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D^{*+} intrinsic width

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CLEO collaboration

Outline

- Predictions and previous measurements
- Event reconstruction
- Fitting method
- Conclusion

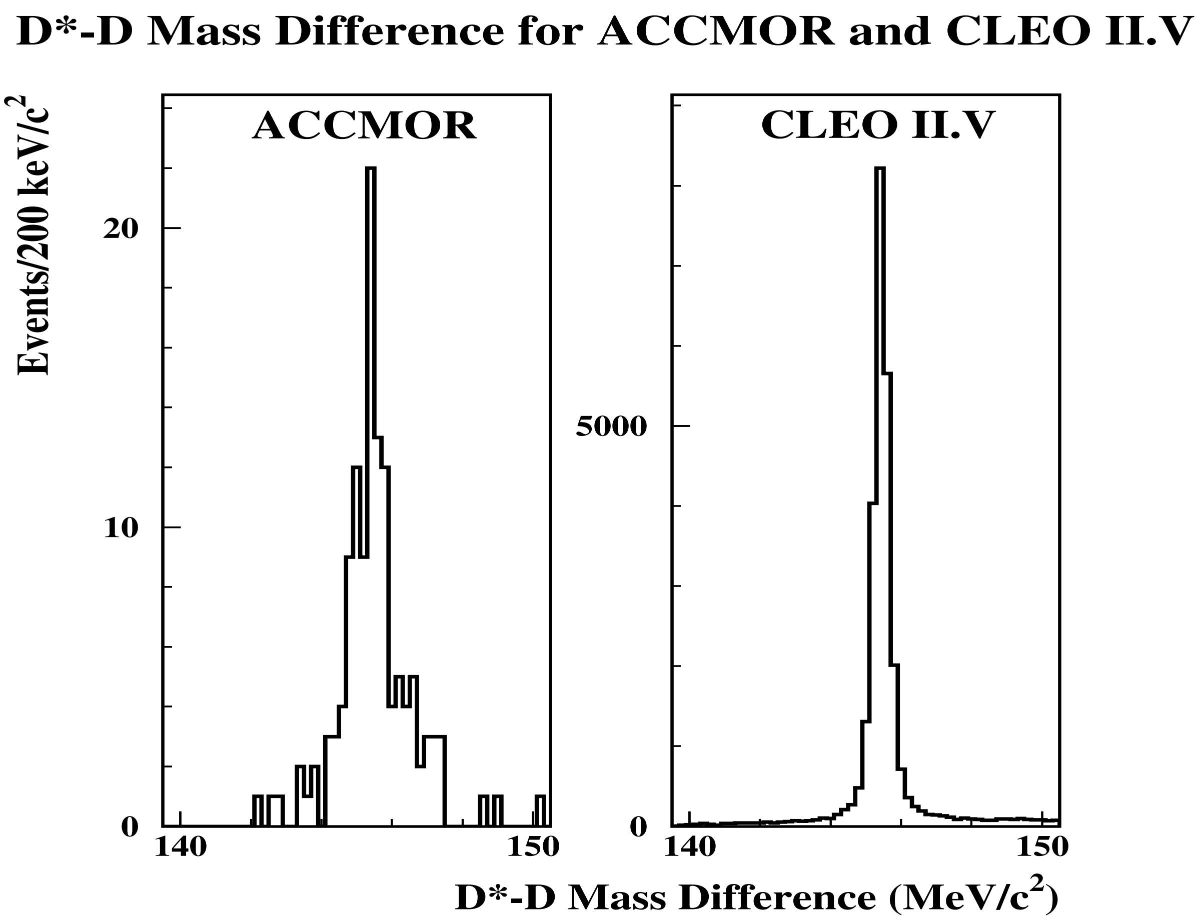
Theoretical predictions on D^{*+} width

- $\Gamma(D^{*+})$ is important to check validity of different models of heavy meson decay dynamic (see Table)
- Theoretical predictions on $\Gamma(D^{*+})$ range from ~15 keV to ~150 keV

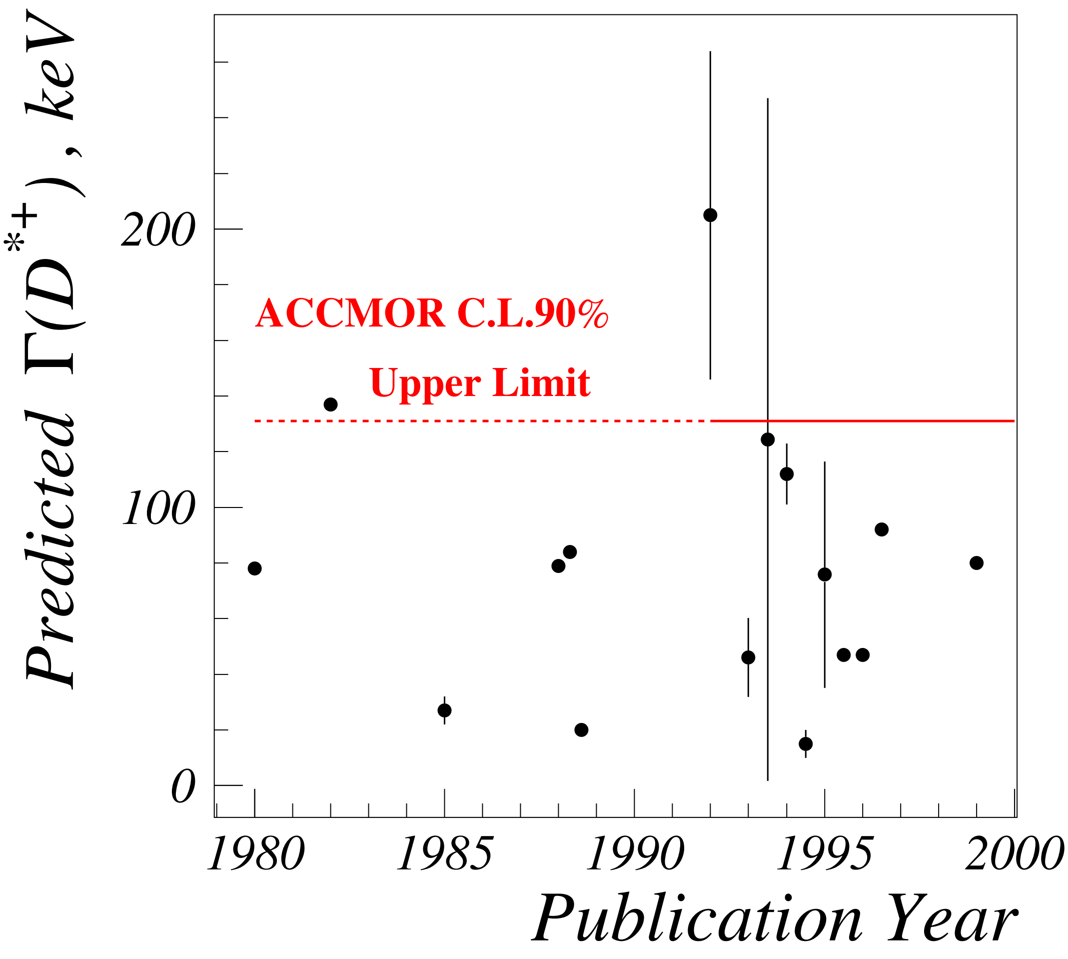
Year	Author(s)	Model	$\Gamma_{tot}(D^{*+})$, keV
1980	E.Eichten et al.	NQM	78
1982	T.N.Pham	PCAC+QM	137
1985	R.L.Thews and A.N.Kamal	SU(4)	27 ± 5
1988	G.A.Miller and P.Singer	CBM	79
1988	J.L.Rosner	N/A	83.9
1988	A.B.Kaidalov, A.V.Nogteva	RQGSM	20
1992	A.N.Kamal and Q.P.Xu	Survey	Table of predictions
1992	T.-M.Yan et al.	Chiral HQET	$146 \div 264$
1993	P.Colangelo et al.	HQET + VDM	46.1 ± 14.2
1993	P.Cho, H.Georgi	HHCPT + HQET	124.4 ± 122.7
1994	P.J.O'Donnel and Q.P.Xu	RQM	$102.1 \div 123$
1994	P.Colangelo et al.	QCD sum rules	15 ± 5
1995	M.A.Ivanov, Yu.M.Valit	RQM	$35.1 \div 116.48$
1995	V.M.Belyaev et al.	QCD sum rules	47
1996	A.Khodjamirian and R.Ruckl	QCD	47
1996	W.Jaus	RQM	91.95
1998	R.Ruckl	Survey	Table of predictions
1999	P.Singer	Based on cit.	$\simeq 80$

Experimental status

- **The best upper limit:** $\Gamma(D^{*+}) < 131\ keV$ **@ C.L. 90%**
  ACCMOR collaboration (PL B278 (1992) 480),
  based on sample of 127 D^{*+} events.
- **CLEO II.V has $\sim$100$\times$ statistics**
  and much cleaner mass difference distribution !



Comparison of predictions and experiment



- **Predictions cover a broad range of $\Gamma(D^{*+})$ close to the upper limit.**

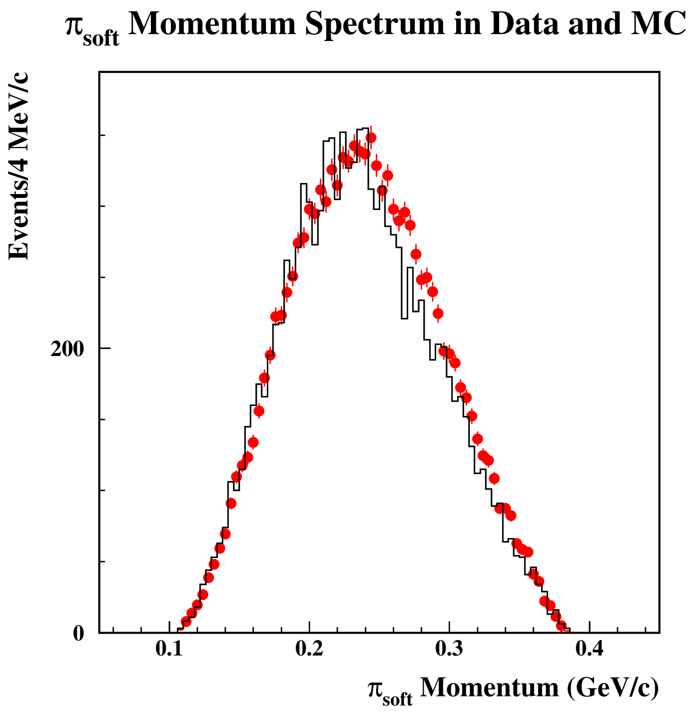
Method of $\Gamma(D^{*+})$ measurement

- Decay mode $D^{*+} \to D^0\pi^+_{soft} \to K^-\pi^+\pi^+_{soft}$.
- We suppose $\Gamma(D^0) \ll \Gamma(D^{*+})$.
- Measure mass difference (kinetic energy)
  $Q_i = M(K^-\pi^+\pi^+_{soft}) - M(K^-\pi^+) - M(\pi^+)$.
- σ_Q is determined by track fitter error matrix
  from Kalman filter.
- $\Gamma(D^{*+})$ can be extracted from Q distribution taking in to account detector resolution.

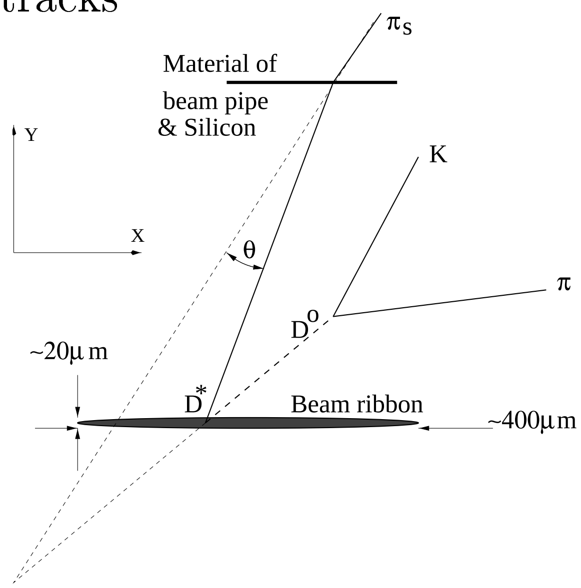
- CLEO II.V with Si vertex detector has sample of $\sim$ 15000 events $D^{*+} \to K^-\pi^+\pi^+_{soft}$ corresponding to $\sim 9\ fb^{-1}$ of e^+e^- collisions.
- We use GEANT simulation of CLEO II.V with complete description of the material with $\sim$10$\times$ data statistics.

Event reconstruction $D^{*+} \to D^0\pi^+_{soft} \to K^-\pi^+\pi^+_{soft}$

- D^0 daughters have high momentum and are well reconstructed in CLEO.
- π^+_{soft} has low momentum $\to$ tracking errors dominated by multiple scattering.
- We reduce the effect of multiple scattering in the inner material by introducing a fitting point for π^+_{soft} inside the beampipe.

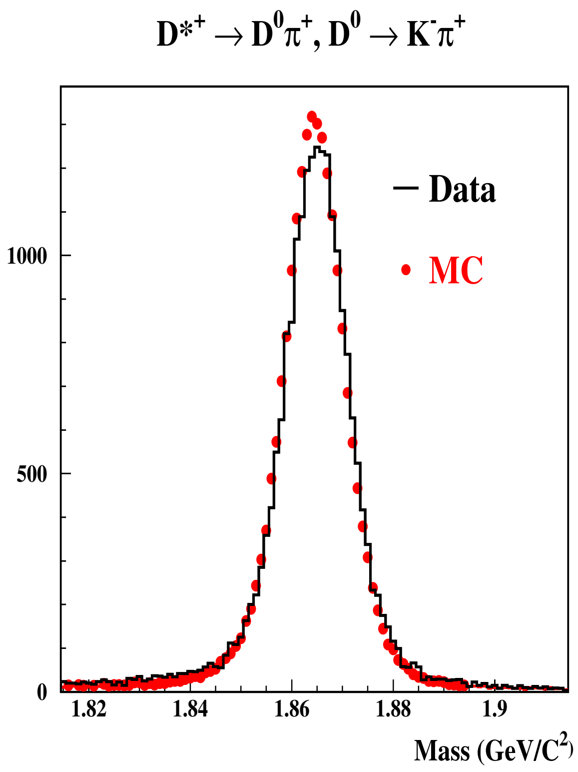


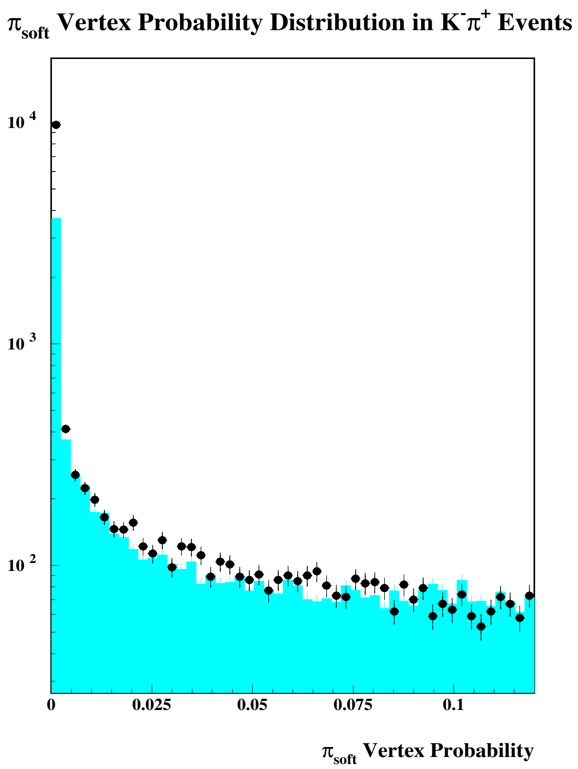
- Standard CLEO II.V track quality cuts on D^0 daughters
- Reconstruct D^0 using K^- and π^+ tracks
- Reconstruct D^{*+} vertex using reconstructed D^0 and beam ribbon profile
- Re-fit π^+_s track using D^{*+} vertex as a tracking point



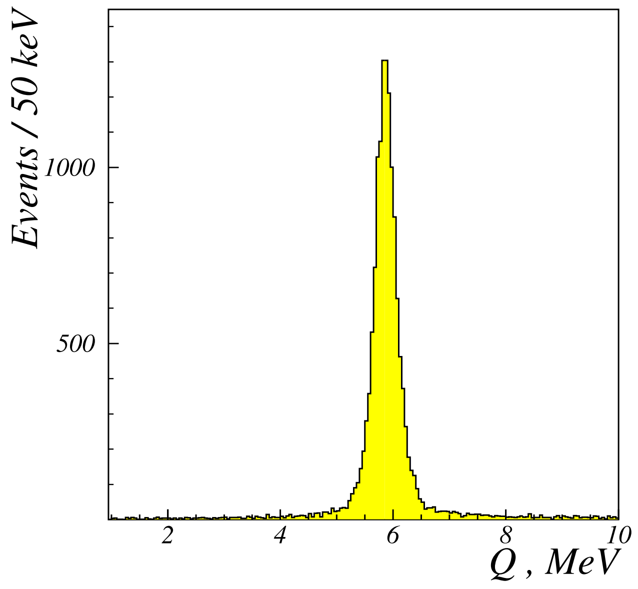
Event selection cuts

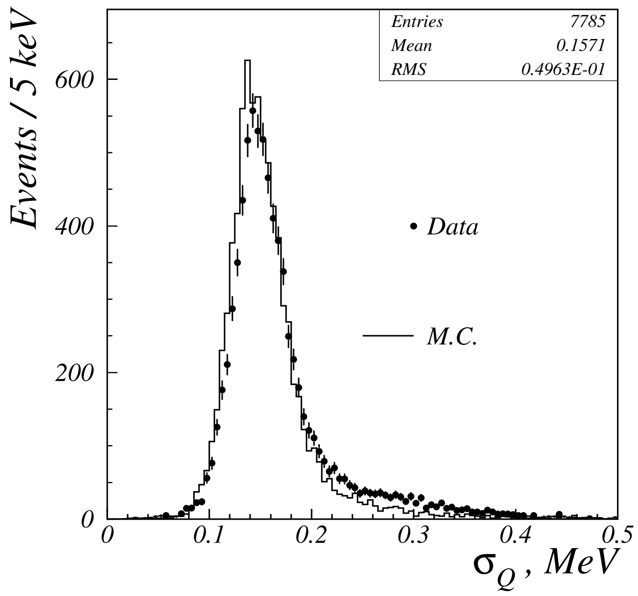
- $P(\chi^2) \geq 0.001$ **for** D^0 **and** D^{*+} **vertex**
- $|M_{D^0} - 1864.5| \leq 15\ MeV$ **(2σ) and** $\sigma_M(D^0) \leq 7\ MeV$
- $|\phi_{\pi_{soft}} - n \cdot \pi| \geq 0.3\ rad$**,** $n = 0, 1, 2$
  remove events with π_{soft} **in median plane**
- $|cos\theta^*| \leq 0.8,$ θ^* **is** D^0 **decay angle**
- $P_{D^0} \geq 2.5\ GeV$





Mass difference and error distributions





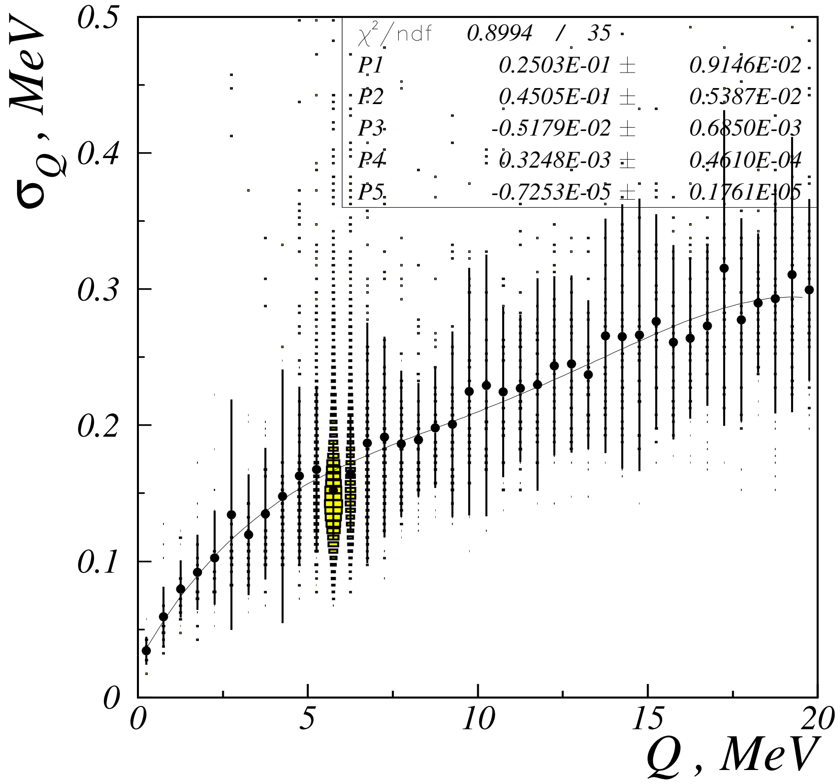
Q–distribution

- Very narrow, clean signal peak
- Very low backgrounds

σ–distribution

- Detector resolution is comparable to current upper limit on $\Gamma(D^{*+})$
- Detector response based on Kalman filter
  - ▷ scale factor, k, (material discrepancy)
  - ▷ fraction of mis-measured events, f_{mis}, with σ_{mis}

Mass difference and error distributions (cont)



- **σ vs Q–distribution** shows strong correlation from kinematics.

Listed properties of Q and σ distributions can be accomodated in an **unbinned maximum likelihood fit** of Q distribution.

Unbinned maximum likelihood fit

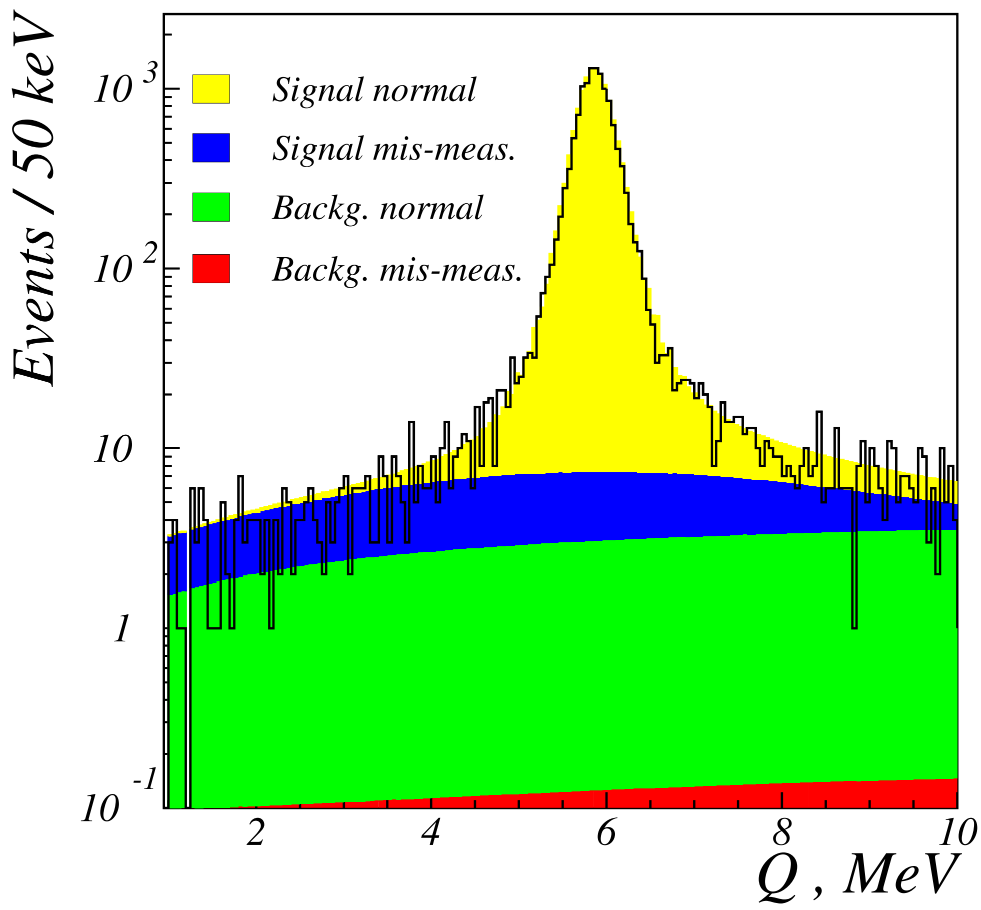
Input variables: N events presented by pairs $(\ Q_i,\ \sigma_i\ )$

7 Parameters: $Q_0,\ \Gamma_0,\ k,\ f_{mis},\ \sigma_{mis},\ N_s,\ N_b$

Algorithm: minimization of logarithmic likelihood function, based on Probability Density Function (PDF) and Poisson distribution.

PDF of Q distribution is calculated as a convolution:

$$(Breit\ Wigner + Polynomial\ Background) \otimes Gaussian$$



Problems of $\Gamma(D^{*+})$ measurement for systematic study

- Detector resolution of Q is most dependent on precision of π^+_{soft} track measurement.
- Tracking errors based on material description used by Kalman filter.
- We do not have (or do not know?) a calibration mode to provide any input on the π^+_{soft} tracking biases.
- Hence, the precision of $\Gamma(D^{*+})$ measurement depends entirely on our understanding of π^+_{soft} tracking.

Analysis of systematics

Done

- Extensive tests of Q and σ_Q on kinematic and tracking parameters
- Tests of the fitter
  - ▷ Toy M.C.
  - ▷ Extreme case @ $\Gamma_{M.C.} = 0$
  - ▷ Regular CLEO II.V M.C.
- Fits of data and M.C. event samples

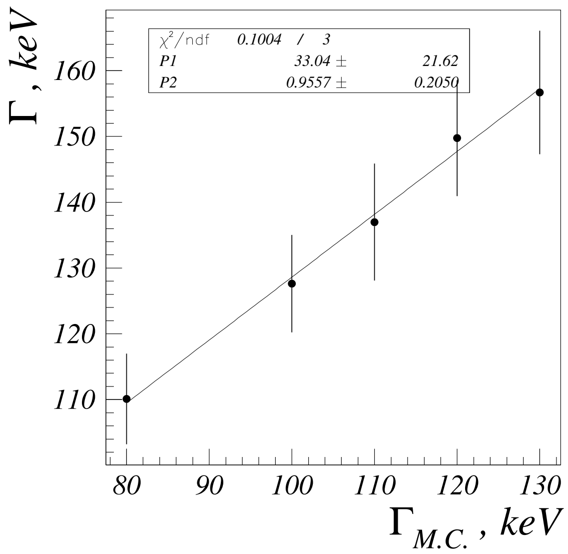
In progress

- Study of contribution from multiple scattering due to the beam pipe and Silicon Vertex Detector material.

Fit of M.C. events

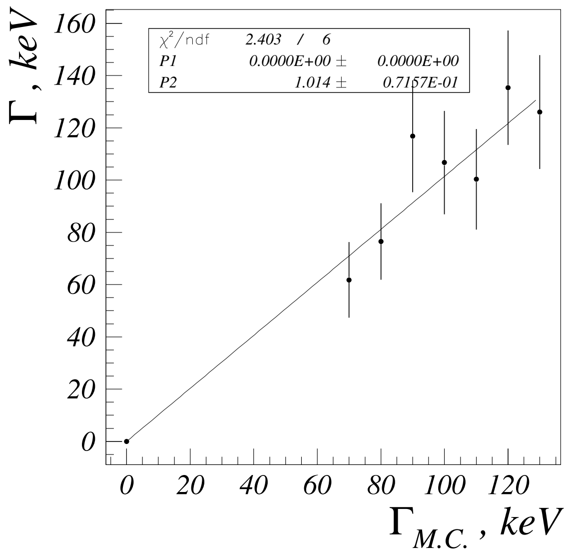
How good can be resolved simulated width?

All parameters free:



- $\Gamma_{meas.} - \Gamma_{M.C.} \sim 33 \pm 22\ keV$
- To use the same fit for exp. data we have to trust the M.C.

"Gold-plated" sample of events:



- "Best" tracks
- Tails in all distributions removed

$\rightarrow$ $\sim$1/40 of statistics, but ...

$\rightarrow$ Q–distribution without tails

$\rightarrow$ $f_{mis} = 0$, scale factor: k=1 – fixed.

All widths resolved.

- Regardless selection of event sample we always measure

$$\frac{\partial\Gamma(D^{*+})}{\partial k} \simeq -2.0\ keV/\%$$

Conclusion

- CLEO II.V statistics and precision tracking should enable us to make the measurement or at least obtain better upper limit of $\Gamma(D^{*+})$.
- Detector resolution needs to be understood.
- Study of systematic effects is in progress.
- Estimated precision of $\Gamma(D^{*+})$ measurement :

Event sample	$\Delta\Gamma_{stat.}$	$\Delta\Gamma_{syst.}$
Full	$\sim 7\ keV$	$< 30\ keV$
“Gold-plated”	$\sim 20\ keV$	$< 15\ keV$