# Di-electron widths of the Upsilon(1S,2S,3S) Resonances

**CLEO Paper Vote**

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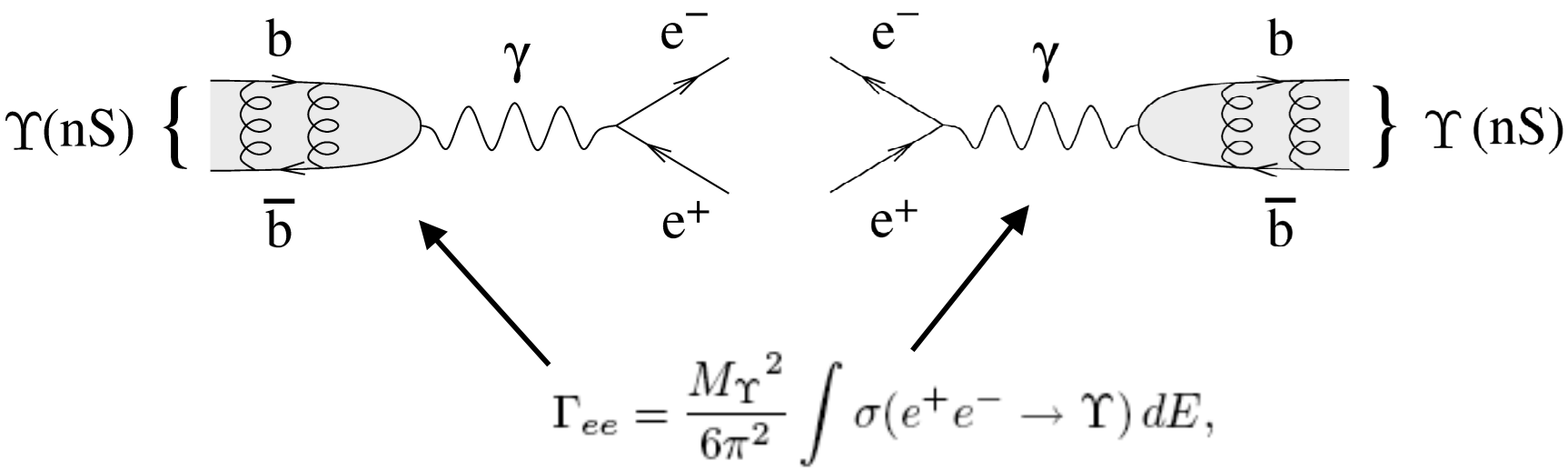
# Lots of prior presentations !

- **15** PTA talks (most recently Sept '05)
- Raw spectra shown **MANY** times (starting with APS 02)
- Analysis writeup in **CBX05-41** (July 2005)
- Plenary talk at **July '05 Physics Fest**
- Prelim results shown at **EPS, PANIC, Lattice05, PAC**
- Follow-up note of this past week (on meeting page)
- Today's **paper vote**

# History and Motivation for Measuring $\Gamma_{ee}$

- Long-known to be an important test of (unquenched) LQCD, which should be able to determine $\Gamma_{ee}$ to a "few" percent
- Want to match that precision
- Current experimental knowledge at 2%, 4% and 9%
- Yellow Book: <3% for $\Gamma_{ee}$ and <5% for $\Gamma_{tot}$




Basic plan … scan the three resonances and integrate the hadronic cross section!!

Get $\Gamma_{ee}\,\Gamma_{had}/\,\Gamma_{tot}$ without knowing $B_{\mu\mu}$

Use $B_{\mu\mu}$ to get $\Gamma_{ee}$

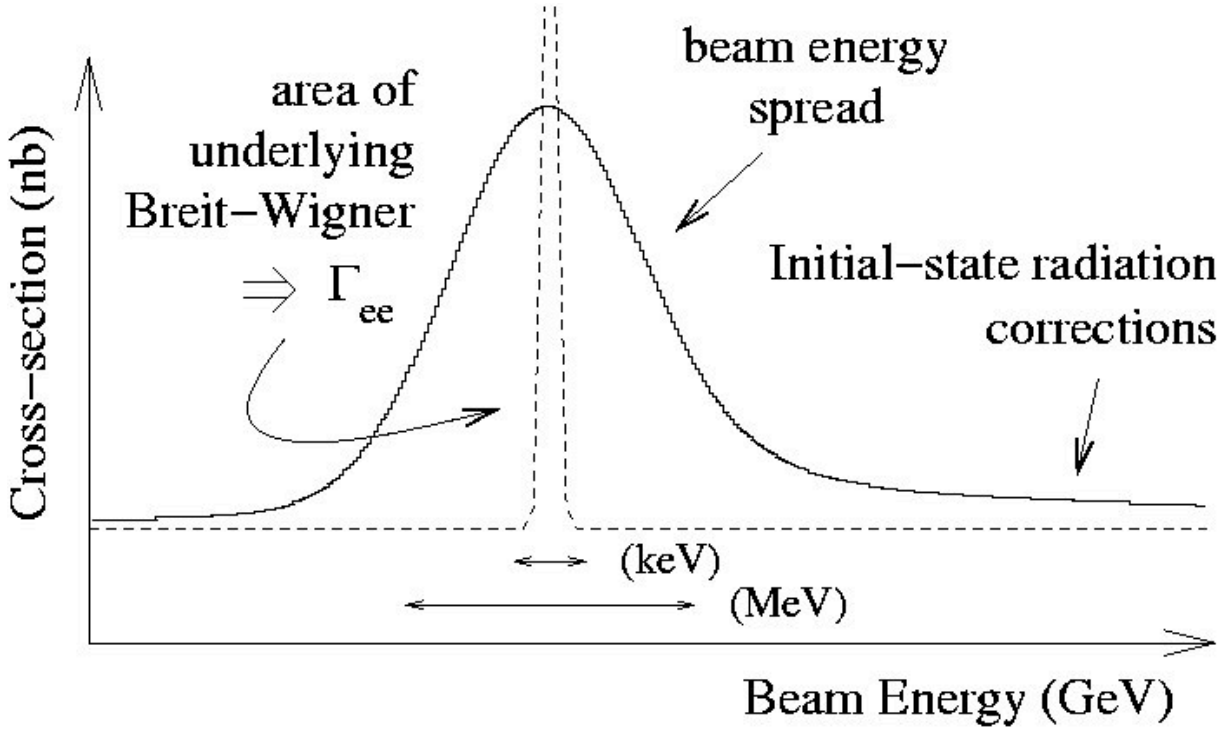
Use $B_{\mu\mu}$ again to get $\Gamma_{tot} = \Gamma_{ee} / B_{\mu\mu}$

Scans:

11 $\Upsilon(1S)$

6 $\Upsilon(2S)$

7 $\Upsilon(3S)$



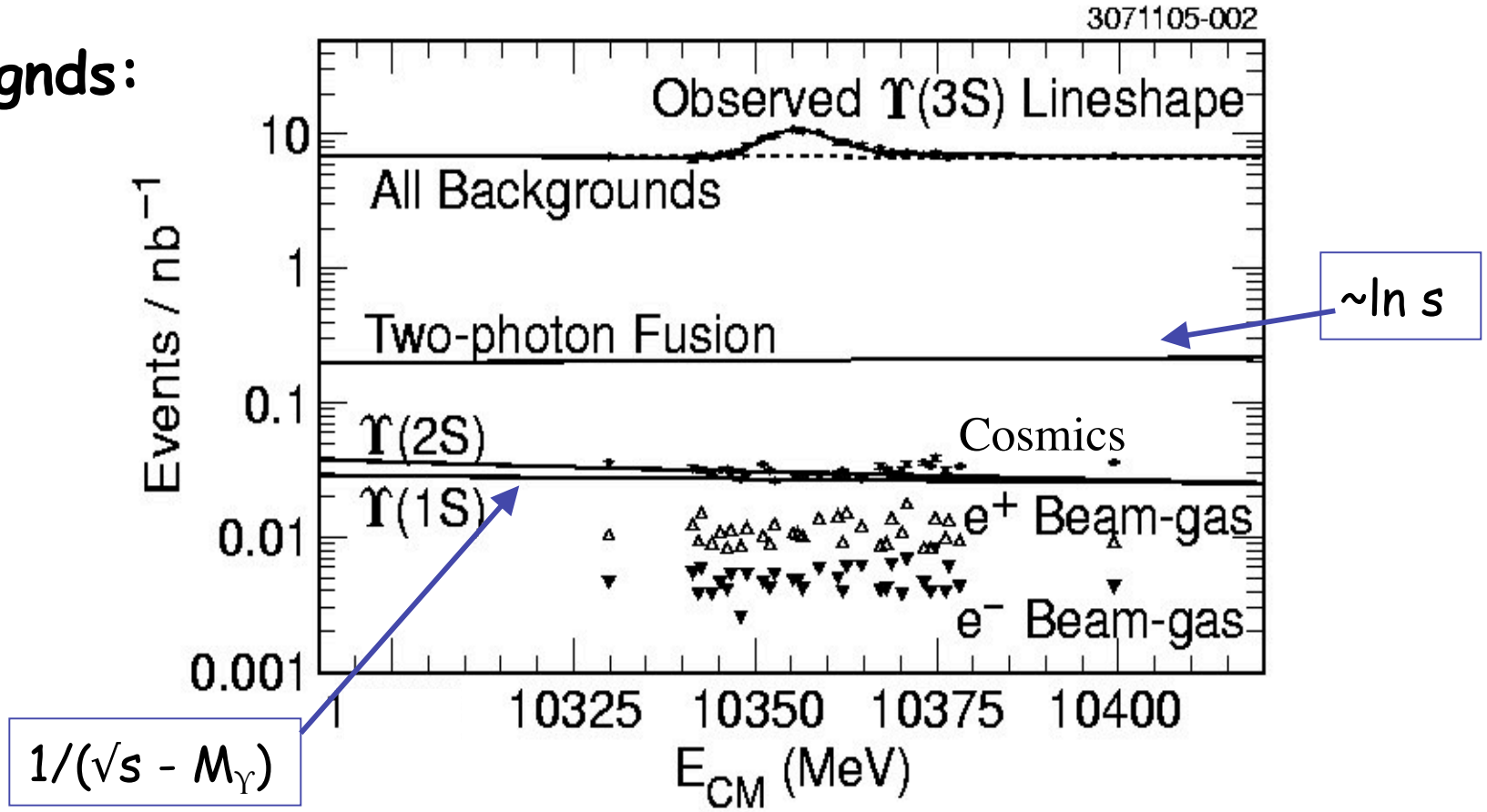

(K-F)

Shape of B-W smeared, but its area preserved, by beam-energy spread; radiative corrections impirtant but well understood

Need to address "height" (lumi, eff, bkgnds, etc.)

Need to address "width" (energy shifts, energy spread)

**Bkgnds:**




Evaluate CR and bm gas with special runs and subtract

Fit includes terms for ln s, $1/(\sqrt{s} - M_\Upsilon)$, and $\tau\tau$ (with interf)

Fit for area is BW ⊕ Gaussian (bm energy spread) ⊕ ISR

## Other "Height" Issues:

- Luminosity "scale" set on continuum point using ee, $\mu\mu$, $\gamma\gamma$; this is biggest single syst uncert at 1.3%

- Point-to-point luminosity done with $\gamma\gamma$ for EPS; redone with Bhabhas (including int) for PRL; 0.4% syst uncert

- cut efficiency obtained from data; for $\Upsilon(1S)$ use dipion cascades from $\Upsilon(2S)$ with trigger effects also taken from data; for $\Upsilon(2S)$ and $\Upsilon(3S)$ correct for energy dependence and specific transitions using MC

- hadronic interference ($\Upsilon \to q\,\bar{q}$ with $e^+e^- \to q\,\bar{q}$ ); slight change in shape; most important on $\Upsilon(1S)$ [more on this later]

## Width Issues:

- Scans from different weeks allowed different energy scales (shifts)
- Runs used for peak limited to be with 48 hr of scan
- Beam energy spread a parameter in the fit
- Beam energy spread for each resonance allowed to be different for each CESR lattice/steering configuration (added since EPS)

## Changes since EPS:

- Bhabhas used for point-to-point lumi; reduces stat uncert; important for 2S, 3S and ratios
- Beam energy spread allowed to vary with CESR configurations of lattice/steering
- Scale factor used on stat uncert to force reduced $\chi^2$ of fit to unity (factors of $\sqrt{1.3}$, $\sqrt{1.6}$, 1.0)
- Level of qq hadronic interference checked; investigation of possible ggg interference as well
- Other "tidying up"

# The Final Fits (figure from the draft):

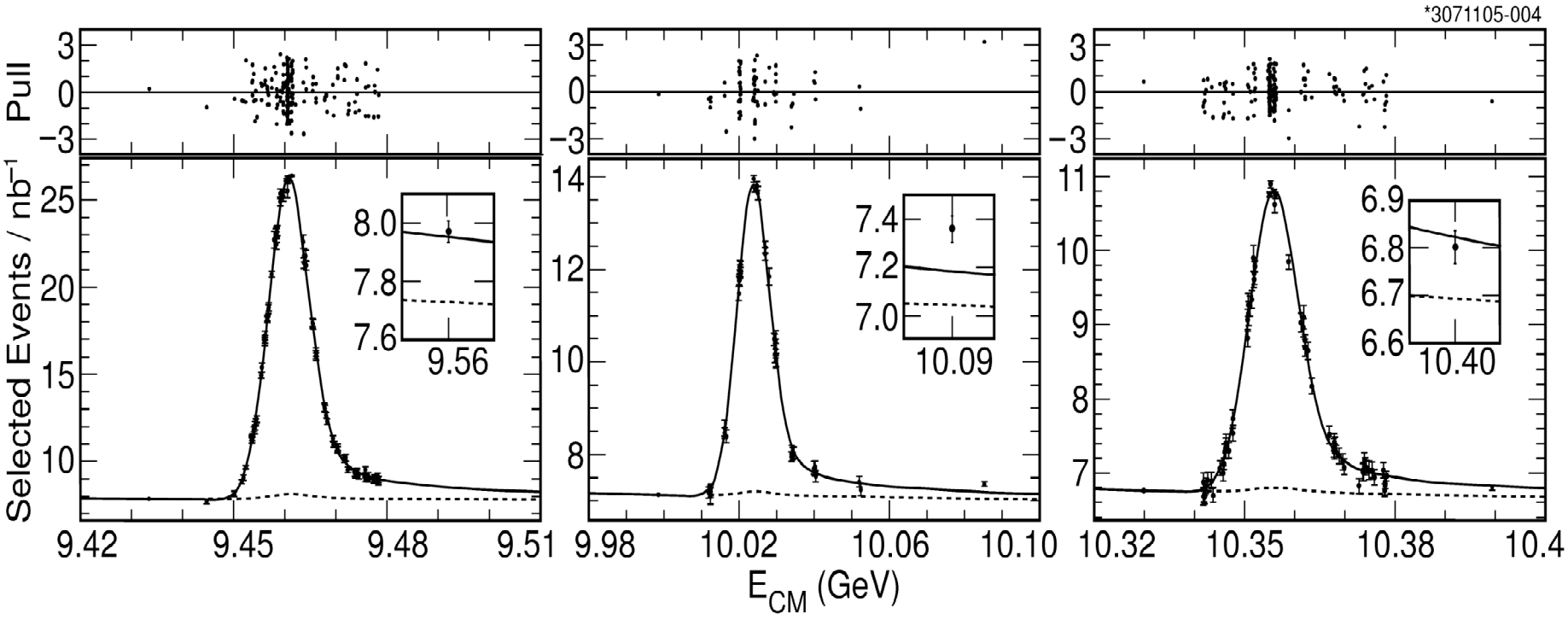


TABLE I: All uncertainties in $\Gamma_{ee}$ measurements in the order in which they are discussed in the text. Uncertainties common to all resonances are indicated with an asterisk (*). Statistical uncertainty is multiplied by the $\chi^2_{\rm red}$ of the fit (see text).

| Contribution to $\Gamma_{ee}$ | $\Upsilon(1S)$ | $\Upsilon(2S)$ | $\Upsilon(3S)$ |
|---|---|---|---|
| Correction for leptonic modes | 0.2% | 0.2% | 0.3% |
| *Hadronic efficiency | 0.5% | 0.5% | 0.5% |
| $Xe^+e^-$, $X\mu^+\mu^-$ correction | 0 | 0.15% | 0.13% |
| *Overall luminosity scale | 1.3% | 1.3% | 1.3% |
| Bhabha/$\gamma\gamma$ inconsistency | 0.4% | 0.4% | 0.4% |
| Beam energy measurement drift | 0.2% | 0.2% | 0.2% |
| Fit function shape | 0.2% | 0.2% | 0.2% |
| Total systematic uncertainty | 1.5% | 1.5% | 1.5% |
| Scaled statistical uncertainty | 1.3×0.3% | 1.6×0.7% | 1.0% |
| Total | 1.5% | 1.9% | 1.8% |

Needs srqt!

All better than 2% !

TABLE II: The results of $\Gamma_{ee}\Gamma_{\rm had}/\Gamma_{\rm tot}$ for the three resonances, the di-electron widths $\Gamma_{ee}$, and their ratios. The first uncertainty is scaled statistical and the second is systematic.

| | | | |
|---|---|---|---|
| $\Gamma_{ee}\Gamma_{\rm had}/\Gamma_{\rm tot}(1S)$ | | $(1.252 \pm 0.005 \pm 0.019)$ keV | |
| $\Gamma_{ee}\Gamma_{\rm had}/\Gamma_{\rm tot}(2S)$ | | $(0.581 \pm 0.006 \pm 0.009)$ keV | % |
| $\Gamma_{ee}\Gamma_{\rm had}/\Gamma_{\rm tot}(3S)$ | EPS | $(0.413 \pm 0.004 \pm 0.006)$ keV | |
| $\Gamma_{ee}(1S)$ | 1.34 | $(1.354 \pm 0.005 \pm 0.020)$ keV | 1.5 |
| $\Gamma_{ee}(2S)$ | 0.62 | $(0.619 \pm 0.007 \pm 0.009)$ keV | 1.9 |
| $\Gamma_{ee}(3S)$ | 0.42 | $(0.446 \pm 0.004 \pm 0.007)$ keV | 1.8 |
| $\Gamma_{ee}(2S)/\Gamma_{ee}(1S)$ | | $(0.457 \pm 0.006 \pm 0.003)$ | 1.5 |
| $\Gamma_{ee}(3S)/\Gamma_{ee}(1S)$ | | $(0.329 \pm 0.004 \pm 0.002)$ | 1.3 |
| $\Gamma_{ee}(3S)/\Gamma_{ee}(2S)$ | | $(0.720 \pm 0.011 \pm 0.006)$ | 1.7 |

# Concluding Comments

Analysis now complete and ready for paper vote

"Math" being checked one last time

Wordsmithing paragraph on hadronic interference

If approved, will go to 7-day review "soon"

Jim Pivarski's thesis to follow in January 2006