Charm Semileptonic Decays

A. Oyanguren, P. Roudeau, J. Serrano

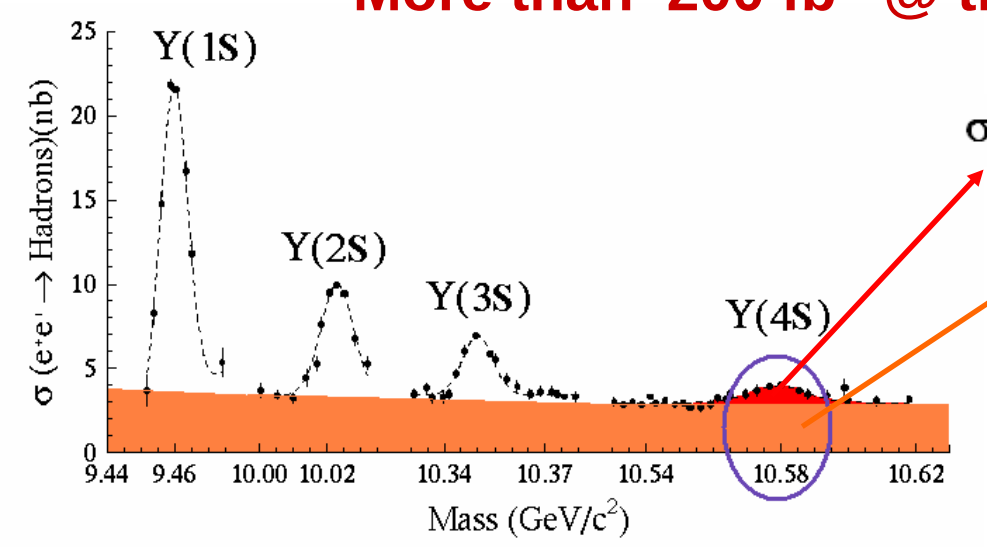
Outline:

- **Motivation**
- **D $\rightarrow$K$\ell\nu$ channel**
- **Starting with D_s**
- **First look at D $\rightarrow\pi e\nu$**
- **Plans**

BaBar LAL 05/06/28

Motivation

More than 200 fb^{-1} @ the Ψ(4S)



$\sigma(e^+e^- \to b\bar{b}) = 1.05$ nb

$\sigma(e^+e^- \to c\bar{c}) = 1.30$ nb

260 M of $c\bar{c}$ events

Use semileptonic decays of charm to:

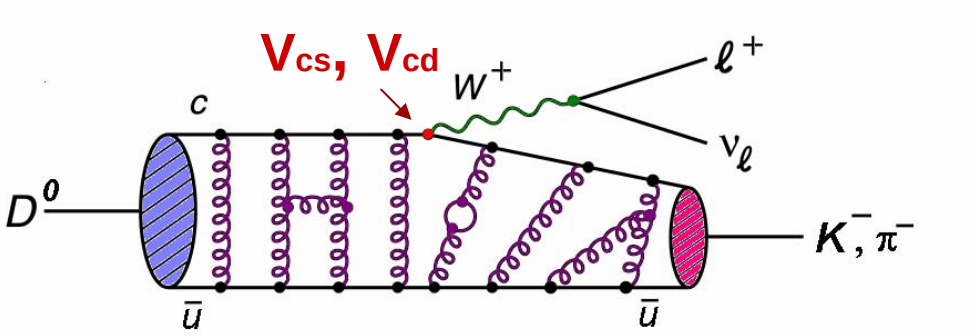
- ★ Measure **form factors and relative BR's** of exclusive channels
- ★ Measure **hadronic mass distributions** of special systems (**0+ states**)

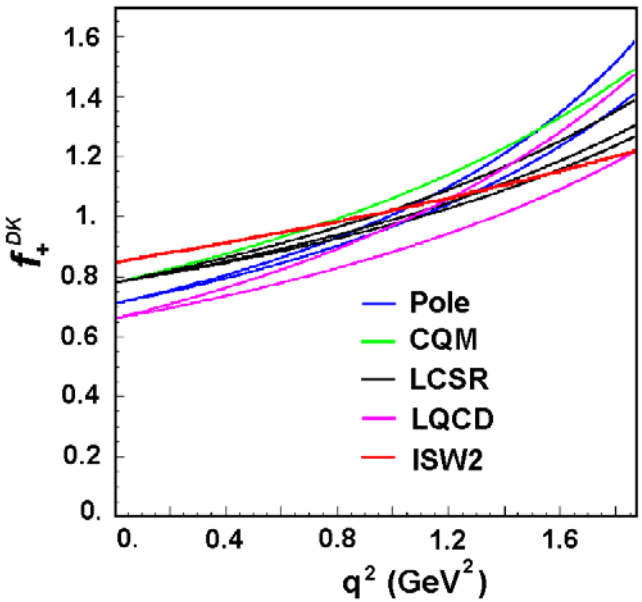
→ **Improve our understanding of B decays**

Motivation

$q^2 = (p_\ell + p_\nu)^2 = (p_D - p_K)^2$

★ Form factors





→ Validate Lattice QCD results

→ Understand hadronic effects

→ Determine $|V_{ub}|$

$f_\pi, f_B, f_{B^*}, g_{B^*B\pi}$

$$\frac{d\Gamma(B \to \pi e \overline{\nu}_e)/dE_\pi}{d\Gamma(D \to \pi e \overline{\nu}_e)/dE_\pi} = \left|\frac{V_{ub}}{V_{cd}}\right|^2 \left(\frac{M_B}{M_D}\right) \left|\frac{f_+^{B\to\pi}}{f_+^{D\to\pi}}\right|^2$$

Purpose

- Training with the simplest channel: $D \to K \ell \nu$

- **Special interest on $D \to \pi \ell \nu$**
  - → Linked to $|V_{ub}|$

- **and D_s s.l. decays**
  - → Better controlled by Lattice QCD (*s* is heavier)
  - → No competition with CLEO-c till 2006

- s.l. decays of charm baryons

★ **Study of hadronic mass distributions (0^+ states)**

$D \to (K\pi, \pi\pi \ldots) \ell \nu$

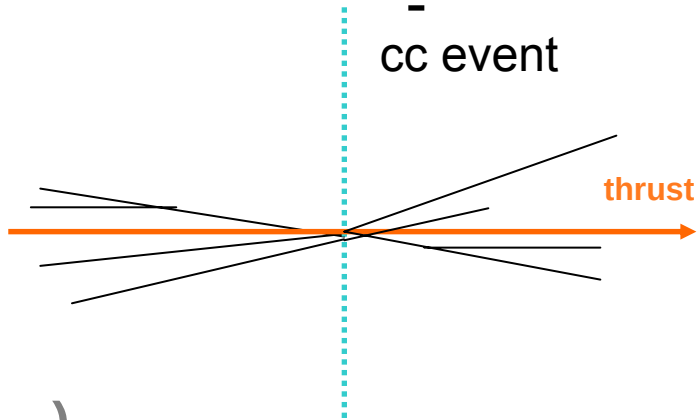
- Of general interest for spectroscopy

Similar systems in B decays ($B \to k\pi\pi, 3\pi \ldots$)

$D \to K \ell \nu$ channel

Measure of form factors as function of q^2

- $D^{*+} \to D^0 \pi^+$, $D^0 \to K^- \ell^+ \nu$
  - Define two hemispheres:
    - Impose soft π^+, K^- and ℓ^+ in the same hemisphere
  - Compute D direction $(- \vec{p}_{\text{all tracks} \neq K,\ell})$
  - Compute the missing energy in the ℓ hemisphere
  - Fit $p_D = p_K + p_\ell + p_\nu$
    - Constraints using m_D and m_{D^*} (1c or 2c fit)
  - Compute $q^2 = (p_D - p_K)^2$



$D \to K \ell \nu$ channel

★ Candidates:

Lists

- **charged tracks → GoodTracksVeryLoose**
- **neutrals → GoodPhotonDefault**
- **electrons → PidLHElectrons**
- **kaons → KMicroTight**
- **pions → GoodTracksVeryLoose**

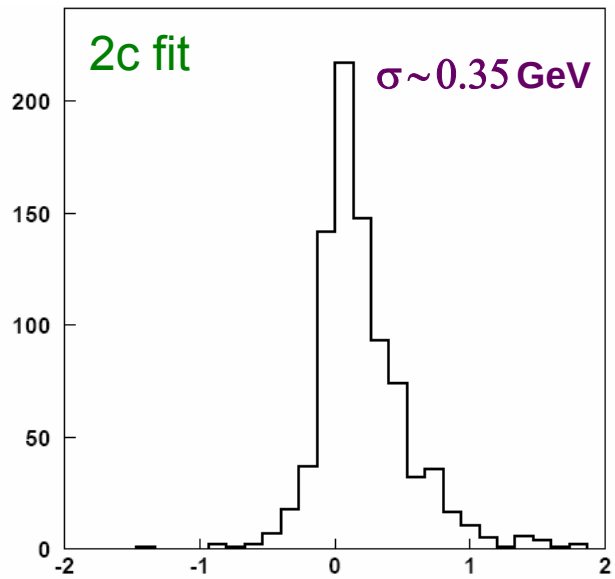
Cuts

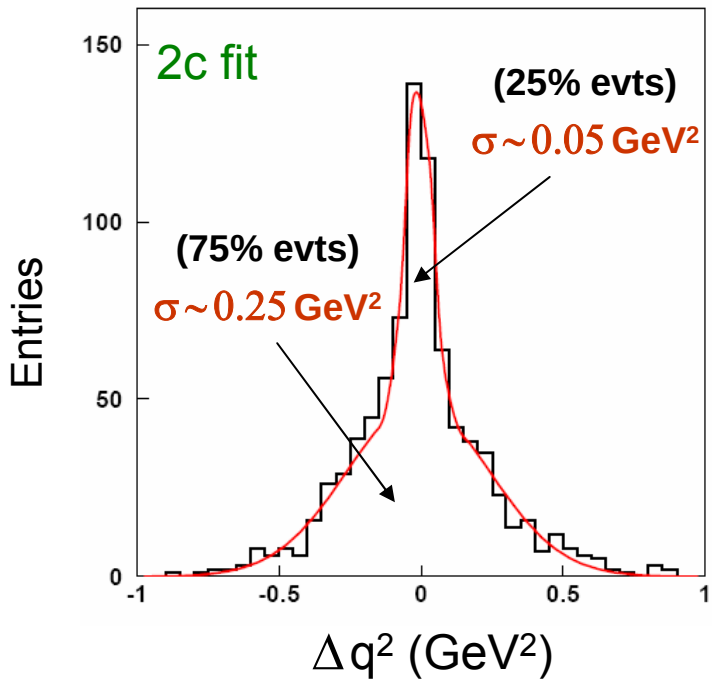
- **p^*_ℓ > 0.5 GeV**
- **$p^*_{\pi^*}$ < 0.45 GeV**

D→Kℓν channel

(MC, 400K events cc)

★ q^2 resolution → $q^2 = (p_\ell + p_\nu)^2 = (p_D - p_K)^2$





	CLEO III	FOCUS	CLEO-c	BABAR
Δq^2 (GeV^2)	0.4	0.22	0.03	0.05-0.25

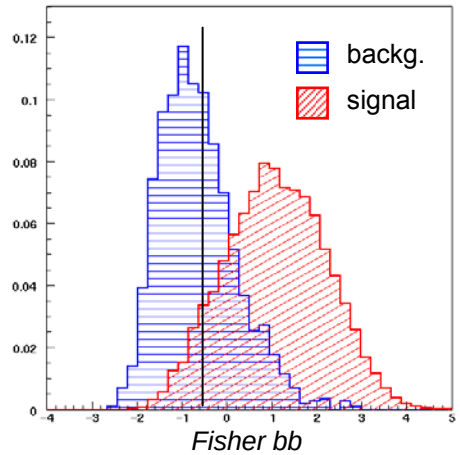
➥ **good resolution to measure form factors**

D→Kℓν channel

★ Background suppresion

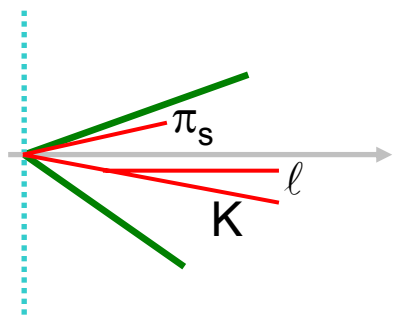
▷ Fisher against bb background

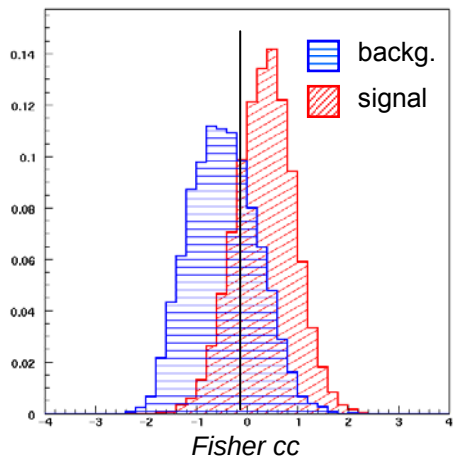
Event shape variables:
R_2 and track multipicity



▷ Fisher against cc background

Spectator system +
other kinematic infos

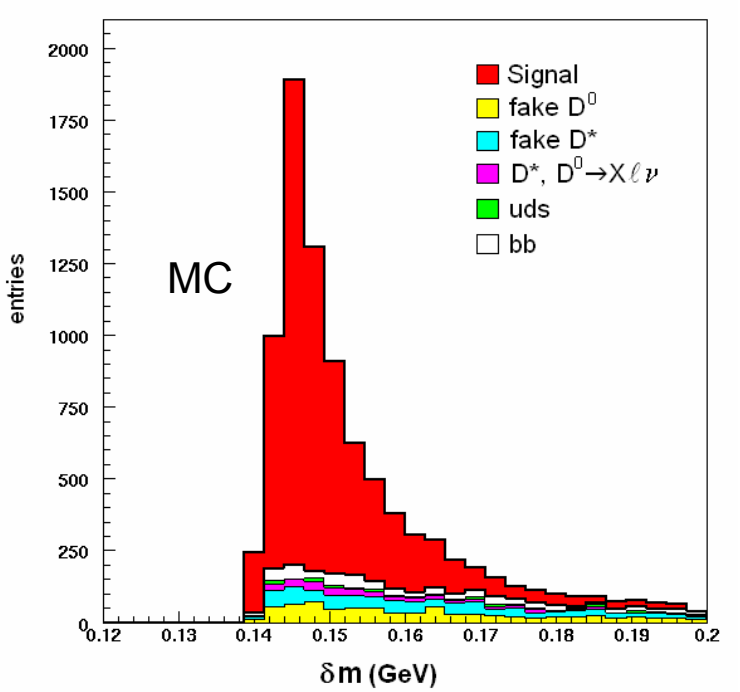




max $S/\sqrt{S+B}$ in the signal region

D→Kℓν analysis

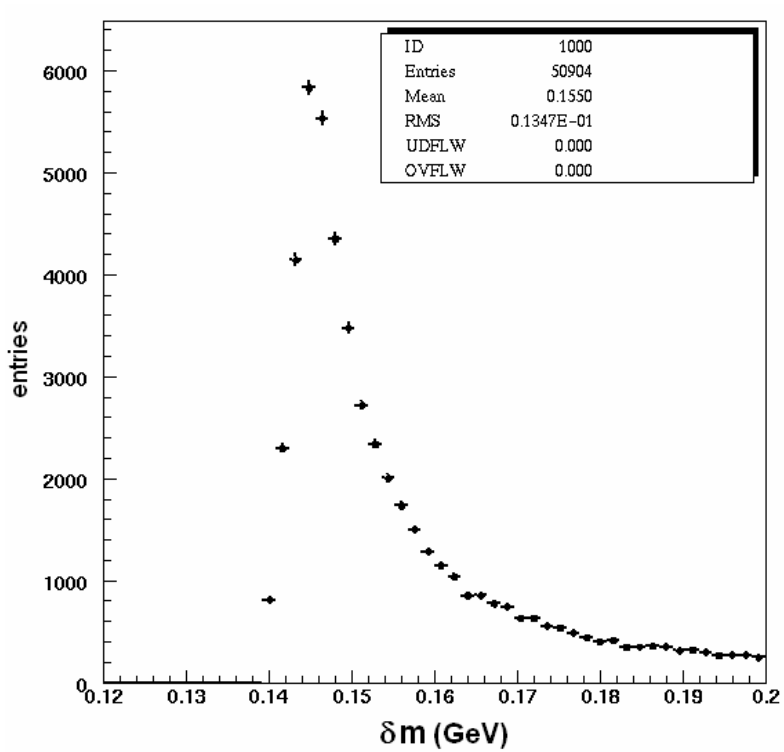
4.5 M cc events



MC yield (δm < 0.16 GeV)

- signal = 82.7 %
- fake D^0 = 5.5%
- fake D* = 5%
- D*, $D^0 \to X\ell\nu$ = 2.5%
- uds evts = 0.7%
- bb evts = 3.5%

Data (Run1: 19.5 fb^{-1})



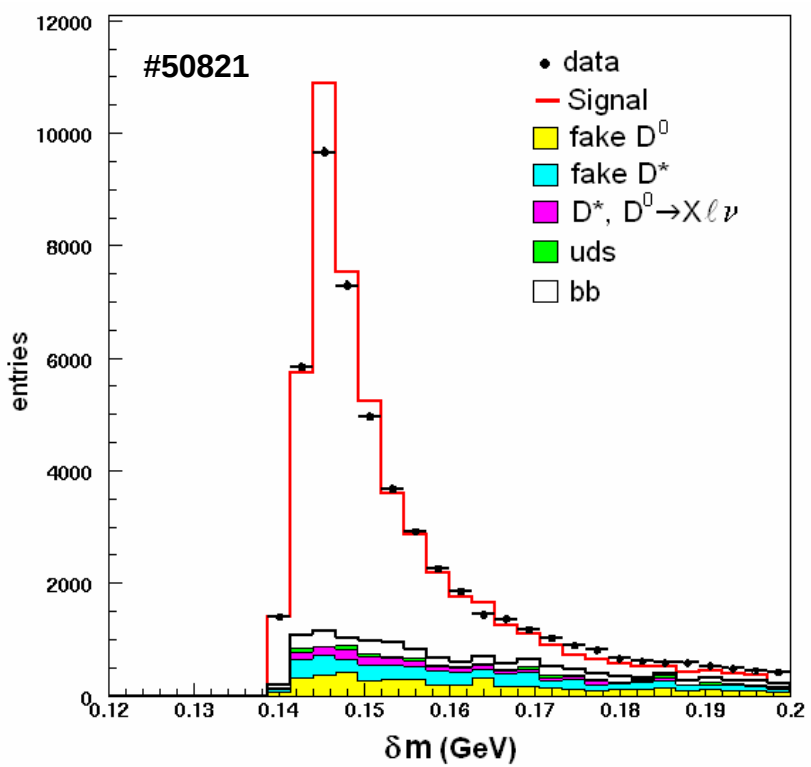
D→Kℓν analysis

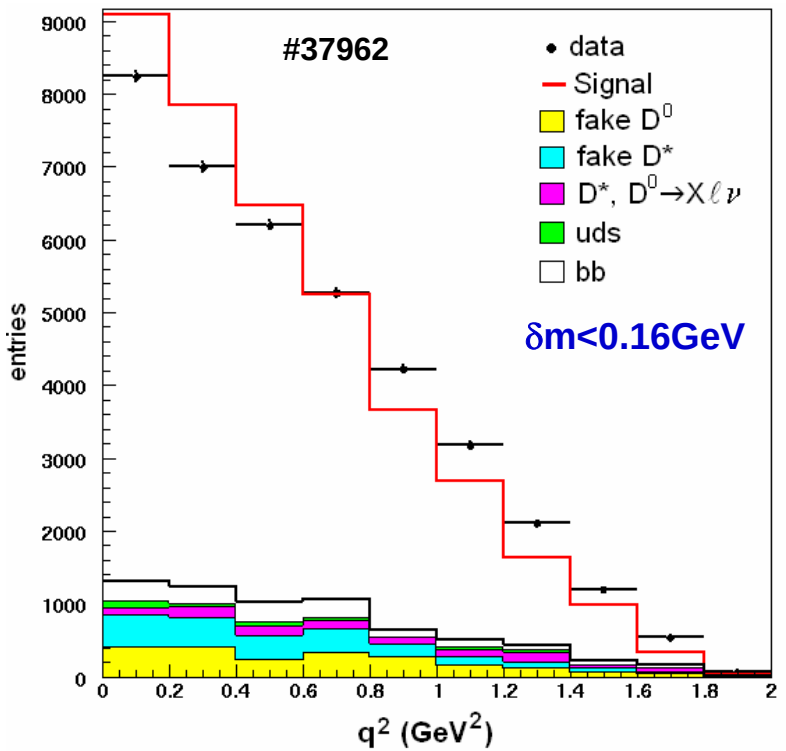
Need to control MC using data

($D^{*+} \rightarrow D^0\pi^+$

$D^0 \rightarrow K^-\pi^+$, $D^0 \rightarrow K^-\pi^+\pi^0$)

Comparison data/MC

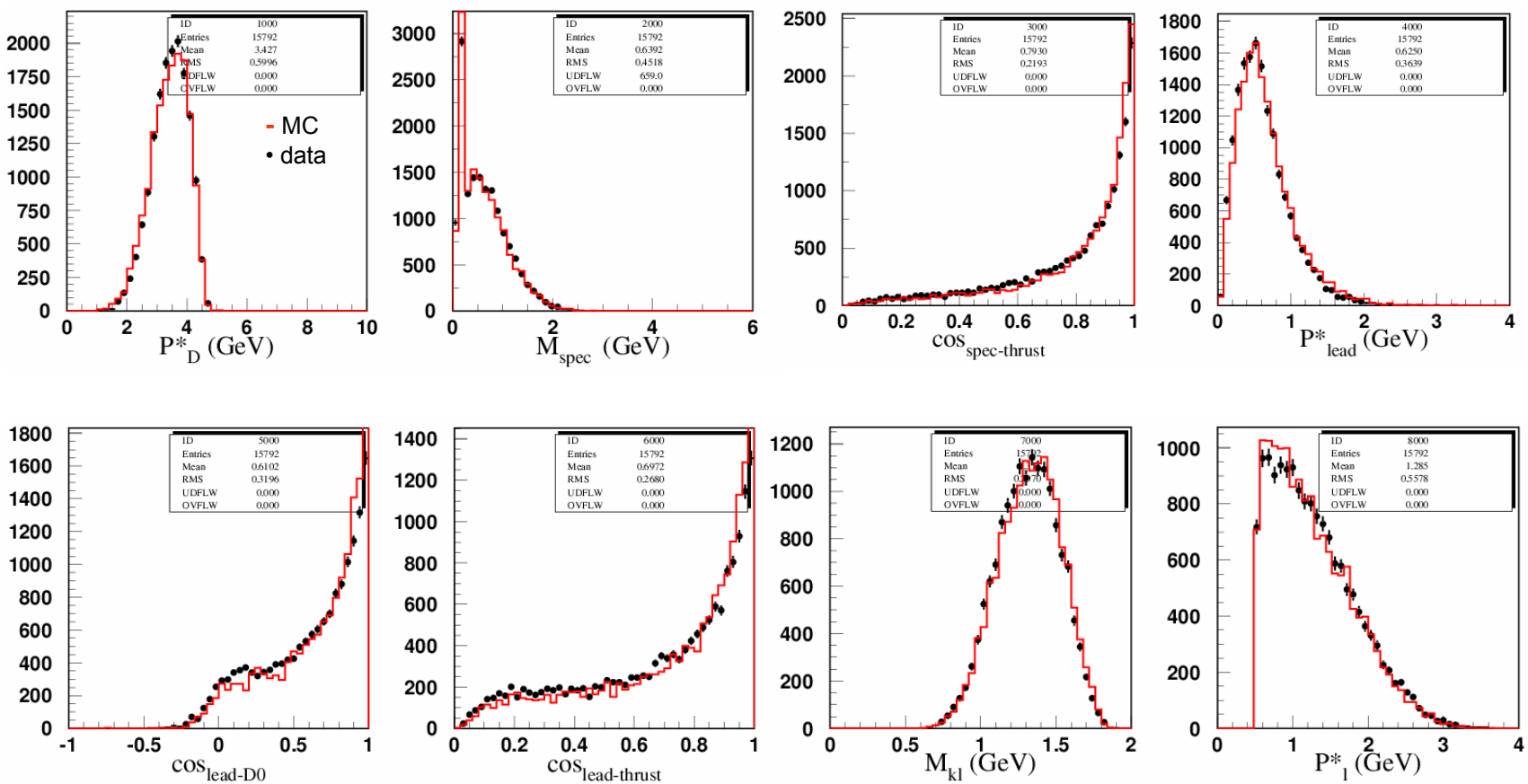




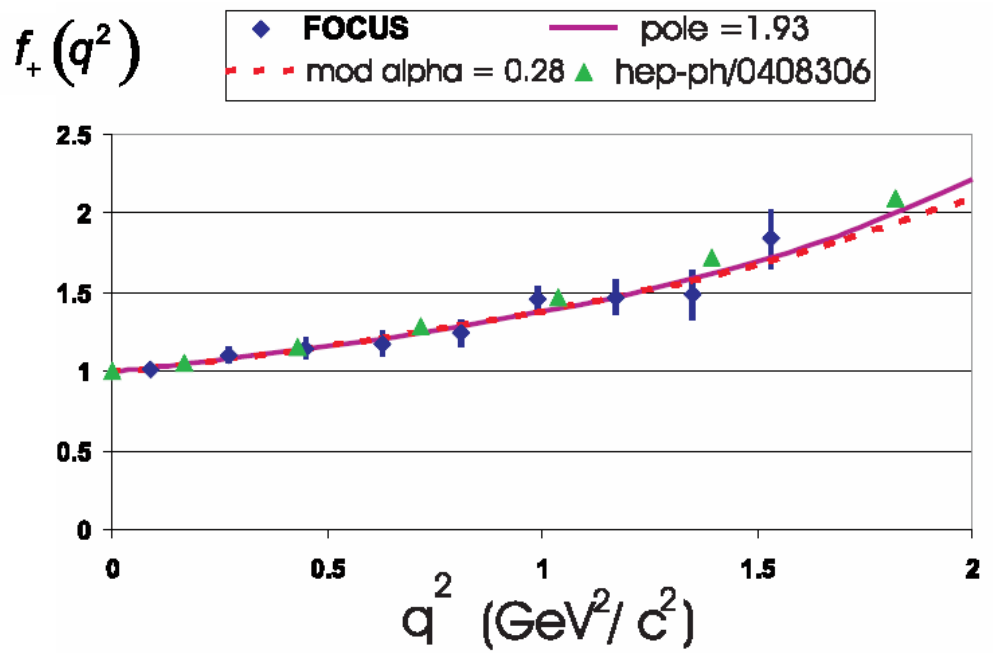
(MC normalized to # data entries)

D→Kℓν analysis

Comparison data/MC → Variables entering in Fisher cc



D→Kℓν channel



Focus with 6K evts

Phys.Lett. B607 (2005) 233-242

→ **BaBar 5 times more stat. only with Run1**

	6.7 fb^{-1}		60 pb^{-1}	2006 3 fb^{-1}	20 fb^{-1}	200 fb^{-1}
	CLEO III	FOCUS	CLEO-c	CLEO-c	BABAR	BABAR
D→Kℓν	10K	6K	1800	90K	30K	300K
D→πℓν	0.9K	0.3K	175	9K	3K	30K

Starting with D_s

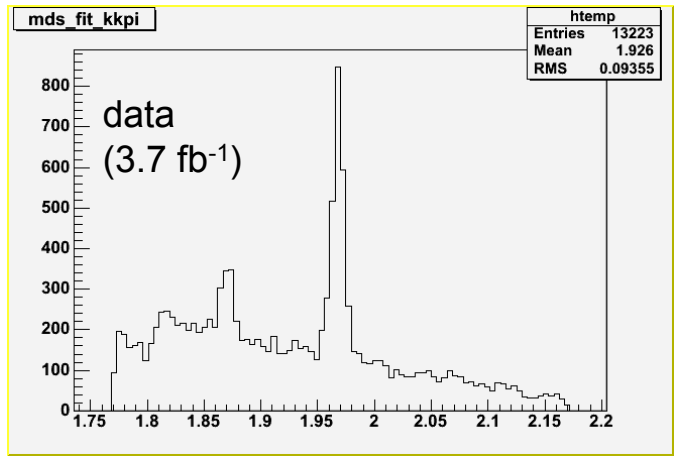
(Justine)

- **Study of the γ visibility in $D^*_s \rightarrow D_s \gamma$**

  $D_s \rightarrow \phi\pi$ ($\phi \rightarrow K^-K^+$)

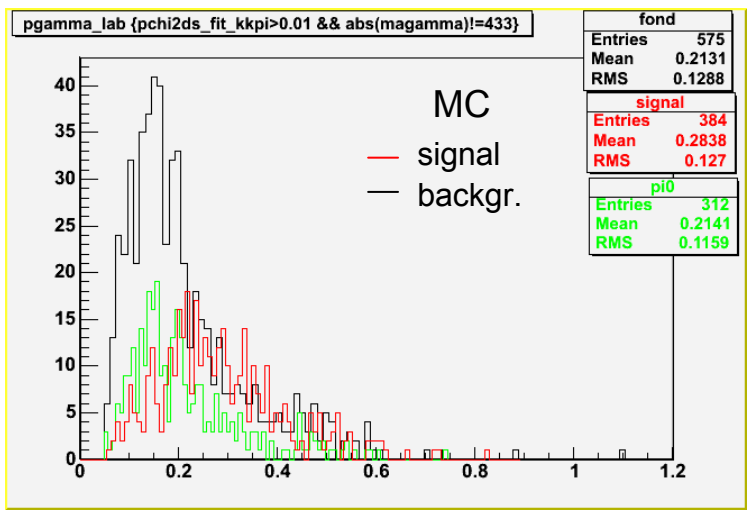
  $\rightarrow$ Large γ fraction from π^0's
  (removed by using E_γ)

Prob χ^2 [KKπ fit] > 0.01

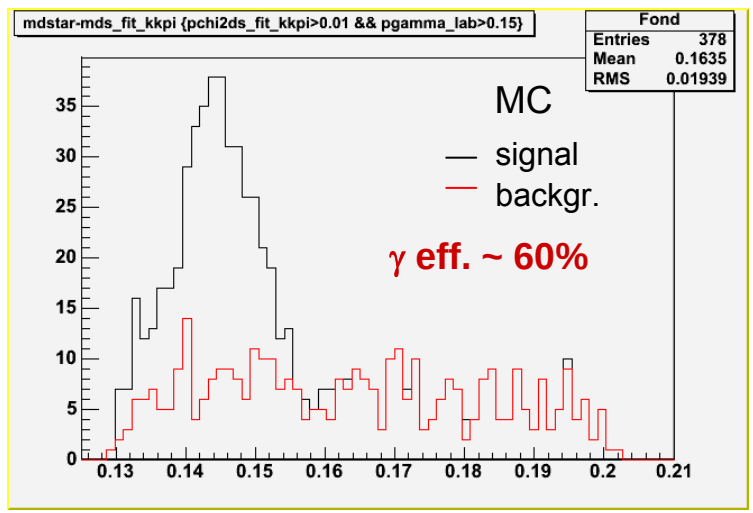


m($K^-K^+\pi$) (GeV)

$E_{\gamma\ lab}$ > 0.15 GeV



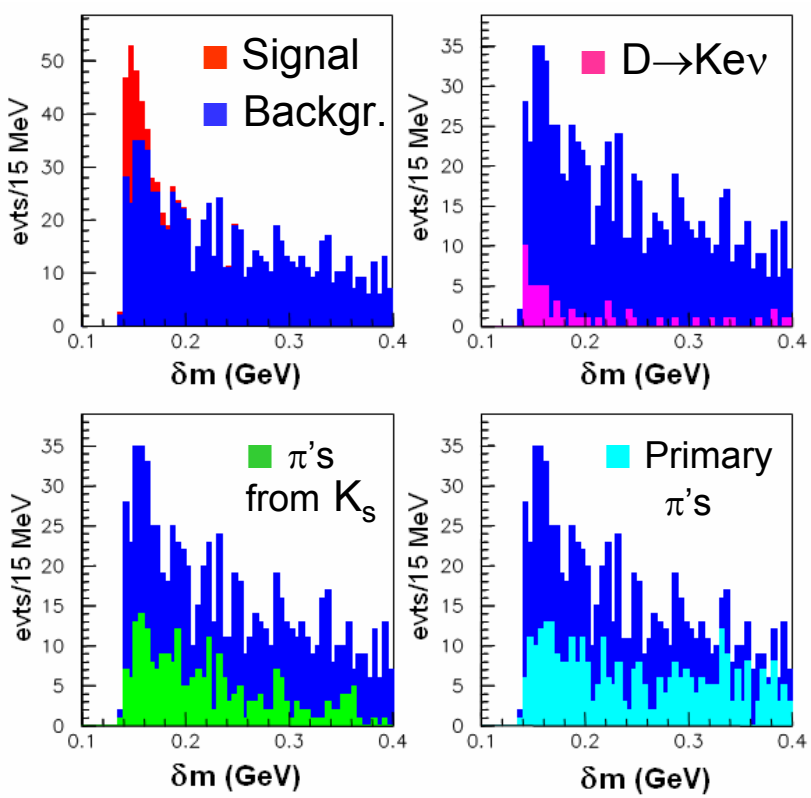
$E_{\gamma\ lab}$ (GeV)



$mD^*_s - mD_s$ (GeV)

First look at D→πeν (Fast simulation)

900k cc evts



- understanding of background sources in progress

At present a large fraction of pions comes from K_s decays and from the primary vertex → vertex information (D vertex, offsets, ..) has to be used

Expect 25k signal with 300M evts

CharmSL skim

(http://www.slac.stanford.edu/BFROOT/www/Physics/Analysis/AWG/Semileptonic/charmsl/CharmSL.html)

Defined in:

FilterTools/CharmSLPath.tcl
FilterTools/CharmSLFilter.cc
FilterTools/CharmSLFilter.hh

Description:

Selects charm events with a semileptonic decay (electrons).

Candidate Lists:

- Charged tracks: **ChargedTracksVeryLoose**
- Neutrals: **GoodPhotonsDefault**
- Electrons: **PidLHElectrons**

Selection Cuts:

- BGFMultiHadron
- **1** electron with $P^*_\ell > 0.5$ GeV
- $R_2 > 0.2$
- $M_{opp} > 0.5$ GeV
- $M_{tag} > 0.13$ GeV

Event rates:

AllEvents: ~ 2%
Charm events: ~ 9%
BB events: ~ 6%
Light quarks: ~ 3%

Prepared for R18.

Plans

$D \to K \ell \nu$

- Understand data/MC differences in δm
- Study of the normalization channels ($D^0 \to K\pi$, $D^0 \to K\pi\pi^0$)
- Fitting procedure to extract physics quantities

$D \to \pi \ell \nu$

- Study of offsets to decrease the background level

$D_s \to \phi \ell \nu$, x $\ell \nu$

- Justine starting in September