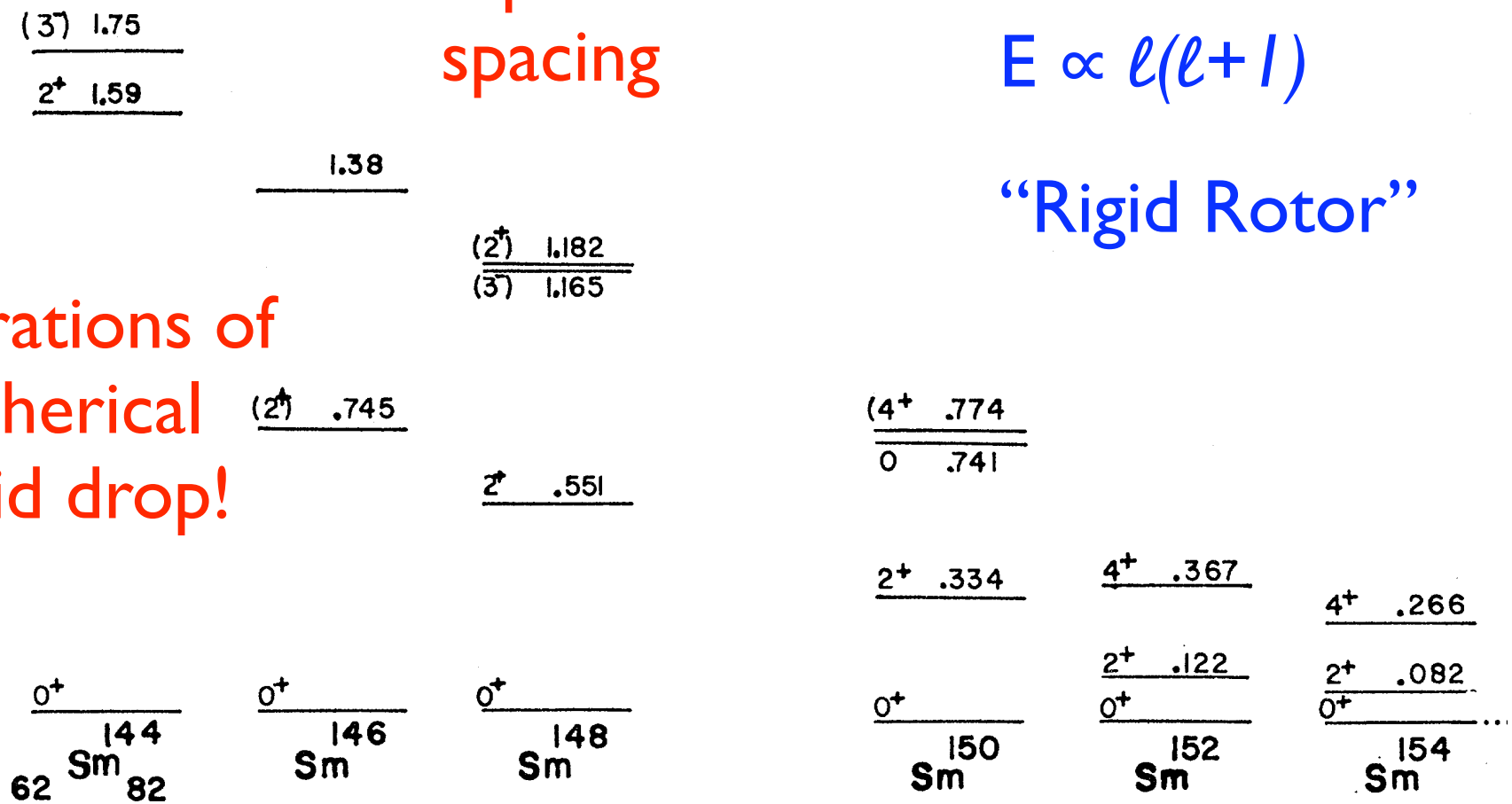
P. Stoler, et al., Phys.Rev. 155(1967)1334

Equal spacing

$E \propto \ell(\ell+1)$

"Rigid Rotor"

Vibrations of a spherical liquid drop!



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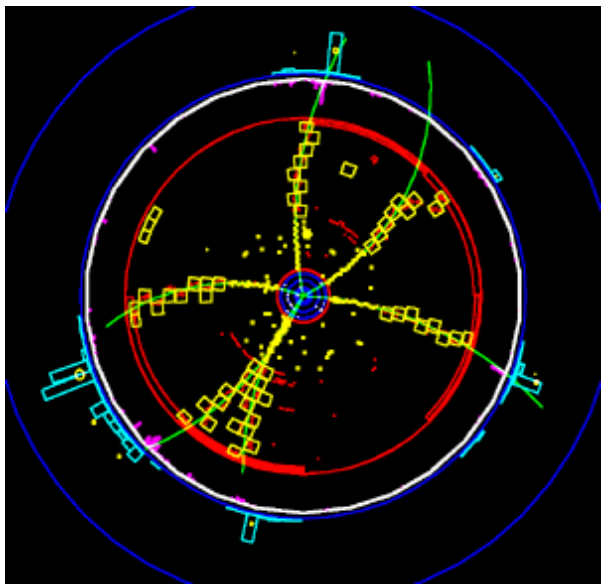
About CLEO

Inclusive detection of e^+e^- annihilation reaction products using varying energies in the center-of-mass.



1979 thru 2002: $E_{CM} \approx 10$ GeV for B's, Υ(nS), charm, ...

2002 thru 2008: $E_{CM} \approx 4$ GeV for low background charm

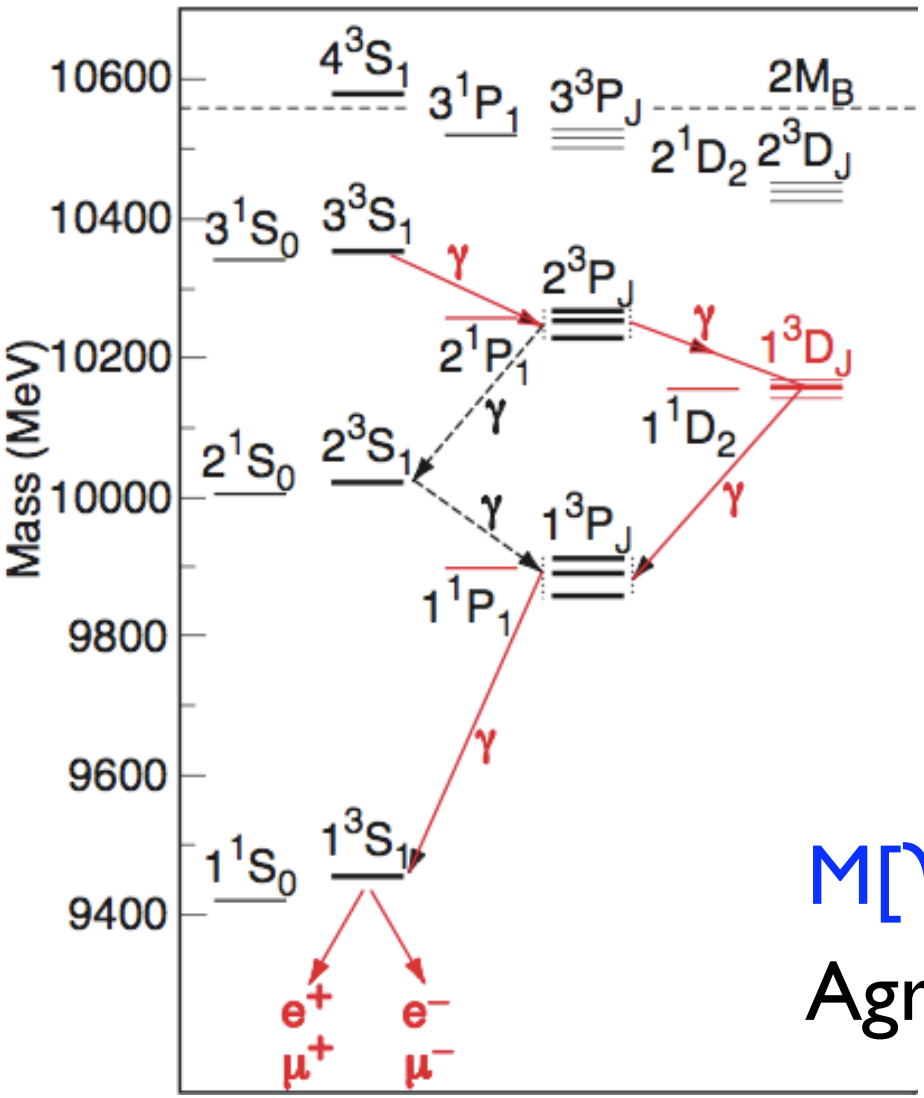
A Personal History of CLEO and CESR
Karl Berkelman, World Scientific (2004)

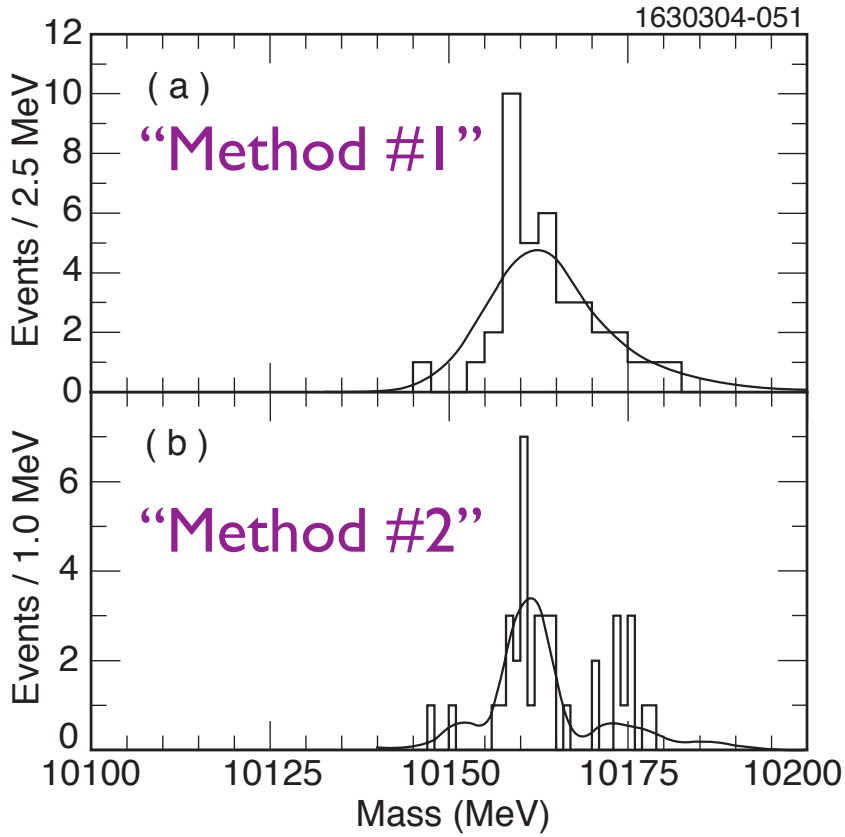
Topics for this talk

- $\Upsilon(1D)$ discovery: Precision test of Lattice QCD
- Discovery of singlet charmonium, the $h_c(3520)$
- Rate for $X_c^0 \to \gamma J/\psi$: New Lattice QCD results
- Light scalars/tensors: $\Upsilon(1S) \to \gamma\pi^0\pi^0$
- Precise masses for Σ_c baryons
- Confirmation and study of $Y(4260)$
- Search for $\psi(2S) \to \eta_c 3\pi$
- Exclusive e^+e^- in the charmonium region
- Coming up: The new $\psi(2S)$ sample

Discovery of the Υ(1D)

Phys.Rev.D 70(2004)032001





$M[\Upsilon(1^3D_2)] = 10161.1 \pm 0.6 \pm 1.6$ MeV

Agreement with Precision LQCD

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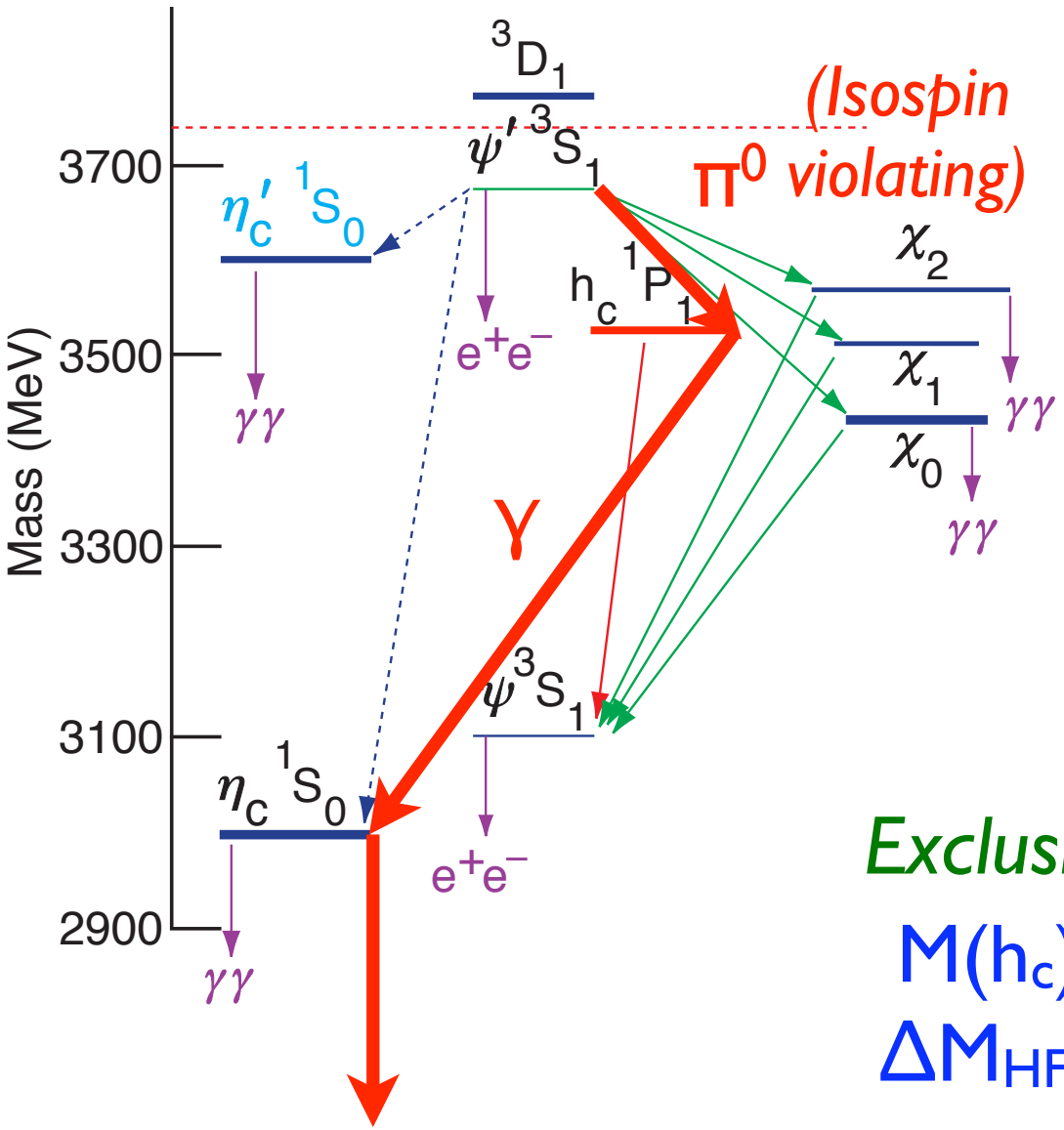
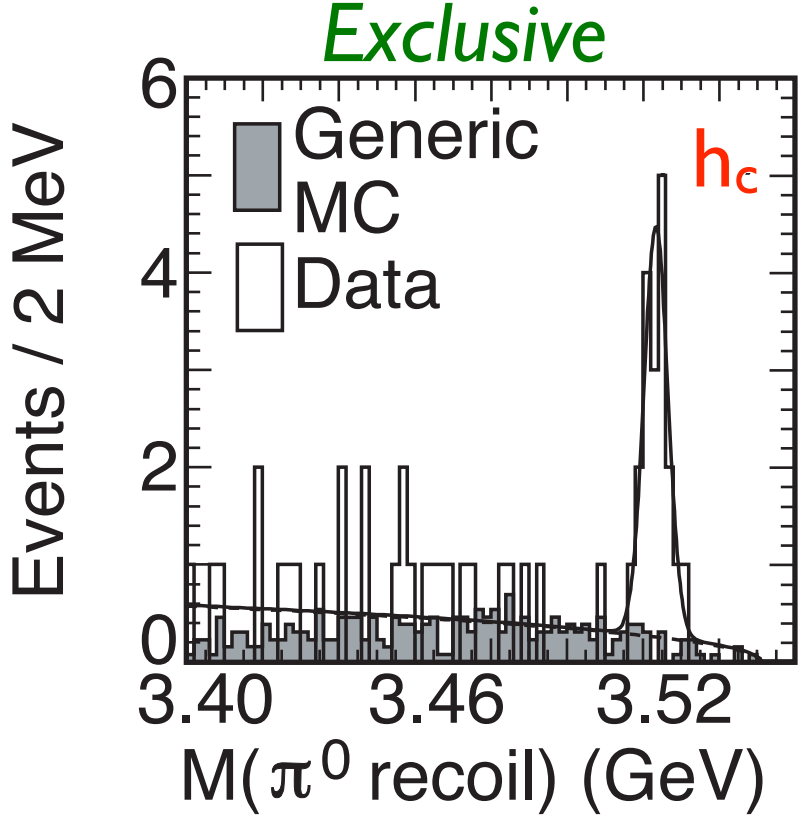
$^1P_1$ Charmonium: The $h_c(3520)$





Exclusive and Inclusive average:

$M(h_c)=3524.4\pm0.6\pm0.4$ MeV

$\Delta M_{HF}(1P)=1.0\pm0.6\pm0.4$ MeV

Phys.Rev.D 72(2005)092004

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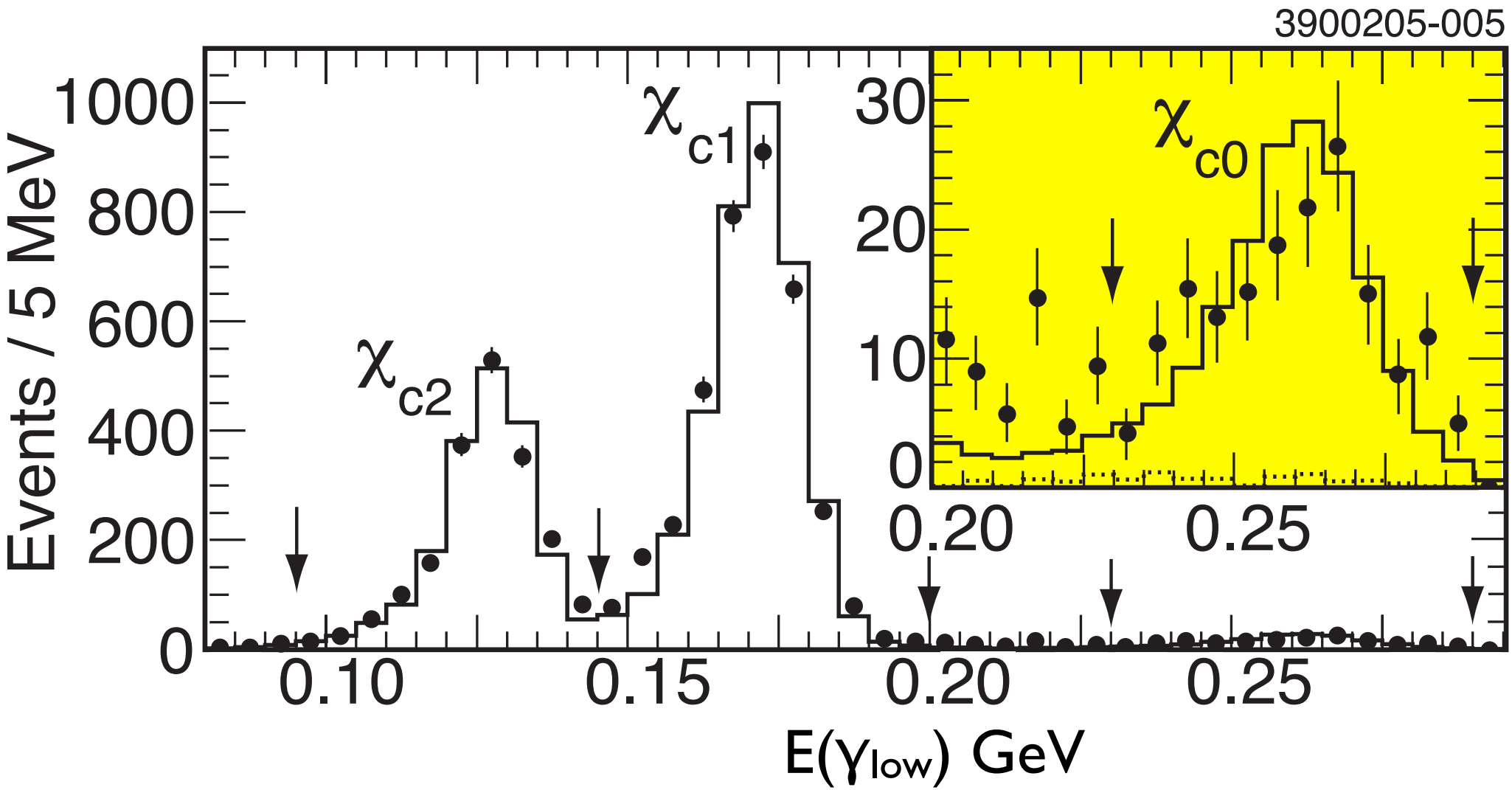
Decay rate: $\chi_c(^3P_0) \rightarrow \gamma J/\psi$

Phys.Rev.Lett. 94(2005)232002

Produce χ_{c0} from $\psi(2S)$ radiative decay



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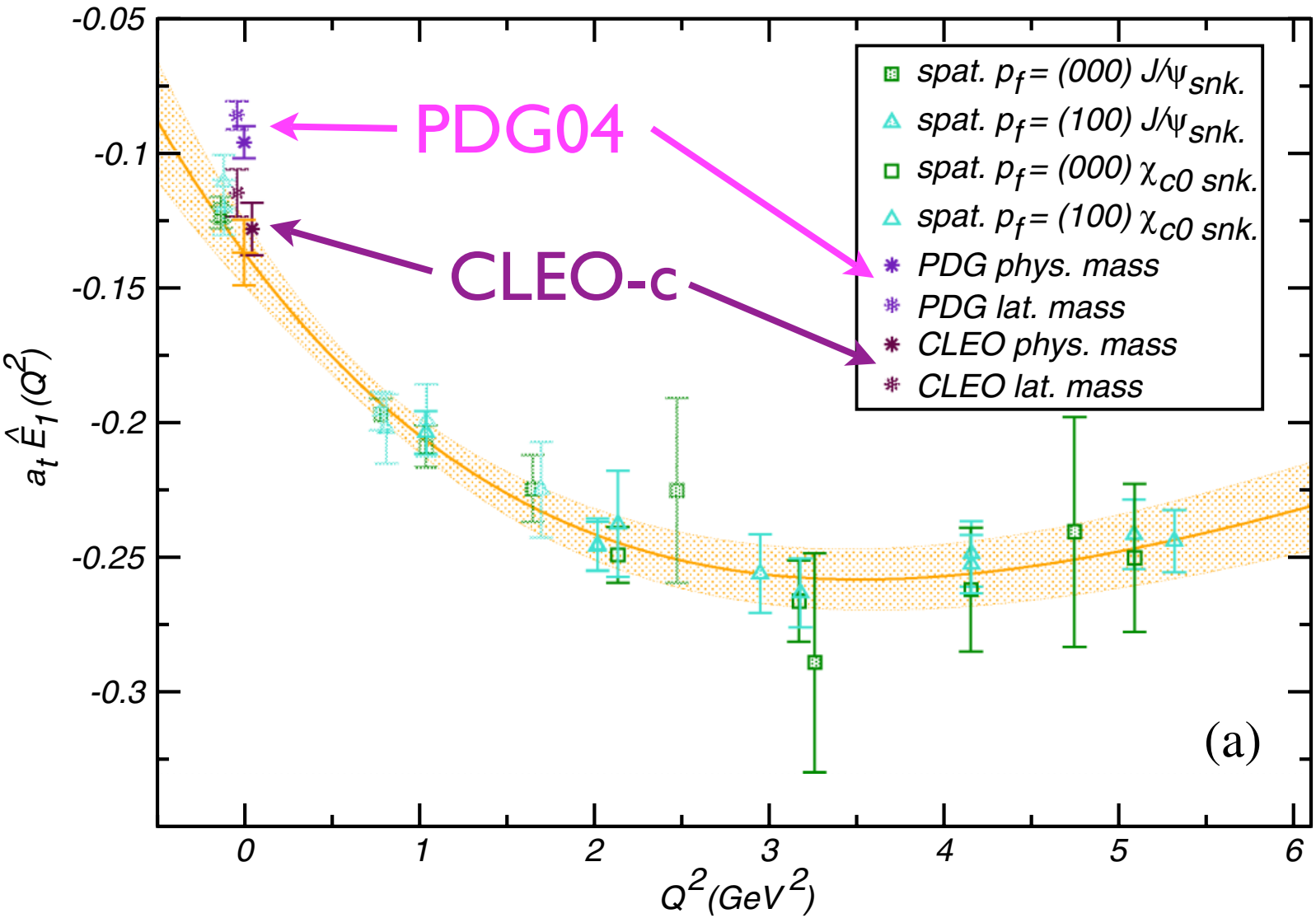
Note: This rate calculated in Lattice QCD

JLab Group: Phys.Rev.D73(2006)074507



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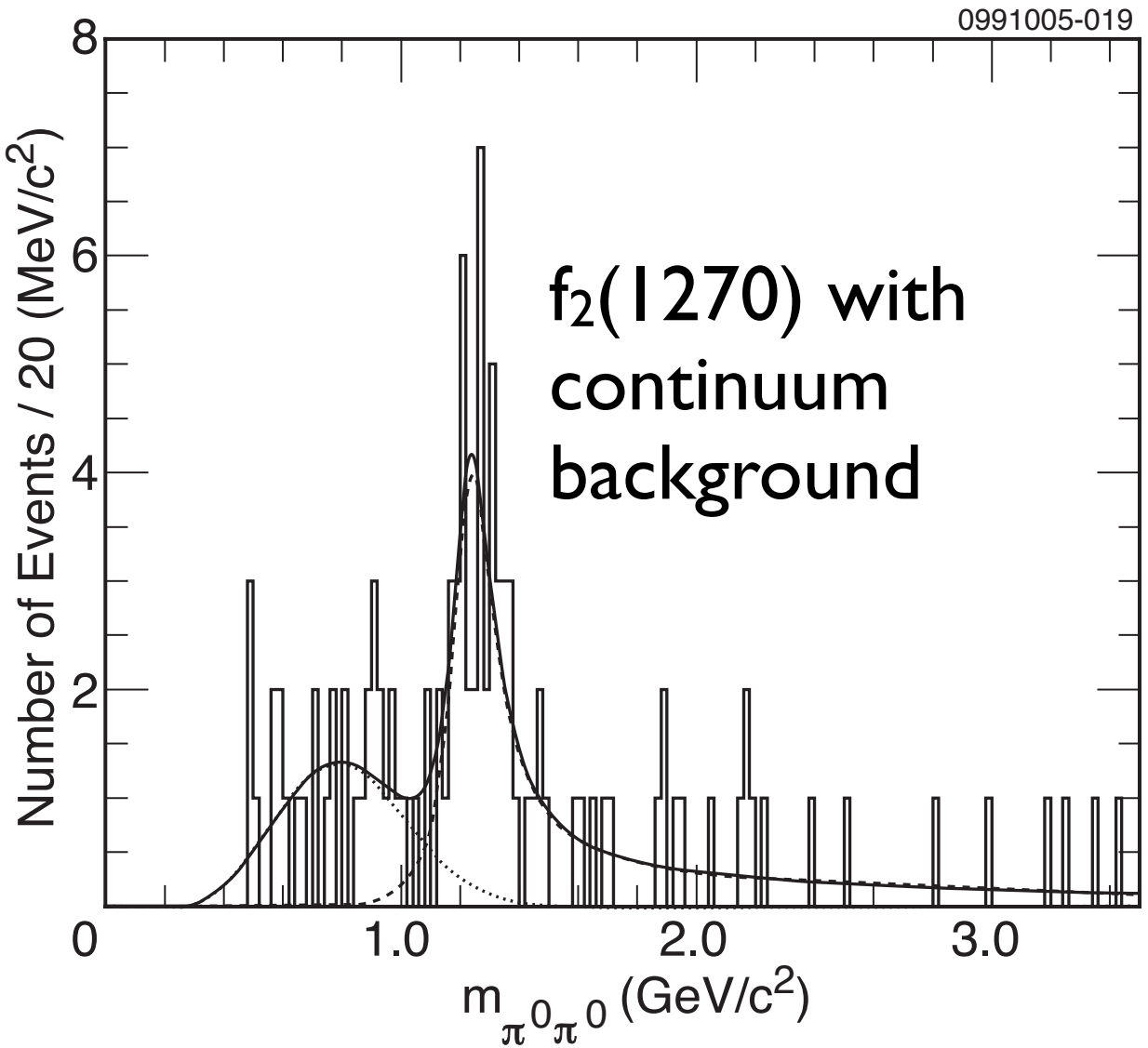
Light scalars or tensors with glue?

$\Upsilon(1S) \to \gamma\pi^0\pi^0$: *hep-ex/0512003*



$B(\Upsilon \to \gamma f_2) = (10.5 \pm 1.6 \pm 2) \times 10^{-5}$

No evidence for exceptional states.

See also $\Upsilon \to \gamma\pi^+\pi^-$ in *Phys.Rev.D 73(2006)032001*

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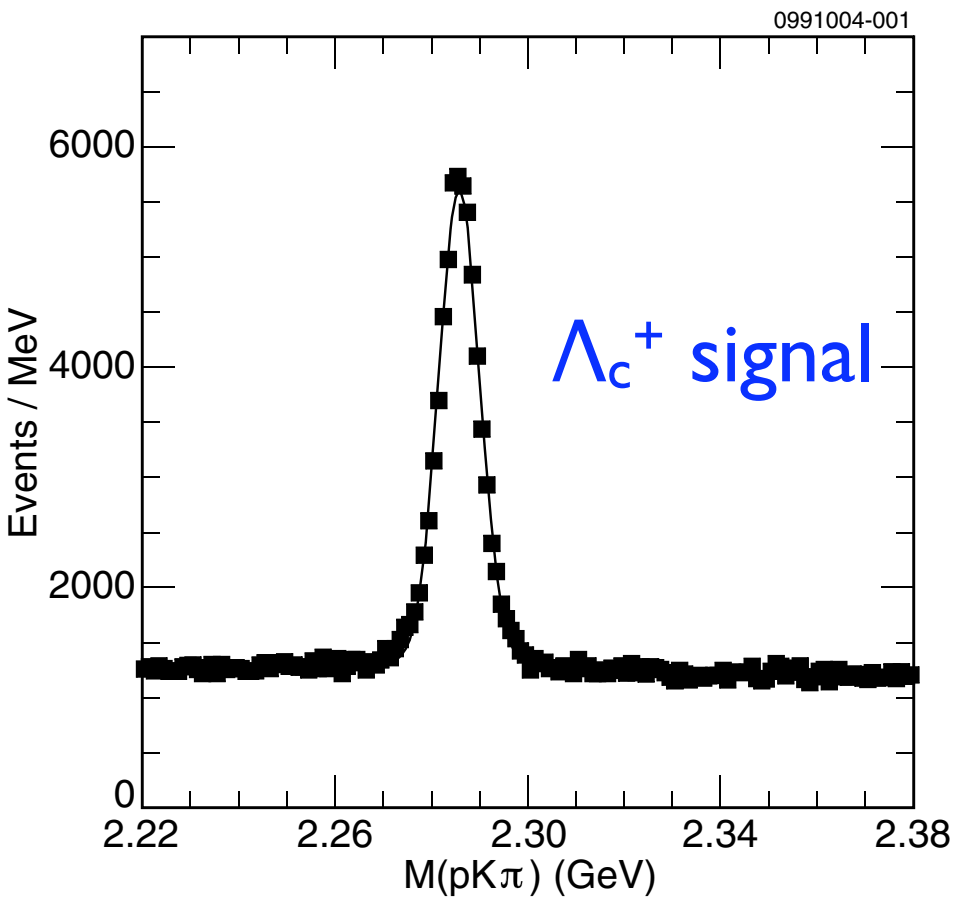
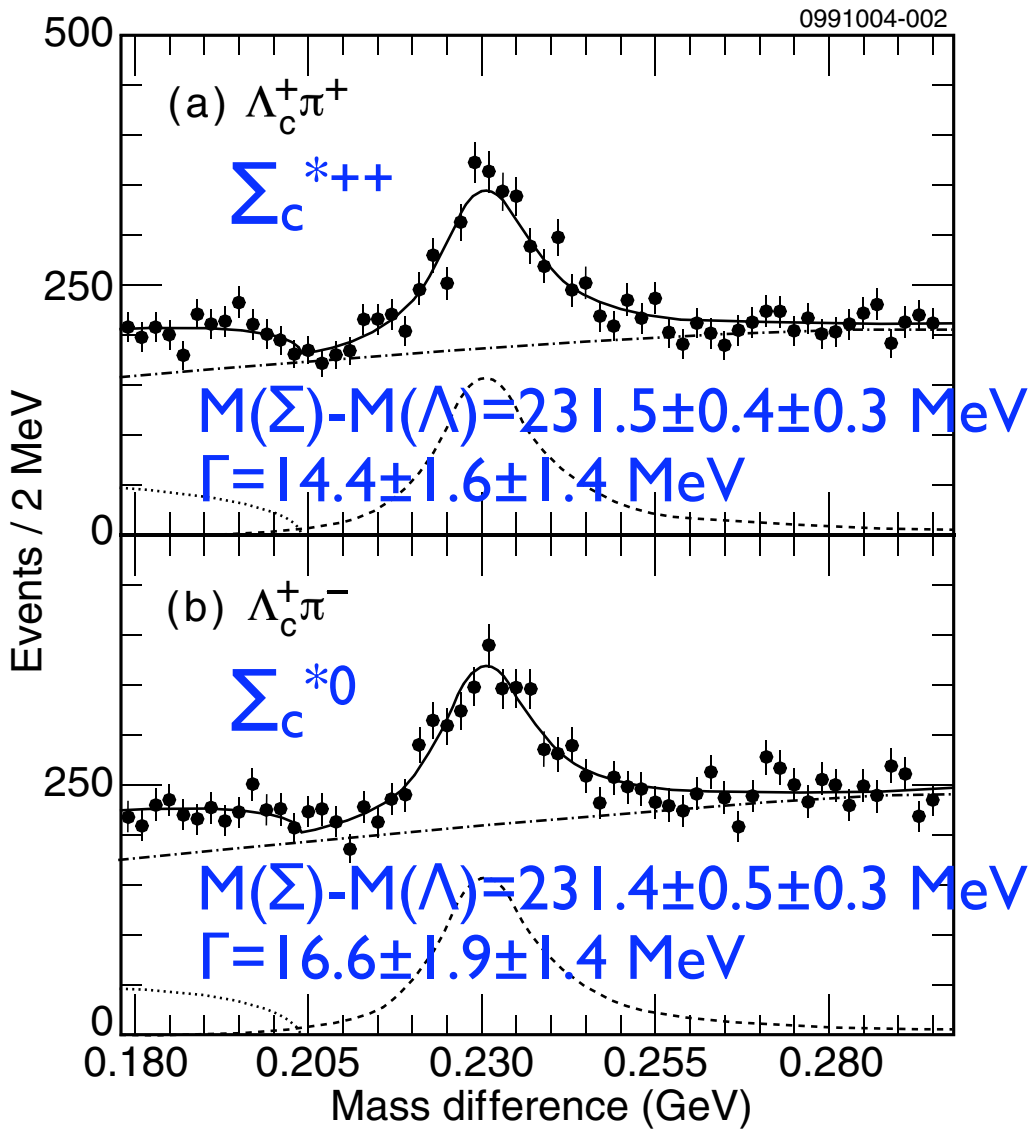
Precise Masses for Σ_c Baryons

Phys.Rev.D 71(2005)051101





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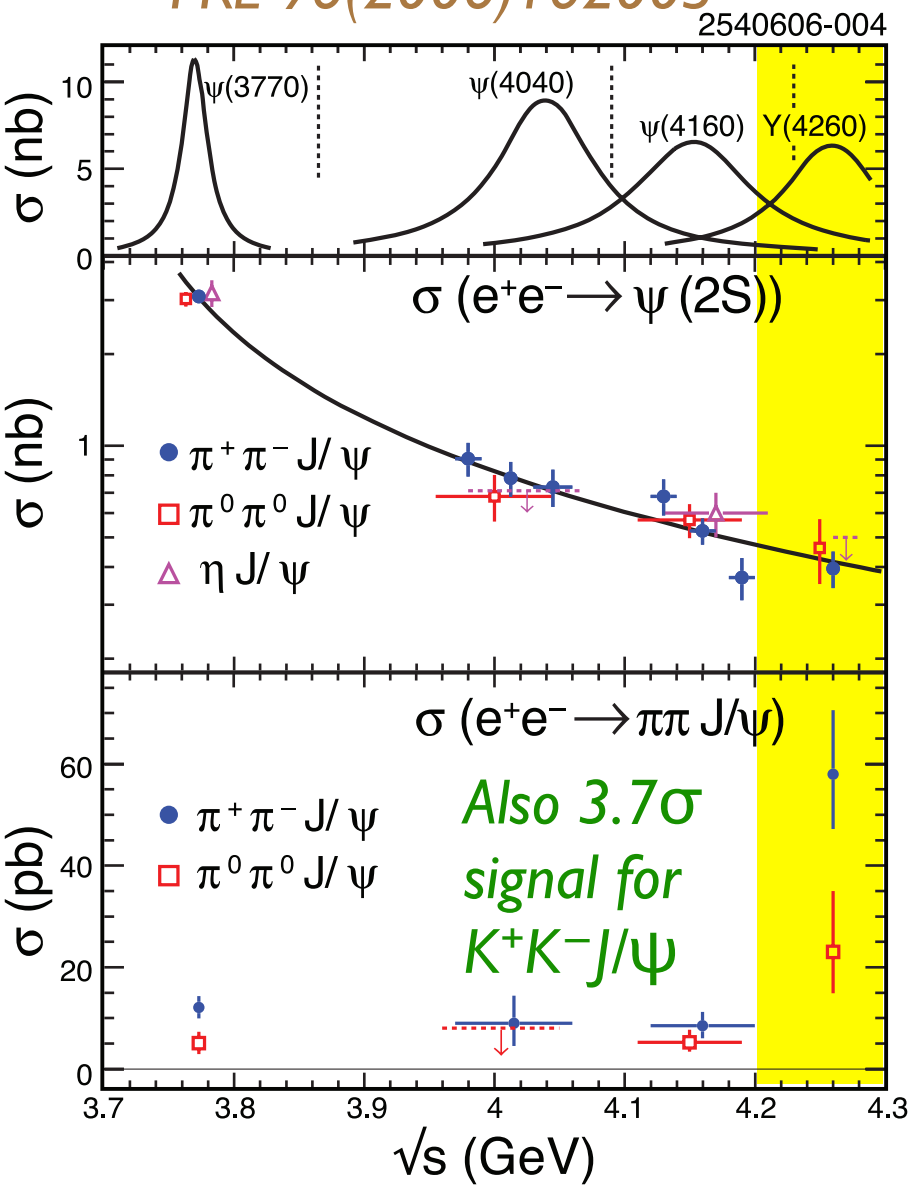
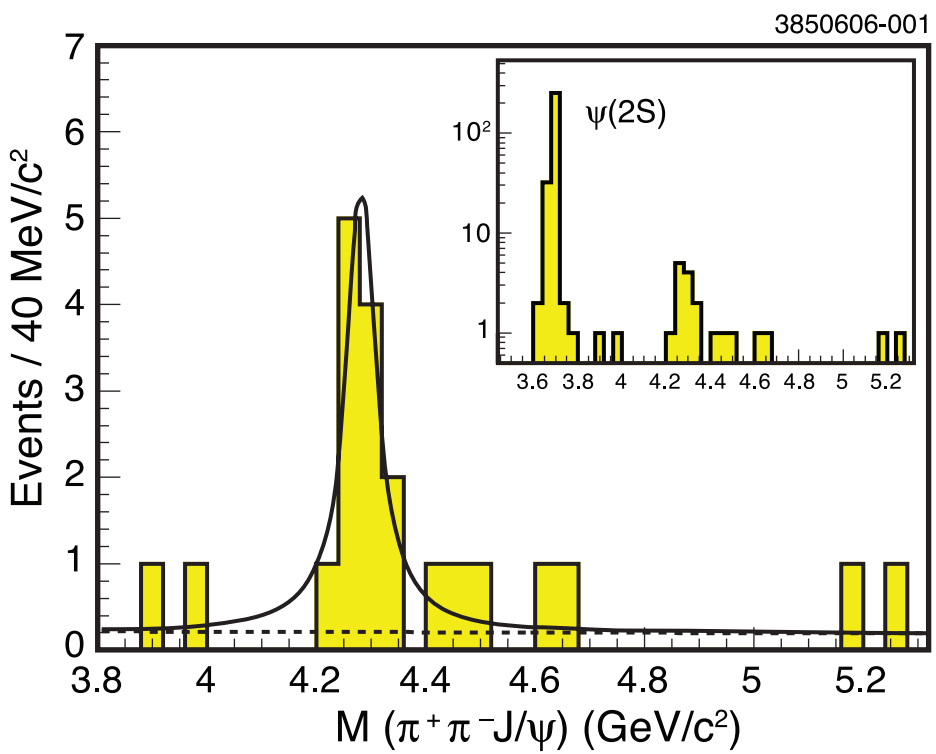
Confirmation and Study of the Y(4260)

PRL 96(2006)162003



Observed by CLEO both in direct e^+e^- annihilation *and* in ISR at high energy

Phys.Rev.D 74(2006)091104



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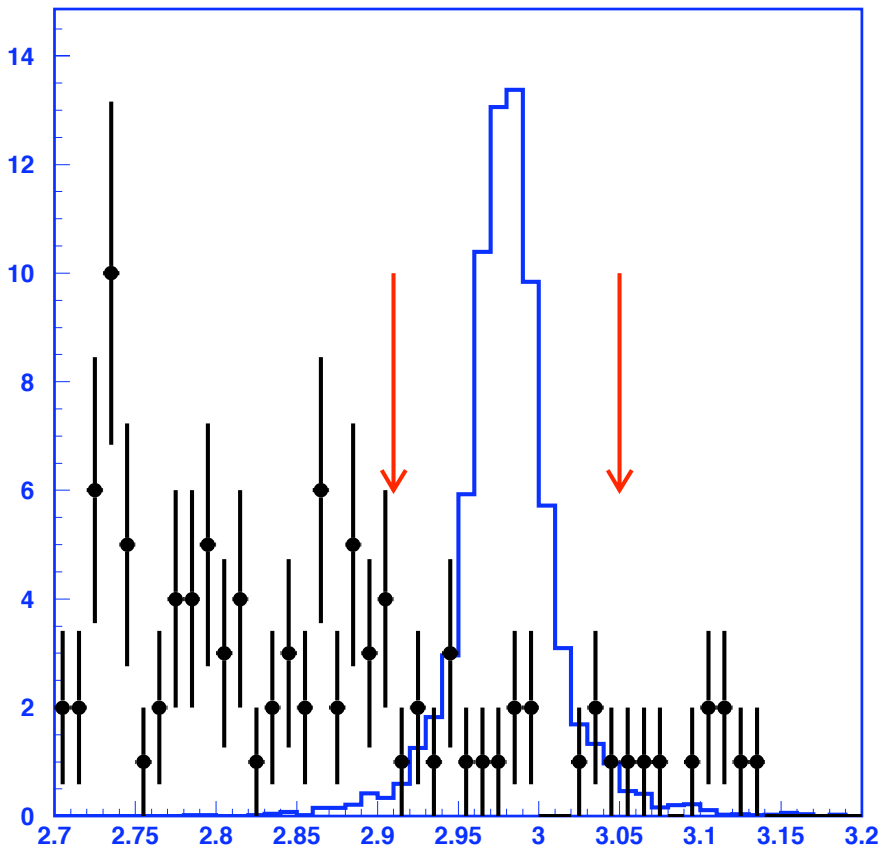
Search for $\psi(2S) \rightarrow \eta_c 3\pi$

Phys.Rev. D75(2007)011102



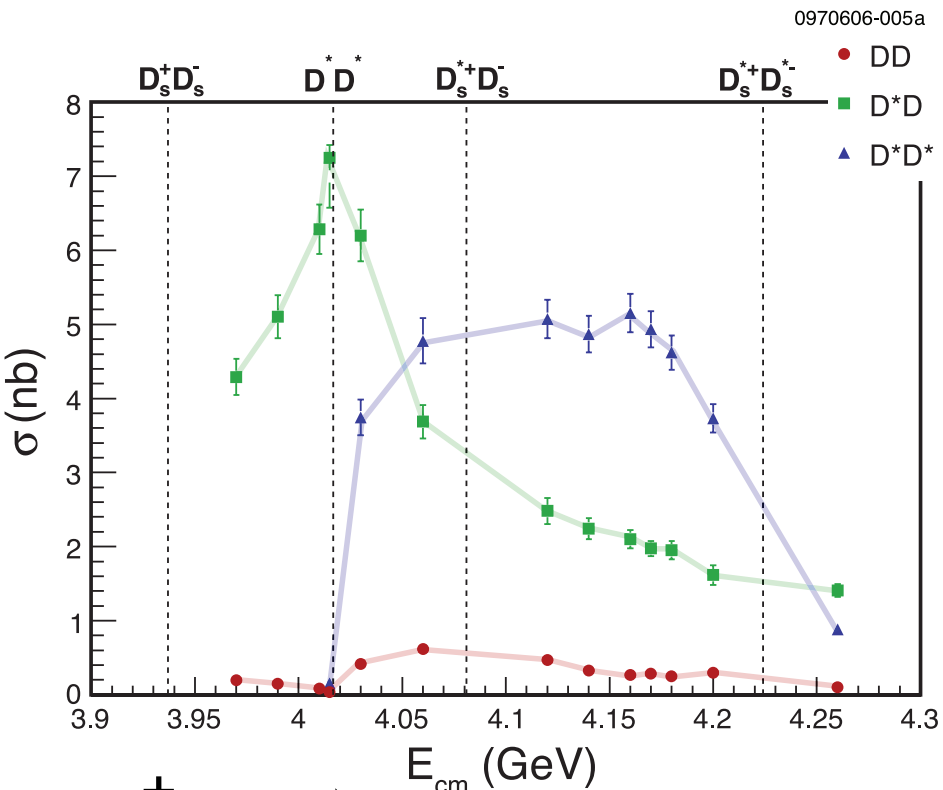
η_c Candidate Mass

Test of the "Survival before Annihilation" model: Artoisenet, et al., Phys.Lett. B628(2005)211

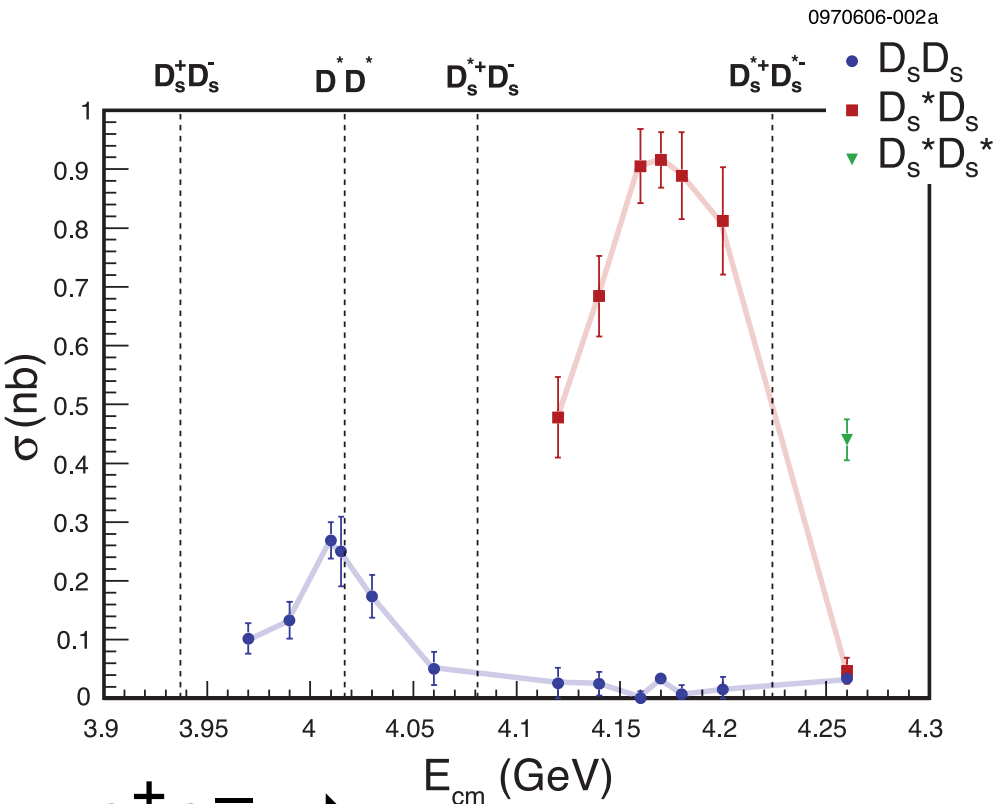
Histogram shows a signal level of 1% which is the model prediction.

Resonances (?) in e^+e^- Annihilation

See R. Poling, FPCP 2006 (hep-ex/0606016) *and* B. Lang, PhD Thesis, University of Minnesota



$e^+e^- \rightarrow$ *charmed mesons*



$e^+e^- \rightarrow$ *charmed strange mesons*

The lines just join the points, but...

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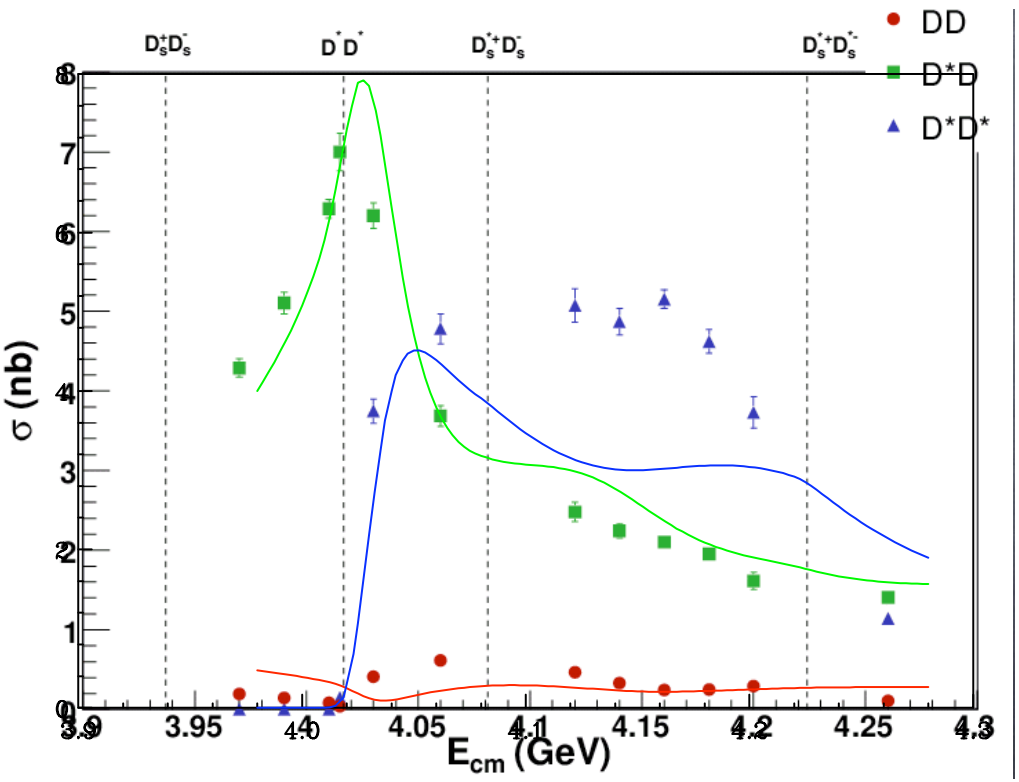
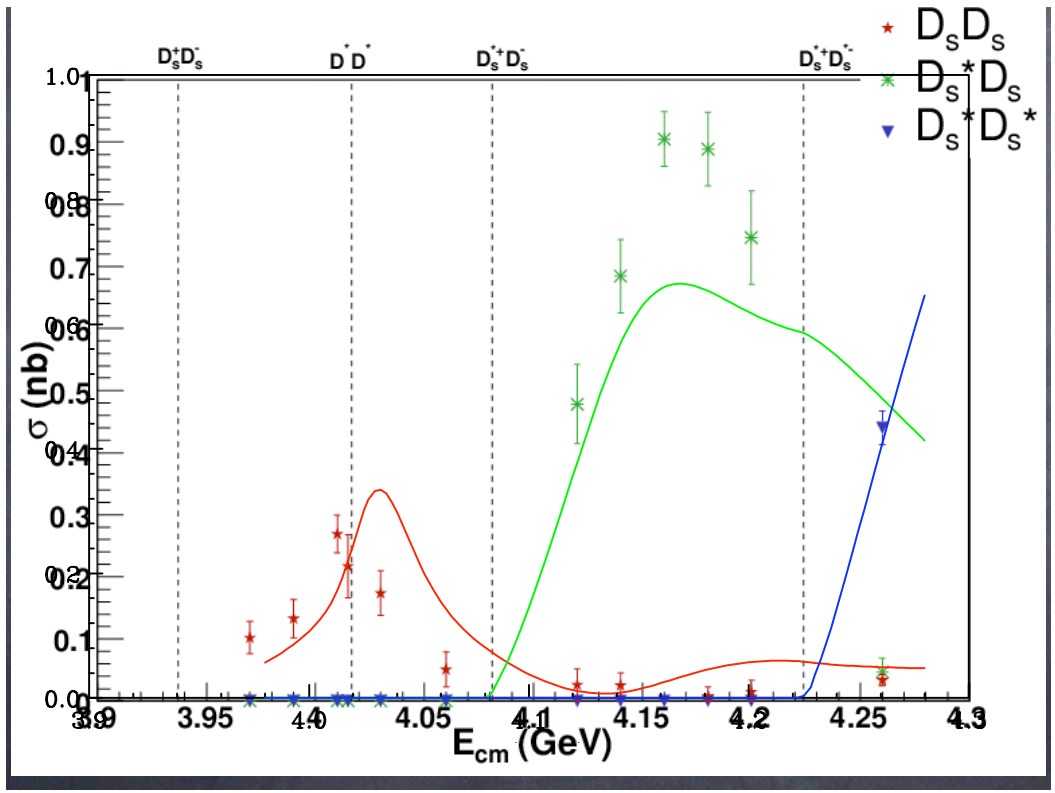
... From Estia Eichten, QWG 2006





Coupled channels calculation ("updated")

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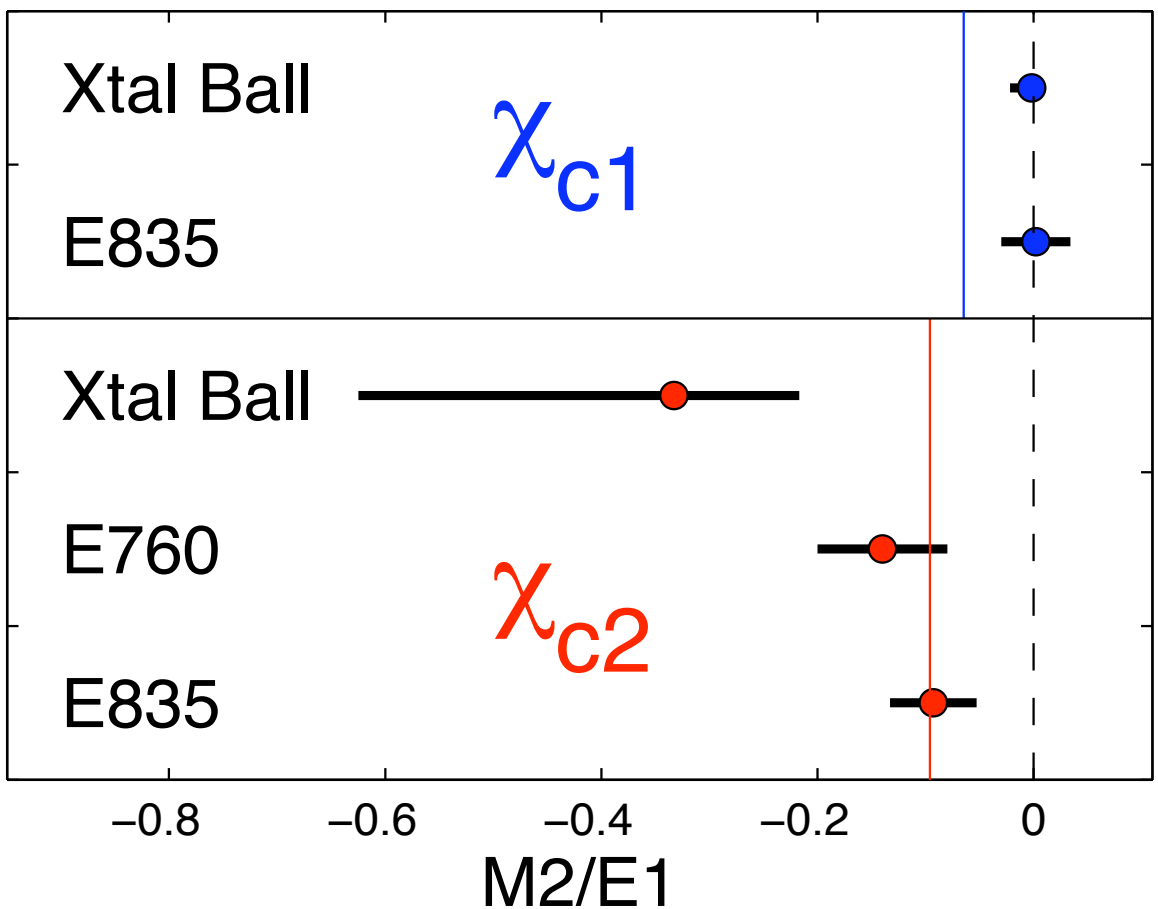
Coming up: The new ψ(2S) sample

25M $e^+e^- \to \psi(2S)$ *(new!)* are in hand and being analyzed

Many analyses are in progress, for example...



...What is wrong with the M2/E1 amplitude ratio in radiative decay of the χ_c states?

Will Lattice QCD give a different answer than the quark model?

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Conclusions

Spectroscopy remains a powerful tool for unraveling the relevant degrees of freedom for complicated physical systems.

CLEO has had a long and illustrious history. We continue to take data (mainly producing charmed mesons) and analysis will go on.

It is important to keep an open mind to the possibilities. Surprises often pop up!

Thank you! and...

… Charm 2007 at Cornell !

Tuesday, 31 July thru
Friday 3 August, 2007

Stay tuned for the official announcement (soon).