# Observation B->D**μ ν

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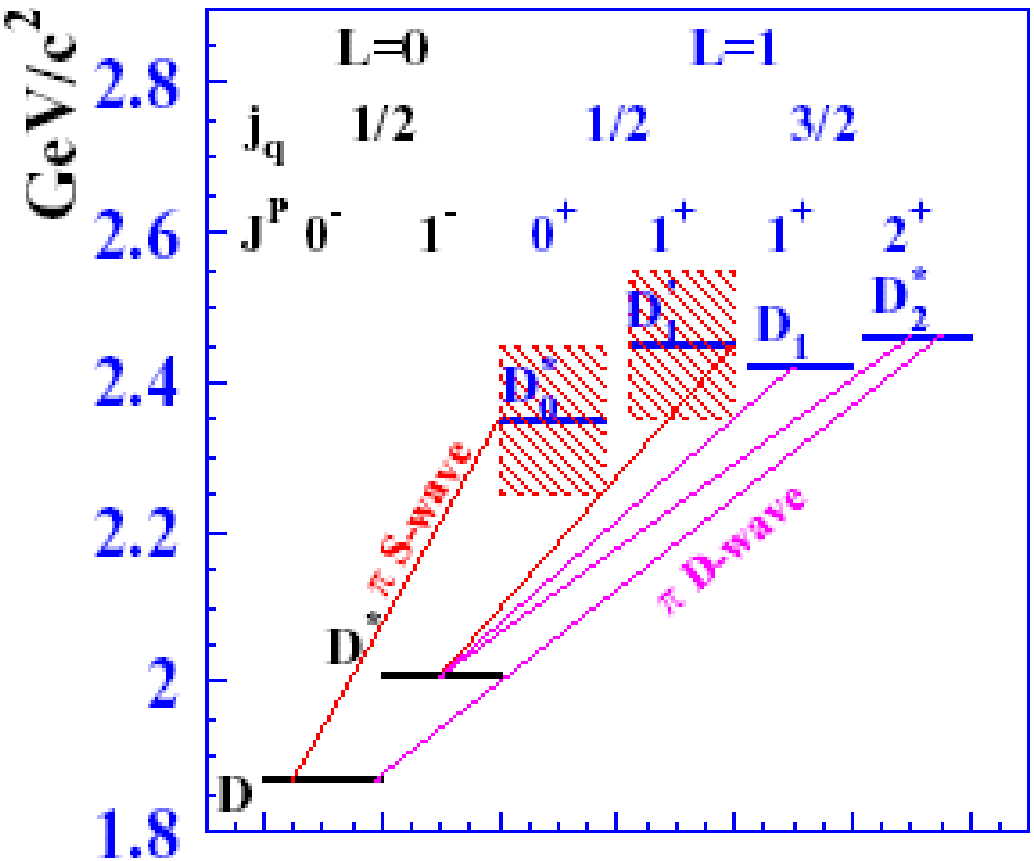
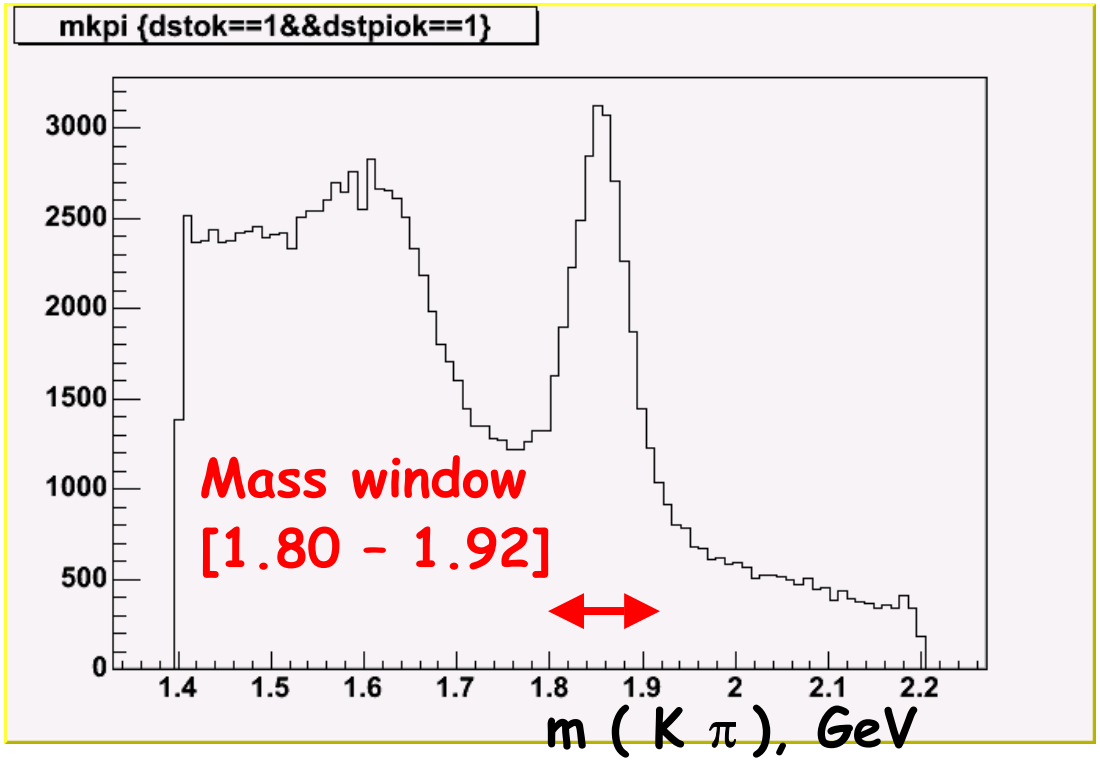
- D** denotes 4 different orbitally excited D meson states, see diagram
  - Two broad states
  - Two narrow states
- Narrow D**
  - $D^0_1(2420) \to D^{*+} \pi^-$
  - $D^{*0}_2(2460) \to D^{*+} \pi^-$



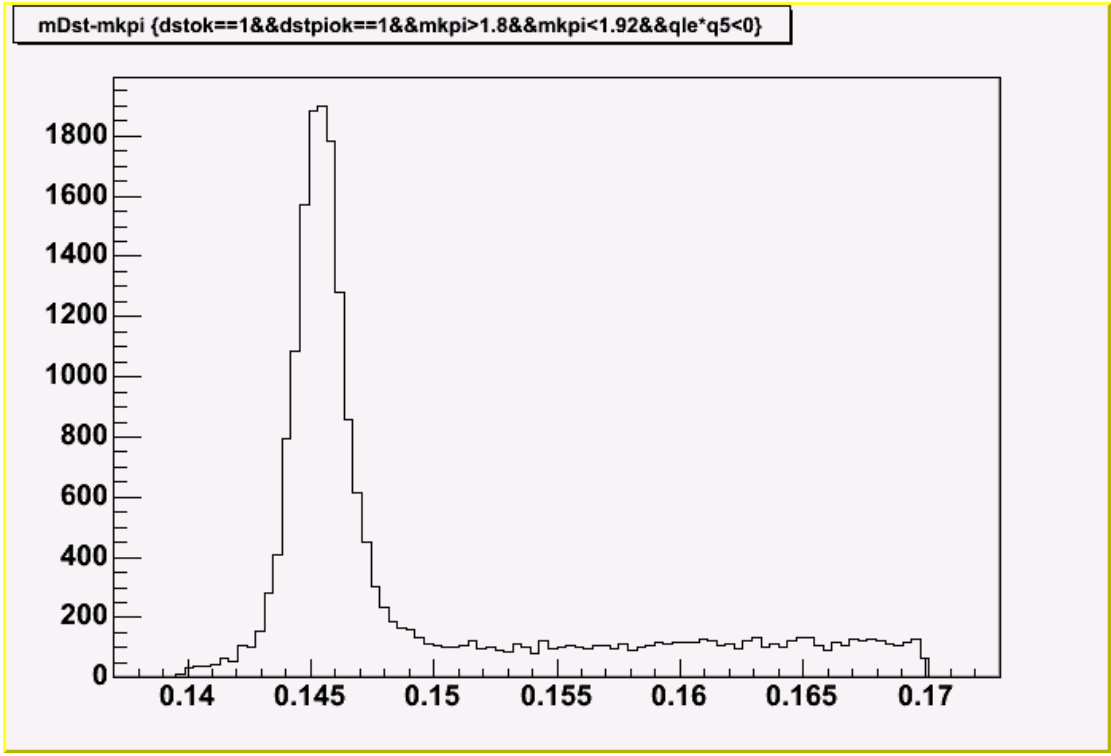
# $D^0$ sample

- Started with B -> $\mu$ D sample from lifetime ratio analysis, see D0 note 4280
  - P14 data, ~225 $pb^{-1}$
  - BANA analysis package V02.10.03
  - ~ 90k B -> $\mu$ D ( -> K $\pi$)
  - This plot has some additional selections (two more tracks)



# D* sample

- Selections
  - Additional pion pt>0.18 GeV
  - Right charge correlation with muon
  - D mass window [1.80-1.92 GeV]
- Total ~ 20k D*



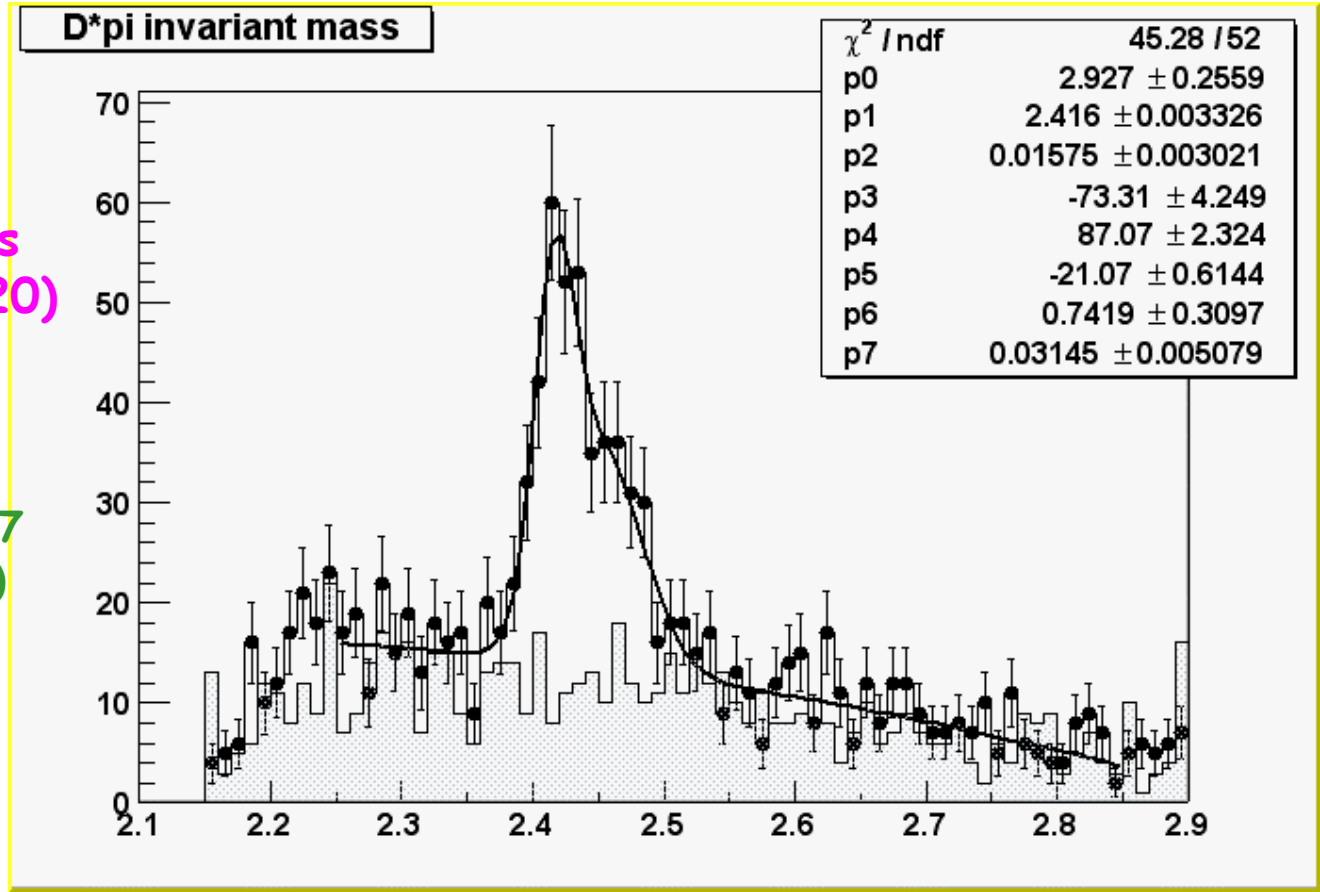

- This plot has additional selections (one more track required)

# D** selections

- Selections
  - D* mass difference window [0.143-0.148 GeV]
  - Additional pion
    - pt > 0.4 GeV
    - Right charge correlation
  - B vertex $\chi^2$ < 9
    - Made of all tracks of D** and muon
  - Lifetime cuts
    - Lxy significance > 3
    - IP significance of the additional pion > 5
  - # CFT hits > 5 for all tracks

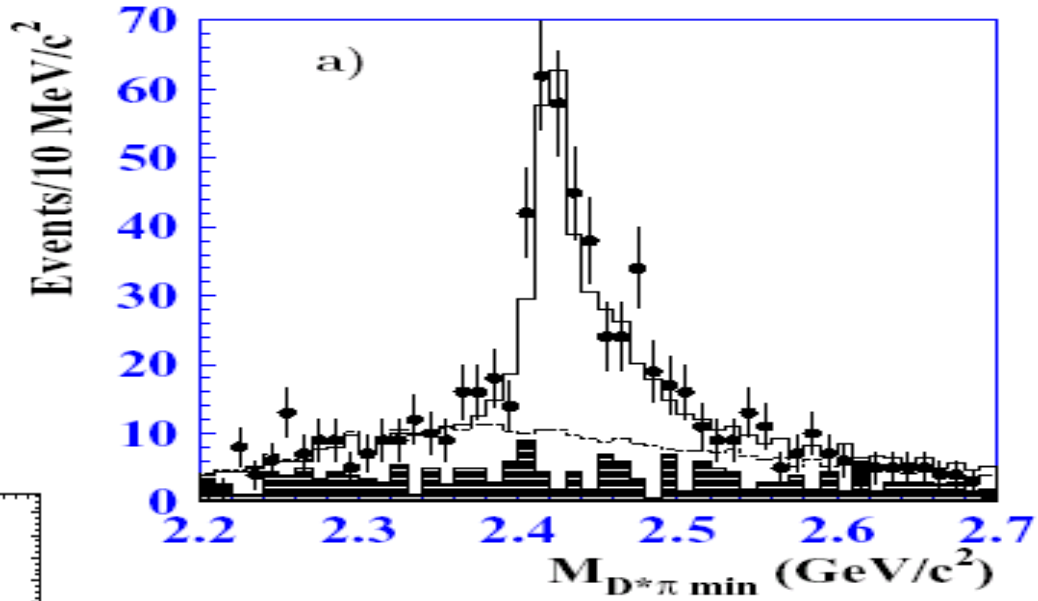
# D** signal

- See B -> D**μ signal
  - 293 +/- 26 events
  - No signal for wrong sign combination
- Two merged resonances
  - PDG natural widths 19 MeV for D(2420) and 23 MeV for D(2460)
    - ? Belle last measurement : 47 MeV for D(2460)
- Mass 2416 MeV
  - PDG 2421 MeV
  - Has mass shift as everybody

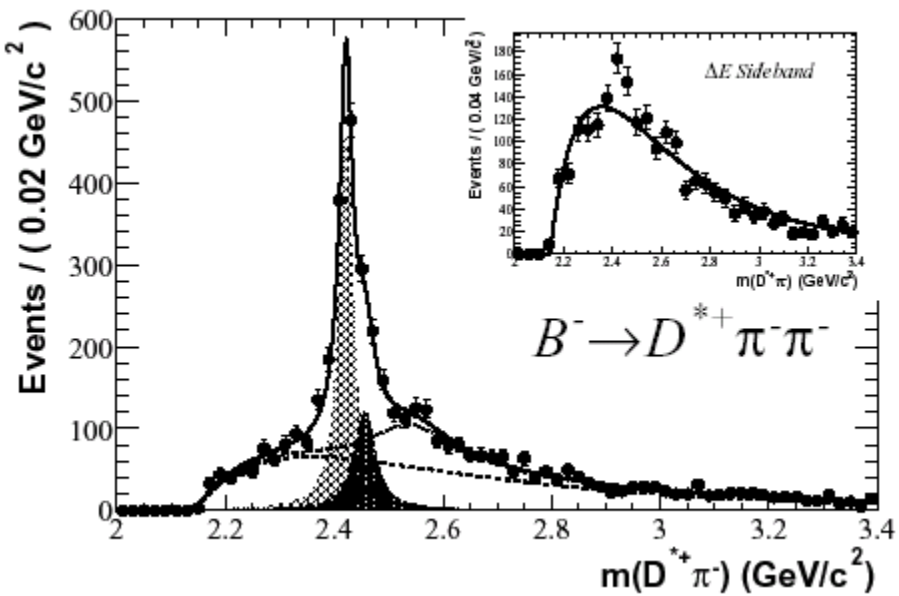


# D** signal in other places

- B-factories showed hadronic modes B->D** $\pi$




BaBar, LP2003

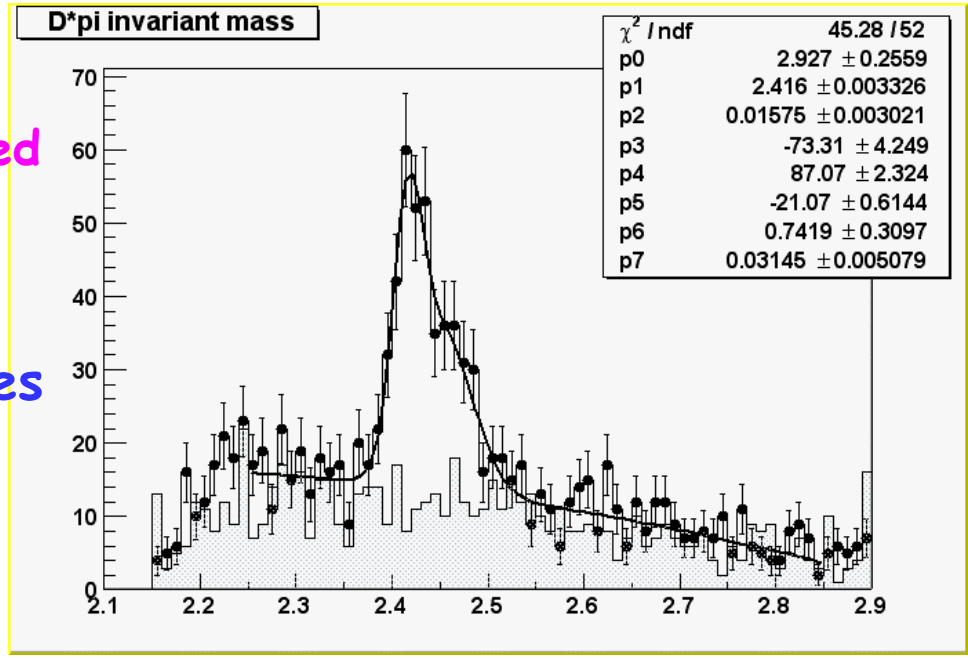



Belle, published in 2003

- LEP, CLEO have lower statistics
- CDF did not see it in Run I
- Did not find semileptonic modes for B-factories

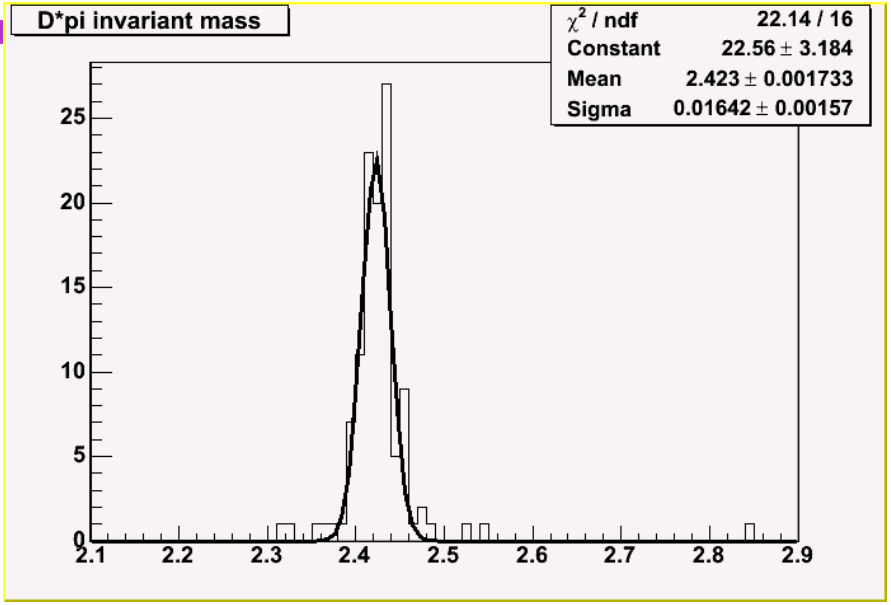
# Fit

- Two gaussians and 2nd order polynomial
  - Two normalizations are substituted by
    - Single normalization constant
    - Ratio of two normalizations
- Fixed distance between two states at 37 MeV (PDG)
- All other parameters (total 8) allowed to float
- Results :
  - $N(D_1)+N(D^*_2)$ = 293 +/- 26 events
  - $N(D^*_2) / N(D_1)$ = 0.74 +/- 0.31
  - Mass $D_1$ = 2416 +/- 3 MeV
  - Sigma $D_1$ = 16 +/- 3 MeV
  - Sigma $D^*_2$ = 31 +/- 5 MeV

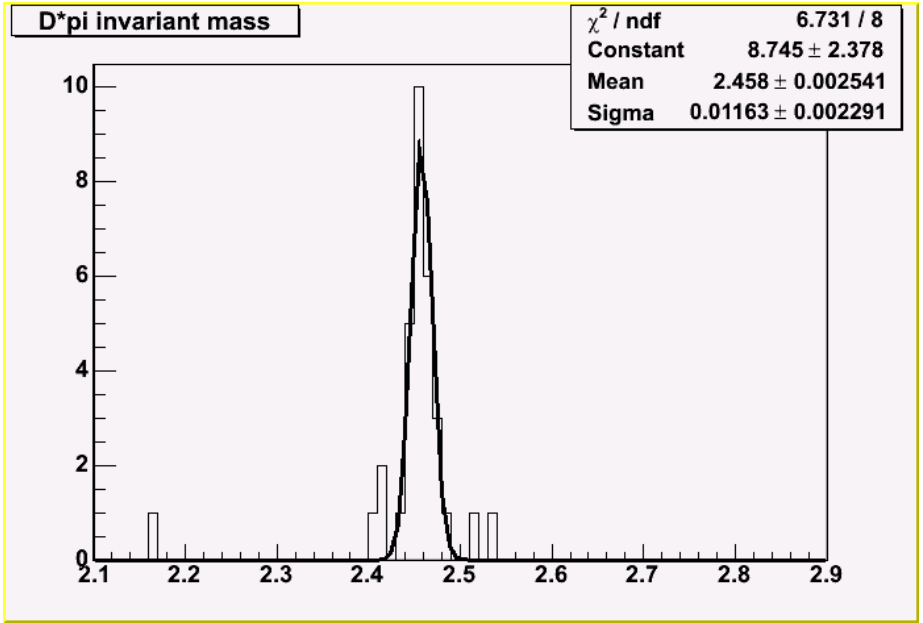


# D** MC

- Selected exclusive D**
- $D_1$ (2420)
  - Sigma 16 MeV
    - Consistent with observed
  - Efficiency xxx (in progress)




- $D^*_2$ (2460)
  - Sigma 12 MeV
    - What's in EvtGen?
  - Efficiency xxx (in progress)



# What can be measured?

- Theoretically semileptonic modes are favored because of simplicity

$$R \equiv \frac{\mathcal{B}(B \to D_2^* \ell \bar{\nu})}{\mathcal{B}(B \to D_1 \ell \bar{\nu})}$$ = 0.4-0.7 predicted by HQET

  - world average 0.4 +/- 0.15
- We can extract
  - R from
    - $N(D^*_2) / N(D_1)$ = 0.74 +/- 0.31
    - Need to correct on ratio of efficiencies (correction should be small) and $Br(D^{**} \to D^* \pi)$
  - $Br(B \to \mu D_1 X) + Br(B \to \mu D^*_2 X)$
    - $N(D_1)+N(D^*_2)$ = 293 +/- 26 events
    - Normalize to $D^0$ so both come from $B^+$
    - Need efficiencies (MC)
- Signal has good purity
  - Interference effects
  - Helicity

# Conclusions

- Observed B -> D** muon decays
- Signal purity and statistics is good
  - Can do competitive measurements of Br and ratio of Br for two narrow D** states
  - Can do helicity analysis of two states
- Plans
  - By conferences : measure R and Br